

2013 Chevrolet Volt

2013 ENGINE Engine Mechanical - 1.4L (LUU) - Volt

2013 ENGINE**Engine Mechanical - 1.4L (LUU) - Volt****SPECIFICATIONS****FASTENER TIGHTENING SPECIFICATIONS****Fastener Tightening Specifications**

Application	Specification	
	Metric	English
Air Conditioning Compressor Bracket Bolts	22 N.m	16 lb ft
Automatic Transmission Flex Plate Bolts	35 N.m + 30° + 15°	26 lb ft + 30° + 15°
Crankshaft Bearing Tie Plate Bolts (M6)	10 N.m + 60° + 15°	89 lb in + 60° + 15°
Crankshaft Bearing Tie Plate Bolts (M8)	25 N.m + 60° + 15°	18 lb ft + 60° + 15°
Camshaft Sprocket Bolt	50 N.m + 60°	37 lb ft + 60°
Camshaft Bearing Cap Bolts	8 N.m	71 lb in
Camshaft Cover Bolts	8 N.m	71 lb in
Camshaft Position Actuator Solenoid Valve	8 N.m	71 lb in
Camshaft Position Sensor Bolt	6 N.m	53 lb in
Catalytic Converter Bracket to Cylinder Block	22 N.m	16 lb ft
Catalytic Converter to Bracket	10 N.m	89 lb in
Connecting Rod Bearing Cap	25 N.m + 45°	18 lb ft + 45°
Crankshaft Position Sensor Bolt	8 N.m	71 lb in
Crankshaft Balancer Bolt	150 N.m + 60°	111 lb ft + 60°
Cylinder Head Bolts M9	35 N.m + 180°	26 lb ft + 180°
Engine Cooling Thermostat Housing Bolts	8 N.m	71 lb in
Engine Front Cover Bolts M10	35 N.m	26 lb ft
Engine Front Cover Bolts M6	8 N.m	71 lb in
Engine Mount Bracket Bolts	60Y + 45-60°	44 lb ft + 45-60°
Engine Mount Right Side to Engine Mount Bracket	55 N.m	41 lb ft
Engine Mount to Body Fastener Nut	50 N.m	37 lb ft
Engine Mount to Body Fastener Bolts	58 N.m	43 lb ft
Exhaust Manifold to Cylinder Head	22 N.m	16 lb ft
Fuel Injection Rail to Intake Manifold	7 N.m	62 lb in
Ignition Coil Bolts	8 N.m	71 lb in
Intake Manifold Bolt	20 N.m	15 lb ft
Knock Sensor	20 N.m	15 lb ft
Oil Filter	20 N.m	15 lb ft
Oil Pan Bolt	10 N.m	89 lb in
Oil Pan Drain Plug	14 N.m	124 lb in
Oil Pressure Indicator	20 N.m	15 lb ft

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Oil Pressure Relief Valve	50 N.m	37 lb ft
Oil Pump Cover Bolts	8 N.m	71 lb in
Oxygen Sensor to Exhaust Manifold	42 N.m	31 lb ft
Spark Plugs	25 N.m	18 lb ft
Starter Cover Bolts	20 N.m	15 lb ft
Throttle Body Bolts	9 N.m	80 lb in
Timing Chain Guide	8 N.m	71 lb in
Timing Chain Tensioner	8 N.m	71 lb in
Timing Chain Tensioner Shoe	20 N.m	15 lb ft
Torque Dampener to Flex Plate	62 N.m	46 lb ft
Transmission to Engine Bolts	80 N.m	59 lb ft
Water Outlet	8 N.m	71 lb in
Water Pump Housing Bolts	8 N.m	71 lb in
Water Pump Drain Plug	15 N.m	11 lb ft
Water Pump Pulley Bolts	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
• Engine Type	4-Cylinder Inline	
• Displacement	1398 ccm	85 cu in
• Bore	73.4 mm	2.9 in
• Stroke	82.6 mm	3.3 in
• Compression Ratio	10.5 : 1	
• Number of Valves	16	
• Maximum Power @ engine speed kW/RPM	55 KW / 4200	
• Maximum Torque @ engine speed /RPM / lbf ft/RPM	123 / 4000	91 lbf ft / 4000
Engine Block, Crankshaft, Pistons, and Connecting Rods		
• Cylinder Bore Diameter Standard	73.392 mm - 73.408 mm	2.8894 in - 2.8901 in
• Cylinder Bore Diameter Oversize 0.5	73.892 mm - 73.908 mm	2.9091 in - 2.9098 in
• Piston Diameter Standard	73.353 mm - 73.367 mm	2.8879 in - 2.8885 in
• Piston Diameter Oversize 0.5	73.853 mm - 73.867 mm	2.9076 in - 2.9081 in

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• Piston Clearance to Bore	0.025 mm - 0.055 mm	0.001 in - 0.0022 in
• Piston - Upper Compression Ring Thickness	1.17 mm - 1.195 mm	0.0461 in - 0.0470 in
• Piston - Upper Compression Ring Gap	0.25 mm - 0.4 mm	0.0098 in - 0.0157 in
• Piston - Upper Compression Ring Side Clearance	0.025 mm - 0.07 mm	0.001 in - 0.0028 in
• Piston - Lower Compression Ring Thickness	1.17 mm - 1.195 mm	0.0461 in - 0.0470 in
• Piston - Lower Compression Ring Gap	0.4 mm - 0.6 mm	0.0157 in - 0.0236 in
• Piston - Lower Compression Ring Side Clearance	0.025 mm - 0.07 mm	0.001 in - 0.0028 in
• Piston - Oil Ring Thickness	1.92 mm - 2 mm	0.0756 in - 0.0787 in
• Piston - Oil Ring Gap	0.25 mm - 0.75 mm	0.0098 in - 0.0295 in
• Piston - Oil Ring Side Clearance	0.04 mm - 0.12 mm	0.0016 in - 0.0047 in
• Piston Pin Bore Diameter	18.006 mm - 18.012 mm	0.7089 in - 0.7091 in
• Piston Pin Outer Diameter	17.995 mm - 18 mm	0.7085 in - 0.7087 in
• Piston Pin Length	52.7 mm - 53 mm	2.0748 in - 2.0866 in
• Piston Pin Clearance to Piston Bore	0.006 mm - 0.017 mm	0.0002 in - 0.0007 in
• Piston Pin Clearance to Conrod Bore	Shrunked in Conrod	
• Crankshaft Balancer Clearance to Engine Front Cover	4.5 mm	0.1772 in
• Crankshaft Bearing Journal Standard Diameter (brown or green)	50.004 mm - 50.017 mm	1.9687 in - 1.9692 in
• Crankshaft Bearing Journal Undersize 0.25 Diameter (brown/blue or green/blue)	49.754 mm - 49.767 mm	1.9588 in - 1.9593 in
• Crankshaft Bearing Journal Undersize 0.5 Diameter (brown/white or green/white)	49.504 mm - 49.517 mm	1.949 in - 1.9495 in
• Crankshaft Bearing Journal Width Standard	23.000 mm - 23.052 mm	0.9055 in - 0.9076 in
• Crankshaft Bearing Journal Width Undersize 0.25	23.200 mm - 23.252 mm	0.9134 in - 0.9154 in
• Crankshaft Bearing Journal Width Undersize 0.4	23.400 mm - 23.452 mm	0.9213 in - 0.9233 in
• Crankshaft Bearing Mark 328N (brown) - Thickness	1.989 mm - 1.995 mm	0.0783 in - 0.0785 in
• Crankshaft Bearing Mark 329N (green) - Thickness	1.995 mm - 2.001 mm	0.0785 in - 0.0788 in
• Crankshaft Bearing Mark 330N - Thickness Undersize 0.25 (brown/blue)	2.114 mm - 2.120 mm	0.0832 in - 0.0835 in
• Crankshaft Bearing Mark 331 - Thickness Undersize	2.120 mm - 2.126	

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0.25 (green/blue)	mm	0.0835 in - 0.0837 in
• Crankshaft Bearing Mark 332 - Thickness Undersize 0.5 (brown/white)	2.239 mm - 2.245 mm	0.0881 in - 0.0884 in
• Crankshaft Bearing Mark 332 - Thickness Undersize 0.5 (green/white)	2.245 mm - 2.251 mm	0.0884 in - 0.0886 in
• Crankshaft Bearing Clearance	0.007 mm - 0.031 mm	0.0003 in - 0.0012 in
• Crankshaft Bearing Clearance Axial	0.100 mm - 0.202 mm	0.0039 in - 0.008 in
• Crankshaft Bearing Out Of Round	0.03 mm	0.0012 in
• Conrod Bearing Journal Diameter Standard	42.971 mm - 42.987 mm	1.6918 in - 1.6924 in
• Conrod Bearing Journal Diameter Undersize 0.25 (blue)	42.721 mm - 42.737 mm	1.6819 in - 1.6826 in
• Conrod Bearing Journal Diameter Undersize 0.5 (white)	42.471 mm - 42.487 mm	1.6721 in - 1.6727 in
• Conrod Bearing Thickness Standard	1.490 mm - 1.500 mm	0.0587 in - 0.0591 in
• Conrod Bearing Thickness Undersize 0.25	1.615 mm - 1.625 mm	0.0636 in - 0.064 in
• Conrod Bearing Thickness Undersize 0.5	1.740 mm - 1.750 mm	0.0685 in - 0.0689 in
• Conrod Bearing Diameter Standard (upper and lower)	1.490 mm - 1.500 mm	0.0587 in - 0.0591 in
• Conrod Bearing Diameter Undersize 0.25 (upper and lower)	1.615 mm - 1.625 mm	0.0636 in - 0.064 in
• Conrod Bearing Diameter Undersize 0.5 (upper and lower)	1.740 mm - 1.750 mm	0.0685 in - 0.0689 in
• Conrod Bearing Clearance	0.013 mm - 0.061 mm	0.0005 in - 0.0024 in
Cylinder Head And Valve Train		
• Cylinder Head - Surface Flatness (max) Block Deck - longitude	0.05 mm	0.00197 in
• Cylinder Head - Surface Flatness (max) Block Deck - transverse	0.03 mm	0.00118 mm
• Cylinder Head - Intake Valve Seat Width	1.4 mm - 1.8 mm	0.0551 in - 0.0709 in
• Cylinder Head - Exhaust Valve Seat Width	1 mm - 1.4 mm	0.0394 in - 0.0551 in
• Cylinder Head - Valve Seat Angle Standard	90° 30'	
• Cylinder Head - Valve Seat Angle Oversize	110°	
• Cylinder Head - Intake Valve Guide Inner Diameter	4.991 mm - 5.007	

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Standard	mm	0.1965 in - 0.1971 in
• Cylinder Head - Intake Valve Guide Inner Diameter + 0.075	5.066 mm - 5.082 mm	0.1994 in - 0.2001 in
• Cylinder Head - Intake Valve Guide Inner Diameter 0.150	5.141 mm - 5.157 mm	0.2024 in - 0.203 in
• Cylinder Head - Exhaust Valve Guide Inner Diameter Standard	4.991 mm - 5.007 mm	0.1965 in - 0.1971 in
• Cylinder Head - Exhaust Valve Guide Inner Diameter + 0.075	5.066 mm - 5.082 mm	0.1994 in - 0.2001 in
• Cylinder Head - Exhaust Valve Guide Inner Diameter + 0.150	5.141 mm - 5.157 mm	0.2024 in - 0.203 in
• Cylinder Head - Valve Guide Length	38.7 mm - 39.3 mm	1.5236 in - 1.5472 in
• Intake Valve Length Standard	92.9 mm	3.6575 in
• Exhaust Valve Length Standard	92.7 mm	3.6496 in
• Intake Valve Stem Diameter Standard	4.950 mm - 4.965 mm	0.1949 in - 0.1955 in
• Exhaust Valve Stem Diameter Standard	4.930 mm - 4.945 mm	0.1941 in - 0.1947 in
• Intake Valve Stem Diameter + 0.075	5.025 mm - 5.040 mm	0.1978 in - 0.1984 in
• Exhaust Valve Stem Diameter + 0.075	5.005 mm - 5.020 mm	0.197 in - 0.1976 in
• Intake Valve Stem Diameter + 0.150	5.100 mm - 5.115 mm	0.2008 in - 0.2014 in
• Exhaust Valve Stem Diameter + 0.150	5.080 mm - 5.095 mm	0.2000 in - 0.2006 in
• Intake Valve Disc Diameter	27.9 mm - 28.1 mm	1.0984 in - 1.1063 in
• Exhaust Valve Disc Diameter	24.9 mm - 25.1	0.9803 in - 0.9882 in
• Valve Spring Height Free	40 mm	1.5748 in
• Valve Spring Height Under Load - Valve Open	21.5 mm	0.8465 in
• Valve Spring Height Under Load - Valve Closed	30 mm	1.1811 in
• Valve Clearance to Guide Intake	0.026 mm - 0.057 mm	0.001 in - 0.0022 in
• Valve Clearance to Guide Exhaust	0.046 mm - 0.077 mm	0.0018 in - 0.0030 in
Engine Oil		
• Quality	Dexos I	
• Filling - With New Oil Filter	3.5 L	3.7 Quarts
• Viscosity	5W30 GF-4	

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• Oil Pressure @ Idle Speed	150 kpa	22 psi
• Oil Pressure @ 3000 rpm - 3500 rpm	380 kpa - 650 kpa	55 psi - 94 psi
Oil Pump		
• Axial Clearance Vane Rotor to Cover	0.01 mm	0.0004 in
• Axial Clearance Vane to Cover	0.09 mm	0.0036 in
• Axial Clearance Vane Ring to Cover	0.04 mm	0.0016 in
• Axial Clearance Slide to Cover	0.08 mm	0.0031 in
• Axial Clearance Slide Seal to Cover	0.09 mm	0.0036 in
• Radial Clearance Vane to Vane Rotor	0.05 mm	0.002 in
• Oil Pump Slide Spring Length	76.5 mm	3.0118 in
• Radial Clearance Vane to Slide	0.2 mm	0.008 in

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Adhesives, Fluids, Lubricants, and Sealers

Application	Type of Material	GM Part Number	
		United States	Canada
Bolt Connections	Screw Locking Compound	12345382	10953489
Camshaft Bearings	Dexos1 Engine Oil	19293000	19286321
Camshaft Cover Bolt	Pipe Sealant	12346004	10953480
Camshaft Front Oil Seal	Sealant	1052943	10953491
Camshafts	Dexos1 Engine Oil	19293000	19286321
Crankshaft Bearing Lubricant	Dexos1 Engine Oil	19293000	19286321
Engine Block Oil Gallery Plugs	Sealant	1052943	10953491
Engine Oil	Dexos1 Engine Oil	19293000	19286321
Intake and Exhaust Valves	Dexos1 Engine Oil	19293000	19286321
Oil Pan	Sealant	12378521	88901148
Oxygen Sensor	Assembly Paste - White	88862477	88862478
Oxygen Sensor Threads	Anti-seize	12397953	NA
Rear Crankshaft Main Bearing Cap	Sealant	12378521	88901148
Rear Crankshaft Oil Seal	Dexos1 Engine Oil	19293000	19286321
Rod Bearing - Rod Pins of Crankshaft	Dexos1 Engine Oil	19293000	19286321
Seal Rings	Silicone Grease - White	12345579	10953481
Turbo Heat Shield Fastener	Lubricant	12345996	10953501
Water Pump Bearing	Sealant	1052943	10953491

COMPONENT LOCATOR

DISASSEMBLED VIEWS

Accessory Drive Components

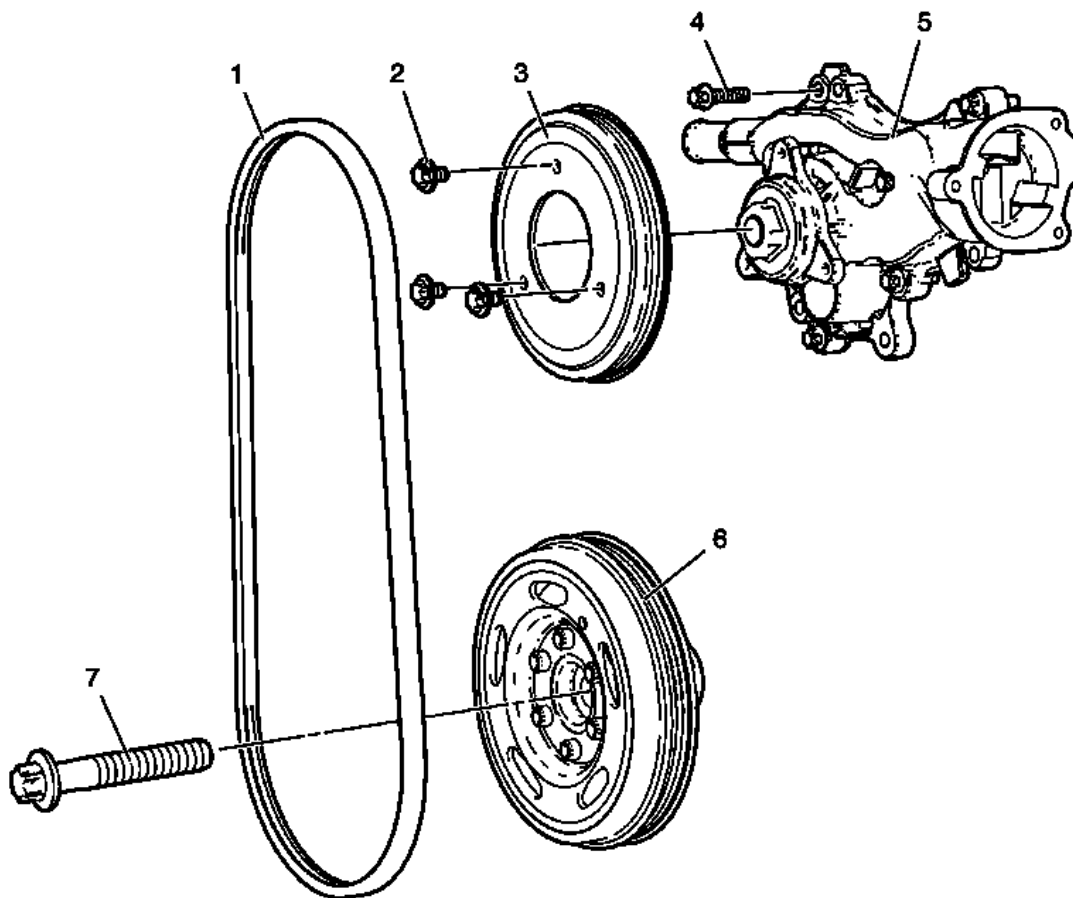


Fig. 1: Accessory Drive Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Belt
2	Water Pump Pulley Bolt
3	Water Pump Pulley
4	Water Pump Bolt
5	Water Pump
6	Crankshaft Balancer
7	Crankshaft Balancer Bolt

Engine Front Cover And Oil Pump Assembly (1 of 2)

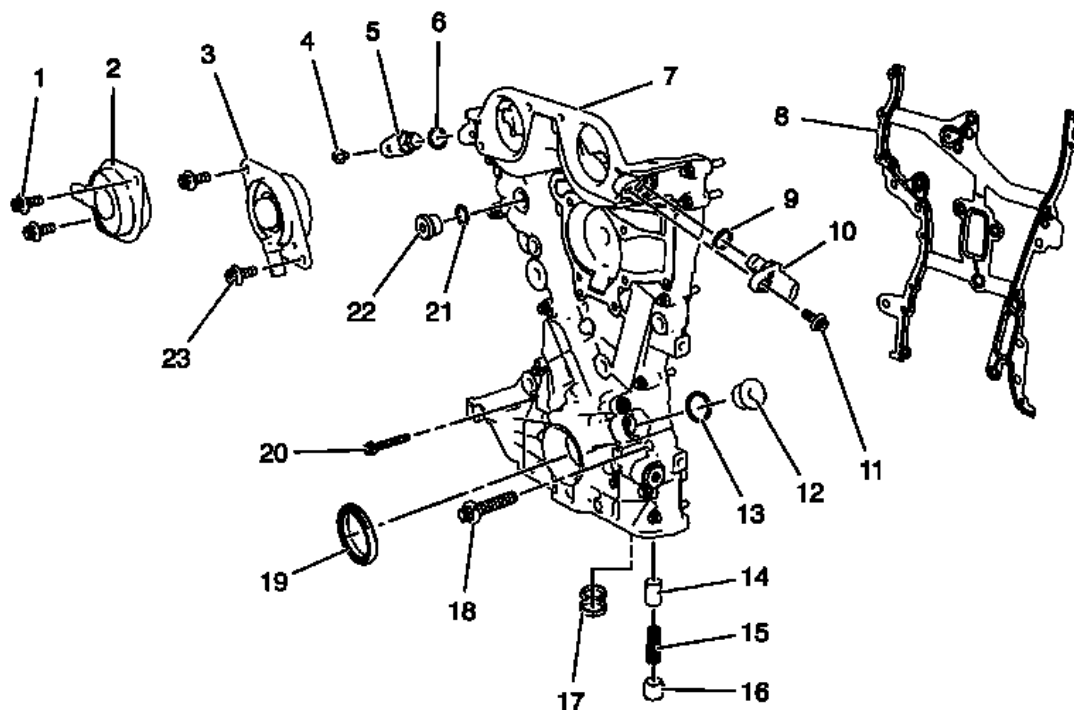


Fig. 2: Engine Front Cover And Oil Pump Assembly (1 of 2)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve Bolt
2	Intake Camshaft Position Actuator Solenoid Valve
3	Exhaust Camshaft Position Actuator Solenoid Valve
4	Intake Camshaft Position Sensor Bolt
5	Intake Camshaft Position Sensor
6	Intake Camshaft Position Sensor Seal Ring
7	Engine Front Cover
8	Engine Front Cover Gasket
9	Exhaust Camshaft Position Sensor Seal Ring
10	Exhaust Camshaft Position Sensor
11	Exhaust Camshaft Position Sensor Bolt

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12	Engine Front Cover Oil Gallery Plug
13	Engine Front Cover Oil Gallery Plug Seal Ring
14	Oil Pressure Relief Valve Piston
15	Oil Pressure Relief Valve Spring
16	Oil Pressure Relief Valve Plug
17	Oil Pan Sealing
18	Engine Front Cover Bolt (M10)
19	Crankshaft Front Oil Seal
20	Engine Front Cover Bolt (M6)
21	Water Drain Plug Seal Ring
22	Water Drain Plug
23	Exhaust Camshaft Position Actuator Solenoid Valve Bolt

Engine Front Cover And Oil Pump Assembly (2 of 2)

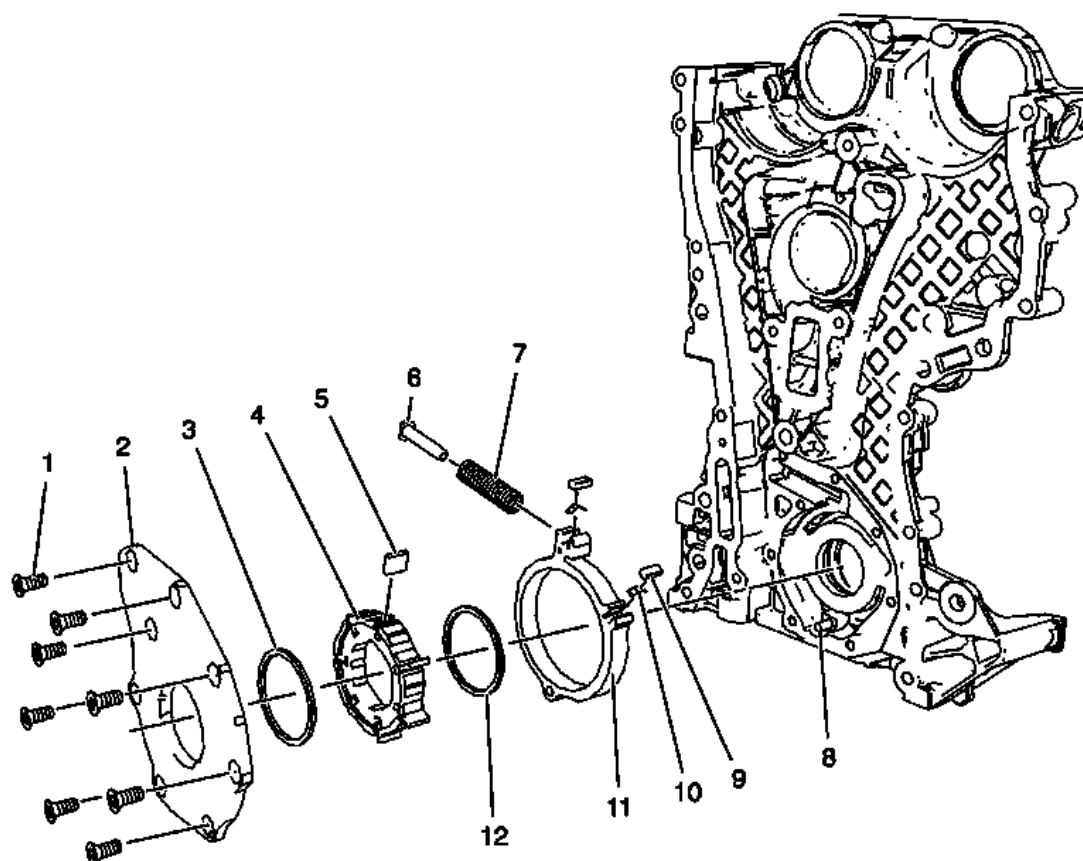


Fig. 3: Engine Front Cover And Oil Pump Assembly Components (2 Of 2)
Courtesy of GENERAL MOTORS COMPANY

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Callout	Component Name
1	Oil Pump Cover Bolt
2	Oil Pump Cover
3	Oil Pump Vane Ring
4	Oil Pump Vane Rotor
5	Oil Pump Vane
6	Oil Pump Slide Spring Pin
7	Oil Pump Slide Spring
8	Oil Pump Slide Pivot Pin
9	Oil Pump Slide Seal
10	Oil Pump Slide Seal Spring
11	Oil Pump Slide
12	Oil Pump Vane Ring

Timing Chain Components

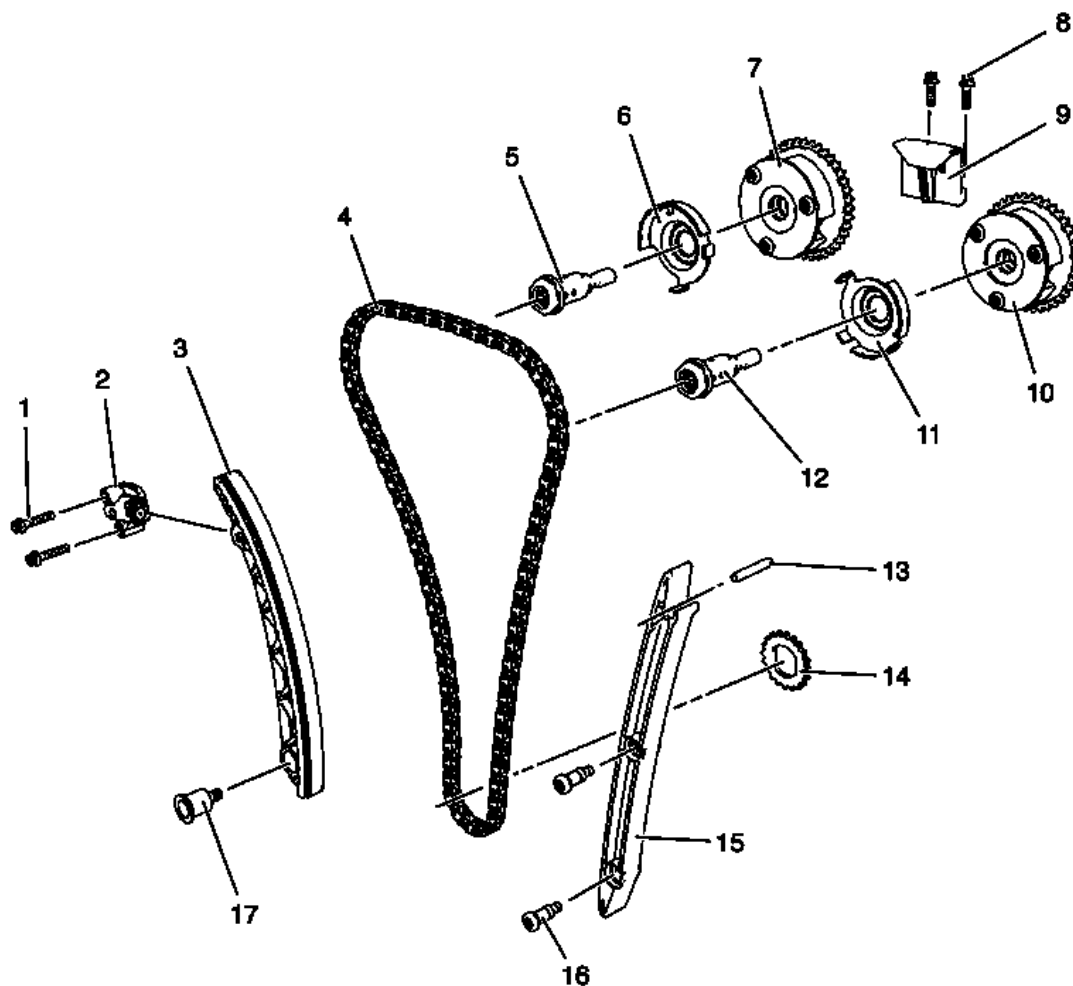


Fig. 4: Timing Chain Components

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Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Timing Chain Tensioner Bolt
2	Timing Chain Tensioner
3	Timing Chain Tensioner Shoe
4	Camshaft Timing Chain
5	Intake Camshaft Sprocket Bolt (With Actuator)
6	Intake Camshaft Position Sensor Exciter Wheel
7	Intake Camshaft Sprocket (With Position Actuator)
8	Upper Timing Chain Guide Bolt
9	Upper Timing Chain Guide
10	Exhaust Camshaft Sprocket (With Position Actuator)
11	Exhaust Camshaft Position Sensor Exciter Wheel
12	Exhaust Camshaft Sprocket Bolt (With Actuator)
13	Timing Chain Guide Pivot Pin
14	Crankshaft Sprocket
15	Timing Chain Guide Right Side
16	Timing Chain Guide Bolt
17	Timing Chain Tensioner Shoe Bolt

Intake Manifold Assembly

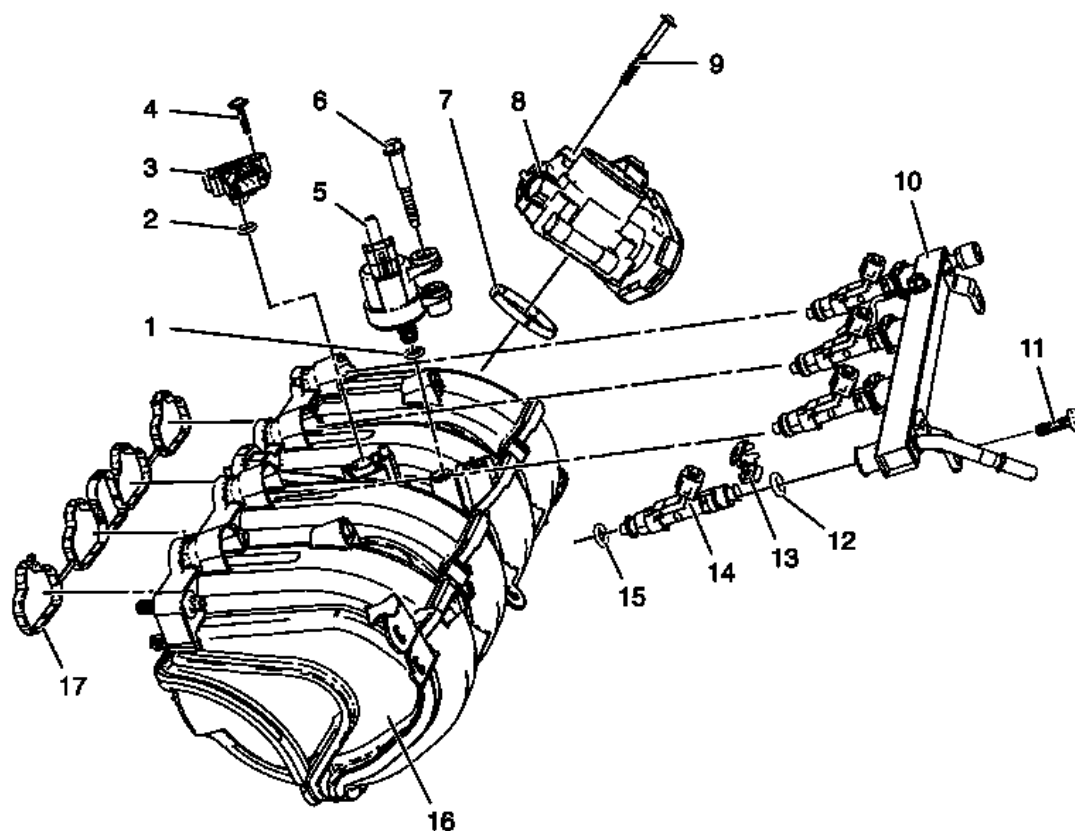


Fig. 5: Intake Manifold Assembly
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Evaporative Emission Canister Purge Solenoid Valve Seal Ring
2	Manifold Absolute Pressure Sensor Seal Ring
3	Manifold Absolute Pressure Sensor
4	Manifold Absolute Pressure Sensor Bolt
5	Evaporative Emission Canister Purge Solenoid Valve
6	Evaporative Emission Canister Purge Solenoid Valve Bolt
7	Throttle Body Seal Ring
8	Throttle Body
9	Throttle Body Bolt
10	Fuel Injection Fuel Rail
11	Fuel Injection Fuel Rail Bolt
12	Fuel Injector Seal Ring

13	Fuel Injector Retainer Clamp
14	Fuel Injector
15	Fuel Injector Seal Ring
16	Intake Manifold
17	Intake Manifold Gasket

Cylinder Head Assembly

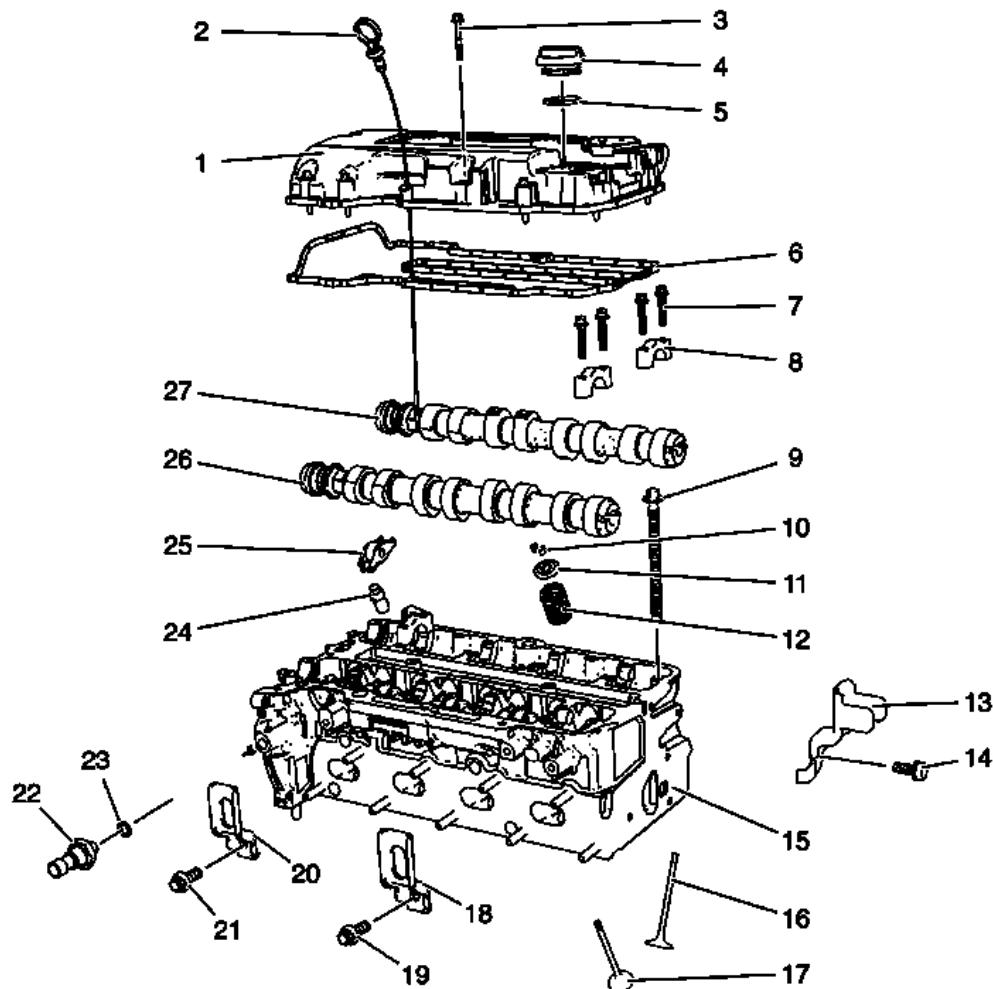


Fig. 6: Identifying Cylinder Head Assembly Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Cover
2	Oil Level Indicator
3	Camshaft Cover Bolt
4	Oil Filler Cap
5	Oil Filler Cap Seal Ring

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6	Camshaft Cover Gasket
7	Camshaft Bearing Cap Bolt
8	Camshaft Bearing Cap
9	Cylinder Head Bolt
10	Valve Keys
11	Valve Spring Retainer
12	Valve Spring
13	Engine Lift Bracket Left Side
14	Engine Lift Bracket Bolt
15	Cylinder Head
16	Intake Valve
17	Exhaust Valve
18	Engine Lift Bracket
19	Engine Lift Bracket Bolt
20	Engine Lift Bracket
21	Engine Lift Bracket Bolt
22	Oil Pressure Indicator Switch
23	Oil Pressure Indicator Switch Seal Ring
24	Hydraulic Valve Lash Adjuster
25	Hydraulic Valve Lash Adjuster Arm
26	Exhaust Camshaft
27	Intake Camshaft

Engine Block Assembly

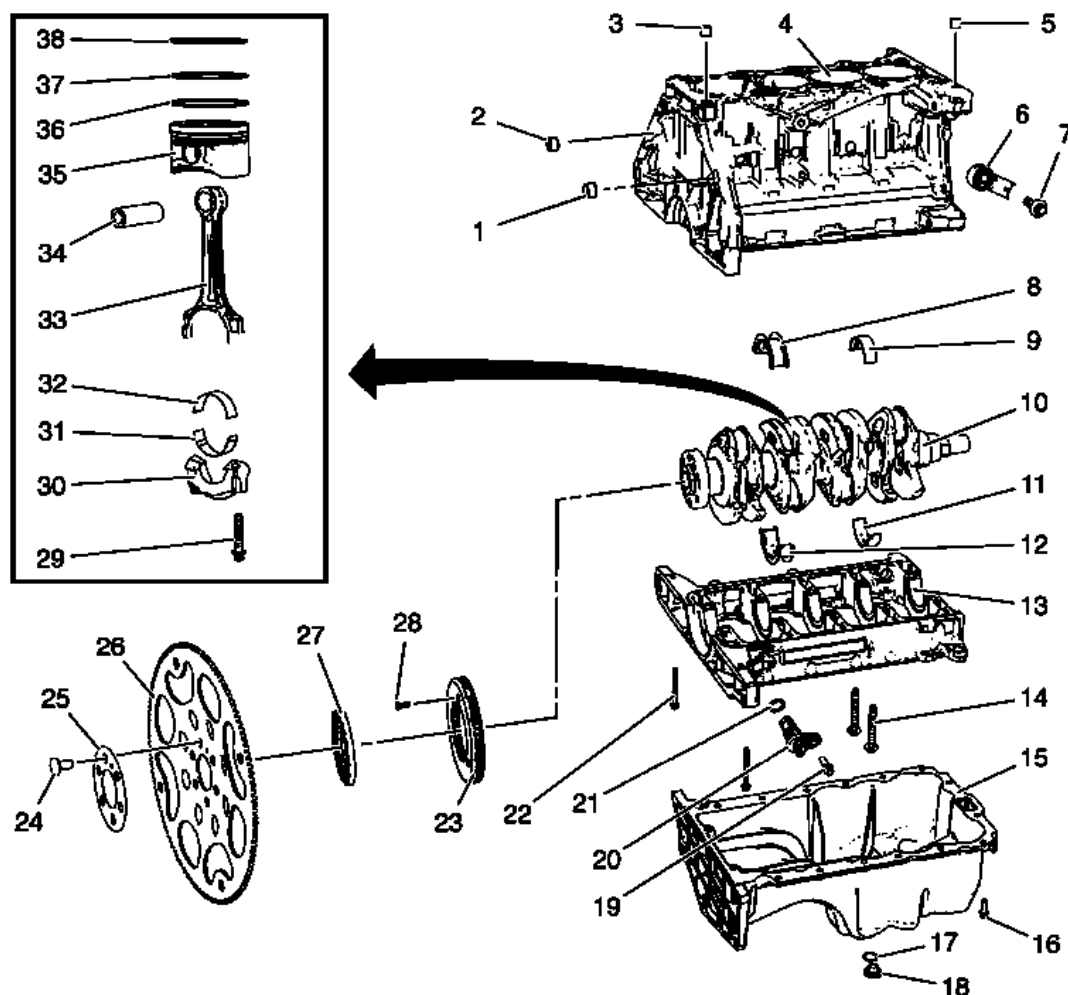


Fig. 7: Engine Block Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Transmission Guide Sleeve
2	Transmission Guide Sleeve
3	Cylinder Head Guide Sleeve
4	Engine Block
5	Cylinder Head Guide Sleeve
6	Knock Sensor
7	Knock Sensor Bolt
8	Upper Crankshaft Thrust Bearing
9	Upper Crankshaft Bearing
10	Crankshaft
11	Lower Crankshaft Bearing
12	Lower Crankshaft Thrust Bearing

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13	Crankshaft Bearing Cap Tie Plate
14	Crankshaft Bearing Cap Tie Plate Bolt (M10)
15	Oil Pan
16	Oil Pan Bolt
17	Oil Pan Drain Plug Seal Ring
18	Oil Pan Drain Plug
19	Crankshaft Position Sensor Bolt
20	Crankshaft Position Sensor
21	Crankshaft Position Sensor Seal Ring
22	Crankshaft Bearing Cap Tie Plate Bolt (M8)
23	Crankshaft Position Sensor Reluctor Ring
24	Flex Plate Bolt
25	Flex Plate Bolt Washer
26	Flex Plate
27	Crankshaft Rear Oil Seal
28	Crankshaft Position Sensor Reluctor Ring Bolt
29	Connecting Rod Bearing Cap Bolt
30	Connecting Rod Bearing Cap
31	Lower Connecting Rod Bearing
32	Upper Connecting Rod Bearing
33	Connecting Rod
34	Piston Pin
35	Piston
36	Piston Oil Ring (With Oil Ring Spacer)
37	Lower Compression Ring
38	Upper Compression Ring

ENGINE IDENTIFICATION

Engine Number

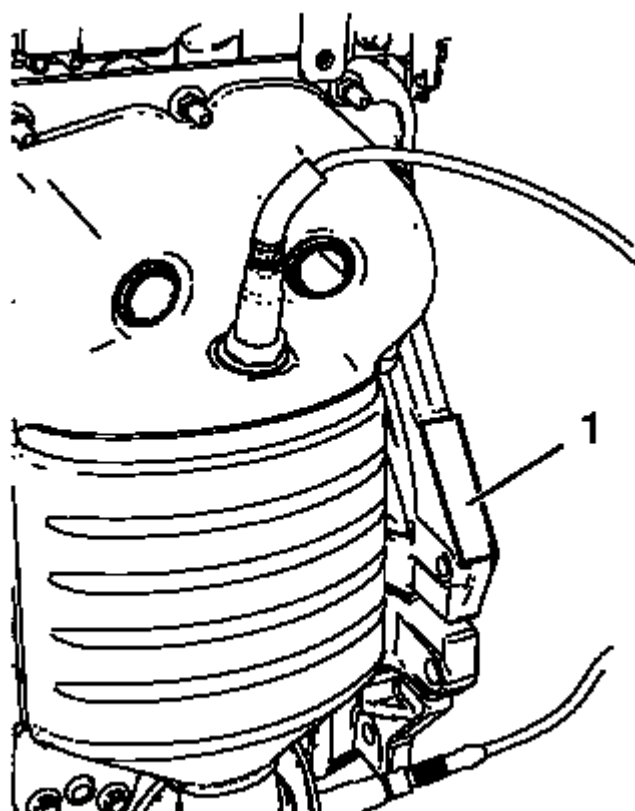


Fig. 8: Locating Engine Identification Number

Courtesy of GENERAL MOTORS COMPANY

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

The engine number is stamped to the engine block (1).

DIAGNOSTIC INFORMATION AND PROCEDURES

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

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

Visual/Physical Inspection

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

cause the symptom.

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

Intermittent

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

Symptom List

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

- **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**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Drive Belt Chirping, Squeal, and Whine Diagnosis**
- **Drive Belt Rumbling and Vibration Diagnosis**
- **Drive Belt Falls Off and Excessive Wear Diagnosis**

OIL PRESSURE DIAGNOSIS AND TESTING

Special Tools

- **EN-498-B** Oil Pressure Gauge
- **EN-498-3** Adapter

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

Removal Procedure

1. Disconnect the oil pressure indicator switch wiring harness plug.

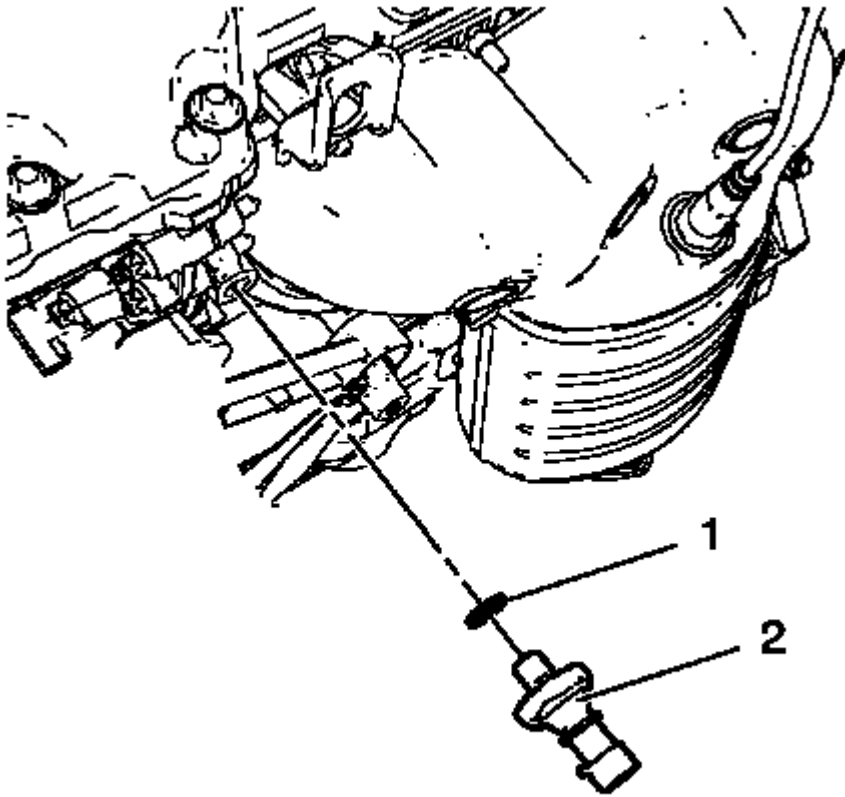


Fig. 9: Oil Pressure Indicator Switch And Oil Pressure Indicator Switch Seal Ring
Courtesy of GENERAL MOTORS COMPANY

2. Remove the oil pressure indicator switch (2) and the oil pressure indicator switch seal ring (1).

Measuring Procedure

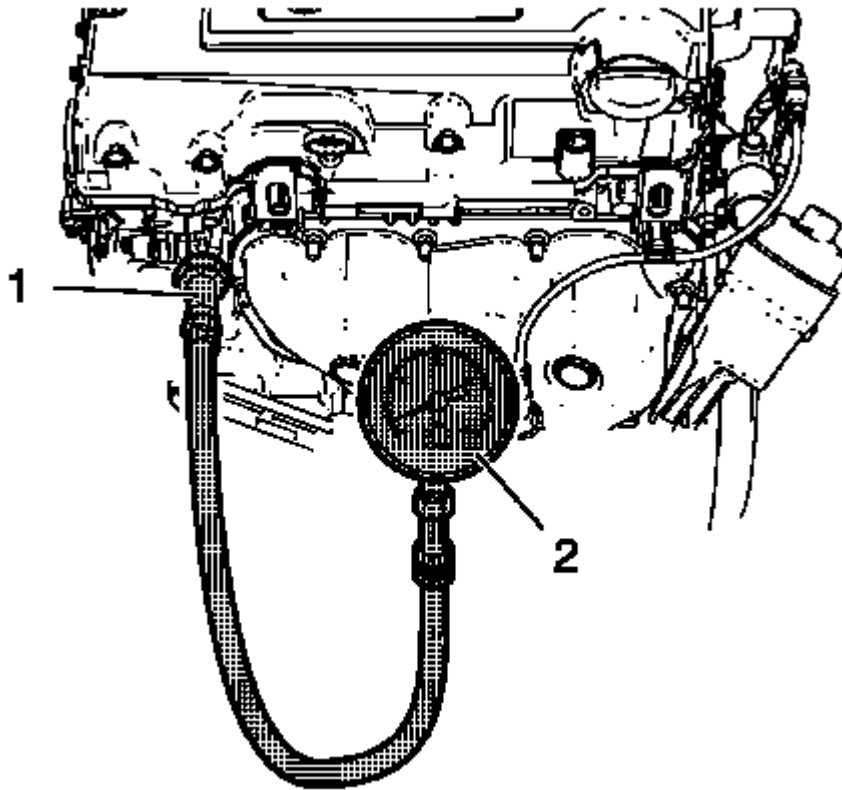


Fig. 10: Gauge And Adapter

Courtesy of GENERAL MOTORS COMPANY

1. Install **EN-498-B** gauge (2) along with **EN-498-3** adapter (1).
2. Using a scan tool, start the engine.

NOTE: The oil temperature should be between 80°C and 100°C.

3. Measure the oil pressure:
 - The oil pressure at idle speed should be 150kpa (22 psi).
 - The oil pressure between 3000 rpm and 3500 rpm should be 380 kpa - 650 kpa (55 psi - 94 psi).
4. Stop the engine.
5. 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 **Engine Front Cover with Oil Pump Replacement**, and **Engine Front Cover and Oil Pump Cleaning and Inspection**.
 - Oil suction gallery clogged or dirty. Refer to **Oil Pan Cleaning and Inspection**
 - Cracked, porous, or restricted oil galleries.
 - Oil pressure relief valve malfunction.
6. Remove **EN-498-B** gauge and **EN-498-3** adapter.

Installation Procedure

1. Install the oil pressure indicator switch and a NEW oil pressure indicator switch seal ring.

CAUTION: Refer to Fastener Caution .

2. Tighten the oil pressure indicator switch to 20 N.m(15 lb ft).

OIL CONSUMPTION DIAGNOSIS**Oil Consumption Diagnosis**

Checks	Causes
The causes of excessive oil consumption may include the following conditions:	
Preliminary	<ul style="list-style-type: none"> • External oil leaks. • Incorrect oil level or improper reading of the oil level indicator. <p>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.</p> <ul style="list-style-type: none"> • Improper oil viscosity. <p>Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures.</p> <ul style="list-style-type: none"> • 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. <p>Allow adequate time for the rings to seat.</p> <p>Replace worn piston rings as necessary.</p> <ul style="list-style-type: none"> • Piston and rings improperly installed or miss-fitted to the cylinder bore.

ENGINE NOISE UNDER LOAD**Engine Noise Under Load**

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Cause	Correction
Low oil pressure	Insufficient or poor oil supply to components. <ol style="list-style-type: none">1. Perform oil pressure test.2. Repair or replace all damaged components.
Loose torque converter bolts	<ol style="list-style-type: none">1. Inspect the torque converter bolts and flywheel.2. Repair or replace all damaged components.
Loose and/or damaged flywheel	<ol style="list-style-type: none">1. Inspect the flywheel and flywheel attaching bolts.2. Repair or replace all damaged components.
Excessive piston-to-cylinder bore clearance	<ol style="list-style-type: none">1. Inspect the piston rings for low ring tension, broken or worn rings, inspect cylinder bore.2. Repair or replace all damaged components.
Excessive crankshaft thrust bearing clearance	<ol style="list-style-type: none">1. Inspect the crankshaft end play and crankshaft thrust bearings.2. Repair or replace all damaged components.
Excessive crankshaft bearing clearance	<ol style="list-style-type: none">1. Inspect the crankshaft bearings and crankshaft journals.2. Repair or replace all damaged components.

ENGINE NOISE ON START-UP, BUT ONLY LASTING A FEW SECONDS**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	<ul style="list-style-type: none">• Inspect the thrust bearing and crankshaft.• Repair or replace as required.
Damaged or faulty oil filter by-pass valve	<ul style="list-style-type: none">• Inspect the oil filter by-pass valve for proper operation.• Repair or replace as required.

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES**Base Engine Misfire without Internal Engine Noises**

Condition	Action
Abnormalities (severe cracking, bumps or missing areas) in the accessory drive belt.	Abnormalities in the accessory drive belt and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual

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Also worn, damaged, or misaligned accessory drive components or excessive pulley runout.	misfire condition. <ol style="list-style-type: none">1. Inspect the accessory drive components.2. Repair or replace all damaged components.
Loose and/or damaged crankshaft pulley	A misfire code may be present without an actual misfire condition. <ol style="list-style-type: none">1. Inspect crankshaft pulley and pulley bolt.2. Repair or replace all damaged components.
Loose torque converter bolts	A misfire code may be present without an actual misfire condition. <ol style="list-style-type: none">1. Inspect torque converter bolts and flywheel.2. Repair or replace all damaged components.
Loose and/or damaged flywheel	A misfire code may be present without an actual misfire condition. <ol style="list-style-type: none">1. Inspect flywheel and flywheel attaching bolts.2. Repair or replace all damaged components.
Restricted exhaust system	A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a misfire code. Possible causes of restrictions include collapsed or dented pipes, plugged mufflers and/or catalytic converters. Repair or replace all damaged components.
Air in fuel system	<ol style="list-style-type: none">1. Inspect fuel filter, fuel system for leaks and/or restrictions.2. Repair or replace all damaged components.
Bent and/or worn valve bridge and finger-follower	<ol style="list-style-type: none">1. Inspect valve bridge and valve finger-follower.2. Repair or replace all damaged components.
Sticking valve	Carbon on the valve stem or valve seat may cause the valve to stick. <ol style="list-style-type: none">1. Inspect valves and valve guides.2. Repair or replace all damaged components.
Damaged or misaligned timing gears	<ol style="list-style-type: none">1. Inspect timing gears.2. Replace all damaged components.
Worn or faulty camshaft lobes	<ol style="list-style-type: none">1. Inspect camshaft lobes.2. Repair or replace all damaged components.
Excessive piston-to-cylinder bore clearance	<ol style="list-style-type: none">1. Perform compression tests.2. Inspect the piston, piston rings and cylinder bore.3. Repair or replace all damaged components.

Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. (Coolant consumption may or may not cause the engine to overheat.)

1. Perform compression tests.
2. Inspect the piston, piston rings and cylinder bore.
3. Repair or replace all damaged components.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Base Engine Misfire with Abnormal Internal Lower Engine Noises

Condition	Actions
Abnormalities (server cracking, bumps or missing areas) in the accessory drive belt	<p>Abnormalities in the accessory drive belt and/or components may cause engine RPM variations, noises similar to faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.</p> <ol style="list-style-type: none"> 1. Inspect the accessory drive components. 2. Repair or replace all damaged components.
Worn, damaged, or misaligned accessory drive components or excessive pulley runout	<p>A misfire code may be present without an actual misfire condition.</p> <ol style="list-style-type: none"> 1. Inspect the accessory drive components. 2. Repair or replace all damage components.
Loose and/or damaged crankshaft pulley	<p>A misfire code may be present without an actual misfire condition.</p> <ol style="list-style-type: none"> 1. Repair or replace all damaged components. 2. Inspect crankshaft pulley and pulley bolt.
Loose torque converter bolts	<p>A misfire code may be present without an actual misfire condition.</p> <ol style="list-style-type: none"> 1. Inspect torque converter bolts and flywheel. 2. Repair or replace all damaged components.
Loose and/or damaged flywheel	<p>A misfire code may be present without an actual misfire condition.</p> <ol style="list-style-type: none"> 1. Inspect flywheel and flywheel attaching bolts. 2. Repair or replace all damaged components.
Excessive piston-to-cylinder bore clearance	<ol style="list-style-type: none"> 1. Perform cylinder leak down and compression tests. 2. Inspect the piston, piston rings and cylinder bore. 3. Repair or replace all damaged components.
	<p>Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit for and aft movement of the crankshaft and create a misfire code without an actual</p>

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Excessive crankshaft thrust bearing clearance

misfire condition.

1. Inspect the crankshaft end play and crankshaft thrust bearings.
2. Repair or replace all damaged.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE**Base Engine Misfire with Abnormal Valve Train Noise**

Condition	Action
Loose, worn or damaged valve bridge and finger-follower	<ol style="list-style-type: none">1. Inspect valve bridge and finger-follower.2. Repair or replace all damaged components.
Broken valve springs	<ol style="list-style-type: none">1. Inspect valve springs.2. Repair or replace all damaged components.
Sticking valve	Carbon on the valve stem or valve seat may cause the valve to stick. <ol style="list-style-type: none">1. Inspect valves and valve guides.2. Repair or replace all damaged components.
Worn or faulty camshaft lobes	<ol style="list-style-type: none">1. Inspect camshaft lobes.2. Repair or replace all damaged components.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION**Base Engine Misfire with Coolant Consumption**

Inspection	Action
DEFINITION: Base engine misfire with coolant consumption	
Preliminary Inspection	Verify that there are no external coolant leaks.
Isolate Affected Cylinders	<ul style="list-style-type: none">• Cylinder balance test with scan tool• Cooling system pressurization• Inspection of glow plugs• Compression test
EGR System Inspection	<ul style="list-style-type: none">• Inspect EGR valve and intake system for evidence of coolant leakage.• Replace the EGR cooler if any problem is found.
Cylinder Head Gasket Leakage	<ul style="list-style-type: none">• Remove cylinder heads of the affected cylinder bank and inspect for damage.• Replace components as necessary.
Cylinder Head or Engine Block	<ul style="list-style-type: none">• Inspect the cylinder head for cracks.• Inspect the cylinder block for damage.

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Damage

- Inspect the cylinder block to head mating surface for straightness.
- Replace components as necessary.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION**Base Engine Misfire with Excessive Oil Consumption**

Condition	Action
Worn valve guides	<ol style="list-style-type: none">1. Inspect the valves and valve guides.2. Repair or replace all damaged components.
Worn valve stem oil seals	<ol style="list-style-type: none">1. Inspect the valve stem oil seals.2. Repair or replace all damaged components.
Excessive piston-to-cylinder bore clearance	<ol style="list-style-type: none">1. Perform compression tests to determine the cause.2. Inspect the piston rings for low ring tension, broken or worn rings.3. Inspect cylinder bore.4. Repair or replace all damaged components.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED**Upper Engine Noise, Regardless of Engine Speed**

Condition	Action
Low oil pressure	<p>Insufficient or poor oil supply to valve train.</p> <ol style="list-style-type: none">1. Perform oil pressure test.2. Repair or replace all damaged components.
Improper lubrication to the valve finger-follower	<ol style="list-style-type: none">1. Inspect valve finger-follower, valve bridge, valve finger follower lifter, oil pump and engine block oil galleries.2. Repair or replace all damaged components.
Worn or damaged valve finger-follower	<ol style="list-style-type: none">1. Inspect valve bridge and finger-follower.2. Repair or replace all damaged components.
Sticking valve	<p>Carbon on the valve stem or valve seat may cause the valve to stick.</p> <ol style="list-style-type: none">1. Inspect valves and valve guides.2. Repair or replace all damaged components.
Worn or faulty camshaft lobes	<ol style="list-style-type: none">1. Inspect camshaft lobes.2. If damaged replace camshaft and all valve finger-followers.
Damaged or misaligned timing gears	<ol style="list-style-type: none">1. Inspect timing gears.2. Replace all damaged components.

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED
Lower Engine Noise, Regardless of Engine Speed

Condition	Action
Worn accessory drive components (abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of the system components.)	<ol style="list-style-type: none"> 1. Inspect the accessory drive components. 2. Repair or replace all damaged components.
Low oil pressure	Insufficient or poor oil supply to crankshaft and connecting rod bearings. <ol style="list-style-type: none"> 1. Perform oil pressure test. 2. Repair or replace all damaged components.
Leaking and/or sticking fuel injection nozzle (A stuck fuel injection nozzle can cause a noise similar to a damaged piston, rod or rod bearing.)	<ol style="list-style-type: none"> 1. Inspect the cylinder balance with scan tool to help locate the cylinder that is the source of the noise. 2. If you cannot locate the cylinder that is the source of the noise, diagnose the engine for mechanical damage. 3. If it has been determined that the fuel injection nozzle is causing the noise, replace the fuel injection nozzle.
Loose and/or damaged crankshaft pulley	<ol style="list-style-type: none"> 1. Inspect crankshaft pulley and pulley bolt. 2. Repair or replace all damaged components.
Loose torque converter bolts	<ol style="list-style-type: none"> 1. Inspect torque converter bolts and flywheel. 2. Repair or replace all damaged components.
Loose and/or damaged flywheel	<ol style="list-style-type: none"> 1. Inspect flywheel and flywheel attaching bolts. 2. Repair or replace all damaged components.
Excessive piston pin-to-bore clearance	<ol style="list-style-type: none"> 1. Inspect the piston, piston pin, and the connecting rod. 2. Repair or replace all damaged components.
Misaligned or bent connecting rod	<ol style="list-style-type: none"> 1. Inspect connecting rod and connecting rod bearings. 2. Repair or replace all damaged components.
Excessive connecting rod bearing clearance	<ol style="list-style-type: none"> 1. Inspect the connecting rod bearings, connecting rods, crankshaft and crankshaft journals. 2. Repair or replace all damaged components.
Excessive crankshaft bearing clearance	<ol style="list-style-type: none"> 1. Inspect the crankshaft bearings and crankshaft journals. 2. Repair or replace all damaged components.

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Engine Will Not Crank - Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component	<ol style="list-style-type: none"> 1. Inspect the accessory drive system components. 2. Repair or replace all damaged components.
Hydraulically locked cylinder <ul style="list-style-type: none"> • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder 	<ol style="list-style-type: none"> 1. Inspect for broken head gasket(s). 2. Inspect for cracked engine block or cylinder head. 3. Inspect for a sticking fuel injector.
Seized automatic transmission torque converter	<ol style="list-style-type: none"> 1. Remove the engine assembly. The torque converter bolts are not accessible with the engine installed to the transmission. 2. Rotate the crankshaft at the pulley.
Seized manual transmission	<ol style="list-style-type: none"> 1. Disengage the clutch. 2. Rotate crankshaft at the pulley.
Material in cylinder <ul style="list-style-type: none"> • Broken valve • Piston material • Foreign material 	<ol style="list-style-type: none"> 1. Inspect the cylinder for damaged components and/or foreign materials. 2. Repair or replace as required.
Seized crankshaft or connecting rod bearing	<ol style="list-style-type: none"> 1. Inspect the crankshaft and connecting rod bearings. 2. Repair as required.
Bent or broken connecting rod	<ol style="list-style-type: none"> 1. Inspect the connecting rods. 2. Repair as required.
Broken crankshaft	<ol style="list-style-type: none"> 1. Inspect the crankshaft. 2. Repair as required.

ENGINE COMPRESSION TEST

Special Tools

EN 48248 Cylinder Compression Pressure Gauge

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

Removal Procedure

IMPORTANT: DO NOT leave vehicle connected to charge port or theft deterrent system

will be active and compression test will not run.

1. Bring vehicle into service bay and make sure vehicle has at least 50% charge.
2. Remove the ignition coils. Refer to **Ignition Coil Replacement** .
3. Remove the spark plugs. Refer to **Spark Plug Replacement** .

Diagnostic Procedure

NOTE: In order to perform the compression test it will be necessary to use GDS in order to crank engine.

1. Place vehicle into service mode and connect GDS.
2. Without compression gauge attached Crank the engine using the "Compression Test" function in GDS to remove any foreign substances from the cylinders.
3. Install **EN-48248** gauge in the spark plug bore for the cylinder that is being checked.
4. Using the "Compression Test" function in GDS, select "crank" on the diagnostics screen and let the test run for the cylinder being tested. The engine will now crank then stop.
5. Record the compression reading for the cylinder just tested.
6. Repeat starting at step 7 for all remaining cylinders. All 4 cylinders must be tested to obtain valid test results. Record the readings.

Installation Procedure

1. Remove **EN-48248** gauge.
2. Install the spark plugs. Refer to **Spark Plug Replacement** .
3. Install the ignition coils. Refer to **Ignition Coil Replacement** .

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

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

Test Description

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

2

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

3

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

4

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

6

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

10

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

12

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

14

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

15

This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from

working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.

16

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

17

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

19

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

Drive Belt Chirping, Squeal, and Whine Diagnosis

Step	Action	Yes	No
CAUTION: Do not use belt dressing on the drive belt. Belt dressing causes the breakdown of the composition of the drive belt. Failure to follow this recommendation will damage the drive belt.			
DEFINITION: The following items are indications of chirping: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • A high pitched continuous noise. • The noise may be caused by an accessory drive component failed bearing. 			
	Did you review the Drive Belt Symptom		

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1	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	<p>1. Remove the drive belt.</p> <p>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.</p> <p>2. Operate the engine for no longer than 30-40 seconds.</p> <p>3. Repeat this test if necessary by removing the remaining belt(s).</p> <p>Does the chirping, squeal or whine noise still exist?</p>	Go to Symptoms - Engine Mechanical	Go to Step 4
4	<p>If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth.</p> <p>If diagnosing a squeal or whine noise, proceed to Step 13.</p> <p>Do the belt grooves have pilling?</p>	Go to Step 5	Go to Step 6
5	<p>Clean the drive belt pulleys with a suitable wire brush.</p> <p>Did you complete the repair?</p>	Go to Step 20	Go to Step 6
6	<p>Inspect for misalignment of the pulleys.</p> <p>Are any of the pulleys misaligned?</p>	Go to Step 7	Go to Step 8
7	<p>Replace or repair any misaligned pulleys.</p> <p>Did you complete the repair?</p>	Go to Step 20	Go to Step 8
8	<p>Inspect for bent or cracked brackets.</p> <p>Did you find any bent or cracked brackets?</p>	Go to Step 9	Go to Step 10
9	<p>Replace any bent or cracked brackets.</p> <p>Did you complete the repair?</p>	Go to Step 20	Go to Step 10
10	<p>Inspect for improper, loose or missing fasteners.</p> <p>Did you find the condition?</p>	Go to Step 11	Go to Step 12
11	<p>CAUTION: Refer to <u>Fastener Caution</u> .</p> <p>1. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u>.</p>		

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	2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?	Go to Step 20	Go to Step 14
14	Test the drive belt tensioner for proper operation. 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 Symptoms - Engine Mechanical . Did you complete the repair?	Go to Step 20	Go to Diagnostic Aids
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

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

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

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

accessory drive components may aid in identifying which component is causing the rumbling noise.

Test Description

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

2

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

3

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

4

Inspecting the drive belts is to ensure that they are not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation can be recognized at the edge of the belt or felt as a lump in the belt.

5

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

9

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

11

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

12

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

Drive Belt Rumbling and Vibration Diagnosis

Step	Action	Yes	No
<p>DEFINITION: The following items are indications of drive belt rumbling:</p> <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> ○ 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. <p>DEFINITION: The following items are indications of drive belt vibration:</p> <ul style="list-style-type: none"> • The vibration is engine-speed related. • The vibration may be sensitive to accessory load. 			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to Step 3	Go to Diagnostic Aids
3	<p>1. Remove the drive belt.</p> <p>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.</p> <p>2. Operate the engine for no longer than 30-40 seconds.</p> <p>3. Repeat this test if necessary by removing the remaining belt(s).</p> <p>Does the rumbling or vibration still exist?</p>	Go to Symptoms - Engine Mechanical	Go to Step 4
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
	1. Clean the drive belt pulleys using a		

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6	suitable wire brush. 2. Reinstall the drive belts. Did you correct the condition?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Did you complete the replacement?	Go to Step 8	Go to Step 9
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 9
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to Step 10	Go to Step 11
10	CAUTION: Refer to <u>Fastener Caution</u> . 1. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u> . 2. Replace improper or missing fasteners. Did you complete the repair?	Go to Step 12	Go to Step 11
11	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 12	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 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 or sections of ribs missing.

4

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

5

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

6

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

7

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

13

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

14

The installation of a drive belt that is 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

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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.

Drive Belt Falls Off and Excessive Wear Diagnosis

Step	Action	Yes	No
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 high 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. Does the drive belt continue to fall off?	Go to Step 4	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to Step 12	Go to Step 7
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	CAUTION: Refer to <u>Fastener Caution</u> . 1. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u> . 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. 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. Did you find this condition?	Go to Step 16	Go to Step 14

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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. 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	-

REPAIR INSTRUCTIONS - ON VEHICLE

POWERTRAIN MOUNT BALANCING

WARNING: Do not use a service jack in locations other than those specified to lift this vehicle. Lifting the vehicle with a jack in those other locations could cause the vehicle to slip off the jack and roll; this could cause injury or death.

NOTE: Follow the balance procedure steps listed below when no starting point has been established such as in a collision repair.

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
2. Loosen the rear transaxle mount to transaxle bracket through bolt until it is finger tight.
3. Lower the vehicle.
4. Install the engine support fixture. Refer to Engine Support Fixture.
5. Remove the drive motor generator power inverter module cover. Refer to Drive Motor Generator Power Inverter Module Cover Replacement .

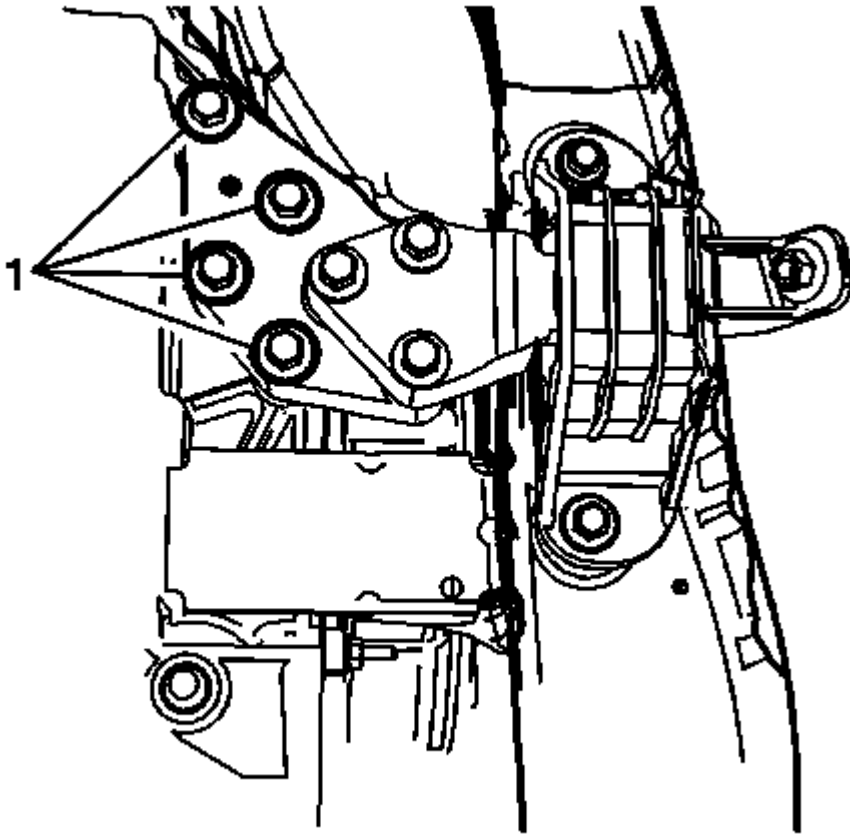


Fig. 11: Transaxle Bolts

Courtesy of GENERAL MOTORS COMPANY

6. Loosen the transaxle adapter to transaxle bolts (1).

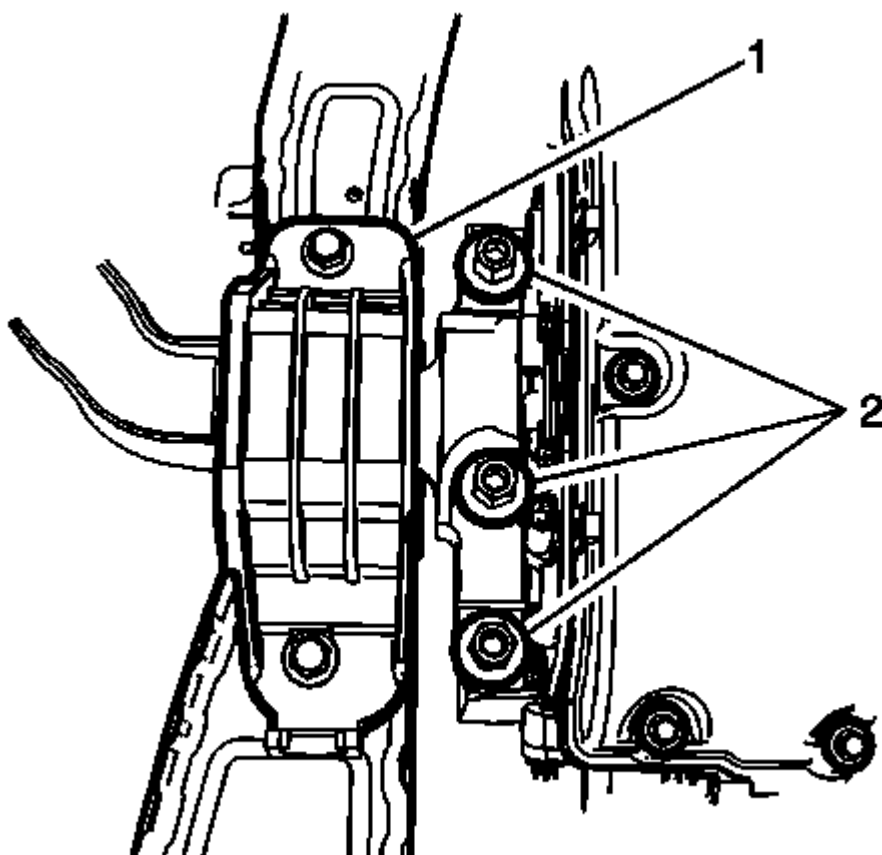


Fig. 12: Engine Mount And Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Loosen the engine mount (1) to bracket bolts (2).
8. Raise the engine and transmission in order to allow a 1/4 inch (6 mm) gap between the upper engine mount and engine mount bracket, and also between the transmission and left transmission mount.
9. Tighten the left hand (transaxle side) mount bolts, starting with the bolt nearest to the center of the mount. See the appropriate transmission mount replacement procedure for the fastener tightening specifications.
10. Tighten the right hand (engine side) mount bolts, starting with the bolt nearest to the center of the mount. See the appropriate engine mount replacement procedure for the fastener tightening specifications.

WARNING: Do not use a service jack in locations other than those specified to lift this vehicle. Lifting the vehicle with a jack in those other locations could cause the vehicle to slip off the jack and roll; this could cause injury or death.

11. Raise the vehicle.
12. Shake the powertrain from front to rear and allow the powertrain to settle.
13. Tighten the rear transaxle mount through bolt. See the appropriate transmission mount replacement procedure for the fastener tightening specifications.

14. Lower the vehicle.
15. Install the drive motor generator power inverter module. Refer to **Drive Motor Generator Power Inverter Module Cover Replacement**.
16. Remove the engine support fixture. Refer to **Engine Support Fixture**.
17. Raise the vehicle.

CAUTION: Refer to **Fastener Caution**.

18. Tighten the rear transaxle mount to transaxle bracket through bolt to 100 (74 lb ft).
19. Lower the vehicle and remove supports. Refer to **Lifting and Jacking the Vehicle**.

