Back To Article

COMPONENT LOCATOR

DISASSEMBLED VIEWS (LGW)

Turbocharger Wastegate Actuator Vacuum Tank Assembly

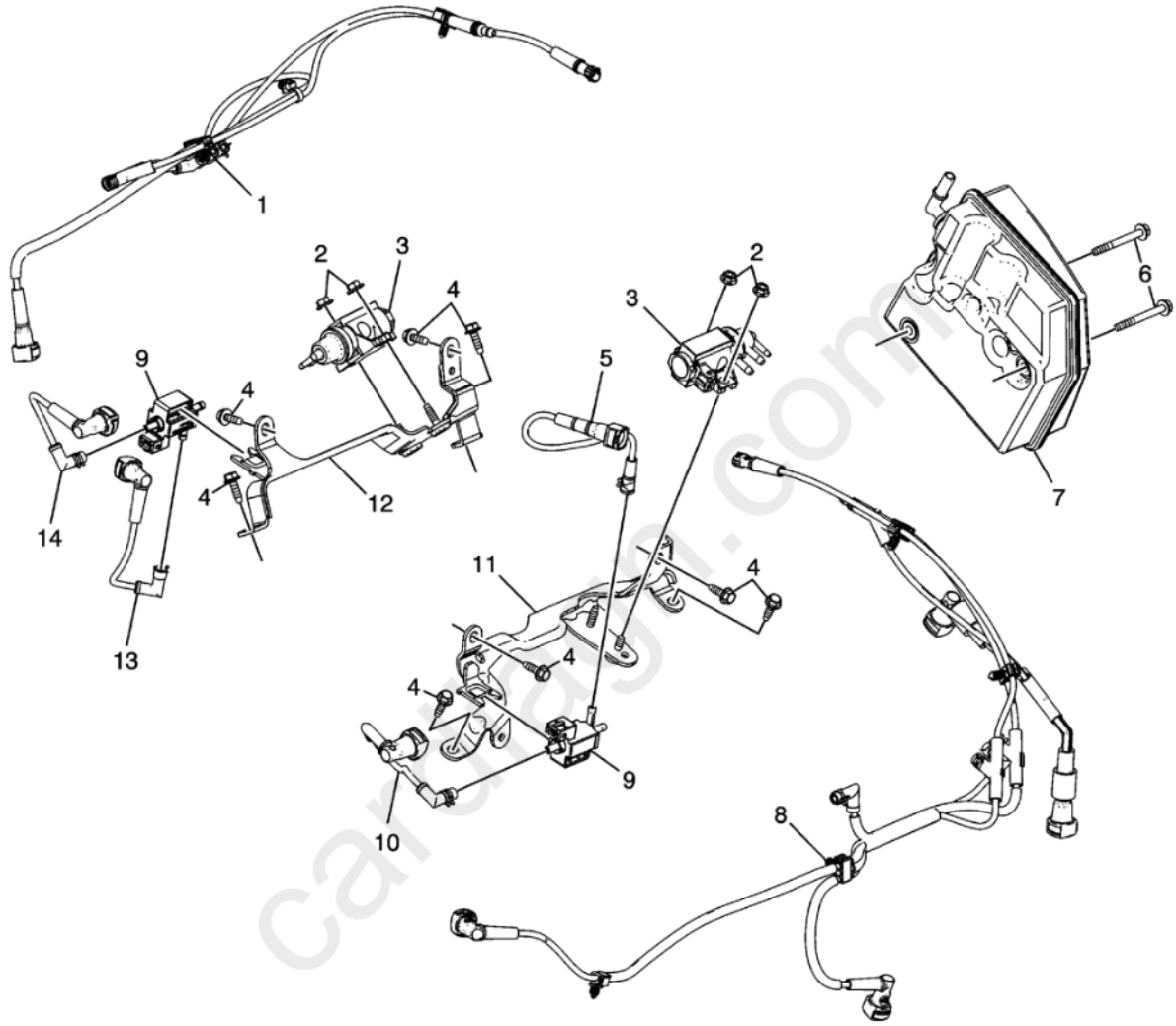


Fig. 1: Turbocharger Wastegate Actuator Vacuum Tank Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Charge Air Bypass Valve Vacuum Tank Tube
2	Turbocharger Wastegate Regulator Solenoid Valve Nut [4x]
3	Turbocharger Wastegate Regulator Solenoid Valve [2x]
4	Turbocharger Wastegate Actuator Vacuum Tank Bracket Bolt [8x]
5	Turbocharger Wastegate Actuator Vacuum Source Tube
6	Turbocharger Wastegate Actuator Vacuum Tank Bolt [2x]
7	Turbocharger Wastegate Actuator Vacuum Tank
8	Charge Air Bypass Valve Vacuum Tank Tube
9	Turbocharger Wastegate Regulator Solenoid Valve [2x]
10	Turbocharger Wastegate Actuator Vacuum Source Tube
11	Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket - Left Side

Callout	Component Name
12	Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket - Right Side
13	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube
14	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube

Engine Accessory Component Assemblies

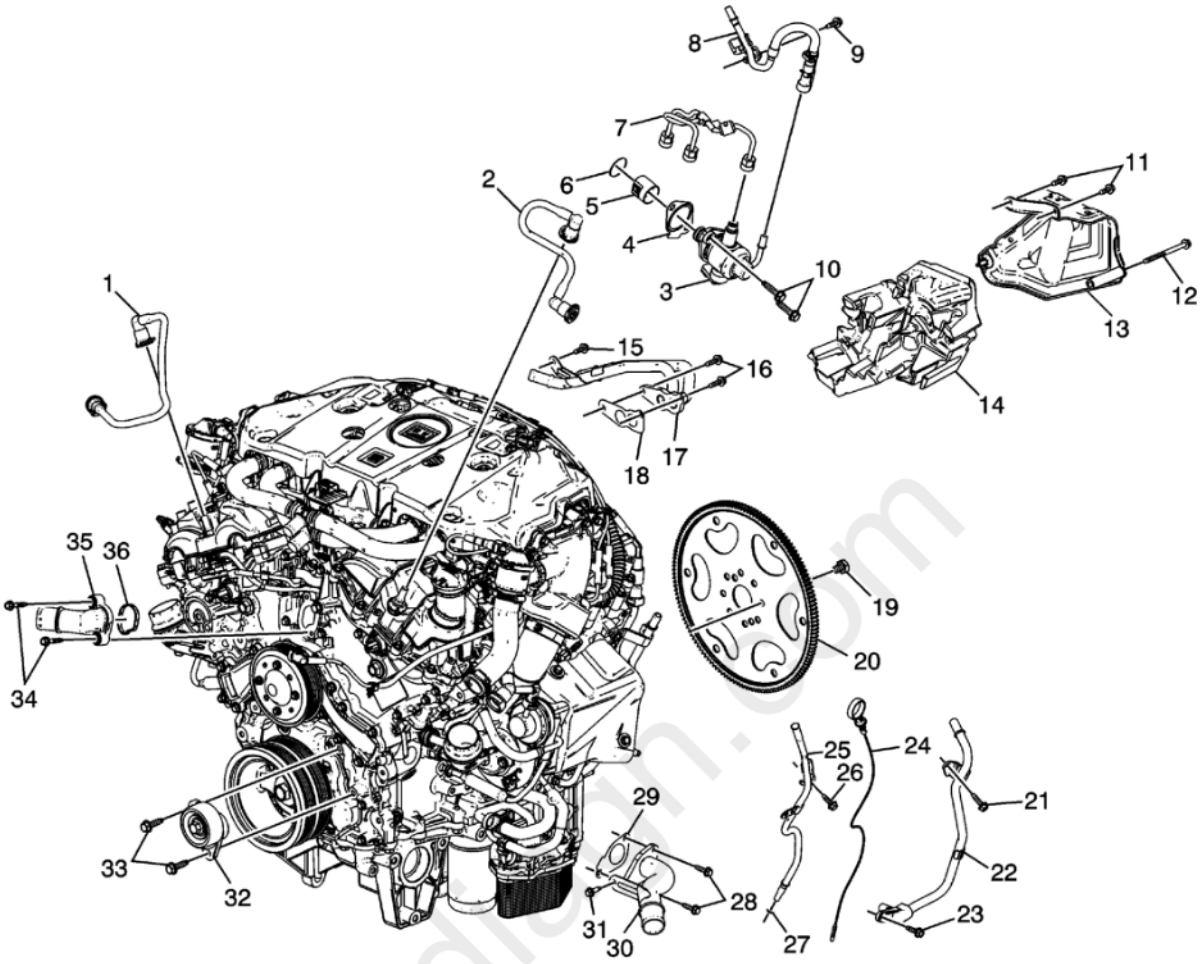


Fig. 2: Engine Accessory Component Assemblies
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Tube Connector (PCV)
2	Positive Crankcase Ventilation Tube Connector (PCV)
3	Fuel Pump
4	Fuel Pump Bracket Gasket
5	Valve Lifter Follower
6	Fuel Pump O-Ring
7	Fuel Feed Intermediate Pipe
8	Fuel Feed Pipe Bolt
9	Fuel Feed Pipe
10	Fuel Pump Bolt [2x]
11	Fuel Pipe Shield Bolt [2x]
12	Fuel Pipe Shield Bolt
13	Fuel Pipe Shield
14	Engine Rear Noise Shield
15	Heater Inlet and Outlet Pipe Bolt
16	Heater Inlet and Outlet Pipe Bolt [2x]

Callout	Component Name
17	Heater Inlet and Outlet Pipe
18	Heater Inlet and Outlet Pipe Gasket
19	Turbocharger Wastegate Actuator Vacuum Tank Bolt [2x]
20	Turbocharger Wastegate Actuator Vacuum Tank
21	Automatic Transmission Flex Plate Bolt [8x]
22	Automatic Transmission Flex Plate
23	Vacuum Pump Pipe Bolt
24	Vacuum Pump Pipe
25	Vacuum Pump Pipe Bolt
26	Oil Level Indicator
27	Oil Level Indicator Tube
28	Oil Level Indicator Tube Bolt
29	Oil Level Indicator Tube Seal
30	Water Pump Inlet Pipe Bolt [2x]
31	Water Inlet Seal
32	Water Pump Inlet Pipe
33	Water Pump Inlet Pipe Bolt
34	Drive Belt Tensioner
35	Drive Belt Tensioner Bolt [2x]
36	Water Outlet Bolt [2x]

Charge Air Cooler and Components

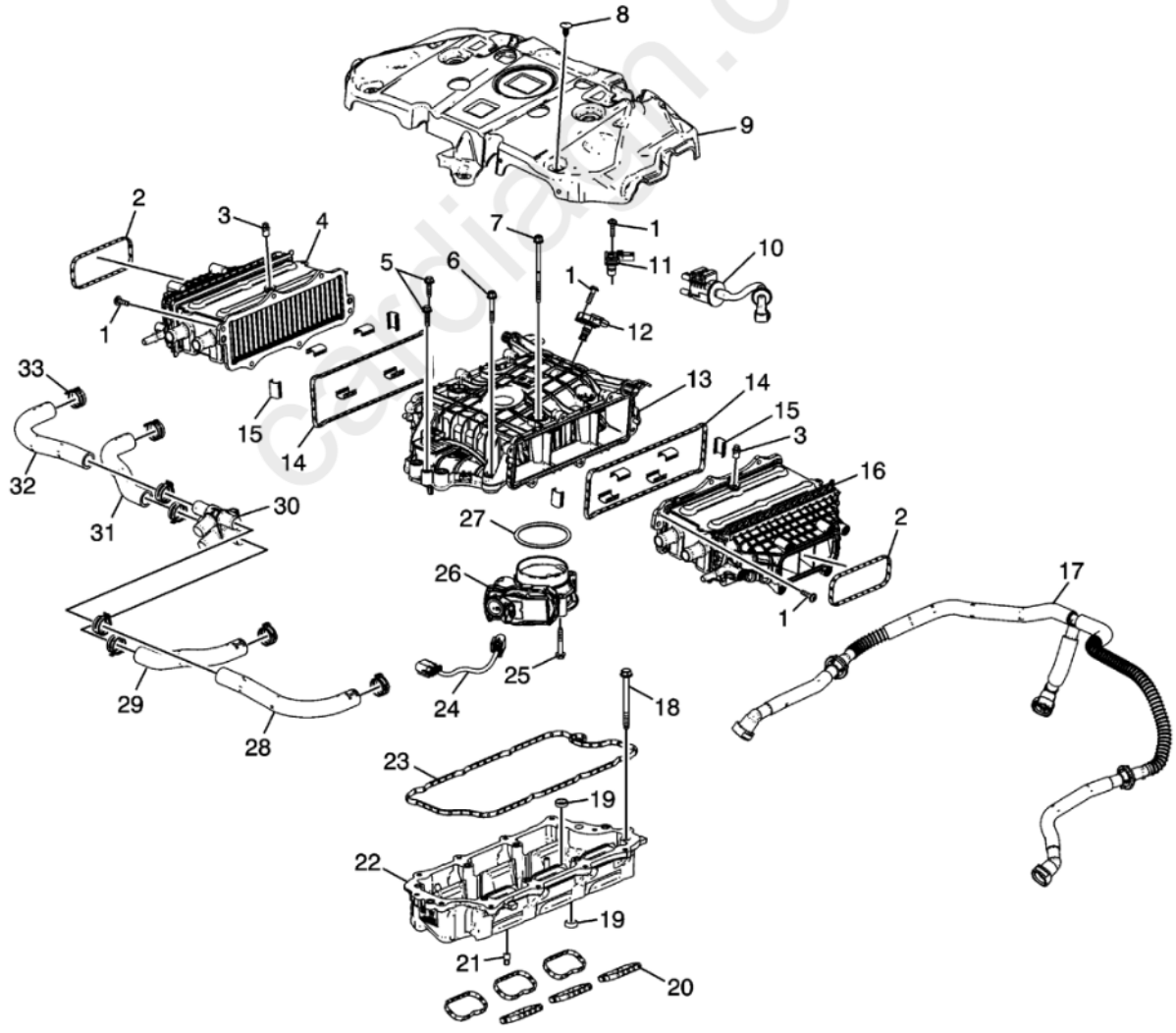


Fig. 3: Charge Air Cooler and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
1	Charge Air Cooler Bolt [12x] M6 x 23
2	Charge Air Cooler Inlet Air Tube Seal [2x]
3	Engine Coolant Air Bleed Valve [2x]
4	Charge Air Cooler - Right Side
5	Charge Air Cooler Coolant Manifold Bolt [2x]
6	Charge Air Cooler Cover Bolt [8x] M6 x 43.45
7	Charge Air Cooler Cover Bolt [4x] M6 x 102.75
8	Charge Air Cooler Insulator Retainer [6x]
9	Charge Air Cooler Insulator
10	Evaporative Emission Canister
11	Manifold Absolute Pressure Sensor
12	Intake Air Pressure and Temperature Sensor
13	Charge Air Cooler Cover
14	Charge Air Cooler Housing Gasket [2x]
15	Charge Air Cooler Retainer [12x]
16	Charge Air Cooler - Left Side
17	Positive Crankcase Ventilation Tube Connector
18	Lower Intake Manifold Bolt [8x] M8 x 90.8
19	Intake Manifold Core Hole Plug [2x]
20	Intake Manifold Seal [6x]
21	Intake Manifold Locating Pin
22	Intake Manifold
23	Charge Air Cooler Cover Seal
24	Throttle Actuator Wire
25	Throttle Body Bolt [4x]
26	Throttle Body
27	Throttle Body Gasket
28	Charge Air Cooler Coolant Hose
29	Charge Air Cooler Coolant Hose
30	Charge Air Cooler Coolant Hose Connector
31	Charge Air Cooler Coolant Hose
32	Charge Air Cooler Coolant Hose
33	Charge Air Cooler Coolant Hose Clamp [8x]

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Fuel Rail Assembly

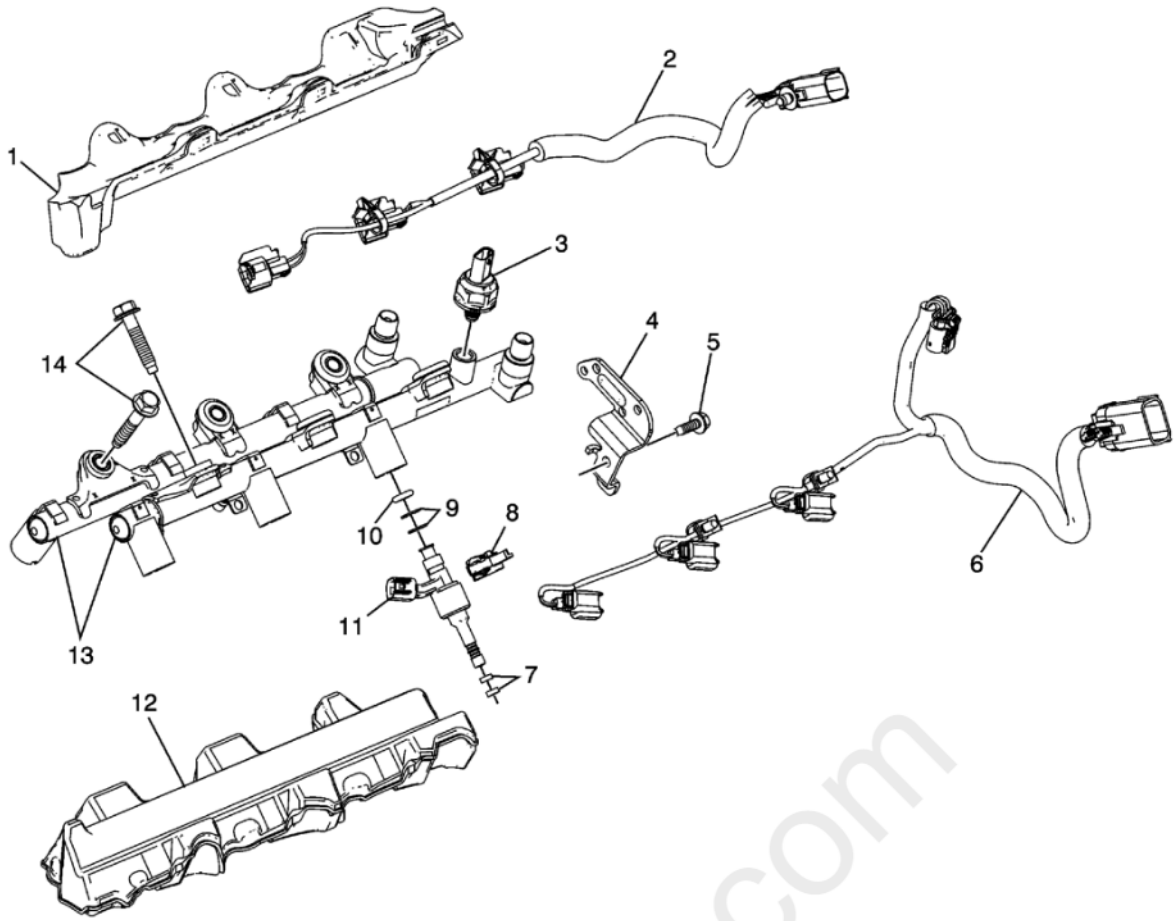


Fig. 4: Fuel Rail Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injection Fuel Rail Noise Shield
2	Fuel Injector Wiring Harness
3	Fuel Injection Fuel Rail Fuel Pressure Sensor
4	Fuel Injector Wiring Harness Bracket
5	Fuel Injector Wiring Harness Bracket Bolt [2x]
6	Fuel Injector Wiring Harness
7	Fuel Injector Nozzle Housing Seal
8	Fuel Injector Retainer
9	Fuel Injector Spacer
10	Fuel Injection Fuel Rail Seal - (O-ring)
11	Direct Fuel Injector
12	Fuel Injection Fuel Rail Noise Shield
13	Direct Fuel Injection Fuel Rail
14	Fuel Injection Fuel Rail Bolt [6x]

Camshaft Cover and Components

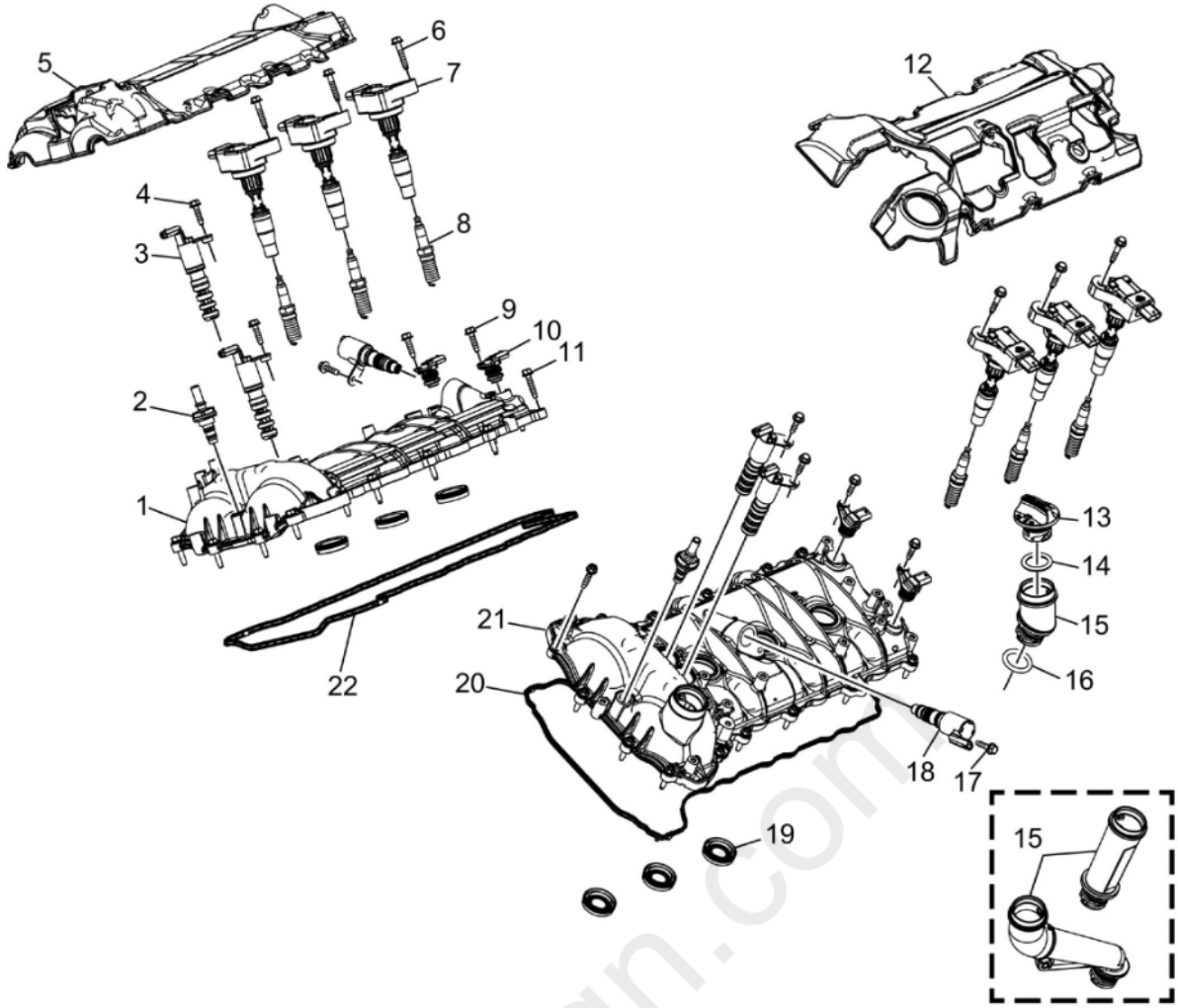


Fig. 5: Camshaft Cover and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Cover - Right
2	Positive Crankcase Ventilation Valve
3	Camshaft Position Actuator Solenoid Valve
4	Camshaft Position Actuator Solenoid Valve Bolt [4x]
5	Camshaft Housing Cover Insulator - Right
6	Ignition Coil Bolt [6x]
7	Ignition Coil
8	Spark Plug [6x]
9	Camshaft Position Sensor Bolt [4x]
10	Camshaft Position Sensor [4x]
11	Camshaft Cover Bolt [36x]
12	Camshaft Housing Cover Insulator - Left
13	Oil Filler Cap (Model Dependant)
14	Oil Filler Cap Seal (Model Dependant)
15	Oil Filler Cap Tube (Model Dependant)
16	Oil Filler Cap Tube Seal (Model Dependant)
17	Valve Rocker Arm Oil Control Valve Bolt [2x]
18	Valve Rocker Arm Oil Control Valve
19	Spark Plug Shield Seal
20	Camshaft Cover Seal - Left
21	Camshaft Cover - Left
22	Camshaft Cover Seal - Right

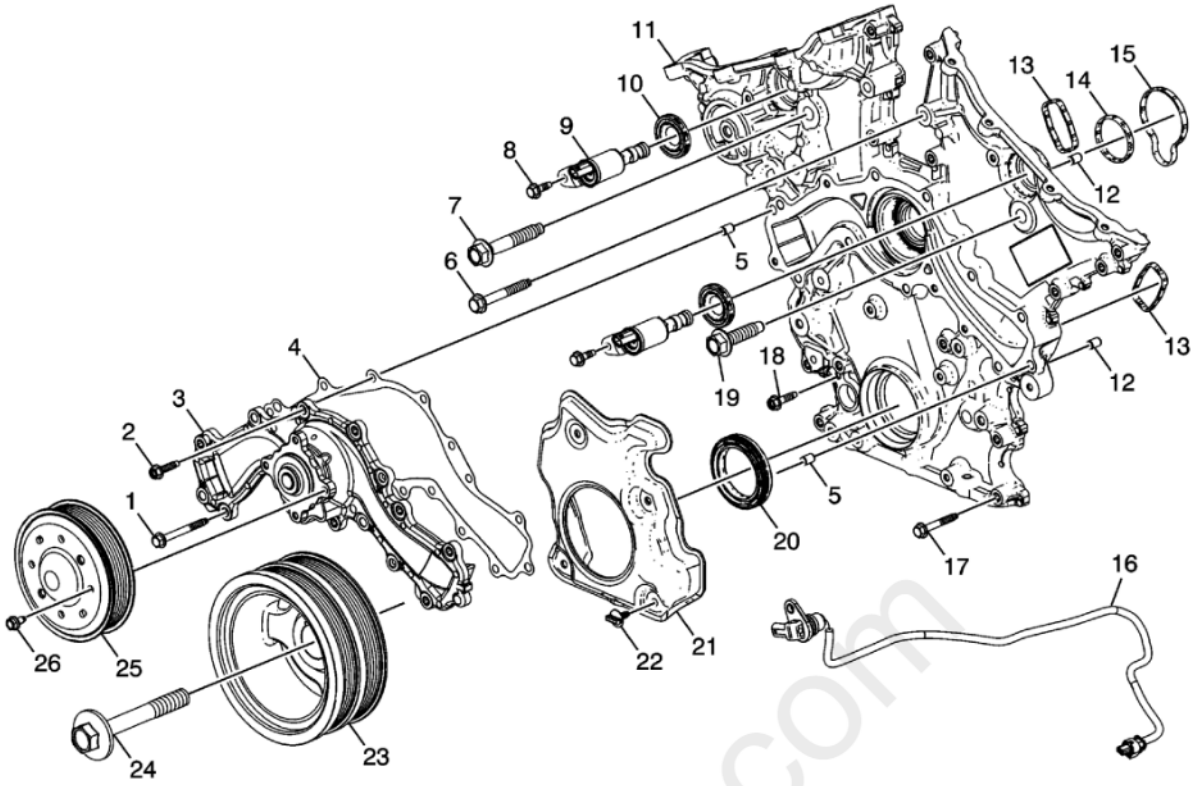


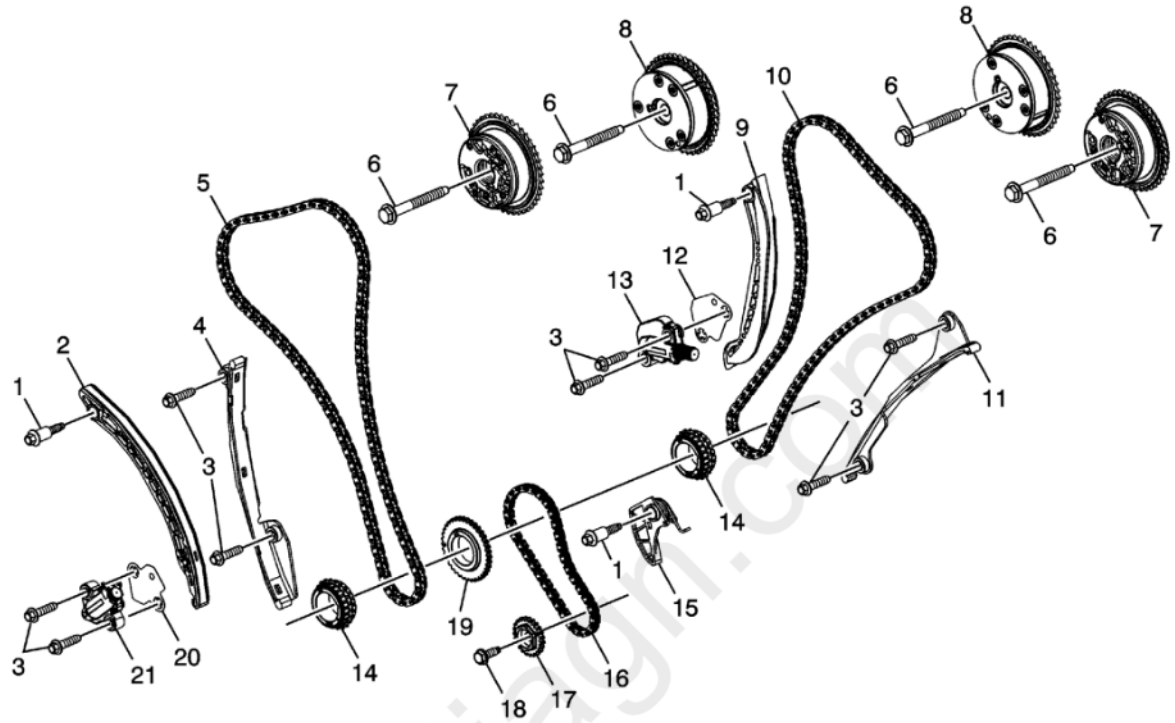
Fig. 6: Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Bolt [5x] M6 x 20
2	Water Pump Bolt [9x] M6 x 60
3	Water Pump Housing
4	Water Pump Gasket
5	Water Pump Locating Pin [2x]
6	Engine Front Cover Bolt [2x] M8 x 66
7	Engine Front Cover Bolt M12 x 75
8	Camshaft Position Actuator Control Valve Bolt [2x]
9	Camshaft Position Actuator Control Valve [2x]
10	Camshaft Position Actuator Control Valve Seal [2x]
11	Engine Front Cover
12	Engine Front Cover Locating Pin [2x]
13	Water Pump Seal [2x]
14	Water Pump Seal
15	Water Pump Seal
16	Oil Pump Flow Control Solenoid Valve Wire
17	Engine Front Cover Bolt [16x] M8 x 45
18	Harness Connector Bolt
19	Engine Front Cover Bolt M12 x 50
20	Crankshaft Front Oil Seal
21	Engine Front Cover Insulator
22	Engine Front Cover Retainer [4x]

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Callout	Component Name
23	Crankshaft Balancer
24	Crankshaft Balancer Bolt
25	Water Pump Pulley
26	Water Pump Pulley Bolt [4x]

Camshaft Timing Components



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Fig. 7: Camshaft Timing Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Timing Chain Guide Bolt [2x]
2	Timing Chain Guide - Right
3	Timing Chain Tensioner Bolt [8x]
4	Timing Chain Guide - Right
5	Timing Chain - Right
6	Camshaft Position Actuator Bolt [4x]
7	Camshaft Position Actuator - Exhaust
8	Camshaft Position Actuator - Intake
9	Timing Chain Guide - Left
10	Timing Chain - Left
11	Timing Chain Guide - Left
12	Timing Chain Tensioner Gasket
13	Timing Chain Tensioner - Left
14	Timing Chain Crankshaft Sprocket
15	Timing Chain Tensioner
16	Oil Pump Timing Chain

Callout	Component Name
17	Oil Pump Sprocket
18	Oil Pump Drive Bolt
19	Crankshaft Sprocket
20	Timing Chain Tensioner Gasket
21	Timing Chain Tensioner - Right

Camshaft Carrier Components

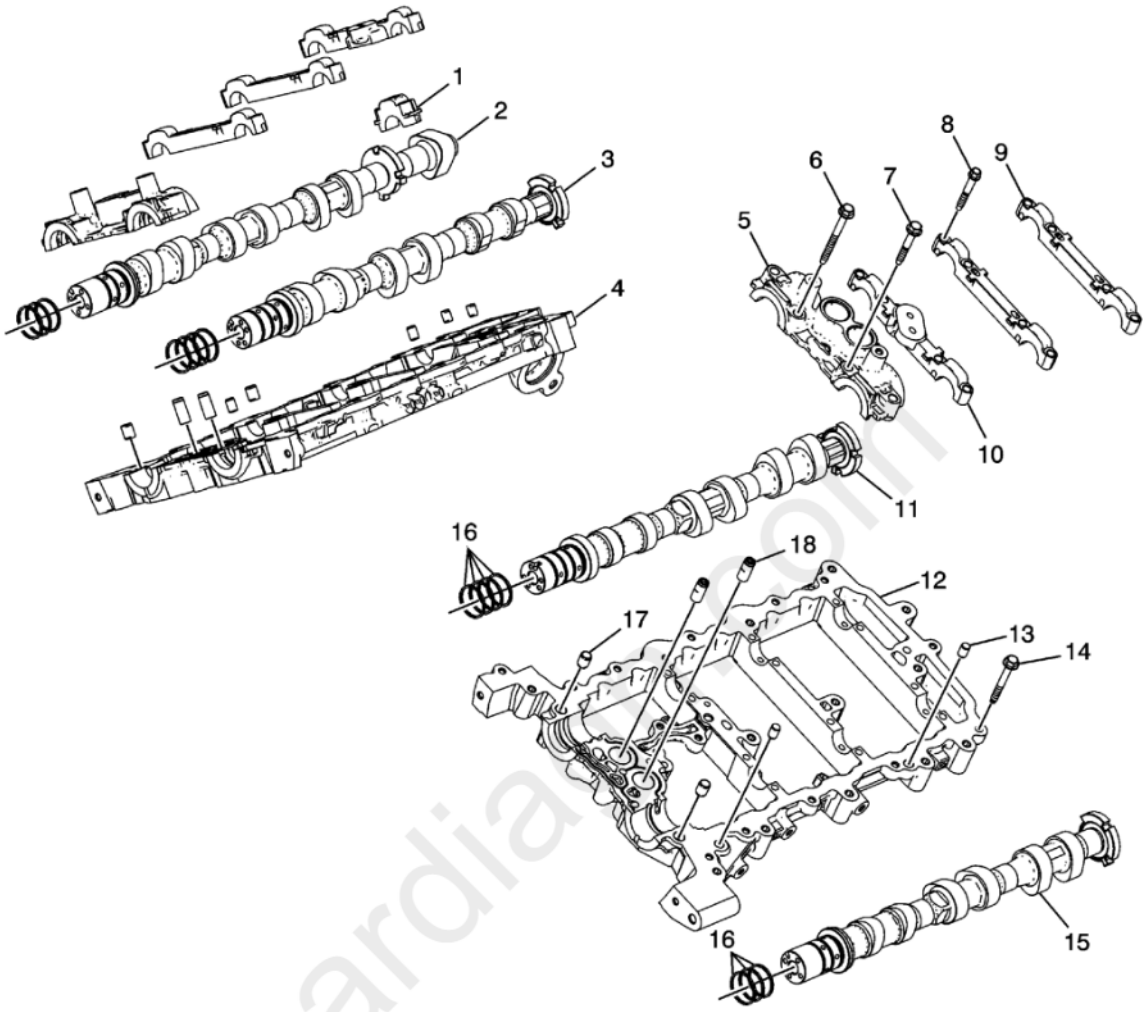


Fig. 8: Camshaft Carrier Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Bearing Cap - Intermediate
2	Exhaust Camshaft - Right
3	Intake Camshaft - Right
4	Camshaft Carrier - Right
5	Camshaft Bearing Cap
6	Camshaft Bearing Cap Bolt [8x]
7	Camshaft Bearing Cap Bolt [8x]
8	Camshaft Bearing Cap Bolt [26x]
9	Camshaft Bearing Cap
10	Camshaft Bearing Cap
11	Intake Camshaft - Left
12	Camshaft Carrier - Left
13	Dowel Pin
14	Camshaft Carrier Bolt
15	Exhaust Camshaft - Left

Callout	Component Name
16	Camshaft Oil Seal Ring
17	Dowel Pin
18	Engine Oil Manifold Check Valve

Cylinder Head Assemblies

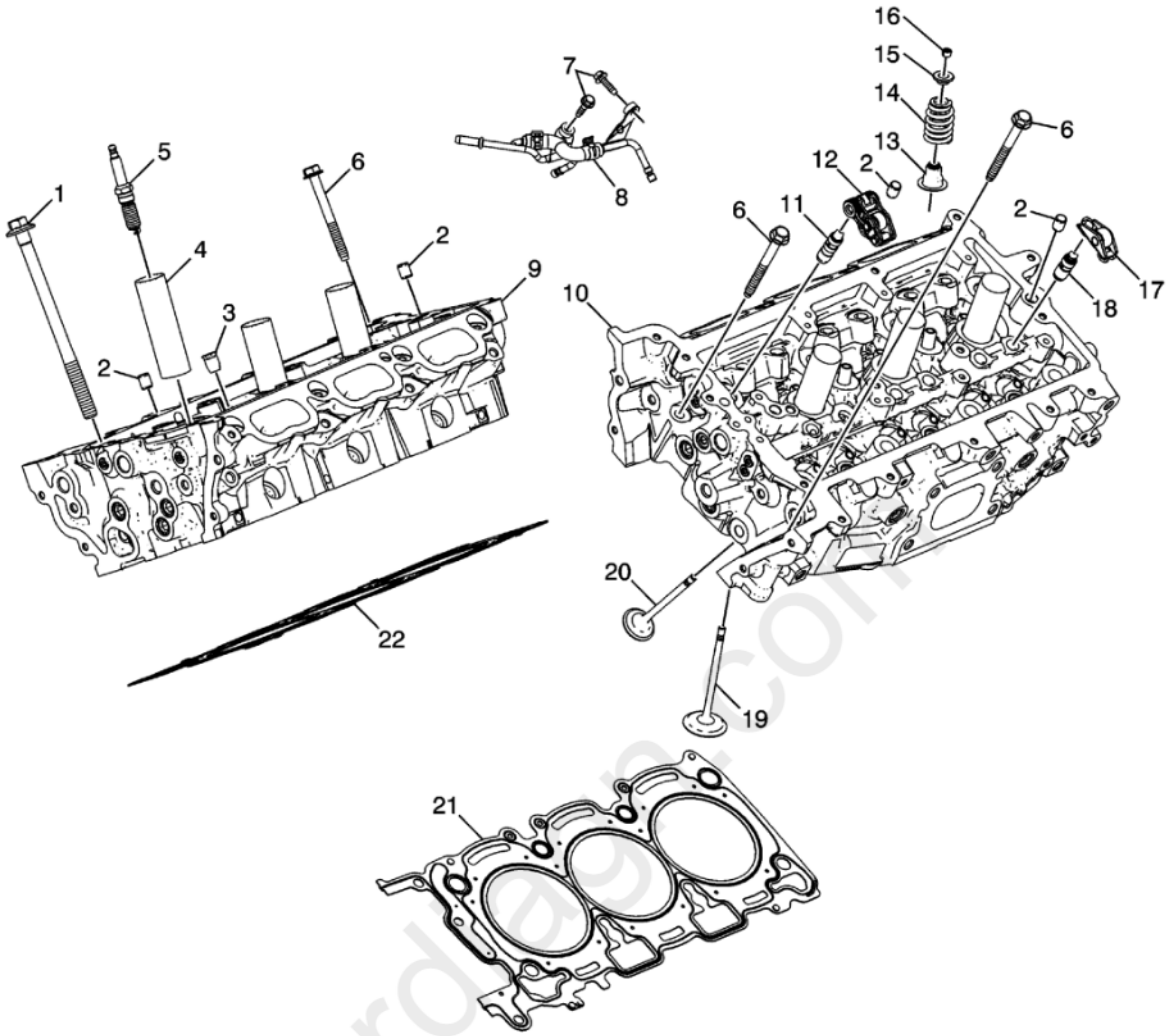


Fig. 9: Cylinder Head Assemblies
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Cylinder Head Bolt [16x]
2	Dowel Pin
3	Cylinder Head Oil Gallery Plug
4	Spark Plug Wire Sleeve
5	Spark Plug
6	Cylinder Head Bolt [3x]
7	Engine Coolant Air Bleed Pipe Bolt [2x]
8	Engine Coolant Air Bleed Pipe
9	Cylinder Head - Left
10	Cylinder Head - Right
11	Dual Feed Hydraulic Valve Adjustor
12	Valve Rocker Switching Arm
13	Valve Stem Oil Seal
14	Valve Spring
15	Valve Spring Cap
16	Valve Stem Key
17	Valve Rocker Arm

Callout	Component Name
18	Hydraulic Valve Lash Adjuster
19	Intake Valve
20	Exhaust Valve
21	Cylinder Head Gasket - Right
22	Cylinder Head Gasket - Left

Oil Pan and Components with Oil Cooler

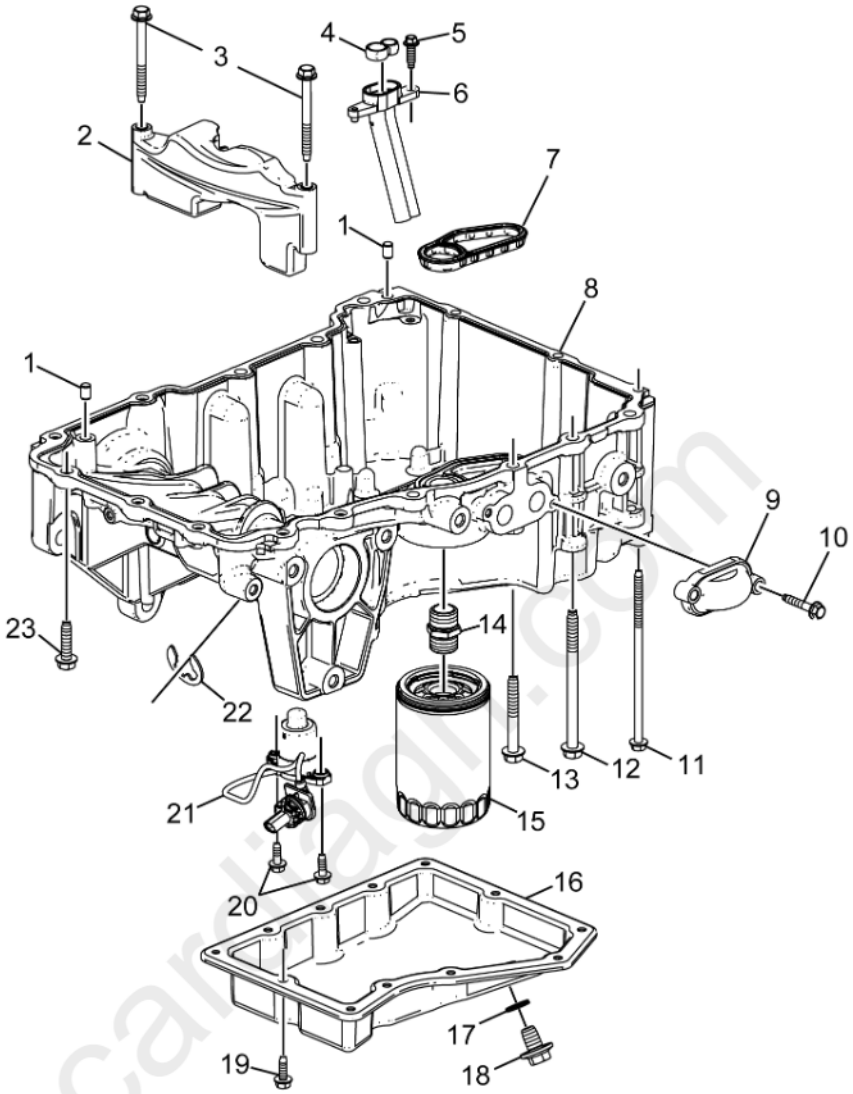


Fig. 10: Oil Pan and Components with Oil Cooler
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Dowel Pin [2x]
2	Oil Pan Baffle
3	Oil Pan Baffle Bolt [2x]
4	Positive Crankcase Ventilation Oil Separator Drain Seal
5	Positive Crankcase Ventilation Oil Separator Drain Bolt
6	Positive Crankcase Ventilation Oil Separator Drain
7	Oil Pan High Pressure Port Seal
8	Oil Pan
9	Oil Pan Cover
10	Oil Pan Cover Bolt [2x]
11	Oil Pan Bolt [3x] M6 x 150
12	Oil Pan Bolt [5x] M8 x 120
13	Oil Pan Bolt M8 x 80
14	Oil Filter Adapter Fitting

Callout	Component Name
15	Oil Filter
16	Lower Oil Pan
17	Oil Pan Drain Plug Seal
18	Oil Pan Drain Plug
19	Lower Oil Pan Bolt [13x] M6 x 20.65
20	Engine Oil Level Indicator Switch Bolt [2x]
21	Engine Oil Level Indicator Switch
22	Engine Oil Level Switch Clip
23	Oil Pan Bolt [8x] M8 x 35

Oil Cooler Adapter Assembly

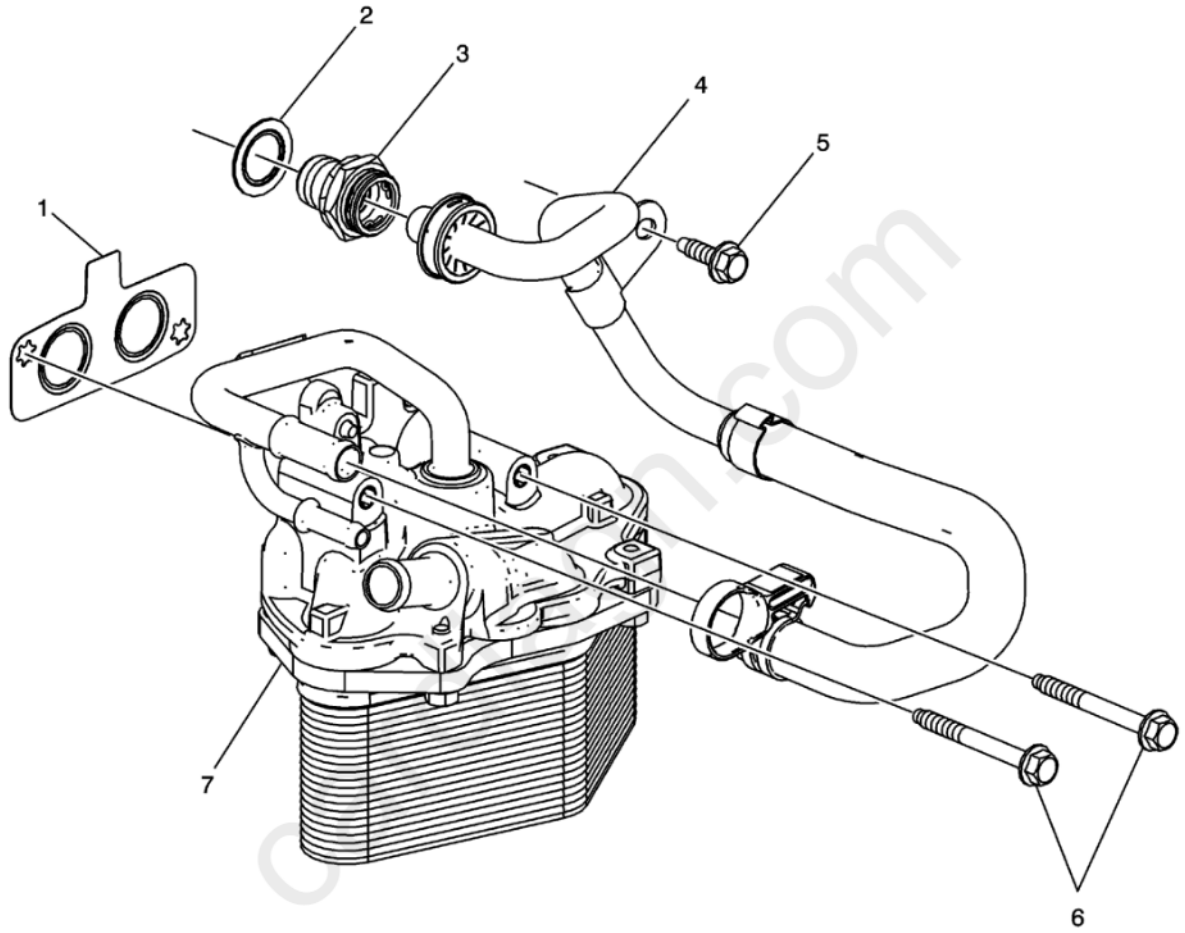


Fig. 11: Oil Cooler Adapter Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Filter Adapter Gasket
2	Turbocharger Coolant Feed and Return Pipe Gasket
3	Engine Oil Cooler Adapter Bolt
4	Engine Oil Cooler Inlet Pipe
5	Engine Oil Cooler Inlet Pipe Bolt
6	Engine Oil Cooler Adapter Bolt
7	Engine Oil Cooler Adapter

Oil Pump Assembly

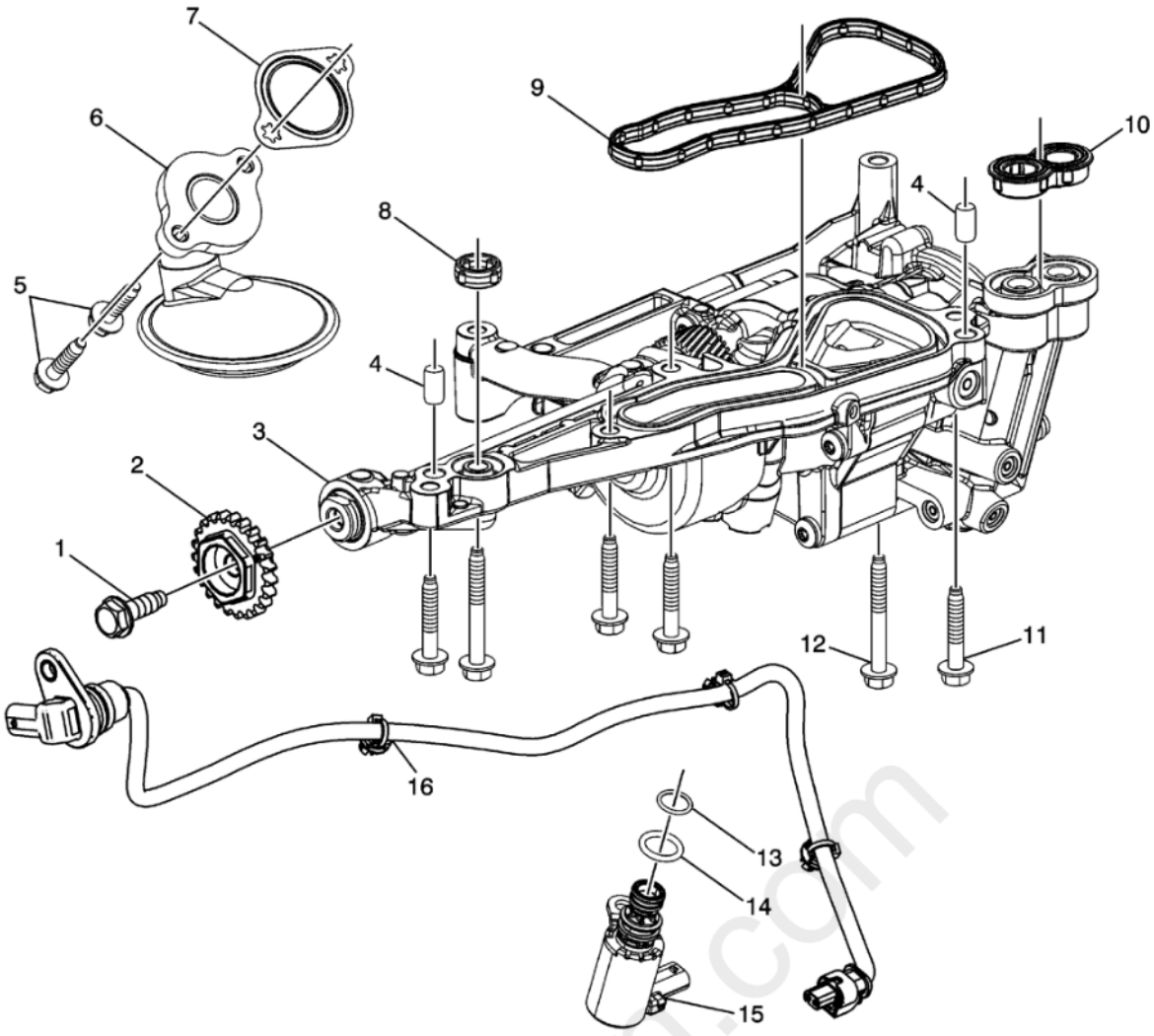


Fig. 12: Oil Pump Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Sprocket Bolt
2	Oil Pump Sprocket
3	Oil Pump
4	Dowel Pin - Not Serviceable
5	Oil Pump Suction Pipe Bolt [2x]
6	Oil Pump Suction Pipe
7	Oil Pump Suction Pipe Gasket
8	Oil Pump Housing Passage Seal
9	Oil Pump Housing Passage Seal
10	Vacuum Pump Seal
11	Oil Pump Bolt [2x]
12	Oil Pump Bolt [4x]
13	Oil Pump Flow Control Valve Seal O-Ring
14	Oil Pump Flow Control Valve Seal
15	Oil Pump Flow Control Valve
16	Oil Pump Flow Control Solenoid Valve Wiring

Engine Block Components

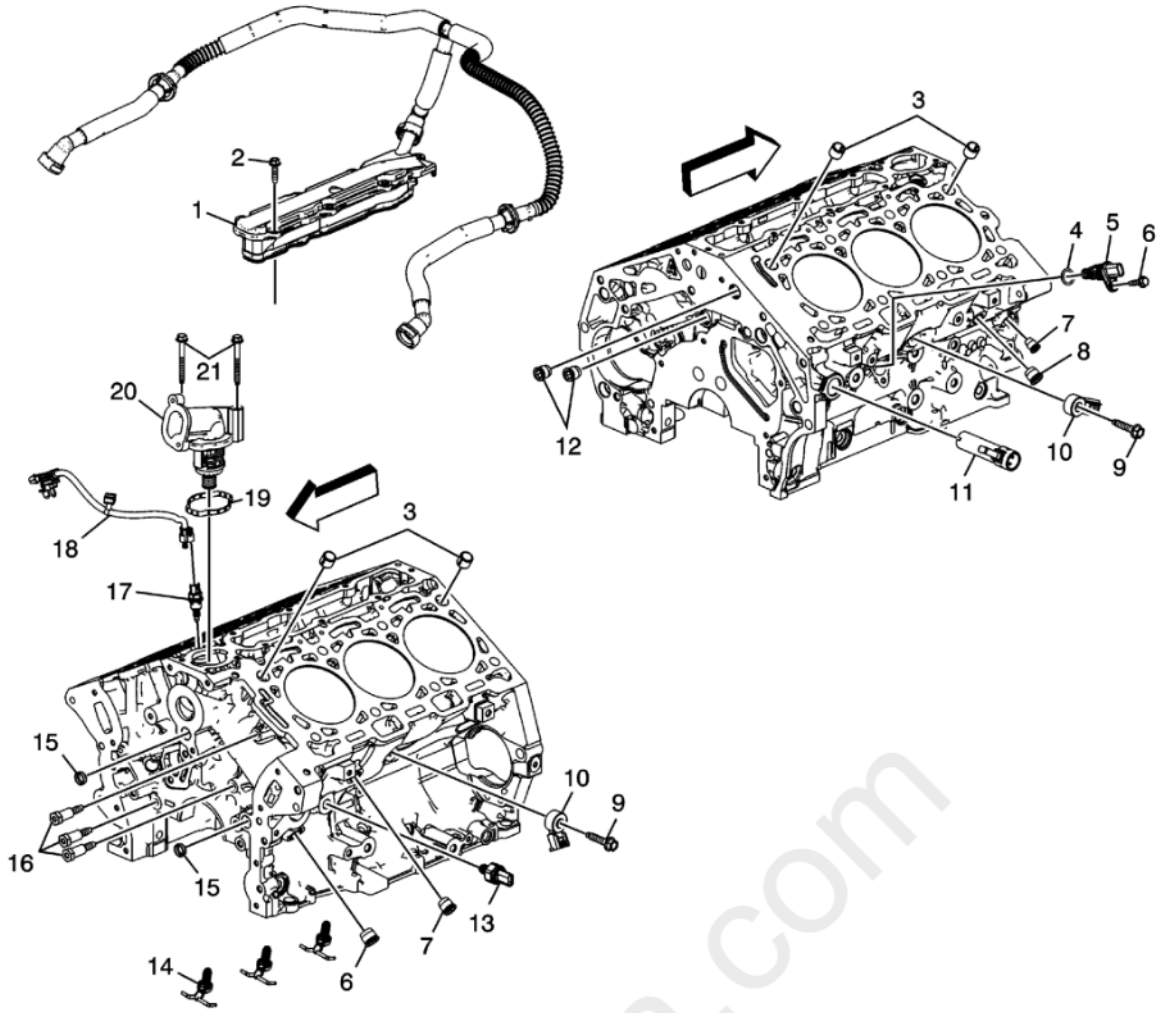


Fig. 13: Engine Block Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Oil Separator
2	Positive Crankcase Ventilation Oil Separator Bolt [6x]
3	Cylinder Head Locating Pin
4	Crankshaft Position Sensor Seal
5	Crankshaft Position Sensor
6	Crankshaft Position Sensor Bolt
7	Engine Block Core Hole Plug M16 x 16.25
8	Engine Block Core Hole Plug M18 x 16.25
9	Knock Sensor Bolt [2x]
10	Knock Sensor
11	Engine Coolant Heater
12	Engine Block Oil Gallery Plug M16 x 16.25
13	Engine Oil Pressure Sensor
14	Piston Oil Nozzle [3x]
15	Engine Block Oil Gallery Plug 14 mm
16	Engine Front Cover Stud [3x]
17	Engine Coolant Temperature Sensor
18	Engine Coolant Temperature Sensor Wire
19	Engine Coolant Thermostat Seal
20	Engine Coolant Thermostat Housing
21	Engine Coolant Thermostat Housing Bolt [2x]

Piston, Rings, Bearings and Connecting Rod Assembly

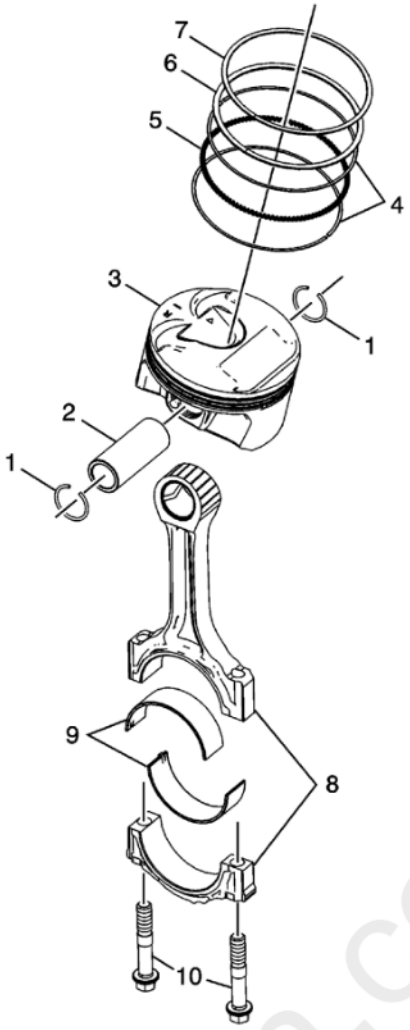


Fig. 14: Piston, Rings, Bearings and Connecting Rod Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Piston Pin Retainer
2	Piston Pin
3	Piston
4	Piston Oil Ring Rail
5	Piston Oil Ring Rail Spacer
6	Piston Compression Ring - Lower
7	Piston Compression Ring - Upper
8	Connecting Rod
9	Connecting Rod Bearing
10	Connecting Rod Bolt [2x]

Engine Block Assembly

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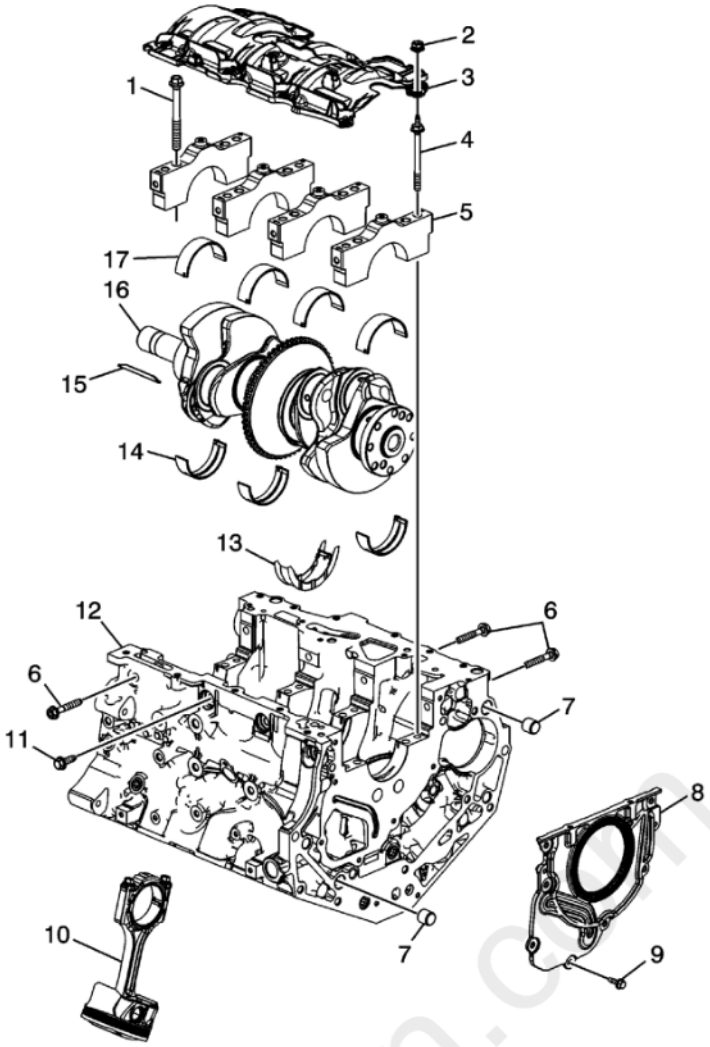


Fig. 15: Engine Block Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Bearing Cap Bolt [8x]
2	Crankshaft Oil Deflector Nut [8x]
3	Crankshaft Oil Deflector
4	Crankshaft Bearing Cap Bolt [8x]
5	Crankshaft Bearing Cap
6	Crankshaft Bearing Cap Bolt [3x]
7	Crankshaft Rear Oil Seal Housing Locating Pin
8	Crankshaft Rear Oil Seal Housing
9	Crankshaft Rear Oil Seal Housing Bolt [8x]
10	Piston and Connecting Rod Assembly
11	Crankshaft Bearing Cap Bolt
12	Engine Block
13	Crankshaft Thrust Upper Bearing
14	Crankshaft Upper Bearing
15	Crankshaft Balancer Key
16	Crankshaft
17	Crankshaft Lower Bearing

Turbocharger and Components (Right Side)

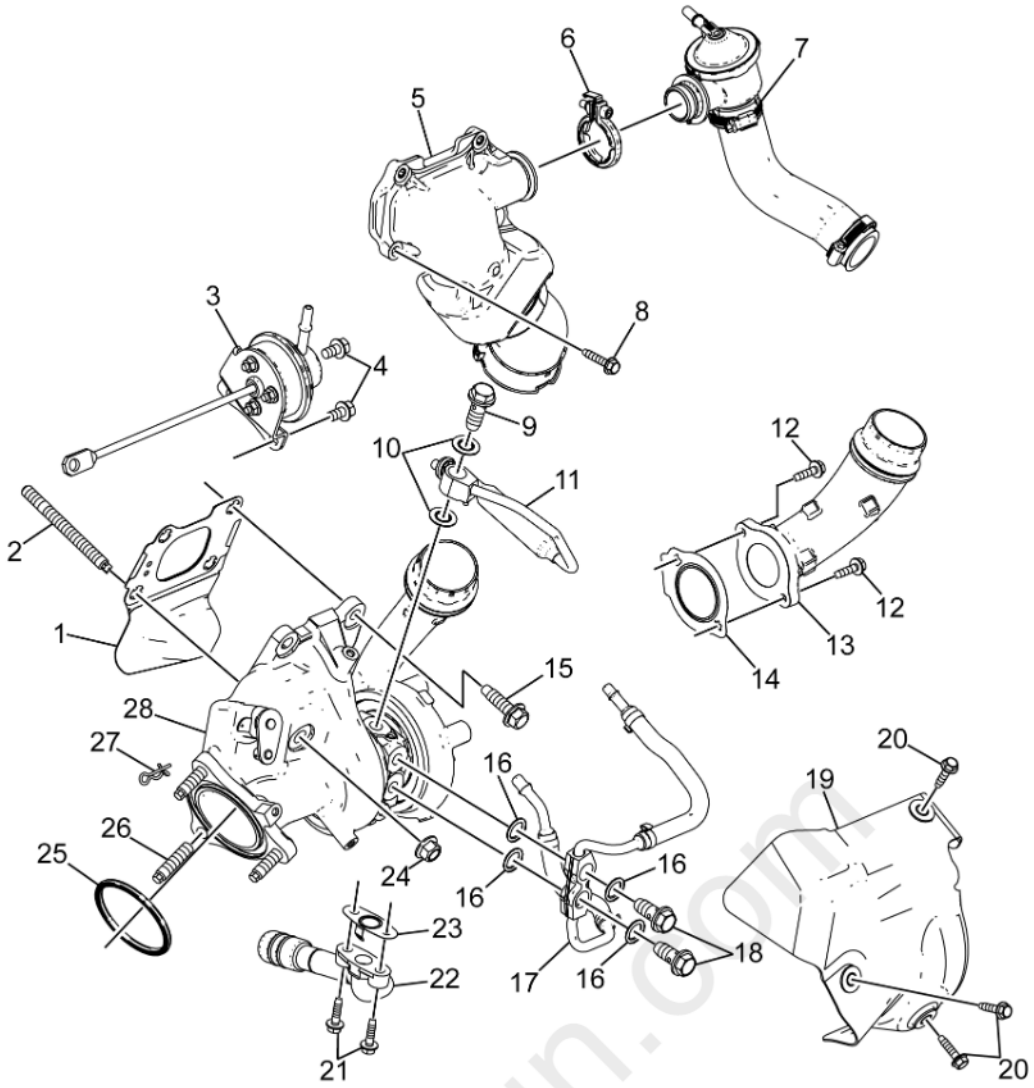


Fig. 16: Turbocharger and Components (Right Side)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Turbocharger Gasket
2	Turbocharger Stud
3	Turbocharger Wastegate Actuator
4	Turbocharger Wastegate Actuator Bolt [2x]
5	Charge Air Cooler Inlet Air Tube
6	Charge Air Bypass Valve Tube Clamp
7	Charge Air Bypass Valve
8	Charge Air Cooler Inlet Air Tube Bolt [4x]
9	Turbocharger Oil Feed Pipe Bolt
10	Turbocharger Oil Feed Pipe Gasket [2x]
11	Turbocharger Oil Feed Pipe
12	Turbocharger Air Inlet Adapter Bolt [2x]
13	Turbocharger Air Inlet Adapter
14	Turbocharger Air Inlet Adapter Seal
15	Turbocharger Bolt [3x]
16	Turbocharger Coolant Feed and Return Pipe Gasket [4x]
17	Turbocharger Coolant Feed and Return Pipe
18	Turbocharger Coolant Feed and Return Pipe Bolt [2x]
19	Turbocharger Heat Shield
20	Turbocharger Heat Shield Bolt [3x]
21	Turbocharger Oil Return Pipe Bolt [2x]
22	Turbocharger Oil Return Pipe

Callout	Component Name
23	Turbocharger Oil Return Pipe Gasket
24	Turbocharger Nut
25	Turbocharger Exhaust Pipe Gasket
26	Turbocharger Exhaust Pipe Stud [3x]
27	Turbocharger Wastegate Actuator Arm Retainer
28	Turbocharger - Left Side

Turbocharger and Components (Left Side)

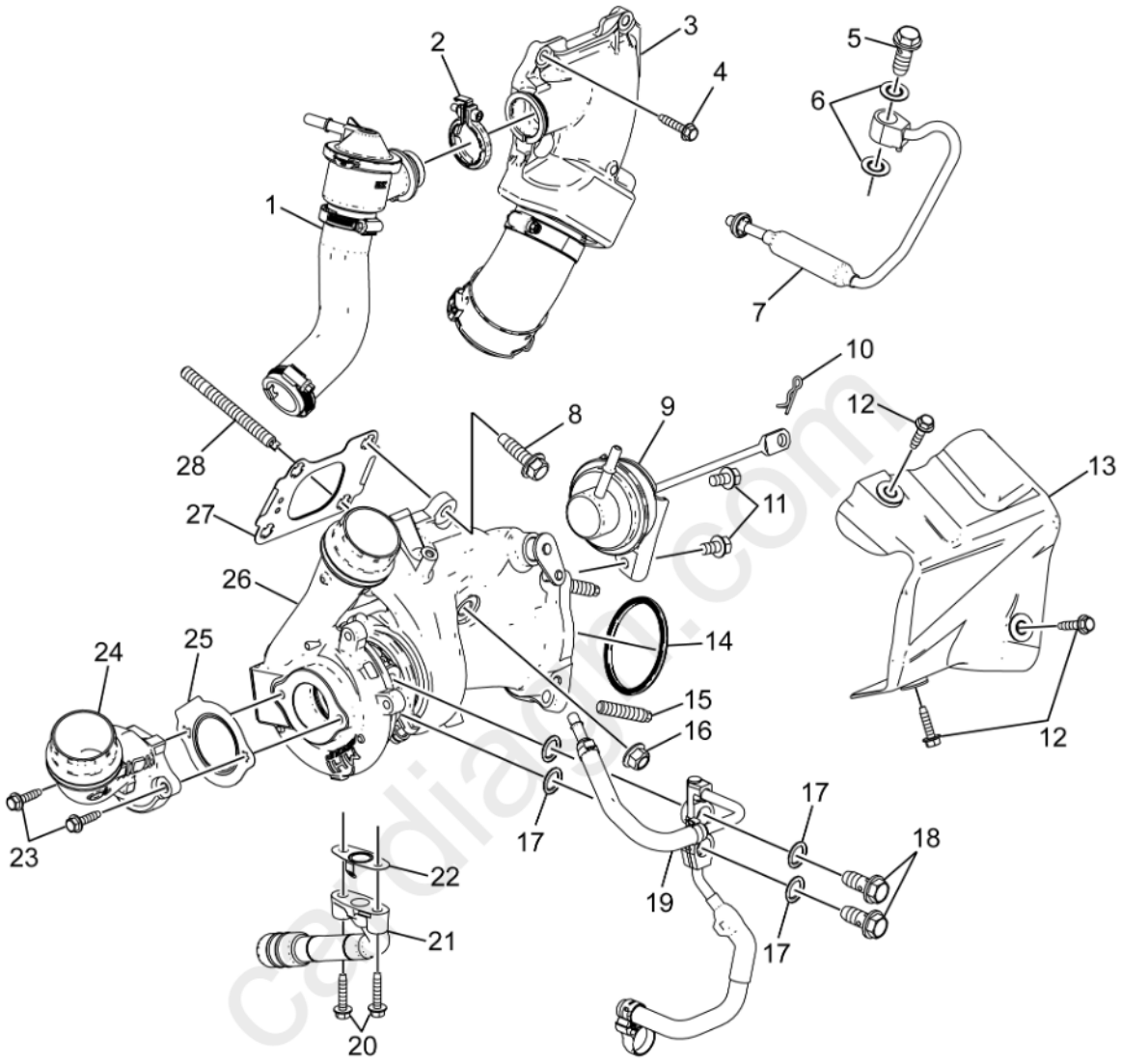


Fig. 17: Turbocharger and Components (Left Side)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Charge Air Bypass Valve
2	Charge Air Bypass Valve Tube Clamp
3	Charge Air Cooler Inlet Air Tube
4	Charge Air Cooler Inlet Air Tube Bolt [4x]
5	Turbocharger Oil Feed Pipe Bolt
6	Turbocharger Oil Feed Pipe Gasket [2x]
7	Turbocharger Oil Feed Pipe
8	Turbocharger Bolt [3x]
9	Turbocharger Wastegate Actuator
10	Turbocharger Wastegate Actuator Arm Retainer
11	Turbocharger Wastegate Actuator Bolt [2x]
12	Turbocharger Heat Shield Bolt [3x]
13	Turbocharger Heat Shield

Callout	Component Name
14	Turbocharger Exhaust Pipe Gasket
15	Turbocharger Exhaust Pipe Stud [3x]
16	Turbocharger Nut
17	Turbocharger Coolant Feed and Return Pipe Gasket [4x]
18	Turbocharger Coolant Feed and Return Pipe Bolt [2x]
19	Turbocharger Coolant Feed and Return Pipe
20	Turbocharger Oil Return Pipe Bolt [2x]
21	Turbocharger Oil Return Pipe
22	Turbocharger Oil Return Pipe Gasket
23	Turbocharger Air Inlet Adapter Bolt [2x]
24	Turbocharger Air Inlet Adapter
25	Turbocharger Air Inlet Adapter Seal
26	Turbocharger - Right Side
27	Turbocharger Gasket
28	Turbocharger Stud

DISASSEMBLED VIEWS (LGX)

Engine Component Assemblies

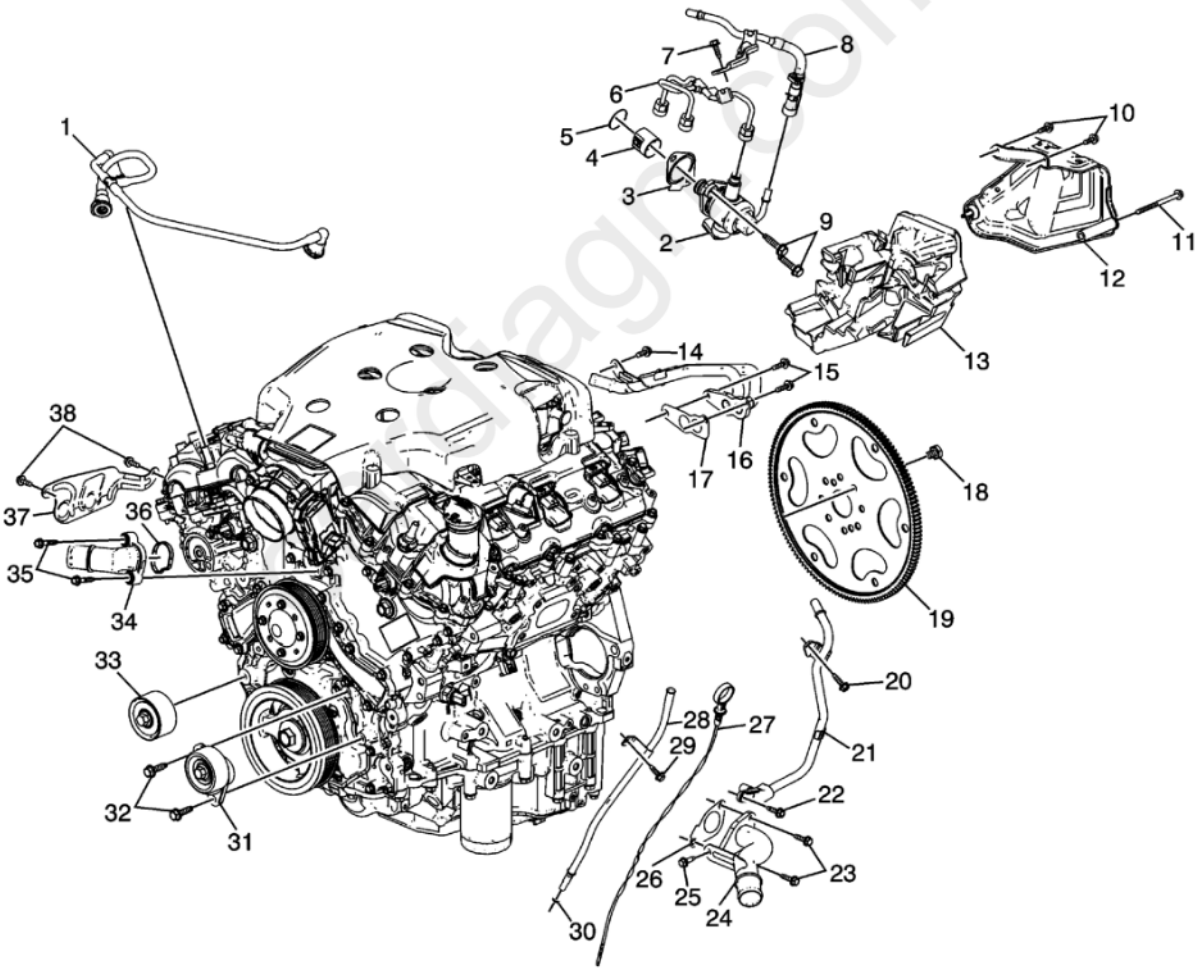


Fig. 18: Engine Component Assemblies
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Tube Connector (PCV)
2	Fuel Pump
3	Fuel Pump Bracket Gasket

Callout	Component Name
4	Valve Lifter Follower
5	Fuel Pump O-Ring
6	Fuel Feed Intermediate Pipe
7	Fuel Feed Pipe Bolt
8	Fuel Feed Pipe
9	Fuel Pump Bolt [2x]
10	Fuel Pipe Shield Bolt [2x]
11	Fuel Pipe Shield Bolt
12	Fuel Pipe Shield
13	Engine Rear Noise Shield
14	Heater Inlet and Outlet Pipe Bolt
15	Heater Inlet and Outlet Pipe Bolt
16	Heater Inlet and Outlet Pipe
17	Heater Inlet and Outlet Pipe Gasket
18	Automatic Transmission Flex Plate Bolt [8x]
19	Automatic Transmission Flex Plate
20	Vacuum Pump Pipe Bolt
21	Vacuum Pump Pipe
22	Vacuum Pump Pipe Bolt
23	Water Pump Inlet Pipe Bolt [2x]
24	Water Pump Inlet Pipe
25	Water Pump Inlet Pipe Bolt
26	Water Inlet Seal
27	Oil Level Indicator
28	Oil Level Indicator Tube
29	Oil Level Indicator Tube Bolt
30	Oil Level Indicator Tube Seal
31	Drive Belt Tensioner
32	Drive Belt Tensioner Bolt [2x]
33	Belt Idler Pulley
34	Water Outlet Bolt [2x]
35	Water Outlet Pipe
36	Water Outlet Pipe Seal
37	Knock Sensor Heat Shield
38	Knock Sensor Heat Shield Bolt [2x]

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Intake Manifold and Components

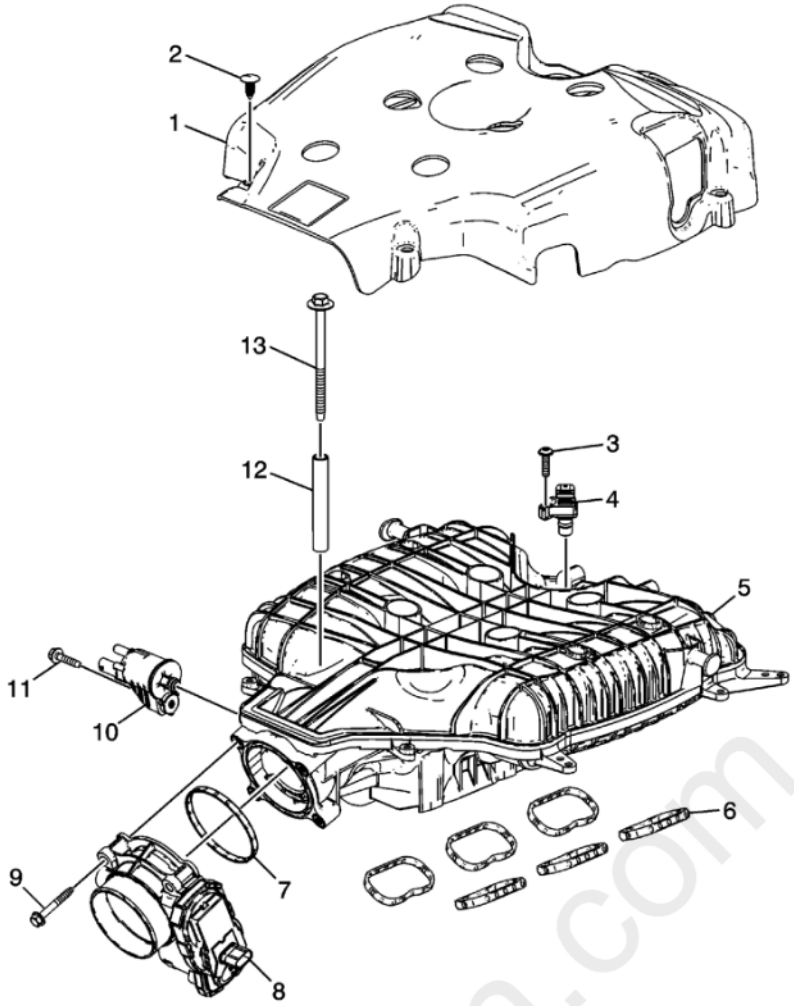


Fig. 19: Intake Manifold and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Insulator
2	Intake Manifold Insulator Retainer
3	Manifold Absolute Pressure Sensor Bolt
4	Manifold Absolute Pressure Sensor
5	Intake Manifold
6	Intake Manifold Seal
7	Throttle Body Gasket
8	Throttle Body
9	Throttle Body Bolt [4x]
10	Evaporative Emission Canister
11	Evaporative Emission Canister Purge Solenoid Valve Bolt
12	Intake Manifold Insulator
13	Intake Manifold Bolt [8x]

Fuel Rail Assembly

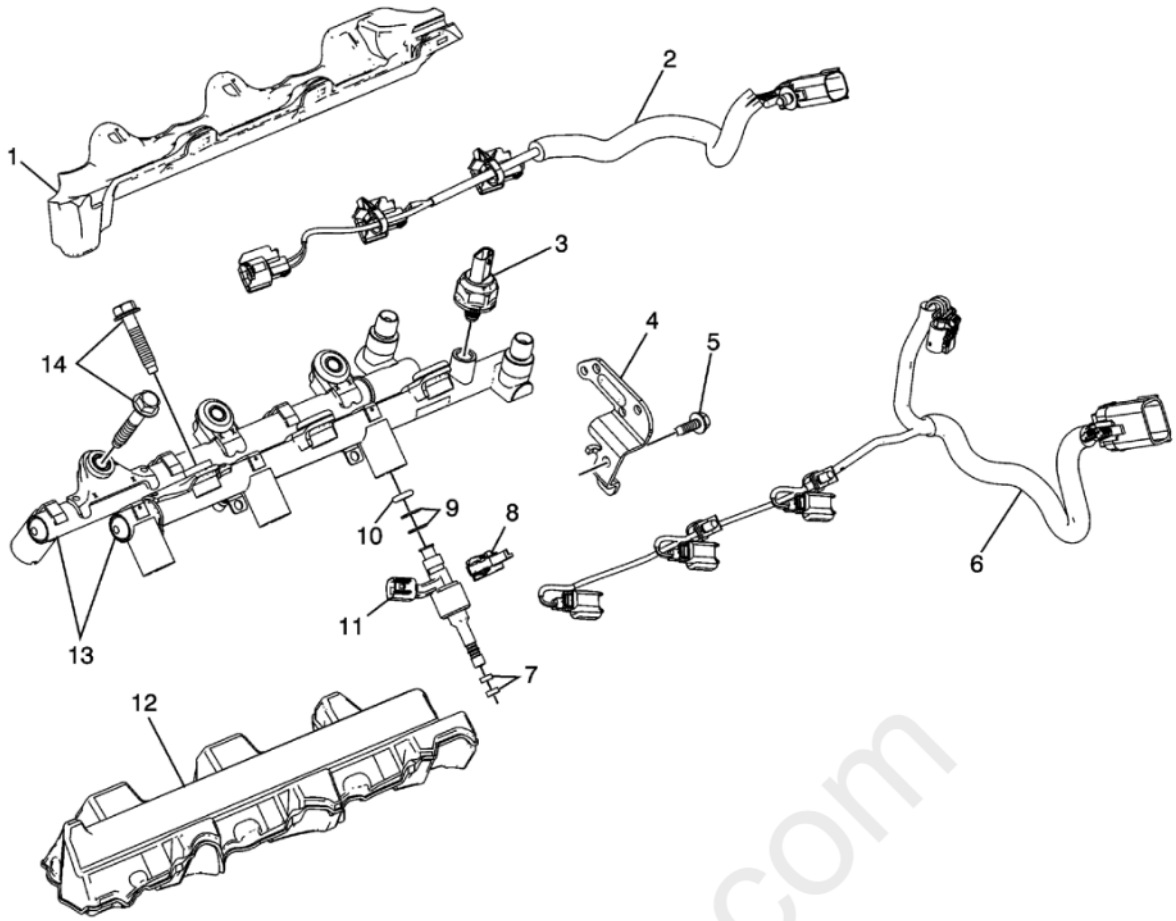


Fig. 20: Fuel Rail Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injection Fuel Rail Noise Shield
2	Fuel Injector Wiring Harness
3	Fuel Injection Fuel Rail Fuel Pressure Sensor
4	Fuel Injector Wiring Harness Bracket
5	Fuel Injector Wiring Harness Bracket Bolt [2x]
6	Fuel Injector Wiring Harness
7	Fuel Injector Nozzle Housing Seal
8	Fuel Injector Retainer
9	Fuel Injector Spacer
10	Fuel Injection Fuel Rail Seal - (O-ring)
11	Direct Fuel Injector
12	Fuel Injection Fuel Rail Noise Shield
13	Direct Fuel Injection Fuel Rail
14	Fuel Injection Fuel Rail Bolt [6x]

Camshaft Cover and Components

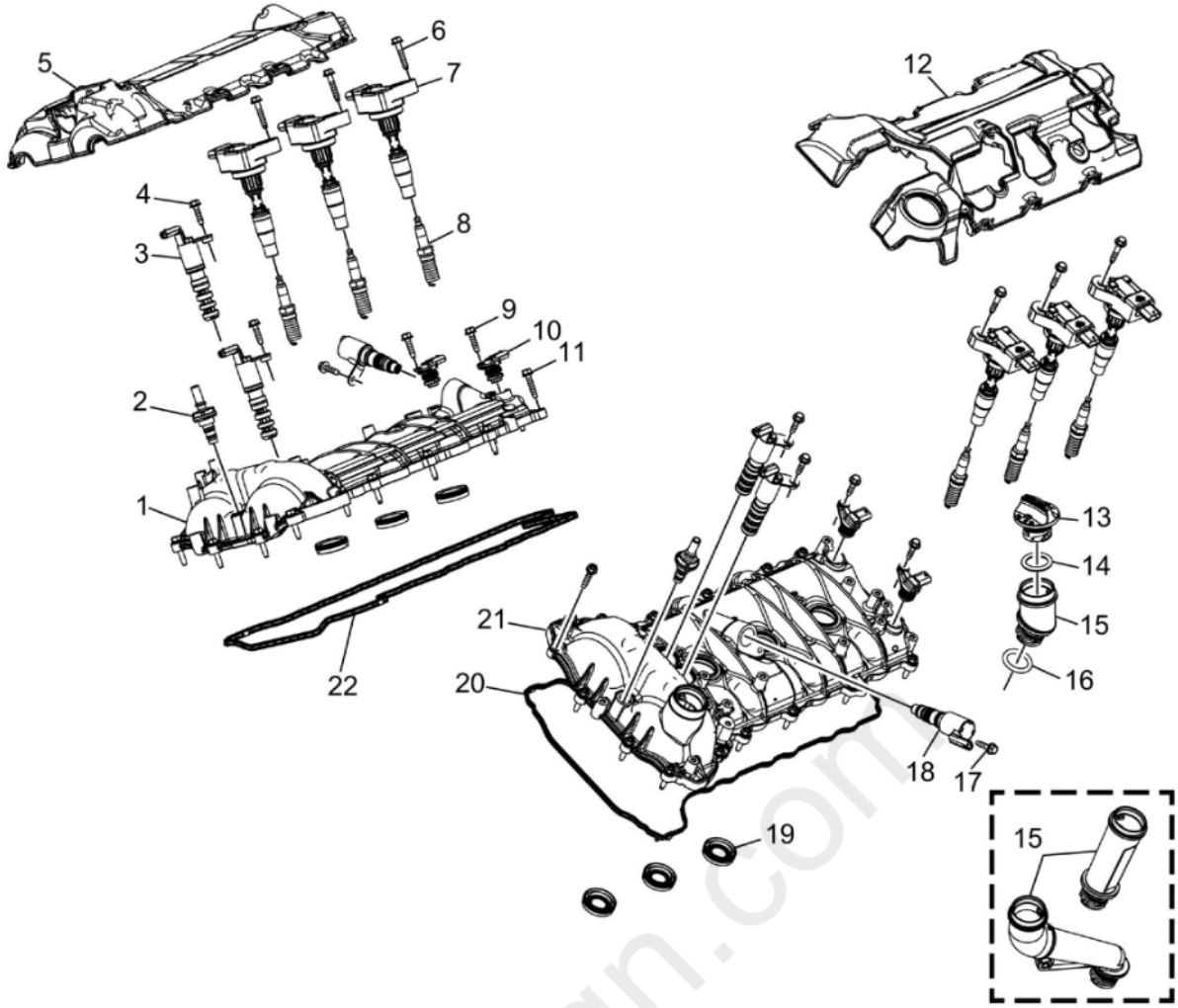


Fig. 21: Camshaft Cover and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Cover - Right
2	Positive Crankcase Ventilation Valve
3	Camshaft Position Actuator Solenoid Valve
4	Camshaft Position Actuator Solenoid Valve Bolt [4x]
5	Camshaft Housing Cover Insulator - Right
6	Ignition Coil Bolt [6x]
7	Ignition Coil
8	Spark Plug [6x]
9	Camshaft Position Sensor Bolt [4x]
10	Camshaft Position Sensor [4x]
11	Camshaft Cover Bolt [36x]
12	Camshaft Housing Cover Insulator - Left
13	Oil Filler Cap (Model Dependant)
14	Oil Filler Cap Seal (Model Dependant)
15	Oil Filler Cap Tube (Model Dependant)
16	Oil Filler Cap Tube Seal (Model Dependant)
17	Valve Rocker Arm Oil Control Valve Bolt [2x]
18	Valve Rocker Arm Oil Control Valve
19	Spark Plug Shield Seal
20	Camshaft Cover Seal - Left
21	Camshaft Cover - Left
22	Camshaft Cover Seal - Right

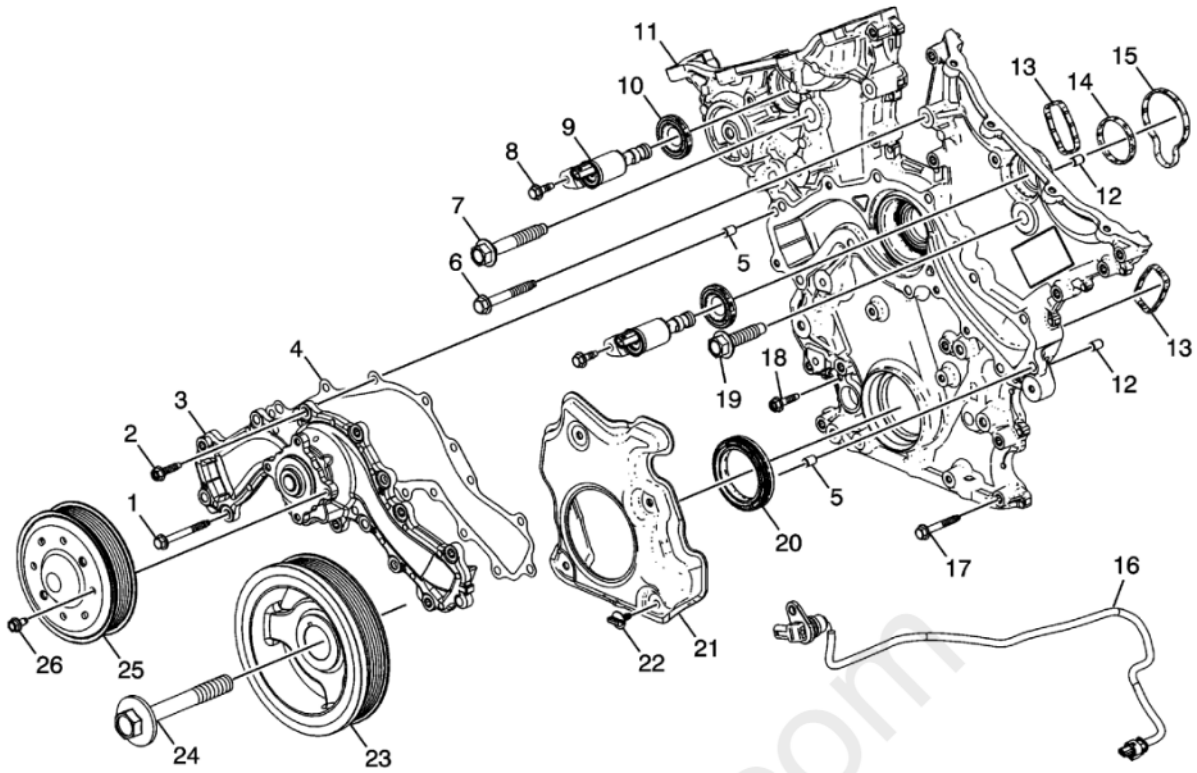
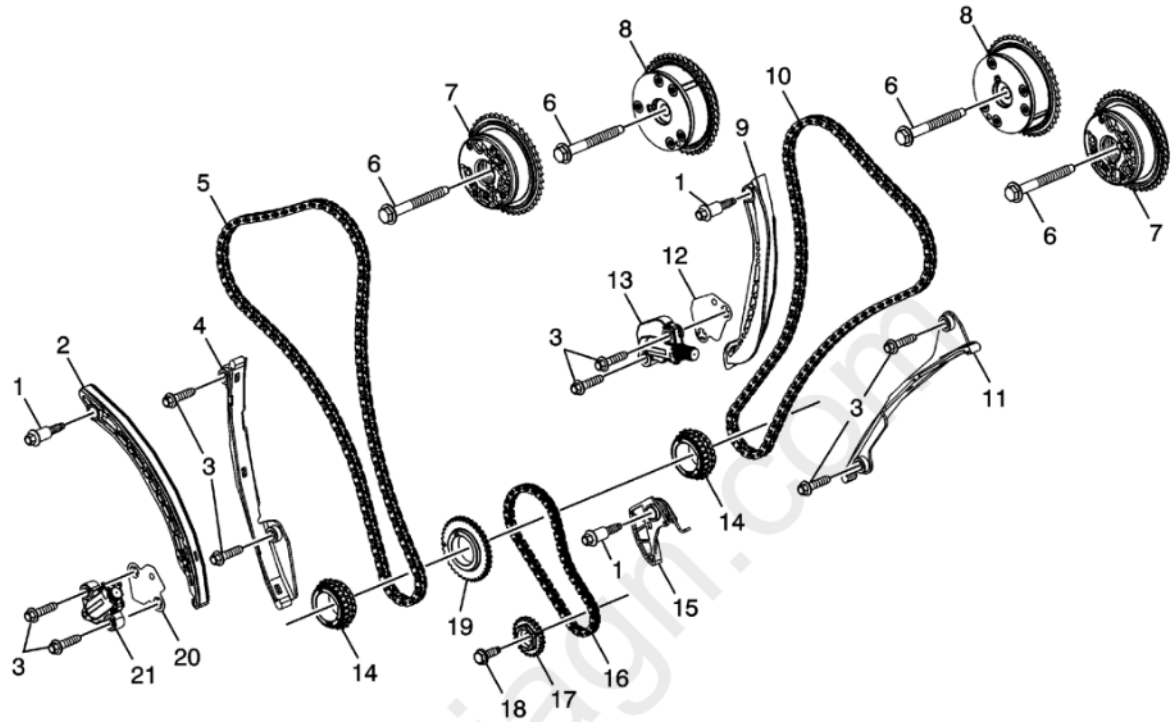


Fig. 22: Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Bolt [5x] M6 x 20
2	Water Pump Bolt [9x] M6 x 60
3	Water Pump Housing
4	Water Pump Gasket
5	Water Pump Locating Pin [2x]
6	Engine Front Cover Bolt [2x] M8 x 66
7	Engine Front Cover Bolt M12 x 75
8	Camshaft Position Actuator Control Valve Bolt [2x]
9	Camshaft Position Actuator Control Valve [2x]
10	Camshaft Position Actuator Control Valve Seal [2x]
11	Engine Front Cover
12	Engine Front Cover Locating Pin [2x]
13	Water Pump Seal [2x]
14	Water Pump Seal
15	Water Pump Seal
16	Oil Pump Flow Control Solenoid Valve Wire
17	Engine Front Cover Bolt [16x] M8 x 45
18	Harness Connector Bolt
19	Engine Front Cover Bolt M12 x 50
20	Crankshaft Front Oil Seal
21	Engine Front Cover Insulator
22	Engine Front Cover Retainer [4x]

Callout	Component Name
23	Crankshaft Balancer
24	Crankshaft Balancer Bolt
25	Water Pump Pulley
26	Water Pump Pulley Bolt [4x]

Camshaft Timing Components



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Fig. 23: Camshaft Timing Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Timing Chain Guide Bolt [2x]
2	Timing Chain Guide - Right
3	Timing Chain Tensioner Bolt [8x]
4	Timing Chain Guide - Right
5	Timing Chain - Right
6	Camshaft Position Actuator Bolt [4x]
7	Camshaft Position Actuator - Exhaust
8	Camshaft Position Actuator - Intake
9	Timing Chain Guide - Left
10	Timing Chain - Left
11	Timing Chain Guide - Left
12	Timing Chain Tensioner Gasket
13	Timing Chain Tensioner - Left
14	Timing Chain Crankshaft Sprocket
15	Timing Chain Tensioner
16	Oil Pump Timing Chain

Callout	Component Name
17	Oil Pump Sprocket
18	Oil Pump Drive Bolt
19	Crankshaft Sprocket
20	Timing Chain Tensioner Gasket
21	Timing Chain Tensioner - Right

Camshaft Carrier Components

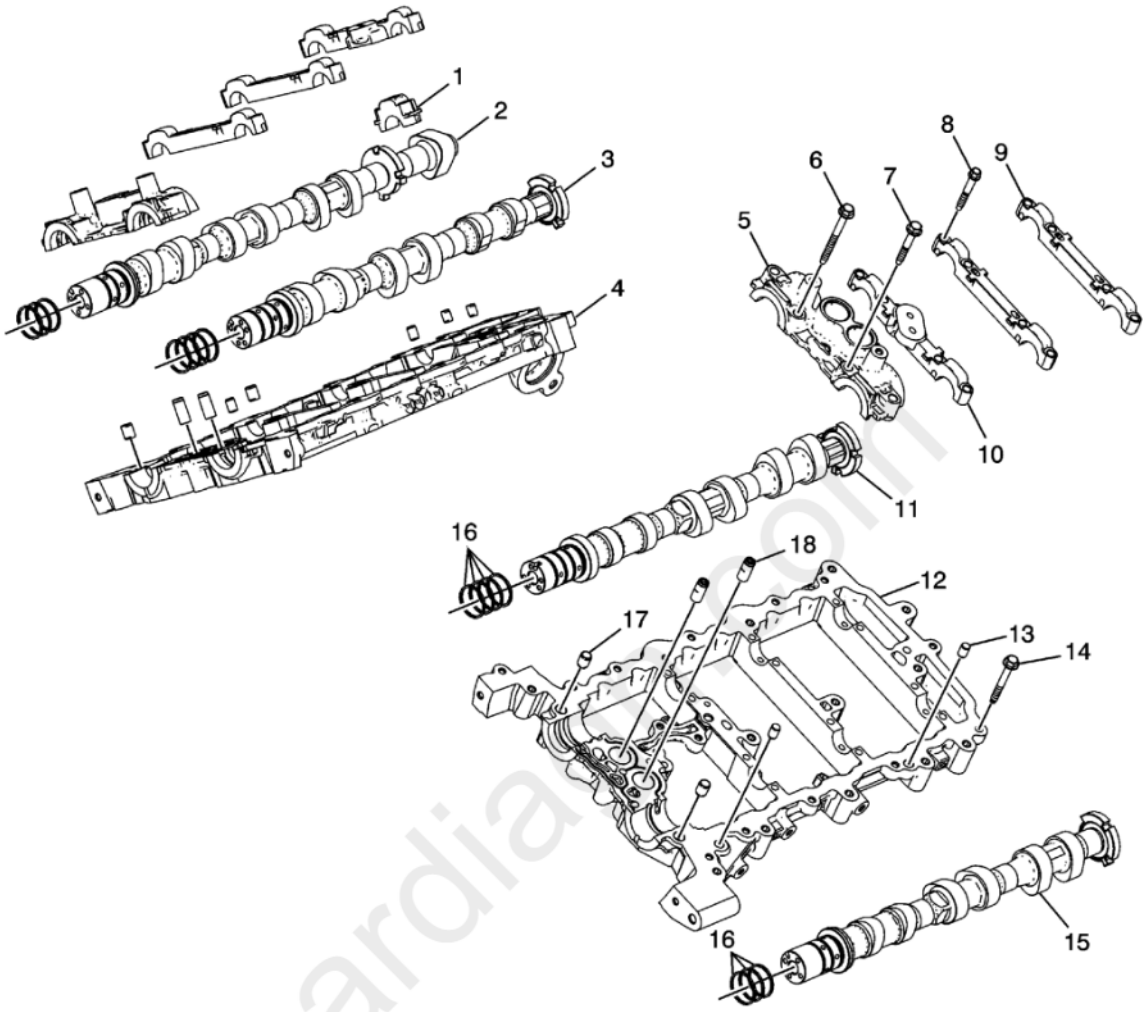


Fig. 24: Camshaft Carrier Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Bearing Cap - Intermediate
2	Exhaust Camshaft - Right
3	Intake Camshaft - Right
4	Camshaft Carrier - Right
5	Camshaft Bearing Cap
6	Camshaft Bearing Cap Bolt [8x]
7	Camshaft Bearing Cap Bolt [8x]
8	Camshaft Bearing Cap Bolt [26x]
9	Camshaft Bearing Cap
10	Camshaft Bearing Cap
11	Intake Camshaft - Left
12	Camshaft Carrier - Left
13	Dowel Pin
14	Camshaft Carrier Bolt
15	Exhaust Camshaft - Left

Callout	Component Name
16	Camshaft Oil Seal Ring
17	Dowel Pin
18	Engine Oil Manifold Check Valve

Cylinder Head Assemblies

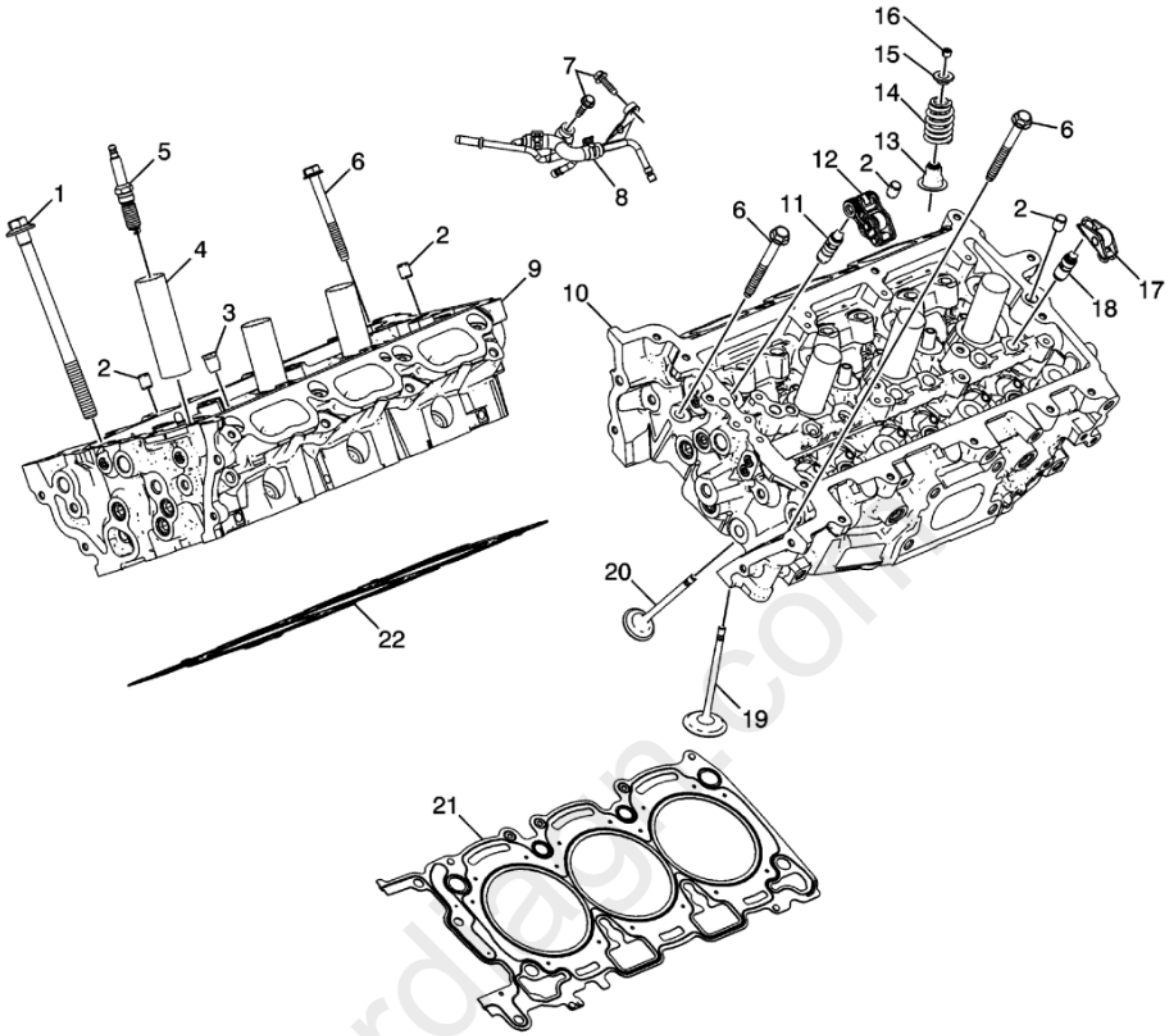


Fig. 25: Cylinder Head Assemblies
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Cylinder Head Bolt [16x]
2	Dowel Pin
3	Cylinder Head Oil Gallery Plug
4	Spark Plug Wire Sleeve
5	Spark Plug
6	Cylinder Head Bolt [3x]
7	Engine Coolant Air Bleed Pipe Bolt [2x]
8	Engine Coolant Air Bleed Pipe
9	Cylinder Head - Left
10	Cylinder Head - Right
11	Dual Feed Hydraulic Valve Adjustor
12	Valve Rocker Switching Arm
13	Valve Stem Oil Seal
14	Valve Spring
15	Valve Spring Cap
16	Valve Stem Key
17	Valve Rocker Arm

Callout	Component Name
18	Hydraulic Valve Lash Adjuster
19	Intake Valve
20	Exhaust Valve
21	Cylinder Head Gasket - Right
22	Cylinder Head Gasket - Left

Engine Oil Cooler Adapter Assembly

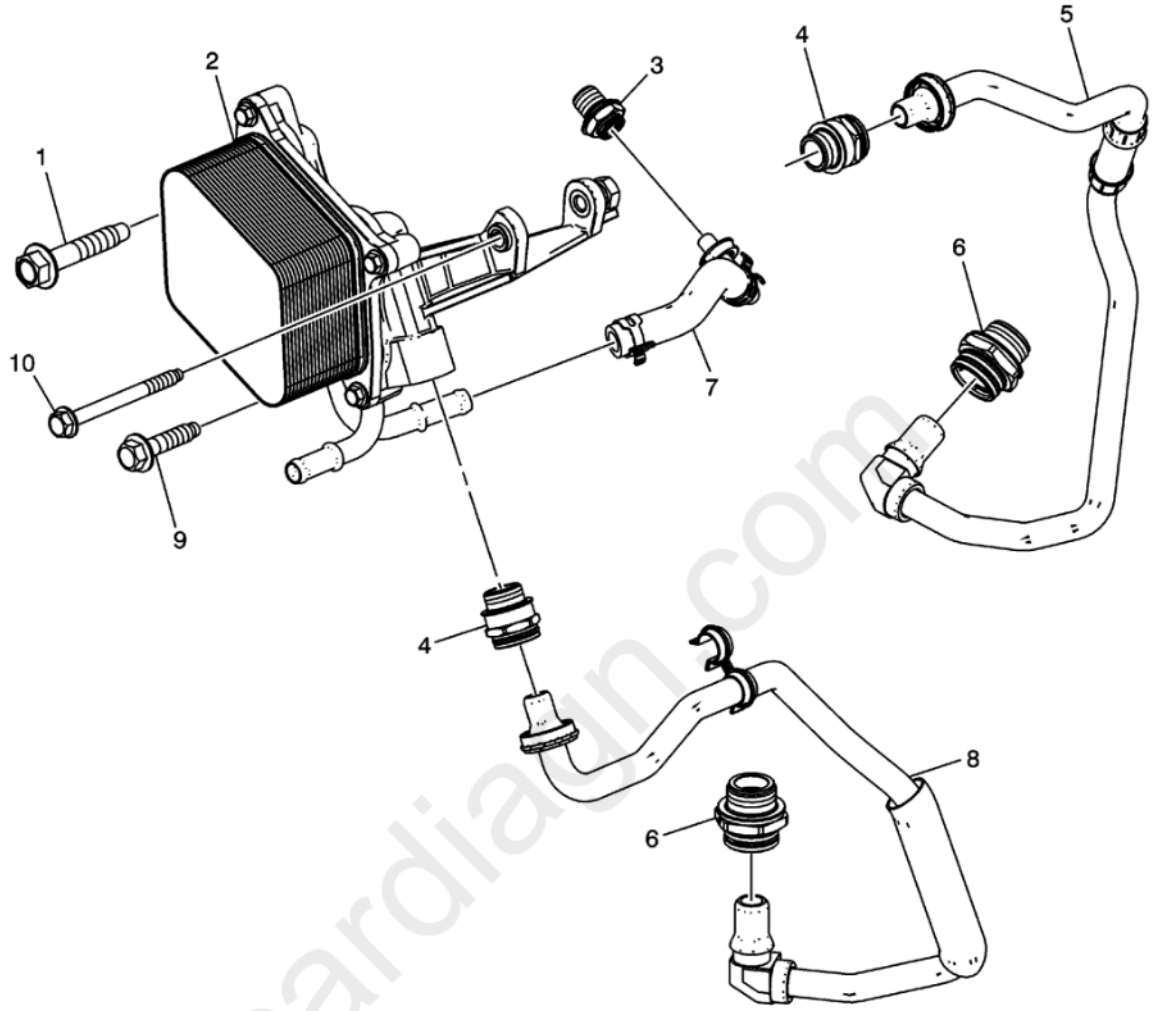


Fig. 26: Engine Oil Cooler Adapter Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Cooler Adapter Bolt M12 x 65.90
2	Engine Oil Cooler Adapter Assembly
3	Engine Oil Cooler Fitting
4	Engine Oil Cooler Fitting [2x]
5	Engine Oil Cooler Pipe
6	Engine Oil Cooler Fitting [2x]
7	Engine Oil Cooler Inlet Pipe
8	Engine Oil Cooler Pipe
9	Engine Oil Cooler Adapter Bolt M10 x 45.75
10	Engine Oil Cooler Adapter Bolt M8 x 90.8

Oil Pan and Components with Oil Cooler

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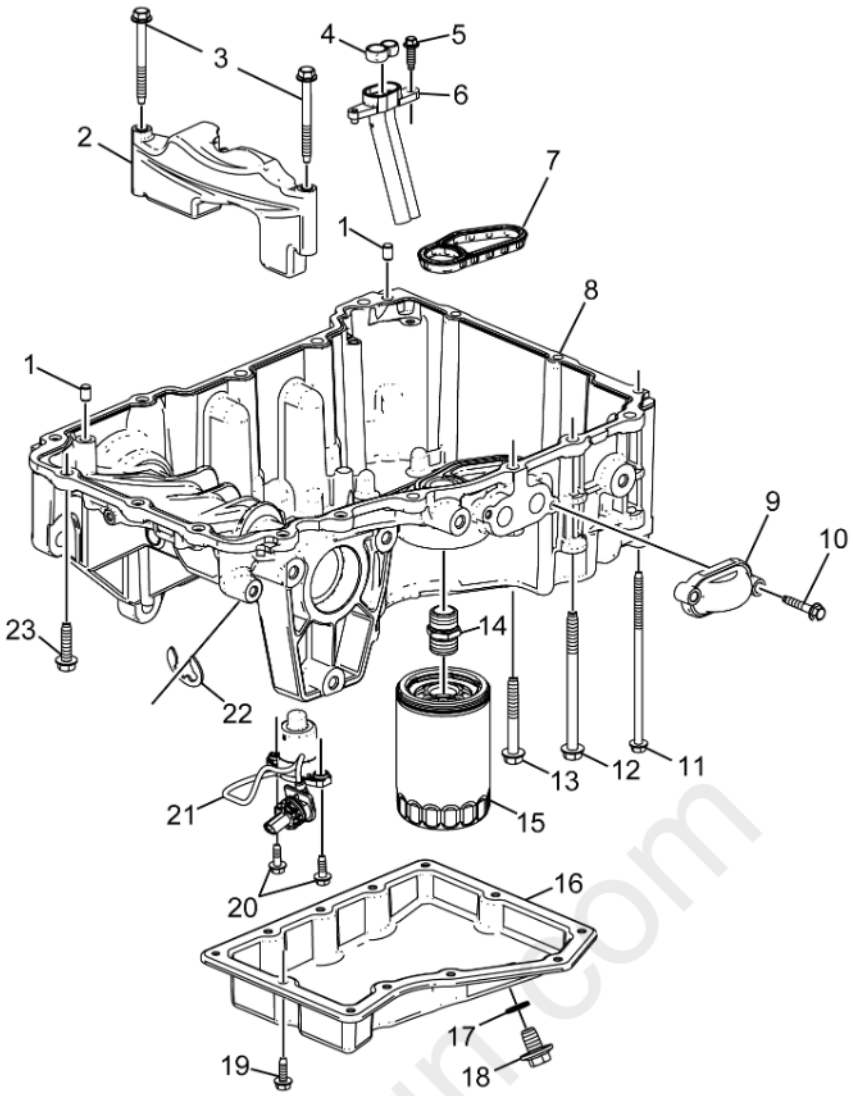


Fig. 27: Oil Pan and Components with Oil Cooler
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Dowel Pin [2x]
2	Oil Pan Baffle
3	Oil Pan Baffle Bolt [2x]
4	Positive Crankcase Ventilation Oil Separator Drain Seal
5	Positive Crankcase Ventilation Oil Separator Drain Bolt
6	Positive Crankcase Ventilation Oil Separator Drain
7	Oil Pan High Pressure Port Seal
8	Oil Pan
9	Oil Pan Cover
10	Oil Pan Cover Bolt [2x]
11	Oil Pan Bolt [3x] M6 x 150
12	Oil Pan Bolt [5x] M8 x 120
13	Oil Pan Bolt M8 x 80
14	Oil Filter Adapter Fitting
15	Oil Filter
16	Lower Oil Pan
17	Oil Pan Drain Plug Seal
18	Oil Pan Drain Plug
19	Lower Oil Pan Bolt [13x] M6 x 20.65
20	Engine Oil Level Indicator Switch Bolt [2x]
21	Engine Oil Level Indicator Switch
22	Engine Oil Level Switch Clip

Callout	Component Name
23	Oil Pan Bolt [8x] M8 x 35

Oil Pan and Components with Oil Cooler

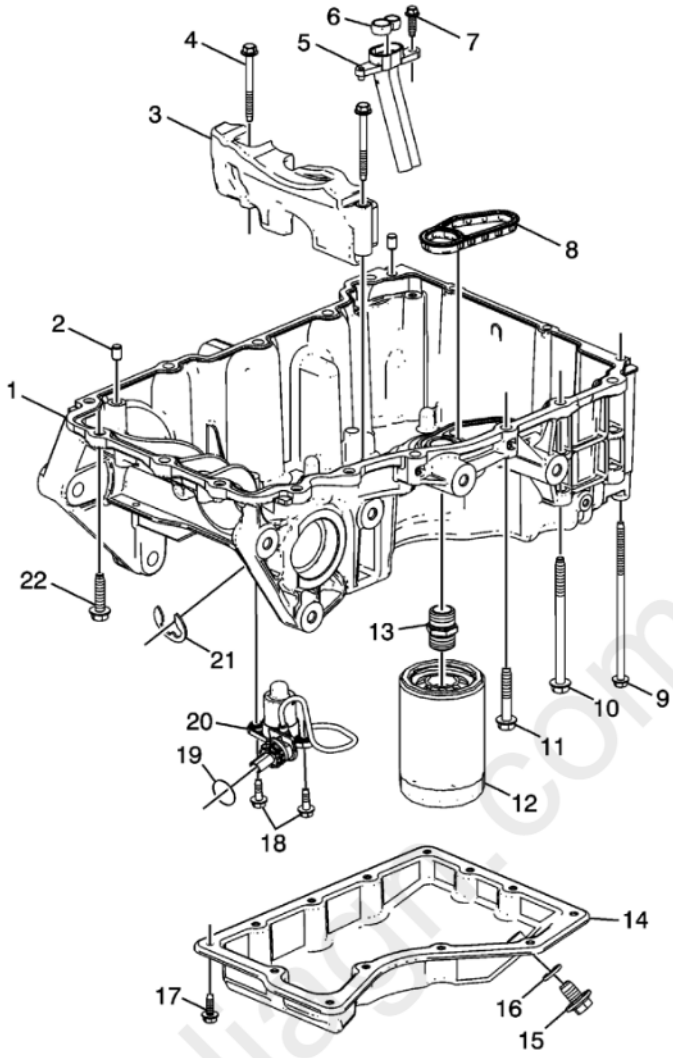


Fig. 28: Oil Pan and Components with Oil Cooler
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan
2	Dowel Pin [2x]
3	Oil Pan Baffle
4	Oil Pan Baffle Bolt [2x]
5	Positive Crankcase Ventilation Oil Separator Drain
6	Positive Crankcase Ventilation Oil Separator Drain Seal
7	Positive Crankcase Ventilation Oil Separator Drain Bolt
8	Oil Pan High Pressure Port Seal
9	Oil Pan Bolt [3x] M6 x 150
10	Oil Pan Bolt [5x] M8 x 120
11	Oil Pan Bolt [2x] M8 x 50
12	Oil Filter
13	Oil Filter Adapter Fitting
14	Lower Oil Pan
15	Oil Pan Drain Plug
16	Oil Pan Drain Plug Seal
17	Lower Oil Pan Bolt [13x]
18	Engine Oil Level Indicator Switch Bolt [2x]
19	Engine Oil Level Indicator Switch O-Ring Seal

Callout	Component Name
20	Engine Oil Level Indicator Switch
21	Engine Oil Level Switch Clip
22	Oil Pan Bolt [7x] M8 x 35

Oil Pump Assembly

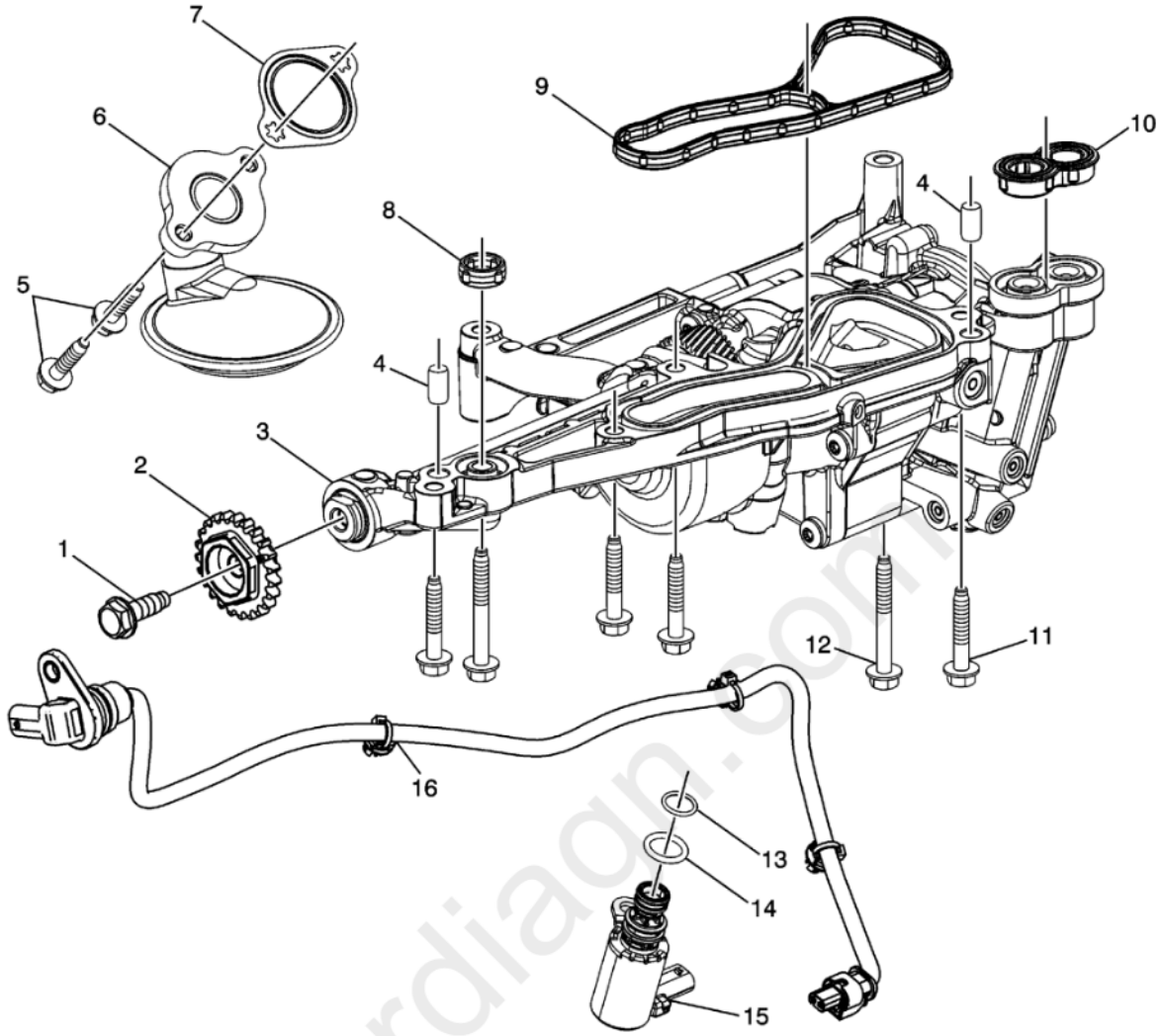


Fig. 29: Oil Pump Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Sprocket Bolt
2	Oil Pump Sprocket
3	Oil Pump
4	Dowel Pin - Not Serviceable
5	Oil Pump Suction Pipe Bolt [2x]
6	Oil Pump Suction Pipe
7	Oil Pump Suction Pipe Gasket
8	Oil Pump Housing Passage Seal
9	Oil Pump Housing Passage Seal
10	Vacuum Pump Seal
11	Oil Pump Bolt [2x]
12	Oil Pump Bolt [4x]
13	Oil Pump Flow Control Valve Seal O-Ring
14	Oil Pump Flow Control Valve Seal
15	Oil Pump Flow Control Valve
16	Oil Pump Flow Control Solenoid Valve Wiring

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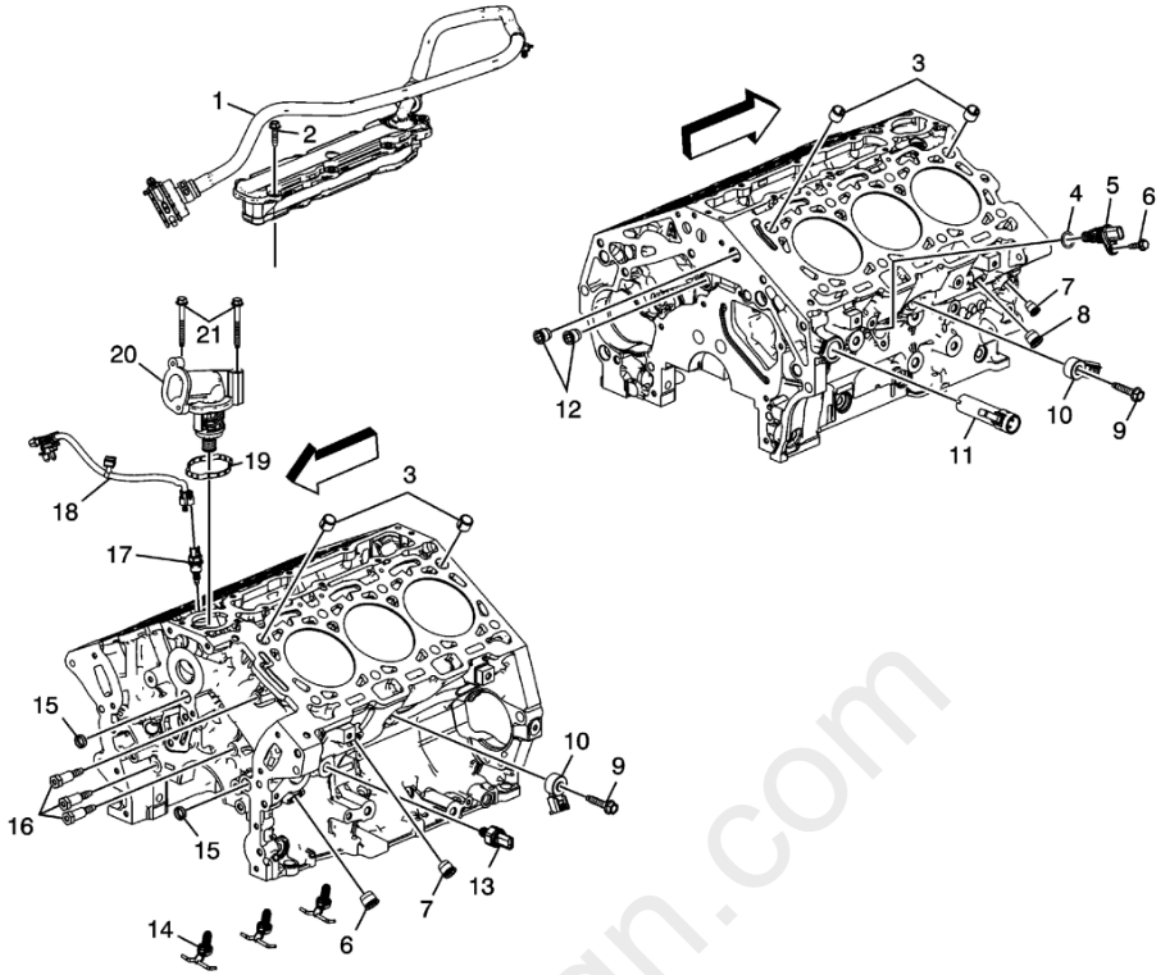


Fig. 30: Engine Block Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Oil Separator
2	Positive Crankcase Ventilation Oil Separator Bolt [6x]
3	Cylinder Head Locating Pin
4	Crankshaft Position Sensor Seal
5	Crankshaft Position Sensor
6	Crankshaft Position Sensor Bolt
7	Engine Block Core Hole Plug M16 x 16.25
8	Engine Block Core Hole Plug M18 x 16.25
9	Knock Sensor Bolt [2x]
10	Knock Sensor
11	Engine Coolant Heater
12	Engine Block Oil Gallery Plug M16 x 16.25
13	Engine Oil Pressure Sensor
14	Piston Oil Nozzle [3x]
15	Engine Block Oil Gallery Plug 14 mm
16	Engine Front Cover Stud [3x]
17	Engine Coolant Temperature Sensor
18	Engine Coolant Temperature Sensor Wire
19	Engine Coolant Thermostat Seal
20	Engine Coolant Thermostat Housing
21	Engine Coolant Thermostat Housing Bolt [2x]

Piston, Rings, Bearings and Connecting Rod Assembly

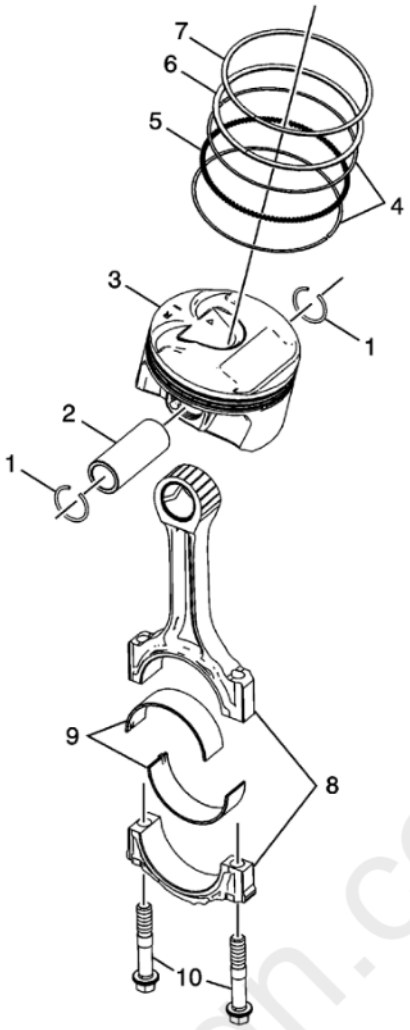


Fig. 31: Piston, Rings, Bearings and Connecting Rod Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Piston Pin Retainer
2	Piston Pin
3	Piston
4	Piston Oil Ring Rail
5	Piston Oil Ring Rail Spacer
6	Piston Compression Ring - Lower
7	Piston Compression Ring - Upper
8	Connecting Rod
9	Connecting Rod Bearing
10	Connecting Rod Bolt [2x]

Engine Block Assembly

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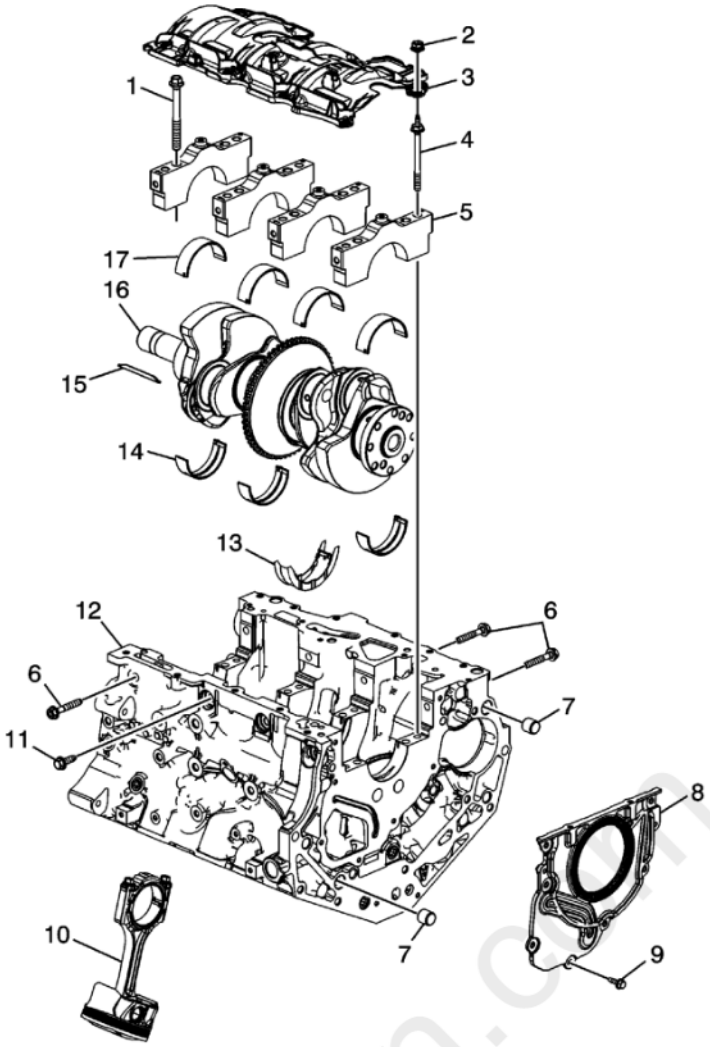


Fig. 32: Engine Block Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Bearing Cap Bolt [8x]
2	Crankshaft Oil Deflector Nut [8x]
3	Crankshaft Oil Deflector
4	Crankshaft Bearing Cap Bolt [8x]
5	Crankshaft Bearing Cap
6	Crankshaft Bearing Cap Bolt [3x]
7	Crankshaft Rear Oil Seal Housing Locating Pin
8	Crankshaft Rear Oil Seal Housing
9	Crankshaft Rear Oil Seal Housing Bolt [8x]
10	Piston and Connecting Rod Assembly
11	Crankshaft Bearing Cap Bolt
12	Engine Block
13	Crankshaft Thrust Upper Bearing
14	Crankshaft Upper Bearing
15	Crankshaft Balancer Key
16	Crankshaft
17	Crankshaft Lower Bearing

ENGINE IDENTIFICATION

Vehicle Identification Number

The Vehicle Identification Number (VIN) Derivative is located in two places on the engine and is a nine digit number stamped or laser etched onto the block at the vehicle assembly plant. If reading the identification number the following information can be obtained:

- The first digit identifies the vehicle division.
- The second digit is the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the Vehicle Identification Number (VIN).

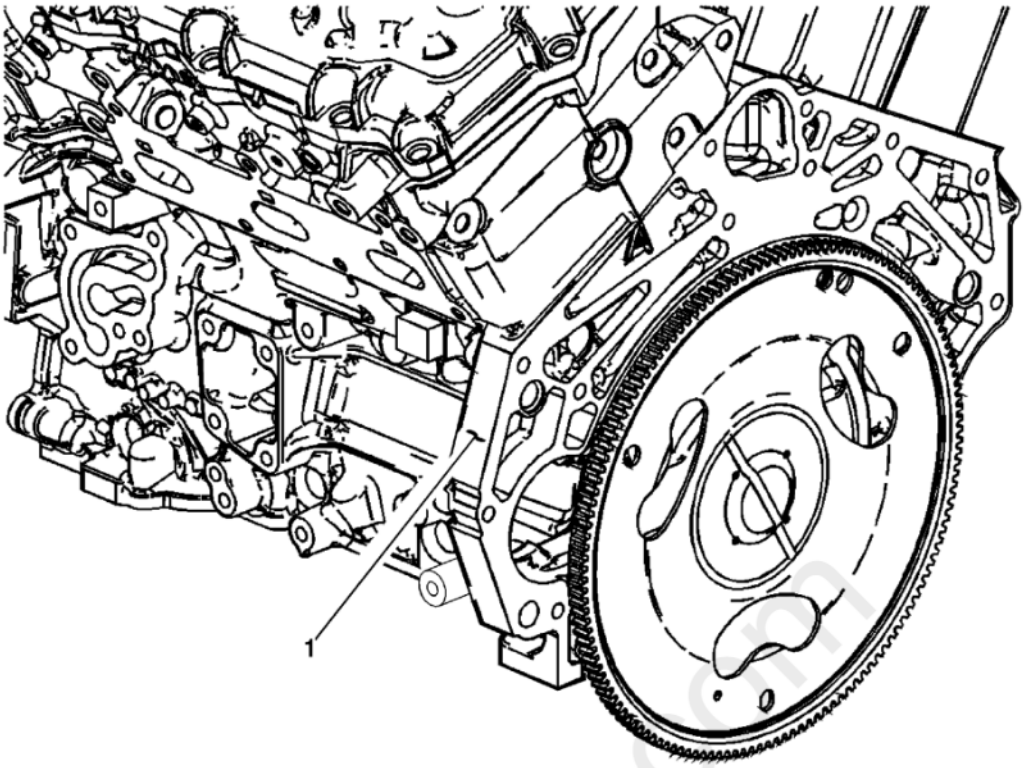


Fig. 33: Locating Engine VIN - Left Rear Side
Courtesy of GENERAL MOTORS COMPANY

The engine block is marked with the VIN on a pad area on the left rear side (1).

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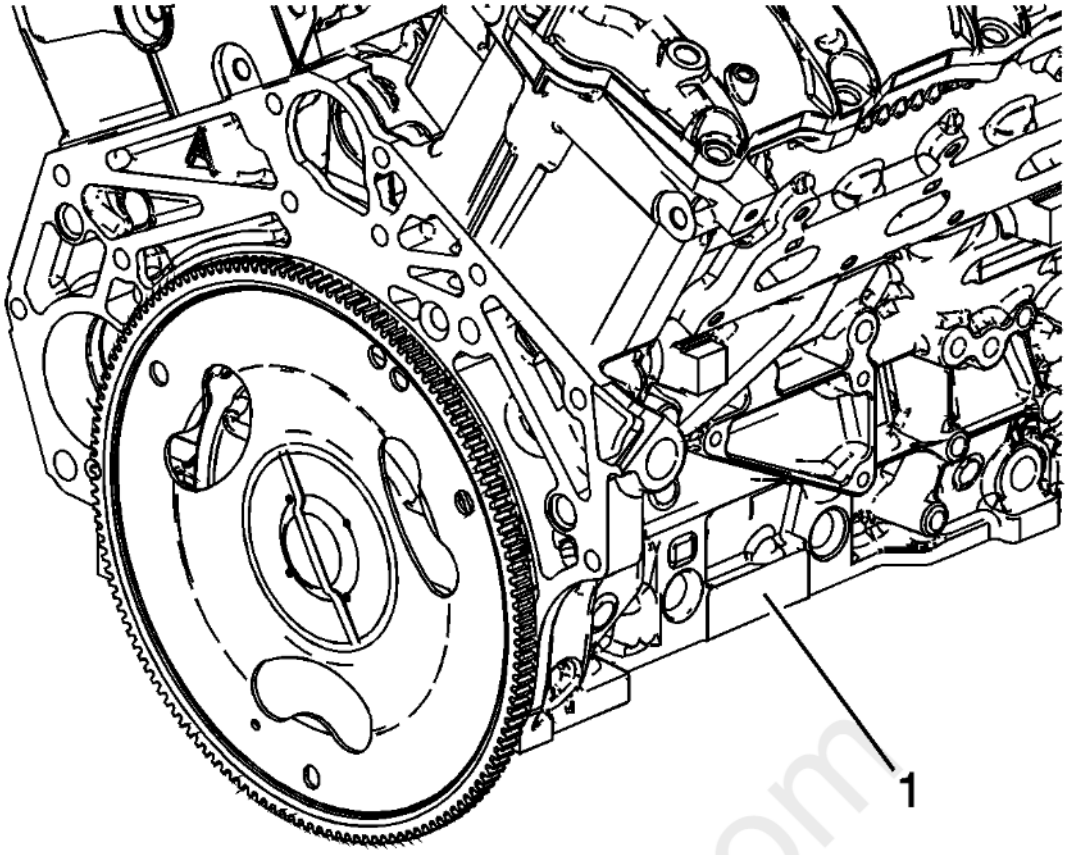


Fig. 34: Locating Vehicle Identification Number (VIN) - Center Lower Right Side
Courtesy of GENERAL MOTORS COMPANY

The engine block is marked with the VIN on a pad area on the center lower right side (1).

Engine Traceability Label

The engine traceability label is located in two places on the engine and consists of the broadcast code, bar code and sequence number. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

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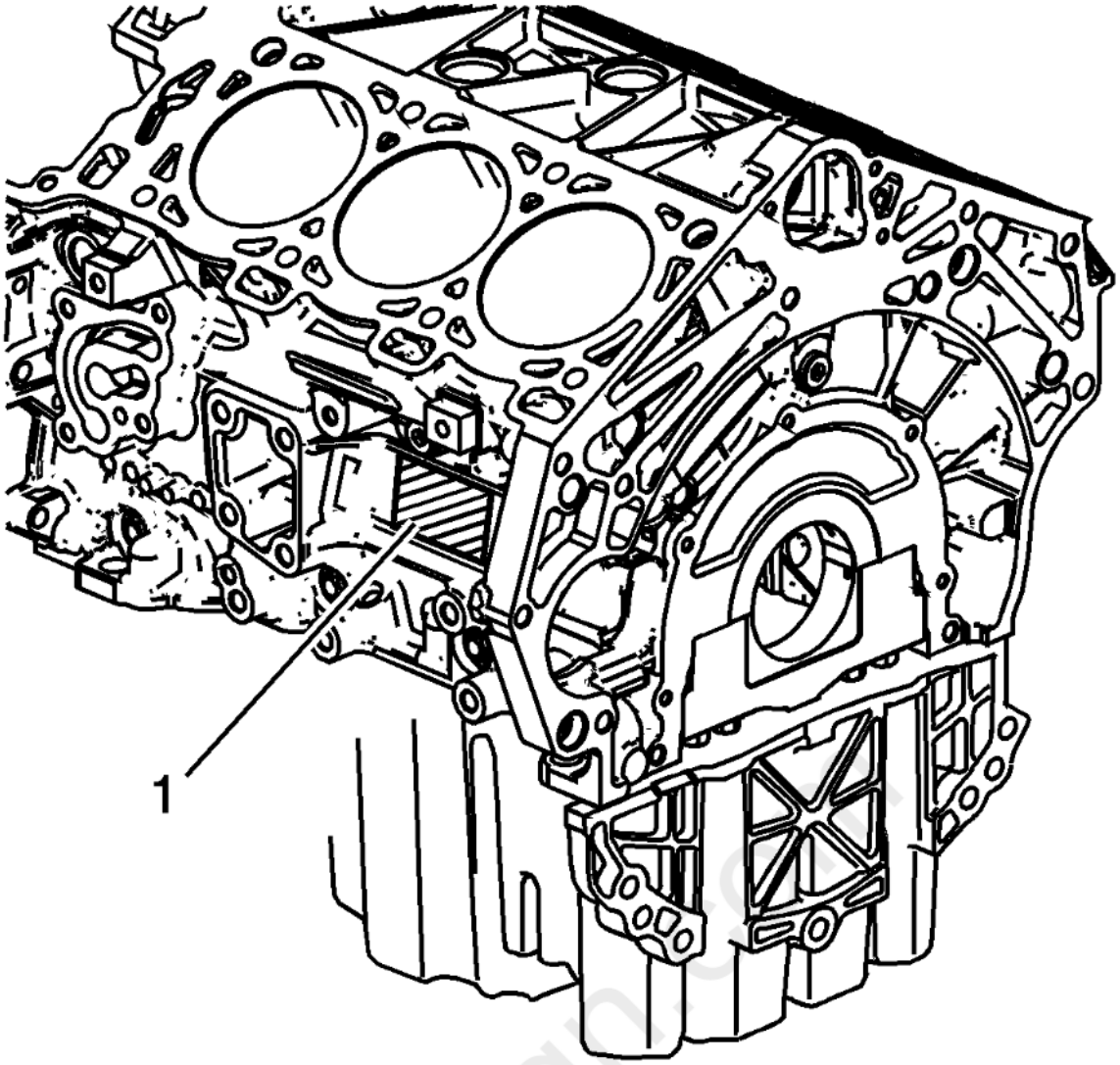


Fig. 35: Locating Left Rear Engine Traceability Label
Courtesy of GENERAL MOTORS COMPANY

One engine traceability label (1) is located on the left rear side of the engine block. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

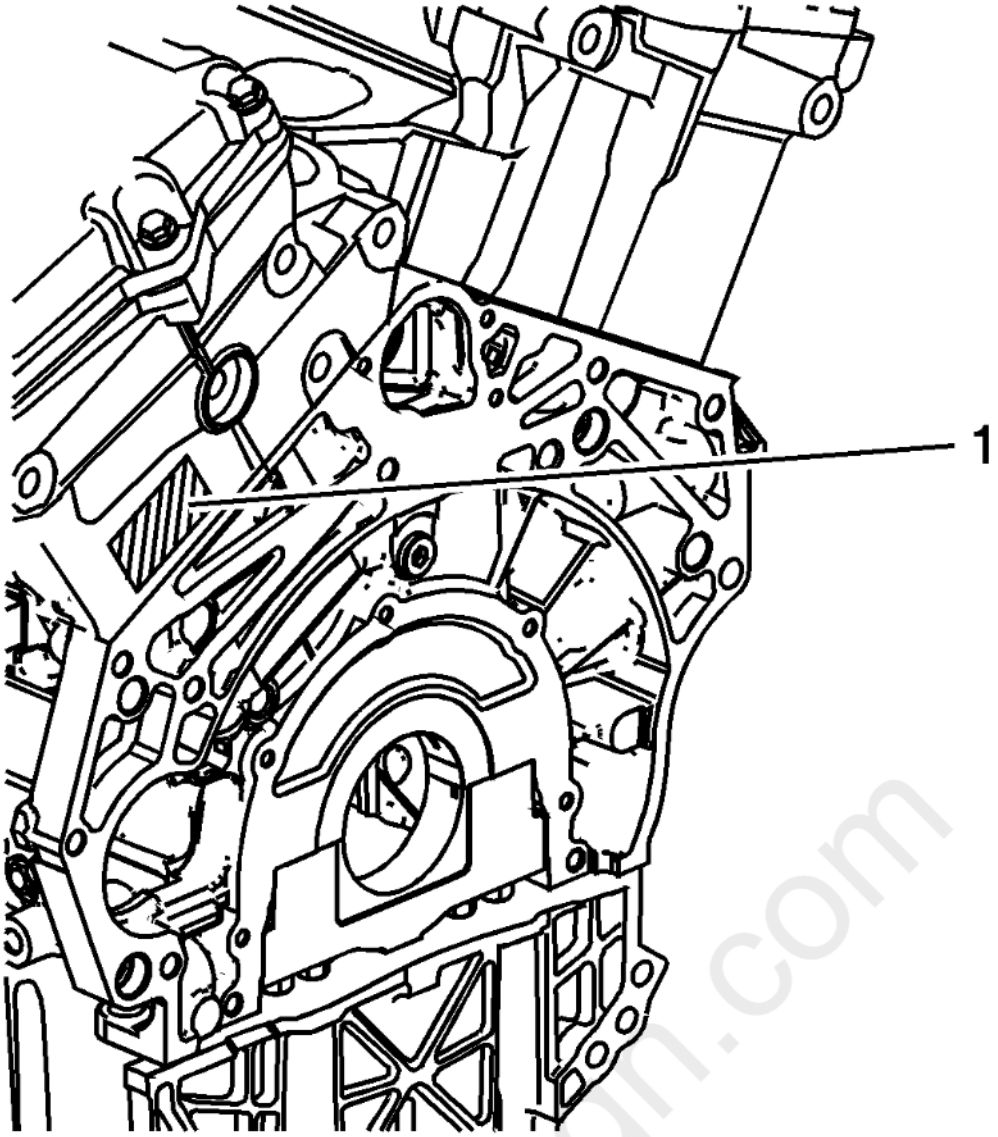


Fig. 36: View Of Engine Traceability Label On Left Cylinder Head
Courtesy of GENERAL MOTORS COMPANY

Another engine traceability label (1) is located on the rear of the left cylinder head. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

Engine Verification Label

The engine verification label is located in two places on the engine and consists of the broadcast code and bar code. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

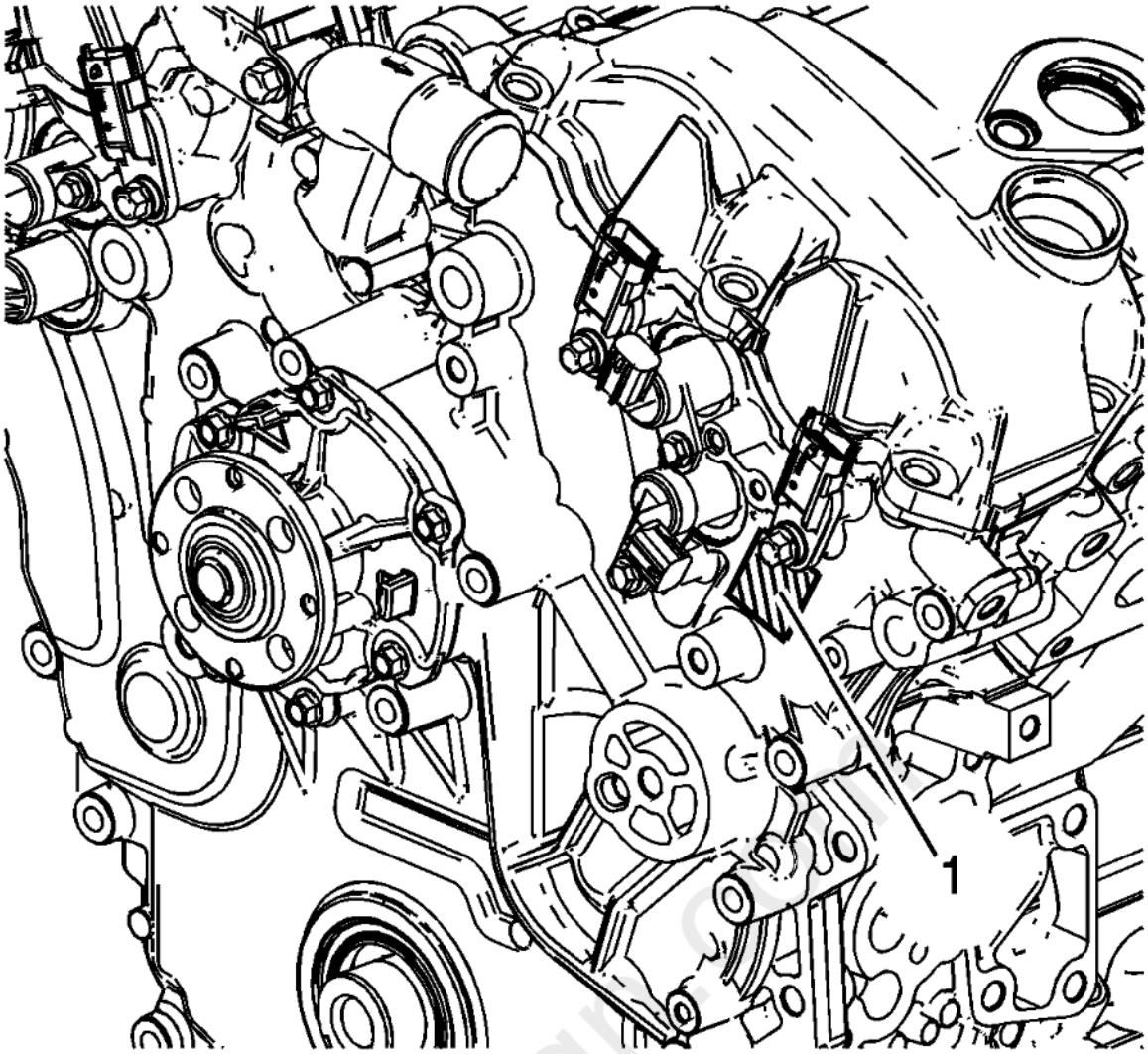


Fig. 37: Locating Left Engine Verification Label
Courtesy of GENERAL MOTORS COMPANY

One engine verification label (1) is located on the left side of the engine front cover below the exhaust camshaft position sensor. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

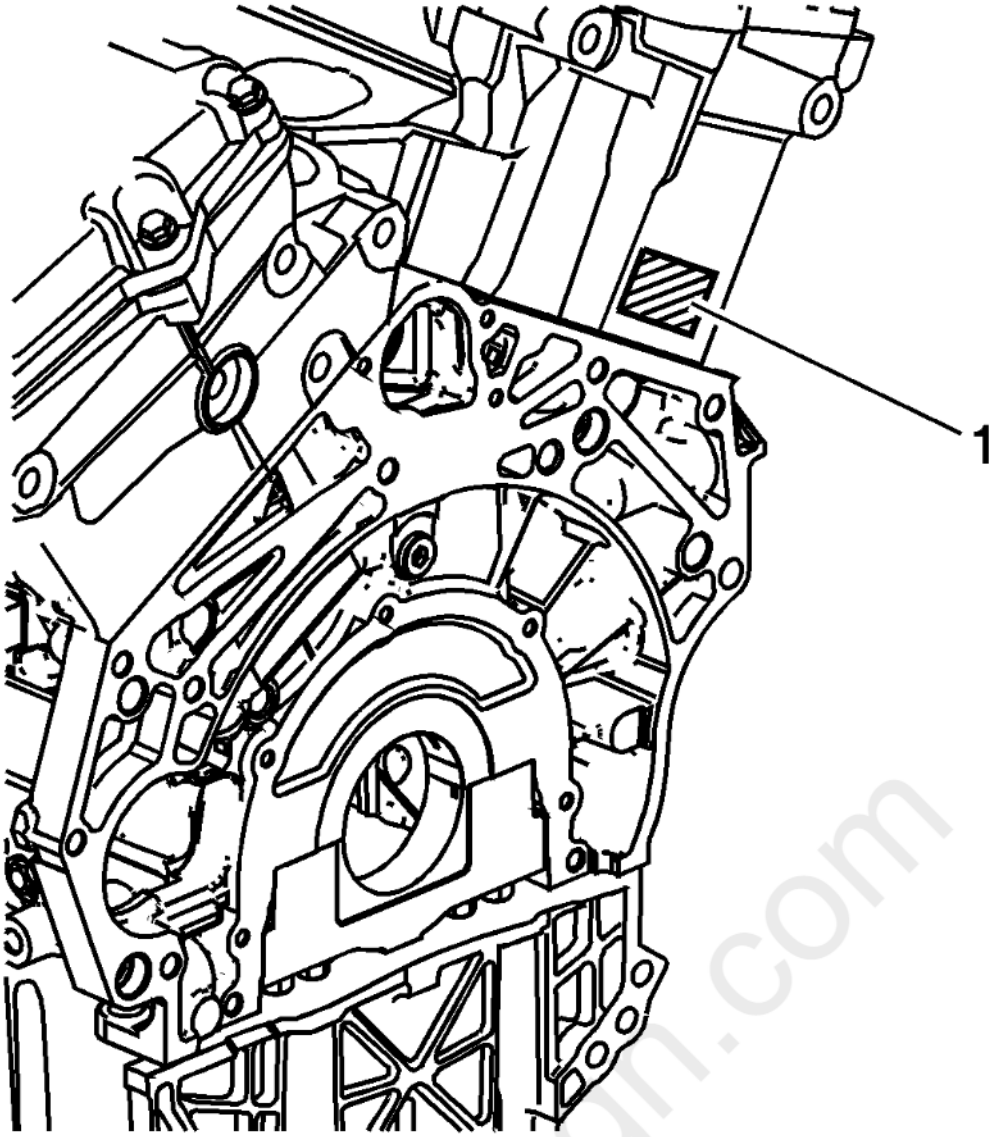


Fig. 38: Identifying Engine Verification Label On Rear Of Right Cylinder Head
Courtesy of GENERAL MOTORS COMPANY

Another engine verification label (1) is located on the rear of the right cylinder head. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

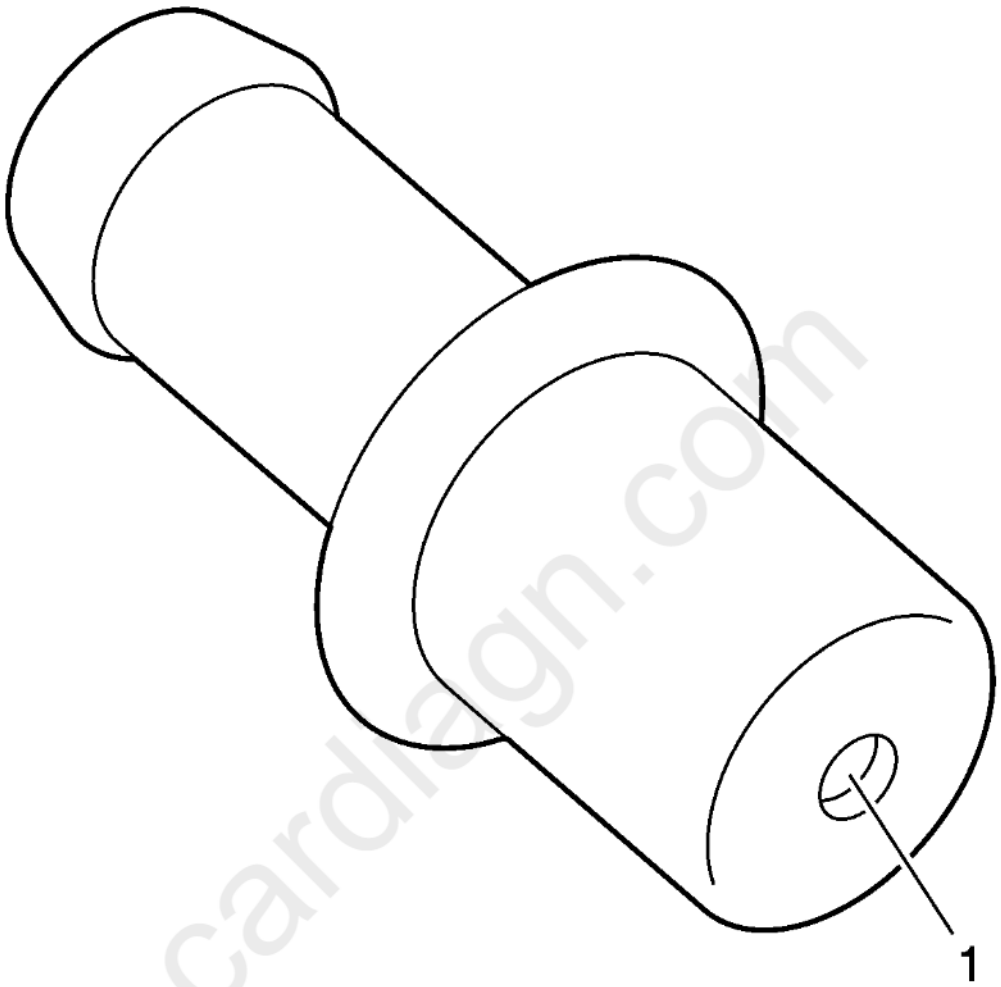
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2017 ENGINE

Engine Mechanical - 3.0L (LGW) or 3.6L (LGX) - Description and Operation - CT6

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION



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Fig. 1: PCV Orificed Tube
Courtesy of GENERAL MOTORS COMPANY

A crankcase ventilation system is used to consume crankcase vapors created during the combustion process instead of venting them to the atmosphere.

Fresh air is supplied through a filter to the crankcase, the crankcase mixes the fresh air with the blow-by gases and then passed through a positive crankcase ventilation (PCV) orificed tube into the intake manifold.

The PCV orificed tube restricts the flow rate of the blow-by gases using an orifice (1) located at the end of the tube. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the throttle body in order to be consumed by normal combustion.

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt

- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
    - The power steering pump, if belt driven
    - The generator
    - The A/C compressor, if equipped
    - The engine cooling fan, if belt driven
    - The water pump, if belt driven
    - The vacuum pump, if equipped
    - The air compressor, if equipped

The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. The drive belts are made of different types of rubbers, chloroprene or EPDM and have different layers or plies containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION (LGX)

The High Feature V6 (VIN Code Identifier "S") RPO LGX is a 3.6 Liter VVT (Variable Valve Timing) engine with direct injection. The direct injection system places the high pressure injectors in the cylinder heads. This engine incorporates 2 intake and 2 exhaust valves per cylinder and uses a dual overhead cam design with individual intake and exhaust camshafts. A camshaft position actuator is mounted on each camshaft. The cylinders are arranged in 2 banks of 3 with a 60 degree included angle. The right bank of cylinders are number 1-3-5 and the left bank of cylinders are 2-4-6, viewed from the flywheel end of the engine. The engine firing order is 1-2-3-4-5-6.

Active Fuel Management System (AFM)

The AFM consists of the camshafts, valves, the switching roller finger followers (SRFF), also known as the valve switching rocker arm, the dual feed hydraulic lash adjusters and the oil control valve (OCV) which is also known as the valve rocker arm oil control valve.

Depending on engine RPM, the ECM sends a signal to the OCV commanding it either ON or OFF.

With the AFM system ON, the OCV directs oil to the dual feed hydraulic lash adjuster unlatching the switching roller finger followers creating zero lift and not allowing the valves to open on cylinders two and five. AFM is active at this time.

With the AFM system off, the OCV is not active and no oil is directed to the dual feed hydraulic lash adjuster. The switching roller finger followers operate as a normal rocker arm and all valves open 11.5 mm of lift at 90Â° BTDC. AFM is inactive at this time.

Camshaft Drive System

The camshaft drive system consists of two timing drive chains driven by the crankshaft which drives the respective cylinder head's intake and exhaust camshaft position actuators. Cushioned actuator chain

sprockets have been added contributing to quieter engine operation.

The timing drive chains use moveable timing drive chain guides and a hydraulic-actuated tensioner. The tensioner minimizes timing drive chain noise and provides accurate valve action by keeping slack out of the timing drive chains and continuously adjusting for timing drive chain wear. The tensioner incorporates a plunger that adjusts out with wear allowing only a minimal amount of backlash. All tensioners are sealed to the head or block using a rubber coated steel gasket. The gasket traps an adequate oil reserve to ensure quiet start-up.

Camshaft Position Actuator System

The engine incorporates a camshaft position actuator for each intake and exhaust camshaft. Camshaft phasing changes valve timing as engine operating conditions vary. Dual camshaft phasing allows the further optimization of performance, fuel economy and emissions without compromising overall engine response and drivability. Variable valve timing also contributes to a reduction in exhaust emissions. It optimizes exhaust and inlet valve overlap and eliminates the need for an exhaust gas recirculation (EGR) system.

The camshaft position actuator is a hydraulic vane-type actuator that changes the camshaft lobe timing relative to the camshaft drive sprocket. Engine oil is directed by a camshaft position actuator oil control valve to the appropriate passages in the camshaft position actuator. Oil acting on the vane in the camshaft position actuator rotates the camshaft relative to the sprocket. At idle, both camshafts are at the default or "home" position. At this position, the exhaust camshaft is fully advanced and the intake is fully retarded to minimize valve overlap for smooth idle. In addition, this engine has intermediate park technology, which incorporates an intermediate-lock intake variable valve timing cam phaser, allowing the cams to be parked at the most favorable position for cold starting. Under other engine operating conditions, the camshaft position actuator is controlled by the engine control module (ECM) to deliver optimal intake and exhaust valve timing for performance, drivability and fuel economy. The camshaft position actuator incorporates an integral trigger wheel, which is sensed by the camshaft position sensor mounted in the front cover, to accurately determine the position of each camshaft. The exhaust camshaft position actuator has a different internal configuration than the intake camshaft position actuator since the exhaust camshaft position actuator phases in the opposite direction relative to the inlet camshaft position actuator.

The camshaft position actuator oil control valve (OCV) directs oil from the oil feed in the head to the appropriate camshaft position actuator oil passages. There is one OCV for each camshaft position actuator. The OCV is sealed and mounted to the front cover. The ported end of the OCV is inserted into the cylinder head with a sliding fit. A filter screen protects each OCV oil port from any contamination in the oil supply.

Connecting Rods and Pistons

The connecting rods are sinter-forged with a high copper content and have press-in-place piston pin bushings. The connecting rods and rod cap are aligned by dowel pins retained in the cap. The cast aluminum pistons incorporate a polymer-coated skirt to reduce friction. The pistons are unique to the LGX both for compression ratio and combustion efficiency. The piston uses two low tension compression rings and one multi-piece oil control ring.

Cooling System

This engine has a targeted cooling system which sends coolant simultaneously to each water jacket in the heads and block. This new, parallel-flow design maximizes heat extraction in the area of the upper deck, intake and exhaust valve bridges in the heads and integrated exhaust manifold with a minimal amount of coolant. The result is more even and consistent cooling, which enhances performance and faster engine warm up, which improves cold-start efficiency and reduces emissions.

Crankcase

The cylinder block is constructed of aluminum alloy by precision sand-casting with cast in place iron cylinder liners. Each nodular main bearing cap incorporates 6 bolts bolting the cap into the engine block. Along with 2 outer and 2 inner bolts, 2 side bolts are used in the deep skirt block. To prevent aeration, oil return from the valve train and cylinder heads is channeled away from the rotating and reciprocating components through oil drain back passages incorporated into the cylinder heads and engine block. Pressure-actuated piston oil cooling jets are mounted between opposing cylinders. Twin knock sensors

are located in the valley of the block between the cylinder heads. The knock sensors have an acoustic foam noise barrier that surrounds them in the valley.

Crankshaft

The crankshaft is a hardened, forged steel design with 4 main bearings. Crankshaft thrust is controlled by the upper portion of the number 3 main bearing. The crankshaft position reluctor wheel is pressed onto the rear of the crankshaft in front of the rear main journal. A micro encapsulated adhesive is used on the reluctor wheel to aid retention. This crankshaft is internally balanced.

Cylinder Heads

The cylinder heads are a two piece design consisting of a head and a camshaft carrier which are cast aluminum with powdered metal valve seat inserts and valve guides. The two piece design allows for the Active Fuel Management (AFM) System. The cylinder heads also feature integrated exhaust manifolds; the exhaust manifolds are incorporated into the head casting. Two intake valves and two exhaust valves are actuated by roller finger followers pivoting on a stationary hydraulic lash adjuster (SHLA). In the LGX engine, the valves and seats are constructed with specialized materials and coatings and the exhaust valves are sodium filled for robustness. The cylinder heads also feature a "high-tumble" port design and are sealed with LGX specific head gaskets. The head gaskets are also specific to the LH and RH sides.

Separate exhaust and intake camshafts are supported by bearings machined into the camshaft carrier. The front camshaft bearing cap is used as a thrust control surface for each camshaft. Each spark plug is shielded by a tube that is pressed into the cylinder head. Each spark plug ignition coil is also mounted through the spark plug tube. The LGX engine uses specific spark plugs and a different spark plug gap from other HFV6 engines. The engine coolant temperature (ECT) sensor is mounted in the thermostat housing near the flywheel end of the engine. With direct injection, the high pressure injectors are located in machined bores below the intake ports. A stainless steel, high pressure fuel rail is attached to the intake side of the head. The LGX engine has unique higher-flow injectors and fuel pump. The cylinder head has a larger bore for the new larger diameter fuel pump follower that operates the higher-flow pump. The fuel injectors are retained to the fuel rail in a new "twist-lock" retention scheme that does not require special tools for service.

Oiling System

The LGX engine contains a dual-pressure control and variable-displacement vane pump that enhances efficiency by optimizing oil pressure as a function of engine speed. The oil pump is located beneath the cylinder block inside the oil pan, contributing to the engines smoother and quieter operation. The oiling system components differ depending on the engine being in a transverse or longitudinal orientation. The LGX has unique oil pans depending on orientation, with the pans being separated into an upper (traditional aluminum) and lower (stamped steel) pan. This configuration helps with noise and mass concerns. It also affords some serviceability improvements through not needing to remove the entire upper pan for some service procedures; the procedures can be performed through removing the lower pan. The LGX oil pans contain oil level switches as do nearly all HFV6 applications. The oil level switch is normally open and closes at oil levels above minimum requirements.

Right and Left Bank Designation

Right hand (RH) and left hand (LH) designation through the engine mechanical section are viewed from the rear, flywheel side, of the engine or from inside the vehicle. These banks are also referred to as Bank 1 (RH) and Bank 2 (LH).

Vacuum Pump

The HFV6 Gen 2 LGX engine utilizes a mechanical vacuum pump to provide a vacuum source for the braking system. The vacuum pump is integrated into the oil pump assembly located in the oil pan. Both vacuum pump and oil pump are part of a common assembly, referred to as a tandem pump. Neither pump is serviceable individually. If either the oil pump or vacuum pump are defective, replace the entire tandem pump assembly.

ENGINE COMPONENT DESCRIPTION (LGW)

The High Feature V6 (VIN Code Identifier "6") RPO LGW is a 3.0 Liter VVT (Variable Valve Timing) engine with direct injection and twin turbochargers. The LGW has an Integral Charge-Air Cooler Module (IACM) with an internally-mounted throttle body to cool and meter the airflow into the engine. The direct injection system places the high pressure injectors in the cylinder heads. This engine incorporates 2 intake and 2 exhaust valves per cylinder and uses a dual overhead cam design with individual intake and exhaust camshafts. A camshaft position actuator is mounted on each camshaft. The cylinders are arranged in 2 banks of 3 with a 60 degree included angle. The right bank of cylinders are number 1-3-5 and the left bank of cylinders are 2-4-6, viewed from the flywheel end of the engine. The engine firing order is 1-2-3-4-5-6.

Active Fuel Management System (AFM)

The AFM consists of the camshafts, valves, the switching roller finger followers (SRFF), also known as the valve switching rocker arm, the dual feed hydraulic lash adjusters and the oil control valve (OCV) which is also known as the valve rocker arm oil control valve.

Depending on engine RPM, the ECM sends a signal to the OCV commanding it either ON or OFF.

With the AFM system ON, the OCV directs oil to the dual feed hydraulic lash adjuster unlatching the switching roller finger followers creating zero lift and not allowing the valves to open on cylinders two and five. AFM is active at this time.

With the AFM system off, the OCV is not active and no oil is directed to the dual feed hydraulic lash adjuster. The switching roller finger followers operate as a normal rocker arm and all valves open 11.5 mm of lift at 90Â° BTDC. AFM is inactive at this time.

Camshaft Drive System

The camshaft drive system consists of two timing drive chains driven by the crankshaft which drives the respective cylinder head's intake and exhaust camshaft position actuators. Cushioned actuator chain sprockets have been added contributing to quieter engine operation.

The timing drive chains use moveable timing drive chain guides and a hydraulic-actuated tensioner. The tensioner minimizes timing drive chain noise and provides accurate valve action by keeping slack out of the timing drive chains and continuously adjusting for timing drive chain wear. The tensioner incorporates a plunger that adjusts out with wear allowing only a minimal amount of backlash. All tensioners are sealed to the head or block using a rubber coated steel gasket. The gasket traps an adequate oil reserve to ensure quiet start-up.

Camshaft Position Actuator System

The engine incorporates a camshaft position actuator for each intake and exhaust camshaft. Camshaft phasing changes valve timing as engine operating conditions vary. Dual camshaft phasing allows the further optimization of performance, fuel economy and emissions without compromising overall engine response and drivability. Variable valve timing also contributes to a reduction in exhaust emissions. It optimizes exhaust and inlet valve overlap and eliminates the need for an exhaust gas recirculation (EGR) system.

The camshaft position actuator is a hydraulic vane-type actuator that changes the camshaft lobe timing relative to the camshaft drive sprocket. Engine oil is directed by a camshaft position actuator oil control valve to the appropriate passages in the camshaft position actuator. Oil acting on the vane in the camshaft position actuator rotates the camshaft relative to the sprocket. At idle, both camshafts are at the default or "home" position. At this position, the exhaust camshaft is fully advanced and the intake is fully retarded to minimize valve overlap for smooth idle. In addition, this engine has intermediate park technology, which incorporates an intermediate-lock intake variable valve timing cam phaser, allowing the cams to be parked at the most favorable position for cold starting. Under other engine operating conditions, the camshaft position actuator is controlled by the engine control module (ECM) to deliver optimal intake and exhaust valve timing for performance, drivability and fuel economy. The camshaft position actuator incorporates an integral trigger wheel, which is sensed by the camshaft position sensor mounted in the front cover, to accurately determine the position of each camshaft. The exhaust camshaft position actuator has a different internal configuration than the intake camshaft position actuator since the exhaust camshaft position actuator phases in the opposite direction relative to the inlet camshaft position actuator.

The camshaft position actuator oil control valve (OCV) directs oil from the oil feed in the head to the appropriate camshaft position actuator oil passages. There is one OCV for each camshaft position actuator. The OCV is sealed and mounted to the front cover. The ported end of the OCV is inserted into the cylinder head with a sliding fit. A filter screen protects each OCV oil port from any contamination in the oil supply.

Connecting Rods and Pistons

The connecting rods are forged titanium alloy and have press-in-place piston pin bushings. The connecting rods and rod cap are aligned by dowel pins retained in the cap. The cast aluminum pistons incorporate a polymer-coated skirt to reduce friction. The pistons are unique to the LGW both for compression ratio and combustion efficiency. The piston uses two low tension compression rings and one multi-piece oil control ring.

Cooling System

This engine has a targeted cooling system which sends coolant simultaneously to each water jacket in the heads and block. This new, parallel-flow design maximizes heat extraction in the area of the upper deck, intake and exhaust valve bridges in the heads and integrated exhaust manifold with a minimal amount of coolant. The result is more even and consistent cooling, which enhances performance and faster engine warm up, which improves cold-start efficiency and reduces emissions.

Crankcase

The cylinder block is unique to the LGW due to the need for specific turbocharger oil and coolant connections and PCV flow and is constructed of aluminum alloy by precision sand-casting with cast in place iron cylinder liners. Each nodular main bearing cap incorporates 6 bolts bolting the cap into the engine block. Along with 2 outer and 2 inner bolts, 2 side bolts are used in the deep skirt block. To prevent aeration, oil return from the valve train and cylinder heads is channeled away from the rotating and reciprocating components through oil drain back passages incorporated into the cylinder heads and engine block. Pressure-actuated piston oil cooling jets are mounted between opposing cylinders. Twin knock sensors are located in the valley of the block between the cylinder heads. The knock sensors have an acoustic foam noise barrier that surrounds them in the valley.

Crankshaft

The crankshaft is a hardened, forged steel design with 4 main bearings. Crankshaft thrust is controlled by the upper portion of the number 3 main bearing. The crankshaft position reluctor wheel is pressed onto the rear of the crankshaft in front of the rear main journal. A micro encapsulated adhesive is used on the reluctor wheel to aid retention. This crankshaft is internally balanced.

Cylinder Heads

The cylinder heads are a two piece design consisting of a head and a camshaft carrier which are cast aluminum with powdered metal valve seat inserts and valve guides. The two piece design allows for the Active Fuel Management (AFM) System. The cylinder heads also feature integrated exhaust manifolds; the exhaust manifolds are incorporated into the head casting. Two intake valves and two exhaust valves are actuated by roller finger followers pivoting on a stationary hydraulic lash adjuster (SHLA). In the LGW engine, the valves and seats are constructed with specialized materials and coatings and the exhaust valves are sodium filled for robustness with the high temperature turbocharged environment. The cylinder heads also feature a "high-tumble" port design and are sealed with LGW specific head gaskets. The head gaskets are also specific to the LH and RH sides.

Separate exhaust and intake camshafts are supported by bearings machined into the camshaft carrier. The front camshaft bearing cap is used as a thrust control surface for each camshaft. Each spark plug is shielded by a tube that is pressed into the cylinder head. Each spark plug ignition coil is also mounted through the spark plug tube. The LGW engine uses specific spark plugs and a different spark plug gap from other HFV6 engines. The engine coolant temperature (ECT) sensor is mounted in the thermostat housing near the flywheel end of the engine. With direct injection, the high pressure injectors are located in machined bores below the intake ports. A stainless steel, high pressure fuel rail is attached to the intake side of the head. The LGW engine has unique higher-flow injectors and fuel pump. The cylinder head has a larger bore for the new larger diameter fuel pump follower that operates the higher-flow pump. The fuel injectors are retained to the fuel rail in a new "twist-lock" retention scheme that does not require special tools for service.

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Oiling System

The LGW engine contains a unique engine oil cooler and filter adapter for the specific needs of the turbocharged engine. This engine also features a dual-pressure control and variable-displacement vane pump that enhances efficiency by optimizing oil pressure as a function of engine speed. The oil pump is located beneath the cylinder block inside the oil pan, contributing to the engines smoother and quieter operation. The oiling system components differ depending on the engine being in a transverse or longitudinal orientation. The LGW has unique oil pans depending on orientation, with the pans being separated into an upper (traditional aluminum) and lower (stamped steel) pan. This configuration helps with noise and mass concerns. It also affords some serviceability improvements through not needing to remove the entire upper pan for some service procedures; the procedures can be performed through removing the lower pan. The LGW oil pans contain oil level switches as do nearly all HFV6 applications. The oil level switch is normally open and closes at oil levels above minimum requirements.

Right and Left Bank Designation

Right hand (RH) and left hand (LH) designation through the engine mechanical section are viewed from the rear, flywheel side, of the engine or from inside the vehicle. These banks are also referred to as Bank 1 (RH) and Bank 2 (LH).

Vacuum Pump

The HFV6 Gen 2 LGW engine utilizes a mechanical vacuum pump to provide a vacuum source for the braking system and turbocharger waste gate actuators. The vacuum pump is integrated into the oil pump assembly located in the oil pan. Both vacuum pump and oil pump are part of a common assembly, referred to as a tandem pump. Neither pump is serviceable individually. If either the oil pump or vacuum pump are defective, replace the entire tandem pump assembly.

LUBRICATION DESCRIPTION

Lubrication Description

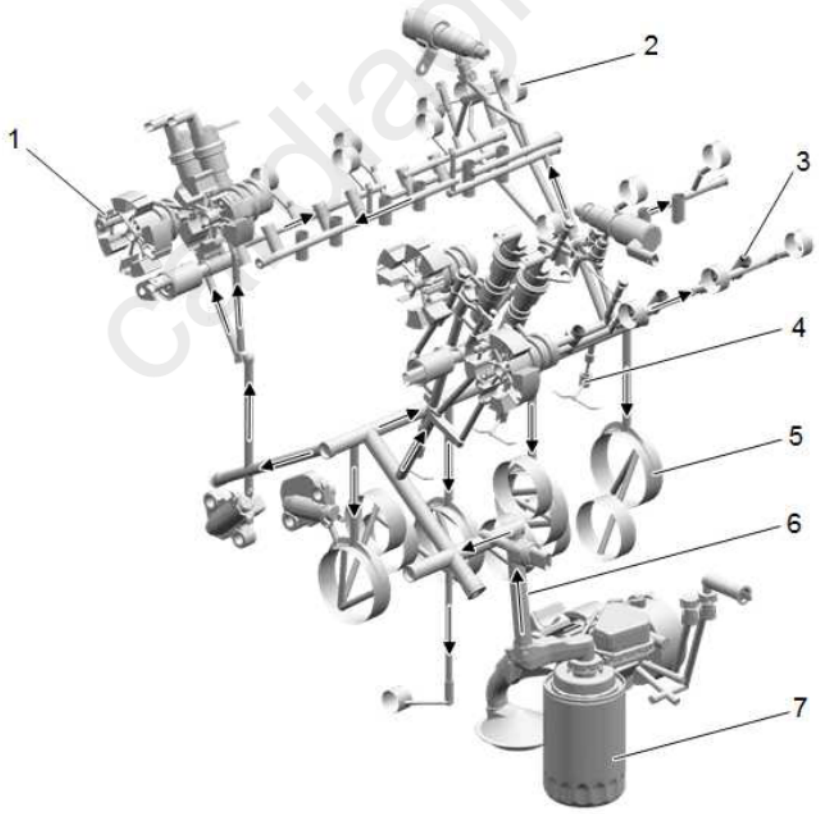


Fig. 2: Lubrication Description (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Phaser
2	Cam Bearing
3	Lifter Bore

Callout	Component Name
4	Oil Squirter
5	Main Bearing
6	Pump Out
7	Filter

Engine lubrication is supplied by a variable displacement two-stage vane-type oil pump assembly. An oil control solenoid valve, controlled by the engine control module (ECM) and mounted to the oil pump, will vary engine oil pressure according to engine needs based on speed and load. Oil pressure may change quickly as the engine speed or load varies. Oil pressure may also vary with outside temperature and oil viscosity. This is considered normal. The oil pump is mounted to the engine block oil pan rail and main bearing caps and is driven by a dedicated timing chain. The pump rotor and vanes rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent to the oil cooler if equipped for oil conditioning.

Pressurized oil is directed through the oil pan to the full flow oil filter (7) where harmful contaminants are removed. A bypass valve is incorporated into the oil filter, which permits oil flow in the event the filter becomes restricted. Oil exits the oil filter and is then directed to the main oil gallery. Oil from the main oil gallery is directed to the crankshaft bearings (5), piston oil nozzle (4) used for piston cooling under certain conditions and the cylinder heads via drilled passages.

Oil that has entered the cylinder heads is used to actuate the camshaft position phasors (1), pressurize the hydraulic lash adjusters (3), lubricate the cam bearings (2) and valve train and actuate cylinder deactivation and reactivation though ECM control of the active fuel management (AFM) oil control valves located on the camshaft covers. With active fuel management activated, the ECM commands the two AFM solenoids to open, directing oil through the camshaft cover and cylinder head oil galleries to deactivate the intake and exhaust valve for cylinders 2 and 5.

Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor is located at the left front of the engine.

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. Apply a liberal coating of engine oil to the friction areas during assembly in order to 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.**

Whenever you remove the valve train components, keep the components in order. Follow this procedure in order to install the components in the same locations and with the same mating surfaces as when removed.

WARNING: **Refer to Battery Disconnect Warning .**

Disconnect the negative battery cables before you perform any major work on the engine.

SEPARATING PARTS

In addition to the room temperature vulcanizing (RTV) sealant's sealing capabilities, the RTV sealants may form an adhesive bond between the components. This may make the components difficult to

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remove or to separate. Pry points have been provided in the components that utilize RTV as the sealing system. Pry points are positioned so they can be used without damaging other vital engine components.

REPLACING ENGINE GASKETS

Special Tools

EN-28410 Gasket Remover

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

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 incorporated pry points to separate components using an RTV sealing system.
- Do not try to separate RTV sealed components by prying against other engine components.
- Pry points are positioned so no other vital engine components are damaged when they are used.

Cleaning Gasket Surfaces

- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components.

  Do not use any other method or technique to remove the sealant or the gasket material from a part.

- Do not use abrasive pads, sand paper or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - Abrasive pads also produce a fine grit that the oil filter cannot remove from the engine oil.

    This fine grit is an abrasive and can cause internal engine damage.

Assembling Components

- Assemble components using only the sealant or equivalent, that is specified in the service procedure.
- Sealing surfaces must be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.
- Tighten the fasteners to the proper specifications.

NOTE: **Do not overtighten the fasteners.**

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.**

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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.

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- 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 18Â°C (65Â°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.
- The surfaces to be sealed must be clean and dry.

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.**

- 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.
- Assemble the components while the RTV sealant is still wet to the touch, within 10 minutes.

NOTE: **Do not wait for the RTV sealant to skin over.**

- Tighten the fasteners in sequence, if specified and to the proper torque specifications.

NOTE: **Do not overtighten the fasteners.**

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.
- 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.

CAUTION: **Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause**

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component damage when the fastener is tightened or lead to component failure.

- 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.
- Tighten the fasteners in sequence, if specified and to the proper torque specifications.

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.**

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.
- Apply the pipe sealant bead to the inside of any bolt hole areas.

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 a continuous bead of pipe sealant to one sealing surface.
- Tighten the fasteners in sequence, if specified and to the proper torque specifications.

NOTE: **Do not overtighten the fasteners.**

TOOLS AND EQUIPMENT

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- 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 designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools 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 component cleaning tank
  - A compressed air supply
  - Trays or storage containers to keep components and fasteners organized
  - An adequate set of hand tools
  - Approved engine repair stand
  - An approved engine lifting device that adequately supports the weight of the components

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Engine Mechanical - 3.0L (LGW) or 3.6L (LGX) - Diagnostic Information and Procedures - CT6

DIAGNOSTIC INFORMATION AND PROCEDURES

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform a **Diagnostic System Check - Vehicle** before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to **Disassembled Views (LGW)** , **Disassembled Views (LGX)** , **Engine Component Description (LGX)** , **Engine Component Description (LGW)** , **Drive Belt System 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. Refer to **Checking Aftermarket Accessories** .
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Check for the correct oil level, proper oil viscosity and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

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

Symptom List

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

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **Engine Noise on Start-Up, but Only Lasting a Few Seconds**
- **Upper Engine Noise, Regardless of Engine Speed**
- **Lower Engine Noise, Regardless of Engine Speed**
- **Engine Noise Under Load**
- **Engine Will Not Crank - Crankshaft Will Not Rotate**
- **Engine Compression Test**

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- Oil Consumption Diagnosis
- Oil Pressure Diagnosis and Testing
- Oil Leak Diagnosis

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

Diagnostic Instructions

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

DTC Descriptors

DTC P06DA

Engine Oil Pressure Control Solenoid Valve Control Circuit

DTC P06DB

Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage

DTC P06DC

Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

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

Circuit/System Description

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

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

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

Conditions for Running the DTC

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

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

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

Conditions for Clearing the MIL/DTC

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

Reference Information

Schematic Reference

Engine Mechanical Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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

      Refer to Circuit/System Testing.

    - **If Malfunction is not displayed**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing.

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- **If the DTC is not set**

5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q44 Engine Oil Pressure Control Solenoid Valve, ignition ON.
2. Verify that a test lamp illuminates between the ignition circuit terminal 1/A and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 2 Ω in the ignition circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp.
   2. Test for infinite resistance between the ignition circuit and ground

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

      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance, test all the components connected to fuse and replace as necessary.
   - **If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the ignition circuit terminal 1/A and the control circuit terminal 2/B.
   - **If the test lamp illuminates**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Remove the test lamp, command the Q44 Engine Oil Pressure Control Solenoid Valve to low pressure with a scan tool.
5. Verify the scan tool Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status parameter displays OK.
   - **If OK is not displayed**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If OK is displayed**
6. Install a 3 A fused jumper wire between the control circuit terminal 2/B and the ignition circuit terminal 1/A.
7. Verify the scan tool Engine Oil Pressure Control Solenoid Valve Circuit High Voltage Test Status parameter displays Malfunction when commanding the Engine Oil Pressure Control Solenoid Valve to low pressure.
   - **If Malfunction is not displayed**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the control circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.

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- If less than 2 Ω replace the K20 Engine Control Module.
- **If Malfunction is displayed**

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

Component Testing

Static Test

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

     Replace the Q44 Engine Oil Pressure Control Solenoid Valve.

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

     Replace the Q44 Engine Oil Pressure Control Solenoid Valve.

   - **If infinite**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- **Oil Pump Flow Control Valve Replacement** for Q44 Engine Oil Pressure Control Solenoid Valve replacement.
- **Control Module References** for engine control module replacement, programming and setup.

DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE

Diagnostic Instructions

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

DTC Descriptors

DTC P06DD

Engine Oil Pressure Control Solenoid Valve Stuck Off

DTC P06DE

Engine Oil Pressure Control Solenoid Valve Stuck On

Circuit/System Description

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

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

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

Conditions for Running the DTC

P06DD

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

P06DE

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

Conditions for Setting the DTC

P06DD or P06DE

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

Action Taken When the DTC Sets

P06DD

DTC P06DD is a Type B DTC.

P06DE

DTC P06DE is a Type A DTC.

Conditions for Clearing the DTC

P06DD

DTC P06DD is a Type B DTC.

P06DE

DTC P06DE is a Type A DTC.

Reference Information

Schematic Reference

Engine Mechanical Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

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- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

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

1. Verify correct engine oil level and condition.
2. Engine Running, increase and maintain the engine speed at 1, 800 RPM.
3. Verify the scan tool Engine Oil Pressure parameter changes greater than 30 kPa (4 PSI) when commanding the Engine Oil Pressure Control Solenoid On and Off.

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

   - **If the parameter does not change**

     Replace the Q44 Engine Oil Pressure Control Solenoid.

   - **If the parameter changes**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Oil Pressure Diagnosis and Testing.

   - **If the DTC is not set**
6. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
Abnormalities, severe cracking, bumps or missing areas, in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to Drive Belt Replacement (LGX) and/or Drive Belt Replacement (LGW) .

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Cause	Correction
Worn, damaged or mis-aligned accessory drive components or excessive pulley runout and may lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to **Automatic Transmission Flex Plate Replacement** , **Crankshaft Balancer Replacement (LGX)** and/or **Crankshaft Balancer Replacement (LGW)** .
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads, intake manifold and plenum duct, plenum duct and water crossover, water crossover and throttle body and/or pressure relief valve and intake manifold.	Replace the intake manifold, plenum duct, gaskets, cylinder heads, throttle body and/or pressure relief valve as required.
Improperly installed or damaged MAP sensor and/or seal The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
Improperly installed or damaged EVAP purge solenoid and/or O-ring seal	Repair or replace the EVAP purge solenoid as required.
Worn or loose followers, valve rocker arms The follower, valve rocker arm, roller bearing should be intact and in the proper position.	Replace the followers, valve rocker arms, as required.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain or chains	Replace the timing chain or chains and sprockets as required.
Worn camshaft lobes	Replace the camshaft or camshafts and SHLAs (valve lifters).
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to **Diagnostic Starting Point - Vehicle** . Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** for the 3.6L engine. • Inspect the cylinder heads, engine block and/or head gaskets. • Repair or replace as required.

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Cause	Correction
Worn Piston Rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** for the 3.6L engine. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with SEVERE reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal and then re-sync the crankshaft position. • Systems with SLIGHT reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.	Replace the crankshaft as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities, severe cracking, bumps or missing areas, in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Replacement (LGX)** and/or **Drive Belt Replacement (LGW)** .
Worn, damaged or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the engine flywheel and/or crankshaft balancer as required. Refer to **Automatic Transmission Flex Plate Replacement** , **Crankshaft Balancer Replacement (LGX)** and/or **Crankshaft Balancer Replacement (LGW)** .

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Cause	Correction
Worn or broken piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose followers, valve rocker arms The follower, valve rocker arm, roller bearing should be intact and in the proper position.	Replace the followers, valve rocker arms, as required.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain or chains	Replace the timing chain or chains and sprockets as required.
Worn camshaft lobes	Replace the camshaft or camshafts and SHLAs (valve lifters).
Sticking SHLAs (lifters)	Replace the SHLAs as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to **Diagnostic Starting Point - Vehicle** . Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** for the 3.6L engine. • Perform a cylinder leak down test. • Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. • Repair or replace as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Repair or replace as required.

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

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

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	Drain the engine oil and replace with the correct viscosity oil.
High stationary hydraulic lash adjuster (SHLA), valve lifter, leak down rate	Replace the SHLAs, valve lifters, as required.
Worn crankshaft thrust bearing	• Inspect the thrust bearing and crankshaft. • Repair or replace as required.
Damaged or faulty oil filter by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.
Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to **Camshaft Position Actuator Replacement - Bank 1** or **Camshaft Position Actuator Replacement - Bank 2** .

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace as required.
Loose and/or worn follower, valve rocker arm	1. Inspect the follower, valve rocker arm. 2. Repair or replace as required.

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Cause	Correction
Improper lubrication to the followers, valve rocker arms	Inspect the following components and repair or replace as required: • The follower, valve rocker arm • The SHLA, valve lifter • The oil filter bypass valve • The oil pump and pump screen • The cylinder head oil galleries • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or dirty stationary hydraulic lash adjusters (SHLAs), valve lifters	Replace the SHLAs, valve lifters.
Stretched or broken timing chain or chains and/or damaged sprocket teeth	Replace the timing chain or chains and sprockets.
Worn timing chain tensioner or tensioners	Replace the timing chain tensioner or tensioners as required.
Worn timing chain shoe or shoes	Replace the timing chain shoe or shoes as required.
Worn timing chain guide or guides	Replace the timing chain guide or guides as required.
Worn engine camshaft lobes	1. Inspect the engine camshaft lobes. 2. Replace the camshaft or camshafts and SHLAs, valve lifters, as required.
Worn valve guides or valve stems	Inspect the following components and repair as required: • The valves • The valve guides
• Stuck valves • Carbon on the valve stem or valve seat may cause the valve to stay open	Inspect the following components and repair as required: • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace damaged components as required.
• Worn accessory drive components • Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	1. Inspect the accessory drive system. 2. Repair or replace as required.

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Cause	Correction
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to **Symptoms - Engine Controls** .
Loose torque converter bolts	1. Inspect the torque converter bolts and engine flywheel. 2. Repair or replace as required.
Loose or damaged engine flywheel	Repair or replace the engine flywheel.
• Damaged oil pan, contacting the oil pump screen • An oil pan that has been damaged may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	1. Inspect the oil pan. 2. Inspect the oil pump screen. 3. Repair or replace as required.
Oil pump screen loose, damaged or restricted	1. Inspect the oil pump screen. 2. Repair or replace as required.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore. 2. Repair as required.
Excessive piston pin-to-bore clearance	1. Inspect the piston, piston pin and the connecting rod. 2. Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components and repair as required: • The crankshaft bearings • The crankshaft journals
• Incorrect piston, piston pin and connecting rod installation • Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins and connecting rods are installed correctly. 2. Repair as required.

ENGINE NOISE UNDER LOAD

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Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to **Symptoms - Engine Controls** .
Loose torque converter bolts	1. Inspect the torque converter bolts and engine flywheel. 2. Repair as required.
Cracked engine flywheel	1. Inspect the engine flywheel and bolts. 2. Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove the accessory drive belt or belts. 2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. 3. Repair or replace as required.
Hydraulically locked cylinder • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove the spark plugs and check for fluid. 2. Inspect for broken head gasket or gaskets. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Repair or replace as required.

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Cause	Correction
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. 3. Repair or replace as required.
Material in cylinder • Broken valve • Piston material • Foreign material	1. Inspect the cylinder for damaged components and/or foreign materials. 2. Repair or replace as required.
Seized crankshaft or connecting rod bearings	1. Inspect the crankshaft and the connecting rod bearings. 2. Repair as required.
Bent or broken connecting rod	1. Inspect the connecting rods. 2. Repair as required.
Broken crankshaft	1. Inspect the crankshaft. 2. Repair as required.
Seized or broken camshaft	1. Inspect the camshaft or camshafts. 2. Inspect the cylinder head camshaft journals for damage. 3. Repair as required.
Seized or broken balance shaft	1. Inspect the balance shaft. 2. Inspect the block for damaged balance shaft bearings. 3. Repair as required.

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Cause	Correction
Seized or broken camshaft timing components	1. Inspect the following sprockets: • The crankshaft sprocket • The exhaust sprockets • The intake sprockets 2. Inspect the following chains: • The primary camshaft drive chain • The secondary camshaft drive chains 3. Inspect the following guides: • The lower primary camshaft drive chain guide • The upper primary camshaft drive chain guides 4. Inspect the secondary camshaft drive chain shoe. 5. Inspect the following tensioners: • The primary camshaft drive chain tensioner • The secondary camshaft drive chain tensioners 6. Repair as required.
Seized or broken valve train components	1. Inspect the followers, rocker arms. 2. Inspect the lifters. 3. Inspect the valves. 4. Inspect the valve springs. 5. Repair as required.

COOLANT IN COMBUSTION CHAMBER

Cause	Correction

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Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. **NOTE:** **While not always conclusive, use of hydrocarbon block test kits may reveal hydrocarbons indicating combustion chamber gases in the cooling system. It is important to follow the kit instructions. This is not a substitute for the service information. Combustion leak tests are available from a wide variety of aftermarket suppliers.** 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate**. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a **Cylinder Leakage Test**. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Cracked intake manifold or failed gasket	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** , **Cylinder Head Replacement - Left Side (LGW)** , **Cylinder Head Replacement - Left Side (LGX)** , **Cylinder Head Replacement - Right Side (LGW)** and/or **Cylinder Head Replacement - Right Side (LGX)** .
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection** .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed. 1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to **Lower Engine Noise, Regardless of Engine Speed**. 2. Inspect by performing a **Cylinder Leakage 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 external engine oil cooler	Replace the components as required.

Cause	Correction
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** , **Cylinder Head Replacement - Left Side (LGW)** , **Cylinder Head Replacement - Left Side (LGX)** , **Cylinder Head Replacement - Right Side (LGW)** and/or **Cylinder Head Replacement - Right Side (LGX)** .
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection** .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head, block or manifold porosity	Replace the components as required.

TURBOCHARGER WHINE NOISE

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

TURBOCHARGER HISSING NOISE

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

TURBOCHARGER OIL LEAK FROM COMPRESSOR SEAL

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

TURBOCHARGER OIL LEAK FROM TURBINE SEAL

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

TURBOCHARGER LACK OF OIL SUPPLY

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

ENGINE COMPRESSION TEST

Special Tools

EN-51749 Spark Plug Port Adapter

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

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

1. Run the engine until it reaches normal operating temperature. The battery must be at or near full charge. You may wish to connect a battery charger for the duration of the test to maintain an adequate battery level.
2. Turn the engine OFF.
3. Remove the intake manifold cover.
4. Remove the ignition coils and spark plugs from all cylinders. Refer to **Ignition Coil Replacement - Bank 1** and **Ignition Coil Replacement - Bank 2** .
5. Connect the GDS2 to the vehicle and select "Compression Test". Enabling the Compression Test will disable the fuel pump, fuel injectors and spark. The throttle body is opened to a Wide Open Throttle (WOT) position. The GDS2 will also automatically control the cranking procedure for many applications. If cranking control is not available use a remote start switch in place of the Starter Relay to control cranking.
6. Measure the engine compression, using the following procedure:
    1. Thread the **EN-51749** adapter into the spark plug hole.
    2. Thread the compression gauge into the **EN-51749** adapter.
    3. Enable cranking via the GDS2 or remote start switch. Record the reading after the cranking cycle completes.
    4. When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.
    5. Repeat the compression test for each cylinder.
7. Compare the compression readings from all of the cylinders.
    - The lowest reading should not be less than 70 percent of the highest reading.
    - Turbocharger equipped engines - No cylinder reading should be less than 690 kPa (100 psi).
    - Non-Turbocharger equipped engines - No cylinder reading should be less than 965 kPa (140 psi).
8. The following are indicators of potential problems:
    - When low compression is caused by the piston rings, compression is low on the first stroke and tends to build up on the following strokes, but does not reach normal. Compression improves considerably with the addition of oil to the cylinder. Use approximately 3 squirts of oil from a plunger-type oiler into the cylinder and replace the gauge and measure again.
    - When low compression is caused by the valves, the measurement is low on the first stroke and does not build up even with the addition of oil.

- Leaking head gaskets will provide the same results as worn valves but engine coolant may be identified in the crankcase. In addition, a leaking head gasket will give low readings on paired cylinders.

9. Disconnect GDS2 diagnostic tool or remote start switch.
10. Install the spark plugs. Refer to **Spark Plug Replacement (Bank 1)** and/or **Spark Plug Replacement (Bank 2)** .
11. Install the ignition coils and spark plugs from all cylinders. Refer to **Ignition Coil Replacement - Bank 1** and **Ignition Coil Replacement - Bank 2** .
12. Install the intake manifold cover.

CYLINDER LEAKAGE TEST

Special Tools

- **EN-35667-A** Cylinder Head Leakdown Tester
- **EN-39313** Spark Plug Port Adapter

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

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

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

1. Disconnect the battery ground negative cable.

   WARNING: **Refer to Battery Disconnect Warning .**

2. Remove the spark plugs. Refer to **Spark Plug Replacement (Bank 1)** and/or **Spark Plug Replacement (Bank 2)** .
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.

   CAUTION: **Only turn the engine in a CLOCKWISE direction as viewed from the crankshaft balancer. Counterclockwise rotation may result in the timing chain jumping a tooth, causing poor running, DTCs or severe engine damage.**

4. Thread the **EN-39313** adapter into the spark plug hole.
5. Install the **EN-35667-A** tester or equivalent.
6. Apply shop air pressure to the **EN-35667-A** tester and adjust according to the manufacturers instructions.

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

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

OIL CONSUMPTION DIAGNOSIS

Checks	Causes
DEFINITION: Excessive oil consumption (not due to leaks) is the use of 0.946 L (1 qt) or more of engine oil within 3, 200 km (2, 000 mi). The causes of excessive oil consumption may include the following conditions:	
Preliminary	• 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 • Worn valve guides and/or valve stems • Worn, missing 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 miss-fitted to the cylinder bore

OIL PRESSURE DIAGNOSIS AND TESTING

Special Tools

- **EN-47971** Oil Pressure Gauge Adapter
- **CH-48027** Pressure Gauge

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

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1. With the vehicle on a level surface, run the vehicle for a few minutes, allow adequate drain down time, 2-3 minutes and measure the oil level.
2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine briefly, 10-15 seconds and verify low or no oil pressure on the vehicle gauge or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
    - Oil diluted by water or glycol antifreeze
    - Foamy oil
6. Remove the oil filter.

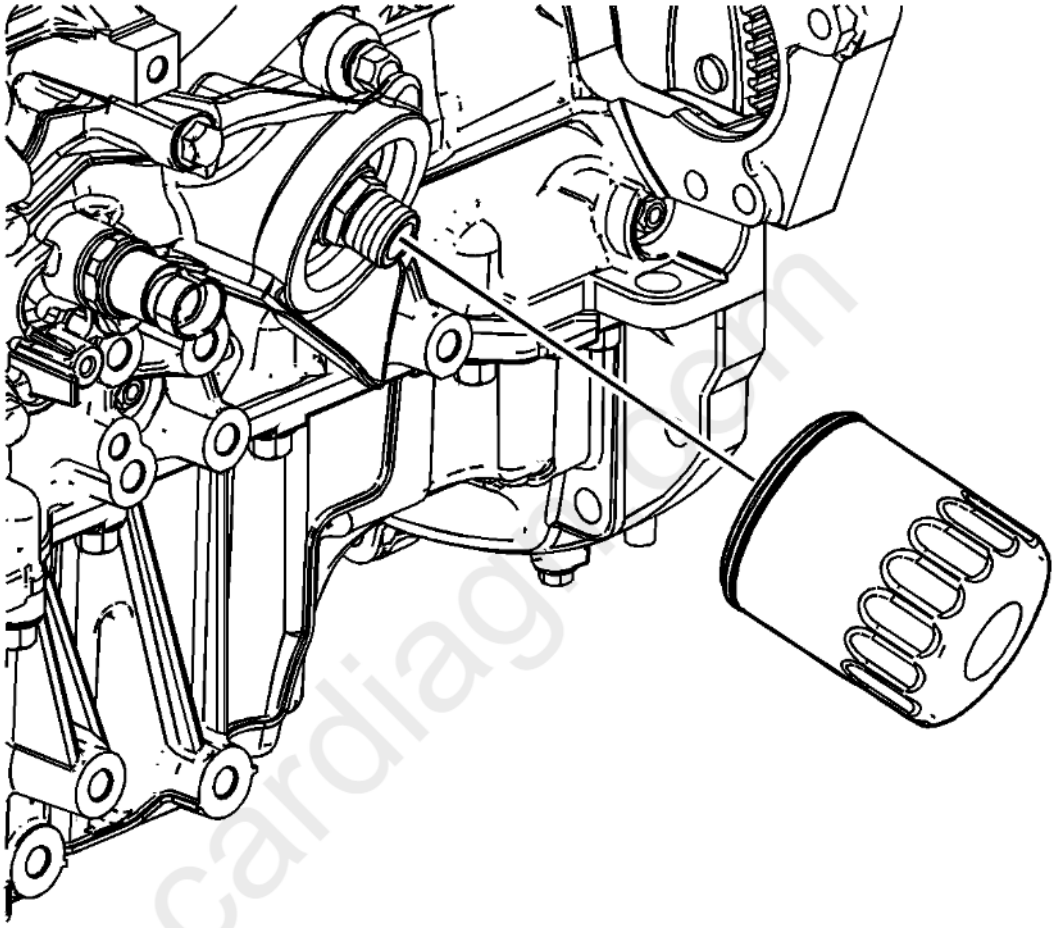


Fig. 1: Identifying Oil Filter
Courtesy of GENERAL MOTORS COMPANY

7. Install the **EN-47971** adapter onto the oil filter adapter.

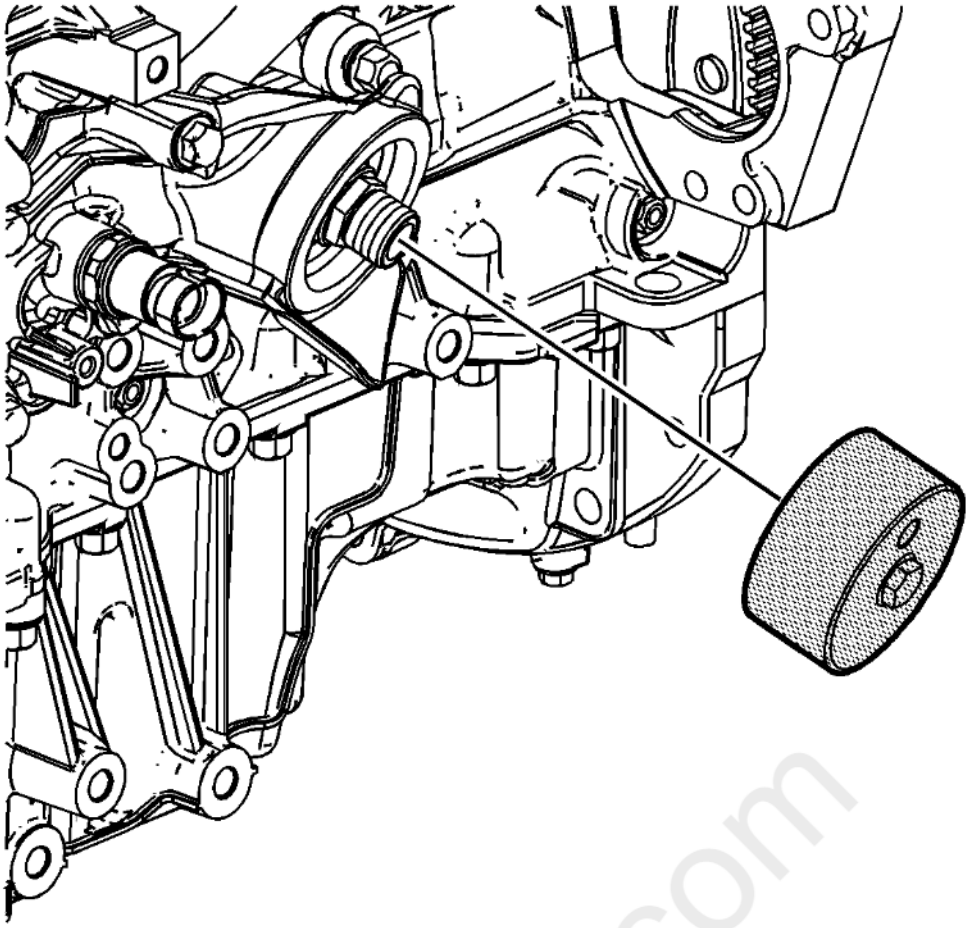


Fig. 2: Oil Pressure Gauge Adapter
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Special new tool EN 47971 must be used. Due to the special size and thread pitch of the oil filter adapter fitting ensure the proper tool is used or component damage will result.**

8. Install the 1/8 NPT fitting from the **CH-48027** gauge into the port on the **EN-47971** adapter.

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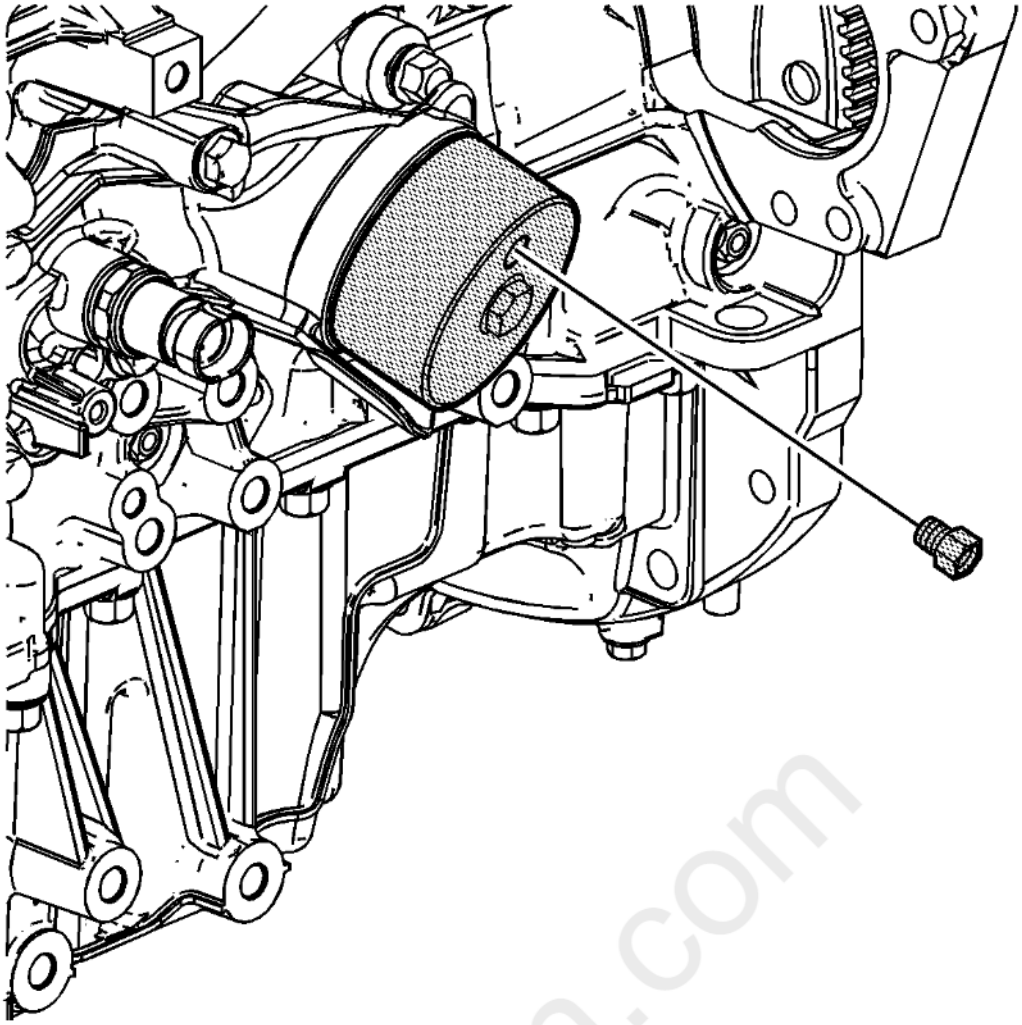


Fig. 3: Oil Pressure gauge Adaptor
Courtesy of GENERAL MOTORS COMPANY

9. Install the **CH-48027** gauge flexible hose to the **EN-47971** adapter.

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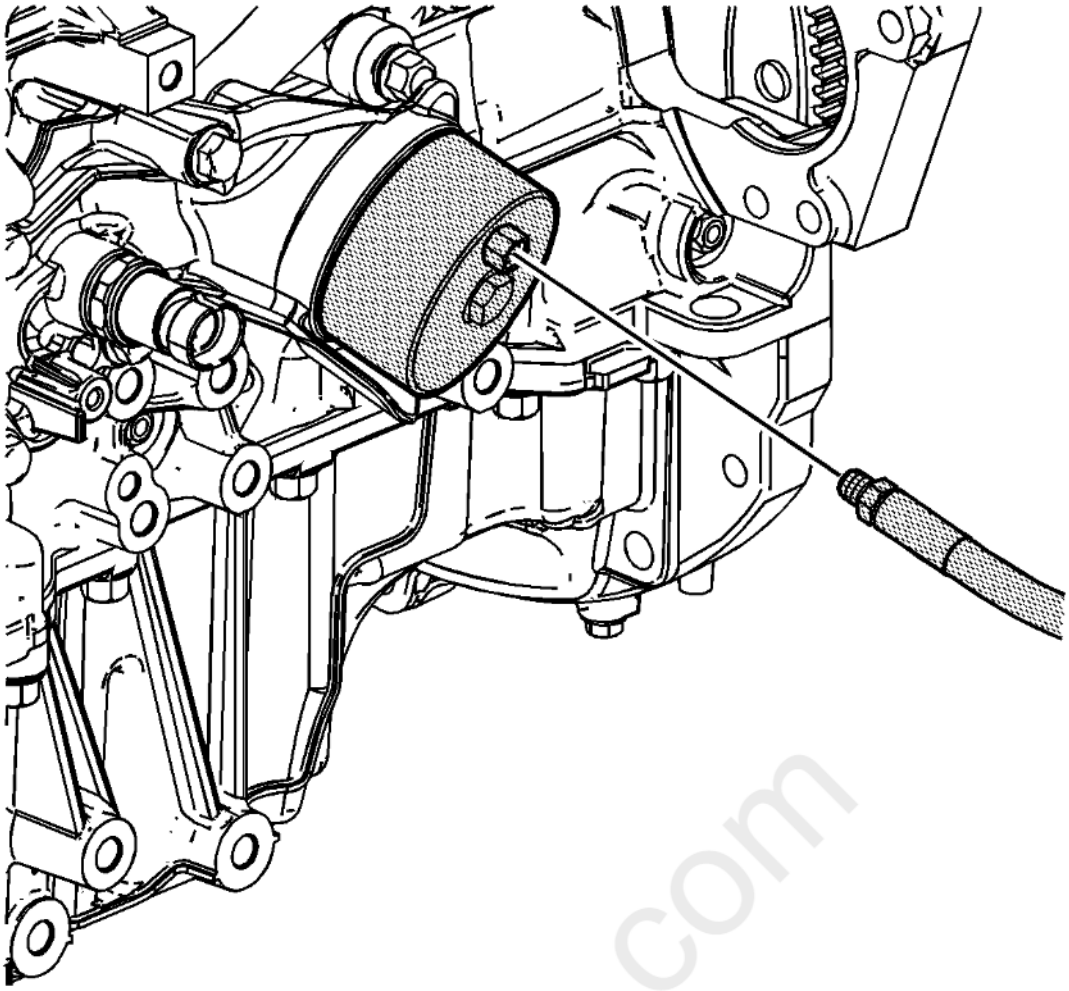


Fig. 4: View Of Special Tool J 21867 & Flexible Hose
Courtesy of GENERAL MOTORS COMPANY

10. Run the engine and measure the engine oil pressure.
11. Compare the readings to **Engine Mechanical Specifications (LGX)** and/or **Engine Mechanical Specifications (LGW)** .
12. If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:
    - Oil pump worn or dirty. Refer to **Oil Pump Replacement** , **Oil Pump Disassemble** and **Oil Pump Cleaning and Inspection** .
    - Oil pump-to-engine block bolts loose. Refer to **Oil Pump Replacement** .
    - Oil pump screen loose, plugged or damaged. Refer to **Oil Pump Suction Pipe and Screen Assembly Replacement** and **Oil Pump Suction Pipe and Screen Cleaning and Inspection** .
    - Oil pump screen O-ring seal missing or damaged. Refer to **Oil Pump Suction Pipe and Screen Assembly Replacement** and **Oil Pump Suction Pipe and Screen Cleaning and Inspection** .
    - Oil pump pressure relief valve malfunction. Refer to **Oil Pump Replacement** .
    - Engine bearing clearance excessive. Refer to **Crankshaft and Bearing Cleaning and Inspection** , **Crankshaft and Bearing Installation** and **Piston, Connecting Rod and Bearing Installation** .
    - Cracked, porous or restricted oil galleries.
    - Oil gallery plugs missing or incorrectly installed. Refer to **Engine Block Assemble** and **Cylinder Head Assemble** .
    - Valve lifters broken. Repair, as necessary. Refer to **Valve Lifter Replacement - Left Side** , **Valve Lifter Replacement - Right Side** and **Valve Lifter Cleaning and Inspection** .
13. If the oil pressure reading on the **CH-48027** gauge or equivalent, is within specifications, inspect for the following conditions:

CAUTION: **This engine uses a special high performance oil filter. Use of any other filter may lead to filter failure and/or severe engine damage.**

- Plugged or incorrect oil filter and/or malfunctioning oil bypass valve. Refer to **Engine Oil and Oil Filter Replacement** .
- Malfunctioning oil pressure gauge or sensor. Repair, as necessary. Refer to **Engine Oil Pressure Sensor and/or Switch Replacement (LGW)** and/or **Engine Oil Pressure Sensor and/or Switch Replacement (LGX)** .

OIL LEAK DIAGNOSIS

Checks	Action
CAUTION: **It is important to correctly identify the source of an oil leak. A power steering fluid leak or spillage can travel across the valley area of the engine and run out the weep hole, which is located at the back of the block. Failure to correctly identify the source of an oil leak can lead to the incorrect or unnecessary replacement of components.** 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.	
Locating and identifying the leak	To determine if the leaking fluid is engine oil, transmission fluid, power steering fluid, brake fluid or some other fluid, use the visual inspection method.
Visual Inspection Method	1. Bring the vehicle to normal operating temperature. 2. Park the vehicle over a large sheet of paper or other clean surface. 3. Wait several minutes, then check for drippings. 4. Identify the type of fluid and the approximate location of the leak. 5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 6. Check for leaks at sealing surfaces, fittings or from cracked or damaged components. 7. If you cannot locate the leak, do the following: 1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several miles at normal operation temperature and at varying speeds. 3. Park the vehicle over a large sheet of paper or other clean surface. 4. Wait several minutes, then check for drippings. 5. Identify the type of fluid and the approximate location of the leak. 6. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 7. See possible causes for leaks. 8. If you still cannot locate the leak, use the powder method or the black light and dye method.

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Checks	Action
Powder Method	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 miles at normal operation 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. 5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 6. See possible causes for leaks.
Black Light and Dye Method	1. A dye and light kit is available for finding leaks. Use the **GE 28428-E** High-Intensity Black Light Kit or equivalent. Refer to the manufacturer's instructions when using the tool. 2. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 3. See possible causes for leaks.
Possible Causes for Leaks	Check for the following conditions: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Crankcase Ventilation (CV) System Inspection

- Test for vacuum at the vacuum hose where it connects to the crankcase ventilation housing. There should be manifold vacuum present at the hose. If there is no vacuum, inspect for a plugged hose, leaking hose or a plugged vent adapter.
- Plug the end of the vacuum hose while the engine is running. Inspect the hose for any areas that collapse when the end of the hose is blocked. Replace the hose if it collapses when blocked.
- If oil has accumulated in the intake air duct, inspect for the following conditions:
  - Plugged vacuum orifice in the crankcase ventilation housing
  - Plugged or restricted crankcase ventilation housing
  - Excessive crankcase pressure or blow-by, refer to **Oil Consumption Diagnosis**.
- Additional items to inspect:
  - Plugged or leaking fresh air vent hose assembly or vent adapter
  - Plugged or restricted passages in the throttle body
  - Missing or damaged O-ring seals on the vent adapter
  - Inspect the cam covers, the oil pan gasket and other sealing areas for leaks

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Results of Incorrect Operation

A plugged crankcase ventilation housing or hose may contribute to the following conditions:

- A rough idle
- Stalling or a slow idle speed
- Oil leaks
- Oil accumulation in the intake air duct
- Sludge in the engine

A leaking housing or hose may contribute to the following conditions:

- A rough idle
- Stalling
- Unstable idle speed

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

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

12

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

14

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

15

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

16

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

17

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

19

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

Step	Action	Yes	No
CAUTION: **Refer to Belt Dressing Caution .** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: • A high pitched continuous noise. • The noise may be caused by an accessory drive component failed bearing.			

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Step	Action	Yes	No
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to **Step 3**	Go to **Diagnostic Aids**
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to **Step 20**	Go to **Step 6**
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to **Step 7**	Go to **Step 8**
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to **Step 20**	Go to **Step 8**
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	1. Tighten any loose fasteners. Refer to **Fastener Specifications (LGW)** and/or **Fastener Specifications (LGX)** . **CAUTION:** **Refer to Fastener Caution .** 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**

Step	Action	Yes	No
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 14**
14	If diagnosing a whine noise and the condition still exist, proceed to **Diagnostic Aids**. Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis**. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 15**
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 16**
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 17**
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 20**	Go to **Diagnostic Aids**
18	Replace the bent pulley. Did you complete the repair?	Go to **Step 20**	Go to **Step 19**
19	Replace the drive belt. Refer to **Drive Belt Replacement (LGX)** and/or **Drive Belt Replacement (LGW)** . 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.

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4

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

5

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

9

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

11

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

12

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

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Step	Action	Yes	No

CAUTION:
Refer to Belt Dressing Caution .
 	
DEFINITION: The following items are indications of drive belt rumbling:
• A low pitch tapping, knocking or thumping noise heard at or just above idle.
• Heard once per revolution of the drive belt or a pulley.
• Rumbling may be caused from:
  • Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove
  • The separation of the drive belt
  • A damaged drive belt
 	
DEFINITION: The following items are indications of drive belt vibration:
• The vibration is engine-speed related.
• The vibration may be sensitive to accessory load.			

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to **Step 3**	Go to **Diagnostic Aids**

Step	Action	Yes	No
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to **Symptoms - Engine Mechanical** or Go to **Vibration Analysis - Engine**	Go to **Step 4**
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs and debris build-up. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 5**
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to **Step 6**	Go to **Step 7**
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to **Drive Belt Replacement (LGX)** and/or **Drive Belt Replacement (LGW)** . Did you correct the condition?	Go to **Step 8**	Go to **Step 7**
7	Install a new drive belt. Refer to **Drive Belt Replacement (LGX)** and/or **Drive Belt Replacement (LGW)** . Did you complete the replacement?	Go to **Step 8**	Go to **Step 9**
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 9**
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 10**	Go to **Step 11**
10	1. Tighten any loose fasteners. Refer to **Fastener Specifications (LGW)** and/or **Fastener Specifications (LGX)** . 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to **Water Pump Replacement (LGW, LGX)** and/or **Water Pump Replacement (LTG)** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 13**	Go to **Diagnostic Aids**

Step	Action	Yes	No
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

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

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

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

Test Description

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

2

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

4

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

5

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

6

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

7

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

13

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

14

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

15

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

Step	Action	Yes	No
CAUTION: **Refer to 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 (LGX)** and/or **Drive Belt Replacement (LGW)** . 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	1. Tighten any loose fasteners. Refer to **Fastener Specifications (LGW)** and/or **Fastener Specifications (LGX)** . **CAUTION:** **Refer to Fastener Caution .** 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to **Step 9**	System OK
9	Test the drive belt tensioner for operating correctly. Refer to **Drive Belt Tensioner Diagnosis**. Does the drive belt tensioner operate correctly?	Go to **Step 11**	Go to **Step 10**

Step	Action	Yes	No
10	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement (LGX)** and/or **Drive Belt Tensioner Replacement (LGW)** . 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 (LGX)** and/or **Drive Belt Replacement (LGW)** . 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 (LGX)** and/or **Drive Belt Replacement (LGW)** . Did you complete the replacement?	Go to **Step 17**	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Step	Action	Yes	No
1	Remove the drive belt and inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to **Step 4**	Go to **Step 2**
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to **Step 3**	Go to **Step 4**
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10 percent of the second torque reading?	System OK	Go to **Step 4**
4	Replace the drive belt tensioner. Is the repair complete?	System OK	-

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Back To Article

REPAIR INSTRUCTIONS - OFF VEHICLE

ENGINE OIL COOLER ADAPTER REMOVAL

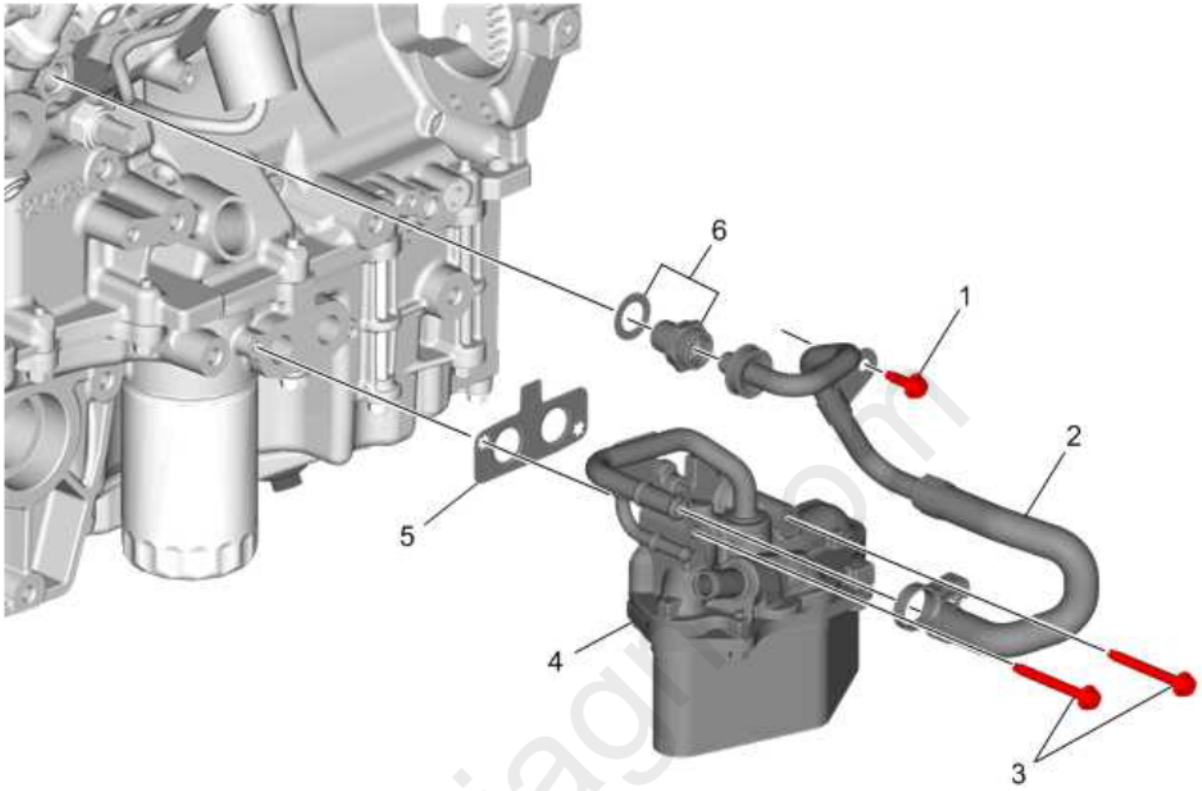


Fig. 1: Engine Oil Cooler Adapter
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Cooler Inlet Pipe Bolt
2	Engine Oil Cooler Inlet Pipe
3	Engine Oil Cooler Adapter Bolt [2x]
4	Engine Oil Cooler Adapter Assembly
5	Oil Filter Adapter Gasket
6	Engine Oil Cooler Fitting **NOTE:** **Remove only if damaged.**

TURBOCHARGER REMOVAL - RIGHT SIDE

Charge Air Cooler Inlet Air Tube Removal

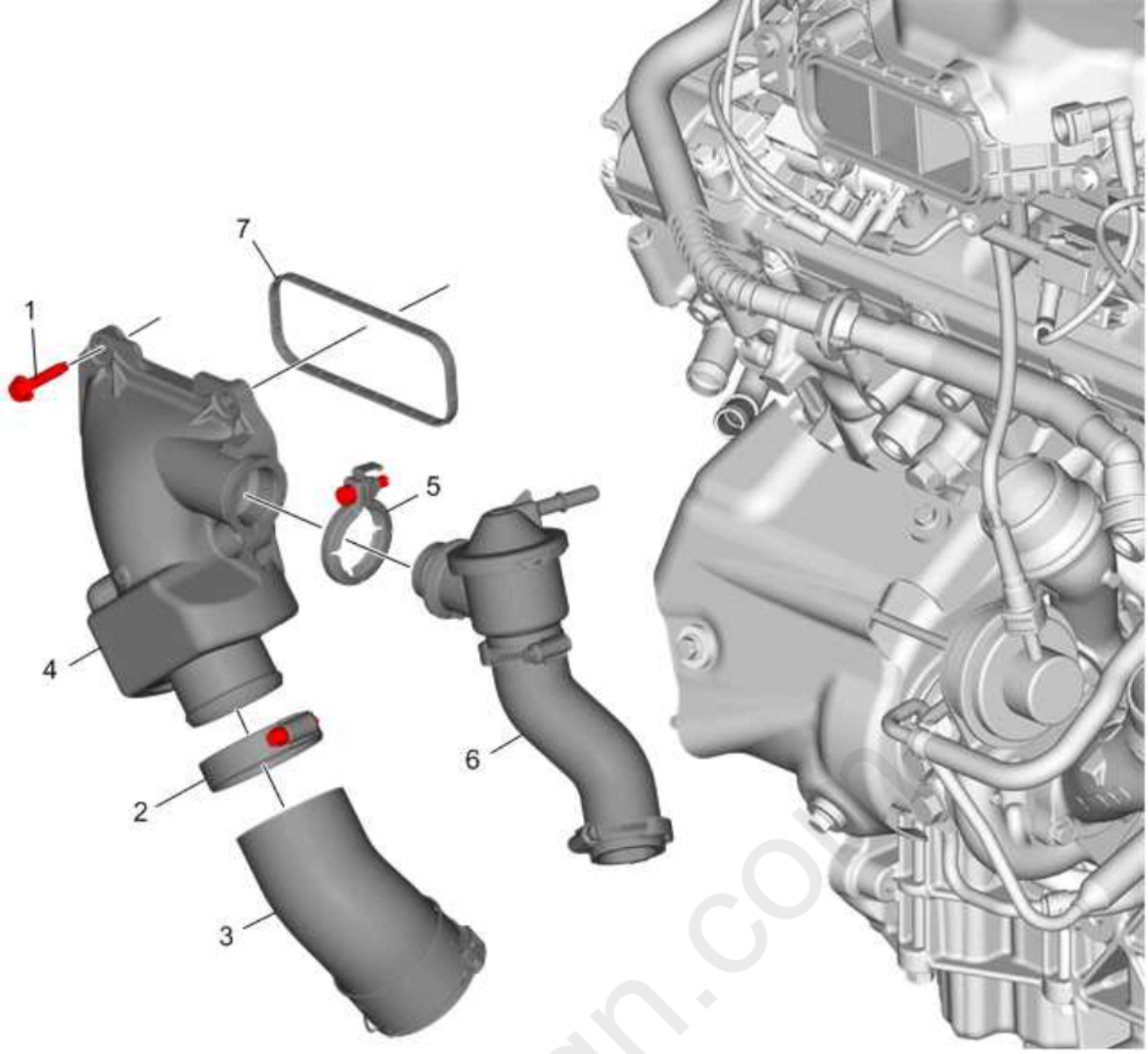


Fig. 2: Charge Air Cooler Inlet Air Tube
Courtesy of GENERAL MOTORS COMPANY

Charge Air Cooler Inlet Air Tube Removal

Callout	Component Name
1	Charge Air Cooler Inlet Air Tube Bolt [4x]
2	Charge Air Cooler Inlet Hose Clamp
3	Charge Air Cooler Inlet Hose
4	Charge Air Cooler Inlet Air Tube **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.** **Procedure** Refer to **Turbocharger Cleaning and Inspection**
5	Charge Air Bypass Valve Tube Clamp
6	Charge Air Bypass Valve
7	Charge Air Cooler Inlet Air Tube Seal **NOTE:** **Remove and DISCARD the seal.**

Turbocharger Heat Shield Removal

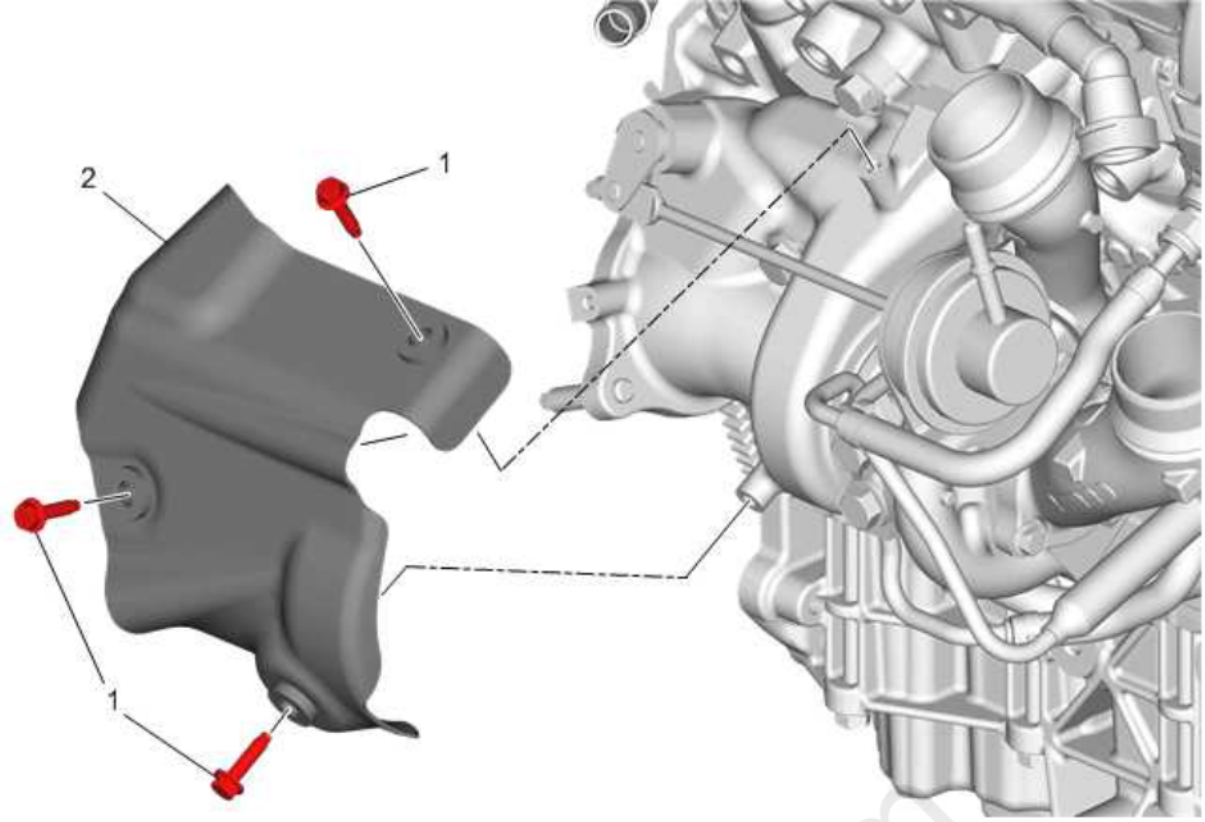


Fig. 3: Turbocharger Heat Shield
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Heat Shield Removal

Callout	Component Name
1	Turbocharger Heat Shield Bolt [3x]
2	Turbocharger Heat Shield

Turbocharger Coolant Feed and Return Pipe Removal

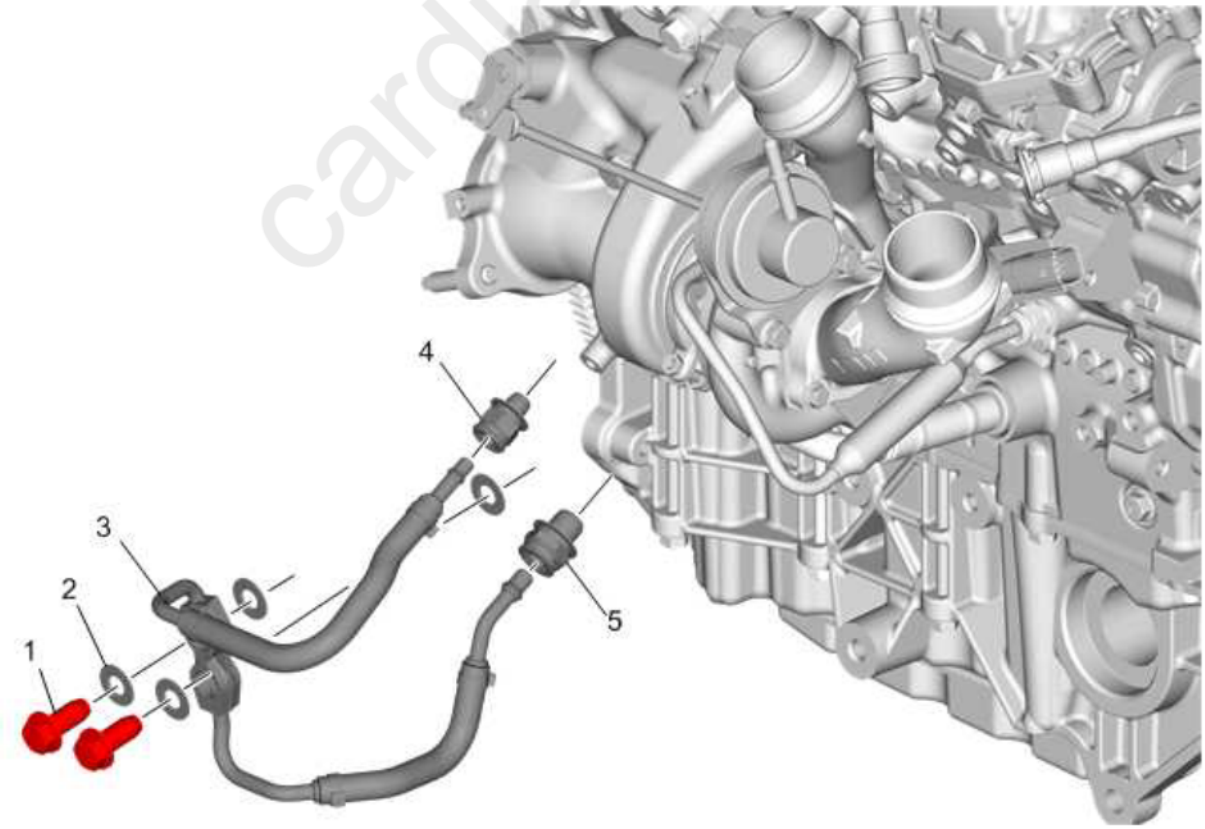


Fig. 4: Turbocharger Coolant Feed and Return Pipe
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Coolant Feed and Return Pipe Removal

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Callout	Component Name
1	Turbocharger Coolant Feed and Return Pipe Bolt
2	Turbocharger Coolant Feed and Return Pipe Gasket [2x] **NOTE:** **Remove and DISCARD the gasket.**
3	Turbocharger Coolant Feed and Return Pipe **NOTE:** **Use 3/8" Jiffy-titeÂ® quick disconnect tool to remove the coolant return pipe.**
4	Turbocharger Oil Feed Pipe Fitting **NOTE:** **Discard fitting, they are not reusable.**
5	Turbocharger Coolant Feed Pipe Fitting **NOTE:** **Discard fitting, they are not reusable.**

Turbocharger Oil Feed Pipe Removal

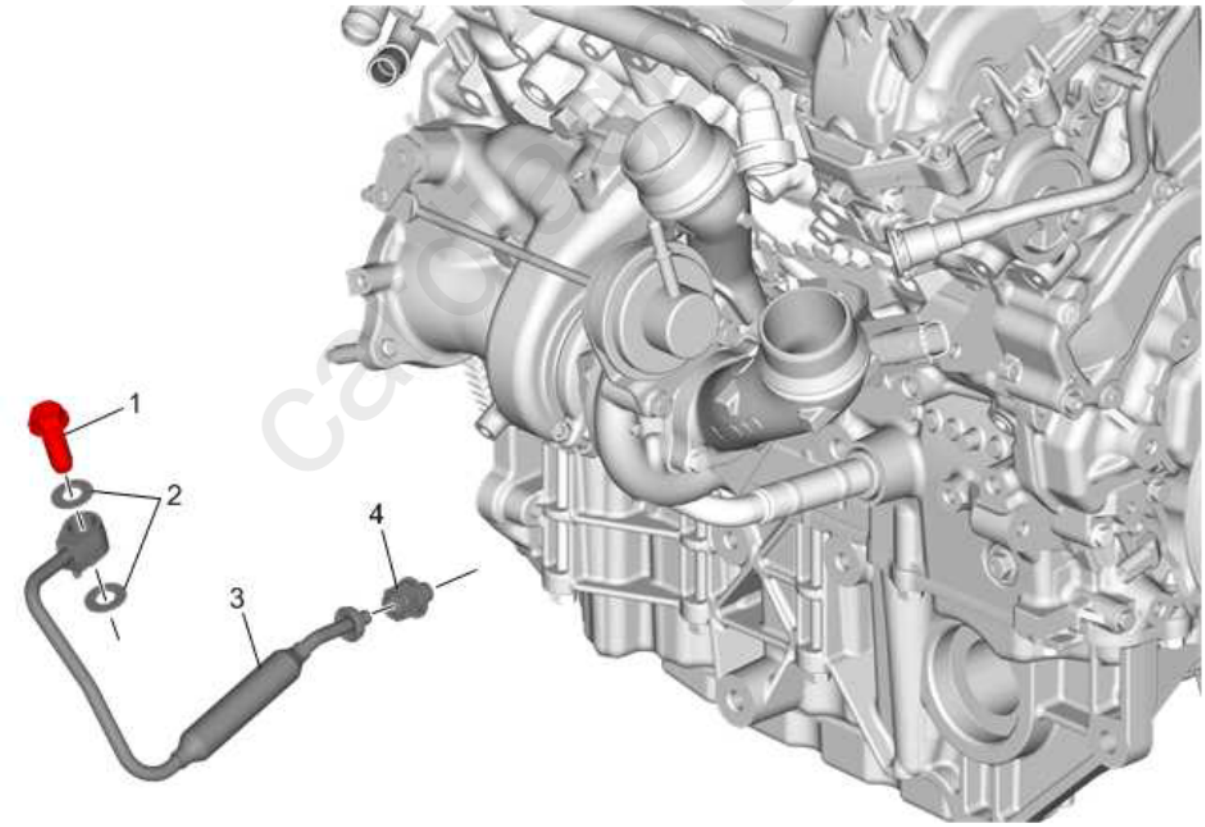


Fig. 5: Turbocharger Oil Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Oil Feed Pipe Removal

Callout	Component Name
1	Turbocharger Oil Feed Pipe Bolt

Callout	Component Name
2	Turbocharger Oil Feed Pipe Gasket [2x] **NOTE:** **Remove and DISCARD the gasket.**
3	Turbocharger Oil Feed Pipe **Procedure** Refer to **Turbocharger Cleaning and Inspection**
4	Turbocharger Oil Feed Pipe Fitting **NOTE:** **Discard fitting, they are not reusable.**

Turbocharger and Oil Return Pipe Removal

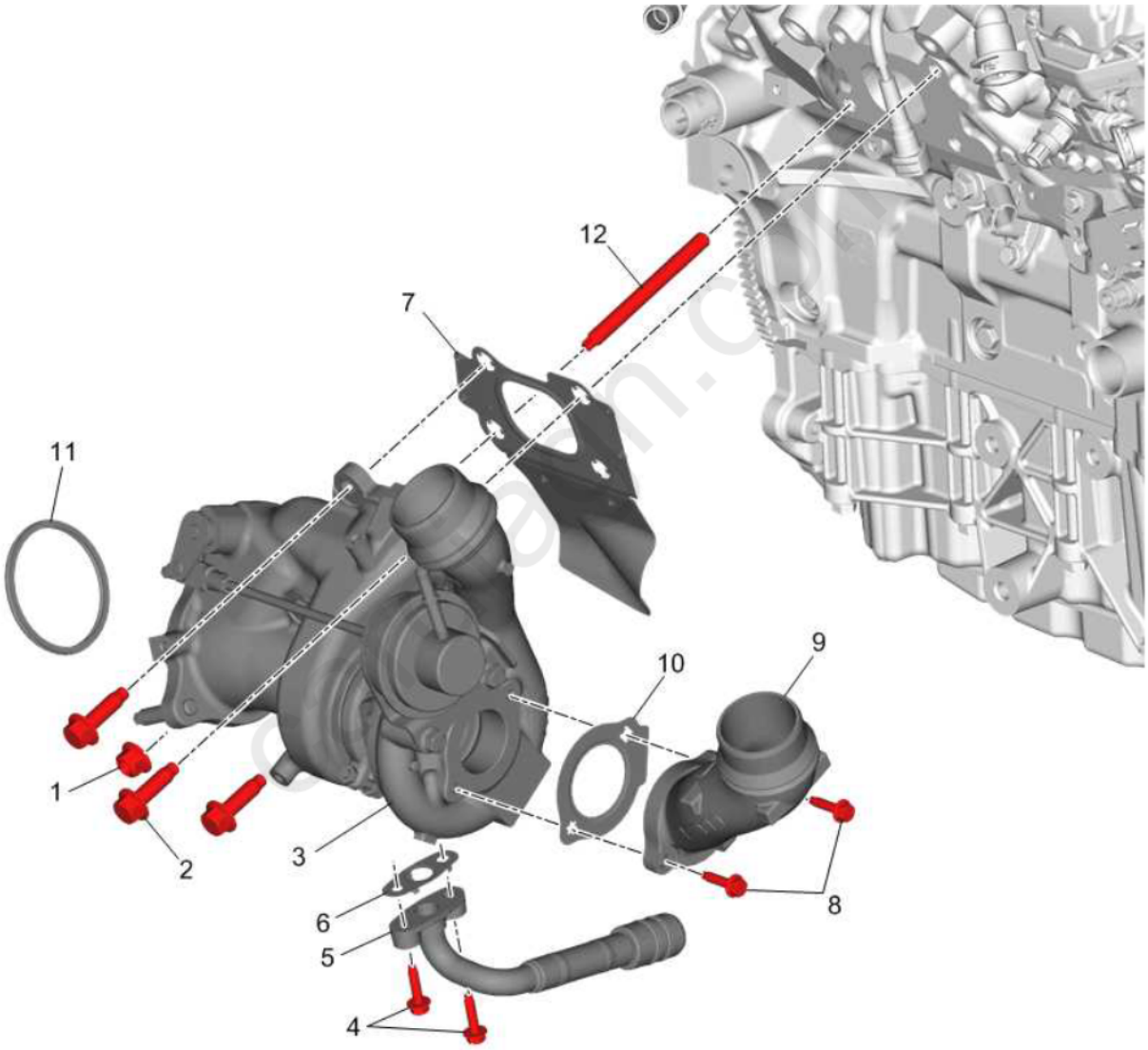


Fig. 6: Turbocharger and Oil Return Pipe
Courtesy of GENERAL MOTORS COMPANY

Turbocharger and Oil Return Pipe Removal

Callout	Component Name
1	Turbocharger Nut
2	Turbocharger Bolt [3x]
3	Turbocharger - Right Side
4	Turbocharger Oil Return Pipe Bolt [2x]

Callout	Component Name
5	Turbocharger Oil Return Pipe **Procedure** Refer to **Turbocharger Cleaning and Inspection**
6	Turbocharger Oil Return Pipe Gasket **NOTE:** **Remove and DISCARD the gasket.**
7	Turbocharger Gasket **NOTE:** **Remove and DISCARD the gasket.**
8	Turbocharger Air Inlet Adapter Bolt [2x]
9	Turbocharger Air Inlet Adapter
10	Turbocharger Air Inlet Adapter Seal
11	Turbocharger Exhaust Pipe Gasket **NOTE:** **Remove and DISCARD the gasket.**
12	Turbocharger Stud

TURBOCHARGER REMOVAL - LEFT SIDE

Charge Air Cooler Inlet Air Tube Removal

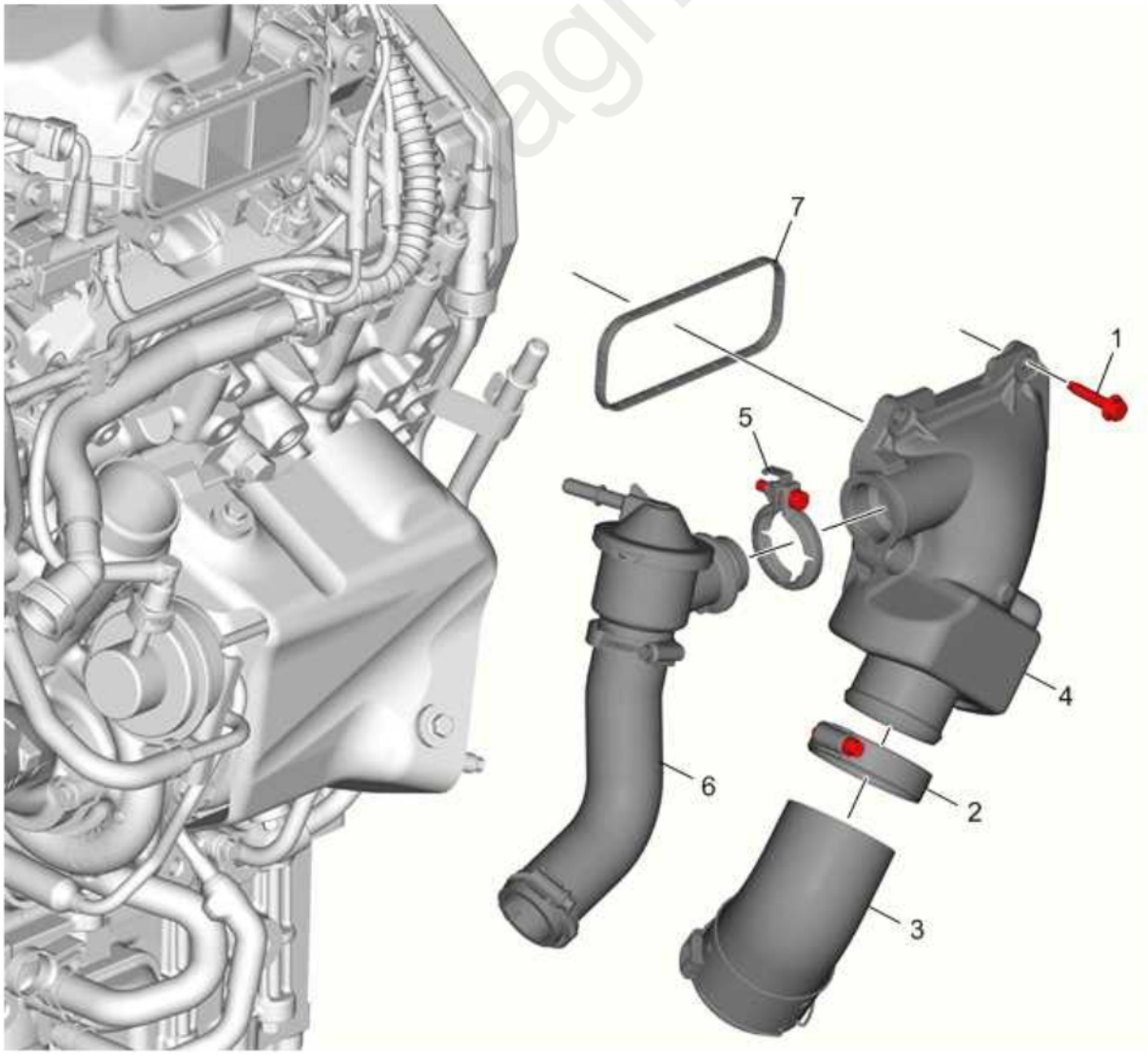


Fig. 7: Charge Air Cooler Inlet Air Tube
Courtesy of GENERAL MOTORS COMPANY

Charge Air Cooler Inlet Air Tube Removal

Callout	Component Name
1	Charge Air Cooler Inlet Air Tube Bolt [4x]
2	Charge Air Cooler Inlet Hose Clamp
3	Charge Air Cooler Inlet Hose
4	Charge Air Cooler Inlet Air Tube **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.** **Procedure** Refer to **Turbocharger Cleaning and Inspection**
5	Charge Air Bypass Valve Tube Clamp
6	Charge Air Bypass Valve
7	Charge Air Cooler Inlet Air Tube Seal **NOTE:** **Remove and DISCARD the seal.**

Turbocharger Heat Shield Removal

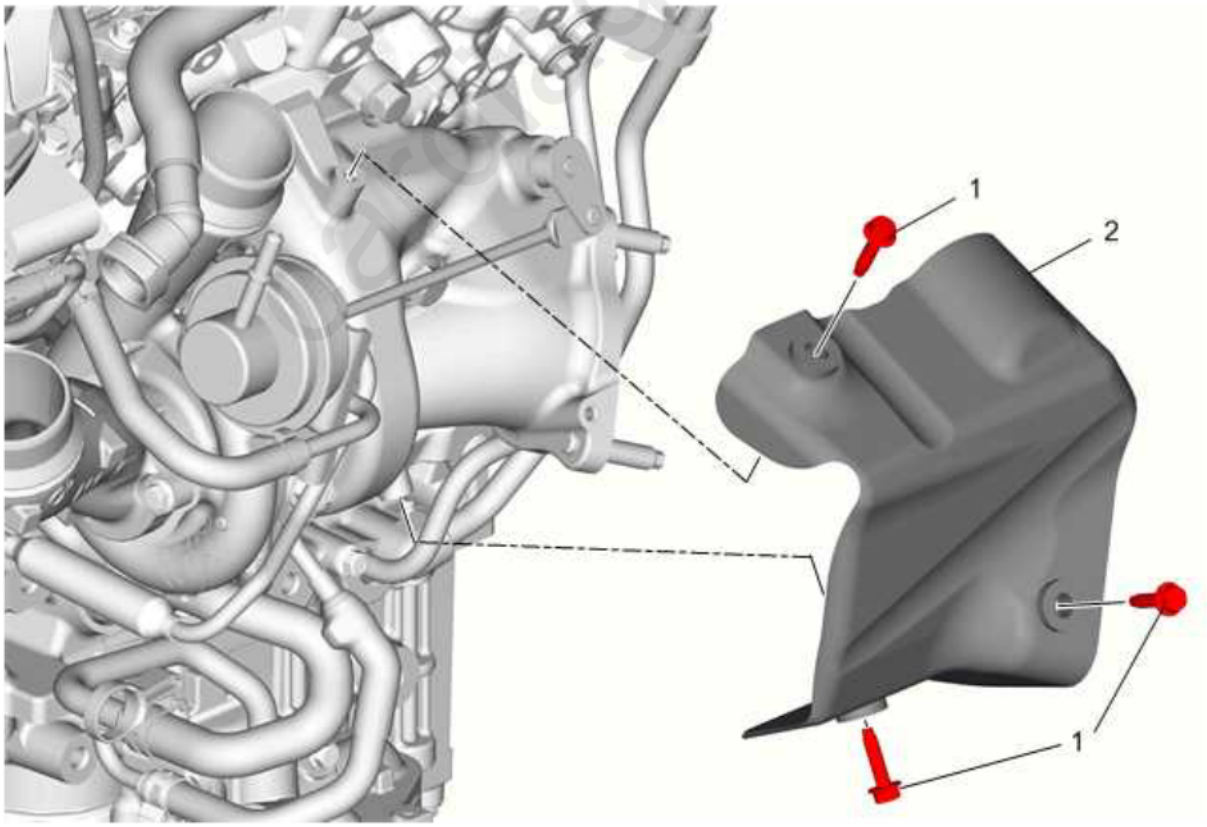


Fig. 8: Turbocharger Heat Shield
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Heat Shield Removal

Callout	Component Name
1	Turbocharger Heat Shield Bolt [3x]

Callout	Component Name
2	Turbocharger Heat Shield

Turbocharger Coolant Feed and Return Pipe Removal

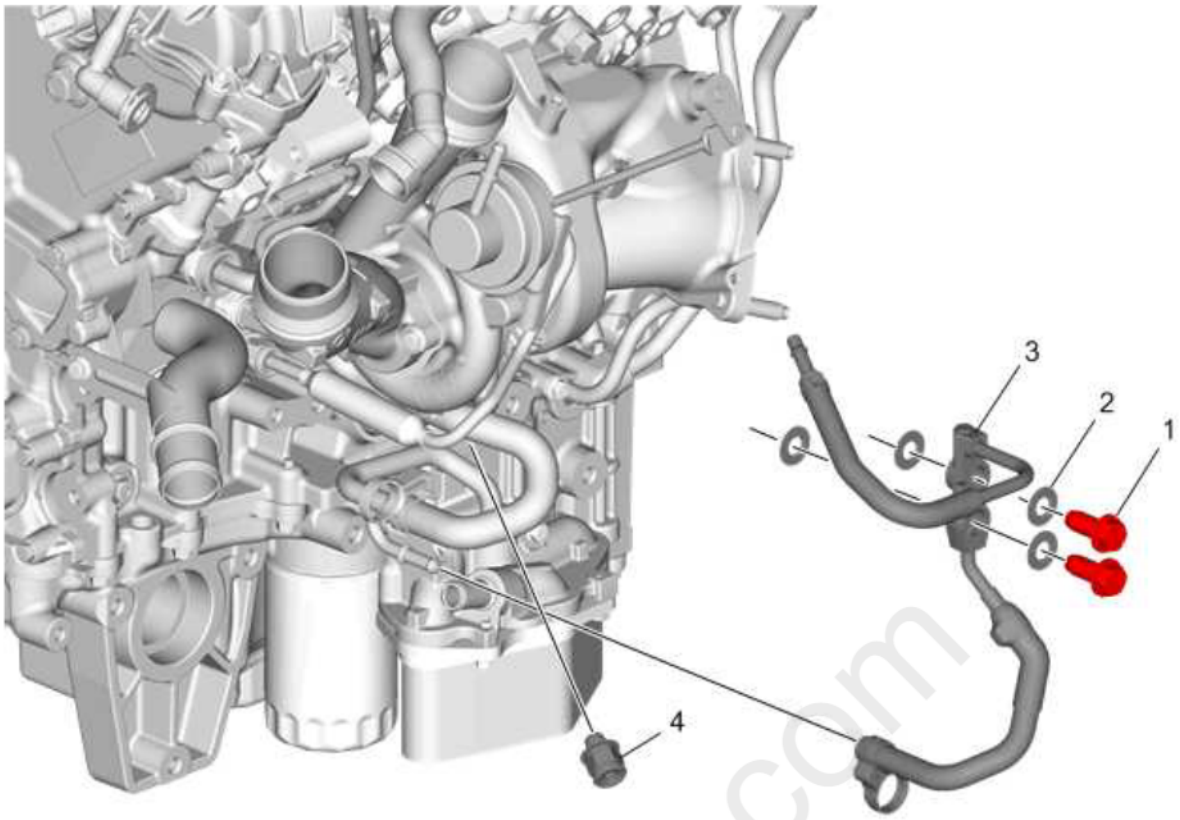


Fig. 9: Turbocharger Coolant Feed and Return Pipe
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Coolant Feed and Return Pipe Removal

Callout	Component Name
1	Turbocharger Coolant Feed and Return Pipe Bolt
2	Turbocharger Coolant Feed and Return Pipe Gasket [2x] **NOTE:** **Remove and DISCARD the gasket.**
3	Turbocharger Coolant Feed and Return Pipe **NOTE:** **Use 3/8" Jiffy-titeÂ® quick disconnect tool to remove the coolant return pipe.**
4	Turbocharger Oil Feed Pipe Fitting **NOTE:** **Discard fitting, they are not reusable.**

Turbocharger Oil Feed Pipe Removal

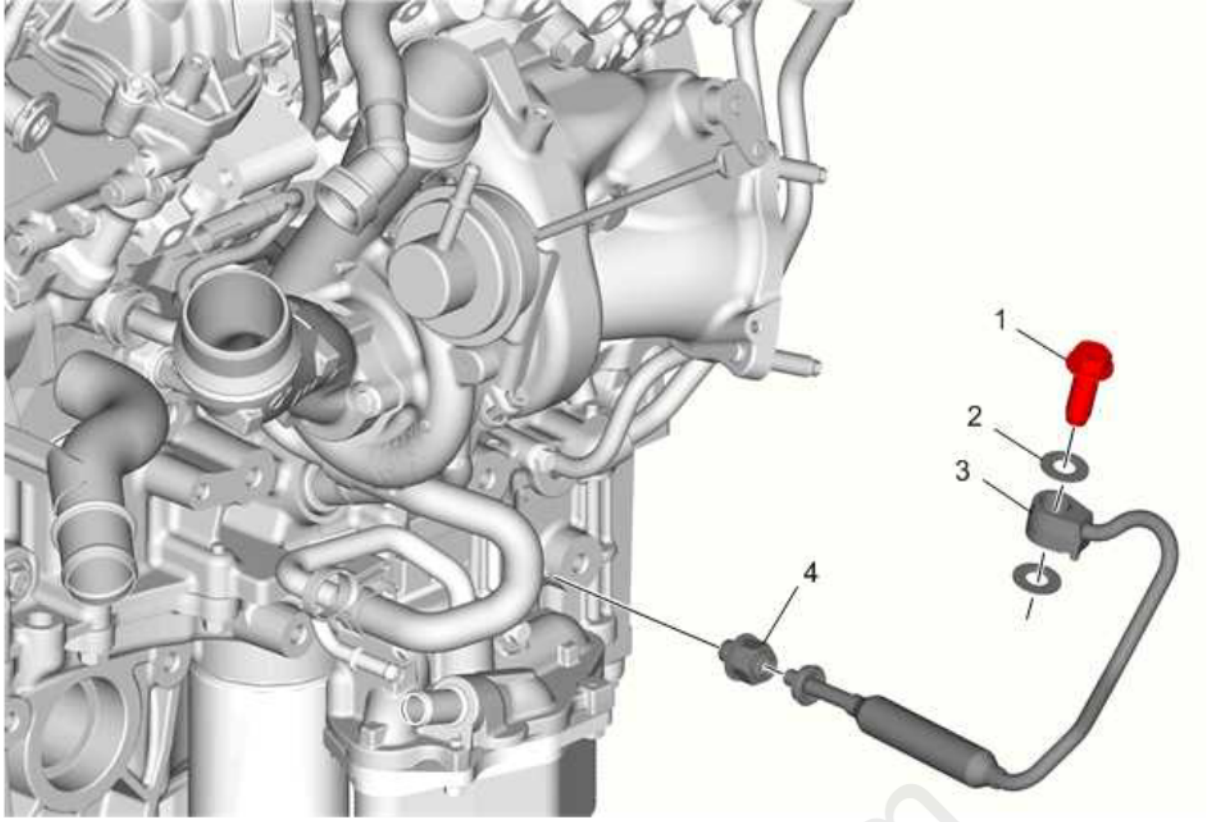


Fig. 10: Turbocharger Oil Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Oil Feed Pipe Removal

Callout	Component Name
1	Turbocharger Oil Feed Pipe Bolt
2	Turbocharger Oil Feed Pipe Gasket [2x] **NOTE:** **Remove and DISCARD the gasket.**
3	Turbocharger Oil Feed Pipe **Procedure** 1. Use 3/8" Jiffy-titeÂ® quick disconnect tool to remove the coolant return pipe. 2. Refer to **Turbocharger Cleaning and Inspection**
4	Turbocharger Oil Feed Pipe Fitting **NOTE:** **Discard fitting, they are not reusable.**

Turbocharger and Oil Return Pipe Removal

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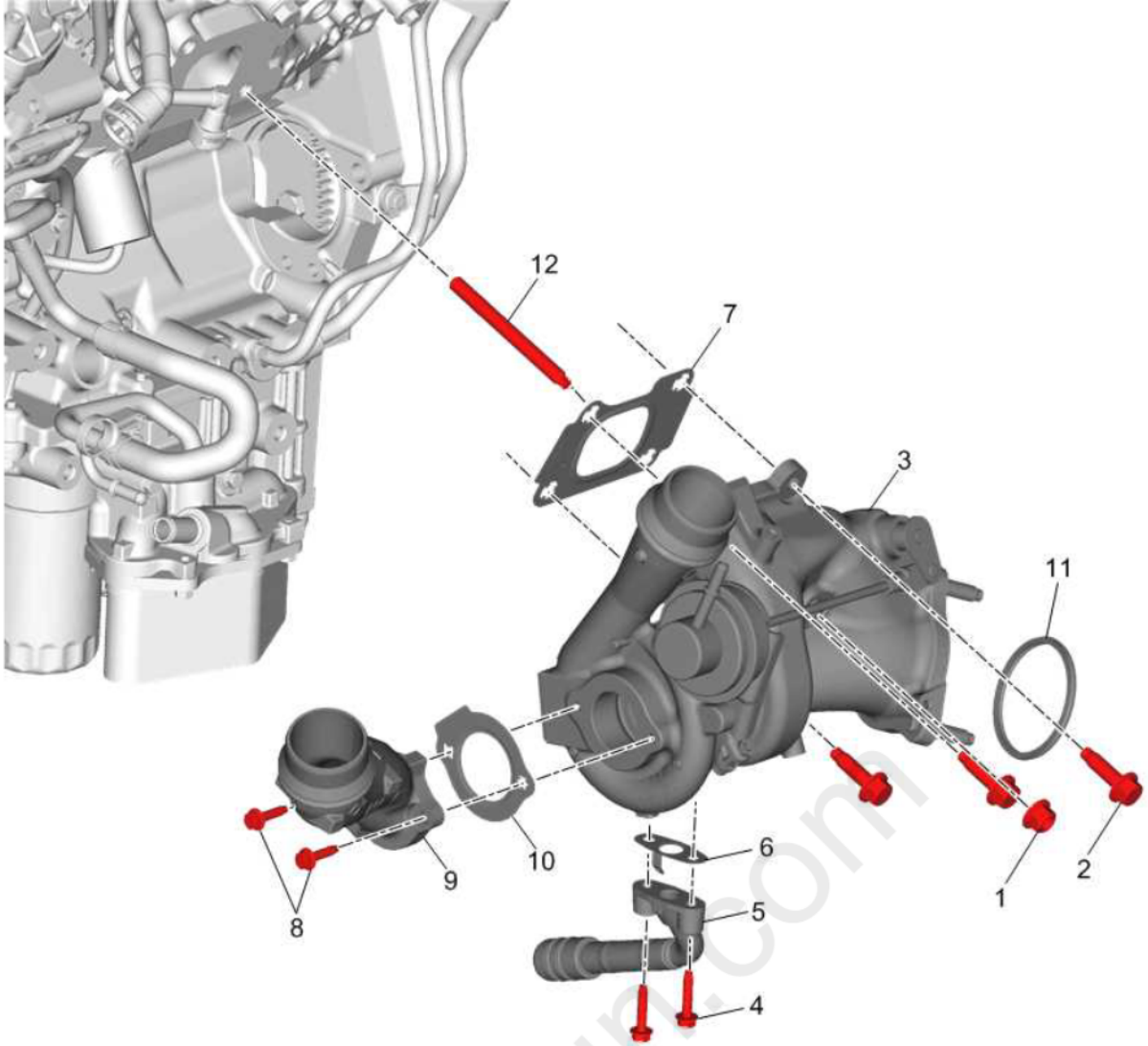


Fig. 11: Turbocharger and Oil Return Pipe
Courtesy of GENERAL MOTORS COMPANY

Turbocharger and Oil Return Pipe Removal

Callout	Component Name
1	Turbocharger Nut
2	Turbocharger Bolt [3x]
3	Turbocharger - Left Side
4	Turbocharger Oil Return Pipe Bolt [2x]
5	Turbocharger Oil Return Pipe **Procedure** Refer to **Turbocharger Cleaning and Inspection**
6	Turbocharger Oil Return Pipe Gasket **NOTE:** **Remove and DISCARD the gasket.**
7	Turbocharger Gasket **NOTE:** **Remove and DISCARD the gasket.**
8	Turbocharger Air Inlet Adapter Bolt [2x]
9	Turbocharger Air Inlet Adapter **NOTE:** **Remove and DISCARD the gasket.**

Callout	Component Name
10	Turbocharger Air Inlet Adapter Seal **NOTE:** **Remove and DISCARD the seal.**
11	Turbocharger Exhaust Pipe Gasket **NOTE:** **Remove and DISCARD the gasket.**
12	Turbocharger Stud

TURBOCHARGER WASTEGATE ACTUATOR VACUUM TANK REMOVAL

Turbocharger Wastegate Hoses, Solenoids and Bracket Removal - Right Side

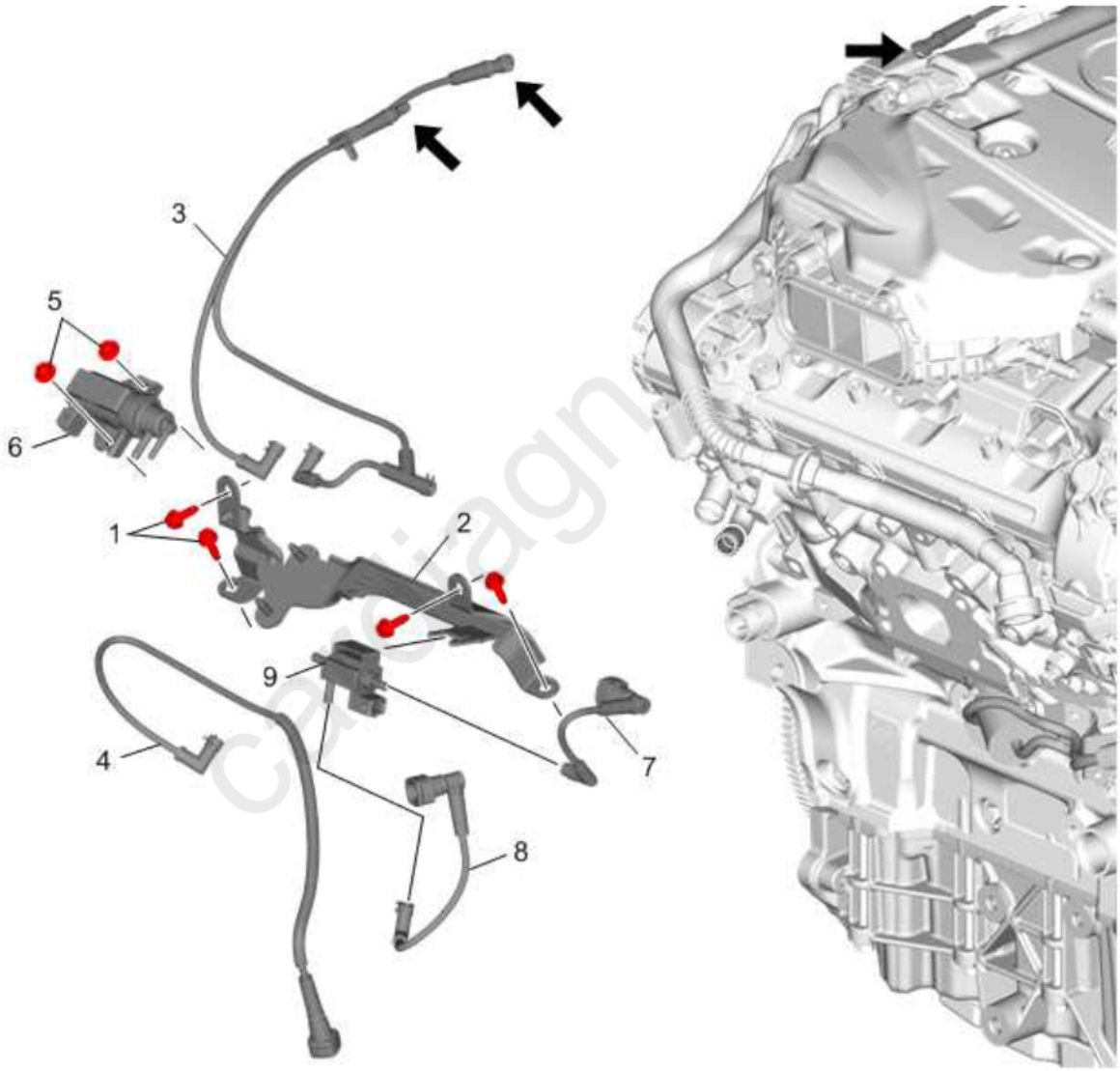


Fig. 12: Turbocharger Wastegate Hoses, Solenoids and Bracket - Right Side
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Wastegate Hoses, Solenoids and Bracket Removal - Right Side

Callout	Component Name
1	Turbocharger Wastegate Actuator Vacuum Tank Bracket Bolt [4x]
2	Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket - Right Side

Callout	Component Name
3	Charge Air Bypass Valve Vacuum Tank Tube **NOTE:** **Ensure the connections to the Left Side are released.**
4	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube
5	Turbocharger Wastegate Regulator Solenoid Valve Nut [2x]
6	Turbocharger Wastegate Regulator Solenoid Valve
7	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube
8	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube
9	Turbocharger Wastegate Regulator Solenoid Valve

Turbocharger Wastegate Hoses, Solenoids and Bracket Removal - Left Side

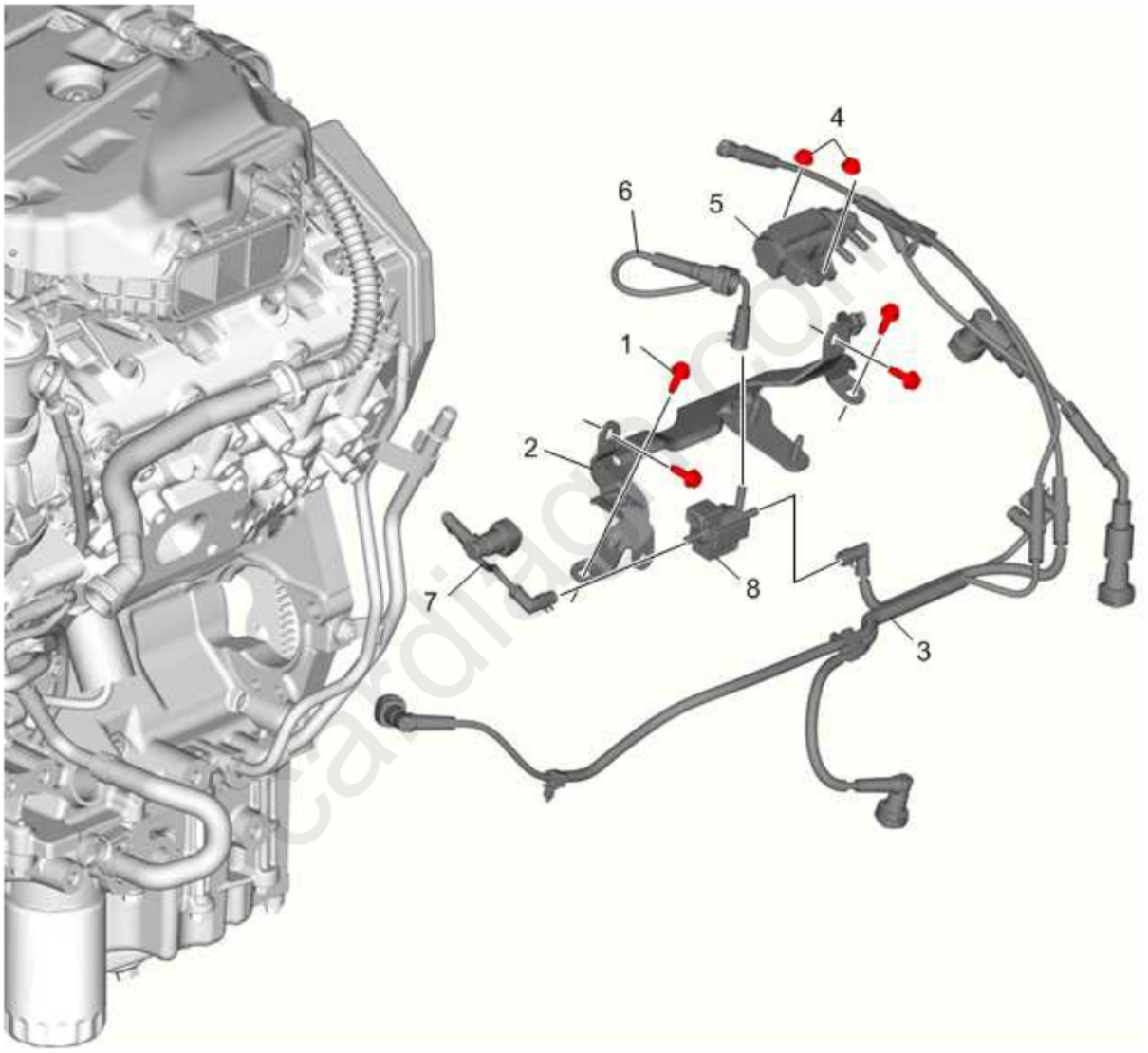


Fig. 13: Turbocharger Wastegate Hoses, Solenoids and Bracket - Left Side
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Wastegate Hoses, Solenoids and Bracket Removal - Left Side

Callout	Component Name
1	Turbocharger Wastegate Actuator Vacuum Tank Bracket Bolt [4x]
2	Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket - Left Side
3	Charge Air Bypass Valve Vacuum Tank Tube
4	Turbocharger Wastegate Regulator Solenoid Valve Nut [2x]
5	Turbocharger Wastegate Regulator Solenoid Valve
6	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube
7	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube

Callout	Component Name
8	Turbocharger Wastegate Regulator Solenoid Valve

Turbocharger Wastegate Actuator Vacuum Tank Removal

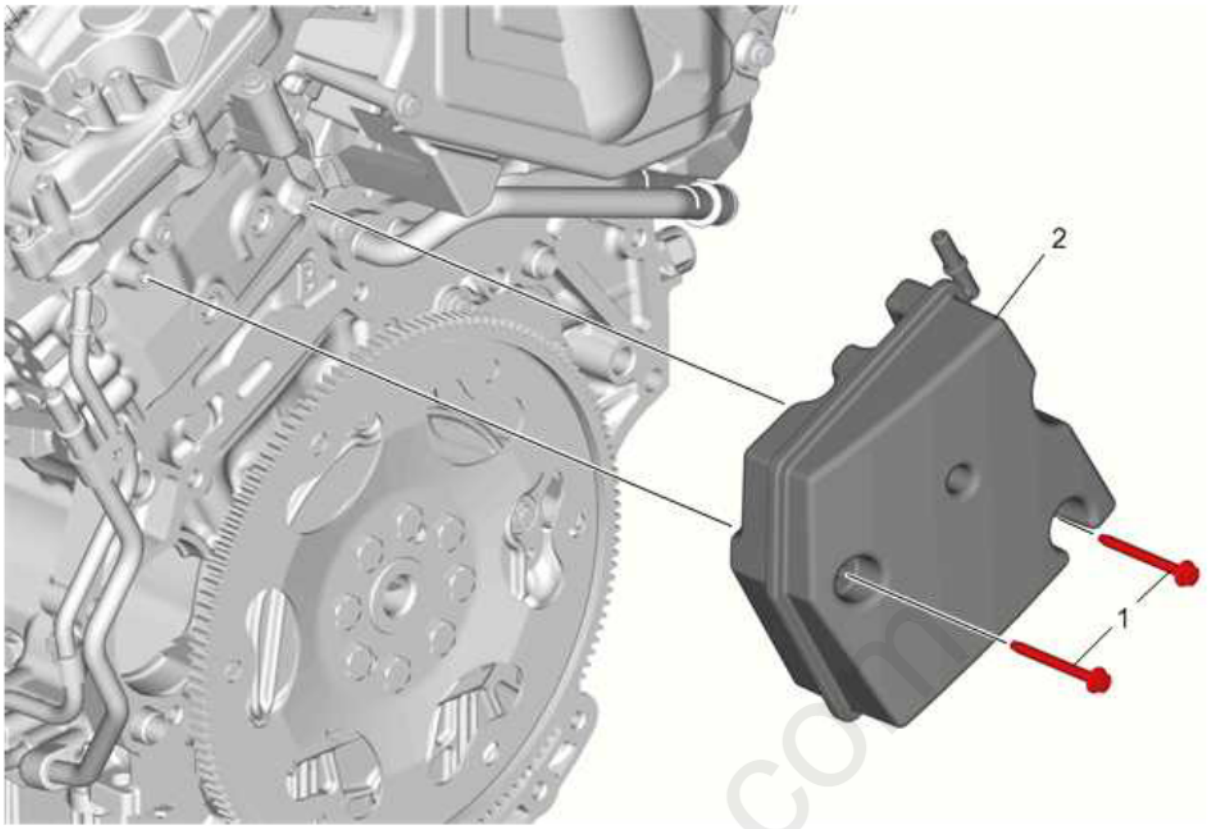


Fig. 14: Turbocharger Wastegate Actuator Vacuum Tank
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Wastegate Actuator Vacuum Tank Removal

Callout	Component Name
1	Turbocharger Wastegate Actuator Vacuum Tank Bolt [2x]
2	Turbocharger Wastegate Actuator Vacuum Tank

WATER PUMP INLET PIPE REMOVAL

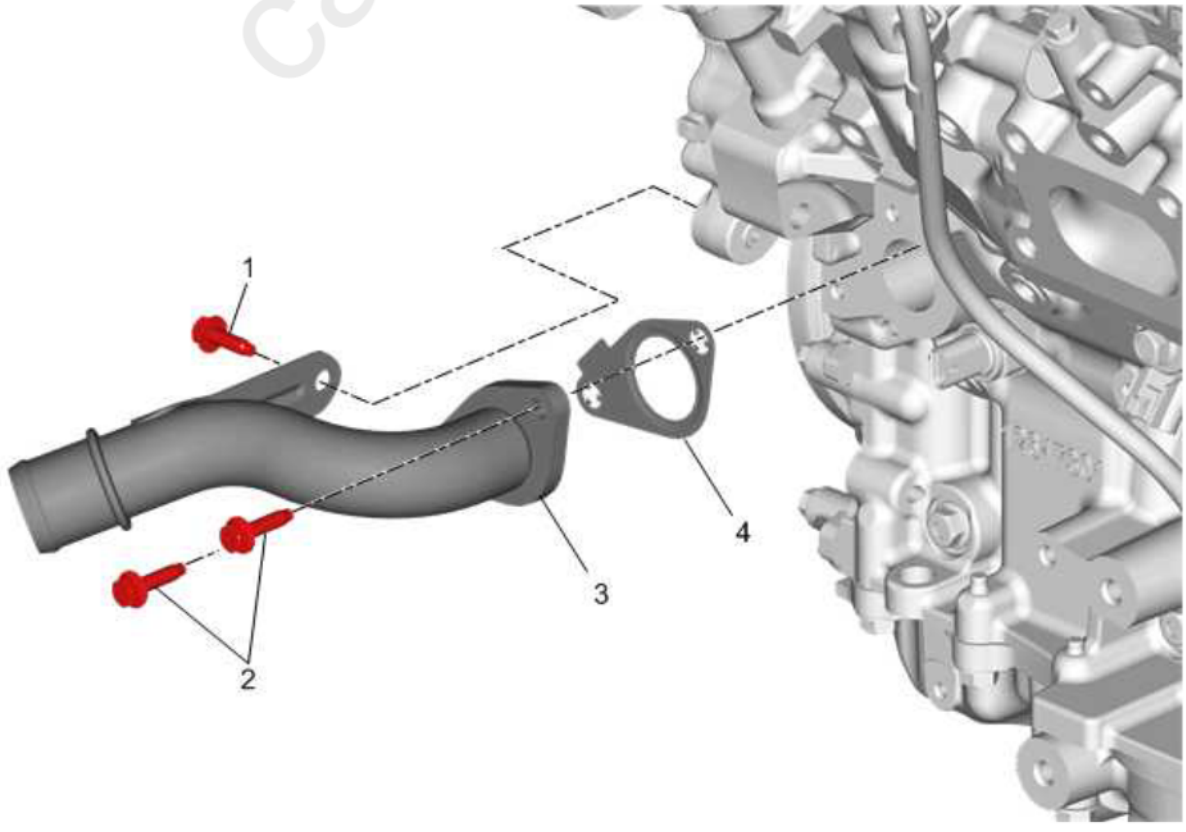


Fig. 15: Water Pump Inlet Pipe
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Inlet Pipe Bolt
2	Water Pump Inlet Pipe Bolt [2x]
3	Water Pump Inlet Pipe
4	Water Inlet Seal **NOTE:** **Remove and DISCARD the seal.**

OIL LEVEL INDICATOR AND TUBE REMOVAL

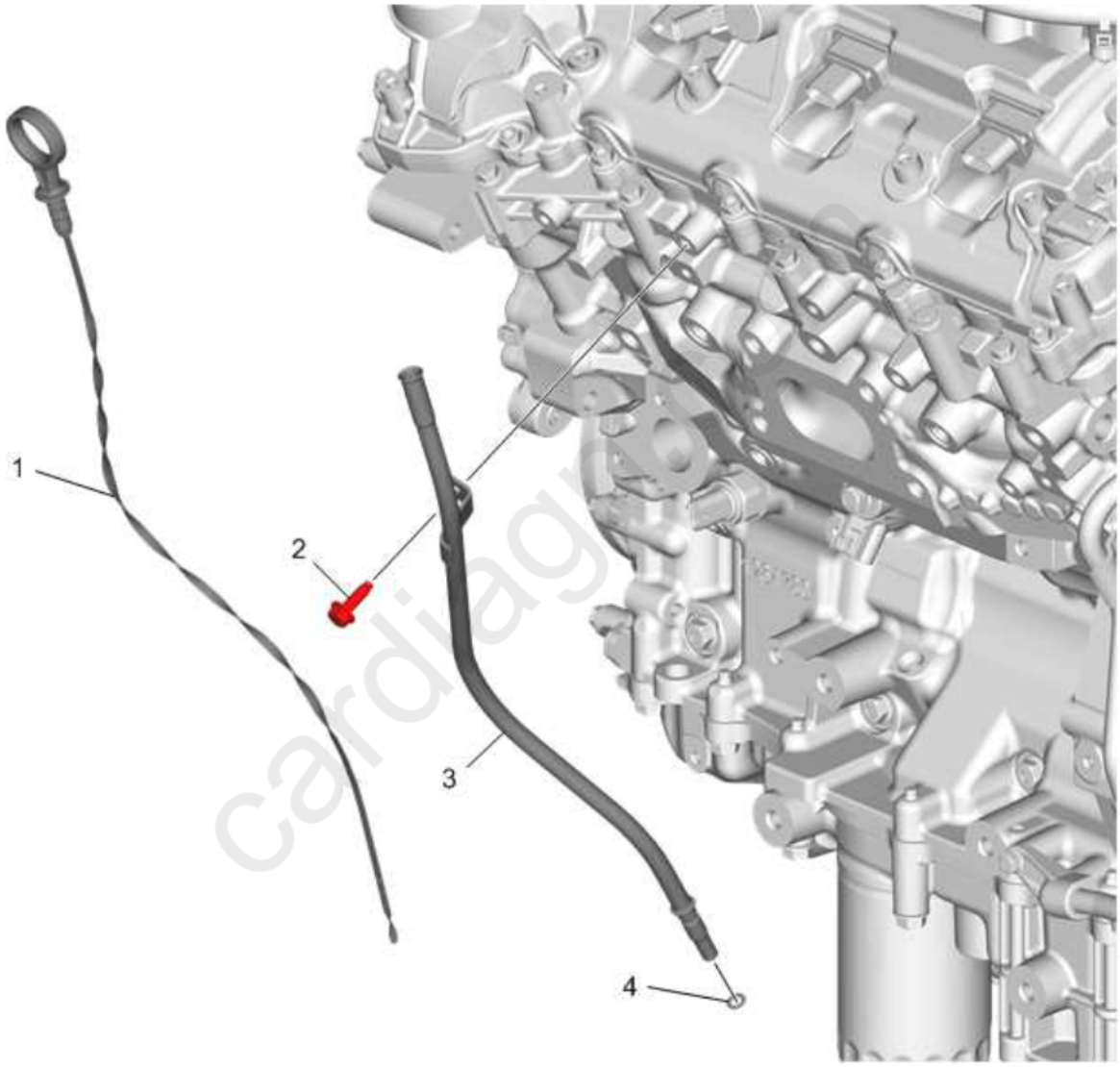


Fig. 16: Oil Level Indicator and Tube
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Level Indicator
2	Oil Level Indicator Tube Bolt
3	Oil Level Indicator Tube
4	Oil Level Indicator Tube Seal **NOTE:** **Remove and DISCARD the seal.**

VACUUM PUMP PIPE REMOVAL (LGX)

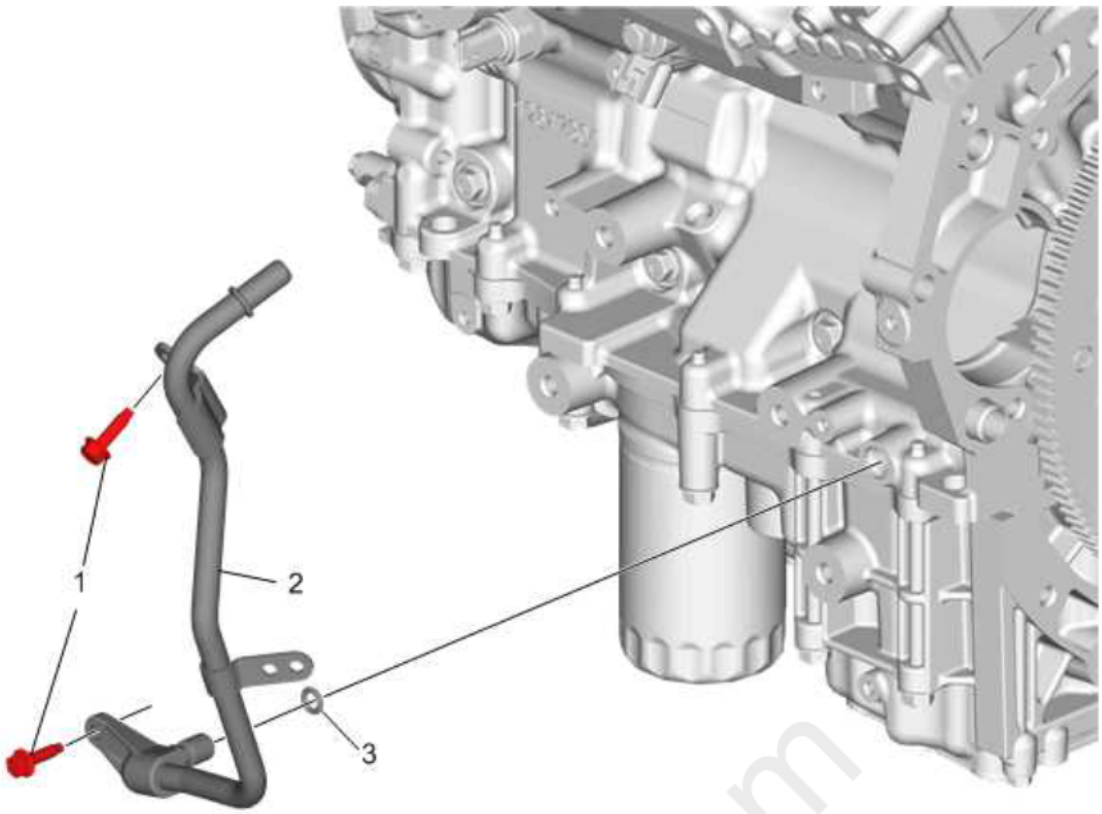


Fig. 17: Vacuum Pump Pipe (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Pipe Bolt [2x]
2	Vacuum Pump Pipe
3	Vacuum Pump Pipe Seal

VACUUM PUMP PIPE REMOVAL (LGW)

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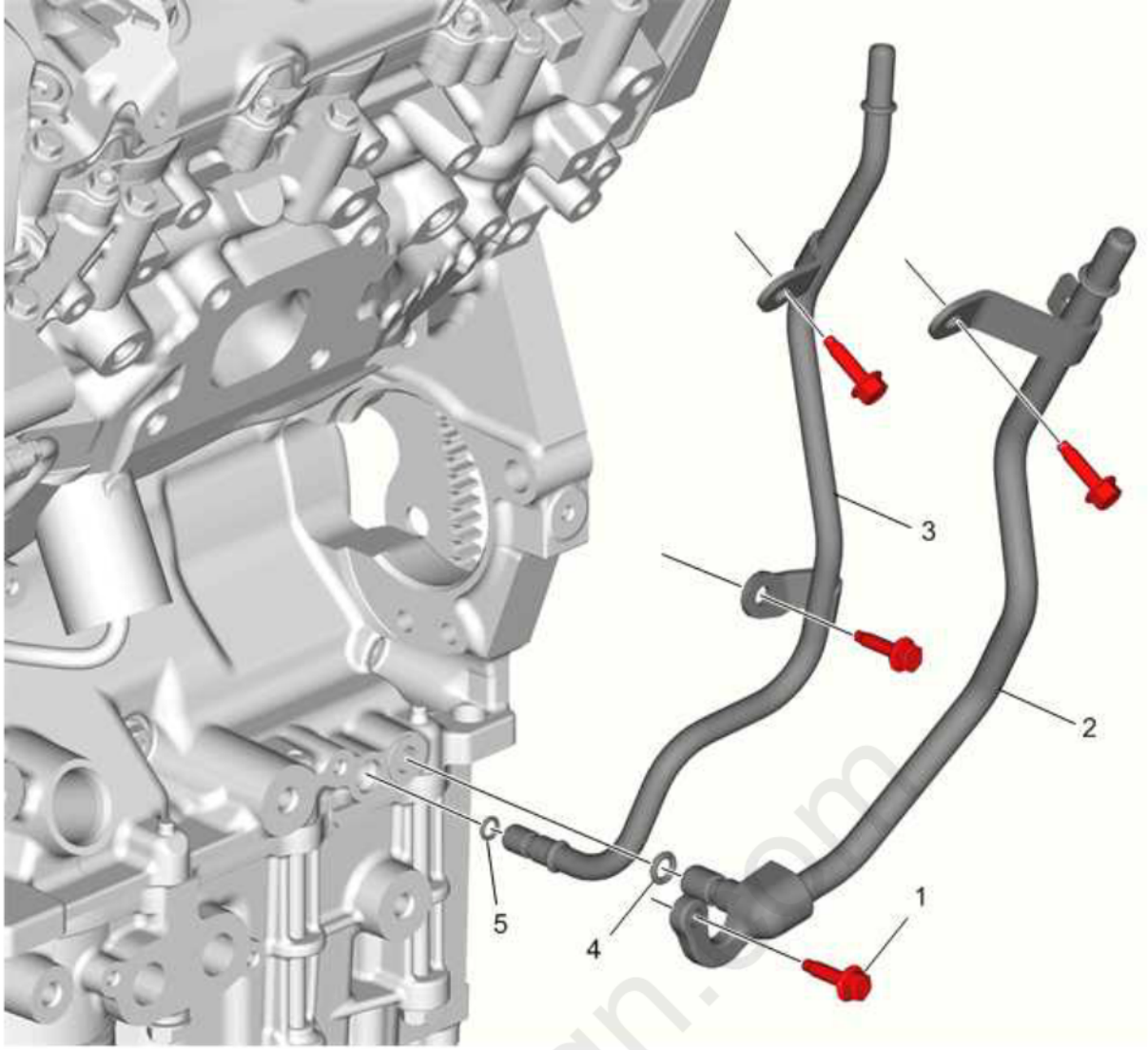


Fig. 18: Vacuum Pump Pipe (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Pipe Bolt [4x]
2	Vacuum Pump Pipe
3	Vacuum Pump Pipe
4	Vacuum Pump Pipe Seal
5	Vacuum Pump Pipe Seal

CHARGE AIR COOLER COVER REMOVAL

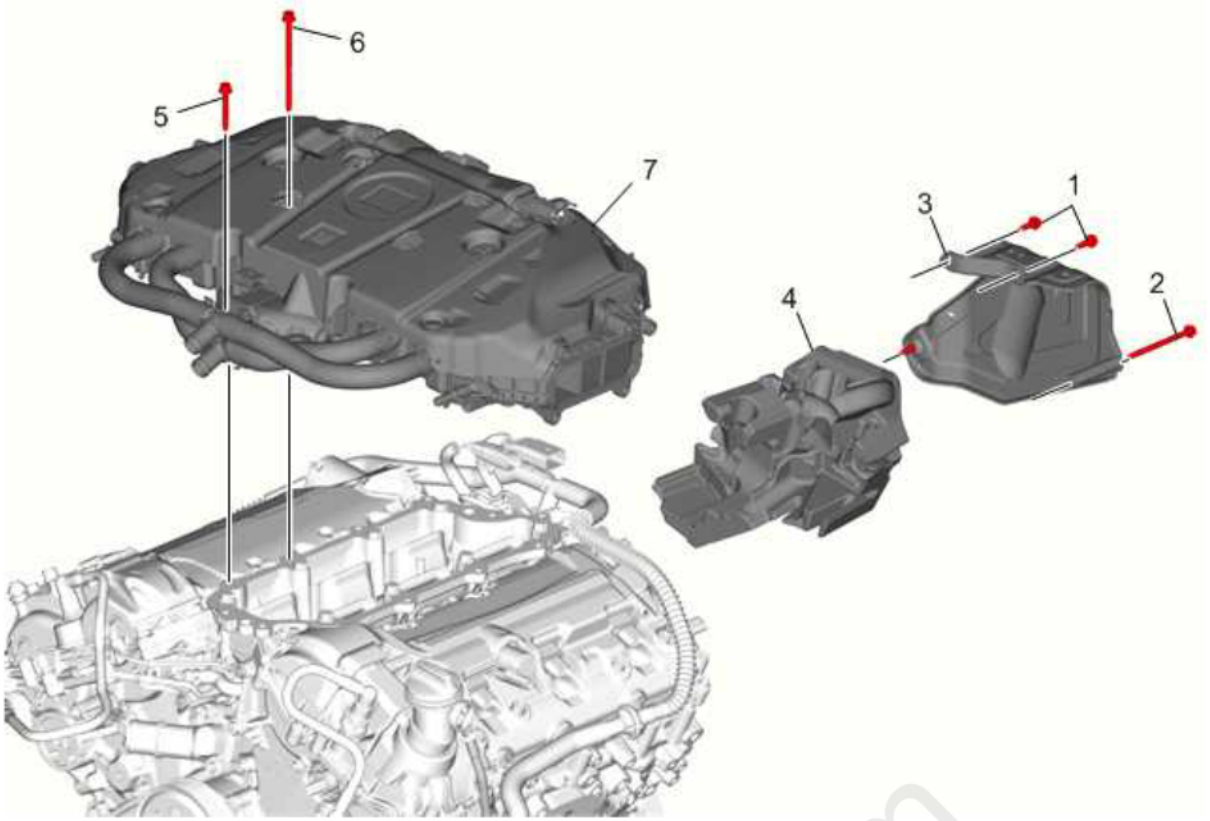


Fig. 19: Charge Air Cooler Cover
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Pipe Shield Bolt [2x]
2	Fuel Pipe Shield Bolt
3	Fuel Pipe Shield
4	Engine Rear Noise Shield **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**
5	Charge Air Cooler Cover Bolt [8x]
6	Charge Air Cooler Cover Bolt [4x]
7	Charge Air Cooler Cover

INTAKE MANIFOLD REMOVAL (LGX)

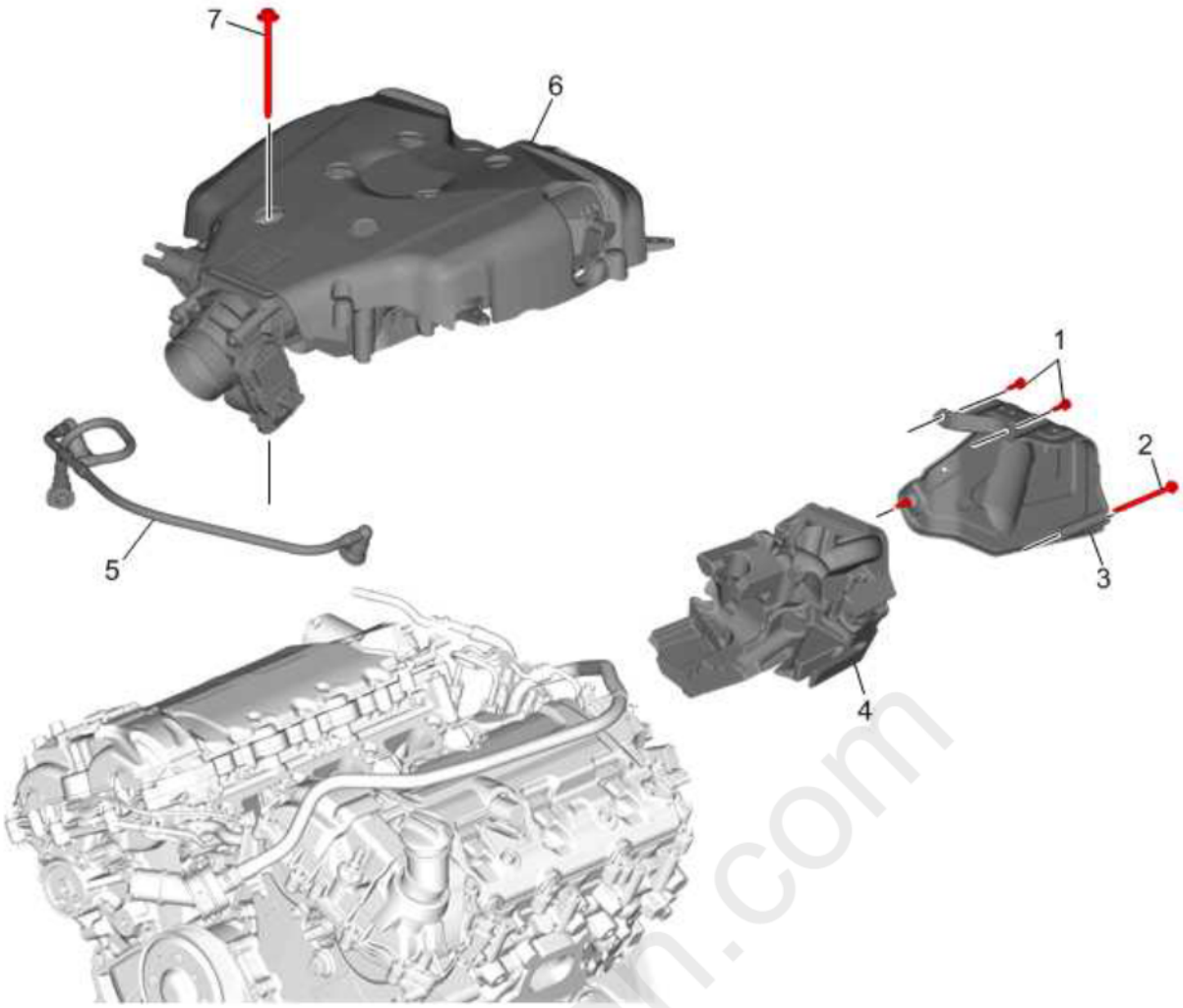


Fig. 20: Intake Manifold (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Pipe Shield Bolt [2x]
2	Fuel Pipe Shield Bolt
3	Fuel Pipe Shield
4	Engine Rear Noise Shield **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**
5	Positive Crankcase Ventilation Tube Connector
6	Intake Manifold Bolt [8x]
7	Intake Manifold

INTAKE MANIFOLD REMOVAL (LGW)

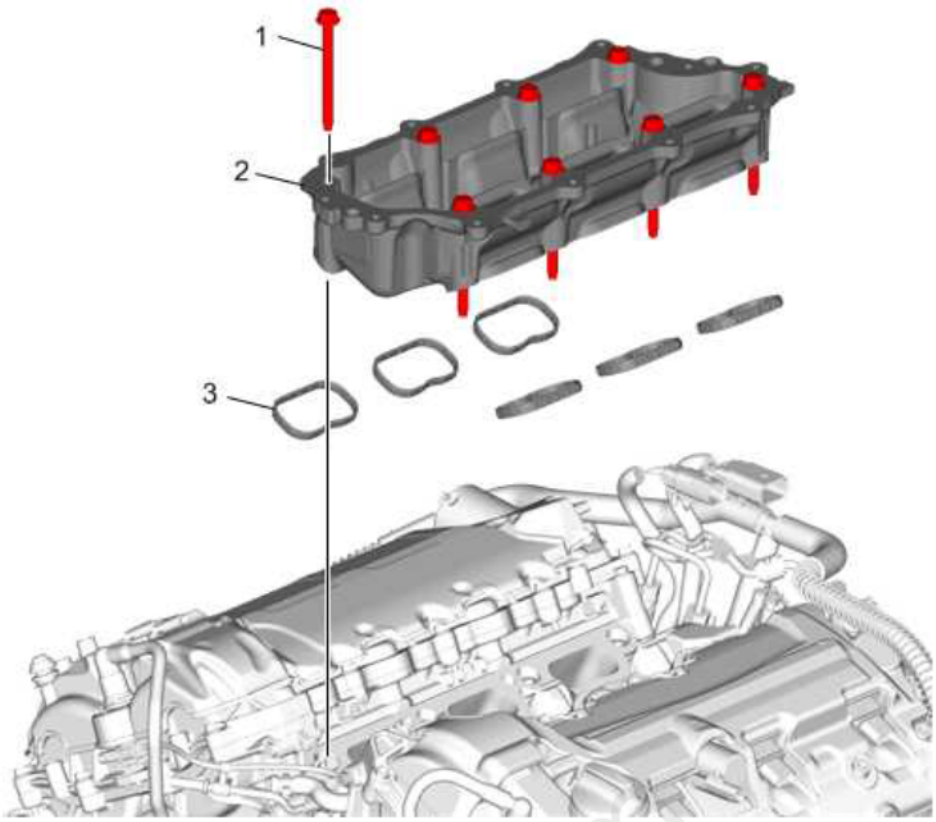
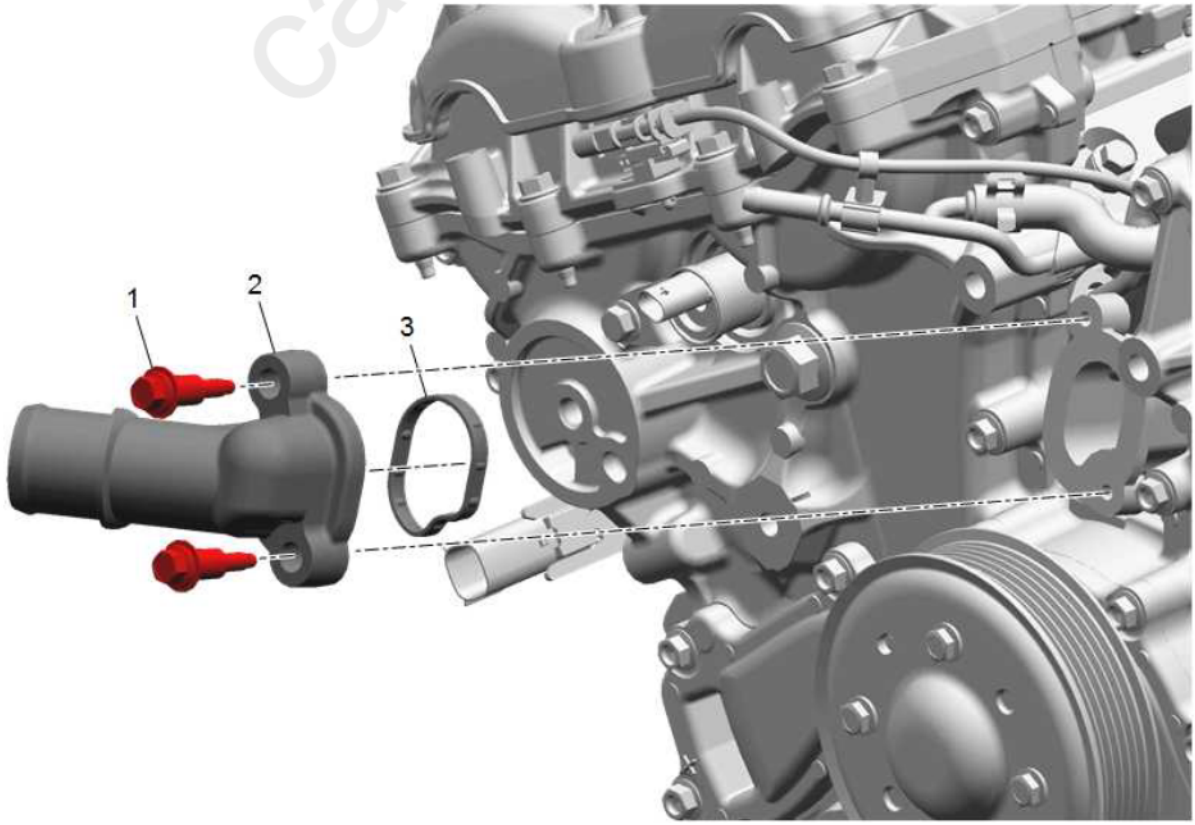


Fig. 21: Intake Manifold (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Lower Intake Manifold Bolt [8x]
2	Intake Manifold
3	Intake Manifold Seal [6x] **NOTE:** **Remove and DISCARD the seal.**

WATER OUTLET REMOVAL



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Fig. 22: Water Outlet
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Outlet Bolt [2x]
2	Water Outlet
3	Water Outlet Seal **NOTE:** **Discard seal, it is not reusable.**
4	Engine Coolant Air Bleed Pipe Bolt
5	Engine Coolant Air Bleed Pipe [2x]

ENGINE COOLANT THERMOSTAT HOUSING REMOVAL

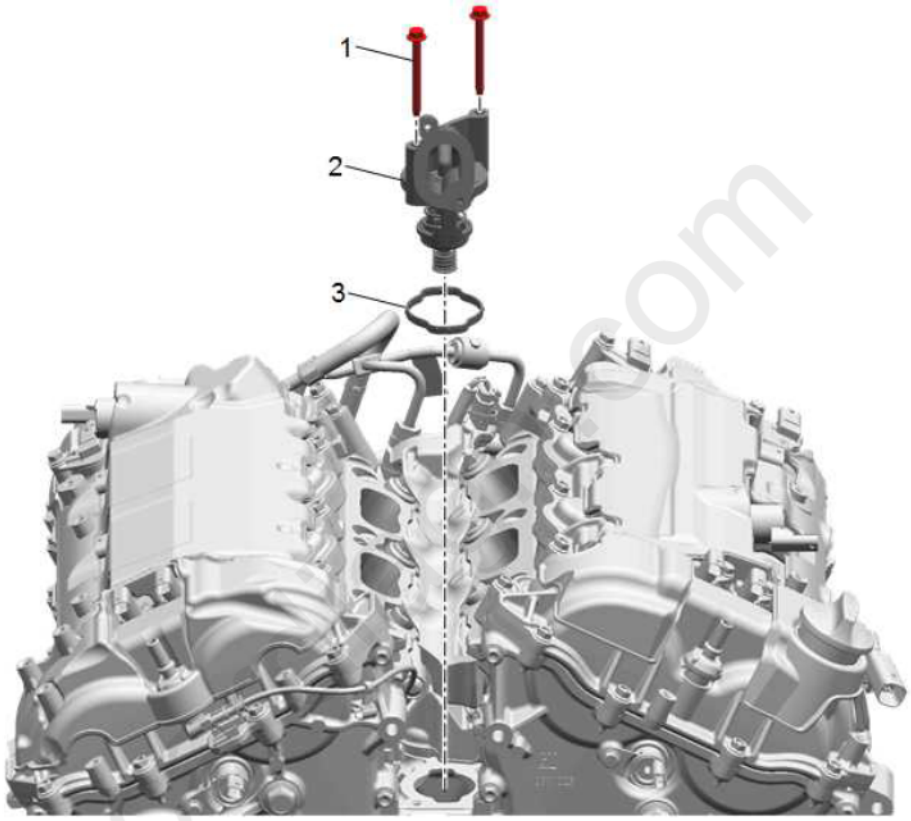


Fig. 23: Engine Coolant Thermostat Housing
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Coolant Thermostat Housing Bolt [2x]
2	Engine Coolant Thermostat Housing
3	Engine Coolant Thermostat Gasket **NOTE:** **Remove and DISCARD the gasket.**
4	Engine Coolant Temperature Sensor Wire
5	Engine Coolant Temperature Sensor

CRANKSHAFT BALANCER REMOVAL (LGX)

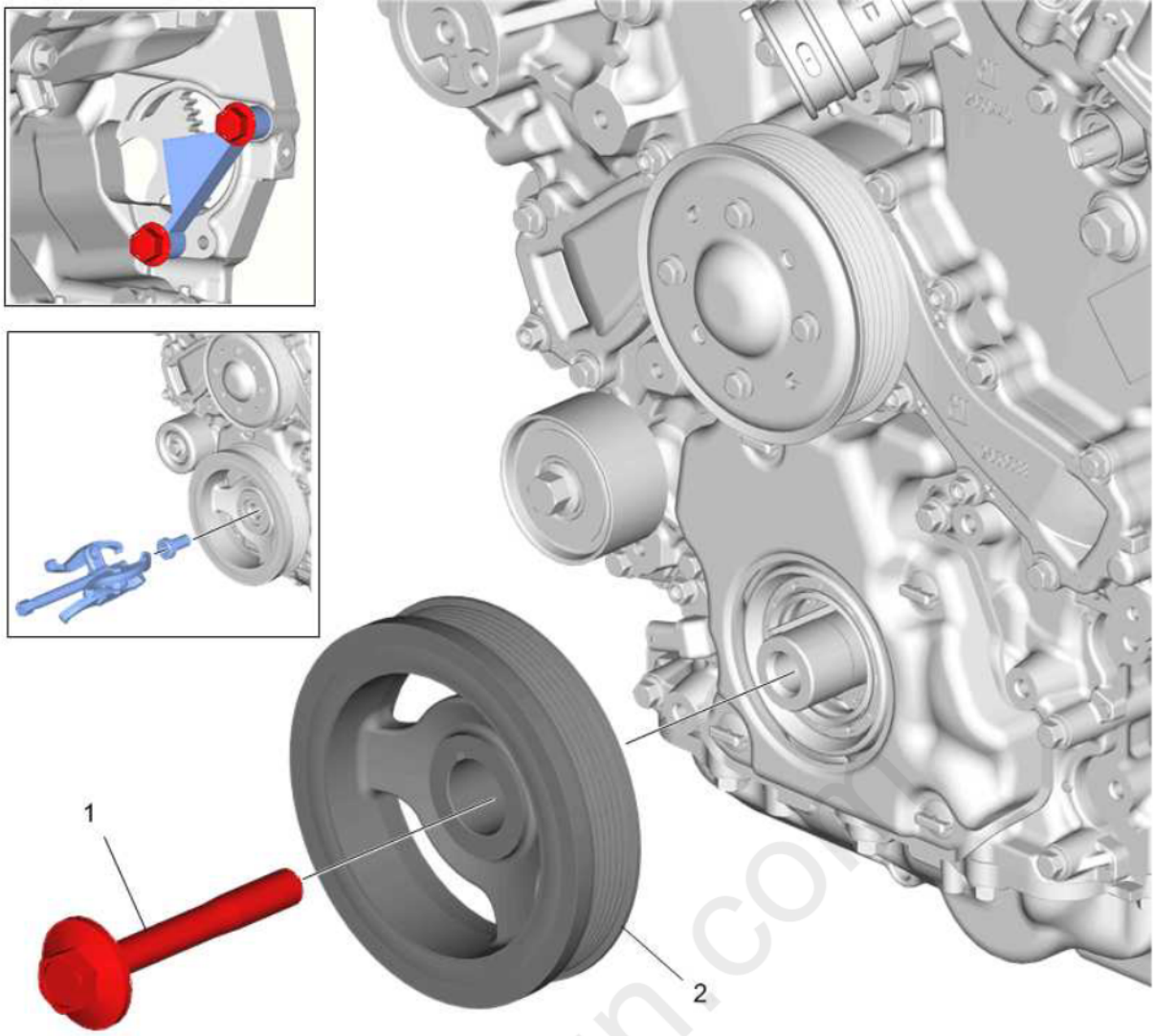


Fig. 24: Crankshaft Balancer (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

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Callout	Component Name

Preliminary Procedure

1. Install the **EN-46106** Flywheel Holding Tool through the starter mounting hole.

   NOTE:
   The top starter hole will require a longer bolt and nut to secure the tool.

2. Remove and discard the crankshaft balancer bolt.
3. Install the **EN-44226-5** Crankshaft Button in the nose of the crankshaft.
4. Install the **EN-25031** 3 Jaw Puller

   NOTE:
   Use of the EN-41816 Crankshaft Balancer Remover with extension arms removed in order to remove the crankshaft balancer as alternate method.

5. Tighten the center bolt of the **EN-25031** 3 Jaw Puller in order to pull the crankshaft balancer off of the crankshaft.
6. Remove the **EN-25031** 3 Jaw Puller remover from the crankshaft balancer.
7. Remove the **EN-46106** Flywheel Holding Tool through the starter mounting hole.

Special Tools

- **EN-25031** 3 Jaw Puller
- **EN-41816** Crankshaft Balancer Remover
- **EN-44226-5** Crankshaft Button
- **EN-46106** Flywheel Holding Tool

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

1	Crankshaft Balancer Bolt **NOTE:** **Remove and DISCARD the bolt.**
2	Crankshaft Balancer

CRANKSHAFT BALANCER REMOVAL (LGW)

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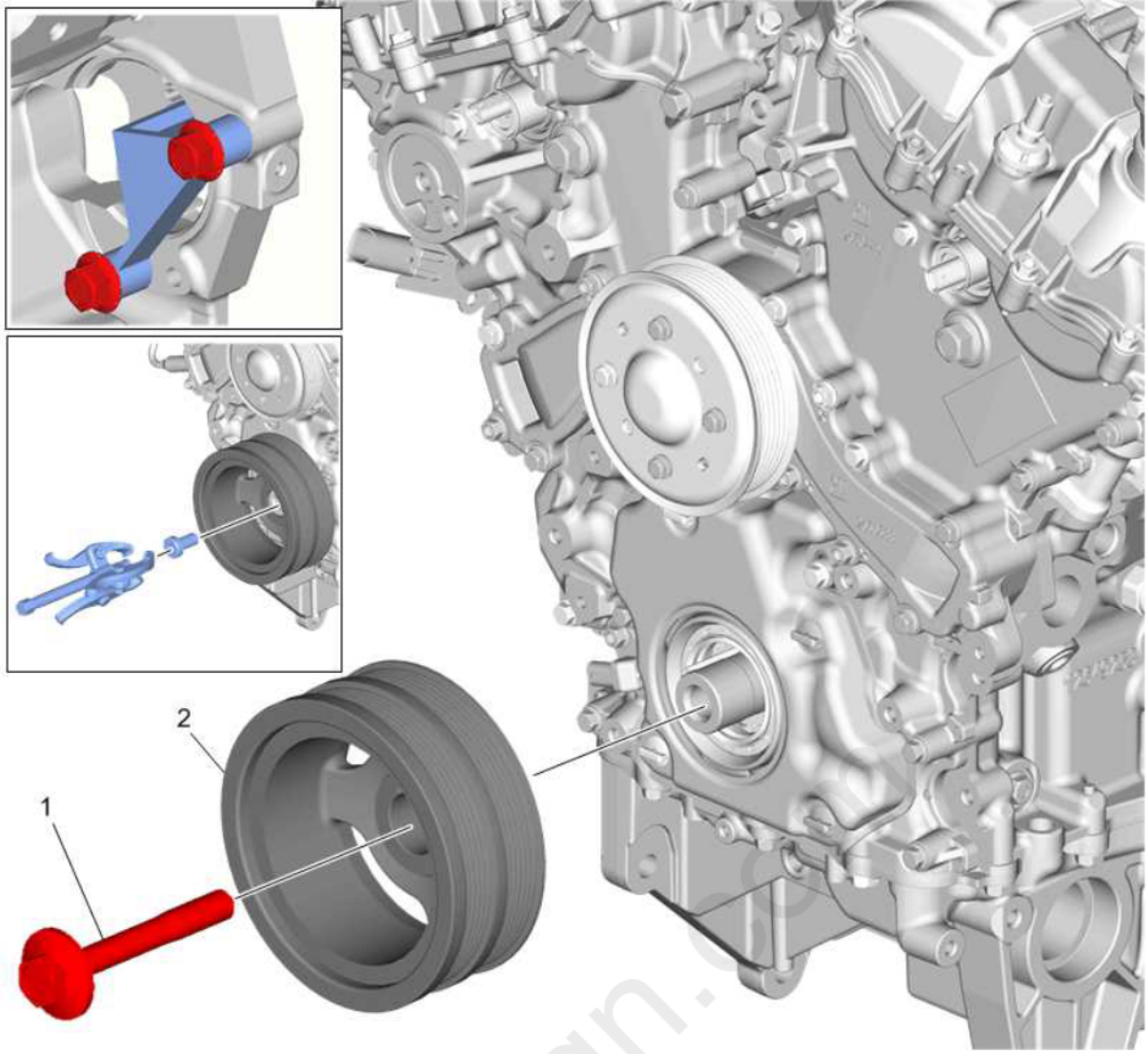


Fig. 25: Crankshaft Balancer (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Procedure 1. Install the **EN-46106** Flywheel Holding Tool through the starter mounting hole. 2. Remove and discard the crankshaft balancer bolt. 3. Install the **EN-44226-5** Crankshaft Button in the nose of the crankshaft. 4. Install the **EN-41816** Crankshaft Balancer Remover with extension arms removed in order to remove the crankshaft balancer. 5. Tighten the center bolt of the **EN-41816** Crankshaft Balancer Remover in order to pull the crankshaft balancer off of the crankshaft. 6. Remove the **EN-41816** Crankshaft Balancer Remover from the crankshaft balancer. 7. Remove the **EN-46106** Flywheel Holding Tool through the starter mounting hole. **Special Tools** • **EN-44226-5** Crankshaft Button • **EN-41816** Crankshaft Balancer Remover • **EN-46106** Flywheel Holding Tool For equivalent regional tools, refer to **Special Tools** .	
1	Crankshaft Balancer Bolt **NOTE:** **Remove and DISCARD the bolt.**
2	Crankshaft Balancer

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Callout	Component Name
2	Crankshaft Balancer

HEATER INLET AND OUTLET PIPE REMOVAL

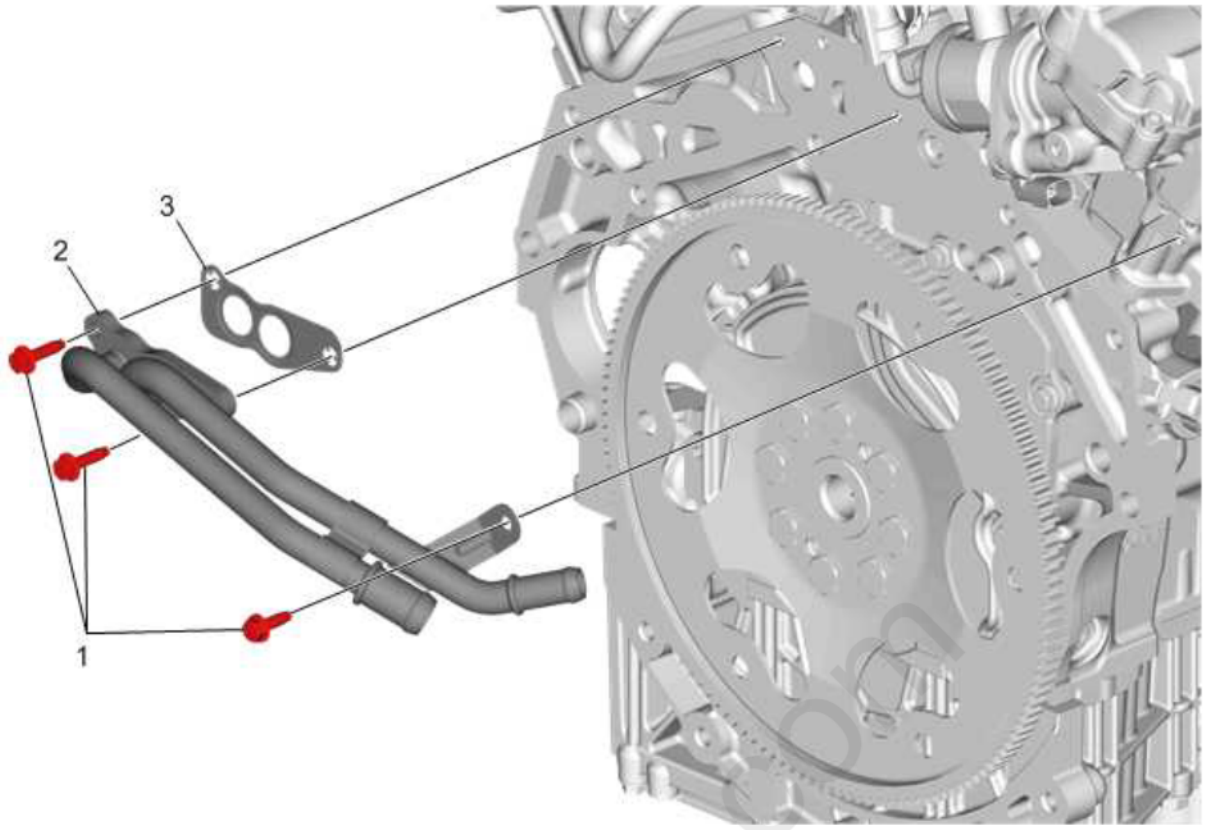


Fig. 26: Heater Inlet and Outlet Pipe
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Heater Inlet and Outlet Pipe Bolt [3x]
2	Heater Inlet and Outlet Pipe
3	Heater Inlet and Outlet Pipe Gasket **NOTE:** **Remove and DISCARD the gasket.**

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

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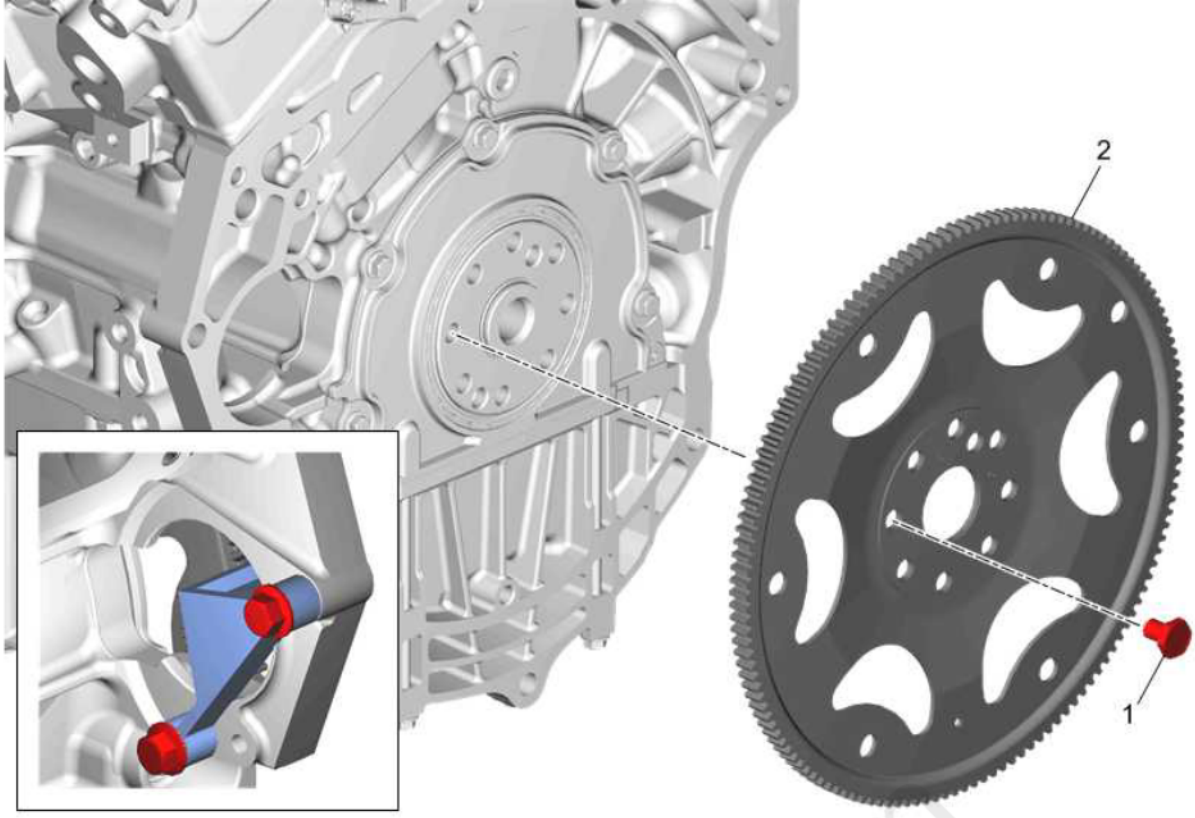


Fig. 27: Automatic Transmission Flex Plate
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Automatic Transmission Flex Plate Bolt **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.** **Procedure** 1. Install the **EN-46106** Flywheel Holding Tool through the starter mounting hole. 2. Remove the flex plate bolts (1) and discard 3. Remove the flex plate (2) from the crankshaft. 4. Remove the **EN-46106** Flywheel Holding Tool through the starter mounting hole. **Special Tools** **EN-46106** Flywheel Holding Tool Equivalent regional tools:**Special Tools**
2	Automatic Transmission Flex Plate

CAMSHAFT COVER REMOVAL - LEFT SIDE

Oil Filler Cap and Tube, Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve Removal

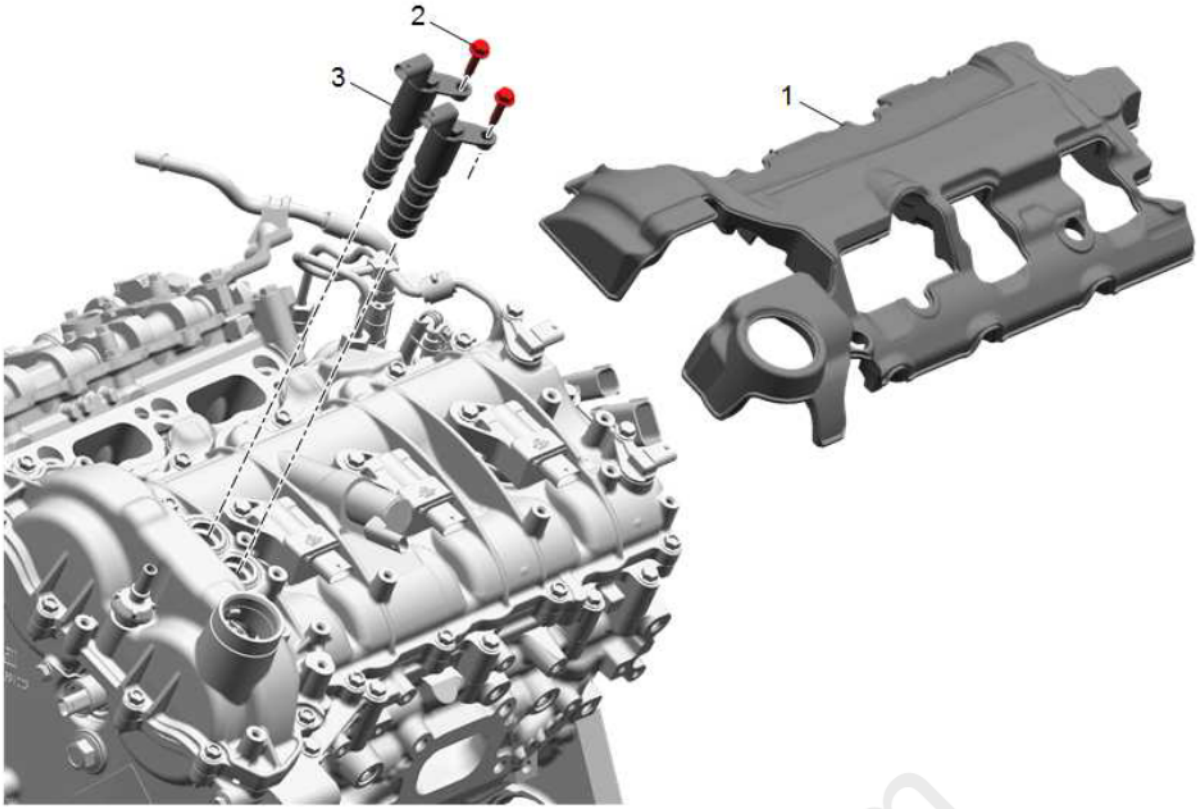


Fig. 28: Oil Filler Cap and Tube, Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Oil Filler Cap and Tube, Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve Removal

Callout	Component Name
1	Oil Filler Cap
2	Oil Filler Cap Seal **NOTE:** **Remove and DISCARD the seal.**
3	Oil Filler Cap Tube - Model Dependent
4	Oil Filler Cap Tube Seal **NOTE:** **Remove and DISCARD the seal.**
5	Camshaft Housing Cover Insulator Left Side Left Side
6	Camshaft Position Actuator Solenoid Valve Bolt [2x]
7	Camshaft Position Actuator Solenoid Valve [2x]

Ignition Coil, Spark Plugs, Camshaft Cover and Seal Removal

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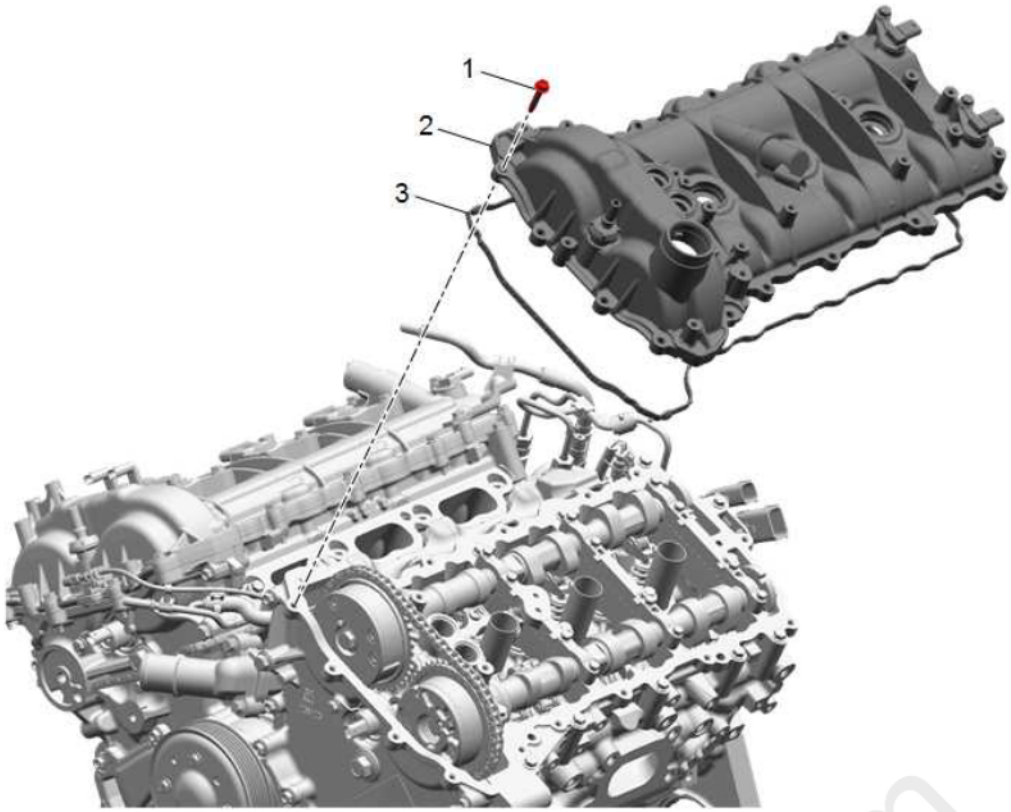


Fig. 29: Ignition Coil, Spark Plugs, Camshaft Cover and Seal
Courtesy of GENERAL MOTORS COMPANY

Ignition Coil, Spark Plugs, Camshaft Cover and Seal Removal

Callout	Component Name
1	Ignition Coil Bolt [3x]
2	Ignition Coil [3x]
3	Spark Plug [3x]
4	Camshaft Cover Bolt [18x]
5	Camshaft Cover Left Side
6	Camshaft Cover Seal Left Side **NOTE:** **Remove and DISCARD the seal.**

CAMSHAFT COVER REMOVAL - RIGHT SIDE

Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve Removal

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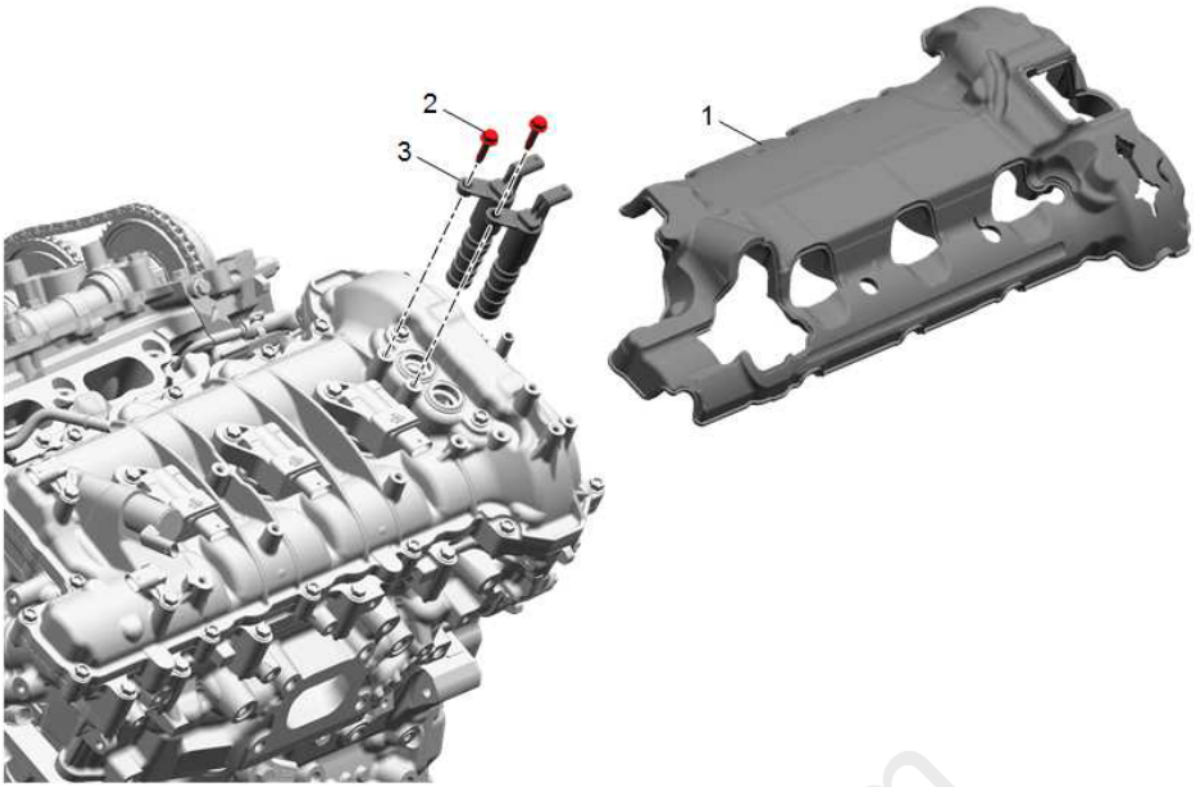


Fig. 30: Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve Removal

Callout	Component Name
1	Camshaft Housing Cover Insulator Right Side **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**
2	Camshaft Position Actuator Solenoid Valve Bolt [2x]
3	Camshaft Position Actuator Solenoid Valve [2x]

Ignition Coil, Spark Plugs, Camshaft Cover and Seal Removal

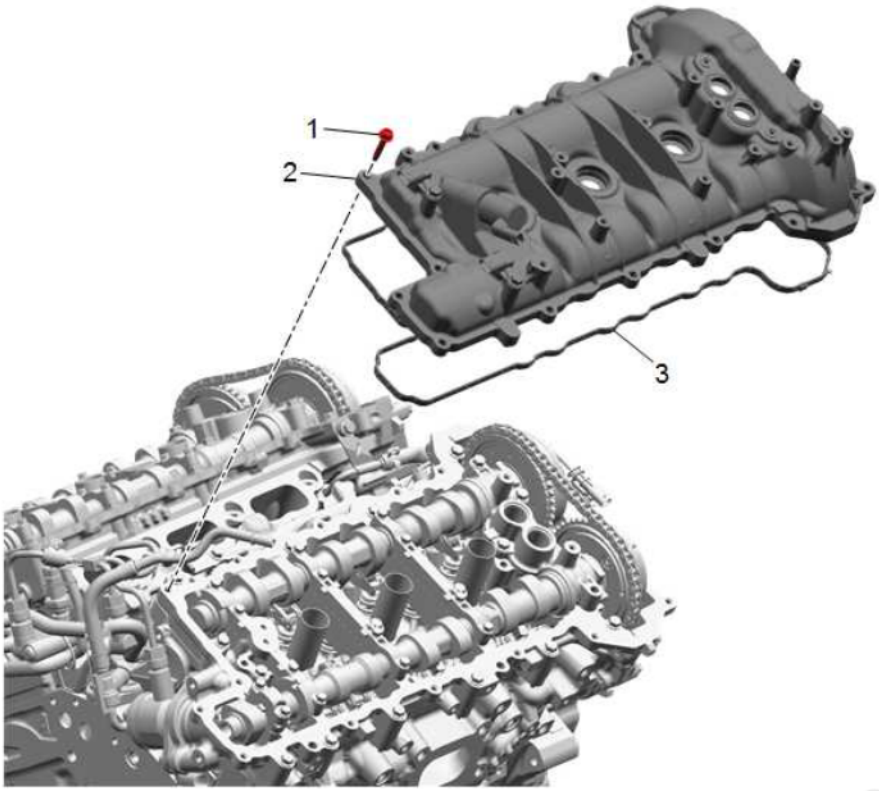


Fig. 31: Ignition Coil, Spark Plugs, Camshaft Cover and Seal
Courtesy of GENERAL MOTORS COMPANY

Ignition Coil, Spark Plugs, Camshaft Cover and Seal Removal

Callout	Component Name
1	Ignition Coil Bolt [3x]
2	Ignition Coil [3x]
3	Spark Plug [3x]
4	Camshaft Cover Bolt [18x]
5	Camshaft Cover Right Side
6	Camshaft Cover Seal Right Side **NOTE:** **Remove and DISCARD the seal.**

WATER PUMP REMOVAL

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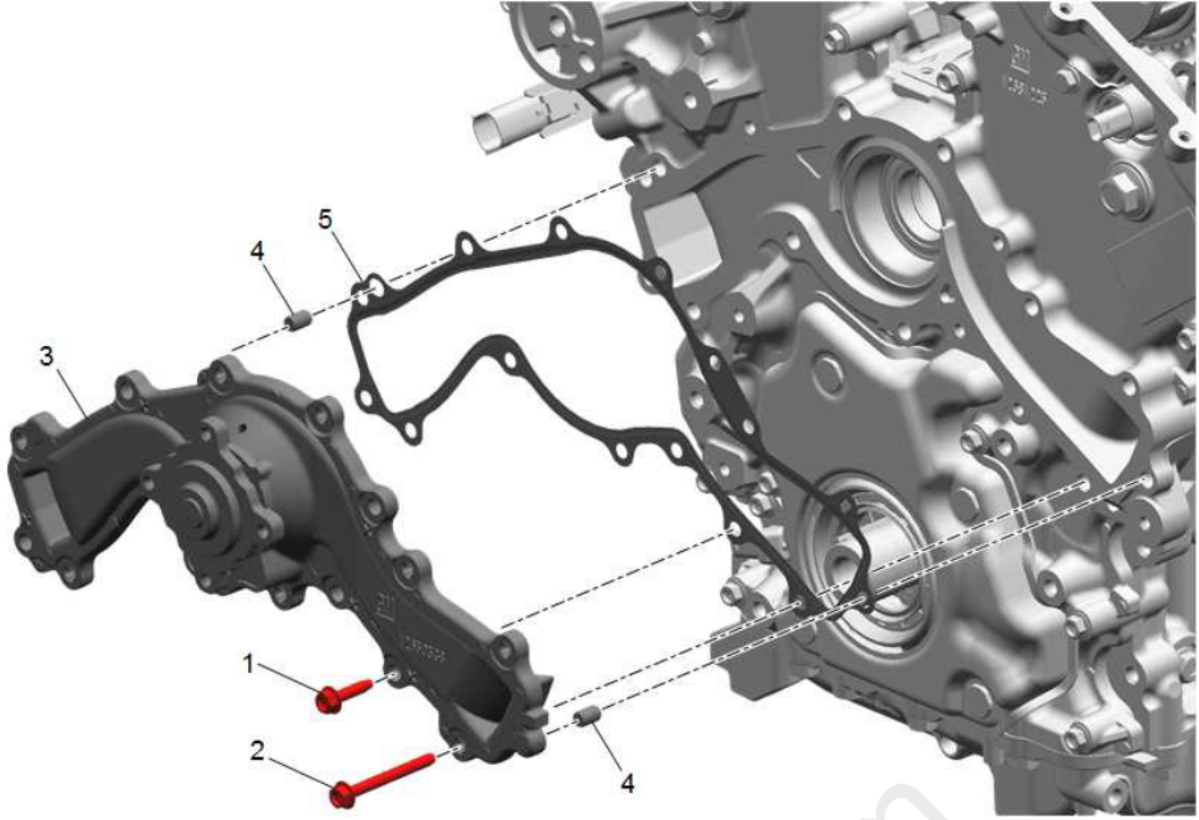


Fig. 32: Water Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Pulley Bolt [4x]
2	Water Pump Pulley **Procedure** 1. Install the **EN-46104** Water Pump Pulley Holding Tool onto the water pump pulley mounting holes. 2. Remove the water pump pulley bolts. 3. Remove the **EN-46104** Water Pump Pulley Holding Tool from the water pump pulley. **Special Tools** **EN-46104** Water Pump Pulley Holding Tool For equivalent regional tools, refer to **Special Tools** .
3	Water Pump Bolt [5x] **NOTE:** **Remove and DISCARD the bolt.**
4	Engine Front Cover Bolt [9x] **NOTE:** **Remove and DISCARD the bolt.**
5	Water Pump
6	Water Pump Locating Pin [2x]
7	Water Pump Gasket **NOTE:** **Remove and DISCARD the gasket.**

ENGINE FRONT COVER REMOVAL

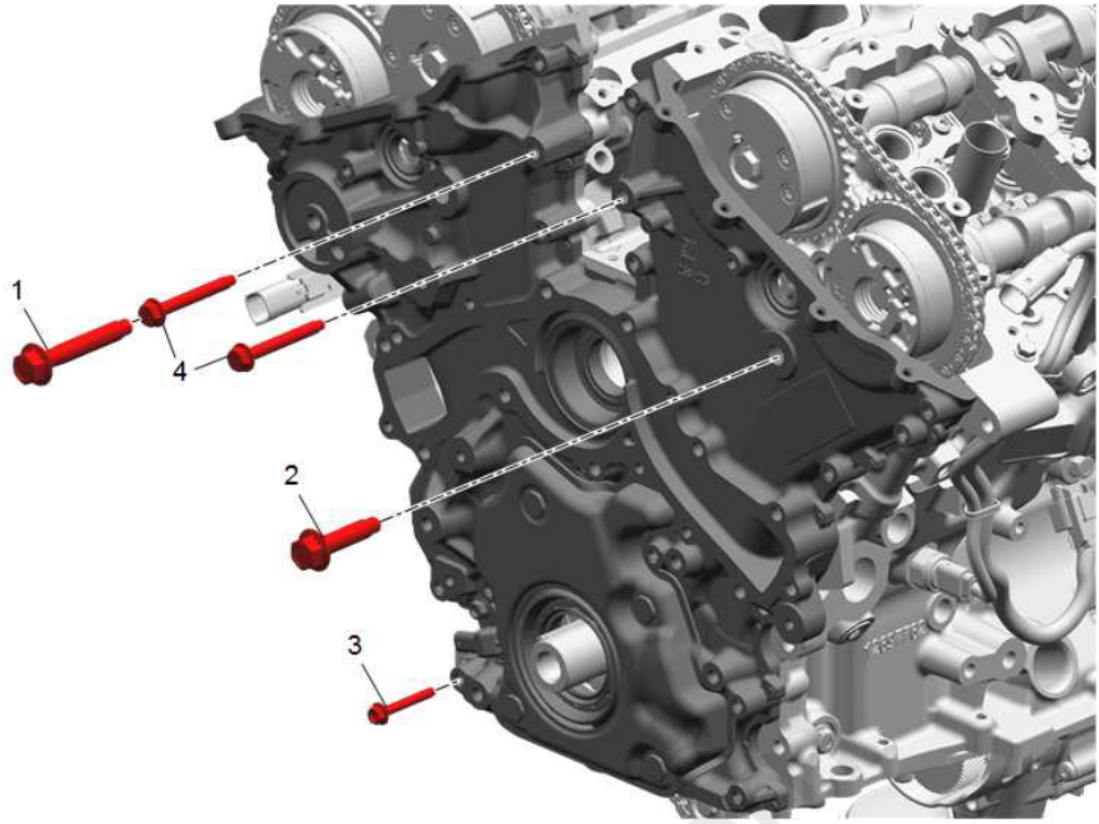


Fig. 33: Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. If the oil pan needs removed it is easier to do before the front cover removal. Refer to **Oil Pan Removal (Without Oil Cooler)** and/or **Oil Pan Removal (With Oil Cooler)**. 2. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**	
1	Oil Pump Flow Control Valve Electrical Connector **NOTE:** **The retaining clips attached to the oil pump flow control solenoid wire are used for initial production only and should be removed and discarded.**
2	Camshaft Position Actuator Control Valve Bolt [2x]
3	Camshaft Position Actuator Control Valve [2x] **CAUTION:** **The camshaft position actuator valves must be removed from the front cover prior to front cover removal or damage to the valves may occur.**
4	Engine Front Cover Bolt [2x]
5	Engine Front Cover Bolt **NOTE:** **Part of engine mount on Front Wheel Drive version.**

Callout	Component Name
6	Engine Front Cover Bolt **NOTE:** **Part of engine mount on Front Wheel Drive version.**
7	Belt Idler Pulley - Model Dependent
8	Engine Front Cover Bolt [16x]
9	Engine Front Cover **CAUTION:** **Do not use the jackscrew hole without first removing all engine front cover bolts. Failure to remove all engine front cover bolts before using the jackscrew hole could result in damage to components.** **CAUTION:** **Do not pry between the engine front cover and the camshaft position sensors or the camshaft position actuators in order to separate the RTV. Use the pry points and a bolt in the jackscrew hole in order to remove the engine front cover. Damage to the camshaft position sensors or the camshaft position actuators may occur if the camshaft position sensors or the camshaft position actuators are used to pry against in order to remove the engine front cover.**
10	Engine Front Cover Locating Pin [2x]

CAMSHAFT TIMING CHAIN COMPONENTS REMOVAL

Right Timing Chain Components Removal

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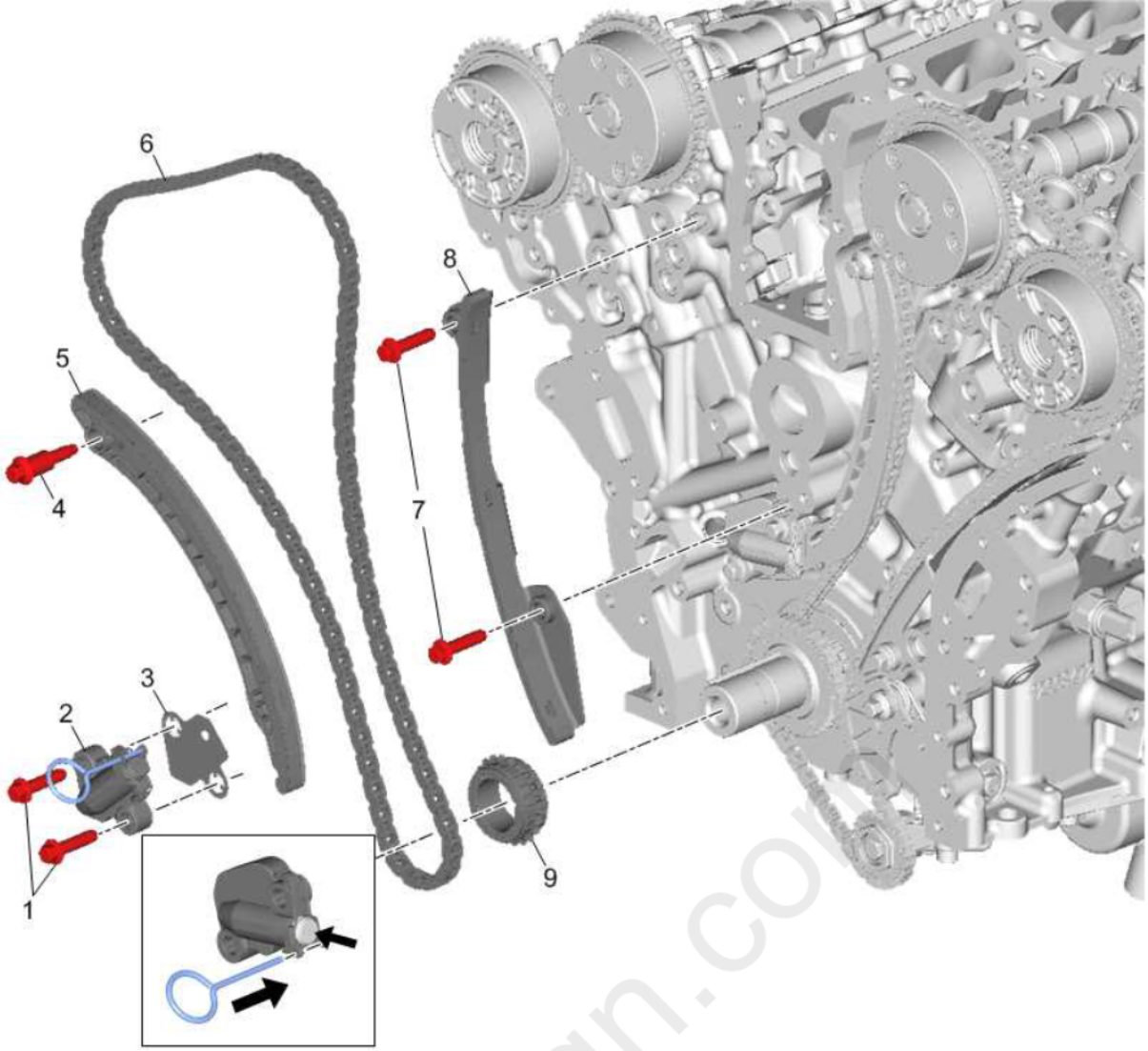


Fig. 34: Right Timing Chain Components
Courtesy of GENERAL MOTORS COMPANY

Right Timing Chain Components Removal

Callout	Component Name

WARNING:

The timing chain tensioner plunger is under high tension and must be retained by using the tensioner retraction pin during removal or installation of the timing chain tensioner. Failure to retain the timing chain tensioner plunger may cause it to be ejected with intense force and cause personal injury.

Preliminary Procedure

1. Rotate the engine clockwise until the right hand bank camshaft flats with laser etched markings are straight up in relation to the cylinder head. The crankshaft key way will be at approximately the 3 o'clock position.
2. Reset the timing chain tensioner plunger using your thumb and **EN-52234** or a 1/8" drill bit to retain the plunger.
3. Compress the plunger into the body and lock the right timing chain tensioner by inserting **EN-52234** or 1/8" drill bit into the access hole in the side of the right timing chain tensioner body.
4. Slowly release pressure on the right timing chain tensioner. The right timing chain tensioner should remain compressed.

Special Tools EN-52234 Timing Chain Tensioner Retaining PinsEquivalent regional tools: Special Tools .

1	Timing Chain Tensioner Bolt [2x]
2	Timing Chain Tensioner - Right Side

Callout	Component Name
3	Timing Chain Tensioner Gasket **NOTE:** **Remove and DISCARD the gasket.**
4	Timing Chain Guide Bolt
5	Timing Chain Guide - Right Side
6	Timing Chain - Right Side
7	Timing Chain Guide Bolt [2x]
8	Timing Chain Guide - Right Side
9	Crankshaft Sprocket

Oil Pump Timing Chain Components Removal

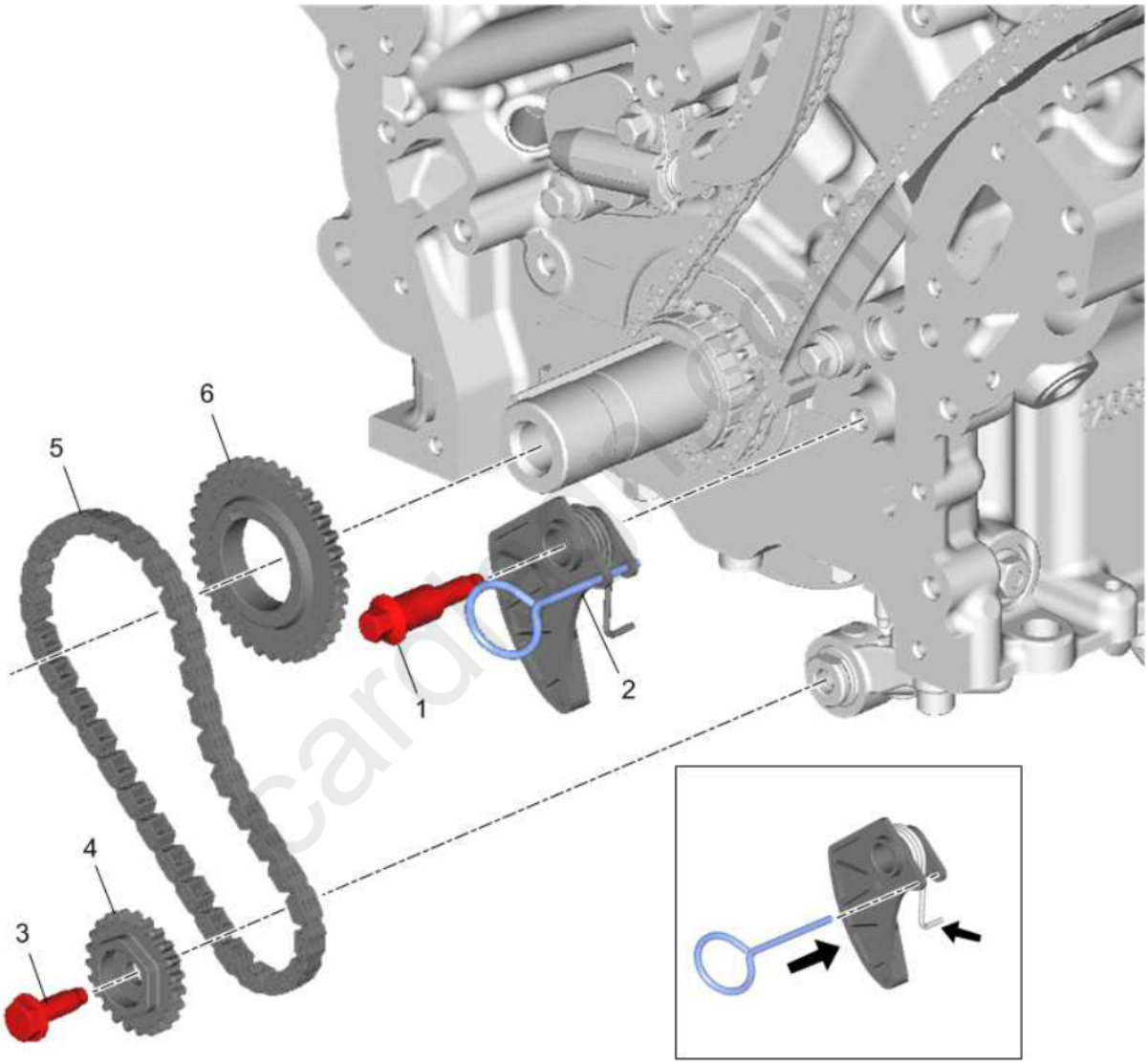


Fig. 35: Oil Pump Timing Chain Components
Courtesy of GENERAL MOTORS COMPANY

Oil Pump Timing Chain Components Removal

Callout	Component Name
1	Timing Chain Tensioner Bolt
2	Timing Chain Tensioner **Procedure** Collapse the oil pump timing tensioner by hand and install **EN-52234** or a 1/8" drill bit to hold it in place. **Special Tools** **EN-52234** Timing Chain Tensioner Retaining Pins Equivalent regional tools: **Special Tools** .

Callout	Component Name
3	Oil Pump Drive BoltÂ» Remove and DISCARD the bolt.
4	Oil Pump Sprocket
5	Oil Pump Timing Chain
6	Crankshaft Sprocket

Left Timing Chain Components Removal

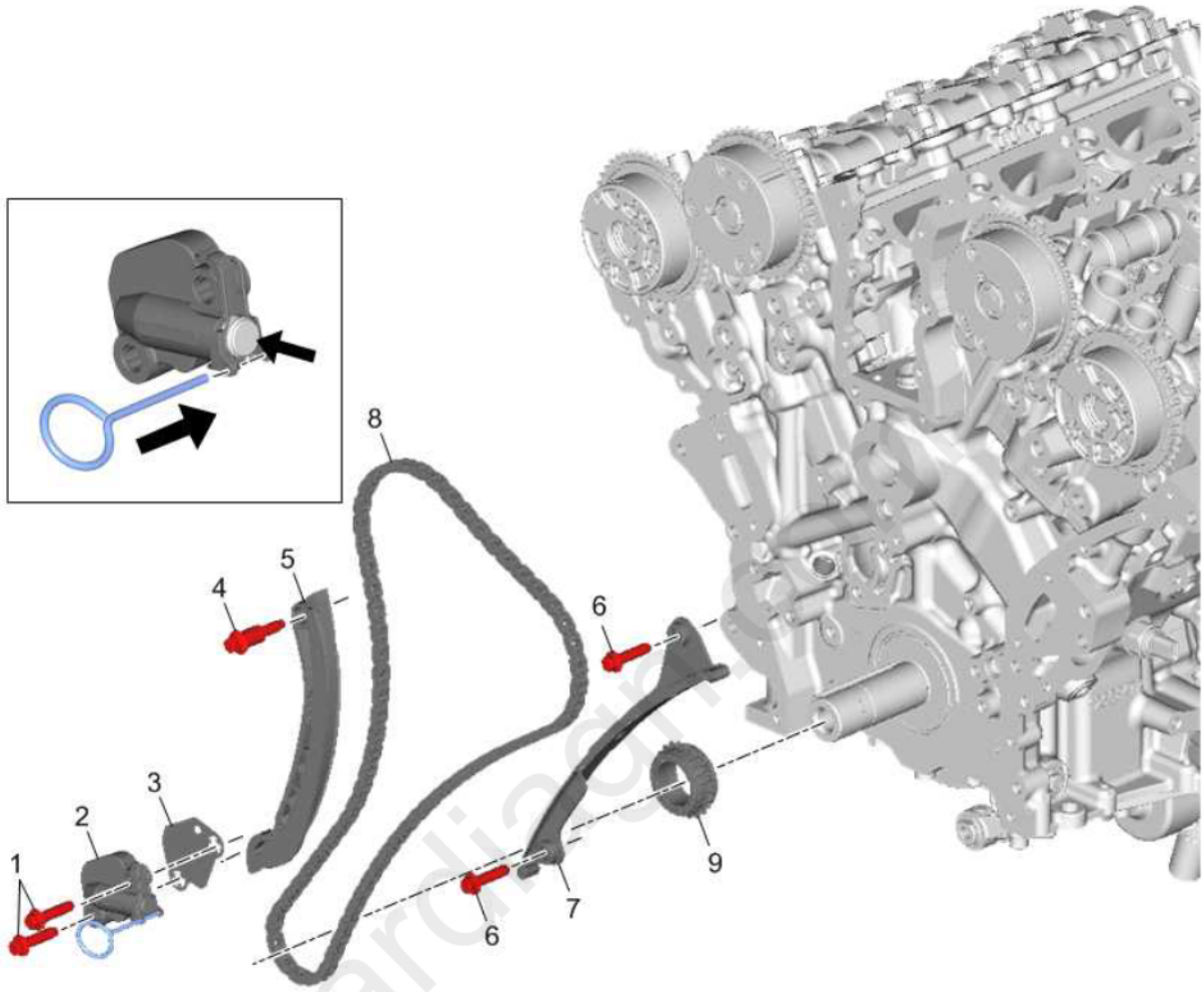


Fig. 36: Left Timing Chain Components
Courtesy of GENERAL MOTORS COMPANY

Left Timing Chain Components Removal

Callout	Component Name

Callout	Component Name

WARNING:

The timing chain tensioner plunger is under high tension and must be retained by using the tensioner retraction pin during removal or installation of the timing chain tensioner. Failure to retain the timing chain tensioner plunger may cause it to be ejected with intense force and cause personal injury.