ENGINE MOUNT REPLACEMENT - RIGHT SIDE

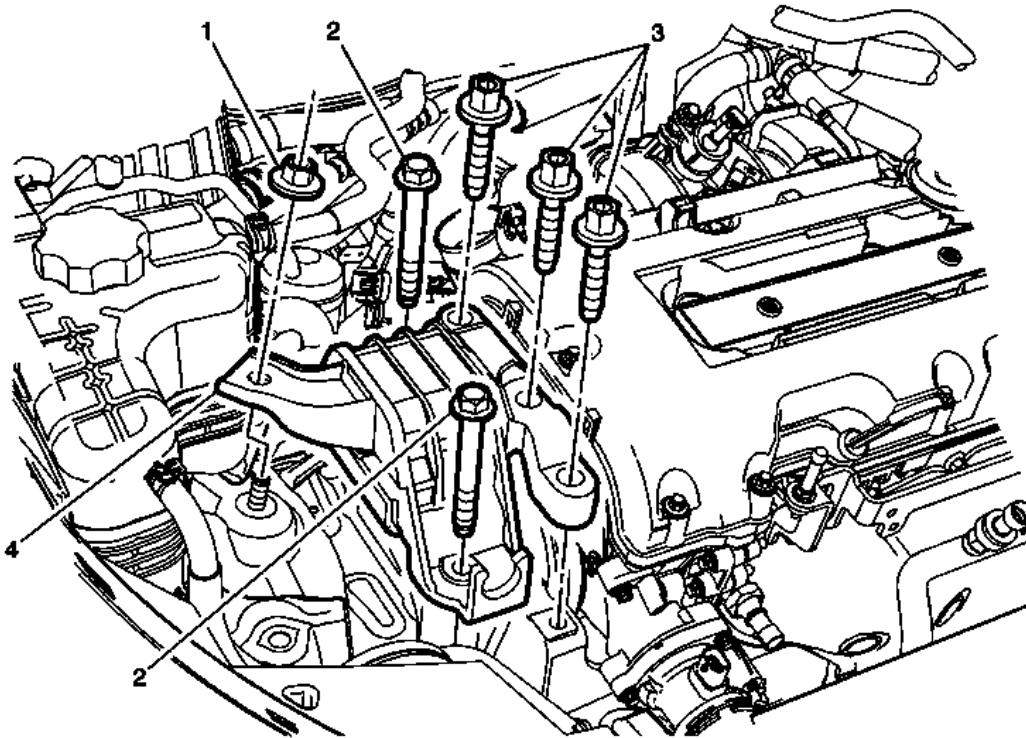


Fig. 13: Engine Mount - Right Side
Courtesy of GENERAL MOTORS COMPANY

Engine Mount Replacement - Right Side

Callout	Component Name
Preliminary Procedures	
1.	Remove the air cleaner assembly. Refer to <u>Air Cleaner Assembly Replacement</u> .
2.	Install engine support fixture. Refer to <u>Engine Support Fixture</u> .

3. Prior to removing the mount, mark the mount location using spray paint or a marker for correct positioning during installation.
4. If all powertrain mounts are replaced, perform the Powertrain Mount Balancing. Refer to **Powertrain Mount Balancing**.

1	Engine Mount Fastener CAUTION: Refer to <u>Fastener Caution</u> . TIP: Perform the powertrain mount balancing - lower after installation of the fastener. Tighten 50 N.m (37 lb ft)
2	Engine Mount Fastener (Qty: 2) Tighten 58 N.m (43 lb ft)
3	Engine Mount Fastener (Qty: 3) Procedure Ensure the washer is in place before installing the bolt. Tighten 58 N.m (43 lb ft)
4	Engine Mount Procedure Transfer components as necessary.

ENGINE MOUNT INSPECTION

1. Install the engine support fixture. Refer to **Engine Support Fixture**.
2. Observe the engine mount while raising the engine. Raising the engine removes the weight from the engine mount and creates slight tension on the rubber.
3. Replace the engine mount if the engine mount exhibits any of the following conditions:
 - The hard rubber is covered with heat check cracks.
 - The rubber is separated from the metal plate of the engine mount.
 - The rubber is split through the center of the engine mount.
4. For engine mount replacement, refer to **Engine Mount Replacement - Right Side**.
5. For rear transmission mount replacement, refer to **Transmission Rear Mount Replacement** .
6. For left transmission mount replacement, refer to **Transmission Mount Replacement - Left Side** .

ENGINE MOUNT BRACKET REPLACEMENT - RIGHT SIDE

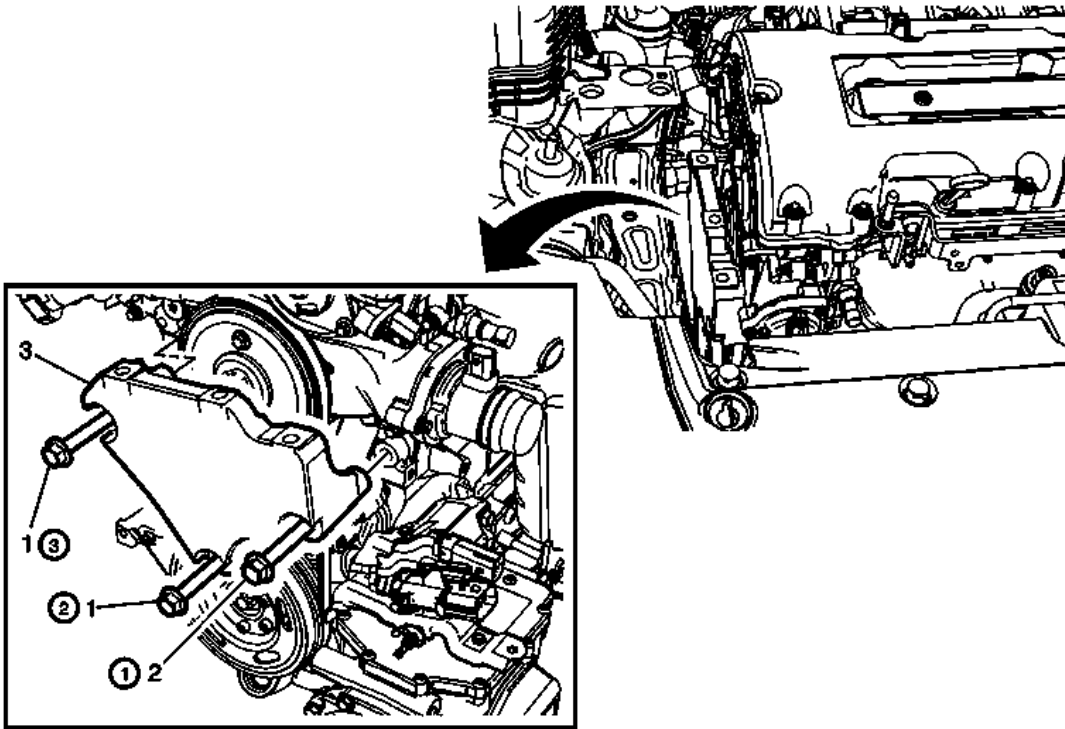


Fig. 14: Engine Mount Bracket - Right Side
 Courtesy of GENERAL MOTORS COMPANY

Engine Mount Bracket Replacement - Right Side

Callout	Component Name
Preliminary Procedures	
<ol style="list-style-type: none"> 1. Remove the engine mount. Refer to <u>Engine Mount Replacement - Right Side</u>. 2. Remove the front wheelhouse front liner. Refer to <u>Front Wheelhouse Front Liner Replacement</u>. 3. Remove the nuts retaining the drive motor battery to charge cable to the frame rail and reposition. Refer to <u>300-Volt Battery Positive and Negative Cable Replacement (Drive Motor Battery-to-Inverter)</u>, <u>300-Volt Battery Positive and Negative Cable Replacement (Drive Motor Battery-to-Charger)</u>, <u>300-Volt Battery Positive and Negative Cable Replacement (Inverter-to-Compressor/Heater Module)</u>, <u>300-Volt Battery Positive and Negative Cable Replacement (Drive Motor Battery-to-APM Module)</u> 4. Reposition hose assembly to access engine mount bracket bolt. 5. Remove the drive motor battery cooler flow control valve inlet hose retainers at inlet hose retainers. 	
	Engine Mount Bracket Fastener (Qty: 2) CAUTION: This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-

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1	<p>to-yield bolts may lead to engine damage.</p> <p>CAUTION: Refer to <u>Fastener Caution</u> .</p> <p>Procedure</p> <ol style="list-style-type: none">1. Raise and lower the engine as needed to access the bolts.2. Ensure to follow the tighten sequence. <p>Tighten</p> <ol style="list-style-type: none">1. First pass: 60 N.m (44 lb ft)2. Final pass: additional 45-60 degrees
2	<p>Engine Mount Bracket Fastener</p> <p>Procedure Ensure to follow the tighten sequence.</p> <p>Tighten</p> <ol style="list-style-type: none">1. First pass: 60 N.m (44 lb ft)2. Final pass: additional 45-60 degrees
3	<p>Engine Mount Bracket</p> <p>Procedure Transfer components as necessary.</p>

ENGINE SUPPORT FIXTURE

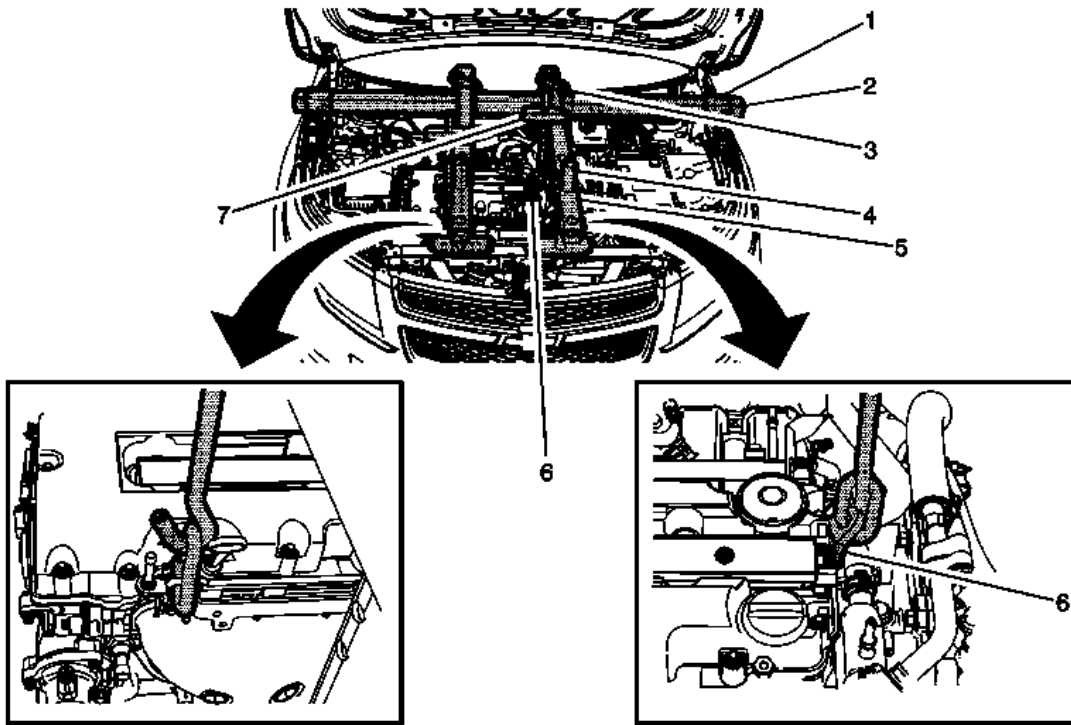


Fig. 15: Engine Support

Courtesy of GENERAL MOTORS COMPANY

Engine Support Fixture

Callout	Component Name
Preliminary Procedure	
<ol style="list-style-type: none"> 1. Remove the air cleaner resonator outlet duct. Refer <u>Air Cleaner Resonator Outlet Duct Replacement</u>. 2. Remove the ground wire retaining bolt and wire by heater water auxiliary pump inlet hose. 	
Special Tools	
<ul style="list-style-type: none"> • EN-43405 Engine Support Fixture Adapter • EN-28467-1A Cross Bracket • EN-28467-5A Strut Tower Support Assembly • EN-28467-8A Hook Assembly • EN-28467-2A Radiator Tube Shelf Assembly • EN-36857 Engine Lift Bracket 	
For equivalent regional tools, refer to <u>Special Tools</u> .	
1	Engine Support Fixture Adapter Leg (Qty: 2) Procedure Install the bracket to fender frame. Do not install on top of fender lip.

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2	Main Support Beam
3	Cross Bracket (Qty: 2)
4	Strut Tower Support Assembly (Qty: 2) Procedure Adjust the length of the strut tower support assembly.
5	Radiator Tube Shelf Assembly (Qty: 2)
6	Engine Lift Bracket Procedure Use a grade 10.9 bolt to install the engine lift bracket.
7	Hook Assembly (Qty: 2)

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

WARNING: Always perform the High Voltage Disabling procedure prior to servicing any High Voltage component or connection. Personal Protection Equipment (PPE) and proper procedures must be followed.

The High Voltage Disabling procedure will perform the following tasks:

- Identify how to disable high voltage.
- Identify how to test for the presence of high voltage.
- Identify condition under which high voltage is always present and personal protection equipment (PPE) and proper procedures must be followed.

Failure to follow the procedures exactly as written may result in serious injury or death.

1. Disable the high voltage system. Refer to High Voltage Disabling .
2. Remove the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement .
3. Remove the fuel injection fuel rail assembly only. Refer to Fuel Injection Fuel Rail Assembly Replacement

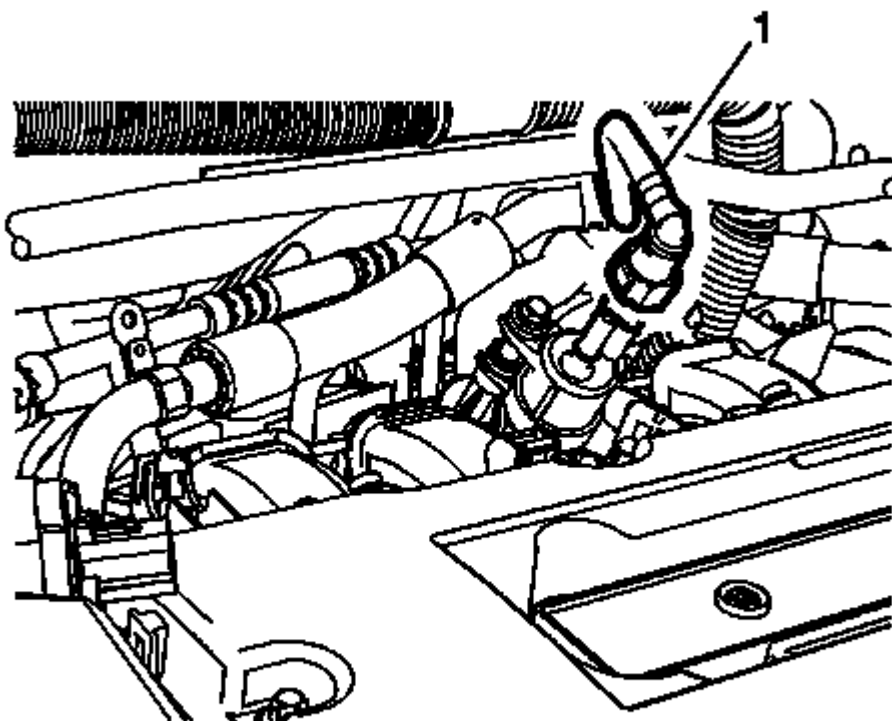


Fig. 16: Evaporative Emission Canister Purge Solenoid Valve Hose
Courtesy of GENERAL MOTORS COMPANY

4. Remove the evaporative emission canister purge solenoid valve hose (1). Refer to **Plastic Collar Quick Connect Fitting Service** .
5. Unclip and reposition the engine coolant air bleed hose without draining coolant. Refer to **Engine Coolant Air Bleed Hose Connector Replacement**

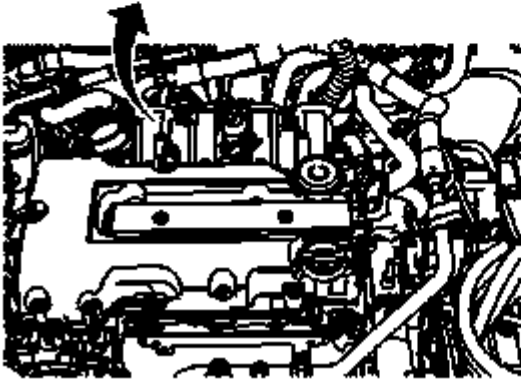
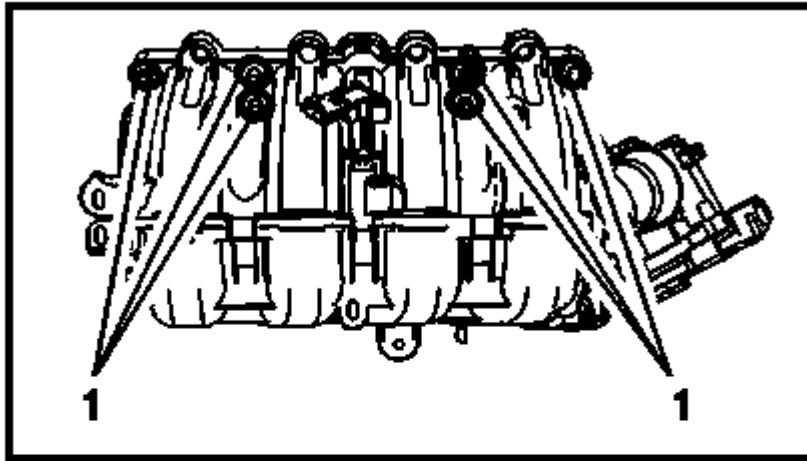


Fig. 17: Intake Manifold Bolts

Courtesy of GENERAL MOTORS COMPANY

6. Remove the 6 intake manifold bolts (1).

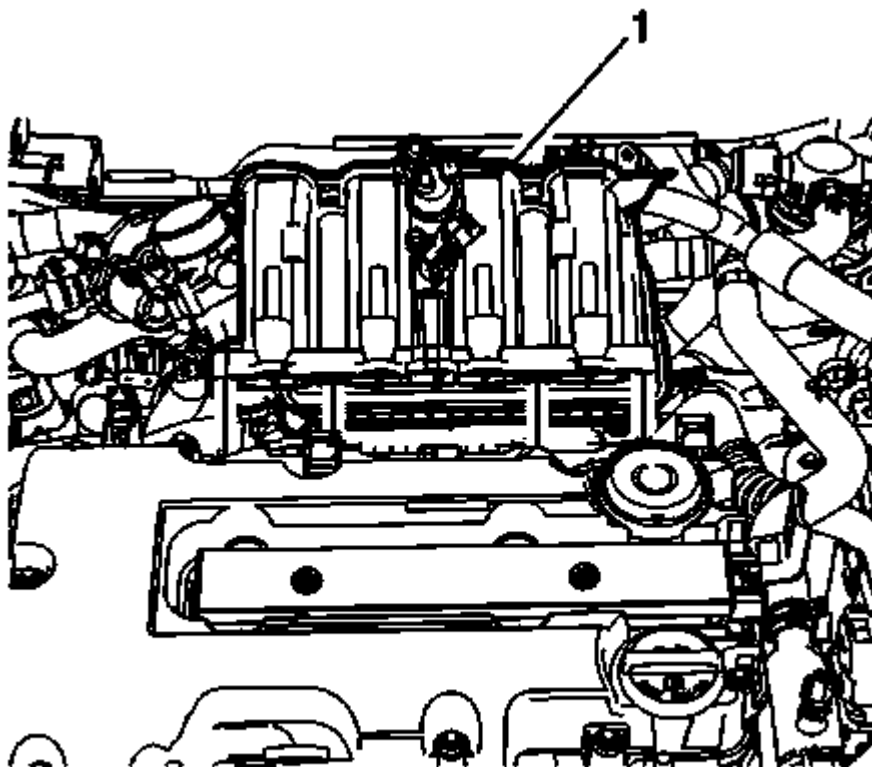


Fig. 18: Intake Manifold

Courtesy of GENERAL MOTORS COMPANY

7. Remove the intake manifold from the vehicle (1).
8. Disconnect the electrical connectors as necessary.
9. To disassemble the intake manifold. Refer to **Intake Manifold Disassemble**
10. For cleaning and inspection of the intake manifold. Refer to **Intake Manifold Cleaning and Inspection.**
11. Transfer the components as necessary.

Installation Procedure

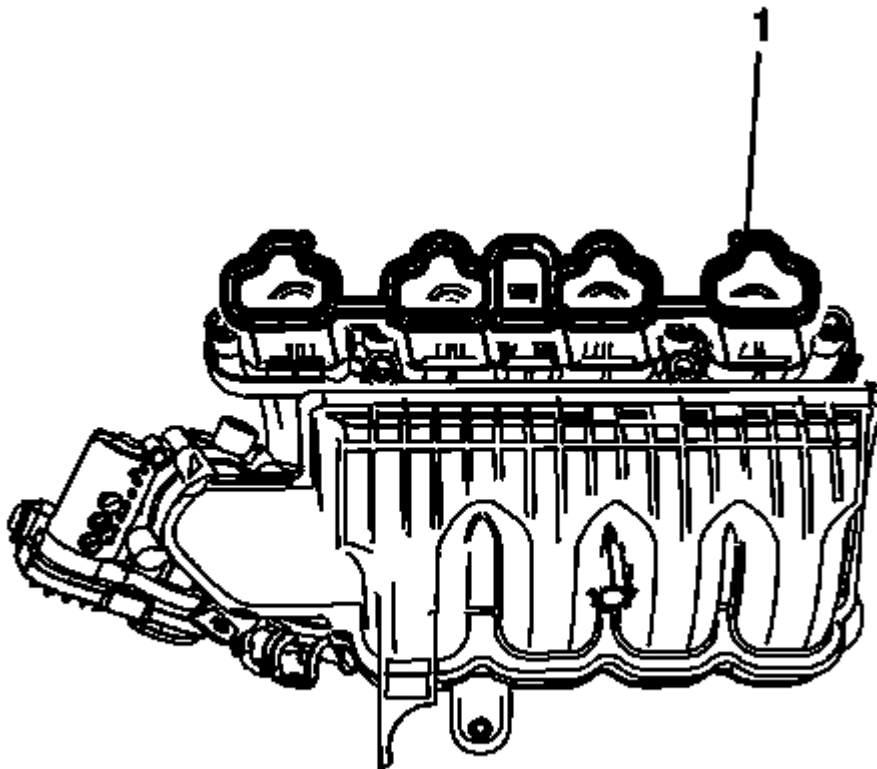


Fig. 19: Intake Manifold Gasket

Courtesy of GENERAL MOTORS COMPANY

1. Ensure the surface of the intake manifold is clean before installing the new gasket.
2. Install the manifold gasket (1).

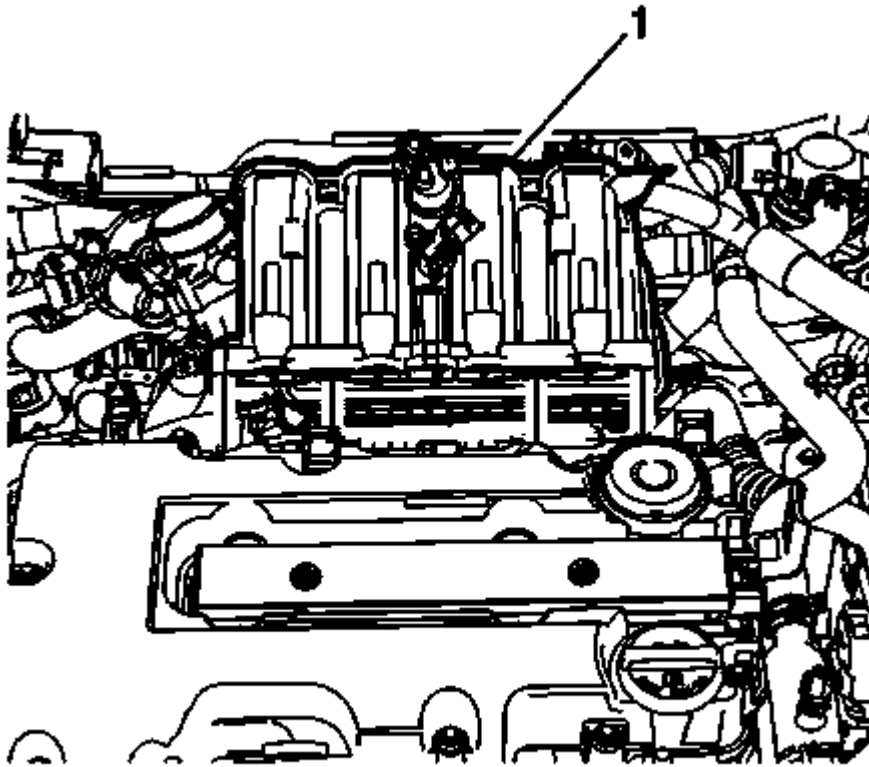


Fig. 20: Intake Manifold

Courtesy of GENERAL MOTORS COMPANY

3. Install the intake manifold in the vehicle (1).

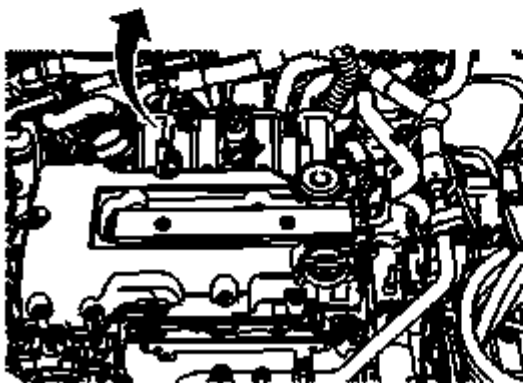
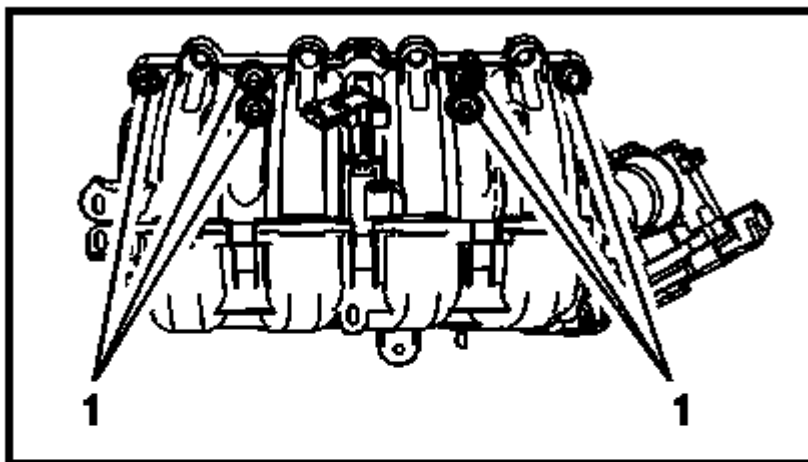


Fig. 21: Intake Manifold Bolts

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

4. Install the intake manifold bolts (1) and tighten to 20 N.m (15 lb ft).

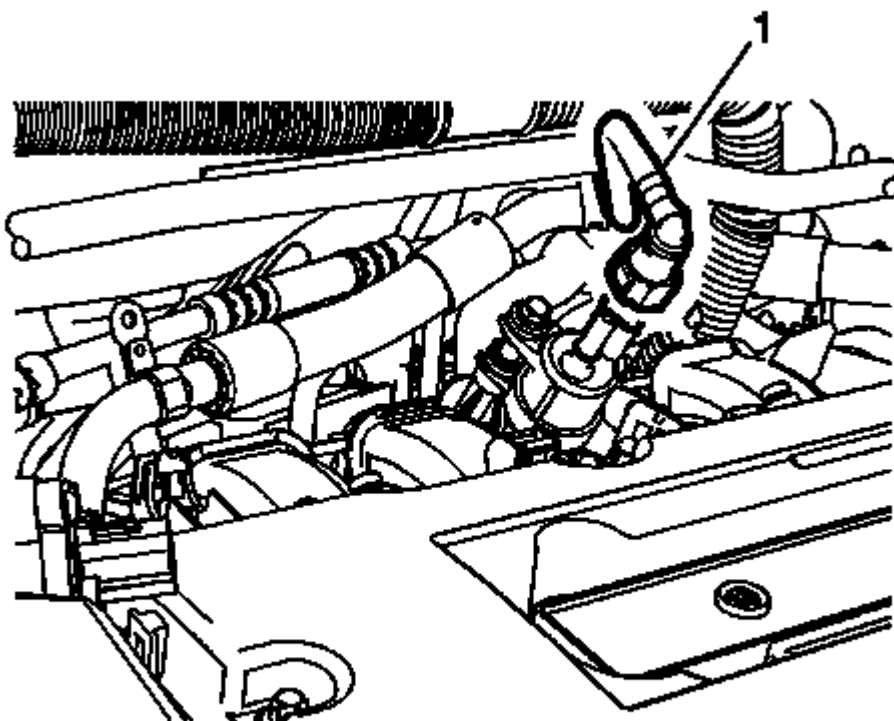


Fig. 22: Evaporative Emission Canister Purge Solenoid Valve Hose
Courtesy of GENERAL MOTORS COMPANY

5. Install the evaporative emission canister purge solenoid valve hose (1). Refer to **Plastic Collar Quick Connect Fitting Service** .
6. Install the fuel injection fuel rail assembly only. Refer to **Fuel Injection Fuel Rail Assembly Replacement** .
7. Install the Air Cleaner Outlet Duct. Refer to **Air Cleaner Outlet Duct Replacement** .
8. Fill the coolant fluid. Refer to **Cooling System Draining and Filling** .
9. Enable the high voltage system. Refer to **High Voltage Enabling** .

CAMSHAFT TIMING CHAIN REPLACEMENT

Special Tools

EN-955-1 Locking Pin

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

Removal Procedure

1. Remove the engine front cover. Refer to **Engine Front Cover with Oil Pump Replacement**.

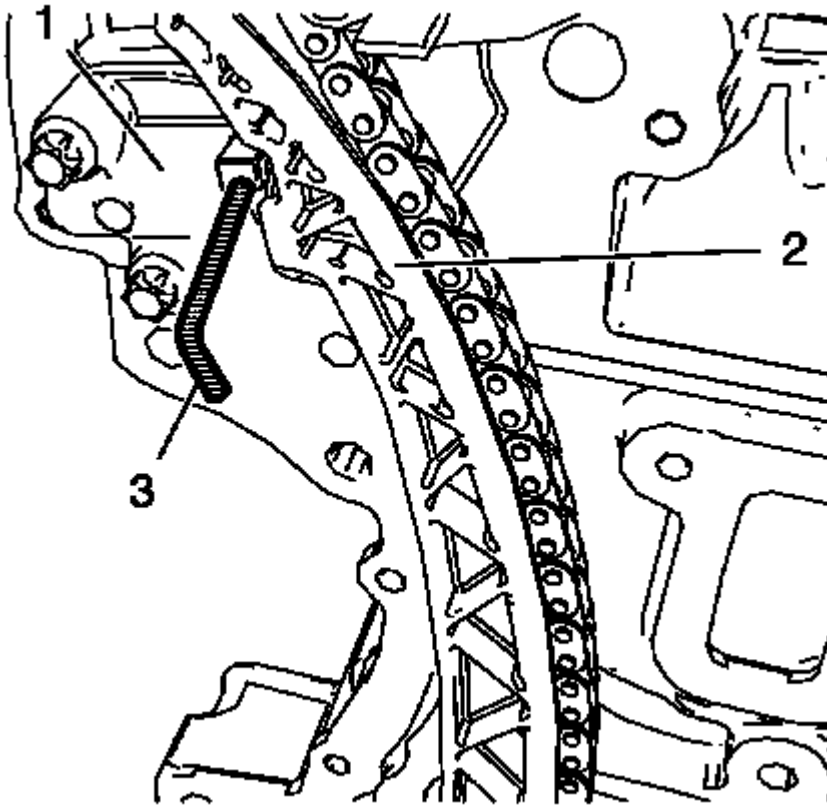


Fig. 23: Timing Chain And Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

2. Push the timing chain (2) in direction to the timing chain tensioner (1) and install the **EN-955-1** pin (3).

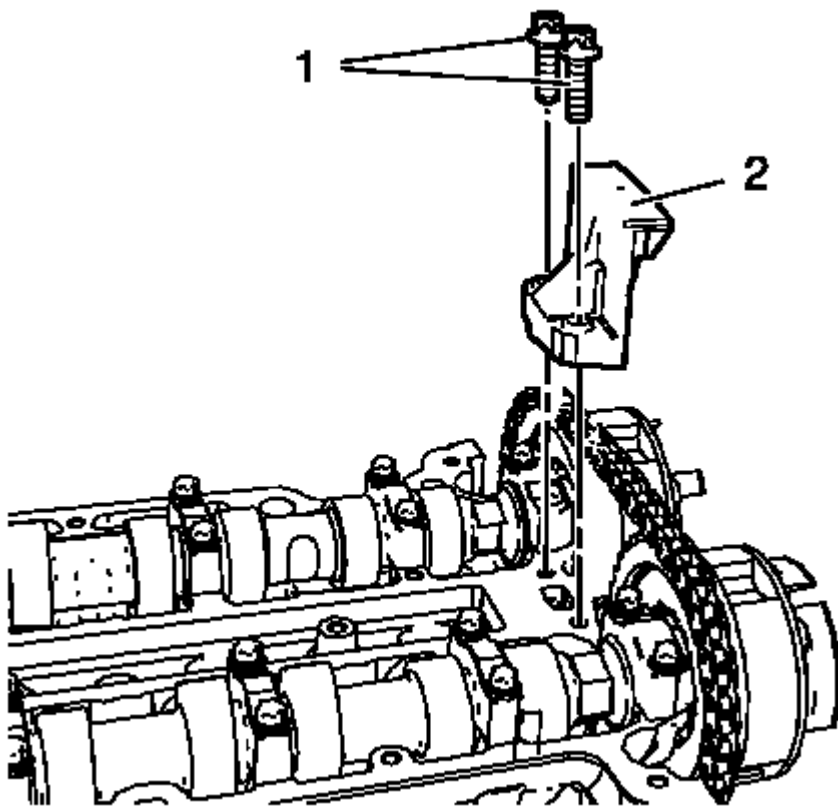


Fig. 24: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

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

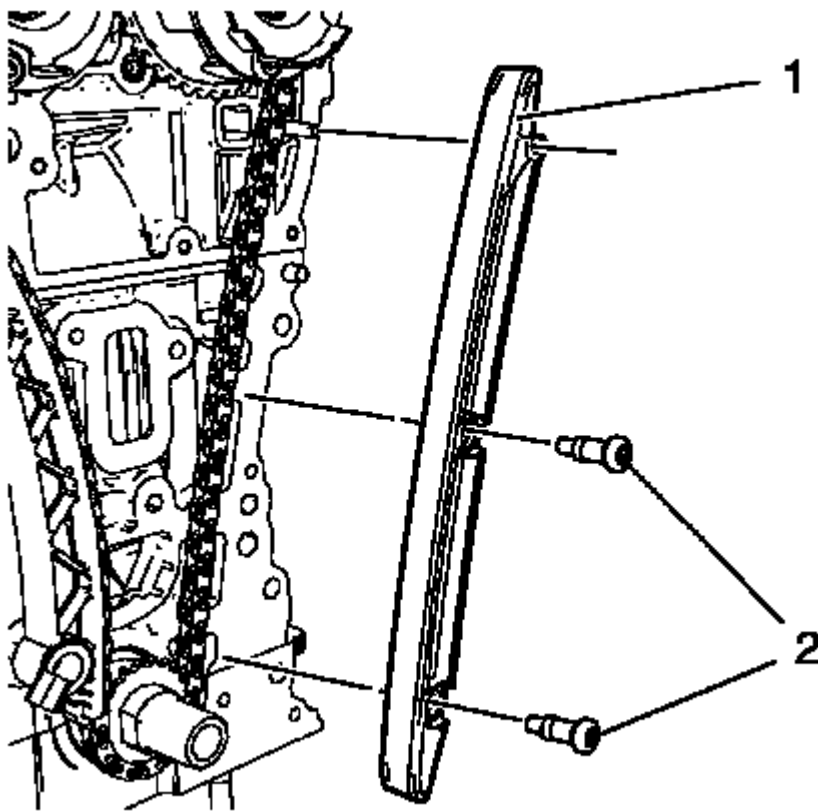


Fig. 25: Timing Chain Guide Right Side

Courtesy of GENERAL MOTORS COMPANY

5. Remove the two timing chain guide right side bolts (2).
6. Remove the timing chain guide right side (1).

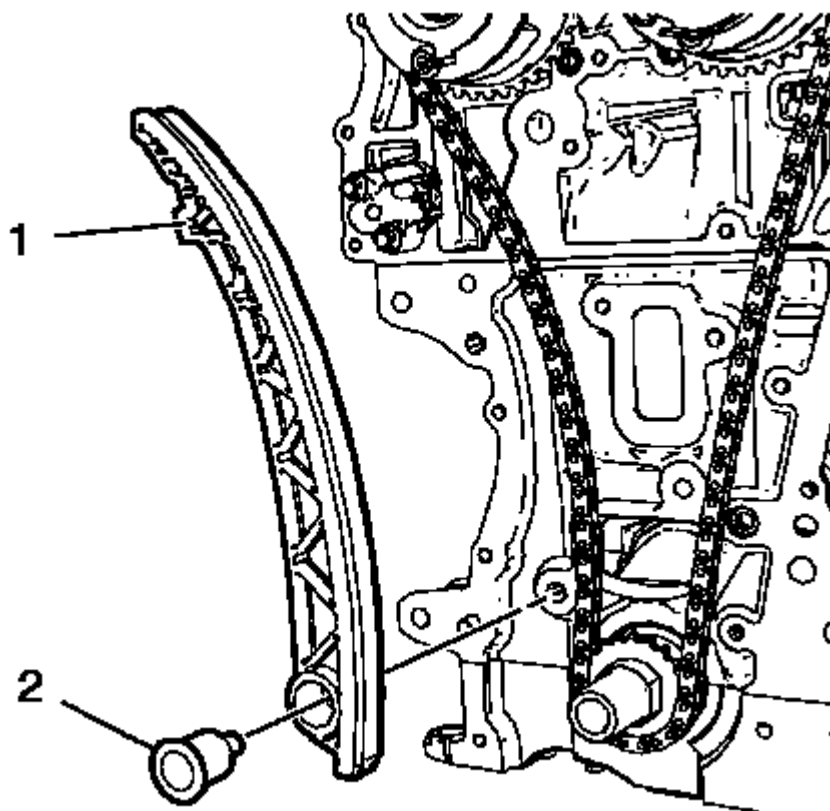


Fig. 26: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

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

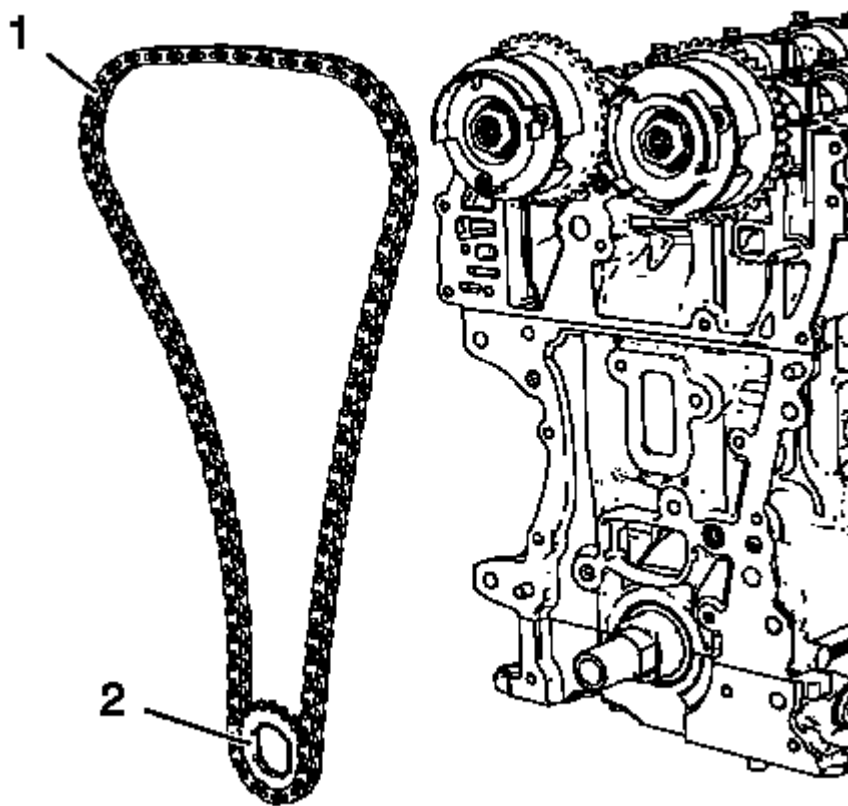


Fig. 27: Timing Chain And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

9. Remove the timing chain (1) and crankshaft sprocket (2) together as a unit.

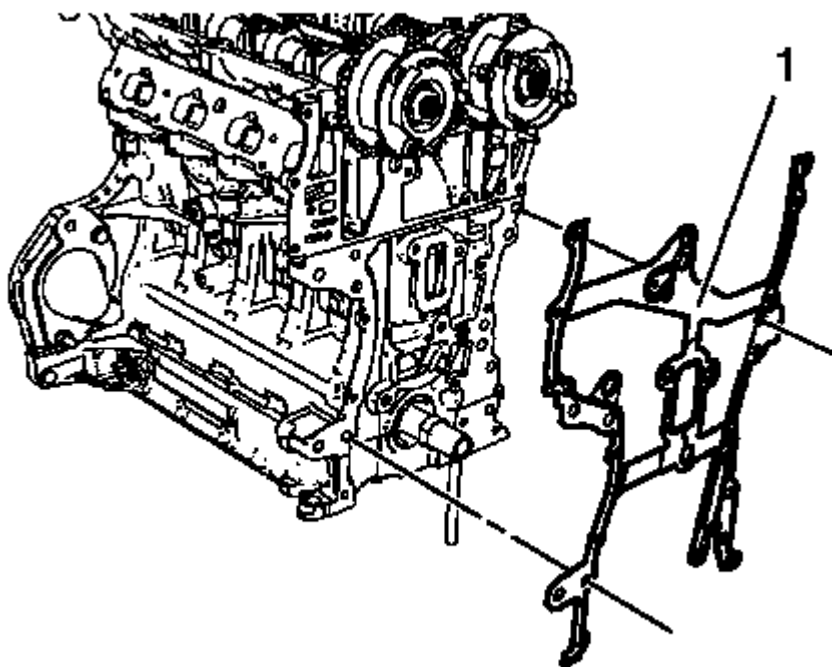


Fig. 28: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS COMPANY

10. Remove the engine front cover gasket (1).

Installation Procedure

1. Clean the engine front cover sealing surfaces on engine block and cylinder head.

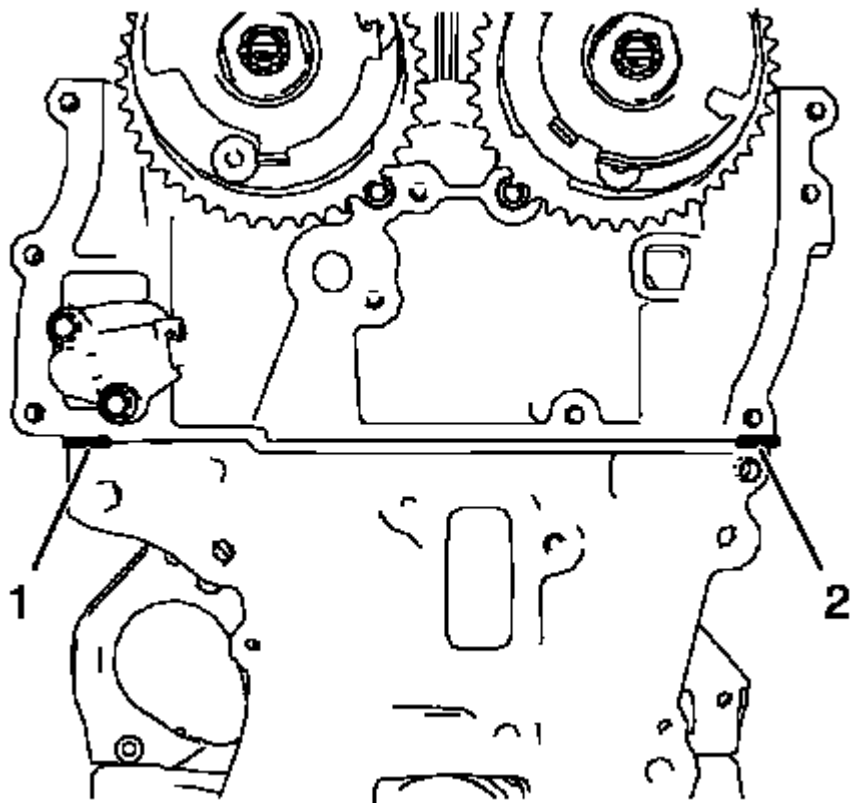


Fig. 29: Sealing Compound Application Areas
Courtesy of GENERAL MOTORS COMPANY

2. Apply a 2 mm (0.0787 in) bead of RTV sealant the areas shown above (1, 2).

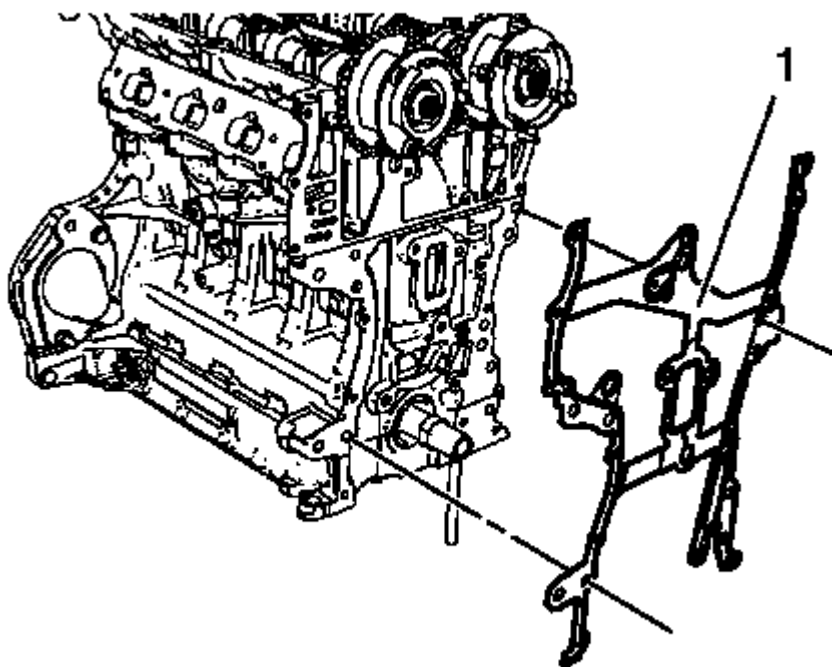


Fig. 30: Engine Front Cover Gasket

Courtesy of GENERAL MOTORS COMPANY

3. Install the engine front cover gasket (1).

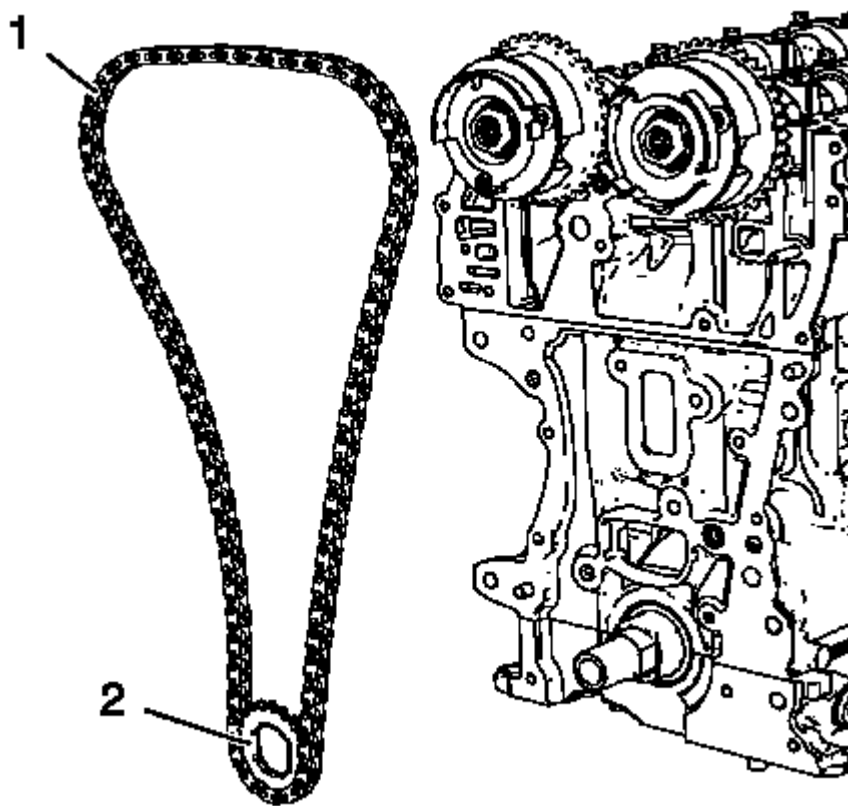


Fig. 31: Timing Chain And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

4. Install the timing chain (1) and crankshaft sprocket (2) together as a unit.

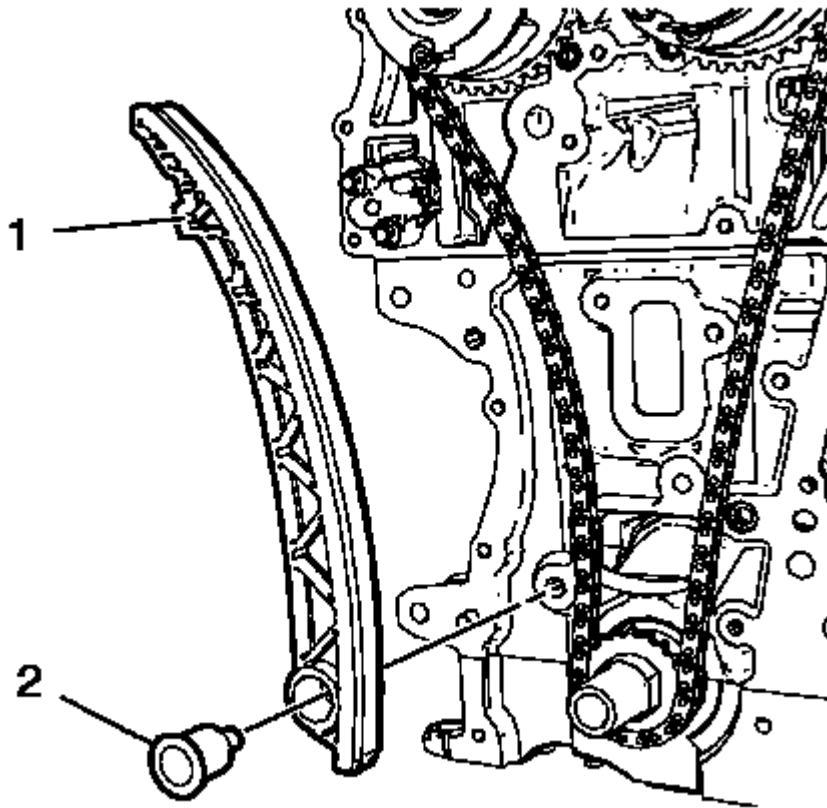


Fig. 32: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Install the timing chain tensioner shoe (1).

CAUTION: Refer to Fastener Caution .

6. Install the timing chain tensioner shoe bolt (2) and tighten to 20 N.m (15 lb ft).

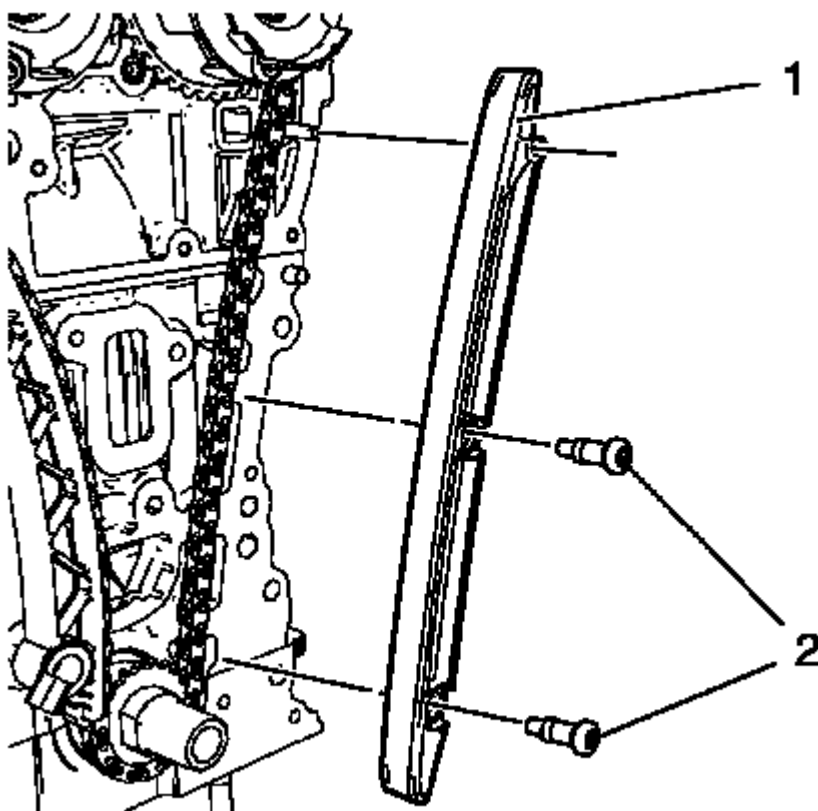


Fig. 33: Timing Chain Guide Right Side
Courtesy of GENERAL MOTORS COMPANY

7. Install the timing chain guide right side (1).
8. Install the timing chain guide right side bolts (2) and tighten to 8 N.m (71 lb in).

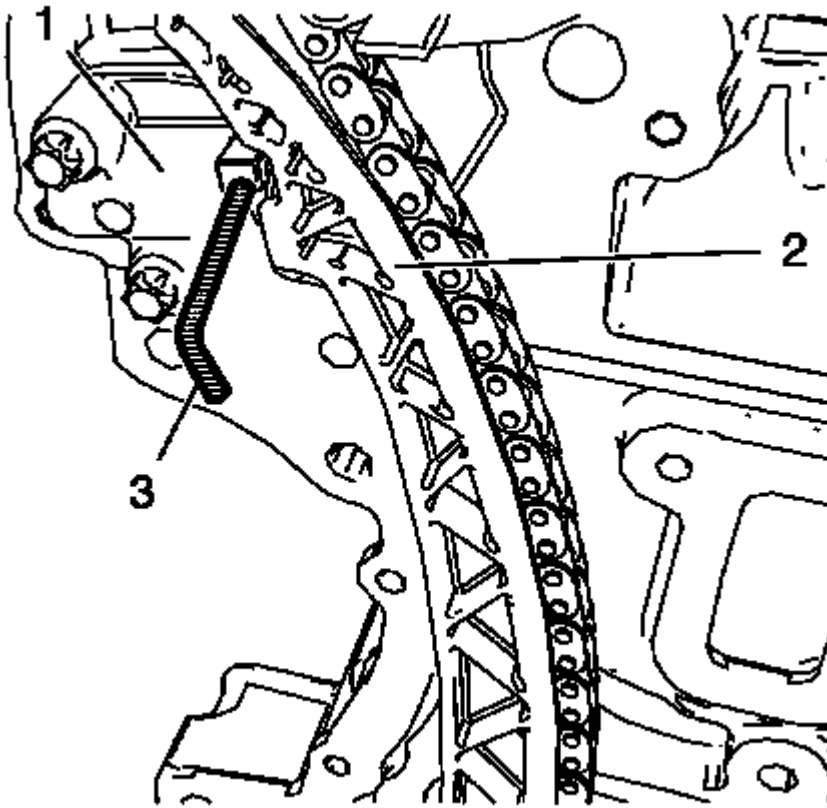
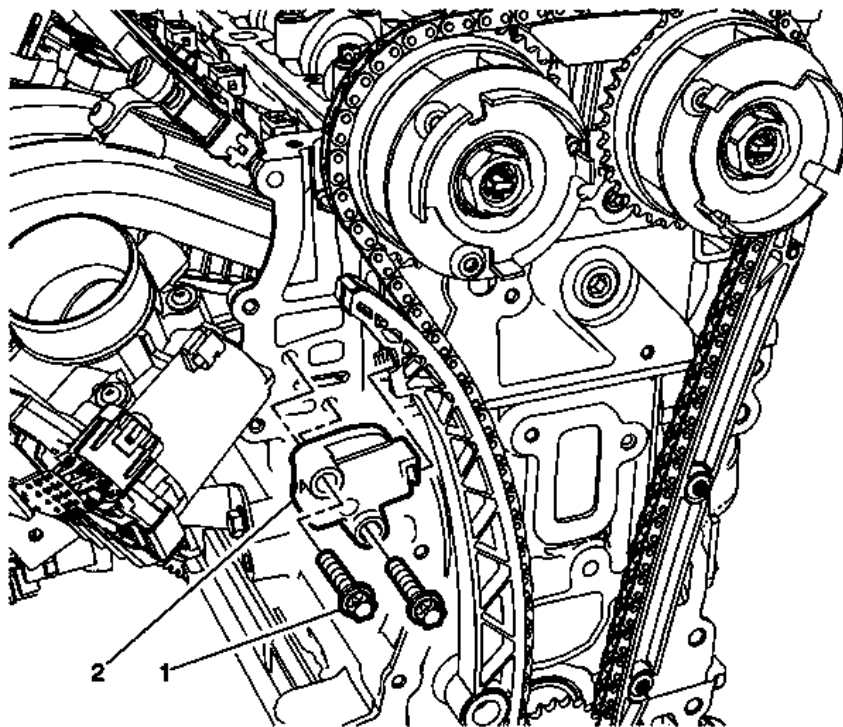


Fig. 34: Timing Chain And Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

9. Push the timing chain (2) in direction of the timing chain tensioner (1) and remove **EN-955-1** pin (3).
10. Install the engine front cover. Refer to **Engine Front Cover with Oil Pump Replacement**.

TIMING CHAIN TENSIONER REPLACEMENT

**Fig. 35: Timing Chain Tensioner**

Courtesy of GENERAL MOTORS COMPANY

Timing Chain Tensioner Replacement

Callout	Component Name
Preliminary Procedure Remove the camshaft timing chain. Refer to <u>Camshaft Timing Chain Replacement</u>	
1	Timing Chain Tensioner Fastener (Qty: 2) CAUTION: Refer to <u>Fastener Caution</u> . NOTE: The timing chain is installed in the graphic for location use only. But is required to be removed to perform the procedure. Tighten 8 N.m (71 lb in)
2	Timing Chain Tensioner Procedure Transfer the parts as necessary.

HYDRAULIC VALVE LASH ADJUSTER ARM REPLACEMENT

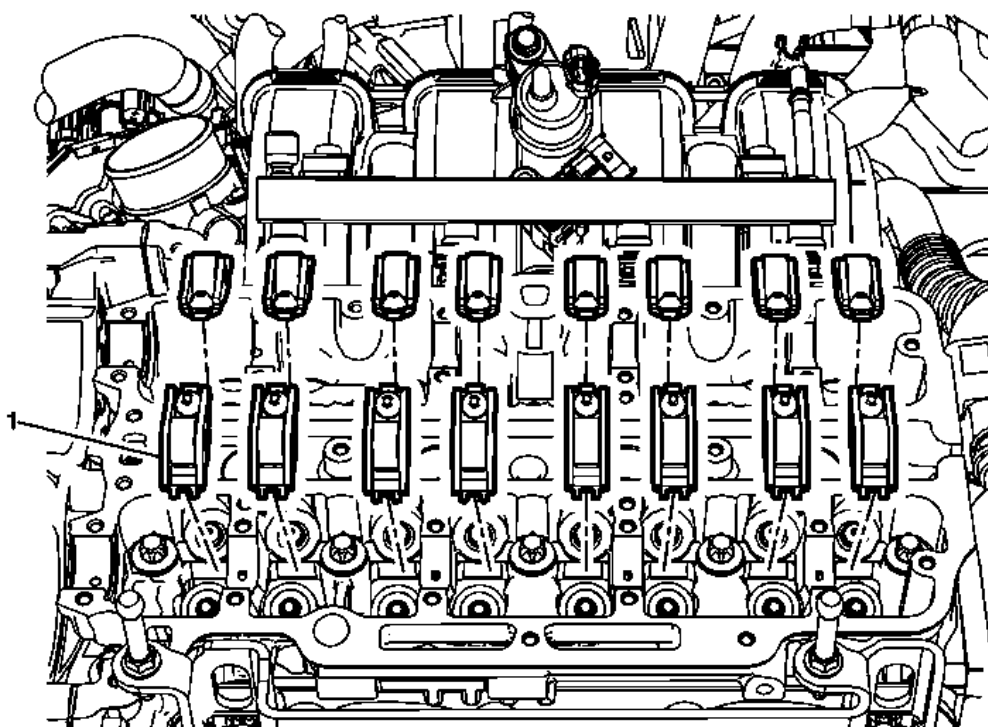


Fig. 36: Hydraulic Valve Lash Adjuster Arms
 Courtesy of GENERAL MOTORS COMPANY

Hydraulic Valve Lash Adjuster Arm Replacement

Callout	Component Name
Preliminary Procedures	
<ol style="list-style-type: none"> 1. Remove the intake camshaft. Refer to <u>Intake Camshaft Replacement</u>. 2. Remove the exhaust camshaft. Refer to <u>Exhaust Camshaft Replacement</u>. 	
1	Hydraulic Valve Lash Adjuster Arms Procedure <ol style="list-style-type: none"> 1. Mark the position of the hydraulic valve lash adjuster arms prior to removal to ensure the proper installation. 2. Lubricate the hydraulic valve lash adjuster arms with engine oil before installing the arms. 3. Transfer the parts as necessary.

HYDRAULIC VALVE LASH ADJUSTER REPLACEMENT

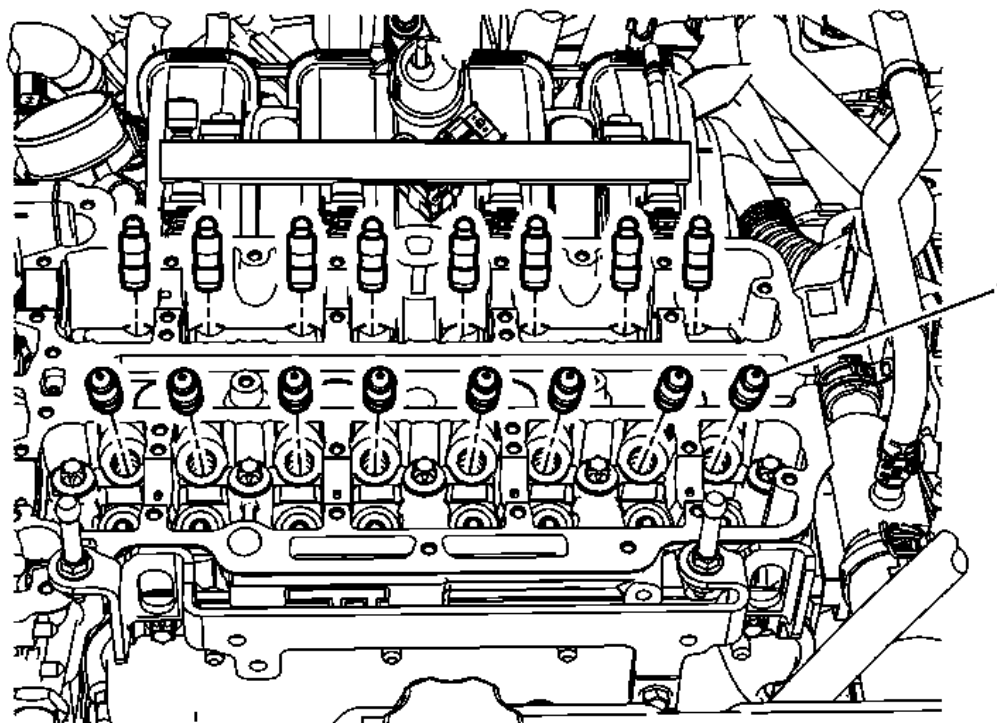


Fig. 37: Hydraulic Valve Lash Adjuster
 Courtesy of GENERAL MOTORS COMPANY

Hydraulic Valve Lash Adjuster Replacement

Callout	Component Name
Preliminary Procedures Remove the hydraulic valve lash adjuster arms. Refer to <u>Hydraulic Valve Lash Adjuster Arm Replacement</u>	
1	Hydraulic Valve Lash Adjuster Procedure <ol style="list-style-type: none"> 1. Mark the position of the hydraulic valve lash adjuster prior to removal to ensure the proper installation. 2. Lubricate the hydraulic valve lash adjuster with engine oil before installtion. 3. Transfer the parts as necessary.

CAMSHAFT INTAKE AND EXHAUST SPROCKET REPLACEMENT

Special Tools

EN-955 Locking Pin

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

Removal Procedure

WARNING: Always perform the High Voltage Disabling procedure prior to servicing any High Voltage component or connection. Personal Protection Equipment (PPE) and proper procedures must be followed.

The High Voltage Disabling procedure will perform the following tasks:

- Identify how to disable high voltage.
- Identify how to test for the presence of high voltage.
- Identify condition under which high voltage is always present and personal protection equipment (PPE) and proper procedures must be followed.

Failure to follow the procedures exactly as written may result in serious injury or death.

1. Disable the high voltage system. Refer to High Voltage Disabling .
2. Drain the cooling system. Refer to Cooling System Draining and Filling .
3. Disable the high voltage system. Refer to High Voltage Disabling .
4. Remove the camshaft cover. Refer to Camshaft Cover Replacement.
5. Remove both camshaft position actuator solenoid valves. Refer to Camshaft Position Actuator Solenoid Valve Replacement (Exhaust) , Camshaft Position Actuator Solenoid Valve Replacement (Intake) .
6. Remove the air conditioning compressor bracket. Refer to Air Conditioning Compressor Bracket Replacement .
7. Loosen the coolant recovery reservoir and position to aside. Refer to Coolant Recovery Reservoir Replacement .
8. Adjust the engine to TDC. Refer to Camshaft Timing Chain Adjustment.

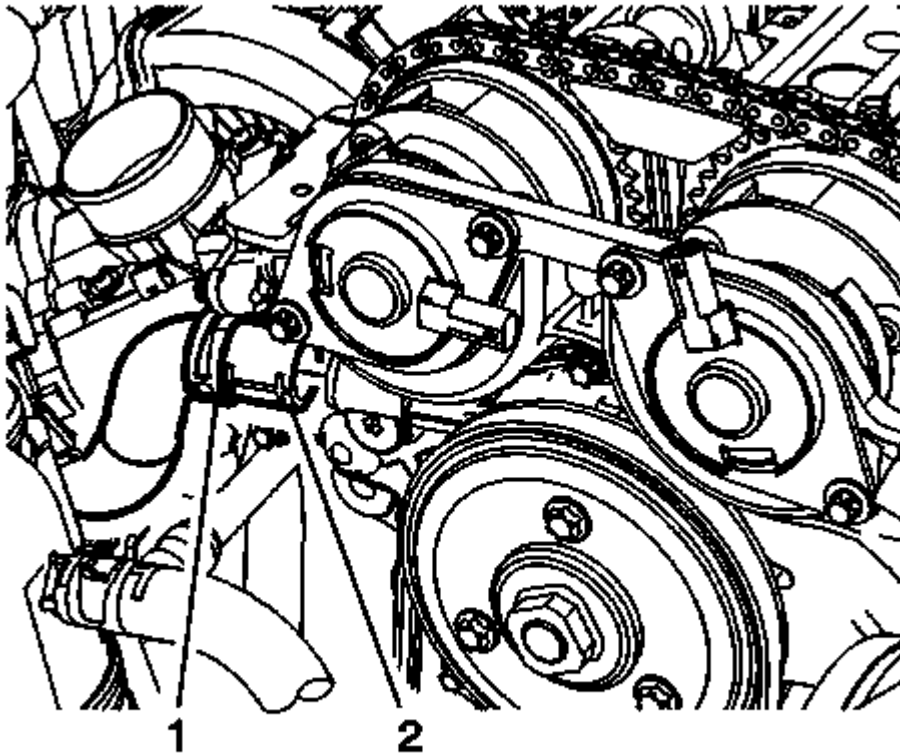


Fig. 38: Heater Water Shutoff Valve Inlet Hose And Clamp
Courtesy of GENERAL MOTORS COMPANY

9. Remove the heater water shutoff valve inlet hose clamp (1).
10. Disconnect the heater water shutoff valve inlet hose (2) from the water pump.

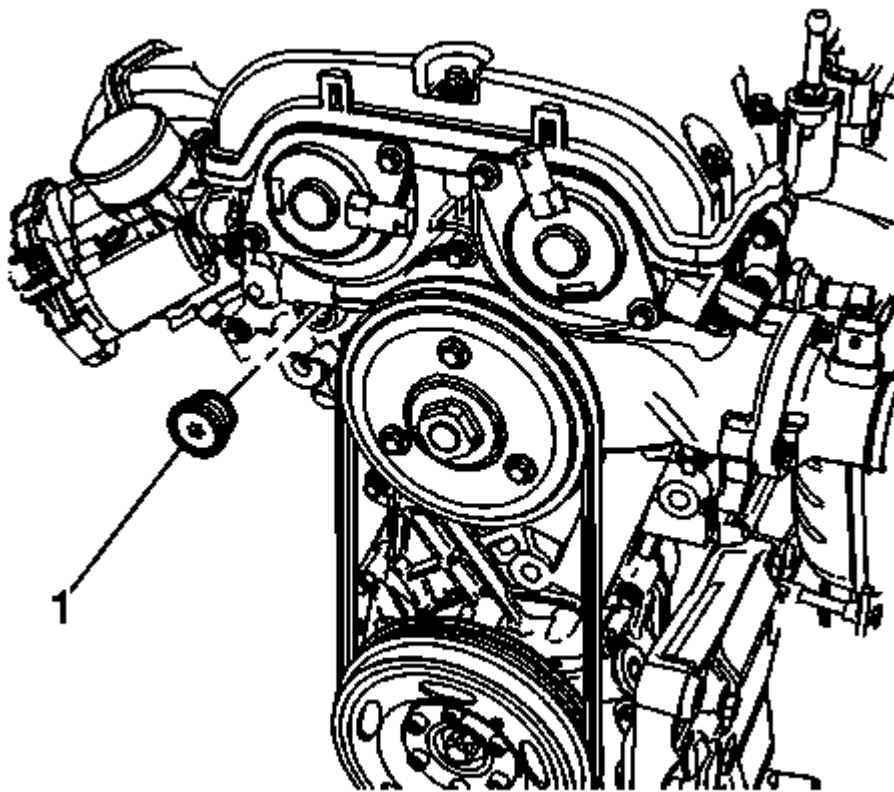


Fig. 39: Timing Chain Tensioner Plug
Courtesy of GENERAL MOTORS COMPANY

11. Remove the timing chain tensioner plug (1) from the engine front cover.

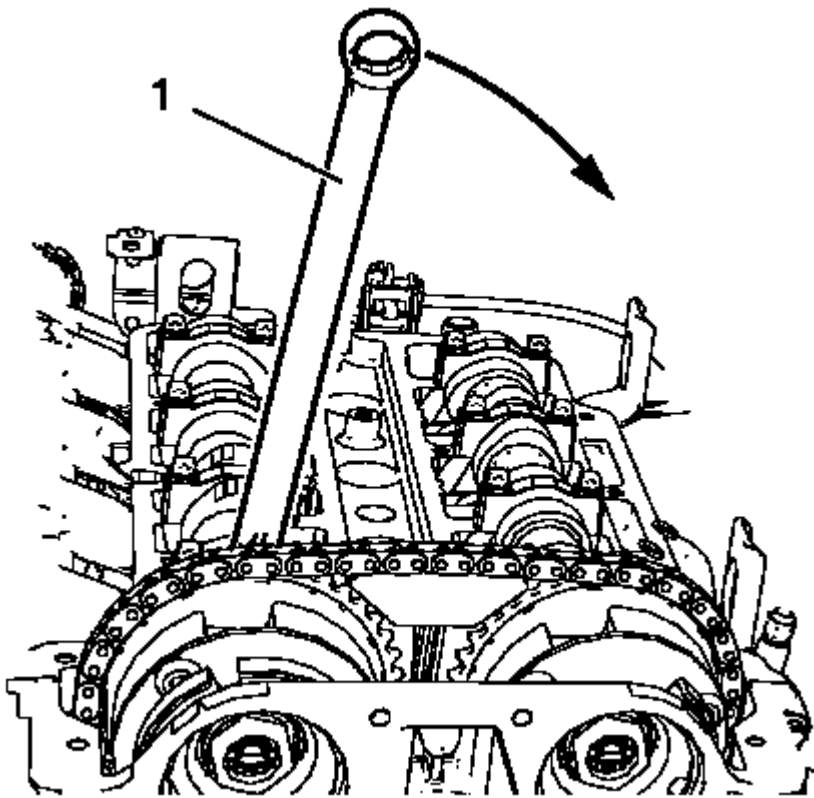


Fig. 40: Hexagonal Wrench Rotation Direction

Courtesy of GENERAL MOTORS COMPANY

12. Install a wrench (1) on the cast hexagonal portion of the intake camshaft, rotate the camshaft toward the exhaust camshaft in order to apply tension.

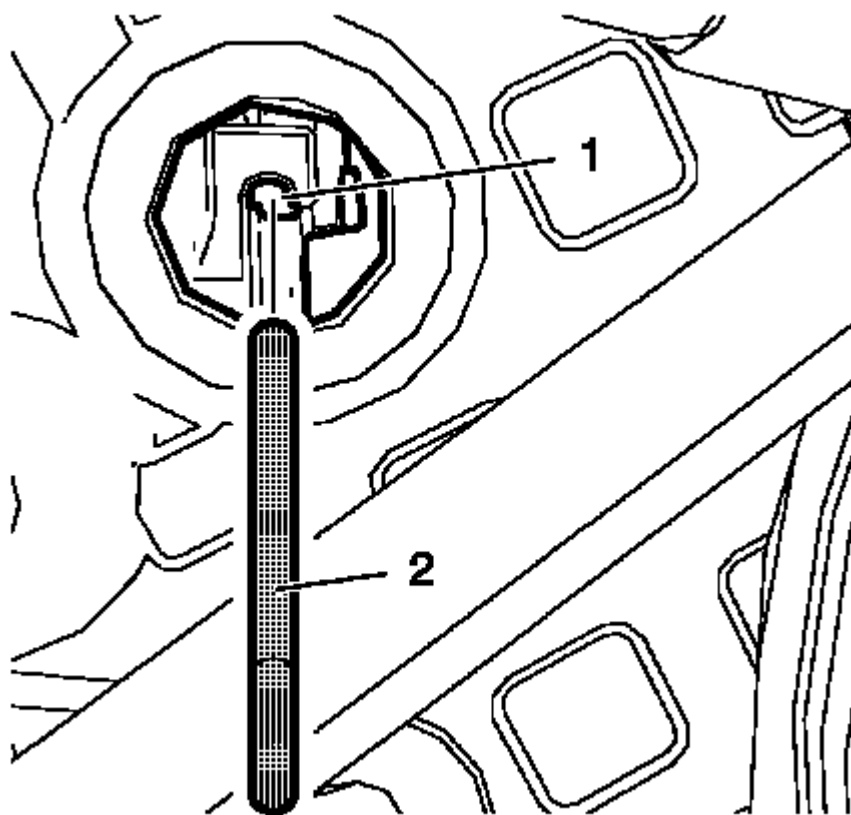


Fig. 41: Timing Chain Tensioner Bore And Pin
Courtesy of GENERAL MOTORS COMPANY

13. Install **EN-955-10** pin (2) to the timing chain tensioner bore (1).
14. Remove the wrench from intake camshaft.

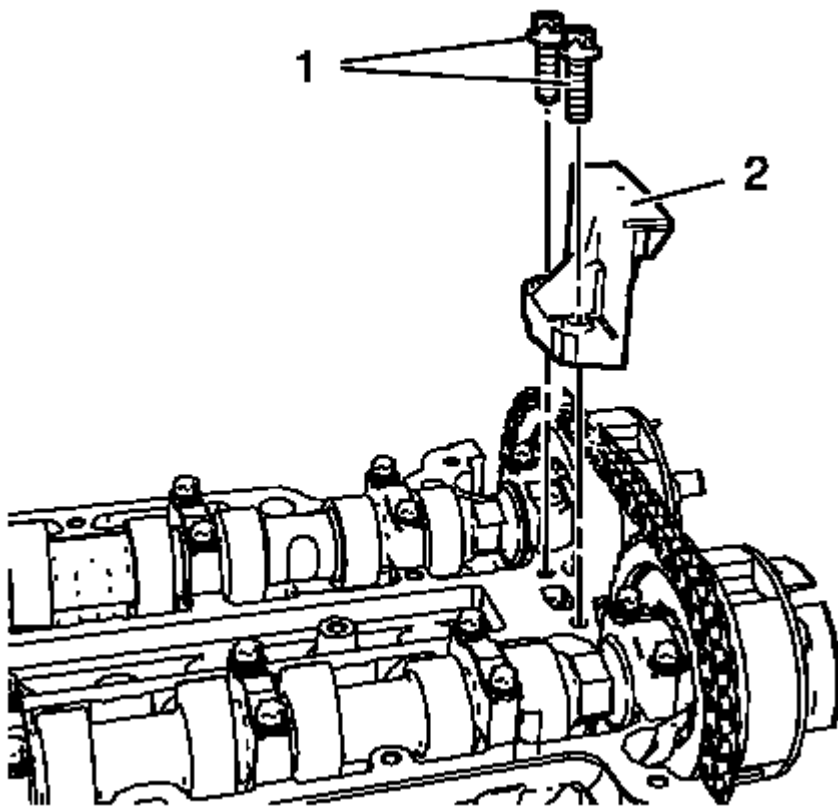


Fig. 42: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

15. Remove the 2 upper timing chain guide bolts (1).
16. Remove the upper timing chain guide (2).

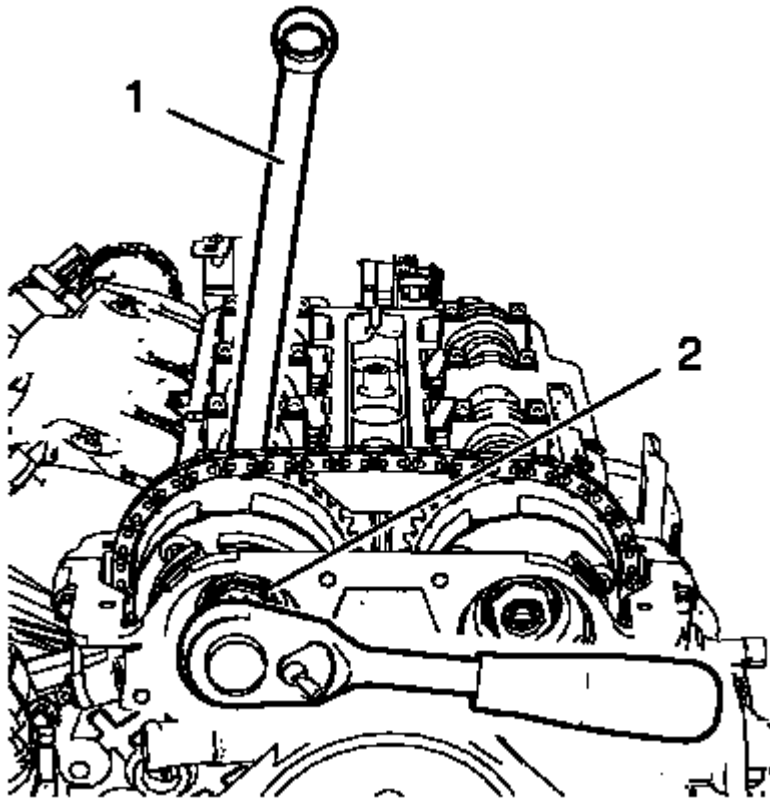


Fig. 43: Intake Camshaft Sprocket Bolt And Hexagonal Wrench
Courtesy of GENERAL MOTORS COMPANY

17. Loosen the intake camshaft sprocket bolt (2) while holding up the hexagon of the intake camshaft with a wrench (1).
18. Loosen the exhaust camshaft sprocket bolt while holding up the hexagon of the exhaust camshaft with a wrench.

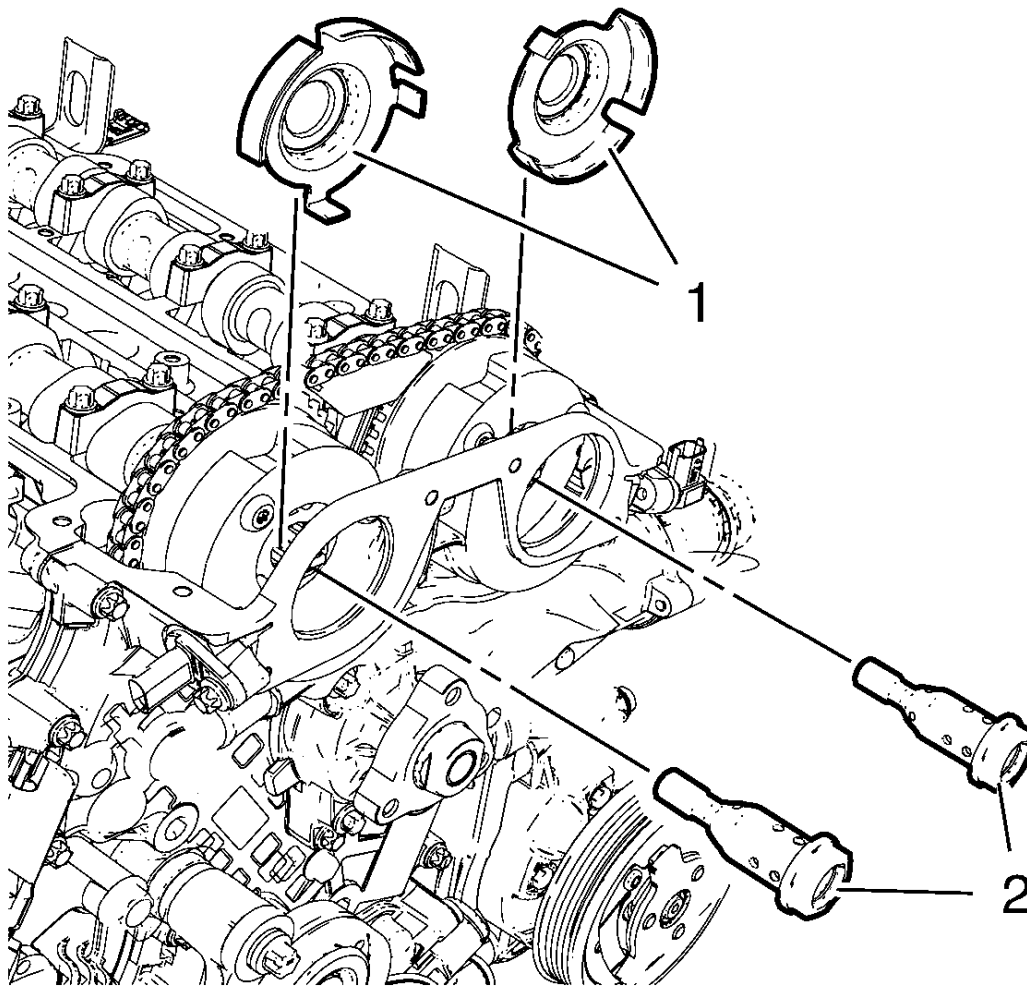


Fig. 44: Camshaft Position Exciter Wheels And Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS COMPANY

19. Remove the camshaft sprocket bolts (2) and the camshaft position exciter wheels (1).

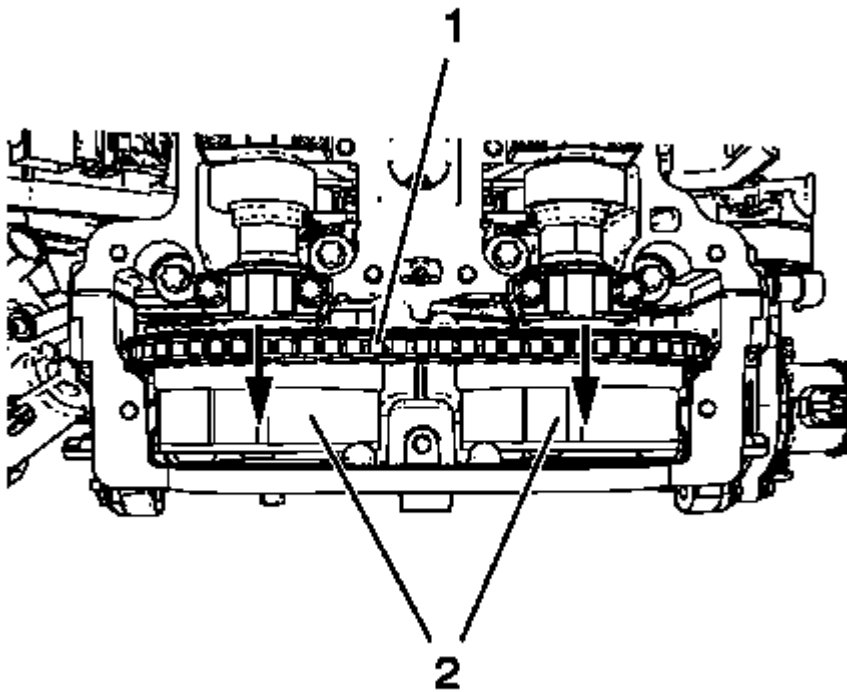


Fig. 45: Timing Chain And Camshaft Sprockets
Courtesy of GENERAL MOTORS COMPANY

20. Remove the camshaft sprockets (2) and timing chain (1) from the camshaft as one unit.

NOTE: The chain will not fall off the crankshaft sprocket because it is trapped by the front cover at the crankshaft sprocket.

21. Allow the chain to rest on the front cover.

Installation Procedure

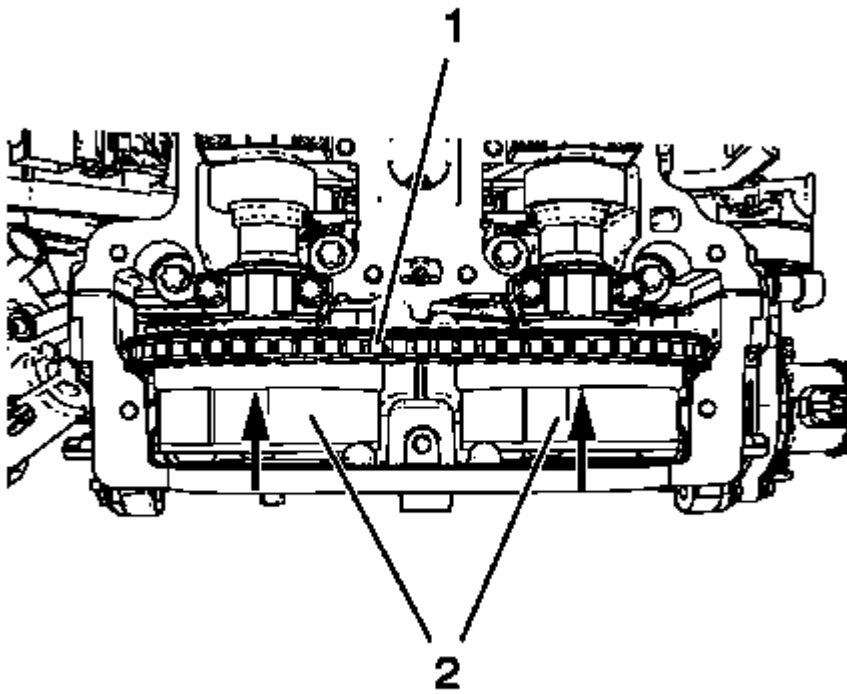


Fig. 46: Timing Chain And Camshaft Sprockets
Courtesy of GENERAL MOTORS COMPANY

1. Install the camshaft sprockets (2) and timing chain (1) as one unit.

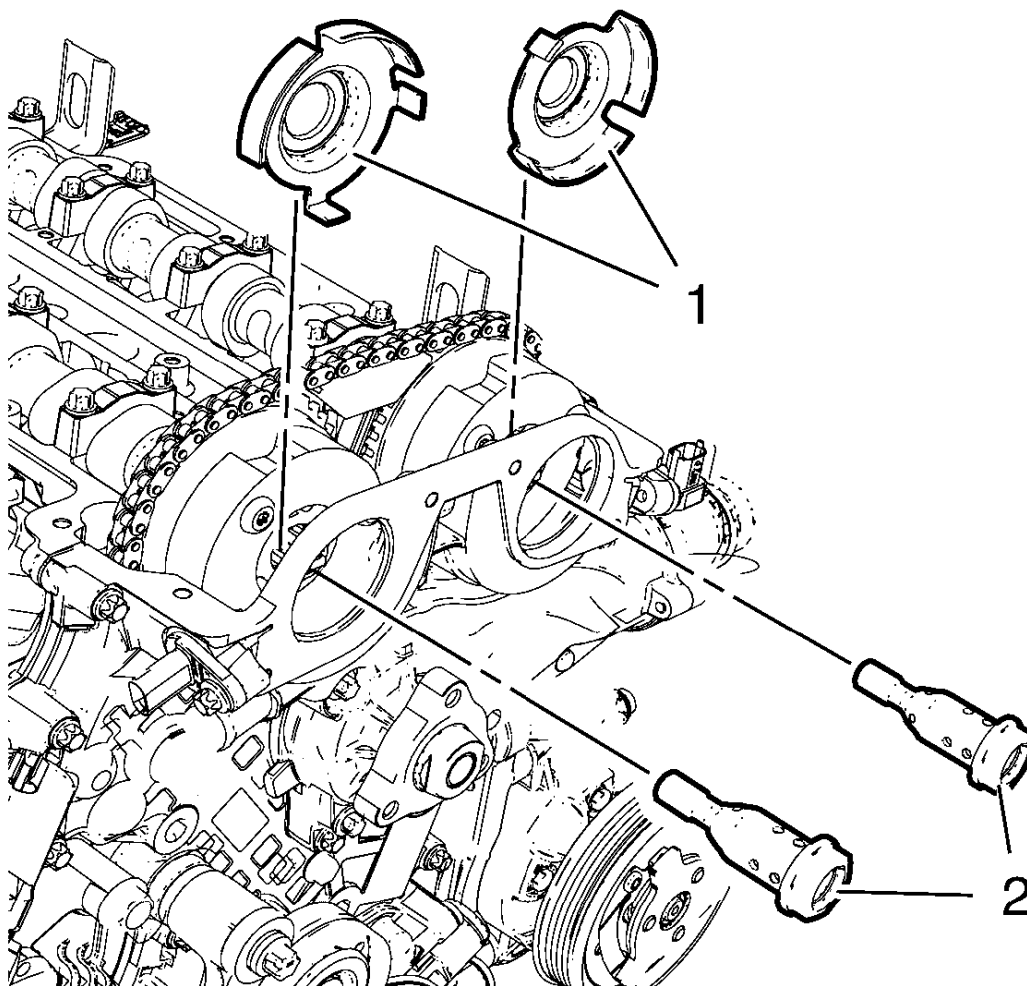


Fig. 47: Camshaft Position Exciter Wheels And Camshaft Sprocket Bolts
 Courtesy of GENERAL MOTORS COMPANY

2. Install the camshaft position exciter wheels (1).

CAUTION: Refer to Fastener Caution .

3. Install the camshaft sprocket bolts (2) and hand tighten.
4. Remove the **EN-955-10** pin.
5. Adjust the camshaft timing chain. Refer to Camshaft Timing Chain Adjustment.

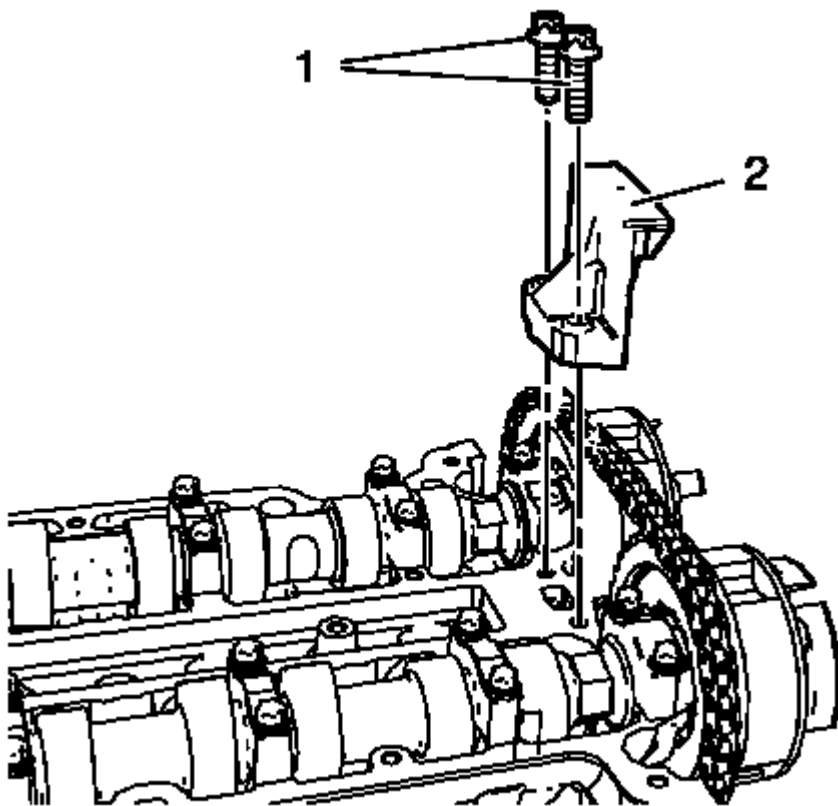


Fig. 48: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Install the upper timing chain guide (2).
7. Install the upper timing chain guide bolts (1) and tighten to 8 N.m (71 lb in).

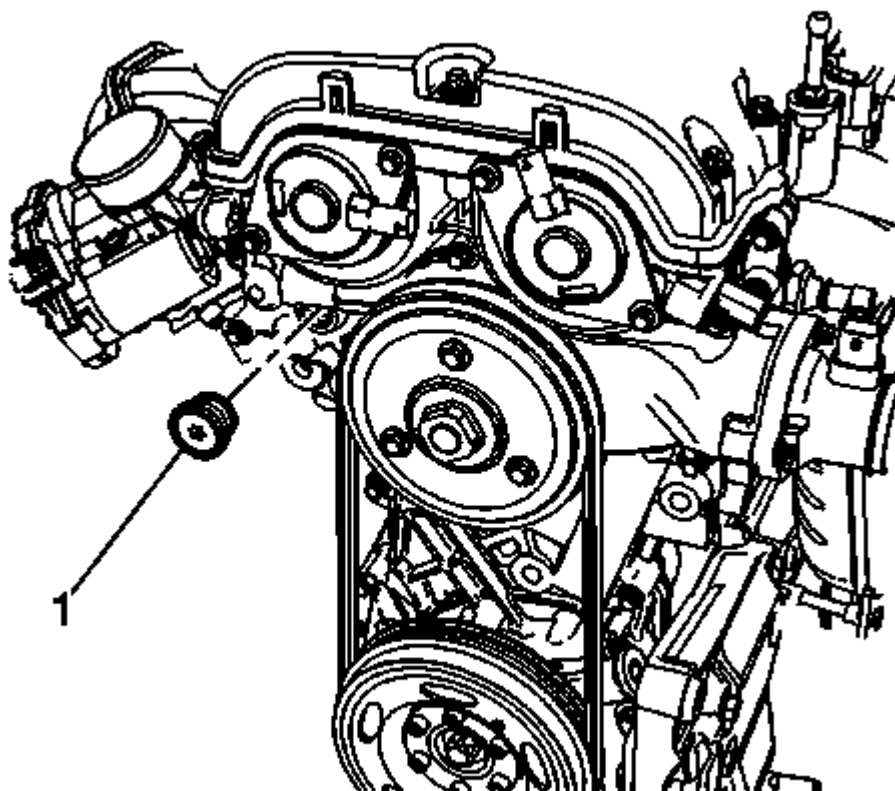


Fig. 49: Timing Chain Tensioner Plug
Courtesy of GENERAL MOTORS COMPANY

8. Install the timing chain tensioner plug (1) and tighten to 50 N.m (37 lb ft).
9. Install both camshaft position actuator solenoid valves. Refer to **Camshaft Position Actuator Solenoid Valve Replacement (Exhaust)** , **Camshaft Position Actuator Solenoid Valve Replacement (Intake)** .

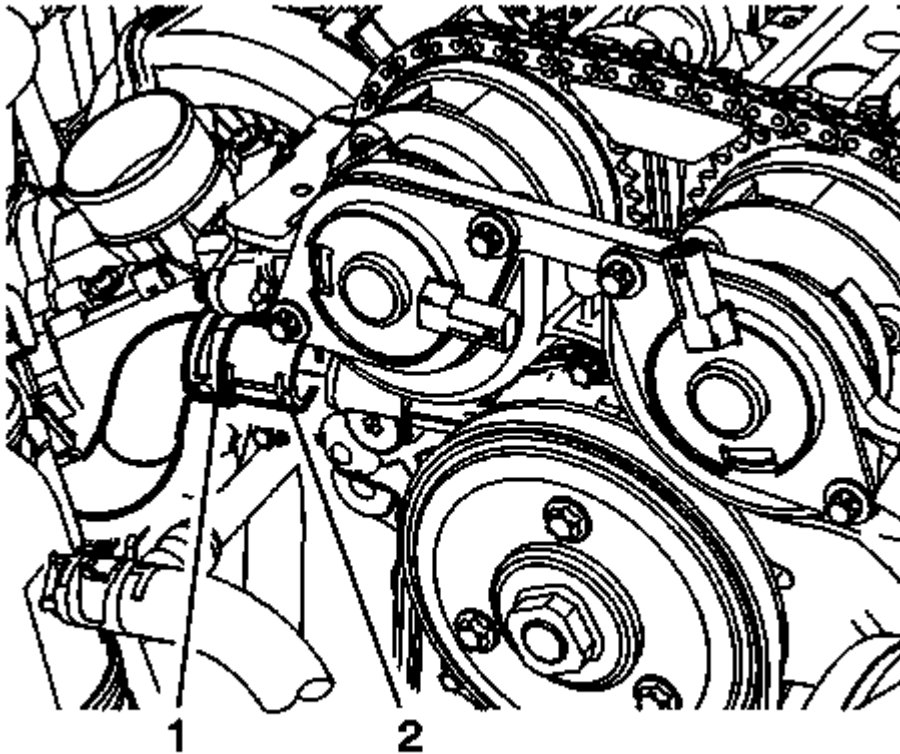


Fig. 50: Heater Water Shutoff Valve Inlet Hose And Clamp
Courtesy of GENERAL MOTORS COMPANY

10. Connect the heater water shutoff valve inlet hose (2) to the water pump.
11. Install the heater water shutoff valve inlet hose clamp (1).
12. Install the air conditioning compressor bracket. Refer to **Air Conditioning Compressor Bracket Replacement** .
13. Install the air conditioning and drive motor battery cooling compressor. Refer to **Air Conditioning and Drive Motor Battery Cooling Compressor Replacement** .
14. Install the coolant recovery reservoir. Refer to **Coolant Recovery Reservoir Replacement** .
15. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
16. Fill the cooling system. Refer to **Cooling System Draining and Filling** .
17. Enable the high voltage system. Refer to **High Voltage Enabling** .

CYLINDER HEAD REPLACEMENT

Special Tools

- **EN-470-B** Angular Torque Wrench
- **EN-955-10** Locking Pin

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

Removal Procedure

WARNING: Always perform the High Voltage Disabling procedure prior to servicing any High Voltage component or connection. Personal Protection Equipment (PPE) and proper procedures must be followed.

The High Voltage Disabling procedure will perform the following tasks:

- Identify how to disable high voltage.
- Identify how to test for the presence of high voltage.
- Identify condition under which high voltage is always present and personal protection equipment (PPE) and proper procedures must be followed.

Failure to follow the procedures exactly as written may result in serious injury or death.

1. Disable the high voltage system. Refer to **High Voltage Disabling** .
2. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
3. Remove the exhaust manifold. Refer to **Exhaust Manifold with Catalytic Converter Replacement** .
4. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
5. Install engine support fixture. Refer to **Engine Support Fixture**.
6. Remove the water pump. Refer to **Water Pump Replacement** .
7. Remove the water outlet. Refer to **Water Outlet Replacement** .
8. Remove the camshaft position actuator solenoid valve intake and exhaust. Refer to **Camshaft Position Actuator Solenoid Valve Replacement (Exhaust)** , **Camshaft Position Actuator Solenoid Valve Replacement (Intake)** .
9. Remove the camshaft position sensor exhaust only. Refer to **Camshaft Position Sensor Replacement (Exhaust)** , **Camshaft Position Sensor Replacement (Intake)** .
10. Remove the air conditioning compressor bracket. Refer to **Air Conditioning Compressor Bracket Replacement** .
11. Adjust the engine to TDC. Refer to **Camshaft Timing Chain Inspection**.

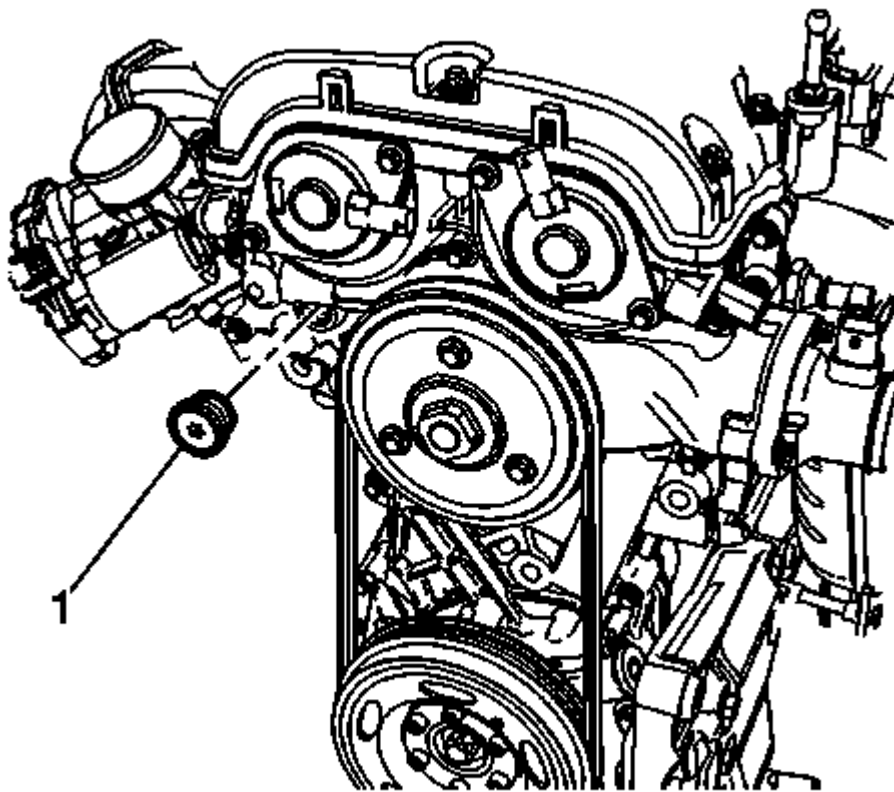


Fig. 51: Timing Chain Tensioner Plug
Courtesy of GENERAL MOTORS COMPANY

12. Remove the timing chain tensioner plug (1) from the engine front cover.

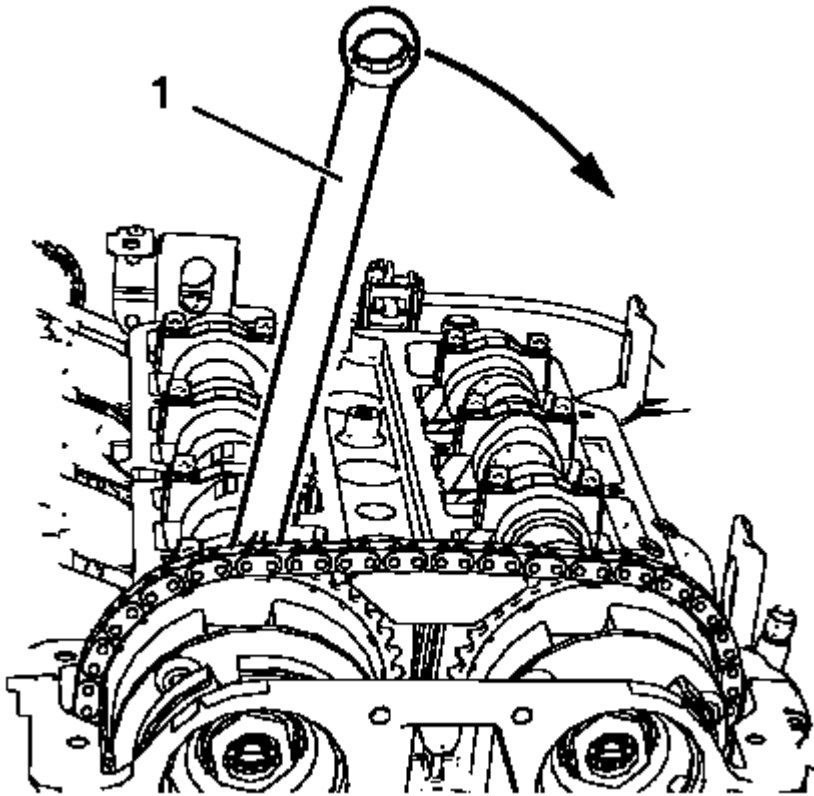


Fig. 52: Hexagonal Wrench Rotation Direction
Courtesy of GENERAL MOTORS COMPANY

13. Install a wrench (1) on the cast hexagonal portion of the intake camshaft, rotate the camshaft toward the exhaust camshaft in order to apply tension.

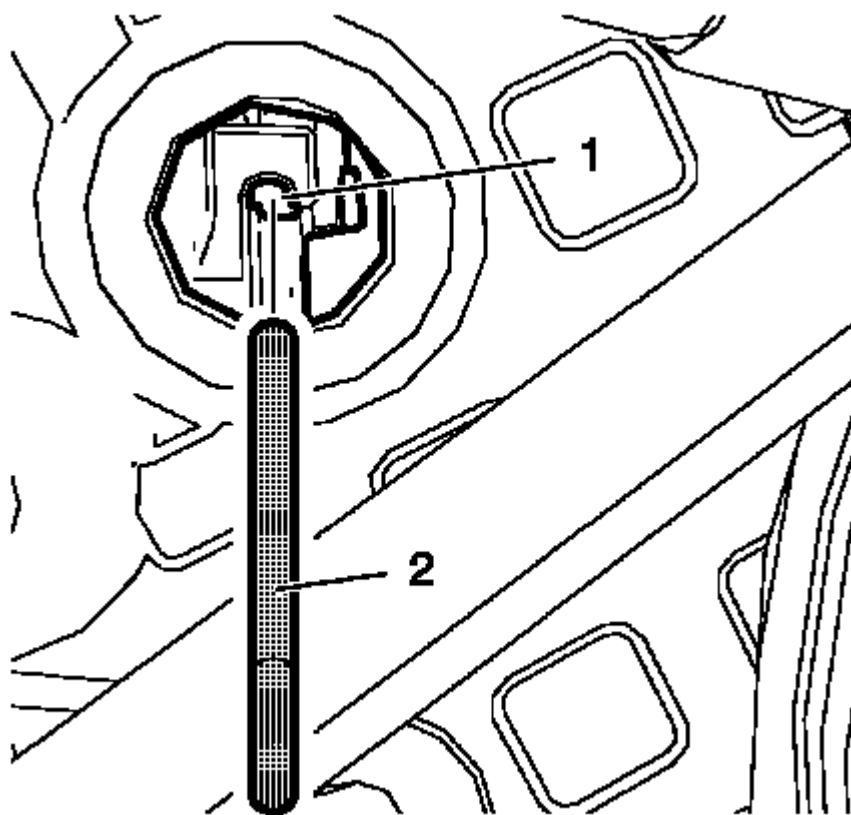


Fig. 53: Timing Chain Tensioner Bore And Pin
Courtesy of GENERAL MOTORS COMPANY

14. Install **EN-955-10** Locking Pin (2) to the timing chain tensioner bore (1).
15. Remove the wrench from intake camshaft.

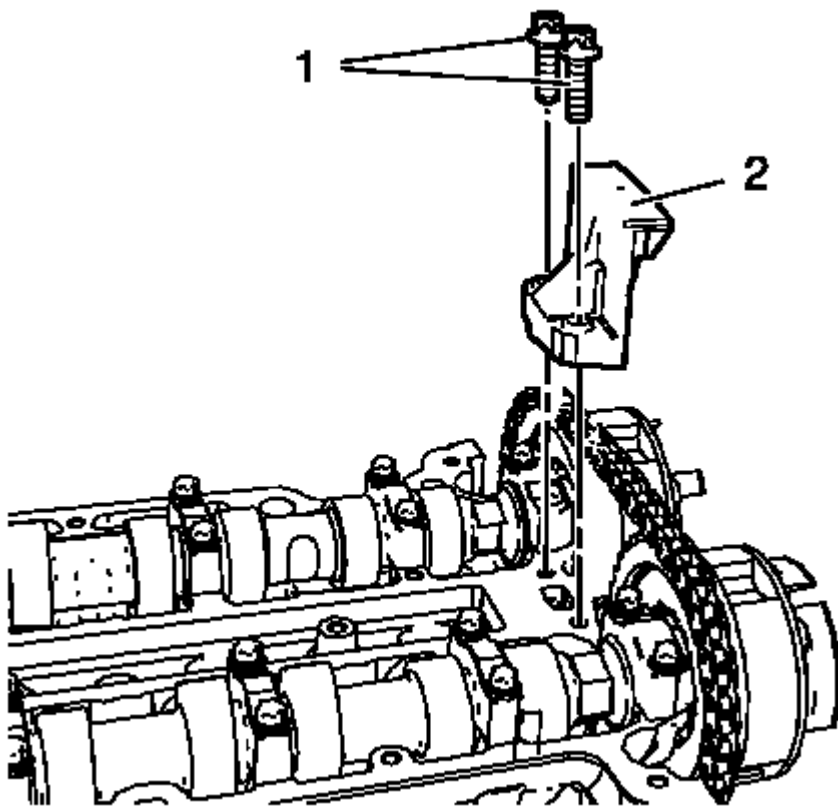


Fig. 54: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

16. Remove the 2 upper timing chain guide bolts (1).
17. Remove the upper timing chain guide (2).

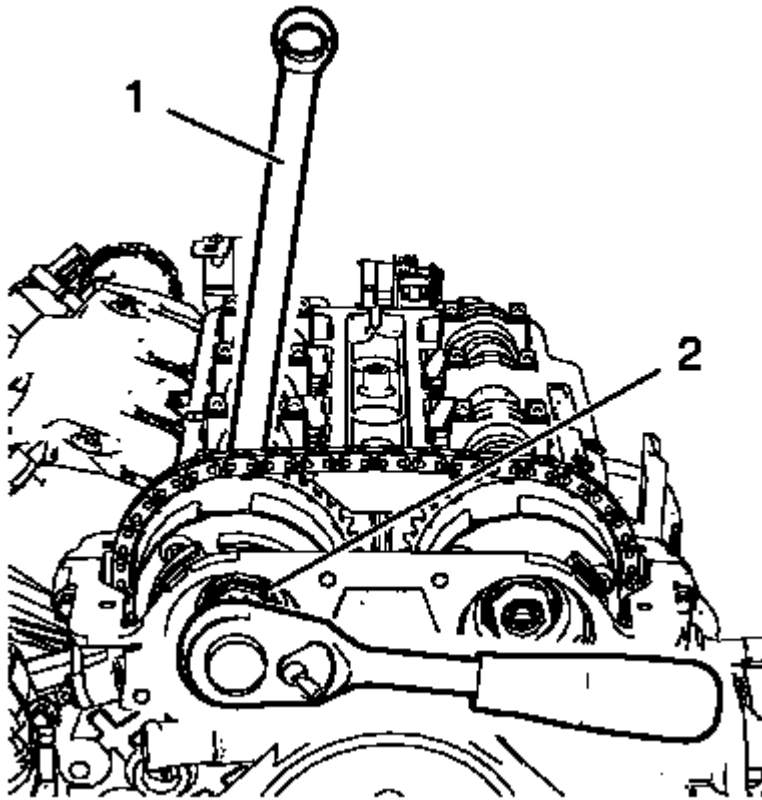


Fig. 55: Intake Camshaft Sprocket Bolt And Hexagonal Wrench
Courtesy of GENERAL MOTORS COMPANY

18. Loosen the intake camshaft sprocket bolt (2) while holding up the hexagon of the intake camshaft with a wrench (1).
19. Loosen the exhaust camshaft sprocket bolt while holding up the hexagon of the exhaust camshaft with a wrench.

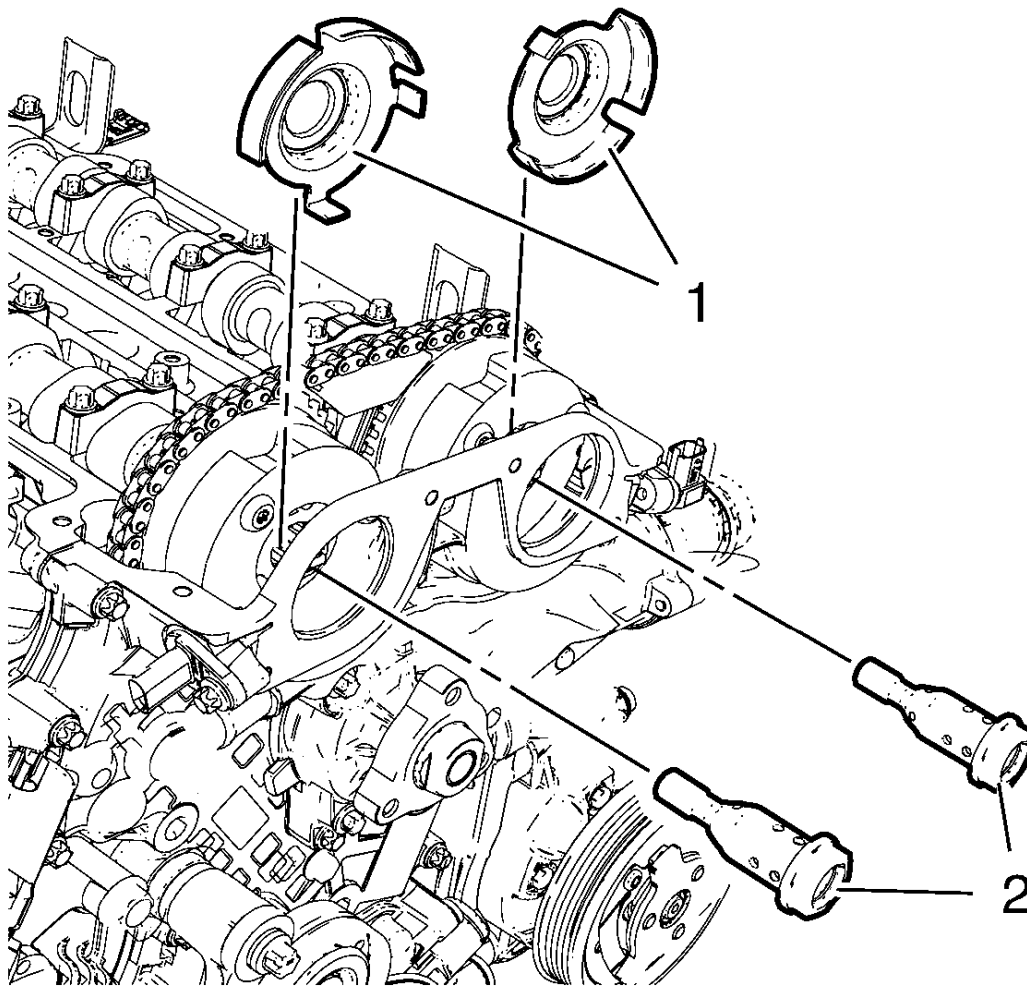


Fig. 56: Camshaft Position Exciter Wheels And Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS COMPANY

20. Remove and Discard the camshaft sprocket bolts (2).
21. Remove the camshaft position exciter wheels (1).

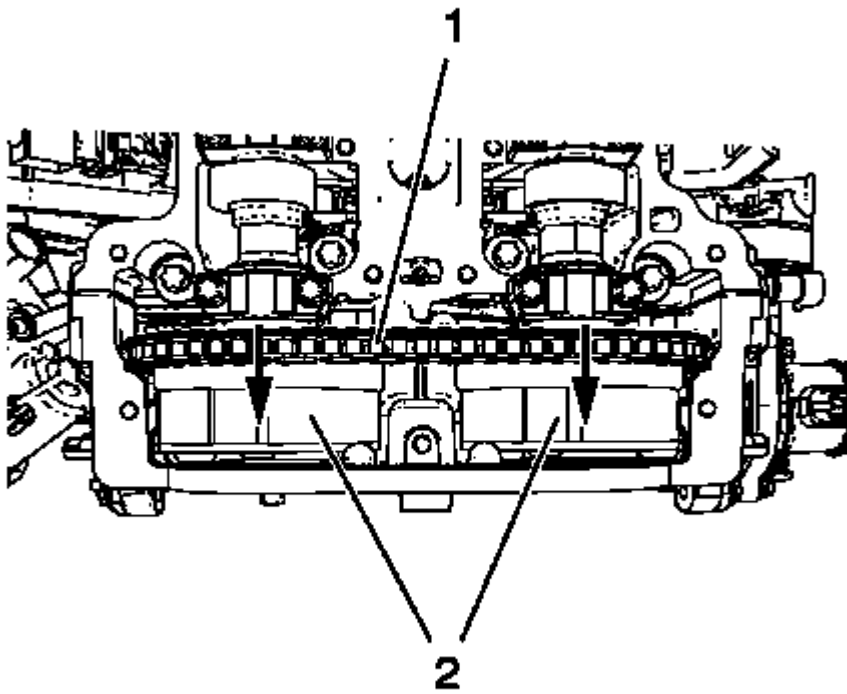


Fig. 57: Timing Chain And Camshaft Sprockets
Courtesy of GENERAL MOTORS COMPANY

22. Remove the camshaft sprockets (2) and timing chain (1) as one unit.
23. Disconnect electrical connectors as necessary.
24. Reposition electrical harness aside.
25. Allow the camshaft sprockets (2) and timing chain (1) rest on the front cover Do NOT remove sprockets or chain.
26. Place a floor jack with block of wood under the oil pan.
27. Remove engine support fixture. Refer **Engine Support Fixture**.

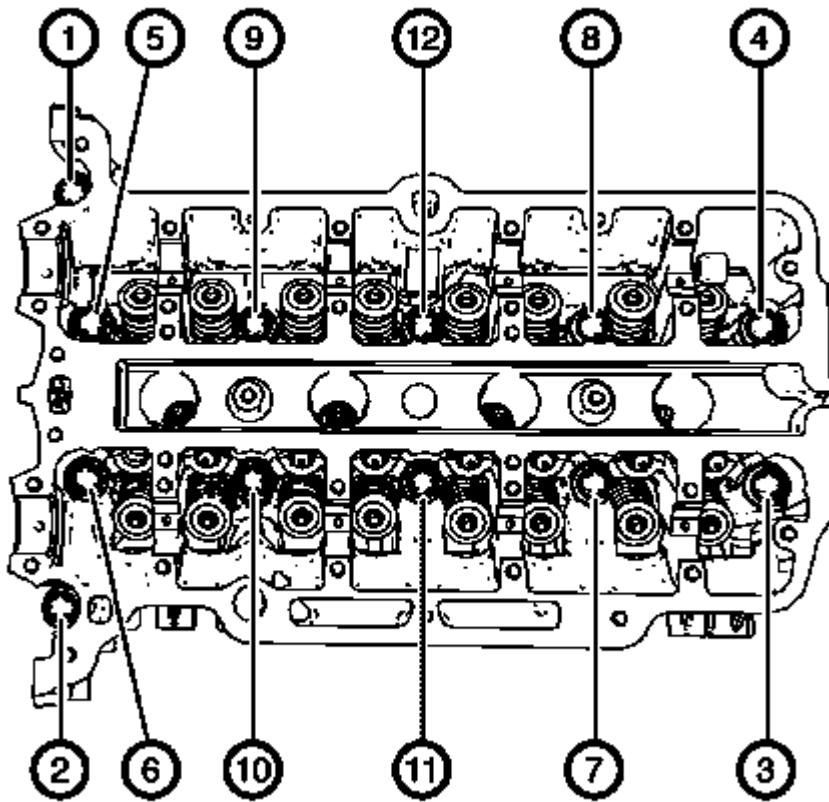


Fig. 58: Cylinder Head Bolts Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

28. Loosen the 12 cylinder head bolts in the sequence as shown above. Use the following procedure:
- First pass: Loosen the cylinder head bolts 90 degrees.
 - Final pass: Loosen the cylinder head bolts 180 degrees.

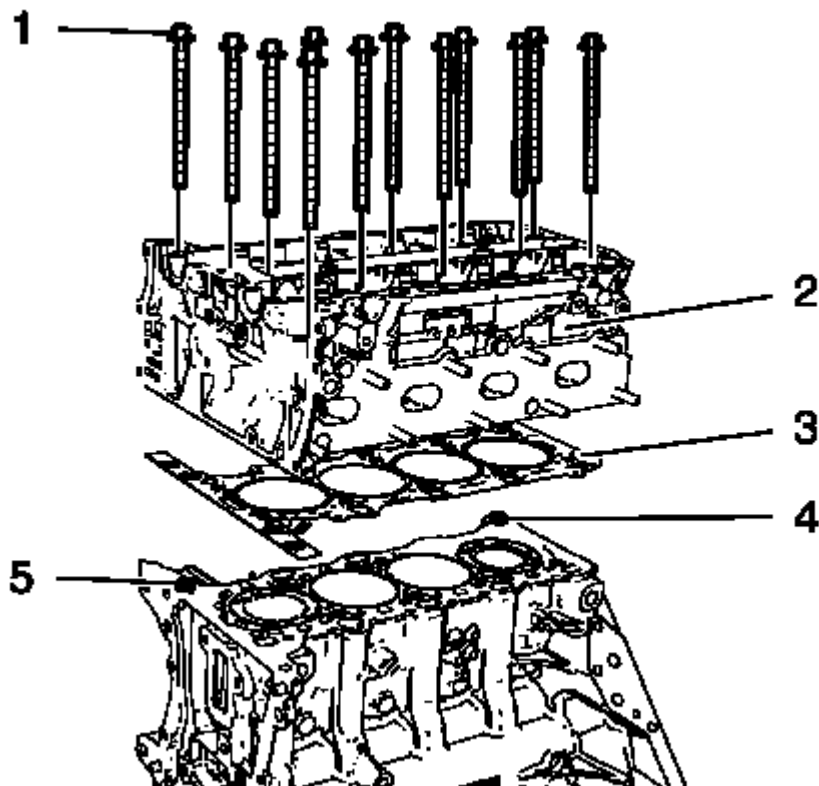


Fig. 59: Cylinder Head, Gasket, Bolts And Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not damage the guide sleeves (4) and (5).

29. Remove the cylinder head bolts (1).
30. With the aid of helper, lift the timing chain side of the cylinder head assembly slightly in direction of the transmission.
31. Remove the cylinder head (2).
32. Remove the cylinder head gasket (3) and discard the gasket.

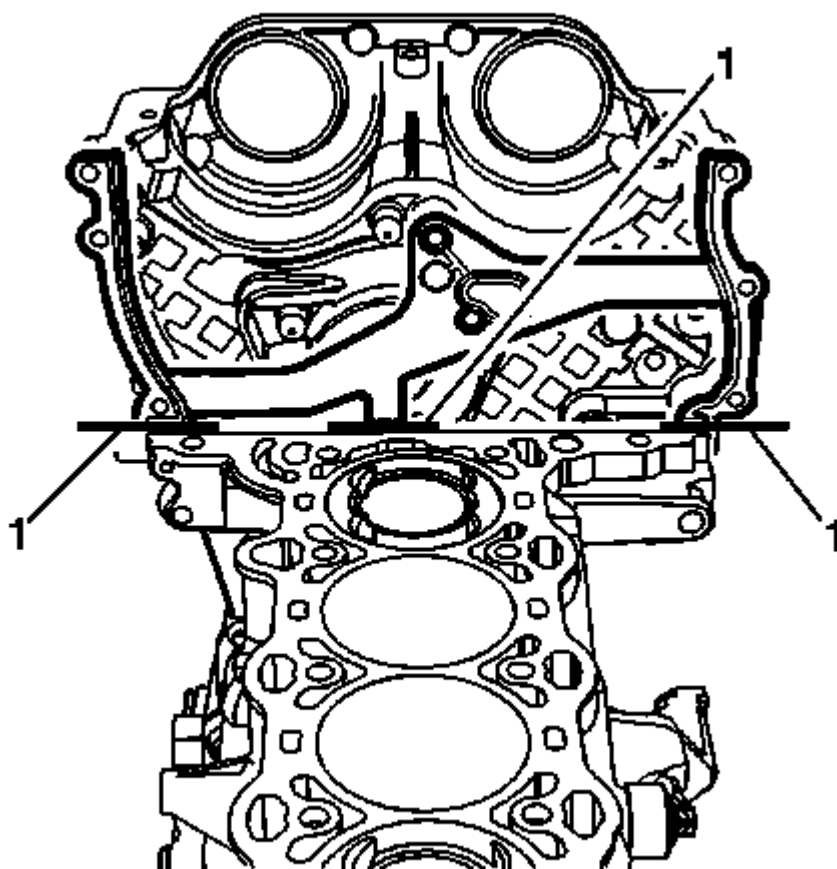


Fig. 60: Top Third Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS COMPANY

33. With the cylinder head out of vehicle bend the top third of the engine front cover gasket (1) back and forth until snaps off at the breaking point.
34. Transfer parts as necessary.
35. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.
36. For disassembly of the cylinder head. Refer to **Cylinder Head Disassemble**.

Installation Procedure

1. For disassembly of the cylinder head. Refer to **Cylinder Head Assemble**.
2. Clean sealing surfaces of engine front cover and engine block from grease and old gasket material.

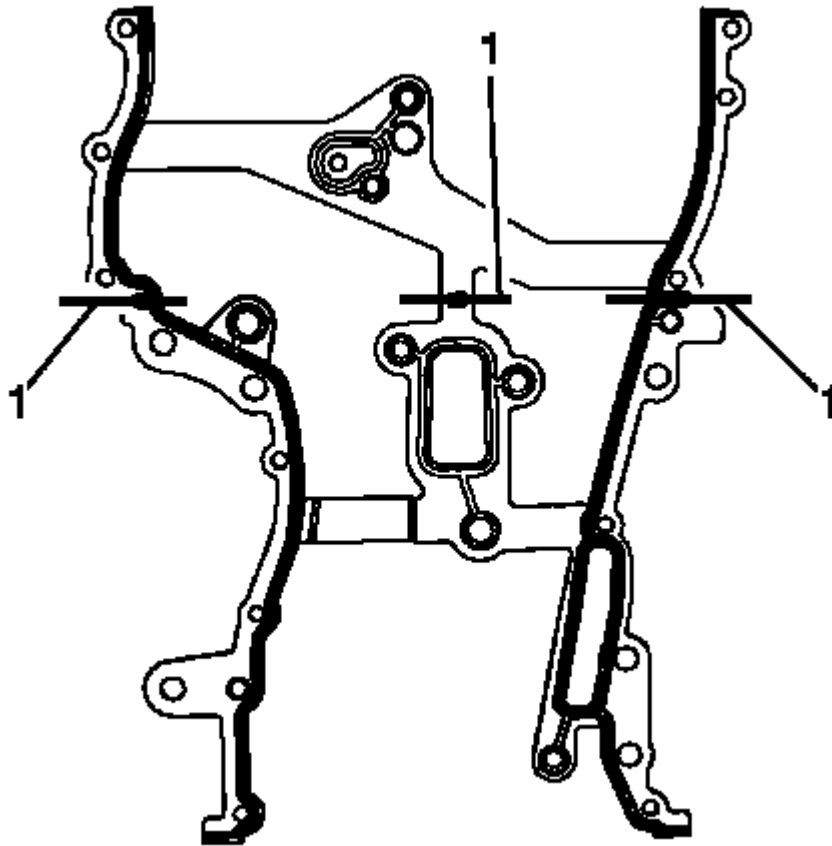
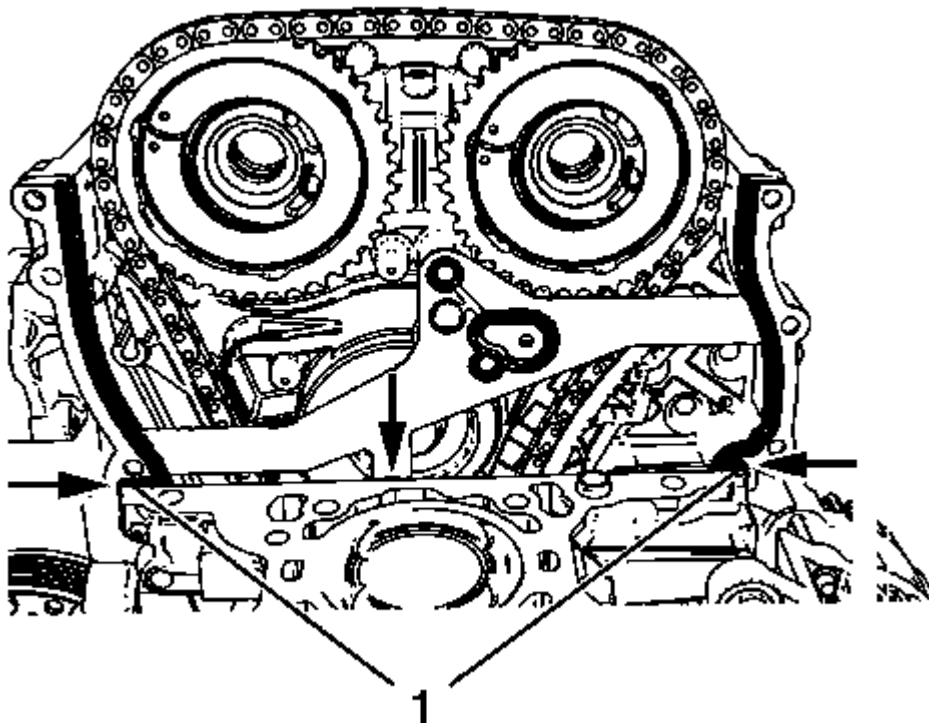


Fig. 61: engine front cover gasket

Courtesy of GENERAL MOTORS COMPANY

NOTE: The engine front cover gasket comes as a complete unit.

3. Before installation the of the new front cover gasket, bend the top third of the engine front cover gasket (1) back and forth until snaps off at the breaking point.

**Fig. 62: Elastomer Sealing Strips****Courtesy of GENERAL MOTORS COMPANY**

4. Install the engine front cover gasket (1) to ensure for a proper fit and alignment.
5. Clean the surface of the cylinder head and engine front cover.
6. Install the cylinder head gasket to engine block.

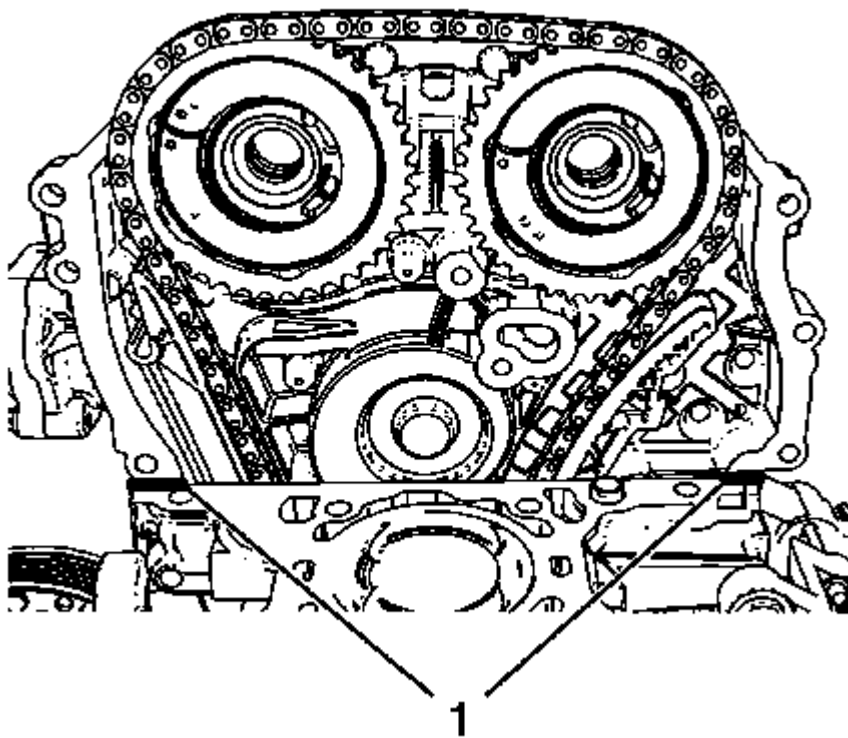


Fig. 63: Sealing Compound Application Area
Courtesy of GENERAL MOTORS COMPANY

7. Apply a 2 mm (0.0787 in) bead of RTV sealant to the areas shown (1).

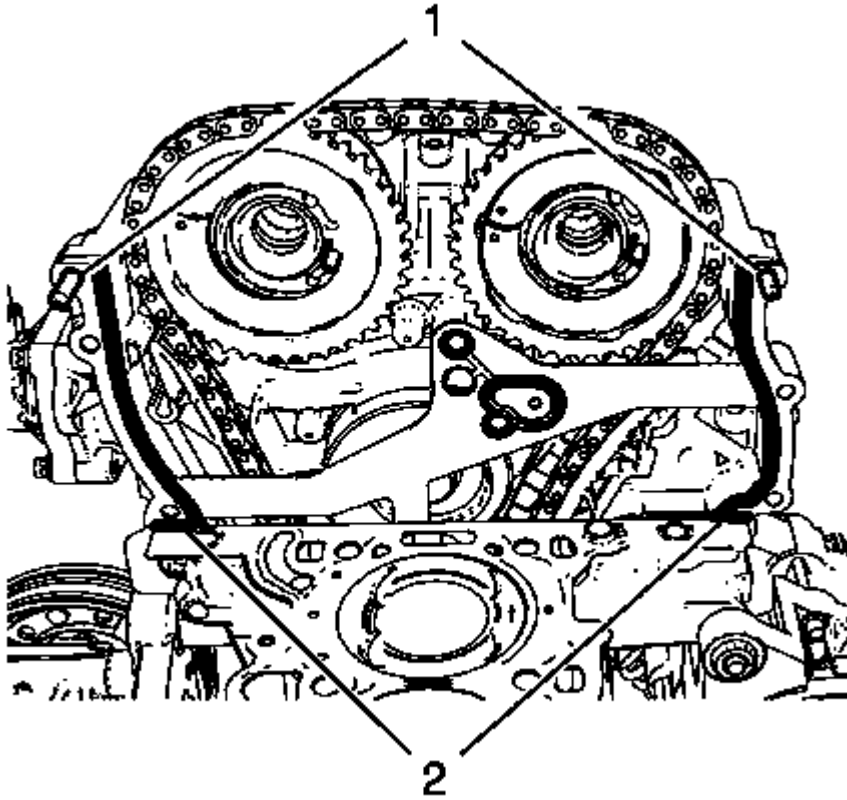


Fig. 64: Engine Front Cover Bolts And Sealing Compound Application Areas
Courtesy of GENERAL MOTORS COMPANY

8. Install engine front cover bolts (1) in order to guide the NEW upper engine front cover gasket.
9. Apply a 2 mm (0.0787 in) bead of RTV sealant to the areas shown (2).

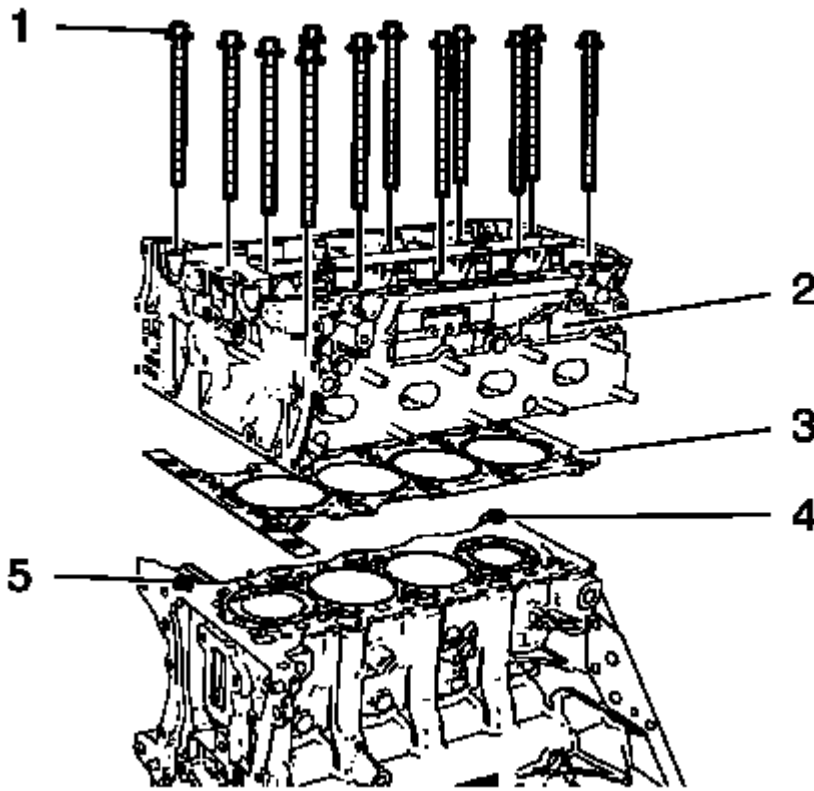


Fig. 65: Cylinder Head, Gasket, Bolts And Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

10. Ensure the guide sleeves are in place (4) and (5) before installing the cylinder head.
11. Install a NEW cylinder head gasket (3). The marking "Top" should point to the cylinder head.
12. Install the cylinder head (2).
13. Install the cylinder head bolts (1) and hand tighten only.

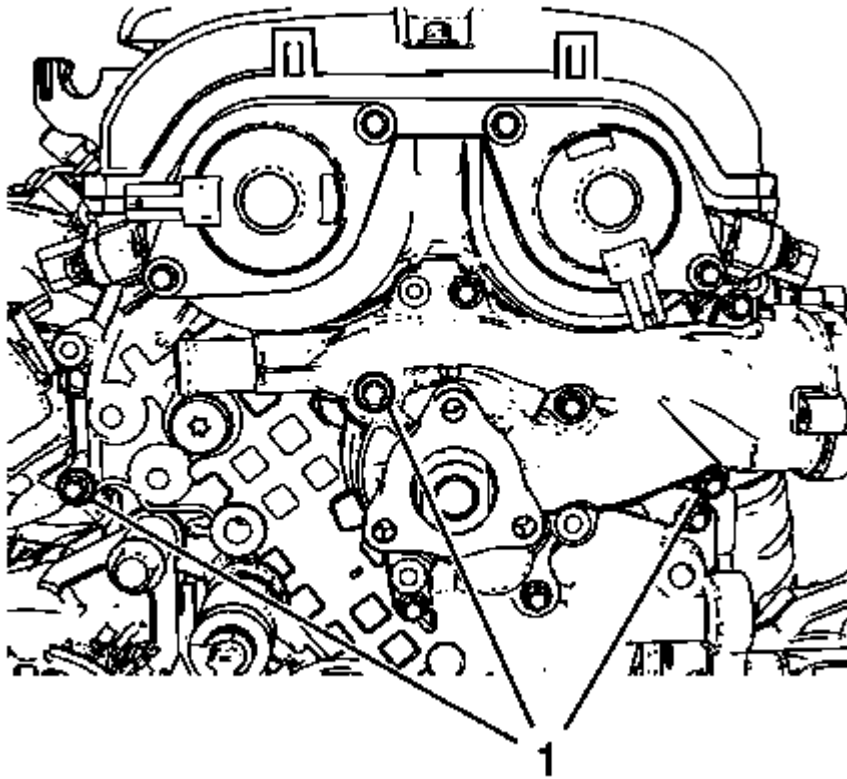


Fig. 66: Engine Front Cover Bolts

Courtesy of GENERAL MOTORS COMPANY

14. Adjust the cylinder head to the engine front cover. Use a rubber mallet.
15. Position the engine front cover to cylinder head by installing 3 bolts (1).

CAUTION: Refer to Fastener Caution .

16. Tighten the 3 bolts (1) to 8 (71 lb in).

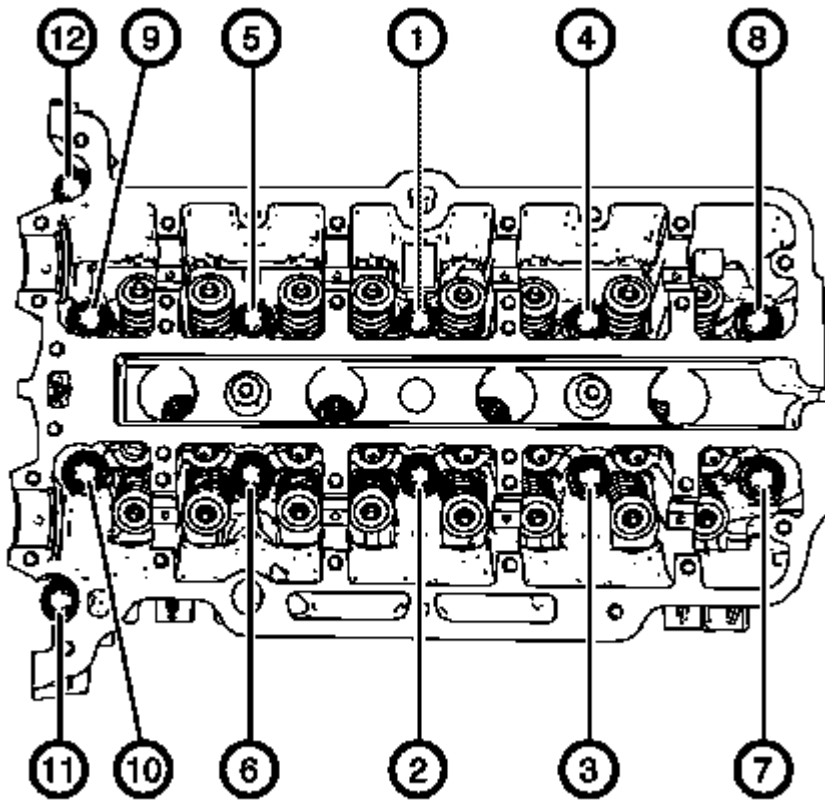


Fig. 67: Cylinder Head Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

17. Using a **EN-470-B** angular torque wrench tighten the cylinder head bolts in the sequence as shown above. Tighten the cylinder head bolts to:
- First pass 35 (26 lb ft).
 - Final pass plus 180 degrees

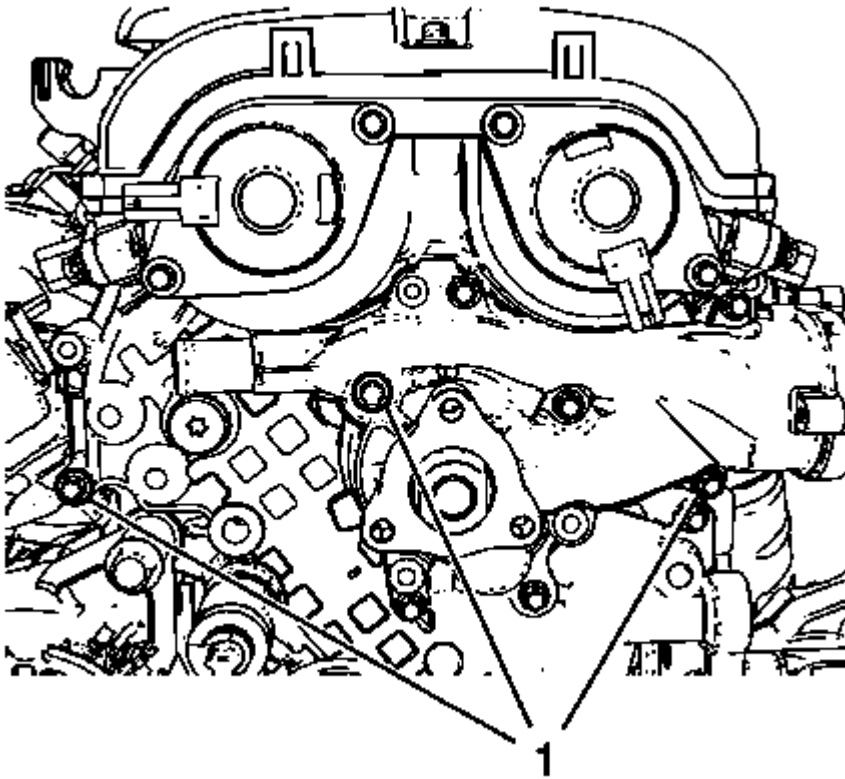


Fig. 68: Engine Front Cover Bolts

Courtesy of GENERAL MOTORS COMPANY

18. Loosen the bolts from engine front cover (1).

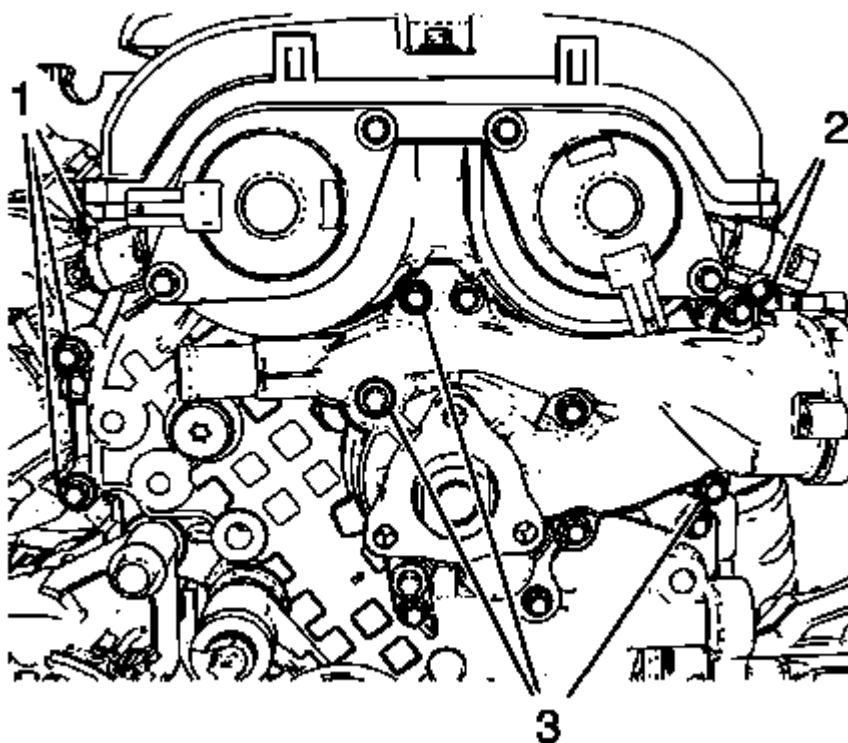


Fig. 69: Engine Front Cover Bolts And Water Pump Bolts
Courtesy of GENERAL MOTORS COMPANY

19. Install the remaining bolts to engine front cover and water pump.
20. Tighten the engine front cover bolts (1) and (2) to 8 (71 lb in).
21. Tighten the water pump bolts (3) to 8 (71 lb in).
22. Install the water pump pulley. Refer to **Water Pump Pulley Replacement** .
23. Install engine mount bracket. Refer to **Engine Mount Bracket Replacement - Right Side**.
24. Install the engine mount. Refer to **Engine Mount Replacement - Right Side**.

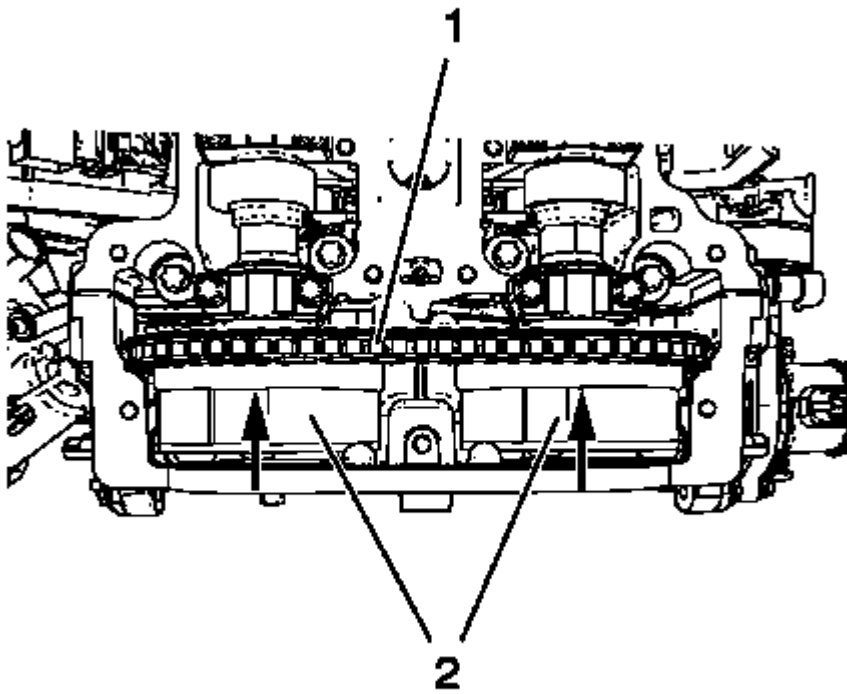


Fig. 70: Timing Chain And Camshaft Sprockets
Courtesy of GENERAL MOTORS COMPANY

25. Install the camshaft sprockets (2) and timing chain (1) as one unit.

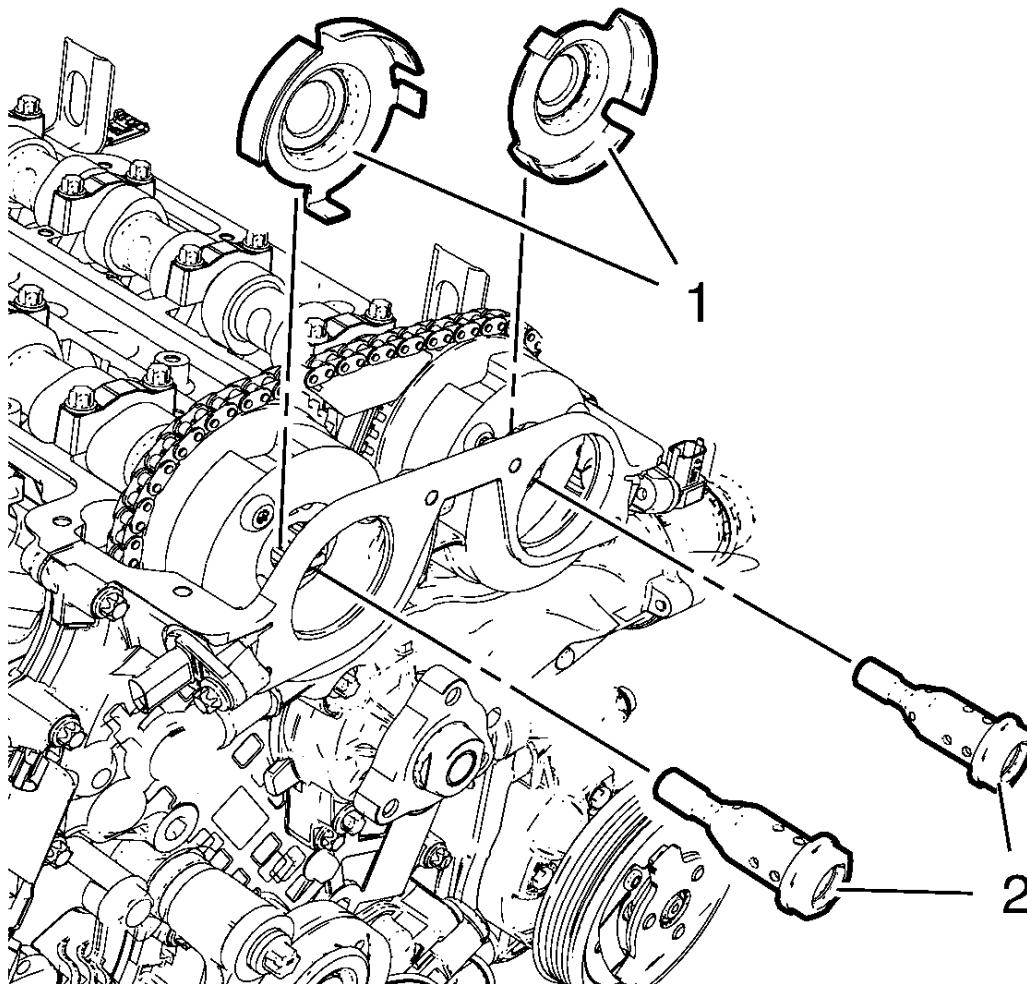


Fig. 71: Camshaft Position Exciter Wheels And Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS COMPANY

26. Install the camshaft position exciter wheels (1).
27. Install a NEW camshaft sprocket bolts (2) and tighten in two passes:
 - First pass 50 (37 lb ft).
 - Final pass plus 60 degrees.
28. Remove the **EN-955-10** locking pin.
29. Adjust the camshaft timing chain. Refer to **Camshaft Timing Chain Inspection**.