Preliminary Procedure

1. Rotate the engine counter clockwise until the left hand bank camshaft flats with laser etched markings are straight up in relation to the cylinder head. The crankshaft key way will be at approximately the 11 o'clock position.
2. Reset the timing chain tensioner plunger using your thumb and **EN-52234** or a 1/8" drill bit to retain the plunger.
3. Compress the plunger into the body and lock the right timing chain tensioner by inserting **EN-52234** or 1/8" drill bit into the access hole in the side of the right timing chain tensioner body.
4. Slowly release pressure on the right timing chain tensioner. The right timing chain tensioner should remain compressed.

Special Tools EN-52234 Timing Chain Tensioner Retaining PinsEquivalent regional tools: **Special Tools** .

1	Timing Chain Tensioner Bolt [2x]
2	Timing Chain Tensioner - Left Side
3	Timing Chain Tensioner Gasket **Procedure** Remove and DISCARD the gasket.
4	Timing Chain Guide Bolt [2x]
5	Timing Chain Guide - Left Side
6	Timing Chain Guide Bolt [2x]
7	Timing Chain Guide - Left Side
8	Timing Chain - Left Side
9	Crankshaft Sprocket

CAMSHAFT POSITION ACTUATOR REMOVAL - BANK 2

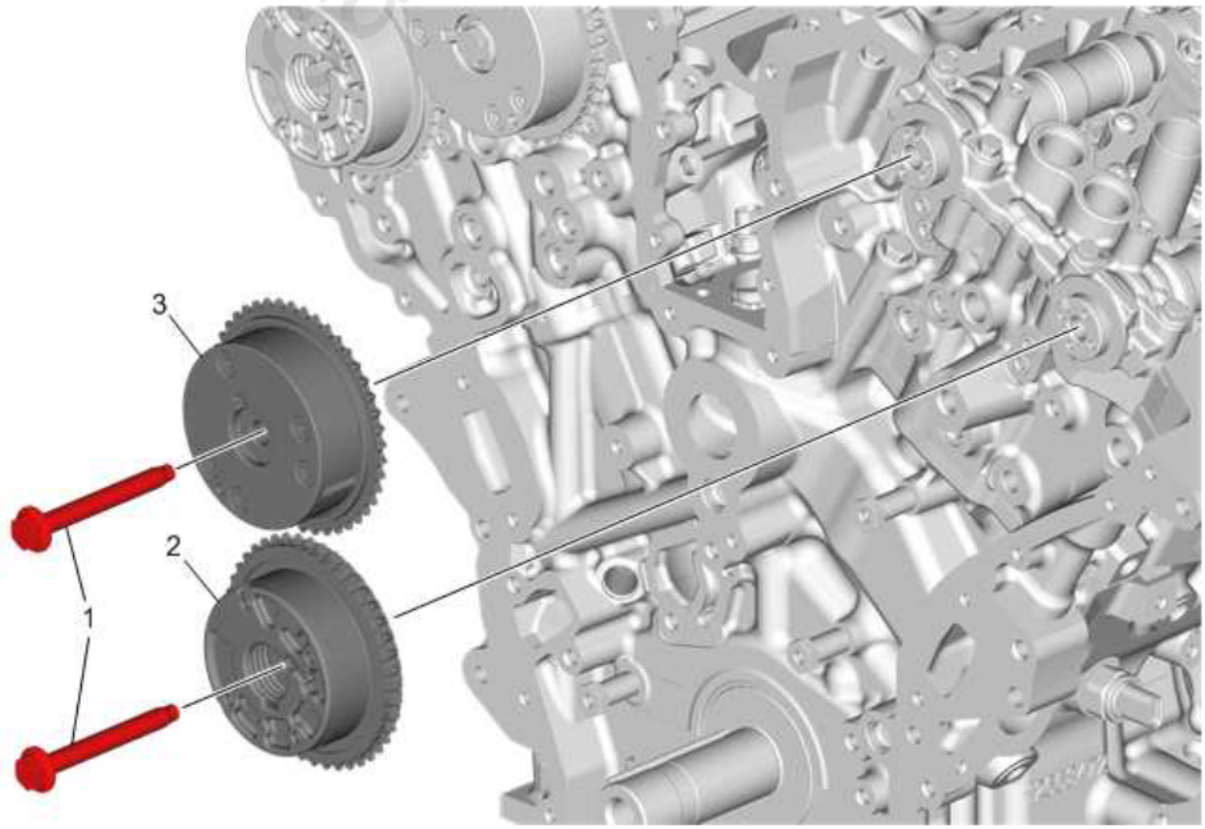


Fig. 37: Camshaft Position Actuator - Bank 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Position Actuator Bolt [2x]
2	Exhaust Camshaft Position Actuator Bank 2
3	Intake Camshaft Position Actuator Bank 2

CAMSHAFT POSITION ACTUATOR REMOVAL - BANK 1

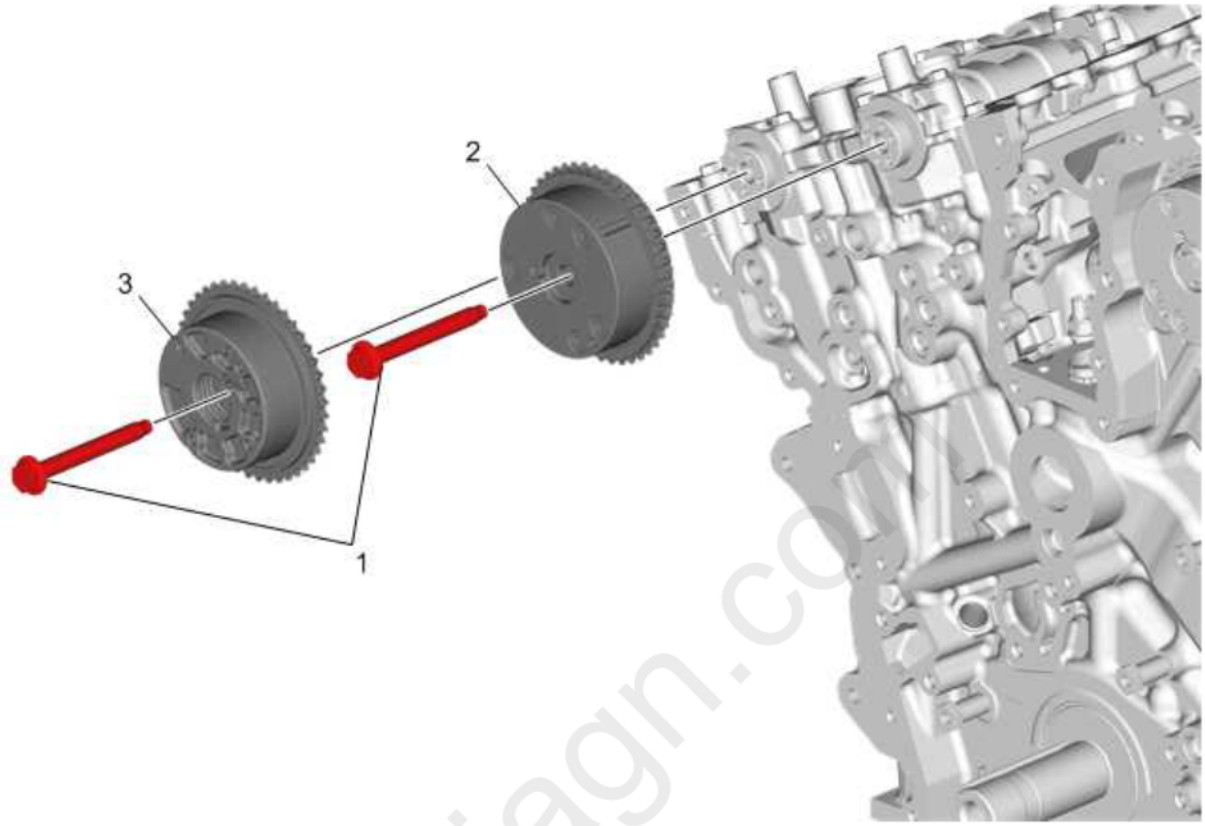


Fig. 38: Camshaft Position Actuator - Bank 1
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Position Actuator Bolt [2x]
2	Intake Camshaft Position Active Counter Bank 1
3	Exhaust Camshaft Position Actuator Bank 1

FUEL PUMP REMOVAL

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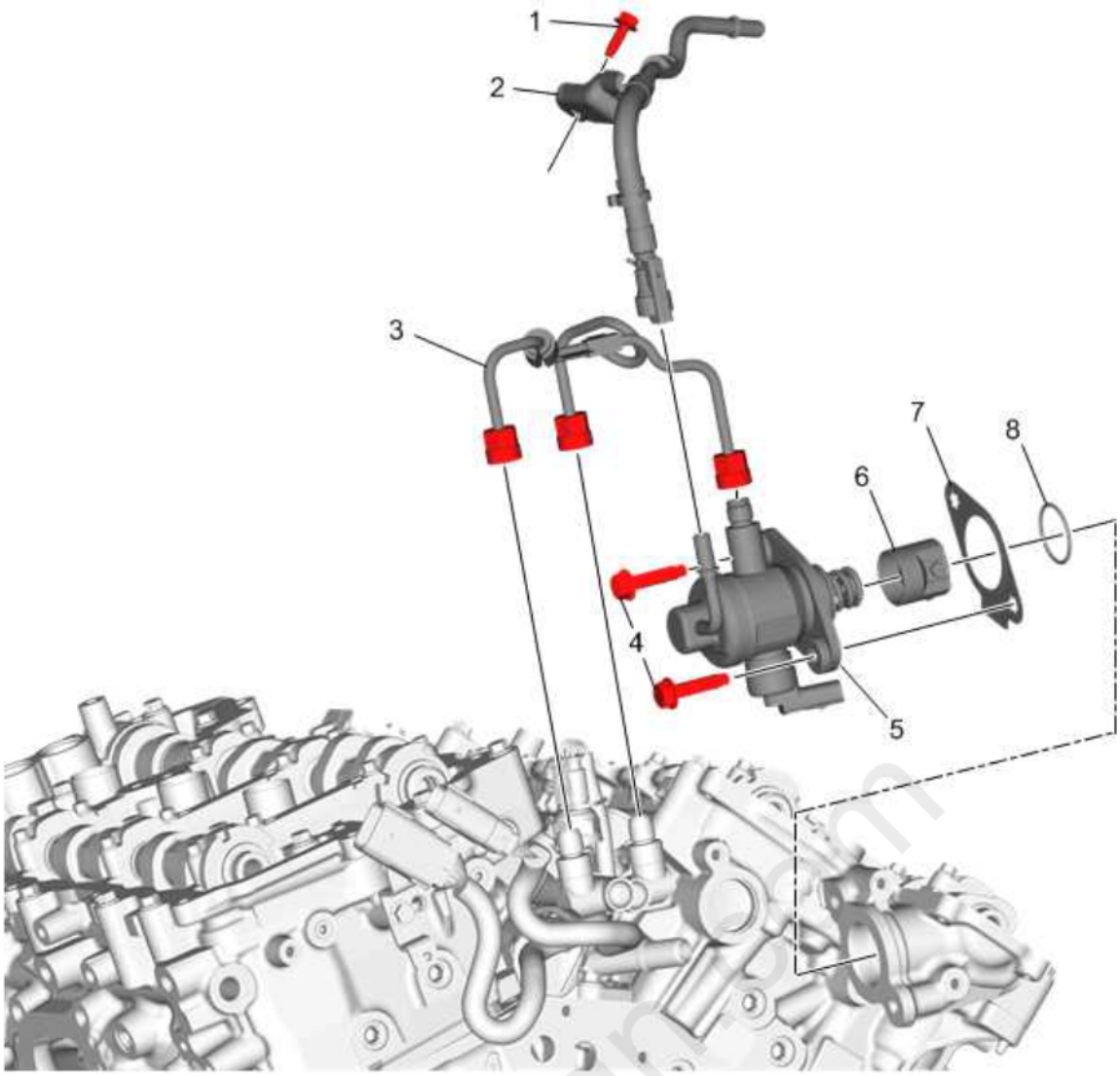


Fig. 39: Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Feed Pipe Bolt **NOTE:** **This is a camshaft cover bolt.**
2	Fuel Feed Pipe
3	Fuel Feed Intermediate Pipe **NOTE:** **Remove and DISCARD the pipe.**
4	Fuel Pump Bolt [2x] **CAUTION:** **Alternately loosen the fuel pump bolts one turn at a time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage** **NOTE:** **Remove and DISCARD the bolt.**
5	Fuel Pump
6	Valve Lifter Follower

Callout	Component Name
7	Fuel Pump Bracket Gasket **NOTE:** **If a high pressure pump is replaced on an engine which originally had a pump WITH a gasket, it must be rebuilt WITH a pump kit that includes the gasket; if a high pressure pump is replaced on an engine which originally had a pump WITHOUT a gasket, it must be rebuilt WITHOUT a gasket.**
8	Fuel Pump O-Ring **NOTE:** **Remove and DISCARD the O-ring seal.**

CAMSHAFT REMOVAL - LEFT SIDE

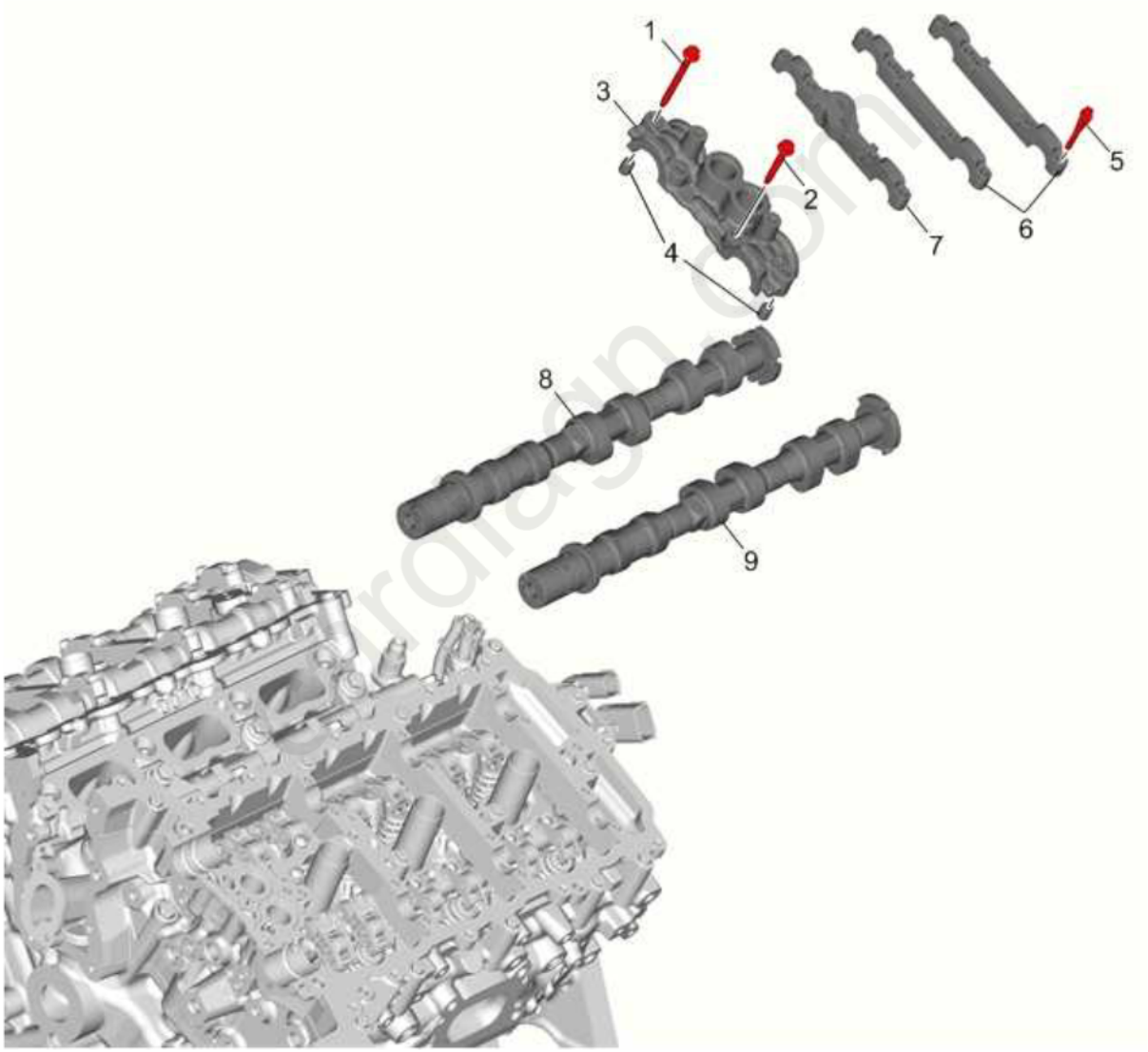


Fig. 40: Camshaft - Left Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Carrier Bolt [4x]
2	Camshaft Bearing Cap Bolt [4x]
3	Camshaft Bearing Cap
4	Dowel Pin
5	Camshaft Bearing Cap Bolt [12x]
6	Camshaft Bearing Cap

Callout	Component Name
7	Camshaft Bearing Cap
8	Intake Camshaft
9	Exhaust Camshaft

CAMSHAFT CARRIER REMOVAL - LEFT SIDE

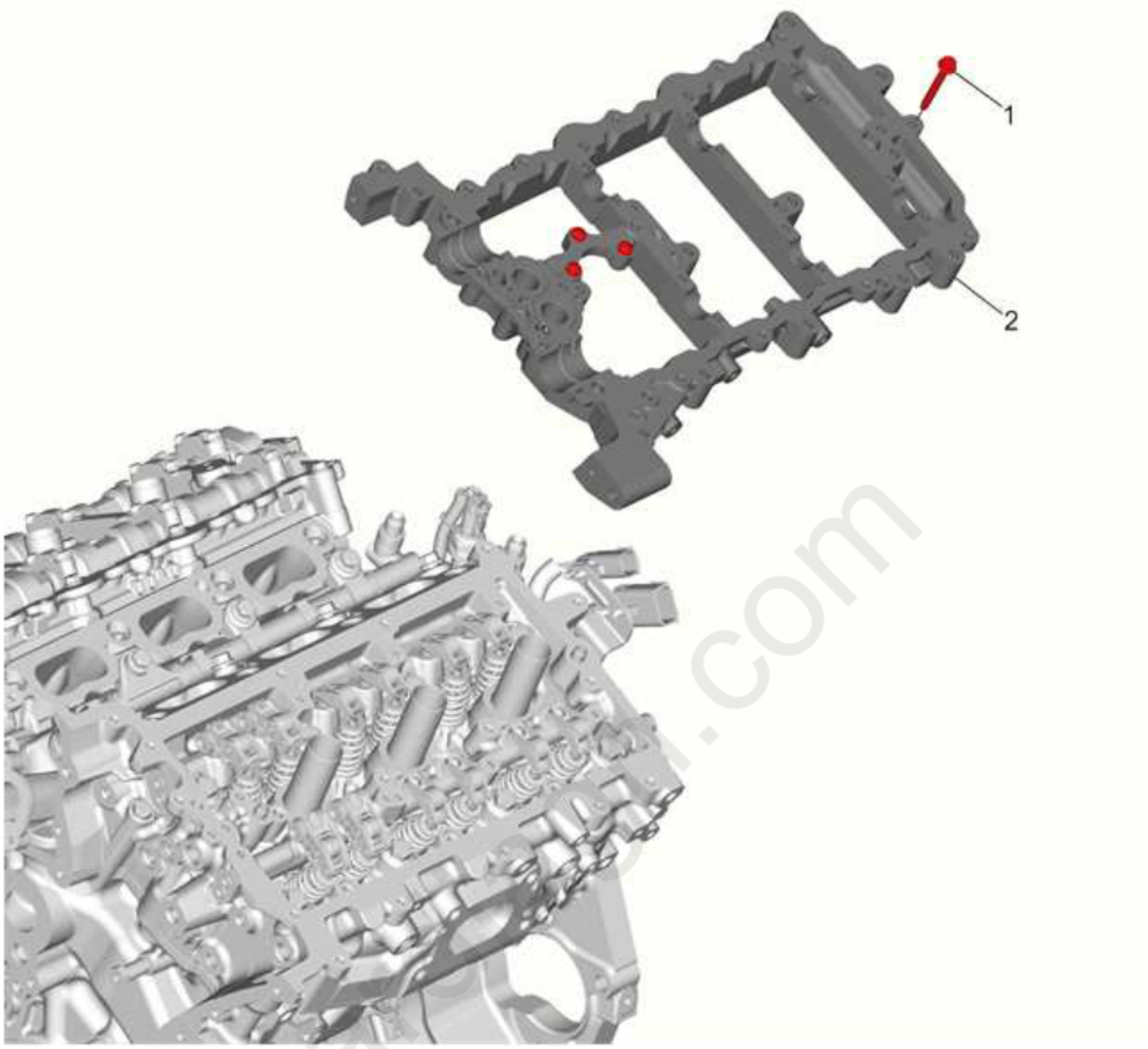


Fig. 41: Camshaft Carrier - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Carrier Bolt [13x]
2	Camshaft Carrier Left

FUEL RAIL REMOVAL

Refer to **Cylinder Head Disassemble**.

VALVE ROCKER ARM REMOVAL - LEFT SIDE

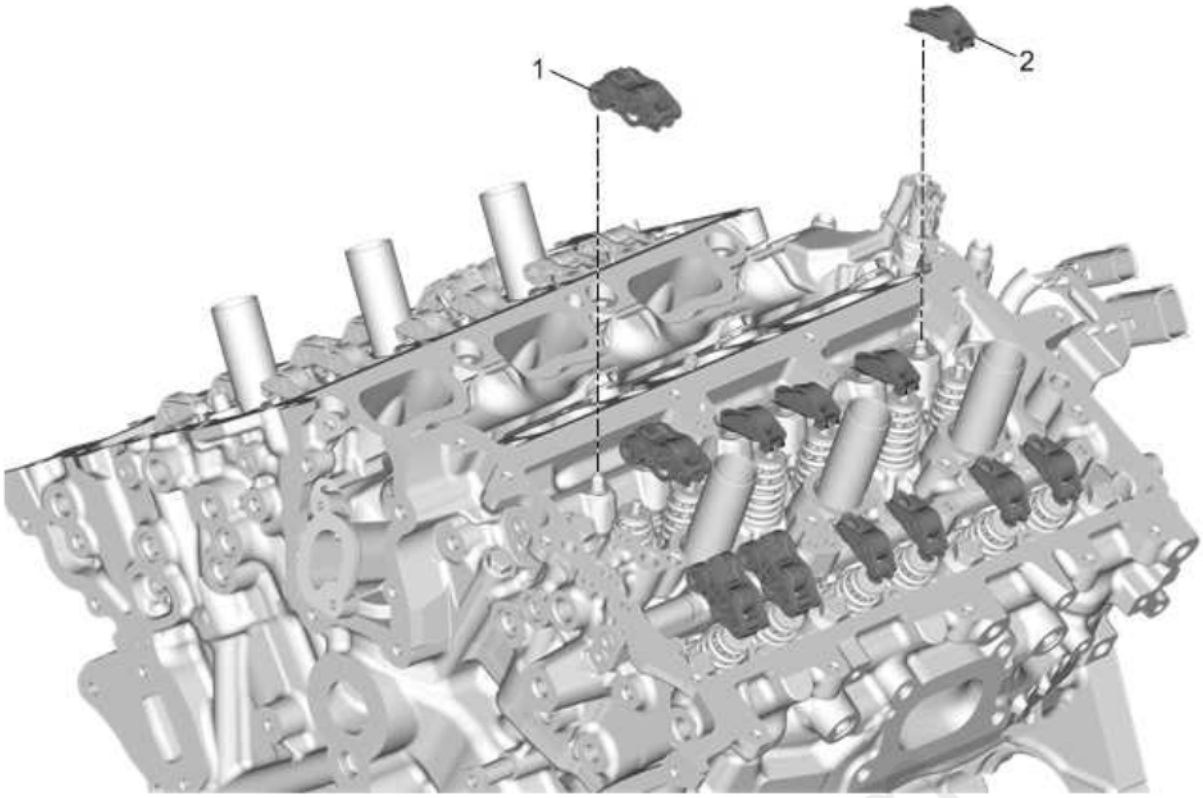


Fig. 42: Valve Rocker Arm - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Valve Rocker Switching Arm [4x] **NOTE:** **If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.**
2	Valve Rocker Arm [8x] **NOTE:** **If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.**

VALVE LIFTER REMOVAL - LEFT SIDE

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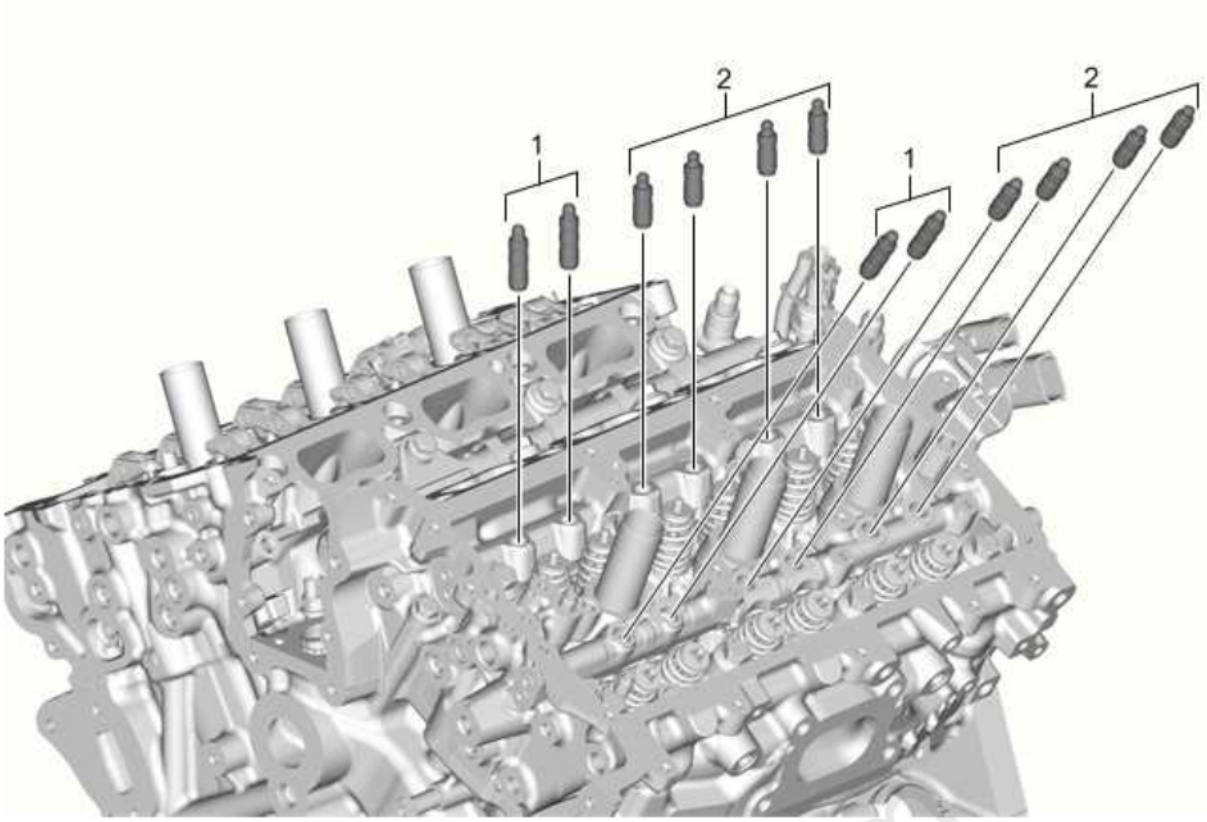


Fig. 43: Valve Lifter - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Dual Feed Hydraulic Valve Adjustor [4x] **NOTE:** **If the lifters are to be reused, keep in order so they can be reinstalled in the same position.**
2	Hydraulic Valve Lash Adjuster [8x] **NOTE:** **If the lifters are to be reused, keep in order so they can be reinstalled in the same position.**

CYLINDER HEAD REMOVAL - LEFT SIDE

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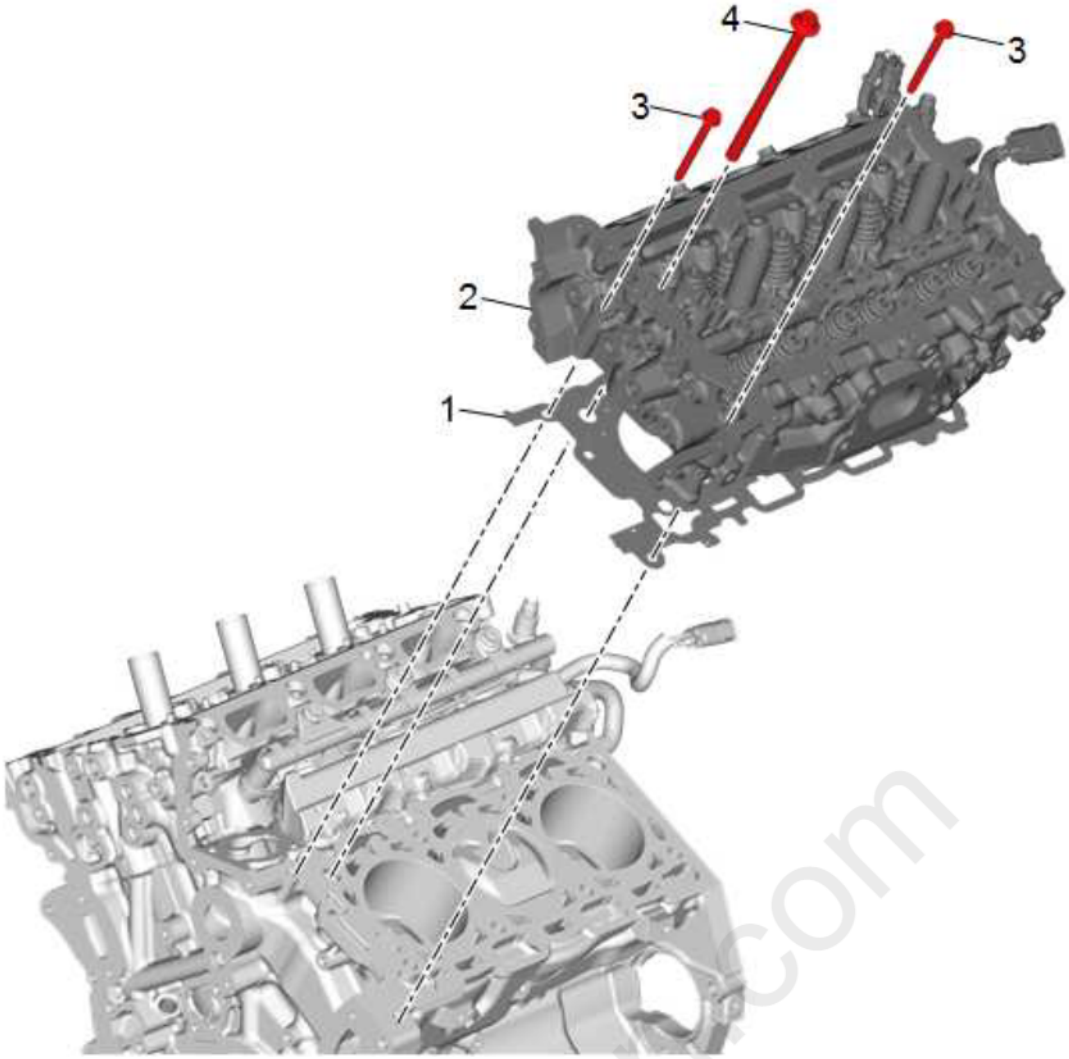


Fig. 44: Cylinder Head - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injector Wiring Harness Bracket Bolt
2	Fuel Injector Wiring Harness Bracket
3	Cylinder Head Bolt [3x]
4	Cylinder Head Bolt [8x]
5	Cylinder Head
6	Cylinder Head Gasket
7	Fuel Injection Fuel Rail Noise Shield **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**
8	Cylinder Head Locating Pin

CAMSHAFT REMOVAL - RIGHT SIDE

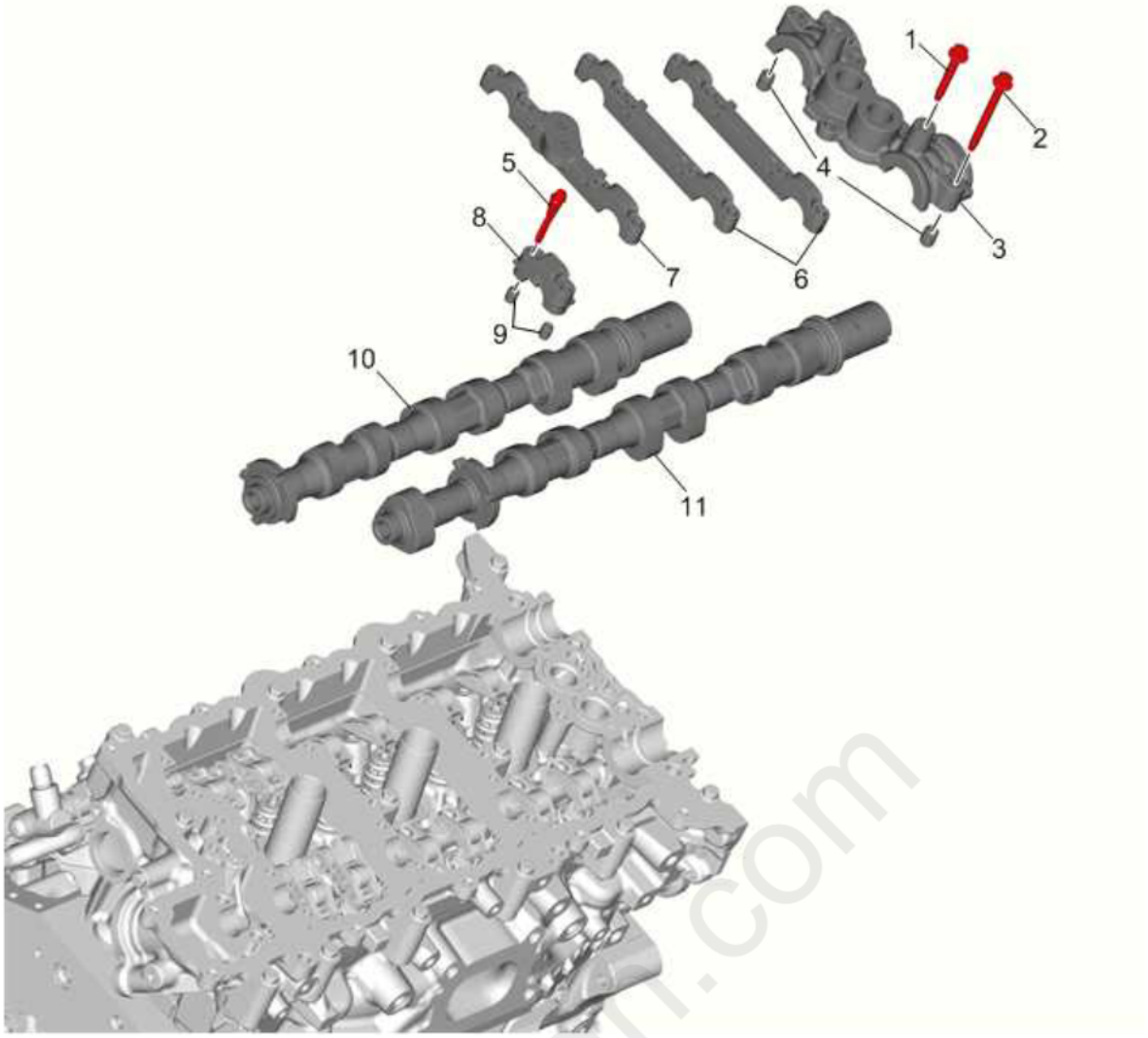


Fig. 45: Camshaft - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Bearing Cap Bolt [4x]
2	Camshaft Bearing Cap Bolt [4x]
3	Camshaft Bearing Cap
4	Dowel Pin
5	Camshaft Bearing Cap Bolt [14x]
6	Camshaft Bearing Cap
7	Camshaft Bearing Cap
8	Camshaft Bearing Cap - Intermediate
9	Dowel Pin
10	Intake Camshaft
11	Exhaust Camshaft

CAMSHAFT CARRIER REMOVAL - RIGHT SIDE

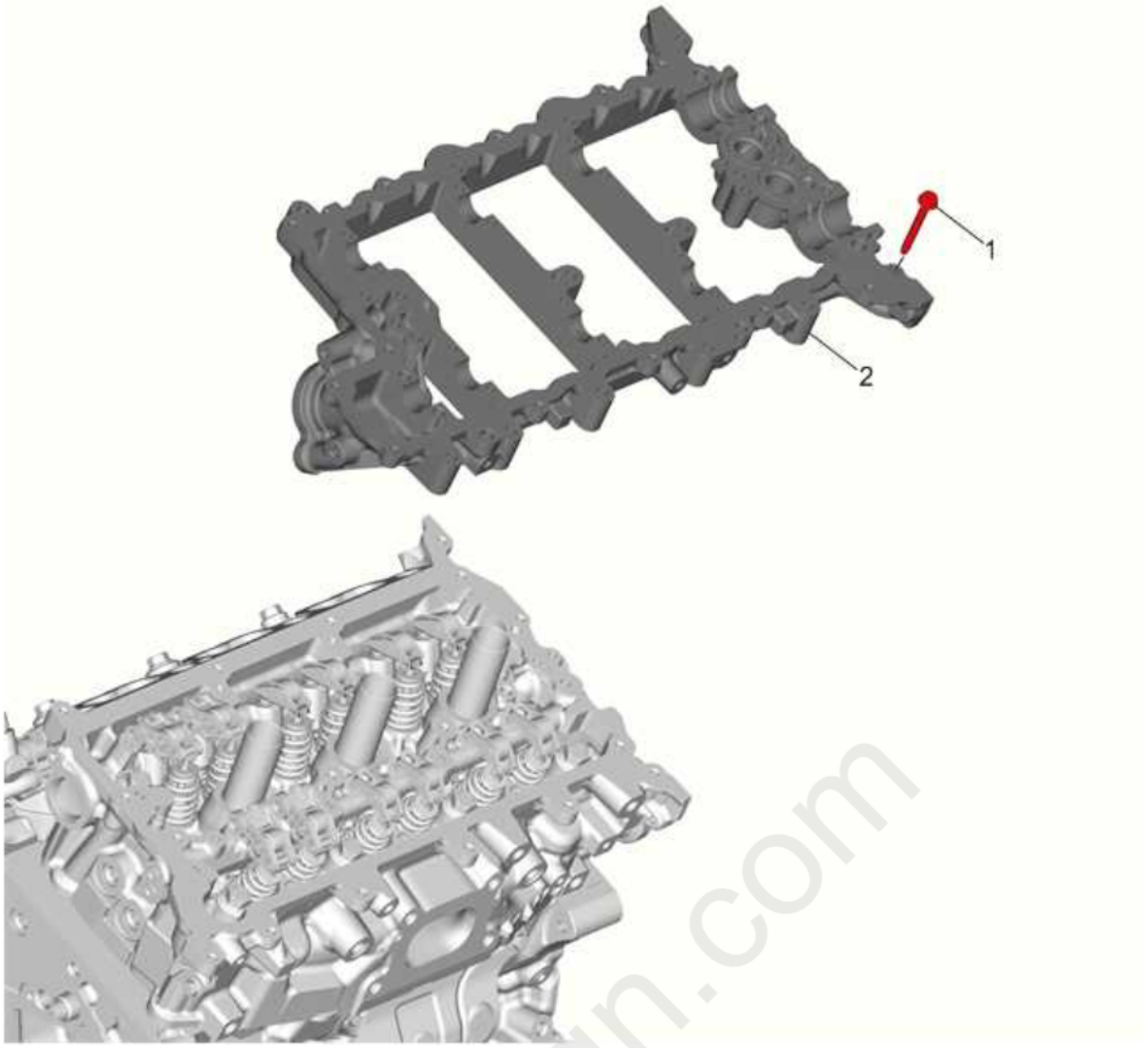


Fig. 46: Camshaft Carrier - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Carrier Bolt [14x]
2	Camshaft Carrier Right

VALVE ROCKER ARM REMOVAL - RIGHT SIDE

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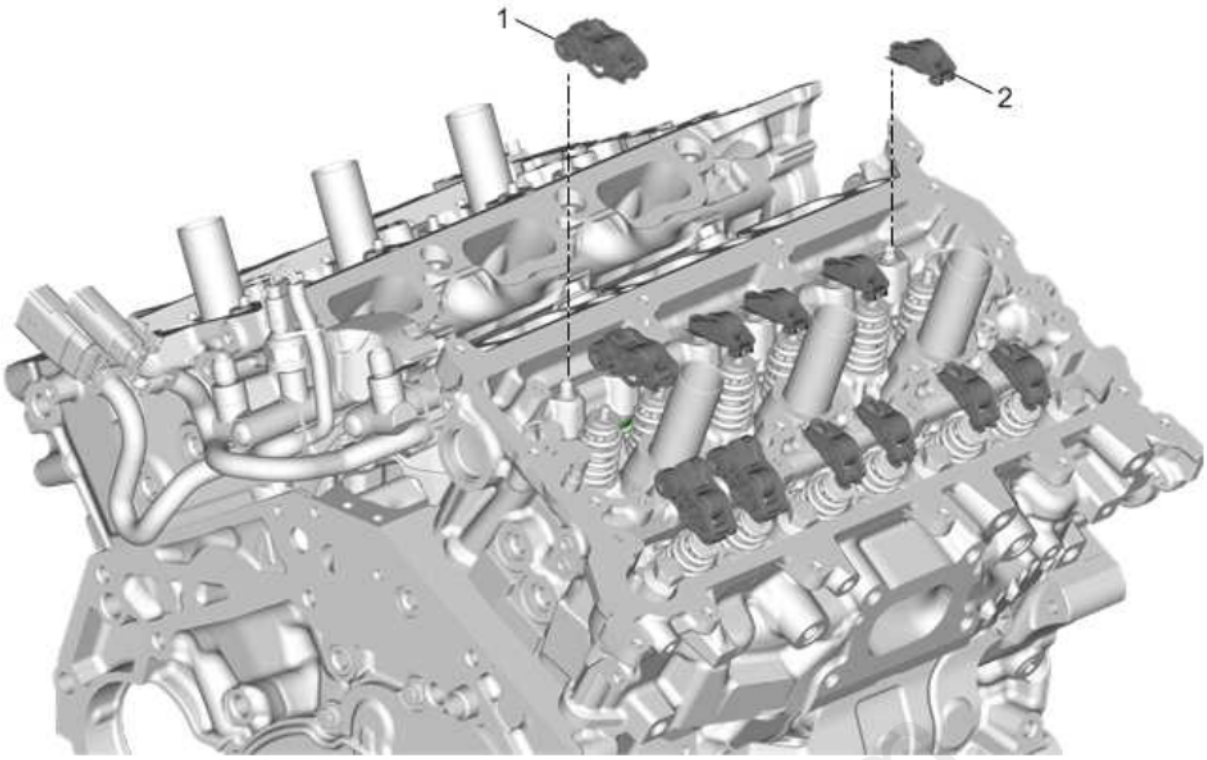


Fig. 47: Valve Rocker Arm - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Valve Rocker Switching Arm [4x] **NOTE:** **If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.**
2	Valve Rocker Arm [8x] **NOTE:** **If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.**

VALVE LIFTER REMOVAL - RIGHT SIDE

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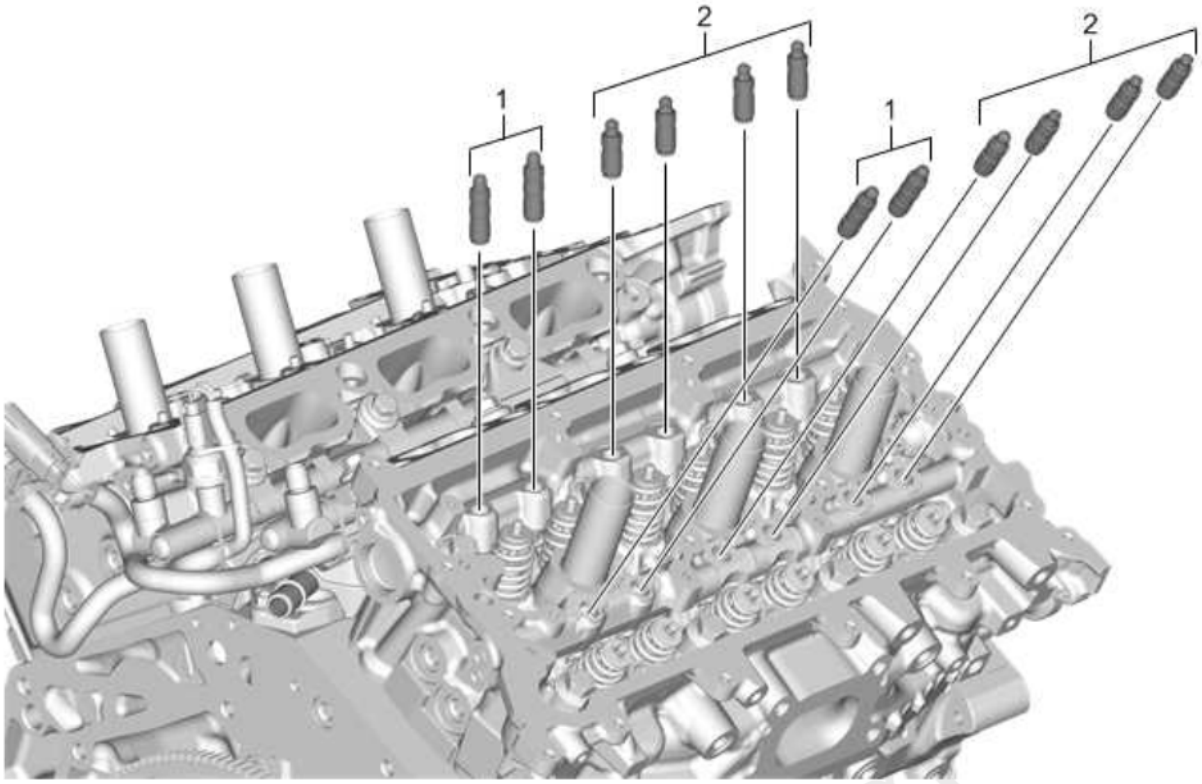


Fig. 48: Valve Lifter Removal - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Dual Feed Hydraulic Valve Adjustor [4x] **NOTE:** **If the lifters are to be reused, keep in order so they can be reinstalled in the same position.**
2	Hydraulic Valve Lash Adjuster [8x] **NOTE:** **If the lifters are to be reused, keep in order so they can be reinstalled in the same position.**

CYLINDER HEAD REMOVAL - RIGHT SIDE

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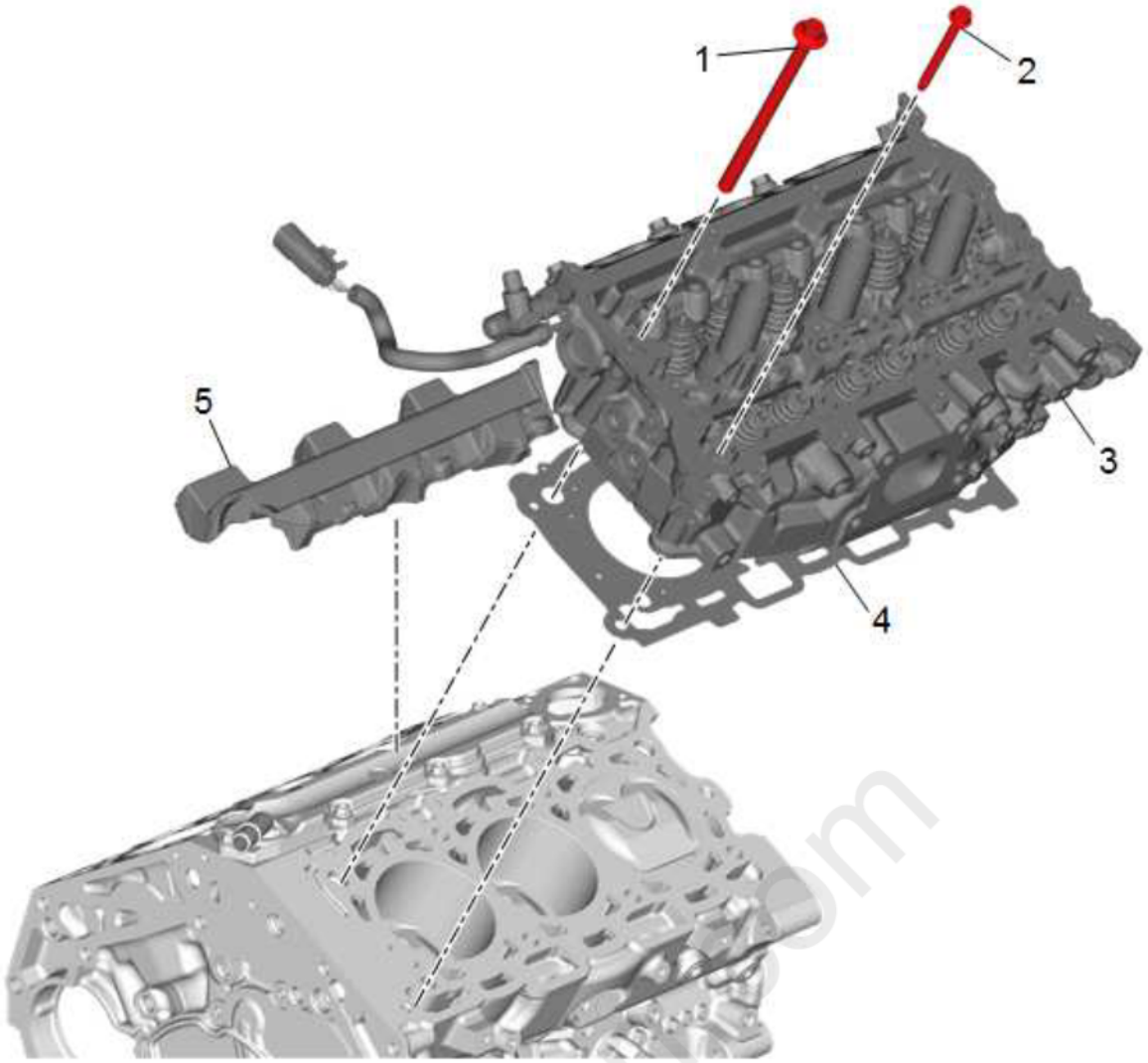


Fig. 49: Cylinder Head Removal - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Cylinder Head Bolt [8x]
2	Cylinder Head Bolt
3	Cylinder Head
4	Cylinder Head Gasket
5	Cylinder Head Locating Pin [2x]
6	Fuel Injection Fuel Rail Noise Shield **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**

POSITIVE CRANKCASE VENTILATION OIL SEPARATOR REMOVAL (LGX)

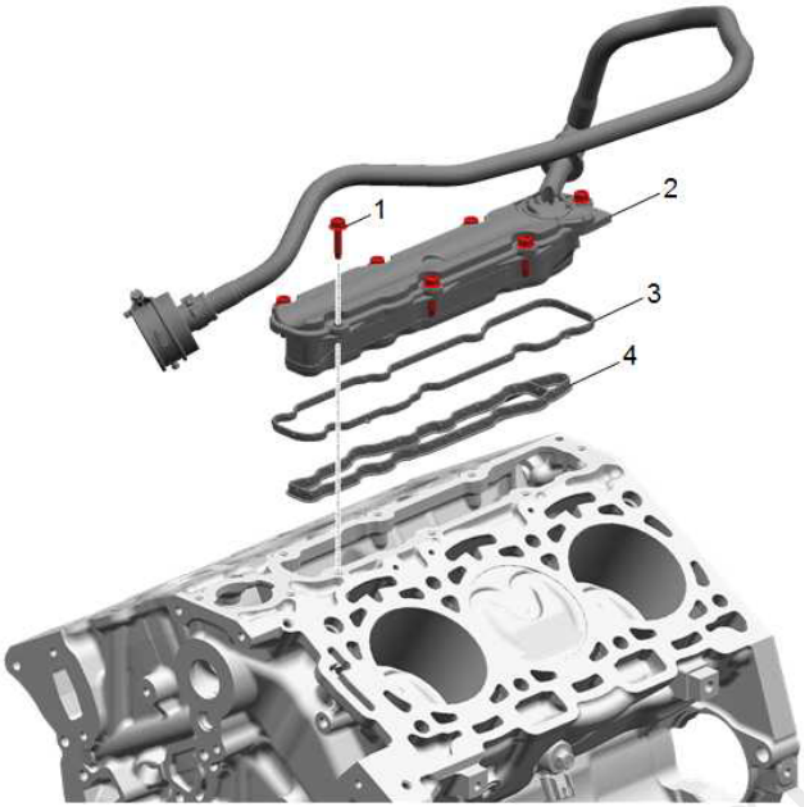


Fig. 50: Positive Crankcase Ventilation Oil Separator (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Oil Separator Bolt [7x]
2	Positive Crankcase Ventilation Oil Separator **NOTE:** **These components have tamper-proof connections and cannot be disassembled.**

POSITIVE CRANKCASE VENTILATION OIL SEPARATOR REMOVAL (LGW)

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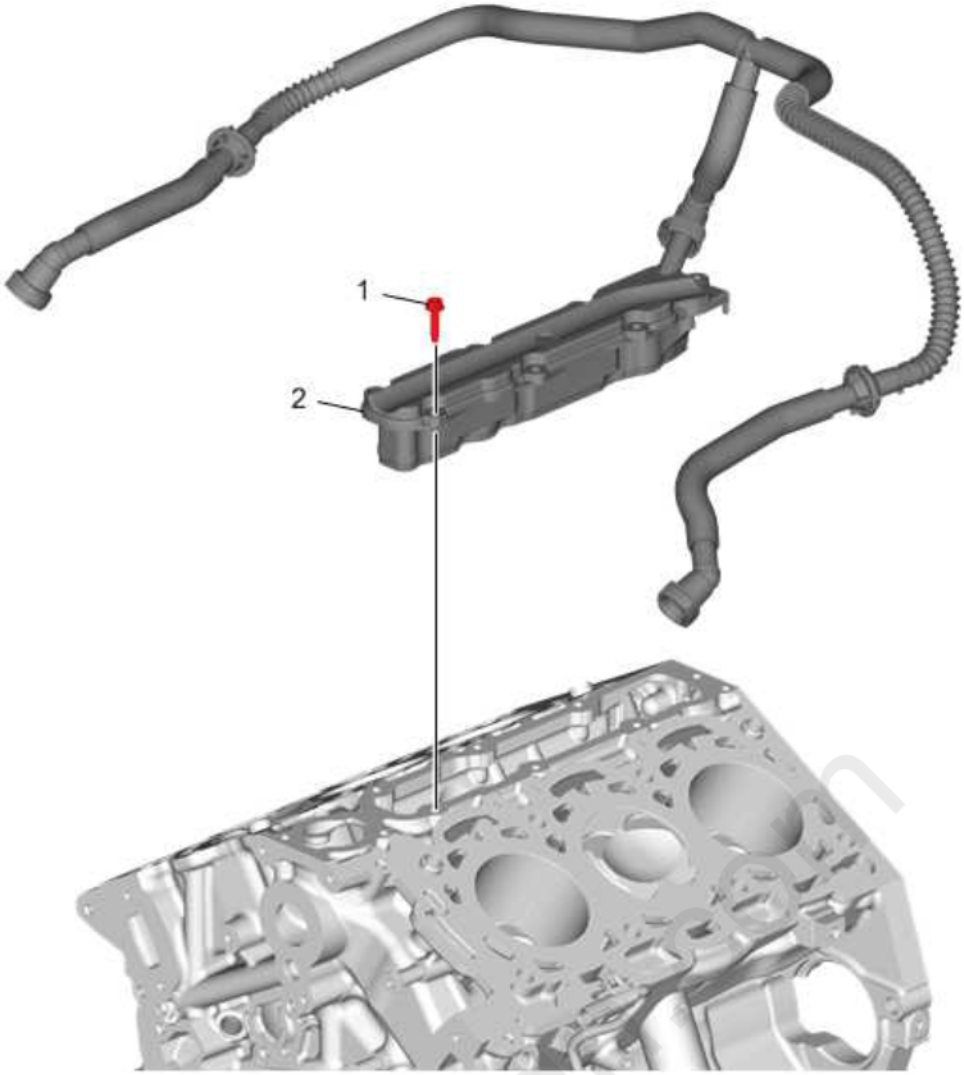


Fig. 51: Positive Crankcase Ventilation Oil Separator (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Oil Separator Bolt [7x]
2	Positive Crankcase Ventilation Oil Separator

OIL PAN REMOVAL (WITHOUT OIL COOLER)

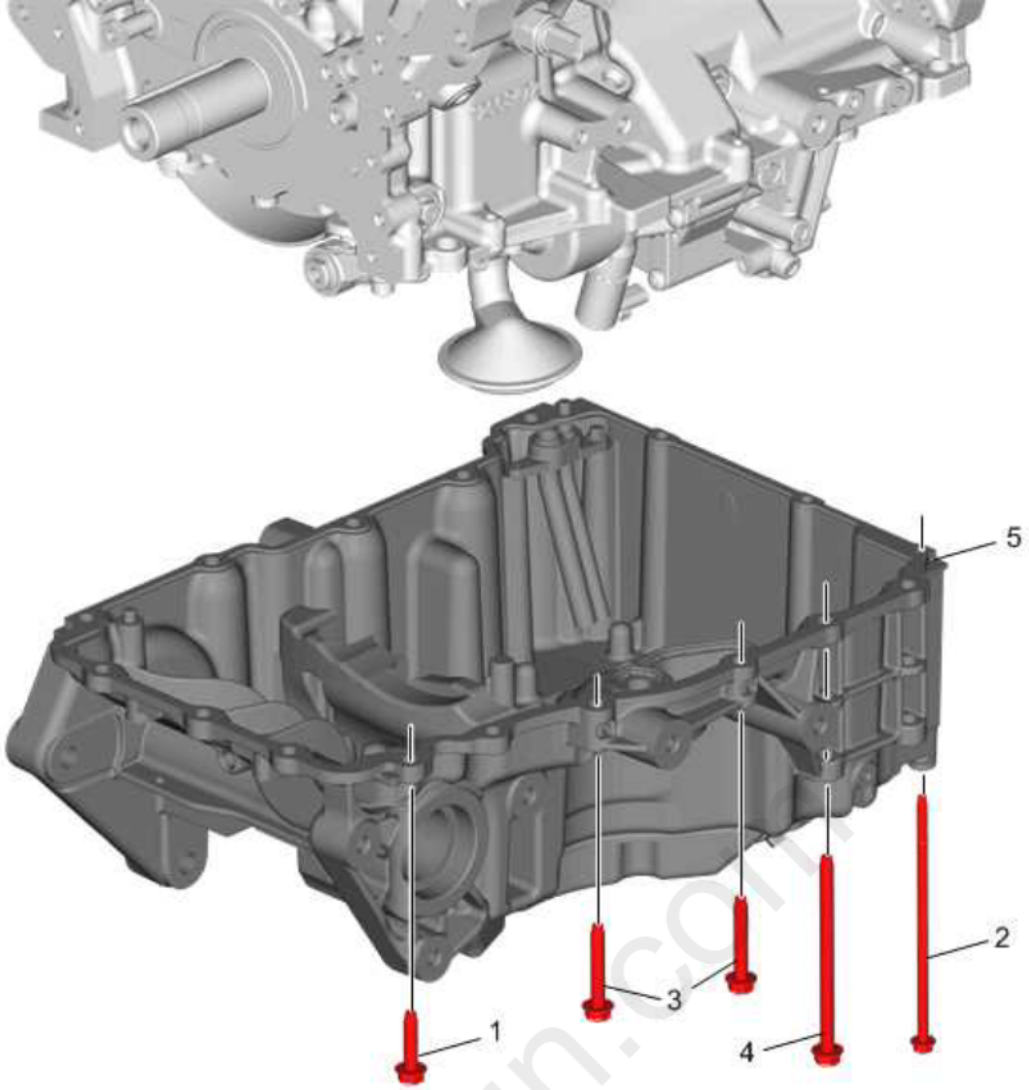


Fig. 52: Oil Pan (Without Oil Cooler)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan Bolt [7x] M8 x 35
2	Oil Pan Bolt [3x] M6 x 150 **NOTE:** **Remove and DISCARD the bolts.**
3	Oil Pan Bolt [2x] M8 x 50
4	Oil Pan Bolt [5x] M8 x 120
5	Oil Pan

OIL PAN REMOVAL (WITH OIL COOLER)

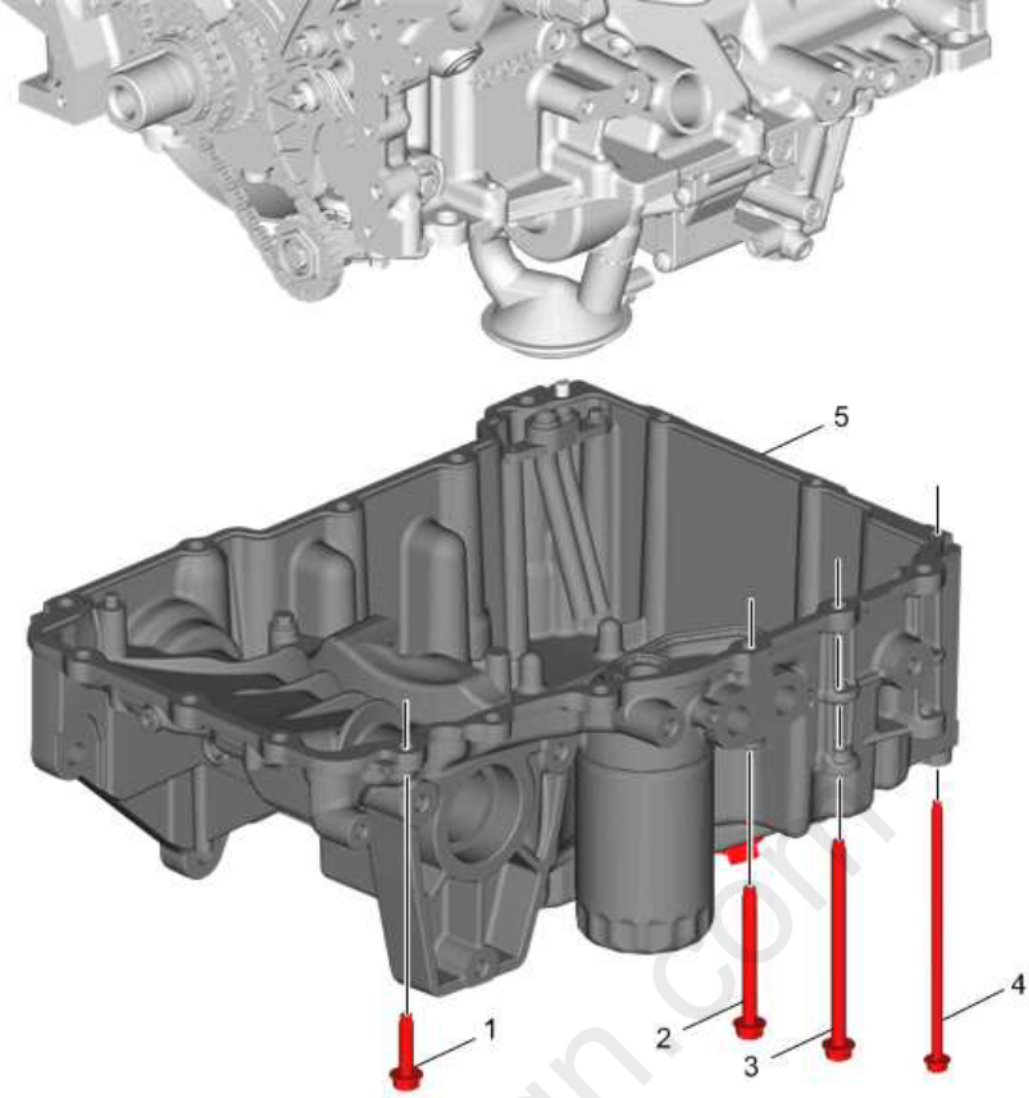


Fig. 53: Oil Pan (With Oil Cooler)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan Bolt [8x] M8 x 35
2	Oil Pan Bolt M8 x 80
3	Oil Pan Bolt [5x] M8 x 80
4	Oil Pan Bolt [3x] M6 x 150 **NOTE:** **Remove and DISCARD the bolts.**
5	Oil Pan

OIL PUMP REMOVAL

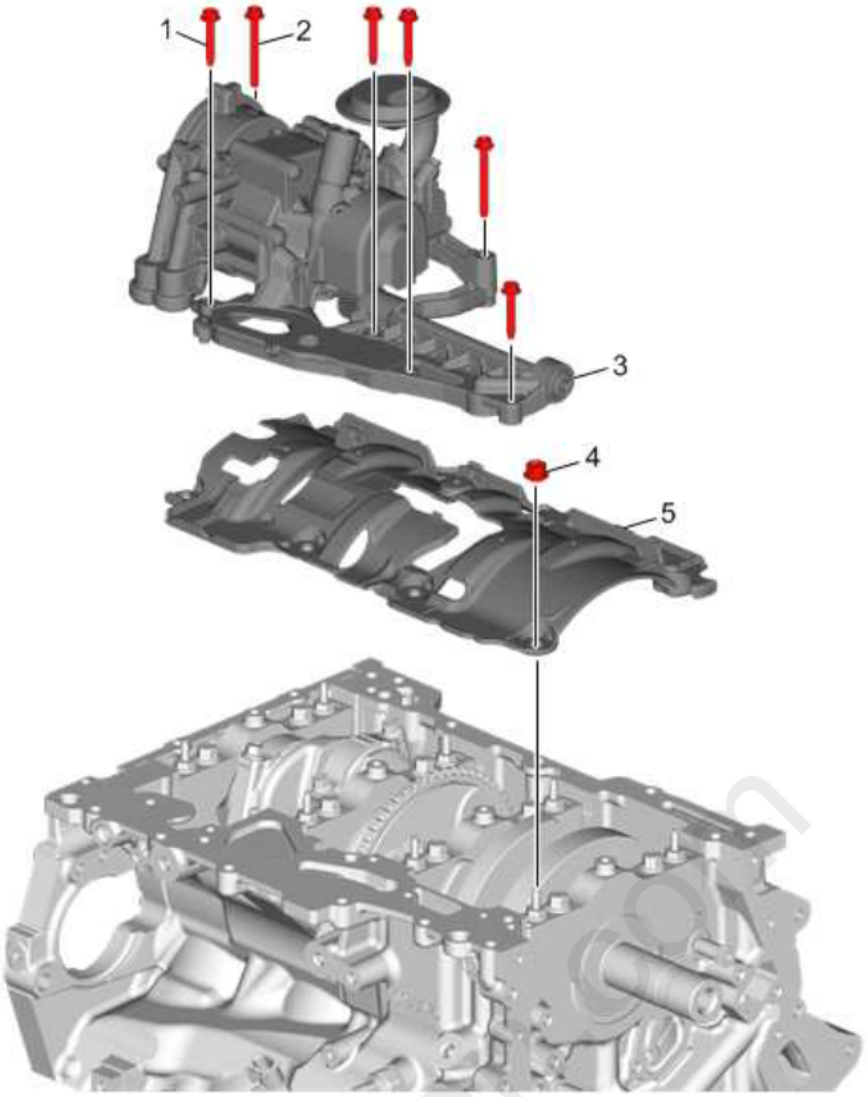


Fig. 54: Oil Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Bolt [4x] M6 x 35.65
2	Oil Pump Bolt [2x] M6 x 53.65
3	Oil Pump
4	Crankshaft Oil Deflector Nut [8x]
5	Crankshaft Oil Deflector

CRANKSHAFT REAR OIL SEAL AND HOUSING REMOVAL

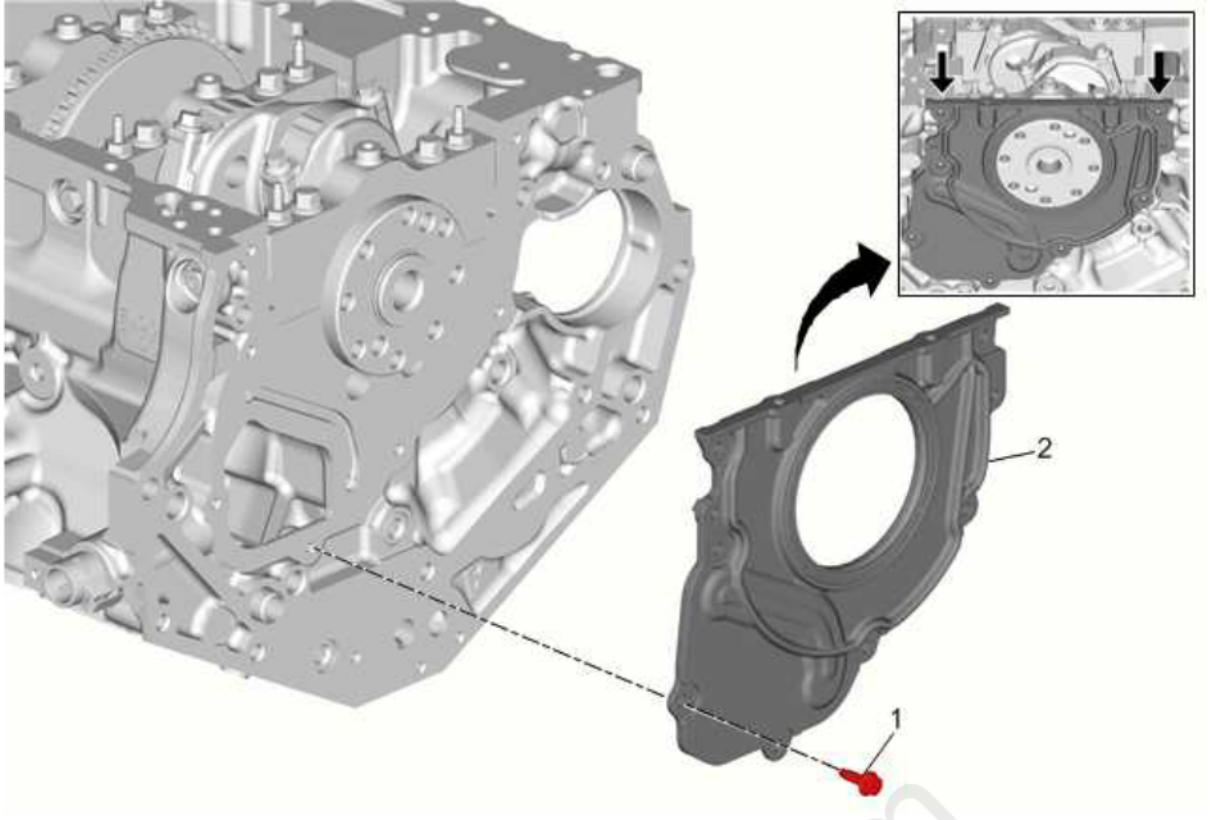


Fig. 55: Crankshaft Rear Oil Seal and Housing
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Rear Oil Seal Housing Bolt [7x]
2	Crankshaft Rear Oil Seal Housing **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Use Pry points located at the edge of the crankshaft rear oil seal housing to separate the RTV sealant. **NOTE:** **Remove and DISCARD the crankshaft rear oil seal housing.**

PISTON, CONNECTING ROD AND BEARING REMOVAL

Special Tools

EN 46121 Connecting Rod Guide Pin Set

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

1. Before removing the connecting rods, check the connecting rod side clearance using the following procedure:

NOTE: **An arrow/dot showing proper piston orientation is located on the top of the piston.**

NOTE: **If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.**

1. Tap the connecting rod to one end of the crankshaft journal with a dead-blow or wooden hammer.
2. Using feeler gauges, measure the clearance between the crankshaft counterweight and the connecting rod.
3. The connecting rod side clearance should not exceed specifications. Refer to **Engine Mechanical Specifications (LGX)** and/or **Engine Mechanical Specifications (LGW)** .
4. If the end play exceeds the specified limits, measure the width of the crankpin end of the connecting rod. Refer to **Piston, Connecting Rod and Bearing Cleaning and Inspection**.
5. If the connecting rod width is significantly smaller than specified and severe wear is present on the side of the connecting rod, replace the connecting rod.
6. If the connecting rod width is within specification and excessive scoring is present on the crankshaft journals, replace the crankshaft.

2. Using a marker, number each piston face. Draw an arrow along the centerline of the piston pointing toward the front of the engine.
3. Mark the cylinder number on the connecting rod and the connecting rod cap with a scribe, paint stick or permanent marker.

CAUTION: **Do not use a stamp, punch or any other method that may distort or stress the connecting rod or connecting rod cap. Extensive engine damage may result from a connecting rod that is distorted or stressed.**

4. Remove the connecting rod bolts.

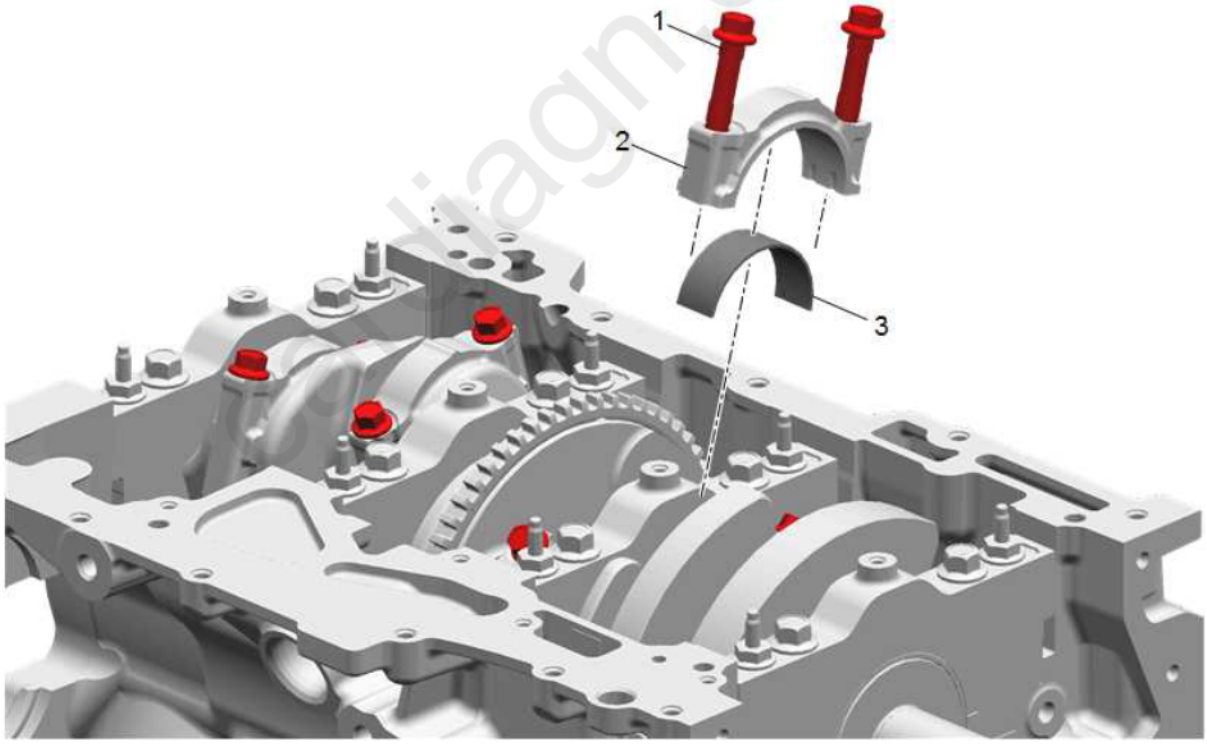


Fig. 56: View Of Connecting Rod Bearing & Cap
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Powdered metal connecting rods have rod bolts which yield when torqued. If the rod bolts are loosened or removed the rod bolts must be replaced. Rod bolts that are not replaced will not torque to the correct clamp load and can lead to serious engine damage.**

5. Remove the connecting rod cap.

NOTE: **The connecting rod caps must remain with the original connecting rod.**

6. Install the **EN 46121** set into the connecting rod bolt holes.

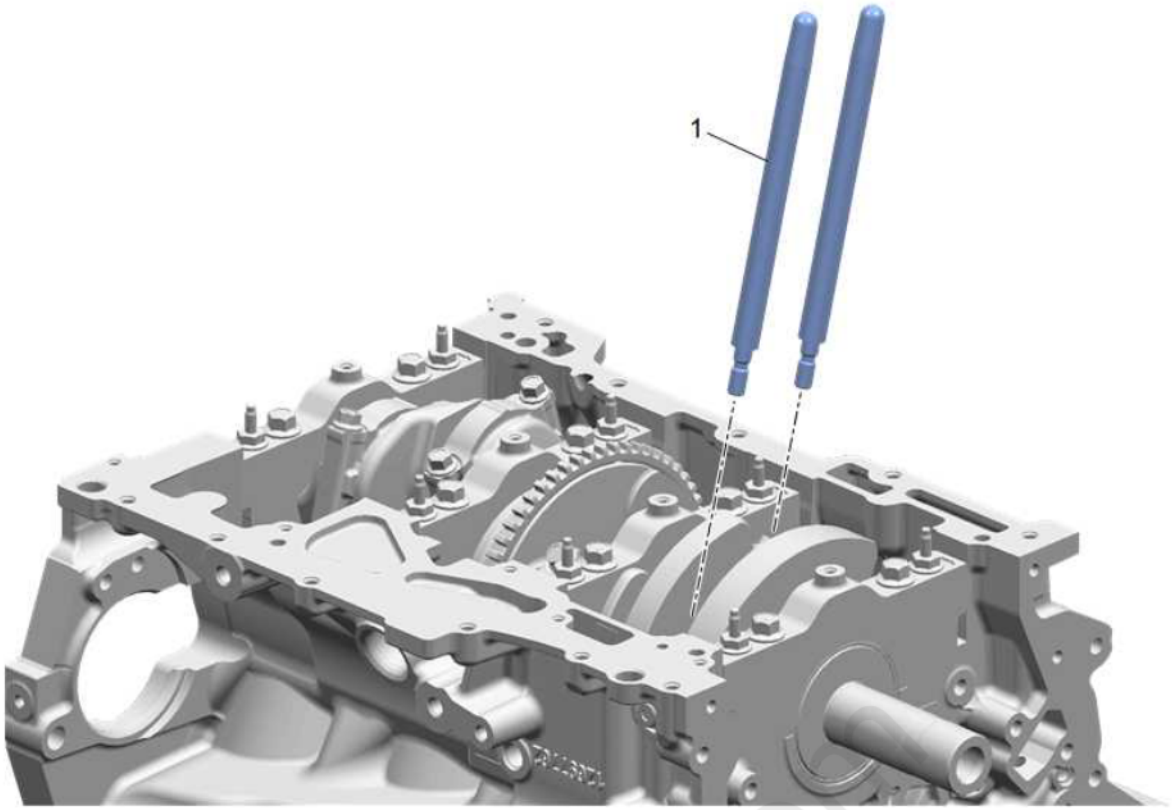


Fig. 57: Crankshaft Protector Pins Installed in Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

7. Using the **EN 46121** set, push the connecting rod and piston assembly through the top of the cylinder. DO NOT scratch the crankshaft journal or cylinder wall and DO NOT damage the oil jets when removing the connecting rod and piston assembly.

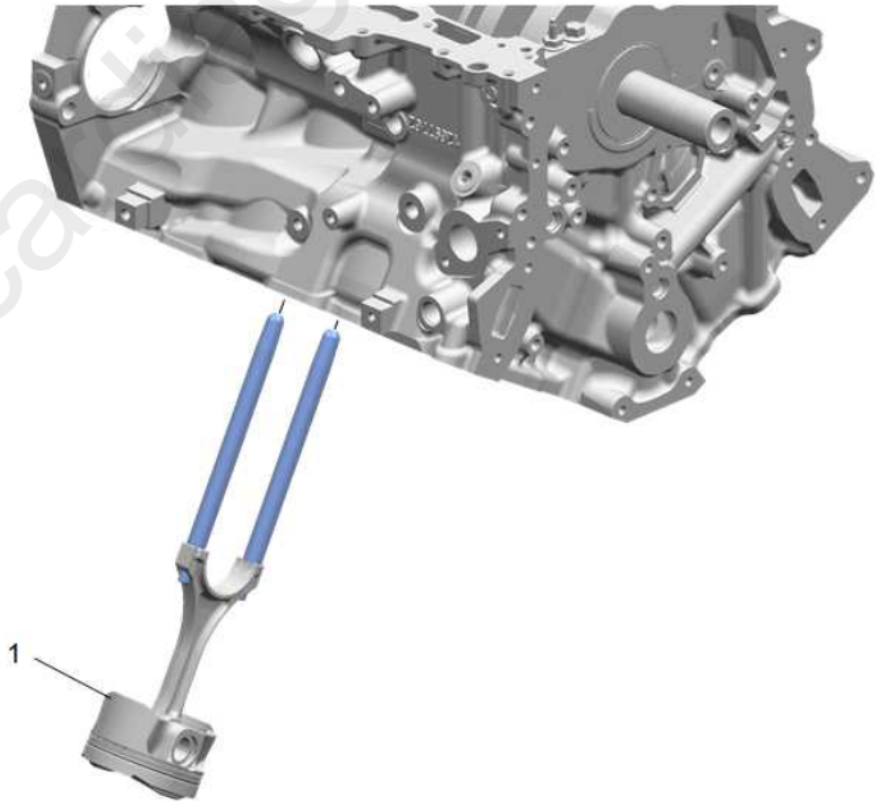


Fig. 58: View Of Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS COMPANY

8. Remove the **EN 46121** set from the connecting rod bolt holes.

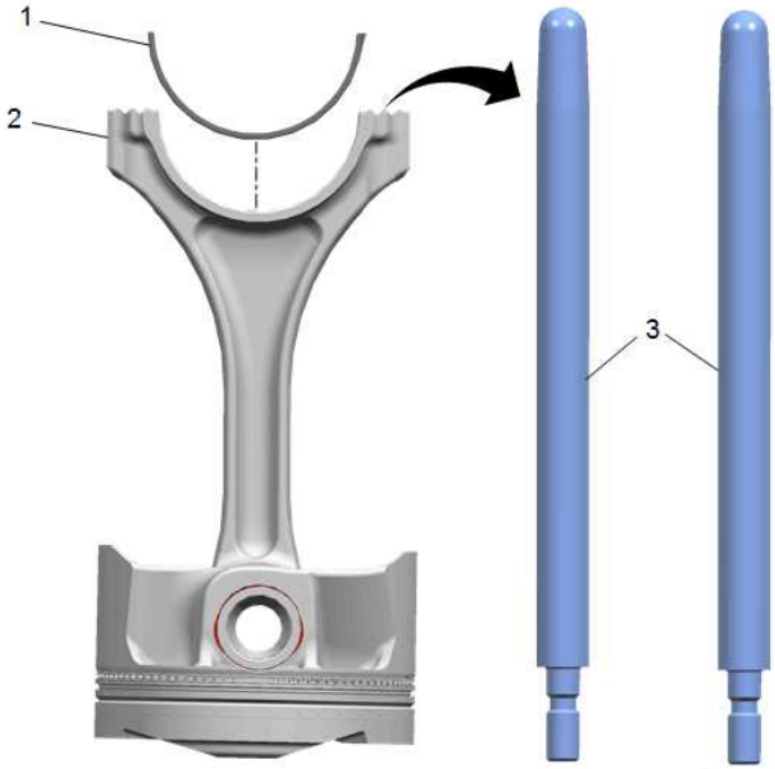


Fig. 59: Crankshaft Protector Pins Installed in Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

9. Remove the upper connecting rod bearing from the connecting rod.
10. Remove the lower connecting rod bearing from the connecting rod cap.

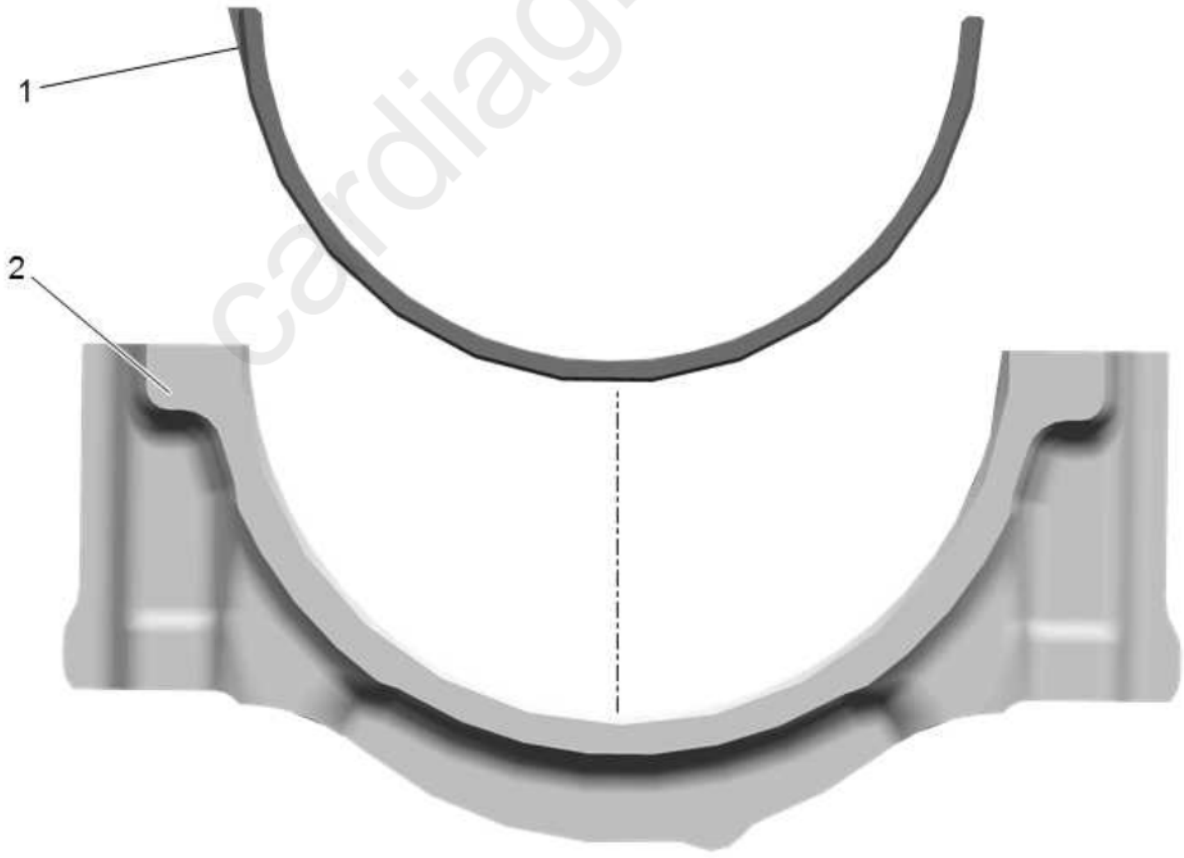


Fig. 60: View Of Lower Connecting Rod Cap & Bearing
Courtesy of GENERAL MOTORS COMPANY

11. Reattach the connecting rod cap to the connecting rod to prevent damage to their mating surfaces. The cap and rod are a matched set and must be kept together.

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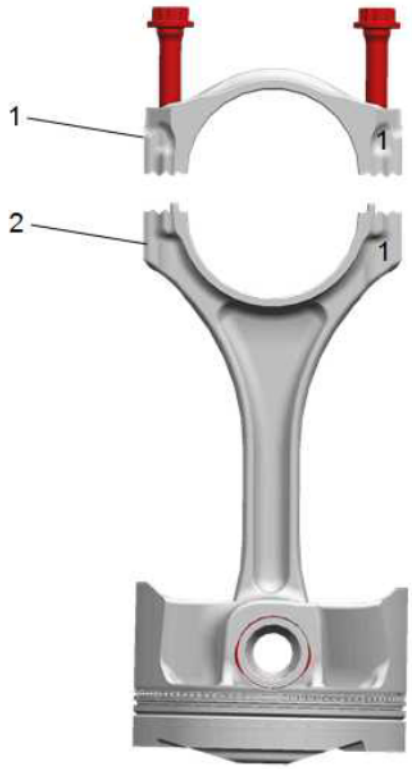


Fig. 61: Attaching Connecting Rod Cap To Connecting Rod (Matched Sets)
Courtesy of GENERAL MOTORS COMPANY

CRANKSHAFT AND BEARING REMOVAL

Special Tools

- **EN J 6125-1B** Slide Hammer Adapter
- **EN 49102** Crankshaft Bearing Cap Remover

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

Crankshaft End Play Measurement

1. Place a dial indicator at the crankshaft nose.
2. Gently force the crankshaft to the extreme front and rear positions with a pry tool while monitoring the movement of the dial indicator.
3. The crankshaft end play should not exceed specifications. Refer to **Engine Mechanical Specifications (LGX)** and/or **Engine Mechanical Specifications (LGW)** .
4. If the specifications are exceeded inspect the thrust bearing thrust OD and the crankshaft thrust wall for wear and/or excessive runout. Refer to **Engine Mechanical Specifications (LGX)** and/or **Engine Mechanical Specifications (LGW)** .
5. Replace the thrust bearing or crankshaft as necessary.

Crankshaft Removal

1. Remove the crankshaft bearing cap side bolts.

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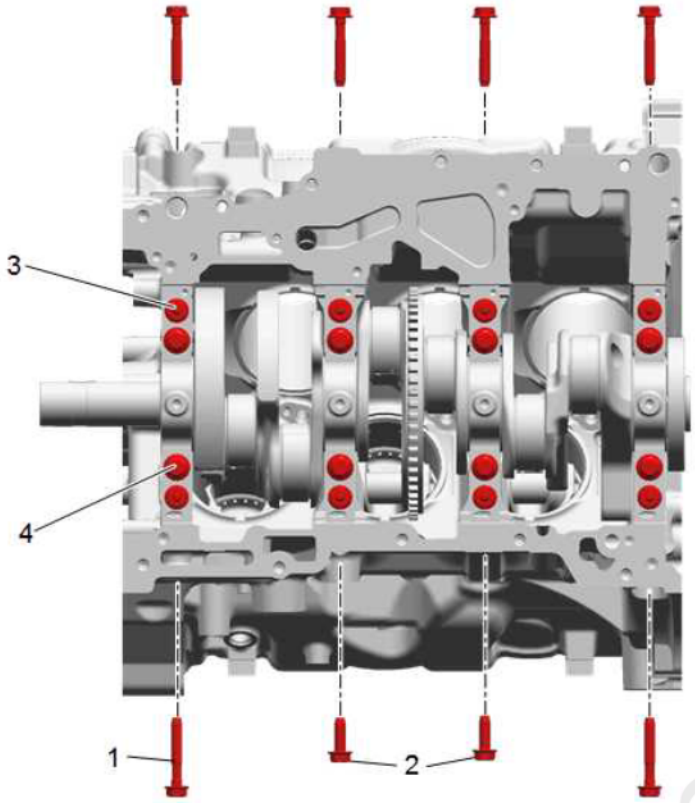


Fig. 62: Identifying Crankshaft Main Bearing Cap Side Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove the crankshaft bearing cap outer bolts.
3. Remove the crankshaft bearing cap inner bolts.
4. Remove the crankshaft bearing caps using the **EN J 6125-1B** adapter (1) and **EN 49102** remover (2).

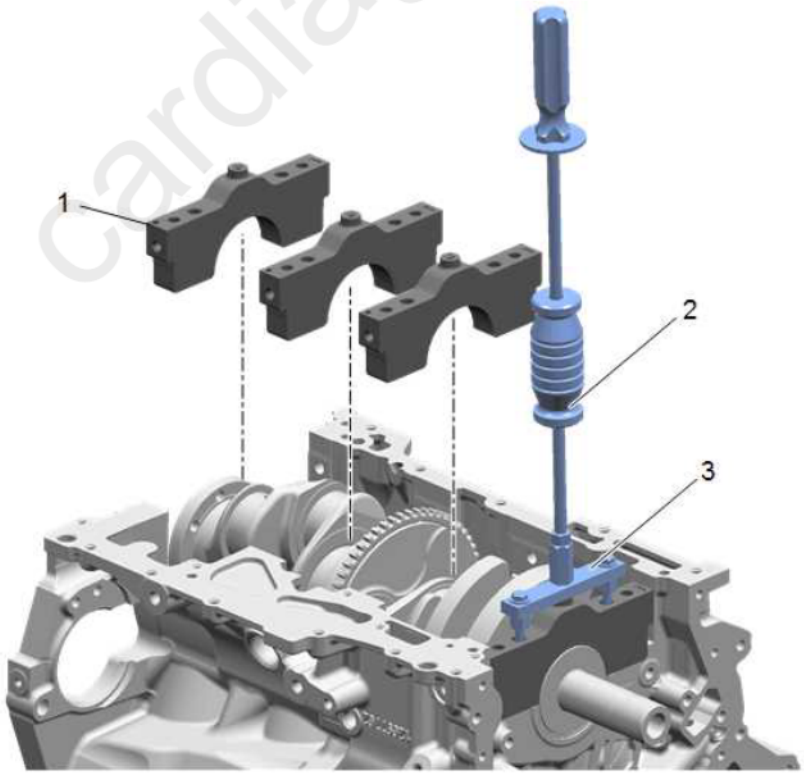


Fig. 63: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

5. Using two hands, lift the crankshaft straight up from the engine block.

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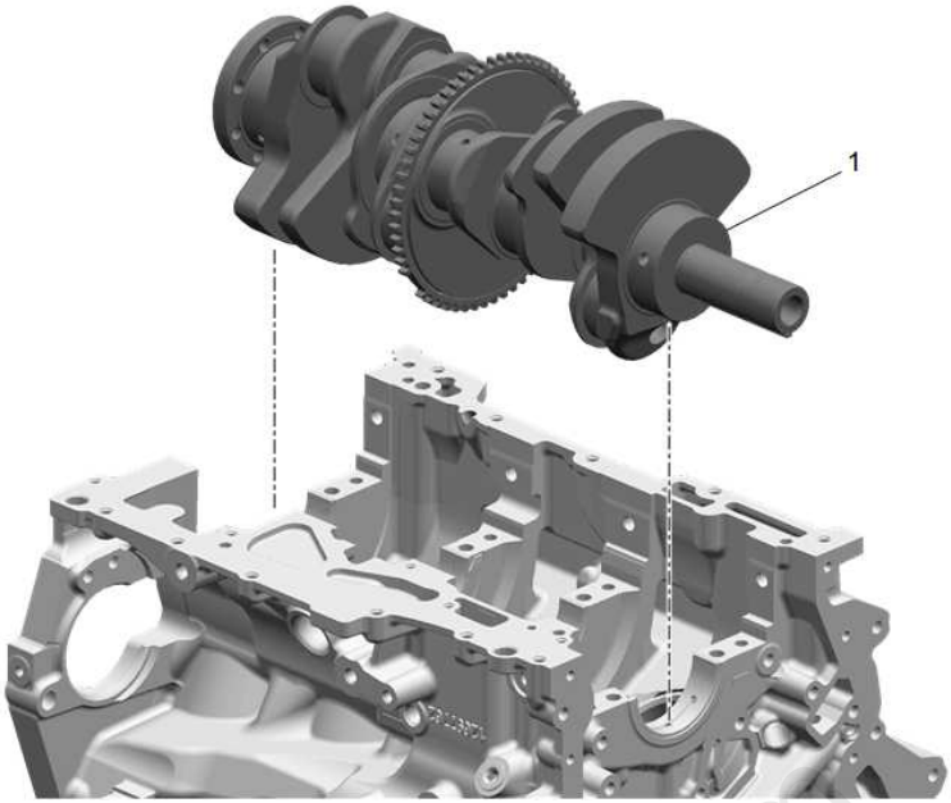


Fig. 64: View Of Crankshaft
Courtesy of GENERAL MOTORS COMPANY

6. Place the crankshaft in a secure place.
7. Remove the crankshaft key from the nose of the crankshaft, if damaged.

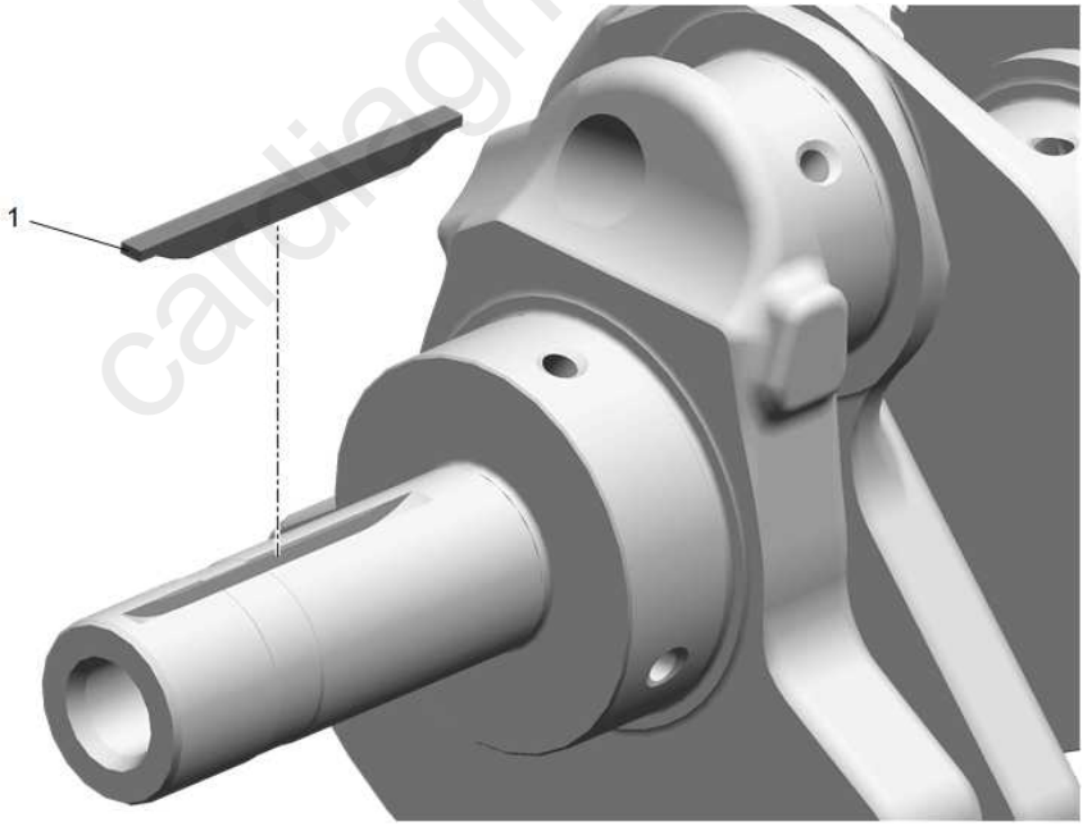


Fig. 65: Locating Crankshaft Sprocket Drive Pin
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Bearing Removal

1. Prepare a piece of cardboard or equivalent, numbered 1-4 for bearing identification. Main bearing journals are numbered from the front of the engine.
2. Remove the crankshaft upper bearing halves from the cylinder block. Note the position of the thrust bearing (1) at the number 3 journal (2).

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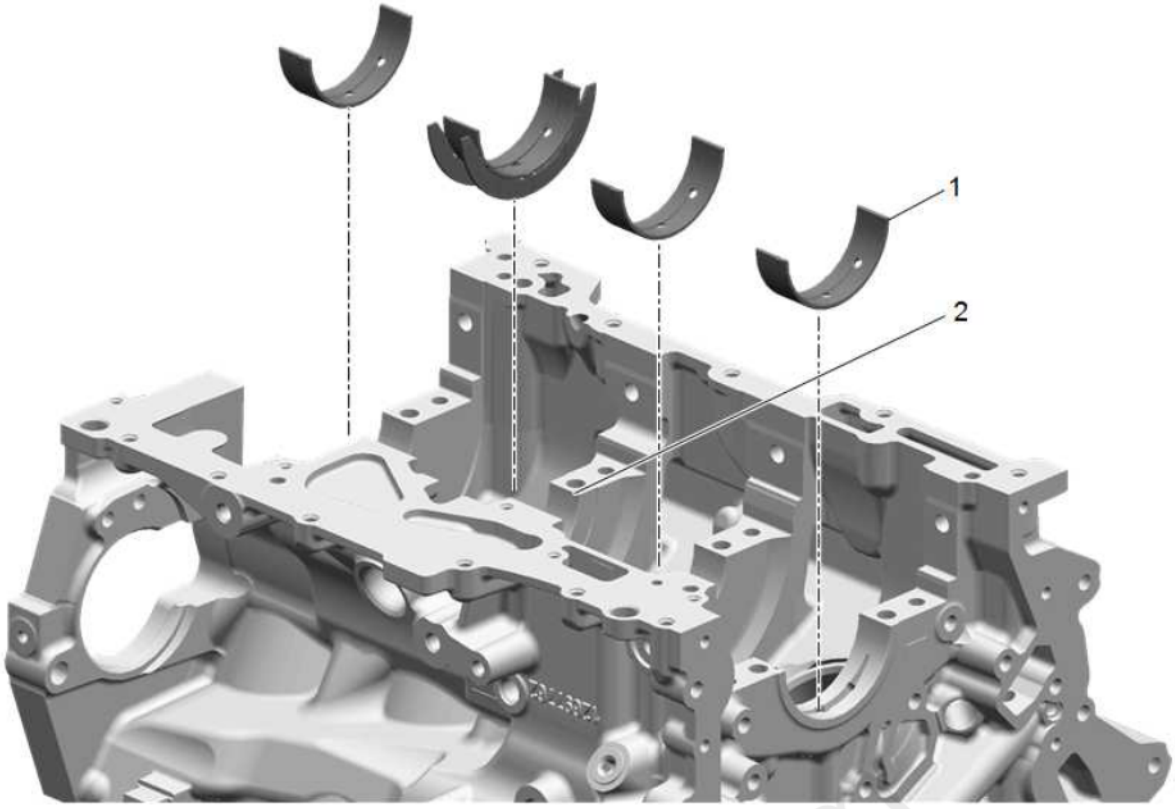


Fig. 66: Locating Thrust Bearing In Number 3 Journal
Courtesy of GENERAL MOTORS COMPANY

3. Place the crankshaft upper bearing halves on the cardboard in the correct positions. Note that the number 3 bearing is the thrust bearing.
4. Remove the crankshaft lower bearing halves from the crankshaft bearing caps.

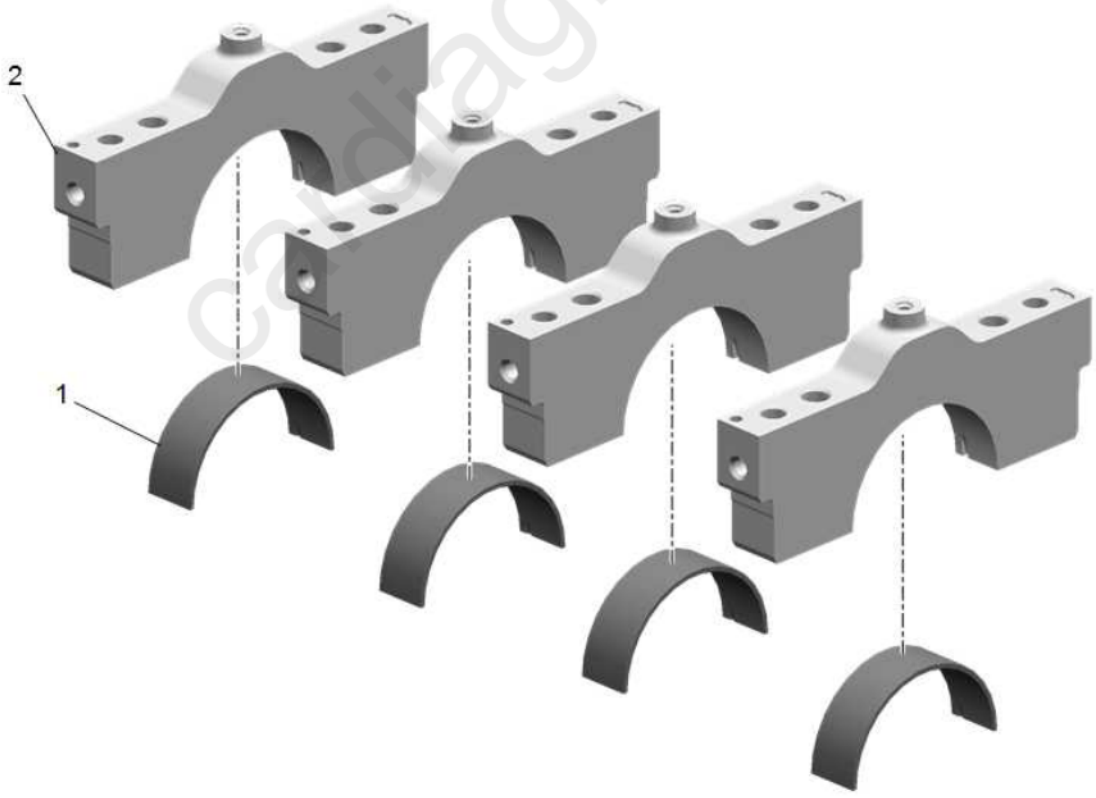


Fig. 67: View Of Crankshaft Bearing Caps & Lower Bearing Halves
Courtesy of GENERAL MOTORS COMPANY

5. Place the crankshaft lower bearing halves in the correct positions on the cardboard.

ENGINE BLOCK DISASSEMBLE

Engine Block - Left - Front

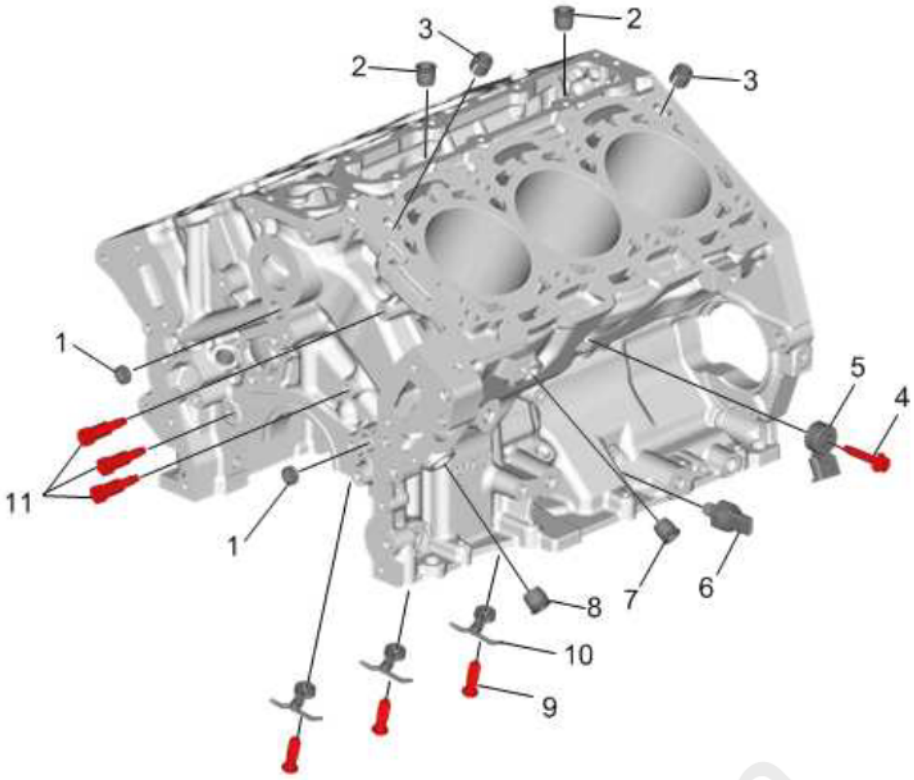


Fig. 68: Engine Block -- Left -- Front
Courtesy of GENERAL MOTORS COMPANY

Engine Block - Left - Front

Callout	Component Name
1	Engine Block Oil Gallery Plug Cap [2x]
2	Engine Block Oil Gallery Plug M16 [2x]
3	Cylinder Head Locating Pin [2x]
4	Knock Sensor Bolt
5	Knock Sensor
6	Engine Oil Pressure Sensor
7	Engine Block Core Hole Plug
8	Engine Block Oil Gallery Plug M16
9	Piston Oil Nozzle Bolt [3x]
10	Piston Oil Nozzle [3x]
11	Engine Front Cover Stud [3x]

Engine Block - Right - Rear

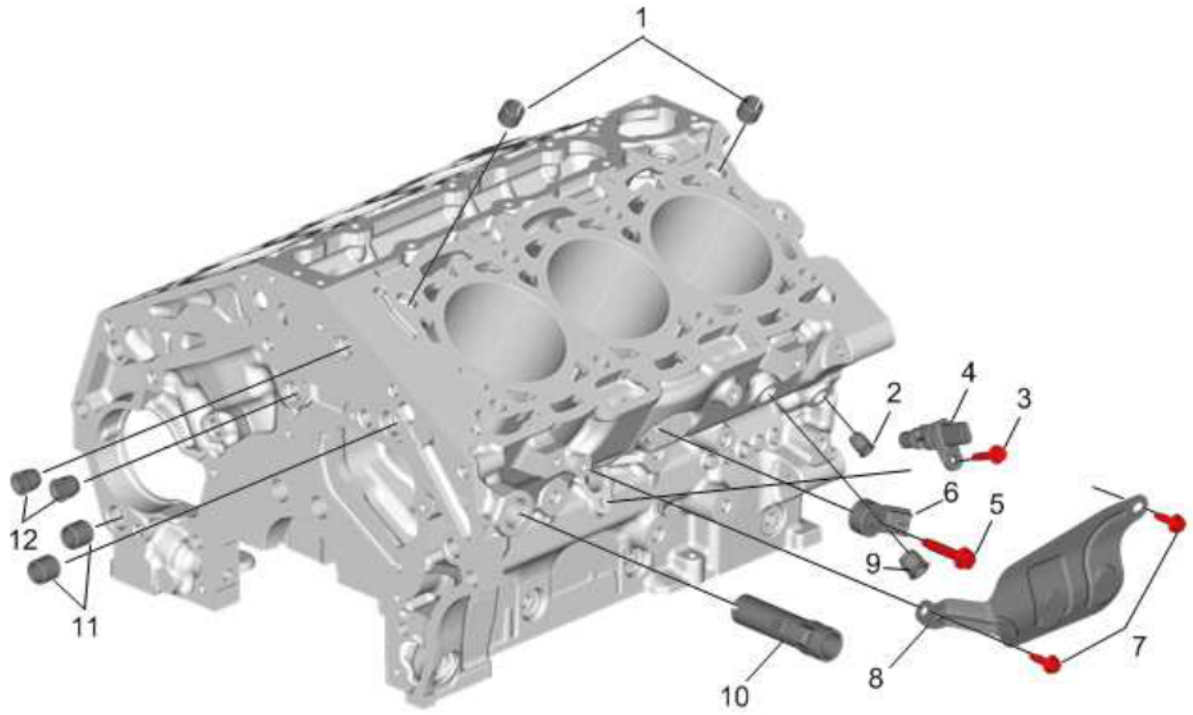


Fig. 69: Engine Block -- Right - Rear
Courtesy of GENERAL MOTORS COMPANY

Engine Block - Right - Rear

Callout	Component Name
1	Cylinder Head Locating Pin [2x]
2	Engine Block Core Hole Plug
3	Crankshaft Position Sensor Bolt
4	Crankshaft Position Sensor
5	Knock Sensor Bolt
6	Knock Sensor
7	Knock Sensor Heat Shield Bolt [2x]
8	Knock Sensor Heat Shield
9	Engine Block Oil Gallery Plug M16
10	Engine Coolant Temperature Sensor
11	Crankshaft Rear Oil Seal Housing Locating Pin [2x]
12	Engine Block Oil Gallery Plug M16 [2x]

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

- **EN-8087** Cylinder Bore Gauge
- **EN-28410** Gasket Remover

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

Cleaning Procedure

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**
2. Remove any old thread sealant, gasket material or sealant using **EN-28410** Gasket Remover.
3. Clean all the following areas with solvent:
   - Sealing surfaces
   - Cooling passages

- Oil passages
- Bearing journals

4. Clean all threaded and through holes with solvent.
5. Dry the engine block with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Visual Inspection

1. Inspect the crankshaft bearings journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the cylinder block assembly must be replaced.

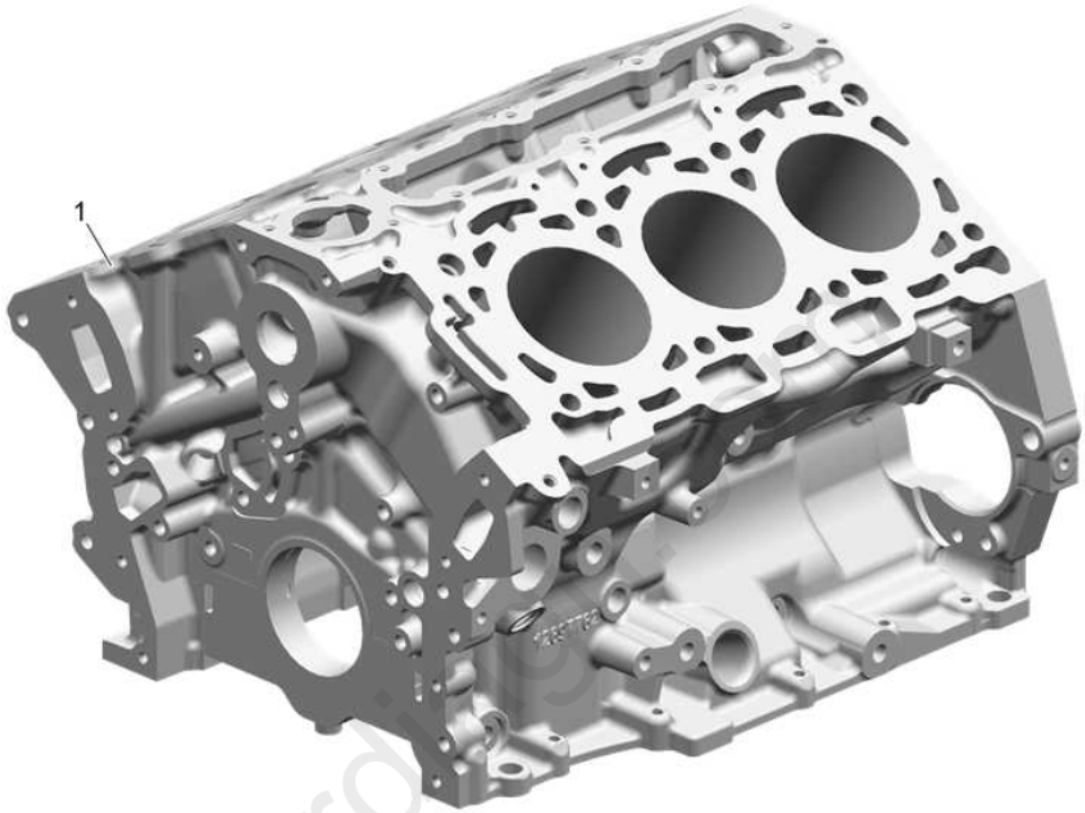


Fig. 70: View Of Engine Block
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the primary camshaft drive chain tensioner mounting surface on the engine block for burrs or any defects that would degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.
3. Inspect all sealing and mating surfaces for damage, repair or replace the cylinder block assembly if necessary.
4. Inspect all threaded and through holes for damage or excessive debris.
5. Inspect all bolts for damage, if damaged replace with NEW bolts only.
6. Check the cylinder condition. Some light vertical marks may be visible on the cylinder wall. In these areas, check that the honing marks are still visible in this marked area. If they are, the cylinder surface has not been compromised and the engine block can be used.
7. Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced separately, if the cylinders are damaged the cylinder block assembly must be replaced.
8. Inspect the engine block for cracks. Do not repair any cracks. If cracks are found, the cylinder block assembly must be replaced.
9. Repair any damaged threaded holes. Refer to **Thread Repair Specifications (LGW and LGX)** and **Thread Repair**.

Measuring Cylinder Bore Diameter

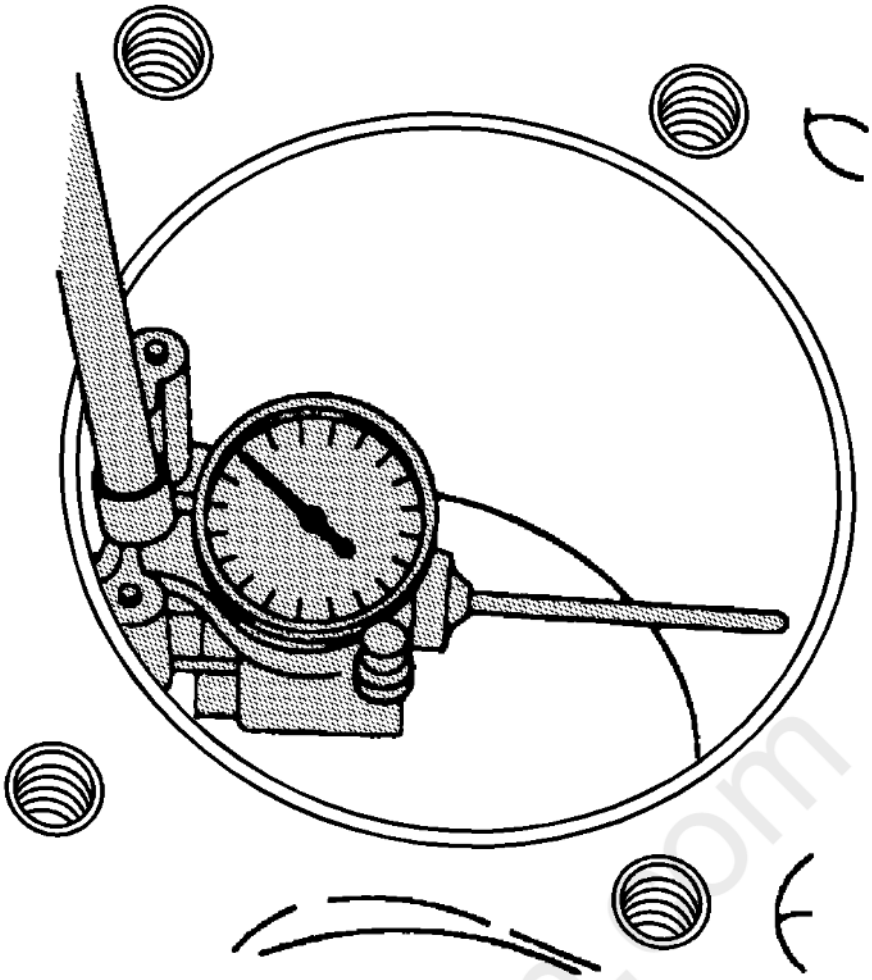


Fig. 71: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS COMPANY

Measure the cylinder bore diameter 37 mm (1.457 in) from the deck face using the **EN-8087** gauge.

Compare your results with the **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** . If the cylinder diameter exceeds the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Measuring Cylinder Bore Taper

1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 10 mm (0.397 in) below the deck surface and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 100 mm (3.976 in) below the deck surface and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** . If the cylinders exceed the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Measuring Cylinder Bore Out-of-Round

1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.397 in) below the deck. Record your measurements.
2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 100 mm (3.976 in) below the deck surface. Record your measurements.

4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** . If the cylinders exceed these specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Deck Flatness Inspection

1. Ensure the engine block decks are clean and free of gasket material.

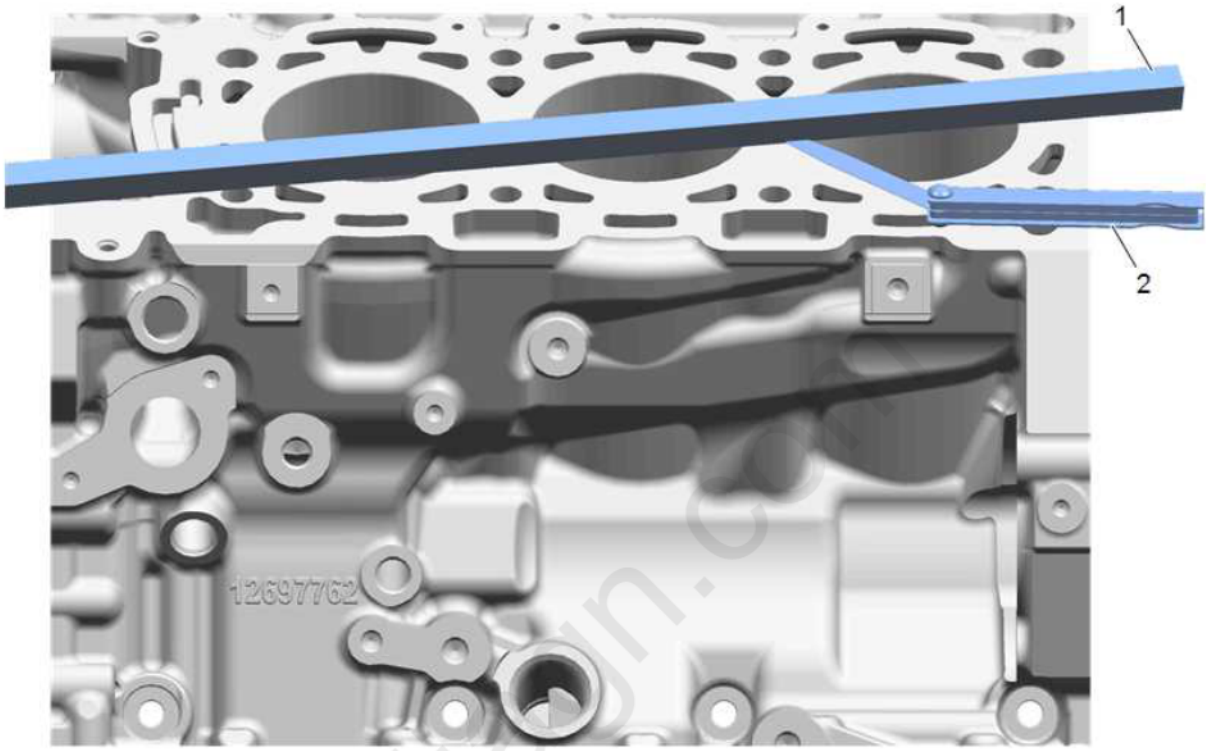


Fig. 72: Measuring Deck Flatness
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder block deck face surface.
4. Measure the clearance between the straight-edge and the cylinder block deck face using a feeler gauge at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder block deck surface does not require resurfacing.
6. If the warpage is between 0.05-0.20 mm (0.002-0.008 in) or any imperfections or scratches that could inhibit proper cylinder head gasket sealing are present, the cylinder block deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder block deck surface requires more than 0.25 mm (0.010 in) material removal the block must be replaced.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the following components in solvent:
   - Crankshaft bearings
   - Connecting rod bearings
   - Crankshaft journals

- Crankpin journals
- Crankshaft oil passages
- Crankshaft threaded holes

2. Dry the following components with compressed air:

WARNING: **Refer to Safety Glasses Warning**

- Crankshaft bearings
- Connecting rod bearings
- Crankshaft journals
- Crankpin journals
- Crankshaft oil passages
- Crankshaft threaded holes

Visual Inspection

1. Perform the following visual inspections:

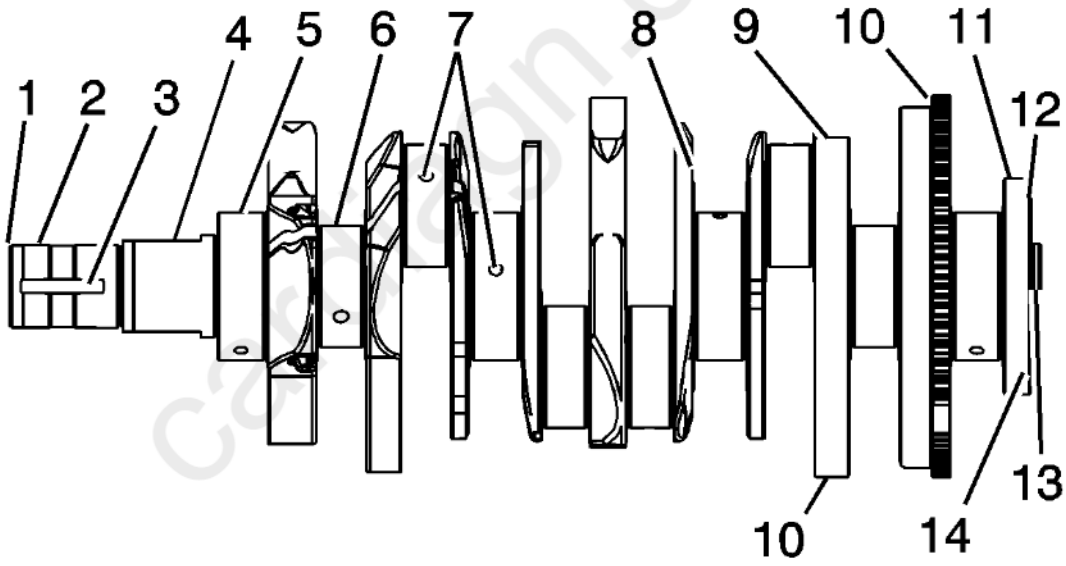


Fig. 73: Identifying Crankshaft Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

- Inspect the crankshaft balancer bolt hole (1) for thread damage.
- Inspect the crankshaft balancer mounting area (2) for damage.
- Inspect the crankshaft keyway (3) for damage.
- Inspect the oil pump drive flats (4) for damage.
- Inspect the crankshaft main journals (5) for damage.
- Inspect the crankshaft connecting rod journals (6) for damage.

- Inspect the crankshaft oil passages (7) for obstructions.
- Inspect the crankshaft main bearing thrust wall surfaces (8) for damage.
- Inspect the crankshaft counterweights (9) for damage.
- Inspect the crankshaft reluctor ring teeth (10) for damage.
- Inspect the crankshaft rear main oil seal surface (11) for damage.
- Inspect the crankshaft engine flywheel mounting surface (12) for damage.
- Inspect the crankshaft pilot hole (13) for damage.
- Inspect the crankshaft engine flywheel bolt holes (14) for thread damage.

2. Repair or replace the crankshaft as necessary.

Crankshaft Bearing Inspection

1. Inspect for fatigue indicated by craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

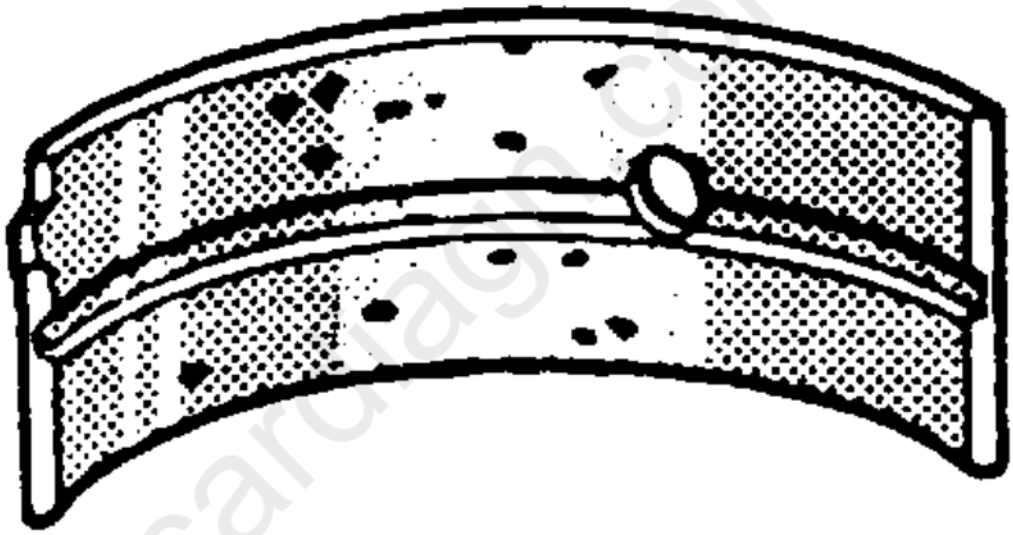


Fig. 74: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **All connecting rod and main journal bearings that have been used in a running engine must be replaced. Never re-use the crankshaft or connecting rod bearings.**
- **The following bearing wear conditions should be used to diagnose engine operating conditions or root cause of a condition.**

2. Inspect for excessive scoring or discoloration on both front and back of the bearing halves.

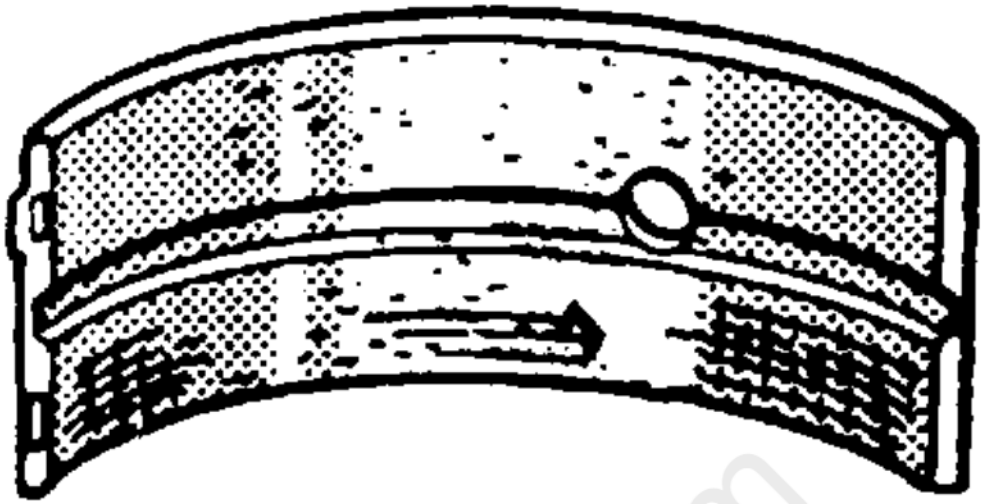


Fig. 75: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the main bearings for dirt embedded into the bearing material.
4. Inspect for improper seating indicated by bright, polished sections.

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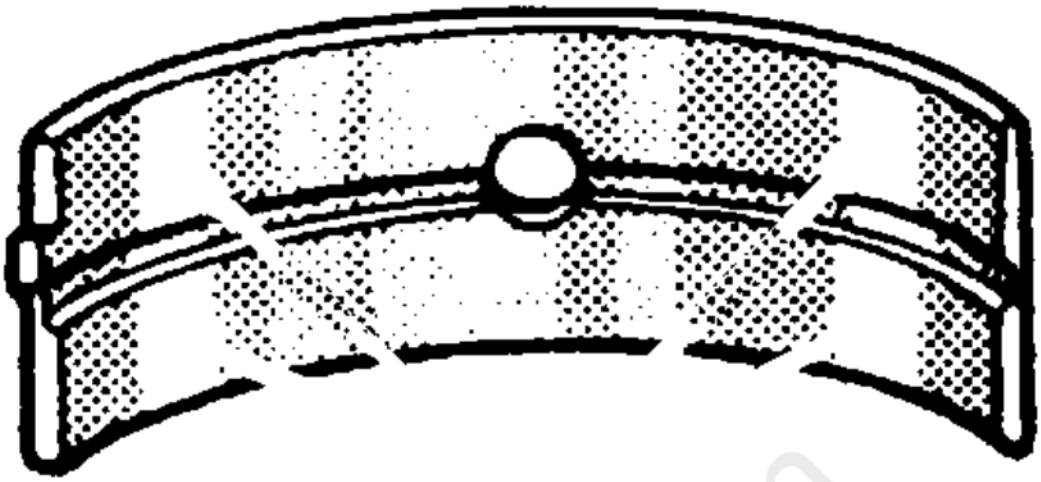


Fig. 76: View Of Crankshaft Bearing Improper Seating
Courtesy of GENERAL MOTORS COMPANY

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Crankshaft Measurement

Special Tools

J 7872 Magnetic Base Dial Indicator

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

1. Using a suitable fixture, support the crankshaft.

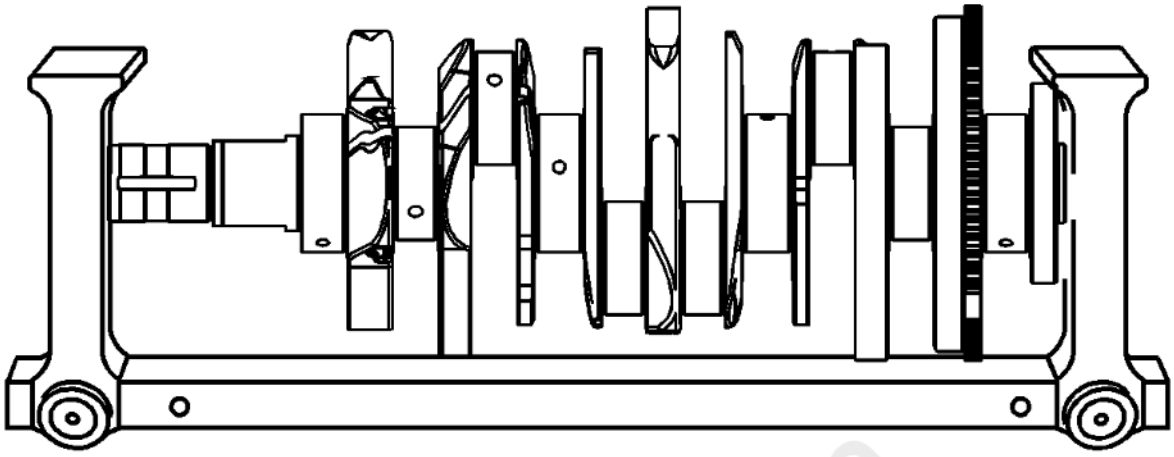


Fig. 77: View Of Crankshaft & Support
Courtesy of GENERAL MOTORS COMPANY

2. Install the **J 7872** indicator.

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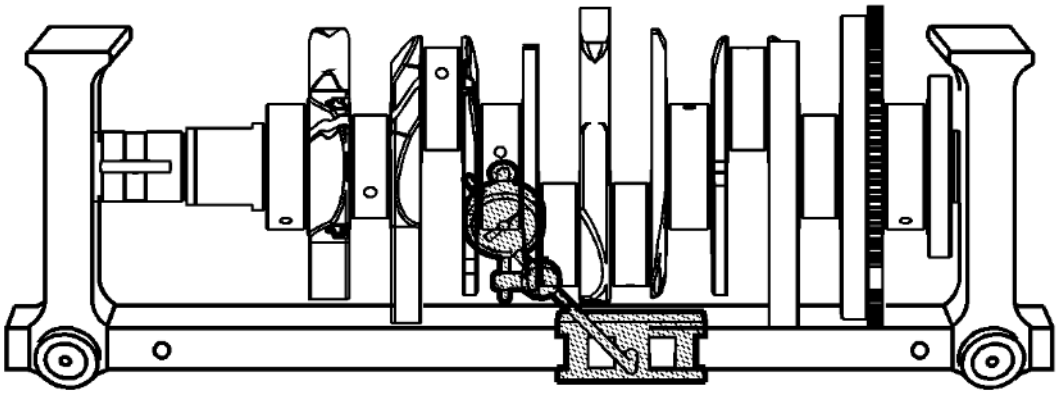


Fig. 78: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS COMPANY

3. Measure the crankshaft runout using the **J 7872** indicator. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .
4. Measure the crankshaft thrust wall width (1) for wear using an inside micrometer. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .

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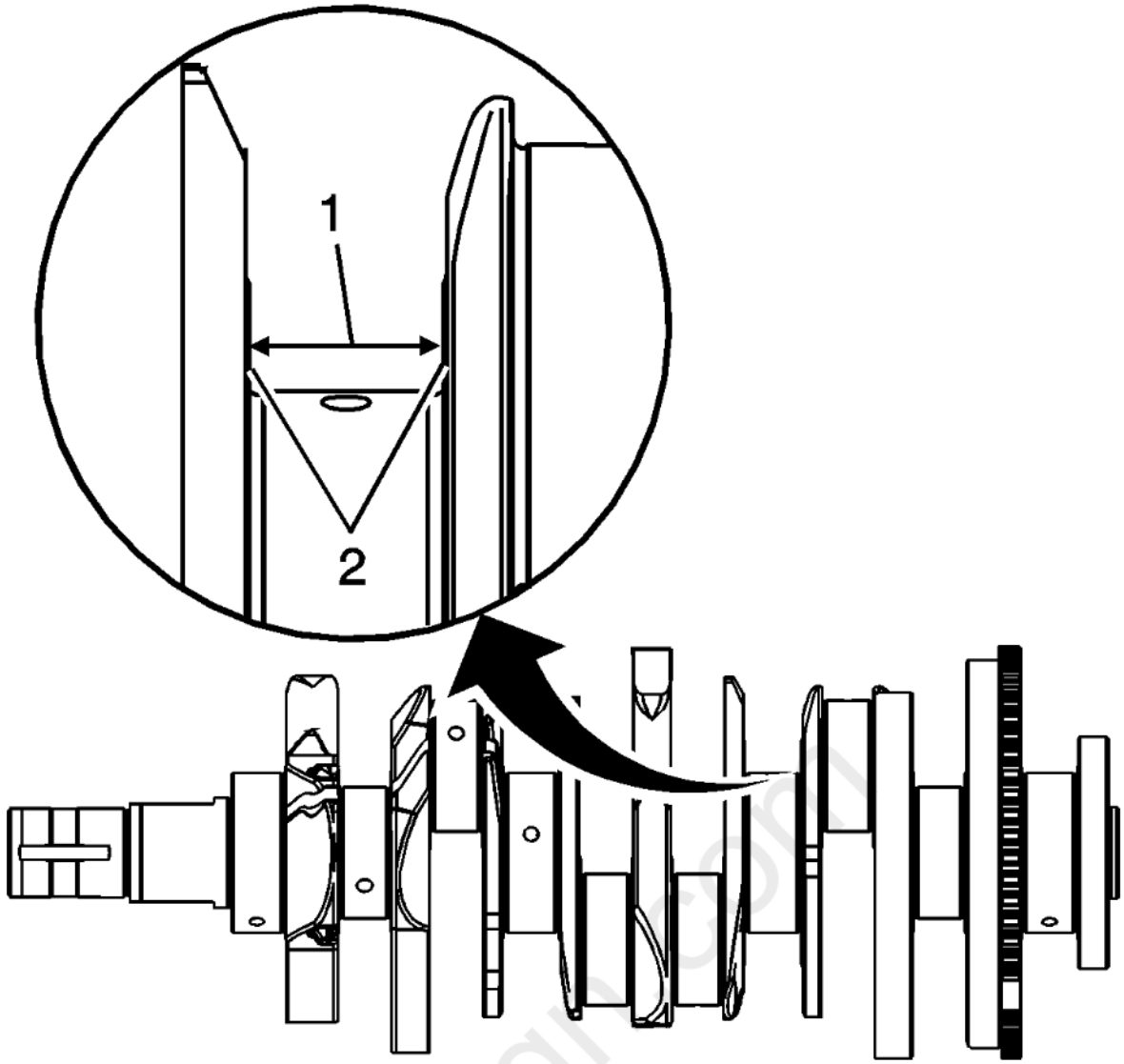


Fig. 79: Identifying Crankshaft Thrust Wall Width & Surface
Courtesy of GENERAL MOTORS COMPANY

5. Measure the crankshaft thrust wall surface (2) for runout using the **J 7872** indicator. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .
6. If the crankshaft journals are damaged or worn beyond specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized main bearings available for service.
7. Inspect the crankshaft main journals for undersize, using an outside micrometer.

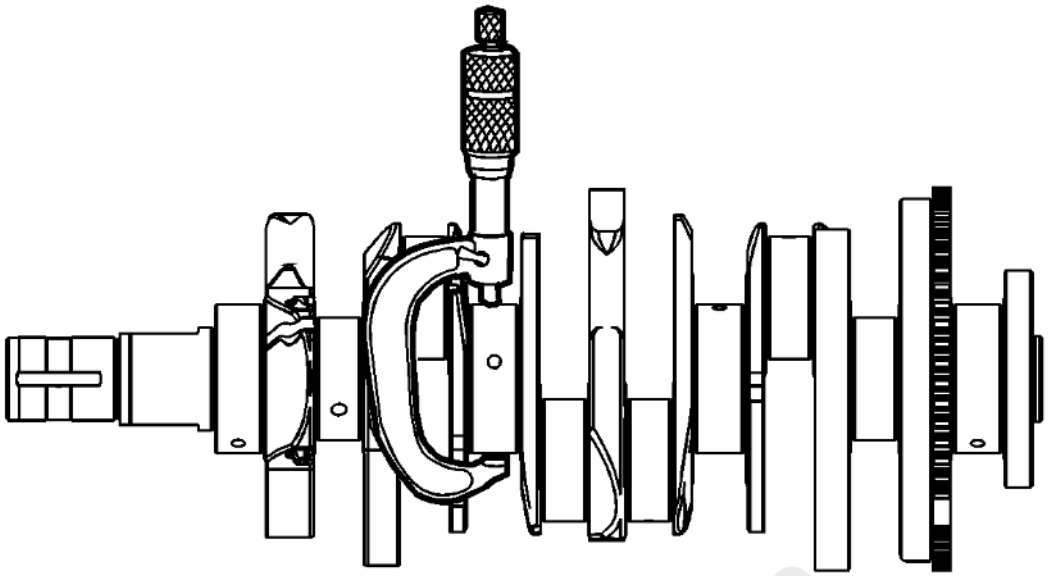


Fig. 80: Using Outside Micrometer To Inspect Crankshaft Main Journals
Courtesy of GENERAL MOTORS COMPANY

8. Inspect the crankpins for undersize using an outside micrometer.

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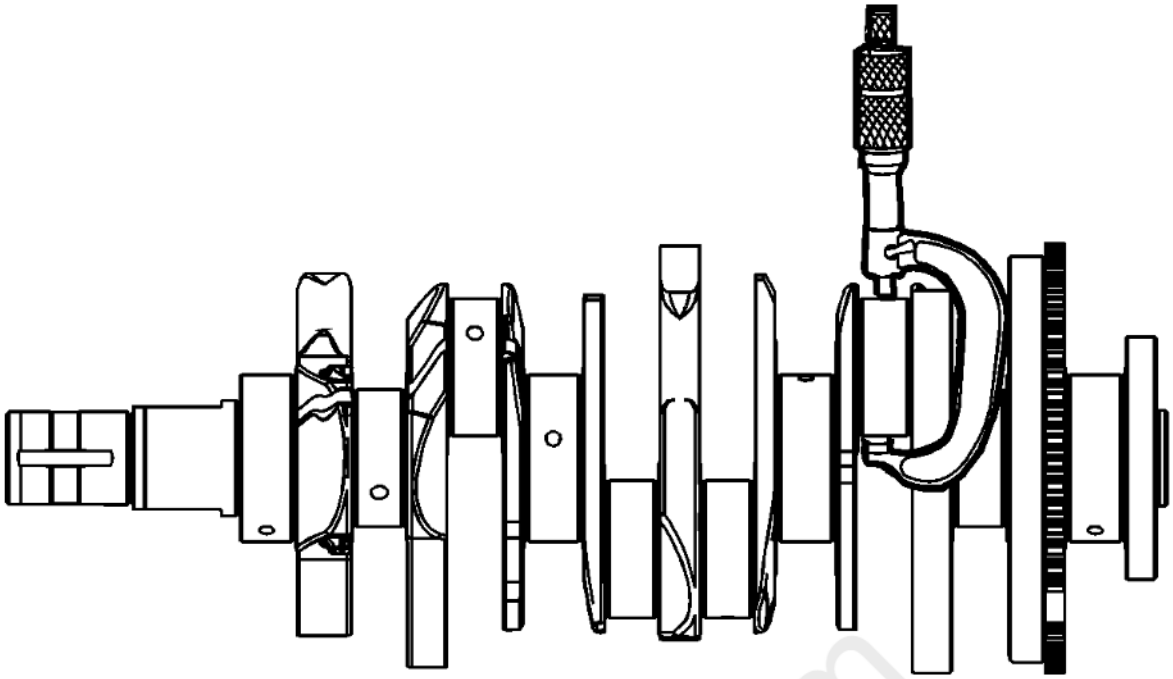


Fig. 81: View Of Micrometer & Crankshaft Journals
Courtesy of GENERAL MOTORS COMPANY

9. Compare your measurements with those listed in the **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** . If the crankpin journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized connecting rod bearings available for service.
10. Measure the main bearing and crankpin journals for out-of-round using the following procedure:

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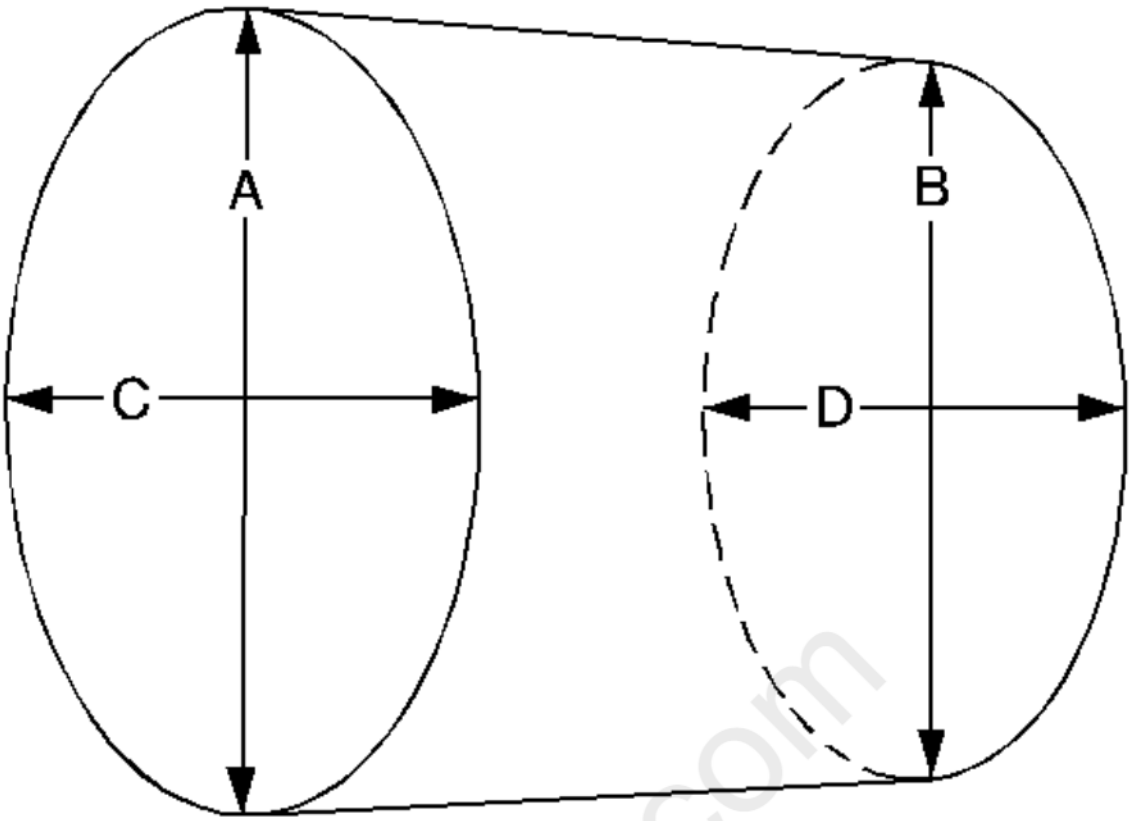


Fig. 82: Identifying Out-Of-Round Measurements
Courtesy of GENERAL MOTORS COMPANY

1. Using an outside micrometer, measure the journal at the extreme front and rear locations on the journal. Call these points A and B.
2. Measure the journal in 2 new locations exactly 90 degrees from the first points. Call these points C and D.
3. Subtract A from C and B from D. The differences will indicate journal out-of-round.
4. The out-of-round should not exceed 0.004 mm (0.00016 in) maximum.
5. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

11. Measure the main bearing and crankpin journals for taper using the following procedure:
    1. Using an outside micrometer, measure the journal at the extreme front (A) and rear (B) of the journal parallel to the crankshaft centerline.
    2. Subtract the smallest from the largest measurement. The result will be the journal taper.
    3. If the main bearing journal taper exceeds 0.004 mm (0.00016 in), replace the crankshaft.
    4. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

AUTOMATIC TRANSMISSION FLEX PLATE CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the flex plate in solvent.

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2. Dry the flex plate with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Inspection Procedure

1. Inspect the flex plate for the following conditions:

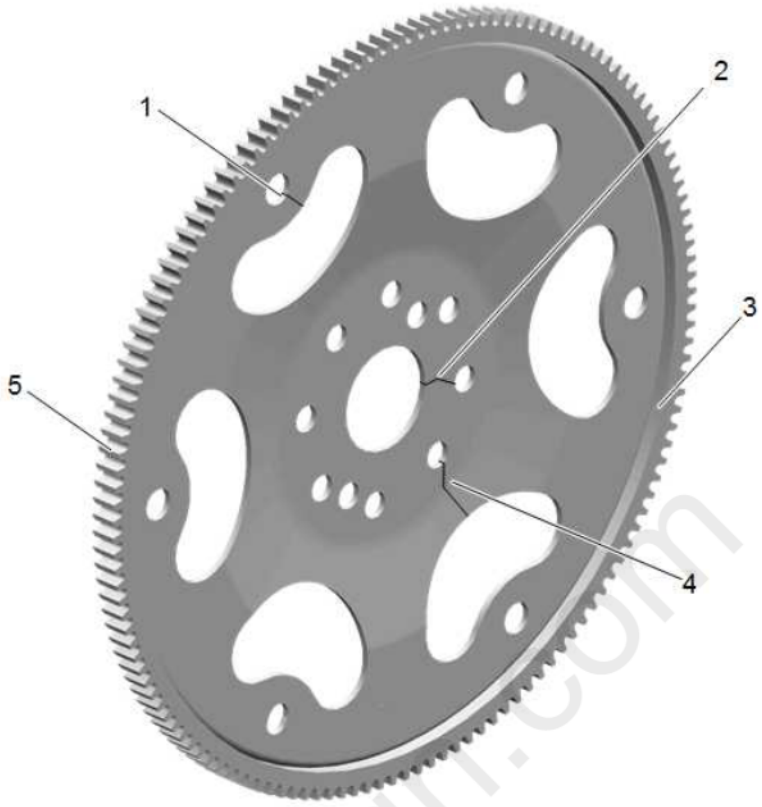


Fig. 83: Identifying Engine Flywheel Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

- Stress cracks around the flex plate-to-torque converter mounting bolt hole locations (1) and/or flex plate-to-crankshaft (2, 4)
- Cracks at welded areas that retain the ring gear onto the flex plate (3)

NOTE: **Do not attempt to repair the welded areas that retain the ring gear to the flex plate. Install a NEW flex plate.**

- Damaged or missing ring gear teeth (5)

2. Replace the flex plate as necessary.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the crankshaft balancer in solvent that is compatible with the rubber (1).



Fig. 84: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

2. Dry the crankshaft balancer with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Inspection Procedure

1. Inspect the crankshaft balancer for the following:



Fig. 85: Identifying Crankshaft Balancer Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

- Worn or damaged hub-to-crankshaft surface (1)

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- Worn, grooved or damaged hub seal surface (2)

  A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

- Worn, chunking or deteriorated rubber between the hub and pulley (3)
- Damaged drive belt ribs (4)
- Damaged webs (5)

2. Repair or replace the crankshaft balancer as necessary.

PISTON AND CONNECTING ROD DISASSEMBLE

Special Tools

EN-46745 Piston Pin Clip Remover/Installer

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

1. Remove the piston rings using a piston ring expander. Place each ring in a clean shop towel for storage.

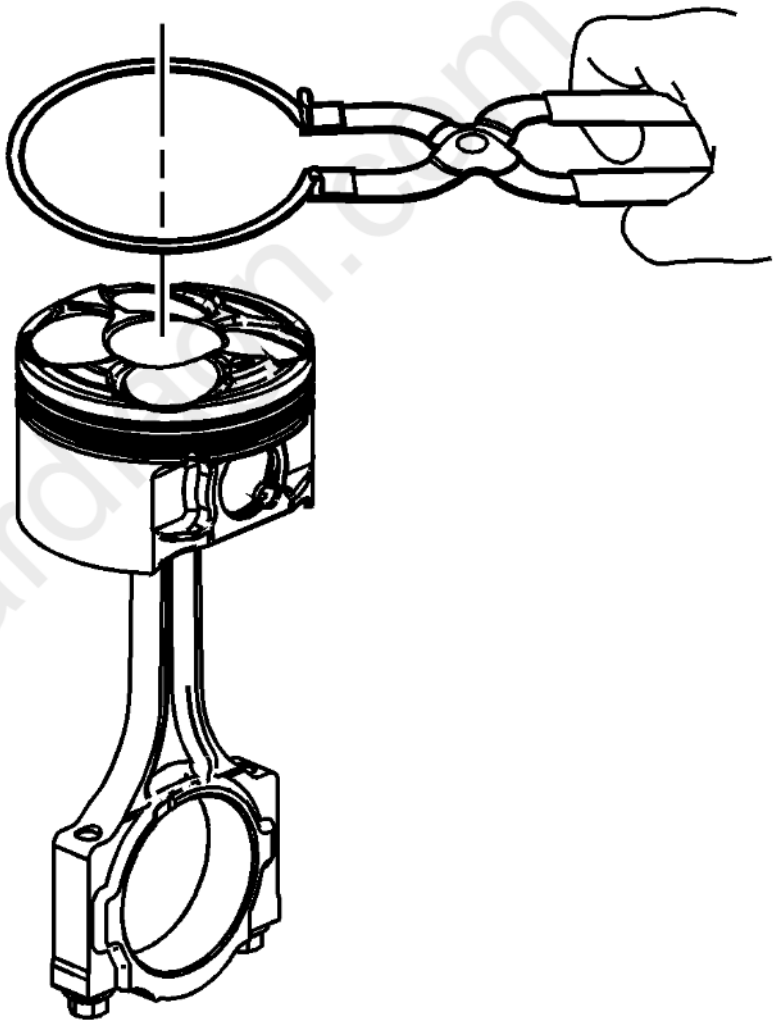


Fig. 86: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **You must use a piston ring expander to remove and install the piston rings. Only expand the rings far enough to fit over the piston lands. If the rings are overexpanded, the top ring will shatter and the others will distort.**

2. Using the **EN-46745** remover/installer, remove the piston pin retainers by using the removal access notch (1) in the side of the piston. Discard the piston pin retainers.



Fig. 87: View Of Piston Pin Retainer
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.**
- **DO NOT reuse the piston pin retainers.**

3. Slide the piston pin out of the piston. The piston will disconnect from the connecting rod.

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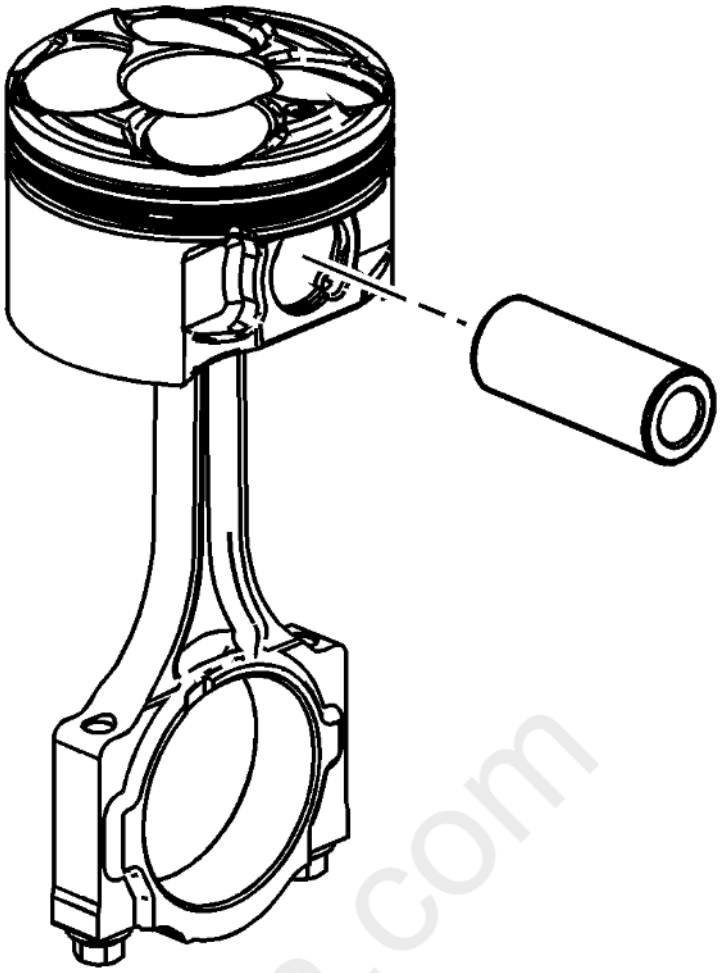


Fig. 88: View Of Piston Pin
Courtesy of GENERAL MOTORS COMPANY

PISTON, CONNECTING ROD AND BEARING CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the piston skirts and the pins with a cleaning solvent.

NOTE: **DO NOT wire brush any part of the piston.**

2. Clean the piston ring grooves with a groove cleaner. Ensure that the oil ring holes and slots are clean.
3. Dry the piston with compressed air.

WARNING: Refer to Safety Glasses Warning .

Piston Inspection Procedure

1. Inspect the pistons for the following conditions:

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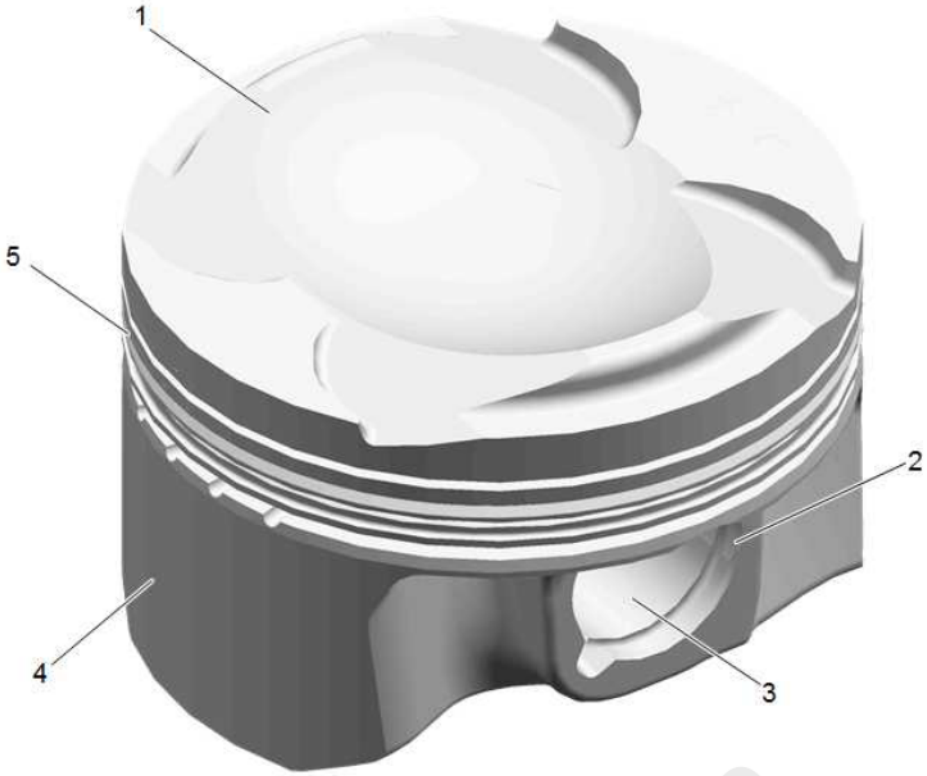


Fig. 89: Identifying Piston Inspection Locations
Courtesy of GENERAL MOTORS COMPANY

- Cracked ring lands, skirts or pin bosses
- Ring grooves for nicks, burrs that may cause binding (5)
- Warped or worn ring lands (5)
- Piston pin retainer grooves for burrs (2)
- Eroded areas at the top of the piston (1)
- Scuffed or damaged skirt coating (4)
- Worn piston pin bores or worn piston pins (3)

2. Replace pistons that show any signs of damage or excessive wear.

Piston Measurement Procedure

1. Measure piston width using the following procedure:

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Fig. 90: Measuring Piston Width
Courtesy of GENERAL MOTORS COMPANY

1. Using an outside micrometer, measure the width of the piston at 30 mm (1.181 in) below the crown, top, (1) at the thrust surfaces of the piston, perpendicular to the piston pin centerline.
2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
3. Check your measurements with the **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .
4. If the clearance obtained through measurement is greater than the provided specifications and the cylinder bores are within specification, replace the piston.

2. Measure the piston pin bore to piston pin clearances using the following procedure:

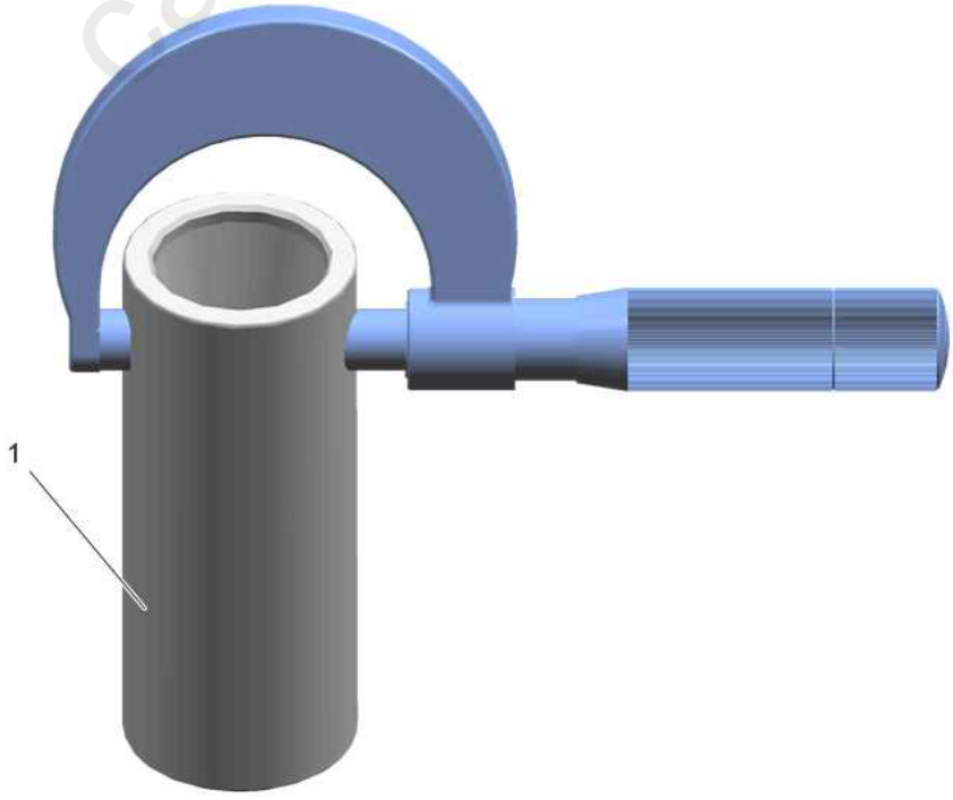


Fig. 91: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS COMPANY

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. Compare your result with the piston pin diameter and piston pin to piston pin bore clearance listed in the **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .

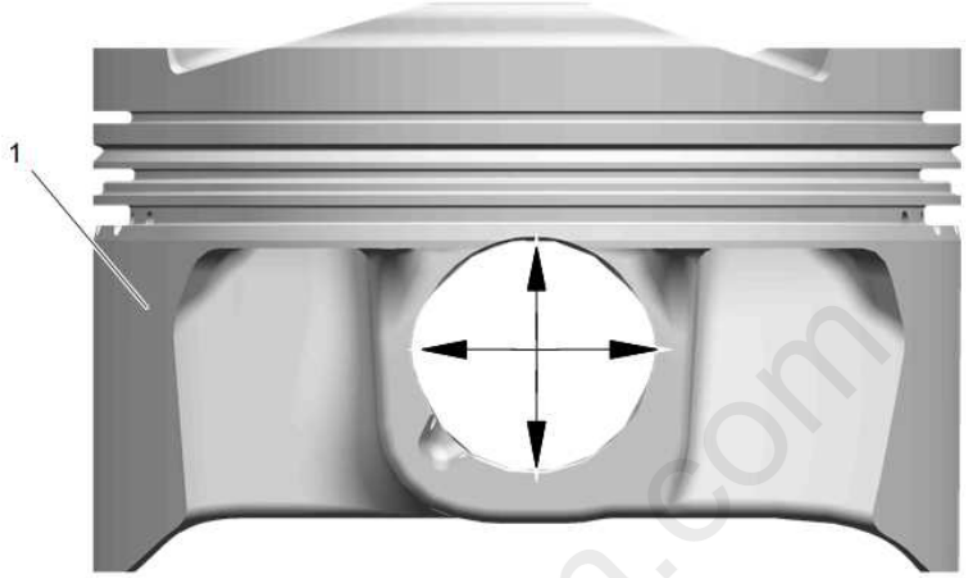


Fig. 92: Measuring Piston Pin Bore
Courtesy of GENERAL MOTORS COMPANY

4. If the clearance is excessive, determine which piece is out of specification and replace as necessary.
5. You must replace the piston if any of its dimensions are out of specification.
6. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Piston Ring Measurement Procedure

1. Measure the piston ring end gap using the following procedure:

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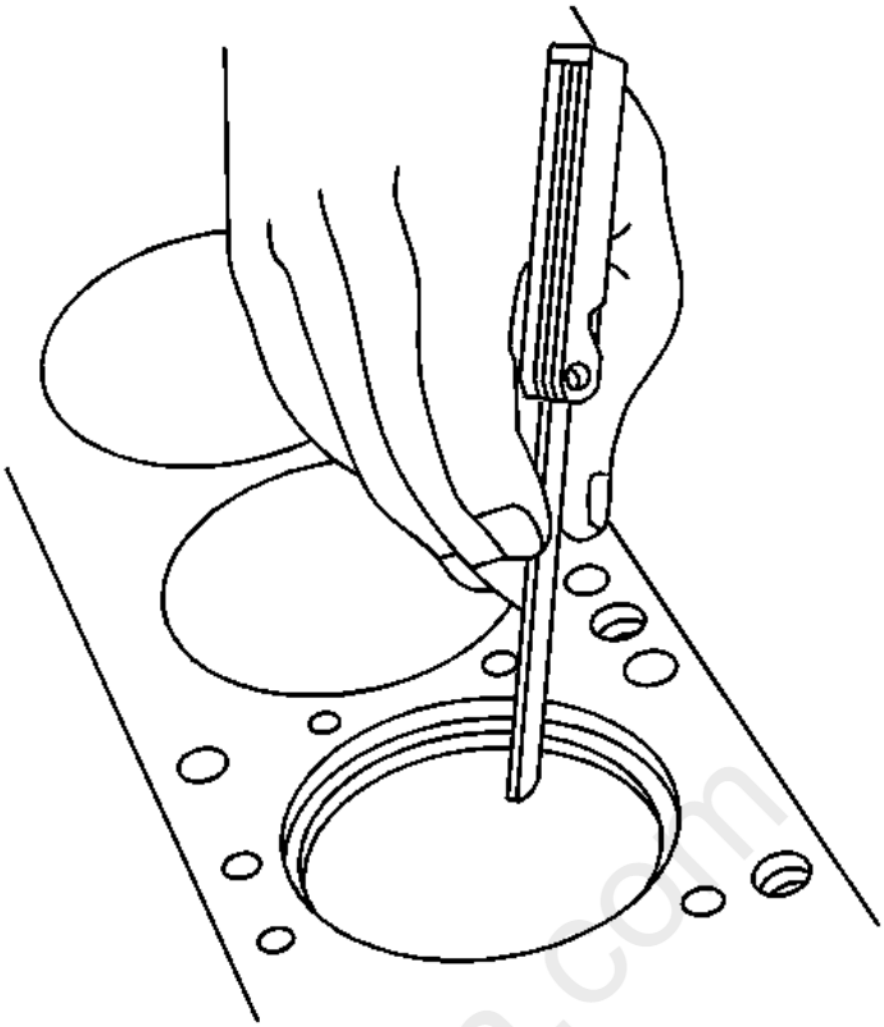


Fig. 93: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS COMPANY

1. Place the piston ring in the area of the bore where the piston ring will travel approximately 25 mm (1 in) down from the deck surface. Ensure that the ring is square with the cylinder bore by positioning the ring with the piston head.
2. Measure the end gap of the piston ring with feeler gauges. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.

2. Measure the piston ring side clearance using the following procedure:

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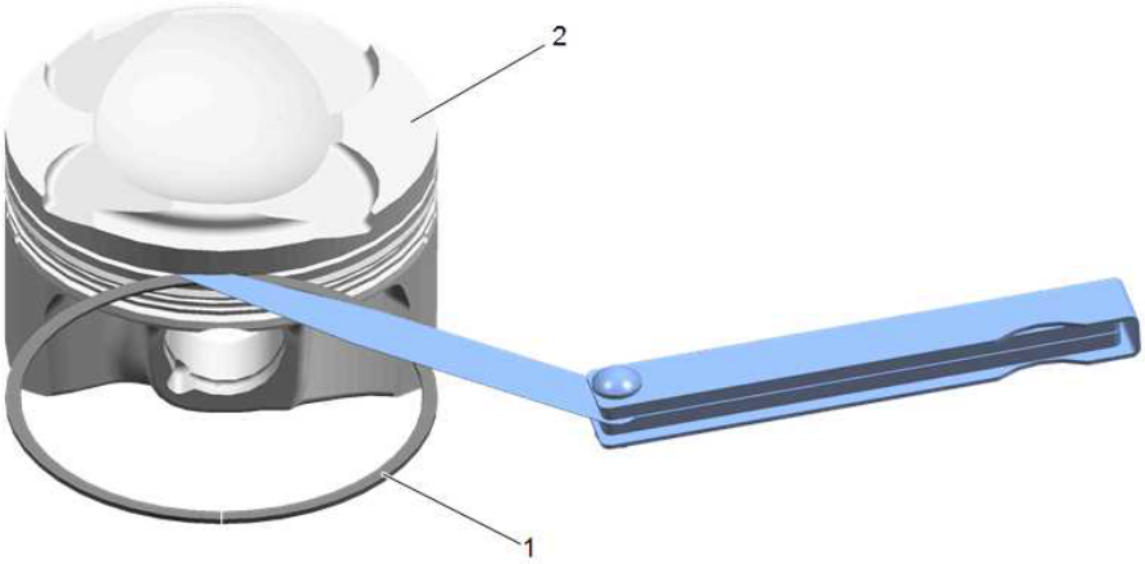


Fig. 94: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS COMPANY

1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston ring, replace the ring.
2. With the piston ring on the piston, use feeler gauges to check clearance at multiple locations.
3. Compare the measurements with piston ring side clearance listed in the **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .
4. If the clearance is greater than specifications, replace the piston rings.

3. There is a locating dimple (1) on the compression rings near the end for identification. Install the compression rings with the dimple facing up.

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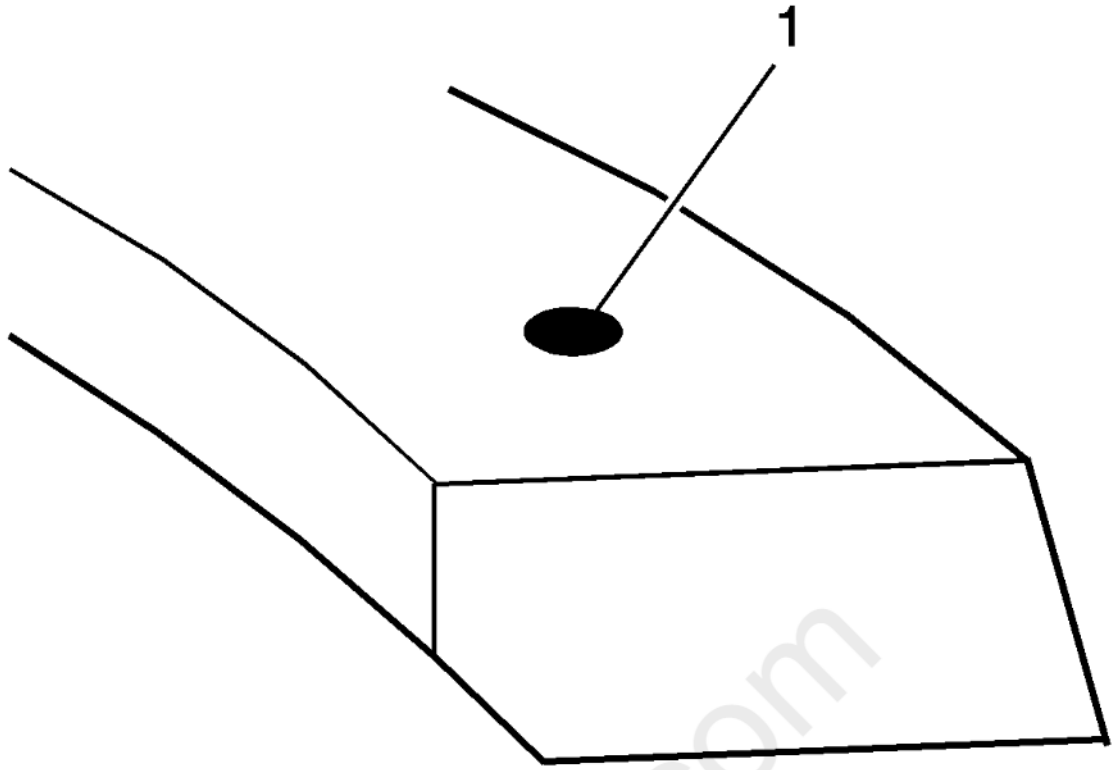


Fig. 95: View Of Lower Compression Piston Ring Mark
Courtesy of GENERAL MOTORS COMPANY

4. If the new ring does not reduce the clearance to the proper specification, install a new piston.
5. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only 1 size of oversized pistons and rings available for service.

Connecting Rod Cleaning Procedure

1. Clean the connecting rods in solvent.
2. Dry the connecting rod using compressed air.

WARNING: **Refer to Safety Glasses Warning .**

3. Remove the connecting rod cap and clean the threads.
4. Remove the connecting rod bearing and discard. Never reuse a connecting rod bearing used in a running engine.

Connecting Rod Visual Inspection Procedure

1. Inspect the piston pin bushing (4) for scoring or damage.

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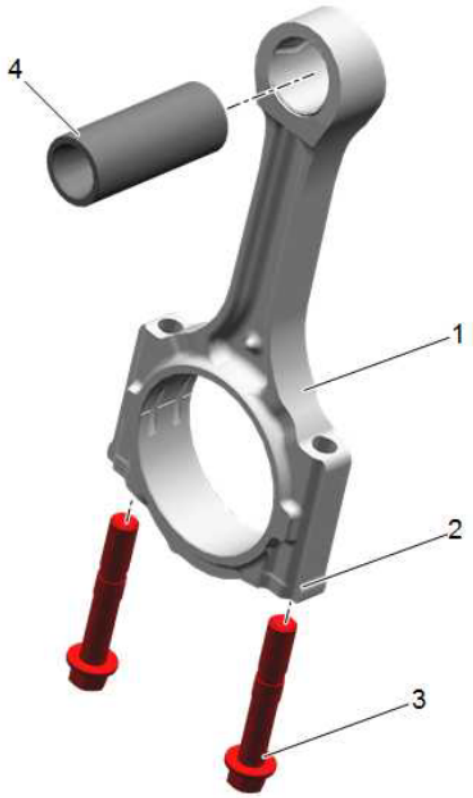


Fig. 96: Inspecting Connecting Rod Components
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the connecting rod beam (1) for twisting or bending.
3. Inspect the rod cap (2) for any nicks or damage caused by possible interference.
4. Inspect for scratches or abrasion on the rod bearing seating surface.
5. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper.

NOTE: **DO NOT scrape the rod or rod cap.**

Connecting Rod Measurement Procedure

Piston Pin End

1. Using an outside micrometer, take 2 measurements of the piston pin in the area of the connecting rod contact.

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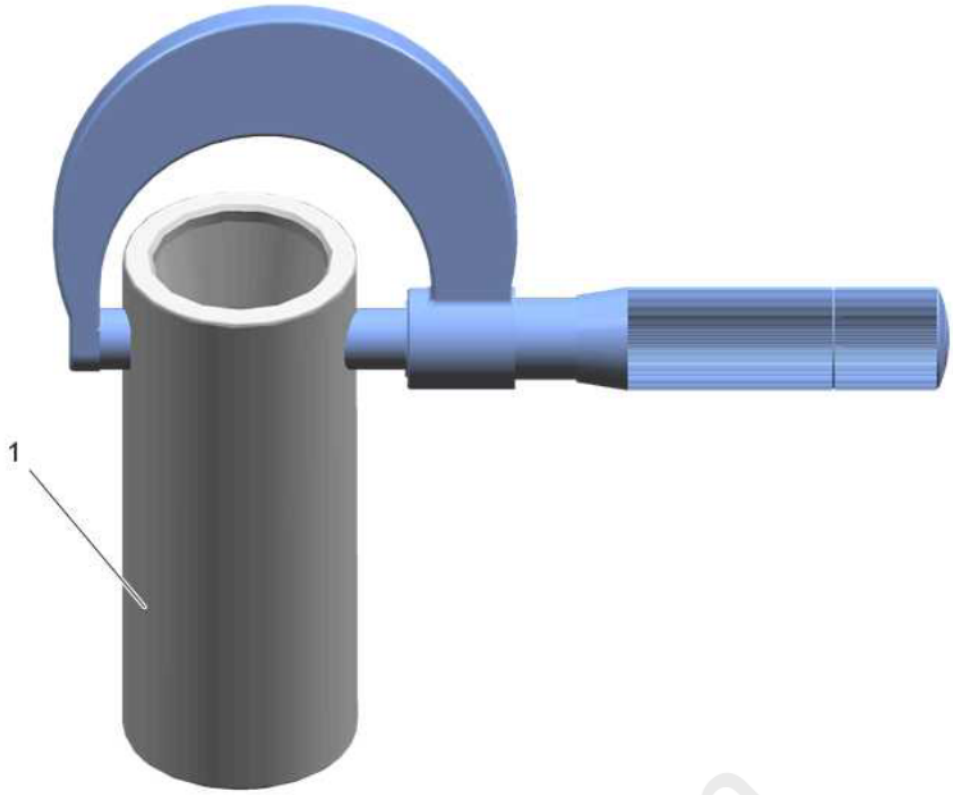


Fig. 97: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Measurements of all components should be taken with the components at normal room temperature.**

2. Using an inside micrometer, measure the connecting rod piston pin bore.

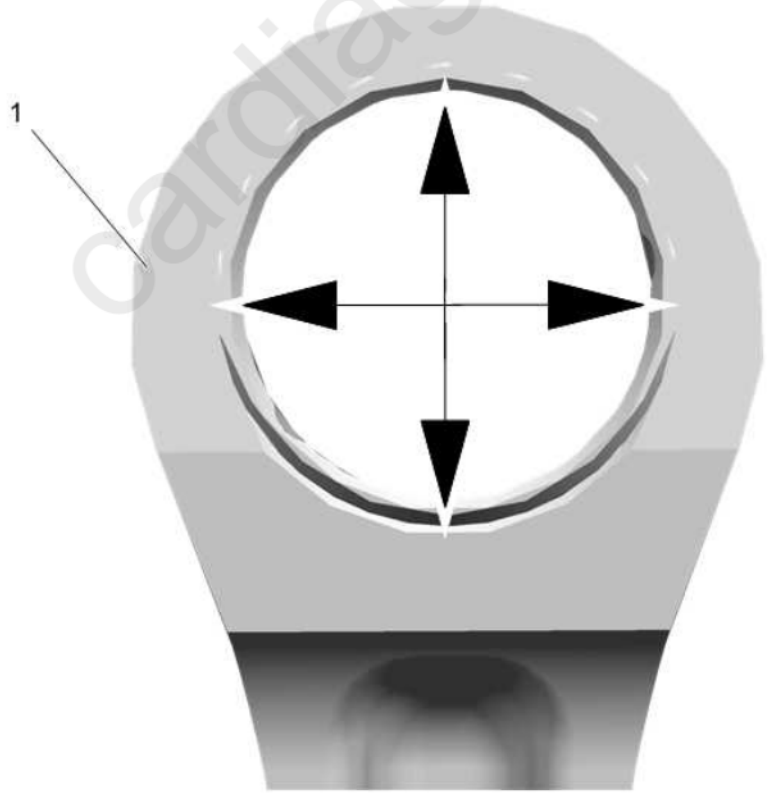


Fig. 98: Checking Connecting Rod Piston Pin Bore Dimensions
Courtesy of GENERAL MOTORS COMPANY

3. Subtract the piston pin diameter from the piston pin bore.
4. Compare the clearance measurements with the **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .

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5. If the clearance is excessive, replace the piston pin. If a new pin does not resolve the clearance problem, replace the connecting rod.

Connecting Rod Crankshaft Bearing End

1. Using an inside micrometer, measure the connecting rod crankshaft bearing bore.

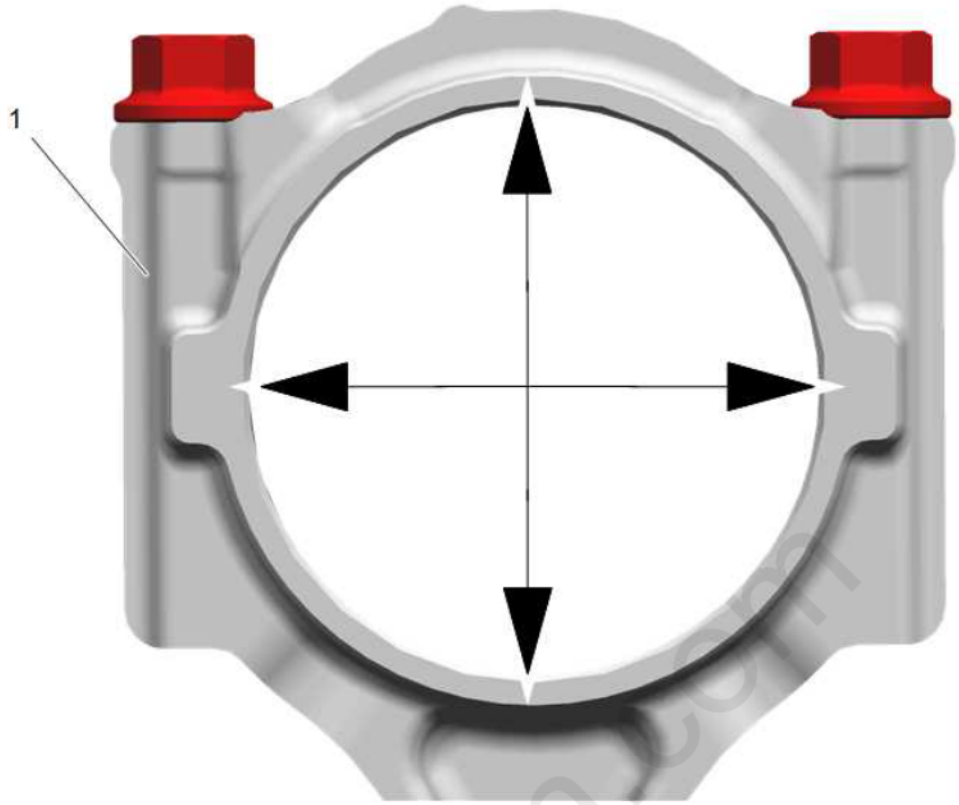


Fig. 99: Measuring Connecting Rod Crankshaft Bearing Bore
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Measurements of all components should be taken with the components at normal room temperature.**

2. Compare the bore measurements with the **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .
3. Replace the connecting rod if the bore is out of specifications. DO NOT recondition the connecting rod.

PISTON AND CONNECTING ROD ASSEMBLE

Special Tools

- **EN-46121** Connecting Rod Guide Pin Set
- **EN-46745** Piston Pin Clip Remover/Installer

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

Piston and Piston Pin Installation Procedure

1. Lubricate the piston pin bores in the piston and the connecting rod with GM prelube lubricant. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended lubricant.

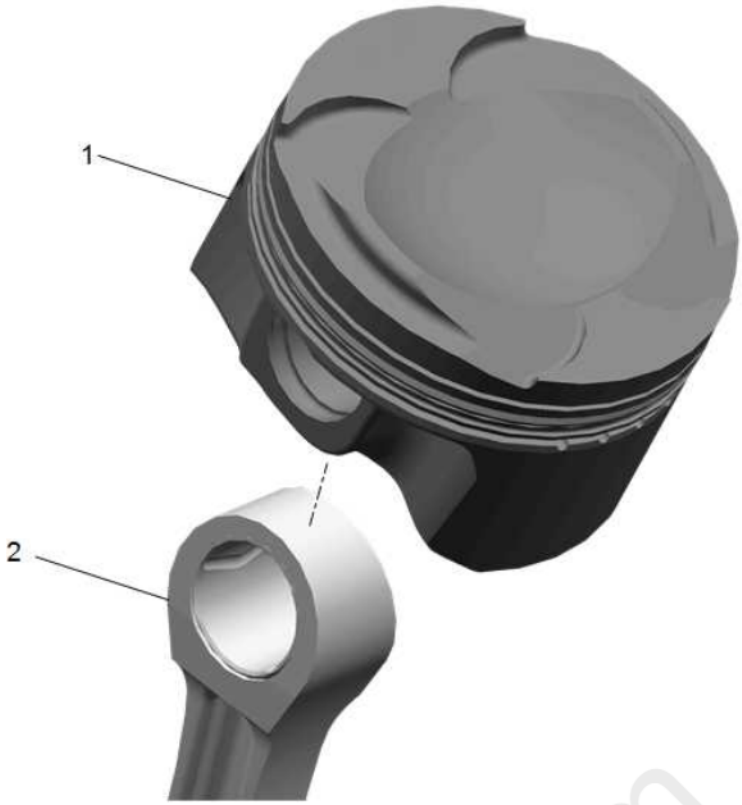


Fig. 100: View Of Piston Pin
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **The piston is directional and must be installed in the engine block in the proper direction. The dot on the top of the piston must face the front of the engine.**
- **The piston is model dependent and may not appear exactly as shown.**

2. Assemble the piston and piston pin to the connecting rod. Properly orient the piston when reusing a marked connecting rod.
3. Align the piston pin bore with the connecting rod pin bore.
4. Slide the piston pin into the piston and the connecting rod.
5. Install NEW piston pin retainers using the **EN-46745** remover/installer. Align the **EN-46745** remover/installer to the notch (1) in the piston.

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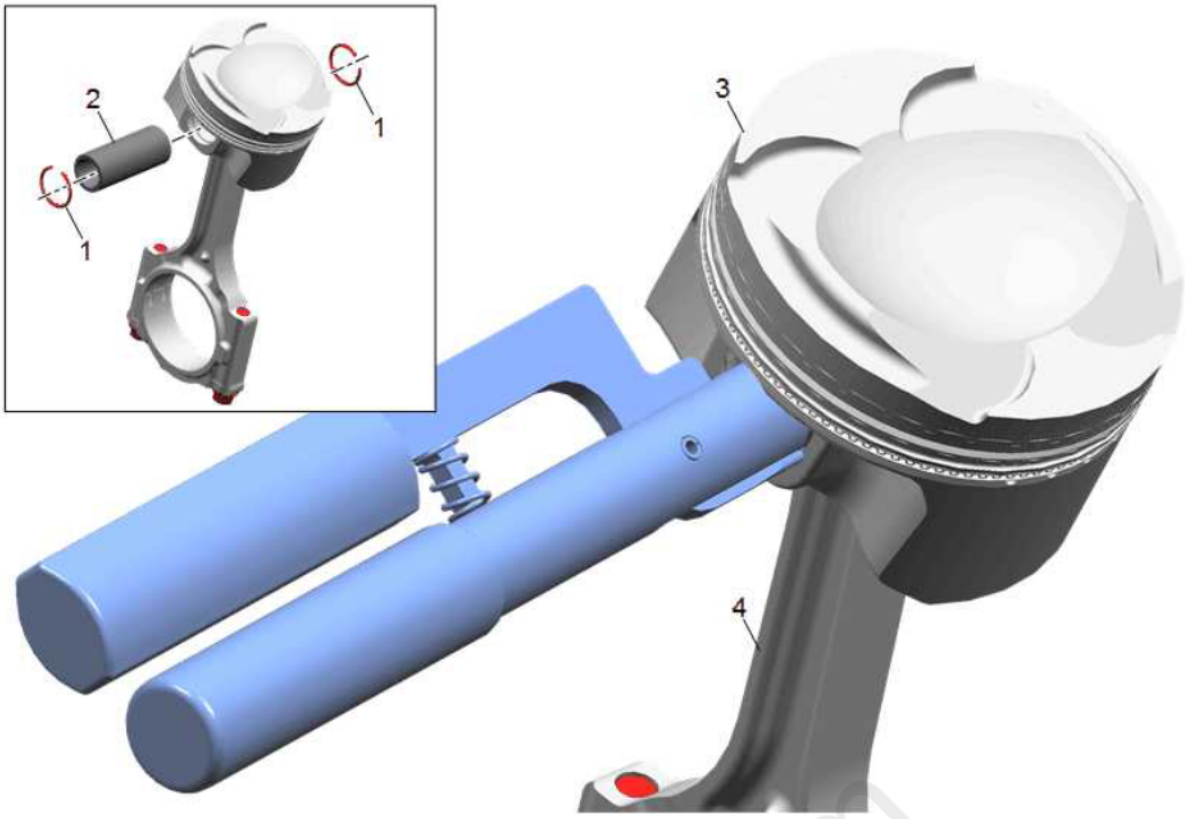


Fig. 101: Identifying Piston Pin Retainers Removal Access Notch
Courtesy of GENERAL MOTORS COMPANY

NOTE: **New piston pin retainers must be used. Never reuse the piston pin retainers.**

6. Ensure that the piston pin retainers are fully seated in their grooves.
7. Repeat these procedures for the remaining pistons.

Piston Ring Installation Procedure

1. Properly orient the oil control ring expander as shown before installation. The ends of the expander must be facing toward the top of the piston.

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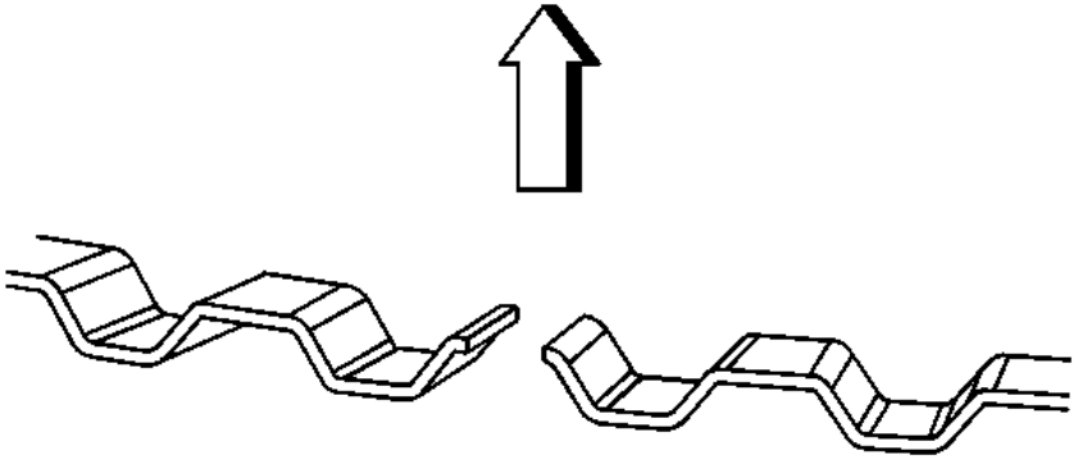
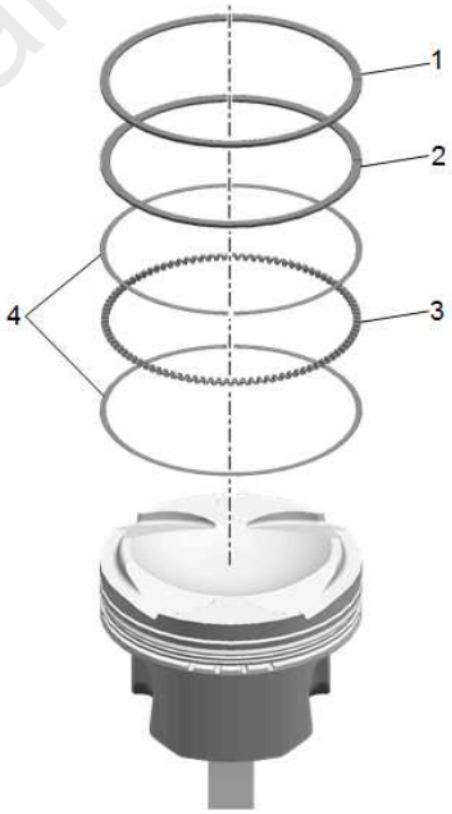


Fig. 102: Aligning Oil Control Ring Expander
Courtesy of GENERAL MOTORS COMPANY

2. Using a piston ring expander, install the oil control ring assembly using the following procedure:



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Fig. 103: Identifying Piston Rings
Courtesy of GENERAL MOTORS COMPANY

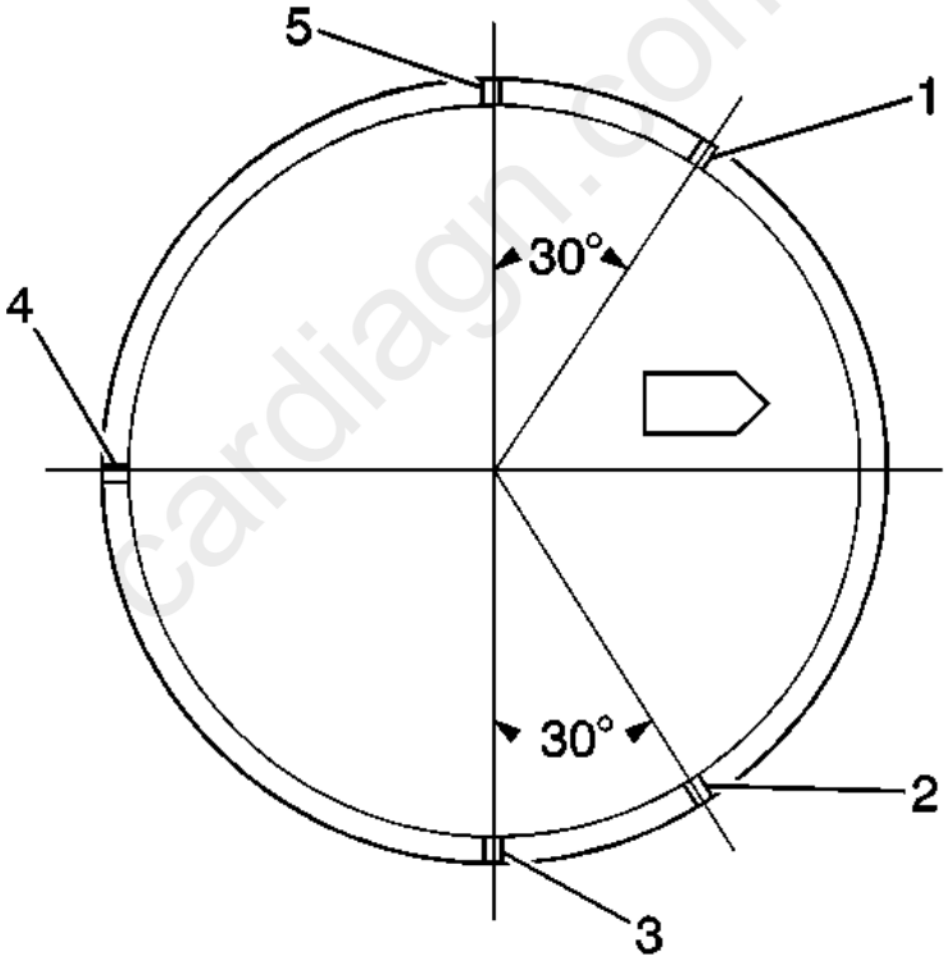
1. Install the expander ring (3).
2. Install the 2 oil scraper rings (4). Expand the rings only enough to clear the piston diameter. Overexpanding the piston rings will distort or crack the rings.

3. Install the lower compression piston ring (2) onto the piston with the mark facing the top of the piston.

NOTE: **The lower compression piston ring (2) is thicker and will not fit in the upper compression rings (1) position.**

NOTE: **For the LY7, the upper compression ring is symmetrical and may be installed either side up. For all other RPO's, the mark on the piston ring should face the top of the piston.**

4. Install the upper compression piston ring (1) onto the piston with the mark facing the top of the piston, if required.
5. Once the rings are installed, set the ring gaps for the oil control, second and top ring as follows. Use the piston location arrow for reference.



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Fig. 104: Illustrating Ring Gap Positions
Courtesy of GENERAL MOTORS COMPANY

1. Lower oil control ring - position 1
2. Upper oil control ring - position 2
3. Top Ring - position 3
4. Oil control ring expander - position 4

5. Second ring - position 5

Connecting Rod Bearing Installation Procedure

1. Clean the connecting rod and the connecting rod cap bearing bore with a lint-free cloth.

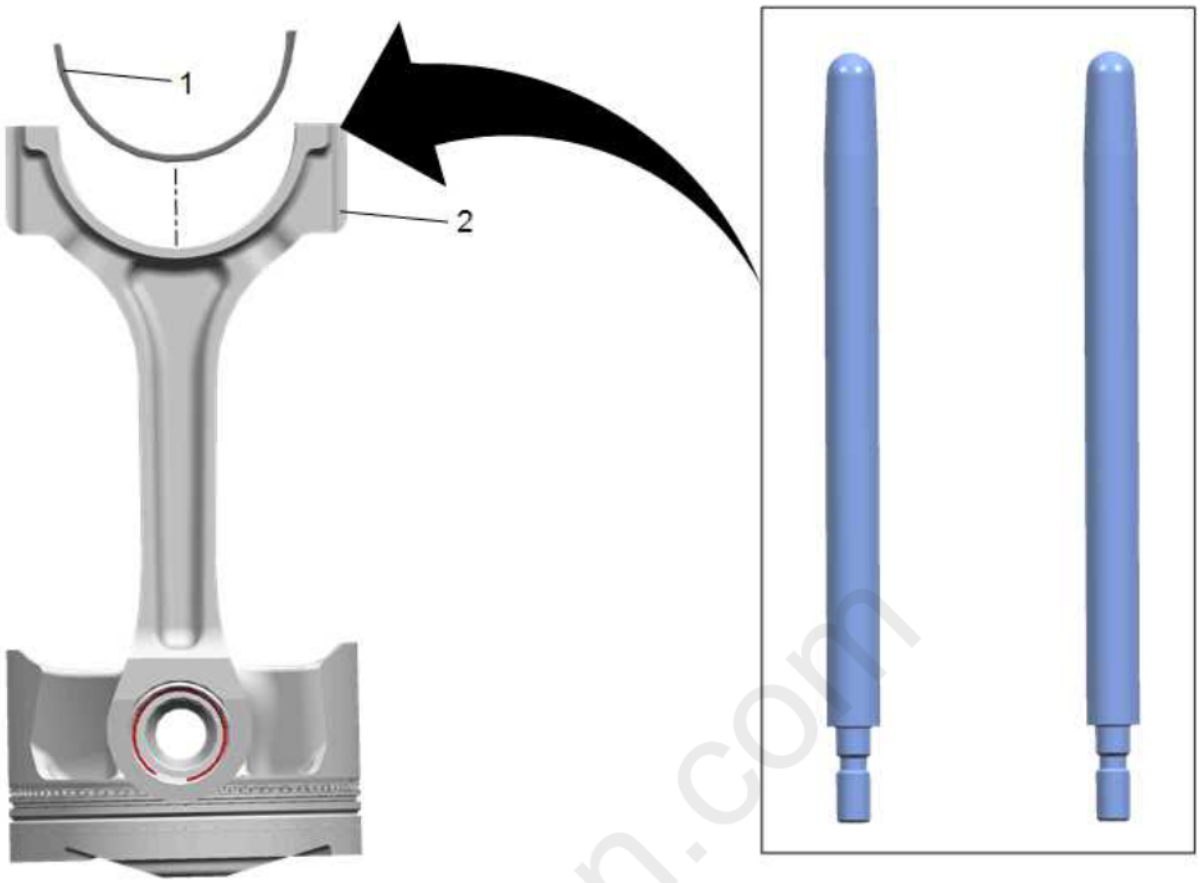


Fig. 105: View Of Piston/Connecting Rod Installation Tool
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.**

2. Clean all the oil from behind the connecting rod bearing halves.
3. Install NEW upper connecting rod bearings into position. Roll the bearing into position so that the lock tang engages the alignment slot. The bearing must fit flush in the connecting rod.
4. Install the **EN-46121** set into the connecting rod bolt holes.
5. Install NEW lower connecting rod bearings into position in the connecting rod cap. Roll the bearing into position so that the lock tang engages the alignment slot. The bearings must fit flush with the connecting rod cap.

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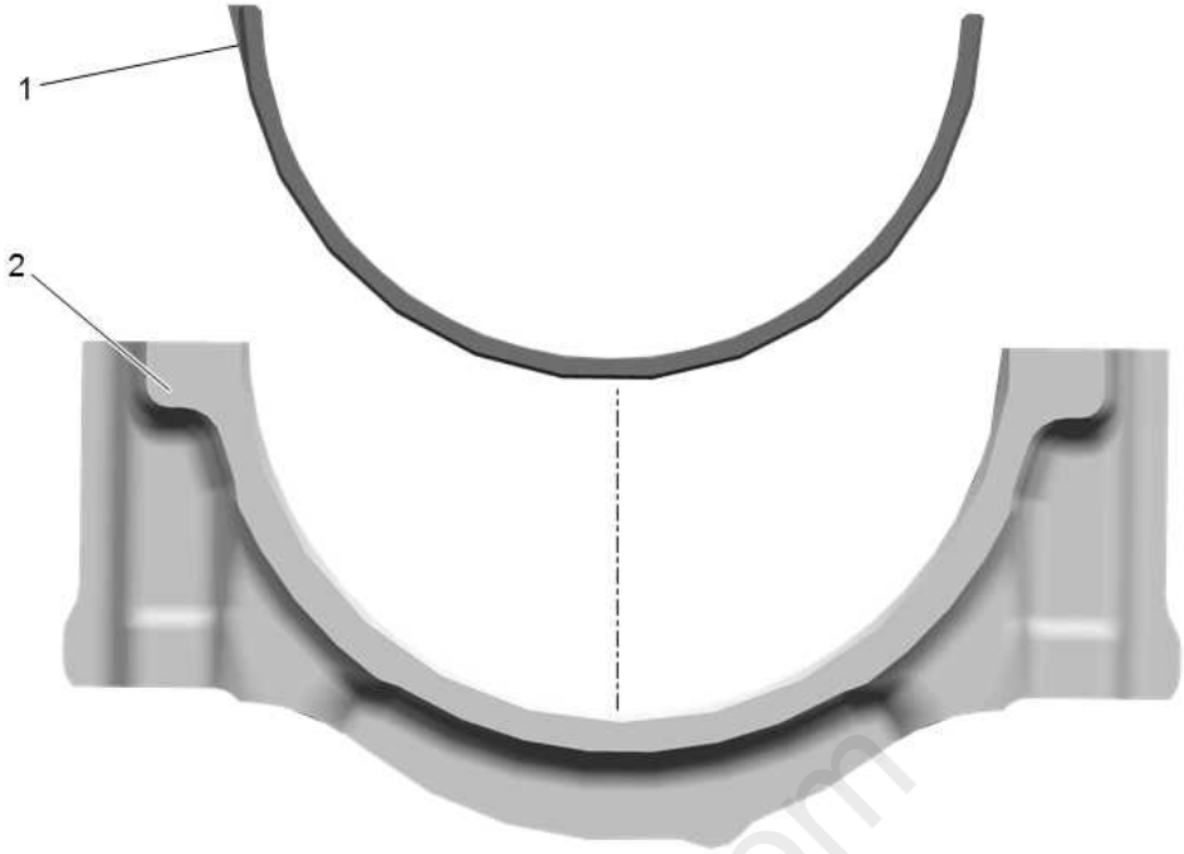


Fig. 106: View Of Lower Connecting Rod Cap & Bearing
Courtesy of GENERAL MOTORS COMPANY

CYLINDER HEAD DISASSEMBLE

Special Tools

- **EN-8062** Valve Spring Compressor - Head Off
- **EN-46116** Valve Stem Seal Remover/Installer
- **EN-46117** Valve Stem Key Remover/Installer
- **EN-46119** Off-Vehicle Valve Spring Compressor Adapter
- **EN-49248** Injector Rail Assembly Remover

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

1. Remove the fuel rail bolts (1) from the fuel rail (2).

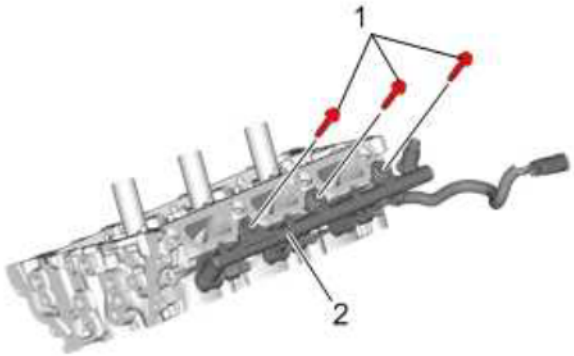


Fig. 107: Fuel Rail Bolts
Courtesy of GENERAL MOTORS COMPANY

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2. Remove the fuel rail and injectors (1) as an assembly using the **EN-49248** remover.

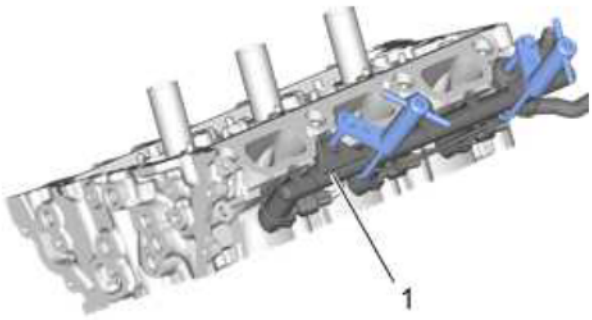


Fig. 108: Removing Fuel Rail And Injectors
Courtesy of GENERAL MOTORS COMPANY

CAUTION:

- **Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.**
- **Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.**

3. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve keepers.

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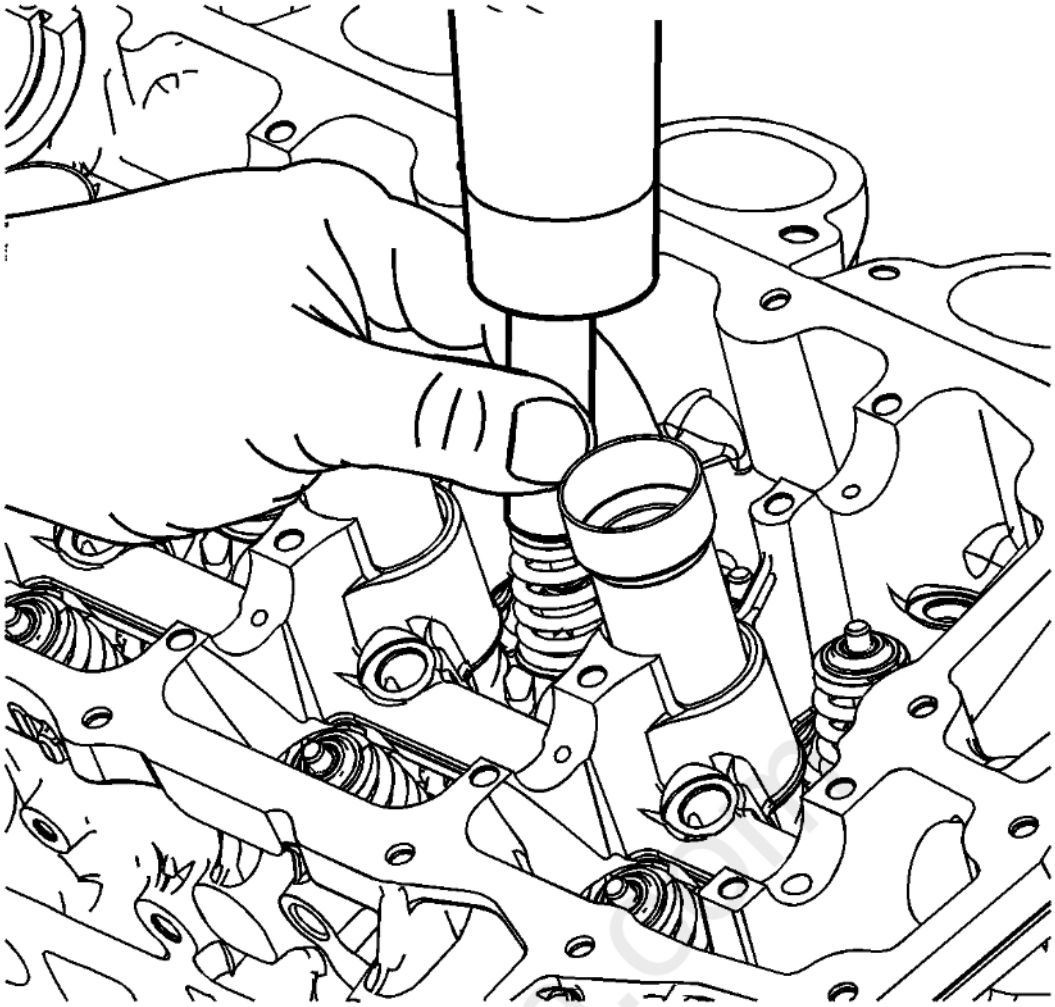


Fig. 109: Loosening Valve Keepers
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure valve heads will not contact anything during the following step in order to avoid bending or damage.**

4. Compress the valve spring using the **EN-8062** compressor and the **EN-46119** adapter.

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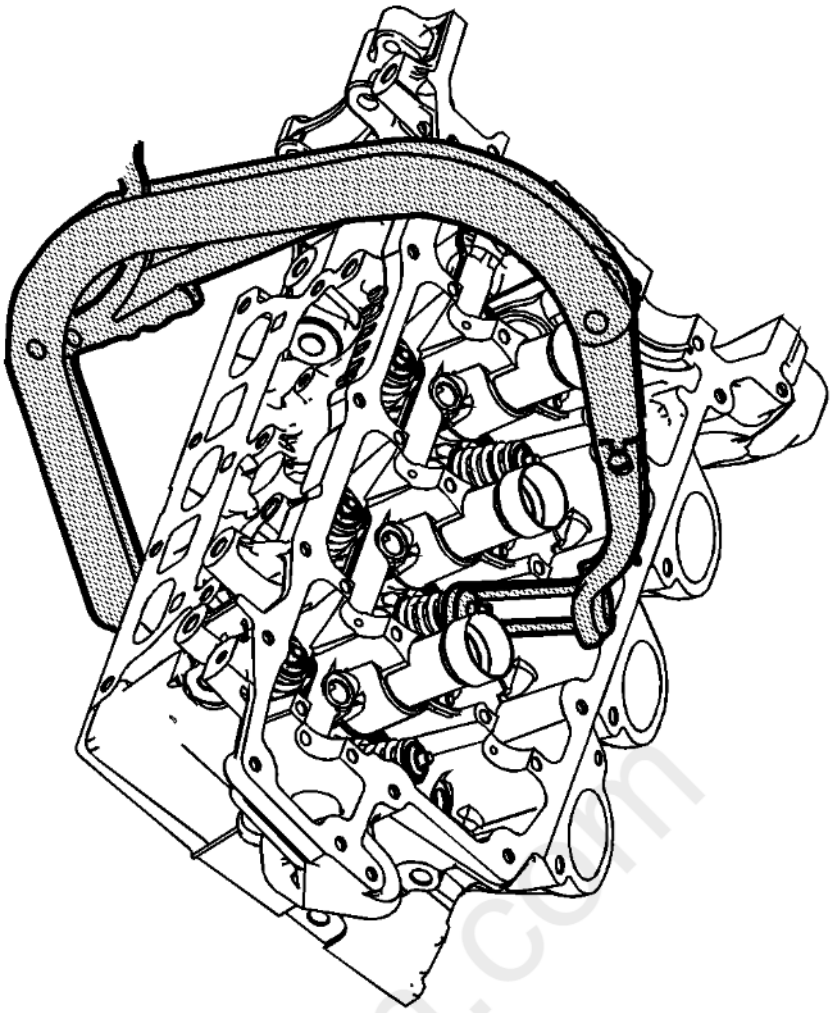


Fig. 110: Compressing Valve Spring
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.**

CAUTION: **Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.**

5. Use the magnet of the **EN-46117** remover/installer in order to remove the valve keepers.

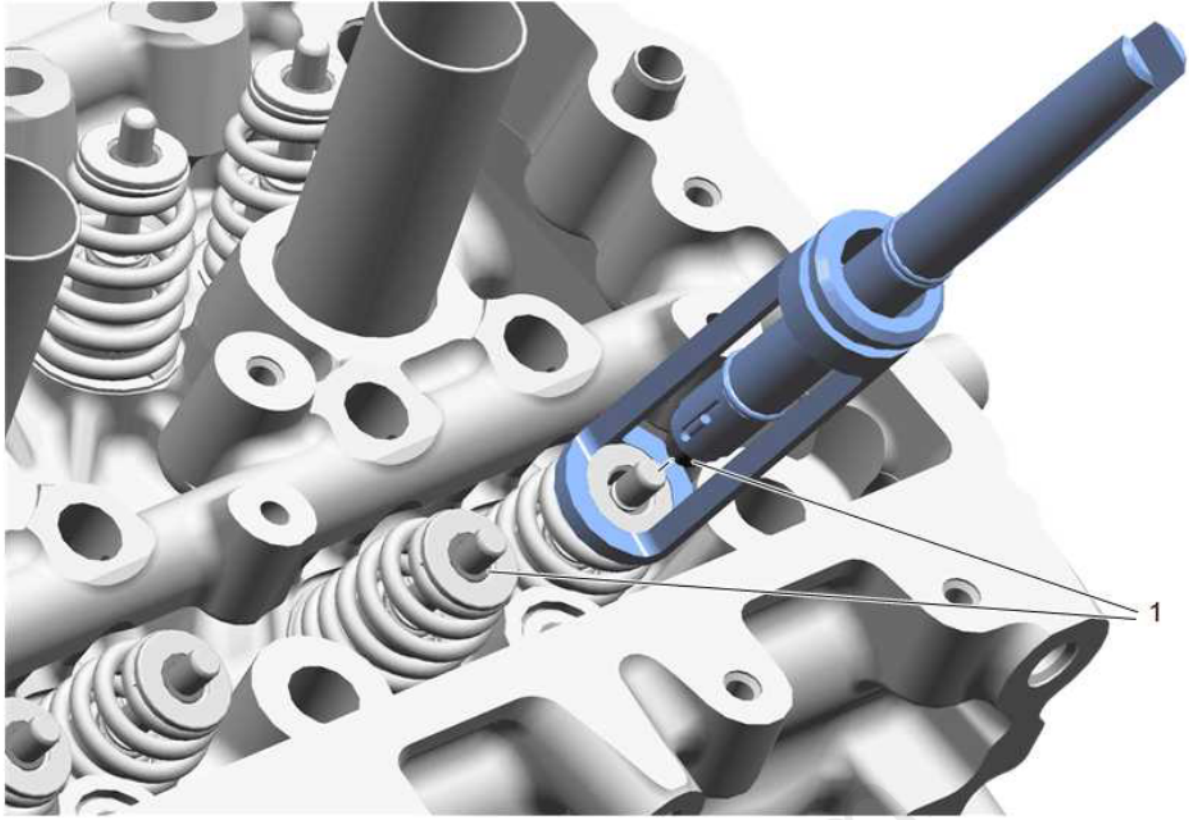


Fig. 111: Removing/Installing Valve Keepers
Courtesy of GENERAL MOTORS COMPANY

6. Remove the valve spring compressor and the adapter.
7. Remove the valve spring retainer.

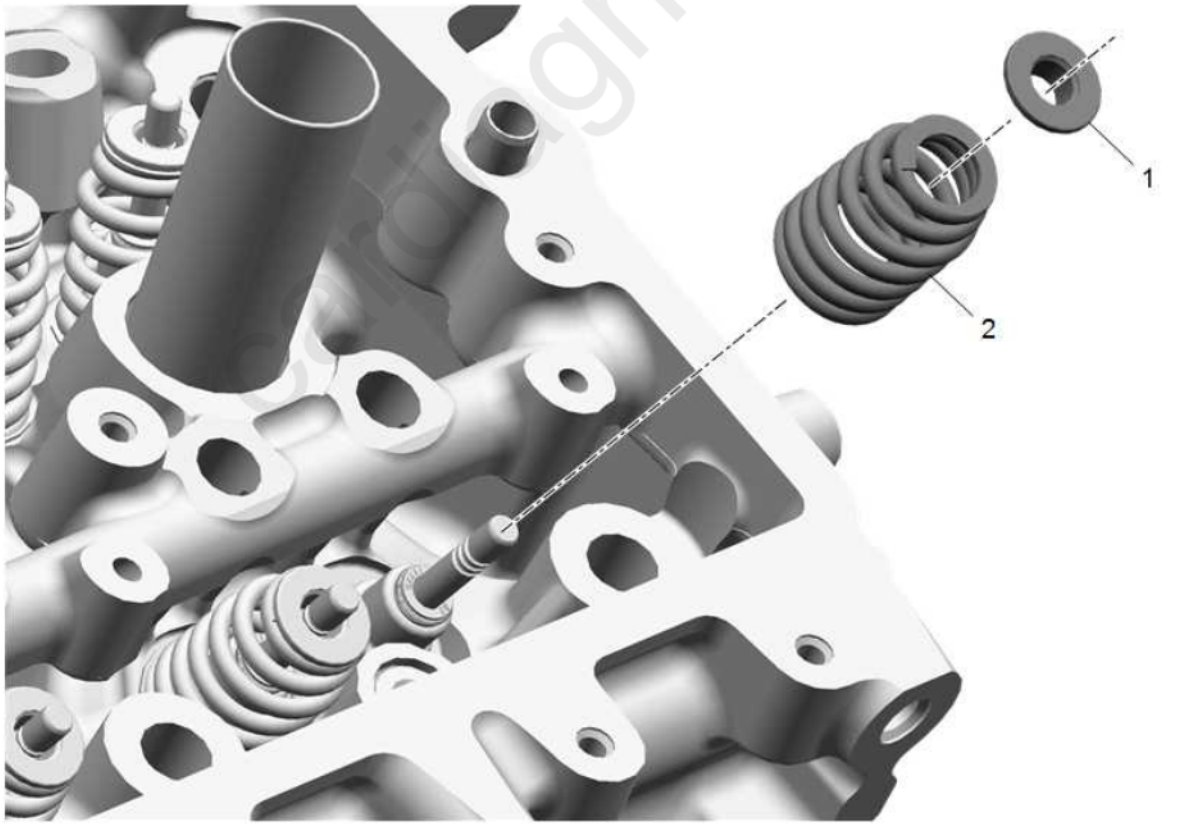


Fig. 112: View Of Valve Spring & Retainer
Courtesy of GENERAL MOTORS COMPANY

8. Remove the valve spring.
9. Remove the valve.

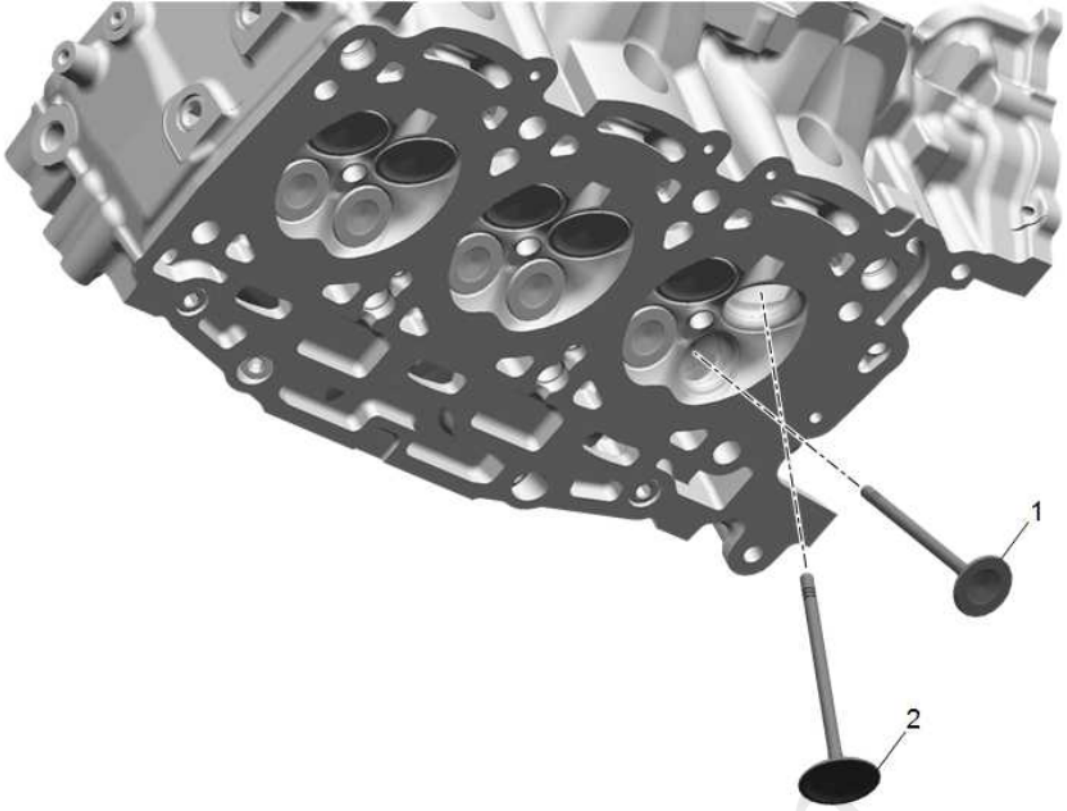


Fig. 113: View of Oil Seal and Valve Guide
Courtesy of GENERAL MOTORS COMPANY

10. Remove the valve stem oil seal using the **EN-46116** remover/installer and discard.



Fig. 114: Removing/Installing Valve Stem Oil Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: **NEVER reuse a valve stem oil seal.**

11. Repeat these procedures for the remaining valves.
12. Remove the cylinder head oil gallery expansion plugs.

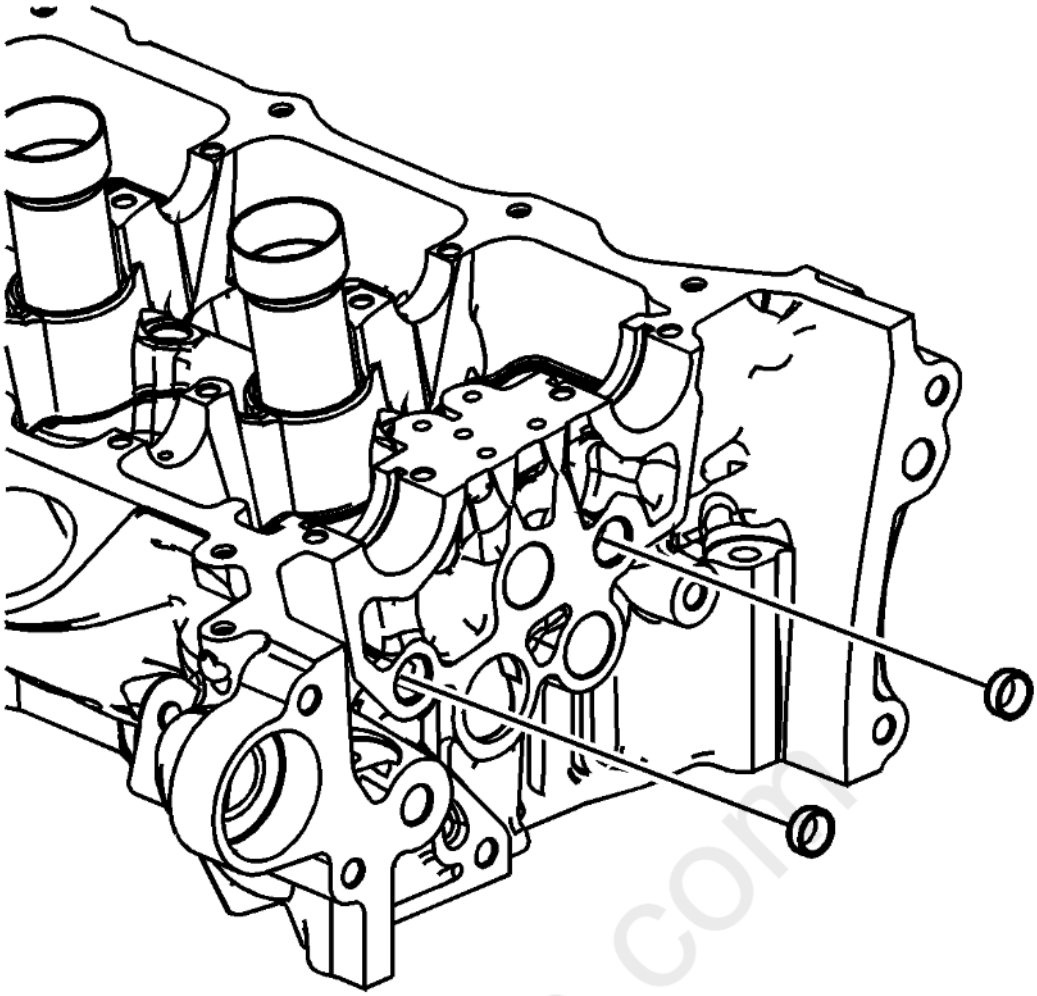


Fig. 115: View Of Cylinder Head Oil Gallery Expansion Plugs
Courtesy of GENERAL MOTORS COMPANY

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **GE-8001** Dial Indicator Set
- **GE-8358** Carbon Removal Brush
- **EN-28410** Gasket Remover
- **EN-42096** Valve Guide Reamer
- **EN-47909** Injector Bore and Sleeve Cleaning Kit

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

Cleaning Procedure

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**
2. Remove any old thread sealant, gasket material or sealant using **EN-28410** remover.
3. Clean all cylinder head surfaces with non-corrosive solvent.
4. Blow out all the oil galleries using compressed air.

WARNING: **Refer to Safety Glasses Warning .**

5. Remove any carbon deposits from the combustion chambers using the **GE-8358** brush.
6. Clean any debris or build-up from the lifter pockets.

Visual Inspection

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1. Inspect the cylinder head camshaft bearing surfaces for the following conditions:

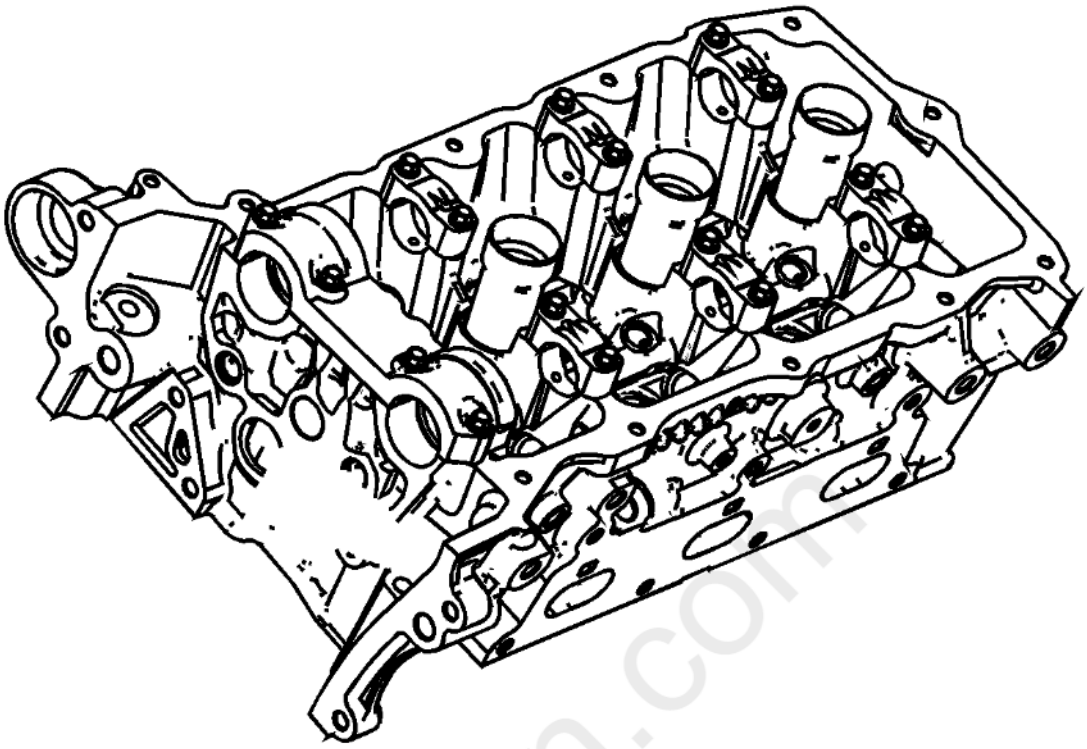


Fig. 116: View Of Cylinder Head
Courtesy of GENERAL MOTORS COMPANY

- Excessive scoring or pitting
- Discoloration from overheating
- Deformation from excessive wear
- If the camshaft bearing journals appear to be scored or damaged, you must replace the cylinder head. DO NOT machine the camshaft bearing journals.

2. If any of the above conditions exist on the camshaft bearing surfaces, replace the cylinder head.
3. Inspect the cylinder head for the following:
   - Cracks, damage or pitting in the combustion chambers
   - Debris in the oil galleries - Continue to clean the galleries until all debris is removed.
   - Coolant leaks or damage to the deck face sealing surface - If coolant leaks are present, measure the surface warpage as described under Cylinder Head Measurement - Deck Flatness Inspection.
   - Burrs or any defects that would degrade the sealing of the NEW secondary camshaft drive chain tensioner gasket
   - Damage to any gasket surfaces
   - Damage to any threaded bolt holes
   - Burnt or eroded areas in the combustion chamber
   - Cracks in the exhaust ports and combustion chambers
   - External cracks in the water passages
   - Restrictions in the intake or exhaust passages
   - Restrictions in the cooling system passages

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- Rusted, damaged or leaking core plugs

4. If the cylinder head is cracked or damaged, it must be replaced. No welding or patching of the cylinder head is recommended.
5. Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced. Refer to **Cylinder Head Disassemble**.

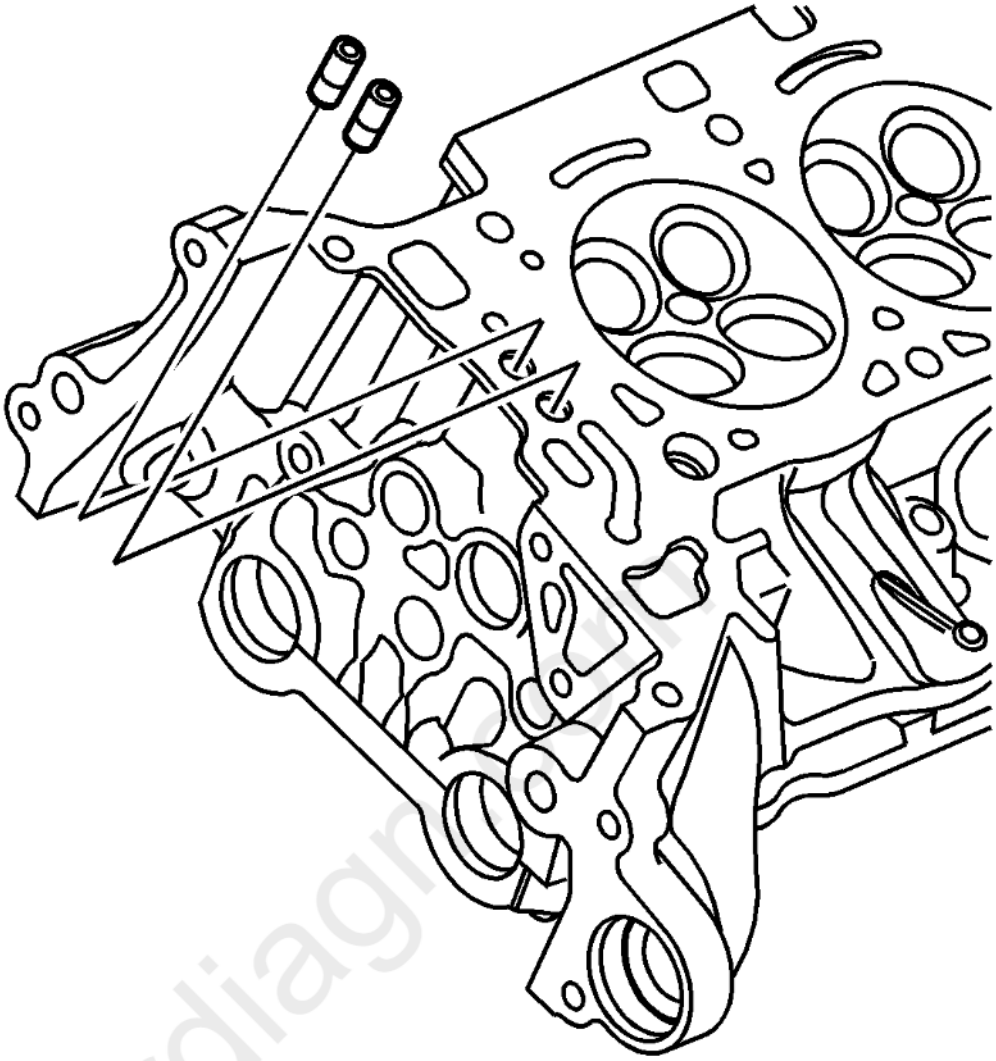


Fig. 117: View Of Camshaft Position Actuator Oil Feed Check Valve
Courtesy of GENERAL MOTORS COMPANY

6. Inspect the fuel rail injector bores and clean with **EN-47909** kit, if required.

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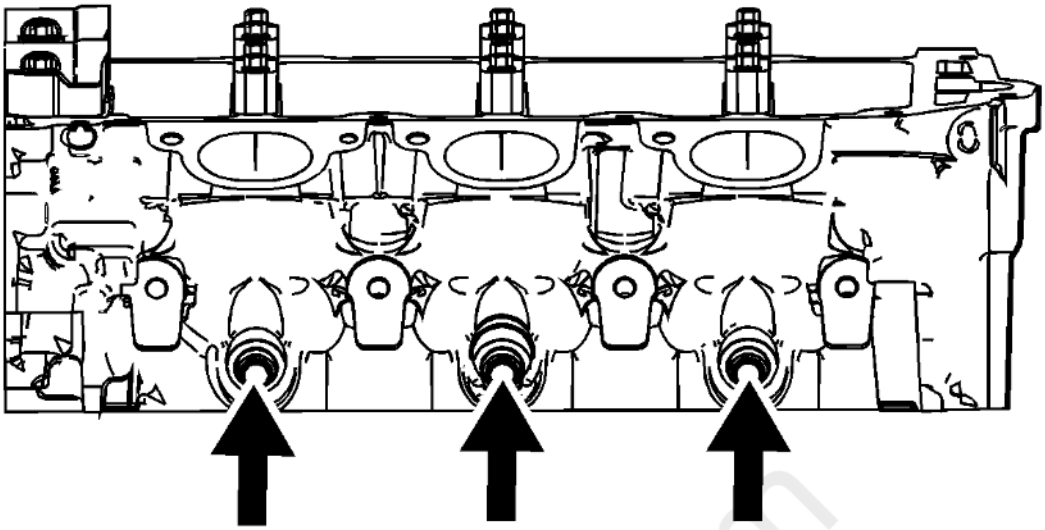


Fig. 118: View of Fuel Rail injector Bores
Courtesy of GENERAL MOTORS COMPANY

Cylinder Head Measurement

Camshaft Journal Clearance

1. Install the camshaft bearing cap in the cylinder head without the camshaft.
2. Install the camshaft cap bolts and tighten to 10 N.m (89 lb in).

CAUTION: **Refer to Fastener Caution .**

3. Measure the camshaft bearings using an inside micrometer.
4. Subtract the camshaft journal diameter from the camshaft bearing diameter. This will provide the running clearance. If the running clearance exceeds specifications and the camshaft journals are within specification, replace the cylinder head.

Camshaft Journal Alignment

1. Ensure the camshafts are serviceable.
2. Inspect the cylinder head camshaft bearing surfaces for any imperfections or scratches that could inhibit proper camshaft clearances. Repair minor imperfections or scratches.
3. Install the camshafts in the cylinder head.
4. Install the camshaft bearing caps.
5. Install the camshaft cap bolts and tighten to 10 N.m (89 lb in).
6. Ensure the camshafts spin freely in the cylinder head. If the camshaft does not run freely, replace the cylinder head.

Deck Flatness Inspection

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1. Ensure the cylinder head decks are clean and free of gasket material.

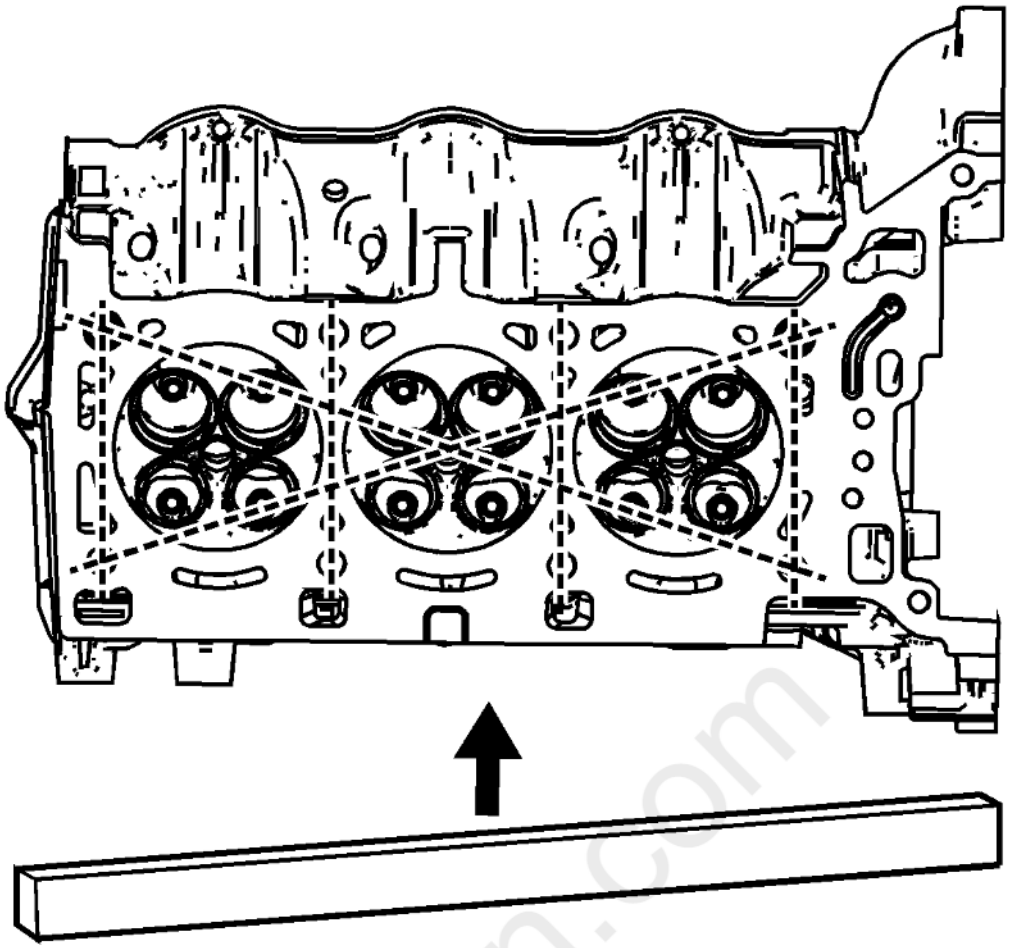


Fig. 119: Measuring Deck Flatness
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder head deck face surface.
4. Measure the clearance between the straight-edge and the cylinder head deck face using a feeler gauge at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder head deck surface does not require resurfacing.
6. If the warpage is between 0.05-0.20 mm (0.002-0.008 in) or any imperfections or scratches that could inhibit proper cylinder head gasket sealing are present, the cylinder head deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder head deck surface requires more than 0.25 mm (0.010 in) material removal the head must be replaced.

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.

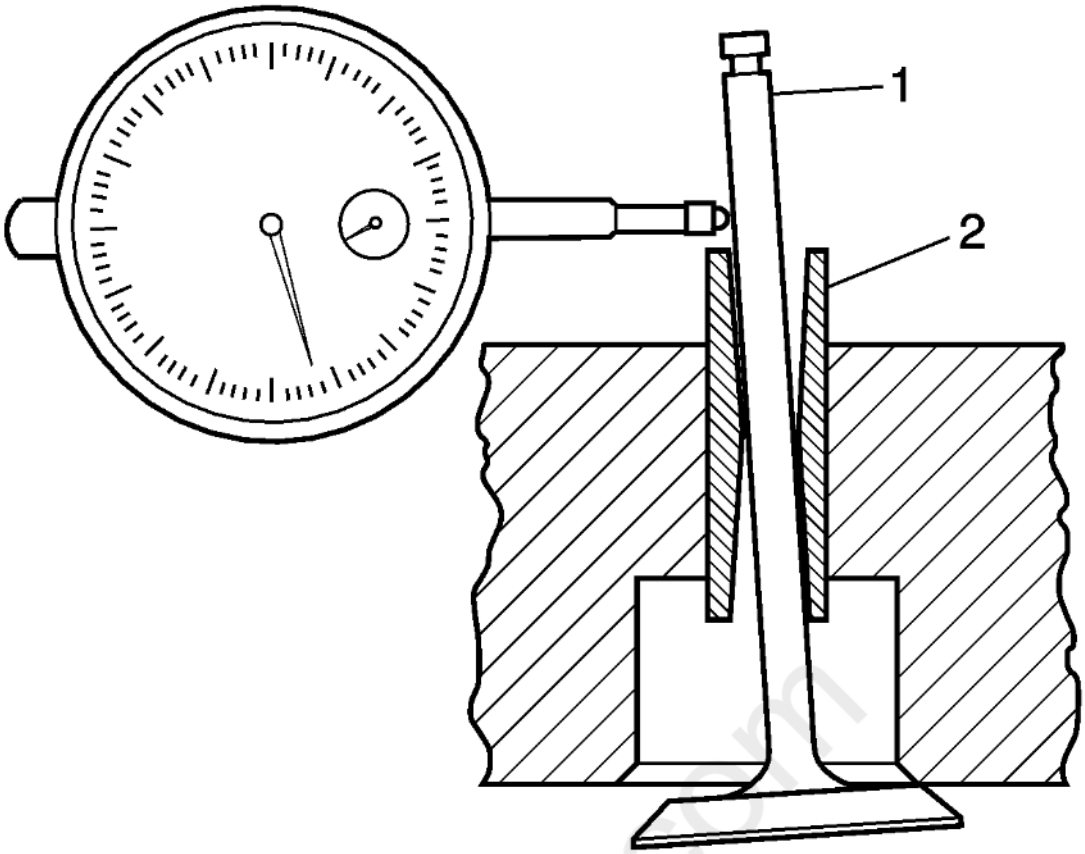


Fig. 120: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS COMPANY

2. Clamp the **GE-8001** set 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 (LGX)** and **Engine Mechanical Specifications (LGW)** for proper clearance.
    - If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, the valve guide may be oversized by 0.075 mm (0.003 in) using the **EN-42096** reamer. There is 1 size of oversized valve stem available for service.
    - Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.
    - If oversizing the guide does not bring the clearance within specifications, replace the cylinder head.

VALVE SPRING INSPECTION AND MEASUREMENT

Special Tools

EN 22738-B Valve Spring Tester

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

Inspection Procedure

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1. Clean the valve springs in solvent.
2. Dry the valve springs with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

3. Inspect the valve springs for broken coils or coil ends.

Measurement Procedure

1. Measure the valve spring tension using the **EN 22738-B** tester. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .

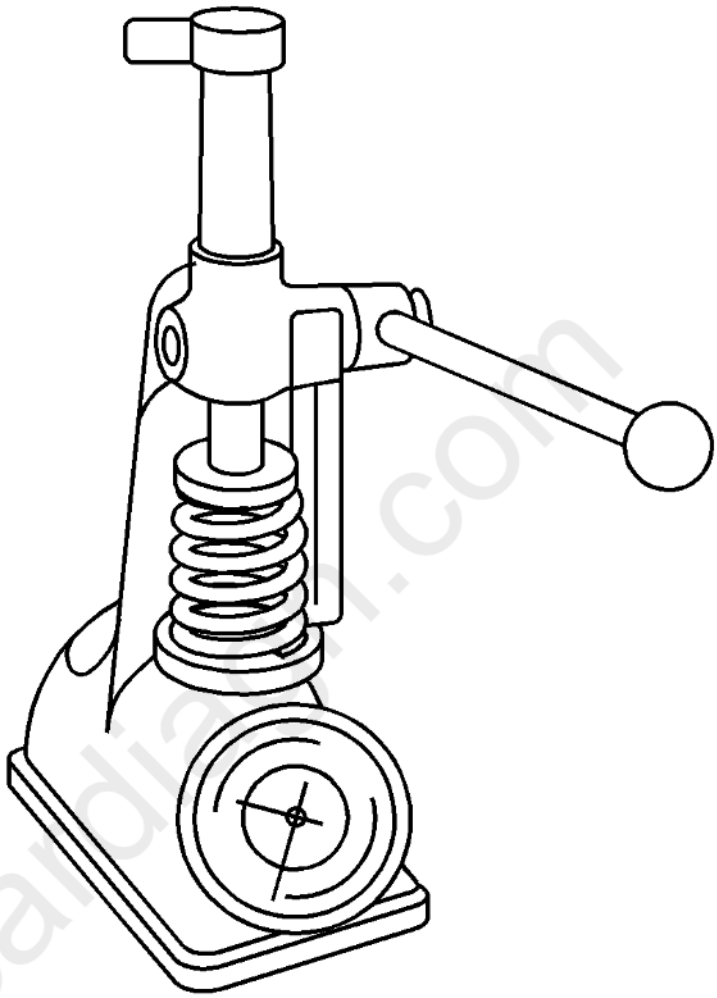


Fig. 121: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS COMPANY

2. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

VALVE AND SEAT GRINDING

Valve Cleaning Procedure

1. Use soft bristle wire brush to clean any carbon build-up from the valve head. DO NOT use a wire brush on any part of the valve stem. The valve stem is chrome plated to provide enhanced wear characteristics. Wire brushing the stem could remove the chrome plating.
2. Thoroughly clean the valve with solvent and wipe dry.

Valve Visual Inspection Procedure

1. Inspect the valve for damage from the head to tip for the following conditions:

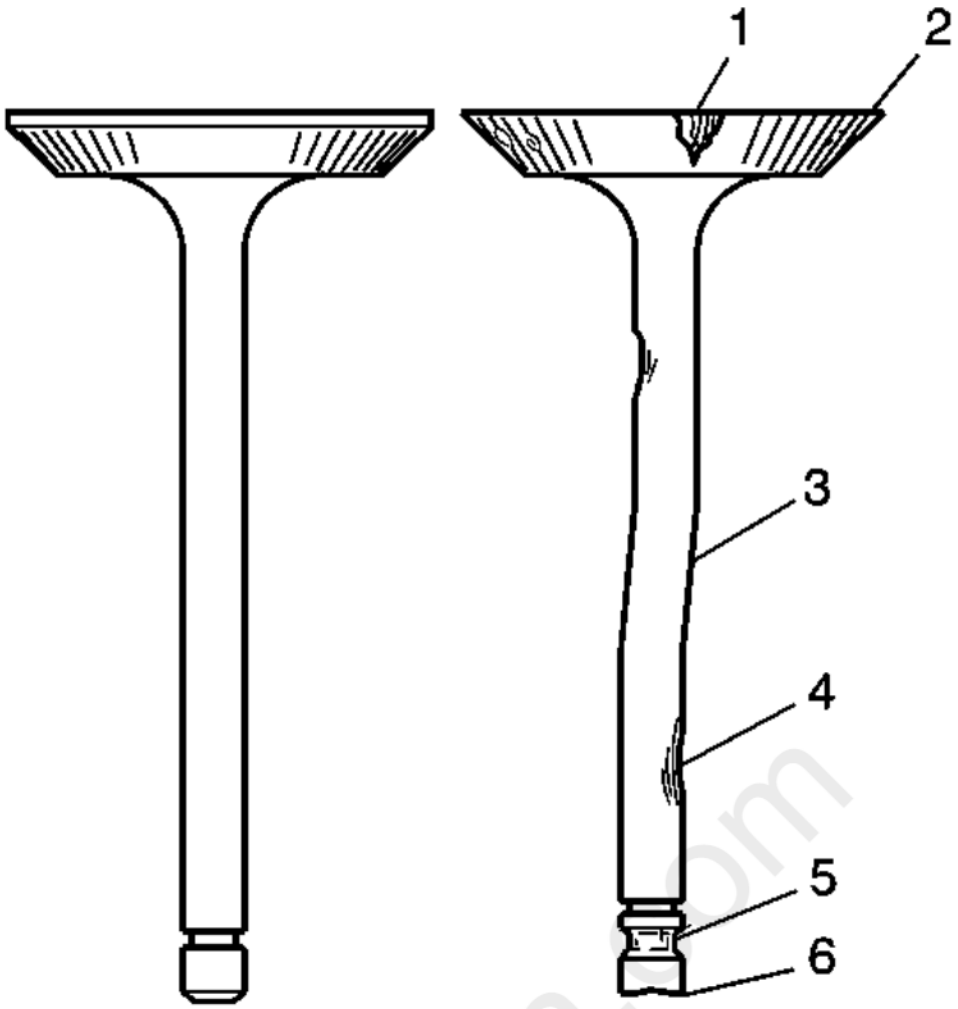


Fig. 122: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS COMPANY

- Pitting in the valve seat area (1)
- Lack of valve margin (2)
- Bending in the valve stem (3)
- Pitting or excessive wear in the stem (4)
- Worn valve key grooves (5)
- Worn valve tip (6)

2. Replace the valve if any of these conditions exist.

Valve Measurement Overview

1. Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.

NOTE: **The following measurement and reconditioning procedures must be followed to ensure proper engine performance.**

2. If the measurement procedures reveal that the valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning. Valves for E85-compatible engines CANNOT be reconditioned. Any grinding, lapping, wire-brushing or other similar procedure will damage or destroy the coating that gives the valve the E-85 compatible features. If an E85-compatible valve is out of specification in any area, replace it.

Valve Seat Width Measurement Procedure

1. Measure the valve seat width in the cylinder head using a proper scale.

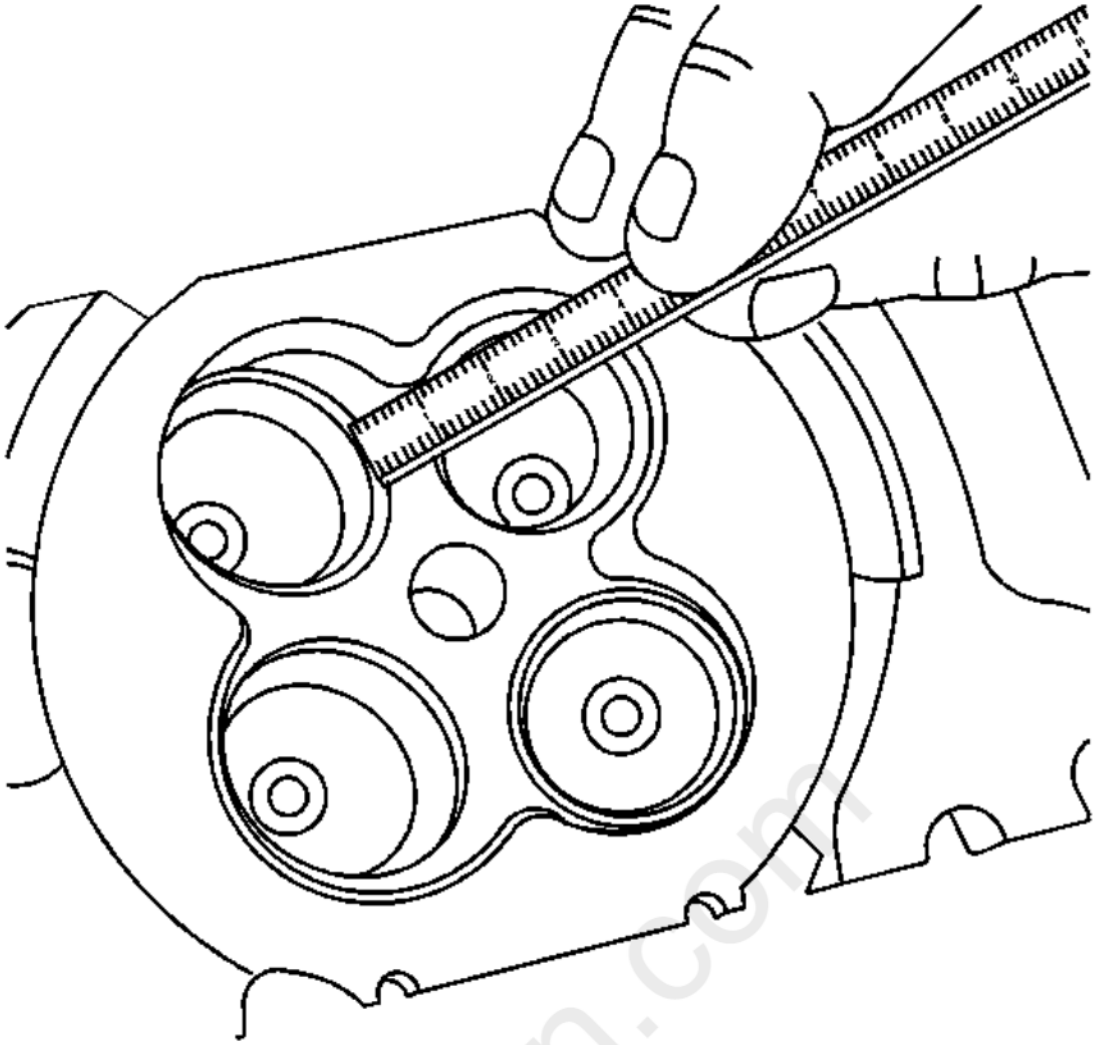


Fig. 123: Checking Valve Seat Width
Courtesy of GENERAL MOTORS COMPANY

2. Measure the seat width on the valve face (1) using a proper scale.

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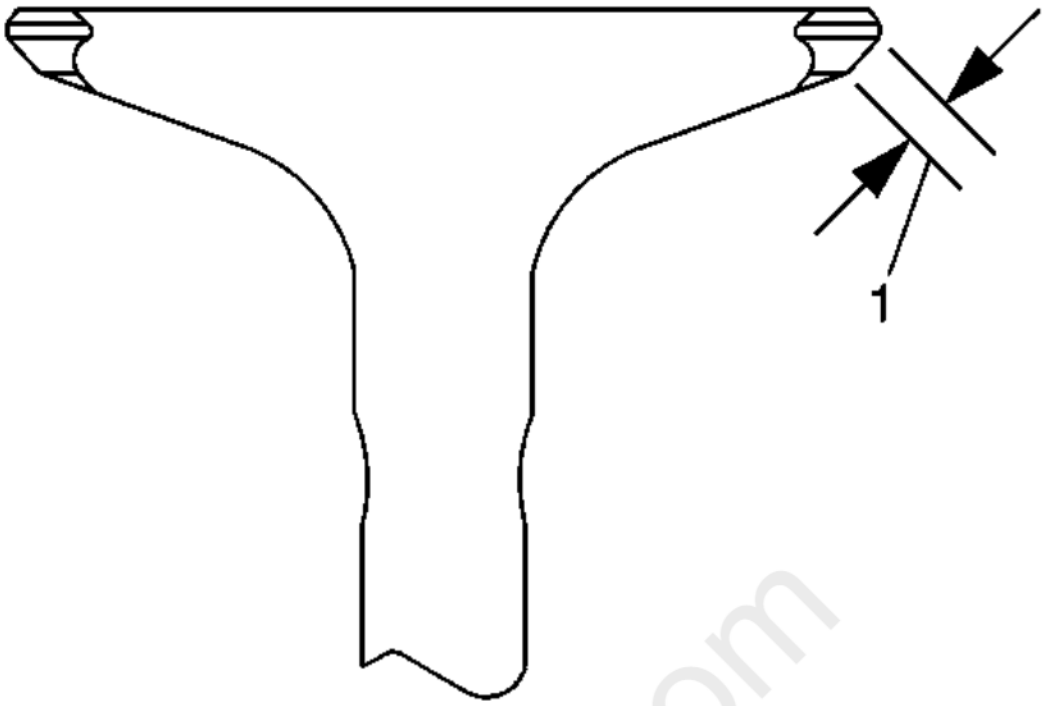


Fig. 124: Measuring Seat Width On Valve Face
Courtesy of GENERAL MOTORS COMPANY

3. Compare your measurements with the specifications listed in **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .

NOTE: **The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter (margin) of the valve. If the contact area is too close to the margins, the valve must be replaced.**

4. If the seat widths are acceptable, check the valve seat roundness using the **Valve Seat Roundness Measurement Procedure**.
5. If the seat width is not acceptable, you must replace the valve. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

Valve Seat Roundness Measurement Procedure

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.
2. Compare your measurements with the specifications listed in **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .

CAUTION: **The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.**

3. If the valve seat exceeds the roundness specification, you must replace the valve.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

Valve Margin Measurement Procedure

1. Measure the valve margin using an appropriate scale.

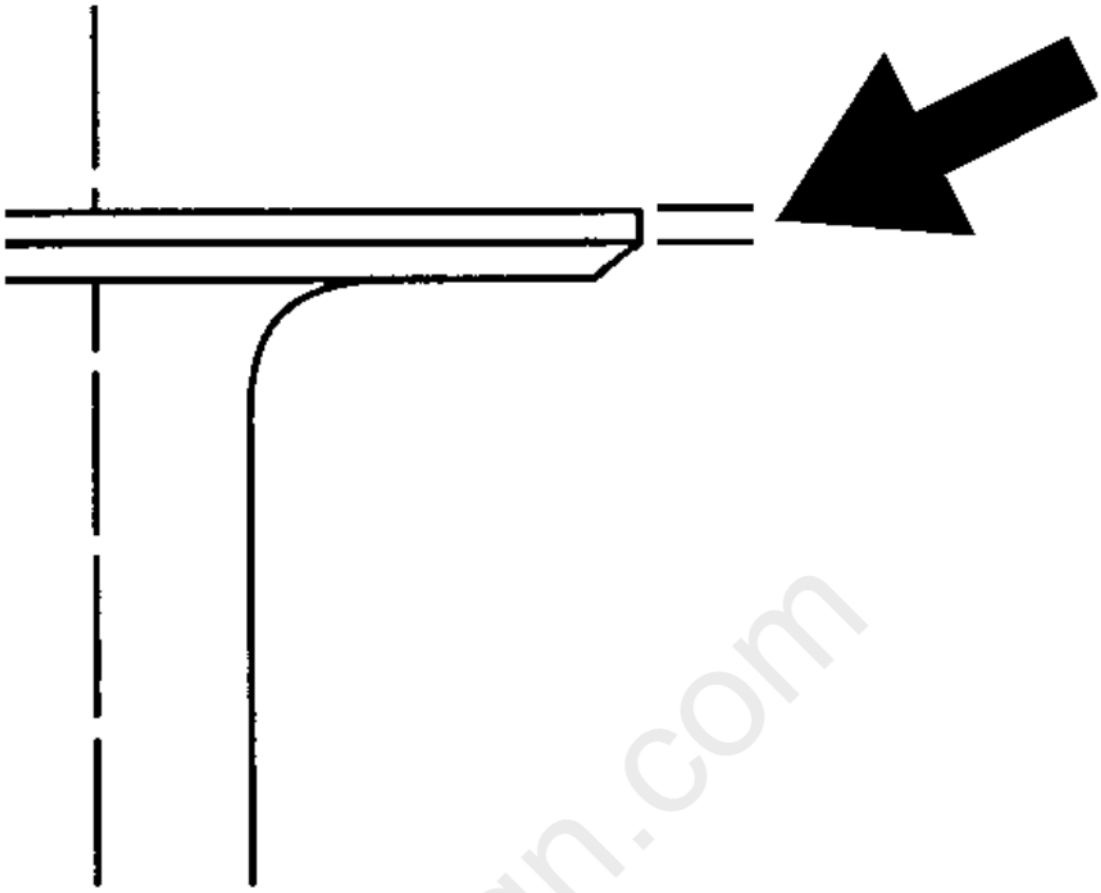


Fig. 125: View Of Valve Margin Measurement
Courtesy of GENERAL MOTORS COMPANY

2. Reference the specifications in this section for minimum valve margin and compare them to your measurements.
3. If the valve margins are beyond specification, replace the valves.
4. If the valve margins are within specification, test the valve for seat concentricity using the **Valve-to-Seat Concentricity Measurement Procedure**.

Valve-to-Seat Concentricity Measurement Procedure

1. Coat the valve face lightly with blue dye (3).

NOTE:

- **Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.**
- **You must measure the valve face and the valve seat to ensure proper valve sealing.**

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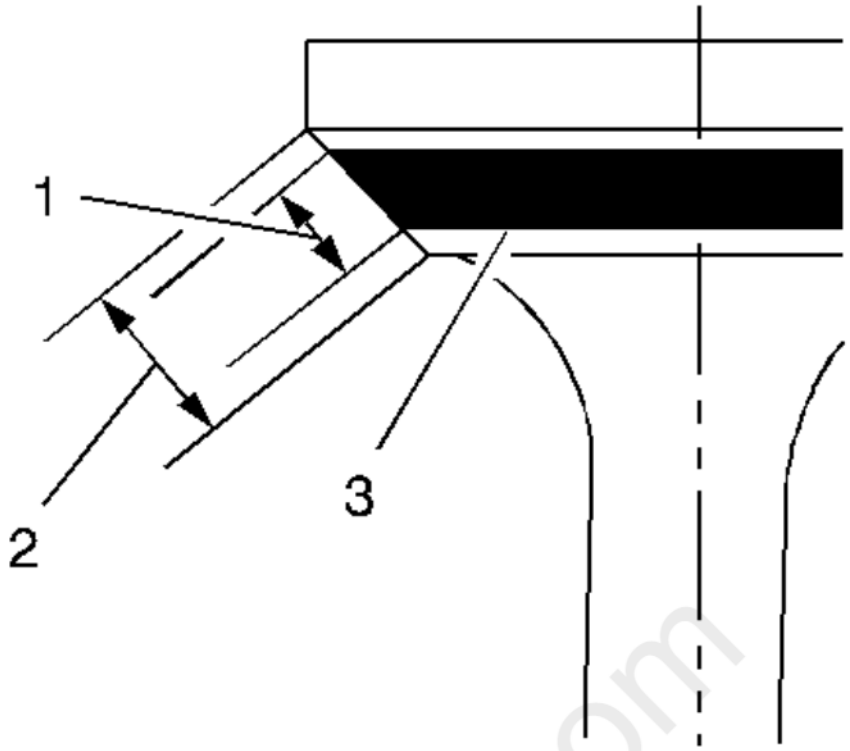


Fig. 126: View Of Valve Contact Face Measurements
Courtesy of GENERAL MOTORS COMPANY

2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.
    - If the valve face is concentric, providing a proper seal-with the valve stem, a continuous mark will be made around the entire face (1).

NOTE: **The wear mark MUST be at least 0.5 mm (0.020 in) from the outer diameter, the margin, of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.**

    - If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be replaced and the seat must be reconditioned using the **Valve and Seat Reconditioning Procedure**.

Valve and Seat Reconditioning Procedure

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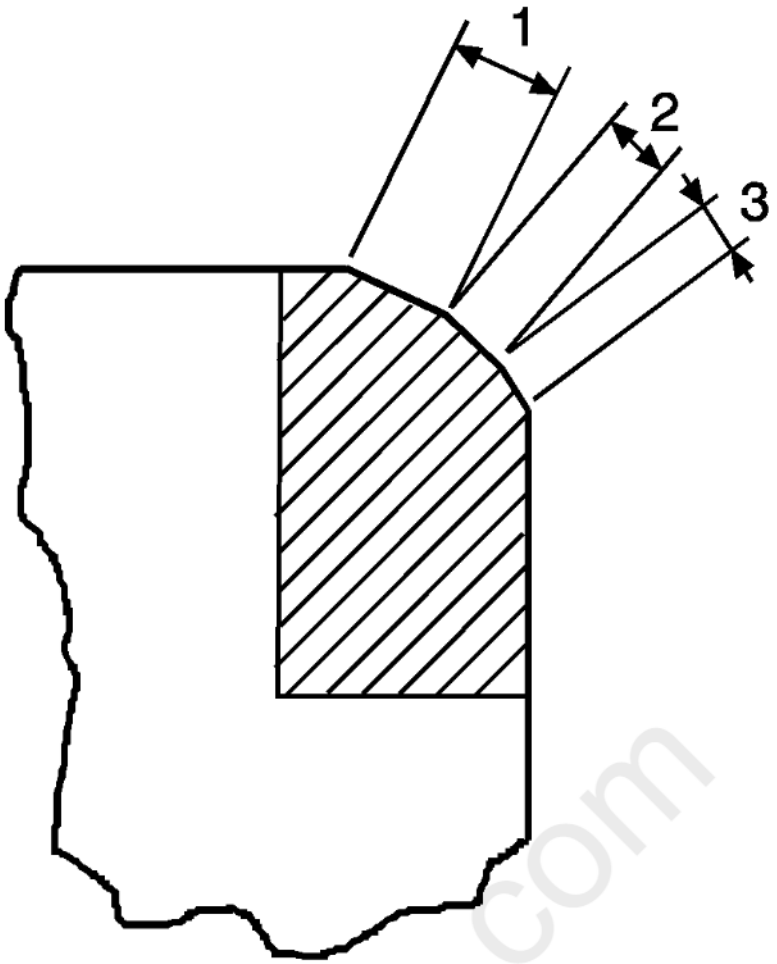


Fig. 127: View Of Valve Seat Proper Angles
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the buildup of carbon on the seats.**
- **A NEW valve must be used with any reconditioned seat.**

1. Grind the valve seats (2) to the proper angle specification listed in **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .
2. Using the proper angle specification listed in **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** , grind, relieve, the valve seats (1) to correctly position the valve seating surface (2) to the valve.
3. Using the proper angle specification listed in **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** , grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .
4. When grinding the seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
5. Install the valve in the cylinder head. Do not lap the valves under any condition, whether the valves are new or used.
6. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the **Valve Stem Height Measurement Procedure**.
7. If the valve stem height is acceptable, test the seats for concentricity using the **Valve-to-Seat Concentricity Measurement Procedure**.

Valve Stem Height Measurement Procedure

1. Install the valve into the valve guide.

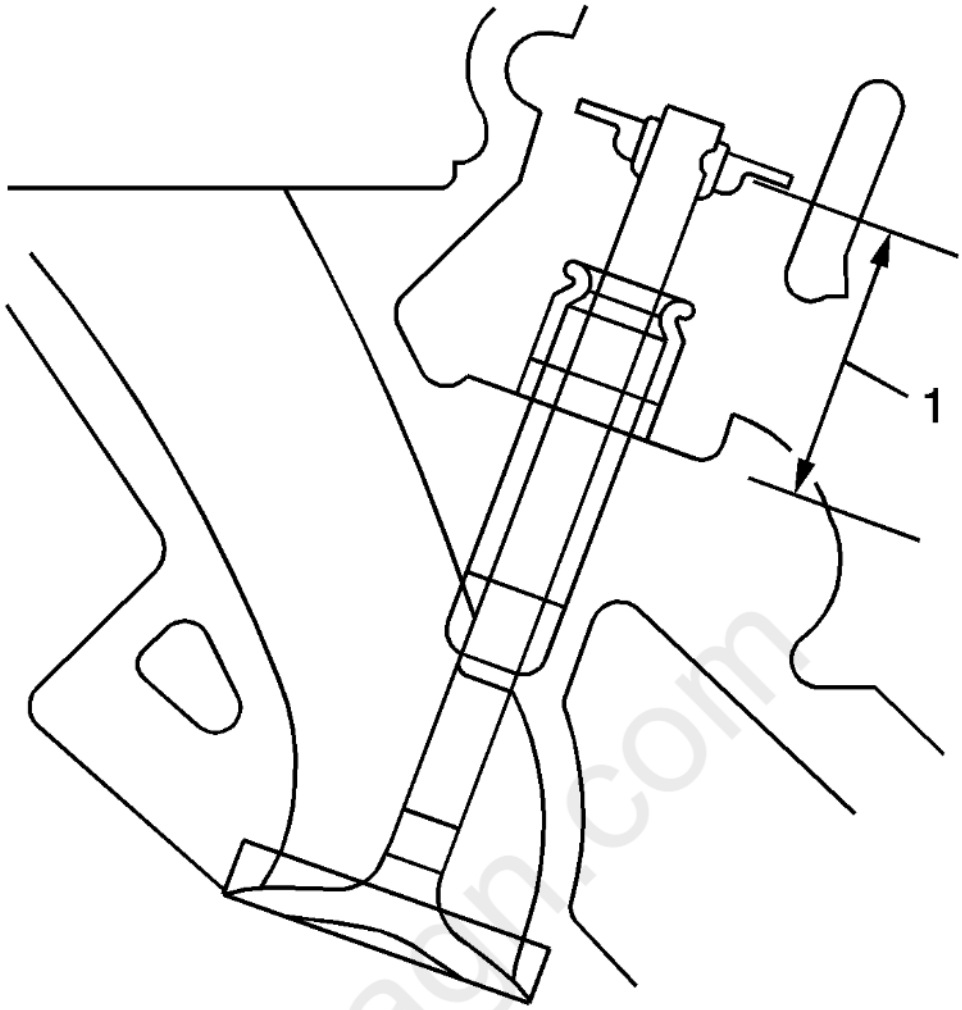


Fig. 128: Measuring Valve Stem Height
Courtesy of GENERAL MOTORS COMPANY

NOTE: **To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.**

2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.
5. Measure the distance (1) between the cylinder head to the bottom of the valve spring retainer. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.
7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

CAUTION: **DO NOT grind the valve stem tip. The tip of the valve is hardened and grinding the tip will eliminate the hardened surface causing premature wear and possible engine damage.**

CAUTION: **DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.**

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FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

Special Tools

- **EN 49245** Injector Seal Installer Kit

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

1. Disconnect and remove the fuel rail wiring harness (1).

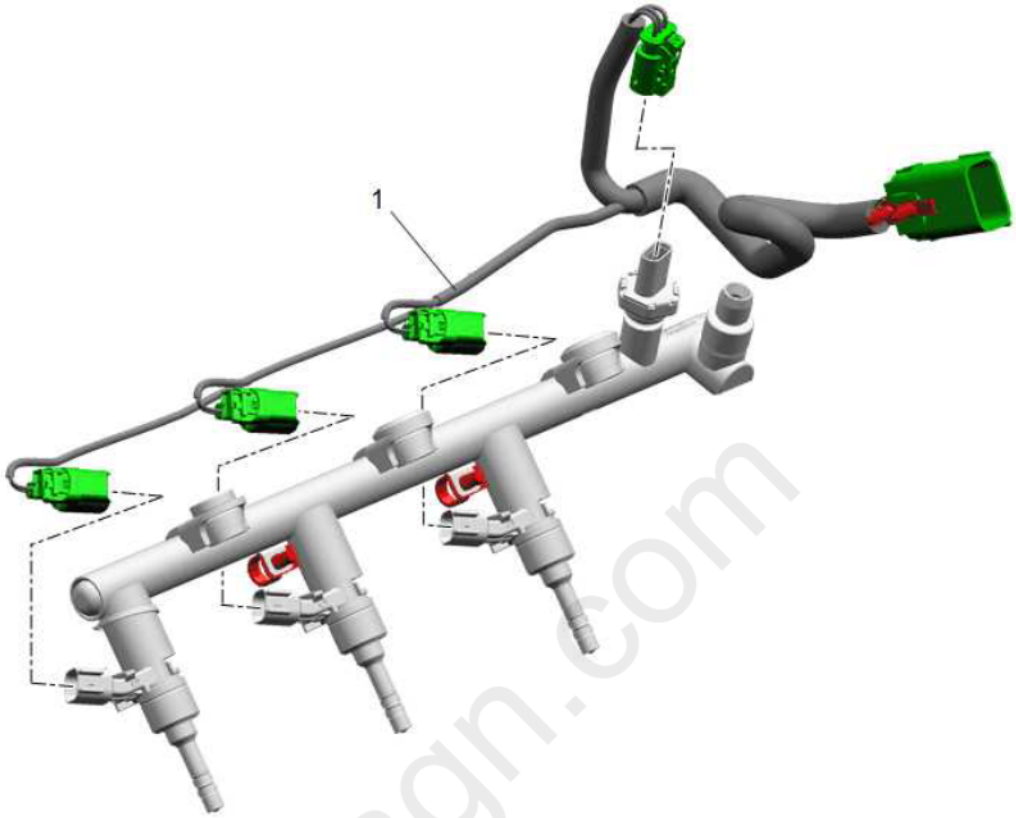


Fig. 129: View Of Fuel Rail Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

2. Taking care not to touch or apply force to the injector tip or electrical connector, remove the fuel injector (1) by pressing down on the retainer lever to release the tab (2) and simultaneously rotating the injector 45 degrees and pulling straight out from the fuel rail.

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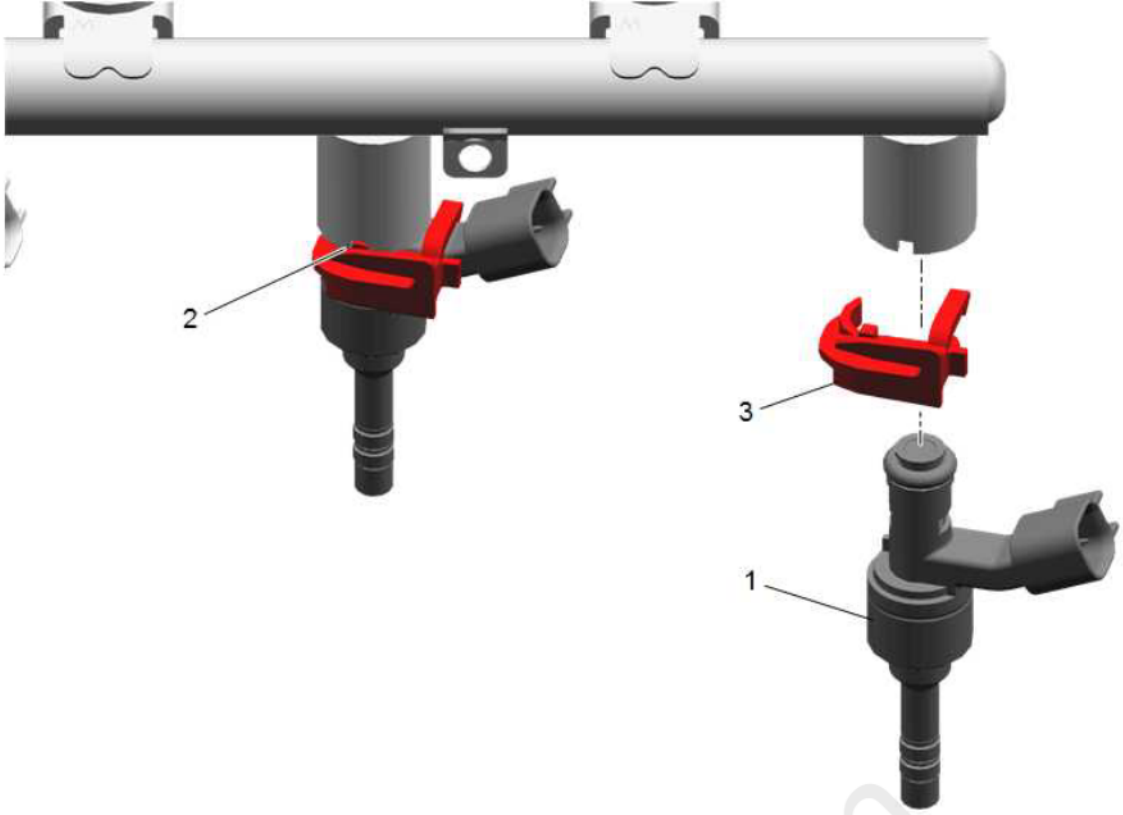


Fig. 130: Fuel Injector
Courtesy of GENERAL MOTORS COMPANY

3. Remove the retainer (3) from the fuel injector and discard.
4. Using pliers, remove the fuel injector bushing (3) straight out from injector body. Discard bushing (3). Remove and discard the fuel injector O-ring (1) and plastic spacers (2).

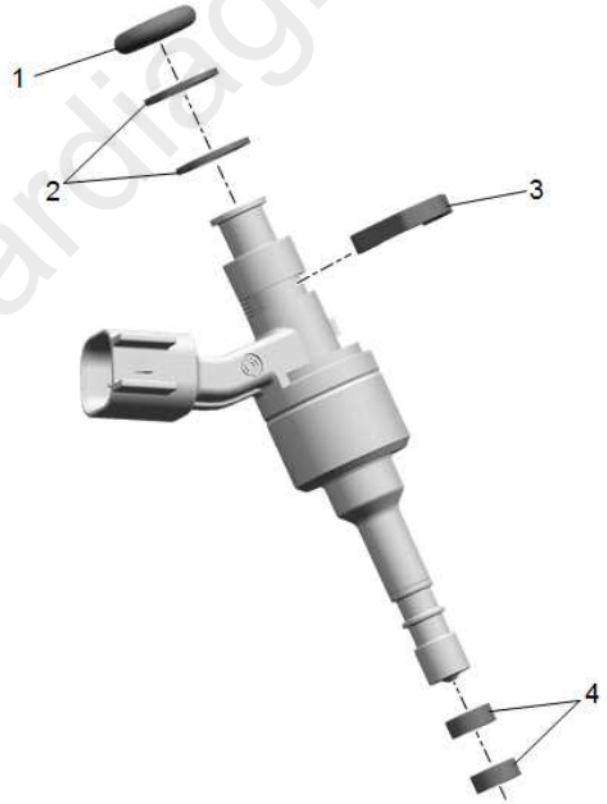


Fig. 131: Fuel Injector Components
Courtesy of GENERAL MOTORS COMPANY

5. Remove and discard the fuel injector seals (4).
6. Remove the fuel pressure sensor (1).

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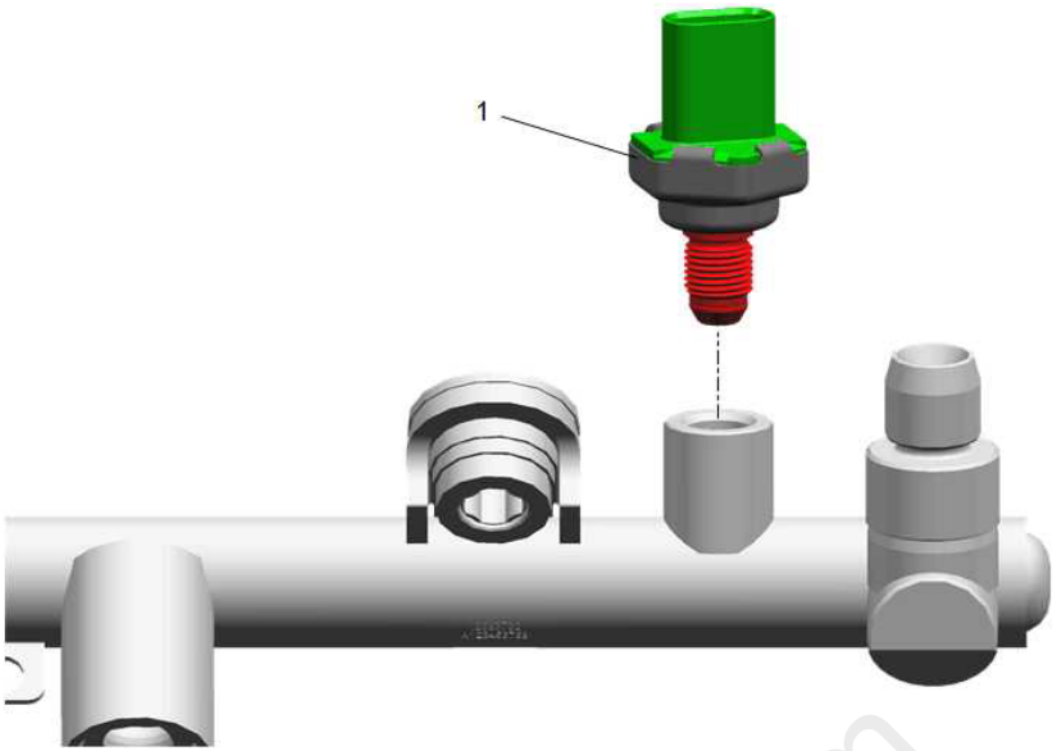


Fig. 132: Identifying Fuel Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Applying force to the plastic housing of the sensor will destroy the sensor. To tighten or loosen, only apply force to the attached hexagon.**

7. Clean the exterior of the fuel rail and injectors with solvent.

NOTE: **Do not soak or submerge the fuel rail or injectors in solvent.**

8. Inspect the fuel rail (1) and components for the following conditions:

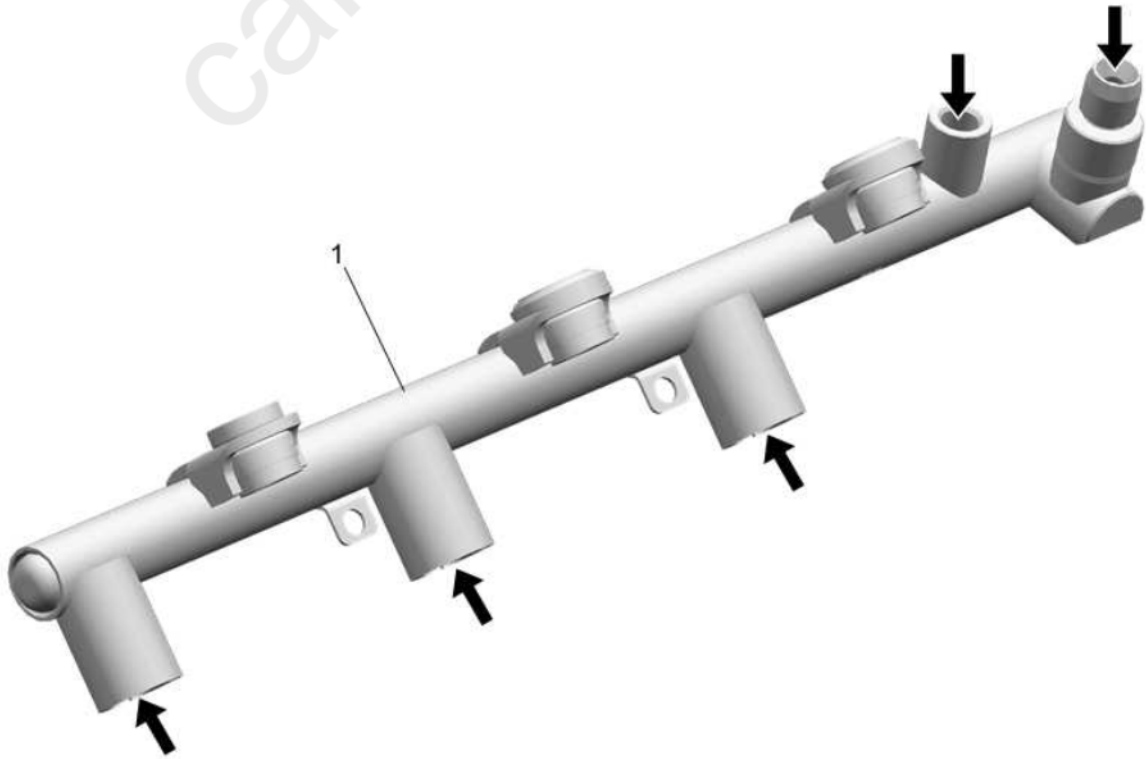


Fig. 133: Identifying Fuel Rail Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

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- Damage, debris or restrictions to the fuel rail
- Damage, debris or restrictions to the fuel ports in the fuel rail
- Damage to the mounting area for the fuel rail
- Damage to the fuel rail mounting bolts or mounting bolt grommets/isolators
- Damage to the threads on the fuel rail feed fitting
- Damage to the threads in the fuel pressure sensor bore
- Damage to the fuel pressure sensor connector, threads or sealing face

9. Install the fuel pressure sensor (1).

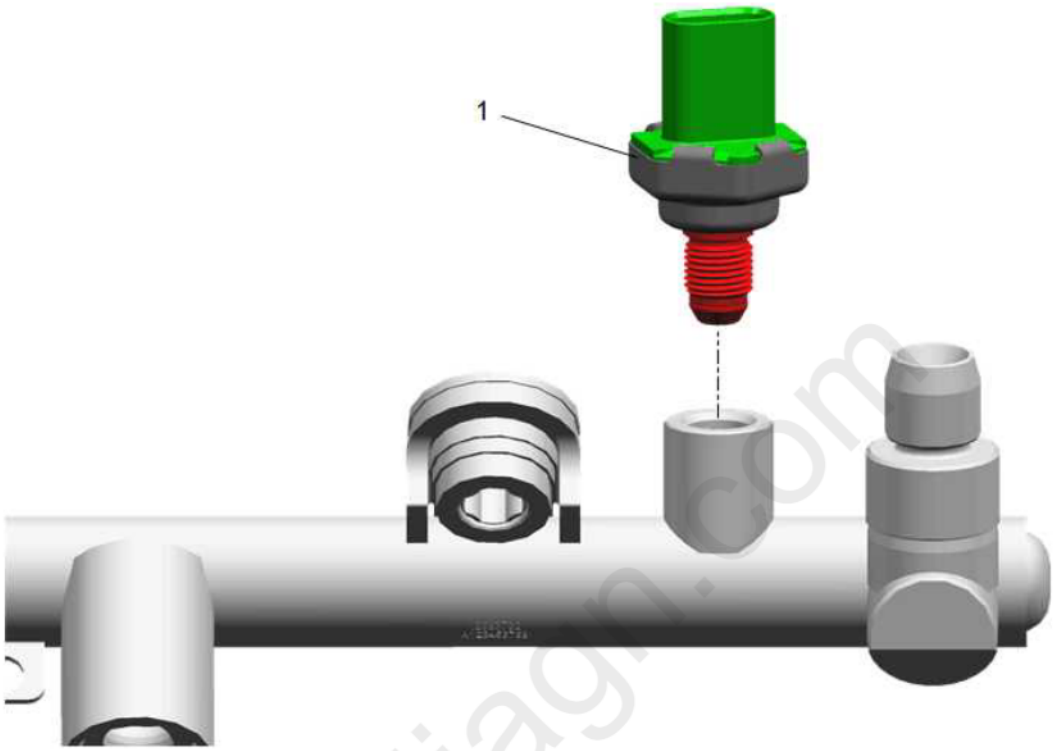


Fig. 134: Identifying Fuel Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Applying force to the plastic housing of the sensor will destroy the sensor. To tighten or loosen, only apply force to the attached hexagon.**

1. Lubricate the threads and the sealing area in the fuel rail with silicon free engine oil. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended lubricant.

   NOTE: **Ensure that the fuel rail threads have been cleaned of any excess fuel or the fuel pressure sensor will NOT seal properly.**

2. Lubricate the threads and the sealing area on the fuel pressure sensor with silicon free engine oil. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended lubricant.
3. Install the fuel pressure sensor hand tight.
4. Remove the fuel pressure sensor and re-lubricate.
5. Install the fuel pressure sensor and tighten to 33 N.m (25 lb ft).

   CAUTION: **Refer to Fastener Caution .**

10. Inspect the fuel injectors for the following conditions:

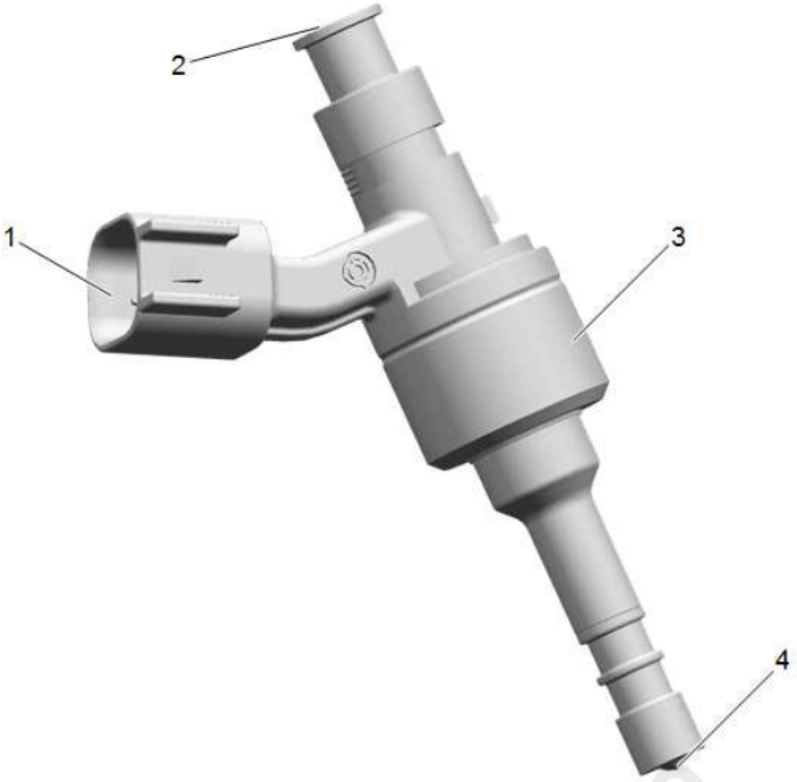


Fig. 135: Identifying Fuel Injector Components
Courtesy of GENERAL MOTORS COMPANY

- Damage to the fuel injector connector (1)
- Damage to the fuel inlet cone (2)
- Damage to the fuel injector body (3)
- Damage to the fuel injector tip (4)

11. Replace the fuel rail or injector if any damage is found. Do not attempt to repair a fuel rail or injector.
12. Install NEW fuel injector bushing (1) onto injector body. Bushing should seat with a distinct "snap" sound and feel. Ensure bushing is fully seated.



Fig. 136: Fuel Injector Bushing
Courtesy of GENERAL MOTORS COMPANY

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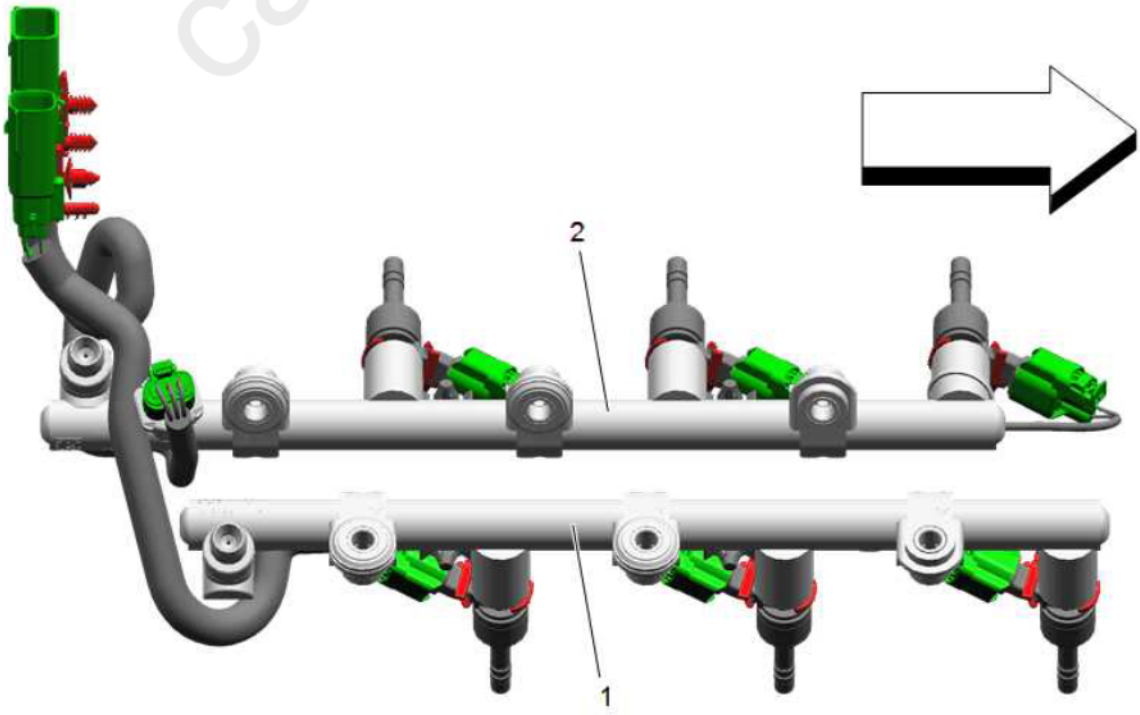
NOTE: **The fuel injector bushing (1) is to be installed BEFORE O-ring or backup rings are installed.**

13. Install the NEW white plastic spacer (3) on the fuel injector first.



Fig. 137: Injector And Components
Courtesy of GENERAL MOTORS COMPANY

14. Install the brown plastic spacer (2) second.
15. Lubricate the NEW O-ring (1) with one drop of clean engine oil.
16. The right side (bank 1) fuel injector wiring harness connectors (1) should point to the rear of the engine. The left side (bank 2) fuel injector wiring harness connectors (2) should point to the front of the engine.



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Fig. 138: Fuel Injector Wiring Harness Connectors
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Ensure the fuel injectors are installed in the correct orientation. Improper orientation of the fuel injectors may result in engine misfire and possible engine damage.**

17. Install NEW retainer (3) onto the fuel injector.

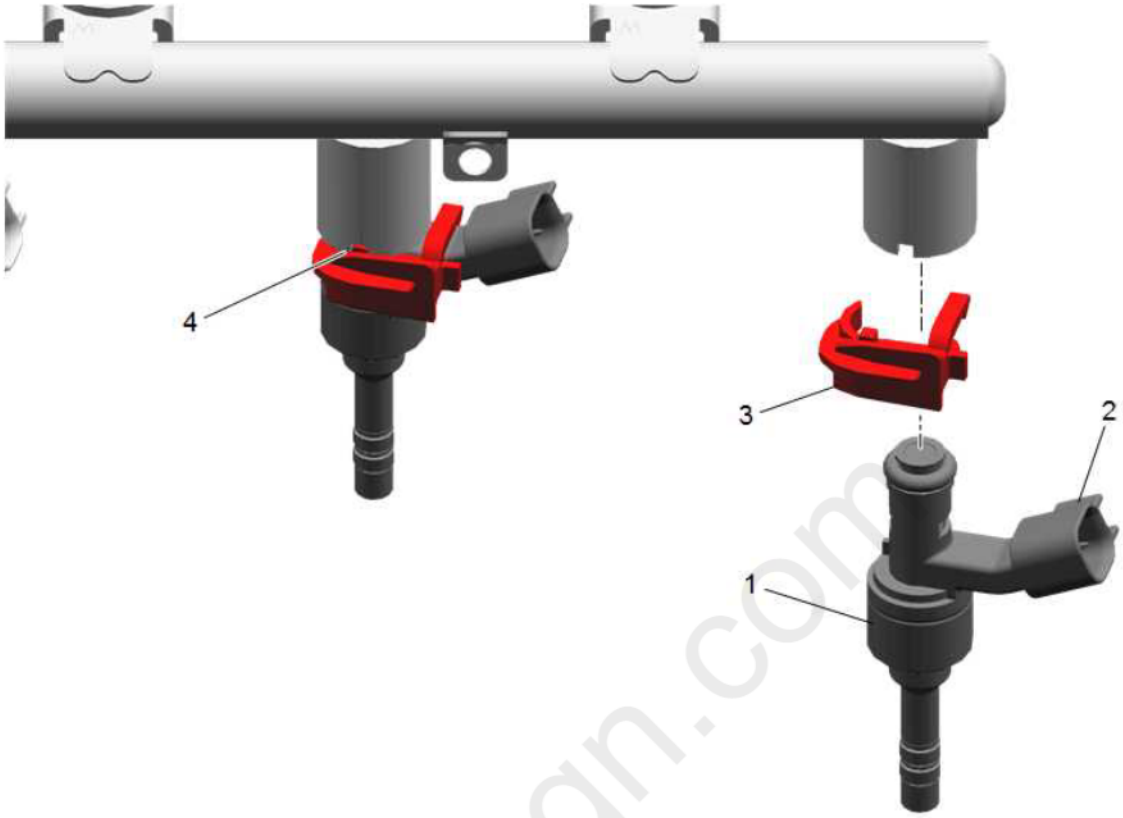


Fig. 139: Injector Retainer
Courtesy of GENERAL MOTORS COMPANY

18. Holding the largest diameter/body of the injector only, indicated by arrow in graphic, insert the injector assembly (1) into the fuel rail. Ensure correct orientation of the electrical connector (2).
19. Rotate the fuel injector approximately 45 degrees until the tab on the retainer (4) locks into the notch on the fuel rail.
20. Repeat for remaining injectors until all are installed and retained in fuel rail.
21. Install the fuel rail wiring harness (1).

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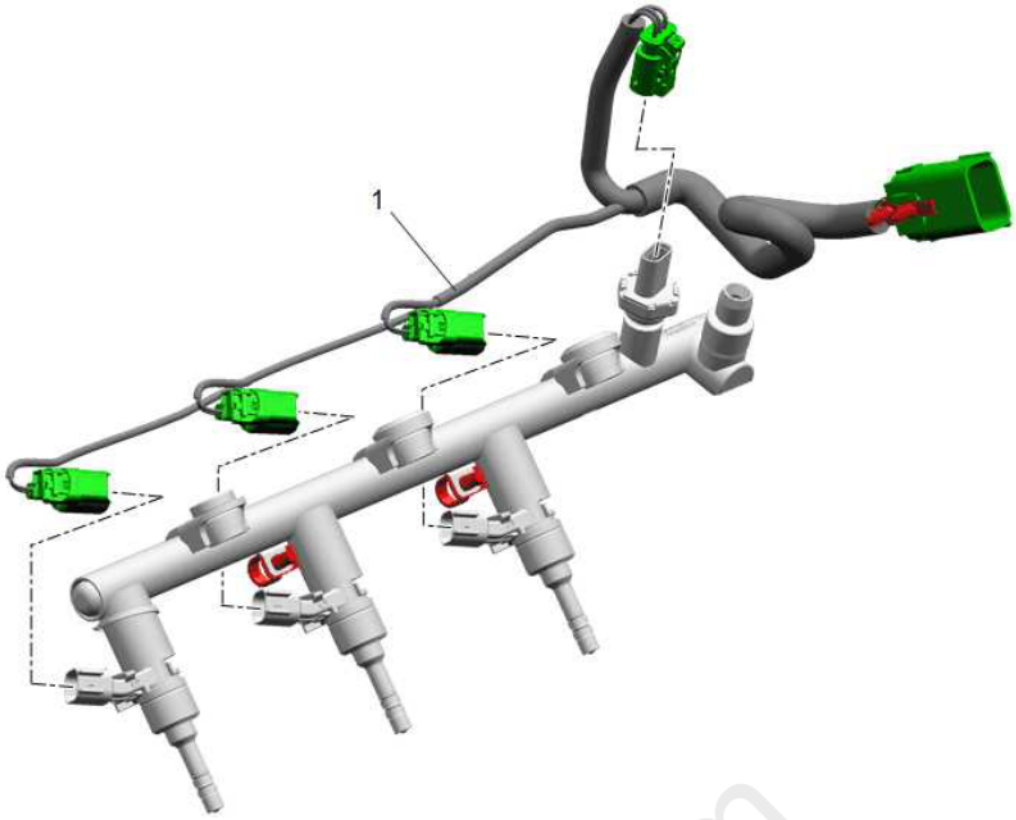


Fig. 140: View Of Fuel Rail Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

22. Install **EN 49245-1** long protector (3) onto the fuel injector tip, covering the first recessed area closest to the tip. Place a NEW seal (2) on **EN-49245-1** long protector.

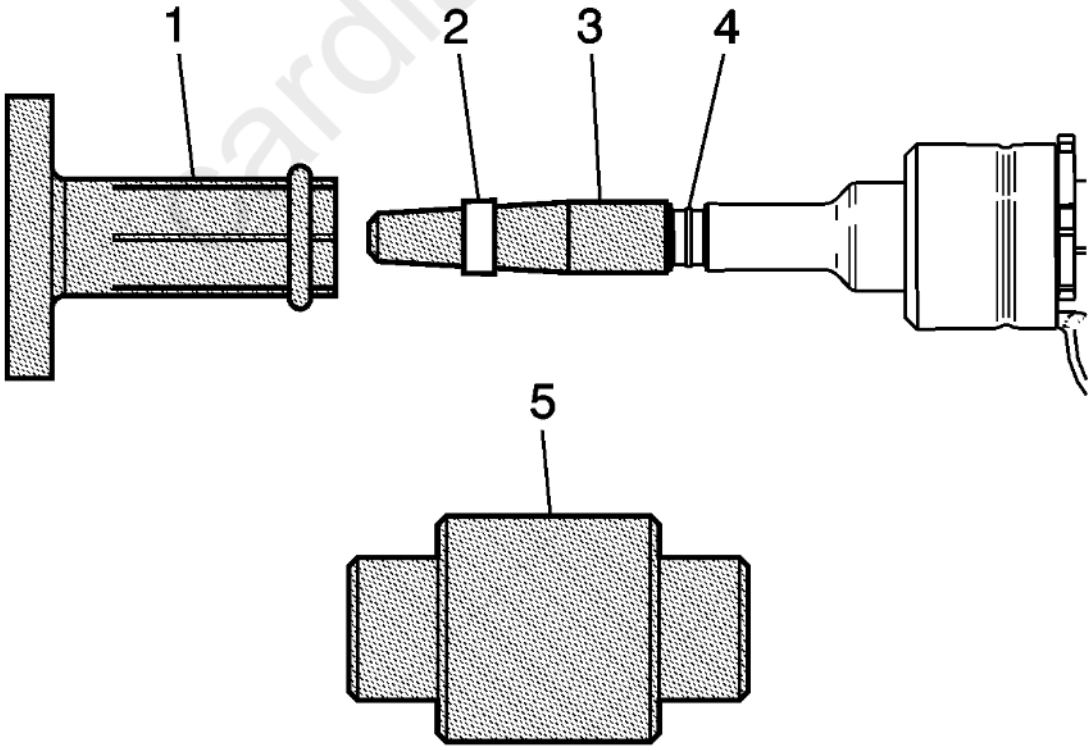


Fig. 141: Identifying Fuel Injector Tip & Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector tip.**

23. Using **EN-49245-3** pusher (1), install the seal into the second recessed area (4) of the fuel injector.
24. Compress the seal with your fingers, then resize the seal using the **EN-49245-4** sizer (5).

NOTE: **The EN-49245-4 sizer is two sided and either direction will size the seal correctly.**

25. Install **EN-49245-2** short protector (3) onto the fuel injector tip. Place a NEW seal (2) on **EN-49245-2** short protector.

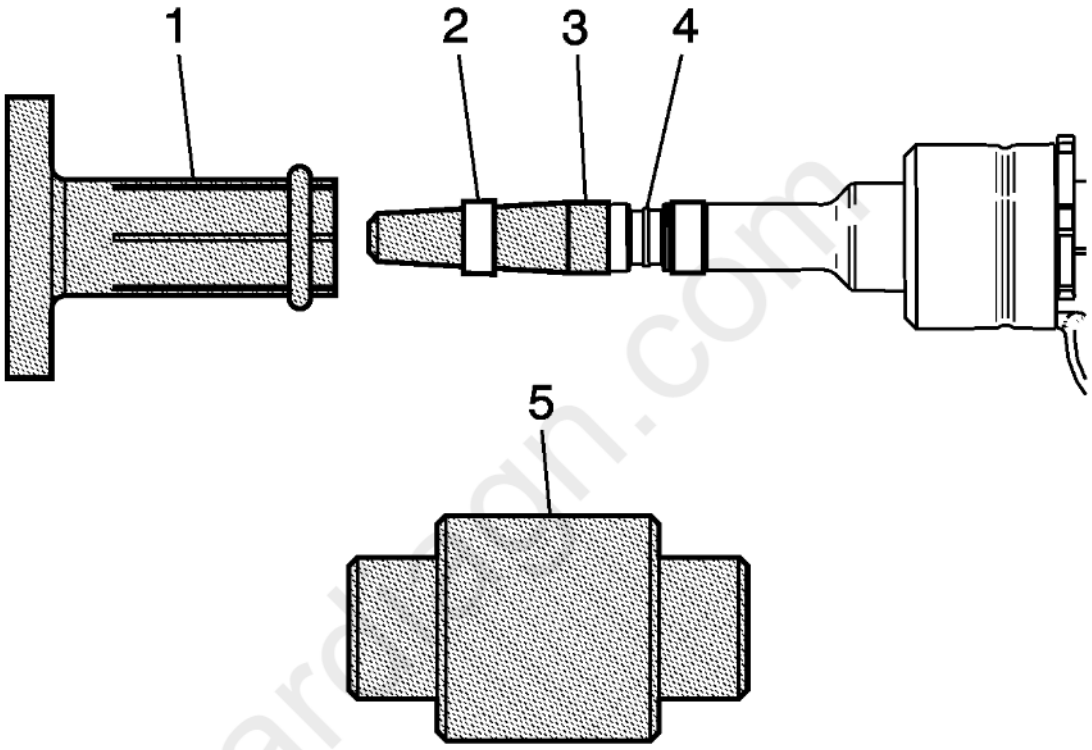


Fig. 142: Identifying Fuel Injector Tip & Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector tip.**

26. Using **EN-49245-3** pusher (1), install the seal into the first recessed area (4) of the fuel injector.
27. Compress the seal with your fingers, then resize the seal using the **EN-49245-4** sizer (5).

NOTE: **The EN-49245-4 sizer is two sided and either direction will size the seal correctly.**

CYLINDER HEAD ASSEMBLE

Special Tools

- **EN-8062** Valve Spring Compressor - Head Off
- **EN-46116** Valve Stem Seal Remover/Installer

- **EN-46117** Valve Stem Key Remover/Installer
- **EN-46119** Off-Vehicle Valve Spring Compressor Adapter

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

1. Install the cylinder head coolant threaded plugs and tighten to 75 N.m (55 lb ft).

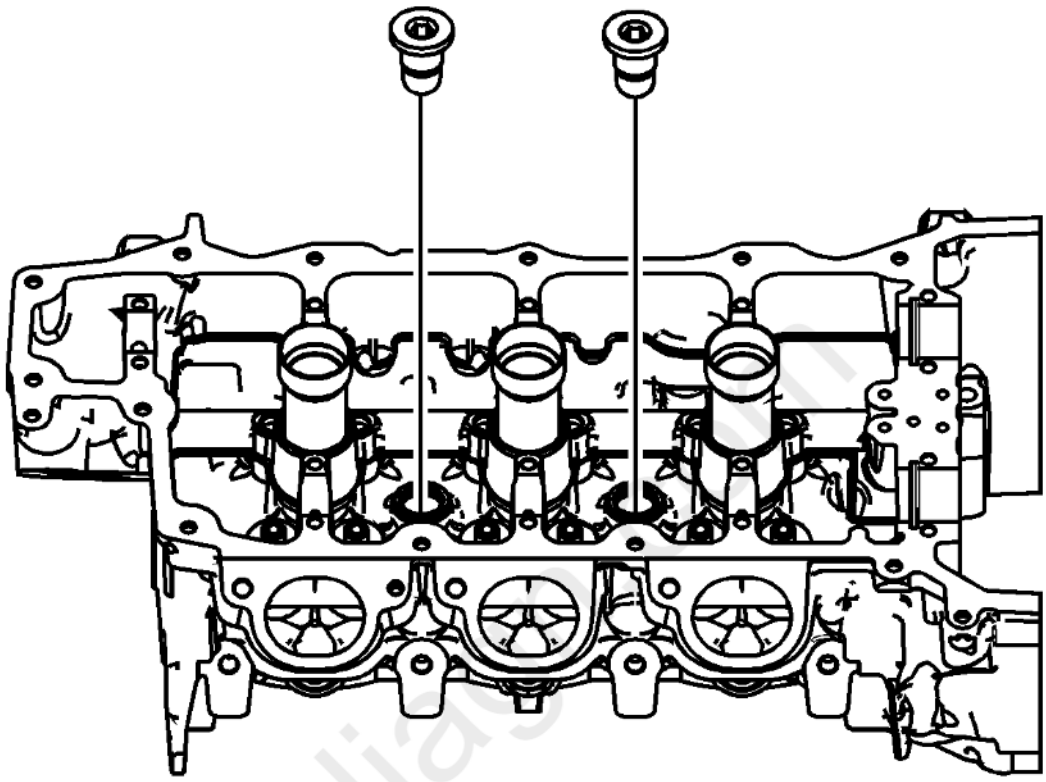


Fig. 143: View Of Cylinder Head Coolant Threaded Plugs
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

2. Install the NEW cylinder head oil gallery expansion plugs.

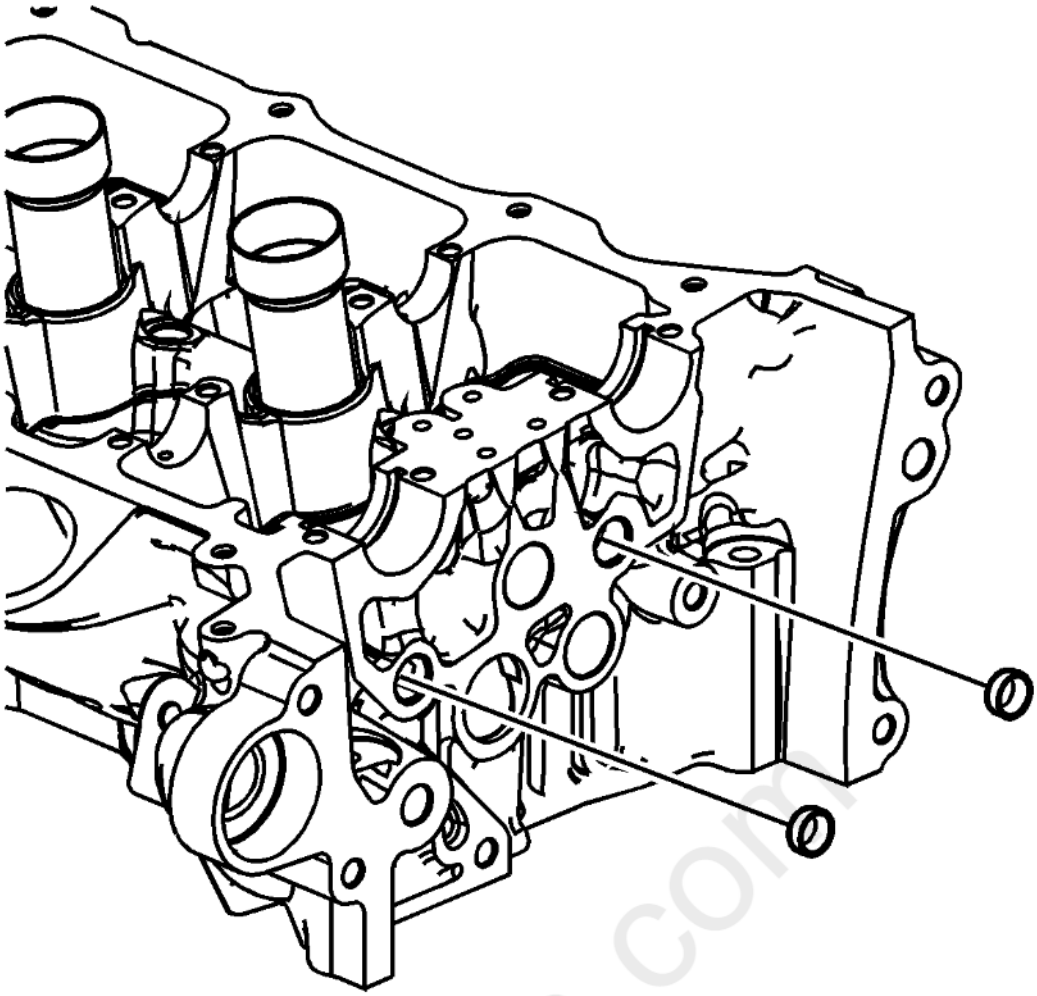


Fig. 144: View Of Cylinder Head Oil Gallery Expansion Plugs
Courtesy of GENERAL MOTORS COMPANY

3. Place the valve stem oil seals onto the guides.

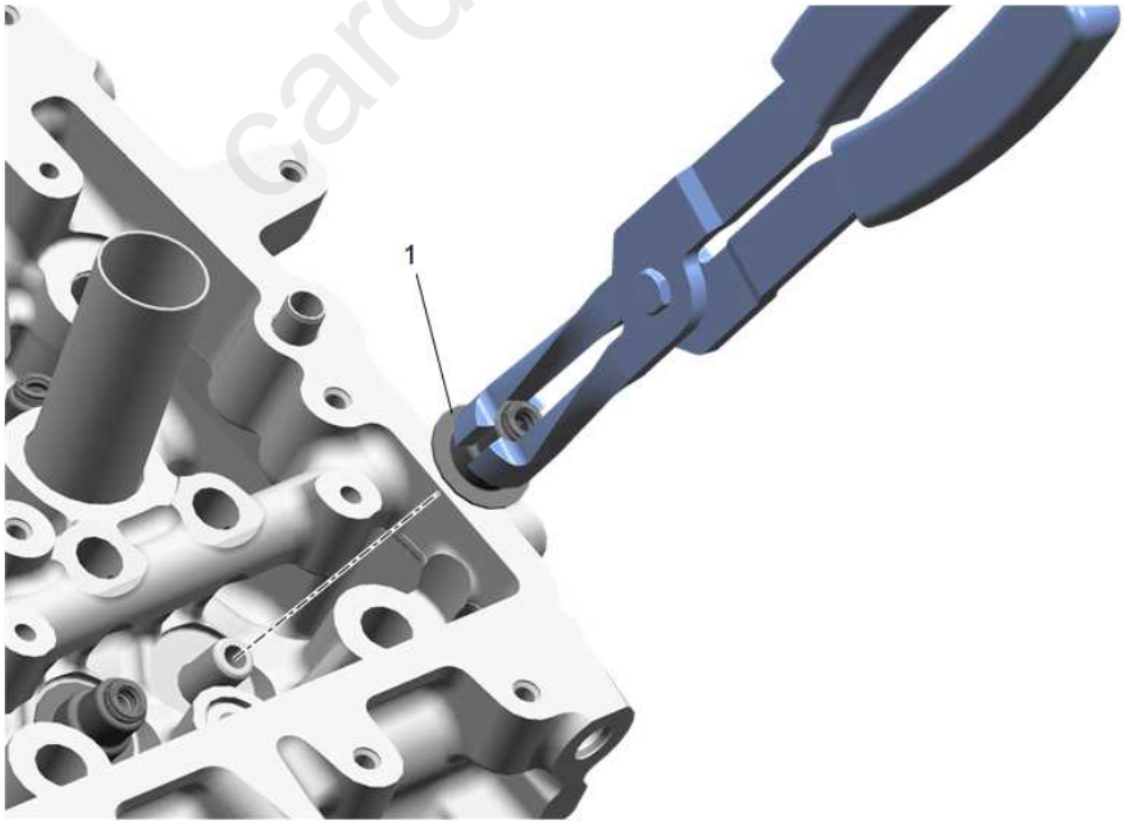


Fig. 145: Removing/Installing Valve Stem Oil Seals
Courtesy of GENERAL MOTORS COMPANY

4. Mount a new valve stem oil seal using the **EN-46116** remover/installer.

NOTE: **NEVER reuse a valve stem oil seal. Always use new seals when assembling the cylinder head.**

5. Push and twist the valve stem oil seal into position on the valve guide until the seal positively locks on the guide using the **EN-46116** remover/installer.

NOTE: **Force should only be applied to the valve spring contact area of the new valve stem oil seal during installation.**

6. Lubricate the valve stem and valve guide ID with clean engine oil. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended lubricant.
7. Insert the valve into the valve guide until it bottoms on the valve seat.

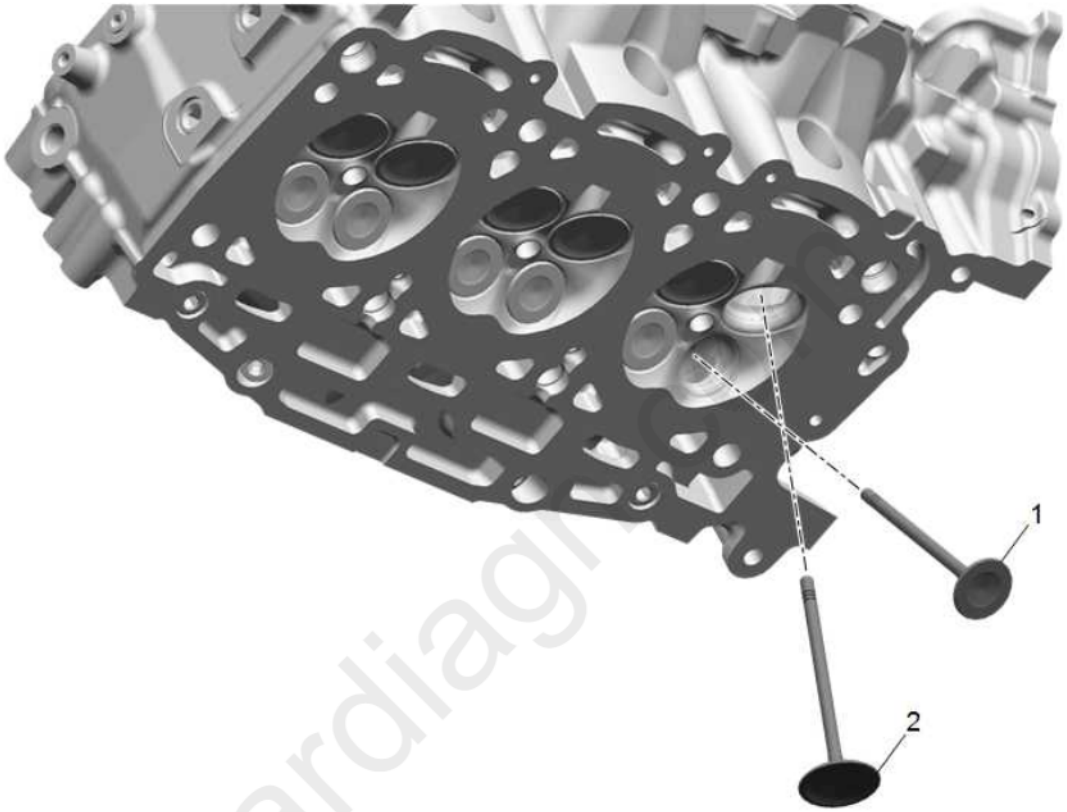


Fig. 146: View of Oil Seal and Valve Guide
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The valve stem oil seal must not come loose from the valve guide when the valve is installed.**

8. Position the valve spring on the spring seat.

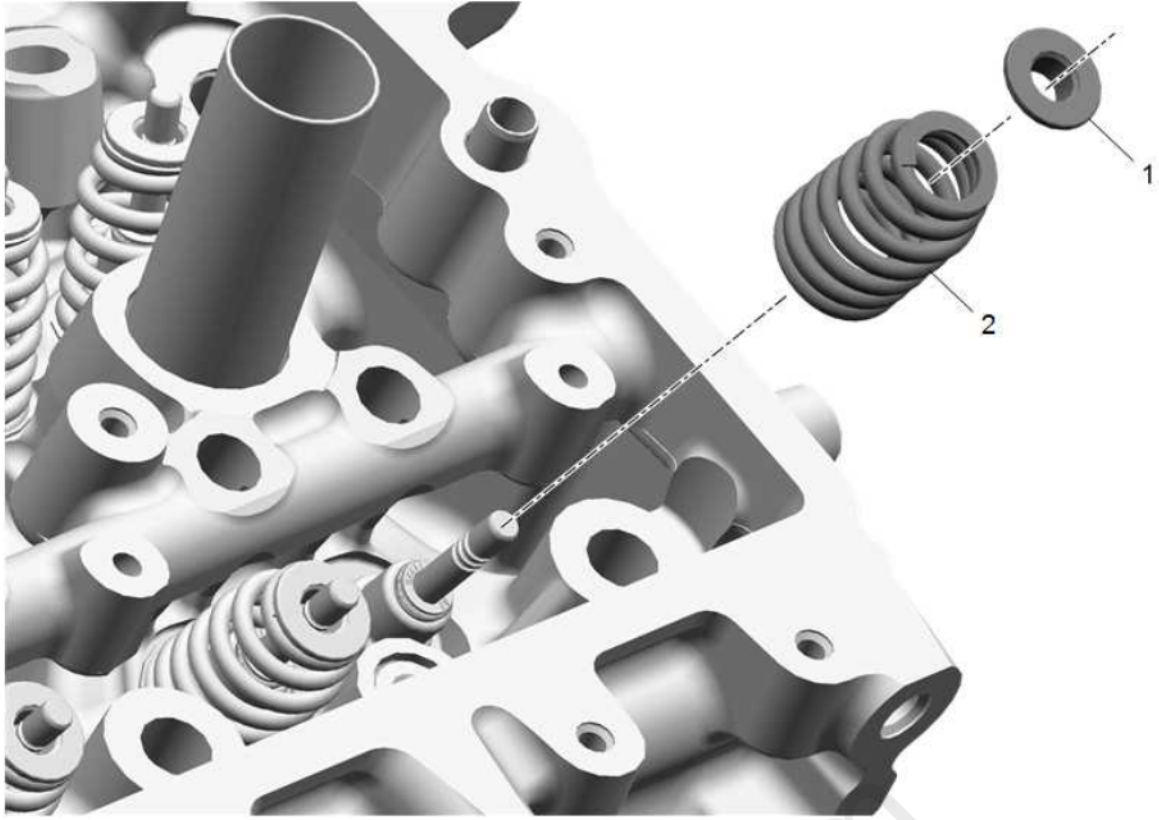


Fig. 147: View Of Valve Spring & Retainer
Courtesy of GENERAL MOTORS COMPANY

9. Place the valve spring retainer onto the valve spring.
10. Compress the valve spring using the **EN-8062** compressor and the **EN-46119** adapter.

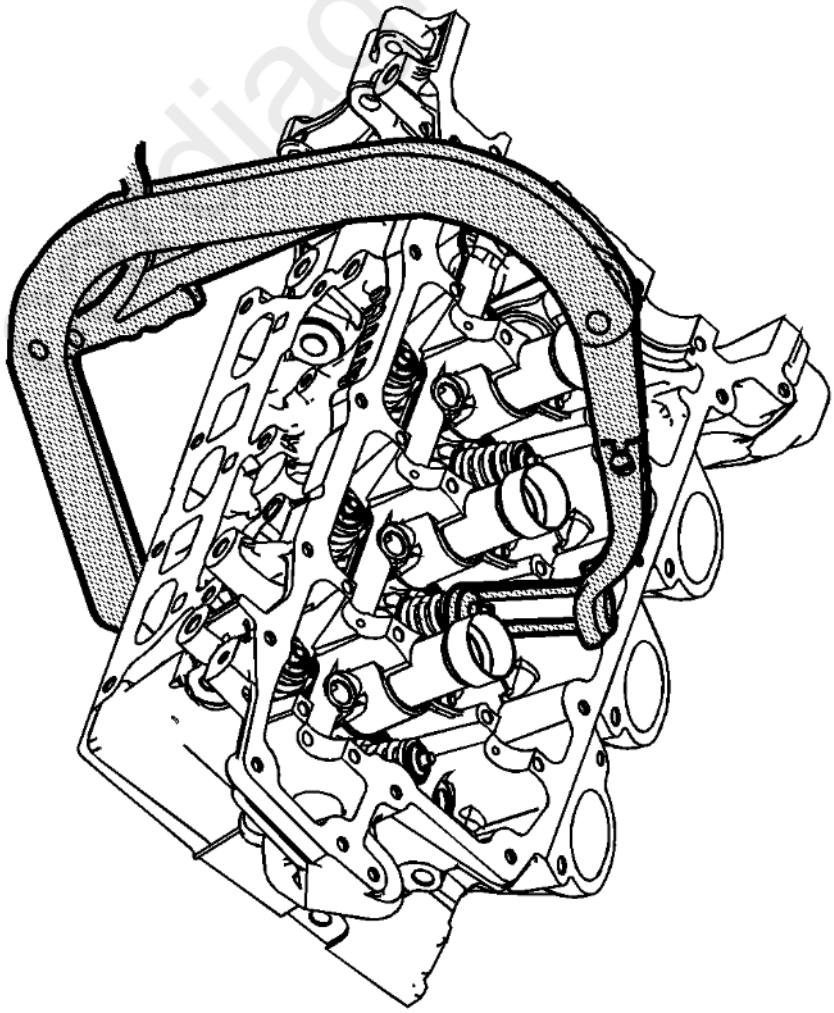


Fig. 148: Compressing Valve Spring
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.**

CAUTION: **Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.**

11. With the spring compressed, install the valve keepers into the **EN-46117** remover/installer.



Fig. 149: View Of Valve Keepers
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure proper directional placement of valve keepers in the EN-46117 remover/installer. The valve keepers must be installed with the tapered end towards the valve stem seal.**

12. Place the keepers into position by pushing the tool downward. While holding the tool lightly together in the area between the O-rings, using the thumb and forefinger, release tension on the **EN-46119** adapter and the **EN-8062** compressor. This will slowly push the **EN-46117** remover/installer off the valve stem, leaving the keepers in place.

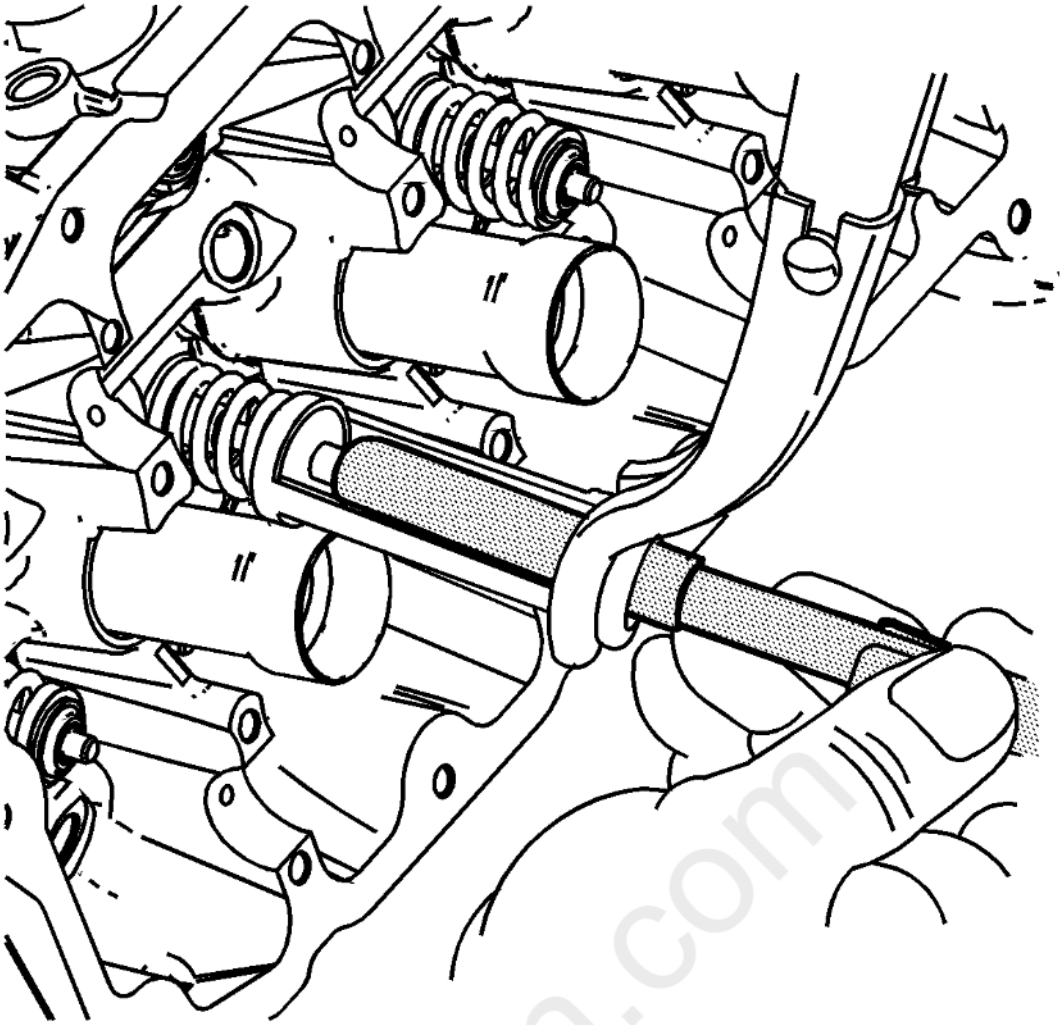


Fig. 150: Identifying Valve Spring Compressor & Adapter
Courtesy of GENERAL MOTORS COMPANY

13. Verify that the valve keepers are installed by placing a rag over the valve tip and tapping with a dead-blow hammer.
14. Install the fuel rail with injectors (2) into the cylinder head evenly.

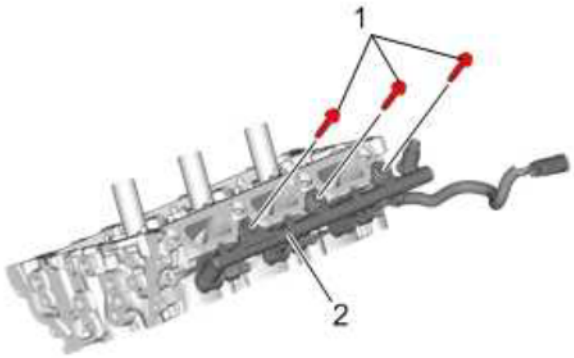


Fig. 151: Fuel Rail Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the fuel rail was removed from the cylinder head, the fuel injector tip seals must be replaced. Refer to Fuel Rail and Injectors Cleaning and Inspection.**

15. Install and hand tighten the three fuel rail bolts (1) to seat the injectors in the injector bores.
16. Tighten the fuel rail bolts in the sequence shown to 25 N.m (18 lb ft).

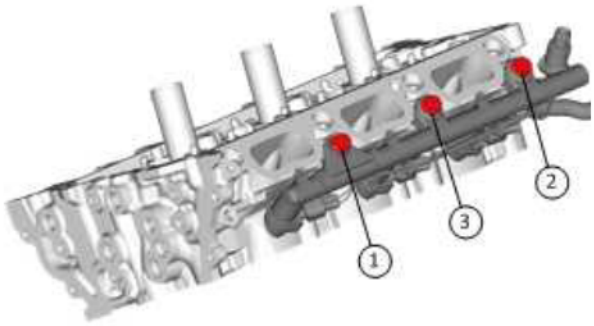


Fig. 152: Fuel Rail Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAMSHAFT CLEANING AND INSPECTION

Special Tools

GE 7872 Magnetic Base Dial Indicator

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

Cleaning Procedure

1. Clean the camshaft in solvent.
2. Dry the camshaft with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Visual Inspection

1. Inspect the camshaft oil feed holes (1) to the camshaft position actuator for dirt, debris or blockage.

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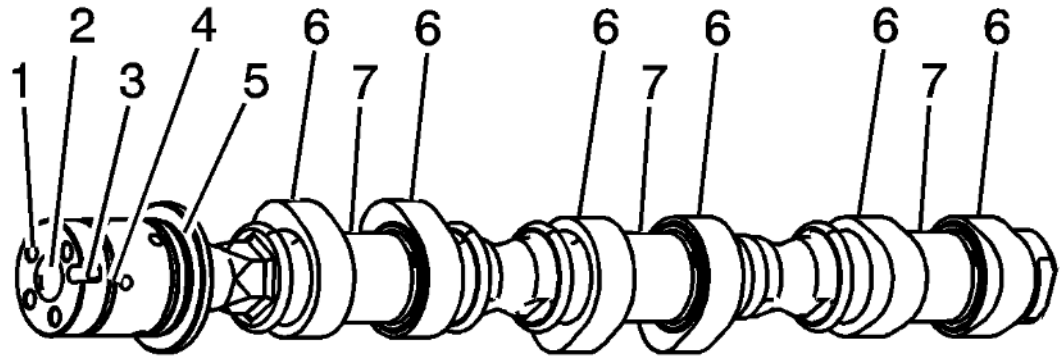


Fig. 153: Identifying Camshaft Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the threaded hole (2) for damage.
3. Inspect the camshaft position actuator locating notch (3) for damage or wear.
4. Inspect the camshaft sealing grooves (4) for damage.
5. Inspect the camshaft thrust surface (5) for damage.
6. Inspect the camshaft lobes (6) and journals (7) for the following conditions:
    - Excessive scoring or pitting
    - Discoloration from overheating
    - Deformation from excessive wear, especially the camshaft lobes
7. If any of the above conditions exist on the camshaft, replace the camshaft.

Camshaft Measurement

1. With the camshaft in a suitable fixture, measure the camshaft for wear.

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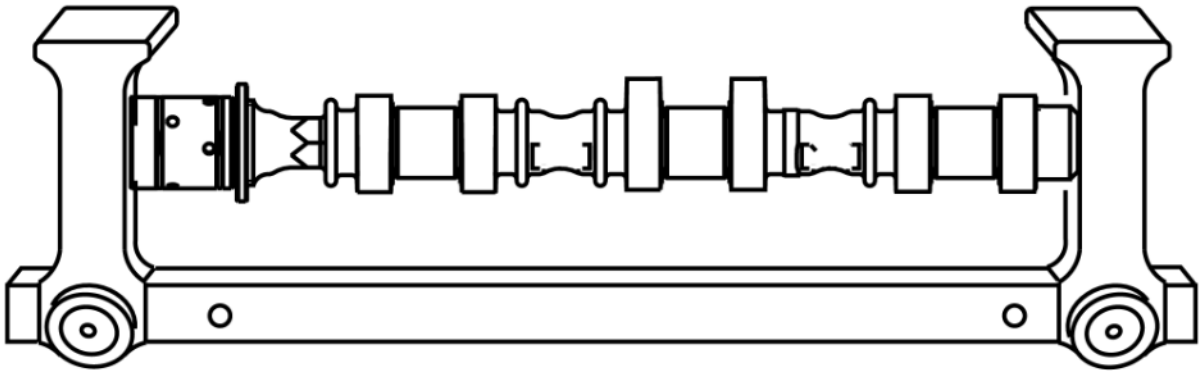


Fig. 154: Supporting Camshaft In Fixture
Courtesy of GENERAL MOTORS COMPANY

2. Measure the camshaft journals for diameter and out-of-round using an outside micrometer. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .

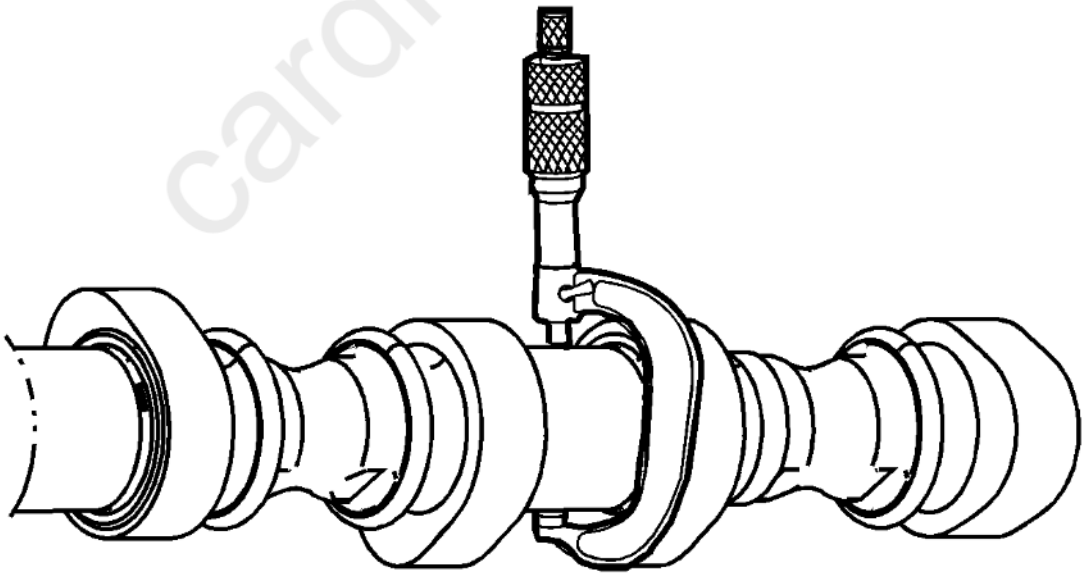


Fig. 155: Measuring Camshaft Journals
Courtesy of GENERAL MOTORS COMPANY

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- If the diameter is smaller than specifications, replace the camshaft.
- If the out-of-round exceeds specifications, replace the camshaft.

3. Measure the camshaft runout using the **GE 7872** indicator. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .

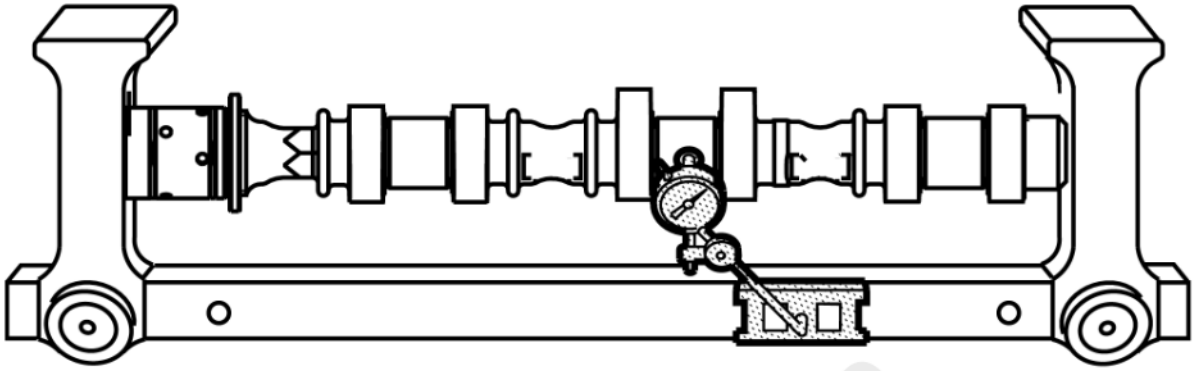


Fig. 156: Checking Camshaft Runout
Courtesy of GENERAL MOTORS COMPANY

4. Measure the camshaft thrust width for wear using a depth micrometer. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .

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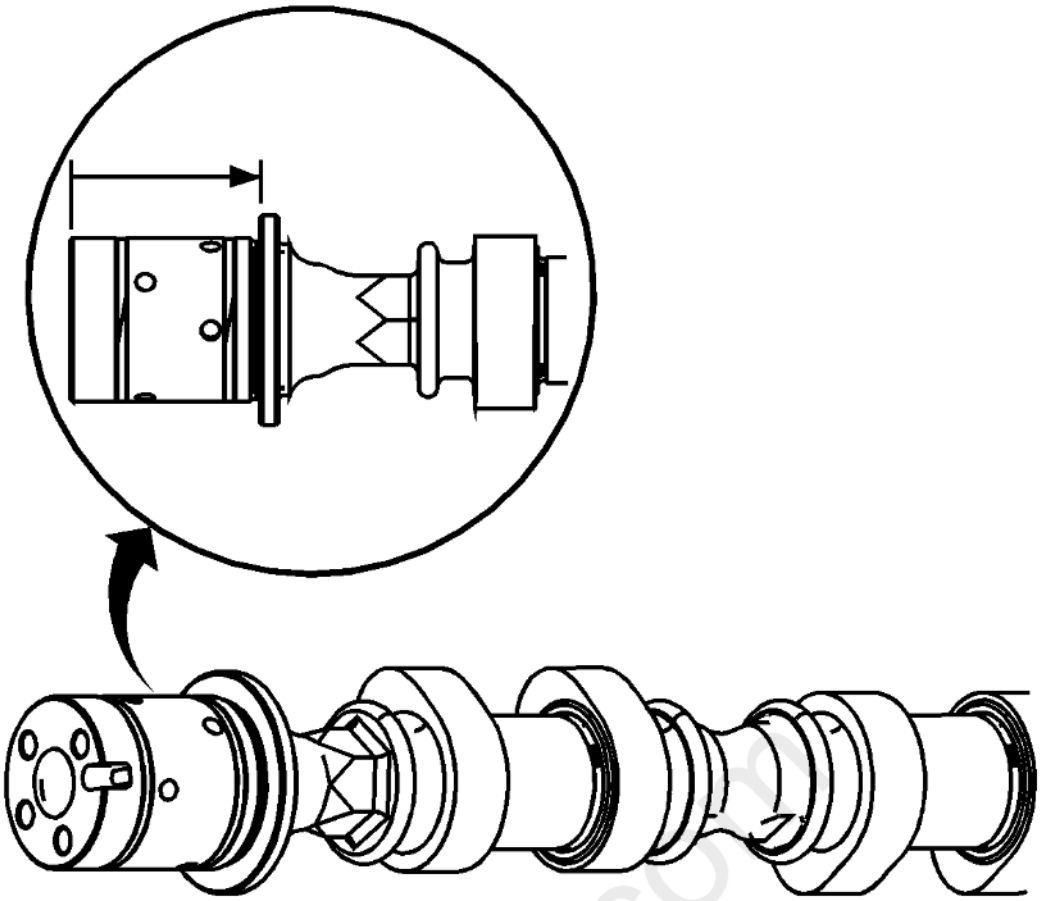


Fig. 157: Measuring Camshaft Thrust Width
Courtesy of GENERAL MOTORS COMPANY

5. Measure the camshaft thrust wall surface for runout using **GE 7872** indicator. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .

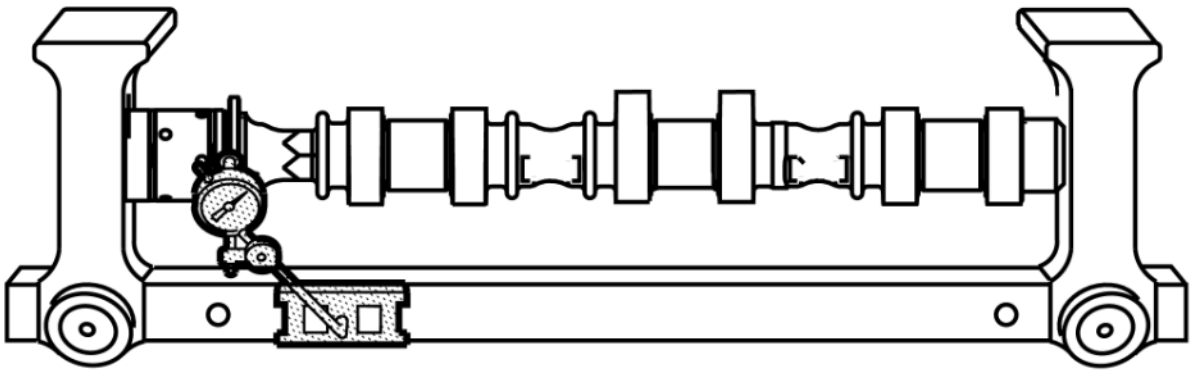


Fig. 158: Measuring Camshaft
Courtesy of GENERAL MOTORS COMPANY

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6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.
7. Measure the camshaft lobes for wear using the **GE 7872** indicator.

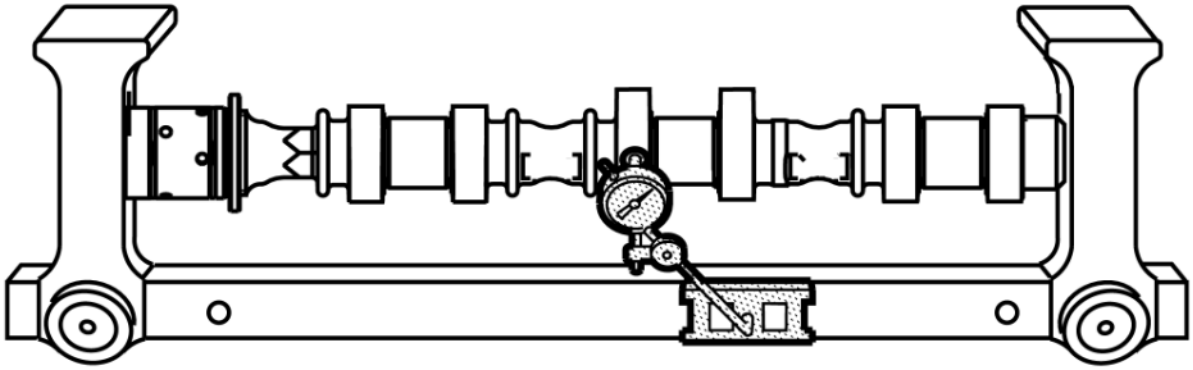


Fig. 159: Measuring Camshaft Lobes For Wear
Courtesy of GENERAL MOTORS COMPANY

8. Place the **GE 7872** indicator with the indicator tip on the base circle (1) of the camshaft lobe.

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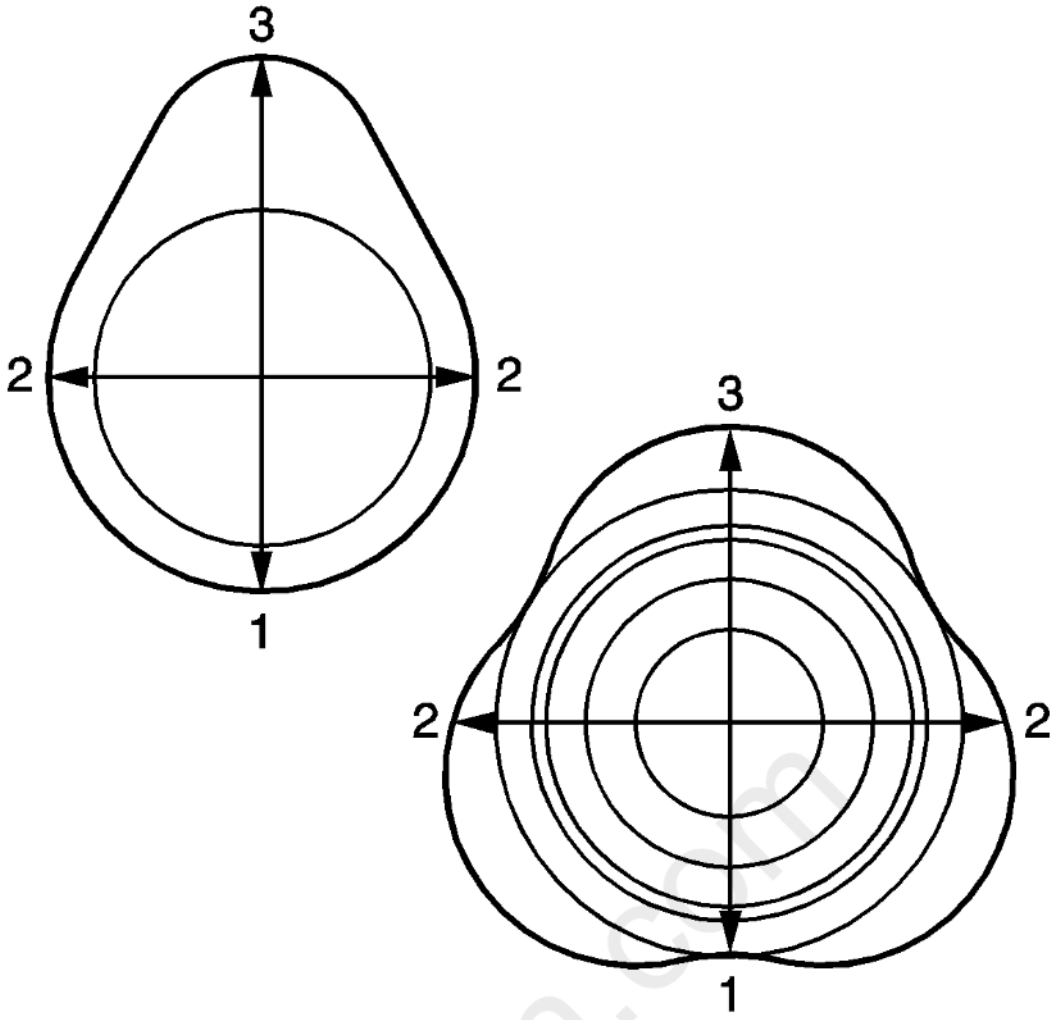


Fig. 160: View of Lobe Diagram
Courtesy of GENERAL MOTORS COMPANY

1. Place the **GE 7872** indicator at zero.
2. Rotate the camshaft until the indicator tip is at the highest point (3) on the lobe. This reading is the lift of the camshaft lobe. Refer to **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** .
3. If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

VALVE LIFTER CLEANING AND INSPECTION

1. Inspect the hydraulic lash adjuster (HLA) in the following areas:

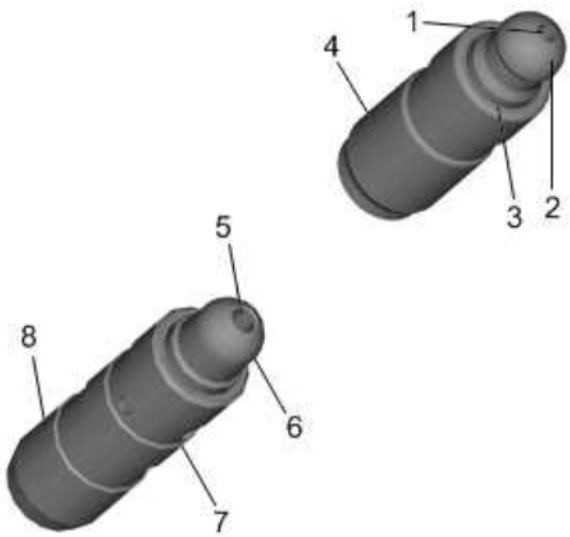


Fig. 161: Valve Lifter Inspection Points
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Valve Lifter Priming Caution .

- A plugged oil passage (1)
- A scored or worn camshaft follower pivot area (2)
- A damaged or broken retainer (3), some applications
- A severely scuffed or worn HLA body (4)

2. Inspect the duel feed hydraulic lash adjuster (DFHLA) in the following areas:
   - A plugged oil passage (5)
   - A scored or worn camshaft follower pivot area (6)
   - A damaged or broken retainer (7), some applications
   - A severely scuffed or worn DFHLA body (8)
3. Replace the HLA or DFHLAs as necessary.

VALVE ROCKER ARM CLEANING AND INSPECTION

1. Inspect the valve rocker arm roller (1) for the following:



Fig. 162: Valve Rocker Arm Roller
Courtesy of GENERAL MOTORS COMPANY

   - Flat spots
   - Excessive scoring and pitting
   - Ensure the roller spins freely
2. Inspect the valve rocker arm tip area (2).
3. Inspect the valve rocker arm hydraulic lash adjuster (HLA) pivot area (3).
4. Inspect the valve rocker arm retaining clip (4).
5. Inspect the valve rocker switching arm roller (5) for the following:
   - Flat spots
   - Excessive scoring and pitting
   - Ensure the roller spins freely
6. Inspect the valve rocker switching arm tip area (6).
7. Inspect the valve rocker switching arm duel feed hydraulic lash adjuster (DFHLA) pivot area (7).
8. Replace the valve rocker switching arm or followers as necessary.

CAMSHAFT TIMING DRIVE COMPONENTS CLEANING AND INSPECTION

Cleaning Procedure

1. Clean all the following components with solvent:
    - Crankshaft sprocket
    - Timing drive chains
    - Right timing drive chain guides
    - Right timing drive chain tensioner
    - Left timing drive chain guides
    - Left timing drive chain tensioners
    - Timing component fastening bolts
2. Clean each camshaft position actuator's exterior with solvent.
3. Dry the timing components with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Visual Inspection

Camshaft Position Actuator

1. Inspect the front of the right exhaust camshaft position actuators for the following:

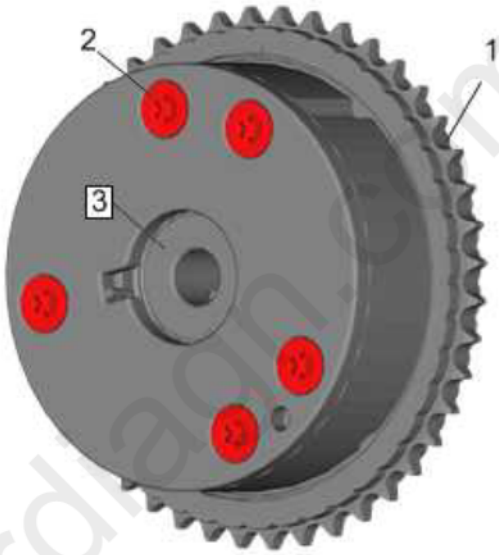


Fig. 163: Camshaft Position Actuator Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Loose or missing housing bolts (2)
- Camshaft position actuator bolt seating/sealing inner hub flange damage (3)

2. Inspect the back of the right exhaust camshaft position actuators for the following:

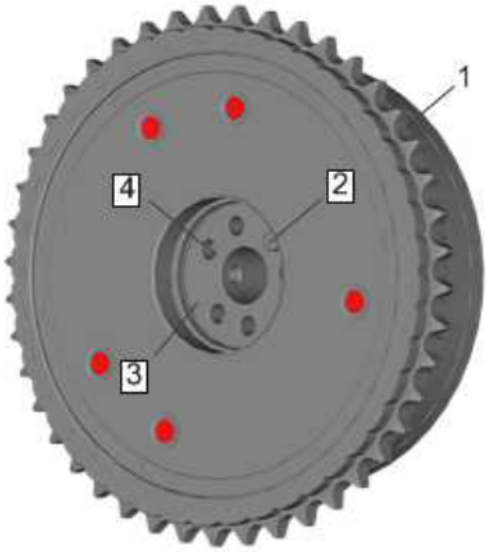


Fig. 164: Camshaft Position Actuator Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Camshaft locating pin damage (2)
- Camshaft seating/sealing inner hub flange damage (3)
- Blockage to the oil passages (4)

3. Inspect the front of the right intake camshaft position actuators for the following:

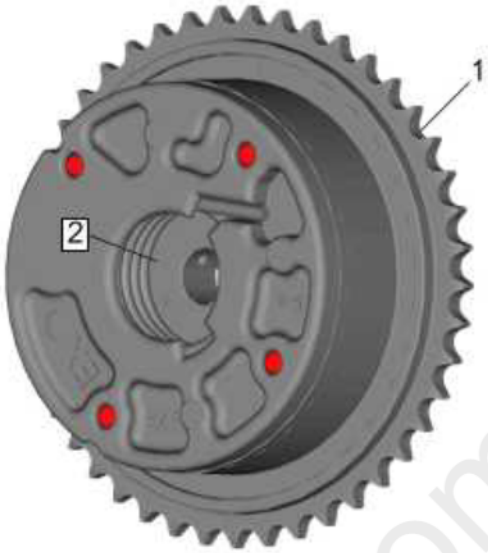


Fig. 165: Camshaft Position Actuator Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (2)

4. Inspect the back of the right intake camshaft position actuators for the following:

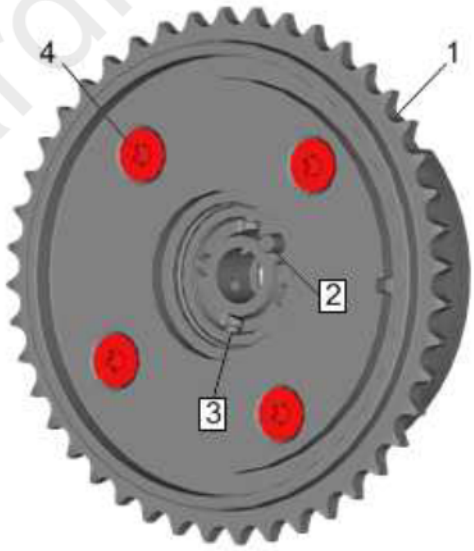


Fig. 166: Camshaft Position Actuator Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Camshaft locating pin damage (2)
- Blockage to the oil passages (3)
- Loose or missing housing bolts (4)

5. Inspect the front of the left exhaust camshaft position actuators for the following:

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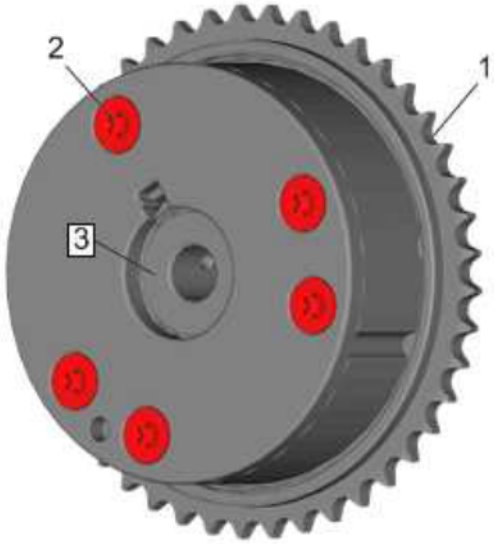


Fig. 167: Camshaft Position Actuator Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Loose or missing housing bolts (2)
- Camshaft position actuator bolt seating/sealing inner hub flange damage (3)

6. Inspect the back of the left exhaust camshaft position actuators for the following:

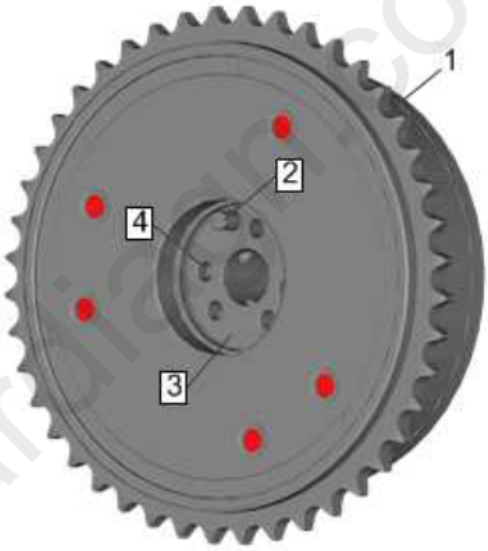


Fig. 168: Camshaft Position Actuator Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Camshaft locating pin damage (2)
- Camshaft seating/sealing inner hub flange damage (3)
- Blockage to the oil passages (4)

7. Inspect the front of the left intake camshaft position actuators for the following:

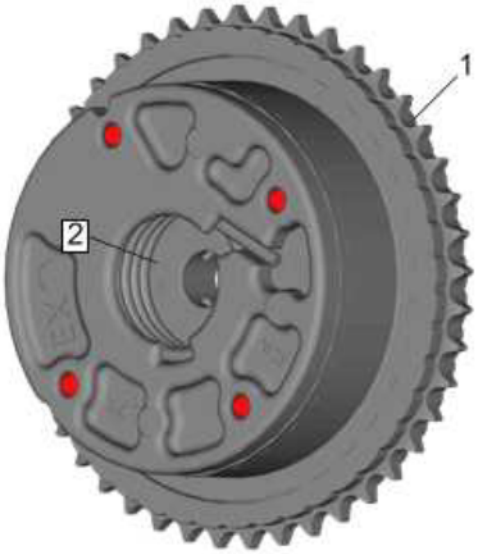


Fig. 169: Camshaft Position Actuator Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (2)

8. Inspect the back of the left intake camshaft position actuators for the following:

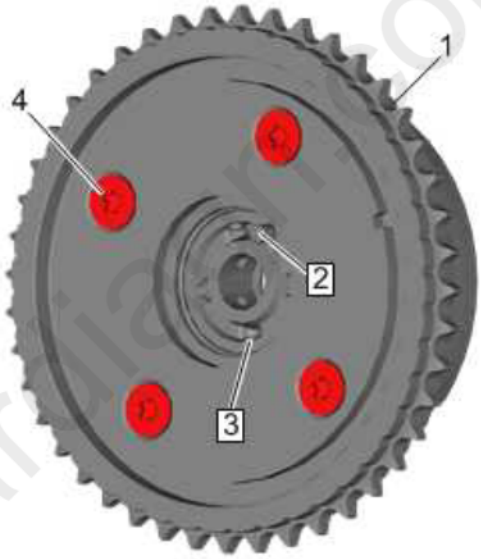


Fig. 170: Camshaft Position Actuator Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Camshaft locating pin damage (2)
- Blockage to the oil passages (3)
- Loose or missing housing bolts (4)

9. Replace a damaged camshaft position actuator.

Camshaft Position Actuator Solenoid Valve

1. Inspect the camshaft position actuator solenoid valves for the following:

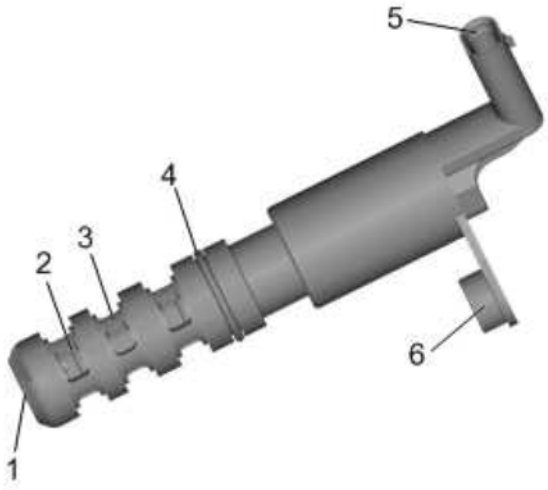


Fig. 171: Camshaft Position Actuator Solenoid Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Blockage to the oil passage (1)
- Missing or damaged oil screen clip (2)
- Blockage or damage to the oil screen (3)
- Damage to the sealing surface for the camshaft position actuator solenoid valve solenoid oil seal (4)
- Damage to the wiring harness connection and/or terminals (5)
- Damage to the bracket (6)

2. Inspect the camshaft position actuator solenoid valves for the following:

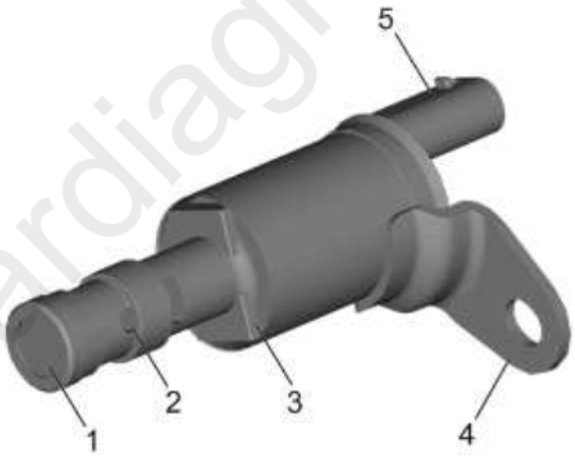


Fig. 172: Camshaft Position Actuator Solenoid Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Blockage to the oil passage (1)
- Missing or damaged oil screen clip (2)
- Blockage or damage to the oil screen (3)
- Damage to the bracket (4)
- Damage to the wiring harness connection and/or terminals (5)

3. Replace a damaged camshaft position actuator solenoid valve.

Camshaft Position Sensor

1. Inspect the camshaft position sensor for the following:

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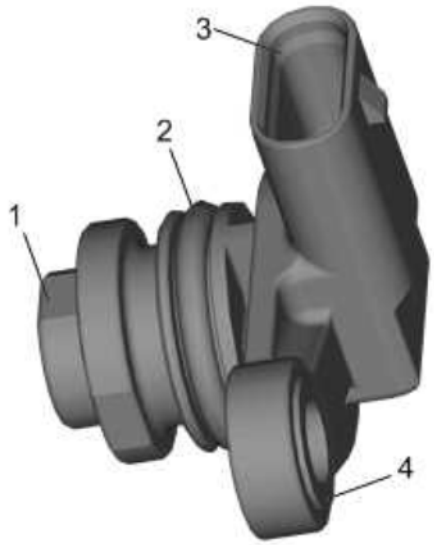


Fig. 173: Camshaft Position Sensor Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage to the camshaft position sensor (1)
- Damage to the sealing surface for the camshaft position sensor (2)
- Damage to the wiring harness connection and/or terminals (3)
- Damage to the bracket (4)

2. Replace a damaged camshaft position sensor.

Crankshaft Sprocket

1. Inspect the crankshaft sprocket for the following:



Fig. 174: Crankshaft Sprocket Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Bore damage (2)
- Keyway damage (3)

2. Replace a damaged crankshaft sprocket.

Crankshaft Sprocket

1. Inspect the crankshaft sprocket for the following:

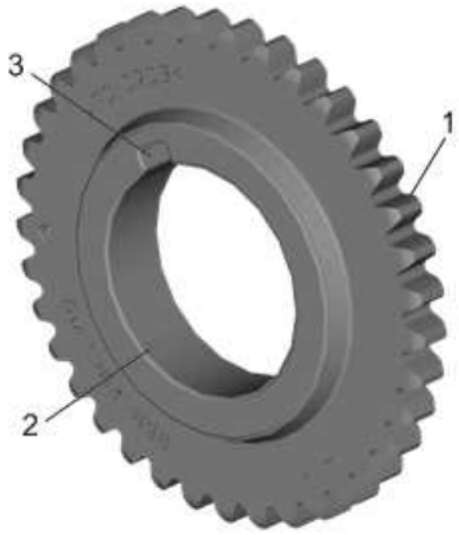


Fig. 175: Crankshaft Sprocket Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Bore damage (2)
- Keyway damage (3)

2. Replace a damaged crankshaft sprocket.

Oil Pump Sprocket

1. Inspect the crankshaft sprocket for the following:



Fig. 176: Crankshaft Sprocket Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Sprocket damage (1)
- Bore damage (2)
- Bore damage (3)
- Keyway damage (4)

2. Replace a damaged crankshaft sprocket.

Timing Chains with Inverted Tooth (IT) Chain

1. Inspect the timing chain for the following:

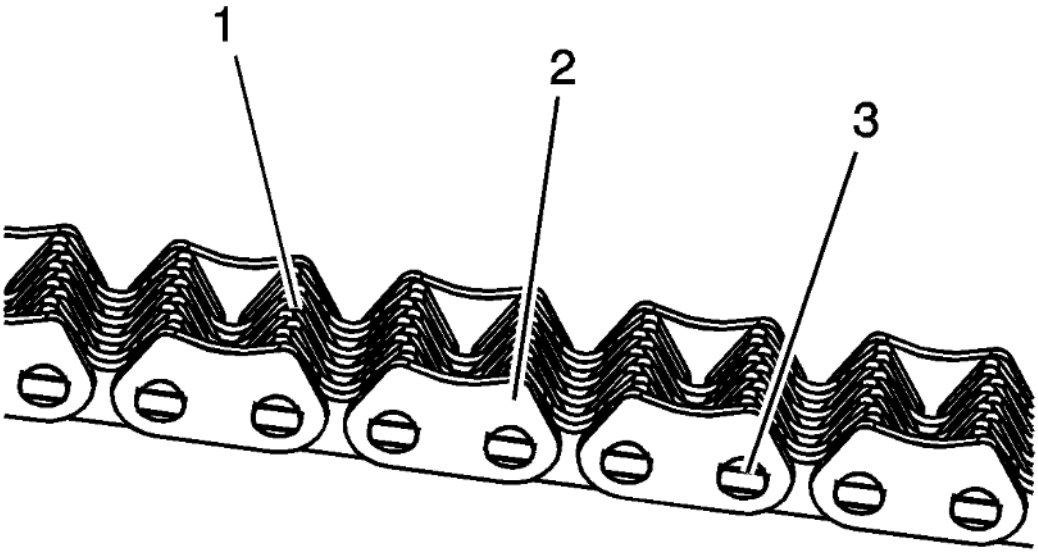


Fig. 177: Identifying Primary & Secondary Timing Chain Inspection Locations
Courtesy of GENERAL MOTORS COMPANY

- Binding or worn links (1)
- Loose links (2)
- Loose pins (3)

2. Replace a damaged timing chain.

Timing Chain Guide

1. Inspect the timing chain guide for the following:

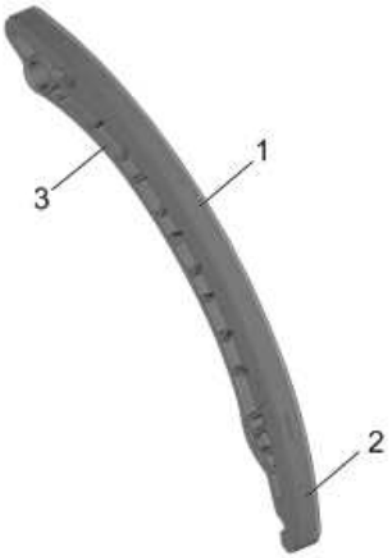


Fig. 178: Timing Chain Guide Inspection Points
Courtesy of GENERAL MOTORS COMPANY

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- Worn guide surface (1)
- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)

2. Replace a damaged primary timing chain upper guide.

Timing Chain Guide

1. Inspect the timing chain guide for the following:



Fig. 179: Timing Chain Guide Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Worn guide surface (1)
- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)

2. Replace a damaged primary timing chain upper guide.

Timing Chain Tensioner

1. Inspect the timing chain tensioner for worn timing chain tensioner surface (1).

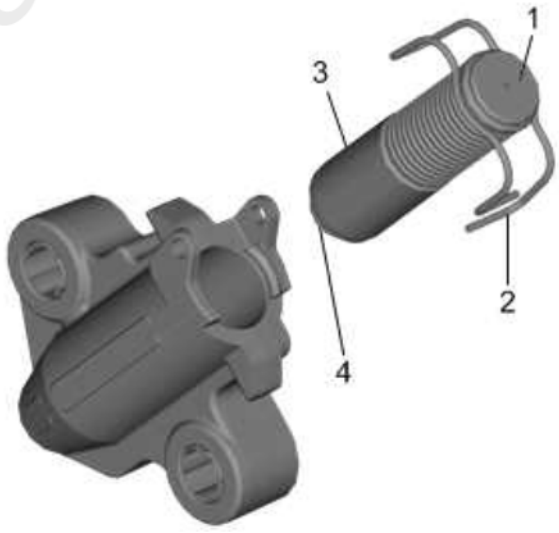


Fig. 180: Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the timing chain tensioner for worn timing chain tensioner spring (2).
3. Inspect the timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (4) and ensure the plunger moves freely (3) in and out of the body of the tensioner. Refer to **Camshaft Timing Chain Components Installation**.