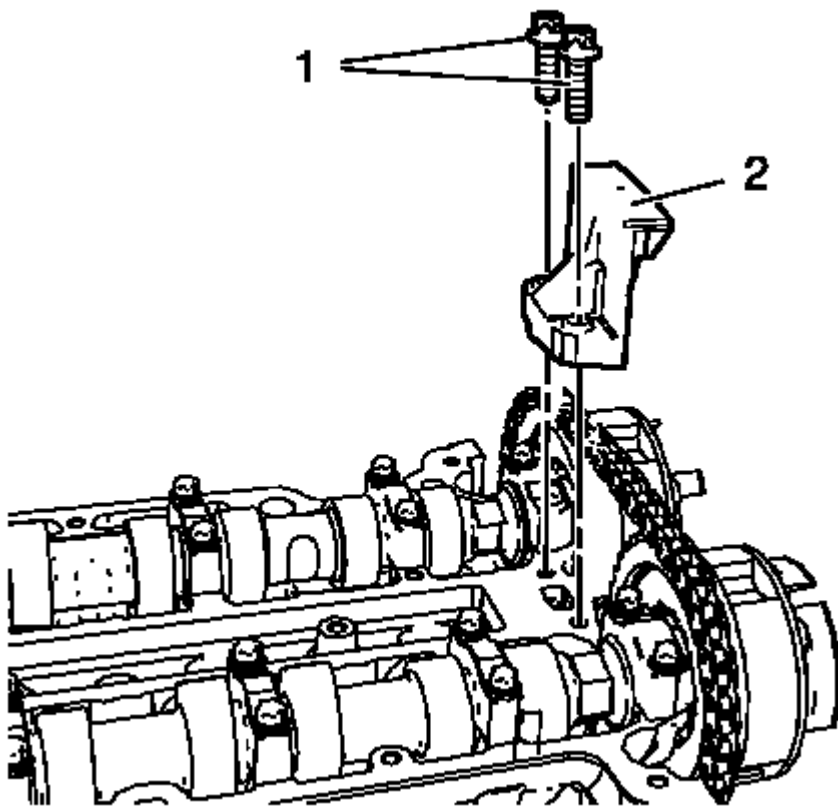


Fig. 72: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

30. Install the upper timing chain guide (2).
31. Install the upper timing chain guide bolts (1) and tighten to 8 (71 lb in).

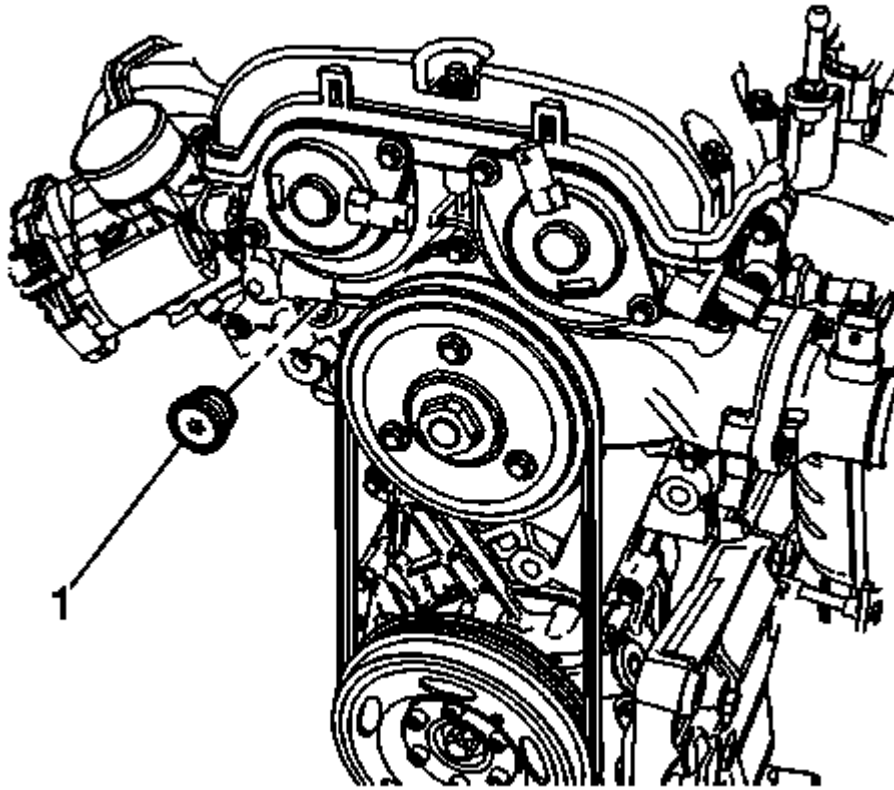


Fig. 73: Timing Chain Tensioner Plug
Courtesy of GENERAL MOTORS COMPANY

32. Install the timing chain tensioner plug and tighten to 50 (37 lb ft).
33. Install the camshaft position actuator solenoid valve intake and exhaust. Refer to **Camshaft Position Actuator Solenoid Valve Replacement (Exhaust)** , **Camshaft Position Actuator Solenoid Valve Replacement (Intake)** .
34. Install the air conditioning compressor bracket. Refer to **Air Conditioning Compressor Bracket Replacement** .
35. Install the camshaft position sensor exhaust only. Refer to **Camshaft Position Sensor Replacement (Exhaust)** , **Camshaft Position Sensor Replacement (Intake)** .
36. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
37. Install the exhaust manifold. Refer to **Exhaust Manifold with Catalytic Converter Replacement** .
38. Install intake manifold. Refer to **Intake Manifold Replacement**.
39. Install the water outlet. Refer to **Water Outlet Replacement** .
40. Fill coolant fluid. Refer to **Cooling System Draining and Filling** .
41. Enable the high voltage system. Refer to **High Voltage Enabling** .
42. Test the vehicle using the following procedure:
 - Crank the engine several times. Listen for any unusual noises or evidence that parts are binding.

- Start the engine and listen for unusual noises.
- Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.
- Run the engine speed at about 1, 000 RPM until the engine has reached normal operating temperature.
- Listen for sticking lifter and other unusual noises.
- Inspect for fuel, oil and/or coolant leaks while the engine is running.

43. Road test the vehicle for normal operation.

44. Inspect for coolant, oil, gas or exhaust leaks.

OIL PAN REPLACEMENT

Special Tools

EN-49980 Guidance Pins

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

Removal Procedure

1. Remove the oil filter and drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
2. Remove the catalytic converter. Refer to **Catalytic Converter Replacement**.
3. Remove the heater inlet and outlet pipes. Refer to **Heater Inlet And Outlet Pipe Replacement**.
4. Remove the crankshaft pulley. Refer to **Crankshaft Balancer Replacement**.

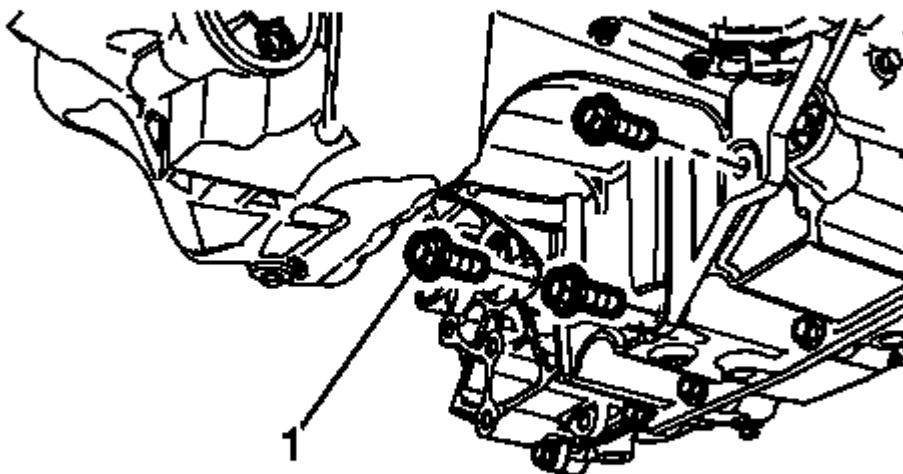


Fig. 74: Oil Pan To Transmission Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove the oil pan to transmission bolts (1).

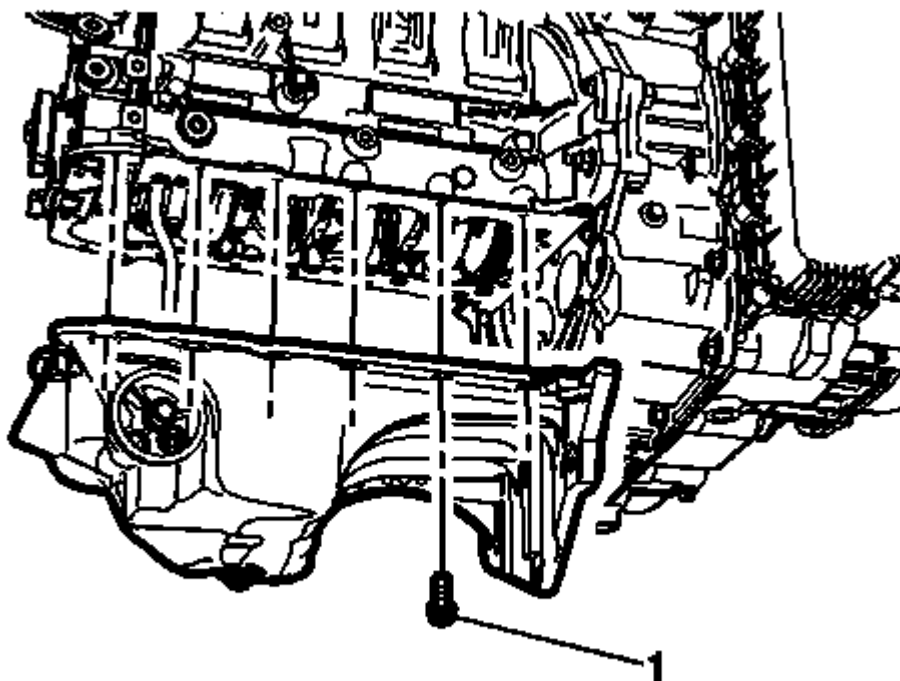


Fig. 75: Oil Pan Bolts

Courtesy of GENERAL MOTORS COMPANY

6. Remove the oil pan bolts (1).

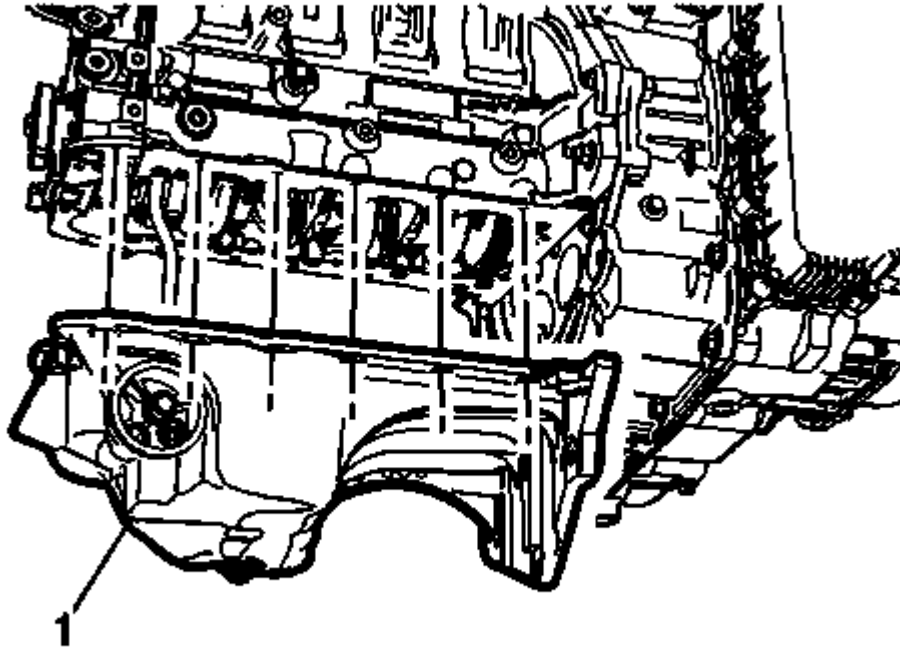


Fig. 76: Oil Pan

Courtesy of GENERAL MOTORS COMPANY

7. Remove the oil pan.

Installation Procedure

1. Clean the sealing surface of crankshaft bearing cap tie plate and the groove in the engine front cover from old gasket material, oil, dirt and grease.

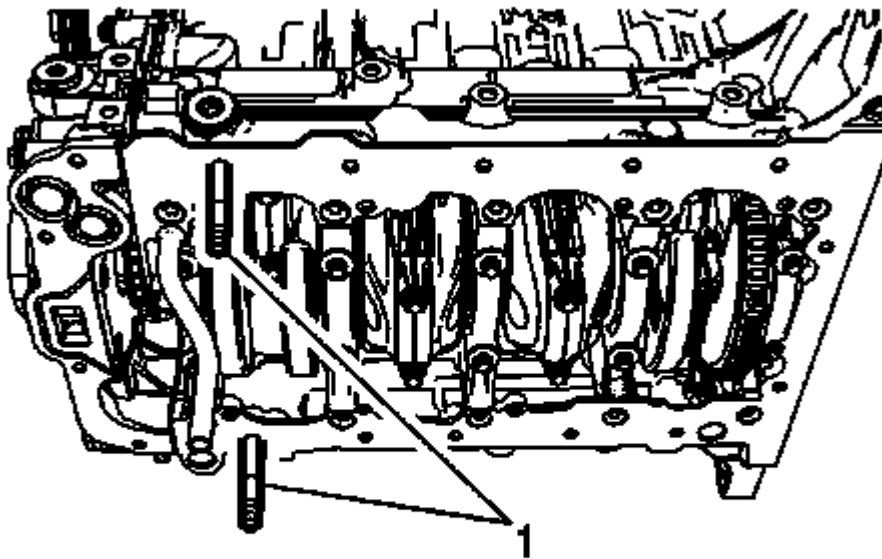


Fig. 77: Oil Pan Guidance Pins

Courtesy of GENERAL MOTORS COMPANY

2. Install the 2 **EN-49980** guidance pins (1) to the shown oil pan screw bores.

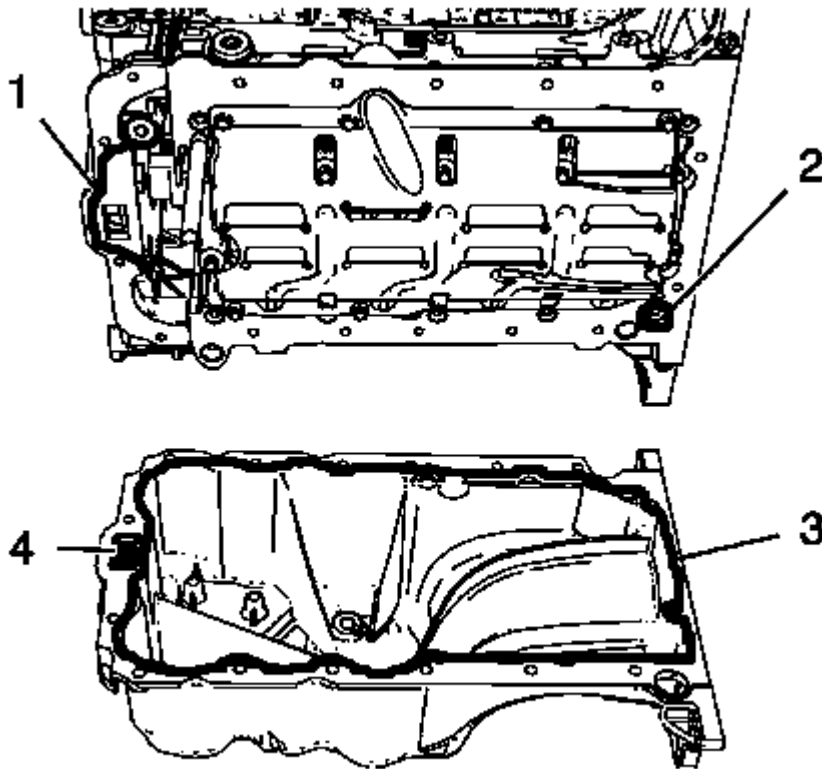


Fig. 78: Engine Front Cover, Oil Suction Gallery And Screw Bore
Courtesy of GENERAL MOTORS COMPANY

NOTE: The sealing bead should be applied close to the inner edge of the oil pan. Take care that the oil suction gallery (4) will not get contaminated with sealing compound or dirt.

3. Apply 2 mm (0.0787 in) thickness of sealing compound (3, 2, 1).

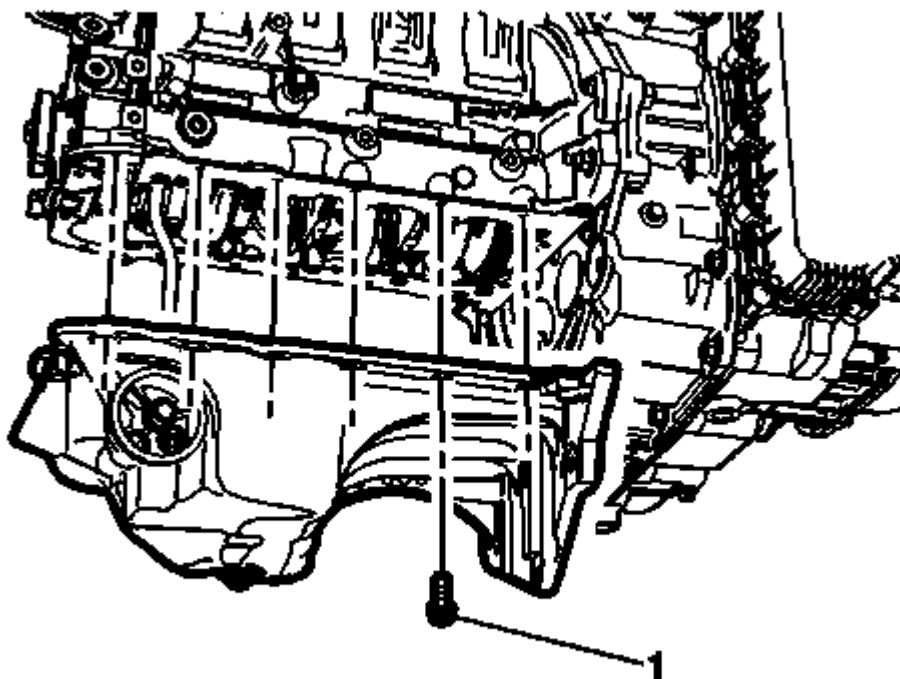


Fig. 79: Oil Pan Bolts

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

NOTE: The complete installation procedure of the oil pan should be done in 10 minutes.

4. Loosely install the oil pan bolts (1) in all but the guidance pin locations.
5. Remove the **EN-49980** guidance pins and install the remaining oil pan bolts.
6. Tighten the oil pan bolts to 10 N.m (89 lb in).
7. Position the transmission converter cover and hand tighten the cover to transmission bolt.

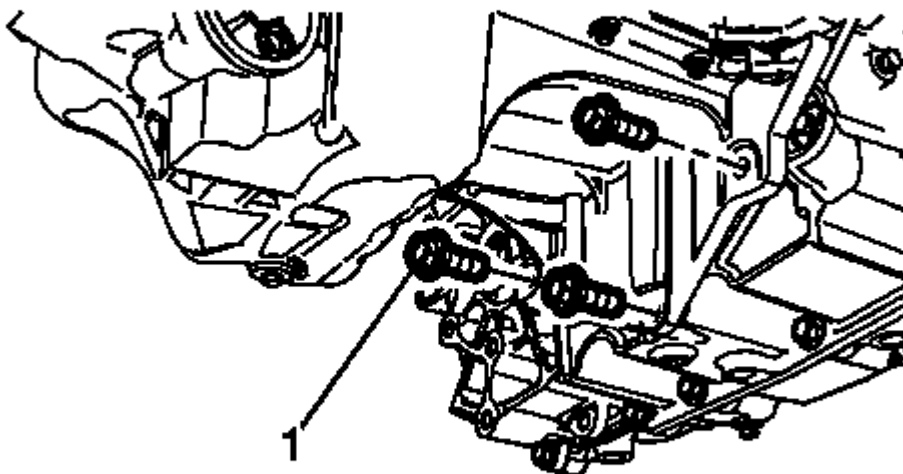


Fig. 80: Oil Pan To Transmission Bolts

Courtesy of GENERAL MOTORS COMPANY

8. Install the oil pan to transmission bolts (1), and tighten to 40 N.m (30 lb ft).
9. Install a NEW oil filter and fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.
10. Install the catalytic converter. Refer to **Catalytic Converter Replacement**.
11. Install the crankshaft pulley. Refer to **Crankshaft Balancer Replacement**.
12. Install the heater inlet and outlet pipes, and refill the coolant system. Refer to **Heater Inlet And Outlet Pipe Replacement**

AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT

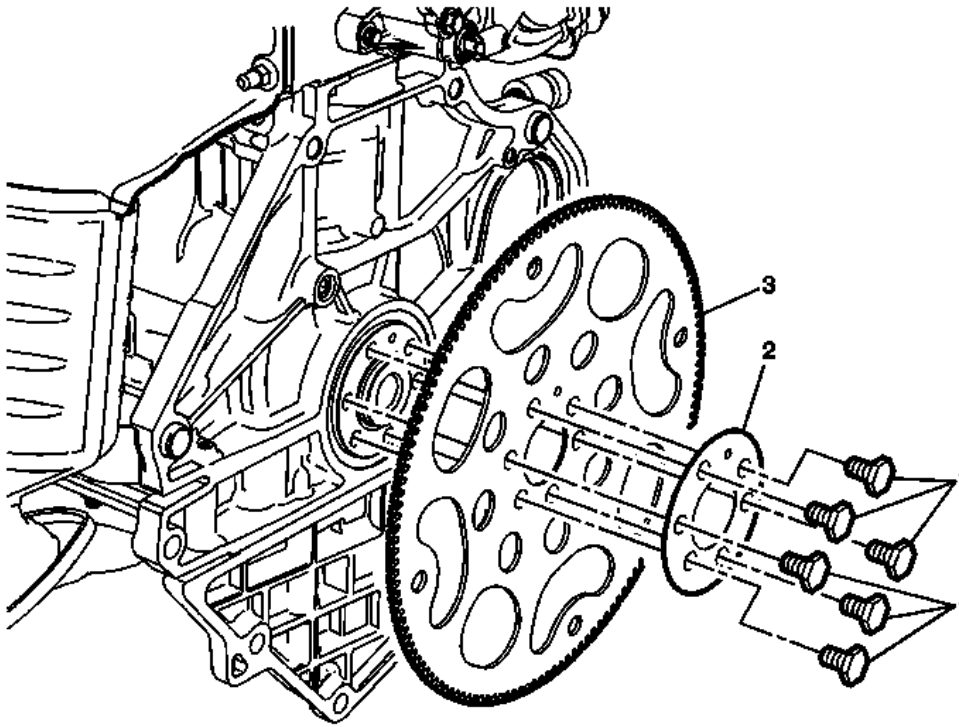


Fig. 81: Automatic Transmission Flex Plate And Bolts
 Courtesy of GENERAL MOTORS COMPANY

Automatic Transmission Flex Plate Replacement

Callout	Component Name
Preliminary Procedure Remove the transmission. Refer to Transmission Replacement .	
Special Tools <ul style="list-style-type: none"> • EN-470-B Angular Torque Wrench • EN-956-1 Extension • EN-49979 Crankshaft Shock Mount Retainer 	
For equivalent regional tools, refer to Special Tools .	
1	Automatic Transmission Flex Plate Fastener (Qty: 6) CAUTION: Refer to Fastener Caution . Tighten <ul style="list-style-type: none"> • 35 N.m (26 lb ft)

	<ul style="list-style-type: none"> Tighten the bolt an additional 30 degrees, and one more pass at 15 degrees using EN-470-B wrench.
2	Flex Plate
3	<p>Automatic Transmission Flex Plate</p> <p>Procedure</p> <p>Inspect the engine flywheel for the following:</p> <ol style="list-style-type: none"> Stress cracks around the engine flywheel Cracks at welded areas that retain the ring gear onto the engine flywheel Damaged or missing ring gear teeth Do not attempt to repair the welded areas that retain the ring gear to the engine flywheel plate. Install a new engine flywheel.

CRANKSHAFT BALANCER REPLACEMENT

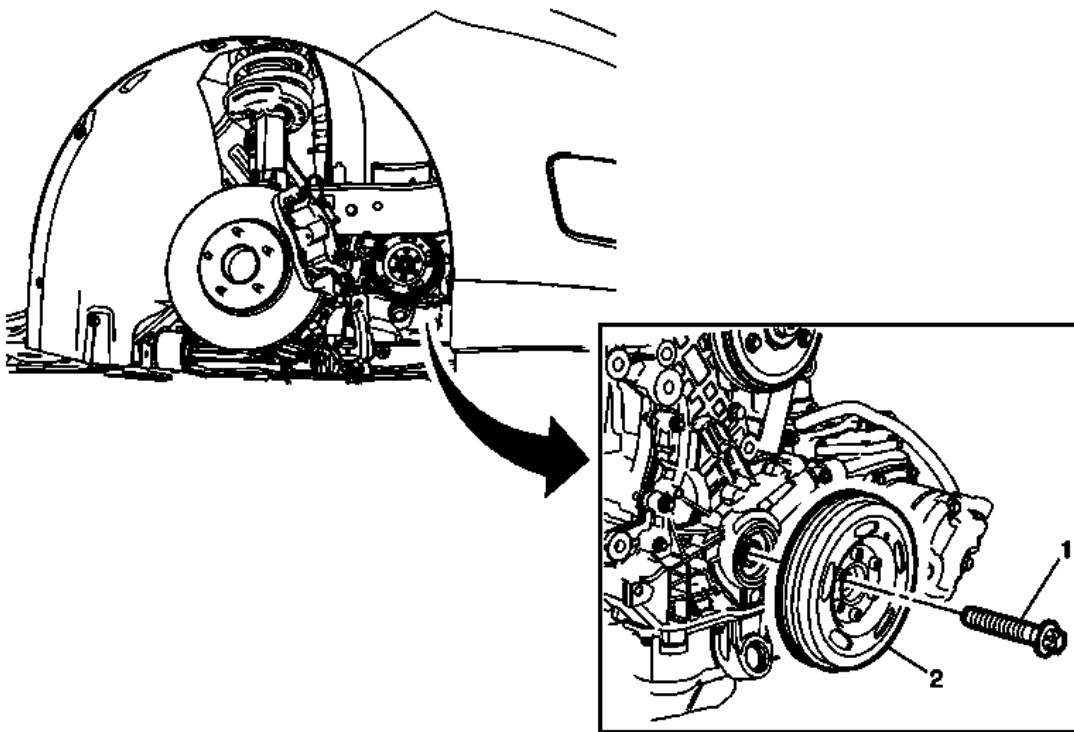


Fig. 82: Crankshaft Balancer

Courtesy of GENERAL MOTORS COMPANY

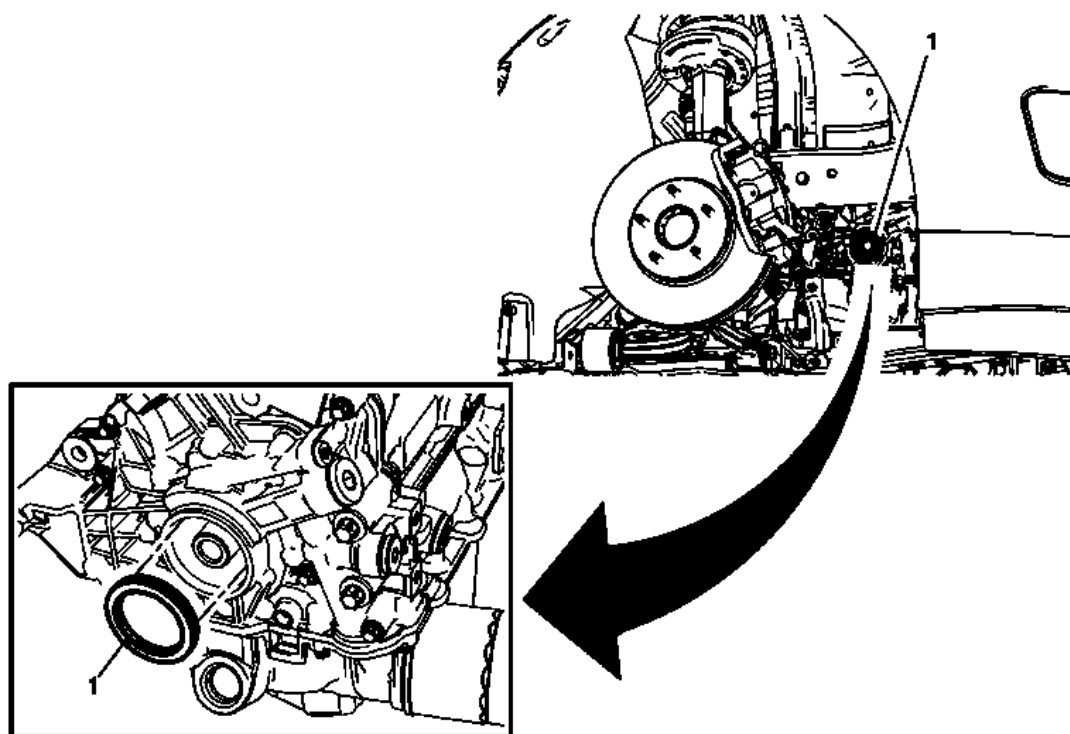
Crankshaft Balancer Replacement

Callout	Component Name
Preliminary Procedures	
1.	Mark the balancer to the cover relationship or Set to TDC.

2. Remove the water pump belt. Refer to **Water Pump Belt Replacement** .
3. Remove the heater water auxiliary pump. Refer to **Heater Water Auxiliary Pump Replacement**
4. Remove the drive motor battery coolant cooler Inlet hose assembly. Refer to **Drive Motor Battery Coolant Cooler Inlet Hose Assembly Replacement**

1	<p>Crankshaft Pulley Fastener</p> <p>CAUTION: Refer to <u>Fastener Caution</u> .</p> <p>Tighten</p> <ul style="list-style-type: none"> • 150 N.m (111 lb ft) • Tighten the bolt an additional 60 degrees.
2	<p>Crankshaft Pulley</p> <p>Procedure</p> <ol style="list-style-type: none"> 1. Use EN-49979 retainer and EN-956-1 extension to remove the crankshaft pulley. 2. To ensure correct installation of the crankshaft pulley, measure the distance between the pulley and the front cover. Refer to <u>Crankshaft Balancer Installation</u>. <p>Special Tools</p> <ul style="list-style-type: none"> • EN-470-B Angular Torque Wrench • EN-956-1 Extension • EN-49979 Crankshaft Shock Mount Retainer <p>For equivalent regional tools, refer to <u>Special Tools</u>.</p>

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

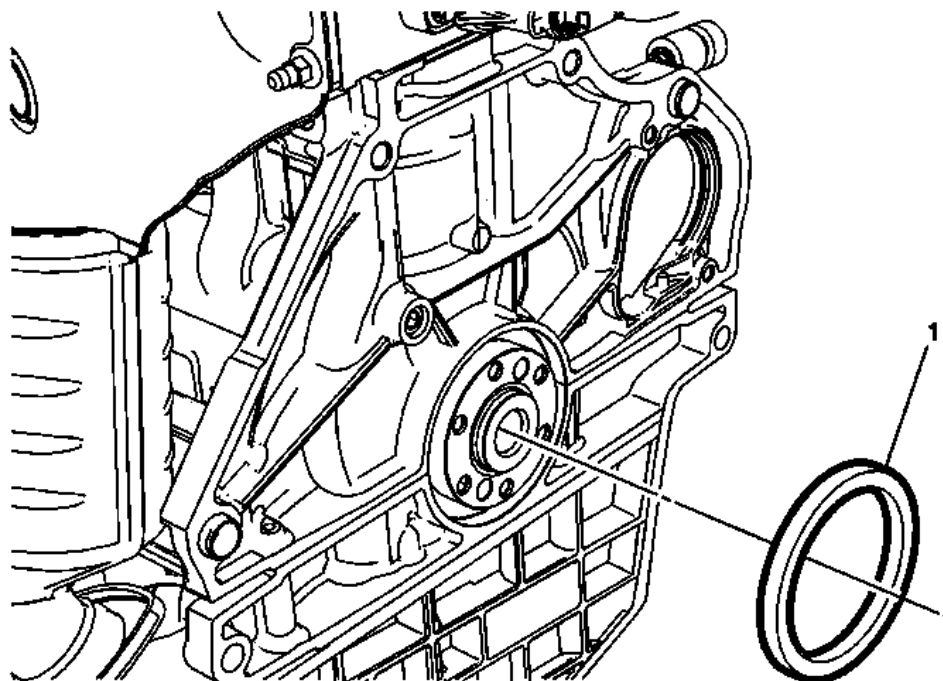
**Fig. 83: Crankshaft Front Oil Seal**

Courtesy of GENERAL MOTORS COMPANY

Crankshaft Front Oil Seal Replacement

Callout	Component Name
Preliminary Procedure Remove the crankshaft balancer. Refer to <u>Crankshaft Balancer Replacement</u> .	
1	Camshaft Front Oil Seal Procedure <ol style="list-style-type: none"> 1. Using a flat-bladed tool, remove the crankshaft front oil seal. 2. Use EN-960 installer to install the new crankshaft front oil seal. Special Tools EN-960 Crankshaft Front Oil Seal Installer For equivalent regional tools, refer to <u>Special Tools</u> .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

**Fig. 84: Crankshaft Rear Oil Seal**

Courtesy of GENERAL MOTORS COMPANY

Crankshaft Rear Oil Seal Replacement

Callout	Component Name
Preliminary Procedure Remove the automatic transmission flex plate. Refer to <u>Automatic Transmission Flex Plate Replacement.</u>	
1	Crankshaft Rear Oil Seal NOTE: Do not damage the outside diameter of the crankshaft or chamber with any tool. Procedure <ol style="list-style-type: none"> Using a flat-bladed tool, remove the rear crankshaft oil seal. Using the EN-658 installer to install a NEW crankshaft real oil seal. Special Tools EN-658 Rear Main Seal Installer For equivalent regional tools, refer to <u>Special Tools.</u>

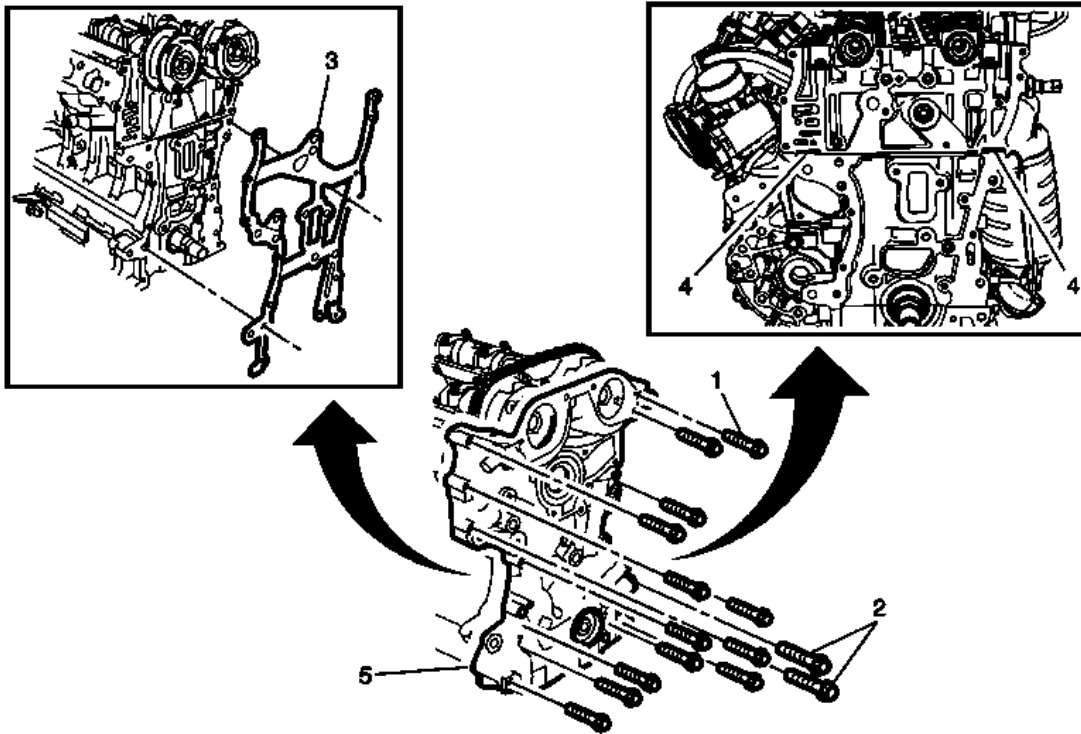
ENGINE FRONT COVER WITH OIL PUMP REPLACEMENT

Fig. 85: Engine Front Cover with Oil Pump
 Courtesy of GENERAL MOTORS COMPANY

Engine Front Cover with Oil Pump Replacement

Callout	Component Name
Preliminary Procedures	
<ol style="list-style-type: none"> 1. Remove the camshaft cover. Refer to <u>Camshaft Cover Replacement</u>. 2. Remove the air cleaner assembly. Refer to <u>Air Cleaner Assembly Replacement</u>. 3. Remove both camshaft position actuator solenoid valves. Refer to <u>Camshaft Position Actuator Solenoid Valve Replacement (Exhaust)</u>, <u>Camshaft Position Actuator Solenoid Valve Replacement (Intake)</u>. 4. Remove the air conditioning compressor bracket. Refer to <u>Air Conditioning Compressor Bracket Replacement</u>. 5. Remove the water pump. Refer to <u>Water Pump Replacement</u>. 6. Set the crankshaft to TDC. Refer to <u>Camshaft Timing Chain Inspection</u>. 7. Remove the oil pan. Refer to <u>Oil Pan Replacement</u>. 	
	Engine Front Cover with Oil Pump Fastener (Qty: 13) CAUTION: Refer to <u>Fastener Caution</u> .

2013 Chevrolet Volt

2013 ENGINE Engine Mechanical - 1.4L (LUU) - Volt

1	Procedure Ensure to mark the location of each bolt. Tighten 8 N.m (71 lb in)
2	Engine Front Cover with Oil Pump Fastener (Qty: 2) Tighten 35 N.m (26 lb ft)
3	Engine Front Cover with Oil Pump Gasket Procedure <ol style="list-style-type: none">1. Remove the camshaft timing chain out of the way before removing the engine front cover gasket. Refer to <u>Camshaft Timing Chain Replacement</u>.2. Replace the engine front cover gasket whenever the cover is removed.3. Adjust timing chain on installation. Refer to <u>Camshaft Timing Chain Adjustment</u> NOTE: Removal of timing chain is necessary to get access to engine front cover gasket.
4	Engine Front Cover RTV Sealant Procedure Apply a 2 mm (0.0787 in) bead of RTV sealant to the areas shown (3).
5	Engine Front Cover with Oil Pump Procedure <ol style="list-style-type: none">1. To disassemble oil pump, refer to <u>Engine Front Cover and Oil Pump Disassemble</u>.2. For cleaning and inspection of the oil pump, refer to <u>Engine Front Cover and Oil Pump Cleaning and Inspection</u>.3. Reposition coolant hoses as necessary.4. Disconnect electrical connector as necessary.5. Transfer components as necessary.

ENGINE OIL PRESSURE INDICATOR SWITCH REPLACEMENT

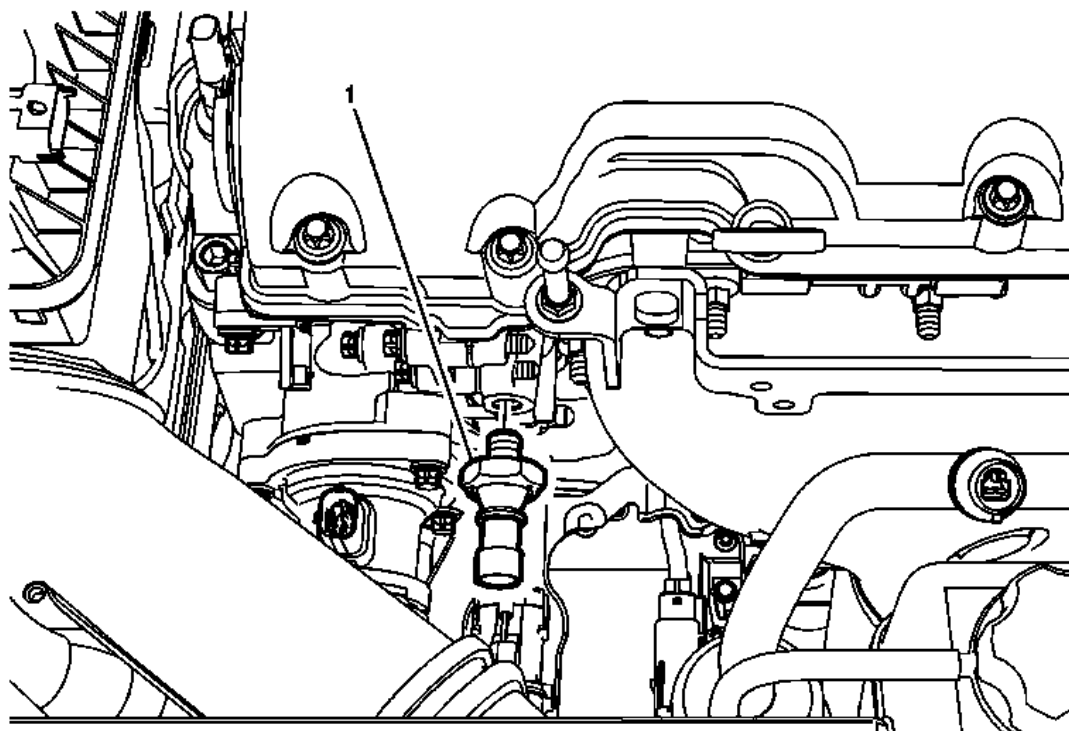


Fig. 86: Engine Oil Pressure Indicator Switch
Courtesy of GENERAL MOTORS COMPANY

Engine Oil Pressure Indicator Switch Replacement

Callout	Component Name
Preliminary Procedure Remove the air cleaner resonator outlet duct. Refer to <u>Air Cleaner Resonator Outlet Duct Replacement</u> .	
1	Engine Oil Pressure Sensor and/or Switch CAUTION: Refer to <u>Component Fastener Tightening Caution</u> . Procedure 1. Disconnect the oil pressure sensor electrical connector. 2. Transfer the components as necessary. Tighten 20 N.m (15 lb ft)

ENGINE REPLACEMENT (VOLT)

Removal Procedure

WARNING: Always perform the High Voltage Disabling procedure prior to servicing any High Voltage component or connection. Personal Protection Equipment (PPE) and proper procedures must be followed.

The High Voltage Disabling procedure will perform the following tasks:

- Identify how to disable high voltage.
- Identify how to test for the presence of high voltage.
- Identify condition under which high voltage is always present and personal protection equipment (PPE) and proper procedures must be followed.

Failure to follow the procedures exactly as written may result in serious injury or death.

1. Disable the high voltage system. Refer to High Voltage Disabling .
2. Drain the drive motor generator battery cooling system. Refer to Drive Motor Battery Cooling System Draining and Filling .
3. Drain the engine cooling system. Refer to Cooling System Draining and Filling .
4. Drain the drive motor generator cooling system. Refer to Drive Motor Generator Power Inverter Module Cooling System Draining and Filling .
5. Recover the air conditioning refrigerant. Refer to Refrigerant Recovery and Recharging (High Voltage Electric Compressor) .
6. Remove the drive motor generator power inverter module. Refer to Drive Motor Generator Power Inverter Module Replacement .

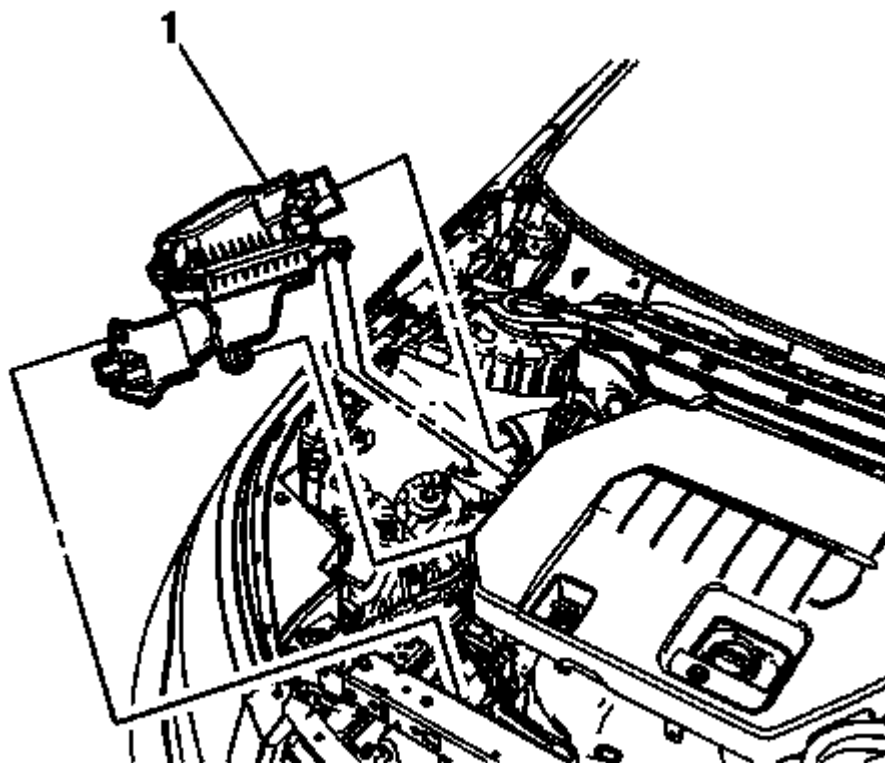


Fig. 87: Air Cleaner Assembly

Courtesy of GENERAL MOTORS COMPANY

7. Remove the air cleaner assembly (1). Refer to **Air Cleaner Assembly Replacement** .

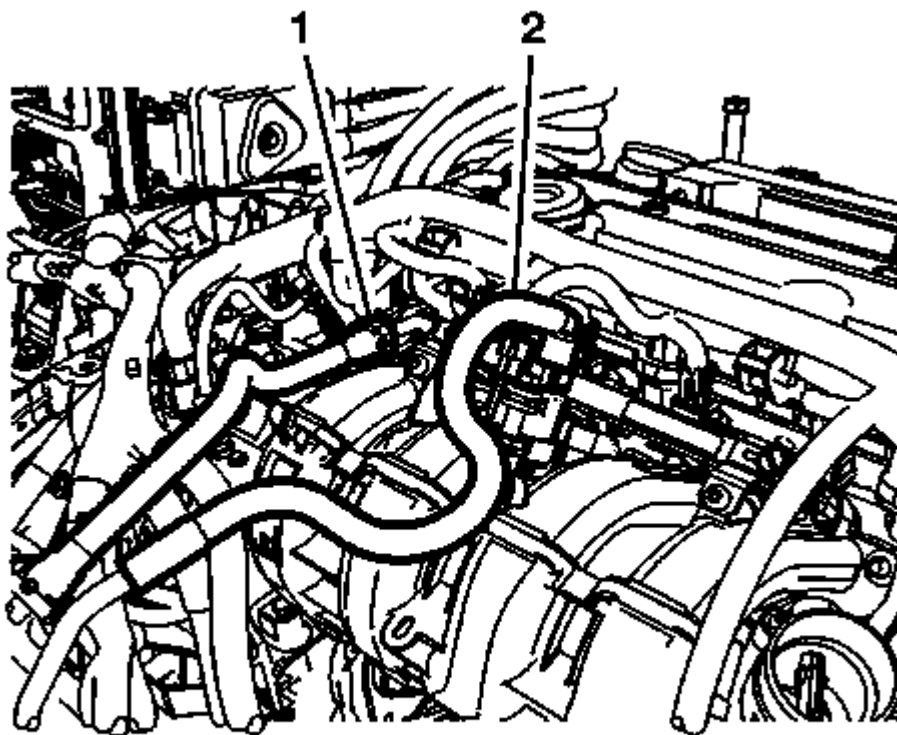


Fig. 88: Canister Purge Hose

Courtesy of GENERAL MOTORS COMPANY

8. Disconnect the canister purge hose (2) from the purge solenoid located at the back of the of the valve cover.
9. Disconnect the fuel feed pipe (1) from the fuel rail assembly. Refer to **Fuel Feed Pipe Replacement (Engine Compartment)** , **Fuel Feed Pipe Replacement (Chassis)** .

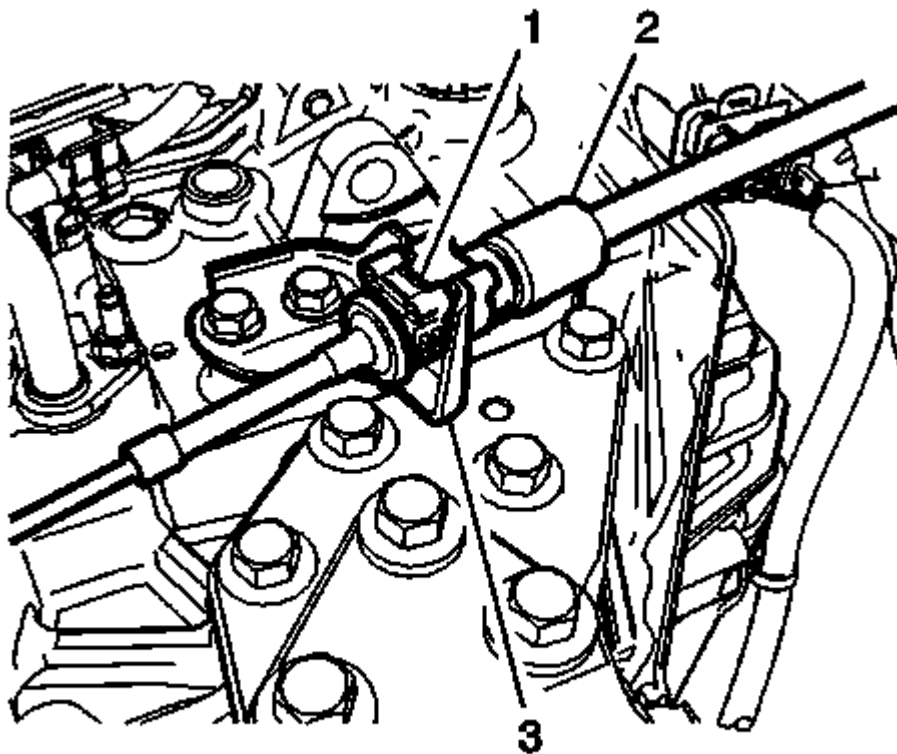


Fig. 89: Transmission Range Selector Lever Cable And Cable Bracket
Courtesy of GENERAL MOTORS COMPANY

10. Press the locking tab (1) rearward in order to release the transmission range selector lever cable (2) from the cable bracket.

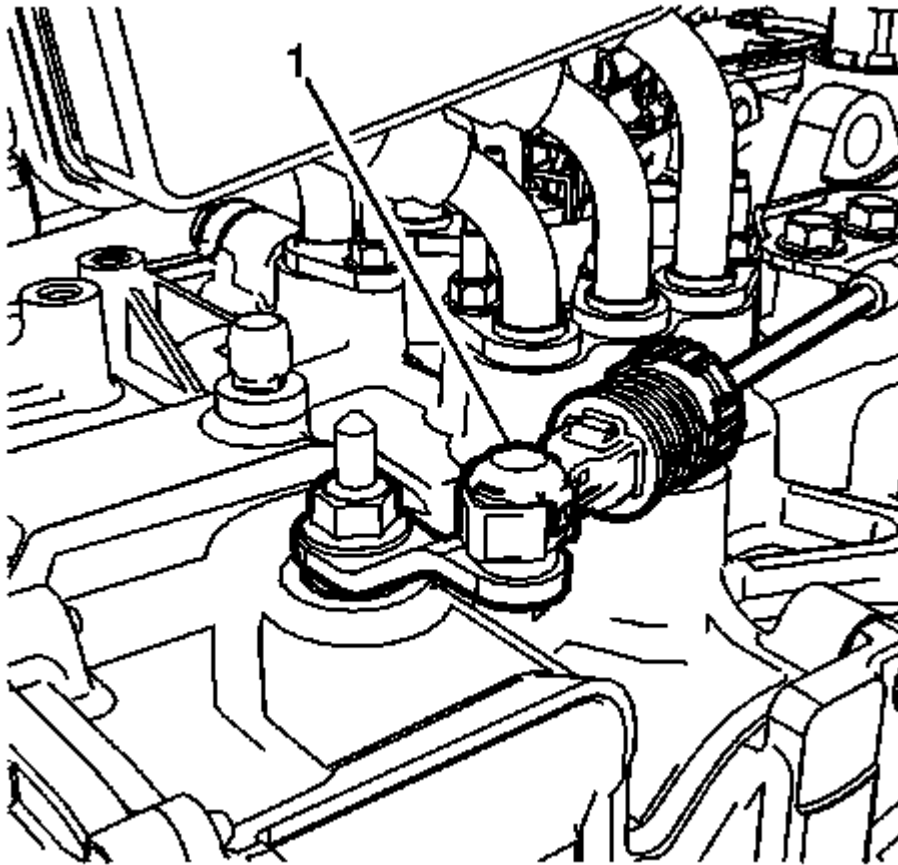


Fig. 90: Transmission Range Selector Lever Cable Terminal
Courtesy of GENERAL MOTORS COMPANY

11. Disconnect the transmission range selector lever cable terminal (1) from the transmission manual pin, then position the cable out of the way.

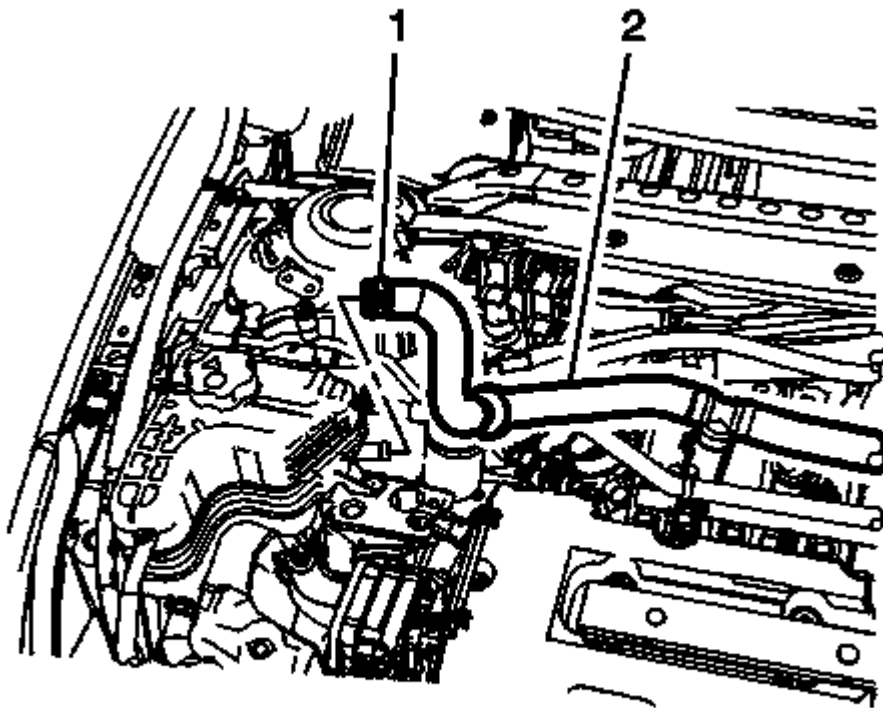


Fig. 91: Heater Water Auxiliary Pump Inlet Hose And Clamp
Courtesy of GENERAL MOTORS COMPANY

12. Disconnect the heater water auxiliary pump inlet hose (2) from the coolant reservoir.

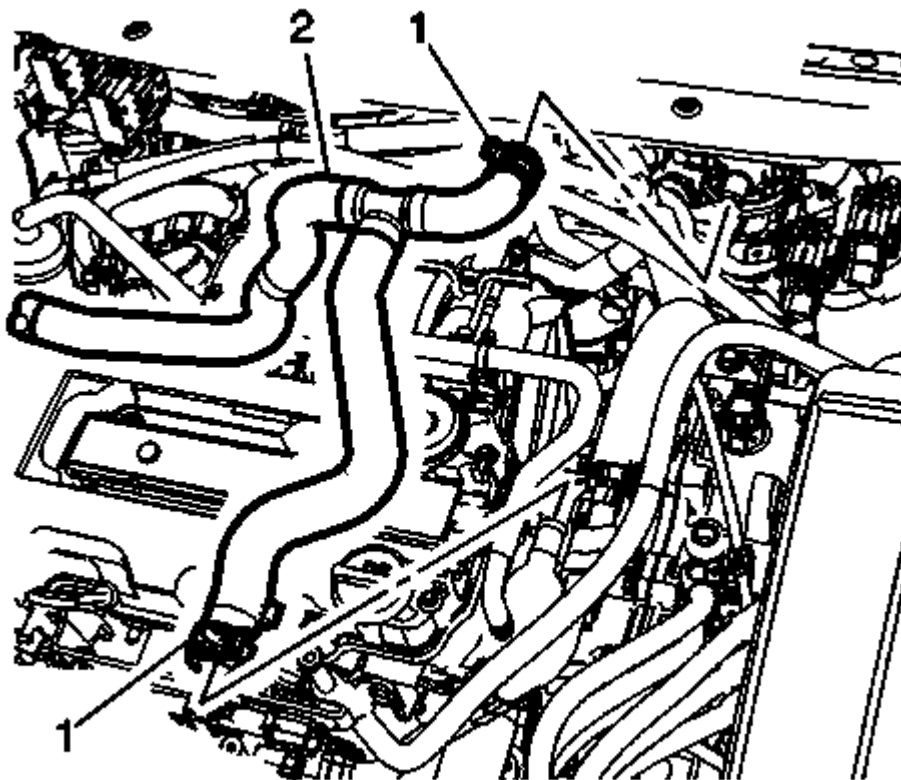


Fig. 92: Heater Water Auxiliary Pump Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

13. Disconnect the heater water auxiliary pump inlet hose (2) from the water outlet.

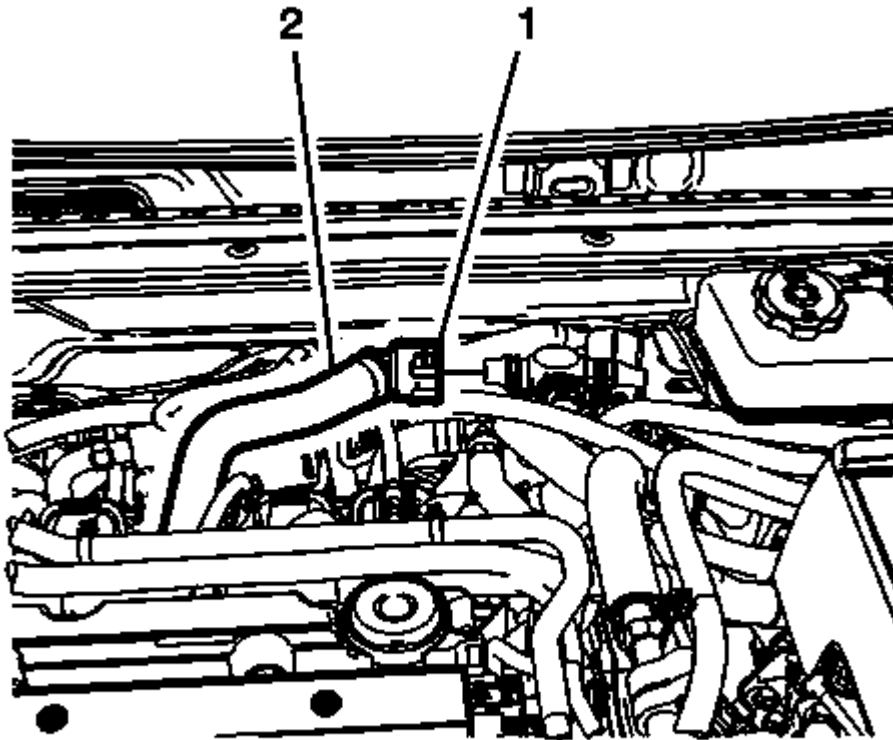


Fig. 93: Heater Water Shutoff Valve Inlet Hose Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

14. Disconnect the heat water shutoff valve inlet hose (2) from the valve assembly. Refer to **Heater Water Shutoff Valve Inlet Hose Replacement** .
15. Disconnect the heater inlet and outlet pipe. Refer to **Heater Inlet And Outlet Pipe Replacement** .

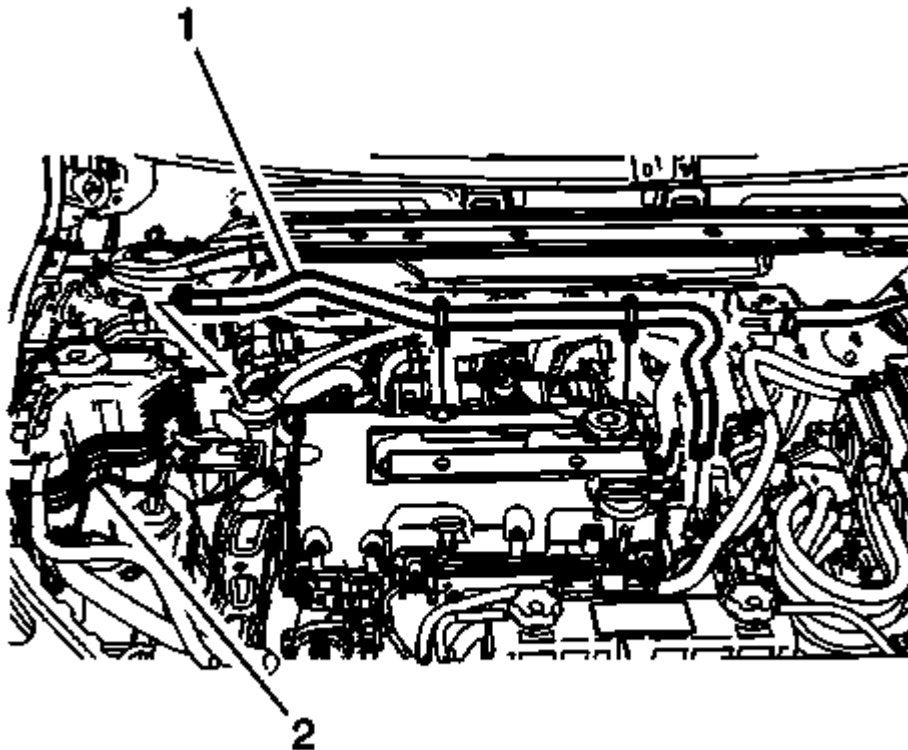


Fig. 94: Heater Outlet Hose Vapor Vent Hose
Courtesy of GENERAL MOTORS COMPANY

16. Disconnect the heater outlet hose vapor vent hose (1) from the coolant reservoir (2). Refer to **Heater Outlet Hose Vapor Vent Hose Replacement** .

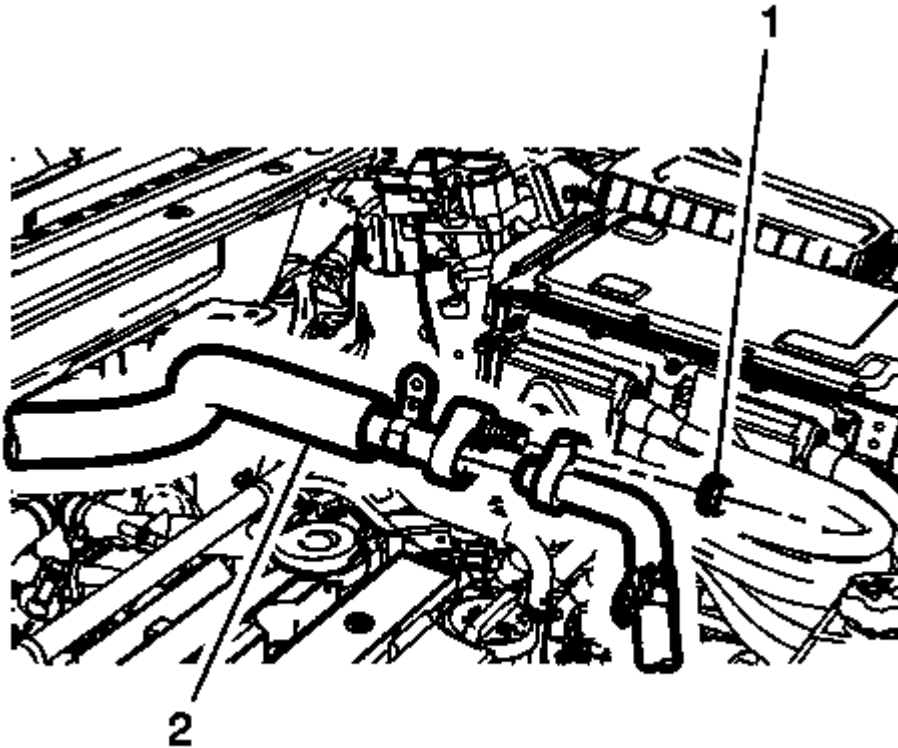


Fig. 95: Air Conditioning Compressor And Evaporator Hose And Nut
 Courtesy of GENERAL MOTORS COMPANY

17. Separate the air conditioning compressor and evaporator hose (2) at the connection above the valve cover. Refer to **Air Conditioning Compressor and Evaporator Hose Replacement** .
18. Remove the front wheelhouse front liners. Refer to **Front Wheelhouse Front Liner Replacement** .
19. Remove the front end panel outer deflectors. Refer to **Front End Panel Outer Deflector Replacement** .
20. Disconnect the air conditioning evaporator thermal expansion valve tube from the condenser. Refer to **Air Conditioning Evaporator Thermal Expansion Valve Tube Replacement**
21. Disconnect the electrical connector from the engine coolant temperature sensor on the radiator assembly.
22. Disconnect the electrical connectors from the engine control module (ECM). Refer to **Engine Control Module Replacement** .
23. Disconnect the wiring connectors from the transmission.
24. Disconnect the wheel speed connectors from the steering knuckles and the frame, then position out of the way.
25. Disconnect the drive motor battery coolant cooler inlet hose quick connect at the right frame. Refer to **Drive Motor Battery Coolant Cooler Inlet Hose Assembly Replacement** .
26. Disconnect the drive motor generator control module cooling outlet hose. Refer to **Drive Motor Generator Control Module Cooling Outlet Hose Replacement** .

27. Disconnect the wiring harness from the accessory wiring junction block. Refer to **Accessory Wiring Junction Block Replacement**.
28. Remove the positive battery cable from the strut tower junction block.
29. Remove the ground wire from the left strut tower.
30. Remove the left headlamp. Refer to **Headlamp Replacement**.
31. Disconnect in-line harness at the left frame rail.
32. Place the ECM, transmission and the accessory wiring junction block wiring harnesses on the top of engine assembly.
33. Remove the strap from the right frame rail and reposition to engine
34. Remove the ground wire from the stud behind the right headlight and reposition harness to the engine.
35. Disconnect A/C compressor electrical connectors.

NOTE: Do Not disconnect the brake hoses from the calipers.

36. Remove the front brake calipers from the caliper brackets, then suspend the calipers with mechanics wire to the body.

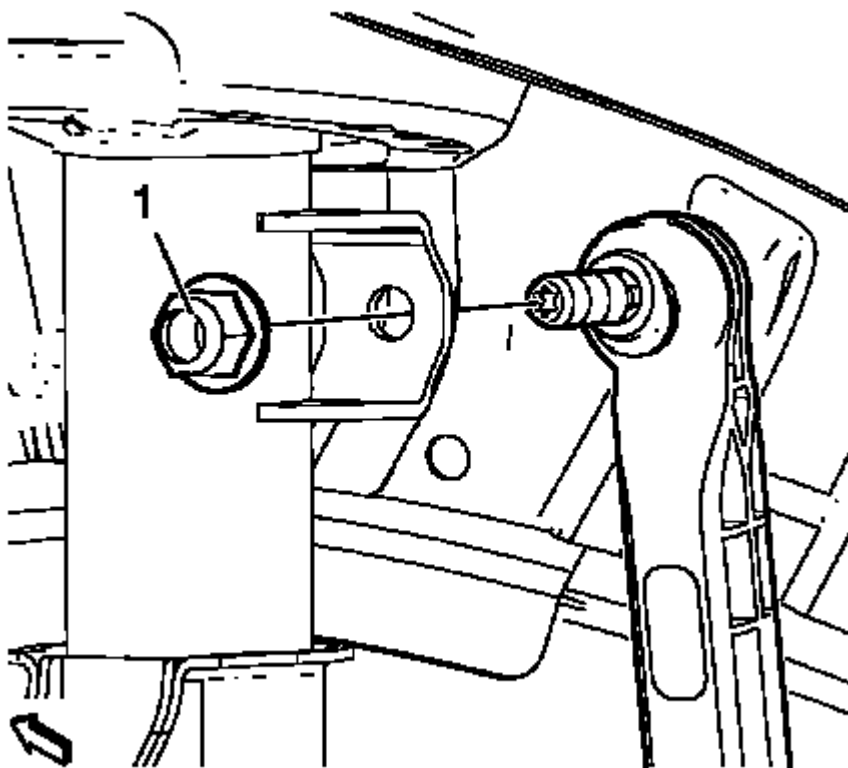


Fig. 96: Stabilizer Link Nut

Courtesy of GENERAL MOTORS COMPANY

37. Remove the stabilizer link (1) nuts from the strut assemblies. Refer to **Stabilizer Shaft Link Replacement**.
38. Disconnect the stabilizer links from the strut assemblies.
39. Disconnect the intermediate steering shaft from the steering gear. Refer to **Intermediate Steering Shaft Replacement**.
40. Disconnect the front steering knuckles from the strut assemblies. Refer to **Steering Knuckle Replacement**.

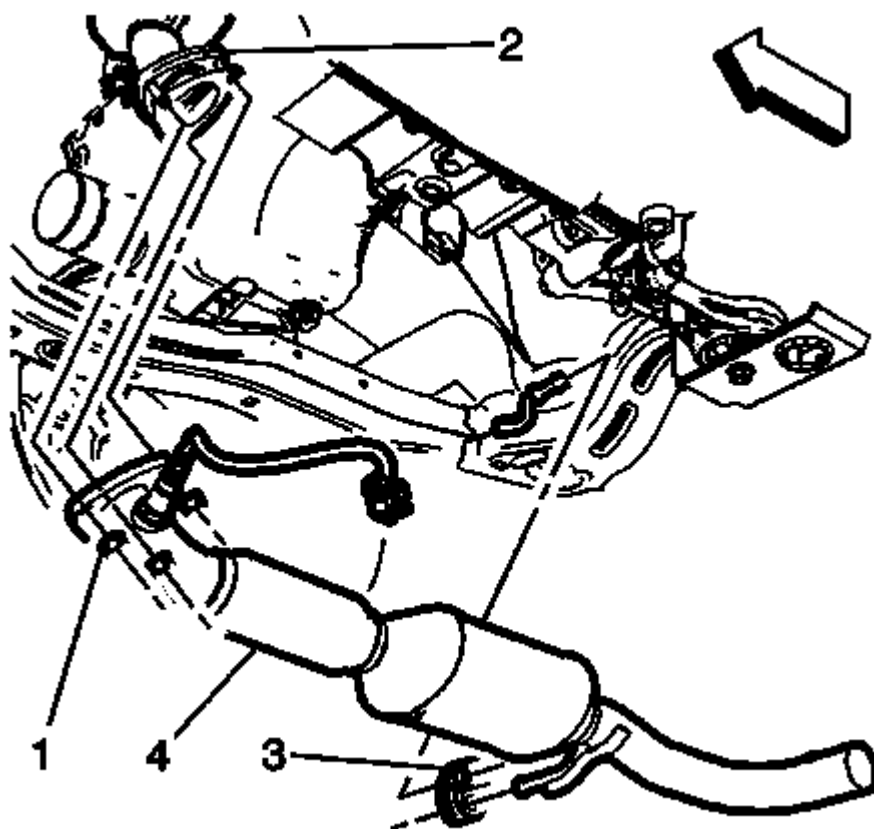


Fig. 97: Catalytic Converter Assembly
Courtesy of GENERAL MOTORS COMPANY

41. Remove the catalytic converter assembly (4) from the vehicle. Refer to **Catalytic Converter Replacement**.
42. Disconnect the radiator assembly wiring harness connectors from the radiator assembly.
43. Install the engine support fixture. Refer to **Engine Support Fixture**.
44. Use the engine support fixture to slightly raise the powertrain assembly to aid in the removal of the engine and transmission mount bolts.
45. Remove the engine mount to engine mount bracket fasteners. Refer to **Engine Mount Replacement - Right Side**.
46. Remove the transmission mount to transmission mount bracket fasteners. Refer to **Transmission Mount**

Replacement - Left Side .

47. Using suitable straps or chains, secure the front of vehicle to the hoist arms.
48. Using a suitable engine support table, lower the vehicle until the drivetrain and front suspension frame contacts the engine support table.
49. Position blocks of wood below the oil pan and transmission to stabilize the powertrain on the support table.
50. Using the engine support fixture, lower the powertrain down until it is resting on the engine support table.
51. Remove the engine support fixture.

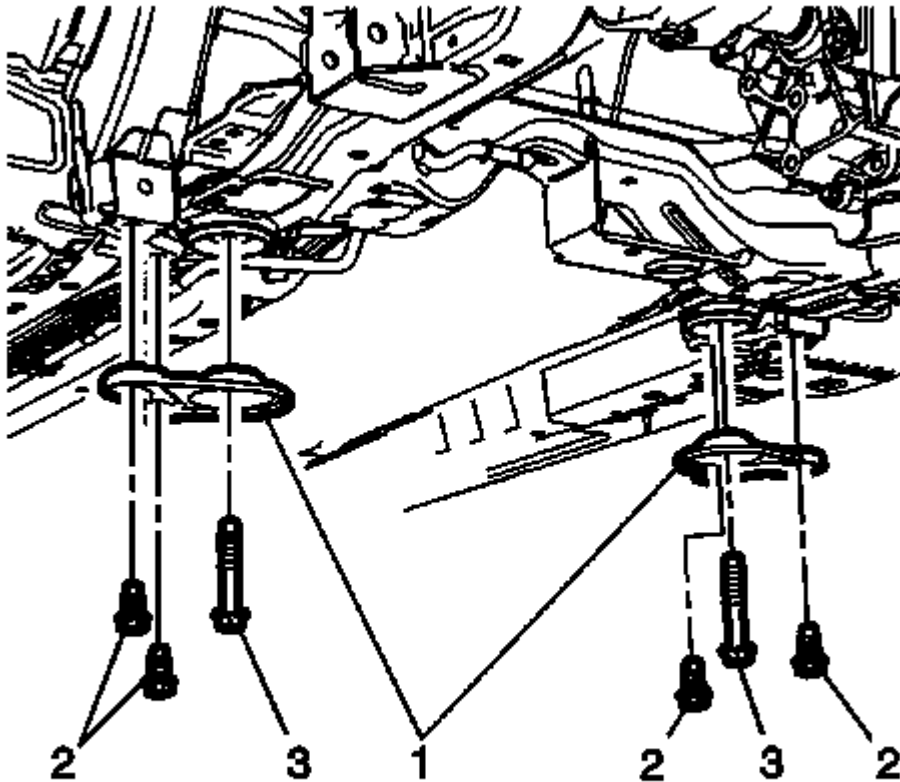


Fig. 98: Drivetrain And Front Suspension Frame Reinforcements
Courtesy of GENERAL MOTORS COMPANY

52. Remove the drivetrain and front suspension frame reinforcements (1) from the rear of the frame.
53. Remove the front drivetrain and front suspension frame retaining bolts.
54. Slowly and carefully raise the vehicle, ensure the engine, transmission, radiator assembly and drivetrain suspension frame are free from wiring, hoses and other engine compartment components.
55. Remove the starter opening cover located below the intake manifold.
56. Remove the four torque dampener to flywheel bolts.
57. Remove the intermediate drive shaft from the engine and transmission. Refer to **Front Wheel Drive**

Intermediate Shaft Replacement .