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4. Replace a damaged primary timing chain tensioner.

Timing Chain Guide

1. Inspect the timing chain guide for the following:



Fig. 181: Timing Chain Guide Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Worn guide surface (1)
- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)

2. Replace a damaged primary timing chain upper guide.

Timing Chain Guide

1. Inspect the timing chain guide for the following:



Fig. 182: Timing Chain Guide Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Worn guide surface (1)
- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)

2. Replace a damaged primary timing chain upper guide.

Timing Chain Tensioner

1. Inspect the timing chain tensioner for worn timing chain tensioner surface (1).

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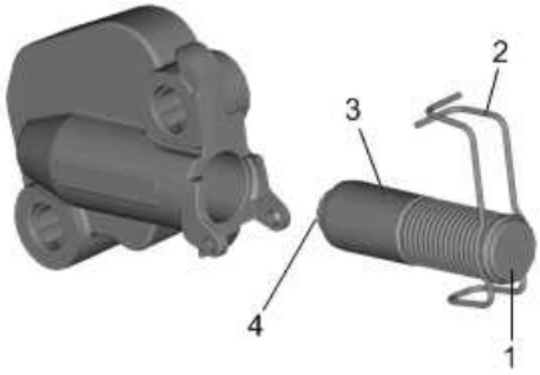


Fig. 183: Timing Chain Tensioner Inspection Points
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the timing chain tensioner for worn timing chain tensioner spring (2).
3. Inspect the timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (4) and ensure the plunger moves freely (3) in and out of the body of the tensioner. Refer to **Camshaft Timing Chain Components Installation**.
4. Replace a damaged primary timing chain tensioner.

Timing Chain Tensioner

1. Inspect the timing chain tensioner for worn timing chain tensioner surface (1).



Fig. 184: Timing Chain Tensioner Inspection Points
Courtesy of GENERAL MOTORS COMPANY

2. Cracked or broken tensioner surface (2)
3. Inspect the timing chain tensioner for worn timing chain tensioner spring (3).
4. Replace a damaged primary timing chain tensioner.

OIL PUMP DISASSEMBLE

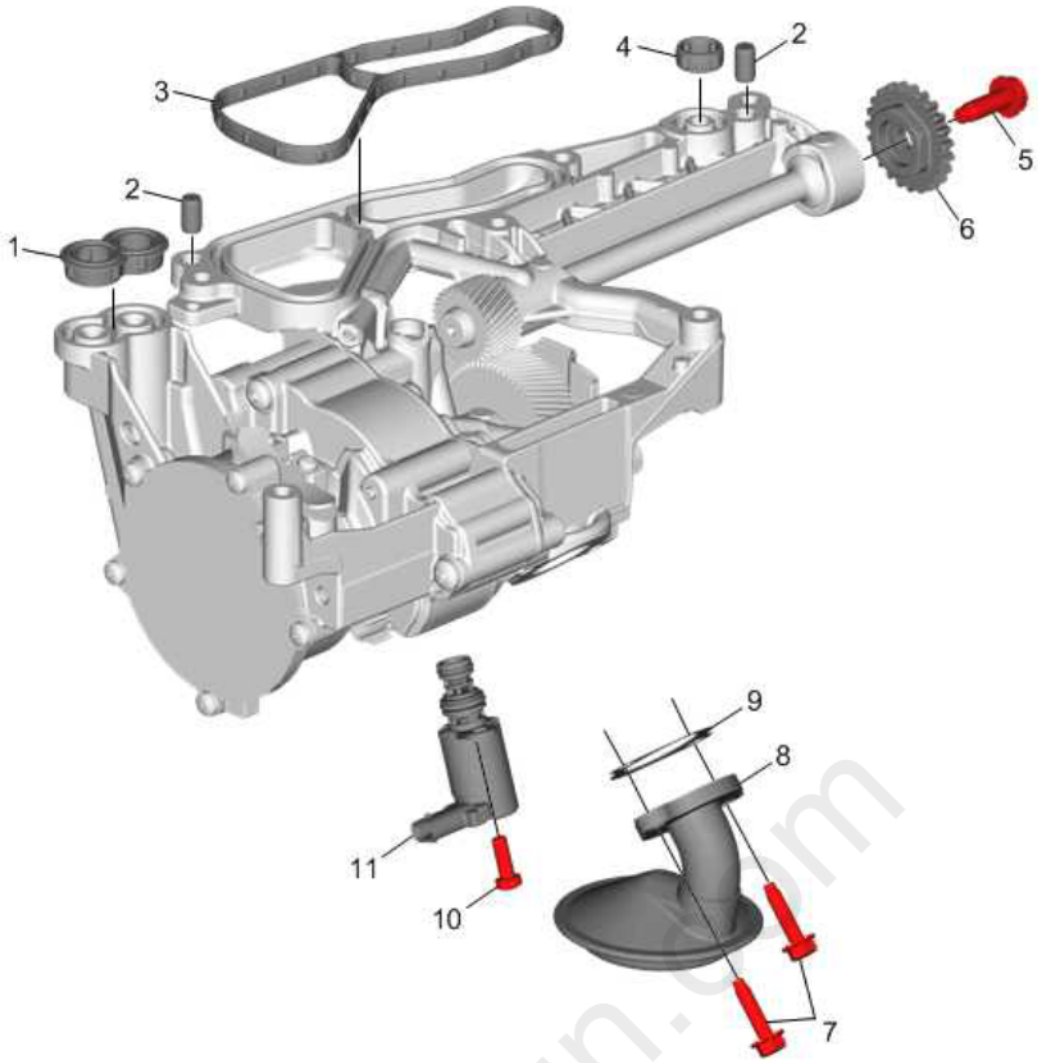


Fig. 185: Oil Pump Disassemble
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump SealÂ» Remove and DISCARD the seal.
2	Dowel Pin **NOTE:** **This is press fit and not serviceable.**
3	Oil Pump Housing Passage SealÂ» Remove and DISCARD the seal.
4	Oil Pump Housing Passage SealÂ» Remove and DISCARD the seal.
5	Oil Pump Drive BoltÂ» Remove and DISCARD the bolt.
6	Oil Pump Sprocket
7	Oil Pump Suction Pipe Bolt
8	Oil Pump Suction Pipe
9	Oil Pump Suction Pipe GasketÂ» Remove and DISCARD the gasket.
10	Oil Pump Flow Control Valve Bolt
11	Oil Pump Flow Control Valve **CAUTION:** **After removing the oil pump flow control valve, ensure the entire valve has been removed and there is no debris left in the oil pump bore. Failure to ensure the oil pump bore is free from debris may result in engine damage.**

OIL PUMP CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the oil pump components with non-corrosive solvent.
2. Dry the oil pump components with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Inspection Procedure

1. Inspect the oil pump housing for the following:

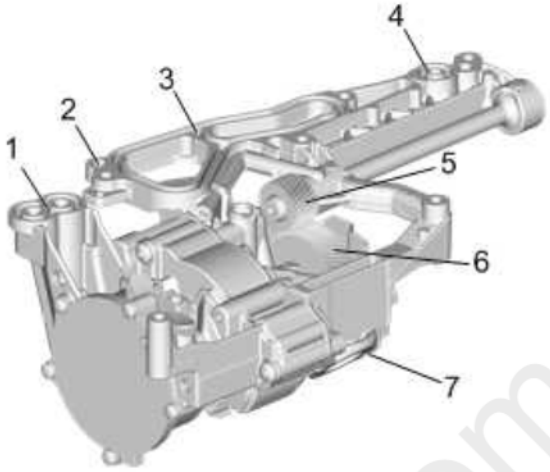


Fig. 186: Oil Pump Inspection Points
Courtesy of GENERAL MOTORS COMPANY

NOTE: **There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.**

- Damage to the vacuum pump seal surface (1)
- Damage to the oil pump mounting bosses (2)
- Damage to the oil pump housing seal surface (3)
- Damage to the oil pump housing seal surface (4)
- Damage to the gear (5)
- Damage to the gear (6)
- Damage to the mounting surface for the suction pipe (7)

OIL PUMP ASSEMBLE

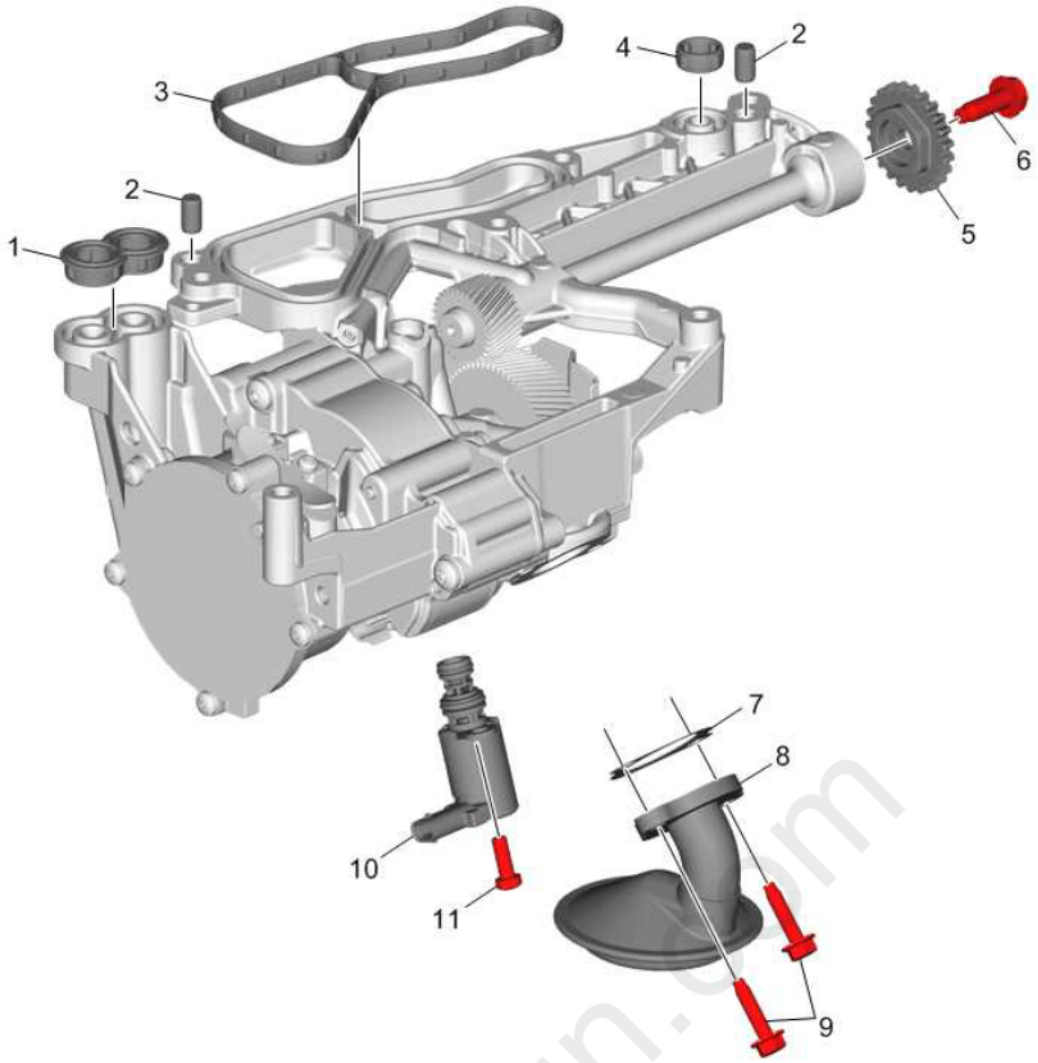


Fig. 187: Oil Pump Assemble
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump SealÂ» Install a NEW seal.
2	Dowel Pin **NOTE:** **This is press fit and not serviceable.**
3	Oil Pump Housing Passage SealÂ» Install a NEW seal.
4	Oil Pump Housing Passage SealÂ» Install a NEW seal.
5	Oil Pump Sprocket
6	Oil Pump Drive BoltÂ» Install a NEW bolt. Do NOT reuse the old bolt. **CAUTION:** **Refer to Fastener Caution .** **Tighten** First Pass: 15 N.m (11 lb ft) Final Pass: 110 degrees
7	Oil Pump Suction Pipe GasketÂ» Install a NEW gasket.
8	Oil Pump Suction Pipe
9	Oil Pump Suction Pipe Bolt **Tighten** 10 N.m (89 lb in)
10	Oil Pump Flow Control Valve

Callout	Component Name
11	Oil Pump Flow Control Valve Bolt with Insulator **Tighten** 5 N.m (44 lb in)

OIL PAN DISASSEMBLE (WITHOUT OIL COOLER)

Lower Oil Pan, Drain Plug and Oil Filter Disassemble

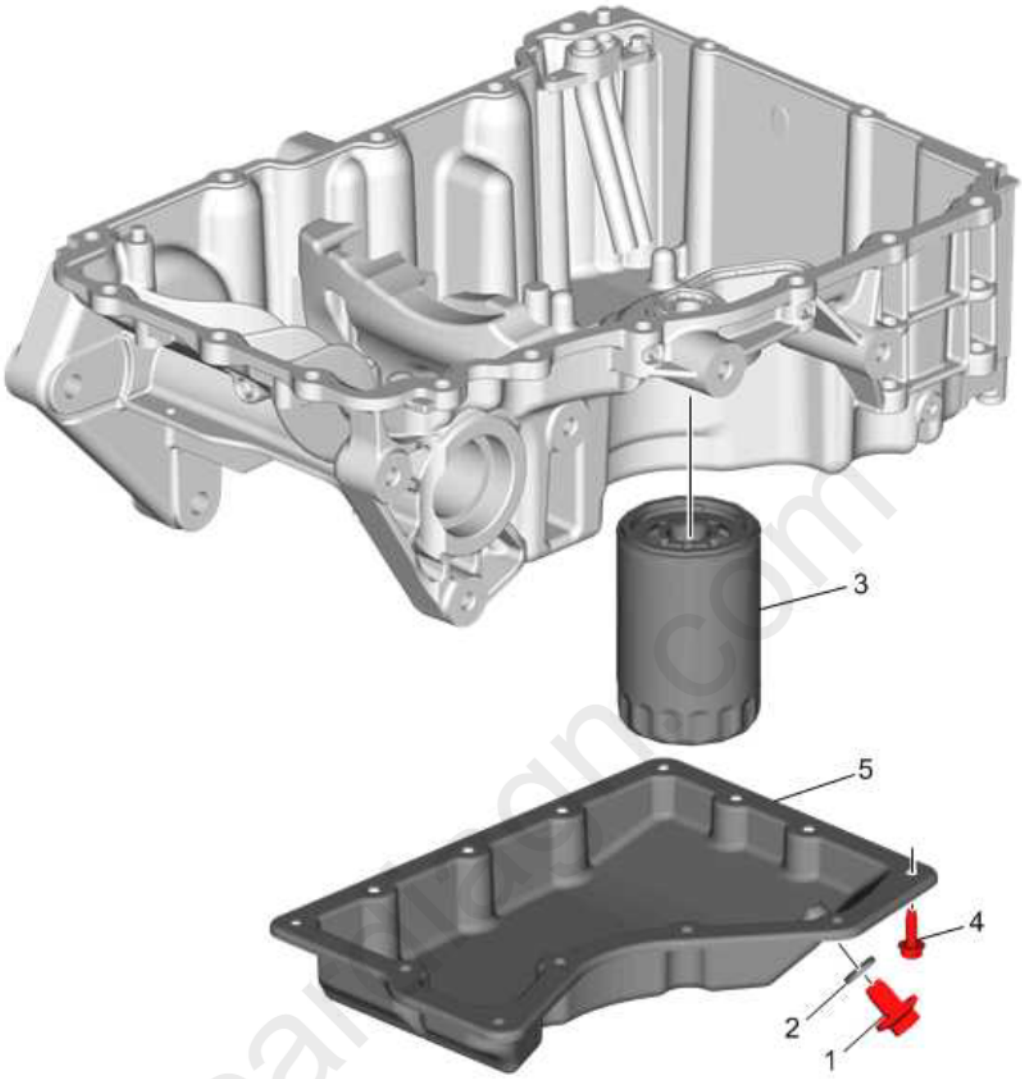


Fig. 188: Lower Oil Pan, Drain Plug and Oil Filter Disassemble
Courtesy of GENERAL MOTORS COMPANY

Lower Oil Pan, Drain Plug and Oil Filter Disassemble

Callout	Component Name
1	Oil Pan Drain Plug
2	Oil Pan Drain Plug Seal **NOTE:** **Remove and DISCARD the seal.**
3	Oil Filter
4	Lower Oil Pan Bolt [13x]
5	Lower Oil Pan **NOTE:** **If the lower oil pan is removed, it must be discarded and replaced with NEW one.**

Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Disassemble

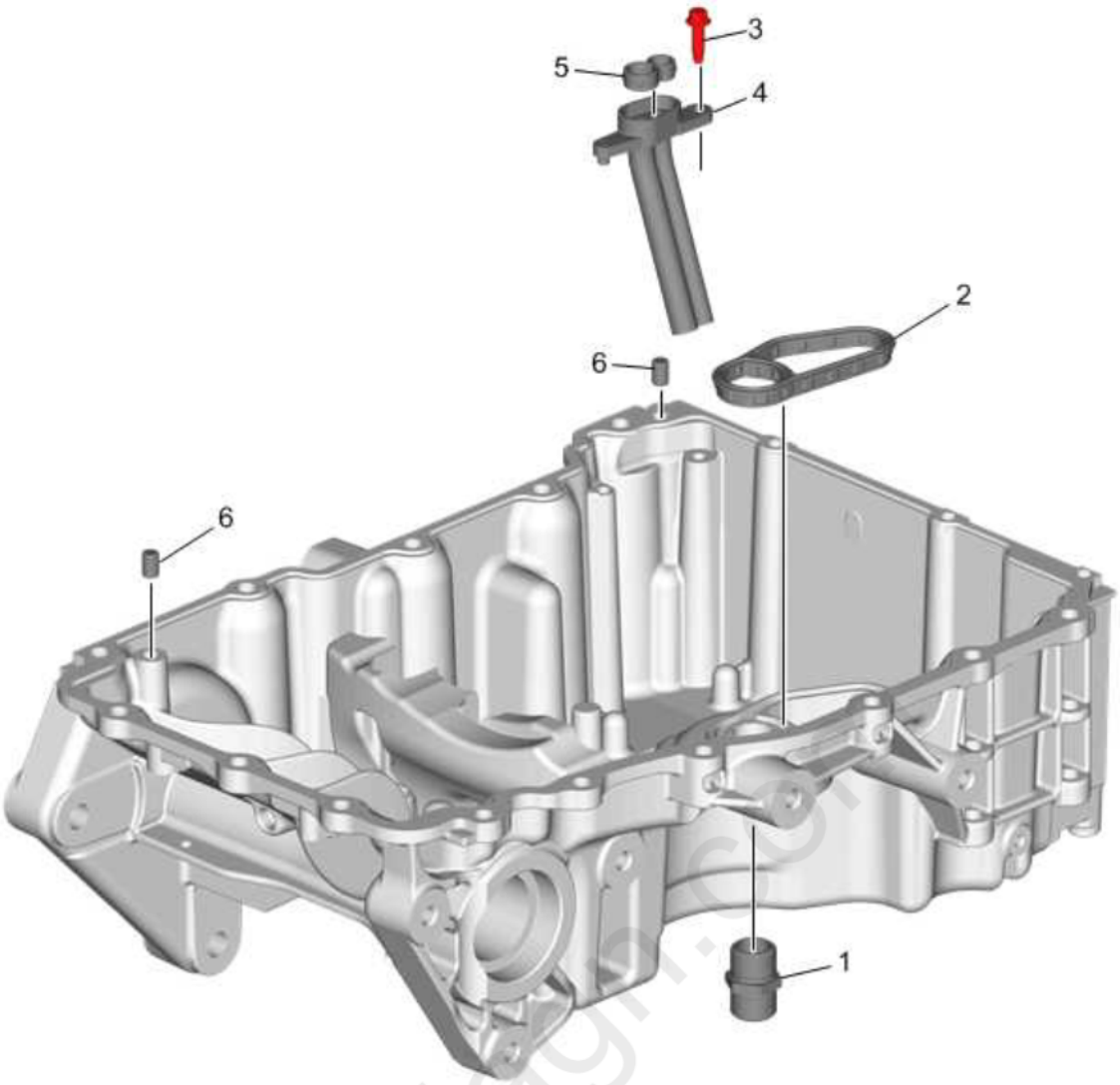


Fig. 189: Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Disassemble
Courtesy of GENERAL MOTORS COMPANY

Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Disassemble

Callout	Component Name
1	Oil Filter Adapter Fitting
2	Oil Pan High Pressure Port Seal **NOTE:** **Remove and DISCARD the seal.**
3	Positive Crankcase Ventilation Oil Separator Bolt
4	Positive Crankcase Ventilation Oil Separator
5	Positive Crankcase Ventilation Oil Separator Seal **NOTE:** **Remove and DISCARD the seal.**
6	Dowel Pin [2x]

Oil Pan Baffle and Engine Oil Level Indicator Switch Disassemble

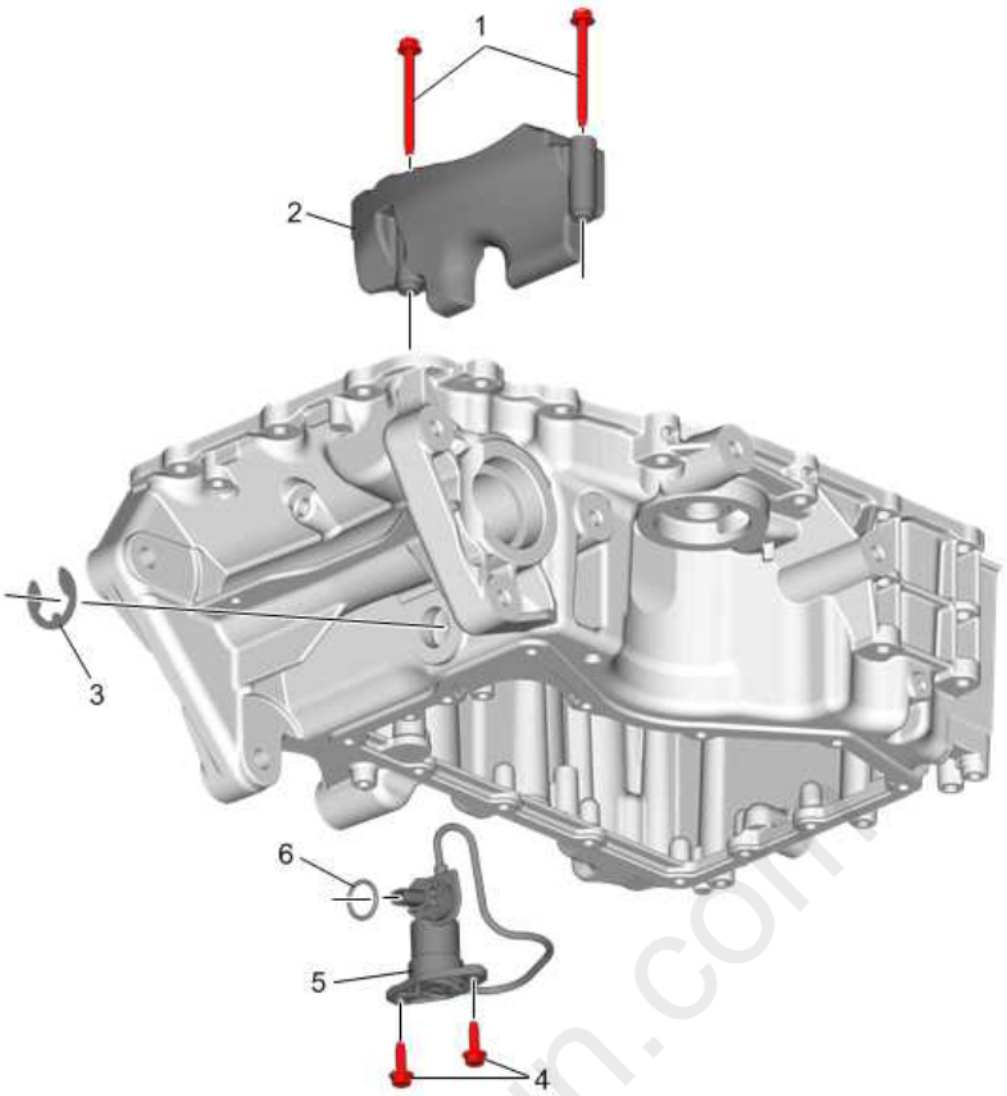


Fig. 190: Oil Pan Baffle and Engine Oil Level Indicator Switch Disassemble
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Baffle and Engine Oil Level Indicator Switch Disassemble

Callout	Component Name
1	Oil Pan Baffle Bolt [2x]
2	Oil Pan Baffle
3	Engine Oil Level Switch Clip
4	Engine Oil Level Indicator Switch Bolt [2x]
5	Engine Oil Level Indicator Switch
6	Engine Oil Level Indicator Switch O-Ring Seal **NOTE:** **Remove and DISCARD the seal.**

OIL PAN DISASSEMBLE (WITH OIL COOLER)

Lower Oil Pan, Drain Plug and Oil Filter Disassemble

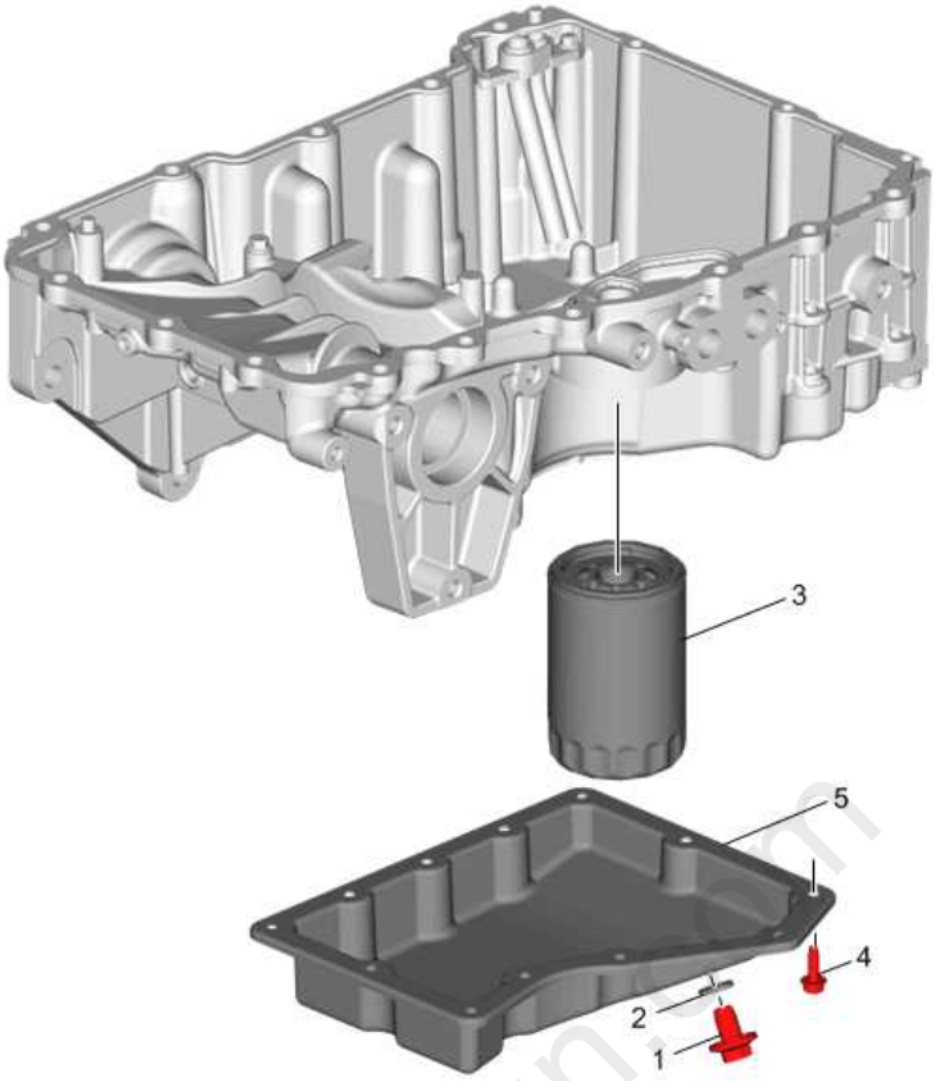


Fig. 191: Lower Oil Pan, Drain Plug and Oil Filter Disassemble
Courtesy of GENERAL MOTORS COMPANY

Lower Oil Pan, Drain Plug and Oil Filter Disassemble

Callout	Component Name
1	Oil Pan Drain Plug
2	Oil Pan Drain Plug Seal **NOTE:** **Remove and DISCARD the seal.**
3	Oil Filter
4	Lower Oil Pan Bolt [13x]
5	Lower Oil Pan **NOTE:** **If the lower oil pan is removed, it must be discarded and replaced with NEW one.**

Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Disassemble

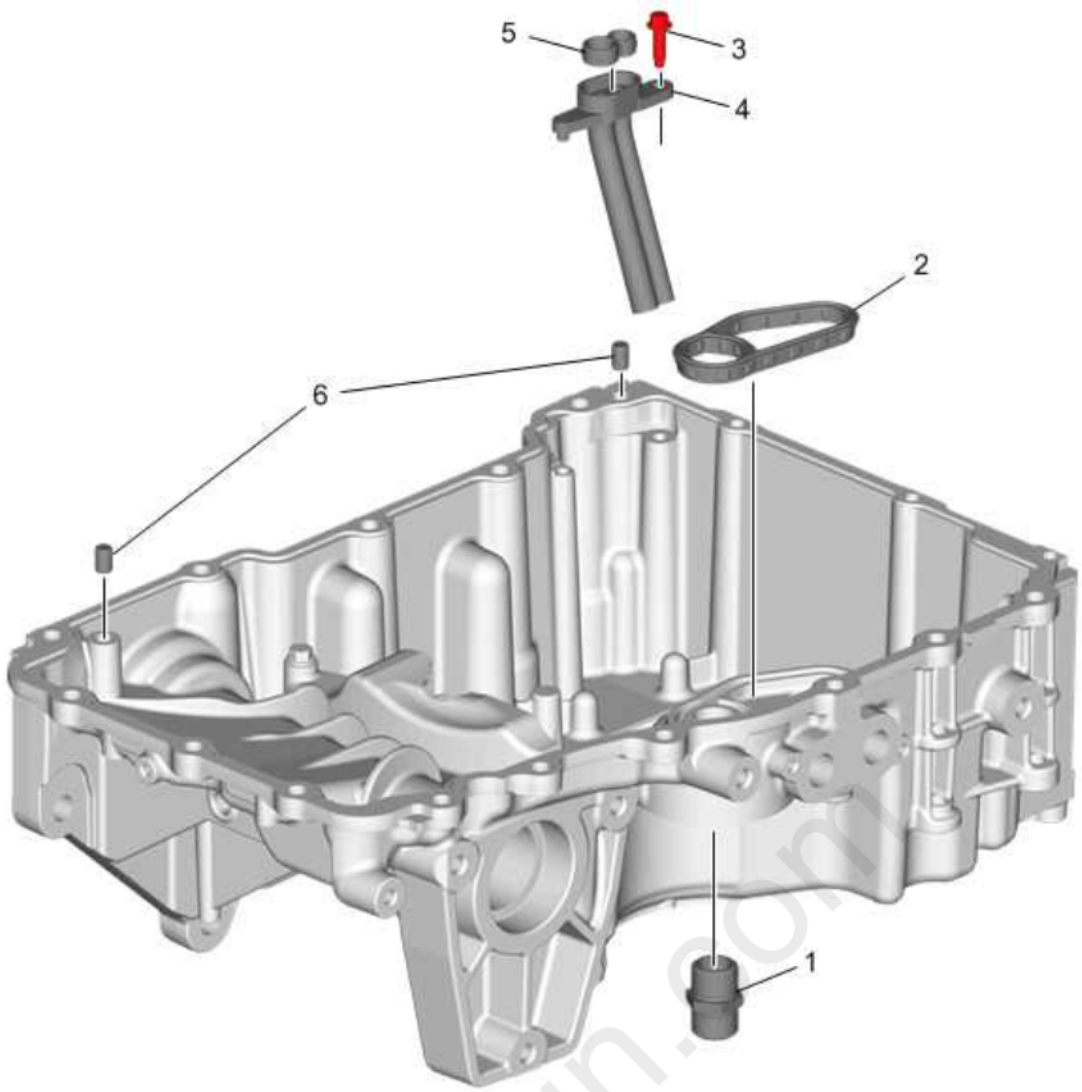


Fig. 192: Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Disassemble
Courtesy of GENERAL MOTORS COMPANY

Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Disassemble

Callout	Component Name
1	Oil Filter Adapter Fitting
2	Oil Pan High Pressure Port Seal **NOTE:** **Remove and DISCARD the seal.**
3	Positive Crankcase Ventilation Oil Separator Bolt
4	Positive Crankcase Ventilation Oil Separator
5	Positive Crankcase Ventilation Oil Separator Seal **NOTE:** **Remove and DISCARD the seal.**
6	Dowel Pin [2x]

Oil Pan Baffle and Engine Oil Level Indicator Switch Disassemble

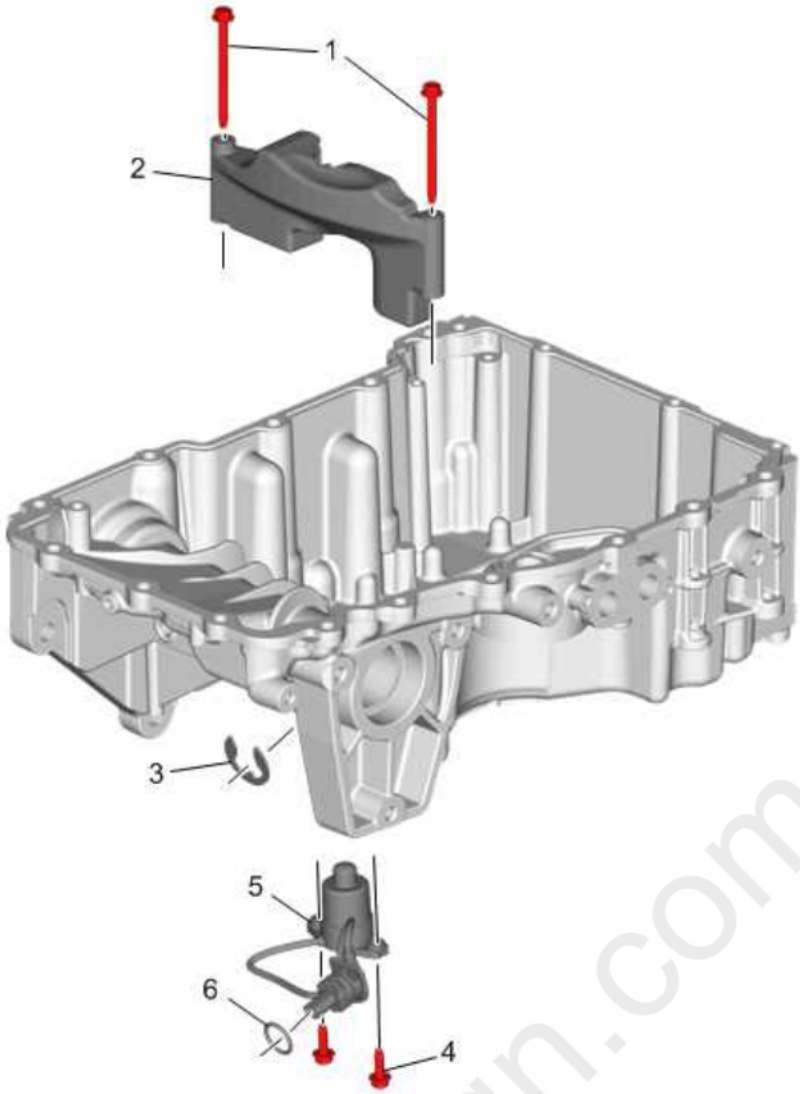


Fig. 193: Oil Pan Baffle and Engine Oil Level Indicator Switch Disassemble
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Baffle and Engine Oil Level Indicator Switch Disassemble

Callout	Component Name
1	Oil Pan Baffle Bolt [2x]
2	Oil Pan Baffle
3	Engine Oil Level Switch Clip
4	Engine Oil Level Indicator Switch Bolt [2x]
5	Engine Oil Level Indicator Switch
6	Engine Oil Level Indicator Switch O-Ring Seal **NOTE:** **Remove and DISCARD the seal.**

OIL PAN CLEANING AND INSPECTION (WITHOUT OIL COOLER)

Special Tools

EN-28410 Gasket Remover

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

Cleaning Procedure

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**
2. Remove any old thread sealant, gasket material or sealant using **EN-28410** remover.

3. Clean the oil pan and oil pan components in solvent.
4. Clean out debris from the bolt holes.
5. Dry the oil pan and oil pan components with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Inspection Procedure Oil Pan

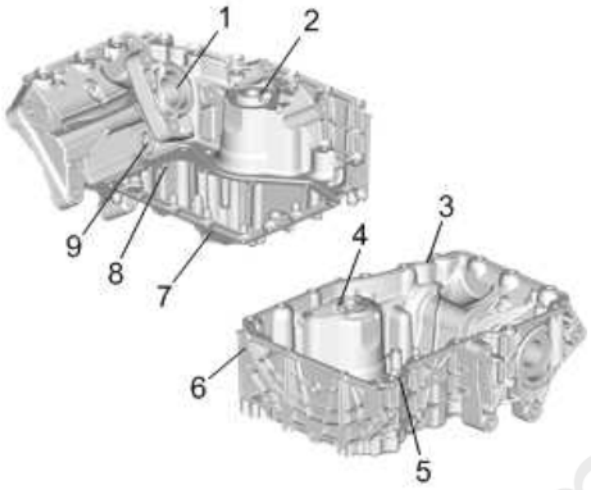


Fig. 194: Oil Pan Inspection Points
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the oil pan for the following conditions:
    - Damage to the front differential hole (1)
    - Damage to the oil filter sealing surface (2)
    - Gouges or damage to the oil pan sealing surfaces (3)
    - Damage to the high pressure part seal area (4)
    - Damage to the positive crankcase ventilation separator drain bolt hole (5)
    - Damage to the brace mounting bosses (6)
    - Gouges or damage to the lower oil pan sealing surfaces (7)
    - Damage to the engine oil level switch mounting holes (8)
    - Damage to the engine oil level switch hole (9)
2. Repair or replace the oil pan and/or oil pan components as necessary.

Inspection Procedure Lower Oil Pan

1. Replace the lower oil pan if removed from the upper oil pan.
2. Inspect the oil pan for the following conditions:

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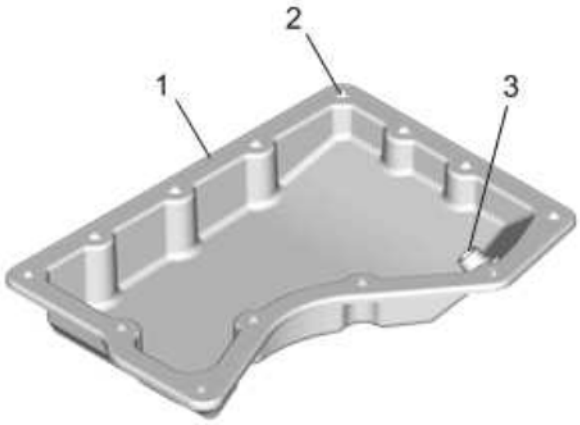


Fig. 195: Inspection Points Lower Oil Pan
Courtesy of GENERAL MOTORS COMPANY

- Gouges or damage to the lower oil pan sealing surfaces (1)
- Damage to the lower oil pan mounting holes (2)
- Damage to the drain plug or drain plug hole (3)

OIL PAN CLEANING AND INSPECTION (WITH OIL COOLER)

Special Tools

EN-28410 Gasket Remover

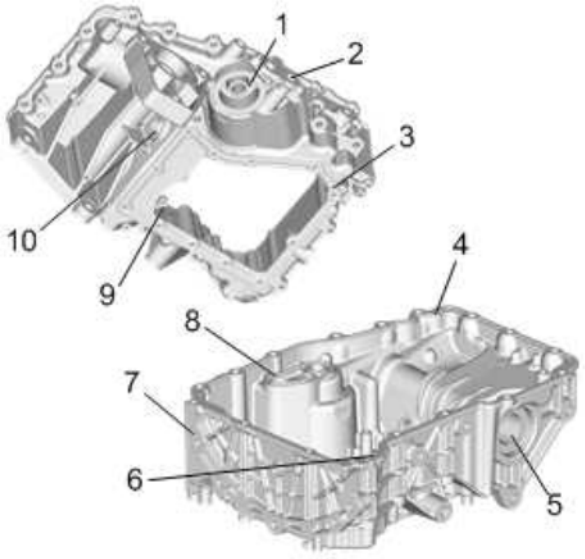
For equivalent regional tools, refer to **Special Tools**

Cleaning Procedure

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**
2. Remove any old thread sealant, gasket material or sealant using **EN-28410** remover.
3. Clean the oil pan and oil pan components in solvent.
4. Clean out debris from the bolt holes.
5. Dry the oil pan and oil pan components with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Inspection Procedure Oil Pan



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Fig. 196: Oil Pan Inspection Points
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the oil pan for the following conditions:
    - Damage to the oil filter sealing surface (1)
    - Gouges or damage to the lower oil pan sealing surfaces (2)
    - Gouges or damage to the oil pan sealing surfaces (3)
    - Gouges or damage to the upper oil pan sealing surfaces (4)
    - Damage to the front differential hole (5)
    - Damage to the positive crankcase ventilation separator drain bolt hole (6)
    - Damage to the brace mounting bosses (7)
    - Damage to the high pressure part seal area (8)
    - Damage to the engine oil level switch mounting holes (9)
    - Damage to the engine oil level switch hole (10)
2. Repair or replace the oil pan and/or oil pan components as necessary.

Inspection Procedure Lower Oil Pan

1. Replace the lower oil pan if removed from the upper oil pan.

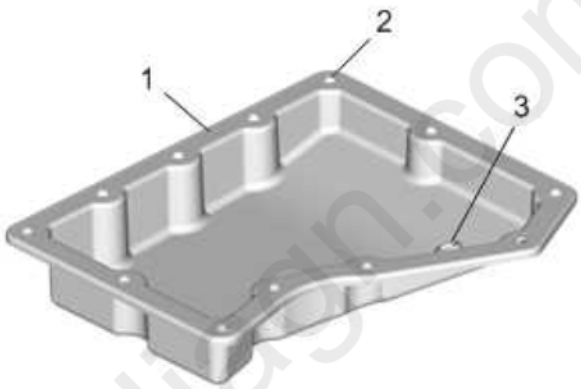


Fig. 197: Inspection Points Lower Oil Pan
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the oil pan for the following conditions:
    - Gouges or damage to the lower oil pan sealing surfaces (1)
    - Damage to the lower oil pan mounting holes (2)
    - Damage to the drain plug or drain plug hole (3)

OIL PUMP SUCTION PIPE AND SCREEN CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the oil pump pipe and screen with solvent.
2. Dry the oil pump pipe and screen with compressed air.

WARNING: Refer to Safety Glasses Warning .

Inspection Procedure

1. Inspect the mounting surface (1) for possible leakage paths.

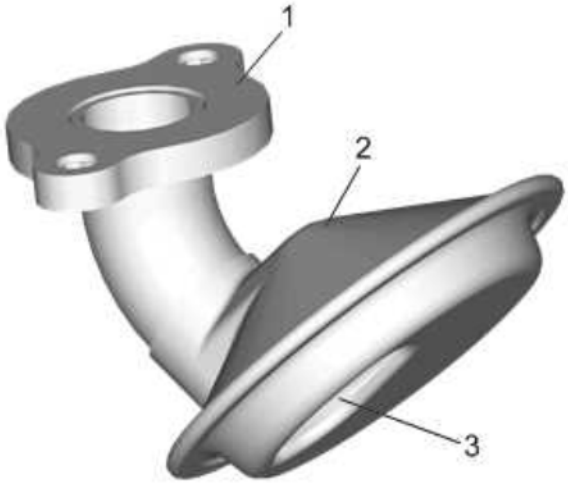


Fig. 198: Oil Pump Pickup Inspection Points
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the oil pump pipe tube (2) for cracks, imperfections and/or damage.
3. Inspect the oil pump screen (3) for blockage, foreign material, tears, cracks and/or damage.

OIL PAN ASSEMBLE (WITHOUT OIL COOLER)

Oil Pan Baffle and Engine Oil Level Indicator Switch Assemble

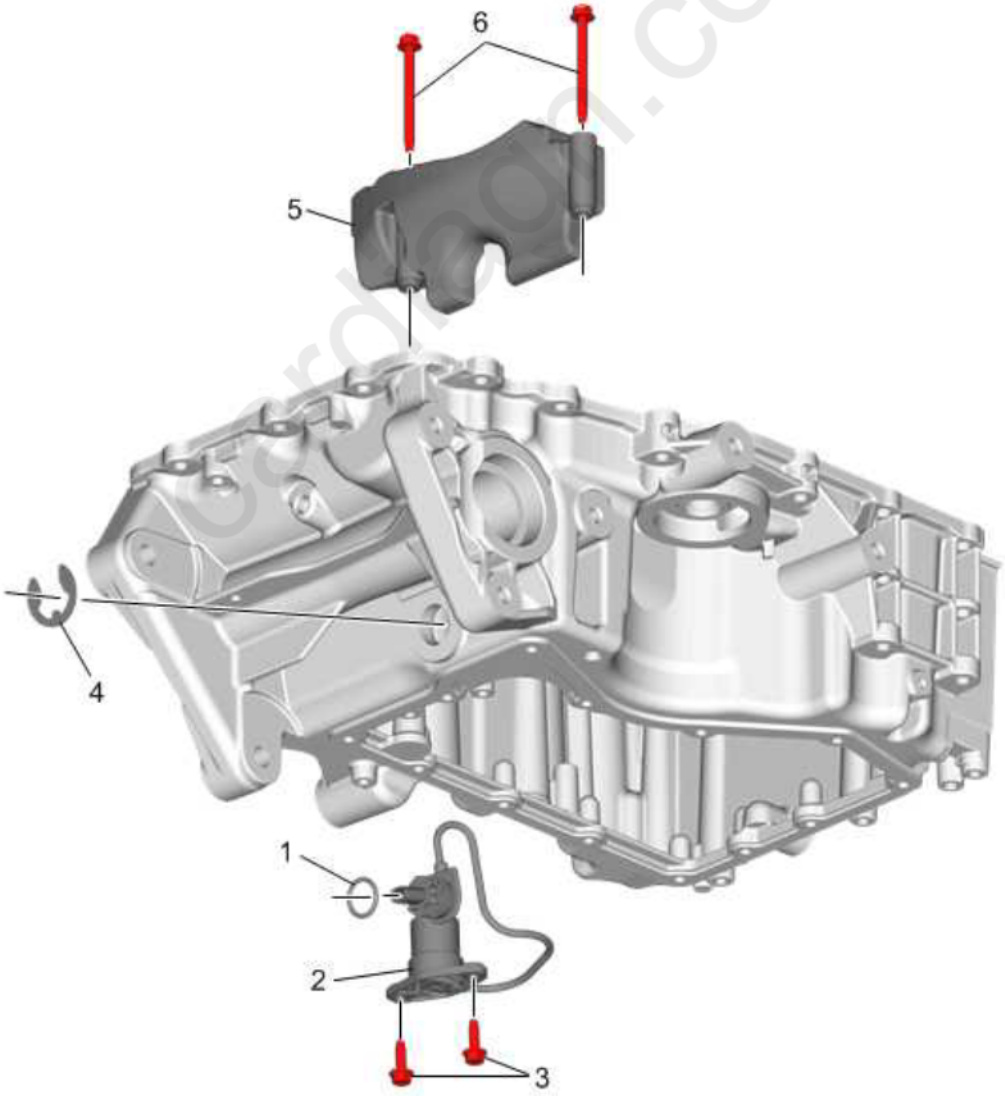


Fig. 199: Oil Pan Baffle and Engine Oil Level Indicator Switch Assemble
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Baffle and Engine Oil Level Indicator Switch Assemble

Callout	Component Name
1	Engine Oil Level Indicator Switch O-Ring Seal **NOTE:** **Install a NEW seal.**
2	Engine Oil Level Indicator Switch
3	Engine Oil Level Indicator Switch Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
4	Engine Oil Level Switch Clip
5	Oil Pan Baffle
6	Oil Pan Baffle Bolt [2x] **Tighten** 10 N.m (89 lb in)

Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Assemble

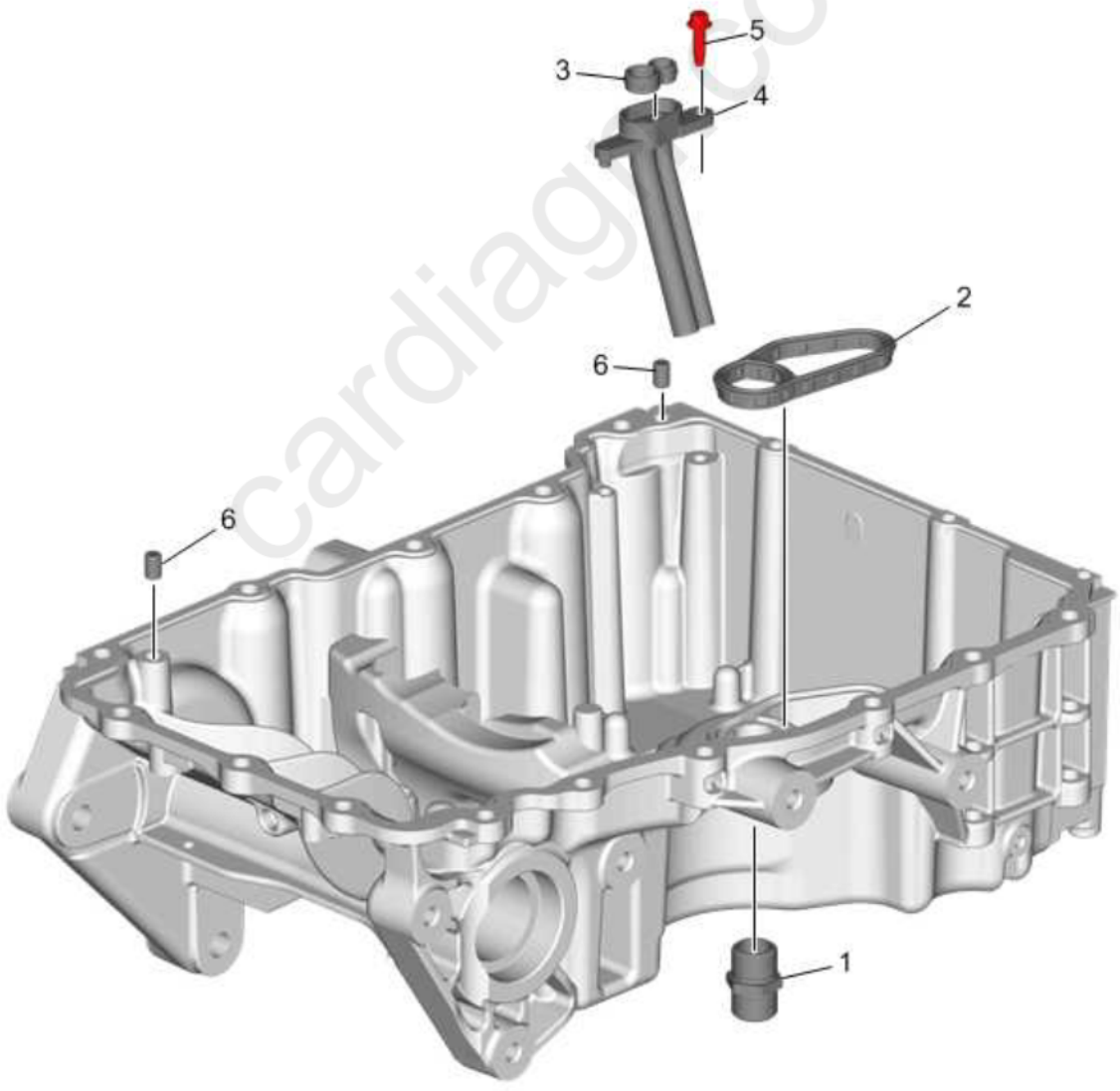


Fig. 200: Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Assemble
Courtesy of GENERAL MOTORS COMPANY

Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Assemble

Callout	Component Name
1	Oil Filter Adapter Fitting **Tighten** 50 N.m (37 lb ft)
2	Oil Pan High Pressure Port Seal **NOTE:** **Install a NEW seal.**
3	Positive Crankcase Ventilation Oil Separator Seal **NOTE:** **Install a NEW seal.**
4	Positive Crankcase Ventilation Oil Separator
5	Positive Crankcase Ventilation Oil Separator Bolt **Tighten** 10 N.m (89 lb in)
6	Dowel Pin

Lower Oil Pan, Drain Plug and Oil Filter Assemble

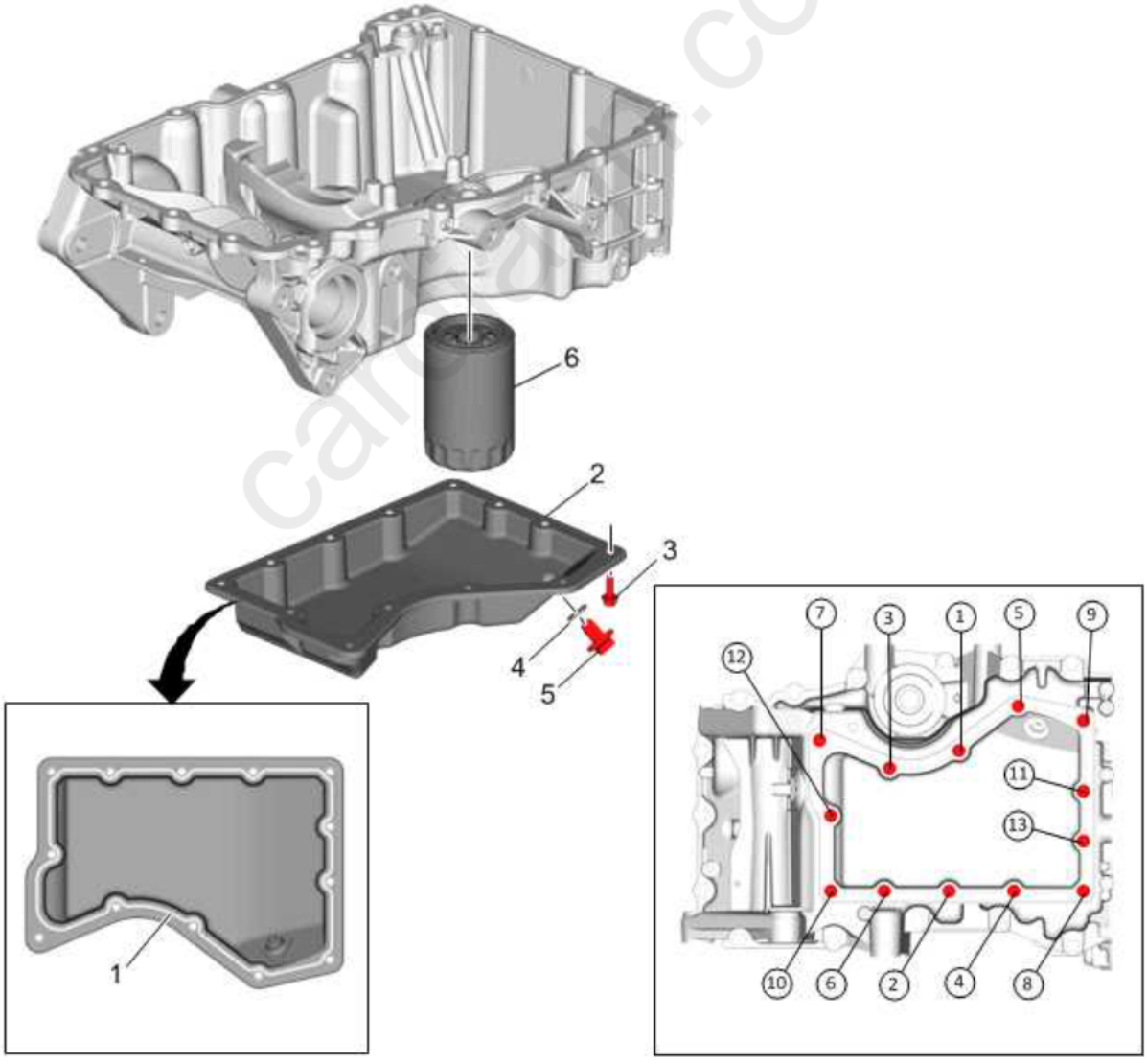


Fig. 201: Lower Oil Pan, Drain Plug and Oil Filter Assemble
Courtesy of GENERAL MOTORS COMPANY

Lower Oil Pan, Drain Plug and Oil Filter Assemble

Callout	Component Name

Callout	Component Name
1	Sealant **Procedure** Apply proper sealant. Refer to **Adhesives, Fluids, Lubricants and Sealers** .
2	Lower Oil Pan **NOTE:** **If lower oil pan was removed, it must be replaced with a NEW one.**
3	Lower Oil Pan Bolt [13x] **Tighten in sequence** 10 N.m (89 lb in)
4	Oil Pan Drain Plug Seal **NOTE:** **Install a NEW seal.**
5	Oil Pan Drain Plug **Tighten** 10 N.m (89 lb in)
6	Oil Filter **Tighten** Install a NEW oil filter and tighten 3/4 to 1 full turn after the gasket makes contact with the sealing surface on the filter mounting flange.

OIL PAN ASSEMBLE (WITH OIL COOLER)

Oil Pan Baffle and Engine Oil Level Indicator Switch Assemble

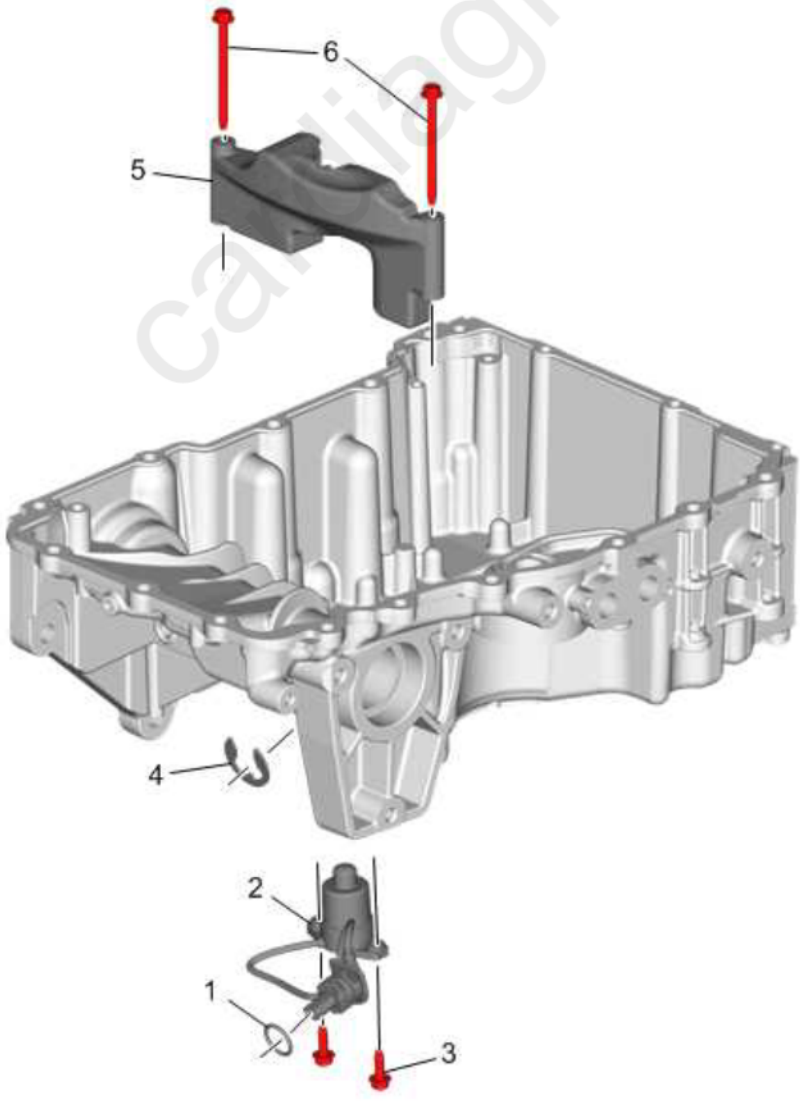
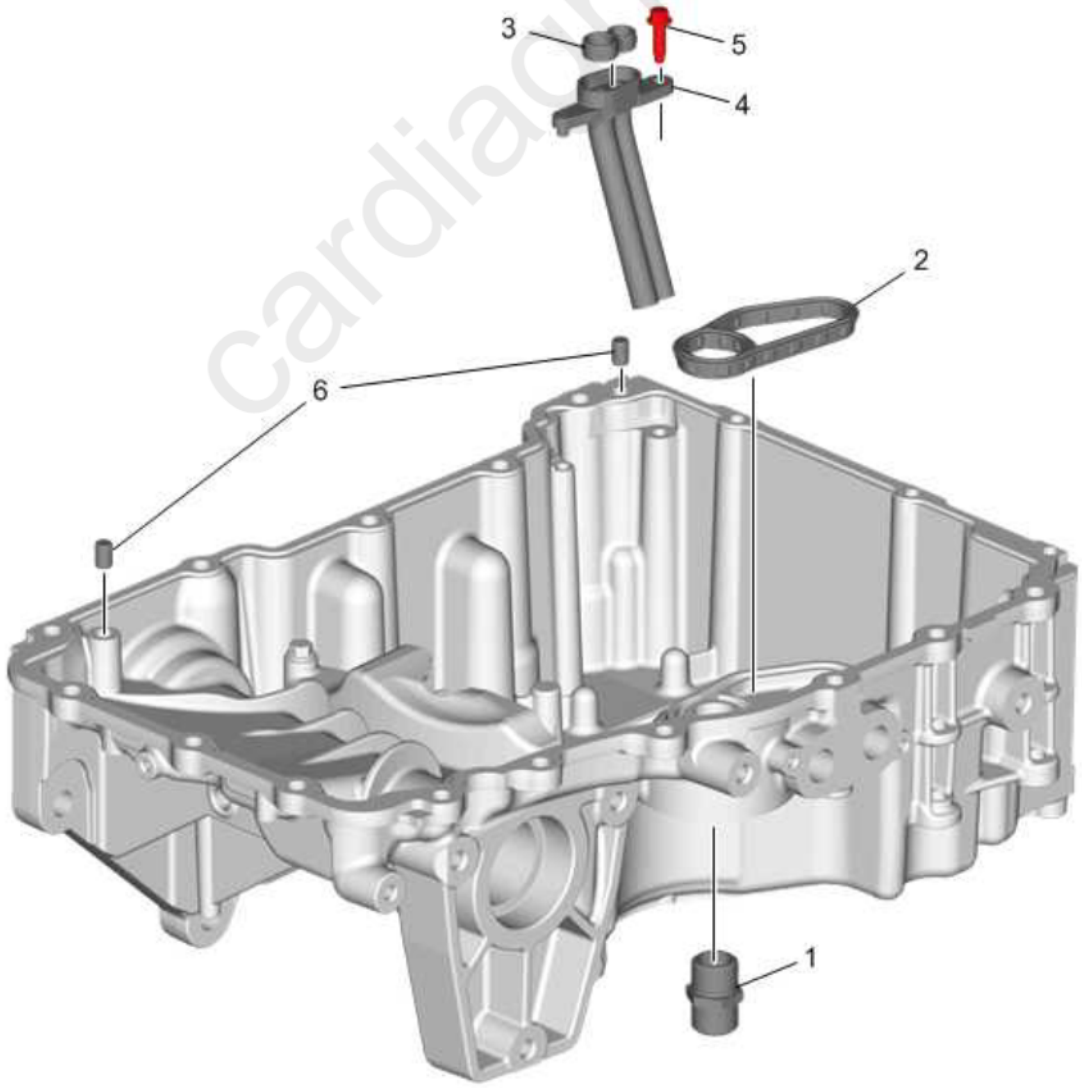


Fig. 202: Oil Pan Baffle and Engine Oil Level Indicator Switch Assemble
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Baffle and Engine Oil Level Indicator Switch Assemble

Callout	Component Name
1	Engine Oil Level Indicator Switch O-Ring Seal **NOTE:** **Install a NEW seal.**
2	Engine Oil Level Indicator Switch
3	Engine Oil Level Indicator Switch Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
4	Engine Oil Level Switch Clip
5	Oil Pan Baffle
6	Oil Pan Baffle Bolt [2x] **Tighten** 10 N.m (89 lb in)

Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Assemble



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Fig. 203: Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Assemble
Courtesy of GENERAL MOTORS COMPANY

Oil Filter Adapter Fitting, Oil Pan High Pressure Seal, Positive Crankcase Ventilation Oil Separator Drain and Dowel Pins Assemble

Callout	Component Name
1	Oil Filter Adapter Fitting **Tighten** 35 N.m (26 lb ft)
2	Oil Pan High Pressure Port Seal **NOTE:** **Install a NEW seal.**
3	Positive Crankcase Ventilation Oil Separator Seal **NOTE:** **Install a NEW seal.**
4	Positive Crankcase Ventilation Oil Separator
5	Positive Crankcase Ventilation Oil Separator Bolt **Tighten** 10 N.m (89 lb in)
6	Dowel Pin

Lower Oil Pan, Drain Plug and Oil Filter Assemble

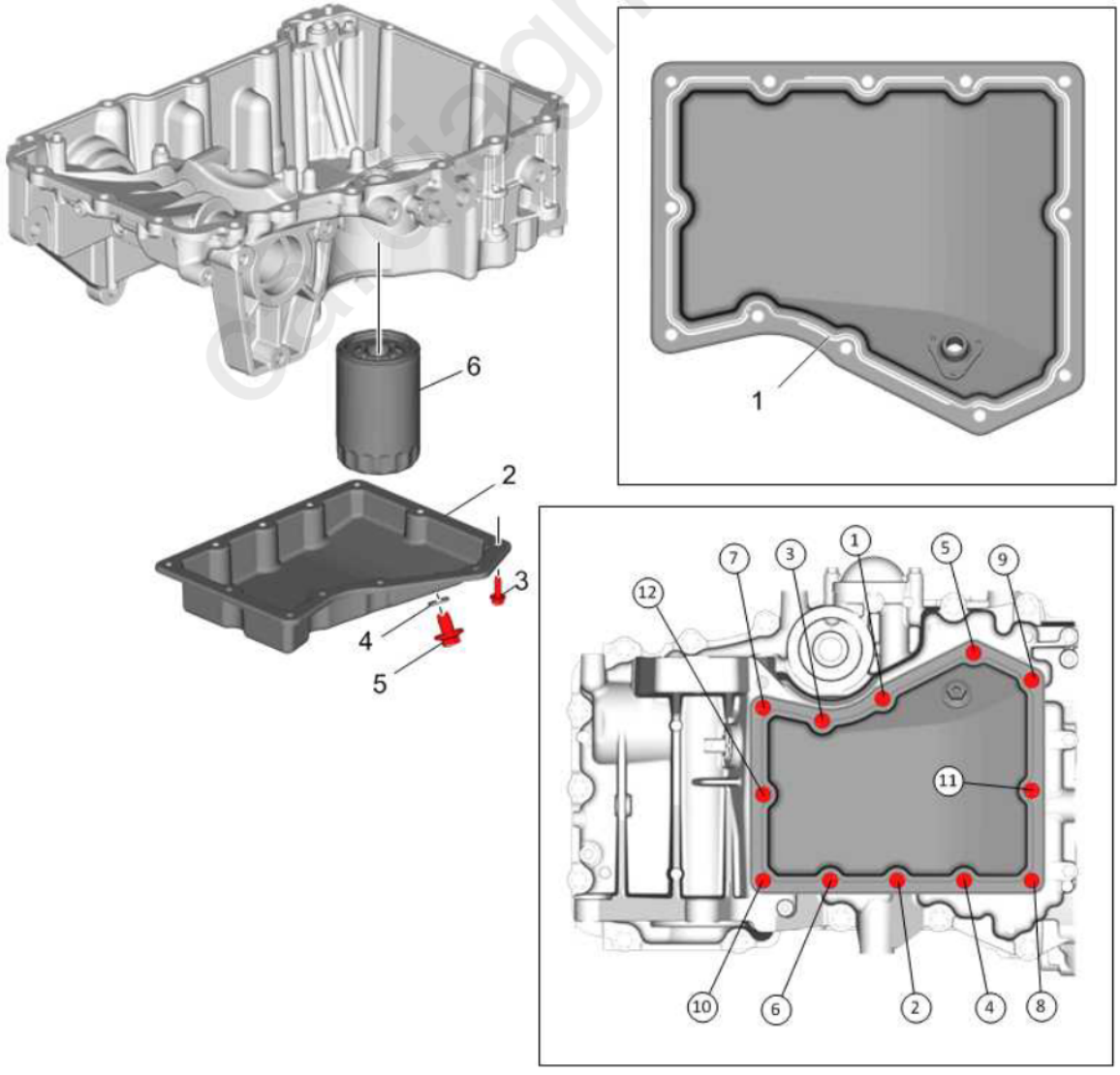


Fig. 204: Lower Oil Pan, Drain Plug and Oil Filter Assemble
Courtesy of GENERAL MOTORS COMPANY

Lower Oil Pan, Drain Plug and Oil Filter Assemble

Callout	Component Name
1	Sealant **Procedure** Apply proper sealant. Refer to **Adhesives, Fluids, Lubricants and Sealers** .
2	Lower Oil Pan **NOTE:** **If lower oil pan was removed, it must be replaced with a NEW one.**
3	Lower Oil Pan Bolt [12x] **Tighten in sequence** 10 N.m (89 lb in)
4	Oil Pan Drain Plug Seal **NOTE:** **Install a NEW seal.**
5	Oil Pan Drain Plug **Tighten** 10 N.m (89 lb in)
6	Oil Filter **Tighten** Install a NEW oil filter and tighten 3/4 to 1 full turn after the gasket makes contact with the sealing surface on the filter mounting flange.

ENGINE FRONT COVER DISASSEMBLE

Crankshaft Front Oil Seal Disassemble

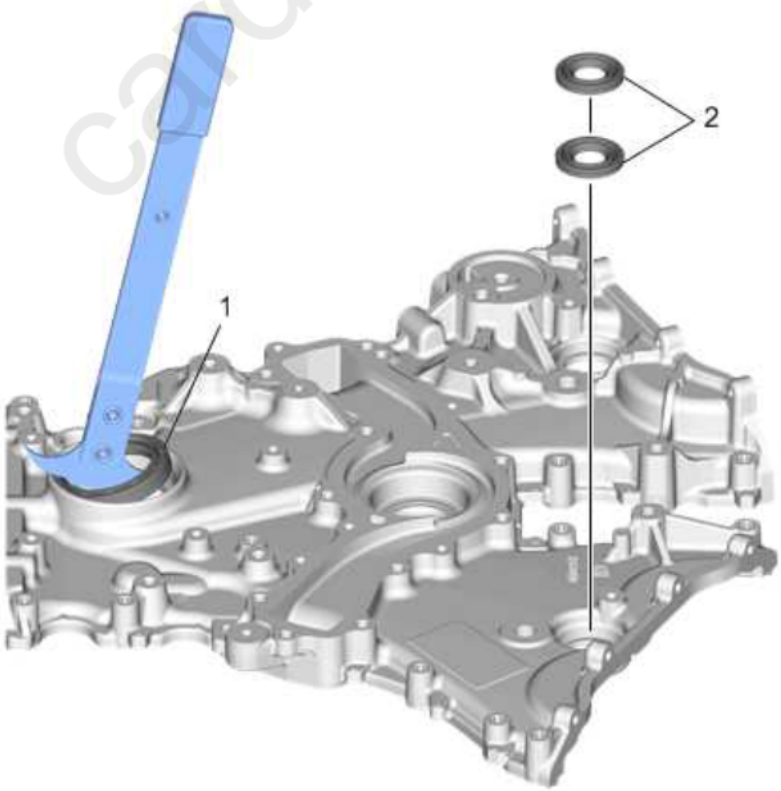


Fig. 205: Crankshaft Front Oil Seal Disassemble
Courtesy of GENERAL MOTORS COMPANY

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Crankshaft Front Oil Seal Disassemble

Callout	Component Name
1	Crankshaft Front Oil Seal **Special Tools** **EN-45000** Seal Remover For equivalent regional tools, refer to **Special Tools** .
2	Camshaft Position Actuator Control Valve Seal [2x]

Engine Front Cover Insulator Disassemble

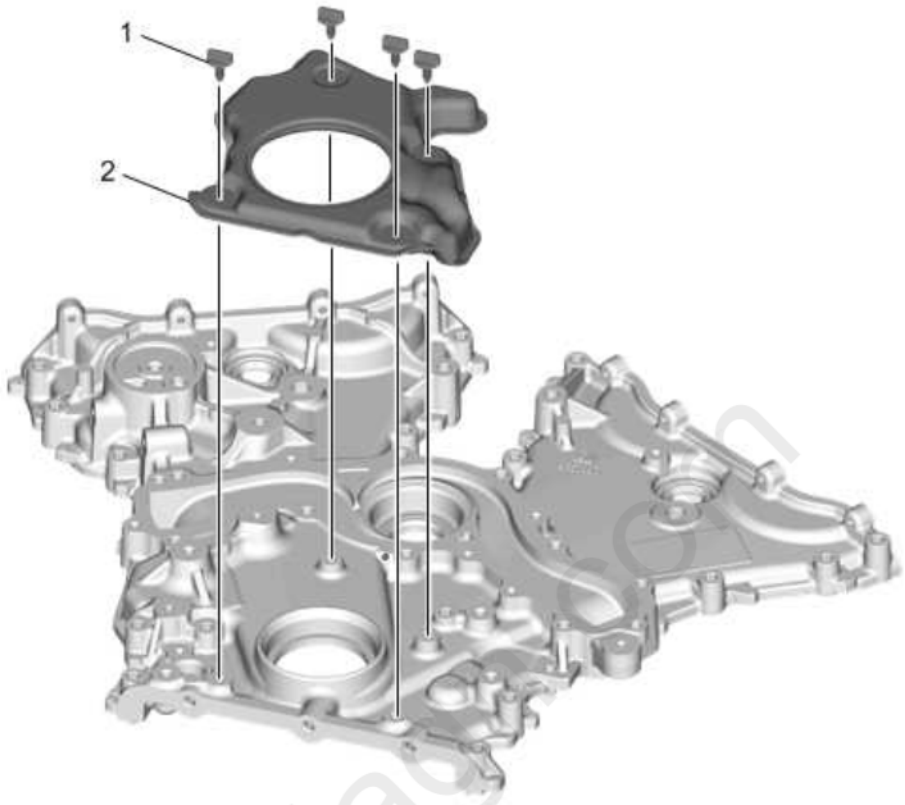


Fig. 206: Engine Front Cover Insulator Disassemble
Courtesy of GENERAL MOTORS COMPANY

Engine Front Cover Insulator Disassemble

Callout	Component Name
1	Engine Front Cover Retainer [4x]
2	Engine Front Cover Insulator

Water Pump Seal Disassemble

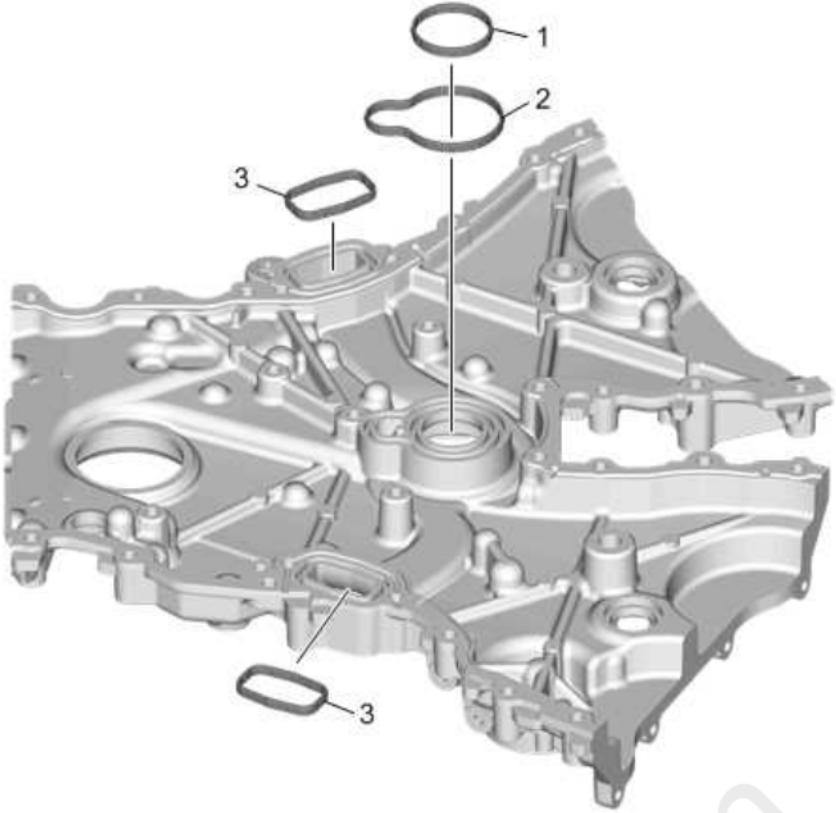


Fig. 207: Water Pump Seal Disassemble
Courtesy of GENERAL MOTORS COMPANY

Water Pump Seal Disassemble

Callout	Component Name
1	Water Pump Seal
2	Water Pump Seal
3	Water Pump Seal [2x]

ENGINE FRONT COVER CLEANING AND INSPECTION

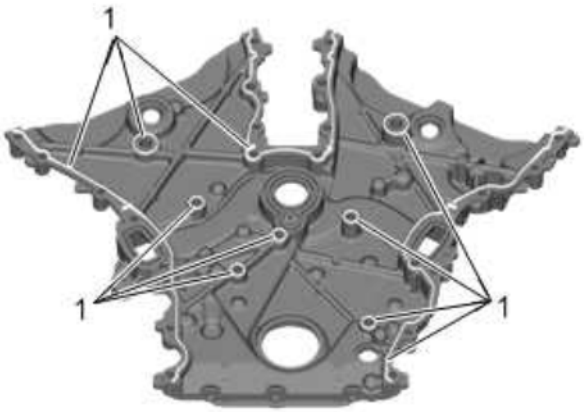
Special Tools

EN-28410 Gasket Remover

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

Cleaning Procedure

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**



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Fig. 208: Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

2. Remove any RTV sealant (1) from the engine front cover using **EN-28410** remover.
3. Clean out debris from the bolt holes.
4. Clean the engine front cover in solvent.
5. Dry the engine front cover with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Inspection Procedure

1. Inspect the exterior of the engine front cover for the following conditions:

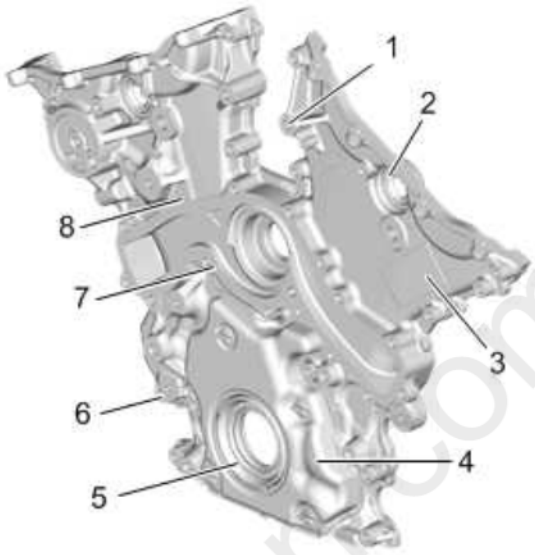


Fig. 209: Engine Front Cover Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage to the engine front cover bolt holes (1)
- Damage to the camshaft position actuator valve oil seals and bores (2)
- Damage and/or corrosion to the engine front cover (3)
- Damage to the engine front cover insulator (4)
- Damage to the crankshaft front oil seal bore (5)
- Damage to the oil pump flow control valve wire mounting surface (6)
- Gouges or damage to the water pump sealing surfaces (7)
- Damage to the water pump bolt hole threads (8)

2. Inspect the interior of the engine front cover for the following conditions:

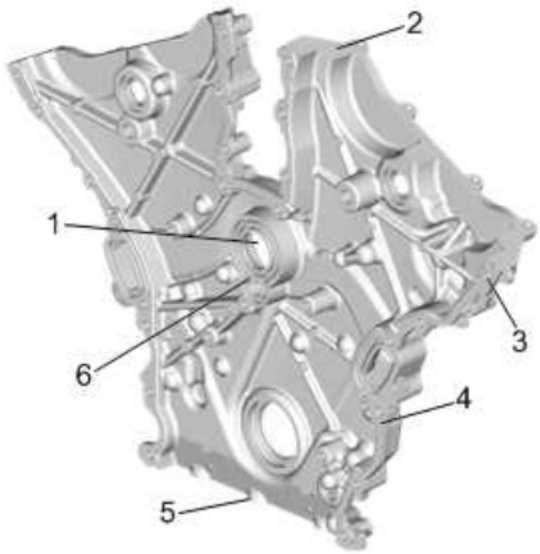


Fig. 210: Engine Front Cover Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage and/or corrosion to the engine coolant passage (1)
- Gouges or damage to the engine front cover sealing surfaces to the engine block (6), oil pan (4) and/or camshaft covers (2)
- Damage to the engine front cover bolt holes (3)
- Damage to the engine front cover to oil pan mounting bolt holes (5)
- Gouges or damage to the water pump seal area
- Damage to the crankshaft front oil seal bore
- Gouges or damage to the O-ring sealing areas

3. Repair or replace the engine front cover as necessary.

ENGINE FRONT COVER ASSEMBLE

Water Pump Seal Assemble

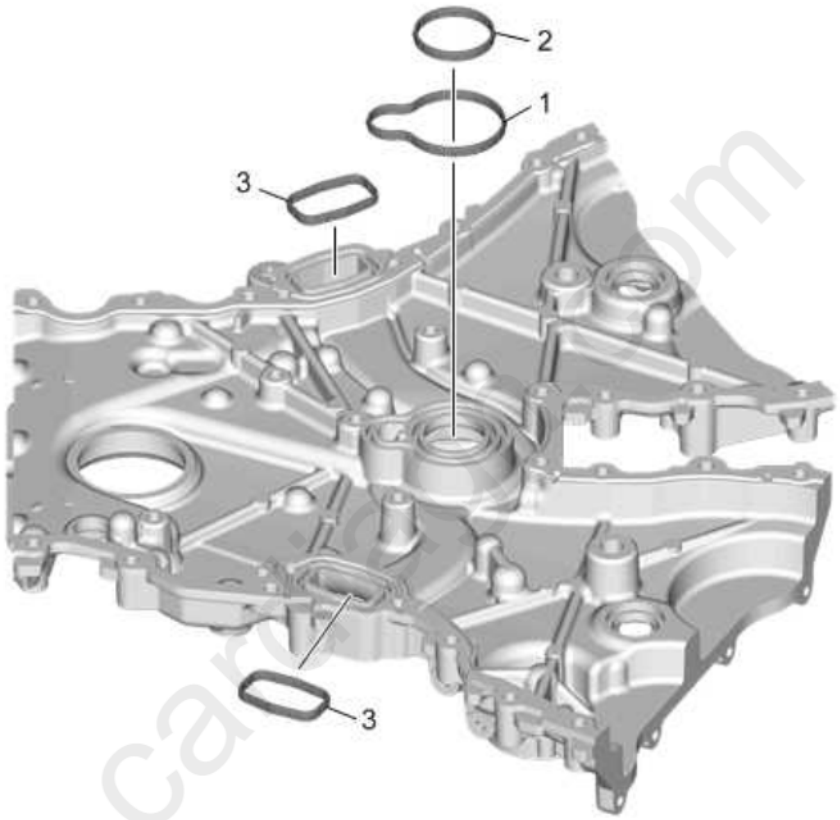


Fig. 211: Water Pump Seal Assemble
Courtesy of GENERAL MOTORS COMPANY

Water Pump Seal Assemble

Callout	Component Name
1	Water Pump Seal
2	Water Pump Seal
3	Water Pump Seal [2x]

Engine Front Cover Insulator Assemble

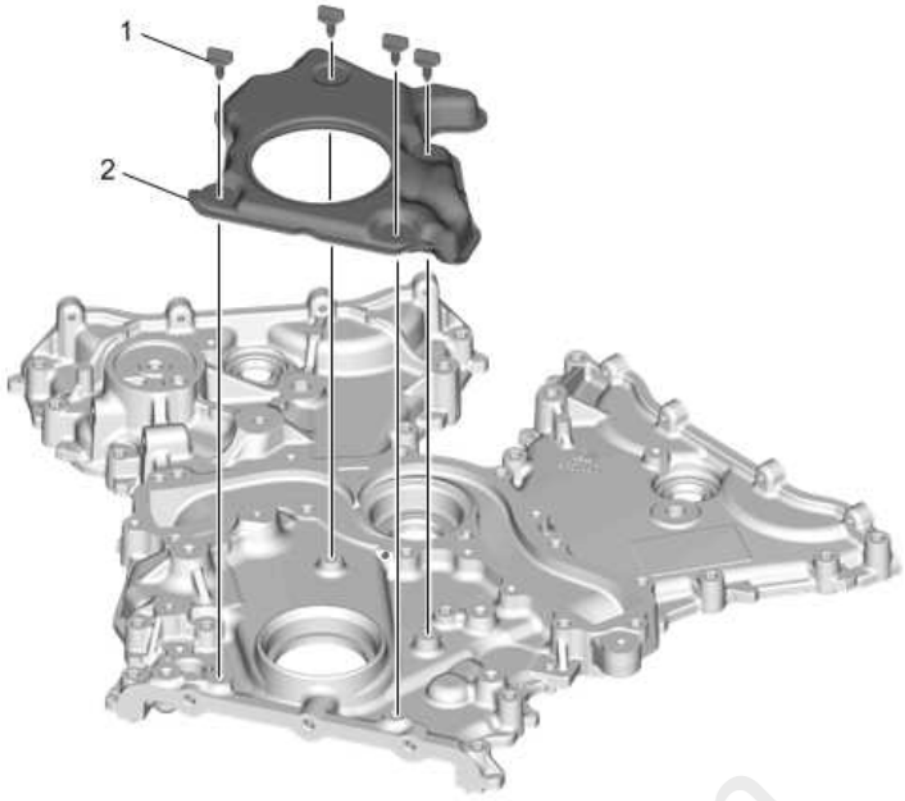


Fig. 212: Engine Front Cover Insulator Assemble
Courtesy of GENERAL MOTORS COMPANY

Engine Front Cover Insulator Assemble

Callout	Component Name
1	Engine Front Cover Insulator
2	Engine Front Cover Retainer [4x]

Crankshaft Front Oil Seal Assemble

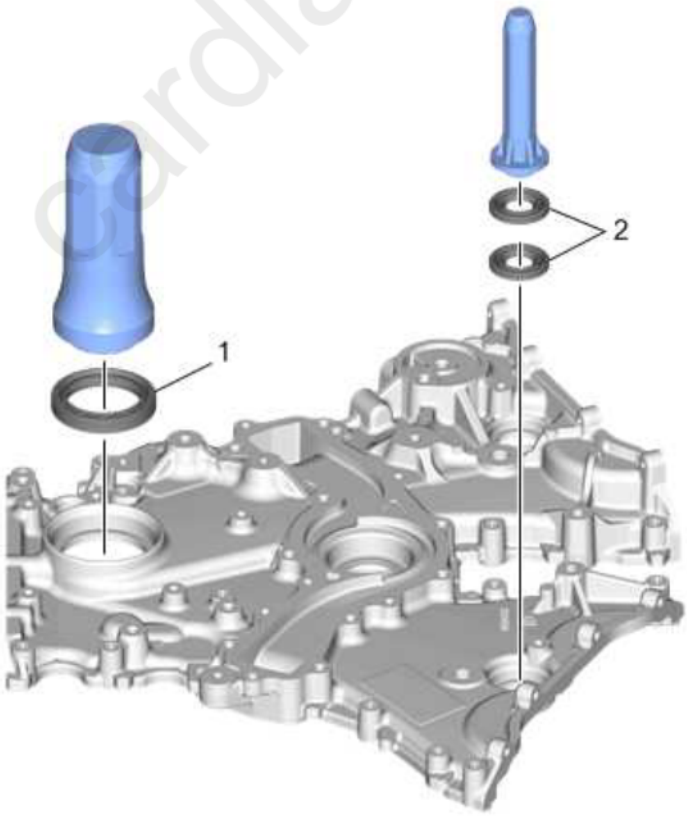


Fig. 213: Crankshaft Front Oil Seal Assemble
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Front Oil Seal Assemble

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Callout	Component Name
1	Crankshaft Front Oil Seal **Special Tools** **EN-29184** Seal Installer For equivalent regional tools, refer to **Special Tools** .
2	Camshaft Position Actuator Control Valve Seal [2x] **Special Tools** **EN-46103** Camshaft Actuator Valve Seal Installer

CAMSHAFT COVER DISASSEMBLE

Left Camshaft Cover

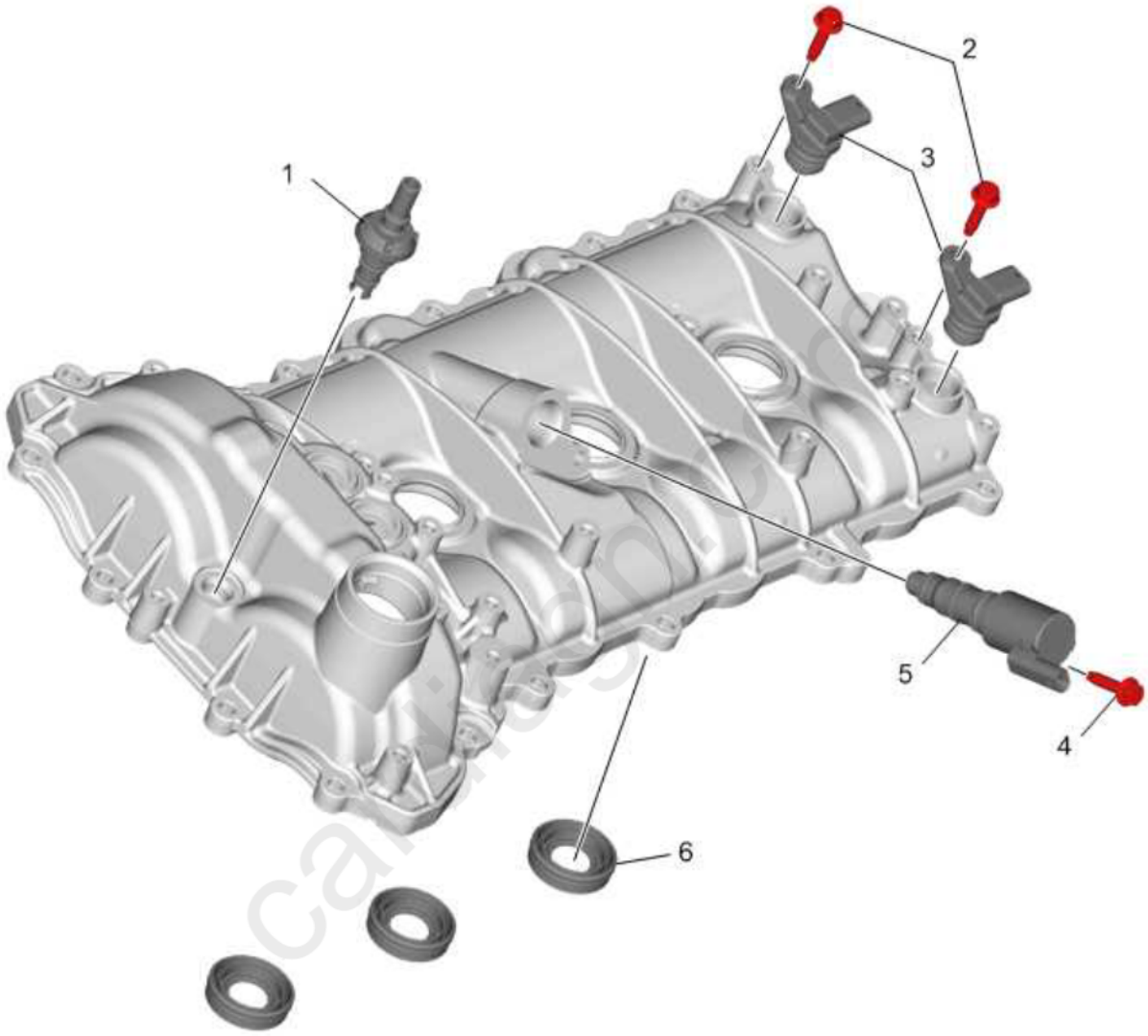


Fig. 214: Left Camshaft Cover
Courtesy of GENERAL MOTORS COMPANY

Left Camshaft Cover

Callout	Component Name
1	Positive Crankcase Ventilation Valve **NOTE:** **These components have tamper-proof connections and cannot be disassembled.**
2	Camshaft Position Sensor Bolt [2x]
3	Camshaft Position Sensor [2x]
4	Valve Rocker Arm Oil Control Valve Bolt
5	Valve Rocker Arm Oil Control Valve

Callout	Component Name
6	Spark Plug Shield Seal **NOTE:** **Remove and DISCARD the seal.**

Right Camshaft Cover

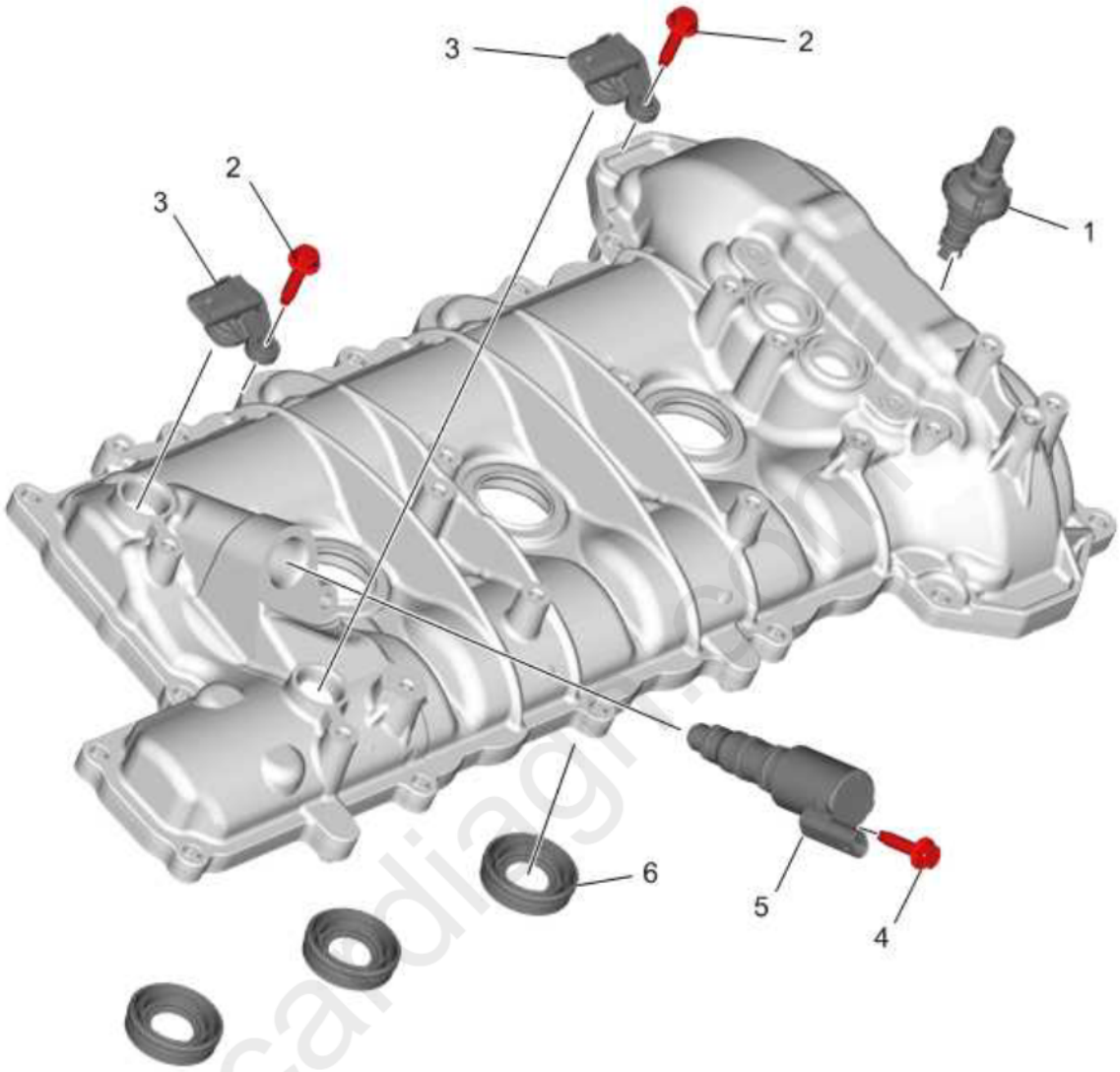


Fig. 215: Right Camshaft Cover
Courtesy of GENERAL MOTORS COMPANY

Right Camshaft Cover

Callout	Component Name
1	Positive Crankcase Ventilation Valve **NOTE:** **These components have tamper-proof connections and cannot be disassembled.**
2	Camshaft Position Sensor Bolt [2x]
3	Camshaft Position Sensor [2x]
4	Valve Rocker Arm Oil Control Valve Bolt
5	Valve Rocker Arm Oil Control Valve

Callout	Component Name
6	Spark Plug Shield Seal **NOTE:** **Remove and DISCARD the seal.**

CAMSHAFT COVER CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the camshaft covers in solvent.
2. Dry the camshaft covers with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Inspection Procedure

1. Inspect each camshaft cover for the dents or damage to the exterior. A dented or damaged camshaft cover may:
   - Leak engine oil
   - Affect crankcase ventilation
   - Interfere with the camshafts
   - Interfere with the ignition coil sealing
   - Allow water or condensation to enter the engine
2. Inspect the exterior of the right camshaft cover for the following conditions:

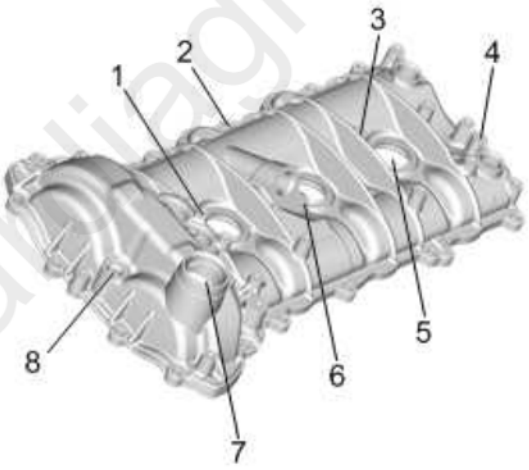


Fig. 216: Camshaft Cover Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage to the camshaft position actuator solenoid valve bolt hole (1).
- Damage to the camshaft cover bolt holes (2)
- Damage to the mounting holes (3) for the ignition coil assembly and fuel injector sight shield ballstud.
- Damage to the camshaft position sensor bolt hole (4).
- Damage to the spark plug shield seal bore (5)
- Damage to the valve rocker arm oil control valve bolt hole (6).
- Damage to the oil fill hole (7)
- Damage to the positive crankcase ventilation (PCV) hose connector (8)-A damaged PCV hose connector is not replaceable.

NOTE: **Not servicable - cam cover must be removed to replace PCV**

check valve. Can't service check valve alone (tangs will break on removal thus leaving foreign material in engine)

3. Inspect the interior of the right camshaft cover for the following conditions:

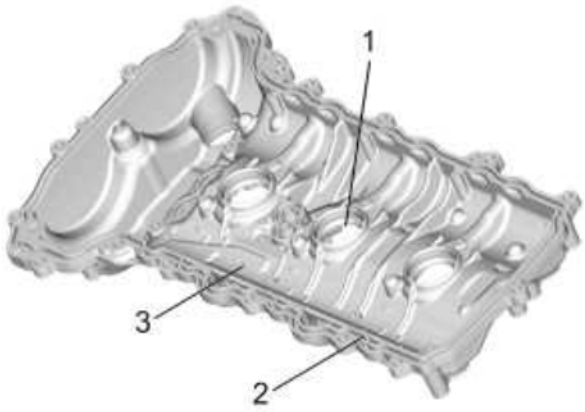


Fig. 217: Camshaft Cover Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Gouges or damage to the spark plug shield seal bore (1)
- Gouges or damage to the camshaft cover sealing groove (2)
- Damaged, loose or missing baffle (3)

4. Inspect the exterior of the left camshaft cover for the following conditions:

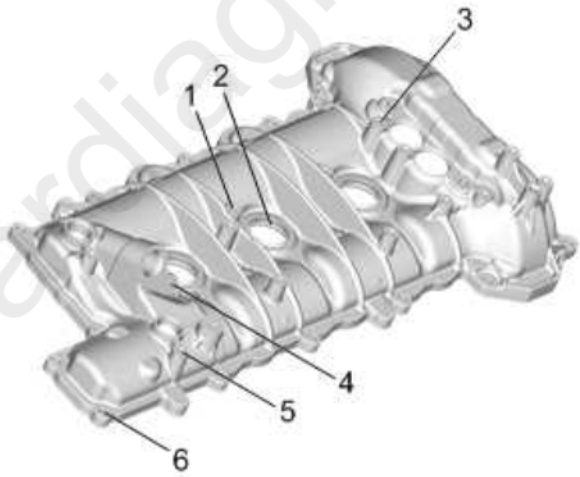


Fig. 218: Camshaft Cover Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage to the mounting holes (1) for the ignition coil assembly
- Gouges or damage to the spark plug shield seal bore (2)
- Damage to the camshaft position actuator solenoid valve bolt hole (3).
- Damage to the valve rocker arm oil control valve bolt hole (4).
- Damage to the camshaft position sensor bolt hole (5).
- Damage to the camshaft cover bolt holes (6)

5. Inspect the interior of the left camshaft cover for the following conditions:

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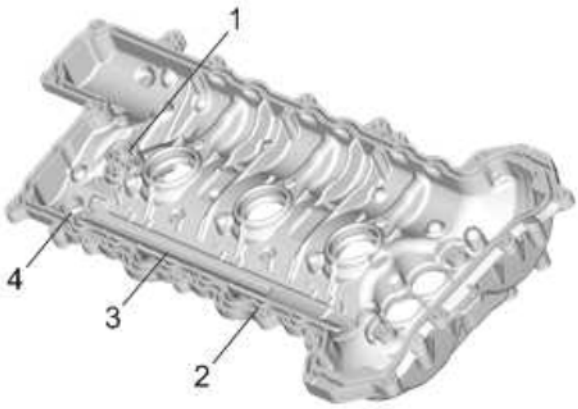


Fig. 219: Camshaft Cover Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Gouges or damage to the spark plug shield seal bore (1)
- Gouges or damage to the camshaft cover sealing groove (2)
- Damaged, loose or missing baffle (3)
- Damage to the positive crankcase ventilation (PCV) hose connector (8)-A damaged PCV hose connector is not replaceable.

NOTE: **Not servicable - cam cover must be removed to replace PCV check valve. Can't service check valve alone (tangs will break on removal thus leaving foreign material in engine)**

6. Repair or replace the camshaft cover or covers as necessary.

CAMSHAFT COVER ASSEMBLE

Left Camshaft Cover

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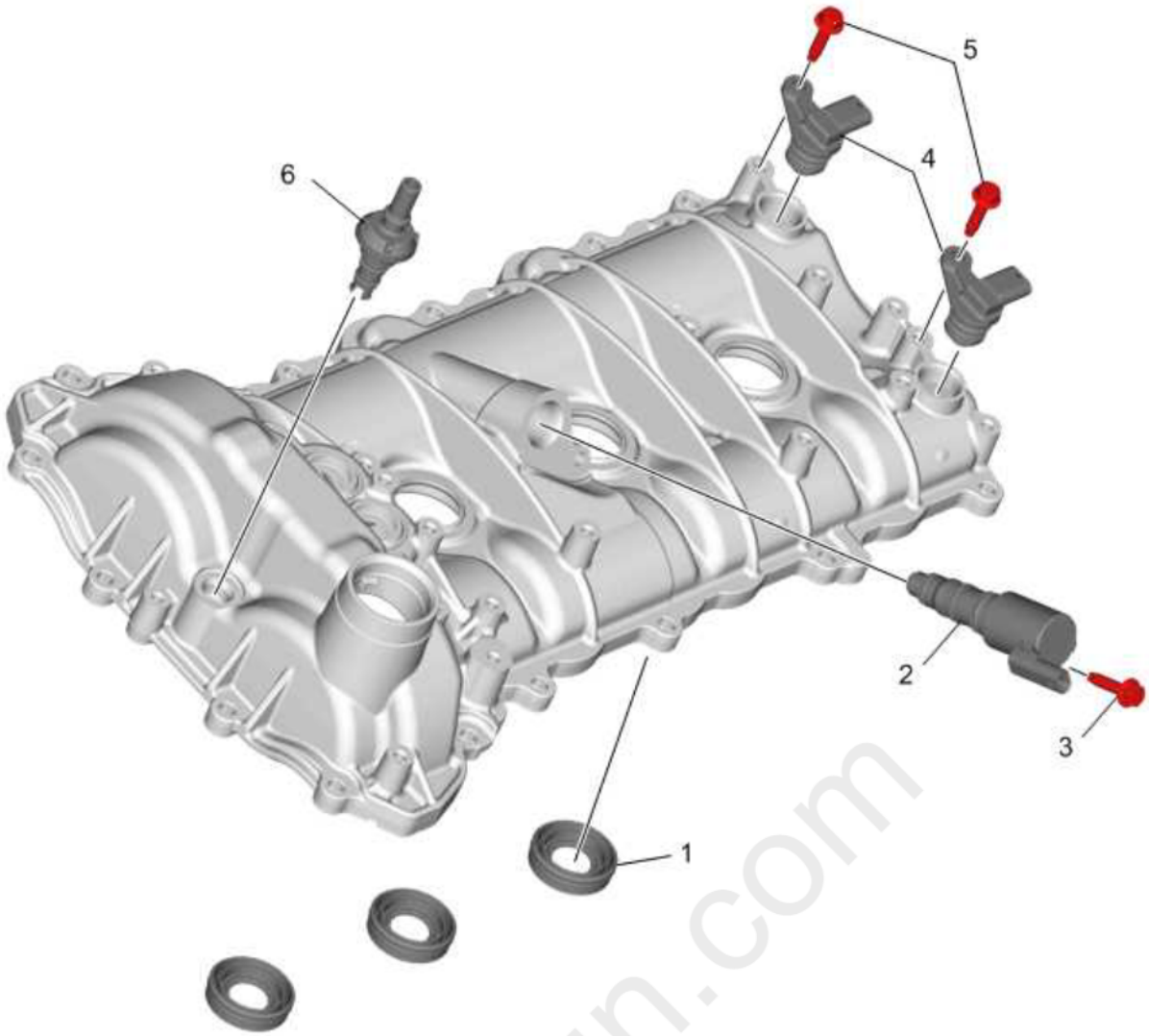


Fig. 220: Left Camshaft Cover
Courtesy of GENERAL MOTORS COMPANY

Left Camshaft Cover

Callout	Component Name
1	Spark Plug Shield Seal **NOTE:** **Install a NEW seal.** **Special Tools** **J-46103** Camshaft Actuator Valve Seal Installer For equivalent regional tools, refer to **Special Tools** .
2	Valve Rocker Arm Oil Control Valve
3	Valve Rocker Arm Oil Control Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
4	Camshaft Position Sensor [2x]
5	Camshaft Position Sensor Bolt [2x] **Tighten** 10 N.m (89 lb in)

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Callout	Component Name
6	Positive Crankcase Ventilation Valve **NOTE:** **These components have tamper-proof connections and cannot be disassembled.**

Right Camshaft Cover

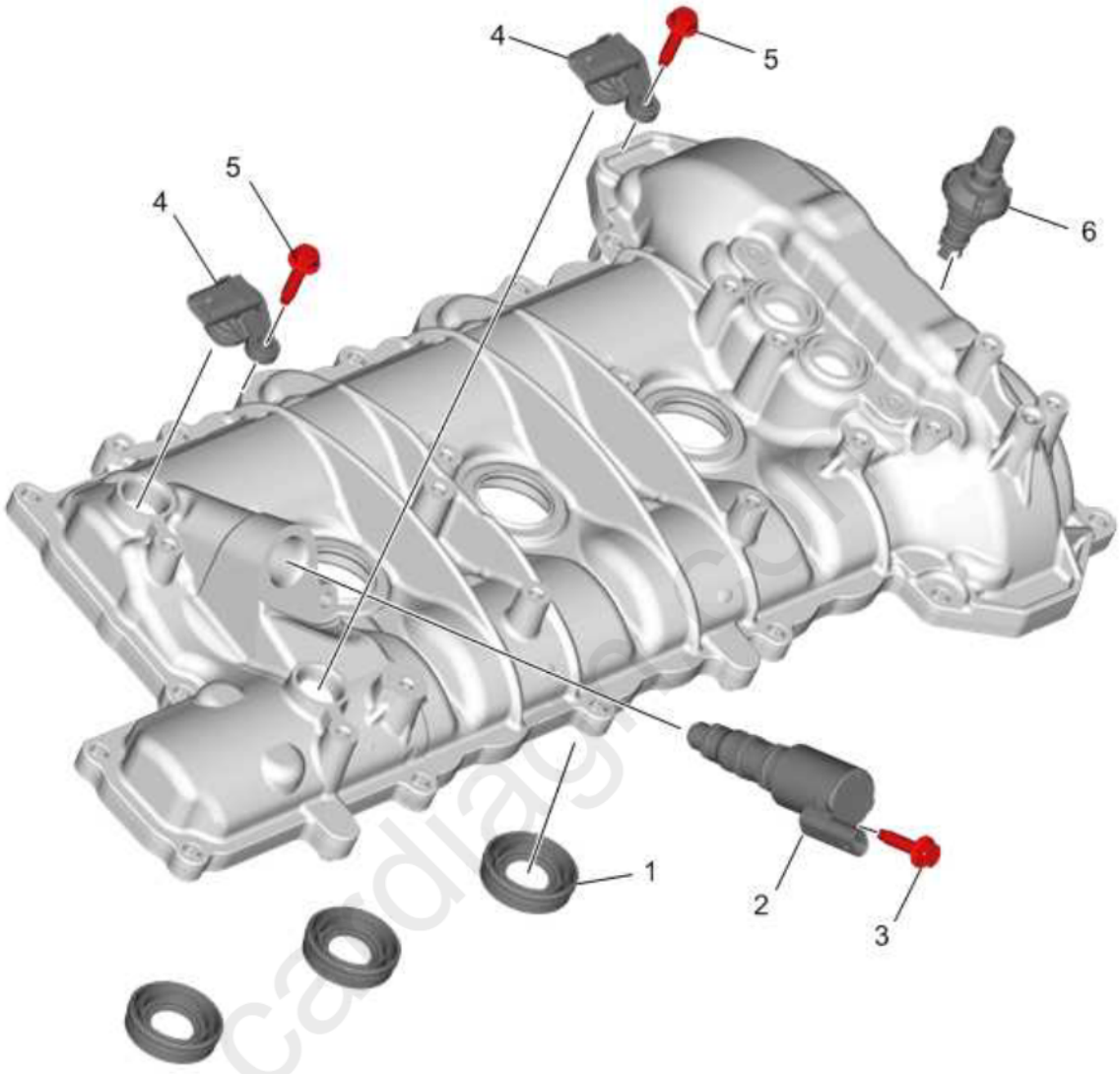


Fig. 221: Right Camshaft Cover
Courtesy of GENERAL MOTORS COMPANY

Right Camshaft Cover

Callout	Component Name
1	Spark Plug Shield Seal **NOTE:** **Install a NEW seal.** **Special Tools** **J-46103** Camshaft Actuator Valve Seal Installer For equivalent regional tools, refer to **Special Tools** .
2	Valve Rocker Arm Oil Control Valve
3	Valve Rocker Arm Oil Control Valve Bolt **Tighten** 10 N.m (89 lb in)
4	Camshaft Position Sensor [2x]

Callout	Component Name
5	Camshaft Position Sensor Bolt [2x] **Tighten** 10 N.m (89 lb in)
6	Positive Crankcase Ventilation Valve **NOTE:** **These components have tamper-proof connections and cannot be disassembled.**

CHARGE AIR COOLER COVER DISASSEMBLE

Insulator and Hose Disassemble

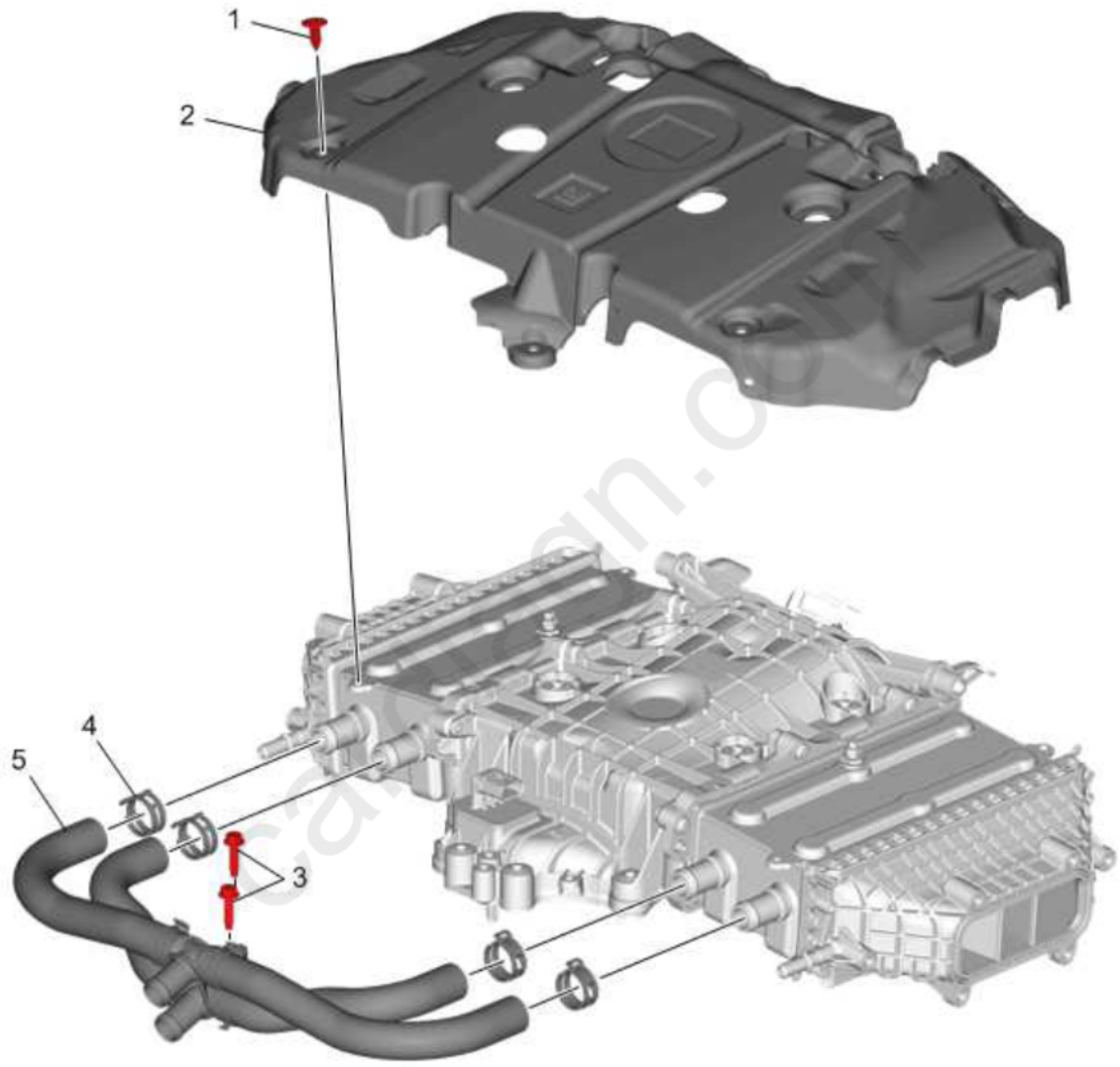


Fig. 222: Insulator and Hose Disassemble
Courtesy of GENERAL MOTORS COMPANY

Insulator and Hose Disassemble

Callout	Component Name
1	Charge Air Cooler Insulator Retainer [6x]
2	Charge Air Cooler Insulator
3	Charge Air Cooler Coolant Manifold Bolt [2x]
4	Charge Air Cooler Coolant Hose Clamp [8x]
5	Charge Air Cooler Coolant Hose

Left Side of Charger Air Cooler Disassemble

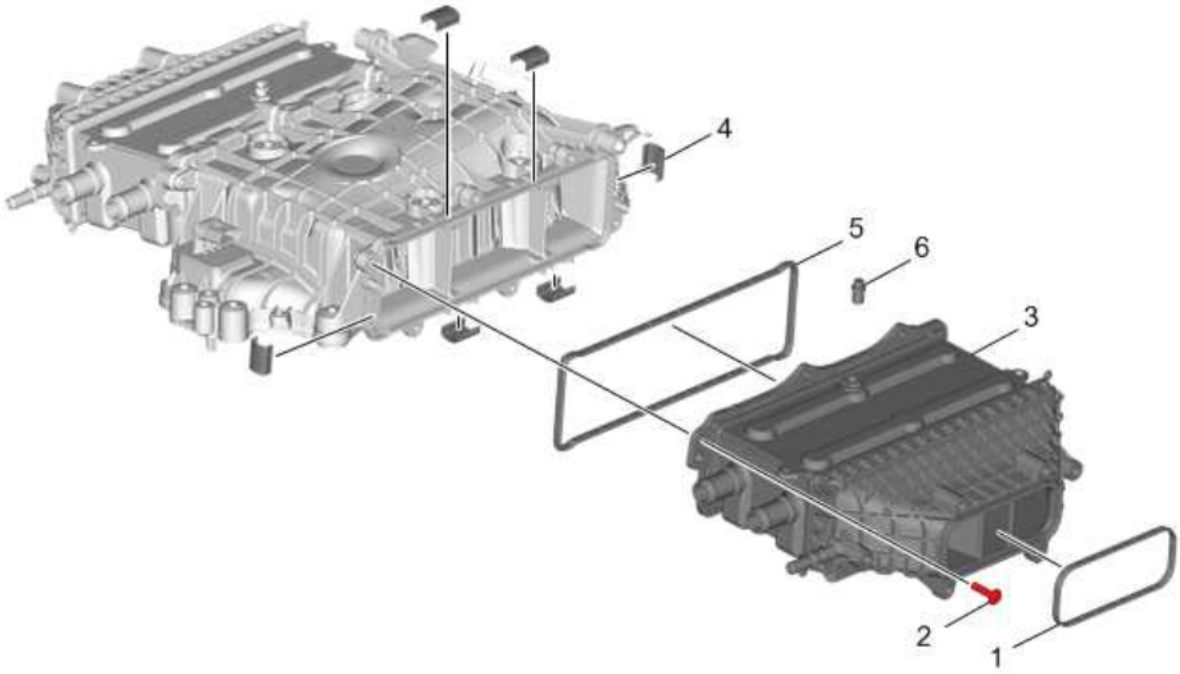


Fig. 223: Left Side of Charger Air Cooler Disassemble
Courtesy of GENERAL MOTORS COMPANY

Left Side of Charger Air Cooler Disassemble

Callout	Component Name
1	Charge Air Cooler Inlet Air Tube Seal
2	Charge Air Cooler Bolt [6x]
3	Charge Air Cooler - Left Side
4	Charge Air Cooler Retainer [6x]
5	Charge Air Cooler Housing Gasket
6	Engine Coolant Air Bleed Valve

Right Side of Charger Air Cooler and Sensors Disassemble

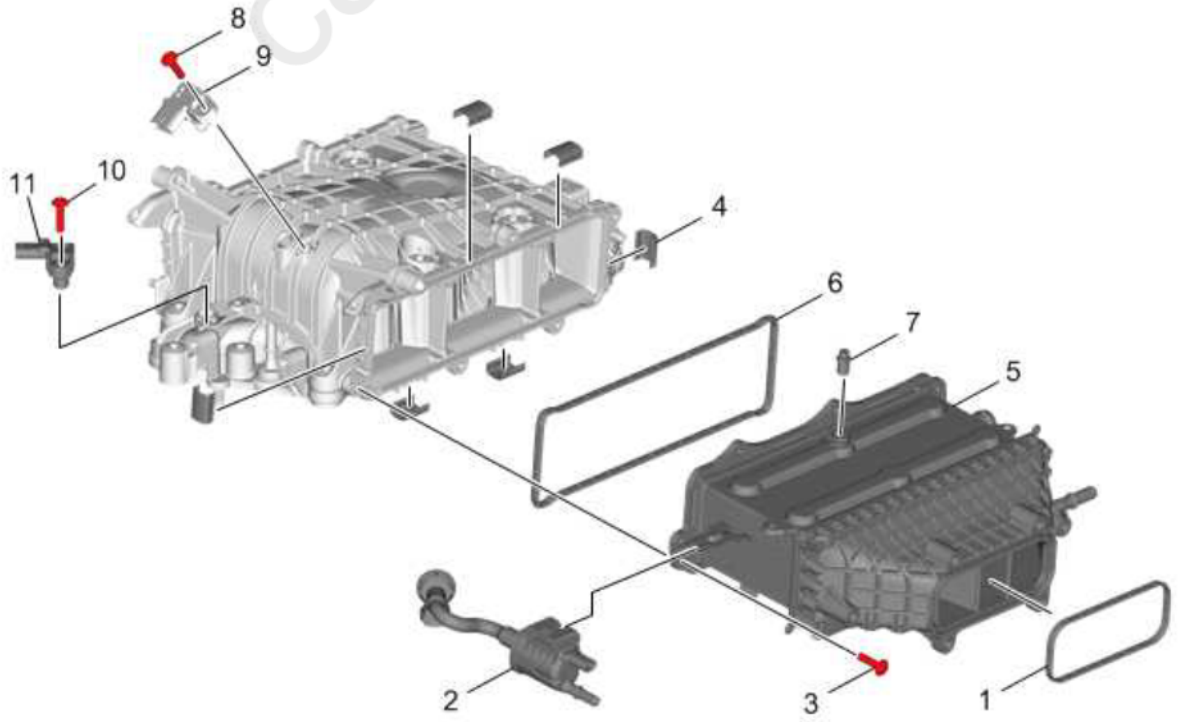


Fig. 224: Right Side of Charger Air Cooler and Sensors Disassemble
Courtesy of GENERAL MOTORS COMPANY

Right Side of Charger Air Cooler and Sensors Disassemble

Callout	Component Name
1	Charge Air Cooler Inlet Air Tube Seal
2	Evaporative Emission Canister
3	Charge Air Cooler Bolt [6x]
4	Charge Air Cooler Retainer [6x]
5	Charge Air Cooler - Right Side
6	Charge Air Cooler Housing Gasket
7	Engine Coolant Air Bleed Valve
8	Charge Air Cooler Bolt
9	Intake Air Pressure and Temperature Sensor
10	Charge Air Cooler Bolt
11	Manifold Absolute Pressure Sensor

Throttle Body and Components Disassemble

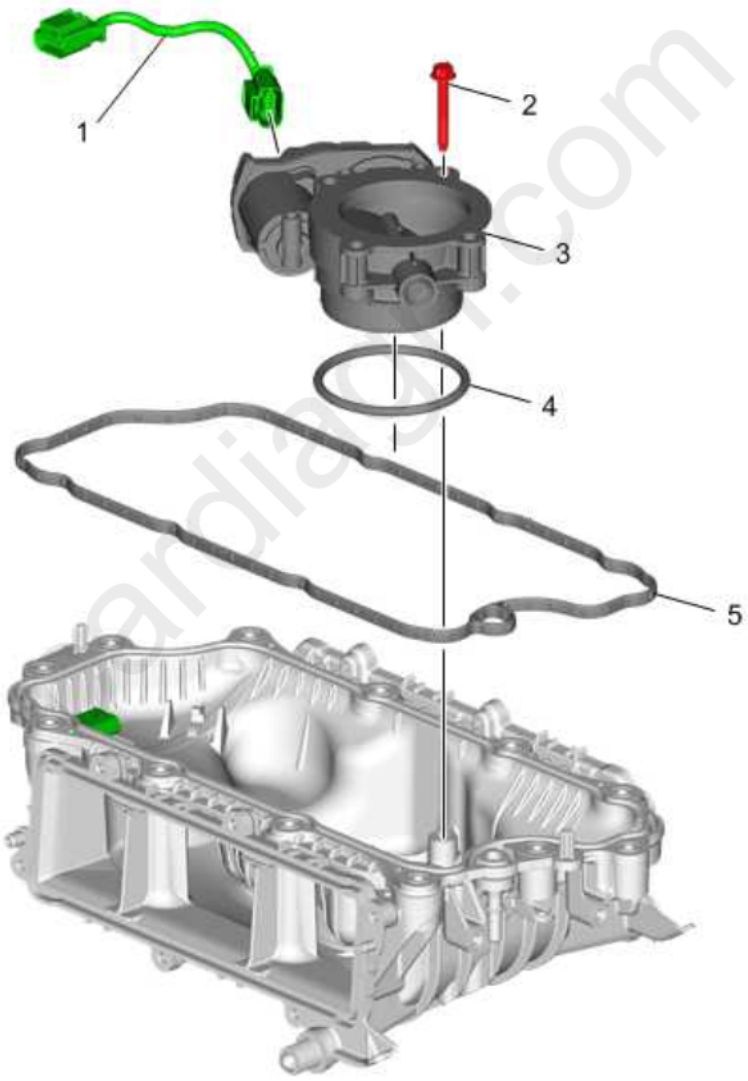


Fig. 225: Throttle Body and Components Disassemble
Courtesy of GENERAL MOTORS COMPANY

Throttle Body and Components Disassemble

Callout	Component Name
1	Throttle Actuator Wire
2	Throttle Body Bolt [4x]
3	Throttle Body
4	Throttle Body Gasket

Callout	Component Name
5	Charge Air Cooler Cover Seal

CHARGE AIR COOLER COVER CLEANING AND INSPECTION

Charger Air Cooler Cover Cleaning Procedure

1. Remove any remaining gasket and/or gasket material from the following:
   - Throttle body mounting surface
   - Intake manifold mounting surface
   - Charger air cooler mounting surfaces
2. Clean the following charge air cooler cover areas in solvent.
   - Charge air cooler cover gasket sealing areas
   - Charge air cooler cover passages
   - Evaporative emission (EVAP) solenoid passage
3. Dry the charge air cooler cover and throttle body with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Charger Air Cooler Cover Inspection Procedure

1. Inspect the charge air cooler cover for the following conditions:

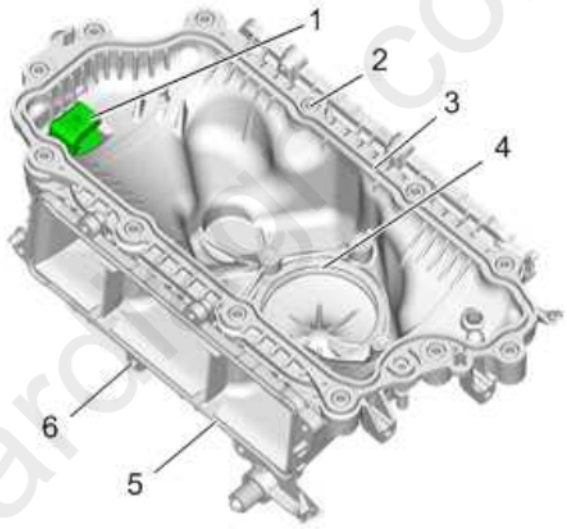


Fig. 226: Charger Air Cooler Cover Inspection Points
Courtesy of GENERAL MOTORS COMPANY

   - Damage to the inside of the connector (1)
   - Damage to the mounting holes to intake manifold (2)
   - Damage to the intake manifold seal surface (3)
   - Damage to the throttle body seal surface (4)
   - Damage to the right side charge air cooler seal surface (5)
   - Damage to the right side charge air cooler mounting holes (6)
2. Inspect the charge air cooler cover for the following conditions:

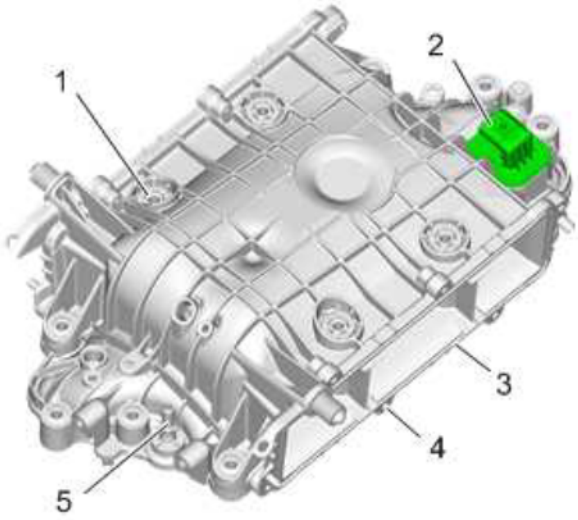


Fig. 227: Charger Air Cooler Cover Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage to the charge air cooler mounting holes (1)
- Damage to the outside of the connector (2)
- Damage to the left side charge air cooler seal surface (3)
- Damage to the left side charge air cooler mounting holes (4)
- Damage to the evaporative emission canister purge connector (5)

3. Inspect the charge air cooler cover sealing surface for warpage.
    1. Locate a straight edge across the lower intake manifold sealing surface.
    2. Insert a feeler gauge between the lower intake manifold and the straight edge. A lower intake manifold with warpage in excess of 0.50 mm (0.020 in) must be replaced.
4. Repair or replace the charge air cooler cover as necessary.

Charger Air Coolers Cleaning Procedure

1. Remove any remaining gaskets or seals.
2. Blow off the charge air coolers with compressed air.

Charger Air Coolers Inspection Procedure

1. Inspect the charge air coolers for the following conditions:

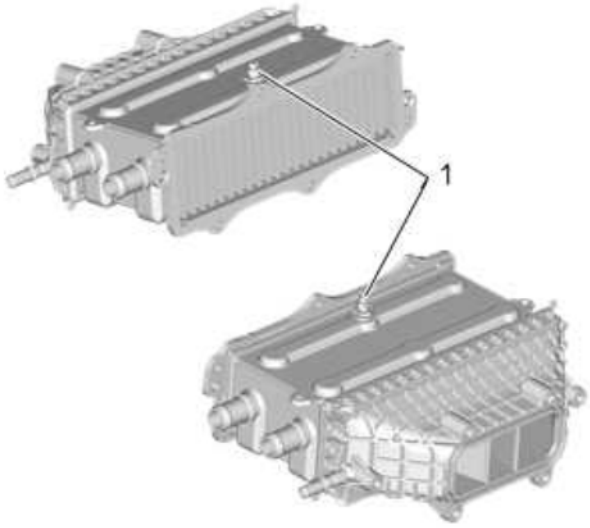


Fig. 228: Charger Air Coolers Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage or loose engine coolant air bleed valves (1)

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2. Inspect the charge air coolers sealing surface for warpage.
    1. Locate a straight edge across the charge air coolers sealing surface.
    2. Insert a feeler gauge between the charge air coolers and the straight edge. A charge air coolers with warpage in excess of 0.50 mm (0.020 in) must be replaced.
3. Repair or replace the charge air coolers as necessary.

CHARGE AIR COOLER COVER ASSEMBLE

Throttle Body and Components Assemble

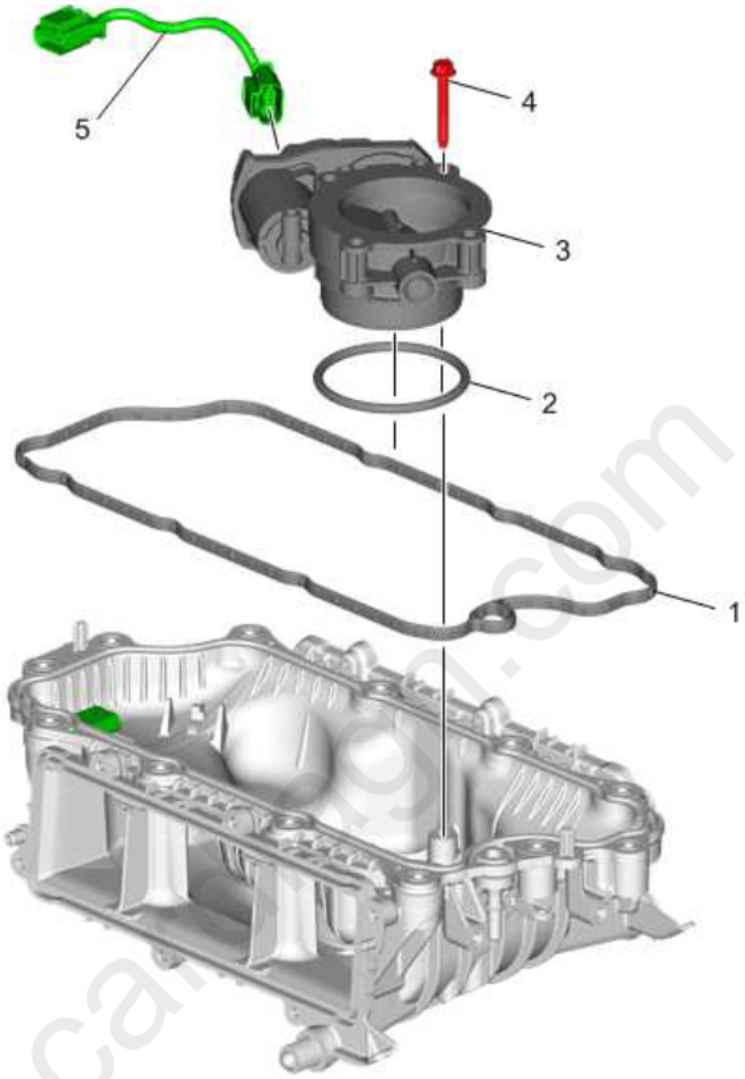


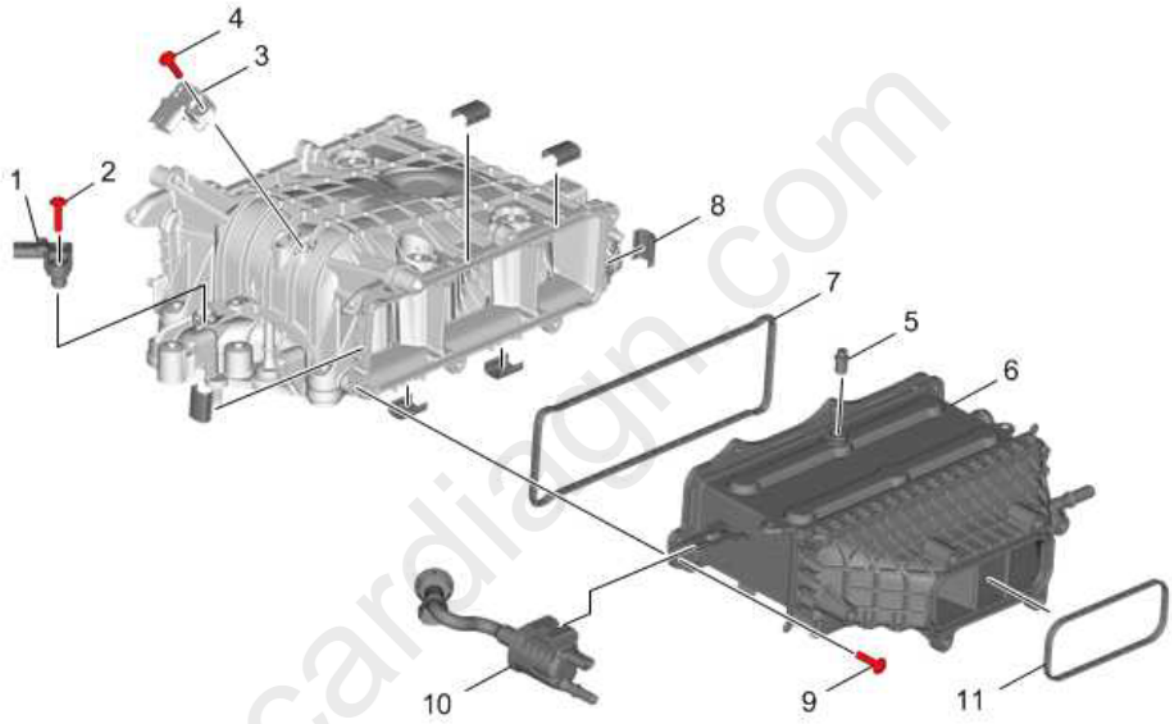
Fig. 229: Throttle Body and Components Assemble
Courtesy of GENERAL MOTORS COMPANY

Throttle Body and Components Assemble

Callout	Component Name
1	Charge Air Cooler Cover Seal **NOTE:** **Install a NEW seal.**
2	Throttle Body Gasket **NOTE:** **Install NEW gasket to the charger air cooler cover groove rather than over the throttle body.**
3	Throttle Body

Callout	Component Name
4	Throttle Body Bolt [4x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
5	Throttle Actuator Wire **NOTE:** **Ensure the throttle actuator wire is clipped into place on the charge air cooler cover.**

Right Side of Charger Air Cooler and Sensors Assemble



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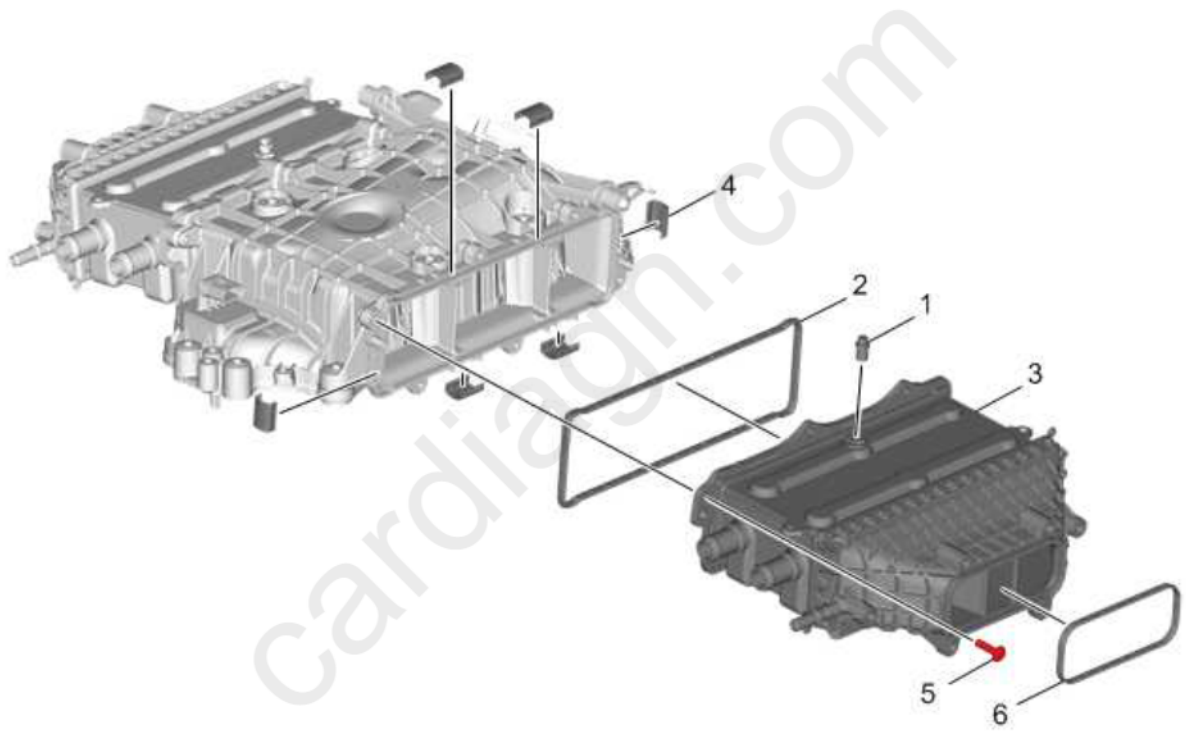
Fig. 230: Right Side of Charger Air Cooler and Sensors Assemble
Courtesy of GENERAL MOTORS COMPANY

Right Side of Charger Air Cooler and Sensors Assemble

Callout	Component Name
1	Manifold Absolute Pressure Sensor
2	Charge Air Cooler Bolt **Tighten** 4 N.m (39 lb in)
3	Intake Air Pressure and Temperature Sensor
4	Charge Air Cooler Bolt **Tighten** 4 N.m (39 lb in)
5	Engine Coolant Air Bleed Valve
6	Charge Air Cooler - Right Side

Callout	Component Name
7	Charge Air Cooler Housing Gasket **NOTE:** **Install a NEW gasket.**
8	Charge Air Cooler Retainer [6x]
9	Charge Air Cooler Bolt [6x] **Tighten** 12 N.m (106 lb in)
10	Evaporative Emission Canister
11	Charge Air Cooler Inlet Air Tube Seal **NOTE:** **Install a NEW seal.**

Left Side of Charger Air Cooler Assemble



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Fig. 231: Left Side of Charger Air Cooler Assemble
Courtesy of GENERAL MOTORS COMPANY

Left Side of Charger Air Cooler Assemble

Callout	Component Name
1	Engine Coolant Air Bleed Valve
2	Charge Air Cooler Housing Gasket **NOTE:** **Install a NEW gasket.**
3	Charge Air Cooler - Left Side
4	Charge Air Cooler Retainer [6x]
5	Charge Air Cooler Bolt [6x] **Tighten** 12 N.m (106 lb in)

Callout	Component Name
6	Charge Air Cooler Inlet Air Tube Seal **NOTE:** **Install a NEW seal.**

Insulator and Hose Assemble

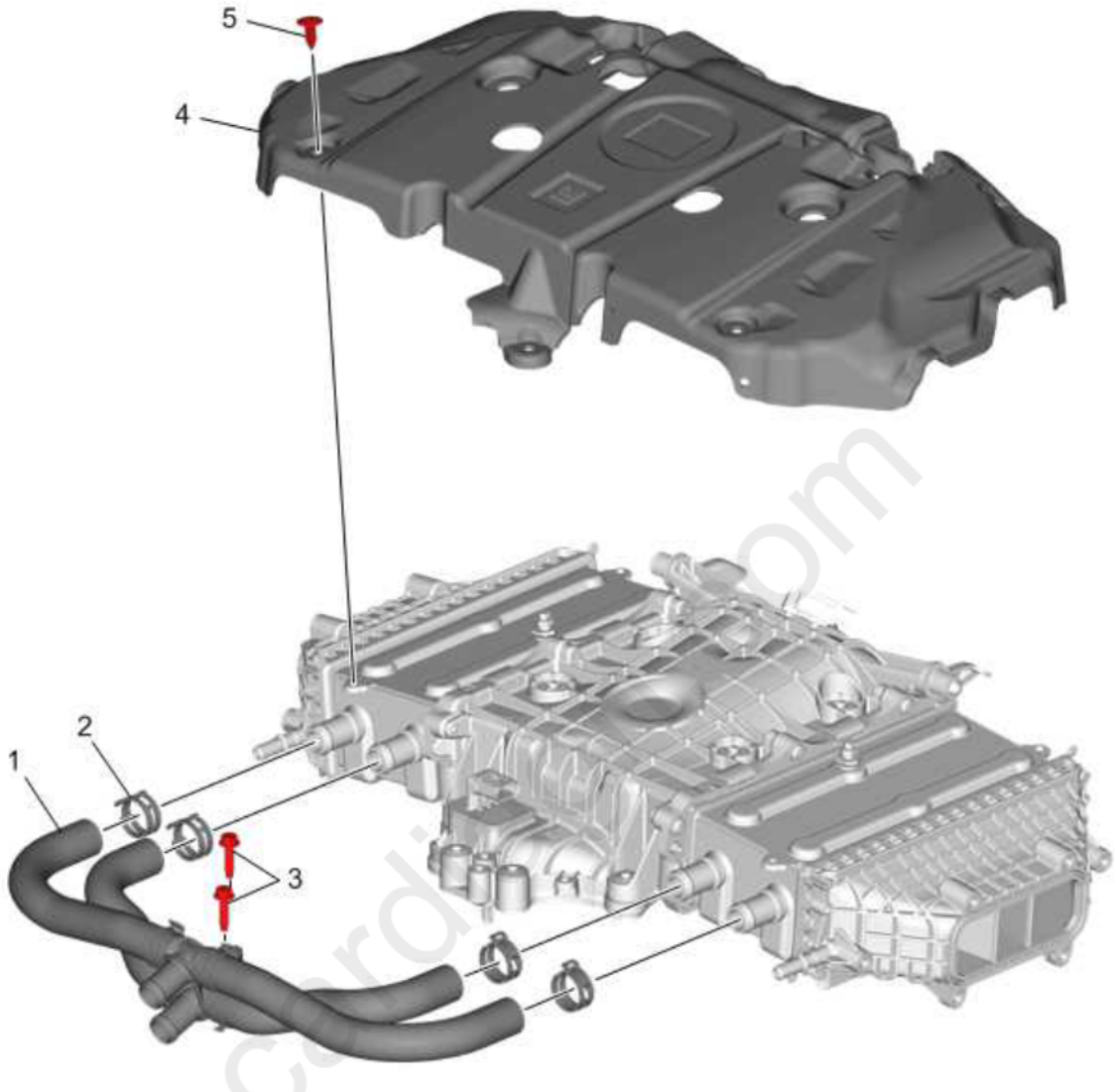


Fig. 232: Insulator and Hose Assemble
Courtesy of GENERAL MOTORS COMPANY

Insulator and Hose Assemble

Callout	Component Name
1	Charge Air Cooler Coolant Hose
2	Charge Air Cooler Coolant Hose Clamp [8x]
3	Charge Air Cooler Coolant Manifold Bolt [2x] **Tighten** 10 N.m (89 lb in)
4	Charge Air Cooler Insulator
5	Charge Air Cooler Insulator Retainer [6x]

INTAKE MANIFOLD DISASSEMBLE (LGX)

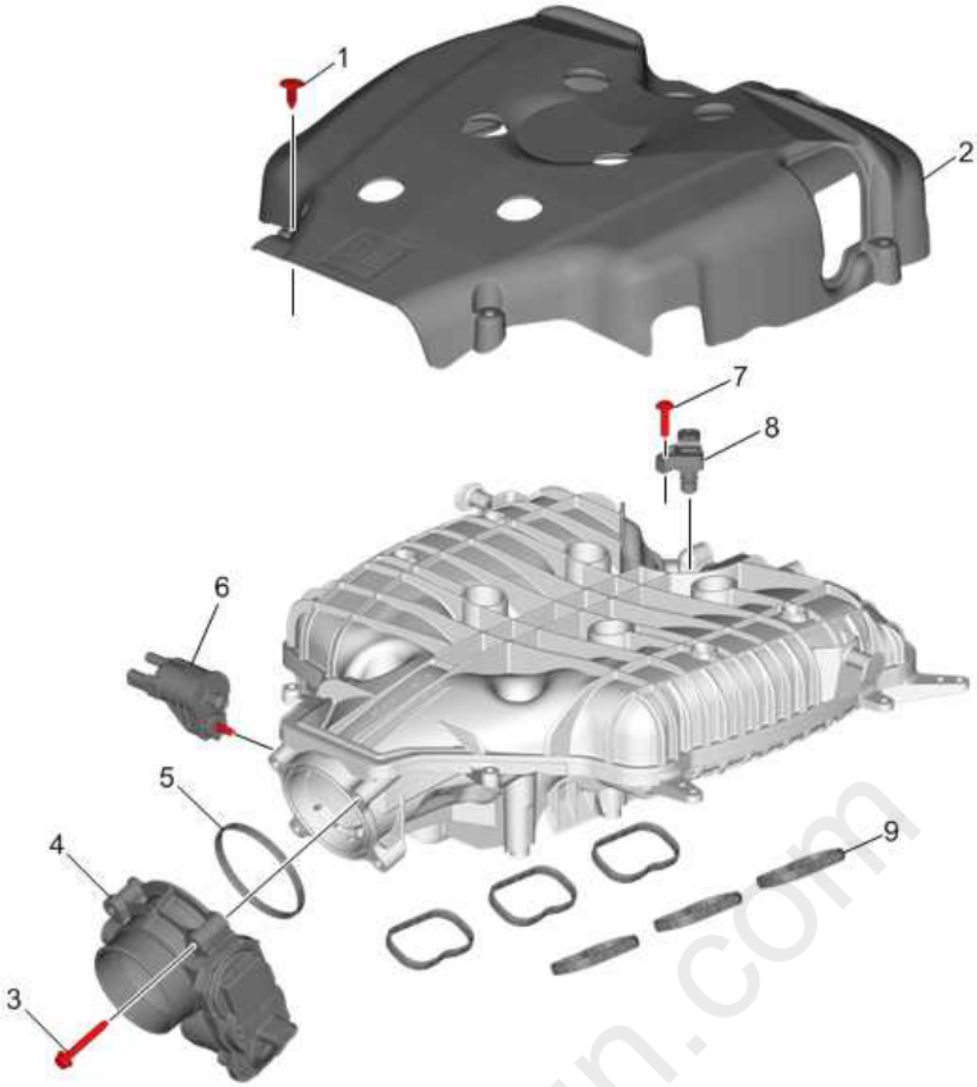


Fig. 233: Intake Manifold Disassemble (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Insulator Retainer [4x]
2	Intake Manifold Insulator
3	Throttle Body Bolt [4x]
4	Throttle Body
5	Throttle Body Gasket **NOTE:** **Remove and DISCARD the gasket.**
6	Evaporative Emission Canister
7	Manifold Absolute Pressure Sensor Bolt
8	Manifold Absolute Pressure Sensor
9	Intake Manifold Seal **NOTE:** **Remove and DISCARD the seal.**

INTAKE MANIFOLD CLEANING AND INSPECTION (LGX)

Intake Manifold Cleaning Procedure

1. Remove any remaining gasket and/or gasket material from the following:
   - Throttle body

- Intake manifold

2. Clean the following intake manifold areas in solvent.
    - Intake manifold gasket sealing areas
    - Intake manifold passages
    - Brake booster hose passage
    - Evaporative emission (EVAP) solenoid passage
    - Positive crankcase ventilation (PCV) vacuum hose passages
3. Dry the intake manifold and throttle body with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Inspection Procedure

1. Inspect the intake manifold for the following conditions:

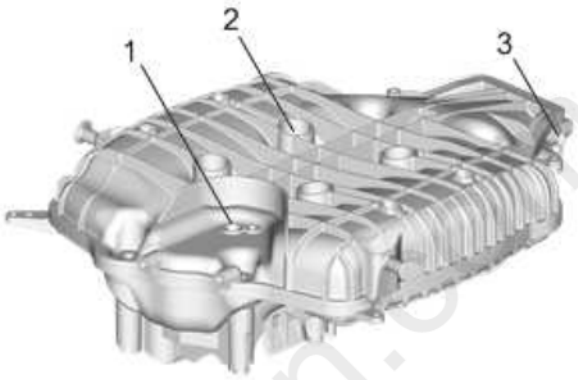


Fig. 234: Intake Manifold Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage, debris or restrictions to the MAP sensor hole (1)
- Damage to the intake manifold bolt holes (2)
- Damage, debris or restrictions to the (EVAP) (3)

2. Inspect the lower intake manifold for the following conditions:

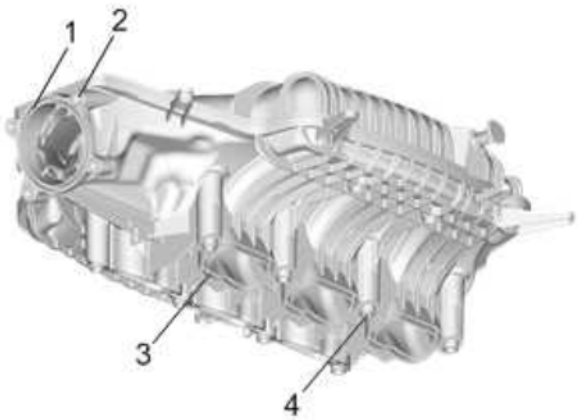


Fig. 235: Lower Intake Manifold Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage to the throttle body sealing surface (1)

- Damage, debris or restrictions to the throttle body hole (2)
- Gouges or damage to the intake manifold sealing surfaces (3)
- Damage to the intake manifold tube (4)

3. Inspect the lower intake manifold sealing surface for warpage.
    1. Locate a straight edge across the lower intake manifold sealing surface.
    2. Insert a feeler gauge between the lower intake manifold and the straight edge. An lower intake manifold with warpage in excess of 0.50 mm (0.020 in) must be replaced.
4. Repair or replace the intake manifold as necessary.

INTAKE MANIFOLD CLEANING AND INSPECTION (LGW)

Intake Manifold Cleaning Procedure

1. Remove any remaining gasket and/or gasket material from the following:
    - Throttle body
    - Intake manifold
2. Clean the following intake manifold areas in solvent.
    - Intake manifold gasket sealing areas
    - Intake manifold passages
    - Brake booster hose passage
    - Evaporative emission (EVAP) solenoid passage
    - Positive crankcase ventilation (PCV) vacuum hose passages
3. Dry the intake manifold and throttle body with compressed air.

WARNING: **Refer to Safety Glasses Warning .**

Inspection Procedure

1. Inspect the intake manifold for the following conditions:

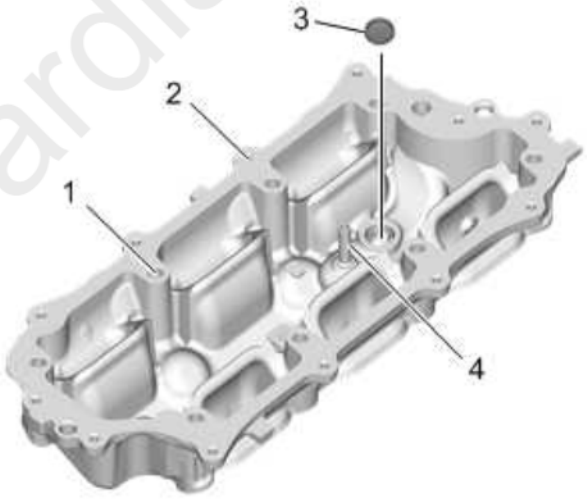


Fig. 236: Intake Manifold Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage to the intake manifold bolt holes (1)
- Damage to the charge air cooler bolt holes (2)
- Damage to the intake manifold core hole plug (3)
- Damage to the intake manifold tube (4)

2. Inspect the lower intake manifold for the following conditions:

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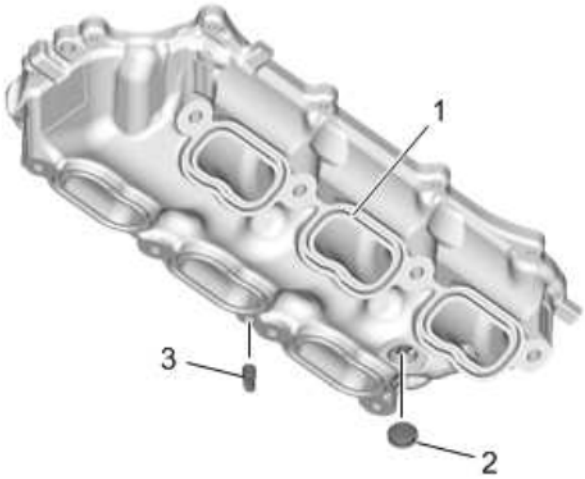


Fig. 237: Lower Intake Manifold Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Gouges or damage to the intake manifold sealing surfaces (1)
- Damage to the intake manifold core hole plug (2)
- Damage to the intake manifold locating pin (3)

3. Inspect the lower intake manifold sealing surface for warpage.
    1. Locate a straight edge across the lower intake manifold sealing surface.
    2. Insert a feeler gauge between the lower intake manifold and the straight edge. An lower intake manifold with warpage in excess of 0.50 mm (0.020 in) must be replaced.
4. Repair or replace the intake manifold as necessary.

INTAKE MANIFOLD ASSEMBLE (LGX)

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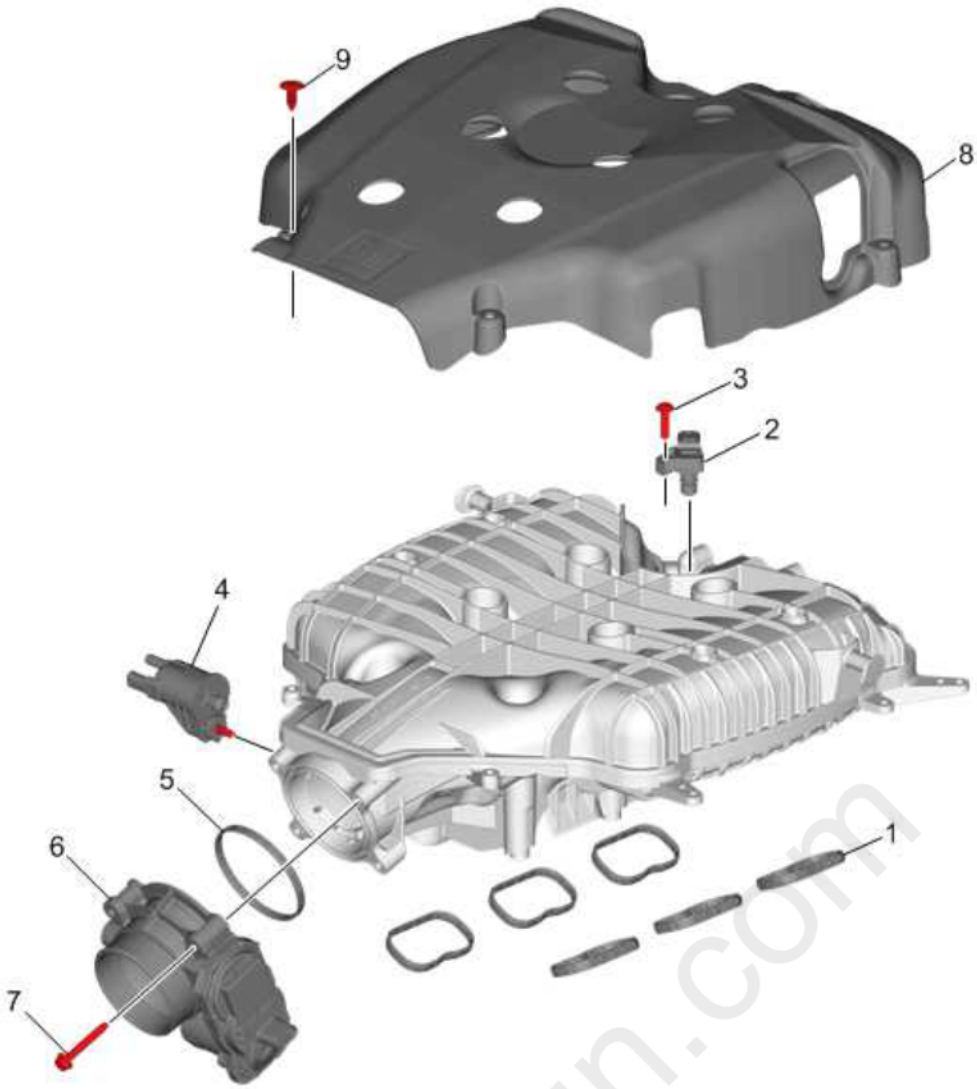


Fig. 238: Intake Manifold Assemble (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Seal **NOTE:** **Install a NEW seal.**
2	Manifold Absolute Pressure Sensor
3	Manifold Absolute Pressure Sensor Bolt **CAUTION:** **Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Do not use paints, lubricants or corrosion inhibitors on fasteners or fastener joint surfaces, unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems. When using fasteners that are threaded directly into plastic, use extreme care not to strip the mating plastic part(s). Use hand tools only and do not use any kind of impact or power tools. Fastener should be hand tightened, fully seated and not stripped.** **Tighten** 4 N.m (35 lb in)

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Callout	Component Name
4	Evaporative Emission Canister **Tighten** 10 N.m (89 lb in)
5	Throttle Body Gasket **NOTE:** **Install a NEW gasket.**
6	Throttle Body
7	Throttle Body Bolt [4x] **Tighten** 10 N.m (89 lb in)
8	Intake Manifold Insulator
9	Intake Manifold Insulator Retainer [4x]

CAMSHAFT CARRIER DISASSEMBLE

1. Inspect the camshaft position actuator oil feed check valves (1). Damaged, restricted or clogged check valves must be replaced. If check valves require replacement, proceed to step 2.

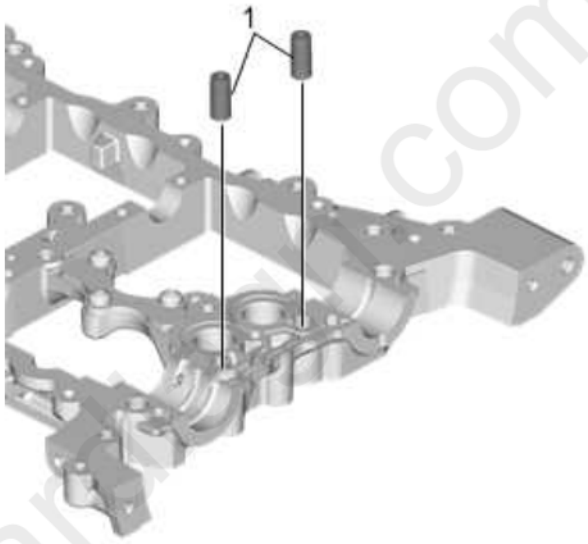


Fig. 239: Camshaft Position Actuator Oil Feed Check Valves
Courtesy of GENERAL MOTORS COMPANY

2. Flip over and push out from the bottom side.
3. Clean check valve bore and related passages thoroughly to remove any debris.

CAMSHAFT CARRIER CLEANING AND INSPECTION

Special Tools

EN-28410 Gasket Remover

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

Cleaning Procedure

1. Remove any old thread sealant, gasket material or RTV sealant using **EN-28410** remover.
2. Clean the camshaft carriers using a non corrosive solvent.
3. Clean out debris from the bolt holes.
4. Dry the camshaft carriers with compressed air.

WARNING: Refer to **Safety Glasses Warning** .

Inspection Procedure Right Camshaft Carrier

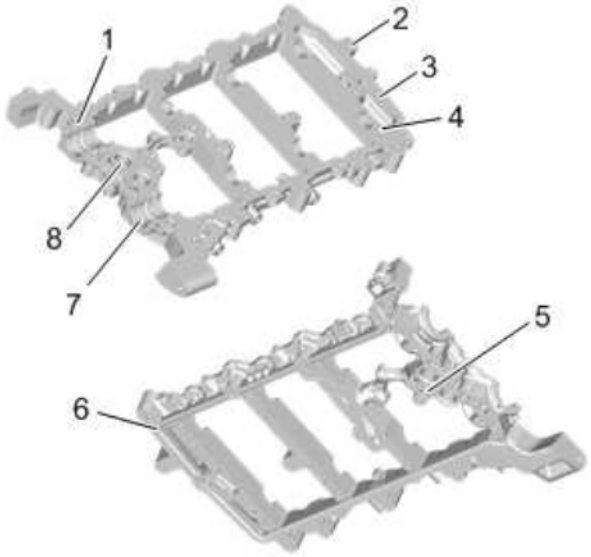


Fig. 240: Camshaft Carrier Conditions
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the camshaft carrier for the following conditions:
    - Damage to the camshaft bearing cap bolt holes (1)
    - Damage to the camshaft carrier bolt holes (2)
    - Damage to the top sealing surface (3)
    - Damage to the camshaft bearing cap bolt holes (4)
    - Damage to the engine oil manifold check valve mounting areas (5)
    - Damage to the bottom sealing surface (6)
    - Damage to the camshafts mounting surface areas (7)
    - Damage to the camshaft position actuator solenoid valve holes (8)
2. Repair or replace the camshaft carrier as necessary.

Inspection Procedure Left Camshaft Carrier

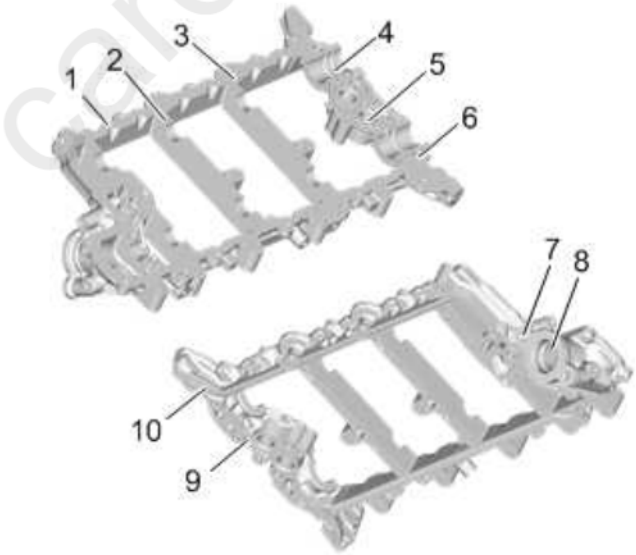


Fig. 241: Camshaft Carrier Conditions
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the camshaft carrier for the following conditions:
    - Damage to the top sealing surface (1)
    - Damage to the camshaft bearing cap bolt holes (2)
    - Damage to the camshaft carrier bolt holes (3)
    - Damage to the camshafts mounting surface areas (4)

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- Damage to the camshaft position actuator solenoid valve holes (5)
- Damage to the camshaft bearing cap bolt holes (6)
- Damage to the fuel pump bolt holes (7)
- Damage to the fuel pump mounting surface and the valve lifter follower area (8)
- Damage to the engine oil manifold check valve mounting areas (9)
- Damage to the bottom sealing surface (10)

2. Repair or replace the camshaft carrier as necessary.

CAMSHAFT CARRIER ASSEMBLE

Special Tools

EN-46122 Camshaft Position Actuator Check-Ball Valve Remover/Installer

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

1. Use lubricant included with **EN-46122** remover/installer to lubricate outside of new check valve (1).

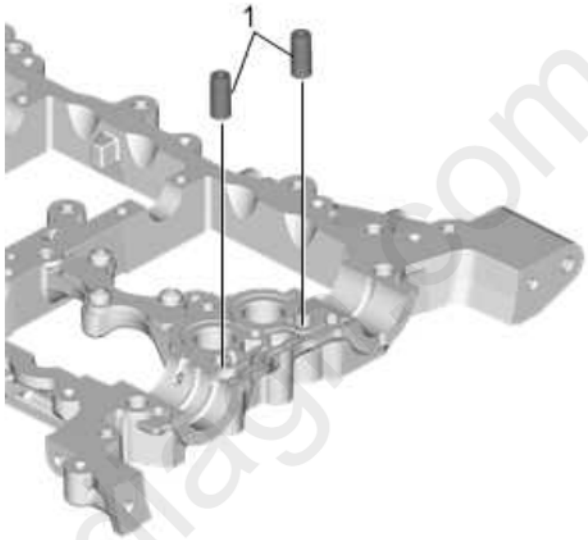


Fig. 242: Camshaft Position Actuator Oil Feed Check Valves
Courtesy of GENERAL MOTORS COMPANY

2. With the check ball end of the check valve facing UP, away from the head, insert the NEW check valve into the check valve bore in the cylinder head.
3. Place collar **EN-46122-2** (1) over the new check valve with the slightly-larger inside diameter of the collar DOWN toward the cylinder head.

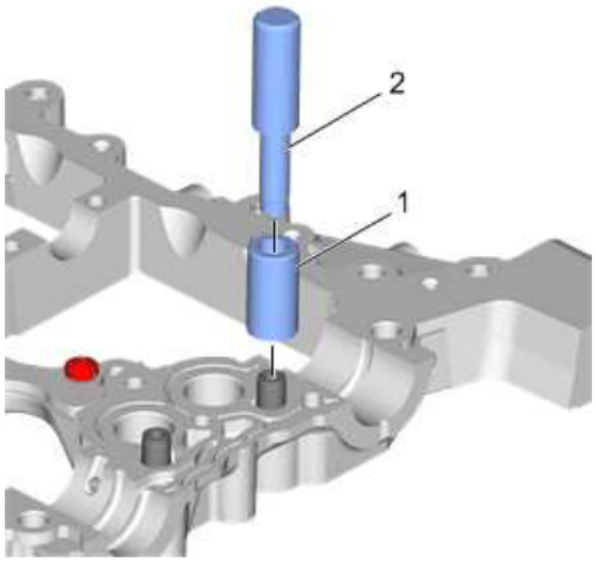


Fig. 243: Installing Camshaft Carrier Check Valves
Courtesy of GENERAL MOTORS COMPANY

4. Using the driver **EN-46122-1** (2), lightly tap the new check valve into place until the driver stops against the top of the collar.
5. Inspect the camshaft position actuator oil feed check valves in order to ensure they are properly installed in the cylinder head. The camshaft position actuator oil feed check valve should be flush to.75 mm (0.0295 in) below the cylinder head deck surface (a).

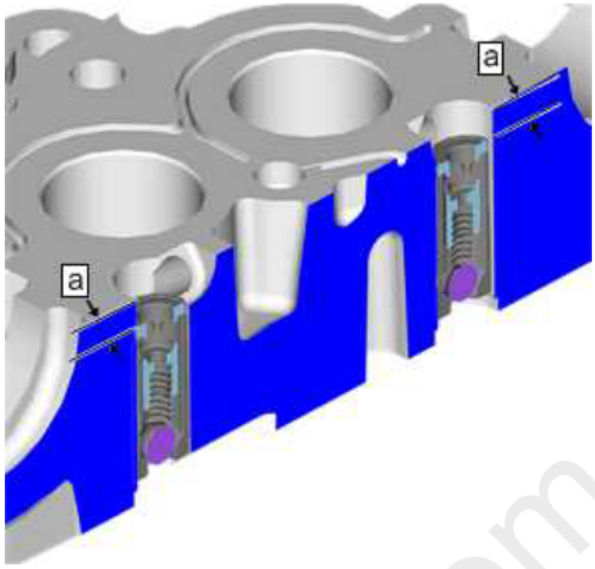


Fig. 244: Camshaft Position Actuator Oil Feed Check Valve Installed Depth
Courtesy of GENERAL MOTORS COMPANY

WATER PUMP CLEANING AND INSPECTION

Cleaning Procedure

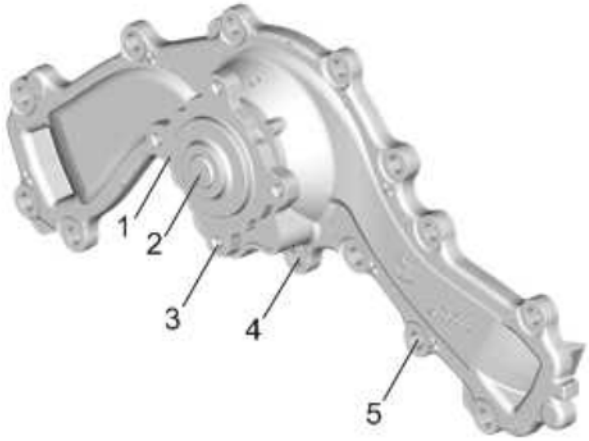
1. Remove the old gasket material from the water pump sealing surfaces.

CAUTION: **Do not immerse the water pump in solvent. The solvent may enter the water pump's permanently lubricated bearings and cause premature bearing failure.**

2. Clean all excess dirt and debris from the water pump housing.

Inspection Procedure

1. Rotate the water pump hub (2). The water pump hub and impeller should turn straight and smoothly. If the hub wobbles, is noisy or feels rough when rotated, replace the water pump.



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Fig. 245: Water Pump Hub
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the exterior of the water pump for the following:
    - Damage to the water pump hub mating surface (1) for the water pump pulley
    - Damage to the water pump hub bolt threads (3) for the water pump pulley
    - Damage to the water pump axy rads (4)
    - Damage to the water pump bolt holes (5)
3. Inspect the interior of the water pump for the following:

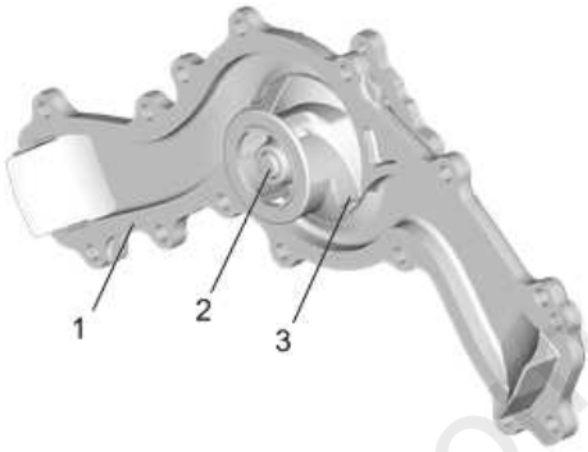


Fig. 246: Water Pump Inspection Points
Courtesy of GENERAL MOTORS COMPANY

- Damage to the water pump gasket sealing surface (1)
- Damage, corrosion or restrictions to the water pump impeller (2)
- Damage, corrosion or restrictions to the coolant passages (3)

4. Repair or replace the water pump as necessary.

TURBOCHARGER CLEANING AND INSPECTION

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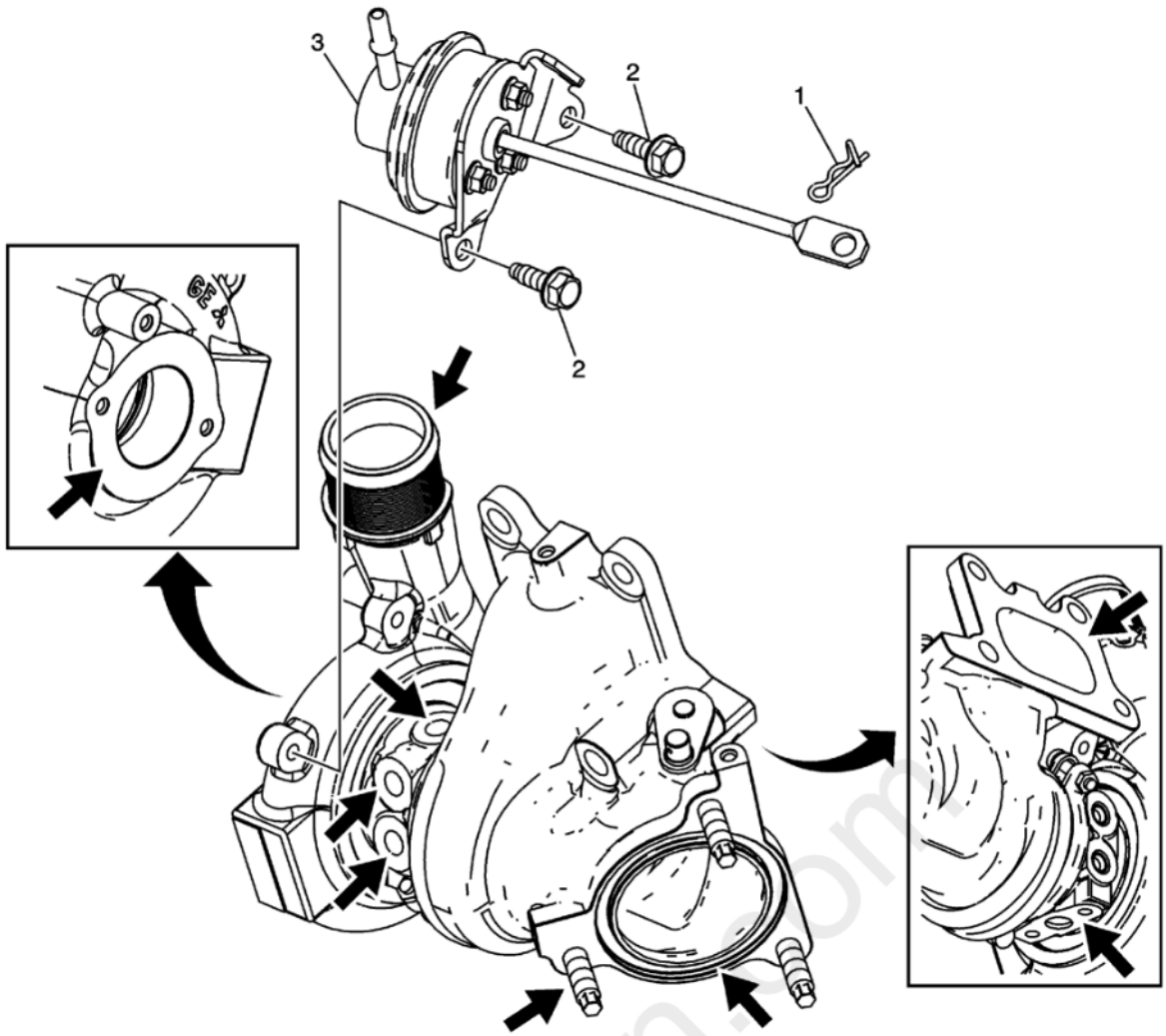


Fig. 247: Turbocharger
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Preliminary Procedures

1. Completely inspect the turbocharger and all other engine components that may cause similar conditions before replacing the turbocharger. Refer to **Symptoms - Engine Mechanical** .

   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.

2. Clean all mating surfaces.
3. Inspect all threaded holes for damage.
4. Inspect the compressor and turbine blades for bent or broken conditions and foreign material. PCV fluids and combustion product buildup are common and not a sign of failure. Replace the turbocharger if damage is found.
5. Check the oil feed pipe for restrictions.
6. Check the oil return pipe for restrictions.
7. Replace the pipe if restrictions are found

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Callout	Component Name
1	Turbocharger Wastegate Actuator Arm Retainer **NOTE:** **Remove and discard retainer. Install NEW.**
2	Turbocharger Wastegate Actuator Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 8 N.m (71 lb in)
3	Turbocharger Wastegate Actuator **NOTE:** **Inspect the wastegate actuator rod for damage or tampering. Replace the wastegate actuator if damage is found.**

THREAD REPAIR

Special Tools

- **EN-42385-70** Head Bolt Thread Repair Fixture
- **EN-42385-700** High Feature Thread Repair Kit
- **EN-42385-2000** Thread Insert Kit
- **EN-43965** Thread Repair Extension Kit

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

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert. During the insert installation process, the installation driver tool cold-rolls the bottom internal threads and expands the bottom external threads of the insert into the base material. This action mechanically locks the insert into place.

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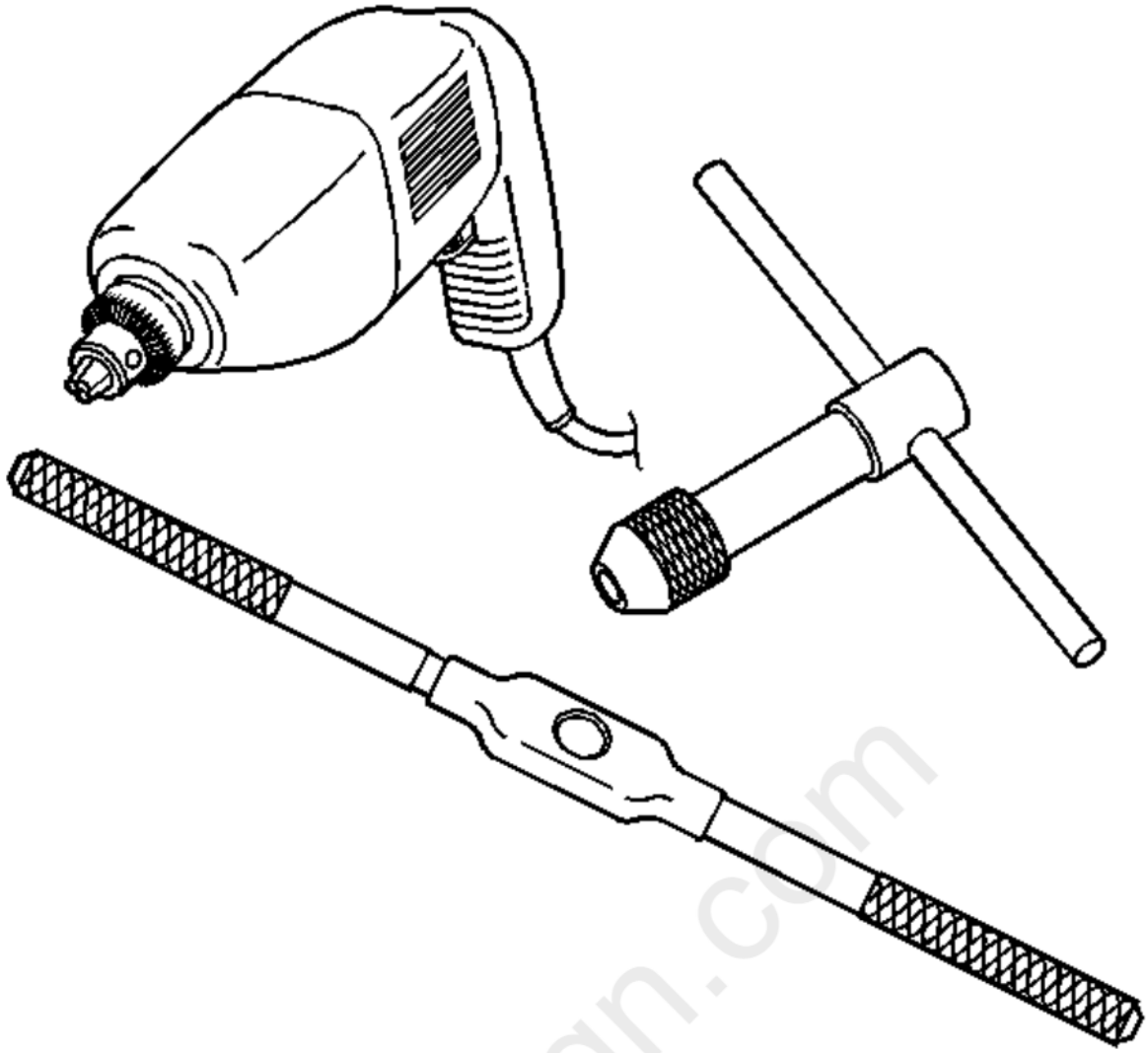


Fig. 248: View Of J 42385-400 Tool Kit
Courtesy of GENERAL MOTORS COMPANY

The drill bit and counter bore tool from the tool kit **EN-42385-700** kit and **EN-42385-2000** insert kit is designed for use with either a suitable tap wrench or drill motor. Limited access and larger hole repair may process better using a tap wrench. An extension from kit **EN-43965** extension kit may also be necessary to drive the thread repair tooling dependent on access to the hole being repaired. Use only a tap wrench when tapping the hole and during installation of the insert.

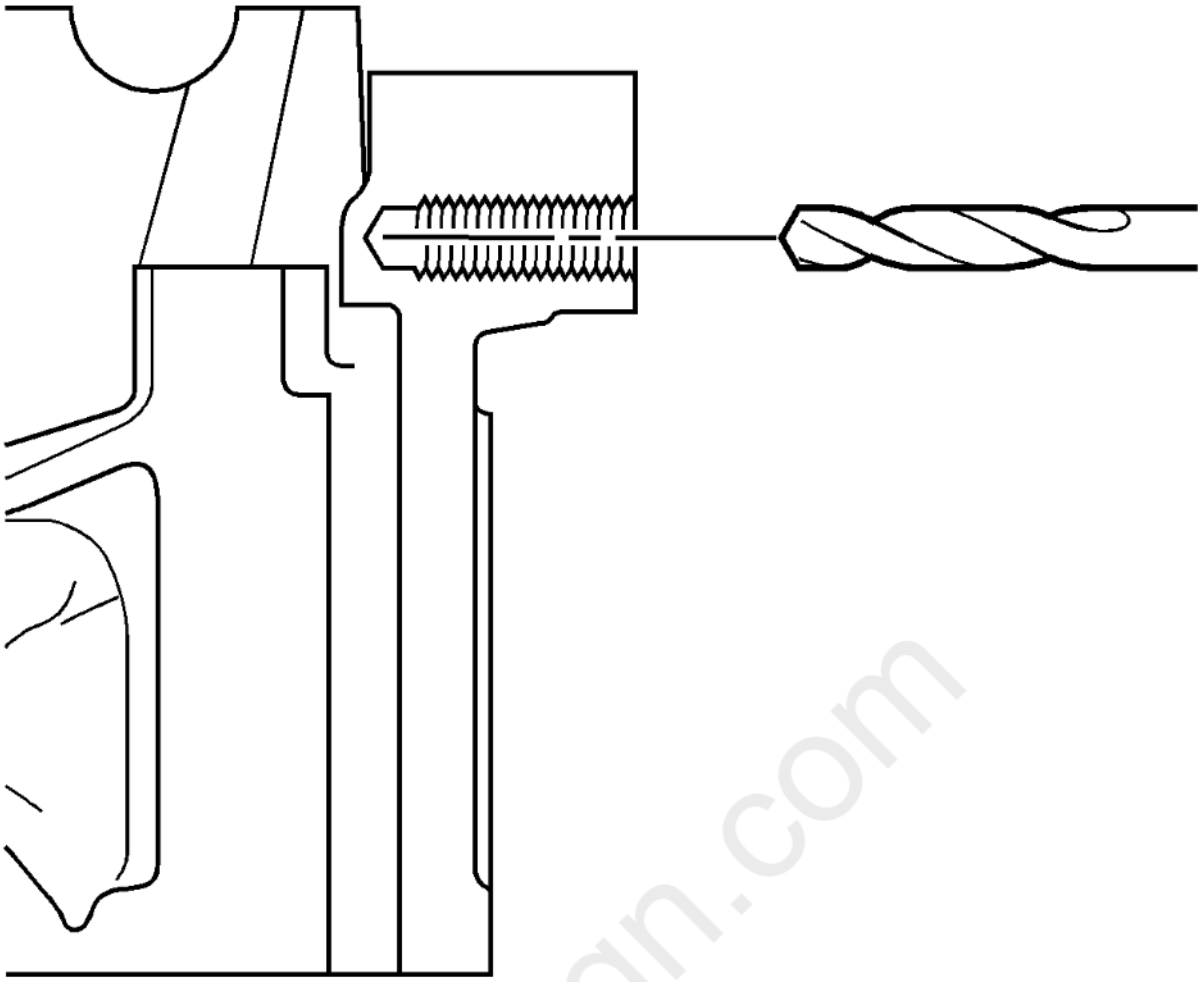


Fig. 249: Drilled Hole Centerline
Courtesy of GENERAL MOTORS COMPANY

It is critical that the drilling, counterboring and tapping of the hole to be repaired follows the same centerline as the original hole.

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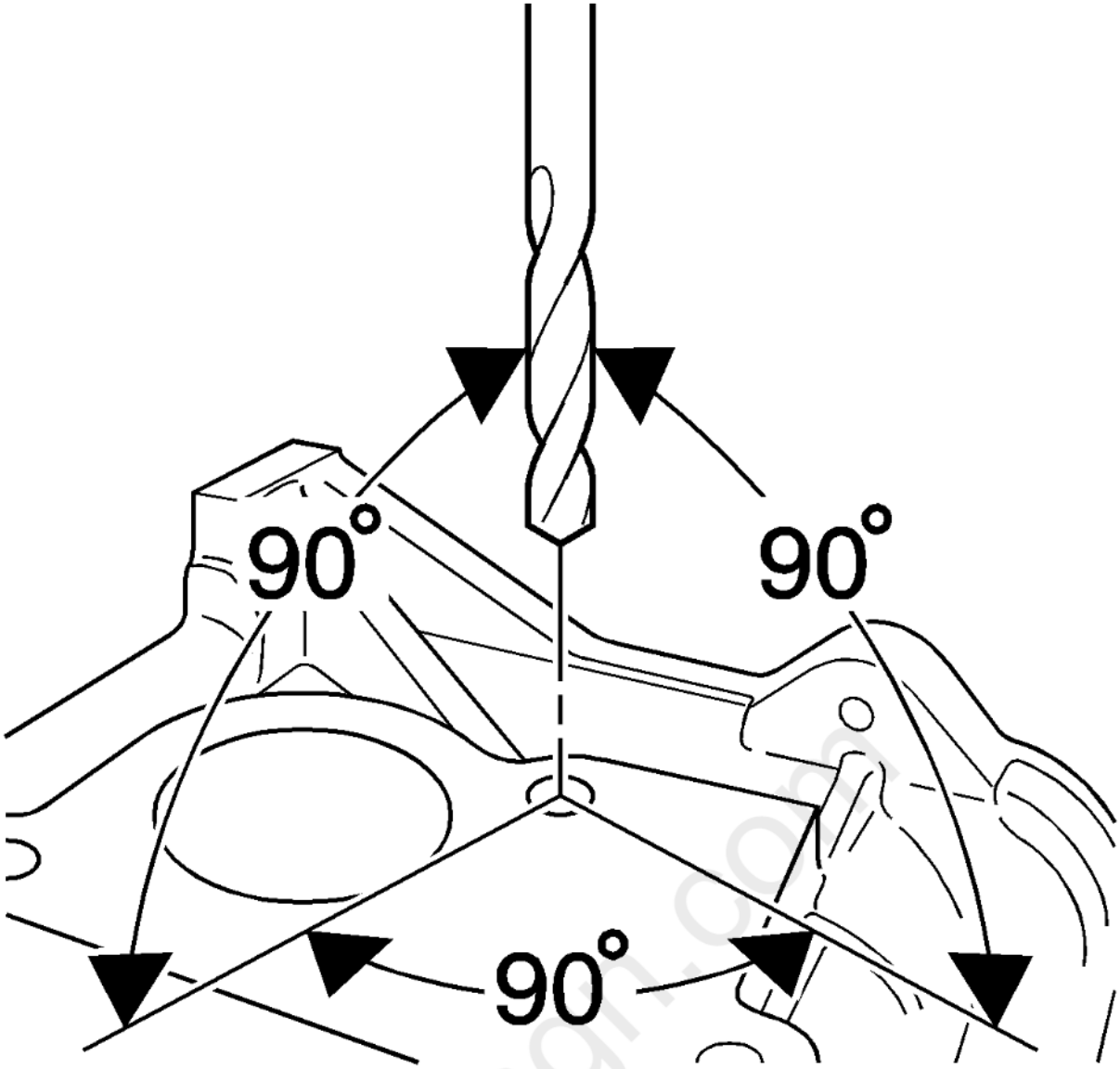


Fig. 250: Identifying Proper Drilling Angle
Courtesy of GENERAL MOTORS COMPANY

During the drilling and tapping of the hole being repaired ensure the tooling is consistently machining perpendicular to the surface of the base material.

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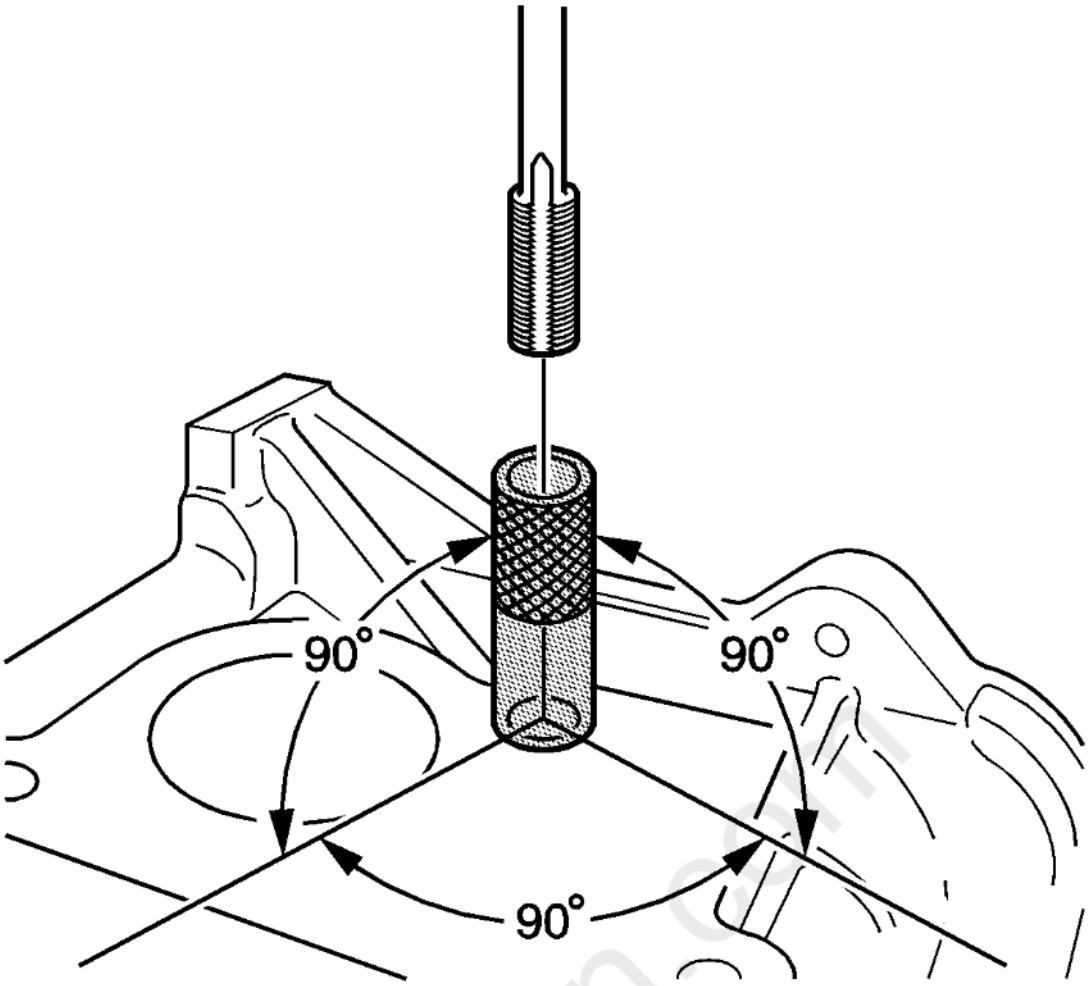


Fig. 251: View Of Tapping Guide
Courtesy of GENERAL MOTORS COMPANY

If the threaded hole being repaired has a base surface perpendicular to the hole centerline, tapping guides are available to aid in tapping the hole.

Tap Size	Tap Guide	Tap Size	Tap Guide	Tap Size	Tap Guide
-	EN 42385-	-	EN 42385-	-	EN 42385-
6 x 1.0	729	10 x 1.5	731	14 x 1.5	736
8 x 1.25	730	12 x 1.5	732	20 x 1.5	737

Standard Thread Repair - Flush Hole

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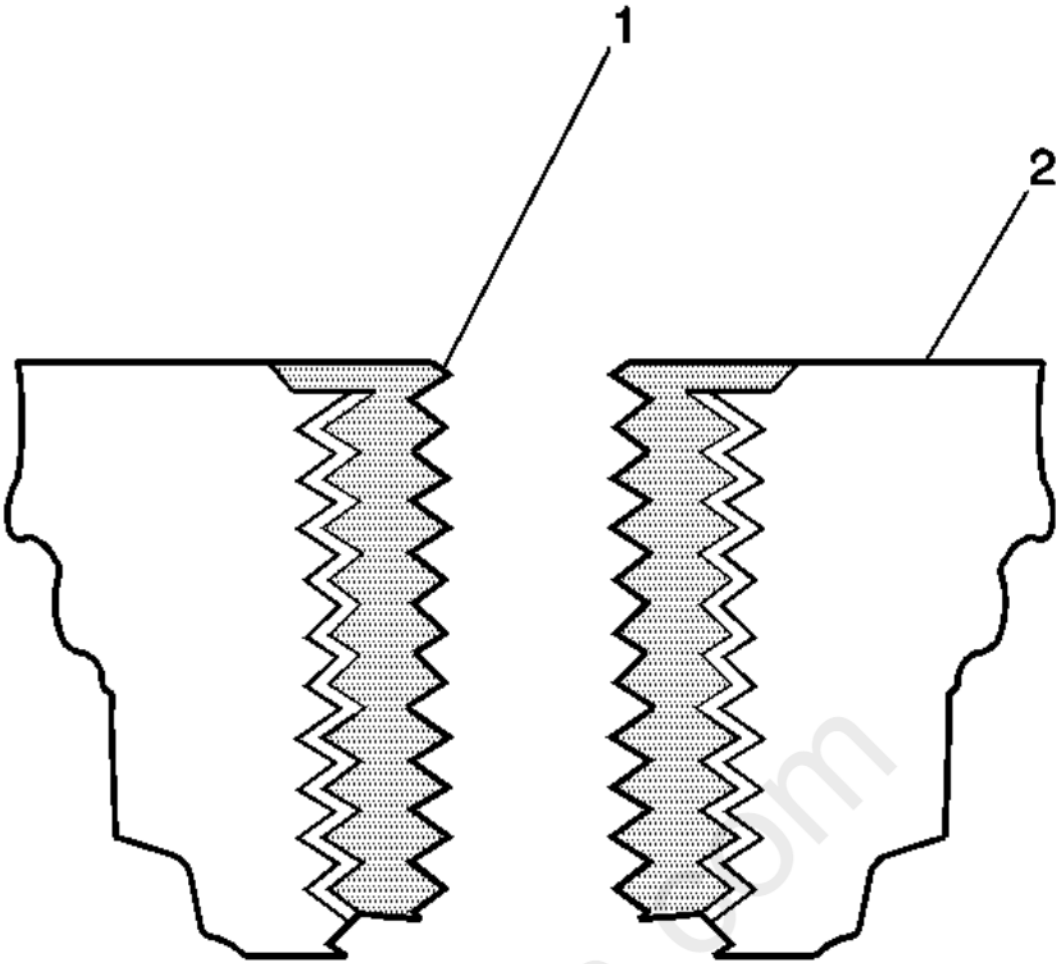


Fig. 252: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Safety Glasses Warning .

NOTE: The use of a cutting type fluid is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants and Sealers for recommended cutting fluid.

When installed to the proper depth, the flange (1) of the insert will be seated against the counterbore of the drilled/tapped hole and just below the surface (2) of the base material.

1. Drill out the threads of the damaged hole.

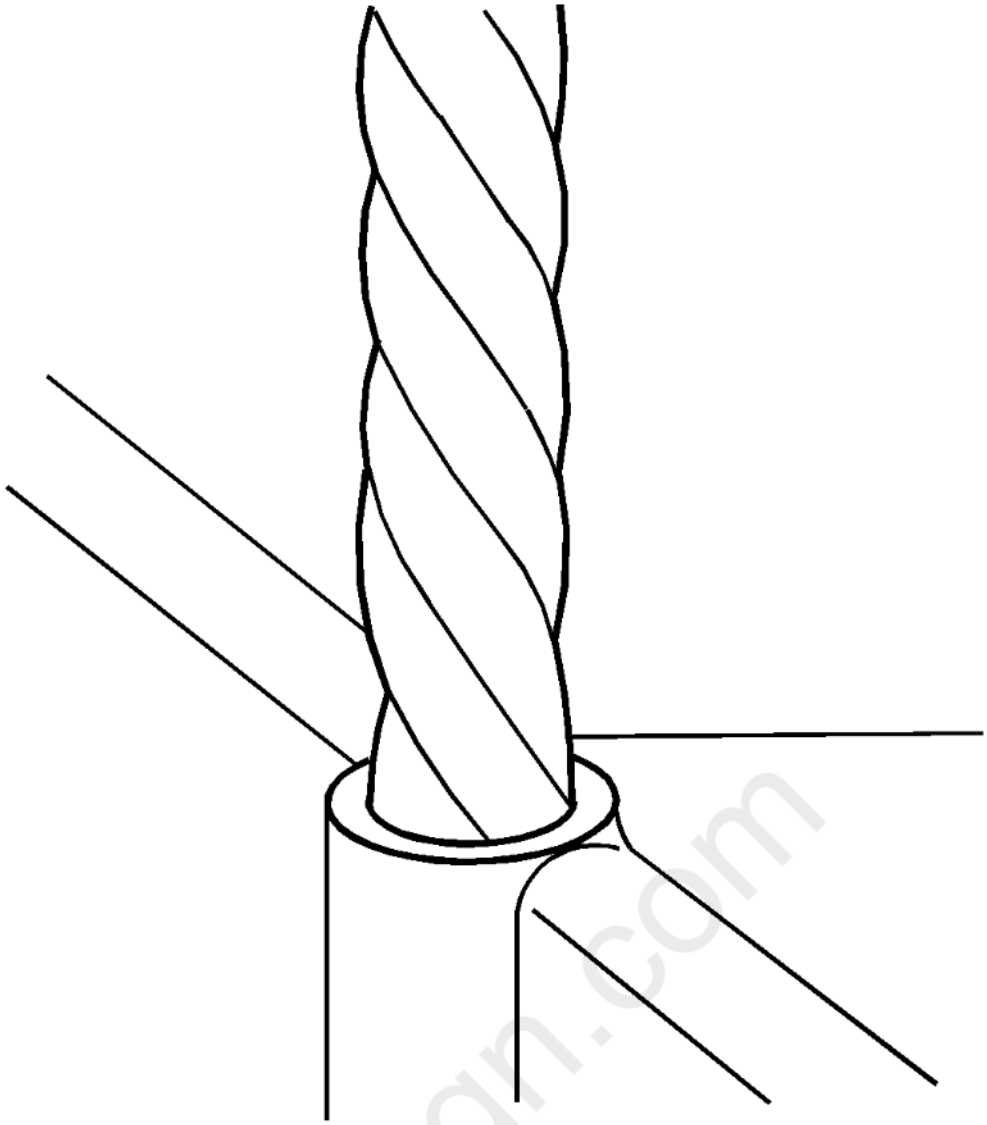


Fig. 253: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Do NOT drill any further than the original hole depth.**

Specifications

- M6 inserts require a minimum drill depth of 15 mm (0.59 in).
- M8 inserts require a minimum drill depth of 20 mm (0.79 in).
- M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).

2. Using compressed air, clean out any chips.

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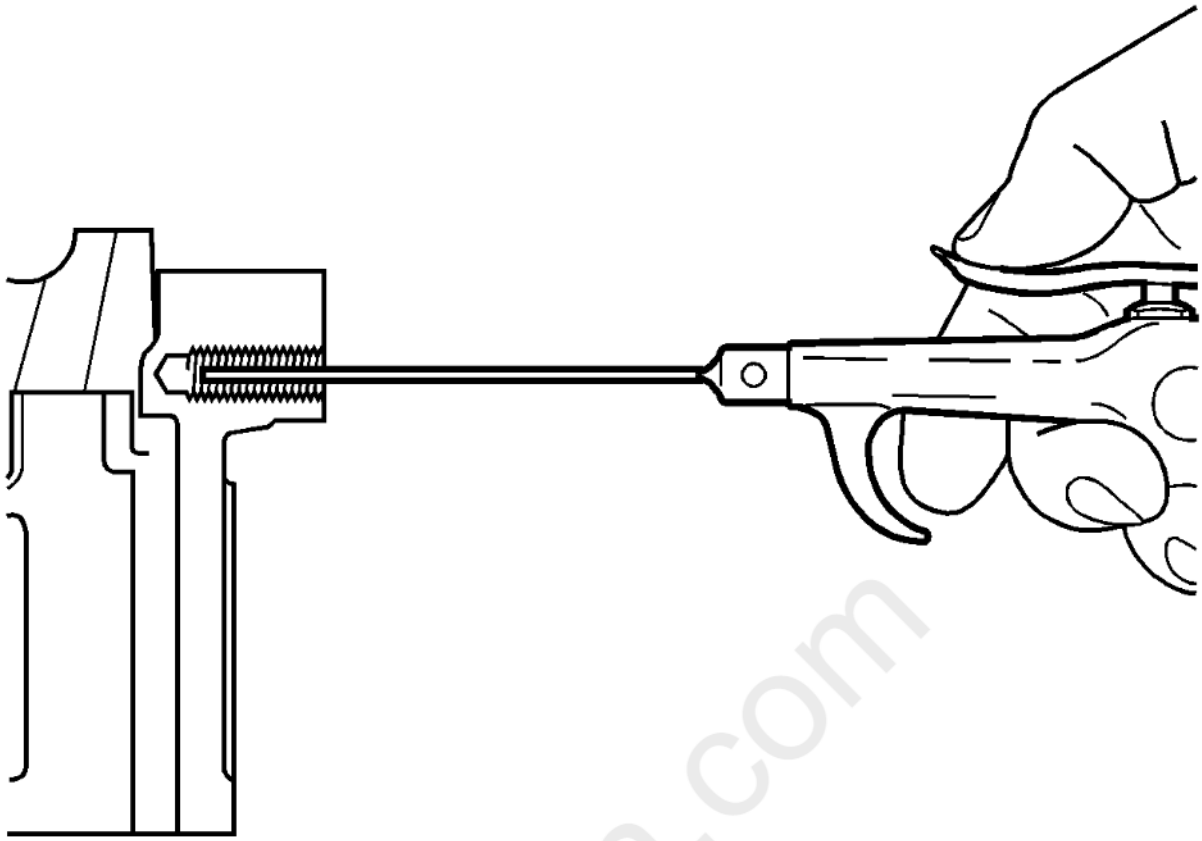


Fig. 254: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the drilled hole prior to tapping.**

3. Counterbore the drilled hole to the full depth permitted by the tool (1).

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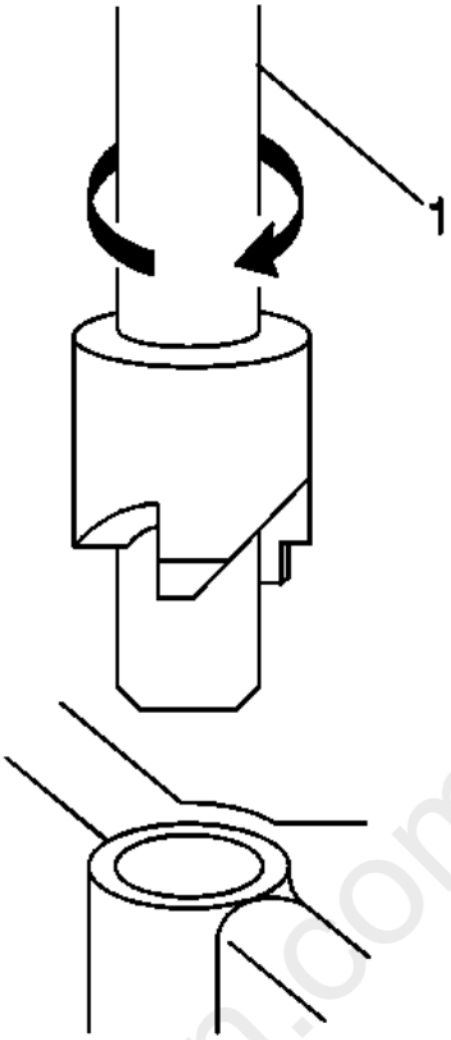


Fig. 255: Identifying Tool Used To Counterbore The Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE: **A properly counterbored hole will show a slight burnishing on the surface of the base material for 360 degrees around the drilled hole.**

4. Using compressed air, clean out any chips.

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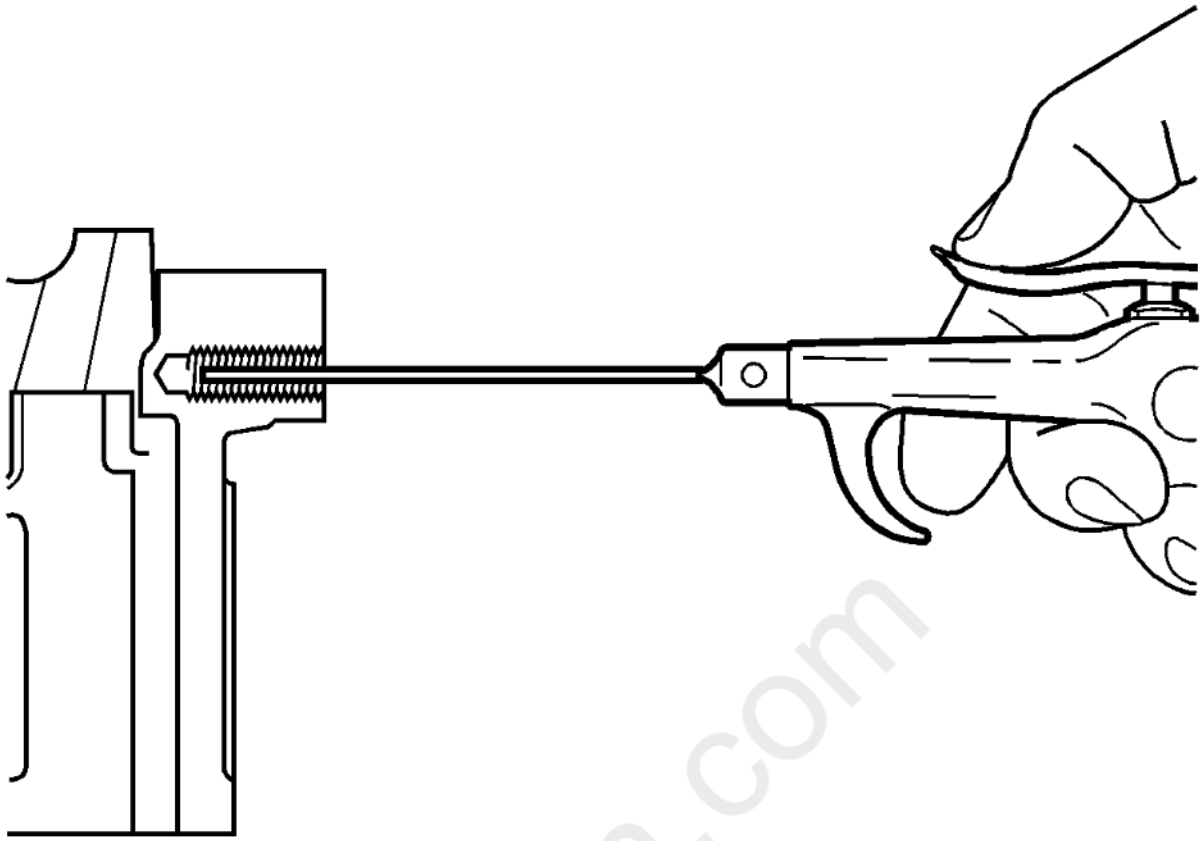


Fig. 256: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the drilled hole prior to tapping.**

5. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

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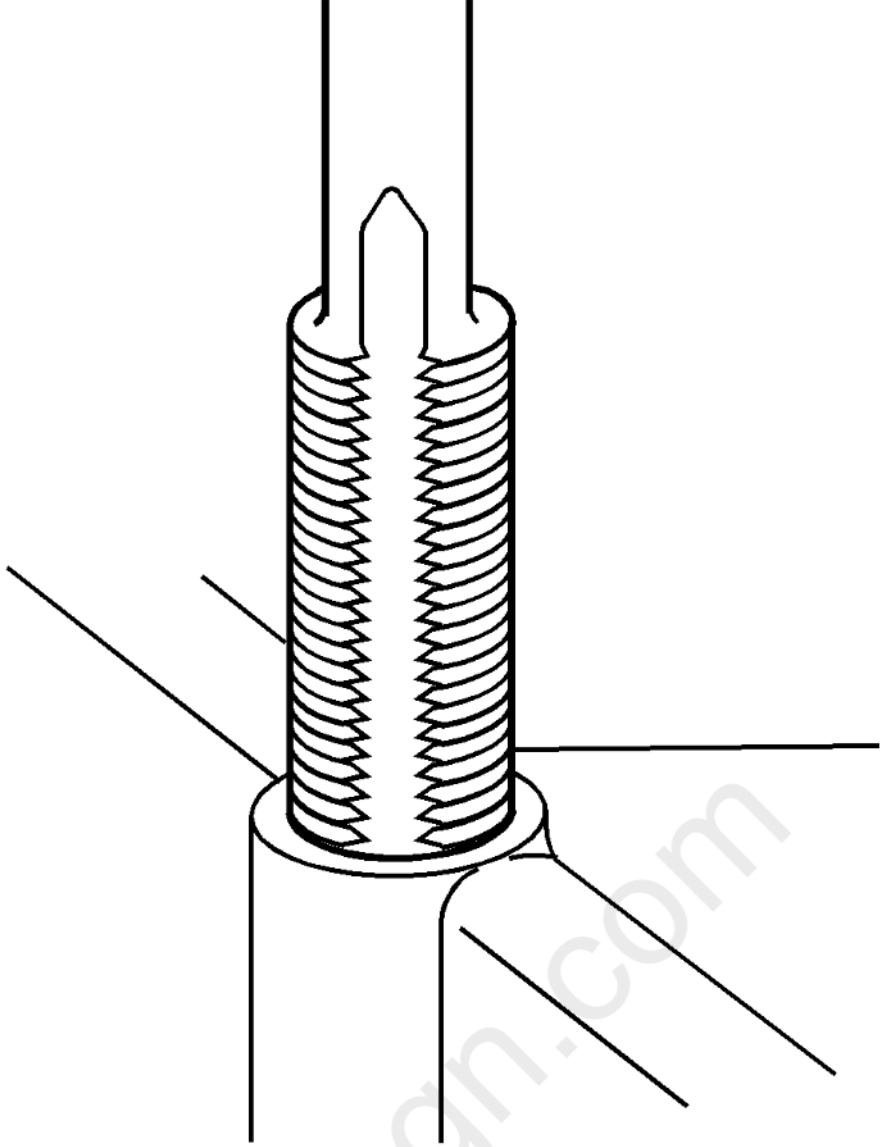


Fig. 257: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

Specifications

- M6 inserts require a minimum tap depth of 15 mm (0.59 in).
- M8 inserts require a minimum tap depth of 20 mm (0.79 in).
- M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).

6. Using compressed air, clean out any chips.

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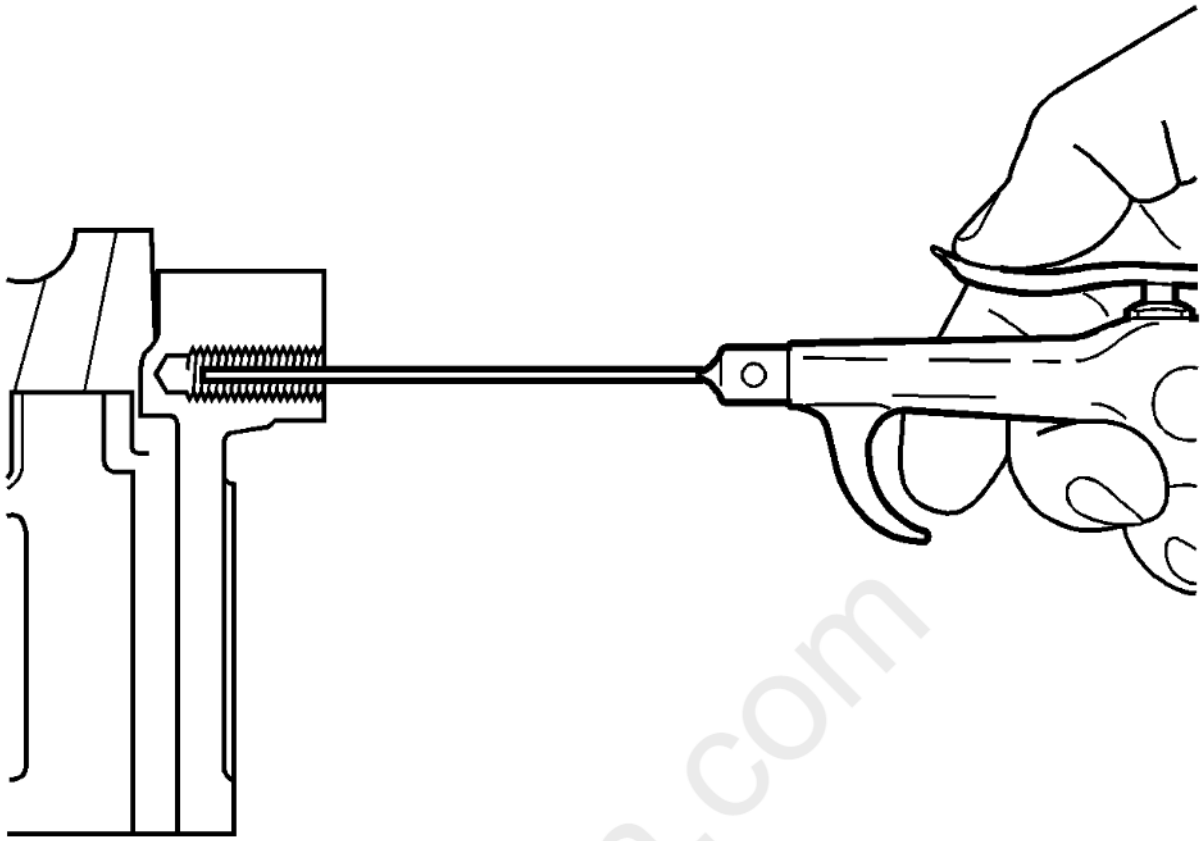


Fig. 258: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

7. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended cleaner.

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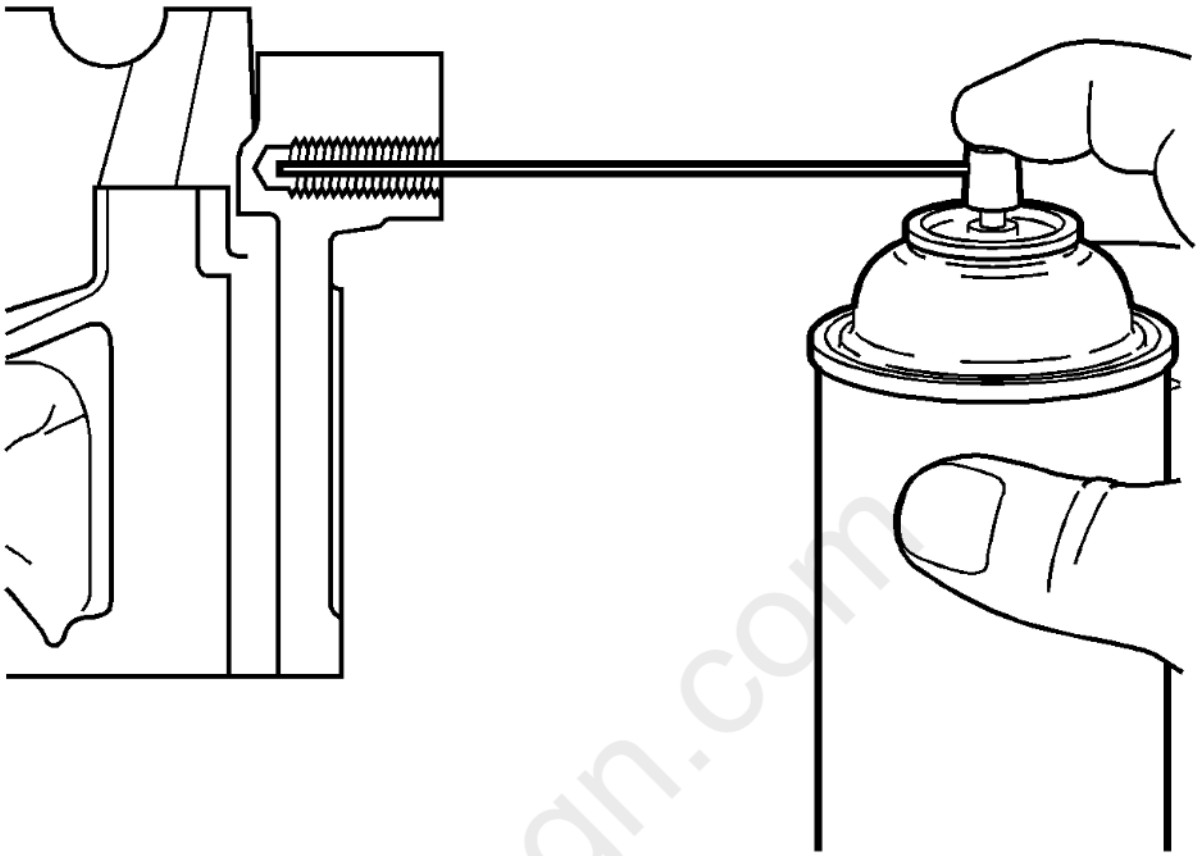


Fig. 259: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS COMPANY

8. Using compressed air, clean out any chips.

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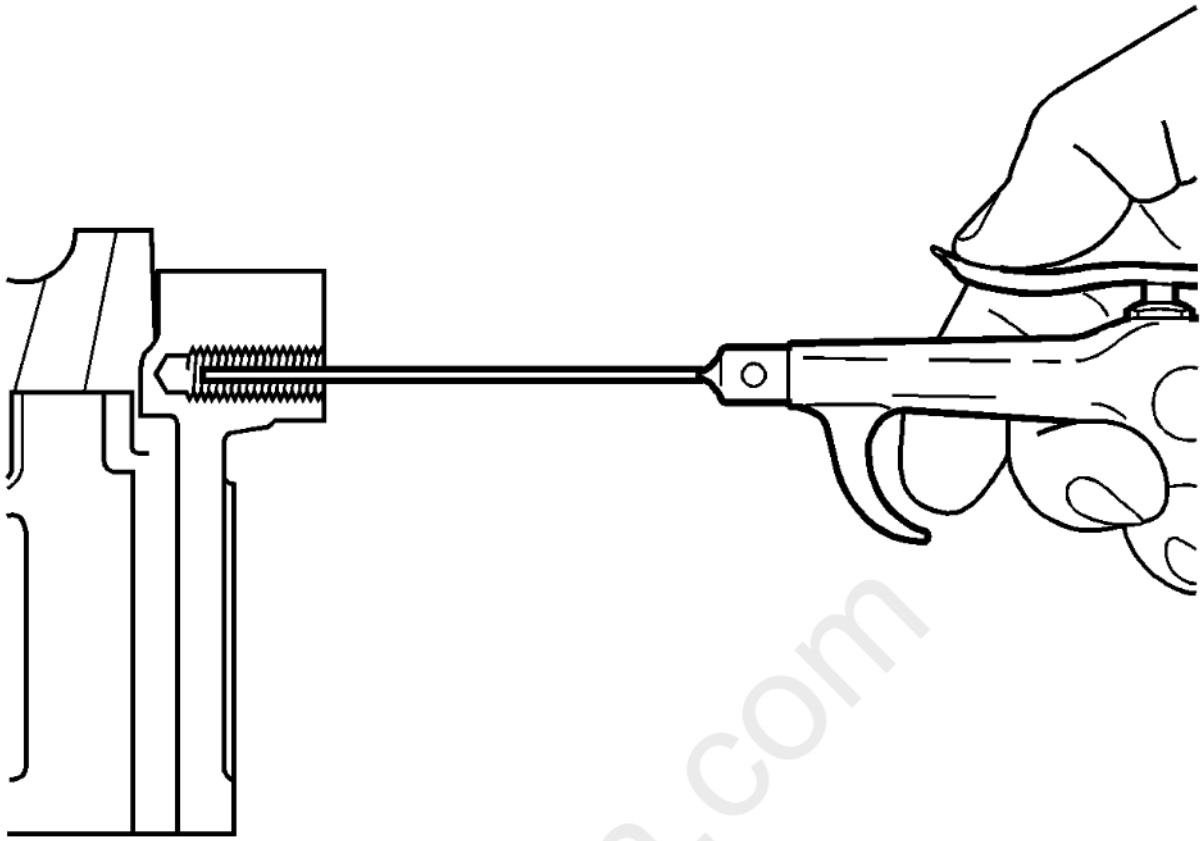


Fig. 260: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

9. Lubricate the threads of the driver installation tool (2) with the **EN-42385-110** (1).

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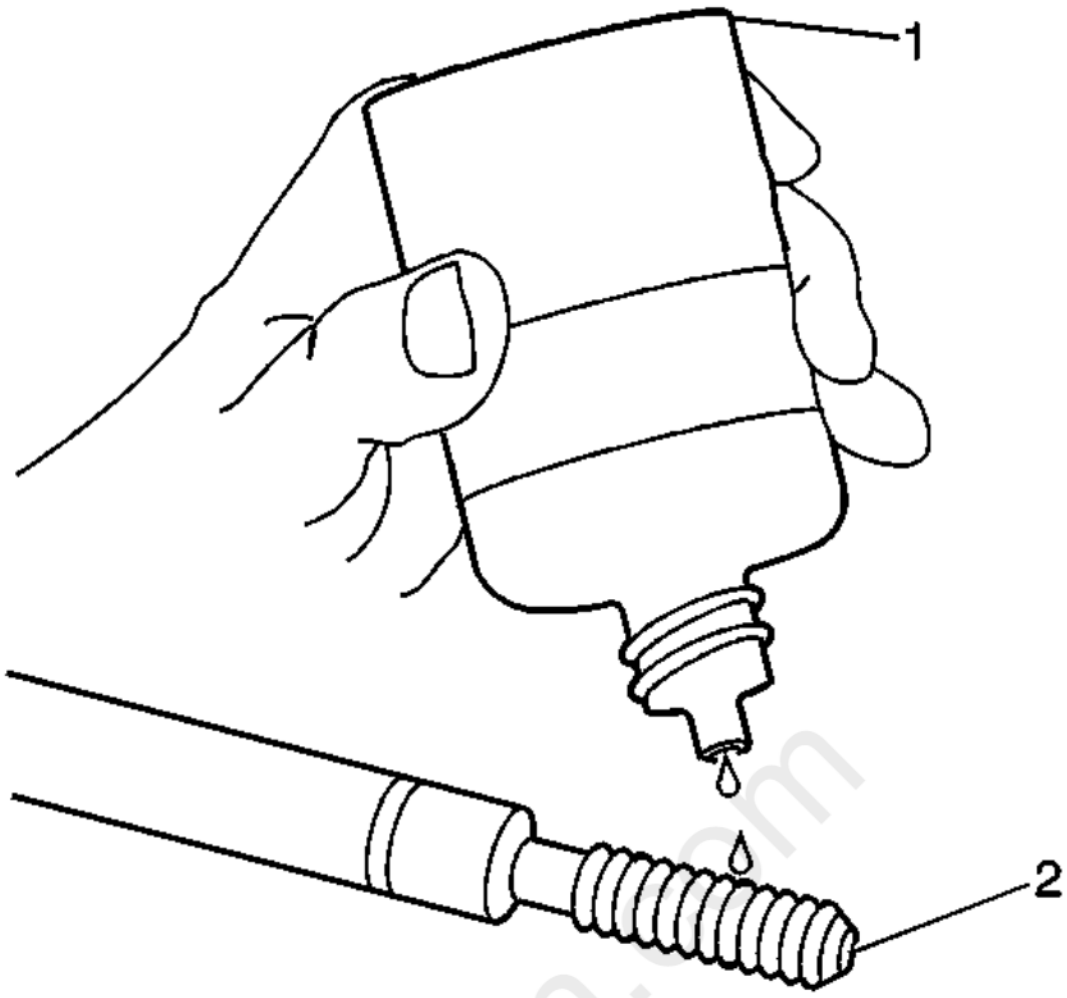


Fig. 261: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.**

10. Install the insert (2) onto the driver installation tool (1).

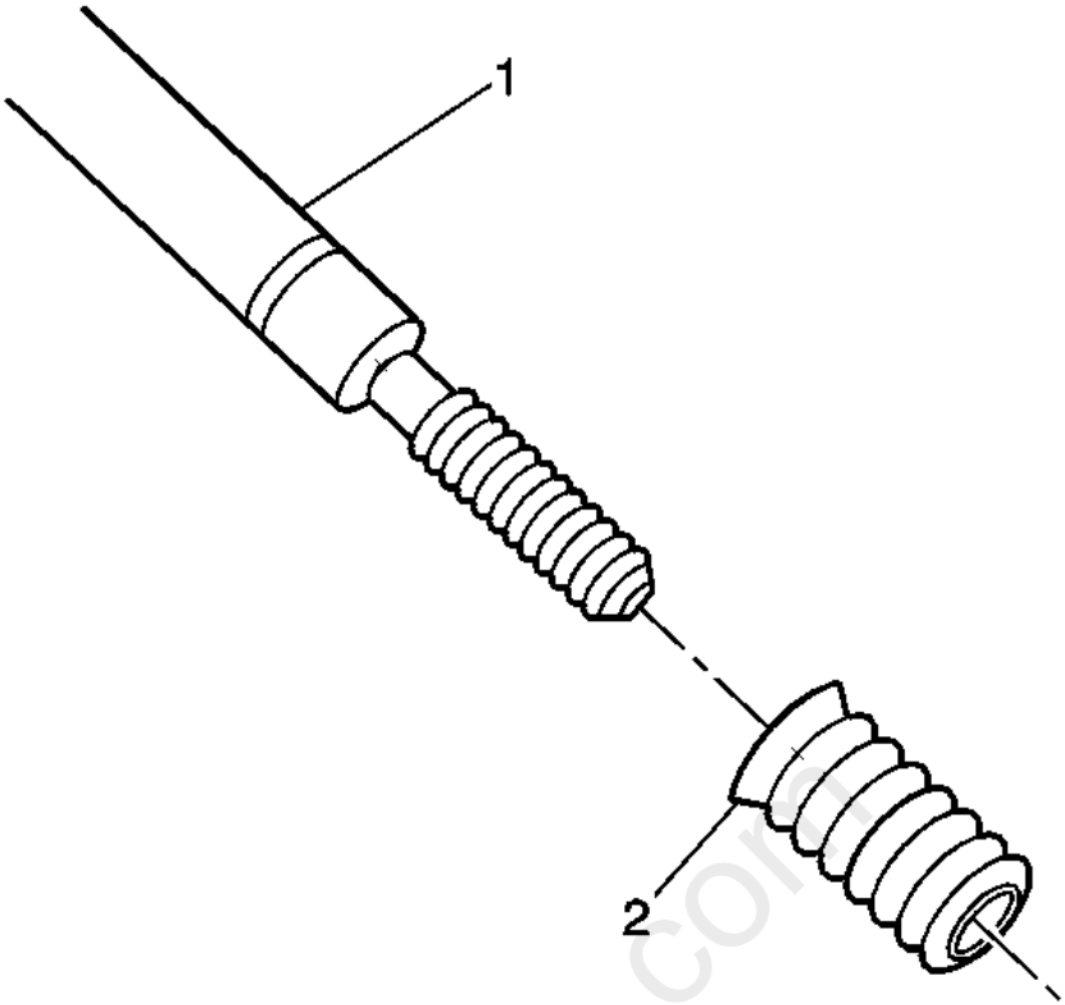


Fig. 262: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

11. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277Â® or equivalent (1) to the insert OD threads (2). Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant.

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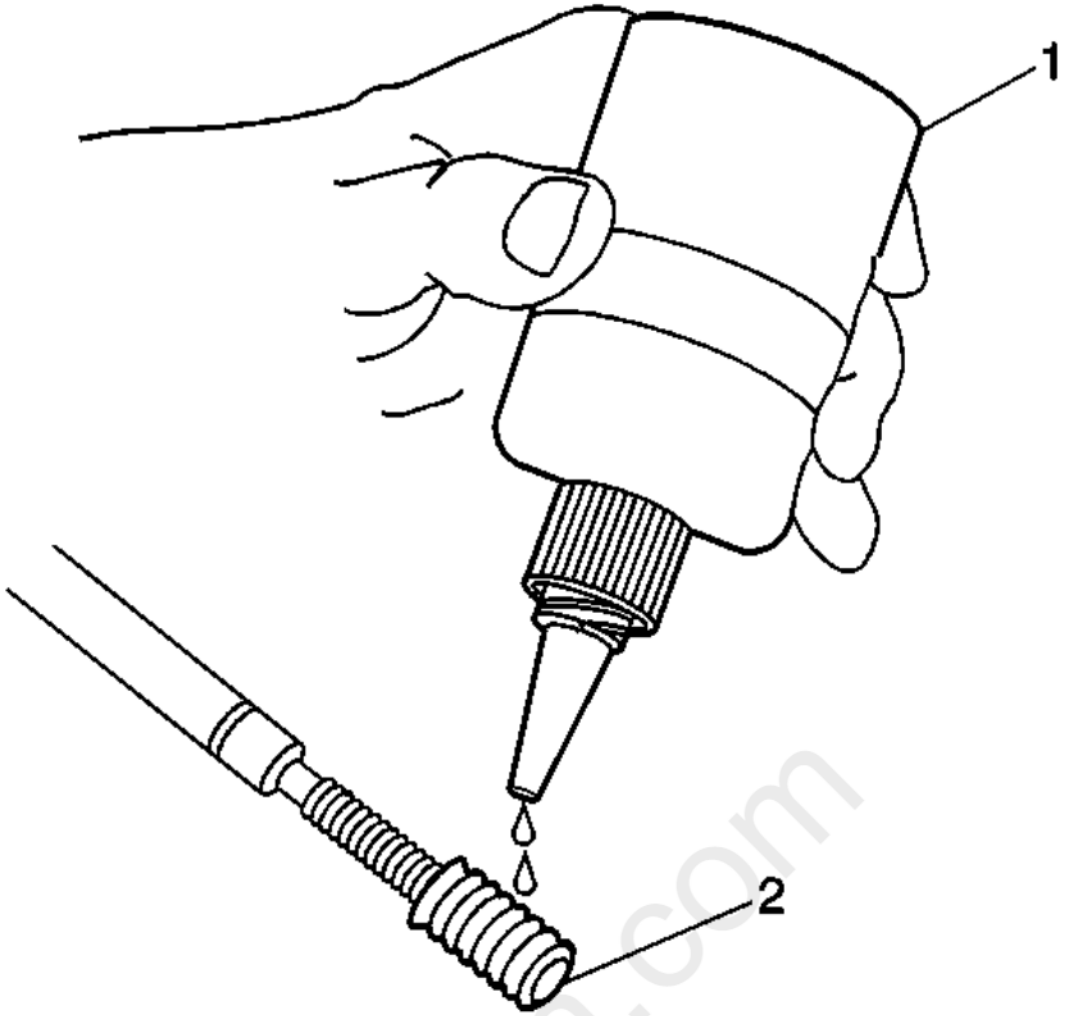


Fig. 263: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

12. Install the insert (2) into the tapped hole by hand only.

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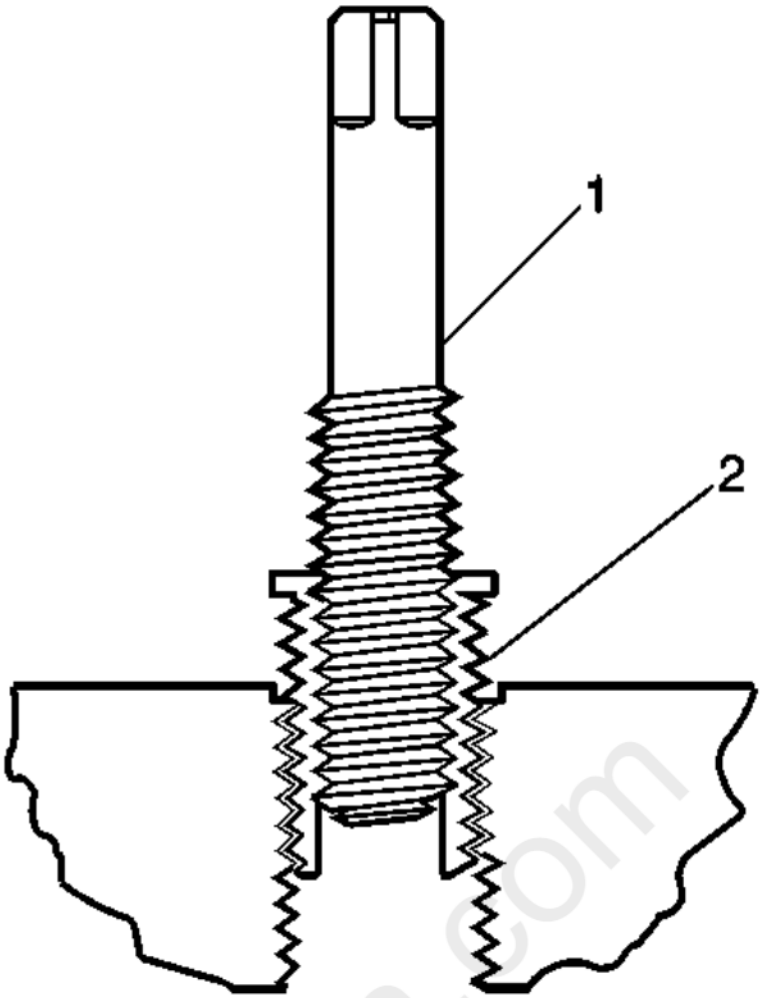


Fig. 264: View Of Insert In Tapped Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

13. Install the insert until the flange (2) of the insert contacts the counterbored surface.

NOTE: **If the insert will not thread down until the flange contacts the counterbored surface, remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.**

14. Continue to rotate the driver installation tool (1) through the insert (2).

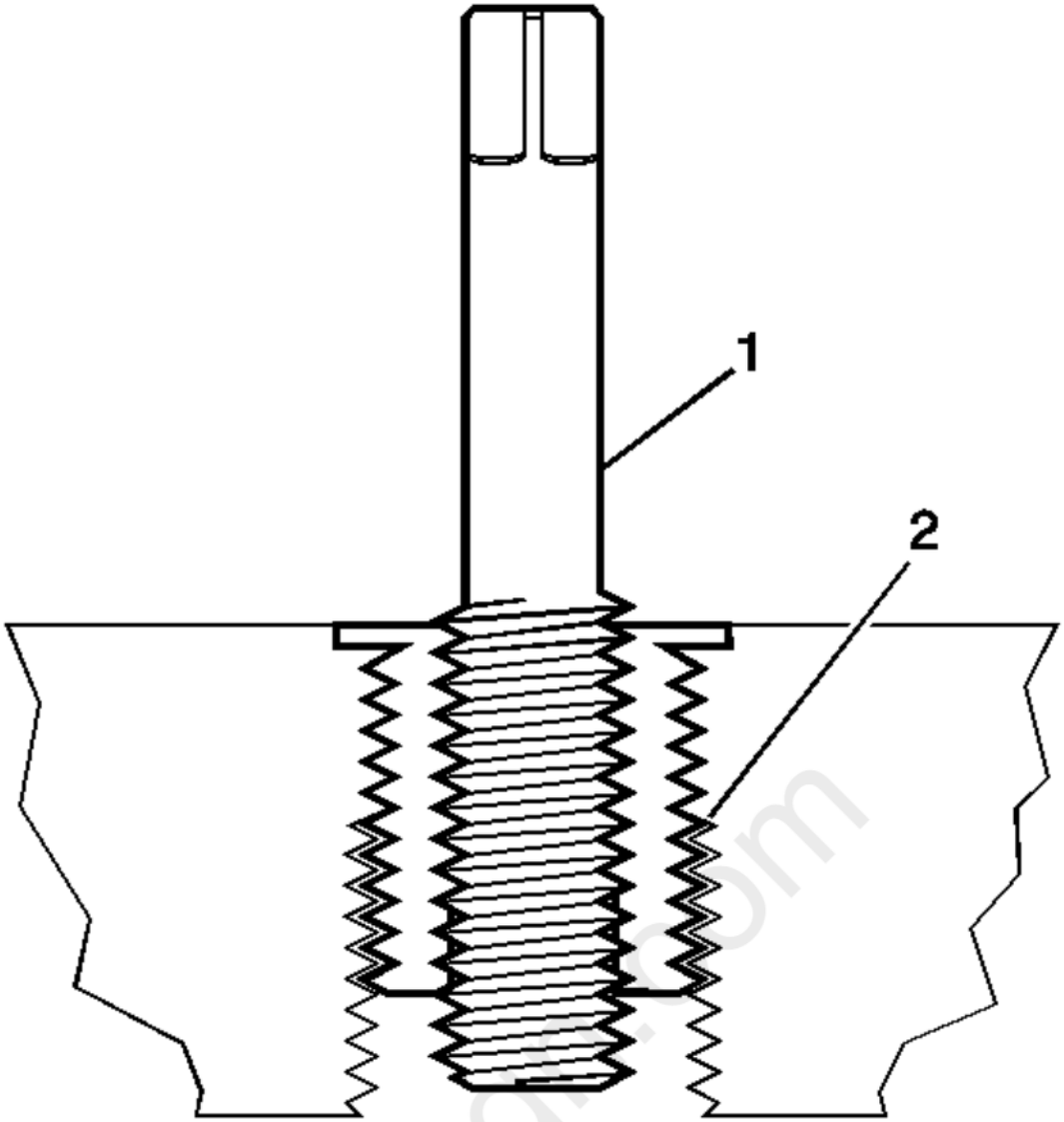


Fig. 265: View Insert & Tool - Standard Thread
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.**

15. Inspect the insert for proper installation into the tapped hole. A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

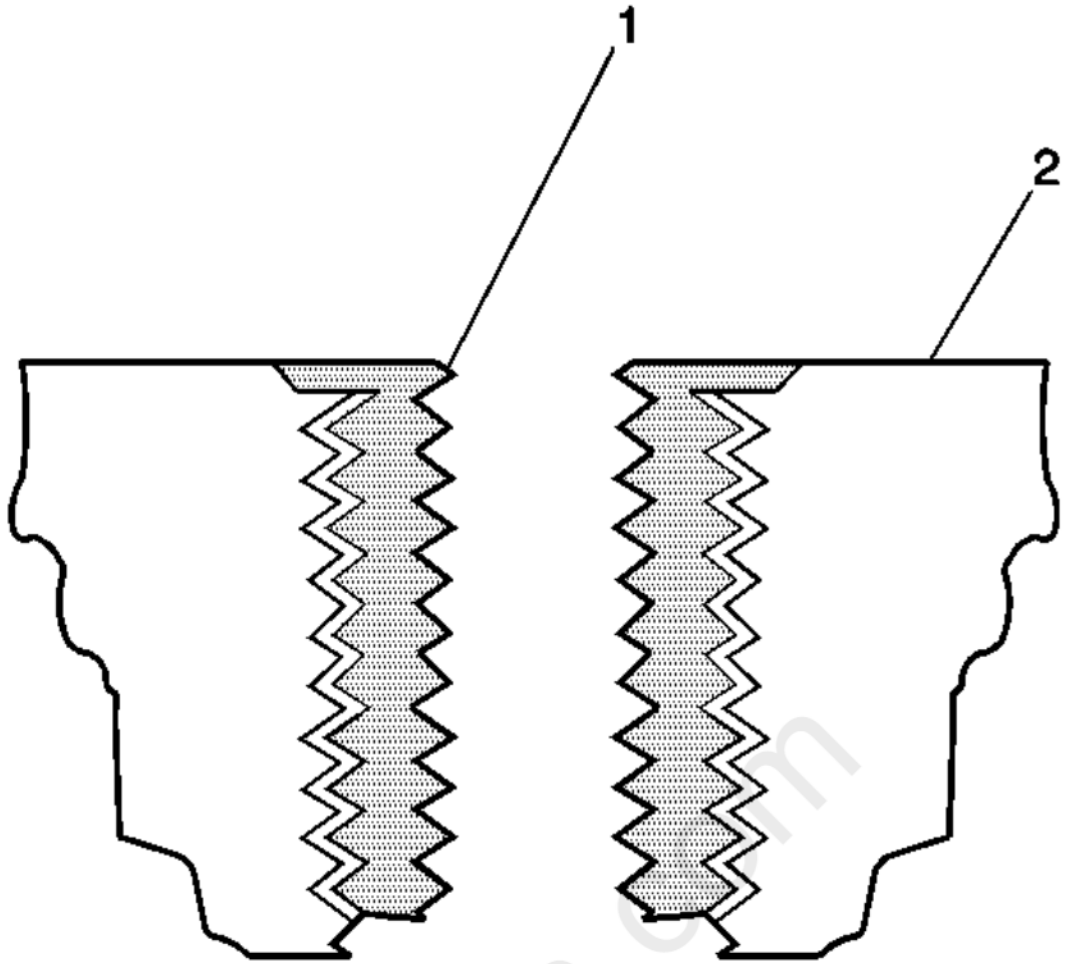


Fig. 266: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS COMPANY

16. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

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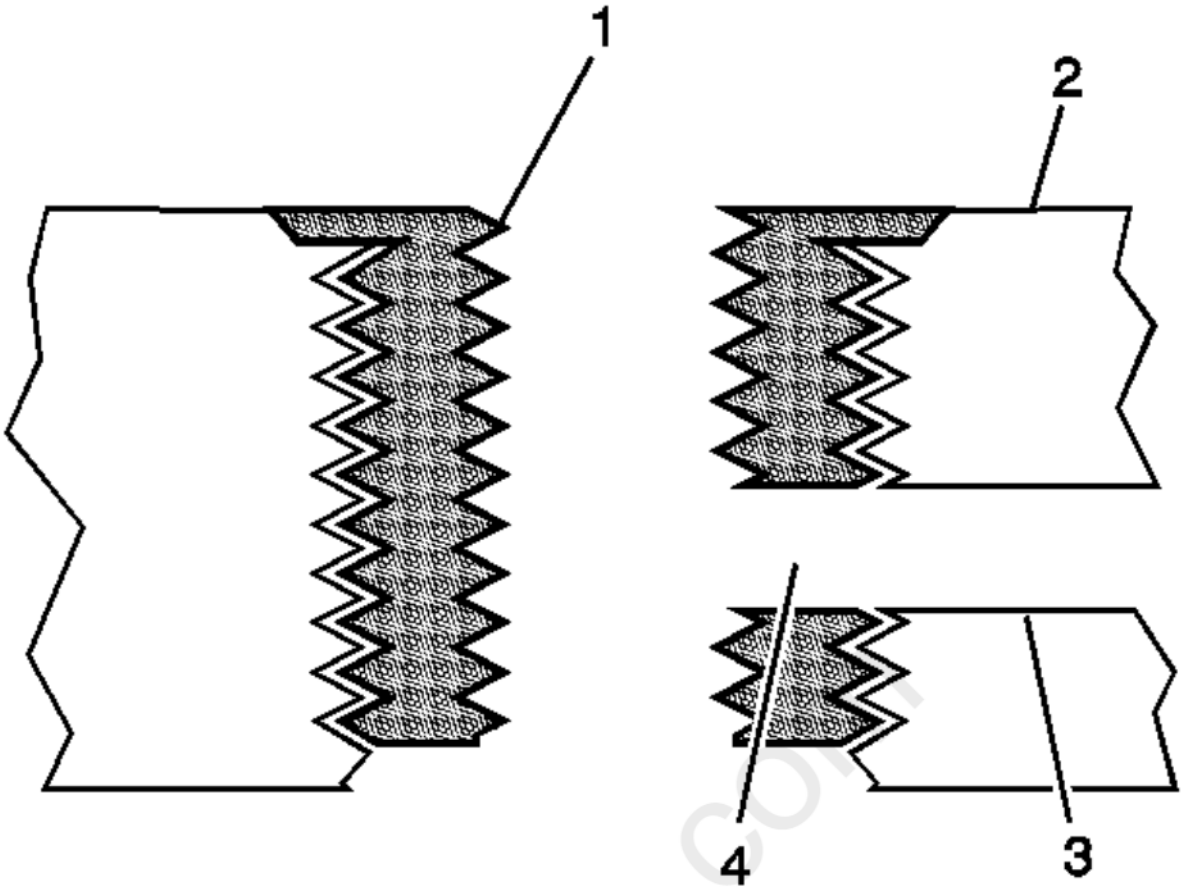


Fig. 267: View Of Restricted Engine Coolant Passages - Standard Thread Repair
Courtesy of GENERAL MOTORS COMPANY

Recessed Thread Repair

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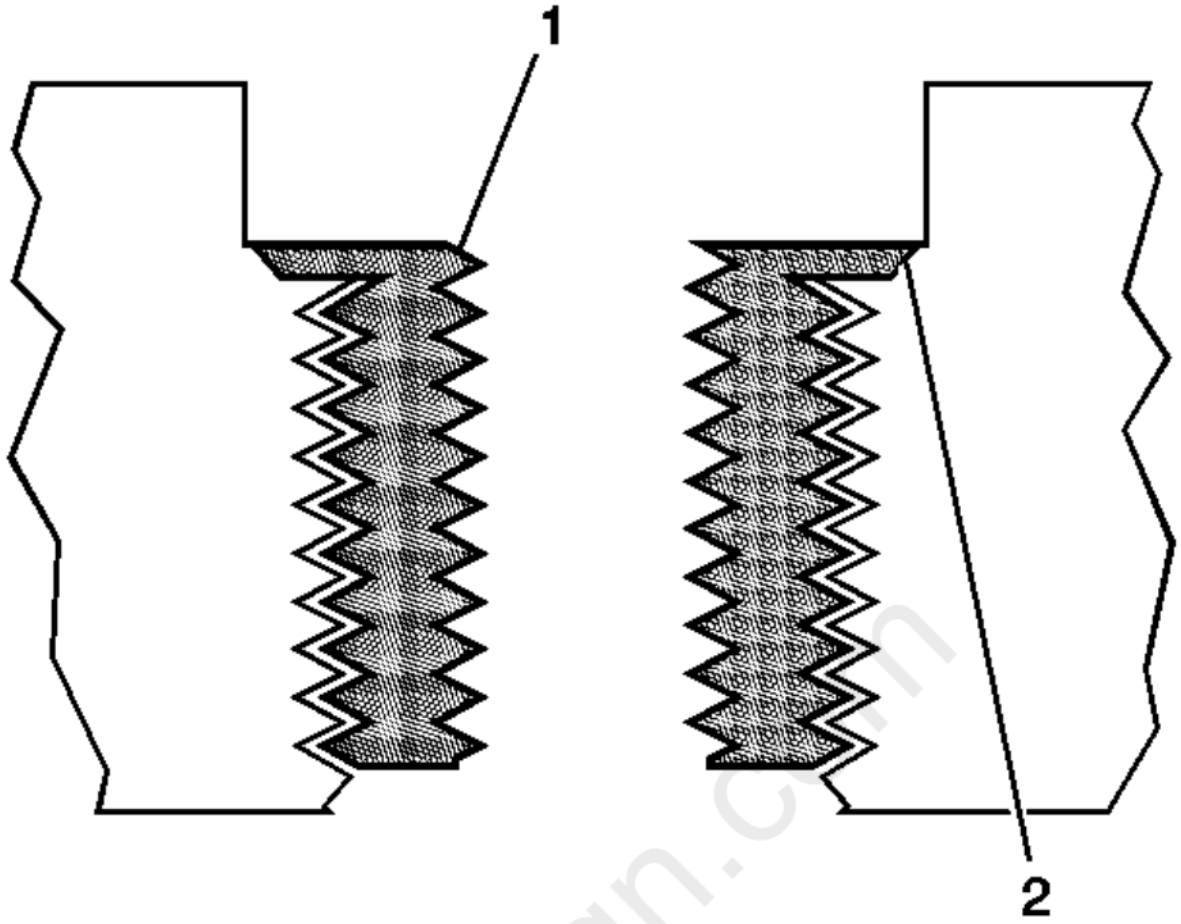


Fig. 268: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Safety Glasses Warning .

NOTE:

- The use of a cutting type fluid, WD 40Â® or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants and Sealers for recommended cutting fluid.
- Do NOT remove the original stop collar from a counterbore drill.

When installed to the proper depth, the flange of the insert (1) will be seated against the counterbore (2) of the drilled/tapped hole.

1. Install a stop collar (2) on the counterbore drill (1), if required.

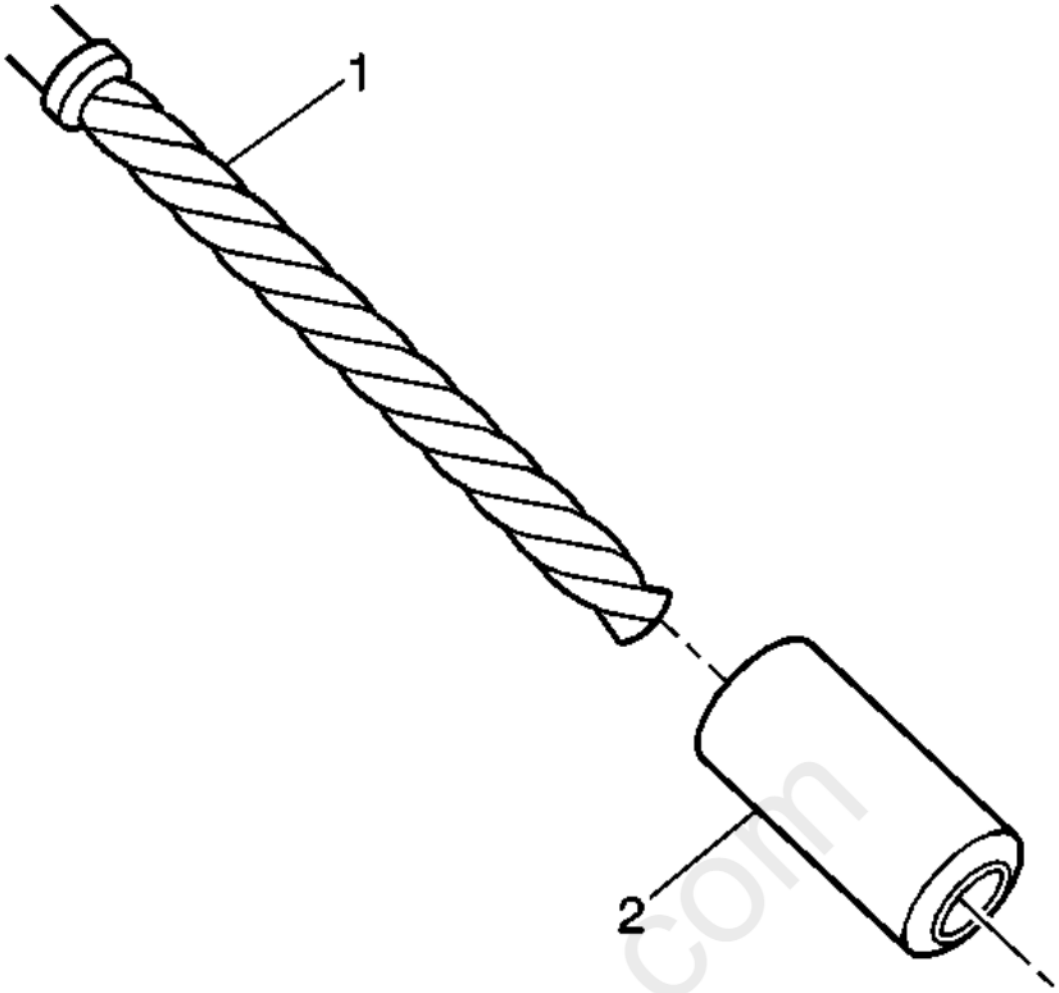


Fig. 269: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS COMPANY

2. Drill out the threads of the damaged hole.

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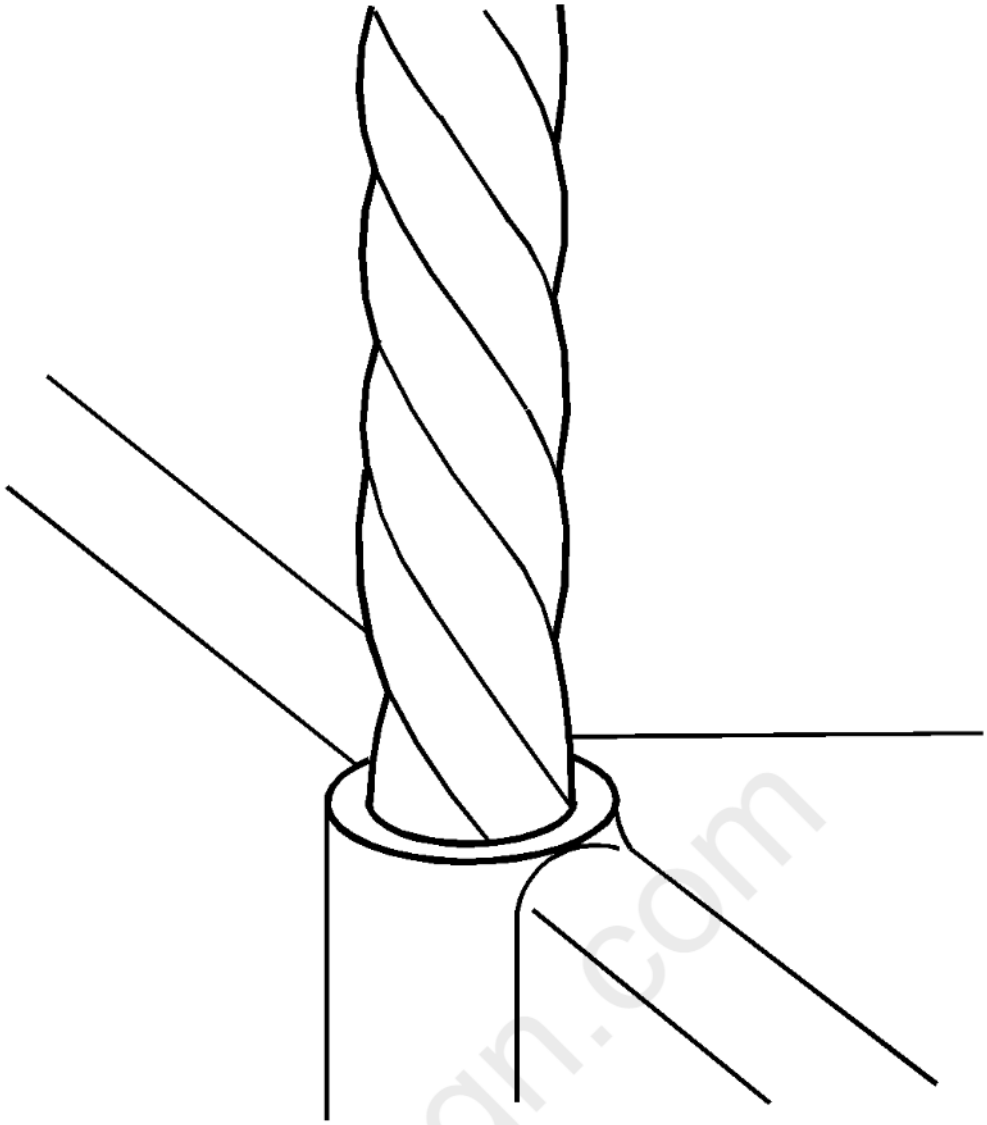


Fig. 270: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the hole until the stop collar contacts the surface of the base material.**

3. Using compressed air, clean out any chips.

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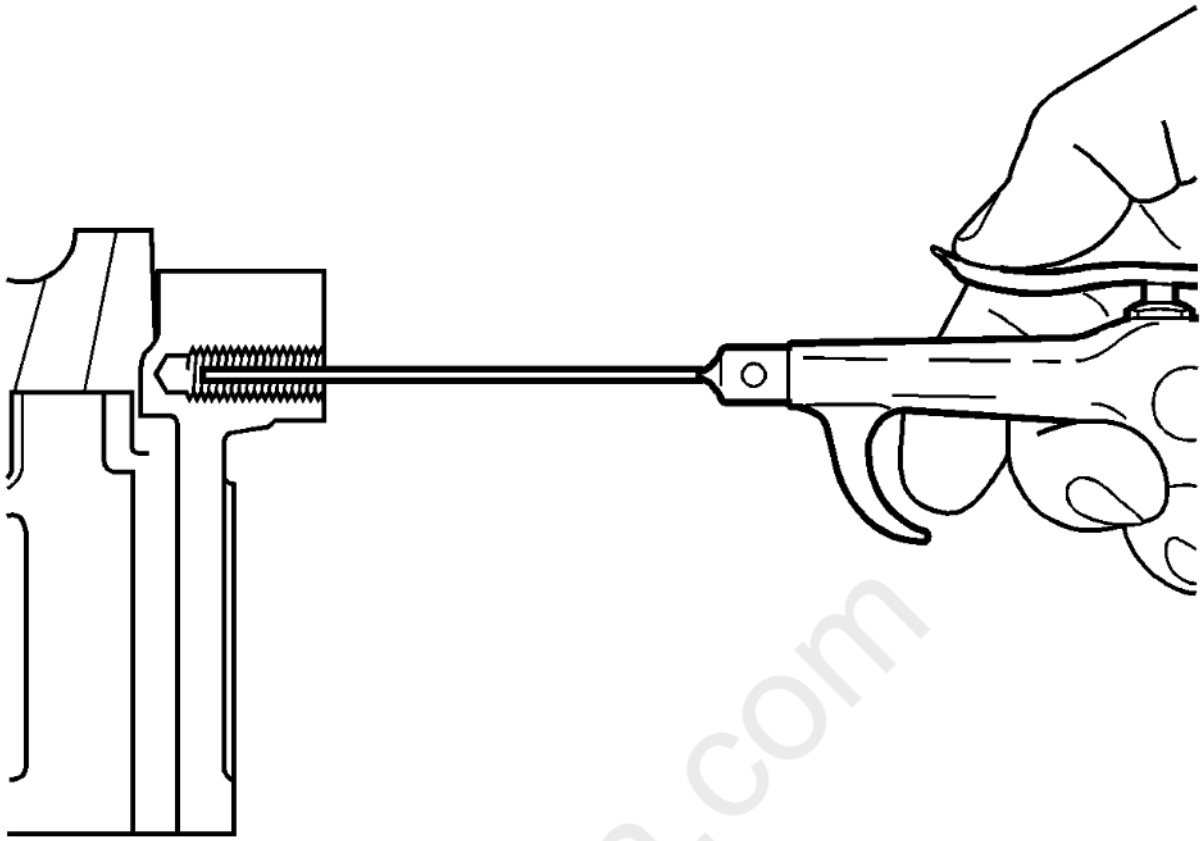


Fig. 271: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the drilled hole prior to tapping.**

4. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

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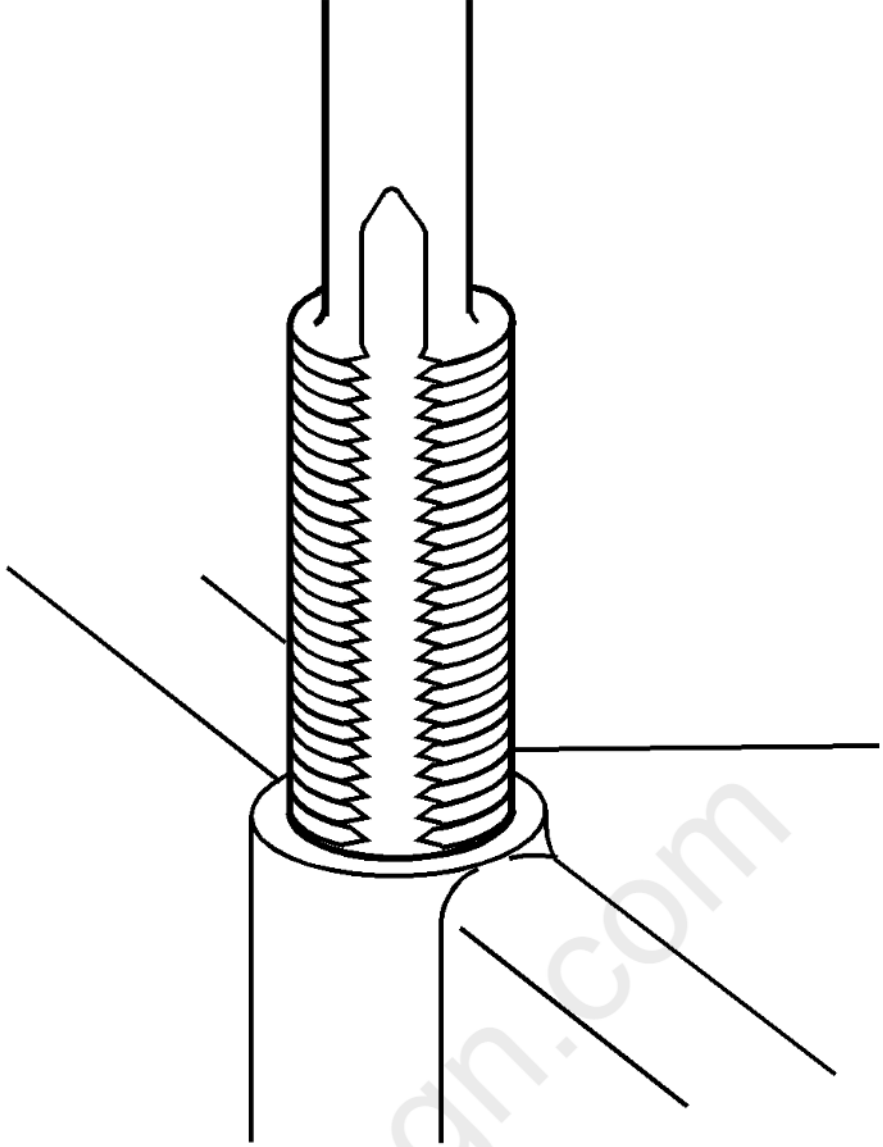


Fig. 272: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

5. Using compressed air, clean out any chips.

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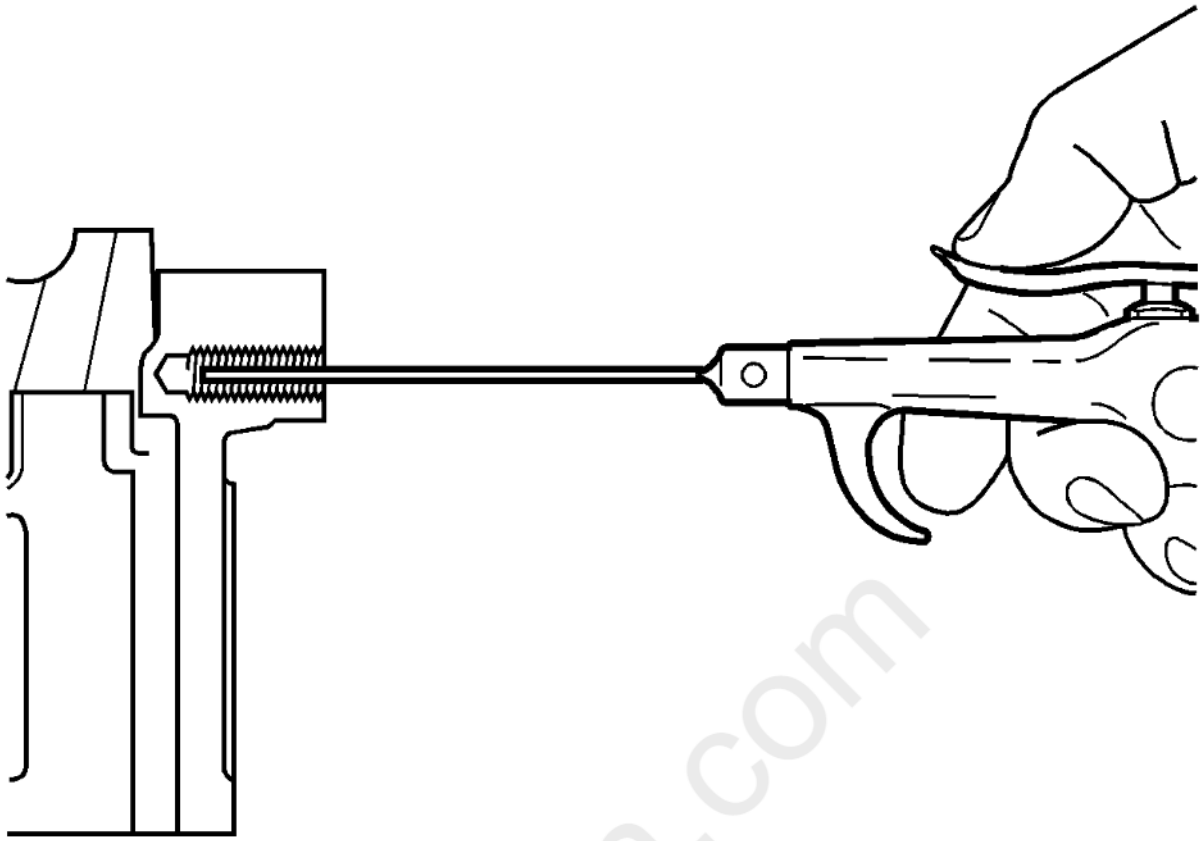


Fig. 273: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

6. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended cleaner.

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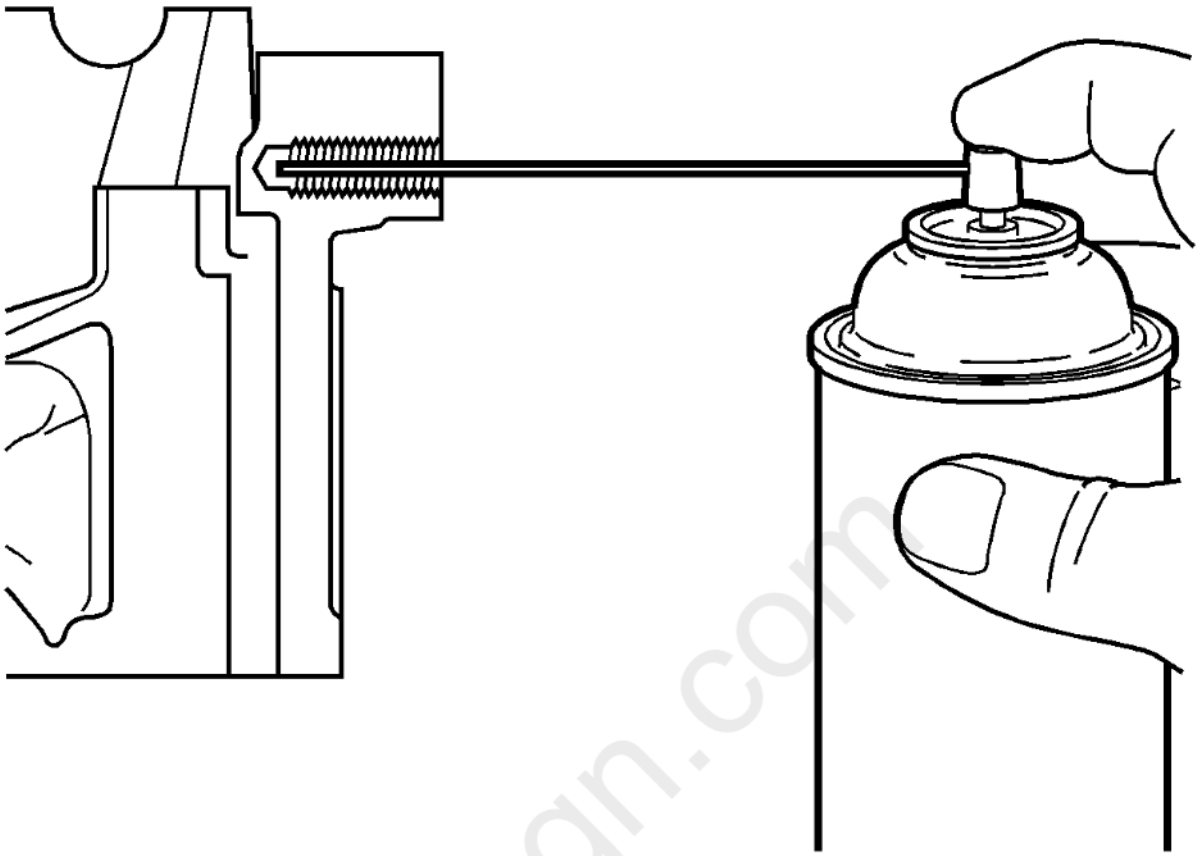


Fig. 274: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS COMPANY

7. Using compressed air, clean out any chips.

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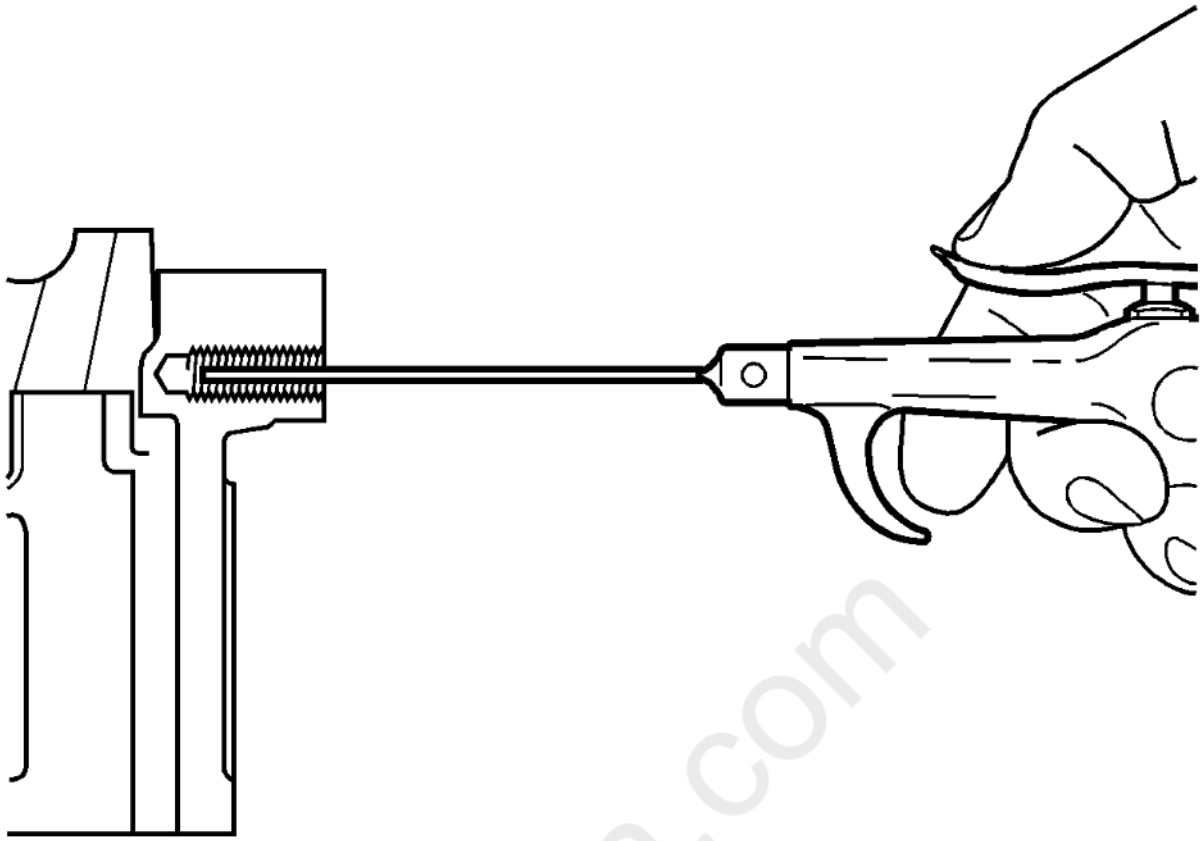


Fig. 275: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

8. Lubricate the threads of the driver installation tool (2) with the EN 42385-110 (1).

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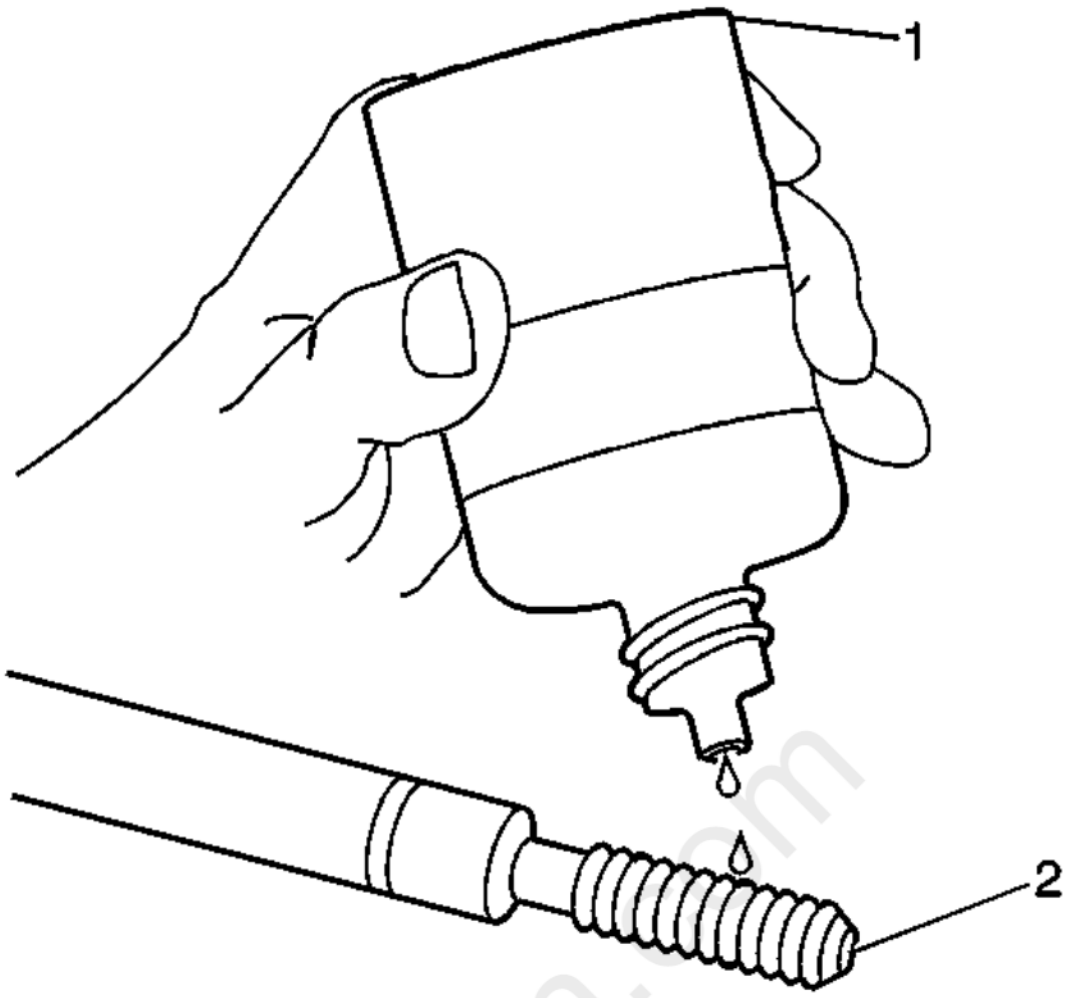


Fig. 276: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.**

9. Install the insert (2) onto the driver installation tool (1).

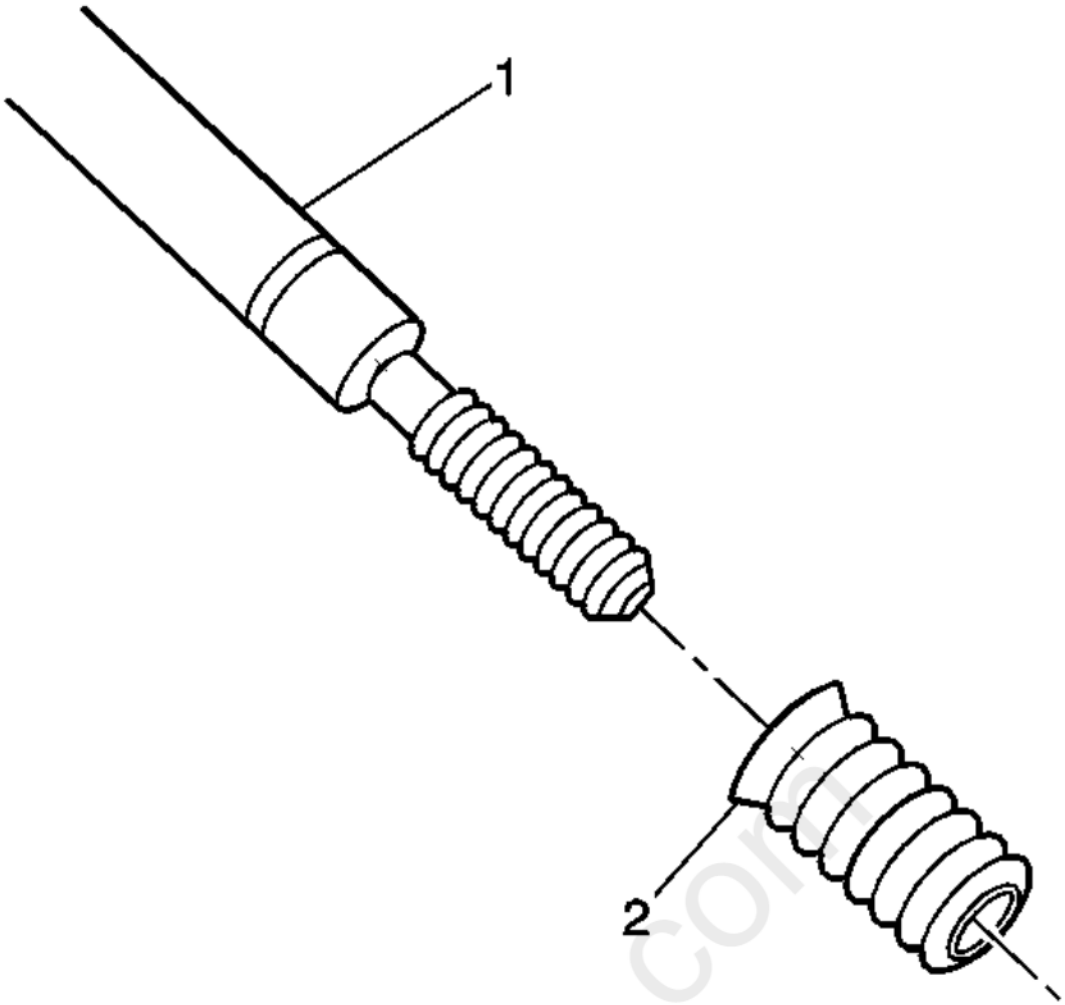


Fig. 277: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

10. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277Â® or equivalent (1) to the insert OD threads (2). Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant.

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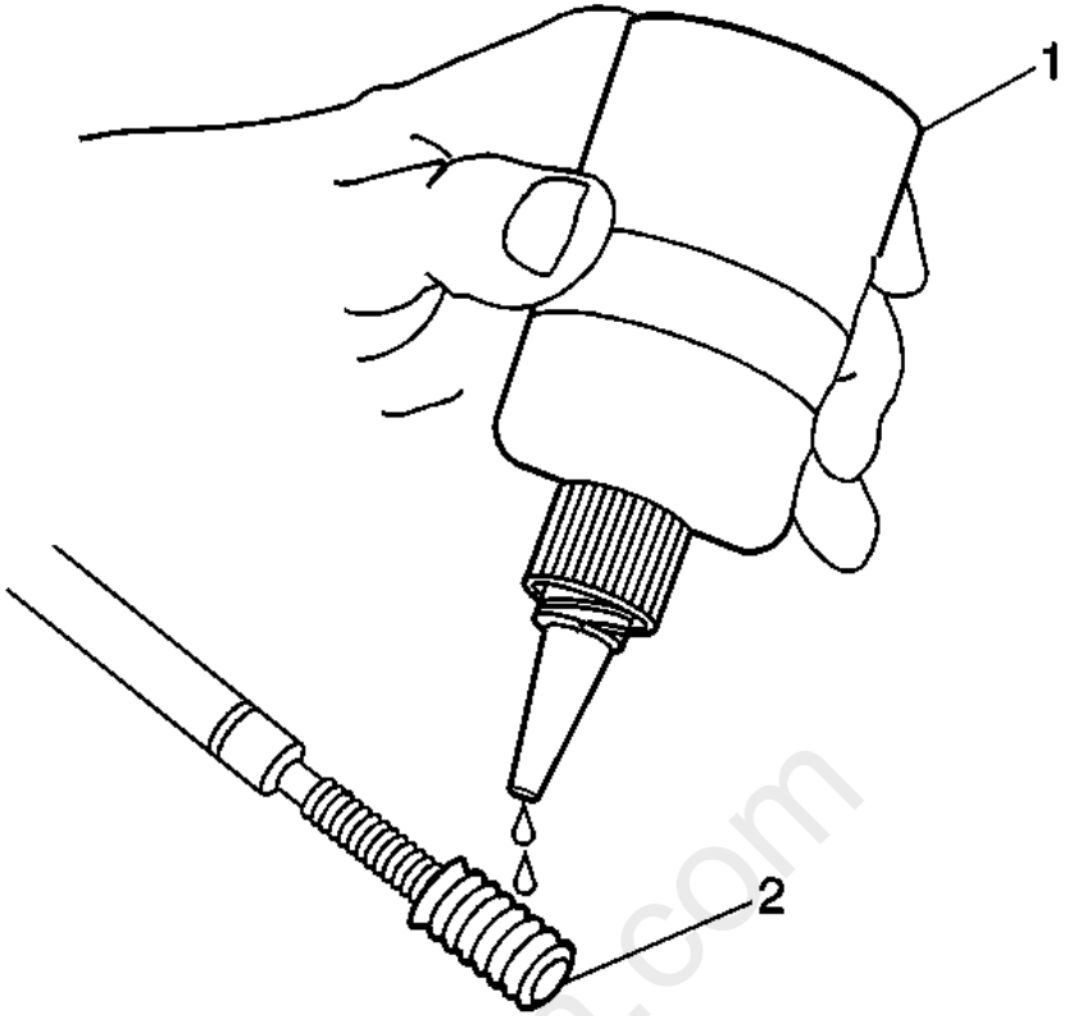


Fig. 278: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

11. Install the insert (2) into the tapped hole by hand only.

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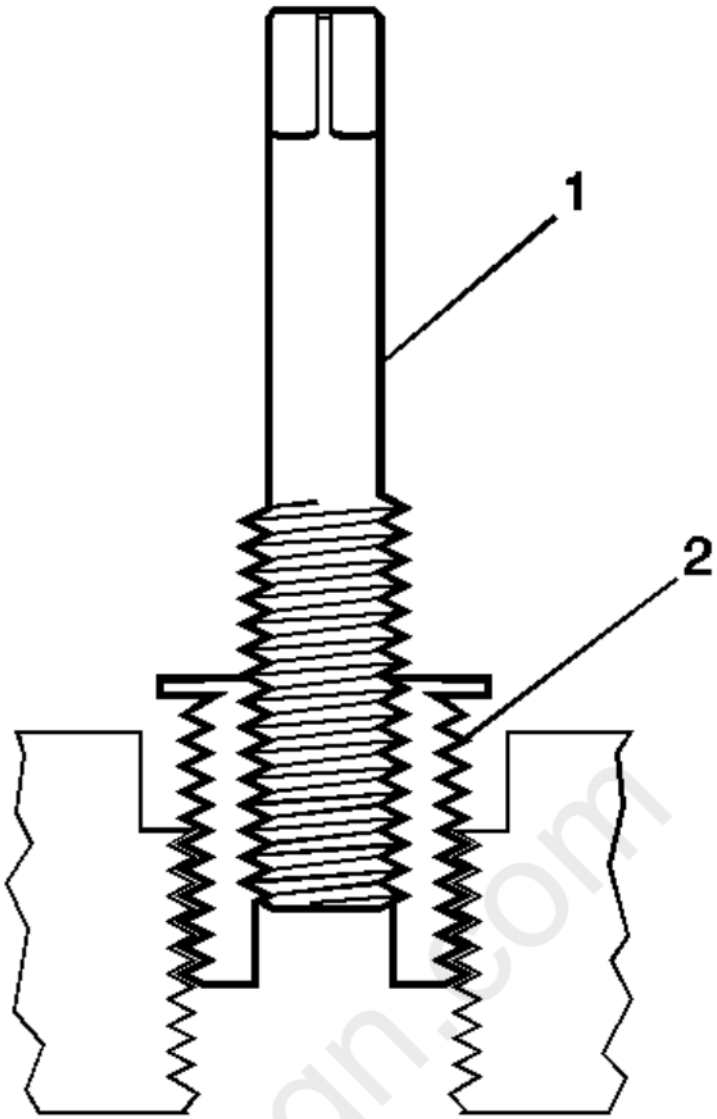


Fig. 279: Installing Insert - Recessed Thread
Courtesy of GENERAL MOTORS COMPANY

12. Install the insert until the flange (2) of the insert contacts the counterbored surface.

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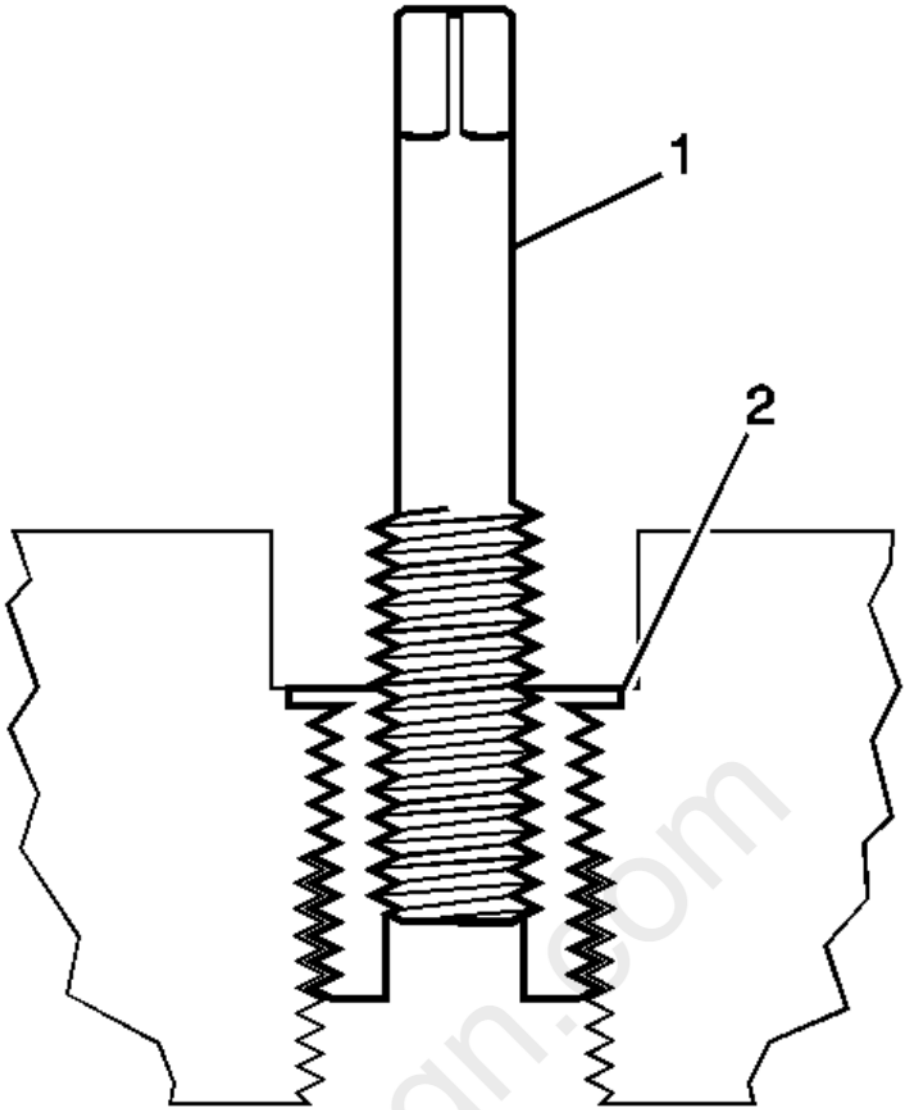


Fig. 280: View Of Installed Insert - Recessed Thread
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.**

13. Continue to rotate the driver installation tool (1) through the insert (2).

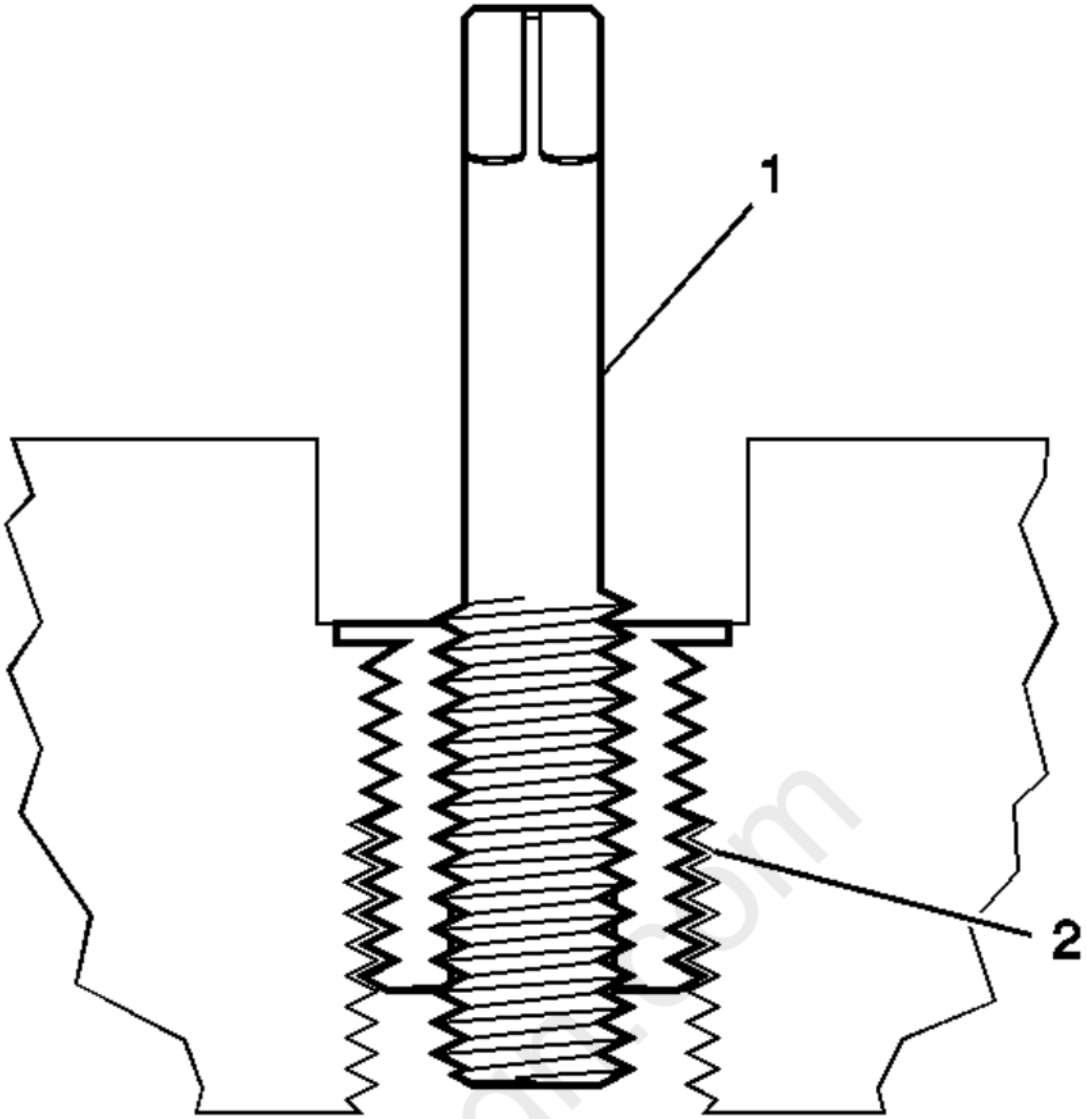


Fig. 281: Installed Insert - Recessed Thread Repair
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.**

14. Inspect the insert (1) for proper installation (2) into the tapped hole.

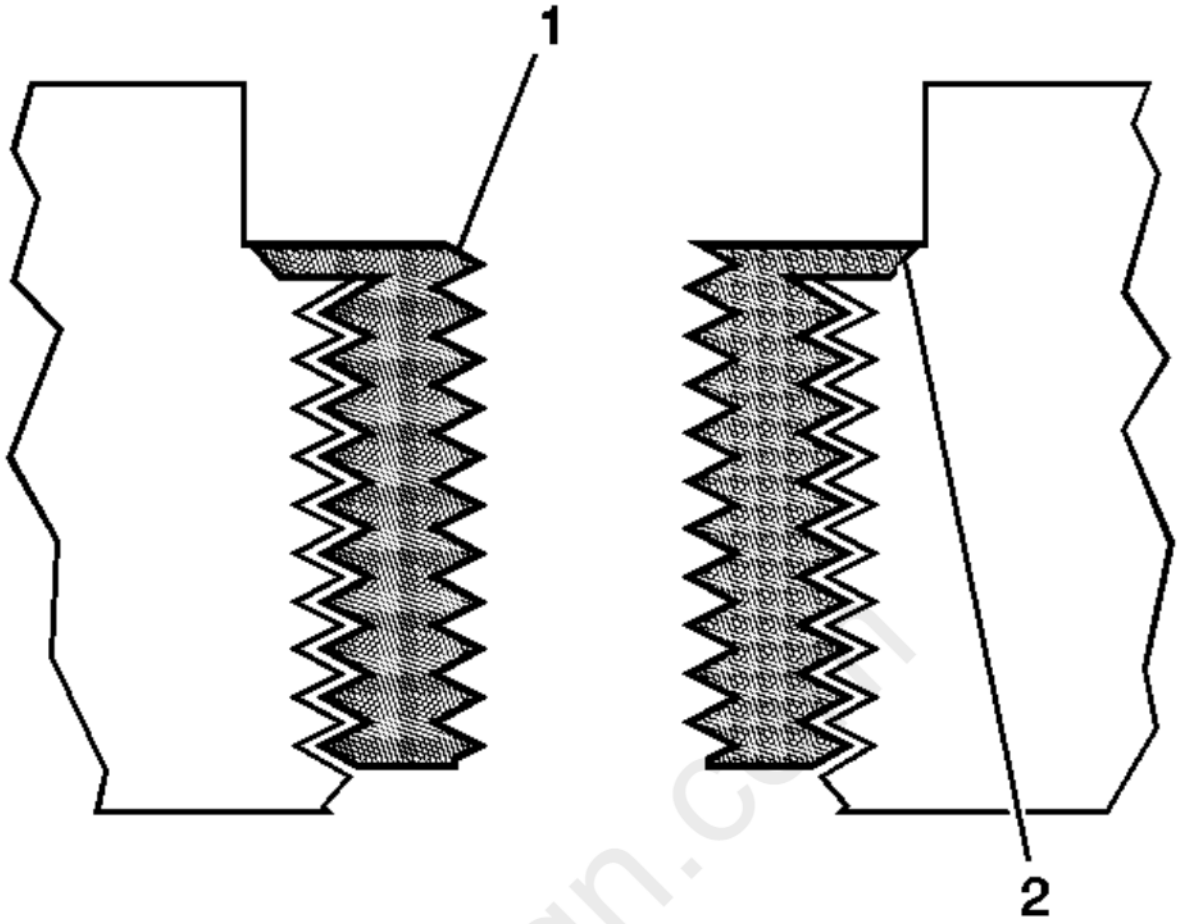


Fig. 282: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS COMPANY

15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

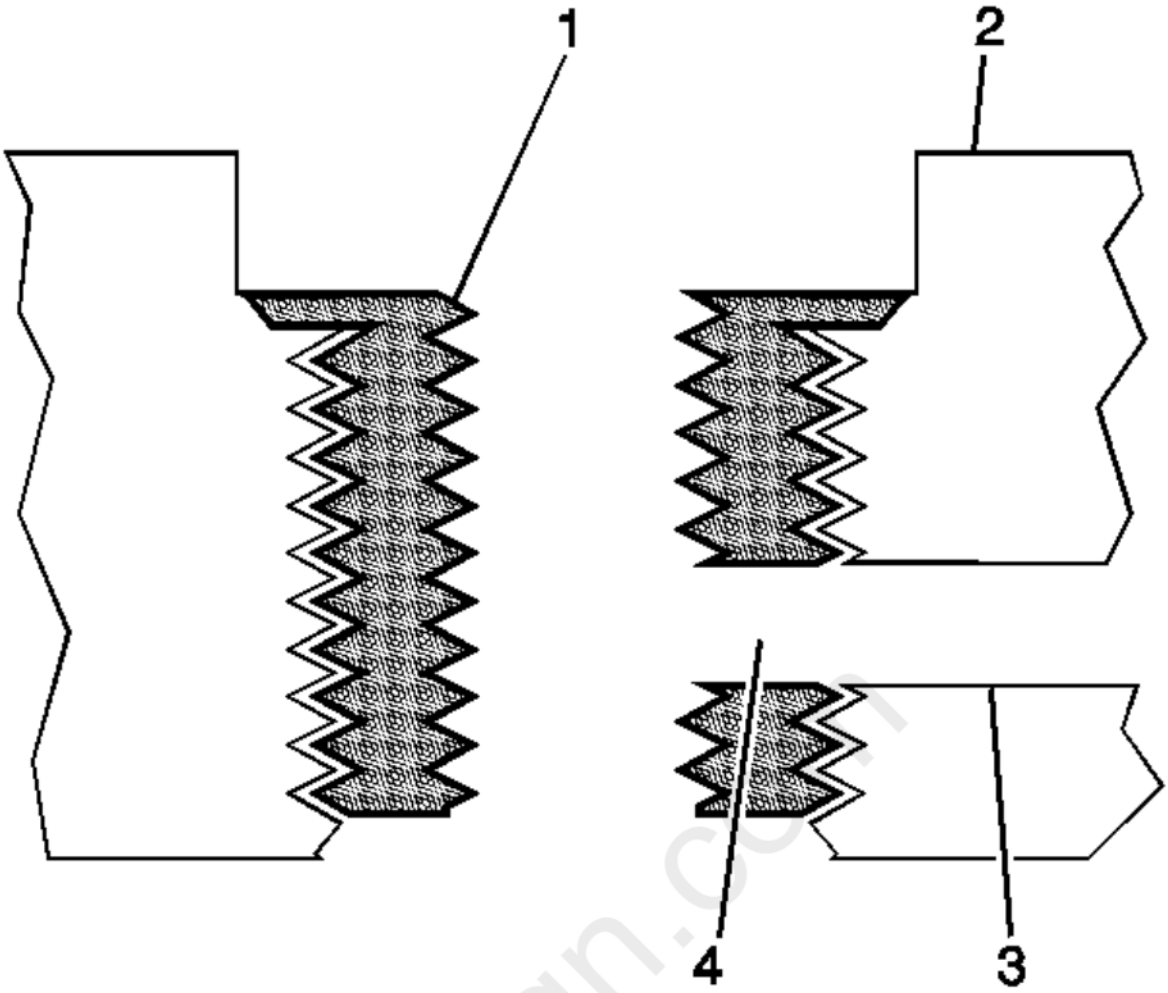


Fig. 283: View Of Restricted Engine Coolant Passage - Recessed Thread Repair
Courtesy of GENERAL MOTORS COMPANY

Tapered Pipe Thread Repair

The thread repair insert for tapered pipe threads is coated with a clear silver zinc coating.

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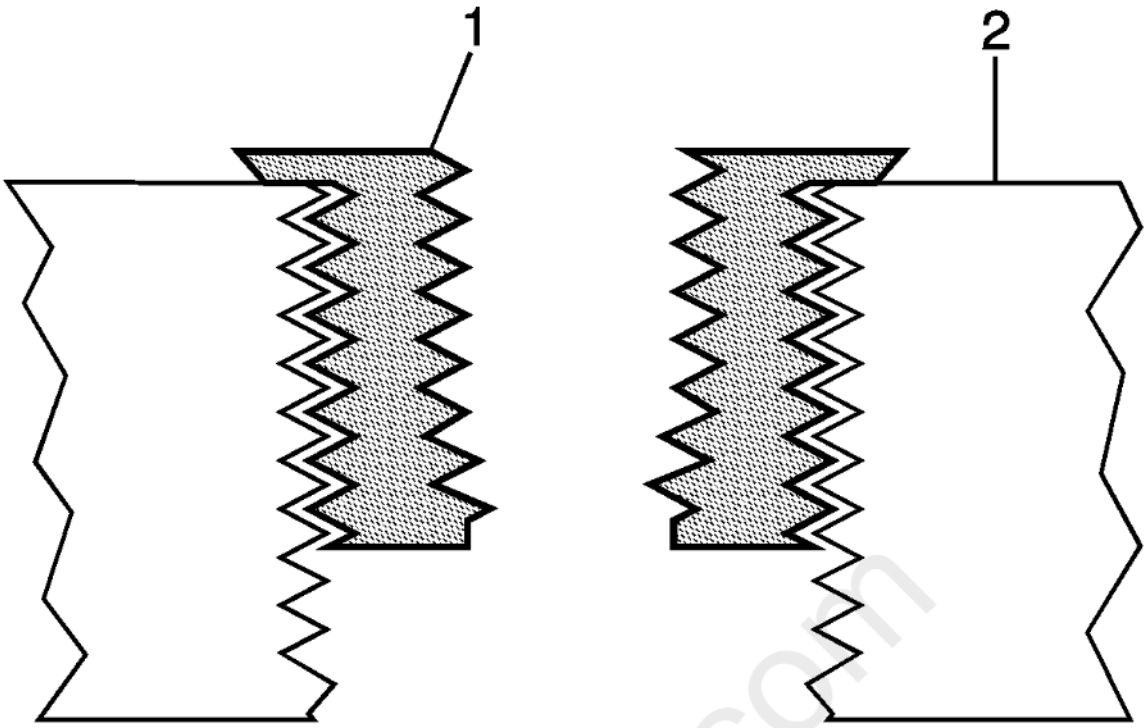


Fig. 284: Inspecting Insert For Proper Installation - Tapered Thread
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Safety Glasses Warning .

NOTE: The use of a cutting type fluid, WD 40Â® or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants and Sealers for recommended cutting fluid.

When installed to the proper depth, the flange (1) of the insert will be seated against surface (2) of the base material of the drilled/tapped hole.

1. Drill out the threads of the damaged hole.

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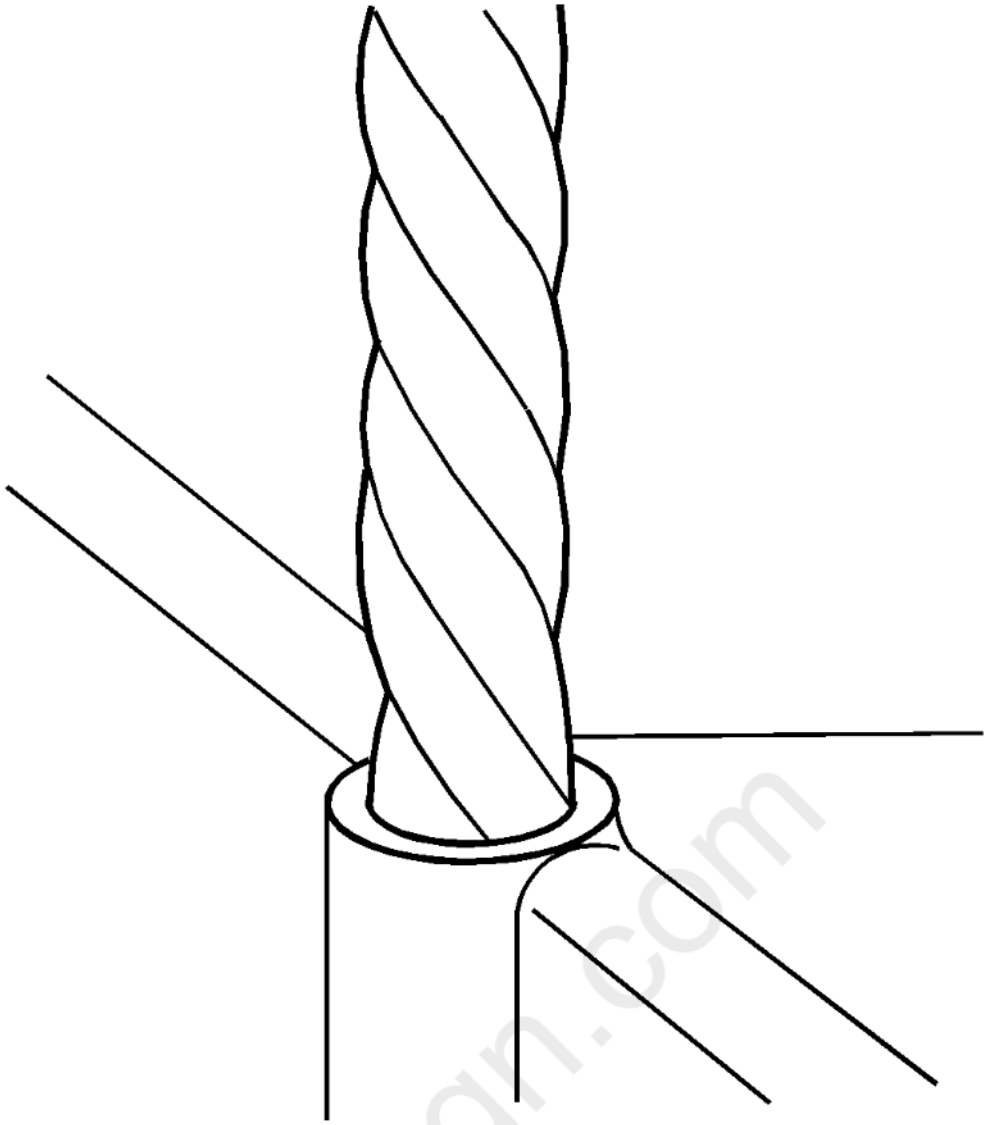


Fig. 285: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the hole until the stop collar contacts the surface of the base material.**

2. Using compressed air, clean out any chips.

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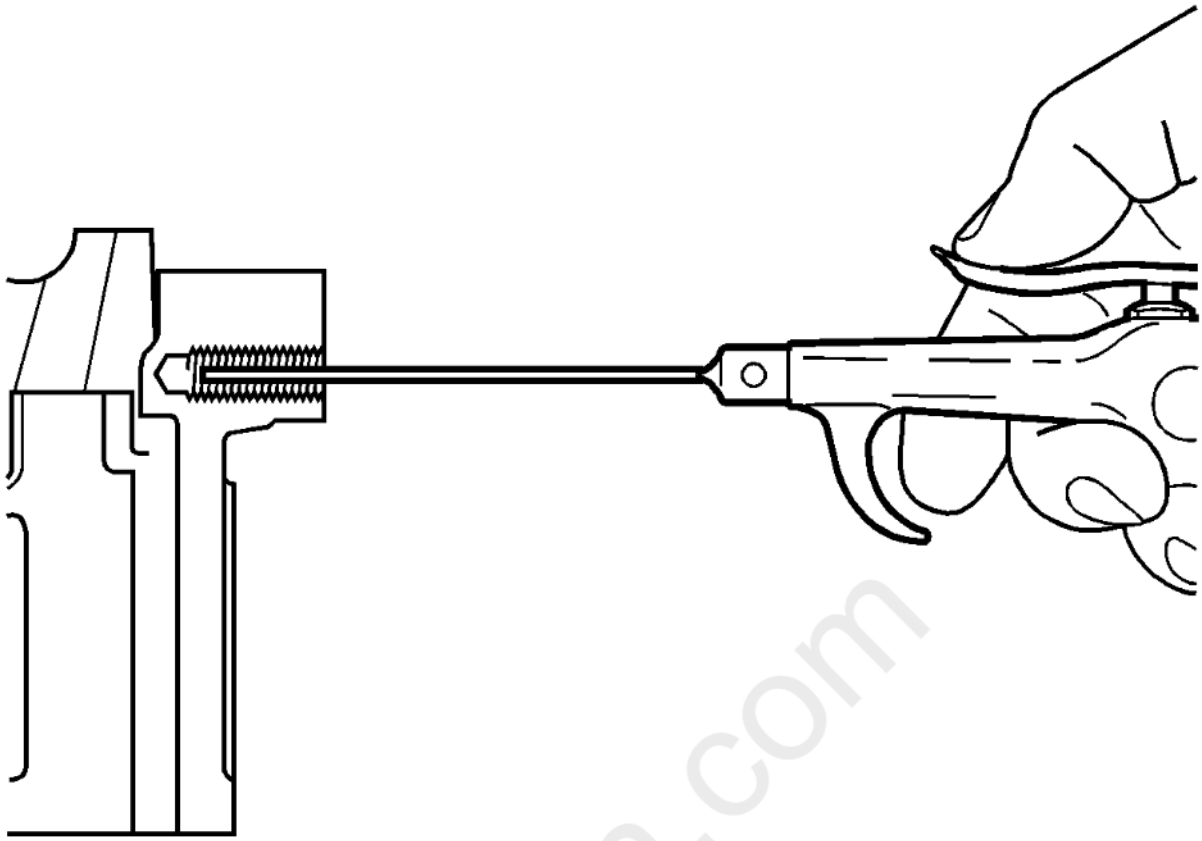


Fig. 286: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the drilled hole prior to tapping.**

3. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

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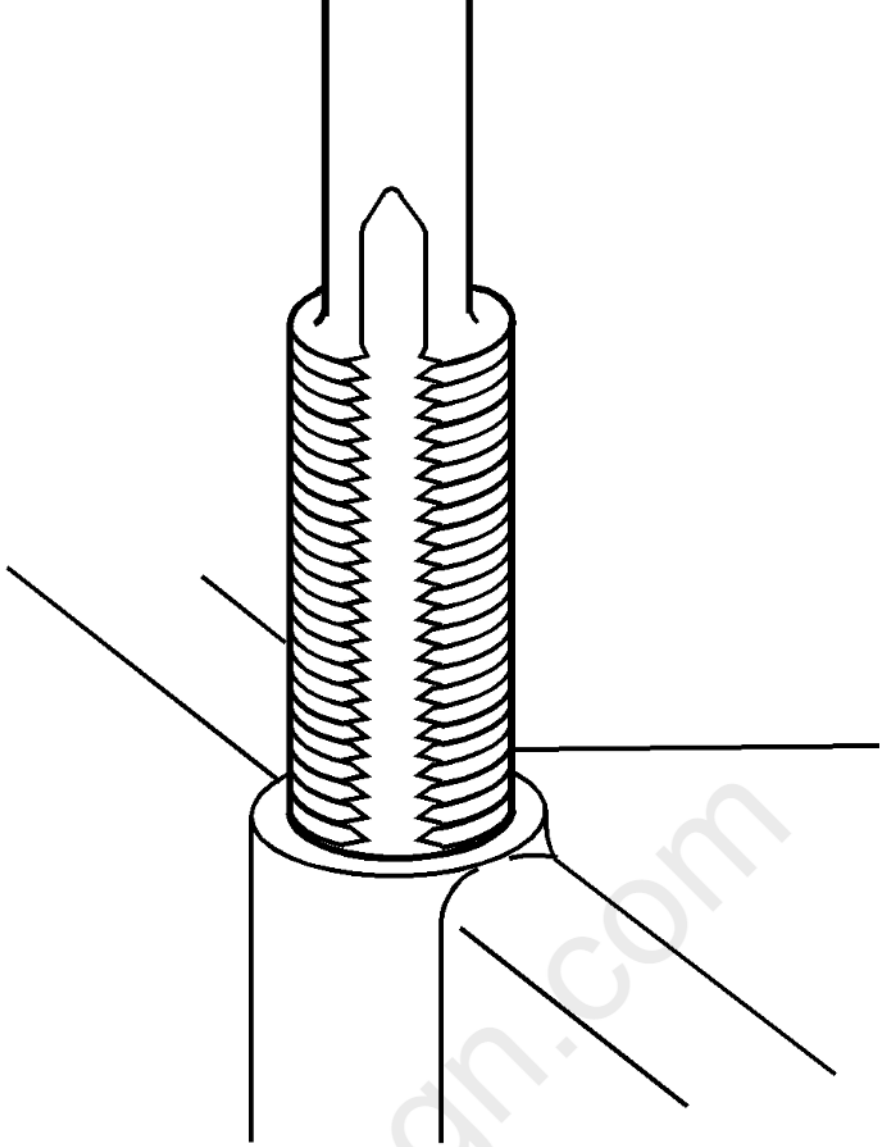


Fig. 287: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

4. Tap the drilled hole until the threads at the top of the tap (2) are down to the surface of the base material.

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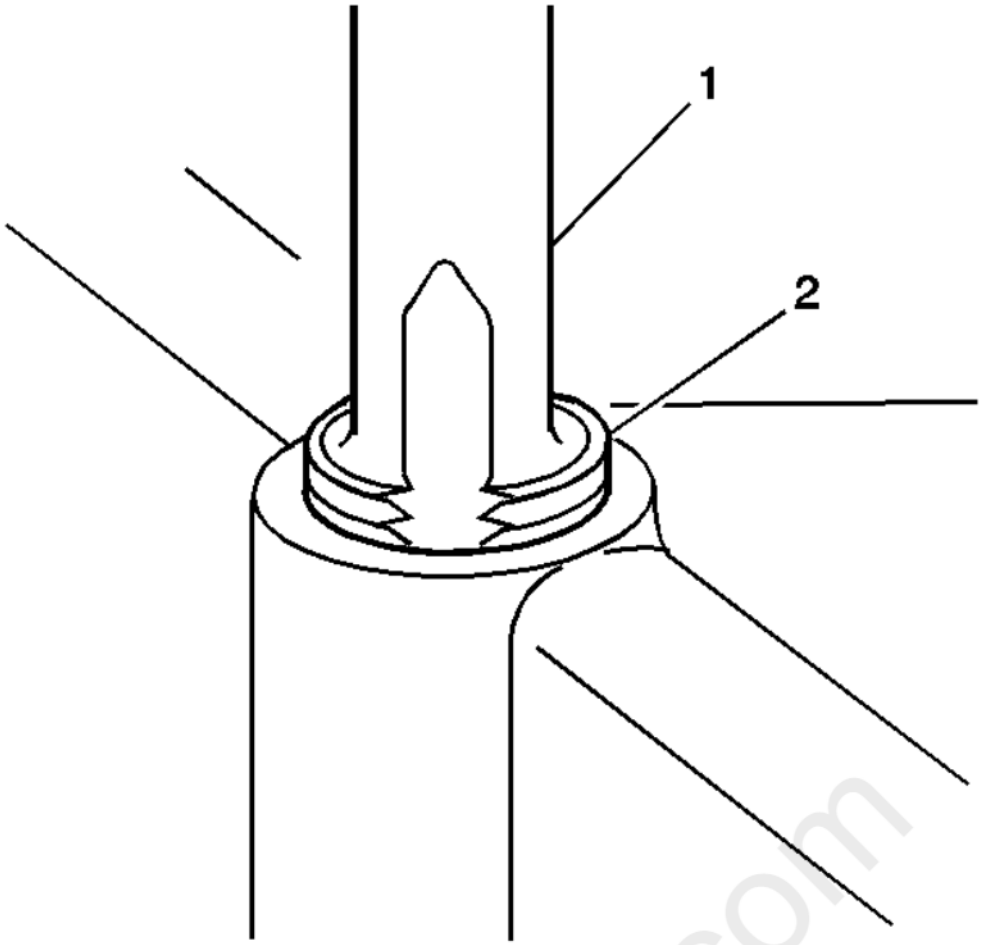


Fig. 288: View Of Proper Tapping Distance - Tapered Thread
Courtesy of GENERAL MOTORS COMPANY

5. Using compressed air, clean out any chips.

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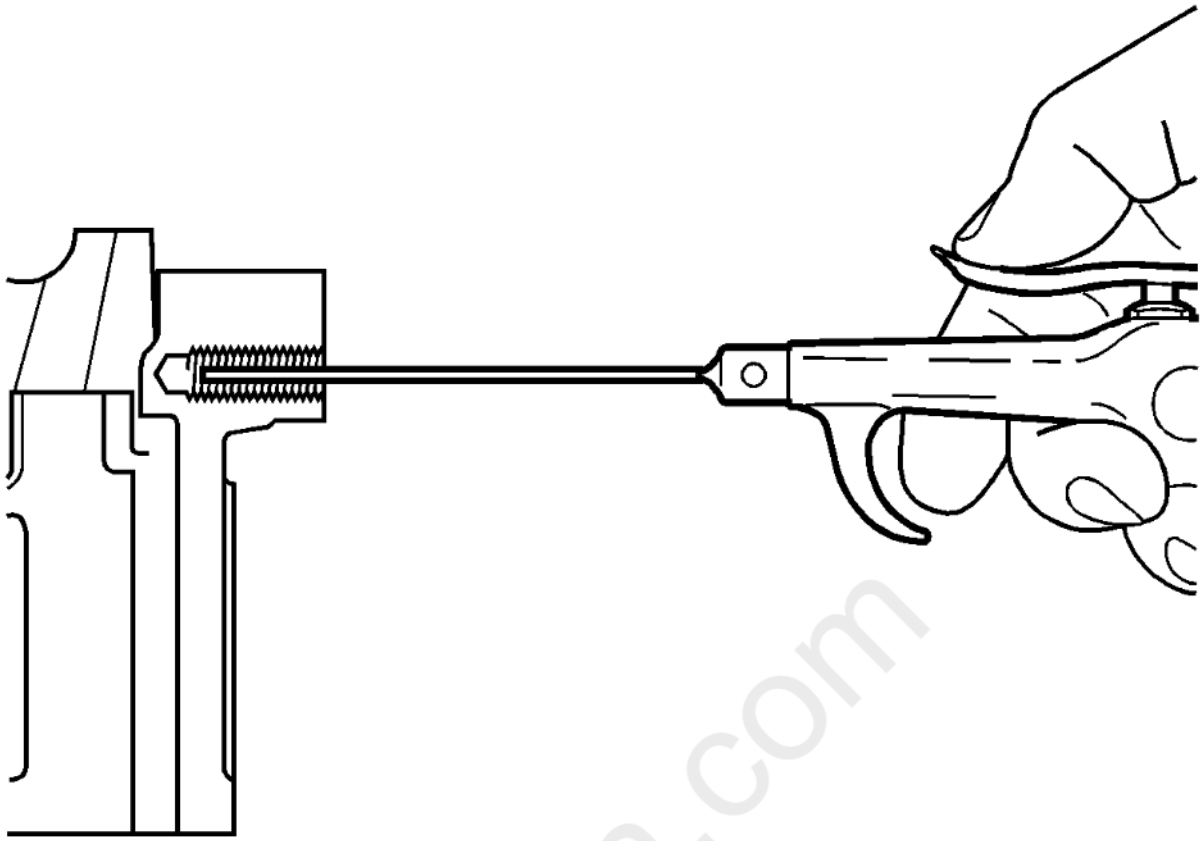


Fig. 289: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

6. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended cleaner.

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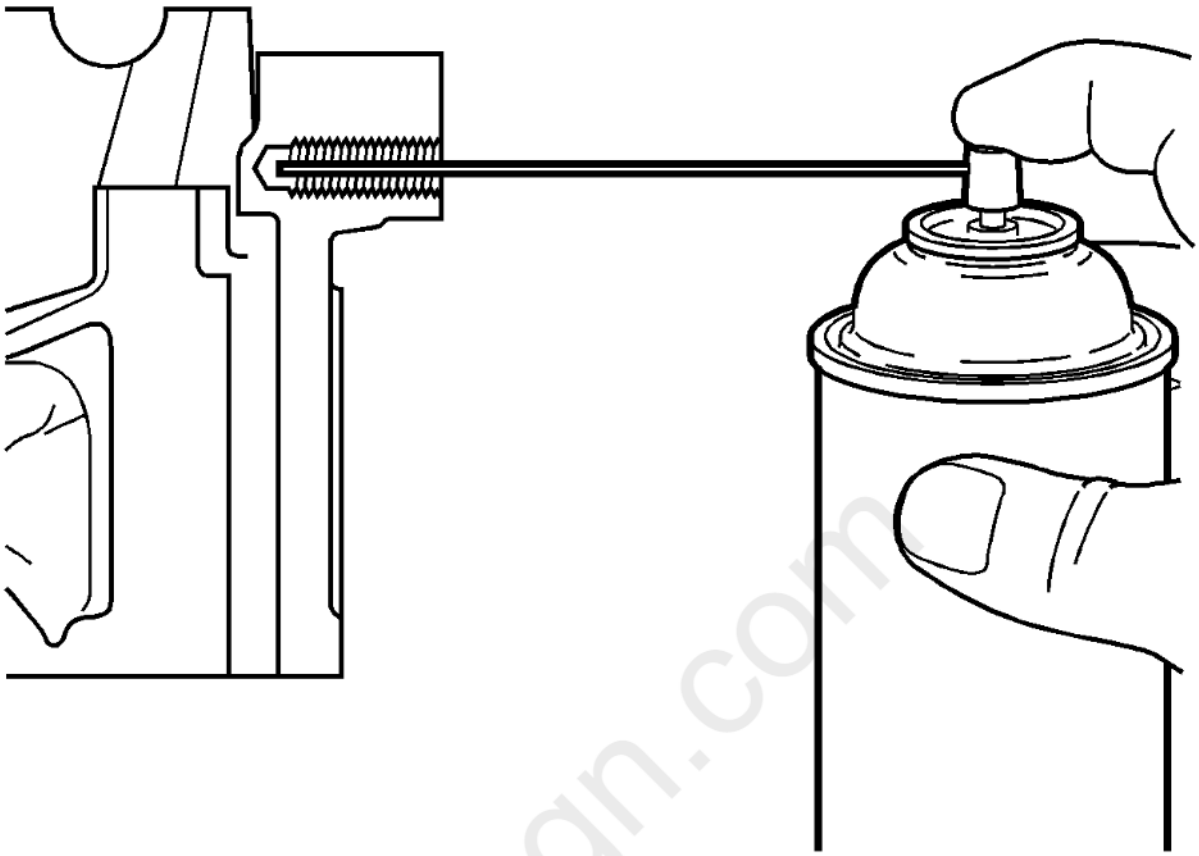


Fig. 290: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS COMPANY

7. Using compressed air, clean out any chips.

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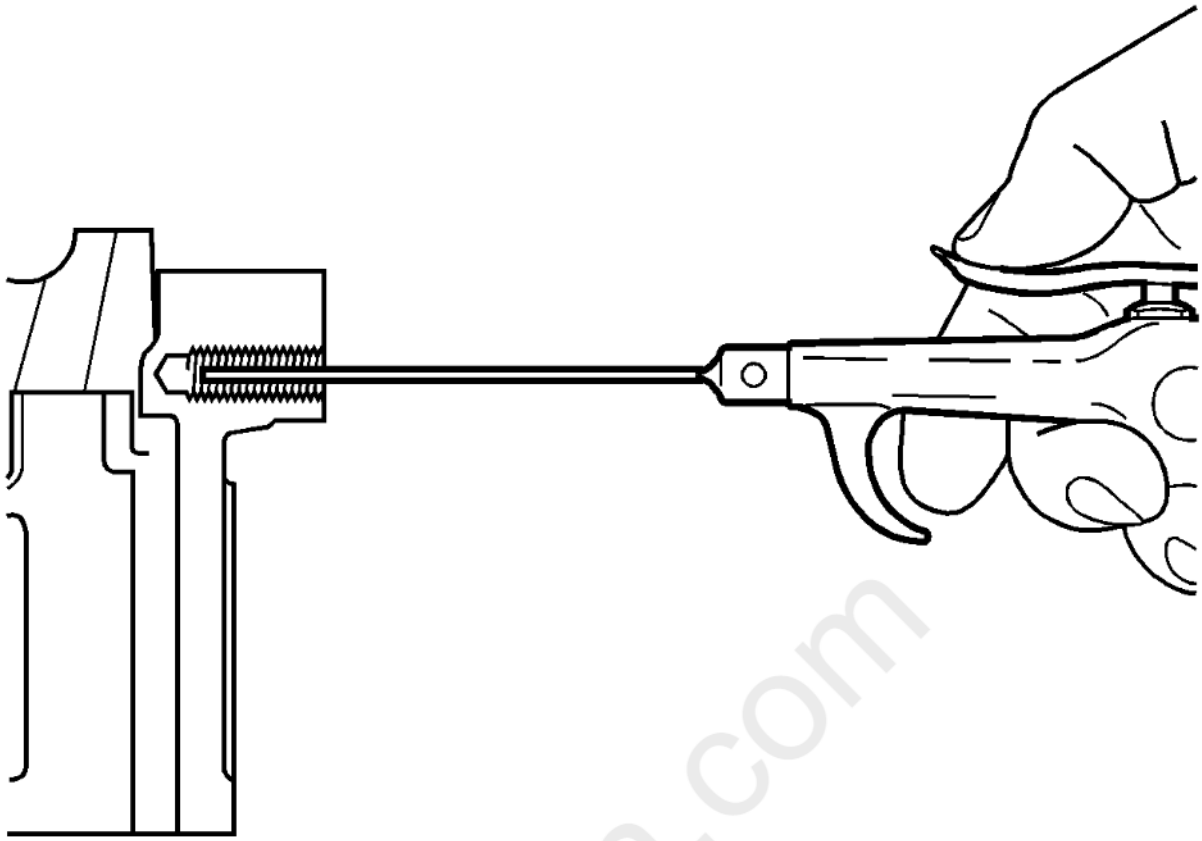


Fig. 291: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

8. Lubricate the threads of the driver installation tool (2) with the **EN 42385-110** (1).

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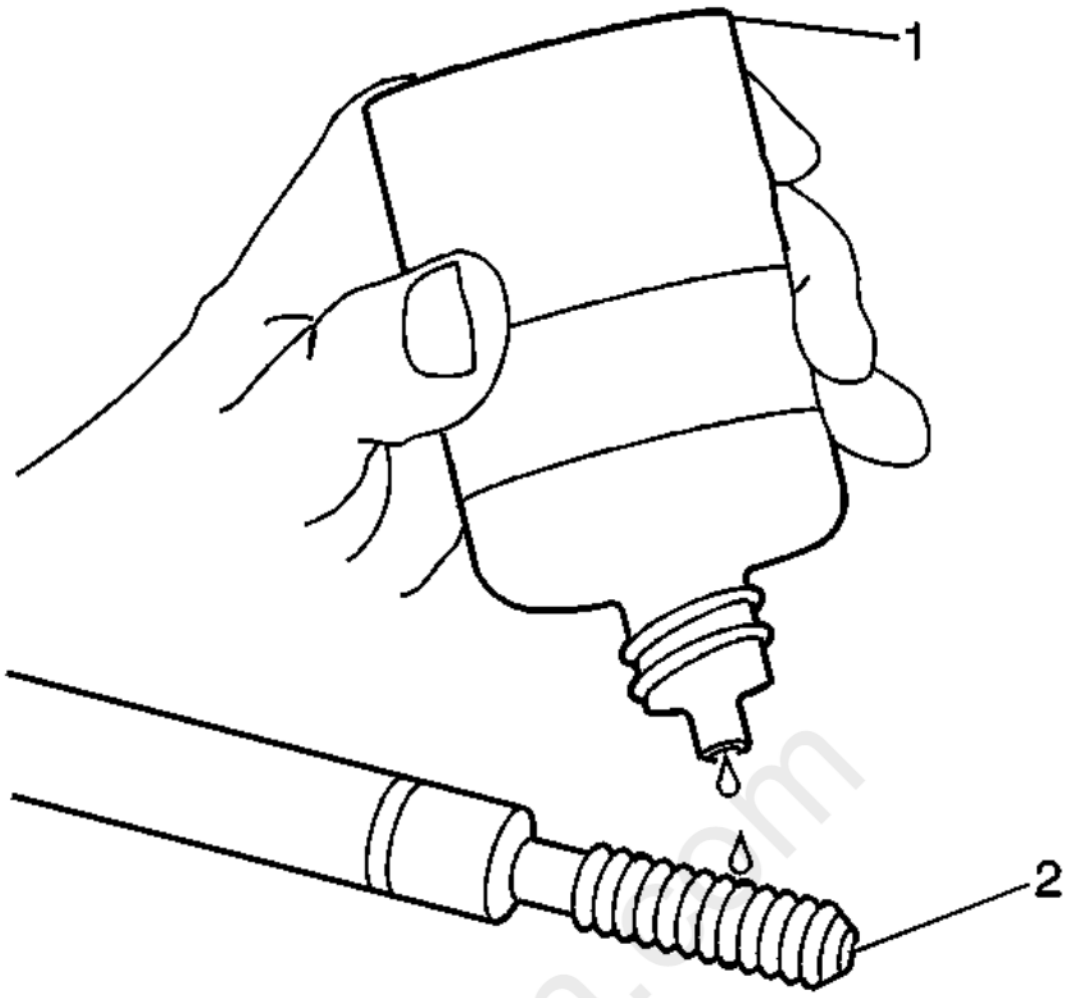


Fig. 292: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.**

9. Install the insert (2) onto the driver installation tool (1).

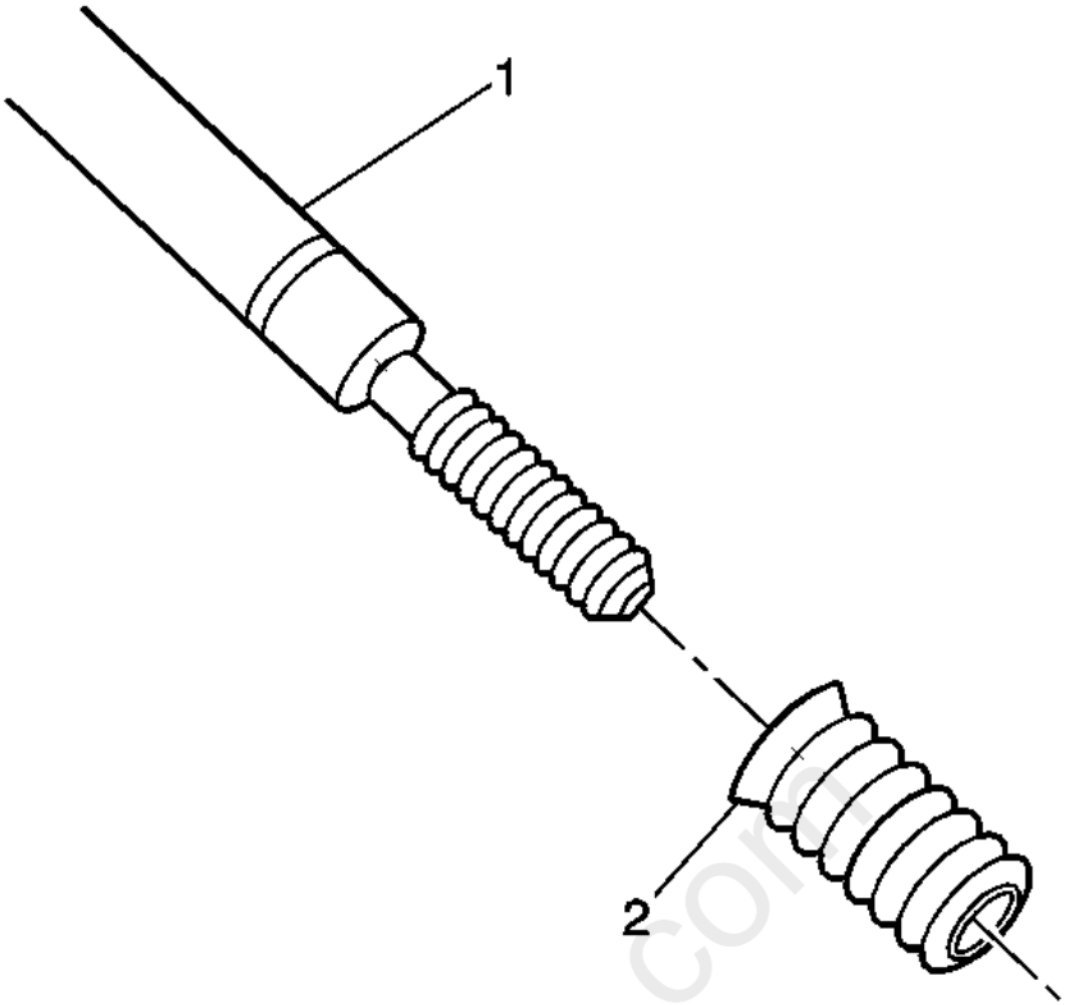


Fig. 293: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

10. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277Â® or equivalent (1) to the insert OD threads (2). Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant.

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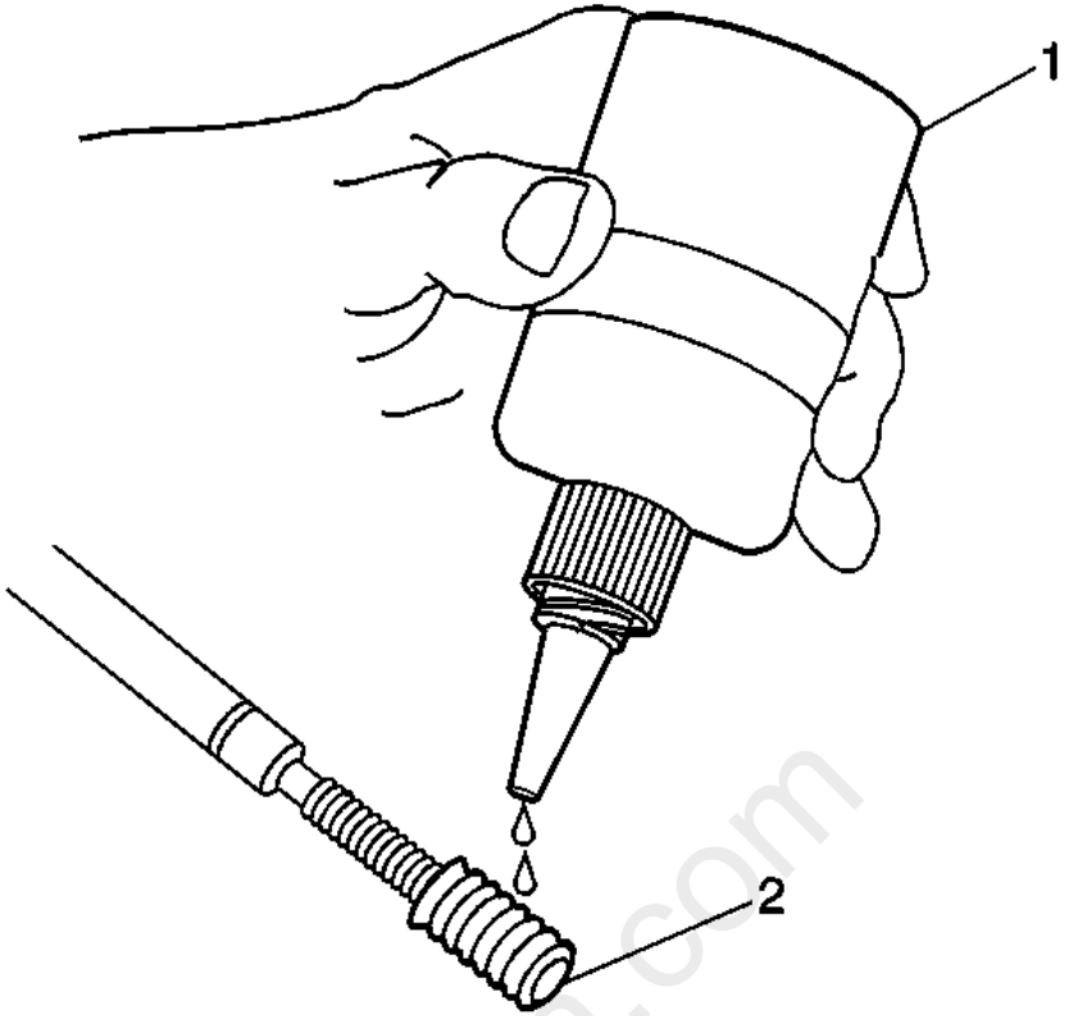


Fig. 294: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

11. Install the insert (2) into the tapped hole by hand only.

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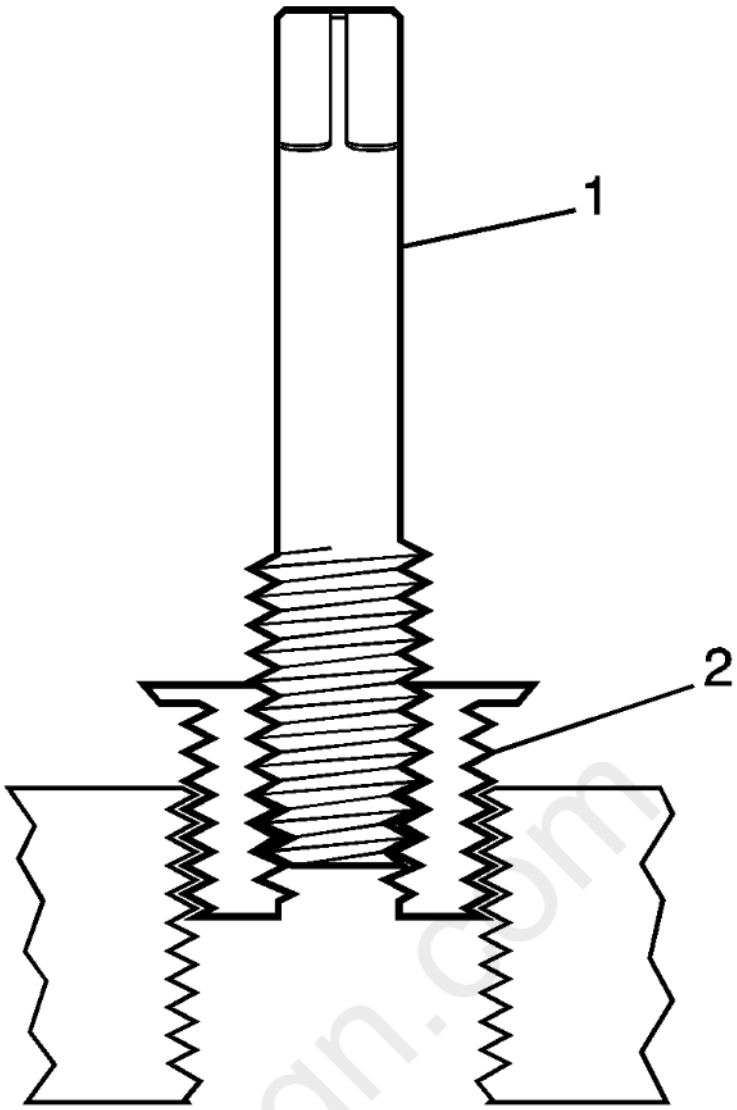


Fig. 295: View Of Insert - Tapered Thread
Courtesy of GENERAL MOTORS COMPANY

12. Install the insert until the flange of the insert (3) contacts the surface of the base material.

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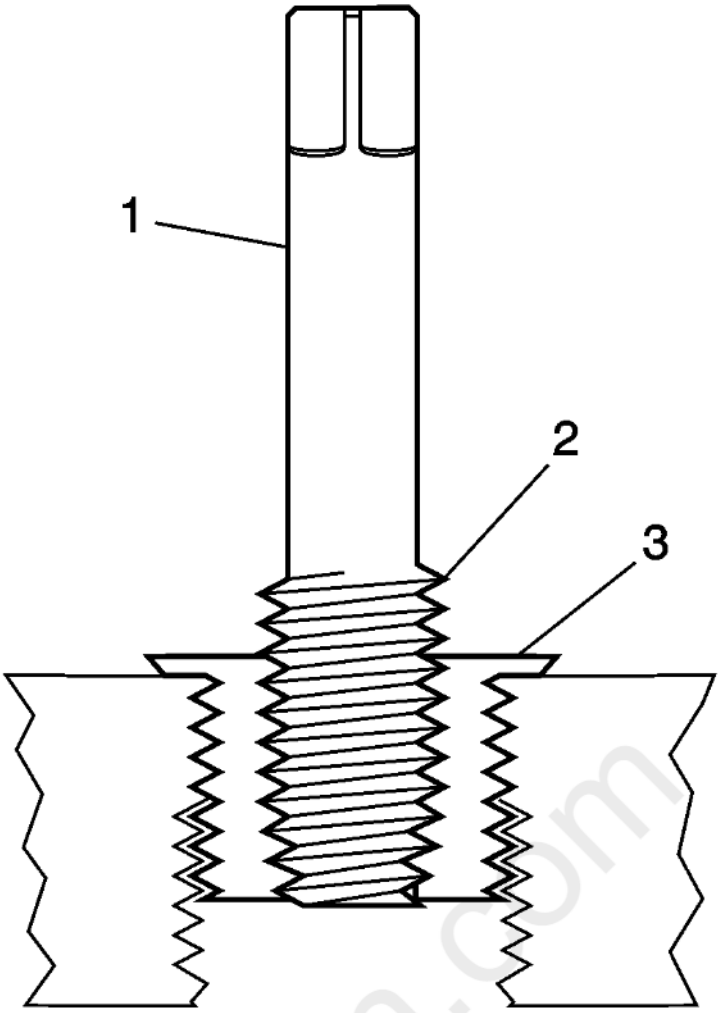


Fig. 296: View Of Insert - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the insert will not thread down until the flange contacts the surface of the base material remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.**

13. Continue to rotate the driver installation tool (1) until the top of the threaded section (2) is level with the top of the insert (3).

NOTE: **The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.**

14. Inspect the insert (1) for proper installation (2) into the tapped hole.

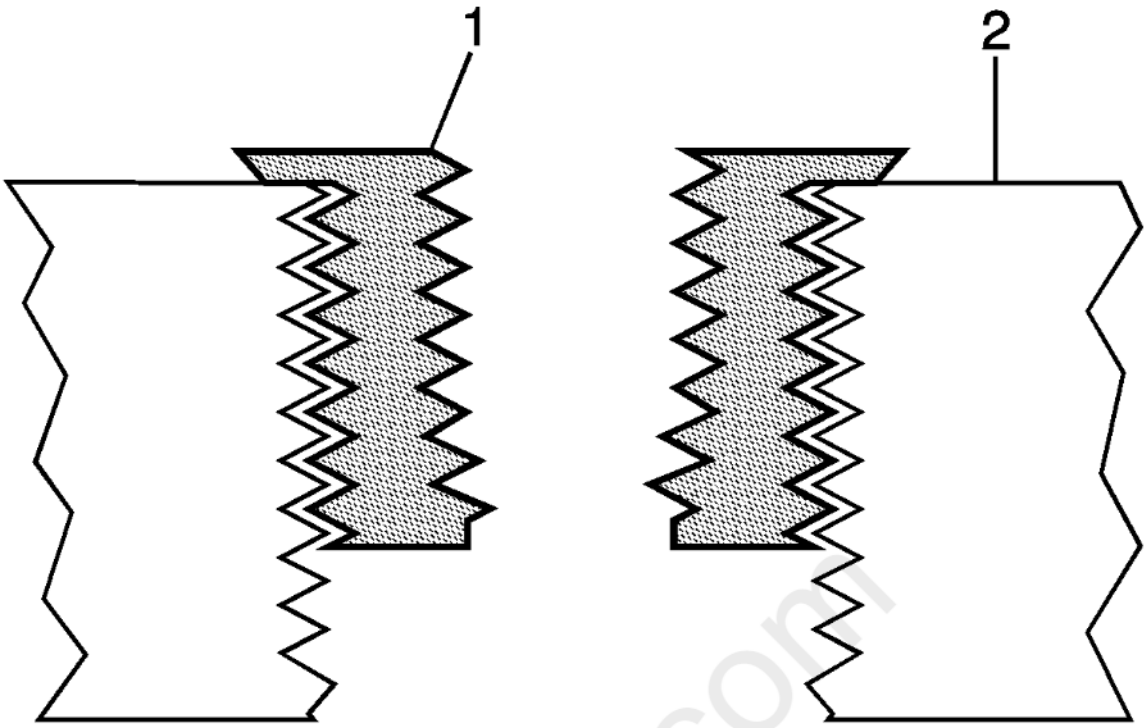


Fig. 297: Inspecting Insert For Proper Installation - Tapered Thread
Courtesy of GENERAL MOTORS COMPANY

15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

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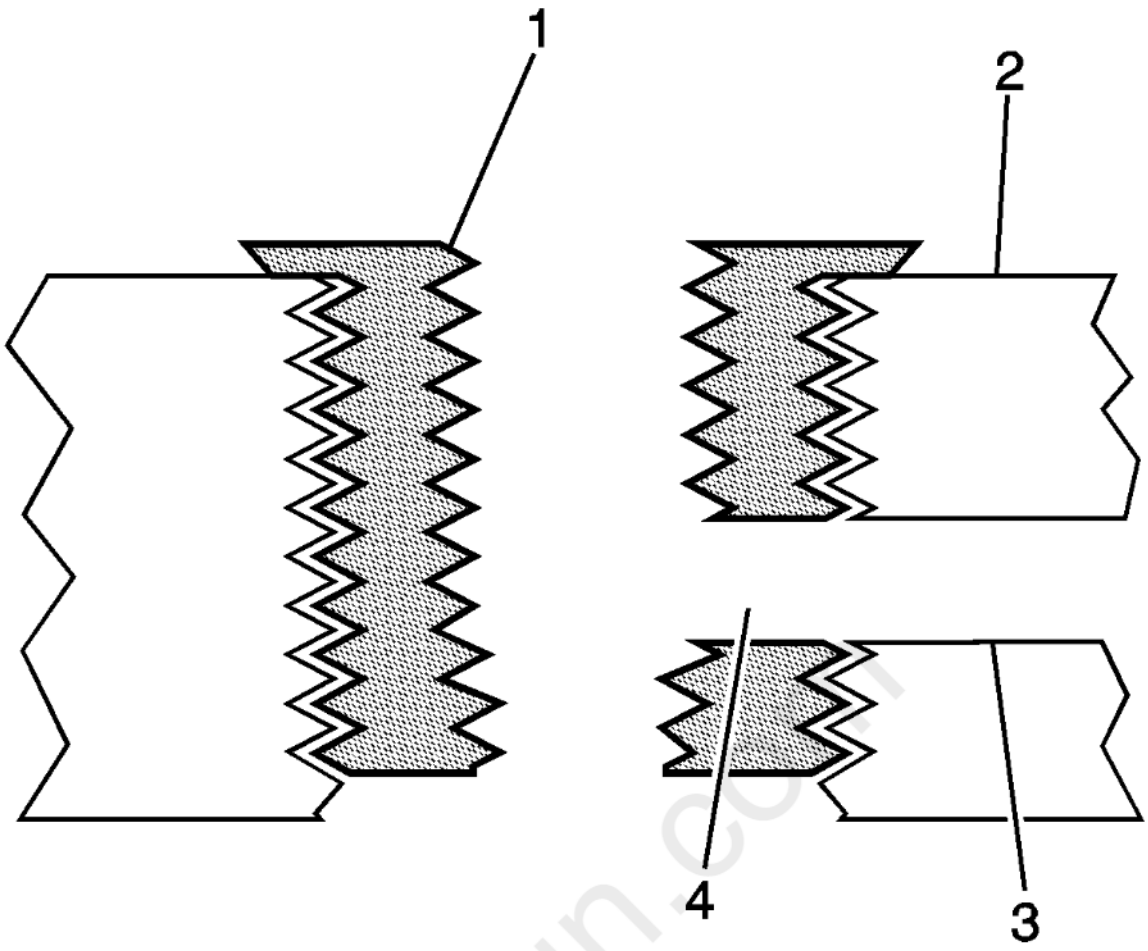


Fig. 298: View Of Restricted Engine Coolant Passages - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS COMPANY

Cylinder Head Bolt Hole Thread Repair

Special Tools

- **EN-42385-70** Head Bolt Thread Repair Fixture
- **EN-42385-700** High Feature Thread Repair Kit
- **EN-42385-2000** Thread Insert Kit

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

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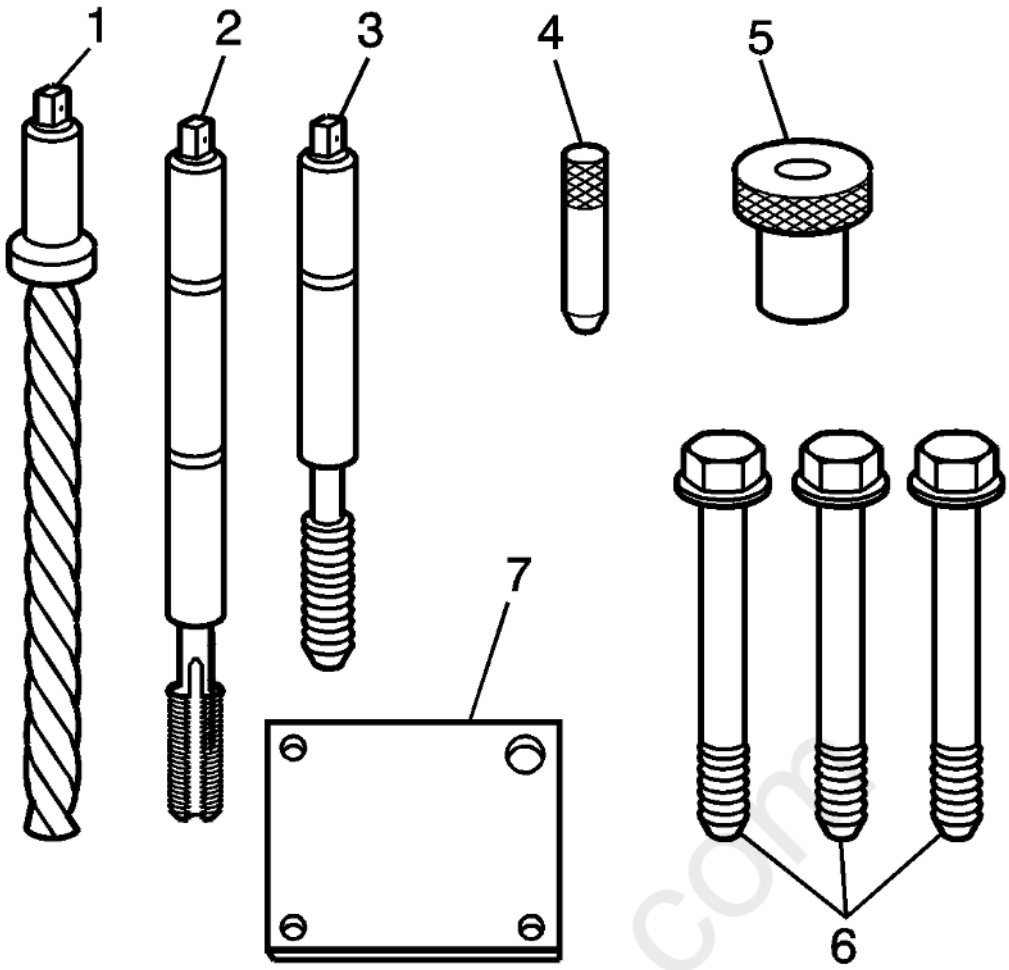


Fig. 299: Identifying Cylinder Head Bolt Hole Thread Repair Kit Components
Courtesy of GENERAL MOTORS COMPANY

The cylinder head bolt hole thread repair tooling are in the kits **EN-42385-2000** insert kit and **EN-42385-700** kit. The cylinder head bolt hole thread repair components consist of the following:

- **EN-42385-723** Drill (1)
- **EN-42385-724** Tap (2)
- **EN-42385-725** Installation driver (3)
- **EN-42385-303** Alignment pin (4)
- **EN-42385-70** Bushing (5)
- **EN-42385-733** Bolts (6)
- **EN-42385-70** Fixture plate (7)

WARNING: **Refer to Safety Glasses Warning .**

NOTE:

- **Remove the fixture plate prior to installing the insert with the installer tool.**
- **The use of a cutting type fluid, WD 40Â®; or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants and Sealers for recommended cutting fluid.**

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

1. Position the fixture plate (3) with the bushing (1) installed over the cylinder head bolt hole to be repaired (4).

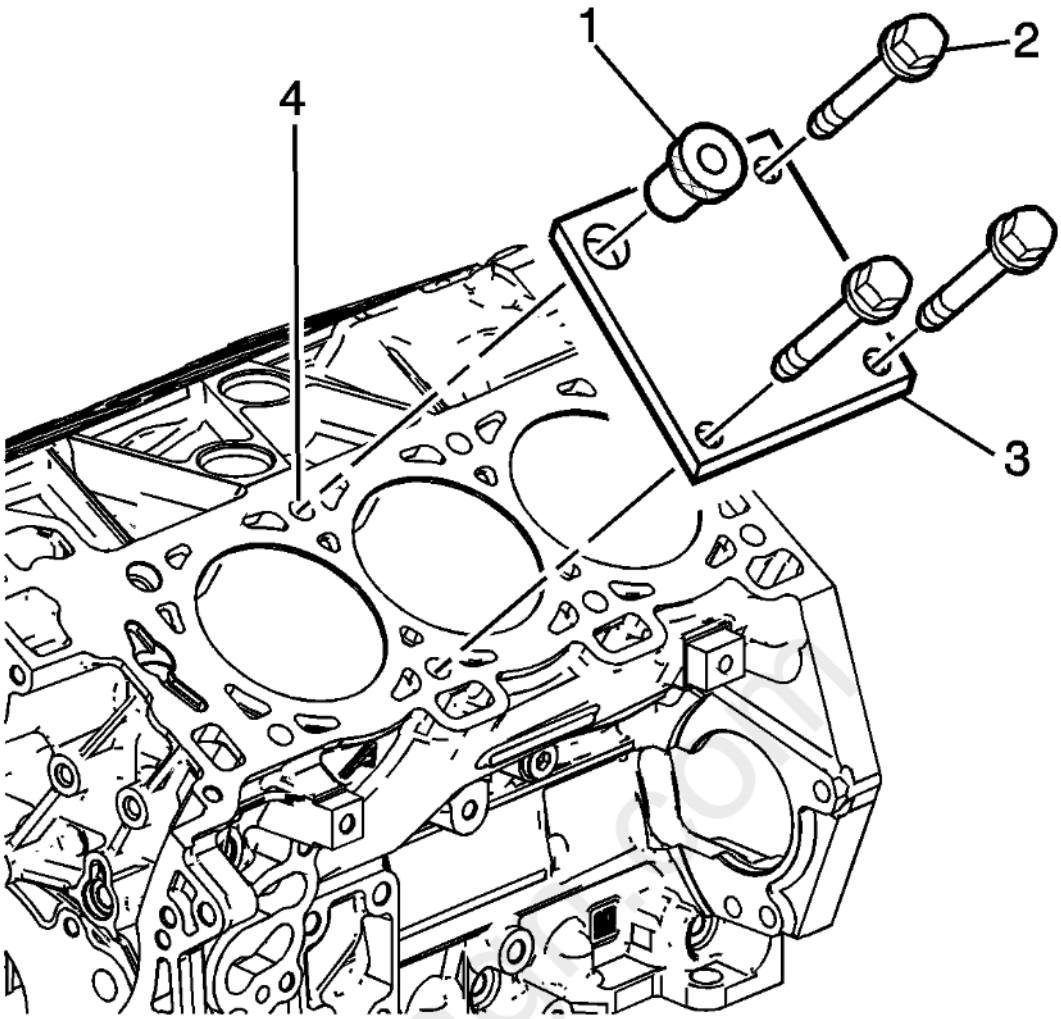


Fig. 300: View Of Fixture Plate & Components - Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

2. Loosely install the fixture plate bolts (2) into the remaining cylinder head bolt holes.
3. Position the alignment pin (1) through the bushing and into the cylinder head bolt hole.

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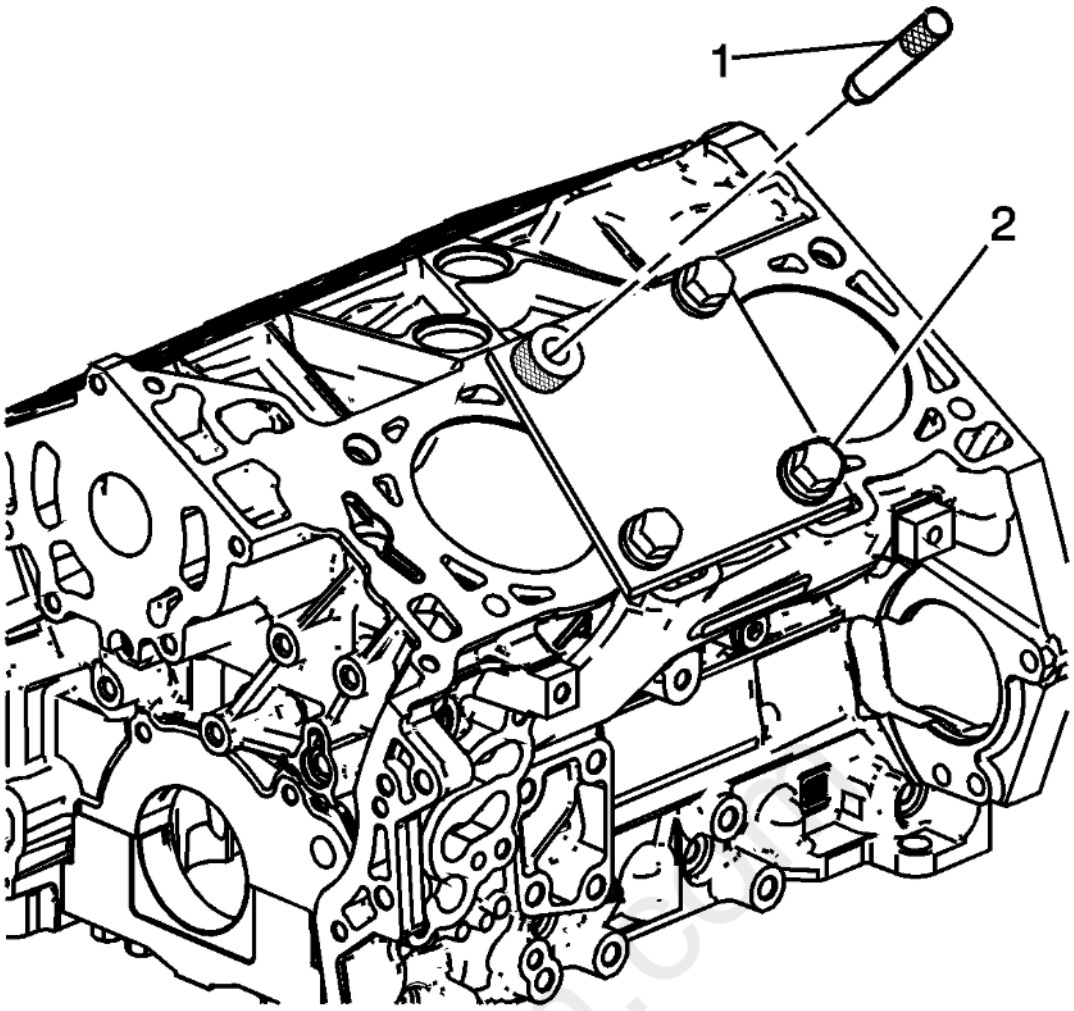


Fig. 301: Locating Alignment Pin
Courtesy of GENERAL MOTORS COMPANY

4. With the alignment pin in the desired cylinder head bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the cylinder head bolt hole.
6. Drill out the threads of the damaged hole.

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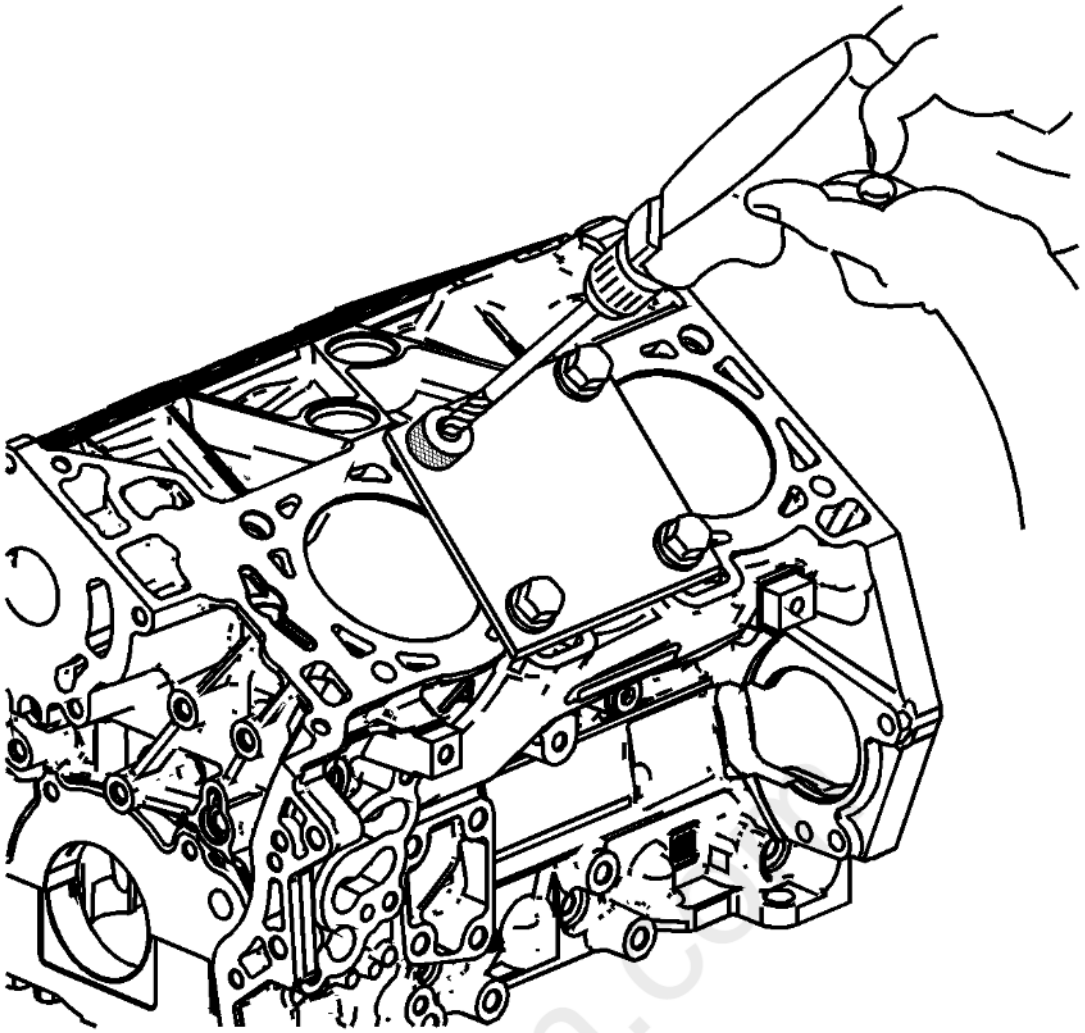


Fig. 302: Drilling Out Threads Of Damaged Hole - Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the hole until the stop collar contacts the top of the drill bushing.**

7. Using compressed air, clean out any chips.

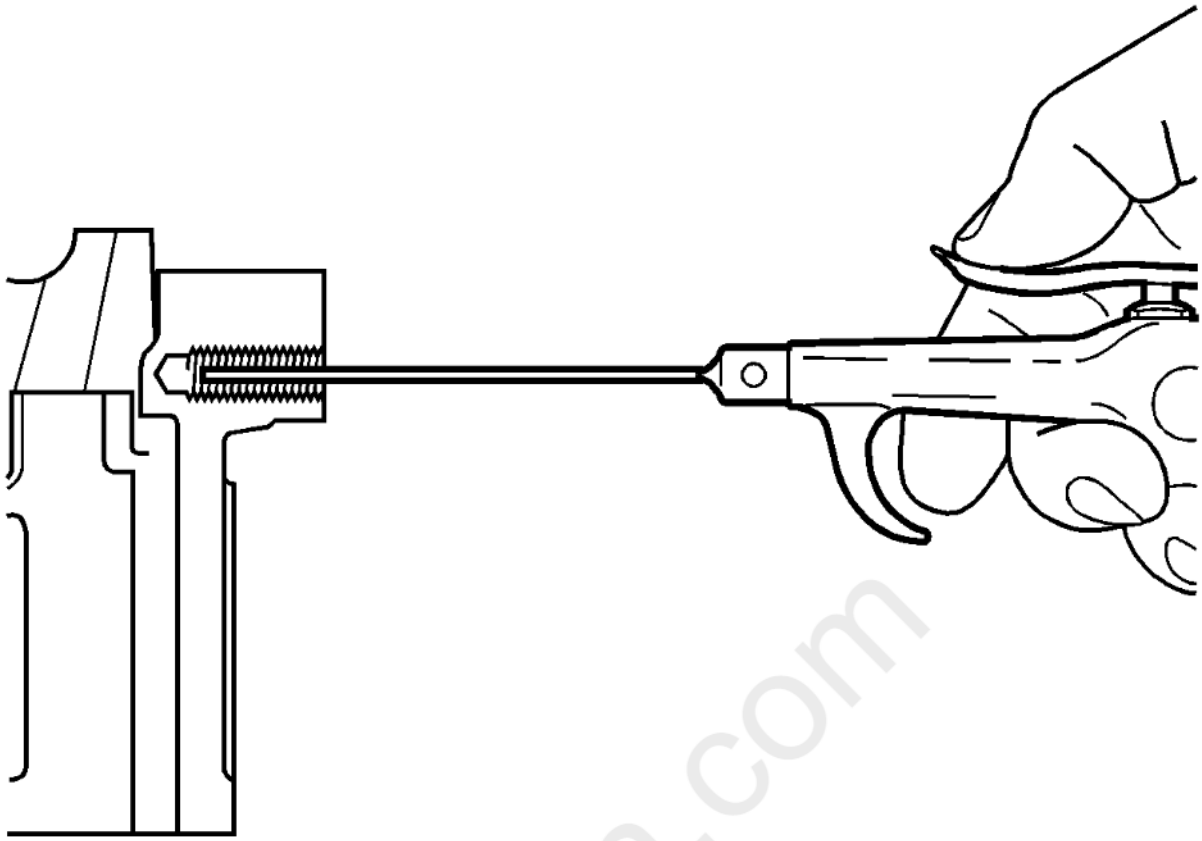


Fig. 303: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the drilled hole prior to tapping.**

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

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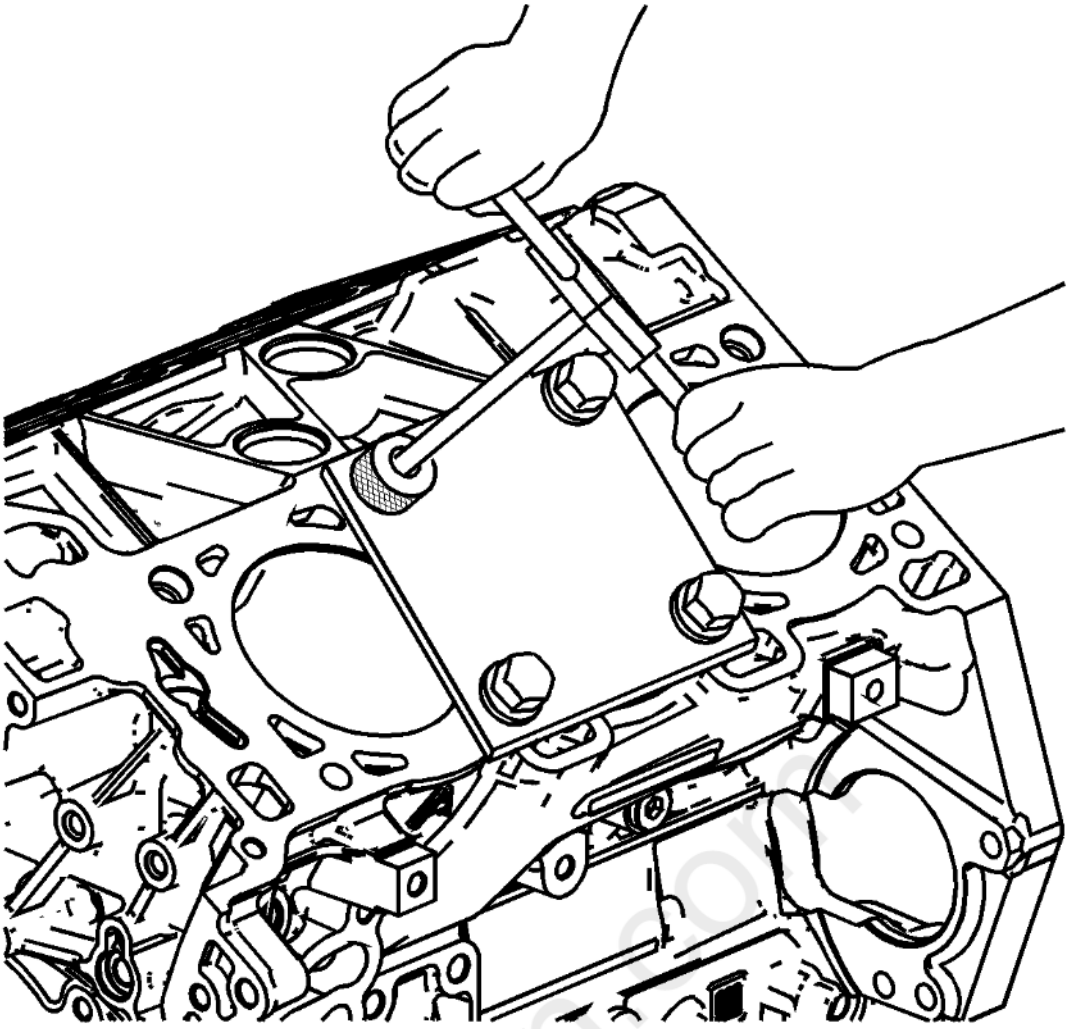


Fig. 304: Tapping Threads Of Drilled Hole Using Tapping Wrench - Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the cylinder head bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

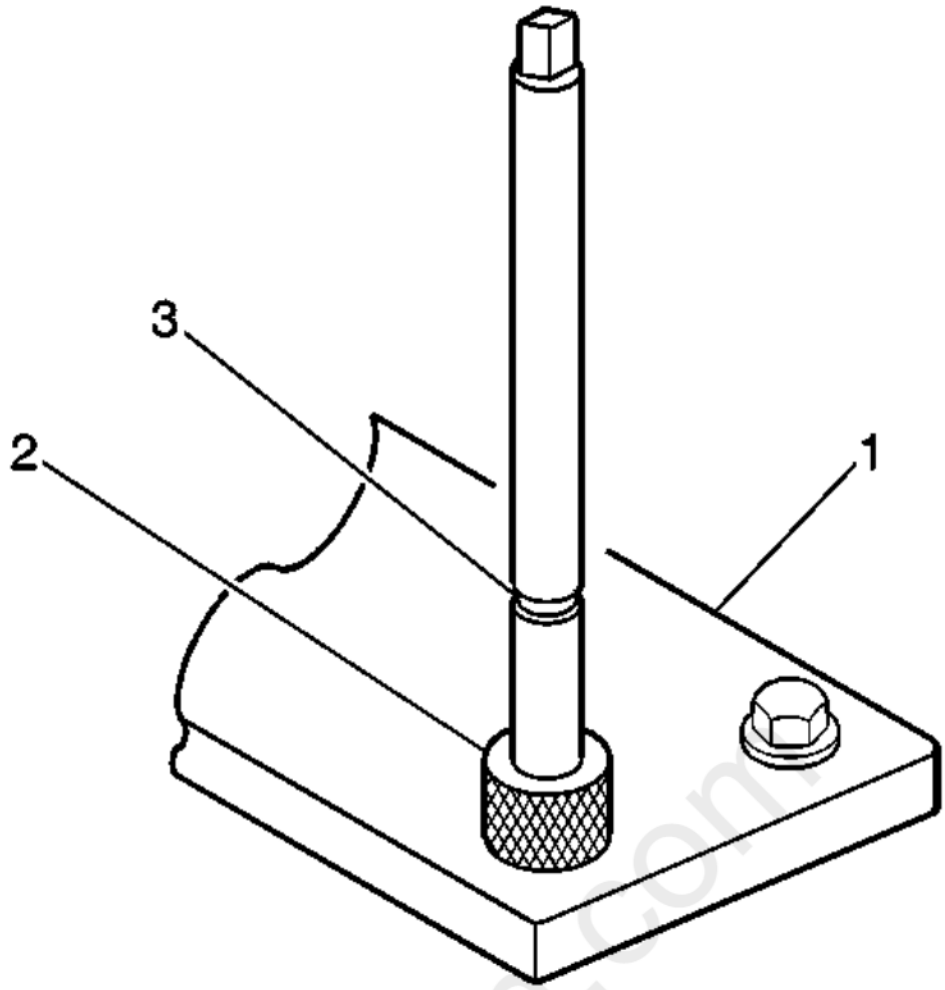


Fig. 305: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS COMPANY

10. Remove the fixture plate bolts (2).

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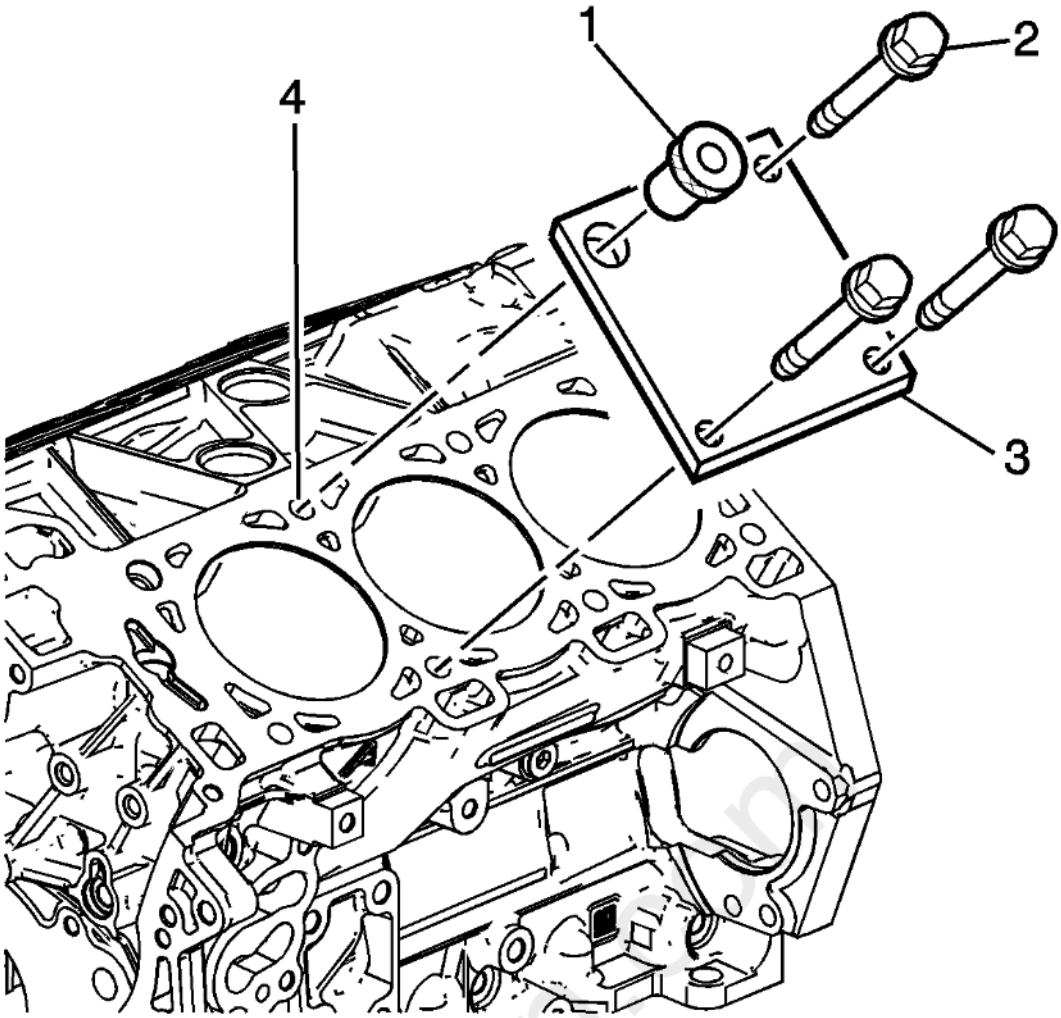


Fig. 306: View Of Fixture Plate & Components - Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Remove the fixture plate prior to installing the insert with the installer tool.**

11. Remove the fixture plate (3) and bushing (1).
12. Using compressed air, clean out any chips.

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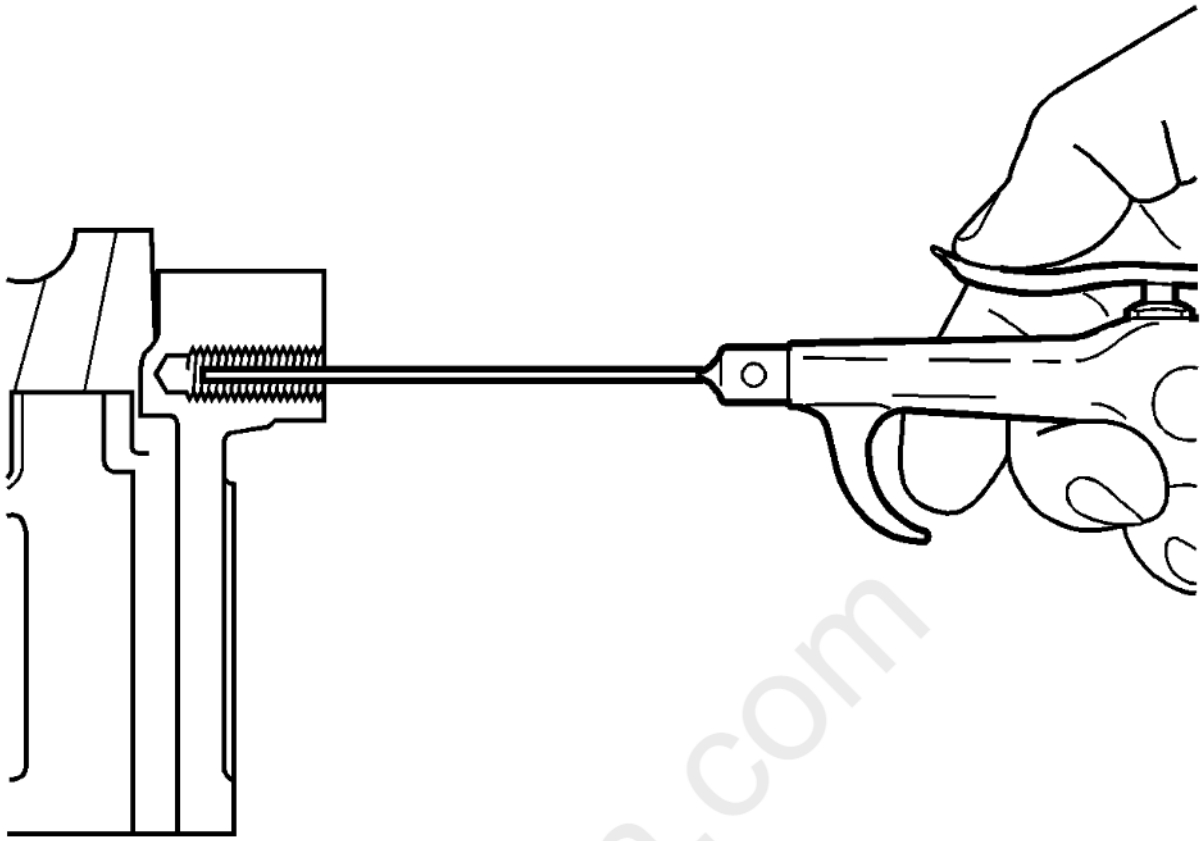


Fig. 307: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

13. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended cleaner.

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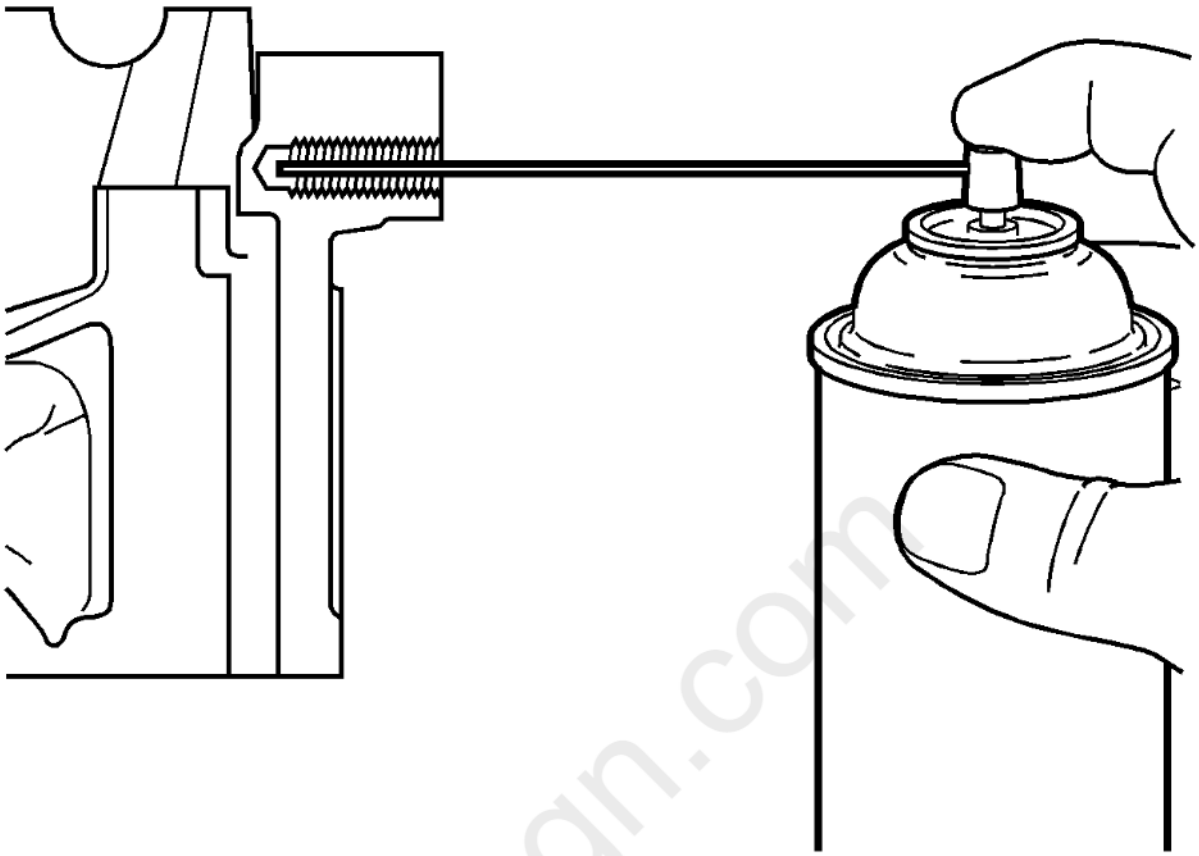


Fig. 308: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS COMPANY

14. Using compressed air, clean out any chips.

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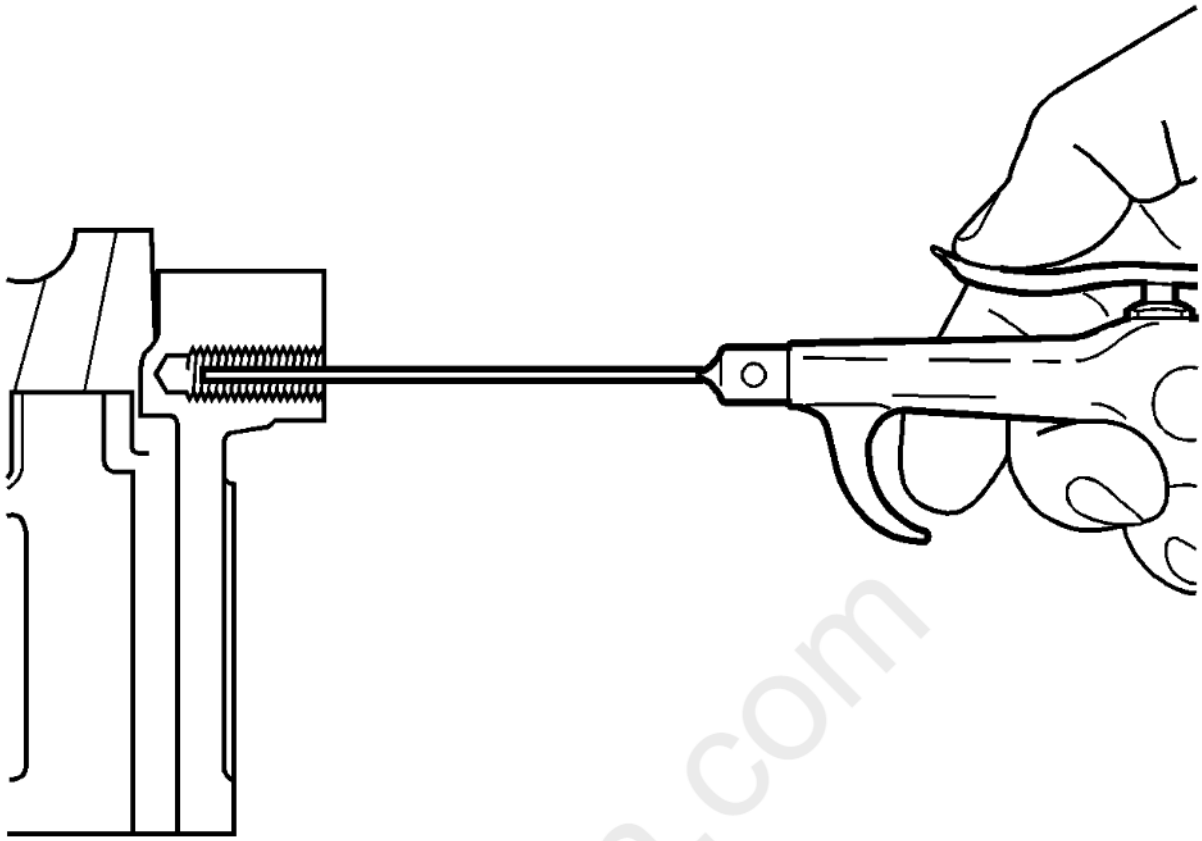


Fig. 309: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

15. Lubricate the threads of the driver installation tool (2) with the **EN-42385-110** (1).

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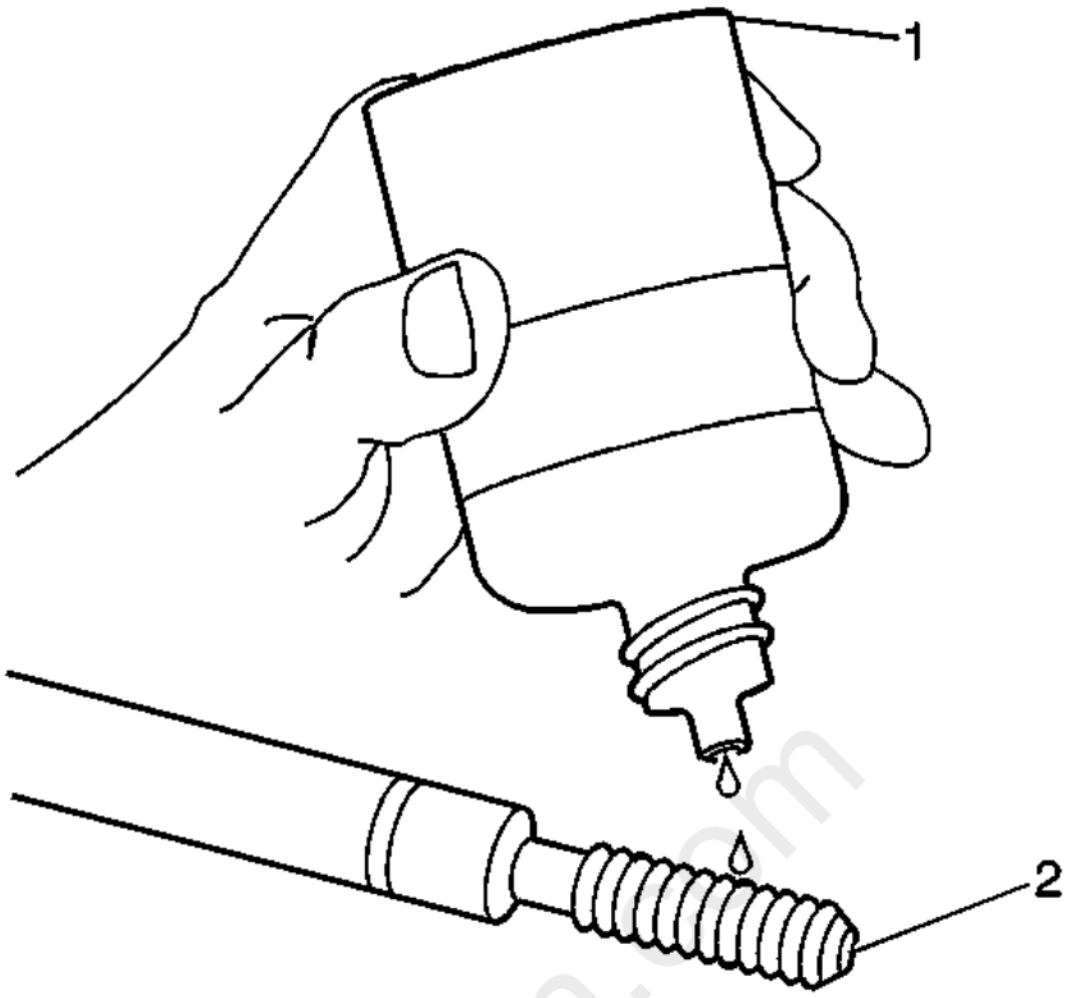


Fig. 310: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.**

16. Install the insert (2) onto the driver installation tool (1).

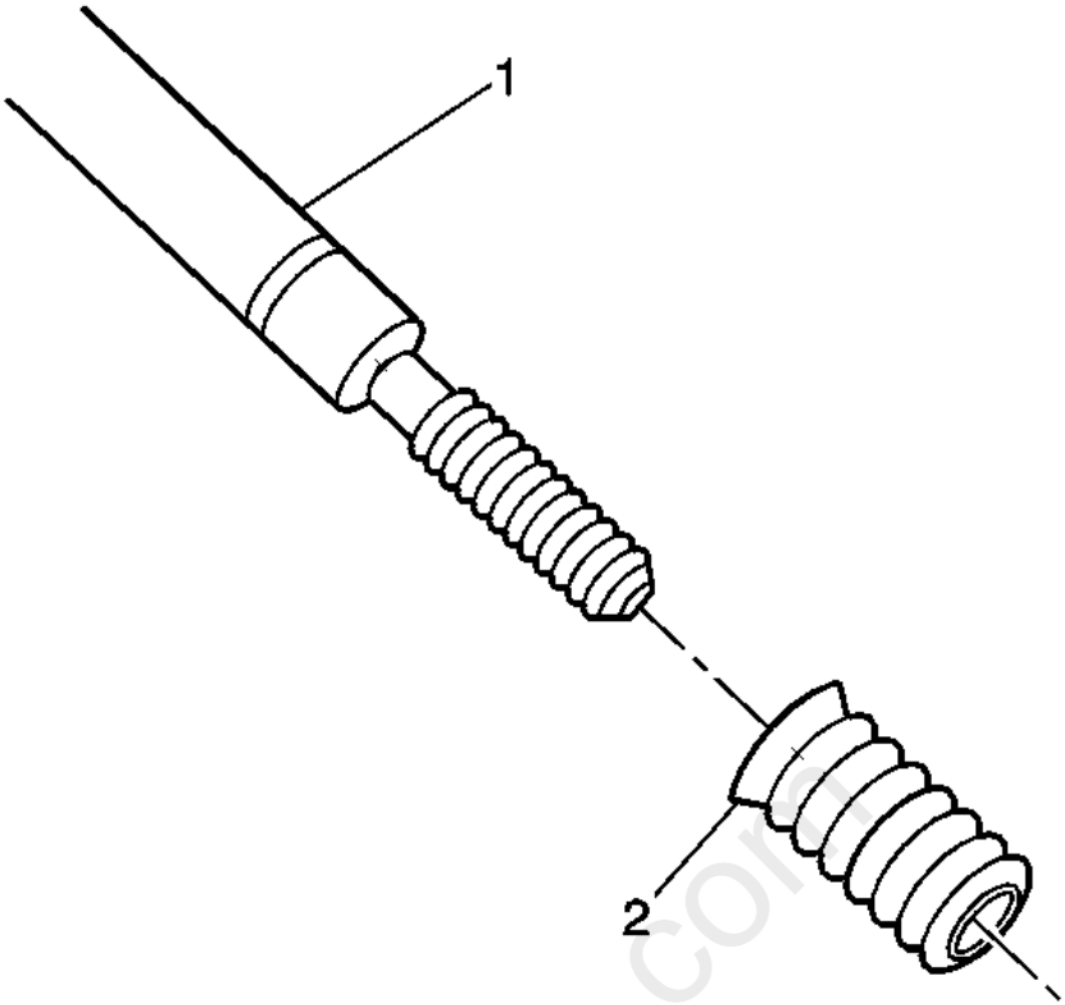


Fig. 311: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

17. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277Â®; or equivalent (1) to the insert OD threads (2). Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant.

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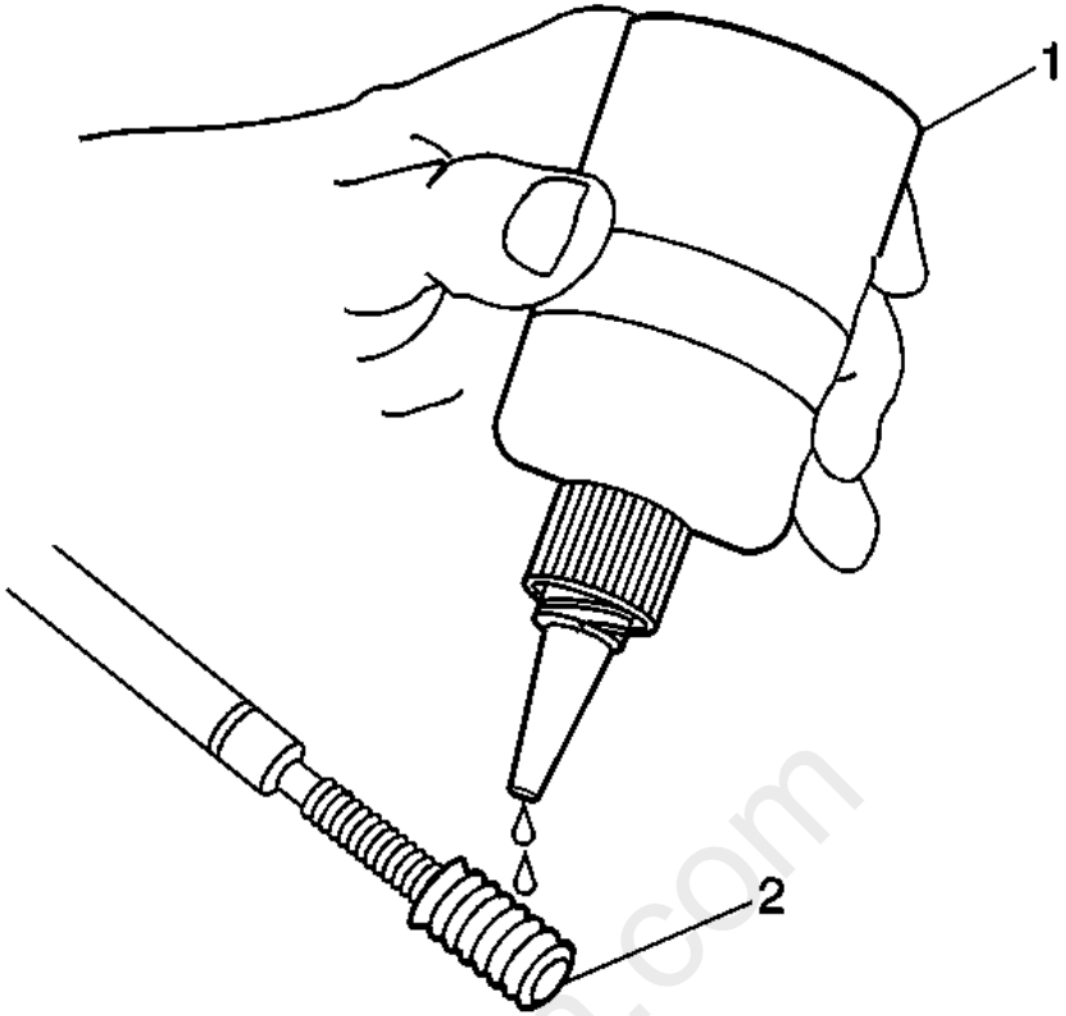


Fig. 312: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

18. Install the insert and installation driver (1) into the tapped hole by hand only.

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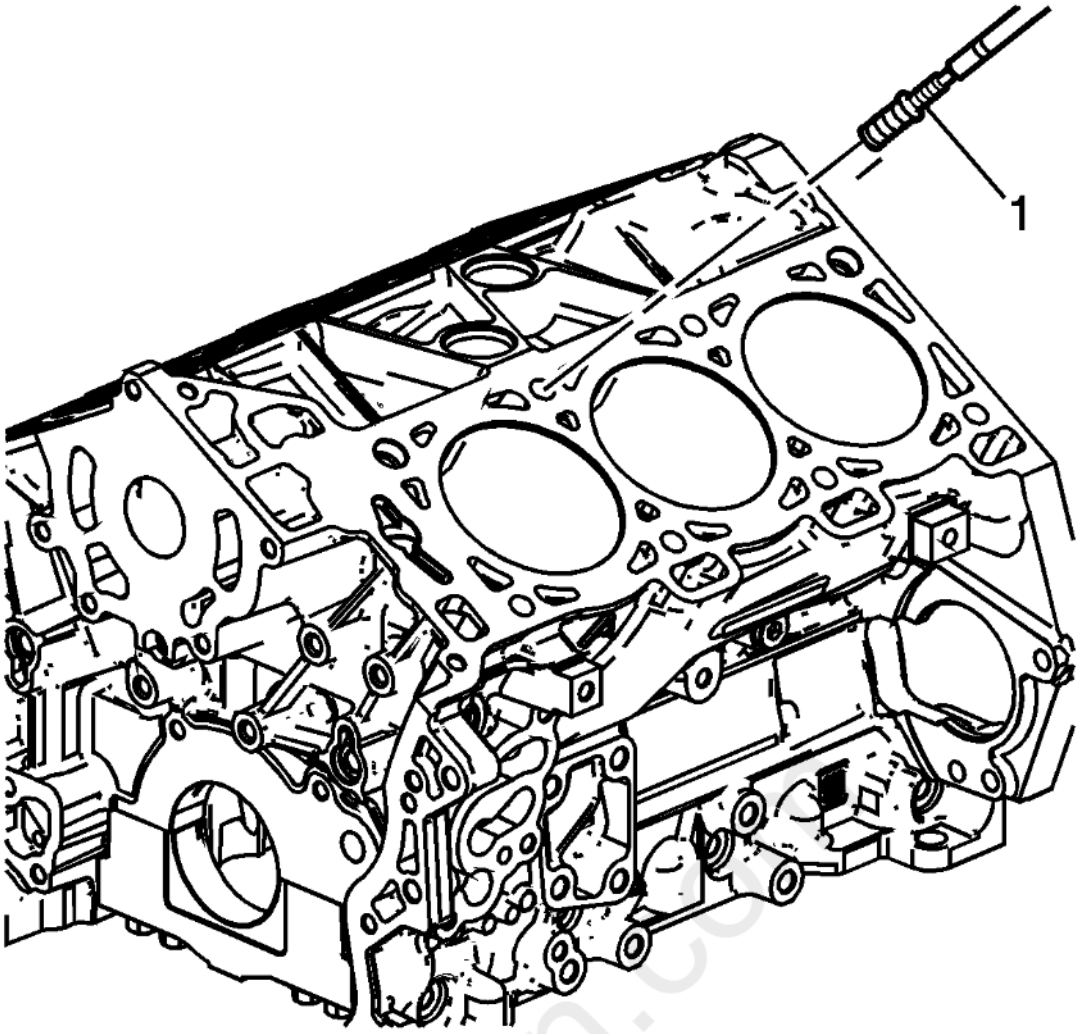


Fig. 313: Installing Installation Driver By Hand
Courtesy of GENERAL MOTORS COMPANY

19. Start the insert into the threaded hole.
20. Install the insert until the flange of the insert contacts the counterbored surface.

NOTE: **If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.**

21. Continue to rotate the driver installation tool through the insert.

NOTE: **The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.**

22. In order to completely form the new threads in the insert, rotate the driver installation tool through the insert until the mark (1) on the driver installation tool aligns with the surface of the engine block deck (2).

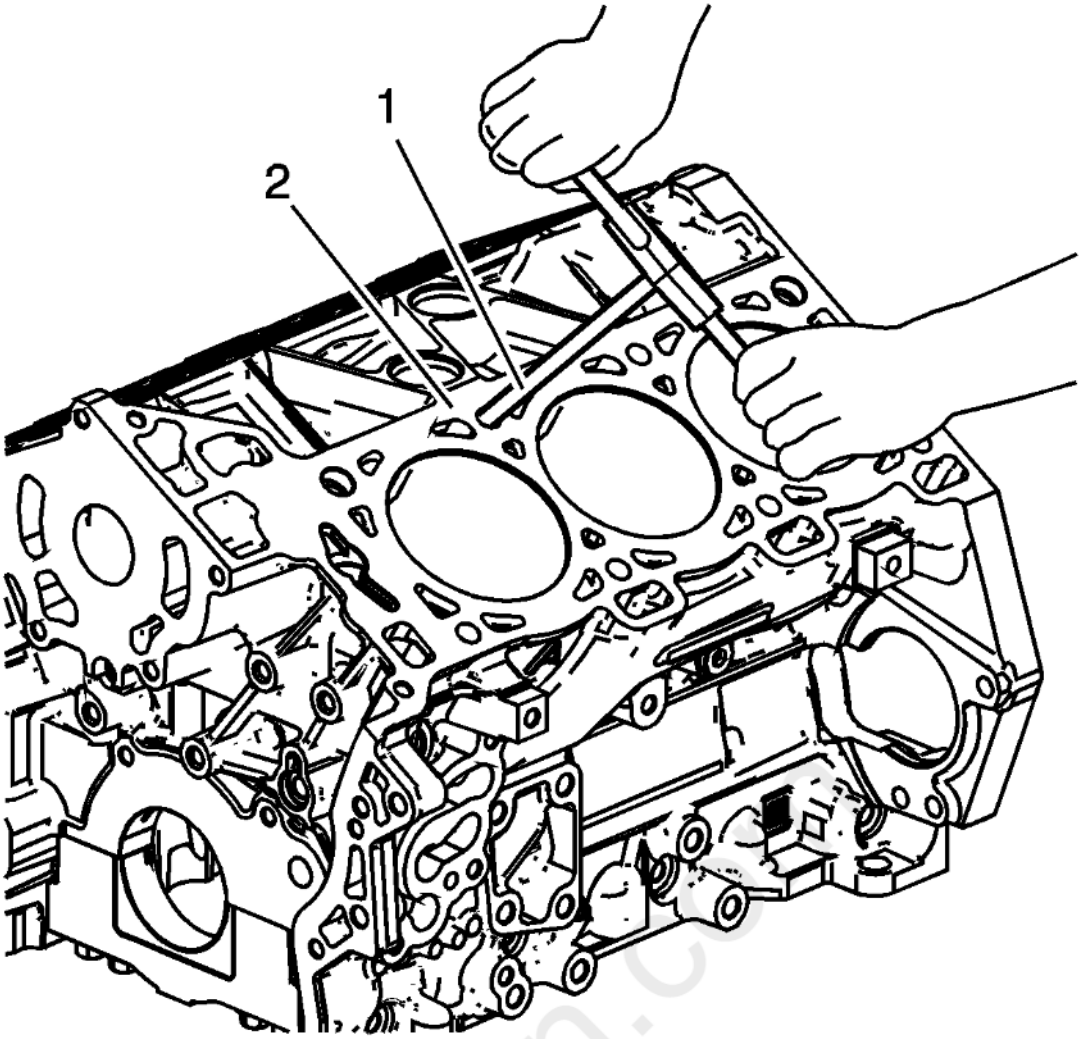


Fig. 314: View Of Driver Installation Tool & Surface Of Engine Block Deck
Courtesy of GENERAL MOTORS COMPANY

23. Inspect the insert for proper installation into the tapped hole.

Crankshaft Main Bolt Hole Thread Repair

Special Tools

- **EN-42385-700** High Feature Thread Repair Kit
- **EN-42385-2000** Thread Insert Kit

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

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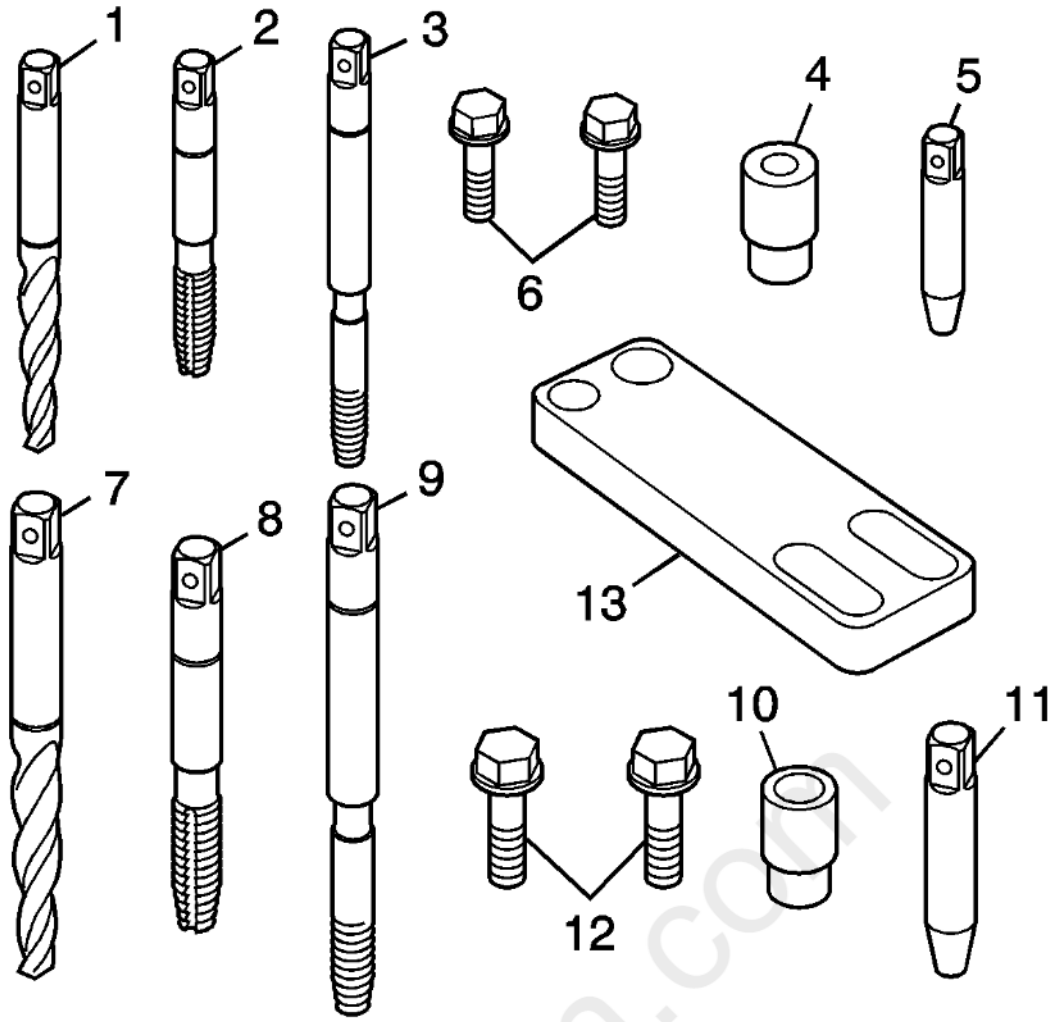


Fig. 315: High Feature Thread Repair Kit
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **In order to repair some crankshaft main bolt holes it will be necessary to mount the fixture plate upside down.**
- **Do NOT remove the fixture plate prior to installing the insert with the installation driver. The fixture plate remains in position throughout the thread repair process.**

The crankshaft main bearing bolt hole thread repair tooling are in the kits **EN-42385-2000** insert kit and **EN-42385-700** kit. The crankshaft main bearing bolt hole thread repair components consist of the following:

- **EN-42385-702** Drill (1) for outboard holes
- **EN-42385-703** Tap (2) for outboard holes
- **EN-42385-704** Installation driver (3) for outboard holes
- **EN-42385-726** Bushing (4) for outboard holes
- **EN-42385-727** Alignment pin (5) for outboard holes
- **EN-42385-728** Bolts (6) for outboard holes
- **EN-42385-720** Drill (7) for inboard holes
- **EN-42385-721** Tap (8) for inboard holes
- **EN-42385-722** Installation driver (9) for inboard holes
- **EN-42385-713** Bushing (10)
- **EN-42385-308** Alignment pin (11)
- **EN-42385-734** Bolts (12)
- **EN-42385-712** Fixture plate (13)

WARNING: Refer to Safety Glasses Warning .

NOTE:

- **Ensure the fixture plate is installed during the machining and installation processes of the insert.**
- **The use of a cutting type fluid, WD 40Â® or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants and Sealers for recommended cutting fluid.**

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

1. Position the fixture plate (3) with the bushing (2) installed over the crankshaft main cap bolt hole to be repaired.

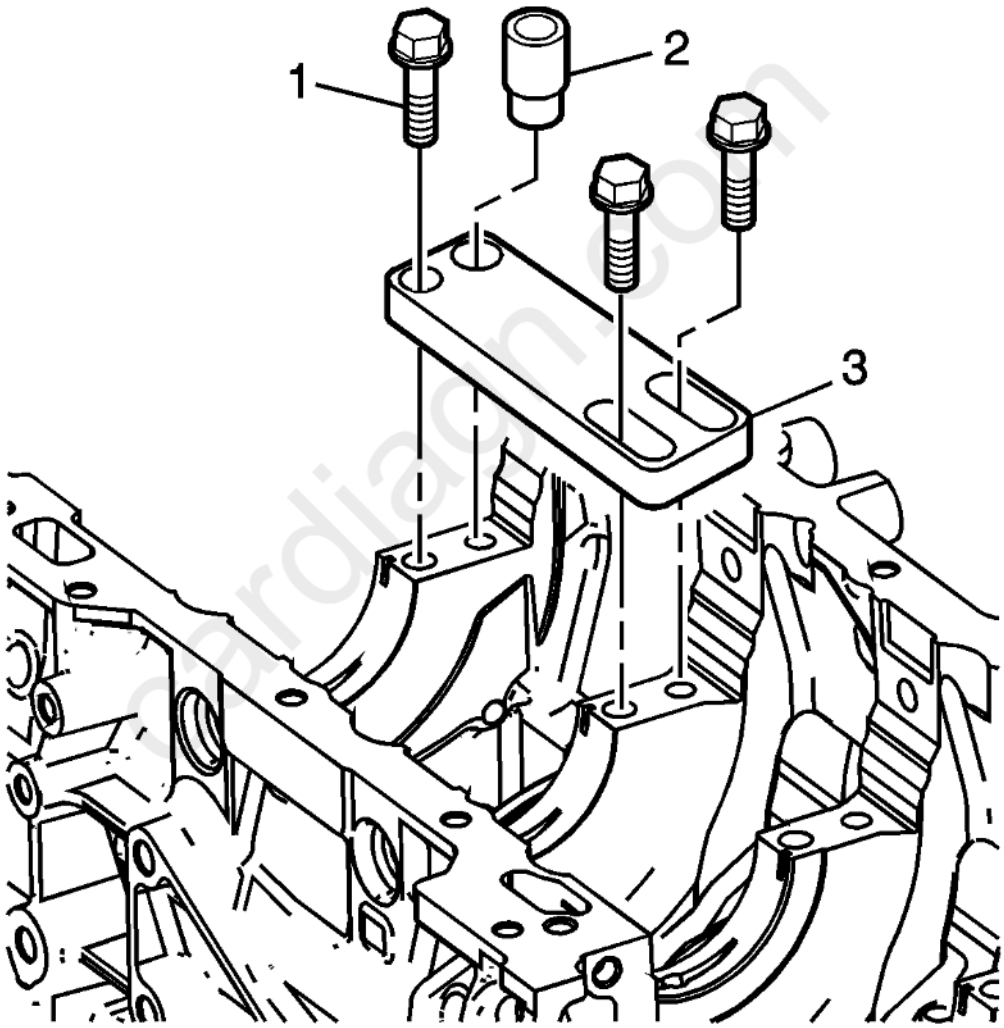


Fig. 316: Identifying Fixture Plate Over Crankshaft Main Cap Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

2. Loosely install the fixture plate bolts (1) into the remaining crankshaft main cap bolt holes.
3. Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole.

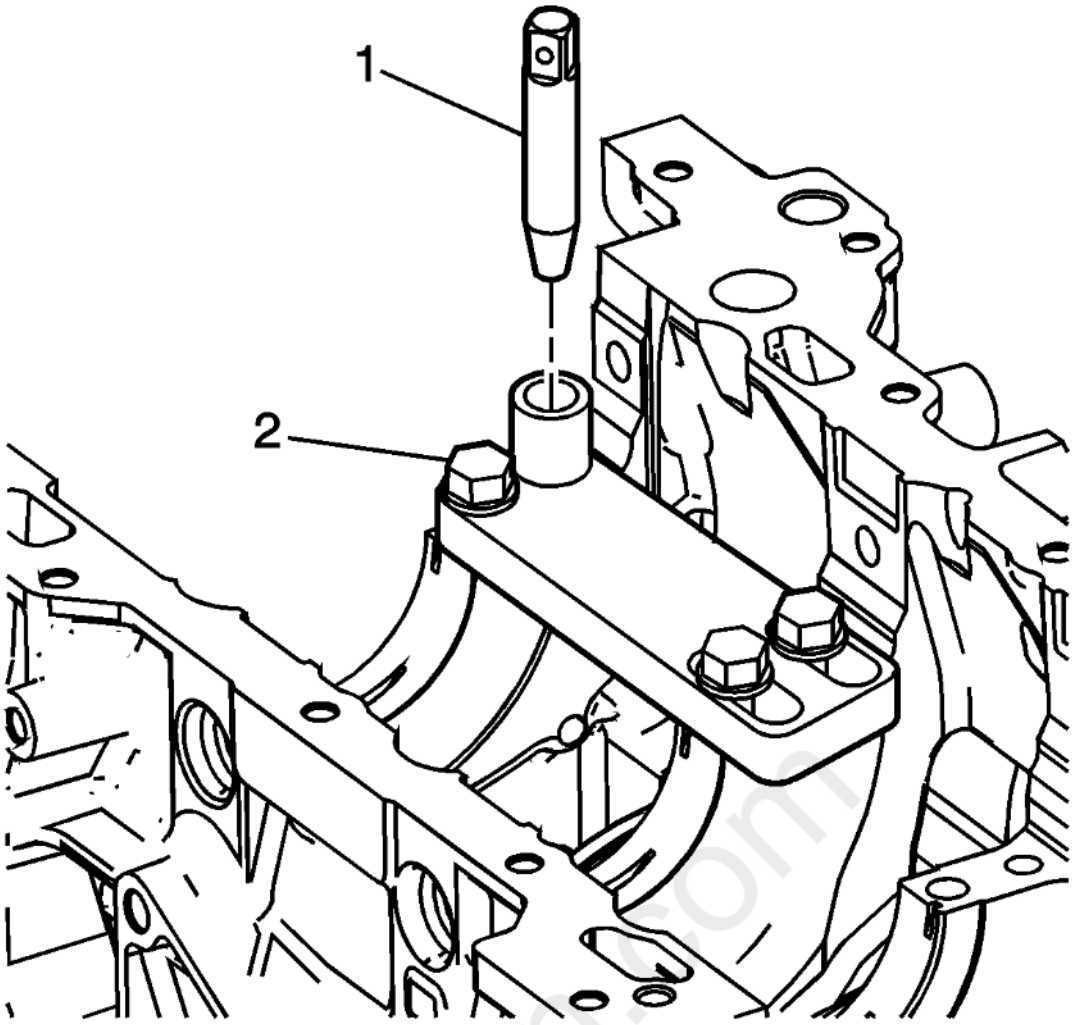


Fig. 317: Identifying Alignment Pin & Bushing
Courtesy of GENERAL MOTORS COMPANY

4. With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the crankshaft main cap bolt hole.
6. Drill out the threads of the damaged hole.

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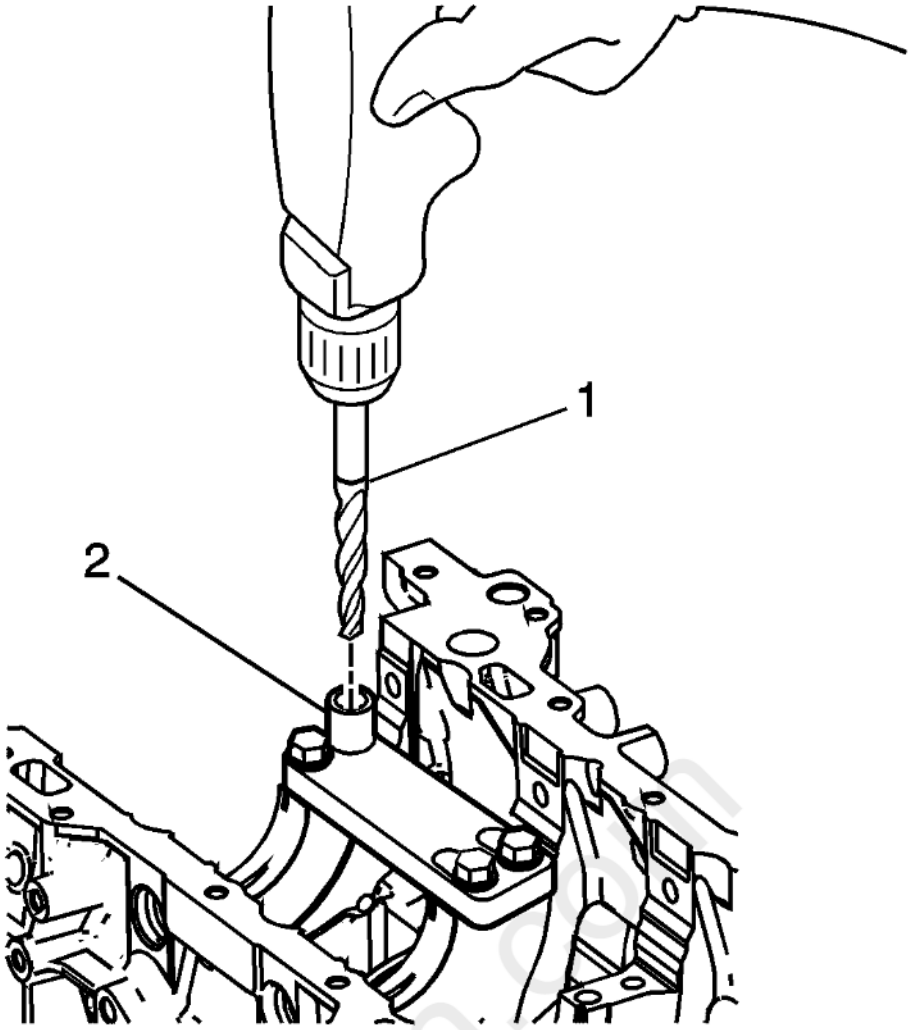


Fig. 318: Aligning Drill & Drill Bushing
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).**

7. Using compressed air, clean out any chips.

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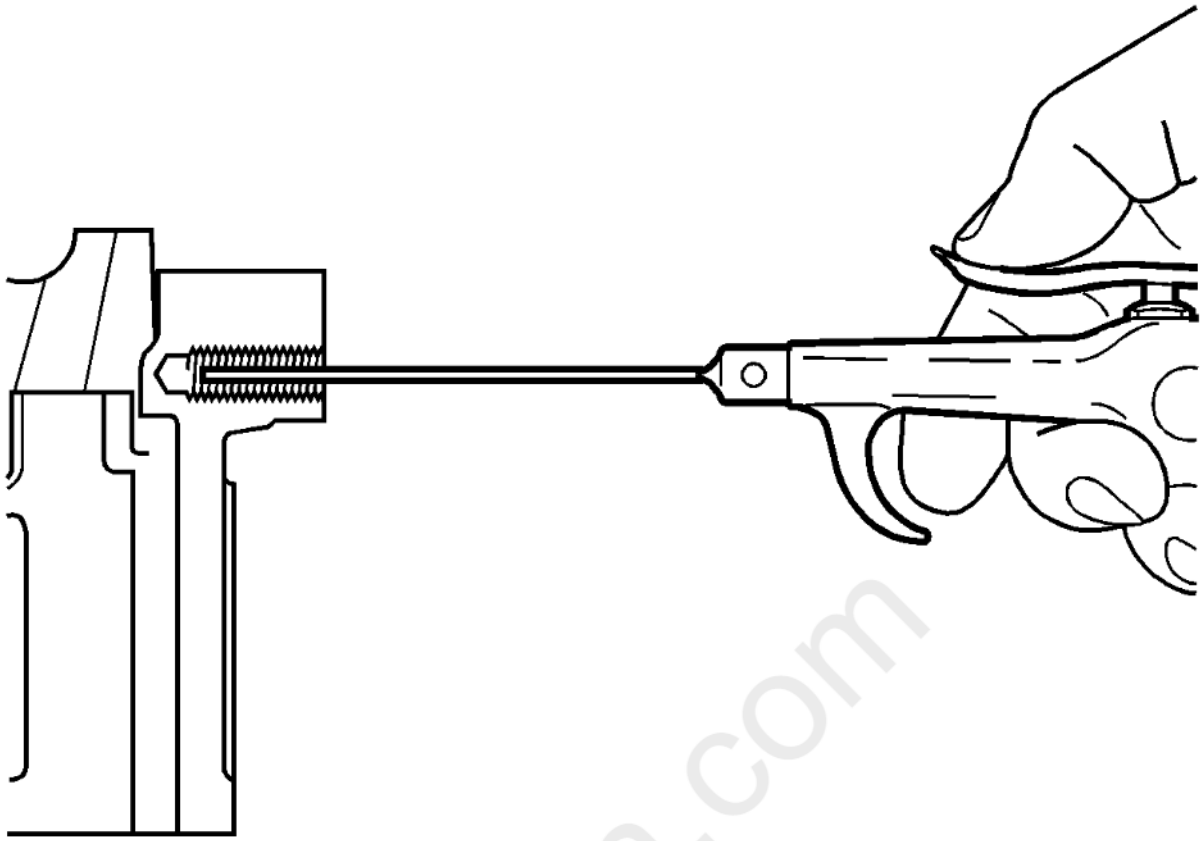


Fig. 319: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the drilled hole prior to tapping.**

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

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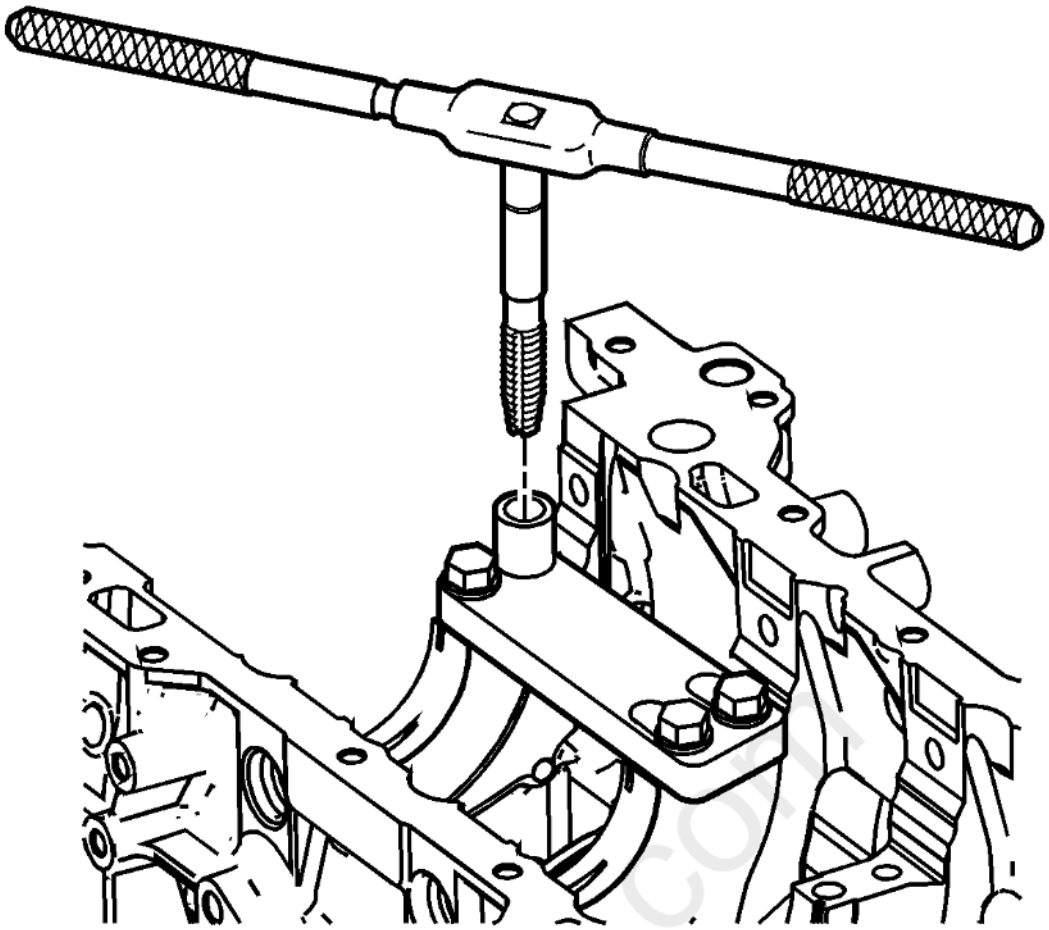


Fig. 320: View Of Tapping Wrench
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.**
- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

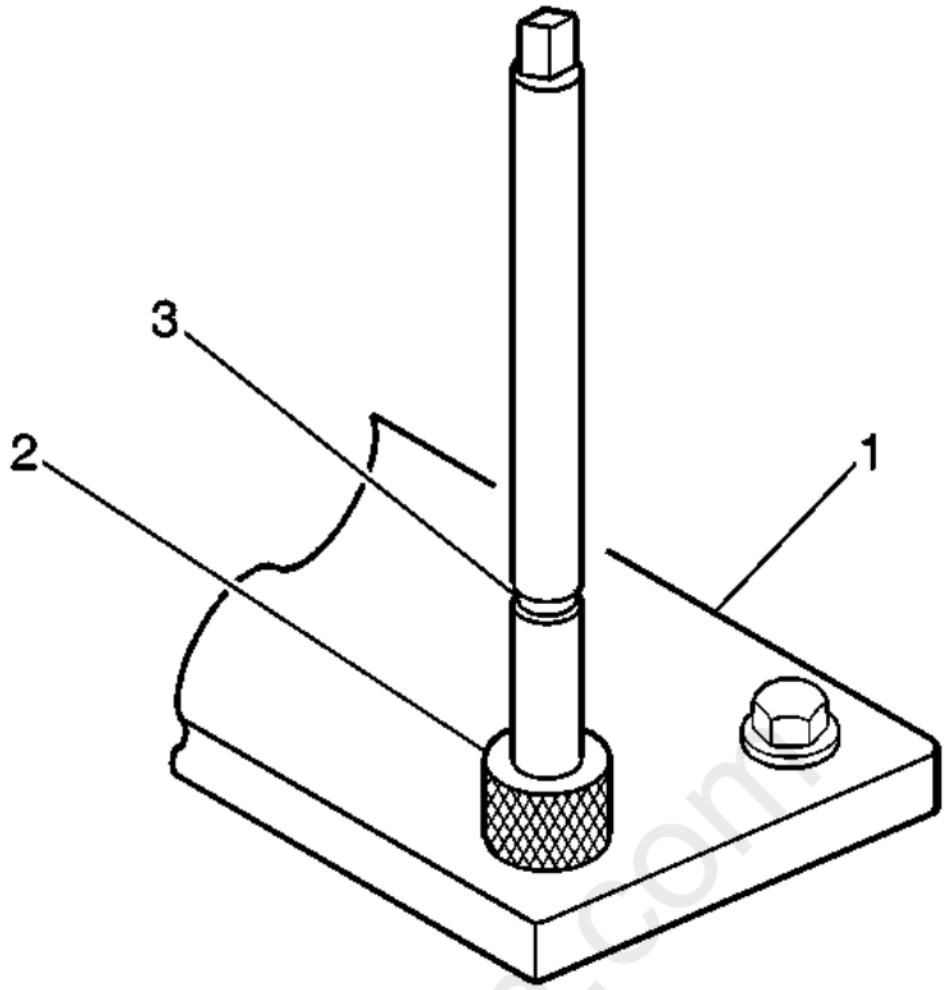


Fig. 321: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS COMPANY

10. Using compressed air, clean out any chips.

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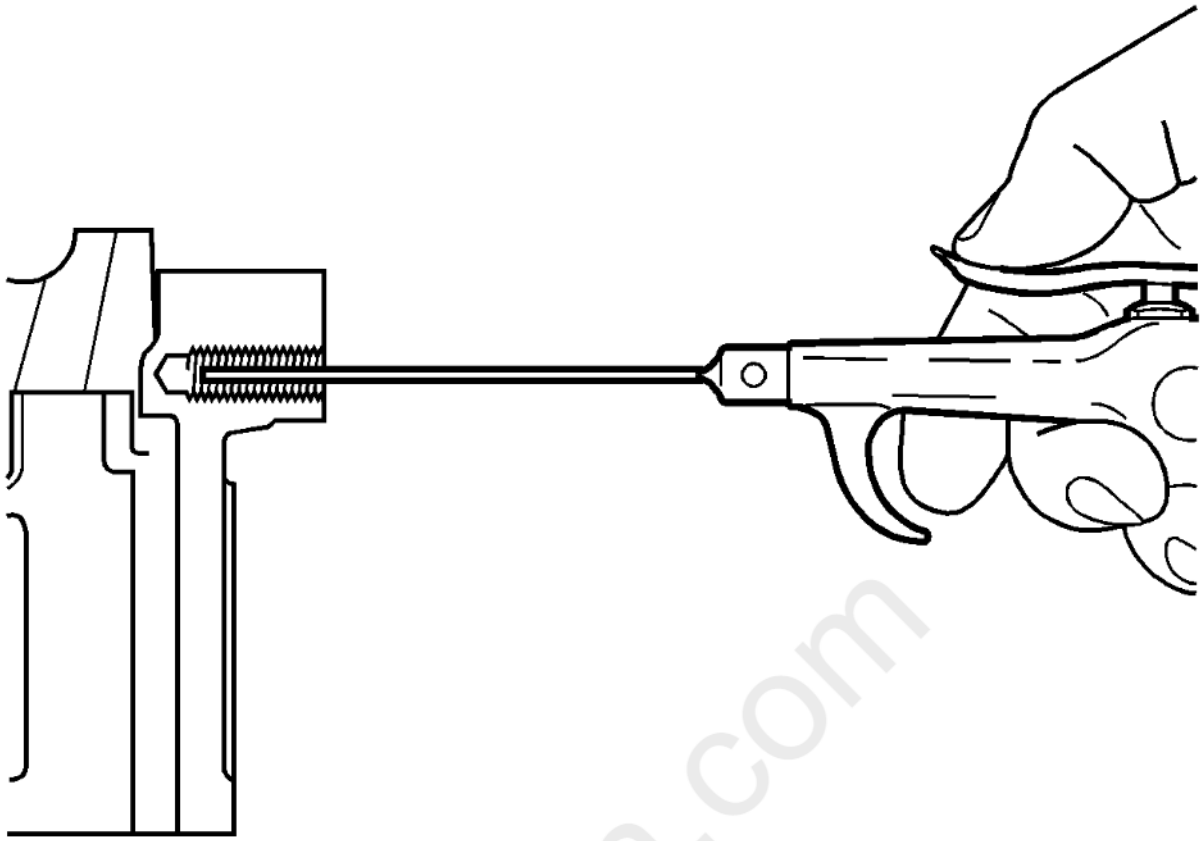


Fig. 322: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

11. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended cleaner.

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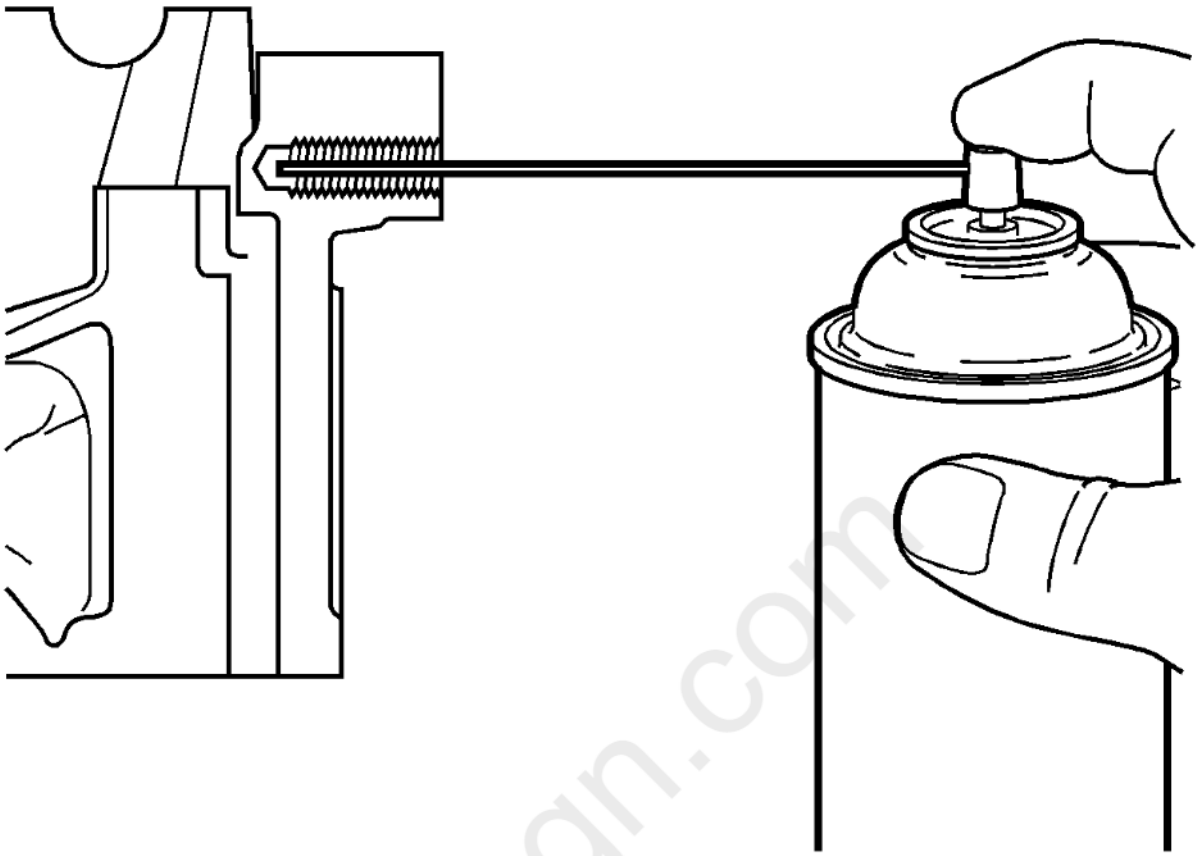


Fig. 323: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS COMPANY

12. Using compressed air, clean out any chips.

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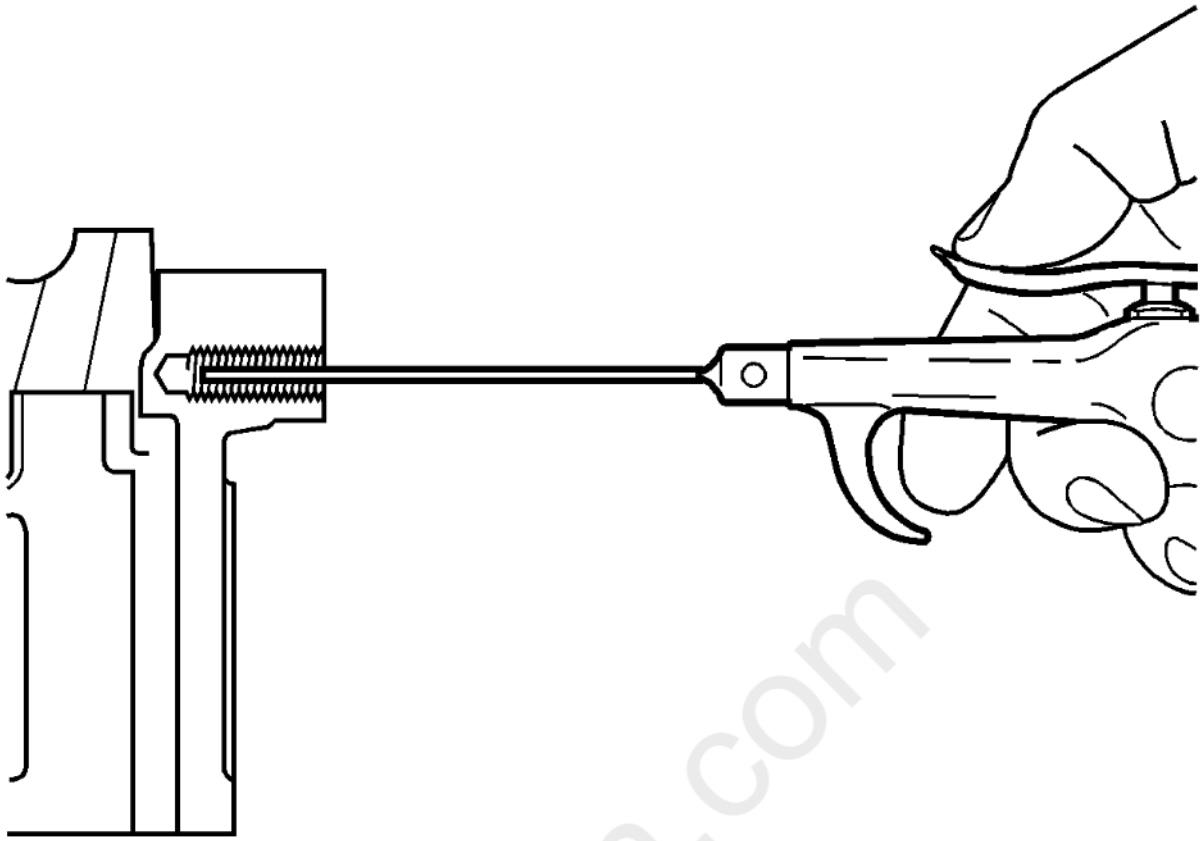


Fig. 324: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

13. Lubricate the threads of the driver installation tool (2) with the **EN-42385-110** (1).

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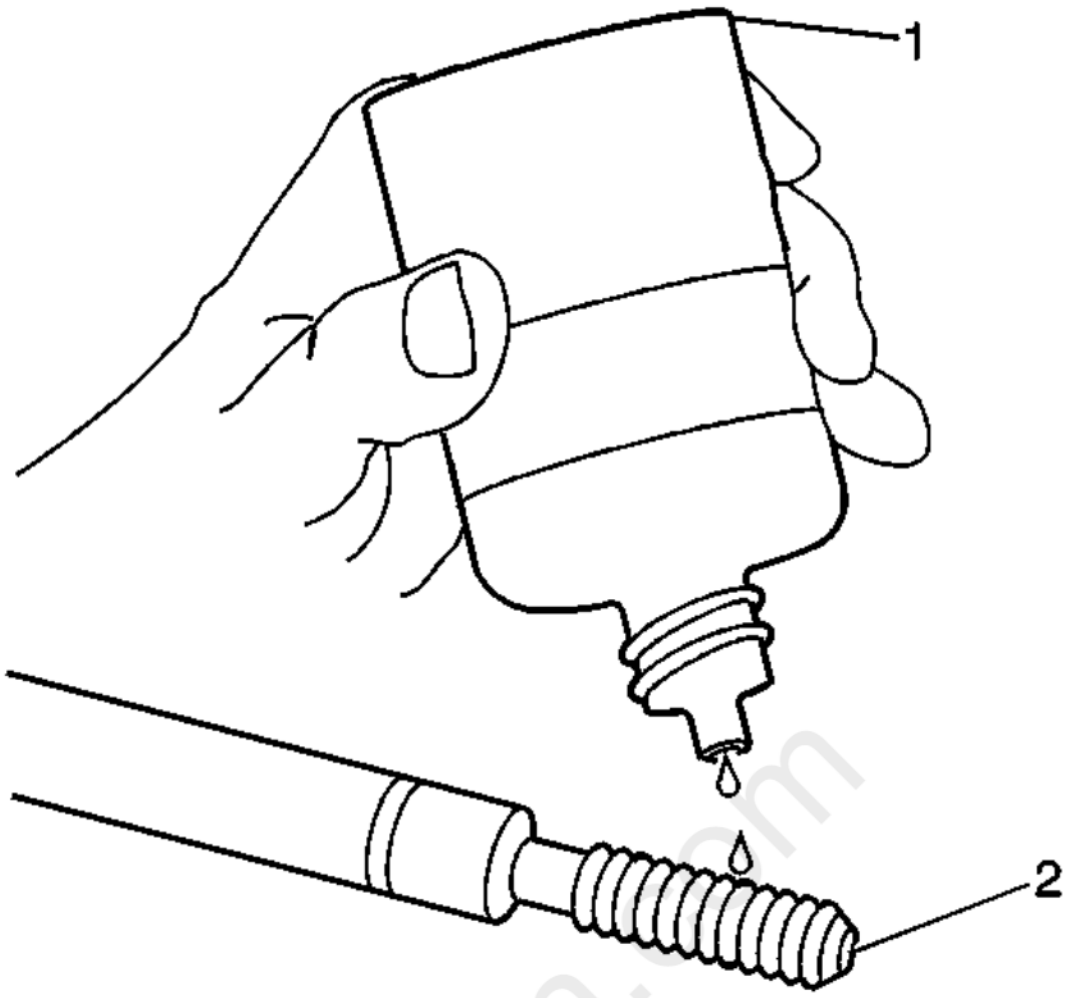


Fig. 325: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not remove the fixture plate, ensure the fixture plate is installed during the installation process of the insert.**
- **Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.**

14. Install the insert (2) onto the driver installation tool (1).

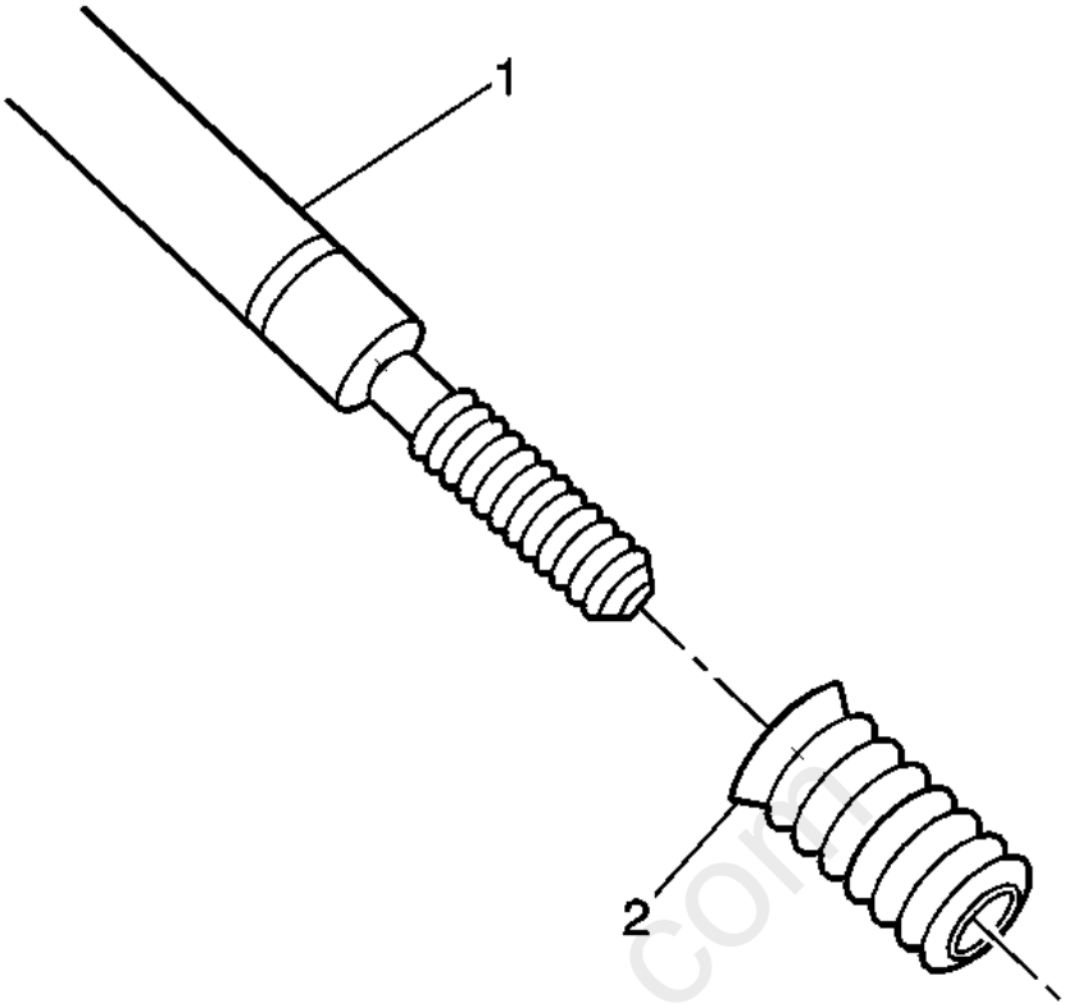


Fig. 326: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

15. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277Â® or equivalent (1) to the insert OD threads (2). Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant.

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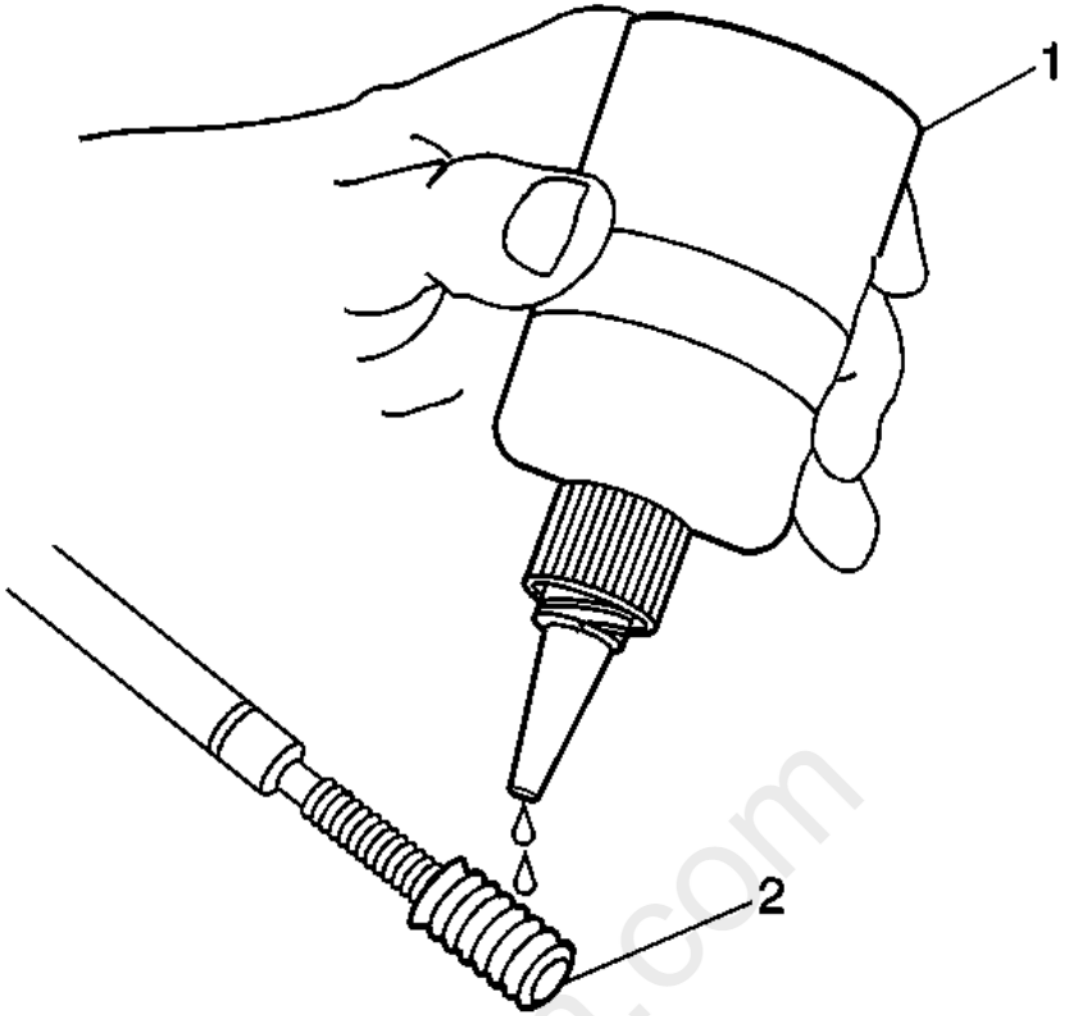


Fig. 327: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

16. Install the insert and installation driver into the tapped hole by hand only.

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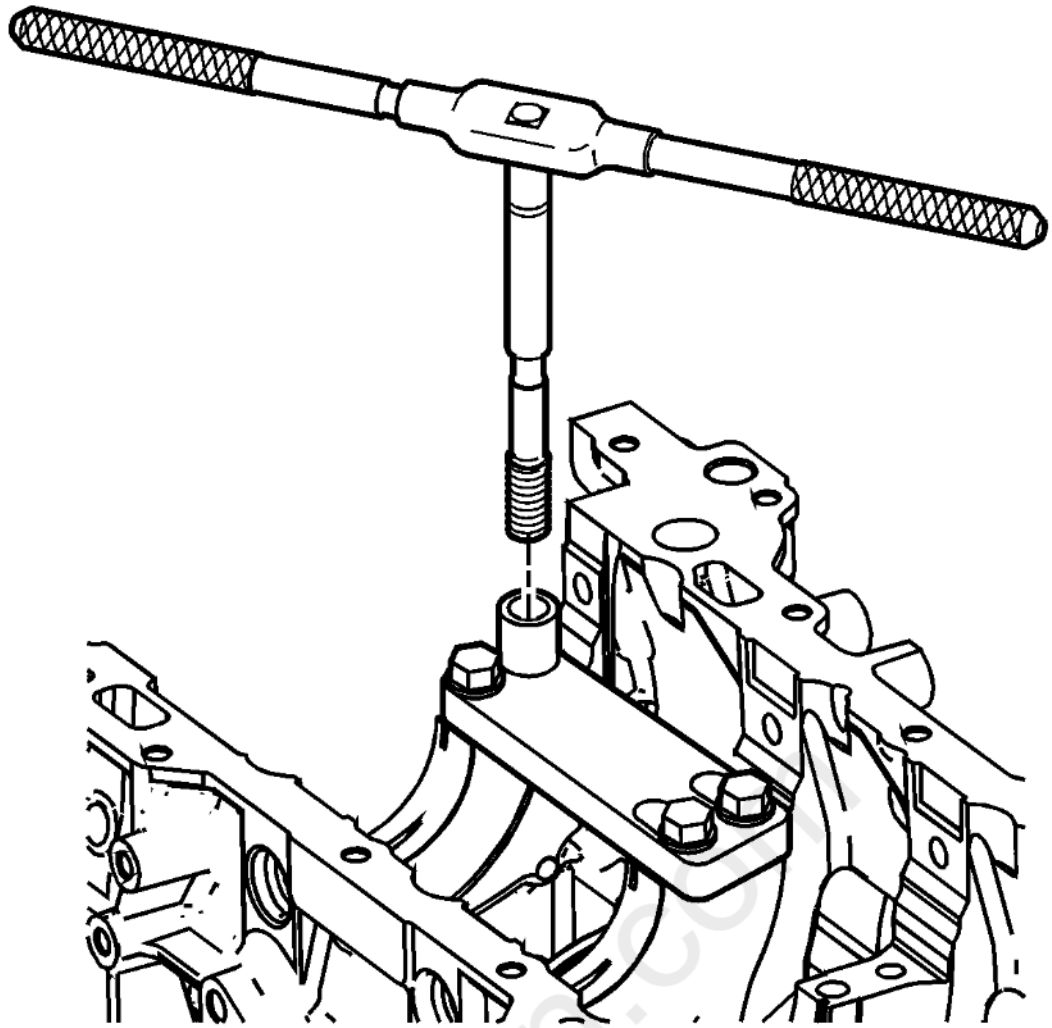


Fig. 328: Identifying Tapping Wrench
Courtesy of GENERAL MOTORS COMPANY

17. Start the insert into the threaded hole.
18. Install the insert until the flange of the insert contacts the counterbored surface.

NOTE: **If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.**

19. Continue to rotate the driver installation tool through the insert.

NOTE: **The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.**

20. Rotate the driver installation tool until the mark (3) on the driver installation tool aligns with the top of the drill bushing (2).

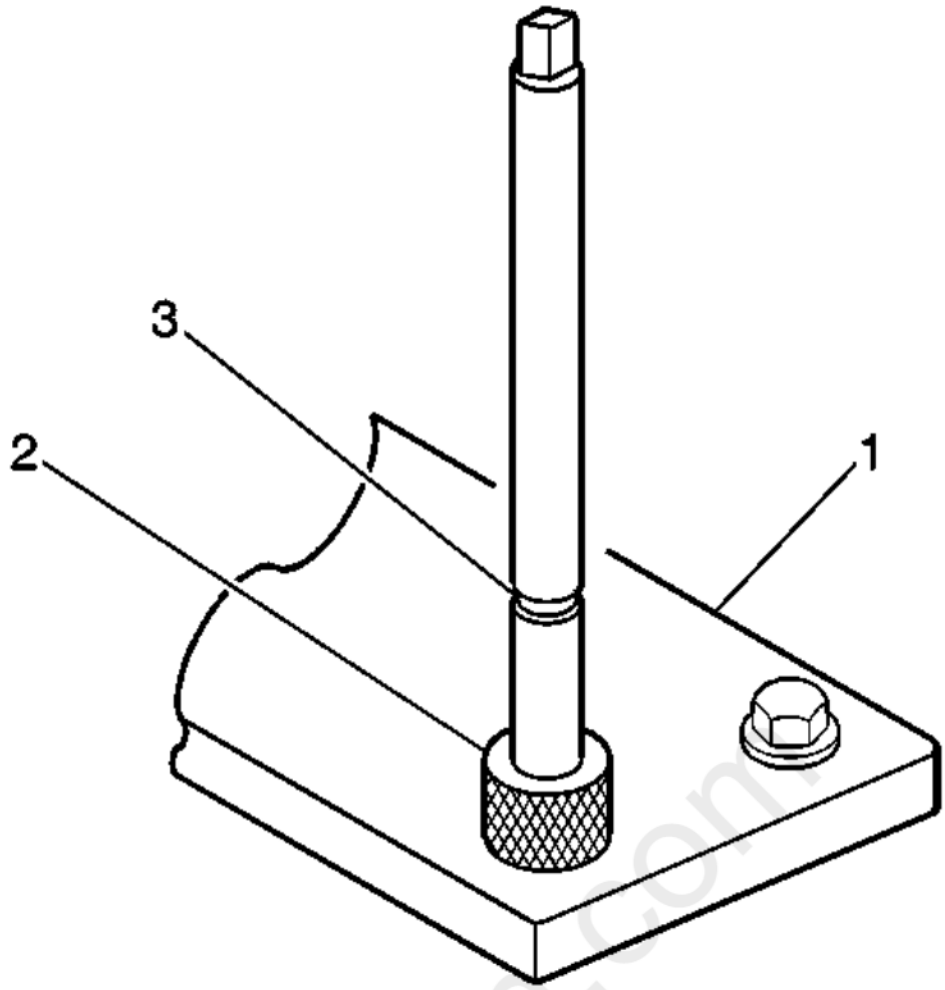


Fig. 329: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS COMPANY

21. Inspect the insert for proper installation into the tapped hole.
22. Remove the fixture plate bolts (1).

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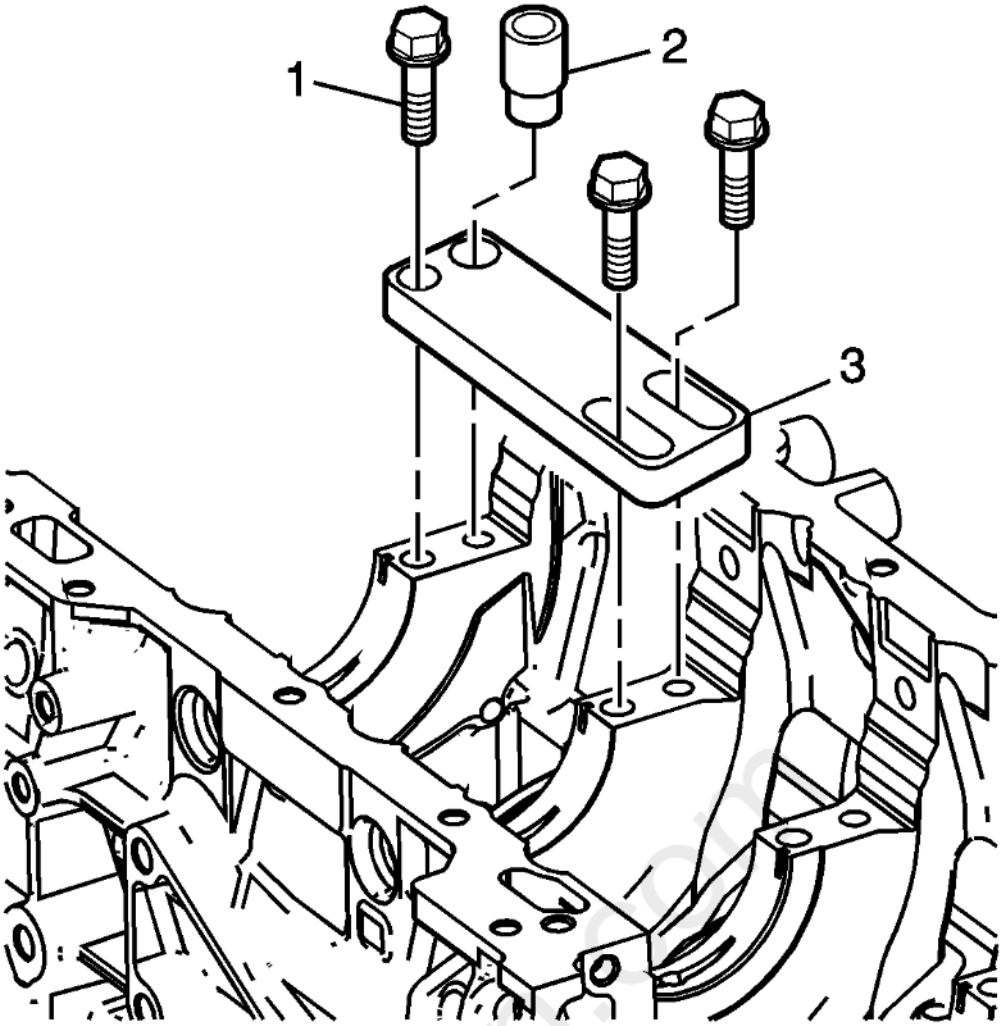


Fig. 330: Identifying Fixture Plate Over Crankshaft Main Cap Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

23. Remove the fixture plate (3) and bushing (2).

Inboard Bolt Holes

1. Position the fixture plate (3) with the bushing (1) installed over the crankshaft main cap bolt hole to be repaired.

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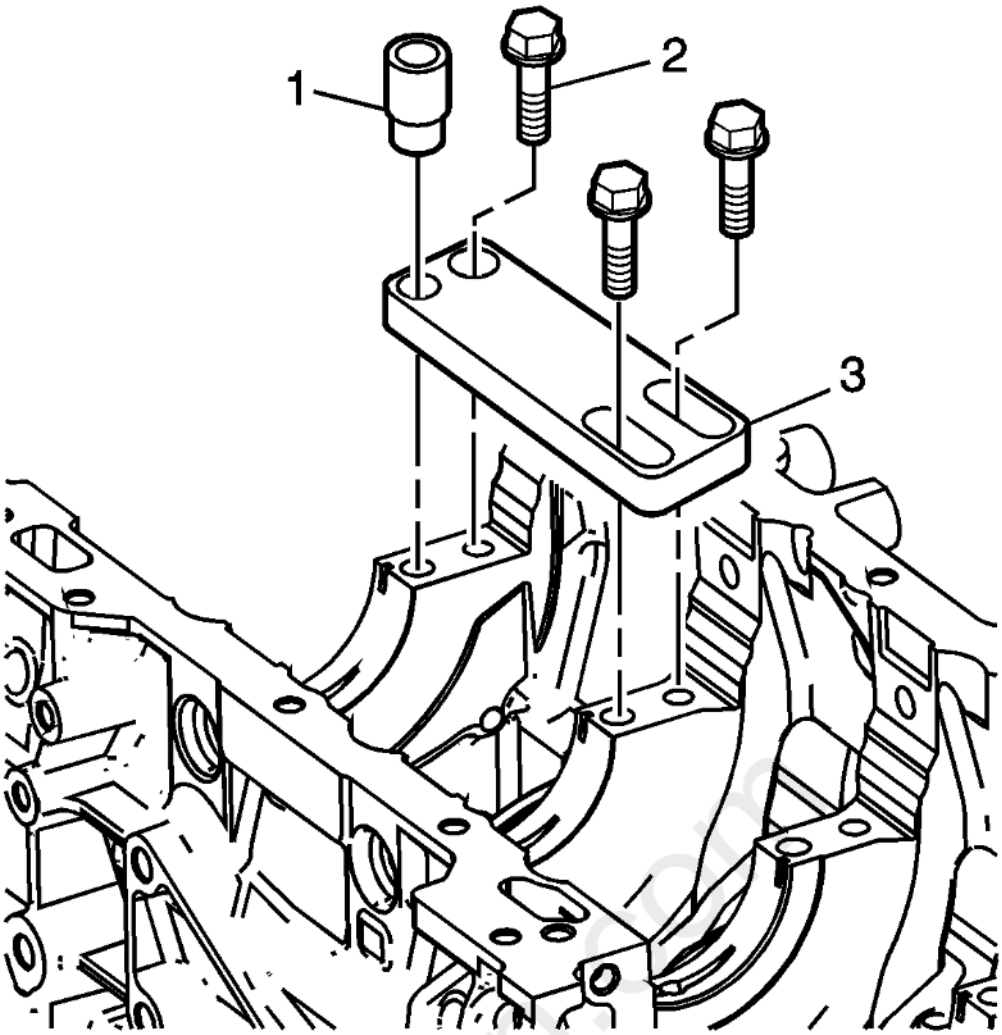


Fig. 331: View Of Fixture Plate & Components - Inboard Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Safety Glasses Warning .

NOTE:

- Ensure the fixture plate is installed during the machining and installation processes of the insert.
- The use of a cutting type fluid, WD 40Â® or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants and Sealers for recommended cutting fluid.

  When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

2. Loosely install the fixture plate bolts (2) into the remaining crankshaft main cap bolt holes.
3. Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole.

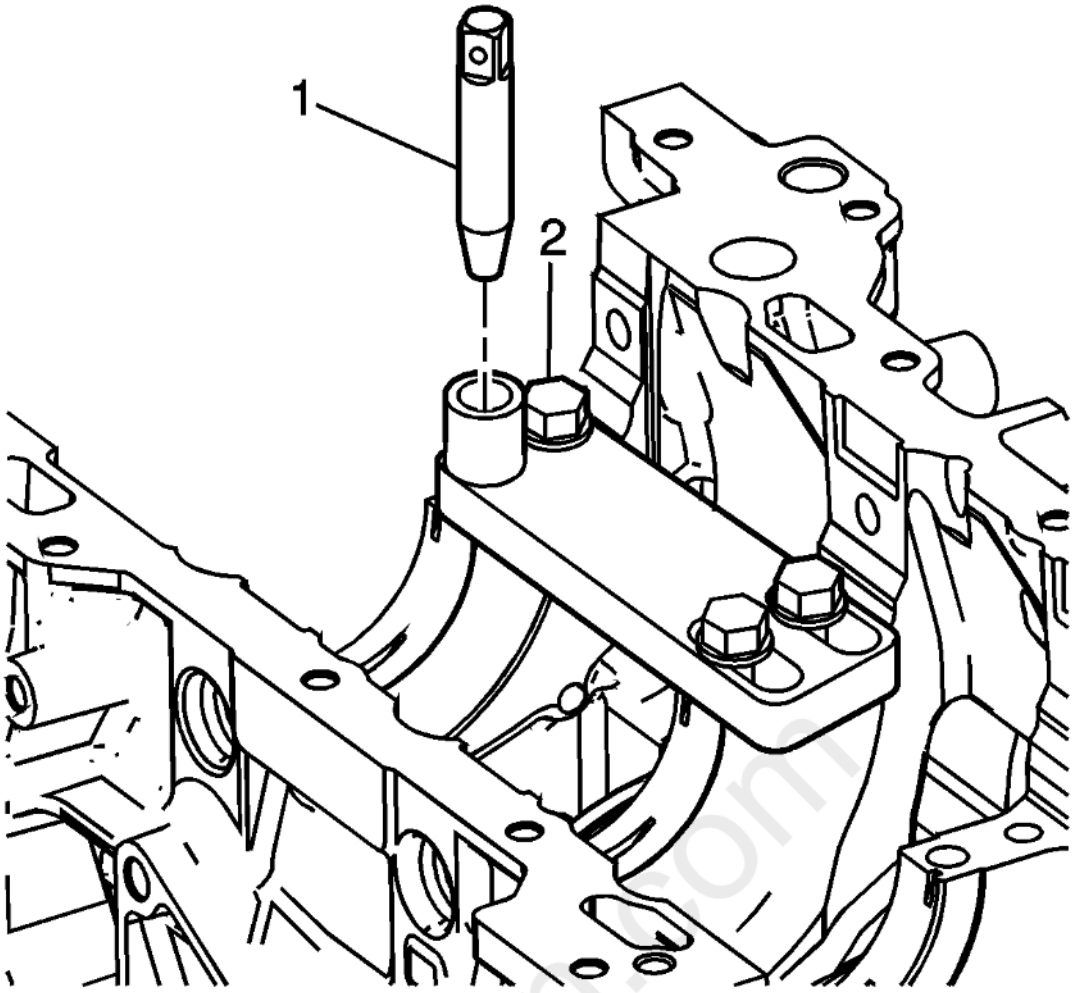


Fig. 332: Locating Alignment Pin
Courtesy of GENERAL MOTORS COMPANY

4. With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the crankshaft main cap bolt hole.
6. Drill out the threads of the damaged hole.

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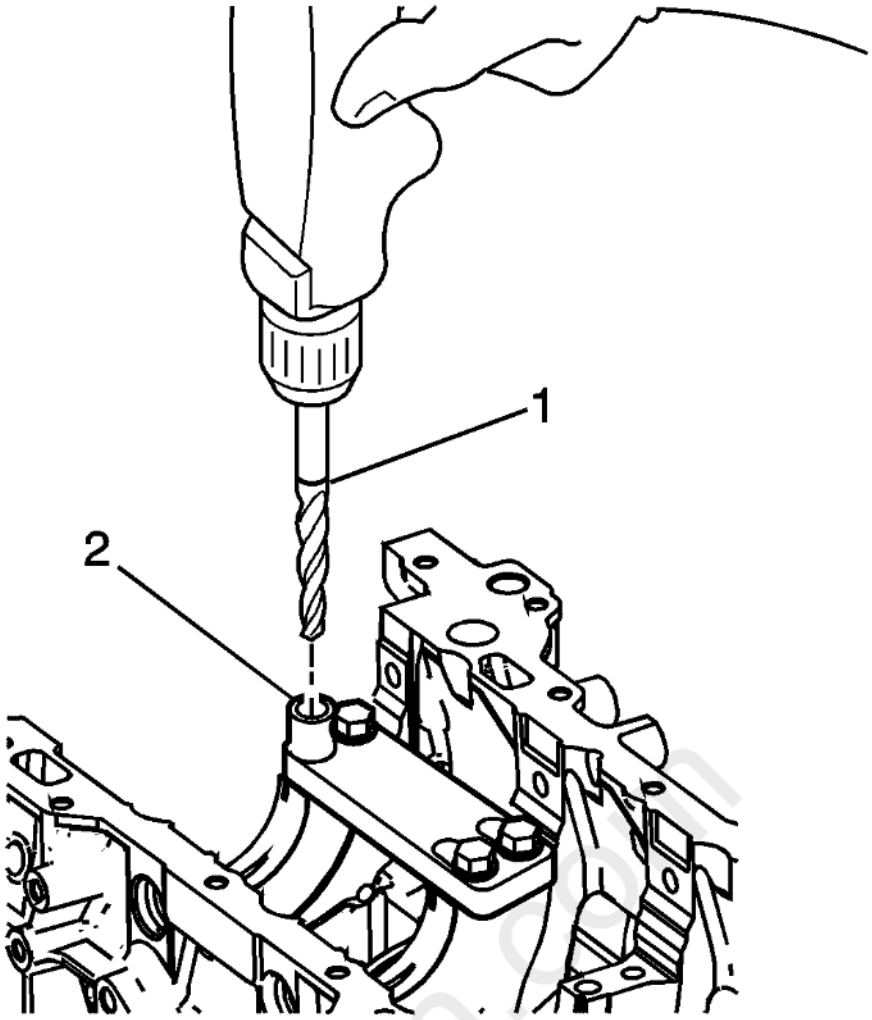


Fig. 333: Drilling Out Threads Of Damaged Hole - Inboard Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).**

7. Using compressed air, clean out any chips.

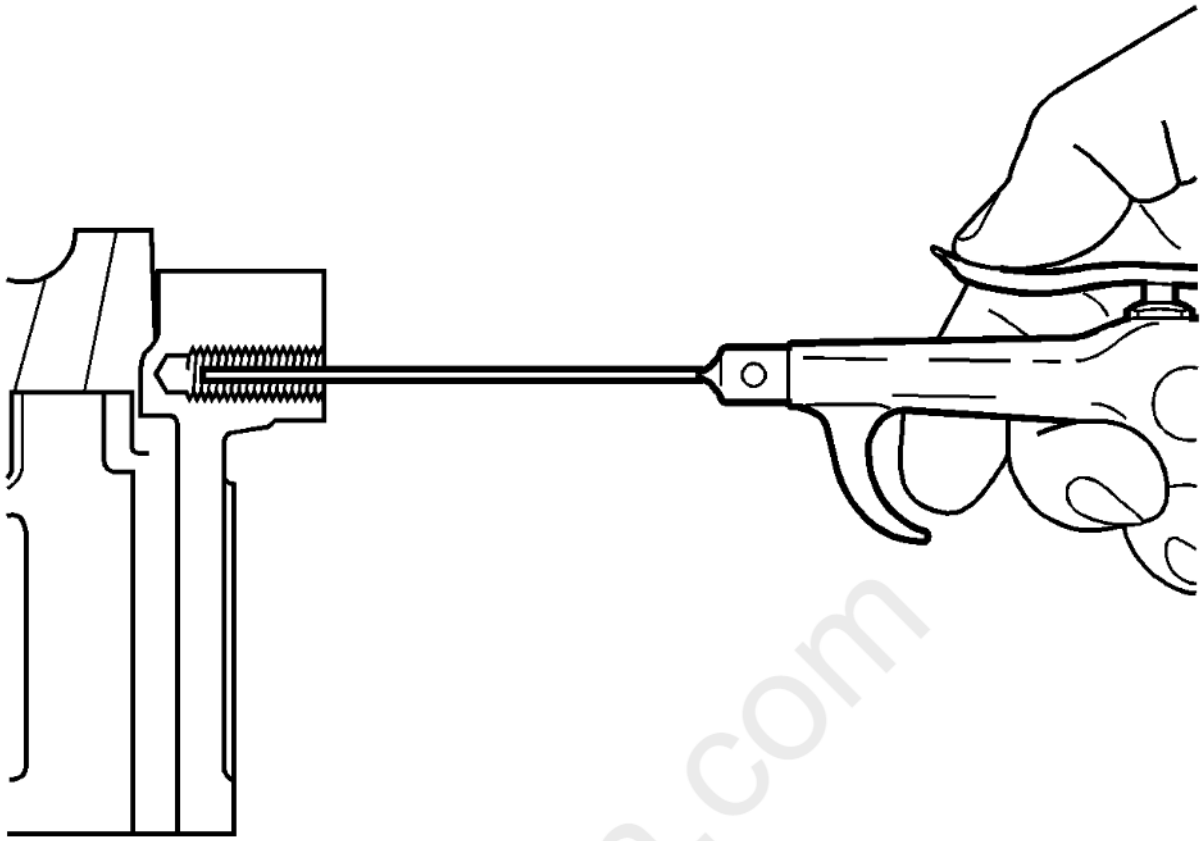


Fig. 334: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the drilled hole prior to tapping.**

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

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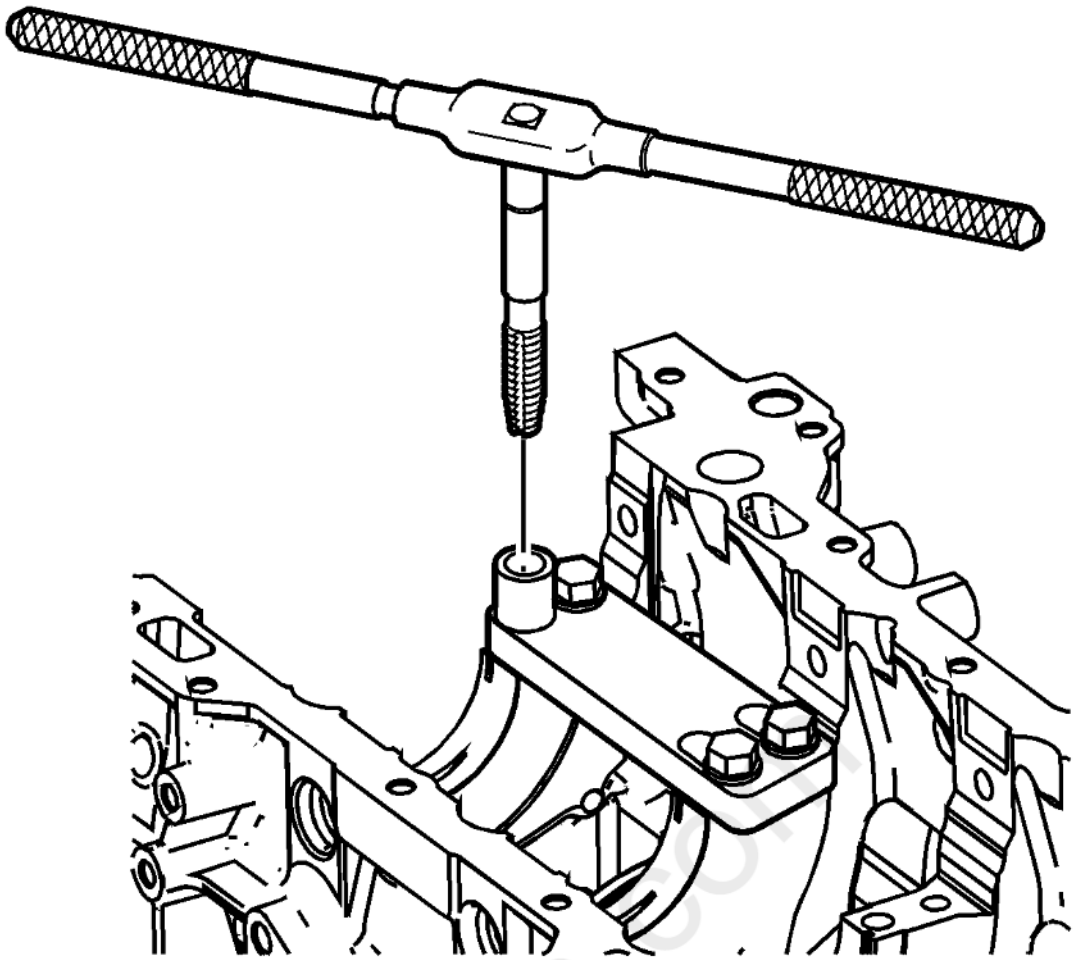


Fig. 335: Positioning Tapping Wrench
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.**
- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

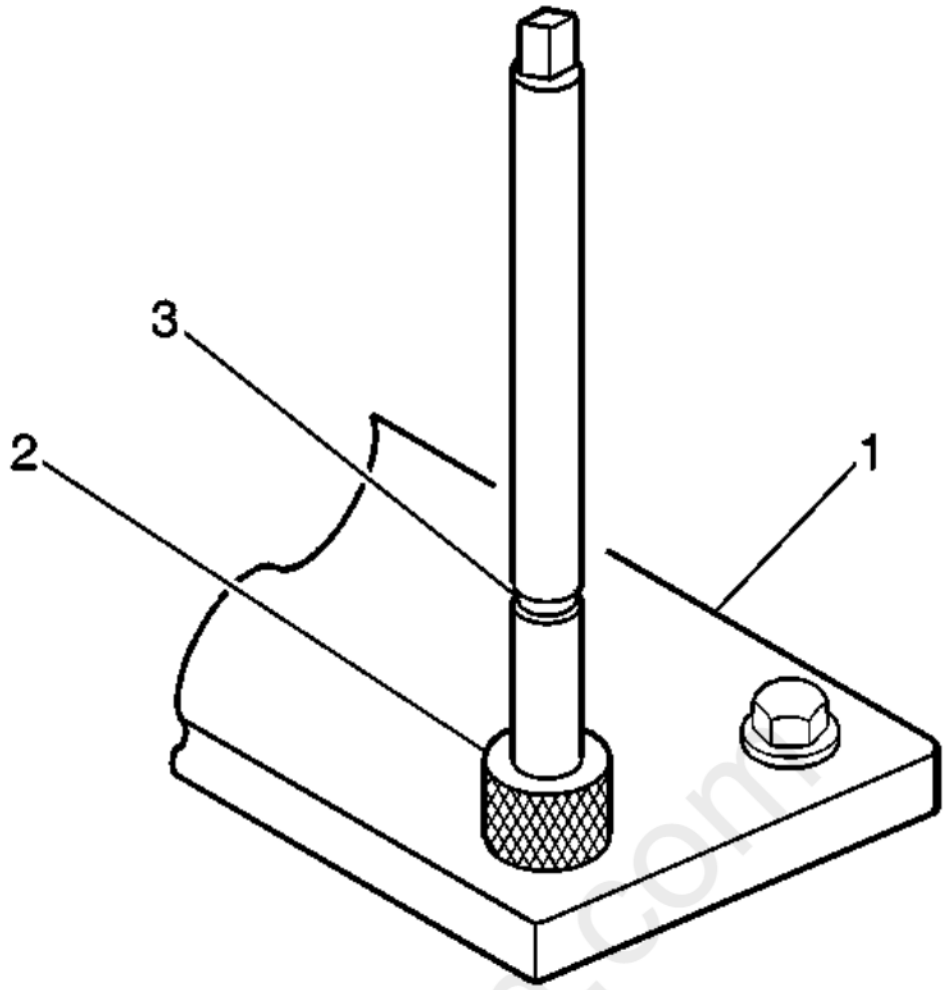


Fig. 336: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS COMPANY

10. Using compressed air, clean out any chips.

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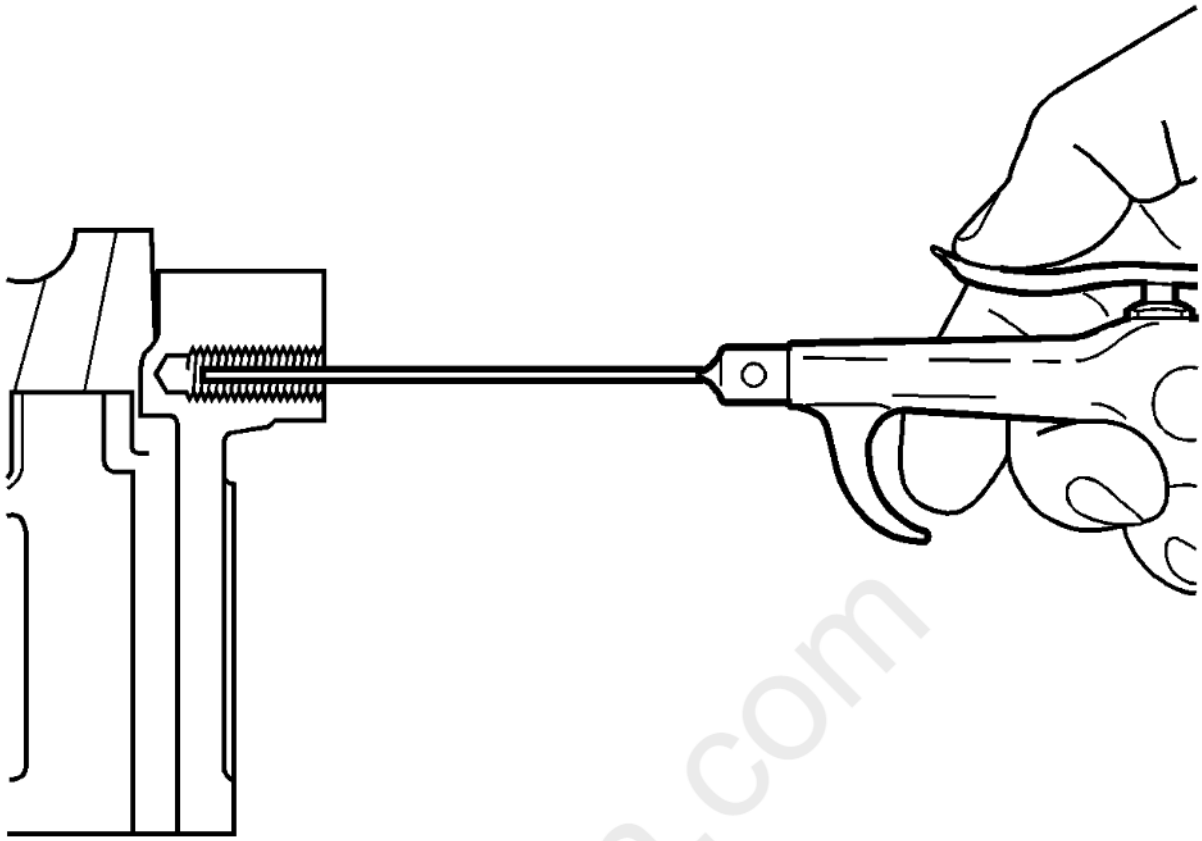


Fig. 337: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

11. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended cleaner.

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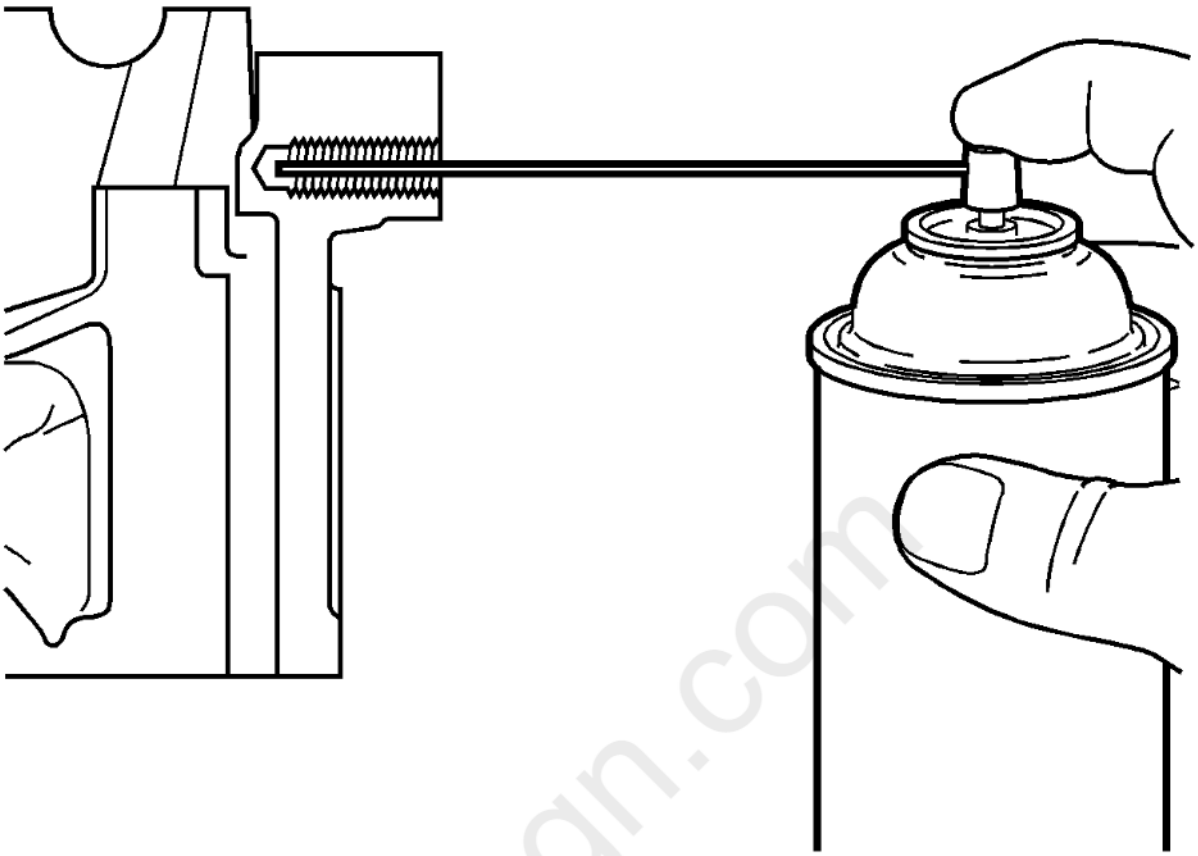


Fig. 338: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS COMPANY

12. Using compressed air, clean out any chips.

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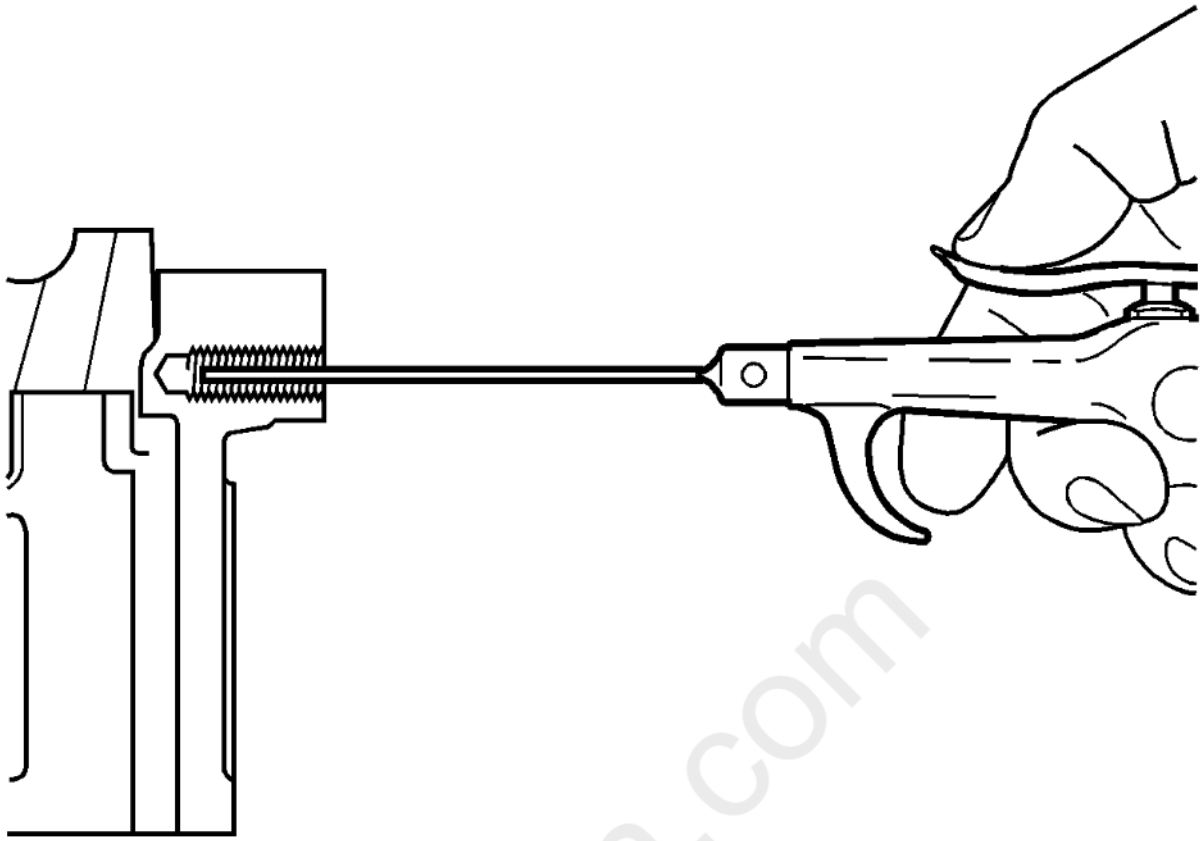


Fig. 339: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS COMPANY

NOTE: **All chips must be removed from the tapped hole prior to insert installation.**

13. Lubricate the threads of the driver installation tool (2) with the **EN-42385-110** (1).

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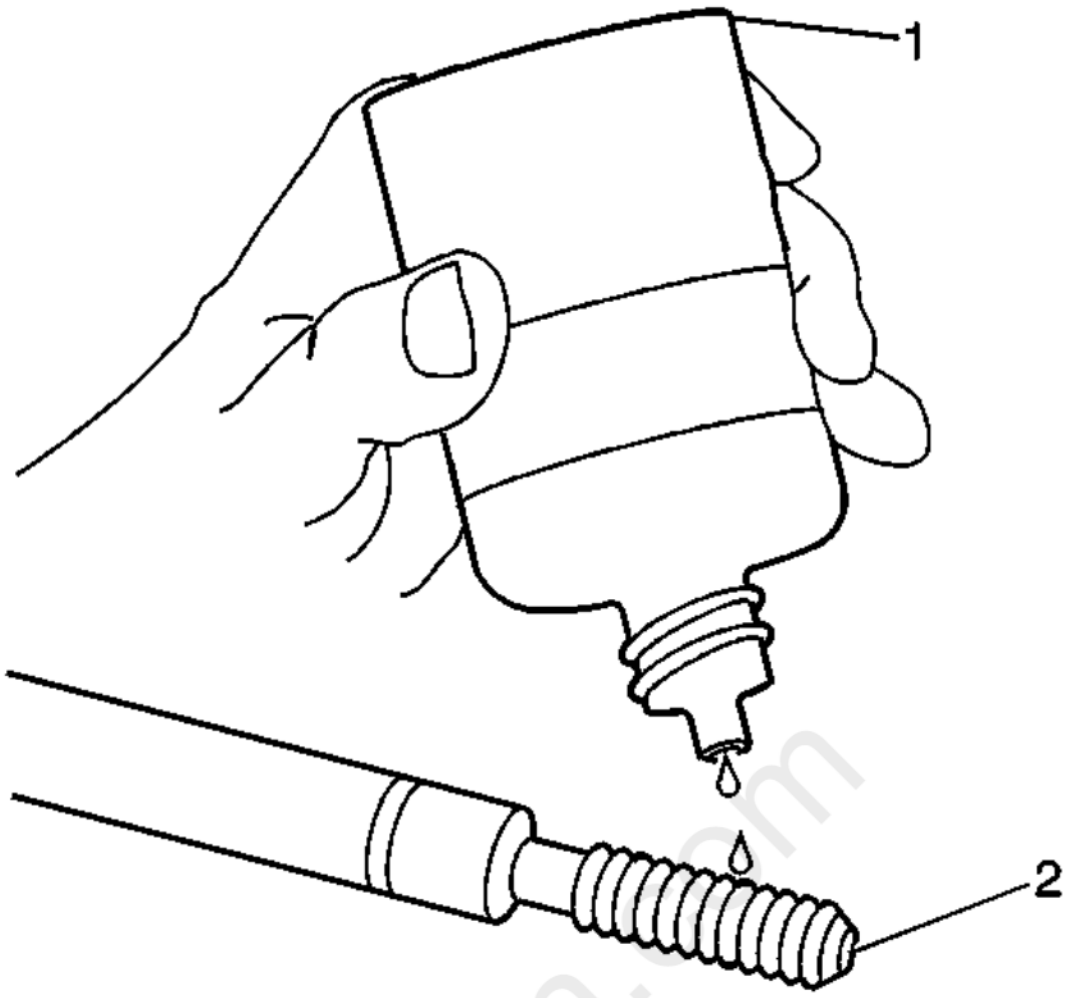


Fig. 340: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not remove the fixture plate, ensure the fixture plate is installed during the installation process of the insert.**
- **Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.**

14. Install the insert (2) onto the driver installation tool (1).

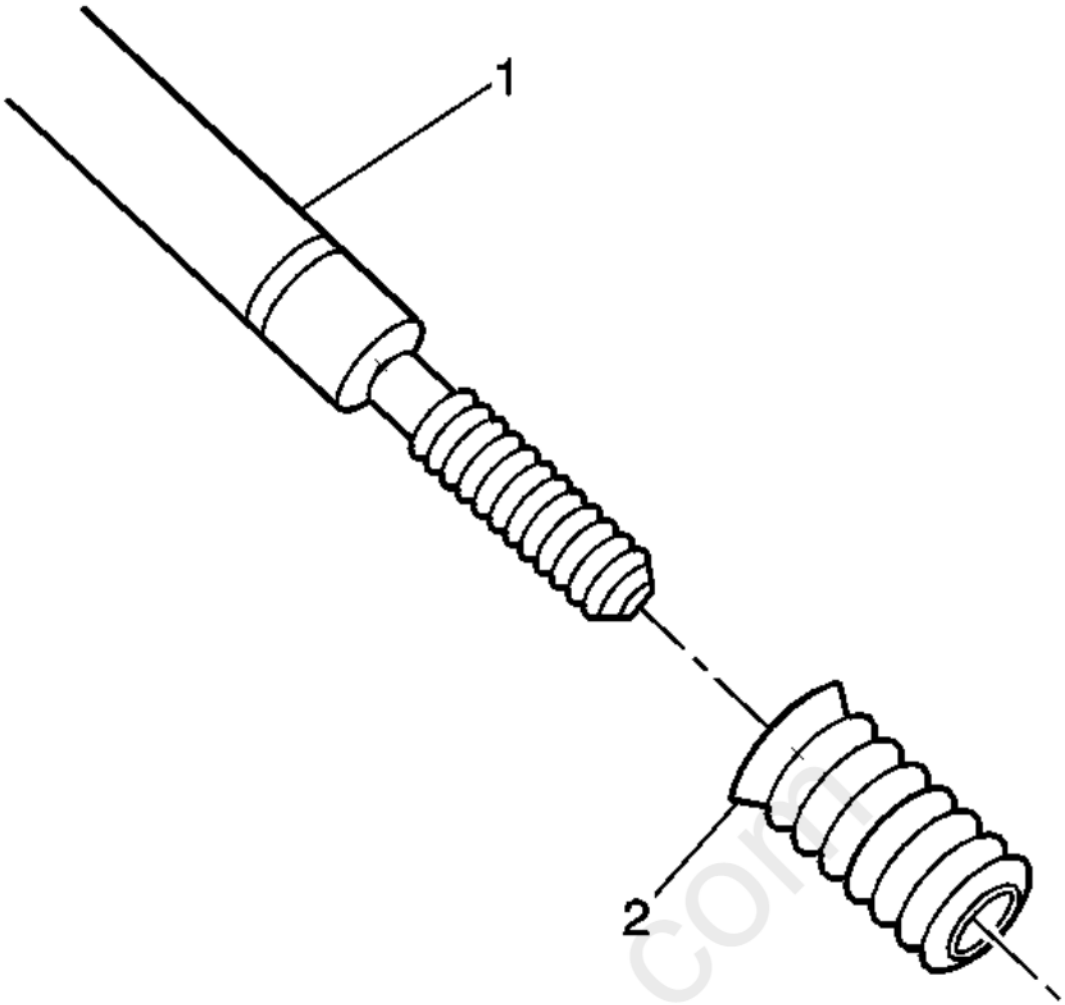


Fig. 341: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

15. Apply threadlock sealant, **EN-42385-109** , LOCTITE 277Â® or equivalent (1) to the insert OD threads (2). Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant.

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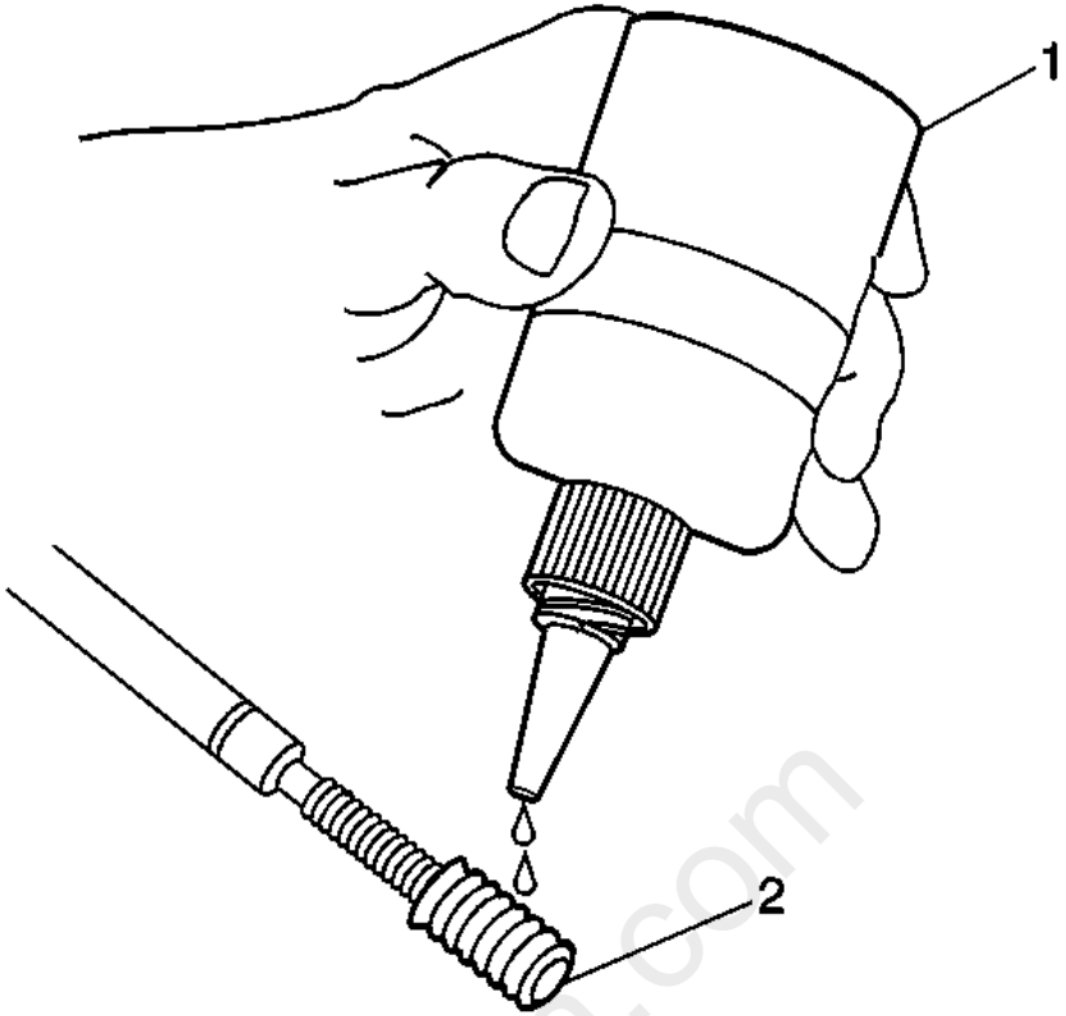


Fig. 342: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

16. Install the insert and installation driver into the tapped hole by hand only.

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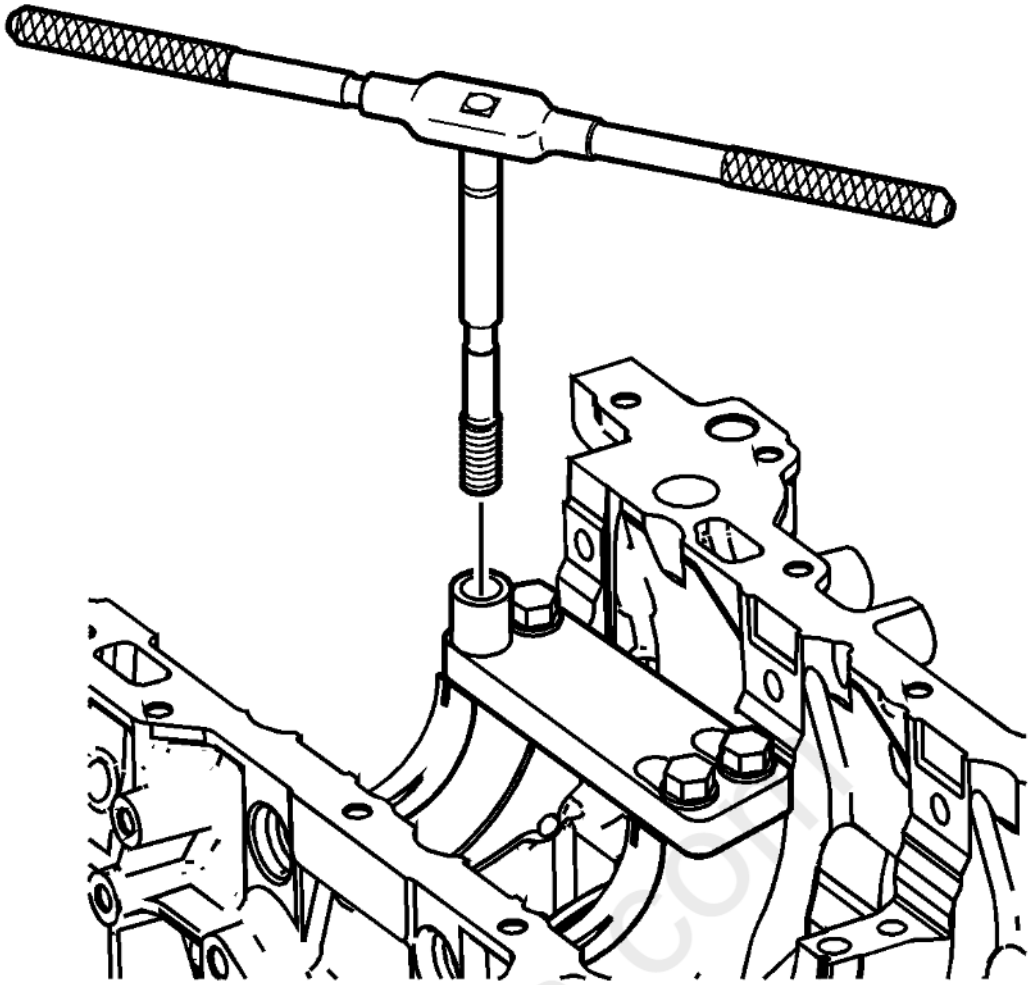


Fig. 343: View Of Insert & Installation Driver
Courtesy of GENERAL MOTORS COMPANY

17. Start the insert into the threaded hole.
18. Install the insert until the flange of the insert contacts the counterbored surface.

NOTE: **If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.**

19. Continue to rotate the driver installation tool through the insert.

NOTE: **The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.**

20. Rotate the driver installation tool until the mark (3) on the driver installation tool aligns with the top of the drill bushing (2).

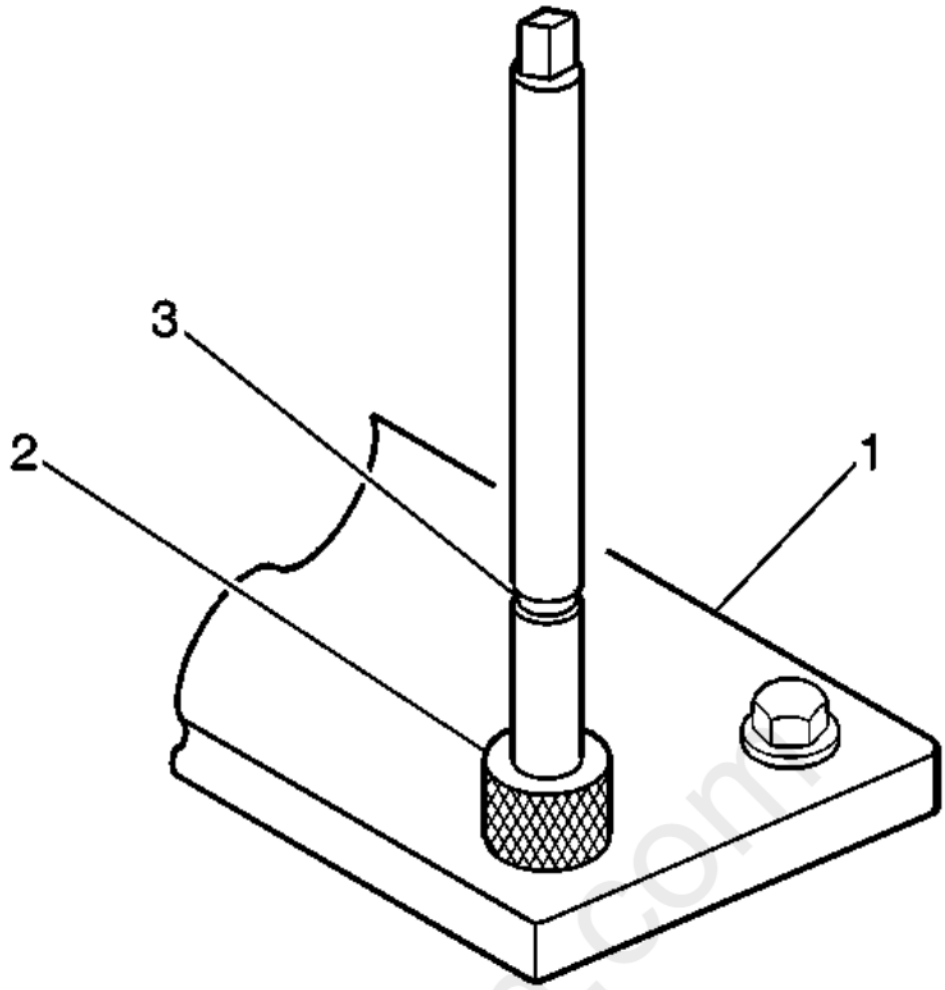


Fig. 344: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS COMPANY

21. Inspect the insert for proper installation into the tapped hole.
22. Remove the fixture plate bolts (2).

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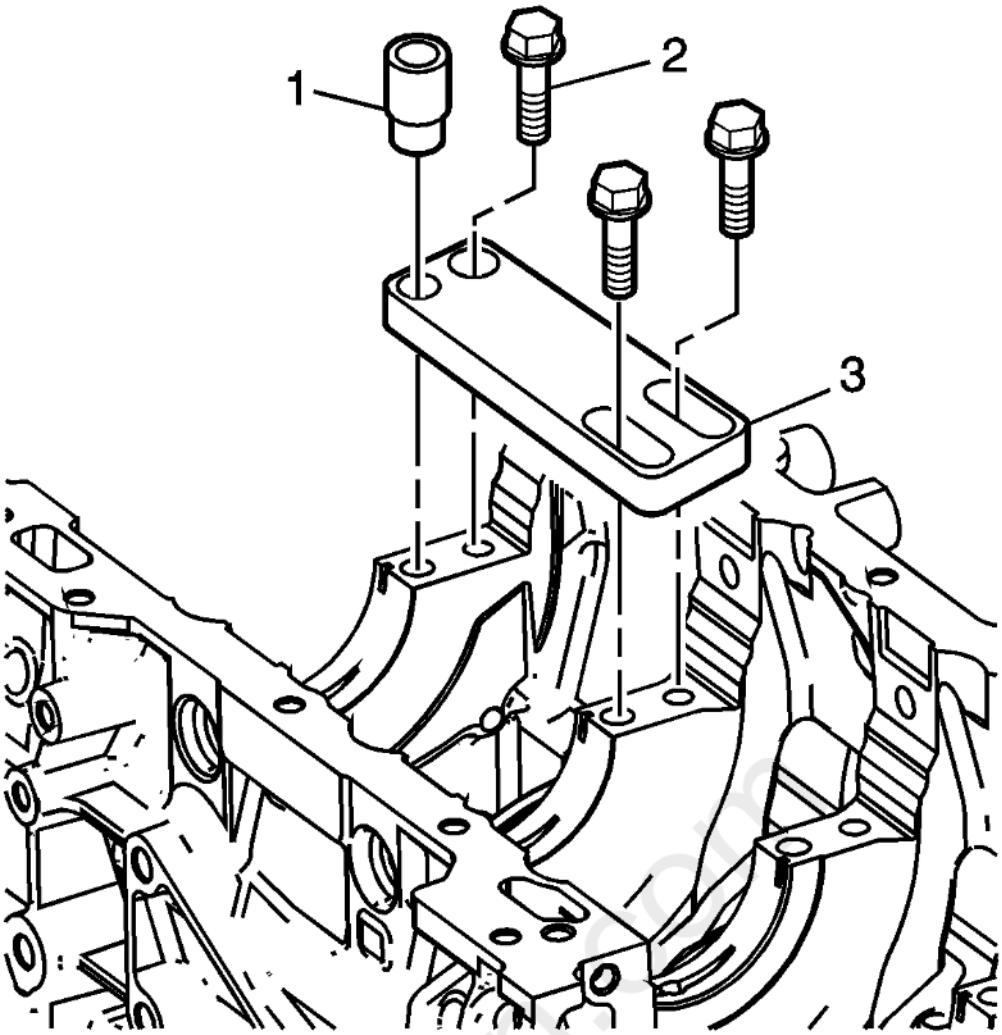


Fig. 345: View Of Fixture Plate & Components - Inboard Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

23. Remove the fixture plate (3) and bushing (1).

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.

ENGINE BLOCK ASSEMBLE

Engine Block - Left - Front

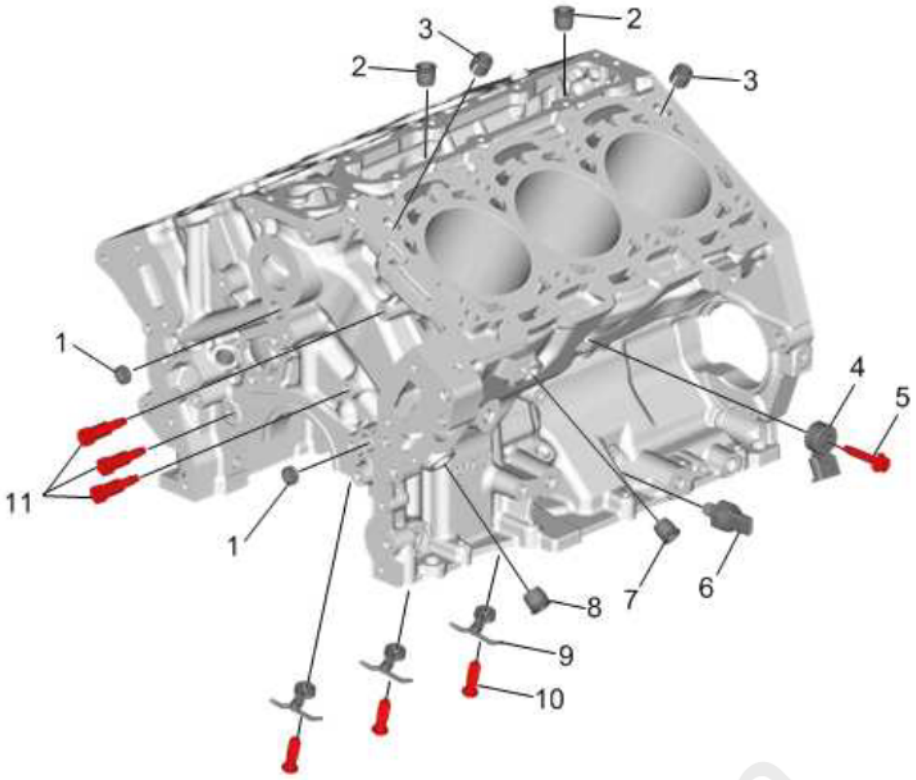


Fig. 346: Engine Block -- Left -- Front
Courtesy of GENERAL MOTORS COMPANY

Engine Block - Left - Front

Callout	Component Name
1	Engine Block Oil Gallery Plug Cap [2x]
2	Engine Block Oil Gallery Plug M16 [2x] **CAUTION:** **Refer to Fastener Caution .** **Procedure** Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** **Tighten** 40 N.m (30 lb ft)
3	Cylinder Head Locating Pin [2x]
4	Knock Sensor
5	Knock Sensor Bolt **Tighten** 25 N.m (18 lb ft)
6	Engine Oil Pressure Sensor **Tighten** 35 N.m (26 lb ft)
7	Engine Block Core Hole Plug **Tighten** 45 N.m (33 lb ft)
8	Engine Block Oil Gallery Plug M16 **Tighten** 40 N.m (30 lb ft)
9	Piston Oil Nozzle [3x]
10	Piston Oil Nozzle Bolt [3x] **Tighten** 10 N.m (89 lb in)

Callout	Component Name
11	Engine Front Cover Stud [3x] **Tighten** 15 N.m (11 lb ft)

Engine Block - Right - Rear

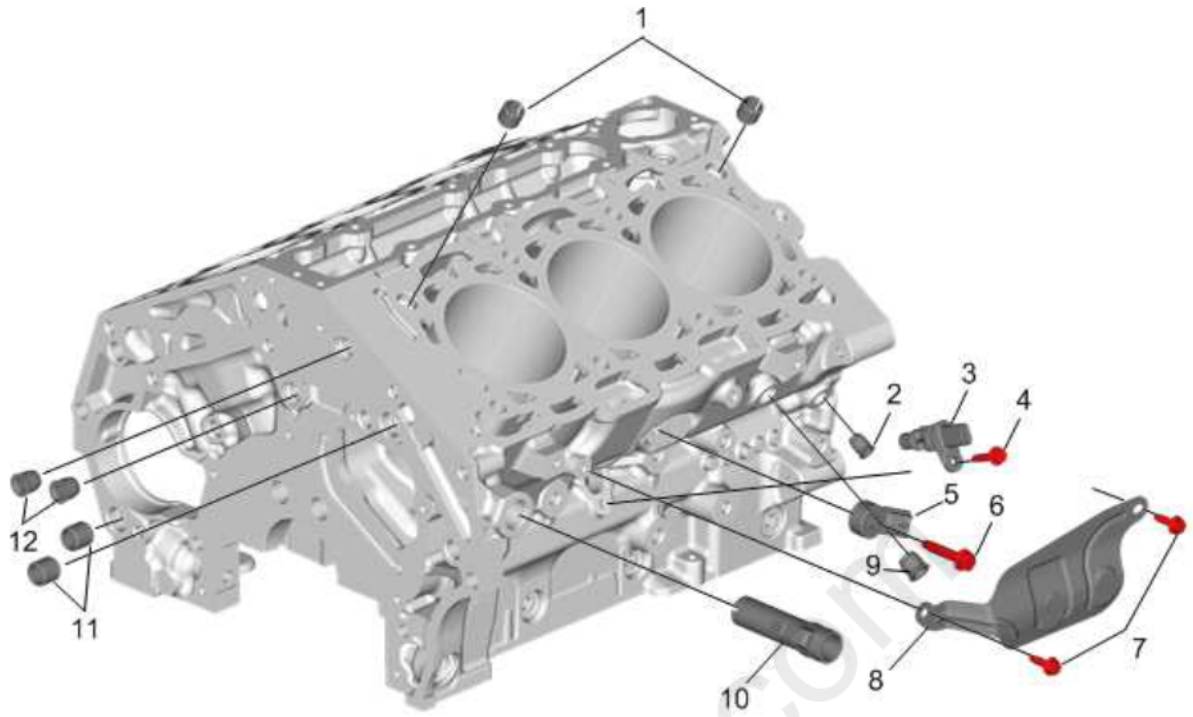


Fig. 347: Engine Block -- Right - Rear
Courtesy of GENERAL MOTORS COMPANY

Engine Block - Right - Rear

Callout	Component Name
1	Cylinder Head Locating Pin [2x]
2	Engine Block Core Hole Plug **Procedure** Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** **Tighten** 40 N.m (30 lb ft)
3	Crankshaft Position Sensor
4	Crankshaft Position Sensor Bolt **Tighten** 10 N.m (89 lb in)
5	Knock Sensor
6	Knock Sensor Bolt **Tighten** 25 N.m (18 lb ft)
7	Knock Sensor Heat Shield Bolt [2x] **Tighten** 10 N.m (89 lb in)
8	Knock Sensor Heat Shield
9	Engine Block Oil Gallery Plug M16 **Tighten** 40 N.m (30 lb ft)

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Callout	Component Name
10	Engine Coolant Temperature Sensor **Tighten** 9 N.m (80 lb in)
11	Crankshaft Rear Oil Seal Housing Locating Pin [2x]
12	Engine Block Oil Gallery Plug M16 [2x] **Tighten** 40 N.m (30 lb ft)

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

- **GE 6125-1B** Slide Hammer Adapter
- **EN 45059** Angle Meter
- **EN 49102** Crankshaft Bearing Cap Remover

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

Crankshaft Bearing Installation Procedure

1. Clean the crankcase crank bore with a lint-free cloth.

   NOTE: **If the crankshaft bearings have been used in a running engine, you must replace them with NEW crankshaft bearings for reassembly.**

2. Clean all the oil from the backside of new bearing halves.
3. Install the NEW upper crankshaft bearings into position. The thrust bearing belongs in the number 3 journal. Ensure that the upper bearing insert contains the oil transfer hole and groove. Roll the bearing into position so that the lock tang engages the crank slot. The bearing must fit flush with the upper crankcase.

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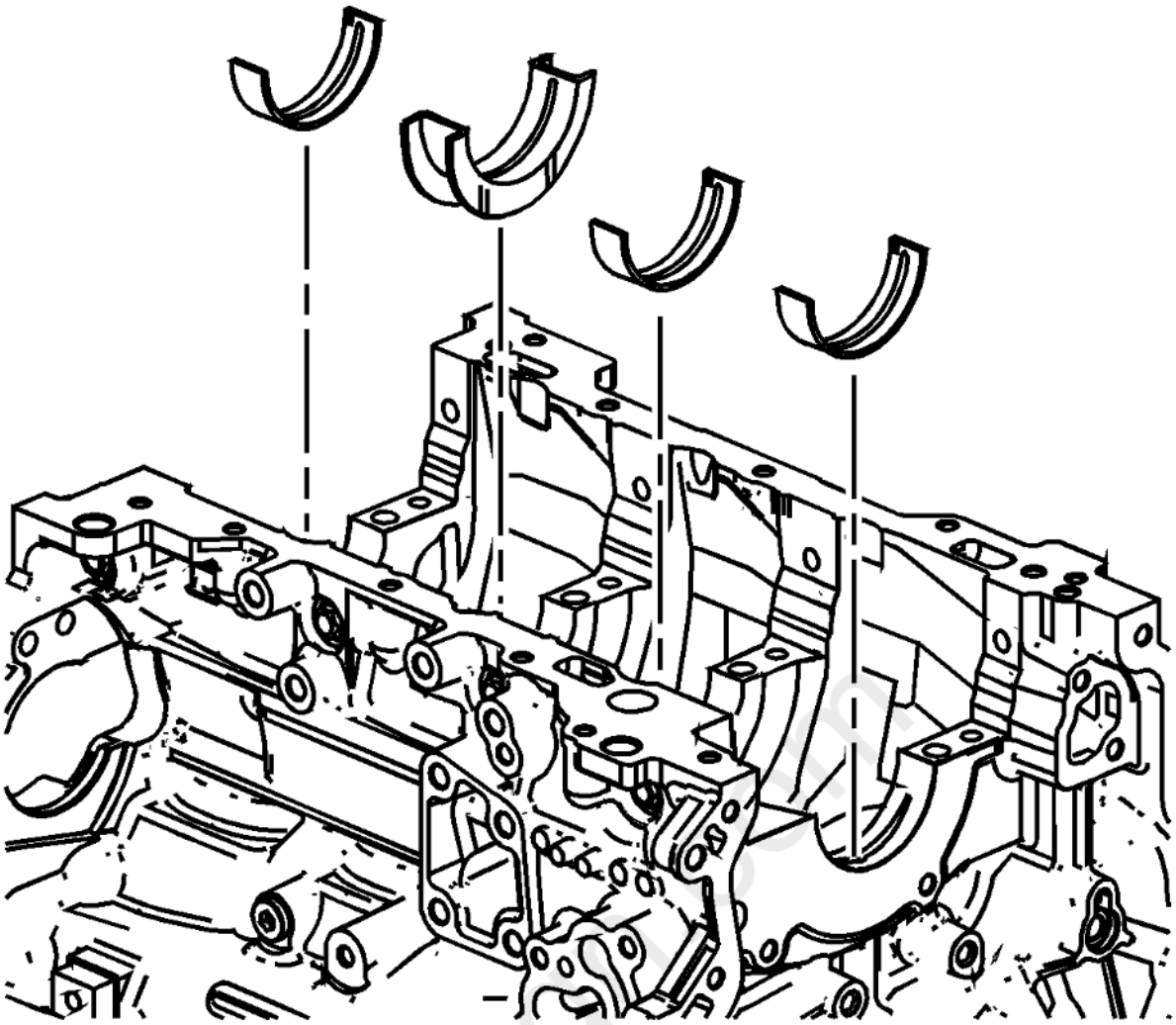


Fig. 348: View Of Upper Crankshaft Bearings
Courtesy of GENERAL MOTORS COMPANY

4. Install the NEW lower crankshaft bearings into position in the main bearing caps. The lower crankshaft bearings are identified by NO grooves or holes. The bearings must fit flush with the crankshaft bearing caps.

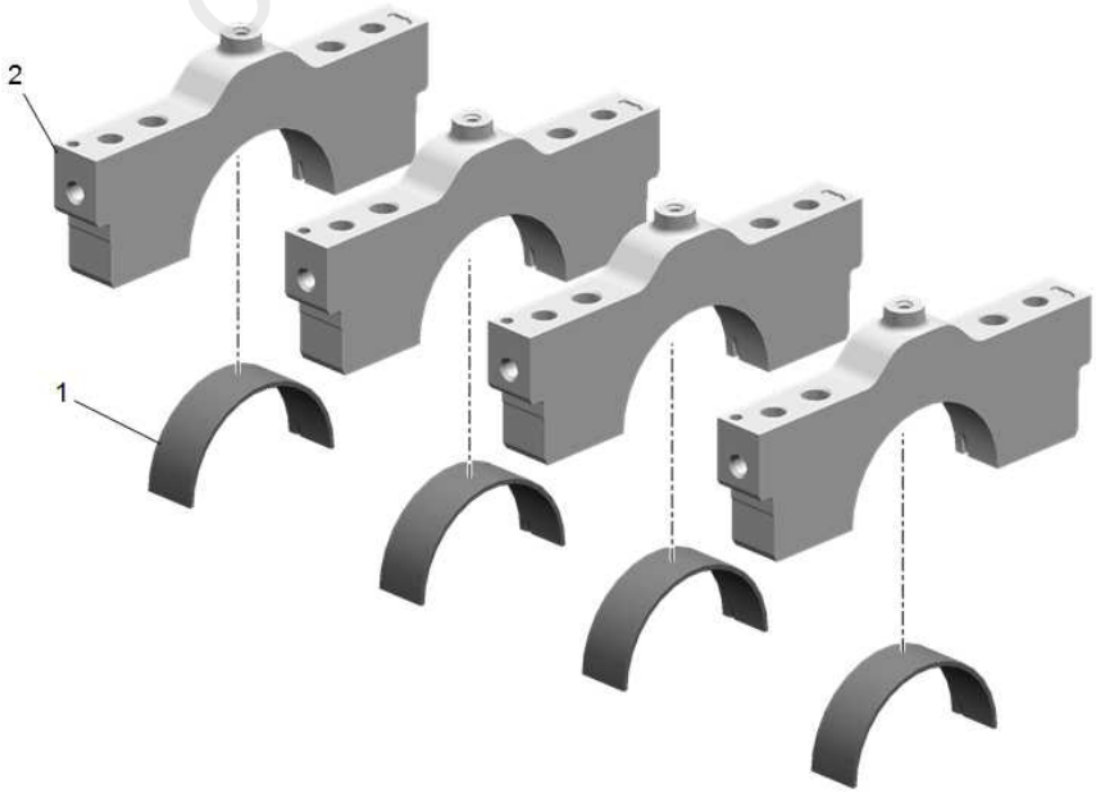


Fig. 349: View Of Crankshaft Bearing Caps & Lower Bearing Halves
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Installation Procedure

1. If removed, install the crankshaft key. Lightly tap the key in place with a small soft face, bronze/plastic, hammer until it bottoms in the keyway.

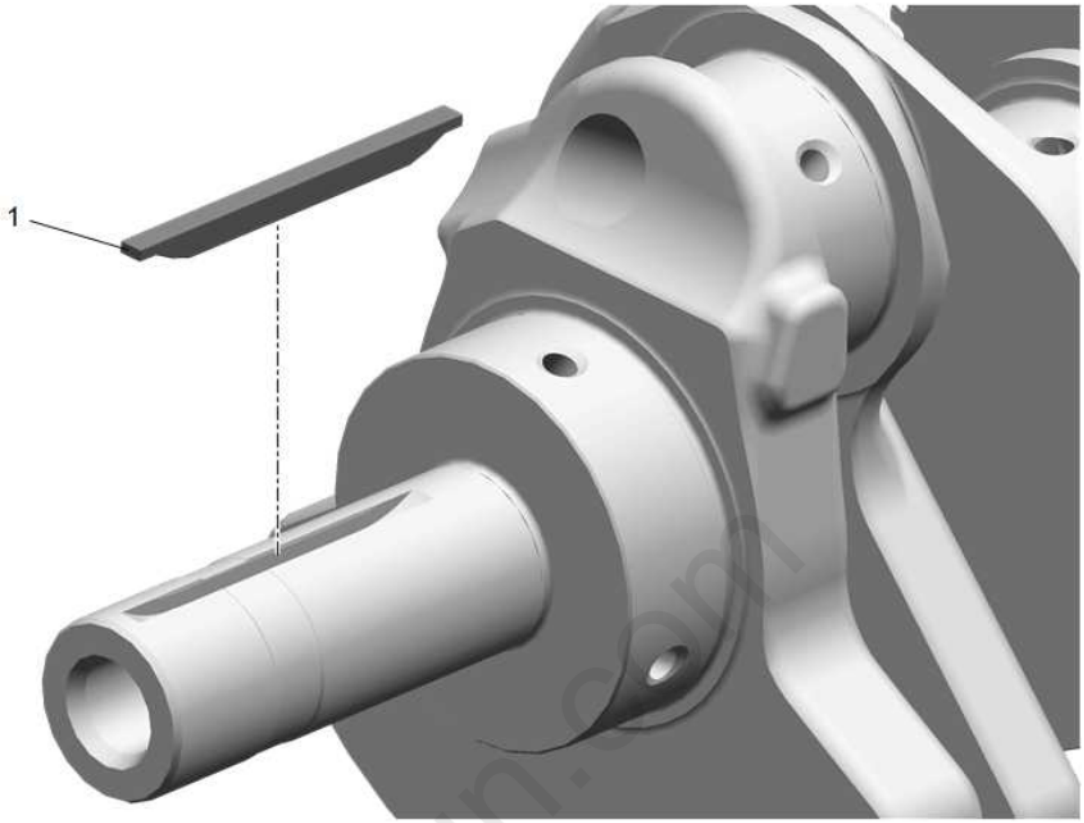


Fig. 350: Locating Crankshaft Sprocket Drive Pin
Courtesy of GENERAL MOTORS COMPANY

2. Gently lower the crankshaft into position in the cylinder block.

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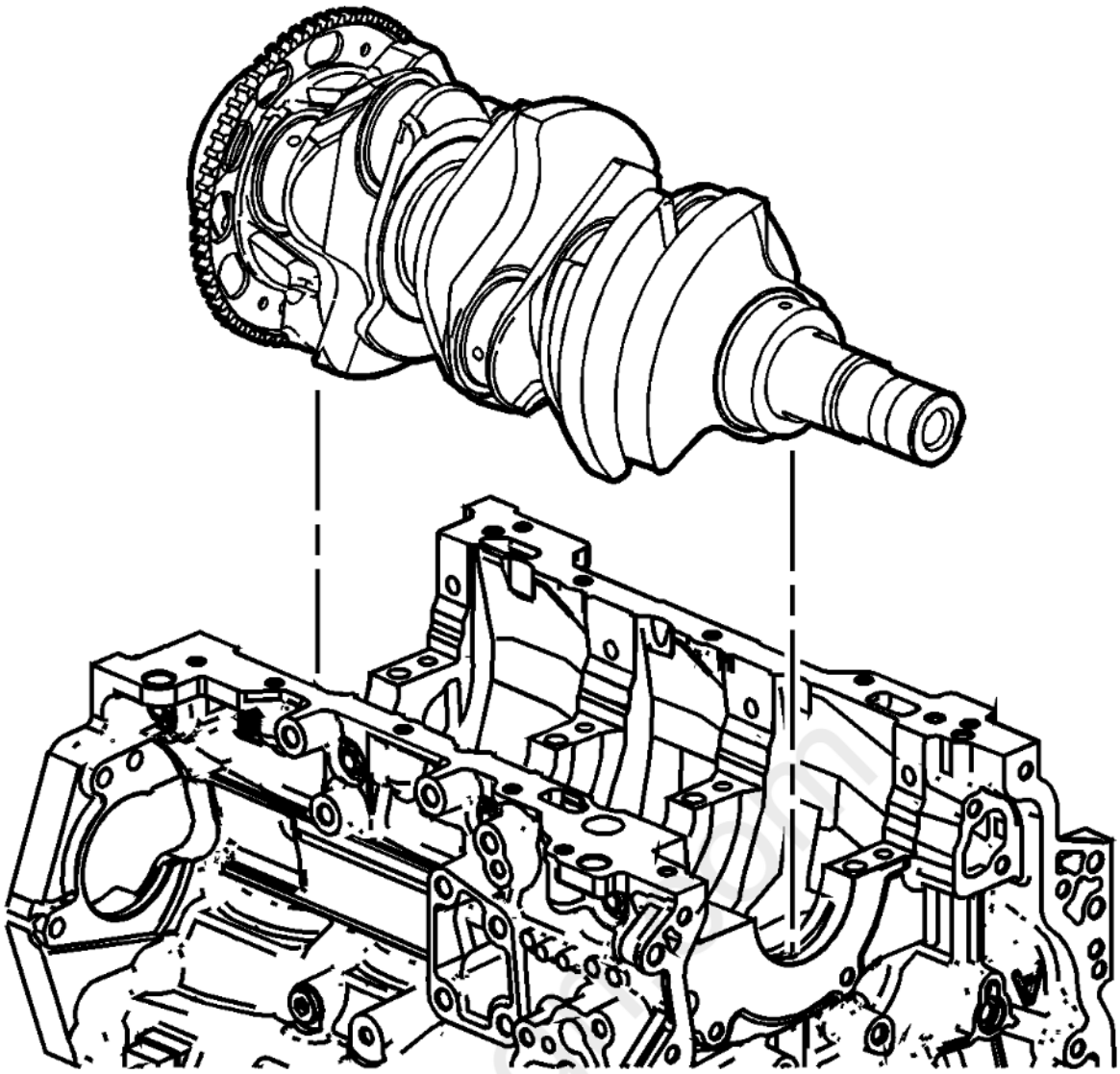


Fig. 351: View Of Crankshaft
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Bearing Clearance Measurement Procedure

1. Place a length of fresh, room temperature plastic gaging material all the way across all the crankshaft bearing journals.

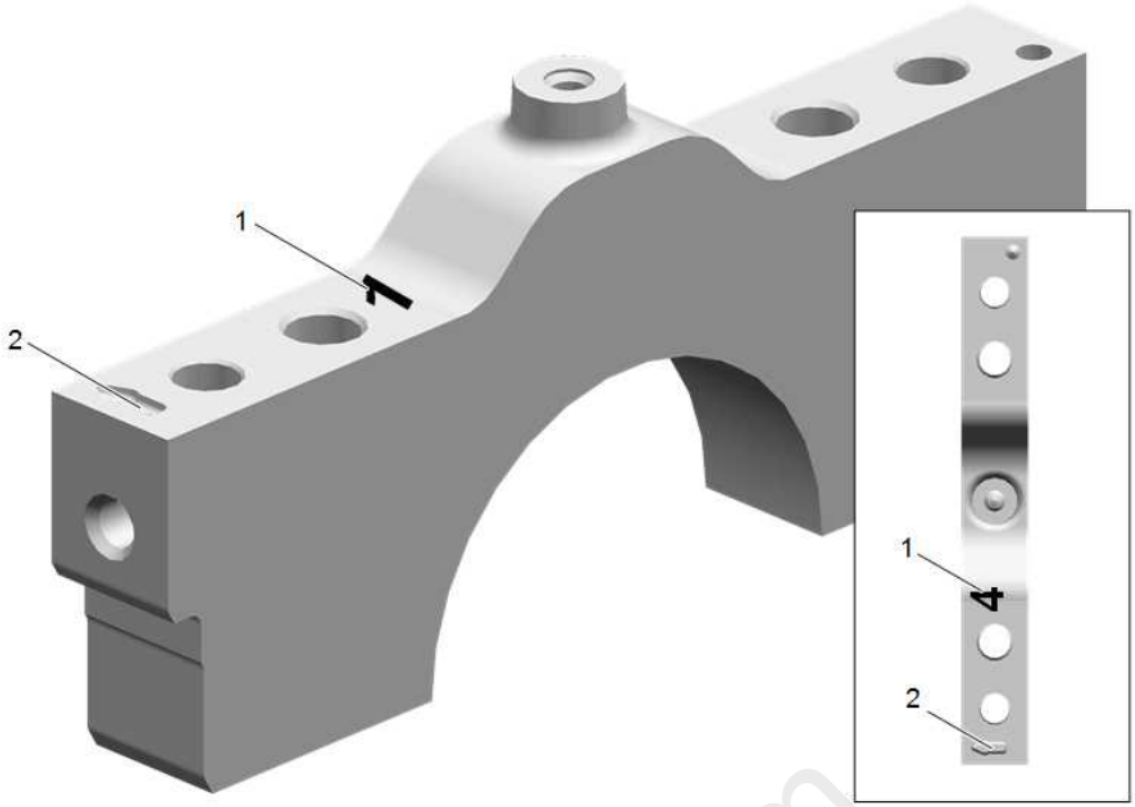


Fig. 352: Identifying Front Main Bearing Cap
Courtesy of GENERAL MOTORS COMPANY

2. Identify the proper order of the main bearing caps. The main bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the engine.
3. Install the crankshaft main bearing caps.

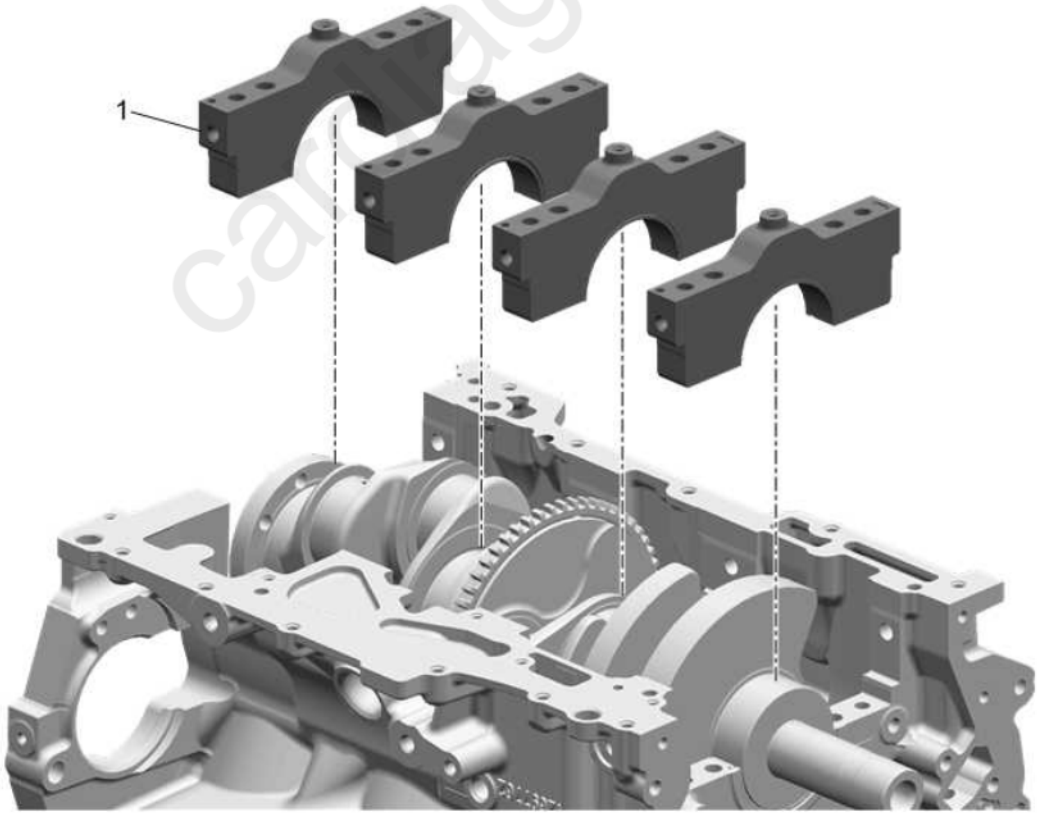


Fig. 353: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

4. Loosely install the original inner main cap bolts.
5. Loosely install the original outer main cap bolts.
6. Loosely install the original short/inner side main cap bolts.

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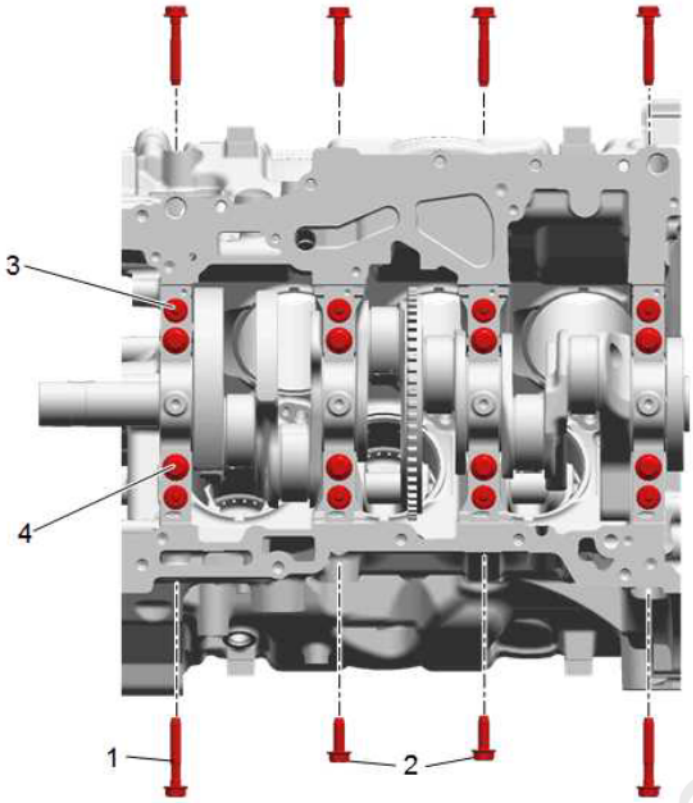
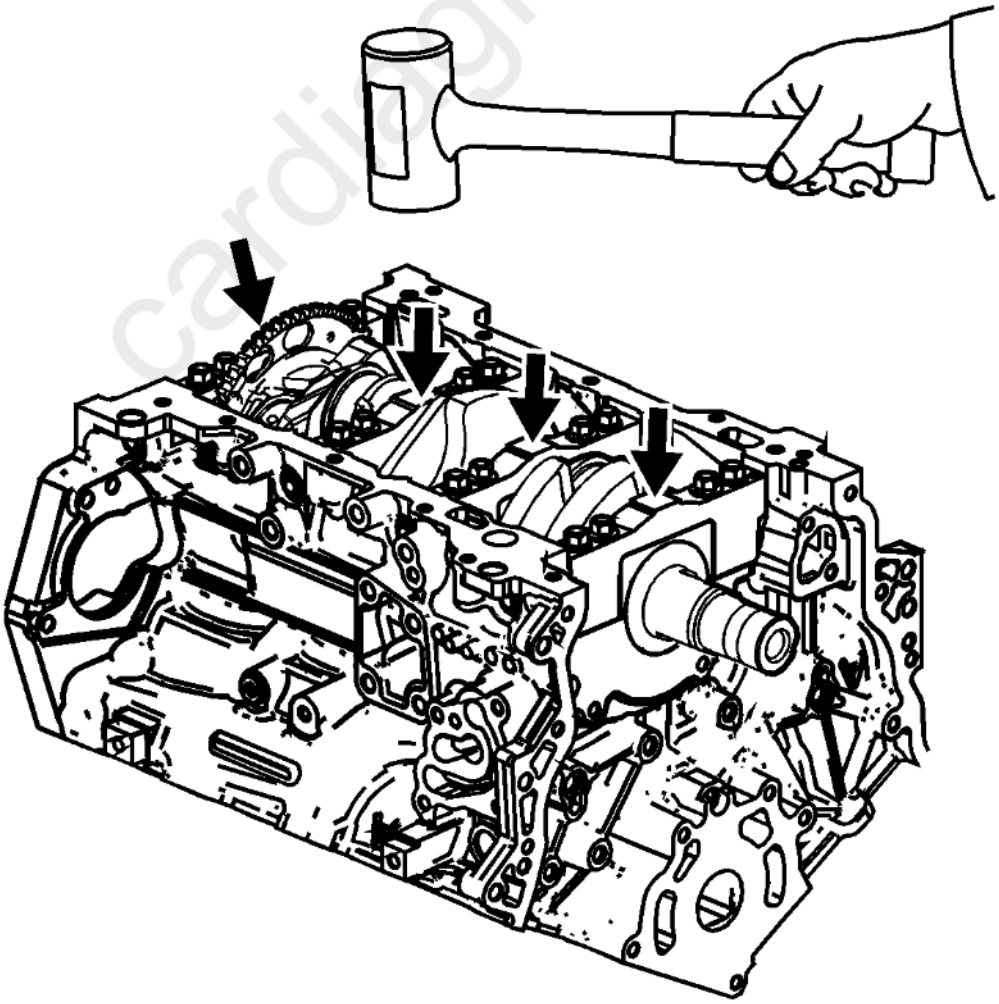


Fig. 354: Identifying Crankshaft Main Bearing Cap Side Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Loosely install the original long/outer side main cap bolts.
8. Tap the crankshaft main bearing caps with a soft-faced hammer.



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Fig. 355: Setting Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

9. Tighten the main caps bolts using the **EN 45059** meter in the following sequence:

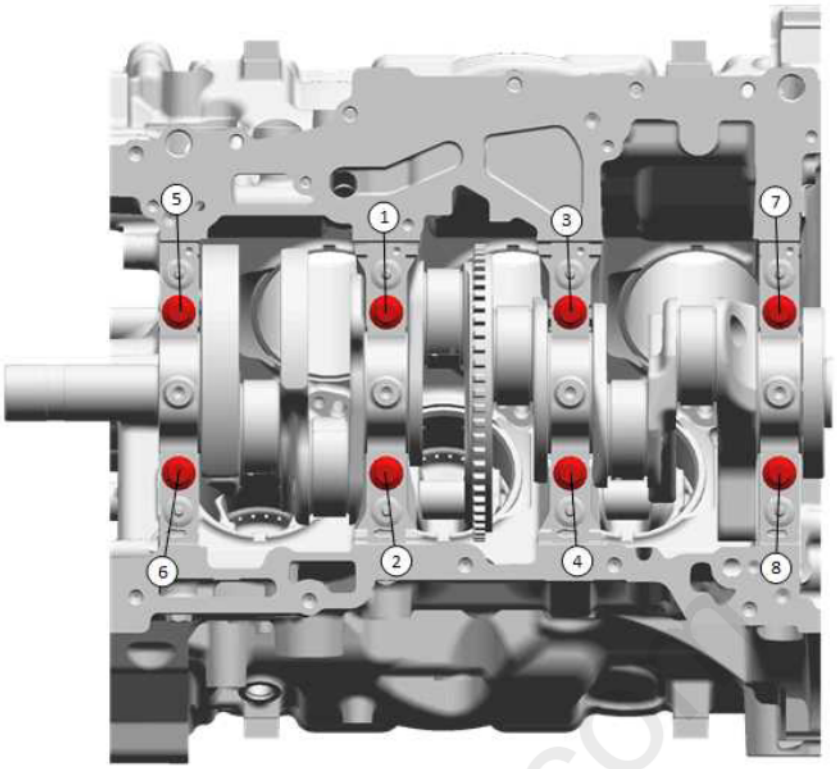


Fig. 356: Identifying Crankshaft Main Bearing Inboard Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

10. Tighten the inboard bolts (1-8) first, in two passes.

CAUTION: **Refer to Fastener Caution .**

    1. Tighten the inboard bolts to 20 N.m (15 lb ft) on the first pass.
    2. Tighten the inboard bolts (1-8) an additional 80 degrees on the 2nd pass.

11. Tighten the outboard bolts (9-16) second, in two passes.

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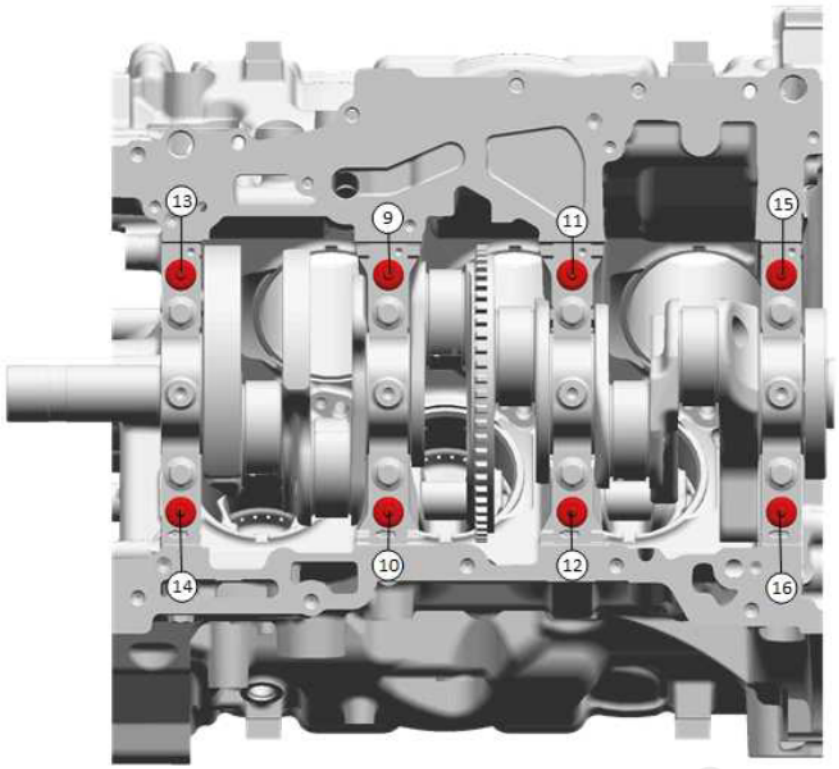


Fig. 357: Identifying Outboard Crankshaft Main Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

1. Tighten the outboard bolts to 15 N.m (11 lb ft) on the first pass.
2. Tighten the outboard bolts (9-16) an additional 110 degrees on the 2nd pass.

12. Tighten the short/inner bolts (17-20) third, in two passes.

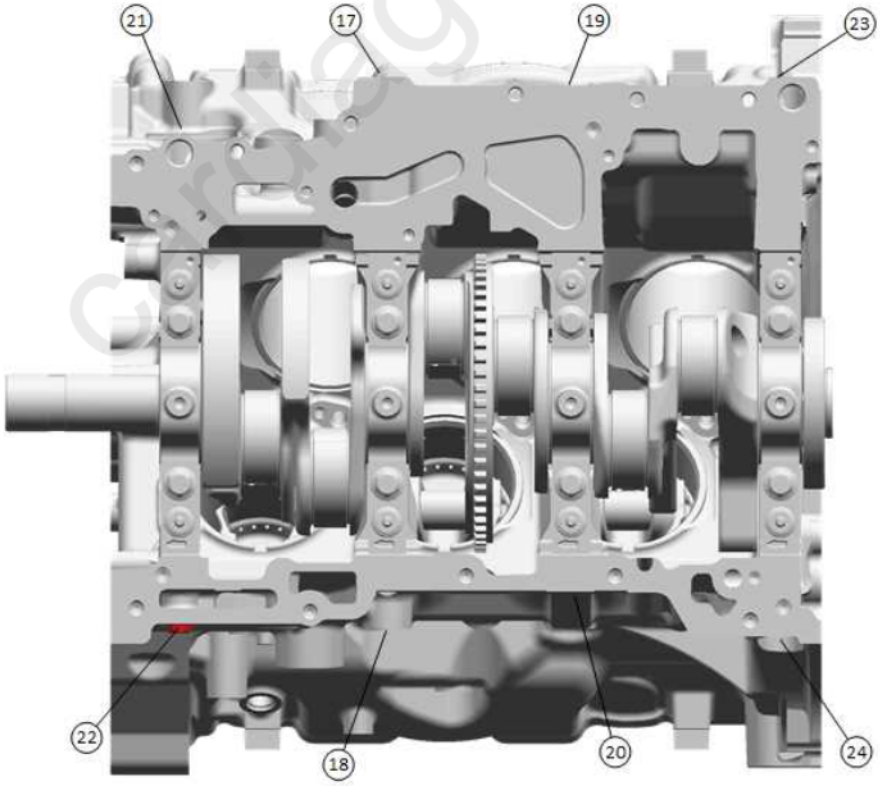


Fig. 358: Identifying Short/Inner Crankshaft Main Bearing (Bolt Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

1. Tighten the short/inner bolts to 30 N.m (22 lb ft) on the first pass.
2. Tighten the short/inner bolts (17-20) an additional 60 degrees on the 2nd pass.

13. Tighten the long/outer bolts (21-24) fourth, in two passes.
    1. Tighten the long/outer bolts to 30 N.m (22 lb ft) on the first pass.

2. Tighten the long/outer bolts (21-24) an additional 60 degrees on the 2nd pass.

14. After reaching final torque, allow the assembly to sit for 2 minutes.

NOTE: **Do not rotate the crankshaft.**

15. Remove the crankshaft bearing cap side bolts.

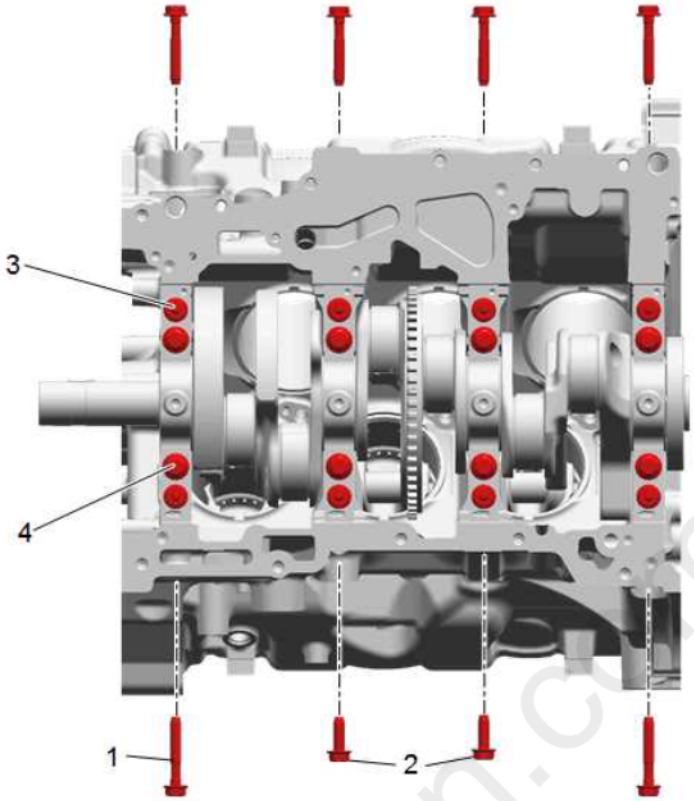


Fig. 359: Identifying Crankshaft Main Bearing Cap Side Bolts
Courtesy of GENERAL MOTORS COMPANY

16. Remove the crankshaft bearing cap outer bolts.

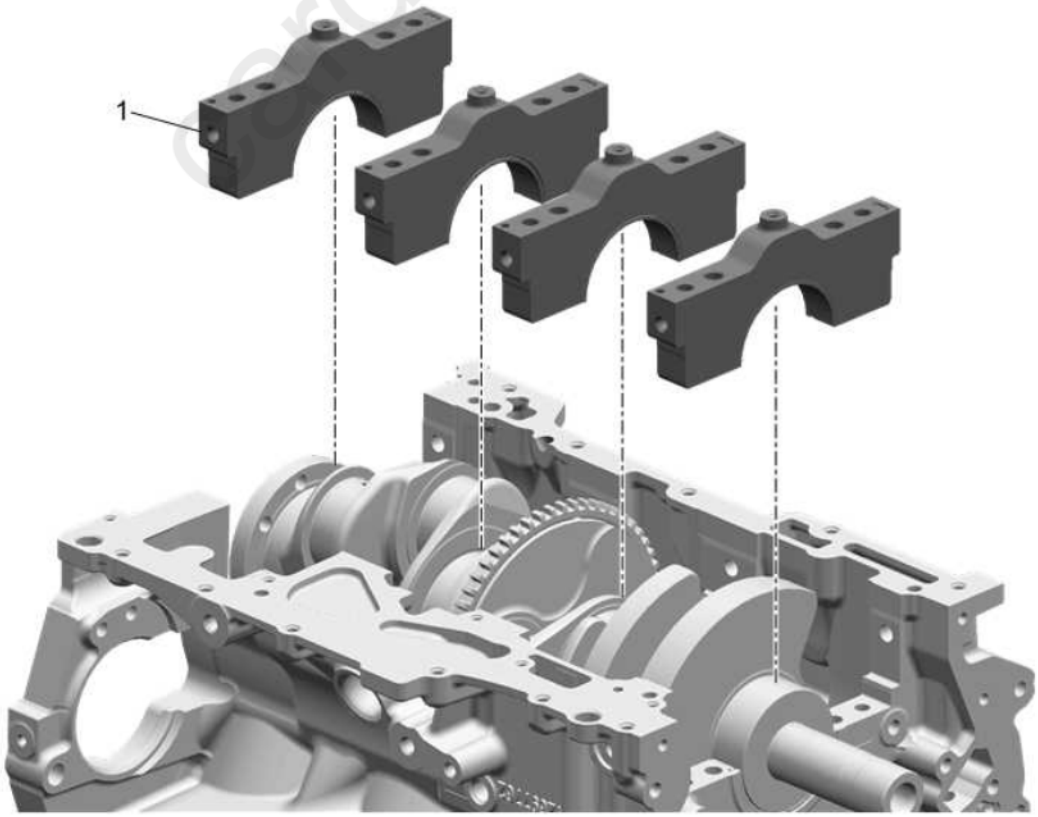


Fig. 360: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

17. Remove the crankshaft bearing cap inner bolts.
18. Remove the crankshaft bearing caps using the **GE 6125-1B** adapter and **EN 49102** remover.
19. Determine the crankshaft bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gaging material container.

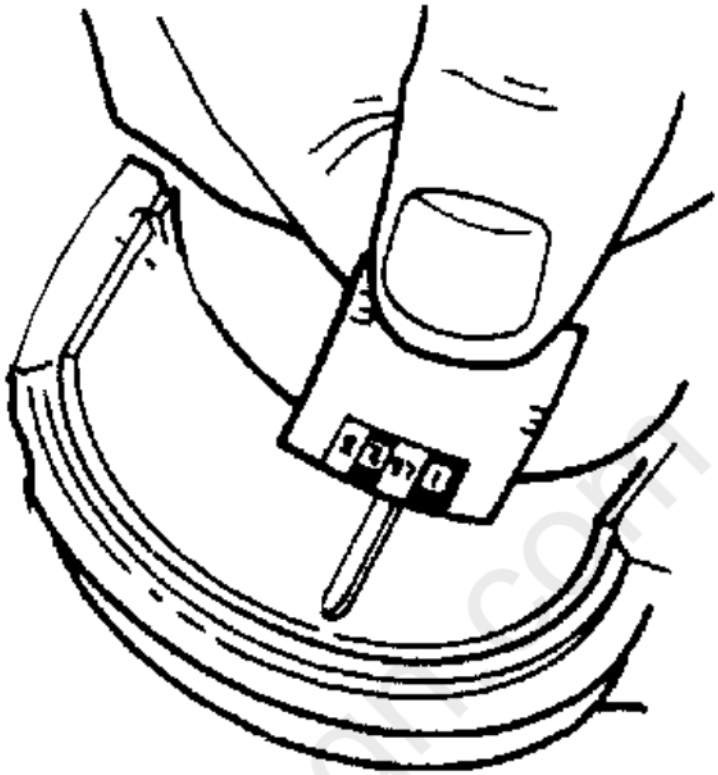


Fig. 361: Measuring Plastigage
Courtesy of GENERAL MOTORS COMPANY

20. Compare your measurements with the **Engine Mechanical Specifications (LGX)** and **Engine Mechanical Specifications (LGW)** . If the new bearings do not provide the proper crankshaft to bearing clearance, inspect the following:

NOTE: **The crankshaft bearings CAN be reused after checking the clearance if the bearings have never been used in a running engine.**

1. Re-measure the crankshaft journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.
2. Re-measure the engine block crankshaft bearing bore diameter to ensure proper size. The engine block crankshaft bearing bore is not machinable and the block must be replaced if out of specification.

21. Clean the plastic gaging material from the crankshaft bearing journals with a soft, lint-free cloth.
22. Lift the crankshaft out of the cylinder block.

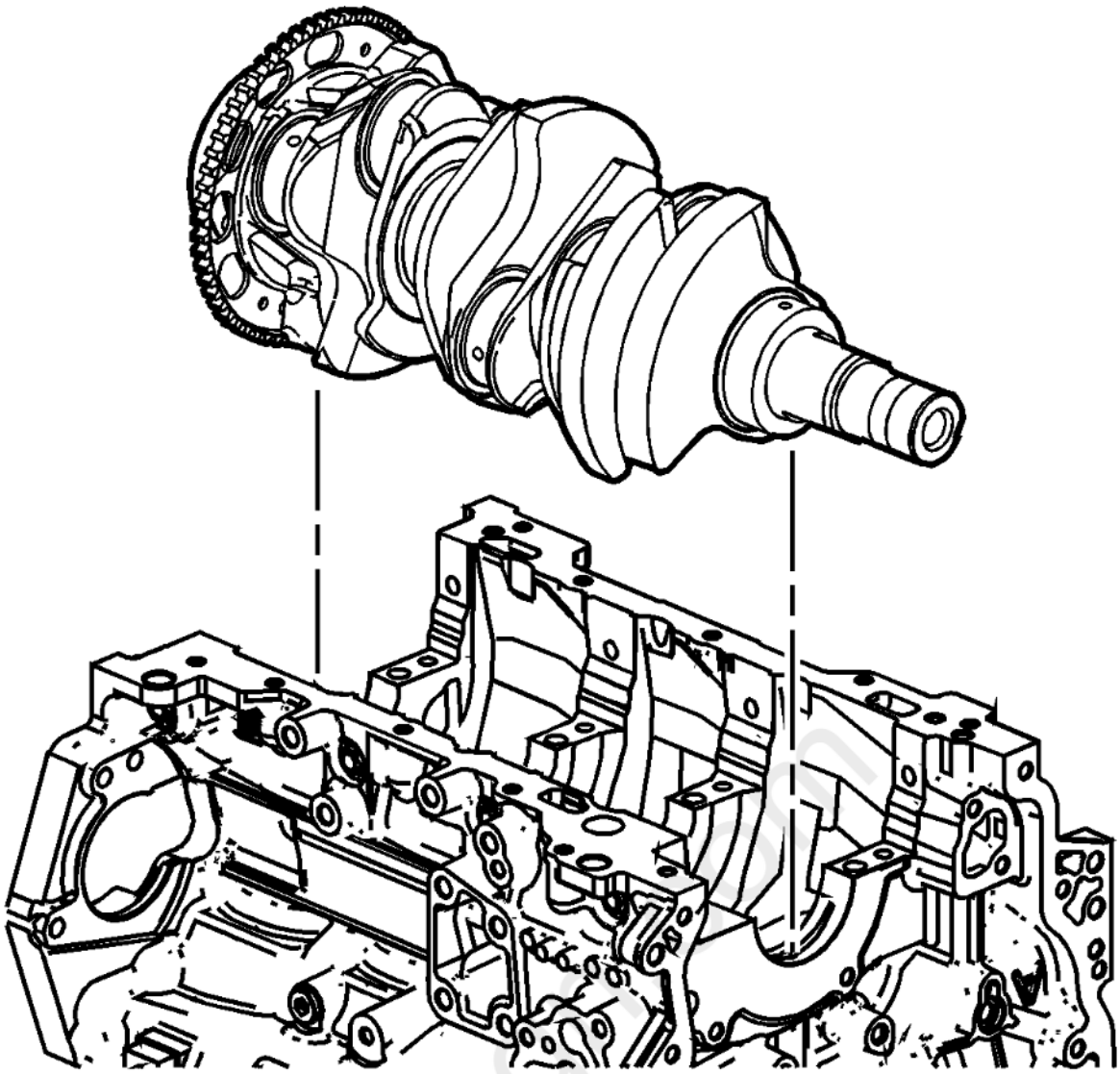


Fig. 362: View Of Crankshaft
Courtesy of GENERAL MOTORS COMPANY

23. Apply a liberal amount of crankshaft prelube or clean engine oil to the upper and lower bearing surfaces. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended lubricant.

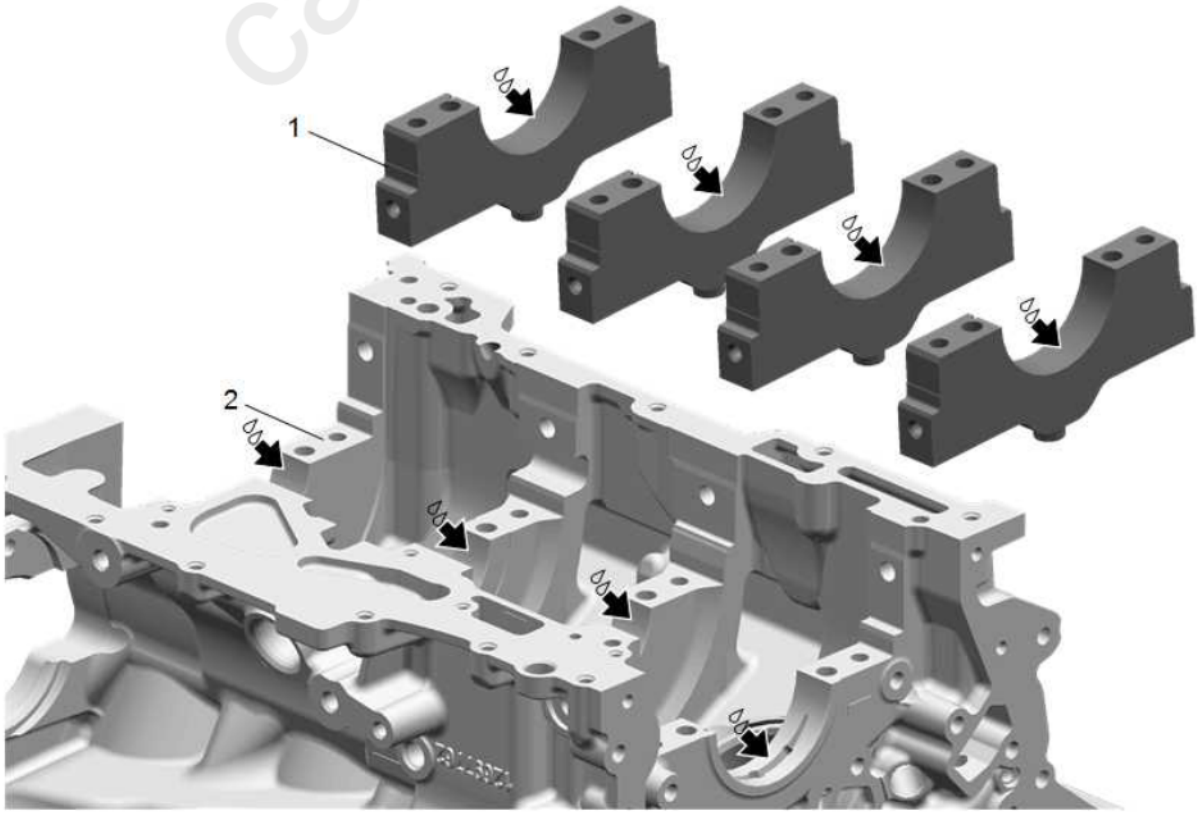


Fig. 363: Prelubing Upper & Lower Bearing Surfaces
Courtesy of GENERAL MOTORS COMPANY

24. Gently lower the crankshaft into position in the cylinder block.

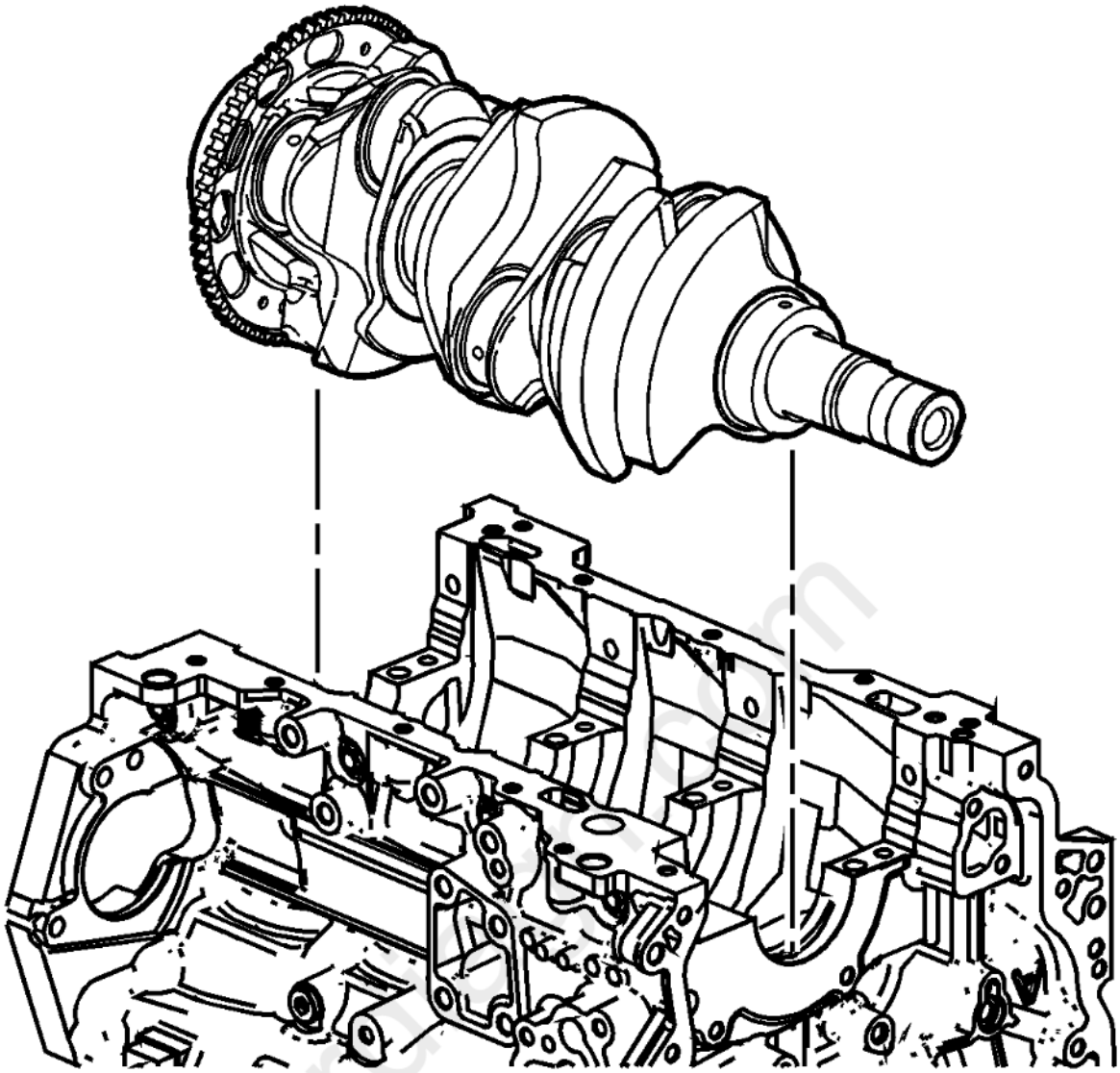


Fig. 364: View Of Crankshaft
Courtesy of GENERAL MOTORS COMPANY

25. Identify the proper order of the main bearing caps. The main bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the engine.

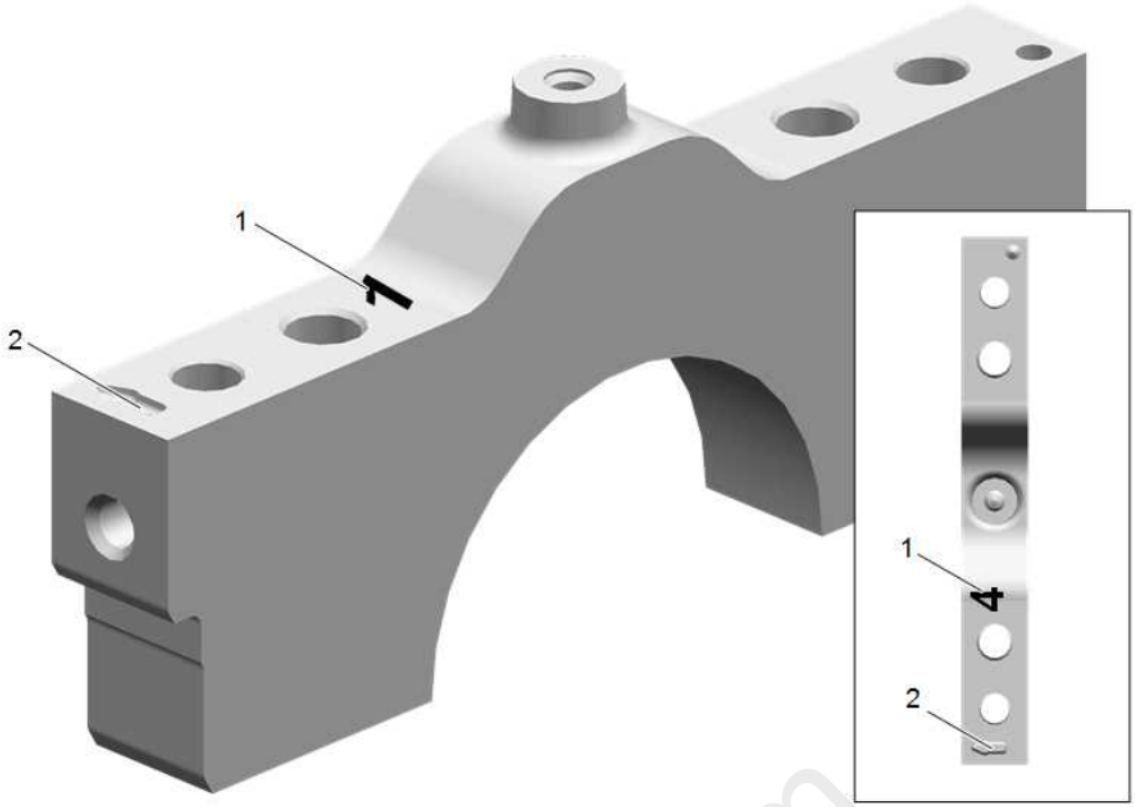


Fig. 365: Identifying Front Main Bearing Cap
Courtesy of GENERAL MOTORS COMPANY

26. Install the crankshaft main bearing caps.

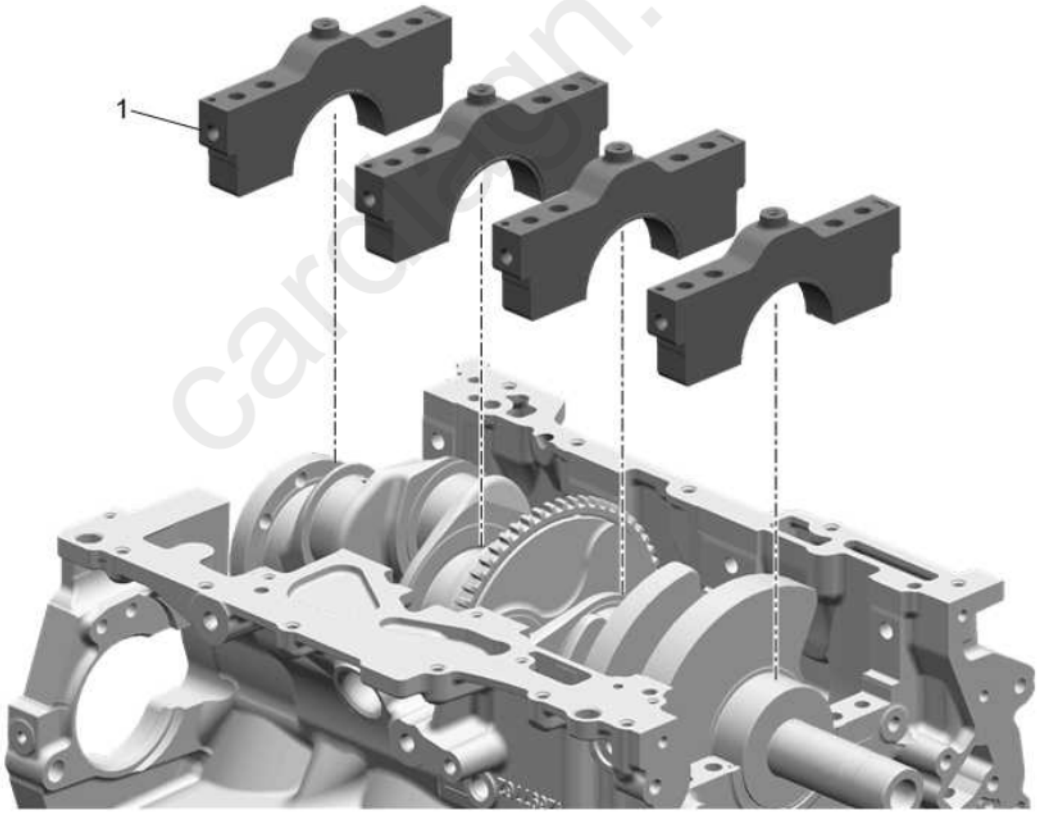


Fig. 366: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

27. Loosely install the NEW inner main cap bolts.

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.**

28. Loosely install the NEW outer main cap bolts.
29. Tap the crankshaft main bearing caps with a soft-faced hammer.

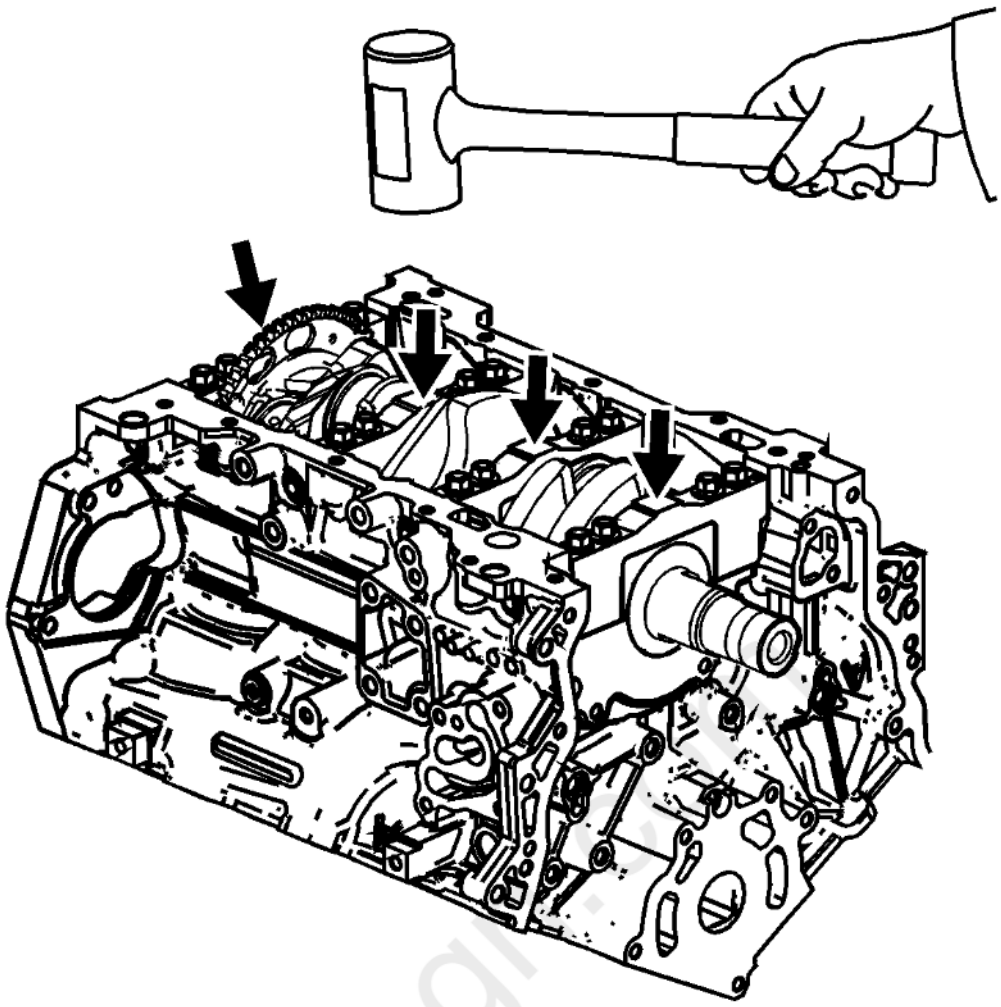


Fig. 367: Setting Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

30. Loosely install the NEW short/inner side main cap bolts.

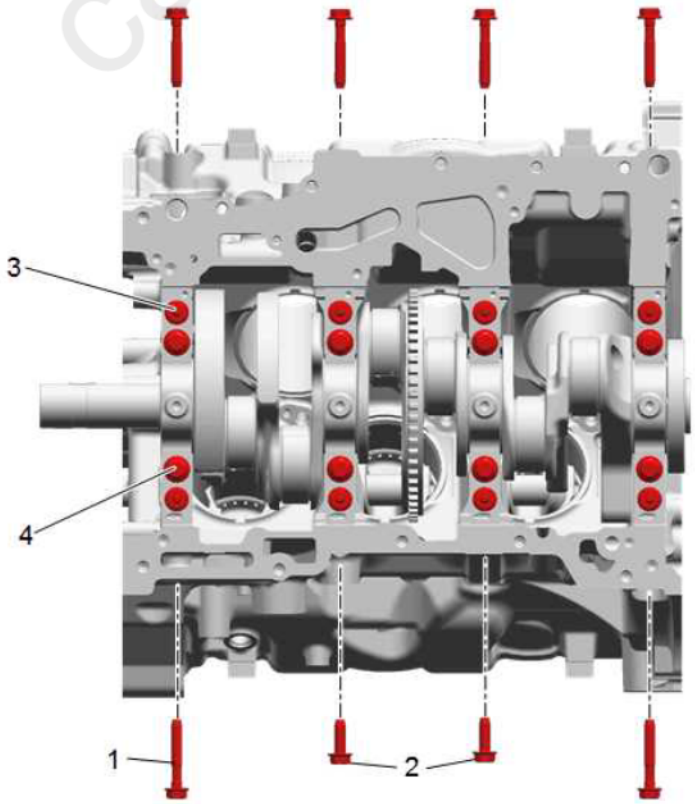


Fig. 368: Identifying Crankshaft Main Bearing Cap Side Bolts
Courtesy of GENERAL MOTORS COMPANY

31. Loosely install the NEW long/outer side main cap bolts.
32. Tighten the main cap bolts using the **EN 45059** meter in the following sequence:

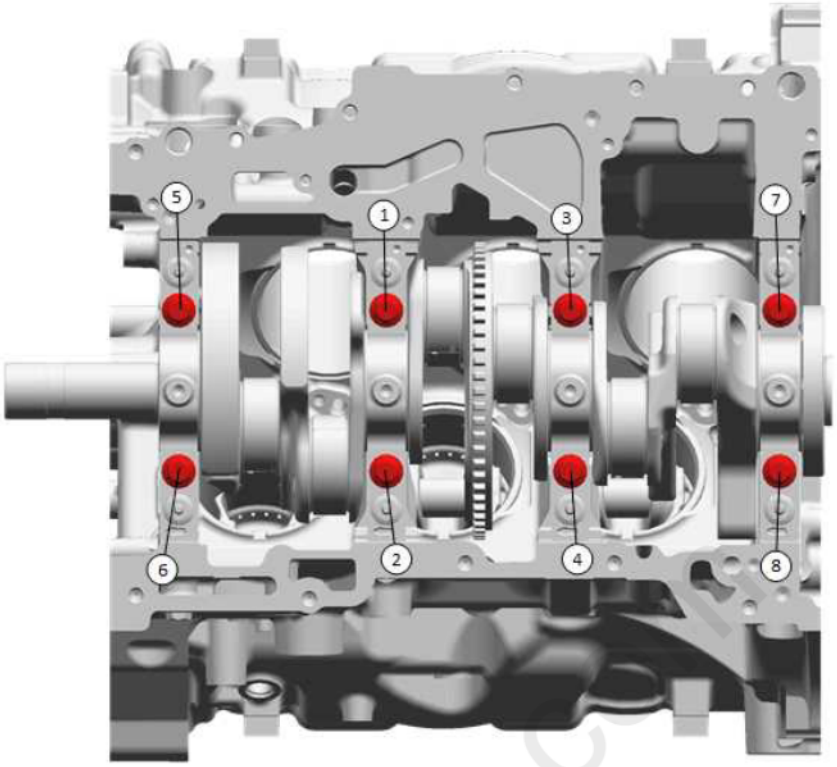


Fig. 369: Identifying Crankshaft Main Bearing Inboard Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

33. Tighten the inboard bolts (1-8) first, in two passes.
    1. Tighten the inboard bolts to 20 N.m (15 lb ft) on the first pass.
    2. Tighten the inboard bolts (1-8) an additional 80 degrees on the 2nd pass.
34. Tighten the outboard bolts (9-16) second, in two passes.

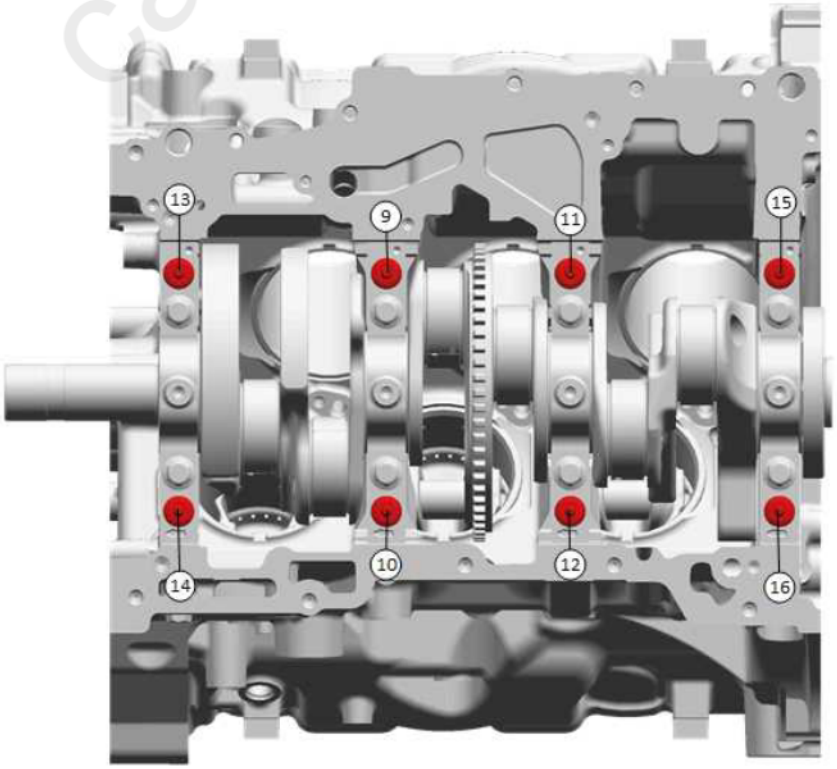


Fig. 370: Identifying Outboard Crankshaft Main Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

1. Tighten the outboard bolts to 15 N.m (11 lb ft) on the first pass.
2. Tighten the outboard bolts (9-16) an additional 110 degrees on the 2nd pass.

35. Tighten the short/inner bolts (17-20) third, in two passes.

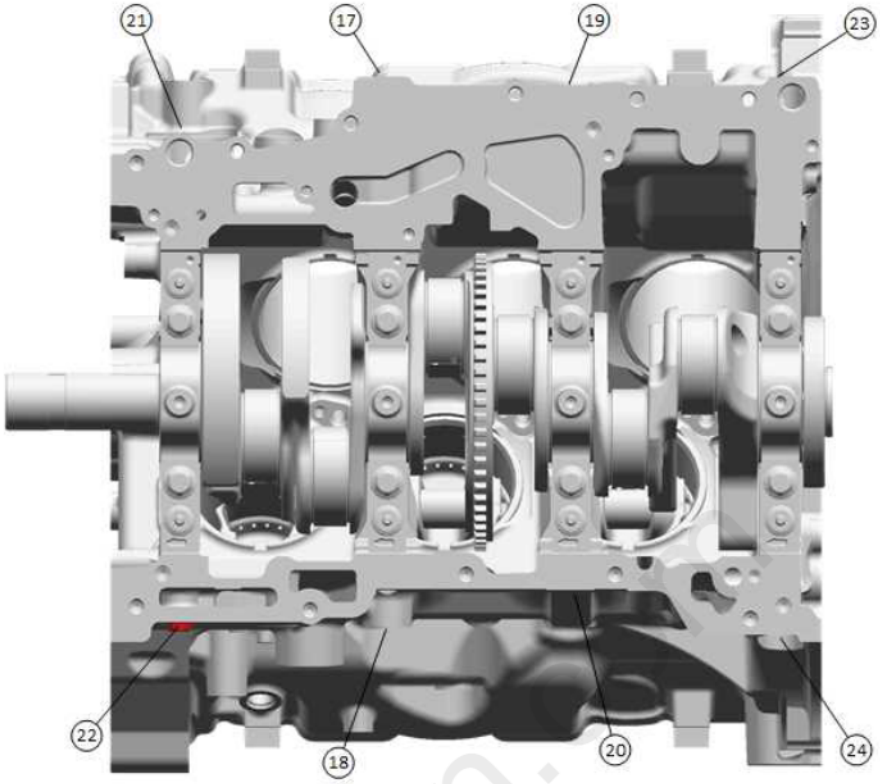


Fig. 371: Identifying Short/Inner Crankshaft Main Bearing (Bolt Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

1. Tighten the short/inner bolts to 30 N.m (22 lb ft) on the first pass.
2. Tighten the short/inner bolts (17-20) an additional 60 degrees on the 2nd pass.

36. Tighten the long/outer bolts (21-24) fourth, in two passes.
    1. Tighten the long/outer bolts to 30 N.m (22 lb ft) on the first pass.
    2. Tighten the long/outer bolts (21-24) an additional 60 degrees on the 2nd pass.
37. Ensure that the crankshaft turns without binding or noise.

PISTON, CONNECTING ROD AND BEARING INSTALLATION

Special Tools

- **EN-43690-A** Rod Bearing Clearance Checking Tool
- **EN-43690-100** Rod Bearing Clearance Checking Tool - Adapter Kit
- **EN-45059** Angle Meter
- **EN-46121** Connecting Rod Guide Pin Set
- **EN-48589** Crankshaft Rotation Socket

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

Piston and Connecting Rod Assembly Procedure

1. Liberally lubricate the cylinder walls, piston rings and piston skirts with engine oil.

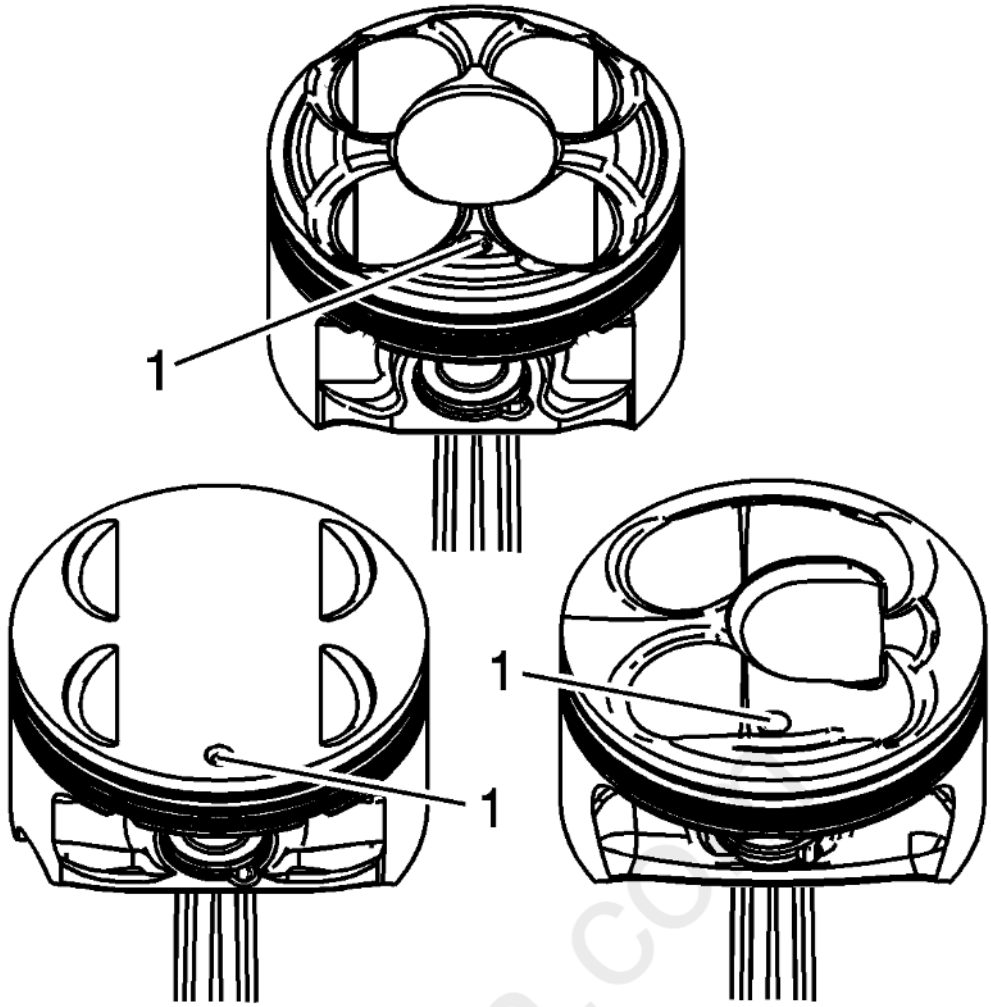


Fig. 372: View of Lubrication Points of the Piston Ring Assembly
Courtesy of GENERAL MOTORS COMPANY

2. Select the correctly numbered piston/connecting rod assembly for the cylinder. A dot (1) showing proper piston orientation is located on the top of the piston. Piston is model dependent.

NOTE:

- **The piston is directional and must be installed in the engine block in the proper direction. The dot on the top of the piston must face the front of the engine.**
- **Ensure the Bowl of the piston faces the intake.**

3. Install the connecting rod bearing into the connecting rod.

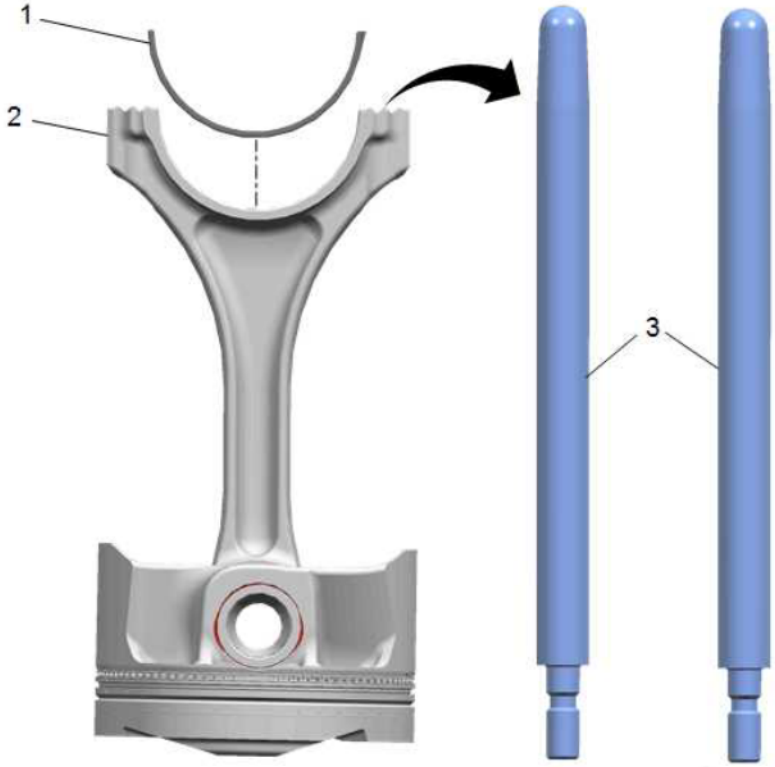


Fig. 373: Crankshaft Protector Pins Installed in Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.**

4. Install the **EN-46121** set into the connecting rod bolt holes.
5. Compress the piston rings using the a ring compressor sleeve or equivalent.

NOTE: **When installing a piston into a cylinder, use a ring compressor sleeve or equivalent for best results. The following features should be looked for when selecting a ring compressor sleeve.**

1. **Hard anodized and Teflon coated for low friction and prolonged wear resistance.**
2. **Smooth radius that tapers down to the specific bore size.**
3. **Sleeve should compress the piston rings smoothly and evenly.**
4. **Using a ring compressor sleeve greatly reduces the difficulty with installing thin high-performance oil rings.**

If a ring compressor sleeve is unavailable, a universal ring compressor will work but is more difficult to use.

6. Using both hands, slowly guide the piston and connecting rod assembly into the cylinder from the top and bottom of the cylinder. DO NOT allow the connecting rod to contact the cylinder wall.

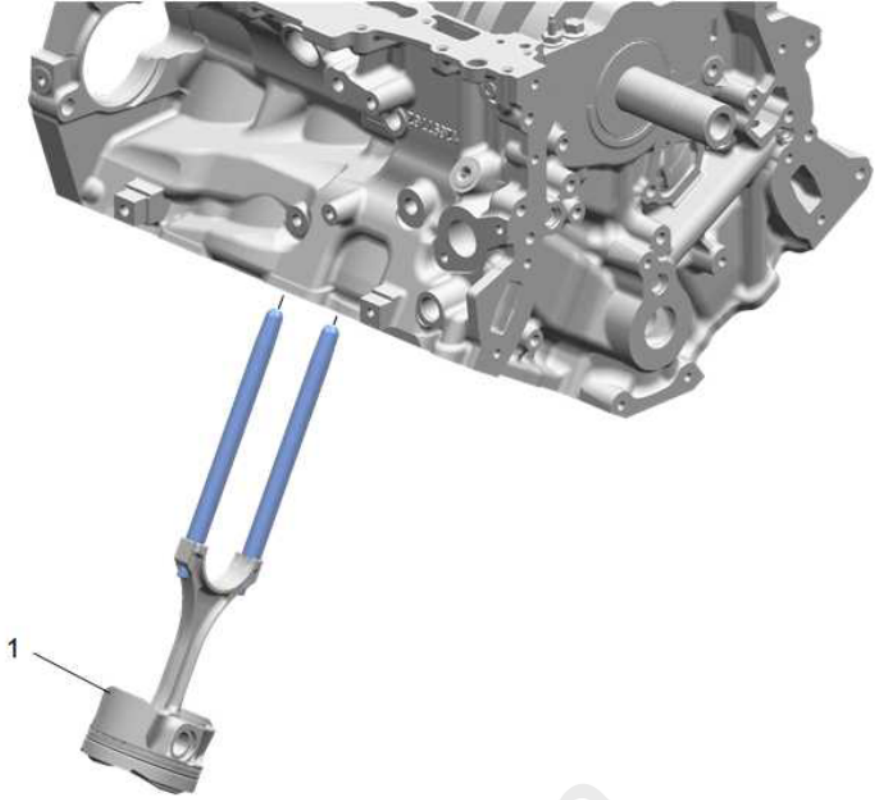
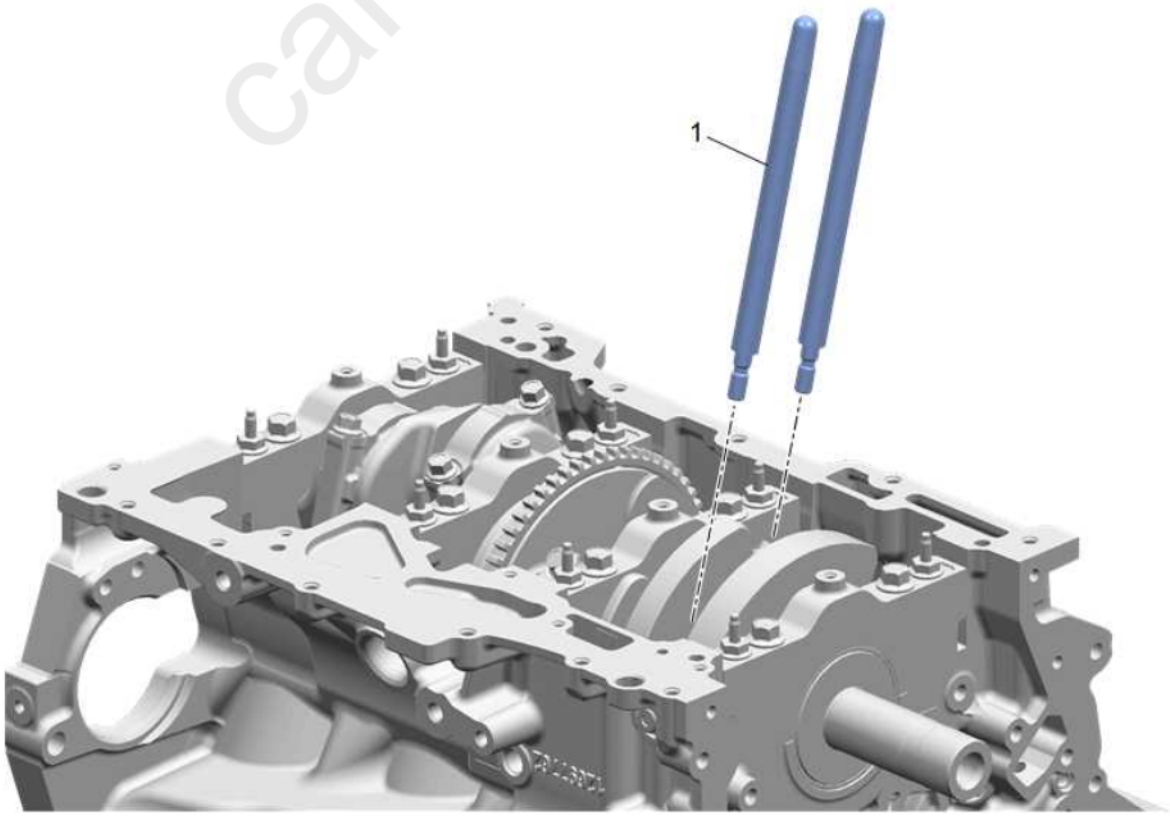


Fig. 374: View Of Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Extreme care must be used when installing the piston and connecting rod in order to be sure the rod does not scrape or nick the cylinder bore, the oil jets or the crankshaft surfaces.**

7. Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal using the **EN-46121** set while gently tapping the piston into place. Hold the ring compressor sleeve or equivalent against the engine block until all the rings have entered the cylinder bore.
8. Remove the **EN-46121** set from the connecting rod bolt holes.



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Fig. 375: Crankshaft Protector Pins Installed in Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

Connecting Rod Bearing Clearance Measurement Procedure - Using Plastic Gaging

1. Place a length of fresh, room temperature plastic gaging material all the way across the connecting rod bearing journal.

NOTE: **Connecting rod bearings that have been run in an engine should NEVER be reused.**

Before final assembly it is important to check the clearance of the new connecting rod bearings.

2. Install the connecting rod bearing into the connecting rod cap.
3. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.

NOTE: **The connecting rod is non-directional therefore the connecting rod bearing lock tangs can face inboard or outboard.**

4. Install the connecting rod bolts into the connecting rod cap.

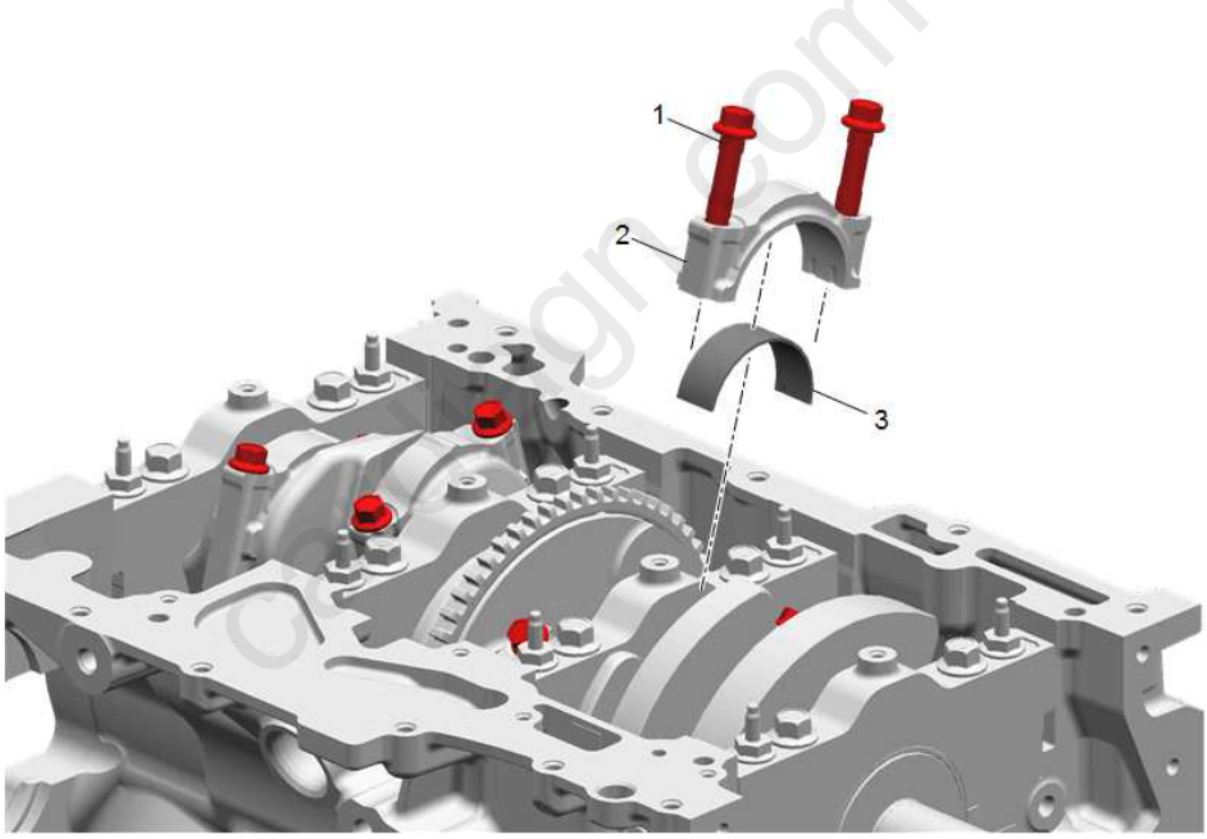


Fig. 376: View Of Connecting Rod Bearing & Cap
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.**

NOTE: **Reuse the old connecting rod bolts ONLY for measuring the connecting rod bearing clearance.**

5. Tighten the connecting rod bolts.

- First Pass

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

- Final Pass

  Tighten the connecting rod bolts an additional 110 degrees using the **EN-45059** meter.

6. Allow the assembly to sit for at least 2 minutes.
7. Remove the connecting rod cap bolts.
8. Remove the connecting rod cap.
9. Determine the connecting rod bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gaging material container.

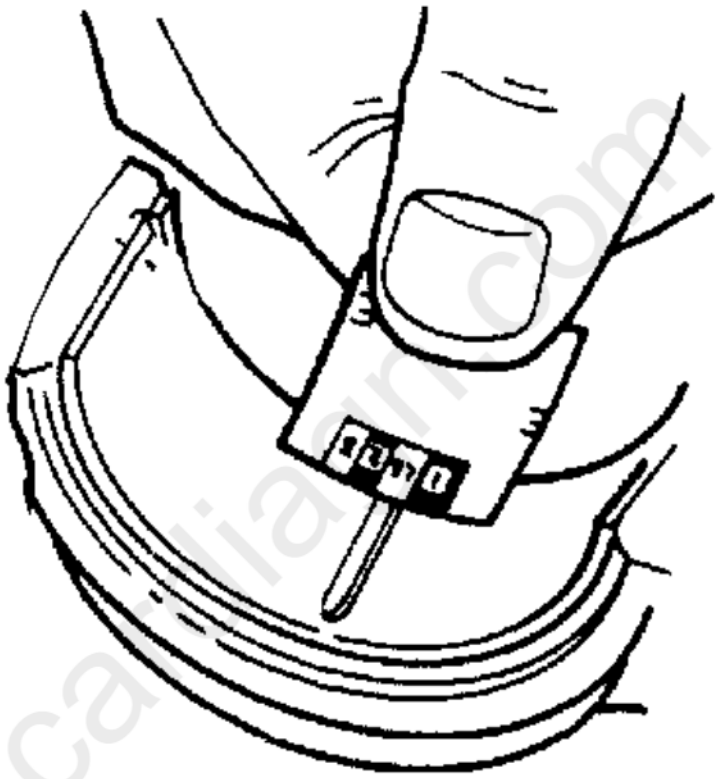
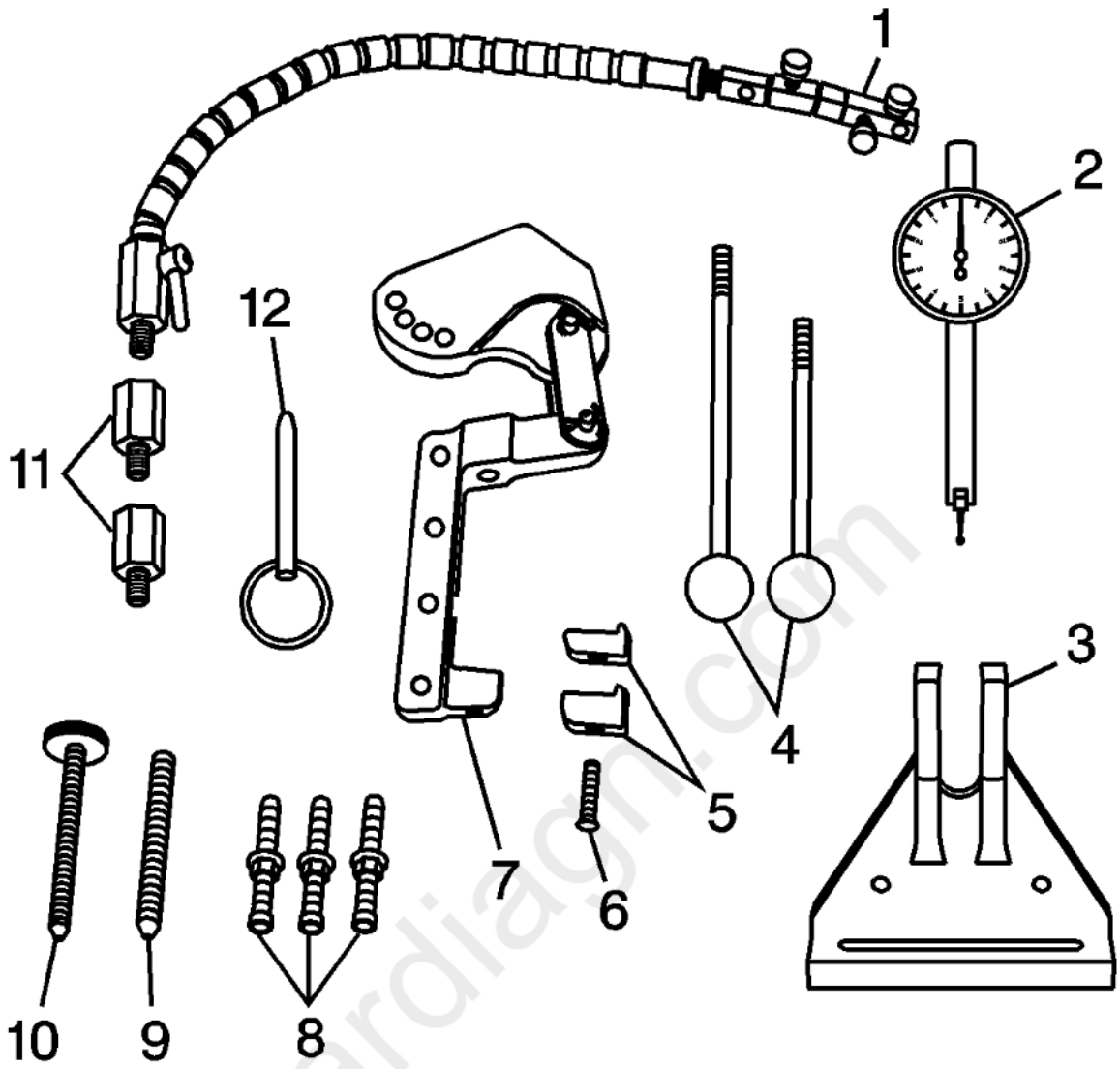


Fig. 377: Measuring Plastigage
Courtesy of GENERAL MOTORS COMPANY

10. Compare your measurements with the engine mechanical specifications. If the new bearings do not provide the proper crankshaft to connecting rod bearing clearance, inspect the following:
    1. Re-measure the crankshaft connecting rod journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft connecting rod journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.
    2. Re-measure the connecting rod bearing bore diameter to ensure proper size. The connecting rod is not machinable and the connecting rod must be replaced if out of specification.
11. Clean the plastic gaging material from the connecting rod bearing journals using a soft lint-free cloth.

Connecting Rod Bearing Clearance Measurement Procedure - Using EN-43690-A and EN-43690-100

The **EN-43690-A** tool and the **EN-43690-100** kit have been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer.



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Fig. 378: Identifying Rod Bearing Clearance Checking Tool
Courtesy of GENERAL MOTORS COMPANY

EN-43690-A tool

- EN-43690-20 Swivel Base (1)
- EN-43690-19 Dial Indicator (2)
- EN-43690-2 Base (3)
- EN-43690-5, -6 Handle (4)
- EN-43690-10, -11 Foot (5)
- 280307 Screw (6)
- EN-43690-1 Pivot Arm Assembly (7)
- EN-43690-3, -7, -8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- EN-43690-17, -18 Adapter (11)
- 280310 Pin (12)

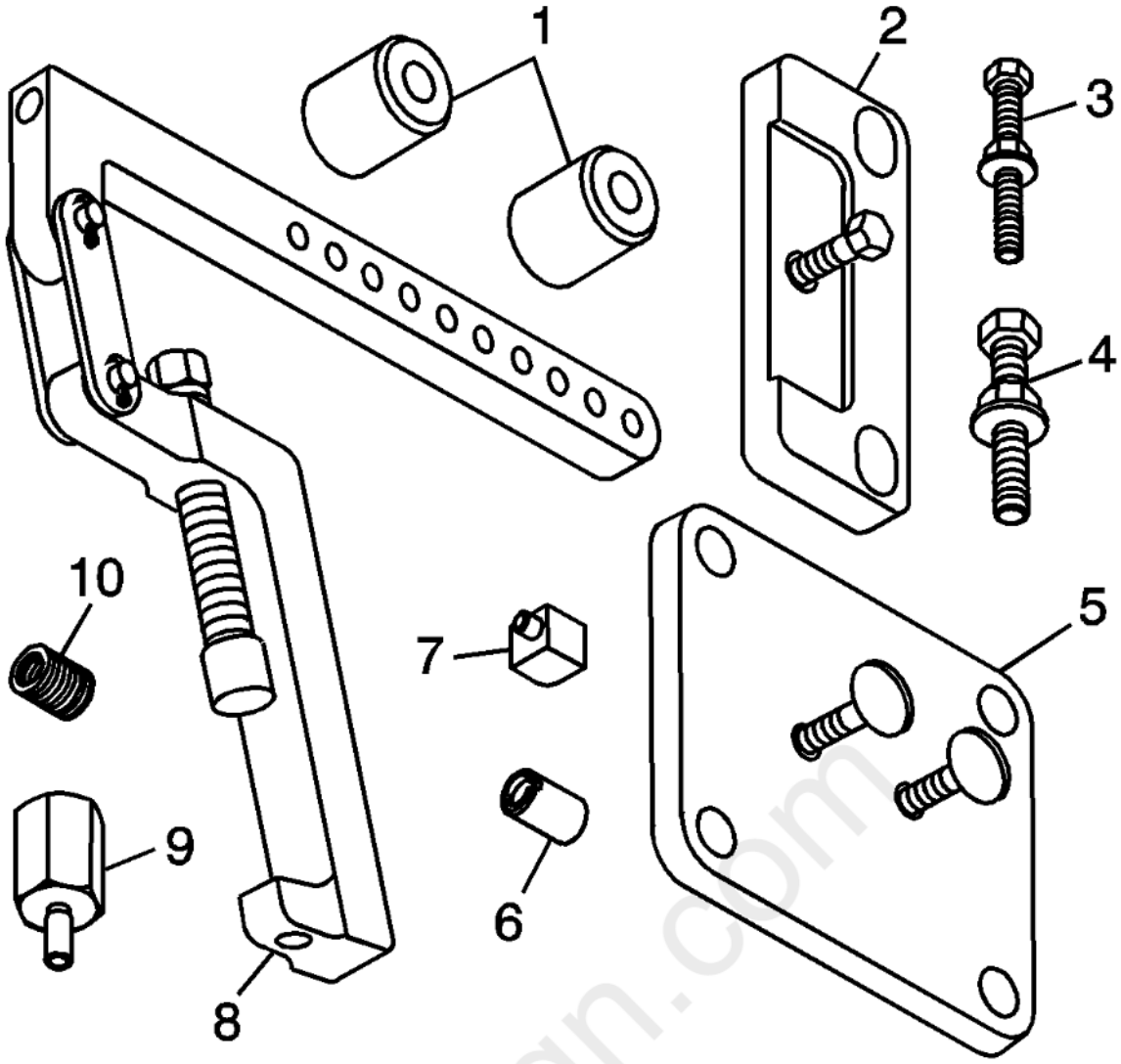


Fig. 379: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS COMPANY

EN-43690-100 kit

- EN-43690-104 Spacer (1)
- EN-43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- EN-43690-106 Retainer Plate (5)
- EN-43690-107 Cap (6)
- EN-43690-102 Foot (7)
- EN-43690-101 Pivot Arm Assembly (8)
- EN-43690-103 Adapter (9)
- 505439 Adapter (10)

1. Install the connecting rod bearing into the connecting rod cap.

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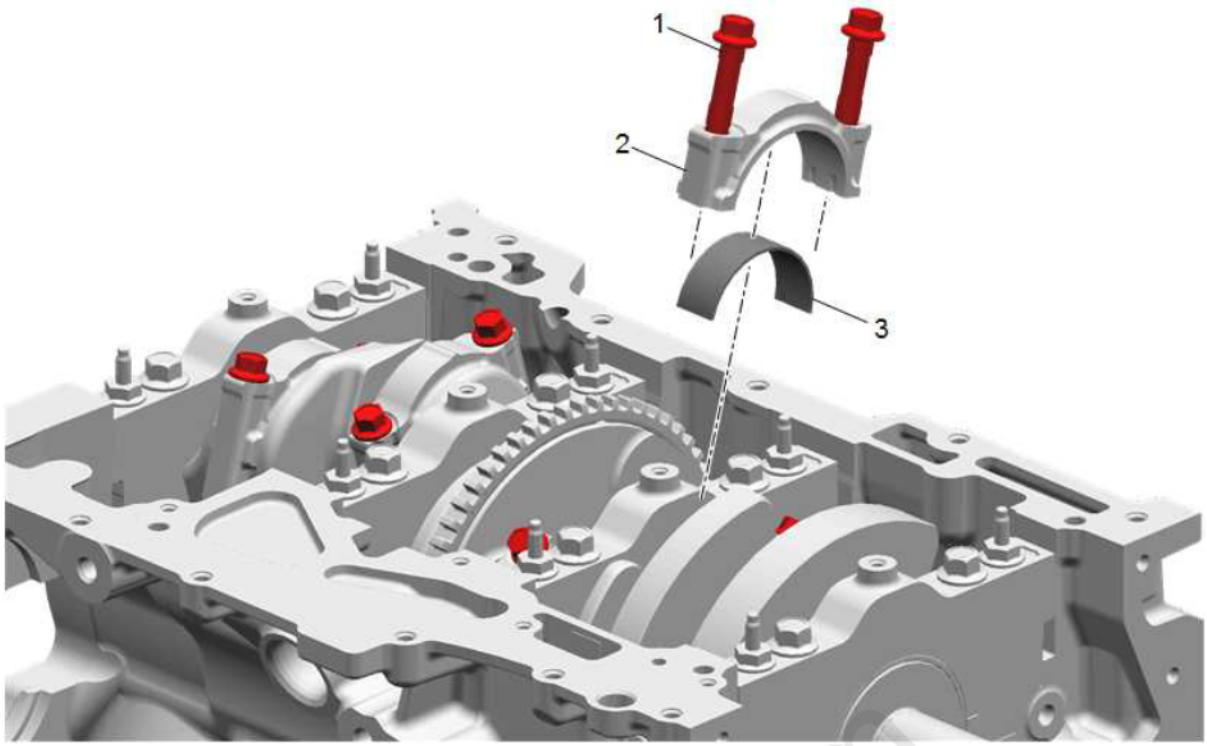


Fig. 380: View Of Connecting Rod Bearing & Cap
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Connecting rod bearings that have been run in an engine should NEVER be reused.**

Before final assembly it is important to check the clearance of the new connecting rod bearings.

2. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.

NOTE: **The connecting rod is non-directional therefore the connecting rod bearing lock tangs can face inboard or outboard.**

3. Install the connecting rod bolts into the connecting rod cap.

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.**

NOTE: **Reuse the old connecting rod bolts ONLY for measuring the connecting rod bearing clearance.**

4. Tighten the connecting rod bolts.
   - First Pass

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

   - Final Pass

     Tighten the connecting rod bolts an additional 110 degrees using the **EN-45059** meter.

5. Rotate the crankshaft until the crankshaft journal and the connecting rod to be measured is in the 12 o'clock position.
6. Remove the crankshaft main bolts required to install the retainer plate **EN-43690-105** .

NOTE: **The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.**

7. Install the EN 43690-105 and crankshaft main bolts.

NOTE: **Do not allow the EN-43690-105 retainer plate screw to contact the reluctor ring.**

8. Loosen the connecting rod bolts until the torque reading is zero.
9. Re-tighten the connecting rod bolts.
    - First Pass

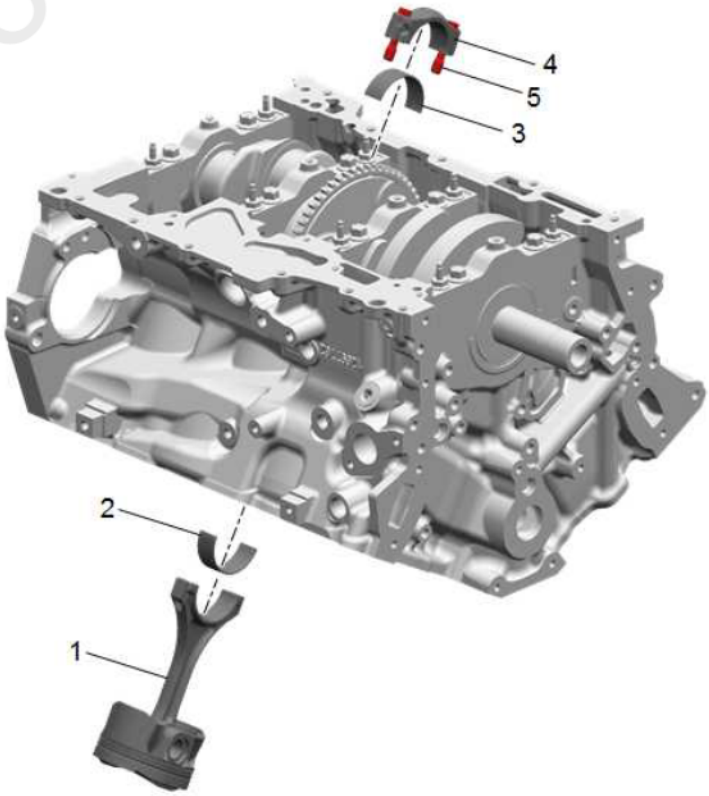
      Tighten the connecting rod bolts to 25 N.m (18 lb ft).

    - Final Pass

      Tighten the connecting rod bolts an additional 110 degrees using the **EN-45059** meter.
10. During and after installation, ensure each piston is positioned properly in the correct cylinder. The locating arrow on the top of each piston must be pointing toward the front of the engine.
11. Repeat these procedures for the remaining piston/connecting rod assemblies using the **EN-48589** socket in order to rotate the crankshaft.

Connecting Rod Final Assembly Procedure

1. Guide the connecting rod away from the crankshaft connecting rod journal in order to lubricate the crankshaft connecting rod bearing journal.
2. Apply a liberal amount of crankshaft prelube to the crankshaft connecting rod bearing journal. Refer to **Adhesives, Fluids, Lubricants and Sealers** .
3. Guide the connecting rod to the crankshaft connecting rod journal.
4. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.
5. Install the NEW connecting rod bolts into the connecting rod cap.



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Fig. 381: Identifying Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.**

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

6. Tighten the connecting rod bolts.
    1. First Pass

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

    2. Final Pass

       Tighten the connecting rod bolts an additional 110 degrees using the **EN-45059** meter.
7. During and after installation, ensure each piston is positioned properly in the correct cylinder. The locating arrow on the top of each piston must be pointing toward the front of the engine.
8. Repeat these procedures for the remaining piston/connecting rod assemblies using the **EN-48589** socket in order to rotate the crankshaft.

CRANKSHAFT REAR OIL SEAL AND HOUSING INSTALLATION

Crankshaft Rear Oil Seal Housing Sealant Installation

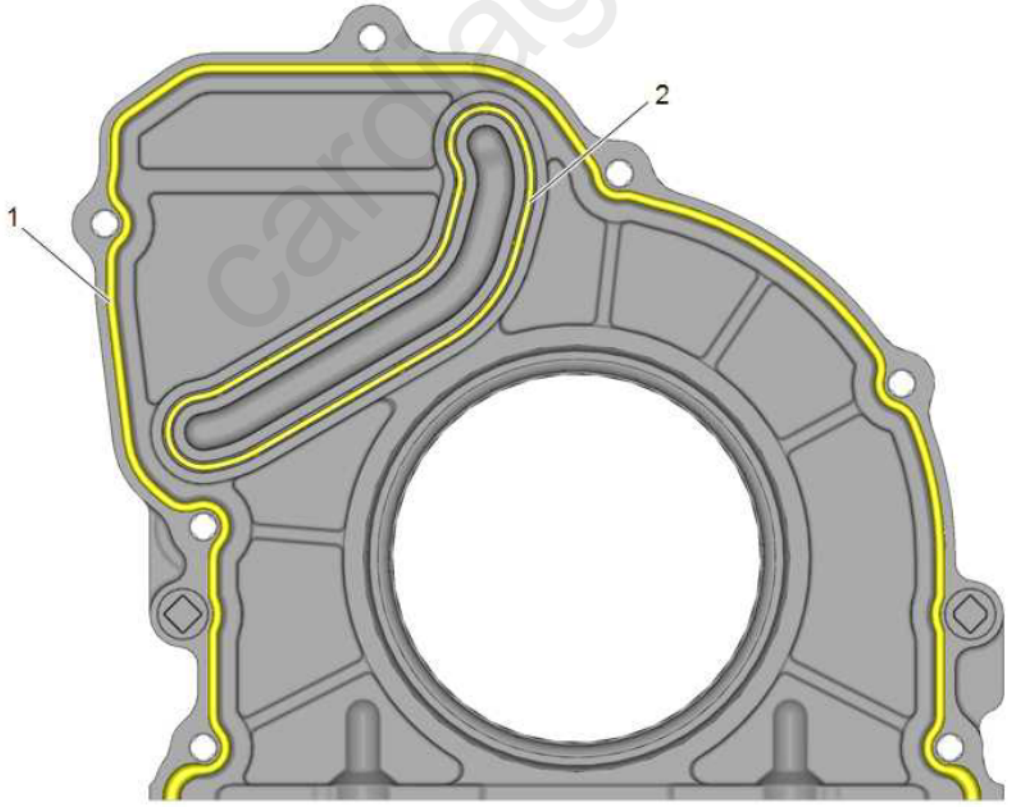


Fig. 382: Crankshaft Rear Oil Seal and Housing Sealant Application Points
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Rear Oil Seal Housing Sealant Installation

Callout	Component Name

Callout	Component Name
1	Sealant **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Place a 3 mm (0.118 in) bead of RTV sealant to the NEW crankshaft rear oil seal housing as shown (1). Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant. **NOTE:** **DO NOT allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed.**

Crankshaft Rear Oil Seal Housing Installation

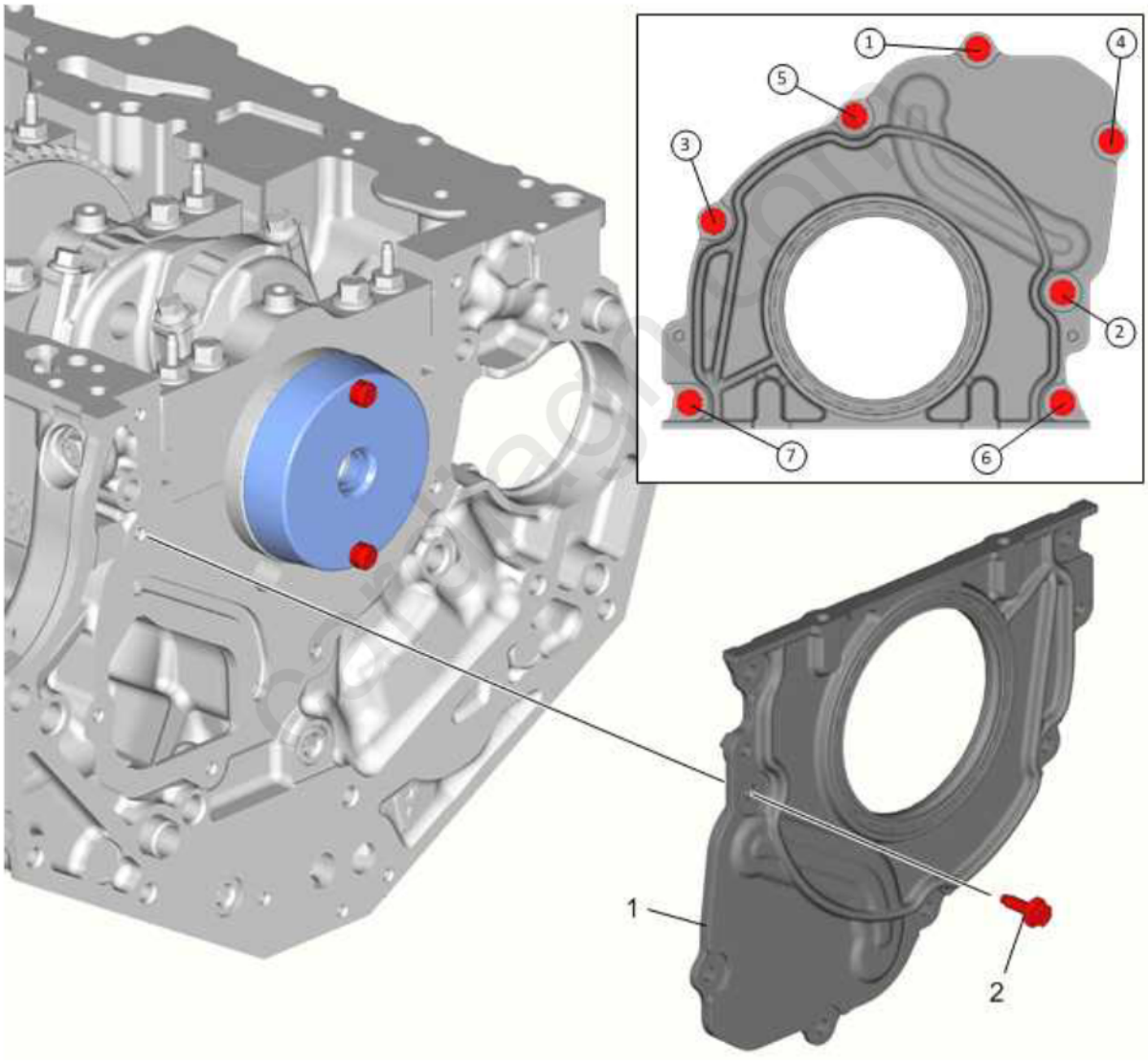


Fig. 383: Crankshaft Rear Oil Seal and Housing
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Rear Oil Seal Housing Installation

Callout	Component Name

Callout	Component Name

Procedure

1. Install the **EN-51766** tool onto the rear of the crankshaft flange.

   NOTE:
   The crankshaft rear oil seal is a dry seal do not lubricate.

2. Install the crankshaft rear oil seal housing (1) to the engine block.
3. Install the crankshaft rear oil seal housing bolts (2) and tighten in sequence shown.
4. Remove the **EN-51766** tool from the crankshaft flange.

Special Tools EN-51766 Crankshaft Rear Oil Seal Installation ToolFor equivalent regional tools, refer to **Special Tools** .

1	Crankshaft Rear Oil Seal Housing
2	Crankshaft Rear Oil Seal Housing Bolt [7x] **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 10 N.m (89 lb in)

OIL PUMP INSTALLATION

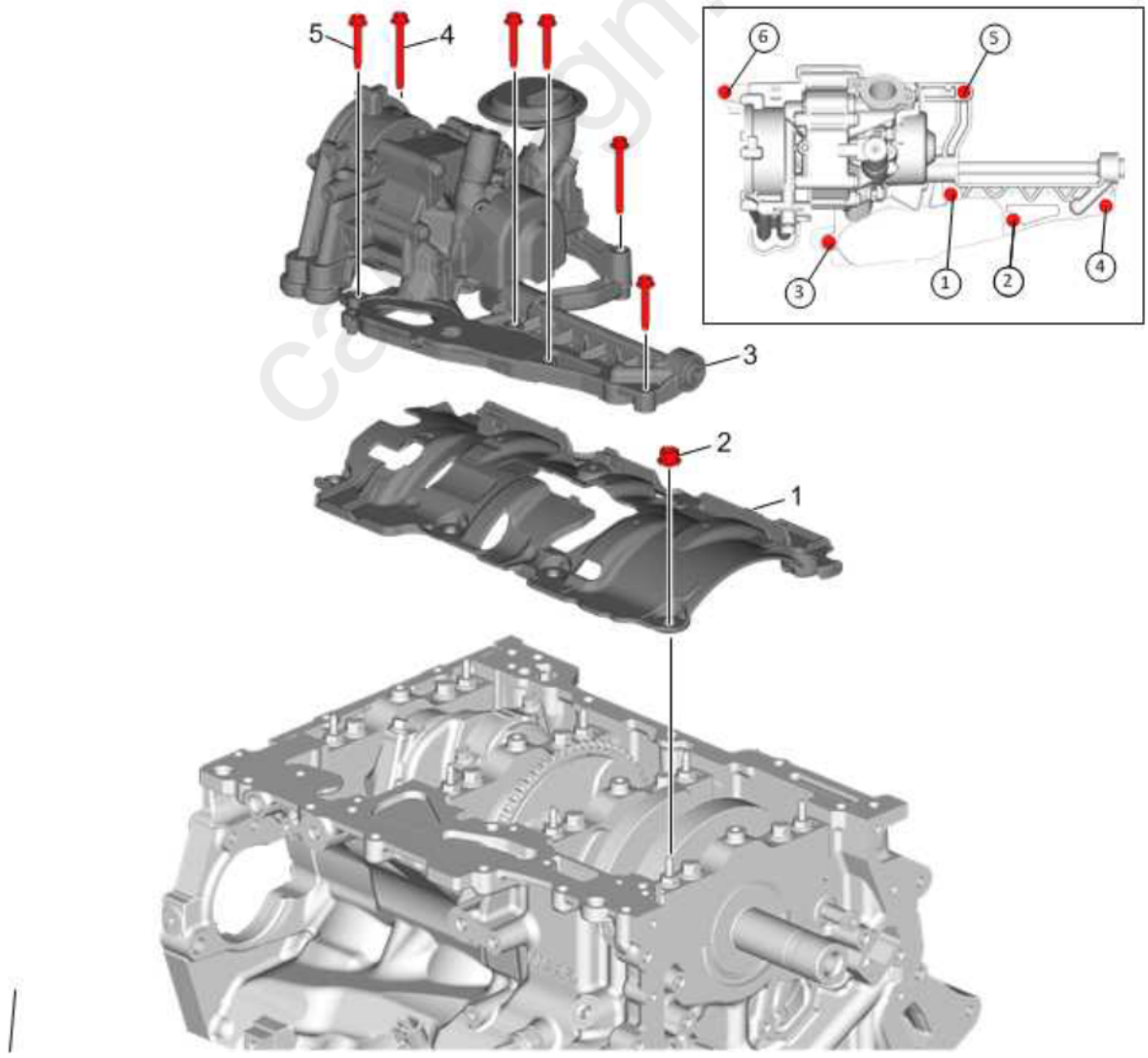


Fig. 384: Oil Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Oil Deflector
2	Crankshaft Oil Deflector Nut [8x]
3	Oil Pump
4	Oil Pump Bolt [2x] M6 x 53.65 **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 15 N.m (11 lb ft)
5	Oil Pump Bolt [4x] M6 x 35.65 **Tighten in sequence** 15 N.m (11 lb ft)

OIL PAN INSTALLATION (WITHOUT OIL COOLER)

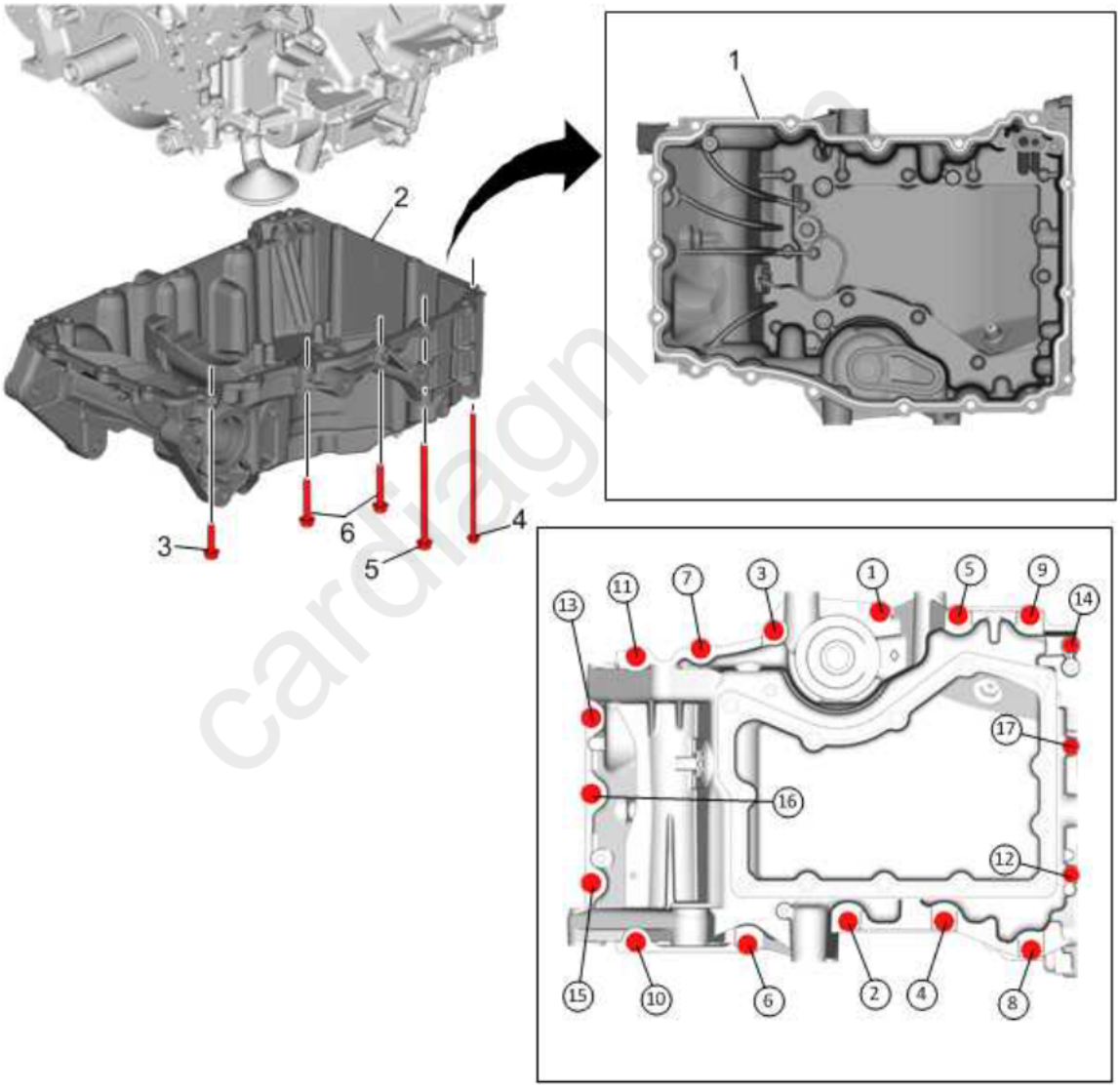


Fig. 385: Oil Pan (Without Oil Cooler)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
1	Sealant **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Place a 3 mm (0.118 in) bead of RTV sealant on the block pan rail and the crankshaft rear oil seal housing (1). Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant.
2	Oil Pan
3	Oil Pan Bolt [7x] M8 x 35 **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Tighten the oil pan bolts in sequence shown.** **Tighten** 25 N.m (18 lb ft)
4	Oil Pan Bolt [3x] M6 x 150 **NOTE:** • **Install a NEW bolt. Do NOT reuse the old bolt.** • **Tighten the bolts in the sequence shown.** **Tighten** 1. First Pass: 7 N.m (62 lb in) 2. Final Pass: 180 Degrees
5	Oil Pan Bolt [5x] M8 x 120 **NOTE:** **Tighten the oil pan bolts in sequence shown.** **Tighten** 25 N.m (18 lb ft)
6	Oil Pan Bolt [2x] M8 x 50 **NOTE:** **Tighten the oil pan bolts in sequence shown.** **Tighten** 25 N.m (18 lb ft)

OIL PAN INSTALLATION (WITH OIL COOLER)

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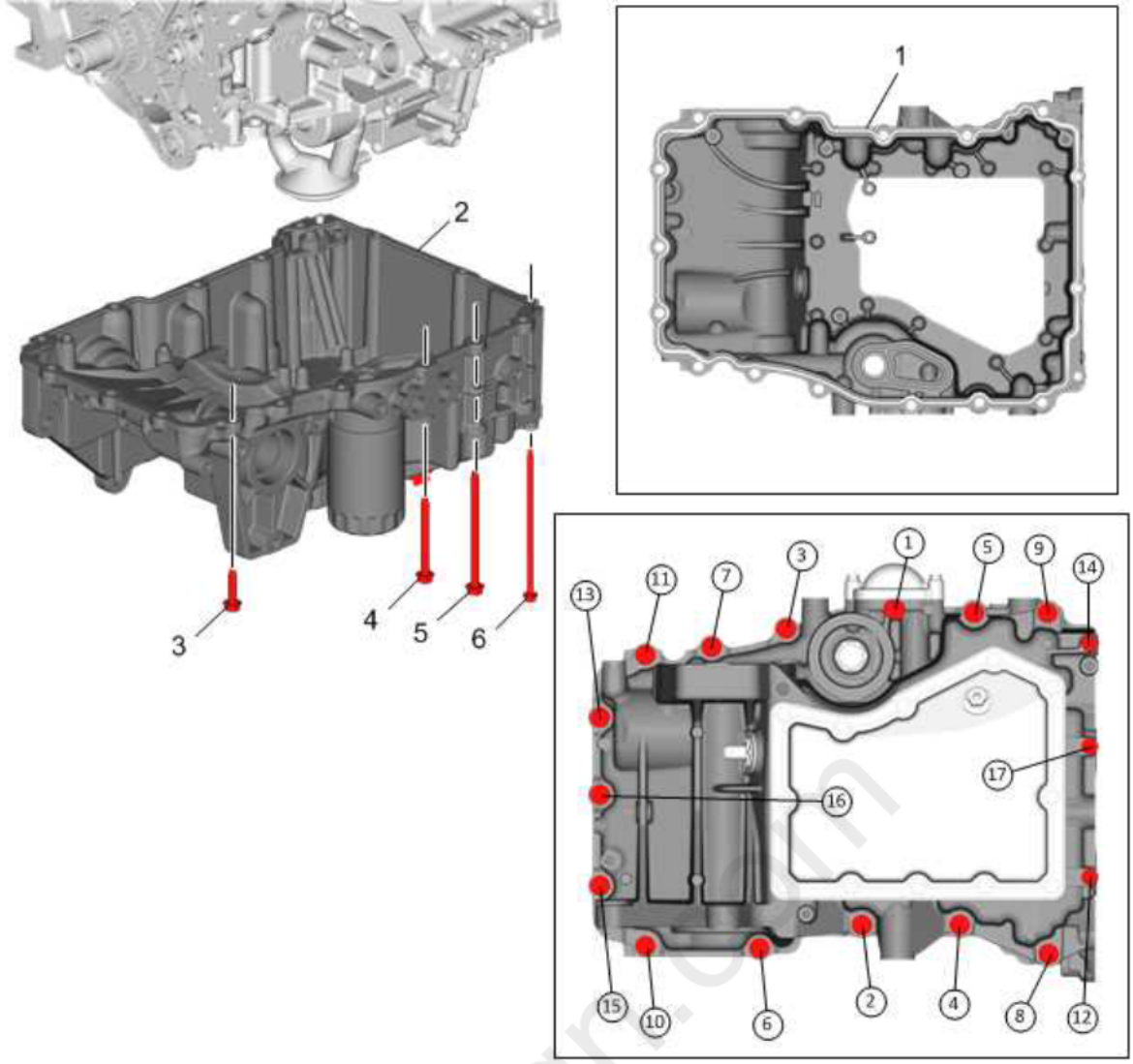


Fig. 386: Oil Pan (With Oil Cooler)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Sealant **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Place a 3 mm (0.118 in) bead of RTV sealant on the block pan rail and the crankshaft rear oil seal housing (1). Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant.
2	Oil Pan
3	Oil Pan Bolt [8x] M8 x 35 **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)

Callout	Component Name
4	Oil Pan Bolt M8 x 80 **Procedure** Tighten the bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
5	Oil Pan Bolt [5x] M8 x 120 **Procedure** Tighten the bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
6	Oil Pan Bolt [3x] M6 x 150 **NOTE:** **Install a NEW bolt. Do NOT reuse the old bolt.** **Tighten in sequence** 1. First Pass: 7 N.m (62 lb in) 2. Final Pass: 180 Degrees

POSITIVE CRANKCASE VENTILATION OIL SEPARATOR INSTALLATION (LGX)

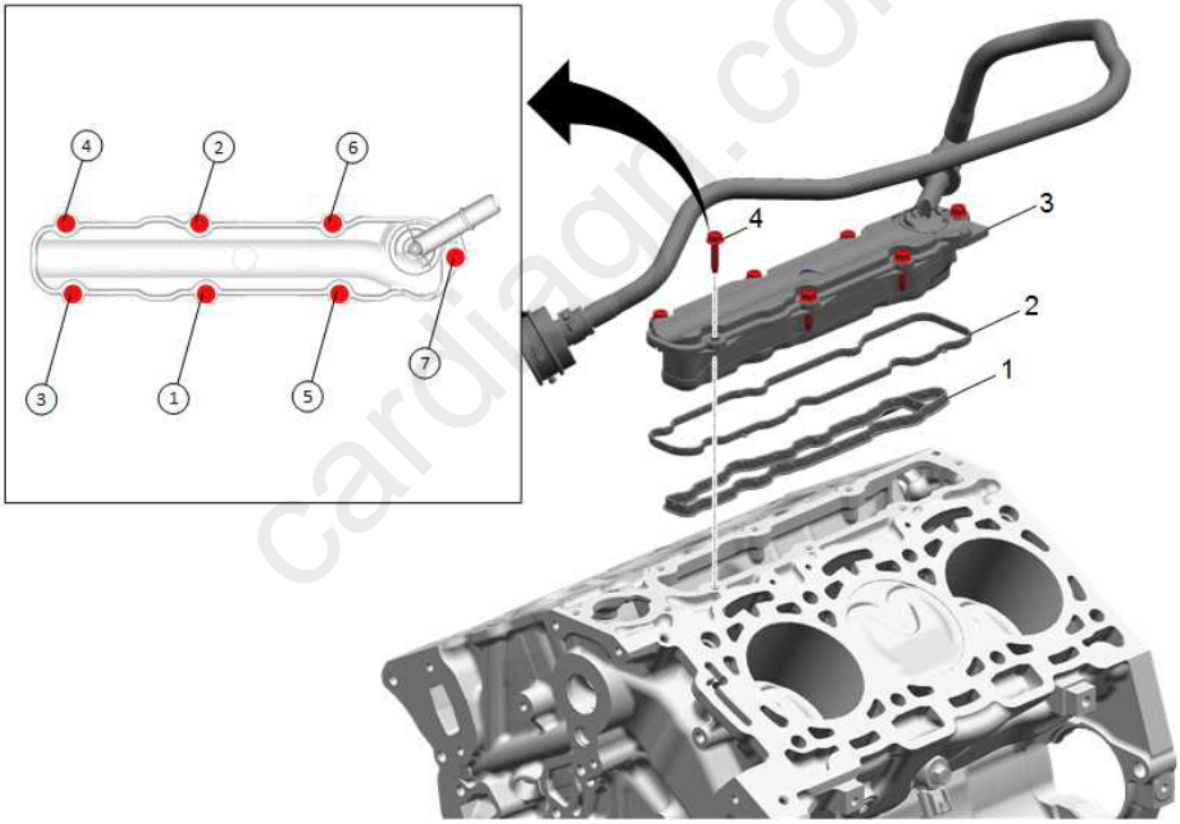


Fig. 387: Positive Crankcase Ventilation Oil Separator (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Oil Separator **NOTE:** **These components have tamper-proof connections and cannot be disassembled.**

Callout	Component Name
2	Positive Crankcase Ventilation Oil Separator Bolt [7x] **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 10 N.m (89 lb in)

POSITIVE CRANKCASE VENTILATION OIL SEPARATOR INSTALLATION (LGW)

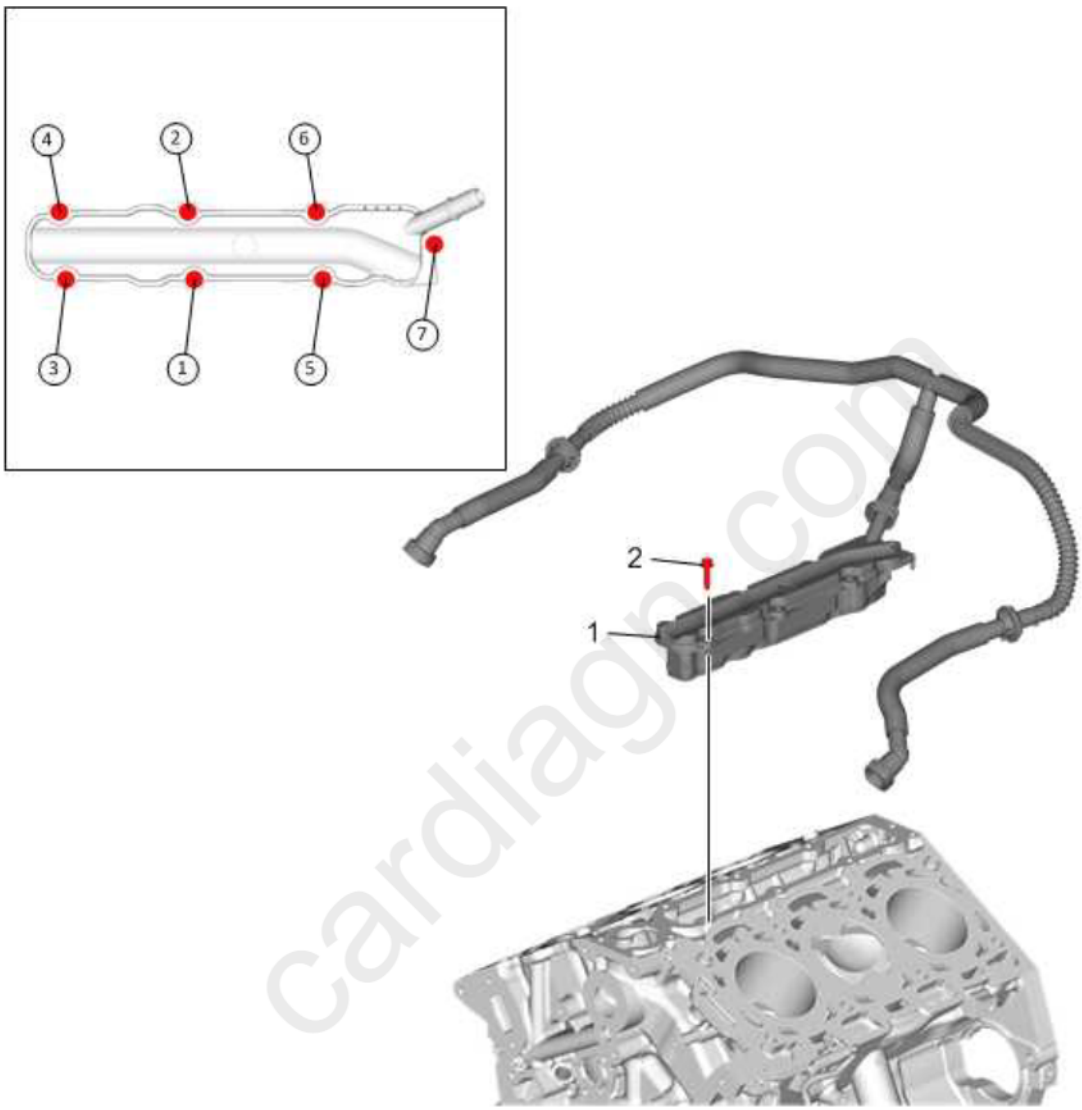


Fig. 388: Positive Crankcase Ventilation Oil Separator (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Oil Separator
2	Positive Crankcase Ventilation Oil Separator Bolt [7x] **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 10 N.m (89 lb in)

CYLINDER HEAD INSTALLATION - RIGHT SIDE

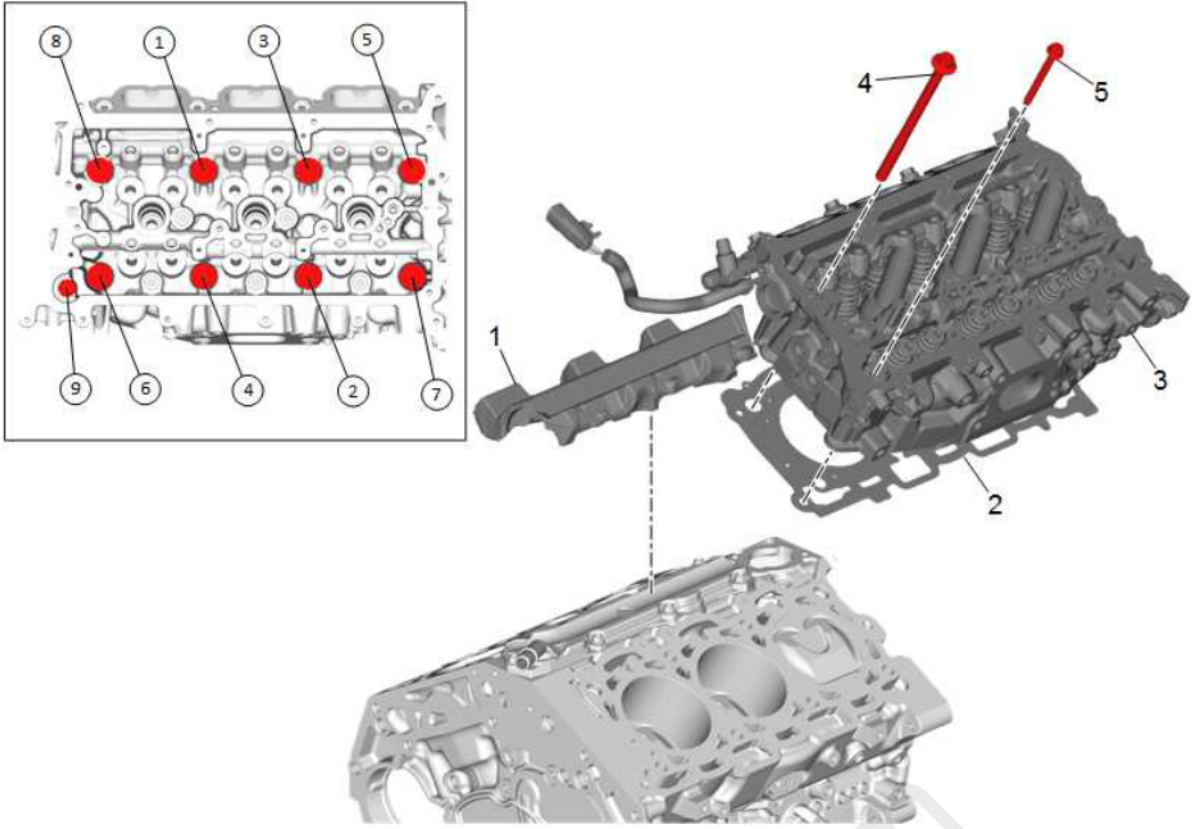


Fig. 389: Cylinder Head - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injection Fuel Rail Noise Shield **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**
2	Cylinder Head Locating Pin [2x] **NOTE:** **Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face.**
3	Cylinder Head Gasket **NOTE:** **Install a NEW gasket.**
4	Cylinder Head

Callout	Component Name
5	Cylinder Head Bolt M11 x 178 [8x] **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:** **Install NEW bolts. Do NOT reuse old bolts.** **Tighten in sequence** 1. First Pass: 60 N.m (44 lb ft) 2. Final Pass: 150 degrees **Special Tools** **EN-45059** Angle Meter Equivalent regional tools: **Special Tools** .
6	Cylinder Head Bolt M8 x 80.8 **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. Do NOT reuse old bolts.** **Tighten in sequence** 1. First Pass: 15 N.m (11 lb ft) 2. Final Pass: 75 degrees

VALVE LIFTER INSTALLATION - RIGHT SIDE

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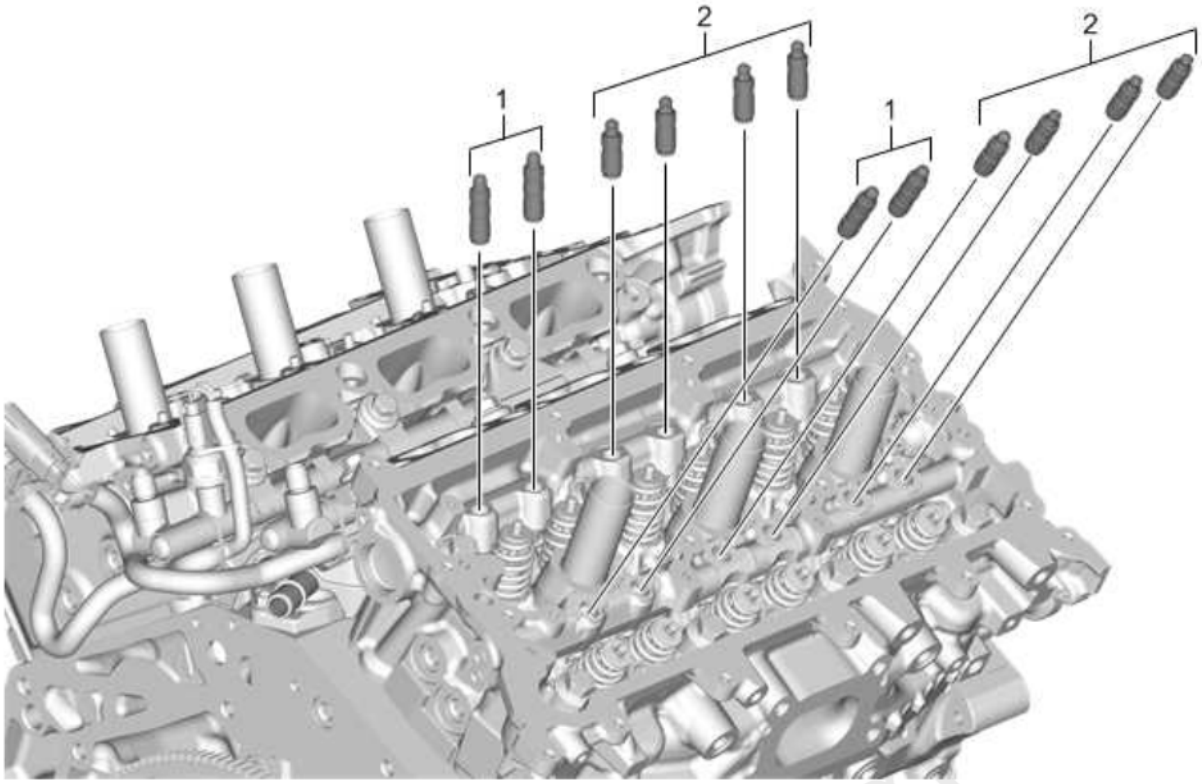


Fig. 390: Valve Lifter Removal - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Fill the adjusters with clean engine oil. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended engine oil. Take precautions to prevent scratching the pivot sphere area of the. 2. Lubricate the adjusters bores in the cylinder head with clean engine oil. 3. Install the adjusters in the cylinder head. 4. Apply a liberal amount of lubricant to the adjusters pivot spheres. **NOTE:** • **Do not stroke/cycle the adjusters without oil in the lower pressure chamber.** • **Do not allow the adjusters to tip over, plunger down, after the oil fill.**	
1	Dual Feed Hydraulic Valve Adjustor [4x]
2	Hydraulic Valve Lash Adjuster [8x]

VALVE ROCKER ARM INSTALLATION - RIGHT SIDE

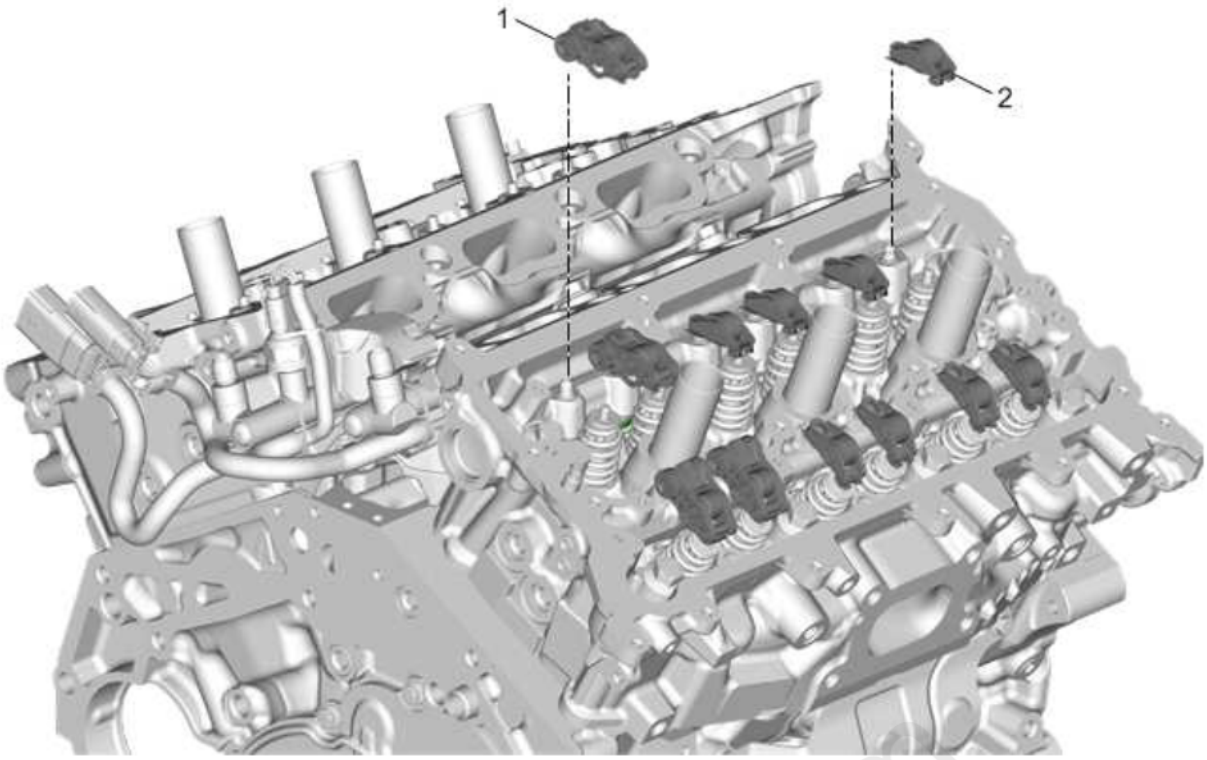


Fig. 391: Valve Rocker Arm - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Apply a liberal amount of lubricant to the pivot pocket, roller and valve slot areas of the camshaft followers. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended lubricant. 2. Place the camshaft followers in position on the valve tip and adjuster. 3. The rounded head end of the follower goes on the adjuster while the flat end goes on the valve tip. 4. Clean the camshaft journals and carriers with a clean, lint-free cloth. **NOTE:** **The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.**	
1	Valve Rocker Switching Arm [4x]
2	Valve Rocker Arm [8x]

CAMSHAFT CARRIER INSTALLATION - RIGHT SIDE

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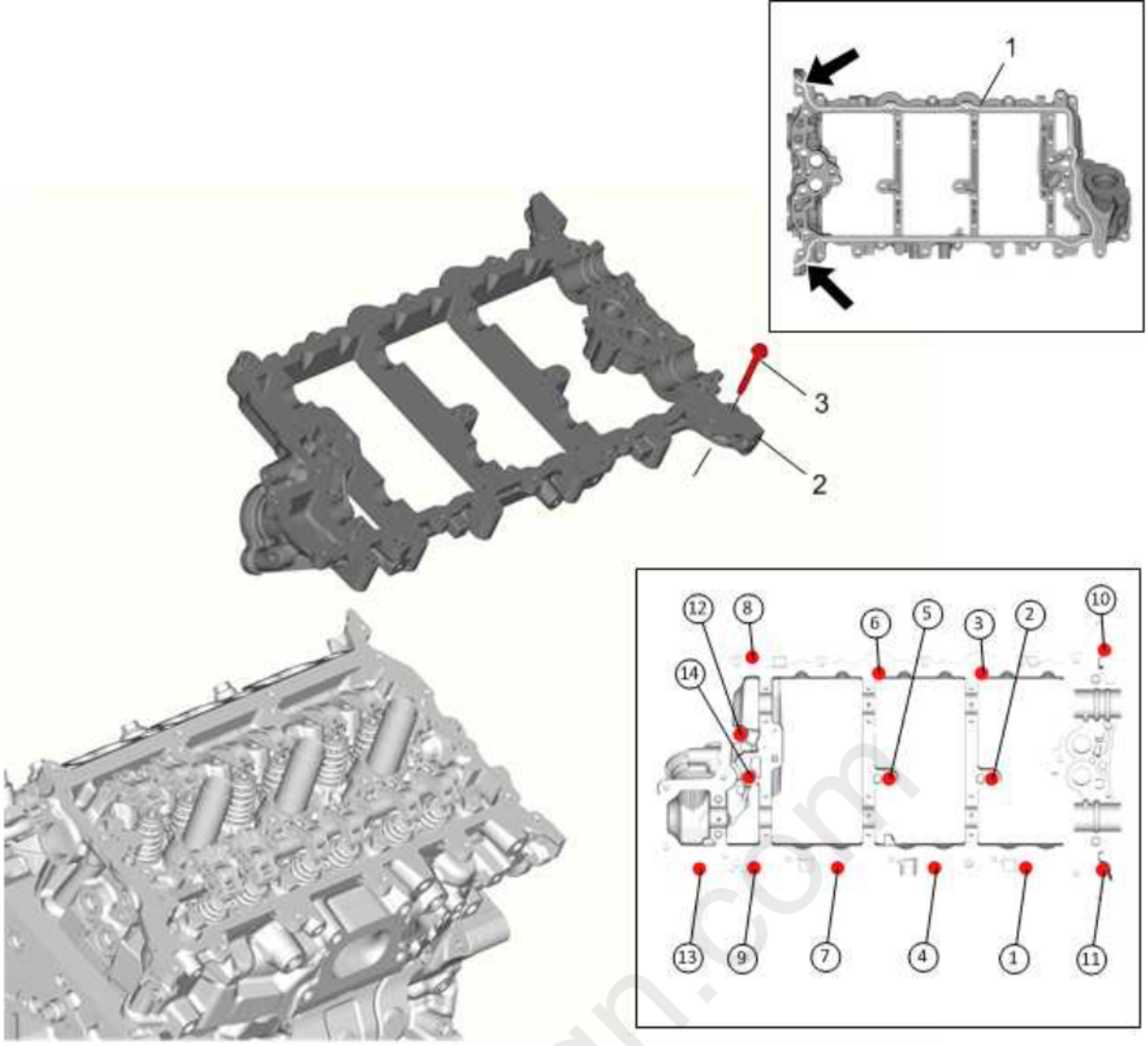


Fig. 392: Camshaft Carrier - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Sealant **CAUTION:** **Do not apply more room temperature vulcanization (RTV) silicone than specified. Excess RTV silicone could plug up oil passage holes in the camshaft carrier and lead to engine damage.** **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Place a 3 mm (0.118 in) bead of RTV sealant on the bottom of the camshaft carrier, following the specific bead path. 3. Place a 5 mm (0.197 in) bead of RTV sealant on the bottom of the camshaft carrier as arrows show. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant. **NOTE:** **Camshaft carrier surfaces should be free and clean of oil and foreign substances.**
2	Camshaft Carrier Right

Callout	Component Name
3	Camshaft Carrier Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 1. First Pass: 6 N.m (53 lb in) 2. Final Pass: 60 degrees

CAMSHAFT INSTALLATION - RIGHT SIDE

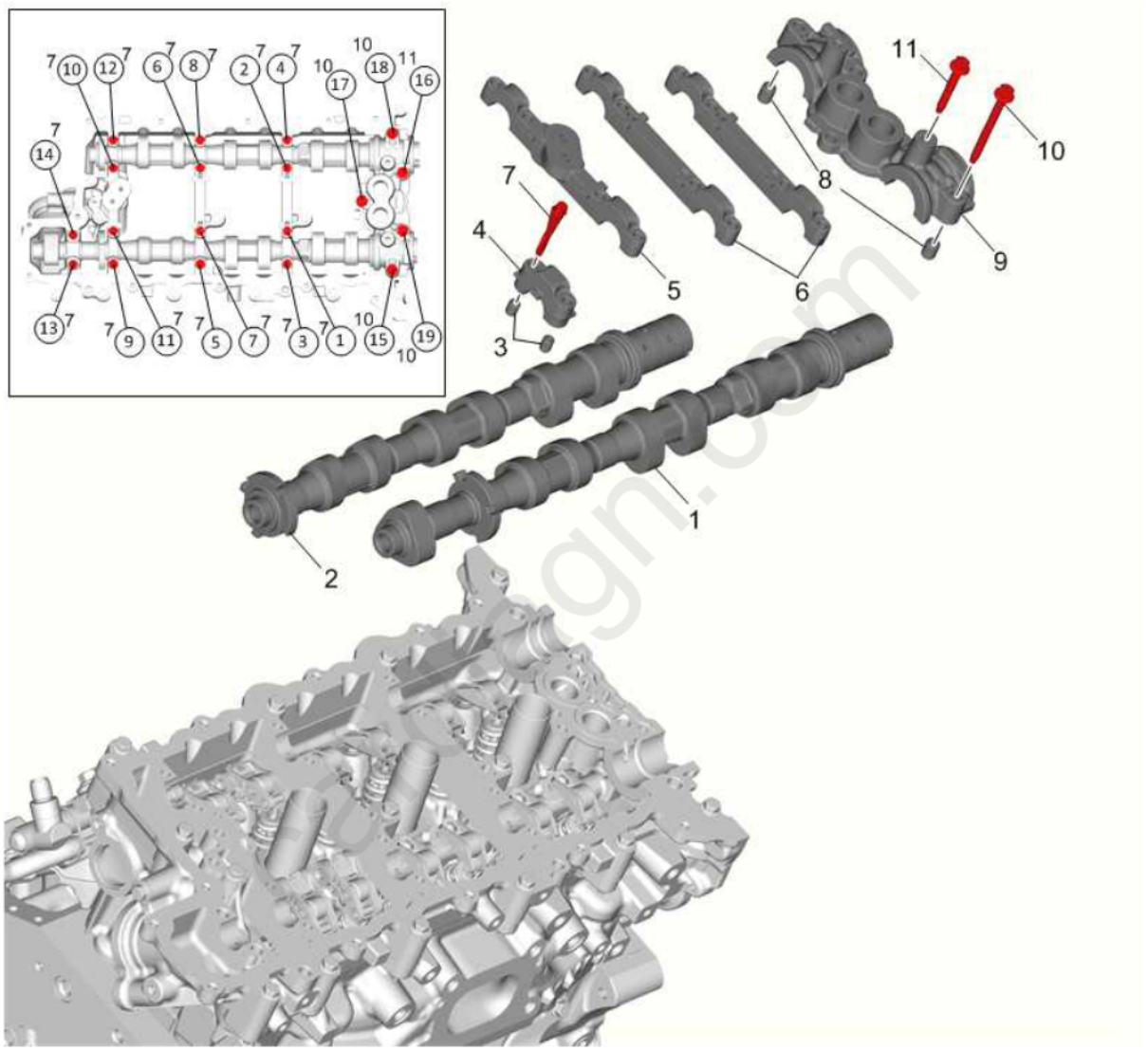


Fig. 393: Camshaft - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Camshaft **Procedure** Make sure the camshaft flats with laser etched markings are straight up in relation to the cylinder head and that the crankshaft is in the stage 2 position. The crankshaft key way will be at approximately the 3 o'clock position. Refer to **Timing Chain Alignment Diagram** . **NOTE:** **Ensure the flat is facing upward when installed to help when installing timing chains.**

Callout	Component Name
2	Intake Camshaft **Procedure** Make sure the camshaft flats with laser etched markings are straight up in relation to the cylinder head and that the crankshaft is in the stage 2 position. The crankshaft key way will be at approximately the 3 o'clock position. Refer to **Timing Chain Alignment Diagram** . **NOTE:** **Ensure the flat is facing upward when installed to help when installing timing chains.**
3	Dowel Pin
4	Camshaft Bearing Cap - Intermediate
5	Camshaft Bearing Cap
6	Camshaft Bearing Cap
7	Camshaft Bearing Cap Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 1. First Pass: 6 N.m (53 lb in) 2. Final Pass: 60 degrees
8	Dowel Pin
9	Camshaft Bearing Cap
10	Camshaft Carrier Bolt **Tighten in sequence** 1. First Pass: 6 N.m (53 lb in) 2. Final Pass: 45 degrees
11	Camshaft Bearing Cap Bolt **Tighten in sequence** 1. First Pass: 6 N.m (53 lb in) 2. Final Pass: 45 degrees

FUEL RAIL INSTALLATION

Refer to **Cylinder Head Assemble**.

CYLINDER HEAD INSTALLATION - LEFT SIDE

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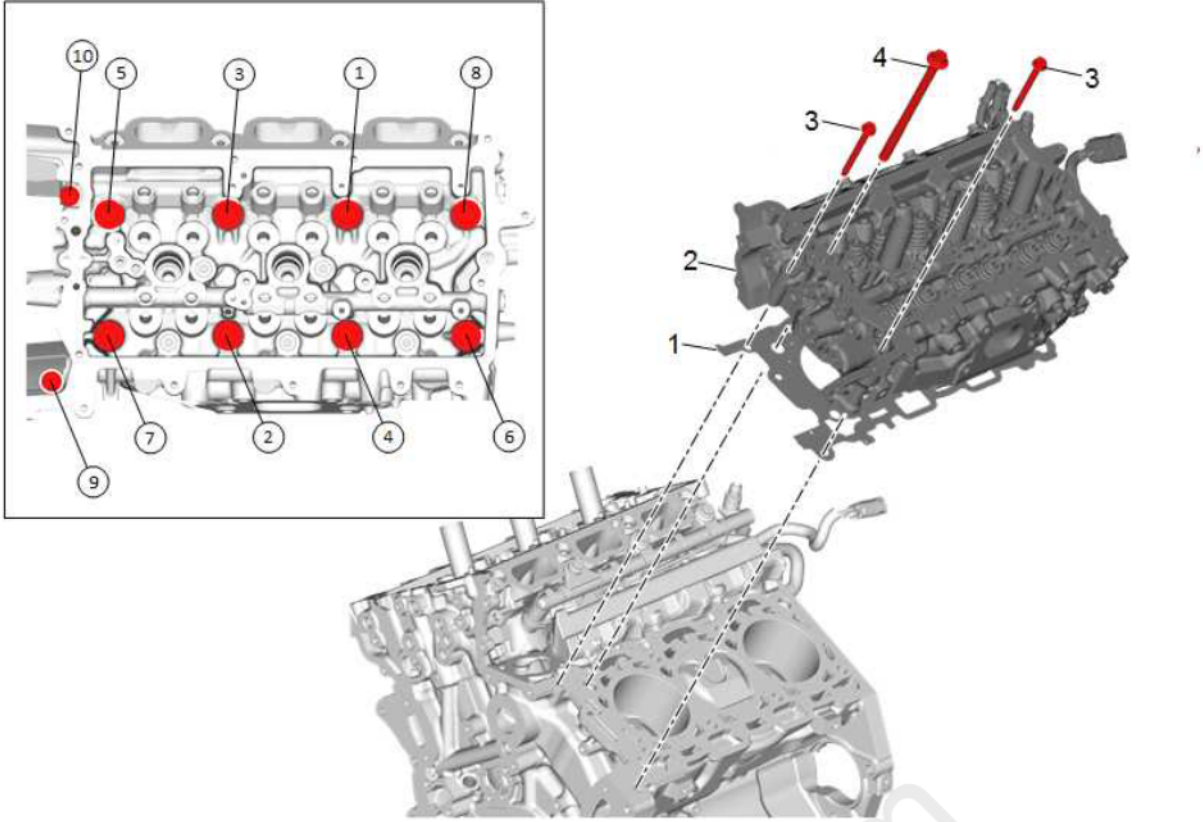
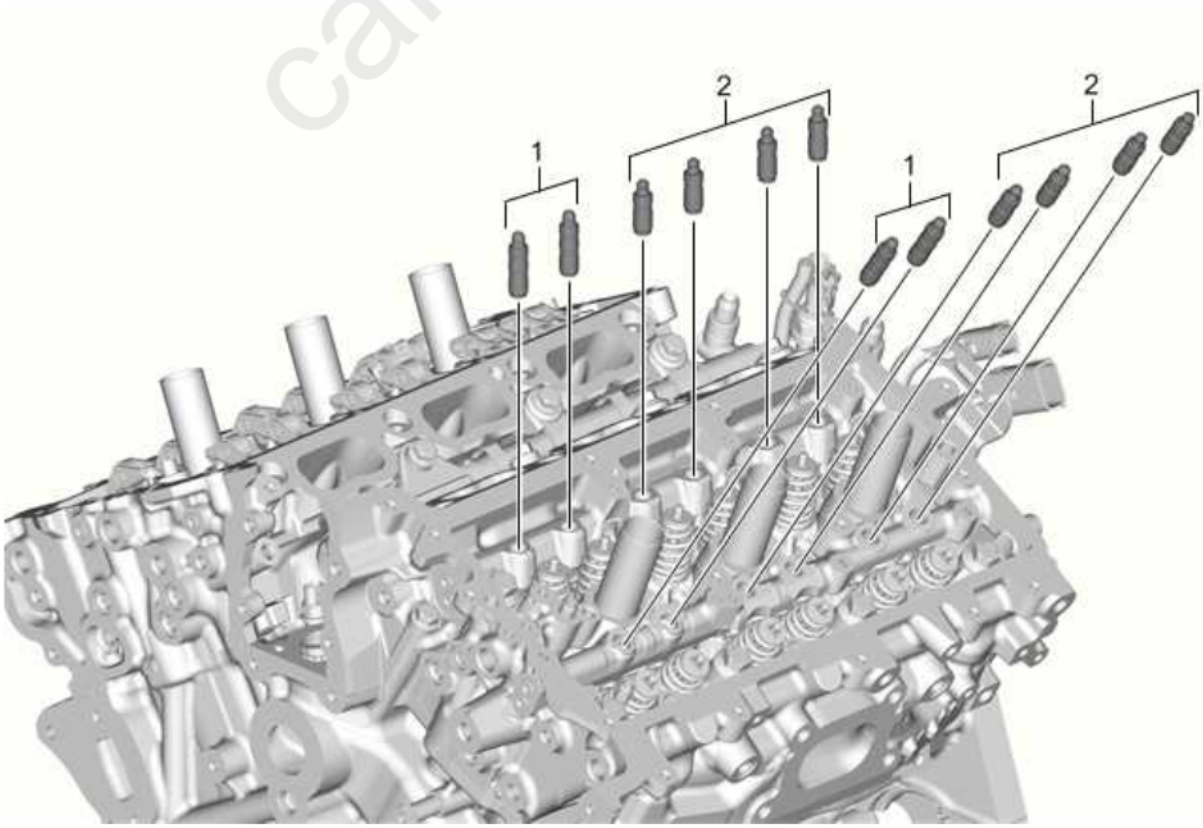


Fig. 394: Cylinder Head - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injection Fuel Rail Noise Shield **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**
2	Cylinder Head Locating Pin **NOTE:** **Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face.**
3	Cylinder Head Gasket **NOTE:** **Install a NEW gasket.**
4	Cylinder Head

Callout	Component Name
5	Cylinder Head Bolt M8 x 80.8 [2x] **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 in sequence** 1. First Pass: 15 N.m (11 lb ft) 2. Final Pass: 75 degrees **Special Tools** **EN-45059** Angle Meter Equivalent regional tools: **Special Tools** .
6	Cylinder Head Bolt M11 x 178 [8x] **Tighten in sequence** 1. First Pass: 60 N.m (44 lb ft) 2. Final Pass: 150 degrees
7	Fuel Injector Wiring Harness Bracket
8	Fuel Injector Wiring Harness Bracket Bolt **Tighten** 10 N.m (89 lb in)

VALVE LIFTER INSTALLATION - LEFT SIDE



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Fig. 395: Valve Lifter - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Fill the adjusters with clean engine oil. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended engine oil. Take precautions to prevent scratching the pivot sphere area of the. 2. Lubricate the adjusters bores in the cylinder head with clean engine oil. 3. Install the adjusters in the cylinder head. 4. Apply a liberal amount of lubricant to the adjusters pivot spheres. **NOTE:** • **Do not stroke/cycle the adjusters without oil in the lower pressure chamber.** • **Do not allow the adjusters to tip over, plunger down, after the oil fill.**	
1	Dual Feed Hydraulic Valve Adjustor [4x]
2	Hydraulic Valve Lash Adjuster [8x]

VALVE ROCKER ARM INSTALLATION - LEFT SIDE

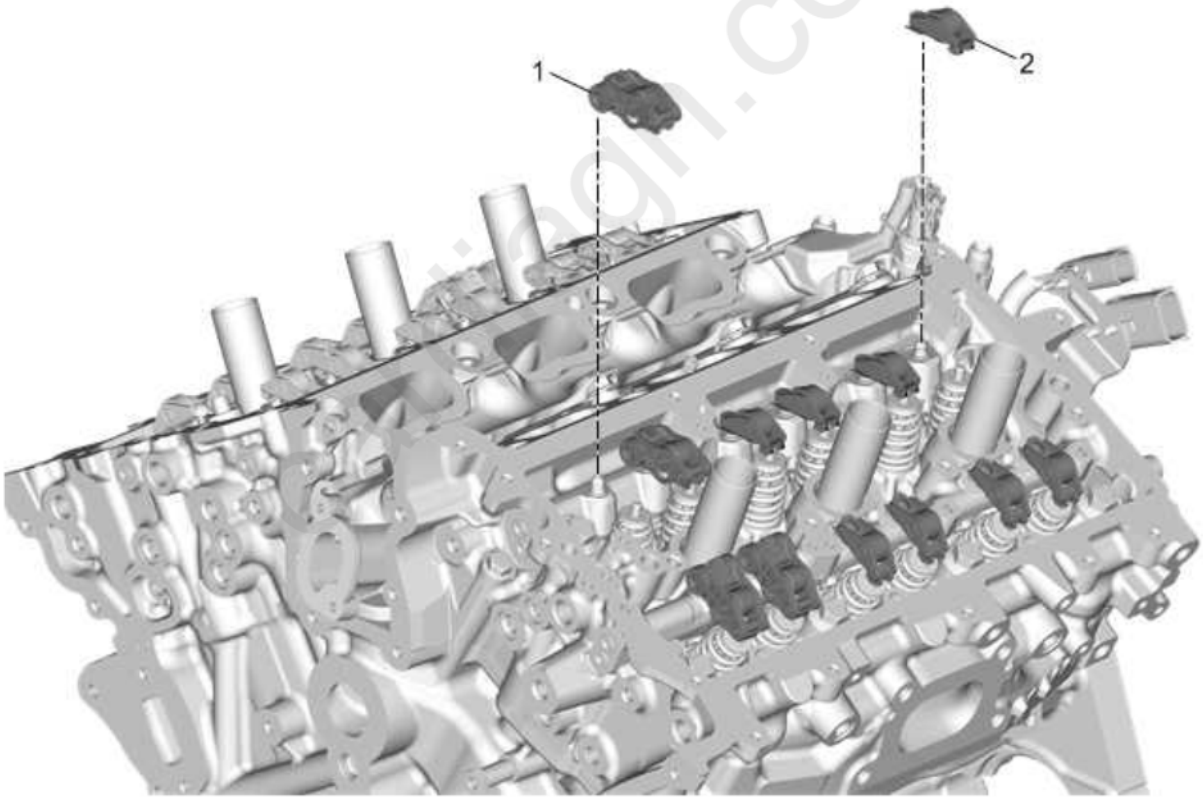


Fig. 396: Valve Rocker Arm - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name

Preliminary Procedure

1. Apply a liberal amount of lubricant to the pivot pocket, roller and valve slot areas of the camshaft followers. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended lubricant.
2. Place the camshaft followers in position on the valve tip and adjuster.
3. The rounded head end of the follower goes on the adjuster while the flat end goes on the valve tip.
4. Clean the camshaft journals and carriers with a clean, lint-free cloth.

NOTE:

The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

1	Valve Rocker Switching Arm [4x]
2	Valve Rocker Arm [8x]

CAMSHAFT CARRIER INSTALLATION - LEFT SIDE

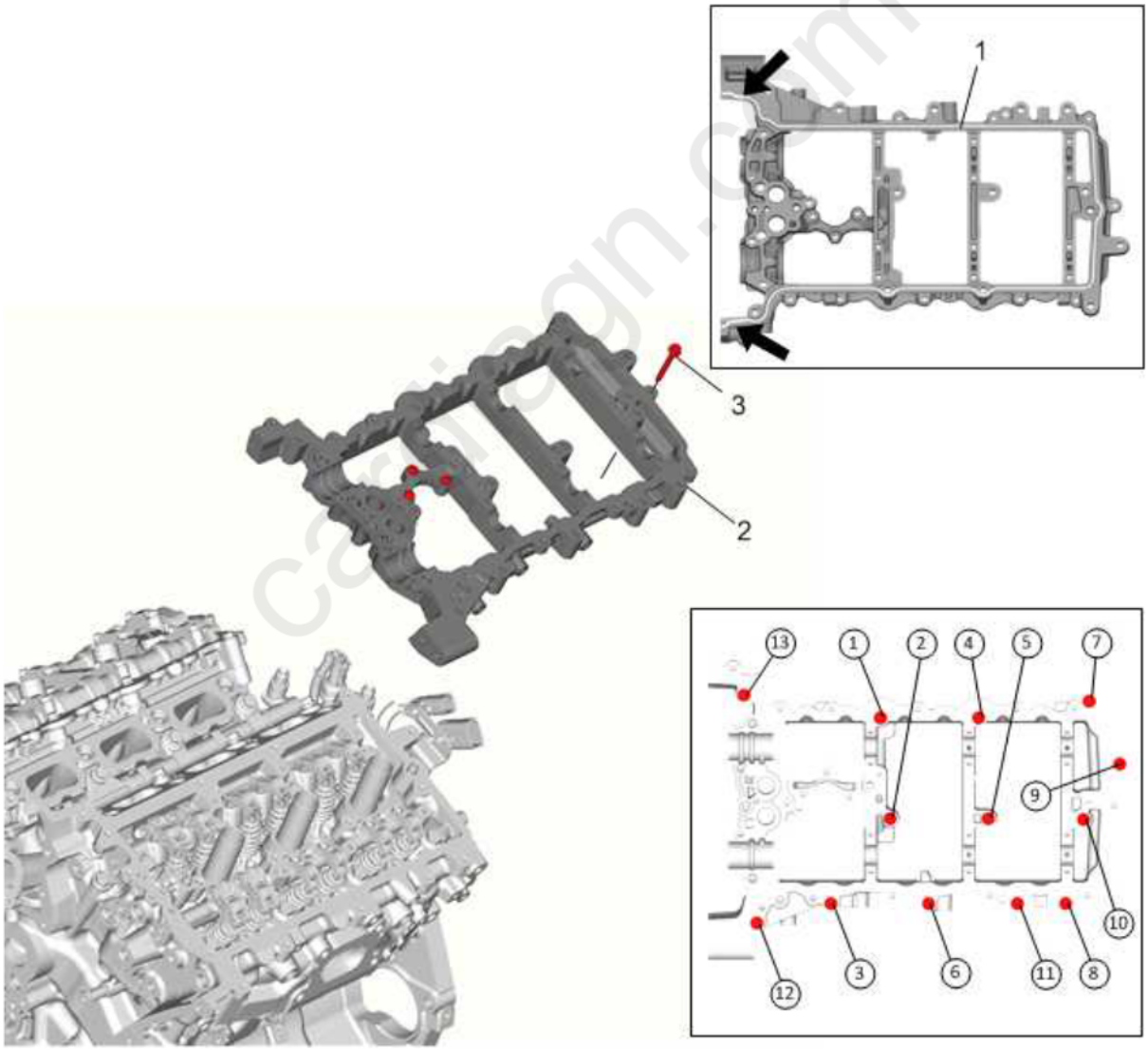


Fig. 397: Camshaft Carrier - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
1	Sealant **CAUTION:** **Do not apply more room temperature vulcanization (RTV) silicone than specified. Excess RTV silicone could plug up oil passage holes in the camshaft carrier and lead to engine damage.** **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Place a 3 mm (0.118 in) bead of RTV sealant on the bottom of the camshaft carrier, following the specific bead path. 3. Place a 5 mm (0.197 in) bead of RTV sealant on the bottom of the camshaft carrier as arrows show. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant. **NOTE:** **Camshaft carrier surfaces should be free and clean of oil and foreign substances.**
2	Camshaft Carrier Left
3	Camshaft Bearing Cap Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 1. First Pass: 6 N.m (53 lb in) 2. Final Pass: 60 degrees

CAMSHAFT INSTALLATION - LEFT SIDE

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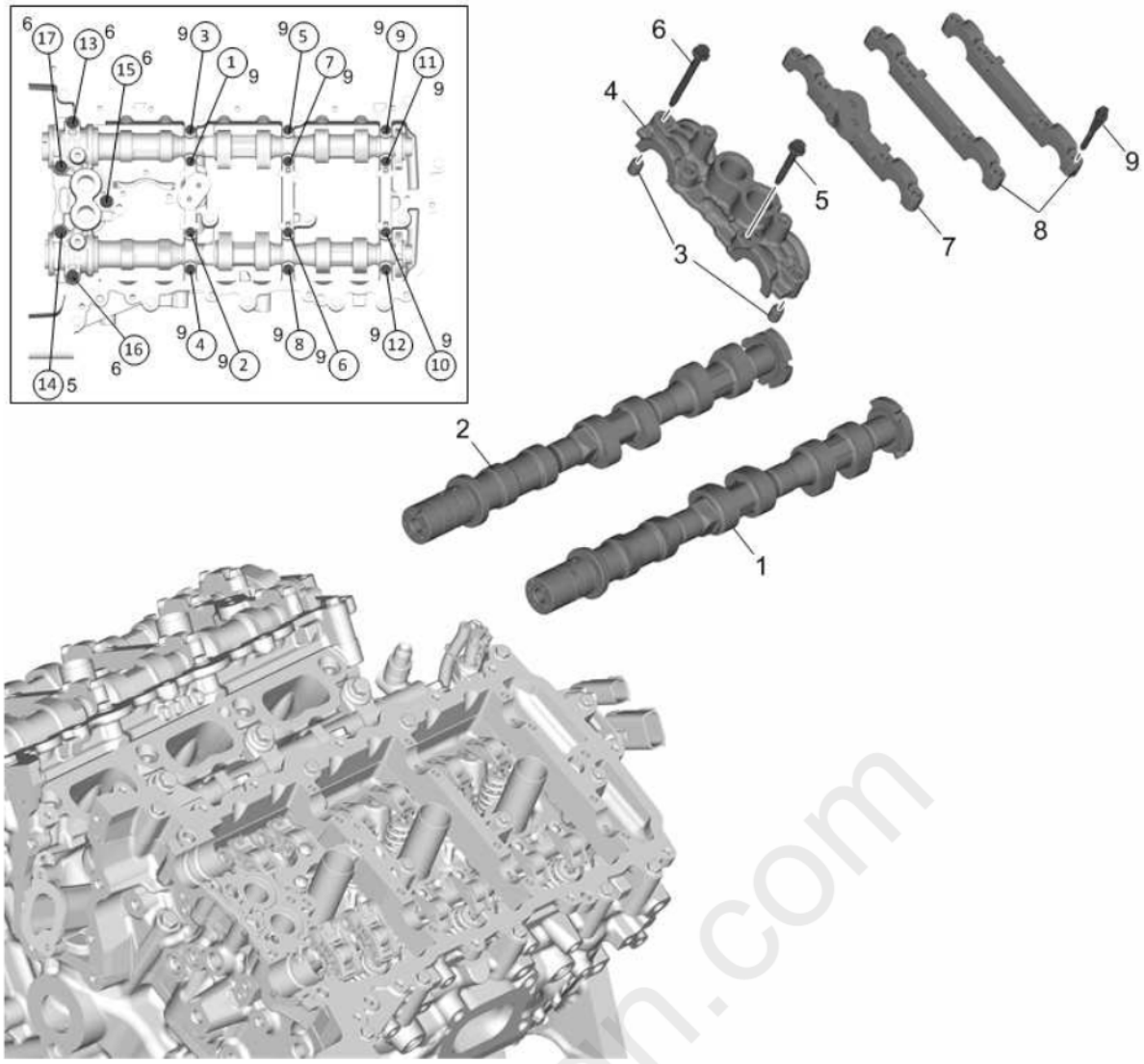


Fig. 398: Camshaft - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Camshaft **Procedure** Make sure the camshaft flats with laser etched markings are straight up in relation to the cylinder head and that the crankshaft is in the stage 1 position. The crankshaft key way will be at approximately the 11 o'clock position. Refer to **Timing Chain Alignment Diagram** . **NOTE:** **Ensure the flat is facing upward when installed to help when installing timing chains.**
2	Intake Camshaft **Procedure** Make sure the camshaft flats with laser etched markings are straight up in relation to the cylinder head and that the crankshaft is in the stage 1 position. The crankshaft key way will be at approximately the 11 o'clock position. Refer to **Timing Chain Alignment Diagram** . **NOTE:** **Ensure the flat is facing upward when installed to help when installing timing chains.**
3	Dowel Pin
4	Camshaft Bearing Cap

Callout	Component Name
5	Camshaft Bearing Cap Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 1. First Pass: 6 N.m (53 lb in) 2. Final Pass: 45 degrees
6	Camshaft Carrier Bolt **Tighten in sequence** 1. First Pass: 6 N.m (53 lb in) 2. Final Pass: 45 degrees
7	Camshaft Bearing Cap
8	Camshaft Bearing Cap
9	Camshaft Bearing Cap Bolt **Tighten in sequence** 1. First Pass: 6 N.m (53 lb in) 2. Final Pass: 60 degrees

FUEL PUMP INSTALLATION

Special Tools

EN-48896 HP Fuel Pump Installation Alignment Gauge

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

1. Use the **EN-48896** alignment gauge to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the head.

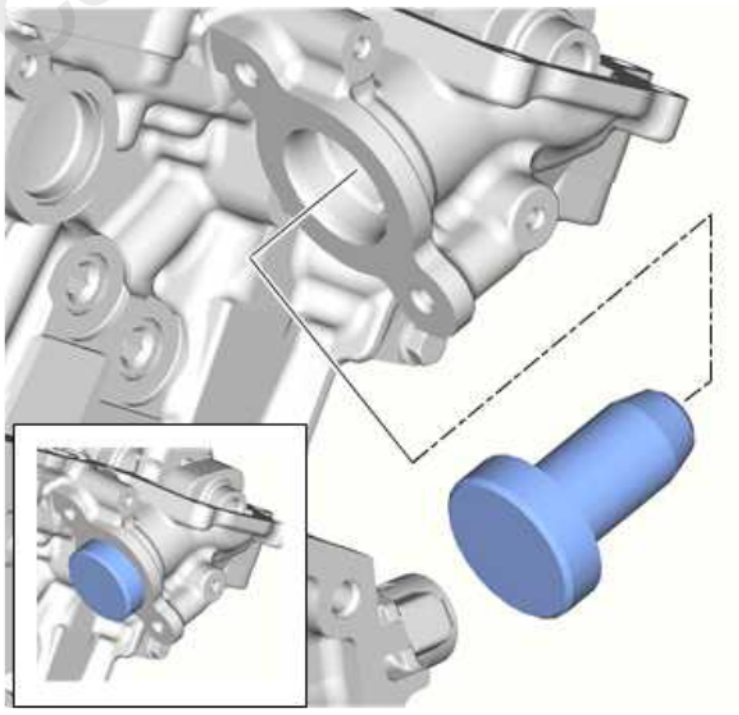


Fig. 399: Camshaft Alignment Gauge
Courtesy of GENERAL MOTORS COMPANY

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

2. Lubricate the high pressure fuel pump cylinder head bore with clean engine oil.

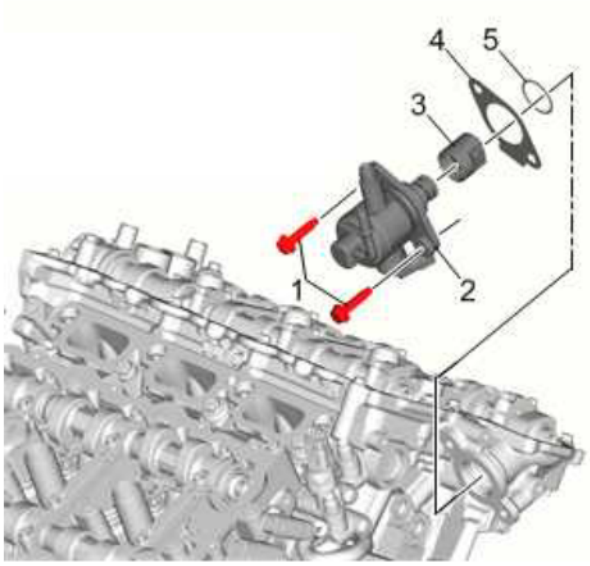


Fig. 400: High Pressure Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

3. Lubricate the high pressure fuel pump roller lifter with clean engine oil and install into the cylinder head bore.

NOTE: **Ensure that the high pressure fuel pump roller lifter is oriented properly, the camshaft is at base circle and the number 1 piston is at top dead center (TDC) on the exhaust stroke.**

4. Install a NEW high pressure fuel pressure fuel pump gasket (4).

NOTE: **If a high pressure pump is replaced on an engine which originally had a pump WITH a gasket, it must be rebuilt WITH a pump kit that includes the gasket; if a high pressure pump is replaced on an engine which originally had a pump WITHOUT a gasket, it must be rebuilt WITHOUT a gasket.**

5. Lubricate NEW high pressure fuel pump O-ring (5) with one drop of clean engine oil and install.
6. Install the valve lifter follower (3).

NOTE: **Ensure the plastic bolt retainers are installed in the high pressure fuel pump mounting holes before installing.**

7. Install the high pressure fuel pump (2).
8. Start and hand-tighten the NEW high pressure fuel pump bolts (1) evenly.

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in pump plunger damage.**

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

9. Tighten the fuel pump bolts (1) to 25 N.m (19 lb ft).

10. Install the NEW high pressure LH to RH fuel rail crossover pipe by starting all three fuel crossover pipe fitting nuts (1), (2) and (3) to finger-tight only.

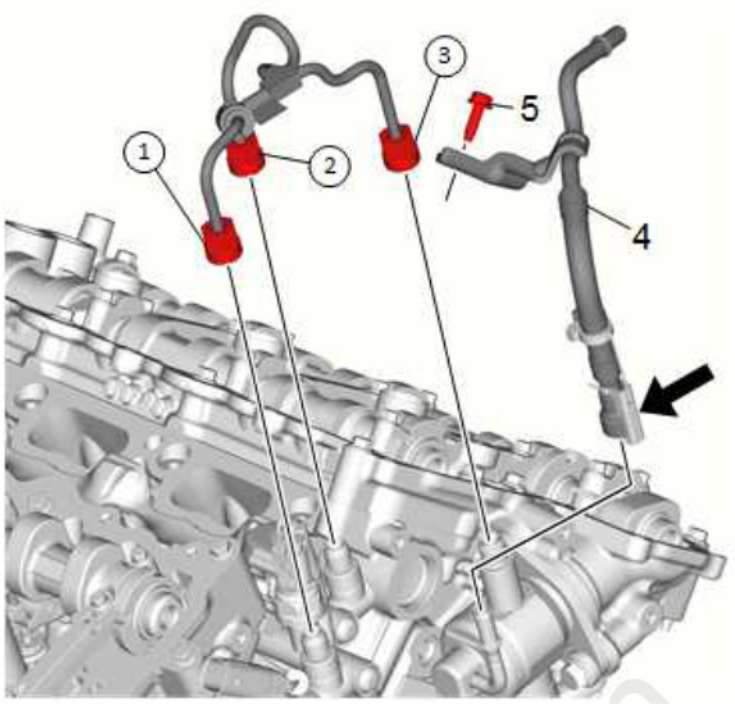


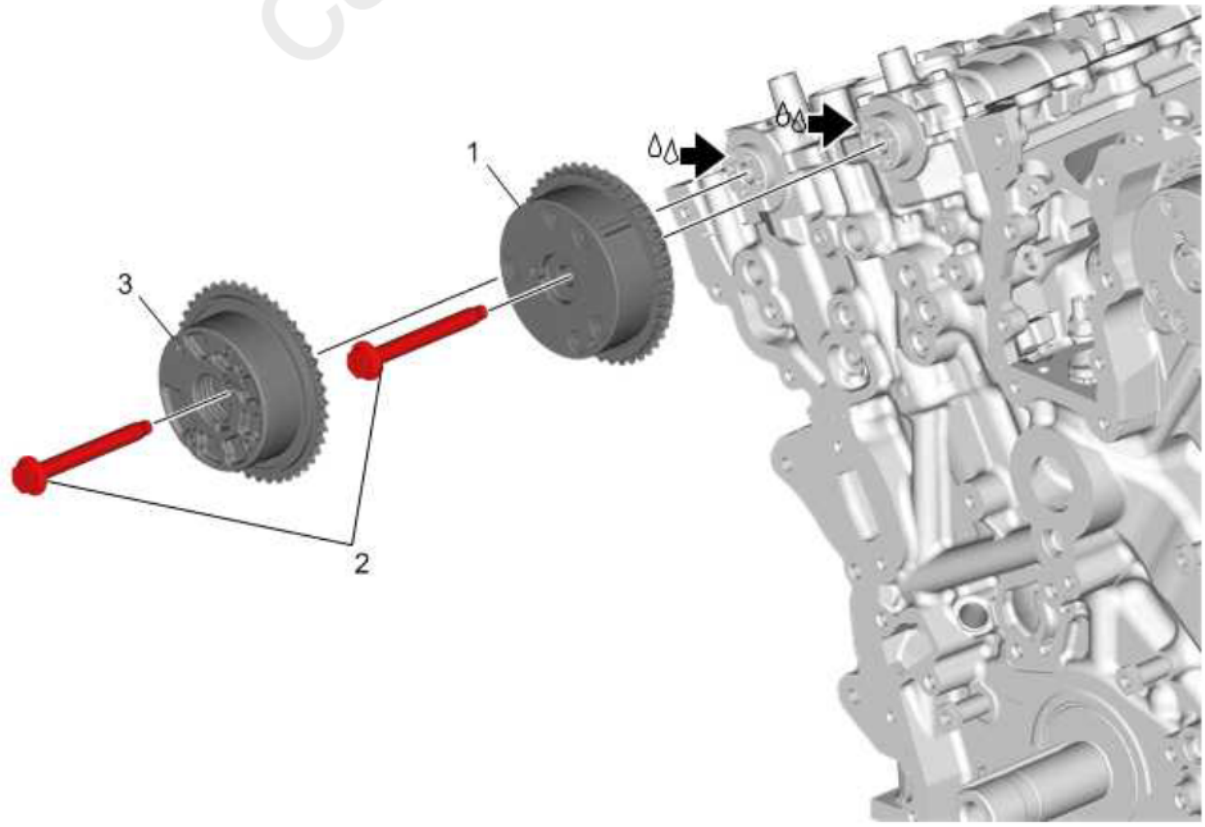
Fig. 401: Fuel Crossover Pipe Fitting Nuts
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **DO NOT reuse the high pressure fuel rail crossover pipe.**
- **The tightening order and torque are critical to proper fuel system fit and function. Be sure to follow installation and tightening steps exactly.**

11. Tighten the fuel feed intermediate pipe fittings to 28 N.m (21 lb ft) in the following order: (1) Left Fuel Rail, (2) Right Fuel Rail, then (3) Fuel Pump.
12. Install the fuel feed pipe (4) by installing the fuel line nut to the fuel pump finger-tight.
13. Tighten the fuel feed pipe bolt (5) to 10 N.m (89 lb in).

CAMSHAFT POSITION ACTUATOR INSTALLATION - BANK 1



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Fig. 402: Camshaft Position Actuator - Bank 1
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Camshaft Position Actuator Bank 1 **CAUTION:** **Ensure the proper camshaft position actuator is installed in the correct position. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.** **CAUTION:** **Refer to Torque Reaction Against Timing Drive Chain Caution .** **Procedure** 1. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt. 2. Apply a liberal amount of lubricant to the back of the camshaft position actuator and front of the camshaft bearing cap. Refer to **Adhesives, Fluids, Lubricants and Sealers** .
2	Camshaft Position Actuator Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** First Pass: 20 N.m (15 lb ft) Final Pass: 45 Degrees
3	Intake Camshaft Position Active Counter Bank 1 **Procedure** 1. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt. 2. Apply a liberal amount of lubricant to the back of the camshaft position actuator and front of the camshaft bearing cap. Refer to **Adhesives, Fluids, Lubricants and Sealers** .

CAMSHAFT POSITION ACTUATOR INSTALLATION - BANK 2

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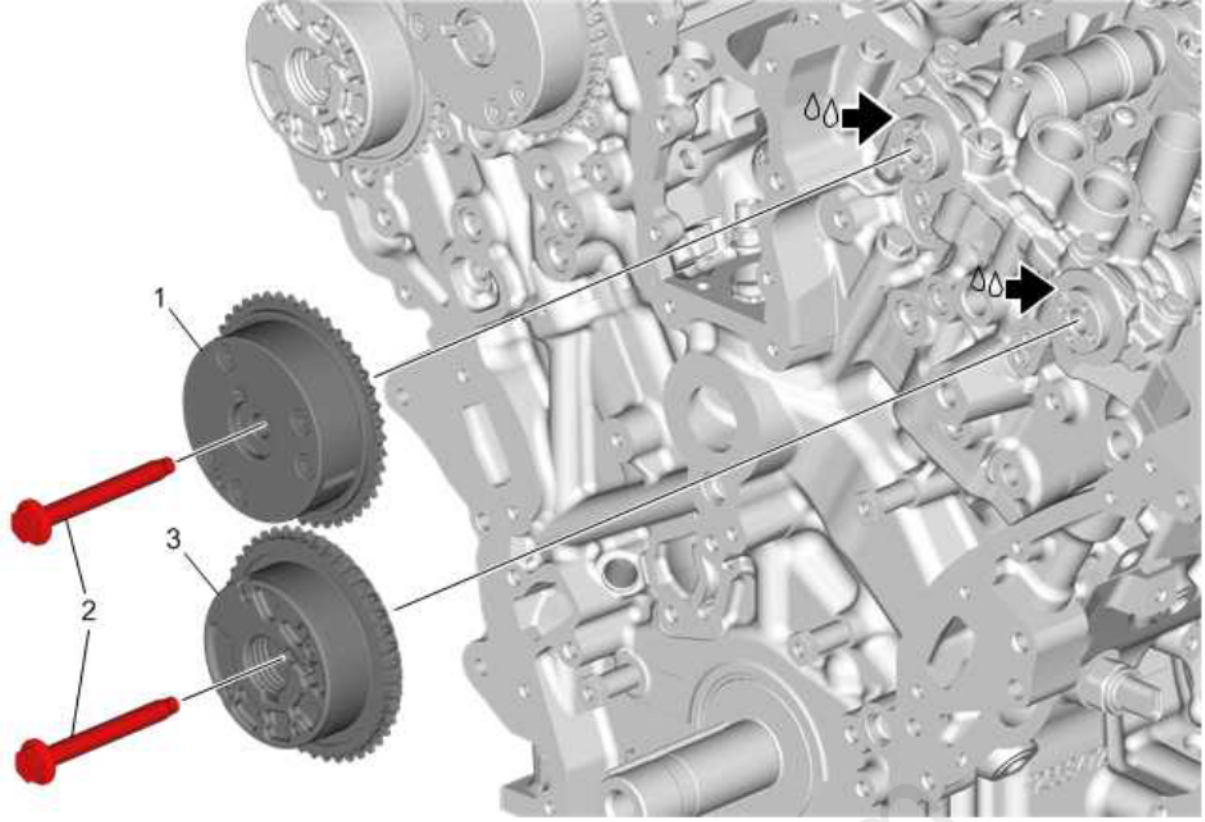


Fig. 403: Camshaft Position Actuator - Bank 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Camshaft Position Actuator Bank 2 **CAUTION:** **Ensure the proper camshaft position actuator is installed in the correct position. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.** **CAUTION:** **Refer to Torque Reaction Against Timing Drive Chain Caution .** **Procedure** 1. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt. 2. Apply a liberal amount of lubricant to the back of the camshaft position actuator and front of the camshaft bearing cap. Refer to **Adhesives, Fluids, Lubricants and Sealers** .
2	Camshaft Position Actuator Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** First Pass: 20 N.m (15 lb ft) Final Pass: 45 Degrees

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Callout	Component Name
3	Exhaust Camshaft Position Actuator Bank 2 **Procedure** 1. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt. 2. Apply a liberal amount of lubricant to the back of the camshaft position actuator and front of the camshaft bearing cap. Refer to **Adhesives, Fluids, Lubricants and Sealers** .