58. Remove the nine transmission to engine fasteners.
59. Separate the transmission from the engine assembly.
60. Disconnect engine coolant hoses as necessary.
61. Disconnect electrical connectors as necessary.
62. Transfer components as necessary.

Installation Procedure

1. Position the engine to the transmission assembly.

CAUTION: Refer to Fastener Caution .

2. Install the nine transmission to engine fasteners, then tighten to 80 N.m (59 lb ft)
3. Install the four torque dampener to flywheel bolts, then tighten to 62 N.m (46 lb ft).
4. Install the starter opening cover, then tighten to 20 N.m (15 lb ft).
5. Position the engine, transmission, radiator assembly and drivetrain suspension frame under the vehicle.
6. Slowly and carefully lower the vehicle, ensure the engine, transmission, radiator assembly and drivetrain suspension frame are free from wiring, hoses and other engine compartment components.

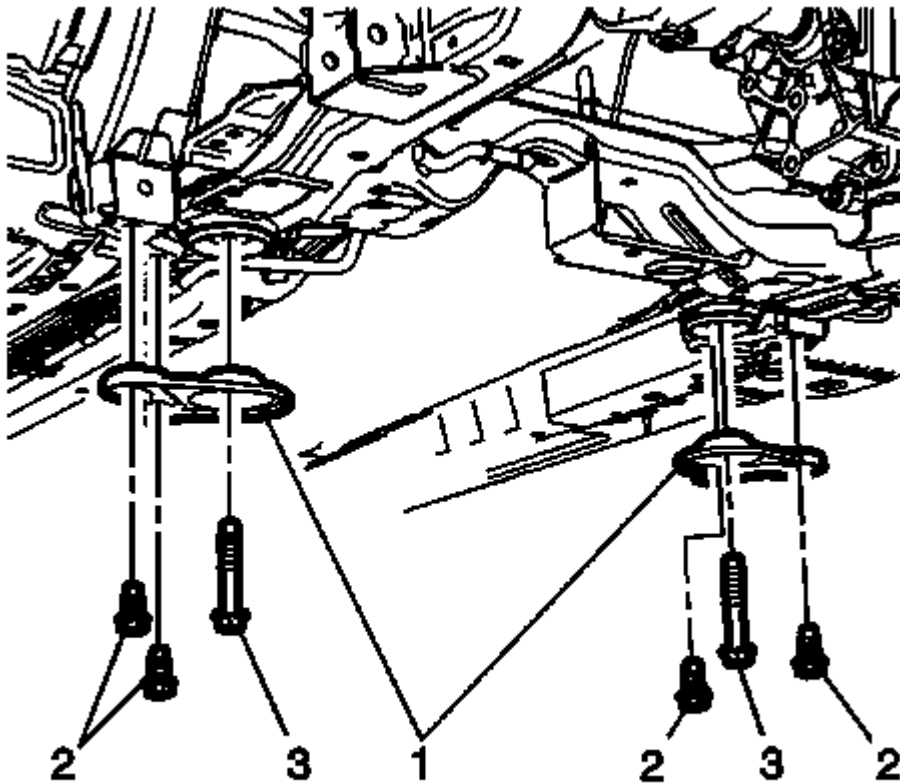


Fig. 99: Drivetrain And Front Suspension Frame Reinforcements
 Courtesy of GENERAL MOTORS COMPANY

7. Install the four front drivetrain and front suspension frame retaining bolts, then tighten to the fasteners to 160 N.m (118 lb ft).
8. Install the drivetrain and front suspension frame reinforcements (1) to the rear of the frame, then tighten the reinforcement fasteners (2) to 22 N.m (16 lb ft).

NOTE: Use the engine support fixture to slightly raise the powertrain assembly to aid in the installation of the engine and transmission mount bolts.

9. Install the engine support fixture. Refer to Engine Support Fixture.
10. Install the engine mount to engine mount bracket fasteners. Refer to Engine Mount Replacement - Right Side.
11. Install the transmission mount to transmission mount bracket fasteners. Refer to Transmission Mount Replacement - Left Side.
12. Install the intermediate drive shaft to the engine and transmission. Refer to Front Wheel Drive Intermediate Shaft Replacement.
13. Connect the right wheel drive shaft to the intermediate shaft.
14. Connect the electronic power steering connectors to the electronic power steering assembly. Refer to FEP

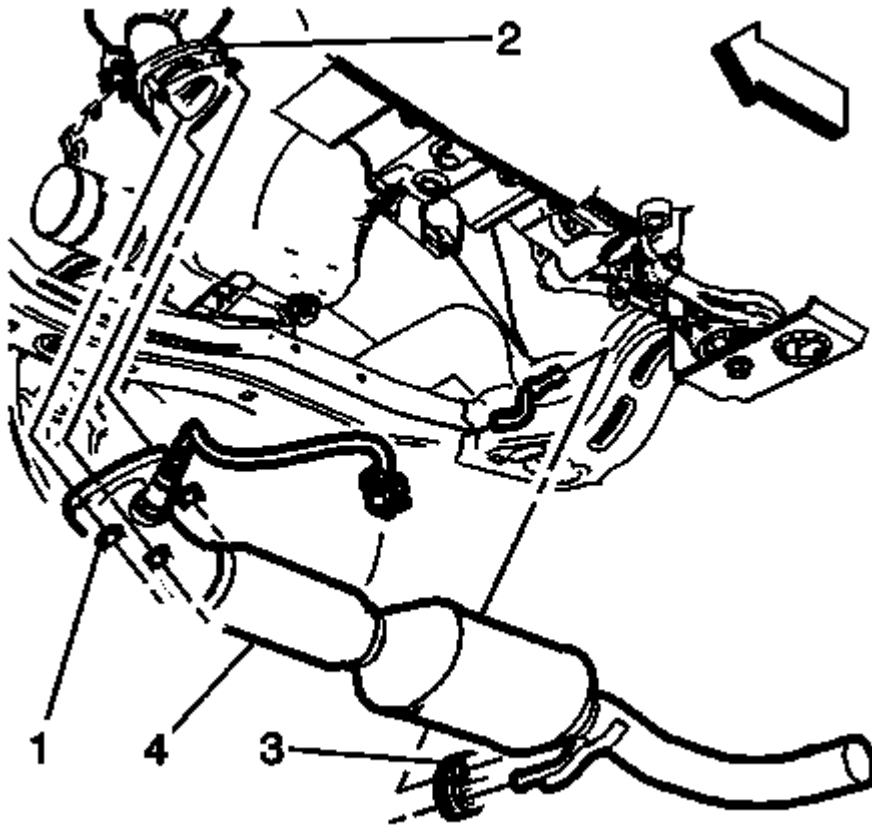
Connectors (Steering Gear) .

Fig. 100: Catalytic Converter Assembly
Courtesy of GENERAL MOTORS COMPANY

15. Install the catalytic converter assembly (4). Refer to Catalytic Converter Replacement .
16. Connect the front steering knuckles to the strut assemblies. Refer to Steering Knuckle Replacement .

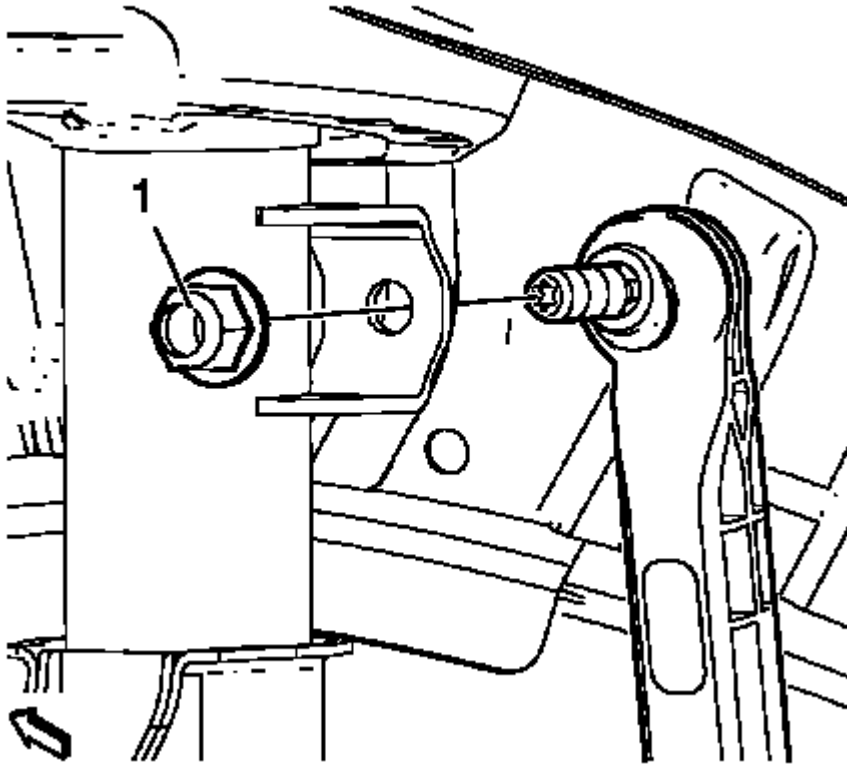


Fig. 101: Stabilizer Link Nut

Courtesy of GENERAL MOTORS COMPANY

17. Connect the stabilizer link (1) to the strut assemblies. Refer to **Stabilizer Shaft Link Replacement**.
18. Install the front brake calipers to the caliper brackets. Refer to Step 2 of the installation procedure. **Front Brake Caliper Replacement**.
19. Connect the wheel speed connectors to the steering knuckles.
20. Remove the engine support fixture.
21. Install the engine ground strap which is located above the air conditioning compressor on the engine block.
22. Connect the wiring connectors and ground strap to the transmission.
23. Connect the wiring harness to the accessory wiring junction block. Refer to **Accessory Wiring Junction Block Replacement**.
24. Install the left headlamp. Refer to **Headlamp Replacement**.
25. Connect the electrical connectors to the ECM. Refer to **Engine Control Module Replacement**.
26. Connect the electrical connector to the engine coolant temperature sensor on the radiator assembly.

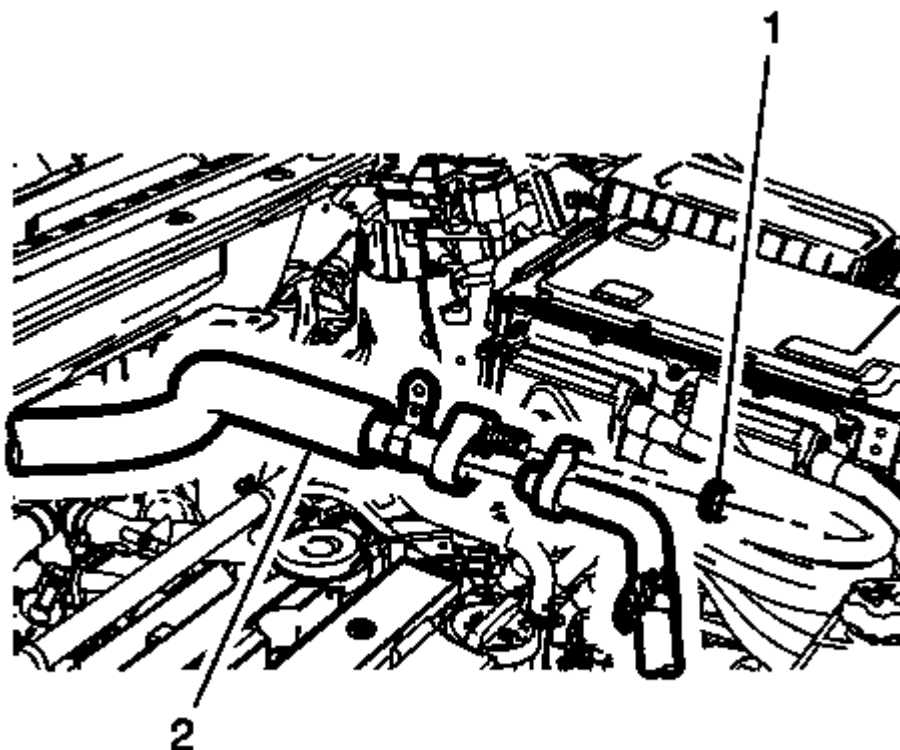


Fig. 102: Air Conditioning Compressor And Evaporator Hose And Nut
Courtesy of GENERAL MOTORS COMPANY

27. Connect the air conditioning compressor and evaporator hose (2) located above the valve cover. Refer to **Air Conditioning Compressor and Evaporator Hose Replacement** .
28. Connect the drive motor generator control module cooling outlet hose. Refer to **Drive Motor Generator Control Module Cooling Outlet Hose Replacement**
29. Connect the drive motor battery coolant cooler inlet hose quick connect at the right frame. Refer to **Drive Motor Battery Coolant Cooler Inlet Hose Assembly Replacement**

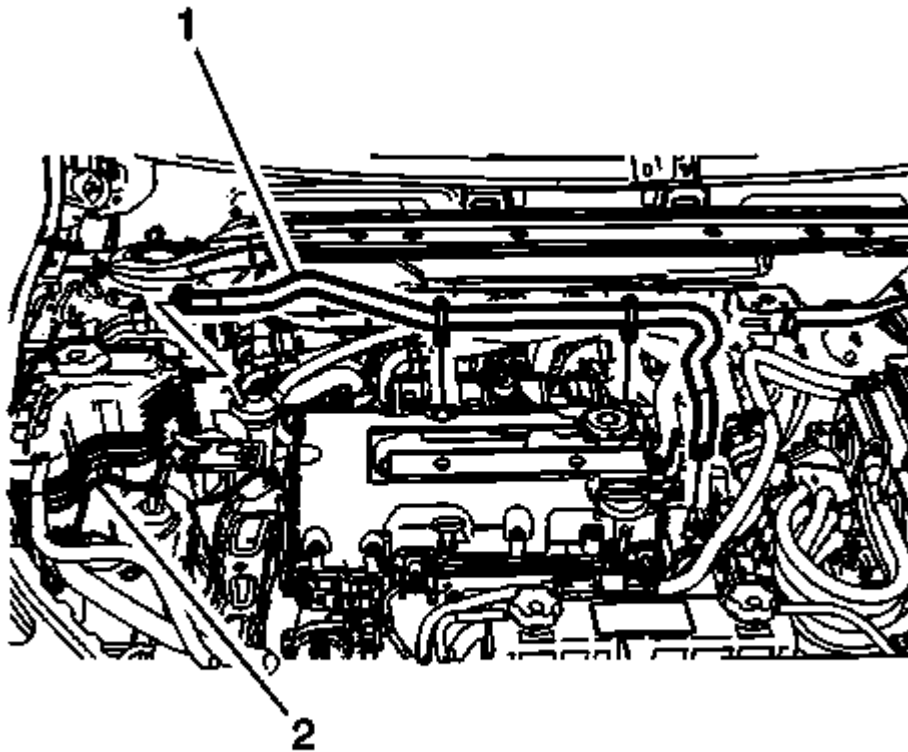


Fig. 103: Heater Outlet Hose Vapor Vent Hose
Courtesy of GENERAL MOTORS COMPANY

30. Connect the heater outlet hose vapor vent hose (1) to the coolant reservoir (2). Refer to **Heater Outlet Hose Vapor Vent Hose Replacement** .

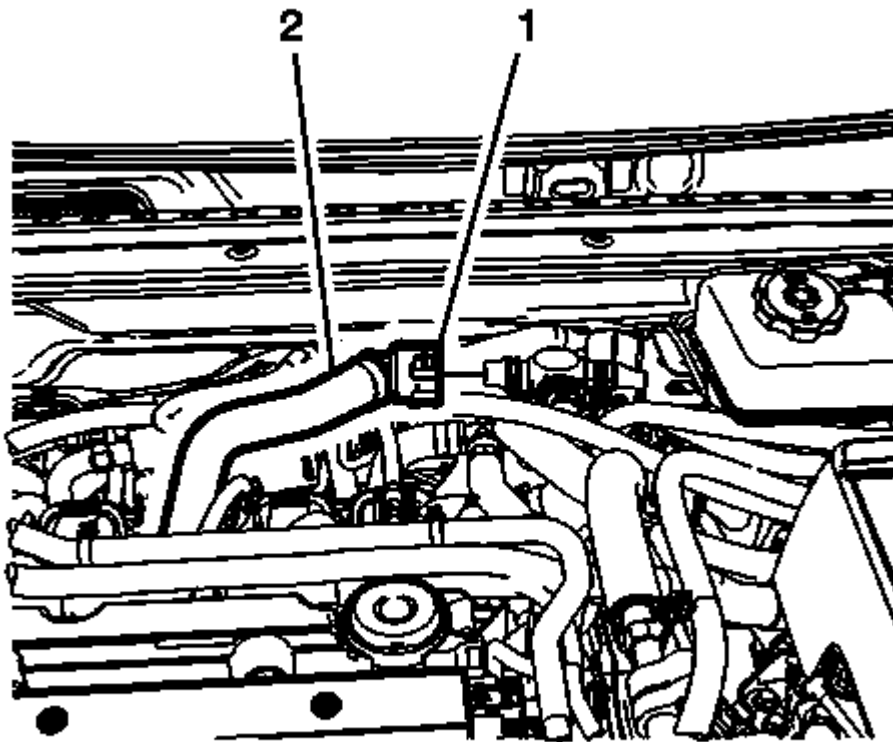


Fig. 104: Heater Water Shutoff Valve Inlet Hose Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

31. Connect the heat water shutoff valve inlet hose (2) to the valve assembly. Refer to **Heater Water Shutoff Valve Inlet Hose Replacement**.
32. Connect the heater inlet and outlet pipe. Refer to **Heater Inlet And Outlet Pipe Replacement**

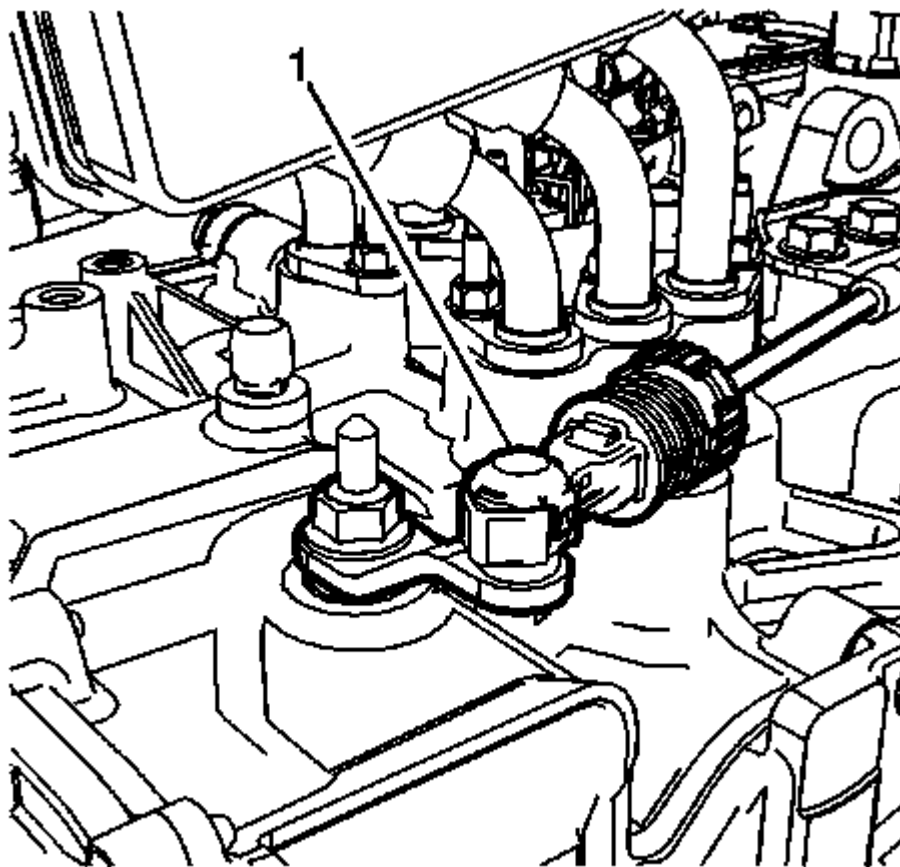


Fig. 105: Transmission Range Selector Lever Cable Terminal
Courtesy of GENERAL MOTORS COMPANY

33. Connect the transmission range selector lever cable terminal (1) to the transmission manual pin.

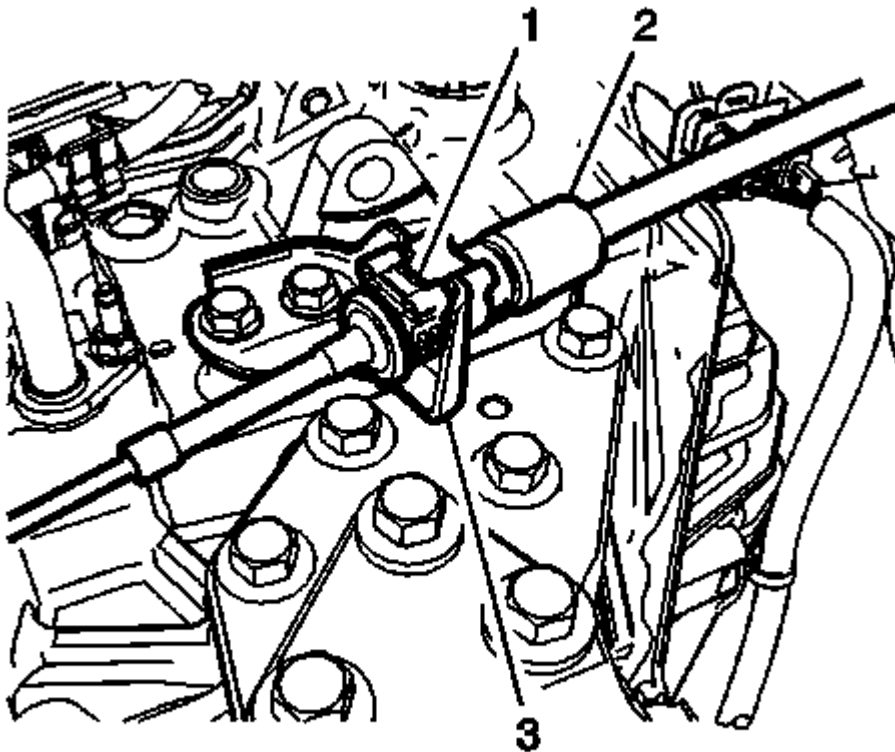


Fig. 106: Transmission Range Selector Lever Cable And Cable Bracket
Courtesy of GENERAL MOTORS COMPANY

34. Press the locking tab (1) forward in order to lock the transmission range selector lever cable (2) to the cable bracket.

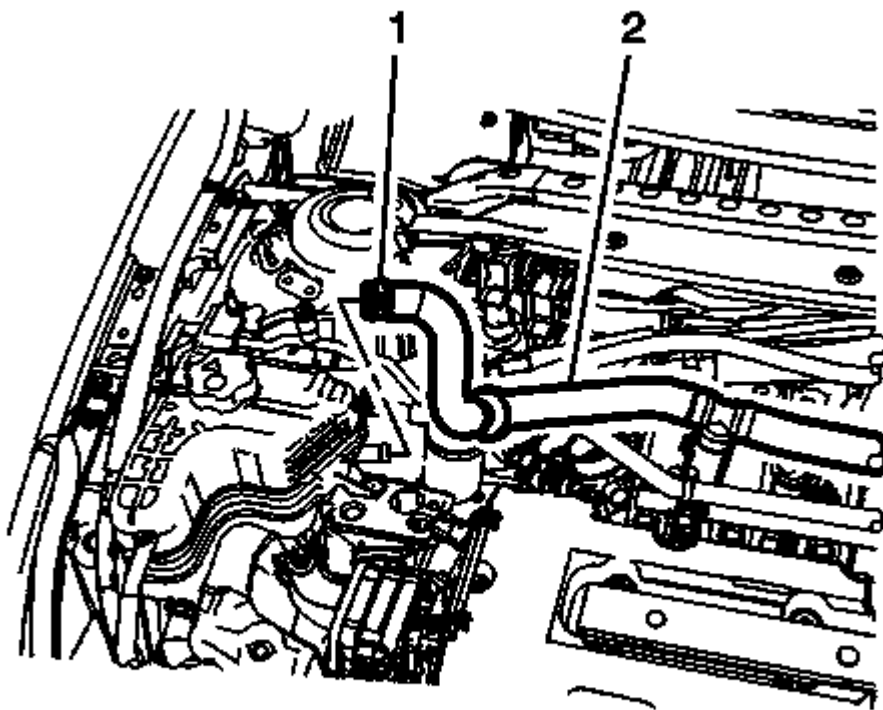


Fig. 107: Heater Water Auxiliary Pump Inlet Hose And Clamp
Courtesy of GENERAL MOTORS COMPANY

35. Connect the heater water auxiliary pump inlet hose (2) to the coolant reservoir.

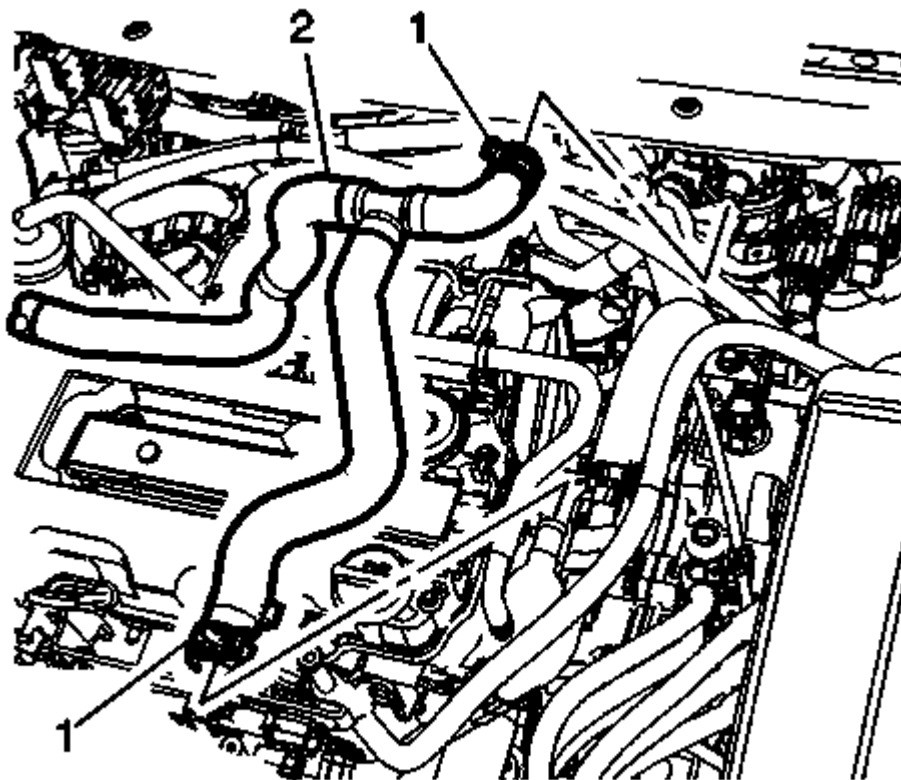


Fig. 108: Heater Water Auxiliary Pump Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

36. Connect the heater water auxiliary pump inlet hose (2) to the heater water shutoff valve.

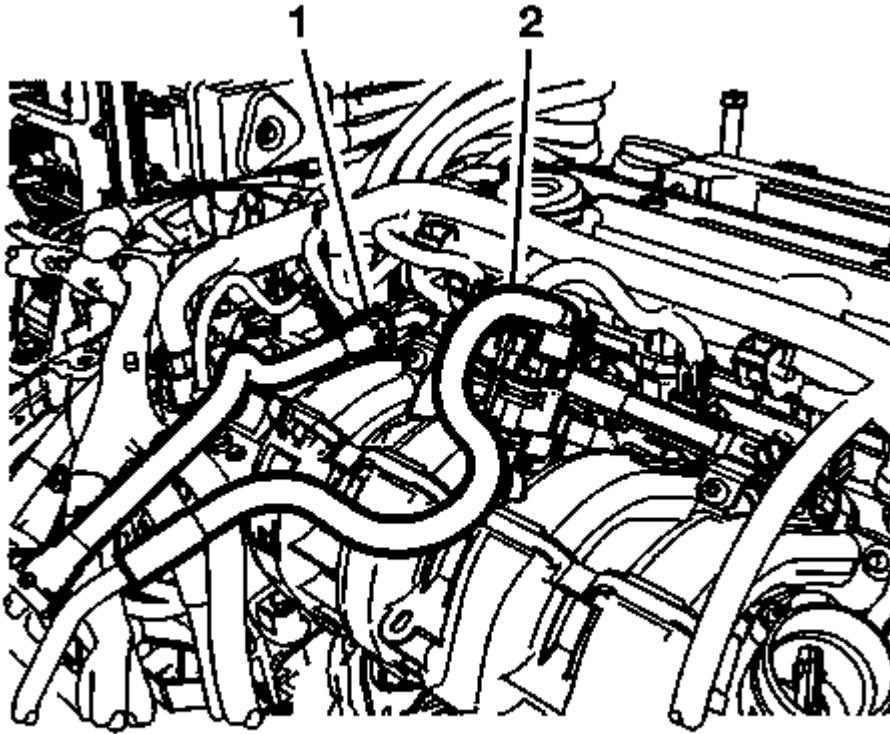


Fig. 109: Canister Purge Hose

Courtesy of GENERAL MOTORS COMPANY

37. Connect the canister purge hose (2) to the purge solenoid located at the back of the of the valve cover.
38. Connect the fuel feed pipe (1) to the fuel rail assembly. Refer to **Fuel Feed Pipe Replacement (Engine Compartment)** , **Fuel Feed Pipe Replacement (Chassis)** .
39. Connect engine coolant hoses as necessary.
40. Connect electrical connectors as necessary.
41. Install the front end panel outer deflectors. Refer to **Front End Panel Outer Deflector Replacement** .
42. Install the front wheelhouse front liners. Refer to **Front Wheelhouse Front Liner Replacement** .
43. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

WARNING: Always perform the High Voltage Disabling procedure prior to servicing any High Voltage component or connection. Personal Protection Equipment (PPE) and proper procedures must be followed.

The High Voltage Disabling procedure will perform the following tasks:

- Identify how to disable high voltage.
- Identify how to test for the presence of high voltage.
- Identify condition under which high voltage is always present and personal protection equipment (PPE) and proper procedures must be followed.

Failure to follow the procedures exactly as written may result in serious injury or death.

44. Install the drive motor generator power inverter module. Refer to **Drive Motor Generator Power Inverter Module Replacement** .
45. Fill the engine cooling system. Refer to **Cooling System Draining and Filling** .
46. Fill the drive motor generator battery cooling system. Refer to **Drive Motor Battery Cooling System Draining and Filling** .
47. Fill the drive motor generator cooling system. Refer to **Drive Motor Generator Power Inverter Module Cooling System Draining and Filling** .
48. Charge the air conditioning system. Refer to **Refrigerant Recovery and Recharging (High Voltage Electric Compressor)** .
49. Check engine oil level. Refer to **Engine Oil and Oil Filter Replacement**
50. Enable the high voltage system. Refer to **High Voltage Enabling** .

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

WARNING: Do not use a service jack in locations other than those specified to lift this vehicle. Lifting the vehicle with a jack in those other locations could cause the vehicle to slip off the jack and roll; this could cause injury or death.

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

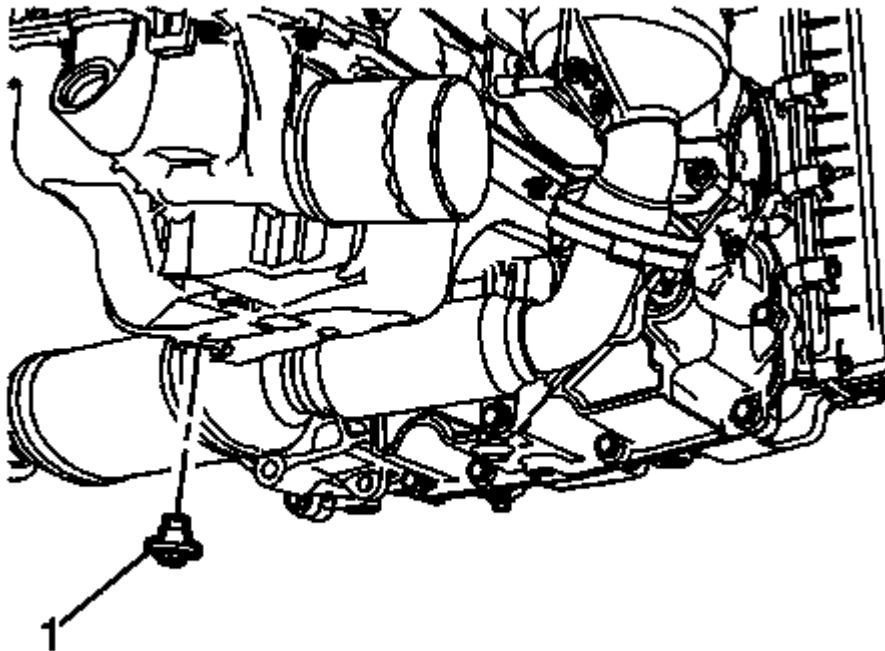


Fig. 110: Oil Pan Drain Plug

Courtesy of GENERAL MOTORS COMPANY

3. Remove the oil pan drain plug (1), and allow the oil to drain completely.

CAUTION: Refer to Fastener Caution .

4. Install the oil pan drain plug and tighten to 14 N.m (124 lb in).

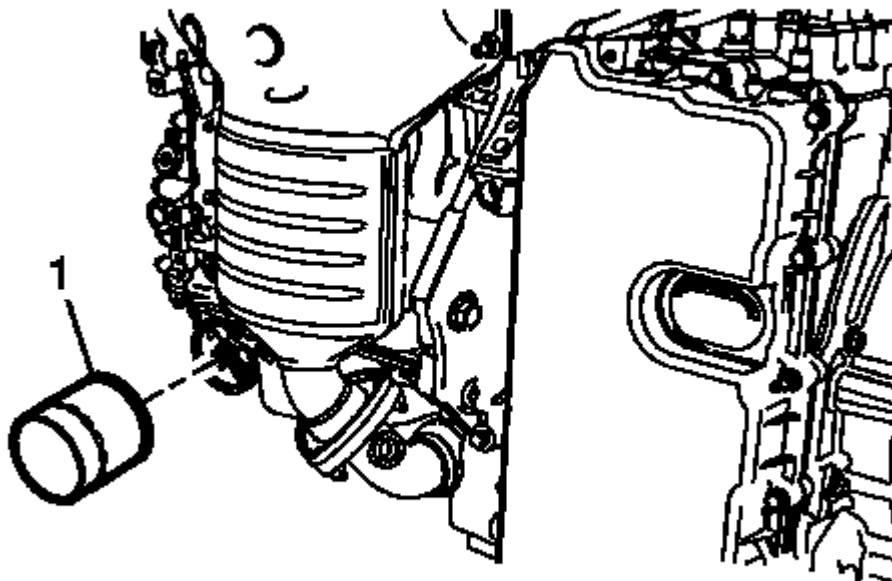


Fig. 111: Oil Filter

Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Hot Exhaust System Warning .

5. Place the drain pan under the oil filter (1).
6. Remove the oil filter. Allow the oil to drain completely.

Installation Procedure

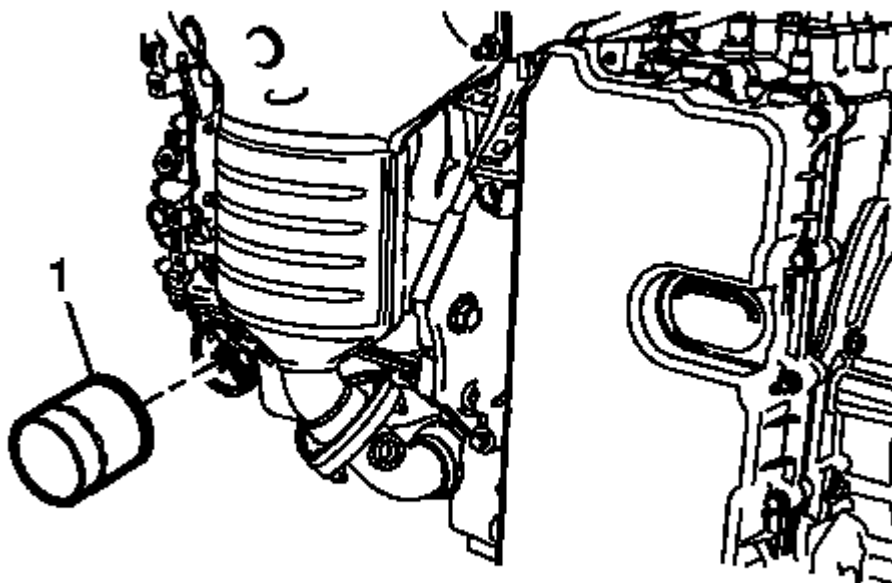


Fig. 112: Oil Filter

Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the NEW oil filter gasket with clean engine oil.
2. Tighten the oil filter (1) to 25 N.m (18 lb ft).
3. Lower the vehicle.

CAUTION: Using engine oils of any viscosity other than those viscosities recommended could result in engine damage.

NOTE: Do not overfill the engine with engine oil.

NOTE: Anytime engine oil is added (top off or oil changes) ensure all engine surfaces are completely free of residual oil. If there is oil on any engine surface clean as necessary.

4. Refill the engine oil. Refer to Approximate Fluid Capacities .

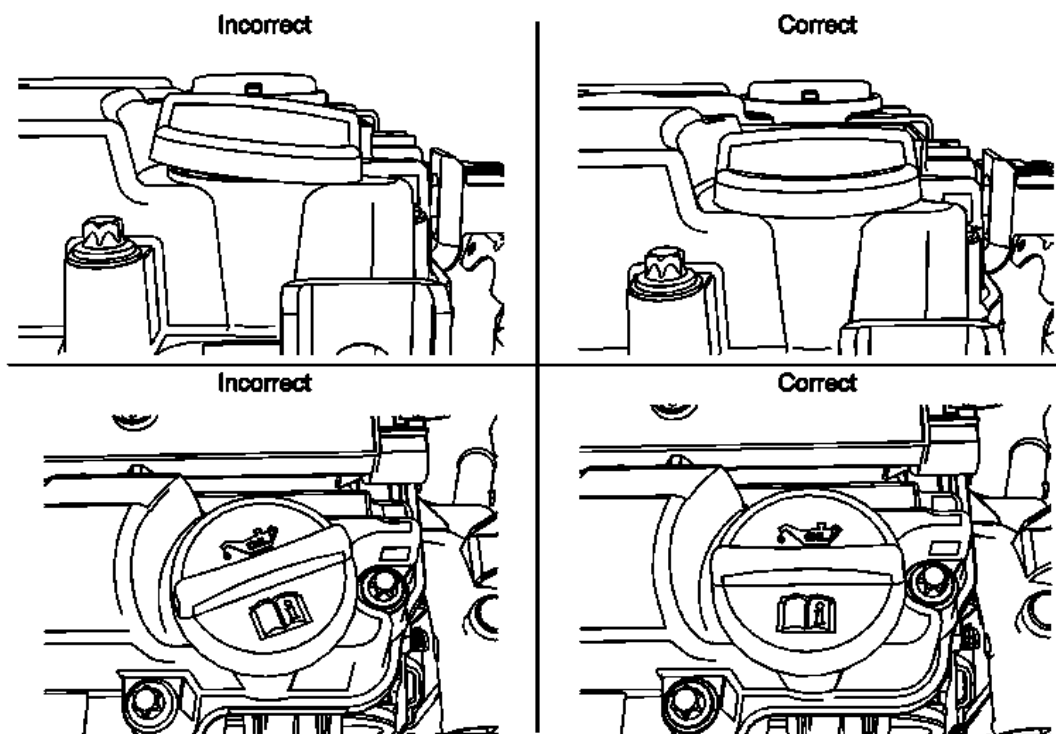


Fig. 113: Proper Oil Filler Cap Seating
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Oil fill cap must be properly seated and tightened during installation.

5. Install oil fill cap.
6. Start the engine and allow it to run until the oil pressure control indicator goes off. Inspect for any oil leaks around the drain plug, oil filter and oil fill cap.

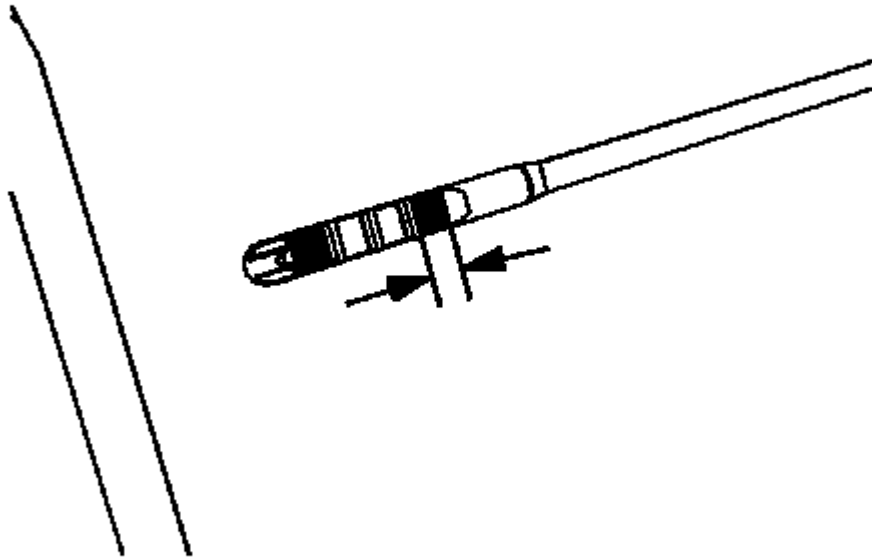


Fig. 114: Engine Oil Level Indicator
Courtesy of GENERAL MOTORS COMPANY

7. Inspect the engine oil level. The oil level should be in the cross-hatched section of the oil level indicator as shown.
8. Close hood.
9. Reset the engine oil life system monitor.

CAMSHAFT COVER REPLACEMENT

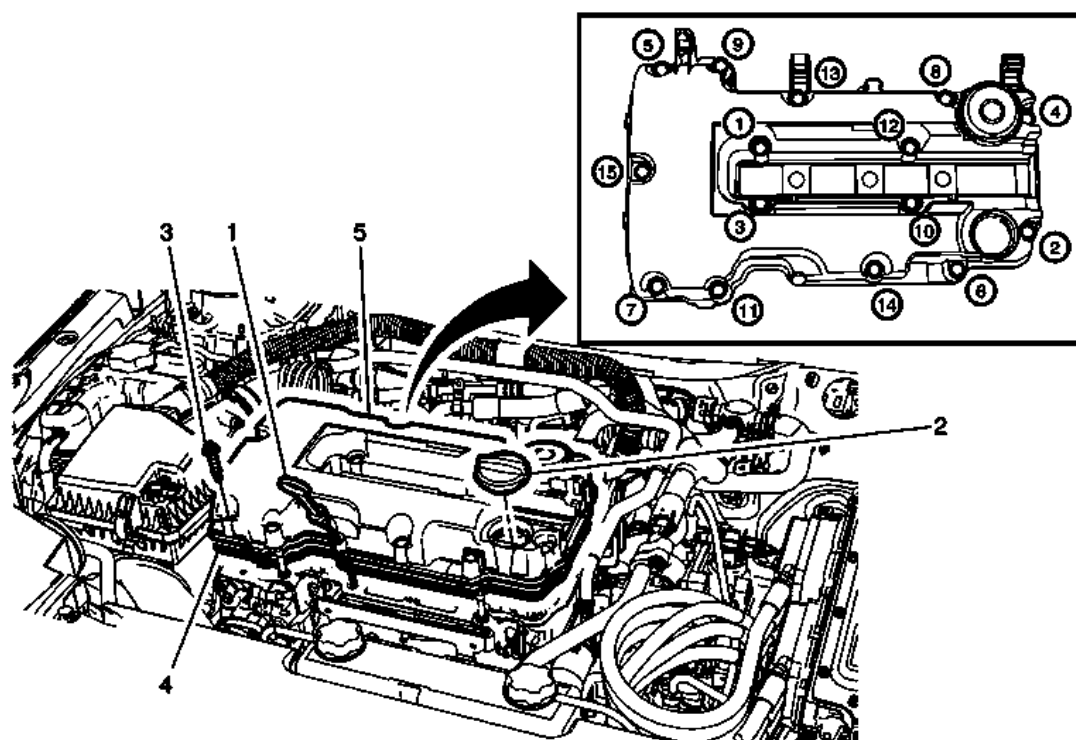


Fig. 115: Camshaft Cover

Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover Replacement

Callout	Component Name
Preliminary Procedure	
Remove the ignition coil. Refer to <u>Ignition Coil Replacement</u> .	
1	Oil Level Indicator
2	Oil Cap
3	Camshaft Cover Fastener (Qty: 15) CAUTION: Refer to <u>Fastener Caution</u> . Procedure Ensure to follow the tighten sequence shown. Tighten 8 N.m (71 lb in)
4	Camshaft Cover Gasket Procedure Do not reuse the camshaft gasket. Also use a new gasket when removing or replacing camshaft cover.
	Camshaft Cover

5

Procedure

1. Remove or reposition the clips as necessary.
2. Disconnect electrical connector as necessary.
3. Transfer components as necessary.

INTAKE CAMSHAFT REPLACEMENT**Removal Procedure**

1. Remove the camshaft sprocket. Refer to Camshaft Intake and Exhaust Sprocket Replacement.

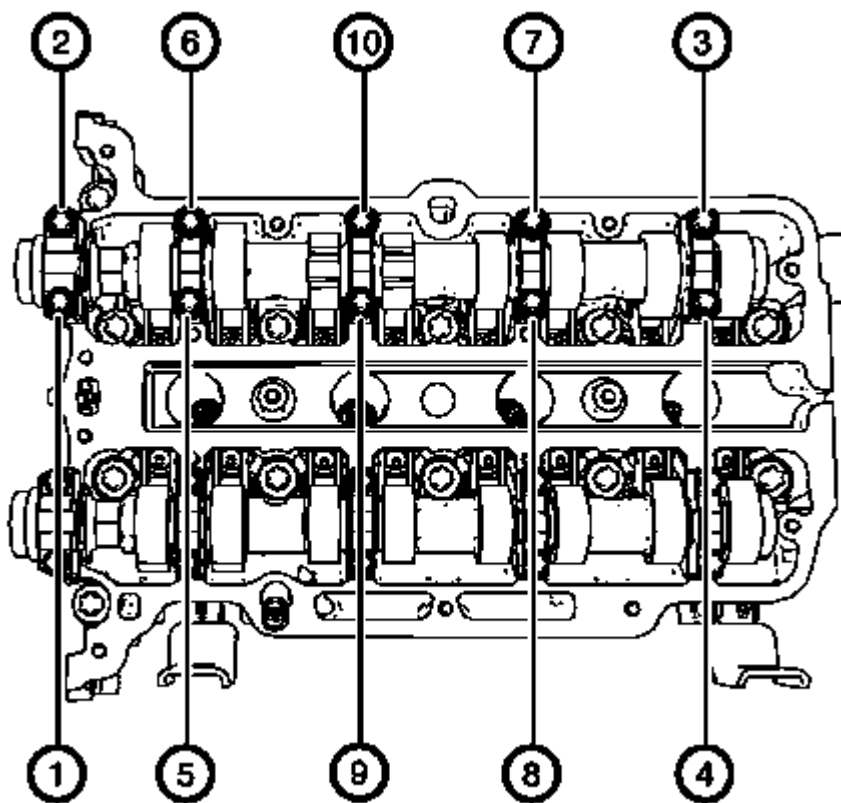


Fig. 116: Intake Camshaft Bearing Cap Bolts Removal Sequence
Courtesy of GENERAL MOTORS COMPANY

2. Remove the camshaft bearing cap bolts in sequence shown. Ensure to remove the bolts one turn at a time until there is no spring tension pushing on the camshaft.

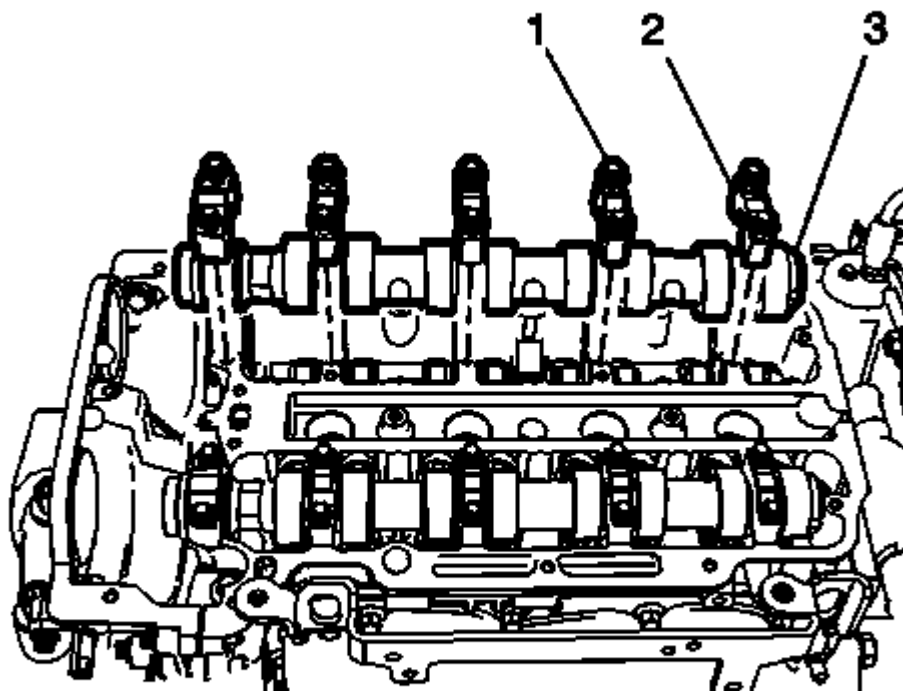


Fig. 117: Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Remove the camshaft bearing cap bolts (1).
4. Remove the camshaft bearing caps (2).
5. Remove the intake camshaft (3).

Installation Procedure

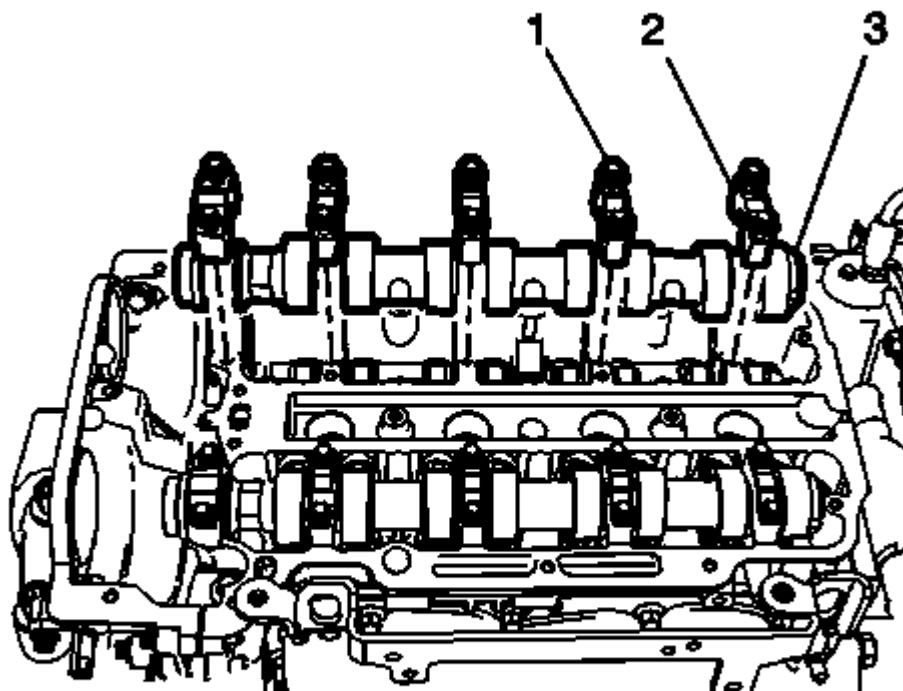


Fig. 118: Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that the camshaft sealing rings are in place in the camshaft grooves. Camshaft sealing rings must be in place below the surface of the camshaft journal in order to avoid being pinched between the cylinder head and the camshaft caps.

1. Lubricate the camshaft and camshaft bearing caps with engine oil.
2. Install the intake camshaft (3).
3. Install the camshaft bearing caps (2).

CAUTION: Refer to Fastener Caution .

4. Install the camshaft bearing cap and hand tighten the bolts (1).

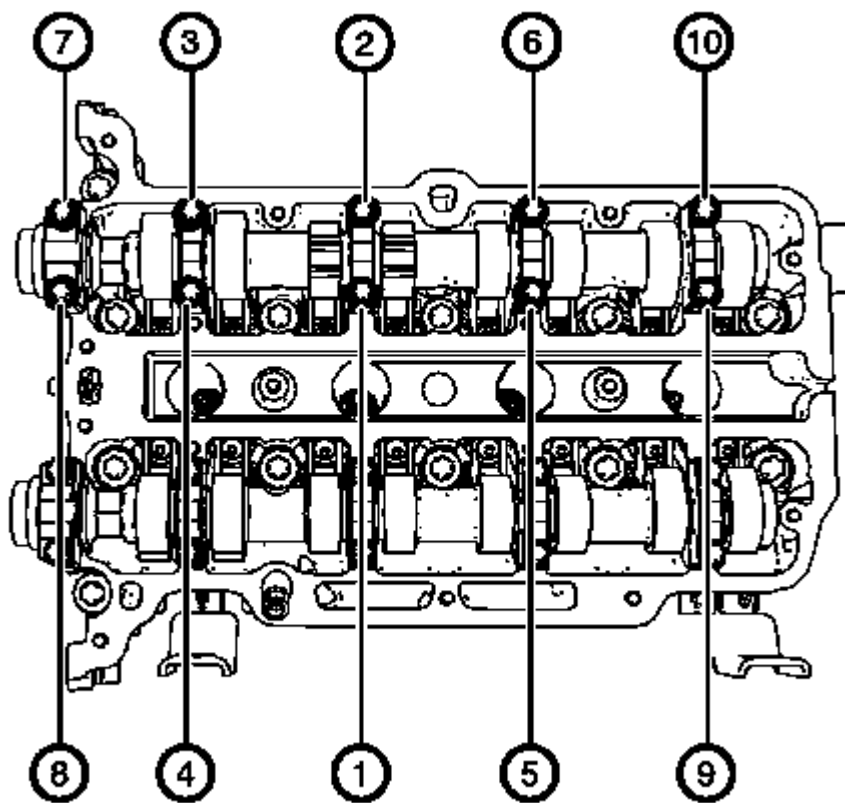


Fig. 119: Intake Camshaft Bearing Cap Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

5. Install and tighten the camshaft bearing cap bolts one turn at a time in sequence as shown to 8 N.m (71 lb in).
6. Install the camshaft intake sprocket. Refer to **Camshaft Intake and Exhaust Sprocket Replacement**.

EXHAUST CAMSHAFT REPLACEMENT

Removal Procedure

1. Remove the camshaft exhaust sprocket. Refer to **Camshaft Intake and Exhaust Sprocket Replacement**.

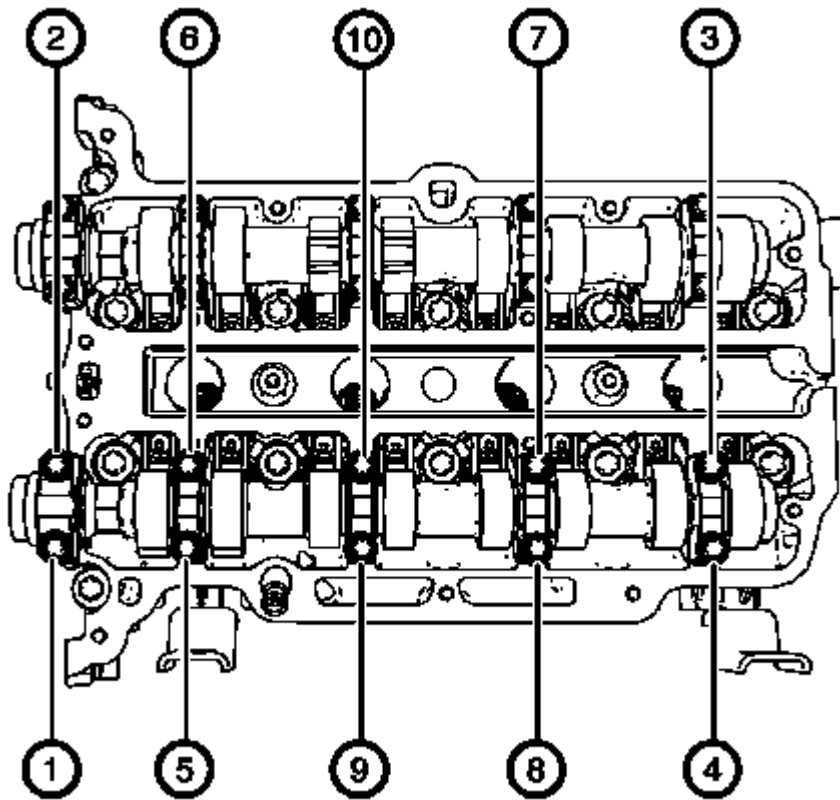


Fig. 120: Exhaust Camshaft Bearing Cap Bolts Removal Sequence
Courtesy of GENERAL MOTORS COMPANY

2. Remove the camshaft bearing cap bolts in sequence shown. Ensure to remove the bolts one turn at a time until there is no spring tension pushing on the camshaft.

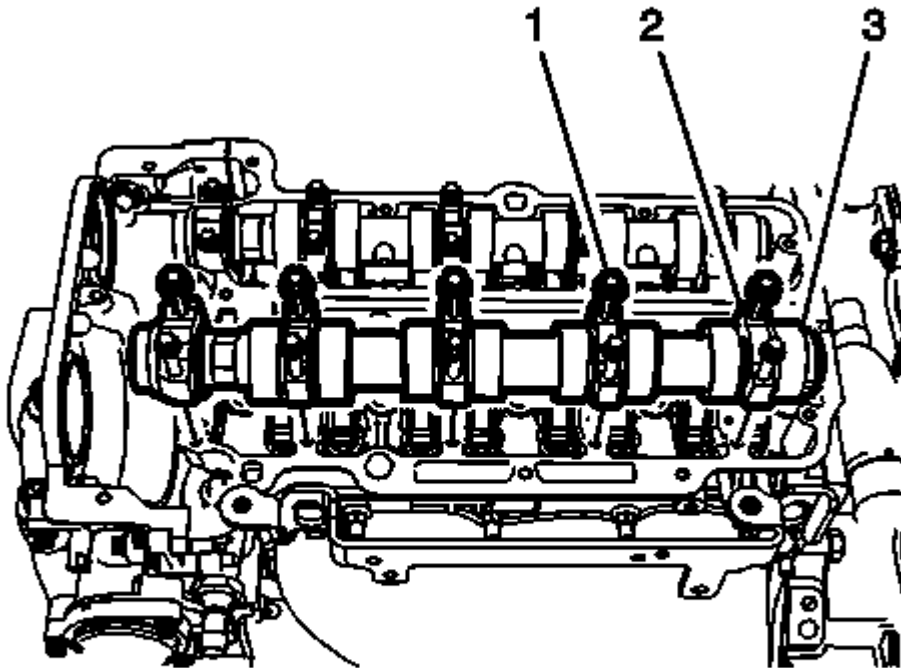


Fig. 121: Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Remove the camshaft bearing cap bolts (1).
4. Remove the camshaft bearing caps (2).
5. Remove the exhaust camshaft (3).

Installation Procedure

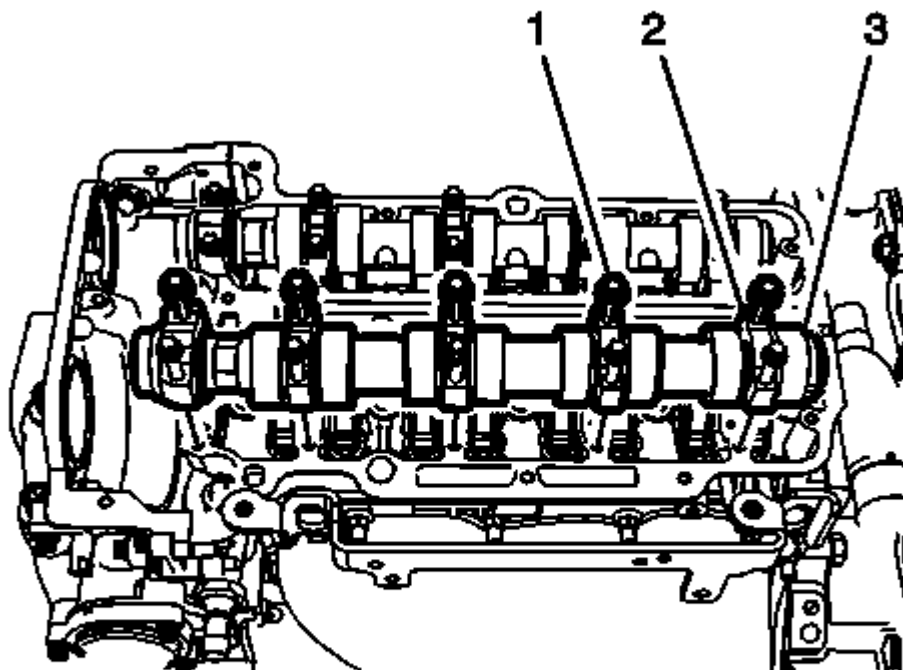


Fig. 122: Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that the camshaft sealing rings are in place in the camshaft grooves. Camshaft sealing rings must be in place below the surface of the camshaft journal in order to avoid being pinched between the cylinder head and the camshaft caps.

1. Lubricate camshaft and camshaft bearing caps with engine oil.
2. Install the exhaust camshaft (3).
3. Install the camshaft bearing caps (2).

CAUTION: Refer to Fastener Caution .

4. Install the camshaft bearing cap and hand tighten the bolts (1).

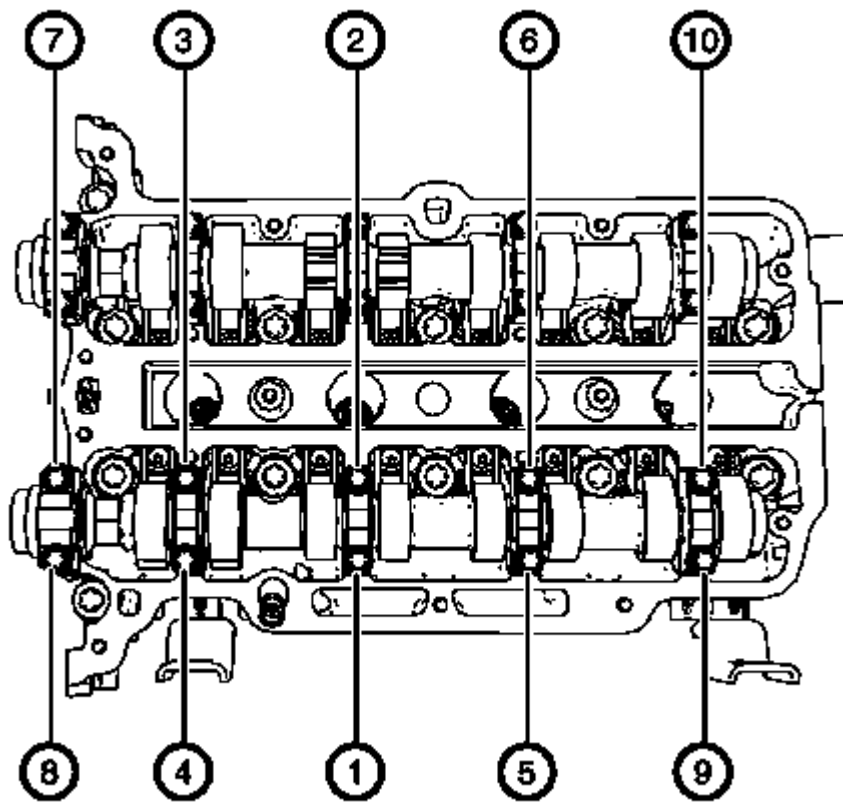


Fig. 123: Exhaust Camshaft Bearing Cap Bolts Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

5. Install and tighten the camshaft bearing cap bolts one turn at a time in sequence as shown 8 N.m (71 lb in).
6. Install the camshaft exhaust sprocket. Refer to **Camshaft Intake and Exhaust Sprocket Replacement**.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Special Tools

- 207649 Rod Hairpin Clips
- 547324 Flange Screws
- EN-958 Installer
- EN-840 Pliers / Remover
- EN-952 Fixing Pin
- EN-50717 Kit
- J-43649-2 Rods

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

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the right front wheel house liner. Refer to **Front Wheelhouse Rear Liner Replacement** .
3. Lower the vehicle.
4. Remove the hydraulic valve lash adjuster arms. Refer to **Hydraulic Valve Lash Adjuster Arm Replacement**.
5. Remove the spark plugs. Refer to **Spark Plug Replacement** .
6. Adjust the engine to TDC of cylinder 1 and fix the crankshaft. Refer to **Camshaft Timing Chain Adjustment**.

NOTE: **Wheels must contact the ground.**

7. Shift to 5. gear (MT) or park position (AT) and apply the park brake.

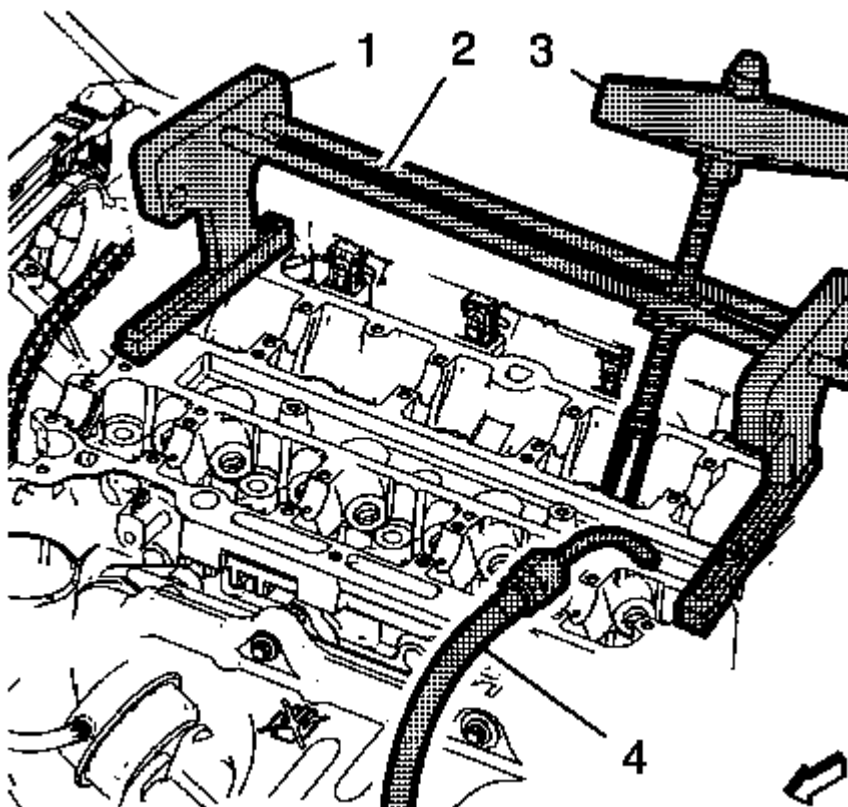
Valve Stem Oil Seal Removal

Fig. 124: Special Seal Removal Tools
Courtesy of GENERAL MOTORS COMPANY

1. Install the 2 **EN-50717-1** stands (1) to the cylinder head and fix them with the **547324** screws.

2. Install the 2 **J-43649-2** rods into the corresponding side, then secure the rods with the 207649 clips:
 - Side "A" (1.4L) engines
 - Side "B" (1.6L, 1.8L) engines.
3. Install the **EN-51717-2** compressor (3) to the **EN-50717-1** stands.
4. Install an suitable air pressure adapter (4) to the spark plug hole.
5. Apply air pressure to the corresponding cylinder.
6. Position the **EN-51717-2** compressor (3) so that its adapter proper contacts the valve spring retainer and pretension the compressor.

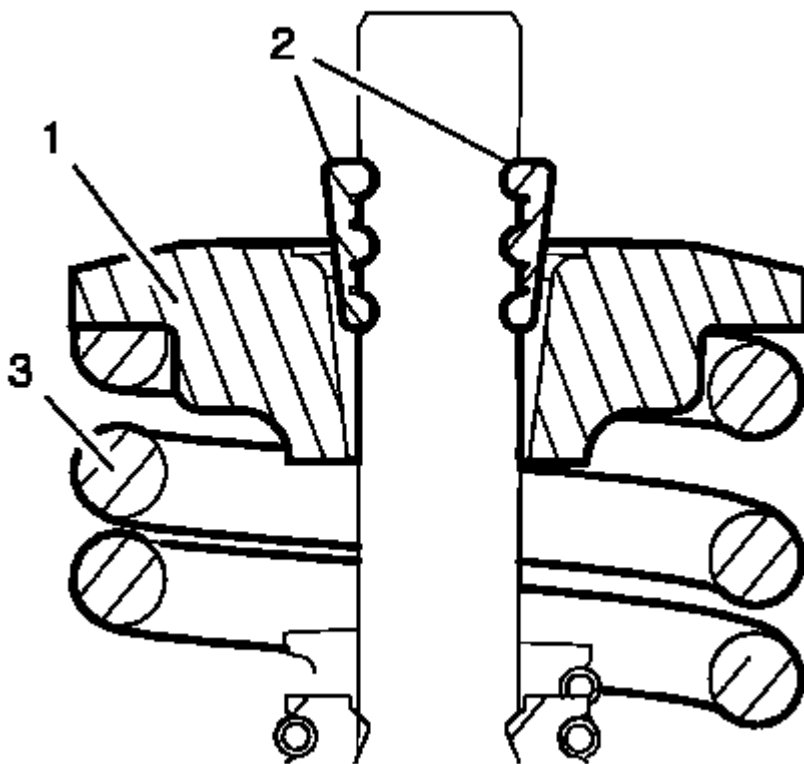


Fig. 125: Valve Spring Retainer And Valve Spring
 Courtesy of GENERAL MOTORS COMPANY

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

7. Apply pressure to the **EN-50717-2** compressor to push down the valve spring retainer (1) and compress the valve spring (3) until the valve keys (2) are free from tension. Carefully remove the valve keys then.
8. Release the tension from the **EN-50717-2** compressor.
9. Remove the valve spring retainer (1) and the valve spring (3).

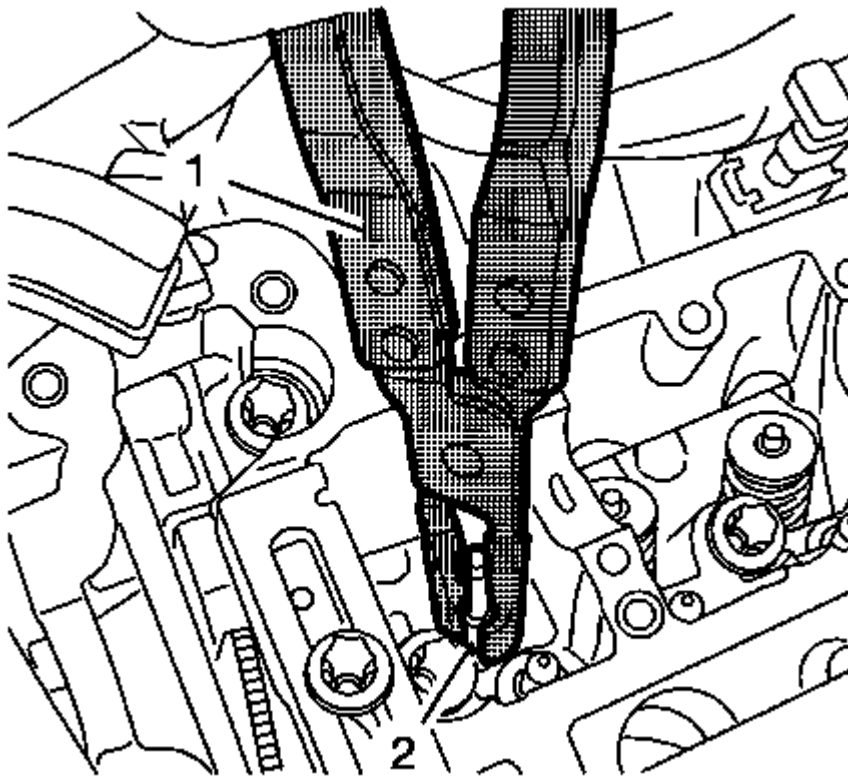


Fig. 126: Pliers And Intake Valve Stem Oil Seals
Courtesy of GENERAL MOTORS COMPANY

10. Remove and DISCARD the valve stem oil seal (2), using the **EN-840** pliers (1).

Valve Stem Oil Seal Installation

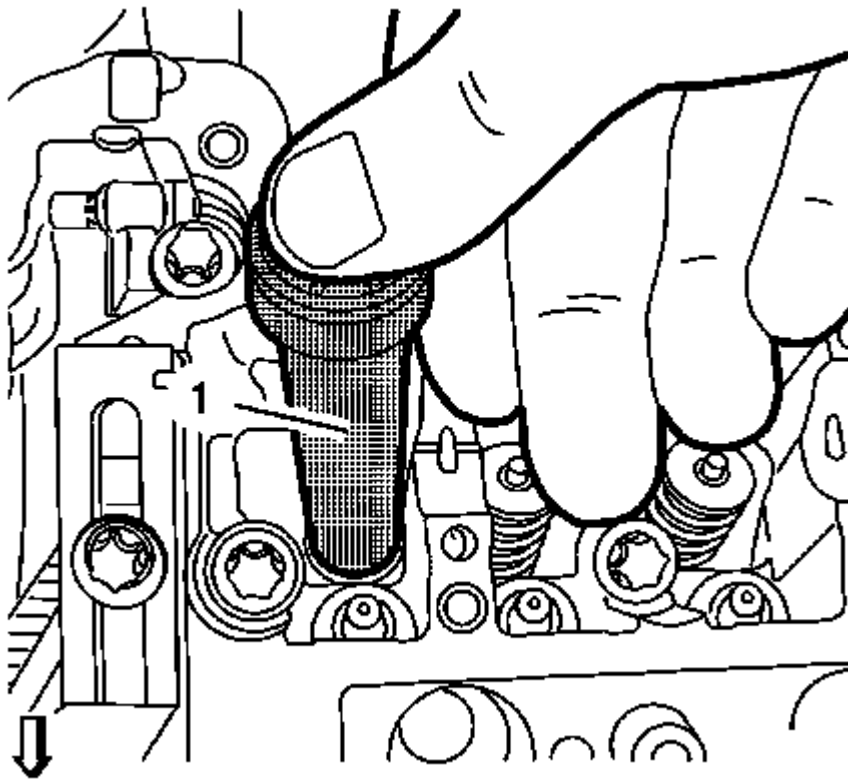


Fig. 127: Intake Valve Stem Oil Seal Installation Tool
Courtesy of GENERAL MOTORS COMPANY

NOTE: Lubricate the **NEW** valve stem oil seal with clean engine oil.

1. Install the NEW valve stem oil seal, using the **EN-958** installer (1).
2. Loosely install the valve spring and the valve spring retainer.