CAMSHAFT TIMING CHAIN COMPONENTS INSTALLATION

Left Timing Chain Guide Installation

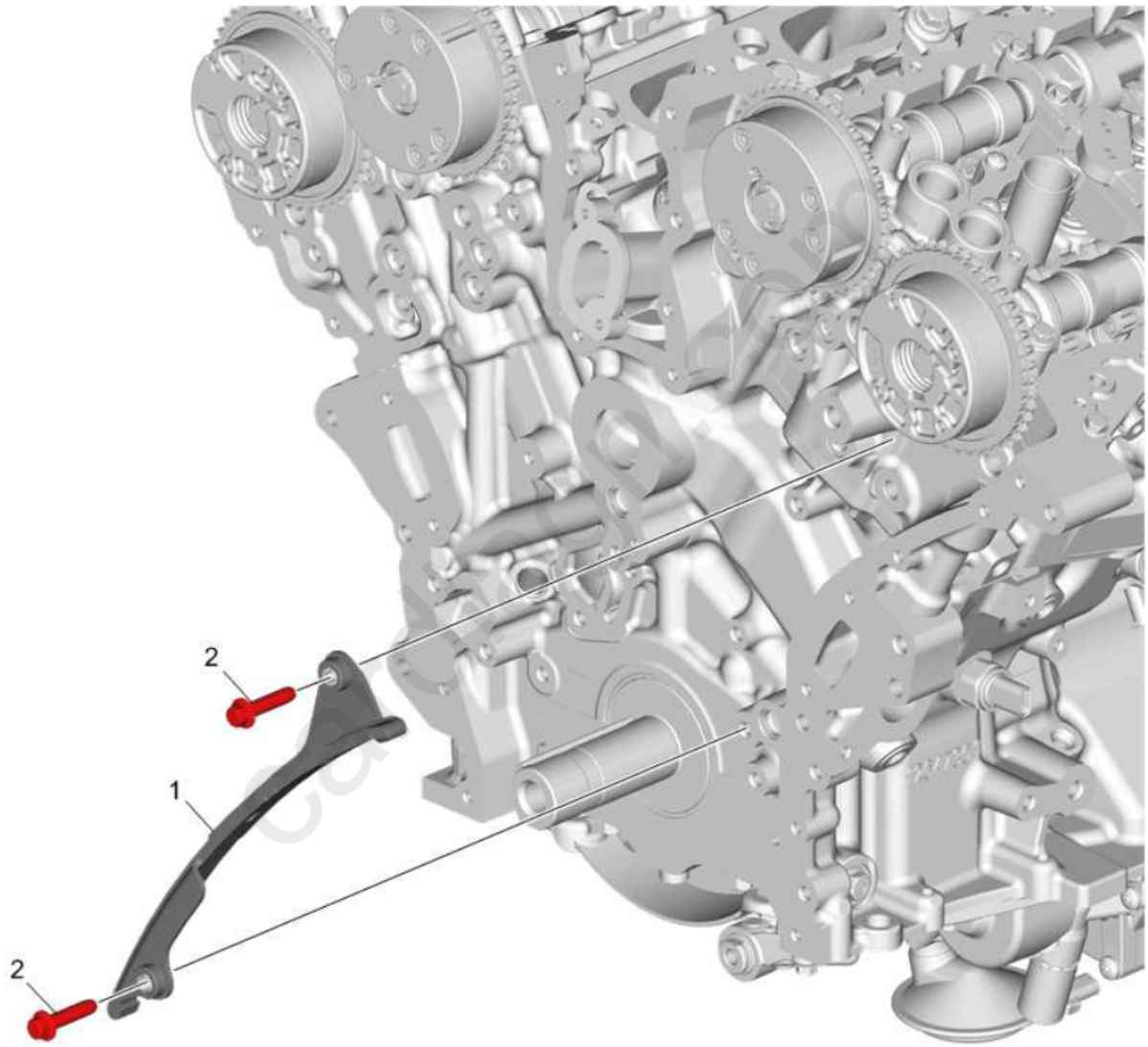


Fig. 404: Left Timing Chain Guide
Courtesy of GENERAL MOTORS COMPANY

Left Timing Chain Guide Installation

Callout	Component Name
1	Timing Chain Guide - Left Side **NOTE:** **Check that the specific Intake and exhaust actuators are in there proper position. There are specific Right and Left actuators.**

Callout	Component Name
2	Timing Chain Guide Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 25 N.m (18 lb ft)

Left Timing Chain Installation

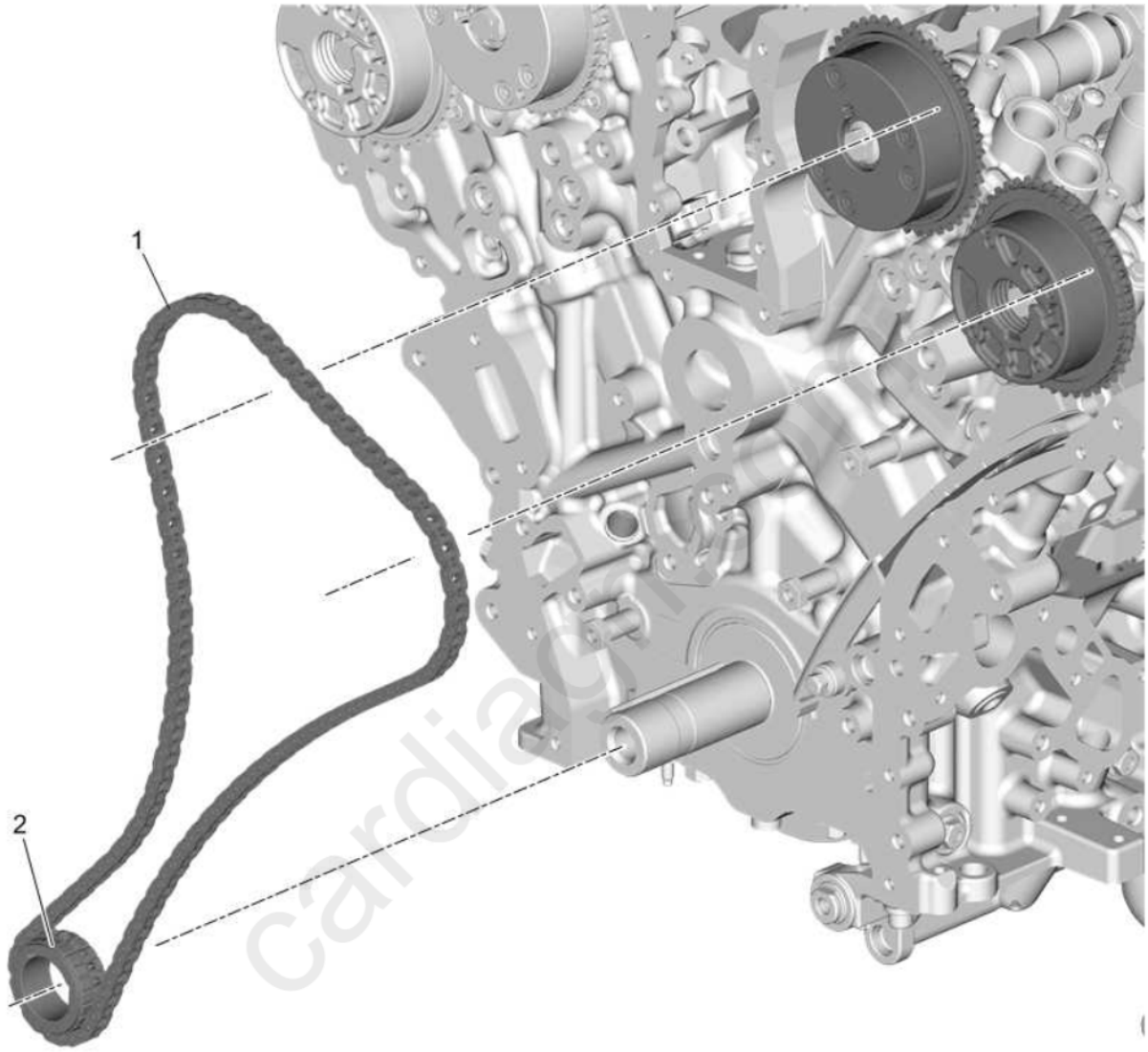


Fig. 405: Left Timing Chain
Courtesy of GENERAL MOTORS COMPANY

Left Timing Chain Installation

Callout	Component Name

Callout	Component Name
1	Timing Chain - Left Side **Procedure** 1. Make sure the camshaft flats with laser etched markings are straight up in relation to the cylinder head and that the crankshaft is in the stage 1 position. The crankshaft key way will be at approximately the 11 o'clock position. Refer to **Timing Chain Alignment Diagram** . 2. Preassemble the crank sprocket (2) to the left timing chain (1). 3. Install the crank sprocket on the crankshaft while holding up the timing chain. 4. Guide timing chain onto the guide and not resting on the plastic side ribs. 5. Use an open ended wrench on the cast hexagonal portion of the camshaft to rotate the camshafts, which will aid in the aligning of the timing marks. 6. There may be more than one marking on the camshaft actuator sprocket area. Locate the (L) on the face of the actuator body. The correct timing mark can be a circle or triangle located straight inboard on the sprocket tooth in line with the (L) identifier. 7. Align the left (L) exhaust camshaft position actuator sprocket alignment circle or triangle mark with the camshaft drive chain timing link. 8. Align the left (L) intake camshaft position actuator sprocket alignment circle or triangle mark with the camshaft drive chain timing link.
2	Crankshaft Sprocket

Left Timing Chain Guide and Timing Chain Tensioner Installation

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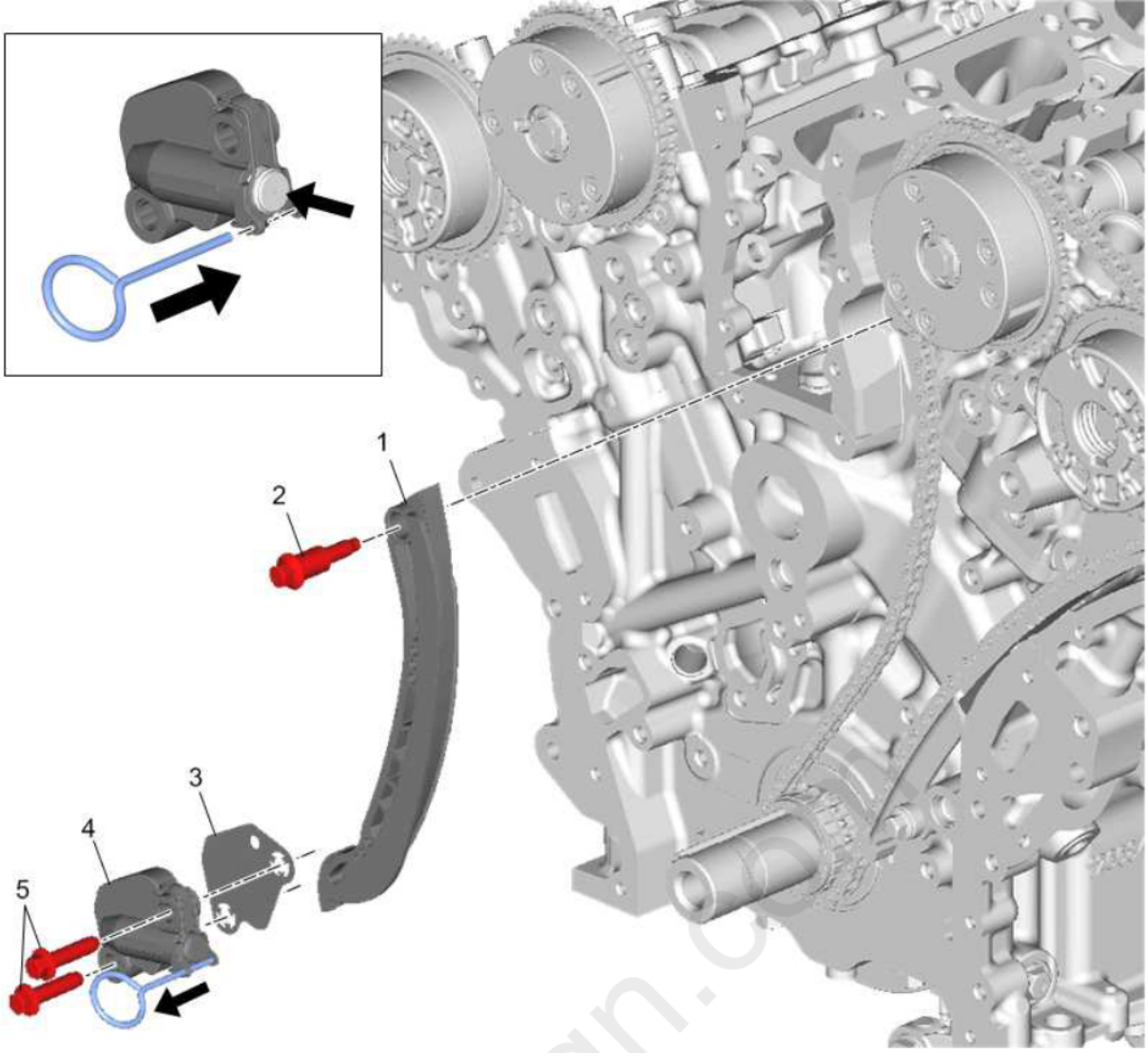


Fig. 406: Left Timing Chain Guide and Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

Left Timing Chain Guide and Timing Chain Tensioner Installation

Callout	Component Name
1	Timing Chain Guide - Left Side
2	Timing Chain Guide Bolt **Tighten** 25 N.m (18 lb ft)
3	Timing Chain Tensioner Gasket **NOTE:** **Ensure the left timing chain tensioner mounting surface on the left cylinder head does not have any burrs or defects that would degrade the sealing of the NEW left timing chain tensioner gasket.**

Callout	Component Name
4	Timing Chain Tensioner - Left Side **WARNING:** **The timing chain tensioner plunger is under high tension and must be retained by using the tensioner retraction pin during removal or installation of the timing chain tensioner. Failure to retain the timing chain tensioner plunger may cause it to be ejected with intense force and cause personal injury.** **Procedure** 1. Reset the timing chain tensioner plunger using your thumb and **EN-52234** or a 1/8" drill bit to retain the plunger. 2. Compress the plunger into the body and lock the right timing chain tensioner by inserting **EN-52234** or 1/8" drill bit into the access hole in the side of the right timing chain tensioner body. 3. Slowly release pressure on the right timing chain tensioner. The right timing chain tensioner should remain compressed. **Special Tools** **EN-52234** Timing Chain Tensioner Retaining Pins Equivalent regional tools:**Special Tools**
5	Timing Chain Tensioner Bolt **Procedure** 1. Place the chain tensioner into position and loosely install the bolts to the block. 2. Tighten the timing chain tensioner bolts. 3. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 4. Release the timing chain tensioner plunger by pulling out the suitable tool. 5. Verify the left timing chain timing mark alignments by referring to **Timing Chain Alignment Diagram** - Stage One. **Tighten** 25 N.m (18 lb ft)

Oil Pump Timing Chain Installation

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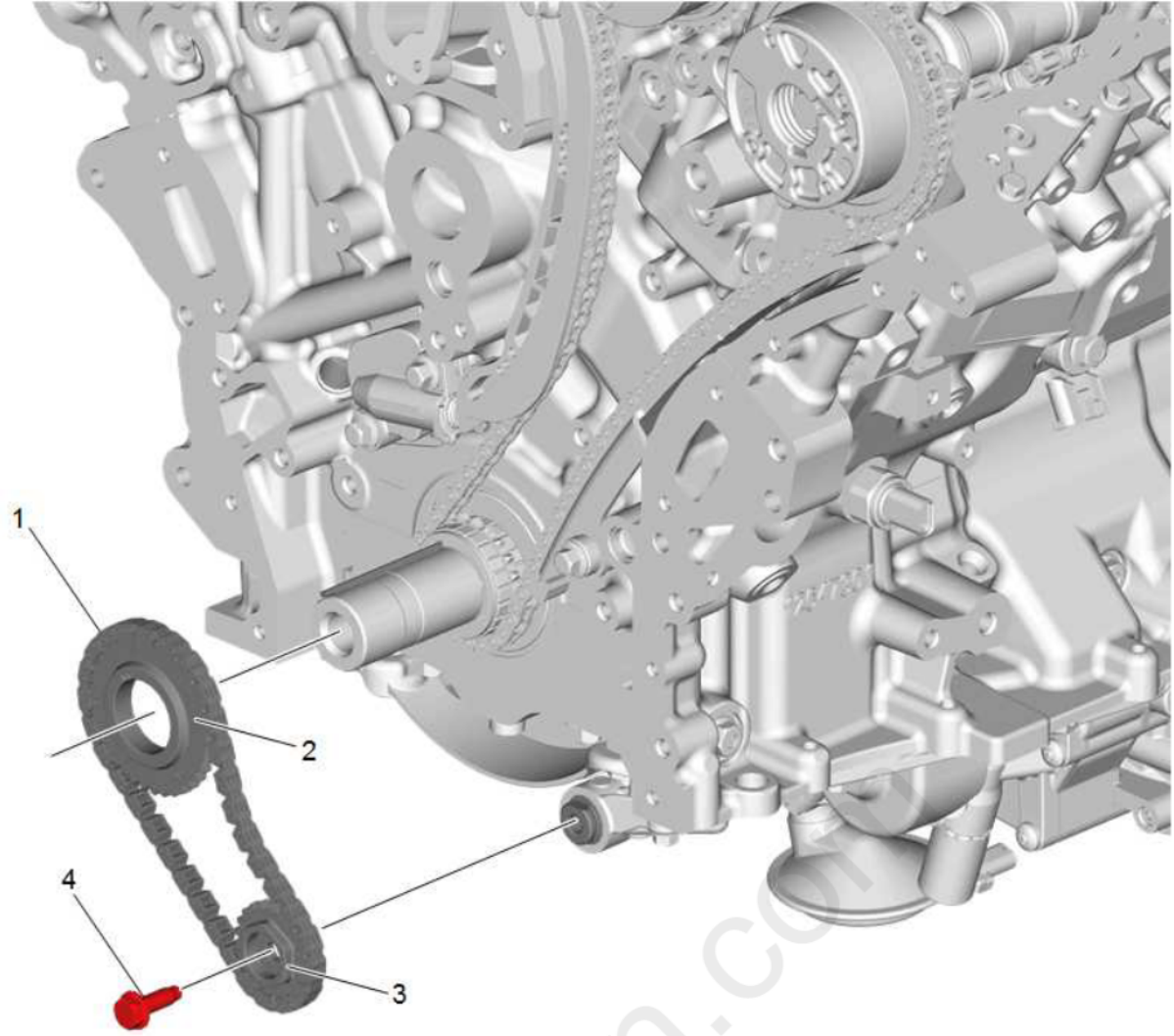


Fig. 407: Oil Pump Timing Chain
Courtesy of GENERAL MOTORS COMPANY

Oil Pump Timing Chain Installation

Callout	Component Name
1	Oil Pump Timing Chain
2	Oil Pump Drive BoltÂ» Install a NEW bolt. Do NOT reuse the old bolt. **Tighten in sequence** 1. First Pass: 15 N.m (11 lb ft) 2. Final Pass: 110 degrees

Oil Pump Timing Chain Tensioner Installation

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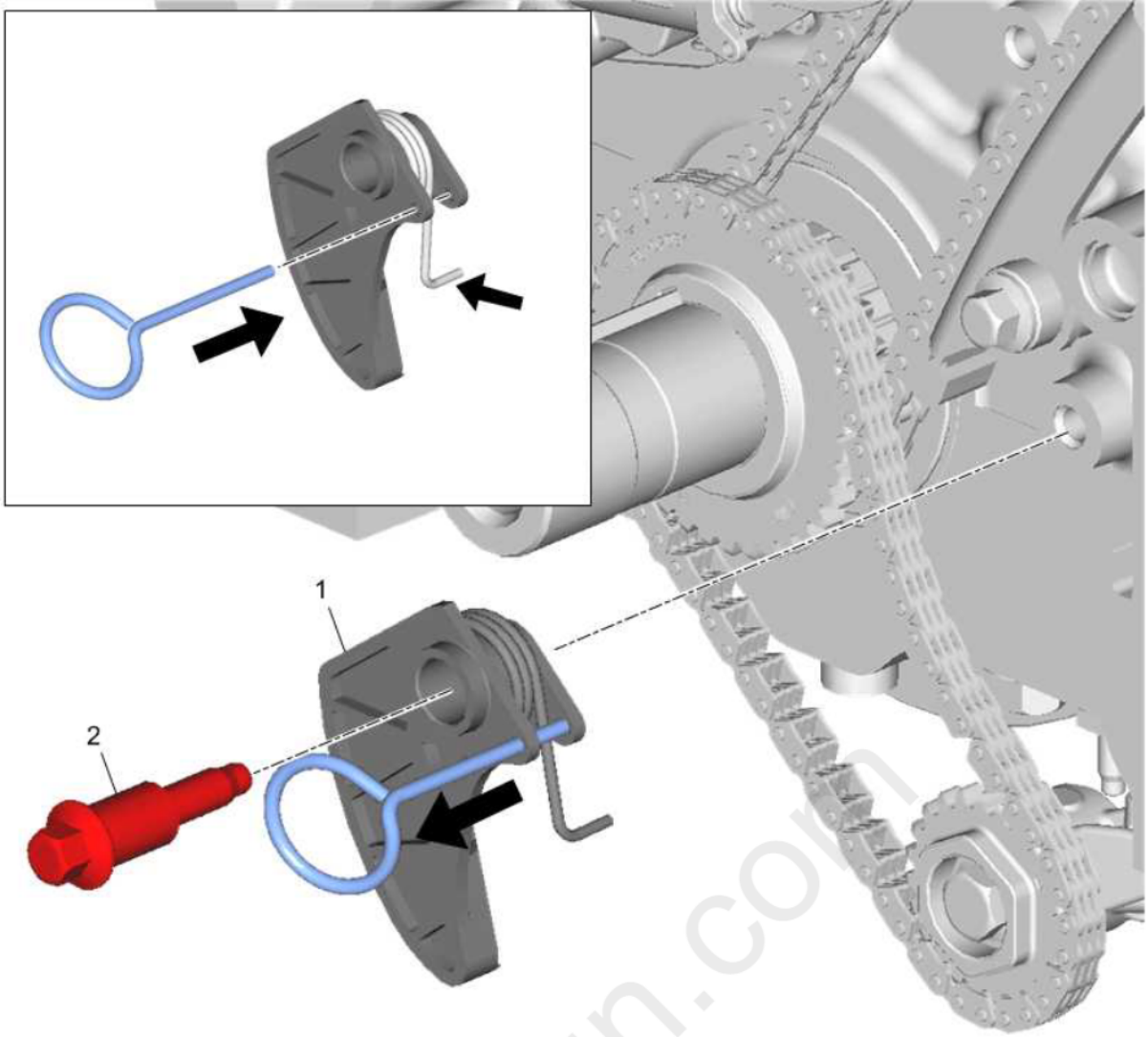


Fig. 408: Oil Pump Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

Oil Pump Timing Chain Tensioner Installation

Callout	Component Name
1	Timing Chain Tensioner **Procedure** Collapse the oil pump timing tensioner by hand and install **EN-52234** or a 1/8" drill bit to hold it in place. **Special Tools** **EN-52234** Timing Chain Tensioner Retaining Pins Equivalent regional tools:**Special Tools**
2	Timing Chain Tensioner Bolt **Procedure** 1. Place the chain tensioner into position and loosely install the bolt to the block 2. Tighten the timing chain tensioner bolt. 3. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 4. Release the drive chain tensioner by pulling out the suitable tool. **Tighten** 25 N.m (18 lb ft)

Right Timing Chain Guide Installation

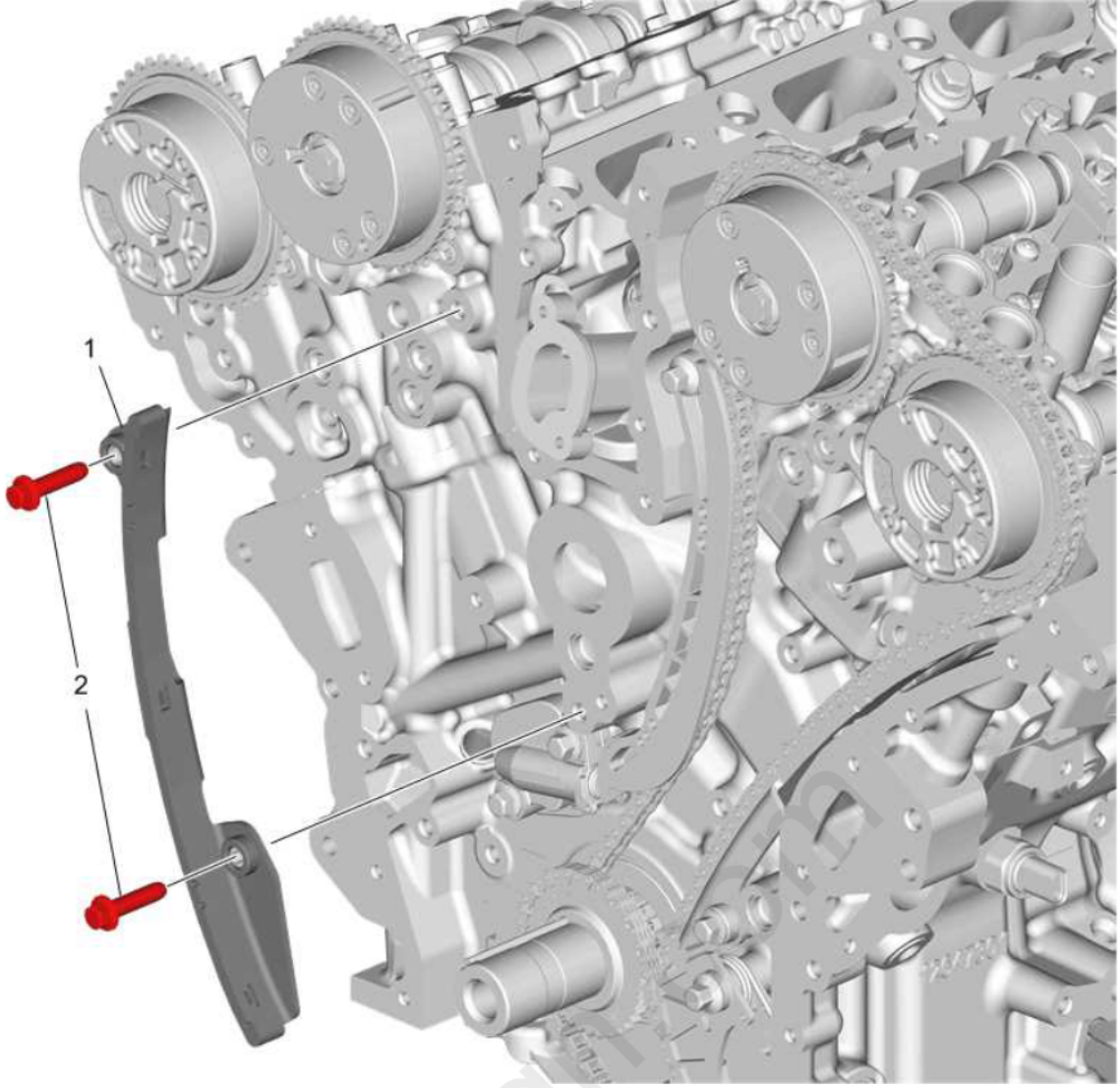


Fig. 409: Oil Pump Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

Right Timing Chain Guide Installation

Callout	Component Name
1	Timing Chain Guide - Right Side **NOTE:** **Check that the specific Intake and exhaust actuators are in there proper position. There are specific Right and Left actuators.**
2	Timing Chain Guide Bolt **Tighten** 25 N.m (18 lb ft)

Right Timing Chain Installation

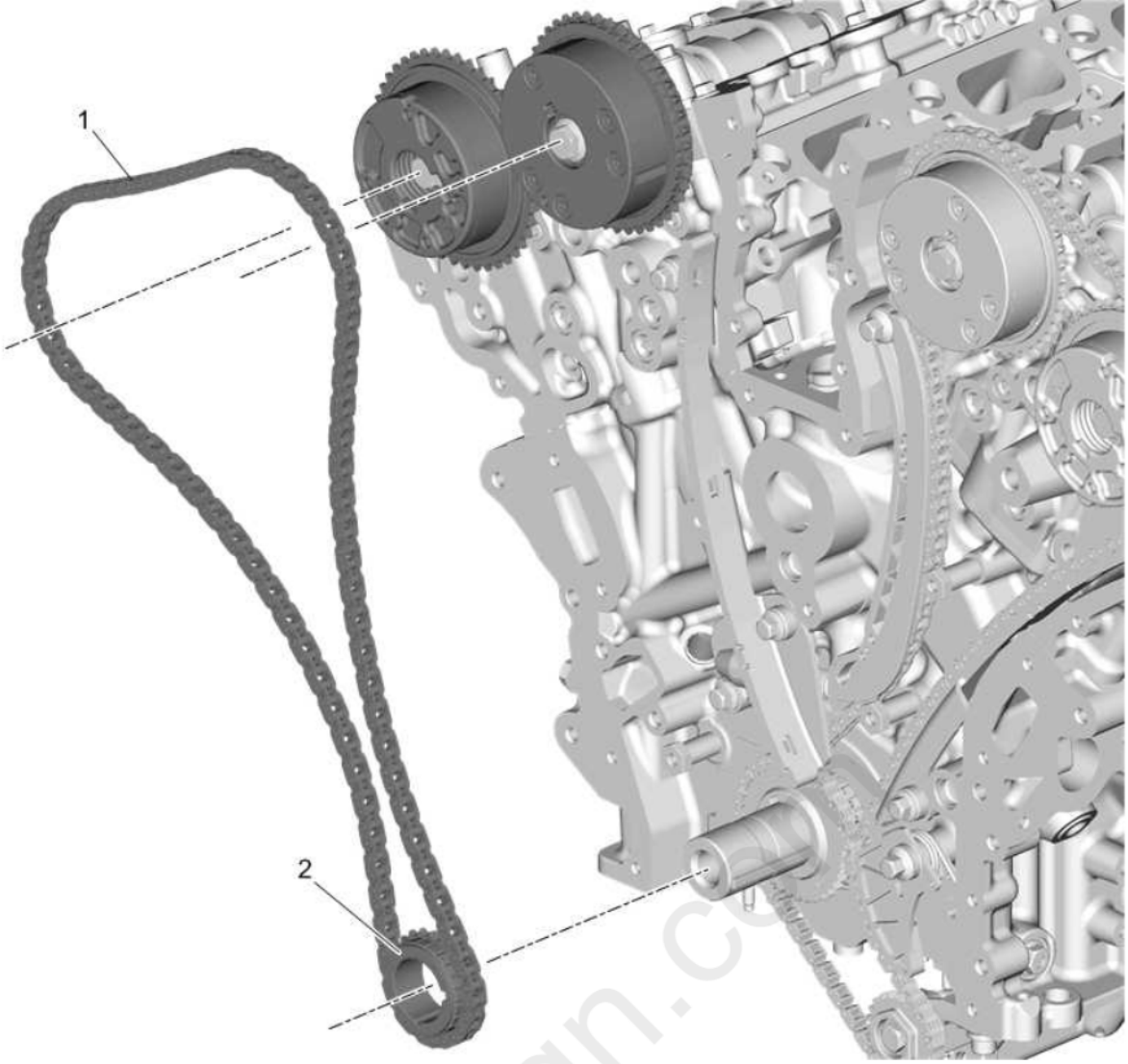


Fig. 410: Right Timing Chain
Courtesy of GENERAL MOTORS COMPANY

Right Timing Chain Installation

Callout	Component Name

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Callout	Component Name
1	Timing Chain - Right Side **Procedure** 1. Make sure the camshaft flats with laser etched markings are straight up in relation to the cylinder head and that the crankshaft is in the stage 2 position. The crankshaft key way will be at approximately the 3 o'clock position. Refer to **Timing Chain Alignment Diagram** . 2. Preassemble the crank sprocket (2) to the right timing chain (1). 3. Install the crank sprocket on the crankshaft while holding up the timing chain. 4. Guide timing chain onto the guide and not resting on the plastic side ribs. 5. Use an open ended wrench on the cast hexagonal portion of the camshaft to rotate the camshafts, which will aid in the aligning of the timing marks. 6. There may be more than one marking on the camshaft actuator sprocket area. Locate the (R) on the face of the actuator body. The correct timing mark can be a circle or triangle located straight inboard on the sprocket tooth in line with the (R) identifier. 7. Align the right (R) exhaust camshaft position actuator sprocket alignment circle or triangle mark with the camshaft drive chain timing link. 8. Align the right (R) intake camshaft position actuator sprocket alignment circle or triangle mark with the camshaft drive chain timing link.
2	Crankshaft Sprocket

Right Timing Chain Guide and Timing Chain Tensioner Installation

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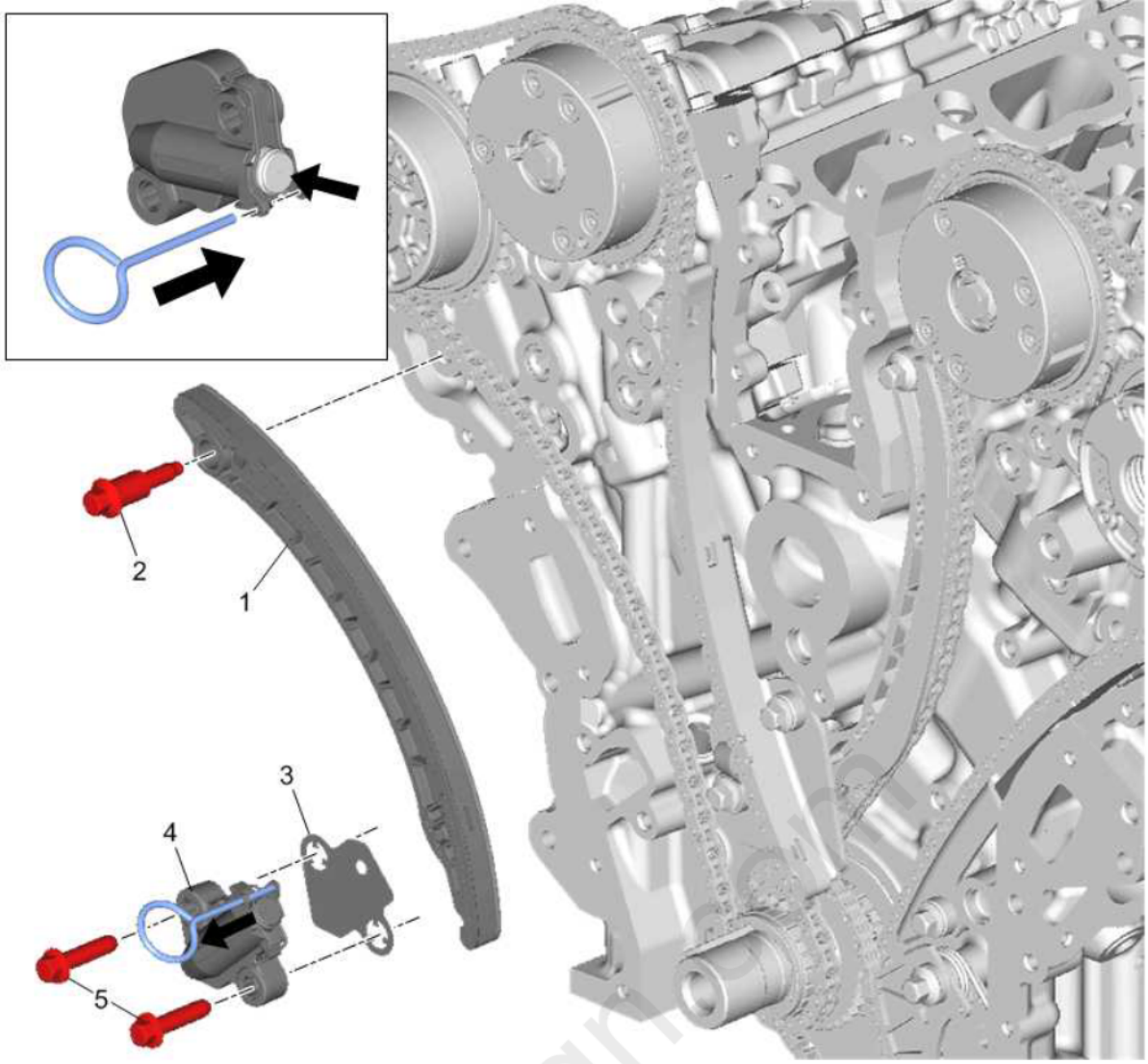


Fig. 411: Right Timing Chain Guide and Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

Right Timing Chain Guide and Timing Chain Tensioner Installation

Callout	Component Name
1	Timing Chain Guide - Right Side
2	Timing Chain Guide Bolt **Tighten** 25 N.m (18 lb ft)
3	Timing Chain Tensioner Gasket **NOTE:** **Ensure the right timing chain tensioner mounting surface on the right cylinder head does not have any burrs or defects that would degrade the sealing of the NEW right timing chain tensioner gasket.**

Callout	Component Name
4	Timing Chain Tensioner - Right Side **WARNING:** **The timing chain tensioner plunger is under high tension and must be retained by using the tensioner retraction pin during removal or installation of the timing chain tensioner. Failure to retain the timing chain tensioner plunger may cause it to be ejected with intense force and cause personal injury.** **Procedure** 1. Reset the timing chain tensioner plunger using your thumb and **EN-52234** or a 1/8" drill bit to retain the plunger. 2. Compress the plunger into the body and lock the right timing chain tensioner by inserting **EN-52234** or 1/8" drill bit into the access hole in the side of the right timing chain tensioner body. 3. Slowly release pressure on the right timing chain tensioner. The right timing chain tensioner should remain compressed. **Special Tools** **EN-52234** Timing Chain Tensioner Retaining Pins Equivalent regional tools: **Special Tools**
5	Timing Chain Tensioner Bolt **Procedure** 1. Place the chain tensioner into position and loosely install the bolts to the block. 2. Tighten the timing chain tensioner bolts. 3. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 4. Release the timing chain tensioner plunger by pulling out the suitable tool. 5. Verify the left timing chain timing mark alignments by referring to **Timing Chain Alignment Diagram** - Stage Two. **Tighten** 25 N.m (18 lb ft)

ENGINE FRONT COVER INSTALLATION

Sealant Application

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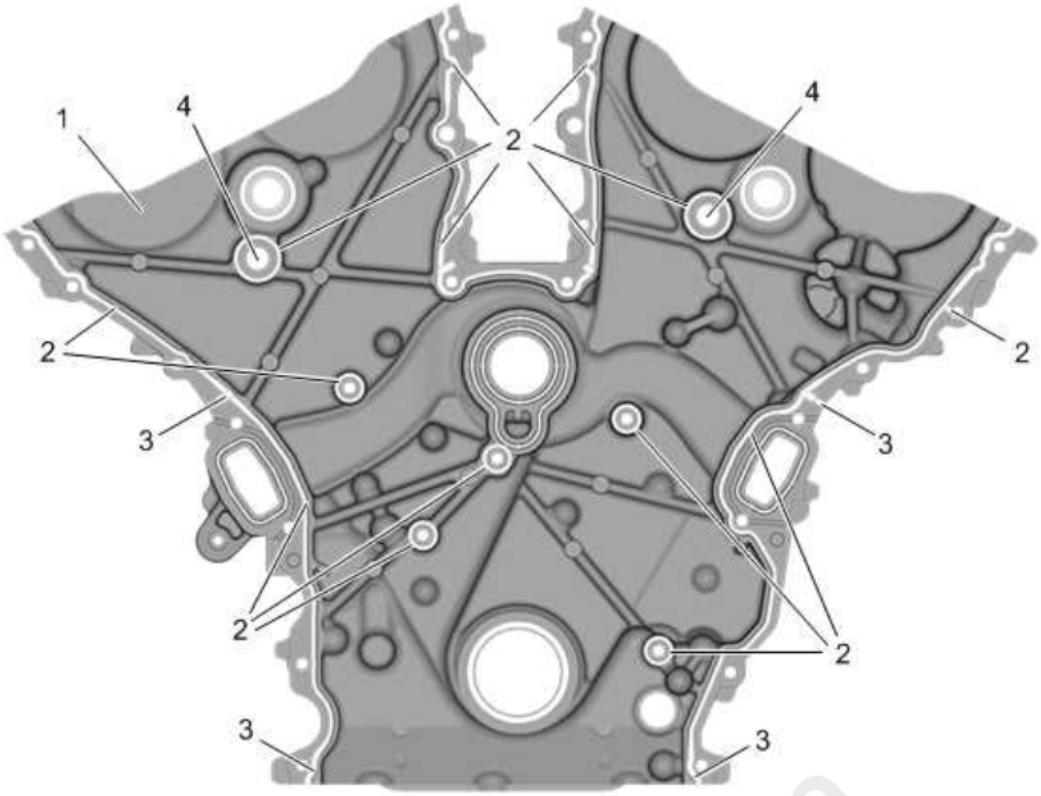


Fig. 412: Engine Front Cover Sealant Application Points
Courtesy of GENERAL MOTORS COMPANY

Sealant Application

Callout	Component Name
1	Engine Front Cover **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown. 3. Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown. Refer to **Adhesives, Fluids, Lubricants and Sealers** . **NOTE:** • **No RTV sealant should be visible in the M12 bolt holes upon final assembly of front cover to engine.** • **Keep the RTV bead path on the outward edge of the t-joints to ensure proper sealant coverage.**
2	3 mm (0.118 in) Bead of RTV Sealant
3	5 mm (0.197 in) Bead of RTV Sealant
4	M12 Bolt Holes

Front Cover Installation

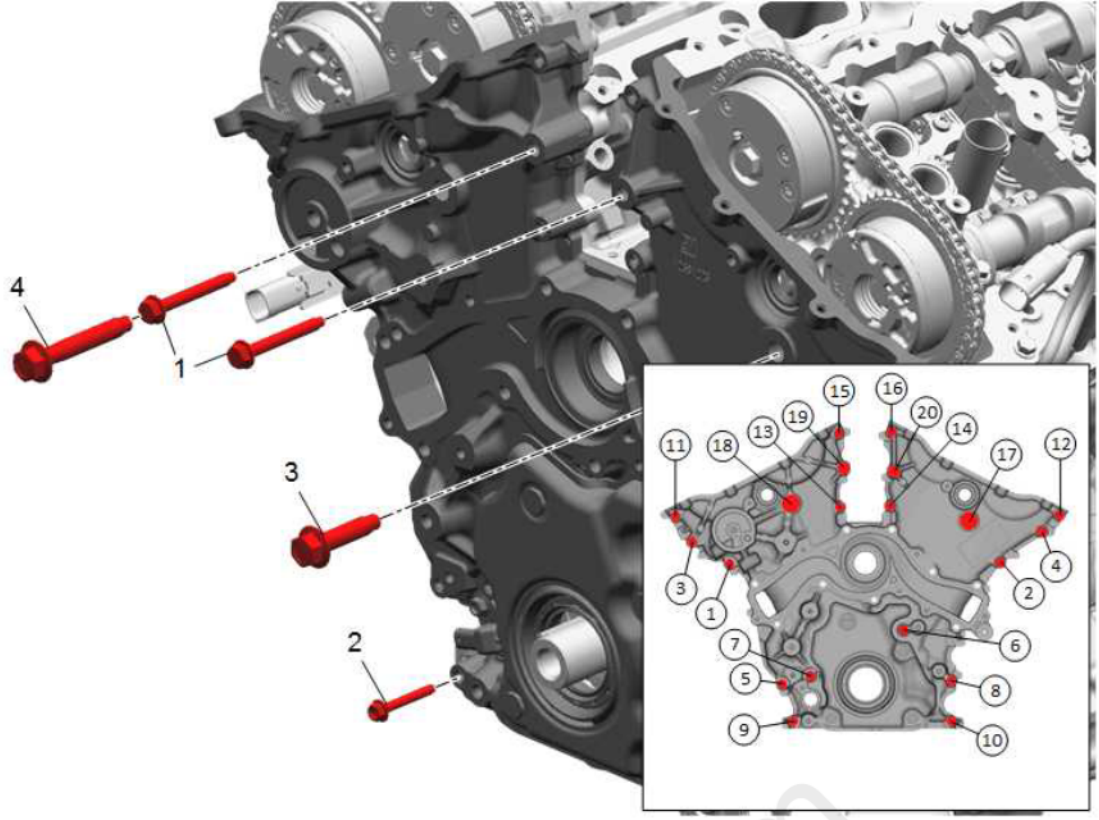


Fig. 413: Front Cover
Courtesy of GENERAL MOTORS COMPANY

Front Cover Installation

Callout	Component Name
Preliminary Procedure If the oil pan was removed it is easier to install after the front cover installation. Refer to **Oil Pan Installation (Without Oil Cooler)** and/or **Oil Pan Installation (With Oil Cooler)**. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**	
1	Engine Front Cover Locating Pin [2x]
2	Engine Front Cover **Procedure** 1. Install the **EN-46109** Guide Pins 2. Install the engine front cover. 3. Loosely install the engine front cover bolts. 4. Remove the **EN-46109** Guide Pins **Special Tools** **EN-46109** Guide Pins For equivalent regional tools, refer to **Special Tools** .
3	Engine Front Cover Bolt [16x] **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 10 N.m (89 lb in)
4	Engine Front Cover Bolt [2x] **Tighten in sequence** 15 N.m (11 lb ft)

Callout	Component Name
5	Engine Front Cover Bolt **NOTE:** **Part of engine mount on Front Wheel Drive version.** **Tighten in sequence** 60 N.m (44 lb ft
6	Engine Front Cover Bolt **NOTE:** **Part of engine mount on Front Wheel Drive version.** **Tighten in sequence** 60 N.m (44 lb ft
7	Oil Pump Flow Control Valve Electrical Connector **NOTE:** **The retaining clips attached to the oil pump flow control solenoid wire are used for initial production only and should be removed and discarded.**

Camshaft Position Actuator Control Valve and Belt Idler Pulley Installation

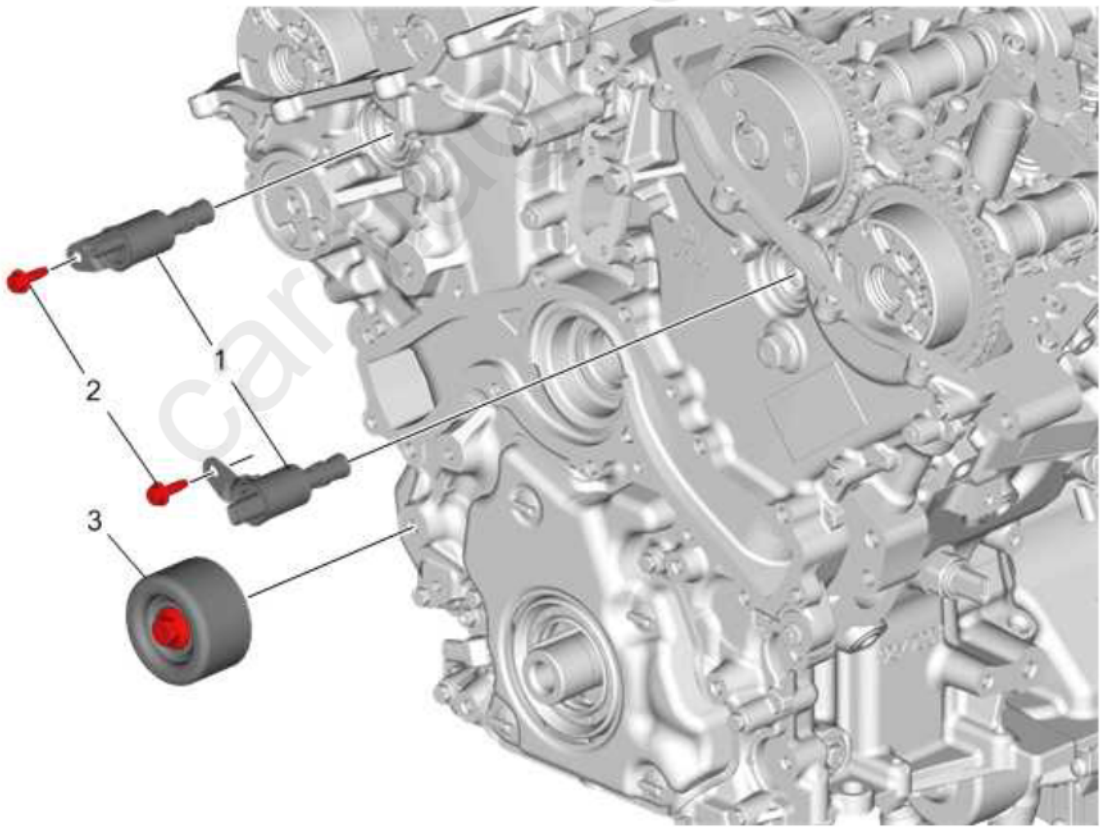


Fig. 414: Camshaft Position Actuator Control Valve and Belt Idler Pulley
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position Actuator Control Valve and Belt Idler Pulley Installation

Callout	Component Name
1	Camshaft Position Actuator Control Valve [2x]
2	Camshaft Position Actuator Control Valve Bolt [2x] **Tighten** 10 N.m (89 lb in)

Callout	Component Name
3	Belt Idler Pulley - Model Dependent **Tighten** 10 N.m (89 lb in)

WATER PUMP INSTALLATION

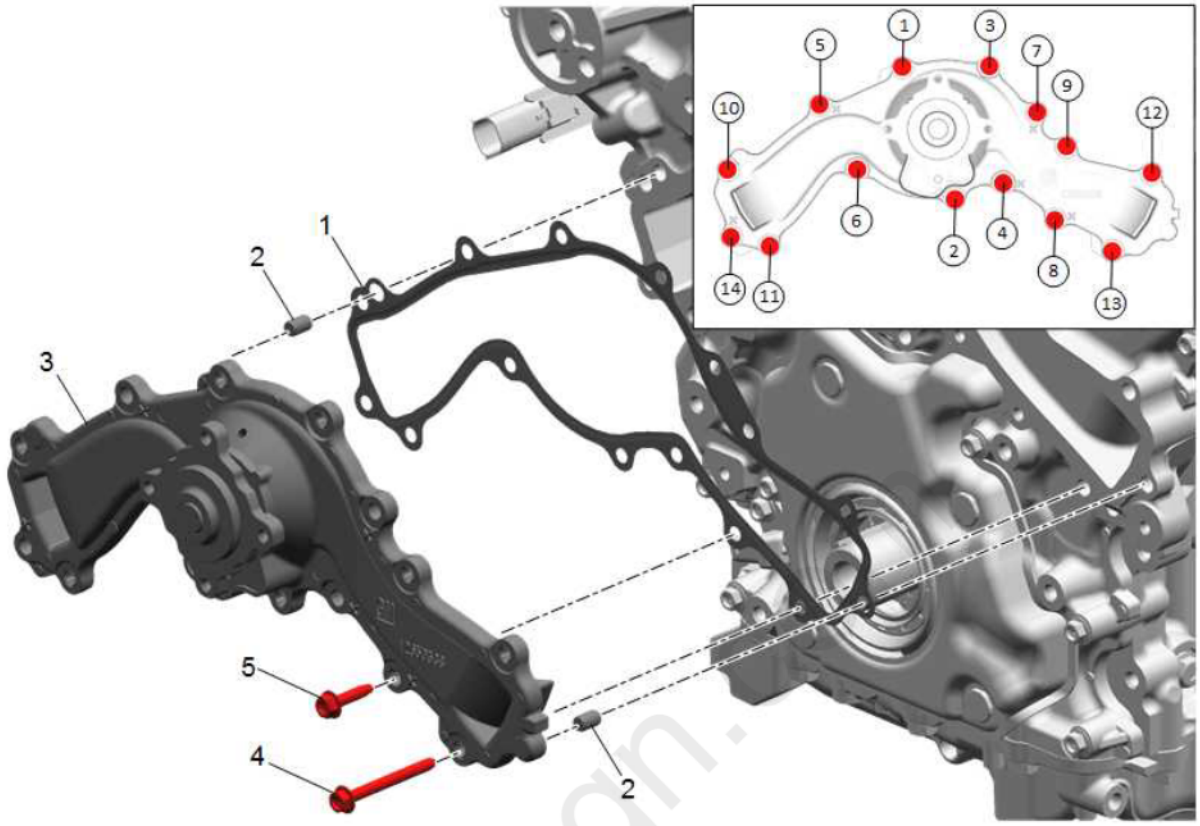


Fig. 415: Water Pump
Courtesy of GENERAL MOTORS COMPANY

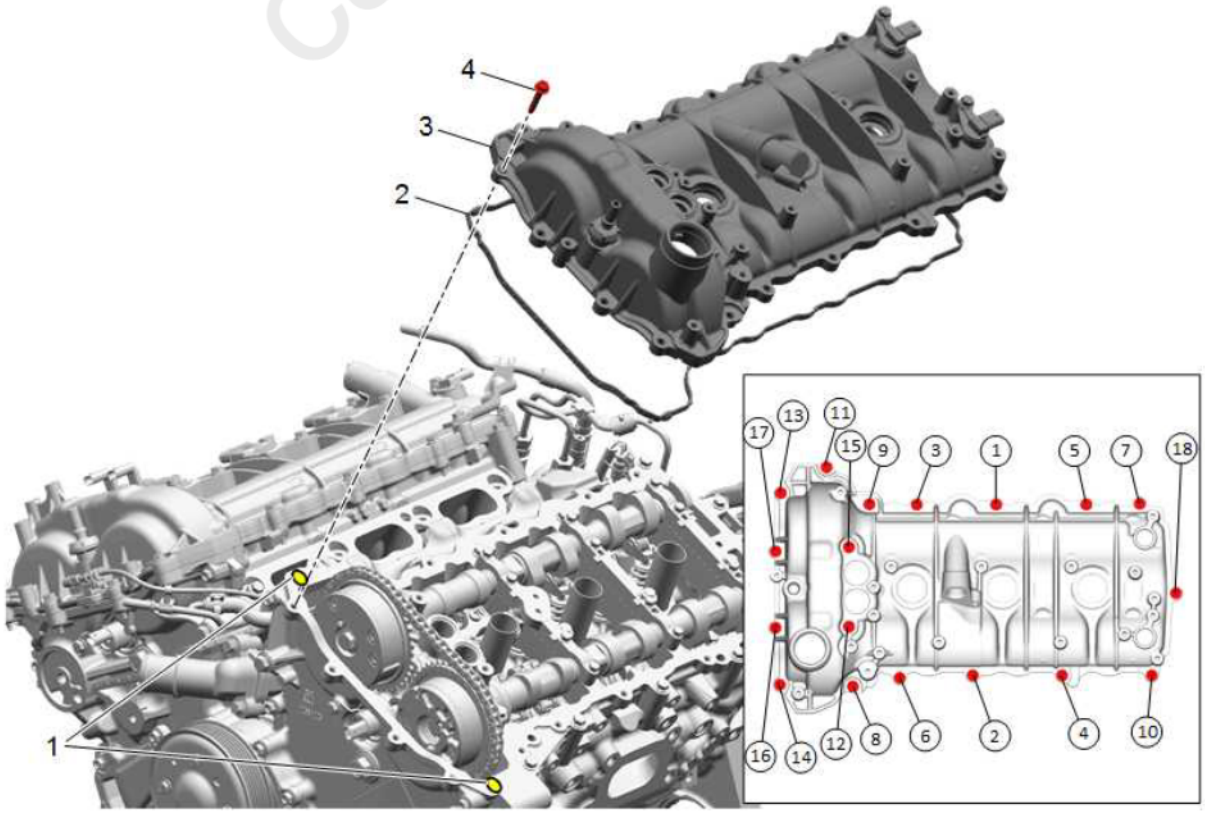
Callout	Component Name
1	Water Pump Gasket **NOTE:** **Install a NEW gasket.**
2	Water Pump Locating Pin [2x]
3	Water Pump
4	Engine Front Cover Bolt [9x] **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 15 N.m (11 lb ft)

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Callout	Component Name
5	Water Pump Bolt [5x] **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.** **Tighten in sequence** 15 N.m (11 lb ft)
6	Water Pump Pulley **Procedure** 1. Install the **EN-46104** Water Pump Pulley Holding Tool onto the water pump pulley mounting holes. 2. Install the water pump pulley bolts. 3. Remove the **EN-46104** Water Pump Pulley Holding Tool from the water pump pulley. **Special Tools** **EN-46104** Water Pump Pulley Holding Tool For equivalent regional tools, refer to **Special Tools** .
7	Water Pump Pulley Bolt [4x] **Tighten** 10 N.m (89 lb in)

CAMSHAFT COVER INSTALLATION - LEFT SIDE

Ignition Coil, Spark Plug, Camshaft Cover and Seal Installation



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Fig. 416: Ignition Coil, Spark Plug, Camshaft Cover and Seal
Courtesy of GENERAL MOTORS COMPANY

Ignition Coil, Spark Plug, Camshaft Cover and Seal Installation

Callout	Component Name
1	Sealant **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant on the engine front cover split lines. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant.
2	Camshaft Cover Seal Left Side **NOTE:** **Install a NEW seal.**
3	Camshaft Cover Left Side
4	Camshaft Cover Bolt [18x] **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 15 N.m (11 lb ft)
5	Spark Plug [3x] **NOTE:** **Install the NEW spark plugs.** **Tighten** 18 N.m (13 lb ft)
6	Ignition Coil [3x] **Procedure** 1. Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure: 1. Apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to **Adhesives, Fluids, Lubricants and Sealers** . 2. Remove any excess grease from around the end of the boot and ensure there is not an excessive amount within the boot.
7	Ignition Coil Bolt [3x] **Tighten** 10 N.m (89 lb in)

Oil Filler Cap and Tube, Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve Installation

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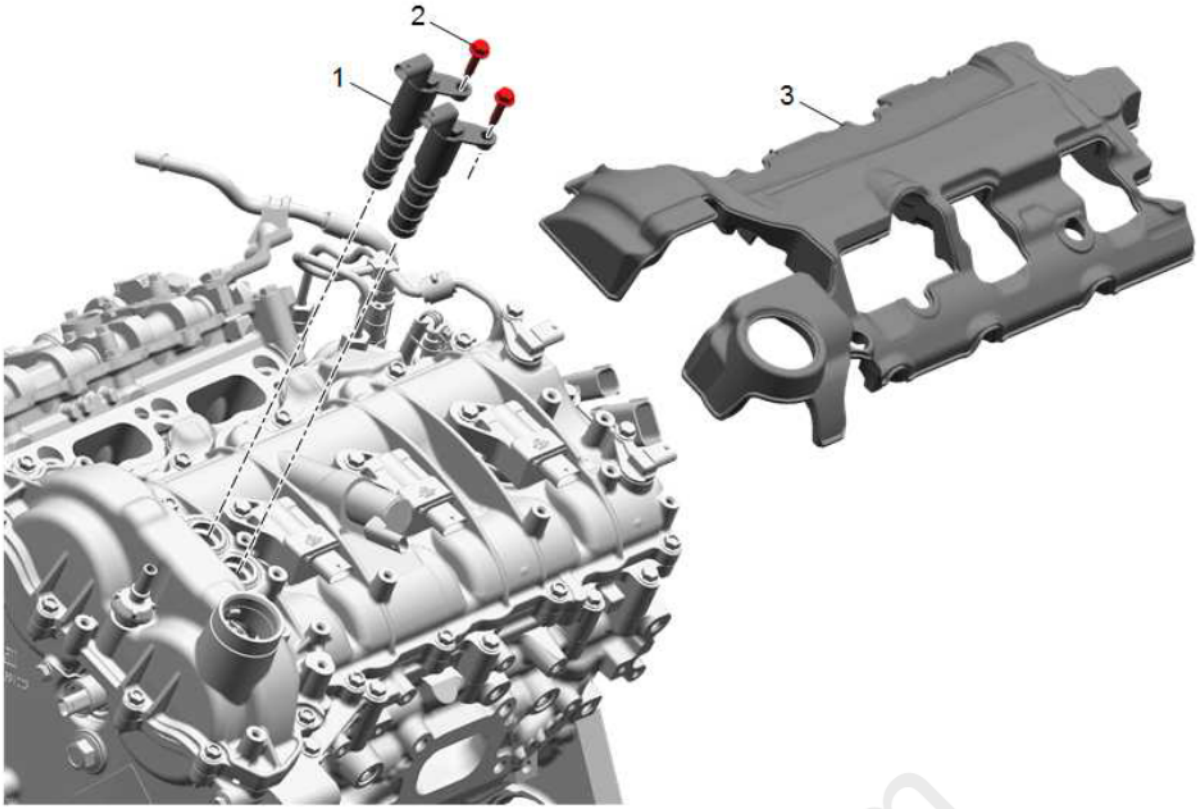


Fig. 417: Oil Filler Cap and Tube, Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Oil Filler Cap and Tube, Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve Installation

Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve [2x]
2	Camshaft Position Actuator Solenoid Valve Bolt [2x] **Tighten** 10 N.m (89 lb in)
3	Camshaft Housing Cover Insulator Left Side **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**
4	Oil Filler Cap Tube Seal **NOTE:** **Install a NEW seal.**
5	Oil Filler Cap Tube - Model Dependent
6	Oil Filler Cap Seal **NOTE:** **Install a NEW seal.**
7	Oil Filler Cap

CAMSHAFT COVER INSTALLATION - RIGHT SIDE

Ignition Coil, Spark Plug, Camshaft Cover and Seal Installation

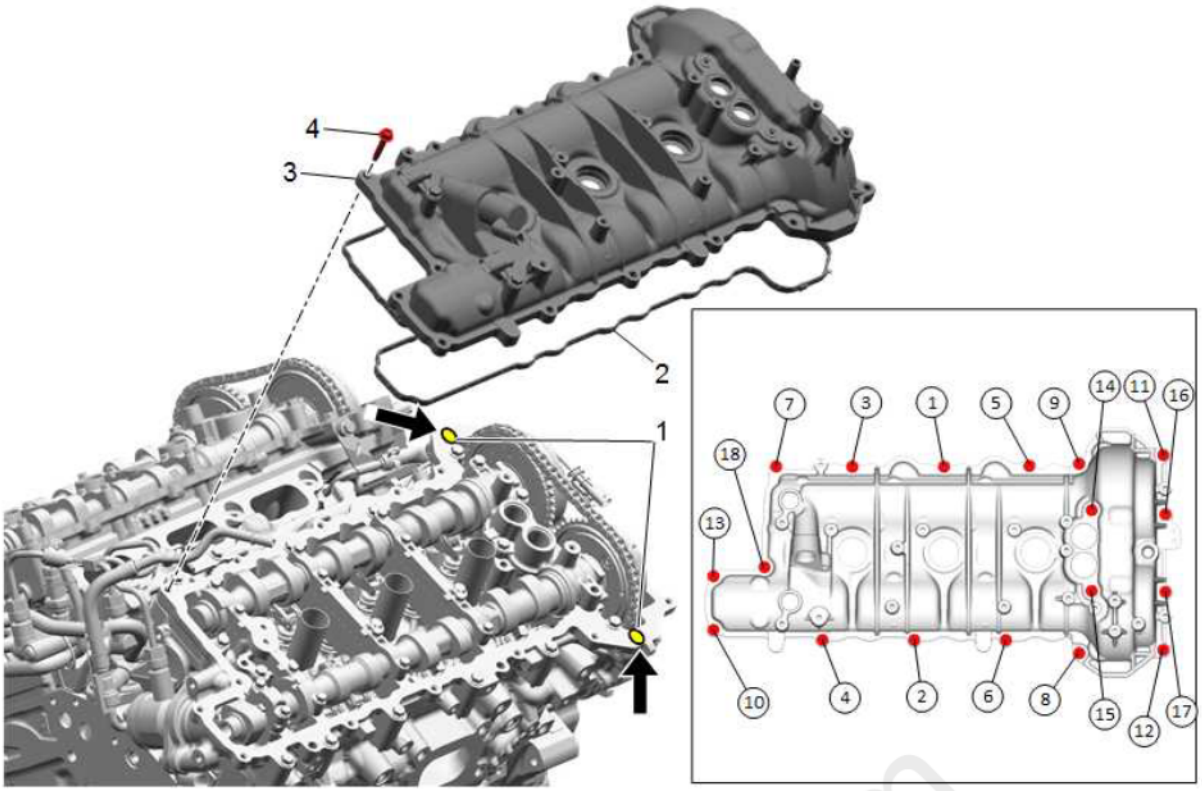


Fig. 418: Ignition Coil, Spark Plug, Camshaft Cover and Seal
Courtesy of GENERAL MOTORS COMPANY

Ignition Coil, Spark Plug, Camshaft Cover and Seal Installation

Callout	Component Name
1	Sealant **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant on the engine front cover split lines. Refer to **Adhesives, Fluids, Lubricants and Sealers** for recommended sealant.
2	Camshaft Cover Seal Right Side **NOTE:** **Install a NEW seal.**
3	Camshaft Cover Right Side
4	Camshaft Cover Bolt [18x] **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 15 N.m (11 lb ft)
5	Spark Plug [3x] **Tighten** 18 N.m (13 lb ft)

Callout	Component Name
6	Ignition Coil [3x] **Procedure** 1. Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure: 1. Apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to **Adhesives, Fluids, Lubricants and Sealers** . 2. Remove any excess grease from around the end of the boot and ensure there is not an excessive amount within the boot.
7	Ignition Coil Bolt [3x] **Tighten** 10 N.m (89 lb in)

Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve Installation

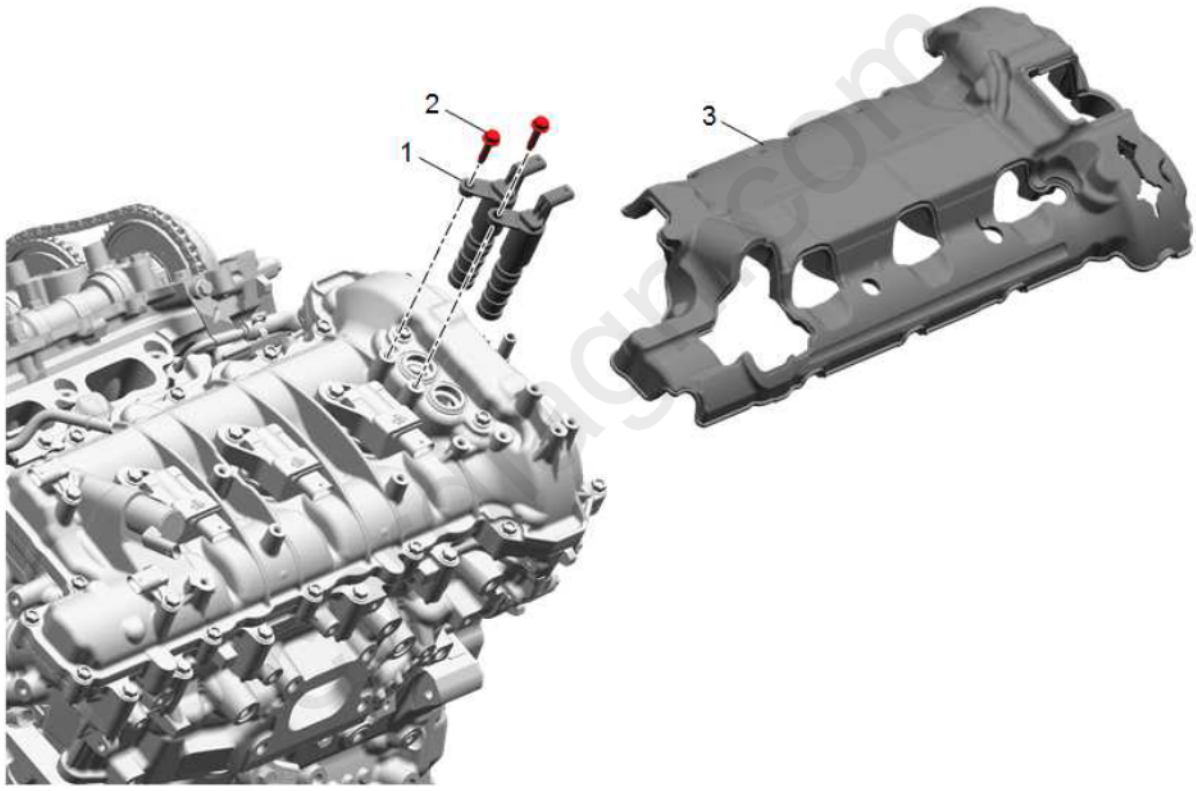


Fig. 419: Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Camshaft Housing Cover Insulator and Camshaft Position Actuator Solenoid Valve Installation

Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve [2x]
2	Camshaft Position Actuator Solenoid Valve Bolt [2x] **Tighten** 10 N.m (89 lb in)

Callout	Component Name
3	Camshaft Housing Cover Insulator Right Side **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**

INTAKE MANIFOLD INSTALLATION (LGX)

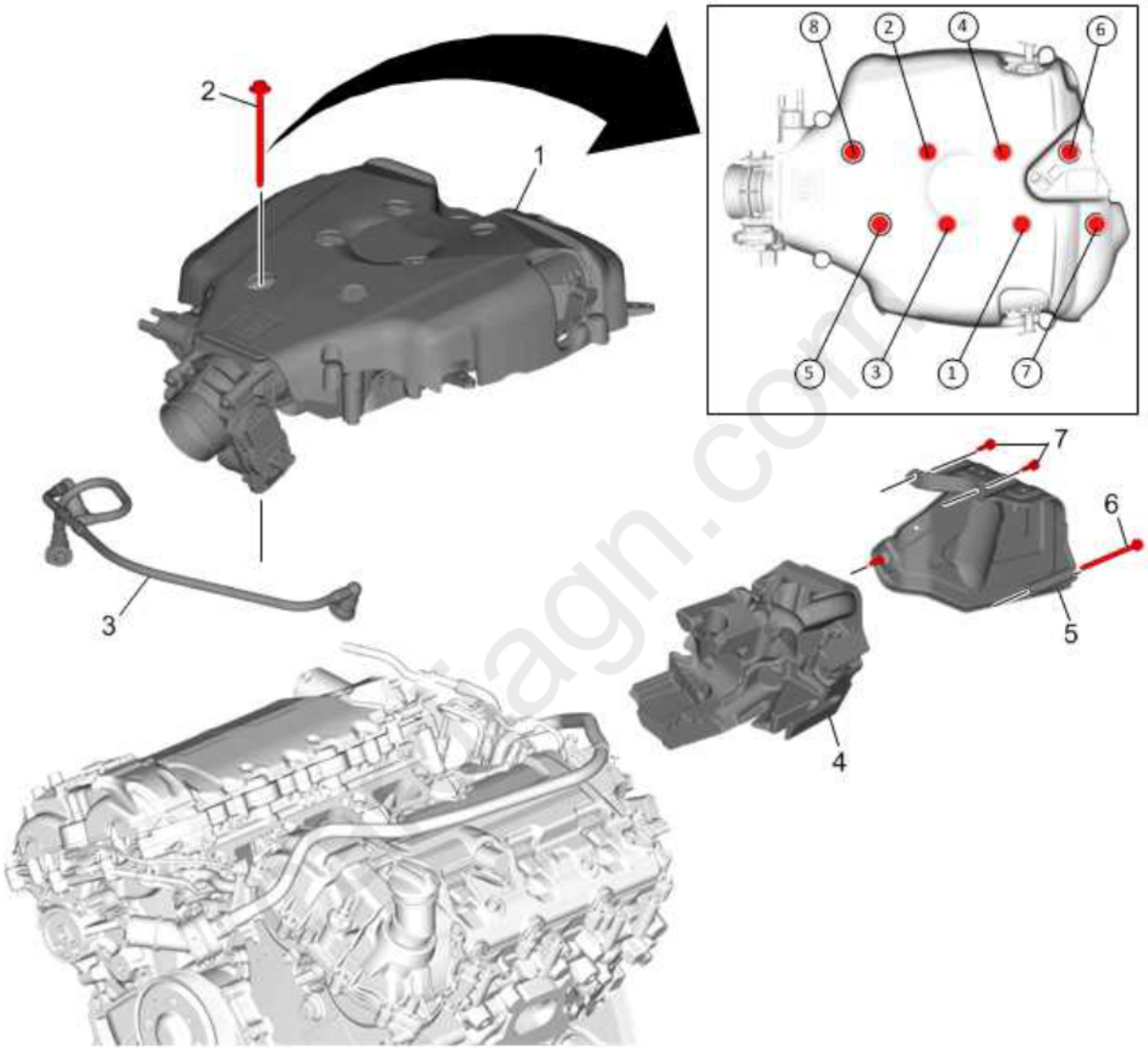


Fig. 420: Intake Manifold (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold
2	Intake Manifold Bolt [8x] **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 25 N.m (18 lb ft)
3	Positive Crankcase Ventilation Tube Connector

Callout	Component Name
4	Engine Rear Noise Shield **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**
5	Fuel Pipe Shield
6	Fuel Pipe Shield Bolt **Tighten** 10 N.m (89 lb in)
7	Fuel Pipe Shield Bolt [2x] **Tighten** 10 N.m (89 lb in)

INTAKE MANIFOLD INSTALLATION (LGW)

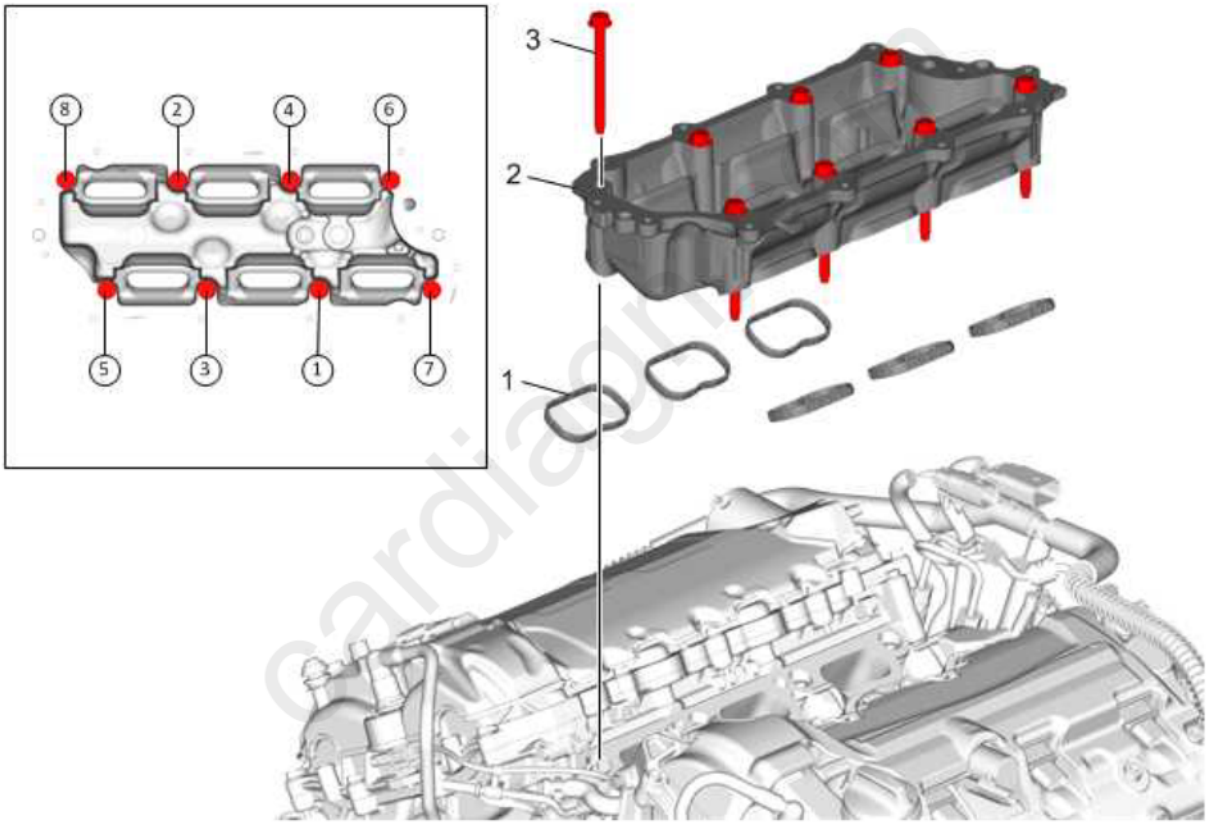


Fig. 421: Intake Manifold (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Seal [6x] **NOTE:** **Install a NEW seal.**
2	Intake Manifold

Callout	Component Name
3	Lower Intake Manifold Bolt [8x] **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Bolts come with sealant pre-applied, if the bolts are being reused, additional sealant should be applied to the bolts before tightening. Refer to Adhesives, Fluids, Lubricants and Sealers .** **Tighten in sequence** 25 N.m (18 lb ft)

CHARGE AIR COOLER COVER INSTALLATION

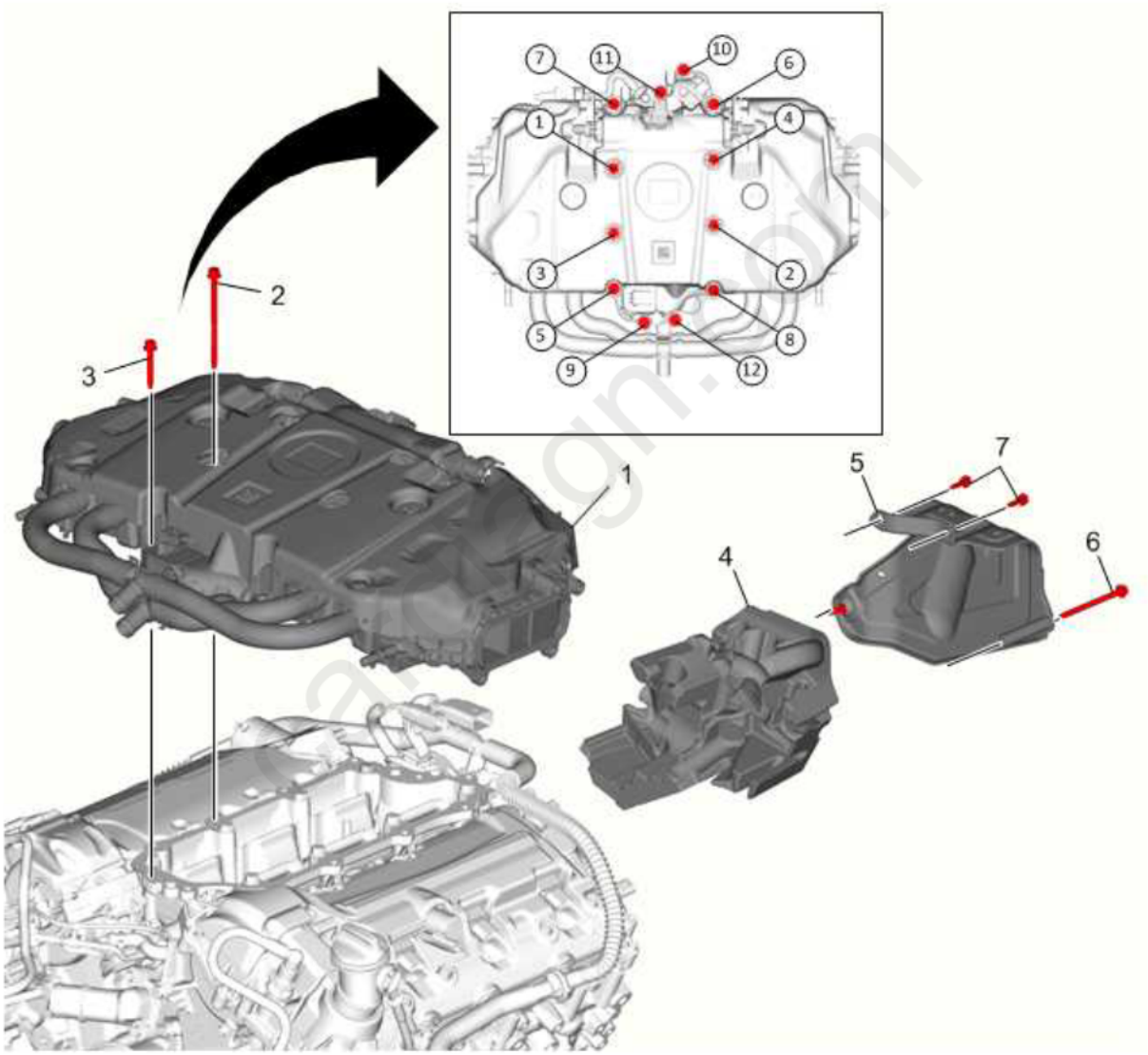


Fig. 422: Charge Air Cooler Cover
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Charge Air Cooler Cover

Callout	Component Name
2	Charge Air Cooler Cover Bolt [4x] **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 12 N.m (106 lb in)
3	Charge Air Cooler Cover Bolt [8x] **Tighten in sequence** 12 N.m (106 lb in)
4	Engine Rear Noise Shield **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**
5	Fuel Pipe Shield
6	Fuel Pipe Shield Bolt **Tighten** 10 N.m (89 lb in)
7	Fuel Pipe Shield Bolt [2x] **Tighten** 10 N.m (89 lb in)

AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

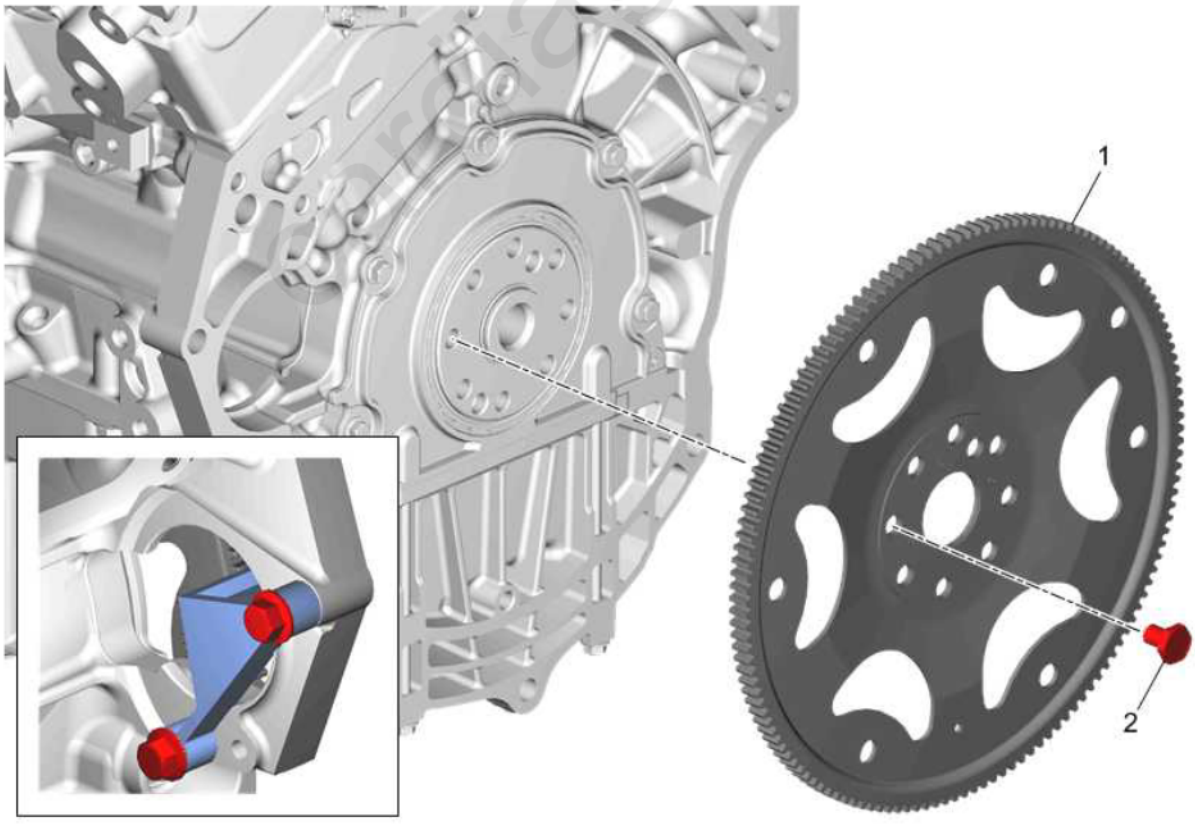


Fig. 423: Automatic Transmission Flex Plate
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Automatic Transmission Flex Plate

Callout	Component Name
2	Automatic Transmission Flex Plate Bolt **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 .** **Procedure** 1. Install 2 NEW bolts (2) in location at the top and bottom of the flex plate bolt pattern allowing the flex plate (2) to hang in position. 2. Install the **EN-46106** Flywheel Holding Tool through the starter mounting hole. 3. Install the remaining NEW flex plate bolts and tighten to specifications. 4. Remove the **EN-46106** Flywheel Holding Tool through the starter mounting hole. **Tighten** 1. First Pass: 30 N.m (22 lb ft) 2. Final Pass: 45 degrees using the **EN-45059** Angle Meter **Special Tools** • **EN-46106** Flywheel Holding Tool • **EN-45059** Angle Meter Equivalent regional tools: **Special Tools**

HEATER INLET AND OUTLET PIPE INSTALLATION

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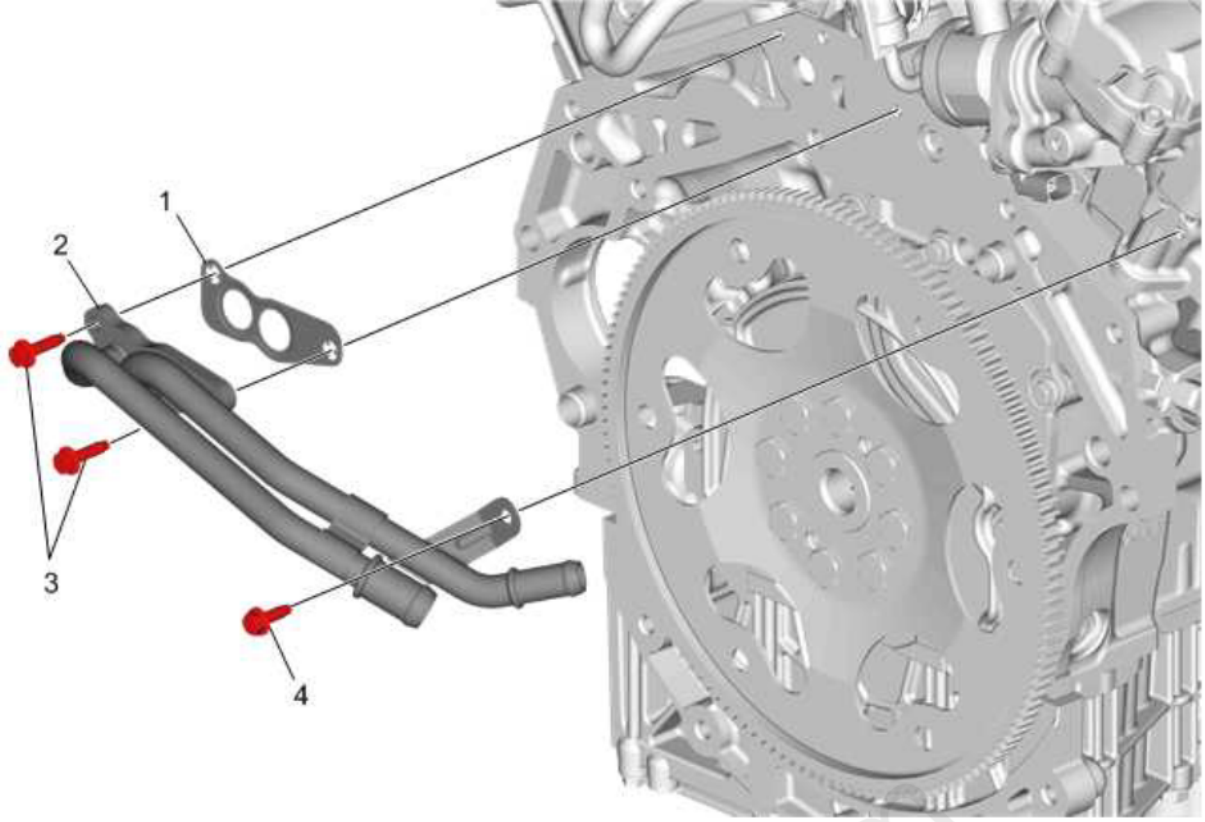


Fig. 424: Heater Inlet and Outlet Pipe
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Heater Inlet and Outlet Pipe Gasket **NOTE:** **Install a NEW gasket.**
2	Heater Inlet and Outlet Pipe
3	Heater Inlet and Outlet Pipe Bolt M6 x 25 [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
4	Heater Inlet and Outlet Pipe Bolt M6 x 20 **Tighten** 9 N.m (80 lb in)

CRANKSHAFT BALANCER INSTALLATION (LGX)

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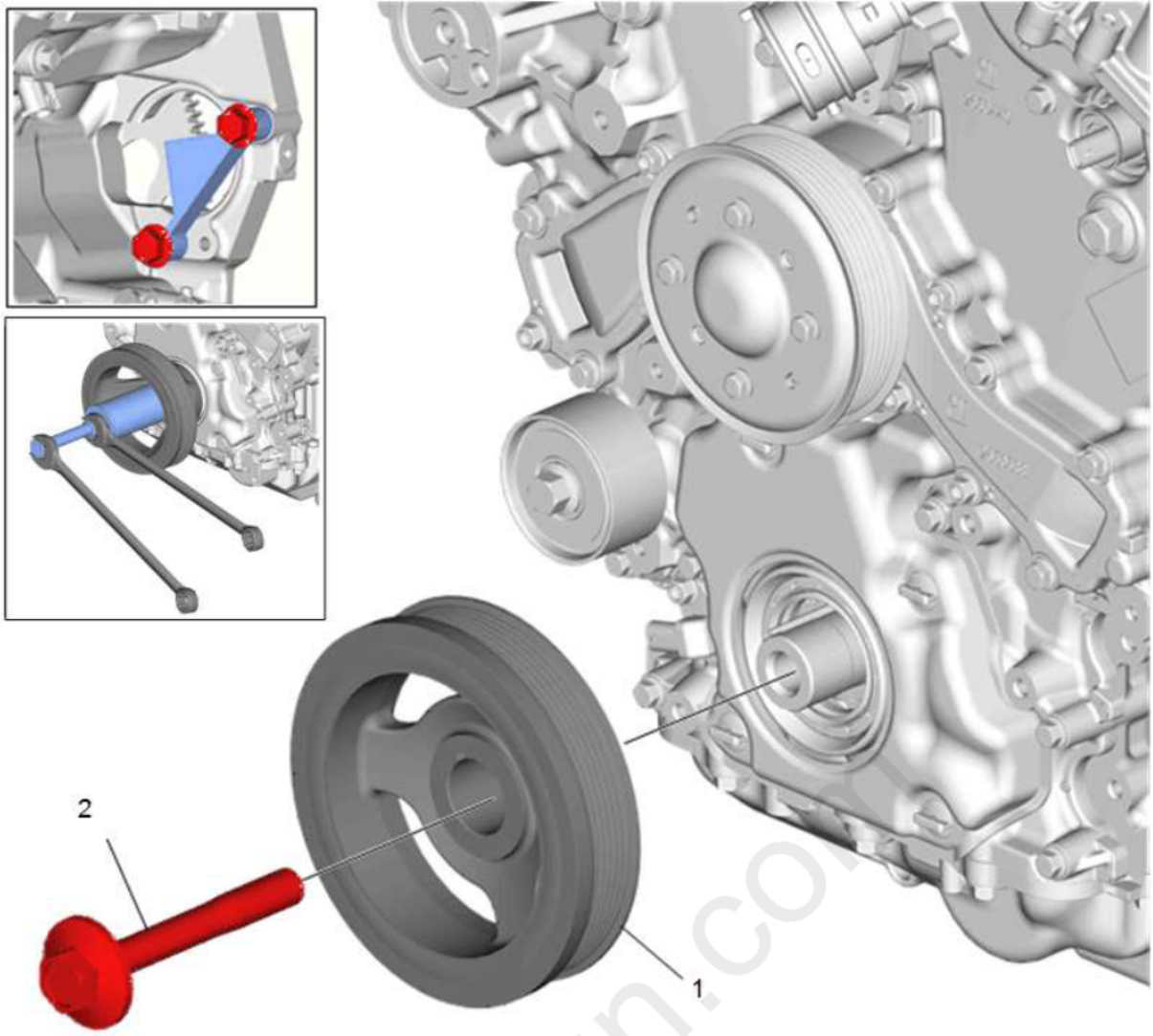


Fig. 425: Crankshaft Balancer (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

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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.

Preliminary Procedures

1. Install the **EN-46106** Flywheel Holding Tool through the starter mounting hole.

   NOTE:
   The top starter hole will require a longer bolt and nut to secure the tool.

2. Apply lubricant to the inside of the crankshaft balancer hub bore.
3. Use the **EN-41478-A** Crankshaft Balancer Installer to install the crankshaft balancer.
4. Thread the **EN-41478-A** Crankshaft Balancer Installer in the crankshaft. Ensure you engage at least 10 threads of the **EN-41478-A** Crankshaft Balancer Installer before pressing the crankshaft balancer in place.
5. Push the crankshaft balancer into position by tightening the nut on the **EN-41478-A** Crankshaft Balancer Installer until the large washer bottoms out on the crankshaft end.
6. Remove the **EN-41478-A** Crankshaft Balancer Installer.
7. Install the NEW crankshaft balancer bolt.
8. Remove the **EN-46106** Flywheel Holding Tool through the starter mounting hole.

Special Tools

- **EN-41478-A** Crankshaft Balancer Installer
- **EN-46106** Flywheel Holding Tool
- **EN-45059** Angle Meter

Equivalent regional tools:**Special Tools** .

1	Crankshaft Balancer **NOTE:** **Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.**
2	Crankshaft Balancer Bolt **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Install a NEW crankshaft balancer bolt.** **Tighten** First Pass: 80 N.m (59 lb ft) Final Pass: 125 degrees

CRANKSHAFT BALANCER INSTALLATION (LGW)

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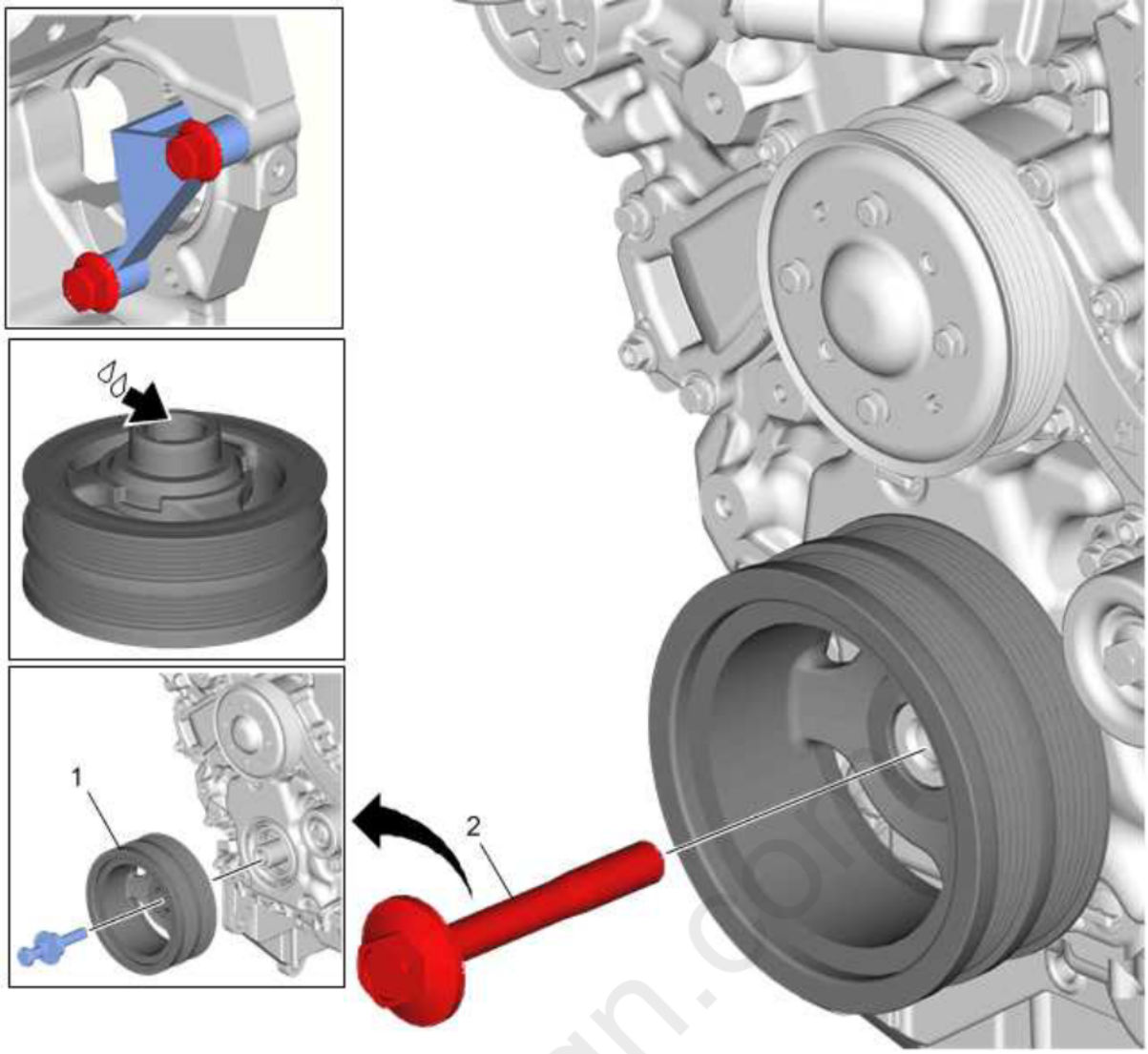


Fig. 426: Crankshaft Balancer (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

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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.

Preliminary Procedures

1. Install the **EN-46106** Flywheel Holding Tool through the starter mounting hole.
2. Apply lubricant to the inside of the crankshaft balancer hub bore.
3. Use the **EN-41478-A** Crankshaft Balancer Installer to install the crankshaft balancer.
4. Thread the **EN-41478-A** Crankshaft Balancer Installer in the crankshaft. Ensure you engage at least 10 threads of the **EN-41478-A** Crankshaft Balancer Installer before pressing the crankshaft balancer in place.
5. Push the crankshaft balancer into position by tightening the nut on the **EN-41478-A** Crankshaft Balancer Installer until the large washer bottoms out on the crankshaft end.
6. Remove the **EN-41478-A** Crankshaft Balancer Installer.
7. Install the NEW crankshaft balancer bolt.
8. Remove the **EN-46106** Flywheel Holding Tool through the starter mounting hole.

Special Tools

- **EN-41478-A** Crankshaft Balancer Installer
- **EN-46106** Flywheel Holding Tool
- **EN-45059** Angle Meter

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

1	Crankshaft Balancer **NOTE:** **Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.**
2	Crankshaft Balancer Bolt **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Install a NEW crankshaft balancer bolt.** **Tighten** First Pass: 80 N.m (59 lb ft) Final Pass: 125 degrees

VACUUM PUMP PIPE INSTALLATION (LGX)

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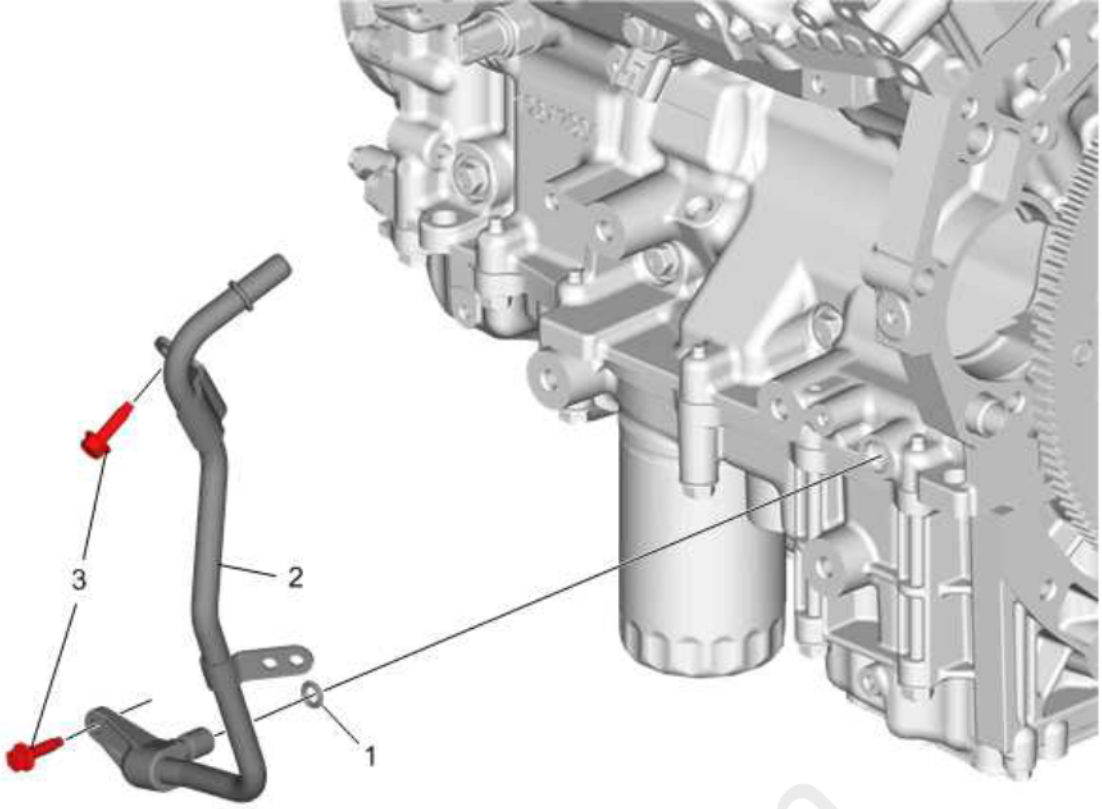


Fig. 427: Vacuum Pump Pipe (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Pipe Seal
2	Vacuum Pump Pipe
3	Vacuum Pump Pipe Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)

VACUUM PUMP PIPE INSTALLATION (LGW)

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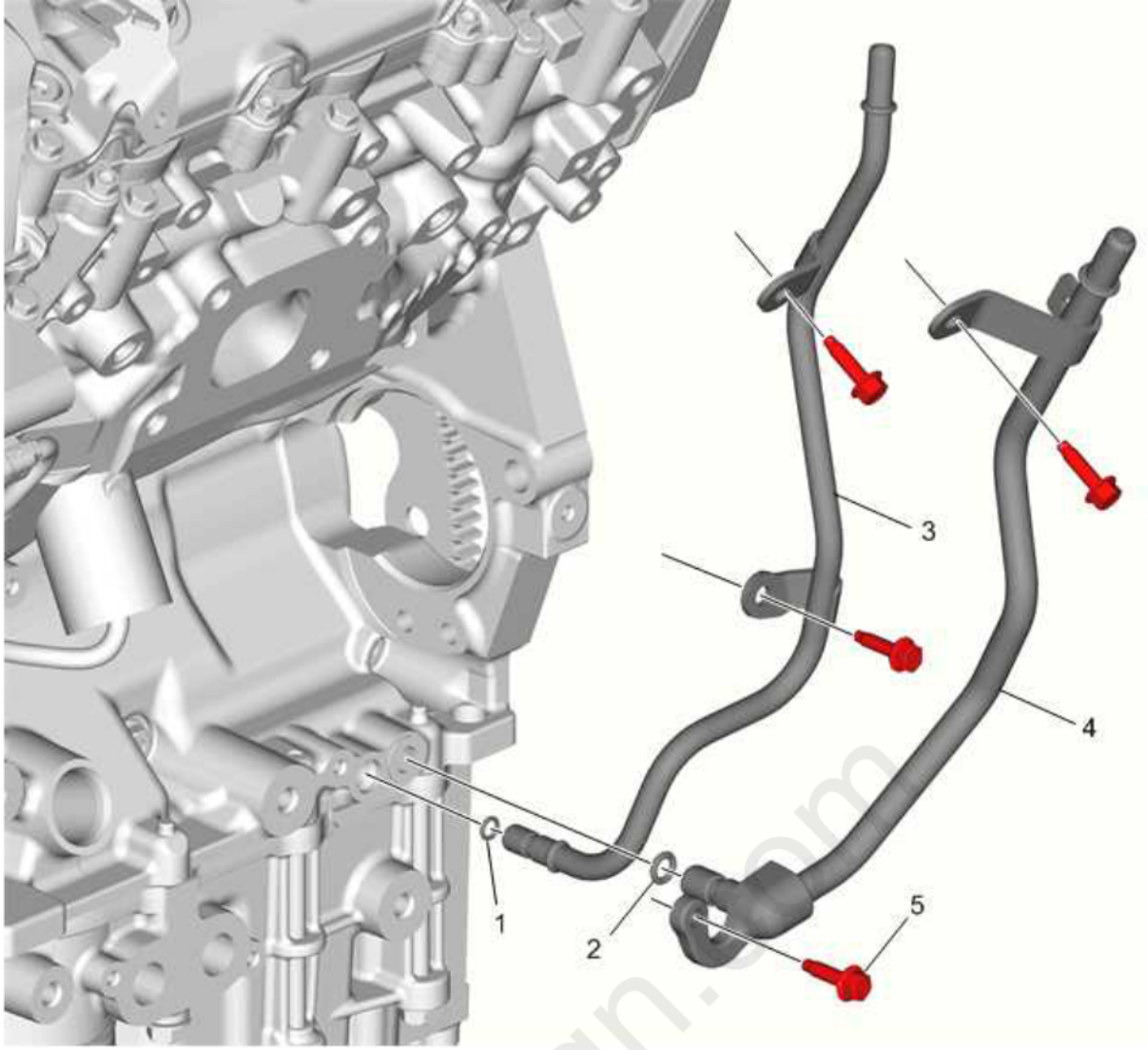


Fig. 428: Vacuum Pump Pipe (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Pipe Seal
2	Vacuum Pump Pipe Seal
3	Vacuum Pump Pipe
4	Vacuum Pump Pipe
5	Vacuum Pump Pipe Bolt [5x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)

OIL LEVEL INDICATOR AND TUBE INSTALLATION

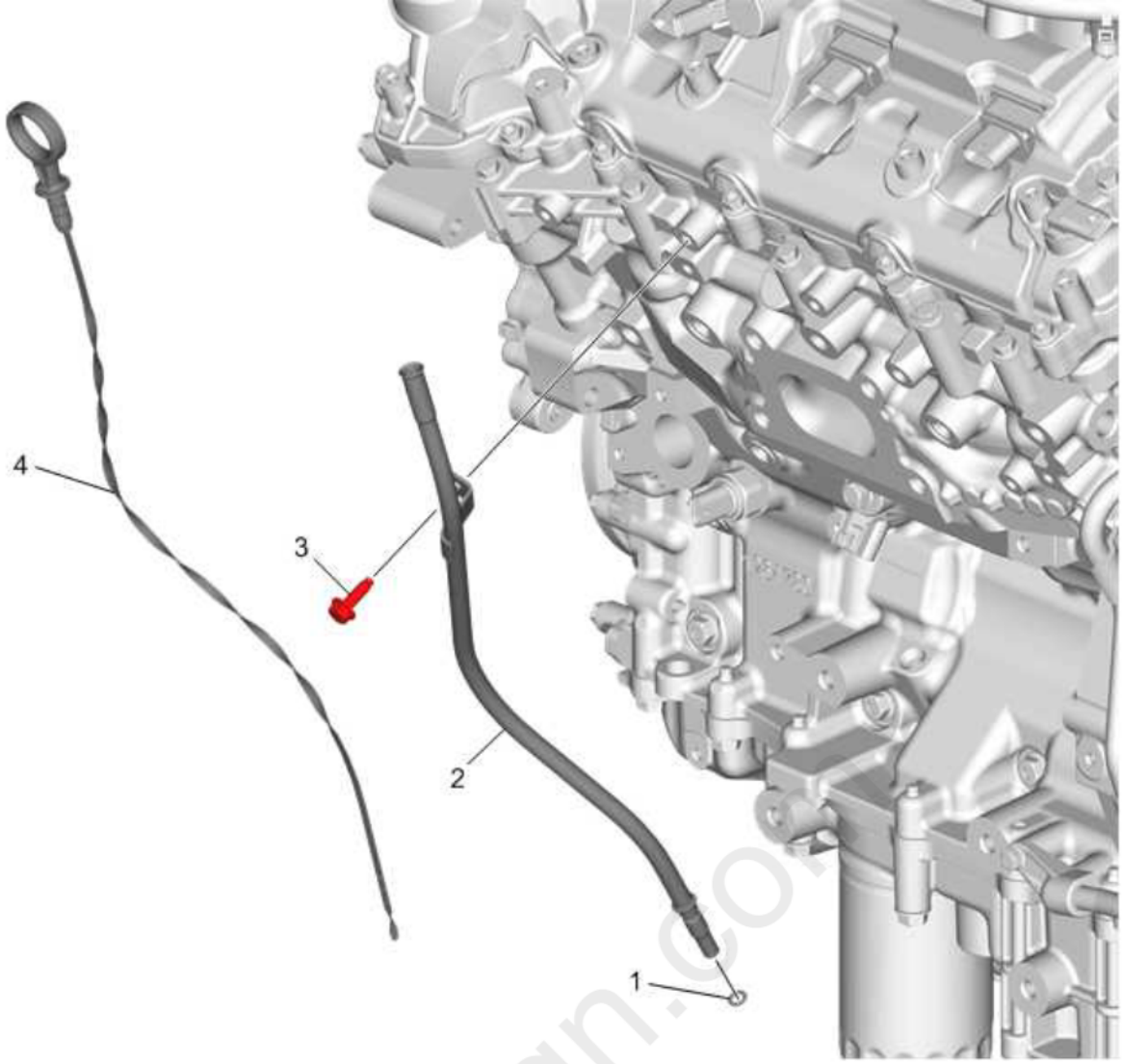


Fig. 429: Oil Level Indicator and Tube (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Level Indicator Tube Seal **NOTE:** **Install a NEW seal.**
2	Oil Level Indicator Tube
3	Oil Level Indicator Tube Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
4	Oil Level Indicator

TURBOCHARGER WASTEGATE ACTUATOR VACUUM TANK INSTALLATION

Turbocharger Wastegate Actuator Vacuum Tank Installation

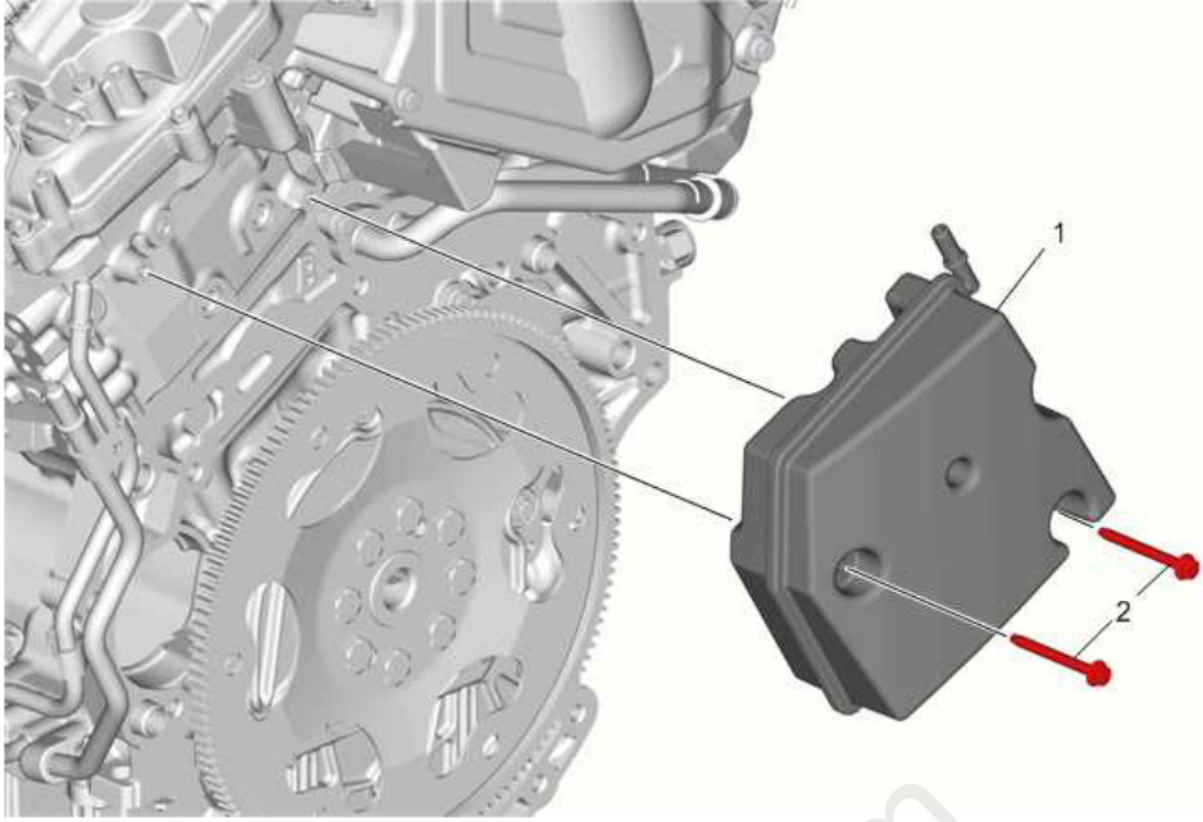


Fig. 430: Turbocharger Wastegate Actuator Vacuum Tank
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Wastegate Actuator Vacuum Tank Installation

Callout	Component Name
1	Turbocharger Wastegate Actuator Vacuum Tank
2	Turbocharger Wastegate Actuator Vacuum Tank Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)

Turbocharger Wastegate Hoses, Solenoids and Bracket Installation - Left Side

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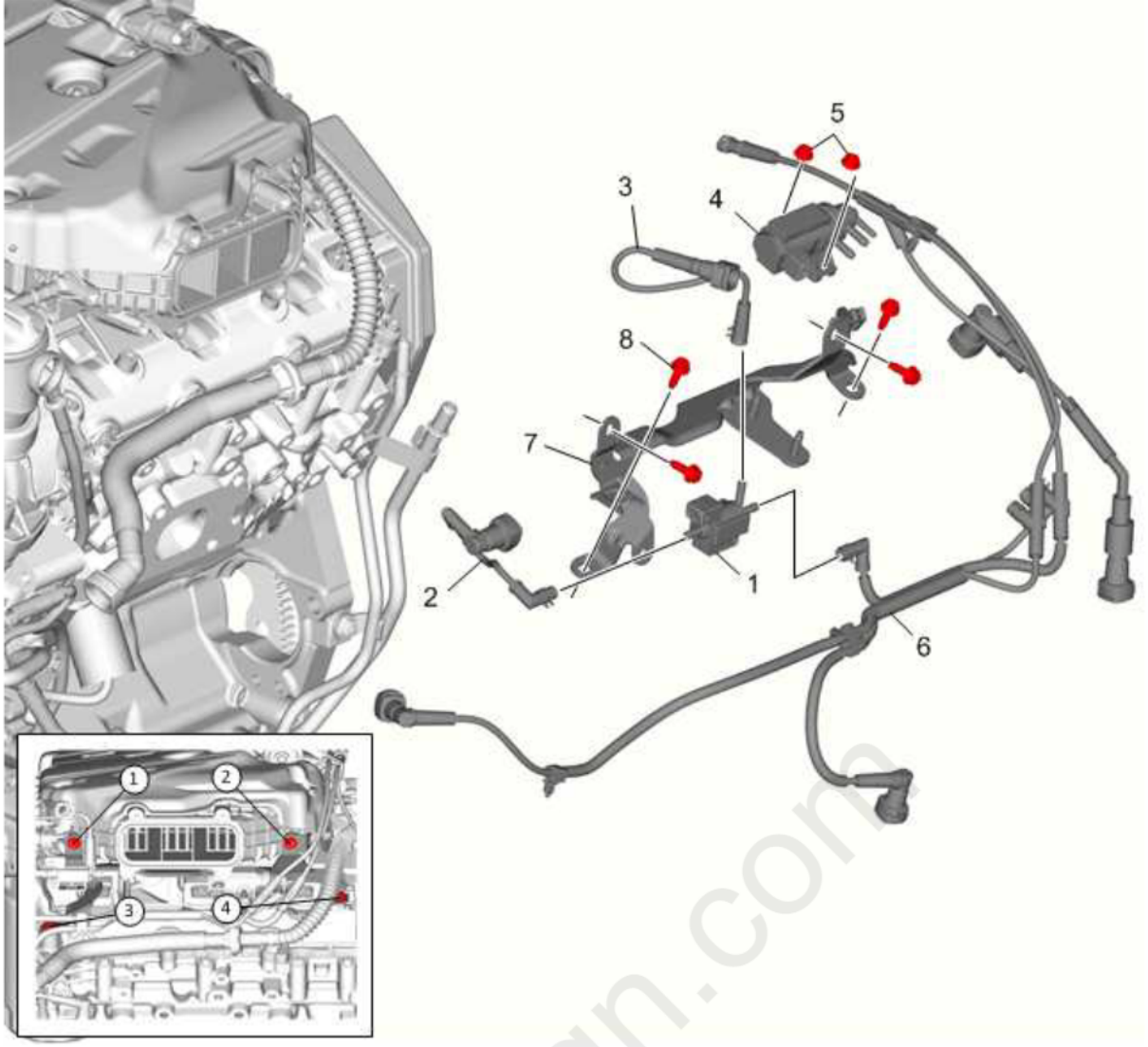


Fig. 431: Turbocharger Wastegate Hoses, Solenoids and Bracket - Left Side
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Wastegate Hoses, Solenoids and Bracket Installation - Left Side

Callout	Component Name
1	Turbocharger Wastegate Regulator Solenoid Valve
2	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube
3	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube
4	Turbocharger Wastegate Regulator Solenoid Valve
5	Turbocharger Wastegate Regulator Solenoid Valve Nut [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
6	Charge Air Bypass Valve Vacuum Tank Tube
7	Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket - Left Side

Callout	Component Name
8	Turbocharger Wastegate Actuator Vacuum Tank Bracket Bolt [4x] **NOTE:** **Install and hand tighten all fasteners prior to performing the torque sequence.** **Tighten in sequence** 9 N.m (80 lb in)

Turbocharger Wastegate Hoses, Solenoids and Bracket Installation - Right Side

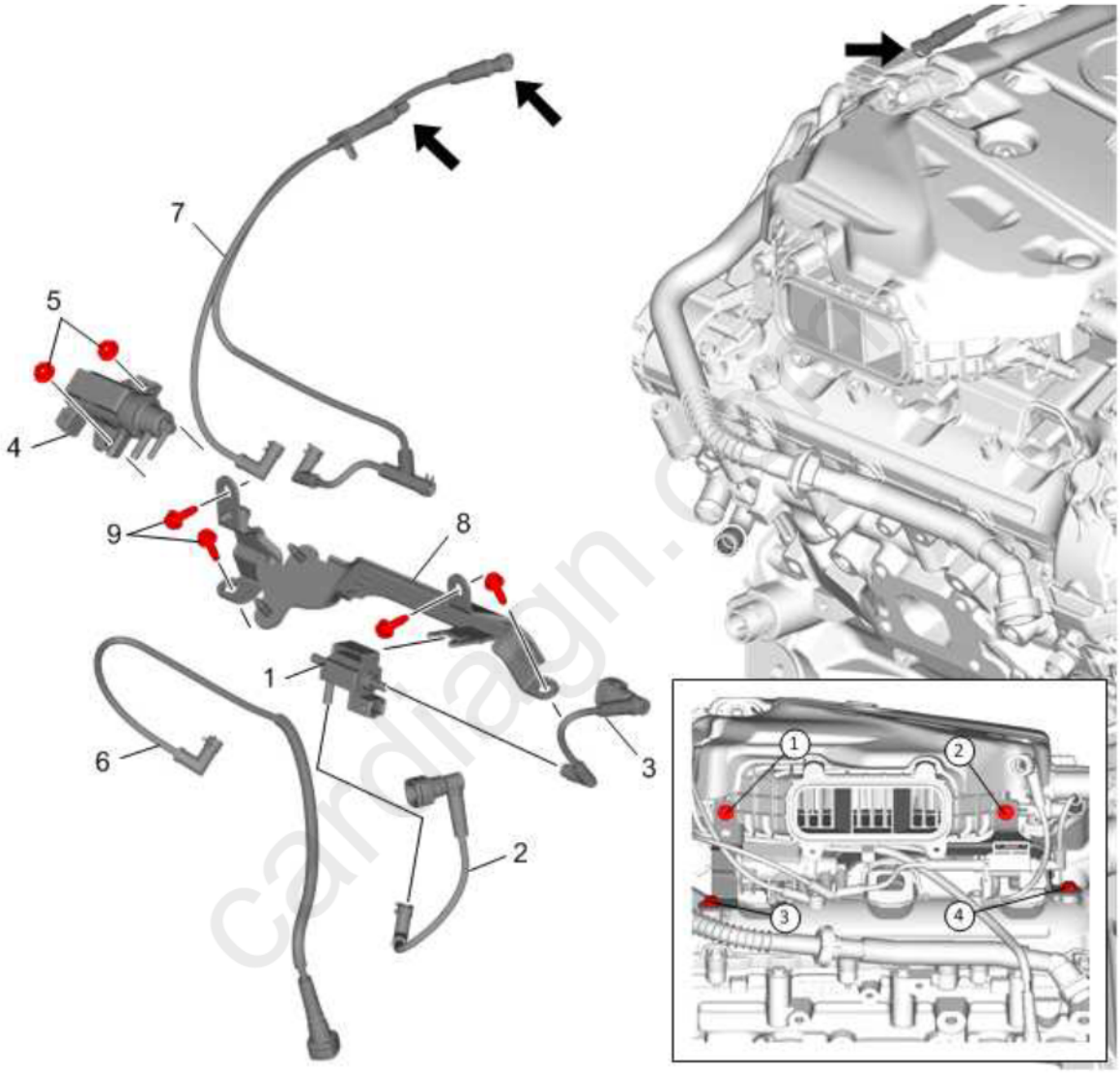


Fig. 432: Turbocharger Wastegate Hoses, Solenoids and Bracket - Right Side
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Wastegate Hoses, Solenoids and Bracket Installation - Right Side

Callout	Component Name
1	Turbocharger Wastegate Regulator Solenoid Valve
2	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube
3	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube
4	Turbocharger Wastegate Regulator Solenoid Valve

Callout	Component Name
5	Turbocharger Wastegate Regulator Solenoid Valve Nut [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
6	Turbocharger Wastegate Actuator Vacuum Tank Solenoid Valve Tube
7	Charge Air Bypass Valve Vacuum Tank Tube **NOTE:** **Ensure the connections to the Left Side are secure.**
8	Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket - Right Side
9	Turbocharger Wastegate Actuator Vacuum Tank Bracket Bolt [4x] **NOTE:** **Install and hand tighten all fasteners prior to performing the torque sequence.** **Tighten in sequence** 9 N.m (80 lb in)

TURBOCHARGER INSTALLATION - LEFT SIDE

Turbocharger and Oil Return Pipe Installation

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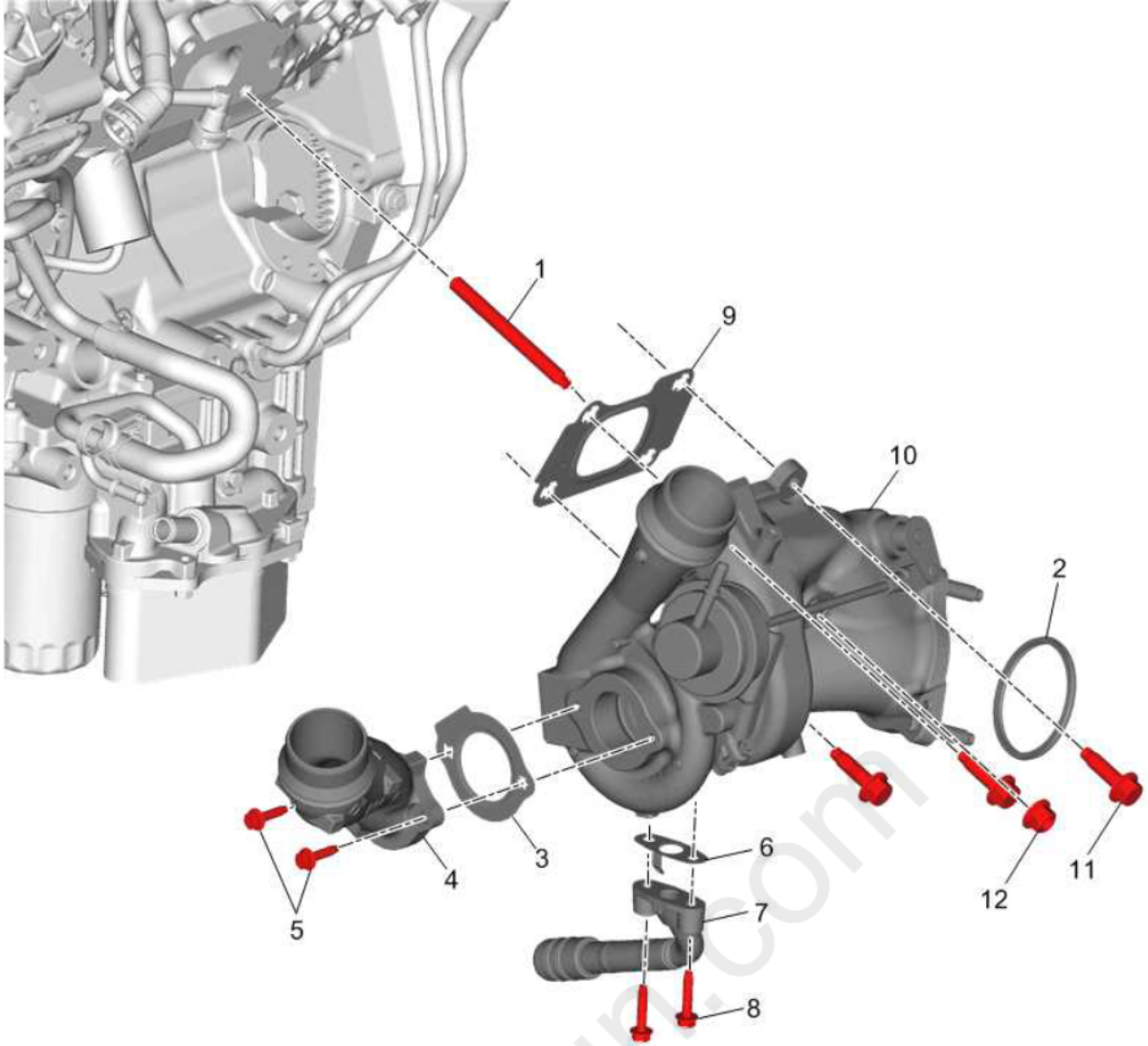


Fig. 433: Turbocharger and Oil Return Pipe
Courtesy of GENERAL MOTORS COMPANY

Turbocharger and Oil Return Pipe Installation

Callout	Component Name
1	Turbocharger Stud **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Turbocharger Exhaust Pipe Gasket **NOTE:** **Install a NEW gasket.**
3	Turbocharger Air Inlet Adapter Seal **NOTE:** **Install a NEW seal.**
4	Turbocharger Air Inlet Adapter
5	Turbocharger Air Inlet Adapter Bolt [2x] **Tighten** 10 N.m (89 lb in)

Callout	Component Name
6	Turbocharger Oil Return Pipe Gasket **NOTE:** **Install a NEW gasket.**
7	Turbocharger Oil Return Pipe
8	Turbocharger Oil Return Pipe Bolt [2x] **Tighten** 10 N.m (89 lb in)
9	Turbocharger Gasket **NOTE:** **Install a NEW gasket.**
10	Turbocharger - Left Side **NOTE:** **Ensure the Wastegate vacuum connection is fully secure and seated. A poor connections can result in a DTC and lead to misdiagnosis.**
11	Turbocharger Bolt [3x] **Tighten** 58 N.m (42 lb ft)
12	Turbocharger Nut **Tighten** 58 N.m (42 lb ft)

Turbocharger Oil Feed Pipe Installation

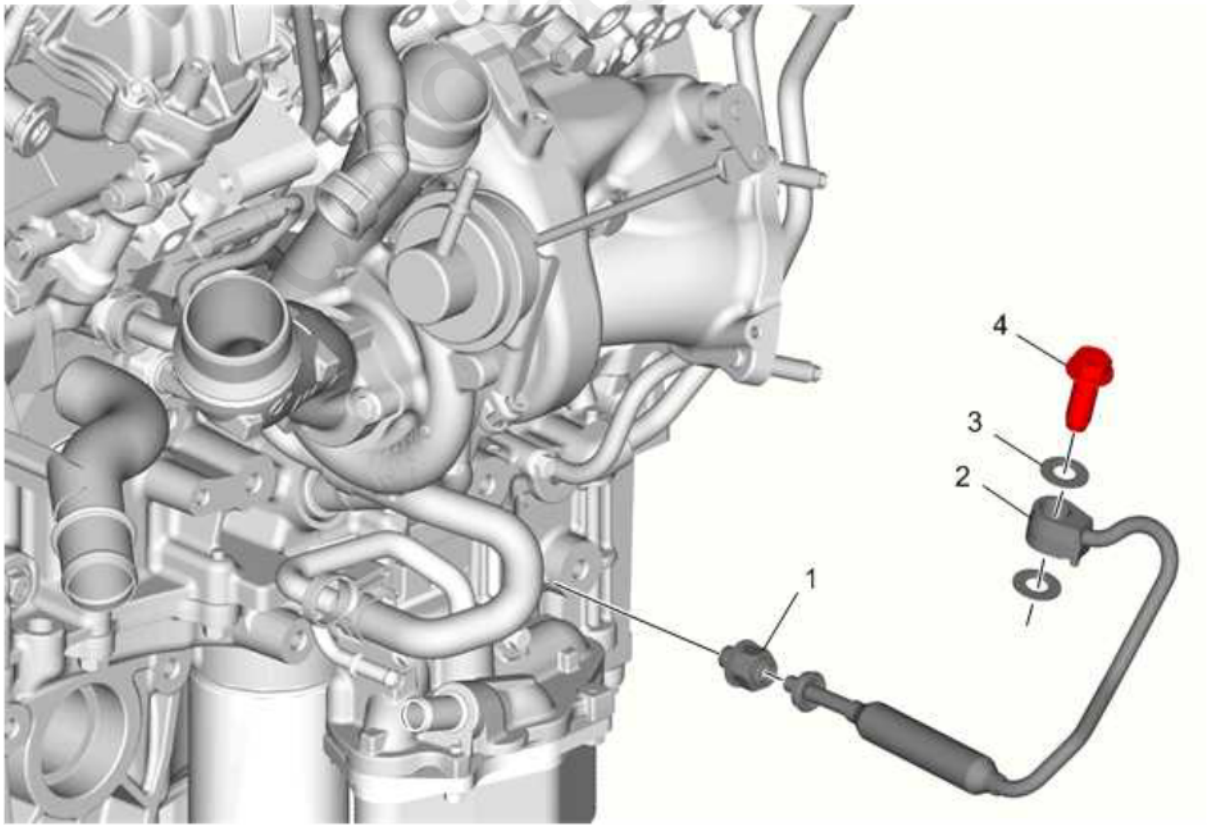


Fig. 434: Turbocharger Oil Feed Pipe (Left Side)
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Oil Feed Pipe Installation

Callout	Component Name

Callout	Component Name
1	Turbocharger Oil Feed Pipe Fitting **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Install NEW fitting. It is not reusable** **Tighten** 35 N.m (26 lb ft)
2	Turbocharger Oil Feed Pipe **CAUTION:** **When installing a quick-connect turbocharger oil feed pipe, ensure that the oil feed pipe is fully secured into the oil feed pipe fitting. An audible click will be heard when the oil feed pipe is seated. If the oil feed pipe is not fully seated, an oil leak can occur in certain RPM ranges and will cause significant component and/or vehicle damage. Due to the possibility of significant component and/or vehicle damage from an oil feed pipe leak, it is necessary to start the engine and inspect for signs of leakage around the connections after performing the repair.**
3	Turbocharger Oil Feed Pipe Gasket [2x] **NOTE:** **Install a NEW gasket.**
4	Turbocharger Oil Feed Pipe Bolt **Tighten** 35 N.m (26 lb ft)

Turbocharger Coolant Feed and Return Pipe Installation

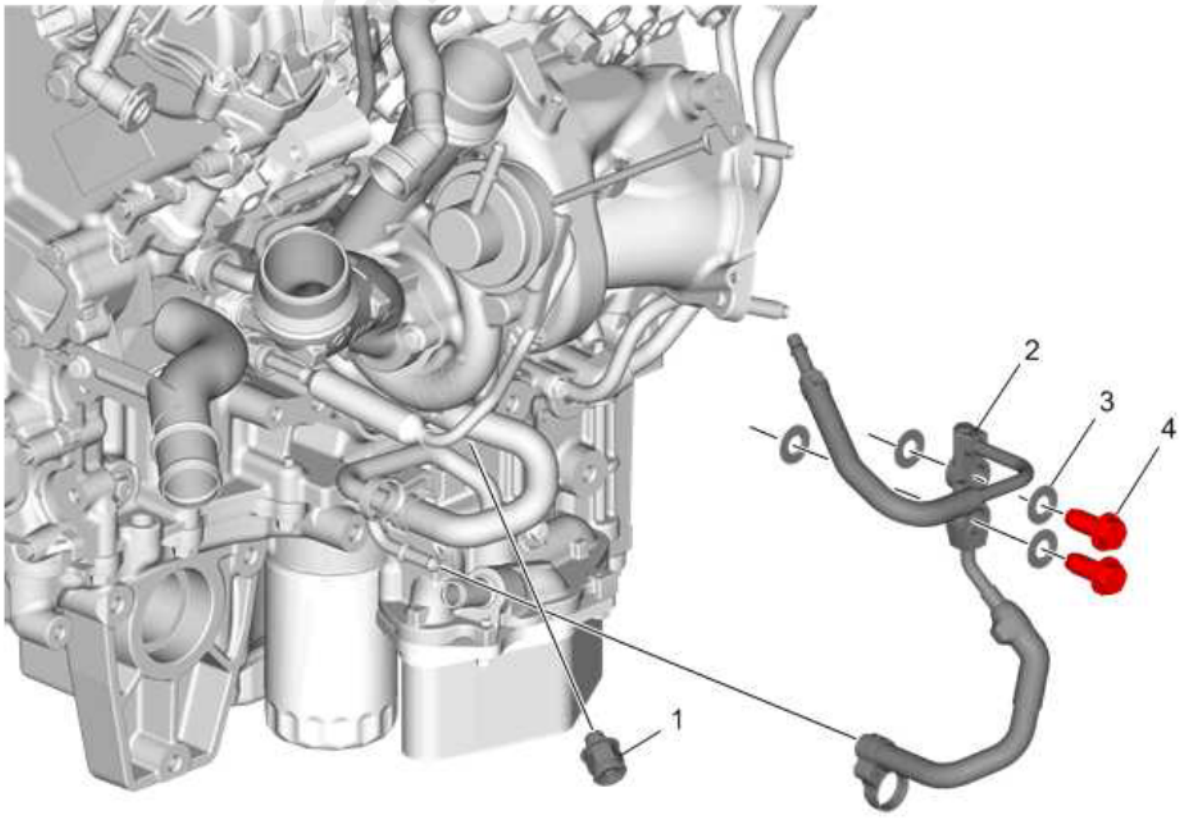


Fig. 435: Turbocharger Coolant Feed and Return Pipe
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Coolant Feed and Return Pipe Installation

Callout	Component Name
1	Turbocharger Coolant Feed Pipe Fitting **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Install NEW fitting. It is not reusable** **Tighten** 35 N.m (26 lb ft)
2	Turbocharger Coolant Feed and Return Pipe **Procedure** Ensure that the coolant feed pipe is fully secured into the turbocharger pipe fitting. An audible click will be heard when the coolant feed pipe is seated.
3	Turbocharger Coolant Feed and Return Pipe Gasket [2x] **NOTE:** **Install a NEW gasket.**
4	Turbocharger Coolant Feed and Return Pipe Bolt **Tighten** 10 N.m (89 lb in)

Turbocharger Heat Shield Installation

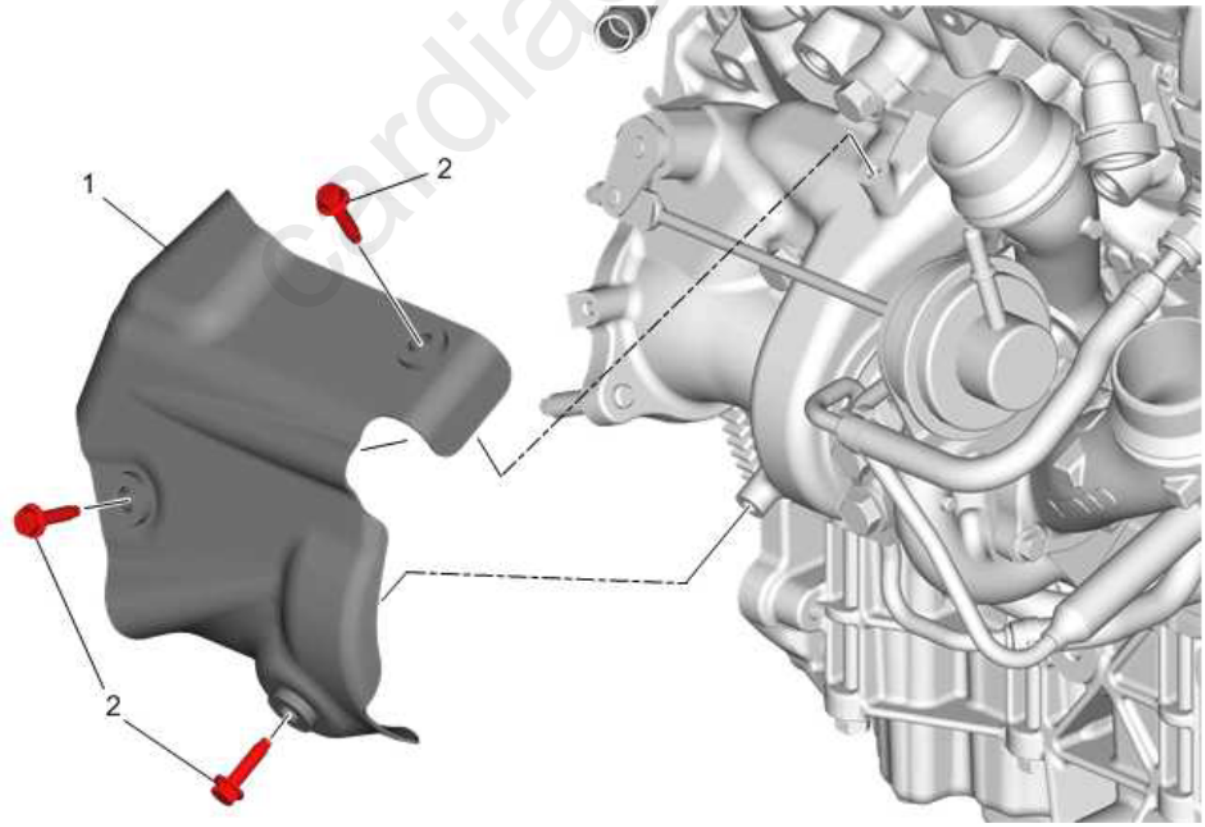


Fig. 436: Turbocharger Heat Shield
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Heat Shield Installation

Callout	Component Name

Callout	Component Name
1	Turbocharger Heat Shield
2	Turbocharger Heat Shield Bolt [3x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)

Charge Air Cooler Inlet Air Tube Installation

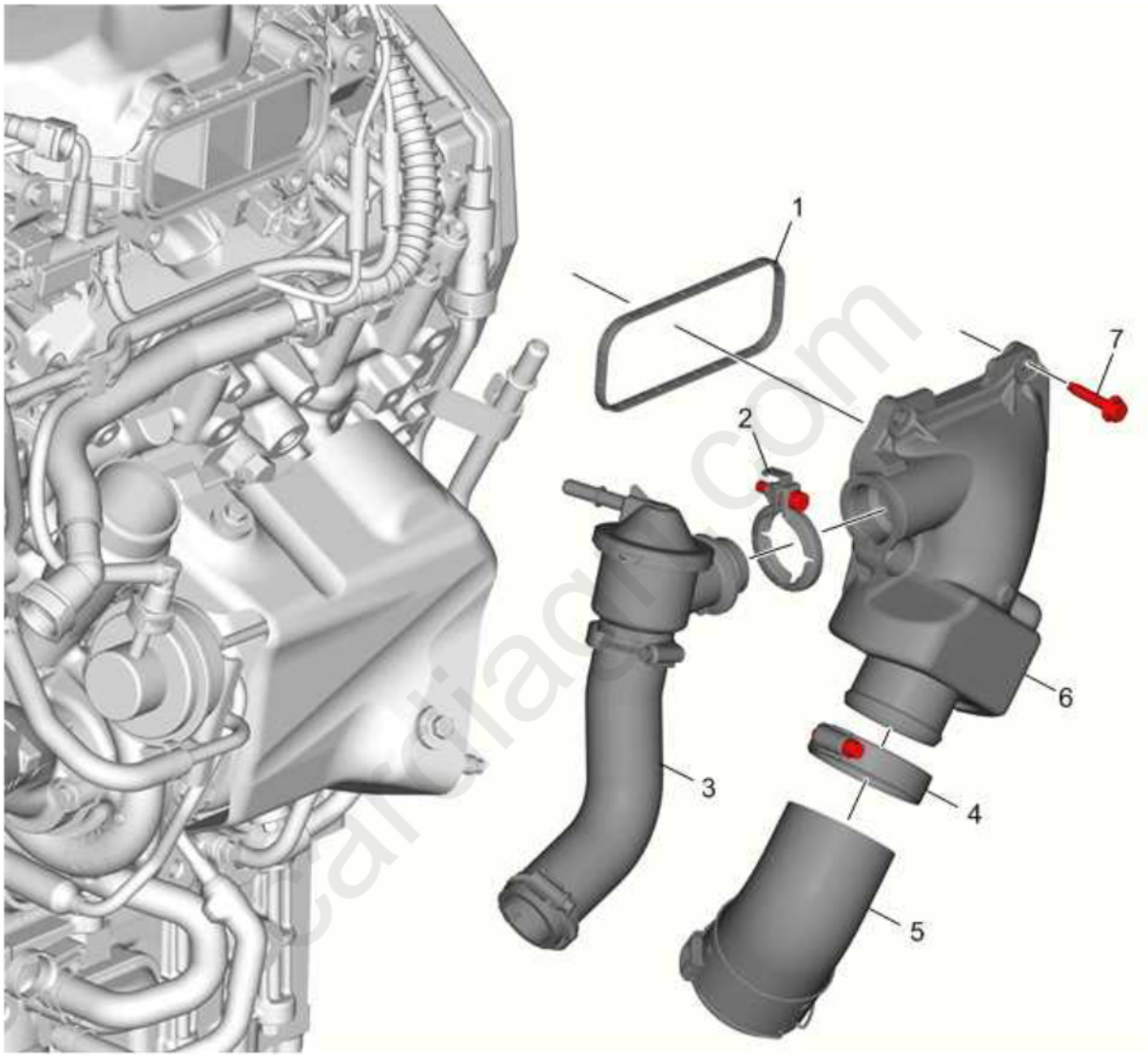


Fig. 437: Charge Air Cooler Inlet Air Tube
Courtesy of GENERAL MOTORS COMPANY

Charge Air Cooler Inlet Air Tube Installation

Callout	Component Name
1	Charge Air Cooler Inlet Air Tube Seal **NOTE:** **Install a NEW seal.**
2	Charge Air Bypass Valve Tube Clamp
3	Charge Air Bypass Valve
4	Charge Air Cooler Inlet Hose Clamp
5	Charge Air Cooler Inlet Hose
6	Charge Air Cooler Inlet Air Tube

Callout	Component Name
7	Charge Air Cooler Inlet Air Tube Bolt [4x] **Tighten** 10 N.m (89 lb in)

TURBOCHARGER INSTALLATION - RIGHT SIDE

Turbocharger and Oil Return Pipe Installation

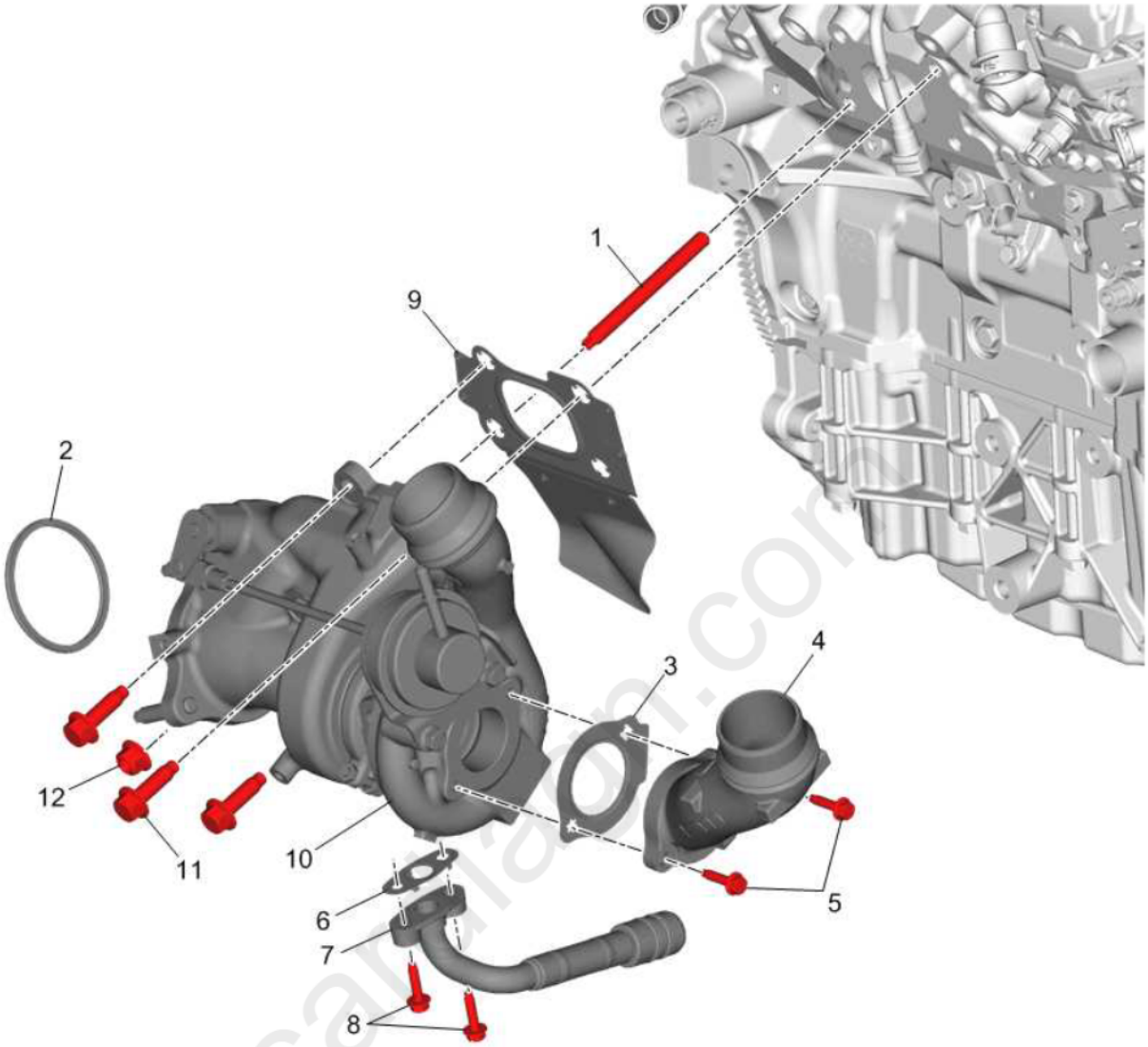


Fig. 438: Turbocharger and Oil Return Pipe
Courtesy of GENERAL MOTORS COMPANY

Turbocharger and Oil Return Pipe Installation

Callout	Component Name
1	Turbocharger Stud **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Turbocharger Exhaust Pipe Gasket **NOTE:** **Install a NEW gasket.**

Callout	Component Name
3	Turbocharger Air Inlet Adapter Seal **NOTE:** **Install a NEW seal.**
4	Turbocharger Air Inlet Adapter
5	Turbocharger Air Inlet Adapter Bolt [2x] **Tighten** 10 N.m (89 lb in)
6	Turbocharger Oil Return Pipe Gasket **NOTE:** **Install a NEW gasket.**
7	Turbocharger Oil Return Pipe
8	Turbocharger Oil Return Pipe Bolt [2x] **Tighten** 10 N.m (89 lb in)
9	Turbocharger Gasket **NOTE:** **Install a NEW gasket.**
10	Turbocharger - Right Side **NOTE:** **Ensure the Wastegate vacuum connection is fully secure and seated. A poor connections can result in a DTC and lead to misdiagnosis.**
11	Turbocharger Bolt [3x] **Tighten** 58 N.m (42 lb ft)
12	Turbocharger Nut **Tighten** 58 N.m (42 lb ft)

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Turbocharger Oil Feed Pipe Installation

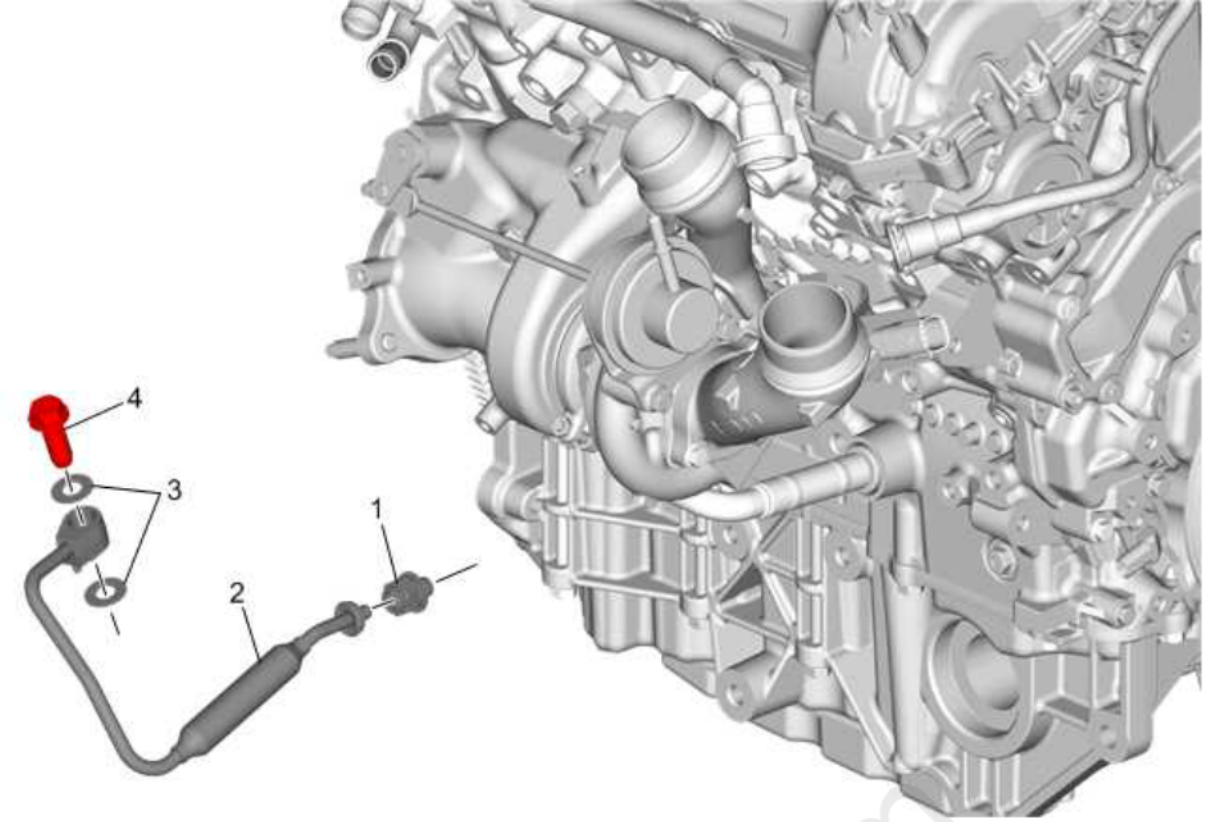


Fig. 439: Turbocharger Oil Feed Pipe (Right Side)
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Oil Feed Pipe Installation

Callout	Component Name
1	Turbocharger Oil Feed Pipe Fitting **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Install NEW fitting. It is not reusable** **Tighten** 35 N.m (26 lb ft)
2	Turbocharger Oil Feed Pipe **CAUTION:** **When installing a quick-connect turbocharger oil feed pipe, ensure that the oil feed pipe is fully secured into the oil feed pipe fitting. An audible click will be heard when the oil feed pipe is seated. If the oil feed pipe is not fully seated, an oil leak can occur in certain RPM ranges and will cause significant component and/or vehicle damage. Due to the possibility of significant component and/or vehicle damage from an oil feed pipe leak, it is necessary to start the engine and inspect for signs of leakage around the connections after performing the repair.**
3	Turbocharger Oil Feed Pipe Gasket [2x] **NOTE:** **Install a NEW gasket.**

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Callout	Component Name
4	Turbocharger Oil Feed Pipe Bolt **Tighten** 35 N.m (26 lb ft)

Turbocharger Coolant Feed and Return Pipe Installation

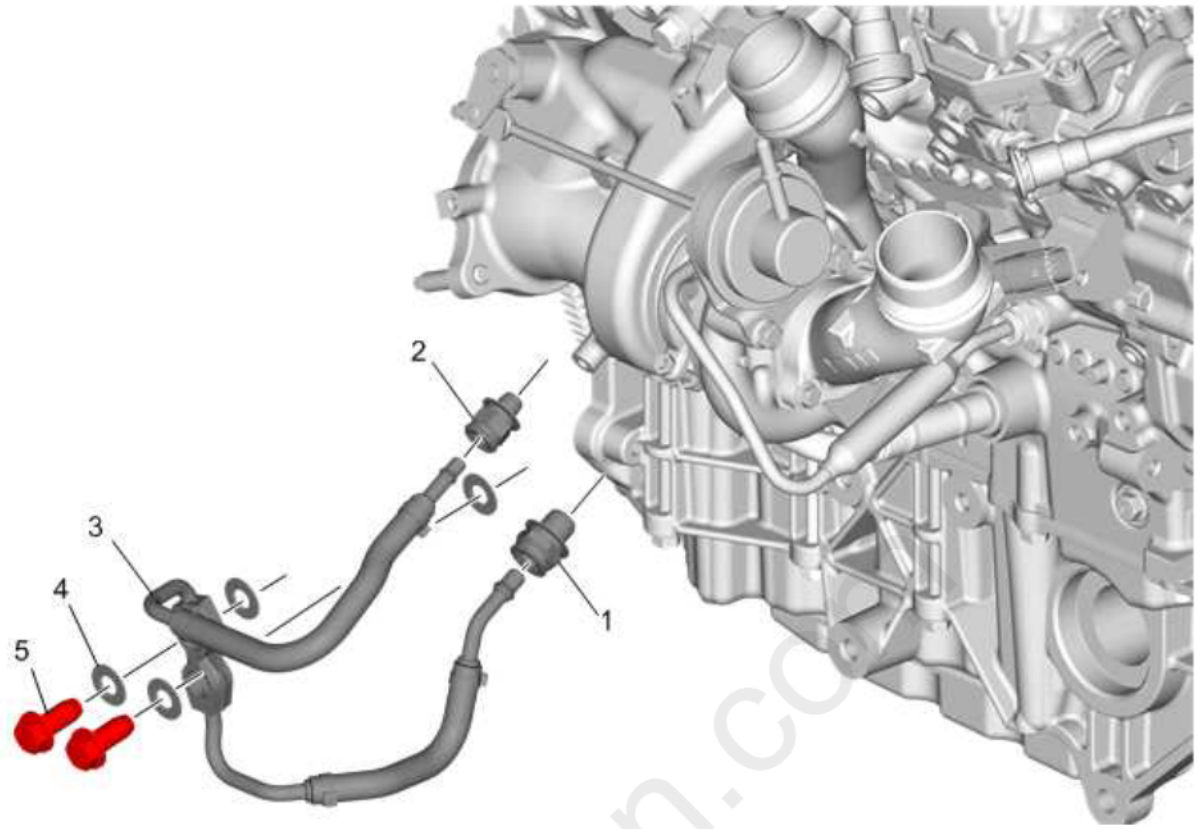


Fig. 440: Turbocharger Coolant Feed and Return Pipe
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Coolant Feed and Return Pipe Installation

Callout	Component Name
1	Turbocharger Coolant Feed Pipe Fitting **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Install NEW fitting. It is not reusable** **Tighten** 35 N.m (26 lb ft)
2	Turbocharger Oil Feed Pipe Fitting **NOTE:** **Install NEW fitting. It is not reusable** **Tighten** 35 N.m (26 lb ft)
3	Turbocharger Coolant Feed and Return Pipe **Procedure** Ensure that the coolant feed pipe is fully secured into the turbocharger pipe fitting. An audible click will be heard when the coolant feed pipe is seated.

Callout	Component Name
4	Turbocharger Coolant Feed and Return Pipe Gasket [2x] **NOTE:** **Install a NEW gasket.**
5	Turbocharger Coolant Feed and Return Pipe Bolt **Tighten** 10 N.m (89 lb in)

Turbocharger Heat Shield Installation

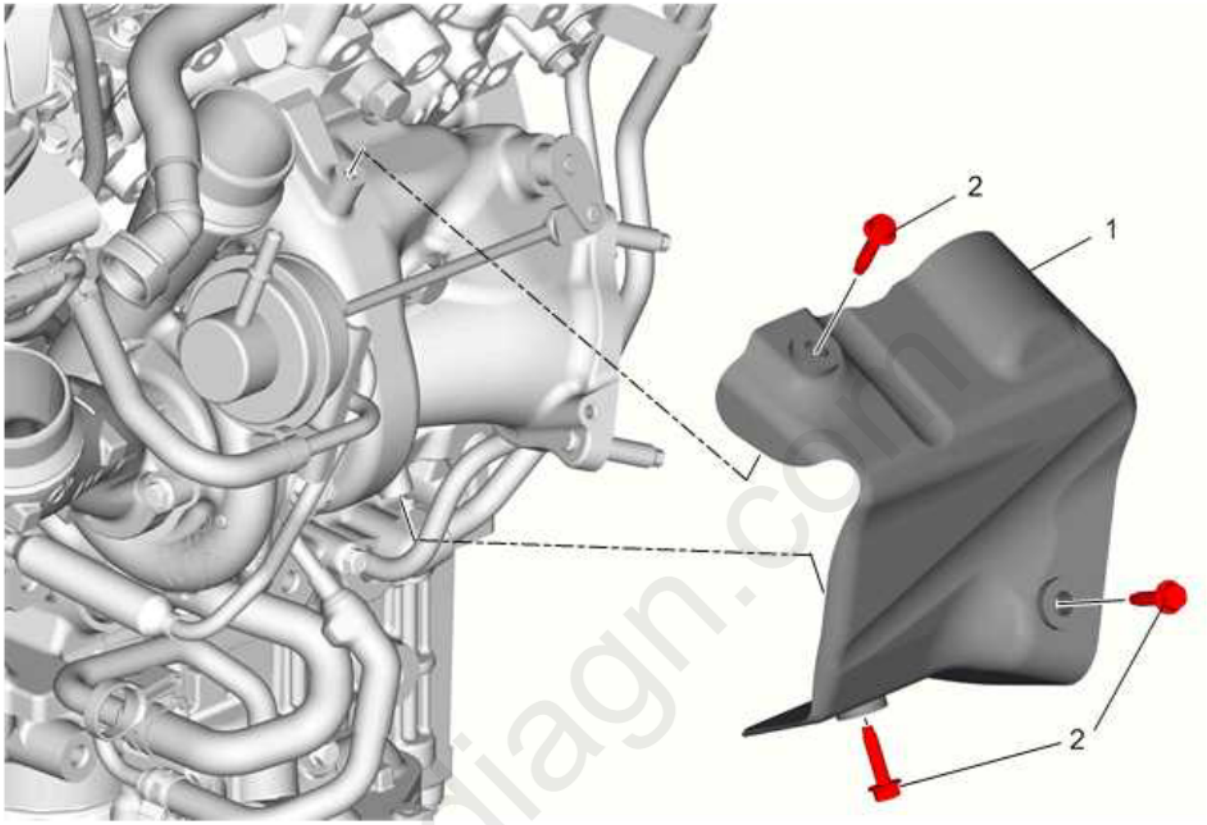


Fig. 441: Turbocharger Heat Shield
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Heat Shield Installation

Callout	Component Name
1	Turbocharger Heat Shield
2	Turbocharger Heat Shield Bolt [3x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)

Charge Air Cooler Inlet Air Tube Installation

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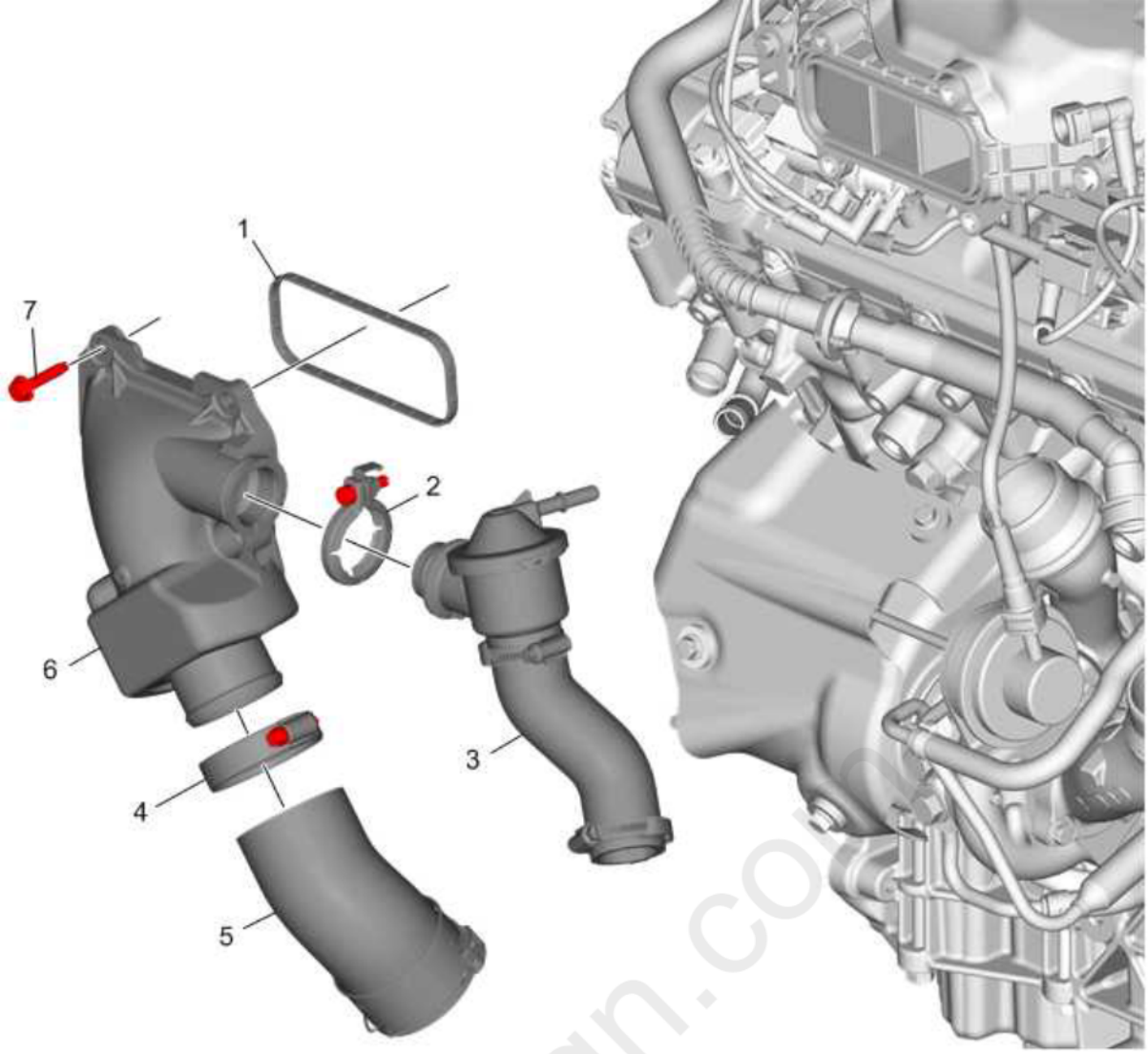


Fig. 442: Charge Air Cooler Inlet Air Tube
Courtesy of GENERAL MOTORS COMPANY

Charge Air Cooler Inlet Air Tube Installation

Callout	Component Name
1	Charge Air Cooler Inlet Air Tube Seal **NOTE:** **Install a NEW seal.**
2	Charge Air Bypass Valve Tube Clamp
3	Charge Air Bypass Valve
4	Charge Air Cooler Inlet Hose Clamp
5	Charge Air Cooler Inlet Hose
6	Charge Air Cooler Inlet Air Tube
7	Charge Air Cooler Inlet Air Tube Bolt [4x] **Tighten** 10 N.m (89 lb in)

WATER PUMP INLET PIPE INSTALLATION

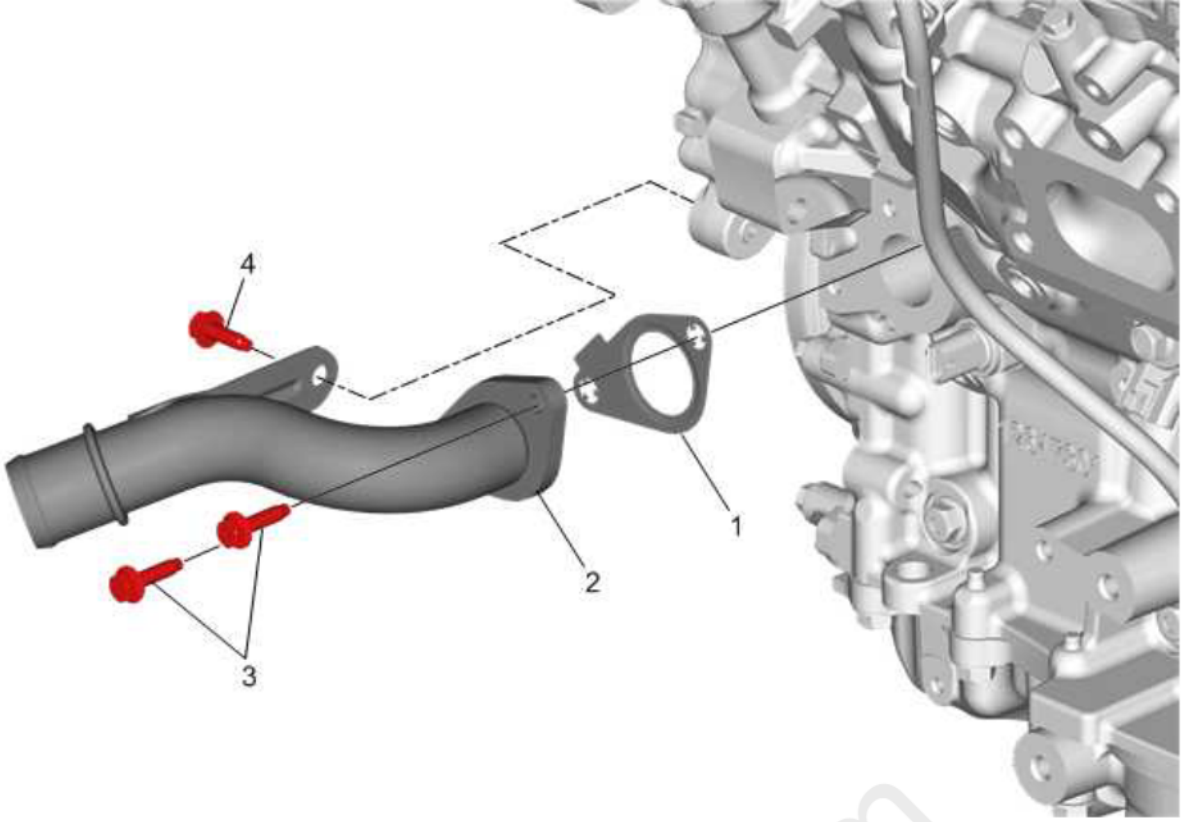


Fig. 443: Water Pump Inlet Pipe
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Inlet Seal **NOTE:** **Install a NEW seal.**
2	Water Pump Inlet Pipe
3	Water Pump Inlet Pipe Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 15 N.m (11 lb ft)
4	Water Pump Inlet Pipe Bolt **Tighten** 15 N.m (11 lb ft)

ENGINE COOLANT THERMOSTAT HOUSING INSTALLATION

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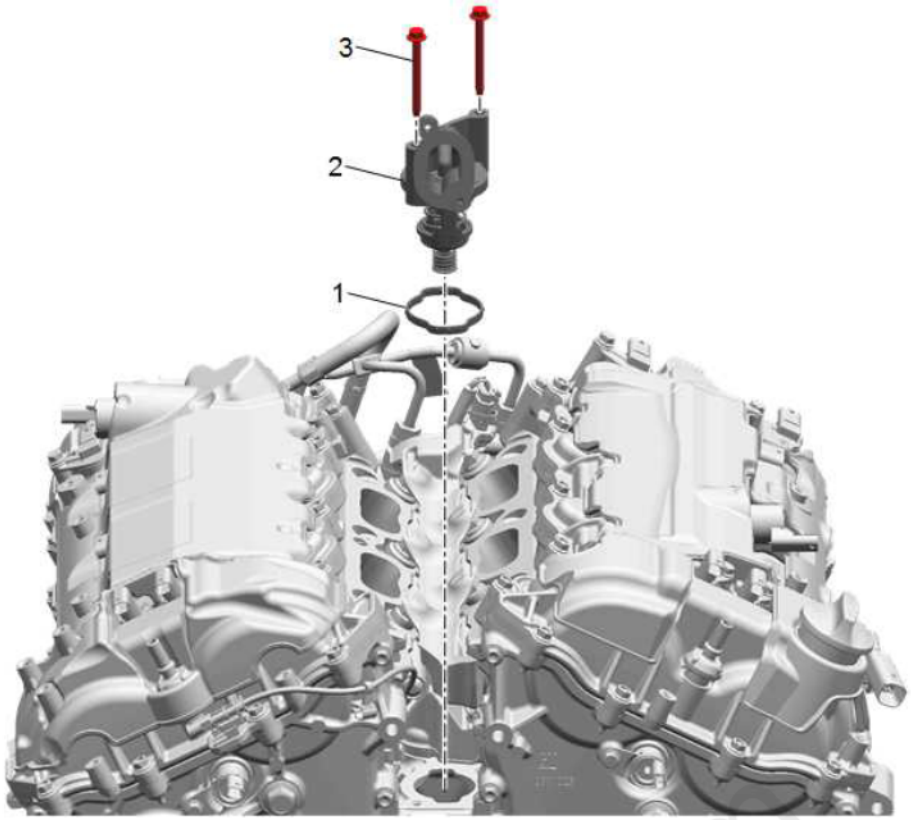


Fig. 444: Engine Coolant Thermostat Housing
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Coolant Temperature Sensor **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Engine Coolant Temperature Sensor Wire
3	Engine Coolant Thermostat Gasket **NOTE:** **Install a NEW gasket.**
4	Engine Coolant Thermostat Housing
5	Engine Coolant Thermostat Housing Bolt **Tighten** 10 N.m (89 lb in)

WATER OUTLET INSTALLATION

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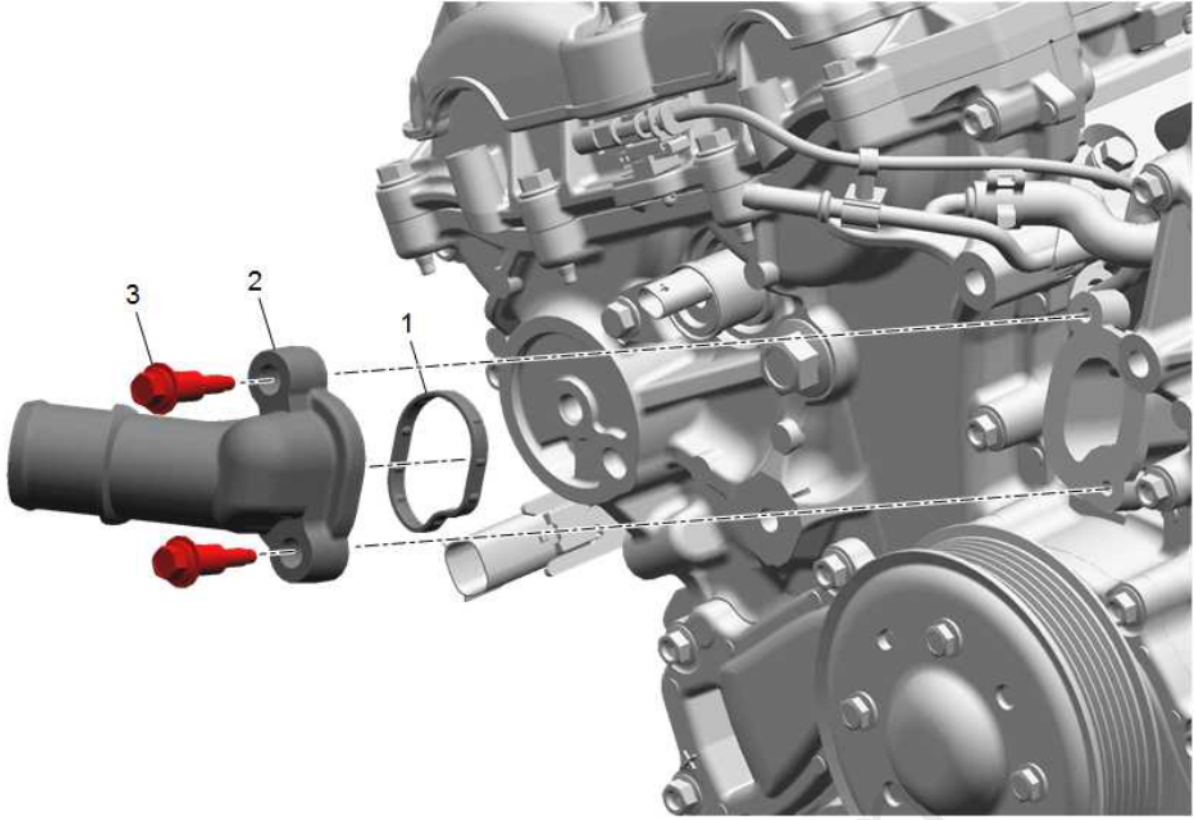


Fig. 445: Water Outlet
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Coolant Air Bleed Pipe
2	Engine Coolant Air Bleed Pipe Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Water Outlet Seal **NOTE:** **Install a NEW seal.**
4	Water Outlet
5	Water Outlet Bolt [2x] **Tighten** 10 N.m (89 lb in)

ENGINE OIL COOLER ADAPTER INSTALLATION

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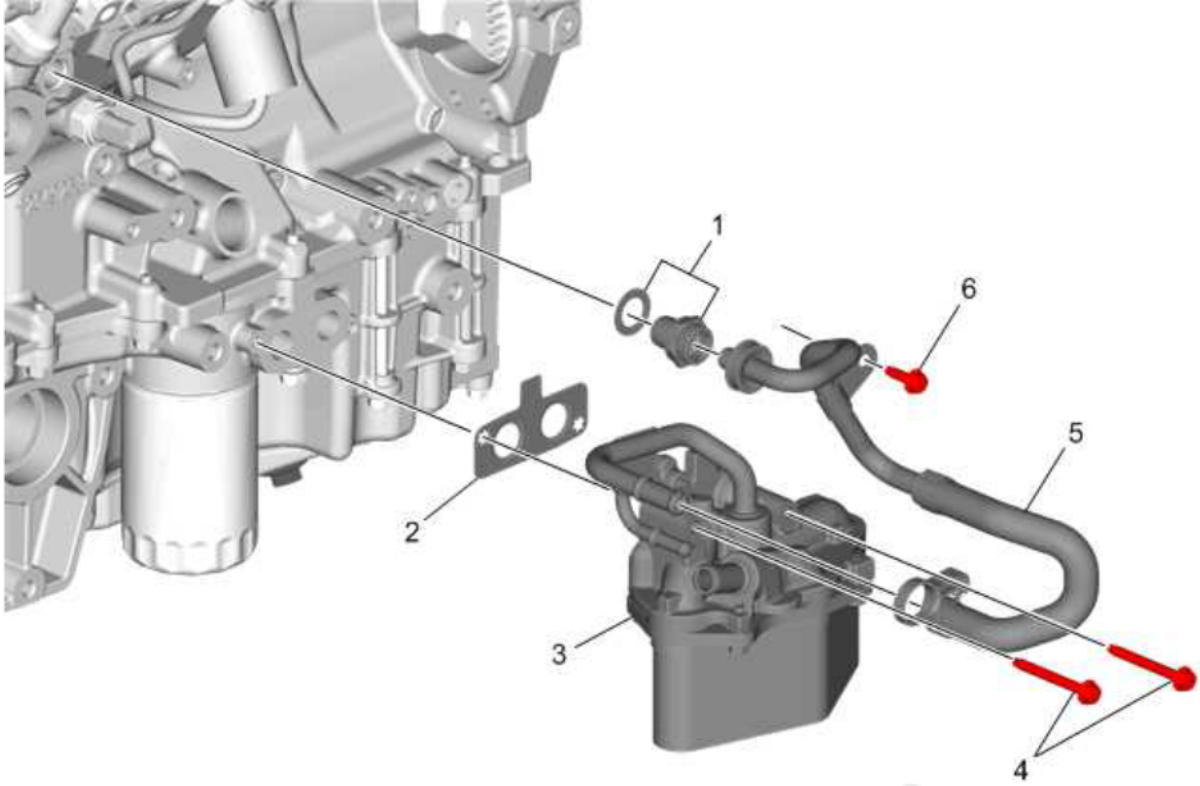


Fig. 446: Engine Oil Cooler Adapter
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Cooler Fitting **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Remove only if damaged.** **Tighten** 25 N.m (18 lb ft)
2	Oil Filter Adapter Gasket
3	Engine Oil Cooler Adapter Assembly
4	Engine Oil Cooler Adapter Bolt [2x] **Tighten** 10 N.m (89 lb in)
5	Engine Oil Cooler Inlet Pipe
6	Engine Oil Cooler Inlet Pipe Bolt **NOTE:** **Make Sure all axi-rads are present for proper alignment of the oil cooler to the oil pan.** **Tighten** 10 N.m (89 lb in)

DRIVE BELT TENSIONER INSTALLATION

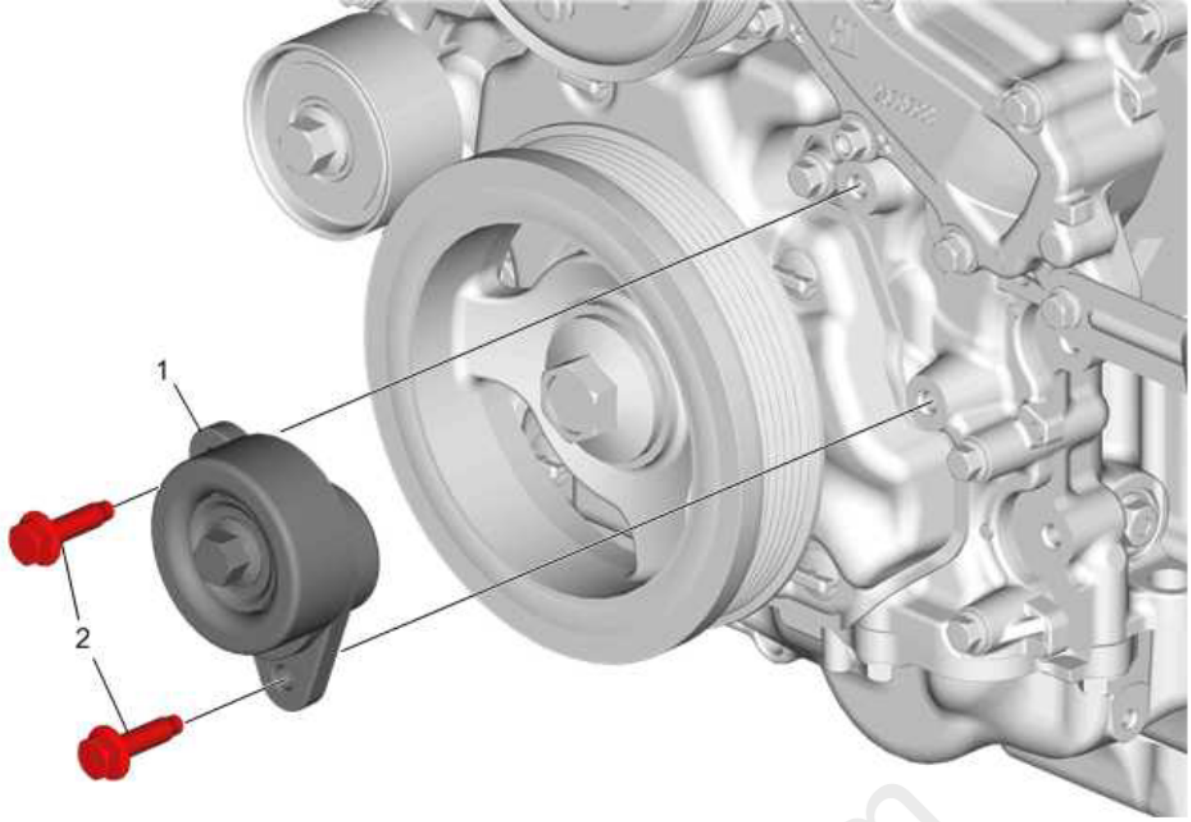


Fig. 447: Drive Belt Tensioner
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Drive Belt Tensioner
2	Drive Belt Tensioner Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 30 N.m (22 lb ft)

ENGINE PRELUBING

NOTE: **This procedure is not used in Europe.**

Special Tools

- **EN 21867-6** Oil Pressure Adapter Fitting
- **EN 45299** Engine Preluber

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

1. Remove the oil filter cap.

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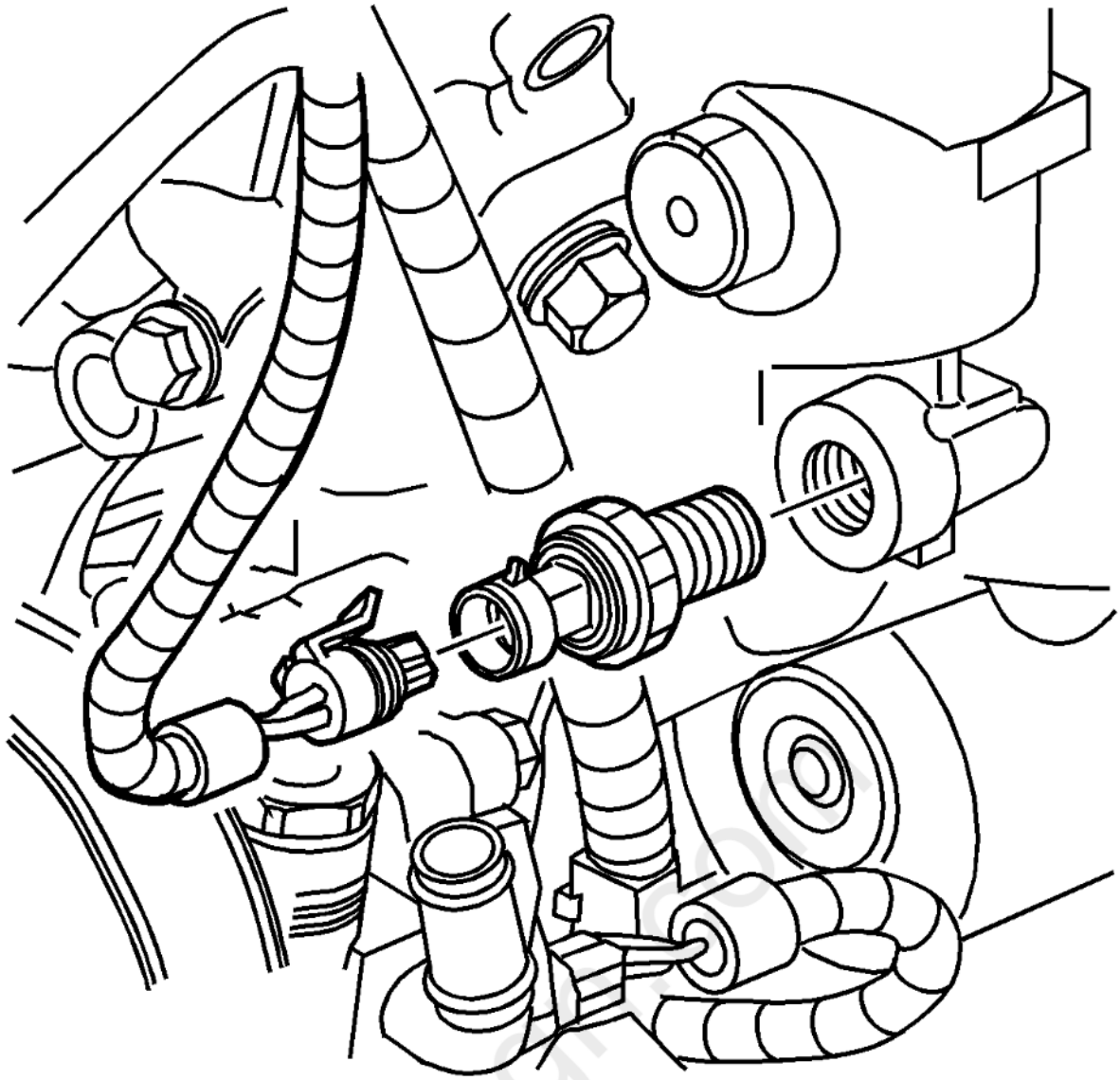


Fig. 448: View Of Oil Pressure Sending Unit
Courtesy of GENERAL MOTORS COMPANY

NOTE: **A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.**

2. Install the NEW oil filter cartridge.
3. Lubricate the threads of the oil filter cap with clean engine oil.
4. Install the oil filter cap and tighten to 25 N.m (18 lb ft).

CAUTION: **Refer to Fastener Caution .**

5. Remove the oil pressure sending unit from the oil filter adapter.
6. Install the **EN 21867-6** fitting.
7. Install the flexible hose to the adapter and open the valve.

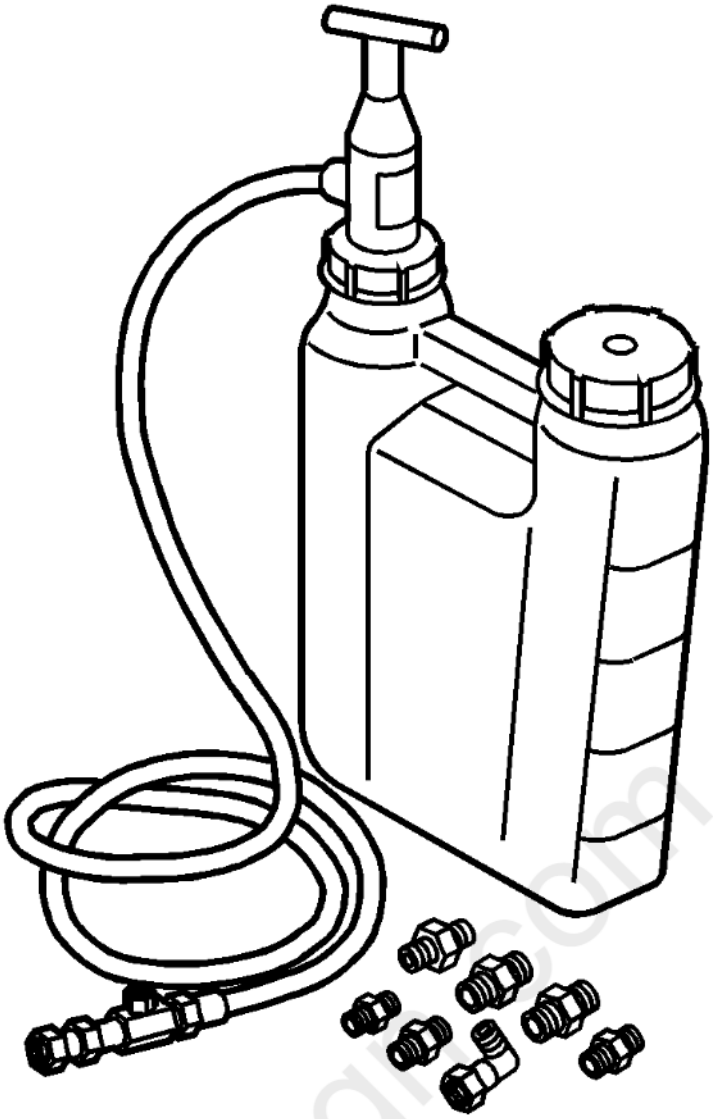


Fig. 449: Preluber Flexible Hose
Courtesy of GENERAL MOTORS COMPANY

8. Pump the handle on the **EN 45299** preluber in order to flow a minimum of 1-1.9 liters (1-2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
9. Close the valve and remove the flexible hose and adapter from the engine.
10. Install the oil pressure sending unit and tighten to 20 N.m (15 lb ft).
11. Top-off the engine oil to the proper level.

REPAIR INSTRUCTIONS - ON VEHICLE

DRIVE BELT REPLACEMENT (LGX)

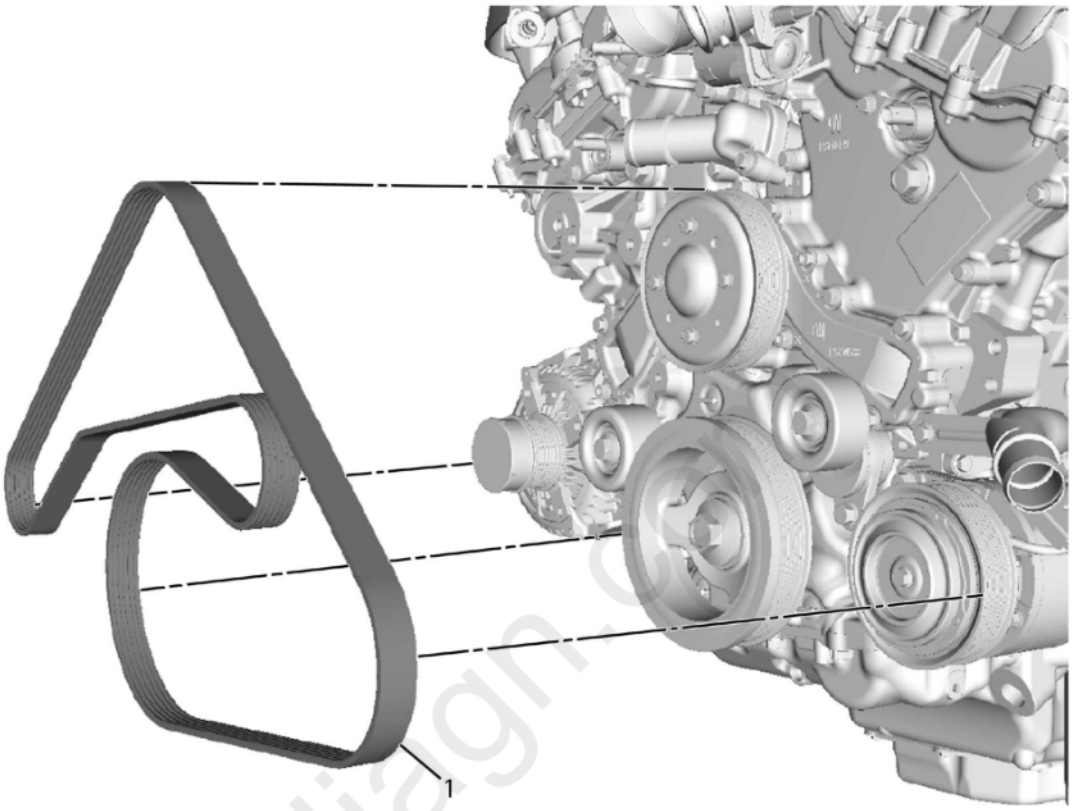


Fig. 1: Drive Belt Routing (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Air Cleaner Outlet Duct Replacement (LGX)	
1	Drive Belt **Procedure** 1. Rotate the drive belt tensioner counterclockwise to release the drive belt tension. 2. Slide the drive belt off of the belt idler pulley. 3. Slowly release the drive belt tensioner.

DRIVE BELT REPLACEMENT (LGW)

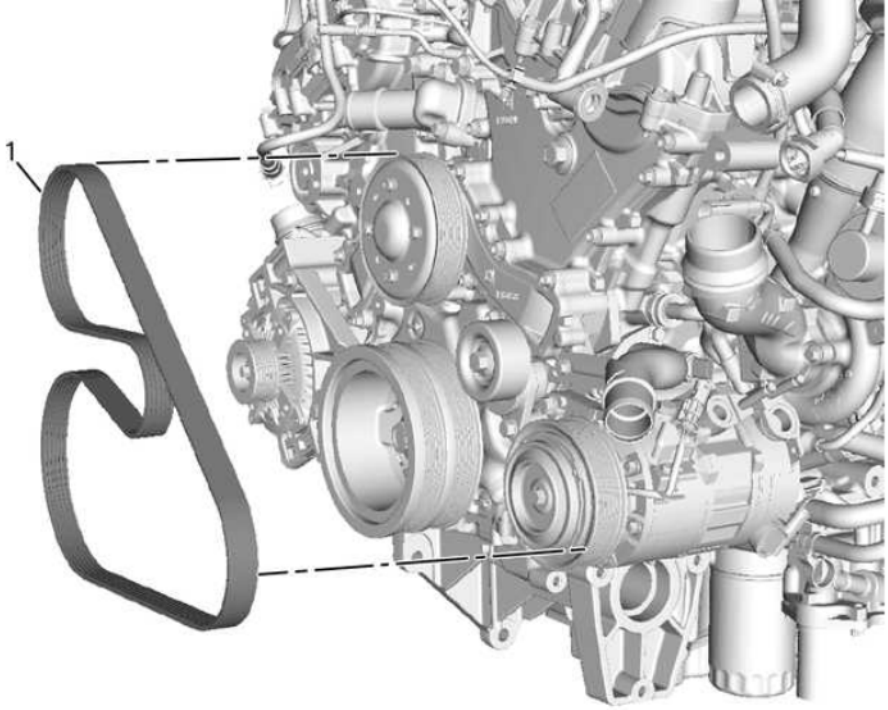


Fig. 2: Drive Belt Routing (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Fan and Generator Belt Replacement	
1	Drive Belt **Procedure** 1. Rotate the drive belt tensioner counter clockwise to release the drive belt tension. 2. Slide the drive belt off of the belt water pump pulley. 3. Slowly release the drive belt tensioner.

FAN AND GENERATOR BELT REPLACEMENT

Special Tools

EN-51767-2 Universal Stretchy Belt Installer

Equivalent regional tools: Special Tools

Removal Procedure

1. Air Cleaner Assembly Replacement (LGW) Air Cleaner Assembly Replacement (LGX) Â» Remove
2. Cut the belt (1) from generator and crankshaft pulleys.

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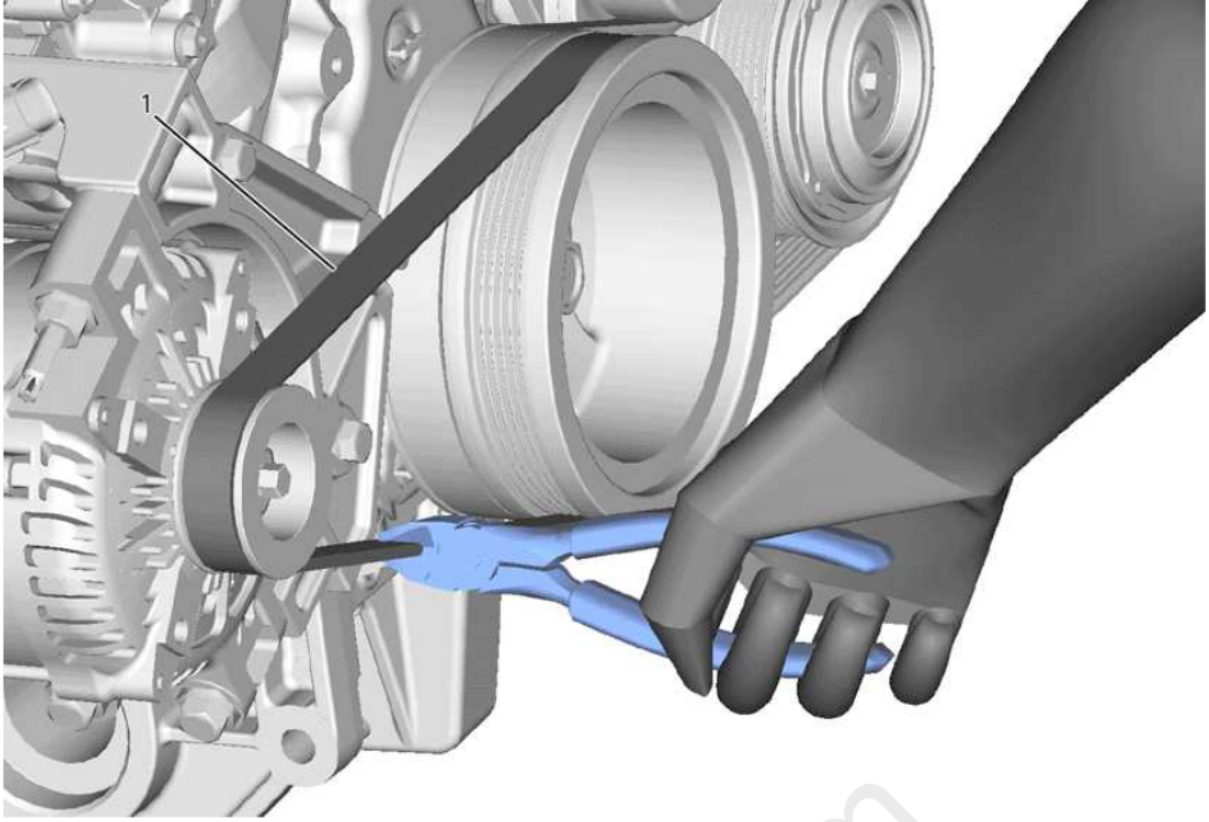


Fig. 3: Cut Belt From Generator And Crankshaft Pulleys
Courtesy of GENERAL MOTORS COMPANY

Installation Procedure

1. Install **EN-51767-2** Universal Stretchy Belt Installer (1) onto the balancer.

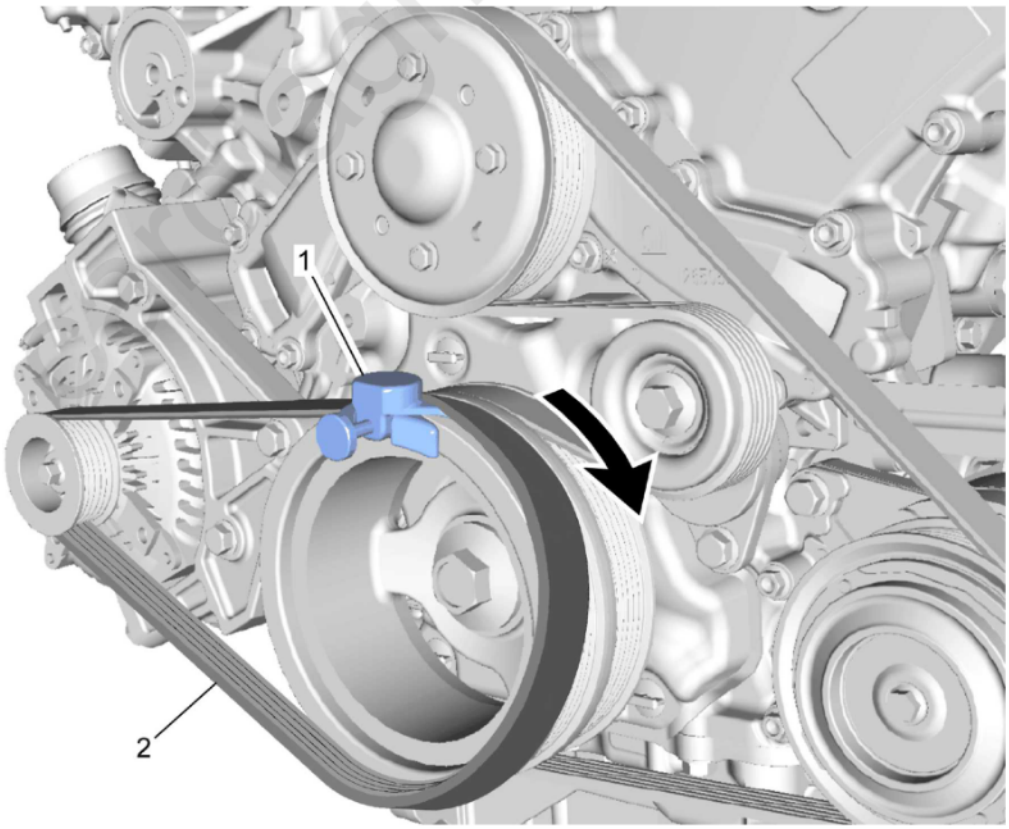


Fig. 4: Universal Stretchy Belt Installer
Courtesy of GENERAL MOTORS COMPANY

2. Position the belt (2) on the generator pulley and the balancer as shown.
3. Slide the belt installation tool downward, positioning the belt onto the generator pulley, applying light tension to the belt.
4. Slowly rotate the crankshaft pulley in a clockwise direction while using finger pressure to pull the belt (2) forward.

5. Inspect the generator belt for proper installation and alignment.
6. Rotate the balancer and additional 360 degrees to ensure proper belt installation.
7. Air Cleaner Assembly Replacement (LGW) Air Cleaner Assembly Replacement (LGX) Â» Install

DRIVE BELT TENSIONER REPLACEMENT (LGX)

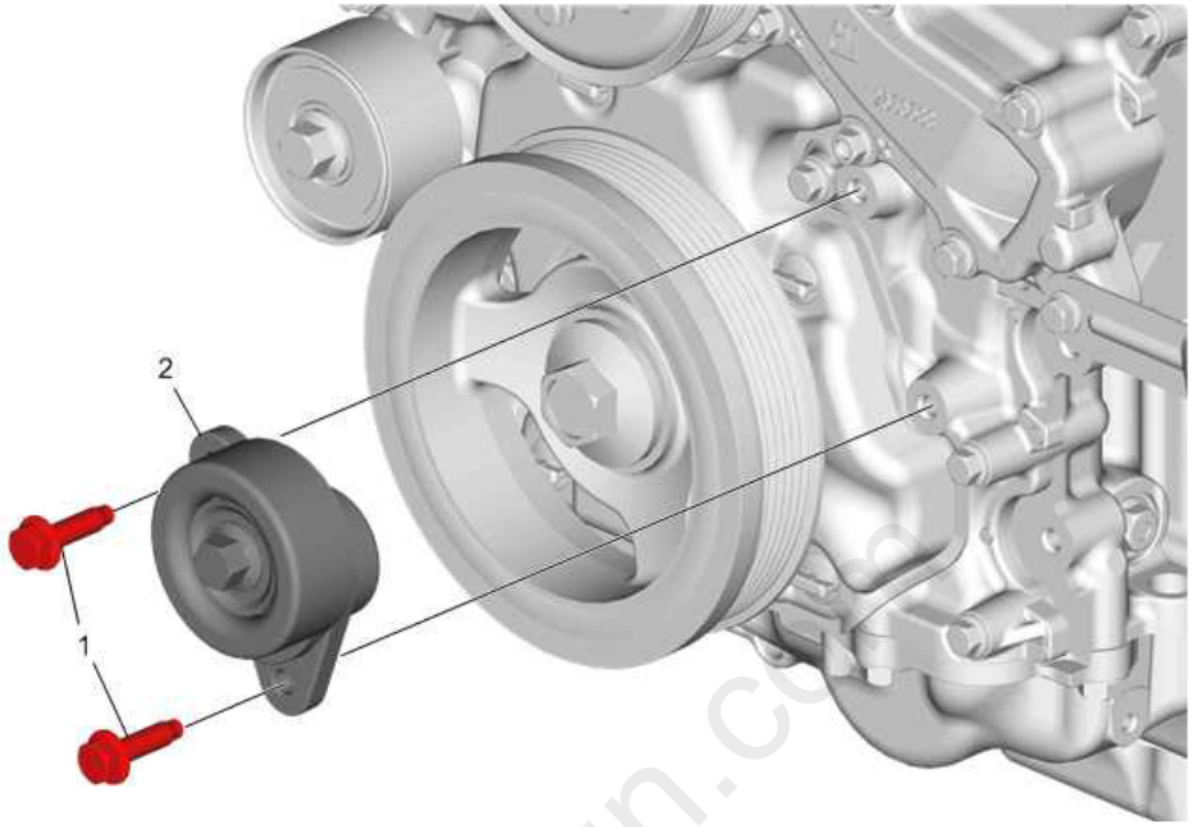


Fig. 5: Drive Belt Tensioner (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Drive Belt Replacement (LGX)	
1	Drive Belt Tensioner Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 30 N.m (22 lb ft)
2	Drive Belt Tensioner

DRIVE BELT TENSIONER REPLACEMENT (LGW)

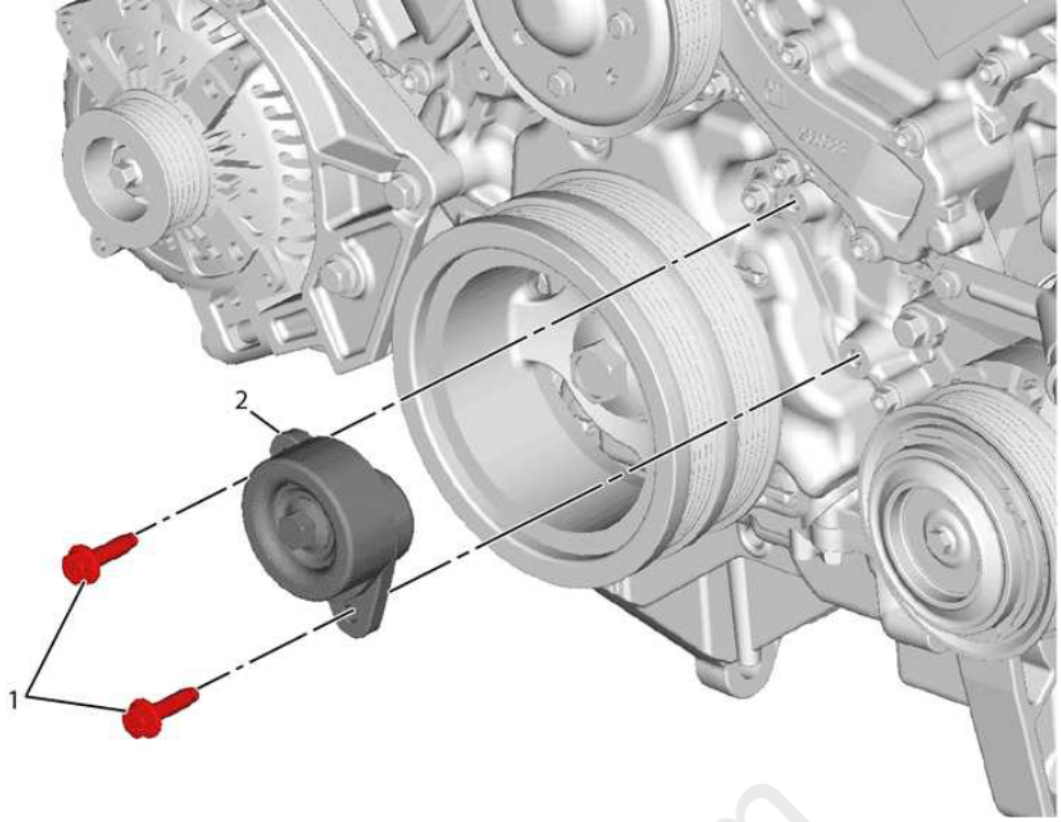


Fig. 6: Drive Belt Tensioner (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Drive Belt Replacement (LGW)	
1	Drive Belt Tensioner Bolt [2x] **CAUTION:** Refer to Fastener Caution . **Tighten** 30 N.m (22 lb ft)
2	Drive Belt Tensioner

ENGINE FRONT COVER INSULATOR REPLACEMENT (LGX)

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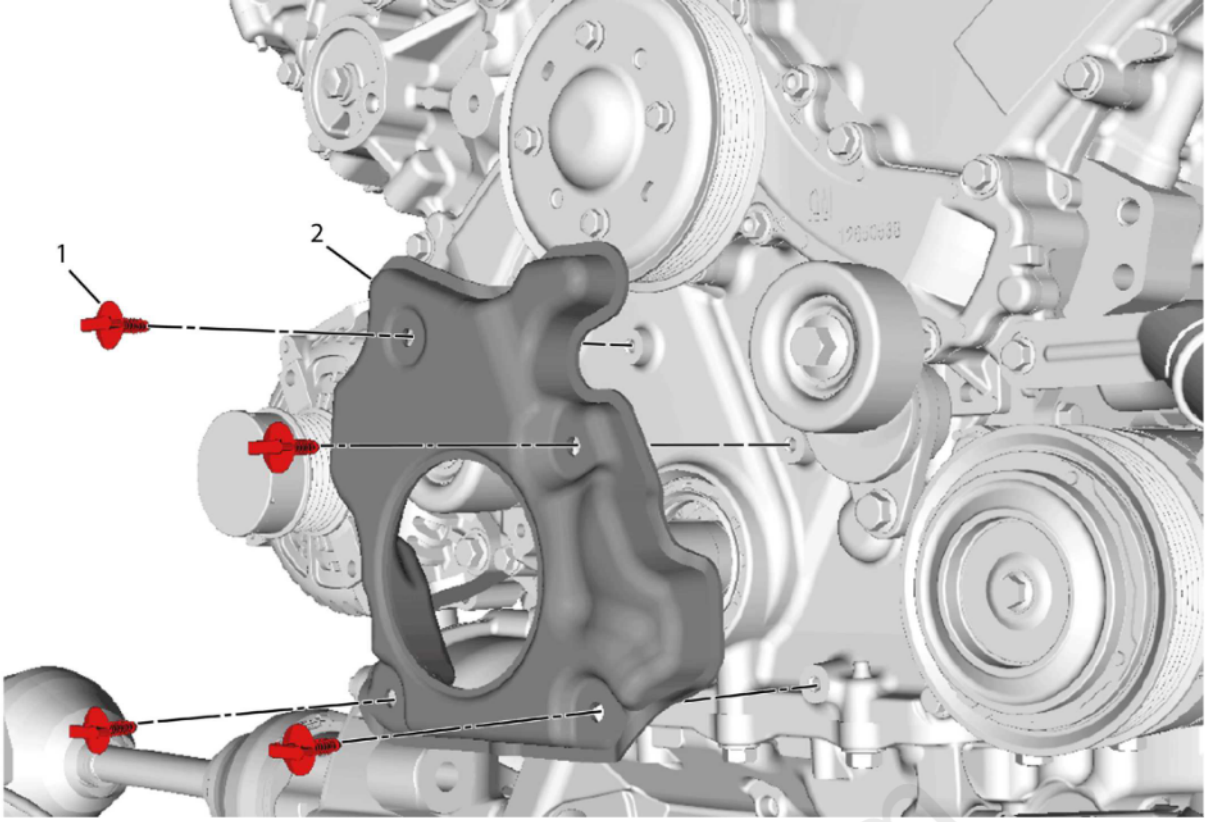


Fig. 7: Engine Front Cover Insulator
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Crankshaft Balancer Replacement (LGX)	
1	Engine Front Cover Retainer [4x]
2	Engine Front Cover Insulator **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**

CHARGE AIR COOLER COVER REPLACEMENT

Removal Procedure

1. Harness Connector (1)Â» Disconnect

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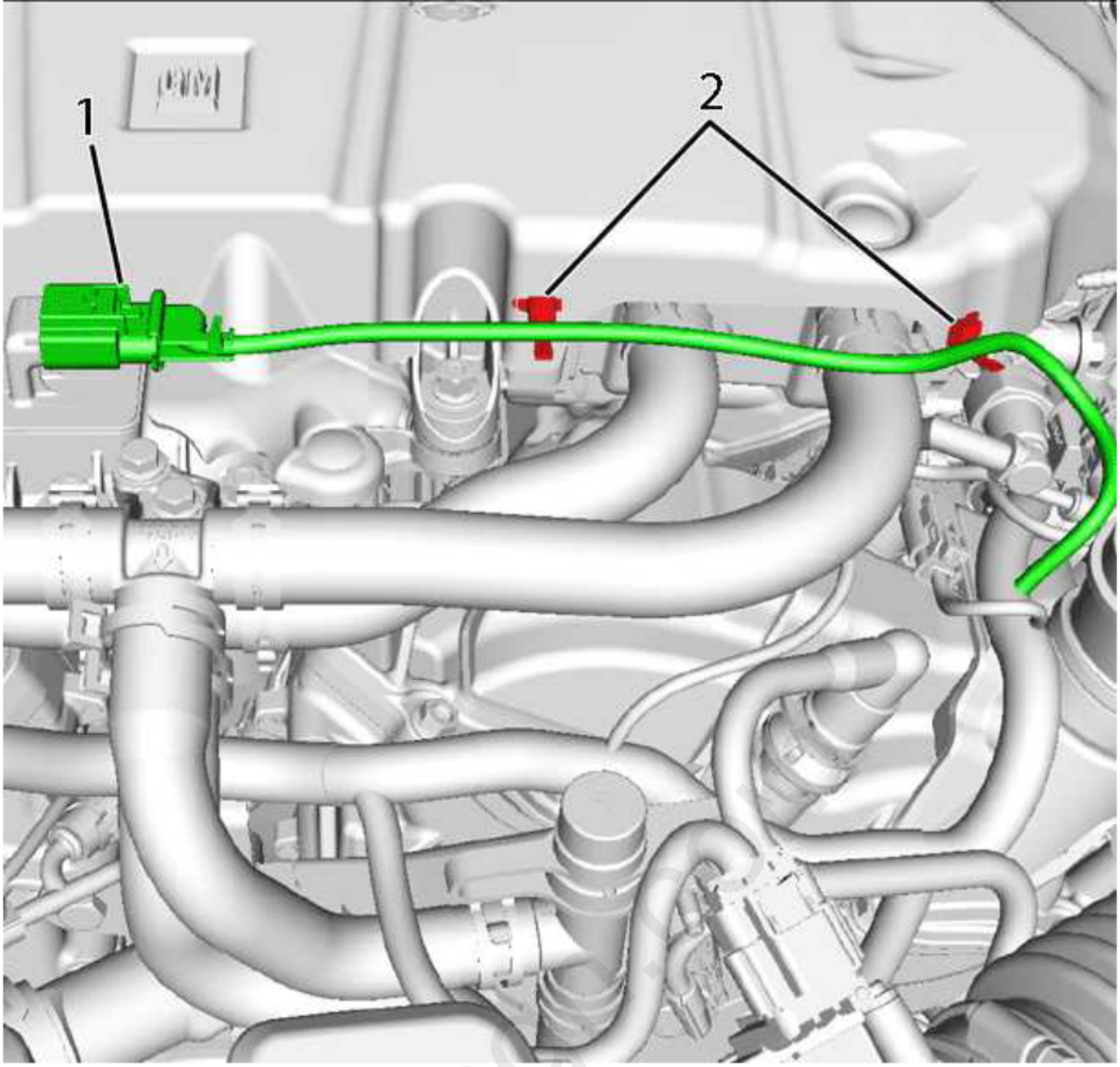


Fig. 8: Harness Connector And Retainer
Courtesy of GENERAL MOTORS COMPANY

2. Retainer (2)Â» Disconnect [2x]
3. Vacuum Hose (1)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

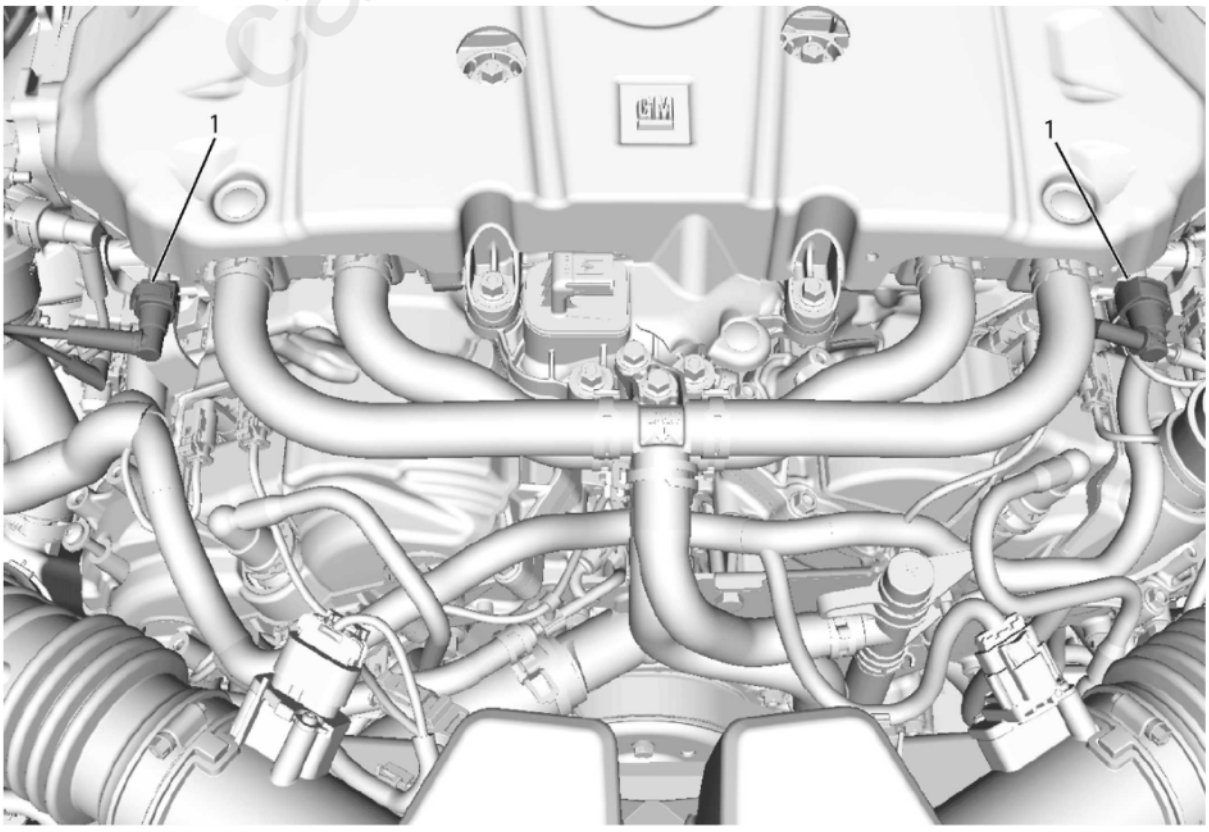


Fig. 9: Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

4. Charge Air Cooler Coolant HoseÂ» Remove - **Charge Air Cooler Coolant Hose Replacement (LGW)**
5. Harness Connector (1)Â» Disconnect

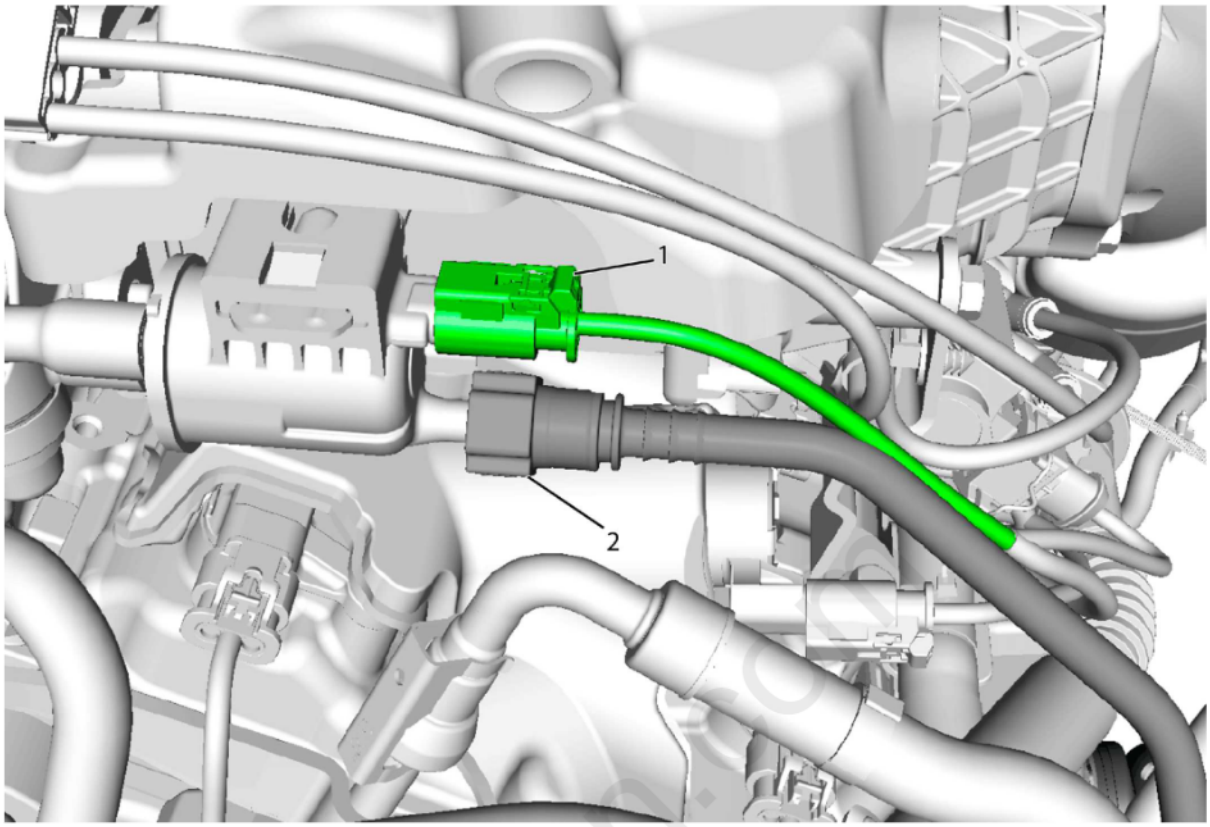


Fig. 10: Harness Connector And Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

6. Vacuum Hose (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**
7. Retainer (1)Â» Disconnect [2x]

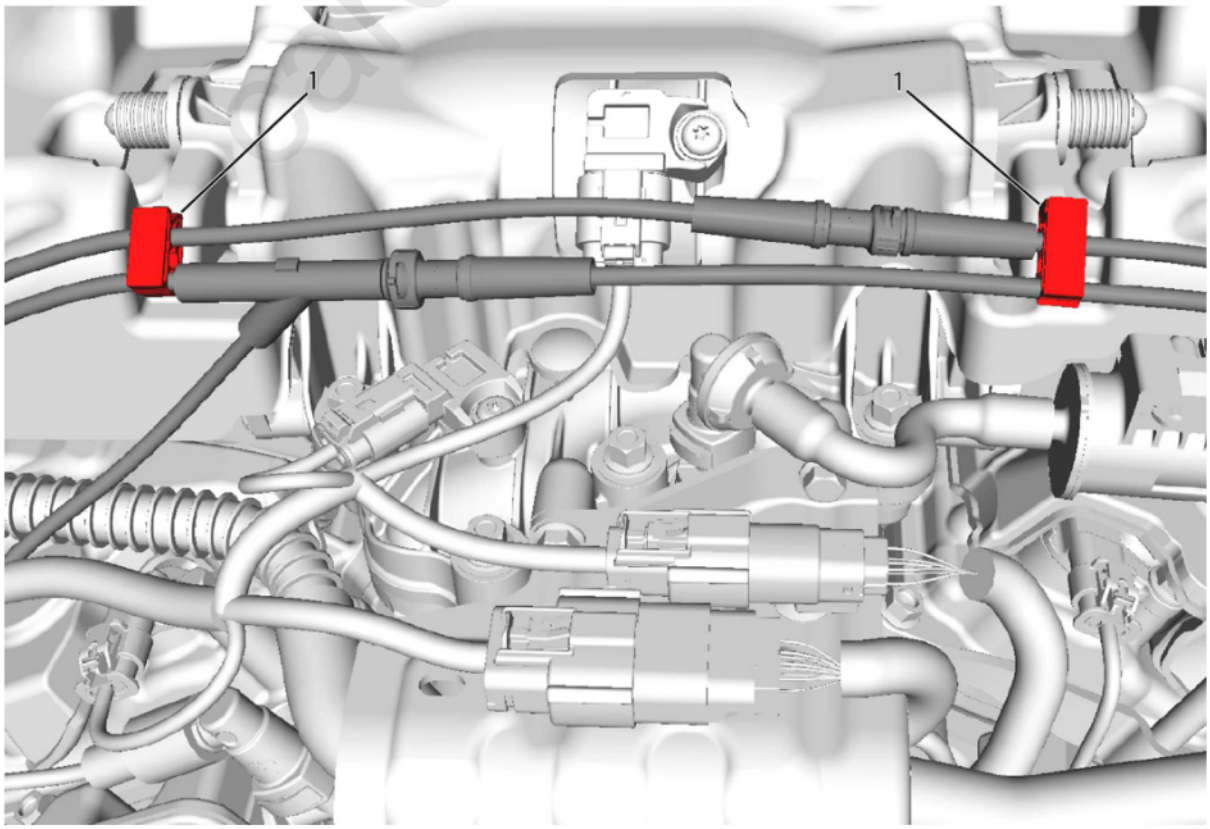


Fig. 11: Retainers
Courtesy of GENERAL MOTORS COMPANY

8. Harness Connector (1, 2, 3, 4)Â» Disconnect

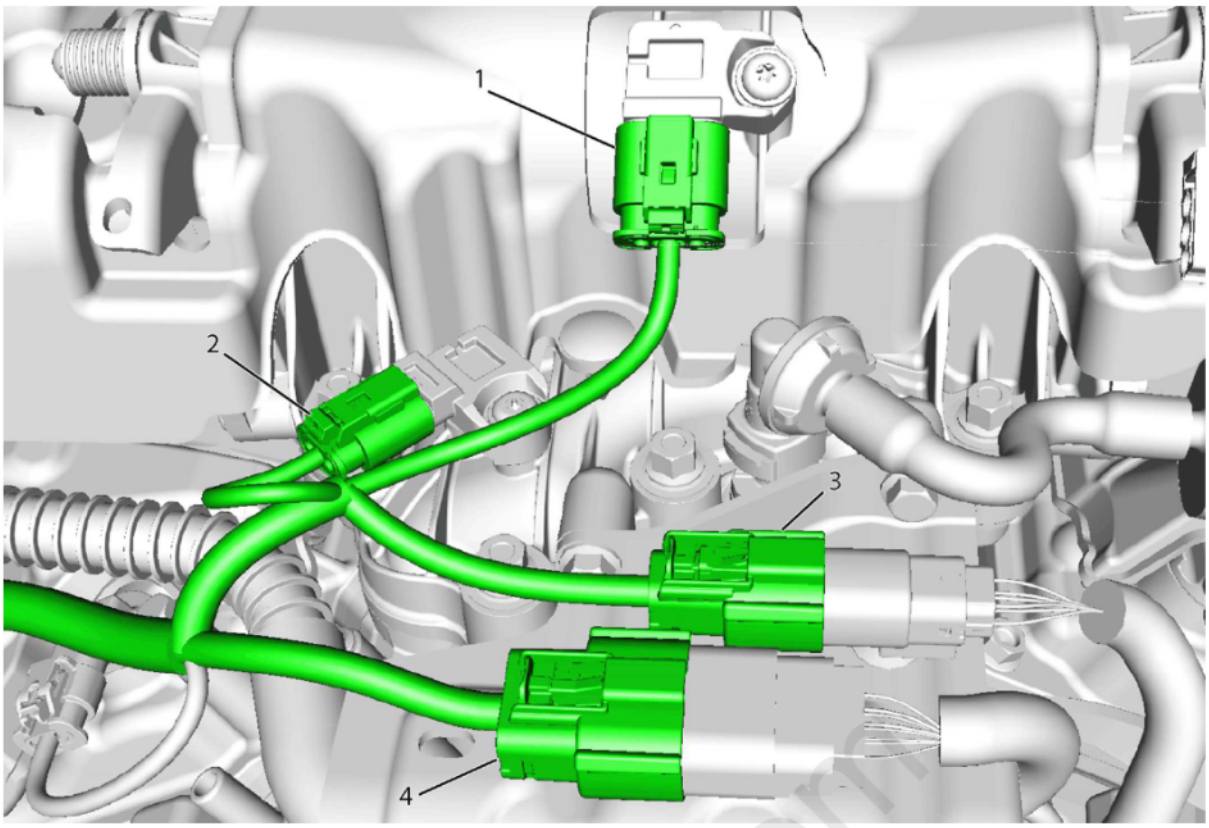


Fig. 12: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

9. Fuel Pipe Shield Bolt (1)Â» Remove [2x]

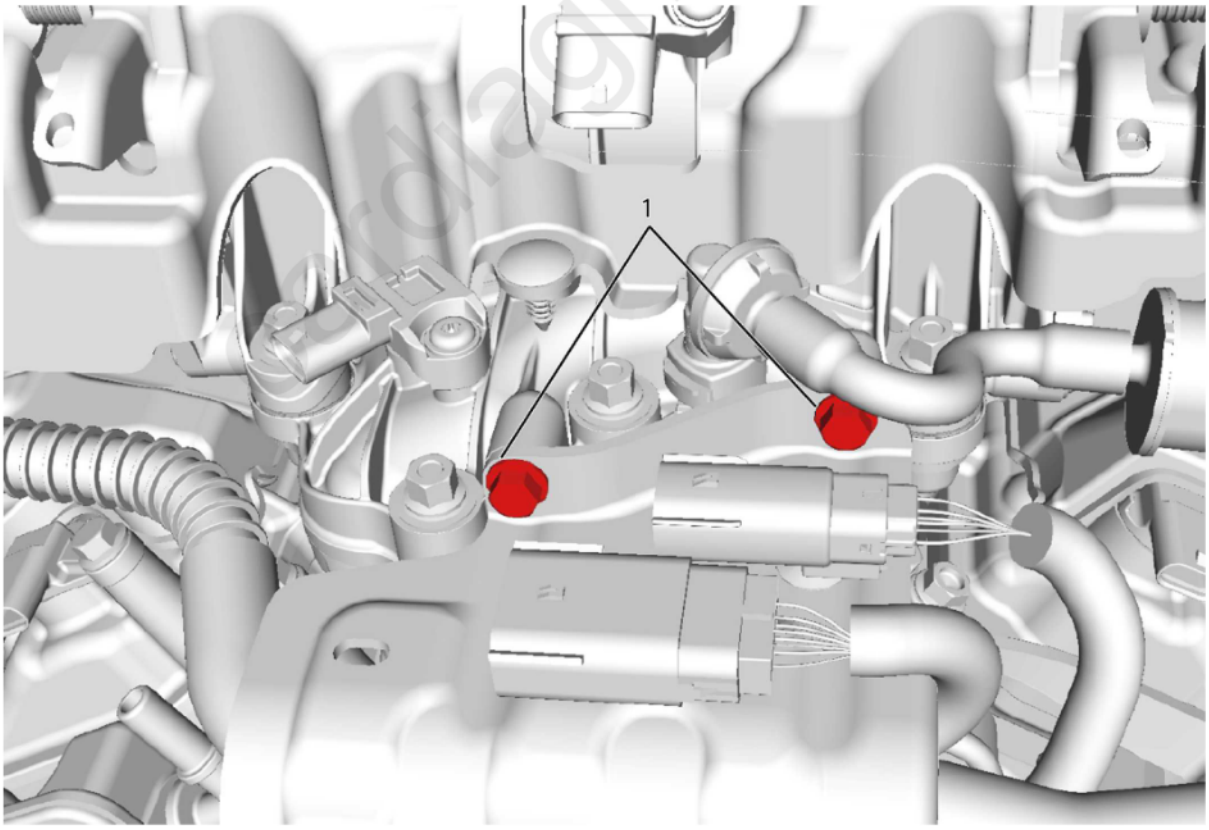


Fig. 13: Fuel Pipe Shield Bolt
Courtesy of GENERAL MOTORS COMPANY

10. Charge Air Cooler Inlet Air Tube @ Right SideÂ» Remove - **Charge Air Cooler Inlet Air Tube Replacement (Right Side)**
11. Remove the right side upper turbocharger wastegate bracket bolts (1).

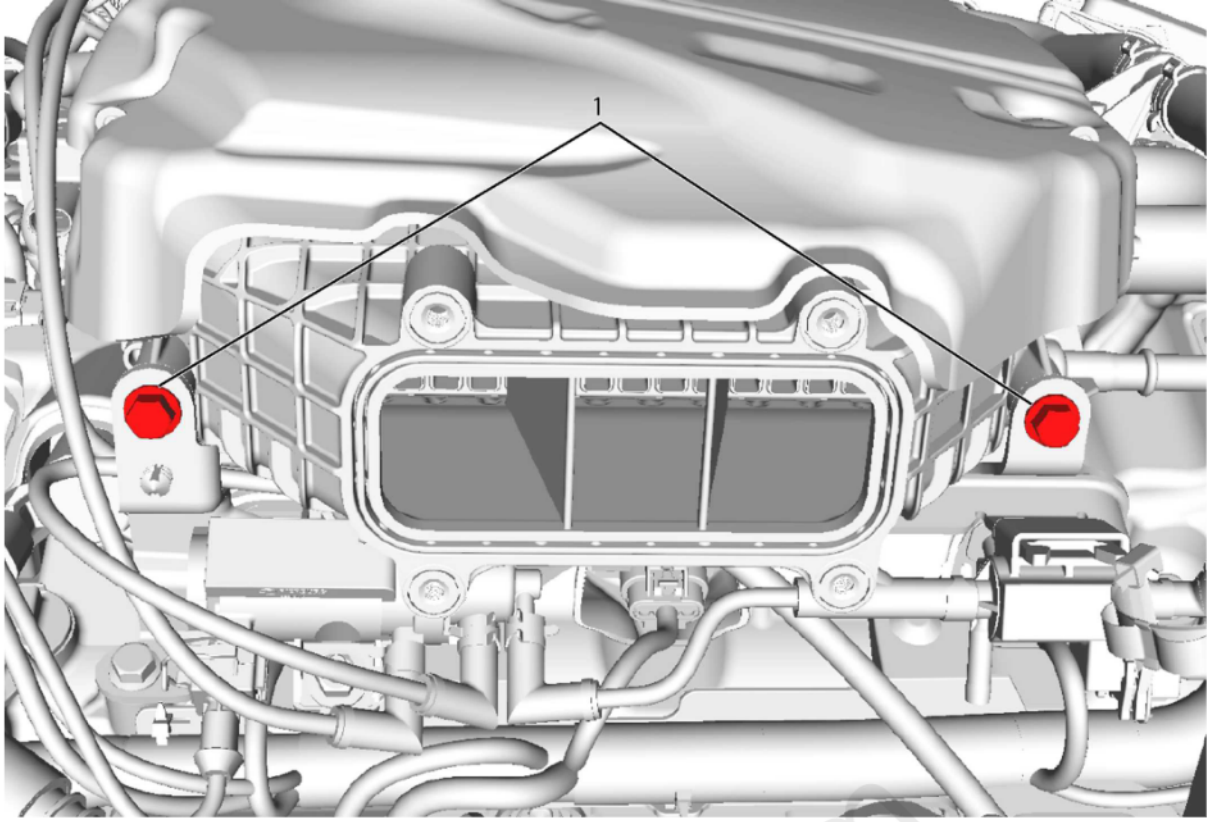


Fig. 14: Right Side Upper Turbocharger Wastegate Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

12. Charge Air Cooler Inlet Air Tube @ Left SideÂ» Remove - **Charge Air Cooler Inlet Air Tube Replacement (Left Side)**
13. Remove the left side upper turbocharger wastegate bracket bolts (1).

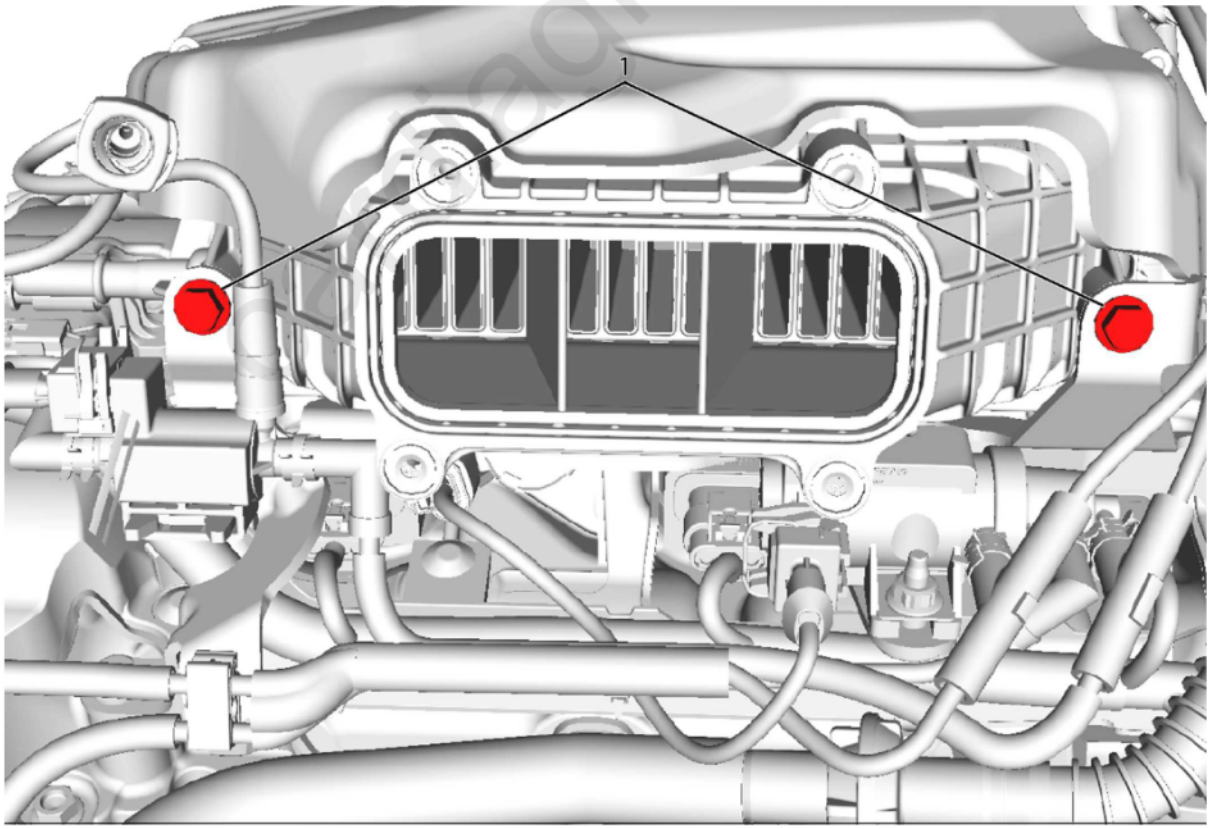


Fig. 15: Left Side Upper Turbocharger Wastegate Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

14. Charge Air Cooler BoltÂ» Remove [12x]

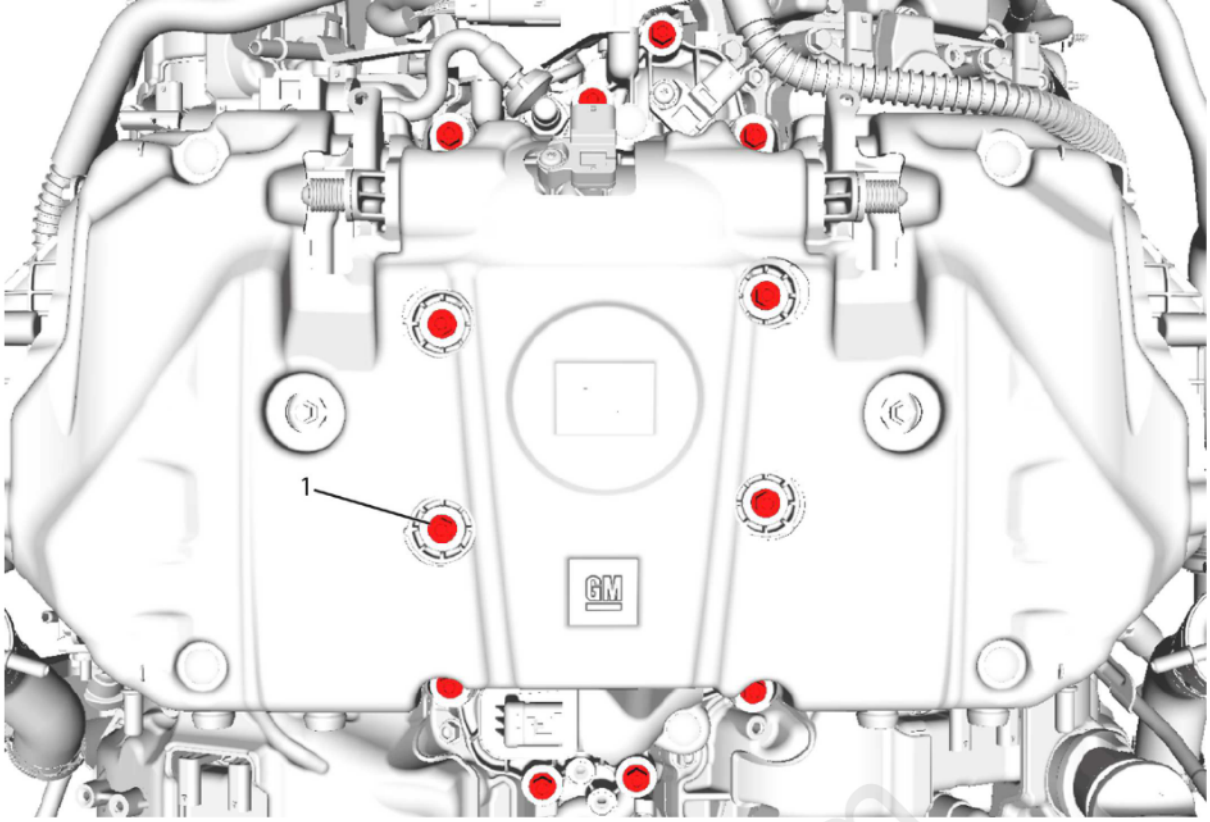


Fig. 16: Charge Air Cooler Bolt
Courtesy of GENERAL MOTORS COMPANY

15. Charge Air Cooler (1)Â» Remove

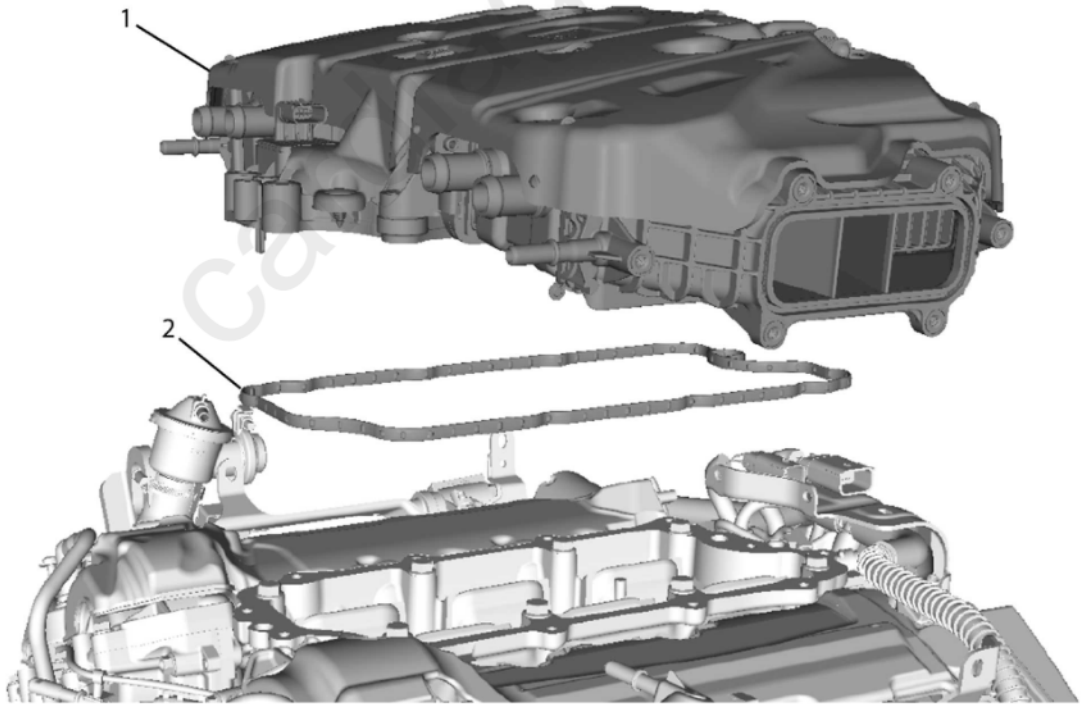


Fig. 17: Charge Air Cooler
Courtesy of GENERAL MOTORS COMPANY

16. Charge Air Cooler Housing Gasket (2)Â» Remove and DISCARD the gasket.
17. Transfer components as necessary. Refer to **Charge Air Cooler Cover Disassemble**
18. Clean and inspect - **Charge Air Cooler Cover Cleaning and Inspection**

Installation Procedure

1. Assemble - **Charge Air Cooler Cover Assemble**

2. Charge Air Cooler Housing Gasket (2)Â» Install NEW

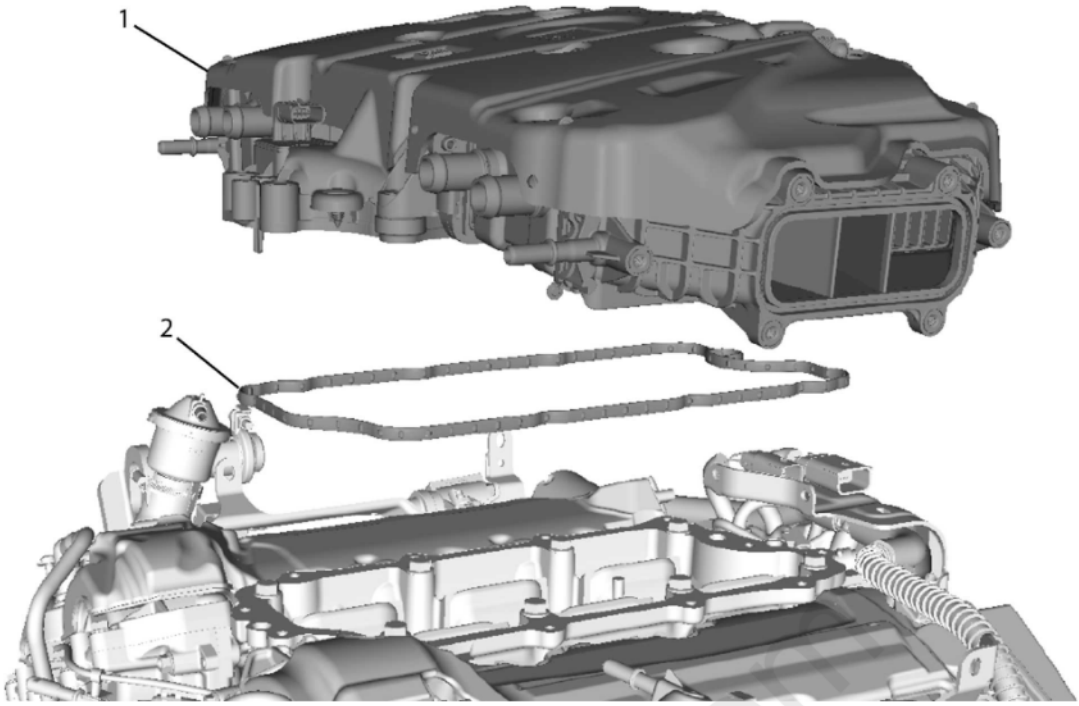


Fig. 18: Charge Air Cooler
Courtesy of GENERAL MOTORS COMPANY

3. Charge Air Cooler (1)Â» Install - **Charge Air Cooler Cover Installation**
4. Install the left side upper turbocharger wastegate bracket bolts (1).

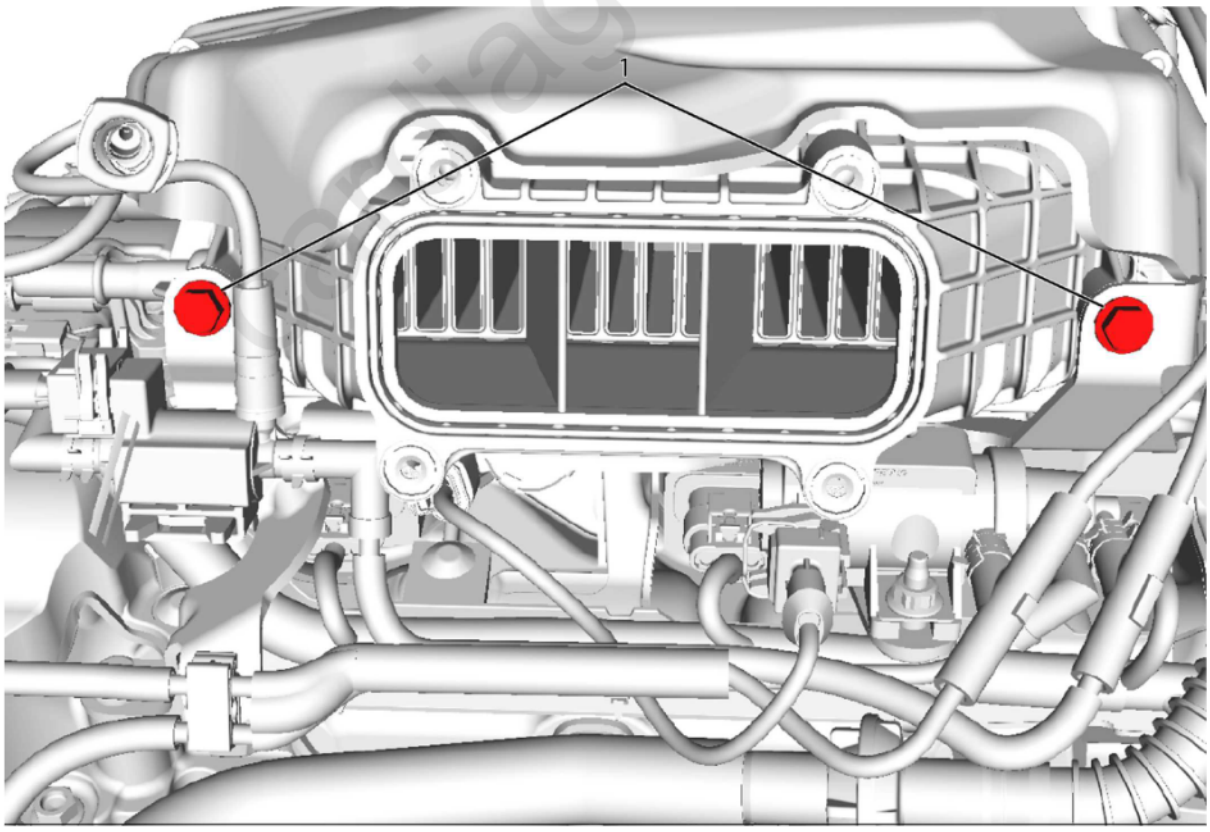


Fig. 19: Left Side Upper Turbocharger Wastegate Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

5. Tighten the bolts (1) to 10 N.m (89 lb in).

6. Charge Air Cooler Inlet Air Tube @ Left SideÂ» Install - **Charge Air Cooler Inlet Air Tube Replacement (Left Side)**
7. Install the right side upper turbocharger wastegate bracket bolts (1).

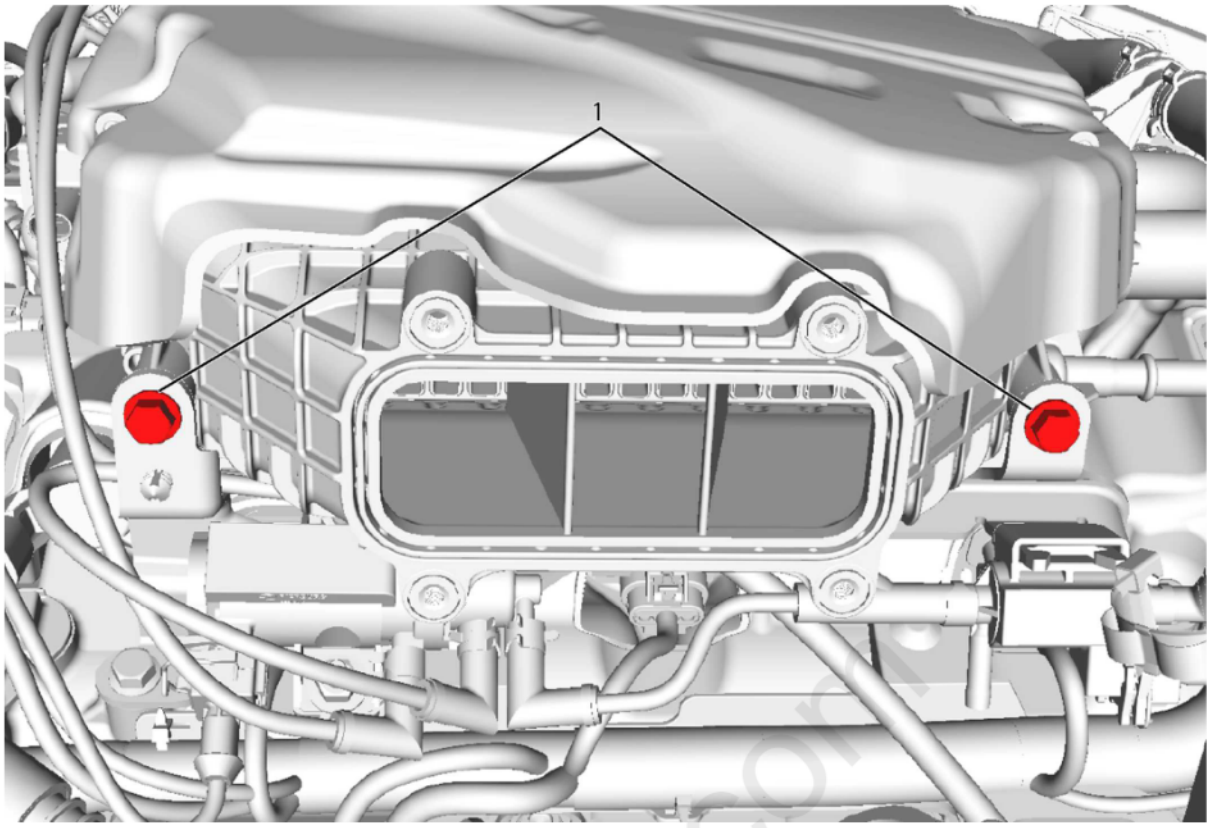


Fig. 20: Right Side Upper Turbocharger Wastegate Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Tighten the bolts (1) to 10 N.m (89 lb in).
9. Charge Air Cooler Inlet Air Tube @ Right SideÂ» Install - **Charge Air Cooler Inlet Air Tube Replacement (Right Side)**
10. Fuel Pipe Shield Bolt (1)Â» Install [2x] - **Fuel Pipe Shield Replacement (LGW)** **Fuel Pipe Shield Replacement (LGX)**

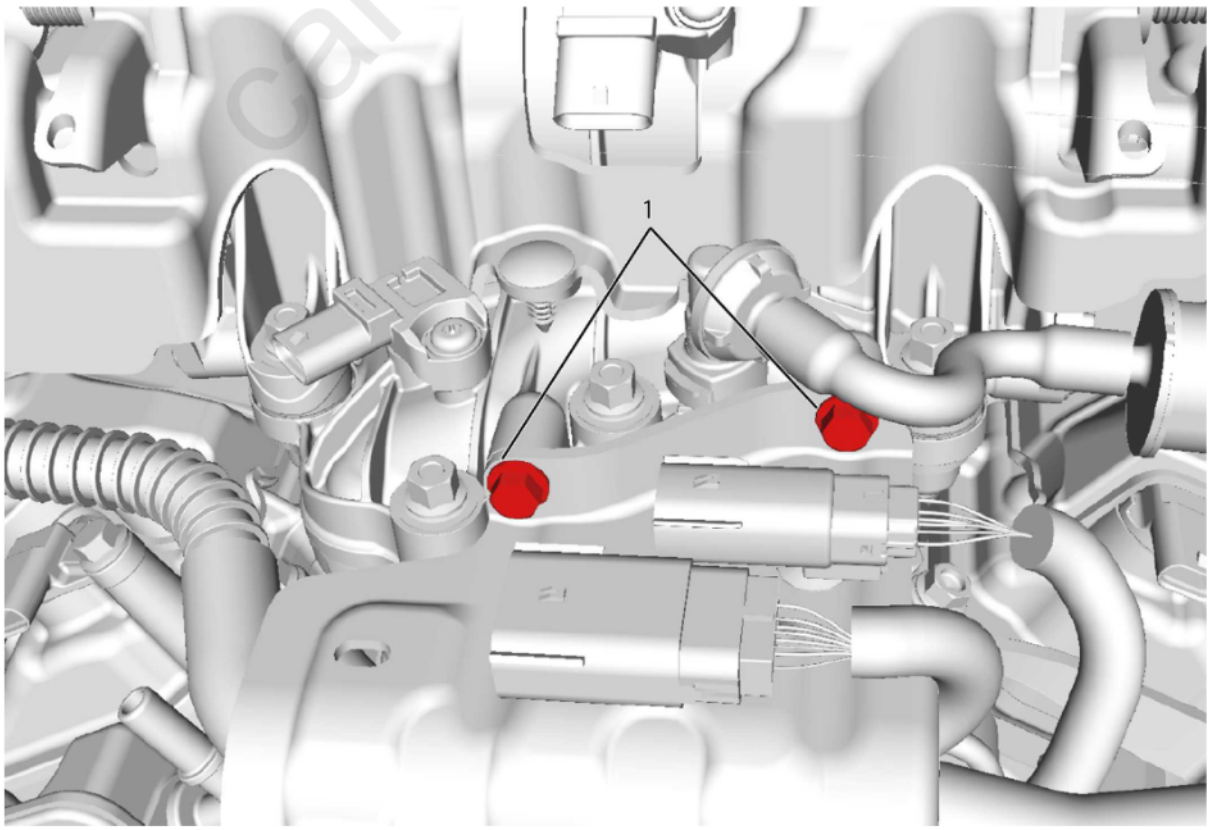


Fig. 21: Fuel Pipe Shield Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Tighten the bolts (1) to 10 N.m (89 lb in).
12. Harness Connector (1, 2, 3, 4)Â» Connect

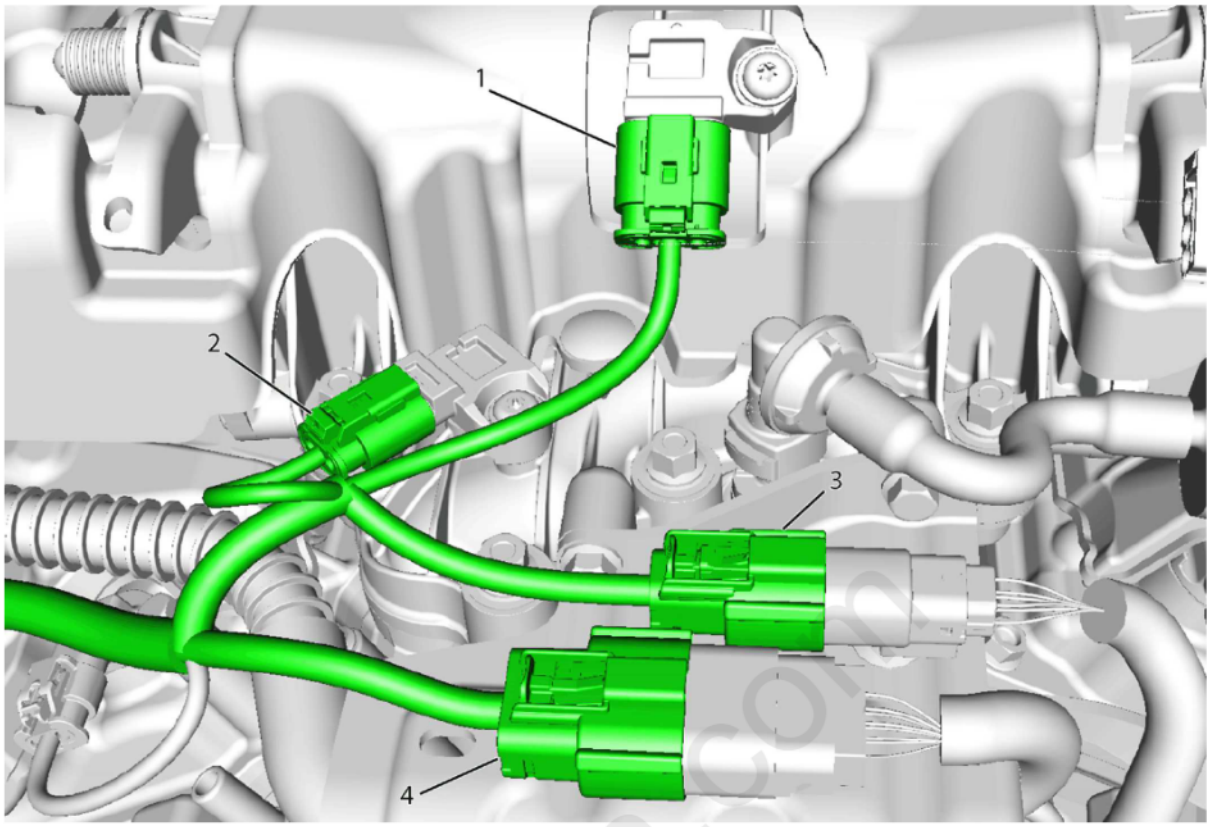


Fig. 22: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

13. Retainer (1)Â» Connect [2x]

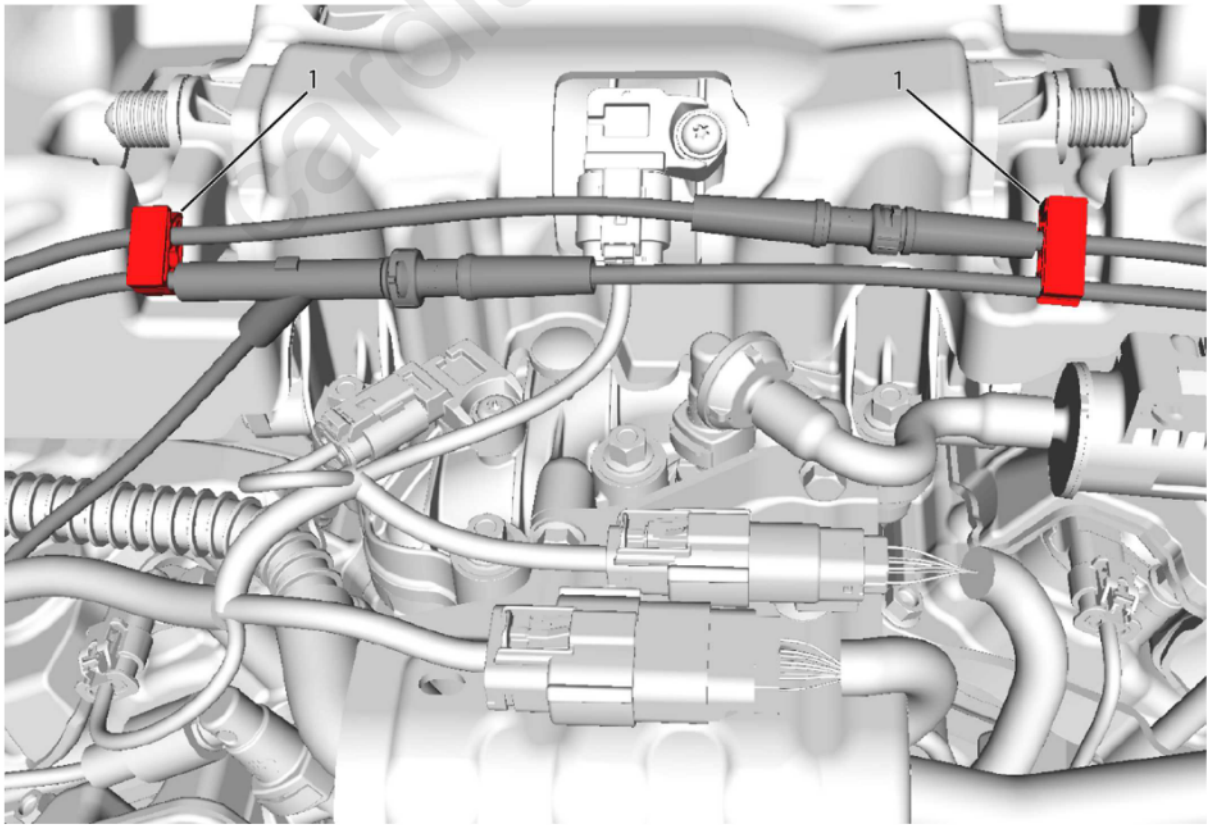


Fig. 23: Retainers
Courtesy of GENERAL MOTORS COMPANY

14. Vacuum Hose (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

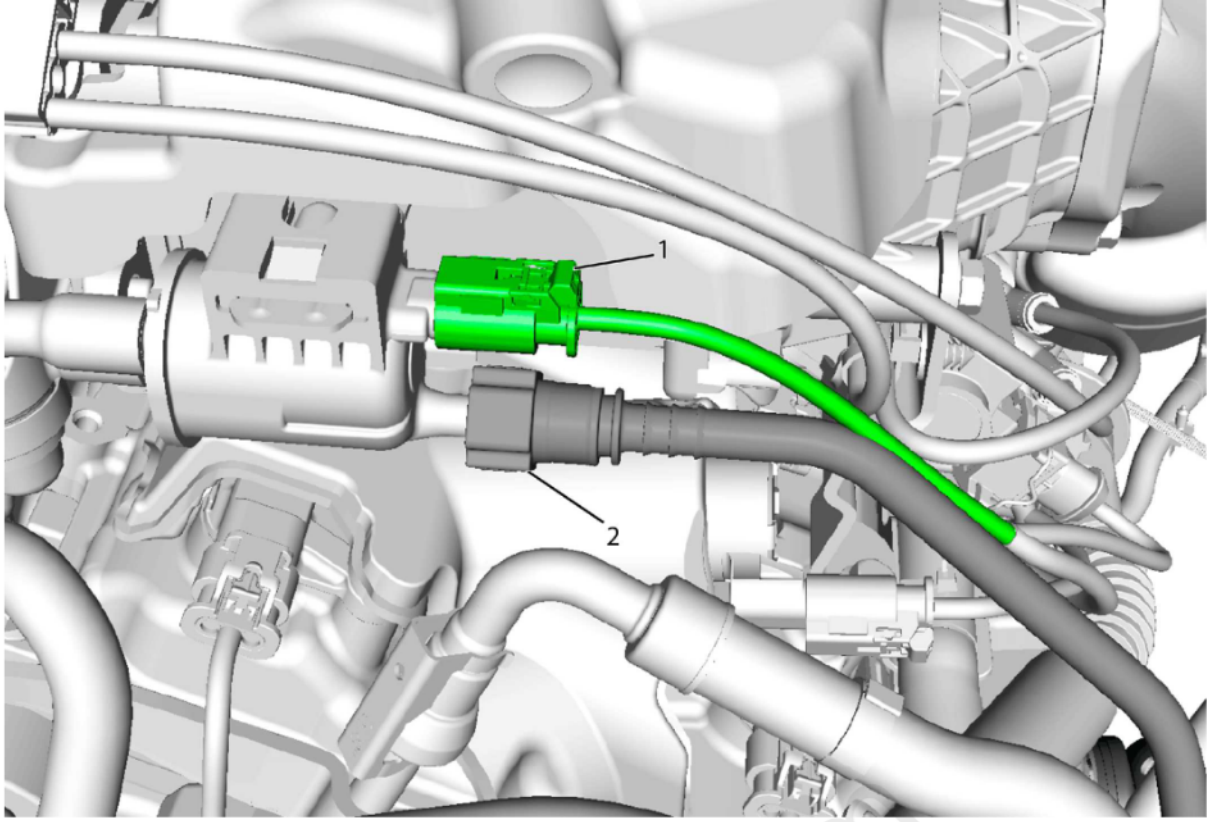


Fig. 24: Harness Connector And Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

15. Harness Connector (1)Â» Connect
16. Charge Air Cooler Coolant HoseÂ» Install - **Charge Air Cooler Coolant Hose Replacement (LGW)**
17. Vacuum Hose (1)Â»Connect - **Plastic Collar Quick Connect Fitting Service**

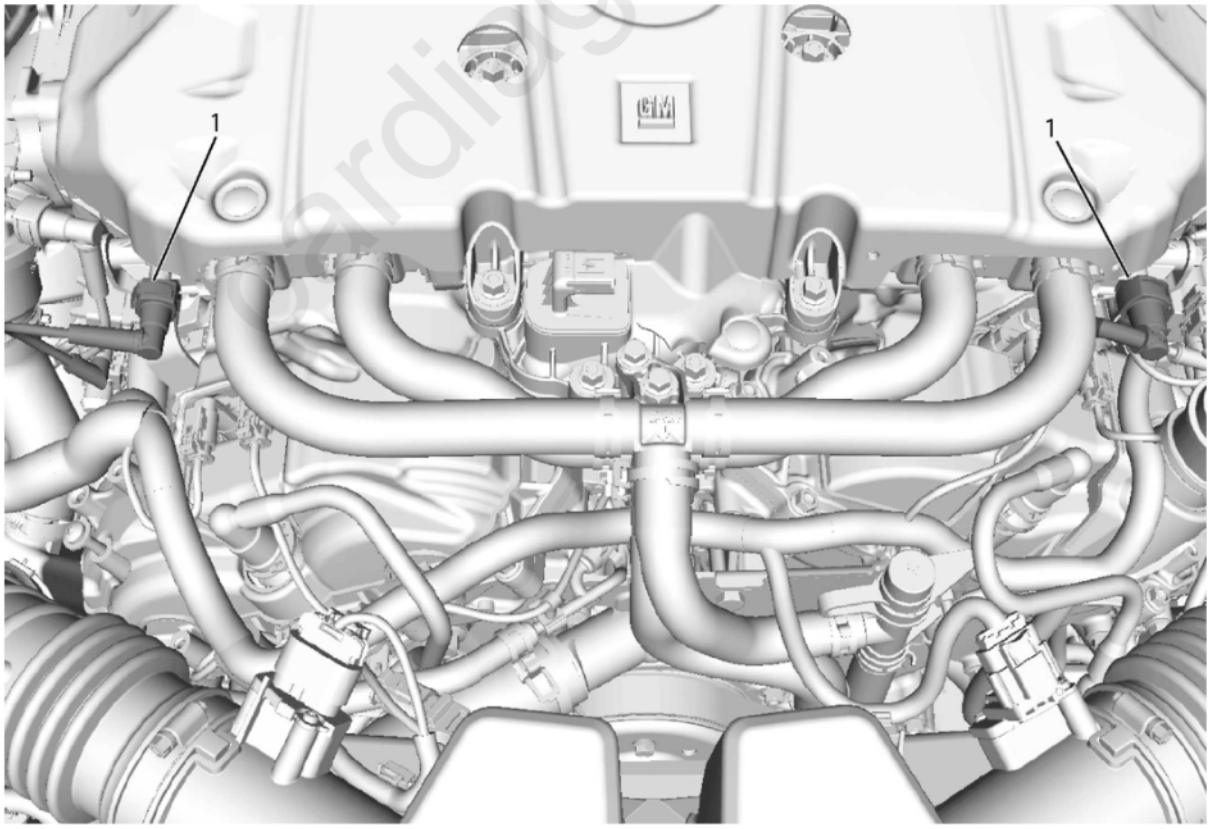


Fig. 25: Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

18. Harness Connector (1)Â» Connect

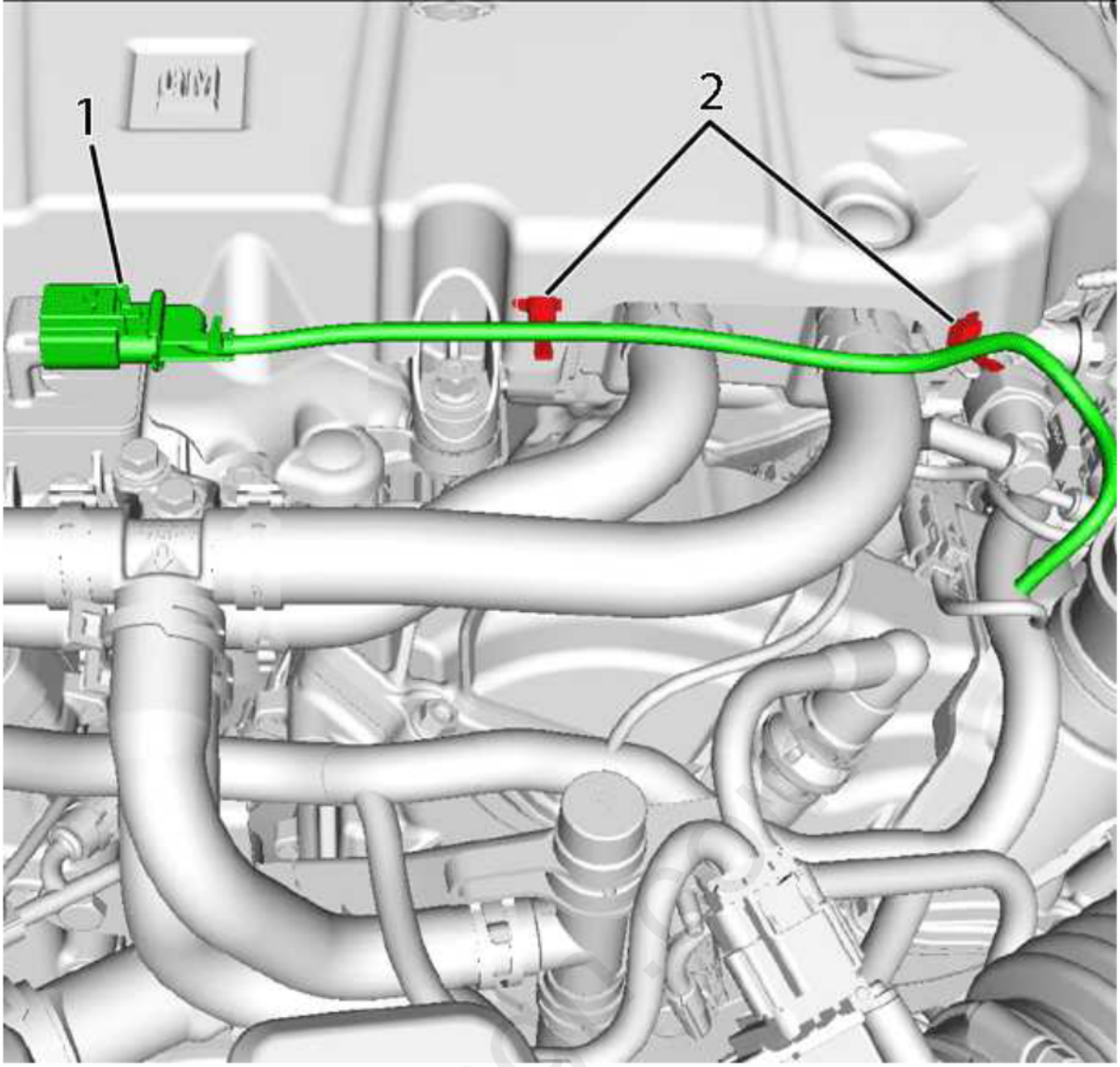


Fig. 26: Harness Connector And Retainer
Courtesy of GENERAL MOTORS COMPANY

19. Retainer (2)Â» Connect [2x]

CHARGE AIR COOLER UPPER INSULATOR REPLACEMENT

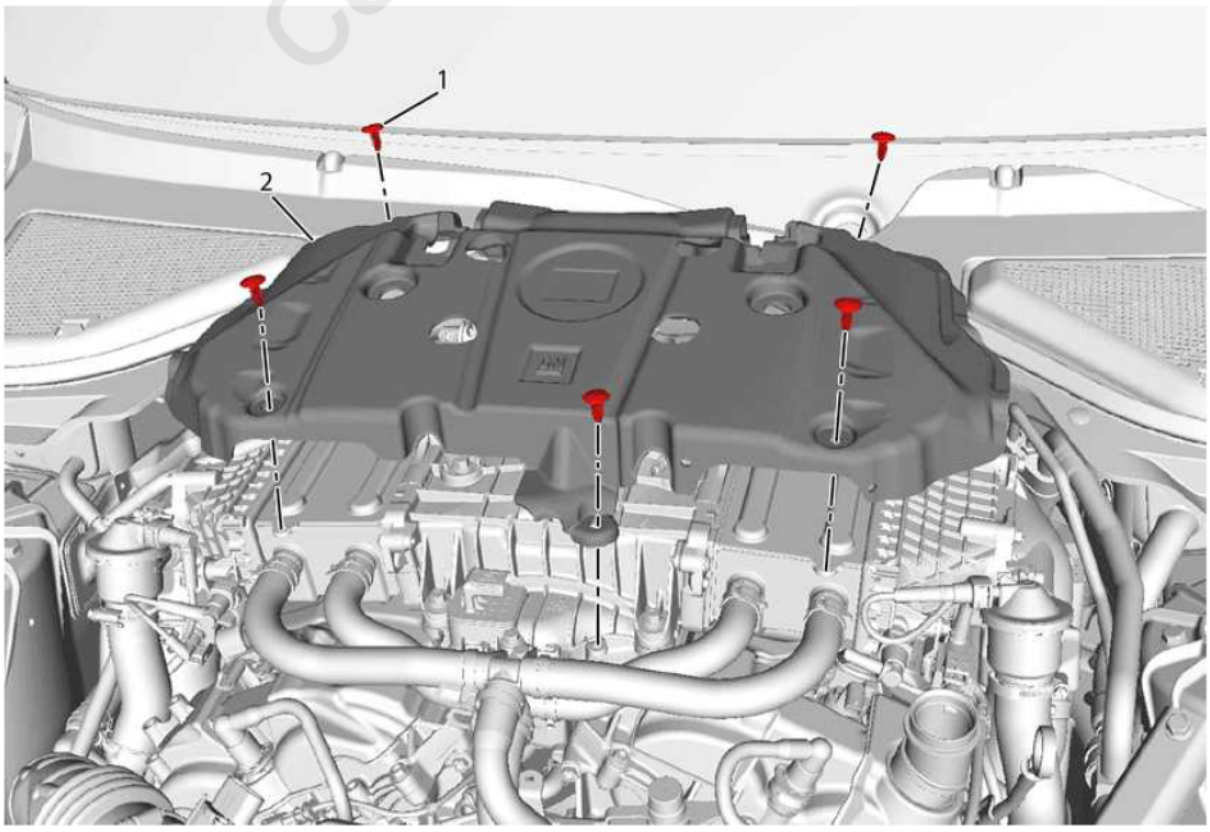


Fig. 27: Charge Air Cooler Upper Insulator
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGW)Intake Manifold Cover Replacement (LGX).	
1	Charge Air Cooler Upper Insulator Retainer [5x]
2	Charge Air Cooler Upper Insulator **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**

ENGINE SUPPORT FIXTURE (LGW)

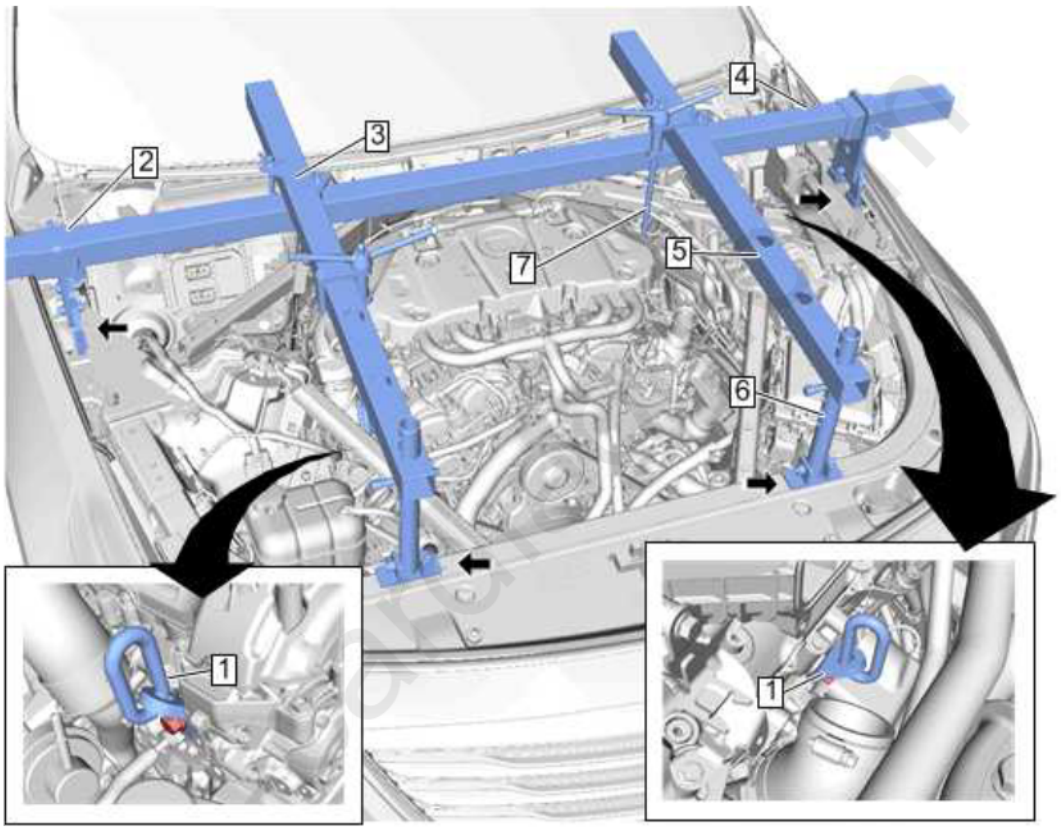


Fig. 28: Engine Support Fixture (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedures 1. **Hood Replacement** 2. **Intake Manifold Cover Replacement (LGW)** 3. **Air Cleaner Assembly Replacement (LGW)** 4. **Air Inlet Grille Panel Replacement** 5. **Charge Air Cooler Inlet Air Tube Replacement (Right Side)** **Charge Air Cooler Inlet Air Tube Replacement (Left Side)** @ Right Side and Left Side **Special Tools** • **EN-36857** Engine Lift Bracket • **EN-51007-1** Main Support Beam • **EN-51007-3** Radiator Support Beam • **EN-51007-4** Clamp • **EN-51007-5** Support Leg, Front • **EN-51007-6** Hook • **EN-51007-7** Support Leg, Side Equivalent regional tools:**Special Tools**	
1	**EN-36857** Engine Lift Bracket **Procedure** Install **EN-36857** Engine Lift Brackets as shown.
2	**EN-51007-7** Support Leg, Side **Procedure** Install the **EN-51007-7** Support Leg, Side to frame as shown. **NOTE:** **Ensure that the engine support fixture only contacts the frame in the area indicated by arrows. Do not install on top of fender lip.**
3	**EN-51007-4** Clamp
4	**EN-51007-1** Main Support Beam
5	**EN-51007-3** Radiator Support Beam
6	**EN-51007-5** Support Leg, Front
7	**EN-51007-6** Hook

ENGINE SUPPORT FIXTURE (LGX)

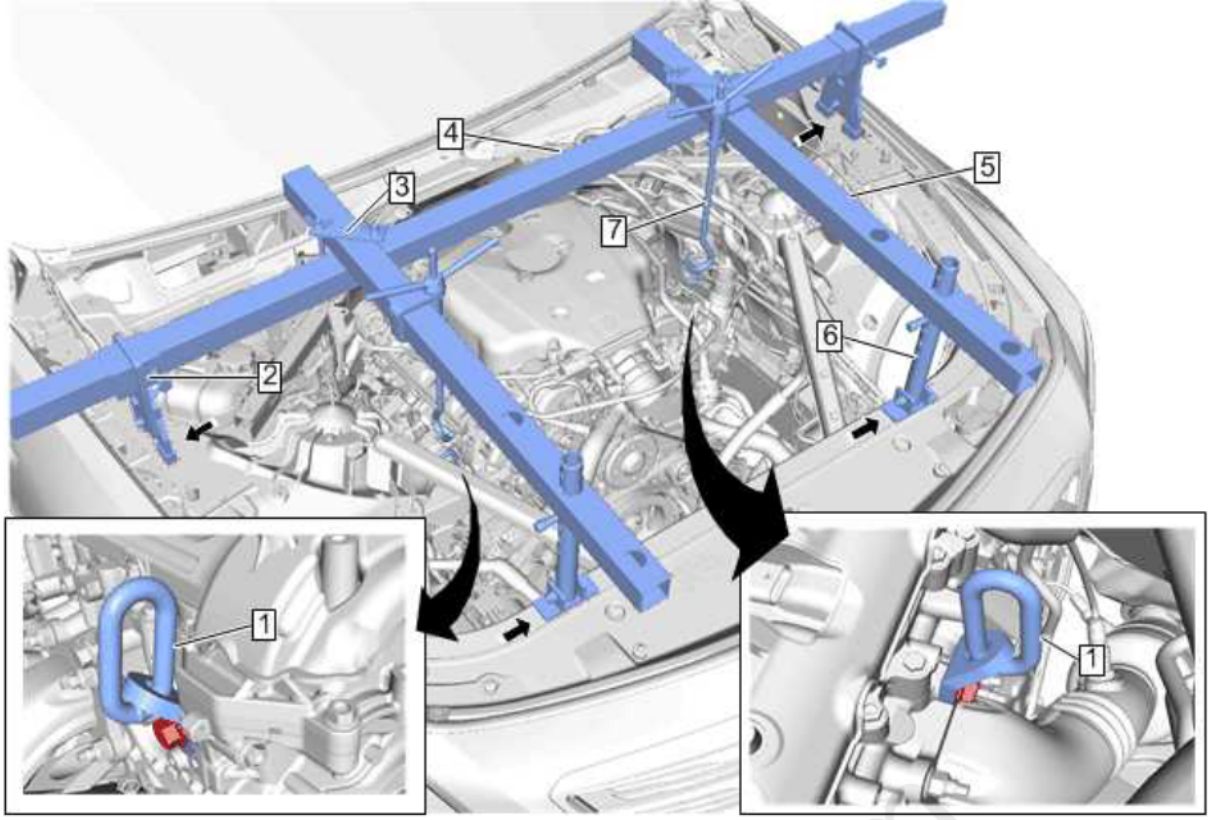


Fig. 29: Engine Support Fixture (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. **Hood Replacement** 2. **Intake Manifold Cover Replacement (LGX)** 3. **Air Cleaner Assembly Replacement (LGX)** 4. **Air Inlet Grille Panel Replacement** **Special Tools** • **EN-36857** Engine Lift Bracket • **EN-51007-1** Main Support Beam • **EN-51007-3** Radiator Support Beam • **EN-51007-4** Clamp • **EN-51007-5** Support Leg, Front • **EN-51007-6** Hook • **EN-51007-7** Support Leg, Side Equivalent regional tools:**Special Tools**	
1	**EN-36857** Engine Lift Bracket **Procedure** Install **EN-36857** Engine Lift Brackets as shown.
2	**EN-51007-7** Support Leg, Side **Procedure** Install the **EN-51007-7** Support Leg, Side to frame as shown. **NOTE:** **Ensure that the engine support fixture only contacts the frame in the area indicated by arrows. Do not install on top of fender lip.**
3	**EN-51007-4** Clamp
4	**EN-51007-1** Main Support Beam

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Callout	Component Name
5	**EN-51007-3** Radiator Support Beam
6	**EN-51007-5** Support Leg, Front
7	**EN-51007-6** Hook

ENGINE MOUNT INSPECTION

1. Install the engine support fixture. Refer to **Engine Support Fixture (LGW)** and/or **Engine Support Fixture (LGX)**. Raising the engine removes the weight from the engine mount and creates slight tension in the rubber.

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

2. Observe the engine mount while raising the engine. Replace the engine mount if the engine mount exhibits any of the following conditions:
   - The hard rubber surface is covered with heat check cracks.
   - The rubber is separated from the metal plate of the engine mount.
   - The rubber is split through the center of the engine mount.
   - The GLYCOL™ fluid is leaking from the engine mount.
3. If there is movement between the metal plate of the engine mount and its attaching points, lower the engine on the engine mount. Tighten the bolts or nuts attaching the engine mount to the frame or engine mount bracket. Refer to **Engine Mount Replacement - Left Side** or **Engine Mount Replacement - Right Side**.

POWERTRAIN MOUNT BALANCING

Removal Procedure

1. Engine Mount Nut (1)Â» Loosen

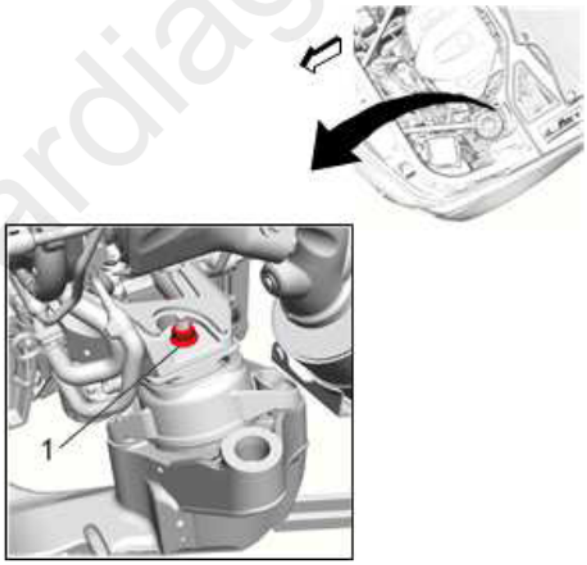


Fig. 30: Engine Mount Nut
Courtesy of GENERAL MOTORS COMPANY

2. Engine Mount Nut (1)Â» Loosen

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Fig. 31: Engine Mount Nut
Courtesy of GENERAL MOTORS COMPANY

3. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle**
4. Transmission Support Crossmember Bolt (1)Â» Loosen

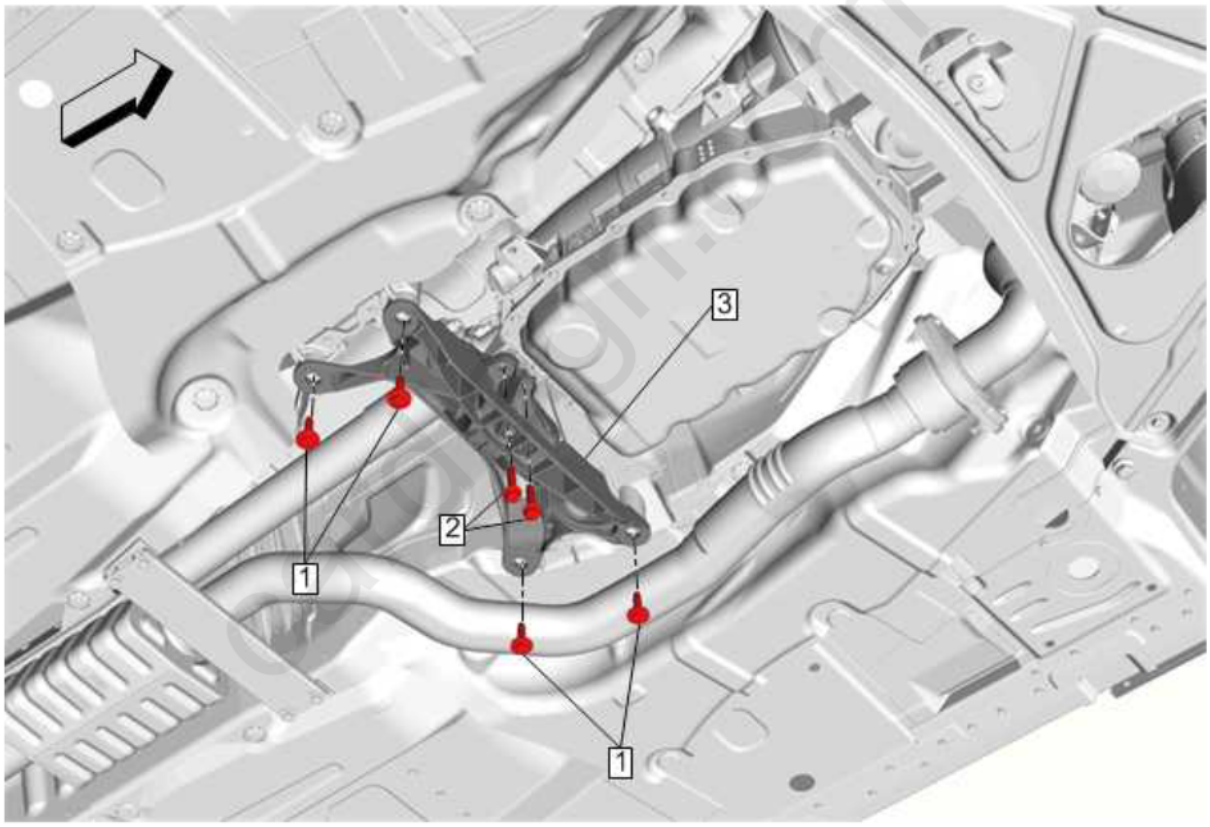


Fig. 32: Transmission Support Crossmember
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Loosen ONLY bolts (1) all others should remain tightened.**

5. Carefully shake transmission crossbar toward the rear of the transmission to neutralize mounts.

Installation Procedure

1. Transmission Support Crossmember Bolt (1)Â» Tighten - **Transmission Support Crossmember Replacement (LTG)**

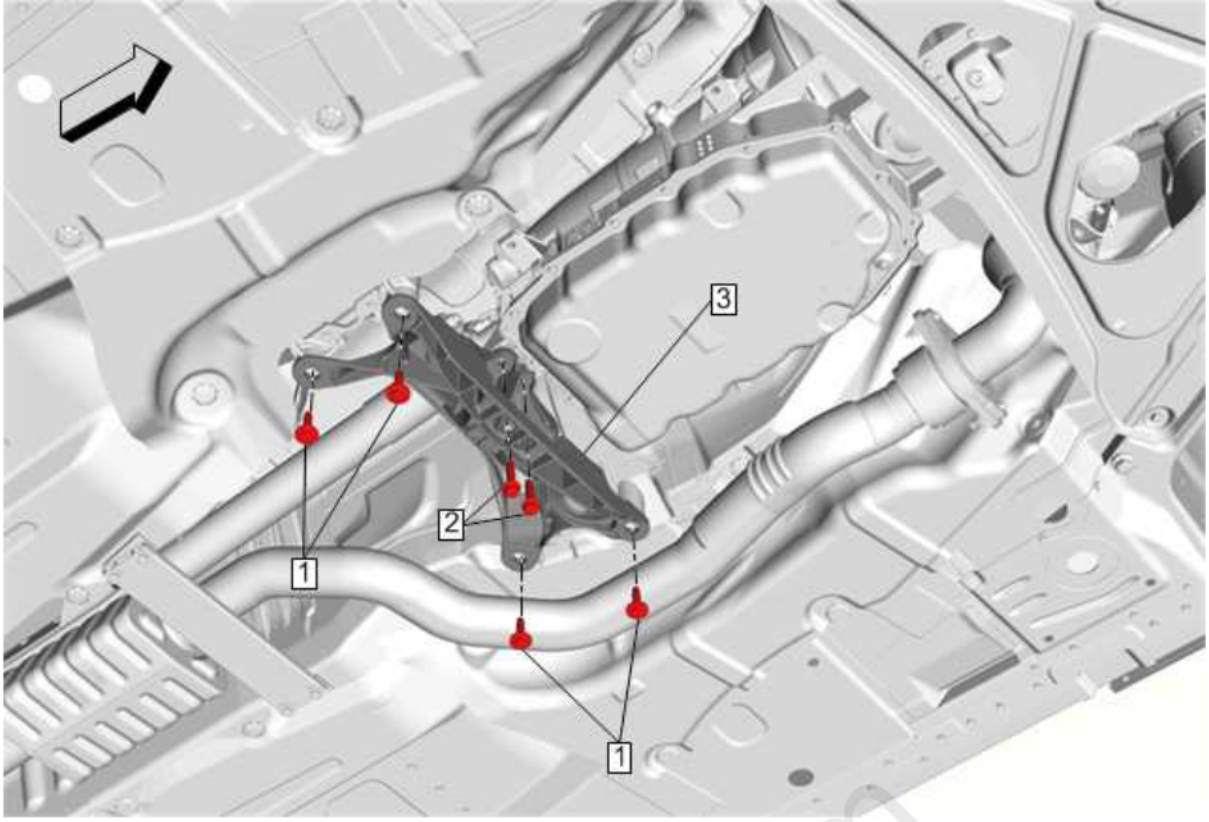


Fig. 33: Transmission Support Crossmember
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Lower the vehicle. Refer to Lifting and Jacking the Vehicle
3. Engine Mount Nut (1)Â» Tighten - Drivetrain and Front Suspension Cradle Removal and Installation



Fig. 34: Engine Mount Nut
Courtesy of GENERAL MOTORS COMPANY

4. Engine Mount Nut (1)Â» Tighten - Drivetrain and Front Suspension Cradle Removal and Installation

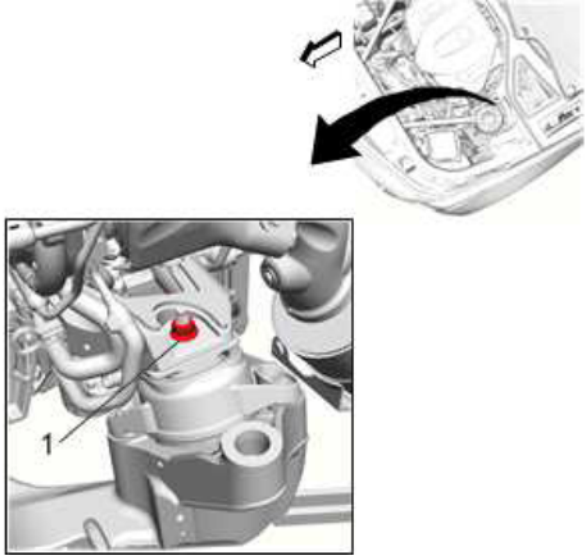


Fig. 35: Engine Mount Nut
Courtesy of GENERAL MOTORS COMPANY

ENGINE MOUNT REPLACEMENT - LEFT SIDE

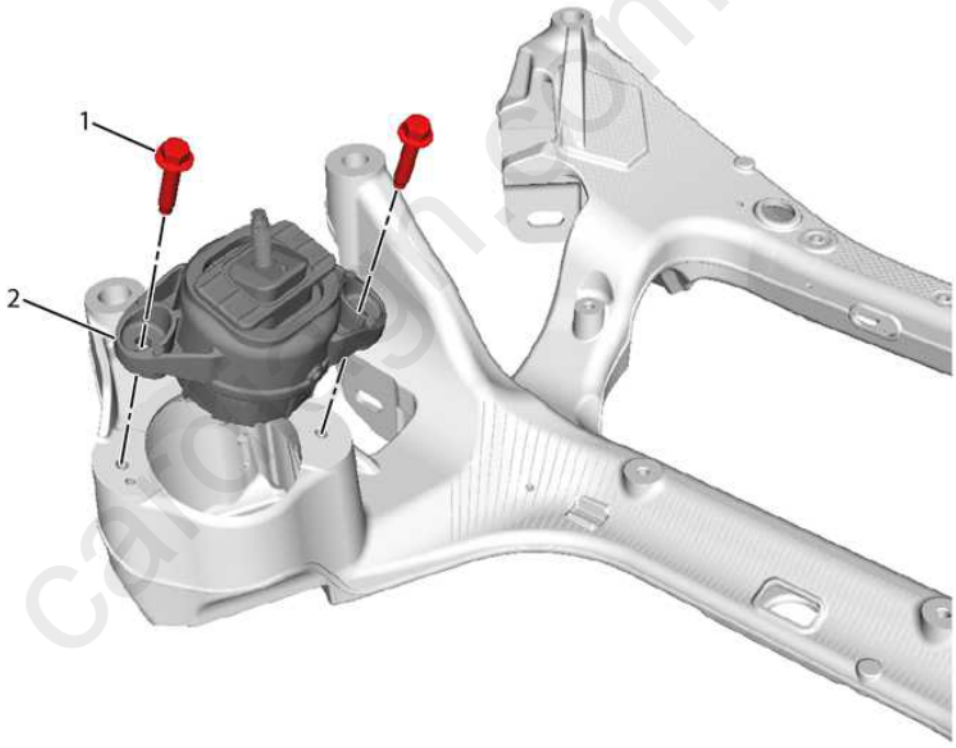


Fig. 36: Engine Mount - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Engine Mount Bracket Replacement - Left Side (LGW)Engine Mount Bracket Replacement - Left Side (LGX)	
1	Engine Mount Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 58 N.m (43 lb ft)
2	Engine Mount

ENGINE MOUNT REPLACEMENT - RIGHT SIDE

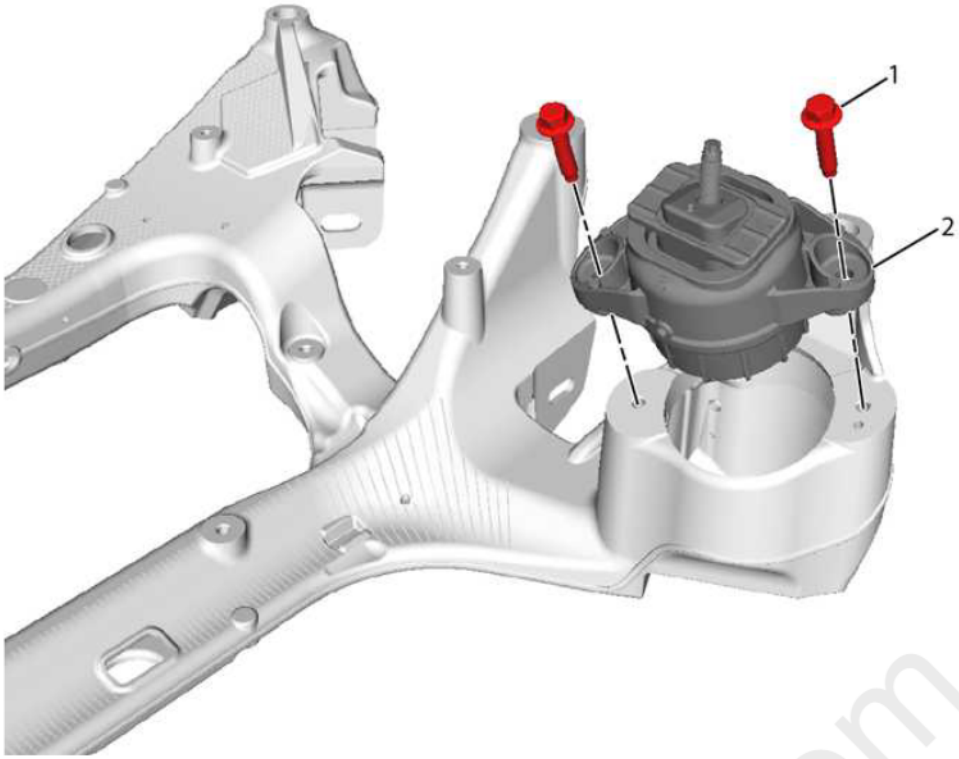


Fig. 37: Engine Mount - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure **Drivetrain and Front Suspension Cradle Removal and Installation**	
1	Engine Mount Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 58 N.m (43 lb ft)
2	Engine Mount

ENGINE MOUNT BRACKET REPLACEMENT - LEFT SIDE (LGW)

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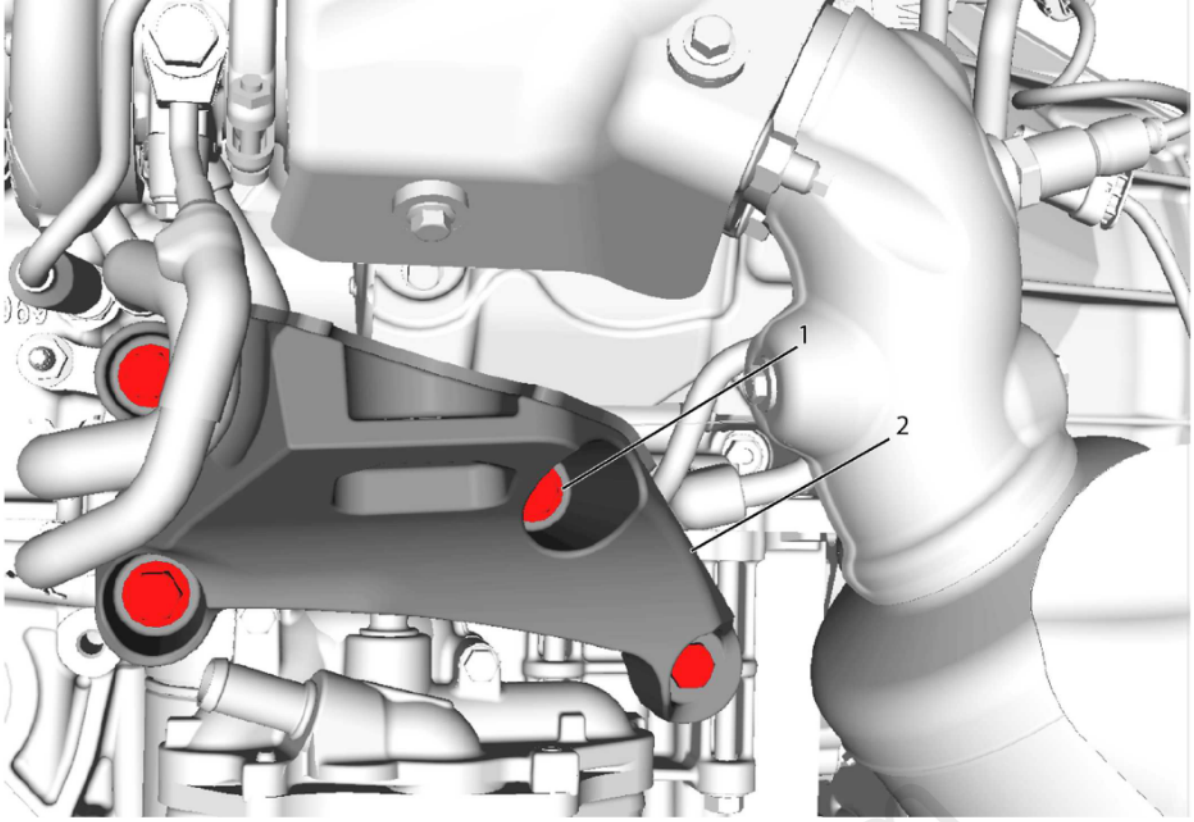


Fig. 38: Engine Mount Bracket - Left Side (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Drivetrain and Front Suspension Cradle Removal and Installation	
1	Engine Mount Bracket Fastener (Qty: 4) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 58 N.m (43 lb ft)
2	Engine Mount Bracket **NOTE:** **Engine mount brackets are magnesium. To prevent galvanic corrosion, the bracket includes pressed on spacers on the back side. Even though it is highly unlikely, the pressed on spacers may loosen and fall off during engine mount bracket removal. Ensure the spacers are in place before reinstalling an existing bracket.**

ENGINE MOUNT BRACKET REPLACEMENT - LEFT SIDE (LGX)

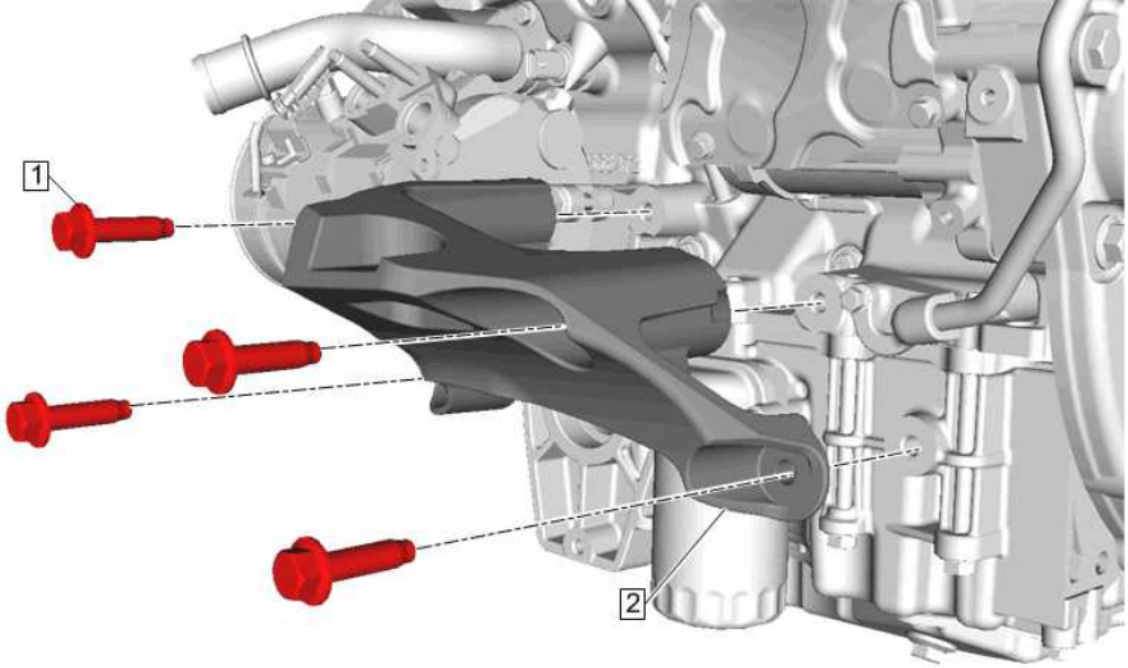


Fig. 39: Engine Mount Bracket - Left Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Front Wheelhouse Liner Replacement 2. Warm Up Three-Way Catalytic Converter Replacement (Left, LGX) Warm Up Three-Way Catalytic Converter Replacement (Right, LGX) 3. Engine Support Fixture (LGX) 4. Engine Mount Nut-Left SideÂ» Remove - Drivetrain and Front Suspension Cradle Removal and Installation	
1	Engine Mount Bracket Fastener (Qty: 4) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 58 N.m (43 lb ft)
2	Engine Mount Bracket **Procedure** Using engine support fixture, raise the powertrain enough to remove the engine mount bracket. **NOTE:** **Engine mount brackets are magnesium. To prevent galvanic corrosion, the bracket includes pressed on spacers on the back side. Even though it is highly unlikely, the pressed on spacers may loosen and fall off during engine mount bracket removal. Ensure the spacers are in place before reinstalling an existing bracket.**

ENGINE MOUNT BRACKET REPLACEMENT - RIGHT SIDE (LGW)

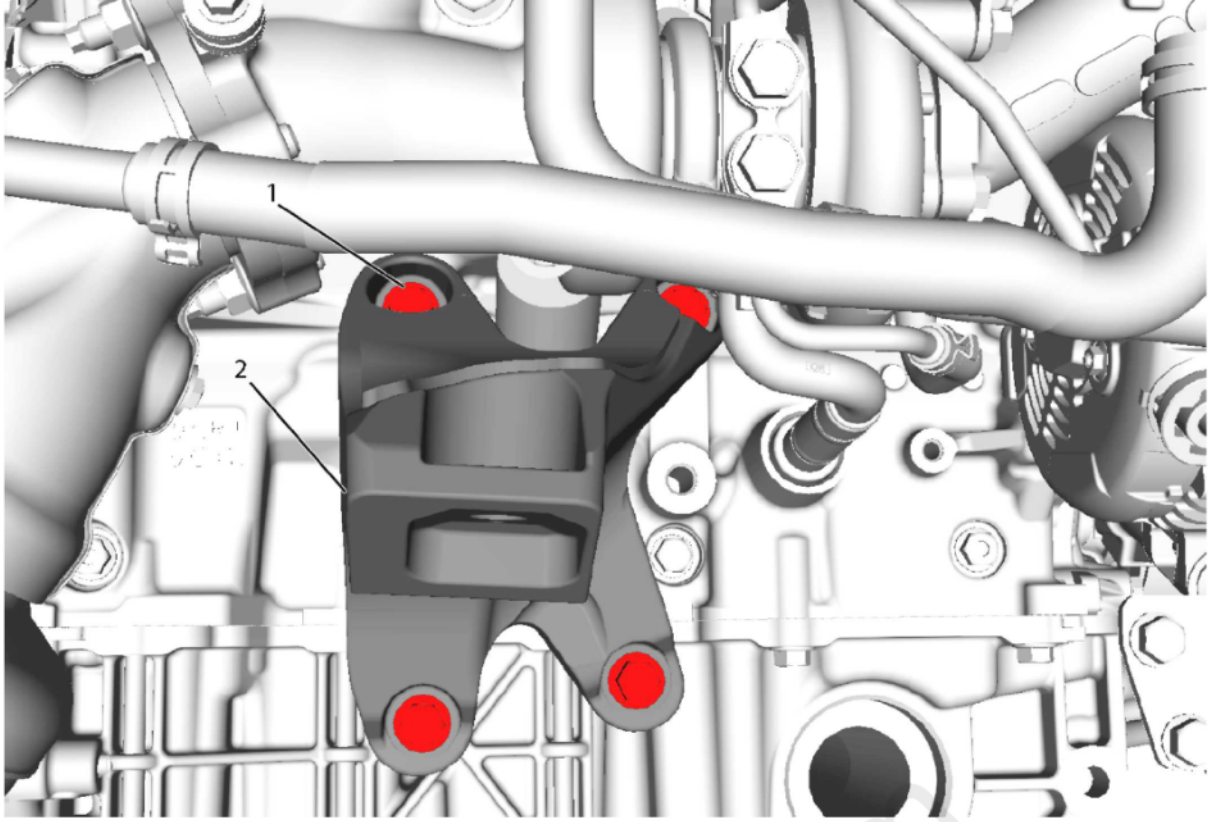


Fig. 40: Engine Mount Bracket - Right Side (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Front Differential Carrier Assembly Replacement 2. Turbocharger Heat Shield Replacement (Left, LGW) Turbocharger Heat Shield Replacement (Right, LGW)	
1	Engine Mount Bracket Fastener [4x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 58 N.m (43 lb ft)
2	Engine Mount Bracket **NOTE:** **Engine mount brackets are magnesium. To prevent galvanic corrosion, the bracket includes pressed on spacers on the back side. Even though it is highly unlikely, the pressed on spacers may loosen and fall off during engine mount bracket removal. Ensure the spacers are in place before reinstalling an existing bracket.**

ENGINE MOUNT BRACKET REPLACEMENT - RIGHT SIDE (LGX)

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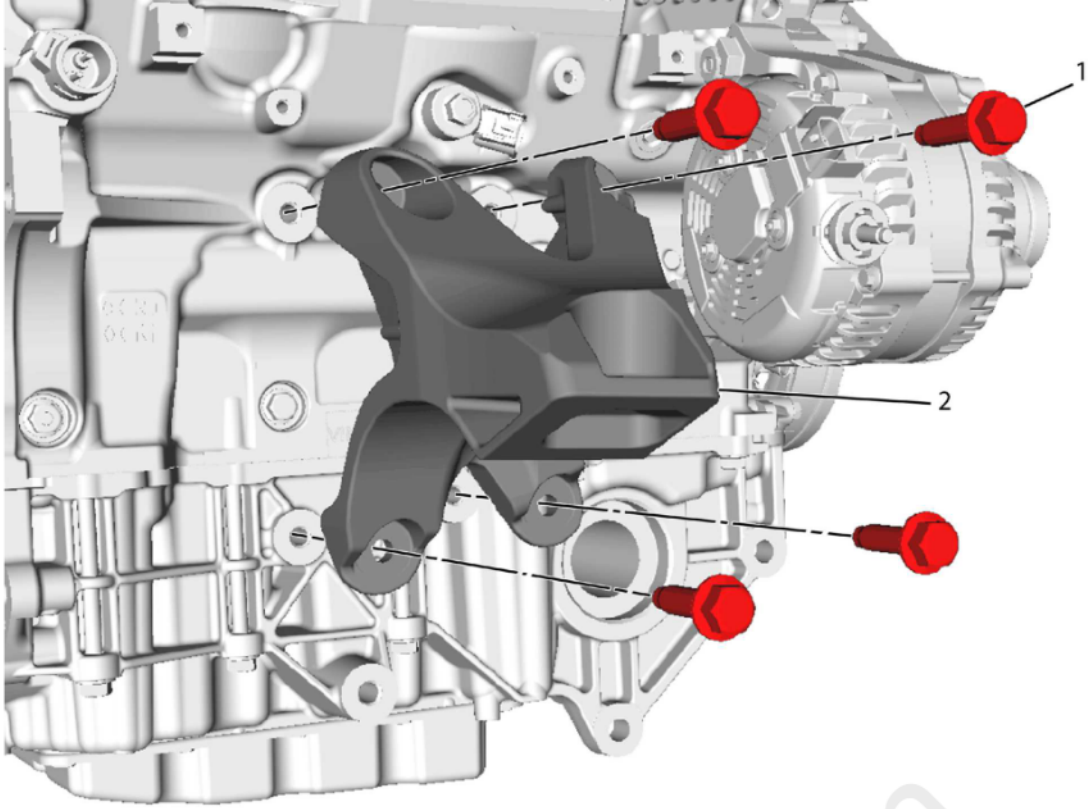


Fig. 41: Engine Mount Bracket - Right Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Drivetrain and Front Suspension Cradle Removal and Installation 2. Warm Up Three-Way Catalytic Converter Replacement (Left, LGX) Warm Up Three-Way Catalytic Converter Replacement (Right, LGX) 3. Front Differential Carrier Assembly Replacement	
1	Engine Mount Bracket Fastener [4x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 58 N.m (43 lb ft)
2	Engine Mount Bracket **NOTE:** **Engine mount brackets are magnesium. To prevent galvanic corrosion, the bracket includes pressed on spacers on the back side. Even though it is highly unlikely, the pressed on spacers may loosen and fall off during engine mount bracket removal. Ensure the spacers are in place before reinstalling an existing bracket.** **Procedure** Detach the wiring harness and remove bracket.

INTAKE MANIFOLD COVER REPLACEMENT (LGW)

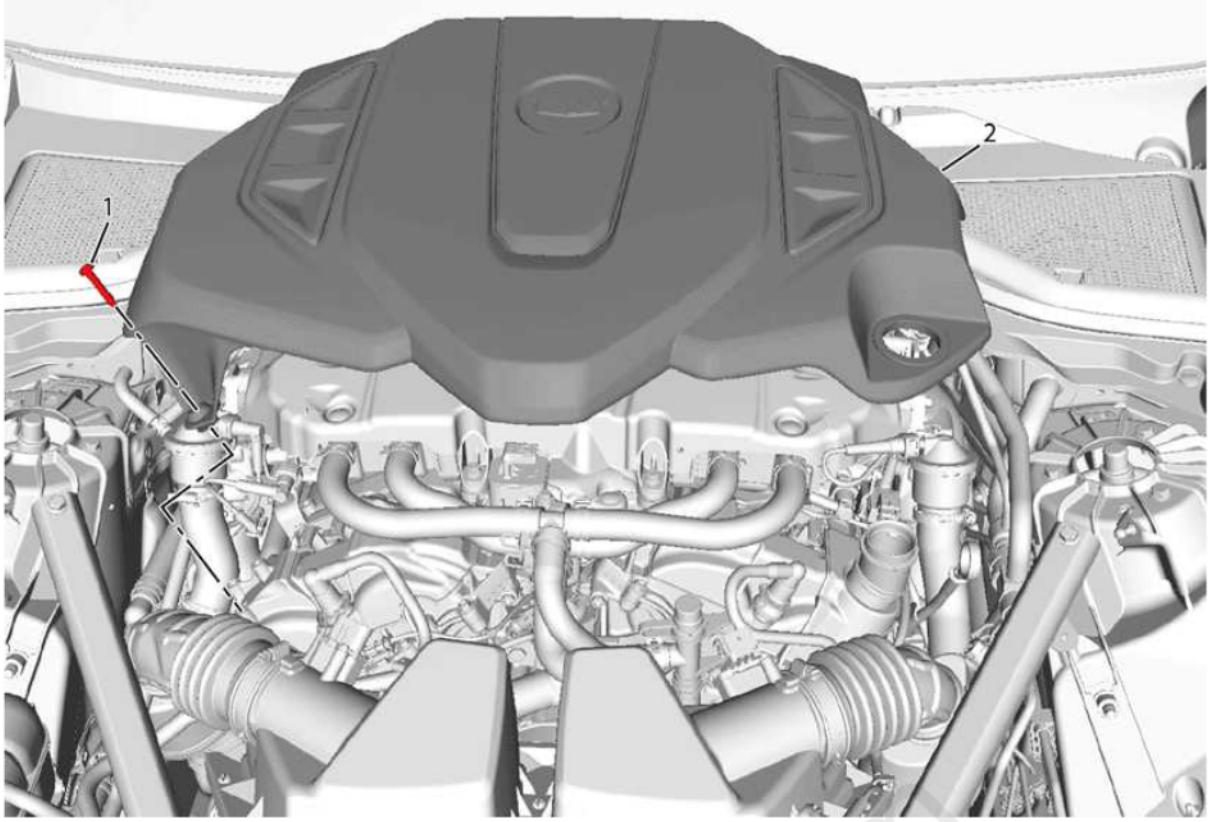


Fig. 42: Intake Manifold Cover (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the oil fill cap.	
1	Intake Manifold Cover Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Intake Manifold Cover **Procedure** Pull the intake manifold cover upward to remove.

INTAKE MANIFOLD COVER REPLACEMENT (LGX)

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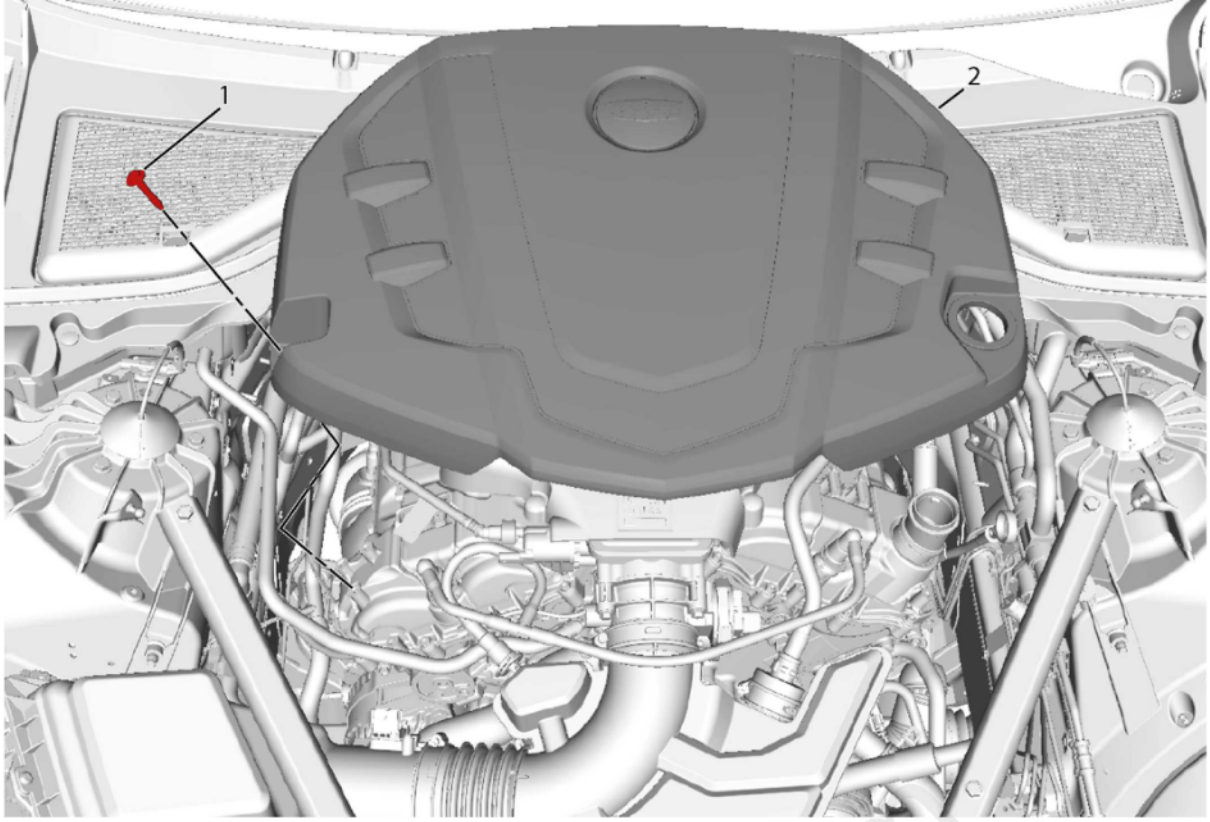


Fig. 43: Intake Manifold Cover (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the oil fill cap.	
1	Intake Manifold Cover Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Intake Manifold Cover **Procedure** Pull the intake manifold cover upward to remove.

INTAKE MANIFOLD INSULATOR REPLACEMENT (LGX)

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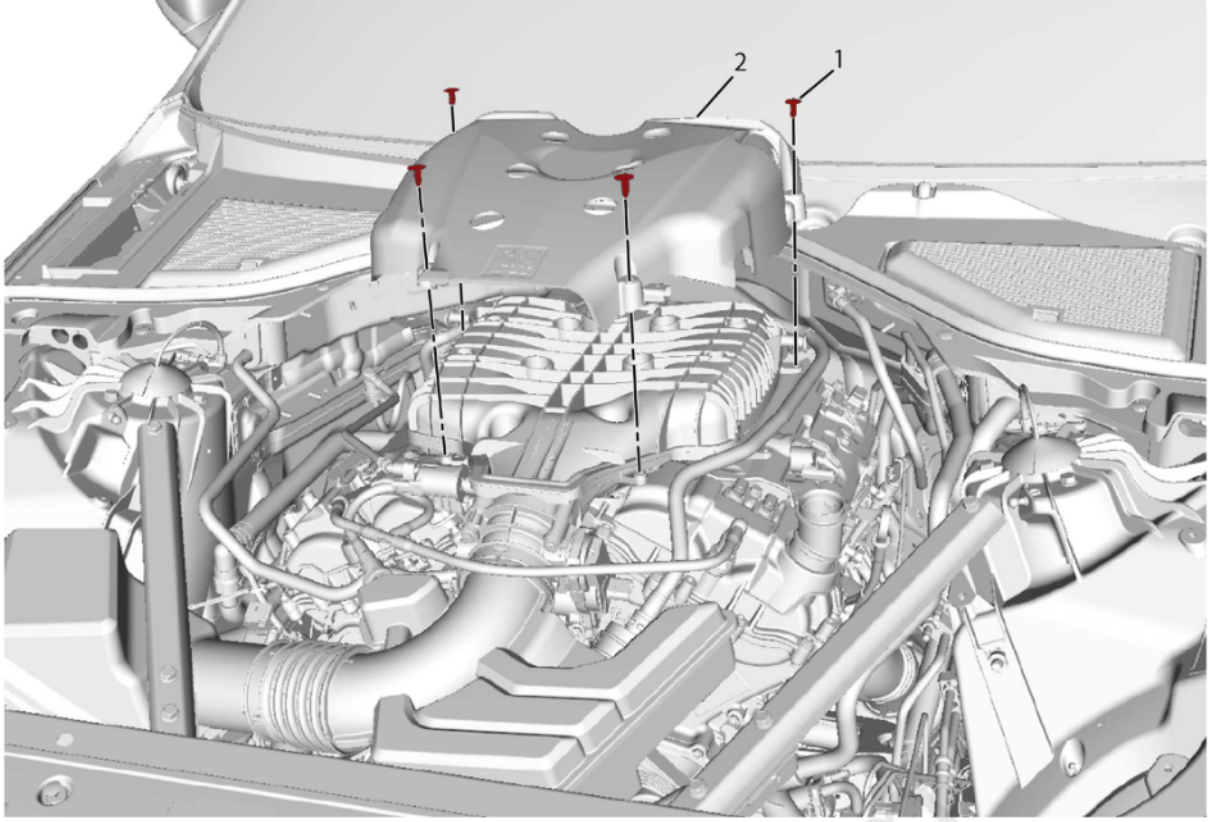


Fig. 44: Intake Manifold Insulator (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Intake Manifold Cover Replacement (LGX) 2. Manifold Absolute Pressure Sensor Electrical ConnectorÂ» Disconnect	
1	Intake Manifold Insulator Retainer
2	Intake Manifold Insulator **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT (LGW)

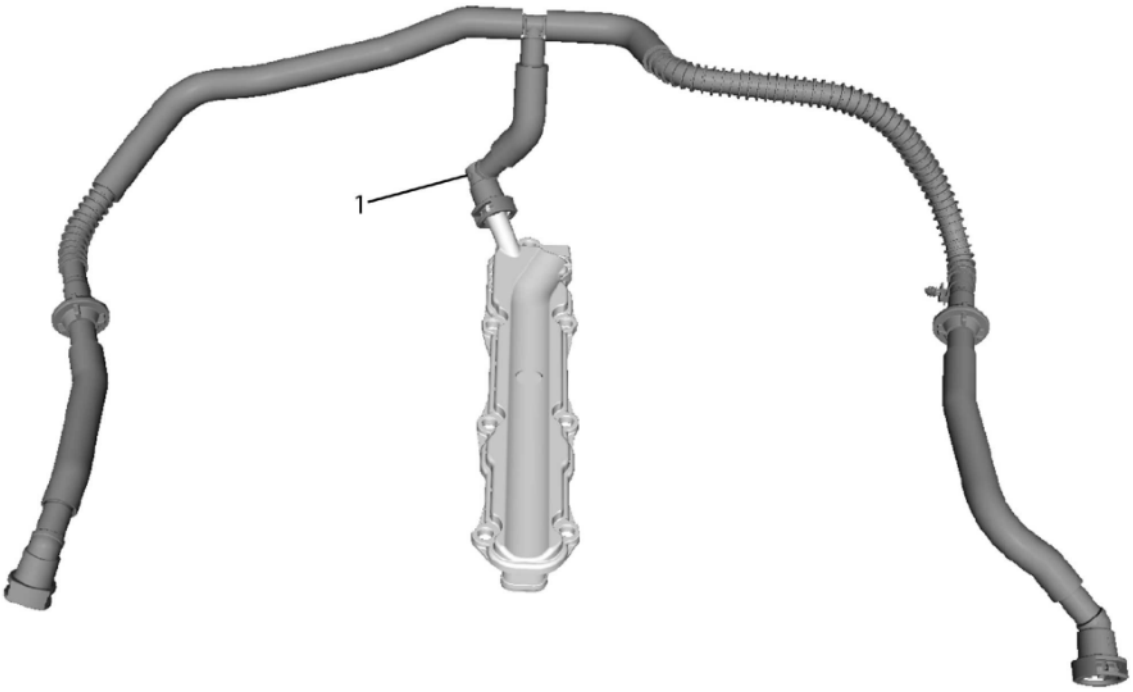


Fig. 45: Positive Crankcase Ventilation Hose/Pipe/Tube (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Positive Crankcase Ventilation Oil Separator Replacement (LGW)	
1	Positive Crankcase Ventilation Tube **CAUTION:** **The Positive Crankcase Ventilation (PCV) line is tamper resistant and must always be replaced once it is removed. The fittings connected to the PCV line must also be replaced if they are damaged when the PCV line is removed. To reduce the risk of damage to the fittings, use a suitable cutting tool and carefully cut the connections away.** **Procedure** Using a suitable cutting tool, carefully cut the PCV tube away from the PCV oil separator. If any damage occurs to the PCV oil separator it must be replaced.

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT (LGX)

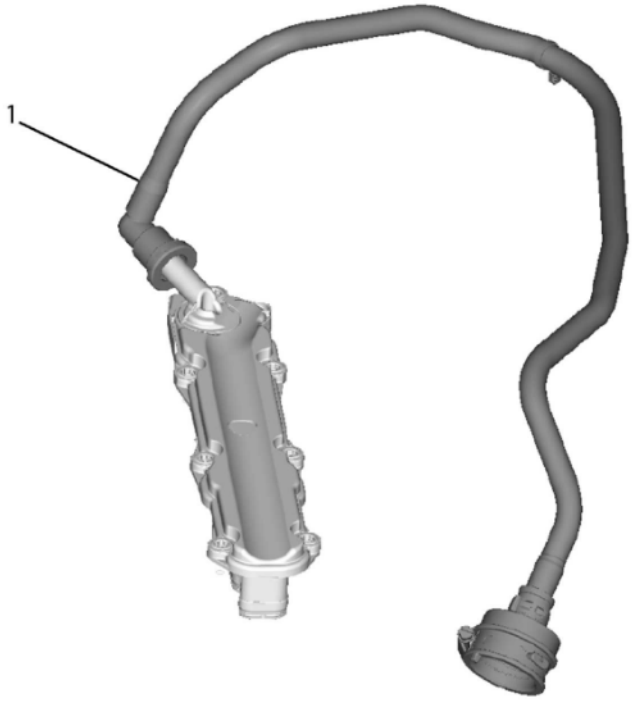


Fig. 46: Positive Crankcase Ventilation Hose/Pipe/Tube (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure **Positive Crankcase Ventilation Oil Separator Replacement (LGX)**	
1	Positive Crankcase Ventilation Tube **CAUTION:** **The Positive Crankcase Ventilation (PCV) line is tamper resistant and must always be replaced once it is removed. The fittings connected to the PCV line must also be replaced if they are damaged when the PCV line is removed. To reduce the risk of damage to the fittings, use a suitable cutting tool and carefully cut the connections away.** **Procedure** Using a suitable cutting tool, carefully cut the PCV tube away from the PCV oil separator. If any damage occurs to the PCV oil separator it must be replaced.

POSITIVE CRANKCASE VENTILATION OIL SEPARATOR REPLACEMENT (LGW)

Removal Procedure

1. Air Cleaner Outlet Front Duct (5)Â» Remove - **Air Cleaner Outlet Front Duct Replacement (LGW)**

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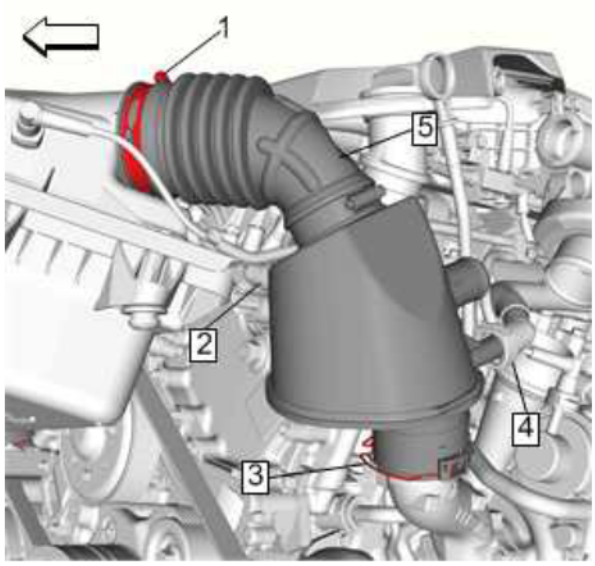


Fig. 47: Air Cleaner Outlet Front Duct
Courtesy of GENERAL MOTORS COMPANY

2. Air Cleaner Outlet Rear Duct (5)Â» Remove - **Air Cleaner Outlet Rear Duct Replacement (LGW)**

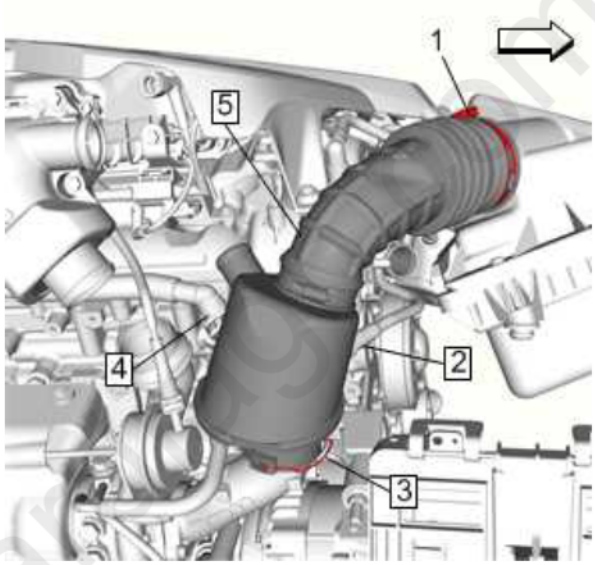


Fig. 48: Air Cleaner Outlet Rear Duct
Courtesy of GENERAL MOTORS COMPANY

3. Fuel Feed Intermediate Pipe (2)Â» Remove - **Fuel Feed Intermediate Pipe Replacement (LGW)**

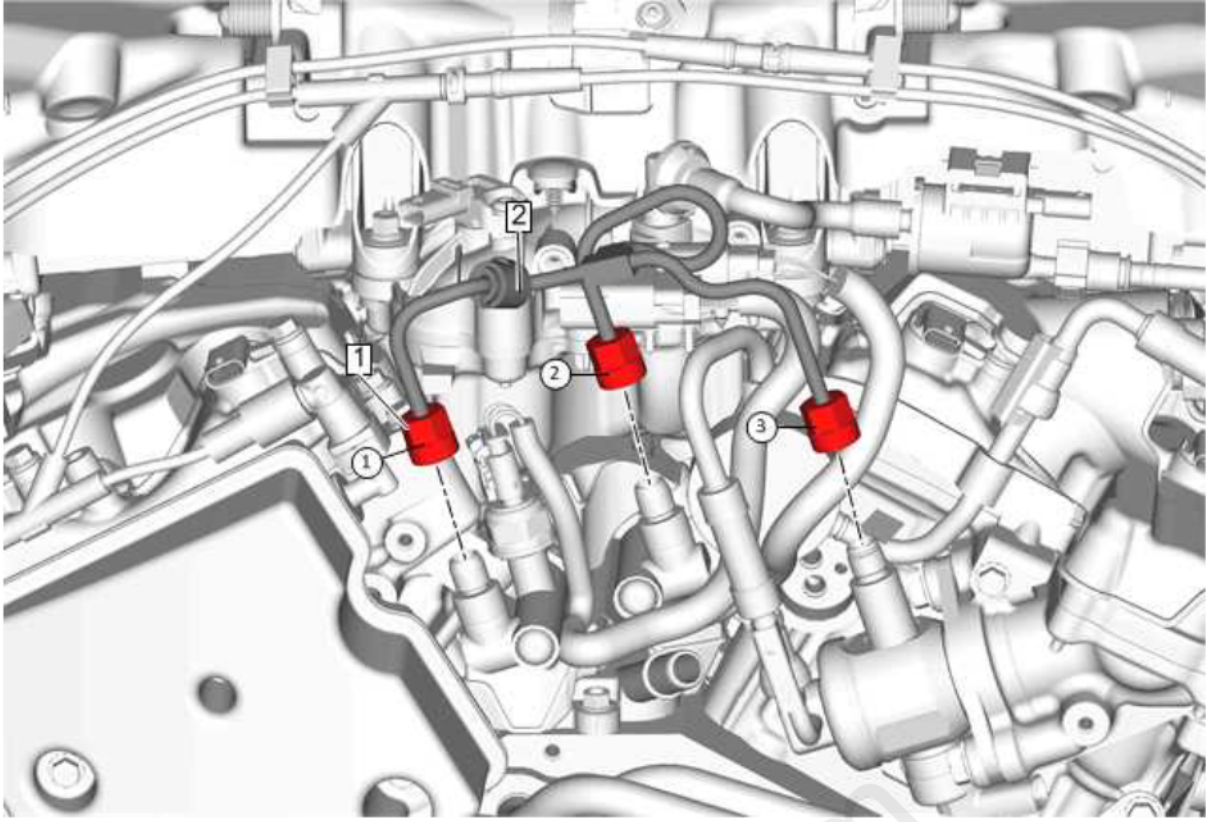


Fig. 49: Fuel Feed Intermediate Pipe
Courtesy of GENERAL MOTORS COMPANY

4. Fuel Injection Fuel Rail AssemblyÂ» Remove - **Fuel Injection Fuel Rail Assembly Replacement - Bank 1**
5. Fuel Injection Fuel Rail AssemblyÂ» Remove - **Fuel Injection Fuel Rail Assembly Replacement - Bank 2**
6. Positive Crankcase Ventilation Oil Separator Bolt (1) @ Positive Crankcase Ventilation Oil Separator (2)Â» Remove [7x]

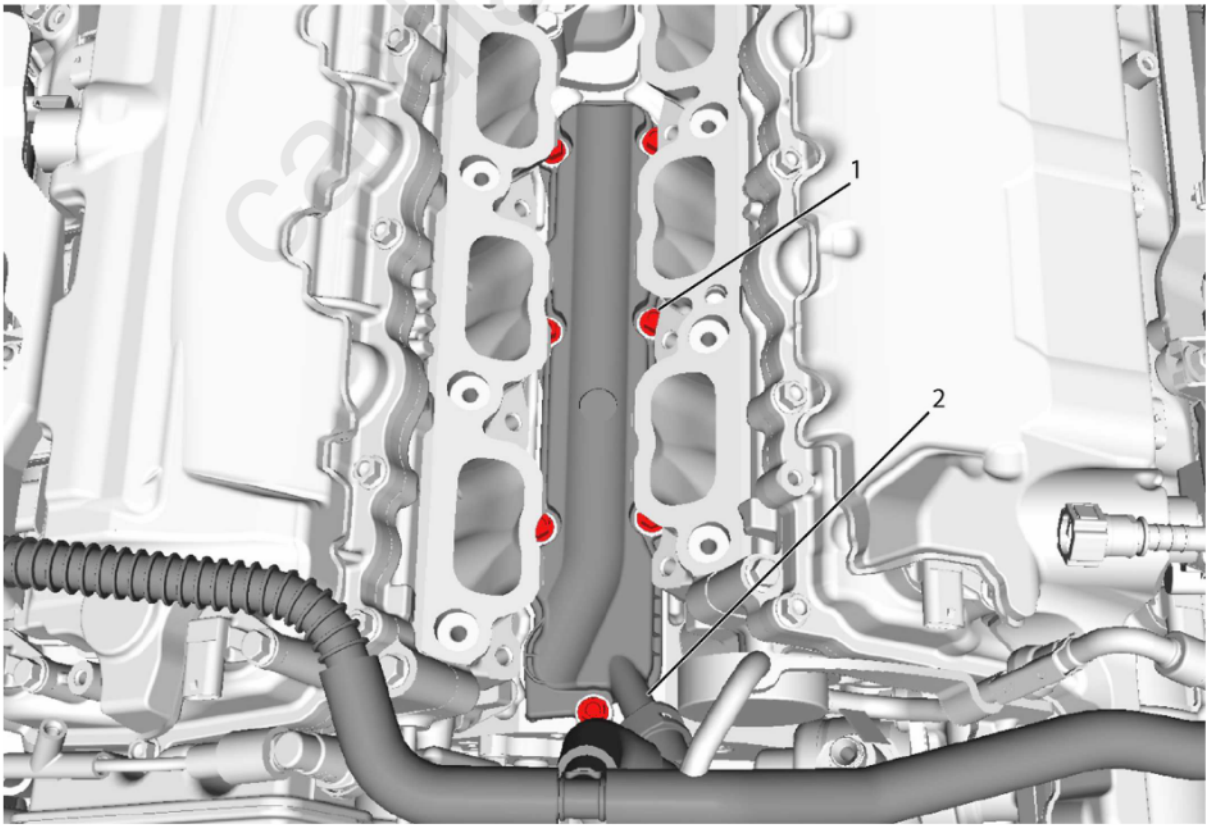


Fig. 50: Positive Crankcase Ventilation Oil Separator Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Positive Crankcase Ventilation Oil Separator (2)Â» Remove

Installation Procedure

1. Positive Crankcase Ventilation Oil Separator (2)Â» Install - **Positive Crankcase Ventilation Oil Separator Installation (LGW)**

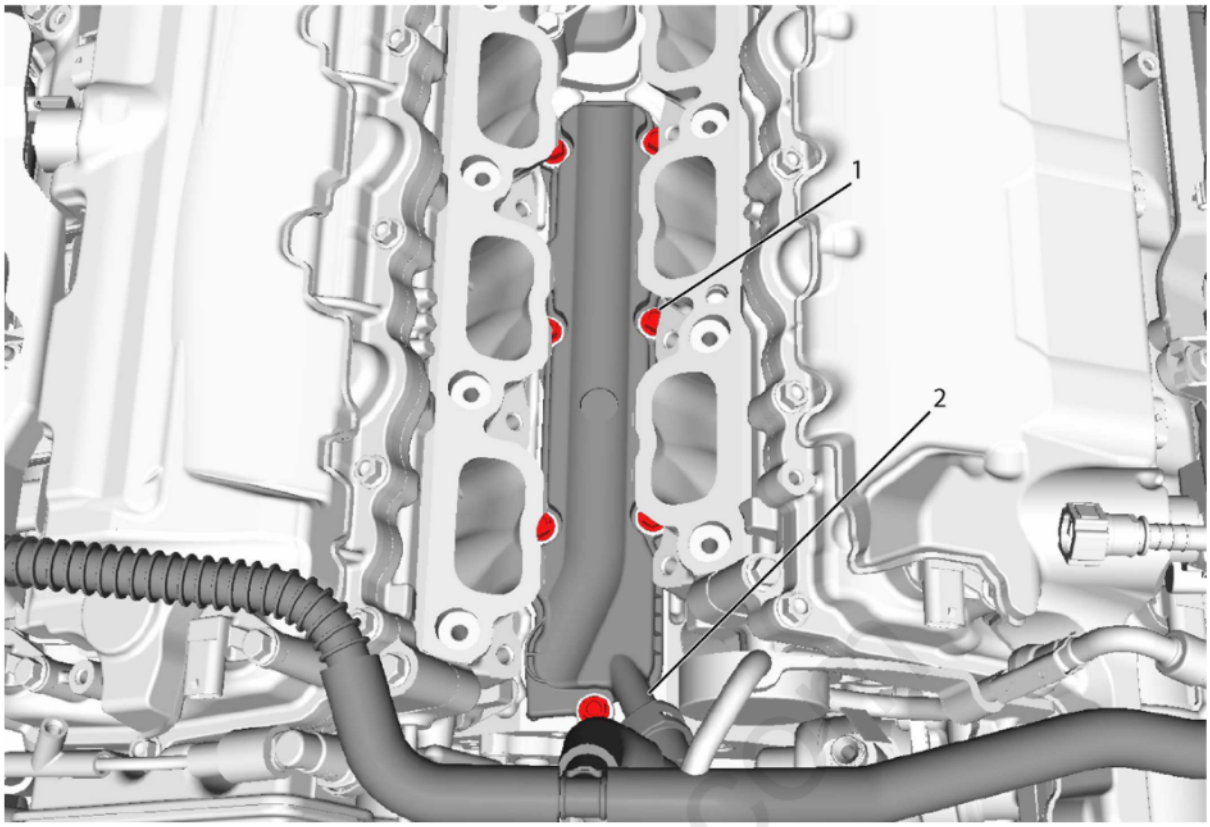


Fig. 51: Positive Crankcase Ventilation Oil Separator Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Fuel Injection Fuel Rail AssemblyÂ» Install - **Fuel Injection Fuel Rail Assembly Replacement - Bank 2**
3. Fuel Injection Fuel Rail AssemblyÂ» Install - **Fuel Injection Fuel Rail Assembly Replacement - Bank 1**
4. Fuel Feed Intermediate Pipe (2)Â» Install - **Fuel Feed Intermediate Pipe Replacement (LGW)**

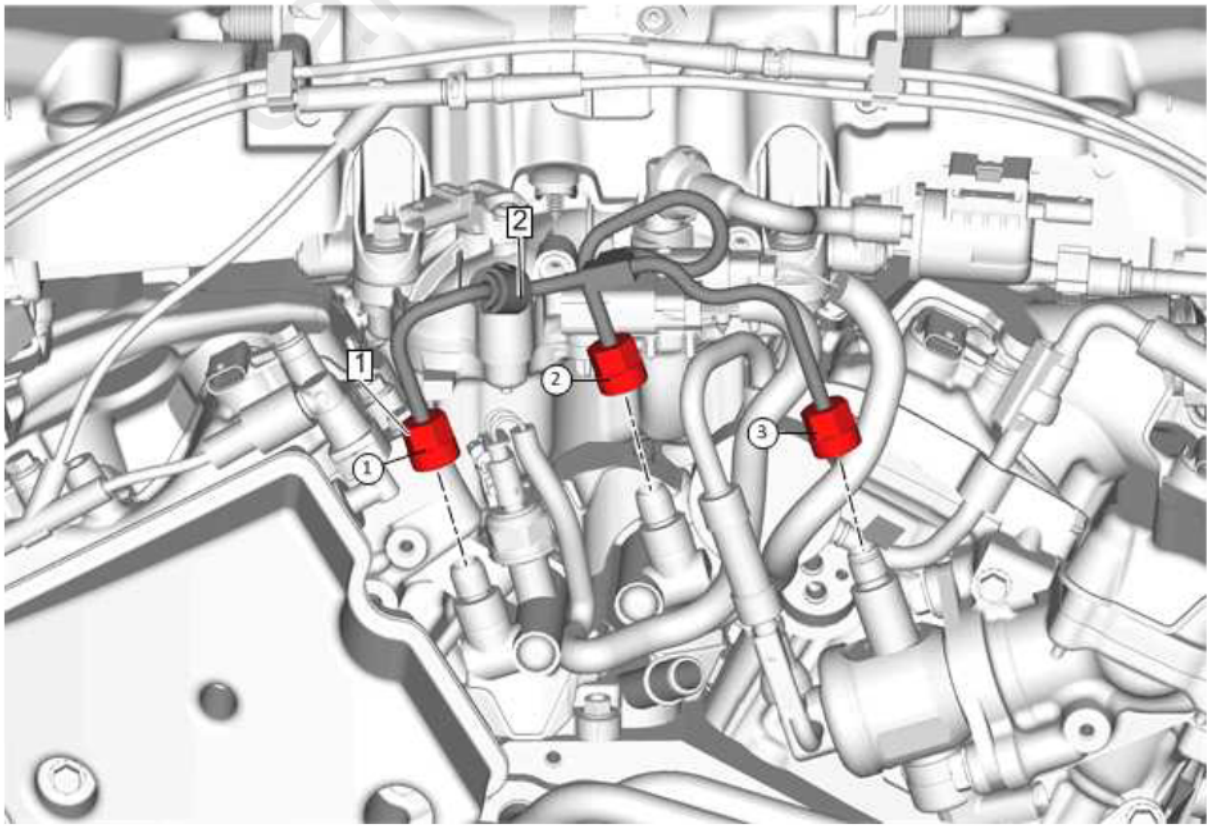


Fig. 52: Fuel Feed Intermediate Pipe
Courtesy of GENERAL MOTORS COMPANY

5. Air Cleaner Outlet Rear Duct (5)Â» Install - **Air Cleaner Outlet Rear Duct Replacement (LGW)**

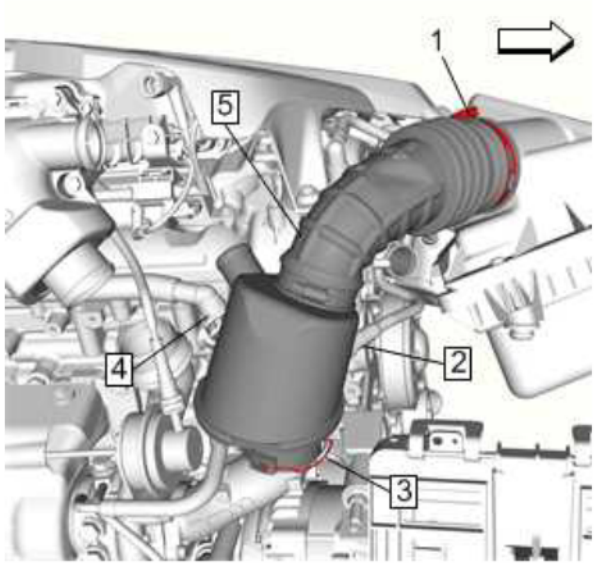


Fig. 53: Air Cleaner Outlet Rear Duct
Courtesy of GENERAL MOTORS COMPANY

6. Air Cleaner Outlet Front Duct (5)Â» Install - **Air Cleaner Outlet Front Duct Replacement (LGW)**

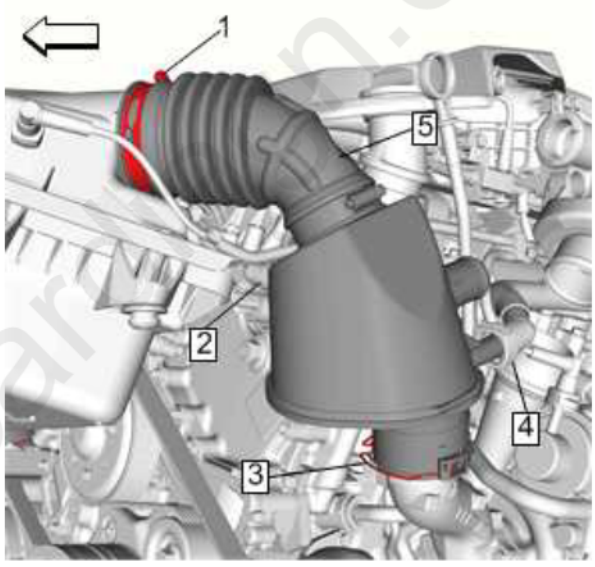


Fig. 54: Air Cleaner Outlet Front Duct
Courtesy of GENERAL MOTORS COMPANY

POSITIVE CRANKCASE VENTILATION OIL SEPARATOR REPLACEMENT (LGX)

Removal Procedure

1. Fuel Injection Fuel Rail AssemblyÂ» Remove - **Fuel Injection Fuel Rail Assembly Replacement - Bank 1**
2. Fuel Injection Fuel Rail AssemblyÂ» Remove - **Fuel Injection Fuel Rail Assembly Replacement - Bank 2**
3. Positive Crankcase Ventilation Oil Separator Bolt (1) @ Positive Crankcase Ventilation Oil Separator (2)Â» Remove [7x]

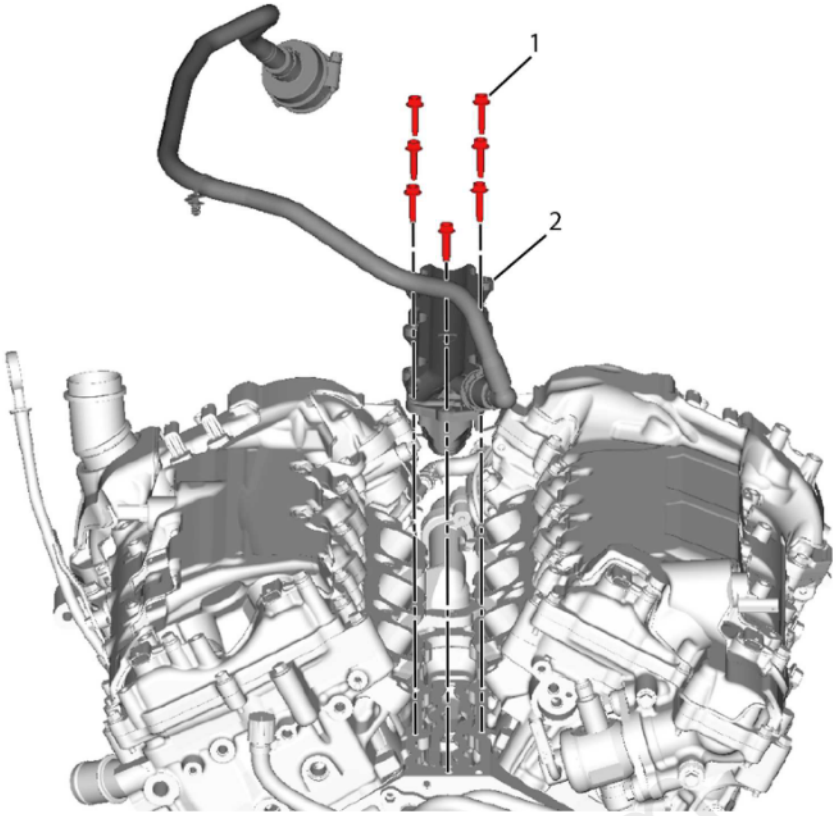


Fig. 55: Positive Crankcase Ventilation Oil Separator
Courtesy of GENERAL MOTORS COMPANY

4. Positive Crankcase Ventilation Oil Separator (2)Â» Remove

Installation Procedure

1. Positive Crankcase Ventilation Oil Separator (2)Â» Install - **Positive Crankcase Ventilation Oil Separator Installation (LGX)**

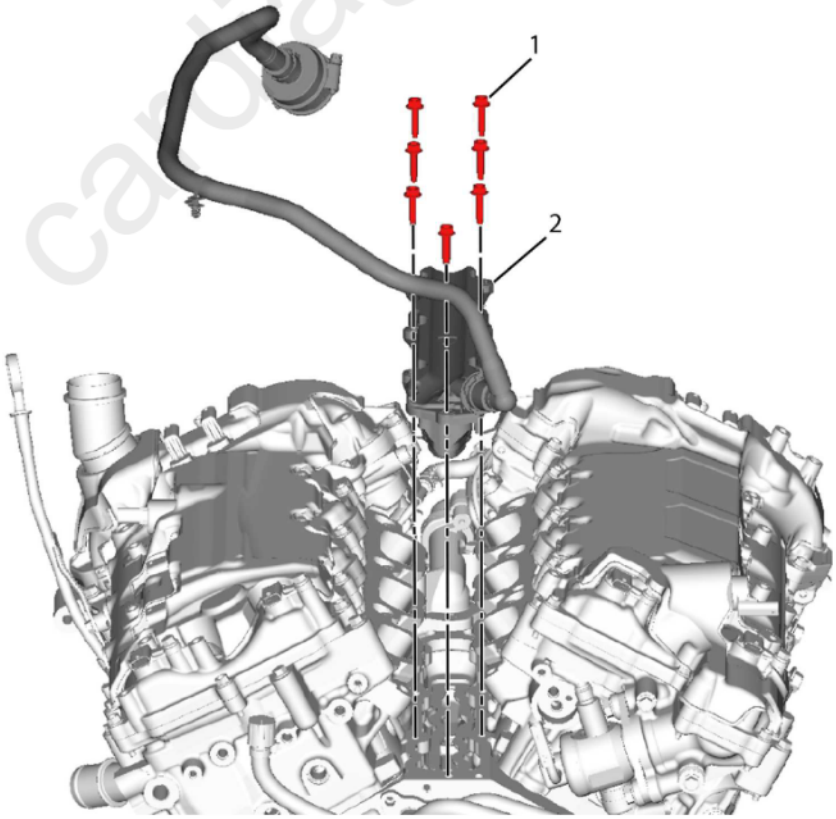


Fig. 56: Positive Crankcase Ventilation Oil Separator
Courtesy of GENERAL MOTORS COMPANY

2. Fuel Injection Fuel Rail AssemblyÂ» Install - **Fuel Injection Fuel Rail Assembly Replacement - Bank 2**

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3. Fuel Injection Fuel Rail AssemblyÂ» Install - **Fuel Injection Fuel Rail Assembly Replacement - Bank 1**

TURBOCHARGER REPLACEMENT (RIGHT SIDE)

Removal Procedure

1. Warm Up Three-Way Catalytic Converter - Right SideÂ» Remove - **Warm Up Three-Way Catalytic Converter Replacement (Right, LGW)** **Warm Up Three-Way Catalytic Converter Replacement (Right, LGX)**
2. **Turbocharger Wastegate Actuator Replacement - Right Side** Â» Remove
3. **Turbocharger Air Inlet Adapter Replacement - Bank 1** Â» Remove
4. Turbocharger Coolant Feed and Return Pipe - Right Side @ TurbochargerÂ» Disconnect - **Turbocharger Coolant Feed and Return Pipe Replacement (Right, LGW)**
5. Turbocharger Oil Feed Pipe - Right Side @ TurbochargerÂ» Disconnect - **Turbocharger Oil Feed Pipe Replacement (Right Side)**
6. Turbocharger Bolt (1)Â» Remove [4x]

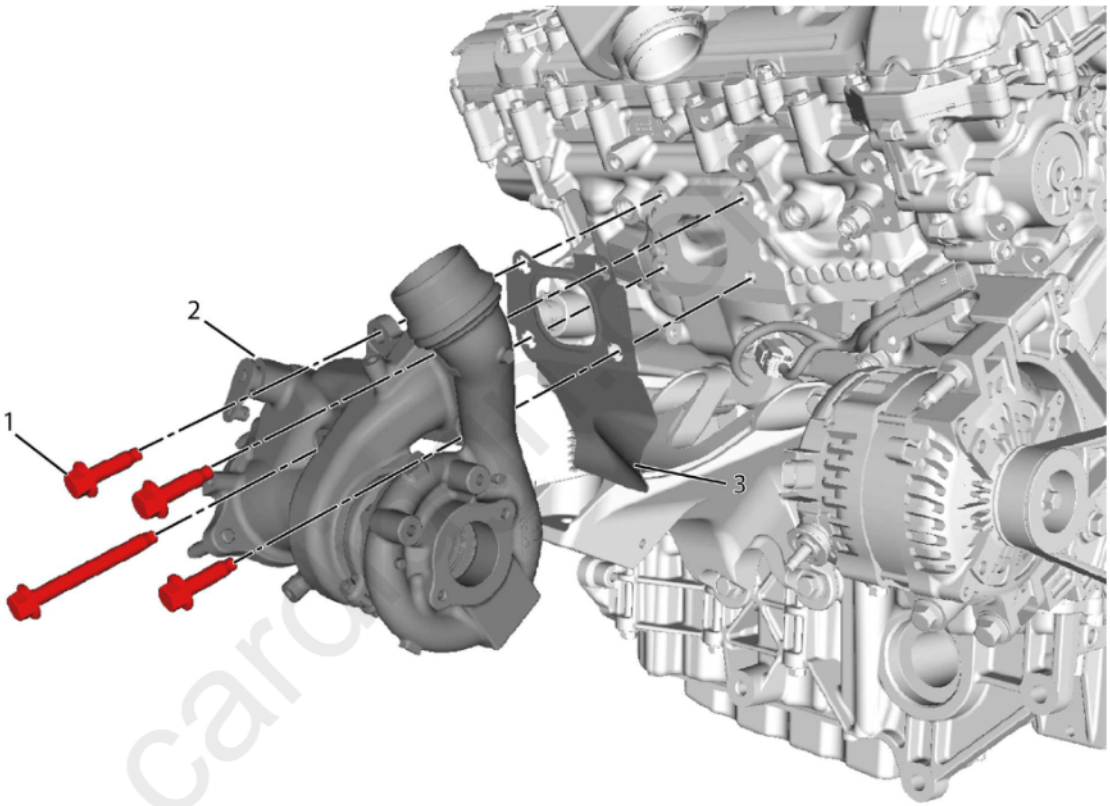


Fig. 57: Turbocharger Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Turbocharger (2)Â» Remove

NOTE: **Remove turbocharger and turbocharger oil return pipe as an assembly.**

8. Turbocharger Gasket (3)Â» Remove and DISCARD
9. Transfer components as necessary.

Installation Procedure

1. Turbocharger Gasket (3)Â» Install NEW

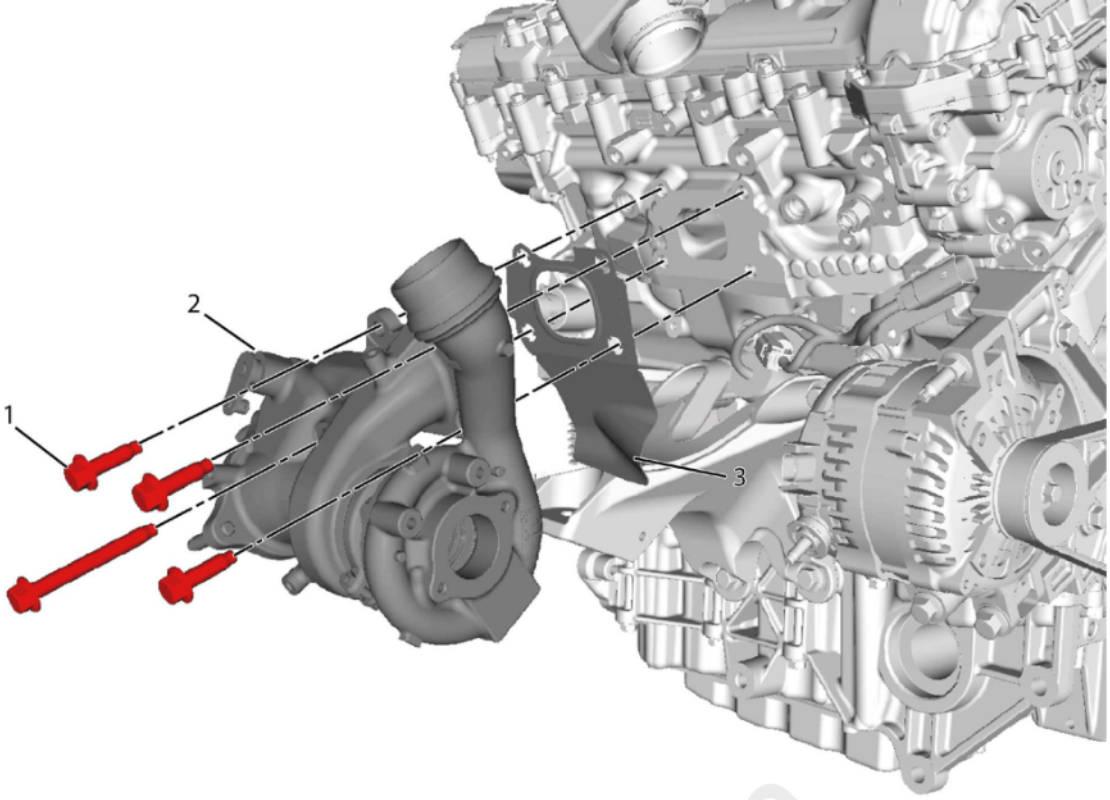


Fig. 58: Turbocharger Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Install turbocharger and turbocharger oil return pipe as an assembly. Refer to **Turbocharger Oil Return Pipe Replacement (Right Side)** and/or **Turbocharger Oil Return Pipe Replacement (Left Side)**
3. Turbocharger Bolt (1)Â» Install [4x]

CAUTION: **Refer to Fastener Caution .**

4. Tighten bolts to 58 N.m (43 lb ft).
5. Turbocharger Oil Feed Pipe - Right Side @ TurbochargerÂ» Connect - **Turbocharger Oil Feed Pipe Replacement (Right Side)**
6. Turbocharger Coolant Feed and Return Pipe - Right Side @ TurbochargerÂ» Connect - **Turbocharger Coolant Feed and Return Pipe Replacement (Right, LGW)**
7. **Turbocharger Air Inlet Adapter Replacement - Bank 1** Â» Install
8. **Turbocharger Wastegate Actuator Replacement - Right Side** Â» Install

NOTE: **Ensure the wastegate vacuum connection is fully seated and secure. A poor connection can result in a DTC and lead to misdiagnosis.**

9. Warm Up Three-Way Catalytic Converter - Right SideÂ» Install - **Warm Up Three-Way Catalytic Converter Replacement (Right, LGW)** **Warm Up Three-Way Catalytic Converter Replacement (Right, LGX)**

TURBOCHARGER REPLACEMENT (LEFT SIDE)

Removal Procedure

1. Warm Up Three-Way Catalytic Converter - Left SideÂ» Remove - **Warm Up Three-Way Catalytic Converter Replacement (Left, LGW)** **Warm Up Three-Way Catalytic Converter Replacement (Left, LGX)**
2. **Turbocharger Wastegate Actuator Replacement - Left Side** Â» Remove
3. **Turbocharger Air Inlet Adapter Replacement - Bank 2** Â» Remove
4. Turbocharger Coolant Feed and Return Pipe - Left Side @ TurbochargerÂ» Disconnect - **Turbocharger Coolant Feed and Return Pipe Replacement (Left, LGW)**

5. Turbocharger Oil Feed Pipe - Left Side @ TurbochargerÂ» Disconnect - **Turbocharger Oil Feed Pipe Replacement (Left Side)**
6. Turbocharger Bolt (1)Â» Remove [4x]

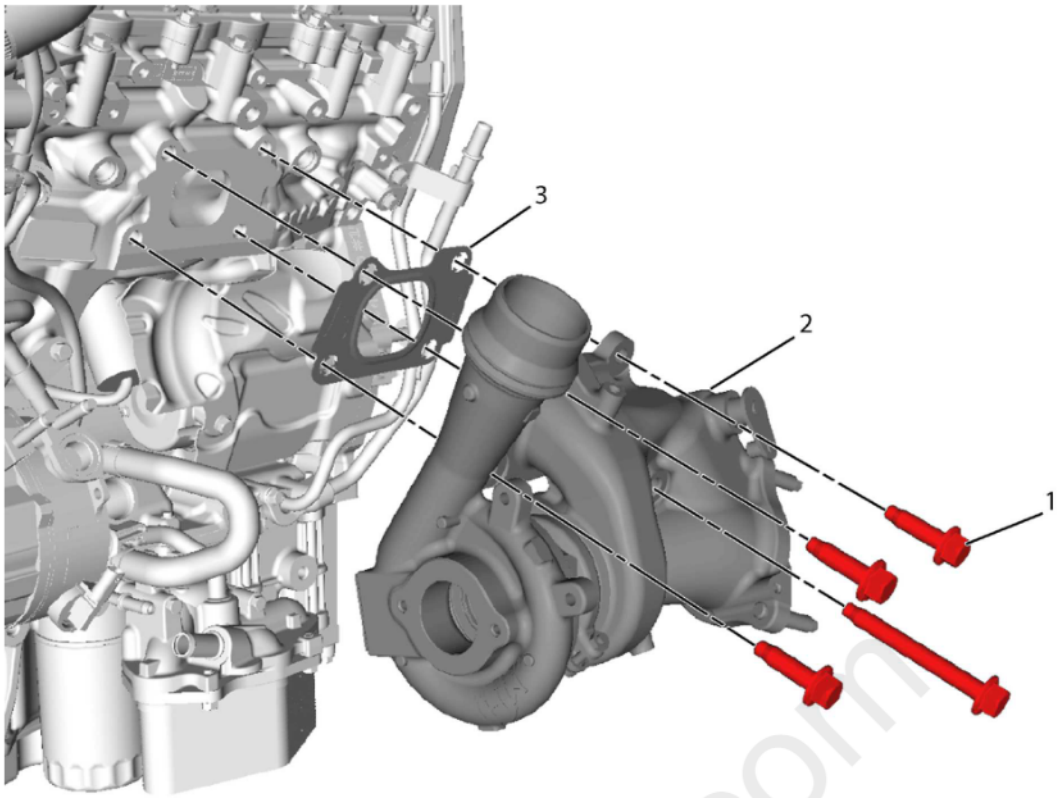


Fig. 59: Turbocharger Gasket
Courtesy of GENERAL MOTORS COMPANY

7. Turbocharger (2)Â» Remove

NOTE: **Remove turbocharger and turbocharger oil return pipe as an assembly.**

8. Turbocharger Gasket (3)Â» Remove and DISCARD
9. Transfer components as necessary.

Installation Procedure

1. Turbocharger Gasket (3)Â» Install NEW

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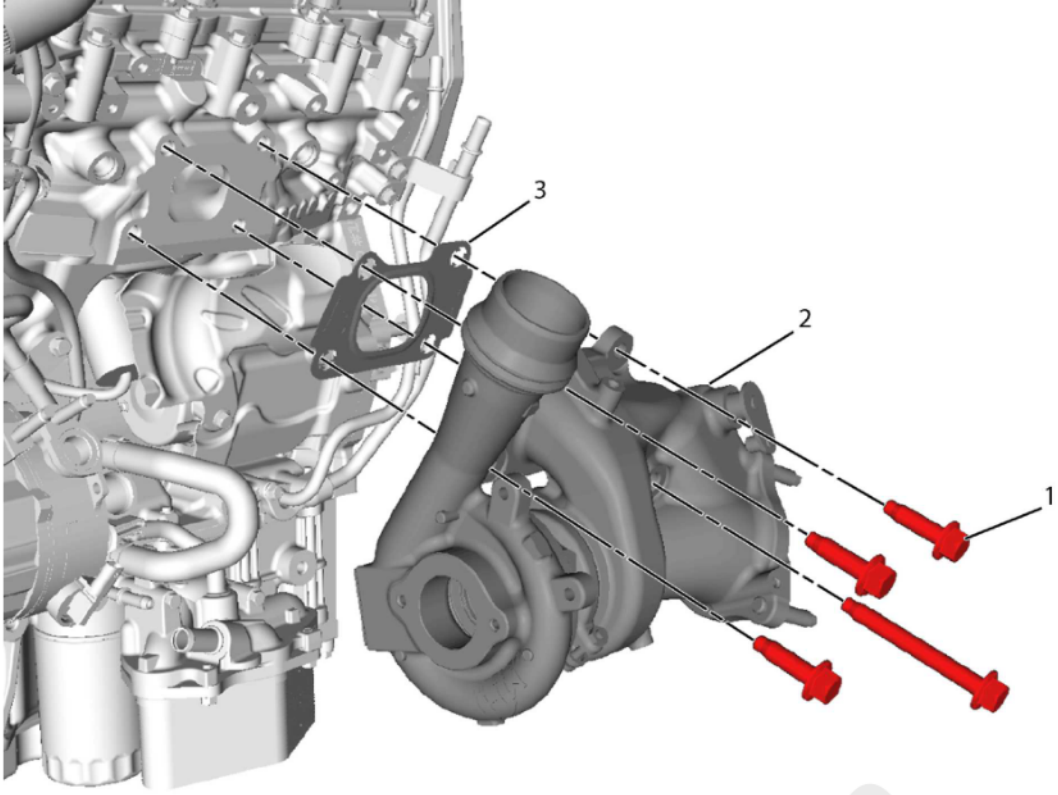


Fig. 60: Turbocharger Gasket
Courtesy of GENERAL MOTORS COMPANY

2. Install turbocharger and turbocharger oil return pipe as an assembly. Refer to **Turbocharger Oil Return Pipe Replacement (Left Side)**
3. Turbocharger Bolt (1)Â» Install [4x]

CAUTION: **Refer to Fastener Caution .**

4. Tighten bolts to 58 N.m (43 lb ft).
5. Turbocharger Oil Feed Pipe - Left Side @ TurbochargerÂ» Connect - **Turbocharger Oil Feed Pipe Replacement (Left Side)**
6. Turbocharger Coolant Feed and Return Pipe - Left Side @ TurbochargerÂ» Connect - **Turbocharger Coolant Feed and Return Pipe Replacement (Left, LGW)**
7. **Turbocharger Air Inlet Adapter Replacement - Bank 2** Â» Install
8. **Turbocharger Wastegate Actuator Replacement - Left Side** Â» Install

NOTE: **Ensure the wastegate vacuum connection is fully seated and secure. A poor connection can result in a DTC and lead to misdiagnosis.**

9. Warm Up Three-Way Catalytic Converter - Left SideÂ» Install - **Warm Up Three-Way Catalytic Converter Replacement (Left, LGW)** **Warm Up Three-Way Catalytic Converter Replacement (Left, LGX)**

TURBOCHARGER OIL RETURN PIPE REPLACEMENT (RIGHT SIDE)

Removal Procedure

1. Turbocharger - Right SideÂ» Remove - **Turbocharger Replacement (Right Side)**
2. Turbocharger Oil Return Pipe Bolt (1)Â» Remove [2x]

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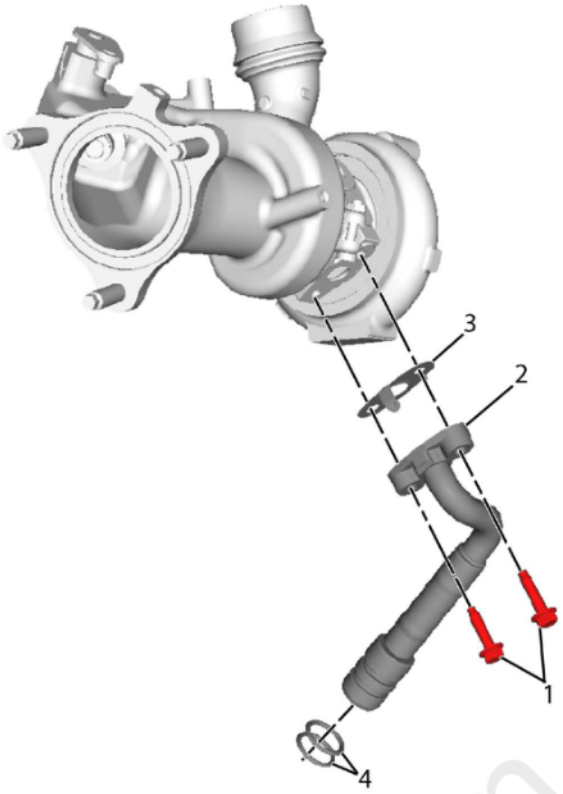


Fig. 61: Turbocharger Oil Return Pipe And Gasket
Courtesy of GENERAL MOTORS COMPANY

3. Turbocharger Oil Return Pipe (2)Â» Remove
4. Turbocharger Oil Return Pipe Gasket (3) Remove and DISCARD
5. Turbocharger Oil Return Pipe Seal (4) Remove and DISCARD [2x]

Installation Procedure

1. Turbocharger Oil Return Pipe Seal (4) Install NEW [2x]

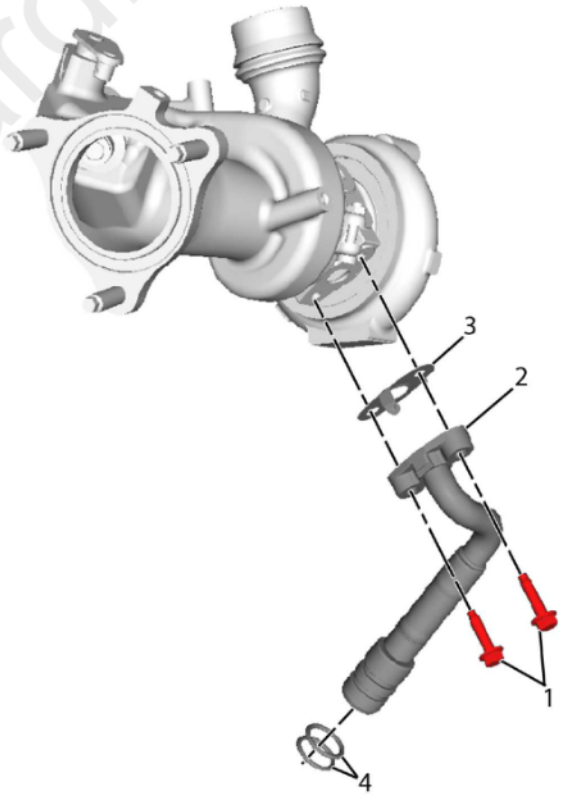


Fig. 62: Turbocharger Oil Return Pipe And Gasket
Courtesy of GENERAL MOTORS COMPANY

2. Turbocharger Oil Return Pipe Gasket (3) Install NEW

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3. Turbocharger Oil Return Pipe (2)Â» Install
4. Turbocharger Oil Return Pipe Bolt (1)Â» Install [2x]
5. Turbocharger Oil Return Pipe Bolt (1)Â» Tighten [2x] 10 N.m (89 lb in)
6. Turbocharger - Right SideÂ» Install - **Turbocharger Replacement (Right Side)**

TURBOCHARGER OIL RETURN PIPE REPLACEMENT (LEFT SIDE)

Removal Procedure

1. Turbocharger - Left SideÂ» Remove - **Turbocharger Replacement (Left Side)**
2. Turbocharger Oil Return Pipe Bolt (1)Â» Remove [2x]

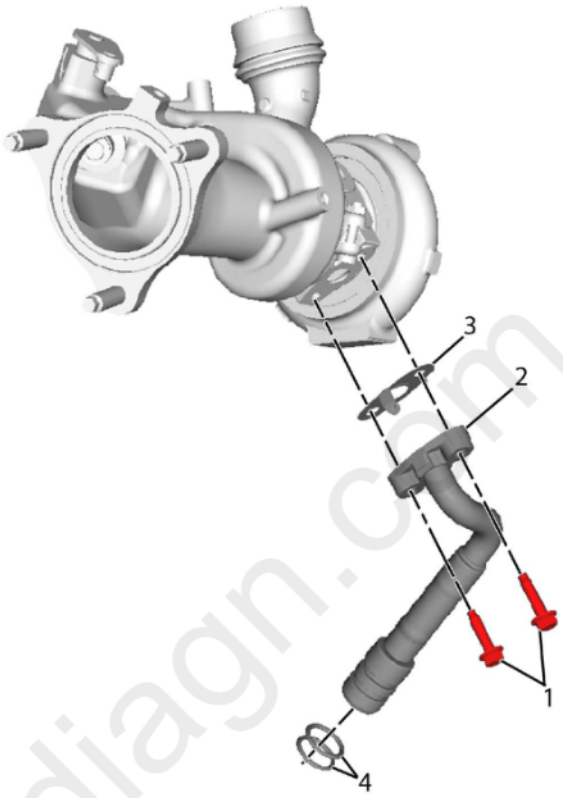


Fig. 63: Turbocharger Oil Return Pipe And Gasket
Courtesy of GENERAL MOTORS COMPANY

3. Turbocharger Oil Return Pipe (2)Â» Remove
4. Turbocharger Oil Return Pipe Gasket (3) Remove and DISCARD
5. Turbocharger Oil Return Pipe Seal (4) Remove and DISCARD [2x]

Installation Procedure

1. Turbocharger Oil Return Pipe Seal (4) Install NEW [2x]

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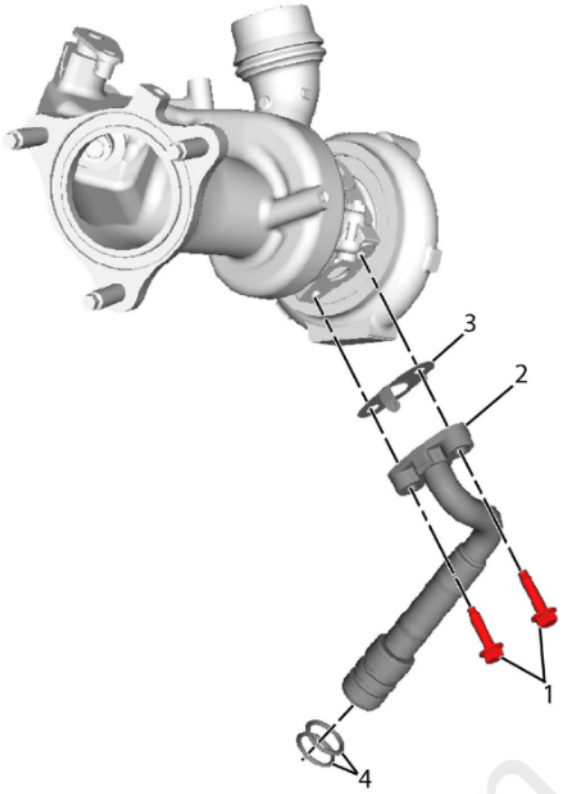


Fig. 64: Turbocharger Oil Return Pipe And Gasket
Courtesy of GENERAL MOTORS COMPANY

2. Turbocharger Oil Return Pipe Gasket (3) Install NEW
3. Turbocharger Oil Return Pipe (2)Â» Install
4. Turbocharger Oil Return Pipe Bolt (1)Â» Install [2x]
5. Turbocharger Oil Return Pipe Bolt (1)Â» Tighten [2x] 10 N.m (89 lb in)
6. Turbocharger - Left SideÂ» Install - **Turbocharger Replacement (Left Side)**

TURBOCHARGER OIL FEED PIPE REPLACEMENT (RIGHT SIDE)

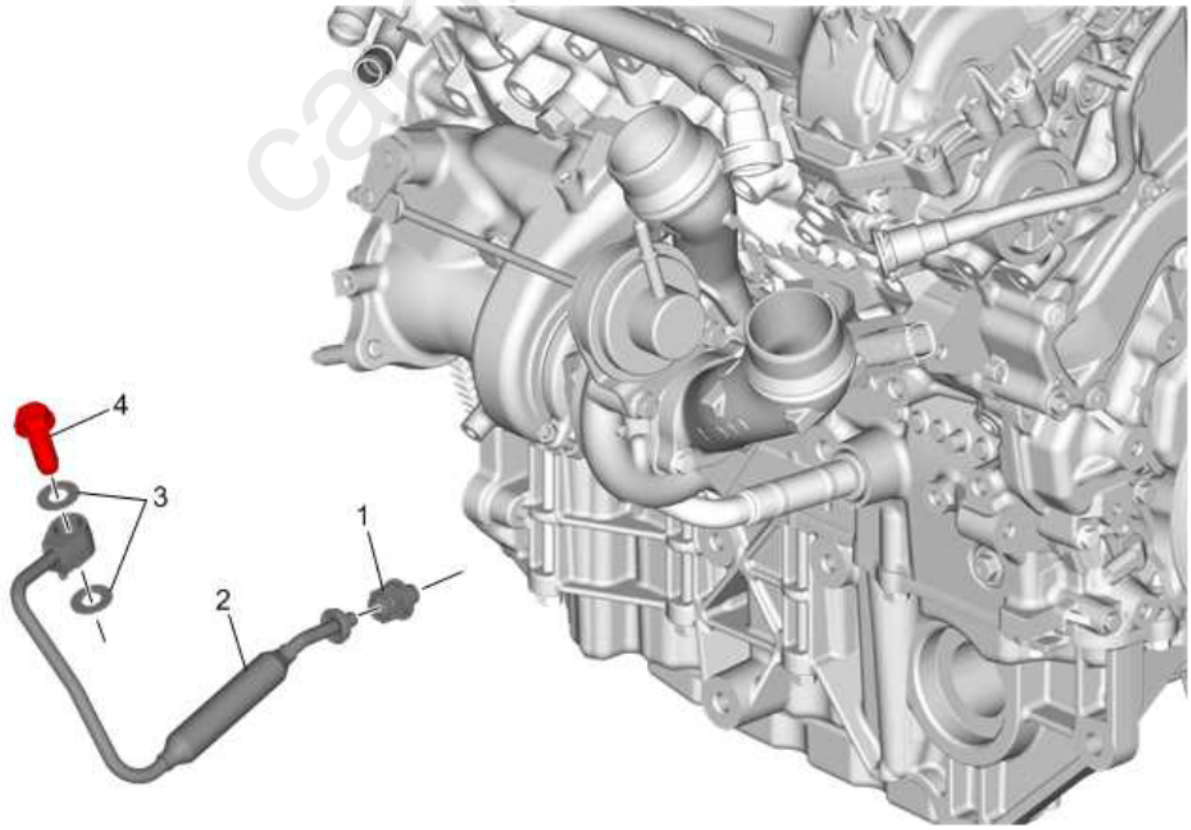


Fig. 65: Turbocharger Oil Feed Pipe (Right Side)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Generator Bracket Replacement (LGW) 2. Turbocharger Heat Shield - Right SideÂ» Remove - Turbocharger Heat Shield Replacement (Right, LGW)	
1	Turbocharger Oil Feed Pipe Fitting Adapter **CAUTION:** **Refer to Fastener Caution .** **Tighten** 35 N.m (26 lb ft) **NOTE:** **Install NEW fitting. It is not reusable.**
2	Turbocharger Oil Feed Pipe Bolt **Tighten** 35 N.m (26 lb ft)
3	Turbocharger Oil Feed Pipe Gasket [2x] **NOTE:** **Install NEW gaskets. They are not reusable.**
4	Turbocharger Oil Feed Pipe

TURBOCHARGER OIL FEED PIPE REPLACEMENT (LEFT SIDE)

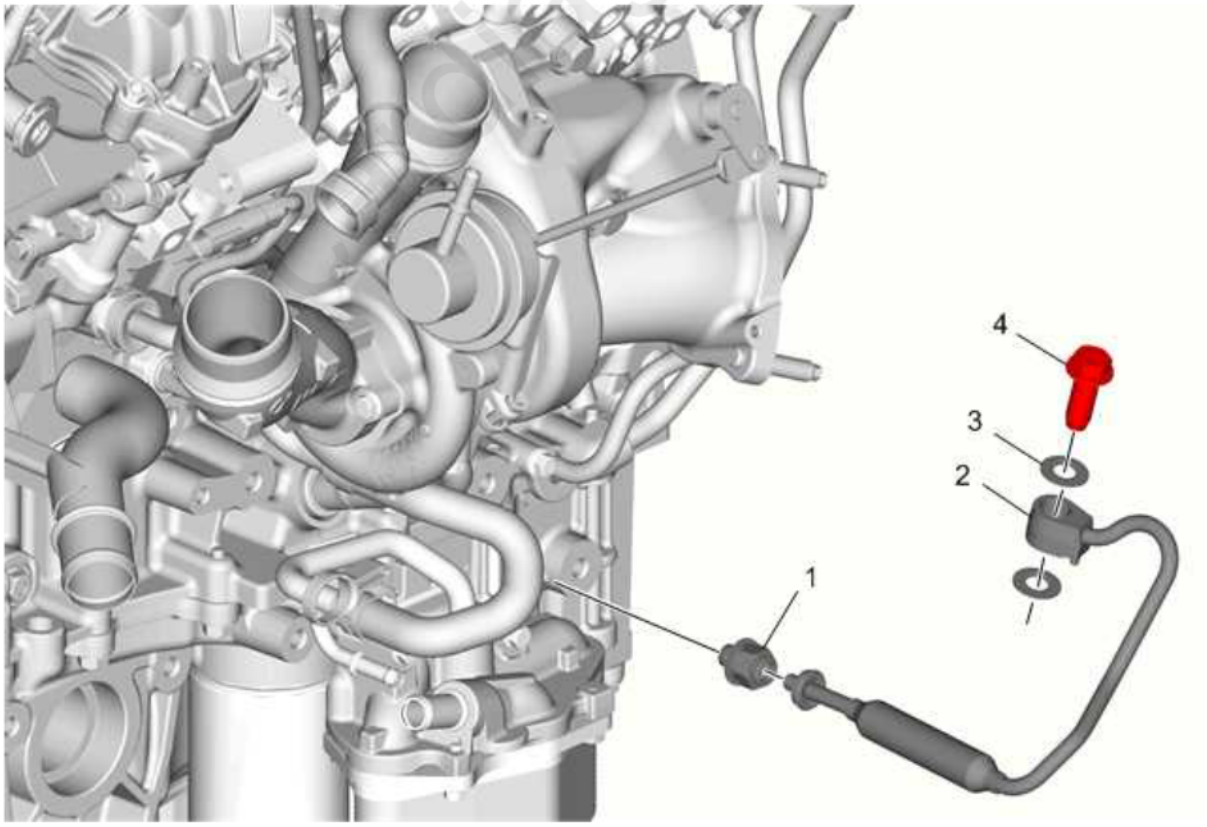


Fig. 66: Turbocharger Oil Feed Pipe (Left Side)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedures 1. **Generator Bracket Replacement (LGW)** 2. Turbocharger Heat Shield - Left SideÂ» Remove - **Turbocharger Heat Shield Replacement (Left, LGW)** 3. **Air Conditioning Compressor Replacement (LGW, LGX)**	
1	Turbocharger Oil Feed Pipe Fitting Adapter **CAUTION:** **Refer to Fastener Caution .** **Tighten** 35 N.m (26 lb ft) **NOTE:** **Install NEW fitting. It is not reusable.**
2	Turbocharger Oil Feed Pipe Bolt **Tighten** 35 N.m (26 lb ft)
3	Turbocharger Oil Feed Pipe Gasket [2x] **NOTE:** **Install NEW gaskets. They are not reusable.**
4	Turbocharger Oil Feed Pipe

INTAKE MANIFOLD REPLACEMENT (LGW)

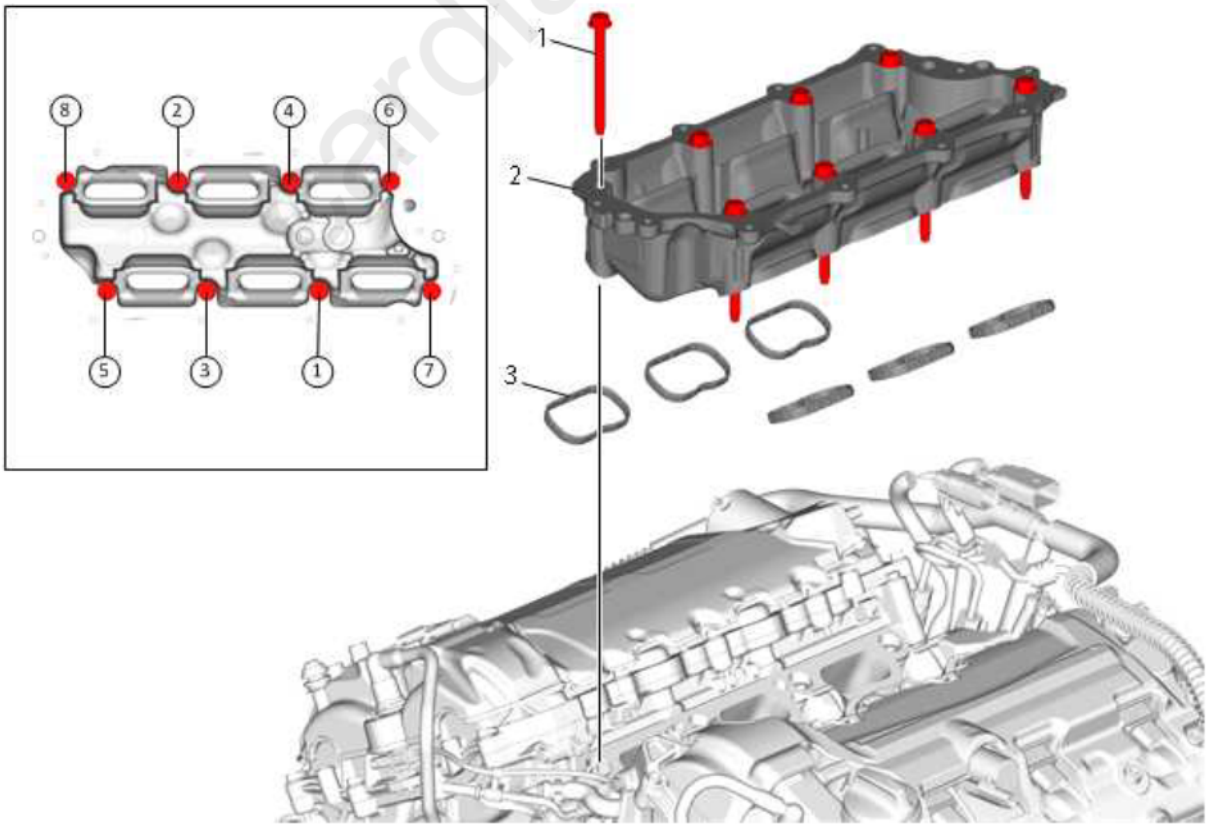
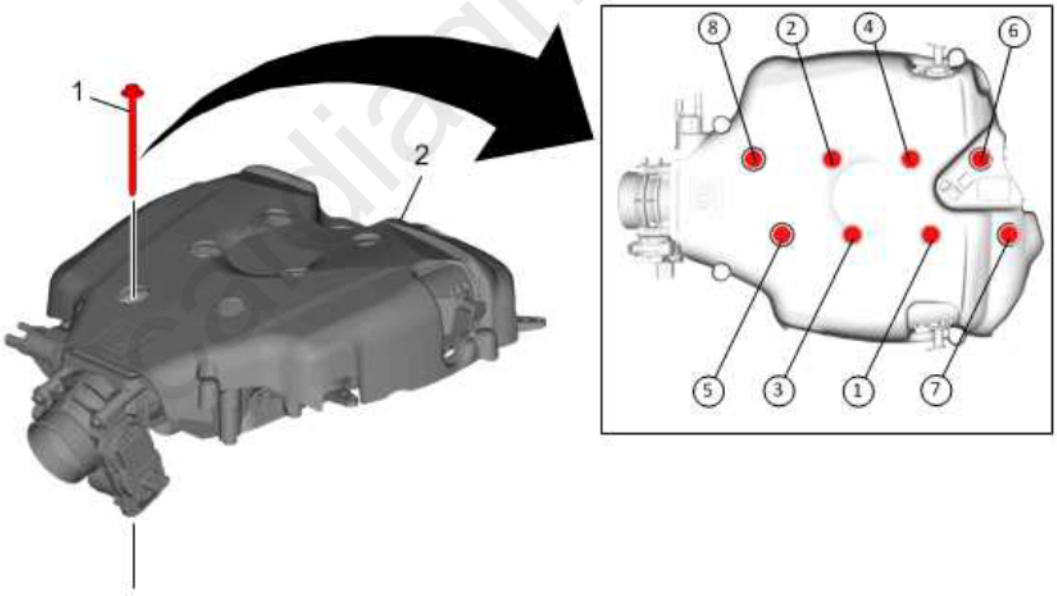


Fig. 67: Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedure **Charge Air Cooler Cover Replacement**	
1	Lower Intake Manifold Bolt [8x] **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Bolts come with sealant pre-applied, if the bolts are being reused, additional sealant should be applied to the bolts before tightening. Refer to Adhesives, Fluids, Lubricants and Sealers .** **Tighten in sequence** 25 N.m (18 lb ft)
2	Intake Manifold **Procedure** Clean and inspect the intake manifold. Refer to **Intake Manifold Cleaning and Inspection (LGW)**
3	Intake Manifold Seal [6x] **NOTE:** **Install NEW seals.**

INTAKE MANIFOLD REPLACEMENT (LGX)



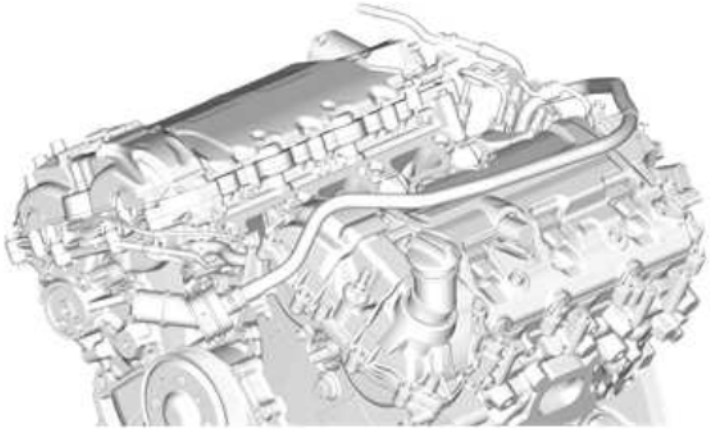


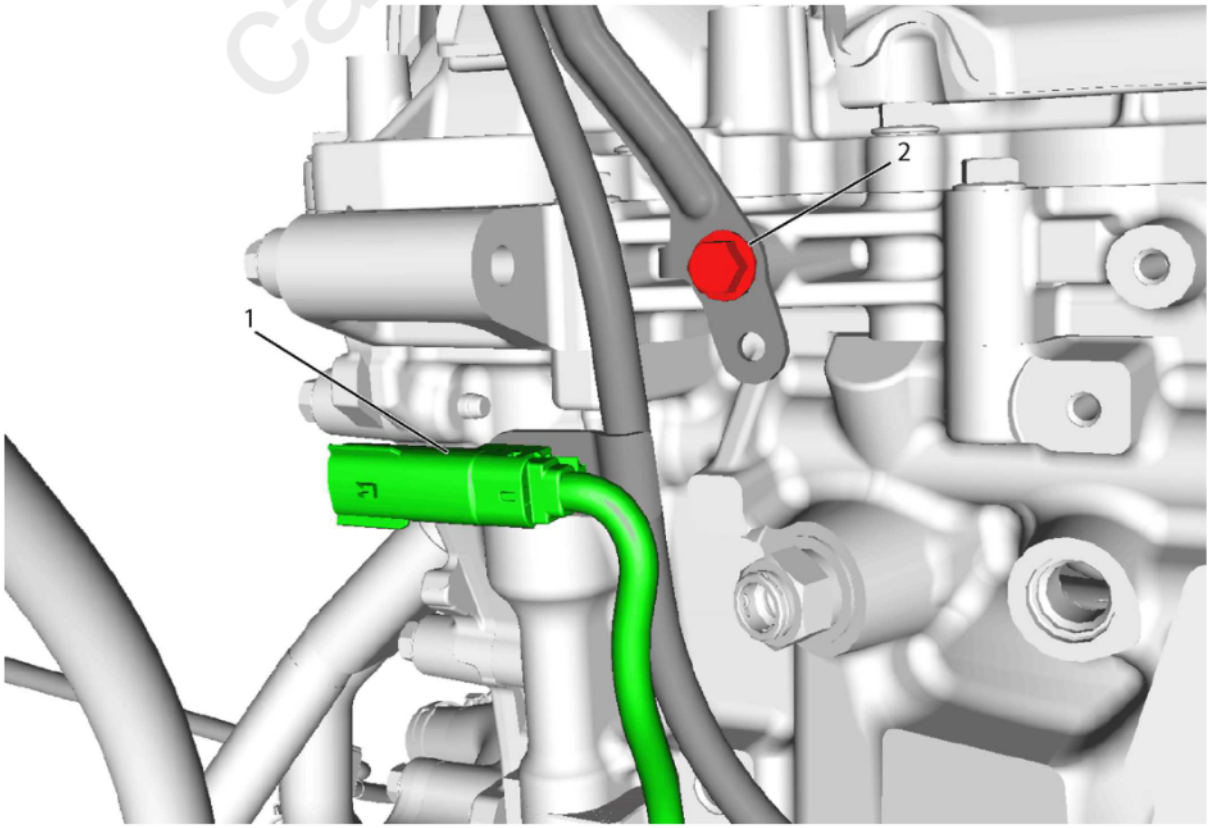
Fig. 68: Intake Manifold Replacement (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Air Cleaner Outlet Duct Replacement (LGX) 2. Disconnect and reposition the EVAP purge tube. Refer to Plastic Collar Quick Connect Fitting Service 3. Disconnect the electrical connectors. 4. Remove the two upper fuel pipe shield fasteners. Refer to Fuel Pipe Shield Replacement (LGX)	
1	Intake Manifold Bolt [8x] **CAUTION:** **Refer to Fastener Caution .** **Tighten in sequence** 25 N.m (18 lb ft)
2	Intake Manifold **Procedure** Transfer components as necessary. Refer to Intake Manifold Disassemble (LGX) and Intake Manifold Assemble (LGX) **NOTE:** **Install NEW gaskets.**

OIL LEVEL INDICATOR TUBE REPLACEMENT (LGW)

Removal Procedure

1. Turbocharger - Left SideÂ» Remove - Turbocharger Replacement (Left Side)
2. Harness Connector (1) @ Oil Level Indicator TubeÂ» Separate



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Fig. 69: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

3. Oil Level Indicator Tube Bracket Bolt (2)Â» Remove
4. Oil Level Indicator Tube (1)Â» Remove

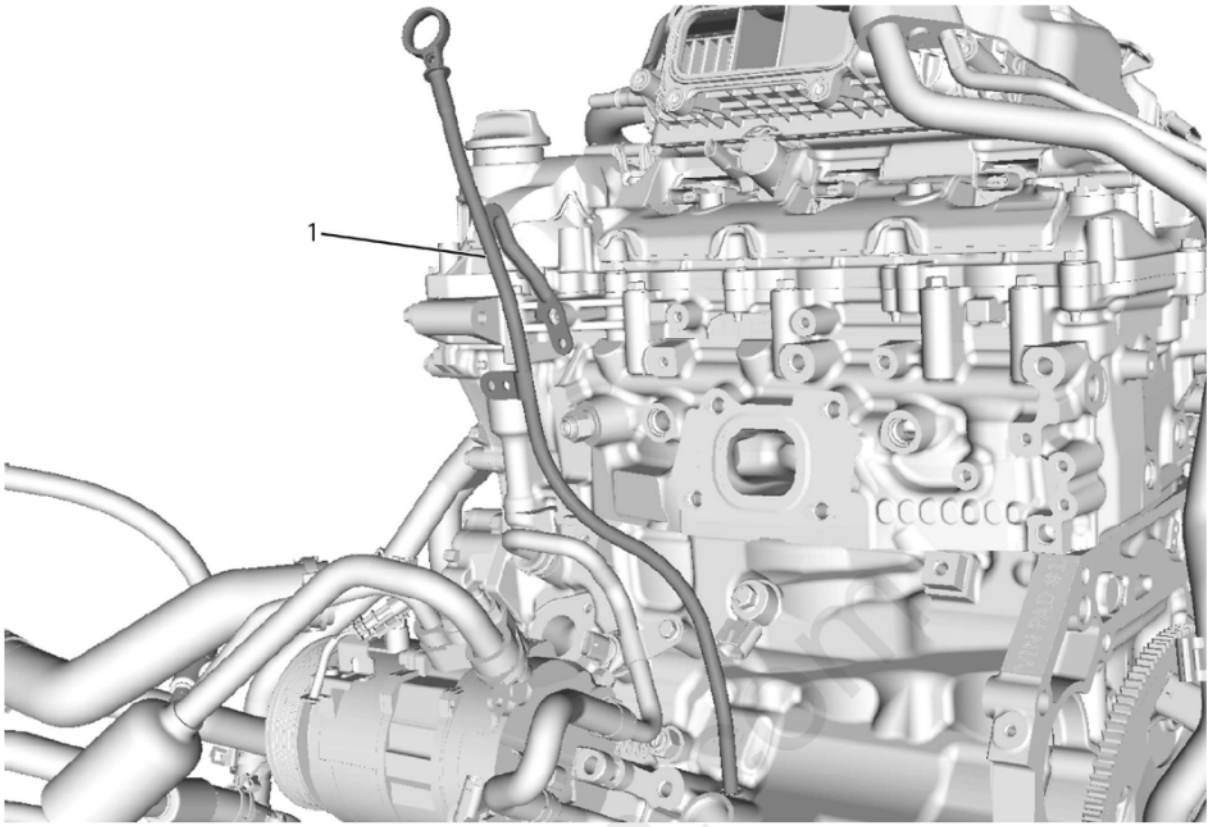


Fig. 70: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

5. Remove the O-ring (1) from the oil level indicator tube (2) and discard.

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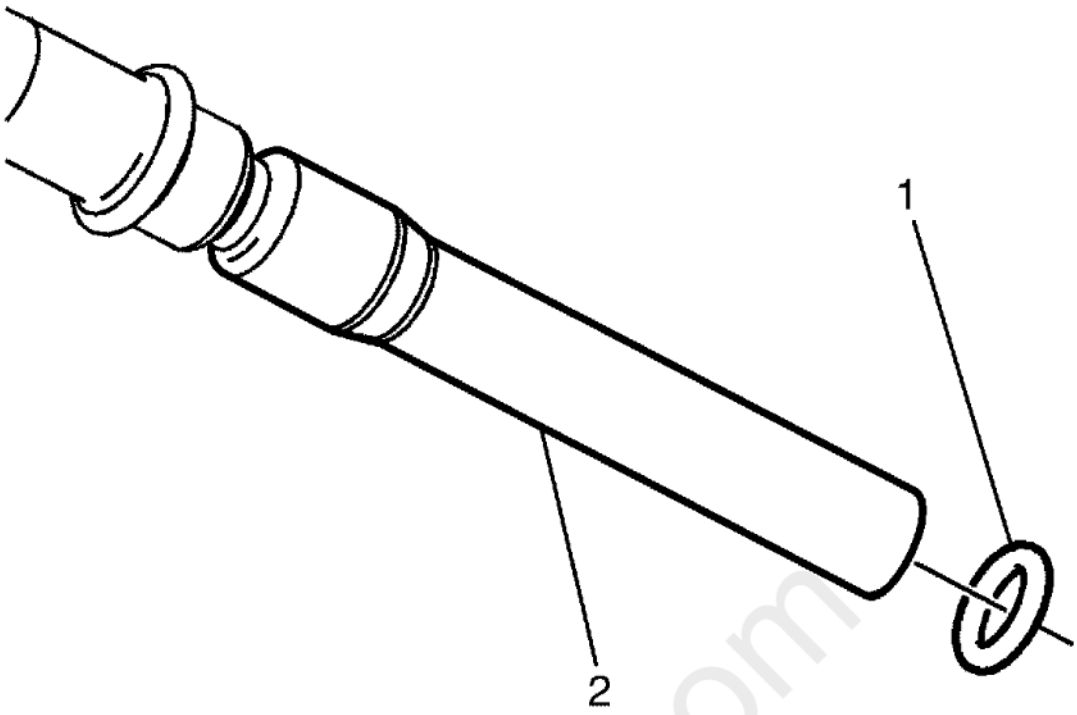


Fig. 71: Identifying Oil Level Indicator Tube & O-Ring
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The oil level indicator tube seal is a single use item.**

Installation Procedure

1. Install the NEW O-ring (1) on the oil level indicator tube (2).

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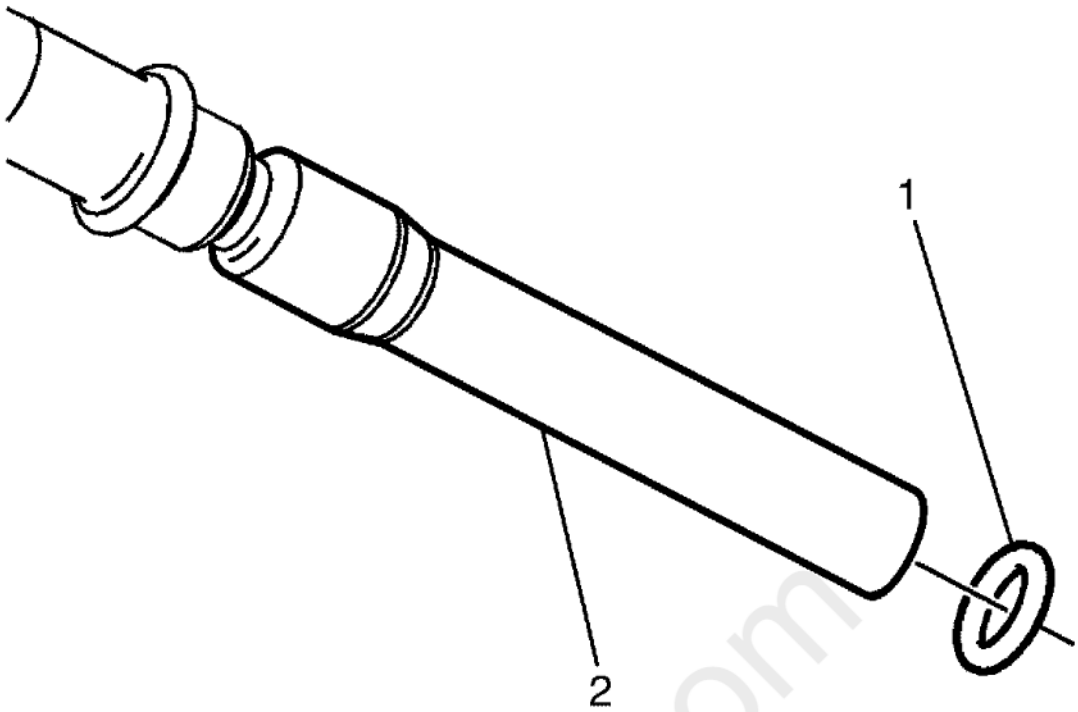
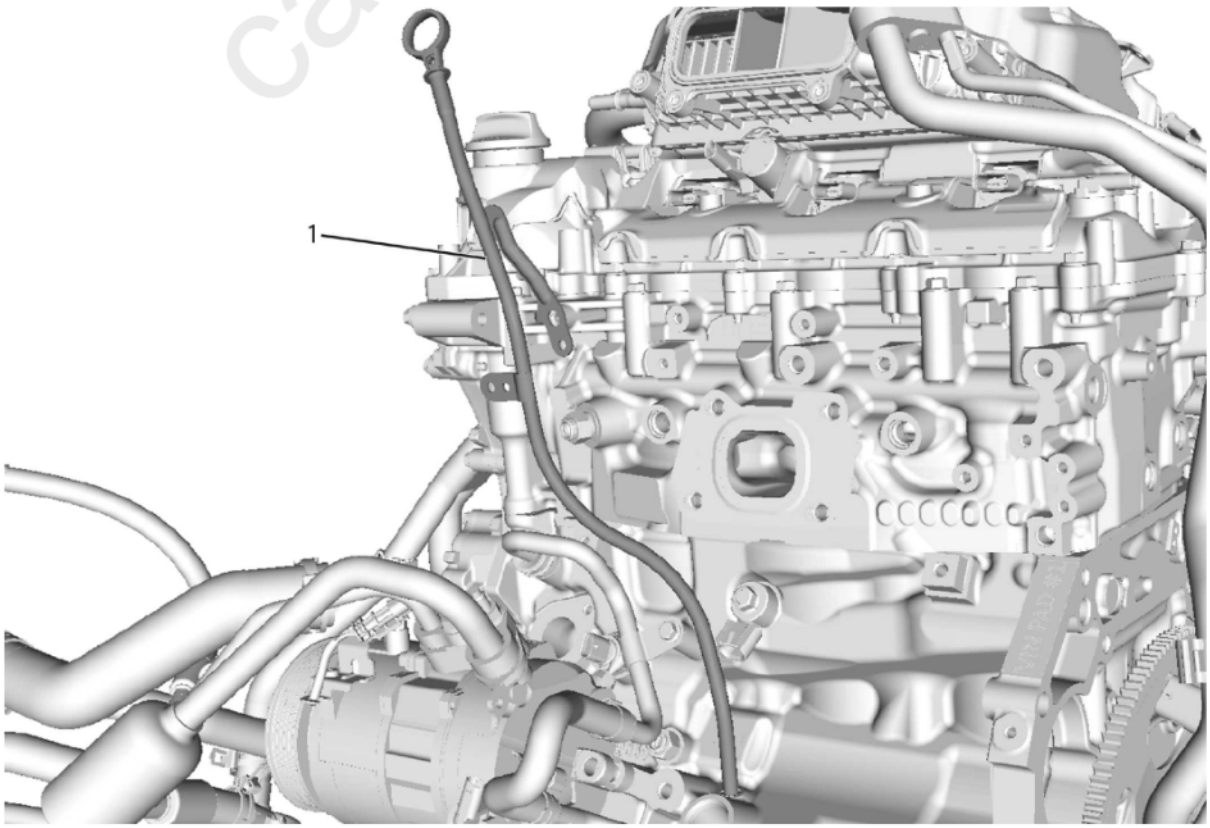


Fig. 72: Identifying Oil Level Indicator Tube & O-Ring
Courtesy of GENERAL MOTORS COMPANY

2. Position the oil level indicator tube (1) by sliding the tube down and in to the approximate location of the lower crankcase hole.



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Fig. 73: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

3. Guide the lower portion of the oil level indicator tube into the lower crankcase hole and seat the oil level indicator tube in place
4. Oil Level Indicator Tube Bracket Bolt (2)Â» Install and tighten 10 N.m (89 lb in)

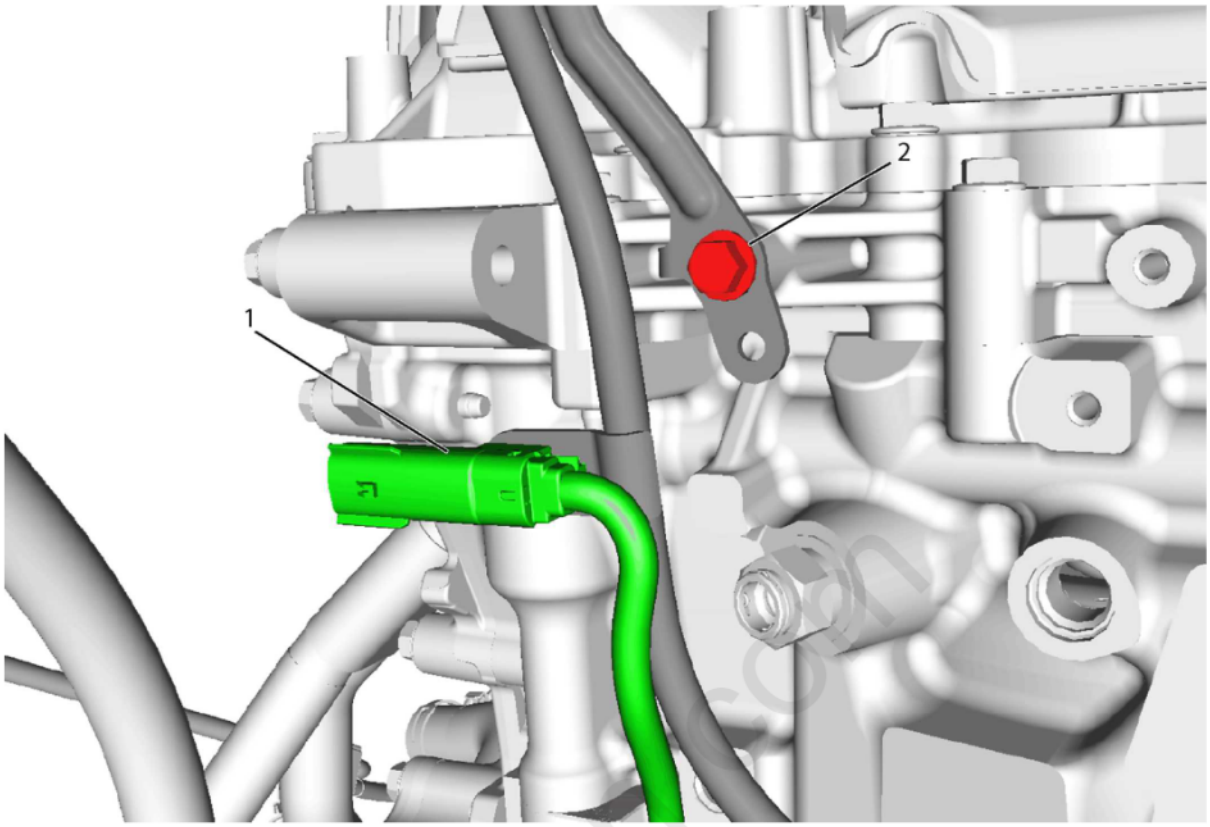


Fig. 74: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

5. Harness Connector (1) @ Oil Level Indicator TubeÂ» Connect
6. Turbocharger - Left SideÂ» Install - Turbocharger Replacement (Left Side)

OIL LEVEL INDICATOR TUBE REPLACEMENT (LGX)

Removal Procedure

1. Harness Connector (1) @ Oil Level Indicator TubeÂ» Separate

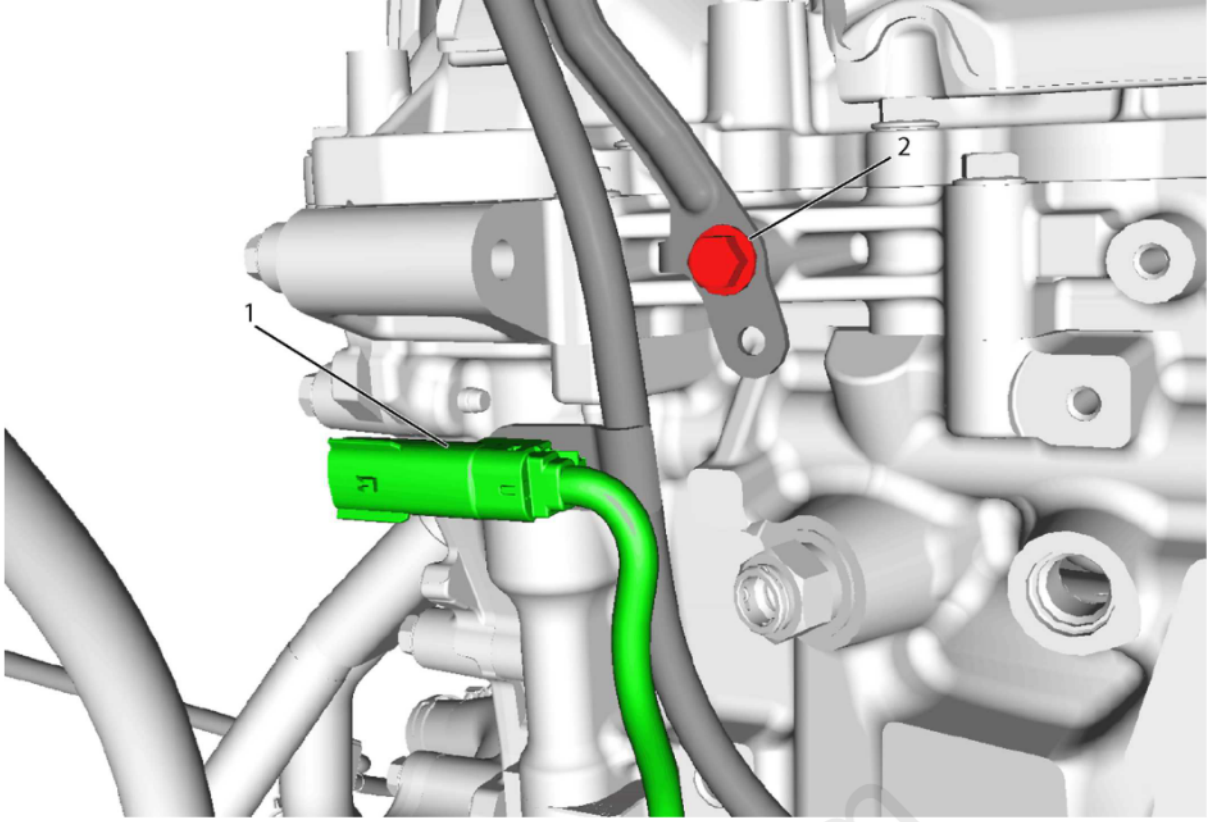


Fig. 75: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

2. Oil Level Indicator Tube Bracket Bolt (2)Â» Remove
3. Oil Level Indicator Tube (1)Â» Remove

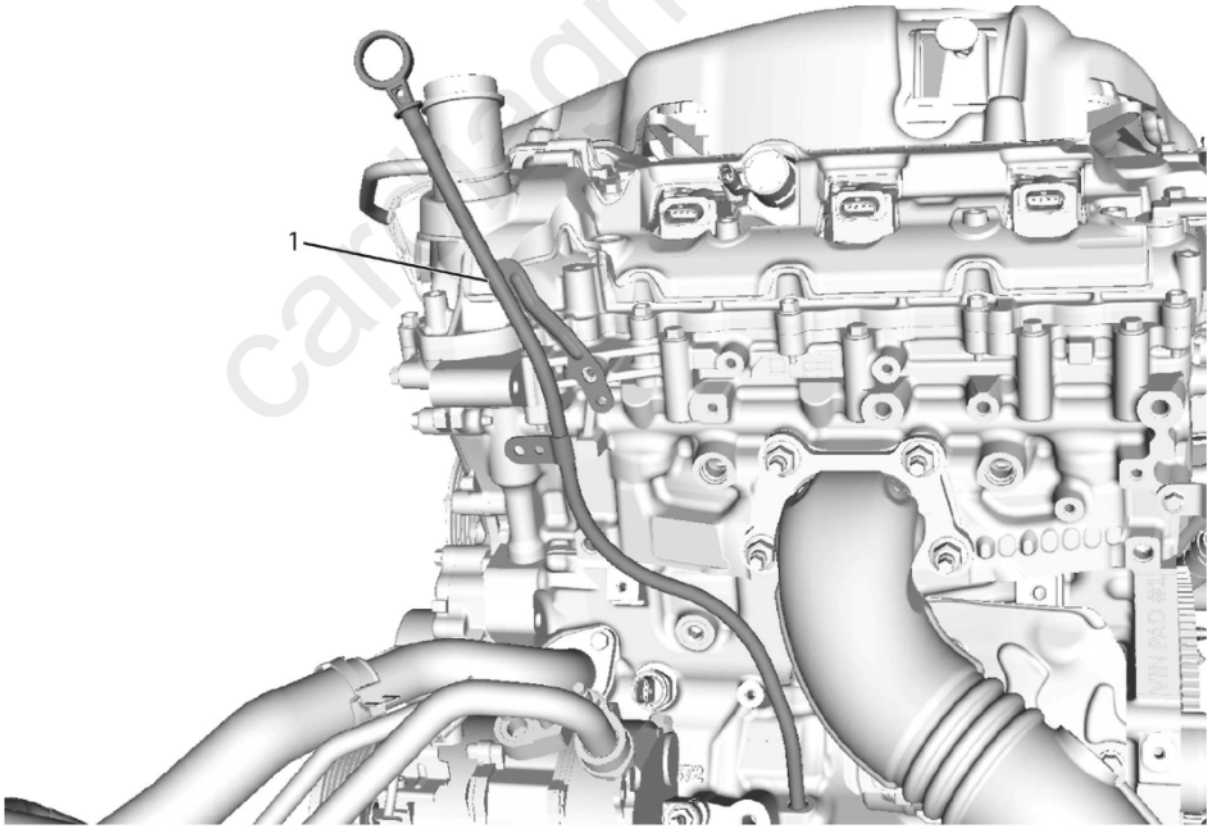


Fig. 76: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

4. Remove the O-ring (1) from the oil level indicator tube (2) and discard.

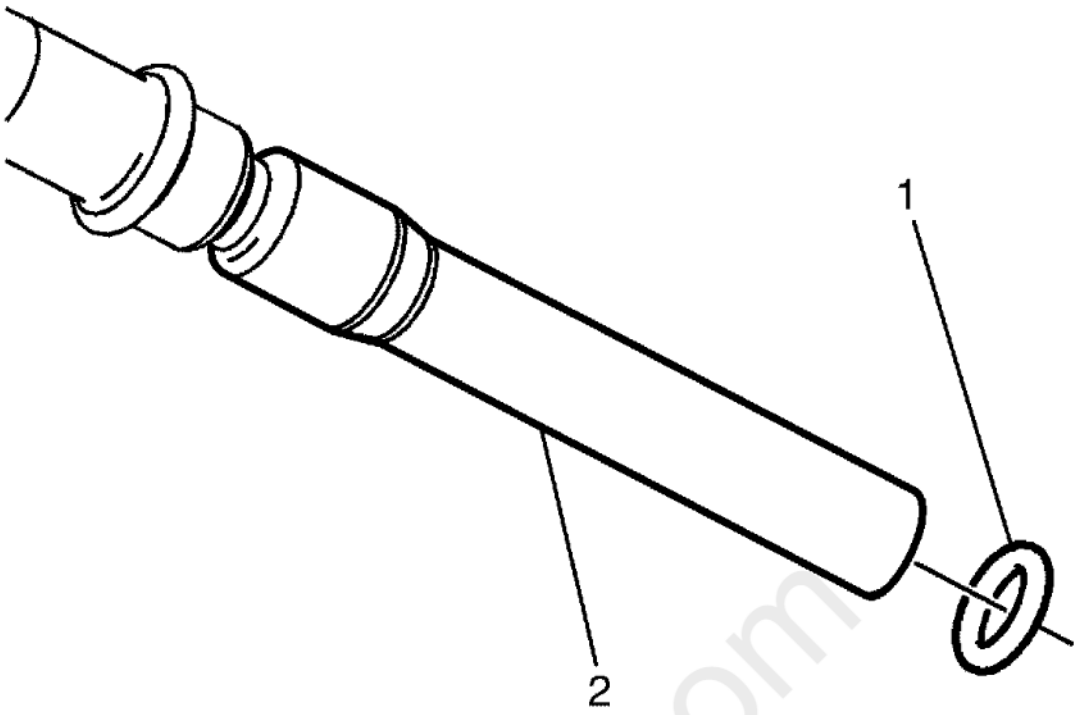


Fig. 77: Identifying Oil Level Indicator Tube & O-Ring
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The oil level indicator tube seal is a single use item.**

Installation Procedure

1. Install the NEW O-ring (1) on the oil level indicator tube (2).

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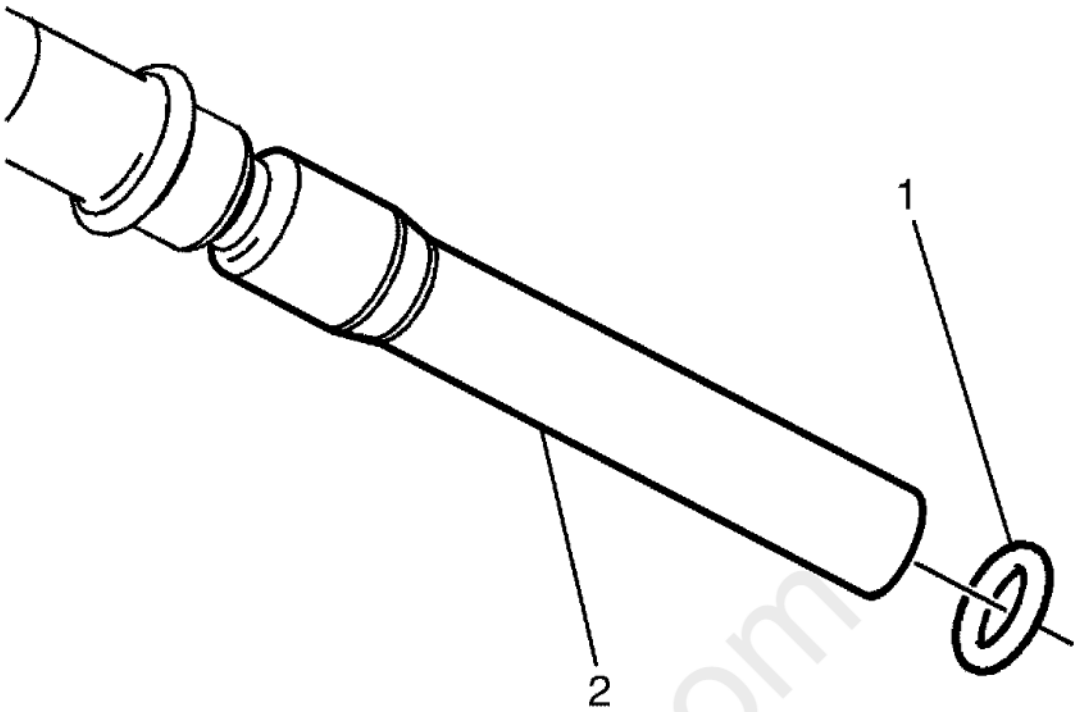
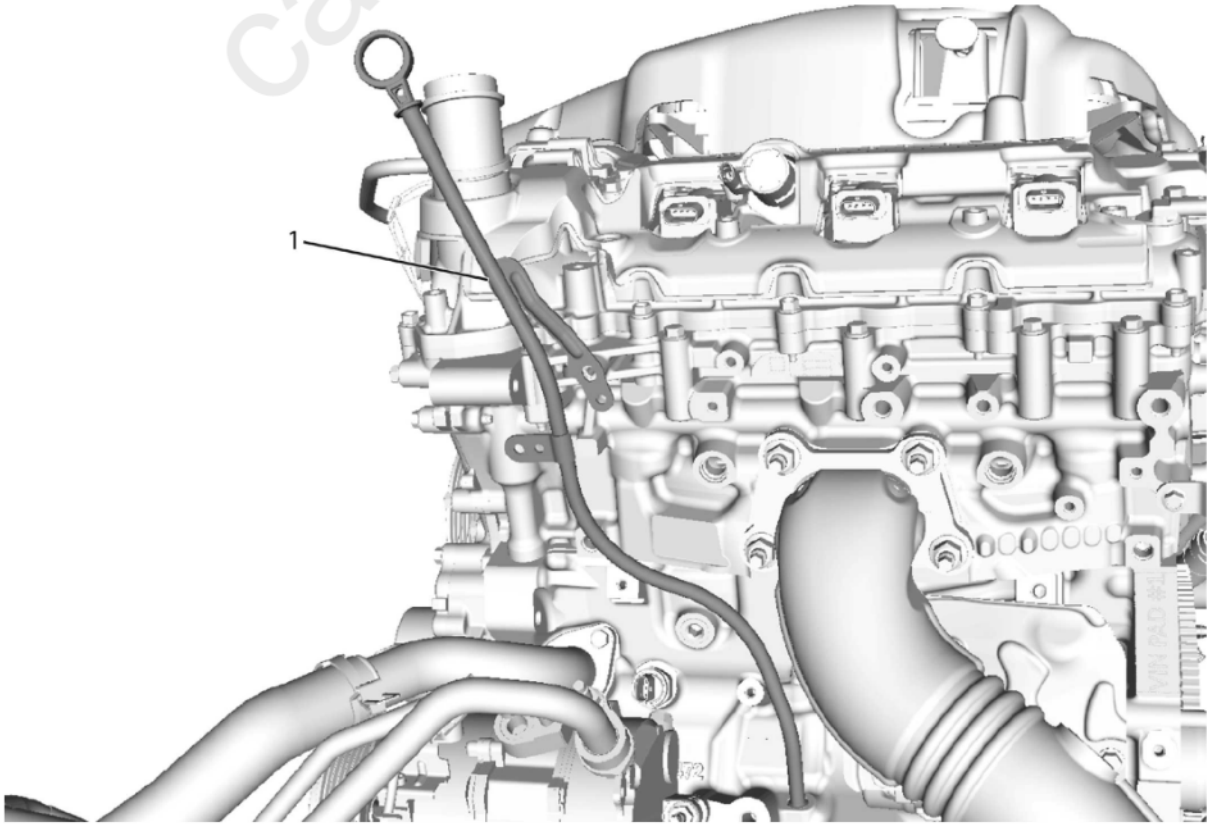


Fig. 78: Identifying Oil Level Indicator Tube & O-Ring
Courtesy of GENERAL MOTORS COMPANY

2. Position the oil level indicator tube (1) by sliding the tube down and in to the approximate location of the lower crankcase hole.



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Fig. 79: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

3. Guide the lower portion of the oil level indicator tube into the lower crankcase hole and seat the oil level indicator tube in place
4. Oil Level Indicator Tube Bracket Bolt (2)Â» Install and tighten 10 N.m (89 lb in)

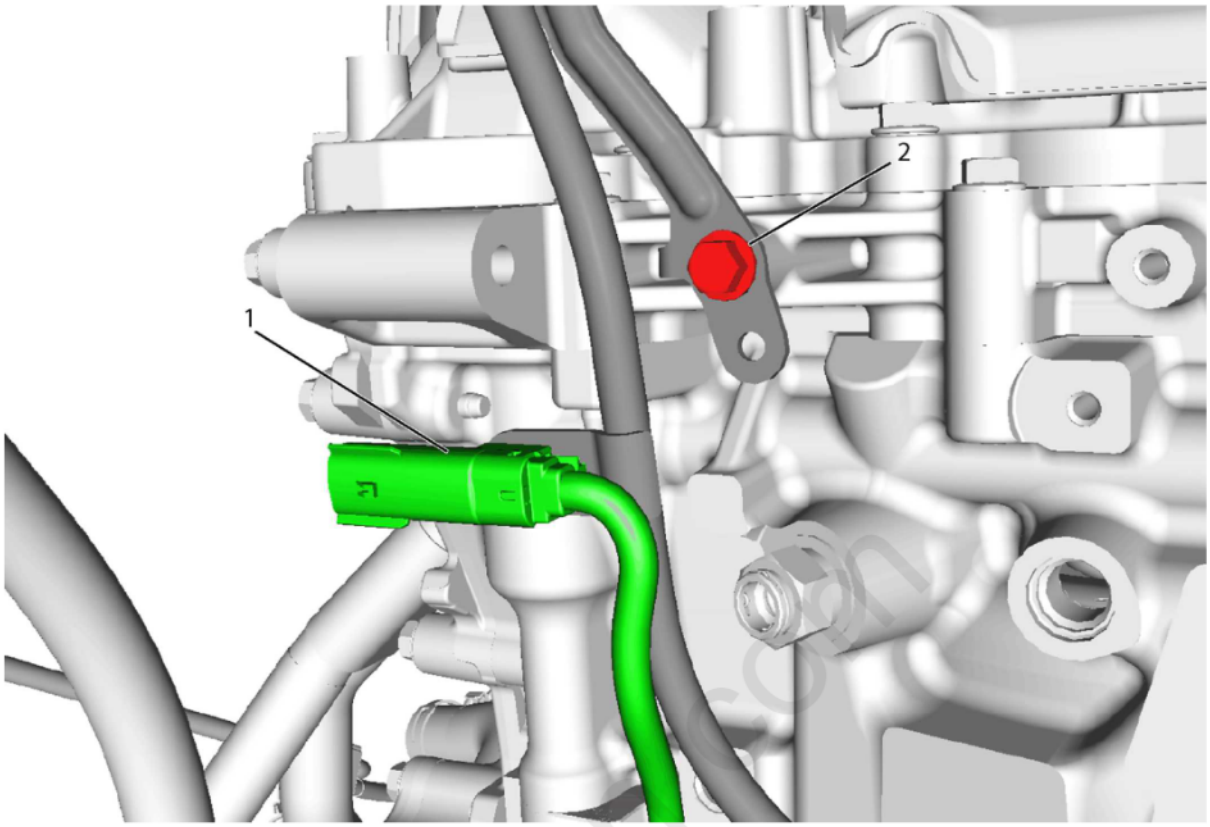


Fig. 80: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

5. Harness Connector (1) @ Oil Level Indicator TubeÂ» Connect

OIL FILTER ADAPTER REPLACEMENT

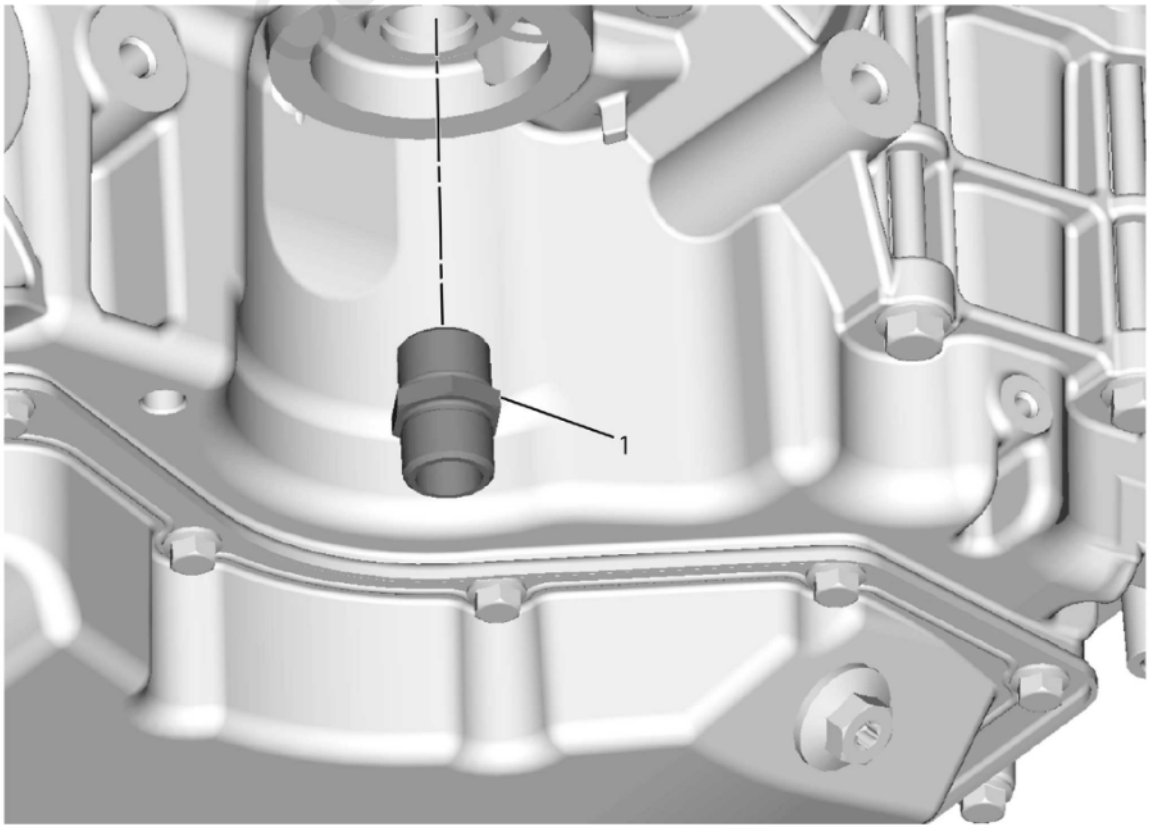


Fig. 81: Oil Filter Adapter
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the oil filter. Refer to **Engine Oil and Oil Filter Replacement**	
1	Oil Filter Adapter **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Tighten** 50 N.m (37 lb ft)

CRANKSHAFT BALANCER REPLACEMENT (LGX)

Special Tools

- **EN-44226-5** Crankshaft Button
- **EN-41816** Crankshaft Balancer Remover
- **EN-46106** Flywheel Holding Tool

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

Removal Procedure

1. **Drive Belt Replacement (LGX)**Â» Remove
2. **Starter Replacement (LGX)** Â» Remove
3. Install the **EN-46106** tool (1) through the starter mounting hole.

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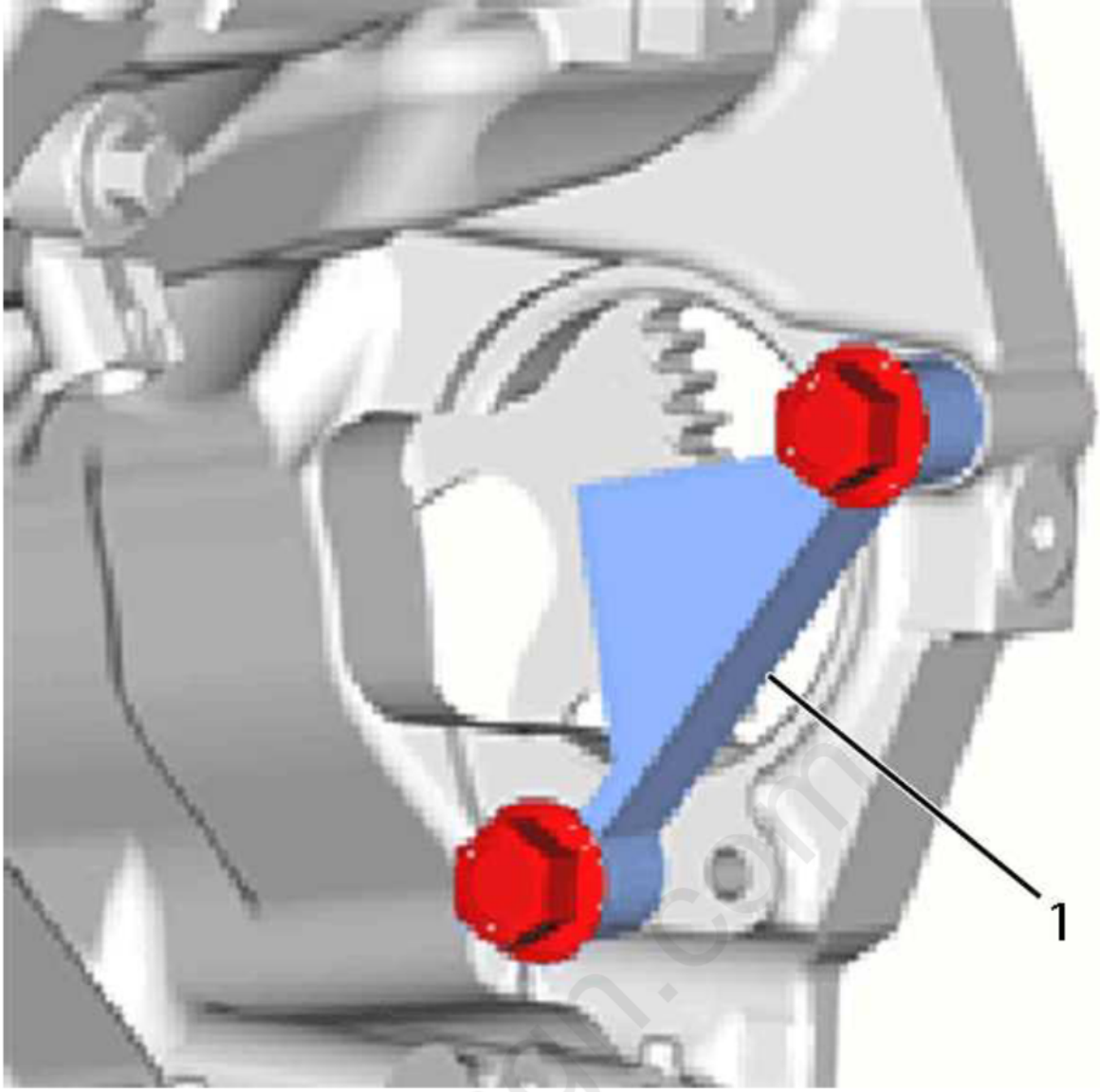


Fig. 82: Flywheel Holder
Courtesy of GENERAL MOTORS COMPANY

4. Remove the crankshaft balancer bolt (1).

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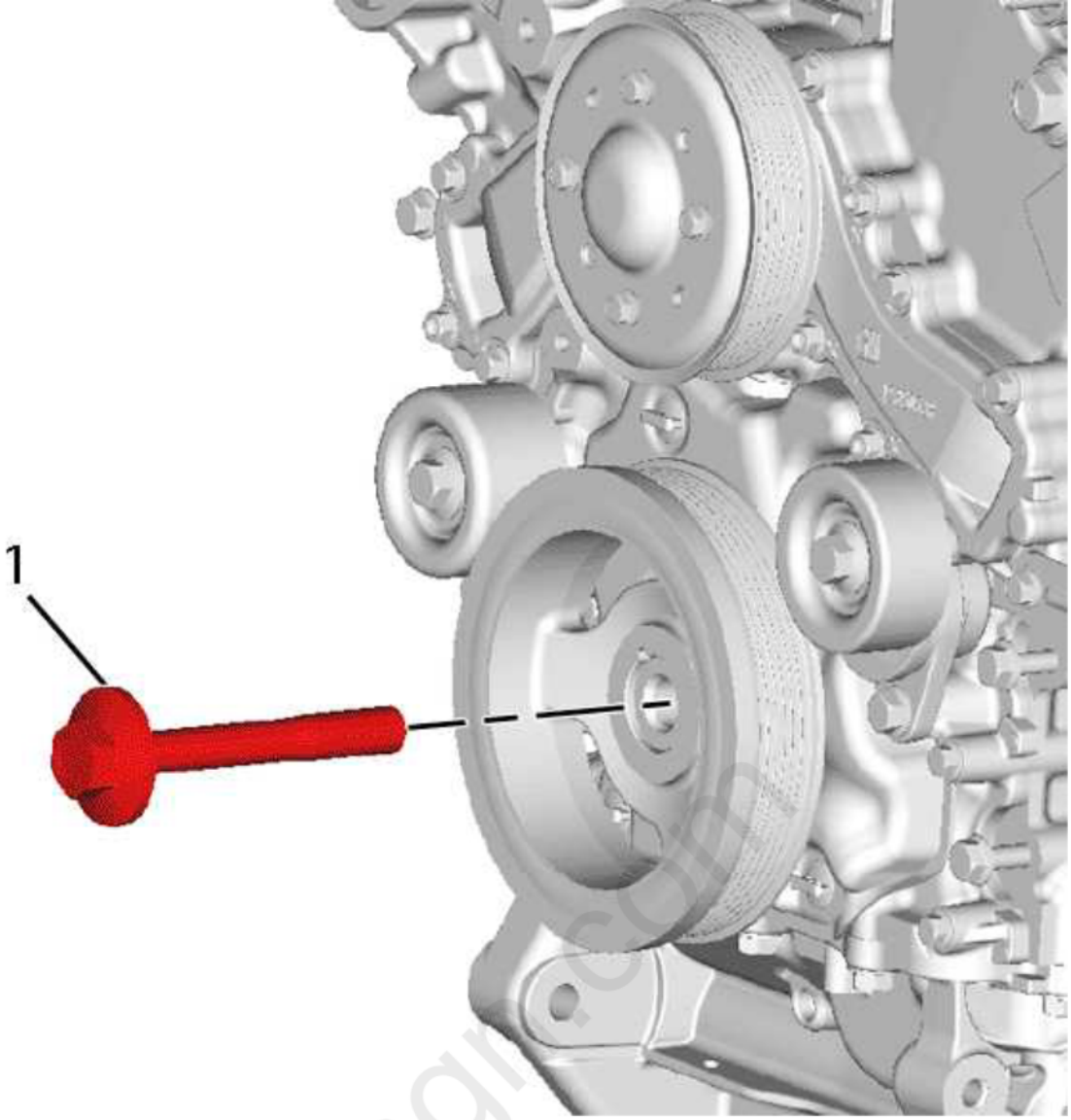


Fig. 83: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation.**

5. Install the **EN-44226-5** button (1) in the nose of the crankshaft.

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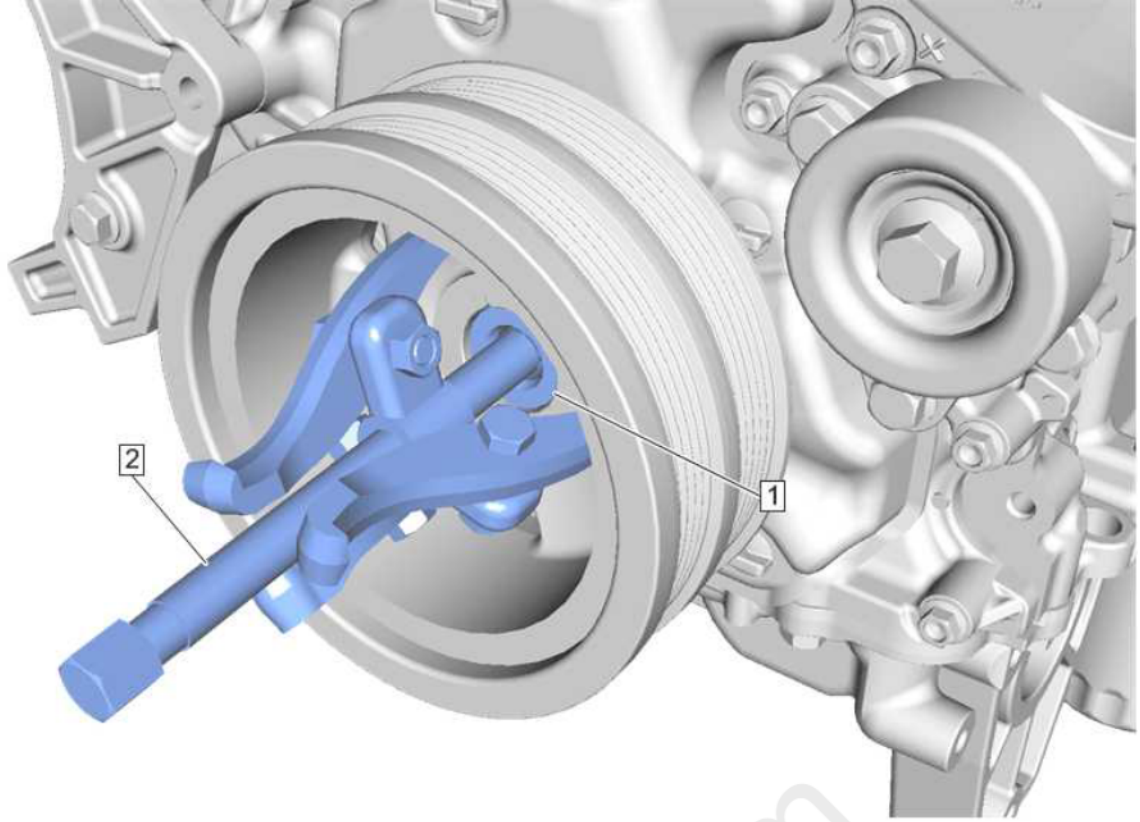


Fig. 84: Crankshaft Balancer Remover
Courtesy of GENERAL MOTORS COMPANY

6. Install the **EN-41816** remover (2) in order to remove the crankshaft balancer.
7. Tighten the center bolt of the **EN-41816** remover (2) in order to pull the crankshaft balancer off of the crankshaft.
8. Remove the **EN-41816** remover and **EN-44226-5** button from the crankshaft balancer.

Installation Procedure

1. **Crankshaft Balancer Installation (LGX)** Â» Install
2. Remove the **EN-46106** tool (1) from the starter mounting hole.

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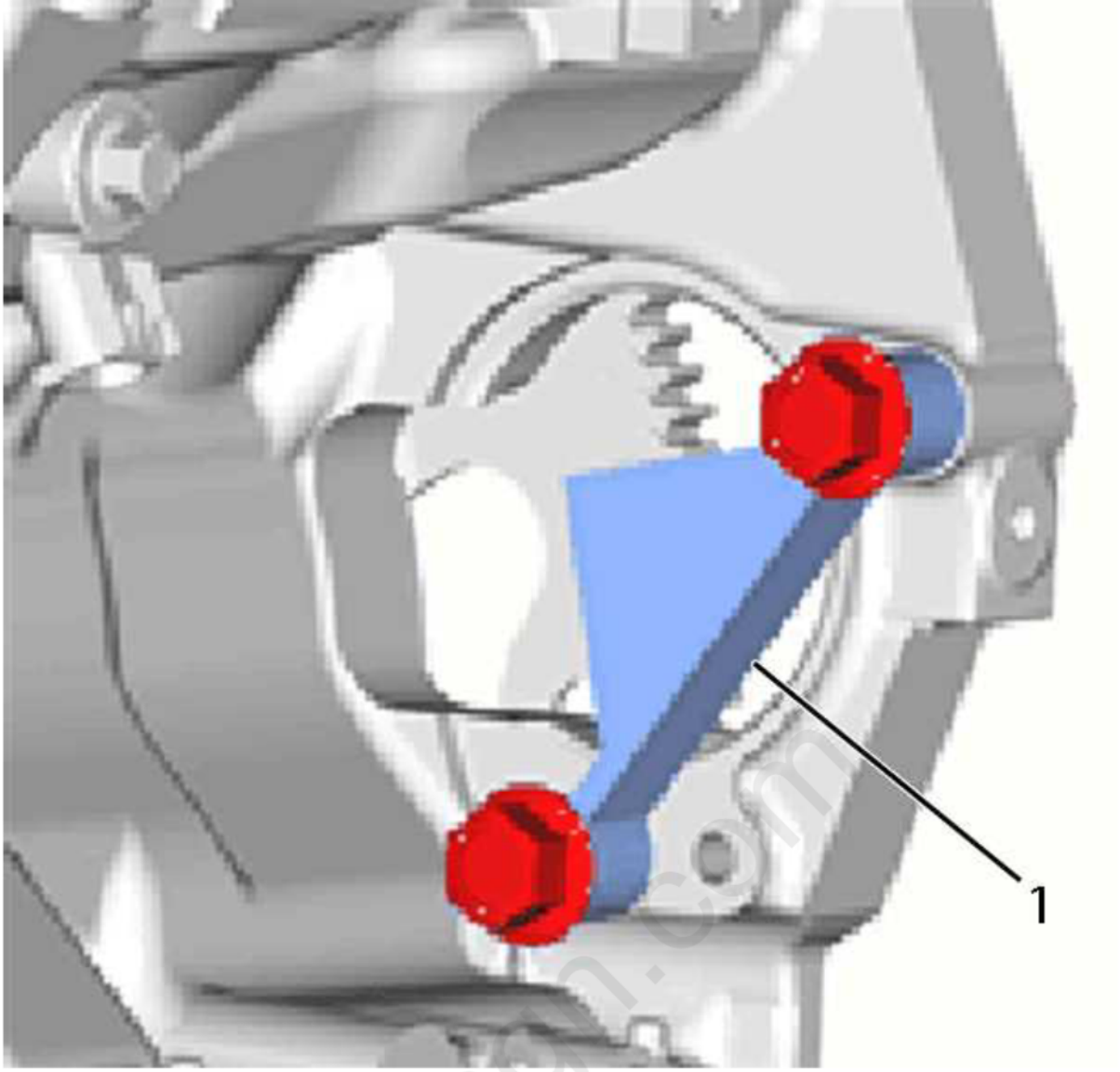


Fig. 85: Flywheel Holder
Courtesy of GENERAL MOTORS COMPANY

3. Starter Replacement (LGX) Â» Install
4. Drive Belt Replacement (LGX)Â» Install
5. Perform the crankshaft position variation learn procedure. Refer to Crankshaft Position Variation Learn

CRANKSHAFT BALANCER REPLACEMENT (LGW)

Special Tools

- **EN-44226-5** Crankshaft Button
- **EN-41816** Crankshaft Balancer Remover
- **EN-46106** Flywheel Holding Tool

For equivalent regional tools, refer to Special Tools .

Removal Procedure

1. Drive Belt Replacement (LGW)Â» Remove
2. Starter Replacement (LGW) Â» Remove
3. Install the **EN-46106** tool (1) through the starter mounting hole.

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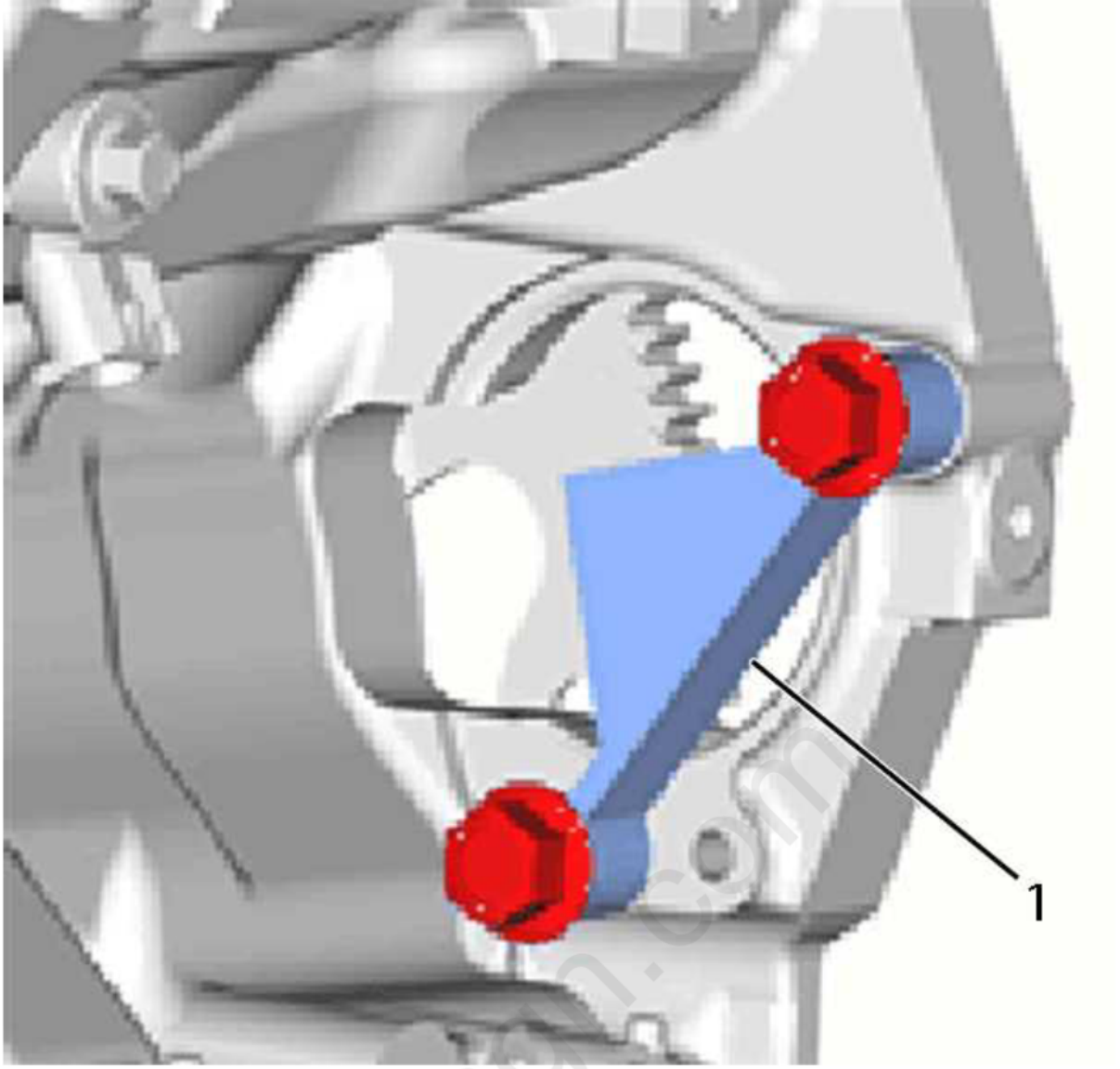


Fig. 86: Flywheel Holder
Courtesy of GENERAL MOTORS COMPANY

4. Remove the crankshaft balancer bolt (1).

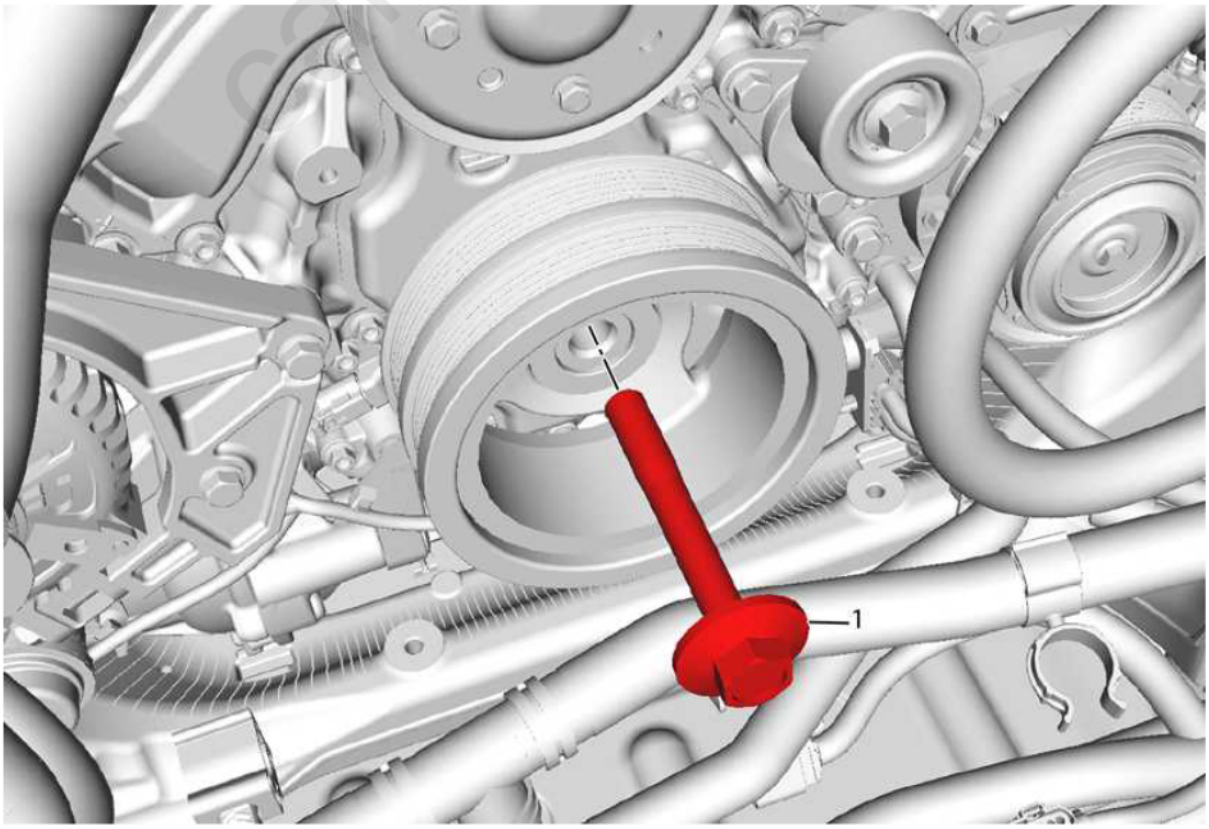


Fig. 87: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation.**

5. Install the **EN-44226-5** button (1) in the nose of the crankshaft.

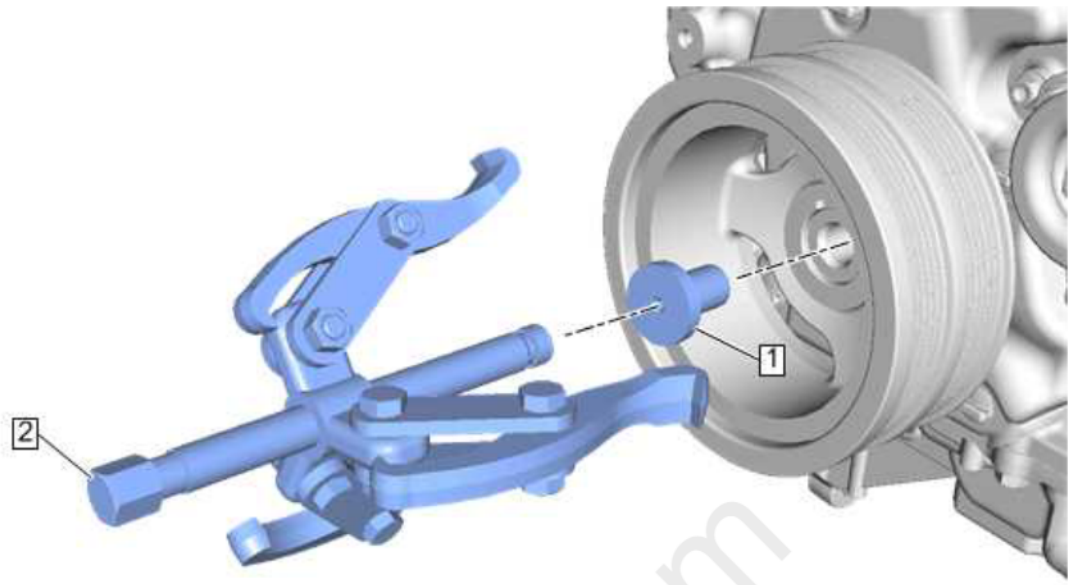


Fig. 88: EN-44226-5 Button
Courtesy of GENERAL MOTORS COMPANY

6. Install the **EN-41816** remover (2) in order to remove the crankshaft balancer.
7. Tighten the center bolt of the **EN-41816** remover (2) in order to pull the crankshaft balancer off of the crankshaft.
8. Remove the **EN-41816** remover and **EN-38416-2** button from the crankshaft balancer.

Installation Procedure

1. Crankshaft Balancer Installation (LGW) Â» Install
2. Remove the **EN-46106** tool (1) from the starter mounting hole.

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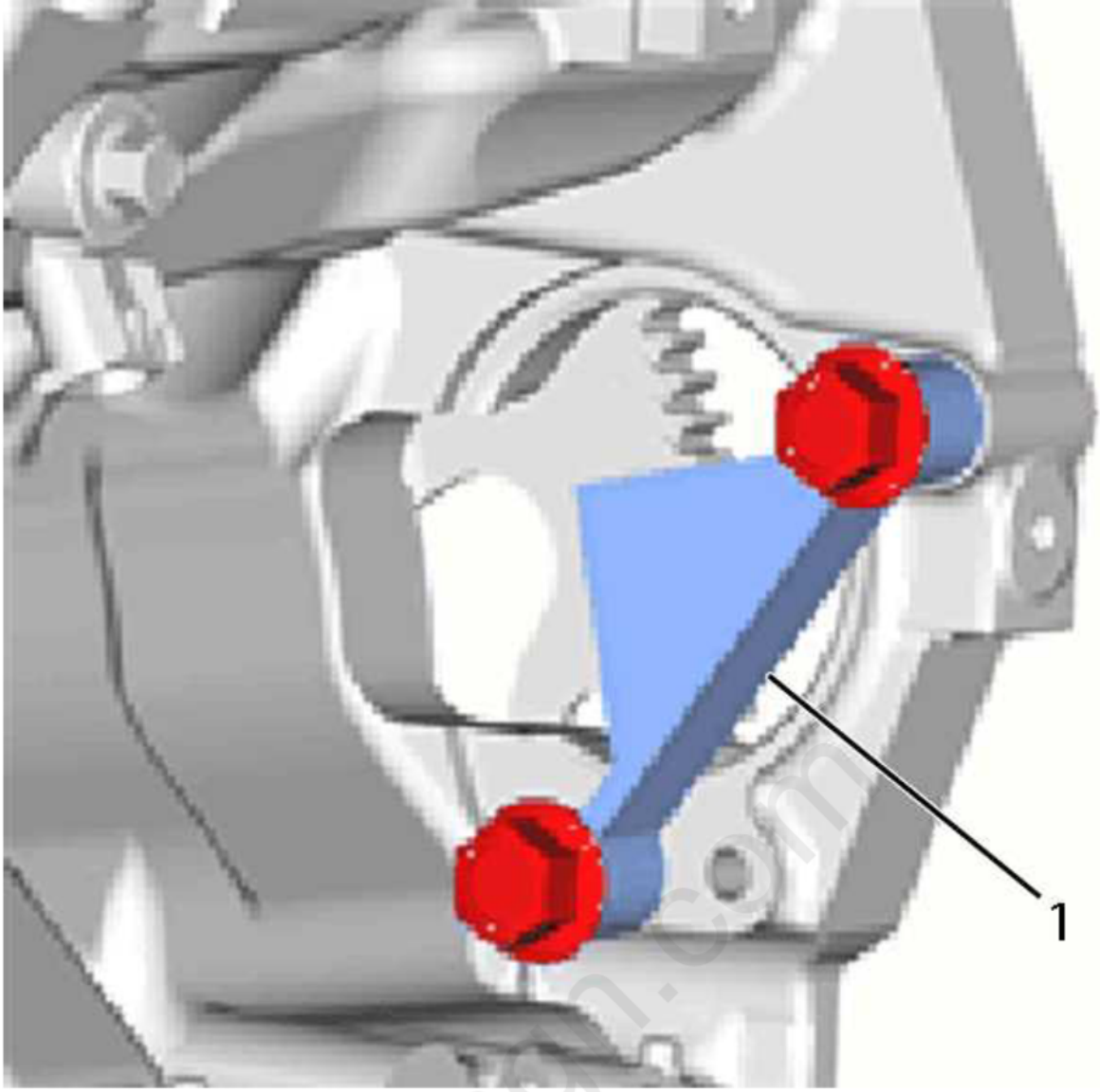


Fig. 89: Flywheel Holder
Courtesy of GENERAL MOTORS COMPANY

3. Starter Replacement (LGW) Â» Install
4. Drive Belt Replacement (LGW)Â» Install
5. Perform the crankshaft position variation learn procedure. Refer to Crankshaft Position Variation Learn

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Special Tools

EN-29184 Oil Seal Installer

For equivalent regional tools, refer to Special Tools .

Removal Procedure

1. Crankshaft Balancer Replacement (LGX)Crankshaft Balancer Replacement (LGW)Â» Remove
2. Remove the crankshaft front cover oil seal with a suitable tool.

Installation Procedure

1. Use the **EN-29184** installer (1) or equivalent to install the crankshaft front oil seal (2).

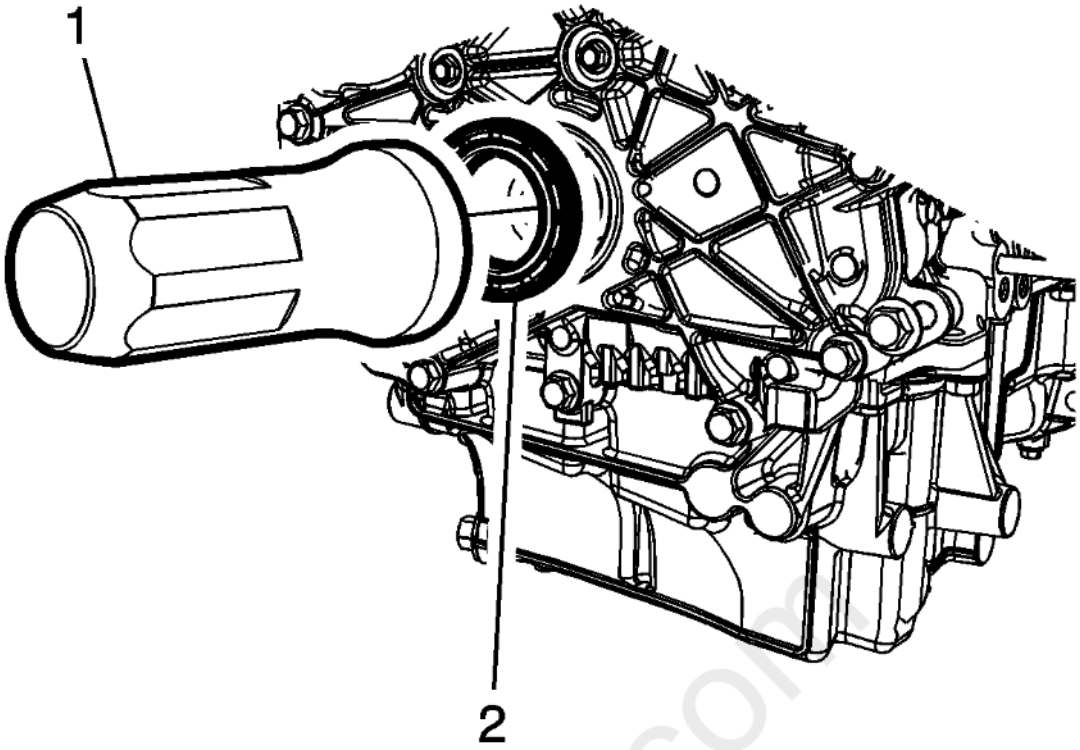


Fig. 90: Crankshaft Front Oil Seal And Installer
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not lubricate the crankshaft front oil seal or the crankshaft balancer sealing surfaces.**

2. Crankshaft Balancer Replacement (LGX)Crankshaft Balancer Replacement (LGW)Â»Install

CRANKSHAFT SPROCKET REPLACEMENT

Removal Procedure

1. Engine Front CoverÂ» Remove - Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)
2. Remove the camshaft timing chain components. Refer to Camshaft Timing Chain Components Removal .
3. Clean and inspect all of the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection . Replace components as necessary.

Installation Procedure

1. Install the camshaft timing chain components. Refer to Camshaft Timing Chain Components Installation
2. Engine Front CoverÂ» Install - Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)

CAMSHAFT COVER REPLACEMENT - LEFT SIDE

Removal Procedure

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1. **Camshaft Housing Cover Insulator Replacement - Left Side (LGX)Camshaft Housing Cover Insulator Replacement - Left Side (LGW)**Â» Remove
2. Positive Crankcase Ventilation Tube @ Camshaft CoverÂ» Disconnect
3. **Ignition Coil Replacement - Bank 2** Â» Remove
4. **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LGX) Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LGW)** Â» Remove
5. **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGX) Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGW)** Â» Remove
6. Disconnect and remove the engine harness from the camshaft cover.
7. Camshaft Cover Bolt (1)Â» Remove [18x]

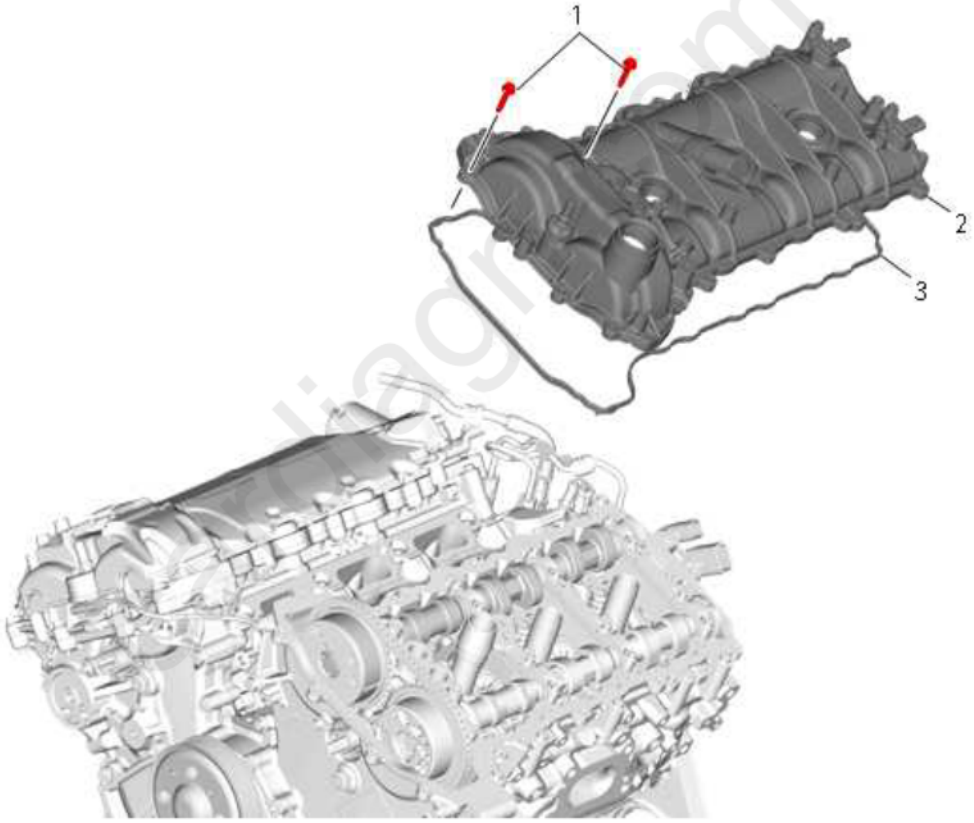


Fig. 91: Camshaft Cover, Bolt, Seal
Courtesy of GENERAL MOTORS COMPANY

8. Camshaft Cover (2)Â» Remove
9. Camshaft Cover Seal (3)Â» Remove and DISCARD
10. Disassemble the camshaft cover as needed. Refer to **Camshaft Cover Disassemble** .
11. Clean the mating surfaces of the cylinder head and the camshaft cover. Refer to **Camshaft Cover Cleaning and Inspection**

Installation Procedure

1. Assemble the camshaft cover as needed. Refer to **Camshaft Cover Assemble** .
2. Place a bead 8 mm (0.3150 in) in width by 4 mm (0.1575 in) in height of RTV sealant equivalent, on the engine front cover split lines (1). Refer to **Adhesives, Fluids, Lubricants and Sealers**

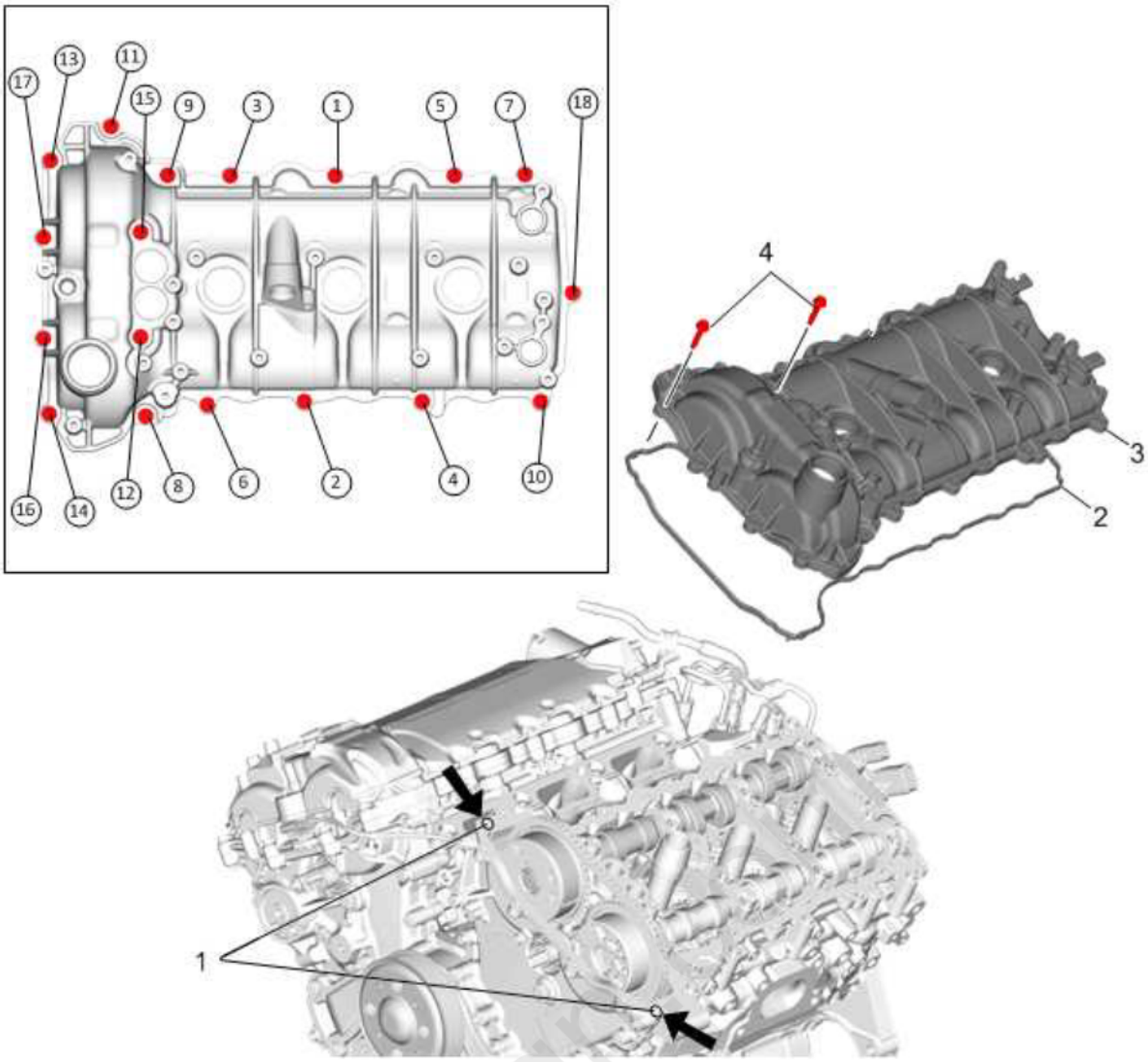


Fig. 92: Camshaft Cover, Bolt, Seal
Courtesy of GENERAL MOTORS COMPANY

3. Camshaft Cover Seal (2)Â» Install a NEW seal.
4. Camshaft Cover (3)Â» Install
5. Camshaft Cover Bolt (4) [18x]Â» Loosely install
6. Camshaft Cover Bolt (4)Â» Tighten in the sequence shown. [18x] 15 N.m (11 lb ft)

CAUTION: **Refer to Fastener Caution .**

7. Position and install the engine harness to the camshaft cover.
8. **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGX) Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGW)** Â» Install
9. **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGW) Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGX)** Â» Install
10. **Ignition Coil Replacement - Bank 2** Â» Install
11. Positive Crankcase Ventilation Tube @ Camshaft CoverÂ» Connect
12. **Camshaft Housing Cover Insulator Replacement - Left Side (LGX)Camshaft Housing Cover Insulator Replacement - Left Side (LGW)**Â» Install

CAMSHAFT COVER REPLACEMENT - RIGHT SIDE

Removal Procedure

1. **Camshaft Housing Cover Insulator Replacement - Right Side (LGX)Camshaft Housing Cover Insulator Replacement - Right Side (LGW)**Â» Remove

2. Positive Crankcase Ventilation Tube @ Camshaft CoverÂ» Disconnect
3. **Ignition Coil Replacement - Bank 1** Â» Remove
4. **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGW)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGX)** Â» Remove
5. **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGW)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGX)** Â» Remove
6. Disconnect and remove the engine harness from the camshaft cover.
7. Camshaft Cover Bolt (1)Â» Remove [18]

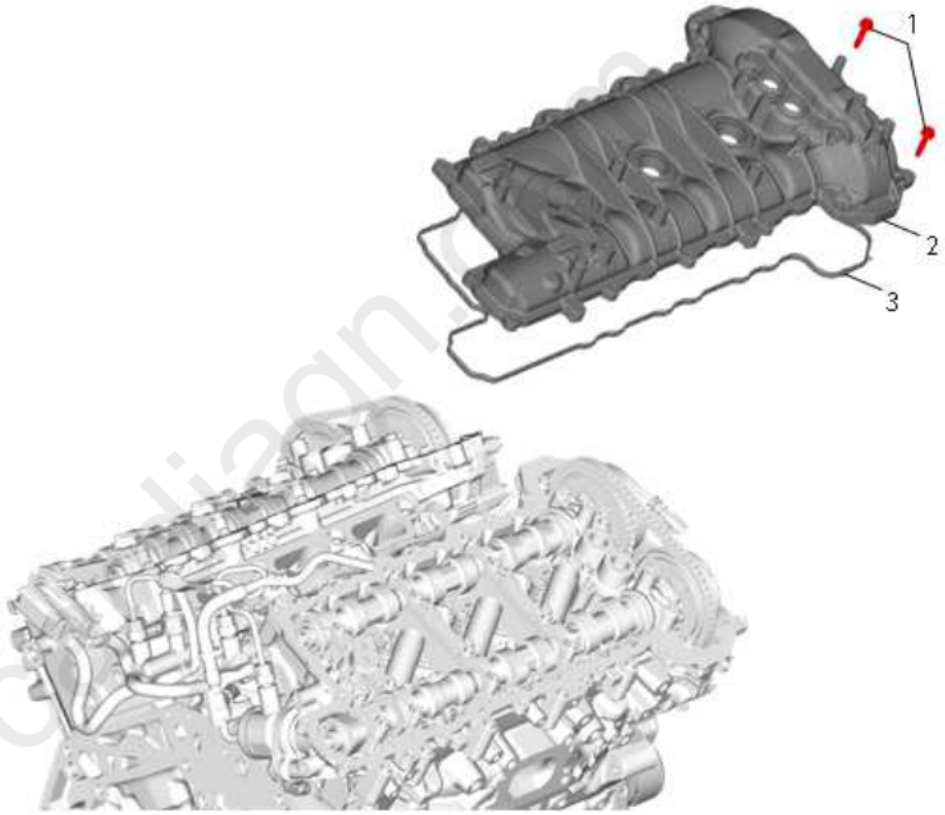


Fig. 93: Camshaft Cover, Bolt, Seal
Courtesy of GENERAL MOTORS COMPANY

8. Camshaft Cover (2)Â» Remove
9. Camshaft Cover Seal (3)Â» Remove and DISCARD
10. Disassemble the camshaft cover as needed. Refer to **Camshaft Cover Disassemble**
11. Clean the mating surfaces of the cylinder head and the camshaft cover. Refer to **Camshaft Cover Cleaning and Inspection**

Installation Procedure

1. Assemble the camshaft cover as needed. Refer to **Camshaft Cover Assemble**
2. Place a bead 8 mm (0.3150 in) in width by 4 mm (0.1575 in) in height of RTV sealant equivalent, on the engine front cover split lines (1). Refer to **Adhesives, Fluids, Lubricants and Sealers**

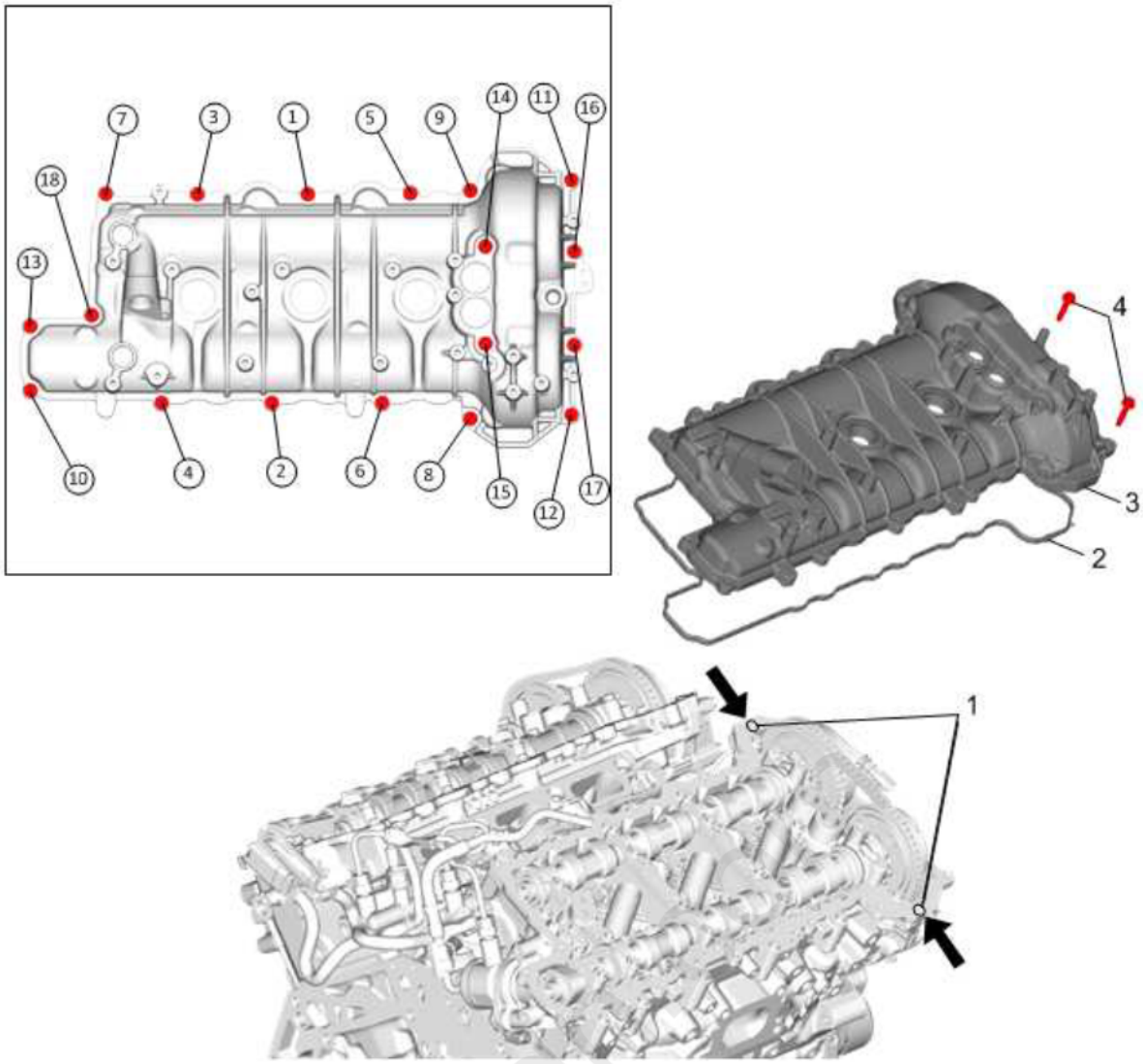


Fig. 94: Camshaft Cover, Bolt, Seal -- With Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

3. Camshaft Cover Seal (2)Â» Install a NEW seal.
4. Camshaft Cover (3)Â» Install
5. Camshaft Cover Bolt (4) [18]Â» Loosely install
6. Tighten in the sequence shown. 15 N.m (11 lb ft).

CAUTION: **Refer to Fastener Caution .**

7. Position and install the engine harness to the camshaft cover.
8. **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGW) Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGX)** Â» Install
9. **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGW) Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGX)** Â» Install
10. **Ignition Coil Replacement - Bank 1** Â» Install
11. Positive Crankcase Ventilation Tube @ Camshaft CoverÂ» Connect
12. **Camshaft Housing Cover Insulator Replacement - Right Side (LGX)Camshaft Housing Cover Insulator Replacement - Right Side (LGW)**Â» Install

ENGINE FRONT COVER REPLACEMENT (LGX)

Special Tools

EN-46109 Engine Front Cover Installation Guide Pins

Equivalent regional tools:**Special Tools**

Removal Procedure

1. Oil Pump Flow Control Solenoid Valve HarnessÂ» Remove - **Oil Pump Flow Control Solenoid Valve Harness Replacement**
2. Air Cleaner AssemblyÂ» Remove - **Air Cleaner Assembly Replacement (LGX)**
3. Water Pump Pulley (2)Â» Remove - **Water Pump Pulley Replacement (LGW, LGX)**

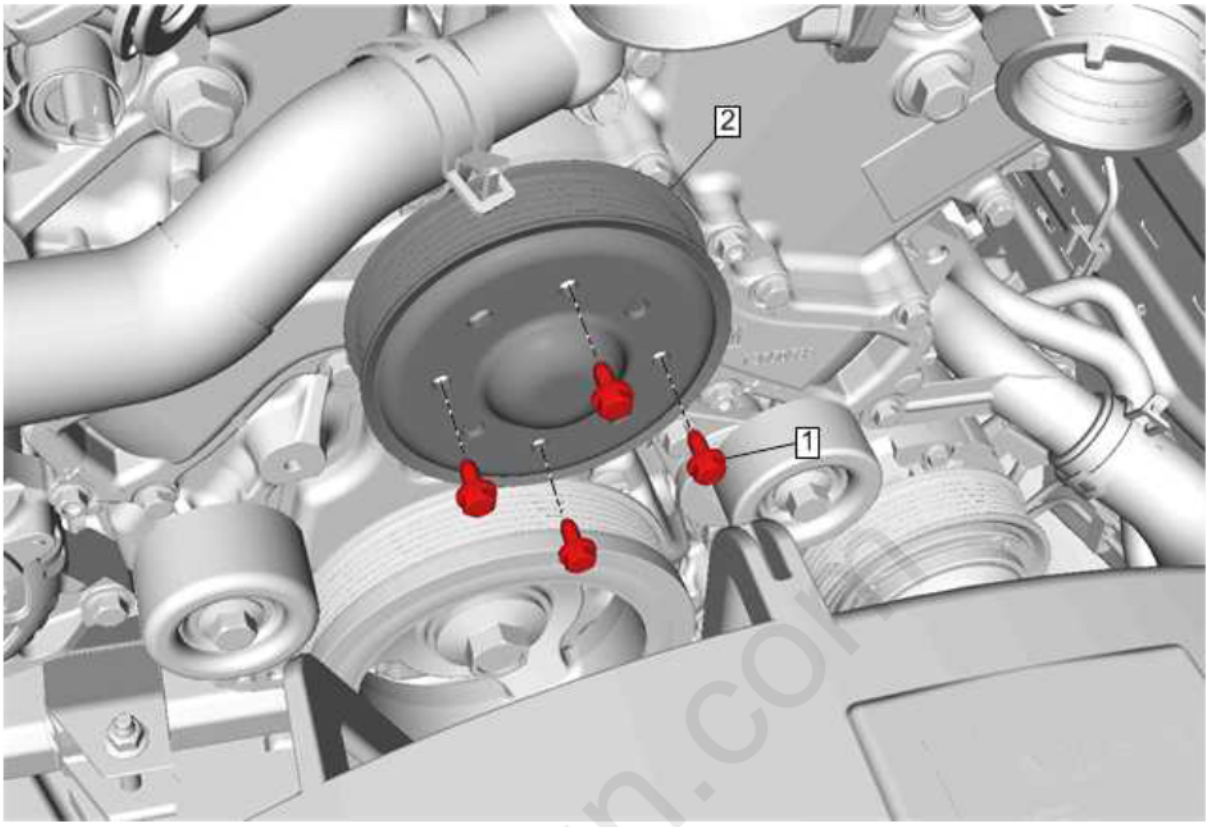


Fig. 95: Water Pump Pulley (LGX)
Courtesy of GENERAL MOTORS COMPANY

4. Camshaft Cover - Left Side (2)Â» Remove - **Camshaft Cover Replacement - Left Side**

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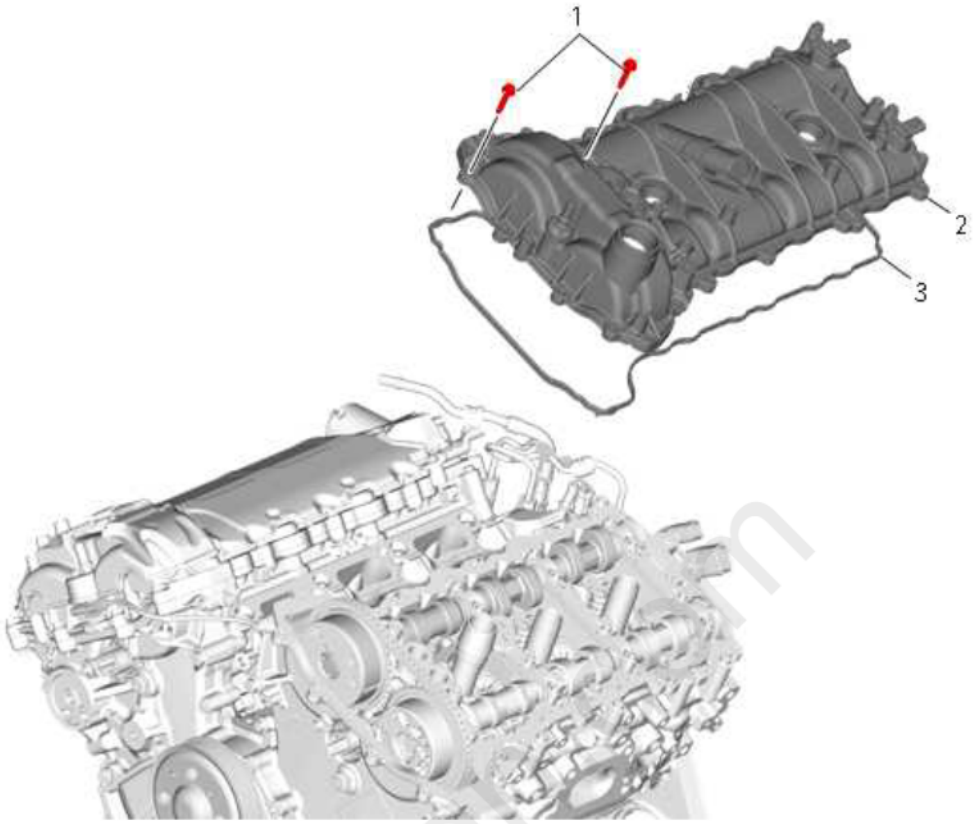


Fig. 96: Camshaft Cover, Bolt, Seal
Courtesy of GENERAL MOTORS COMPANY

5. Camshaft Cover - Right Side (2)Â» Remove - **Camshaft Cover Replacement - Right Side**

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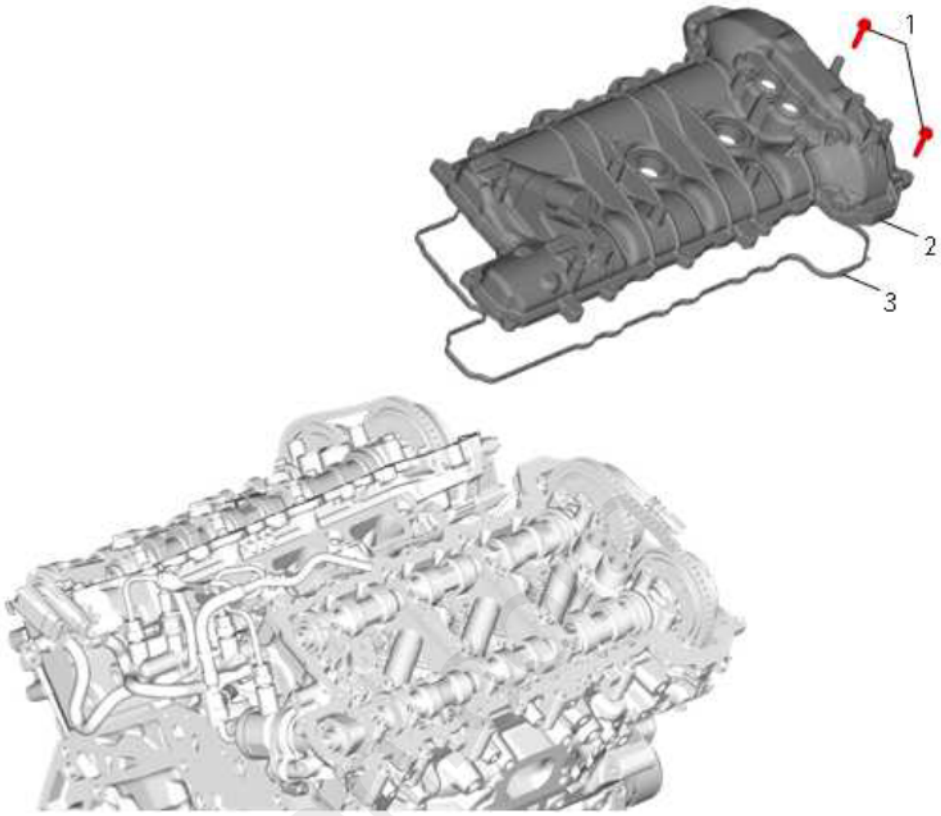


Fig. 97: Camshaft Cover, Bolt, Seal
Courtesy of GENERAL MOTORS COMPANY

6. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static without HP9)** , **Cooling System Draining and Filling (GE 47716 without HP9)** , **Cooling System Draining and Filling (Static LTG with HP9)** and/or **Cooling System Draining and Filling (GE 47716 LTG with HP9)**
7. Engine Oil Cooler AdapterÂ» Remove - **Engine Oil Cooler Adapter Replacement (LGX with AWD)**
8. Remove the water outlet (2) with the radiator hose and reposition aside. Refer to **Water Outlet Replacement (LGX)**

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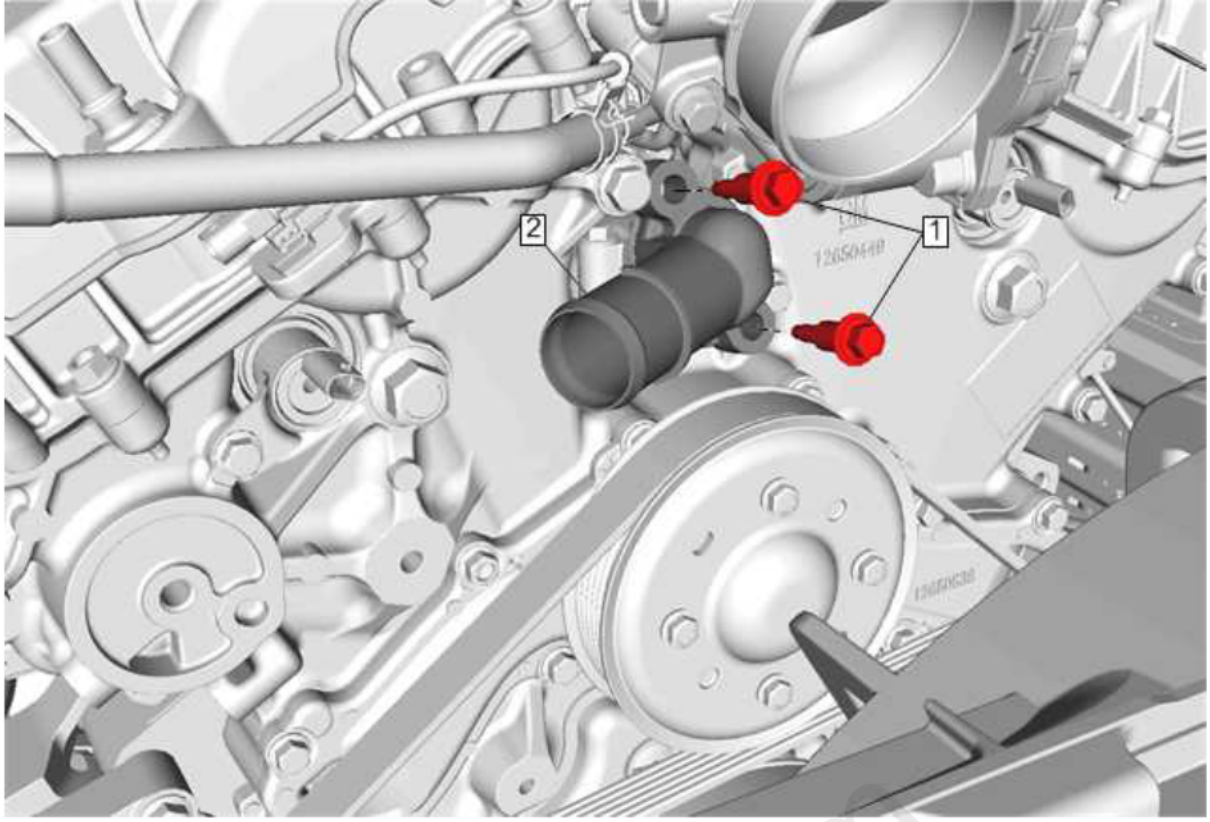


Fig. 98: Water Outlet (LGX)
Courtesy of GENERAL MOTORS COMPANY

9. Crankshaft BalancerÂ» Remove - **Crankshaft Balancer Replacement (LGX)**
10. Engine Coolant Air Bleed PipeÂ» Remove - **Engine Coolant Air Bleed Pipe Replacement (LGW, LGX)**
11. Engine Coolant Temperature Sensor Electrical Connector (1)Â» Disconnect

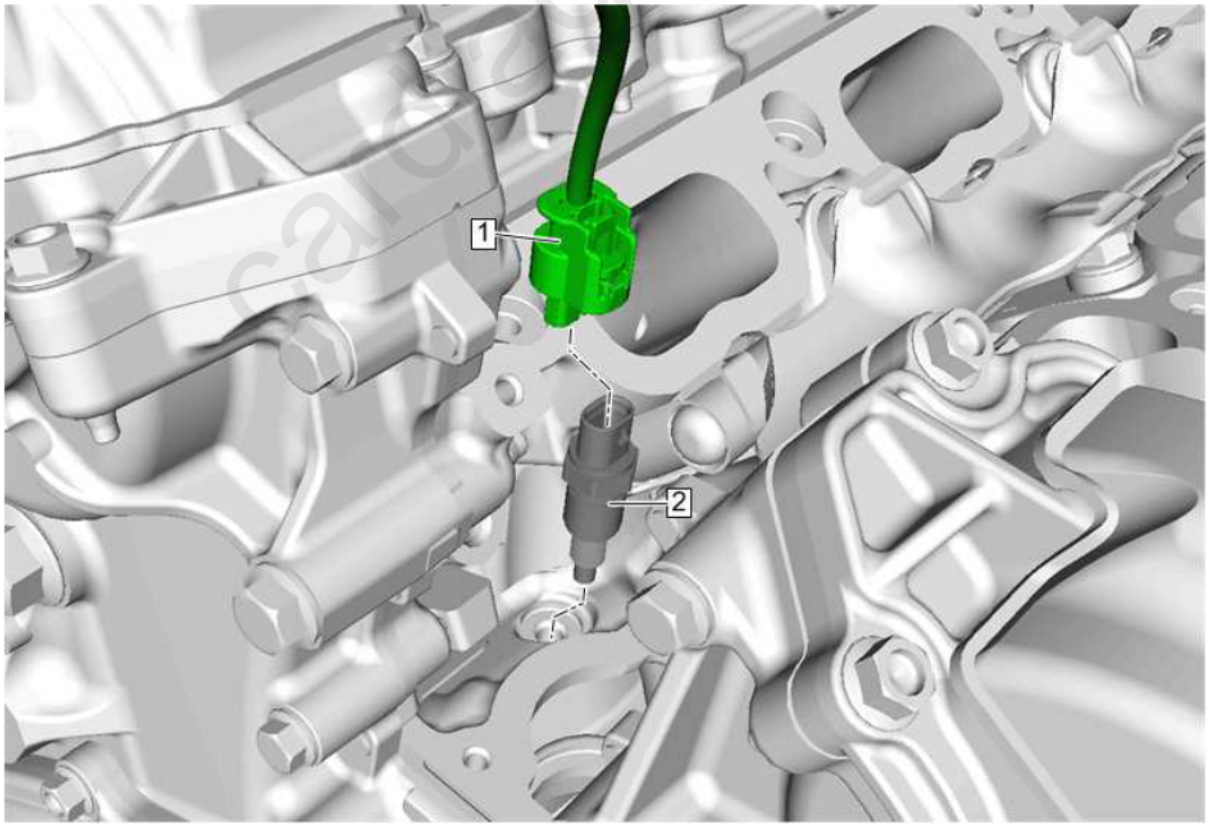


Fig. 99: Engine Coolant Temperature Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

12. Remove the engine ground fastener and ground cable attached to the front cover.
13. Detach retainers and position engine harness aside.
14. Oil Pump Flow Control Solenoid Valve Electrical ConnectorÂ» Disconnect

15. Water Pump Inlet PipeÂ» Remove - **Water Pump Inlet Pipe Replacement (LGX)**
16. Water PumpÂ» Remove - **Water Pump Replacement (LGW, LGX)**
17. Engine Front CoverÂ» Remove - **Engine Front Cover Removal**

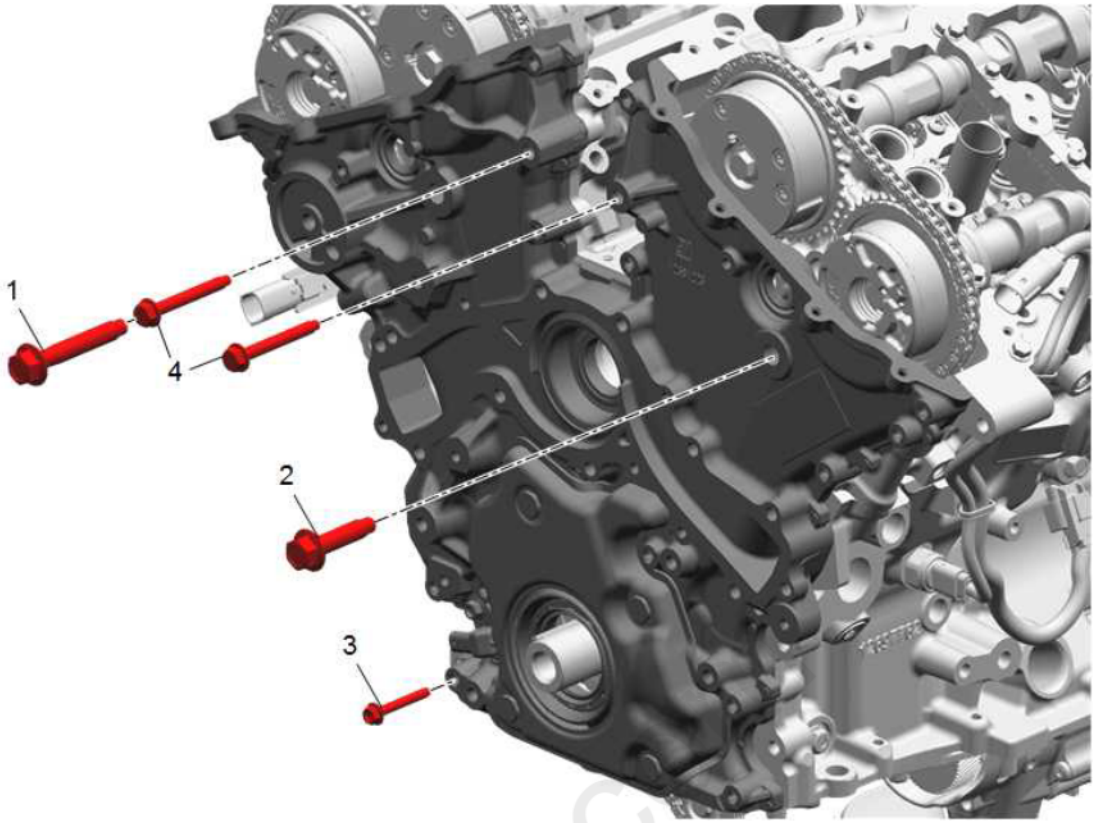


Fig. 100: Engine Front Cover (LGX)
Courtesy of GENERAL MOTORS COMPANY

NOTE: **It is not necessary to remove the upper oil pan when servicing the front cover in vehicle.**

18. Disassemble the engine front cover. Refer to **Engine Front Cover Disassemble**
19. Carefully clean the engine front cover sealing surfaces. Refer to **Engine Front Cover Cleaning and Inspection**

NOTE: **Do NOT use sharp and/or metal gasket scrapers in order to clean the sealing surfaces.**

NOTE: **Insert a piece of cardboard between the oil pan front and the oil pump in order to prevent any contaminants from falling into the oil pan.**

20. Use compressed air in order to remove any engine coolant from the engine cooling passages and from the top of the oil pan scraper (windage tray).

Installation Procedure

1. Assemble the engine front cover. Refer to **Engine Front Cover Assemble**
2. Use the **EN-46109** pins in order to install the engine front cover. Refer to **Engine Front Cover Installation**

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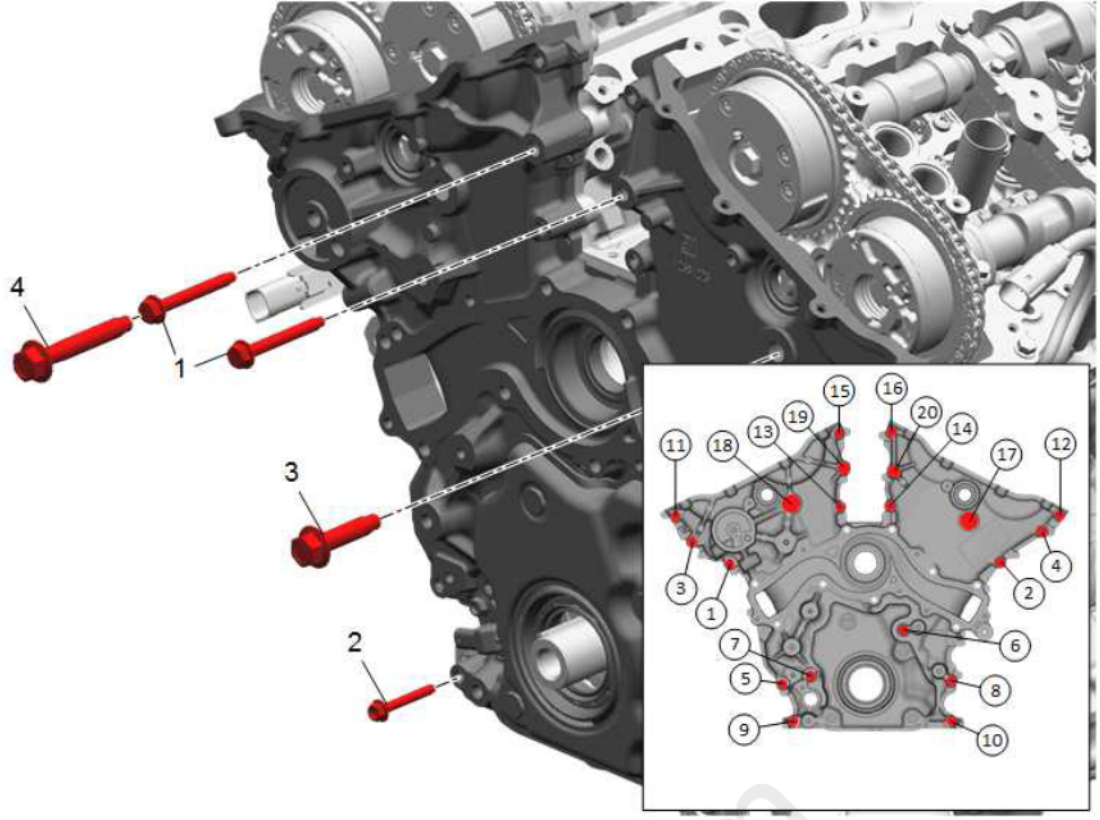


Fig. 101: Front Cover
Courtesy of GENERAL MOTORS COMPANY

3. Water PumpÂ» Install - **Water Pump Replacement (LGW, LGX)**
4. Water Pump Inlet PipeÂ» Install - **Water Pump Inlet Pipe Replacement (LGX)**
5. Oil Pump Flow Control Solenoid Valve Electrical ConnectorÂ» Connect
6. Position engine harness and attach harness retainers to engine front cover.
7. Install the ground cable and the fastener to the front engine cover. Tighten fastener to 22 N.m (16 lb ft)
8. Engine Coolant Temperature Sensor Electrical Connector (1)Â» Connect

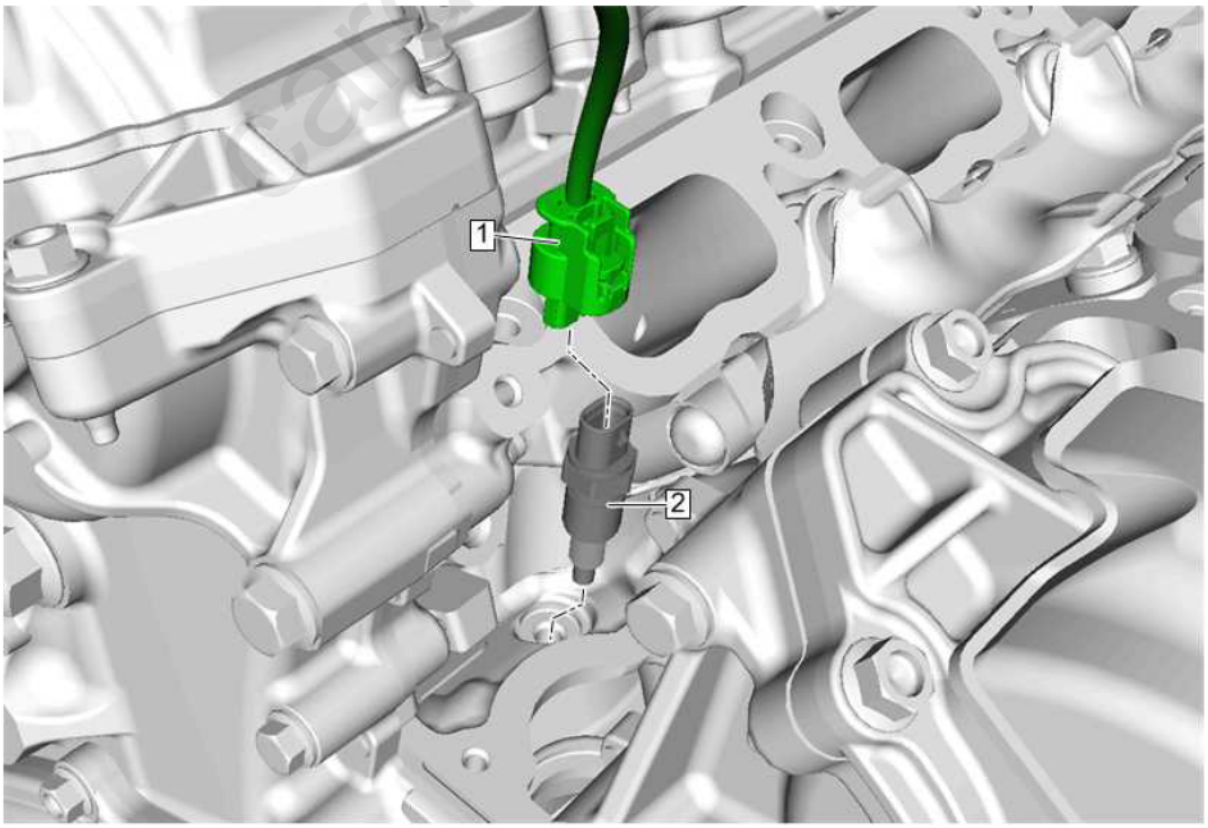


Fig. 102: Engine Coolant Temperature Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

9. Engine Coolant Air Bleed PipeÂ» Install - **Engine Coolant Air Bleed Pipe Replacement (LGW, LGX)**
10. Crankshaft BalancerÂ» Install - **Crankshaft Balancer Replacement (LGX)**
11. Install the water outlet (2) with radiator hose. Refer to **Water Outlet Replacement (LGX)**

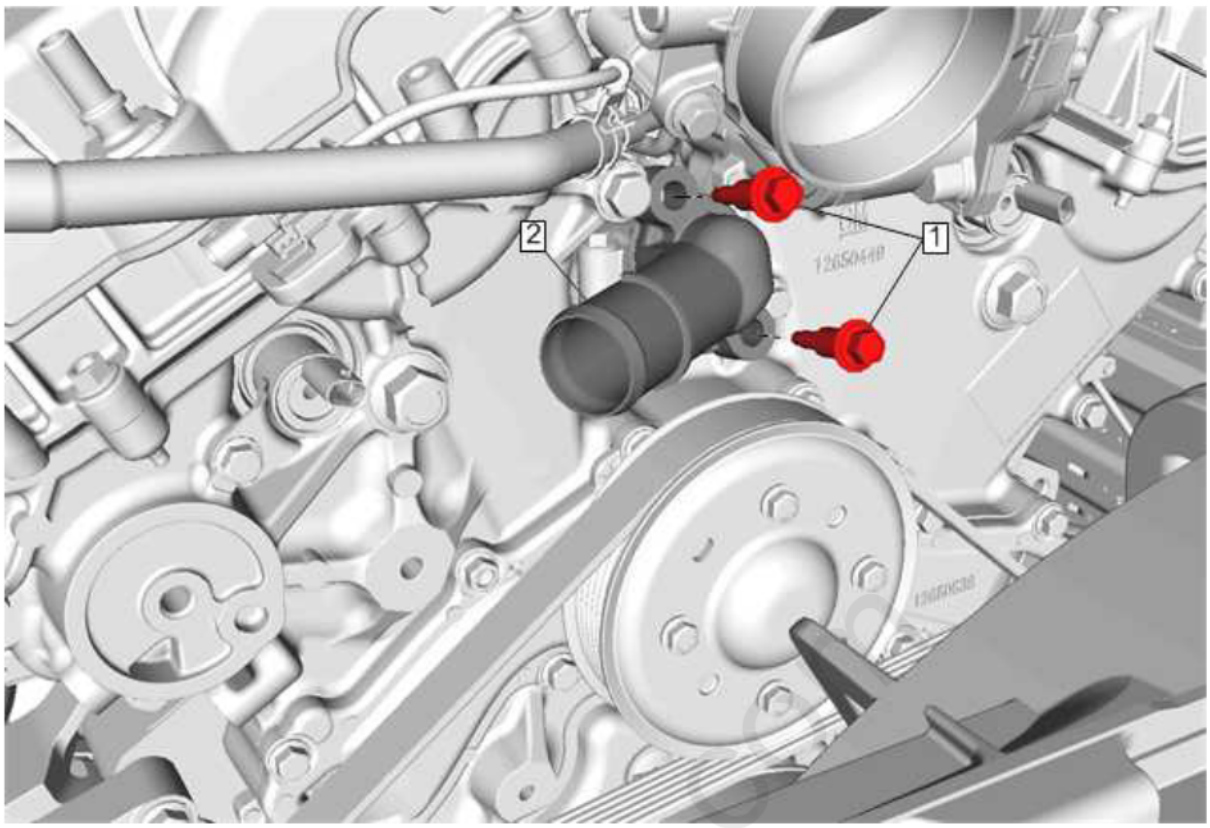


Fig. 103: Water Outlet (LGX)
Courtesy of GENERAL MOTORS COMPANY

12. Engine Oil Cooler AdapterÂ» Install - **Engine Oil Cooler Adapter Replacement (LGX with AWD)**
13. Camshaft Cover - Right Side (2)Â» Install - **Camshaft Cover Replacement - Right Side**

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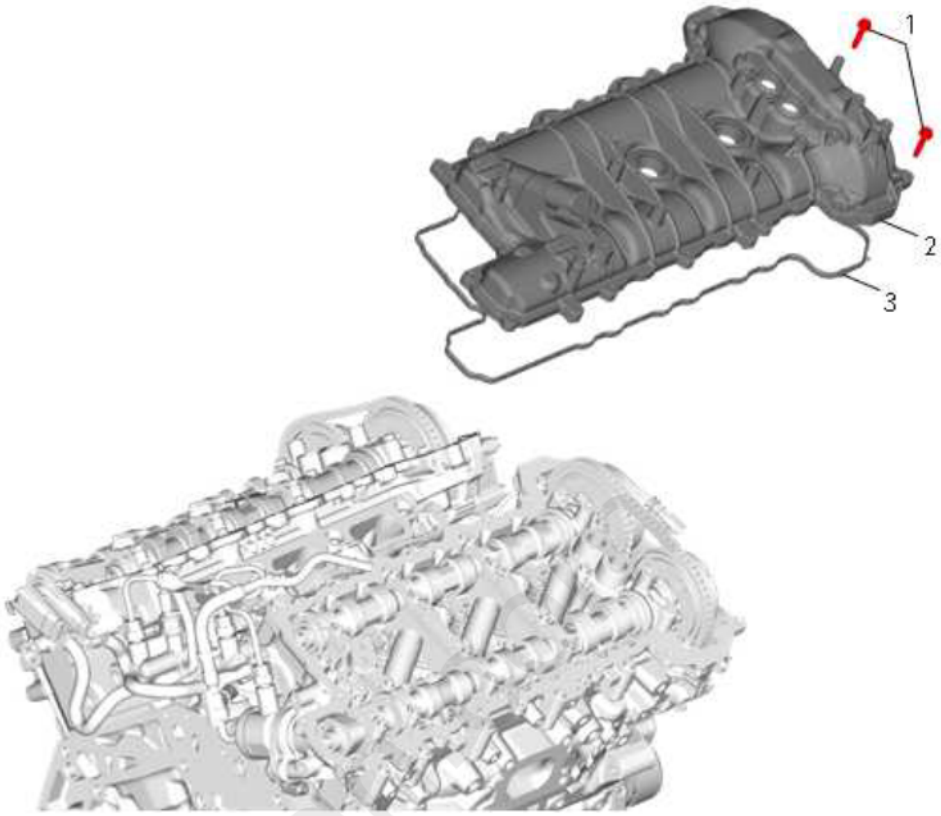


Fig. 104: Camshaft Cover, Bolt, Seal
Courtesy of GENERAL MOTORS COMPANY

14. Camshaft Cover - Left Side (2)Â» Install - **Camshaft Cover Replacement - Left Side**

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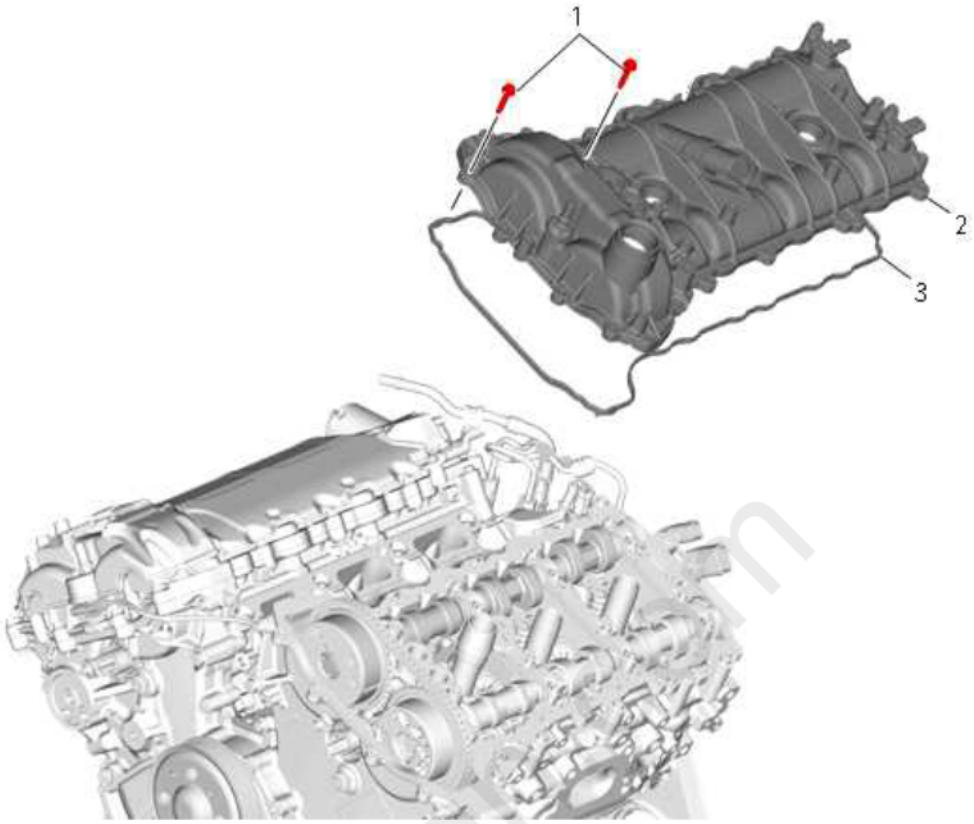


Fig. 105: Camshaft Cover, Bolt, Seal
Courtesy of GENERAL MOTORS COMPANY

15. Water Pump Pulley (2)Â» Install - **Water Pump Pulley Replacement (LGW, LGX)**

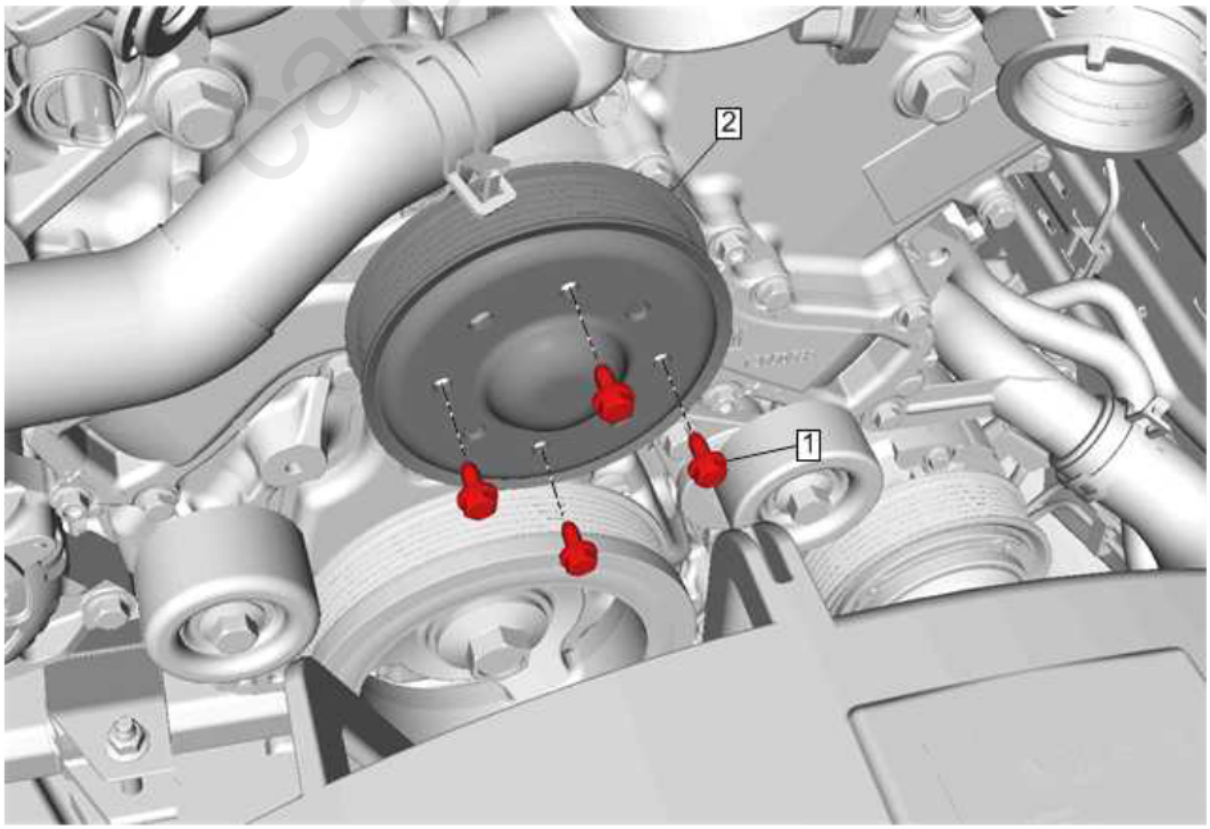


Fig. 106: Water Pump Pulley (LGX)
Courtesy of GENERAL MOTORS COMPANY

16. Air Cleaner AssemblyÂ» Install - **Air Cleaner Assembly Replacement (LGX)**
17. Oil Pump Flow Control Solenoid Valve HarnessÂ» Install - **Oil Pump Flow Control Solenoid Valve Harness Replacement**
18. Fill the cooling system. Refer to **Cooling System Draining and Filling (Static without HP9)** , **Cooling System Draining and Filling (GE 47716 without HP9)** , **Cooling System Draining and Filling (Static LTG with HP9)** and/or **Cooling System Draining and Filling (GE 47716 LTG with HP9)**

ENGINE FRONT COVER REPLACEMENT (LGW)

Special Tools

EN-46109 Engine Front Cover Installation Guide Pins

Equivalent regional tools:**Special Tools**

Removal Procedure

1. **Air Cleaner Assembly Replacement (LGW)** (1)Â» Remove

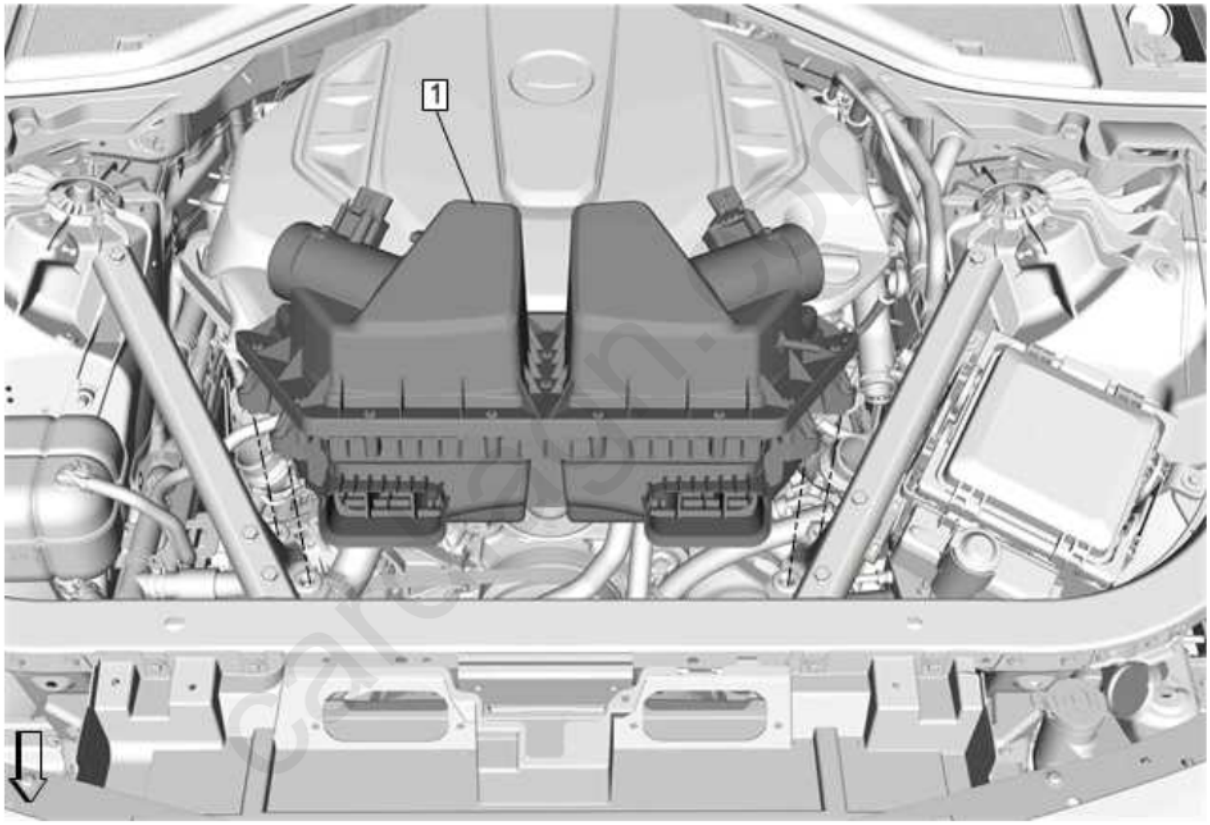


Fig. 107: Air Cleaner Assembly
Courtesy of GENERAL MOTORS COMPANY

2. **Water Pump Pulley Replacement (LGW, LGX)** (2)Â» Remove

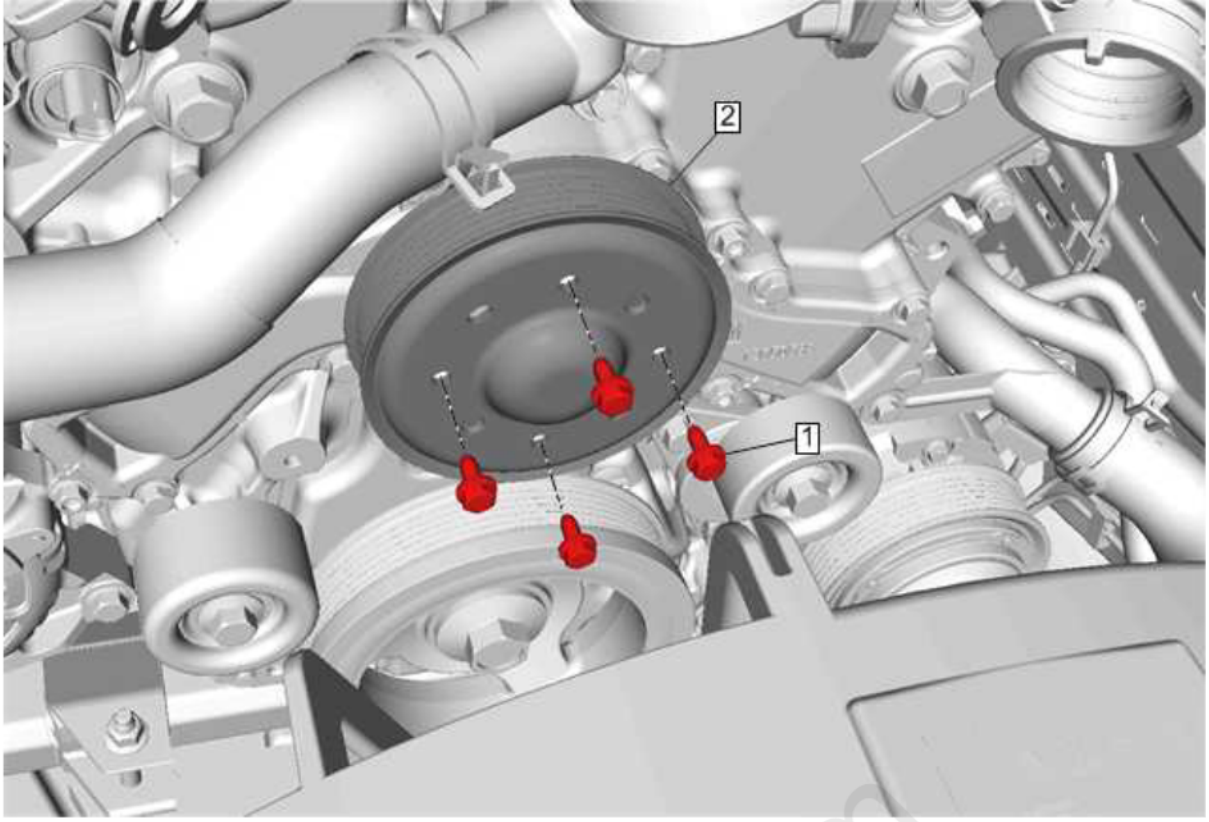


Fig. 108: Water Pump Pulley
Courtesy of GENERAL MOTORS COMPANY

3. Generator Bracket Replacement (LGW) (3)Â» Remove

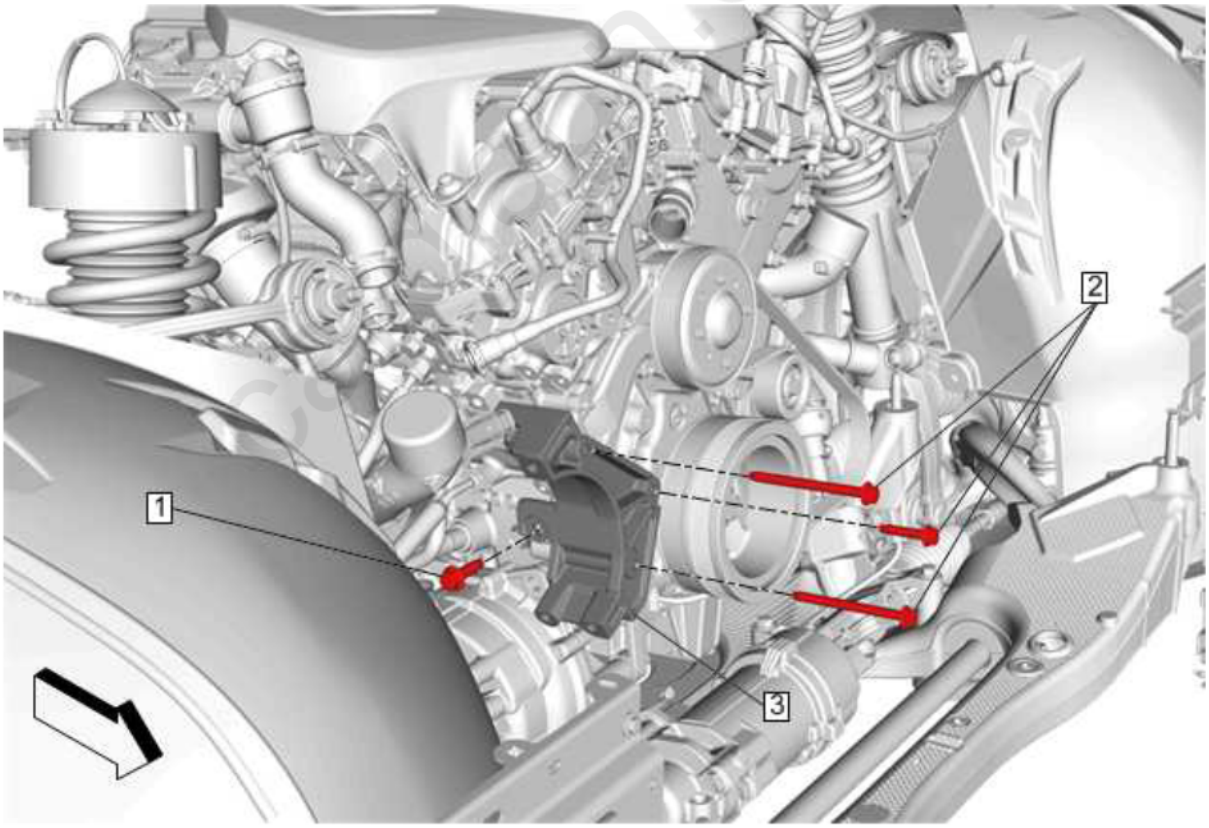


Fig. 109: Generator Bracket
Courtesy of GENERAL MOTORS COMPANY

4. Camshaft Cover Replacement - Left SideÂ» Remove
5. Camshaft Cover Replacement - Right SideÂ» Remove
6. Drain the cooling system. Refer to Cooling System Draining and Filling (Static without HP9) , Cooling System Draining and Filling (GE 47716 without HP9) , Cooling System Draining and Filling (Static LTG with HP9) and/or Cooling System Draining and Filling (GE 47716 LTG with HP9)

7. Remove the water outlet with the radiator hose and reposition aside. Refer to **Water Outlet Replacement (LGW)**
8. **Crankshaft Balancer Replacement (LGW)**Â» Remove
9. Remove the oil pan to engine front cover bolts. Refer to **Oil Pan Replacement**
10. Remove the engine front cover with the water pump. Refer to **Engine Front Cover Removal**

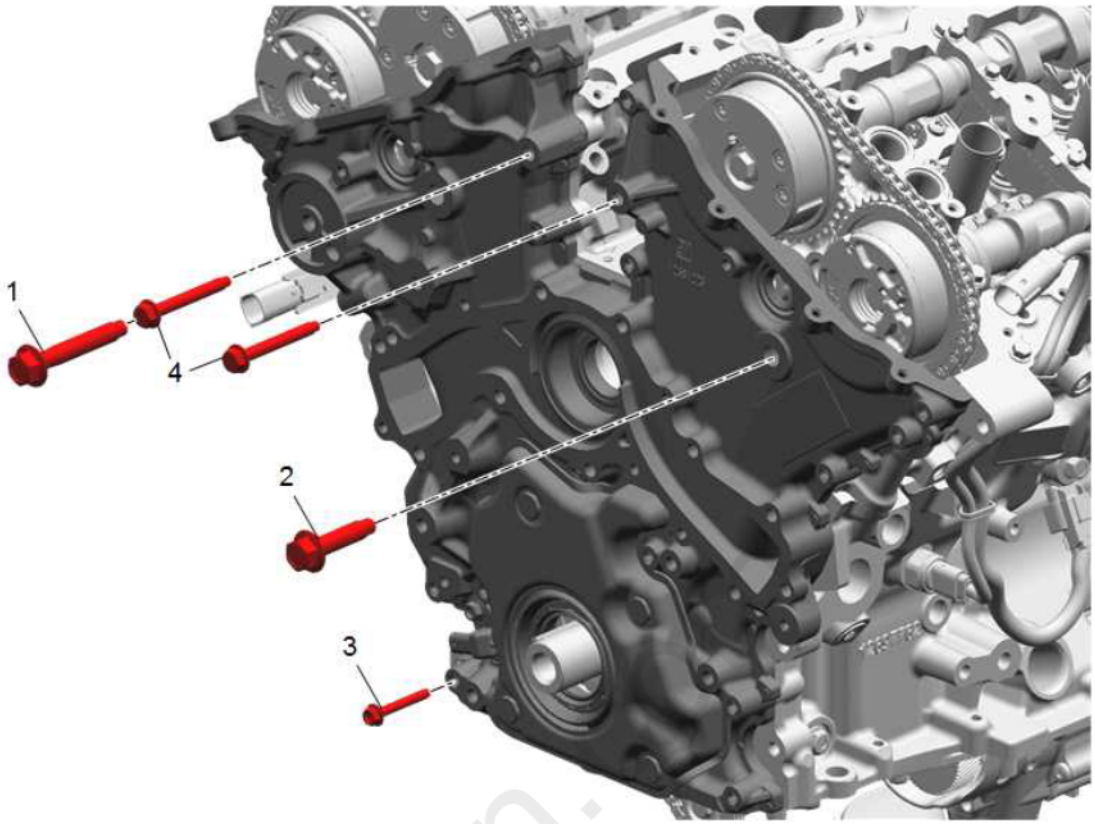


Fig. 110: Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

11. Disassemble the engine front cover. Refer to **Engine Front Cover Disassemble**
12. Carefully clean the engine front cover sealing surfaces. Refer to **Engine Front Cover Cleaning and Inspection**

NOTE: **Do NOT use sharp and/or metal gasket scrapers in order to clean the sealing surfaces.**

NOTE: **Insert a piece of cardboard between the oil pan front and the oil pump in order to prevent any contaminants from falling into the oil pan.**

13. Use compressed air in order to remove any engine coolant from the engine cooling passages and from the top of the oil pan scraper (windage tray).

Installation Procedure

1. Assemble the engine front cover. Refer to **Engine Front Cover Assemble**
2. Use the **EN-46109** pins in order to install the engine front cover. Refer to **Engine Front Cover Installation**

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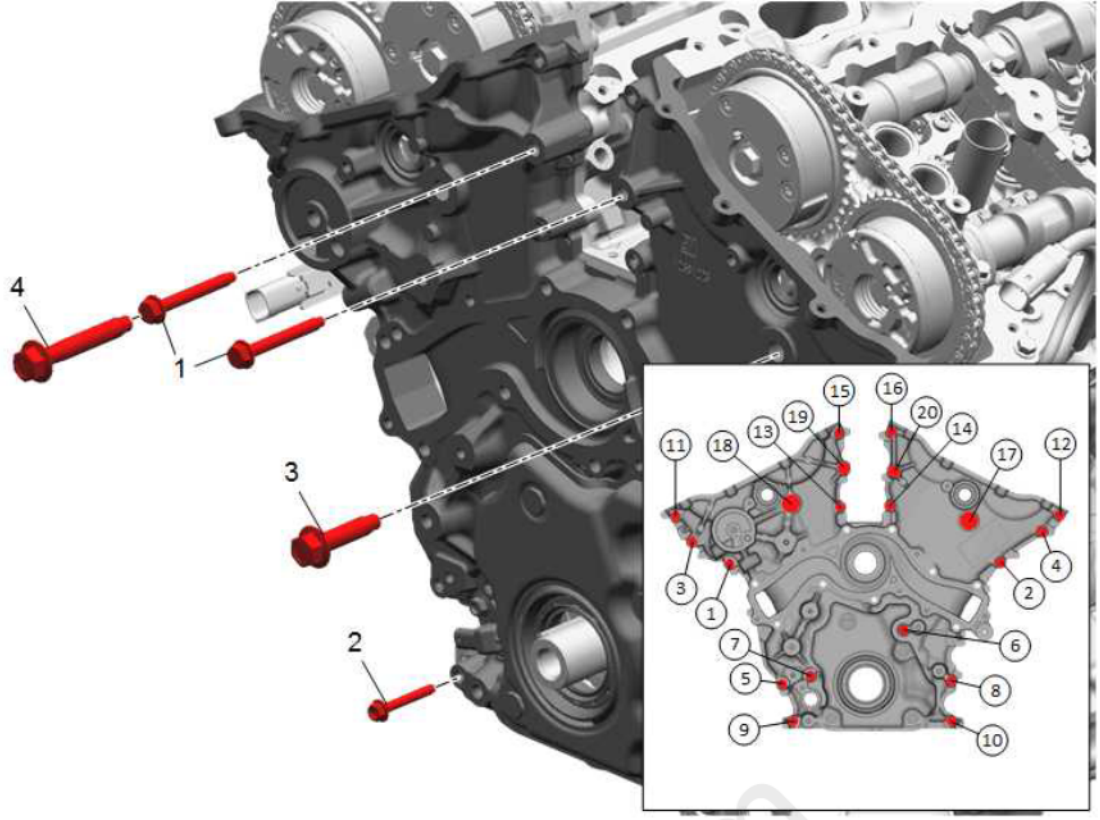


Fig. 111: Front Cover
Courtesy of GENERAL MOTORS COMPANY

3. **Crankshaft Balancer Replacement (LGW)**Â» Install
4. Install the water outlet with radiator hose. Refer to **Water Outlet Replacement (LGW)**
5. **Camshaft Cover Replacement - Right Side**Â» Install
6. **Camshaft Cover Replacement - Left Side**Â» Install
7. **Generator Bracket Replacement (LGW)** (3)Â» Install

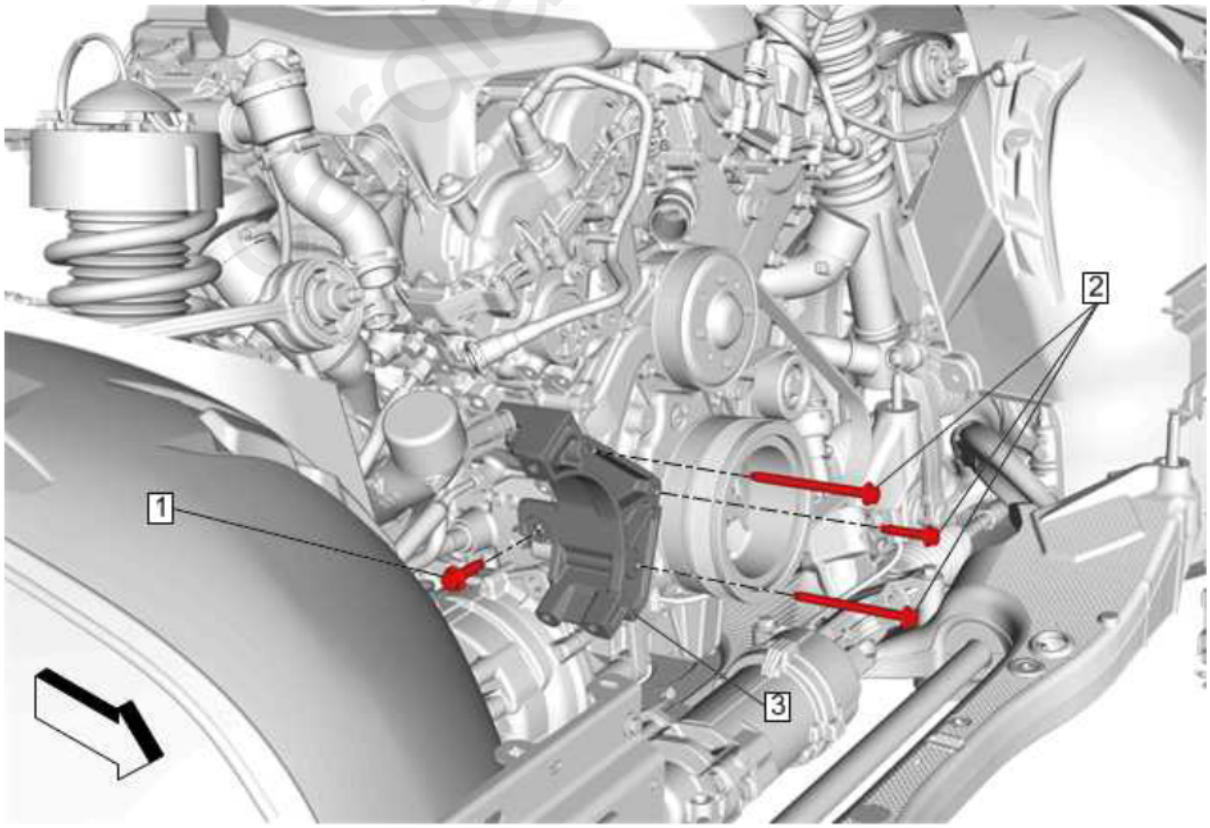


Fig. 112: Generator Bracket
Courtesy of GENERAL MOTORS COMPANY

8. **Water Pump Pulley Replacement (LGW, LGX)** (2)Â» Install

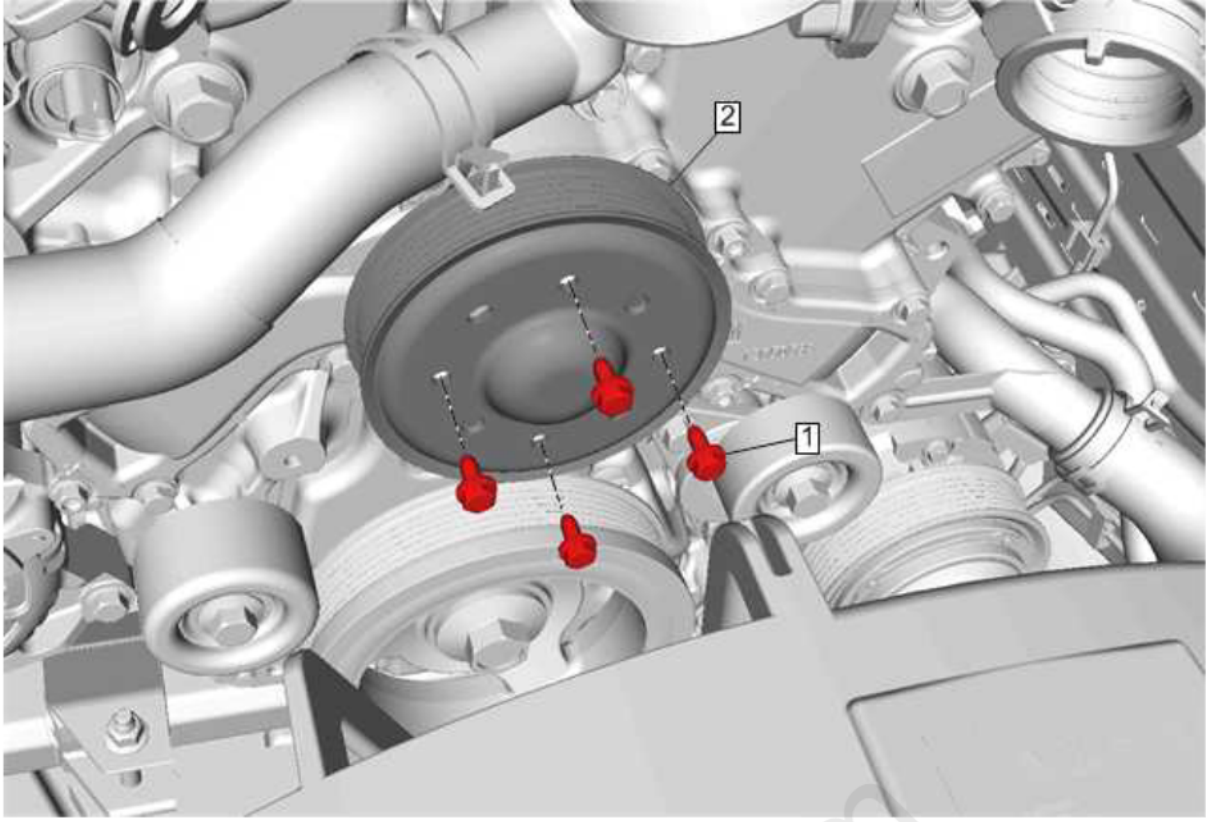


Fig. 113: Water Pump Pulley
Courtesy of GENERAL MOTORS COMPANY

9. Air Cleaner Assembly Replacement (LGW) (1)Â» Install

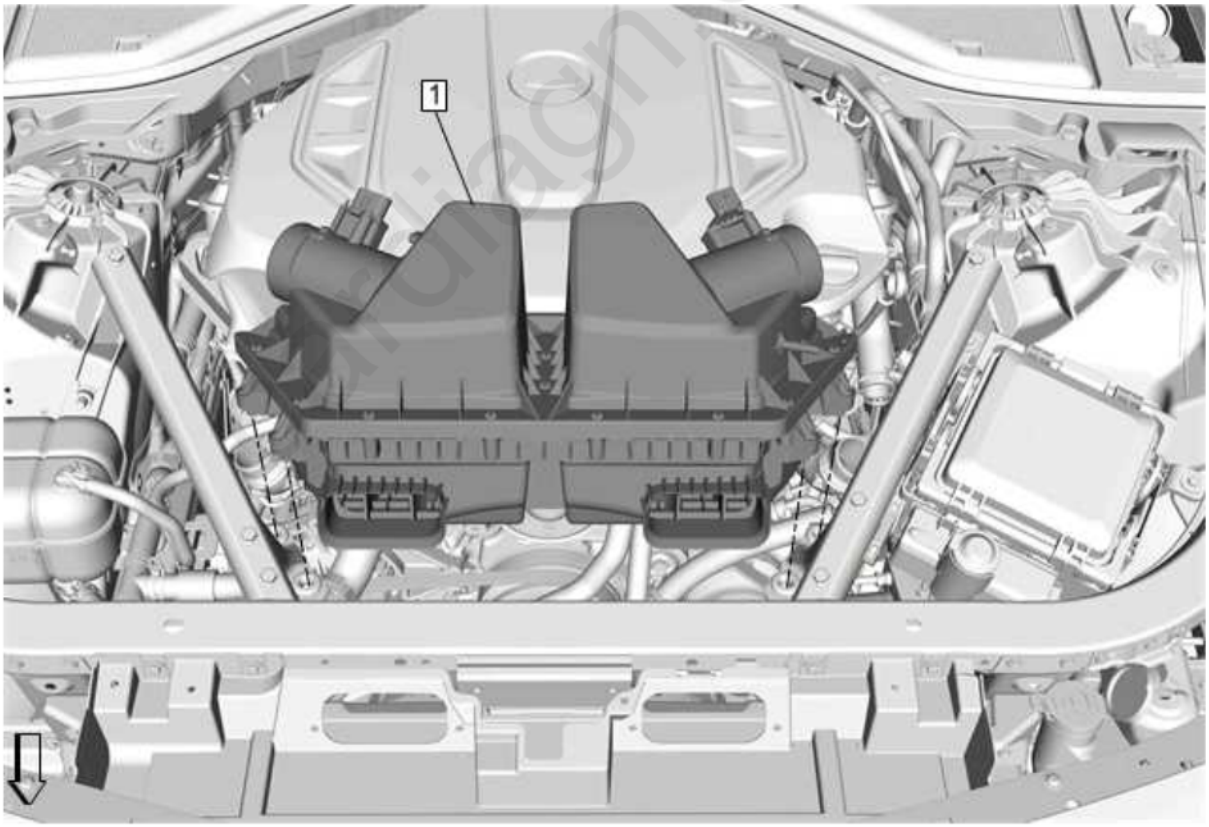


Fig. 114: Air Cleaner Assembly
Courtesy of GENERAL MOTORS COMPANY

10. Fill the cooling system. Refer to Cooling System Draining and Filling (Static without HP9) , Cooling System Draining and Filling (GE 47716 without HP9) , Cooling System Draining and Filling (Static LTG with HP9) and/or Cooling System Draining and Filling (GE 47716 LTG with HP9)

CAMSHAFT TIMING CHAIN ASSEMBLY REPLACEMENT - LEFT SIDE

Removal Procedure

1. Engine Front CoverÂ» Remove - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**
2. Remove the camshaft timing chain components. Refer to **Camshaft Timing Chain Components Removal** .
3. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** . Replace components as necessary.

Installation Procedure

1. Install the camshaft timing chain components. Refer to **Camshaft Timing Chain Components Installation**
2. Engine Front CoverÂ» Install - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**

CAMSHAFT TIMING CHAIN ASSEMBLY REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Engine Front CoverÂ» Remove - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**
2. Remove the camshaft timing chain components. Refer to **Camshaft Timing Chain Components Removal** .
3. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** . Replace components as necessary.

Installation Procedure

1. Install the camshaft timing chain components. Refer to **Camshaft Timing Chain Components Installation**
2. Engine Front CoverÂ» Install - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**

TIMING CHAIN TENSIONER ASSEMBLY REPLACEMENT - LEFT SIDE

Removal Procedure

1. Engine Front CoverÂ» Remove - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**
2. Remove the left side timing chain tensioner assembly. Refer to **Camshaft Timing Chain Components Removal** .
3. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** . Replace components as necessary.

Installation Procedure

1. Install the left side timing chain tensioner assembly. Refer to **Camshaft Timing Chain Components Installation**
2. Engine Front CoverÂ» Install - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**

TIMING CHAIN TENSIONER ASSEMBLY REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Engine Front CoverÂ» Remove - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**
2. Remove the right side timing chain tensioner assembly. Refer to **Camshaft Timing Chain Components Removal** .
3. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** . Replace components as necessary.

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Installation Procedure

1. Install the right side timing chain tensioner assembly. Refer to **Camshaft Timing Chain Components Installation**
2. Engine Front CoverÂ» Install - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**

TIMING CHAIN ASSEMBLY SHOE REPLACEMENT - LEFT SIDE

Removal Procedure

1. Engine Front CoverÂ» Remove - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**
2. Remove the left side timing chain tensioner, shoe and guide. Refer to **Camshaft Timing Chain Components Removal** .
3. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** . Replace components as necessary.

Installation Procedure

1. Install the left side timing chain tensioner, shoe and guide. Refer to **Camshaft Timing Chain Components Installation**
2. Engine Front CoverÂ» Install - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**

TIMING CHAIN ASSEMBLY SHOE REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Engine Front CoverÂ» Remove - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**
2. Remove the right side timing chain tensioner, shoe and guide. Refer to **Camshaft Timing Chain Components Removal** .
3. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** . Replace components as necessary.

Installation Procedure

1. Install the right side timing chain tensioner, shoe and guide. Refer to **Camshaft Timing Chain Components Installation**
2. Engine Front CoverÂ» Install - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**

TIMING CHAIN ASSEMBLY GUIDE REPLACEMENT - LEFT SIDE

Removal Procedure

1. Engine Front CoverÂ» Remove - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**
2. Remove the left side timing chain tensioner, shoe and guide. Refer to **Camshaft Timing Chain Components Removal** .
3. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** . Replace components as necessary.

Installation Procedure

1. Install the left side timing chain tensioner, shoe and guide. Refer to **Camshaft Timing Chain Components Installation**
2. Engine Front CoverÂ» Install - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**

TIMING CHAIN ASSEMBLY GUIDE REPLACEMENT - RIGHT SIDE

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Removal Procedure

1. Engine Front CoverÂ» Remove - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**
2. Remove the right side timing chain tensioner, shoe and guide. Refer to **Camshaft Timing Chain Components Removal** .
3. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** . Replace components as necessary.

Installation Procedure

1. Install the right side timing chain tensioner, shoe and guide. Refer to **Camshaft Timing Chain Components Installation**
2. Engine Front CoverÂ» Install - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**

OIL PUMP CHAIN REPLACEMENT

Removal Procedure

1. Engine Front CoverÂ» Remove - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**
2. Remove the oil pump timing chain tensioner and chain. Refer to **Camshaft Timing Chain Components Removal** .
3. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** . Replace components as necessary.

Installation Procedure

1. Install the oil pump timing chain and chain tensioner. Refer to **Camshaft Timing Chain Components Installation**
2. Engine Front CoverÂ» Install - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**

OIL PUMP CHAIN TENSIONER REPLACEMENT

Removal Procedure

1. Engine Front CoverÂ» Remove - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**
2. Remove the oil pump timing chain tensioner. Refer to **Camshaft Timing Chain Components Removal** .
3. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** . Replace components as necessary.

Installation Procedure

1. Install the oil pump timing chain tensioner. Refer to **Camshaft Timing Chain Components Installation**
2. Engine Front CoverÂ» Install - **Engine Front Cover Replacement (LGX)Engine Front Cover Replacement (LGW)**

CAMSHAFT POSITION ACTUATOR REPLACEMENT - BANK 1

Special Tools

- **EN-51333** Timing Chain Retainer Set

Equivalent regional tools: **Special Tools** .

Removal Procedure

1. **Camshaft Cover Replacement - Right Side**Â» Remove

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2. Rotate the engine clockwise using the crankshaft dampener retaining bolt until laser etched flat is facing up (This will put the camshafts in a rested position and aid in removal).

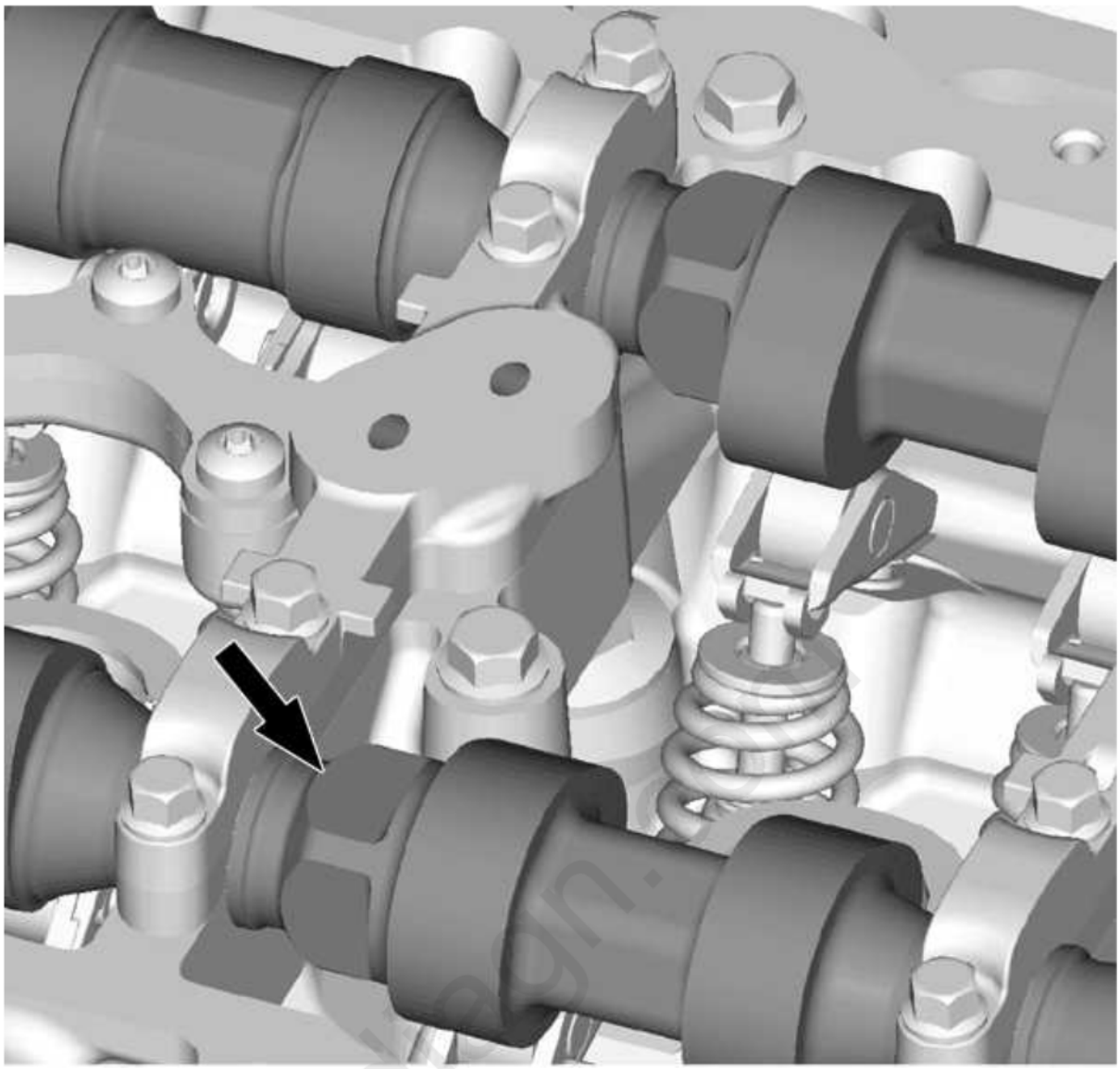


Fig. 115: Laser Etched Flat
Courtesy of GENERAL MOTORS COMPANY

3. Use an opened end wrench on the cast hexagonal portion of the camshafts to hold them in place while breaking the actuator fasteners loose to prevent camshaft rotation.

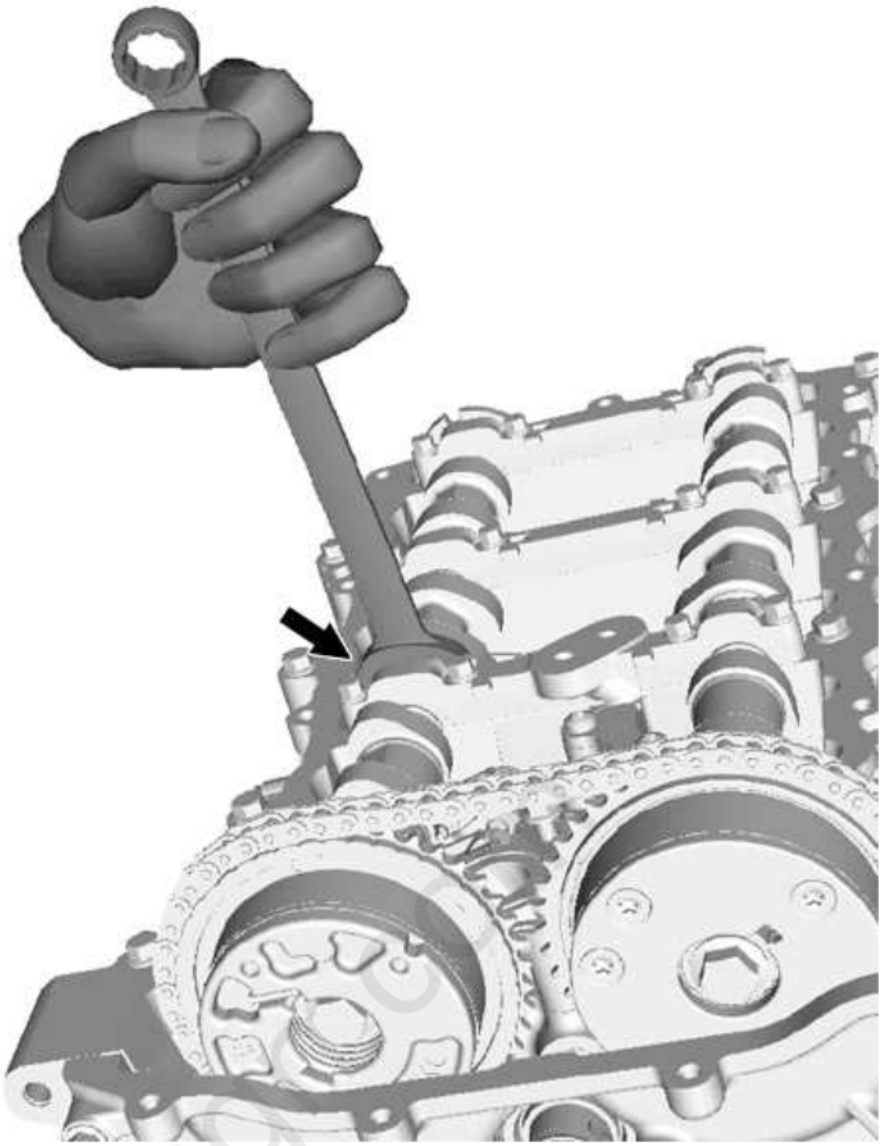


Fig. 116: Opened End Wrench On Cast Hexagonal Portion Of Camshaft
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

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

4. Loosen both intake and exhaust camshaft position actuator retaining bolts but DO NOT remove.

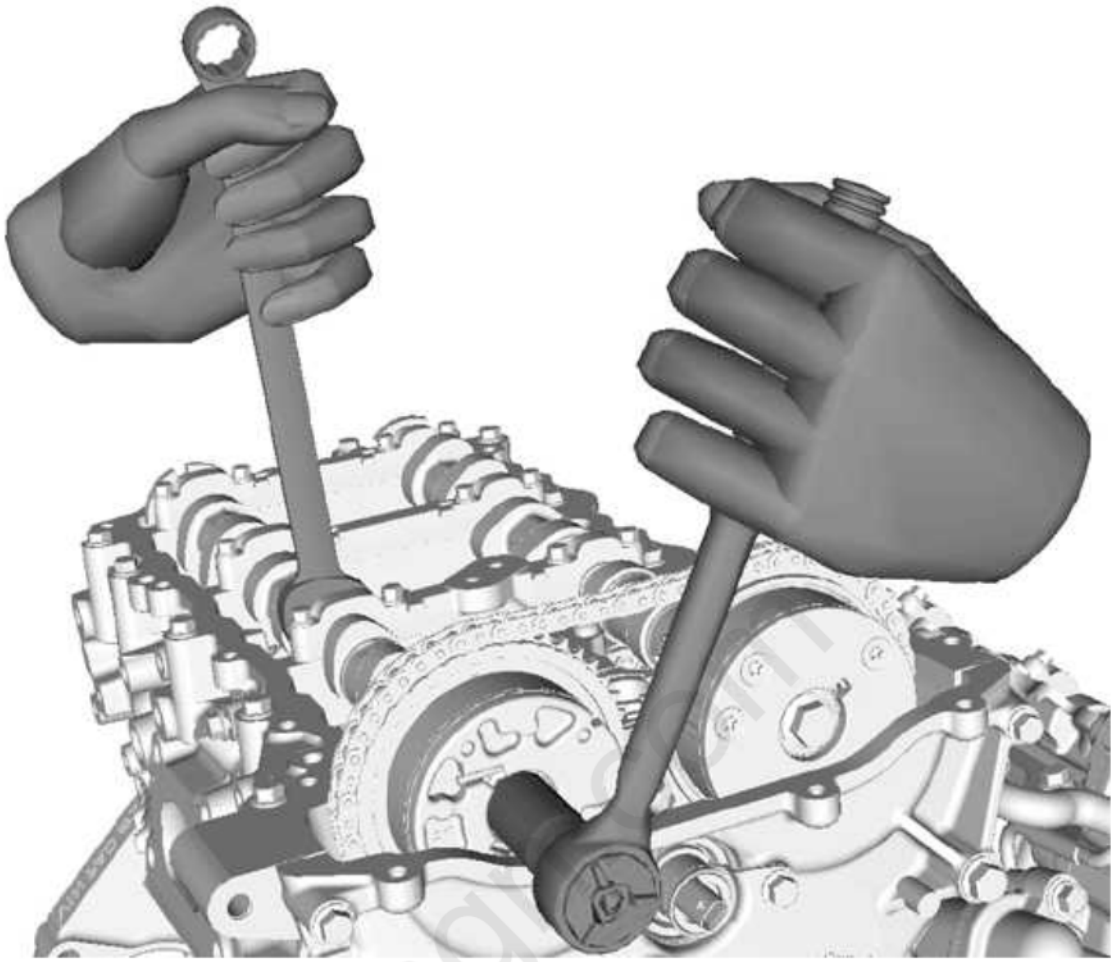


Fig. 117: Loosening Intake And Exhaust Camshaft Position Actuator Retaining Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Clean off any oil residue on camshaft position actuators.
6. Mark the position of the chain to the camshaft position actuator - intake.

NOTE: **Marking the relationship of the timing chain to actuators is critical for timing alignment.**

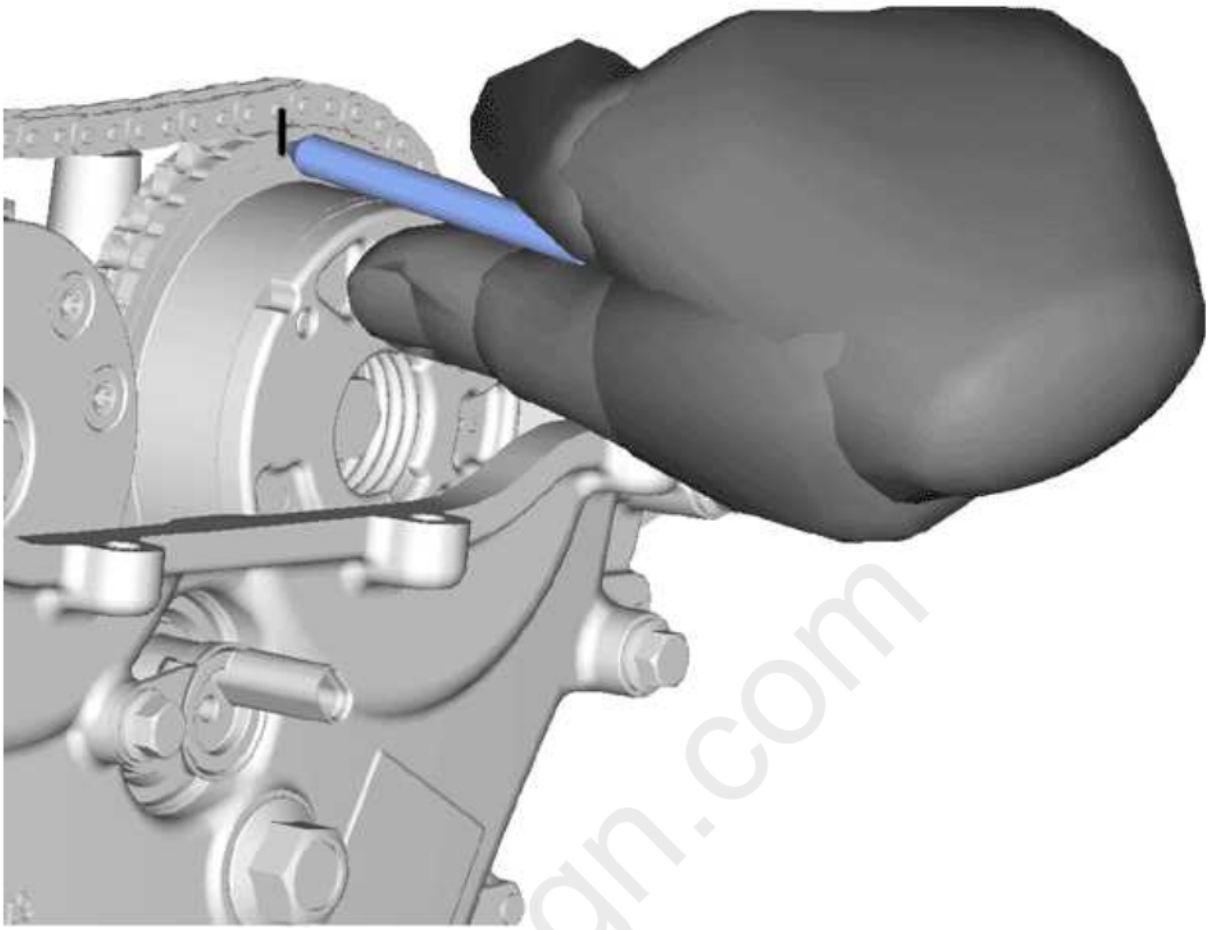


Fig. 118: Position Of Chain To Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

7. Mark the position of the chain to the camshaft position actuator - exhaust.
8. Remove camshaft front cap bolts (1) [5x].

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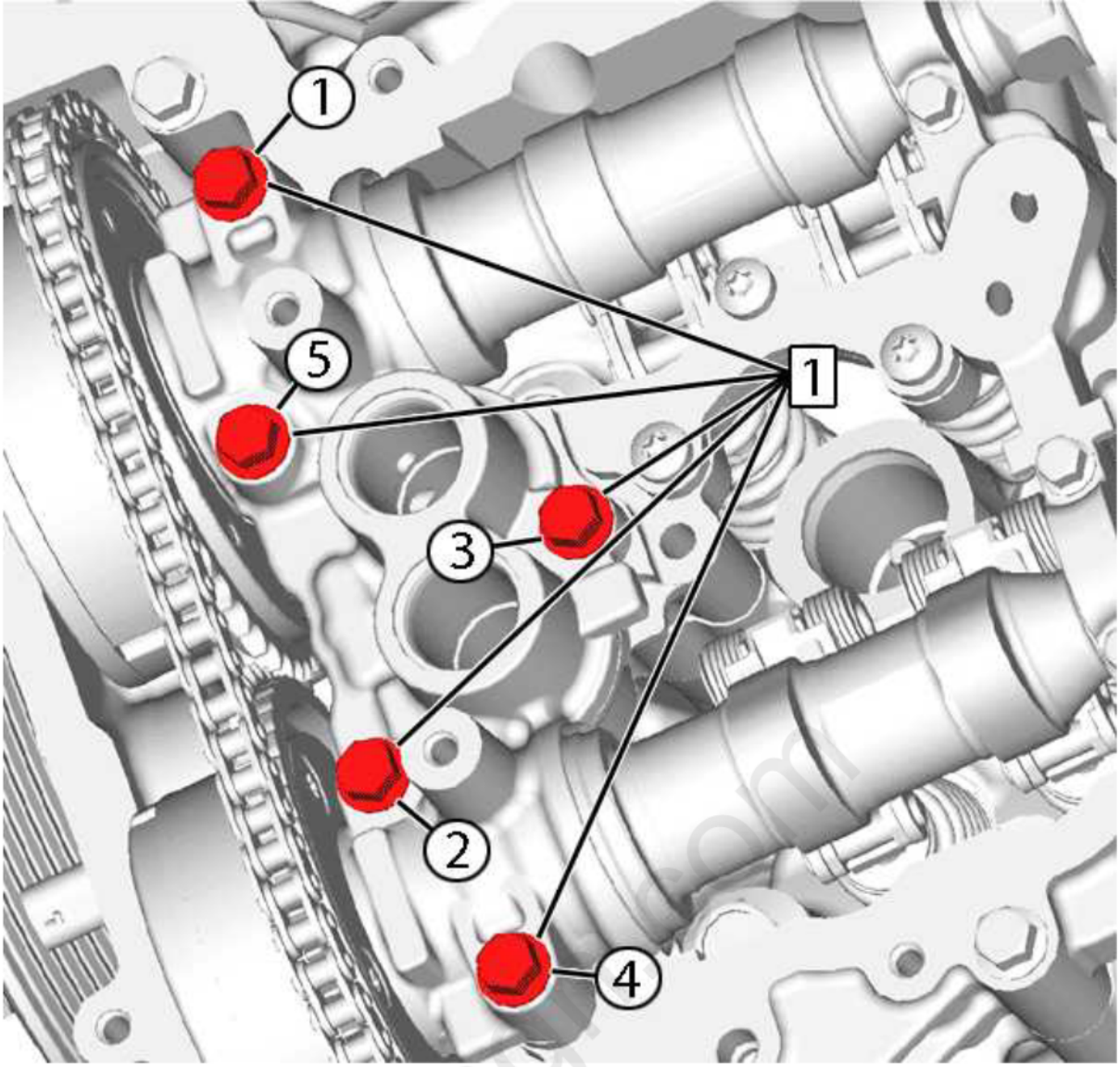


Fig. 119: Camshaft Front Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do NOT remove or loosen any other camshaft bearing caps at this time, even if you intend to eventually remove the camshaft.**

9. Remove the camshaft front cap (1).

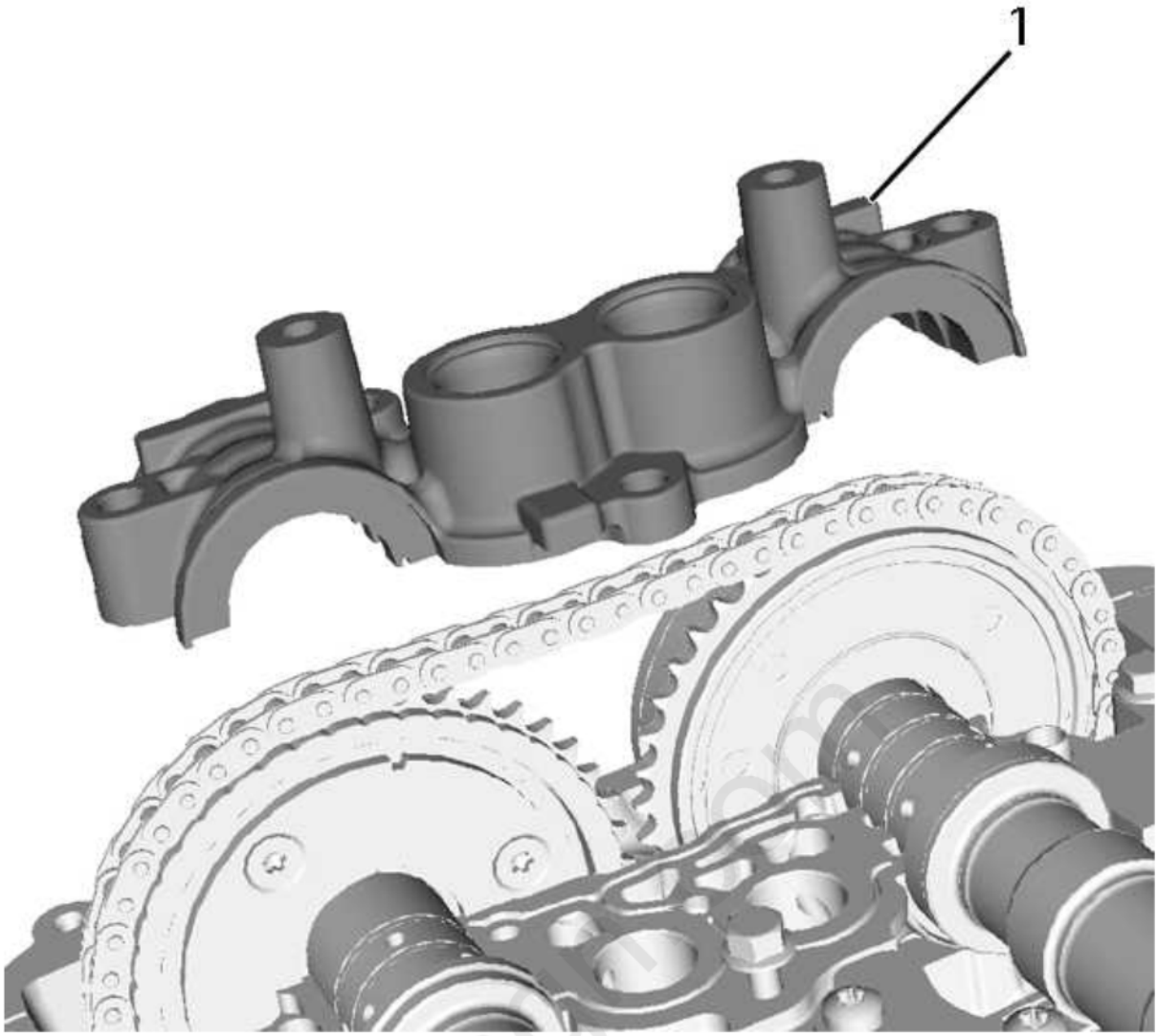


Fig. 120: Camshaft Front Cap
Courtesy of GENERAL MOTORS COMPANY

10. Clean RTV from front cover and cylinder head surface at the indicated locations prior to timing retainer tool installation.

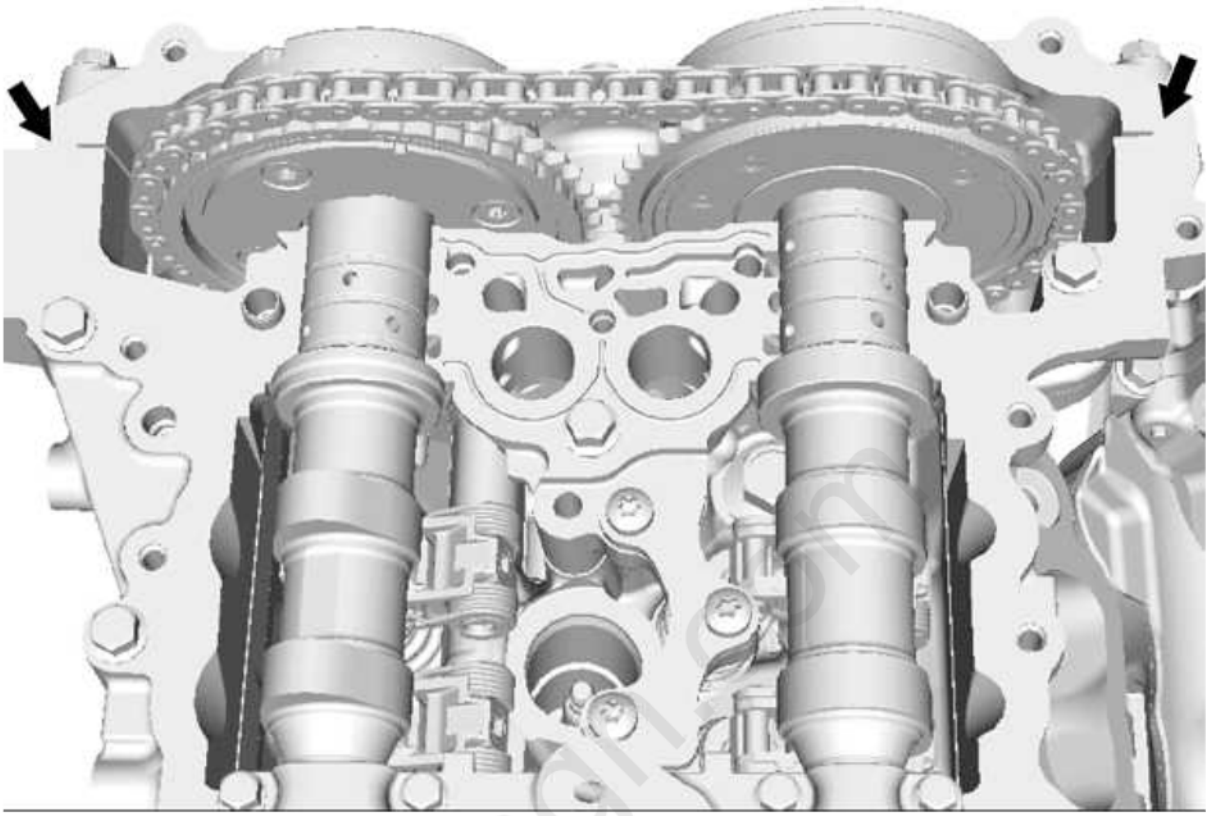


Fig. 121: Locating Front Cover And Cylinder Head Surface Cleaning Areas
Courtesy of GENERAL MOTORS COMPANY

11. Loosen the wingnut (1) to open the clamping area of **EN-51333-1** retainer.

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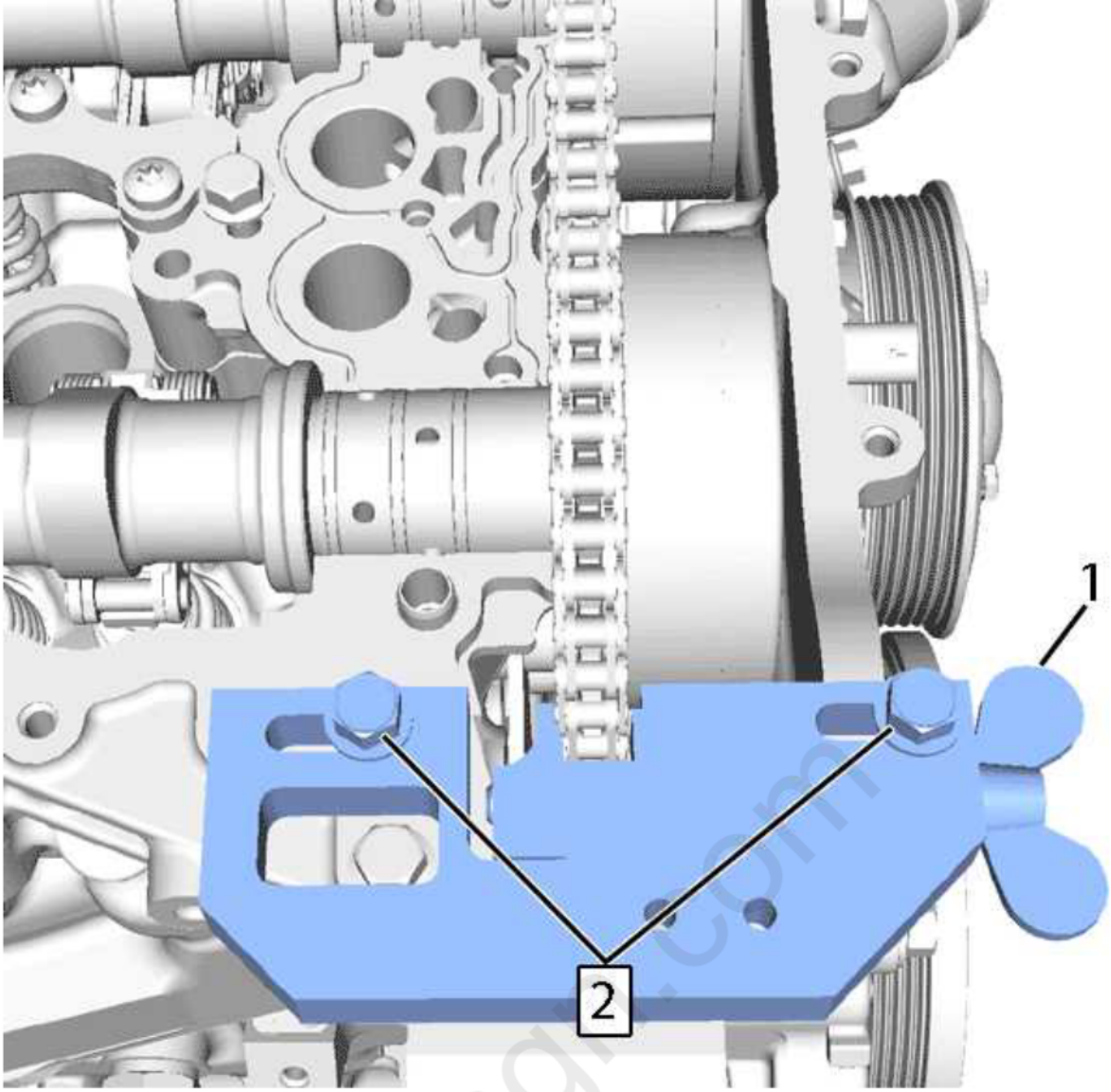


Fig. 122: Wingnut
Courtesy of GENERAL MOTORS COMPANY

12. Install the **EN-51333-1** retainer on the exhaust side front cover and cylinder head by screwing in the bolts (2) on the **EN-51333-1** retainer finger-tight.

NOTE: **Do NOT overtighten the bolts. The EN-51333-1 retainer should be able to slide slightly via the slots the bolts go through. This fore/aft movement will allow easier removal and installation of the chain later.**

13. Loosen the wingnut (1) to open the clamping area of **EN-51333-2** retainer.

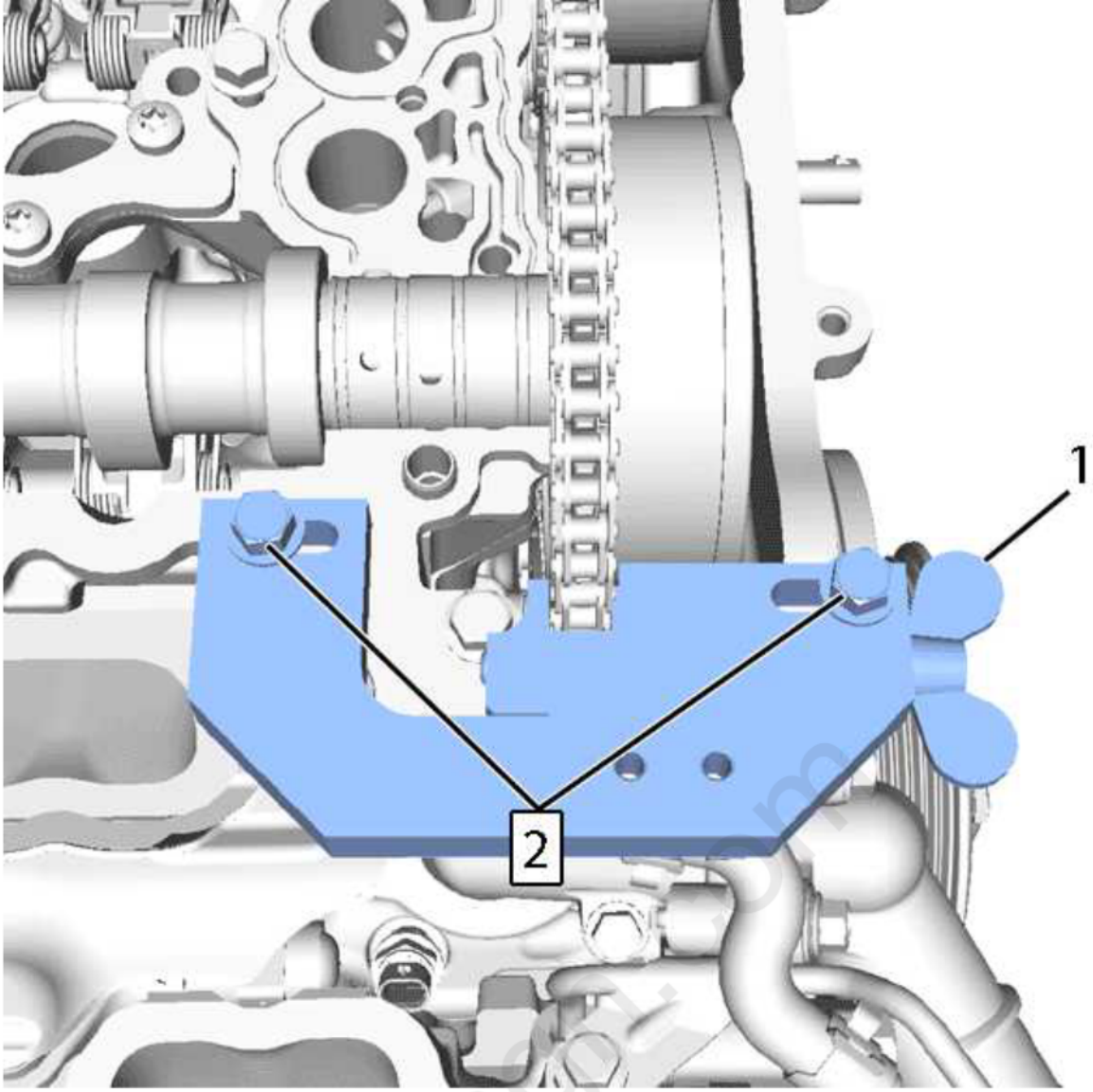


Fig. 123: Retainer
Courtesy of GENERAL MOTORS COMPANY

14. Install the **EN-51333-2** retainer on the intake side front cover and cylinder head by screwing in the bolts (2) on the **EN-51333-2** retainer finger-tight.

NOTE: **Do NOT overtighten the bolts. The EN-51333-2 retainer should be able to slide slightly via the slots the bolts go through. This fore/aft movement will allow easier removal and installation of the chain later.**

15. Using a wrench on the cast hexagonal portion of the intake camshaft, rotate the camshaft toward the exhaust camshaft and then release. Repeat this action three to fully drain the tensioners of oil.

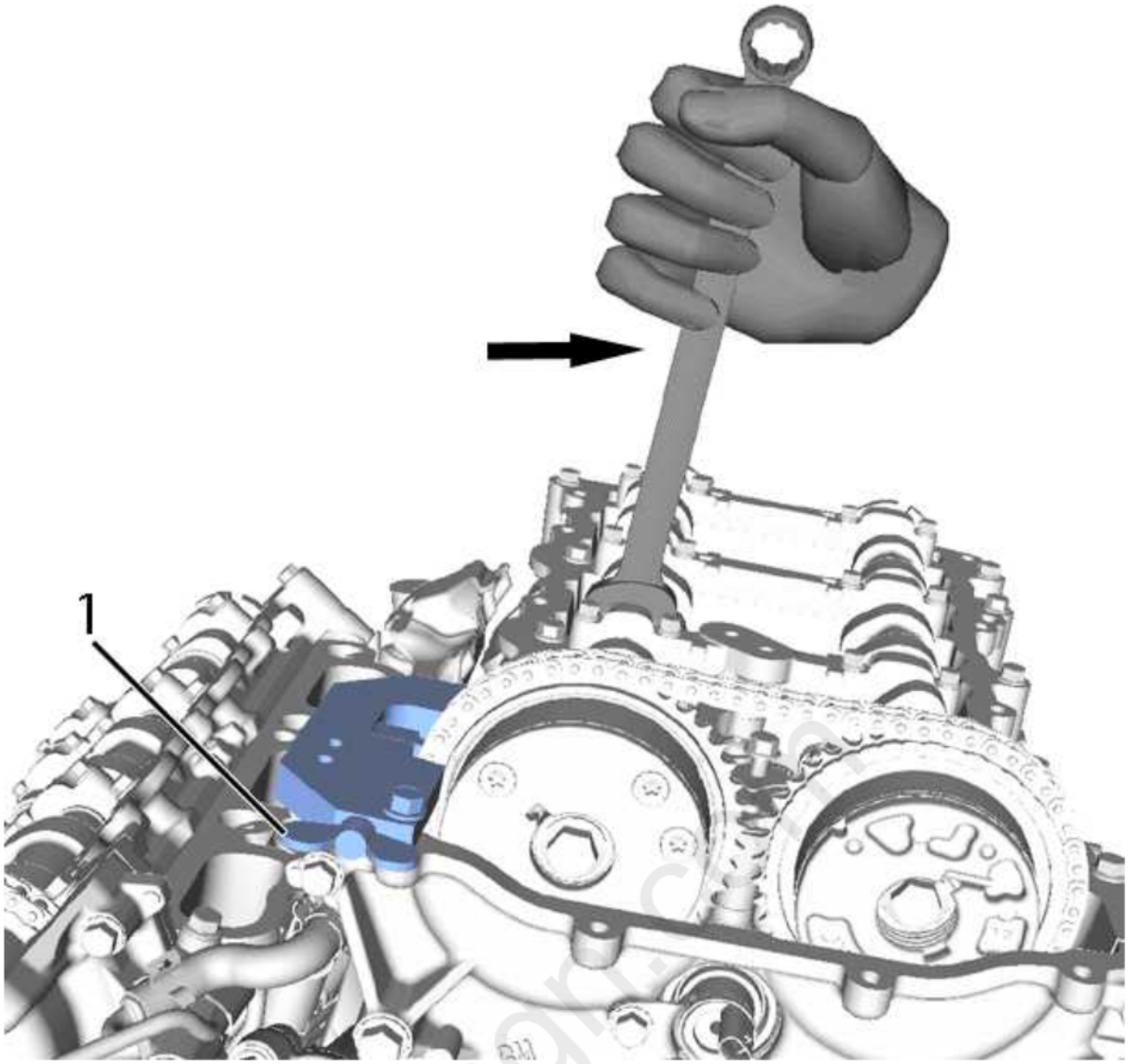


Fig. 124: Wrench On Cast Hexagonal Portion Of Exhaust Camshaft
Courtesy of GENERAL MOTORS COMPANY

16. Rotate the intake camshaft toward the exhaust camshaft and hold.
17. Tighten wingnut (1) so **EN-51333-1** retainer closes and firmly grasps timing chain.

NOTE: **Do NOT tighten the wingnut with a tool of any kind. Firm finger-tightening is sufficient.**

18. Using a wrench on the cast hexagonal portion of the exhaust camshaft, rotate the camshaft toward the intake camshaft and then release. Repeat this action three to fully drain the tensioners of oil.

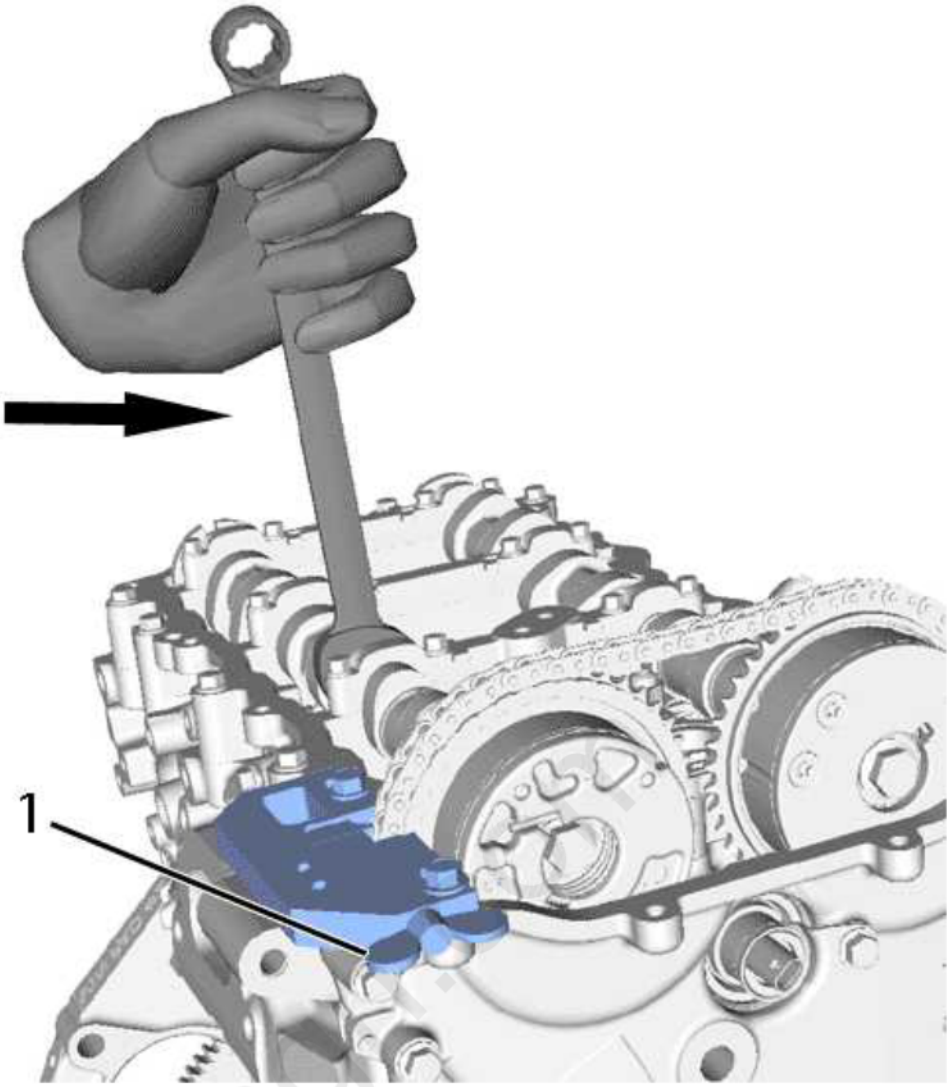


Fig. 125: Cast Hexagonal Portion Of Intake Camshaft
Courtesy of GENERAL MOTORS COMPANY

19. Rotate the exhaust camshaft toward the intake camshaft and hold.
20. Tighten wingnut (1) so **EN-51333-2** retainer closes and firmly grasps timing chain.

NOTE: **Do NOT tighten the wingnut with a tool of any kind. Firm finger-tightening is sufficient.**

21. Fully remove the bolt (1) for the exhaust camshaft position actuator.

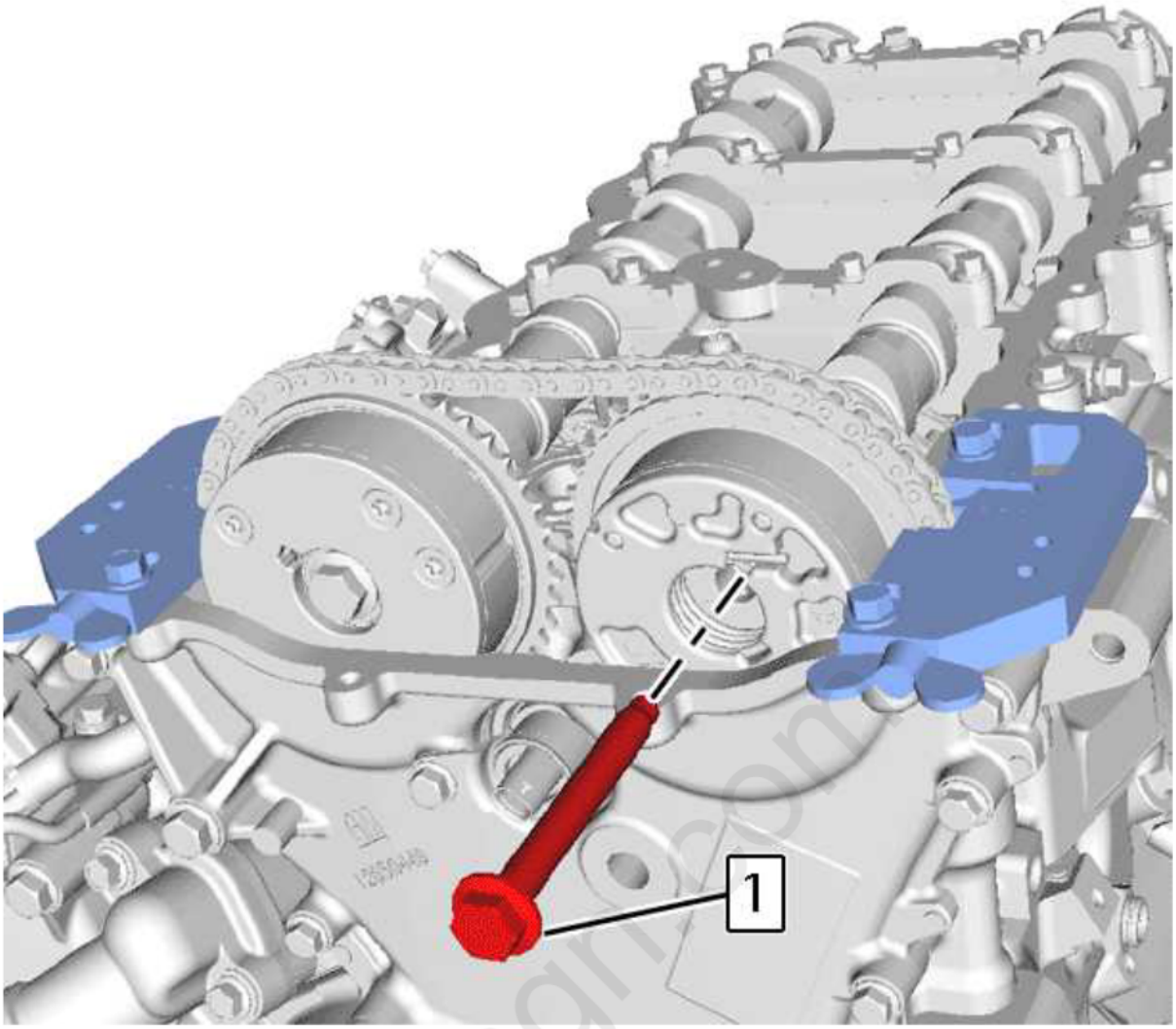


Fig. 126: Exhaust Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The Exhaust camshaft position actuator must be removed first to provide enough chain slack to remove the intake Position Actuator.**

22. Position a screwdriver or small pry bar between a camshaft cap and camshaft lobe. Carefully move/pry the camshafts as far as possible toward the rear/flywheel end of the engine.

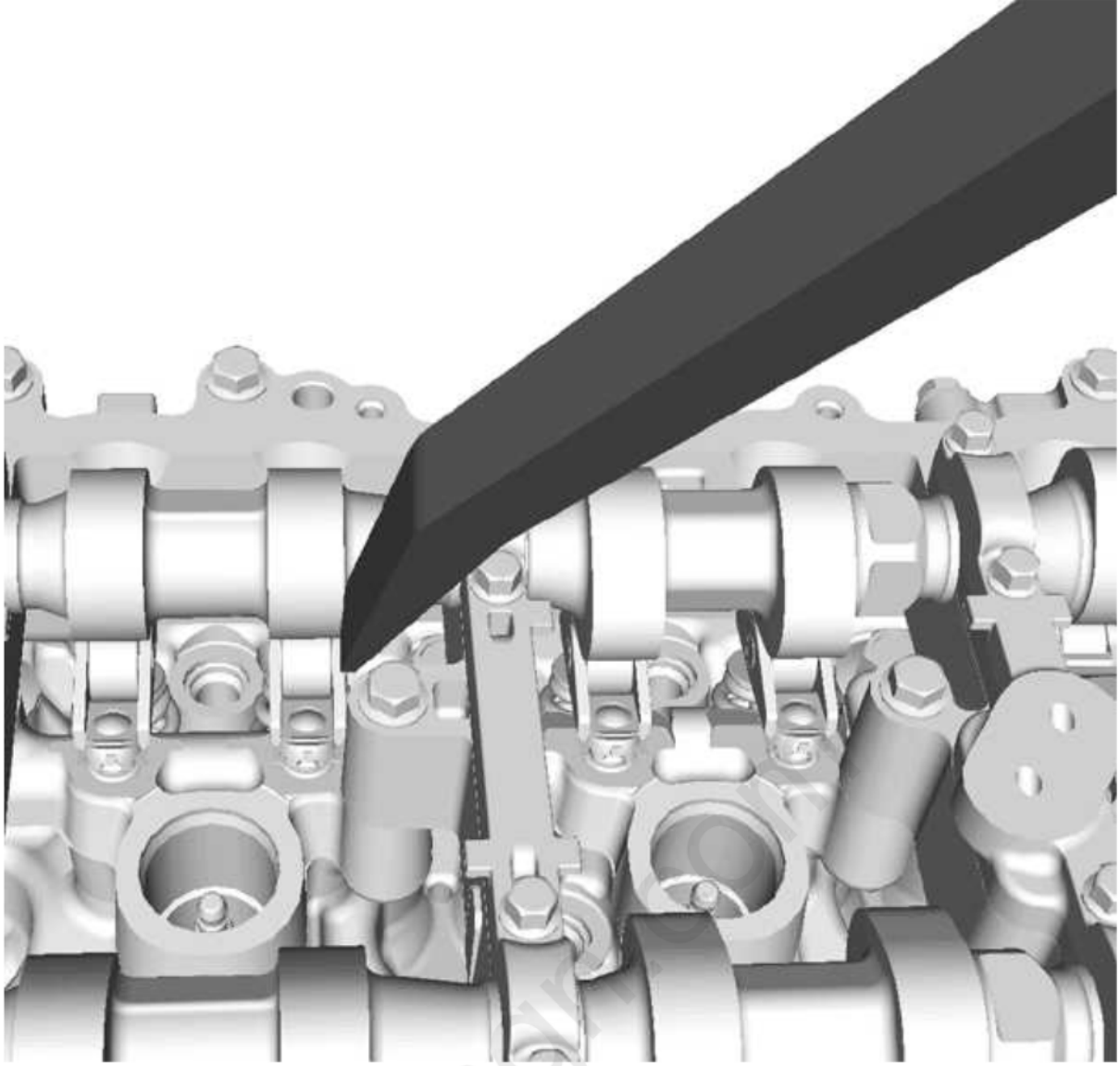


Fig. 127: Prying Camshaft Toward Rear/Flywheel End Of Engine
Courtesy of GENERAL MOTORS COMPANY

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

23. Slide the camshaft position actuator (1) forward and off the end of the exhaust camshaft.

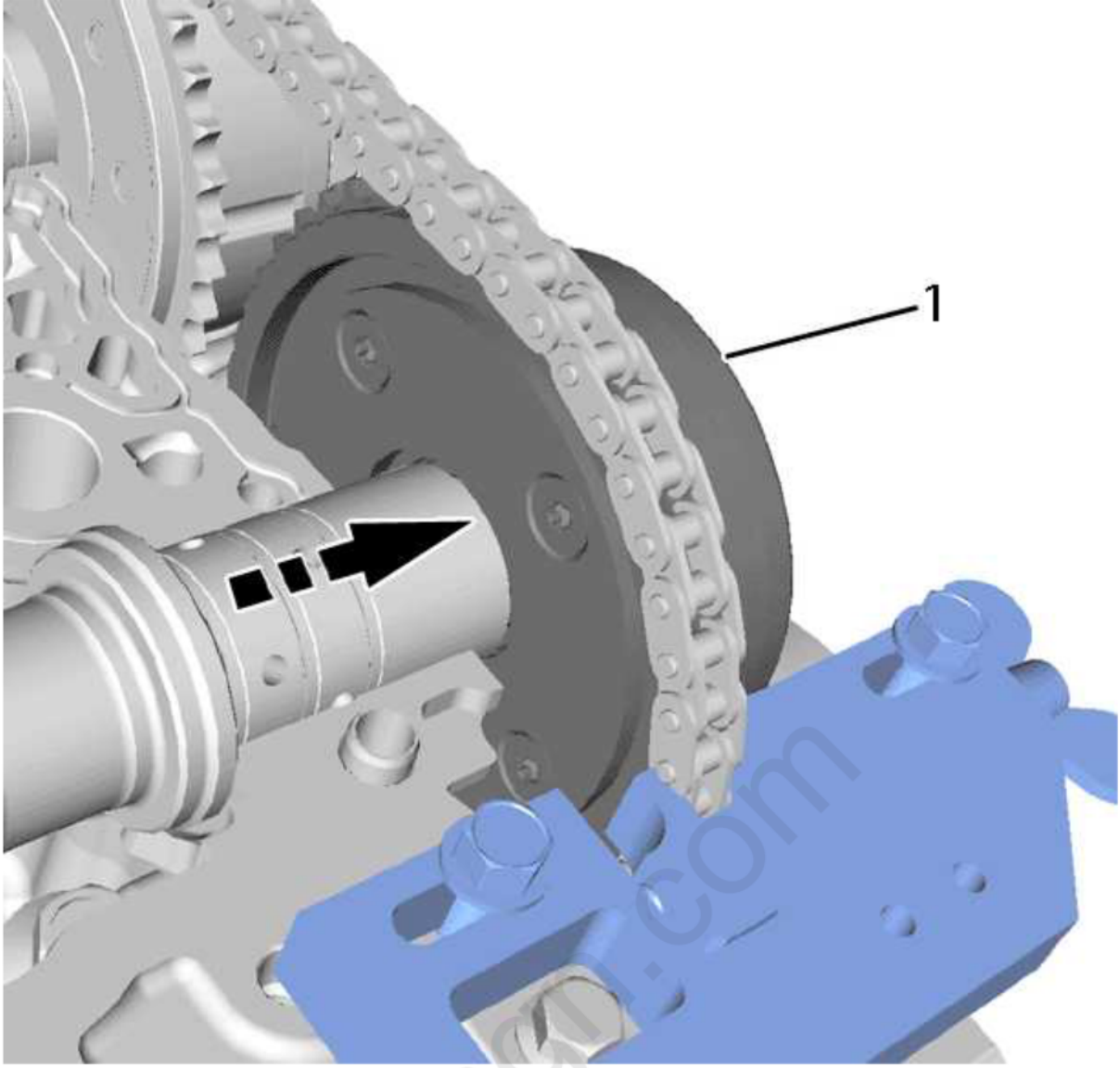


Fig. 128: Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

24. Tilt the camshaft position actuator forward and out/away from the engine.

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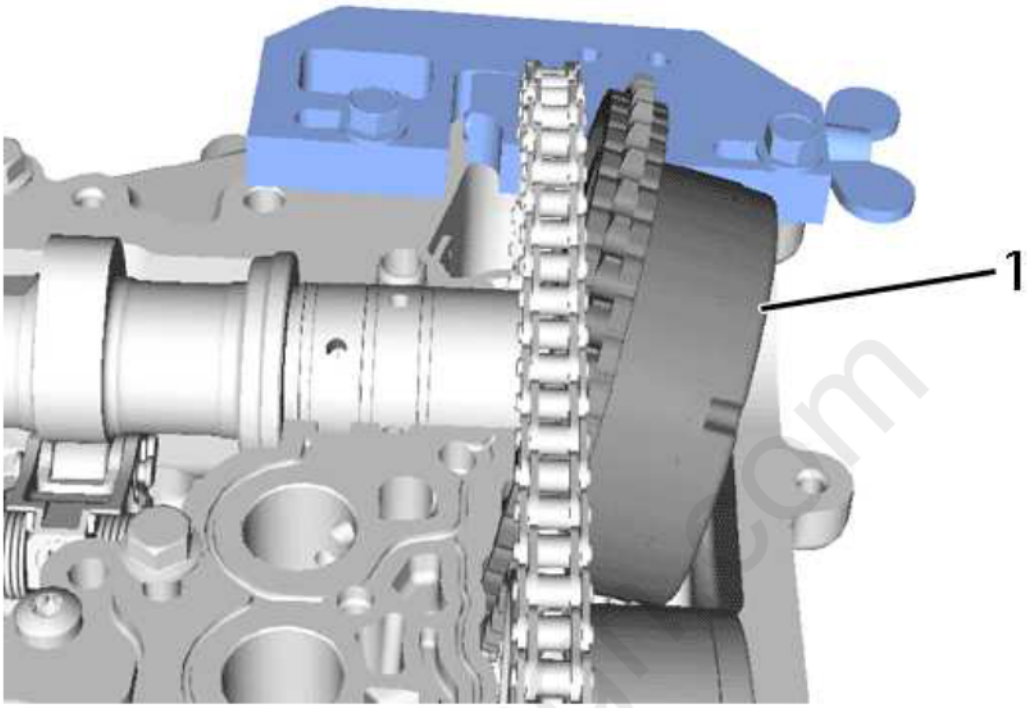


Fig. 129: Tilting Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

25. Repeat steps 19-23 to remove the intake camshaft position actuator.

NOTE: **DO NOT remove the EN-51333 Timing Chain Retainer Set, they are holding the cam chain to maintain the proper timed position.**

Installation Procedure

1. It may help to carefully pry the camshaft forward and to move the **EN-51333** retainers backward via the slot to reengage the position actuator to the camshaft. The dowel pin on the camshaft position actuator must be aligned with the slot in the camshaft nose for reassembly.

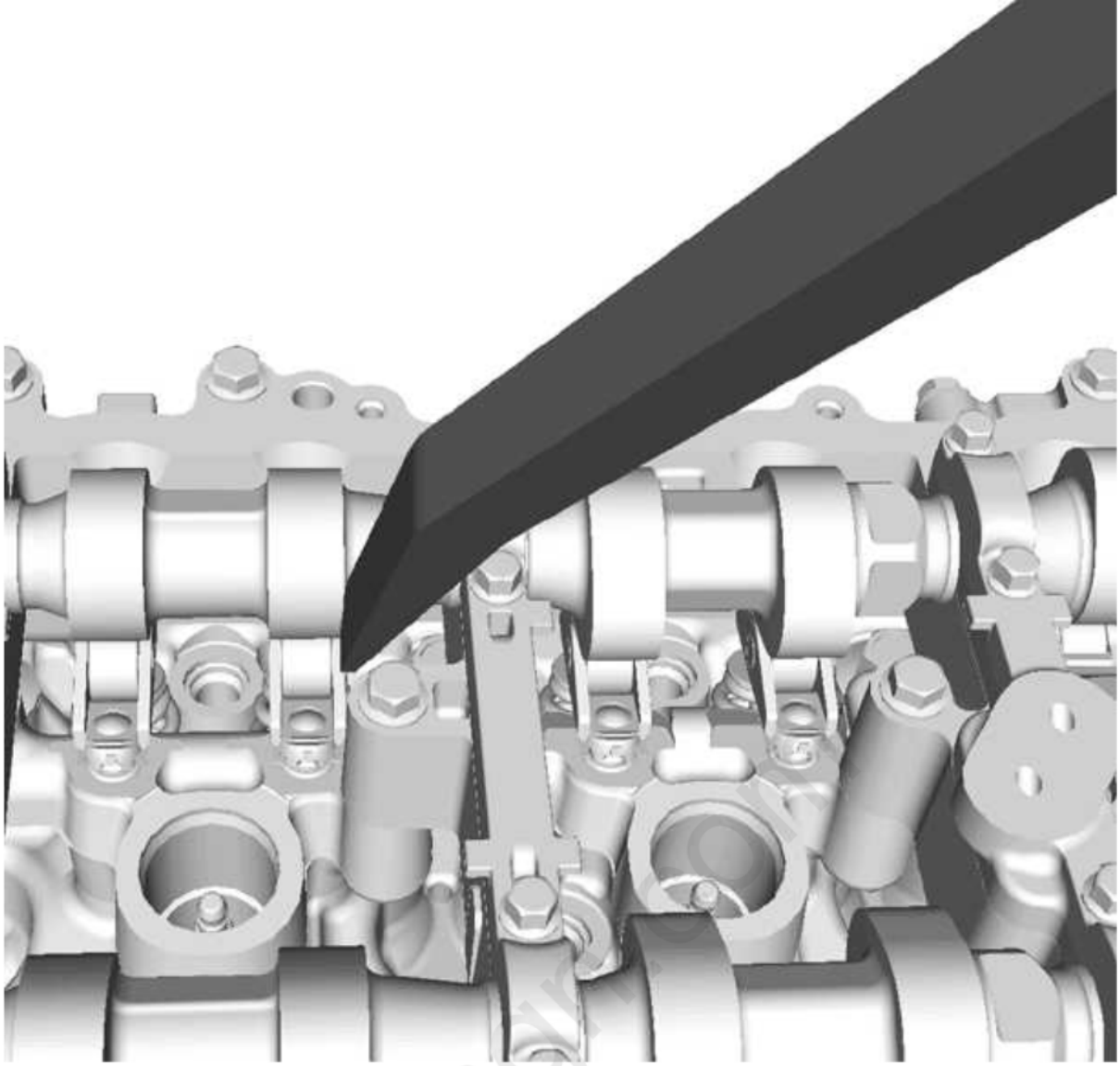


Fig. 130: Prying Camshaft Toward Rear/Flywheel End Of Engine
Courtesy of GENERAL MOTORS COMPANY

2. Use an open ended wrench on the cast hexagonal portion of the intake camshaft to aid in alignment of the timing chain marks.

CAUTION: **Refer to Torque Reaction Against Timing Drive Chain Caution .**

NOTE: **The intake camshaft position actuator must be installed first to provide enough chain slack to install the exhaust position actuator.**

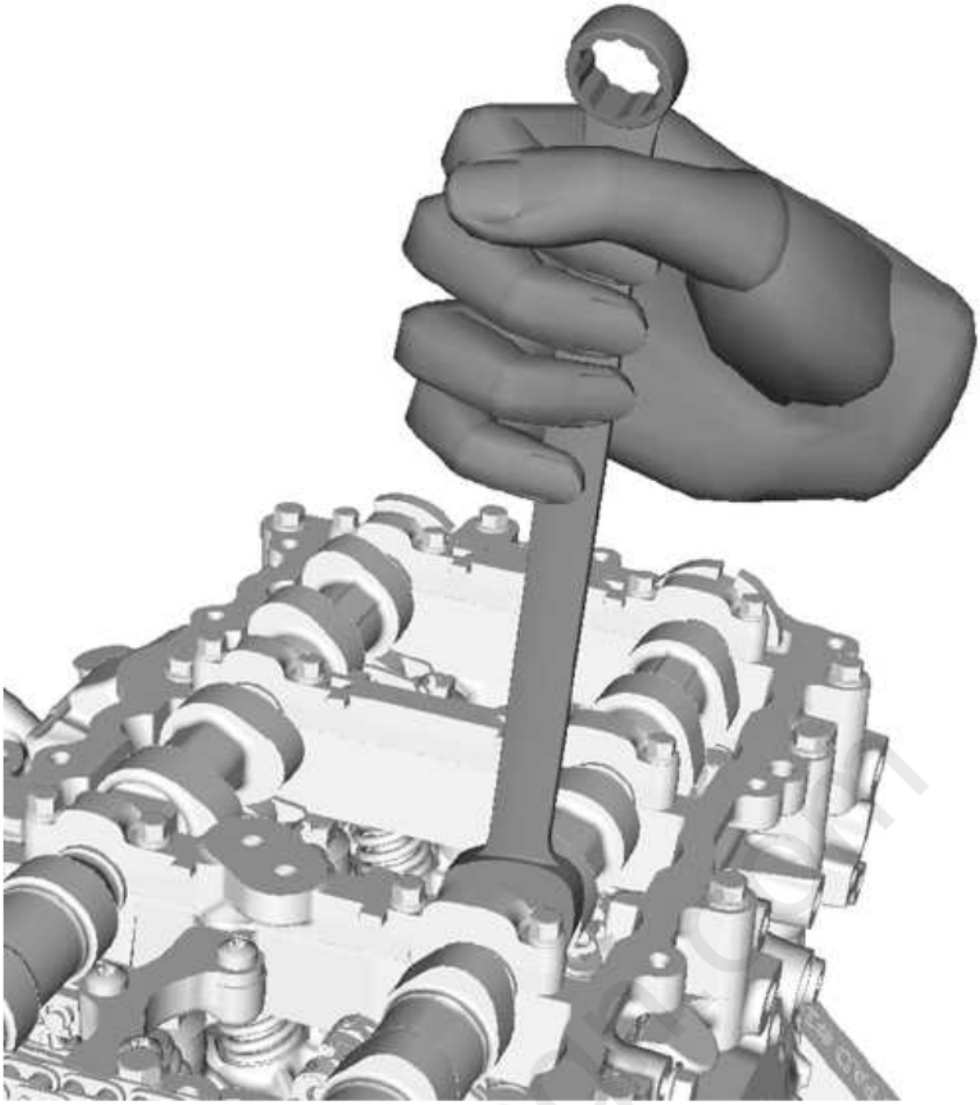


Fig. 131: Open Ended Wrench On Cast Hexagonal Portion Of Intake Camshaft
Courtesy of GENERAL MOTORS COMPANY

3. Apply lubricant to the back of the camshaft position actuator and front of the camshaft bearing cap. Refer to **Adhesives, Fluids, Lubricants and Sealers**
4. Install the intake camshaft position actuator (1) first by inserting the actuator between the timing chain and front cover. While pushing the actuator into the tensioned side of the chain, tilt the actuator while engaging the chain, aligning the marks on the chain and place the actuator in the fully seated position.

NOTE: **Ensure the proper camshaft position actuator is installed in the correct position. The dowel pin on the camshaft position actuator must be aligned with the slot in the camshaft nose for reassembly. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.**

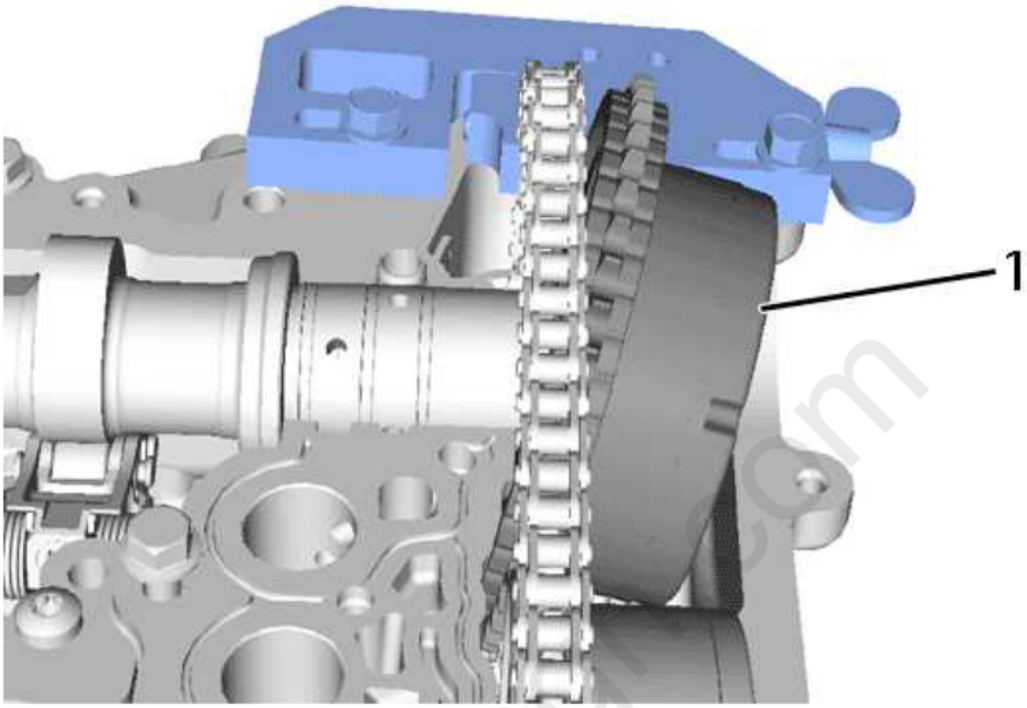


Fig. 132: Tilting Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

5. Ensure the camshaft position actuator is seated properly on the end of the camshaft.

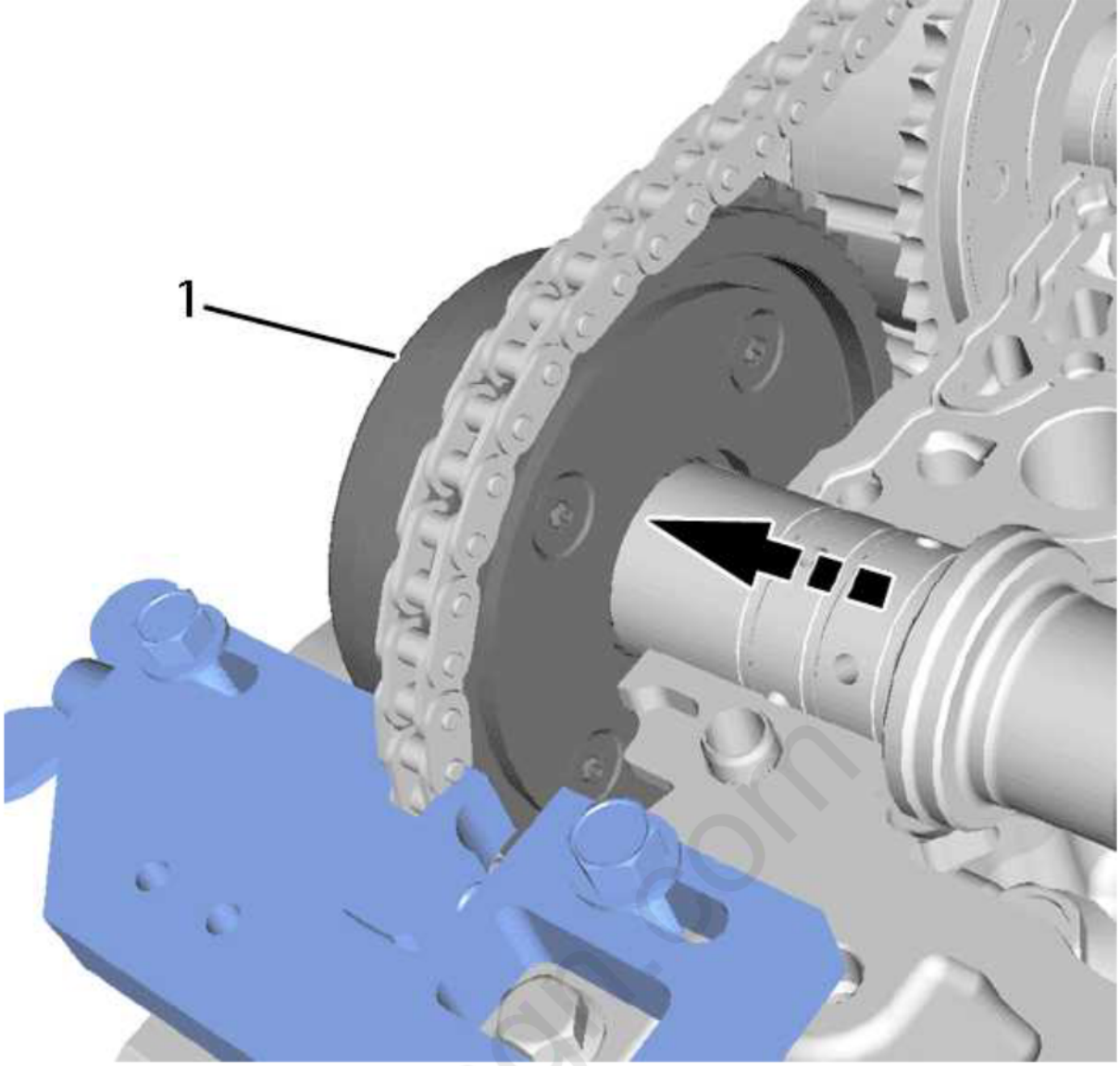


Fig. 133: Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

6. Install the intake camshaft position actuator retaining bolt and lightly tighten the bolt to hold the camshaft actuator in place. DO NOT torque at this time.

CAUTION: **Refer to Fastener Caution .**

7. Install the exhaust camshaft position actuator and retaining bolt following the same steps as the intake side.
8. Check the marks on both the intake and exhaust camshaft position actuators to ensure that they are aligned with their respective paint marks on the chain.
9. Using an open ended wrench on the cast hexagonal portion of the exhaust camshaft, hold the camshaft in place while loosening the wing nut on the **EN-51333-1** retainer after fully loosed, let the camshaft rotate back into tension.

CAUTION: **Refer to Torque Reaction Against Timing Drive Chain Caution .**

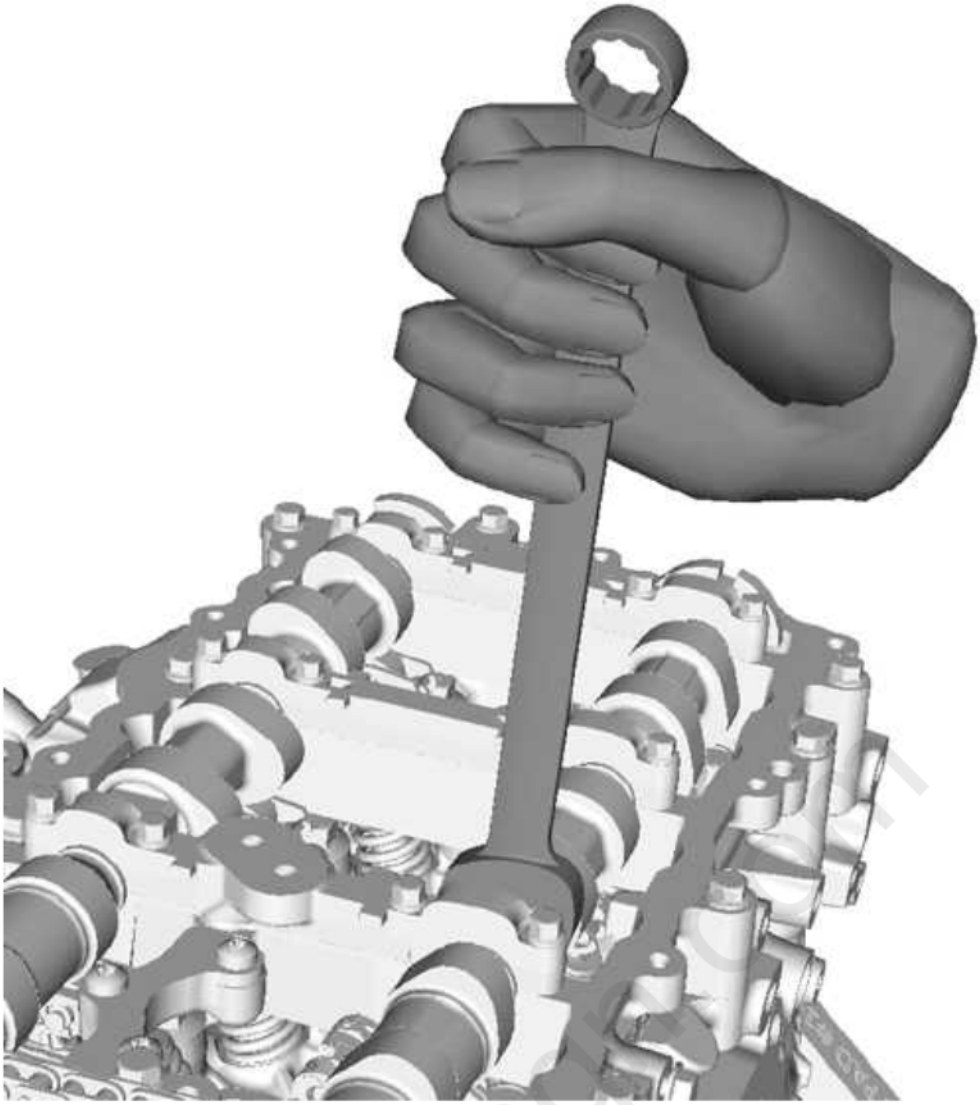


Fig. 134: Open Ended Wrench On Cast Hexagonal Portion Of Intake Camshaft
Courtesy of GENERAL MOTORS COMPANY

10. Repeat step 9 for the intake camshaft and **EN-51333-2** retainer
11. Using an open ended wrench on the cast hexagonal portion of the exhaust camshaft, tighten both camshaft position actuator retaining bolts.

    Tighten

    1. First Pass: 20 N.m (15 lb ft)
    2. Final Pass: 45 degrees
12. Remove the **EN-51333** retainers
13. Install the camshaft front cap (1).

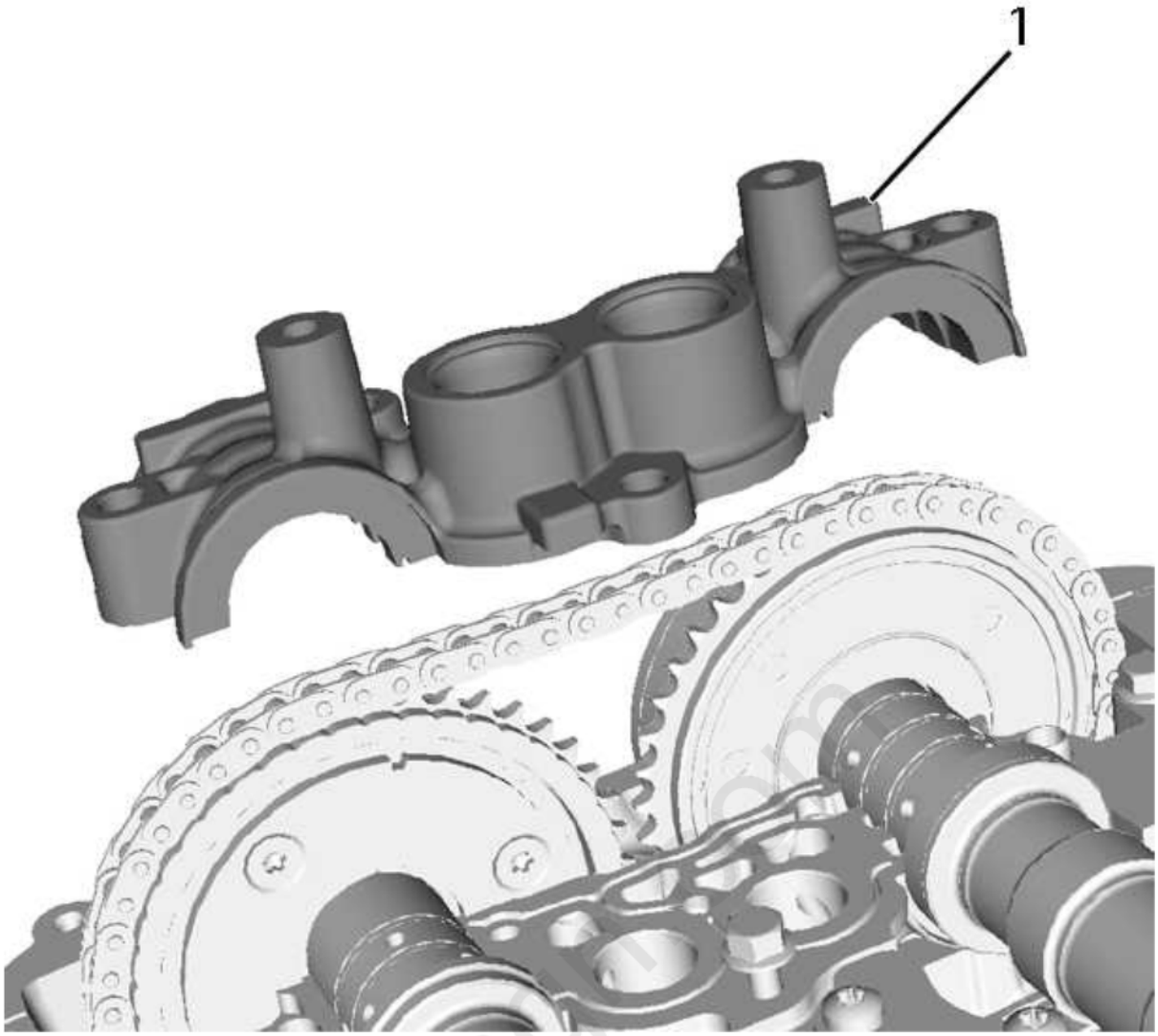


Fig. 135: Camshaft Front Cap
Courtesy of GENERAL MOTORS COMPANY

14. Install the camshaft front cap bolts (1) [5x].

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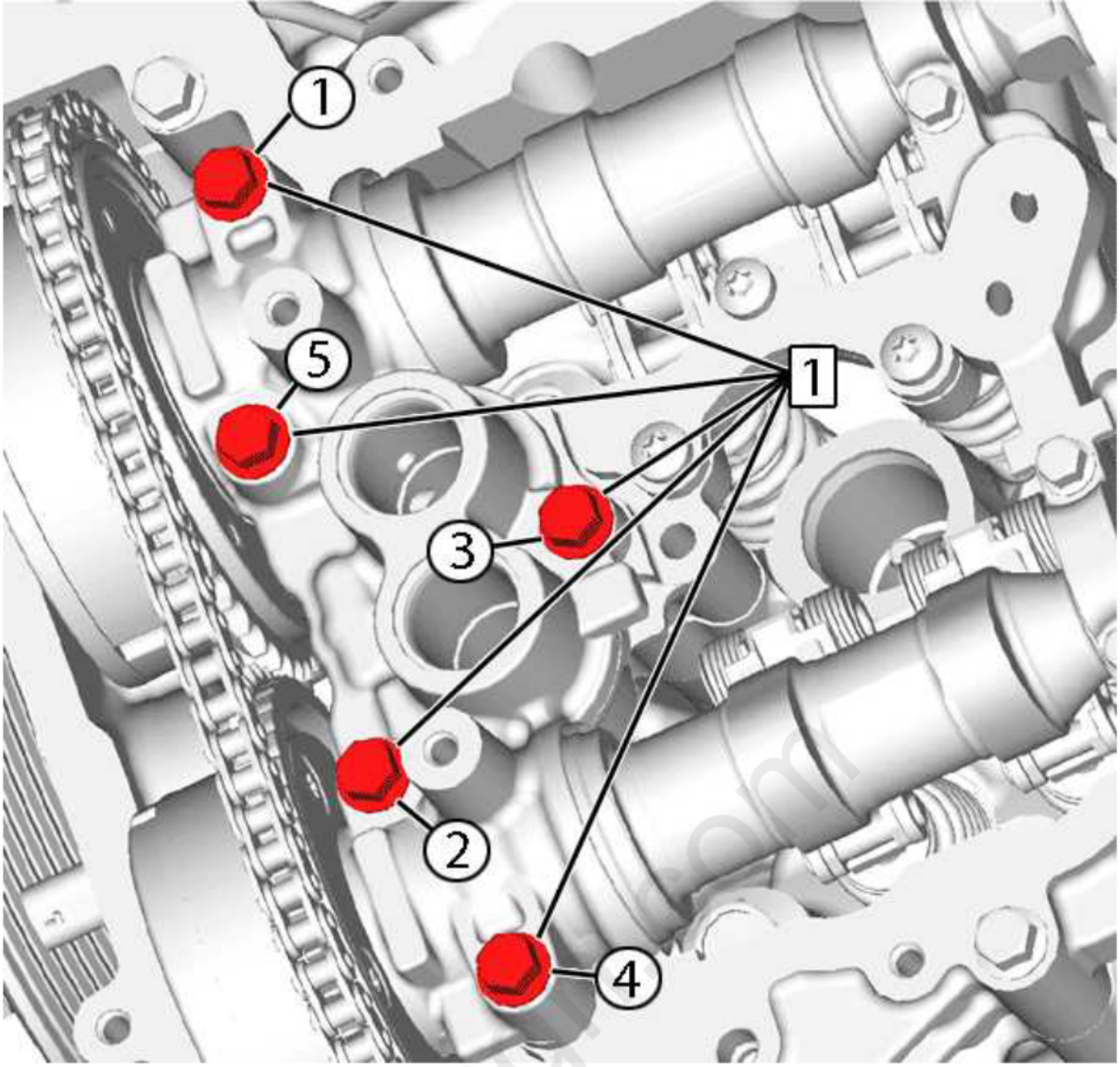


Fig. 136: Camshaft Front Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

15. Tighten the camshaft front cap bolts in sequence to 10 N.m (89 lb in).
16. **Camshaft Cover Replacement - Right Side**Â» Install

CAMSHAFT POSITION ACTUATOR REPLACEMENT - BANK 2

Special Tools

- **EN-51333** Timing Chain Retainer Set

Equivalent regional tools: **Special Tools** .

Removal Procedure

1. **Camshaft Cover Replacement - Left Side**Â» Remove
2. Rotate the engine clockwise using the crankshaft dampener retaining bolt until laser etched flat is facing up (This will put the camshafts in a rested position and aid in removal).

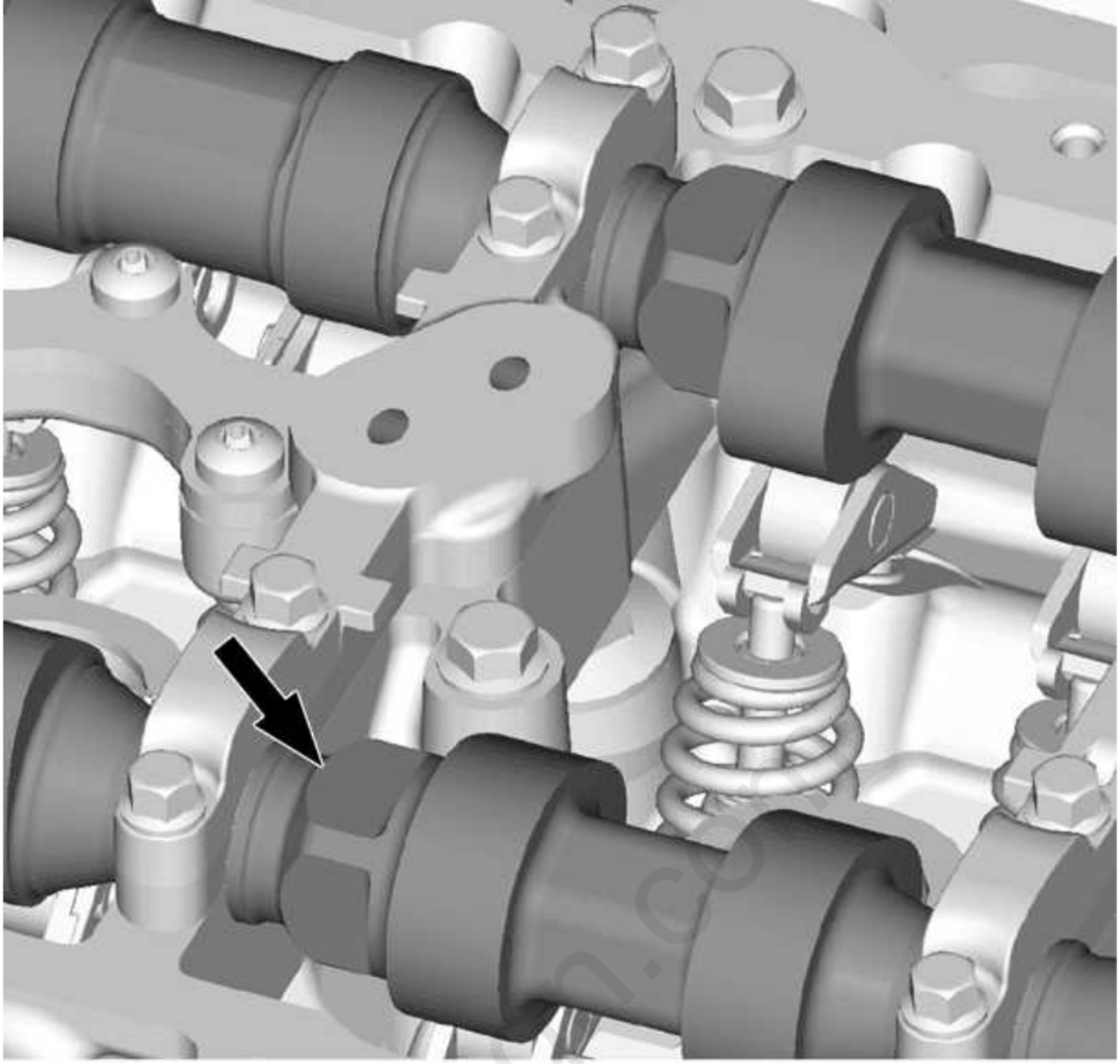


Fig. 137: Laser Etched Flat
Courtesy of GENERAL MOTORS COMPANY

3. Use an opened end wrench on the cast hexagonal portion of the camshafts to hold them in place while breaking the actuator fasteners loose to prevent camshaft rotation.

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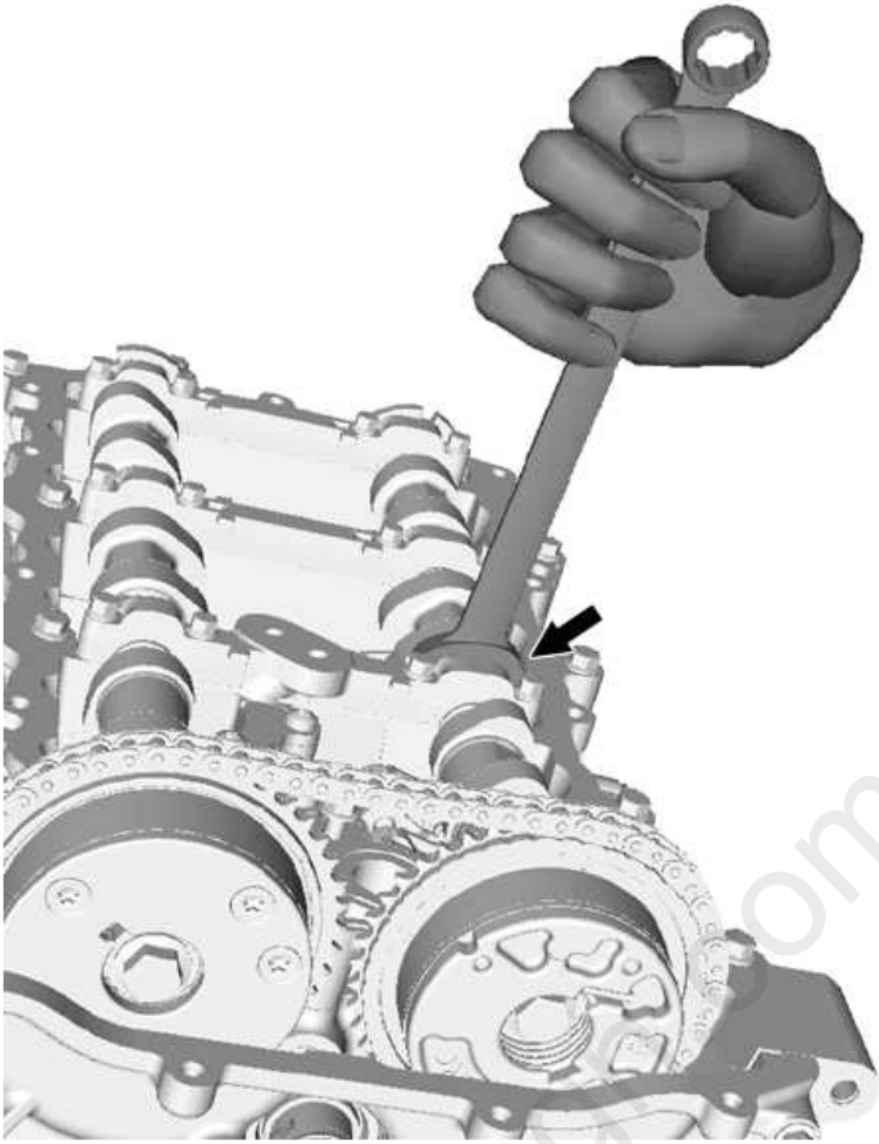


Fig. 138: Opened End Wrench On Cast Hexagonal Portion Of Camshaft
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

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

4. Loosen both intake and exhaust camshaft position actuator retaining bolts but DO NOT remove.

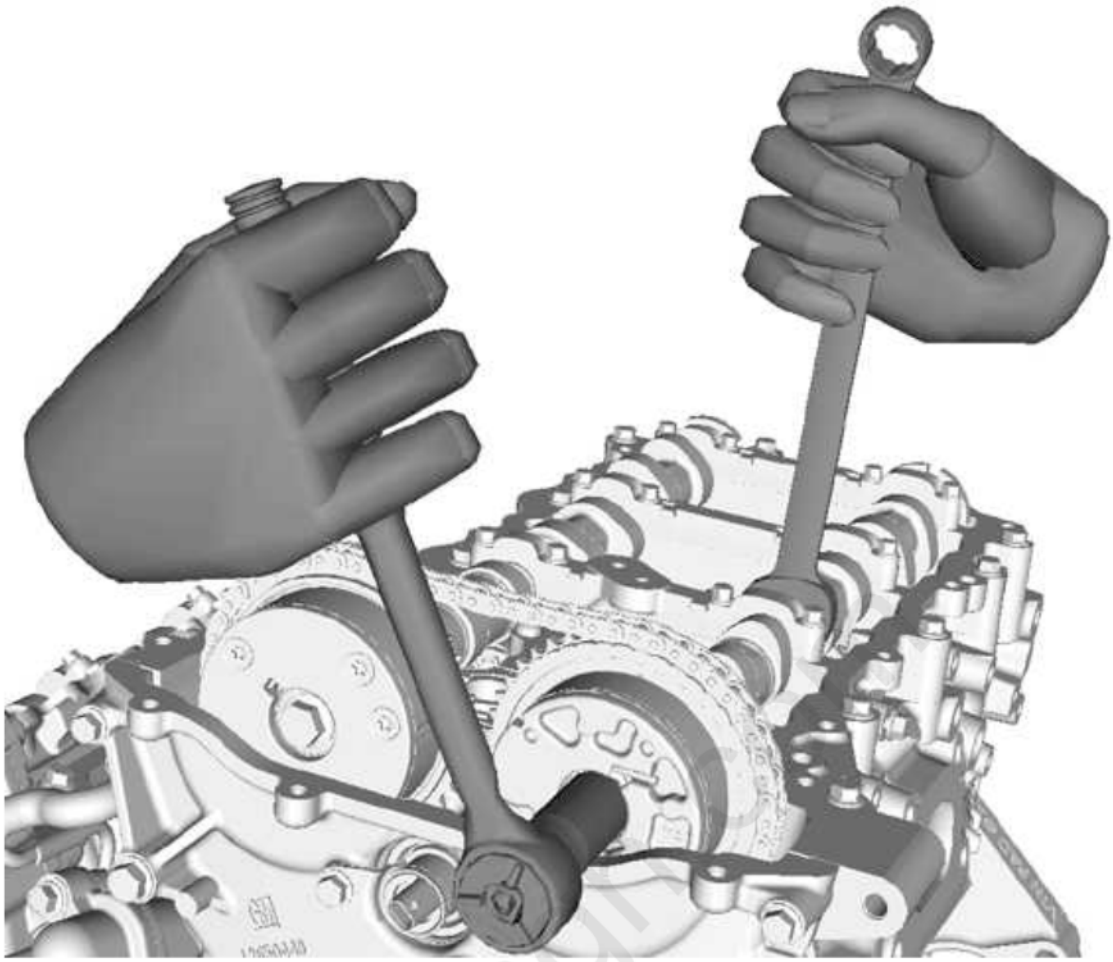


Fig. 139: Opened End Wrench On Cast Hexagonal Portion Of Camshaft
Courtesy of GENERAL MOTORS COMPANY

5. Clean off any oil residue on camshaft position actuators.
6. Mark the position of the chain to the camshaft position actuator - intake.

NOTE: **Marking the relationship of the timing chain to actuators is critical for timing alignment.**

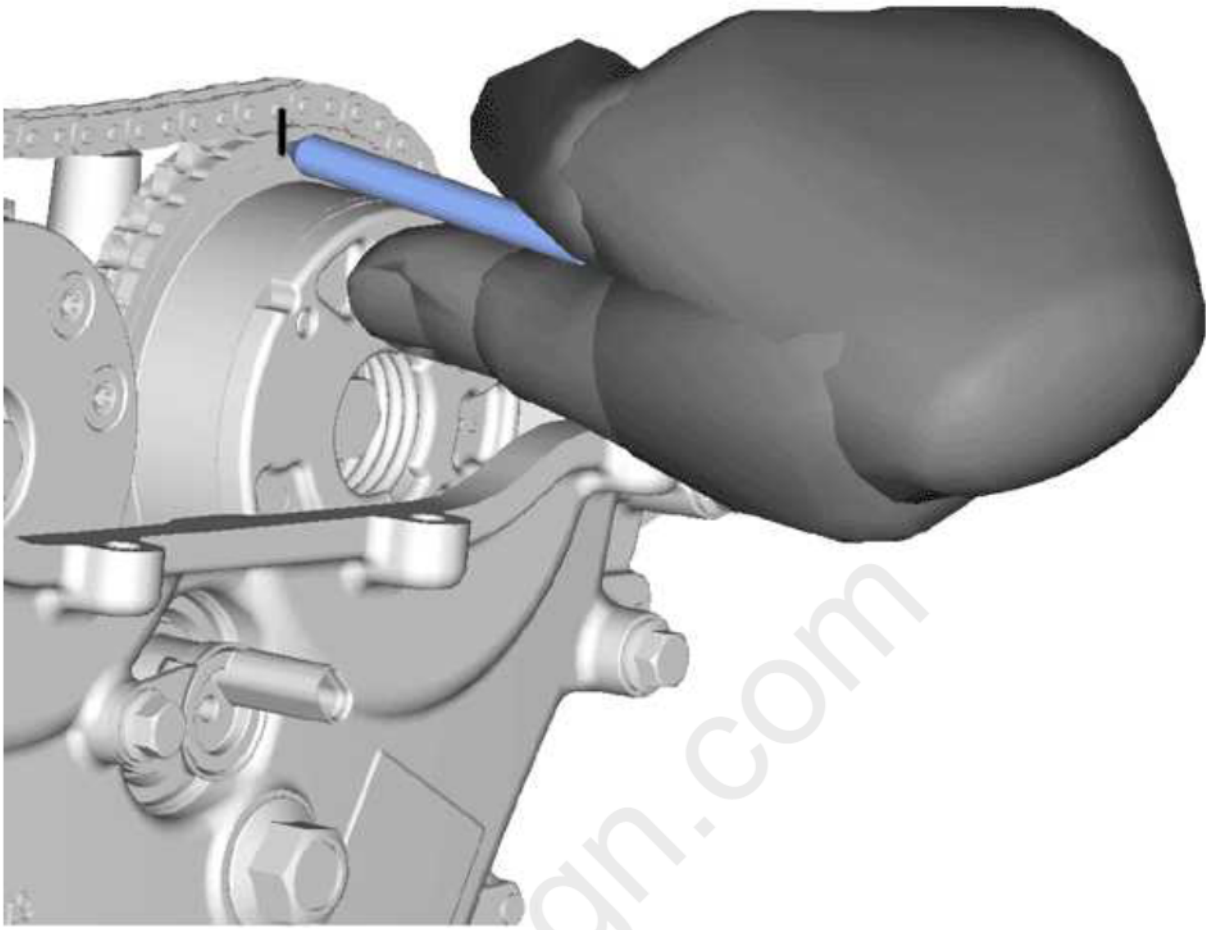


Fig. 140: Position Of Chain To Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

7. Mark the position of the chain to the camshaft position actuator - exhaust.
8. Remove camshaft front cap bolts (1) [5x].

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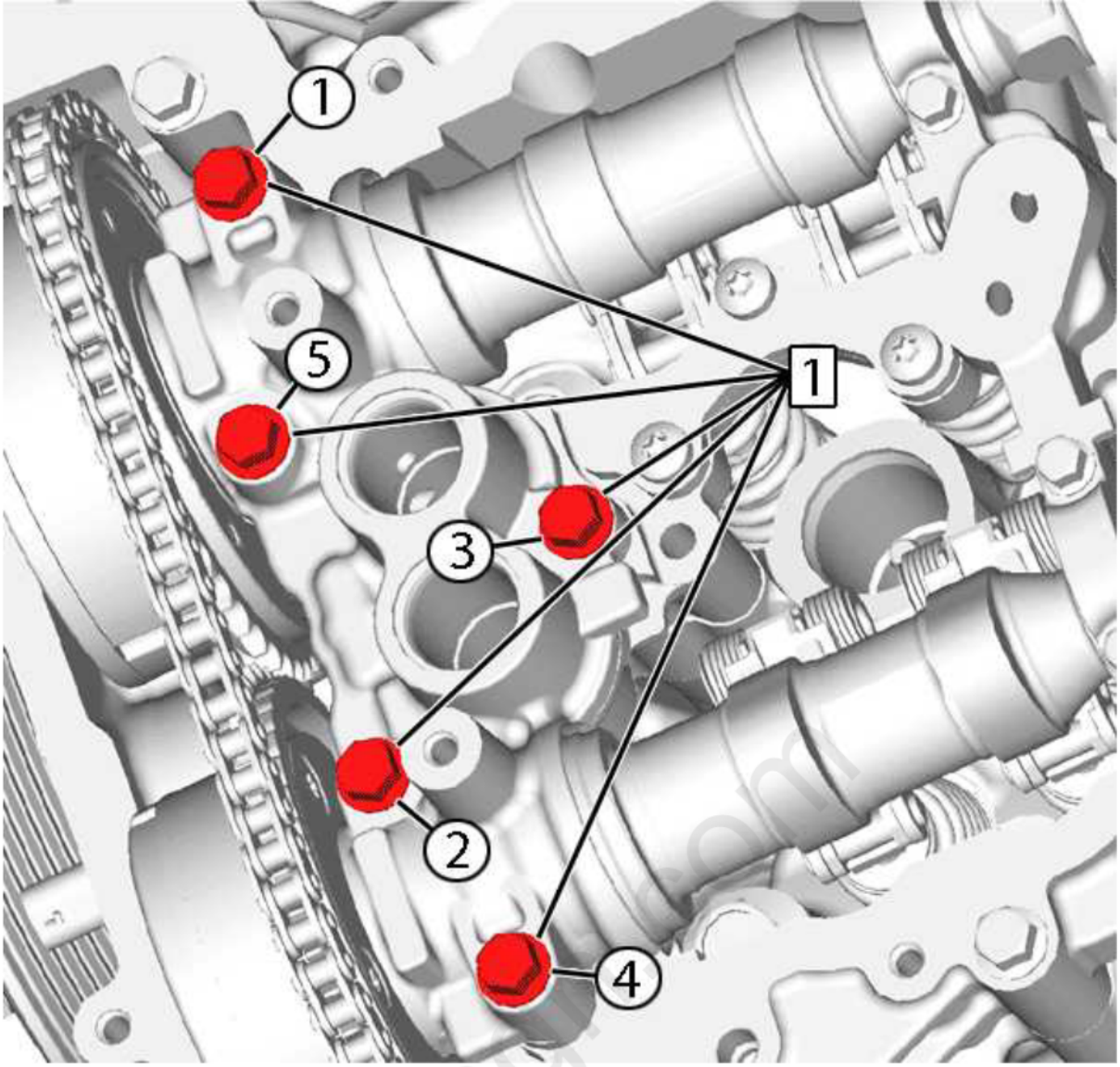


Fig. 141: Camshaft Front Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do NOT remove or loosen any other camshaft bearing caps at this time, even if you intend to eventually remove the camshaft.**

9. Remove the camshaft front cap (1).

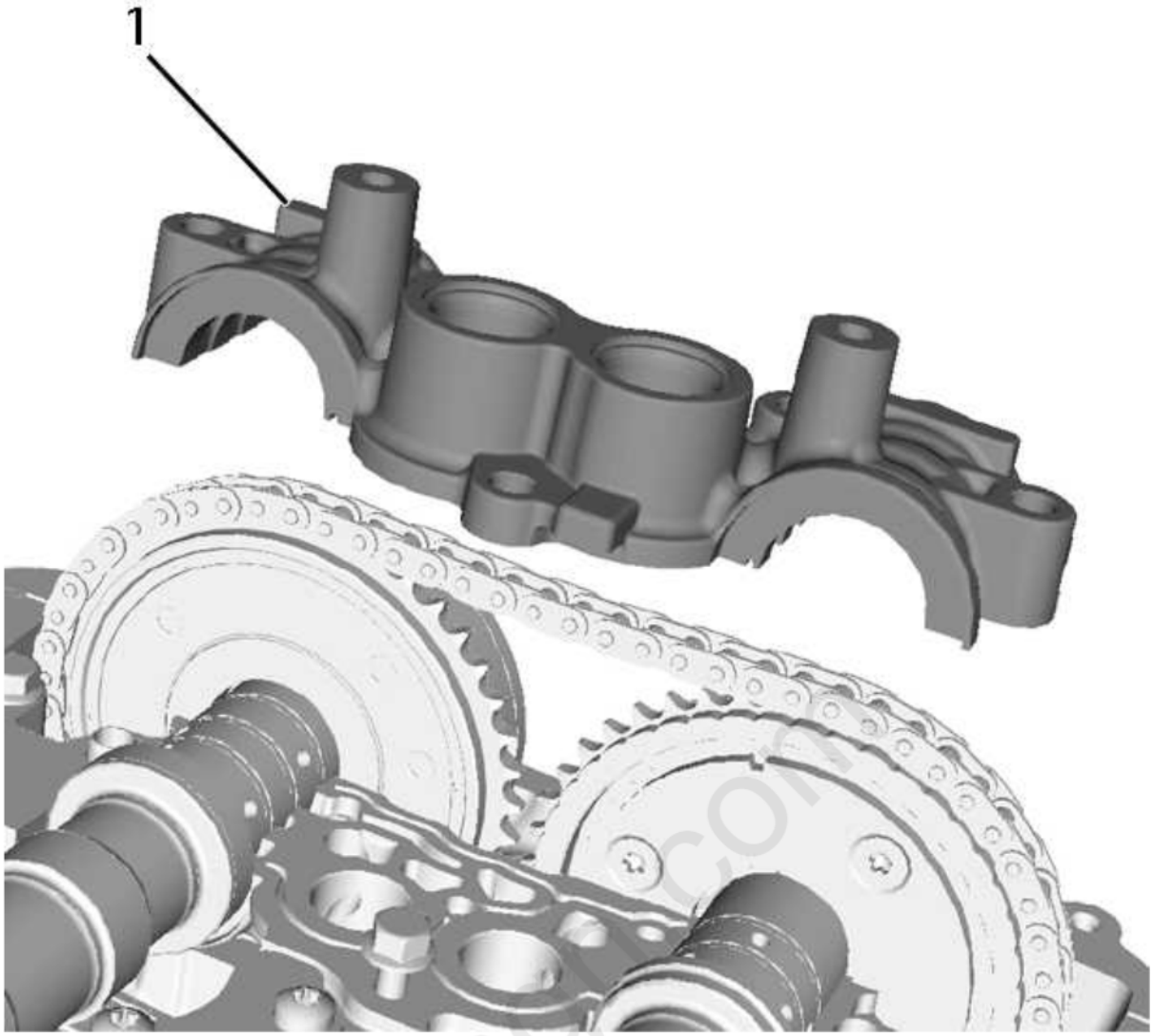


Fig. 142: Camshaft Front Cap
Courtesy of GENERAL MOTORS COMPANY

10. Clean RTV from front cover and cylinder head surface at the indicated locations prior to timing retainer tool installation.

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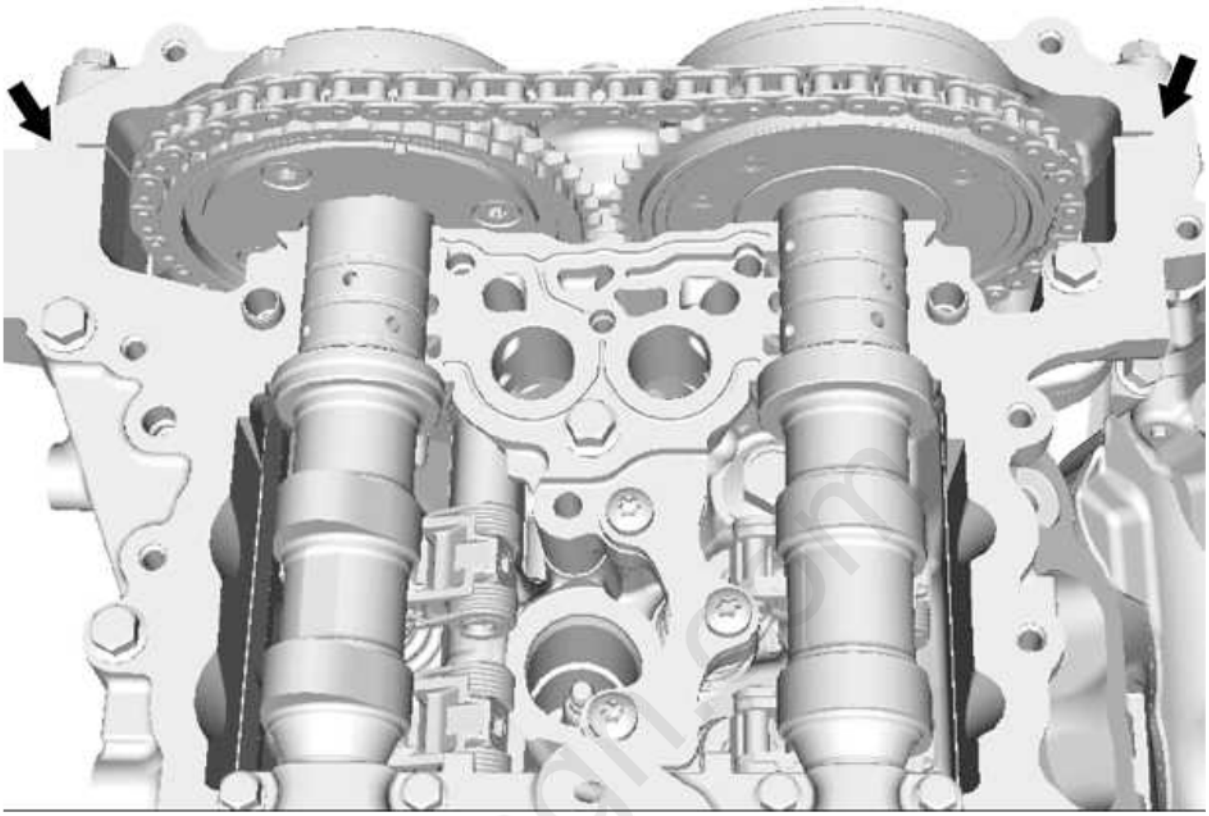


Fig. 143: Locating Front Cover And Cylinder Head Surface Cleaning Areas
Courtesy of GENERAL MOTORS COMPANY

11. Loosen the wingnut (1) to open the clamping area of **EN-51333-1** retainer.

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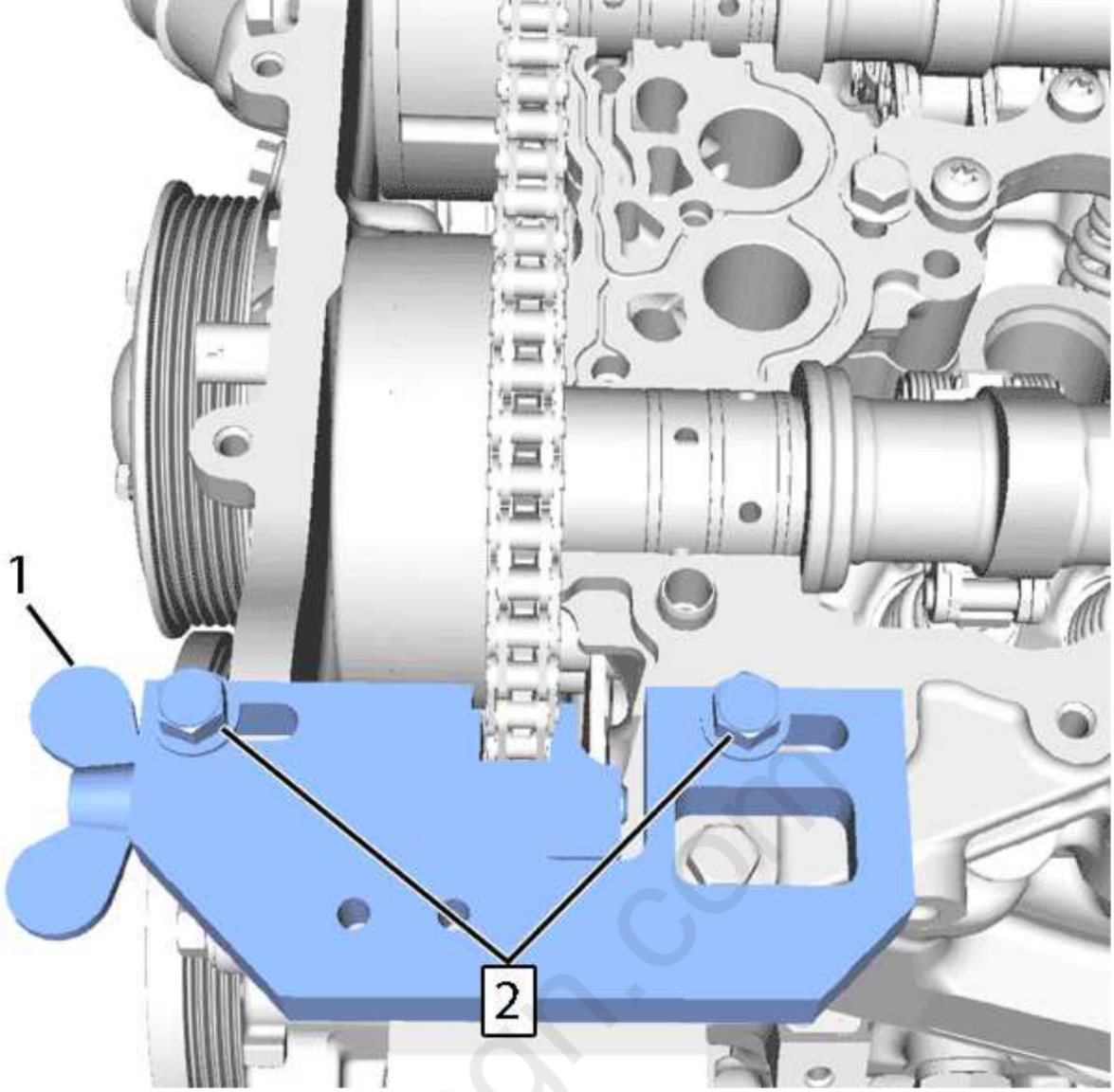


Fig. 144: Retainer
Courtesy of GENERAL MOTORS COMPANY

12. Install the **EN-51333-1** retainer on the exhaust side front cover and cylinder head by screwing in the bolts (2) on the **EN-51333-1** retainer finger-tight.

NOTE: **Do NOT overtighten the bolts. The EN-51333-1 retainer should be able to slide slightly via the slots the bolts go through. This fore/aft movement will allow easier removal and installation of the chain later.**

13. Loosen the wingnut (1) to open the clamping area of **EN-51333-2** retainer.

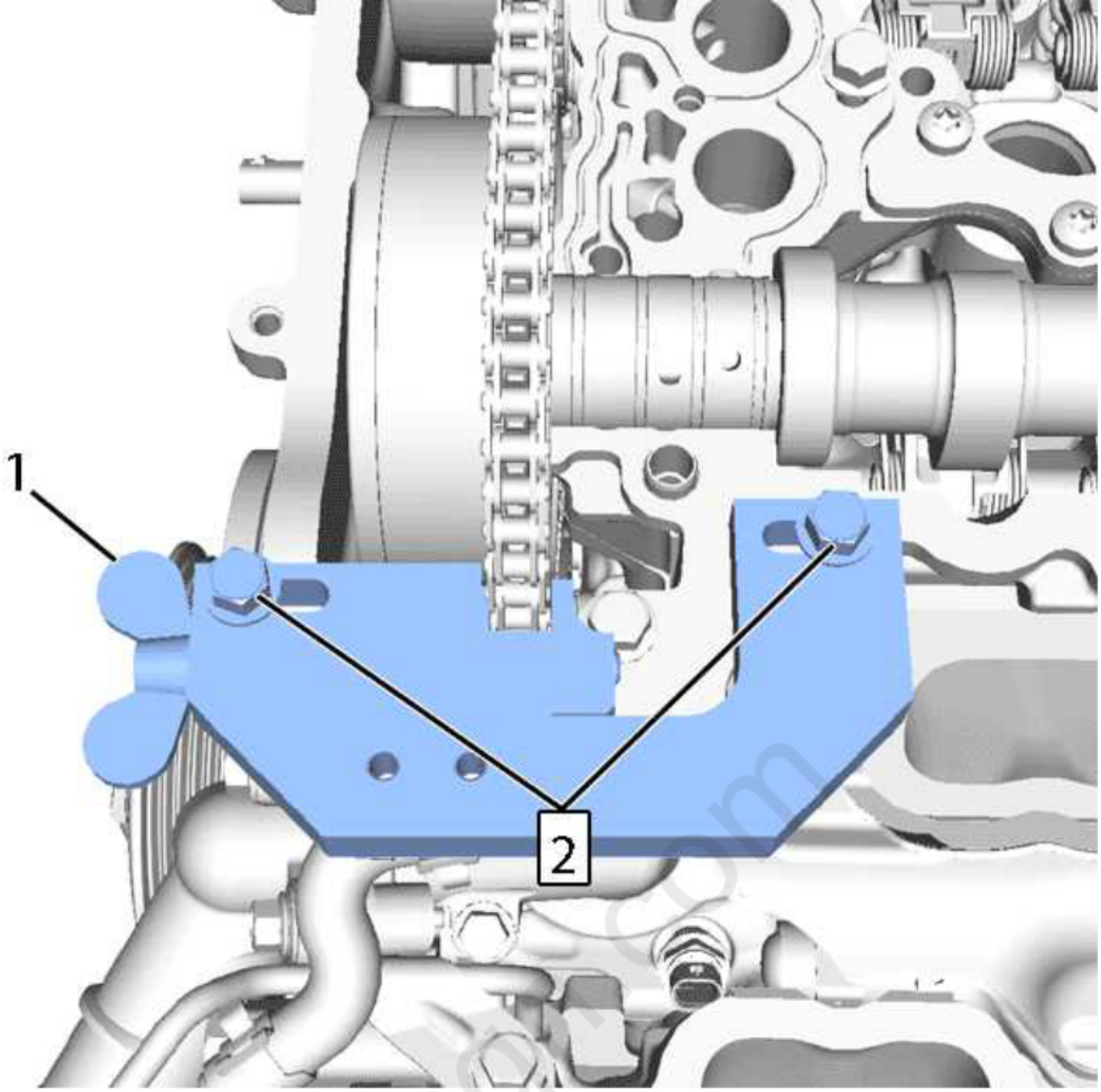


Fig. 145: Wingnut
Courtesy of GENERAL MOTORS COMPANY

14. Install the **EN-51333-2** retainer on the intake side front cover and cylinder head by screwing in the bolts (2) on the **EN-51333-2** retainer finger-tight.

NOTE: **Do NOT overtighten the bolts. The EN-51333-2 retainer should be able to slide slightly via the slots the bolts go through. This fore/aft movement will allow easier removal and installation of the chain later.**

15. Using a wrench on the cast hexagonal portion of the intake camshaft, rotate the camshaft toward the exhaust camshaft and then release. Repeat this action three to fully drain the tensioners of oil.

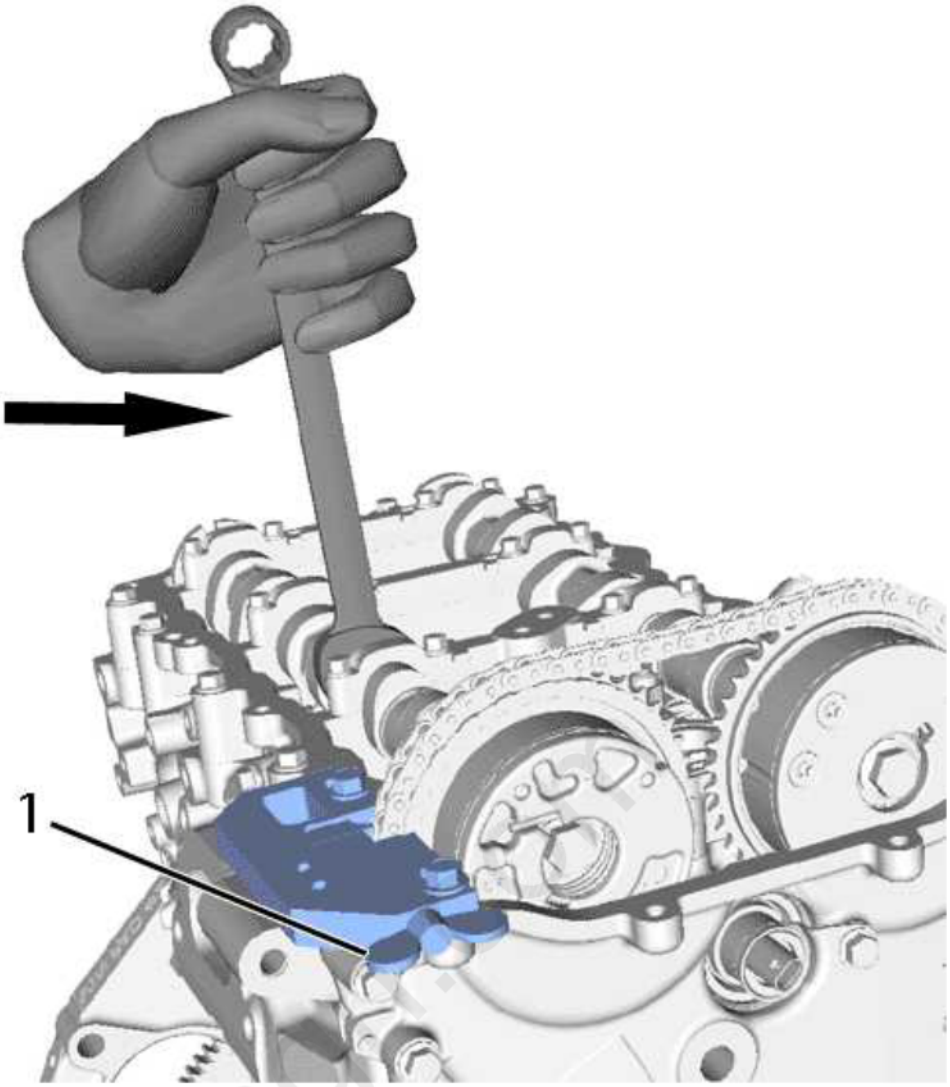


Fig. 146: Cast Hexagonal Portion Of Intake Camshaft
Courtesy of GENERAL MOTORS COMPANY

16. Rotate the intake camshaft toward the exhaust camshaft and hold.
17. Tighten wingnut (1) so **EN-51333-1** retainer closes and firmly grasps timing chain.

NOTE: **Do NOT tighten the wingnut with a tool of any kind. Firm finger-tightening is sufficient.**

18. Using a wrench on the cast hexagonal portion of the exhaust camshaft, rotate the camshaft toward the intake camshaft and then release. Repeat this action three to fully drain the tensioners of oil.

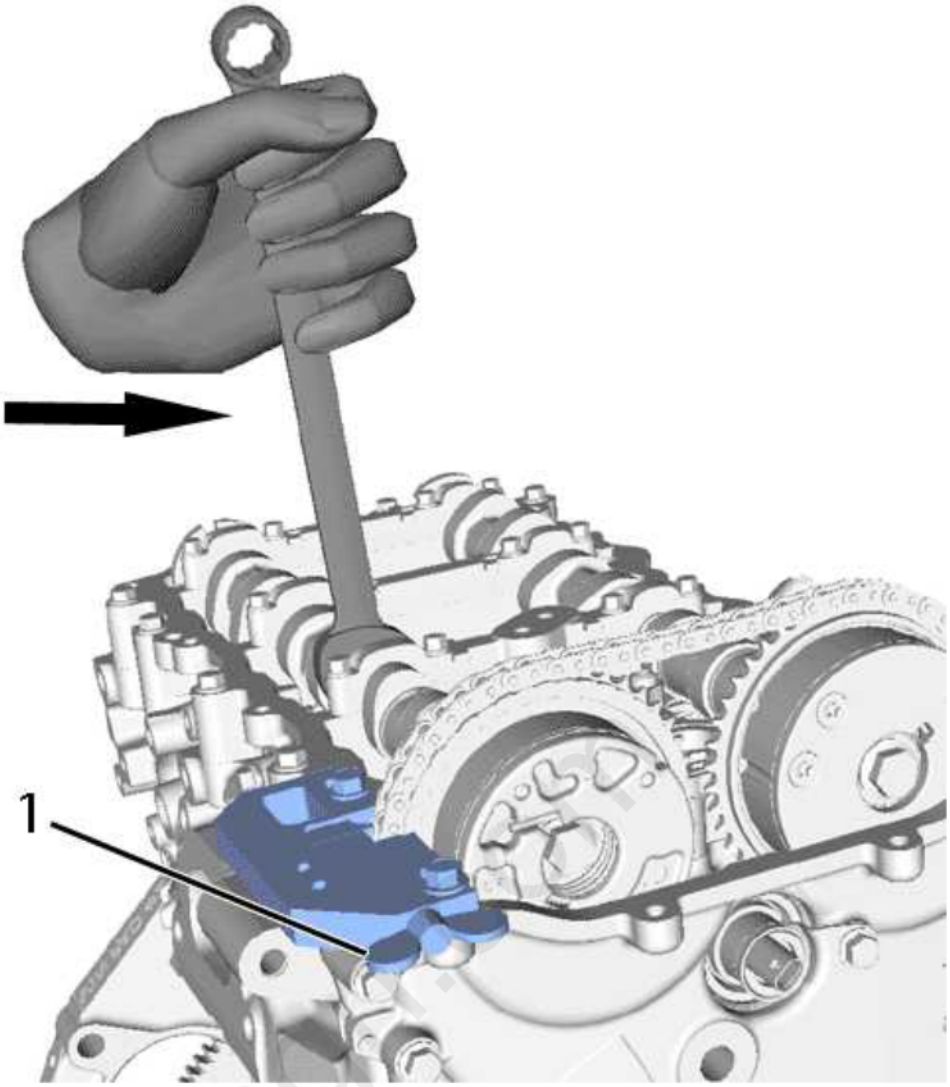


Fig. 147: Cast Hexagonal Portion Of Intake Camshaft
Courtesy of GENERAL MOTORS COMPANY

19. Rotate the exhaust camshaft toward the intake camshaft and hold.
20. Tighten wingnut (1) so **EN-51333-2** retainer closes and firmly grasps timing chain.

NOTE: **Do NOT tighten the wingnut with a tool of any kind. Firm finger-tightening is sufficient.**

21. Fully remove the bolt (1) for the exhaust camshaft position actuator.

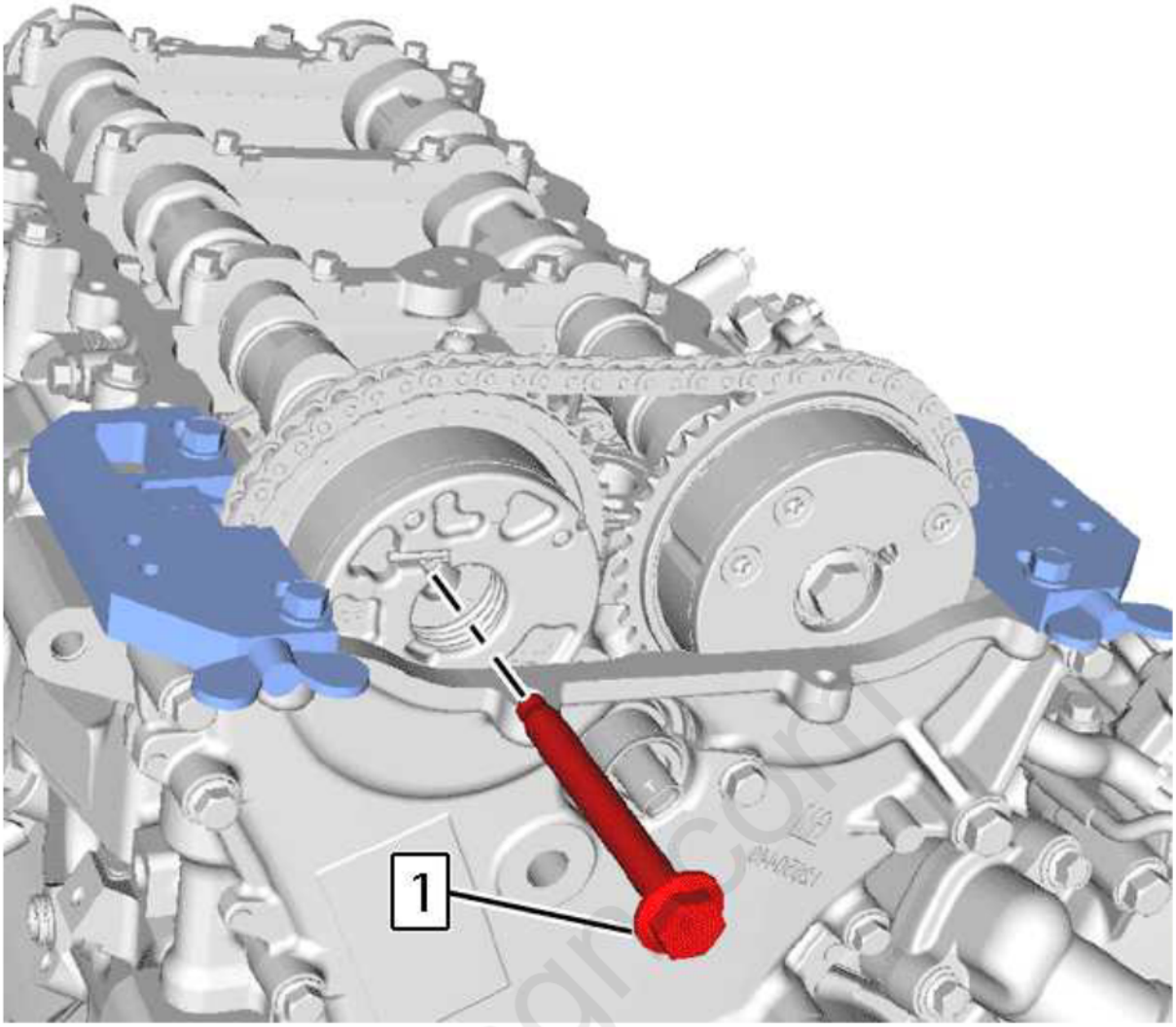


Fig. 148: Exhaust Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The Exhaust camshaft position actuator must be removed first to provide enough chain slack to remove the intake Position Actuator.**

22. Position a screwdriver or small pry bar between a camshaft cap and camshaft lobe. Carefully move/pry the camshafts as far as possible toward the rear/flywheel end of the engine.

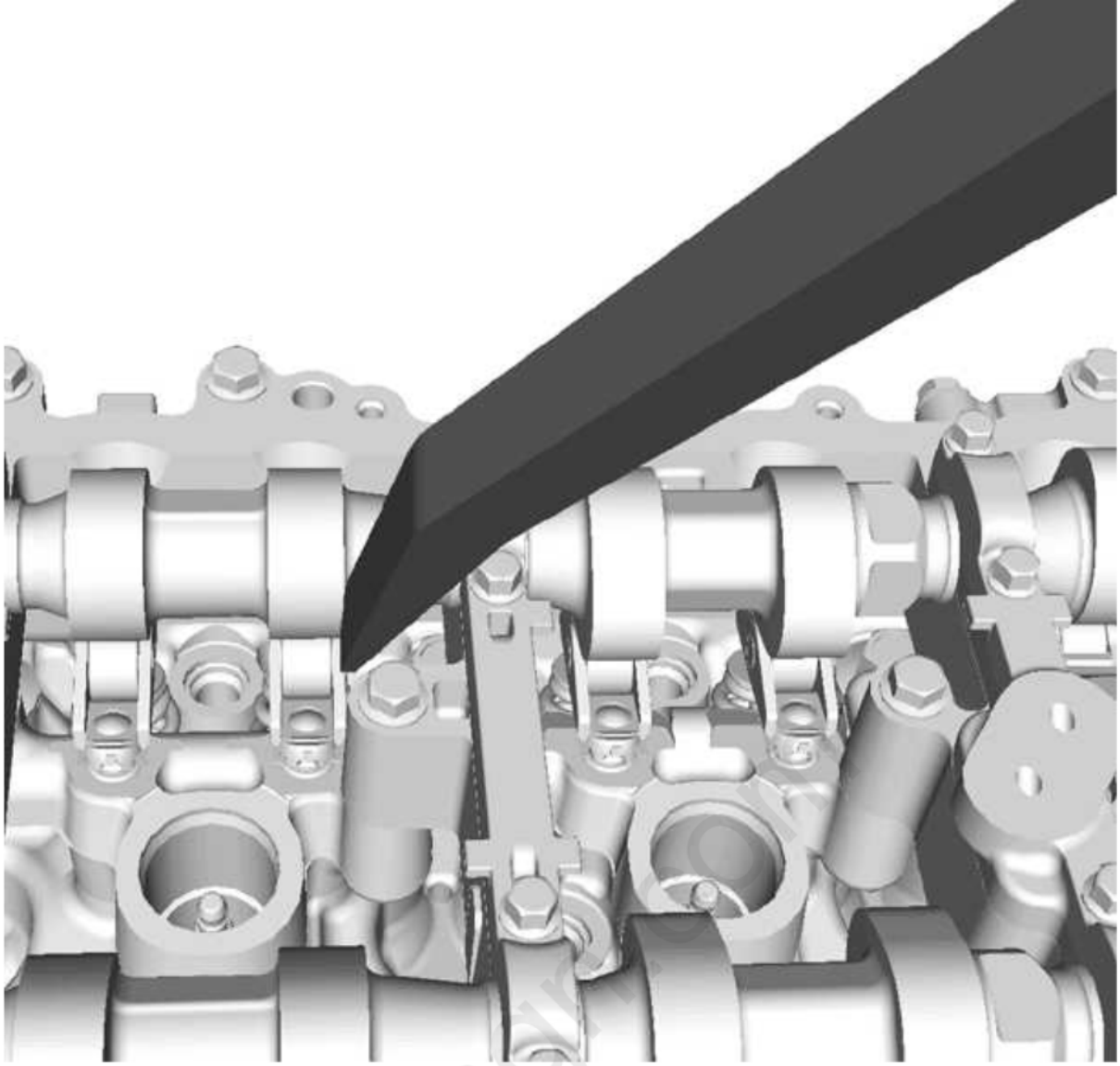


Fig. 149: Prying Camshaft Toward Rear/Flywheel End Of Engine
Courtesy of GENERAL MOTORS COMPANY

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

23. Slide the camshaft position actuator (1) forward and off the end of the exhaust camshaft.

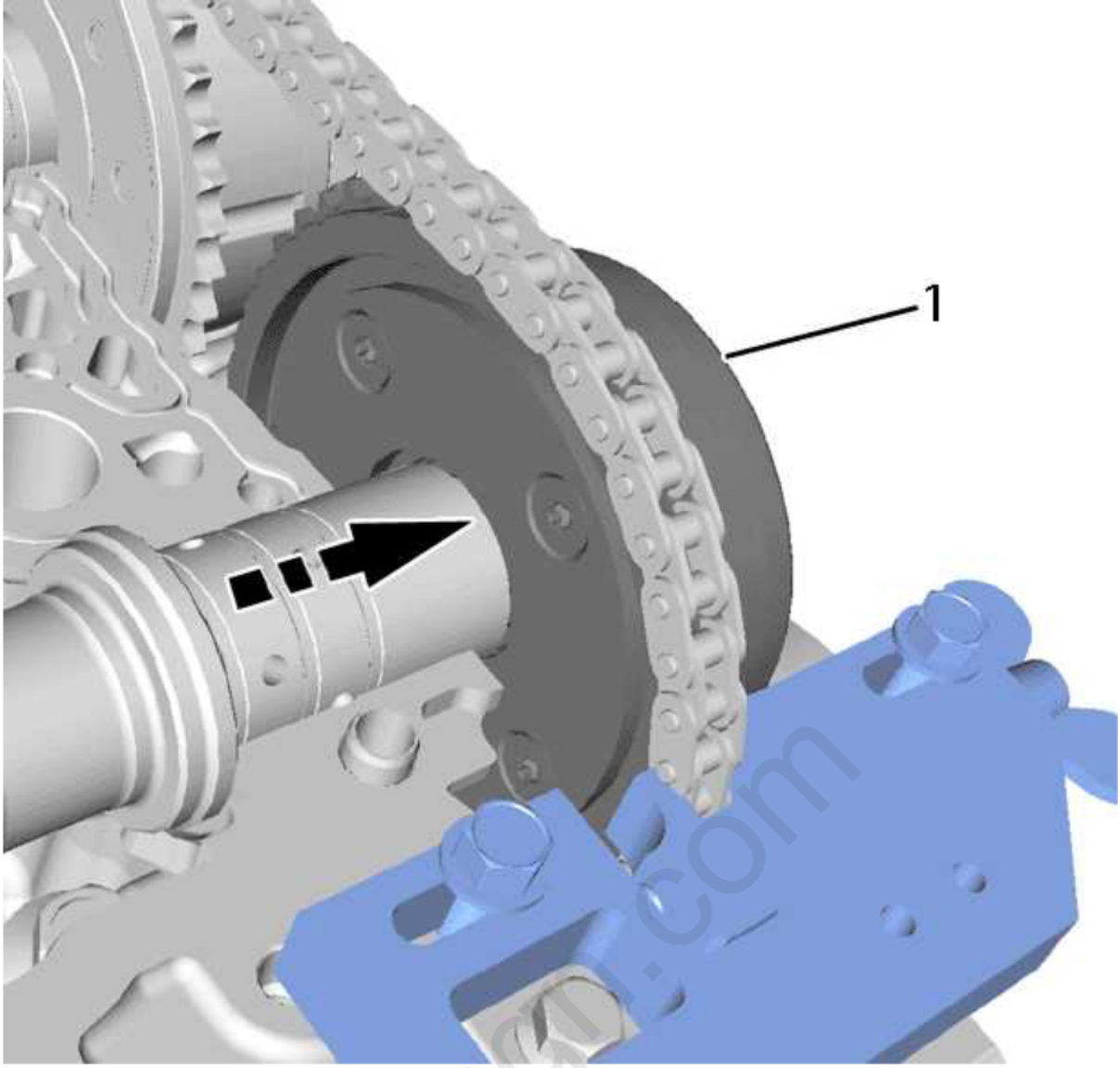


Fig. 150: Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

24. Tilt the camshaft position actuator forward and out/away from the engine.

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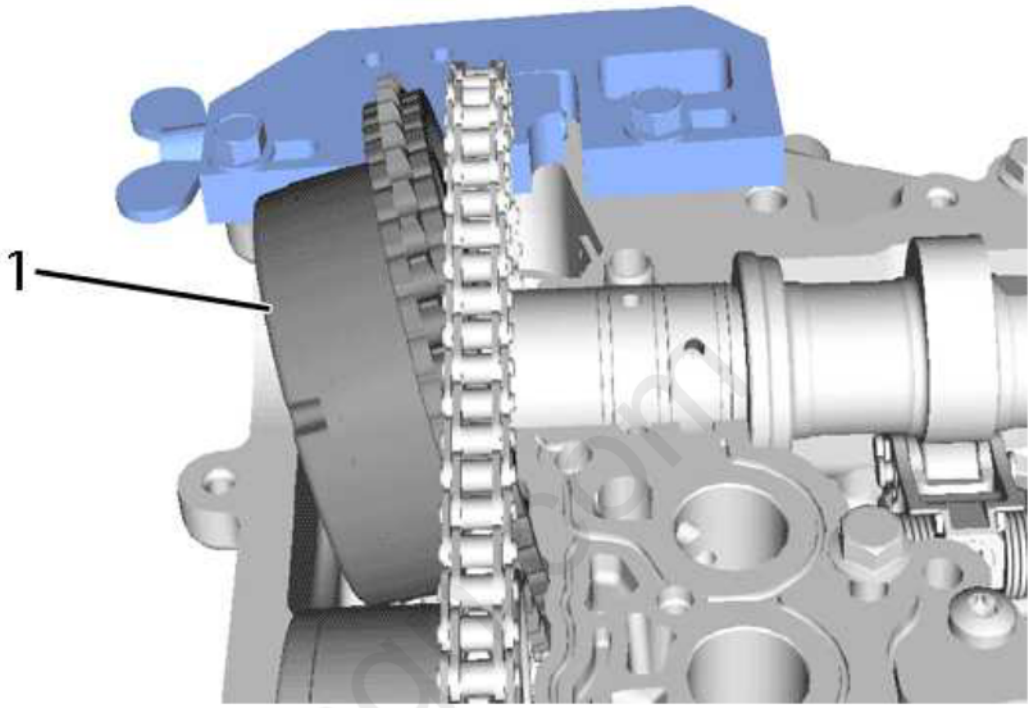


Fig. 151: Tilting Camshaft Position Actuator Forward
Courtesy of GENERAL MOTORS COMPANY

25. Repeat steps 19-23 to remove the intake camshaft position actuator.

NOTE: **DO NOT remove the EN-51333 Timing Chain Retainer Set, they are holding the cam chain to maintain the proper timed position.**

Installation Procedure

1. It may help to carefully pry the camshaft forward and to move the **EN-51333** retainers backward via the slot to reengage the position actuator to the camshaft. The dowel pin on the camshaft position actuator must be aligned with the slot in the camshaft nose for reassembly.

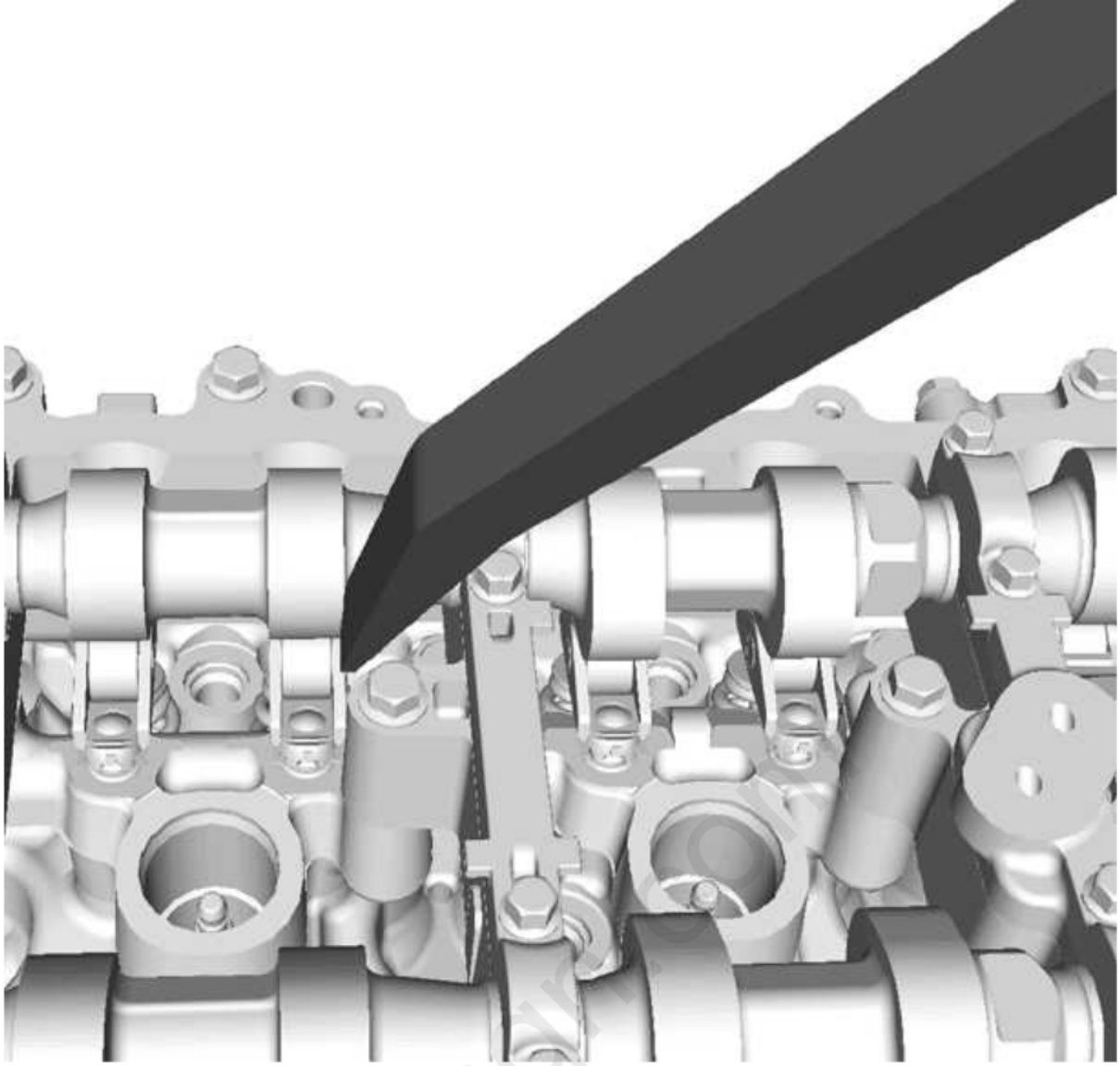


Fig. 152: Prying Camshaft Toward Rear/Flywheel End Of Engine
Courtesy of GENERAL MOTORS COMPANY

2. Use an open ended wrench on the cast hexagonal portion of the intake camshaft to aid in alignment of the timing chain marks.

CAUTION: **Refer to Torque Reaction Against Timing Drive Chain Caution .**

NOTE: **The intake camshaft position actuator must be installed first to provide enough chain slack to install the exhaust position actuator.**

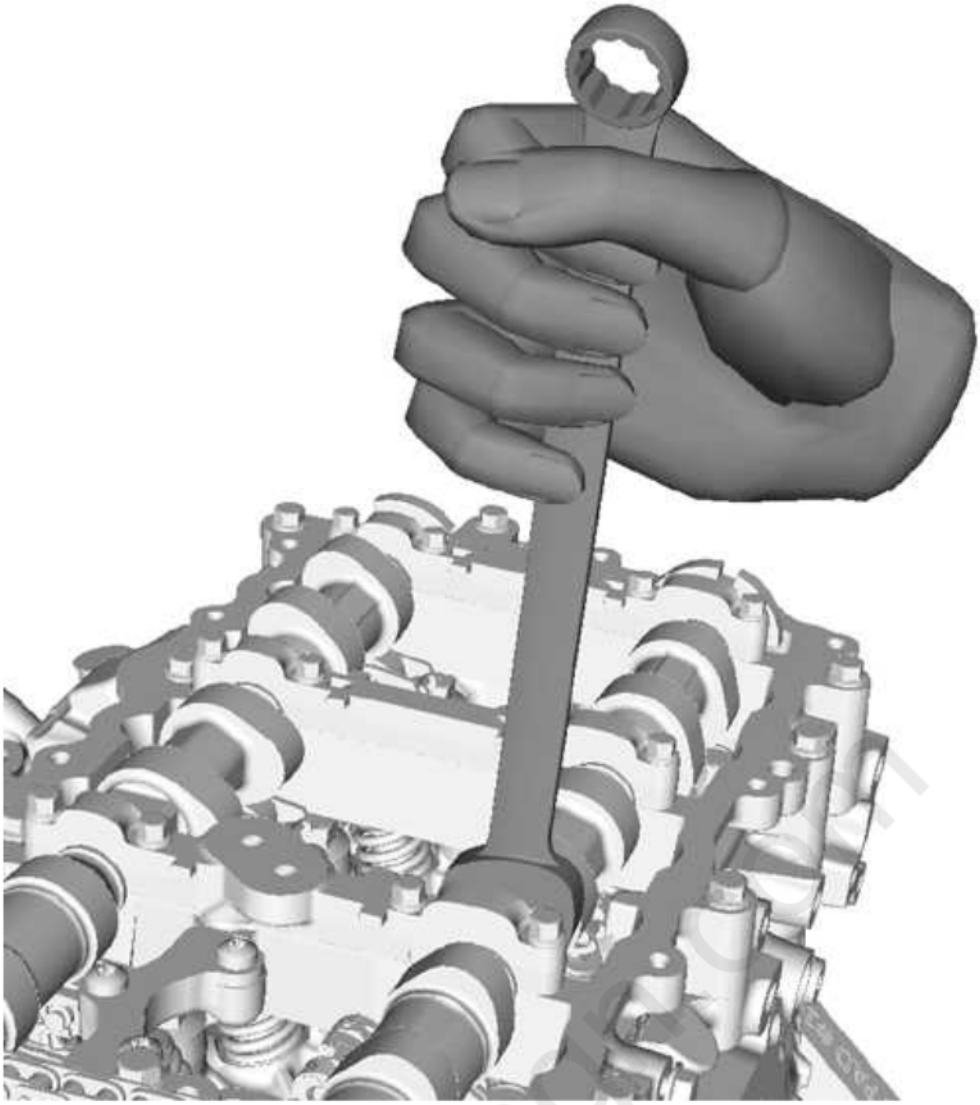


Fig. 153: Open Ended Wrench On Cast Hexagonal Portion Of Intake Camshaft
Courtesy of GENERAL MOTORS COMPANY

3. Apply lubricant to the back of the camshaft position actuator and front of the camshaft bearing cap. Refer to **Adhesives, Fluids, Lubricants and Sealers**
4. Install the intake camshaft position actuator (1) first by inserting the actuator between the timing chain and front cover. While pushing the actuator into the tensioned side of the chain, tilt the actuator while engaging the chain, aligning the marks on the chain and place the actuator in the fully seated position.

NOTE: **Ensure the proper camshaft position actuator is installed in the correct position. The dowel pin on the camshaft position actuator must be aligned with the slot in the camshaft nose for reassembly. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.**

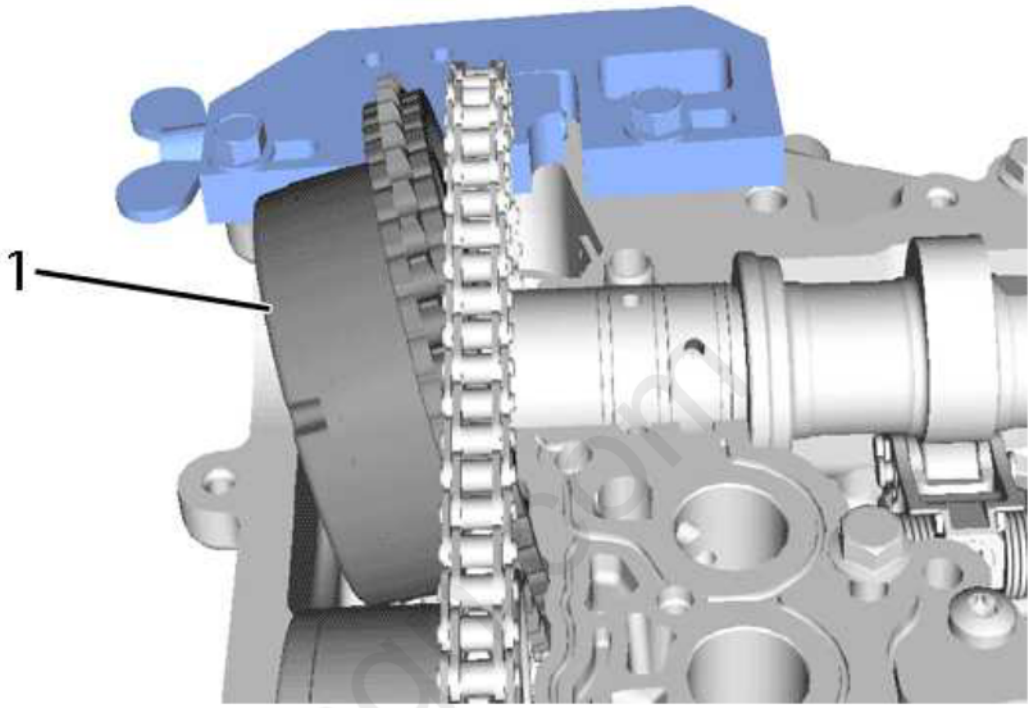


Fig. 154: Tilting Camshaft Position Actuator Forward
Courtesy of GENERAL MOTORS COMPANY

5. Ensure the camshaft position actuator is seated properly on the end of the camshaft.

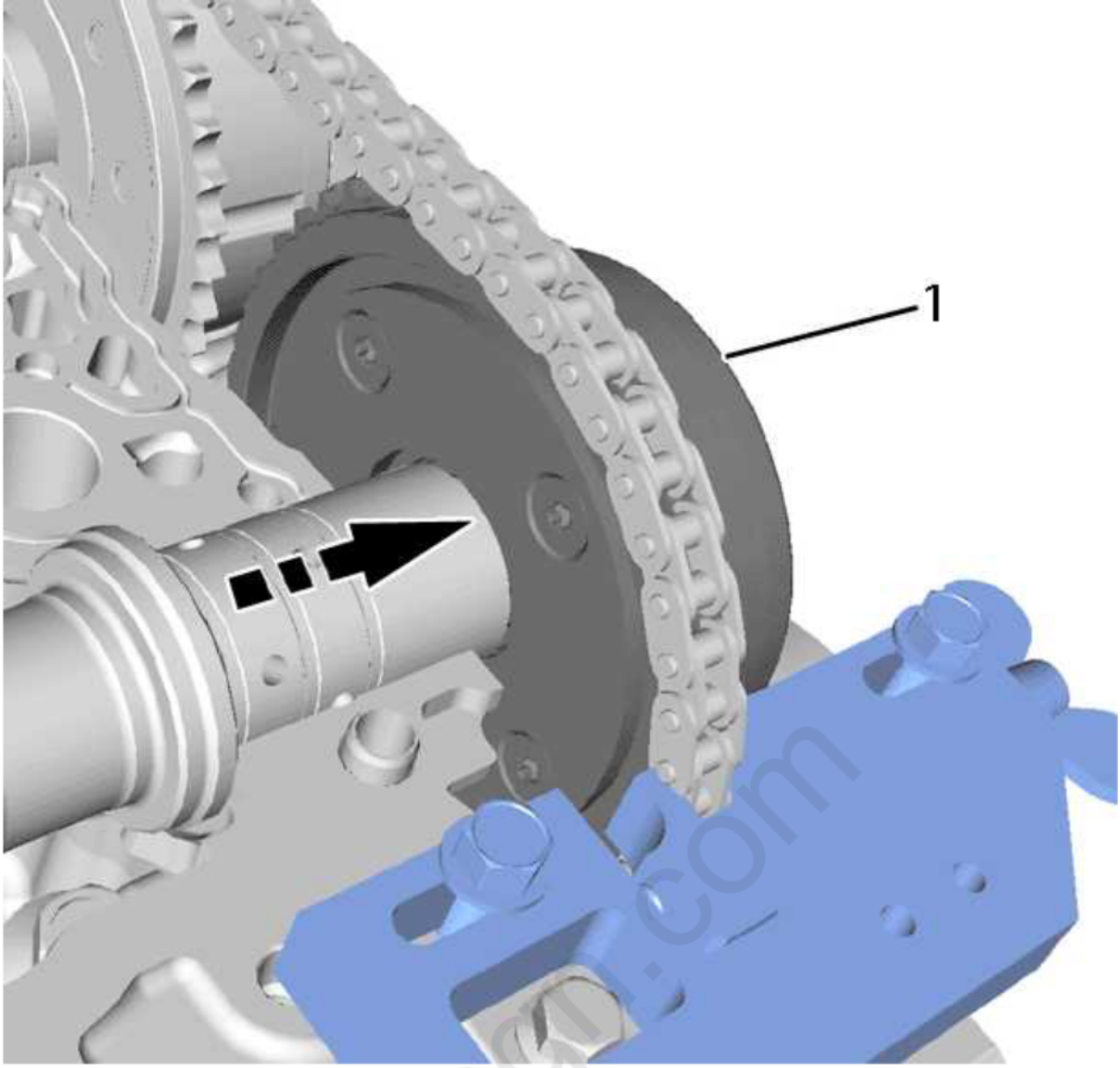


Fig. 155: Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

6. Install the intake camshaft position actuator retaining bolt and lightly tighten the bolt to hold the camshaft actuator in place. DO NOT torque at this time.

CAUTION: **Refer to Fastener Caution .**

7. Install the exhaust camshaft position actuator and retaining bolt following the same steps as the intake side.
8. Check the marks on both the intake and exhaust camshaft position actuators to ensure that they are aligned with their respective paint marks on the chain.
9. Using an open ended wrench on the cast hexagonal portion of the exhaust camshaft, hold the camshaft in place while loosening the wing nut on the **EN-51333-1** retainer after fully loosed, let the camshaft rotate back into tension.

CAUTION: **Refer to Torque Reaction Against Timing Drive Chain Caution .**

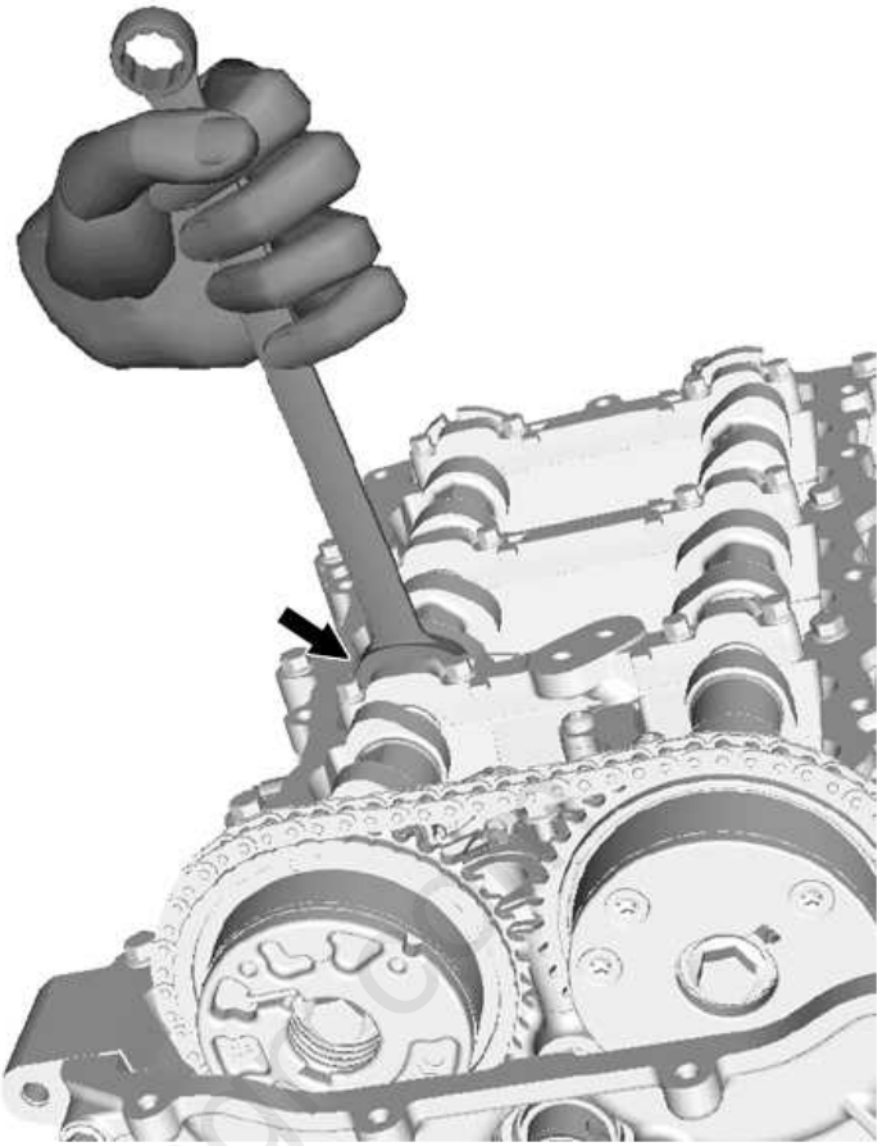


Fig. 156: Opened End Wrench On Cast Hexagonal Portion Of Camshaft
Courtesy of GENERAL MOTORS COMPANY

10. Repeat step 9 for the intake camshaft and **EN-51333-2** retainer
11. Using an open ended wrench on the cast hexagonal portion of the exhaust camshaft, torque both camshaft position actuator retaining bolts.

    Tighten

    1. First Pass: 20 N.m (15 lb ft)
    2. Final Pass: 45 degrees
12. Remove the **EN-51333** retainers
13. Install the camshaft front cap (1).

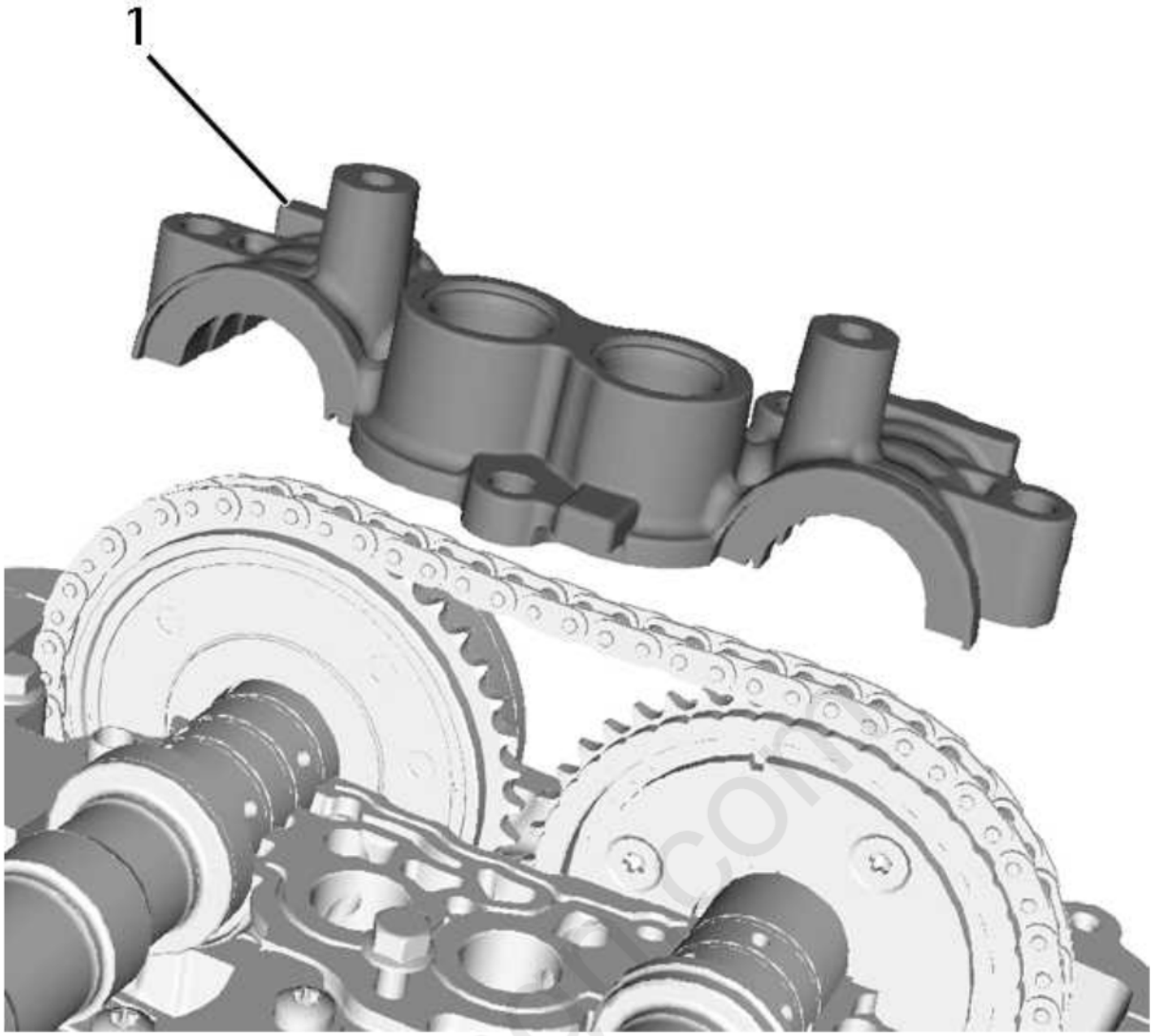


Fig. 157: Camshaft Front Cap
Courtesy of GENERAL MOTORS COMPANY

14. Install the camshaft front cap bolts (1) [5x].

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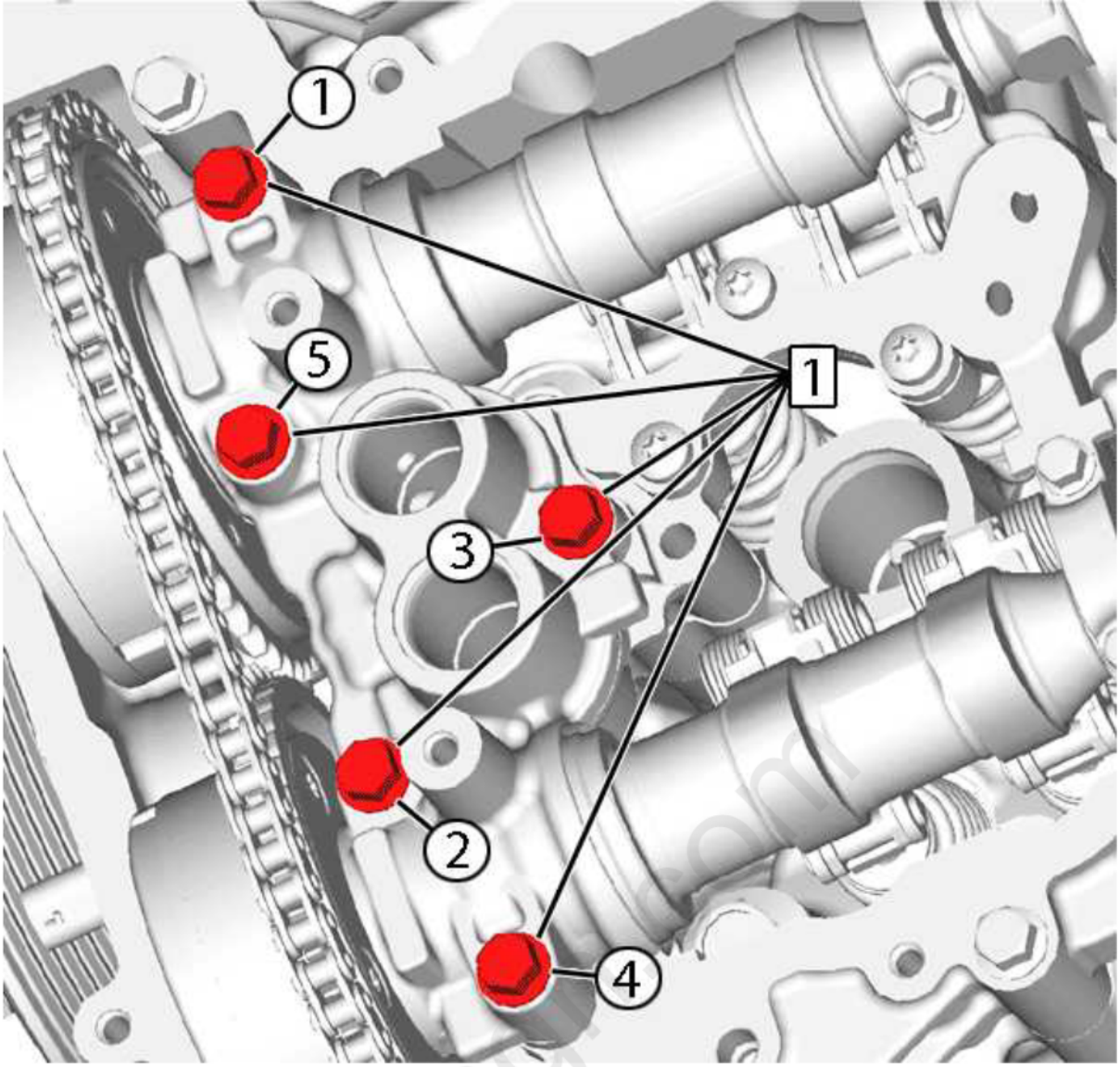


Fig. 158: Camshaft Front Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

15. Tighten the camshaft front cap bolts in sequence to 10 N.m (89 lb in).
16. **Camshaft Cover Replacement - Right Side**Â» Install

SETTING CAMSHAFT TIMING

IMPORTANT: Setting the camshaft timing is necessary whenever the camshaft drive system has been disturbed such that the relationship between any chain and sprocket has been lost. Even when only one sprocket is involved, multiple crankshaft rotations will not produce conditions where correct timing can be confirmed.