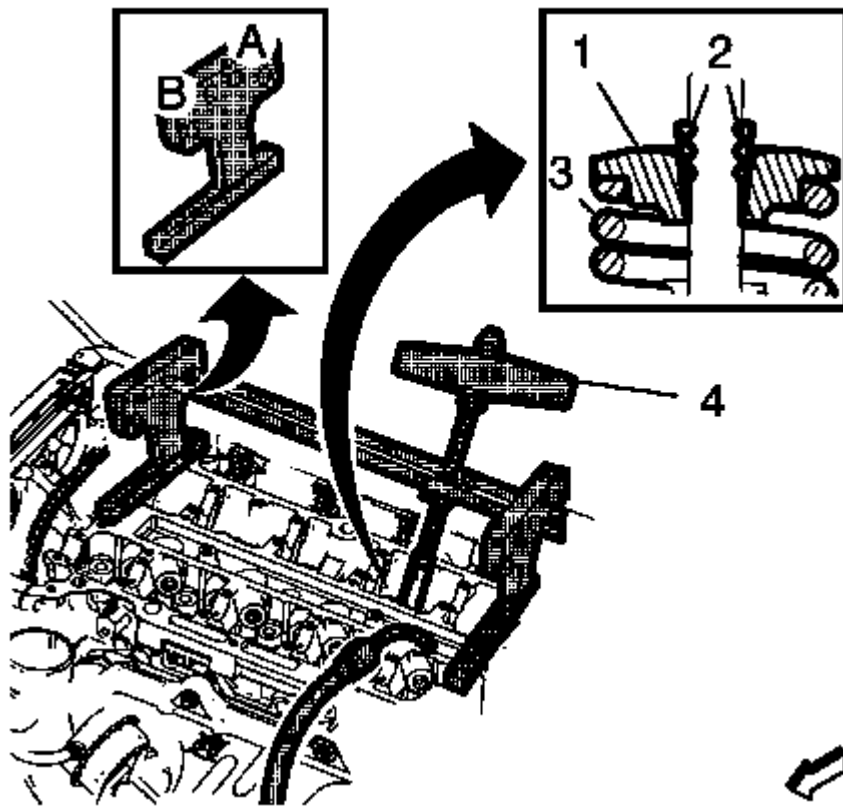


Fig. 128: Special Valve Spring Compression Tool
Courtesy of GENERAL MOTORS COMPANY

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

3. Using the **EN-51717-2** compressor (4), push down the valve spring retainer (1) and compress the valve spring (3) until the valve keys (2) can be inserted. Carefully insert the valve keys then, so that they are proper installed to the valve stem grooves.
4. Carefully release the tension from the **EN-50717-2** compressor.
5. Inspect the valve keys and valve spring retainer for proper seat.
6. Repeat the procedure with the remaining valves and cylinders. Transfer the **EN-50717-1** stands and the **EN-51717-2** compressor as needed.
7. Take care that air pressure is always applied to the combustion chamber of the treated cylinder.

Installation Procedure

1. Remove the tools from the cylinder head.
2. Release the air pressure and remove the air pressure adapter form the spark plug hole.
3. Shift to neutral gear and release the park brake.

4. Install the spark plugs. Refer to [Spark Plug Replacement](#) .
5. Install the hydraulic valve lash adjuster arms. Refer to [Hydraulic Valve Lash Adjuster Arm Replacement](#).
6. Raise the vehicle.
7. Remove the **EN-952** fixing pin and install the crankshaft bearing cap tie plate hole plug.
8. Install the right front wheelhouse liner. Refer to [Front Wheelhouse Rear Liner Replacement](#) .
9. Lower the vehicle.

REPAIR INSTRUCTIONS - OFF VEHICLE

ENGINE MOUNT BRACKET REMOVAL

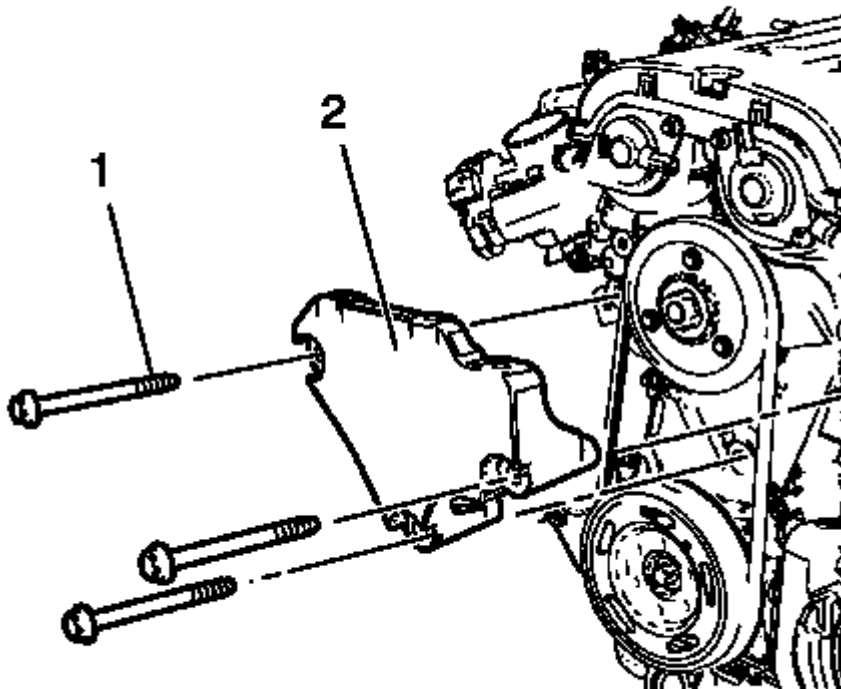


Fig. 129: Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 3 engine mount bracket bolts (1).
2. Remove the engine mount bracket (2).

CAMSHAFT TIMING CHAIN INSPECTION

Special Tools

- **EN-952** Fixing Pin
- **EN-953-A** Fixing Tool
- **EN-49977-100** Transmitter Disc Fixation

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

1. Remove the ignition coil. Refer to **Ignition Coil Removal**.
2. Remove the camshaft cover. Refer to **Camshaft Cover Removal**.
3. Remove the air conditioning compressor bracket. Refer to **Air Conditioning Compressor Bracket Removal**.

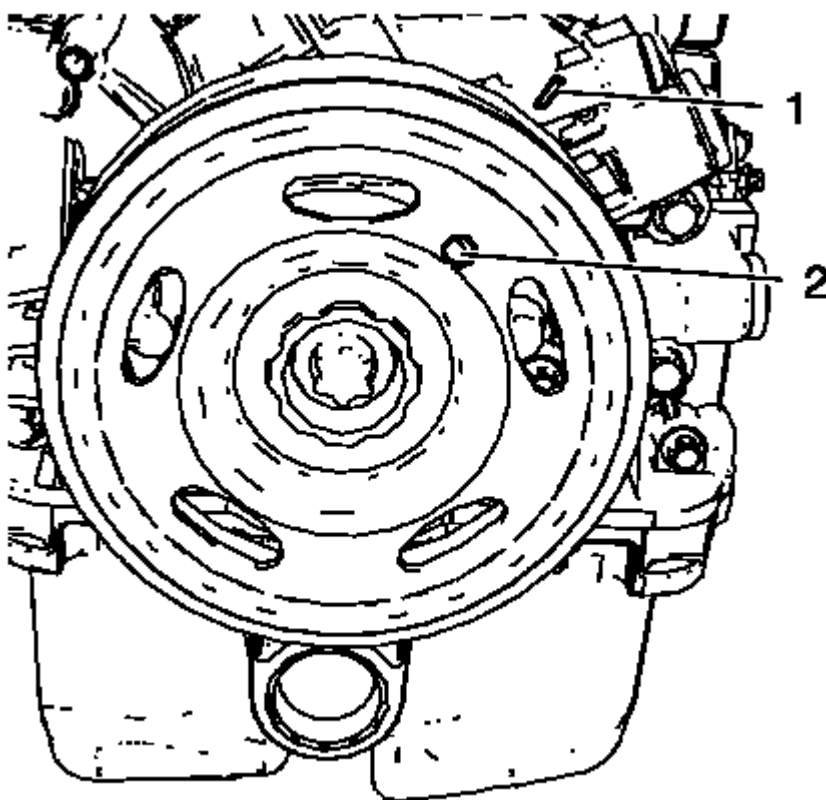


Fig. 130: Bore And Mark

Courtesy of GENERAL MOTORS COMPANY

4. Rotate the engine clockwise until the bore (2) in the crankshaft balancer aligns with the mark (1) on the engine front cover.

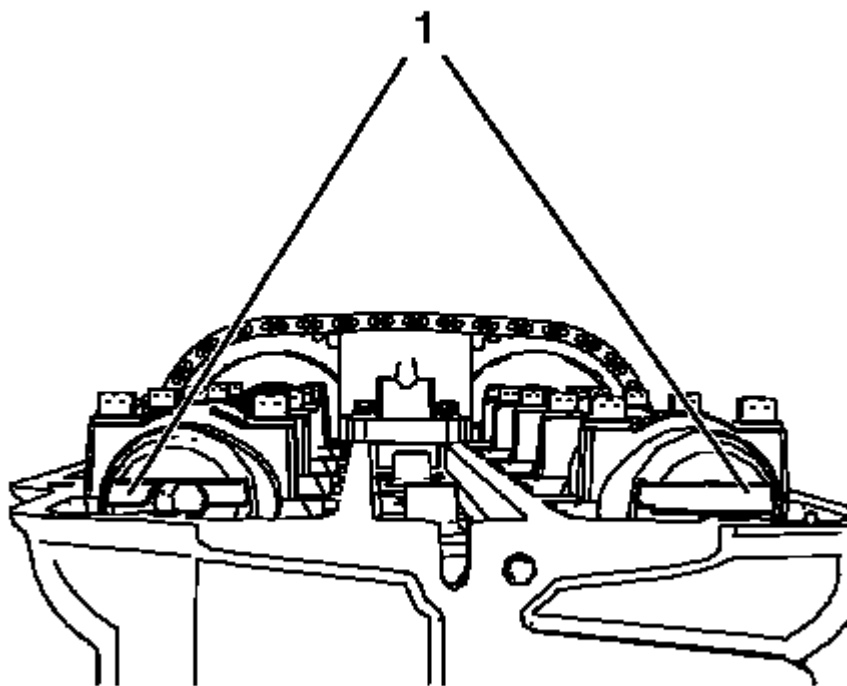


Fig. 131: Camshaft Grooves

Courtesy of GENERAL MOTORS COMPANY

5. Examine that the camshaft grooves (1) are visible as shown. If the camshaft grooves are not visible rotate the crankshaft 360°.

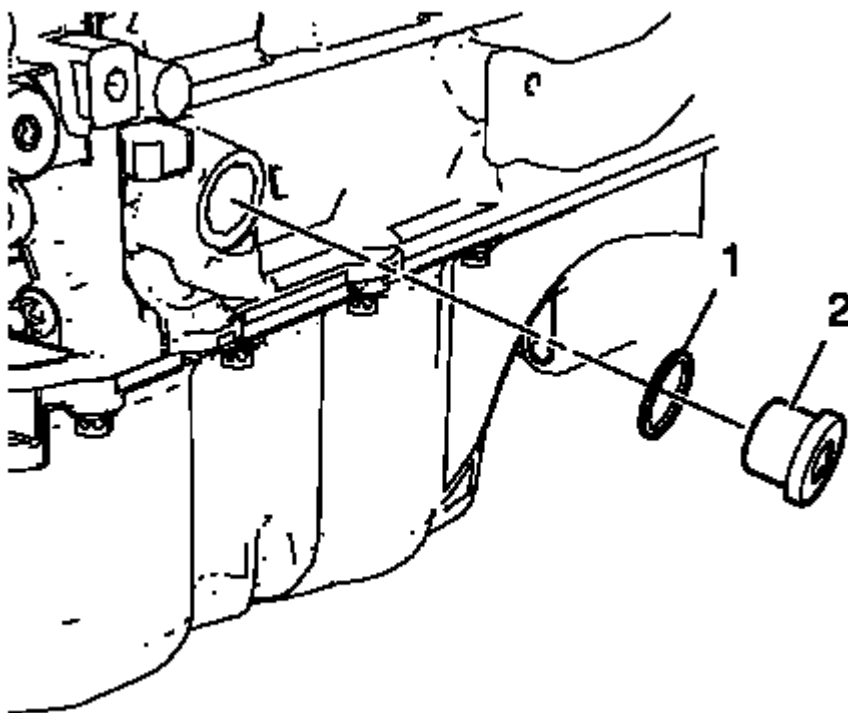


Fig. 132: Crankshaft Bearing Cap Tie Plate Hole Plug And Seal Ring
Courtesy of GENERAL MOTORS COMPANY

6. Remove the crankshaft bearing cap tie plate hole plug (2) and the seal ring (1).

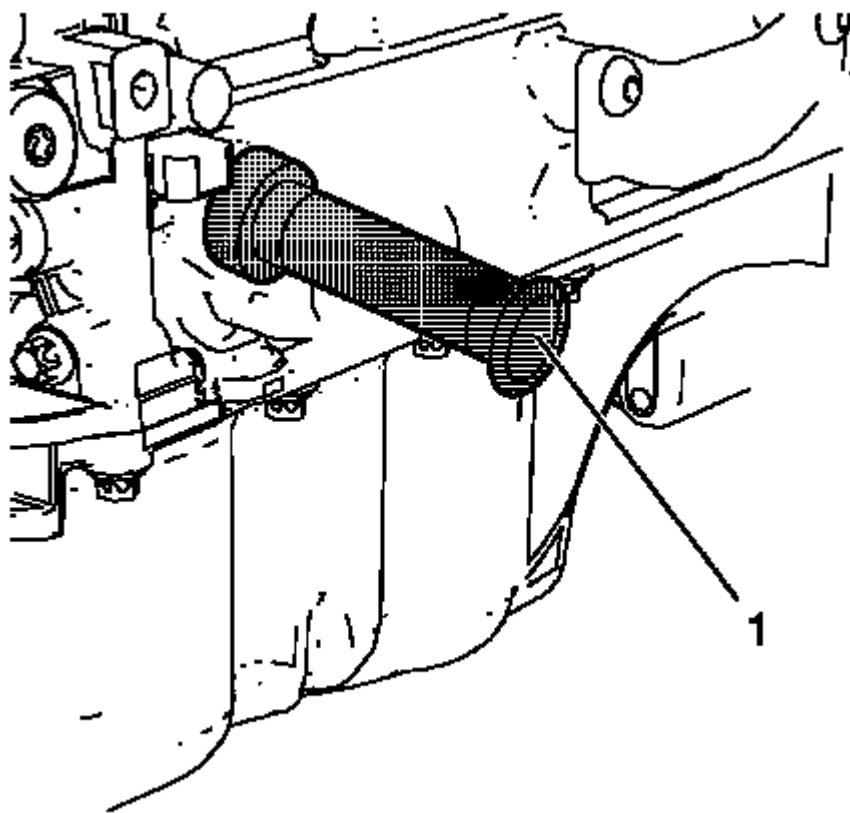


Fig. 133: Fixing Pin

Courtesy of GENERAL MOTORS COMPANY

CAUTION: To ensure proper crankshaft top dead center (TDC) alignment, the retention pin should fit easily through the bore in the crankshaft tie plate and into the crankshaft. Binding of the retention pin could affect proper engine timing.

7. Install **EN-952** fixing pin (1) in order to fix the crankshaft in TDC position.

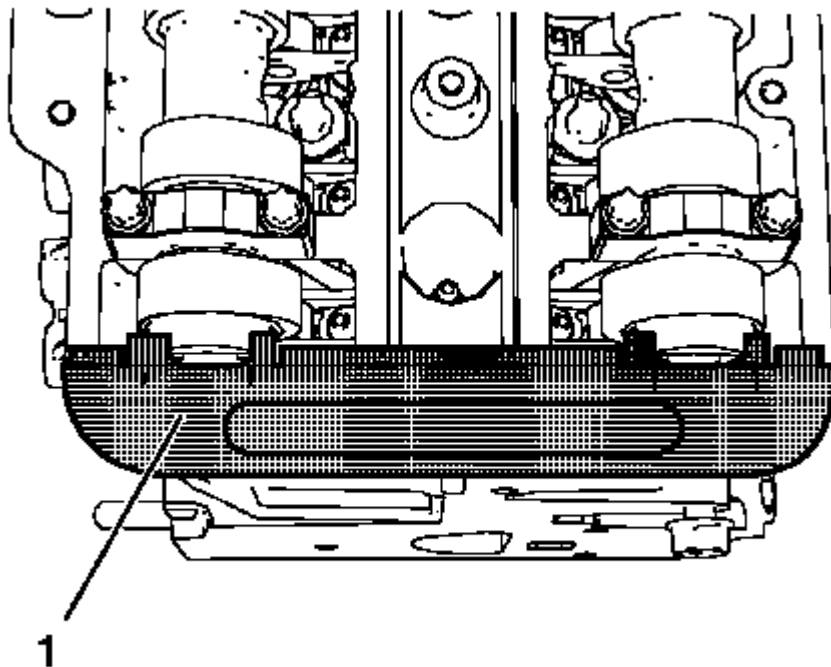


Fig. 134: Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: The fixing tool should be installed completely to both camshaft grooves without high effort.

8. Install **EN-953-A** fixing tool (1) to the camshafts.

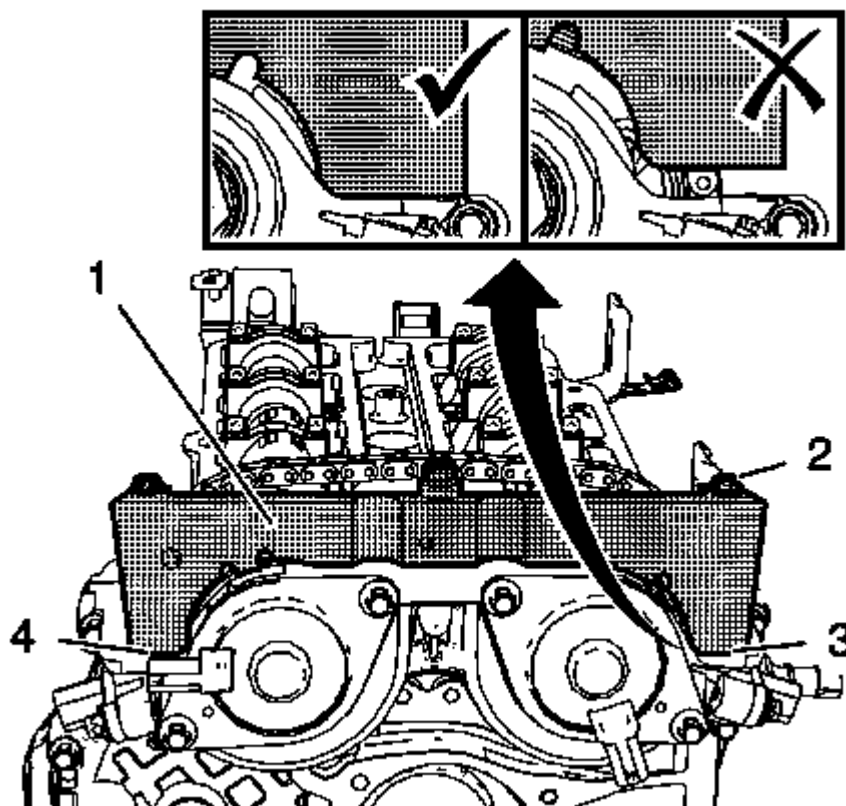


Fig. 135: Transmitter Disc Fixation And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: A wrong installation position is possible. Make sure that the fixation tool is installed without clearance to the cylinder head in areas (3) and (4).

9. Install EN-49977-100 fixation (1) in order to inspect the correct position of the camshaft position exciter wheels.
10. Tighten the bolts (2) of EN-49977-100 fixation.
11. If EN-953-A fixing tool or EN-49977-100 fixation can not be installed, refer to Camshaft Timing Chain Adjustment.
12. Remove EN-49977-100 fixation.
13. Remove EN-953-A fixing tool.
14. Remove EN-952 fixing pin.

CAUTION: Refer to Fastener Caution .

15. Install crankshaft bearing cap tie plate hole plug and seal ring and tighten to 40 N.m (30 lb ft).
16. Install the camshaft cover. Refer to Camshaft Cover Installation.

17. Install the ignition coil. Refer to **Ignition Coil Installation**.
18. Install the air conditioning compressor bracket. Refer to **Air Conditioning Compressor Bracket Installation**.

CAMSHAFT TIMING CHAIN ADJUSTMENT

Special Tools

- **EN-952** Fixing Pin
- **EN-953-A** Fixing Tool
- **EN-49977-100** Transmitter Disc Fixation

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

1. Remove the ignition coil. Refer to **Ignition Coil Removal**.
2. Remove the camshaft cover. Refer to **Camshaft Cover Removal**.
3. Remove the air conditioning compressor bracket. Refer to **Air Conditioning Compressor Bracket Removal**.
4. Remove the camshaft position actuator solenoid valves. Refer to **Camshaft Position Actuator Solenoid Valve Removal**.

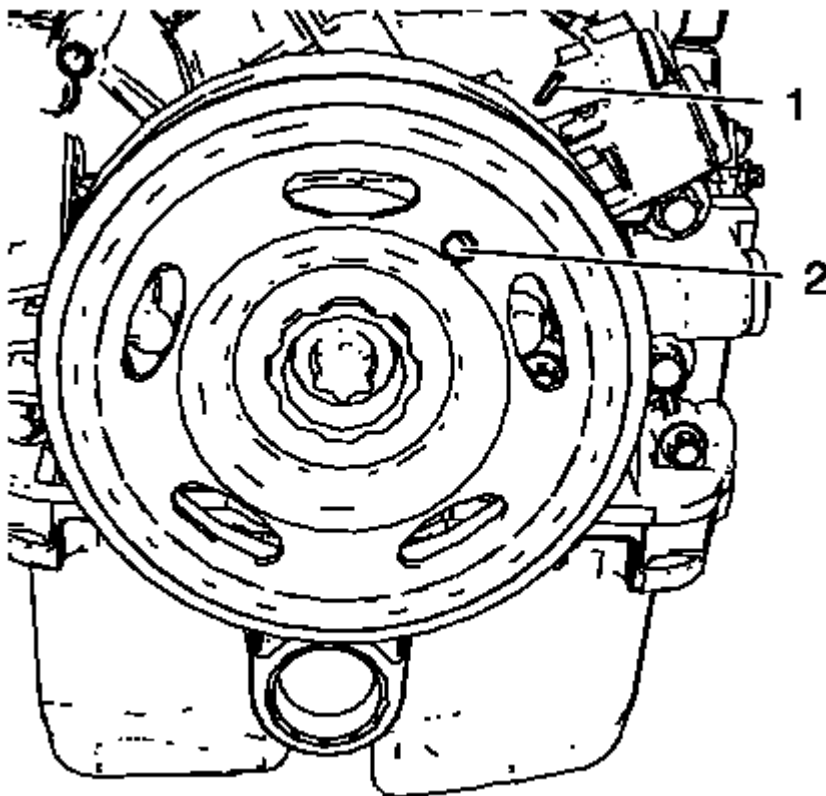
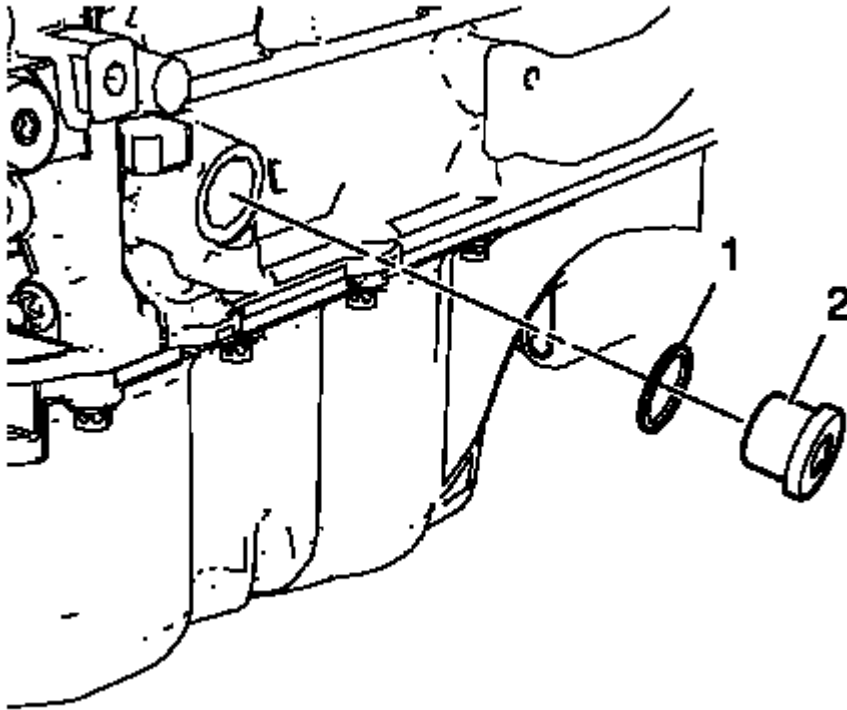


Fig. 136: Bore And Mark**Courtesy of GENERAL MOTORS COMPANY**

5. Rotate the engine clockwise until the bore (2) in the crankshaft balancer aligns with the mark (1) on the engine front cover.

**Fig. 137: Crankshaft Bearing Cap Tie Plate Hole Plug And Seal Ring****Courtesy of GENERAL MOTORS COMPANY**

6. Remove the crankshaft bearing cap tie plate hole plug (2) and the seal ring (1).

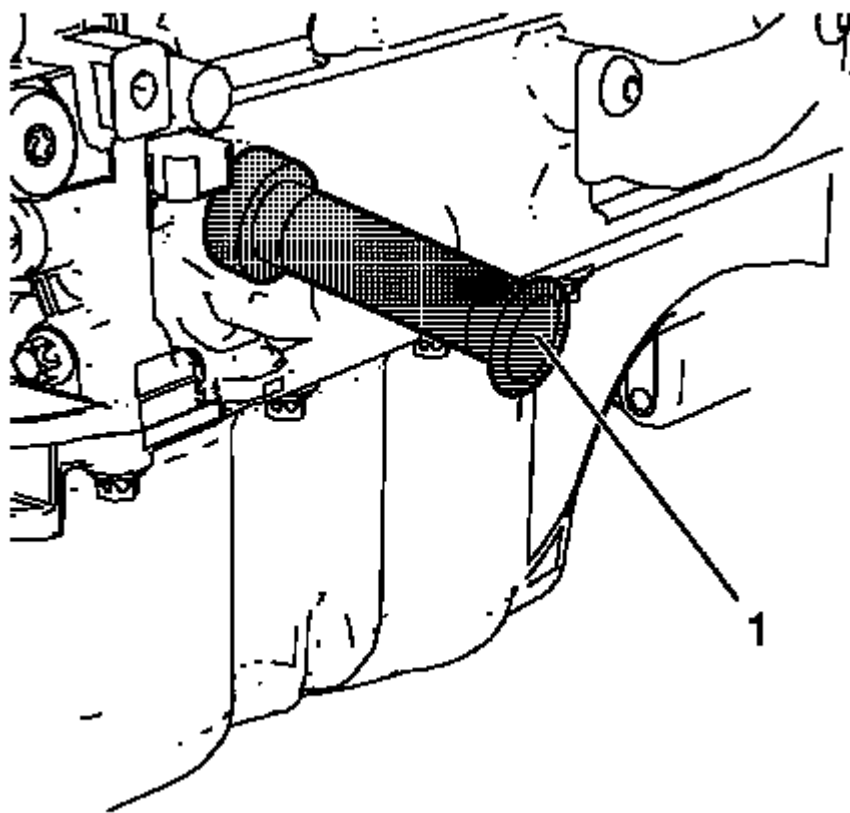


Fig. 138: Fixing Pin

Courtesy of GENERAL MOTORS COMPANY

CAUTION: To ensure proper crankshaft top dead center (TDC) alignment, the retention pin should fit easily through the bore in the crankshaft tie plate and into the crankshaft. Binding of the retention pin could affect proper engine timing.

7. Install **EN-952** fixing pin (1) in order to fix the crankshaft in TDC position.

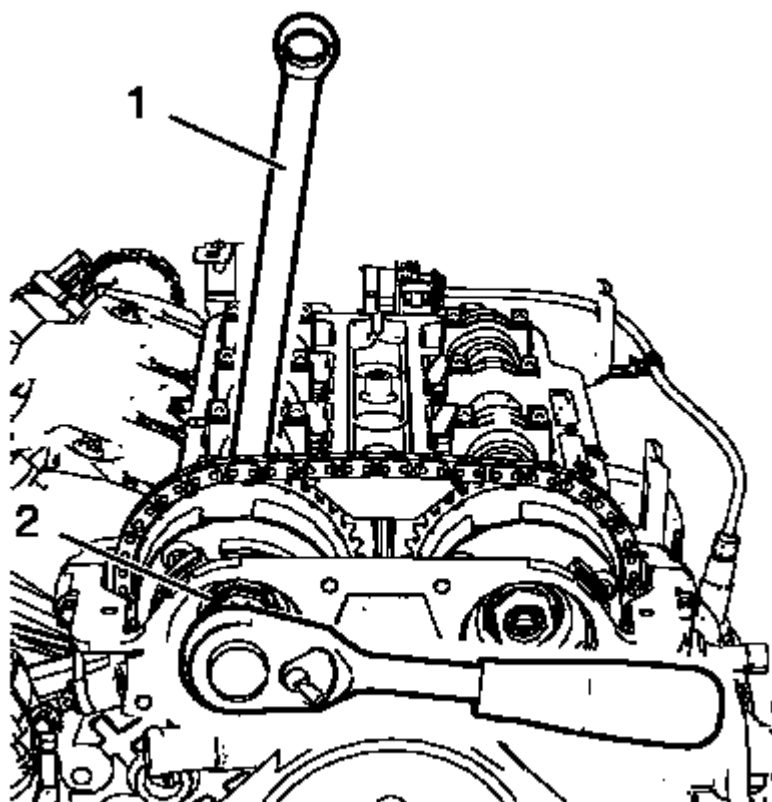


Fig. 139: Intake Camshaft Sprocket Bolt And Wrench
Courtesy of GENERAL MOTORS COMPANY

8. Loosen the intake camshaft sprocket bolt (2) while holding up the hexagon of the intake camshaft with a spanner (1) until the camshaft position exciter wheel is clearly rotatable.
9. Loosen the exhaust camshaft sprocket bolt while holding up the hexagon of the exhaust camshaft with a spanner until the camshaft position exciter wheel is clearly rotatable.

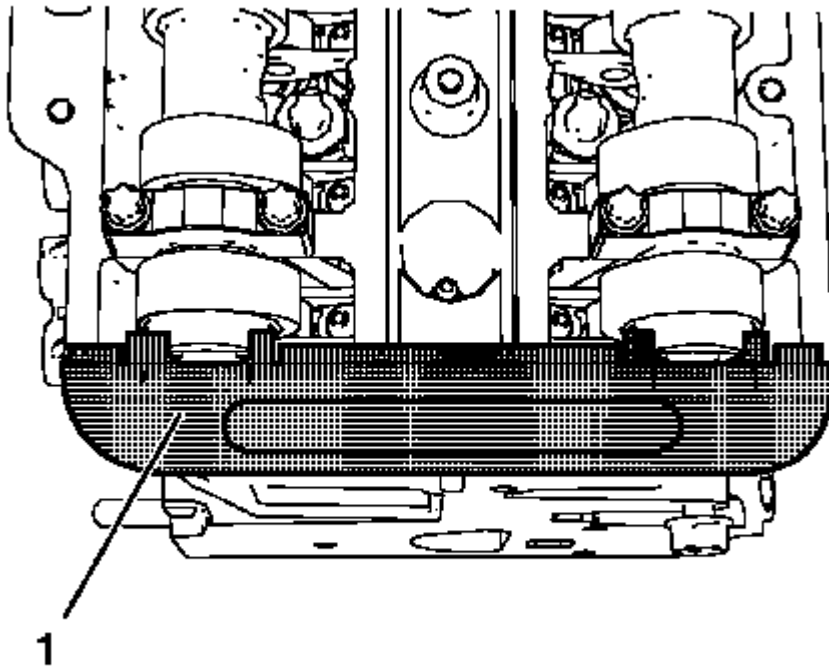


Fig. 140: Fixing Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: The fixing tool should be installed completely to both camshaft grooves without high effort.

10. Adjust camshafts that EN-953-A fixing tool (1) can be installed.

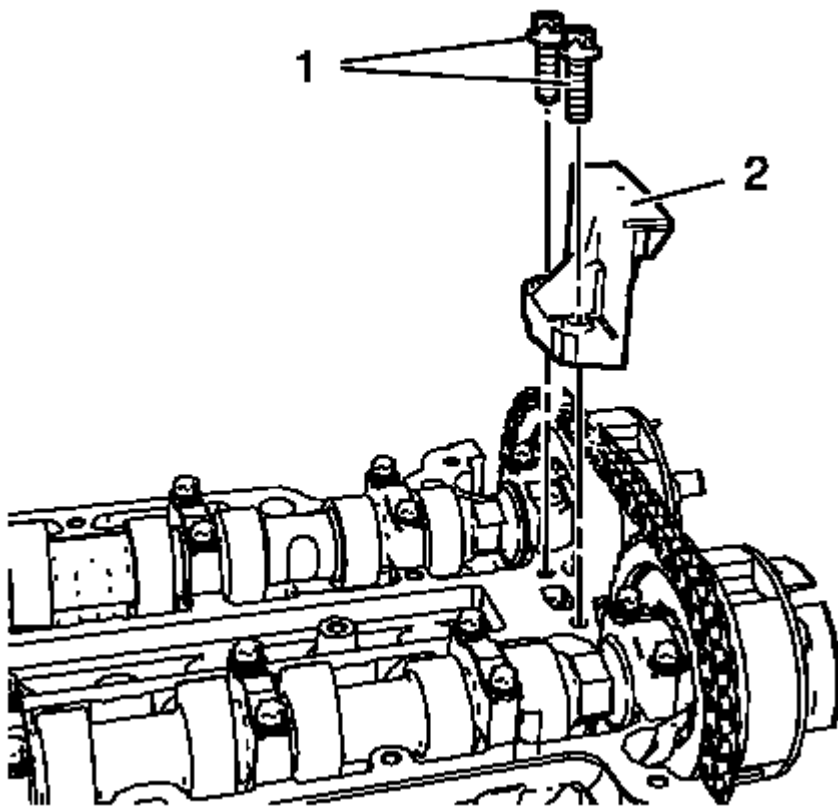


Fig. 141: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

11. Remove 2 upper timing chain guide bolts (1).
12. Remove upper timing chain guide (2).

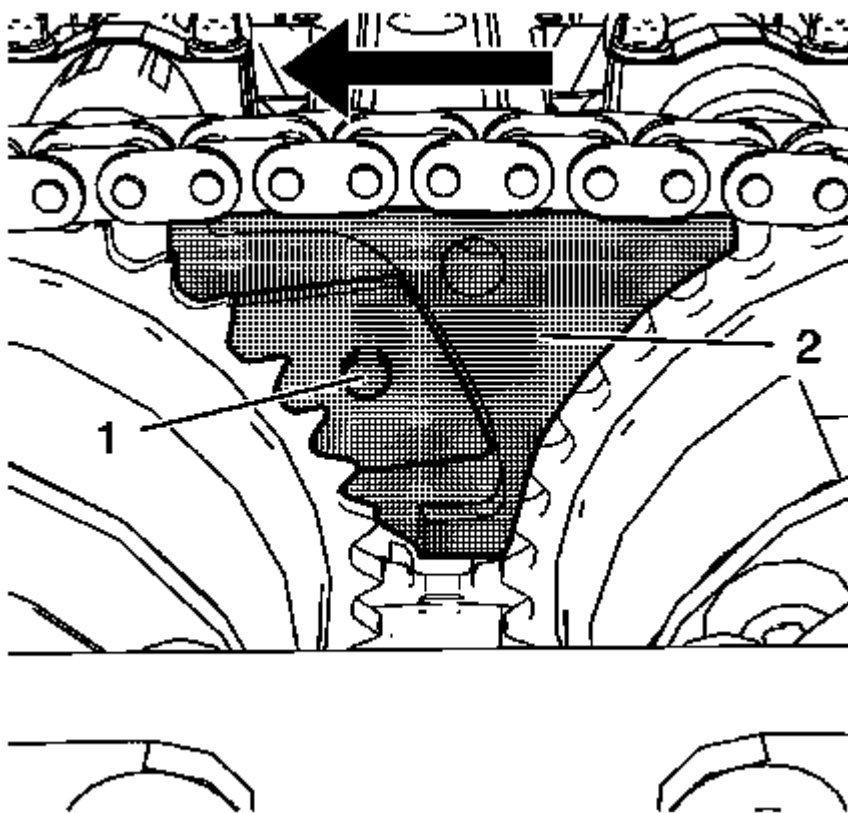


Fig. 142: Intake Camshaft Sprocket Gearing And Special Tool
Courtesy of GENERAL MOTORS COMPANY

NOTE: Push the fixing tool in the direction of the arrow to ensure it engages without clearance.

13. Install EN-49977-200 fixing tool (2) and adjust that the gearing (1) of the fixing tool engages with the intake camshaft sprocket gearing (1).

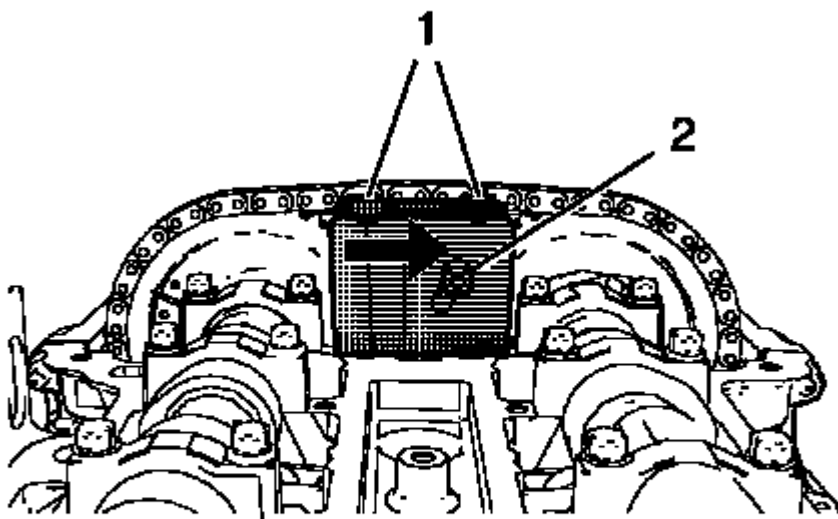


Fig. 143: Adjuster Bolt And Fastening Bolts
Courtesy of GENERAL MOTORS COMPANY

14. Tighten the 2 fastening bolts (1) of **EN-49977-200** fixing tool while pushing the fixing tool in direction of the arrow.
15. Tighten the adjuster bolt (2).

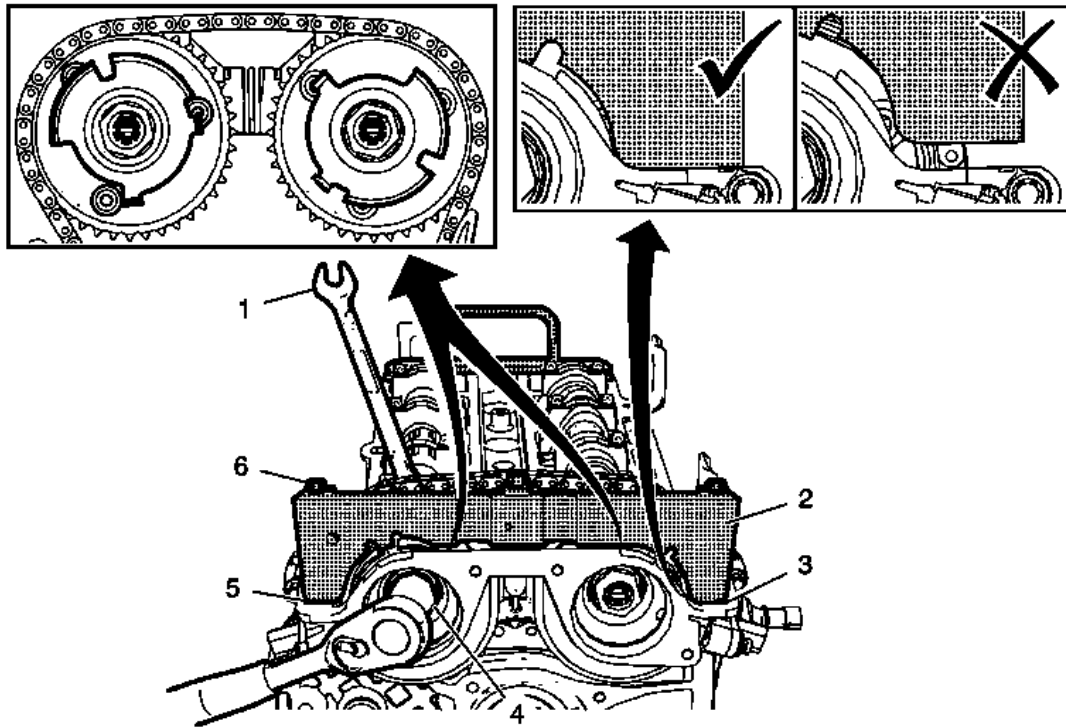


Fig. 144: Intake Camshaft Sprocket Bolt And Cylinder Head
Courtesy of GENERAL MOTORS COMPANY

NOTE: A wrong installation position is possible. Make sure that the fixation tool is installed without clearance to the cylinder head in areas (3) and (5) and the camshaft position exciter wheels are positioned as shown.

16. Install **EN-49977-100** fixation (2) in order to find and fix the correct position of the camshaft position exciter wheels.
17. Tighten the 3 fastening bolts (6) of **EN-49977-100** fixation.

CAUTION: Refer to Fastener Caution .

18. Tighten the intake camshaft sprocket bolt (4) while holding up the hexagon (1) of the intake camshaft to 50 N.m (37 lb ft).
19. Tighten the intake camshaft sprocket bolt (4) while holding up the hexagon (1) of the intake camshaft to an additional 60 degrees.
20. Tighten the exhaust camshaft sprocket bolt while holding up the hexagon of the exhaust camshaft to 50 N.m (37 lb ft).
21. Tighten the exhaust camshaft sprocket bolt while holding up the hexagon of the exhaust camshaft to an additional 60 degrees.
22. Remove **EN-49977-100** transmitter disc fixation and **EN-49977-200** fixing tool.

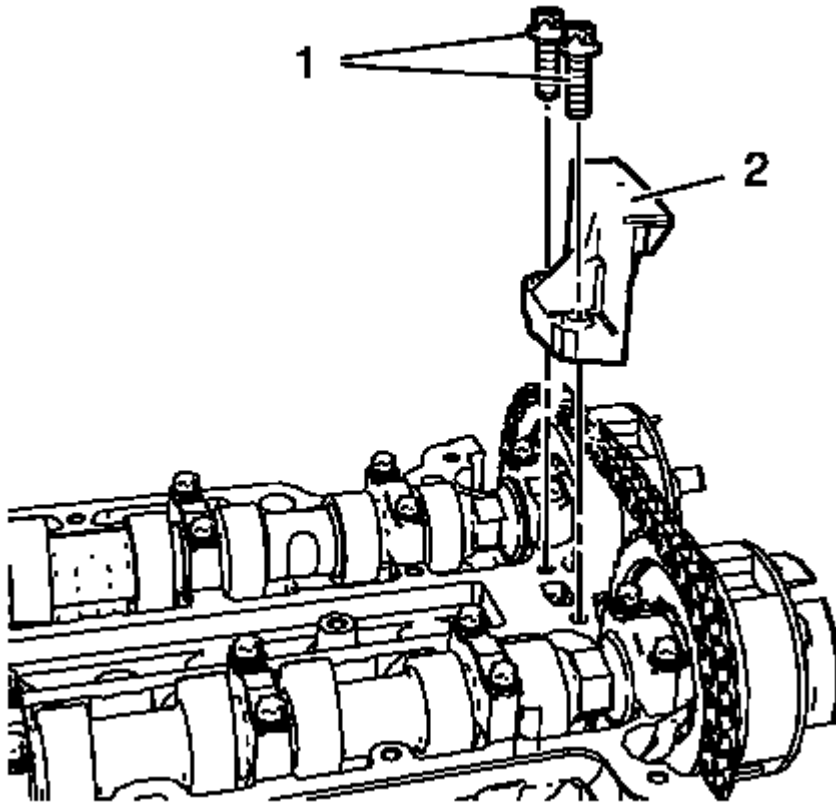


Fig. 145: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

23. Install upper timing chain guide (2).
24. Install 2 upper timing chain guide bolts (1) and tighten to 8 N.m (71 lb in).
25. Remove **EN-953-A** fixing tool.
26. Remove **EN-952** fixing pin.
27. Rotate the crankshaft for 720° and check the engine timing again. Repeat the adjustment procedure if necessary.
28. Install crankshaft bearing cap tie plate hole plug and seal ring and tighten to 40 N.m (30 lb ft).
29. Install the camshaft position actuator solenoid valves. Refer to **Camshaft Position Actuator Solenoid Valve Installation**.
30. Install the camshaft cover. Refer to **Camshaft Cover Installation**.
31. Install the ignition coil. Refer to **Ignition Coil Installation**.
32. Install the air conditioning compressor bracket. Refer to **Air Conditioning Compressor Bracket Installation**.

DRAINING FLUIDS AND OIL FILTER REMOVAL

Special Tools

EN-726-A Oil Filter Wrench

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

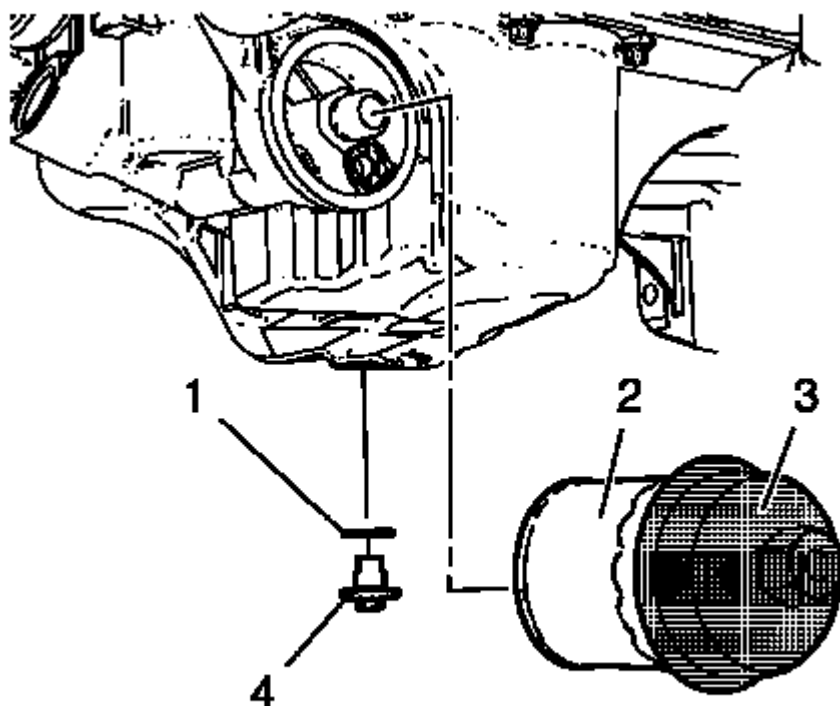


Fig. 146: Oil Pan Drain Plug And Seal Ring
Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil pan drain plug (4) and the seal ring (1) allow the oil to drain out.
2. Remove the oil filter (2). Use **EN-726-A** wrench (3).

CAUTION: Refer to **Fastener Caution** .

3. Install the oil pan drain plug and a NEW seal ring and tighten to 14 N.m (124 lb in).

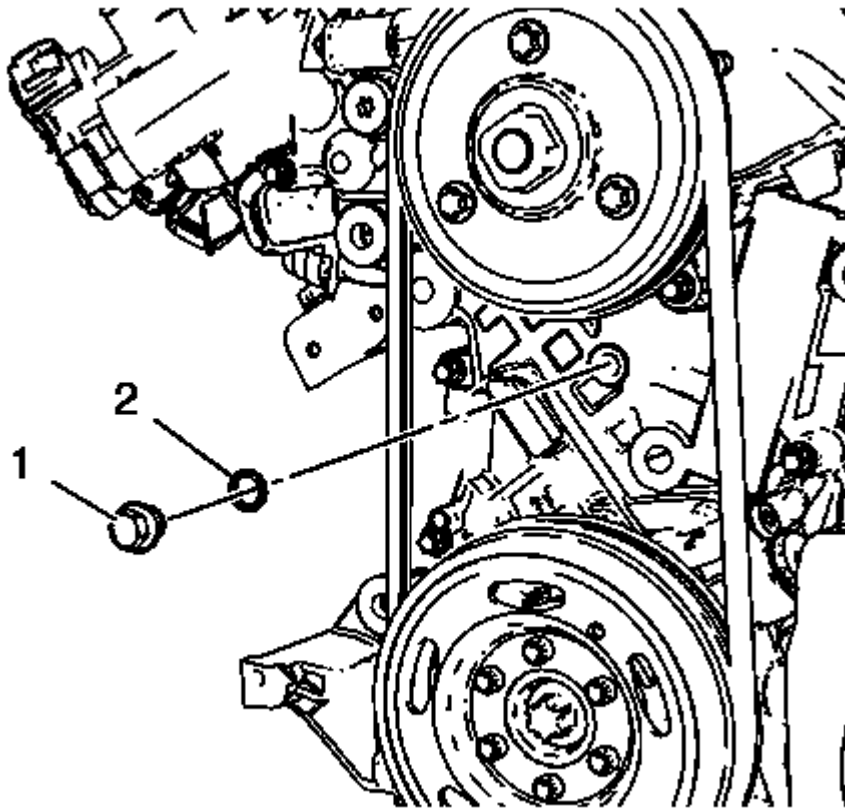


Fig. 147: Water Pump Drain Plug

Courtesy of GENERAL MOTORS COMPANY

4. Remove the water pump drain plug (1) and the water pump drain plug seal ring (2) and allow the remaining coolant fluid to drain out.
5. Install the water pump drain plug and a NEW seal ring and tighten to 15 N.m (11 lb ft).

ENGINE LIFT BRACKET REMOVAL

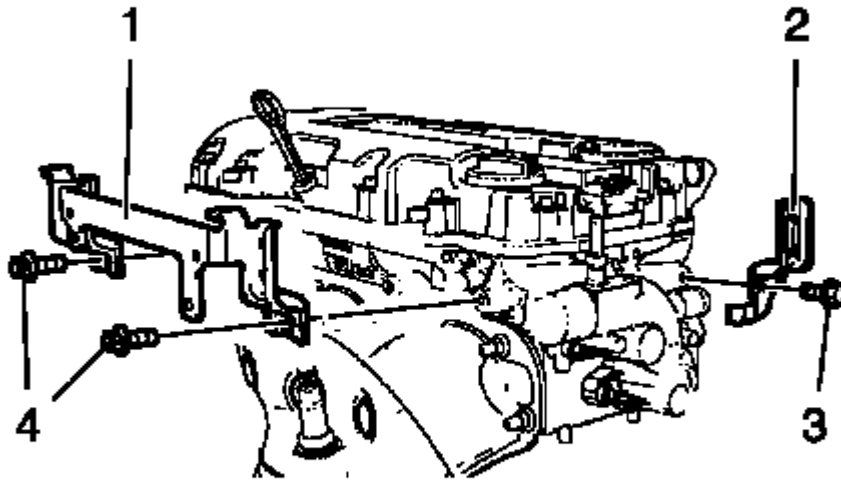


Fig. 148: Sidewise Engine Lift Bracket And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove the sidewise engine lift bracket bolt (3).
2. Remove the sidewise engine lift bracket (2).
3. Remove the 2 engine lift bracket bolts (4).
4. Remove the engine lift bracket (1).

EXHAUST MANIFOLD REMOVAL

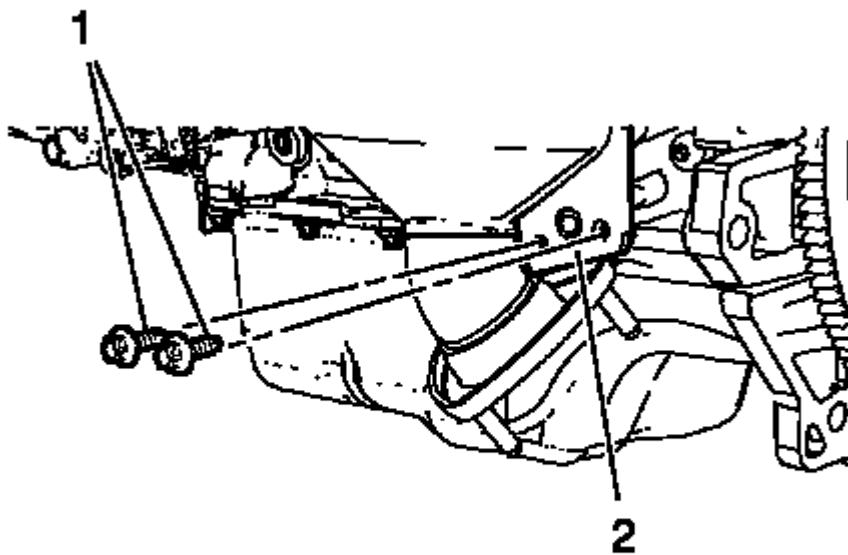


Fig. 149: Catalytic Converter Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 catalytic converter bracket bolts (1) from the catalytic converter bracket (2).

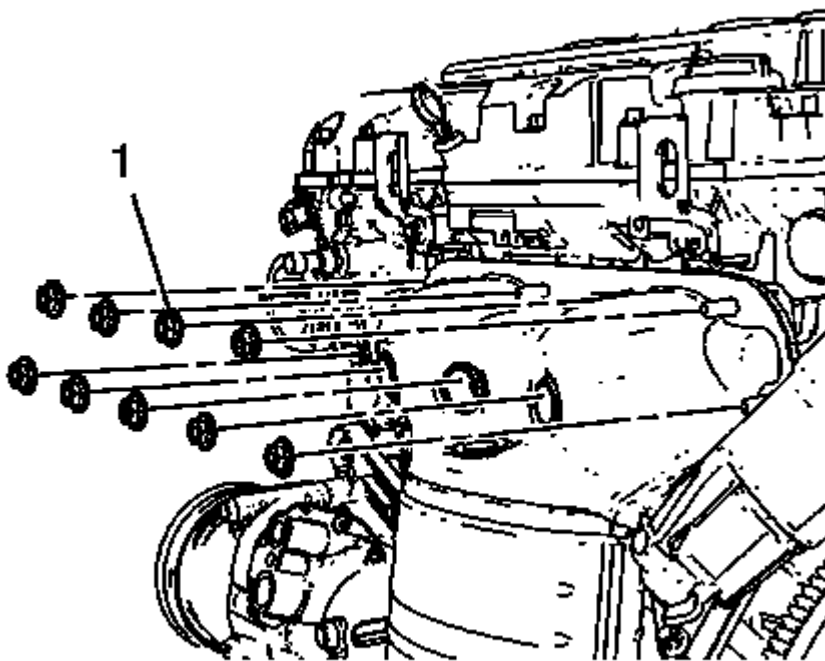


Fig. 150: Exhaust Manifold Nuts

Courtesy of GENERAL MOTORS COMPANY

2. Remove the 9 exhaust manifold nuts (1).

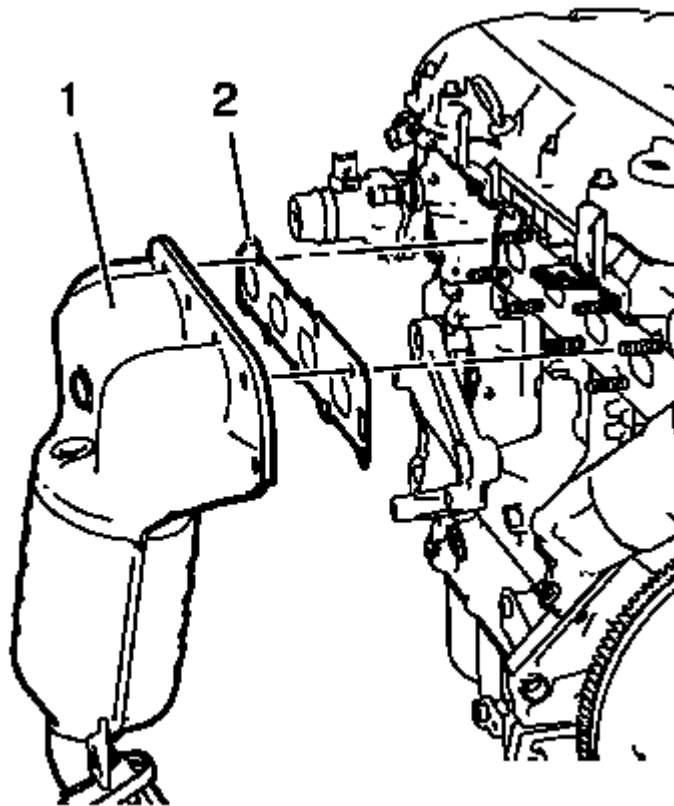


Fig. 151: Exhaust Manifold And Gasket

Courtesy of GENERAL MOTORS COMPANY

3. Remove the exhaust manifold (1) and the exhaust manifold gasket (2).

ENGINE COOLANT THERMOSTAT HOUSING REMOVAL

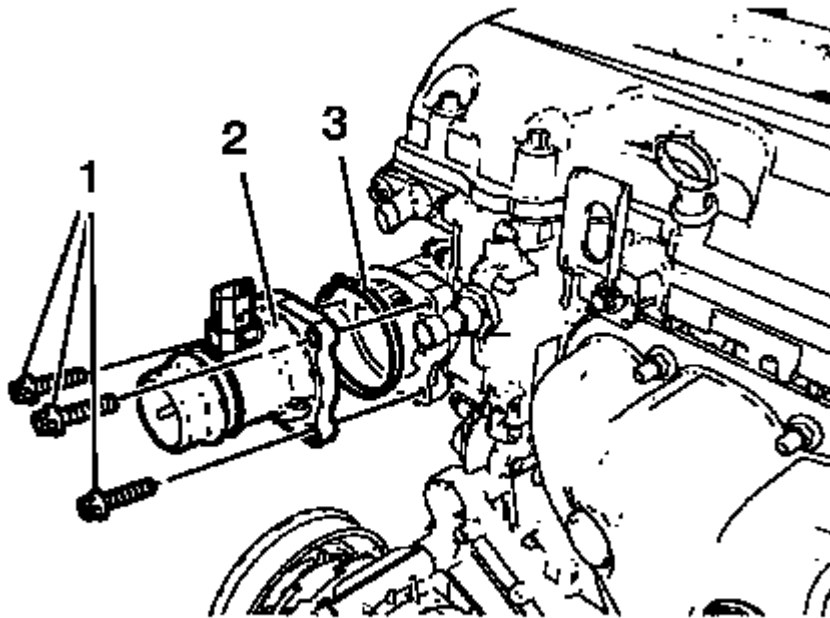


Fig. 152: Engine Coolant Thermostat Housing And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 3 engine coolant thermostat housing bolts (1).
2. Remove the engine coolant thermostat housing (2) and the engine coolant thermostat housing seal ring (3).

WATER OUTLET REMOVAL

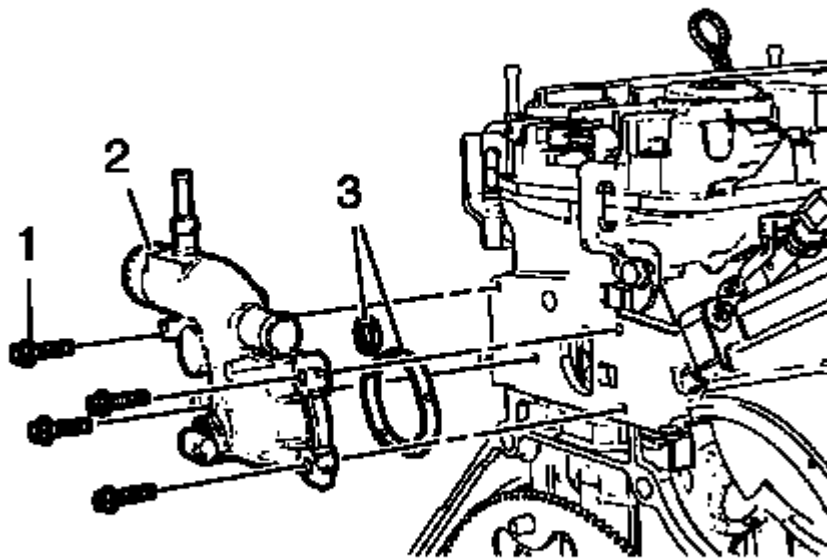


Fig. 153: Water Outlet

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 water outlet bolts (1).
2. Remove the water outlet (2) and the 2 water outlet seal rings (3).

AIR CONDITIONING COMPRESSOR BRACKET REMOVAL

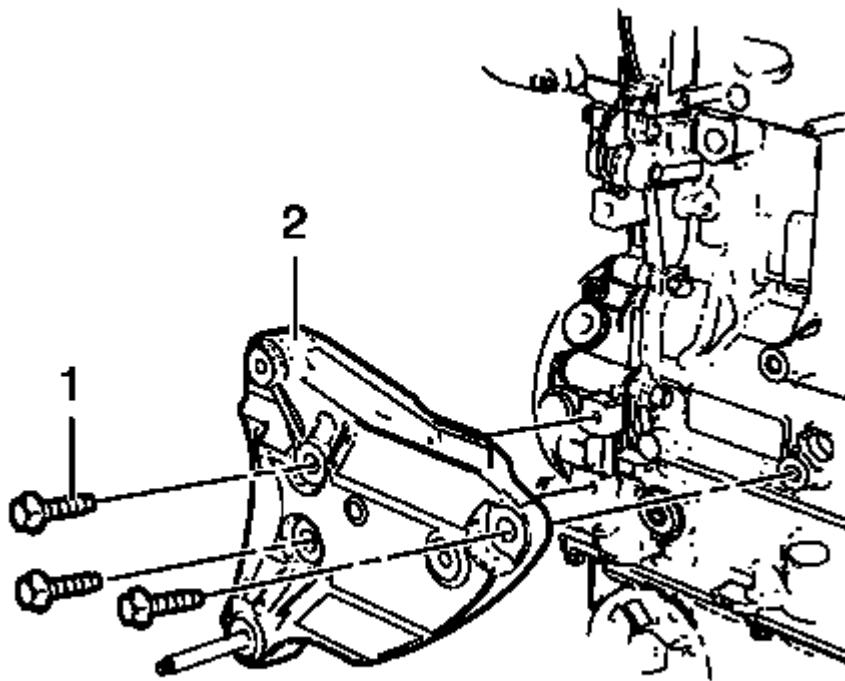


Fig. 154: Air Conditioning Compressor Bracket
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 3 air conditioning compressor bracket bolts (1).
2. Remove the air conditioning compressor bracket (2).

WATER PUMP PULLEY REMOVAL

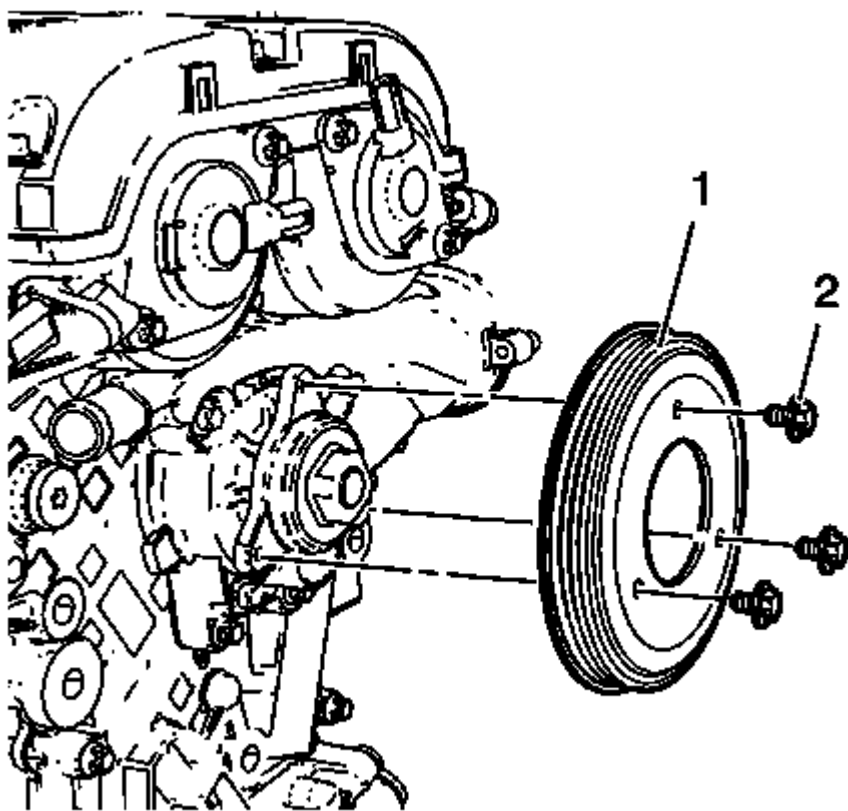


Fig. 155: Water Pump Pulley

Courtesy of GENERAL MOTORS COMPANY

1. Loosen the 3 water pump pulley bolts (2) while holding up the water pump pulley hub with a spanner.
2. Remove the 3 water pump pulley bolts (2).
3. Remove the water pump pulley (1).

CRANKSHAFT BALANCER REMOVAL

Special Tools

- **EN-49979** Crankshaft Shock Mount Retainer.
- **EN-956-1** Extension.

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

1. Install **EN-49979** retainer to **EN-956-1** extension.

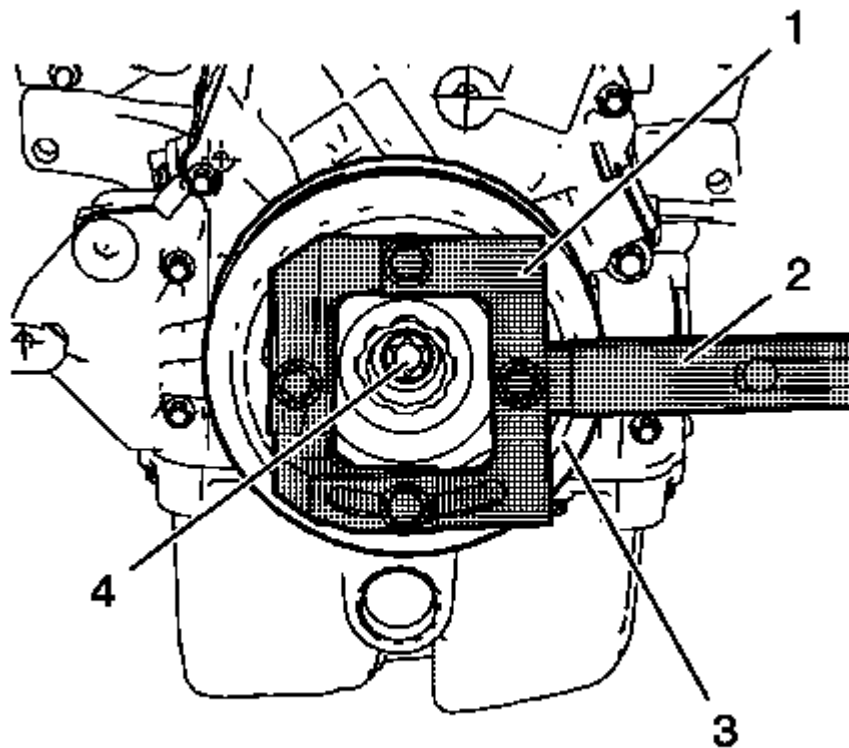


Fig. 156: Crankshaft Balancer, Retainer And Extension
Courtesy of GENERAL MOTORS COMPANY

2. Loosen the crankshaft balancer bolt (4) while fixing the crankshaft balancer (3) with **EN-49979** retainer (1) and **EN-956-1** extension (2).

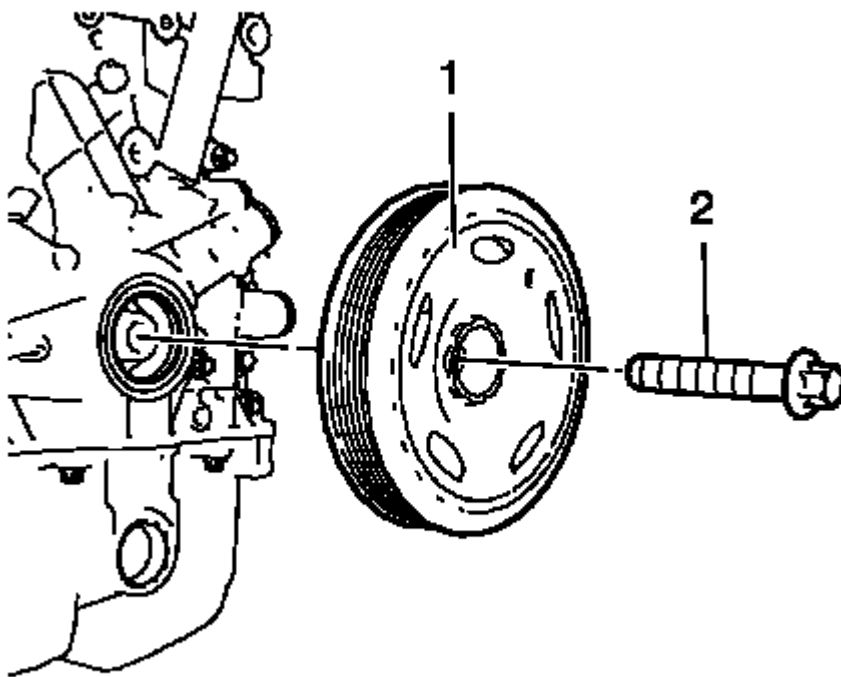


Fig. 157: Crankshaft Balancer And Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Remove the crankshaft balancer bolt (2).
4. Remove the crankshaft balancer (1).

WATER PUMP REMOVAL

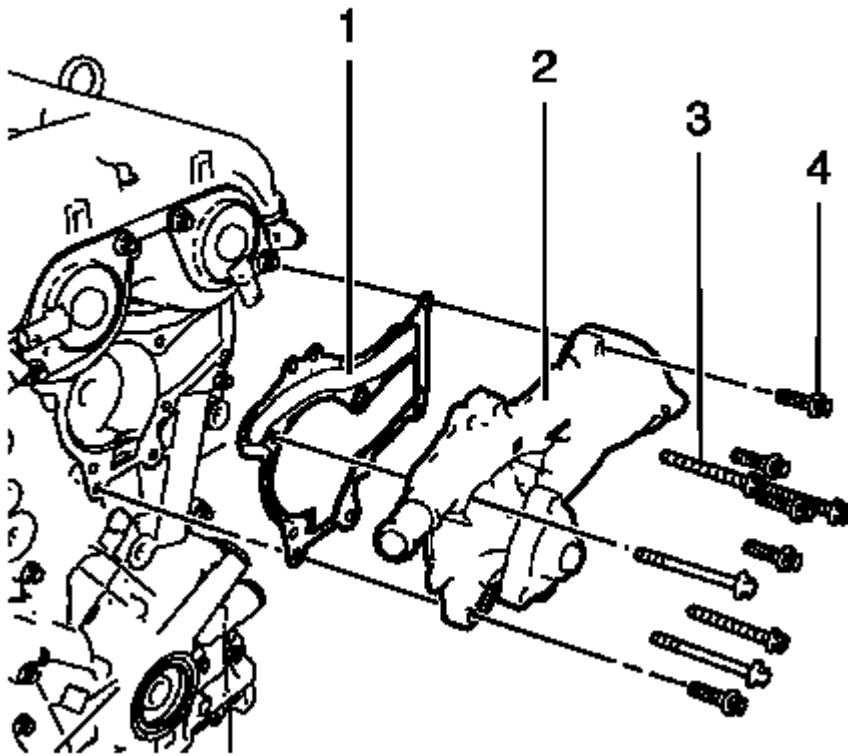


Fig. 158: Water Pump, Gasket And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 5 short water pump bolts (4) and the 5 long water pump bolts (3).
2. Remove the water pump (2).
3. Remove the water pump gasket (1).

THROTTLE BODY REMOVAL

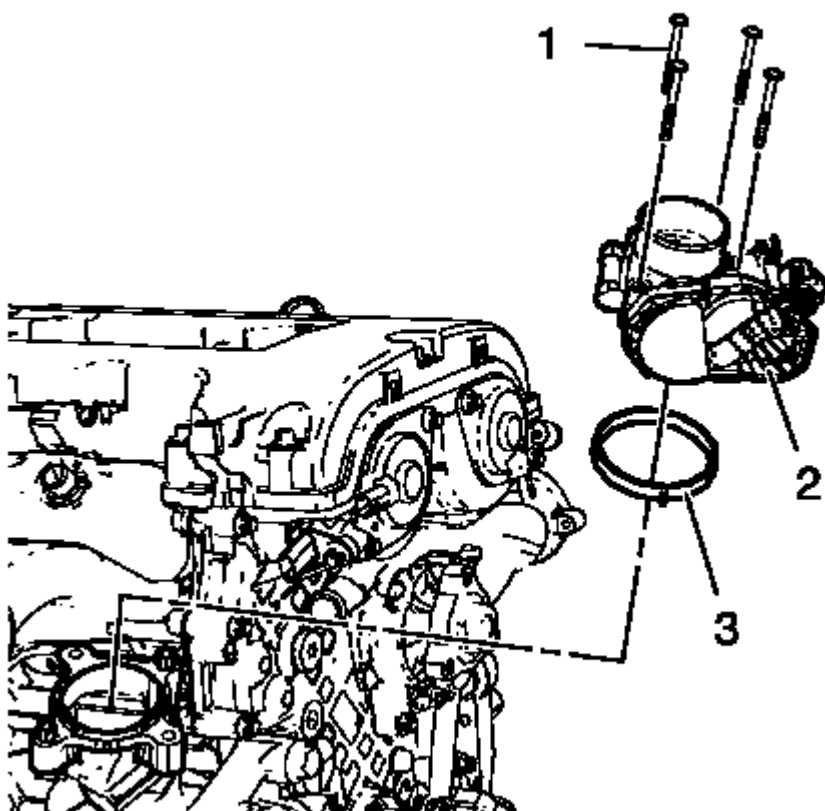


Fig. 159: Throttle Body And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 throttle body bolts (1).
2. Remove the throttle body (2) and the throttle body seal ring (3)

INTAKE MANIFOLD REMOVAL

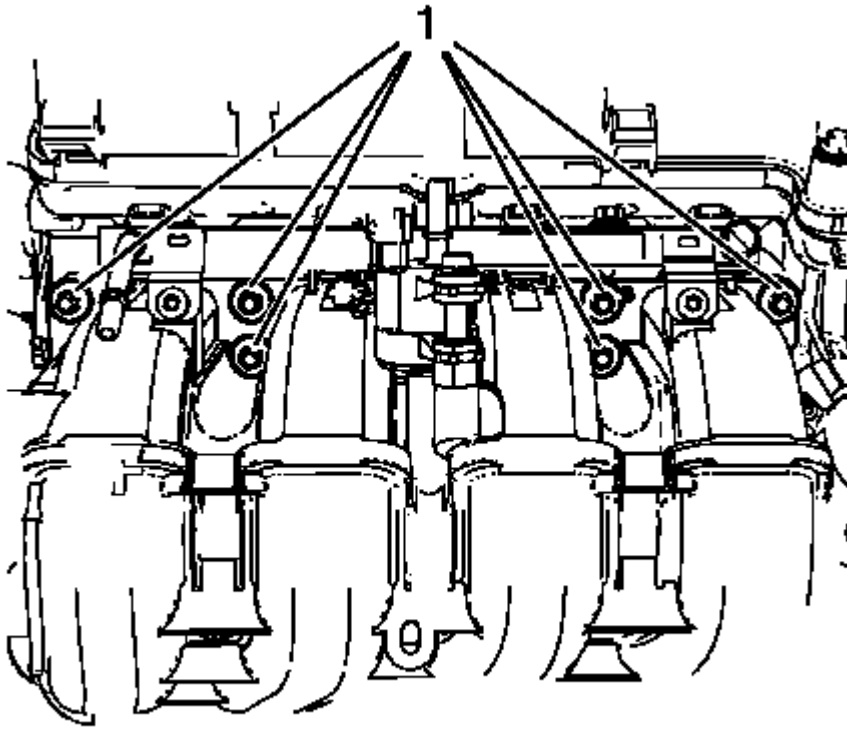


Fig. 160: Intake Manifold Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Loosen the 6 intake manifold bolts (1).