Follow the left camshaft timing chain assembly replacement procedure to reset the camshaft timing. Refer to **Camshaft Timing Chain Assembly Replacement - Left Side**

CAMSHAFT HOUSING COVER INSULATOR REPLACEMENT - LEFT SIDE (LGX)

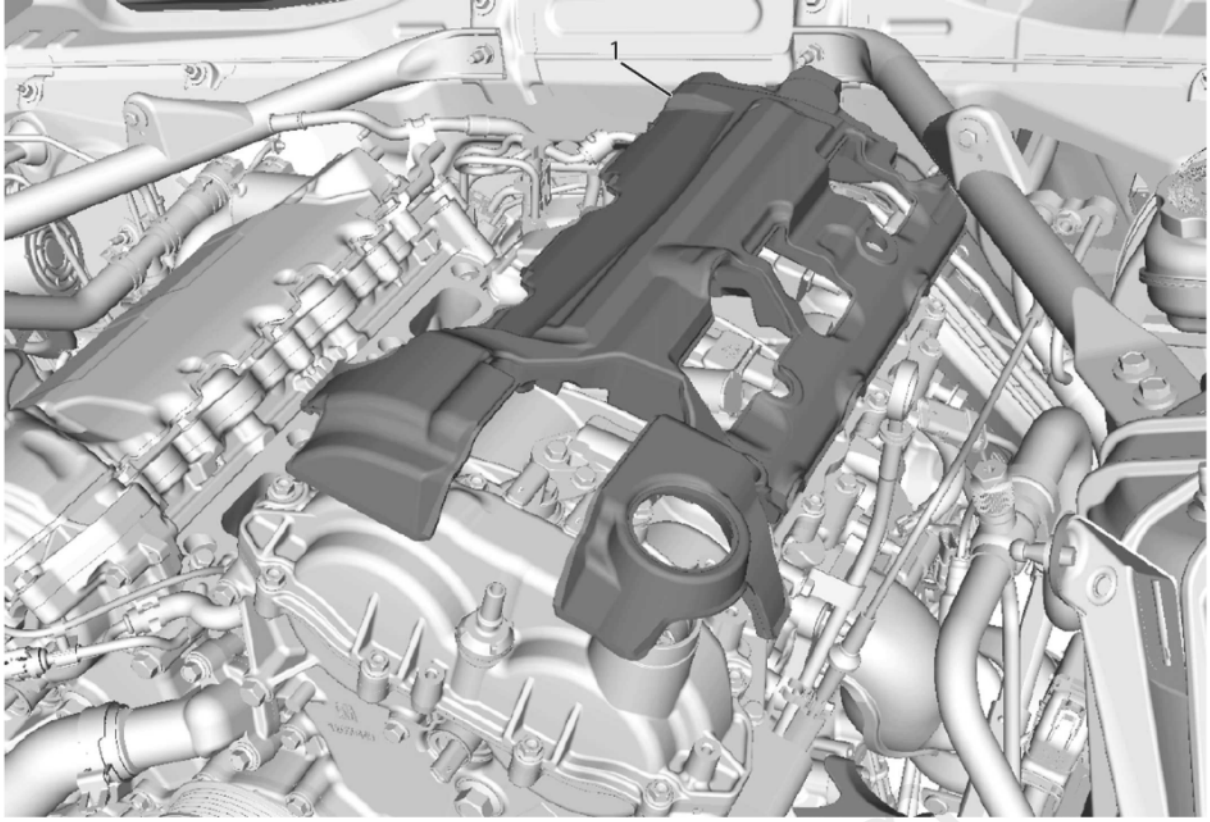


Fig. 159: Camshaft Housing Cover Insulator - Left Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Intake Manifold Replacement (LGX) 2. Remove the oil filler cap tube. 3. Disconnect electrical connectors and remove the engine harness from the camshaft housing cover insulator.	
1	Camshaft Housing Cover Insulator **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**

CAMSHAFT HOUSING COVER INSULATOR REPLACEMENT - LEFT SIDE (LGW)

Removal Procedure

1. Charge Air Cooler CoverÂ» Remove - Charge Air Cooler Cover Replacement
2. Oil Filler Cap TubeÂ» Remove
3. Remove the left side lower turbocharger wastegate bracket bolts (1) [2x]

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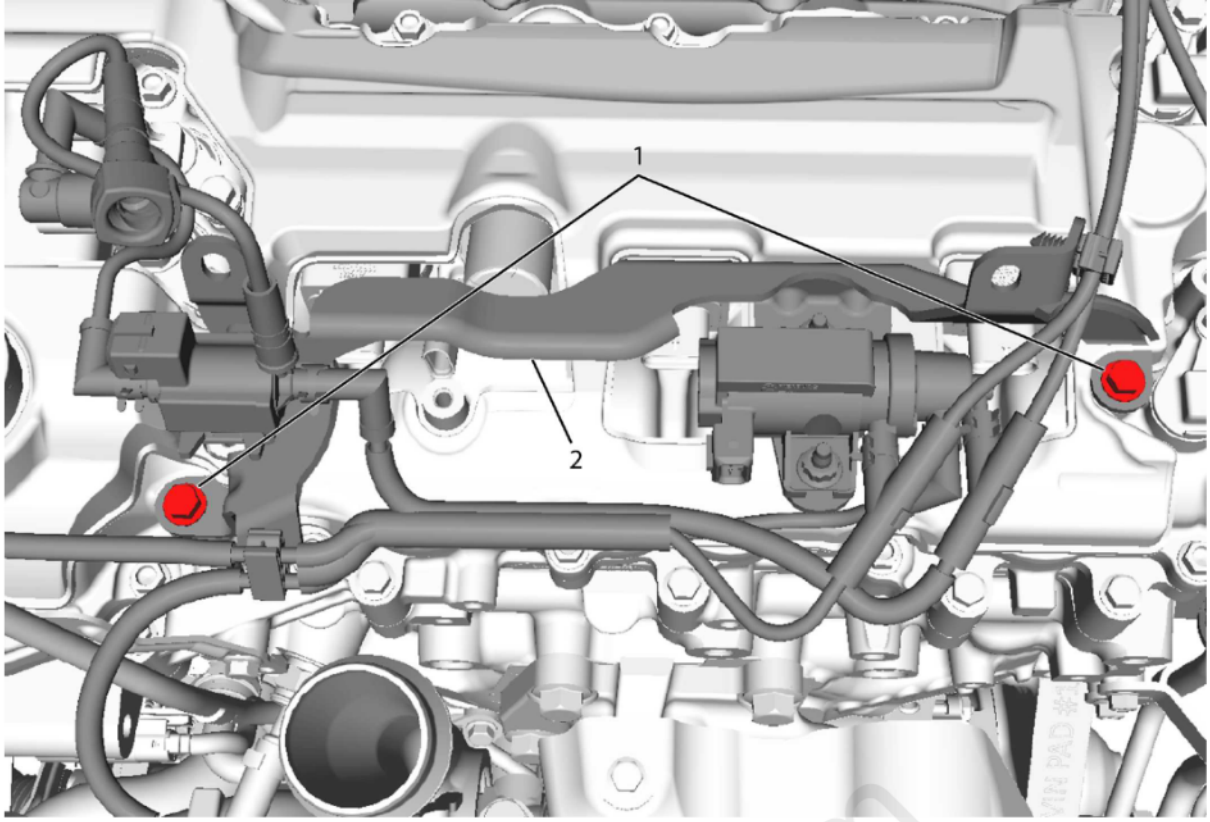


Fig. 160: Left Side Lower Turbocharger Wastegate Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Position the left side lower turbocharger wastegate bracket (2) aside.
5. Disconnect electrical connectors and remove the engine harness from the camshaft housing cover insulator.
6. Camshaft Housing Cover InsulatorÂ» Remove

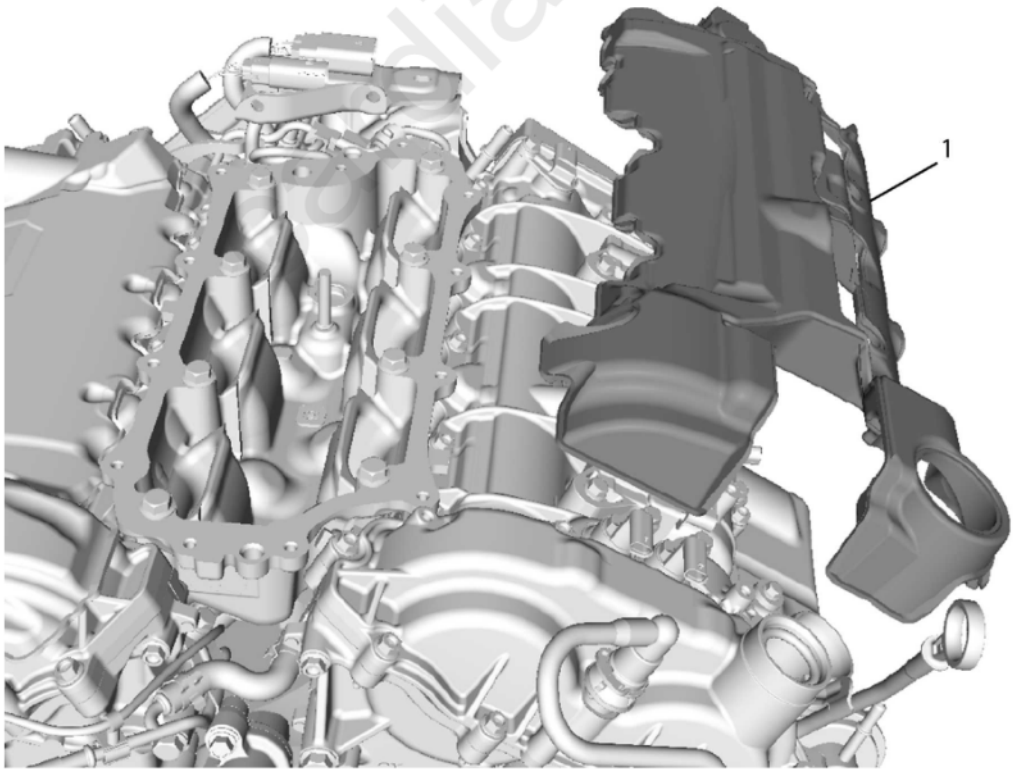


Fig. 161: Camshaft Housing Cover Insulator
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Replace the noise cancelling foam component if it is exposed to and absorbed automotive fluids.**

Installation Procedure

1. Camshaft Housing Cover InsulatorÂ» Install

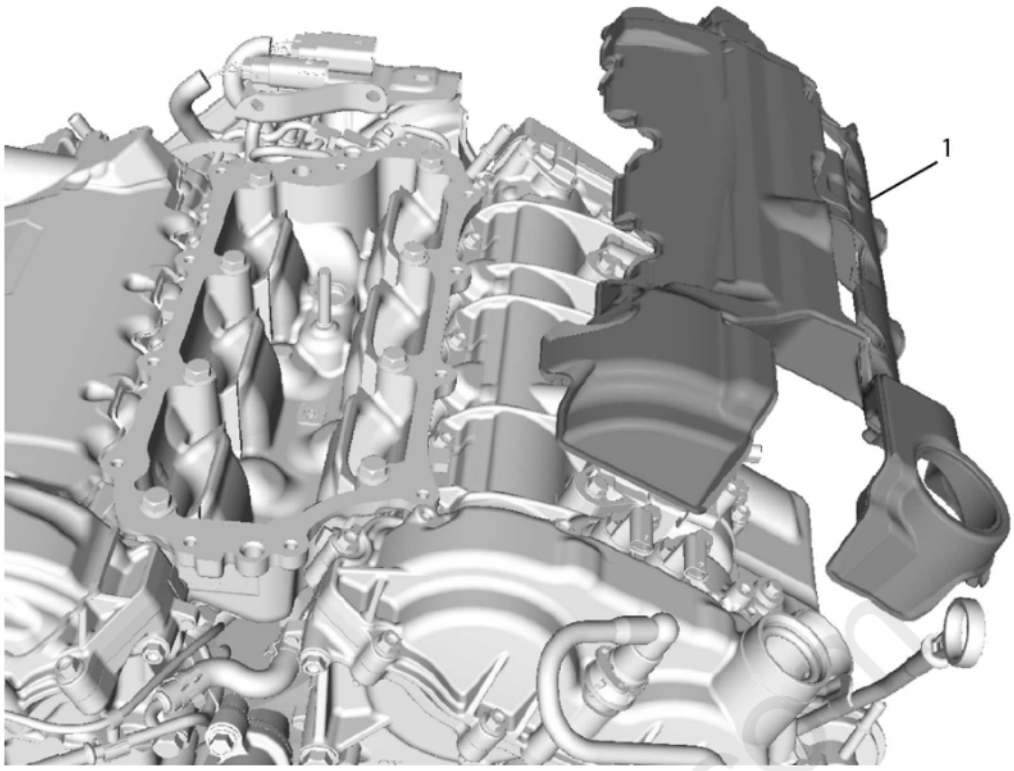


Fig. 162: Camshaft Housing Cover Insulator
Courtesy of GENERAL MOTORS COMPANY

2. Install the engine harness to the camshaft housing cover insulator and connect the electrical connectors.
3. Position the left side lower turbocharger wastegate bracket (2) in place.

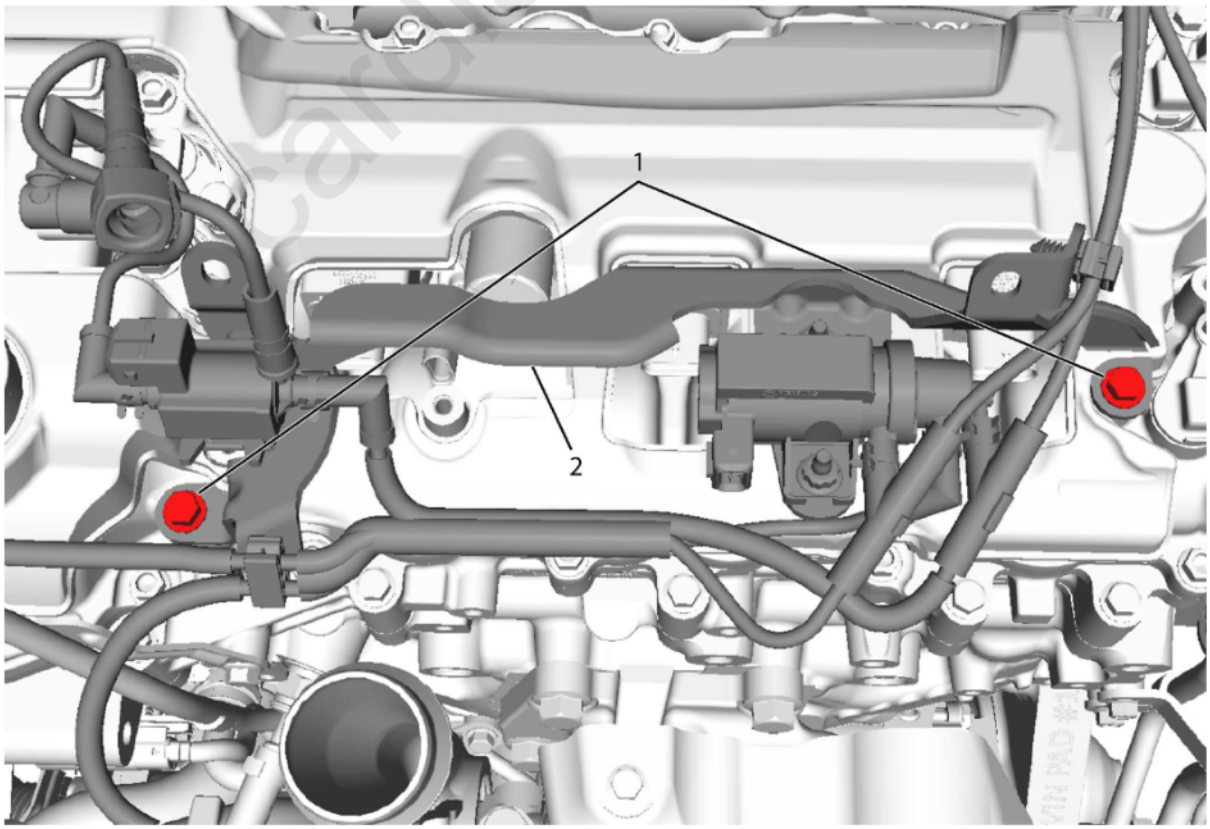


Fig. 163: Left Side Lower Turbocharger Wastegate Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Install the left side lower turbocharger wastegate bracket bolts (1) and tighten to 10 N.m (89 lb in) [2x]
5. Oil Filler Cap TubeÂ» Install
6. Charge Air Cooler CoverÂ» Install - **Charge Air Cooler Cover Replacement**

CAMSHAFT HOUSING COVER INSULATOR REPLACEMENT - RIGHT SIDE (LGX)

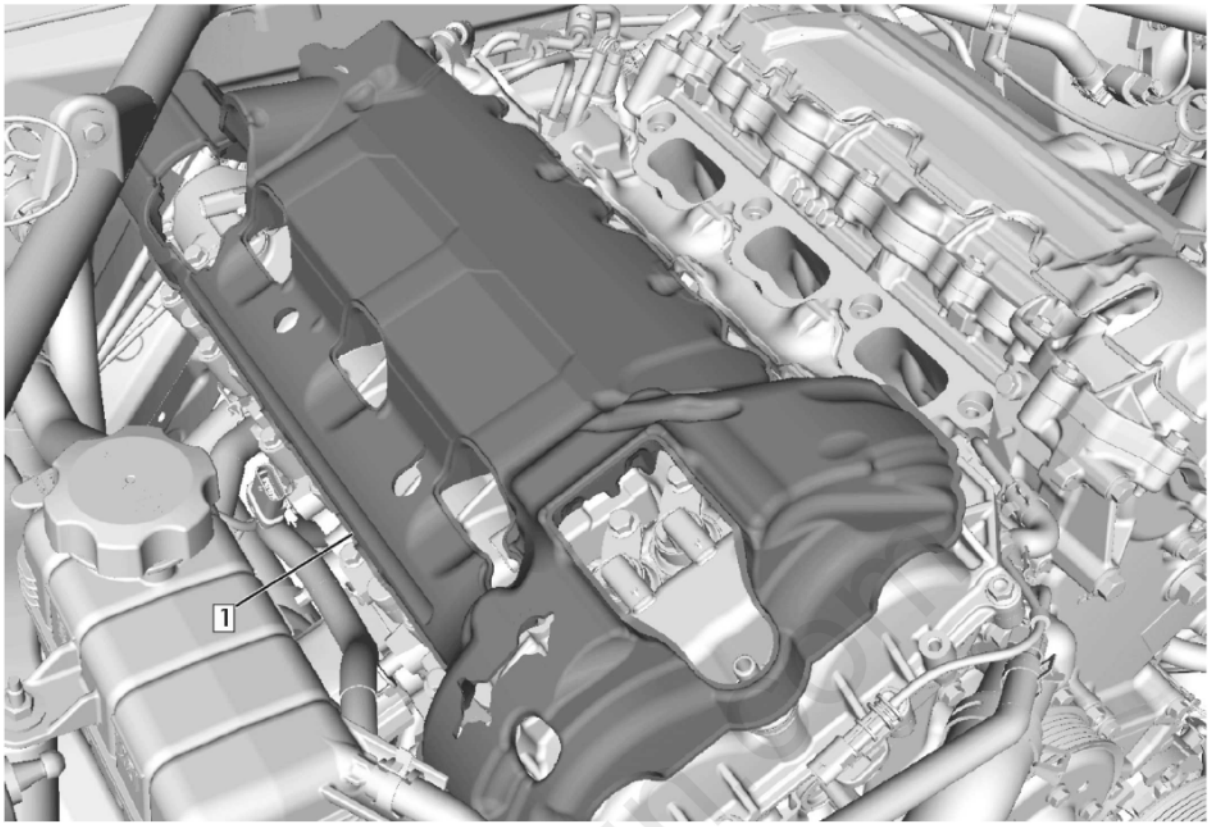


Fig. 164: Camshaft Housing Cover Insulator - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. **Intake Manifold Replacement (LGX)** 2. Disconnect electrical connectors and remove the engine harness from the camshaft housing cover insulator. 3. Positive Crankcase Ventilation Tube @ Camshaft CoverÂ» Disconnect - **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (LGX)**	
1	Camshaft Housing Cover Insulator **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.**

CAMSHAFT HOUSING COVER INSULATOR REPLACEMENT - RIGHT SIDE (LGW)

Removal Procedure

1. Charge Air Cooler CoverÂ» Remove - **Charge Air Cooler Cover Replacement**
2. Remove the right side lower turbocharger wastegate bracket bolts (1) [2x]

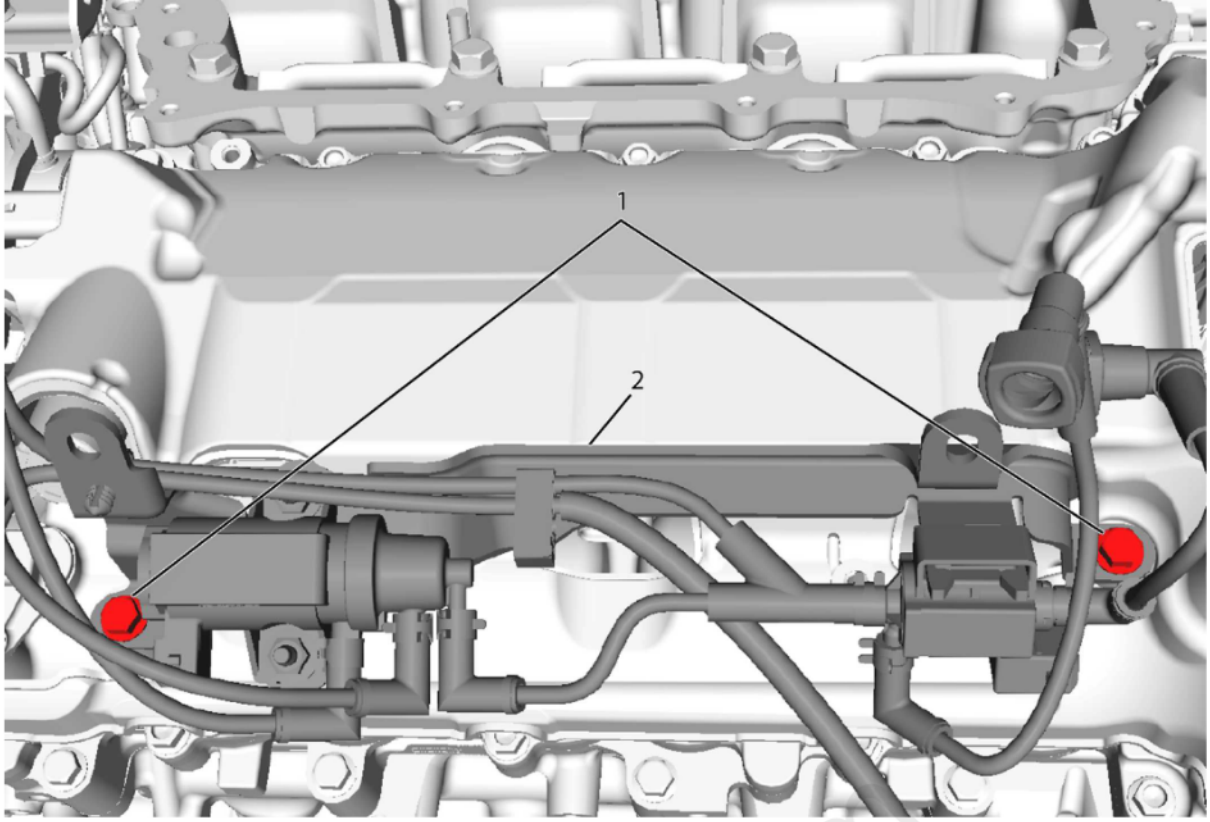


Fig. 165: Right Side Lower Turbocharger Wastegate Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Position the right side lower turbocharger wastegate bracket (2) aside.
4. Disconnect electrical connectors and remove the engine harness from the camshaft housing cover insulator.
5. Disconnect the PCV tube (1) from the PCV valve. Refer to **Plastic Collar Quick Connect Fitting Service**

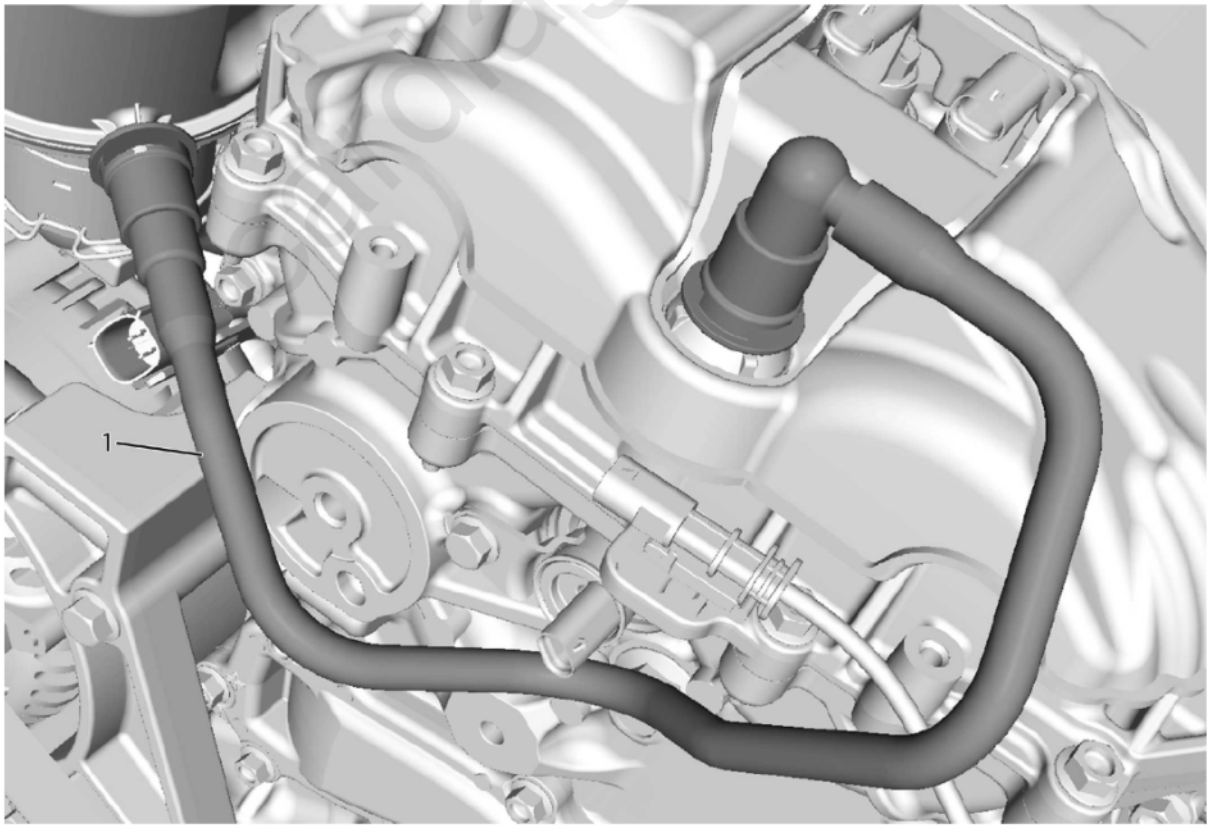


Fig. 166: PCV Tube
Courtesy of GENERAL MOTORS COMPANY

6. Camshaft Housing Cover InsulatorÂ» Remove

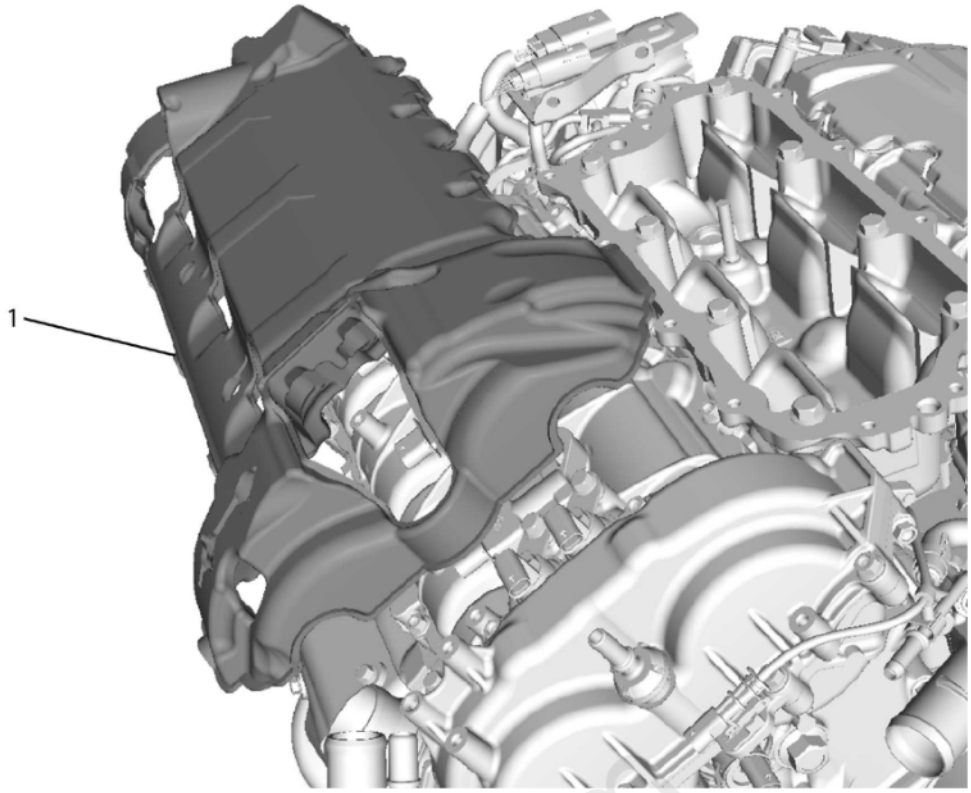


Fig. 167: Camshaft Housing Cover
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Replace the noise cancelling foam component if it is exposed to and absorbed automotive fluids.**

Installation Procedure

1. Camshaft Housing Cover InsulatorÂ» Install

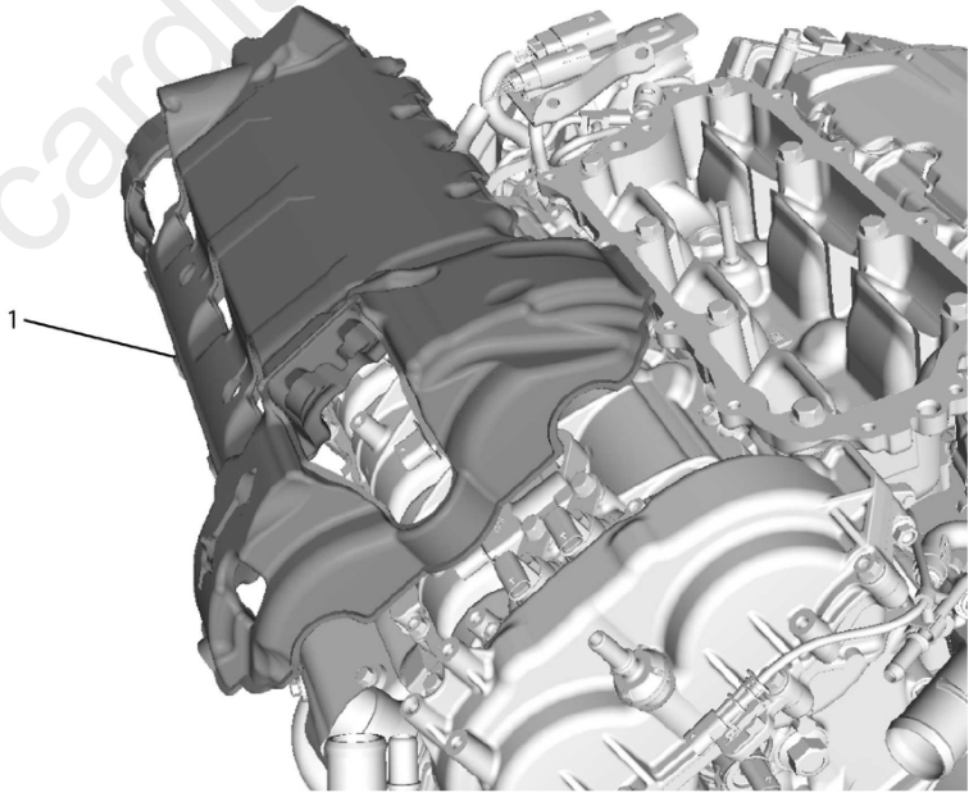


Fig. 168: Camshaft Housing Cover
Courtesy of GENERAL MOTORS COMPANY

2. Connect the PCV tube (1) to the PCV valve. Refer to **Plastic Collar Quick Connect Fitting Service**

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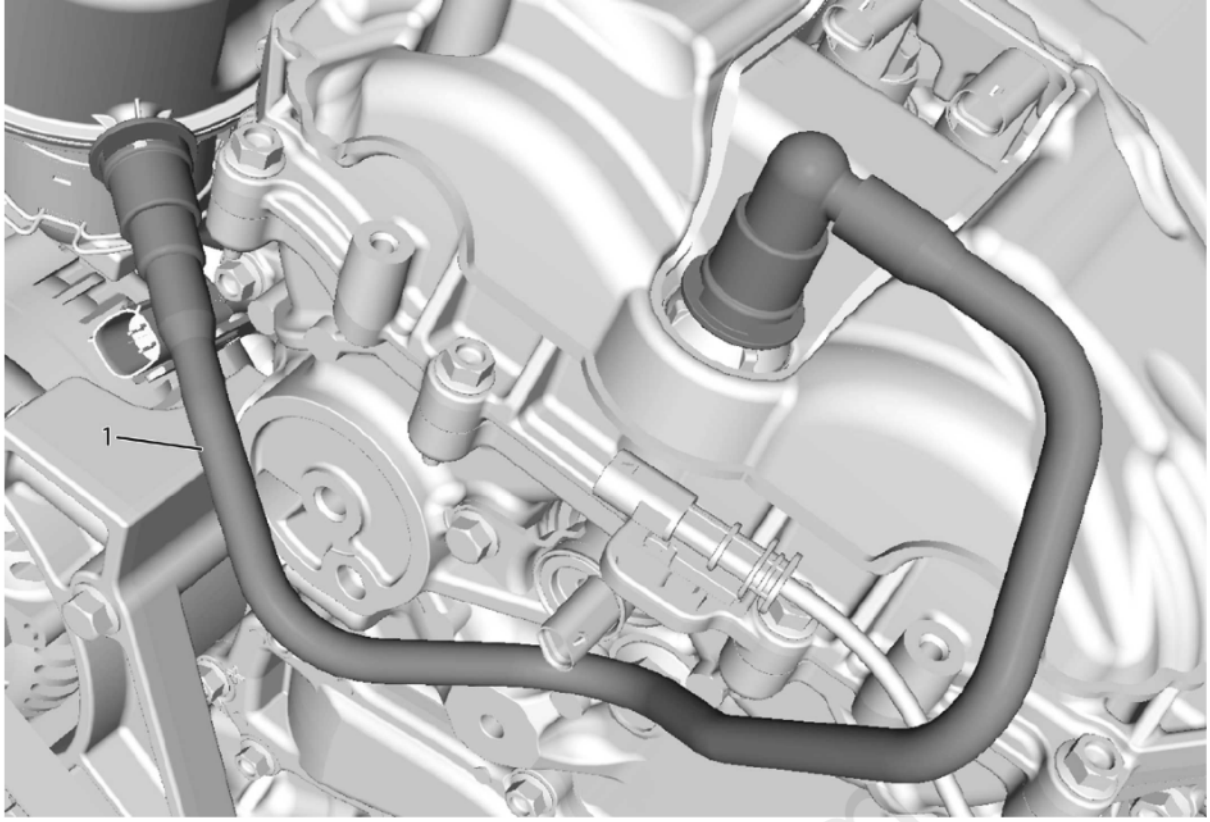


Fig. 169: PCV Tube
Courtesy of GENERAL MOTORS COMPANY

3. Install the engine harness to the camshaft housing cover insulator and connect the electrical connectors.
4. Position the right side lower turbocharger wastegate bracket (2) in place.

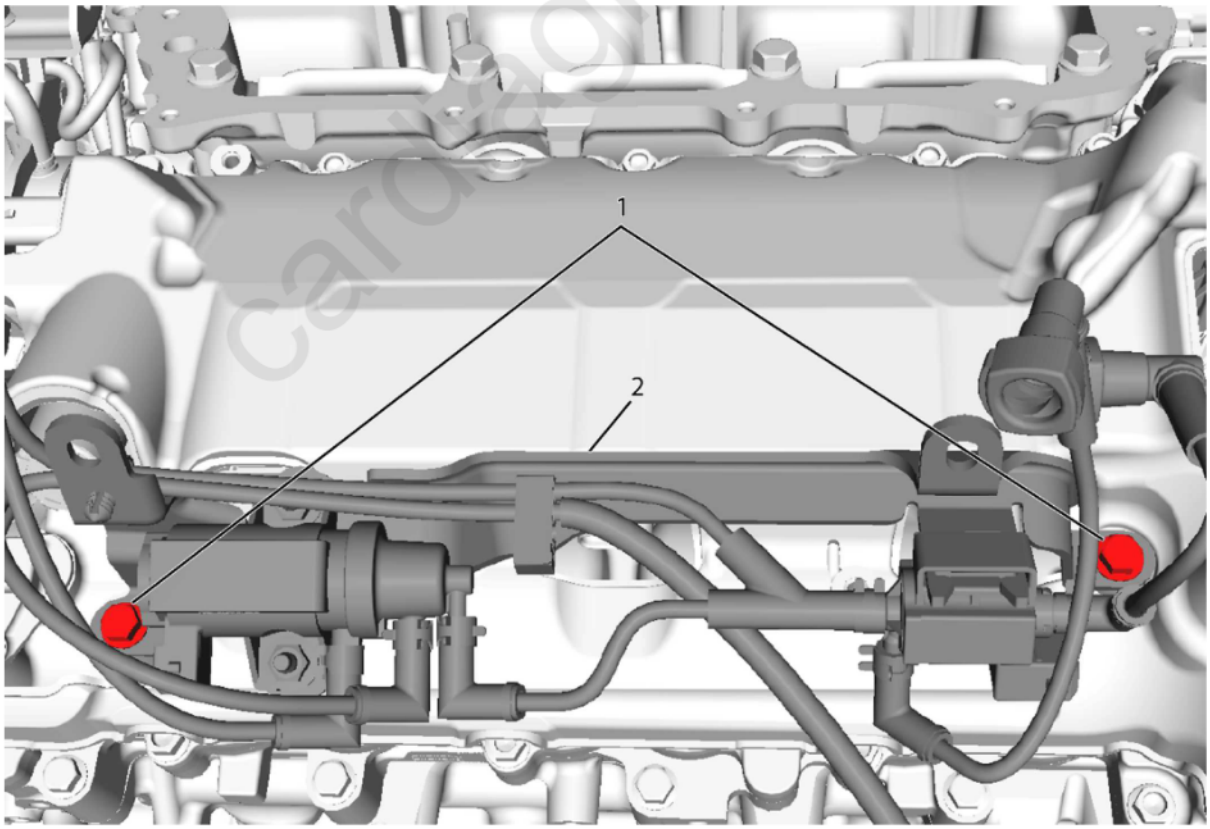


Fig. 170: Right Side Lower Turbocharger Wastegate Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Install the right side lower turbocharger wastegate bracket bolts (1) and tighten to 10 N.m (89 lb in) [2x]

CAUTION: **Refer to Fastener Caution .**

6. Charge Air Cooler CoverÂ» Install - **Charge Air Cooler Cover Replacement**

CAMSHAFT REPLACEMENT - LEFT SIDE

Removal Procedure

1. Camshaft Position Actuator [2x]Â» Remove - **Camshaft Position Actuator Replacement - Bank 2**
2. CamshaftÂ» Remove [2x] - **Camshaft Removal - Left Side**
3. CamshaftÂ» Clean and inspect - **Camshaft Cleaning and Inspection**

Installation Procedure

1. Camshaft [2x]Â» Install - **Camshaft Installation - Left Side**
2. Camshaft Position Actuator [2x]Â» Install - **Camshaft Position Actuator Replacement - Bank 2**

CAMSHAFT REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Camshaft Position Actuator [2x]Â» Remove - **Camshaft Position Actuator Replacement - Bank 1**
2. Camshaft [2x]Â» Remove - **Camshaft Removal - Right Side**
3. **Camshaft Cleaning and Inspection**

Installation Procedure

1. Camshaft [2x]Â» Install - **Camshaft Installation - Right Side**
2. Camshaft Position Actuator [2x]Â» Install - **Camshaft Position Actuator Replacement - Bank 1**

VALVE ROCKER ARM REPLACEMENT - LEFT SIDE

Removal Procedure

1. **Camshaft Replacement - Left Side**Â» Remove
2. Valve Rocker Switching Arm (1) [4x]Â» Remove

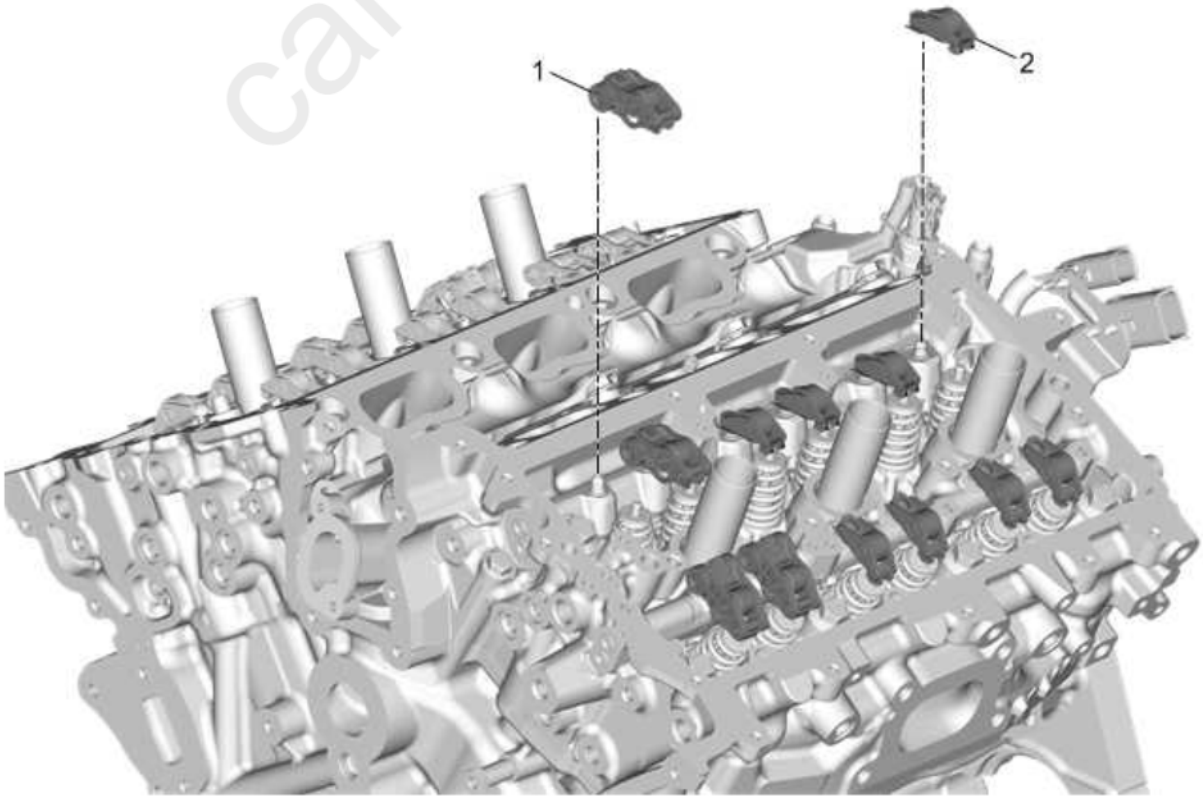


Fig. 171: Valve Rocker Arm - Left Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

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NOTE: **If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.**

3. Valve Rocker Arm (2) [8x]Â» Remove

NOTE: **If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.**

4. CamshaftÂ» Clean and inspect - **Camshaft Cleaning and Inspection**
5. Valve Rocker ArmÂ» Clean and inspect - **Valve Rocker Arm Cleaning and Inspection**
6. Valve LifterÂ» Clean and inspect - **Valve Lifter Cleaning and Inspection**

Installation Procedure

1. **Valve Rocker Arm Installation - Left Side** Â» Install

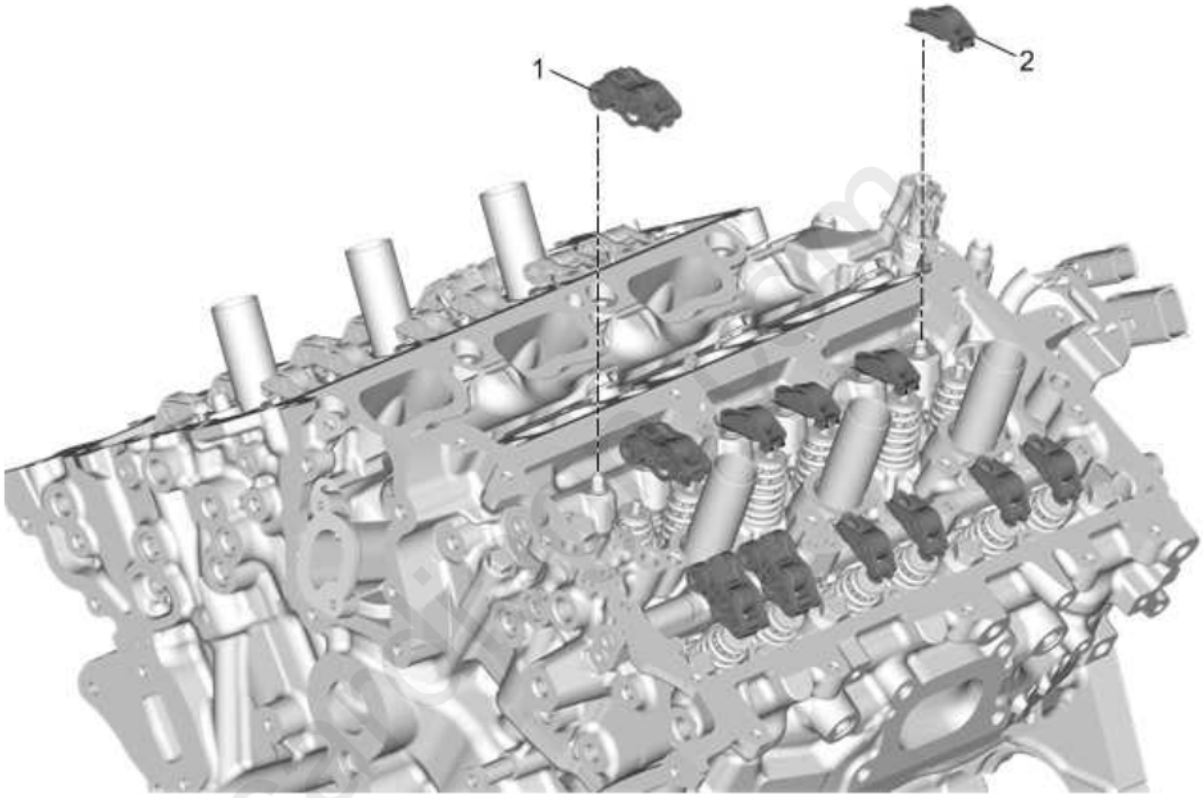


Fig. 172: Valve Rocker Arm - Left Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

2. **Camshaft Replacement - Left Side**Â» Install

VALVE ROCKER ARM REPLACEMENT - RIGHT SIDE

Removal Procedure

1. **Camshaft Replacement - Right Side**Â» Remove
2. Valve Rocker Switching Arm (1) [4x]Â» Remove

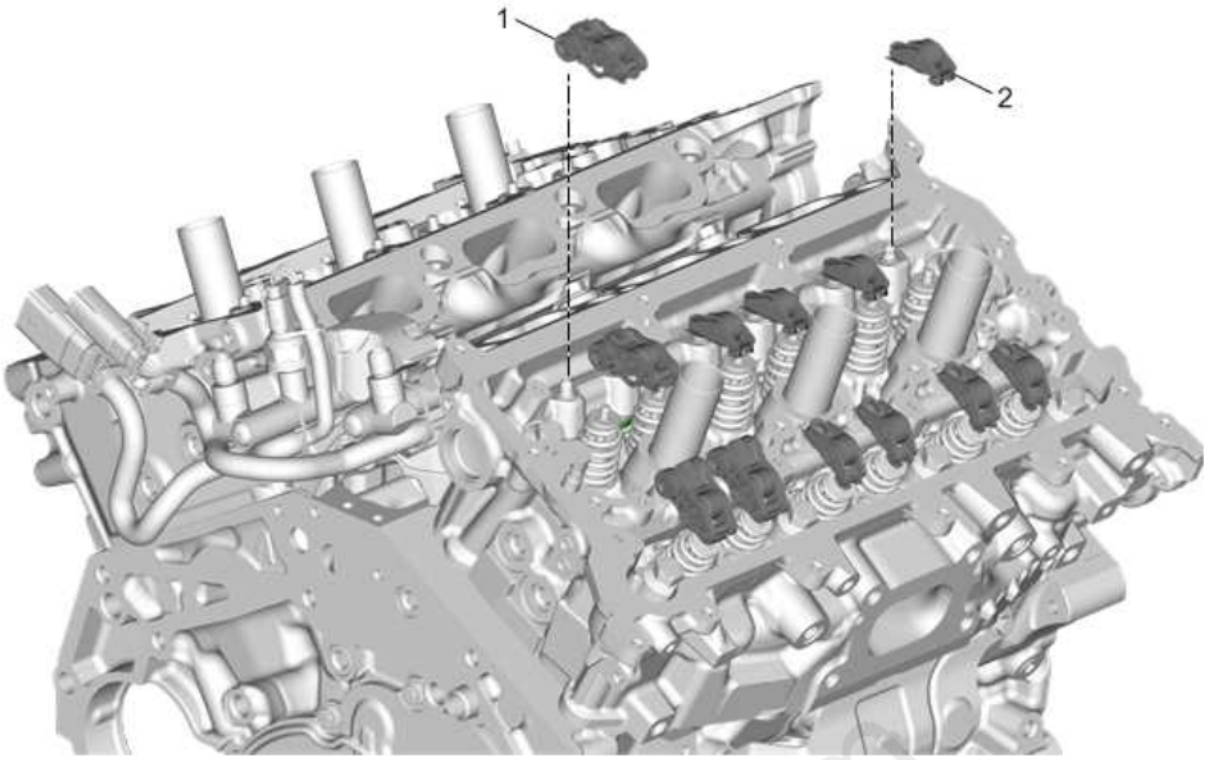


Fig. 173: Valve Rocker Arm - Right Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.**

3. Valve Rocker Arm (2) [8x]Â» Remove

NOTE: **If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.**

4. CamshaftÂ» Clean and inspect - **Camshaft Cleaning and Inspection**
5. Valve Rocker ArmÂ» Clean and inspect - **Valve Rocker Arm Cleaning and Inspection**
6. Valve LifterÂ» Clean and inspect - **Valve Lifter Cleaning and Inspection**

Installation Procedure

1. **Valve Rocker Arm Installation - Right Side** Â» Install

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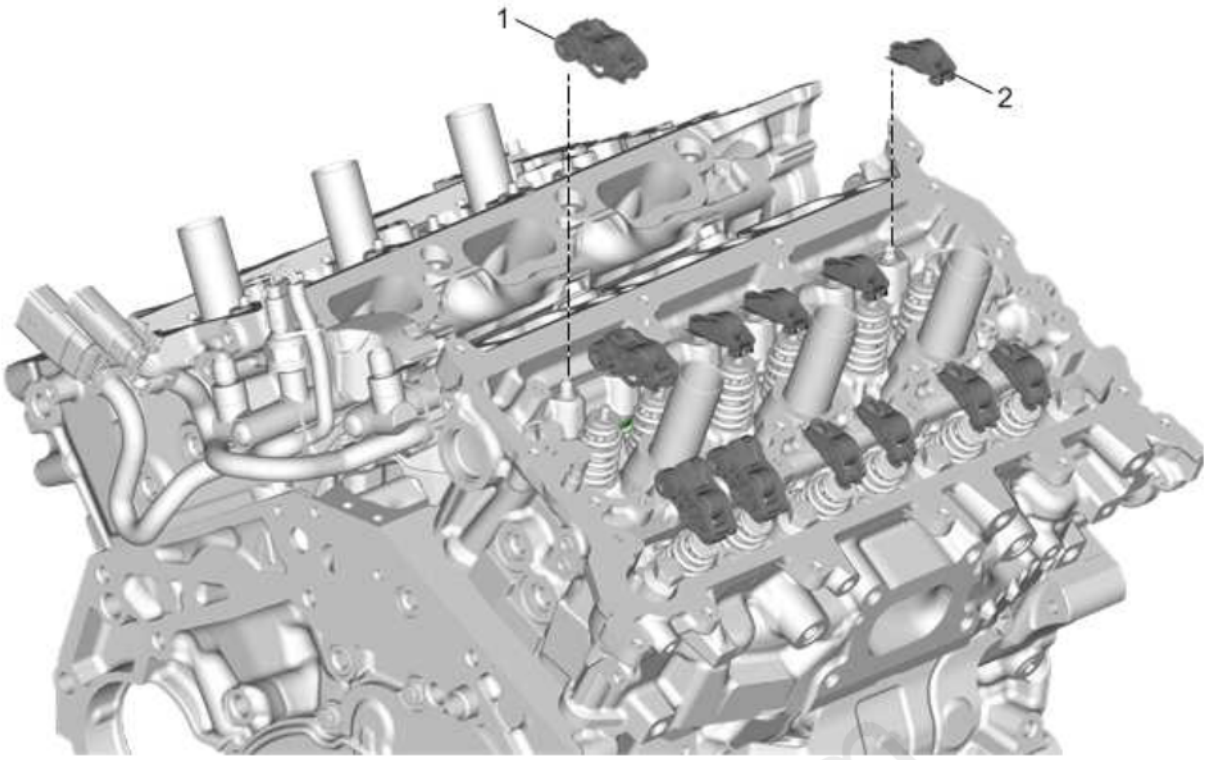


Fig. 174: Valve Rocker Arm - Right Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

2. Camshaft Replacement - Right SideÂ» Install

VALVE LIFTER REPLACEMENT - LEFT SIDE

Removal Procedure

1. Camshaft Replacement - Right SideÂ» Remove
2. Valve Rocker Switching Arm (1) [4x]Â» Remove

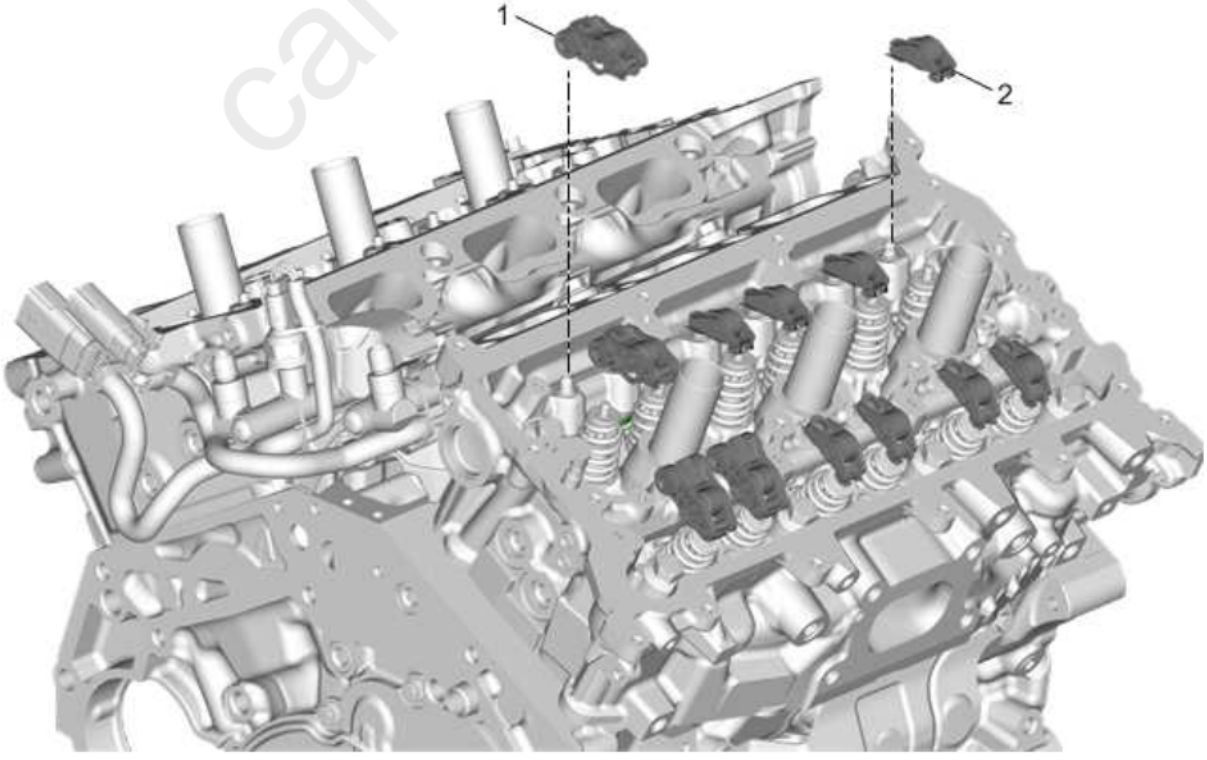


Fig. 175: Valve Rocker Arm - Right Side
Courtesy of GENERAL MOTORS COMPANY

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3. Valve Rocker Arm (2) [8x]Â» Remove
4. Dual Feed Hydraulic Valve Adjustor (1) [4x]Â» Remove

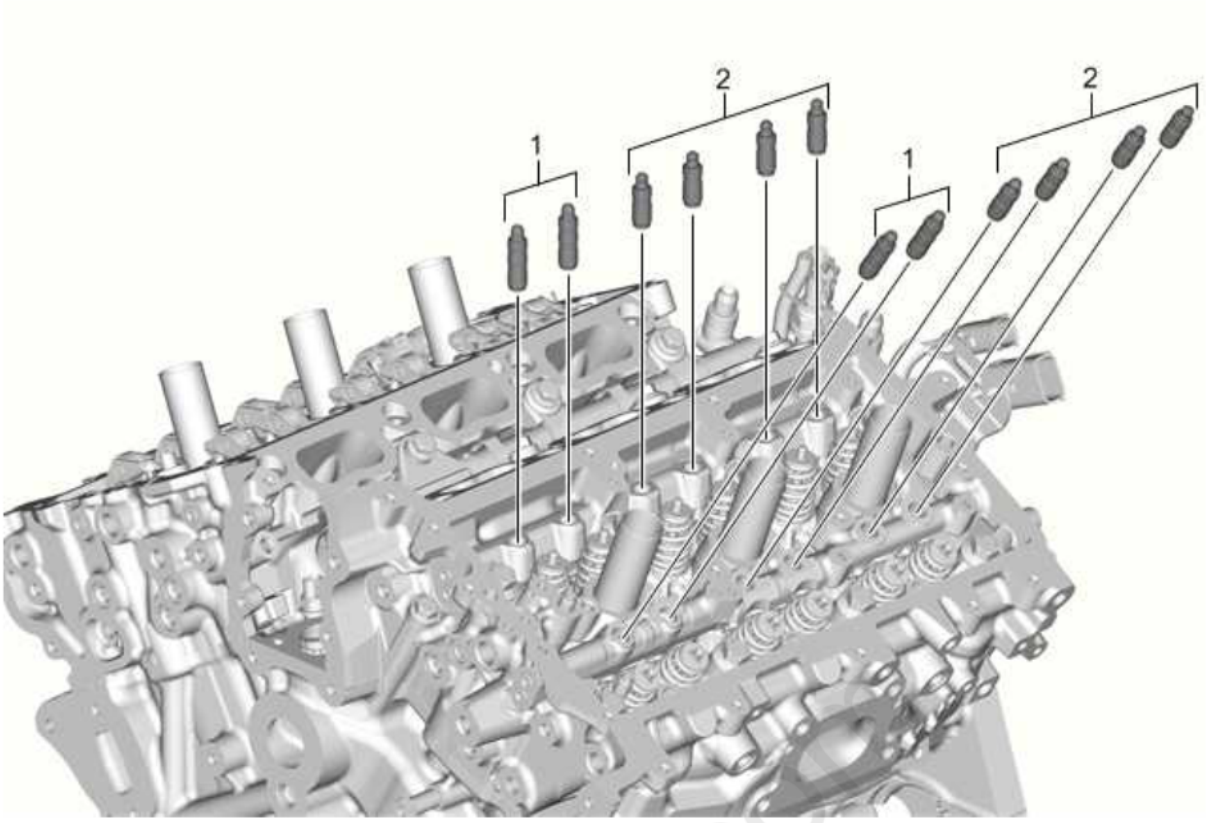


Fig. 176: Valve Lifter - Left Side
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the lifters are to be reused, keep in order so they can be reinstalled in the same position.**

5. Hydraulic Valve Lash Adjuster (2) [8x]Â» Remove

NOTE: **If the lifters are to be reused, keep in order so they can be reinstalled in the same position.**

6. CamshaftÂ» Clean and inspect - **Camshaft Cleaning and Inspection**
7. Valve Rocker ArmÂ» Clean and inspect - **Valve Rocker Arm Cleaning and Inspection**
8. Valve LifterÂ» Clean and inspect - **Valve Lifter Cleaning and Inspection**

Installation Procedure

1. **Valve Lifter Installation - Left Side** Â» Install

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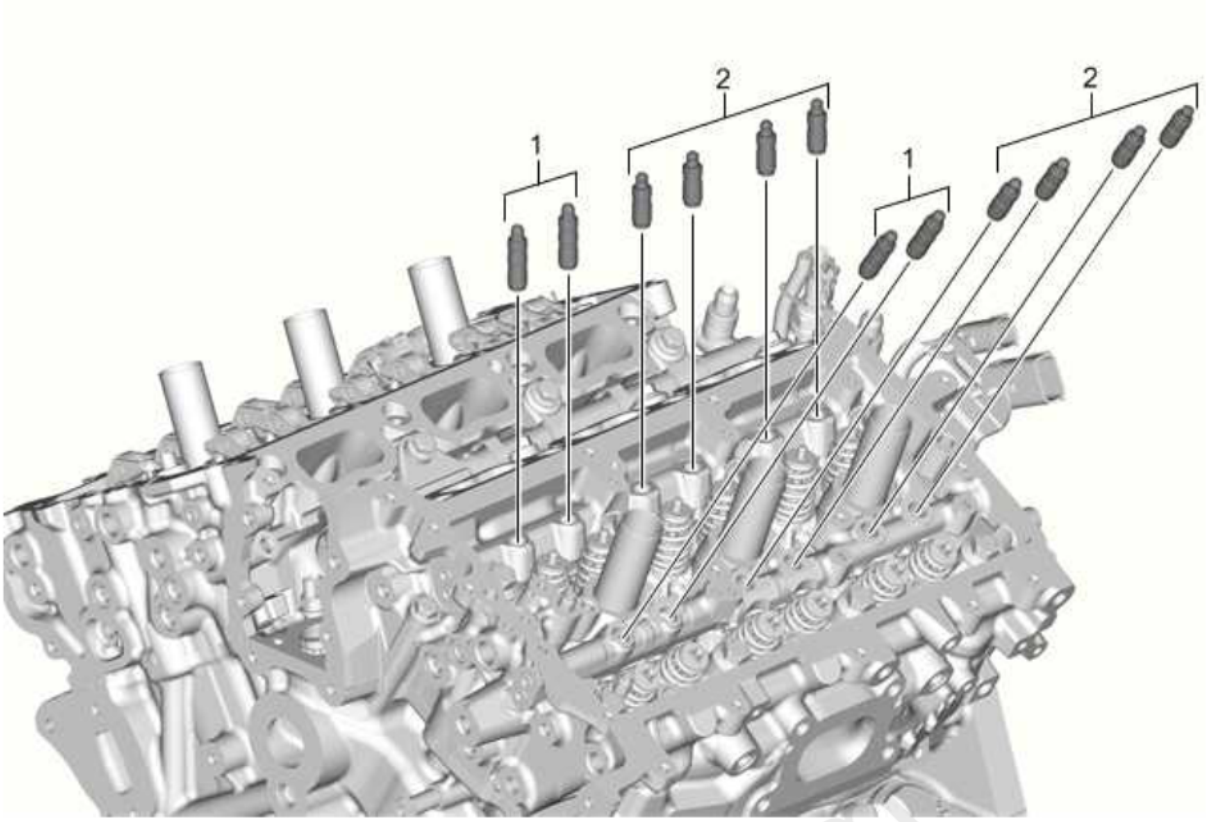


Fig. 177: Valve Lifter - Left Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

2. Valve Rocker Arm Installation - Right Side Â» Install

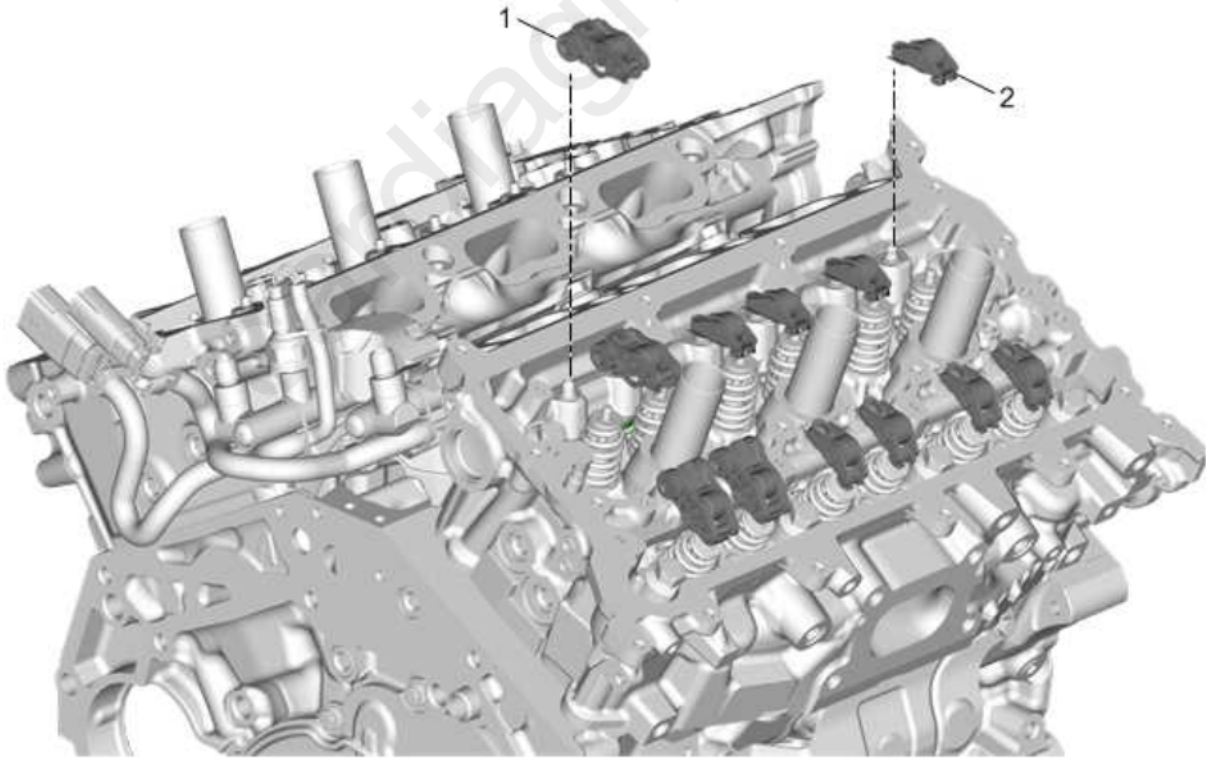


Fig. 178: Valve Rocker Arm - Right Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

3. Camshaft Replacement - Right SideÂ» Install

VALVE LIFTER REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Camshaft Replacement - Right SideÂ» Remove

2. Valve Rocker Switching Arm (1) [4x]Â» Remove

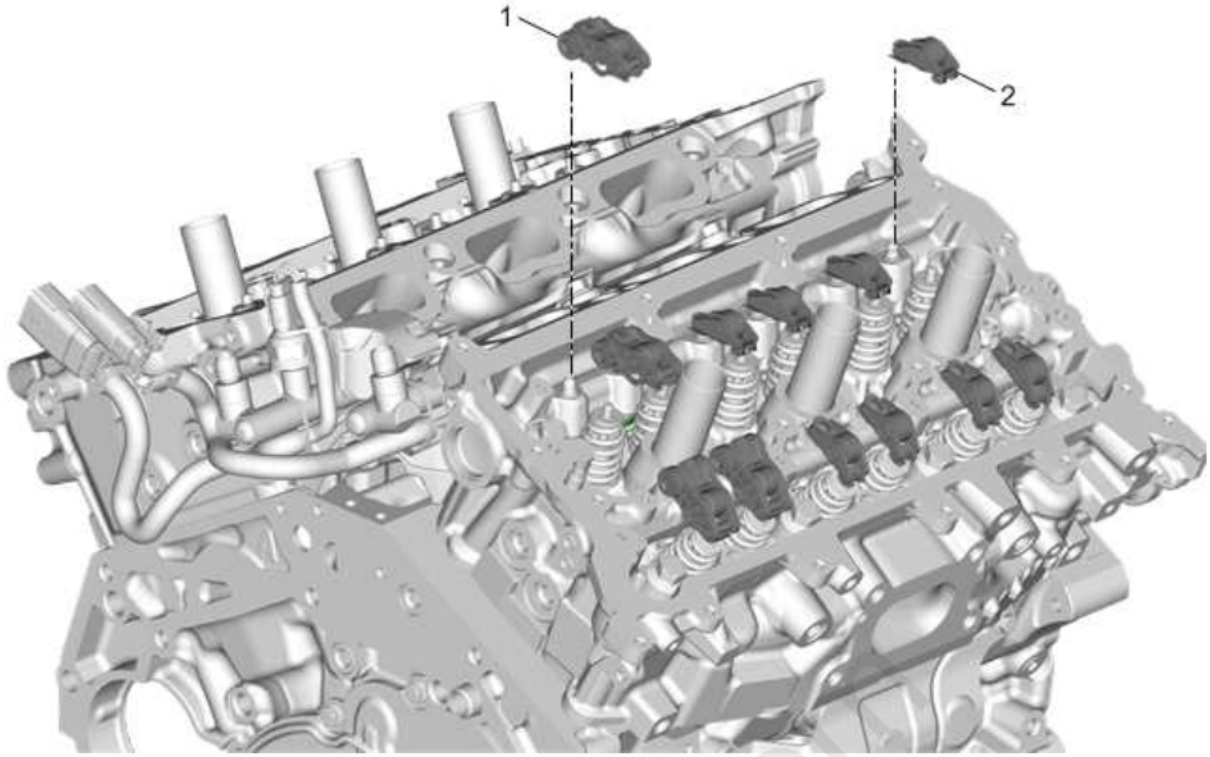


Fig. 179: Valve Rocker Arm - Right Side (LGX)
Courtesy of GENERAL MOTORS COMPANY

3. Valve Rocker Arm (2) [8x]Â» Remove
4. Dual Feed Hydraulic Valve Adjustor (1) [4x]Â» Remove

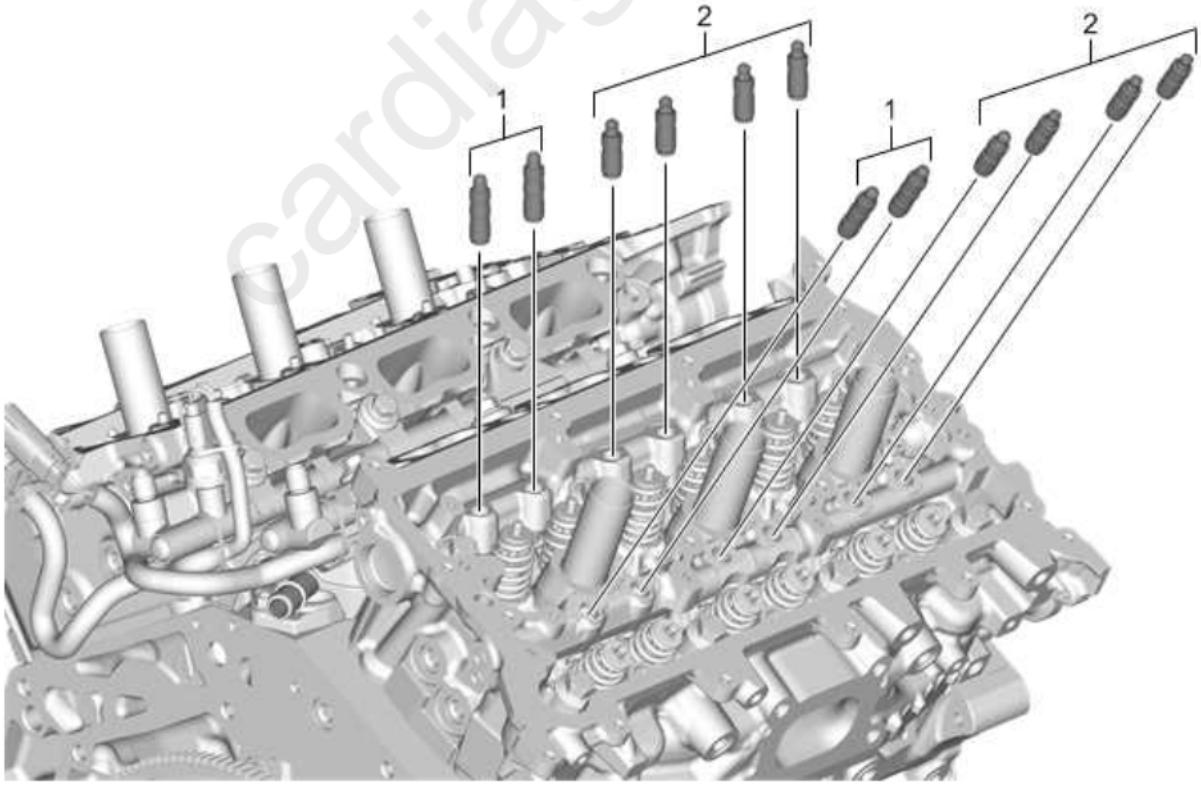


Fig. 180: Valve Lifter Removal - Right Side
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the lifters are to be reused, keep in order so they can be reinstalled in the same position.**

5. Hydraulic Valve Lash Adjuster (2) [8x]Â» Remove

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NOTE: **If the lifters are to be reused, keep in order so they can be reinstalled in the same position.**

6. CamshaftÂ» Clean and inspect - **Camshaft Cleaning and Inspection**
7. Valve Rocker ArmÂ» Clean and inspect - **Valve Rocker Arm Cleaning and Inspection**
8. Valve LifterÂ» Clean and inspect - **Valve Lifter Cleaning and Inspection**

Installation Procedure

1. **Valve Lifter Installation - Right Side** Â» Install

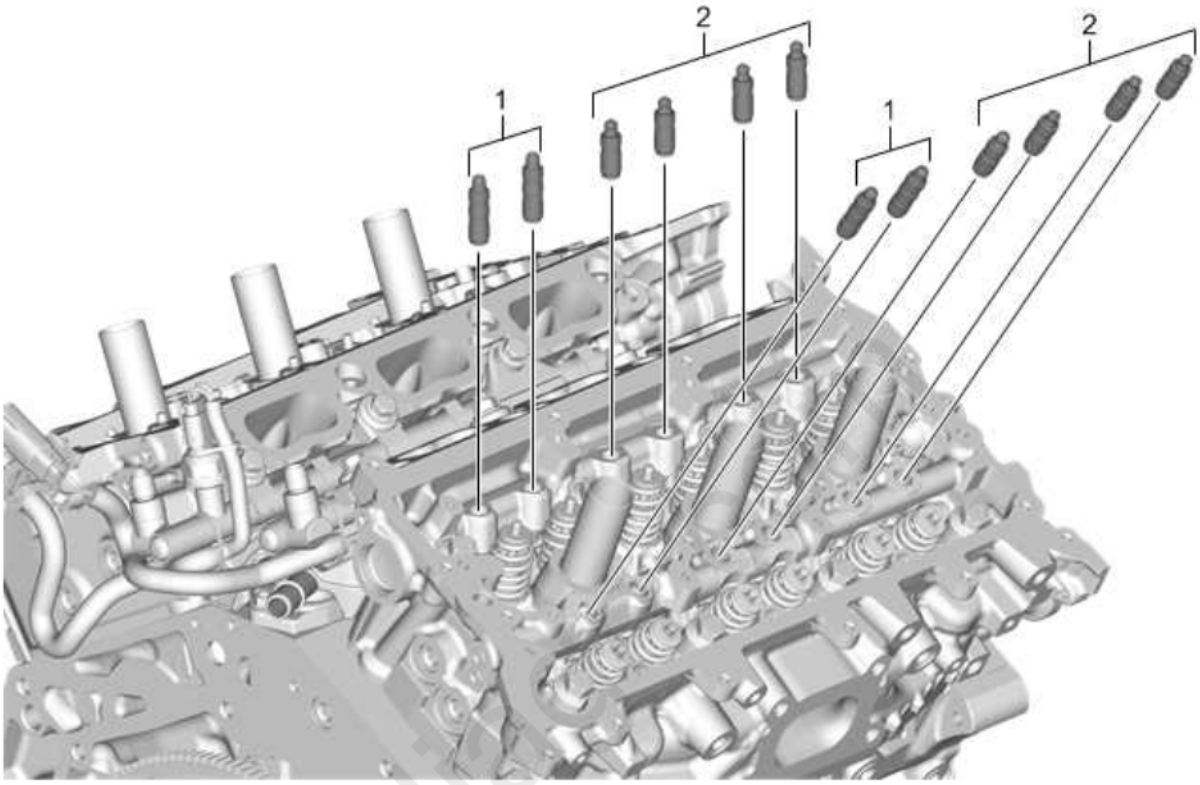


Fig. 181: Valve Lifter Removal - Right Side
Courtesy of GENERAL MOTORS COMPANY

2. **Valve Rocker Arm Installation - Right Side** Â» Install

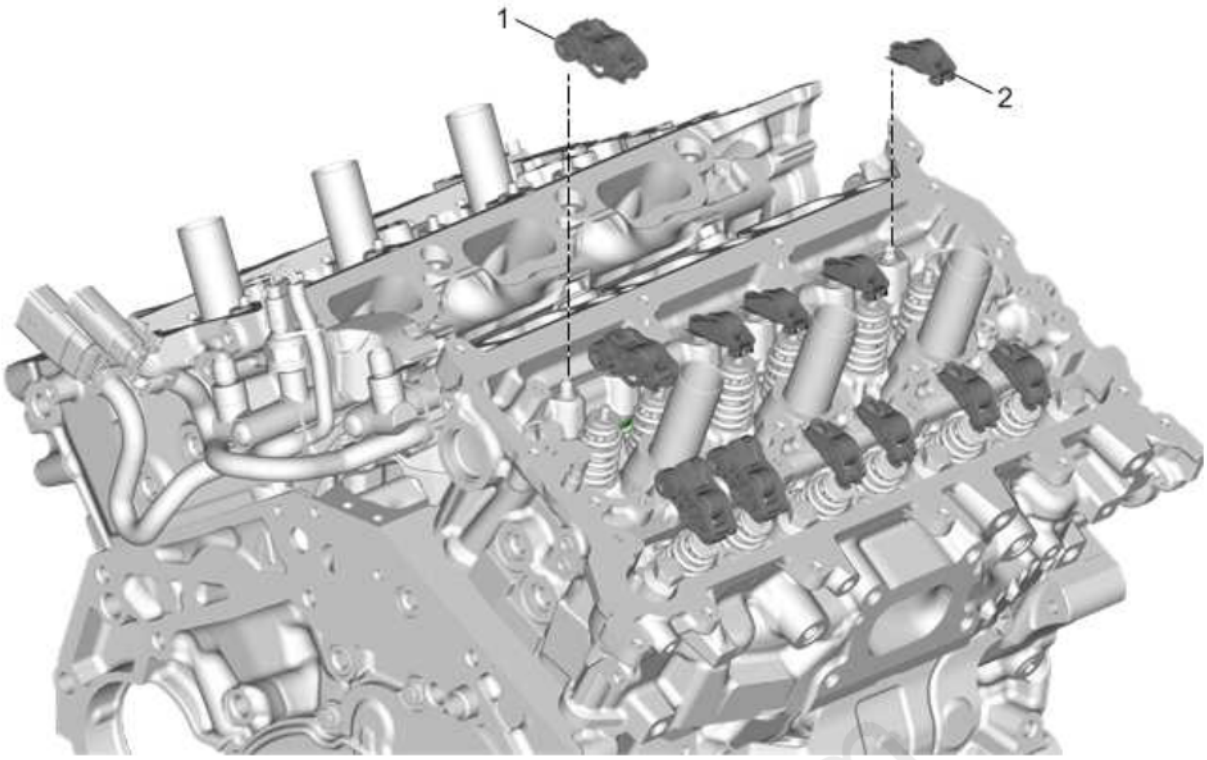


Fig. 182: Valve Rocker Arm - Right Side
Courtesy of GENERAL MOTORS COMPANY

3. **Camshaft Replacement - Right Side**Â» Install

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT - LEFT SIDE

Special Tools

- **EN-39313** Spark Plug Port Adapter
- **EN-46106** Flywheel Holding Tool
- **EN-46335-A** On-Vehicle Valve Spring Compressor
- **EN-46116** Valve Stem Seal Remover/Installer

Equivalent regional tools:**Special Tools** .

Removal Procedure

1. Remove the valve rocker arms. Refer to **Valve Rocker Arm Replacement - Left Side**
2. **Camshaft Carrier Removal - Left Side** Â» Remove
3. Remove the starter. Refer to **Starter Replacement (LGW)** and/or **Starter Replacement (LGX)** .
4. Install the **EN-46106** tool (1) in order to prevent crankshaft rotation.

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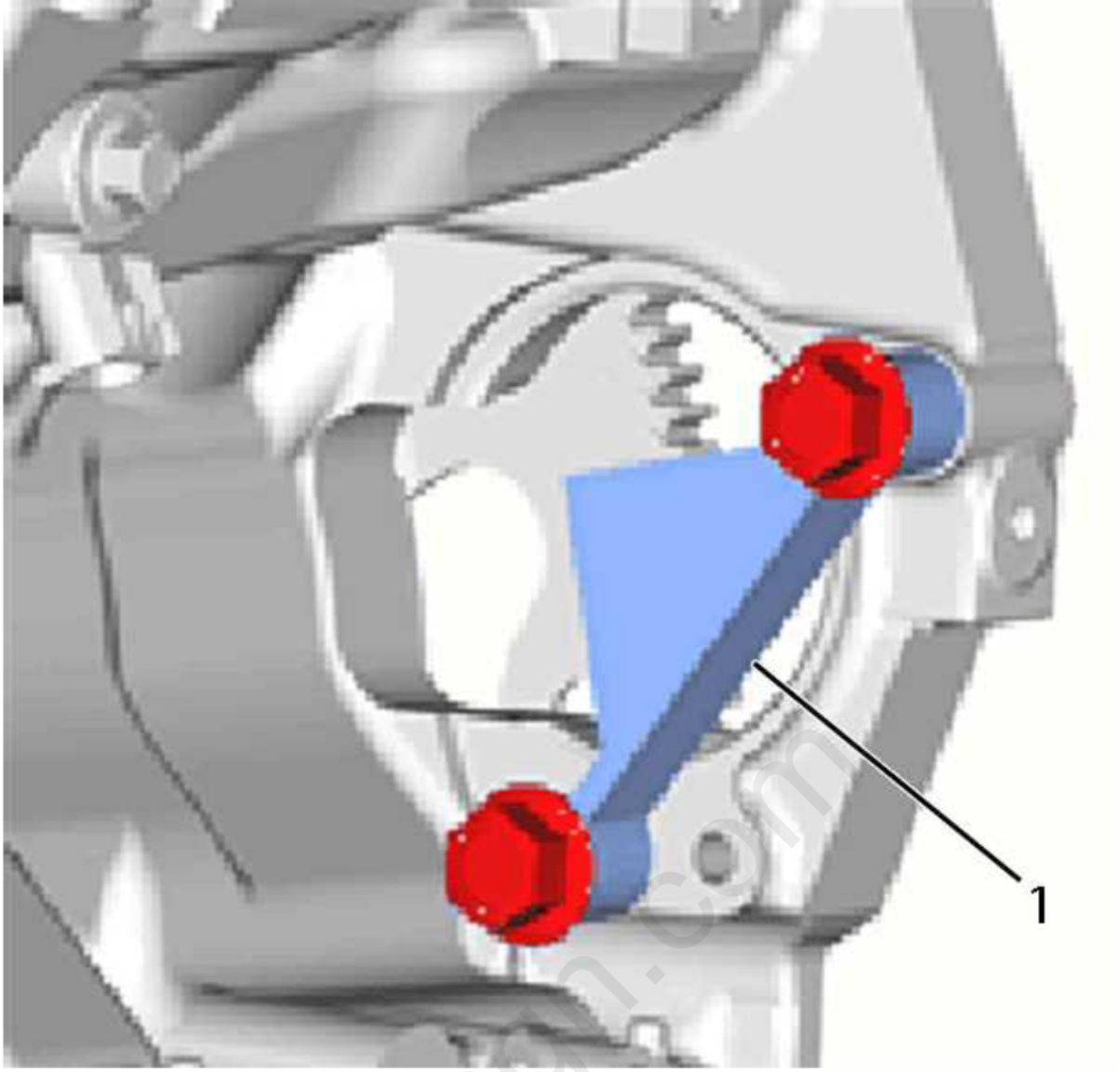


Fig. 183: Flywheel Holder
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the EN-46106 tool is not installed, the crankshaft may rotate. If the crankshaft rotates, disassembly and reassembly of the entire camshaft timing system may be required.**

5. Remove the spark plug from the applicable cylinder. Refer to **Spark Plug Replacement (Bank 1)** and/or **Spark Plug Replacement (Bank 2)**
6. Install the **EN-39313** adapter to the applicable cylinder.
7. Connect the **EN-39313** adapter to a compressed air source.
8. Install the **EN-46335-A** compressor (1) above the applicable cylinder as shown.

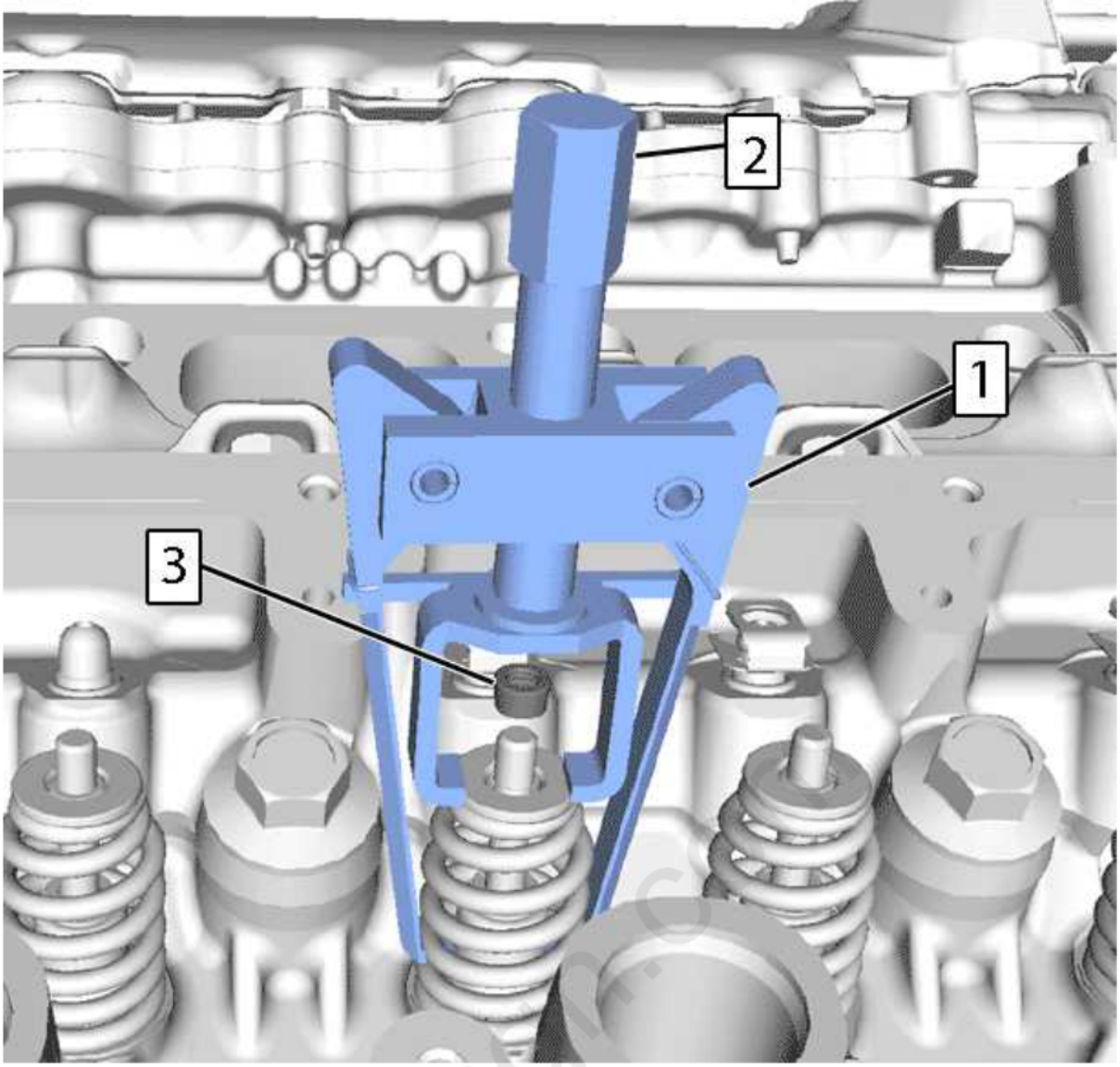


Fig. 184: Valve Spring Compressor
Courtesy of GENERAL MOTORS COMPANY

9. Tighten the **EN-46335-A** compressor bolt (2).
10. Remove the valve keepers (3).
11. Loosen the **EN-46335-A** compressor bolt and remove the compressor.
12. Valve Spring Retainer (1)Â» Remove

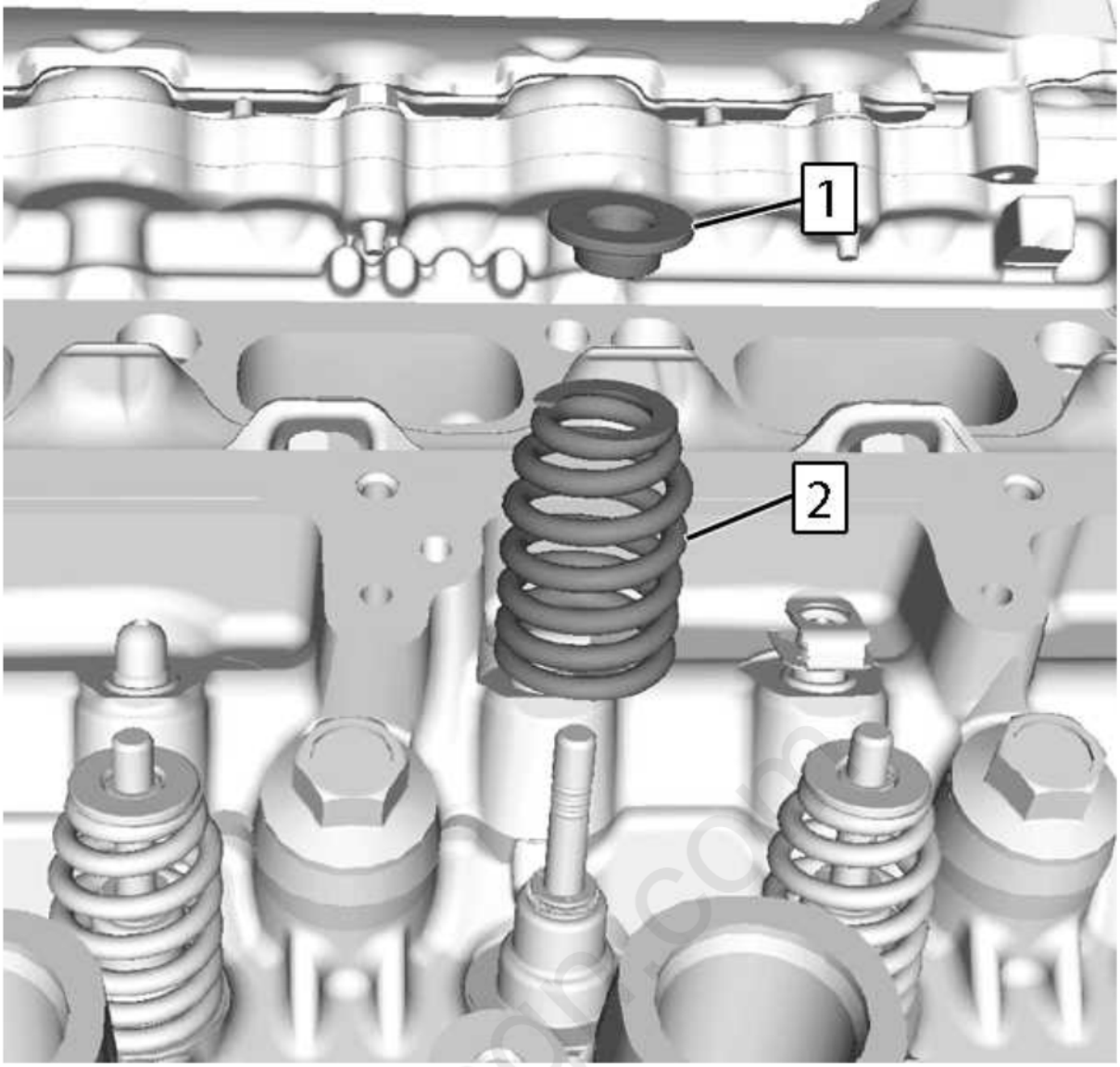


Fig. 185: Valve Spring And Retainer
Courtesy of GENERAL MOTORS COMPANY

13. Valve Spring (2)Â» Remove
14. Use the **EN-46116** remover/installer (1) in order to remove the valve stem seal (2).

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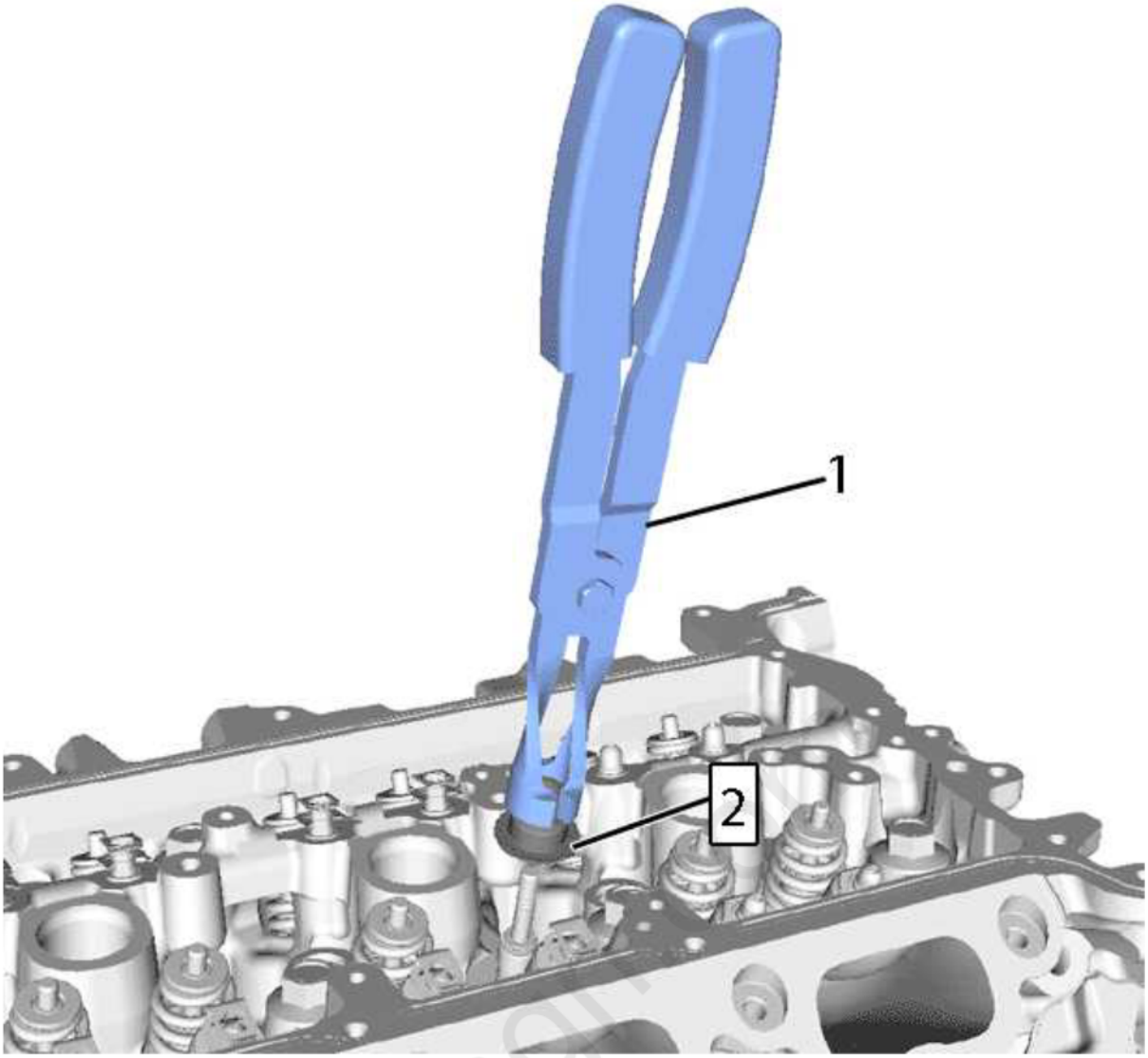


Fig. 186: Valve Stem Seal Remover/Installer
Courtesy of GENERAL MOTORS COMPANY

Installation Procedure

1. Use the **EN-46116** remover/installer (1) in order to install the valve stem seal (2).

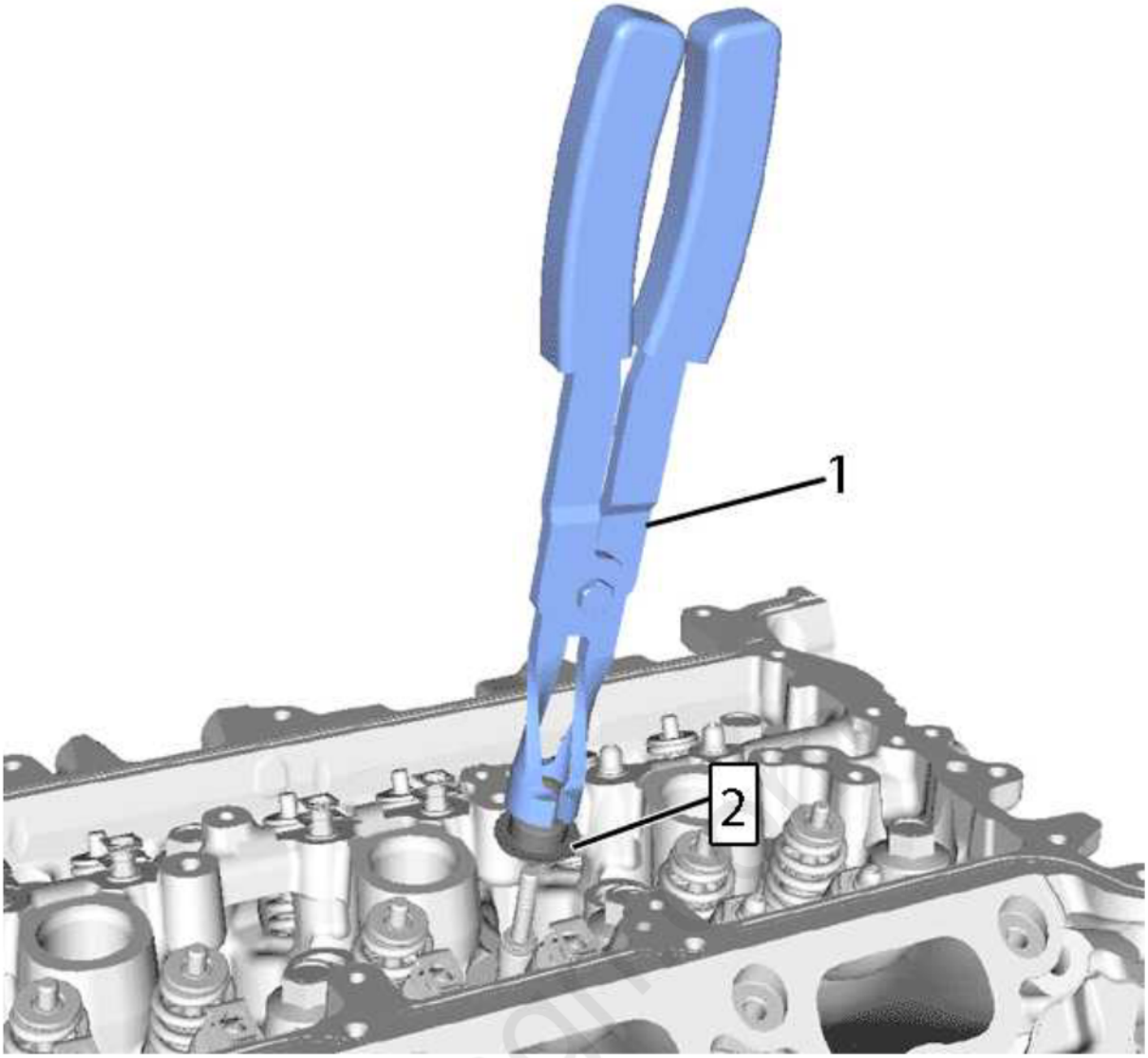


Fig. 187: Valve Stem Seal Remover/Installer
Courtesy of GENERAL MOTORS COMPANY

2. Valve Spring (2)Â» Install

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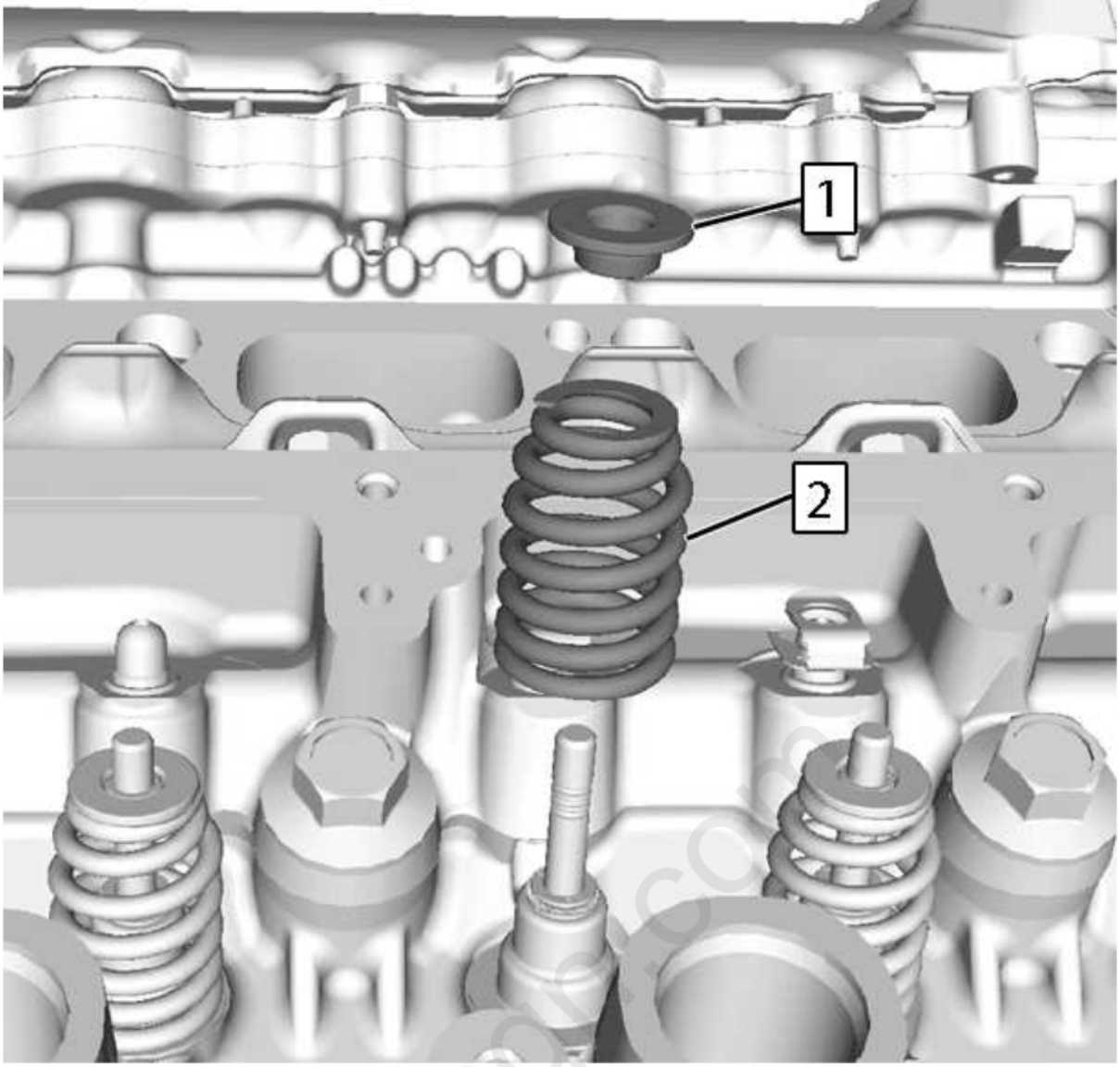


Fig. 188: Valve Spring And Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Valve Spring Retainer (1)Â» Install
4. Install the **EN-46335-A** compressor (1) above the applicable cylinder as shown.

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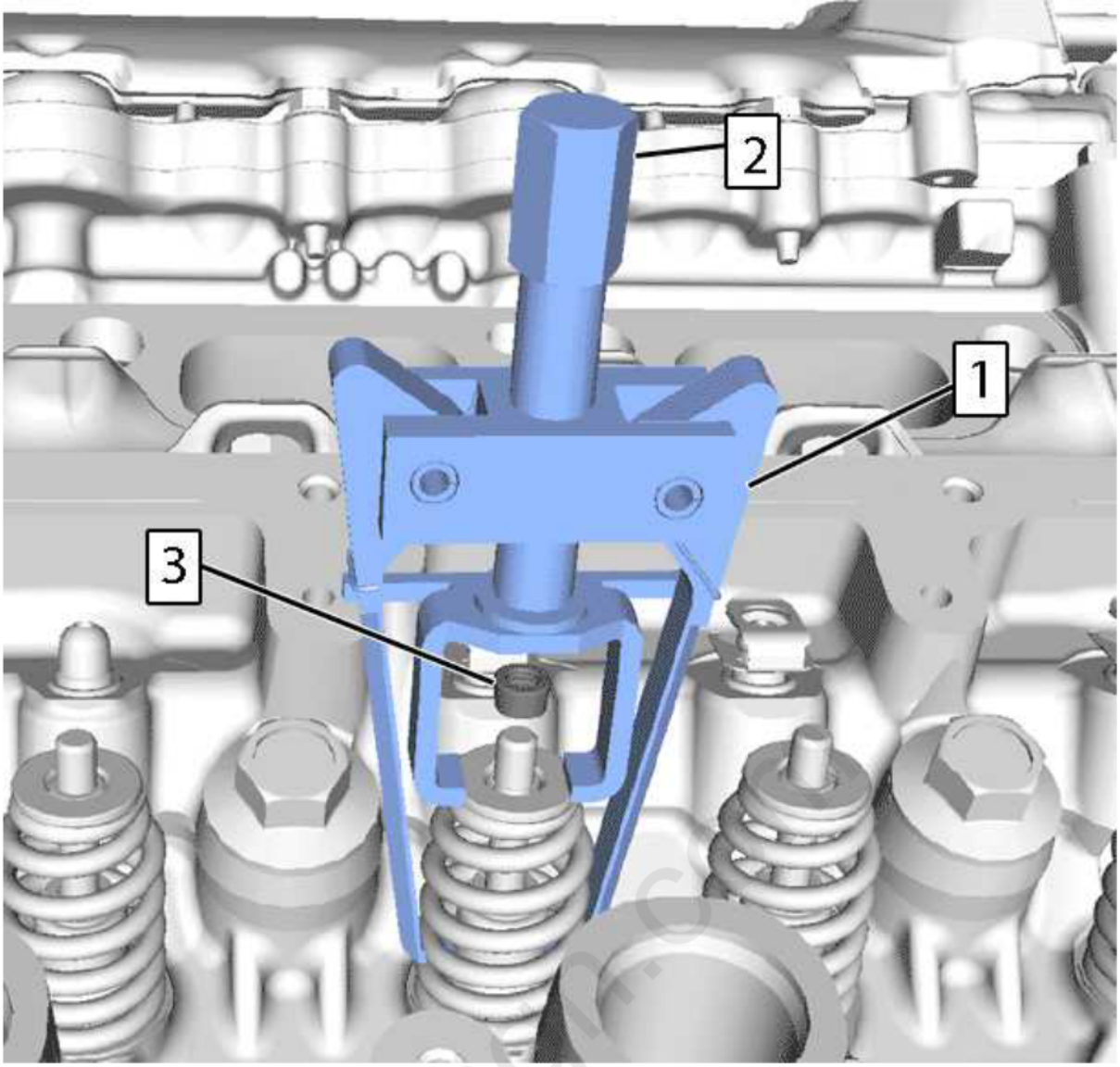


Fig. 189: Valve Spring Compressor
Courtesy of GENERAL MOTORS COMPANY

5. Tighten the **EN-46335-A** compressor bolt (2).
6. Install the valve spring keepers (3).
7. **EN-46335-A** compressorÂ» Remove
8. Disconnect the **EN-39313** adapter from the compressed air source.
9. **EN-39313** adapterÂ» Remove
10. Spark PlugÂ» Install - **Spark Plug Replacement (Bank 1)** **Spark Plug Replacement (Bank 2)**
11. Install the rocker arms. Refer to **Valve Rocker Arm Replacement - Left Side**
12. **EN-46106** tool (1)Â» Remove

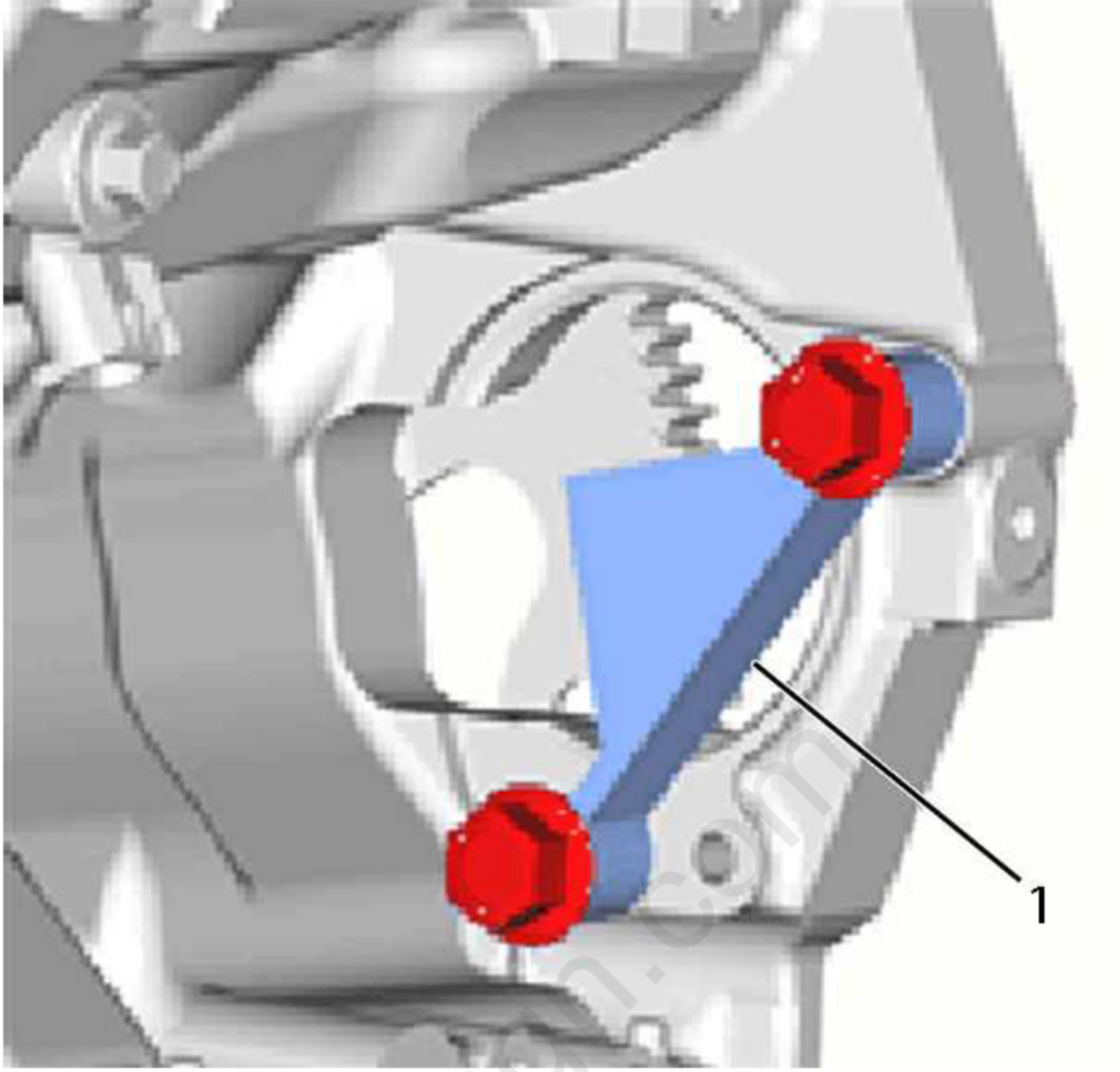


Fig. 190: Flywheel Holder
Courtesy of GENERAL MOTORS COMPANY

13. Camshaft Carrier Installation - Left Side Â» Install
14. Install the starter. Refer to Starter Replacement (LGW) and/or Starter Replacement (LGX) .

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT - RIGHT SIDE

Special Tools

- **EN-39313** Spark Plug Port Adapter
- **EN-46106** Flywheel Holding Tool
- **EN-46335-A** On-Vehicle Valve Spring Compressor
- **EN-46116** Valve Stem Seal Remover/Installer

Equivalent regional tools: Special Tools .

Removal Procedure

1. Remove the valve rocker arms. Refer to Valve Rocker Arm Replacement - Right Side
2. Camshaft Carrier Removal - Right Side Â» Remove
3. Remove the starter. Refer to Starter Replacement (LGW) and/or Starter Replacement (LGX) .
4. Install the **EN-46106** tool (1) in order to prevent crankshaft rotation.

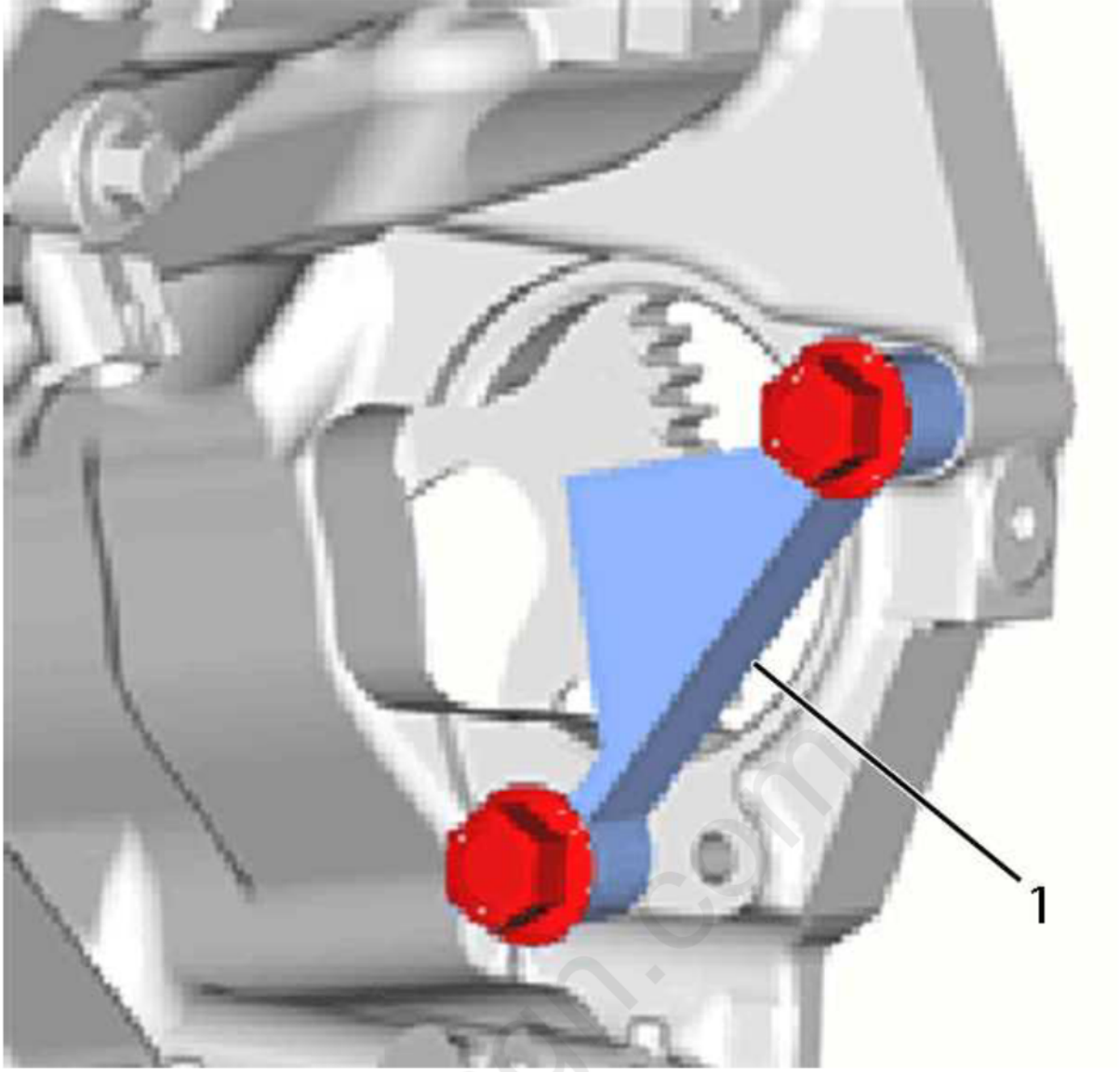


Fig. 191: Flywheel Holder
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the EN-46106 tool is not installed, the crankshaft may rotate. If the crankshaft rotates, disassembly and reassembly of the entire camshaft timing system may be required.**

5. Remove the spark plug from the applicable cylinder. Refer to **Spark Plug Replacement (Bank 1)** and/or **Spark Plug Replacement (Bank 2)**
6. Install the **EN-39313** adapter to the applicable cylinder.
7. Connect the **EN-39313** adapter to a compressed air source.
8. Install the **EN-46335-A** compressor (1) above the applicable cylinder as shown.

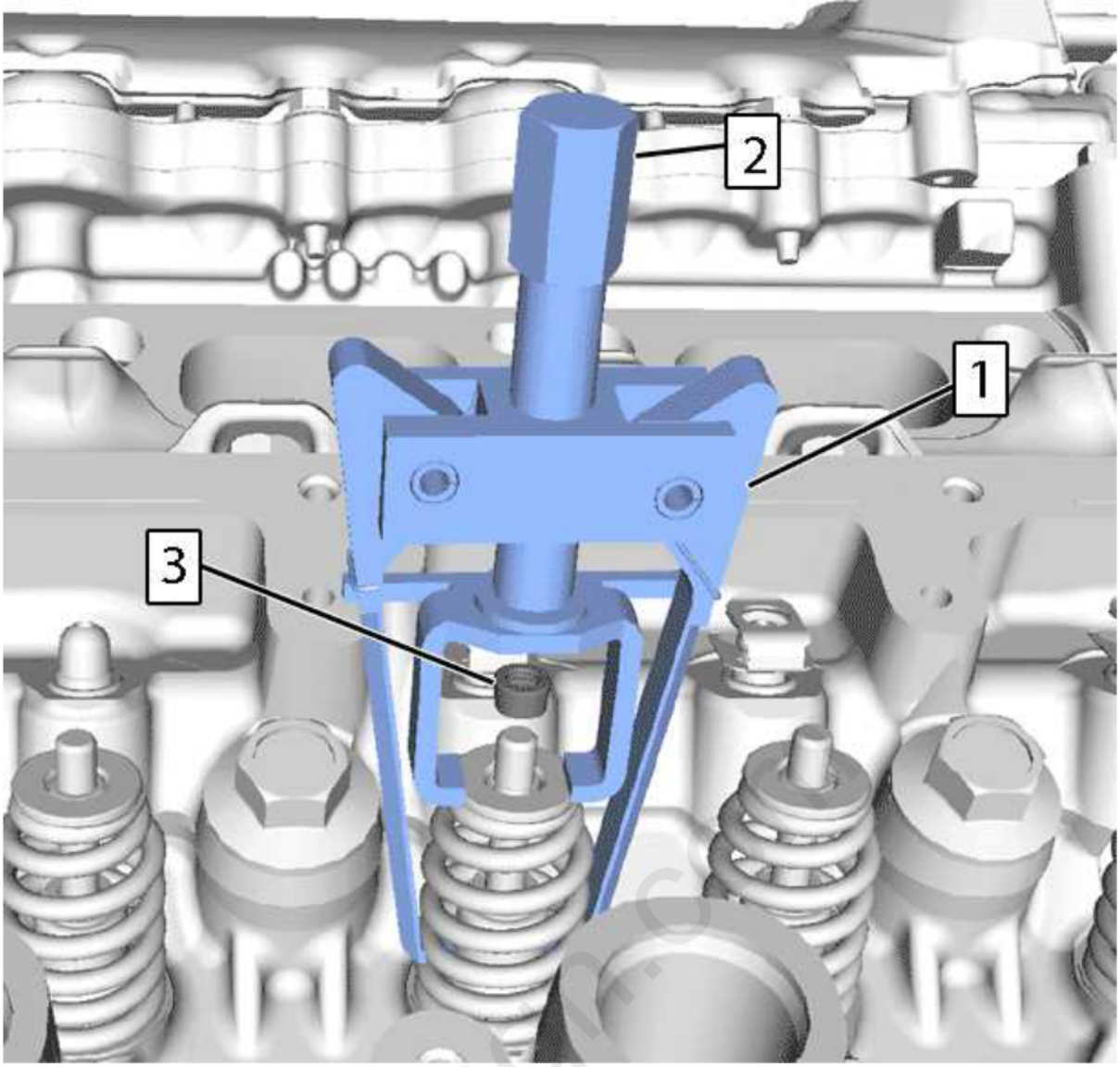


Fig. 192: Valve Spring Compressor
Courtesy of GENERAL MOTORS COMPANY

9. Tighten the **EN-46335-A** compressor bolt (2).
10. Remove the valve keepers (3).
11. Loosen the **EN-46335-A** compressor bolt and remove the compressor.
12. Valve Spring Retainer (1)Â» Remove

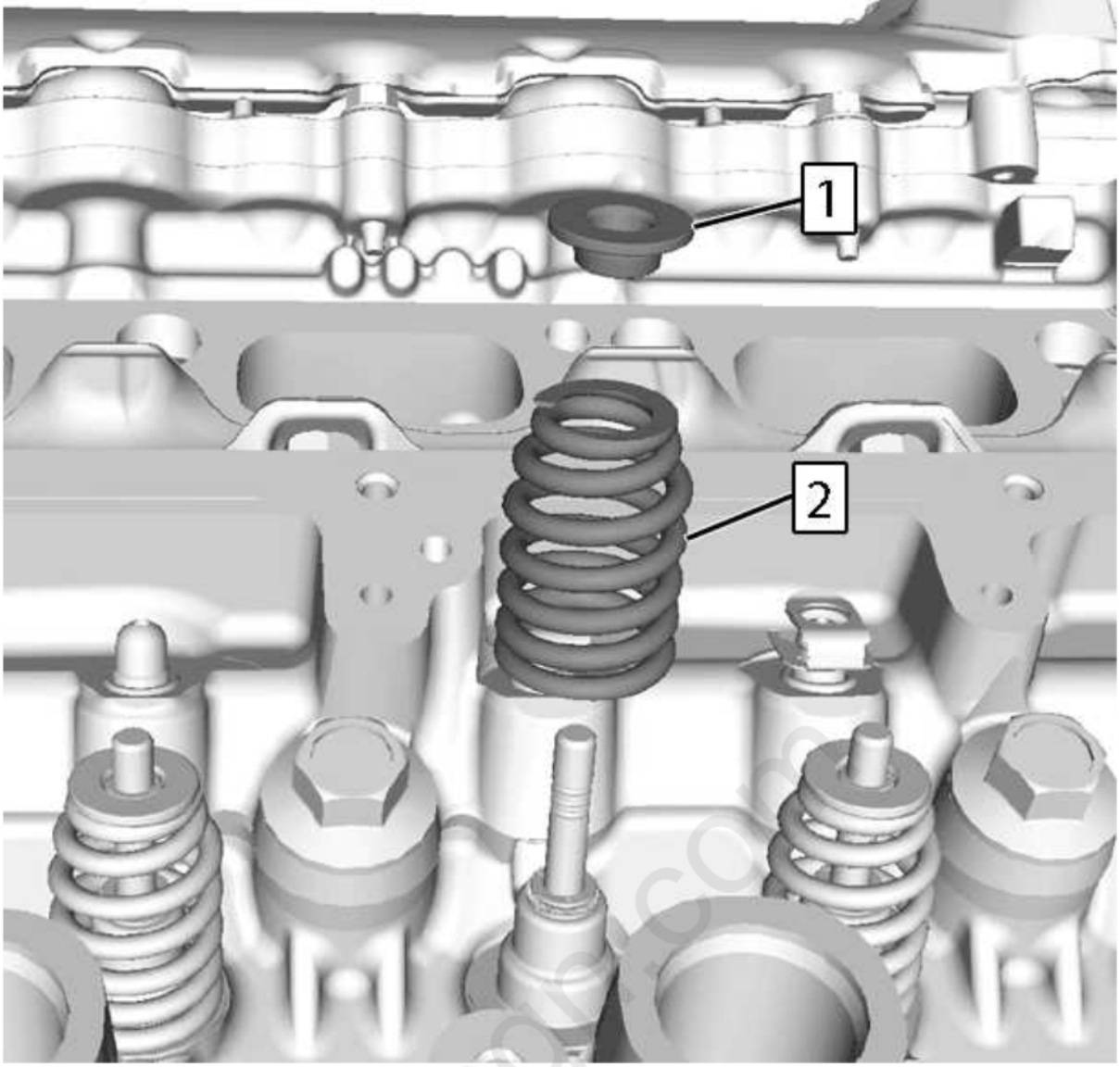


Fig. 193: Valve Spring And Retainer
Courtesy of GENERAL MOTORS COMPANY

13. Valve Spring (2)Â» Remove
14. Use the **EN-46116** remover/installer (1) in order to remove the valve stem seal (2).

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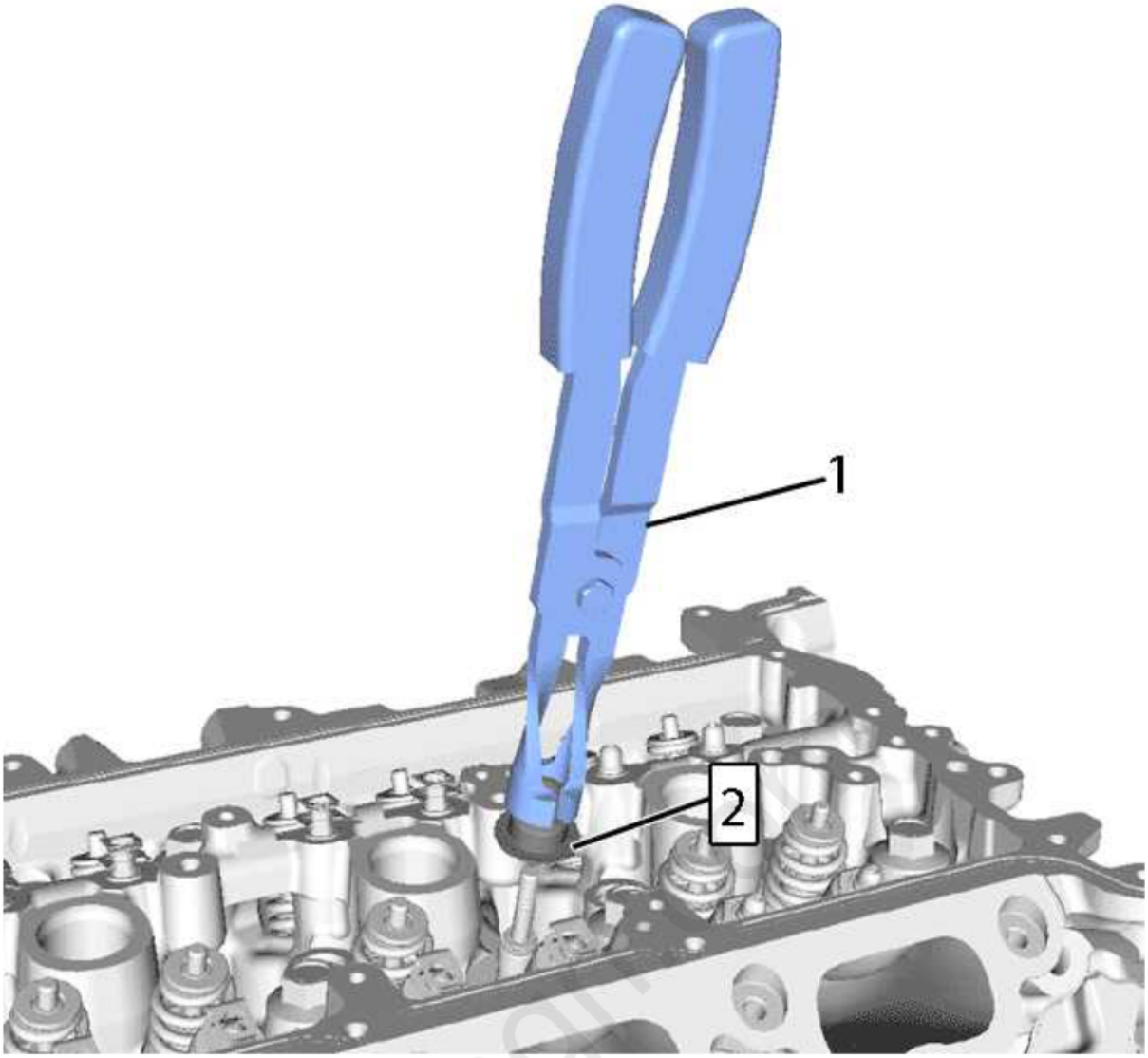


Fig. 194: Valve Stem Seal Remover/Installer
Courtesy of GENERAL MOTORS COMPANY

Installation Procedure

1. Use the **EN-46116** remover/installer (1) in order to install the valve stem seal (2).

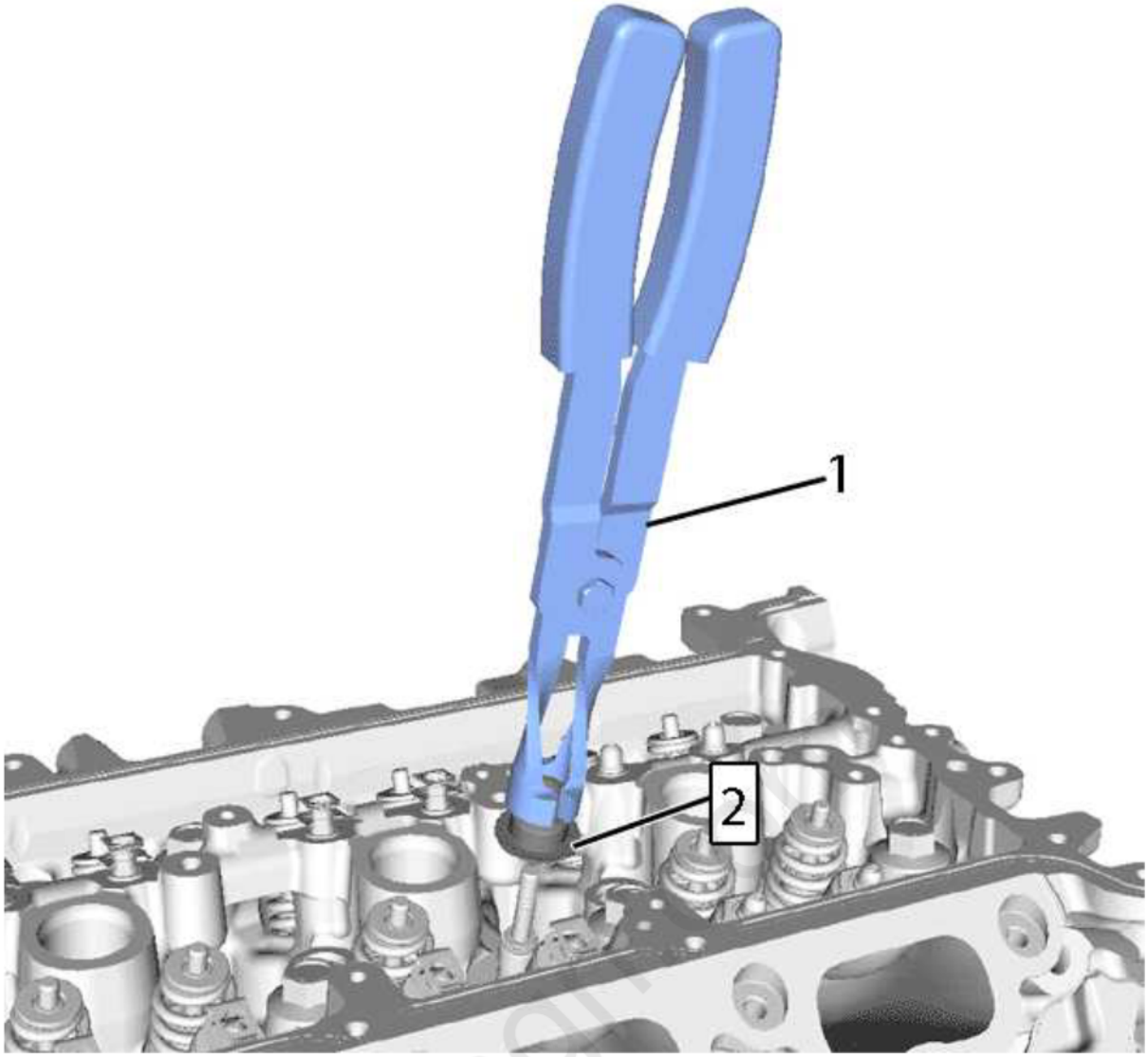


Fig. 195: Valve Stem Seal Remover/Installer
Courtesy of GENERAL MOTORS COMPANY

2. Valve Spring (2)Â» Install

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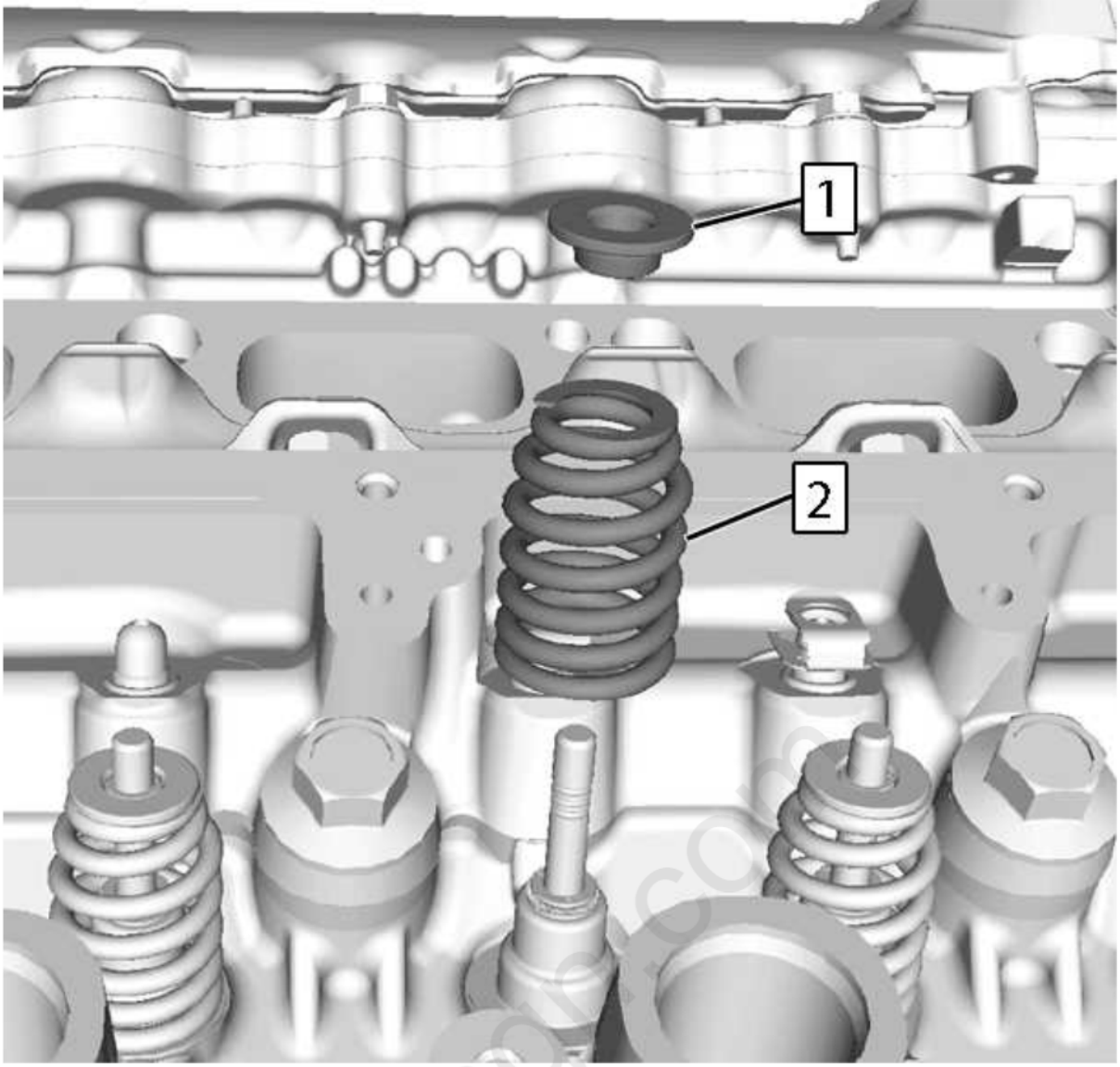


Fig. 196: Valve Spring And Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Valve Spring Retainer (1)Â» Install
4. Install the **EN-46335-A** compressor (1) above the applicable cylinder as shown.

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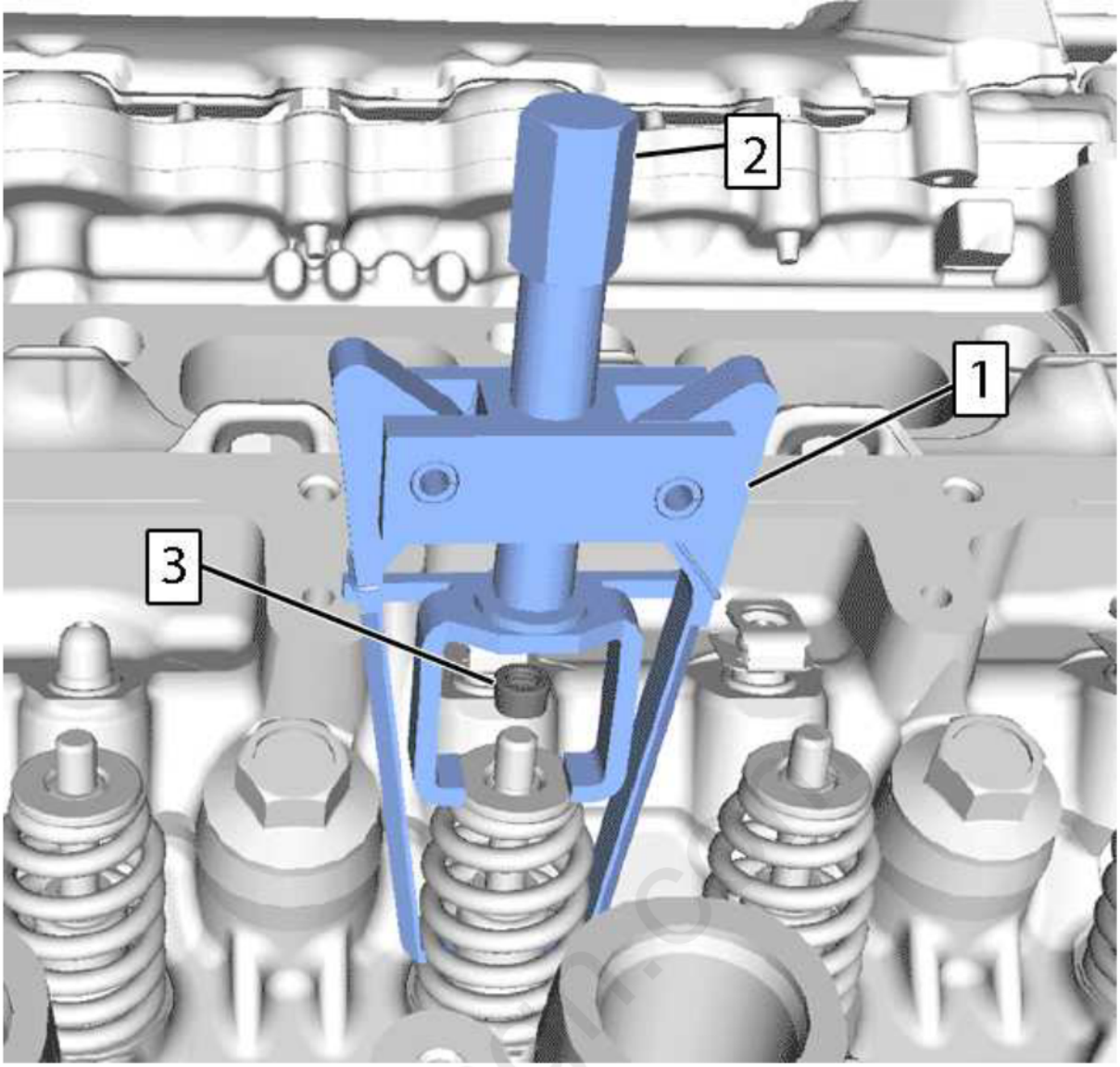


Fig. 197: Valve Spring Compressor
Courtesy of GENERAL MOTORS COMPANY

5. Tighten the **EN-46335-A** compressor bolt (2).
6. Install the valve spring keepers (3).
7. **EN-46335-A** compressorÂ» Remove
8. Disconnect the **EN-39313** adapter from the compressed air source.
9. **EN-39313** adapterÂ» Remove
10. Spark PlugÂ» Install - **Spark Plug Replacement (Bank 1)** **Spark Plug Replacement (Bank 2)**
11. Install the rocker arms. Refer to **Valve Rocker Arm Replacement - Right Side**
12. **EN-46106** tool (1)Â» Remove

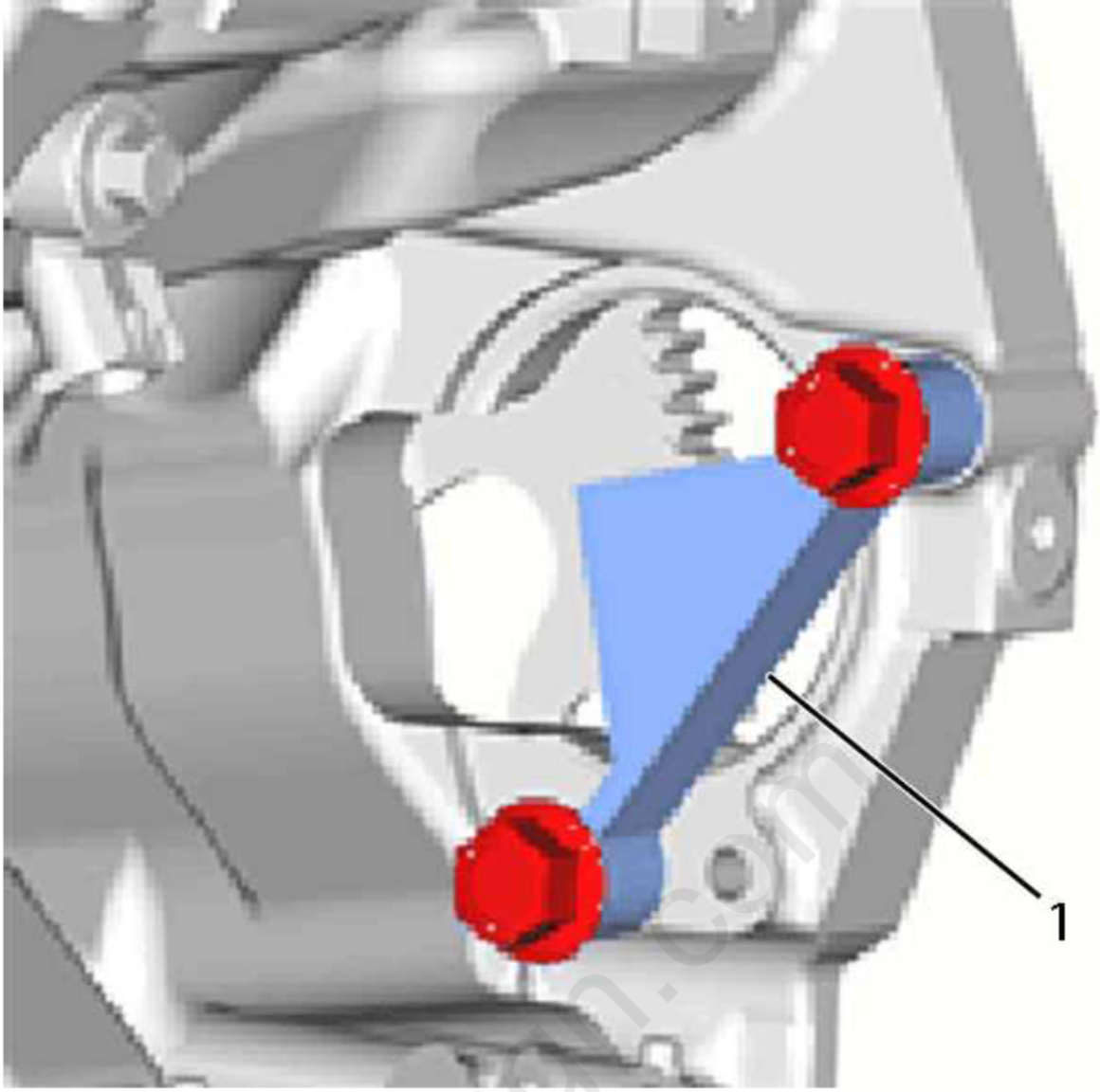


Fig. 198: Flywheel Holder
Courtesy of GENERAL MOTORS COMPANY

13. Camshaft Carrier Installation - Right Side Â» Install
14. Install the starter. Refer to Starter Replacement (LGW) Starter Replacement (LGX) .

CYLINDER HEAD REPLACEMENT - LEFT SIDE (LGW)

Removal Procedure

1. EngineÂ» Remove - Engine Replacement (LGW)
2. Camshaft Timing Chain - Left SideÂ» Remove - Camshaft Timing Chain Assembly Replacement - Left Side
3. Fuel Injection Fuel Rail Noise Shield (1)Â» Remove - Fuel Injection Fuel Rail Noise Shield Replacement

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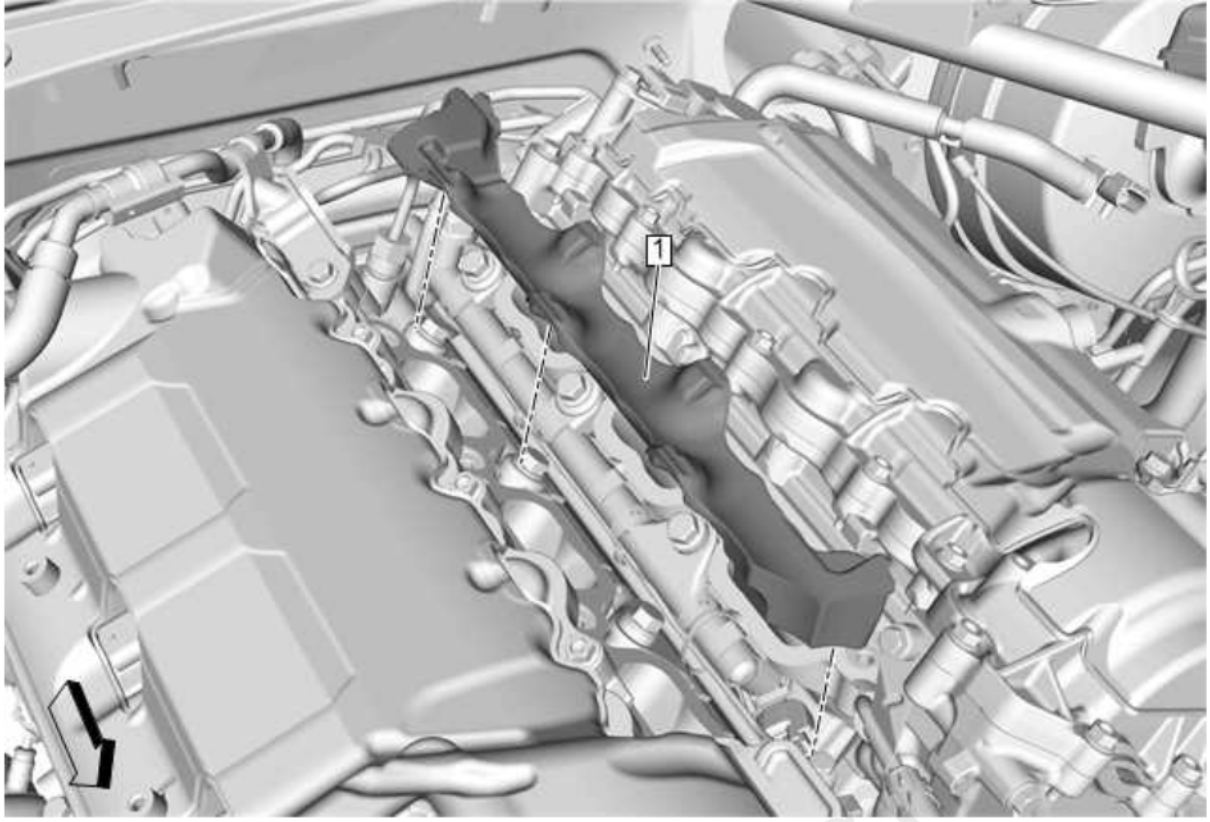


Fig. 199: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

4. Fuel Feed Intermediate Pipe (2)Â» Remove - **Fuel Feed Intermediate Pipe Replacement (LGW)**

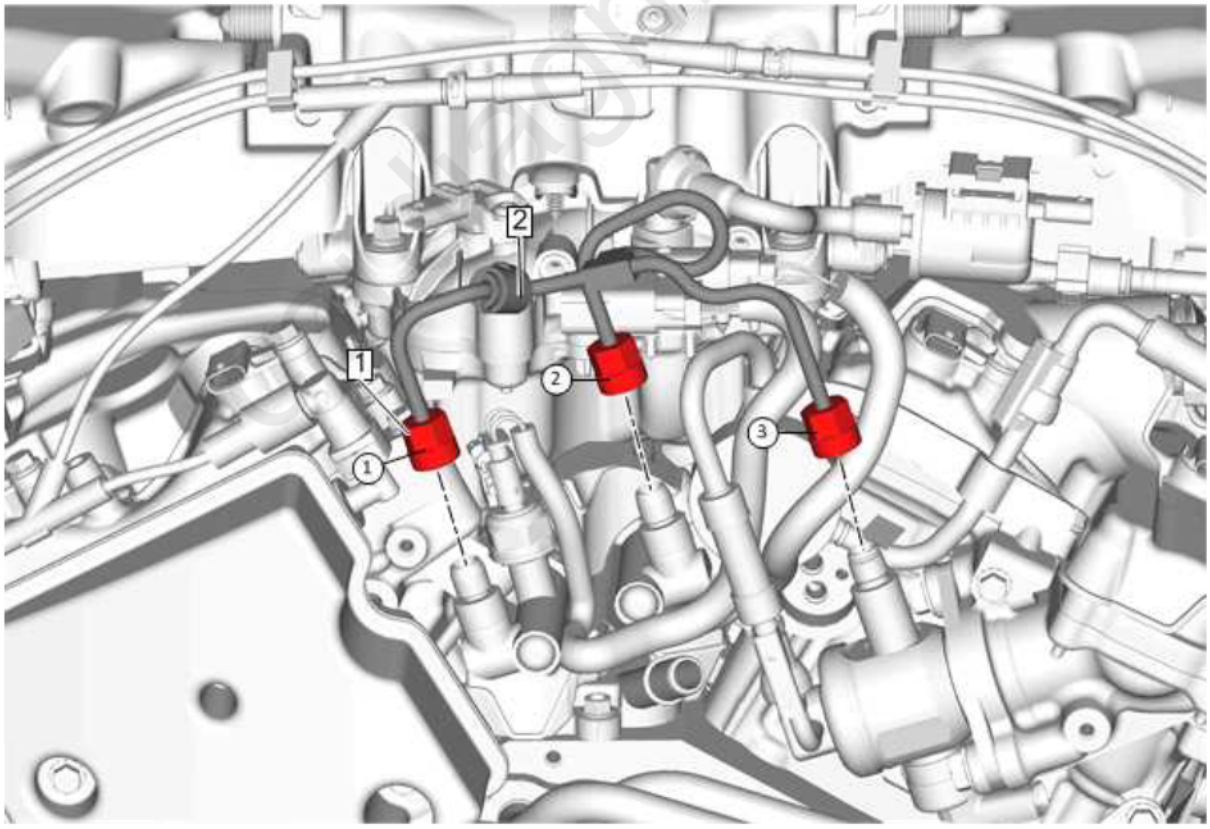


Fig. 200: Fuel Feed Intermediate Pipe
Courtesy of GENERAL MOTORS COMPANY

5. Turbocharger (2) - Left SideÂ» Remove - **Turbocharger Replacement (Left Side)**

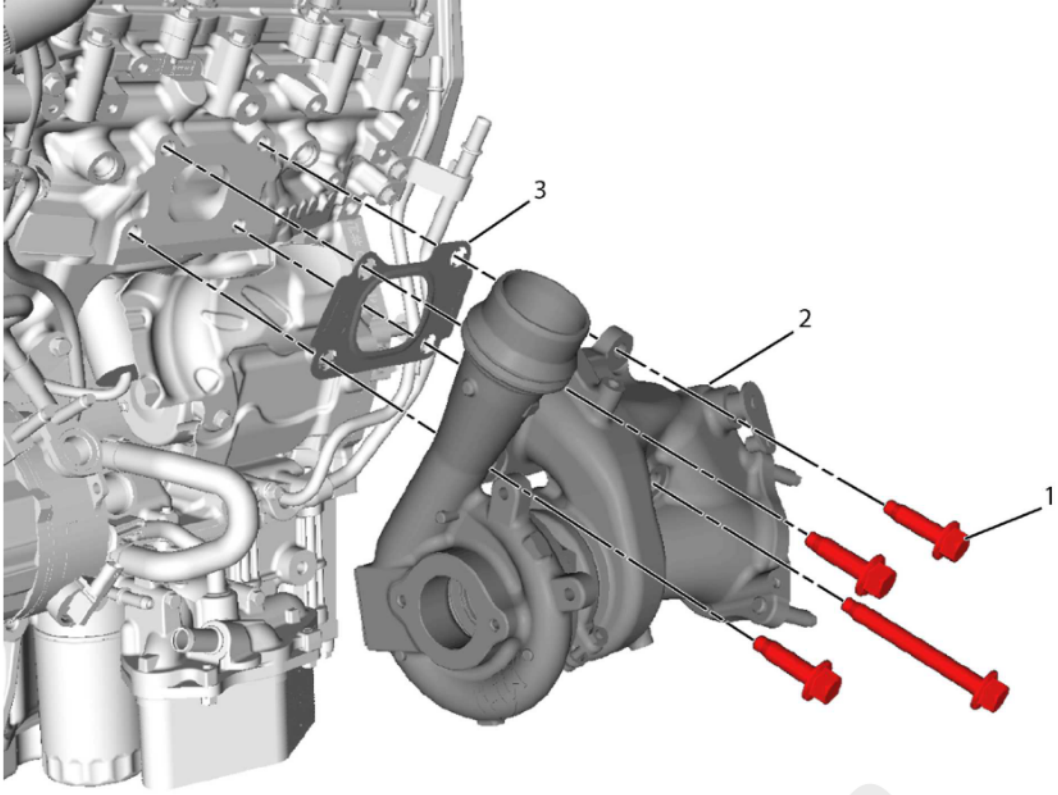


Fig. 201: Turbocharger Gasket
Courtesy of GENERAL MOTORS COMPANY

6. Oil Level Indicator Tube (1)Â» Remove - **Oil Level Indicator Tube Replacement (LGW)**

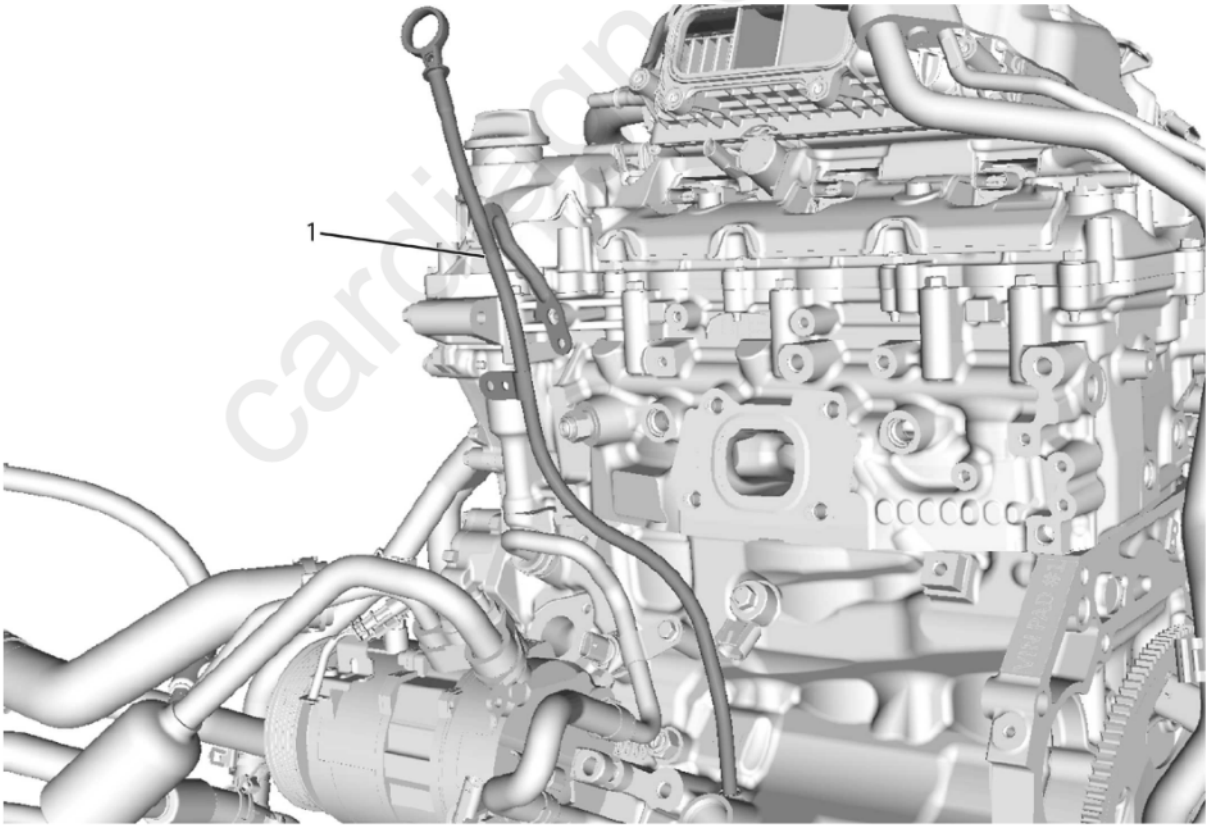


Fig. 202: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

7. Camshaft - Left SideÂ» Remove **Camshaft Replacement - Left Side**
8. Camshaft Carrier (2) - Left SideÂ» Remove **Camshaft Carrier Removal - Left Side**

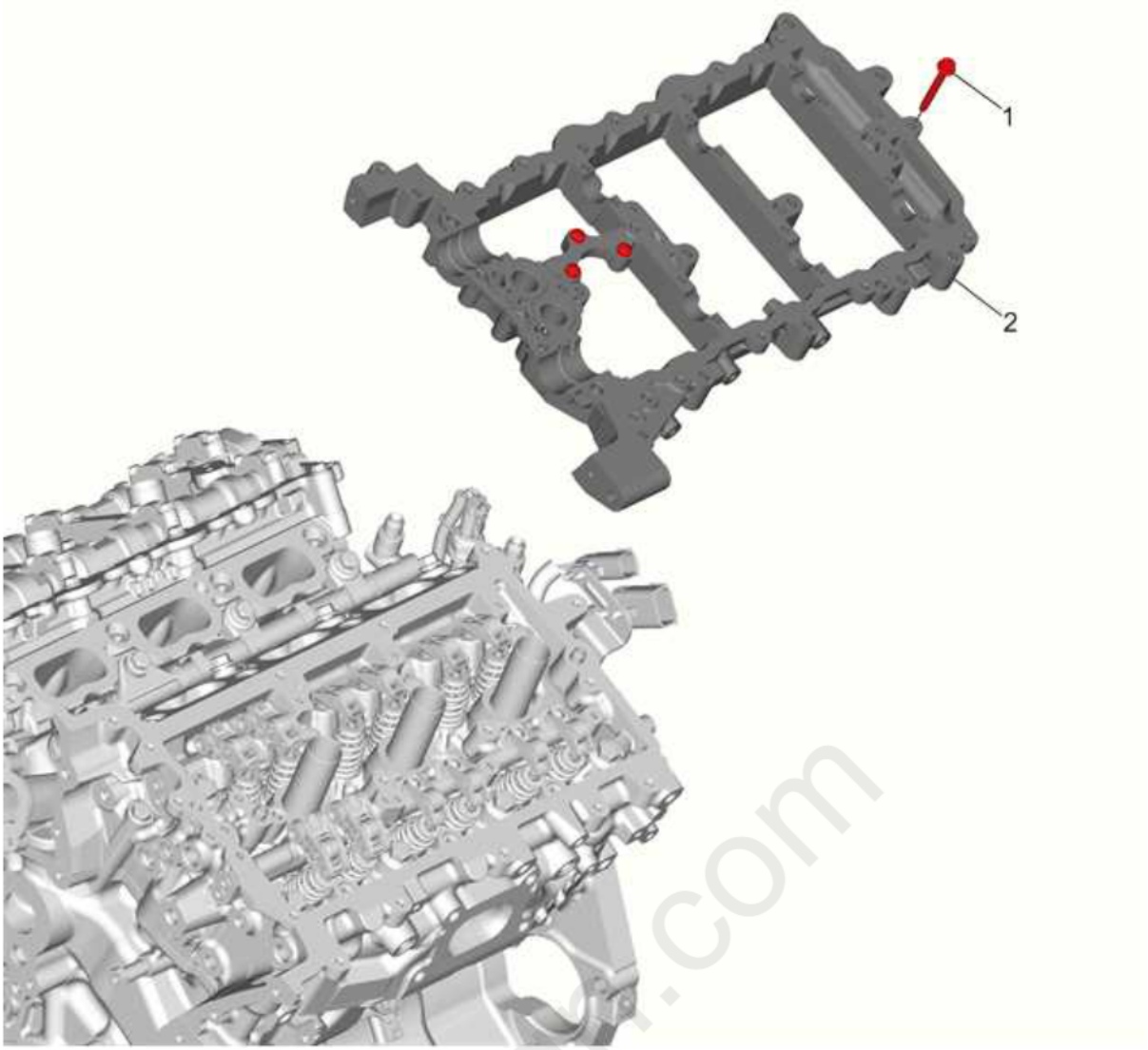


Fig. 203: Camshaft Carrier - Left Side
Courtesy of GENERAL MOTORS COMPANY

9. Remove and DISCARD the 2 front M8 left cylinder head bolts (1).

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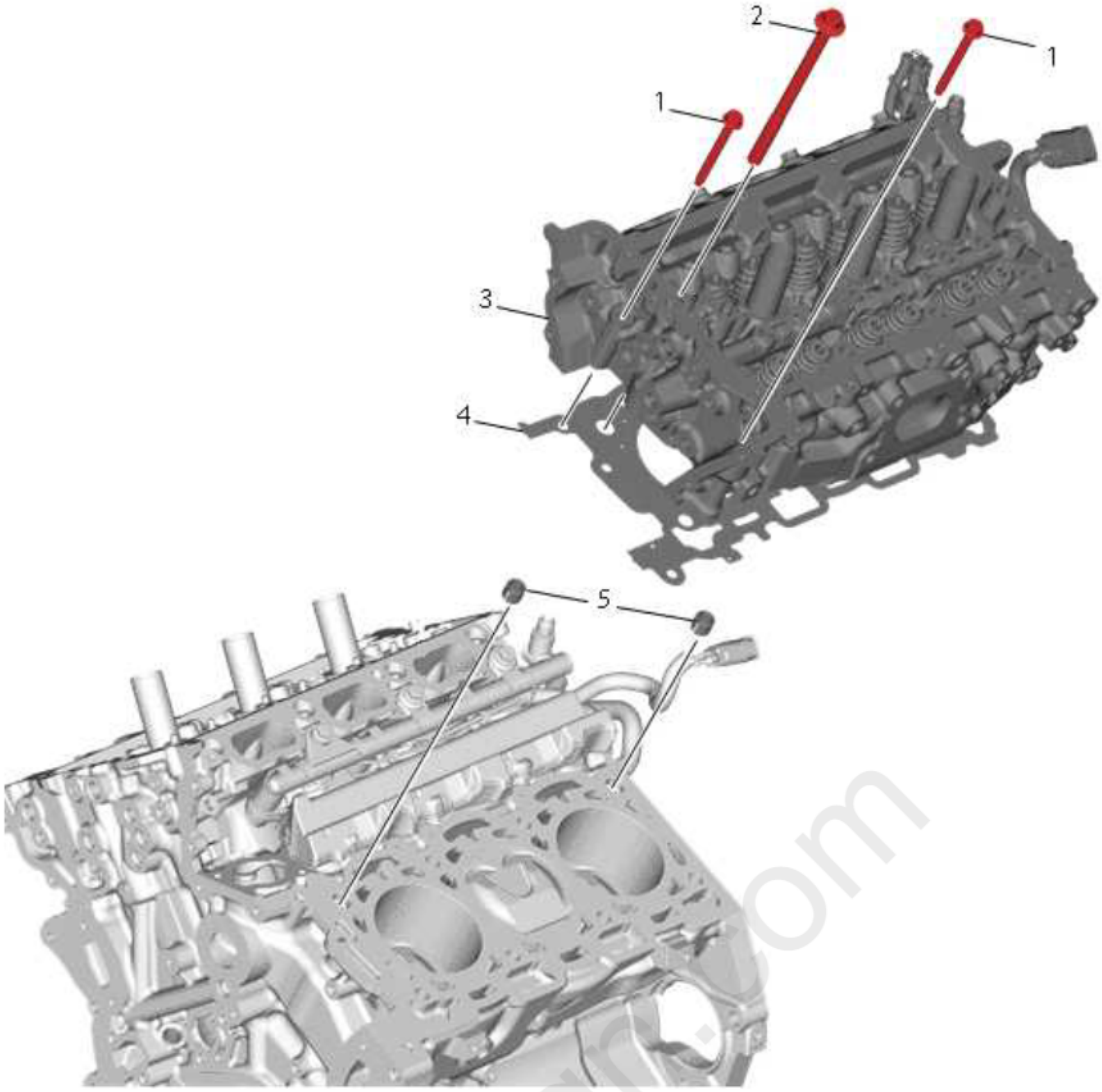


Fig. 204: Cylinder Head Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Cylinder Head Bolt (2) [8x]Â» Remove and DISCARD
11. Cylinder Head Assembly (3)Â» Remove
12. Cylinder Head Gasket (4)Â» Remove and DISCARD
13. Cylinder Head AssemblyÂ» Clean and inspect - **Cylinder Head Cleaning and Inspection**
14. Engine BlockÂ» Clean and inspect - **Engine Block Cleaning and Inspection**
15. Disassemble the cylinder head as necessary. Refer to **Cylinder Head Disassemble**

Installation Procedure

1. Assemble the cylinder head as necessary. Refer to **Cylinder Head Assemble**
2. Ensure the cylinder head locating pins (5) are securely mounted in the cylinder block deck face.

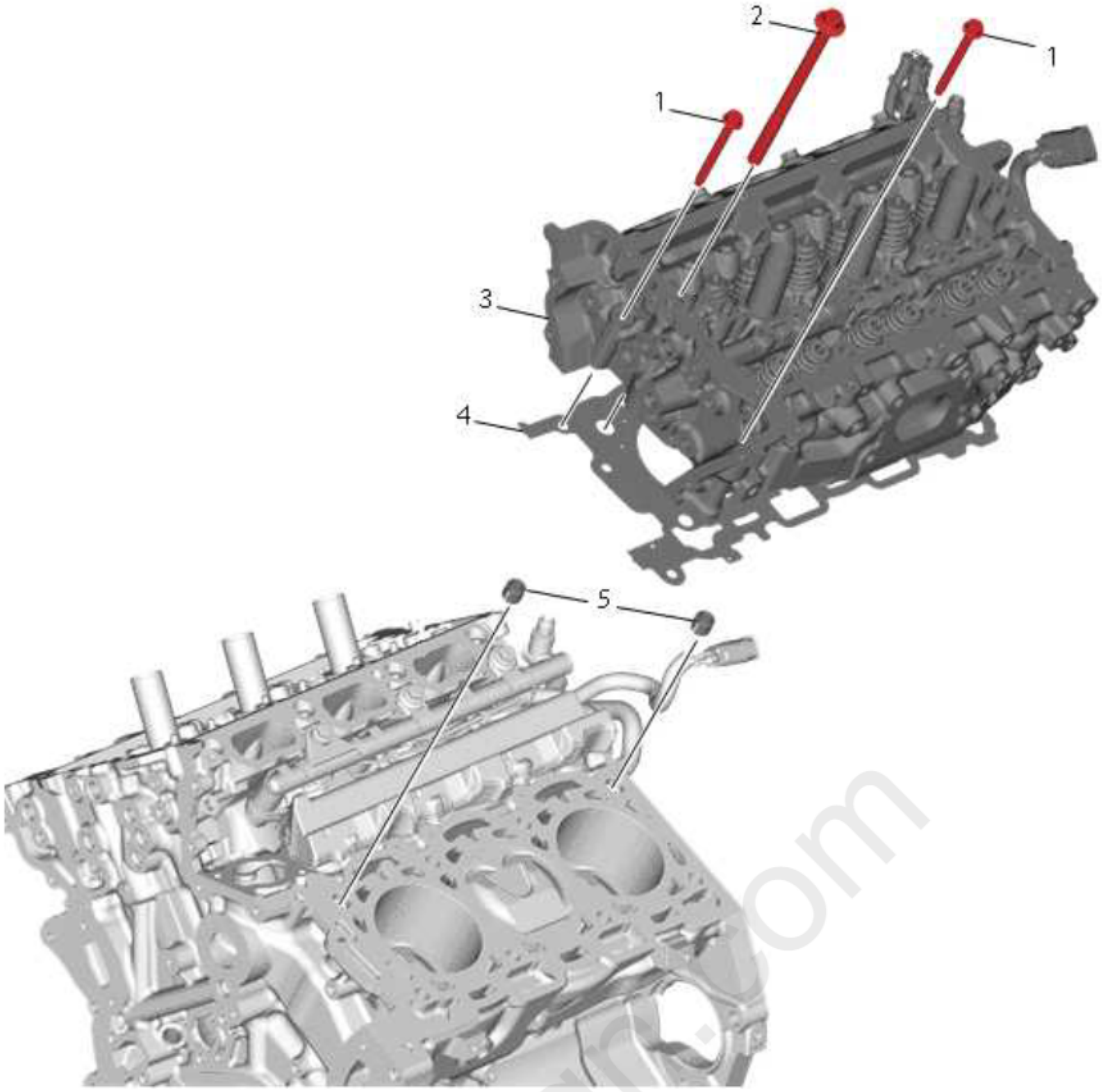


Fig. 205: Cylinder Head Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW left cylinder head gasket (4) using the deck face locating pins for retention.
4. Cylinder Head Assembly (3)Â» Install - **Cylinder Head Installation - Left Side**
5. Camshaft Carrier (2) - Left SideÂ» Install **Camshaft Carrier Installation - Left Side**

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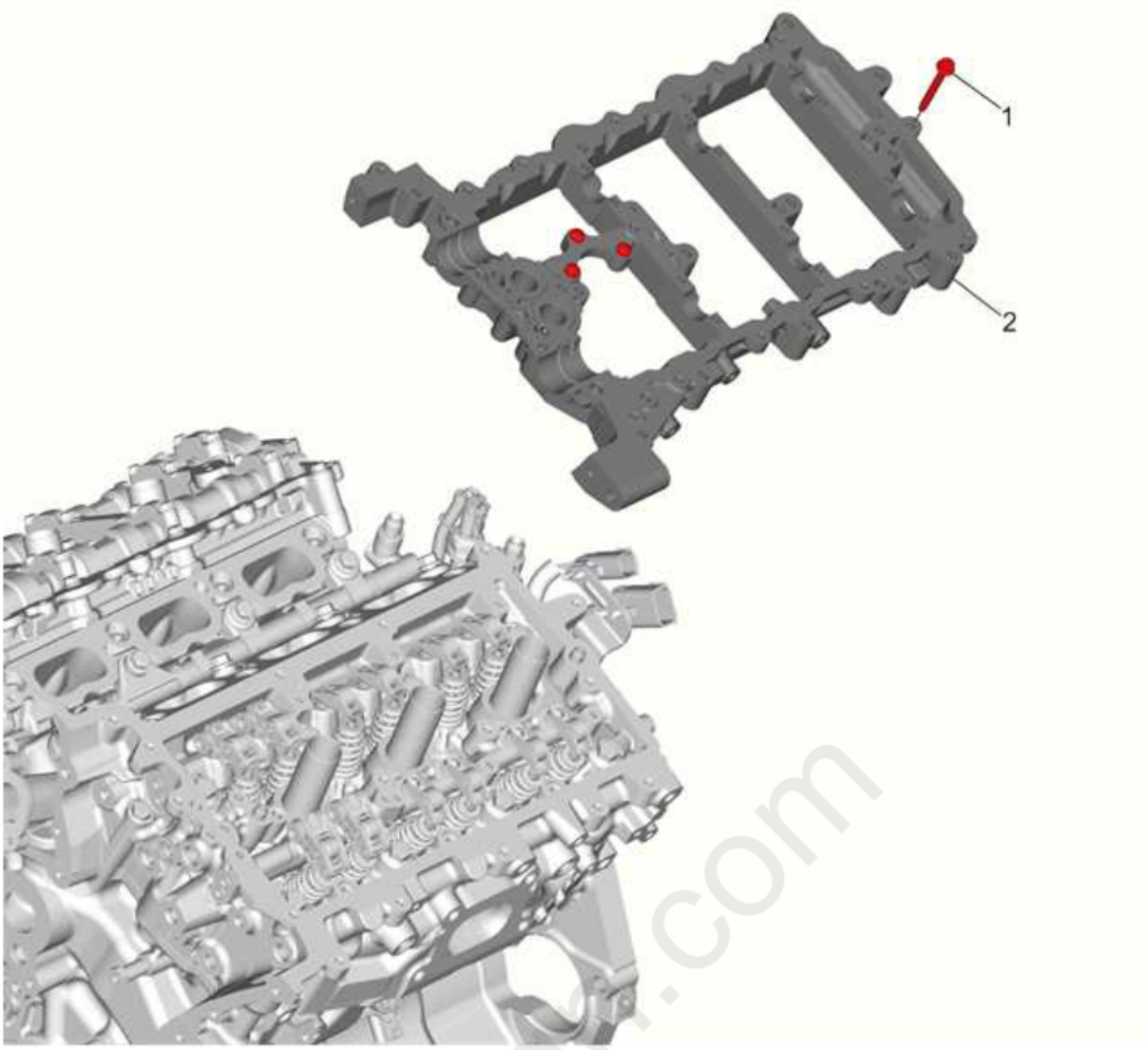
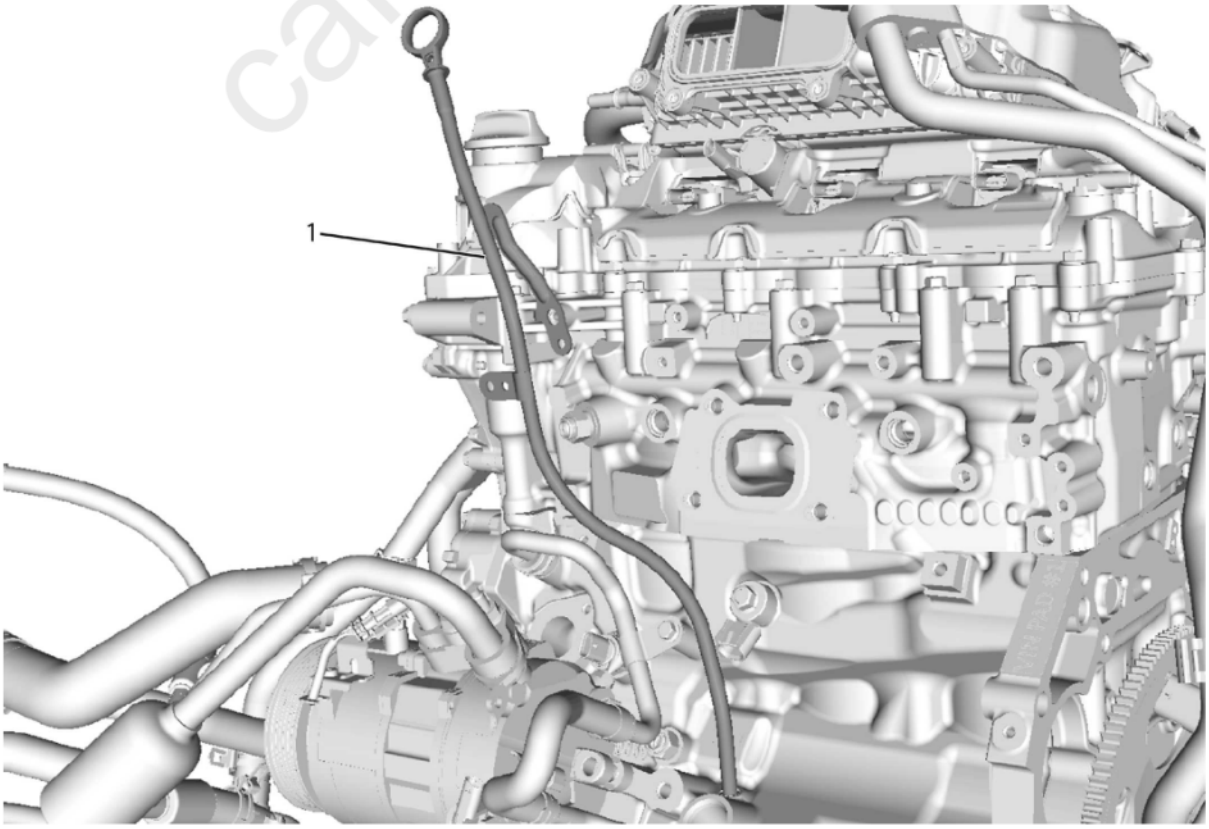


Fig. 206: Camshaft Carrier - Left Side
Courtesy of GENERAL MOTORS COMPANY

6. Camshaft - Left SideÂ» Install **Camshaft Replacement - Left Side**
7. Oil Level Indicator Tube (1)Â» Install - **Oil Level Indicator Tube Replacement (LGW)**



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Fig. 207: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

8. Turbocharger (2) - Left SideÂ» Install - **Turbocharger Replacement (Left Side)**

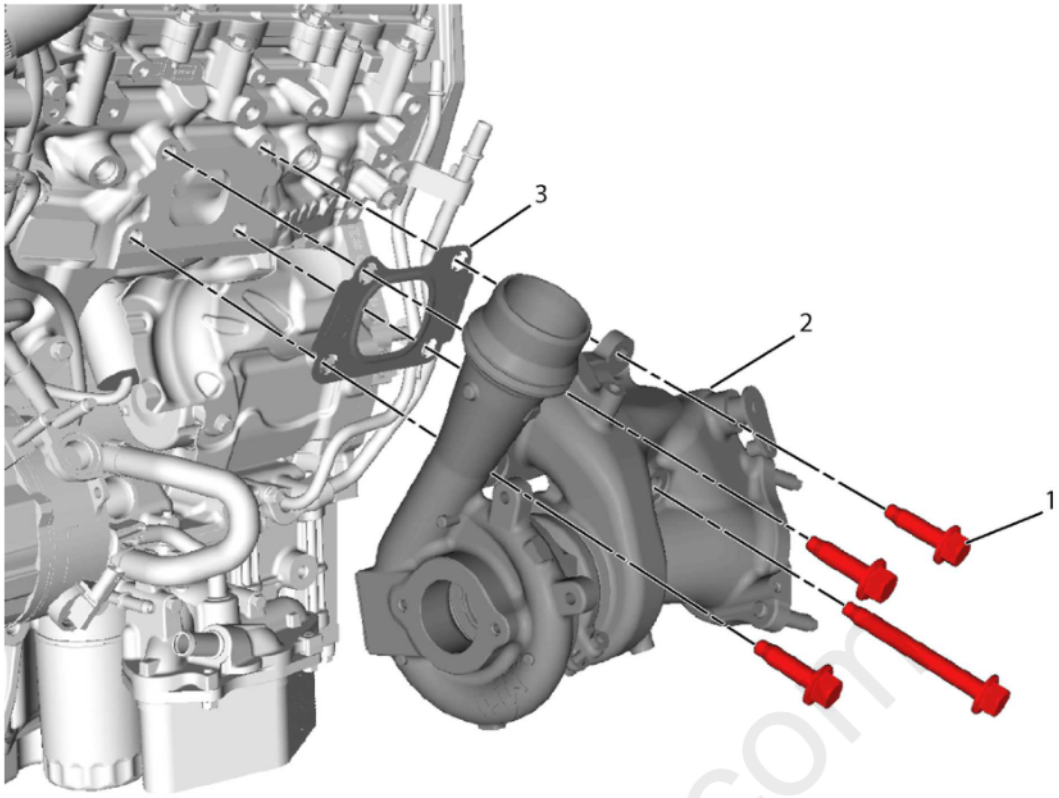


Fig. 208: Turbocharger Gasket
Courtesy of GENERAL MOTORS COMPANY

9. Fuel Feed Intermediate PipeÂ» Install - **Fuel Feed Intermediate Pipe Replacement (LGW)**
10. Fuel Injection Fuel Rail Noise Shield (1)Â» Install - **Fuel Injection Fuel Rail Noise Shield Replacement**

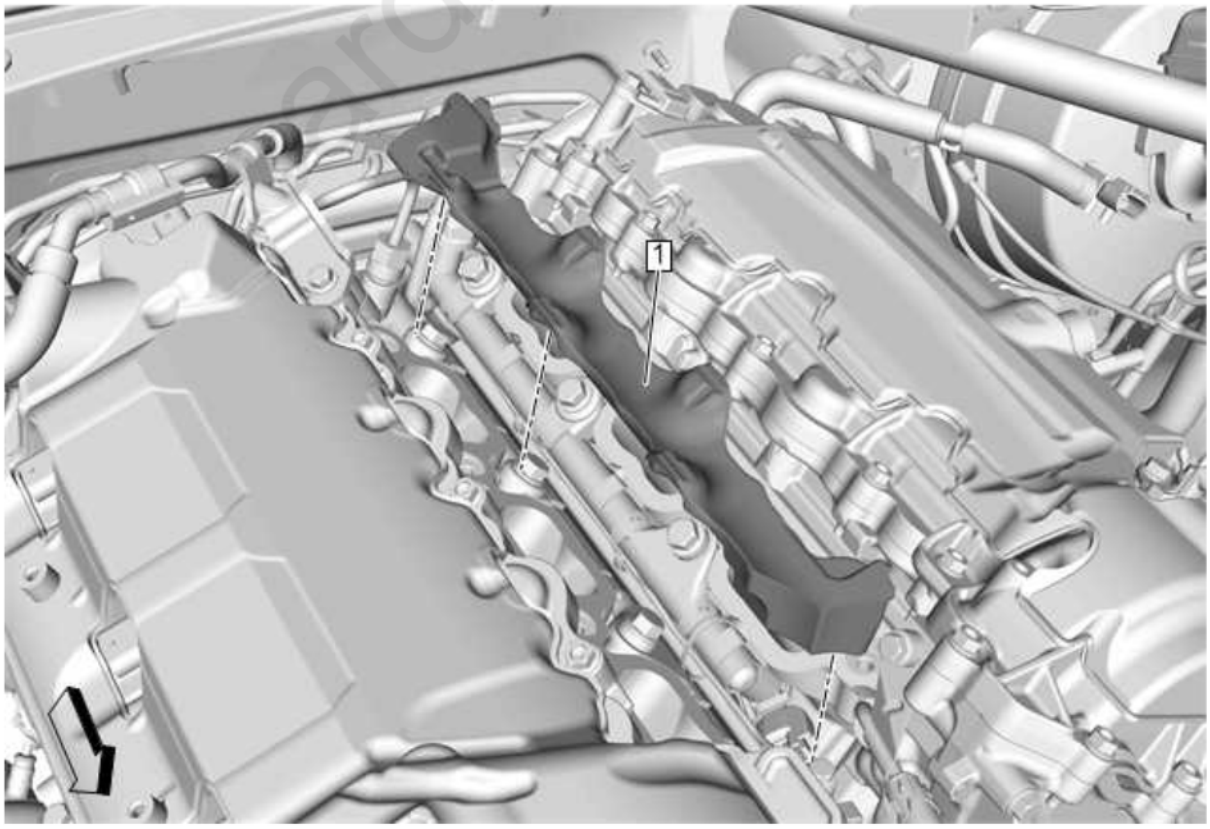


Fig. 209: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

11. Camshaft Timing Chain - Left SideÂ» Install - **Camshaft Timing Chain Assembly Replacement - Left Side**
12. EngineÂ» Install - **Engine Replacement (LGW)**

CYLINDER HEAD REPLACEMENT - LEFT SIDE (LGX)

Removal Procedure

1. EngineÂ» Remove - **Engine Replacement (LGX)**
2. Fuel Feed Intermediate Pipe (2)Â» Remove - **Fuel Feed Intermediate Pipe Replacement (LGX)**

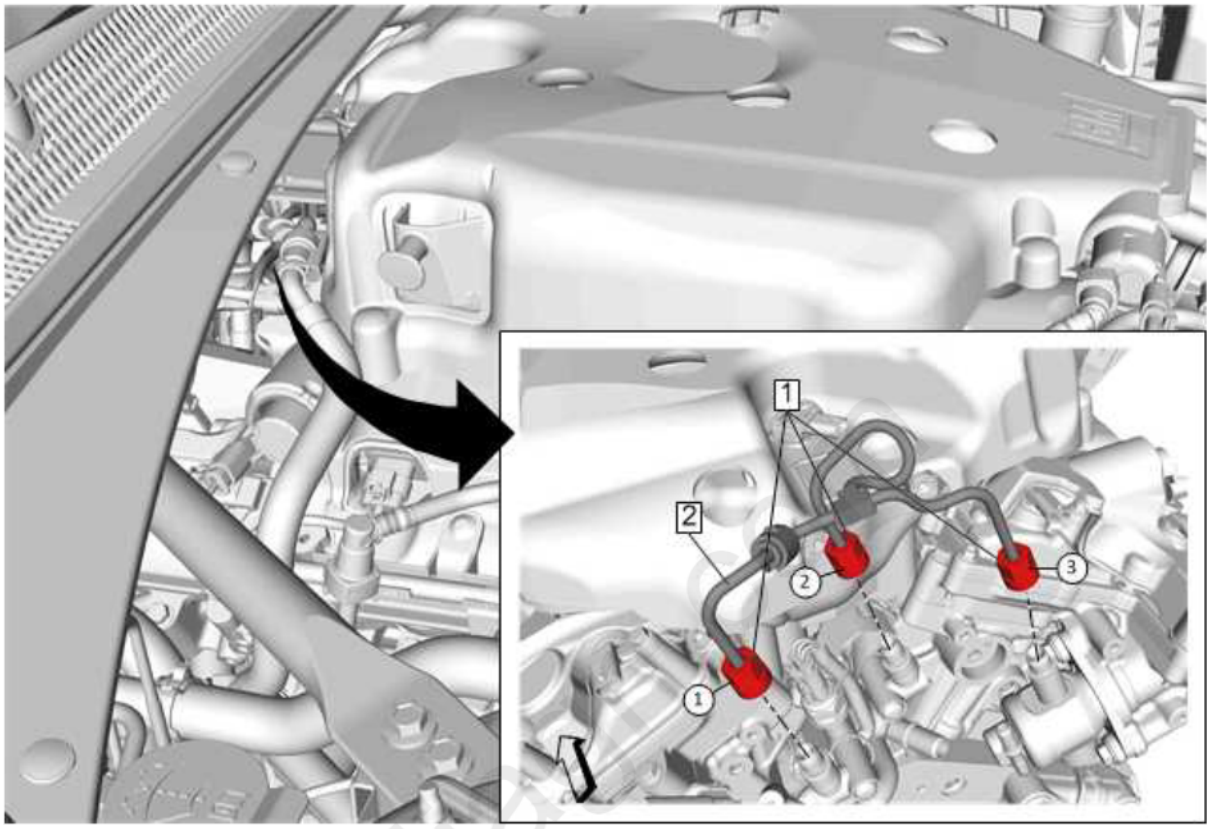


Fig. 210: Fuel Feed Intermediate Pipe
Courtesy of GENERAL MOTORS COMPANY

3. Camshaft Timing Chain - Left SideÂ» Remove - **Camshaft Timing Chain Assembly Replacement - Left Side**
4. Fuel Injection Fuel Rail Noise Shield (1)Â» Remove - **Fuel Injection Fuel Rail Noise Shield Replacement**

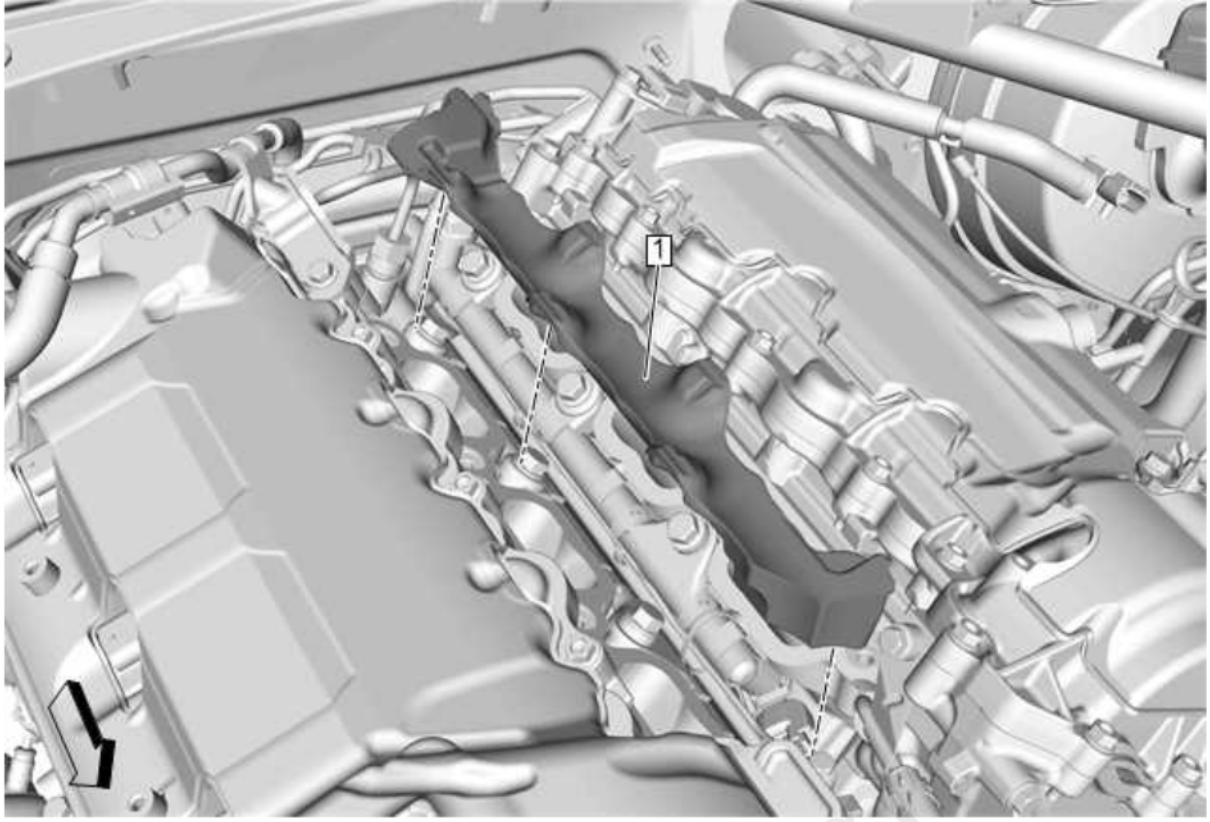


Fig. 211: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

5. Catalytic Converter - Left Side (3)Â» Remove - **Warm Up Three-Way Catalytic Converter Replacement (Left, LGX)**

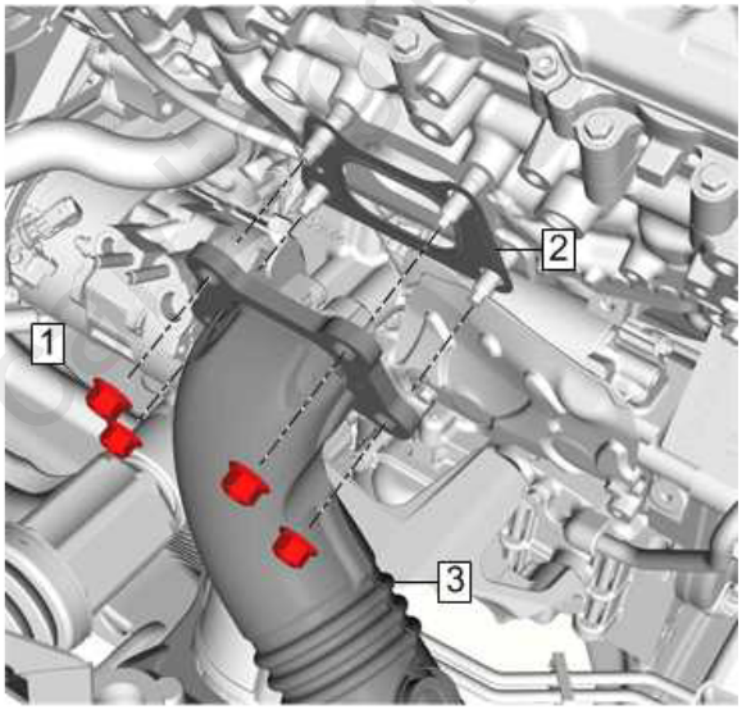


Fig. 212: Catalytic Converter Gasket And Converter
Courtesy of GENERAL MOTORS COMPANY

6. Oil Level Indicator Tube (2)Â» Remove - **Oil Level Indicator Tube Replacement (LGX)**

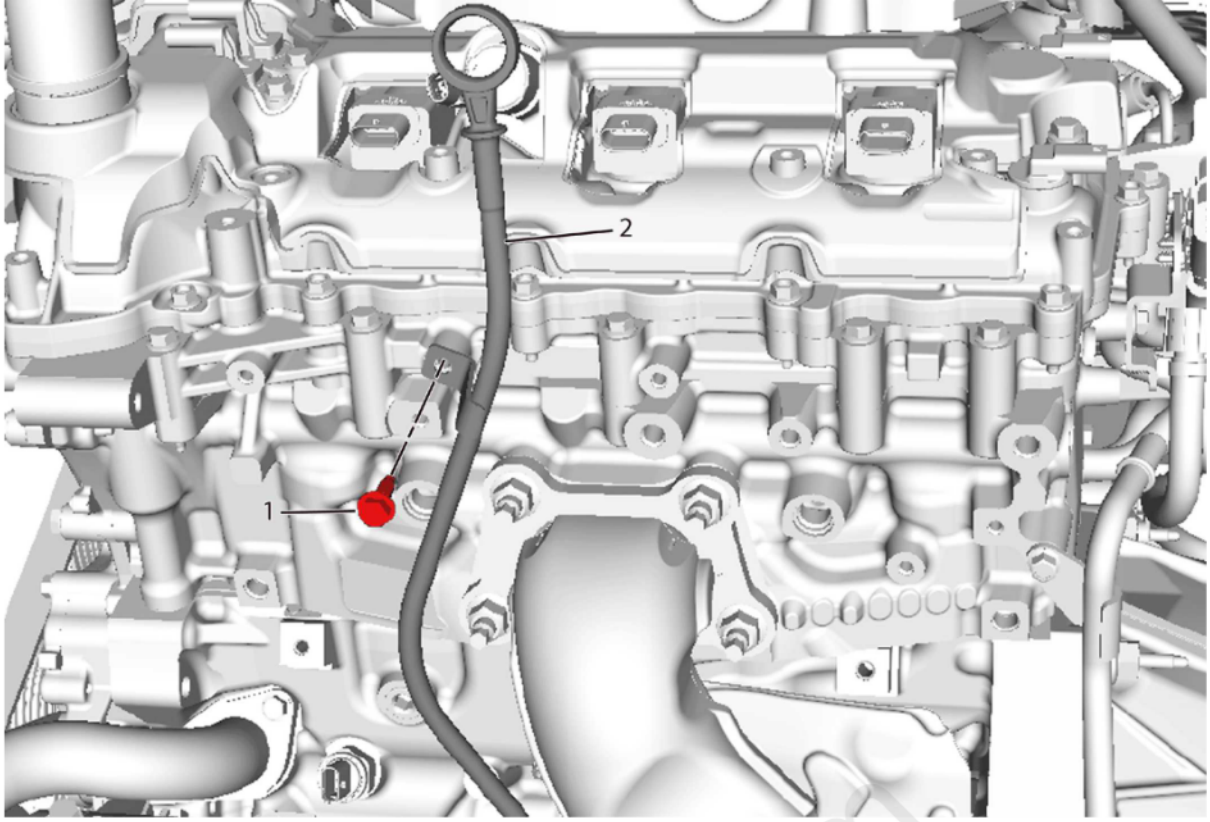


Fig. 213: Oil Level Indicator and Tube
Courtesy of GENERAL MOTORS COMPANY

7. Remove the ground wire bolt (1) and ground wire (2).

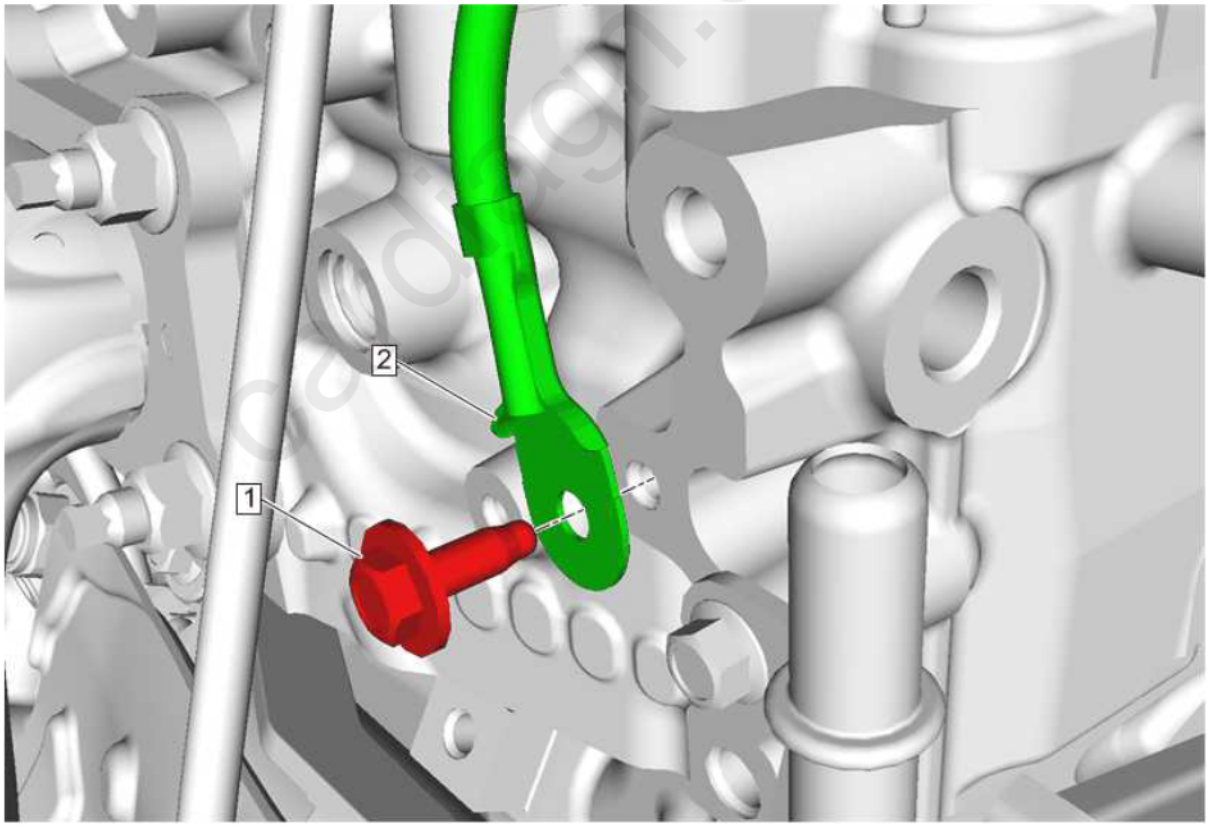


Fig. 214: Ground Wire Bolt And Ground Wire
Courtesy of GENERAL MOTORS COMPANY

8. Vacuum Pump Pipe BoltÂ» Remove

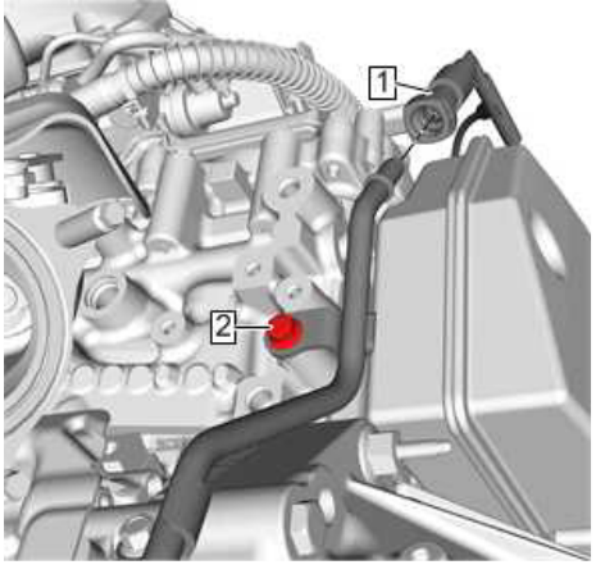


Fig. 215: Vacuum Pump Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

9. Disconnect and reposition harness as necessary.
10. Camshaft - Left SideÂ» Remove [2x] - **Camshaft Replacement - Left Side**
11. Camshaft Carrier - Left Side (2)Â» Remove - **Camshaft Carrier Removal - Left Side**

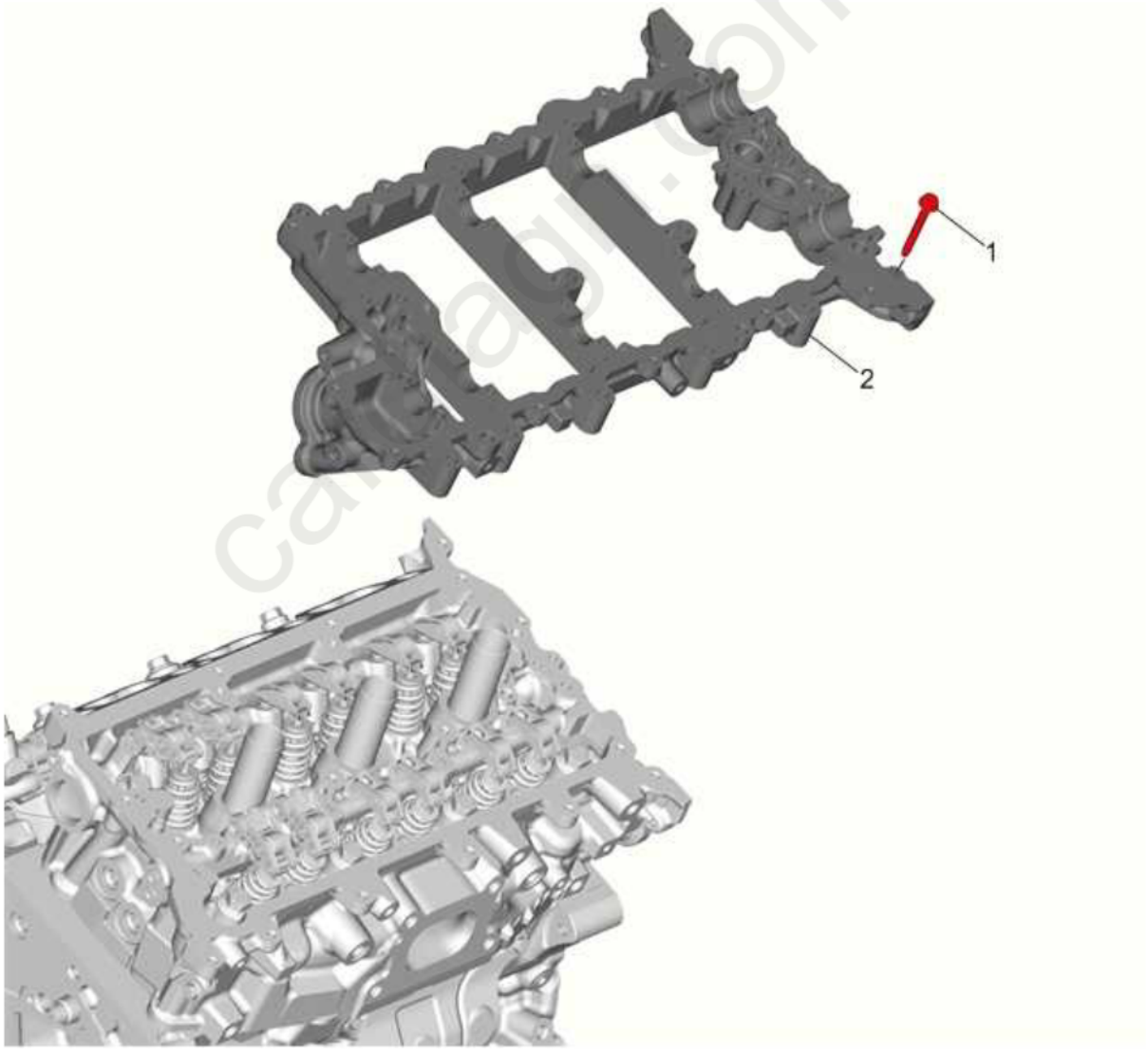


Fig. 216: Camshaft Carrier - Right Side
Courtesy of GENERAL MOTORS COMPANY

12. Remove and DISCARD the 2 front M8 left cylinder head bolts (1).

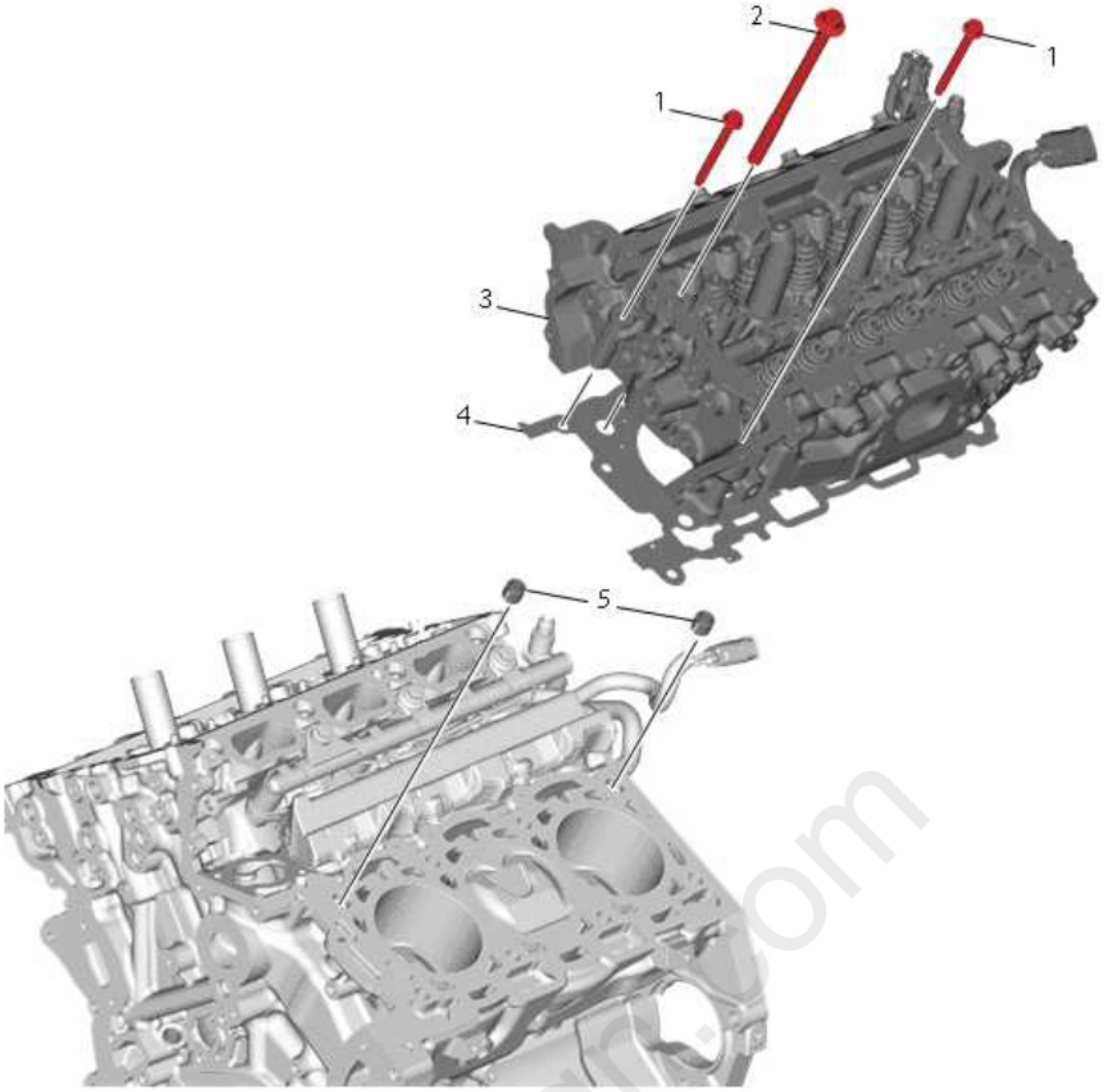


Fig. 217: Cylinder Head Bolts
Courtesy of GENERAL MOTORS COMPANY

13. Cylinder Head Bolt (2)Â» Remove and DISCARD [8x]
14. Cylinder Head Assembly (3)Â» Remove
15. Cylinder Head Gasket (4)Â» Remove and DISCARD
16. **Cylinder Head Cleaning and Inspection**
17. **Engine Block Cleaning and Inspection**
18. Disassemble the cylinder head as necessary. Refer to **Cylinder Head Disassemble**

Installation Procedure

1. Assemble the cylinder head as necessary. Refer to **Cylinder Head Assemble**
2. Ensure the cylinder head locating pins (5) are securely mounted in the cylinder block deck face.

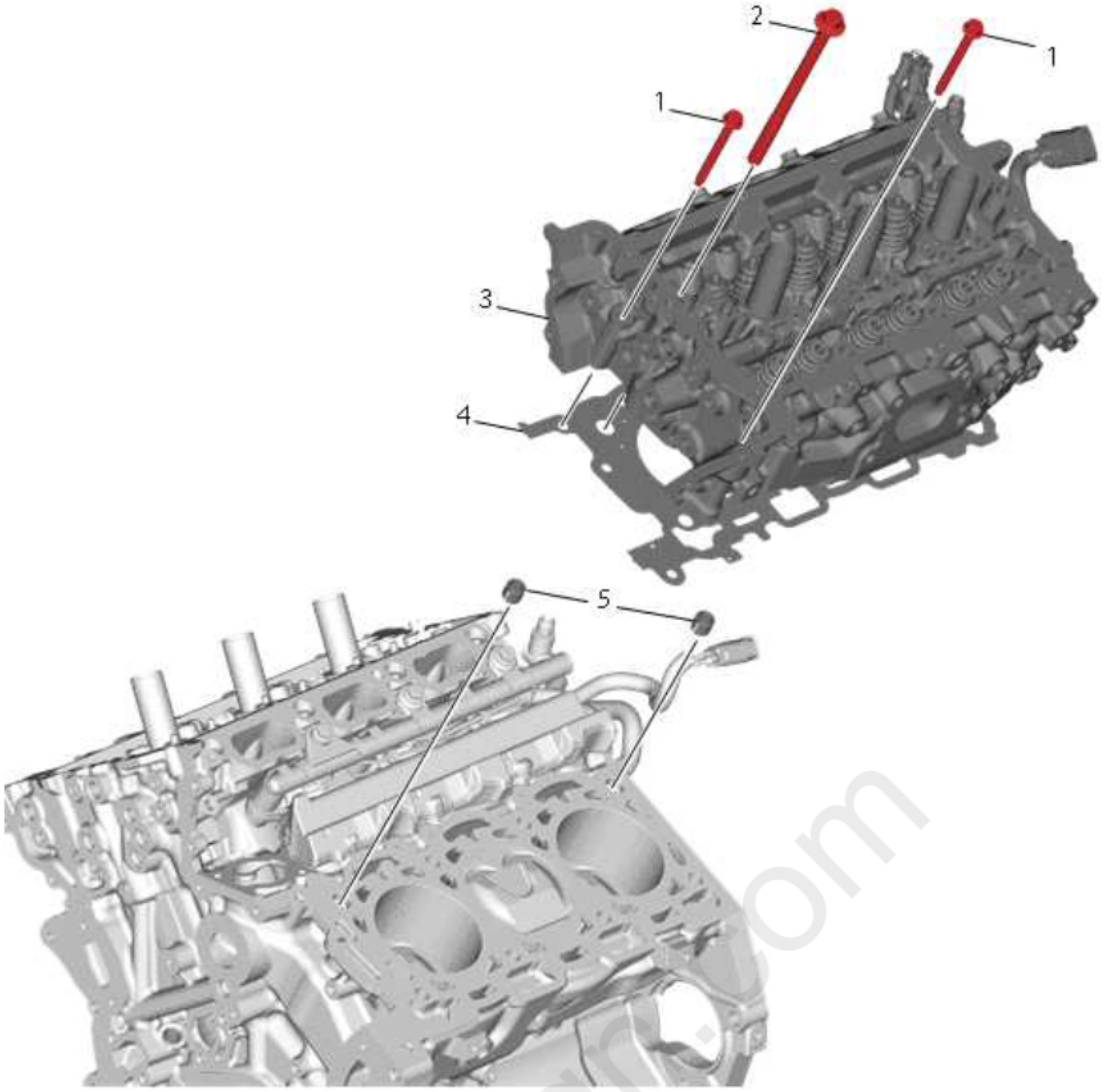


Fig. 218: Cylinder Head Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW left cylinder head gasket (4) using the deck face locating pins for retention.
4. Cylinder Head Assembly (3)Â» Install - **Cylinder Head Installation - Left Side**
5. Camshaft Carrier - Left Side (2)Â» Install - **Camshaft Carrier Removal - Left Side**

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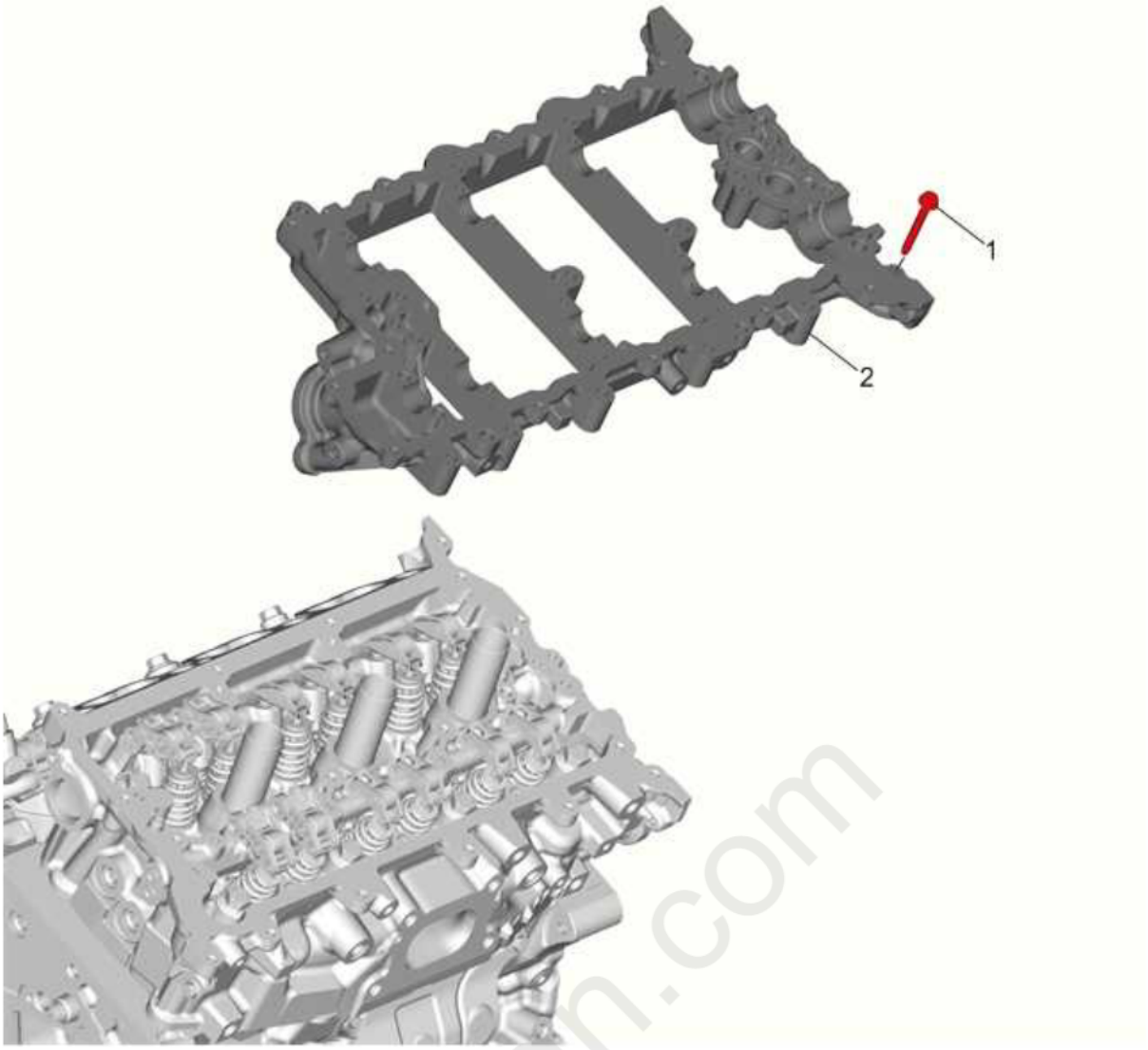


Fig. 219: Camshaft Carrier - Right Side
Courtesy of GENERAL MOTORS COMPANY

6. Camshaft - Left SideÂ» Install [2x] - **Camshaft Replacement - Left Side**
7. Position wire harness and connect as necessary.
8. Vacuum Pump Pipe BoltÂ» Install - **Vacuum Pump Pipe Replacement (To Brake Booster Vacuum Hose)** **Vacuum Pump Pipe Replacement (To Turbocharger Control Solenoid Valve Vacuum Hose)**

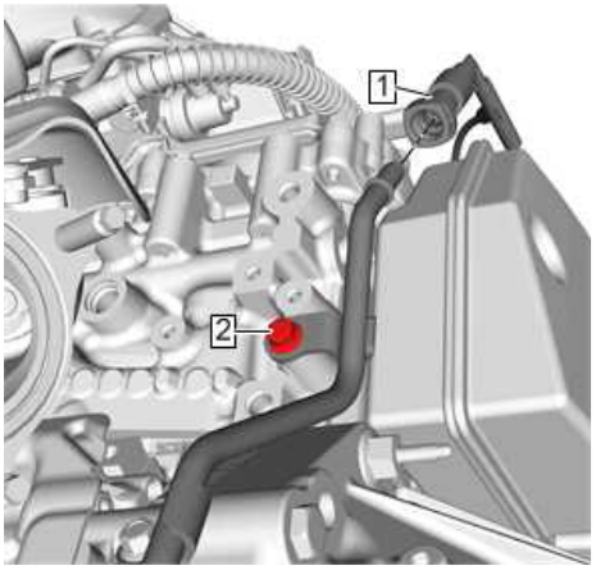


Fig. 220: Vacuum Pump Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

9. Install ground wire and ground wire bolt. Refer to **Ground Repair**

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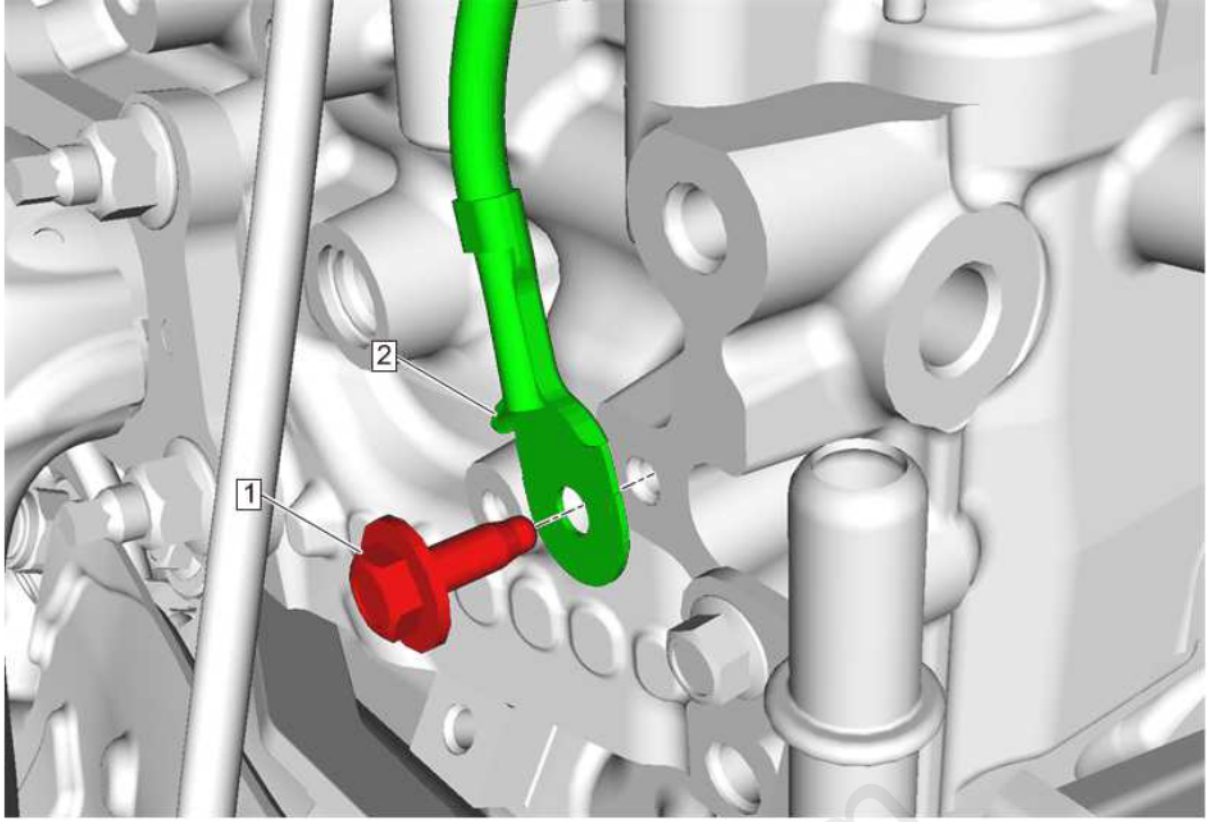


Fig. 221: Ground Wire Bolt And Ground Wire
Courtesy of GENERAL MOTORS COMPANY

10. Oil Level Indicator Tube (2)Â» Install - **Oil Level Indicator Tube Replacement (LGX)**

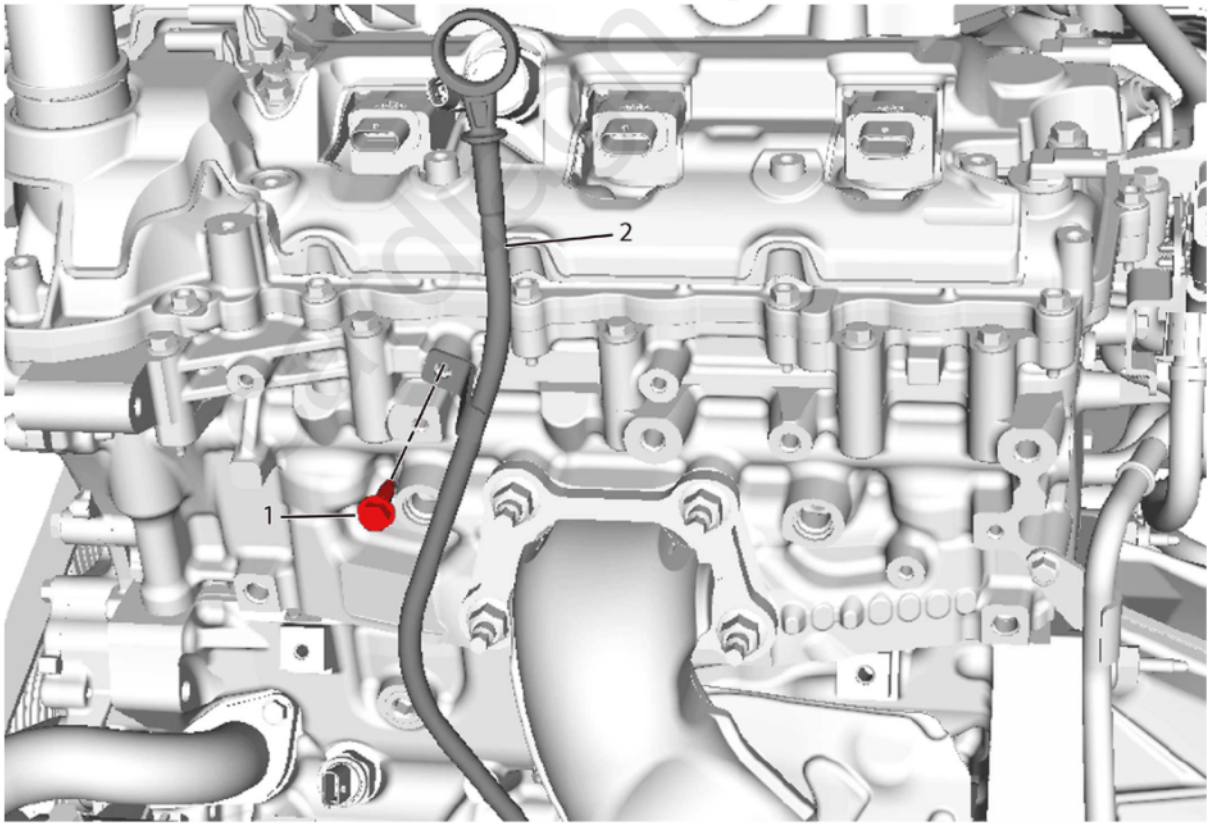


Fig. 222: Oil Level Indicator and Tube
Courtesy of GENERAL MOTORS COMPANY

11. Catalytic Converter - Left Side (3)Â» Install - **Warm Up Three-Way Catalytic Converter Replacement (Left, LGX)**

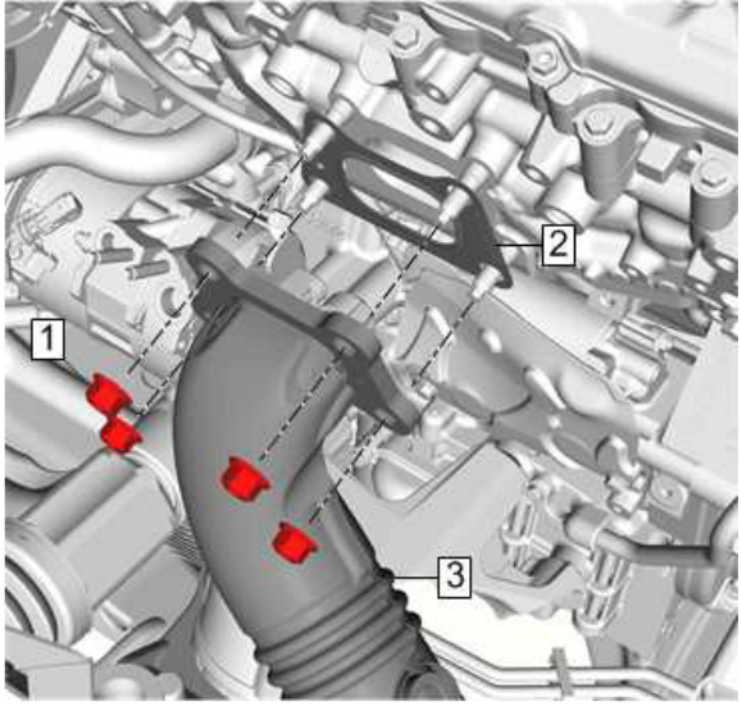


Fig. 223: Catalytic Converter Gasket And Converter
Courtesy of GENERAL MOTORS COMPANY

12. Fuel Injection Fuel Rail Noise Shield (1)Â» Install - **Fuel Injection Fuel Rail Noise Shield Replacement**

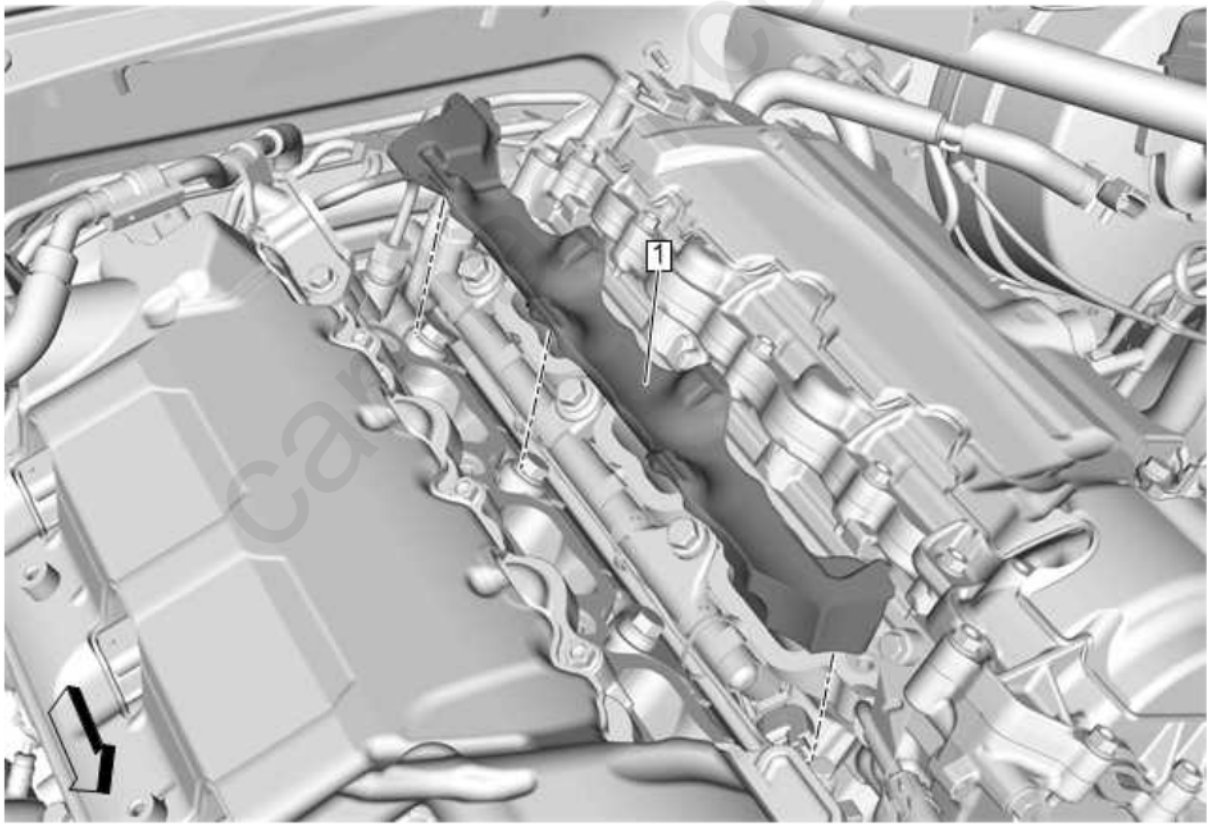


Fig. 224: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

13. Camshaft Timing Chain - Left SideÂ» Install - **Camshaft Timing Chain Assembly Replacement - Left Side**
14. Fuel Feed Intermediate Pipe (2)Â» Install - **Fuel Feed Intermediate Pipe Replacement (LGX)**

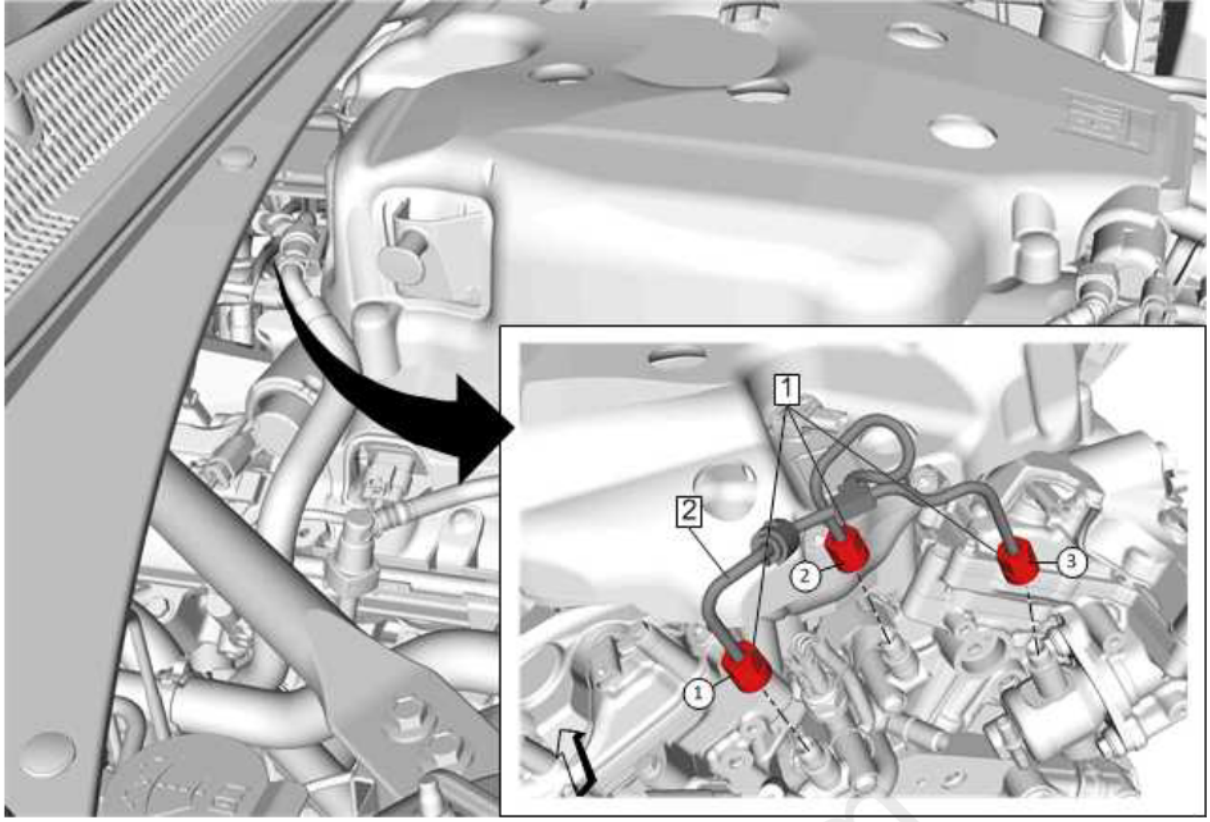


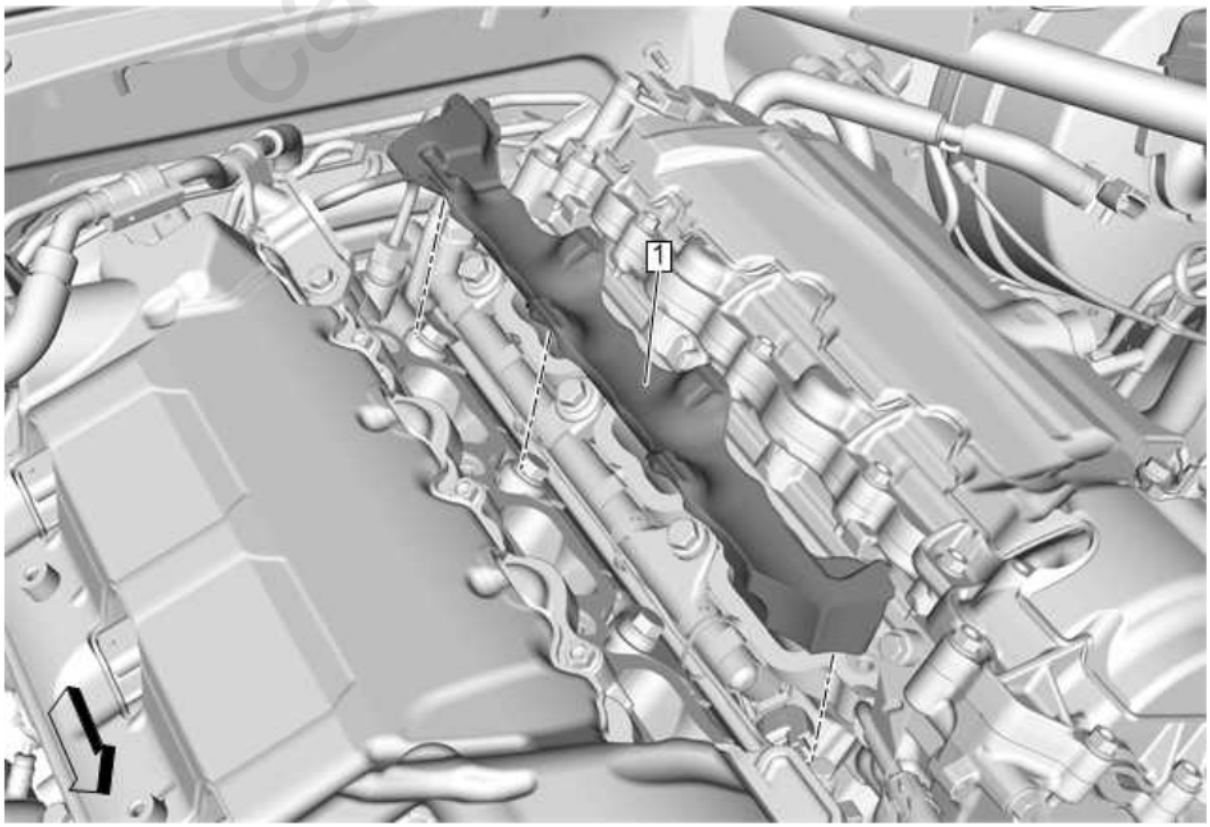
Fig. 225: Fuel Feed Intermediate Pipe
Courtesy of GENERAL MOTORS COMPANY

15. EngineÂ» Install - **Engine Replacement (LGX)**

CYLINDER HEAD REPLACEMENT - RIGHT SIDE (LGW)

Removal Procedure

1. EngineÂ» Remove - **Engine Replacement (LGW)**
2. Camshaft Timing Chain - Right SideÂ» Remove - **Camshaft Timing Chain Assembly Replacement - Right Side**
3. Fuel Injection Fuel Rail Noise Shield (1)Â» Remove - **Fuel Injection Fuel Rail Noise Shield Replacement**



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Fig. 226: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

4. Turbocharger - Right SideÂ» Remove - **Turbocharger Replacement (Right Side)**
5. Fuel PumpÂ» Remove - **Fuel Pump Replacement**
6. Remove the ground wire bolt (1) and ground wire (2).

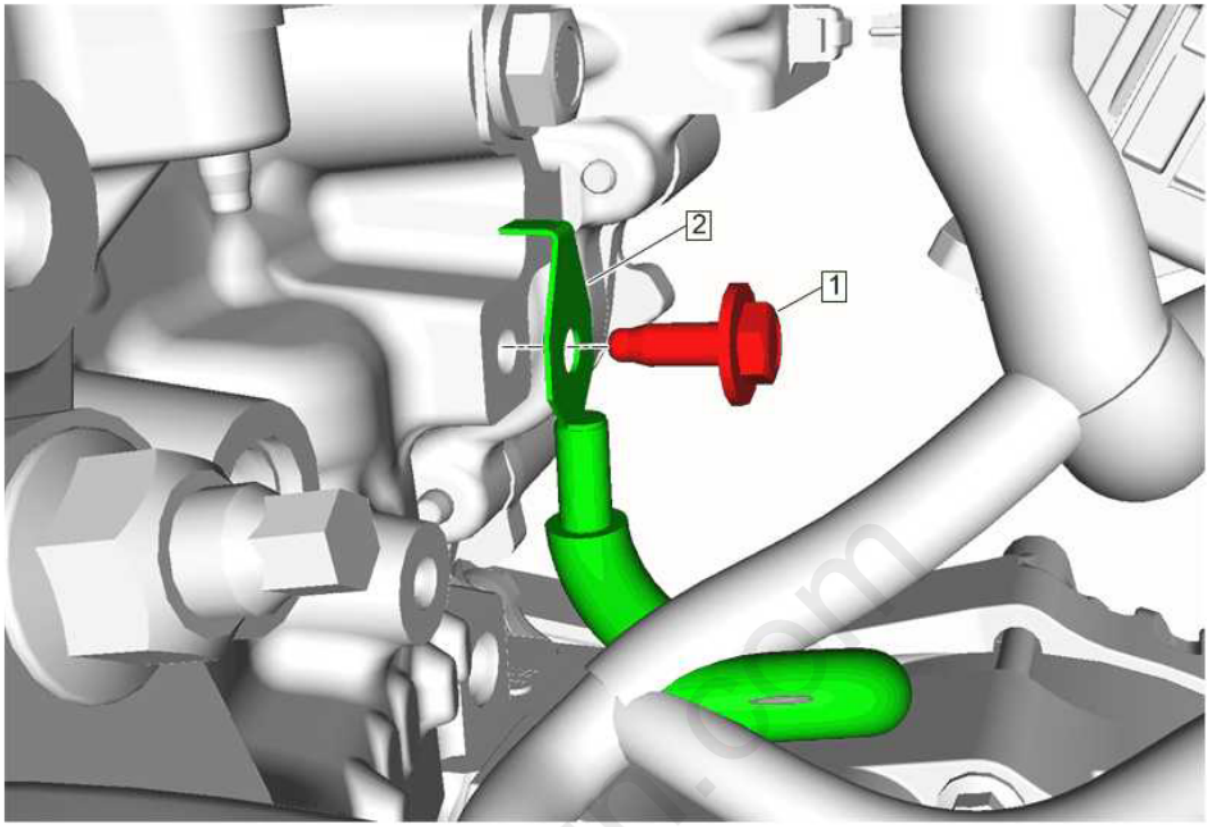


Fig. 227: Ground Wire Bolt And Ground Wire
Courtesy of GENERAL MOTORS COMPANY

7. Disconnect and reposition harness as necessary.
8. Camshaft - Right SideÂ» Remove - **Camshaft Removal - Right Side**
9. Camshaft Carrier - Right Side (2)Â» Remove - **Camshaft Carrier Removal - Right Side**

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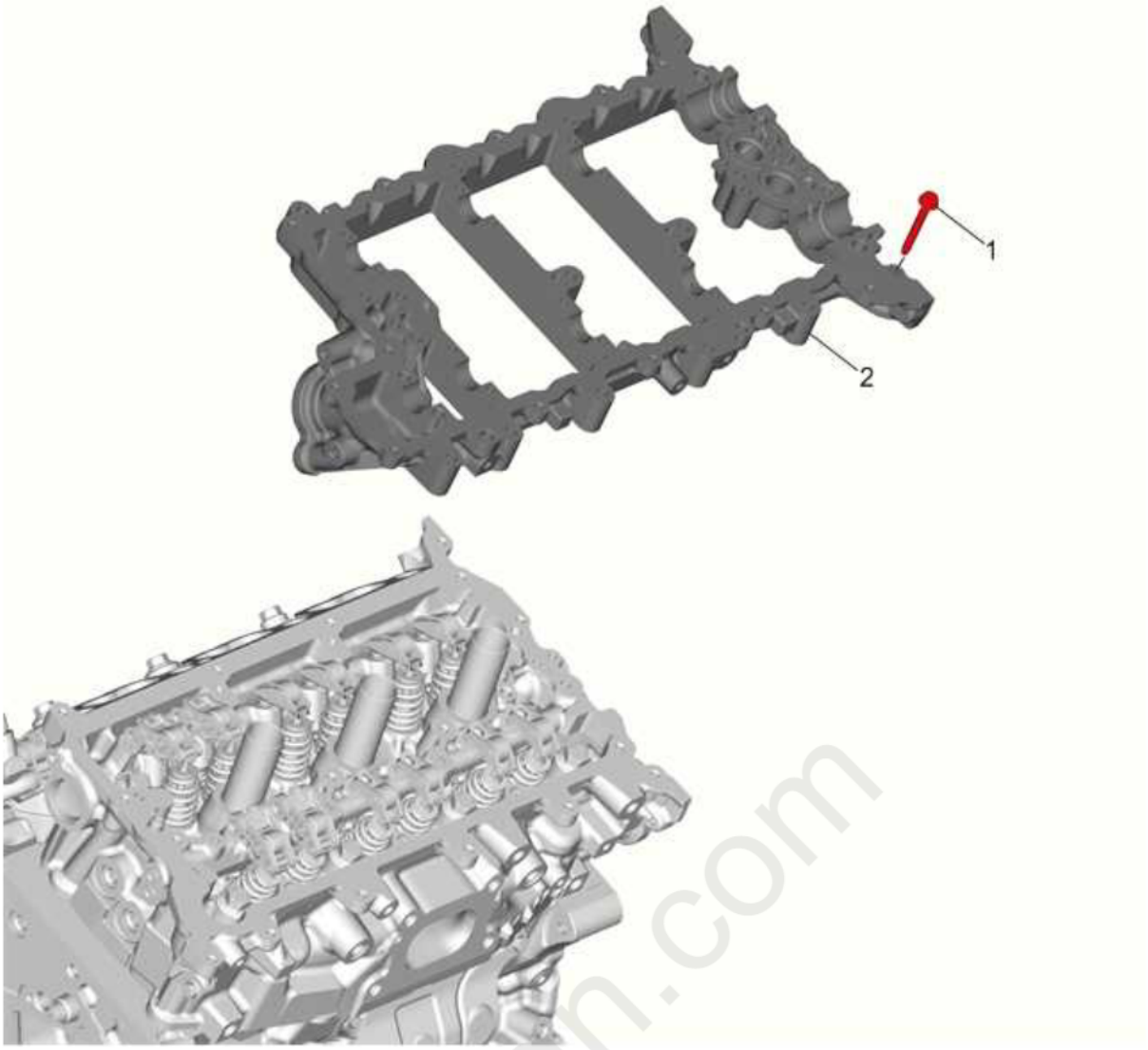


Fig. 228: Camshaft Carrier - Right Side
Courtesy of GENERAL MOTORS COMPANY

10. Valve Lifter 1, 2 - Right SideÂ» Remove [12x] - **Valve Lifter Replacement - Right Side**

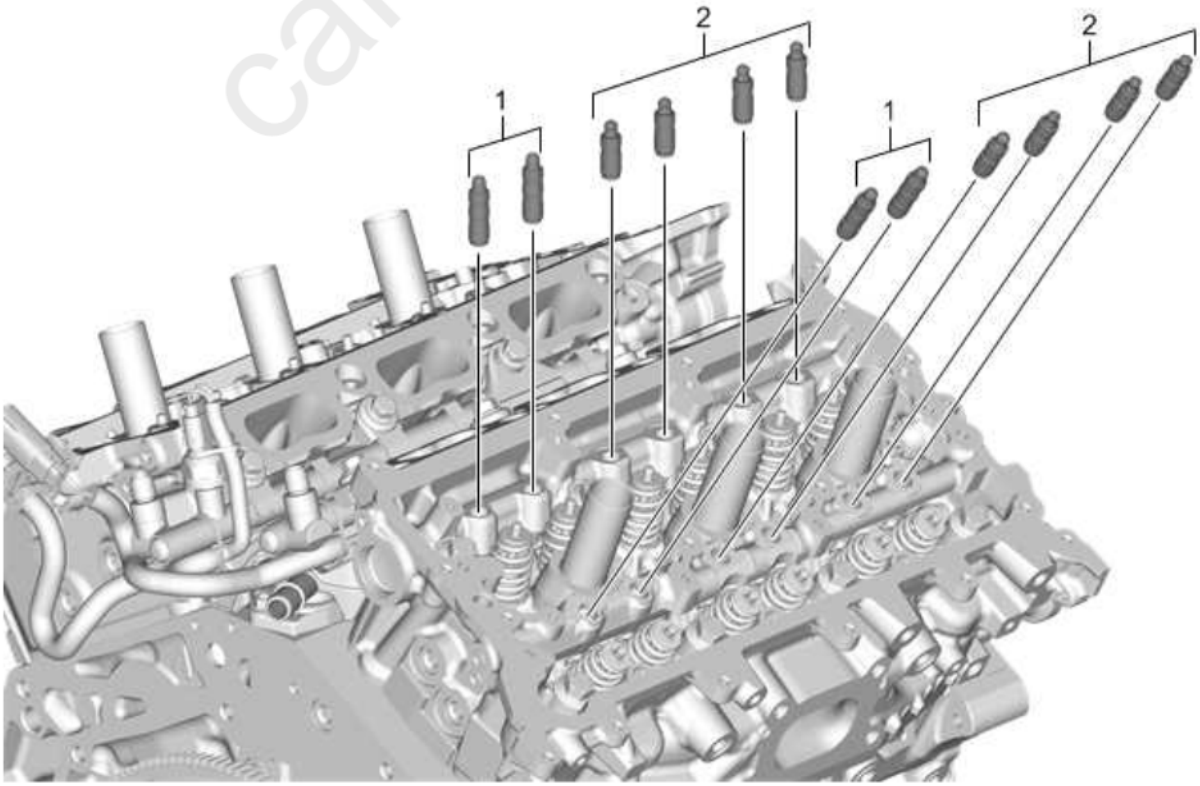


Fig. 229: Valve Lifter Removal - Right Side
Courtesy of GENERAL MOTORS COMPANY

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11. Cylinder Head Bolt (1) [8x]Â» Remove and DISCARD

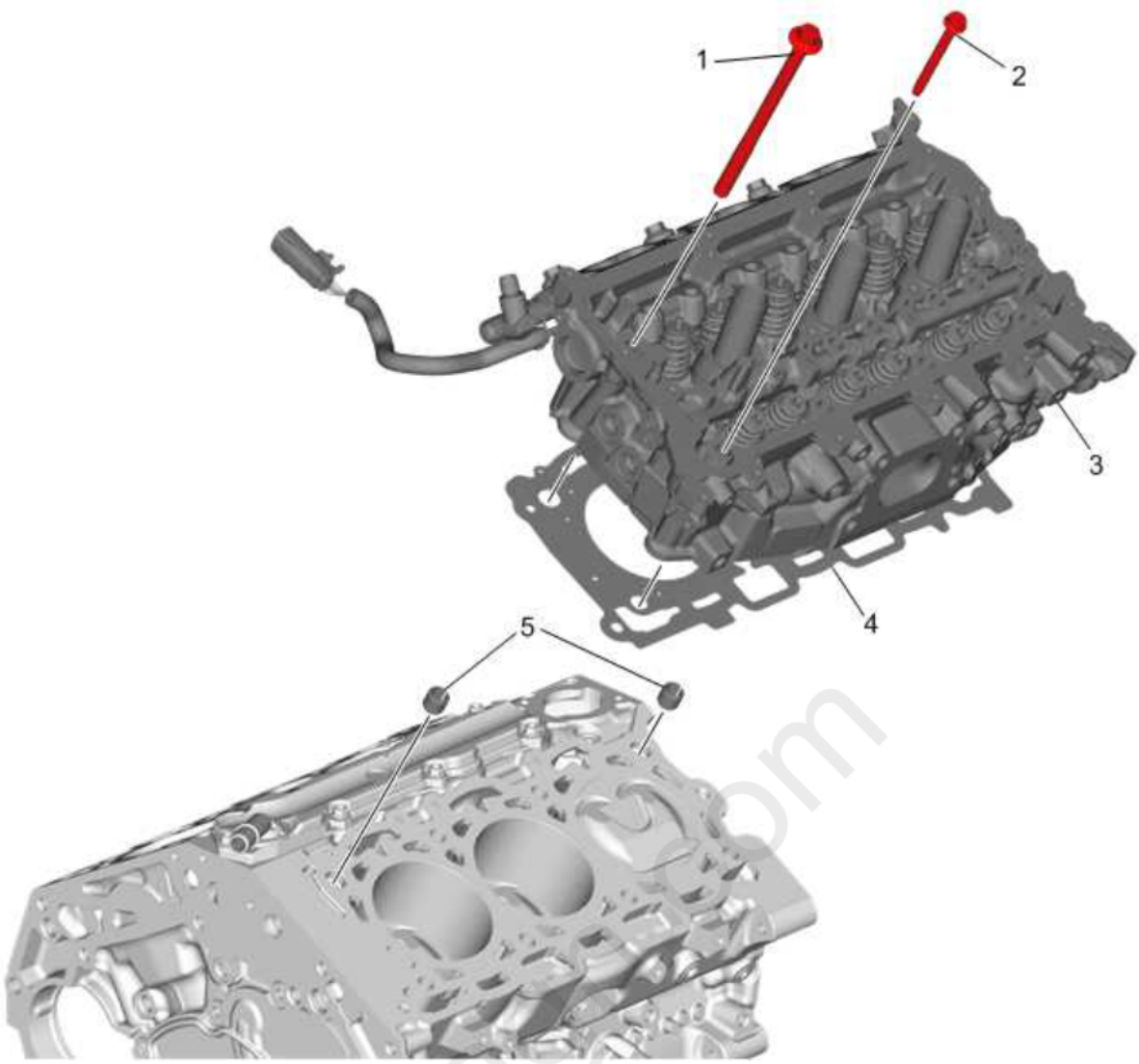


Fig. 230: Cylinder Head Bolt
Courtesy of GENERAL MOTORS COMPANY

12. Remove and DISCARD the rear M8 right cylinder head bolt (2).
13. Cylinder Head Assembly (3)Â» Remove
14. Cylinder Head Gasket (4)Â» Remove and DISCARD
15. Cylinder Head AssemblyÂ» Clean and inspect - **Cylinder Head Cleaning and Inspection**
16. Engine BlockÂ» Clean and inspect - **Engine Block Cleaning and Inspection**
17. Disassemble the cylinder head as necessary. Refer to **Cylinder Head Disassemble**

Installation Procedure

1. Assemble the cylinder head as necessary. Refer to **Cylinder Head Assemble**
2. Ensure the cylinder head locating pins (5) are securely mounted in the cylinder block deck face.

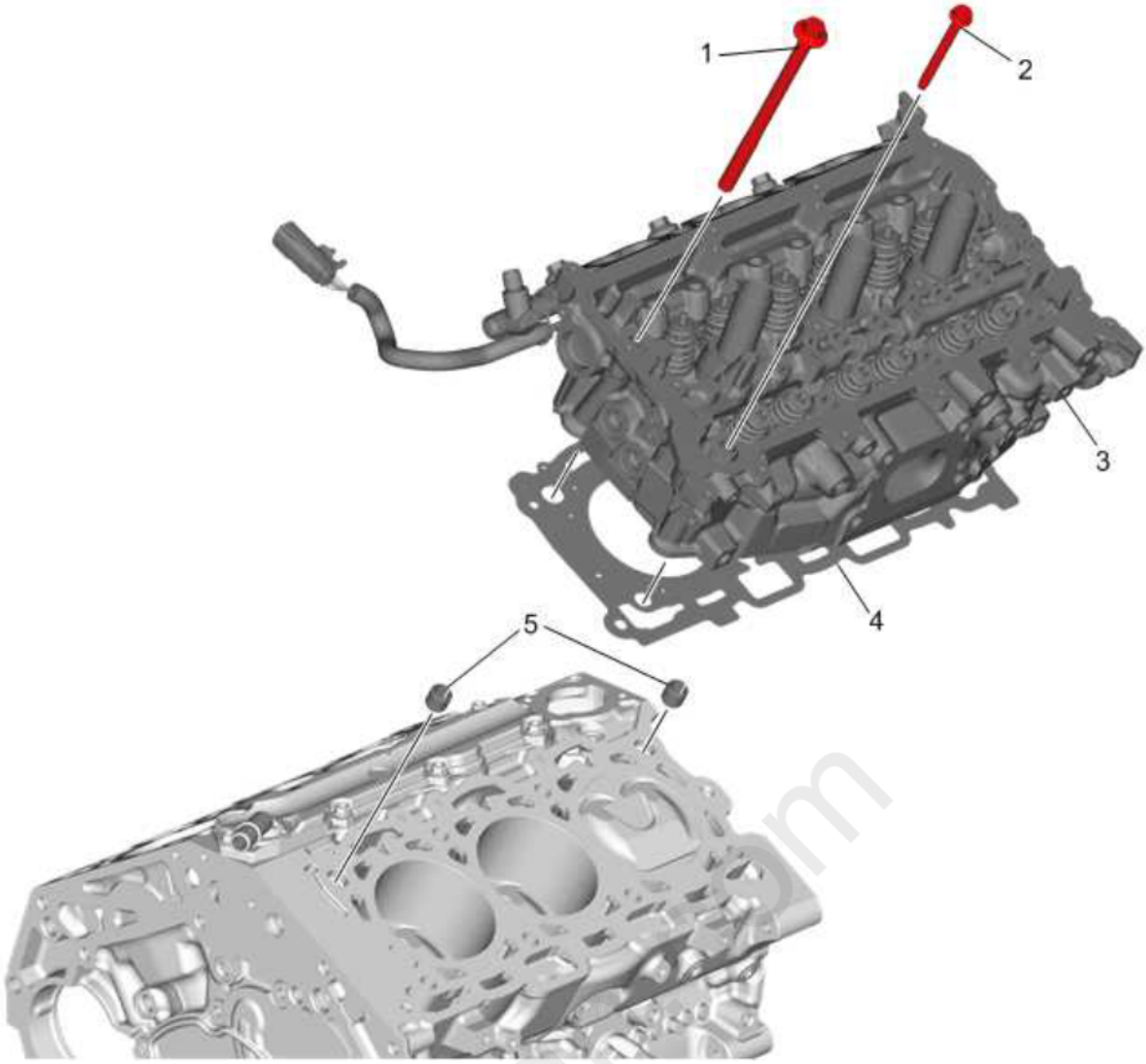


Fig. 231: Cylinder Head Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW left cylinder head gasket (4) using the deck face locating pins for retention.
4. Cylinder Head Assembly (3)Â» Install - **Cylinder Head Installation - Left Side**
5. Valve Lifter 1, 2 - Right SideÂ» Install [12x] - **Valve Lifter Replacement - Right Side**

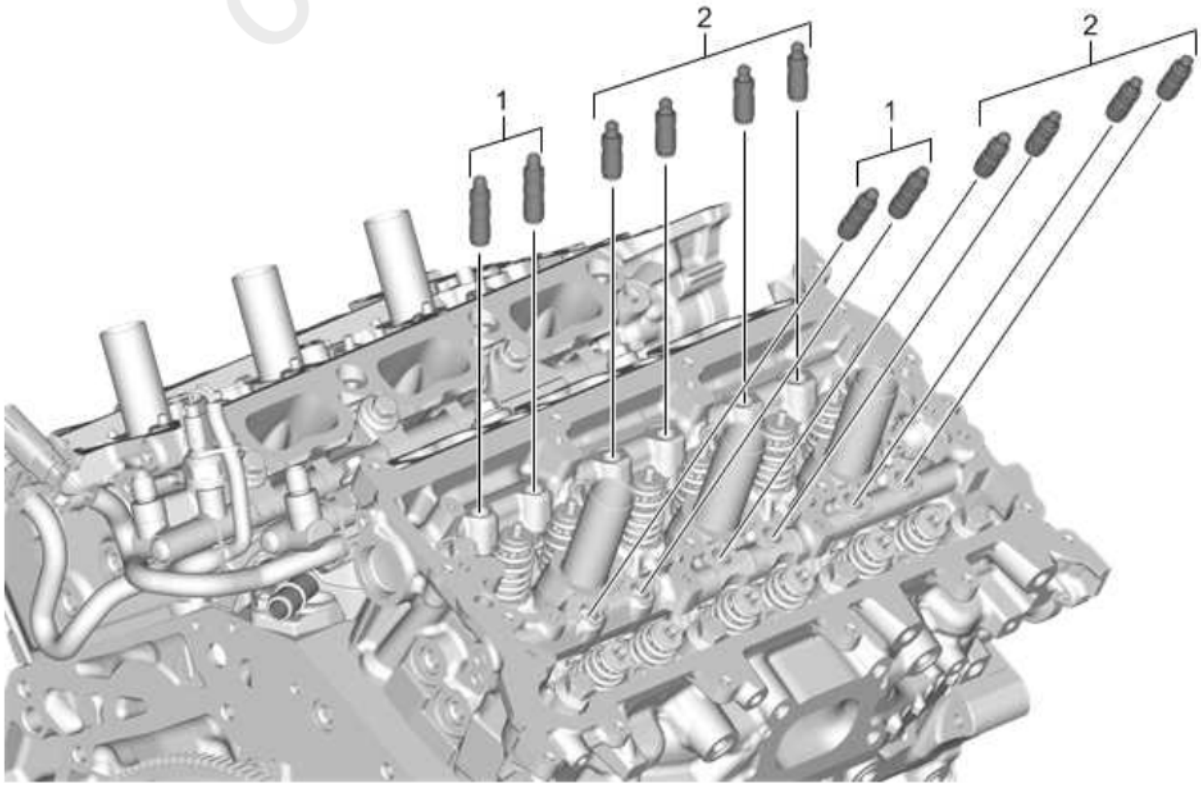


Fig. 232: Valve Lifter Removal - Right Side
Courtesy of GENERAL MOTORS COMPANY

6. Camshaft Carrier - Right Side (2)Â» Install - **Camshaft Carrier Installation - Right Side**

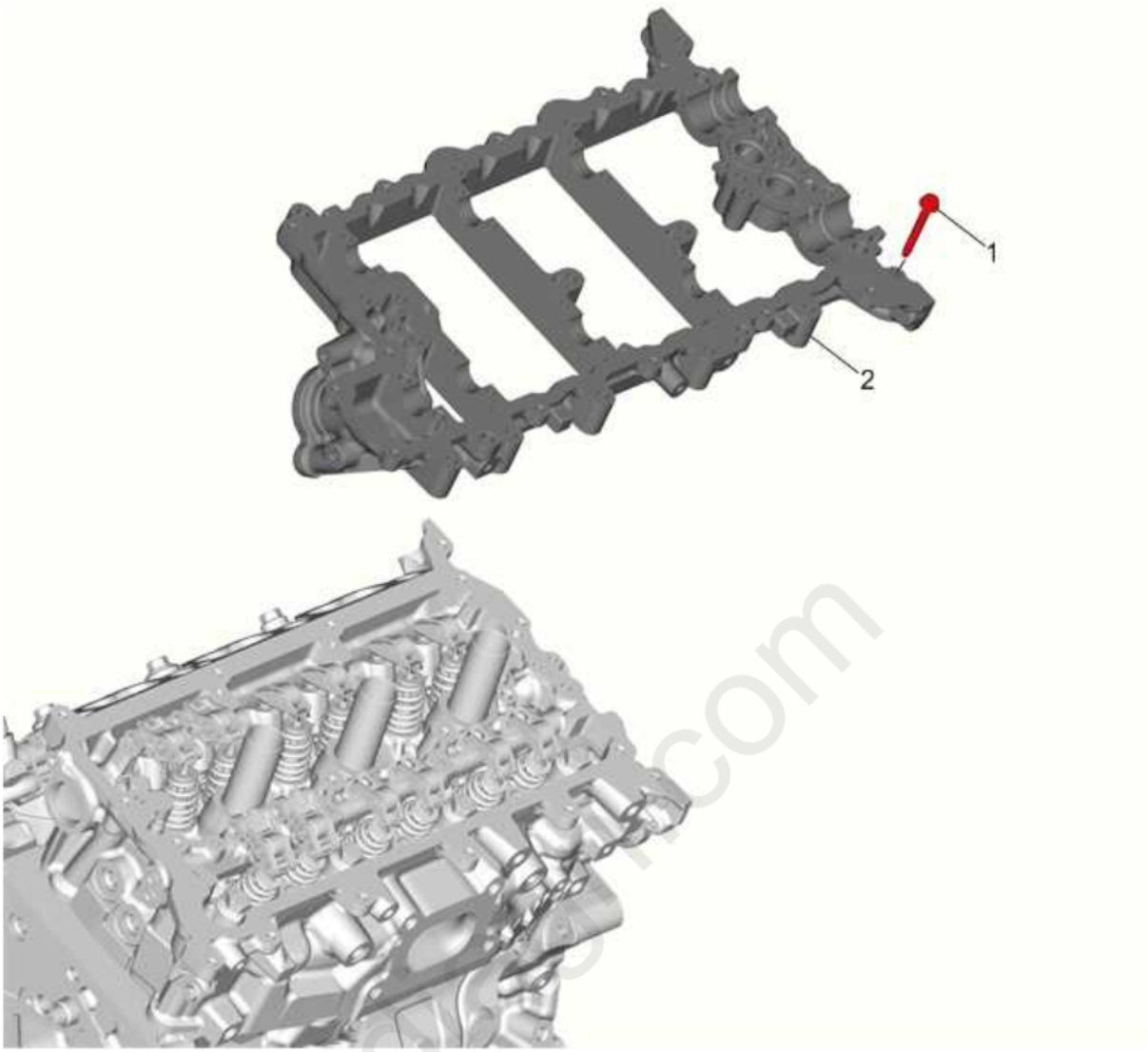


Fig. 233: Camshaft Carrier - Right Side
Courtesy of GENERAL MOTORS COMPANY

7. Camshaft - Right SideÂ» Install - **Camshaft Installation - Right Side**
8. Position wire harness and connect as necessary.
9. Install ground wire and ground wire bolt. **Ground Repair**

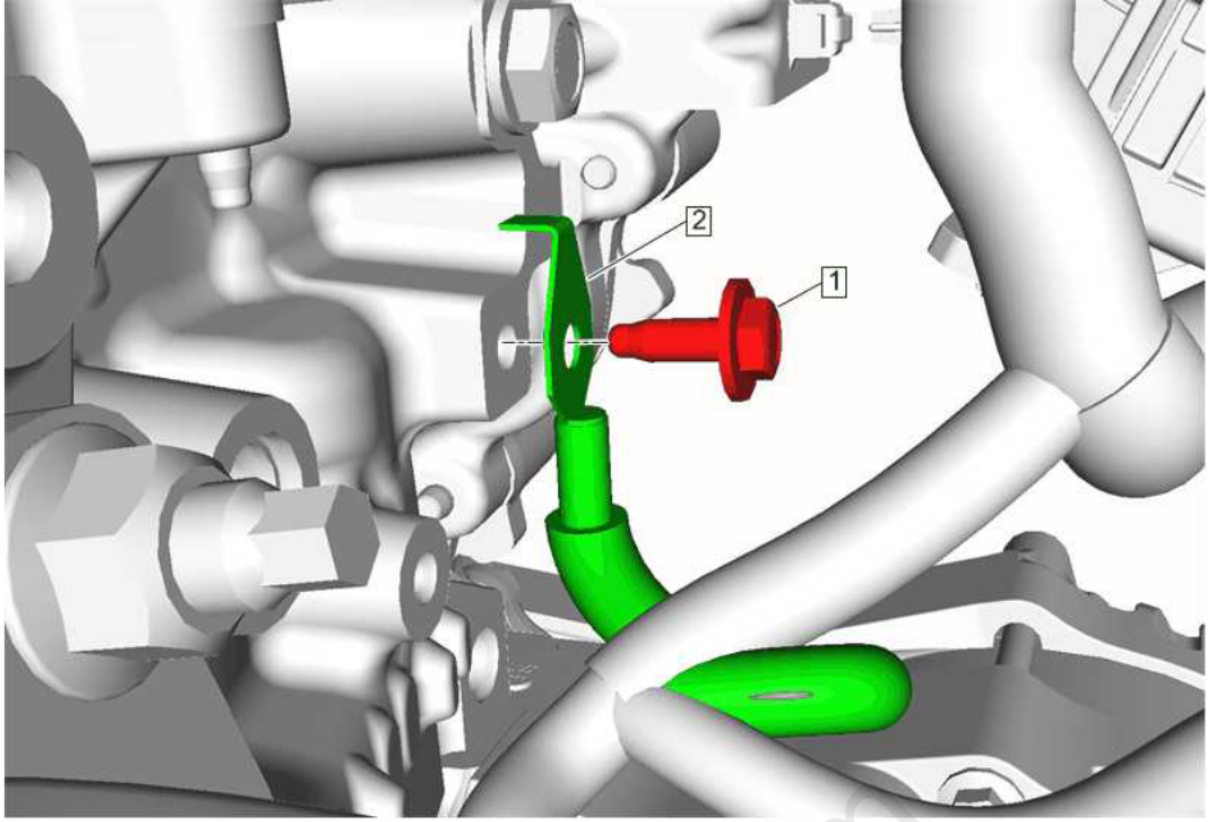


Fig. 234: Ground Wire Bolt And Ground Wire
Courtesy of GENERAL MOTORS COMPANY

10. **Turbocharger Replacement (Right Side)**Â» Install - Right Side
11. Camshaft Timing Chain - Right SideÂ» Install - **Camshaft Timing Chain Assembly Replacement - Right Side**
12. Fuel Injection Fuel Rail Noise Shield (1)Â» Install - **Fuel Injection Fuel Rail Noise Shield Replacement**

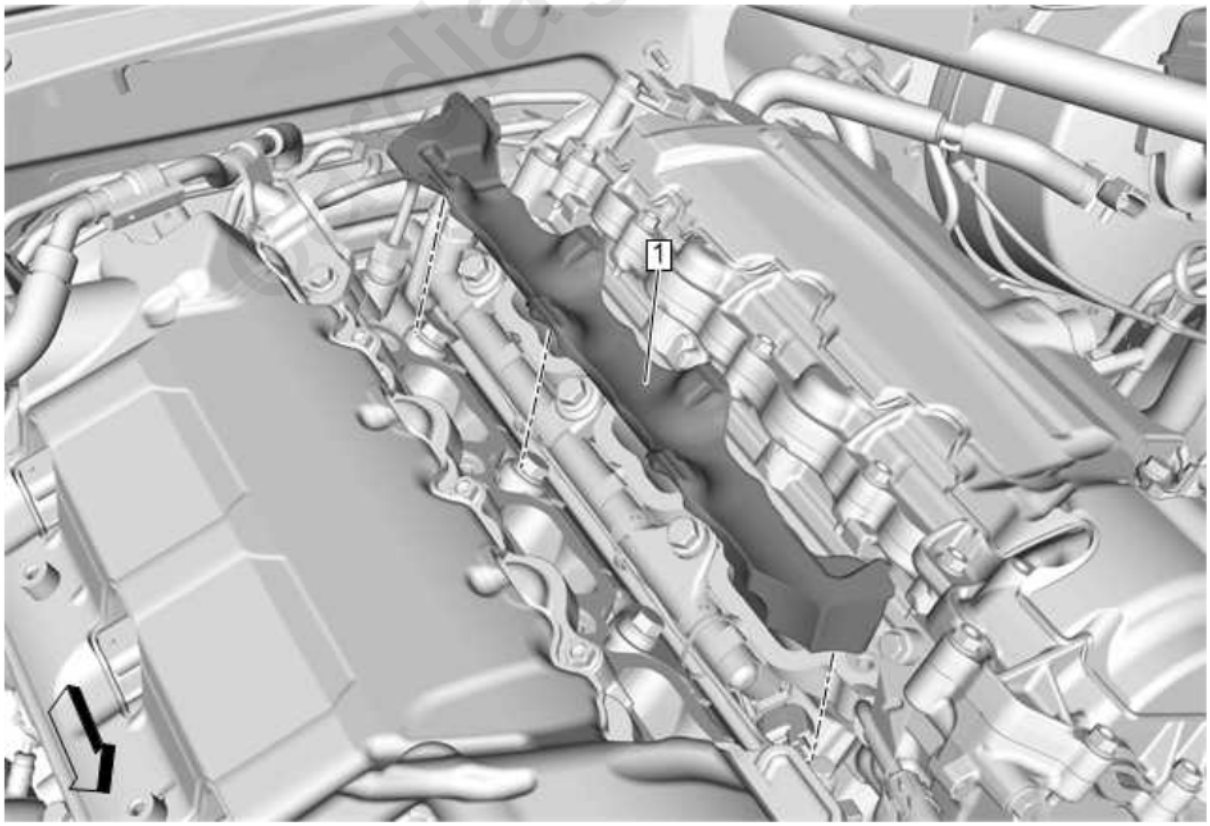


Fig. 235: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

13. Camshaft Timing Chain - Right SideÂ» Install - **Camshaft Timing Chain Assembly Replacement - Right Side**

14. EngineÂ» Install - **Engine Replacement (LGW)**

CYLINDER HEAD REPLACEMENT - RIGHT SIDE (LGX)

Removal Procedure

1. EngineÂ» Remove - **Engine Replacement (LGX)**
2. Camshaft Timing Chain - Right SideÂ» Remove - **Camshaft Timing Chain Assembly Replacement - Right Side**
3. Fuel Injection Fuel Rail Noise Shield (1)Â» Remove - **Fuel Injection Fuel Rail Noise Shield Replacement**

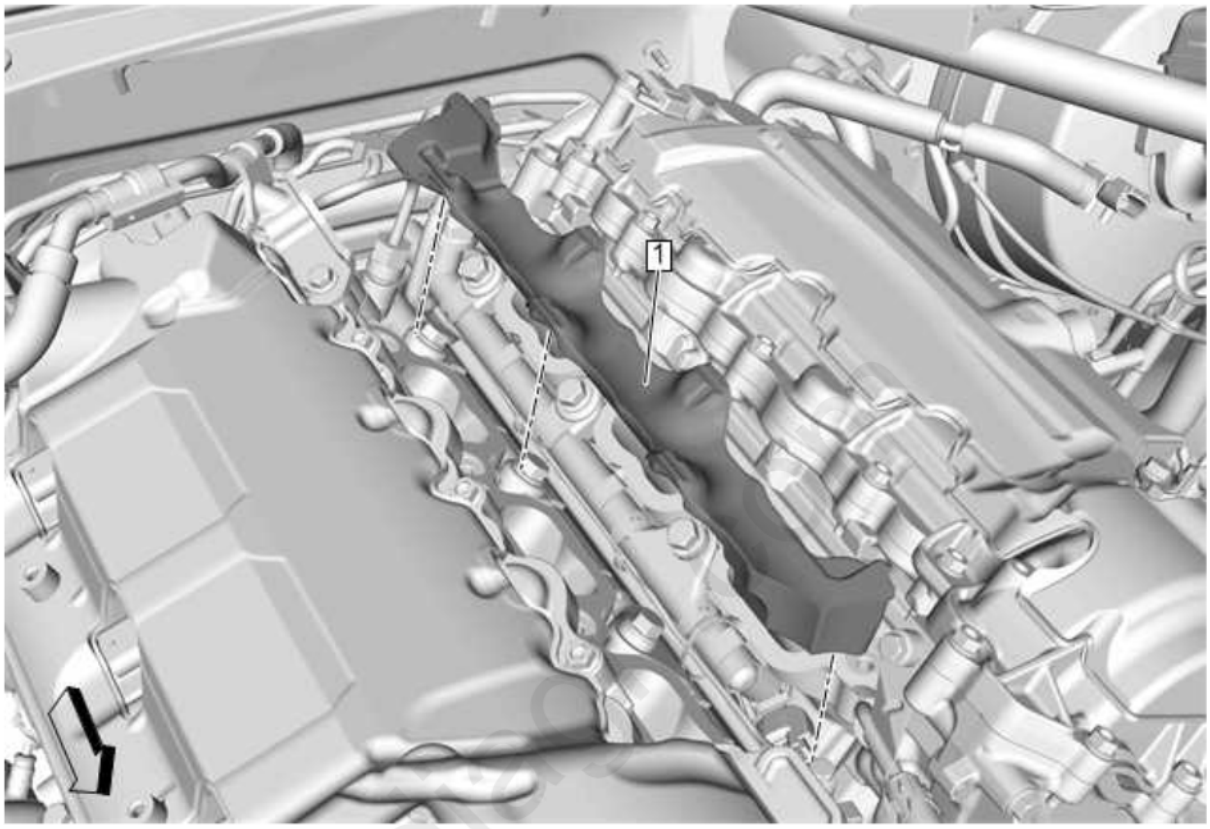


Fig. 236: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

4. Fuel PumpÂ» Remove - **Fuel Pump Replacement**
5. Remove the ground wire bolt (1) and ground wire (2).

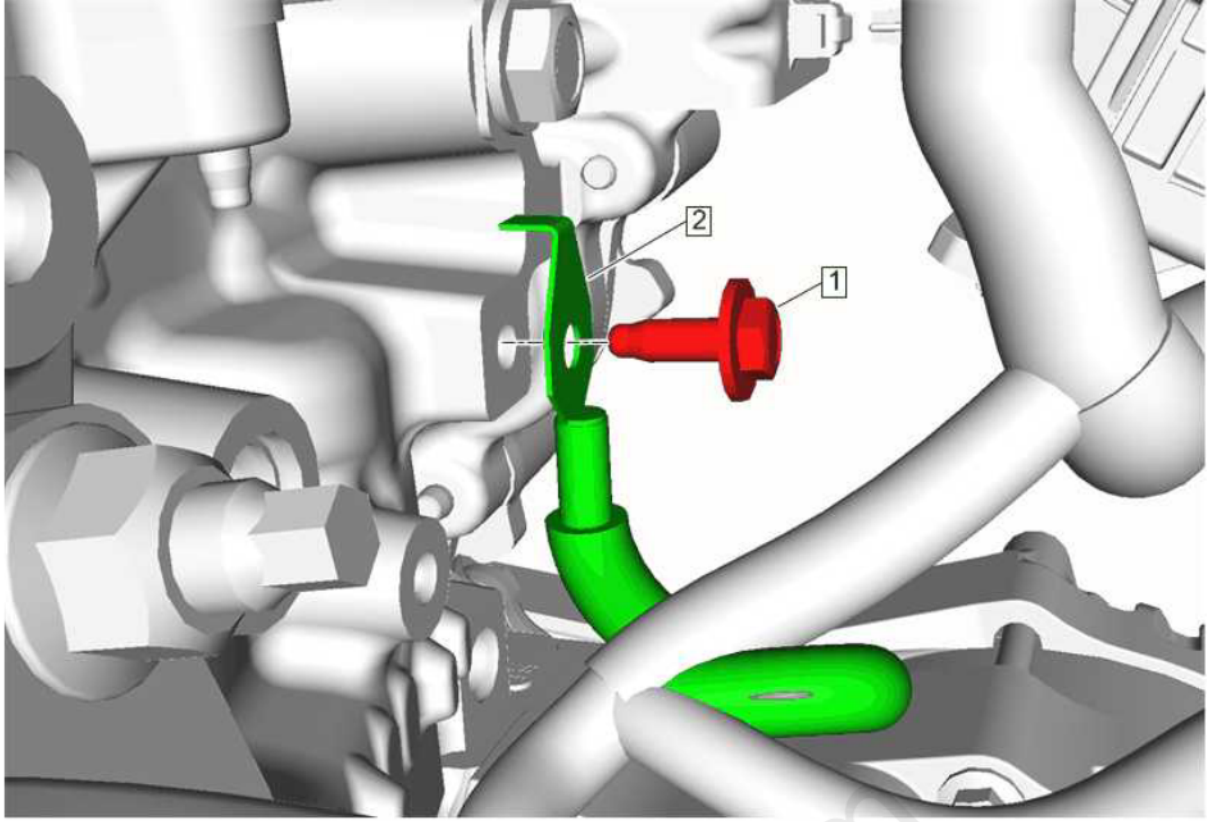
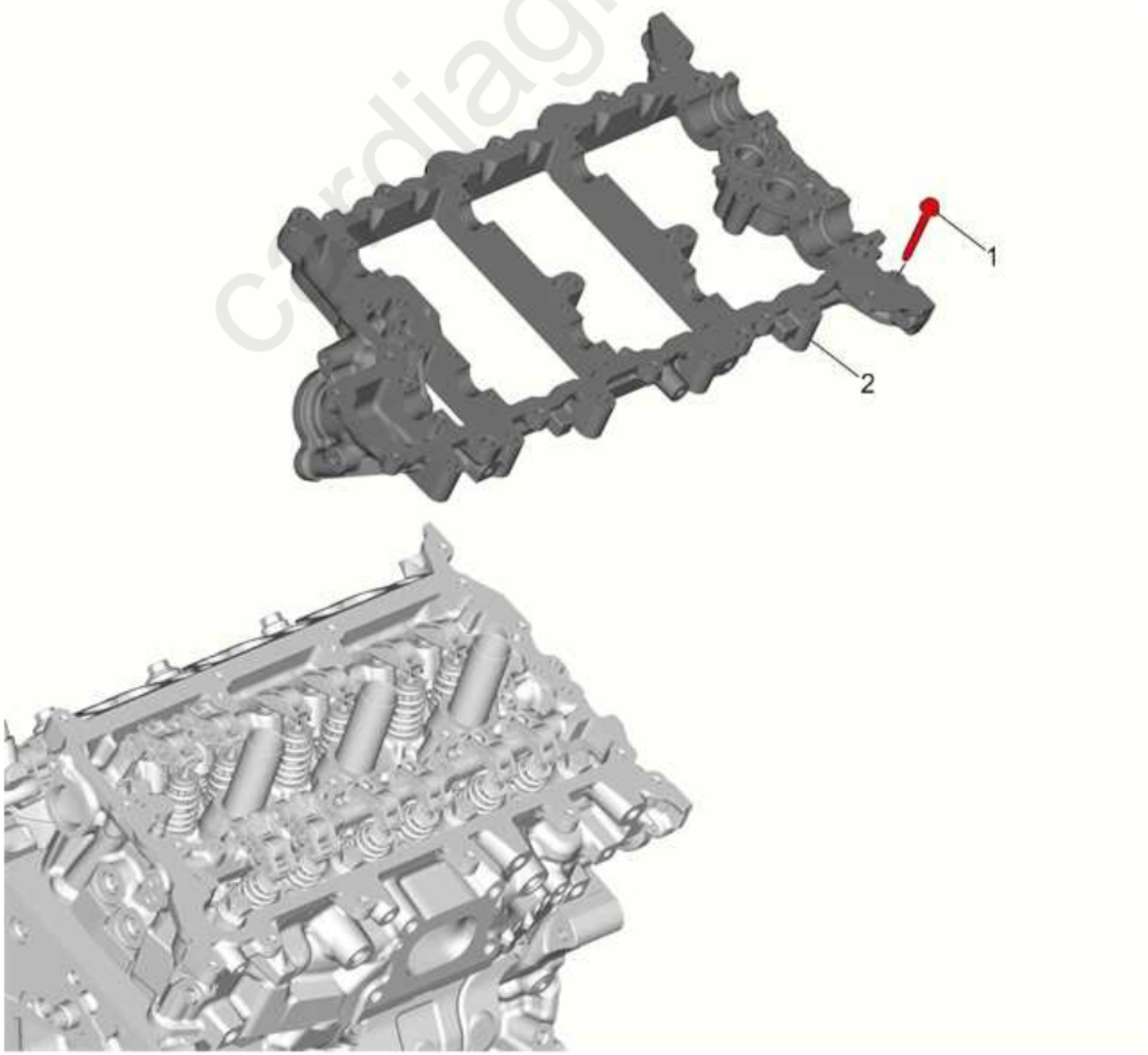


Fig. 237: Ground Wire Bolt And Ground Wire
Courtesy of GENERAL MOTORS COMPANY

6. Disconnect and reposition harness as necessary.
7. Camshaft - Right SideÂ» Remove - **Camshaft Removal - Right Side**
8. Camshaft Carrier - Right Side (2)Â» Remove - **Camshaft Carrier Removal - Right Side**



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Fig. 238: Camshaft Carrier - Right Side
Courtesy of GENERAL MOTORS COMPANY

9. Valve Lifter (1, 2) - Right SideÂ» Remove [12x] - **Valve Lifter Replacement - Right Side**

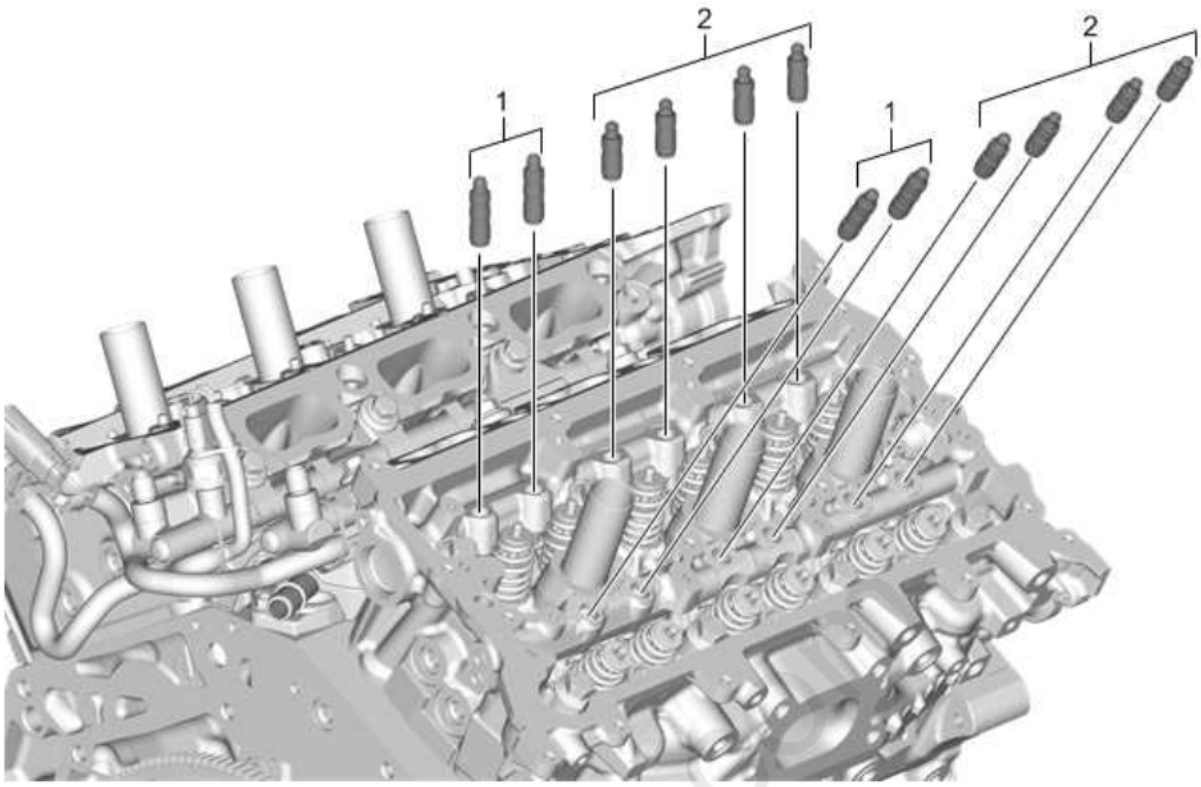


Fig. 239: Valve Lifter Removal - Right Side
Courtesy of GENERAL MOTORS COMPANY

10. Cylinder Head Bolt (1) [8x]Â» Remove and DISCARD

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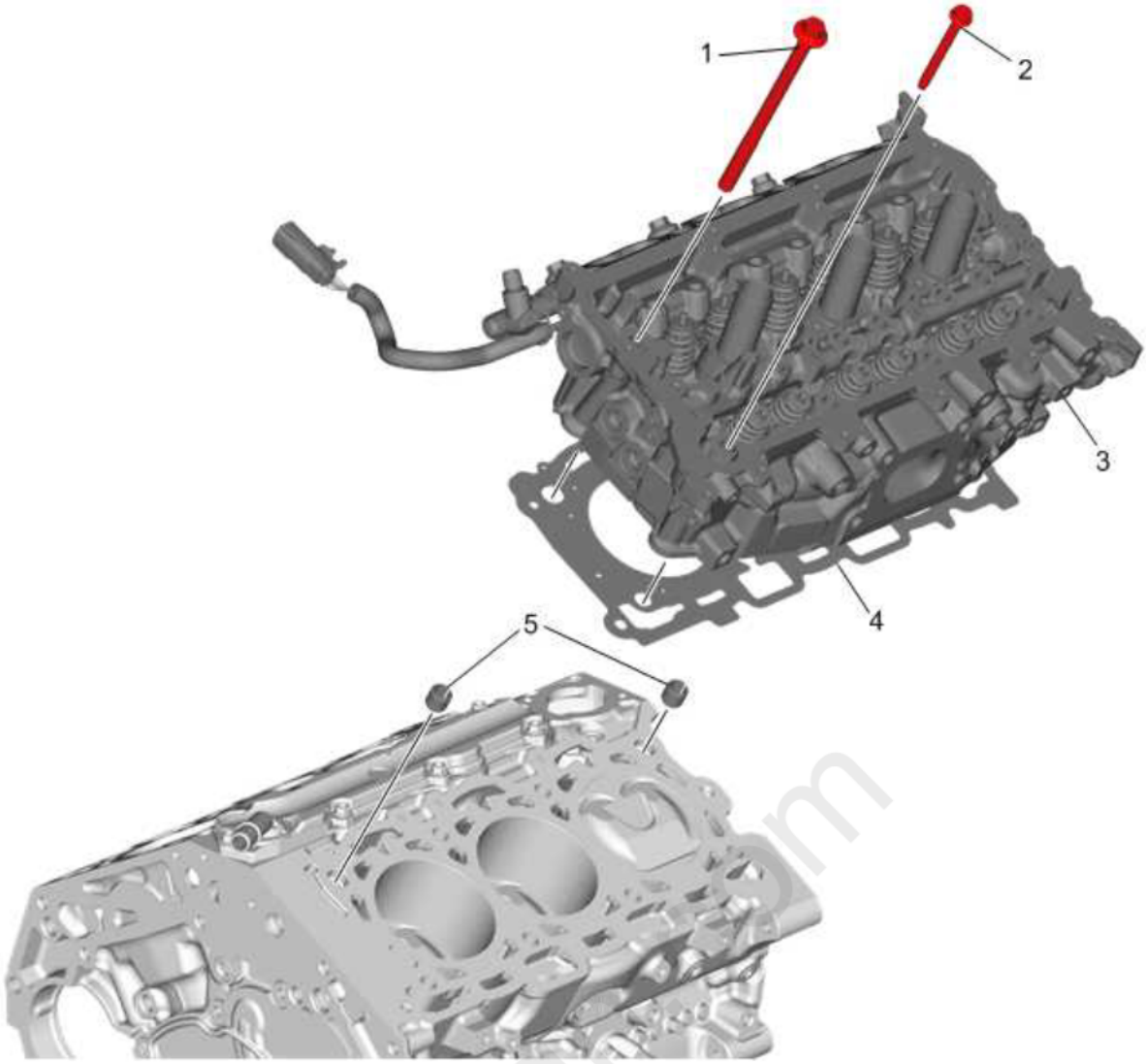


Fig. 240: Cylinder Head Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Remove and DISCARD the rear M8 right cylinder head bolt (2).
12. Cylinder Head Assembly (3)Â» Remove
13. Cylinder Head Gasket (4)Â» Remove and DISCARD
14. Cylinder HeadÂ» Clean and inspect - **Cylinder Head Cleaning and Inspection**
15. Engine BlockÂ» Clean and inspect - **Engine Block Cleaning and Inspection**
16. Disassemble the cylinder head as necessary. Refer to **Cylinder Head Disassemble**

Installation Procedure

1. Assemble the cylinder head as necessary. Refer to **Cylinder Head Assemble**
2. Ensure the cylinder head locating pins (5) are securely mounted in the cylinder block deck face.

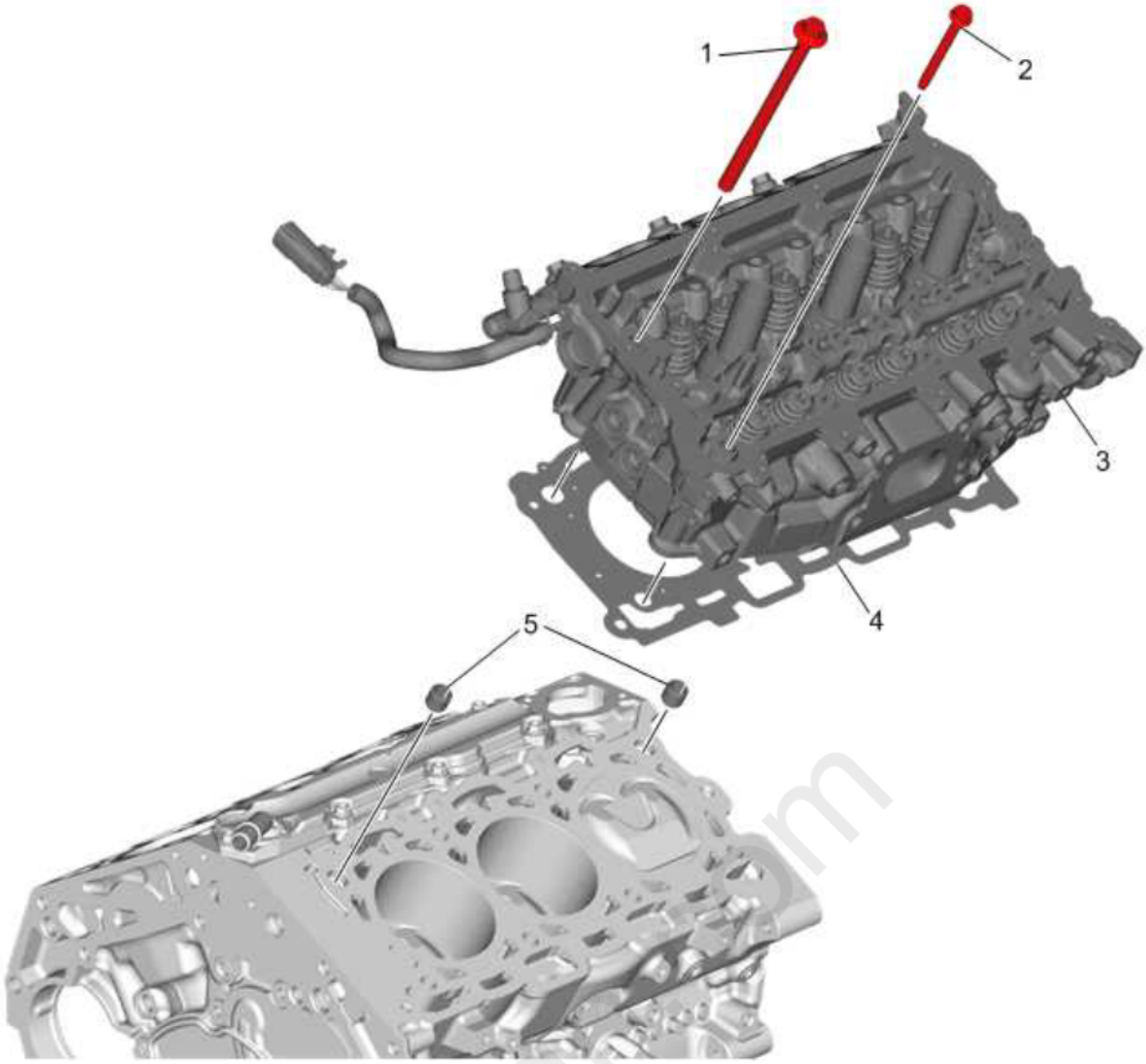


Fig. 241: Cylinder Head Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW right cylinder head gasket (4) using the deck face locating pins for retention.
4. Cylinder Head Assembly (3)Â» Install - **Cylinder Head Installation - Right Side**
5. Valve Lifter (1, 2) - Right SideÂ» Install [12x] - **Valve Lifter Replacement - Right Side**

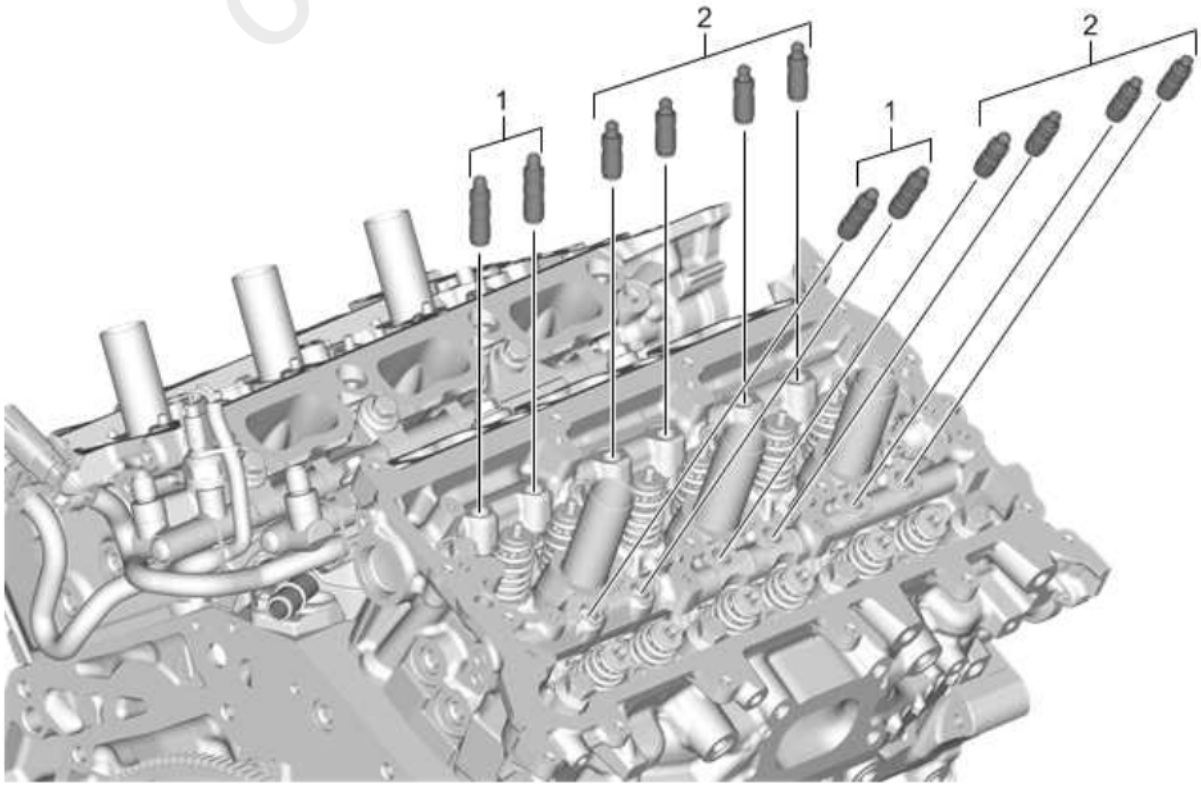


Fig. 242: Valve Lifter Removal - Right Side
Courtesy of GENERAL MOTORS COMPANY

6. Camshaft Carrier - Right Side (2)Â» Install - **Camshaft Carrier Installation - Right Side**

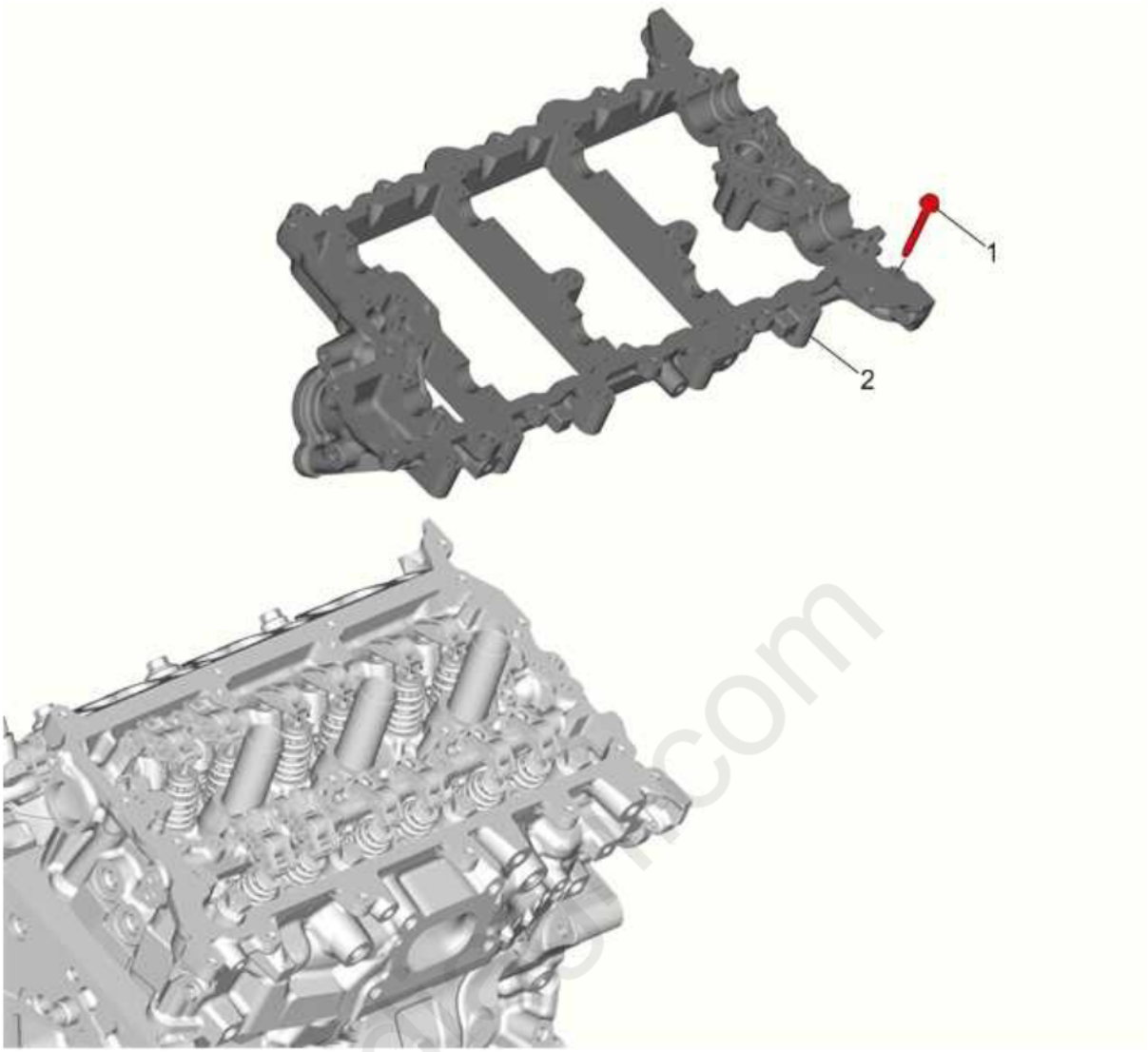


Fig. 243: Camshaft Carrier - Right Side
Courtesy of GENERAL MOTORS COMPANY

7. Camshaft - Right SideÂ» Install - **Camshaft Installation - Right Side**
8. Position wire harness and connect as necessary.
9. Install ground wire and ground wire bolt. Refer to **Ground Repair**

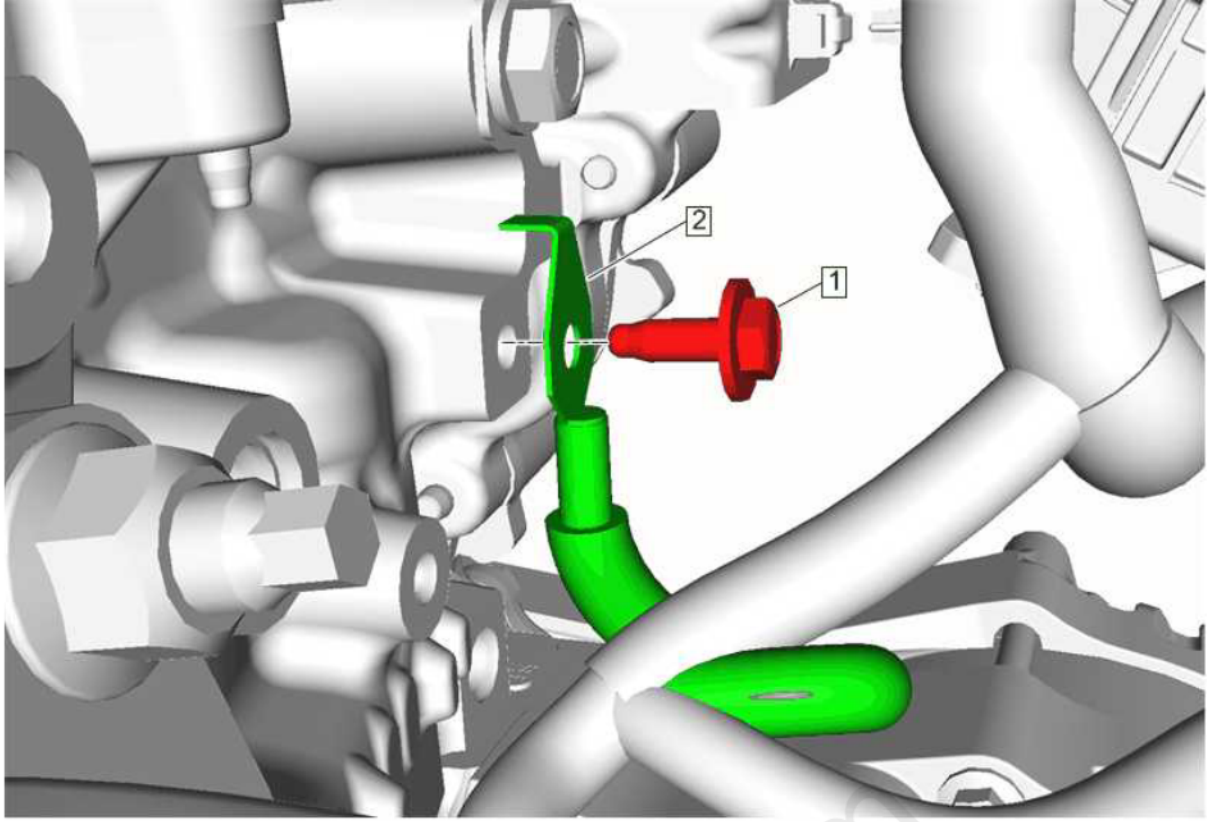


Fig. 244: Ground Wire Bolt And Ground Wire
Courtesy of GENERAL MOTORS COMPANY

10. Fuel PumpÂ» Install - Fuel Pump Replacement
11. Camshaft Timing Chain - Right SideÂ» Install - Camshaft Timing Chain Assembly Replacement - Right Side
12. Fuel Injection Fuel Rail Noise Shield (1)Â» Install - Fuel Injection Fuel Rail Noise Shield Replacement

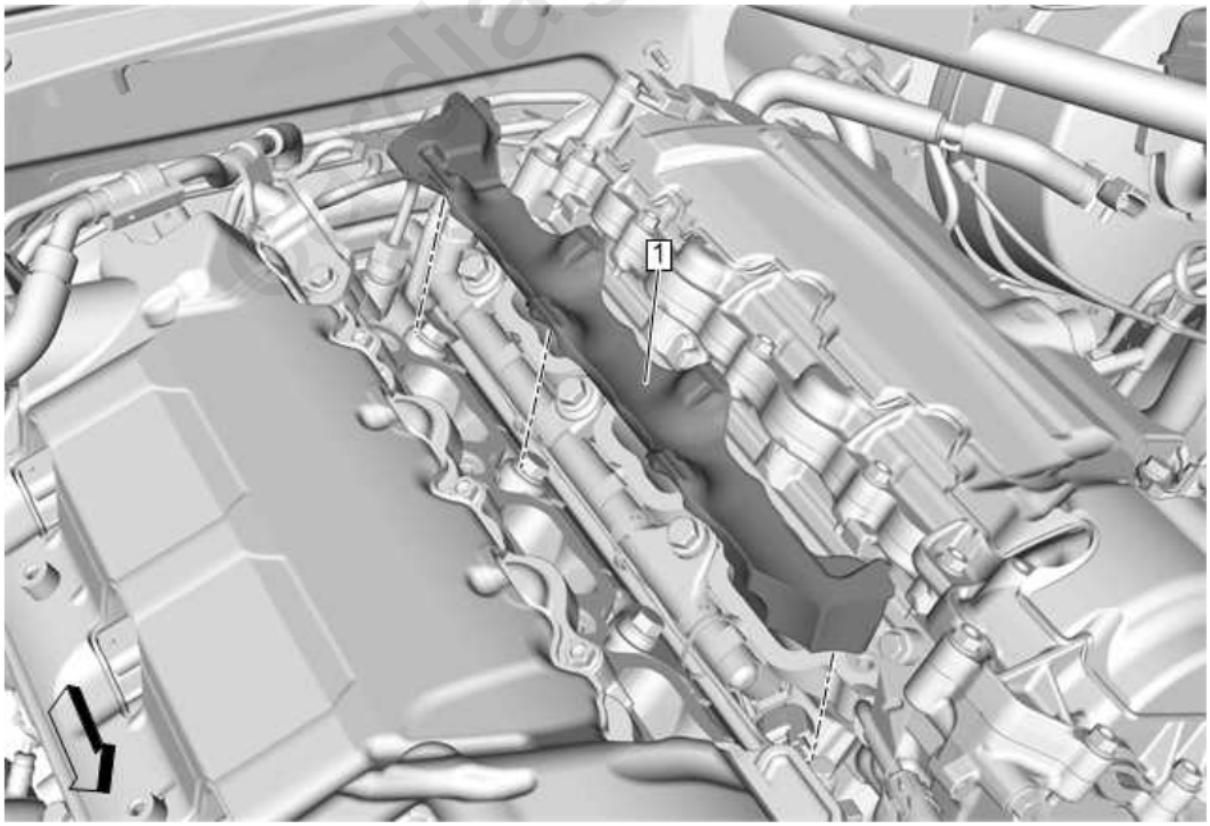


Fig. 245: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

13. EngineÂ» Install - Engine Replacement (LGX)

AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT

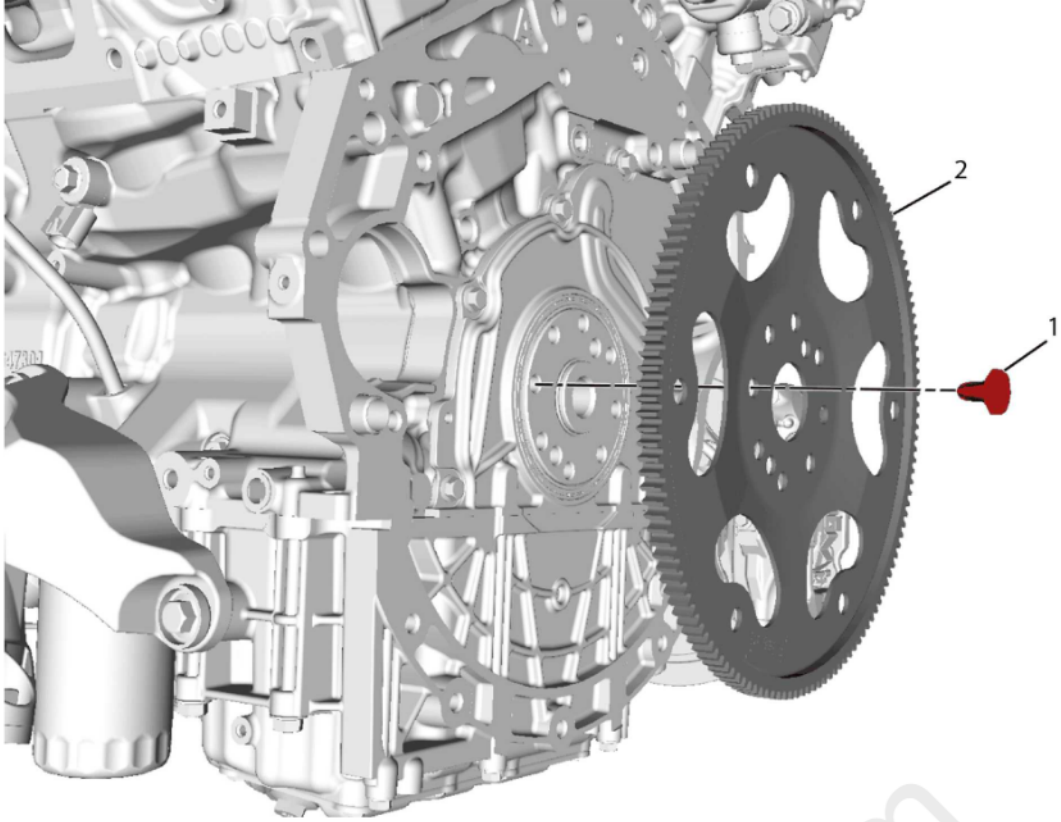


Fig. 246: Automatic Transmission Flex Plate
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Transmission Replacement (LGW Engine) Transmission Replacement (LGX Engine) **Special Tools** • **EN 45059** Angle Meter • **EN 46106** Flywheel Holding Tool Equivalent regional tools:Special Tools .	
1	Automatic Transmission Flex Plate Fastener (Qty: 8) **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:** **NEW bolts must be used whenever removing the automatic transmission flex plate.** **Tighten** 30 N.m (22 lb ft) plus 45 degrees
2	Automatic Transmission Flex Plate **Procedure** Automatic Transmission Flex Plate Cleaning and Inspection .

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CRANKSHAFT REAR OIL SEAL AND HOUSING REPLACEMENT

Removal Procedure

1. **Automatic Transmission Flex Plate Replacement**Â» Remove
2. Remove the oil pan to crankshaft rear oil seal and housing bolts (1).

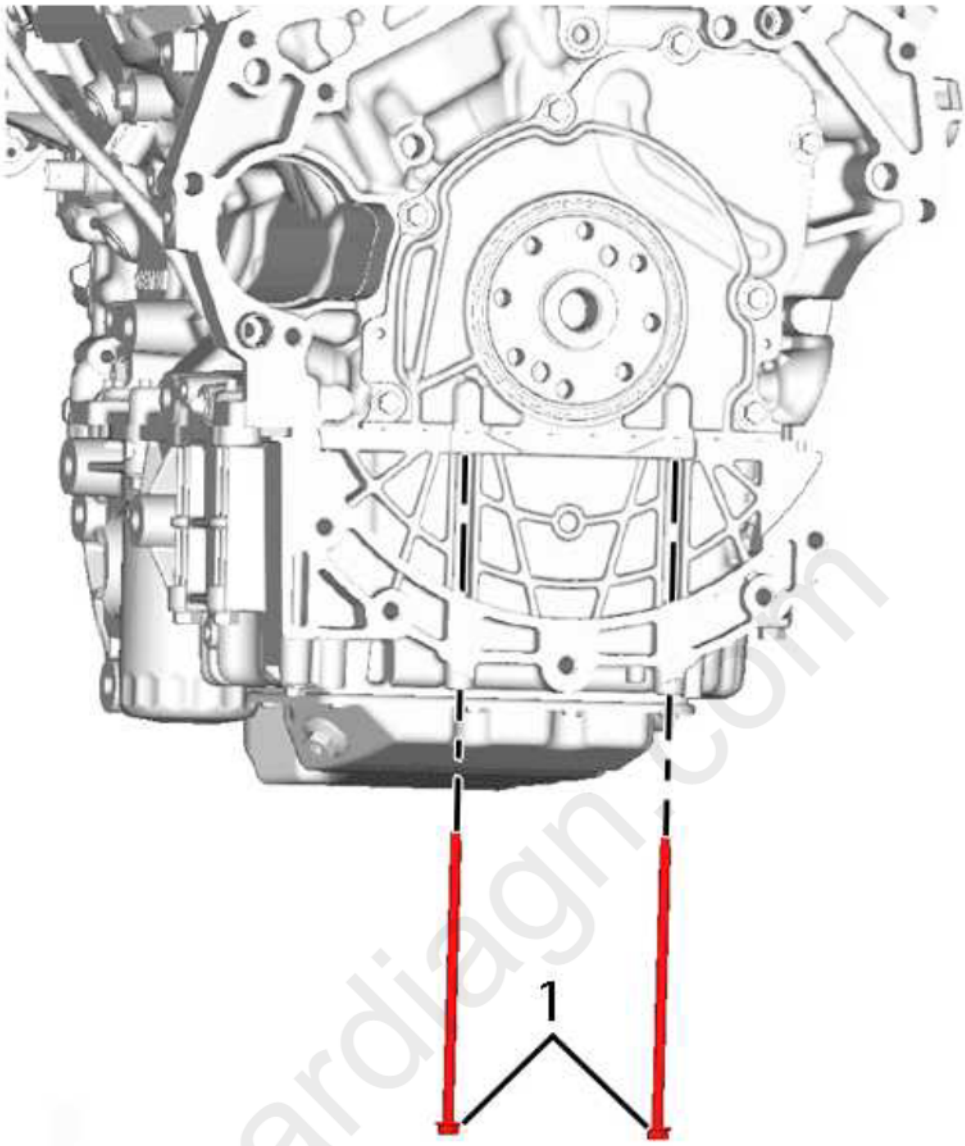


Fig. 247: Rear Oil Seal And Housing
Courtesy of GENERAL MOTORS COMPANY

3. Remove the crankshaft rear oil seal housing bolts. (1) [7x]

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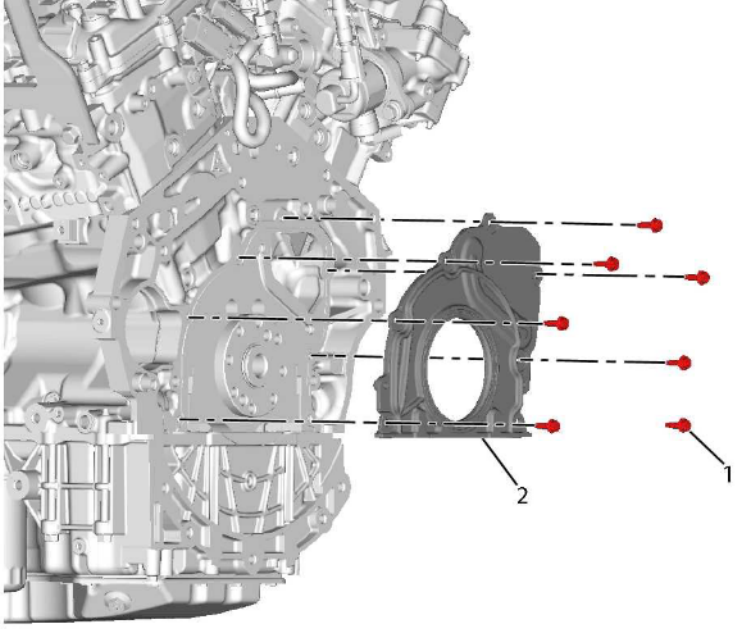


Fig. 248: Crankshaft Rear Oil Seal Housing Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove and DISCARD the crankshaft rear oil seal housing. (2)

Installation Procedure

1. Place a 3 mm (0.118 in) bead of RTV sealant to the oil pan to crankshaft rear oil seal housing surface. Refer to **Adhesives, Fluids, Lubricants and Sealers**
2. Install the crankshaft rear oil seal housing to the engine block. Refer to **Crankshaft Rear Oil Seal and Housing Installation**

NOTE: **DO NOT allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed.**

3. Install the oil pan to crankshaft rear oil seal and housing bolts (1).

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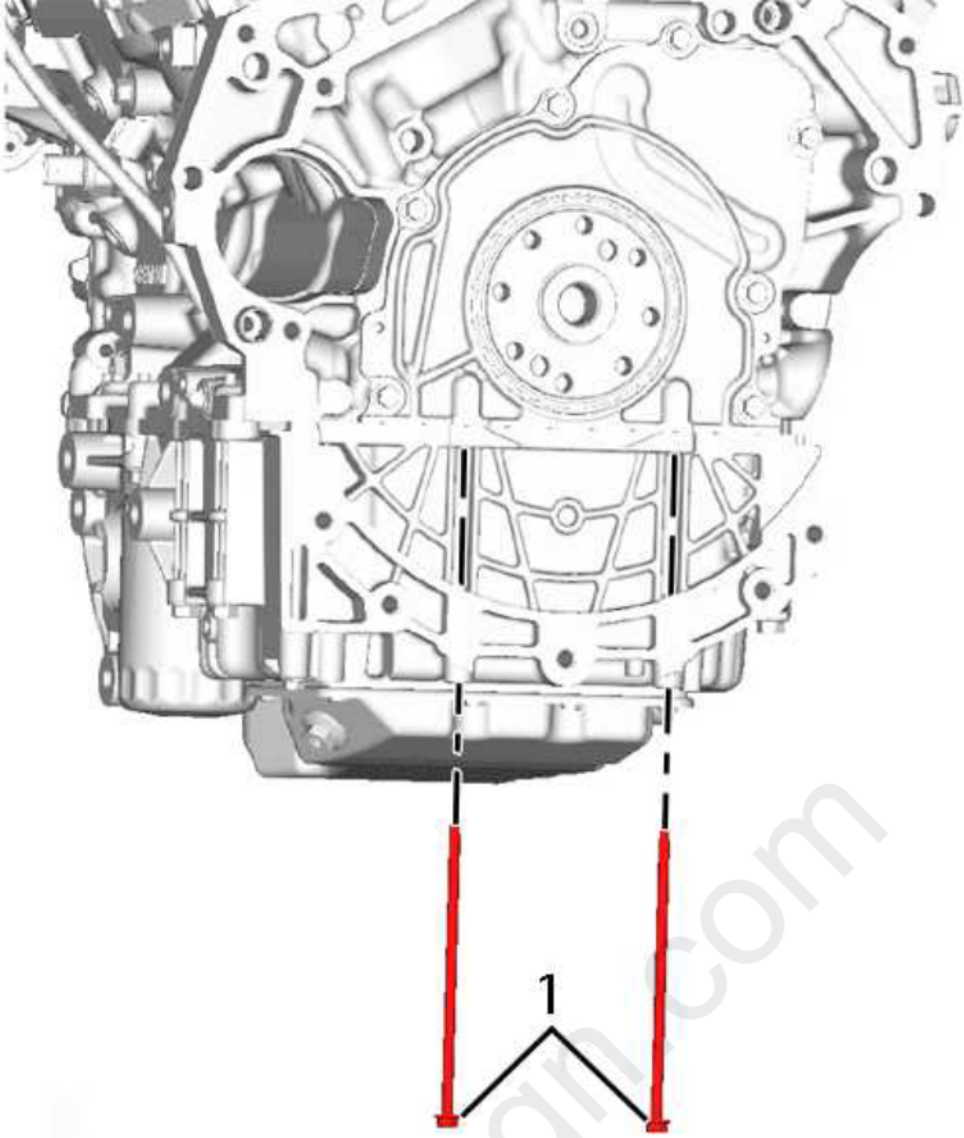


Fig. 249: Rear Oil Seal And Housing
Courtesy of GENERAL MOTORS COMPANY

4. Tighten the oil pan to crankshaft rear oil seal and housing bolts to 15 N.m (11 lb ft).

CAUTION: Refer to Fastener Caution .

5. Automatic Transmission Flex Plate ReplacementÂ» Install

OIL PUMP SPROCKET REPLACEMENT

Removal Procedure

1. Oil PanÂ» Remove - Oil Pan Replacement
2. Oil Pump Drive Bolt (1)Â» Remove.

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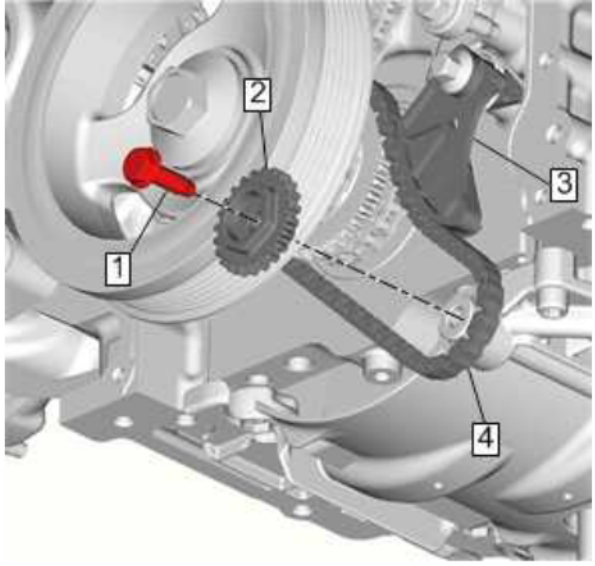


Fig. 250: Oil Pump Drive Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Engine front cover not shown for clarity.**

3. Remove the oil pump sprocket (2) from the oil pump drive shaft leaving the oil pump timing chain (4) on the crankshaft sprocket.
4. Clean and inspect all of the oil pump drive components.

Installation Procedure

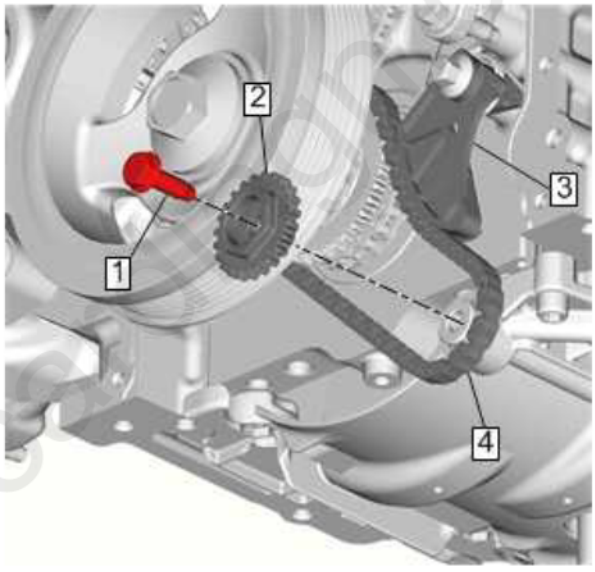


Fig. 251: Oil Pump Drive Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Collapse the oil pump timing chain tensioner (3) by hand.

NOTE: **Engine front cover not shown for clarity.**

2. Install the oil pump sprocket (2) and oil pump timing chain (4) onto the oil pump shaft.

NOTE: **Align the flat on the sprocket with the flat on the oil pump drive shaft.**

3. Oil Pump Drive Bolt (1)Â» Install and tighten - **Camshaft Timing Chain Components Installation**
4. Oil PanÂ» Install - **Oil Pan Replacement**

OIL PUMP REPLACEMENT

Removal Procedure

1. Oil PanÂ» Remove - **Oil Pan Replacement**.
2. Oil Pump SprocketÂ» Remove - **Oil Pump Sprocket Replacement**
3. Oil Pump Bolt (1, 2)Â» Remove [6x]

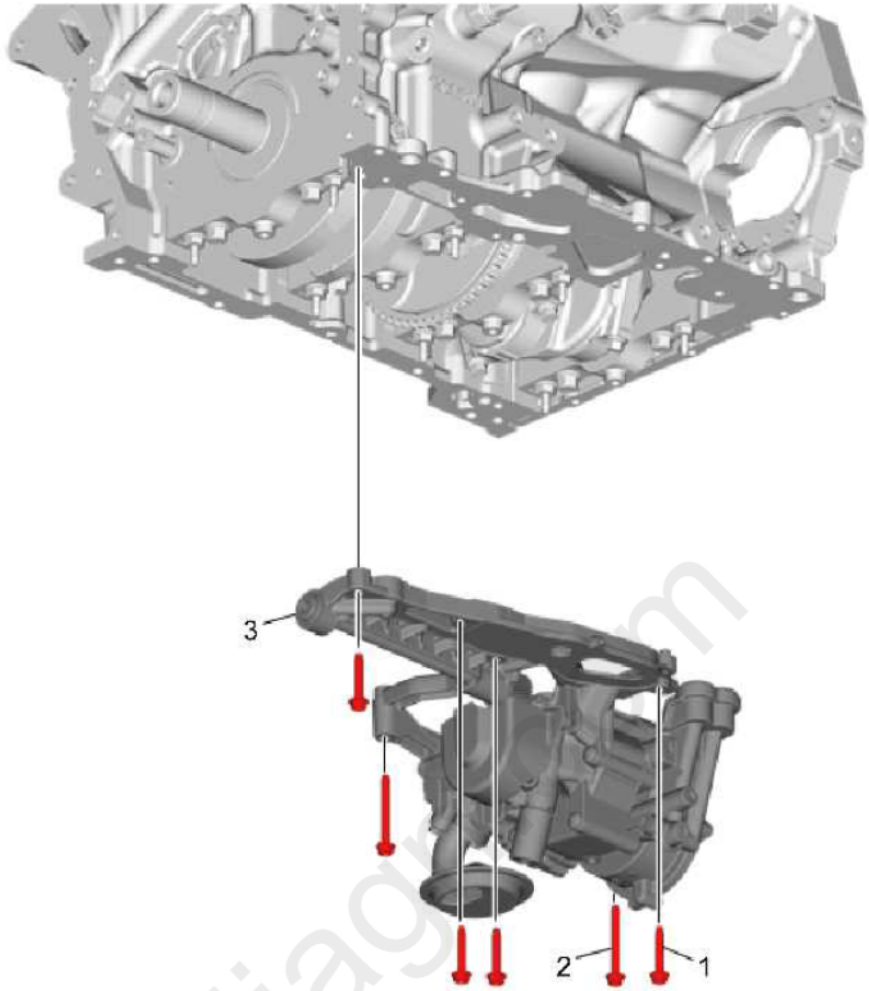


Fig. 252: Oil Pump
Courtesy of GENERAL MOTORS COMPANY

4. Oil Pump (3)Â» Remove

Installation Procedure

1. Oil Pump (3)Â» Install - **Oil Pump Installation**

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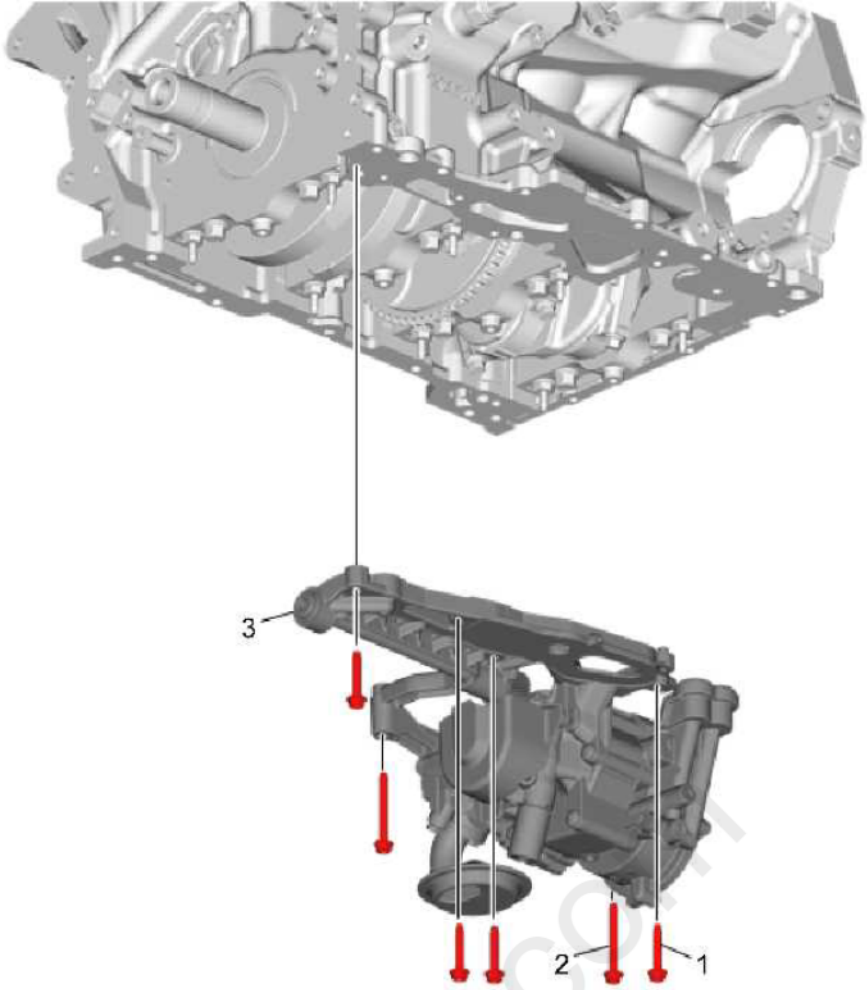


Fig. 253: Oil Pump
Courtesy of GENERAL MOTORS COMPANY

2. Oil Pump SprocketÂ» Install - **Oil Pump Sprocket Replacement**
3. Oil PanÂ» Install - **Oil Pan Replacement**.

OIL PAN REPLACEMENT

Special Tools

EN-46109 Guide Pin Set

Equivalent regional tools: **Special Tools** .

Removal Procedure

1. Front Differential Carrier AssemblyÂ» Remove - **Front Differential Carrier Assembly Replacement**
2. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**
3. {If equipped} Engine Oil Cooler AdapterÂ» Remove - **Engine Oil Cooler Adapter Replacement (LGW)** **Engine Oil Cooler Adapter Replacement (LGX with AWD)**
4. Engine Oil Level Indicator Switch (1)Â» Disconnect the electrical connector.

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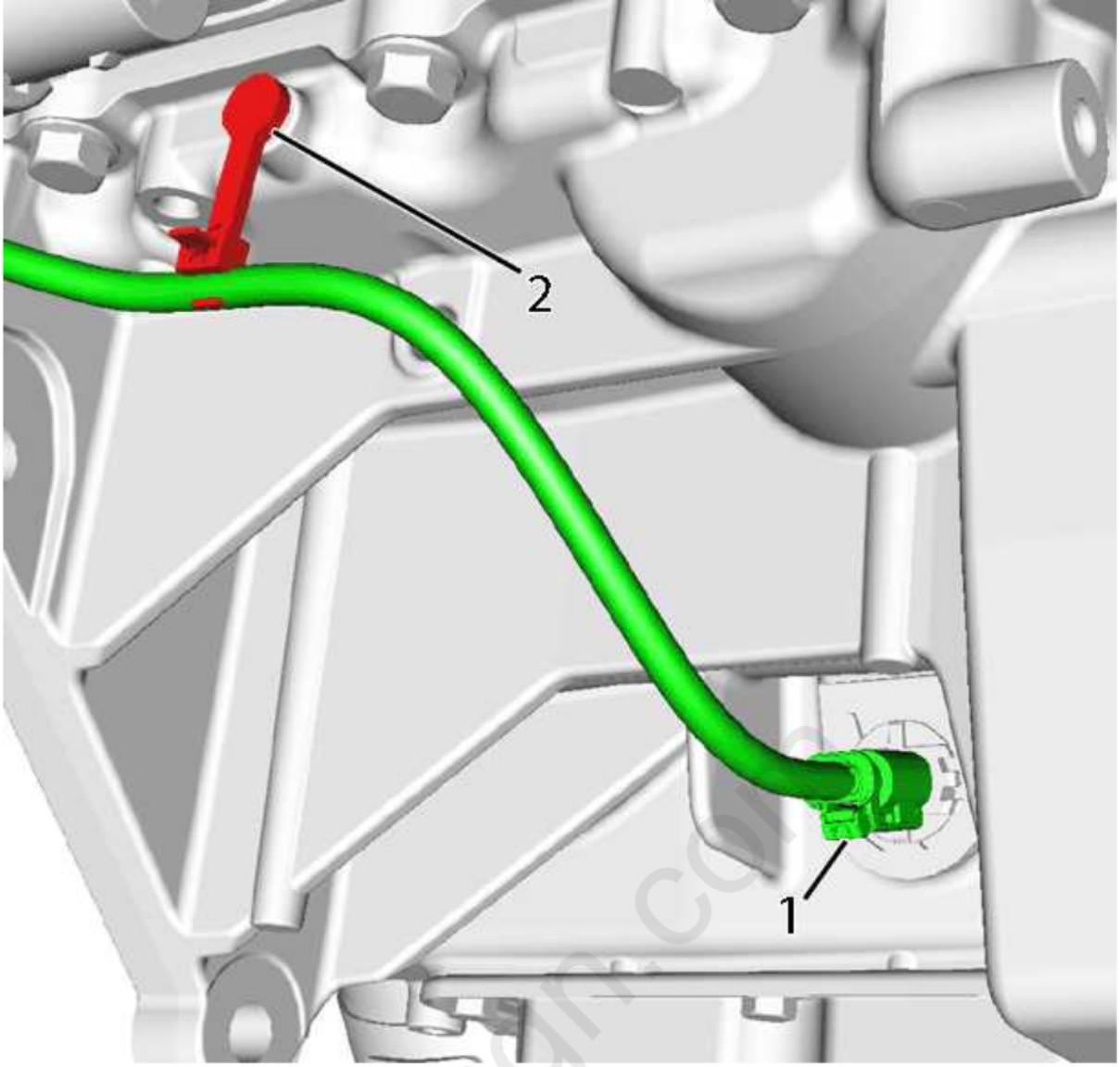


Fig. 254: Engine Oil Level Indicator Switch
Courtesy of GENERAL MOTORS COMPANY

5. Engine Wiring Harness Retainer (2)Â» Disconnect
6. Engine Mount Bracket [2x]Â» Remove - **Engine Mount Bracket Replacement - Left Side (LGW)Engine Mount Bracket Replacement - Left Side (LGX)** and **Engine Mount Bracket Replacement - Right Side (LGW)Engine Mount Bracket Replacement - Right Side (LGX)**
7. Catalytic Converter Brace BracketÂ» Remove - **Catalytic Converter Brace Bracket Replacement (LGW, LGX)**
8. Transmission Fluid Cooler Pipe Clip (1) @ Transmission Fluid Cooler Pipe BracketÂ» Remove

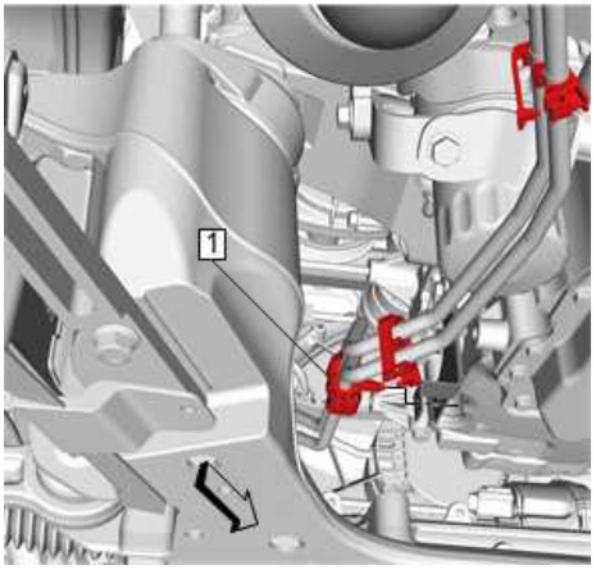


Fig. 255: Transmission Fluid Cooler Pipe Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

9. Remove the lower transmission to engine bolts. (1)

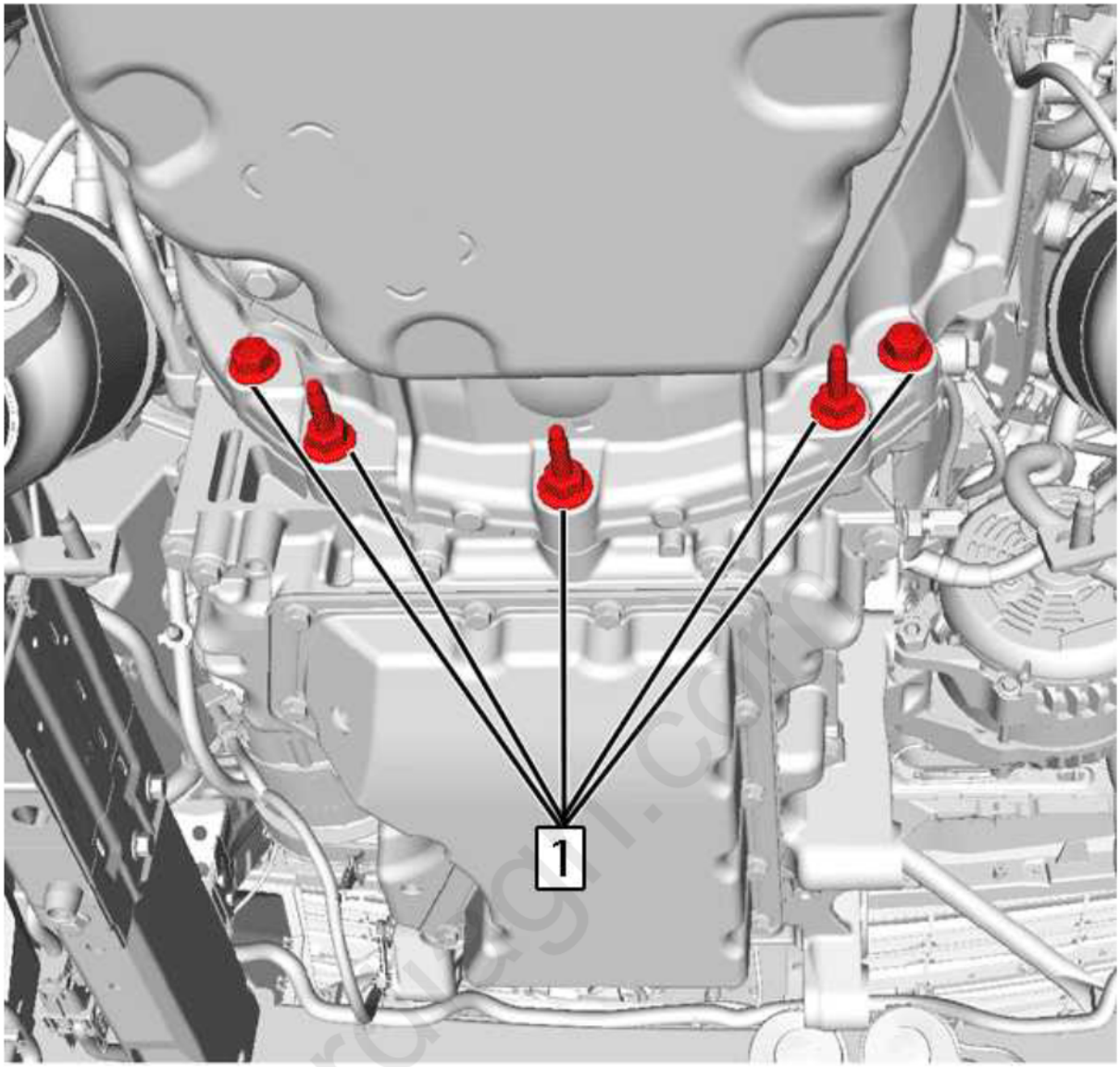


Fig. 256: Lower Transmission To Engine Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Oil Pan Bolt (1-3) [14x]Â» Remove

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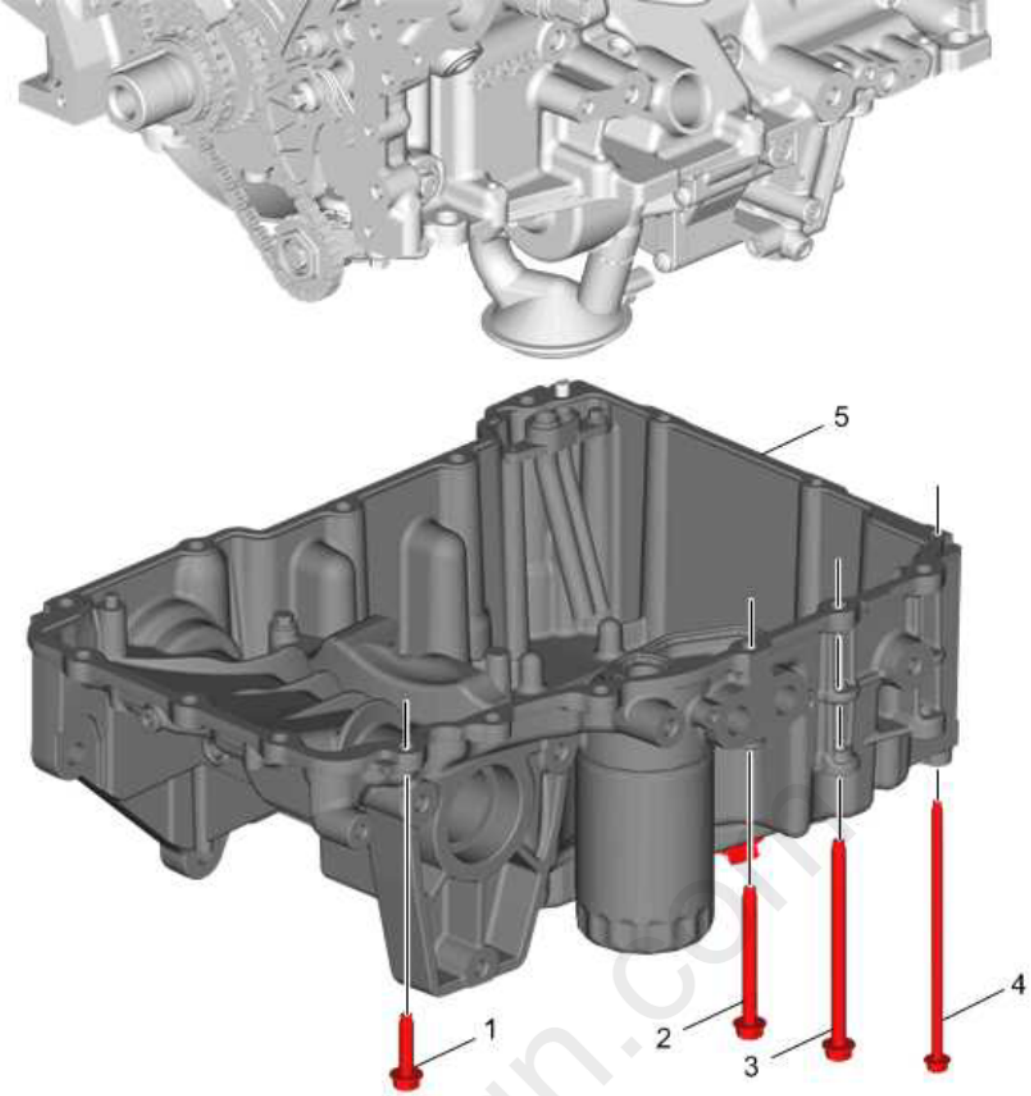


Fig. 257: Oil Pan And Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Oil Pan Bolt (4) [3x]Â» Remove and DISCARD
12. Oil Pan (5)Â» Remove
13. **Oil Pan Cleaning and Inspection (Without Oil Cooler)** **Oil Pan Cleaning and Inspection (With Oil Cooler)**
14. Disassemble the oil pan as necessary. Refer to **Oil Pan Disassemble (Without Oil Cooler)** and/or **Oil Pan Disassemble (With Oil Cooler)**

Installation Procedure

1. Assemble the oil pan as necessary. Refer to **Oil Pan Assemble (Without Oil Cooler)** and/or **Oil Pan Assemble (With Oil Cooler)**
2. Oil PanÂ» Install - **Oil Pan Installation (Without Oil Cooler)** **Oil Pan Installation (With Oil Cooler)**
3. Install the lower transmission to engine bolts. Refer to **Transmission Replacement (LGW Engine)** and/or **Transmission Replacement (LGX Engine)**

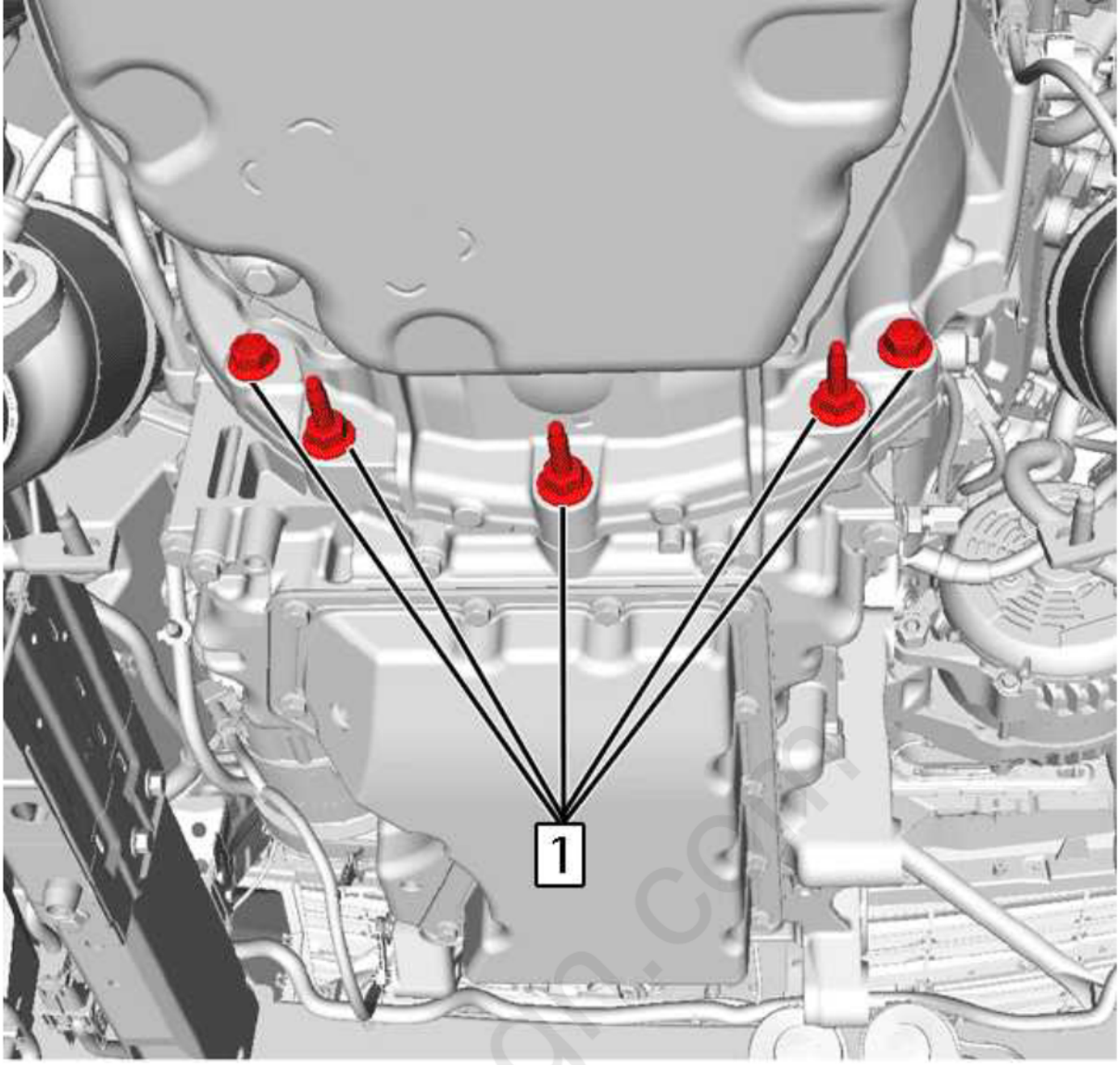


Fig. 258: Lower Transmission To Engine Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Transmission Fluid Cooler Pipe Clip (1) @ Transmission Fluid Cooler Pipe BracketÂ» Install

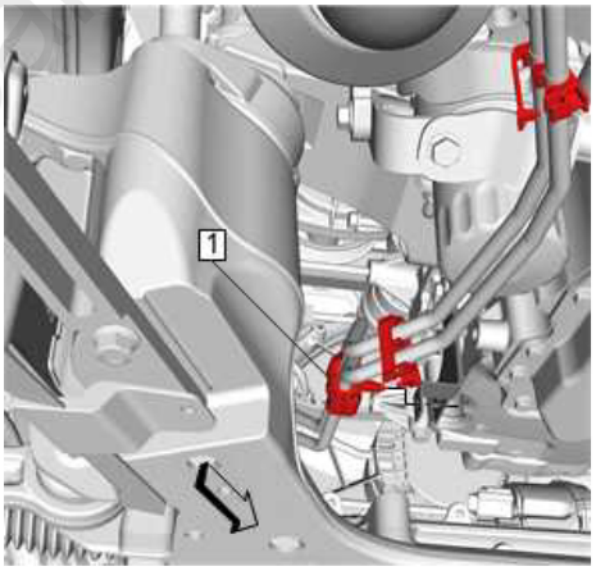


Fig. 259: Transmission Fluid Cooler Pipe Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

5. Catalytic Converter Brace BracketÂ» Install - **Catalytic Converter Brace Bracket Replacement (LGW, LGX)**
6. Engine Mount Bracket [2x]Â» Install - **Engine Mount Bracket Replacement - Left Side (LGW)Engine Mount Bracket Replacement - Left Side (LGX)** and **Engine Mount Bracket Replacement - Right Side (LGW)Engine Mount Bracket Replacement - Right Side (LGX)**

7. Engine Oil Level Indicator Switch (1)Â» Connect the electrical connector.

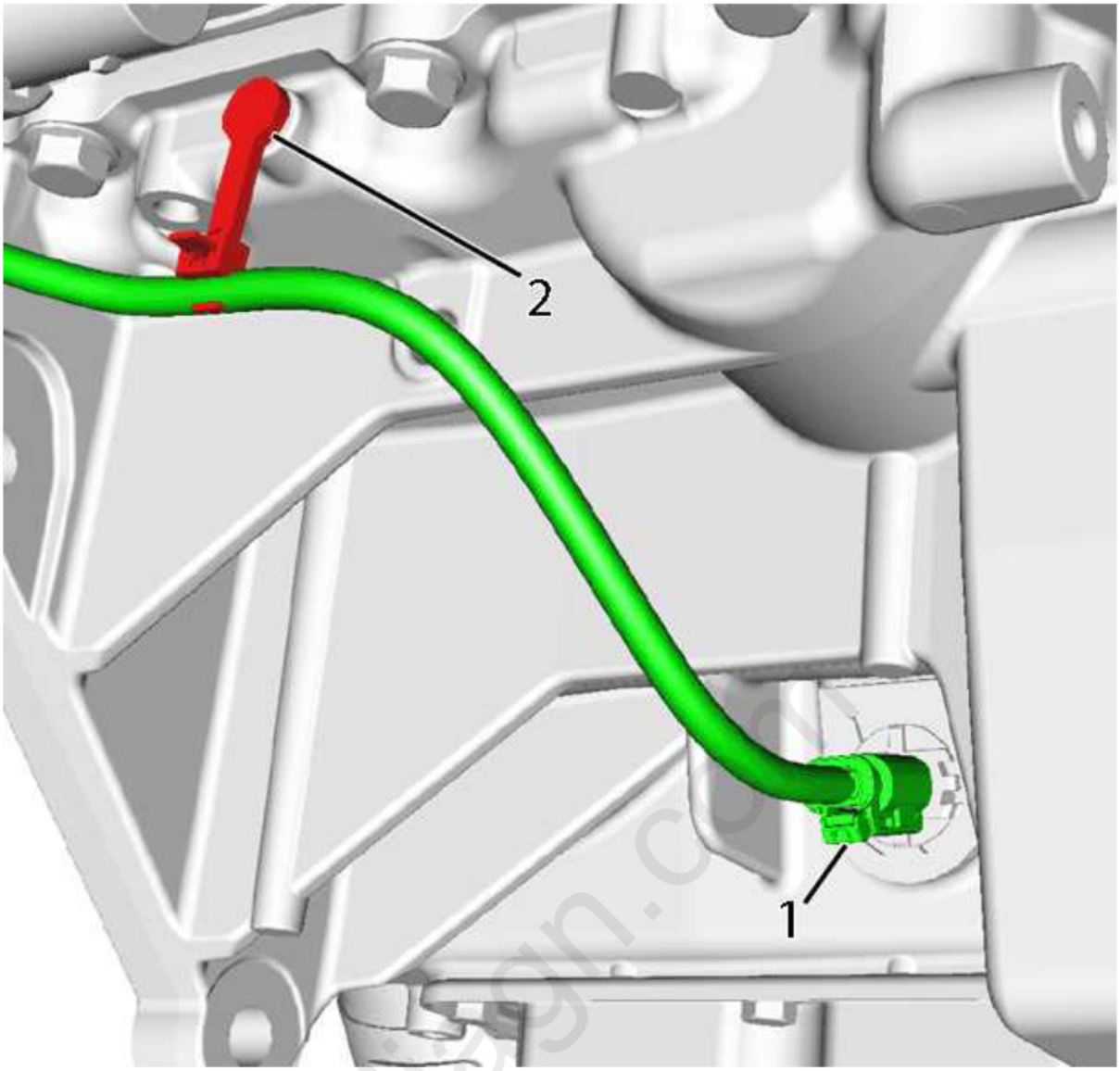


Fig. 260: Engine Oil Level Indicator Switch
Courtesy of GENERAL MOTORS COMPANY

8. Engine Wiring Harness Retainer (2)Â» Connect
9. {If equipped} Engine Oil Cooler AdapterÂ» Install - **Engine Oil Cooler Adapter Replacement (LGW)** **Engine Oil Cooler Adapter Replacement (LGX with AWD)**
10. Front Differential Carrier AssemblyÂ» Install - **Front Differential Carrier Assembly Replacement**
11. Fill the engine oil to the proper level with NEW engine oil. Refer to **Approximate Fluid Capacities** and **Adhesives, Fluids, Lubricants and Sealers**
12. Start the engine and inspect for leaks.

LOWER OIL PAN REPLACEMENT

Removal Procedure

1. **Lifting and Jacking the Vehicle**
2. Drain the engine oil into a suitable container. Refer to **Engine Oil and Oil Filter Replacement**
3. **Drivetrain and Front Suspension Cradle Plate Replacement** Â» Remove
4. Lower Oil Pan Bolt (1) [13x]Â» Remove

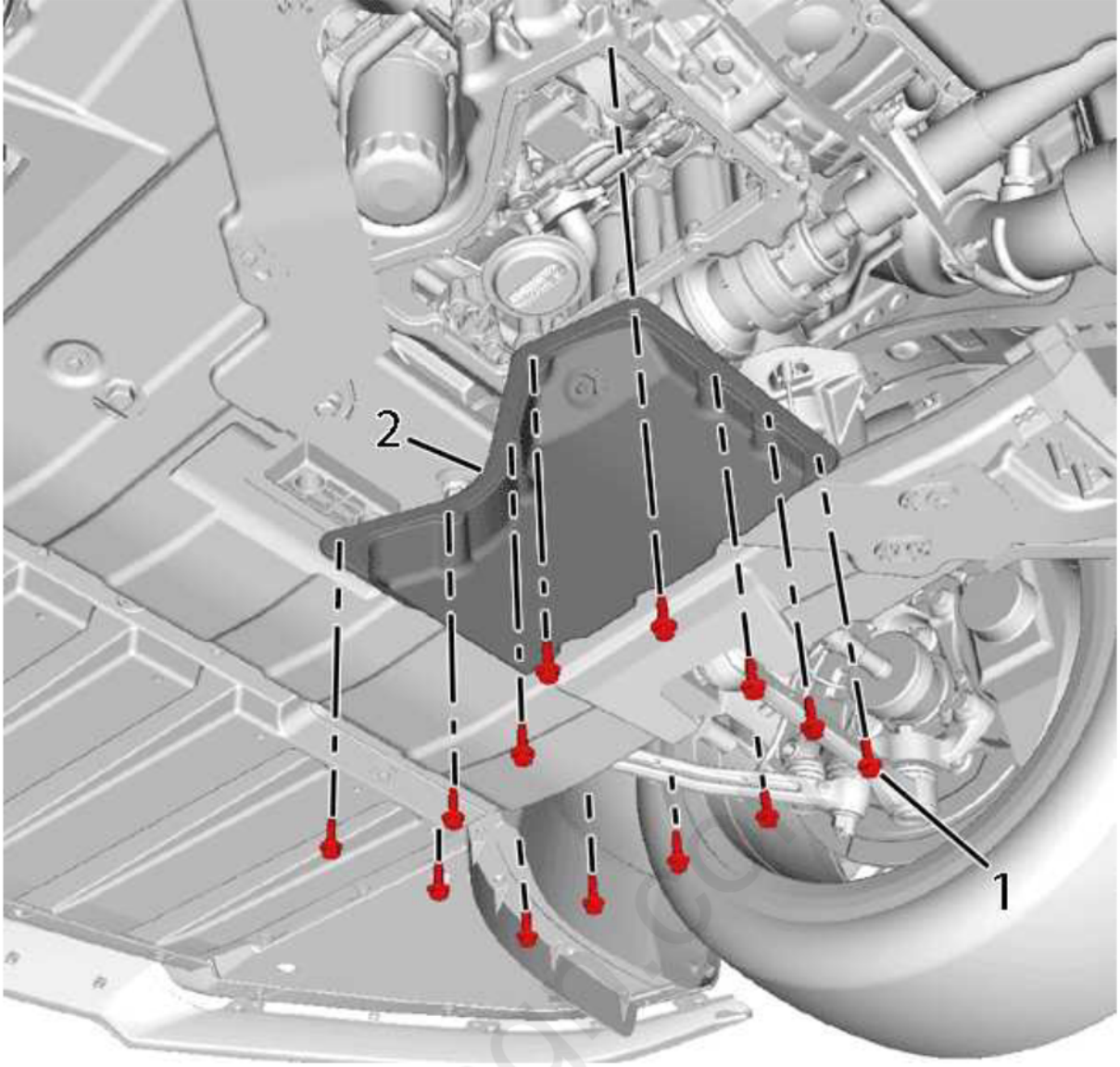


Fig. 261: Lower Oil Pan Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Lower Oil Pan (2)Â» Remove and DISCARD
6. **Oil Pan Cleaning and Inspection (Without Oil Cooler)** **Oil Pan Cleaning and Inspection (With Oil Cooler)**

Installation Procedure

1. Lower Oil PanÂ» Install NEW - **Oil Pan Assemble (Without Oil Cooler)** **Oil Pan Assemble (With Oil Cooler)**
2. **Drivetrain and Front Suspension Cradle Plate Replacement** Â» Install
3. Fill the engine oil to the proper level with NEW engine oil. Refer to **Approximate Fluid Capacities** and **Adhesives, Fluids, Lubricants and Sealers**
4. Start the engine and inspect for leaks.

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT (LGW)

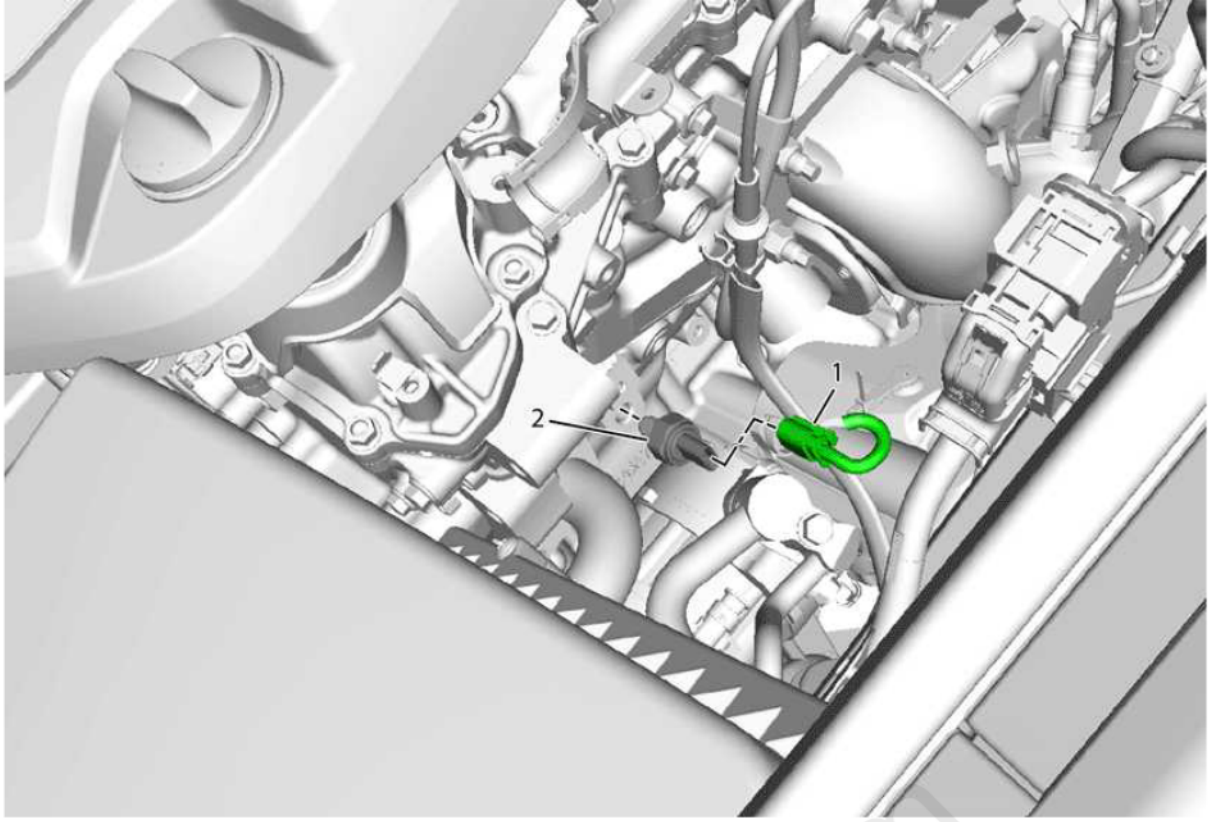


Fig. 262: Engine Oil Pressure Sensor and/or Switch (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Turbocharger Air Inlet Adapter Replacement - Bank 2	
1	Oil Pressure Sensor Electrical Connector
2	Engine Oil Pressure Sensor and/or Switch **CAUTION:** Refer to Component Fastener Tightening Caution . **Tighten** 20 N.m (15 lb ft) **Special Tools** **EN-41712** Oil Pressure Switch Socket Equivalent regional tools: Special Tools .