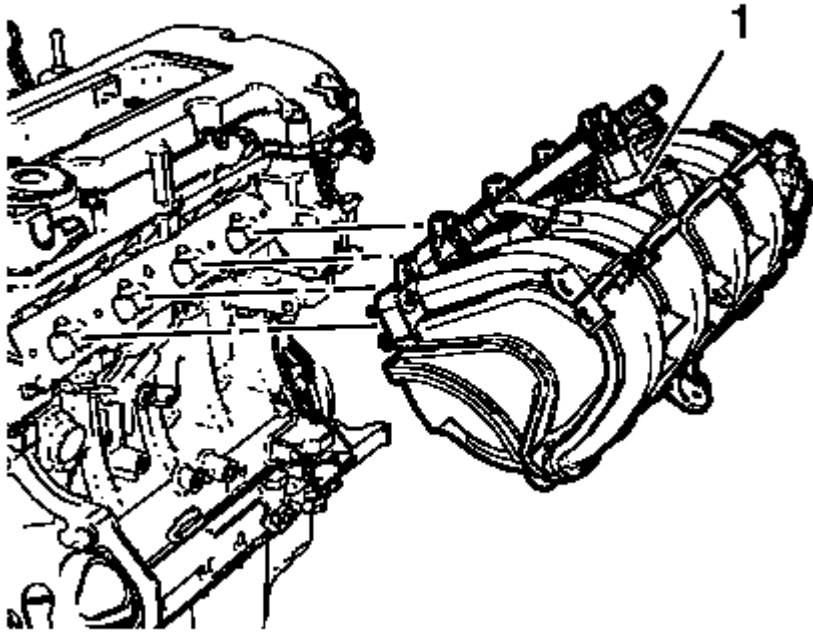


Fig. 161: Intake Manifold

Courtesy of GENERAL MOTORS COMPANY

NOTE: Intake manifold bolts remain in intake manifold screw bores.

2. Remove the intake manifold (1) in compound with the intake manifold gasket.

IGNITION COIL REMOVAL

Special Tools

EN-6009 Remover and Installer Ignition Module

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

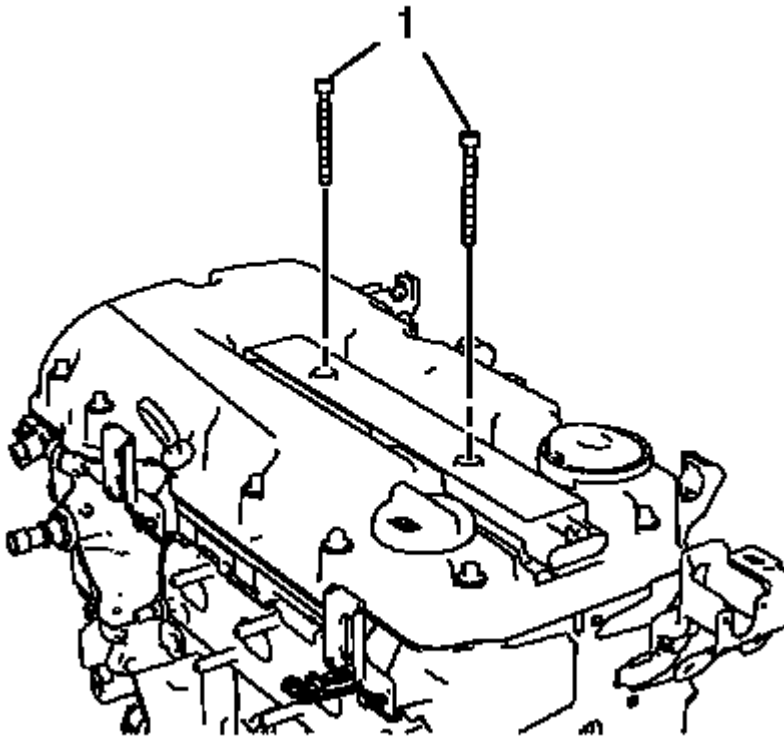


Fig. 162: Ignition Coil Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 ignition coil bolts (1).

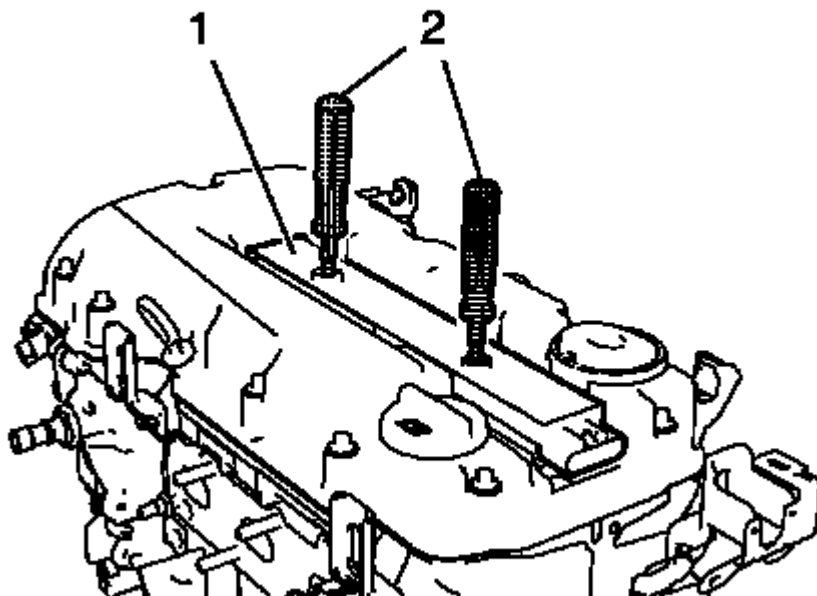


Fig. 163: Ignition Coil And Remover/Installer
Courtesy of GENERAL MOTORS COMPANY

2. Install **EN-6009** remover and installer (2) and remove the ignition coil (1).

CAMSHAFT COVER REMOVAL

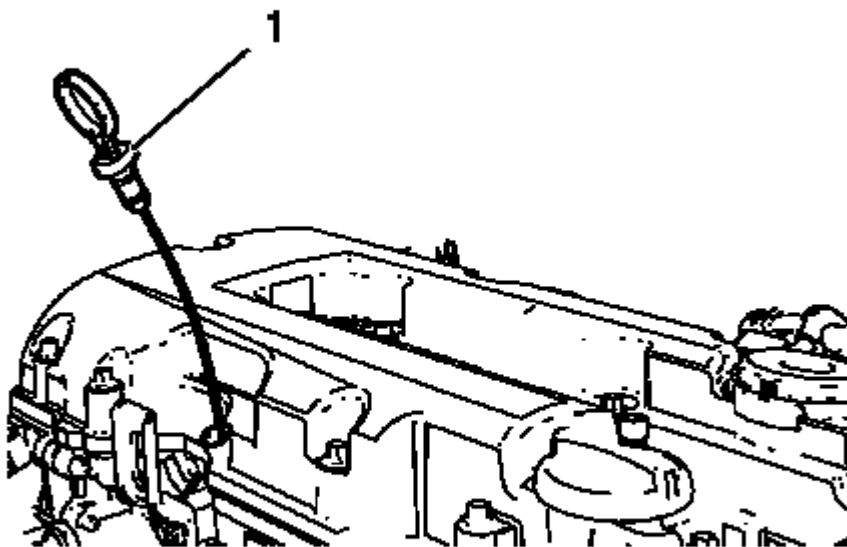


Fig. 164: Engine Oil Level Indicator

Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil level indicator (1).

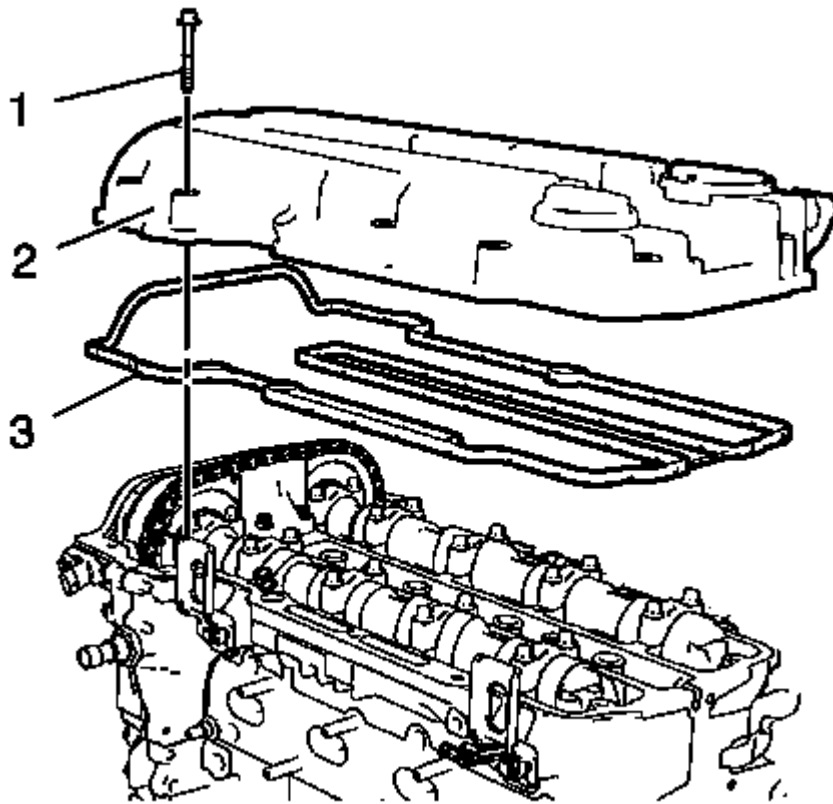


Fig. 165: Camshaft Cover And Gasket
Courtesy of GENERAL MOTORS COMPANY

2. Remove the 15 camshaft cover bolts (1).
3. Remove the camshaft cover (2) and the camshaft cover gasket (3).

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE REMOVAL

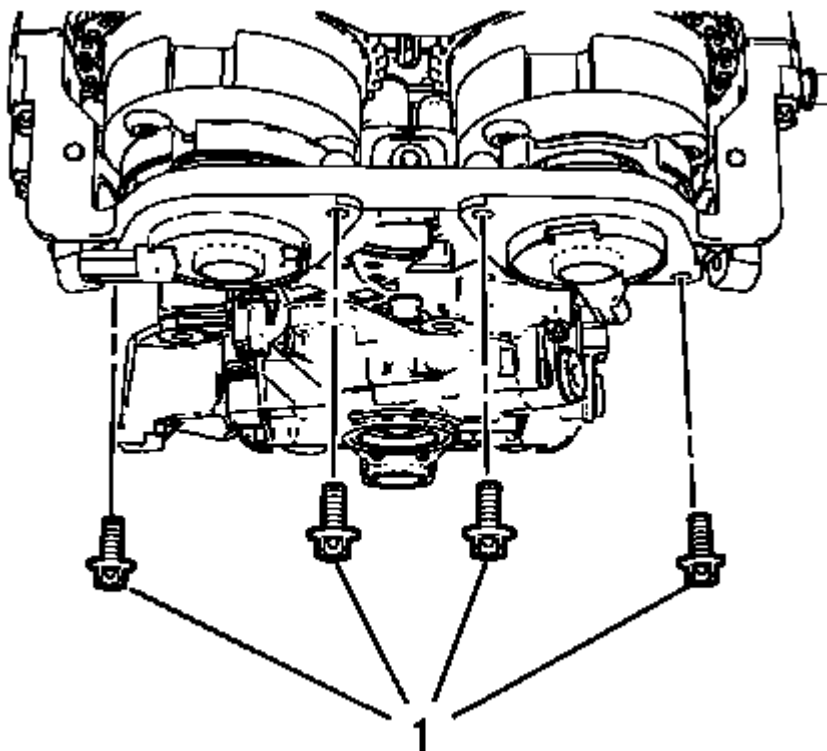


Fig. 166: Camshaft Position Actuator Solenoid Valve Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 4 camshaft position actuator solenoid valve bolts (1).

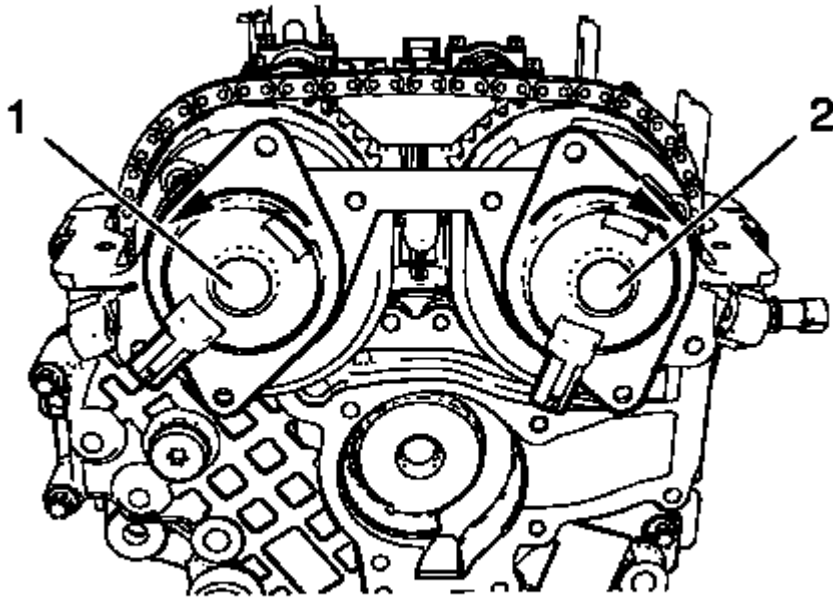


Fig. 167: Intake Camshaft Position Actuator Solenoid Valve And Exhaust Camshaft Position Actuator Solenoid Valve

Courtesy of GENERAL MOTORS COMPANY

2. Move the intake camshaft position actuator solenoid valve (1) carefully counter clockwise in the position shown.
3. Move the exhaust camshaft position actuator solenoid valve (2) carefully clockwise in the position shown.

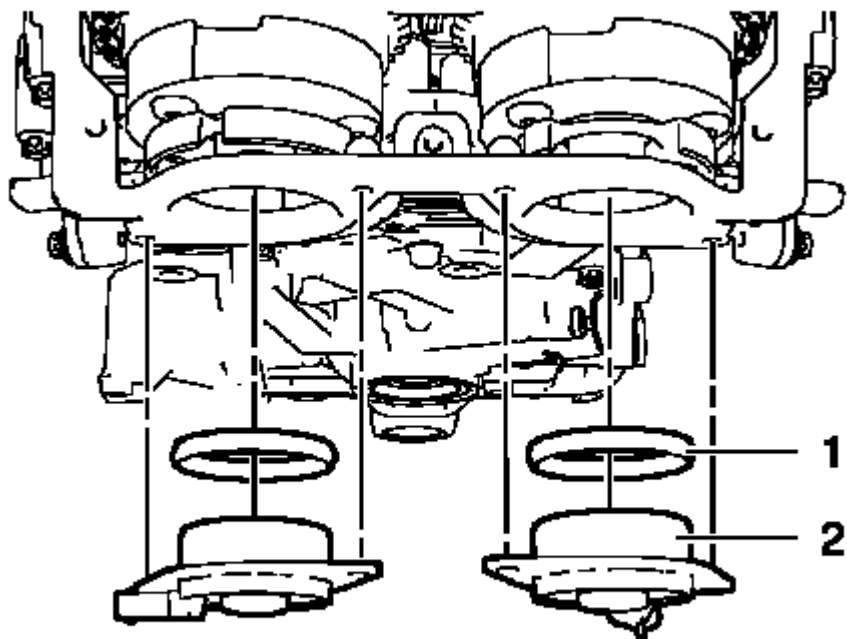


Fig. 168: Camshaft Position Actuator Solenoid Valves And Seal Rings
Courtesy of GENERAL MOTORS COMPANY

CAUTION: The camshaft position actuator solenoid valves must be kept parallel to the engine front cover during removal and installation. The camshaft position actuator solenoid valves can be damaged if they become wedged or stuck during this process.

4. Carefully remove the 2 camshaft position actuator solenoid valves (2) and the seal rings (1).

OIL PAN REMOVAL

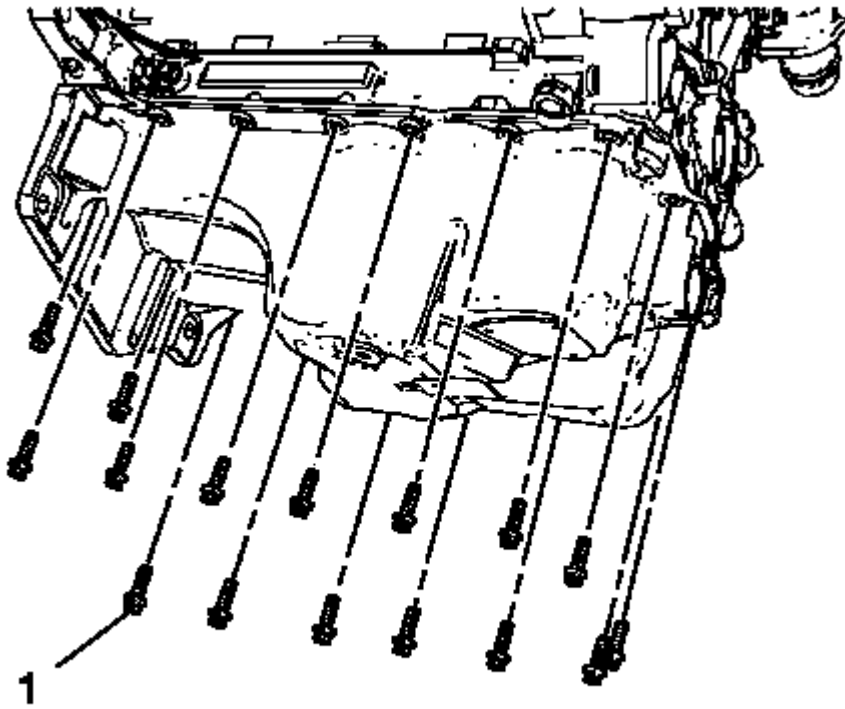


Fig. 169: Oil Pan Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove the 16 oil pan bolts (1).

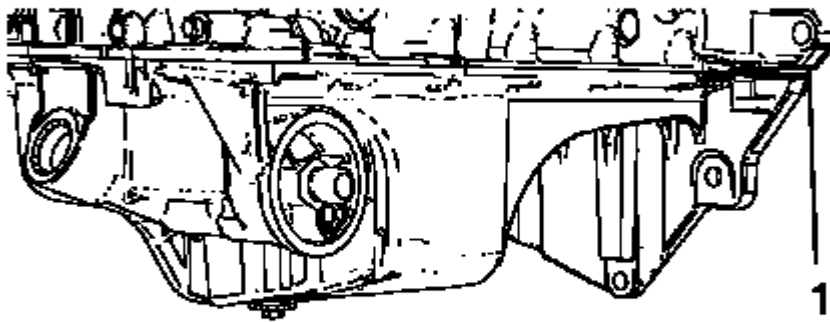


Fig. 170: Oil Pan Loosening Area

Courtesy of GENERAL MOTORS COMPANY

NOTE: Work with care. Do not damage the oil pan or crankshaft bearing tie plate sealing surfaces.

2. Install a mounting lever to the area (1) and loosen the oil pan by cautiously levering.

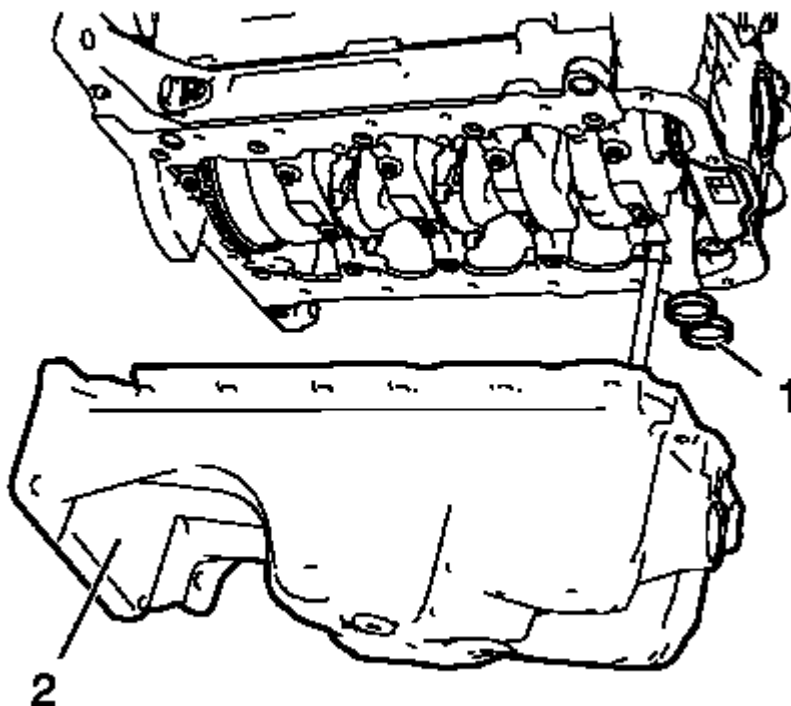


Fig. 171: Engine Oil Pan

Courtesy of GENERAL MOTORS COMPANY

3. Remove the oil pan (2) and the seal rings (1).

ENGINE FRONT COVER AND OIL PUMP REMOVAL

1. Set engine to TDC. Refer to **Camshaft Timing Chain Inspection.**

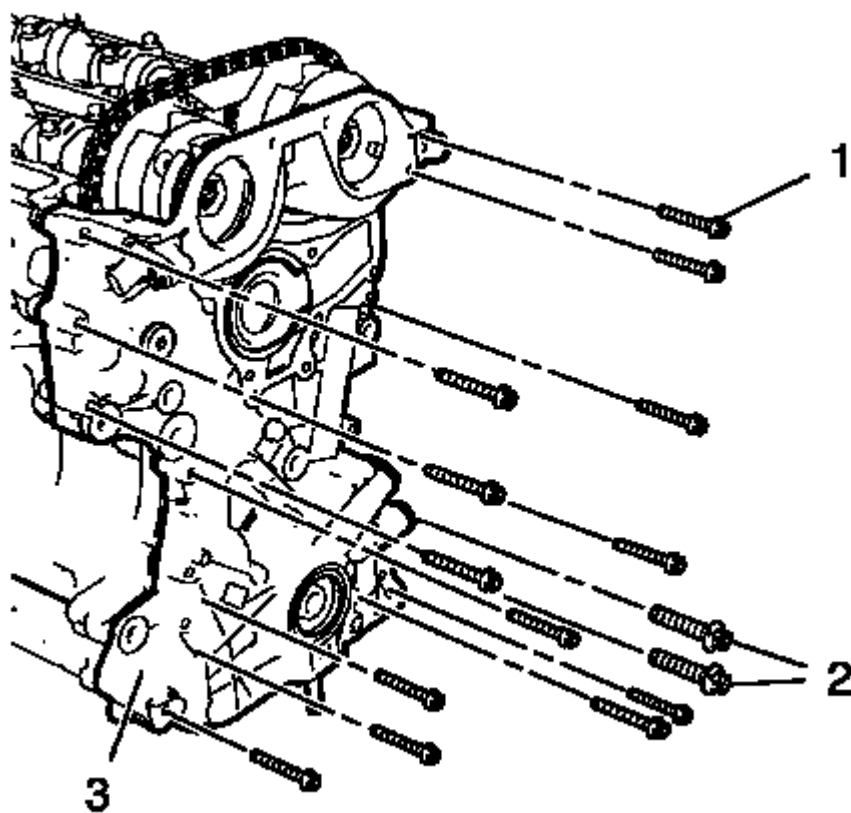


Fig. 172: M6, M10 Front Cover Bolts And Engine Front Cover
 Courtesy of GENERAL MOTORS COMPANY

2. Remove the 13 engine front cover bolts M6 (1).
3. Remove the 2 engine front cover bolts M10 (2).
4. Remove the engine front cover.

CAMSHAFT TIMING CHAIN REMOVAL

Special Tools

- EN-952 Fixing Pin
- EN-953-A Fixing Tool
- EN-955-10 Fixing Pin from EN-955 Kit

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

1. The engine should be adjusted to TDC.
2. The crankshaft should be fixed with **EN-952** fixing pin.
3. The camshaft should be fixed with **EN-953-A** fixing tool.

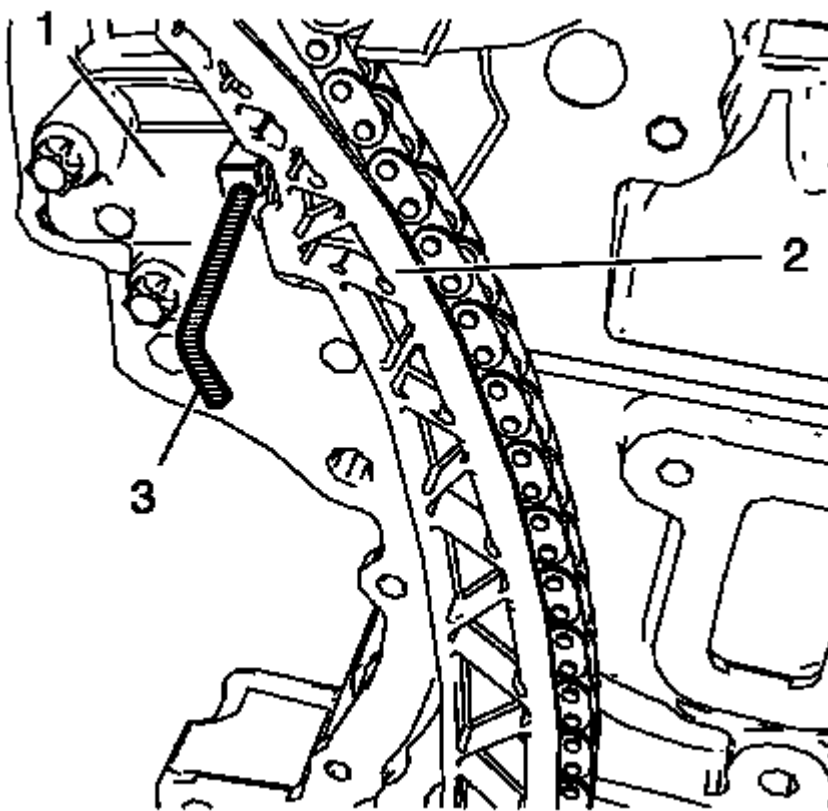


Fig. 173: Timing Chain And Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

4. Push the timing chain (2) in direction to the timing chain tensioner (1) and fix the tensioner with **EN-955-10** fixing pin (3).

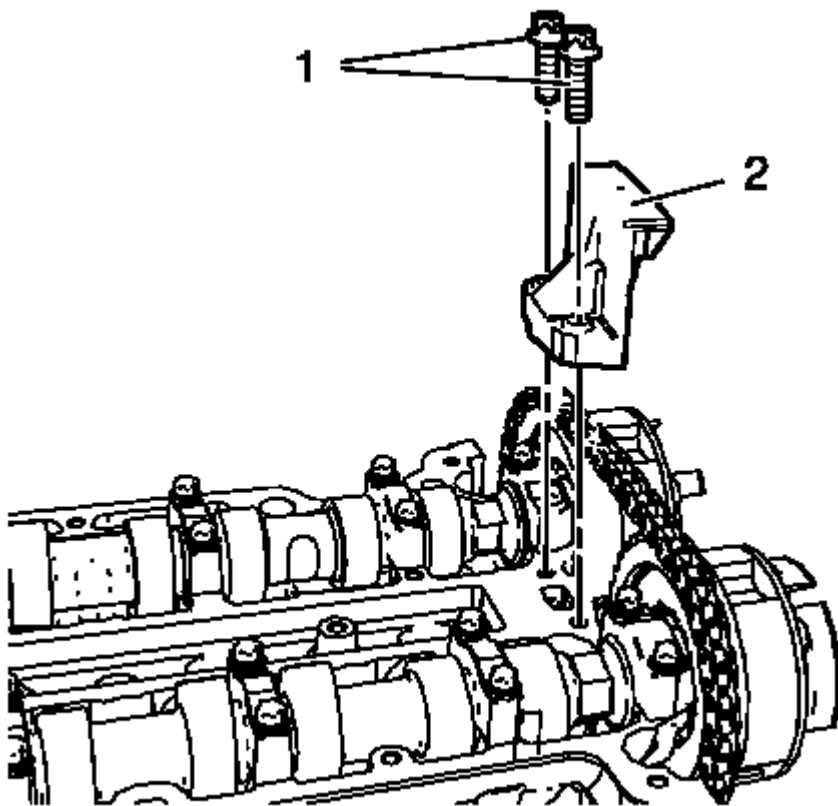


Fig. 174: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove the 2 upper timing chain guide bolts (1).
6. Remove the upper timing chain guide (2).

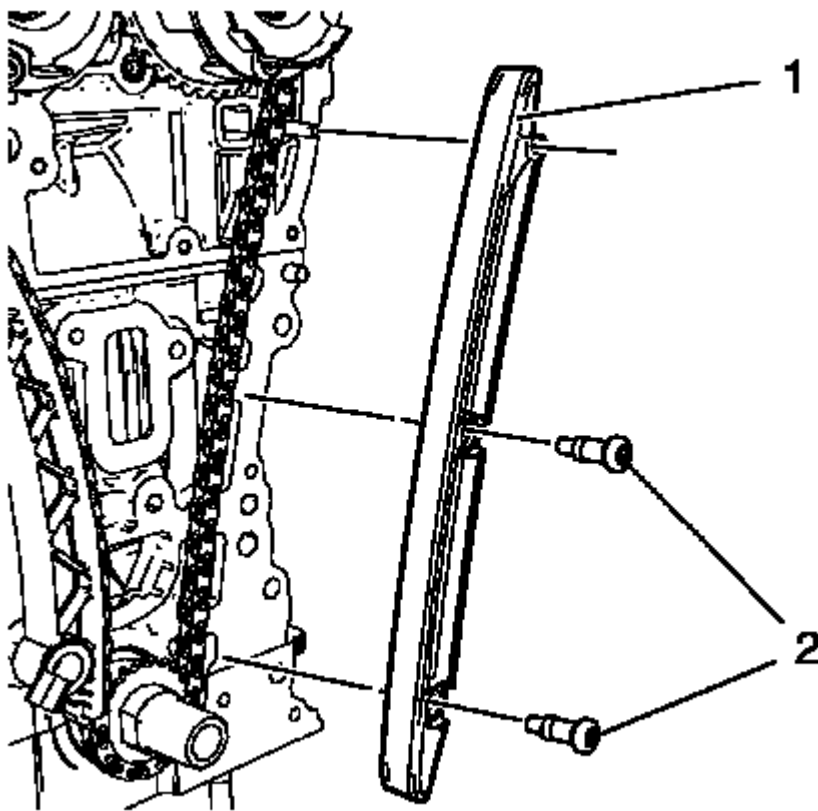


Fig. 175: Timing Chain Guide Right Side
Courtesy of GENERAL MOTORS COMPANY

7. Remove the 2 timing chain guide right side bolts (2).
8. Remove the timing chain guide right side (1).

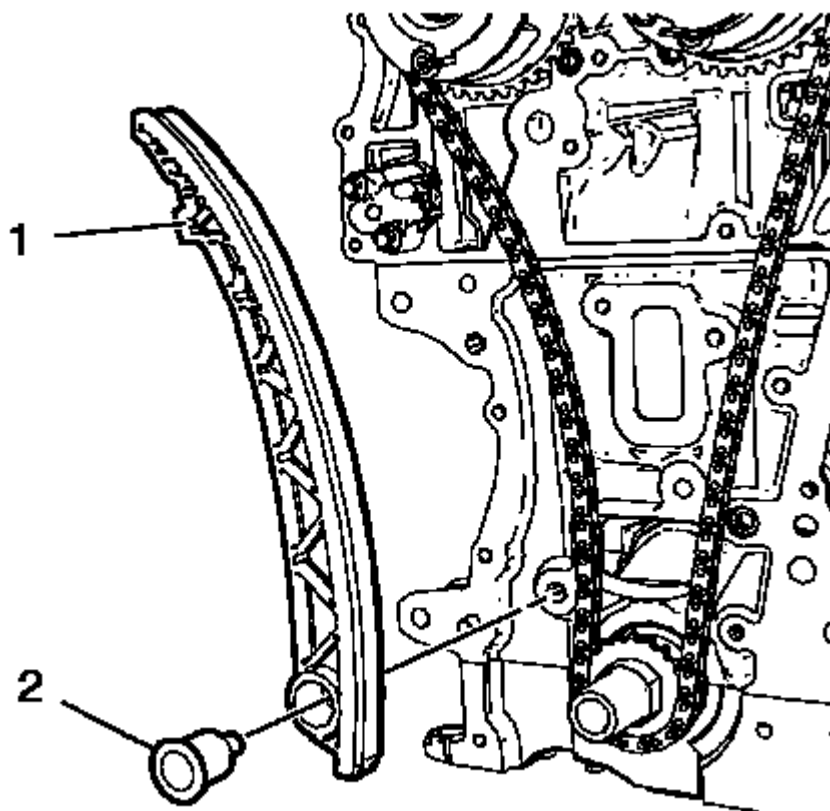


Fig. 176: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

9. Remove the timing chain tensioner shoe bolt (2).
10. Remove the timing chain tensioner shoe (1).

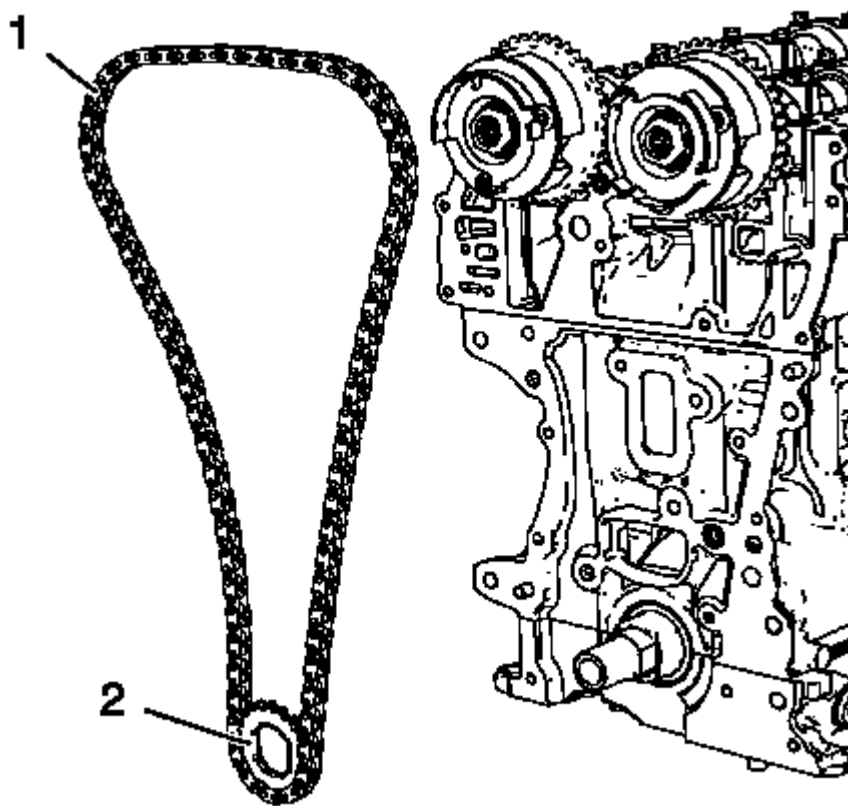


Fig. 177: Timing Chain And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

11. Remove the timing chain (1) in compound with the crankshaft sprocket (2).

TIMING CHAIN TENSIONER REMOVAL

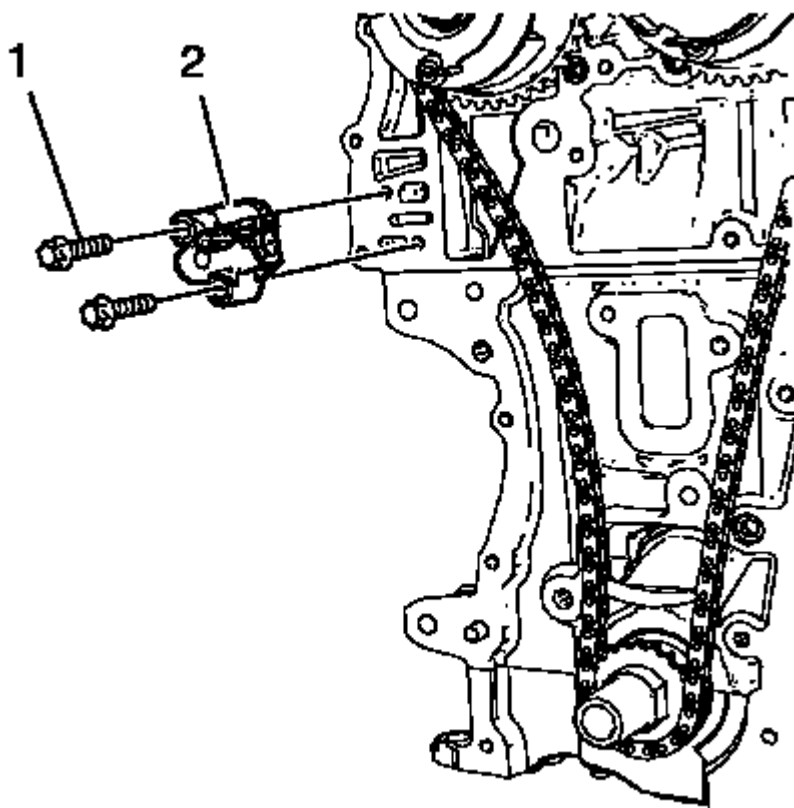


Fig. 178: Timing Chain Tensioner And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 2 timing chain tensioner bolts (1).
2. Remove the timing chain tensioner (2).

ENGINE FRONT COVER GASKET REMOVAL

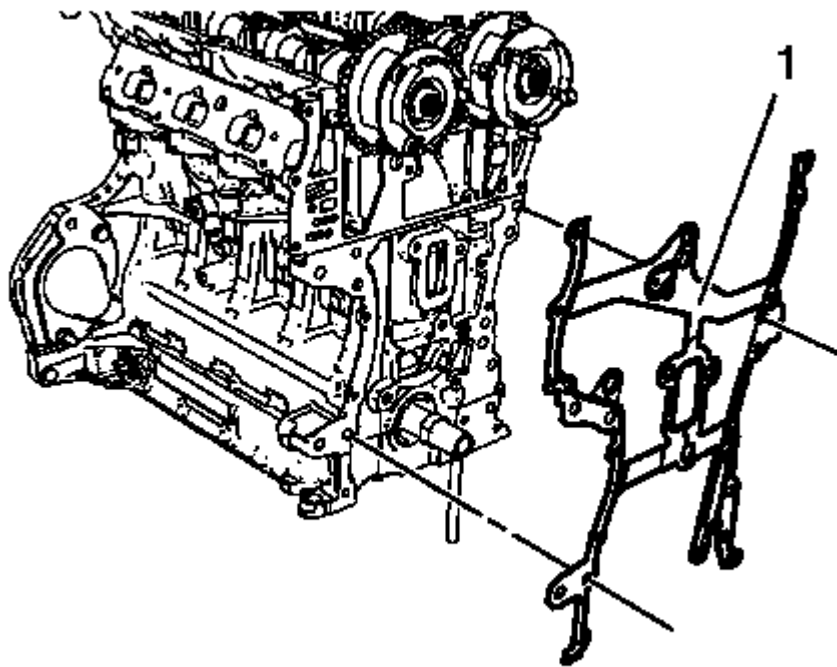


Fig. 179: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS COMPANY

Remove and DISCARD the engine front cover gasket (1).

CAMSHAFT SPROCKET REMOVAL

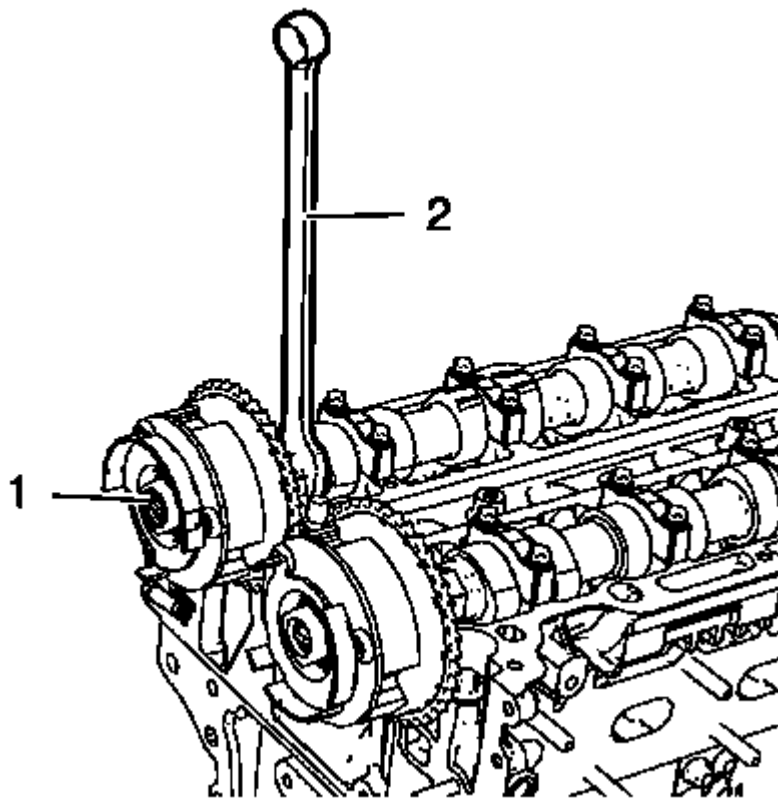


Fig. 180: Intake Camshaft And Intake Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Loosen the intake camshaft sprocket bolt (1) while holding the hexagon of intake camshaft (2) with a wrench.

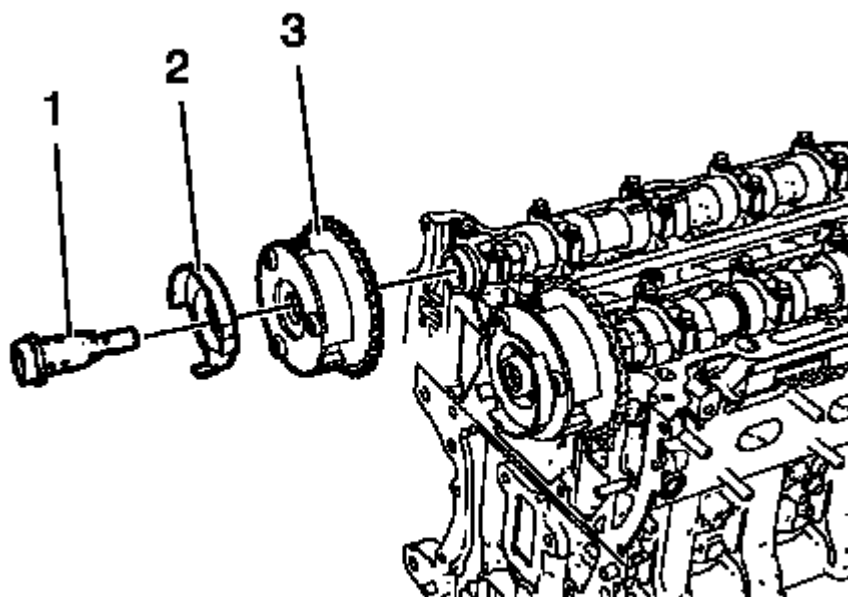


Fig. 181: Intake Camshaft Sprocket, Bolt And Intake Camshaft Position Exciter Wheel
Courtesy of GENERAL MOTORS COMPANY

2. Remove the intake camshaft sprocket bolt (1) and the intake camshaft position exciter wheel (2).
3. Remove the intake camshaft sprocket (3).
4. Loosen the exhaust camshaft sprocket bolt while holding the hexagon of exhaust camshaft with a wrench.
5. Remove the exhaust camshaft sprocket bolt and the exhaust camshaft position exciter wheel.
6. Remove the exhaust camshaft sprocket.

INTAKE CAMSHAFT REMOVAL

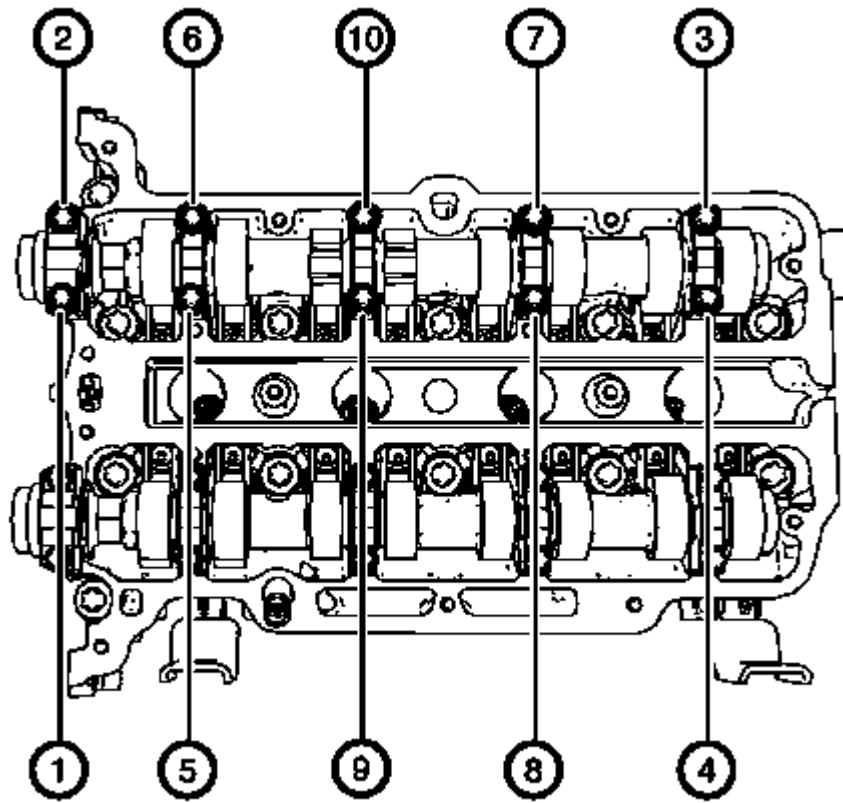


Fig. 182: Intake Camshaft Bearing Cap Bolts Removal Sequence
Courtesy of GENERAL MOTORS COMPANY

1. Remove the camshaft bearing cap bolts in a spiral sequence as shown one turn at a time until there is no spring tension pushing on the camshaft.

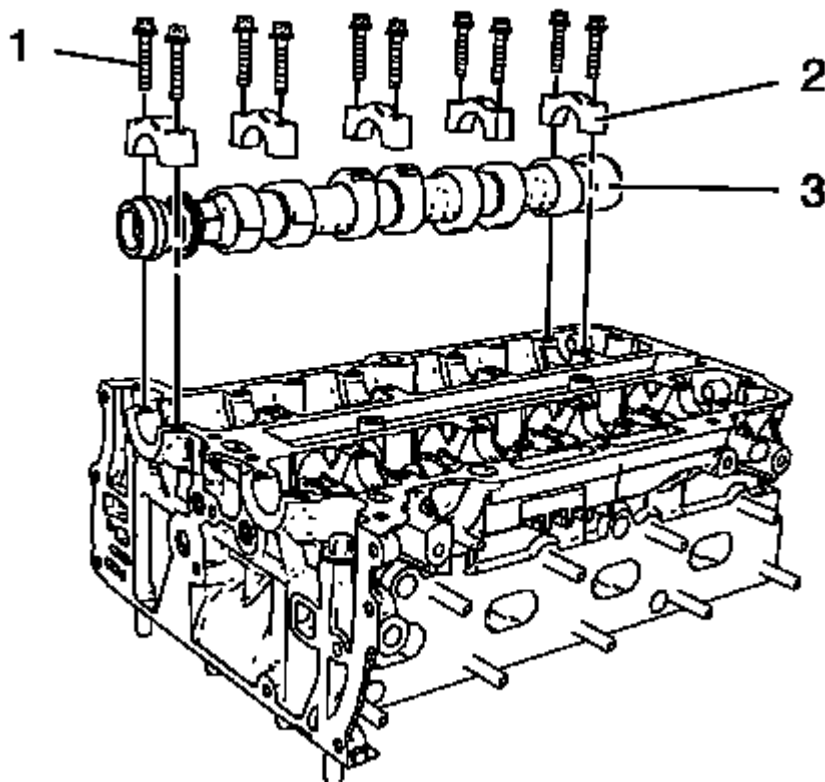


Fig. 183: Intake Camshaft, Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the markings on the camshaft bearing caps to ensure they will be installed in the same position.

2. Remove the 10 camshaft bearing cap bolts (1).
3. Remove the 5 camshaft bearing caps (2).
4. Remove the intake camshaft (3).

EXHAUST CAMSHAFT REMOVAL

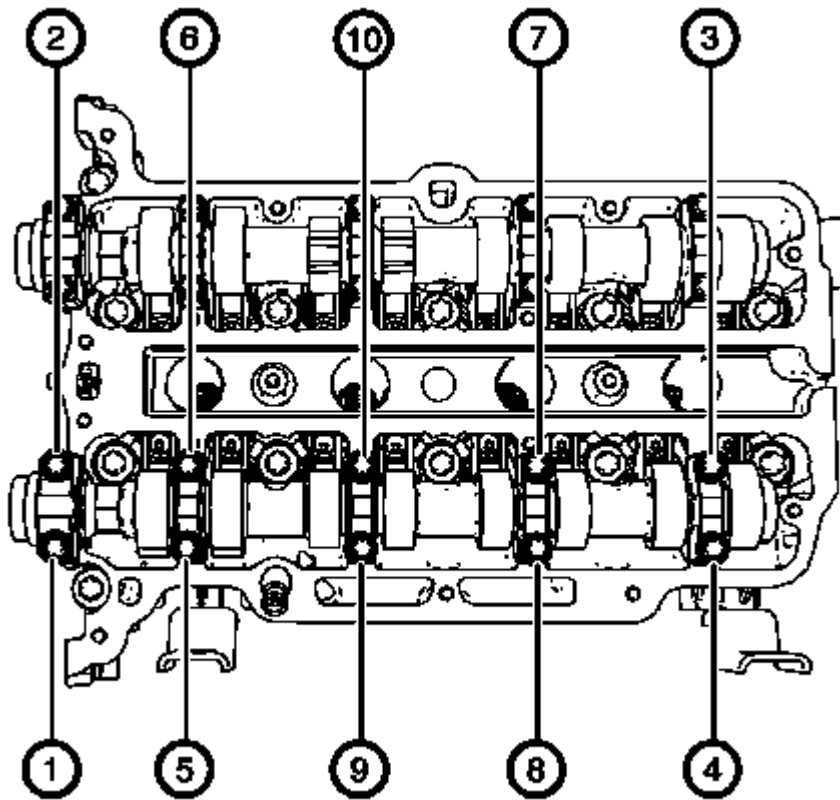


Fig. 184: Exhaust Camshaft Bearing Cap Bolts Removal Sequence
Courtesy of GENERAL MOTORS COMPANY

1. Remove the camshaft bearing cap bolts in a spiral sequence as shown one turn at a time until there is no spring tension pushing on the camshaft.

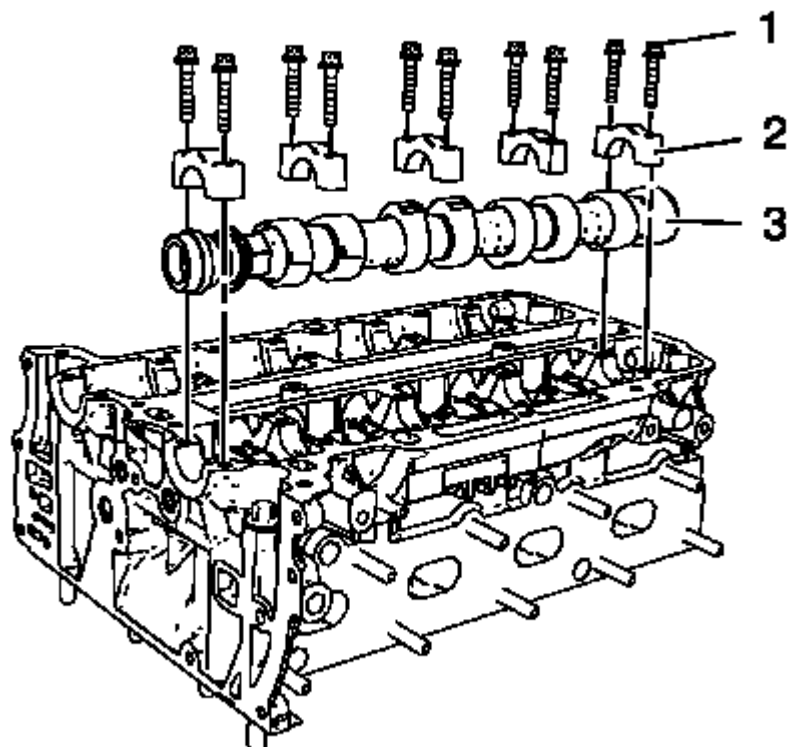


Fig. 185: Exhaust Camshaft, Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the markings on the camshaft bearing caps to ensure they will be installed in the same position.

2. Remove the 10 camshaft bearing cap bolts (1).
3. Remove the 5 camshaft bearing caps (2).
4. Remove the exhaust camshaft (3).

HYDRAULIC VALVE LASH ADJUSTER ARM REMOVAL

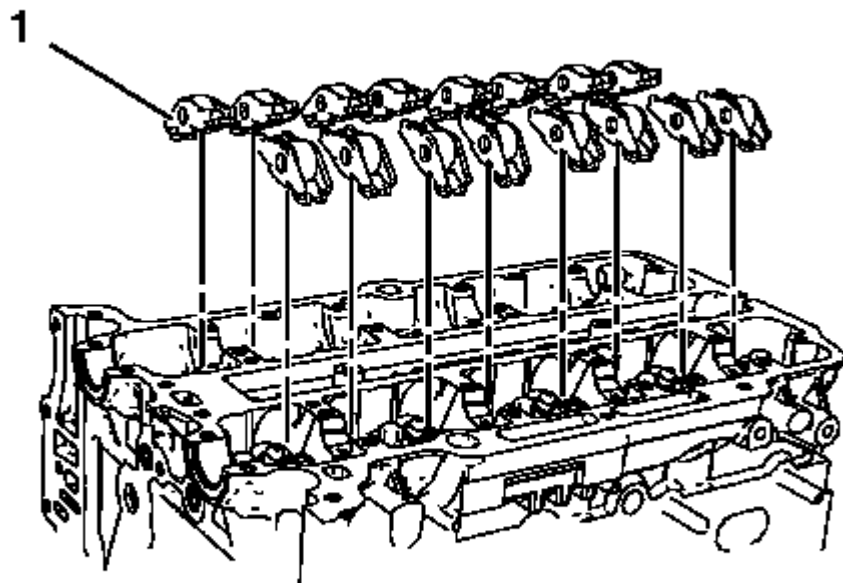


Fig. 186: Hydraulic Valve Lash Adjuster Arms
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the installation position of the hydraulic valve lash adjuster arms.

Remove the 16 hydraulic valve lash adjuster arms (1).

HYDRAULIC VALVE LASH ADJUSTER REMOVAL

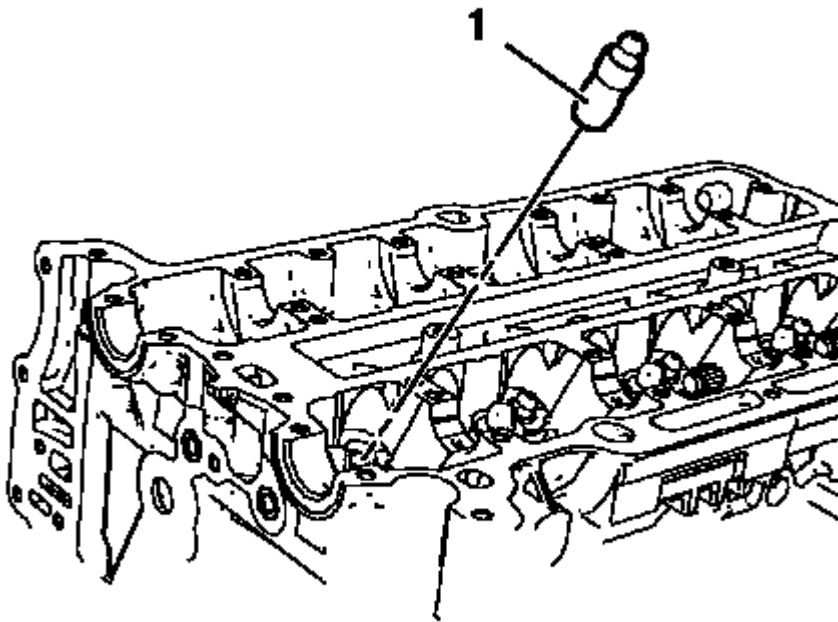


Fig. 187: Hydraulic Valve Lash Adjusters
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the installation position of the hydraulic valve lash adjusters.

Remove the 16 hydraulic valve lash adjusters (1).

CYLINDER HEAD REMOVAL

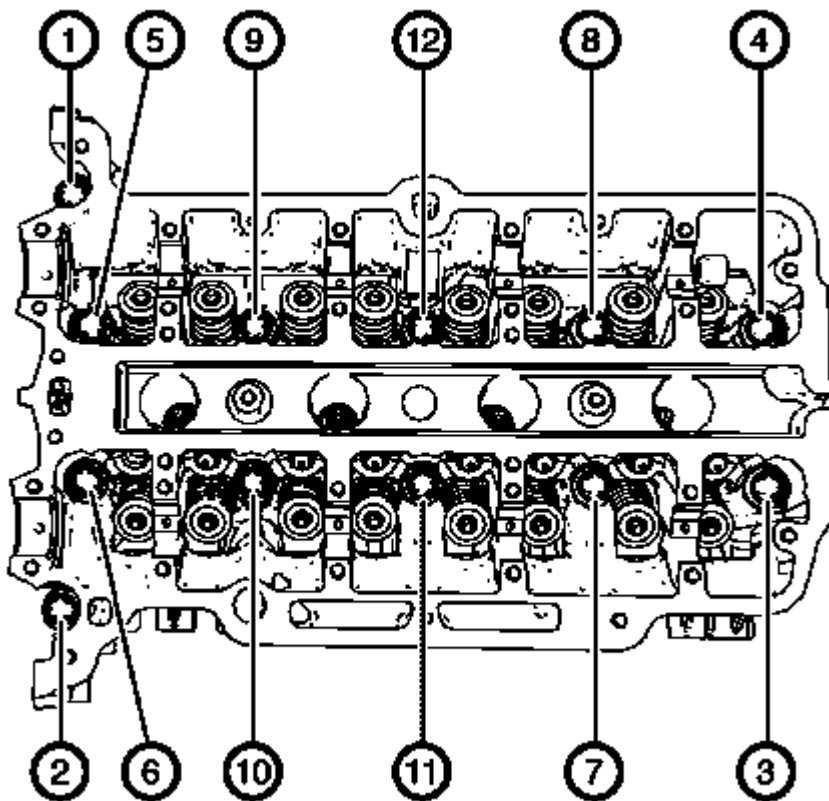


Fig. 188: Cylinder Head Bolts Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

1. Loosen the 12 cylinder head bolts in the sequence as shown. Use the following procedure:
 1. Loosen the cylinder head bolts 90 degrees.
 2. Loosen the cylinder head bolts 180 degrees.

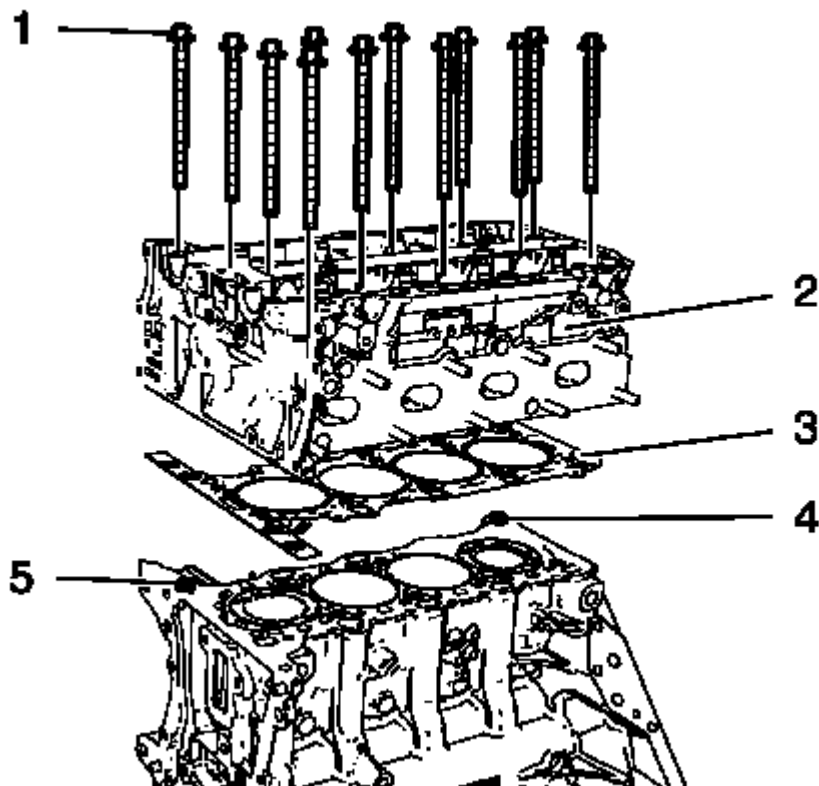


Fig. 189: Cylinder Head, Gasket, Bolts And Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not damage the guide sleeves (4) and (5).

2. Remove the 12 cylinder head bolts (1).
3. Remove the cylinder head (2).
4. Remove the cylinder head gasket (3).

PISTON, CONNECTING ROD, AND BEARING REMOVAL

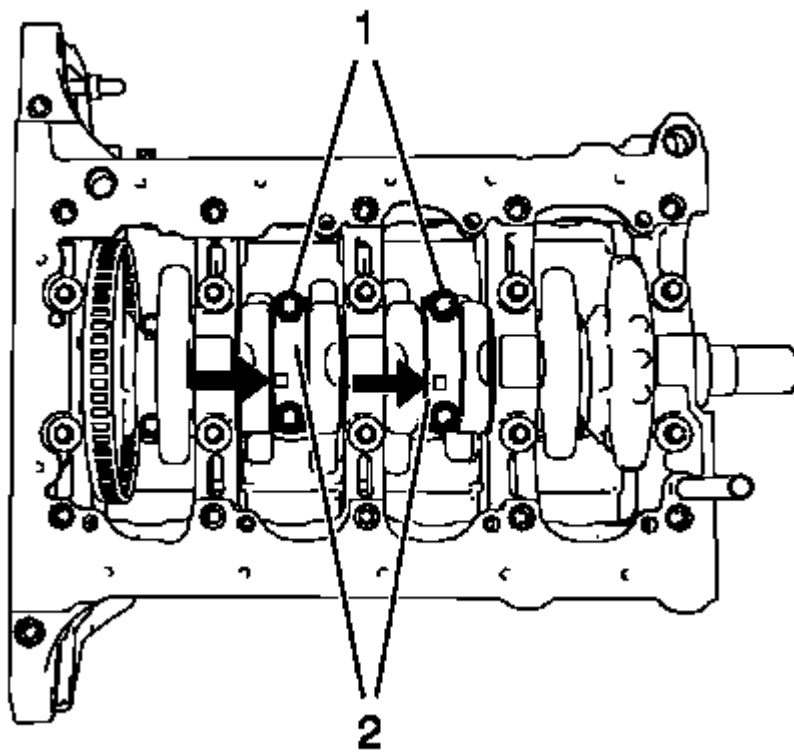


Fig. 190: Connecting Rod Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mark the installation position of the connecting rod bearing caps. The connecting rod bearings and bearing caps must not be interchanged with other connecting rods.

1. Remove the 4 connecting rod bearing cap bolts (1) of cylinder 2 and 3.
2. Remove the 2 connecting rod bearing caps (2) and the 2 connecting rod bearings of cylinder 2 and 3.
3. Rotate the crankshaft 180 degrees.

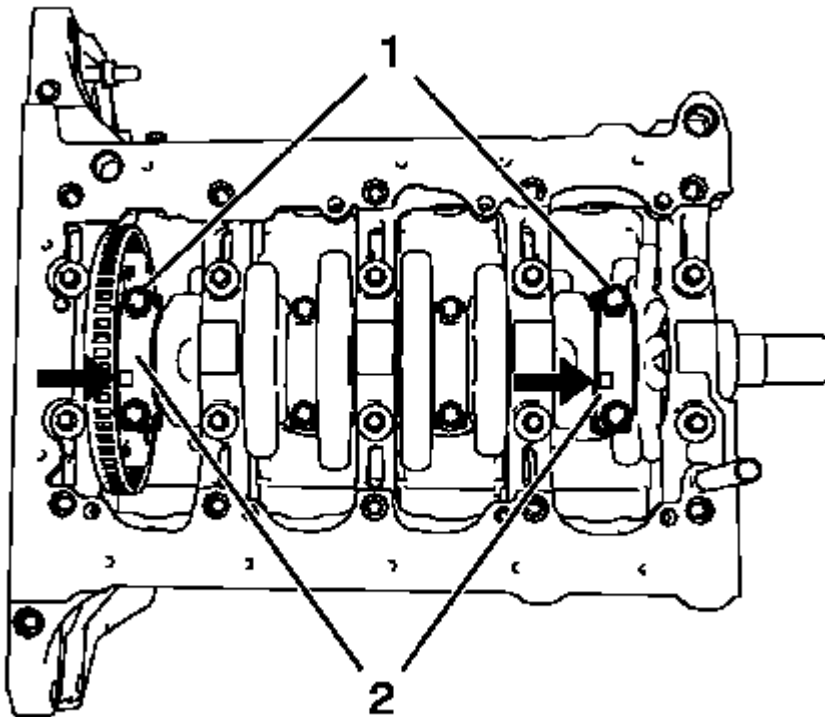


Fig. 191: Connecting Rod Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove the 4 connecting rod bearing cap bolts (1) of cylinder 1 and 4.
5. Remove the 2 connecting rod bearing caps (2) and the 2 connecting rod bearings of cylinder 1 and 4.

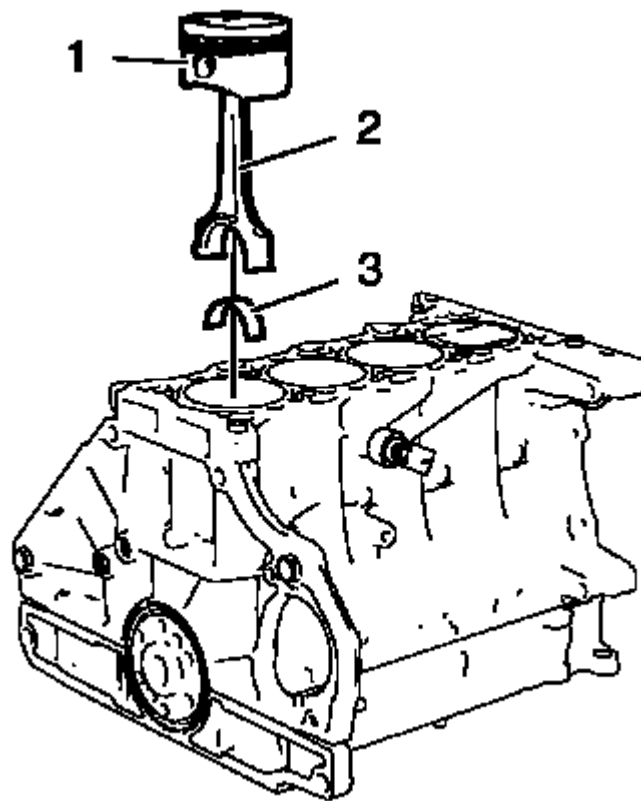


Fig. 192: Pistons, Connecting Rods And Bearings
Courtesy of GENERAL MOTORS COMPANY

6. Remove the 4 pistons (1) and connecting rods (2) and the 4 upper connecting rod bearings (3) from the cylinder block.

CRANKSHAFT AND BEARING REMOVAL

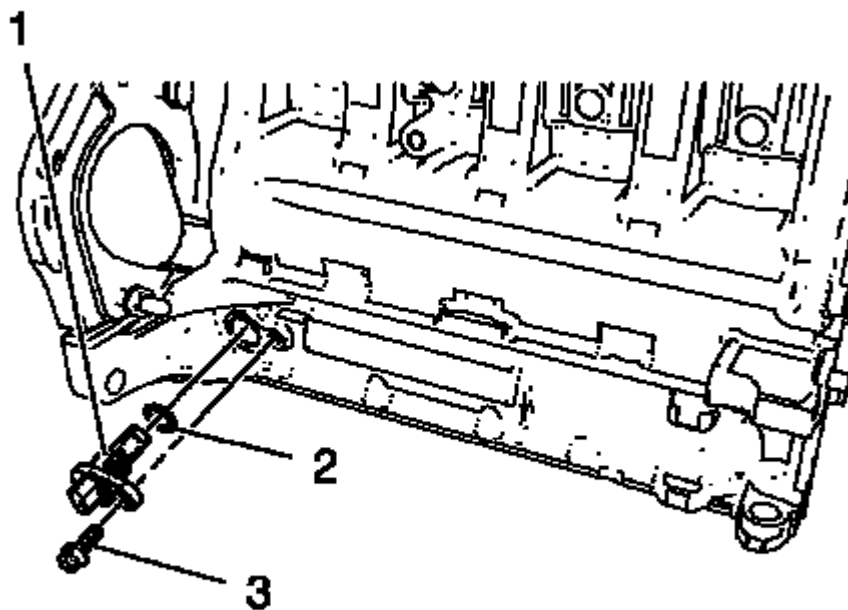


Fig. 193: Crankshaft Position Sensor, Bolt And Seal Ring
Courtesy of GENERAL MOTORS COMPANY

1. Remove the crankshaft position sensor bolt (3).
2. Remove the crankshaft position sensor (1) and the crankshaft position sensor seal ring (2).

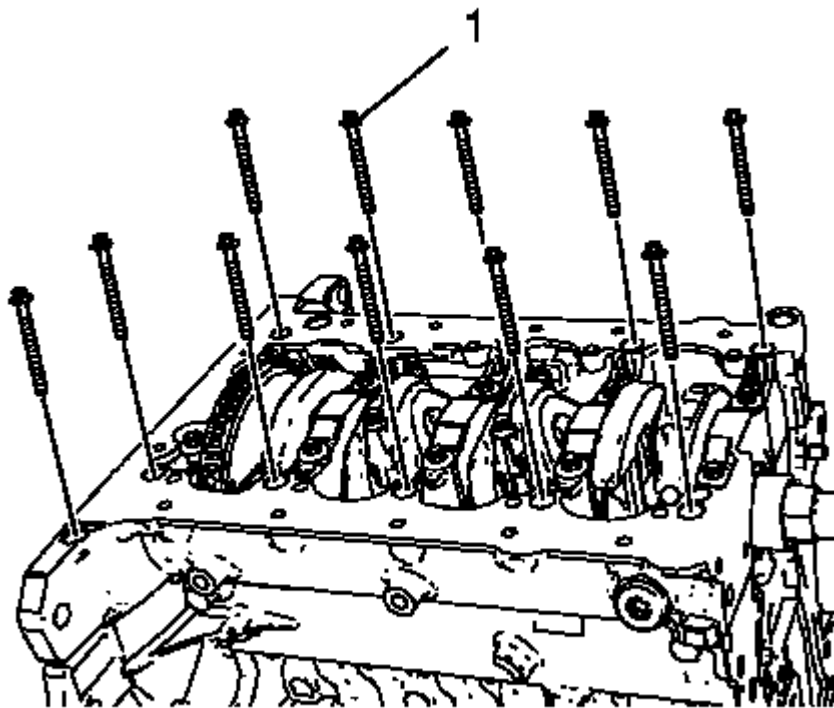


Fig. 194: Outer Crankshaft Bearing Cap Tie Plate Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Remove the 12 outer crankshaft bearing cap tie plate bolts (1).

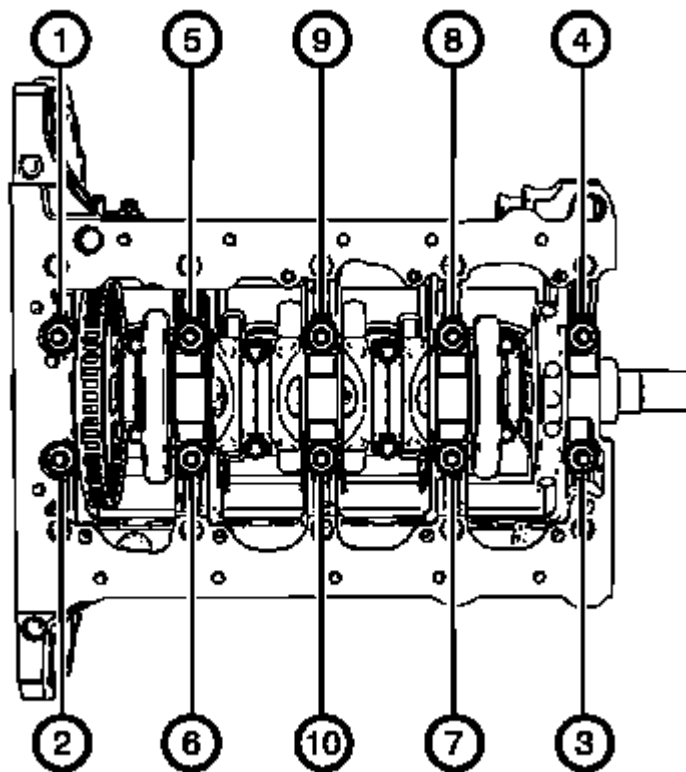


Fig. 195: Inner Crankshaft Bearing Cap Tie Plate Bolts Loosening Sequence
Courtesy of GENERAL MOTORS COMPANY

4. Loosen the 10 inner crankshaft bearing cap tie plate bolts in a sequence as shown.

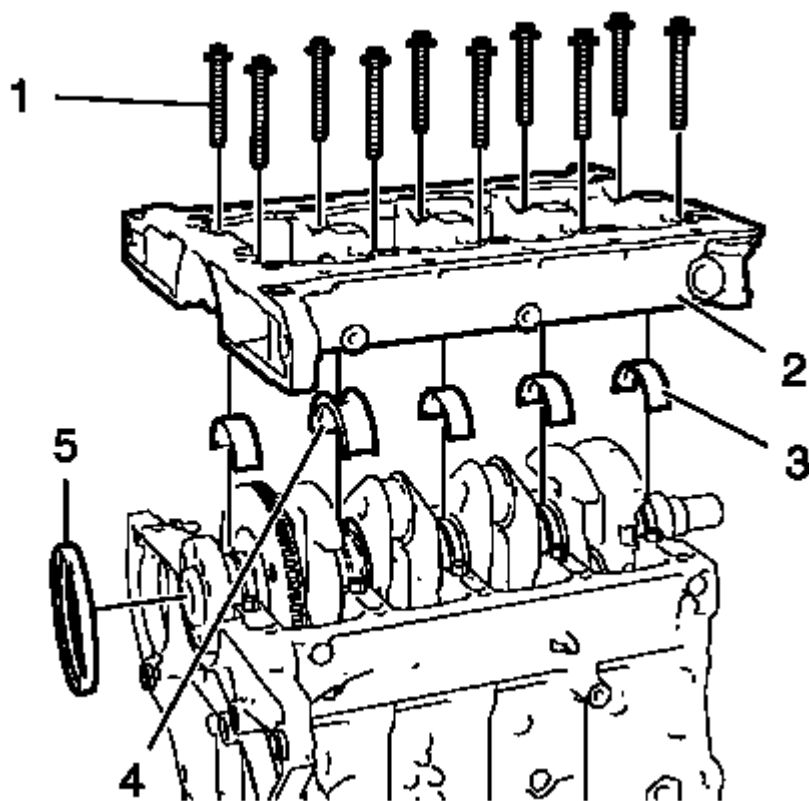


Fig. 196: Crankshaft Bearing Cap Tie Plate, Bolts, Lower Crankshaft Bearings, Lower Crankshaft Thrust Bearing And Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

5. Remove the 10 crankshaft bearing cap tie plate bolts (1)

Remove the crankshaft bearing cap tie plate (2).

6. Remove the 4 lower crankshaft bearings (3) and the lower crankshaft thrust bearing (4).
7. Remove the crankshaft rear oil seal (5).