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT (LGX)

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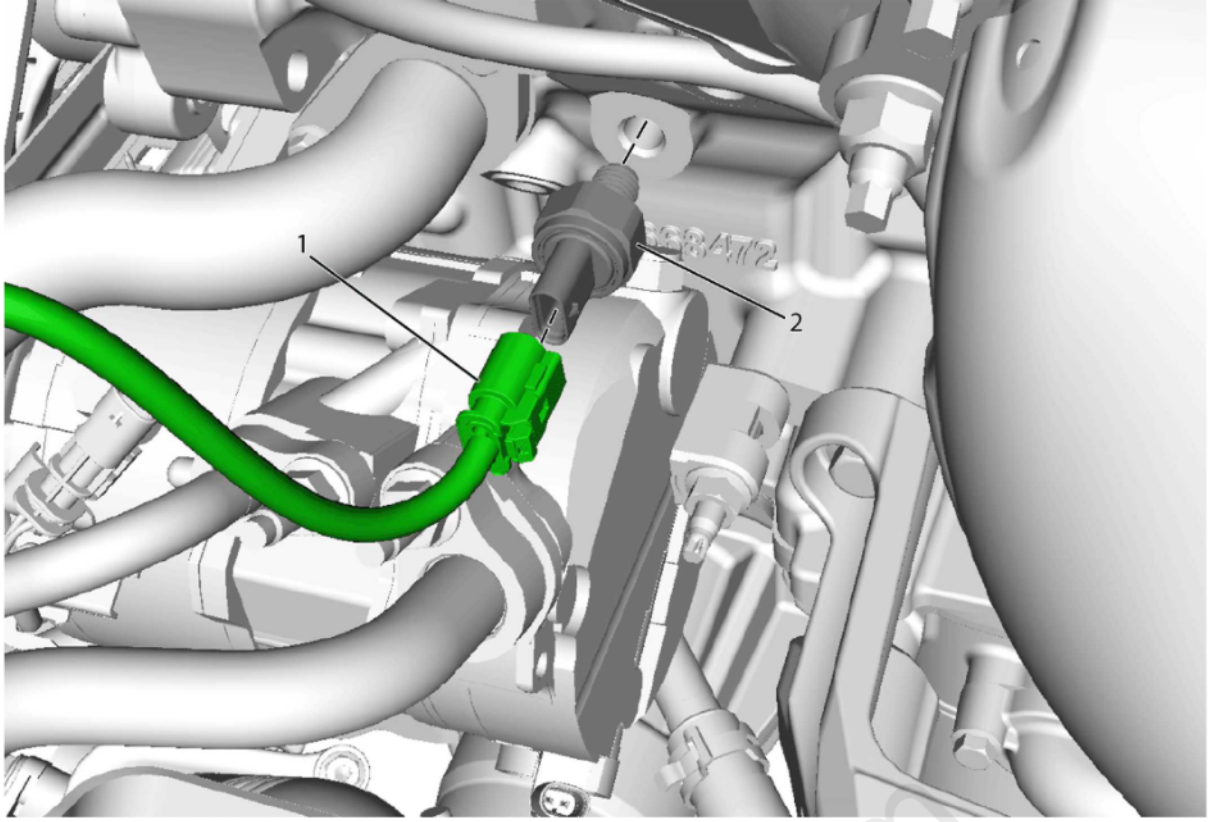


Fig. 263: Engine Oil Pressure Sensor and/or Switch (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pressure Sensor Electrical Connector
2	Engine Oil Pressure Sensor and/or Switch **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Tighten** 20 N.m (15 lb ft)

ENGINE OIL LEVEL SENSOR AND/OR SWITCH REPLACEMENT

Removal Procedure

1. Oil PanÂ» Remove - **Oil Pan Replacement**.

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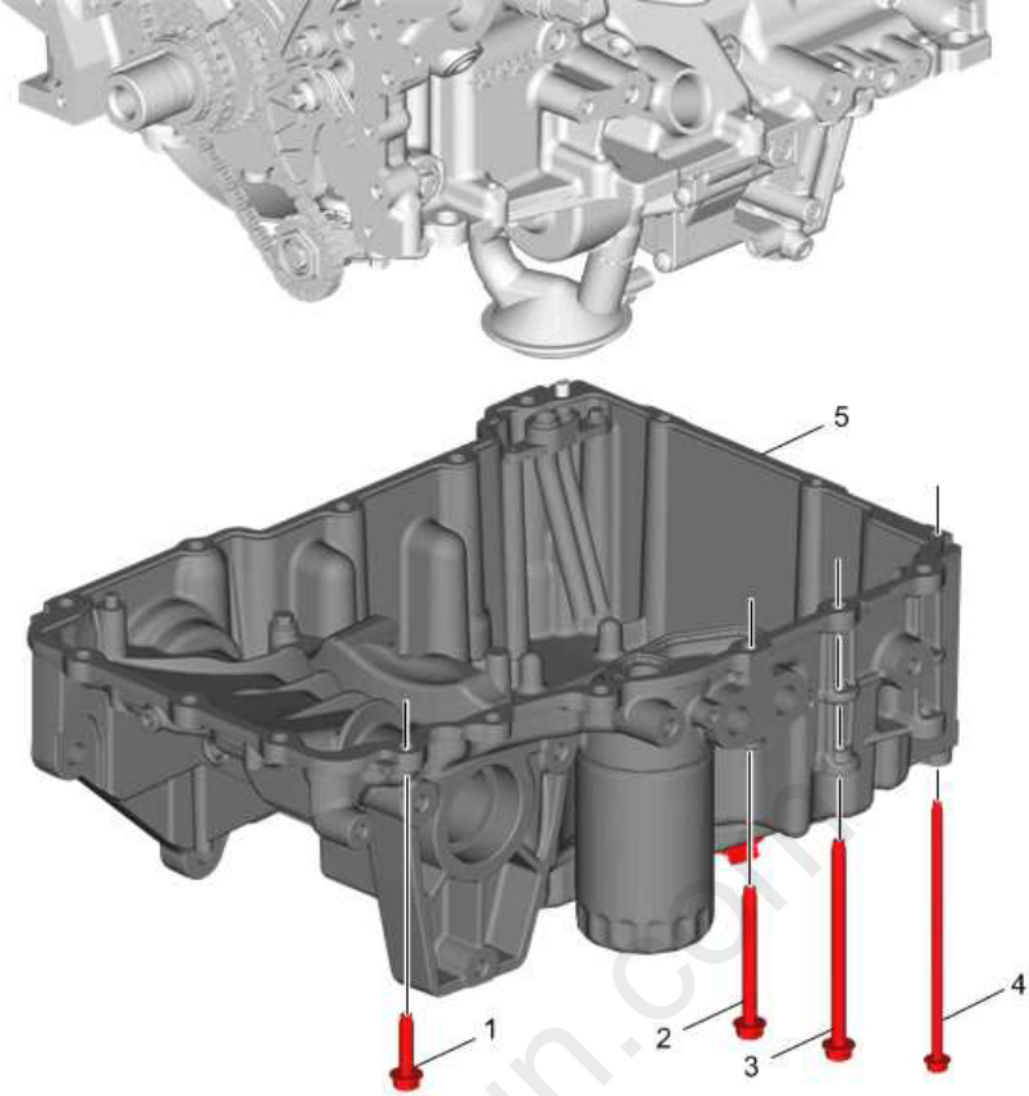


Fig. 264: Oil Pan And Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Oil Pan Baffle (2)Â» Remove - **Oil Pan Disassemble (Without Oil Cooler)** **Oil Pan Disassemble (With Oil Cooler)**

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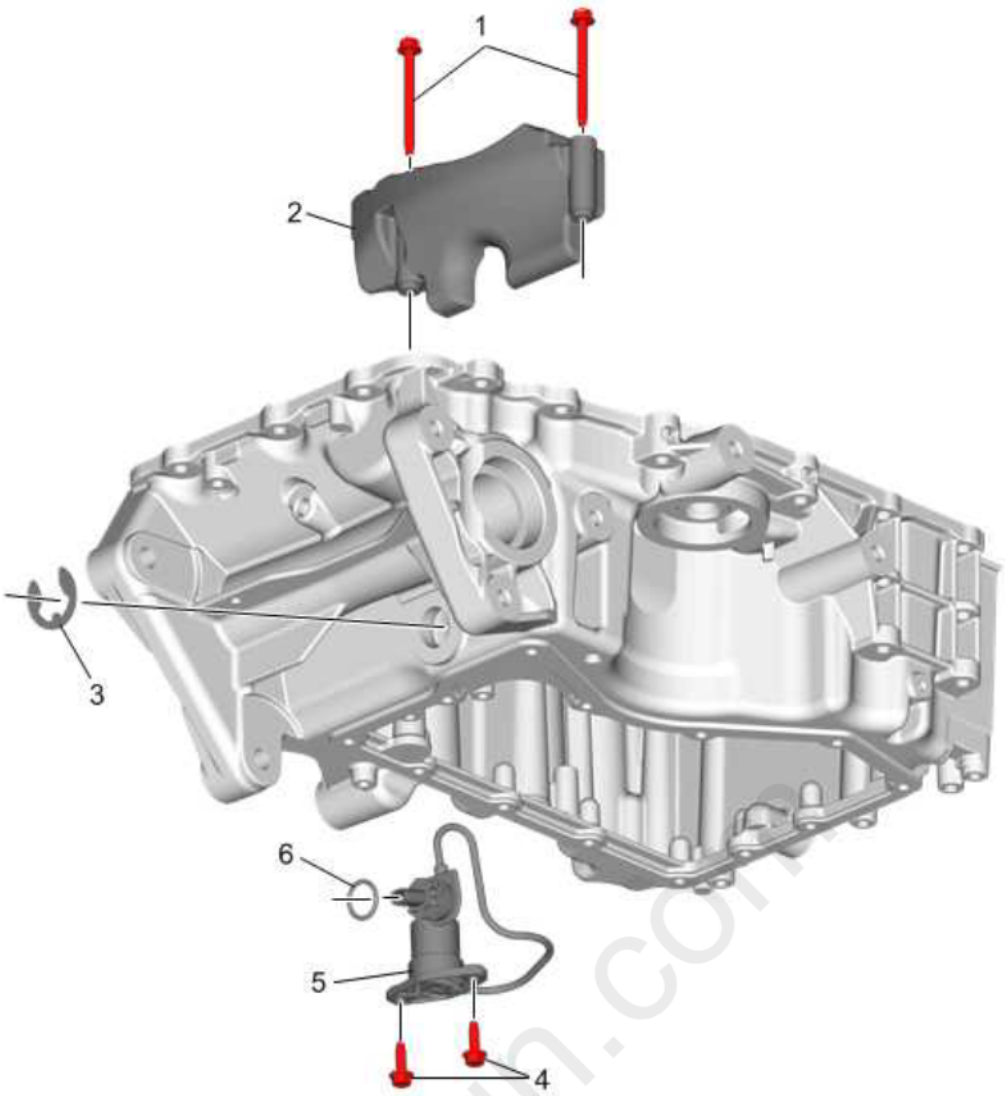


Fig. 265: Oil Pan Baffle and Engine Oil Level Indicator Switch Disassemble
Courtesy of GENERAL MOTORS COMPANY

3. Engine Oil Level Indicator (5)Â» Remove - **Oil Pan Disassemble (Without Oil Cooler)** **Oil Pan Disassemble (With Oil Cooler)**

Installation Procedure

1. Engine Oil Level Indicator (2)Â» Install - **Oil Pan Assemble (Without Oil Cooler)** **Oil Pan Assemble (With Oil Cooler)**

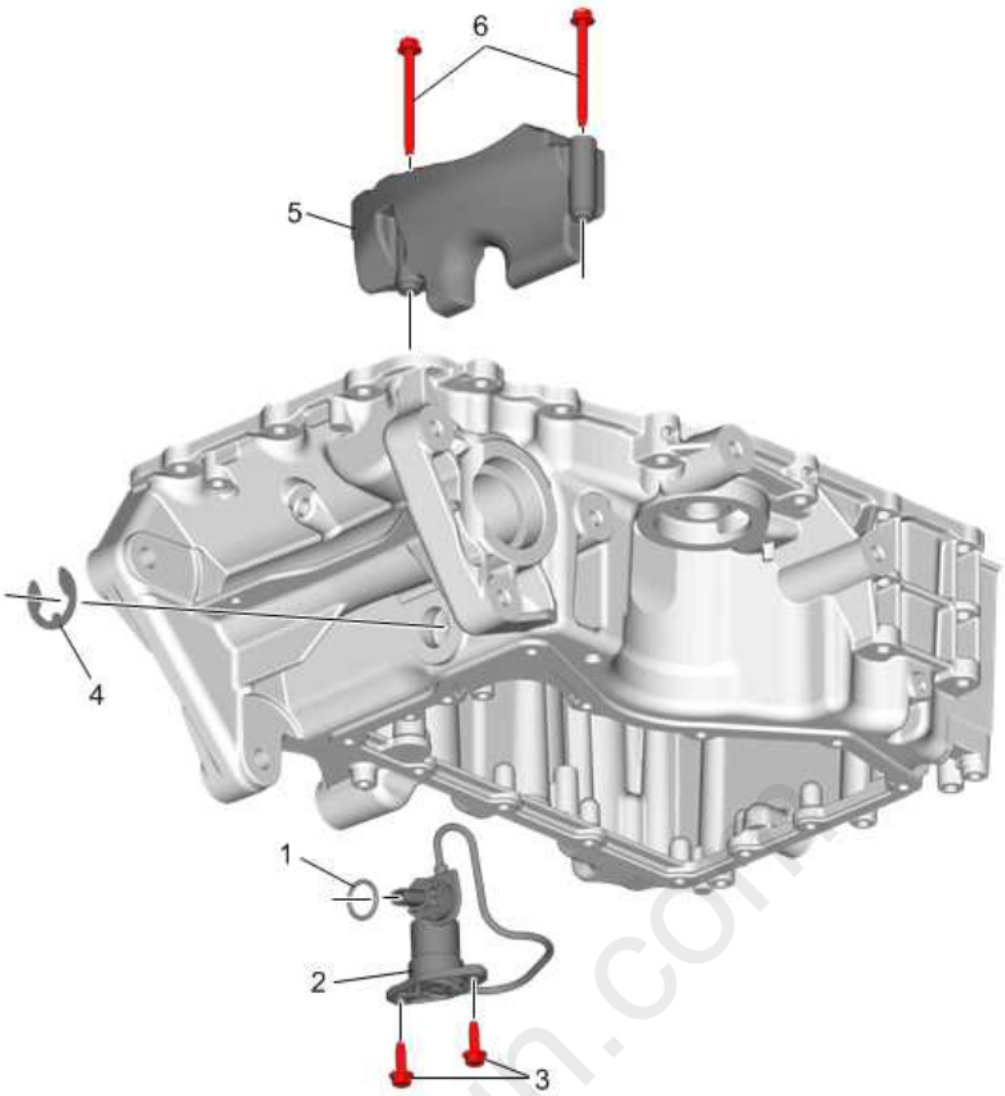


Fig. 266: Oil Pan Baffle and Engine Oil Level Indicator Switch Assemble
Courtesy of GENERAL MOTORS COMPANY

2. Oil Pan Baffle (5)Â» Install - **Oil Pan Assemble (Without Oil Cooler)** **Oil Pan Assemble (With Oil Cooler)**
3. Oil PanÂ» Install - **Oil Pan Replacement**.

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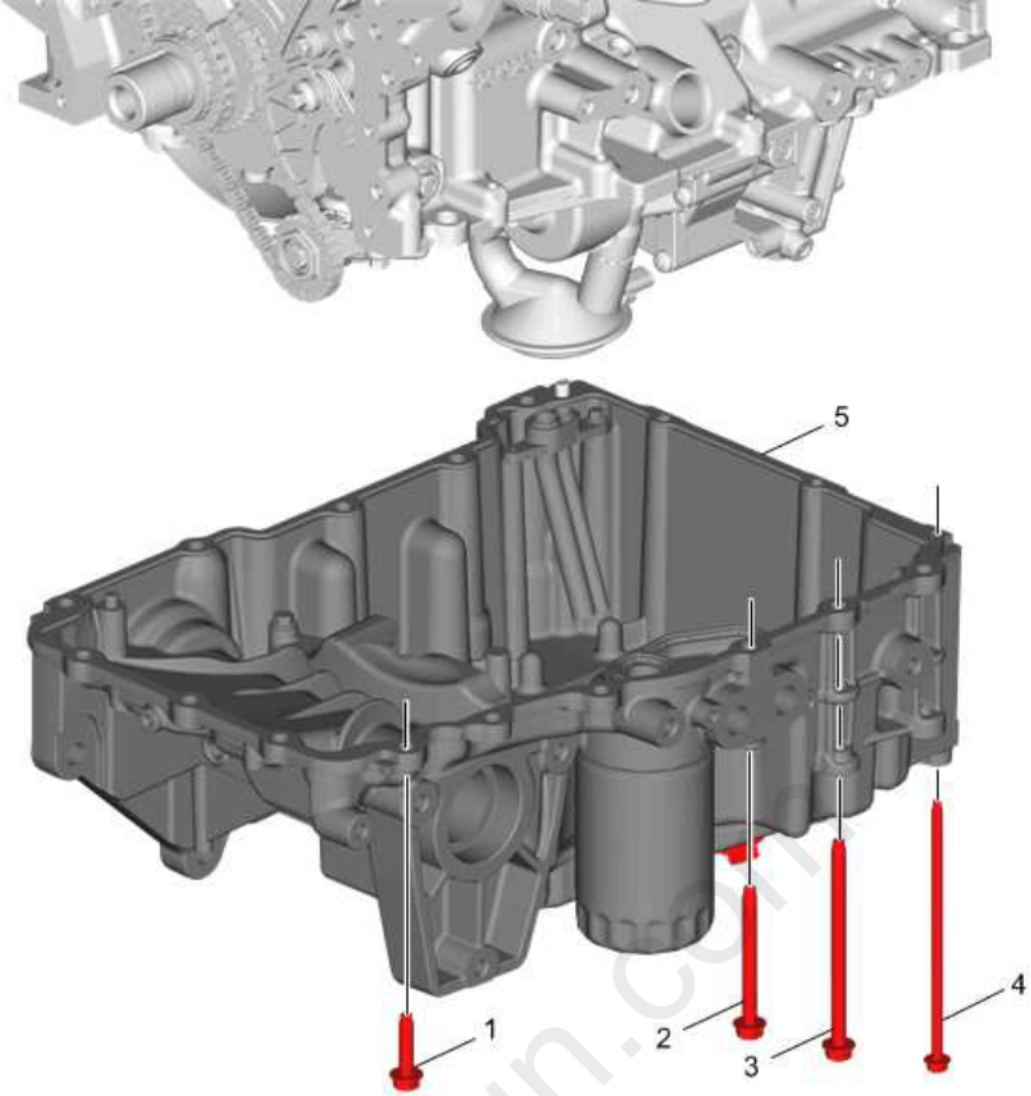


Fig. 267: Oil Pan And Bolt
Courtesy of GENERAL MOTORS COMPANY

OIL PUMP SUCTION PIPE AND SCREEN ASSEMBLY REPLACEMENT

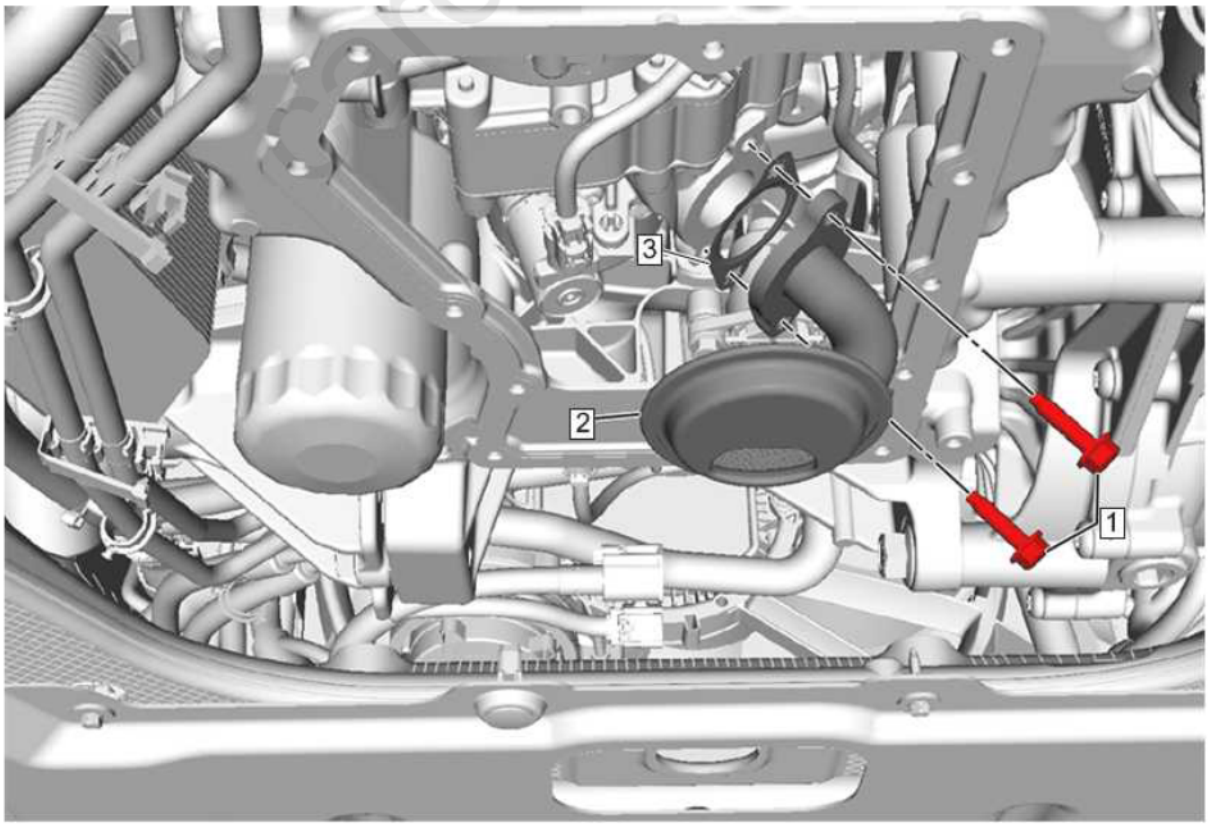


Fig. 268: Oil Pump Suction Pipe and Screen Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure **Lower Oil Pan Replacement**	
1	Oil Pump Suction Pipe Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Oil Pump Suction Pipe and Screen Assembly
3	Oil Pump Suction Pipe Gasket **NOTE:** **Install a NEW gasket**

ENGINE REPLACEMENT (LGW)

Removal Procedure

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**
2. Recover the refrigerant. Refer to **Refrigerant Recovery and Recharging (R-134a)** and/or **Refrigerant Recovery and Recharging (R-1234yf)**
3. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static without HP9)** , **Cooling System Draining and Filling (GE 47716 without HP9)** , **Cooling System Draining and Filling (Static LTG with HP9)** and/or **Cooling System Draining and Filling (GE 47716 LTG with HP9)**
4. Intake Manifold CoverÂ» Remove - **Intake Manifold Cover Replacement (LGW)**
5. Remove the front compartment front sight shield. Refer to **Front Compartment Front Sight Shield Replacement**
6. Radiator Surge Tank Inlet Hose (2) @ Engine Coolant Air Bleed PipeÂ» Disconnect

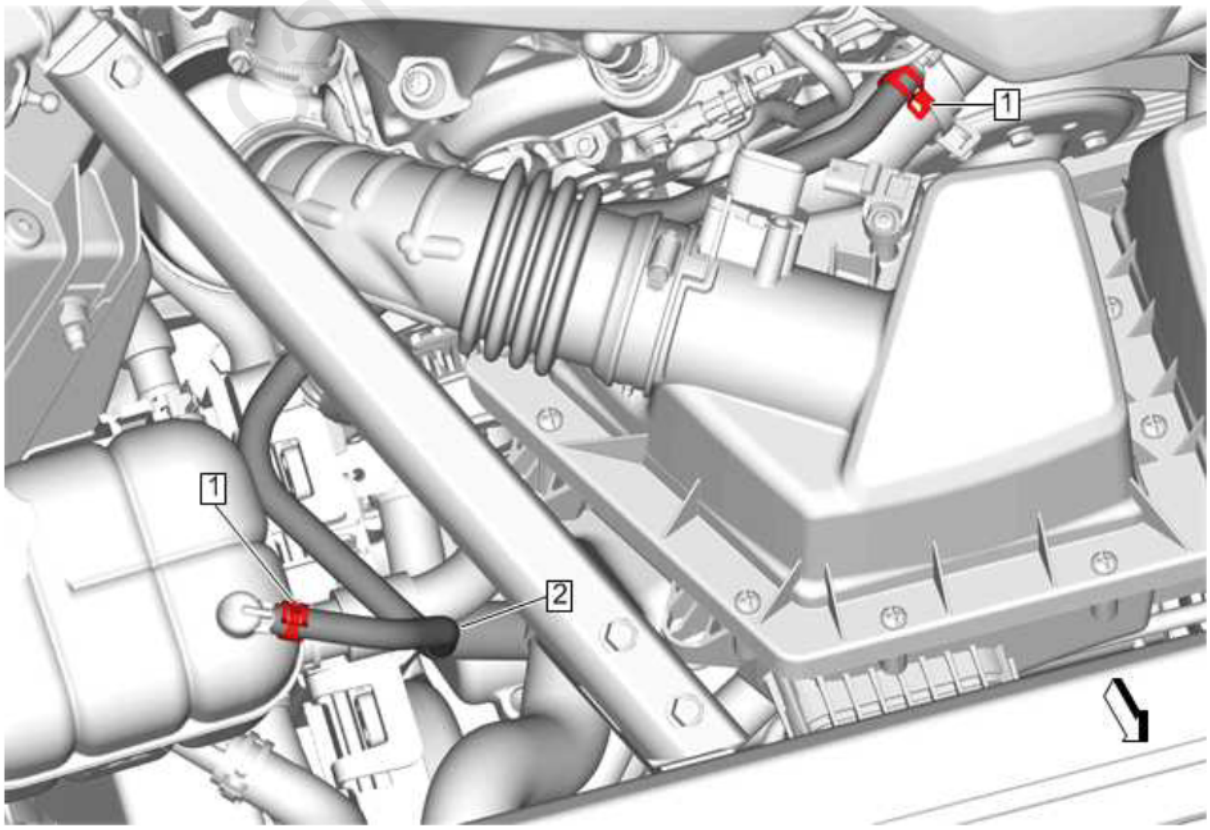


Fig. 269: Engine Coolant Air Bleed Hose
Courtesy of GENERAL MOTORS COMPANY

7. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement (LGW)**
8. Engine Wiring Harness Junction BlockÂ» Remove - **Engine Wiring Harness Junction Block Replacement**
9. Harness Connector (1)Â» Disconnect

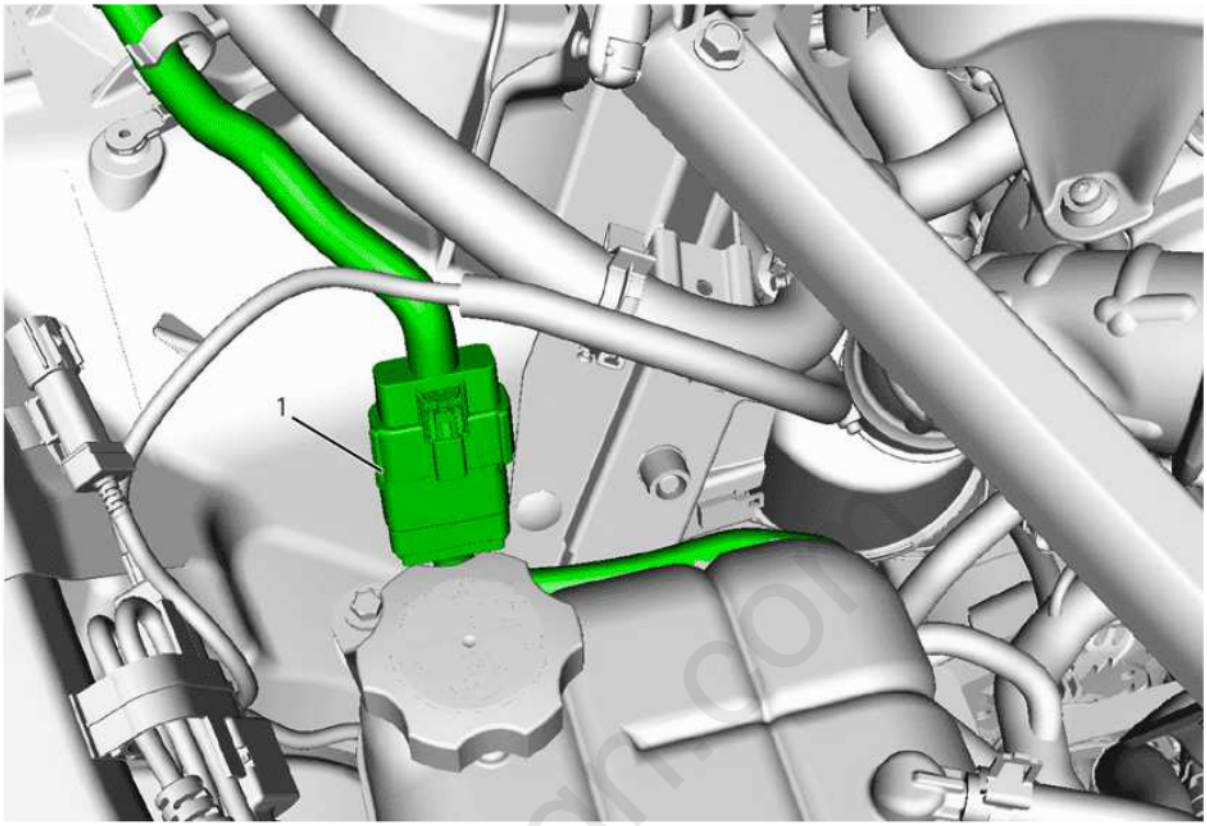


Fig. 270: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

10. Engine Control Module Electrical Connector (1)Â» Disconnect [4x]

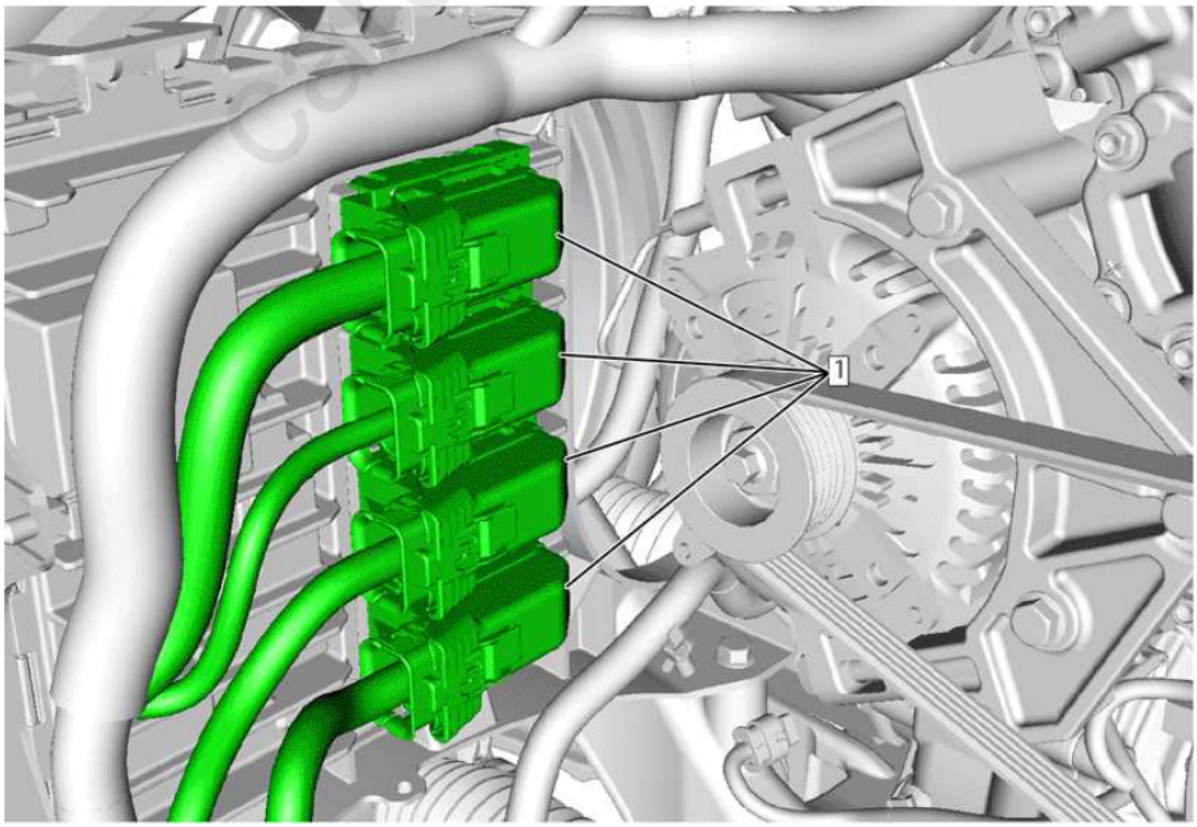


Fig. 271: Engine Control Module Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

11. Detach harness retainers and reposition the engine harness on the engine.
12. Radiator Inlet Hose Clamp (2) @ Water OutletÂ» Disengage - **Hose Clamp Replacement Guidelines - Spring Type**

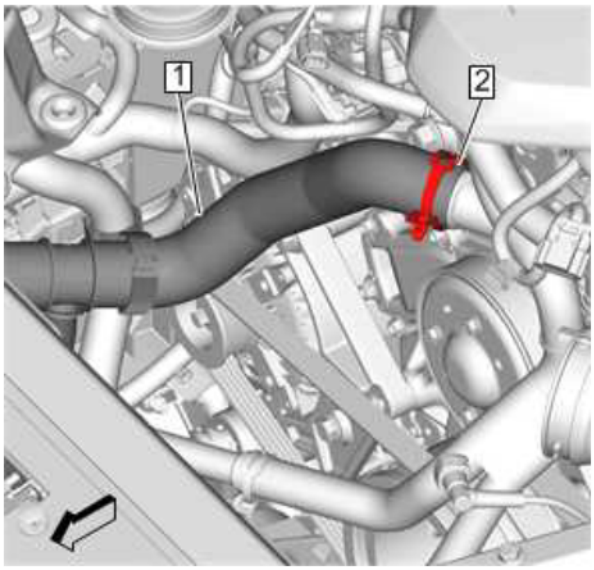


Fig. 272: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

13. Radiator Inlet Hose (1) @ Water OutletÂ» Remove
14. Charge Air Cooler Coolant HoseÂ» Remove - **Charge Air Cooler Coolant Hose Replacement - Inlet (LGW)**
15. Radiator Outlet Hose Clamp (1) @ Water Pump Inlet PipeÂ» Disengage - **Hose Clamp Replacement Guidelines - Spring Type**

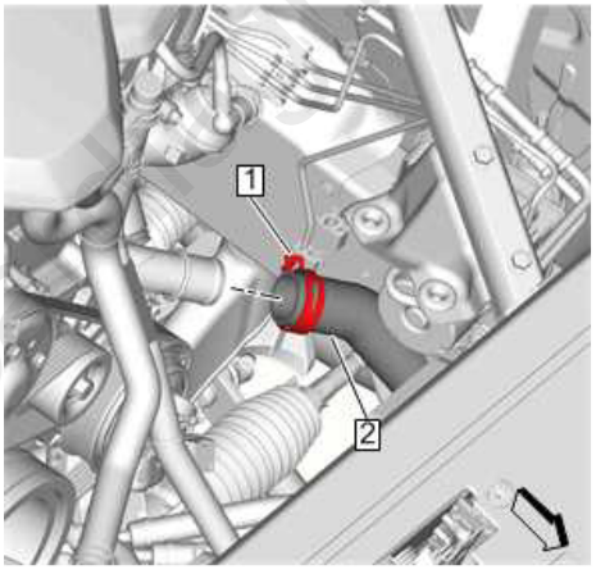


Fig. 273: Radiator Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

16. Radiator Outlet Hose (2) @ Water Pump Inlet PipeÂ» Remove
17. Engine Oil Cooler Inlet Hose Clamp (1) @ Engine Oil Cooler Inlet PipeÂ» Disengage - **Hose Clamp Replacement Guidelines - Spring Type**

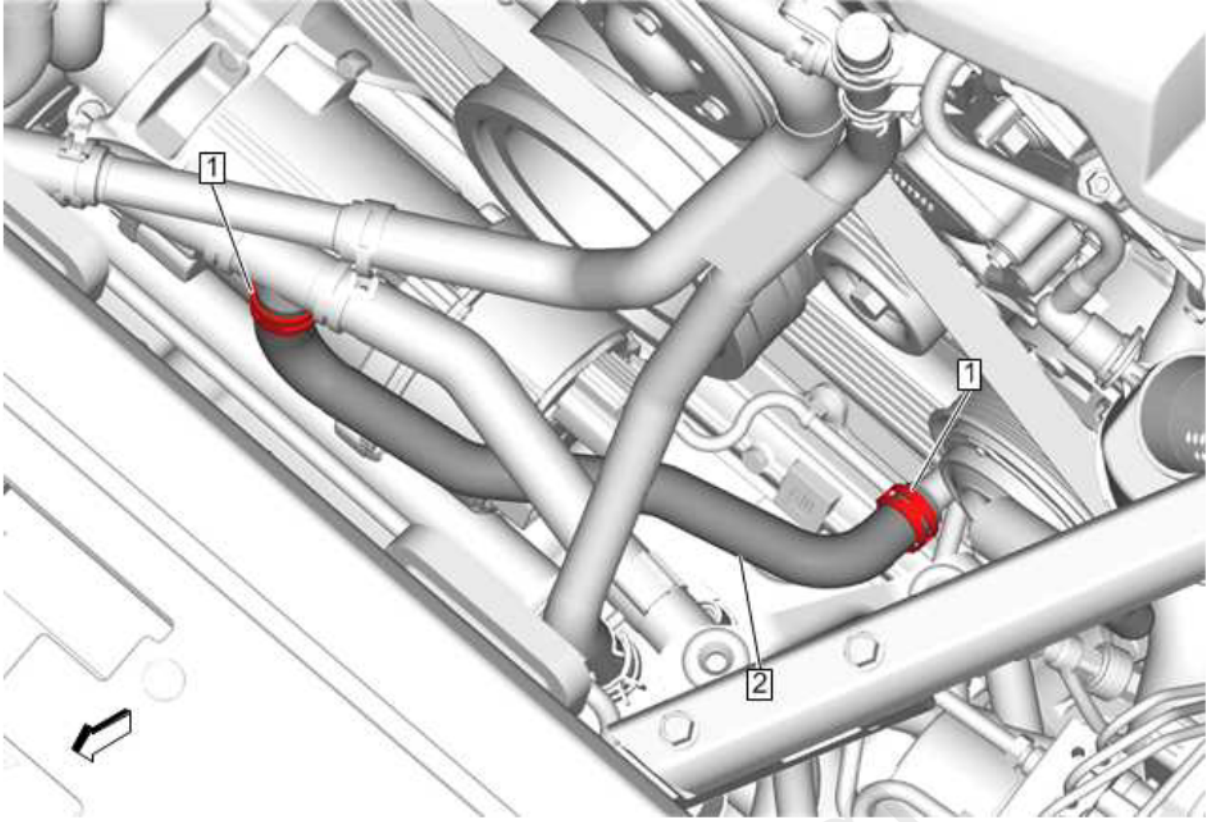


Fig. 274: Engine Oil Cooler Coolant Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

18. Engine Oil Cooler Inlet Hose (2) @ Engine Oil Cooler Inlet PipeÂ» Remove
19. Auxiliary Heater Inlet Hose (1) @ Auxiliary Heater Inlet and Outlet PipeÂ» Disconnect - **Auxiliary Heater Inlet Hose Replacement (LGW)**

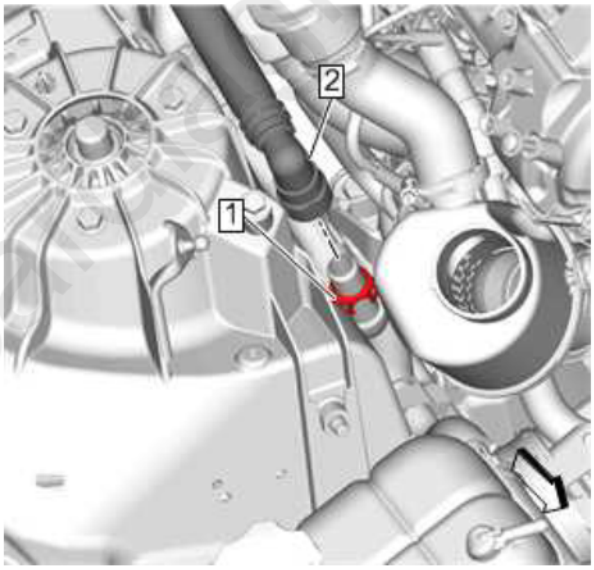


Fig. 275: Auxiliary Heater Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

20. Heater Water Auxiliary Pump Inlet Hose (3) @ Heater Coolant PumpÂ» Disconnect - **Heater Coolant Pump Replacement (LGW)**

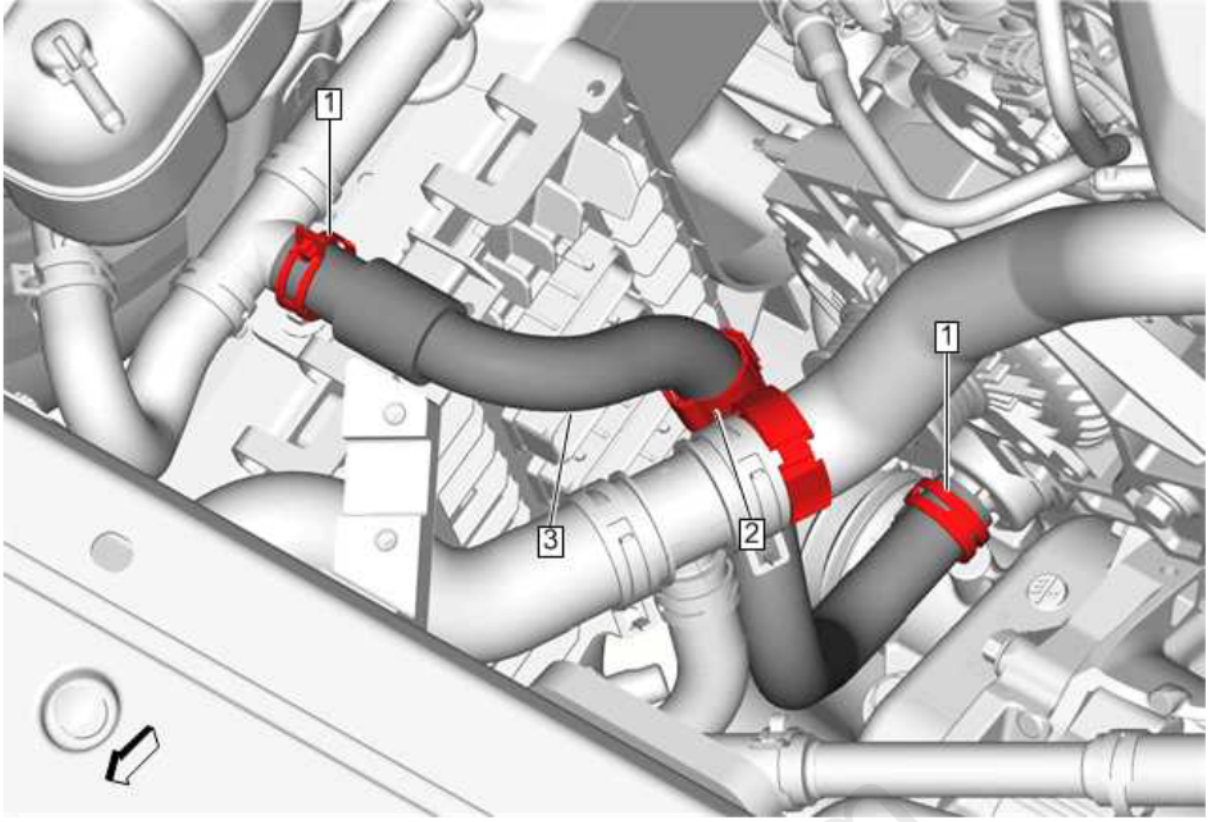


Fig. 276: Heater Water Auxiliary Pump Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

21. Fuel Feed Pipe (1) @ Fuel Pulse DampenerÂ» Disconnect - **Fuel Feed Pipe Replacement (LGW)**

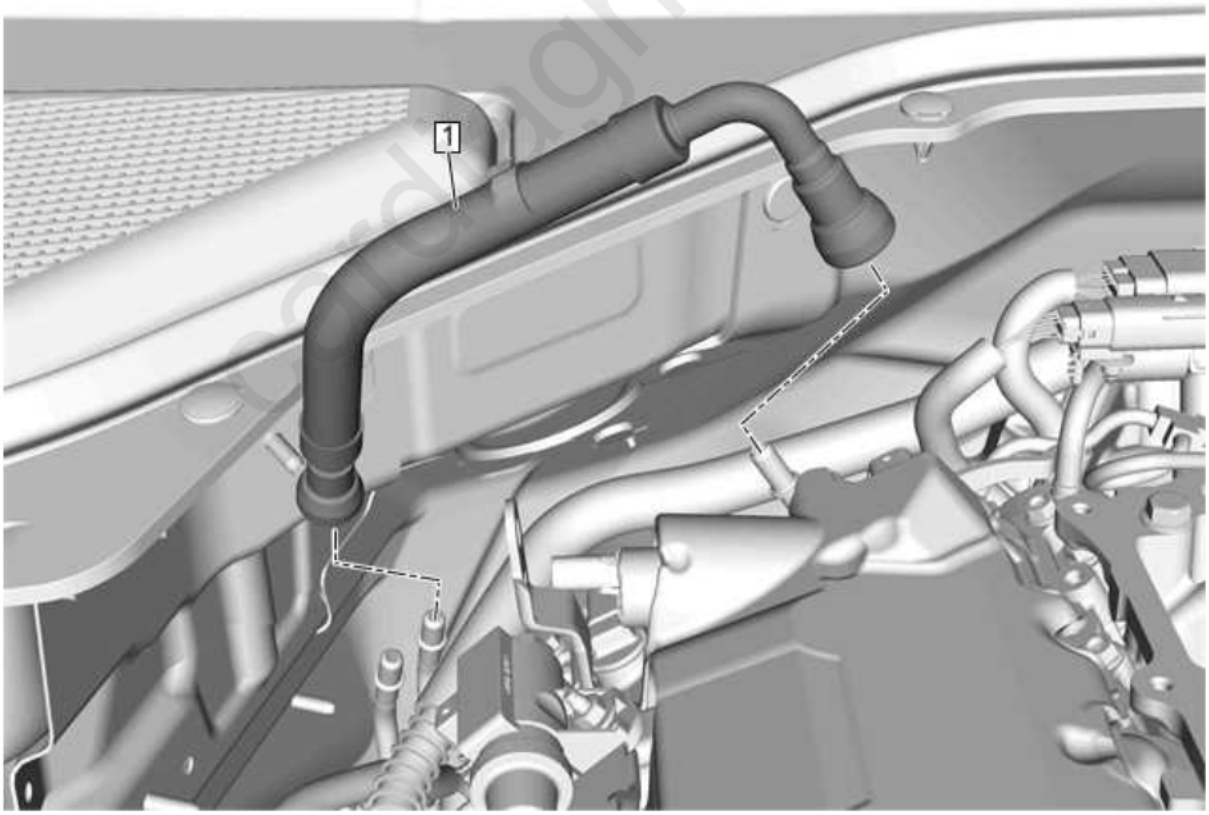


Fig. 277: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

22. Evaporative Emission Canister Purge Pipe @ Evaporative Emission Canister Purge Solenoid ValveÂ» Disconnect - **Evaporative Emission Canister Purge Pipe Replacement (LGW)**
23. Clamp (1) @ Power Brake Booster Vacuum Hose (2)Â» Disengage - **Hose Clamp Replacement Guidelines - Spring Type**

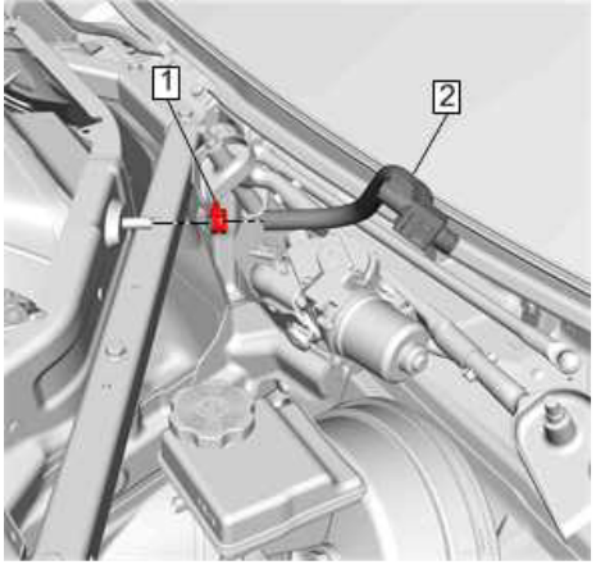


Fig. 278: Power Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

24. Power Brake Booster Vacuum Hose @ Pass Through GrommetÂ» Remove
25. Pass Through Grommet (1)Â» Release

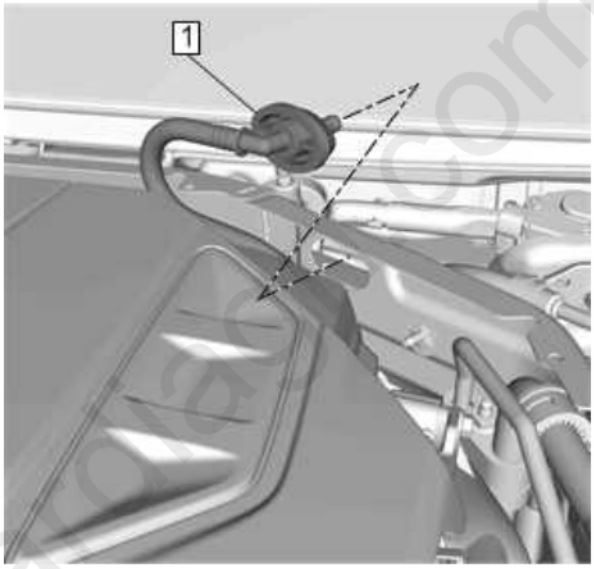


Fig. 279: Power Brake Booster Vacuum Hose Pass Through Grommet
Courtesy of GENERAL MOTORS COMPANY

26. Air Conditioning Compressor and Condenser Hose Nut (2)Â» Remove

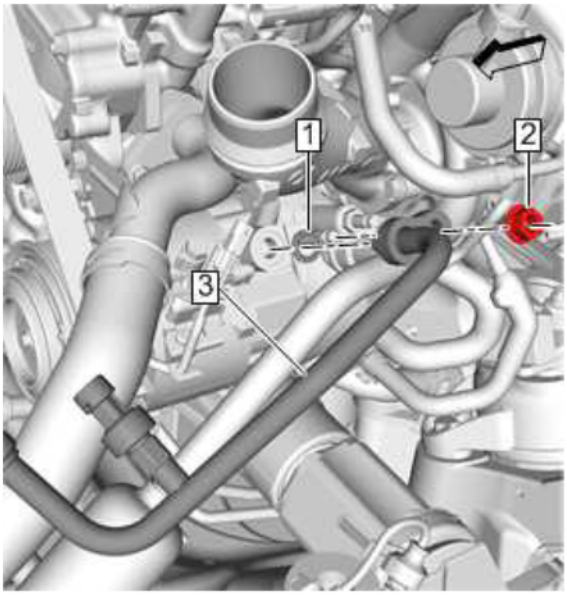


Fig. 280: Air Conditioning Compressor and Condenser Hose
Courtesy of GENERAL MOTORS COMPANY

27. Air Conditioning Compressor and Condenser Hose (3)Â» Remove
28. Sealing Washer (1)Â» Remove and DISCARD
29. Air Conditioning Compressor Hose Nut (1)Â» Remove

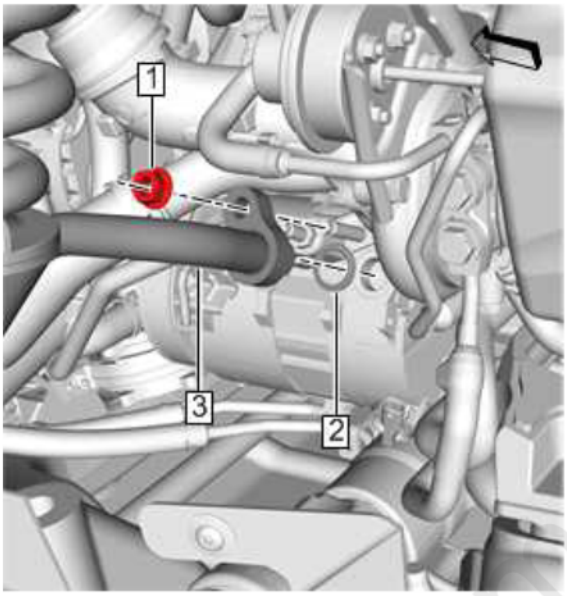


Fig. 281: Air Conditioning Compressor Hose
Courtesy of GENERAL MOTORS COMPANY

30. Air Conditioning Compressor Hose (3)Â» Remove
31. Sealing Washer (2)Â» Remove and DISCARD
32. Disconnect and reposition harness as necessary.
33. Transmission Fluid Cooler Pipe Clip (1) @ Engine Coolant Fan ShroudÂ» Remove [4x]

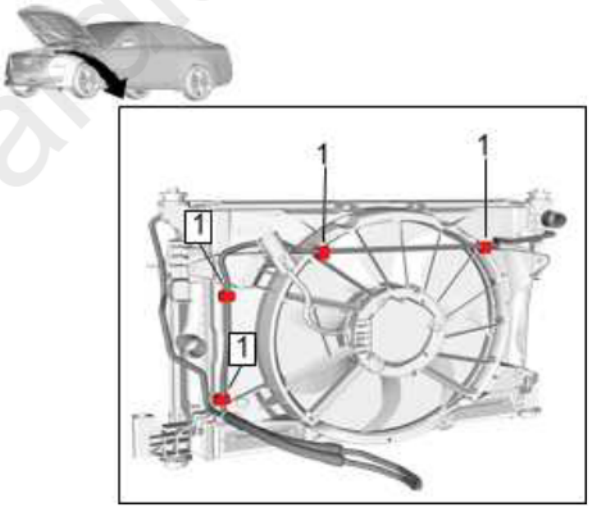


Fig. 282: Transmission Fluid Cooler Pipe Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

34. Transmission Fluid Cooler Inlet Pipe Clip (2) @ Transmission Fluid Cooler FittingÂ» Remove - **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection**

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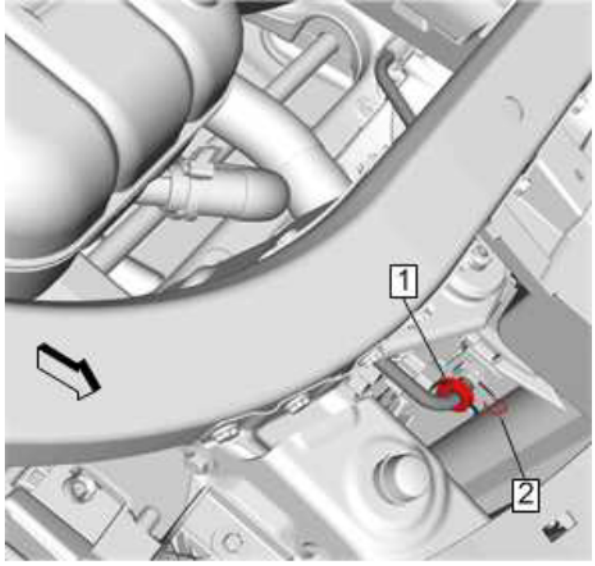


Fig. 283: Transmission Fluid Cooler Inlet Pipe
Courtesy of GENERAL MOTORS COMPANY

35. Transmission Fluid Cooler Inlet Pipe (1) @ RadiatorÂ» Disconnect
36. Transmission Fluid Cooler Outlet Pipe Clip (1) @Â» Transmission Fluid Cooler FittingÂ» Remove - **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection** .

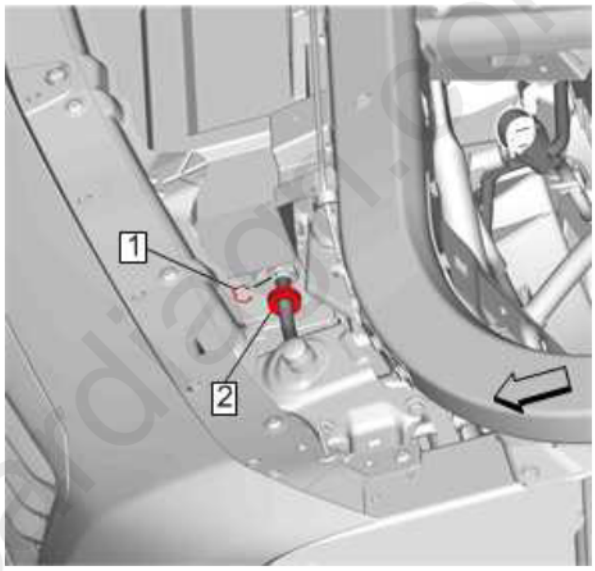


Fig. 284: Transmission Fluid Cooler Outlet Pipe And Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

37. Transmission Fluid Cooler Outlet Pipe (2) @ RadiatorÂ» Disconnect
38. Front Wheelhouse Liner (2)Â» Remove [2x] - **Front Wheelhouse Liner Replacement**

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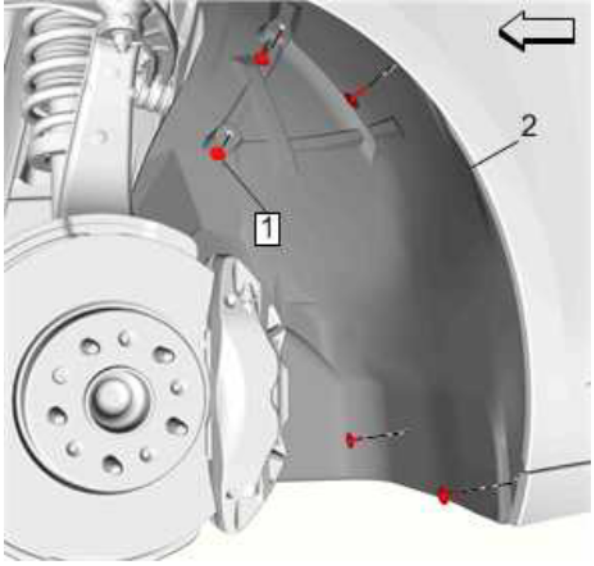


Fig. 285: Front Wheelhouse Liner
Courtesy of GENERAL MOTORS COMPANY

39. Front Tire Front Air Deflector (2)Â» Remove [2x] - **Front Tire Front Air Deflector Replacement**

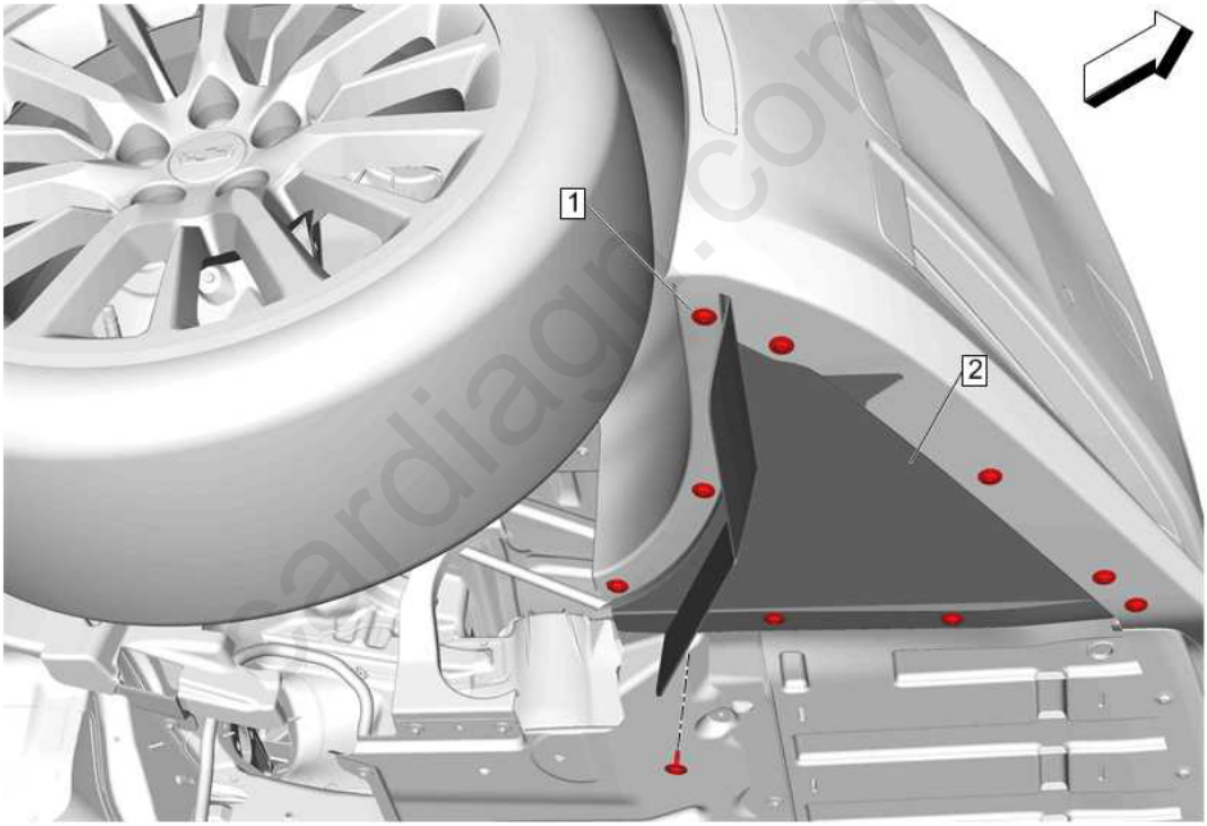


Fig. 286: Front Tire Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

40. Underbody Front Air Deflector (3)Â» Remove - **Underbody Front Air Deflector Replacement**

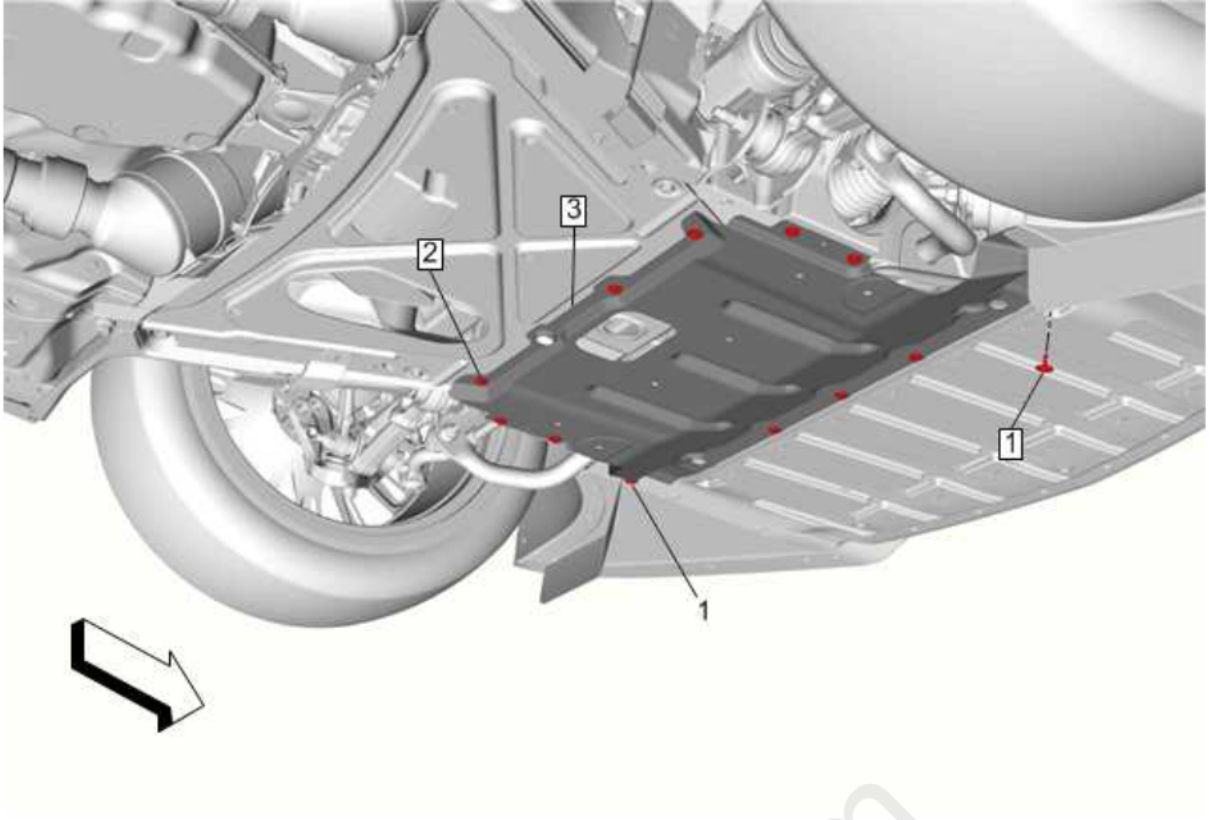


Fig. 287: Underbody Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

41. Front Bumper Fascia Lower Stiffener (1)Â» Remove - **Front Bumper Fascia Lower Stiffener Replacement**

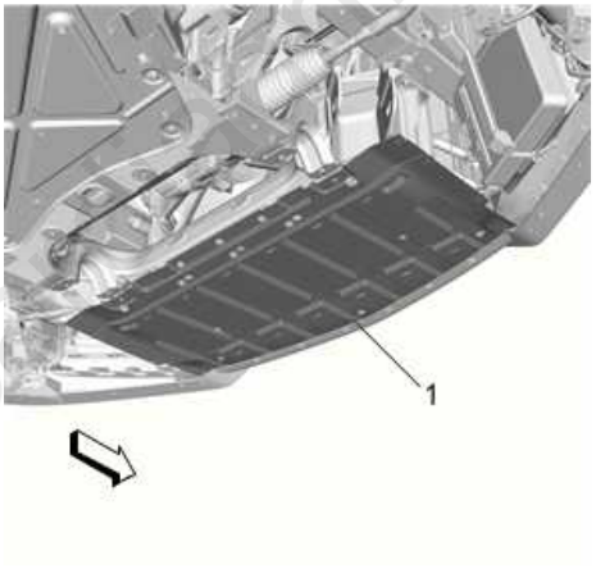


Fig. 288: Front Bumper Fascia Lower Stiffener
Courtesy of GENERAL MOTORS COMPANY

42. Drivetrain and Front Suspension Cradle Plate (3)Â» Remove - **Drivetrain and Front Suspension Cradle Plate Replacement**

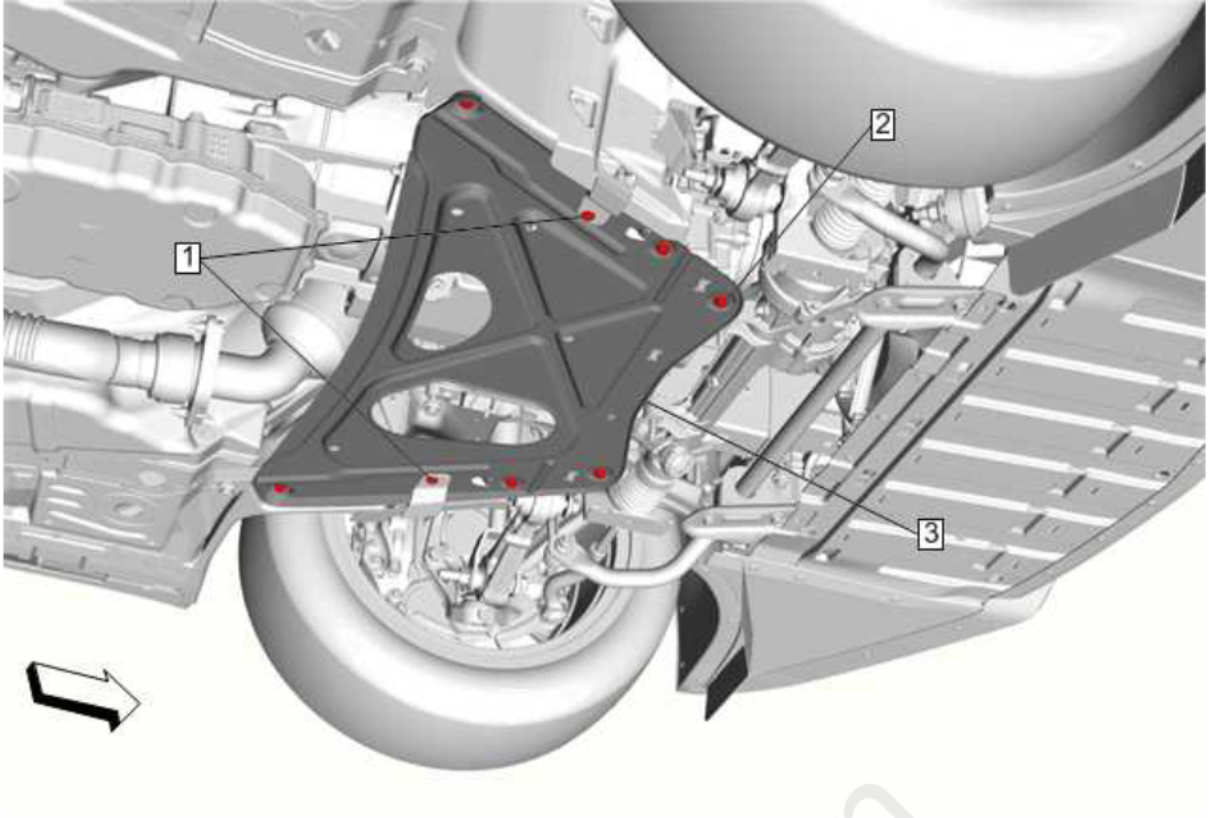


Fig. 289: Drivetrain and Front Suspension Cradle Plate
Courtesy of GENERAL MOTORS COMPANY

43. Warm Up Three-Way Catalytic Converter Replacement (Left, LGW) Warm Up Three-Way Catalytic Converter Replacement (Right, LGW) Â» Remove [2x]
44. Prepare the transmission for removal. Refer to Transmission Replacement (LGW Engine)
45. Prepare the transfer case for removal. Transfer Case Assembly Replacement
46. Secure the vehicle body to the vehicle hoist using suitable straps or binders.

NOTE: **Removing the powertrain assembly from the vehicle could cause an unstable balance condition with the vehicle body on the vehicle hoist. Securing the vehicle body to the hoist is necessary.**

47. Remove the drivetrain and front suspension cradle with the powertrain attached. Refer to Drivetrain and Front Suspension Cradle Removal and Installation

NOTE: **The powertrain assembly will be removed from vehicle on the drivetrain and front suspension frame. In the next step, only perform the necessary procedures required to remove the powertrain assembly.**

48. Lower the powertrain onto a suitable support table.
49. Secure the powertrain to the support table using straps and binders.
50. With the aid of an assistant, carefully raise the body from the frame.
51. Ensure when raising the body the following items are clear from the frame:
    - Vacuum lines
    - Steering knuckles
    - Electrical wiring harnesses
    - Oil cooler lines
52. Separate the engine from the transmission. Refer to Transmission Replacement (LGW Engine) .
53. Transfer components as necessary.

Installation Procedure

1. Install the engine to the transmission. Refer to Transmission Replacement (LGW Engine) .

2. Place the powertrain and frame assembly on the engine support table.
3. Secure the powertrain to the support table using straps and binders.
4. With the aid of an assistant, carefully lower the body onto the powertrain assembly.
5. Ensure when lowering the body the following items are clear from the frame:
    - Vacuum lines
    - Steering knuckles
    - Electrical wiring harnesses
    - Oil cooler lines
6. Install the drivetrain and front suspension cradle with the powertrain attached. Refer to **Drivetrain and Front Suspension Cradle Removal and Installation**
7. Remove the engine support table.
8. Complete installation of the transfer case. Refer to **Transfer Case Assembly Replacement** .
9. Complete installation of the transmission. Refer to **Transmission Replacement (LGW Engine)** .
10. **Warm Up Three-Way Catalytic Converter Replacement (Left, LGW)** **Warm Up Three-Way Catalytic Converter Replacement (Right, LGW)** Â» Install [2x]
11. Drivetrain and Front Suspension Cradle Plate (3)Â» Install - **Drivetrain and Front Suspension Cradle Plate Replacement**

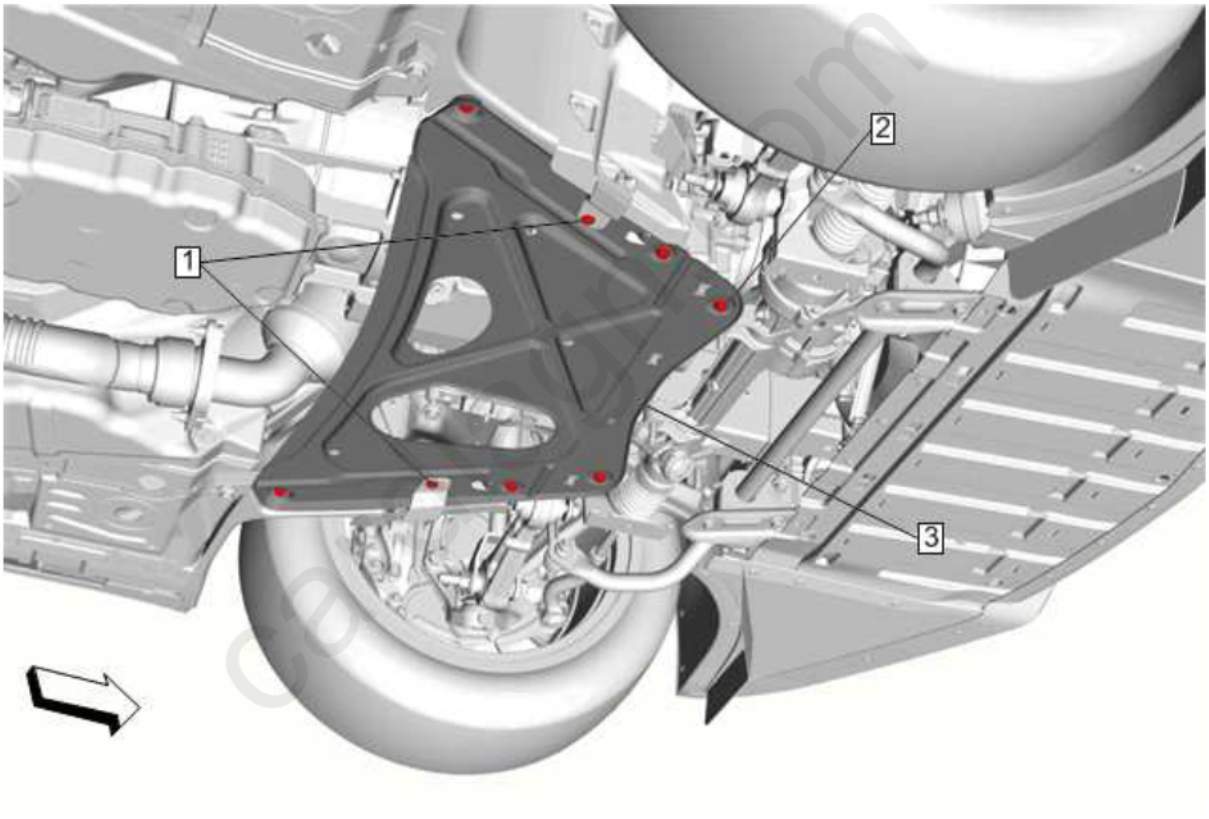


Fig. 290: Drivetrain and Front Suspension Cradle Plate
Courtesy of GENERAL MOTORS COMPANY

12. Front Bumper Fascia Lower Stiffener (1)Â» Install - **Front Bumper Fascia Lower Stiffener Replacement**

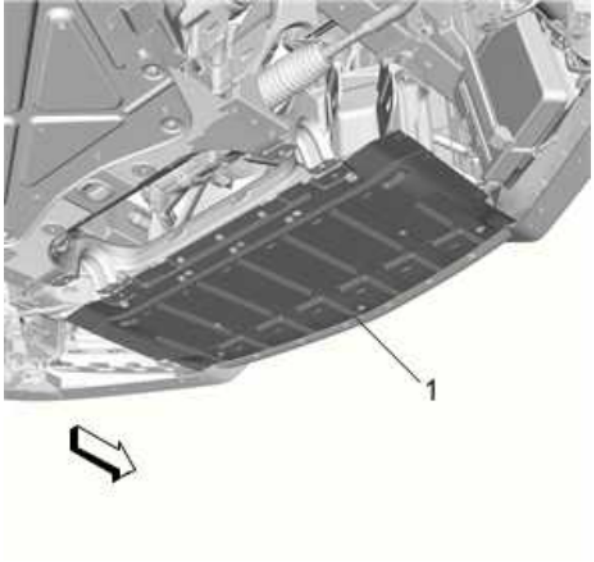


Fig. 291: Front Bumper Fascia Lower Stiffener
Courtesy of GENERAL MOTORS COMPANY

13. Underbody Front Air Deflector (3)Â» Install - **Underbody Front Air Deflector Replacement**

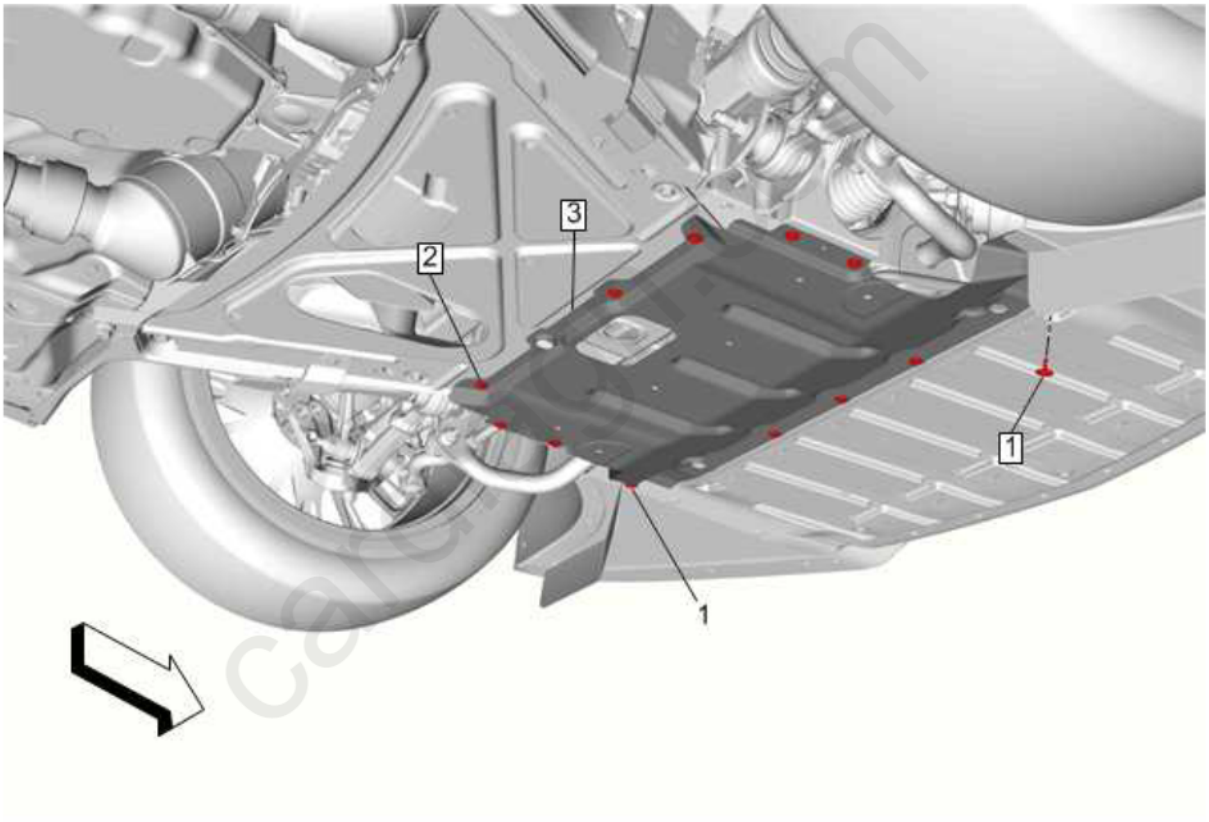


Fig. 292: Underbody Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

14. Front Wheelhouse Liner (2)Â» Install [2x] - **Front Wheelhouse Liner Replacement**

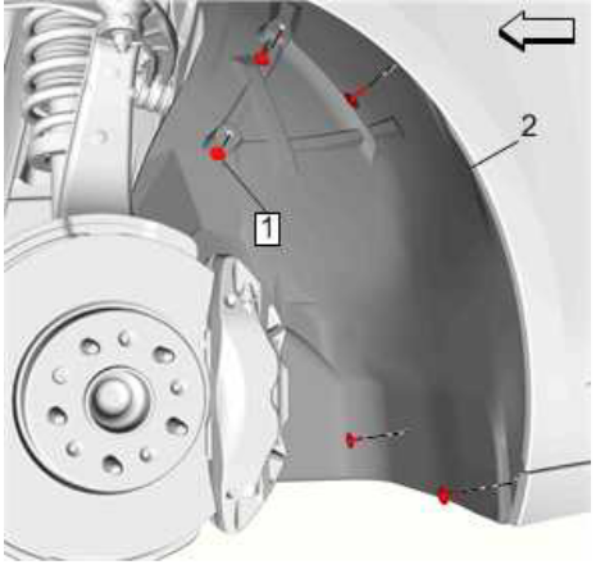


Fig. 293: Front Wheelhouse Liner
Courtesy of GENERAL MOTORS COMPANY

15. Engine Lower Front Splash ShieldÂ» Install - **Engine Lower Front Splash Shield Replacement (LTG)**
16. Lower the vehicle.
17. Transmission Fluid Cooler Outlet Pipe (2) @ RadiatorÂ» Connect
18. Transmission Fluid Cooler Outlet Pipe Clip (1) @Â» Transmission Fluid Cooler FittingÂ» Install - **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection** .
19. Transmission Fluid Cooler Inlet Pipe (1) @ RadiatorÂ» Connect

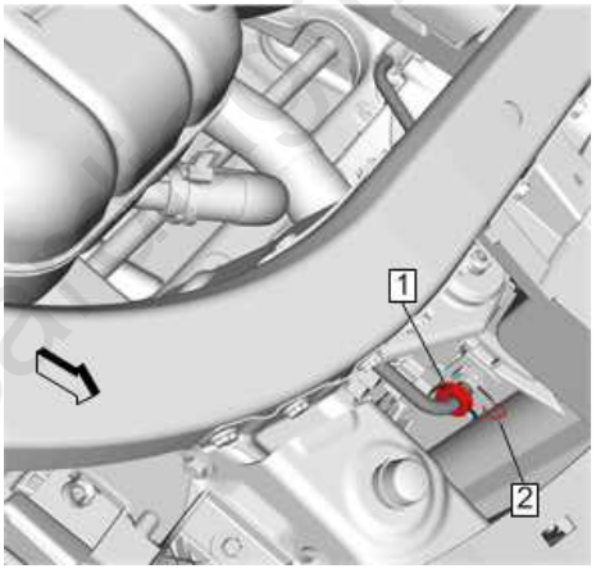


Fig. 294: Transmission Fluid Cooler Inlet Pipe
Courtesy of GENERAL MOTORS COMPANY

20. Transmission Fluid Cooler Inlet Pipe Clip (2) @ Transmission Fluid Cooler FittingÂ» Install - **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection**
21. Transmission Fluid Cooler Pipe Clip (1) @ Engine Coolant Fan ShroudÂ» Install [4x]

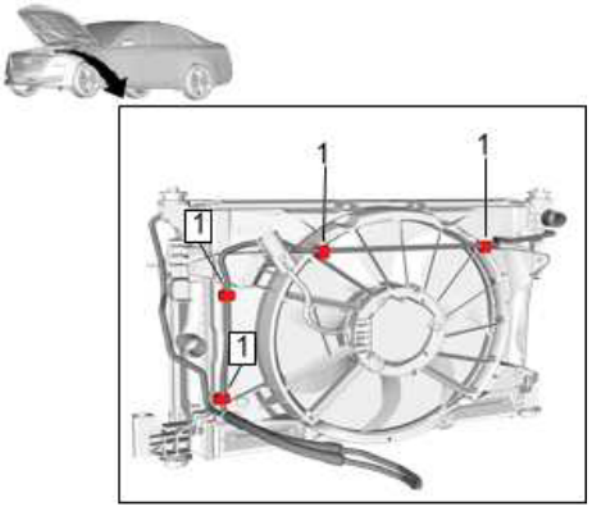


Fig. 295: Transmission Fluid Cooler Pipe Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

22. Air Conditioning Compressor and Condenser Hose (3) @ Air Conditioning CompressorÂ» Connect - **Air Conditioning Compressor and Condenser Hose Replacement (LGW, LGX)**

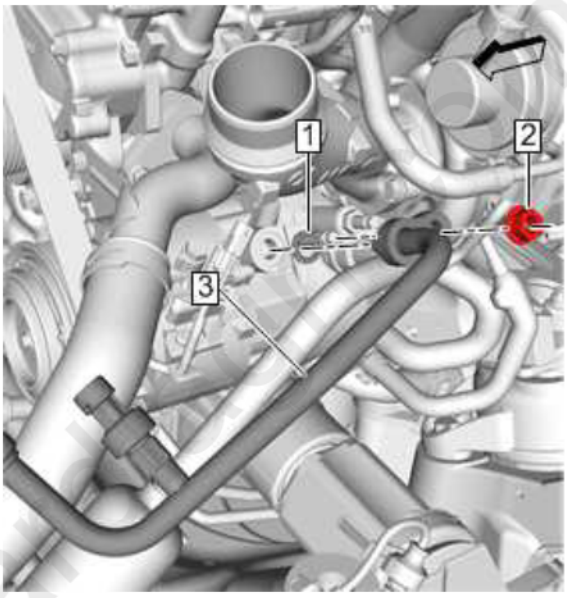


Fig. 296: Air Conditioning Compressor and Condenser Hose
Courtesy of GENERAL MOTORS COMPANY

23. Air Conditioning Compressor Hose (3) @ Air Conditioning CompressorÂ» Connect - **Air Conditioning Compressor Hose Replacement (LGW, LGX)**

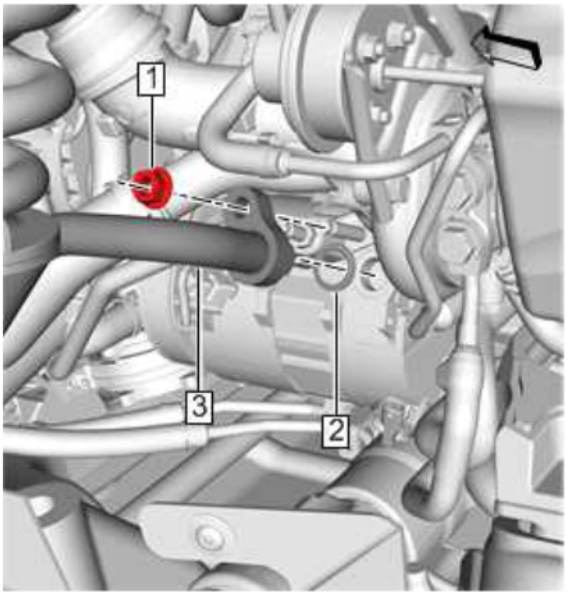


Fig. 297: Air Conditioning Compressor Hose
Courtesy of GENERAL MOTORS COMPANY

24. Pass Through Grommet (1)Â» Install

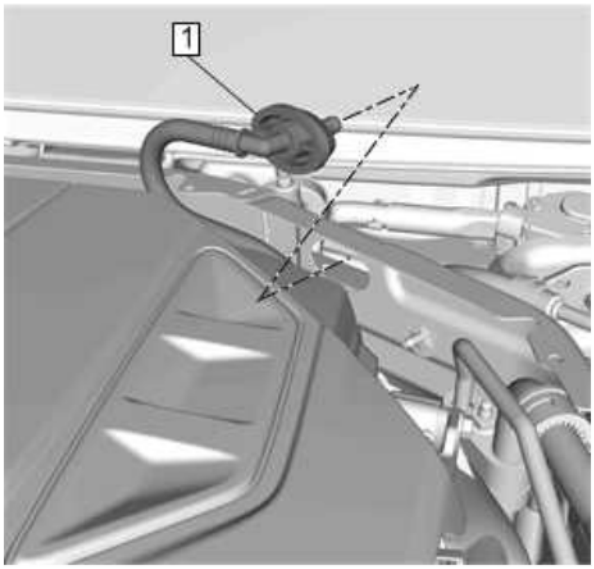


Fig. 298: Power Brake Booster Vacuum Hose Pass Through Grommet
Courtesy of GENERAL MOTORS COMPANY

25. Power Brake Booster Vacuum Hose @ Pass Through GrommetÂ» Connect
26. Clamp (1) @ Power Brake Booster Vacuum Hose (2)Â» Install - **Hose Clamp Replacement Guidelines - Spring Type**

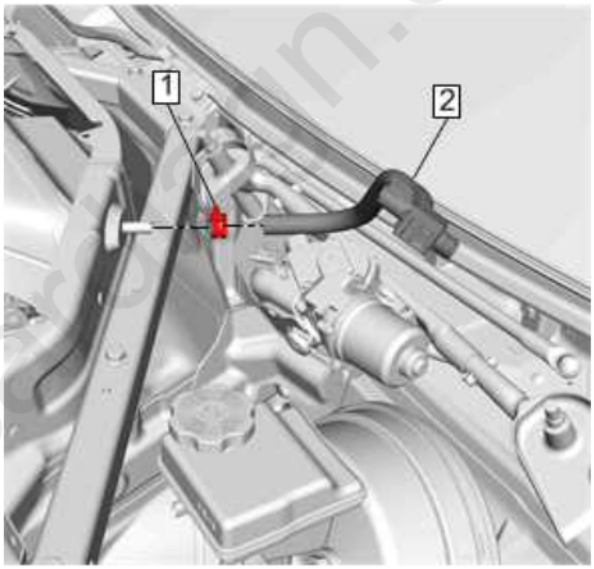


Fig. 299: Power Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

27. Evaporative Emission Canister Purge Pipe @ Evaporative Emission Canister Purge Solenoid ValveÂ» Connect - **Evaporative Emission Canister Purge Pipe Replacement (LGW)**
28. Fuel Feed Pipe (1) @ Fuel Pulse DampenerÂ» Connect - **Fuel Feed Pipe Replacement (LGW)**

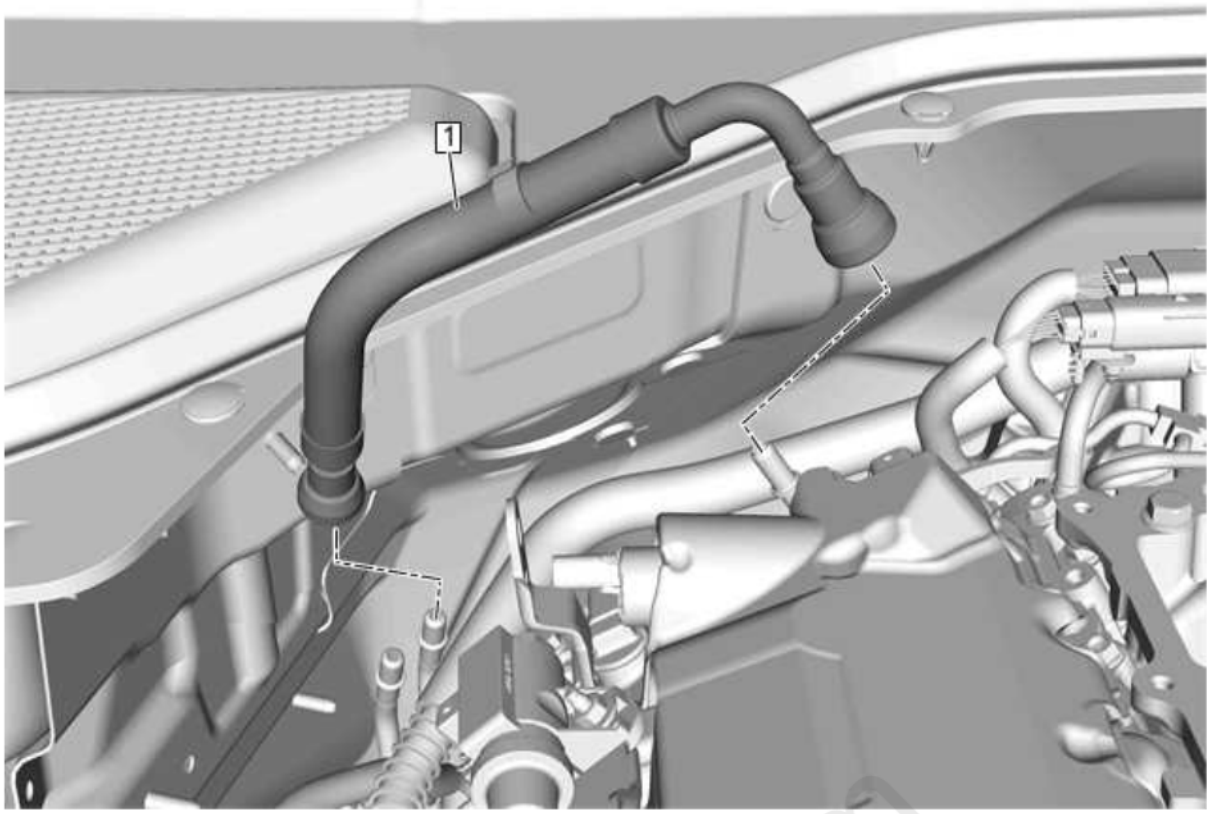


Fig. 300: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

29. Heater Water Auxiliary Pump Inlet Hose (3) @ Heater Coolant PumpÂ» Connect - **Heater Coolant Pump Replacement (LGW)** **Heater Coolant Pump Replacement (LGX)**

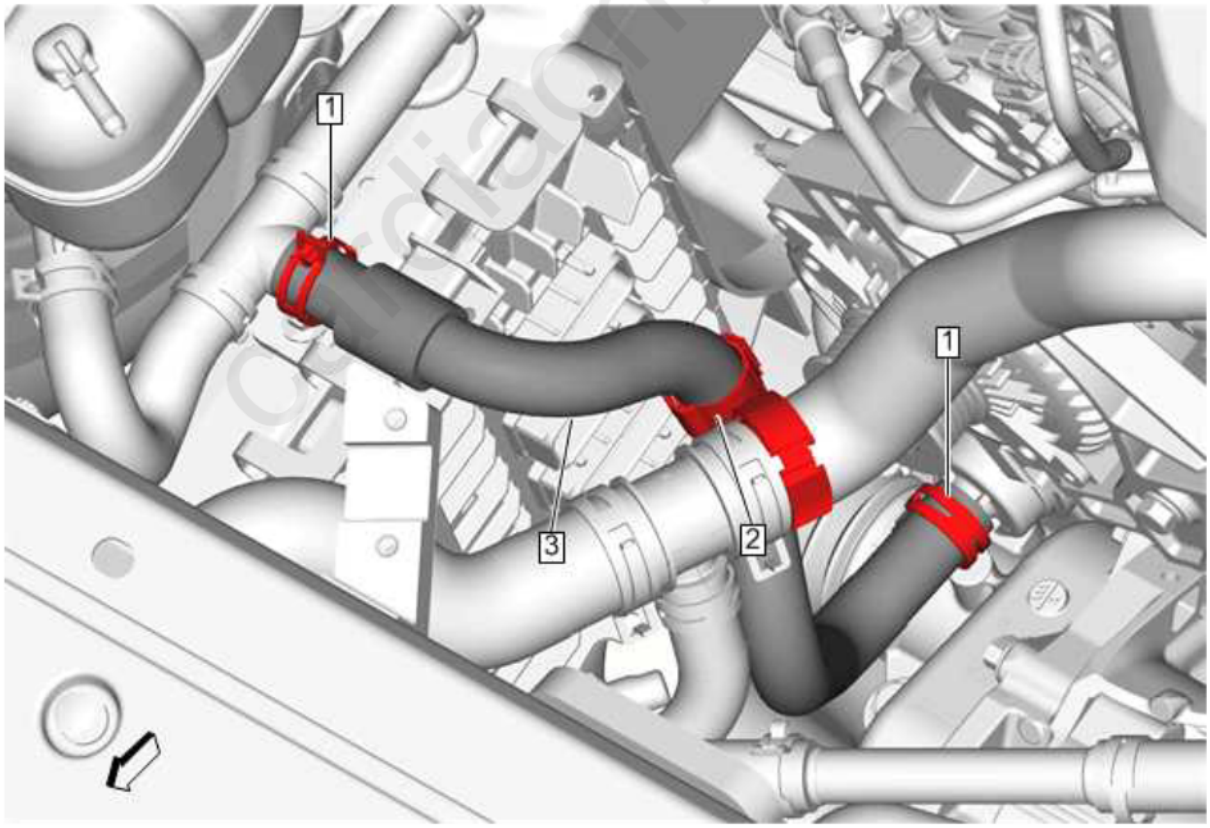


Fig. 301: Heater Water Auxiliary Pump Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

30. Auxiliary Heater Inlet Hose (1) @ Auxiliary Heater Inlet and Outlet PipeÂ» Connect - **Auxiliary Heater Inlet Hose Replacement (LGW)** **Auxiliary Heater Inlet Hose Replacement (LGX)**

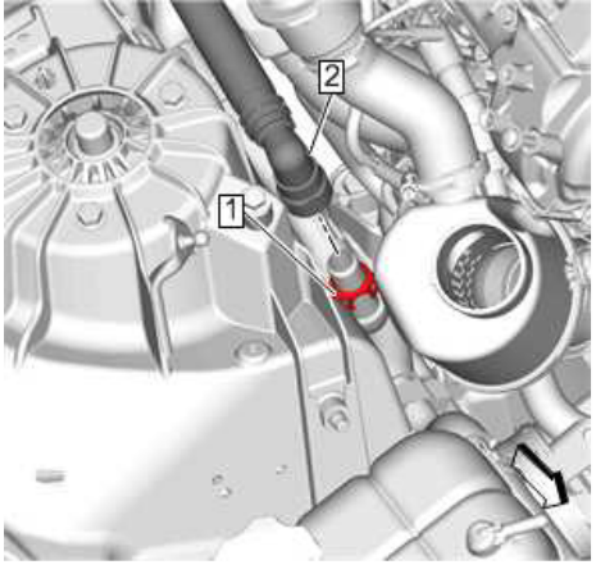


Fig. 302: Auxiliary Heater Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

31. Engine Oil Cooler Inlet Hose (2) @ Engine Oil Cooler Inlet PipeÂ» Connect

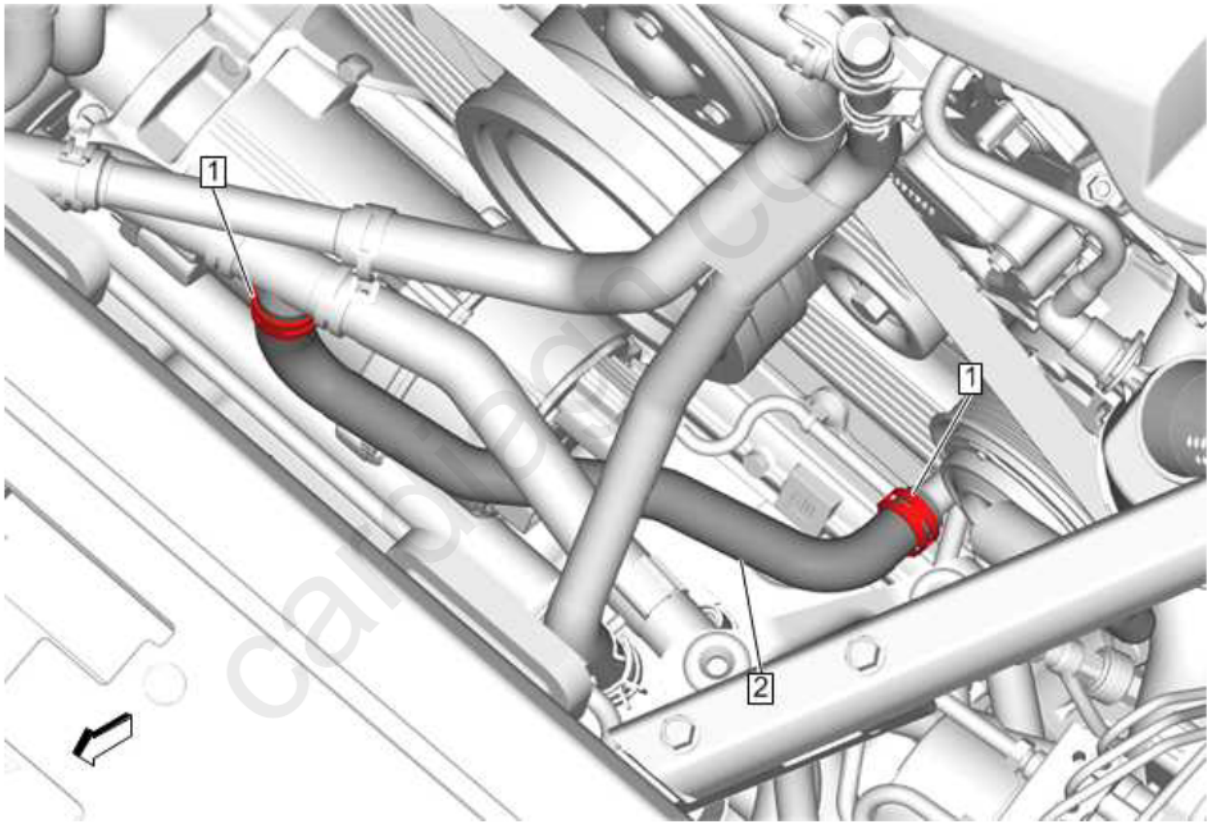


Fig. 303: Engine Oil Cooler Coolant Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

32. Engine Oil Cooler Inlet Hose Clamp (1) @ Engine Oil Cooler Inlet PipeÂ» Install - **Hose Clamp Replacement Guidelines - Spring Type**
33. Radiator Outlet Hose (2) @ Water Pump Inlet PipeÂ» Connect

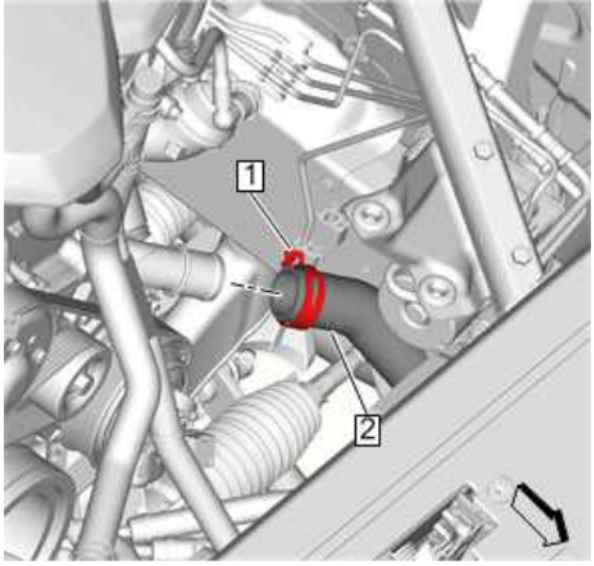


Fig. 304: Radiator Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

34. Radiator Outlet Hose Clamp (1) @ Water Pump Inlet PipeÂ» Install - **Hose Clamp Replacement Guidelines - Spring Type**
35. Charge Air Cooler Coolant HoseÂ» Install - **Charge Air Cooler Coolant Hose Replacement - Inlet (LGW)**
36. Radiator Inlet Hose (1) @ Water OutletÂ» Connect

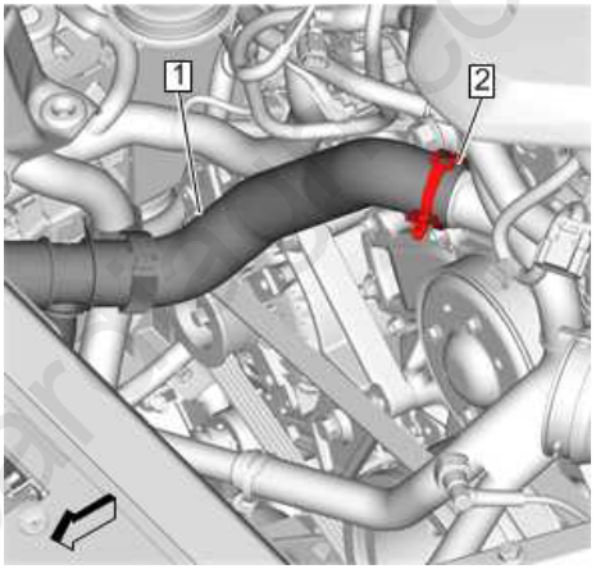


Fig. 305: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

37. Radiator Inlet Hose Clamp (2) @ Water OutletÂ» Install - **Hose Clamp Replacement Guidelines - Spring Type**
38. Position the engine harness and attach harness retainers to the engine.
39. Engine Control Module Electrical Connector (1)Â» Connect [4x]

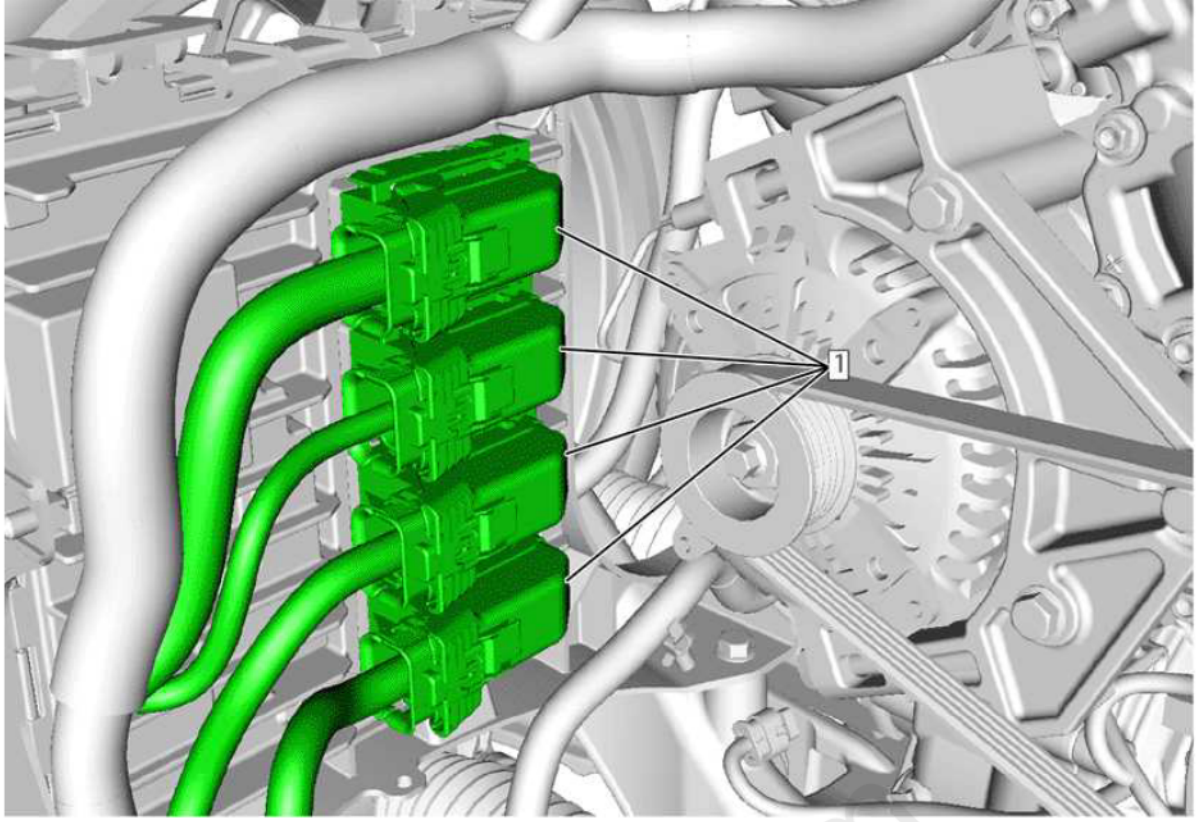


Fig. 306: Engine Control Module Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

40. Harness Connector (1)Â» Connect

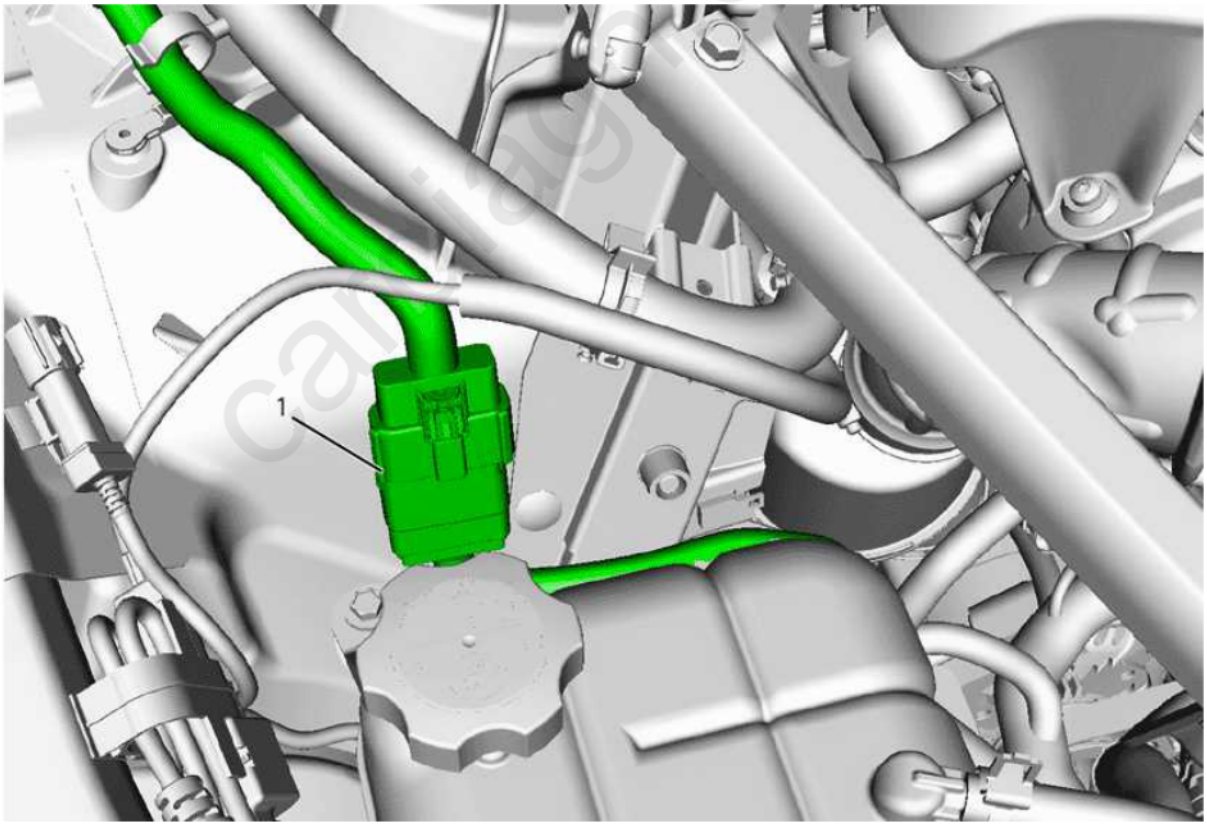


Fig. 307: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

41. Engine Wiring Harness Junction BlockÂ» Install - **Engine Wiring Harness Junction Block Replacement**
42. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement (LGW)** and/or **Air Cleaner Assembly Replacement (LGX)**
43. Radiator Surge Tank Inlet Hose (2) @ Engine Coolant Air Bleed PipeÂ» Connect

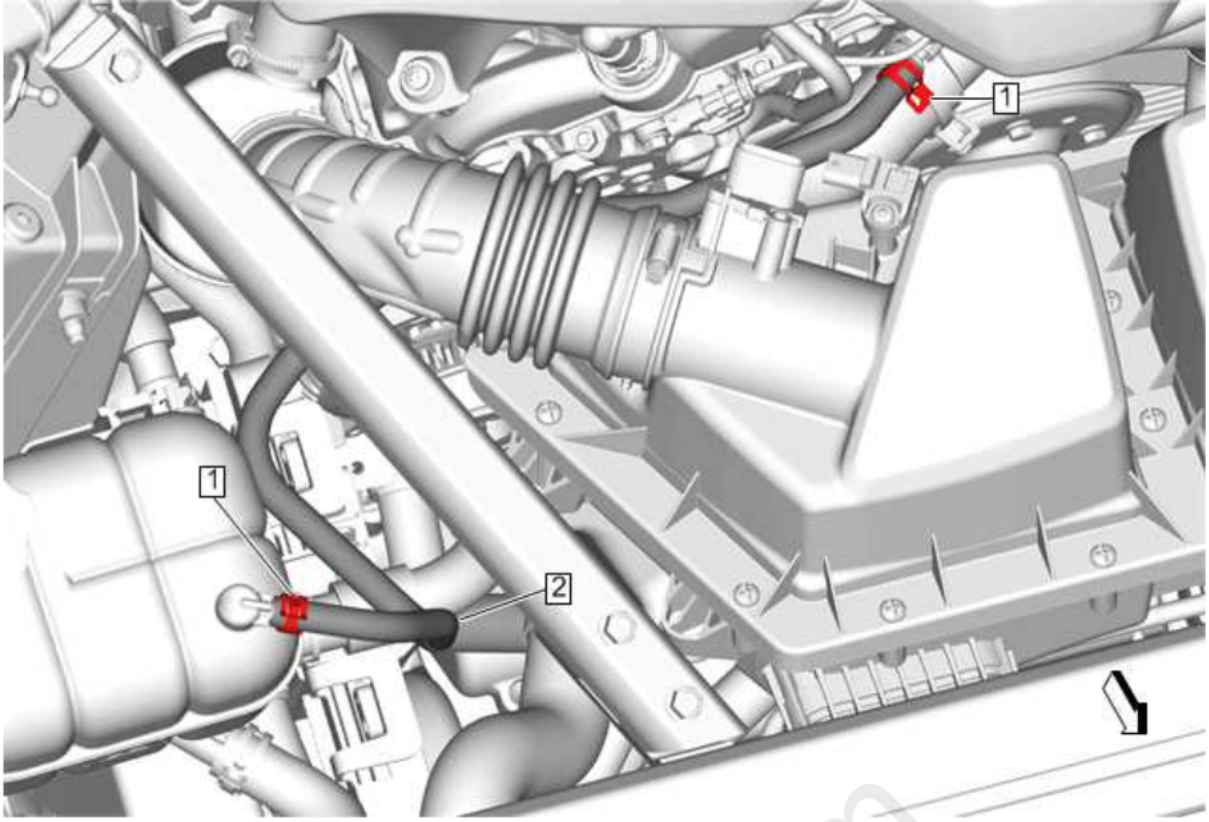


Fig. 308: Engine Coolant Air Bleed Hose
Courtesy of GENERAL MOTORS COMPANY

44. Install the front compartment front sight shield. Refer to **Front Compartment Front Sight Shield Replacement**
45. Intake Manifold CoverÂ» Install - **Intake Manifold Cover Replacement (LGW)**
46. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**
47. Fill the cooling system. Refer to **Cooling System Draining and Filling (Static without HP9)** , **Cooling System Draining and Filling (GE 47716 without HP9)** , **Cooling System Draining and Filling (Static LTG with HP9)** and/or **Cooling System Draining and Filling (GE 47716 LTG with HP9)**
48. Fill the engine oil to the proper level with NEW engine oil. Refer to **Engine Oil and Oil Filter Replacement**
49. If the engine is replaced with a new engine or has been overhauled, perform the Engine Prelubing procedure. Refer to **Engine Prelubing**

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

50. Charge the A/C system. Refer to **Refrigerant Recovery and Recharging (R-134a)** and/or **Refrigerant Recovery and Recharging (R-1234yf)**
51. Perform the crankshaft position variation learn procedure. Refer to **Crankshaft Position Variation Learn**
52. Perform the throttle learn procedure. Refer to **Throttle Body Idle Air Flow Compensation Reset**

ENGINE REPLACEMENT (LGX)

Removal Procedure

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**
2. Recover the refrigerant. Refer to **Refrigerant Recovery and Recharging (R-134a)** **Refrigerant Recovery and Recharging (R-1234yf)**
3. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static without HP9)** , **Cooling System Draining and Filling (GE 47716 without HP9)** , **Cooling System Draining**

and Filling (Static LTG with HP9)** and/or **Cooling System Draining and Filling (GE 47716 LTG with HP9)**

4. Intake Manifold CoverÂ» Remove - **Intake Manifold Cover Replacement (LGX)**
5. Remove the front compartment front sight shield. Refer to **Front Compartment Front Sight Shield Replacement**
6. Air Cleaner Outlet DuctÂ» Remove - **Air Cleaner Outlet Duct Replacement (LGX)**
7. Air Inlet Grille PanelÂ» Remove - **Air Inlet Grille Panel Replacement**
8. Harness Connector (1)Â» Disconnect [3x]

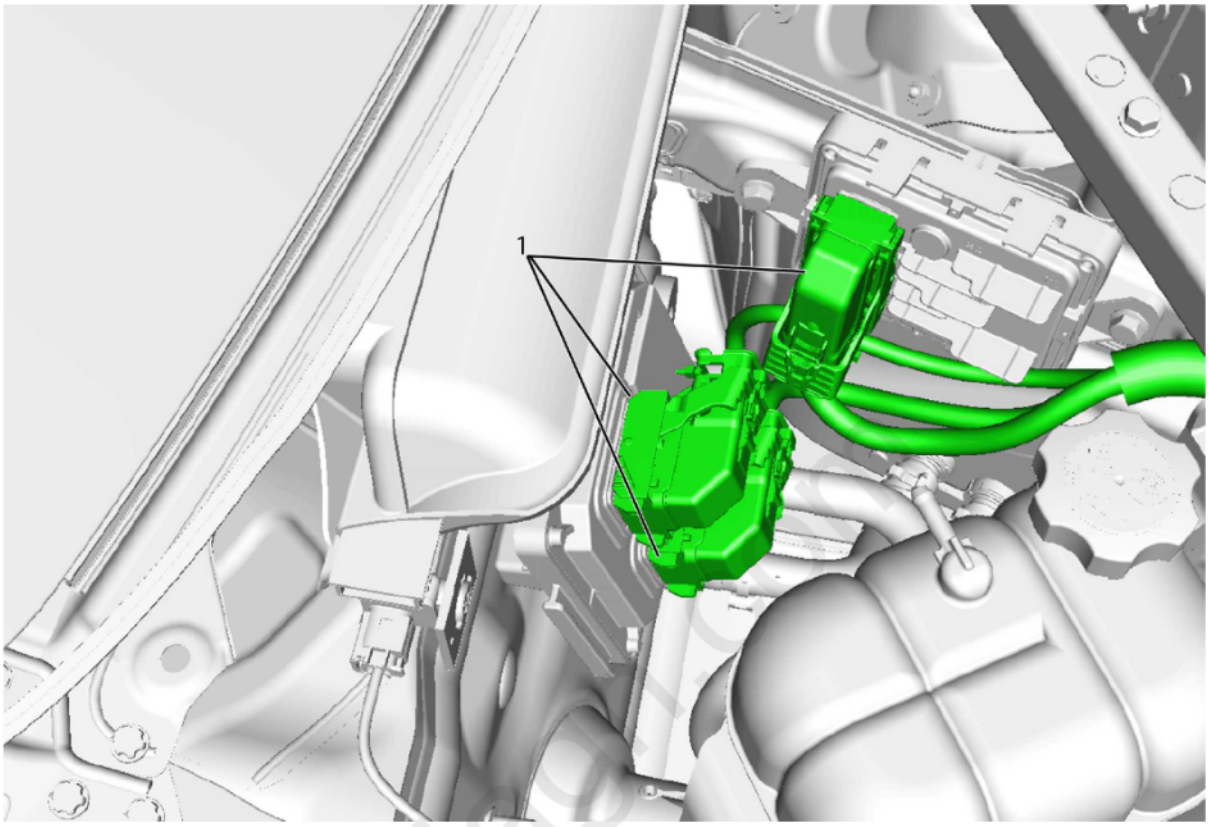


Fig. 309: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

9. Detach harness retainers and reposition the engine harness on the engine.
10. Engine Coolant Air Bleed Hose Clamp (1) Disengage - **Hose Clamp Replacement Guidelines - Spring Type**

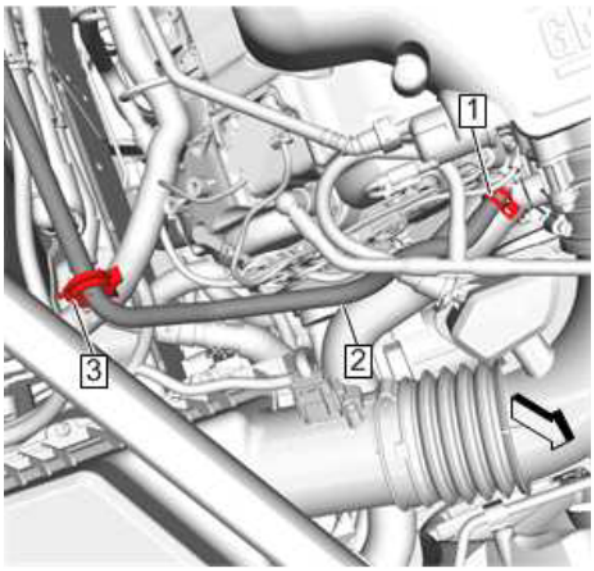


Fig. 310: Engine Coolant Air Bleed Hose
Courtesy of GENERAL MOTORS COMPANY

11. Engine Coolant Air Bleed Hose (2) @ Engine Coolant Air Bleed PipeÂ» Remove

12. Radiator Inlet Hose Clamp (2) @ Water OutletÂ» Disengage - **Hose Clamp Replacement Guidelines - Spring Type**

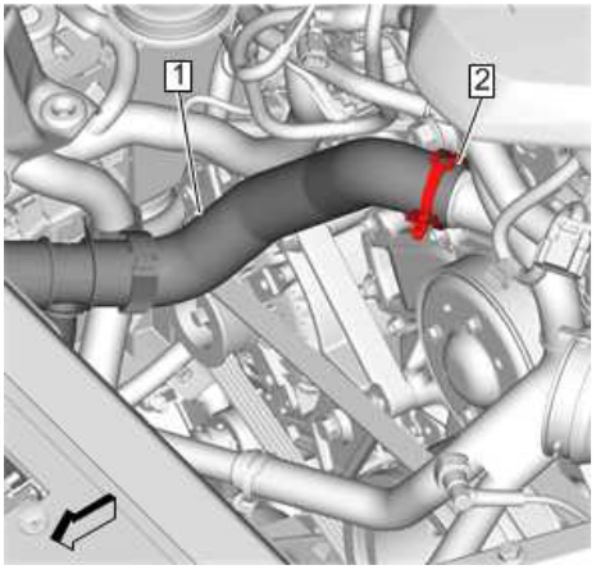


Fig. 311: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

13. Radiator Inlet Hose (1) @ Water OutletÂ» Remove
14. Radiator Outlet Hose Clamp (1) @ Water Pump Inlet PipeÂ» Disengage - **Hose Clamp Replacement Guidelines - Spring Type**

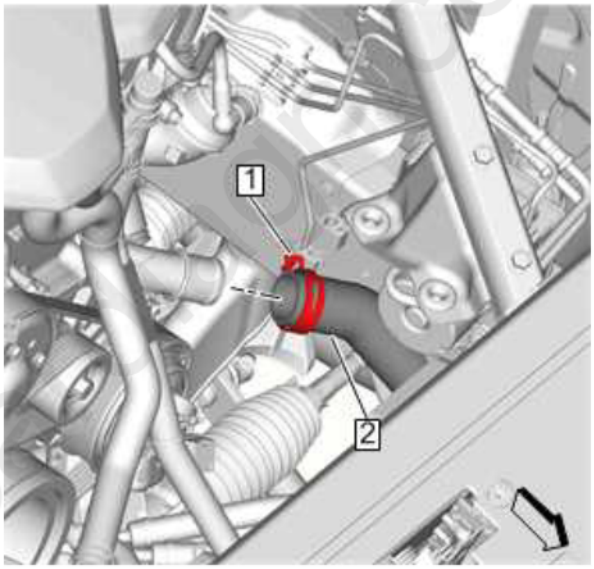


Fig. 312: Radiator Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

15. Radiator Outlet Hose (2) @ Water Pump Inlet PipeÂ» Remove
16. Engine Wiring Harness Junction BlockÂ» Remove - **Engine Wiring Harness Junction Block Replacement**
17. Harness Connector (1)Â» Disconnect

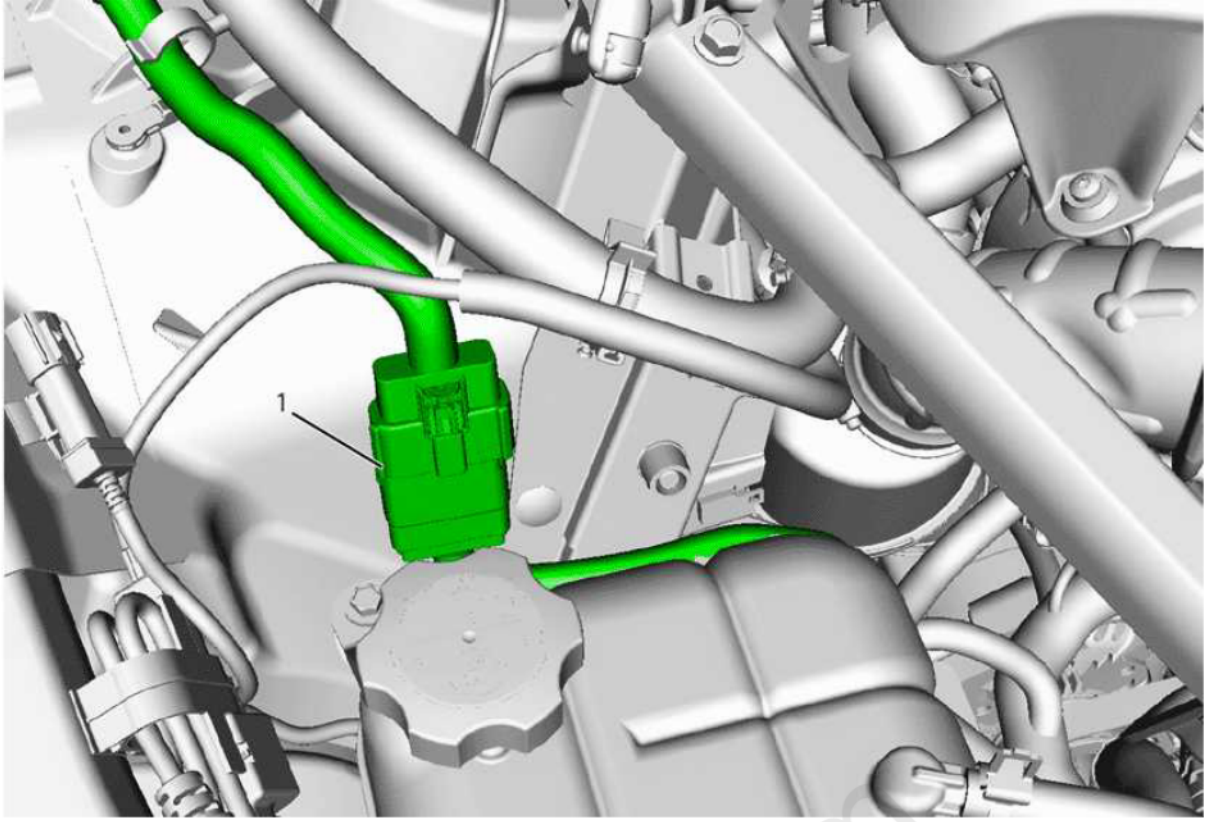


Fig. 313: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

18. Engine Control Module Electrical Connector (1)Â» Disconnect [3x]

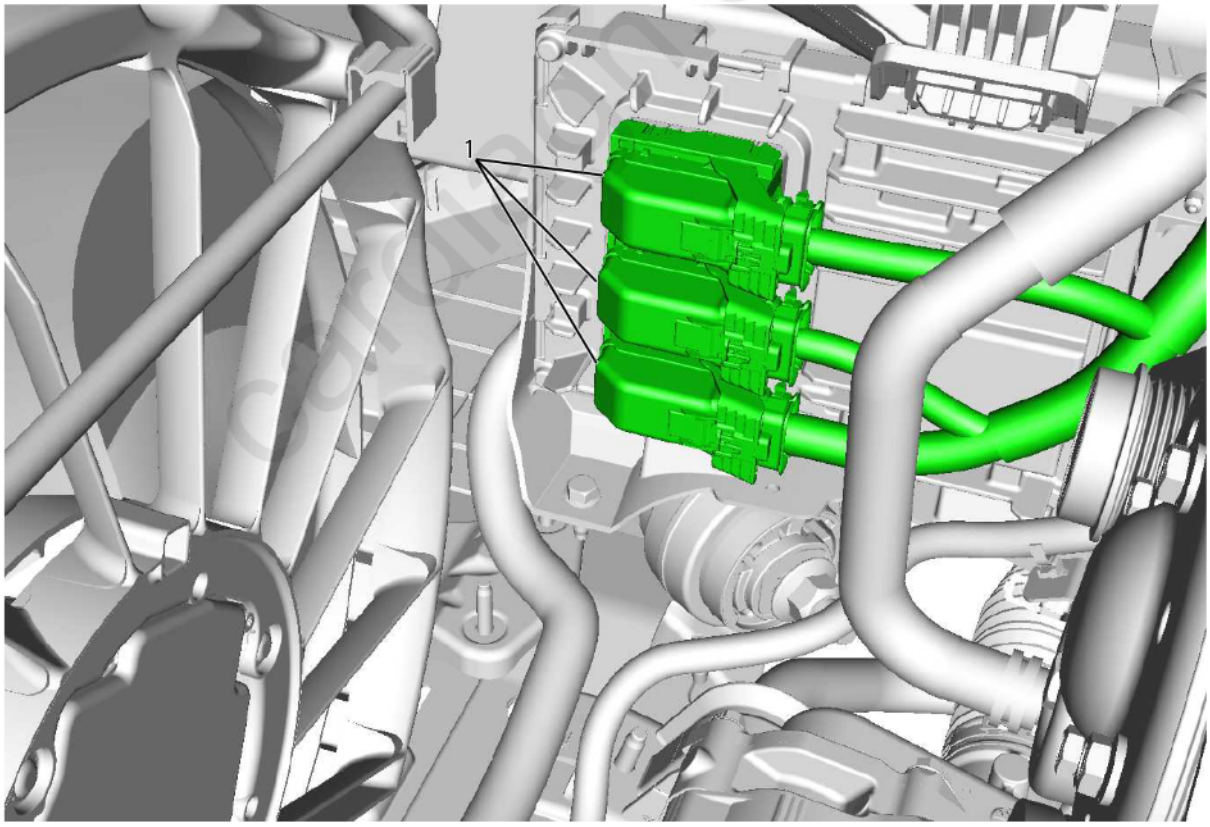


Fig. 314: Engine Control Module Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

19. Detach harness retainers and reposition the engine harness on the engine.
20. Auxiliary Heater Inlet Hose (1) @ Auxiliary Heater Inlet and Outlet PipeÂ» Disconnect - **Auxiliary Heater Inlet Hose Replacement (LGX)**

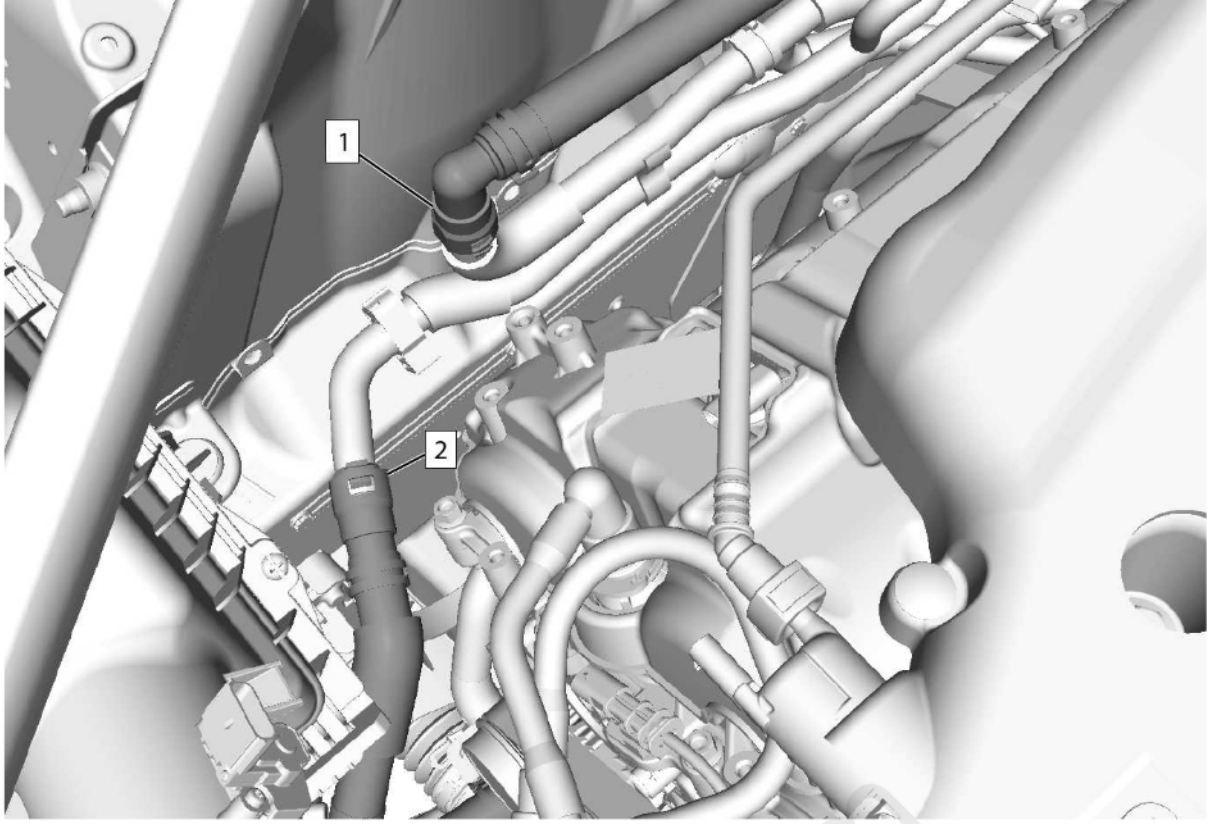


Fig. 315: Disconnect Auxiliary Heater Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

21. Heater Water Auxiliary Pump Inlet Hose (2)Â» Disconnect - **Heater Coolant Pump Replacement (LGX)**
22. Fuel Feed Pipe (1) @ Fuel Pulse DampenerÂ» Disconnect - **Fuel Feed Pipe Replacement (LGX)**

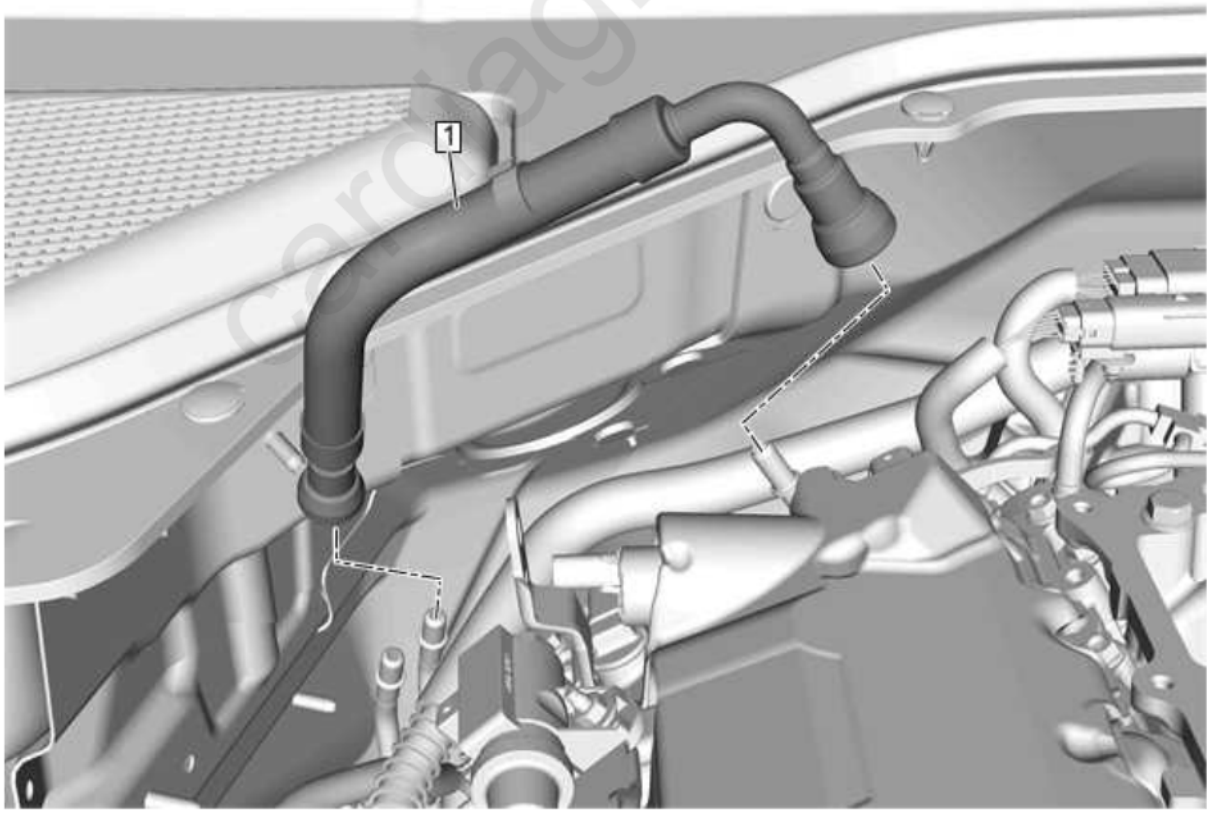


Fig. 316: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

23. Evaporative Emission Canister Purge Pipe @ Evaporative Emission Canister Purge Solenoid ValveÂ» Disconnect - **Evaporative Emission Canister Purge Pipe Replacement (LGX)**
24. Clamp (1) @ Power Brake Booster Vacuum Hose (2)Â» Disengage - **Hose Clamp Replacement Guidelines - Spring Type**

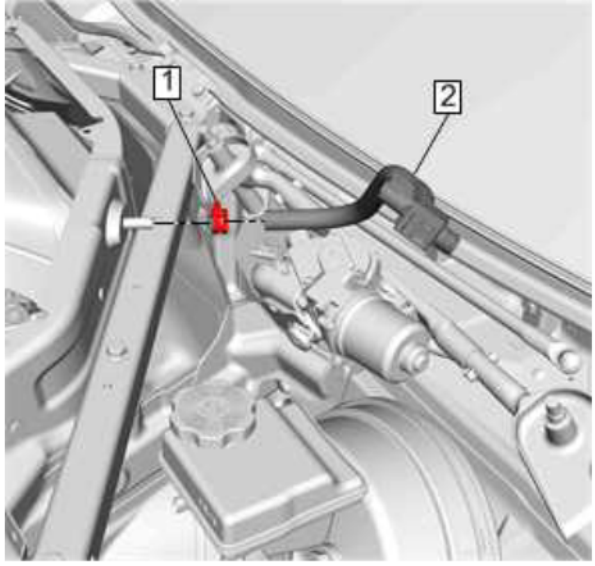


Fig. 317: Power Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

25. Power Brake Booster Vacuum Hose @ Pass Through GrommetÂ» Remove
26. Pass Through Grommet (1)Â» Release

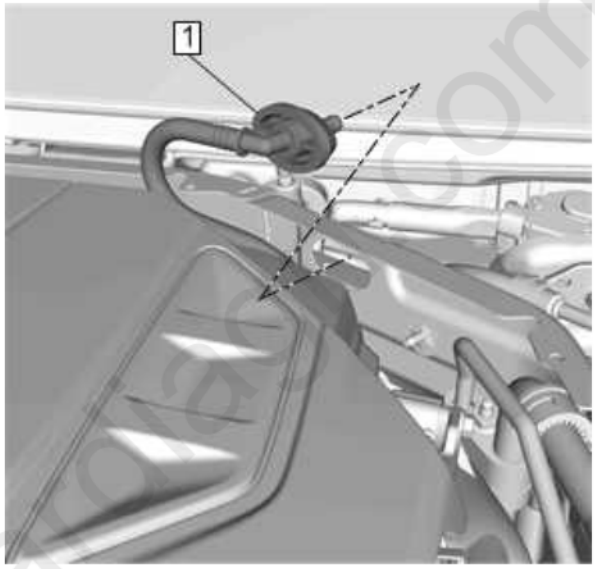


Fig. 318: Power Brake Booster Vacuum Hose Pass Through Grommet
Courtesy of GENERAL MOTORS COMPANY

27. Air Conditioning Compressor and Condenser Hose Nut (2)Â» Remove

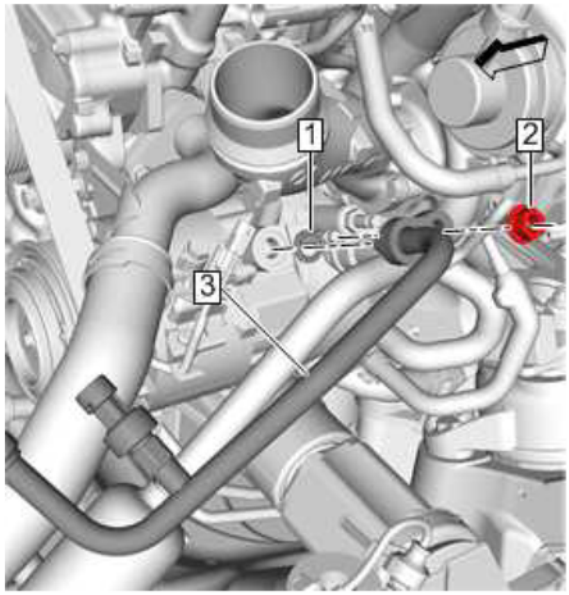


Fig. 319: Air Conditioning Compressor and Condenser Hose
Courtesy of GENERAL MOTORS COMPANY

28. Air Conditioning Compressor and Condenser Hose (3)Â» Remove
29. Sealing Washer (1)Â» Remove and DISCARD
30. Air Conditioning Compressor Hose Nut (1)Â» Remove

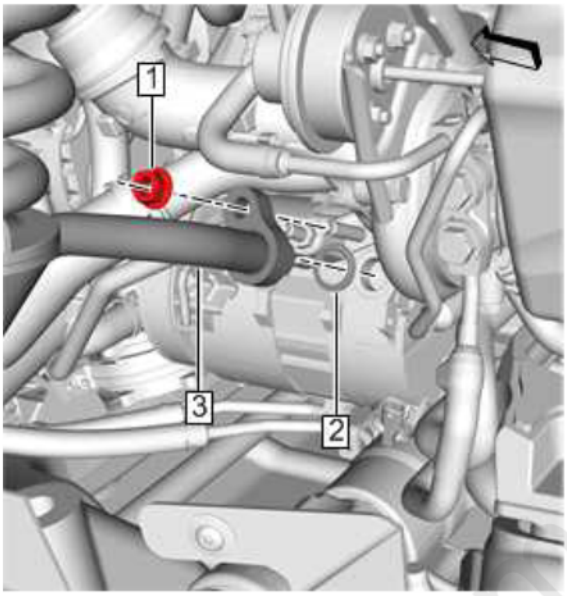


Fig. 320: Air Conditioning Compressor Hose
Courtesy of GENERAL MOTORS COMPANY

31. Air Conditioning Compressor Hose (3)Â» Remove
32. Sealing Washer (2)Â» Remove and DISCARD
33. Disconnect and reposition harness as necessary.
34. Transmission Fluid Cooler Pipe Clip (1) @ Engine Coolant Fan ShroudÂ» Remove [4x]

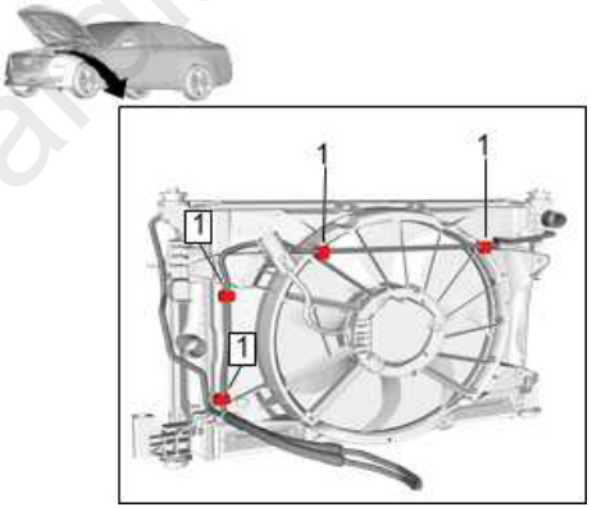


Fig. 321: Transmission Fluid Cooler Pipe Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

35. Transmission Fluid Cooler Inlet Pipe Clip (2) @ Transmission Fluid Cooler FittingÂ» Remove - **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection**

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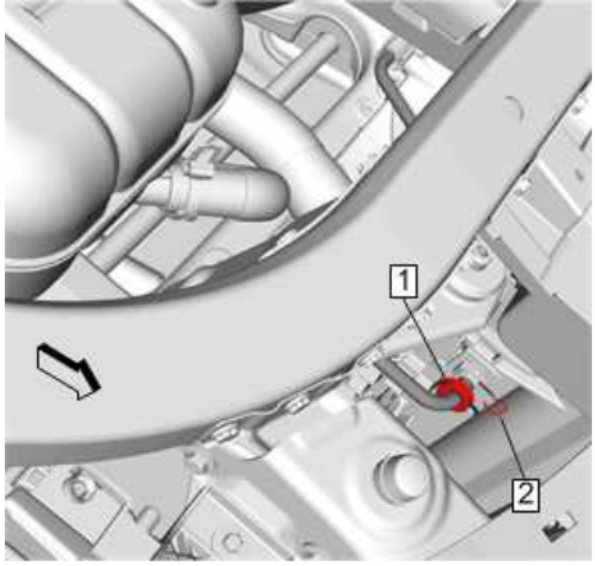


Fig. 322: Transmission Fluid Cooler Inlet Pipe
Courtesy of GENERAL MOTORS COMPANY

36. Transmission Fluid Cooler Inlet Pipe (1) @ RadiatorÂ» Disconnect
37. Transmission Fluid Cooler Outlet Pipe Clip (1) @Â» Transmission Fluid Cooler FittingÂ» Remove - **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection** .

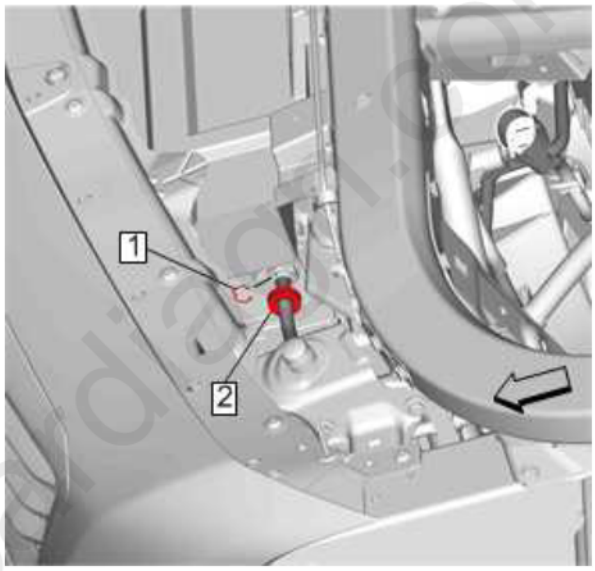


Fig. 323: Transmission Fluid Cooler Outlet Pipe And Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

38. Transmission Fluid Cooler Outlet Pipe (2) @ RadiatorÂ» Disconnect
39. Front Wheelhouse Liner (2)Â» Remove [2x] - **Front Wheelhouse Liner Replacement**

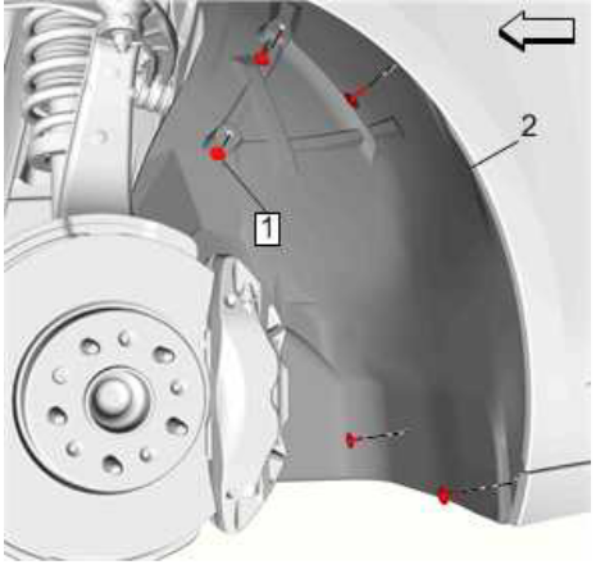


Fig. 324: Front Wheelhouse Liner
Courtesy of GENERAL MOTORS COMPANY

40. Front Tire Front Air Deflector (2)Â» Remove [2x] - **Front Tire Front Air Deflector Replacement**

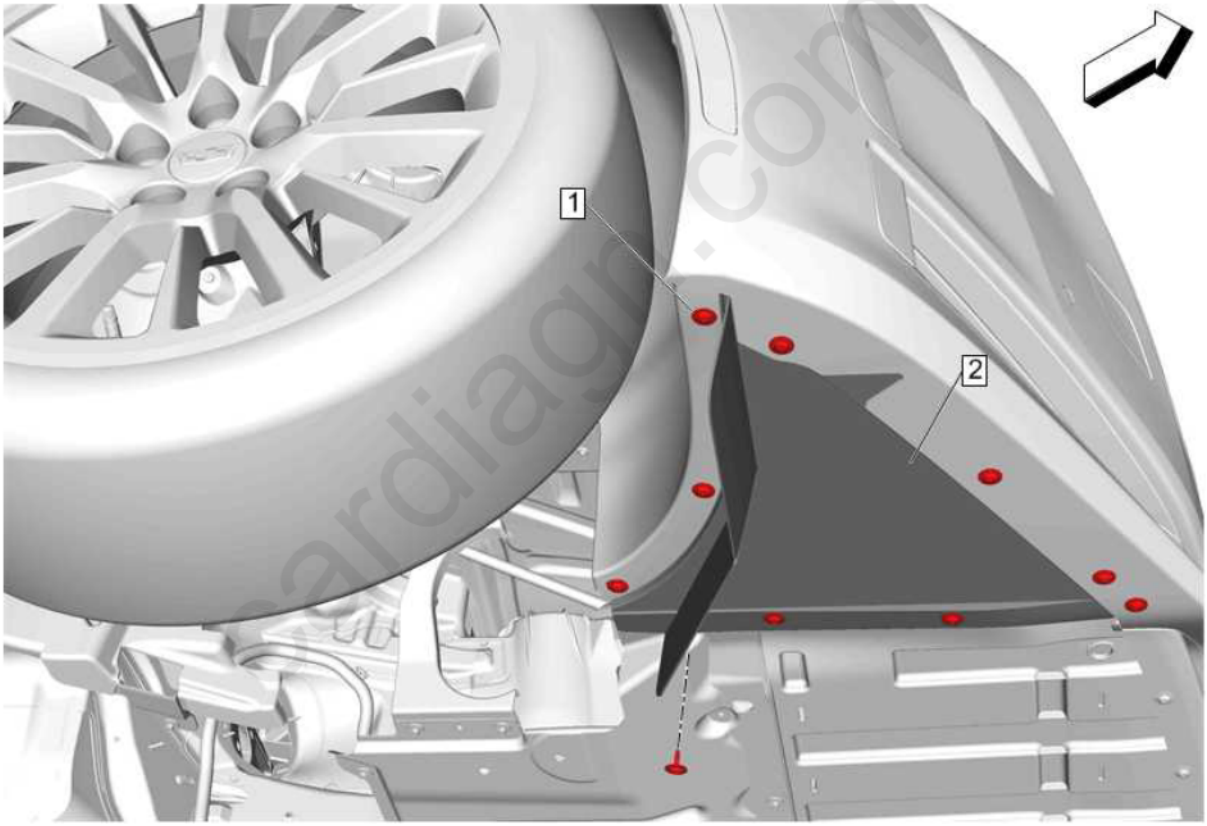


Fig. 325: Front Tire Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

41. Underbody Front Air Deflector (3)Â» Remove - **Underbody Front Air Deflector Replacement**

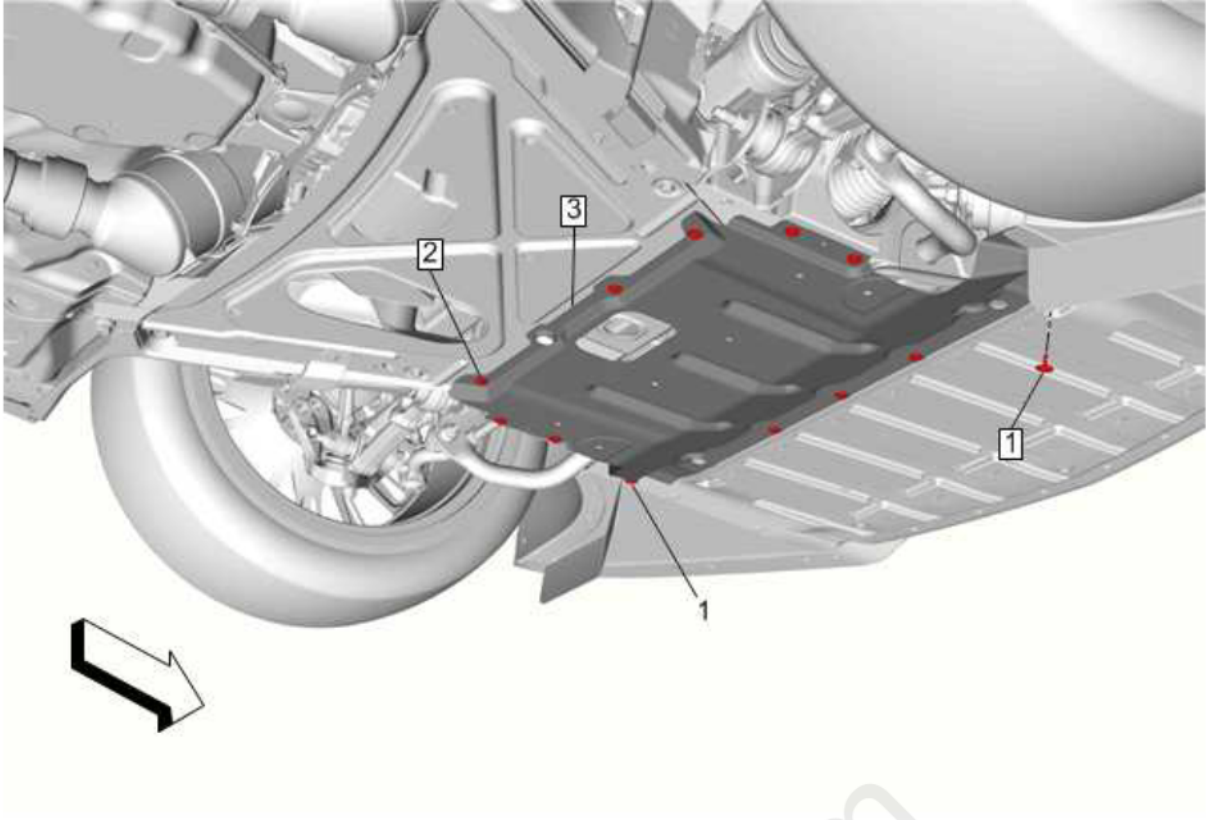


Fig. 326: Underbody Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

42. Front Bumper Fascia Lower Stiffener (1)Â» Remove - **Front Bumper Fascia Lower Stiffener Replacement**

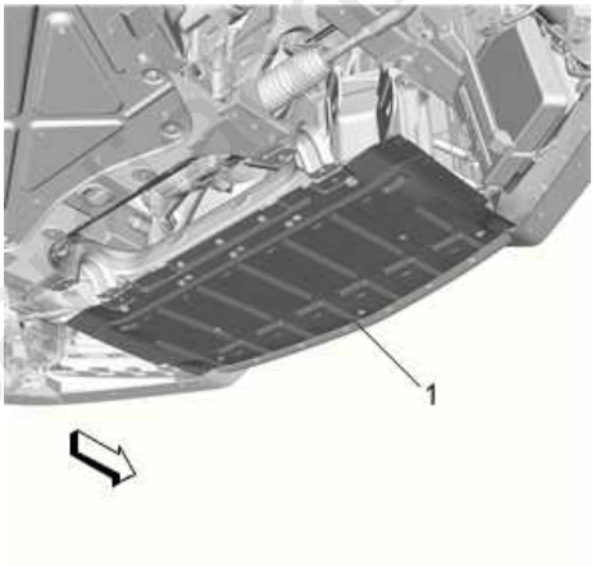


Fig. 327: Front Bumper Fascia Lower Stiffener
Courtesy of GENERAL MOTORS COMPANY

43. Drivetrain and Front Suspension Cradle Plate (3)Â» Remove - **Drivetrain and Front Suspension Cradle Plate Replacement**

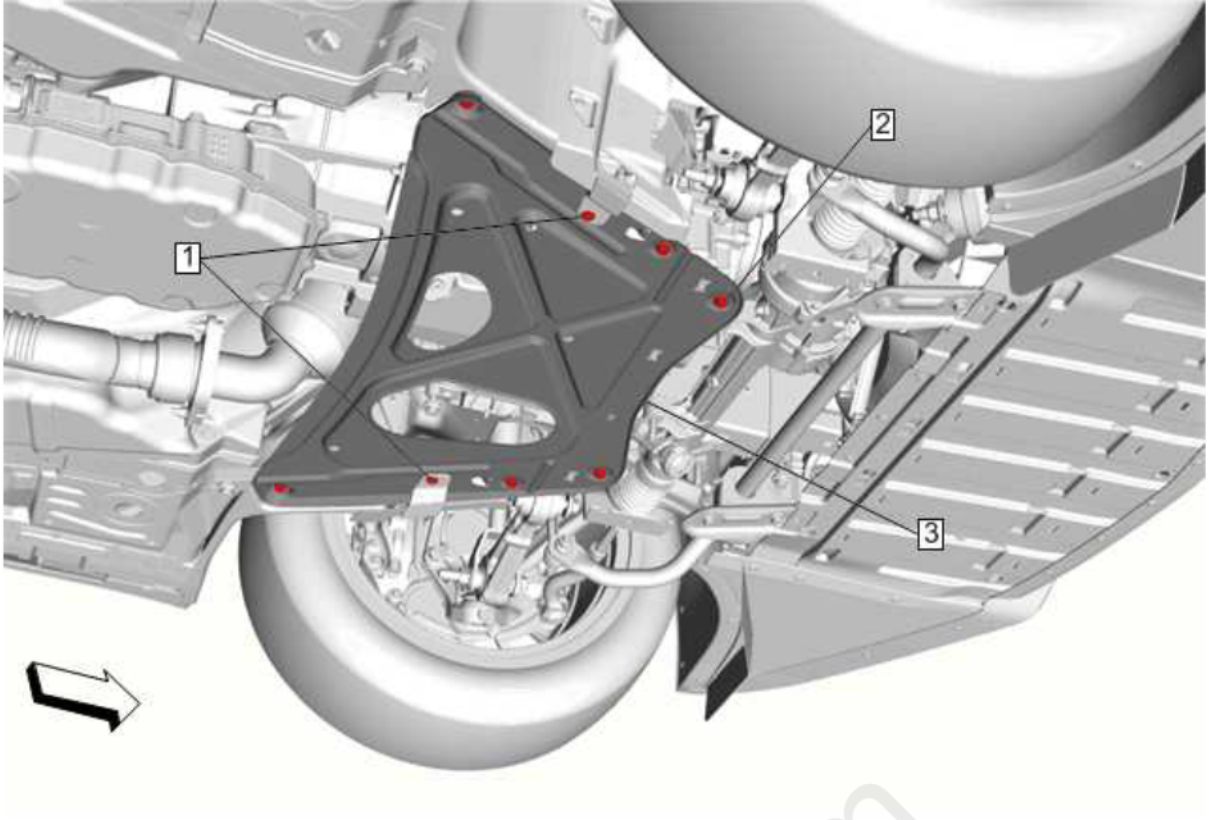


Fig. 328: Drivetrain and Front Suspension Cradle Plate
Courtesy of GENERAL MOTORS COMPANY

44. Warm Up Three-Way Catalytic Converter Replacement (Left, LGW) Warm Up Three-Way Catalytic Converter Replacement (Right, LGW) Warm Up Three-Way Catalytic Converter Replacement (Left, LGX) Warm Up Three-Way Catalytic Converter Replacement (Right, LGX) Â» Remove [2x]
45. Prepare the transmission for removal. Refer to Transmission Replacement (LGW Engine) and/or Transmission Replacement (LGX Engine)
46. Prepare the transfer case for removal. Refer to Transfer Case Assembly Replacement
47. Secure the vehicle body to the vehicle hoist using suitable straps or binders.

NOTE: **Removing the powertrain assembly from the vehicle could cause an unstable balance condition with the vehicle body on the vehicle hoist. Securing the vehicle body to the hoist is necessary.**

48. Remove the drivetrain and front suspension cradle with the powertrain attached. Refer to Drivetrain and Front Suspension Cradle Removal and Installation

NOTE: **The powertrain assembly will be removed from vehicle on the drivetrain and front suspension frame. In the next step, only perform the necessary procedures required to remove the powertrain assembly.**

49. Lower the powertrain onto a suitable support table.
50. Secure the powertrain to the support table using straps and binders.
51. With the aid of an assistant, carefully raise the body from the frame.
52. Ensure when raising the body the following items are clear from the frame:
    - Vacuum lines
    - Steering knuckles
    - Electrical wiring harnesses
    - Oil cooler lines
53. Separate the engine from the transmission. Refer to Transmission Replacement (LGW Engine) and/or Transmission Replacement (LGX Engine) .
54. Transfer components as necessary.

Installation Procedure

1. Install the engine to the transmission. Refer to **Transmission Replacement (LGW Engine)** and/or **Transmission Replacement (LGX Engine)** .
2. Place the powertrain and frame assembly on the engine support table.
3. Secure the powertrain to the support table using straps and binders.
4. With the aid of an assistant, carefully lower the body onto the powertrain assembly.
5. Ensure when lowering the body the following items are clear from the frame:
    - Vacuum lines
    - Steering knuckles
    - Electrical wiring harnesses
    - Oil cooler lines
6. Install the drivetrain and front suspension cradle with the powertrain attached. Refer to **Drivetrain and Front Suspension Cradle Removal and Installation**
7. Remove the engine support table.
8. Complete installation of the transfer case. Refer to **Transfer Case Assembly Replacement** .
9. Complete installation of the transmission. Refer to **Transmission Replacement (LGW Engine)** and/or **Transmission Replacement (LGX Engine)** .
10. **Warm Up Three-Way Catalytic Converter Replacement (Left, LGW)** **Warm Up Three-Way Catalytic Converter Replacement (Right, LGW)** **Warm Up Three-Way Catalytic Converter Replacement (Left, LGX)** **Warm Up Three-Way Catalytic Converter Replacement (Right, LGX)** Â» Install [2x]
11. Drivetrain and Front Suspension Cradle Plate (3)Â» Install - **Drivetrain and Front Suspension Cradle Plate Replacement**

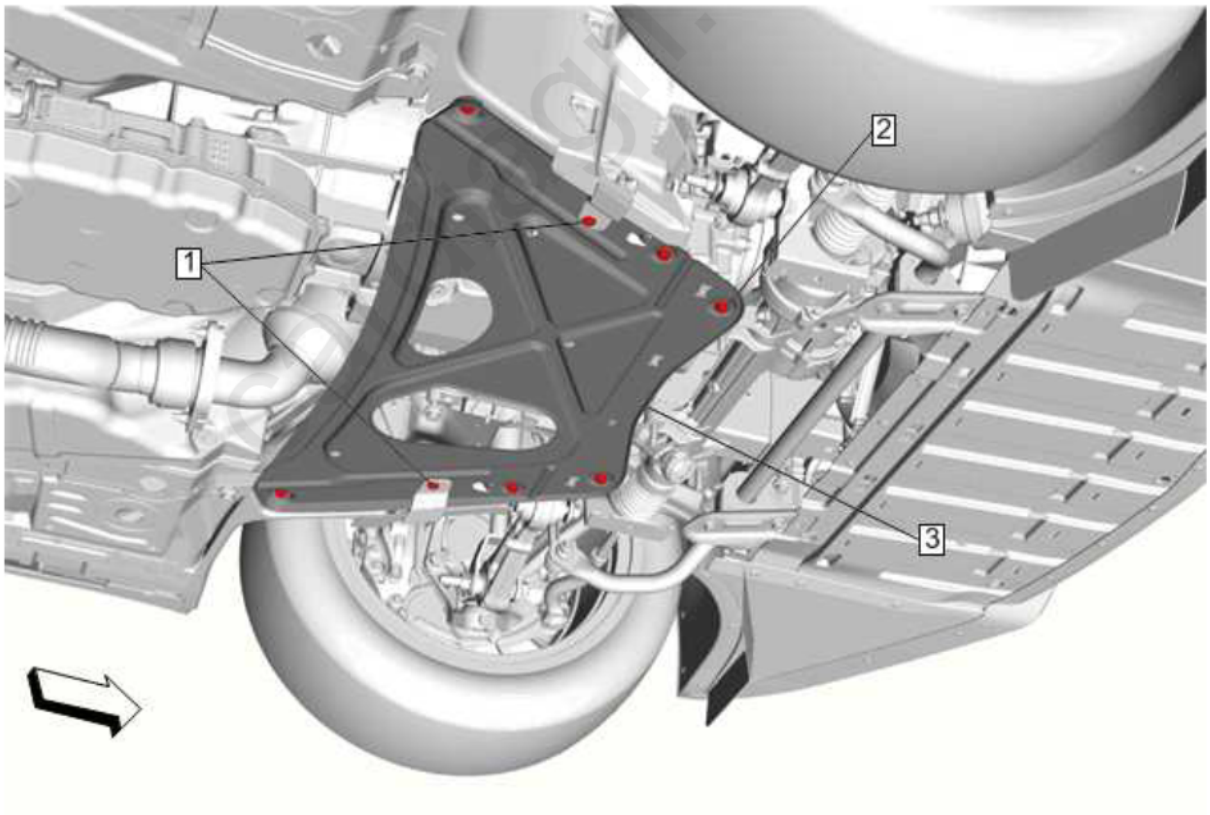


Fig. 329: Drivetrain and Front Suspension Cradle Plate
Courtesy of GENERAL MOTORS COMPANY

12. Front Bumper Fascia Lower Stiffener (1)Â» Install - **Front Bumper Fascia Lower Stiffener Replacement**

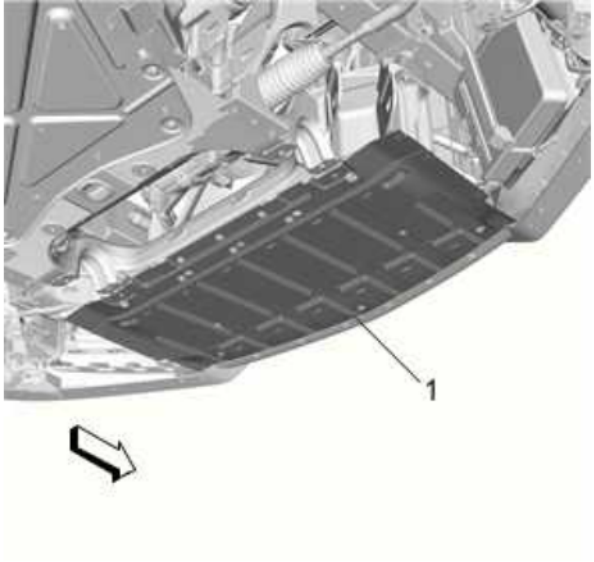


Fig. 330: Front Bumper Fascia Lower Stiffener
Courtesy of GENERAL MOTORS COMPANY

13. Underbody Front Air Deflector (3)Â» Install - **Underbody Front Air Deflector Replacement**

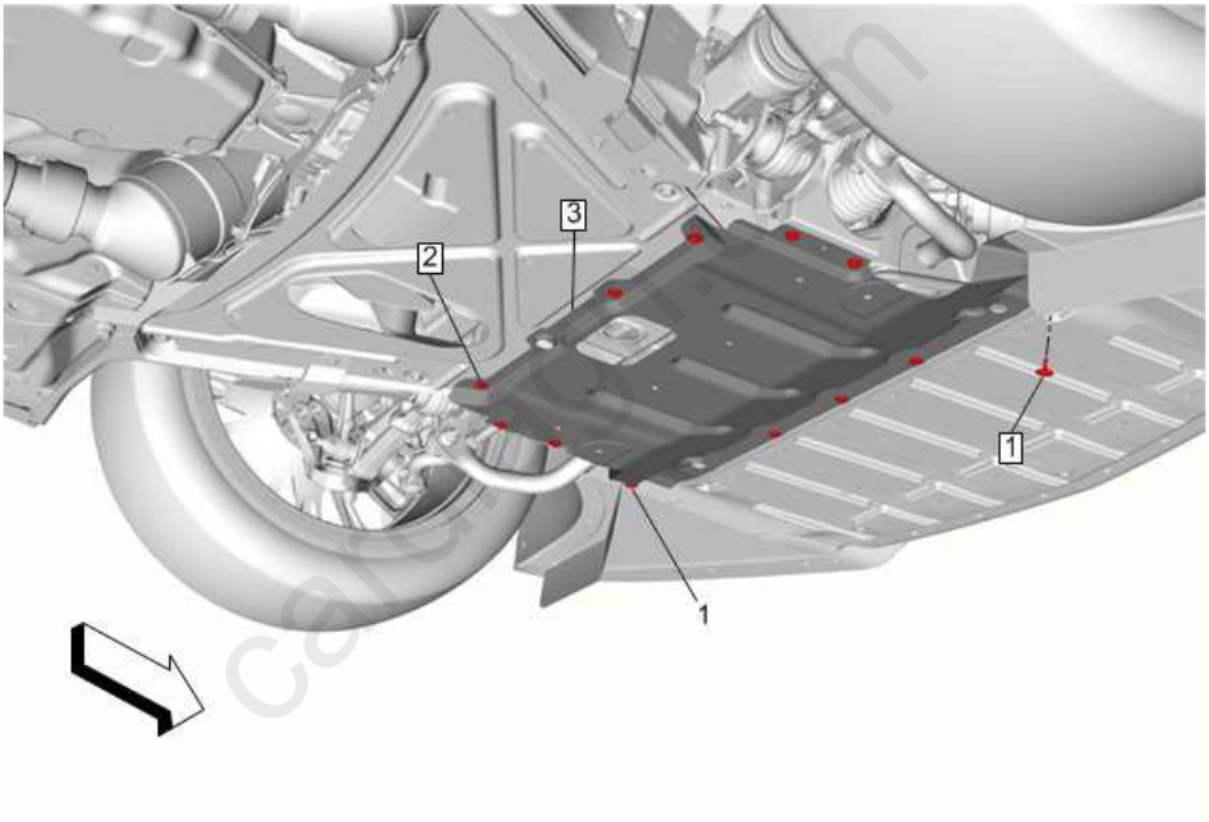


Fig. 331: Underbody Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

14. Front Wheelhouse Liner (2)Â» Install [2x] - **Front Wheelhouse Liner Replacement**

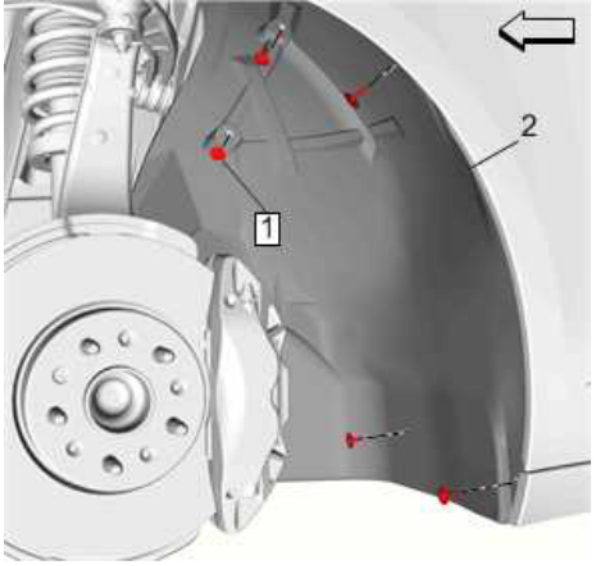


Fig. 332: Front Wheelhouse Liner
Courtesy of GENERAL MOTORS COMPANY

15. Engine Lower Front Splash ShieldÂ» Install - **Engine Lower Front Splash Shield Replacement (LTG)**
16. Lower the vehicle.
17. Transmission Fluid Cooler Outlet Pipe (2) @ RadiatorÂ» Connect
18. Transmission Fluid Cooler Outlet Pipe Clip (1) @Â» Transmission Fluid Cooler FittingÂ» Install - **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection** .
19. Transmission Fluid Cooler Inlet Pipe (1) @ RadiatorÂ» Connect

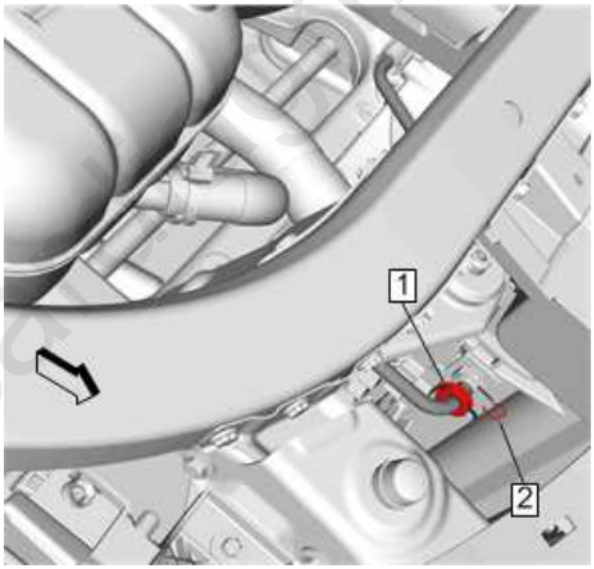


Fig. 333: Transmission Fluid Cooler Inlet Pipe
Courtesy of GENERAL MOTORS COMPANY

20. Transmission Fluid Cooler Inlet Pipe Clip (2) @ Transmission Fluid Cooler FittingÂ» Install - **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection**
21. Transmission Fluid Cooler Pipe Clip (1) @ Engine Coolant Fan ShroudÂ» Install [4x]

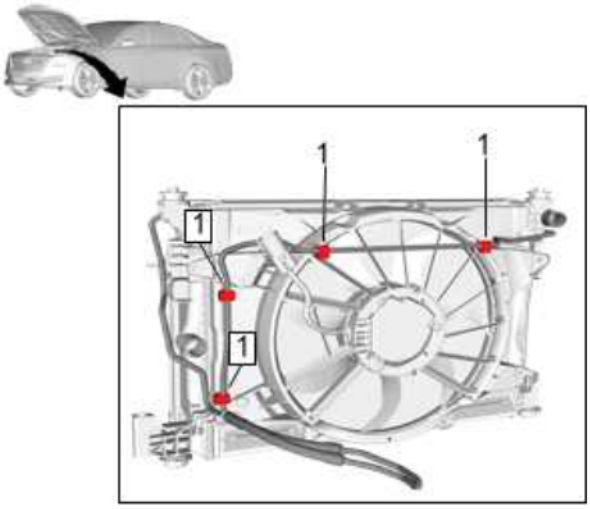


Fig. 334: Transmission Fluid Cooler Pipe Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

22. Air Conditioning Compressor and Condenser Hose (3) @ Air Conditioning CompressorÂ» Connect - **Air Conditioning Compressor and Condenser Hose Replacement (LGW, LGX)**

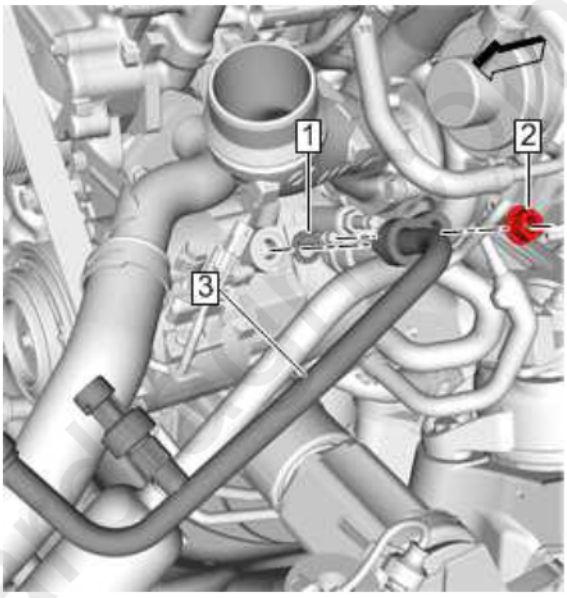


Fig. 335: Air Conditioning Compressor and Condenser Hose
Courtesy of GENERAL MOTORS COMPANY

23. Air Conditioning Compressor Hose (3) @ Air Conditioning CompressorÂ» Connect - **Air Conditioning Compressor Hose Replacement (LGW, LGX)**

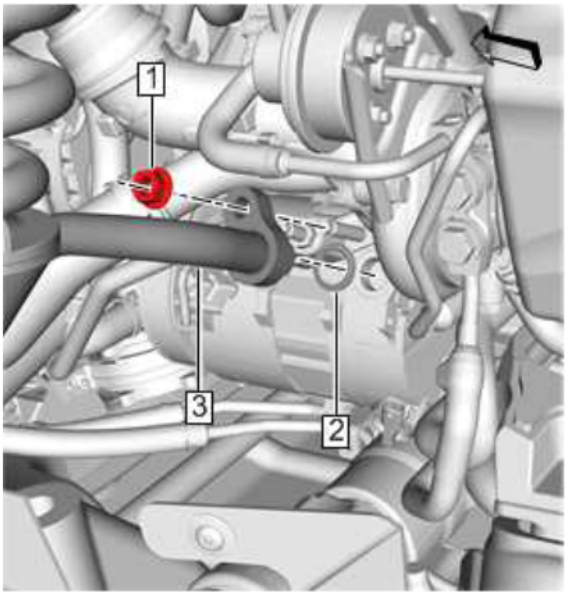


Fig. 336: Air Conditioning Compressor Hose
Courtesy of GENERAL MOTORS COMPANY

24. Pass Through Grommet (1)Â» Install

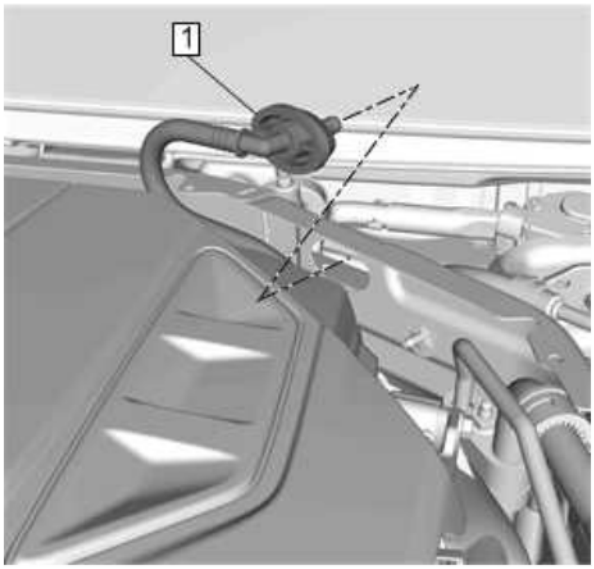


Fig. 337: Power Brake Booster Vacuum Hose Pass Through Grommet
Courtesy of GENERAL MOTORS COMPANY

25. Power Brake Booster Vacuum Hose @ Pass Through GrommetÂ» Connect
26. Clamp (1) @ Power Brake Booster Vacuum Hose (2)Â» Install - **Hose Clamp Replacement Guidelines - Spring Type**

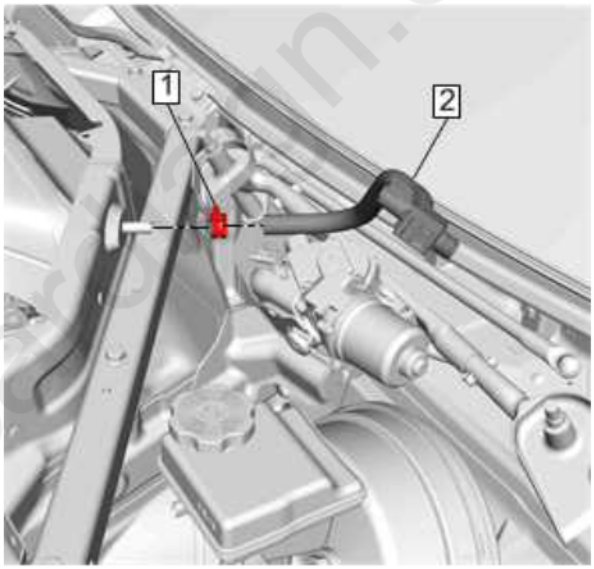


Fig. 338: Power Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

27. Evaporative Emission Canister Purge Pipe @ Evaporative Emission Canister Purge Solenoid ValveÂ» Connect - **Evaporative Emission Canister Purge Pipe Replacement (LGW) Evaporative Emission Canister Purge Pipe Replacement (LGX)**
28. Fuel Feed Pipe (1) @ Fuel Pulse DampenerÂ» Connect - **Fuel Feed Pipe Replacement (LGW) Fuel Feed Pipe Replacement (LGX)**

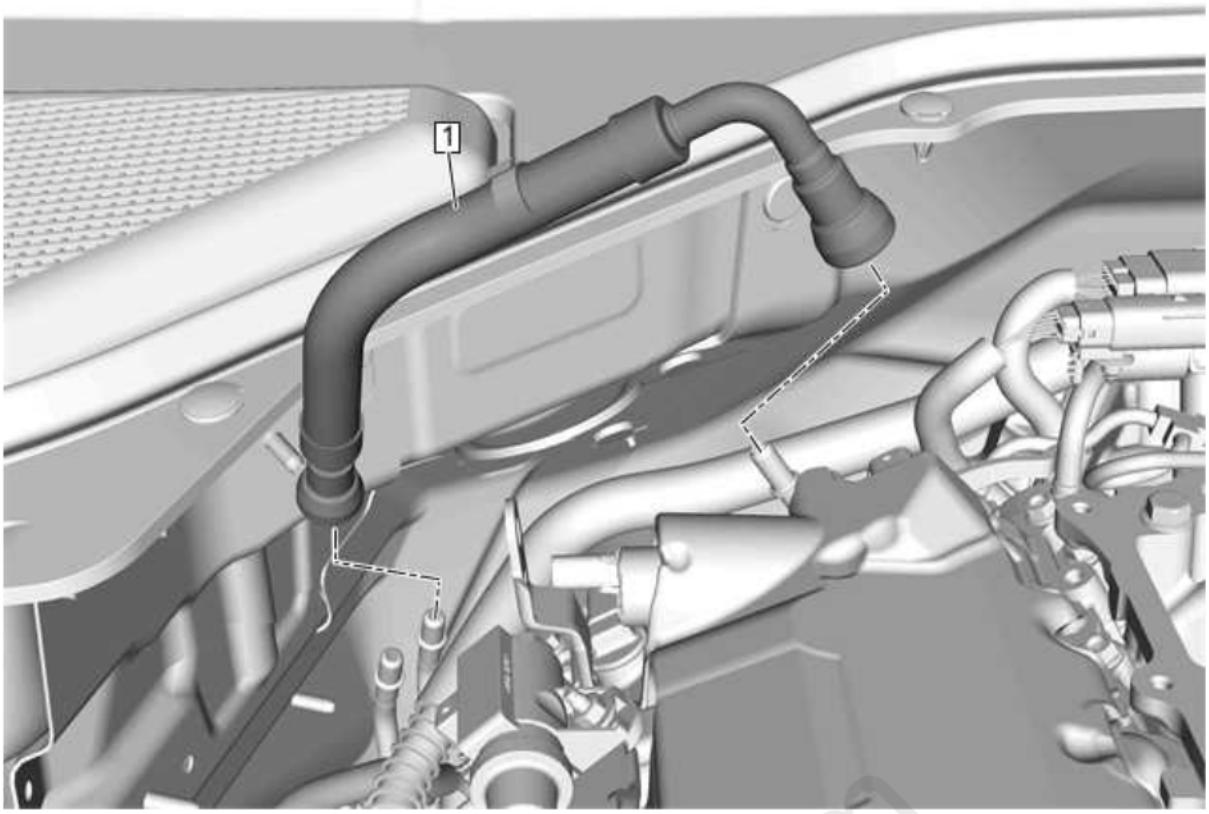


Fig. 339: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

29. Heater Water Auxiliary Pump Inlet Hose (3) @ Heater Coolant PumpÂ» Connect - **Heater Coolant Pump Replacement (LGW)** **Heater Coolant Pump Replacement (LGX)**

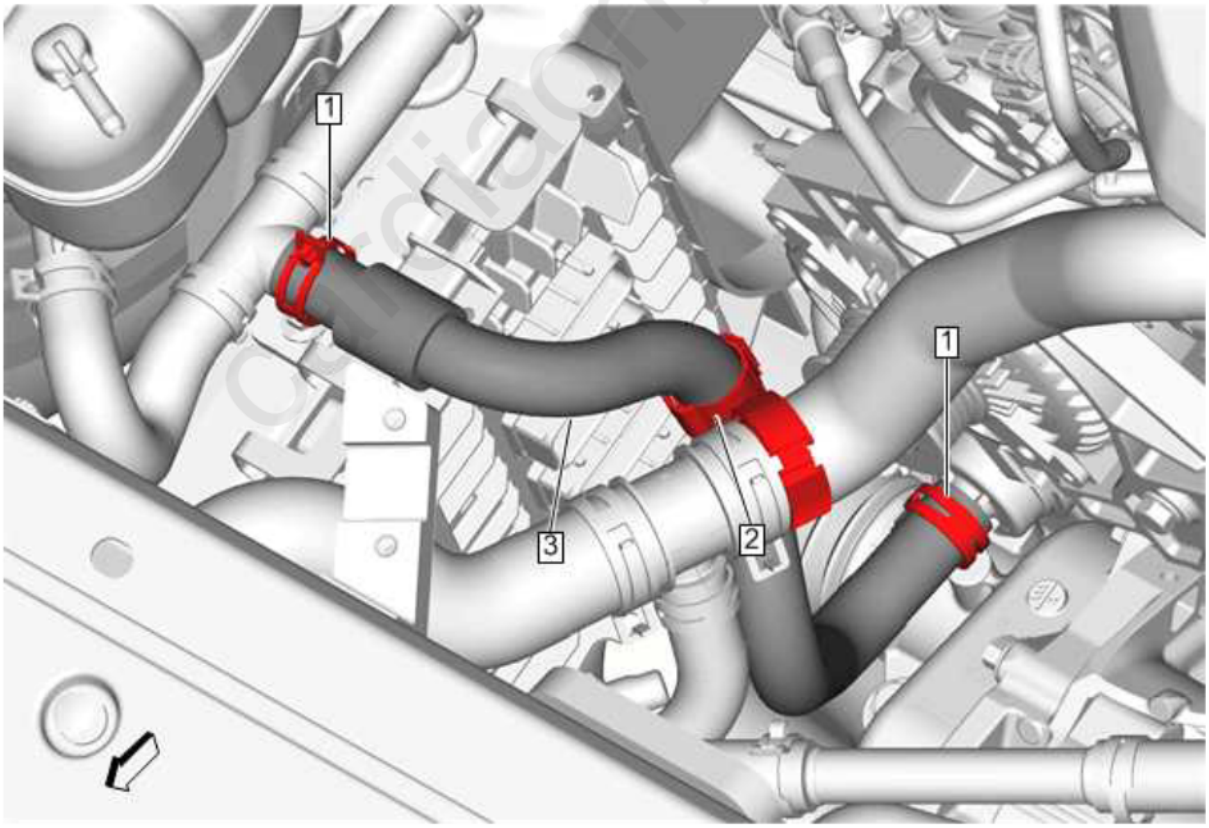


Fig. 340: Heater Water Auxiliary Pump Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

30. Auxiliary Heater Inlet Hose (1) @ Auxiliary Heater Inlet and Outlet PipeÂ» Connect - **Auxiliary Heater Inlet Hose Replacement (LGW)** **Auxiliary Heater Inlet Hose Replacement (LGX)**

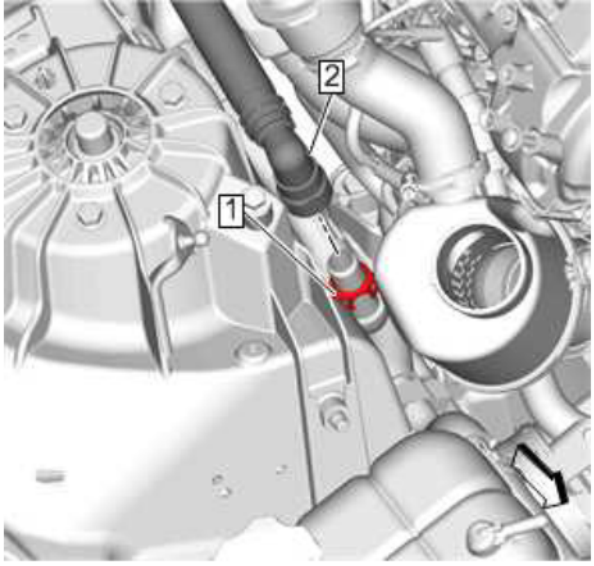


Fig. 341: Auxiliary Heater Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

31. Position the engine harness and attach harness retainers to the engine.
32. Engine Control Module Electrical Connector (1)Â» Connect [3x]

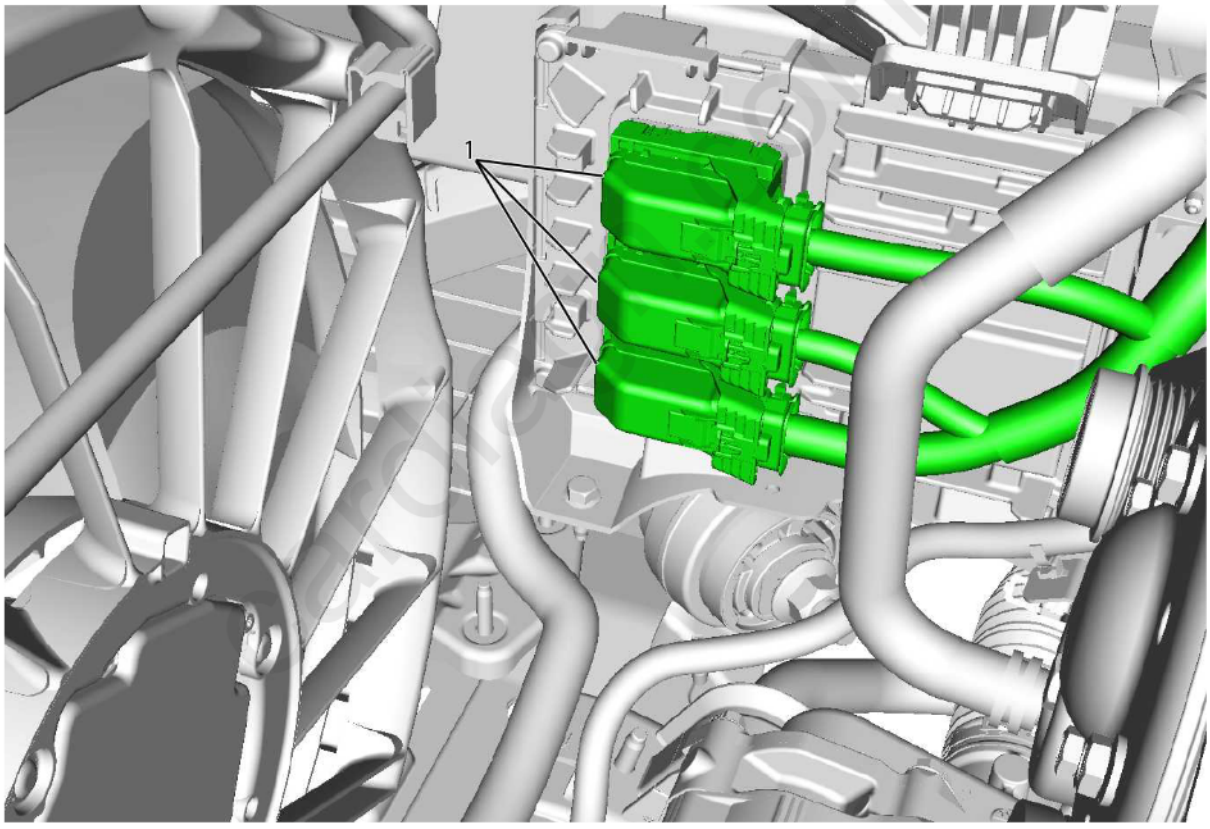


Fig. 342: Engine Control Module Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

33. Harness Connector (1)Â» Connect

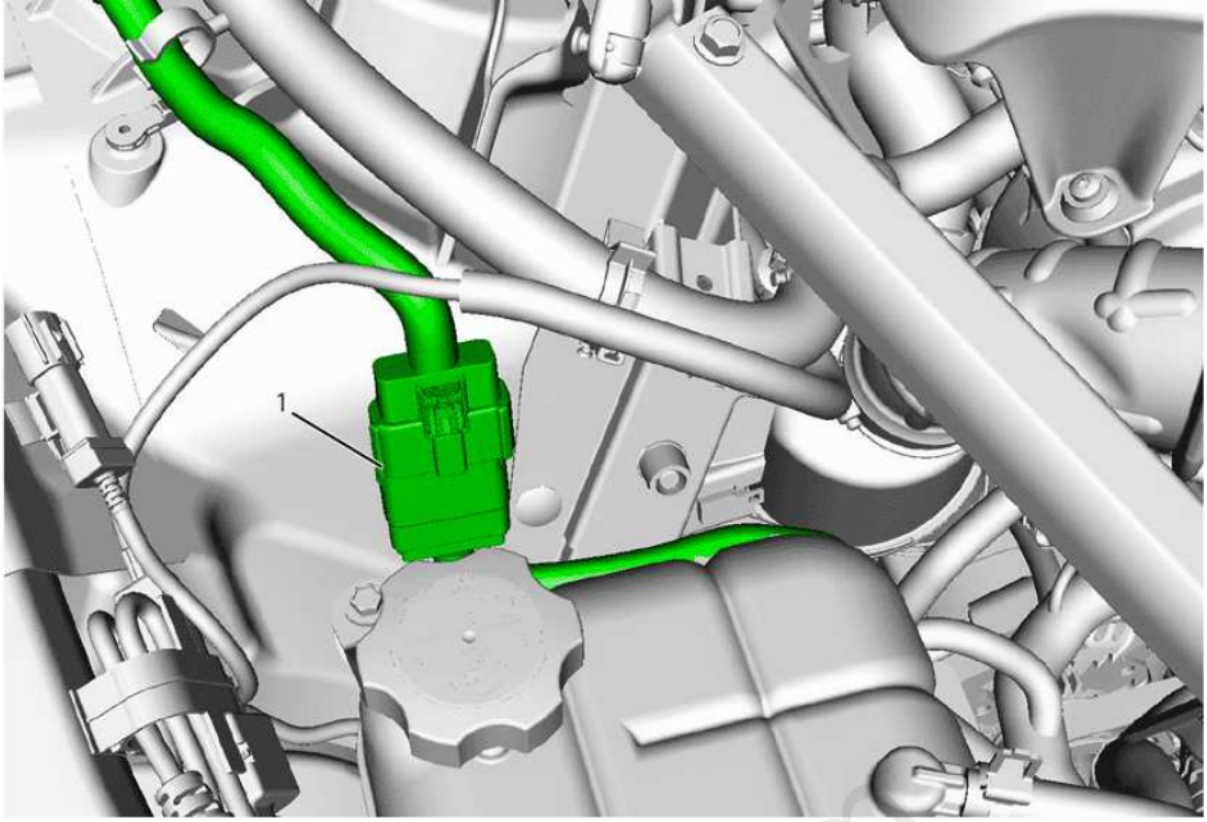


Fig. 343: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

34. Engine Wiring Harness Junction BlockÂ» Install - **Engine Wiring Harness Junction Block Replacement**
35. Radiator Outlet Hose (2) @ Water Pump Inlet PipeÂ» Install

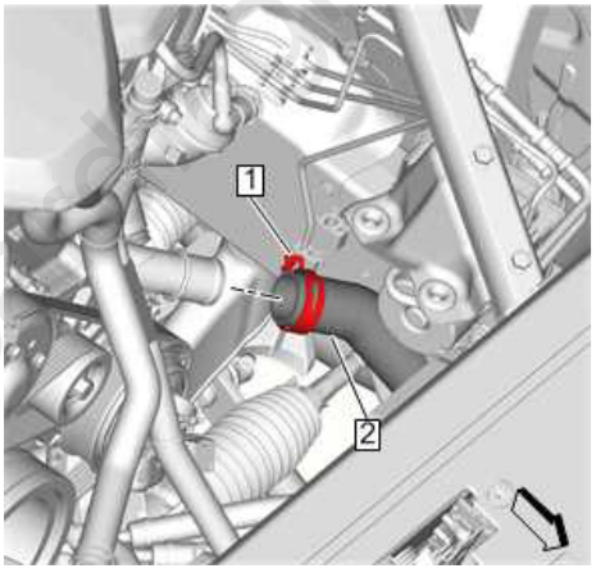


Fig. 344: Radiator Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

36. Radiator Outlet Hose Clamp (1) @ Water Pump Inlet PipeÂ» Engage - **Hose Clamp Replacement Guidelines - Spring Type**
37. Radiator Inlet Hose (2) @ Water OutletÂ» Install

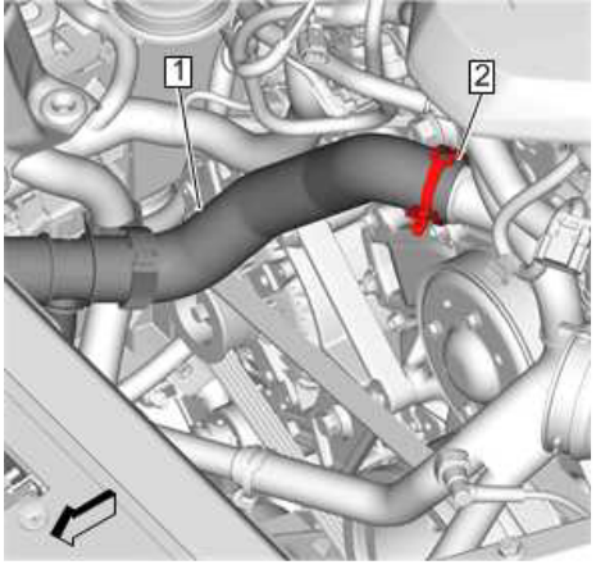


Fig. 345: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

38. Radiator Inlet Hose Clamp (1) @ Water OutletÂ» Engage - **Hose Clamp Replacement Guidelines - Spring Type**
39. Engine Coolant Air Bleed Hose (2) @ Engine Coolant Air Bleed PipeÂ» Install

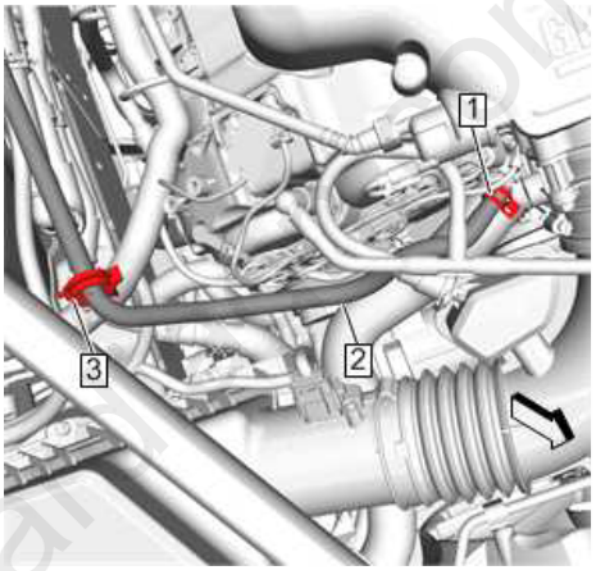


Fig. 346: Engine Coolant Air Bleed Hose
Courtesy of GENERAL MOTORS COMPANY

40. Engine Coolant Air Bleed Hose Clamp (1) Engage - **Hose Clamp Replacement Guidelines - Spring Type**
41. Position the engine harness and attach harness retainers to the engine.
42. Harness Connector (1)Â» Connect [3x]

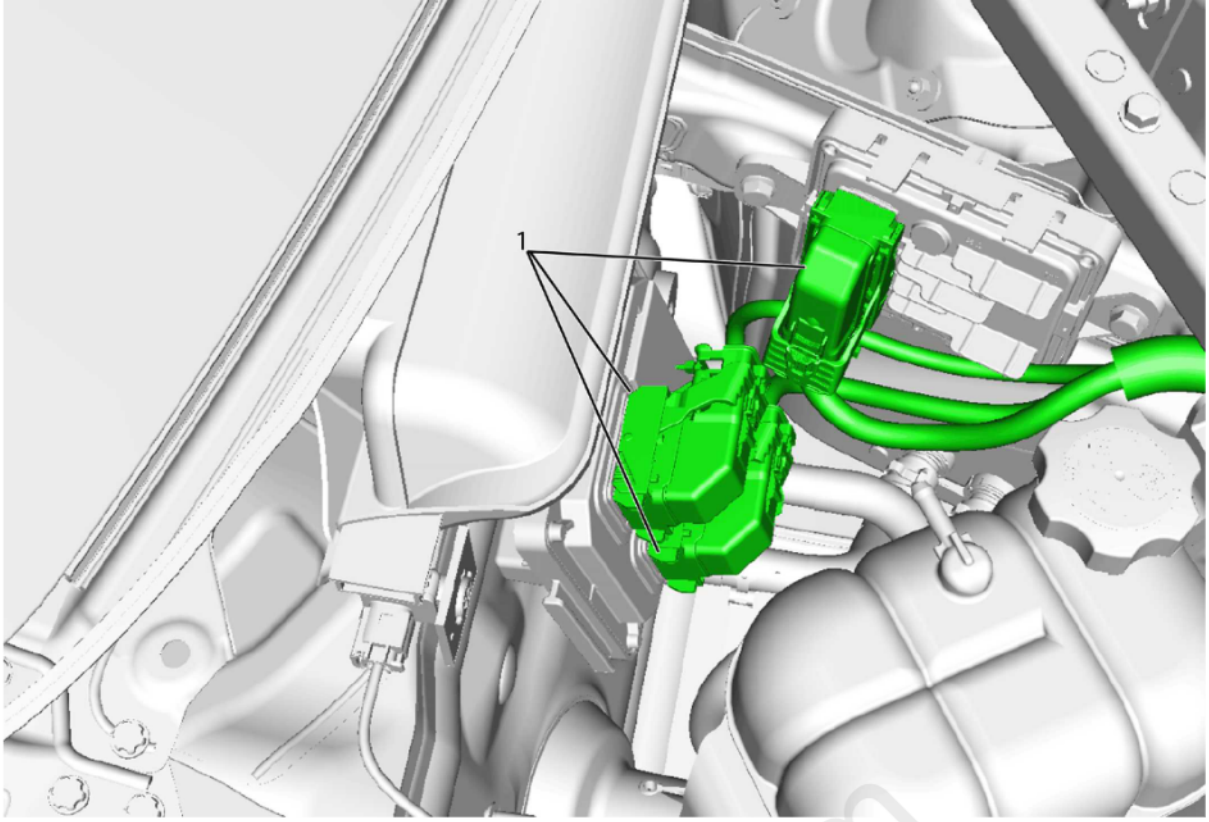


Fig. 347: Harness Connector
Courtesy of GENERAL MOTORS COMPANY

43. Air Inlet Grille PanelÂ» Install - **Air Inlet Grille Panel Replacement**
44. Air Cleaner Outlet DuctÂ» Install - **Air Cleaner Outlet Duct Replacement (LGX)**
45. Install the front compartment front sight shield. Refer to **Front Compartment Front Sight Shield Replacement**
46. Intake Manifold CoverÂ» Install - **Intake Manifold Cover Replacement (LGX)**
47. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**
48. Fill the cooling system. Refer to **Cooling System Draining and Filling (Static without HP9)** **Cooling System Draining and Filling (GE 47716 without HP9)** **Cooling System Draining and Filling (Static LTG with HP9)** **Cooling System Draining and Filling (GE 47716 LTG with HP9)**
49. Fill the engine oil to the proper level with NEW engine oil. Refer to **Engine Oil and Oil Filter Replacement**
50. If the engine is replaced with a new engine or has been overhauled, perform the Engine Prelubing procedure. Refer to **Engine Prelubing**

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

51. Charge the A/C system. Refer to **Refrigerant Recovery and Recharging (R-134a)** and/or **Refrigerant Recovery and Recharging (R-1234yf)**
52. Perform the crankshaft position variation learn procedure. Refer to **Crankshaft Position Variation Learn**
53. Perform the throttle learn procedure. Refer to **Throttle Body Idle Air Flow Compensation Reset**

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**
2. Place a drain pan under the vehicle.
3. Oil Drain Plug (1)Â» Remove

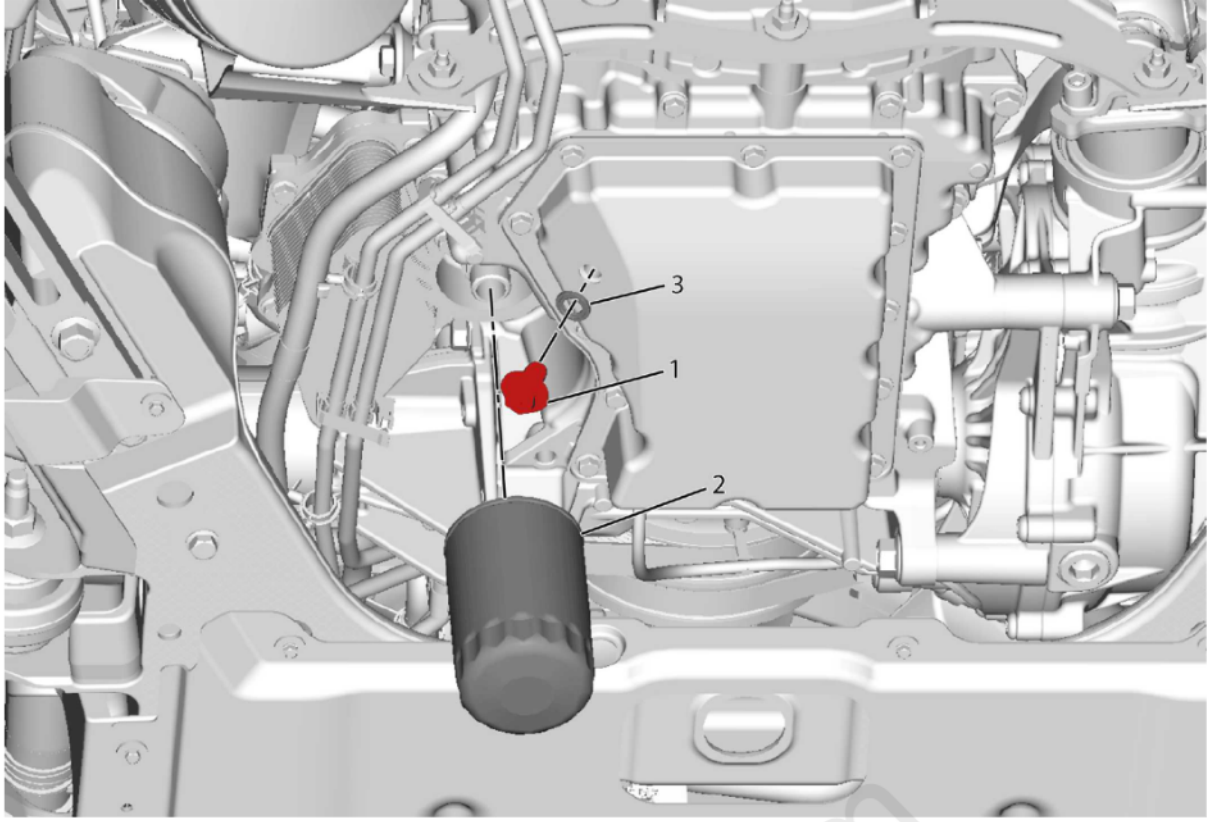


Fig. 348: Oil Drain Plug
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Allow the oil to drain completely.**

4. Oil Drain Plug (1)Â» Install and tighten 25 N.m (18 lb ft)

CAUTION: **Refer to Component Fastener Tightening Caution .**

NOTE: **Clean and inspect the oil pan drain plug seal (3) and replace if necessary.**

5. Oil Filter (2)Â» Remove

WARNING: **Hot Exhaust System Warning**

NOTE: **Allow the oil to drain completely.**

Installation Procedure

1. Lubricate the NEW oil filter gasket with clean engine oil.
2. Install a NEW oil filter and tighten 3/4 to 1 full turn after the gasket makes contact with the sealing surface on the filter mounting flange.
3. Lower the vehicle.
4. Fill the engine oil to the proper level with NEW engine oil. Refer to **Approximate Fluid Capacities** and **Adhesives, Fluids, Lubricants and Sealers**
5. Start the engine and inspect for leaks.
6. Reset the service interval indicator. Refer to **GM Oil Life System Resetting** and/or **GM Oil Life System Resetting (With Scan Tool)**

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2017 ENGINE

Engine Mechanical - 3.0L (LGW) or 3.6L (LGX) - Schematic Wiring Diagrams - CT6

SCHEMATIC WIRING DIAGRAMS

ENGINE MECHANICAL WIRING SCHEMATICS

Engine Oil Pressure Control (LGW/LGX)

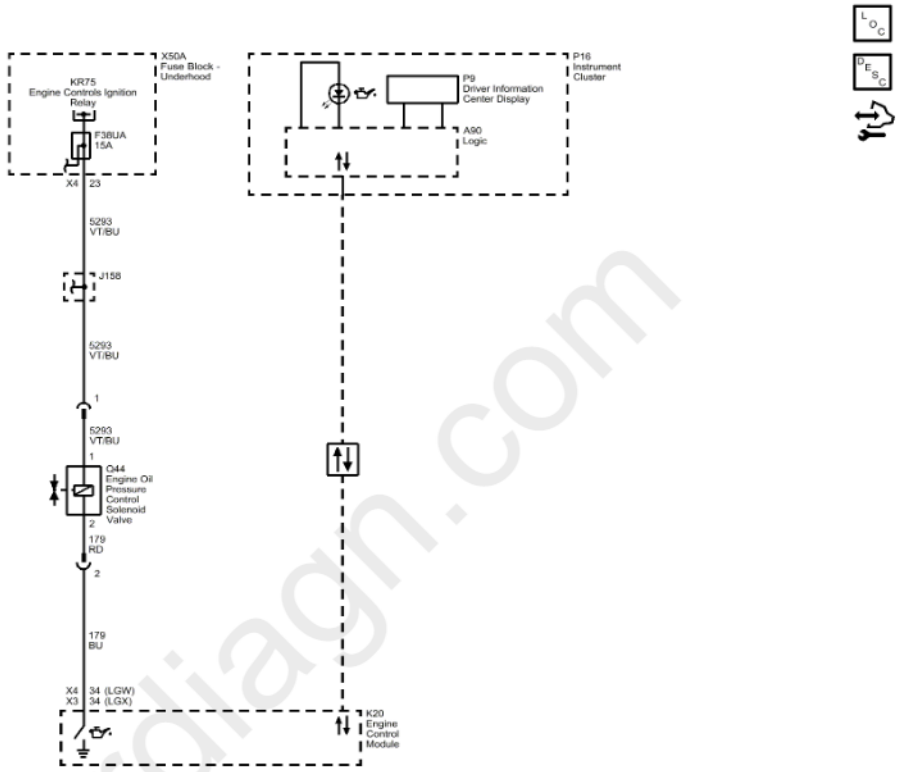


Fig. 1: Engine Oil Pressure Control (LGW/LGX)
Courtesy of GENERAL MOTORS COMPANY

TIMING CHAIN ALIGNMENT WIRING DIAGRAM

Camshaft Position Actuator Timing Marks

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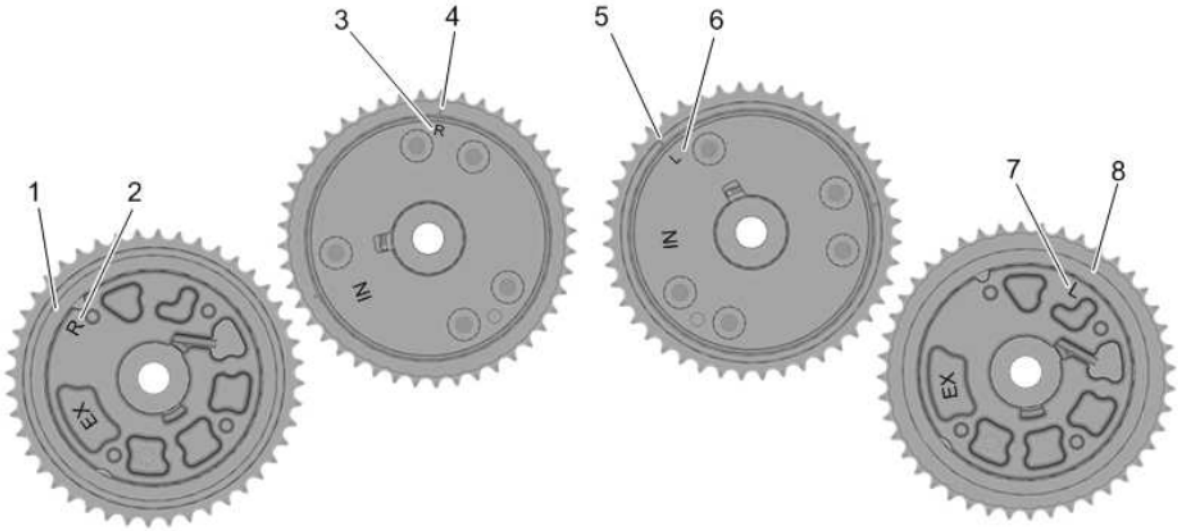


Fig. 2: Timing Chain Actuator Timing Marks
Courtesy of GENERAL MOTORS COMPANY

Stage One

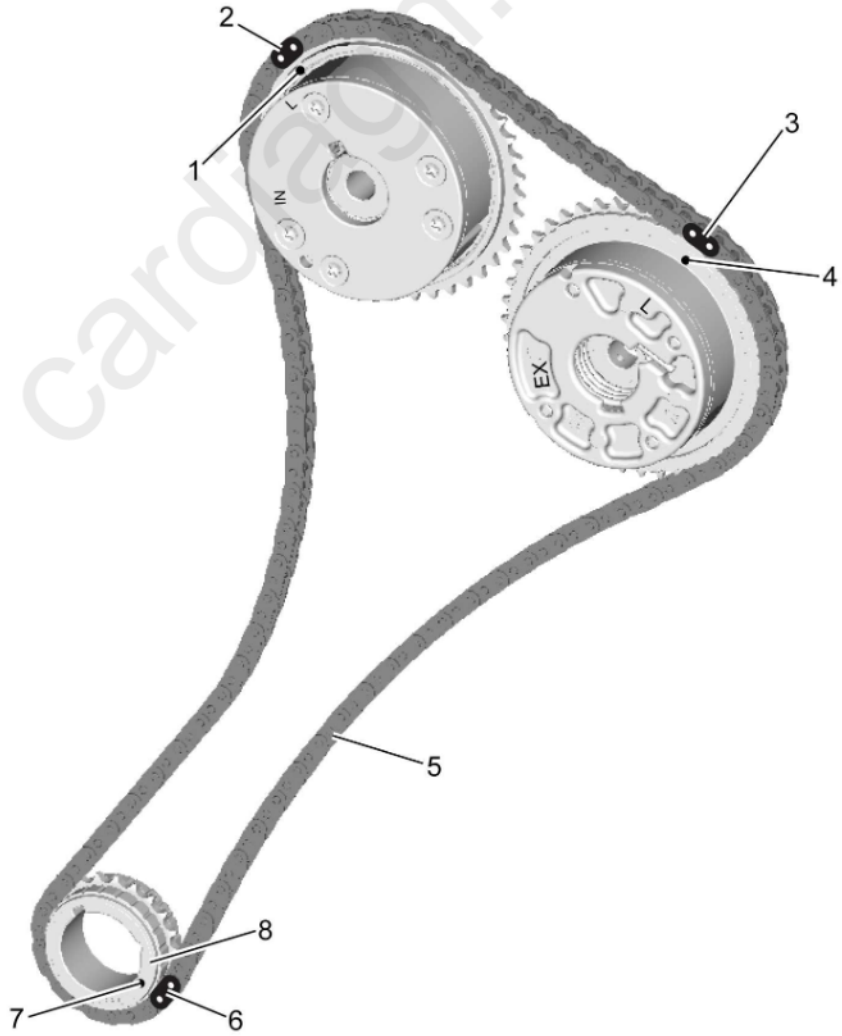


Fig. 3: Stage One
Courtesy of GENERAL MOTORS COMPANY

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Stage Two

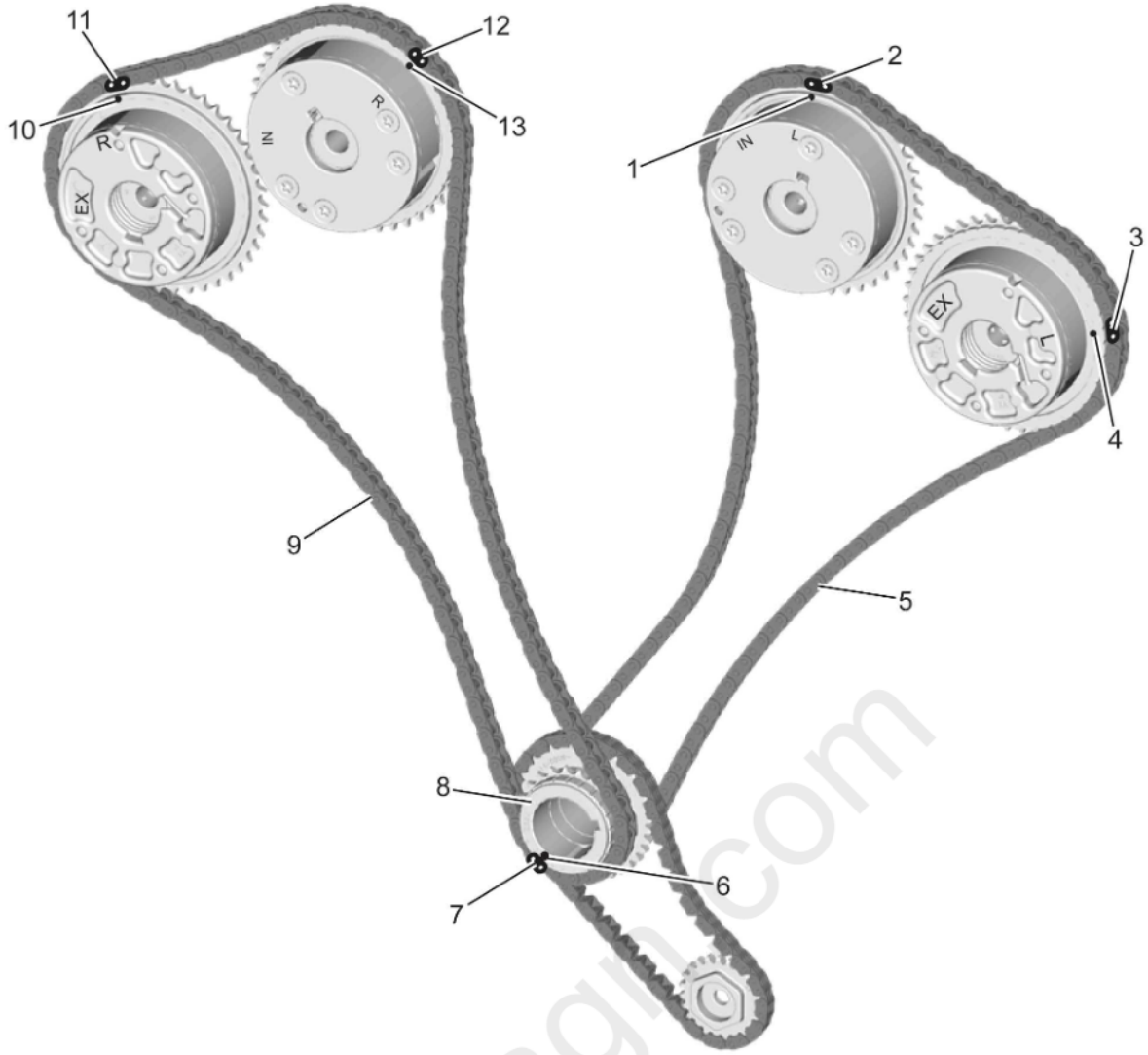


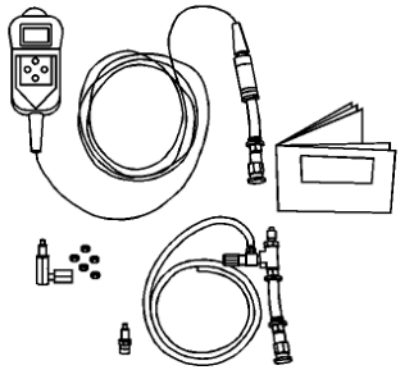
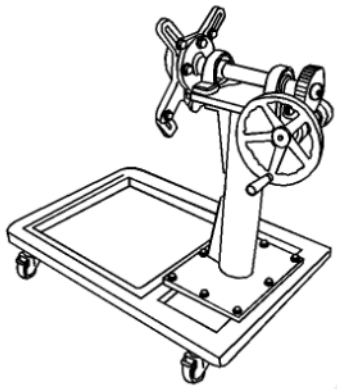
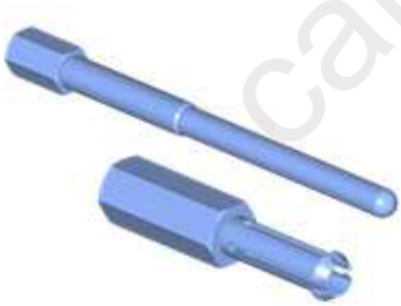
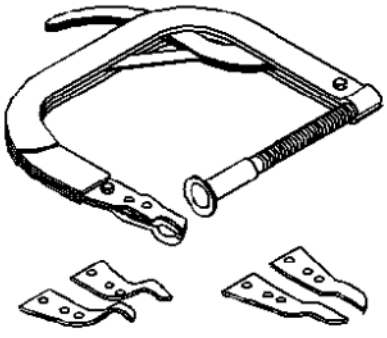
Fig. 4: Stage Two
Courtesy of GENERAL MOTORS COMPANY

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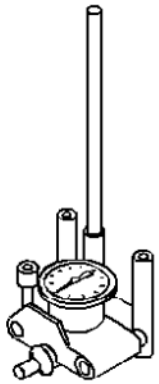
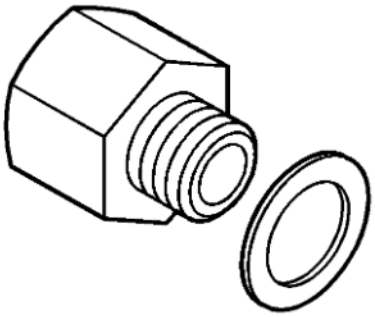
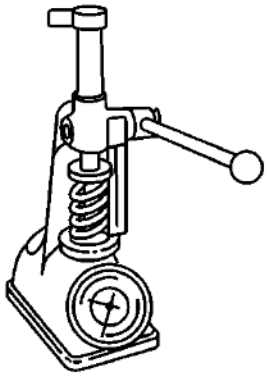
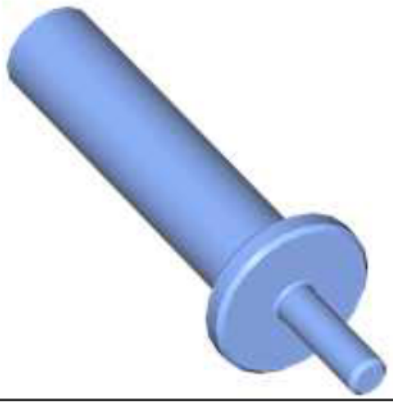
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SPECIAL TOOLS AND EQUIPMENT

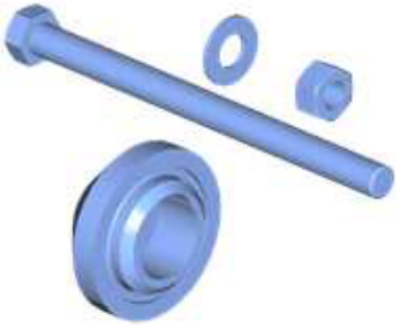
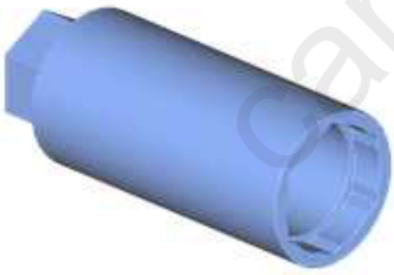
SPECIAL TOOLS

Illustration	Tool Number/Description
	CH-48027 DW-100-010 EN-49495 J-21867 Digital Pressure Gauge
	DW-110-030 Engine Overhaul Stand
	DT-43276 Clutch Pilot Bearing Remover
	EN-8062 J-8062 Valve Spring Compressor - Head Off

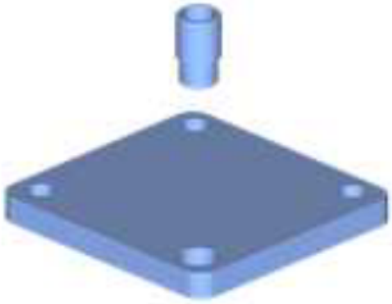
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Illustration	Tool Number/Description
	EN-8087 J-8087 Cylinder Bore Gauge
	EN-21867-6 J-21867-6 83 93 852 Oil Pressure Adapter Fitting
	EN-22738-B J-22738-B Valve Spring Tester
	EN-28410 J-28410 Gasket Remover
	EN-28467-13 J-28467-13 J-28467-20 Strut Tower to Support Beam Adapters

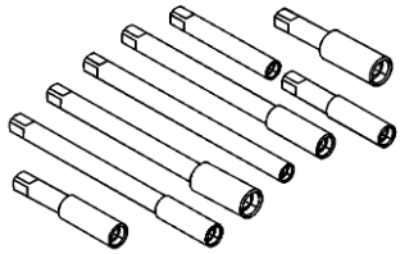
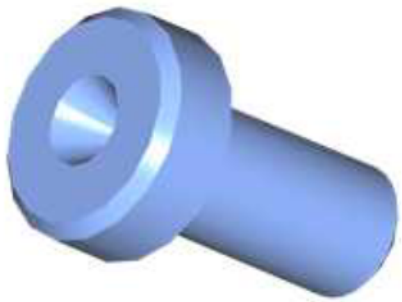
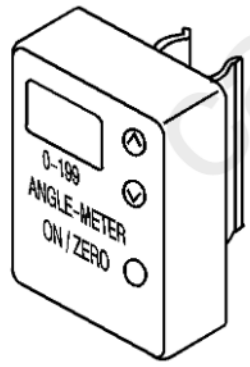
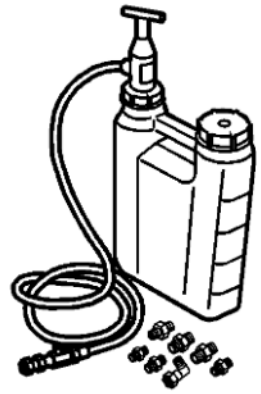
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Illustration	Tool Number/Description
	EN-29184 EN-47635 & J-41998-B EN-47635 J-29184 Oil Seal Installer
	EN-36857 J-36857 Engine Lift Bracket
	EN-41478 J-41478 Crankshaft Front Oil Seal Installer
	EN-41712 J-41712 Oil Pressure Switch Socket
	EN-41816 J-41816 Crankshaft Balancer Remover

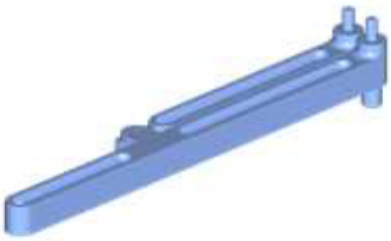
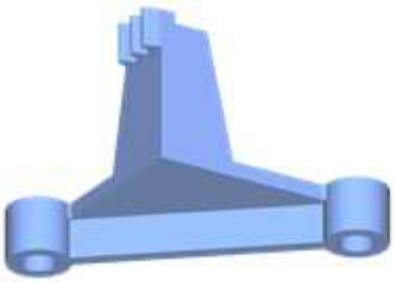
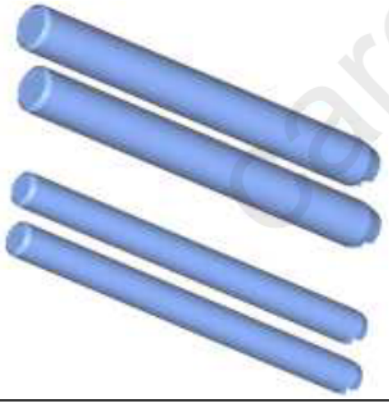
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Illustration	Tool Number/Description
	EN-41998-B J-41998-B J-41998 Crankshaft Balancer Installer
	EN-42183 J-42183 Driver Handle
	EN-42385-70 Head Bolt Thread Repair Fixture
	EN-42385-700 J-42385-700 High Feature Thread Repair Kit
	EN-42385-2000 J-42385-2000 Thread Insert Kit

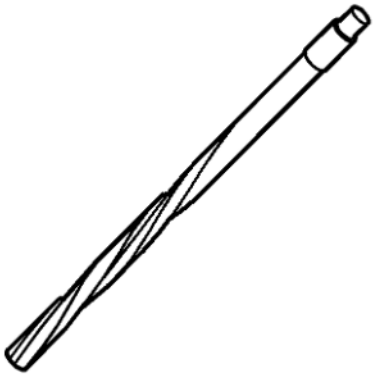
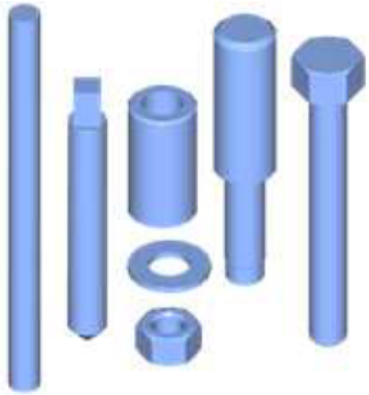
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Illustration	Tool Number/Description
	EN-43690-A J-43690-A Rod Bearing Clearance Checking Tool
	EN-43965 J-43965 Thread Repair Extension Kit
	EN-44226-5 Crankshaft Protector
	EN-45059-A J-45059-A KM-470-B Angle Meter
	EN-45299 J-45299 Engine Preluber

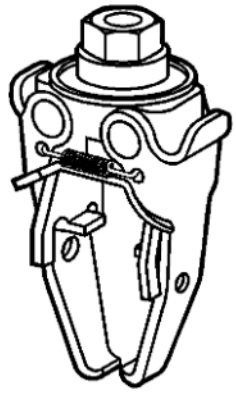
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Illustration	Tool Number/Description
	EN-46103 J-46103 Camshaft Actuator Valve Seal Installer
	EN-46104 J-46104 Water Pump Pulley Holding Tool
	EN-46106 J-46106 KM-652 Flywheel Holding Tool
	EN-46109 J-46109 Guide Pins
	EN-46116 KM-840 (Remover)/ EN-47986 (Installer) 83 94 157 Valve Stem Seal Remover/Installer

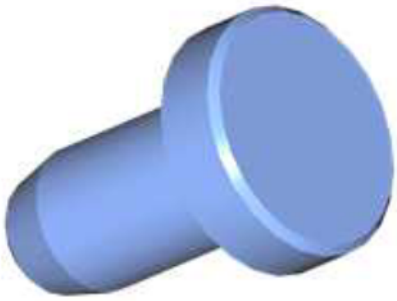
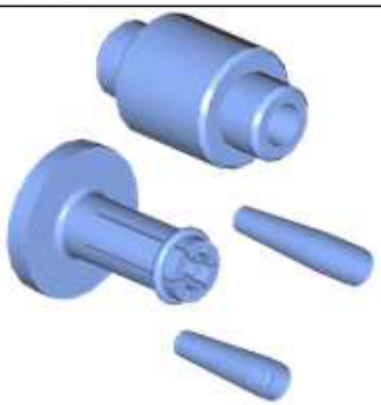
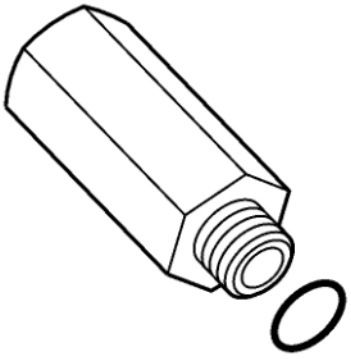
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Illustration	Tool Number/Description
	EN-46117 Valve Stem Key Remover/Installer
	EN-46119 Off-Vehicle Valve Spring Compressor Adapter
	EN-46120 Valve Guide Reamer
	EN-46121 Connecting Rod Guide Pin Set
	EN-46122 Camshaft Position Actuator Check-Ball Valve Remover/Installer

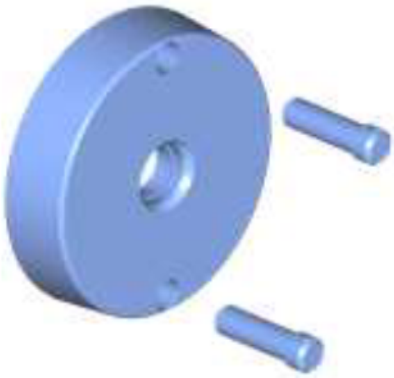
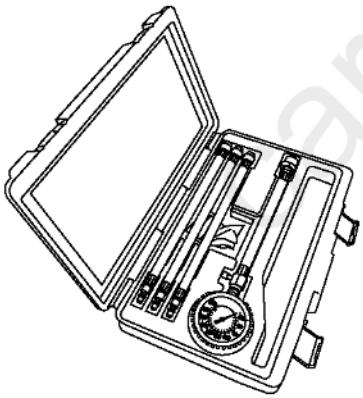
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Illustration	Tool Number/Description
	EN-46335-A Valve Spring Compressor
	EN-46745 J-43654 Piston Pin Clip Remover/Installer
	EN-47909 Injector Bore and Sleeve Cleaning Kit
	EN-47971 Oil Pressure Gauge Adapter
	EN-48244 Engine Assembly Remove/Install Pallet Supporter

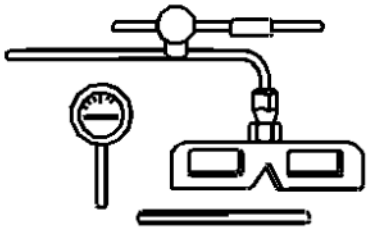
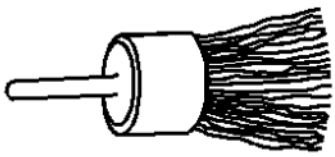
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Illustration	Tool Number/Description
	EN-48896 HP Fuel Pump Installation Alignment Gauge
	EN-49102 J-41818 & EN-47985 Crankshaft Bearing Cap Remover
	EN-49245 Injector Seal Installer Kit
	EN-49248 Injector Rail Assembly Remover
	EN-50789 Oil Pressure Adapter Fitting

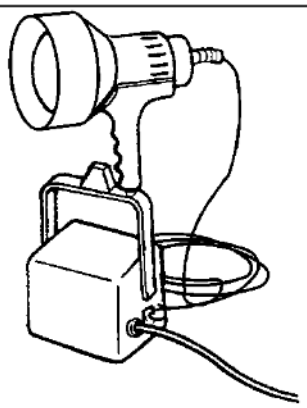
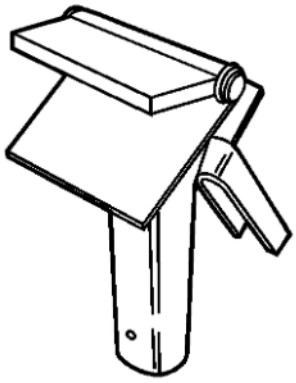
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Illustration	Tool Number/Description
	EN-51096 DT-51096 Crankshaft Rear Oil Seal Remover.
	EN-51333 Timing Chain Retainer
	EN-51766 Crankshaft Rear Oil Seal Installer
	EN-51749 Crankshaft Rear Oil Seal Installer
	EN-51767 Stretchy Belt Installer

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Illustration	Tool Number/Description
	EN-52234 Tensioner Retraction Pins
	GE-6125-1B J-6125-1B Slide Hammer Adapter
	GE-7872 J-7872 Magnetic Base Dial Indicator
	GE-8001 J-8001 Dial Indicator Set
	GE-8358 J-8358 Carbon Removal Brush

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Illustration	Tool Number/Description
	GE-28428-E J-28428-E High Intensity Black Light Kit
	GE-48326 Sealant Dispenser

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SPECIFICATIONS

FASTENER SPECIFICATIONS (LGW)

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 Cover Seal
Connecting Rod Bearing
Crankshaft Lower Bearing
Crankshaft Thrust Upper Bearing
Crankshaft Upper Bearing
Crankshaft Rear Oil Seal Housing
Cylinder Head Gasket
Engine Coolant Thermostat Gasket
Engine Oil Level Indicator Switch O-Ring Seal
Engine Oil Manifold Check Valve
Fuel Feed Intermediate Pipe
Fuel Injector Nozzle Housing Seal
Fuel Injector Retainer
Fuel Injector Spacer
Fuel Pump Bracket Gasket
Fuel Pump O-Ring
Heater Inlet and Outlet Pipe Gasket
Intake Manifold Seal
Oil Level Indicator Tube Seal
Oil Pan High Pressure Port Seal
Oil Pump Housing Passage Seal
Oil Pump Suction Pipe Gasket
Positive Crankcase Ventilation Oil Separator Seal
Piston Pin Retainer
Spark Plug Shield Seal
Throttle Body Gasket
Timing Chain Tensioner Gasket
Vacuum Pump Seal
Valve Stem Oil Seal
Water Inlet Seal
Water Outlet Seal
Water Pump Gasket

Single Use Threaded Fastener/Component Tightening Specifications

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NOTE:

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

Application	Specification Metric (English)
Automatic Transmission Flex Plate Bolt	
• First Pass:	30 N.m (22 lb ft)
• Final Pass:	45 Degrees
Connecting Rod Bolt	
• First Pass:	25 N.m (18 lb ft)
• Final Pass:	110 Degrees
Crankshaft Balancer Bolt	
• First Pass:	100 N.m (74 lb ft)
• Final Pass:	150 Degrees
Crankshaft Bearing Cap Bolt - Inner	
• First Pass:	20 N.m (15 lb ft)
• Final Pass:	80 degrees
Crankshaft Bearing Cap Bolt - Outer	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	110 Degrees
Crankshaft Bearing Cap Bolt - Side	
• First Pass:	30 N.m (22 lb ft)
• Final Pass:	60 Degrees
Cylinder Head Bolt M8 x 80.8	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	75 Degrees
Cylinder Head Bolt M11 x 178	
• First Pass:	60 N.m (44 lb ft)

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NOTE:

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

Application	Specification Metric (English)
• Final Pass:	185 degrees
Engine Flywheel Bolt	67 N.m (49 lb ft)
Fuel Pump Bolt	15 N.m (11 lb ft)
Oil Filter • 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange	
Oil Pump Drive Bolt	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	110 Degrees
Water Pump Bolt	15 N.m (11 lb ft)
Wiring Harness Connector Bolt	10 N.m (89 lb in)

Reusable Threaded Fastener Tightening Specifications

NOTE:

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

Application	Specification Metric (English)
Belt Idler Pulley Bolt	10 N.m (89 lb in)
Camshaft Bearing Cap Bolt	
• First Pass:	6 N.m (53 lb in)
• Final Pass:	60 Degrees
Camshaft Bearing Cap Bolt	10 N.m (89 lb in)
Camshaft Carrier Bolt M6 x 65.65	10 N.m (89 lb in)
Camshaft Carrier Bolt M6 x 50.65	13 N.m (115 lb in)
Camshaft Cover Bolt	10 N.m (89 lb in)
Camshaft Position Actuator Bolt	
• First Pass:	20 N.m (15 lb ft)
• Final Pass:	45 Degrees
Camshaft Position Actuator Solenoid Valve Bolt	10 N.m (89 lb in)
Camshaft Position Sensor Bolt	10 N.m (89 lb in)
Charge Air Cooler Bolt	4 N.m (35 lb in)
Charge Air Cooler Bolt	12 N.m (106 lb in)
Charge Air Cooler Coolant Manifold Bolt	10 N.m (89 lb in)
Charge Air Cooler Inlet Air Tube Bolt	10 N.m (89 lb in)

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NOTE:

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

Application	Specification
	Metric (English)
Clutch Pressure Plate Bolt	30 N.m (22 lb ft)
Coolant Drain Plug	50 N.m (37 lb ft)
Coolant Drain Plug	75 N.m (55 lb ft)
Crankshaft Oil Deflector Nut	10 N.m (89 lb in)
Crankshaft Position Sensor Bolt	10 N.m (89 lb in)
Crankshaft Rear Oil Seal Housing Bolt	10 N.m (89 lb in)
Cylinder Head Core Hole Plug M9	15 N.m (11 lb ft)
Cylinder Head Core Hole Plug M12	25 N.m (18 lb ft)
Cylinder Head Core Hole Plug M14	35 N.m (26 lb ft)
Drive Belt Tensioner Bolt	30 N.m (22 lb ft)
Engine Block Oil Gallery Plug	25 N.m (18 lb ft)
Engine Block Oil Gallery Plug M16	40 N.m (30 lb ft)
Engine Block Core Hole Plug M18	45 N.m (33 lb ft)
Engine Coolant Air Bleed Pipe Bolt	10 N.m (89 lb in)
Engine Coolant Outlet Pipe Bolt	10 N.m (89 lb in)
Engine Coolant Temperature Sensor	9 N.m (80 lb in)
Engine Coolant Thermostat Housing Bolt	10 N.m (89 lb in)
Engine Front Cover Bolt M6 x 45	10 N.m (89 lb in)
Engine Front Cover Bolt M6 x 60	10 N.m (89 lb in)
Engine Front Cover Bolt M8 x 66	15 N.m (11 lb ft)
Engine Front Cover Bolt M12 x 55.8	60 N.m (44 lb ft)
Engine Front Cover Bolt M12 x 75.9	60 N.m (44 lb ft)
Engine Front Cover Stud	15 N.m (11 lb ft)
Engine Oil Cooler Adapter Bolt M8 x 90.8	22 N.m (16 lb ft)
Engine Oil Cooler Adapter Bolt M10 x 45.75	58 N.m (43 lb ft)
Engine Oil Cooler Adapter Bolt M12 x 65.90	100 N.m (74 lb ft)
Engine Oil Cooler Adapter Fitting	25 N.m (18 lb ft)
Engine Oil Level Indicator Switch Bolt	10 N.m (89 lb in)
Engine Oil Pressure Sensor	35 N.m (26 lb ft)
Evaporative Emission Canister Purge Solenoid Valve Bolt	10 N.m (89 lb in)
Engine Wiring Harness Bracket Bolt	15 N.m (11 lb ft)
Fuel Feed Intermediate Pipe Bolt	28 N.m (21 lb ft)
Fuel Feed Pipe Bolt	10 N.m (89 lb in)
Fuel Injection Fuel Rail Bolt	25 N.m (18 lb ft)
Fuel Injection Fuel Rail Fuel Pressure Sensor	33 N.m (24 lb ft)
Fuel Pipe Shield Bolt	10 N.m (89 lb in)
Fuel Feed Intermediate Pipe Fitting	30 N.m (22 lb ft)
Heater Inlet and Outlet Pipe Bolt	9 N.m (80 lb in)
Ignition Coil Bolt	10 N.m (89 lb in)
Intake Air Pressure and Temperature Sensor Bolt	4 N.m (35 lb in)
Intake Manifold Bolt	25 N.m (18 lb ft)
Knock Sensor Bolt	25 N.m (18 lb ft)
Lower Intake Manifold Bolt	25 N.m (18 lb ft)
Manifold Absolute Pressure Sensor Bolt	4 N.m (35 lb in)
Oil Gallery Plug M14	50 N.m (37 lb ft)
Oil Gallery Plug M20	75 N.m (55 lb ft)
Oil Level Indicator Tube Bolt	10 N.m (89 lb in)

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NOTE:

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

Application	Specification
	Metric (English)
Oil Pan Baffle Bolt	10 N.m (89 lb in)
Lower Oil Pan Bolt	10 N.m (89 lb in)
Oil Pan Bolt M6 x 151	15 N.m (11 lb ft)
Oil Pan Bolt M8 x 20	25 N.m (18 lb ft)
Oil Pan Bolt M8 x 36	10 N.m (89 lb in)
Oil Pan Bolt M8 x 66	25 N.m (18 lb ft)
Oil Pan Drain Plug	25 N.m (18 lb ft)
Oil Pump Bolt	15 N.m (11 lb ft)
Oil Pump Suction Pipe Bolt	10 N.m (89 lb in)
Oil Pump Flow Control Valve Bolt	5 N.m (44 lb in)
Positive Crankcase Ventilation Oil Separator Drain Bolt	10 N.m (89 lb in)
Positive Crankcase Ventilation Oil Separator Bolt	15 N.m (11 lb ft)
Positive Crankcase Ventilation Oil Separator Drain Pipe Bolt	10 N.m (89 lb in)
Piston Oil Cooling Nozzle Bolt	10 N.m (89 lb in)
Spark Plug	18 N.m (13 lb ft)
Timing Chain Guide Bolt	25 N.m (18 lb ft)
Timing Chain Tensioner Bolt	25 N.m (18 lb ft)
Throttle Body Bolt	10 N.m (89 lb in)
Turbocharger Bolt	58 N.m (43 lb ft)
Turbocharger Air Inlet Adapter Bolt	10 N.m (89 lb in)
Turbocharger Coolant Feed and Return Pipe Bolt	35 N.m (26 lb ft)
Turbocharger Coolant Feed Bolt	35 N.m (26 lb ft)
Turbocharger Coolant Return Bolt	10 N.m (89 lb in)
Turbocharger Coolant Return Pipe Bolt	35 N.m (26 lb ft)
Turbocharger Exhaust Pipe Stud	25 N.m (18 lb ft)
Turbocharger Heat Shield Bolt	10 N.m (89 lb in)
Turbocharger Oil Feed Pipe Bolt	35 N.m (26 lb ft)
Turbocharger Oil Feed Pipe Fitting Adapter	35 N.m (26 lb ft)
Turbocharger Oil Return Pipe Bolt	10 N.m (89 lb in)
Turbocharger Wastegate Actuator Vacuum Tank Bracket Bolt	9 N.m (80 lb in)
Turbocharger Wastegate Actuator Vacuum Tank Bolt	9 N.m (80 lb in)
Turbocharger Wastegate Regulator Solenoid Valve Bolt	9 N.m (80 lb in)
Vacuum Pump Pipe Bolt	10 N.m (89 lb in)
Water Outlet Bolt	10 N.m (89 lb in)
Water Pump Inlet Pipe Bolt	15 N.m (11 lb ft)
Water Pump Inlet Pipe Bolt	15 N.m (11 lb ft)
Water Pump Pulley Bolt	10 N.m (89 lb in)

FASTENER SPECIFICATIONS (LGX)

Single Use Non-Threaded Fasteners/Components

NOTE:

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

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

Application
Camshaft Cover Seal
Connecting Rod Bearing
Crankshaft Lower Bearing
Crankshaft Thrust Upper Bearing
Crankshaft Upper Bearing
Crankshaft Rear Oil Seal Housing
Cylinder Head Gasket
Engine Coolant Thermostat Gasket
Engine Oil Level Indicator Switch O-Ring Seal
Engine Oil Manifold Check Valve
Fuel Feed Intermediate Pipe
Fuel Injector Nozzle Housing Seal
Fuel Injector Retainer
Fuel Injector Spacer
Fuel Pump Bracket Gasket
Fuel Pump O-Ring
Heater Inlet and Outlet Pipe Gasket
Intake Manifold Seal
Oil Level Indicator Tube Seal
Oil Pan High Pressure Port Seal
Oil Pump Housing Passage Seal
Oil Pump Suction Pipe Gasket
Positive Crankcase Ventilation Oil Separator Seal
Piston Pin Retainer
Spark Plug Shield Seal
Throttle Body Gasket
Timing Chain Tensioner Gasket
Vacuum Pump Seal
Valve Stem Oil Seal
Water Inlet Seal
Water Outlet Seal
Water Pump Gasket

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:	30 N.m (22 lb ft)
• Final Pass:	45 degrees
Connecting Rod Bolt	

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NOTE:

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

Application	Specification Metric (English)
• First Pass:	25 N.m (18 lb ft)
• Final Pass:	110 degrees
Crankshaft Balancer Bolt	
• First Pass:	100 N.m (74 lb ft)
• Final Pass:	150 degrees
Crankshaft Bearing Cap Bolt - Inner	
• First Pass:	20 N.m (15 lb ft)
• Final Pass:	80 degrees
Crankshaft Bearing Cap Bolt - Outer	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	110 degrees
Crankshaft Bearing Cap Bolt - Side	
• First Pass:	30 N.m (22 lb ft)
• Final Pass:	60 degrees
Cylinder Head Bolt M8 x 80.8	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	75 degrees
Cylinder Head Bolt M11 x 178	
• First Pass:	60 N.m (44 lb ft)
• Final Pass:	185 degrees
Engine Flywheel Bolt	67 N.m (49 lb ft)
Fuel Pump Bolt	15 N.m (11 lb ft)

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NOTE:

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

Application	Specification Metric (English)
Oil Filter • 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange	
Oil Pan Bolt M6	
• First Pass:	7 N.m (62 lb in)
• Final Pass:	180 degrees
Oil Pump Drive Bolt	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	110 degrees
Water Pump Bolt	15 N.m (11 lb ft)
Wiring Harness Connector Bolt	10 N.m (89 lb in)

Reusable Threaded Fastener Tightening Specifications

NOTE:

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

Application	Specification Metric (English)
Belt Idler Pulley Bolt	10 N.m (89 lb in)
Camshaft Bearing Cap Bolt M6 x 43.4	
• First Pass:	6 N.m (53 lb in)
• Final Pass:	45 degrees
Camshaft Bearing Cap Bolt M6 x 43.4	
• Final Pass:	60 degrees
• First Pass:	6 N.m (53 lb in)
Camshaft Carrier Bolt M6 x 60	
• First Pass:	6 N.m (53 lb in)
• Final Pass:	45 degrees
Camshaft Carrier Bolt M6 x 60	

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NOTE:

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

Application	Specification Metric (English)
• First Pass:	6 N.m (53 lb in)
Camshaft Cover Bolt	10 N.m (89 lb in)
Camshaft Position Actuator Bolt	
• First Pass:	20 N.m (15 lb ft)
• Final Pass:	45 degrees
Camshaft Position Actuator Solenoid Valve Bolt	10 N.m (89 lb in)
Camshaft Position Sensor Bolt	10 N.m (89 lb in)
Clutch Pressure Plate Bolt	30 N.m (22 lb ft)
Coolant Drain Plug	50 N.m (37 lb ft)
Coolant Drain Plug	75 N.m (55 lb ft)
Crankshaft Oil Deflector Nut	10 N.m (89 lb in)
Crankshaft Position Sensor Bolt	10 N.m (89 lb in)
Crankshaft Rear Oil Seal Housing Bolt	10 N.m (89 lb in)
Cylinder Head Core Hole Plug M9	15 N.m (11 lb ft)
Cylinder Head Core Hole Plug M12	25 N.m (18 lb ft)
Cylinder Head Core Hole Plug M14	35 N.m (26 lb ft)
Drive Belt Tensioner Bolt	30 N.m (22 lb ft)
Engine Block Oil Gallery Plug	25 N.m (18 lb ft)
Engine Block Oil Gallery Plug M16	40 N.m (30 lb ft)
Engine Block Core Hole Plug M18	45 N.m (33 lb ft)
Engine Coolant Air Bleed Pipe Bolt	10 N.m (89 lb in)
Engine Coolant Outlet Pipe Bolt	10 N.m (89 lb in)
Engine Coolant Temperature Sensor	9 N.m (80 lb in)
Engine Coolant Thermostat Housing Bolt	10 N.m (89 lb in)
Engine Front Cover Bolt M6 x 45	10 N.m (89 lb in)
Engine Front Cover Bolt M6 x 60	10 N.m (89 lb in)
Engine Front Cover Bolt M8 x 66	15 N.m (11 lb ft)
Engine Front Cover Bolt M12 x 55.8	60 N.m (44 lb ft)
Engine Front Cover Bolt M12 x 75.9	60 N.m (44 lb ft)
Engine Front Cover Stud	15 N.m (11 lb ft)
Engine Oil Cooler Adapter Bolt	10 N.m (89 lb in)
Engine Oil Cooler Adapter Fitting	25 N.m (18 lb ft)
Engine Oil Cooler Pipe Bracket Bolt	10 N.m (89 lb in)
Engine Oil Level Indicator Switch Bolt	10 N.m (89 lb in)
Engine Oil Pressure Sensor	35 N.m (26 lb ft)
Evaporative Emission Canister Purge Solenoid Valve Bolt	10 N.m (89 lb in)
Engine Wiring Harness Bracket Bolt	15 N.m (11 lb ft)
Fuel Feed Intermediate Pipe Bolt	28 N.m (21 lb ft)
Fuel Feed Pipe Bolt	10 N.m (89 lb in)
Fuel Injection Fuel Rail Bolt	25 N.m (18 lb ft)
Fuel Injection Fuel Rail Fuel Pressure Sensor	33 N.m (24 lb ft)
Fuel Pipe Shield Bolt	10 N.m (89 lb in)

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NOTE:

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

Application	Specification
	Metric (English)
Fuel Rail Crossover Pipe Fitting	30 N.m (22 lb ft)
Heater Inlet and Outlet Pipe Bolt	9 N.m (80 lb in)
Ignition Coil Bolt	10 N.m (89 lb in)
Intake Manifold Bolt	25 N.m (18 lb ft)
Intake Manifold Insulator Retainer	10 N.m (89 lb in)
Knock Sensor Bolt	25 N.m (18 lb ft)
Manifold Absolute Pressure Sensor Bolt	4 N.m (35 lb in)
Oil Gallery Plug M20	15 N.m (11 lb ft)
Oil Level Indicator Tube Bolt	10 N.m (89 lb in)
Oil Pan Baffle Bolt	10 N.m (89 lb in)
Lower Oil Pan Bolt	10 N.m (89 lb in)
Oil Pan Bolt M8 x 20	25 N.m (18 lb ft)
Oil Pan Bolt M8 x 36	25 N.m (18 lb ft)
Oil Pan Bolt M8 x 66	25 N.m (18 lb ft)
Oil Pan Drain Plug	25 N.m (18 lb ft)
Oil Pump Bolt	15 N.m (11 lb ft)
Oil Pump Suction Pipe Bolt	10 N.m (89 lb in)
Oil Pump Flow Control Valve Bolt	5 N.m (44 lb in)
Positive Crankcase Ventilation Oil Separator Drain Bolt	10 N.m (89 lb in)
Positive Crankcase Ventilation Oil Separator Bolt	15 N.m (11 lb ft)
Positive Crankcase Ventilation Oil Separator Drain Pipe Bolt	10 N.m (89 lb in)
Piston Oil Cooling Nozzle Bolt	10 N.m (89 lb in)
Spark Plug	18 N.m (13 lb ft)
Timing Chain Guide Bolt	25 N.m (18 lb ft)
Timing Chain Tensioner Bolt	25 N.m (18 lb ft)
Throttle Body Bolt	10 N.m (89 lb in)
Vacuum Pump Pipe Bolt	10 N.m (89 lb in)
Water Outlet Bolt	10 N.m (89 lb in)
Water Pump Inlet Pipe Bolt	15 N.m (11 lb ft)
Water Pump Pulley Bolt	10 N.m (89 lb in)

APPROXIMATE FLUID CAPACITIES (LGW)

Application	Specification	
	Metric	English
3.0L LGW		
• Oil Capacity - with Filter	5.7 Liters	6.0 Quarts

APPROXIMATE FLUID CAPACITIES (LGX)

Application	Specification	
	Metric	English
3.6L LGX		
• Oil Capacity - with Filter (AWD)	5.68 Liters	6.0 Quarts

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ENGINE MECHANICAL SPECIFICATIONS (LGX)

Application	Specification	
	Metric	English
General		
• Engine Type	V-6	
• Displacement	3.6 Liter	220 cu in
• RPO	LGX	
• VIN	8	
• Bore	95 mm	3.7402 in
• Stroke	85.6 mm	3.37 in
• Compression Ratio	11.5:1	
• Firing Order	1-2-3-4-5-6	
• Spark Plug Gap	0.90 mm	0.035 in
Block		
• Crankshaft Main Bearing Bore Diameter	76.021-76.035 mm	2.9929-2.9935 in
• Cylinder Bore Diameter	94.992-95.008 mm	3.7398-3.7405 in
• Cylinder Bore Out-of-Round - Production Max.	0.026 mm	0.001 in
Camshaft		
• Camshaft Bearing Inside Diameter - Front Number 1	31.000-31.020 mm	1.2205-1.2213 in
• Camshaft Bearing Inside Diameter - Middle and Rear Number 2-4	24.000-24.020 mm	0.9449-0.9457 in
• Camshaft End Play	0.055-0.465 mm	0.0022-0.0183 in
• Camshaft Journal Diameter - Front Number 1	30.936-30.960 mm	0.9424-0.9433 in
• Camshaft Journal Diameter - Middle and Rear Number 2-4	23.936-23.960 mm	1.0605-1.0614 in

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Application	Specification	
	Metric	English
• Camshaft Journal Out-of-Round	0.006 mm	0.0002 in
• Camshaft Journal to Bore Clearance	0.040-0.084 mm	0.0016-0.0033 in
• Camshaft Lobe Lift - Exhaust AFM	40.557-40.707 mm	1.5967-1.6026 in
• Camshaft Lobe Lift - Exhaust Non AFM	42.519-42.669 mm	1.6740-1.6799 in
• Camshaft Lobe Lift - Intake AFM	40.353-42.503 mm	1.5887-1.5946 in
• Camshaft Lobe Lift - Intake Non AFM	42.317-42.467 mm	1.6660-1.6719 in
• Camshaft Runout - Front and Rear Number 1 and 4	0.025 mm	0.0010 in
• Camshaft Runout - Middle 2 and 3	0.050 mm	0.0020 in
• Valve Lift - Exhaust AFM	11.350 mm	0.4468 in
• Valve Lift - Exhaust Non AFM	11.222 mm	0.4418 in
• Valve Lift - Intake AFM	11.00 mm	0.4331 in
• Valve Lift - Intake Non AFM	10.872 mm	0.4280 in
Connecting Rod		
• Connecting Rod Bearing Clearance	0.010-0.070 mm	0.0004-0.0026 in
• Connecting Rod Bore Diameter - Bearing End	60.920-60.936 mm	2.3984-2.3990 in
• Connecting Rod Bore Diameter - Pin End - Production	23.007-23.017 mm	0.9056-0.9062 in
• Connecting Rod Bore Diameter - Pin End - Service Maximum	23.021 mm	0.9063 in
• Connecting Rod Length - Center to Center	148.8 mm	5.86 in
• Connecting Rod Side Clearance	0.095-0.355 mm	0.00037-0.0140 in

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Application	Specification	
	Metric	English
• Connecting Rod Width - Bearing End		
• Production	21.775 mm	0.8573 in
• Service	21.725-21.825 mm	0.8553-0.8593 in
• Connecting Rod Width - Pin End		
• Production	21.775 mm	0.8573 in
• Service	21.725-21.825 mm	0.8553-0.8593 in
Crankshaft		
• Connecting Rod Journal Diameter	57.292-57.308 mm	2.2556-2.2556 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Connecting Rod Journal Taper	0.005 mm	0.0002 in
• Connecting Rod Journal Width		
• Production	23.000 mm	0.9055 in
• Service	22.920-23.080 mm	0.9024-0.9417 in
• Crankshaft End Play	0.100-0.330 mm	0.0039-0.0130 in
• Crankshaft Main Bearing Clearance	0.028-0.063 mm	0.0011-0.0025 in
• Crankshaft Main Journal Diameter	70.992-71.008 mm	2.7950-2.7956 in
• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft Main Journal Taper	0.005 mm	0.0002 in
• Crankshaft Main Journal Thrust Wall		
• Runout	0.000-0.040 mm	0.0000-0.0016 in

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Application	Specification	
	Metric	English
• Square	0.000-0.010 mm	0.0000-0.0004 in
• Crankshaft Main Journal Width, #2, 4		
• Production	25.500 mm	1.0040 in
• Service	25.400-25.600 mm	1.0000-1.0079 in
• Crankshaft Main Journal Width, #3		
• Production	25.900 mm	1.0197 in
• Service	25.875-25.925 mm	1.0187-1.0207 in
• Crankshaft Pilot Bearing Bore Diameter	20.965-20.995 mm	0.8254-0.8266 in
• Crankshaft Rear Flange Runout	0.025 mm	0.0010 in
• Crankshaft Reluctor Ring Runout - Maximum	1.500 mm	0.0591 in
• Crankshaft Runout	0.030 mm	0.0012 in
• Crankshaft Thrust Bearing Clearance	0.076-0.305 mm	0.0030-0.0120 in
• Crankshaft Thrust Surface - Height Diameter	99.500 mm	3.9173 in
• Crankshaft Thrust Surface Runout	0.040 mm	0.0016 in
Cylinder Head		
• Valve Guide Bore - Exhaust	6.000-6.020 mm	0.2362-0.2370 in
• Valve Guide Bore - Intake	6.000-6.020 mm	0.2362-0.2370 in
• Valve Guide Installed Height	16.050-16.550 mm	0.6319-0.5516 in
• Valve Seat Width - Exhaust Seating Surface	1.550-1.950 mm	0.0610-0.0768 in
• Valve Seat Width - Exhaust Relief Surface	0.780-0.980 mm	0.0307-0.0386 in

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Application	Specification	
	Metric	English
• Valve Seat Width - Intake Seating Surface	1.000-1.400 mm	0.0394-0.0551 in
• Valve Seat Width - Intake Relief Surface	0.500-0.700 mm	0.0197-0.0276 in
• Valve Lifter Bore Diameter	12.008-12.030 mm	0.4728-0.4736 in
Lubrication System		
• Oil Pressure - Minimum @ Idle	69 kPa	10 psi
• Oil Pressure - Minimum @ 2, 000 RPM	136 kPa	20 psi
• Piston Cooling Jet Valve Opening Pressure	3.15-3.85 bar	45.7-55.8 psi
Piston Rings		
• Piston Ring End Gap		
• First Compression Ring - Nominal	0.140-0.240 mm	0.0055-0.0102 in
• First Compression Ring - Maximum, Ring in Bore	0.290 mm	0.0094 in
• Second Compression Ring - Nominal	0.300-0.450 mm	0.0118-0.0177 in
• Second Compression Ring - Maximum, Ring in Bore	0.490 mm	0.0193 in
• Oil Control Ring	0.150-0.350 mm	0.0059-0.0138 in
• Piston Ring to Groove Clearance		
• First Compression Ring	0.03-0.08 mm	0.0011-0.0031 in
• Second Compression Ring	0.020-0.060 mm	0.0007-0.0024 in
• Oil Control Ring	0.06-0.19 mm	0.0024-0.0075 in
• Piston Ring Thickness		
• First Compression Ring	0.975-0.990 mm	0.0384-0.0390 in
• Second Compression Ring	1.170-1.195 mm	0.0461-0.0470 in

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Application	Specification	
	Metric	English
• Oil Control Ring	1.360-1.480 mm	0.0535-0.0583 in
Pistons and Pins		
• Piston		
• Piston Diameter - Measured Over Skirt Coating	94.976-95.014 mm	3.7392-3.7407 in
• Piston Diameter - Service Limit Minimum w/more than 10 K miles	94.926 mm	3.7372 in
• Piston Pin Bore Diameter	23.004-23.009 mm	0.9055-0.9056 in
• Piston Ring Groove Width - First Compression Ring	1.02-1.05 mm	0.0402-0.0413 in
• Piston Ring Groove Width - Second Compression Ring	1.210-1.230 mm	0.0476-0.0484 in
• Piston Ring Groove Width - Oil Control Ring	2.01-2.03 mm	0.0791-0.0799 in
• Piston to Bore Clearance - Production; Measured at Skirt Coating	0.022-0.032 mm	0.0009-0.0013 in
• Piston to Bore Clearance - Service Limit Maximum, w/more than 10k miles	0.050 mm	0.0020 in
• Pin		
• Piston Pin Clearance to Connecting Rod Bore - Production	0.007-0.020 mm	0.0002-0.0007 in
• Piston Pin Clearance to Connecting Rod Bore - Service Maximum	0.030 mm	0.0012 in
• Piston Pin Clearance to Piston Pin Bore - Production	0.004-0.012 mm	0.0002-0.0005 in
• Piston Pin Clearance to Piston Pin Bore - Service Maximum	0.015 mm	0.0006 in
• Piston Pin Diameter	22.997-23.000 mm	0.9053-0.9055 in

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Application	Specification	
	Metric	English
• Piston Pin Length	55.7-56.0 mm	2.193-2.205 in
Valve System		
• Valves		
• Valve Face Angle	44 degrees (from combustion face)	
• Valve Face Runout	0.0500 mm	0.0020 in
• Valve Face Width - Exhaust	DO NOT GRIND, REPLACE VALVE	DO NOT GRIND, REPLACE VALVE
• Valve Face Width - Intake	DO NOT GRIND, REPLACE VALVE	DO NOT GRIND, REPLACE VALVE
• Valve Head Diameter - Exhaust	31.37-31.63 mm	1.2350-1.2453 in
• Valve Head Diameter - Intake	39.27-39.53 mm	1.5460-1.5563 in
• Valve Installed Height	35.23-36.69 mm	1.3870-1.4445 in
• Valve Length - Exhaust	100.54 mm	3.9583 in
• Valve Length - Intake	106.321 mm	4.1858 in
• Valve Seat Angle - Seating Surface	45 degrees	
• Valve Seat Angle - Relief Surface	30 degrees	
• Valve Seat Roundness- Maximum	0.008 mm	0.0003 in
• Valve Seat Runout - Maximum	0.025 mm	0.0010 in
• Valve Stem Diameter - Exhaust	5.945-5.965 mm	0.2341-0.2348 in
• Valve Stem Diameter - Intake	5.595-5.975 mm	0.2344-0.2352 in
• Valve Stem-to-Guide Clearance - Exhaust	0.035-0.075 mm	0.0014-0.0030 in
• Valve Stem-to-Guide Clearance - Intake	0.025-0.065 mm	0.0009-0.0025 in

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Application	Specification	
	Metric	English
• Valve Lifters - Stationary Hydraulic Lash Adjuster (SHLA)		
• Valve Lifter (SHLA) Diameter	11.989-12.000 mm	0.4720-0.4724 in
• Valve Lifter (SHLA)-to-Bore Clearance	0.008-0.041 mm	0.0003-0.0016 in
• Rocker Arms		
• Valve Rocker Arm Ratio	1.68 to 1	
• Valve Rocker Arm Roller Diameter	17.750-17.800 mm	0.6988-0.7008 in
• Valve Springs		
• Valve Spring Coil Thickness	3.6 mm	0.1417 in
• Valve Spring Diameter - Inside Top	12.200-12.700 mm	0.4803-0.5000 in
• Valve Spring Diameter - Inside Bottom	17.950-18.450 mm	0.7067-0.7264 in
• Valve Spring Free Length	44.34-47.34 mm	1.7457-1.8638 in
• Valve Spring Installed Height - Closed	37.50 mm	1.4764 in
• Valve Spring Installed Height - Open	26.2 mm	1.0315 in
• Valve Spring Load - Closed	247-273 N	56-61 lb
• Valve Spring Load - Open	611-669 N	137-150 lb

ENGINE MECHANICAL SPECIFICATIONS (LGW)

Application	Specification	
	Metric	English
General		
• Engine Type	V-6	
• Displacement	3.0 Liter	183 cu in
• RPO	LGW	

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Application	Specification	
	Metric	English
• VIN	6	
• Bore	86 mm	3.386 in
• Stroke	85.8 mm	3.378 in
• Compression Ratio	9.8:1	
• Firing Order	1-2-3-4-5-6	
• Spark Plug Gap	0.90 mm	0.035 in
Block		
• Crankshaft Main Bearing Bore Diameter	76.021-76.035 mm	2.9929-2.9935 in
• Cylinder Bore Diameter	85.992-86.008 mm	3.3855-3.386 in
• Cylinder Bore Out-of-Round-Production Max.	0.026 mm	0.001 in
Camshaft		
• Camshaft Bearing Inside Diameter - Front Number 1	31.000-31.020 mm	1.2205-1.2213 in
• Camshaft Bearing Inside Diameter - Middle and Rear Number 2-4	24.000-24.020 mm	0.9449-0.9457 in
• Camshaft End Play	0.055-0.465 mm	0.0022-0.0183 in
• Camshaft Journal Diameter - Front Number 1	30.936-30.960 mm	0.9424-0.9433 in
• Camshaft Journal Diameter - Middle and Rear Number 2-4	23.936-23.960 mm	1.0605-1.0614 in
• Camshaft Journal Out-of-Round	0.006 mm	0.0002 in
• Camshaft Journal to Bore Clearance	0.040-0.084 mm	0.0016-0.0033 in
• Camshaft Lobe Lift - Exhaust AFM	40.557-40.707 mm	1.5967-1.6026 in
• Camshaft Lobe Lift - Exhaust Non AFM	42.519-42.669 mm	1.6740-1.6799 in

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Application	Specification	
	Metric	English
• Camshaft Lobe Lift - Intake AFM	40.353-42.503 mm	1.5887-1.5946 in
• Camshaft Lobe Lift - Intake Non AFM	42.317-42.467 mm	1.6660-1.6719 in
• Camshaft Runout - Front and Rear Number 1 and 4	0.025 mm	0.0010 in
• Camshaft Runout - Middle 2 and 3	0.050 mm	0.0020 in
• Valve Lift - Exhaust AFM	11.350 mm	0.4468 in
• Valve Lift - Exhaust Non AFM	11.222 mm	0.4418 in
• Valve Lift - Intake AFM	11.00 mm	0.4331 in
• Valve Lift - Intake Non AFM	10.872 mm	0.4280 in
Connecting Rod		
• Connecting Rod Bearing Clearance	0.010-0.070 mm	0.0004-0.0026 in
• Connecting Rod Bore Diameter - Bearing End	60.920-60.936 mm	2.3984-2.3990 in
• Connecting Rod Bore Diameter - Pin End - Production	23.007-23.017 mm	0.9056-0.9062 in
• Connecting Rod Bore Diameter - Pin End - Service Maximum	23.021 mm	0.9063 in
• Connecting Rod Length - Center to Center	148.8 mm	5.86 in
• Connecting Rod Side Clearance	0.095-0.355 mm	0.00037-0.0140 in
• Connecting Rod Width - Bearing End		
• Production	21.775 mm	0.8573 in
• Service	21.725-21.825 mm	0.8553-0.8593 in
• Connecting Rod Width - Pin End		

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Application	Specification	
	Metric	English
• Production	21.775 mm	0.8573 in
• Service	21.725-21.825 mm	0.8553-0.8593 in
Crankshaft		
• Connecting Rod Journal Diameter	57.292-57.308 mm	2.2556-2.2556 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Connecting Rod Journal Taper	0.005 mm	0.0002 in
• Connecting Rod Journal Width		
• Production	23.000 mm	0.9055 in
• Service	22.920-23.080 mm	0.9024-0.9417 in
• Crankshaft End Play	0.100-0.330 mm	0.0039-0.0130 in
• Crankshaft Main Bearing Clearance	0.028-0.063 mm	0.0011-0.0025 in
• Crankshaft Main Journal Diameter	70.992-71.008 mm	2.7950-2.7956 in
• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft Main Journal Taper	0.005 mm	0.0002 in
• Crankshaft Main Journal Thrust Wall		
• Runout	0.000-0.040 mm	0.0000-0.0016 in
• Square	0.000-0.010 mm	0.0000-0.0004 in
• Crankshaft Main Journal Width, #2, 4		
• Production	25.500 mm	1.0040 in
• Service	25.400-25.600 mm	1.0000-1.0079 in

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Application	Specification	
	Metric	English
• Crankshaft Main Journal Width, #3		
• Production	25.900 mm	1.0197 in
• Service	25.875-25.925 mm	1.0187-1.0207 in
• Crankshaft Pilot Bearing Bore Diameter	20.965-20.995 mm	0.8254-0.8266 in
• Crankshaft Rear Flange Runout	0.025 mm	0.0010 in
• Crankshaft Reluctor Ring Runout - Maximum	1.500 mm	0.0591 in
• Crankshaft Runout	0.030 mm	0.0012 in
• Crankshaft Thrust Bearing Clearance	0.076-0.305 mm	0.0030-0.0120 in
• Crankshaft Thrust Surface - Height Diameter	99.500 mm	3.9173 in
• Crankshaft Thrust Surface Runout	0.040 mm	0.0016 in
Cylinder Head		
• Valve Guide Bore - Exhaust	6.000-6.020 mm	0.2362-0.2370 in
• Valve Guide Bore - Intake	6.000-6.020 mm	0.2362-0.2370 in
• Valve Guide Installed Height	16.050-16.550 mm	0.6319-0.5516 in
• Valve Seat Width - Exhaust Seating Surface	1.550-1.950 mm	0.0610-0.0768 in
• Valve Seat Width - Exhaust Relief Surface	0.780-0.980 mm	0.0307-0.0386 in
• Valve Seat Width - Intake Seating Surface	1.000-1.400 mm	0.0394-0.0551 in
• Valve Seat Width - Intake Relief Surface	0.500-0.700 mm	0.0197-0.0276 in
• Valve Lifter Bore Diameter	12.008-12.030 mm	0.4728-0.4736 in
Lubrication System		
• Oil Pressure - Minimum @ Idle	69 kPa	10 psi

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Application	Specification	
	Metric	English
• Oil Pressure - Minimum @ 2, 000 RPM	136 kPa	20 psi
• Piston Cooling Jet Valve Opening Pressure	3.15-3.85 bar	45.7-55.8 psi
Piston Rings		
• Piston Ring End Gap		
• First Compression Ring - Nominal	0.140-0.240 mm	0.0055-0.0102 in
• First Compression Ring - Maximum, Ring in Bore	0.290 mm	0.0094 in
• Second Compression Ring - Nominal	0.300-0.450 mm	0.0118-0.0177 in
• Second Compression Ring - Maximum, Ring in Bore	0.490 mm	0.0193 in
• Oil Control Ring	0.150-0.350 mm	0.0059-0.0138 in
• Piston Ring to Groove Clearance		
• First Compression Ring	0.03-0.08 mm	0.0011-0.0031 in
• Second Compression Ring	0.020-0.060 mm	0.0007-0.0024 in
• Oil Control Ring	0.06-0.19 mm	0.0024-0.0075 in
• Piston Ring Thickness		
• First Compression Ring	0.975-0.990 mm	0.0384-0.0390 in
• Second Compression Ring	1.170-1.195 mm	0.0461-0.0470 in
• Oil Control Ring	1.360-1.480 mm	0.0535-0.0583 in
Pistons and Pins		
• Piston		
• Piston Diameter - Measured Over Skirt Coating	94.976-95.014 mm	3.7392-3.7407 in

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Application	Specification	
	Metric	English
• Piston Diameter - Service Limit Minimum w/more than 10K miles	94.926 mm	3.7372 in
• Piston Pin Bore Diameter	23.004-23.009 mm	0.9055-0.9056 in
• Piston Ring Groove Width - First Compression Ring	1.02-1.05 mm	0.0402-0.0413 in
• Piston Ring Groove Width - Second Compression Ring	1.210-1.230 mm	0.0476-0.0484 in
• Piston Ring Groove Width - Oil Control Ring	2.01-2.03 mm	0.0791-0.0799 in
• Piston to Bore Clearance - Production; Measured at Skirt Coating	0.022-0.032 mm	0.0009-0.0013 in
• Piston to Bore Clearance - Service Limit Maximum, w/more than 10k miles	0.050 mm	0.0020 in
• Pin		
• Piston Pin Clearance to Connecting Rod Bore - Production	0.007-0.020 mm	0.0002-0.0007 in
• Piston Pin Clearance to Connecting Rod Bore - Service Maximum	0.030 mm	0.0012 in
• Piston Pin Clearance to Piston Pin Bore - Production	0.004-0.012 mm	0.0002-0.0005 in
• Piston Pin Clearance to Piston Pin Bore - Service Maximum	0.015 mm	0.0006 in
• Piston Pin Diameter	22.997-23.000 mm	0.9053-0.9055 in
• Piston Pin Length	55.7-56.0 mm	2.193-2.205 in
Valve System		
• Valves		
• Valve Face Angle	44 degrees (from combustion face)	

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Application	Specification	
	Metric	English
• Valve Face Runout	0.0500 mm	0.0020 in
• Valve Face Width - Exhaust	DO NOT GRIND, REPLACE VALVE	DO NOT GRIND, REPLACE VALVE
• Valve Face Width - Intake	DO NOT GRIND, REPLACE VALVE	DO NOT GRIND, REPLACE VALVE
• Valve Head Diameter - Exhaust	31.37-31.63 mm	1.2350-1.2453 in
• Valve Head Diameter - Intake	39.27-39.53 mm	1.5460-1.5563 in
• Valve Installed Height	35.23-36.69 mm	1.3870-1.4445 in
• Valve Length - Exhaust	100.54 mm	3.9583 in
• Valve Length - Intake	106.321 mm	4.1858 in
• Valve Seat Angle - Seating Surface	45 degrees	
• Valve Seat Angle - Relief Surface	30 degrees	
• Valve Seat Roundness - Maximum	0.008 mm	0.0003 in
• Valve Seat Runout - Maximum	0.025 mm	0.0010 in
• Valve Stem Diameter - Exhaust	5.945-5.965 mm	0.2341-0.2348 in
• Valve Stem Diameter - Intake	5.595-5.975 mm	0.2344-0.2352 in
• Valve Stem-to-Guide Clearance - Exhaust	0.035-0.075 mm	0.0014-0.0030 in
• Valve Stem-to-Guide Clearance - Intake	0.025-0.065 mm	0.0009-0.0025 in
• Valve Lifters - Stationary Hydraulic Lash Adjuster (SHLA)		
• Valve Lifter (SHLA) Diameter	11.989-12.000 mm	0.4720-0.4724 in
• Valve Lifter (SHLA)-to-Bore Clearance	0.008-0.041 mm	0.0003-0.0016 in
• Rocker Arms		

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Application	Specification	
	Metric	English
• Valve Rocker Arm Ratio	1.68 to 1	
• Valve Rocker Arm Roller Diameter	17.750-17.800 mm	0.6988-0.7008 in
• Valve Springs		
• Valve Spring Coil Thickness	3.6 mm	0.1417 in
• Valve Spring Diameter - Inside Top	12.200-12.700 mm	0.4803-0.5000 in
• Valve Spring Diameter - Inside Bottom	17.950-18.450 mm	0.7067-0.7264 in
• Valve Spring Free Length	44.34-47.34 mm	1.7457-1.8638 in
• Valve Spring Installed Height - Closed	37.50 mm	1.4764 in
• Valve Spring Installed Height - Open	26.2 mm	1.0315 in
• Valve Spring Load - Closed	247-273 N	56-61 lb
• Valve Spring Load - Open	611-669 N	137-150 lb

ADHESIVES, FLUIDS, LUBRICANTS AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
Block Pan Rail*	Sealant	19330905	19330906
Camshaft Prelube	Lubricant	88862586	88862827
Coolant Drain Threaded Plug	Sealant	12346004	10953480
Coolant Expansion Plugs	Threadlocker	12345382	10953489
Coolant and Oil Plug Threads	Sealant	12346004	10953480
Crankshaft Bearing Surfaces	5W-30	19293000	19286321
Crankshaft Connecting Rod Bearing Journal	5W-30	19293000	19286321
Crankshaft Prelube	5W-30	19293000	19286321
Crankshaft Rear Oil Seal Housing*	Sealant	19330905	19330906
Engine Front Cover/Split Lines*	Sealant	19330905	19330906
Engine Oil	5W-30	19293000	19386321
Fuel Injection Fuel Rail Fuel Pressure Sensor Sealing Cone/Threads	5W-30	19293000	19286321
Fuel Rail Sealing Cone/Threads	5W-30	19293000	19286321
Ignition Coils	Lubricant	19260901	19260902

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Application	Type of Material	GM Part Number	
		United States	Canada
Oil Gallery Threaded Plug	Sealant	12346004	10953480
Oil Pan*	Sealant	19330905	19330906
Piston Pin Bores	5W-30	19293000	19286321
Positive Crankcase Ventilation (PCV) Orifice	Sealant	19330905	19330906
(SHLA)	5W-30	19293000	19286321
SHLA Bores in Cylinder Head	5W-30	19293000	19286321
SHLA Pivot Spheres	5W-30	19293000	19286321
Thread Repair	Cleaner	88862650	88901247
	Threadlocker	89021297	10953488
Thread Repair Cutting Oil	Lubricant	1052864	992881
Valve Stem/Guide ID	5W-30	19293000	19286321
*Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**			

THREAD REPAIR SPECIFICATIONS (LGW AND LGX)

Left Cylinder Head Camshaft Carrier Left Face



Fig. 1: Left Cylinder Head Camshaft Carrier Left Face
Courtesy of GENERAL MOTORS COMPANY

Left Cylinder Head Camshaft Carrier Left Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

Left Cylinder Head Camshaft Carrier Right Face

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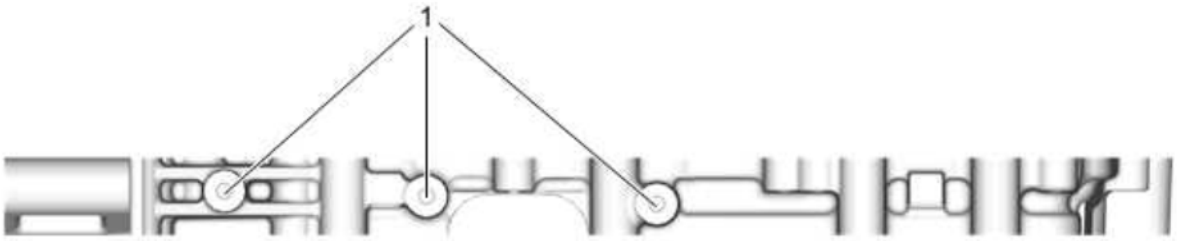


Fig. 2: Left Cylinder Head Camshaft Carrier Right Face
Courtesy of GENERAL MOTORS COMPANY

Left Cylinder Head Camshaft Carrier Right Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

Left Cylinder Head Camshaft Carrier Top Face

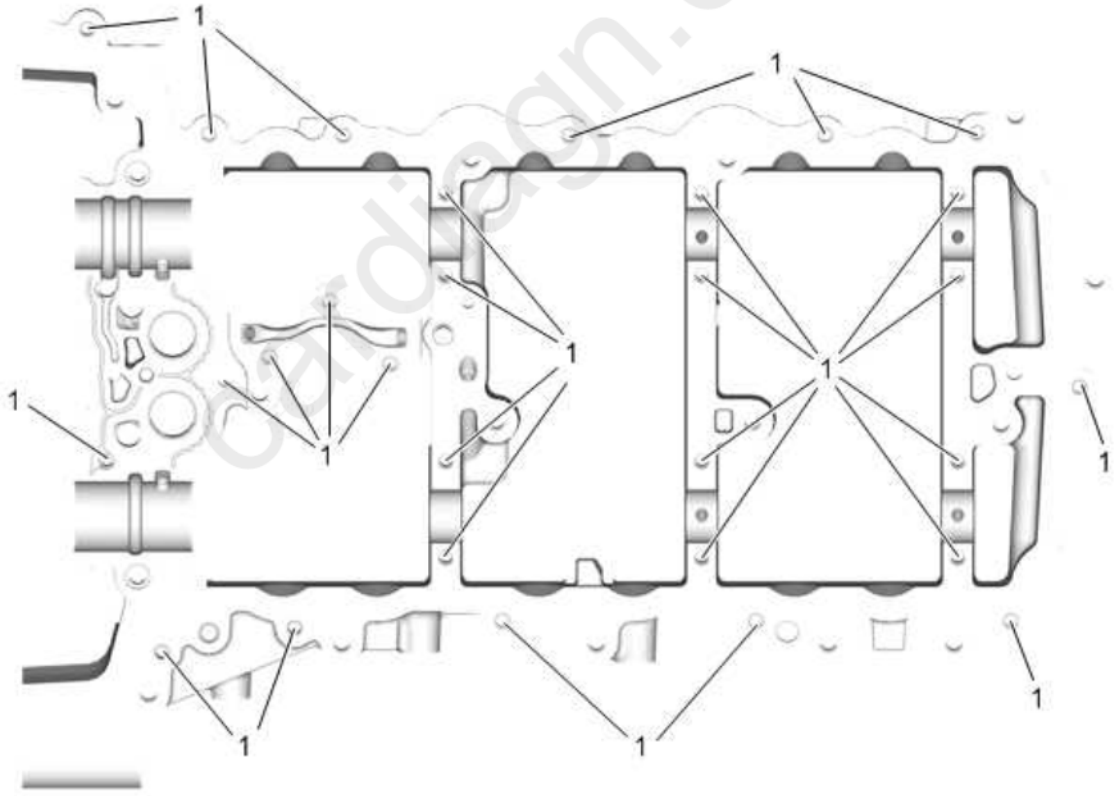


Fig. 3: Left Cylinder Head Camshaft Carrier Top Face
Courtesy of GENERAL MOTORS COMPANY

Left Cylinder Head Camshaft Carrier Top Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

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Left Cylinder Head Top Face

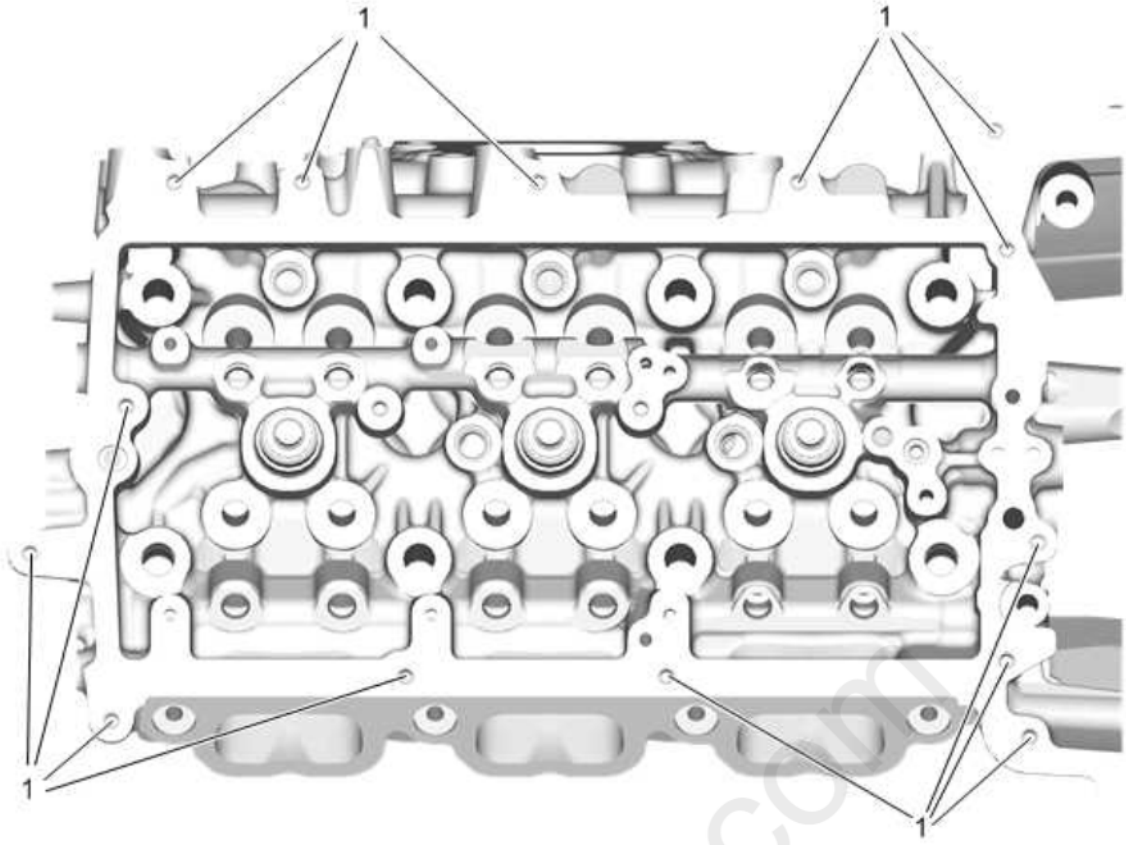


Fig. 4: Left Cylinder Head Top Face
Courtesy of GENERAL MOTORS COMPANY

Left Cylinder Head Top Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

Left Cylinder Head Front Face

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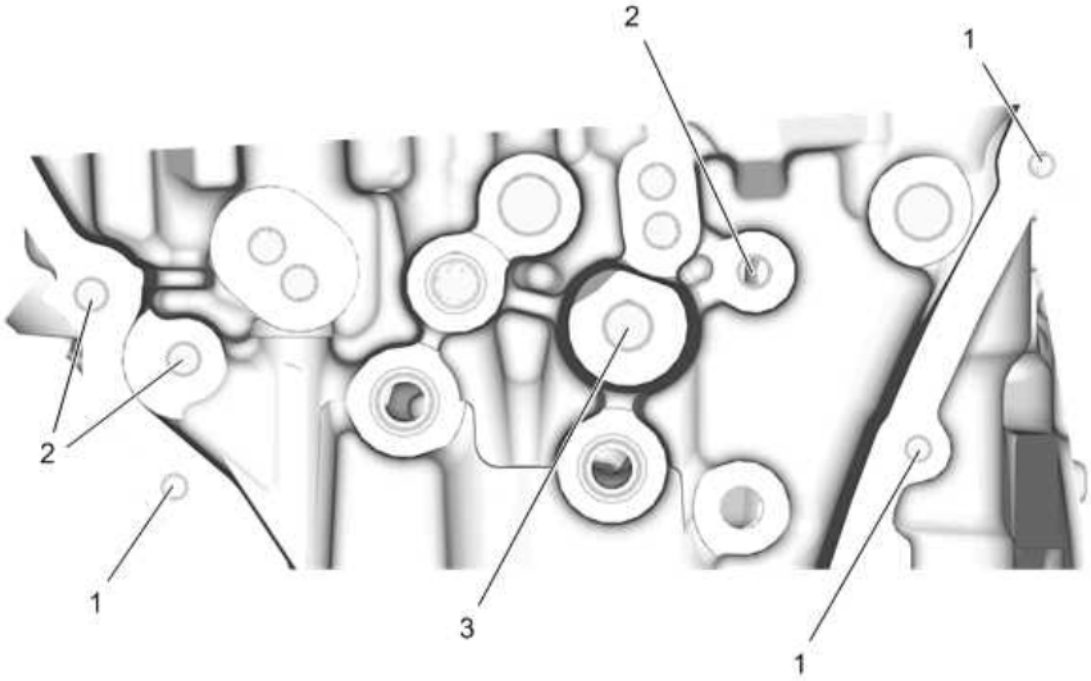


Fig. 5: Left Cylinder Head Front Face
Courtesy of GENERAL MOTORS COMPANY

Left Cylinder Head Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M12 x 1.75	856	857	N/A	858	859	58	35.0	1.38	35.0	1.38

Left Cylinder Head Intake Face

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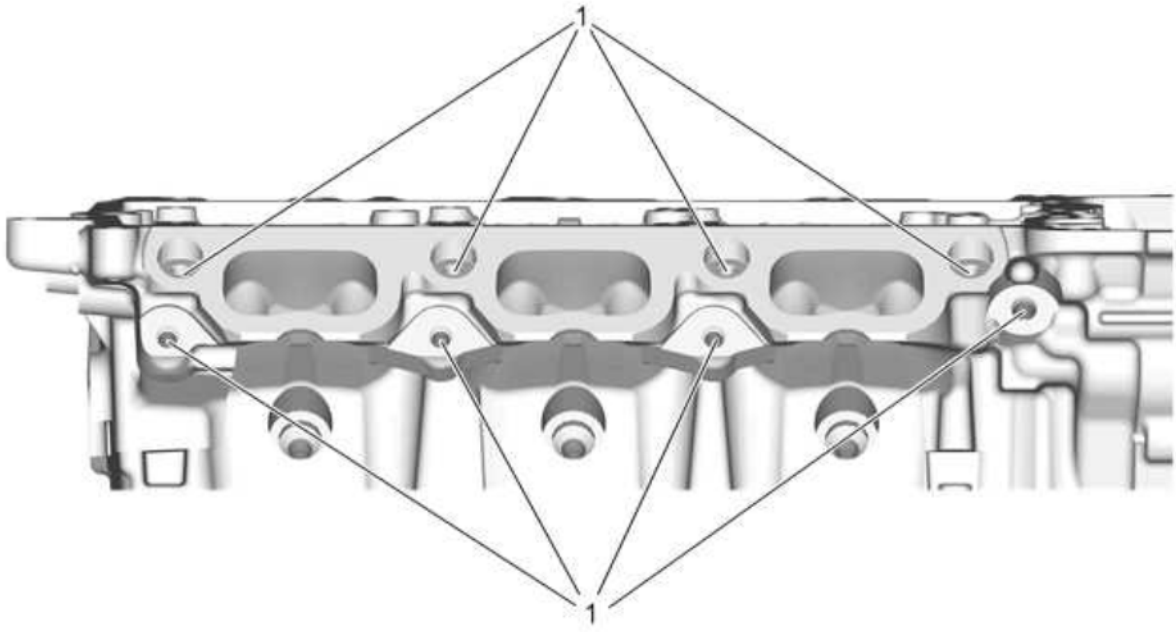
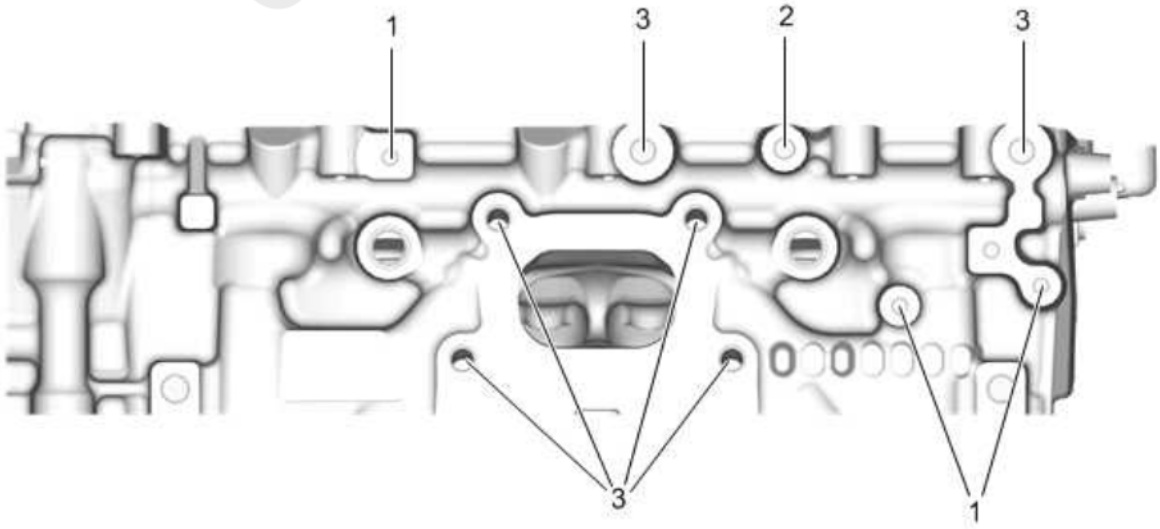


Fig. 6: Left Cylinder Head Intake Face
Courtesy of GENERAL MOTORS COMPANY

Left Cylinder Head Intake Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14

Left Cylinder Head Exhaust Face



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Fig. 7: Left Cylinder Head Exhaust Face
Courtesy of GENERAL MOTORS COMPANY

Left Cylinder Head Exhaust Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M10 x 1.5	211	212	N/A	213	214	514	34.0	1.35	34.0	1.35

Left Cylinder Head Rear Face

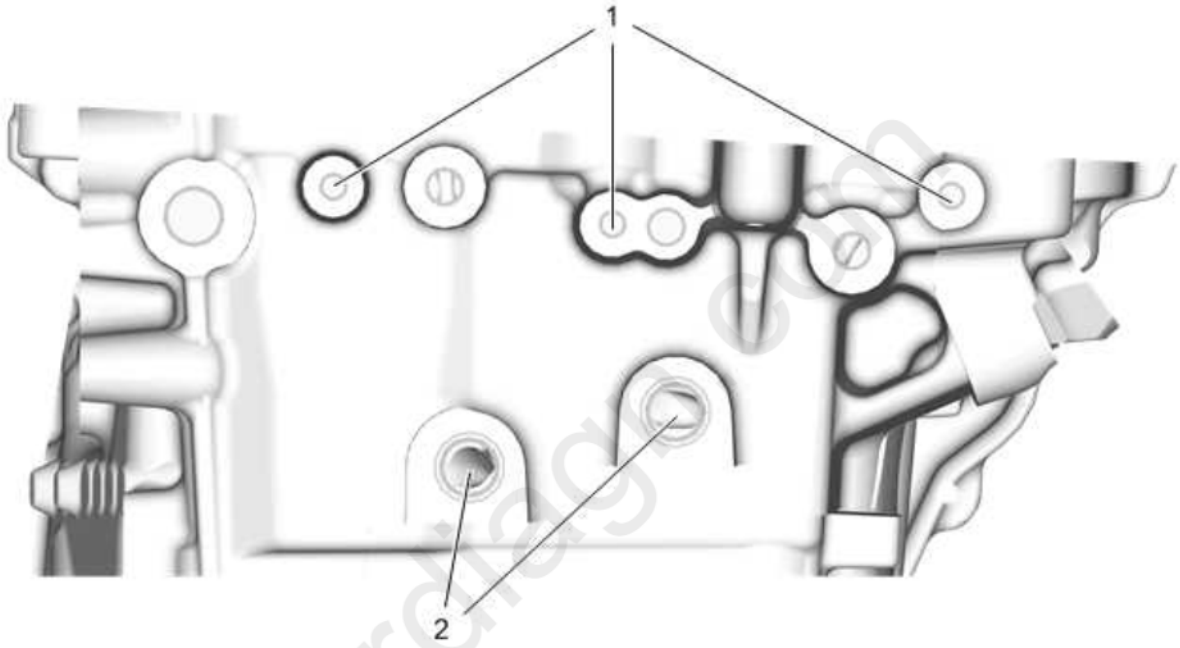


Fig. 8: Left Cylinder Head Rear Face
Courtesy of GENERAL MOTORS COMPANY

Left Cylinder Head Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	14 x 1.5	409	410	N/A	411	412	735	19.0	.748	19.0	.748

Right Cylinder Head Camshaft Carrier Left Face



Fig. 9: Right Cylinder Head Camshaft Carrier Left Face
Courtesy of GENERAL MOTORS COMPANY

Right Cylinder Head Camshaft Carrier Left Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14

Right Cylinder Head Camshaft Carrier Right Face

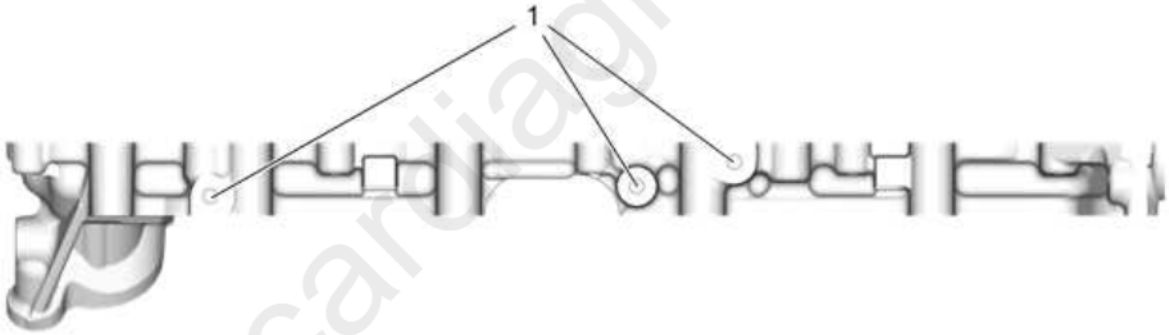


Fig. 10: Right Cylinder Head Camshaft Carrier Right Face
Courtesy of GENERAL MOTORS COMPANY

Right Cylinder Head Camshaft Carrier Right Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

Right Cylinder Head Camshaft Carrier Rear Face

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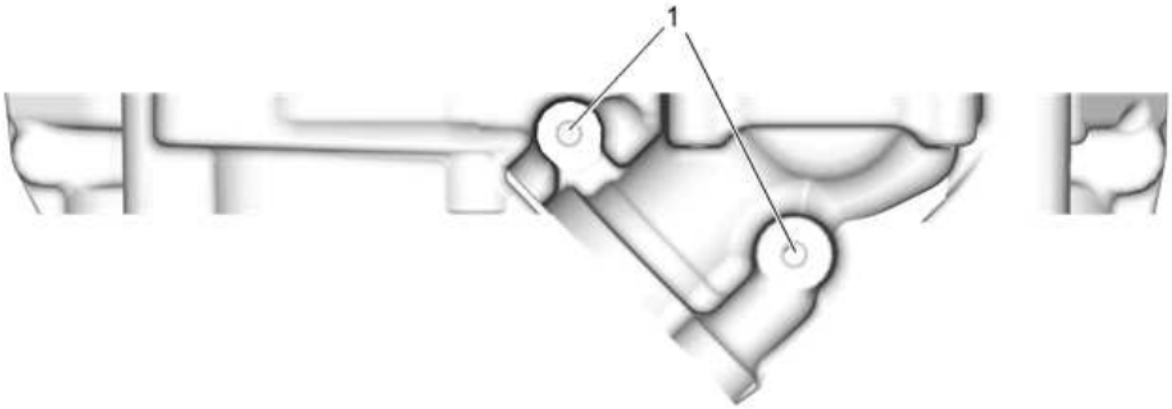


Fig. 11: Right Cylinder Head Camshaft Carrier Rear Face
Courtesy of GENERAL MOTORS COMPANY

Right Cylinder Head Camshaft Carrier Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

Right Cylinder Head Camshaft Carrier Top Face

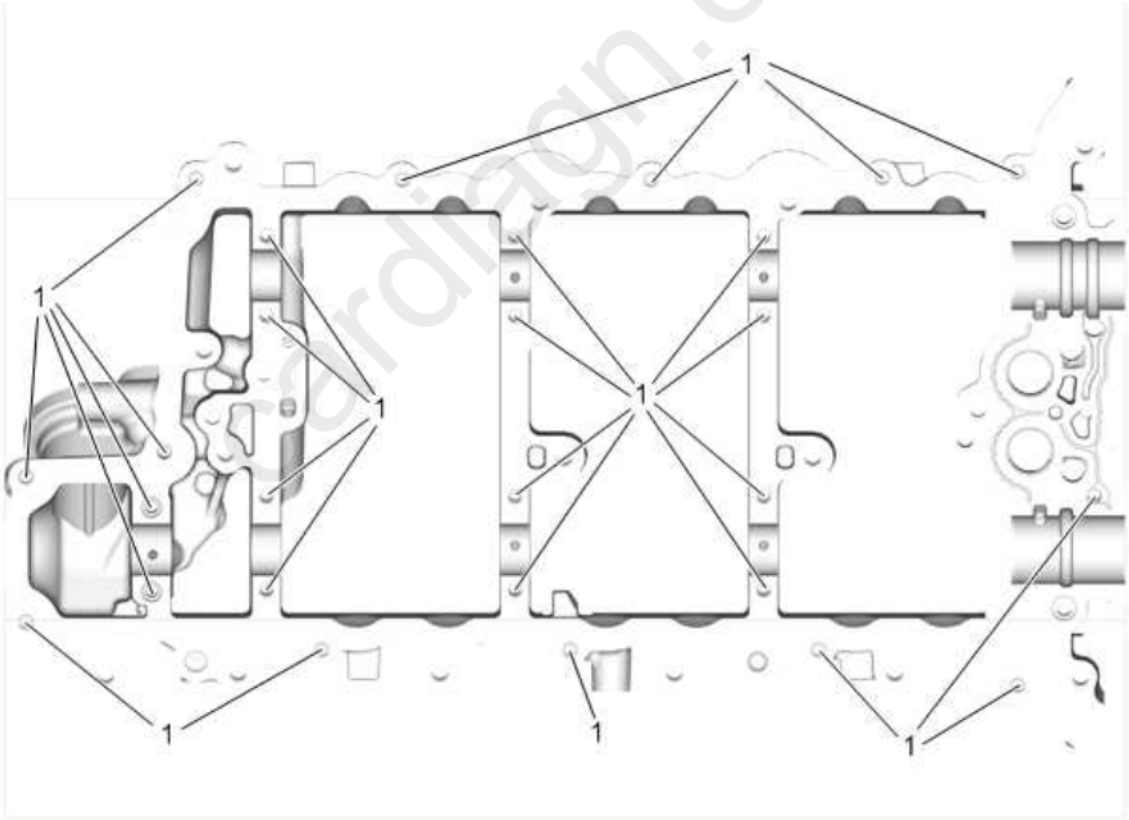


Fig. 12: Right Cylinder Head Camshaft Carrier Top Face
Courtesy of GENERAL MOTORS COMPANY

Right Cylinder Head Camshaft Carrier Top Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

Right Cylinder Head Top Face

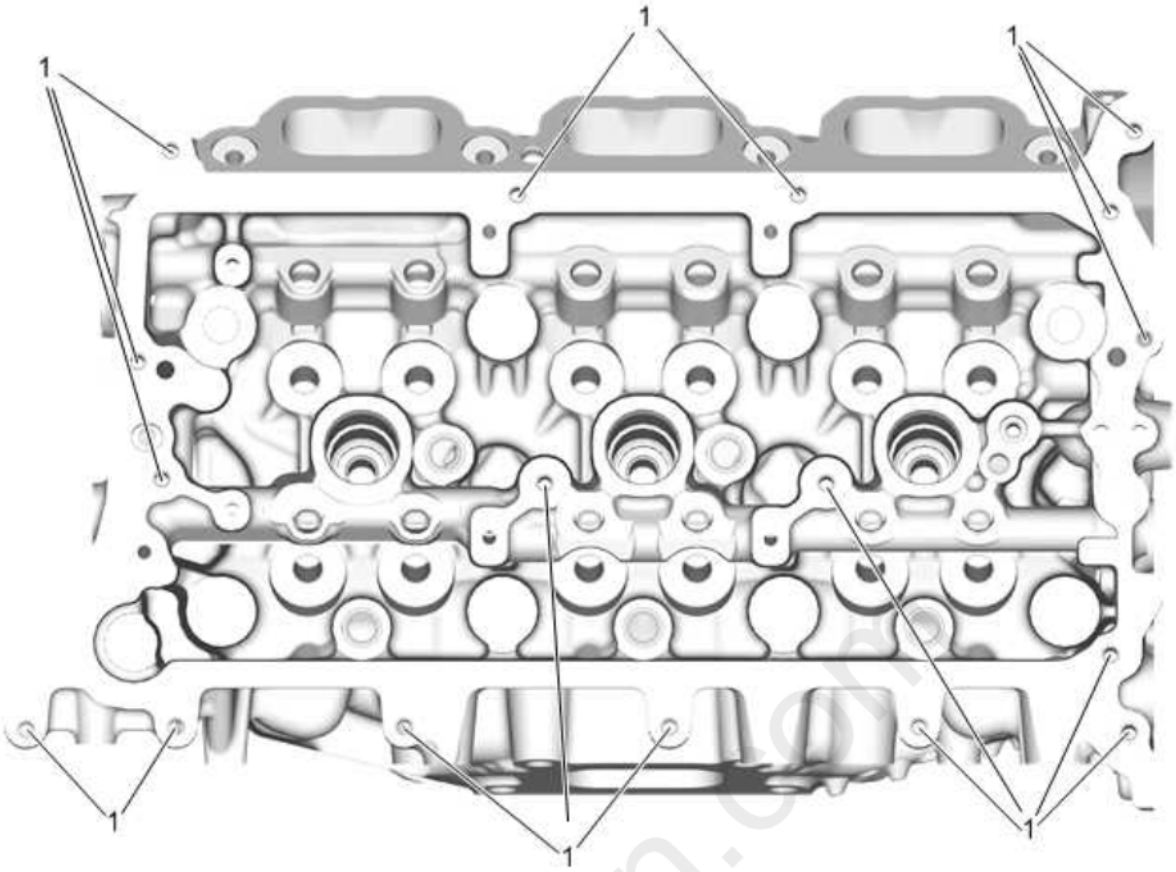


Fig. 13: Right Cylinder Head Top Face
Courtesy of GENERAL MOTORS COMPANY

Right Cylinder Head Top Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

Right Cylinder Head Front Face

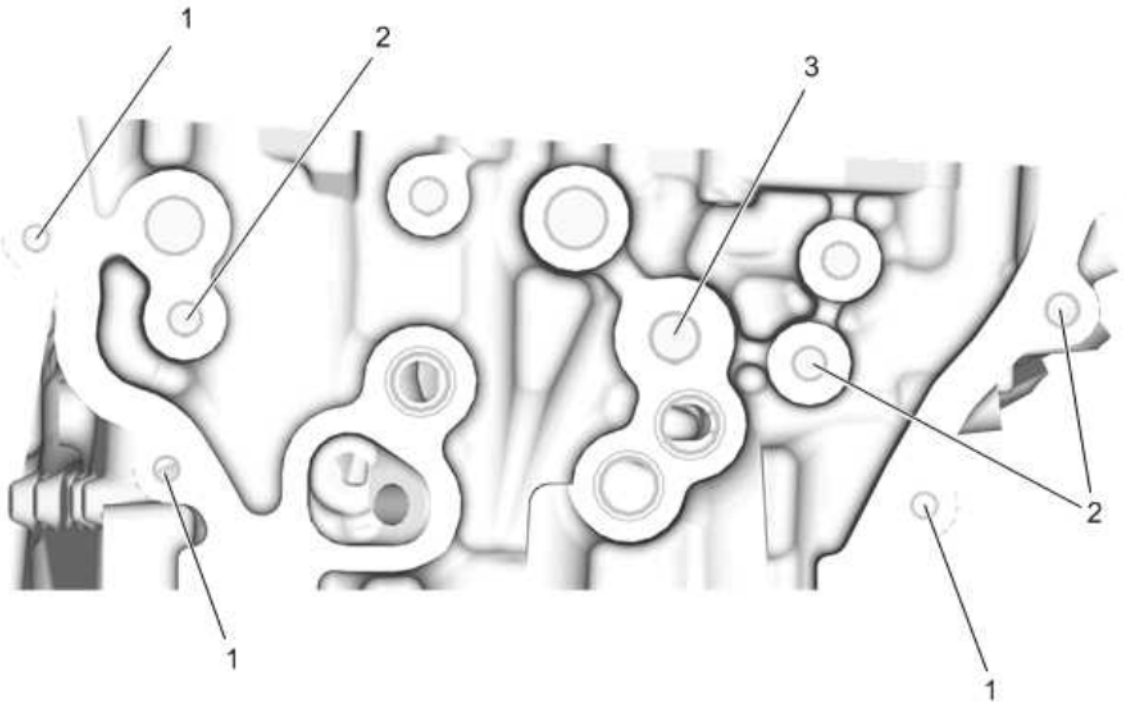


Fig. 14: Right Cylinder Head Front Face
Courtesy of GENERAL MOTORS COMPANY

Right Cylinder Head Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M12 x 1.75	856	857	N/A	858	859	58	35.0	1.38	35.0	1.38

Right Cylinder Head Intake Face

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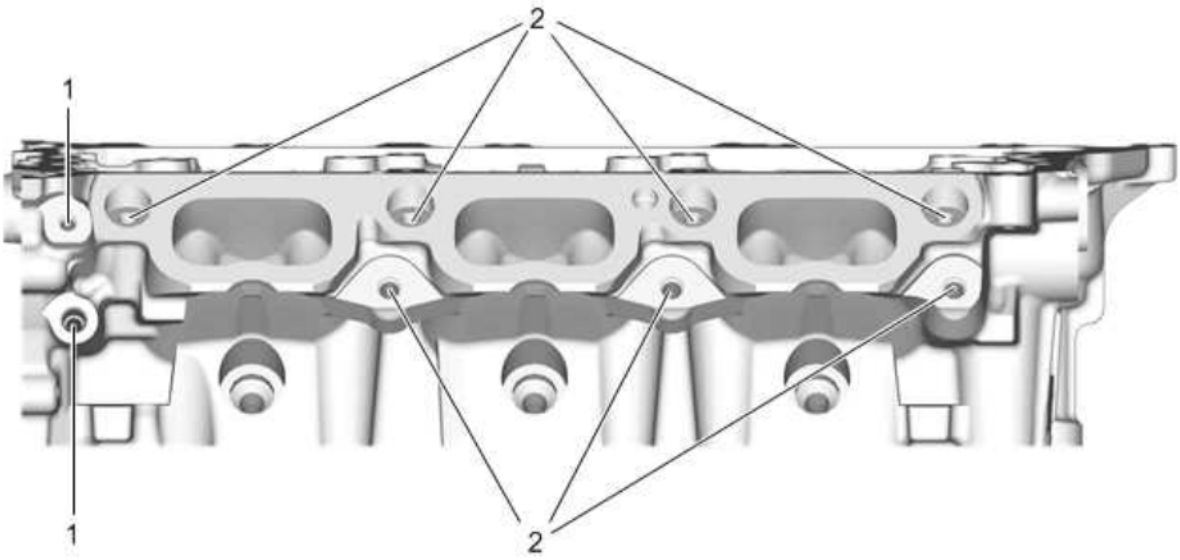


Fig. 15: Right Cylinder Head Intake Face
Courtesy of GENERAL MOTORS COMPANY

Right Cylinder Head Intake Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14

Right Cylinder Head Exhaust Face

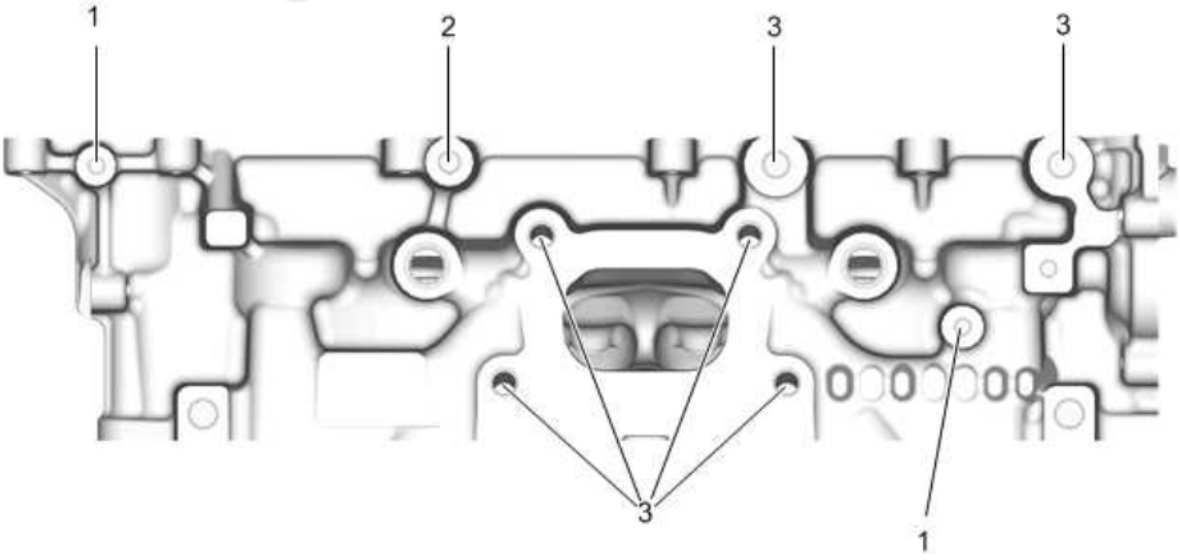


Fig. 16: Right Cylinder Head Exhaust Face
Courtesy of GENERAL MOTORS COMPANY

Right Cylinder Head Exhaust Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M10 x 1.5	211	212	N/A	213	214	514	34.0	1.35	34.0	1.35

Right Cylinder Head Rear Face

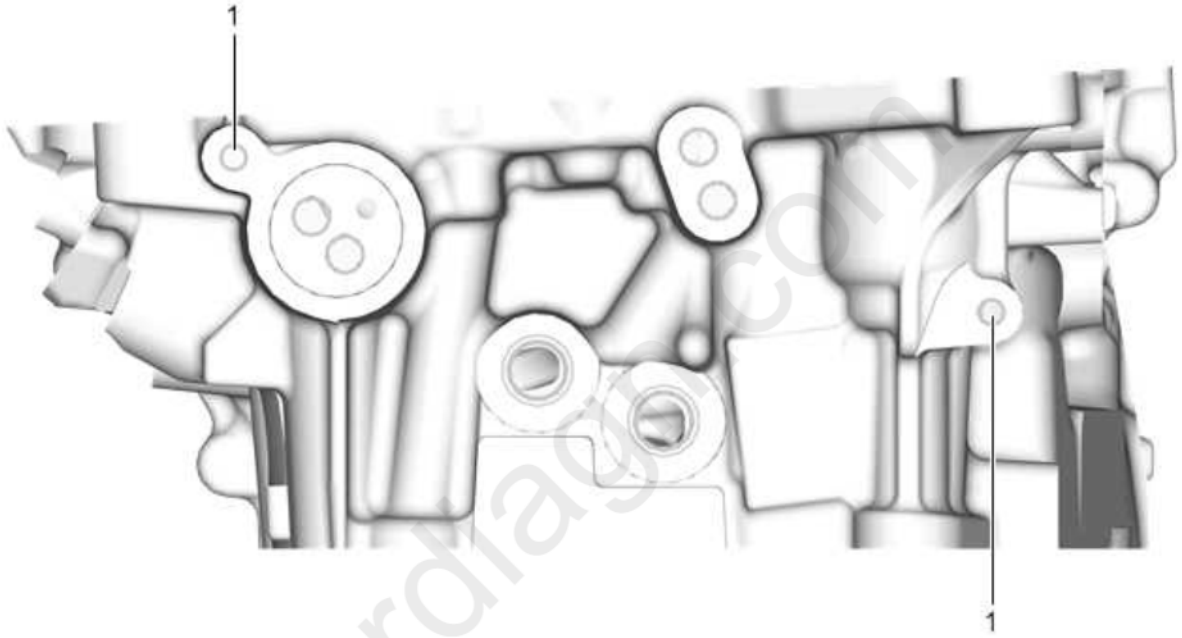


Fig. 17: Right Cylinder Head Rear Face
Courtesy of GENERAL MOTORS COMPANY

Right Cylinder Head Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

Engine Block Front Face

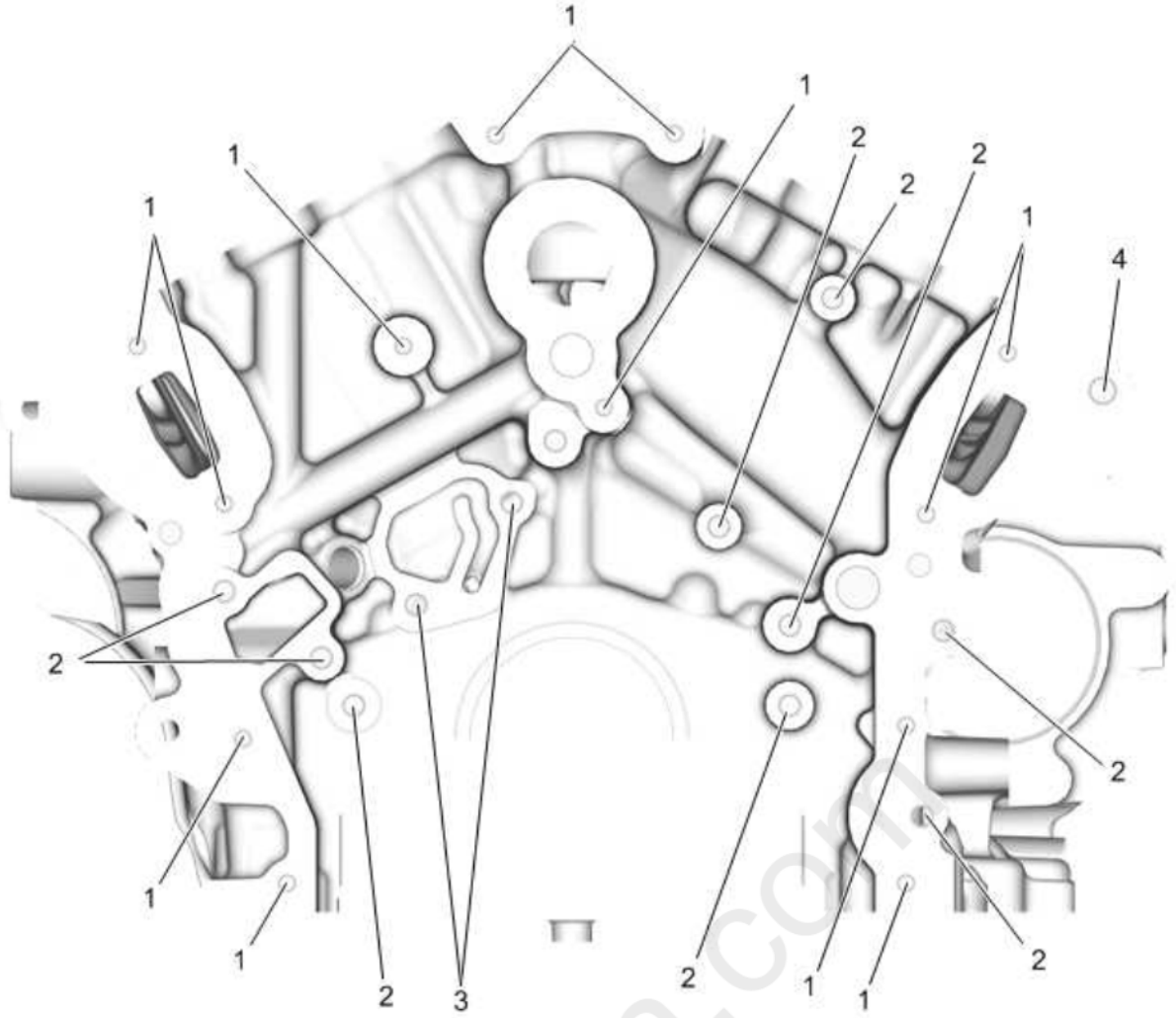


Fig. 18: Engine Block Front Face
Courtesy of GENERAL MOTORS COMPANY

Engine Block Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M8 x 1.25	206	207	N/A	208	209	210	23.0	.905	23.0	.905
4	M10 x 1.5	211	212	N/A	213	214	215	34.0	1.35	34.0	1.35

Engine Block Left Face

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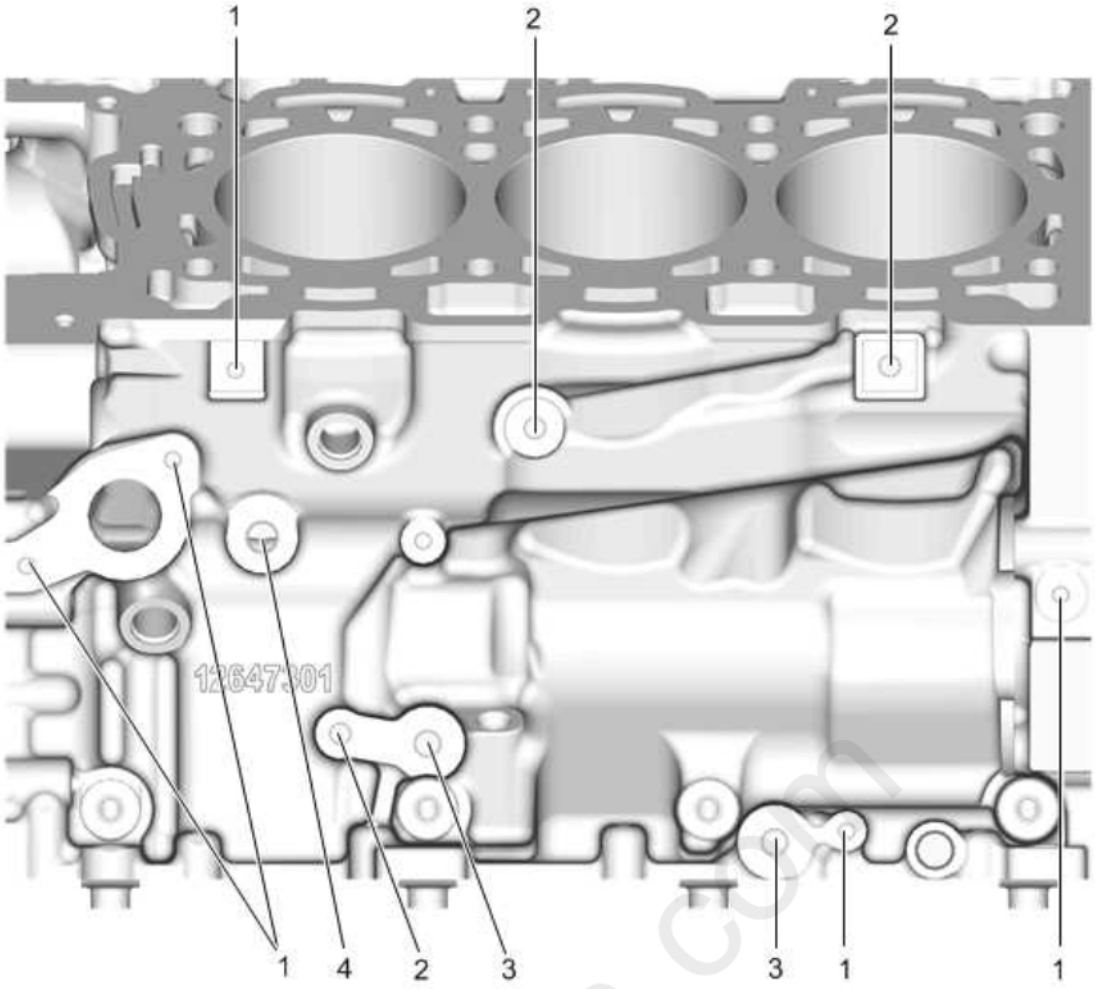


Fig. 19: Engine Block Left Face
Courtesy of GENERAL MOTORS COMPANY

Engine Block Left Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	210	202	N/A	203	204	205	18.0	.709	18.0	.709
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M10 x 1.5	211	212	N/A	213	214	215	34.0	1.35	34.0	1.35
4	M12 x 1.75	856	857	N/A	858	859	416	23.0	.905	23.0	.905

Engine Block Right Face

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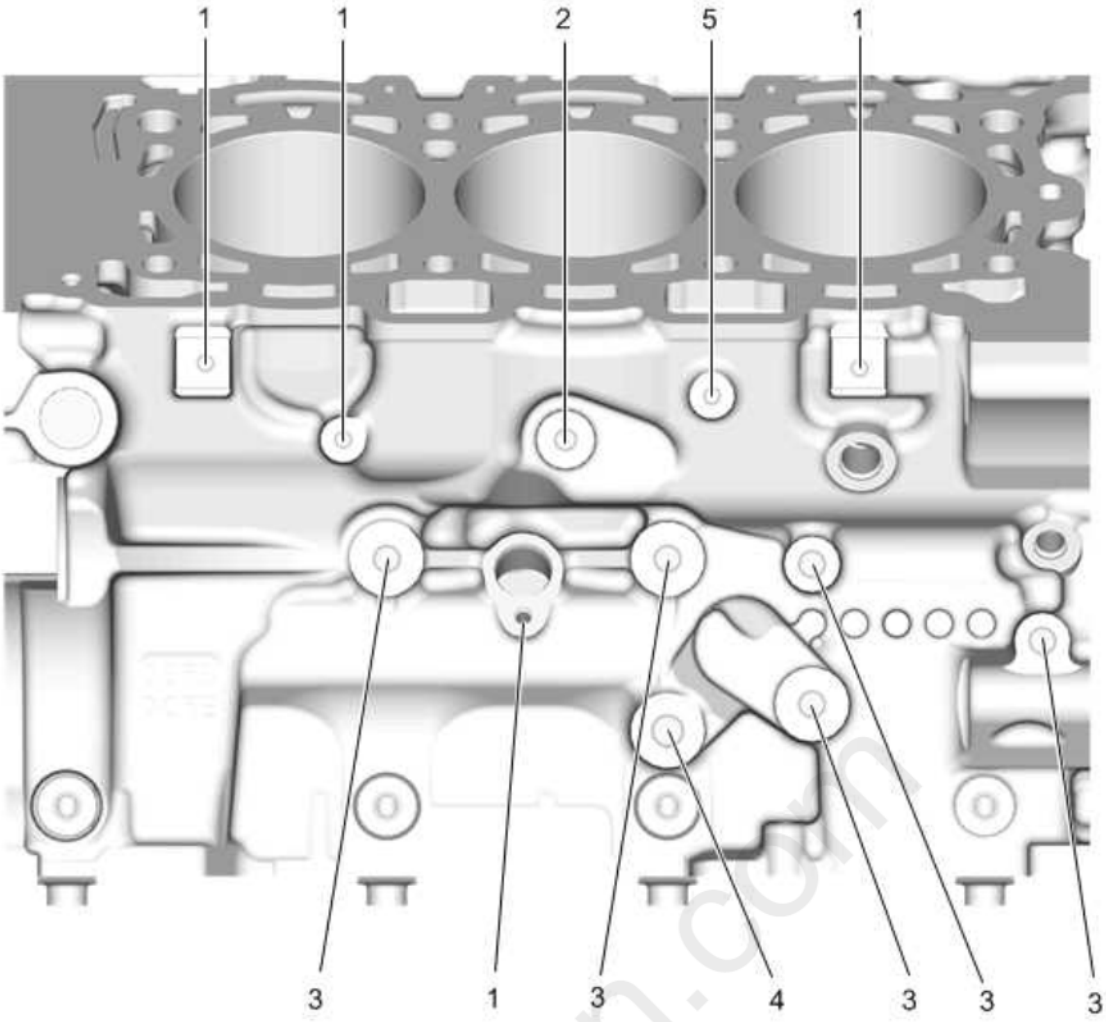


Fig. 20: Engine Block Right Face
Courtesy of GENERAL MOTORS COMPANY

Engine Block Right Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	210	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
3	M10 x 1.5	211	212	N/A	213	214	215	34.0	1.35	34.0	1.35
4	M12 x 1.75	856	857	N/A	858	859	416	23.0	.905	23.0	.905
5	M6 x 1.0	210	202	N/A	203	204	205	18.0	.709	18.0	.709

Engine Block Rear Face

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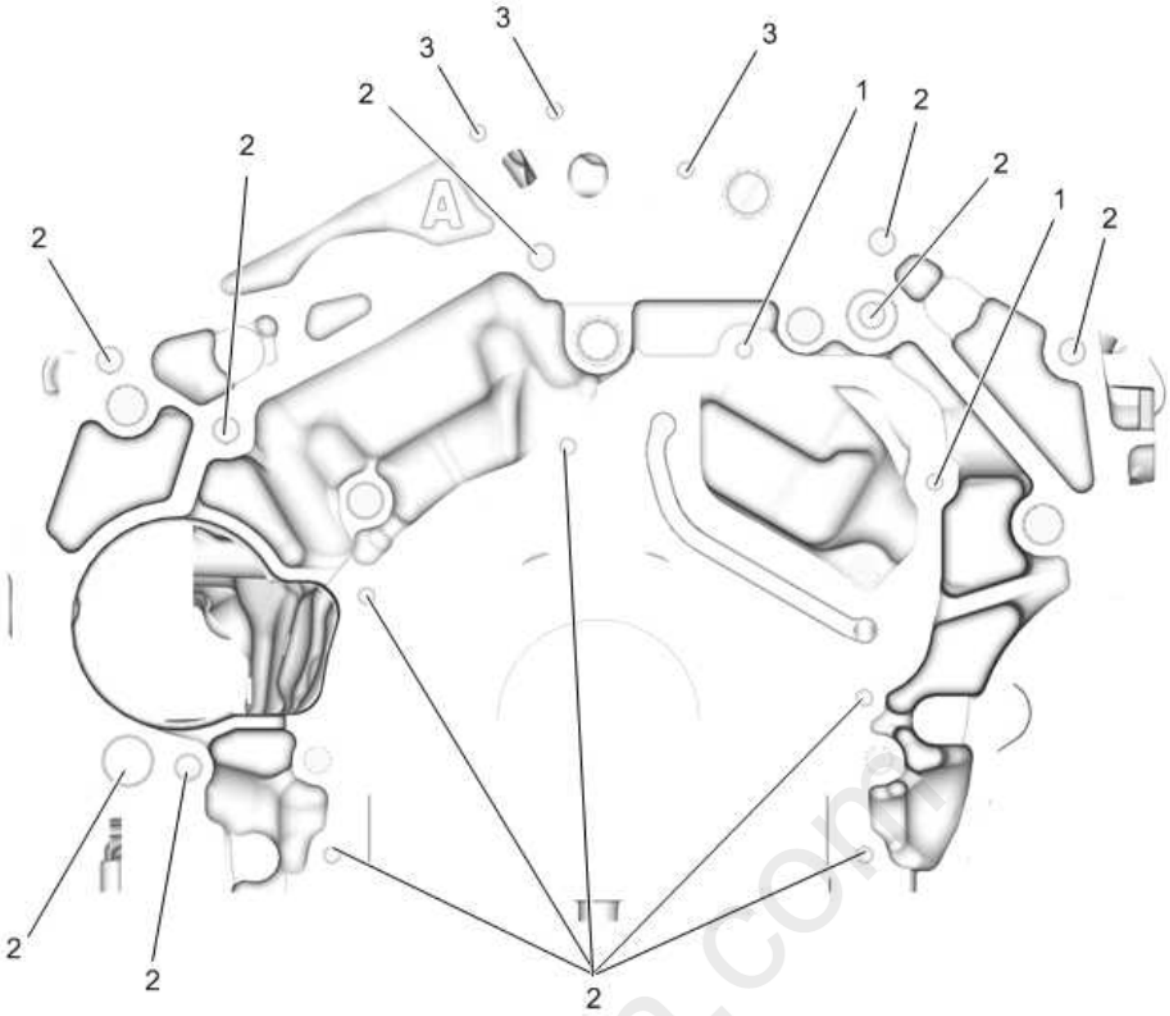


Fig. 21: Engine Block Rear Face
Courtesy of GENERAL MOTORS COMPANY

Engine Block Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	210	202	N/A	203	204	205	18.0	.709	18.0	.709
2	M10 x 1.5	211	212	N/A	213	214	215	34.0	1.35	34.0	1.35
3	M6 x 1.0	210	202	N/A	203	204	63	23.0	.907	23.0	.907

Engine Block Bottom Face

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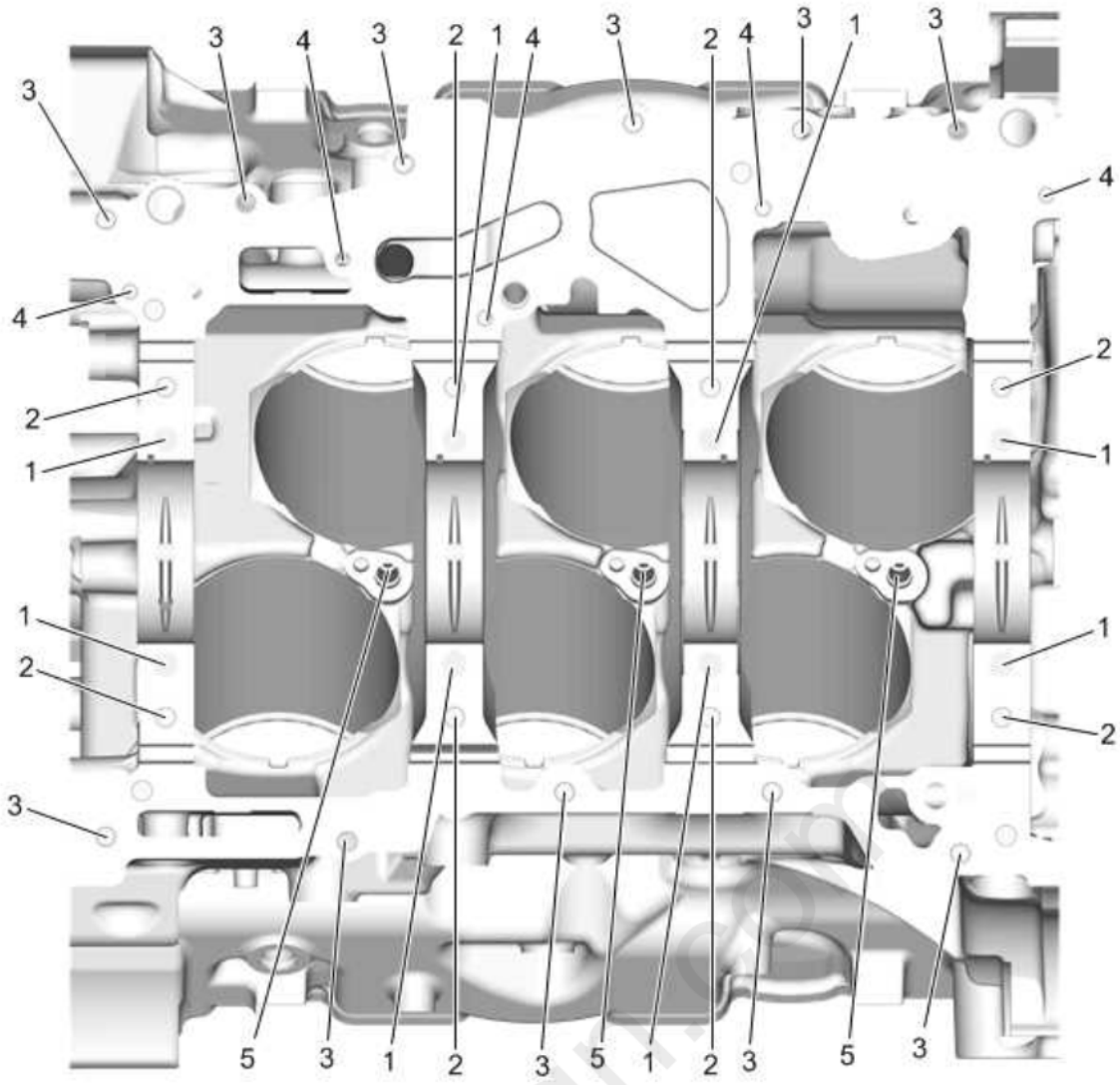


Fig. 22: Engine Block Bottom Face
Courtesy of GENERAL MOTORS COMPANY

Engine Block Bottom Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 2.0	101	N/A	N/A	102	103	104	52.0	2.047	52.0	2.047
2	M8 x 1.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
4	M6 x 1.0	210	202	N/A	203	204	205	18.0	.709	18.0	.709
5	M10 x 1.5	211	212	N/A	213	214	215	34.0	1.35	34.0	1.35

Engine Block Left Deck Face

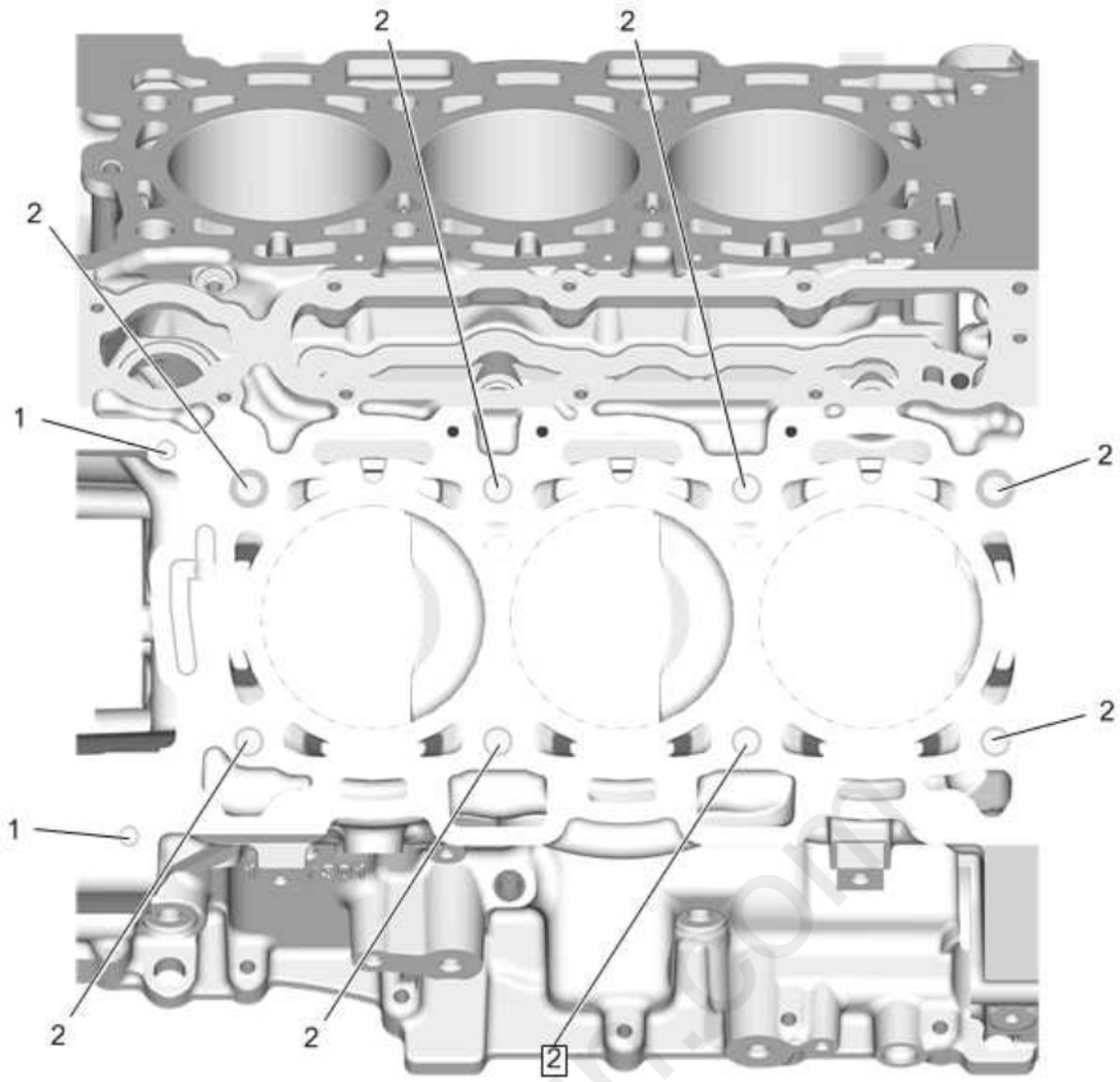


Fig. 23: Engine Block Left Deck Face
Courtesy of GENERAL MOTORS COMPANY

Engine Block Left Deck Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14
2	M12 x 1.75	EN-51	N/A	N/A	EN-52	EN-53	EN-58	29.0	1.14	29.0	1.14

Engine Block Right Deck Face

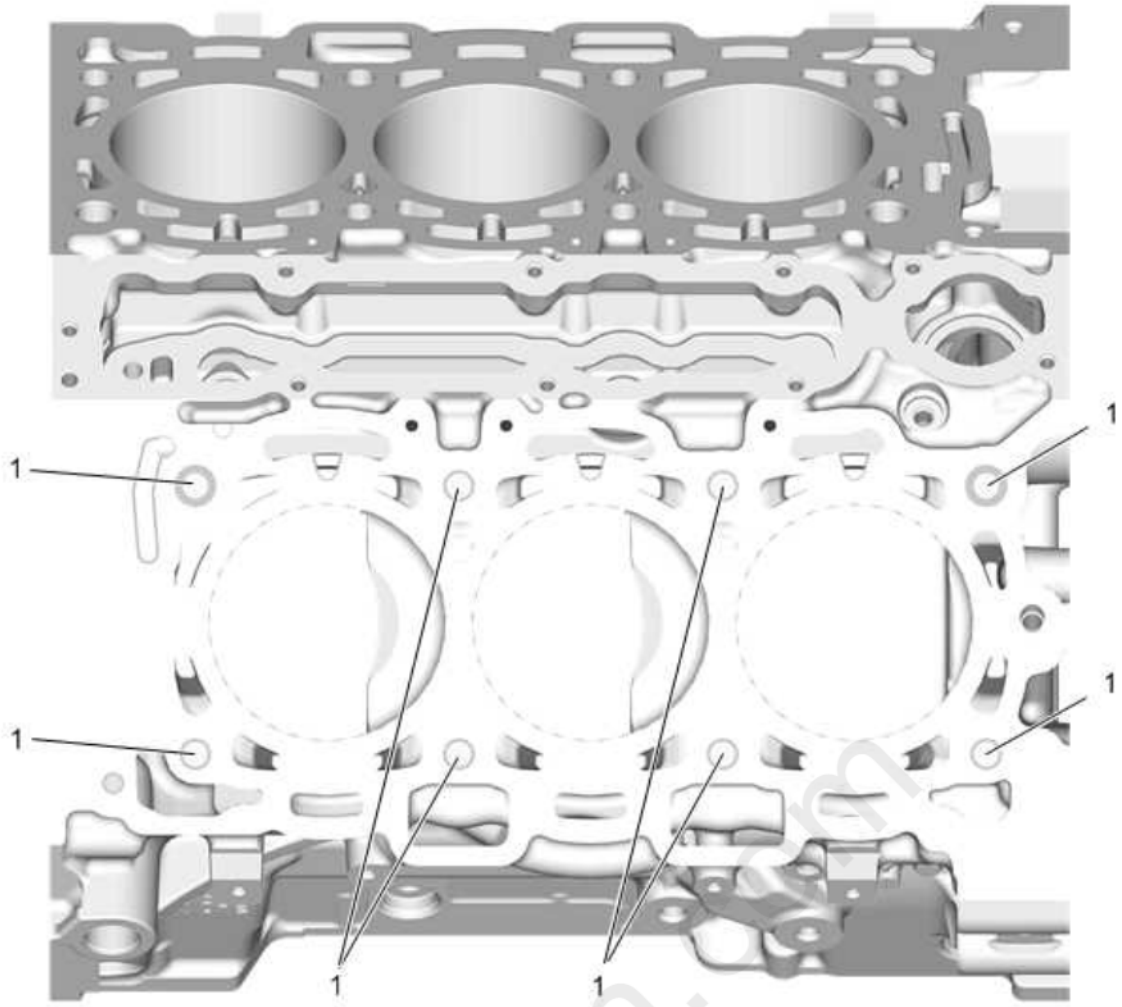


Fig. 24: Engine Block Right Deck Face
Courtesy of GENERAL MOTORS COMPANY

Engine Block Right Deck Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M12 x 1.75	EN-51	N/A	N/A	EN-52	EN-53	EN-58	29.0	1.14	29.0	1.14

Engine Front Cover

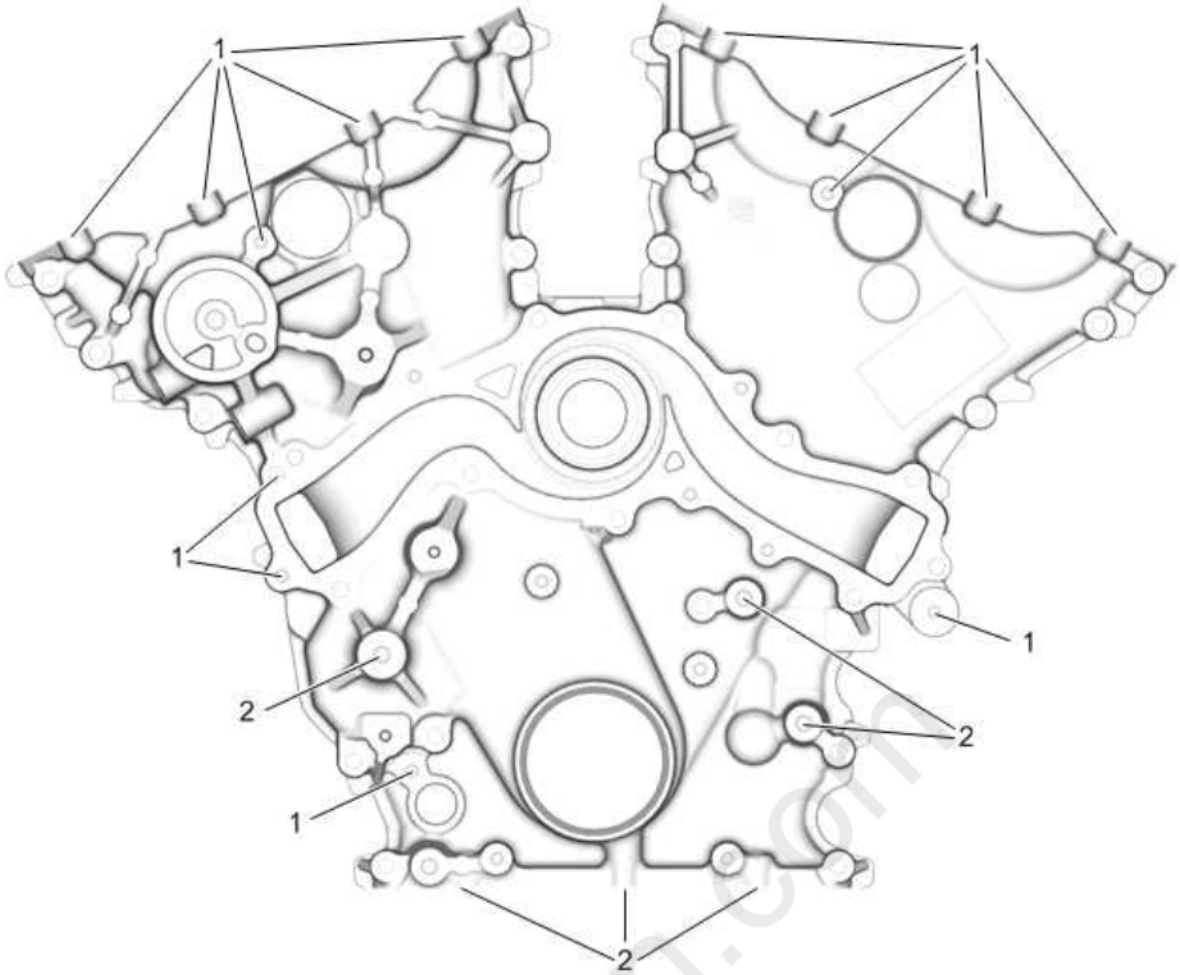


Fig. 25: Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

Engine Front Cover

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
			J 42385-					MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M8 x 1.25	206	207	N/A	208	209	61	29.0	1.14	29.0	1.14

Oil Pan Left Side

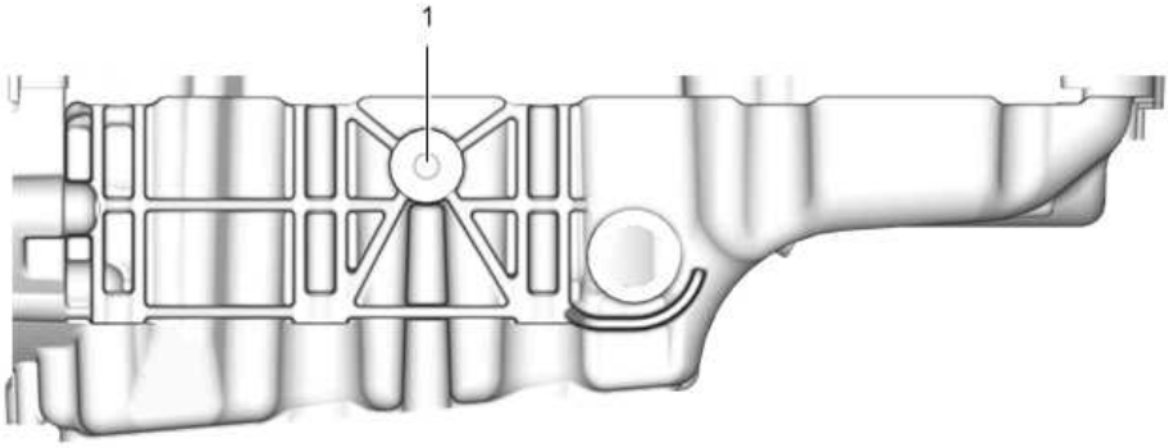
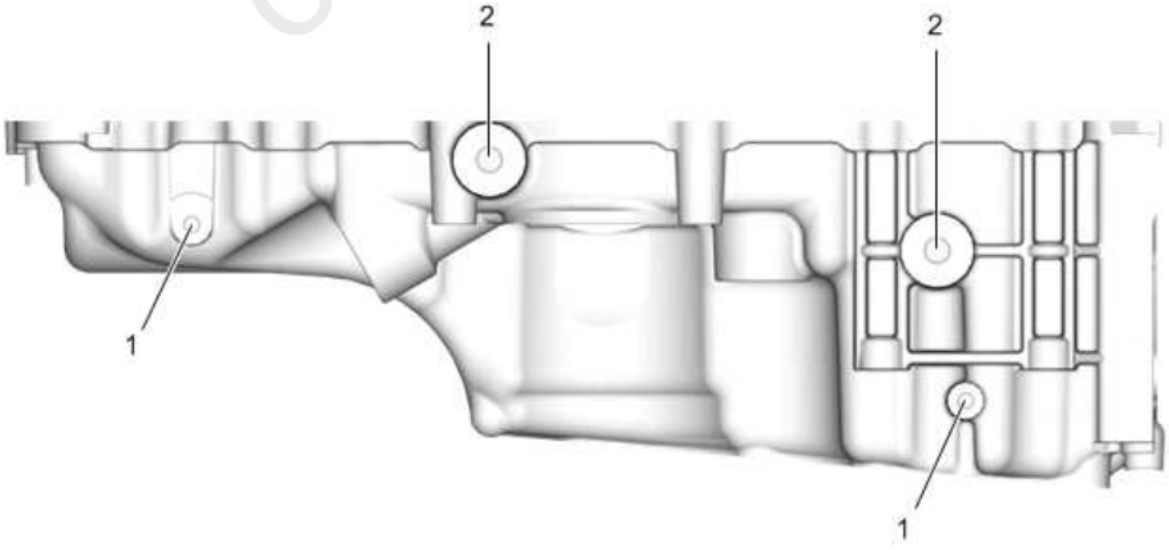


Fig. 26: Oil Pan Left Side
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Left Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	514	34.0	1.35	34.0	1.35

Oil Pan Right Side



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Fig. 27: Oil Pan Right Side
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Right Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907
2	M10 x 1.5	211	212	N/A	213	214	514	34.0	1.35	34.0	1.35

Oil Pan Rear Face

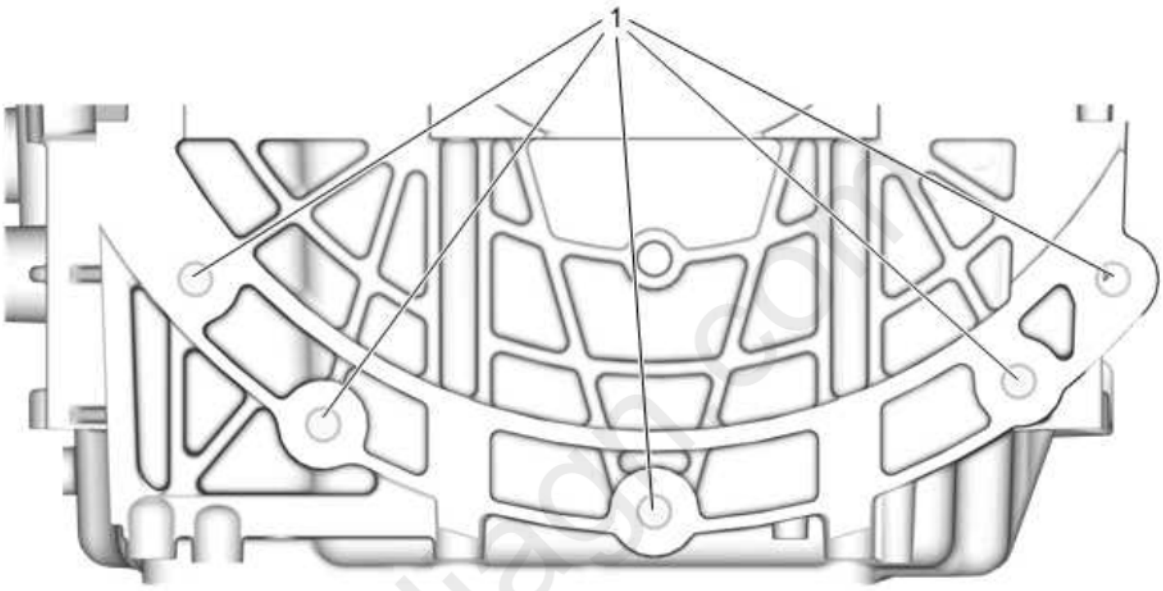


Fig. 28: Oil Pan Rear Face
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	514	34.0	1.35	34.0	1.35

Oil Pan Top Face

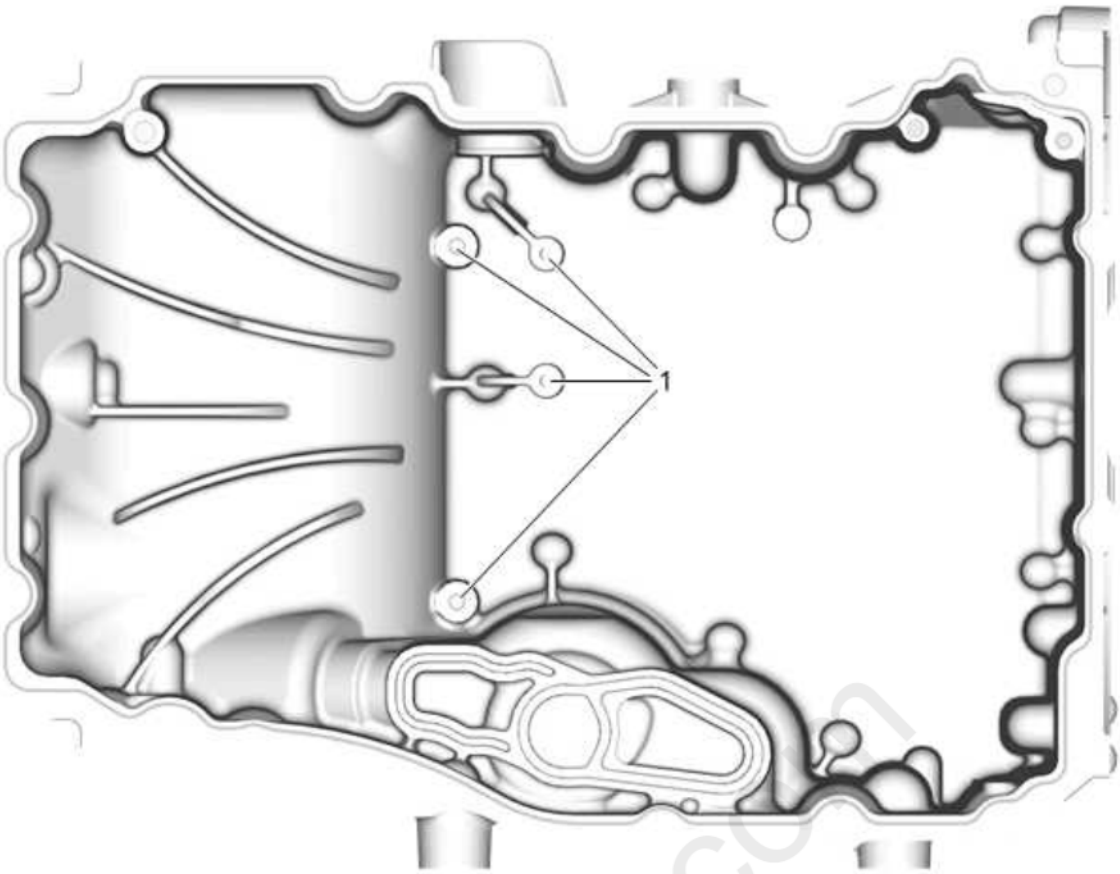


Fig. 29: Oil Pan Top Face
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Top Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

Oil Pan Bottom Face

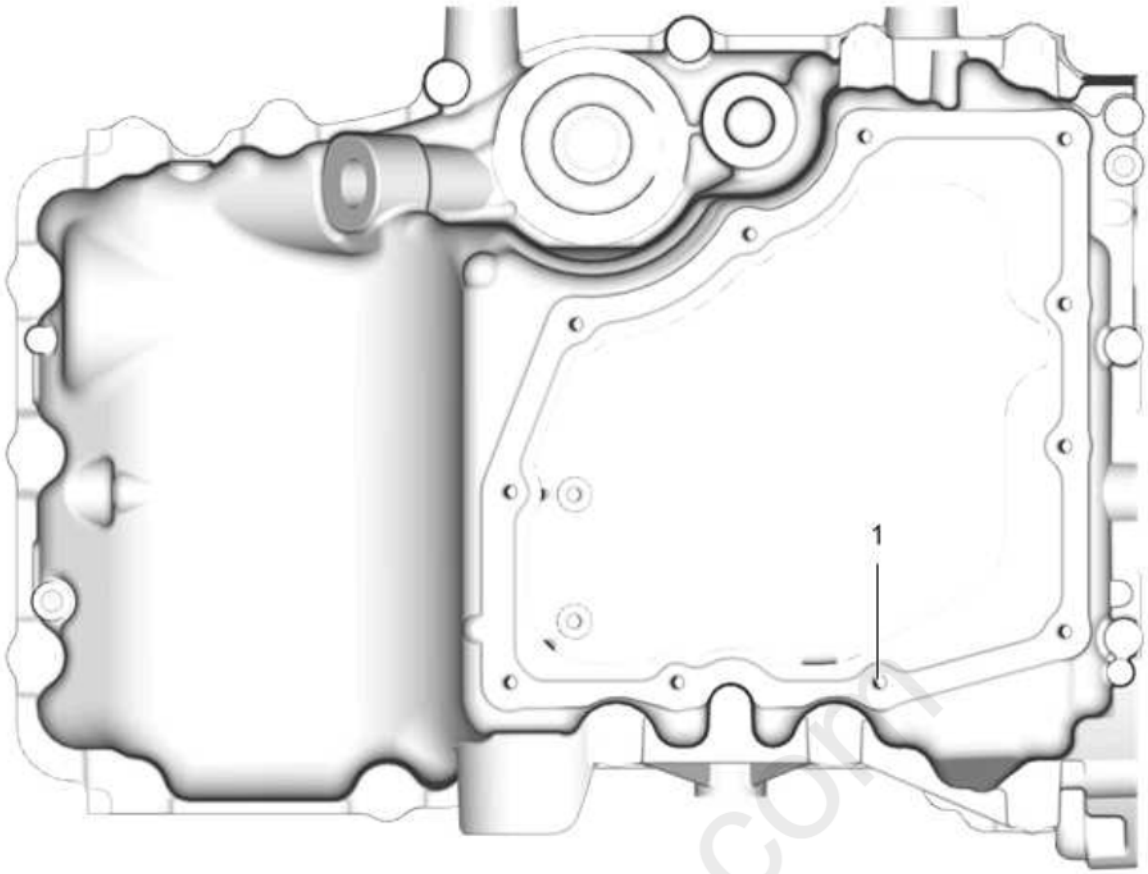


Fig. 30: Oil Pan Bottom Face
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Bottom Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	63	23.0	.907	23.0	.907

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