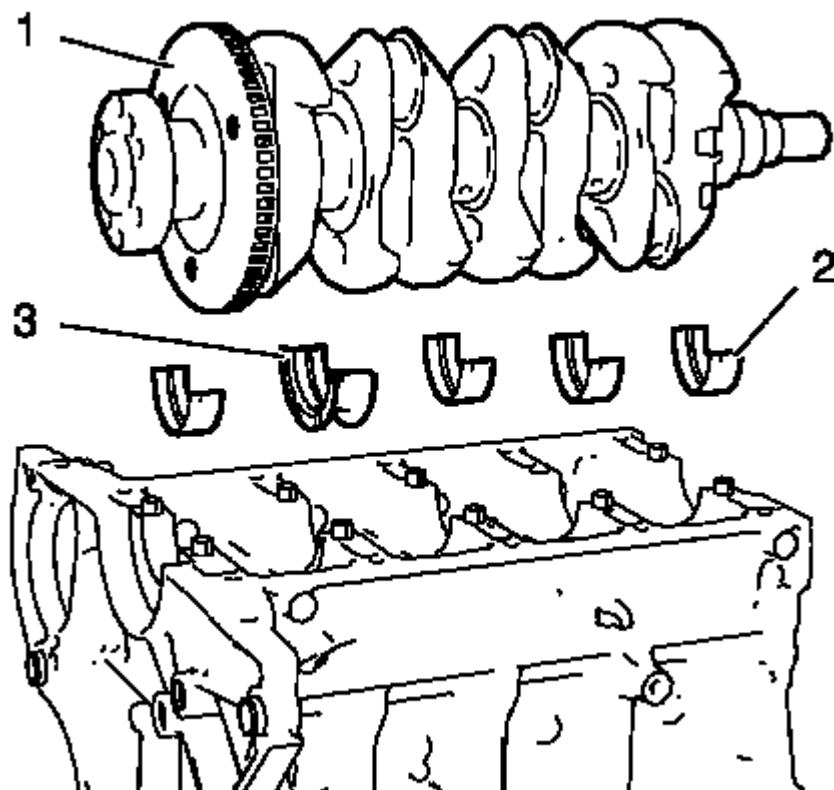


Fig. 197: Crankshaft, Upper Crankshaft Bearings And Upper Crankshaft Thrust Bearing
Courtesy of GENERAL MOTORS COMPANY

8. Remove the crankshaft (1), the 4 upper crankshaft bearings (2) and the upper crankshaft thrust bearing (3).

CYLINDER HEAD DISASSEMBLE

Special Tools

- **EN-840** Pliers/Remover
- **EN-8062** Valve Spring Compressor
- **EN-8062-5** Adapter
- **EN-50717-2** Compressor Assembly of **EN-50717** Kit

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

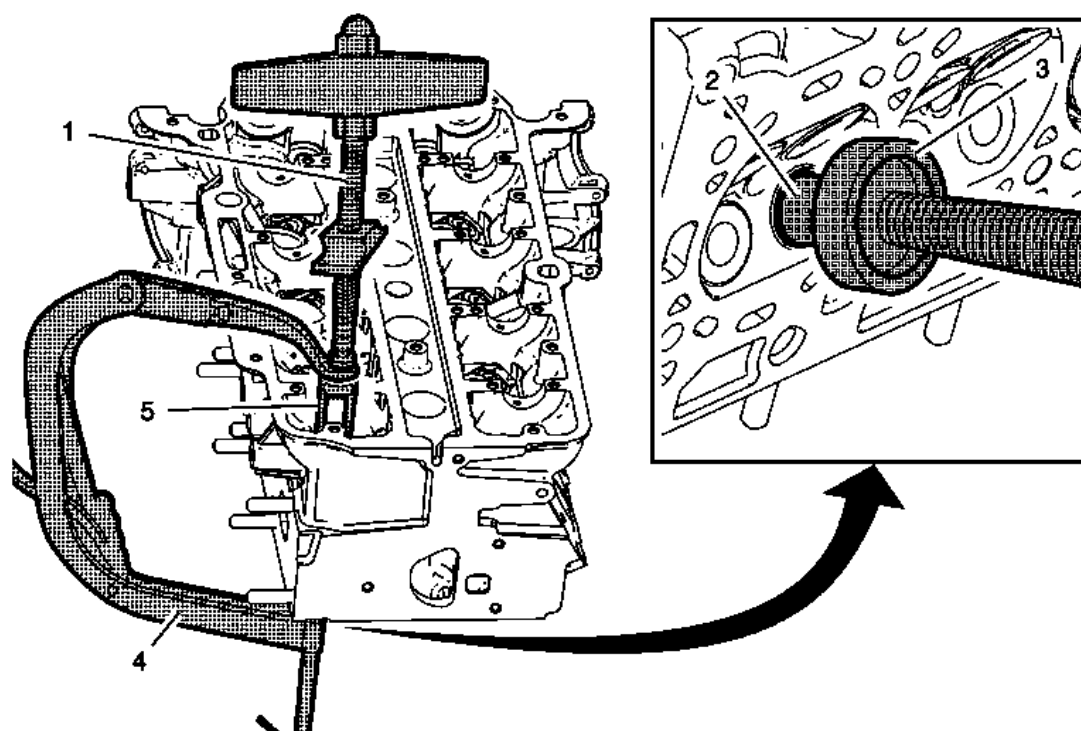


Fig. 198: Valve Spring Compressor And Adapter Assembly
Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN-50717-2** assembly (1) to the **EN-8062** compressor (4).
2. Install the **EN-8062-5** adapter (3) to the **EN-8062** compressor.
3. Install the compressor assembly to the cylinder head, so that the adapter (5) of the **EN-50717-2** assembly (1) proper contacts the valve spring retainer and the **EN-8062-5** adapter (3) contacts the valve disc (2). Prefix the **EN-8062** compressor (4) then.

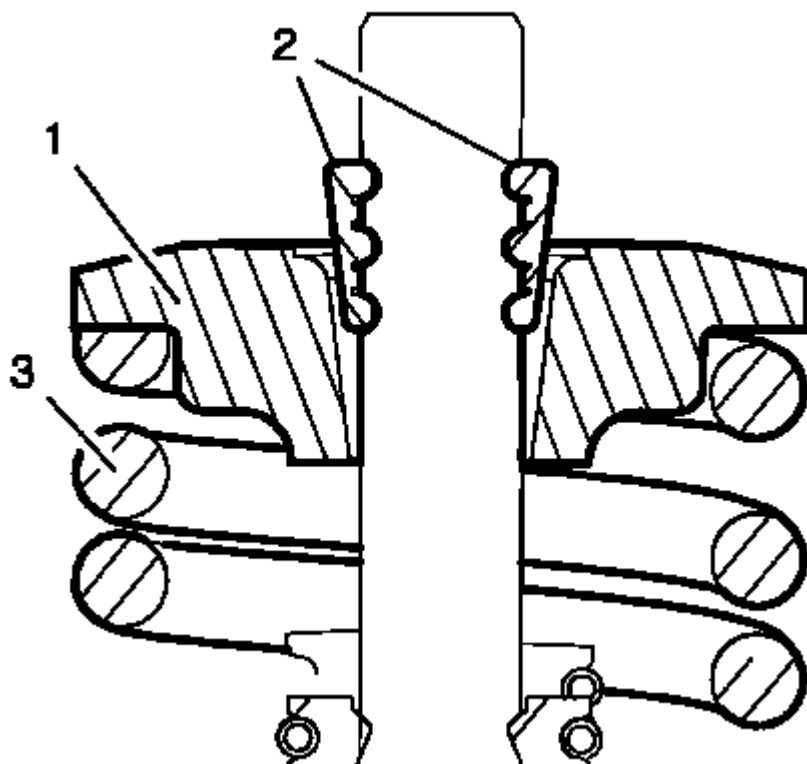


Fig. 199: Valve Spring Retainer And Valve Spring
Courtesy of GENERAL MOTORS COMPANY

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

4. Apply pressure to the EN-50717-2 assembly to push down the valve spring retainer (1) and compress the valve spring (3) until the valve keys (2) are free from tension. Carefully remove the valve keys then.

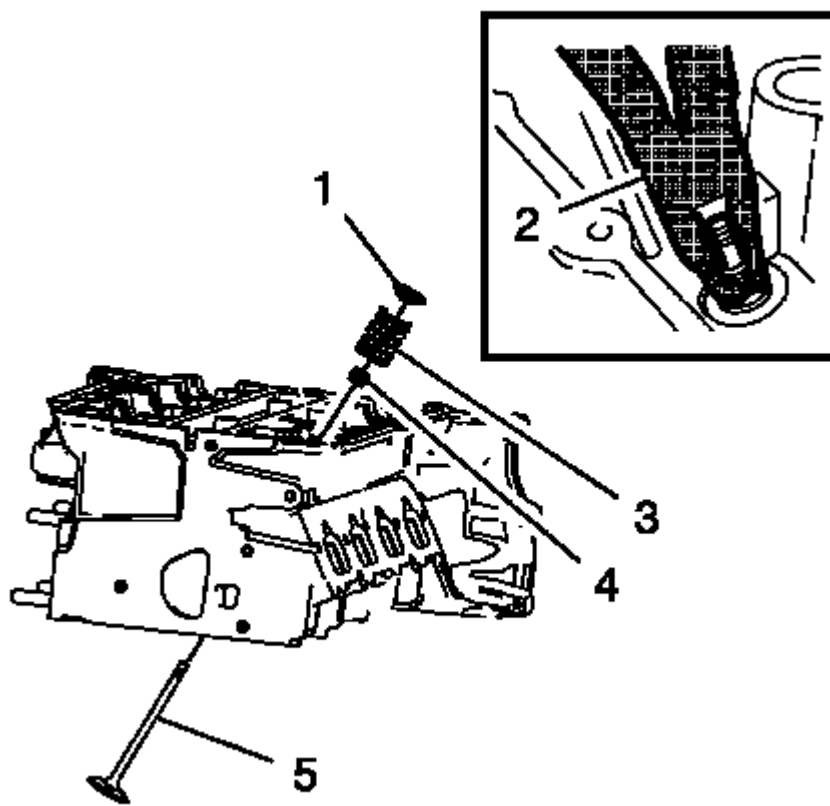


Fig. 200: Spring Compressor

Courtesy of GENERAL MOTORS COMPANY

5. Slowly and carefully loosen the **EN-50717-2** assembly until the valve spring is entirely expanded.
6. Remove the compressor assembly from the cylinder head.
7. Remove the valve spring retainer (1) and the valve spring (3).
8. Remove and DISCARD the valve stem oil seal (4), using the **EN-840** pliers (2).
9. Remove the valve (5).

NOTE: Ensure that the valve train components are kept together and identified in order for proper installation in their original position.

10. Repeat the procedure with the remaining valves.
11. In case of re-using the cylinder head, refer to Cylinder Head Cleaning and Inspection.

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **EN-6216** Gauge
- **EN-6216-200/300/400** Gauge Instruments

- **GE-571-B Gauge**

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

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant.
2. Clean all cylinder head surfaces with non-corrosive sealant.

WARNING: Refer to Safety Glasses Warning .

3. Blow out all the oil galleries using compressed air.
4. Remove any carbon deposits from the combustion chamber.

Visual Inspection

1. Inspect the cylinder head camshaft bearing surfaces for the following conditions:
 - 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.
 - Damage to any gasket surfaces.
 - 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.
 - 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 allowed.

Valve Inspection And Measurement

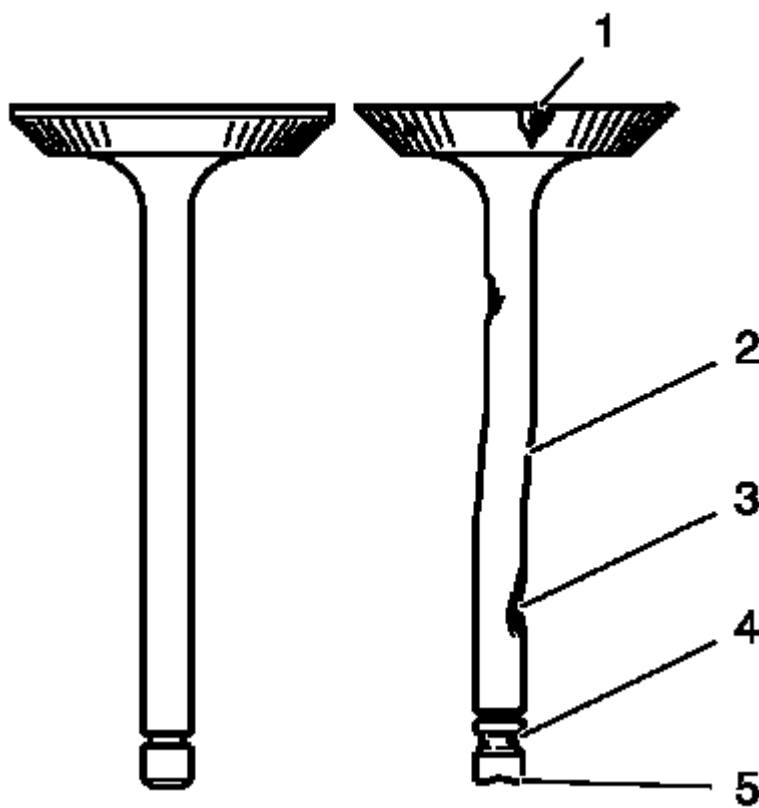


Fig. 201: Valve Inspection And Measurement
Courtesy of GENERAL MOTORS COMPANY

1. Clean the valves of carbon and oil. Carbon can be removed with a wire brush.
2. Inspect the valves for the following conditions:
 1. Inspect the valve faces for burning and cracking (1). If pieces are broken, replace the valve and inspect the corresponding piston and cylinder head area for damage.
 2. Inspect the valve for straightness and distortion (2). Distorted valve must be replaced.
 3. Inspect the valve stem for wear (3).
 4. Inspect the valve key grooves for chipping and wear (5). Replace the valve if chipped or worn.

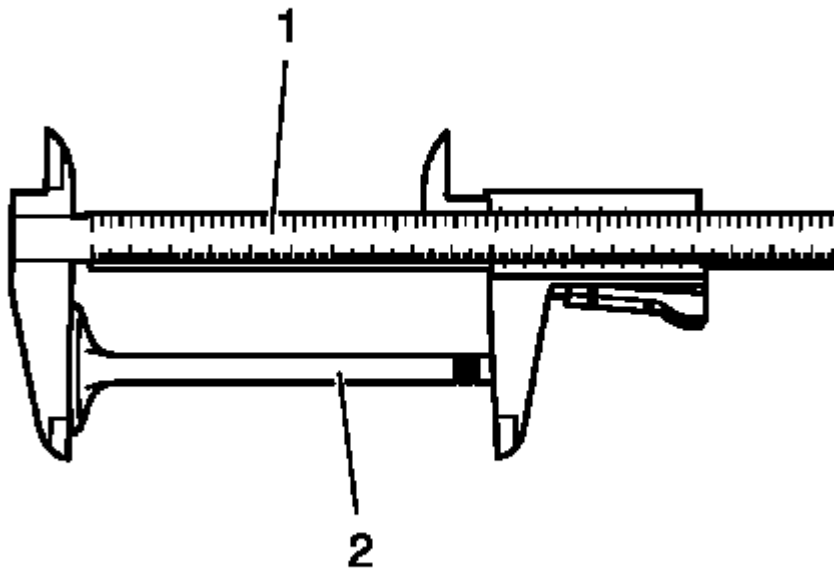


Fig. 202: Measuring Valve Length Using Slide Gauge
Courtesy of GENERAL MOTORS COMPANY

3. Measure the valve length (2). Use a slide gauge (1). Refer to **Engine Mechanical Specifications** to find the permitted values.

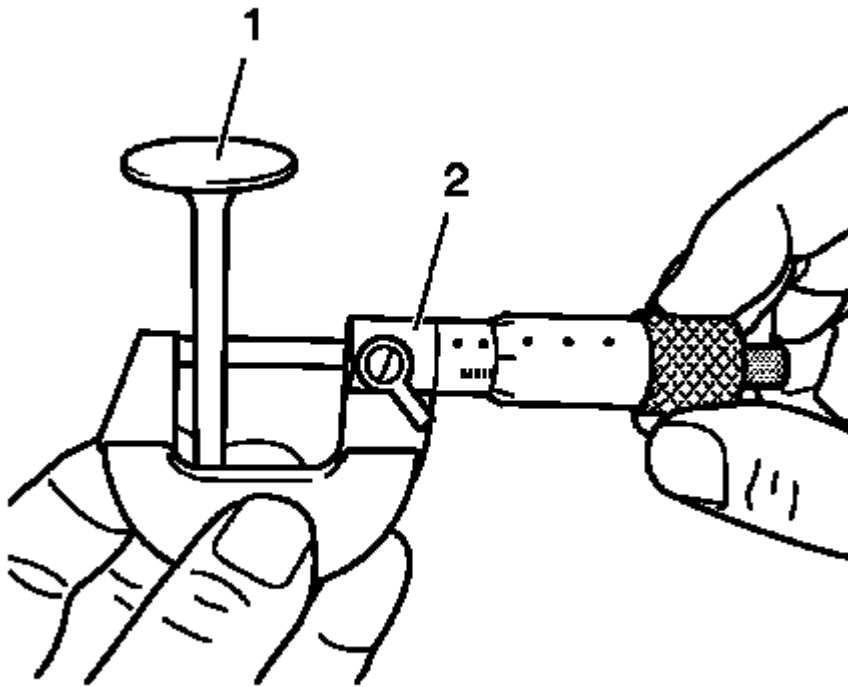


Fig. 203: Measuring Valve Stem Diameter Using Micrometer Gauge
Courtesy of GENERAL MOTORS COMPANY

4. Measure the valve stem diameter. Use a micrometer gauge (2). Refer to **Engine Mechanical Specifications** to find the permitted values. Note the measurement results.

Cylinder Head Measurement

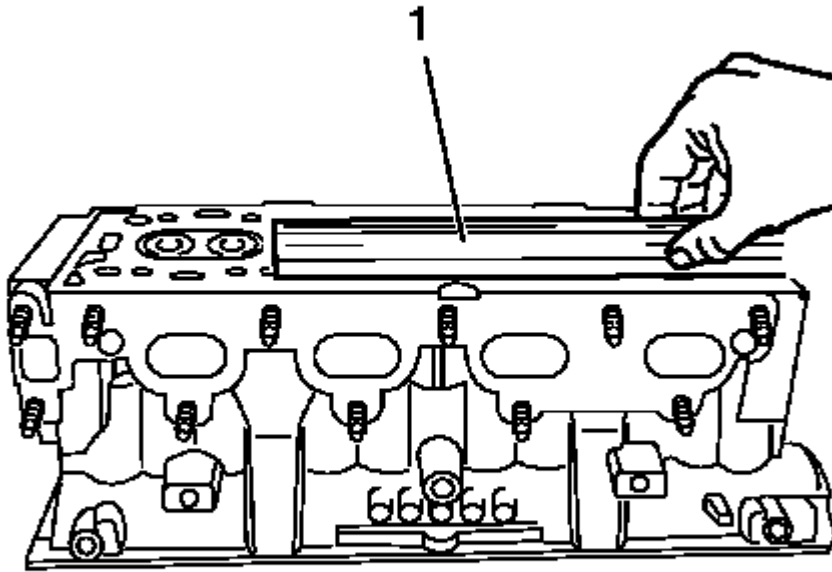


Fig. 204: Using Straightedge To Inspect Cylinder Head Sealing Surface For Flatness
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the cylinder head sealing surface for flatness. Use a straightedge (1). Refer to **Engine Mechanical Specifications** to find the permitted values.

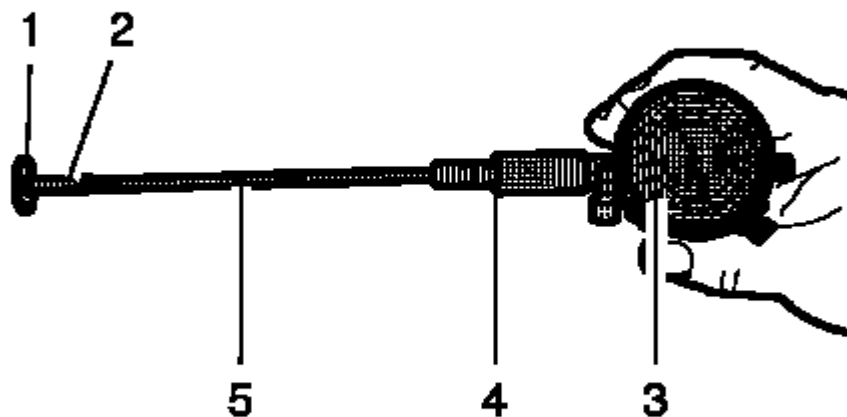


Fig. 205: Checking Valve Stem To Guide Clearance Measurement
Courtesy of GENERAL MOTORS COMPANY

2. Prepare the gauge for valve stem to guide clearance measurement. Assemble the **EN-6216** gauge and the **EN-6216-200/300/400** gauge instruments as followed:
 1. Install the extension (5) to the support (4).
 2. Install the inside caliper (2) to the extension (5).
 3. Install the gauge (3) to the support (4) and pretension to 1 mm (0.0394 in).
 4. Install the calibration washer (1) as shown to justify the gauge.
 5. Adjust the gauge to 0 mm (0 in) by rotating the instrument dial.
 6. Cautious remove the calibration washer (1).

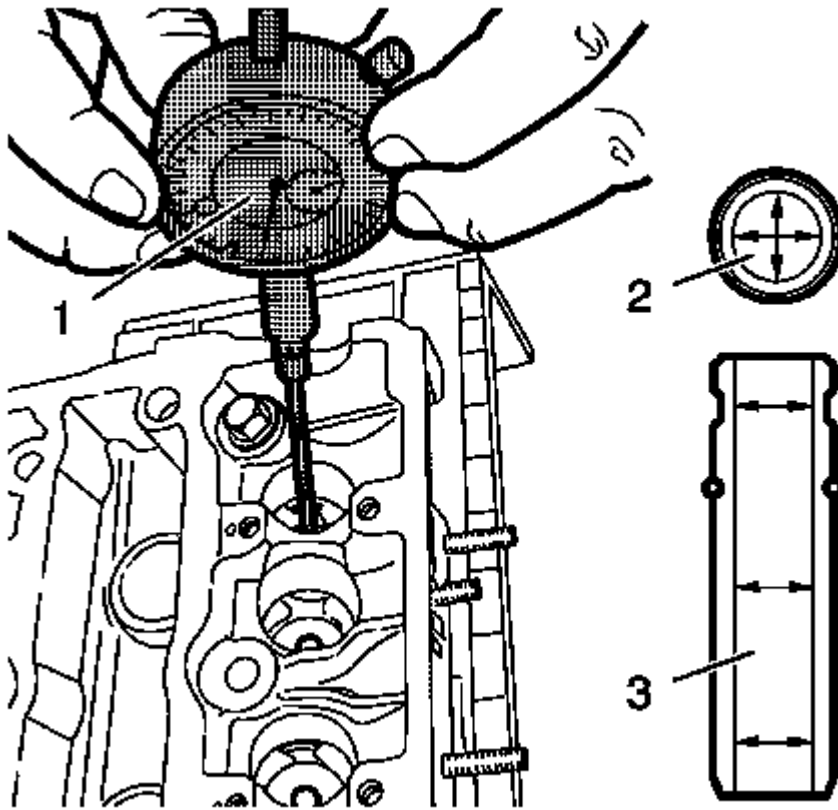


Fig. 206: Measuring Valve Guide Inner Diameter
Courtesy of GENERAL MOTORS COMPANY

3. Measure the valve guide inner diameter (2) as shown in different areas (3). Use **EN-6216** gauge (1) and gauge instruments. Note the measurement results. Refer to **Engine Mechanical Specifications** to find the permitted values.
4. Subtract the valve stem diameter from valve guide inner diameter to calculate the valve stem to guide clearance. Refer to **Engine Mechanical Specifications** to find the permitted values.
5. Turn the cylinder head upside down.

CYLINDER HEAD ASSEMBLE

Special Tools

- **EN-958** Valve Stem Seal Installer
- **EN-8062** Valve Spring Compressor
- **EN-8062-5** Adapter
- **EN-50717-2** Compressor Assembly of **EN-50717** Kit

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

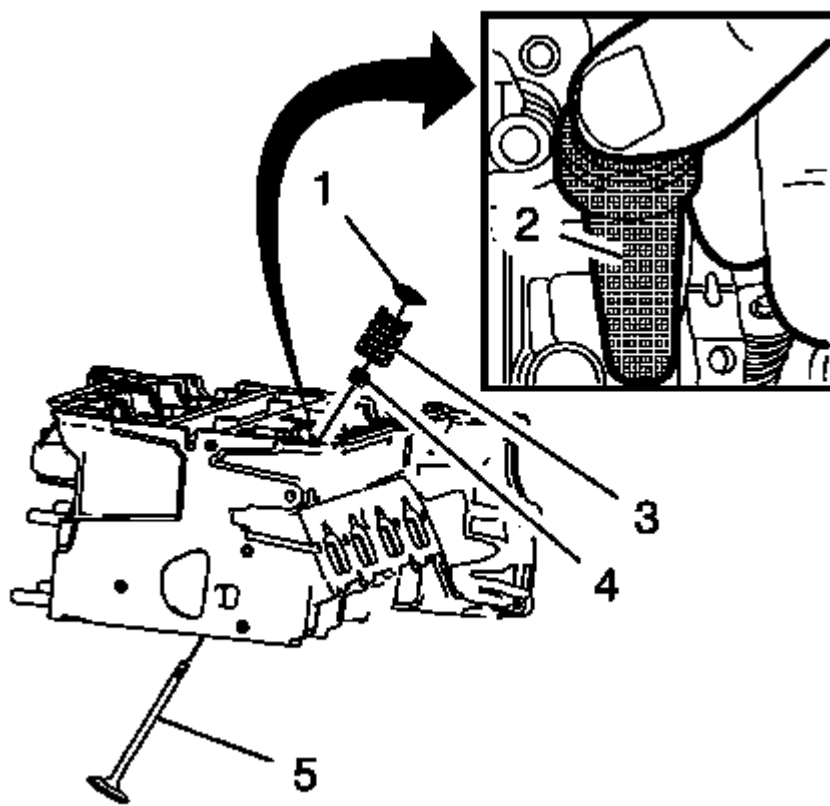


Fig. 207: Valve Stem Oil Seal And Installer
Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the valve stem and the valve guide with clean engine oil.

NOTE: **Ensure all valve train components will be installed in their original position.**

2. Install the valve (5).
3. Install the NEW valve stem oil seal (4), using the **EN-958** installer (2).
4. Loosely install the valve spring (3) and the valve spring retainer (1).

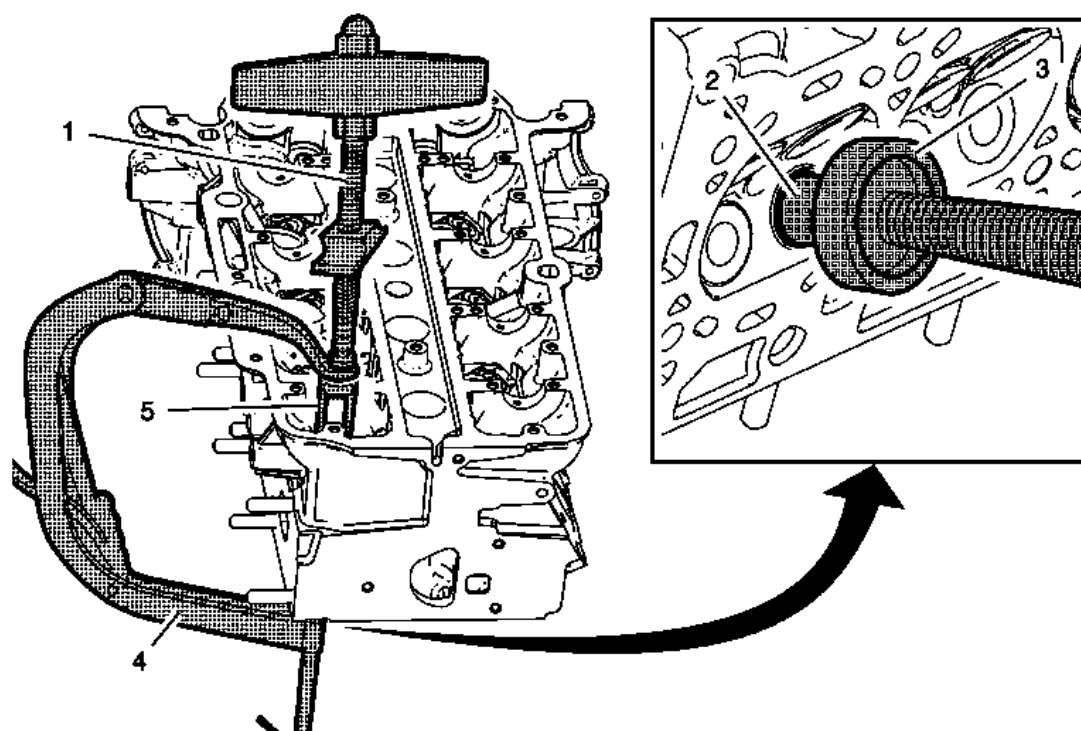


Fig. 208: Valve Spring Compressor And Adapter Assembly
Courtesy of GENERAL MOTORS COMPANY

5. Install the **EN-50717-2** assembly (1) to the **EN-8062** compressor (4).
6. Install the **EN-8062-5** adapter (3) to the **EN-8062** compressor.
7. Install the compressor assembly to the cylinder head, so that the adapter (5) of the **EN-50717-2** assembly (1) proper contacts the valve spring retainer and the **EN-8062-5** adapter (3) contacts the valve disc (2). Prefix the **EN-8062** compressor (4) then.

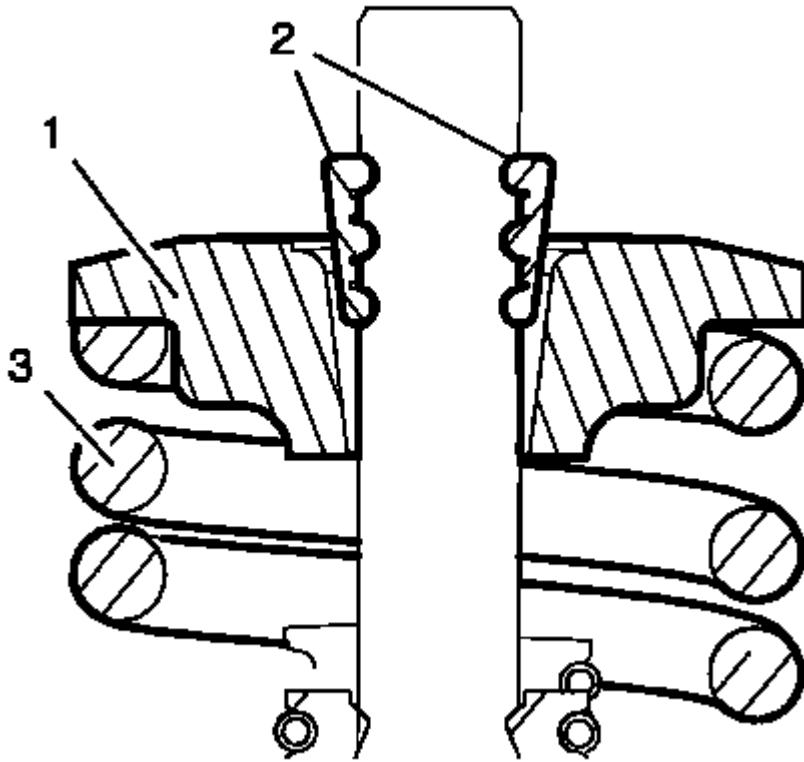


Fig. 209: Valve Spring Retainer And Valve Spring
Courtesy of GENERAL MOTORS COMPANY

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

8. Apply pressure to the **EN-50717-2** assembly to push down the valve spring retainer (1) and compress the valve spring (3) until the valve keys (2) can be inserted. Carefully insert the valve keys then, so that they are properly installed to the valve stem grooves.
9. Carefully release the tension from the **EN-50717-2** assembly.
10. Inspect the valve keys and valve spring retainer for proper seat.
11. Remove the compressor assembly from the cylinder head.
12. Repeat the procedure with the remaining valves.

ENGINE BLOCK DISASSEMBLE

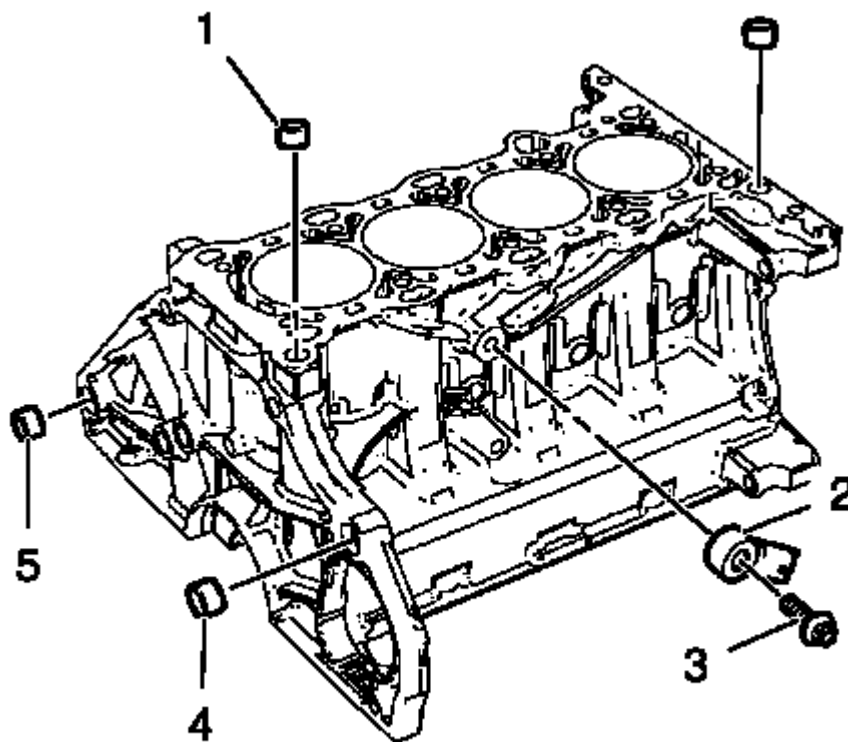


Fig. 210: Knock Sensor, Bolt, Cylinder Head Guide Sleeves And Transmission Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

1. Remove the knock sensor bolt (3).
2. Remove the knock sensor (2).
3. Remove the 2 cylinder head guide sleeves (1). Use suitable pliers.
4. Remove the 2 transmission guide sleeves (4, 5). Use suitable pliers.

ENGINE BLOCK ASSEMBLE

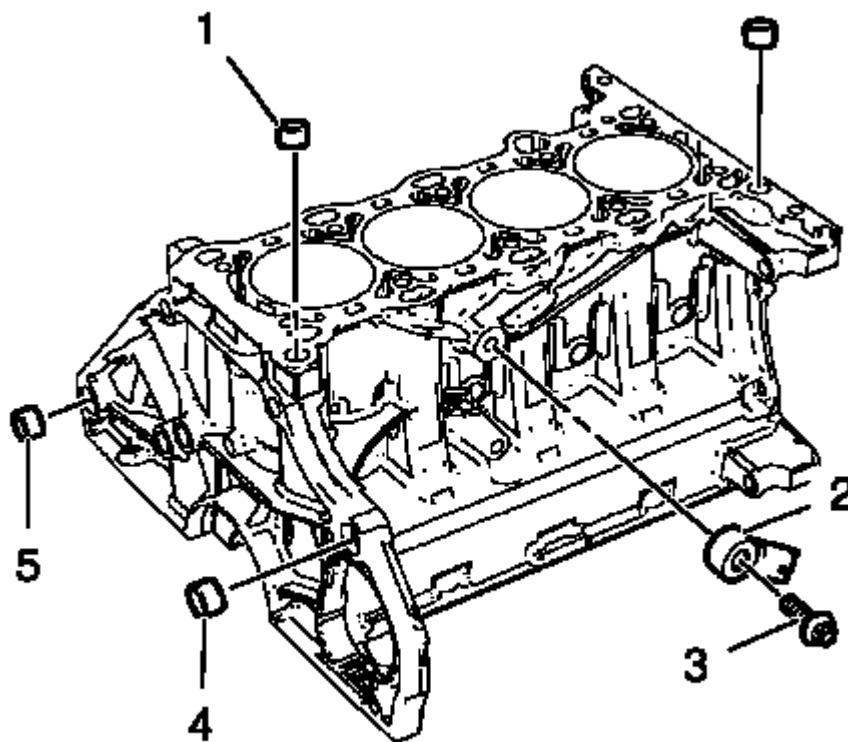


Fig. 211: Knock Sensor, Bolt, Cylinder Head Guide Sleeves And Transmission Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

1. Install the knock sensor (2).

CAUTION: Refer to Fastener Caution .

2. Install the knock sensor bolt (3) and tighten to 20 N.m (15 lb ft).
3. Install the 2 cylinder head guide sleeves (1). Use a rubber mallet.
4. Install the 2 transmission guide sleeves (4, 5). Use a rubber mallet.

PISTON AND CONNECTING ROD DISASSEMBLE

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

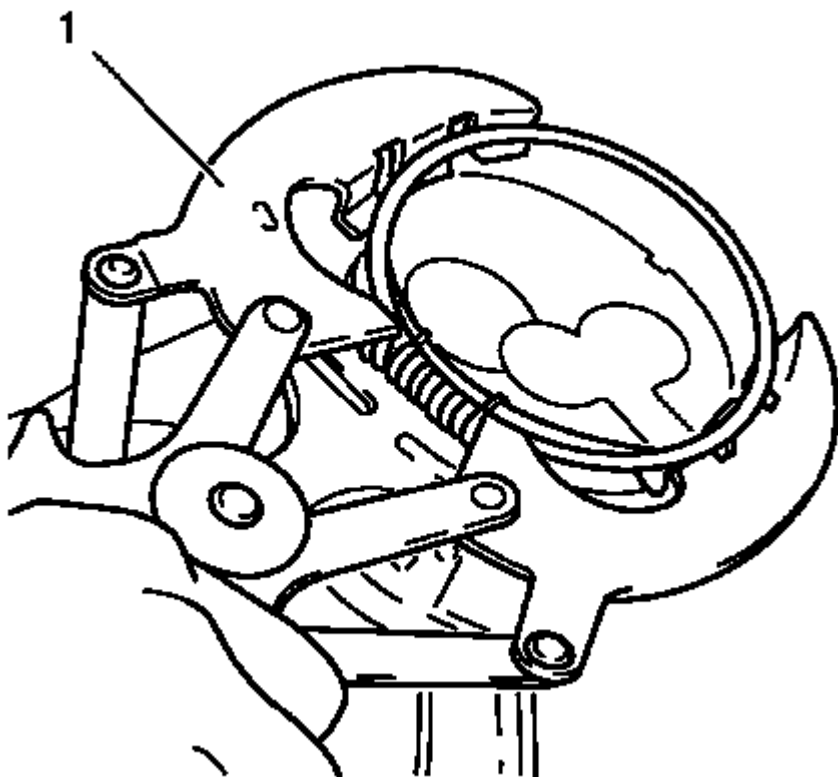


Fig. 212: Using Piston Ring Pliers

Courtesy of GENERAL MOTORS COMPANY

1. Remove the piston rings. Use piston ring pliers (1)

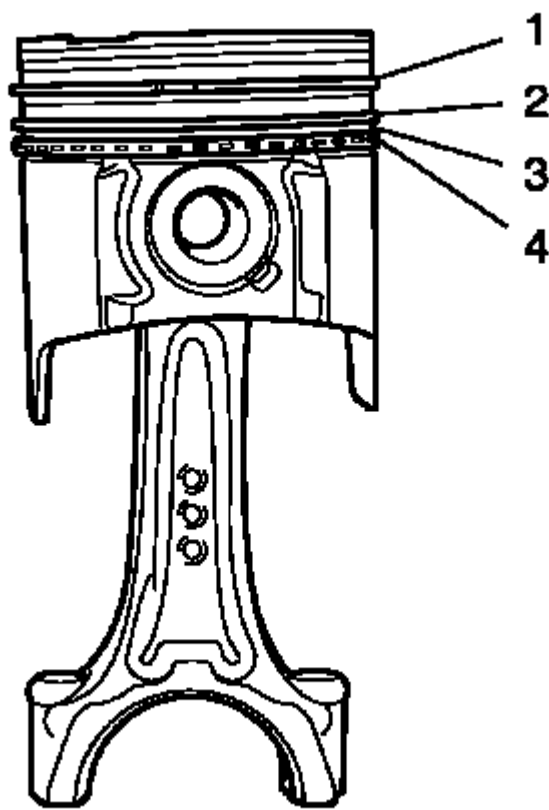


Fig. 213: Upper Compression Ring, Lower Compression Ring, Oil Rings And Oil Ring Spacer
Courtesy of GENERAL MOTORS COMPANY

2. The piston rings are ordered as followed:

- Upper compression ring (1)
- Lower compression ring (2)
- Oil rings and oil ring spacer (3, 4)

In case of damage on piston, piston pin or connecting rod all components of the piston assembly have to be replaced. The piston pin can not be removed and reinstalled due to the shrink fit of connecting rod and piston pin.

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Visual Inspection And Cleaning Procedure

Connecting Rod

WARNING: Wear safety glasses when using compressed air in order to prevent eye injury.

1. Clean the connecting rods in solvent and dry with compressed air.
2. Inspect the connecting rod for the following:
 - Signs of being twisted, bent, nicked or cracked
 - Scratches or abrasion on the connecting rod bearing seating surfaces

Piston

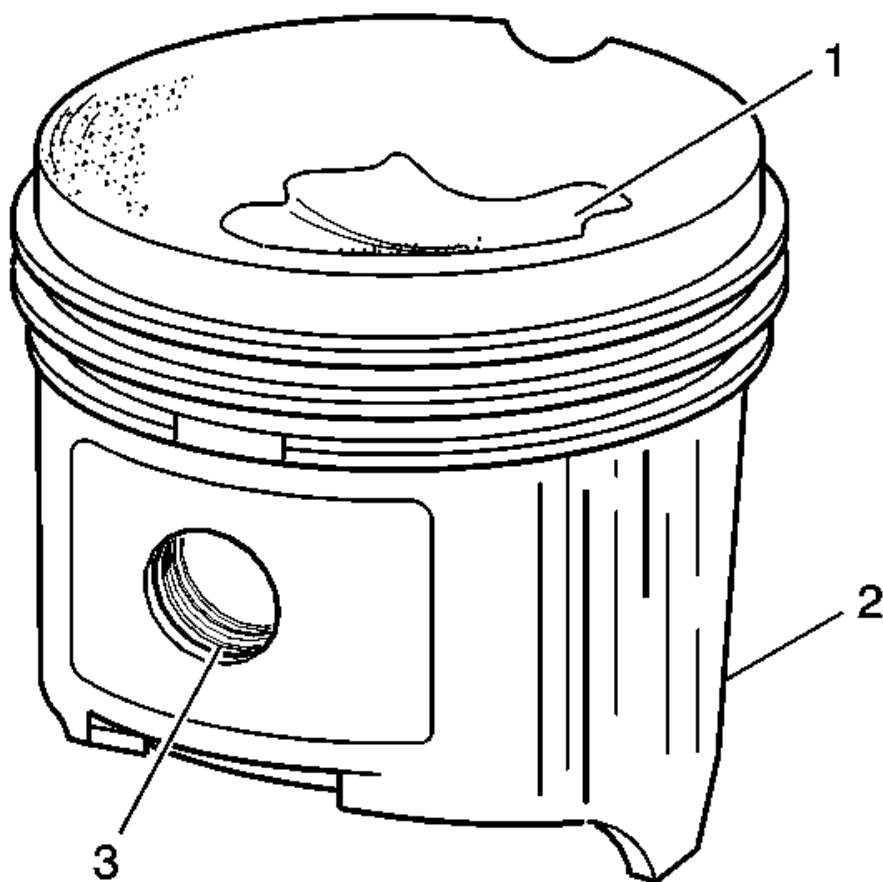


Fig. 214: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

1. Clean the piston with a cleaning solvent. DO NOT wire brush any parts of the piston.
2. Clean the piston ring grooves.
3. Inspect the piston on the following:
 - Cracked ring lands, skirts or pin bosses
 - Ring grooves for nicks

- Eroded areas on the top of the piston (1)
 - Scuffed or damaged skirts (2)
 - Worn piston pin bores (3)
4. If there is any excessive wear, replace the piston.
 5. Measure the clearance between piston pin and piston bore.

Piston And Connecting Rod Measurement Procedure

Piston Ring Clearance

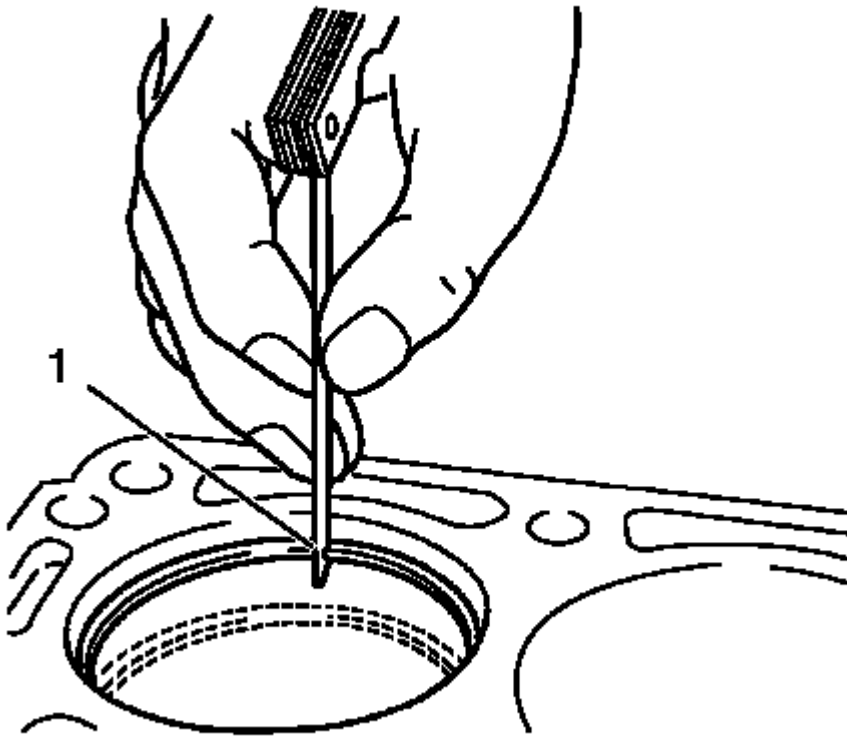


Fig. 215: Measuring Piston Ring End Clearance
Courtesy of GENERAL MOTORS COMPANY

1. Install the piston rings to the cylinder as shown and measure the piston ring end gap (1). Compare the measurements with those provided below:
 - The upper compression ring end gap should be 0.250 mm - 0.400 mm (0.0098 in - 0.0157 in)
 - The lower compression ring end gap should be 0.400 mm - 0.600 mm (0.0157 in - 0.0236 in)
 - The oil ring end gap should be 0.250 mm - 0.750 mm (0.0098 in - 0.0295 in)
2. If the clearance is greater than the provided specifications, the piston rings must be replaced.

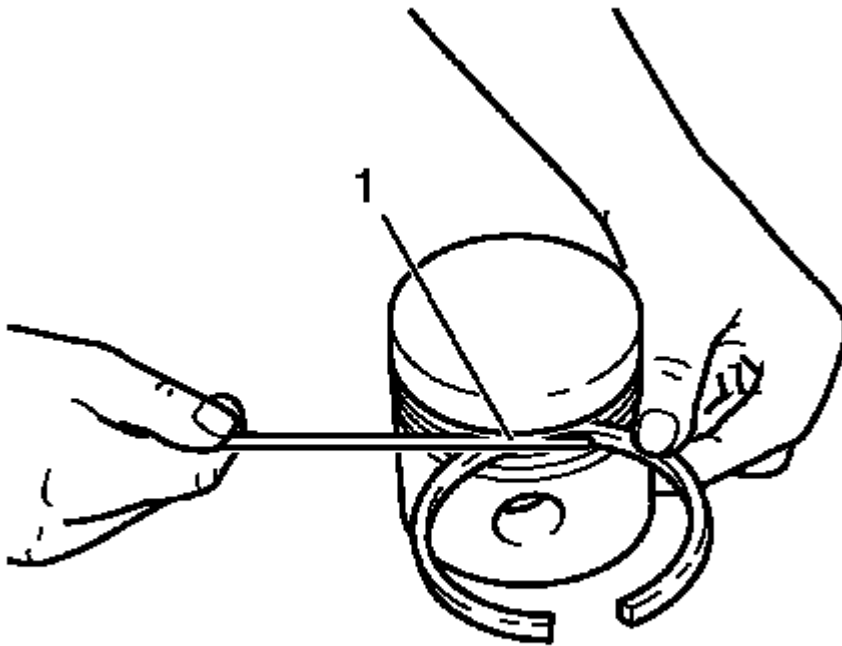


Fig. 216: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS COMPANY

3. Measure the piston ring side clearance as shown (1). Compare the measurements with those provided below:
 - The upper compression ring side clearance should be 0.025 mm - 0.070 mm (0.001 in - 0.0028 in)
 - The lower compression ring side clearance should be 0.025 mm - 0.070 mm (0.001 in - 0.0028 in)
 - The oil ring side clearance should be 0.040 mm - 0.120 mm (0.0016 in - 0.0047 in)
4. If the clearance is greater than the provided specifications, replace the piston rings.
5. If the clearance is still too great, replace the pistons.

Connecting Rod Bearing Clearance (With Micrometer Gauge Internal Measuring Device)

1. Install the connecting bearings and the connecting rod bearing caps.
2. Tighten the connecting rod bearing cap bolts in the following sequence:

CAUTION: Refer to Fastener Caution .

NOTE: The old bolts can be reused for the measuring procedure.

1. Tighten the connecting rod bearing cap bolts to 10 N.m (89 lb in).
2. Tighten the bolts to an additional 60°.
3. Tighten the bolts to an additional 15°.

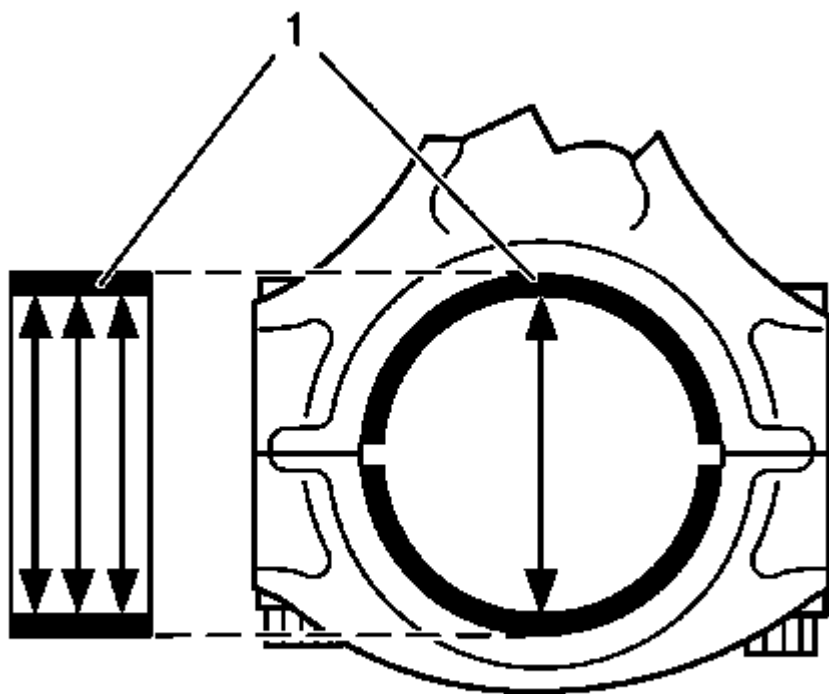


Fig. 217: Measuring Connecting Rod Bearing Diameters
Courtesy of GENERAL MOTORS COMPANY

3. Measure the connecting rod bearing diameters at 3 points as shown (1). Use a internal measuring device.
4. Calculate the average connecting rod inner diameter.

Formula: 1. result + 2. result + 3. result / 3

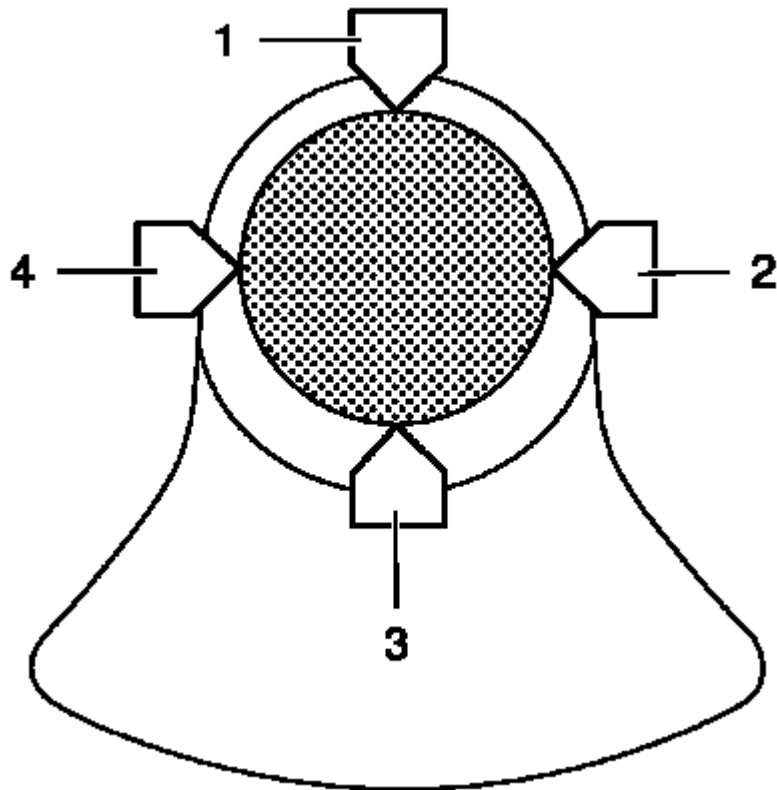


Fig. 218: Connecting Rod Journal Diameter Points
Courtesy of GENERAL MOTORS COMPANY

5. Measure the connecting rod journal diameter at 2 points between 1 and 3 and between 2 and 4. Use a micrometer gauge.
6. Calculate the average connecting rod journal diameter.

Formula: $1. \text{ result} + 2. \text{ result} / 2.$

7. Subtract the average connecting rod journal diameter from the average connecting rod bearing diameter in order to determine the connecting rod bearing clearance.

The clearance should be 0.013 mm - 0.061 mm (0.0005 in - 0.0024 in)

PISTON AND CONNECTING ROD ASSEMBLE

In case of damage on piston, piston pin or connecting rod, all components of the piston assembly have to be replaced. The piston pin can not be removed and reinstalled due to the shrink fit of connecting rod and piston pin. In case of replacement use a suitable, customary assemble tool.

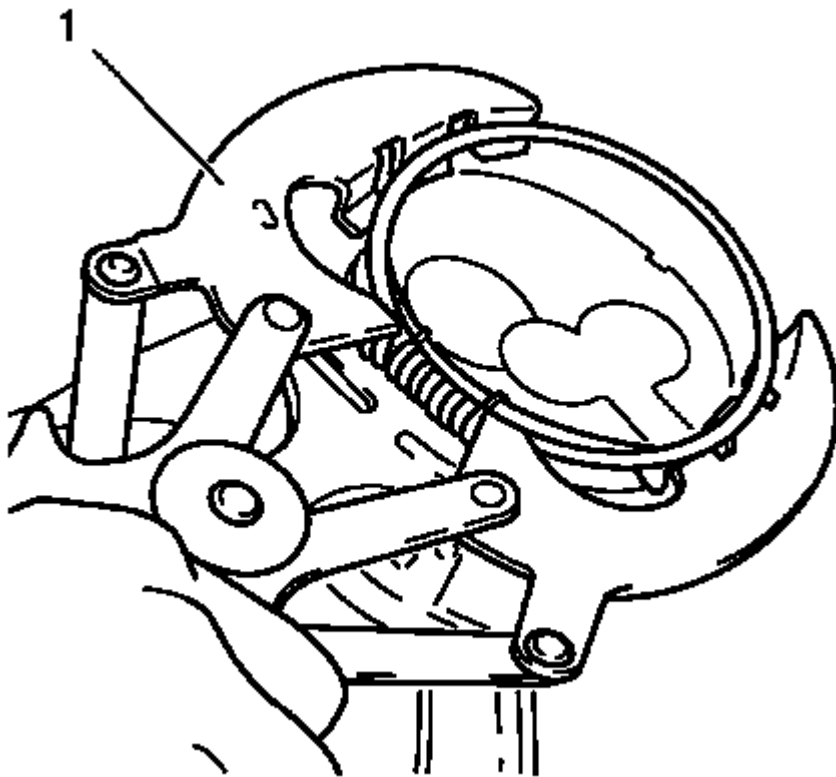


Fig. 219: Using Piston Ring Pliers

Courtesy of GENERAL MOTORS COMPANY

1. Install the piston rings. Use piston ring pliers (1).

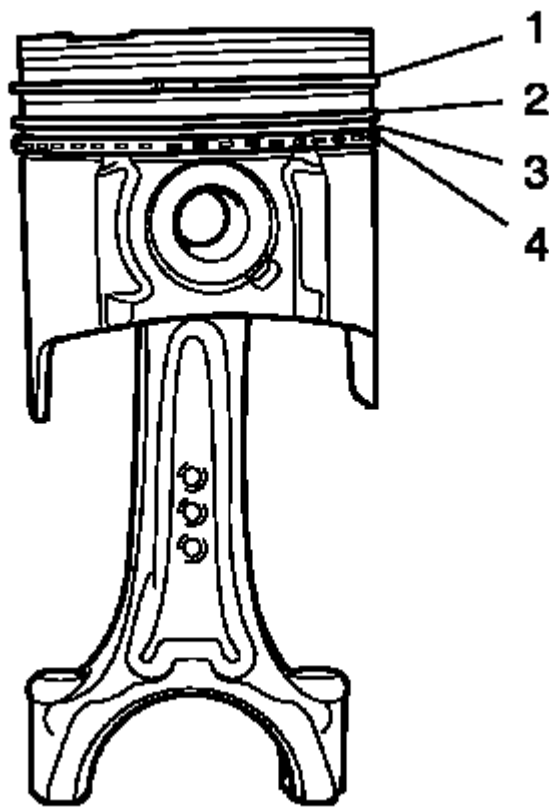


Fig. 220: Upper Compression Ring, Lower Compression Ring, Oil Rings And Oil Ring Spacer
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the TOP marking on the piston rings.

2. The piston rings must be ordered as followed:
- Upper compression ring (1)
 - Lower compression ring (2)
 - Piston oil rings with spacer (3, 4)

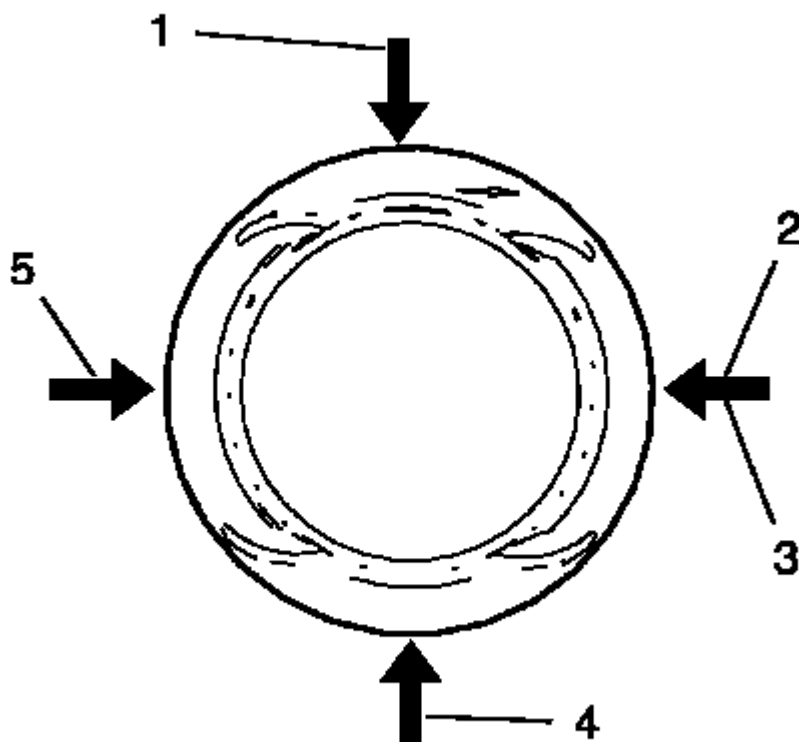


Fig. 221: Oil Ring Joints, Lower Compression Ring Joint, Upper Compression Ring Joint And Oil Ring Spacer Joint

Courtesy of GENERAL MOTORS COMPANY

3. The piston ring joints should be displaced as followed:
- Upper compression ring joint (2)
 - Lower compression ring joint (5)
 - Oil ring joint, upper part (1)
 - Oil ring joint, lower part (4)
 - Oil ring spacer joint (3)

INTAKE MANIFOLD DISASSEMBLE

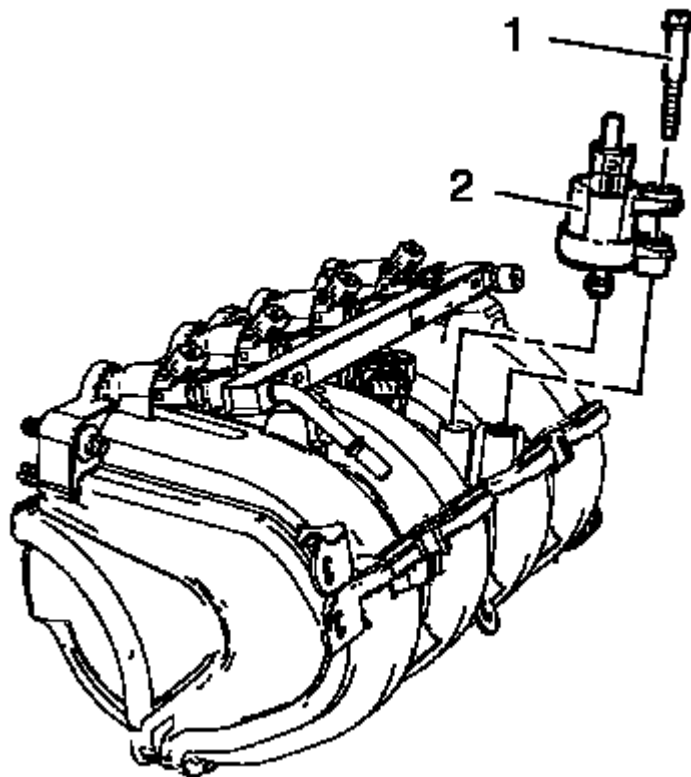


Fig. 222: Evaporative Emission Canister Purge Solenoid Valve And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove the evaporative emission canister purge solenoid valve bolt (1).
2. Remove the evaporative emission canister purge solenoid valve (2) from intake manifold.

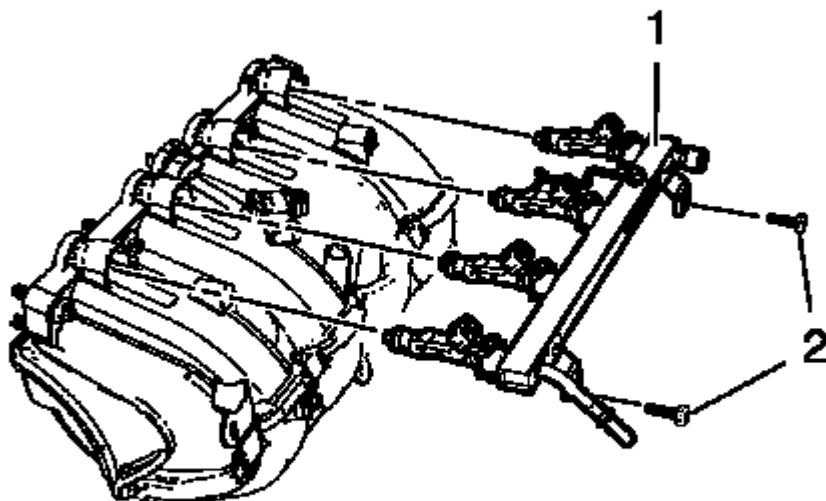


Fig. 223: Fuel Rail

Courtesy of GENERAL MOTORS COMPANY

3. Remove the 2 fuel rail bolts (2).
4. Remove the fuel rail (1).

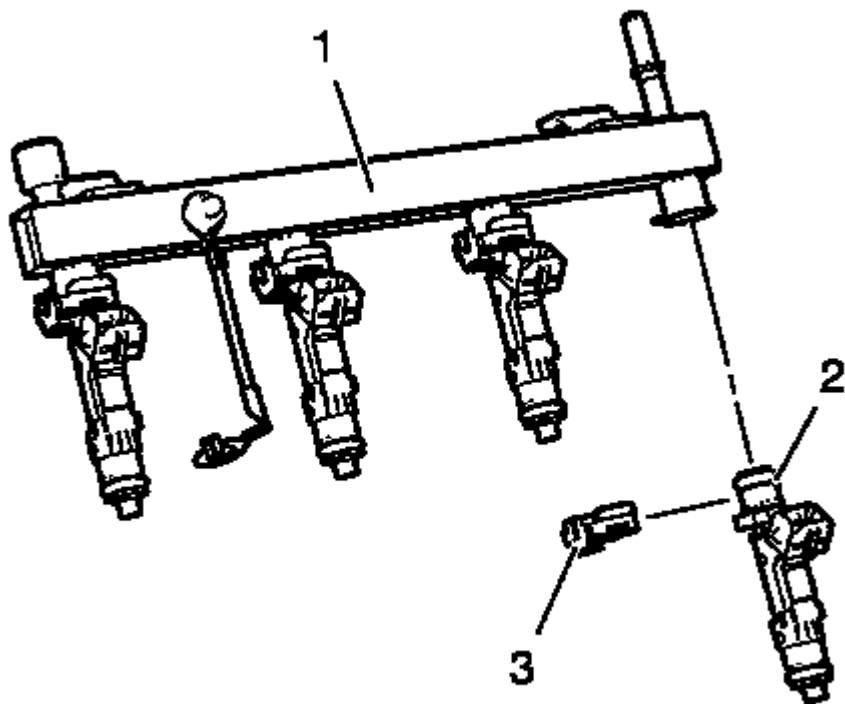


Fig. 224: Fuel Injector And Fuel Rail

Courtesy of GENERAL MOTORS COMPANY

5. Remove the fuel injector retainer clamp (3).
6. Separate the fuel injector (2) from fuel rail (1).

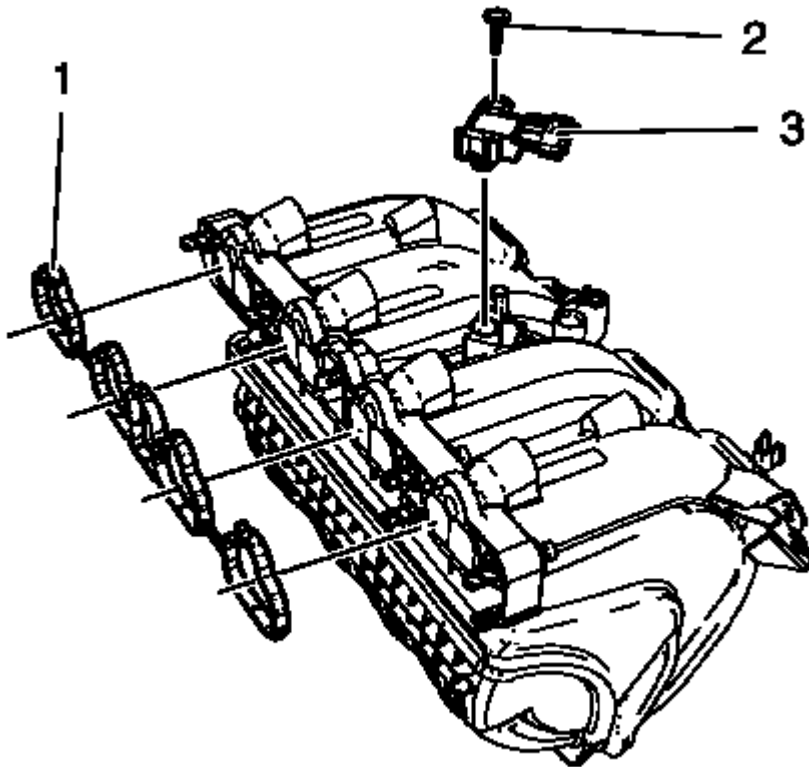


Fig. 225: Manifold Absolute Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

7. Remove the intake manifold gasket (1).
8. Remove the manifold absolute pressure sensor bolt (2).
9. Remove the manifold absolute pressure sensor (3).

INTAKE MANIFOLD CLEANING AND INSPECTION

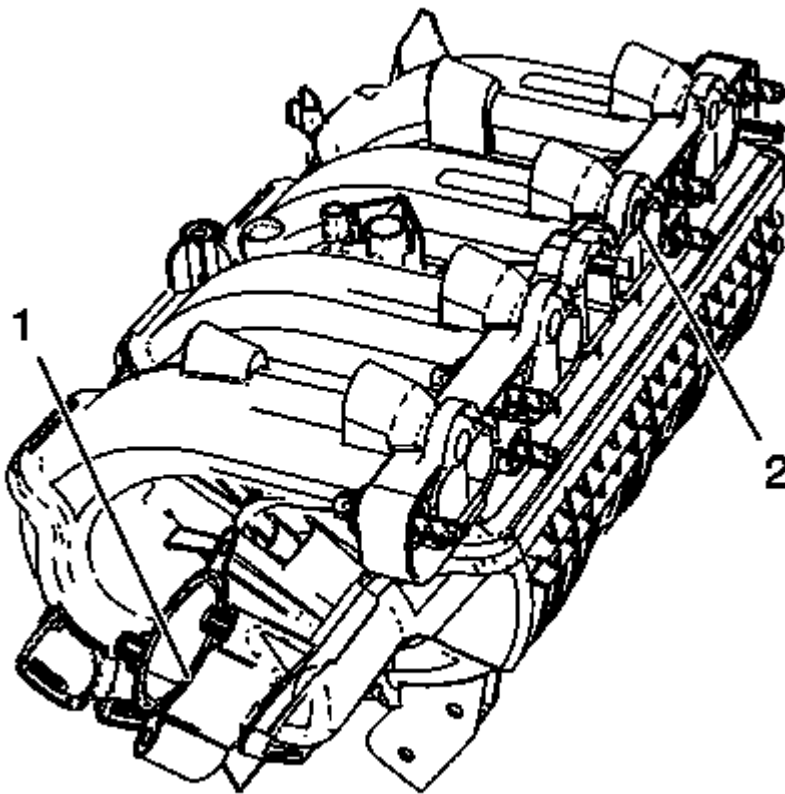


Fig. 226: Inspecting Intake Manifold

Courtesy of GENERAL MOTORS COMPANY

1. Clean the sealing surfaces (1, 2).
2. Inspect the intake manifold for cracks and fractures.

INTAKE MANIFOLD ASSEMBLE

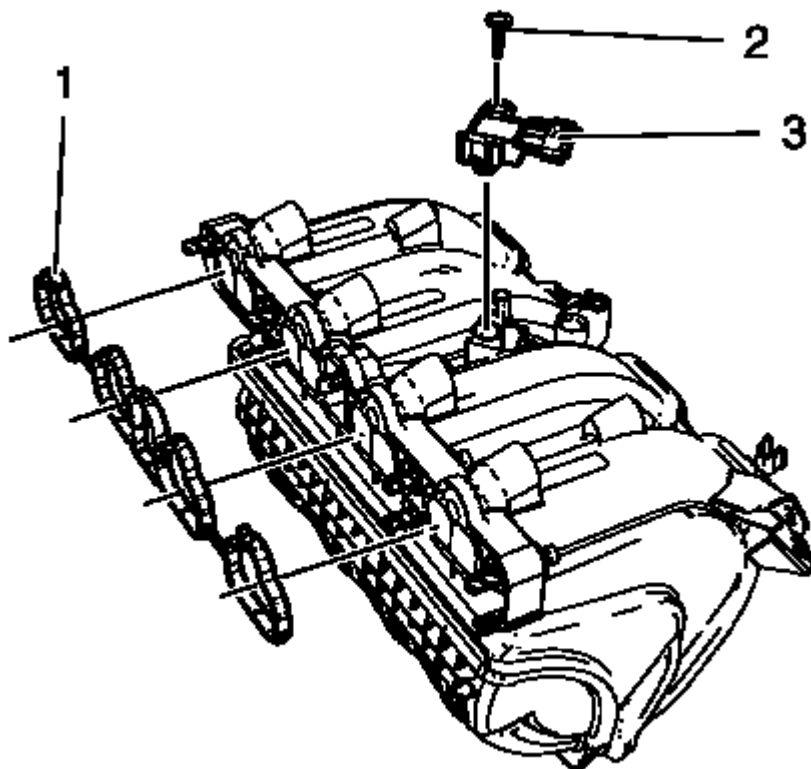


Fig. 227: Manifold Absolute Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW intake manifold gasket (1).
2. Install the manifold absolute pressure sensor (3).
3. Install the manifold absolute pressure sensor bolt (2) and tighten.

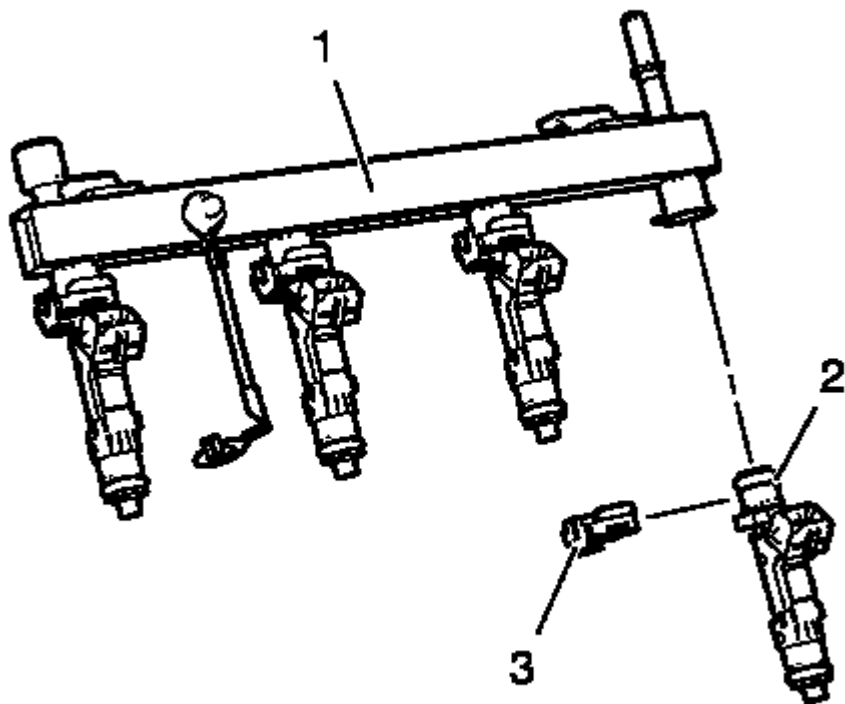


Fig. 228: Fuel Injector And Fuel Rail

Courtesy of GENERAL MOTORS COMPANY

4. Install the fuel injector (2) to fuel rail.
5. Install the fuel injector retainer clamp (3).

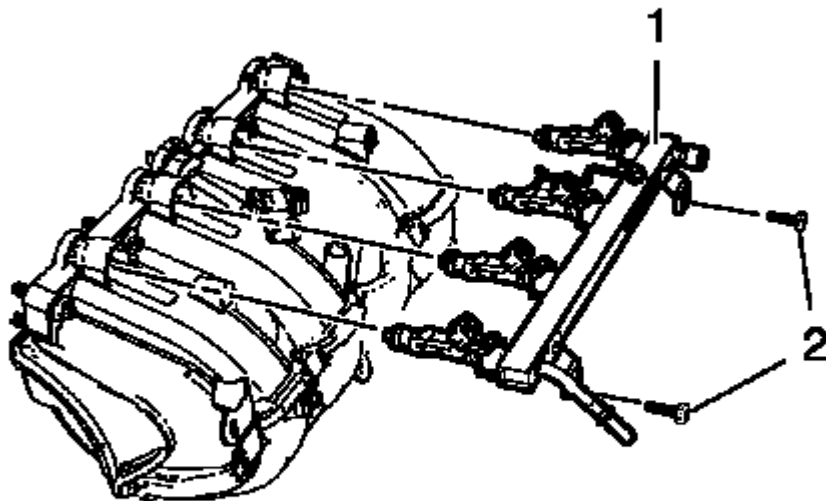


Fig. 229: Fuel Rail

Courtesy of GENERAL MOTORS COMPANY

6. Install the fuel rail (1).

CAUTION: Refer to Fastener Caution .

7. Install the 2 fuel rail bolts (2) and tighten to 7 N.m (62 lb in).

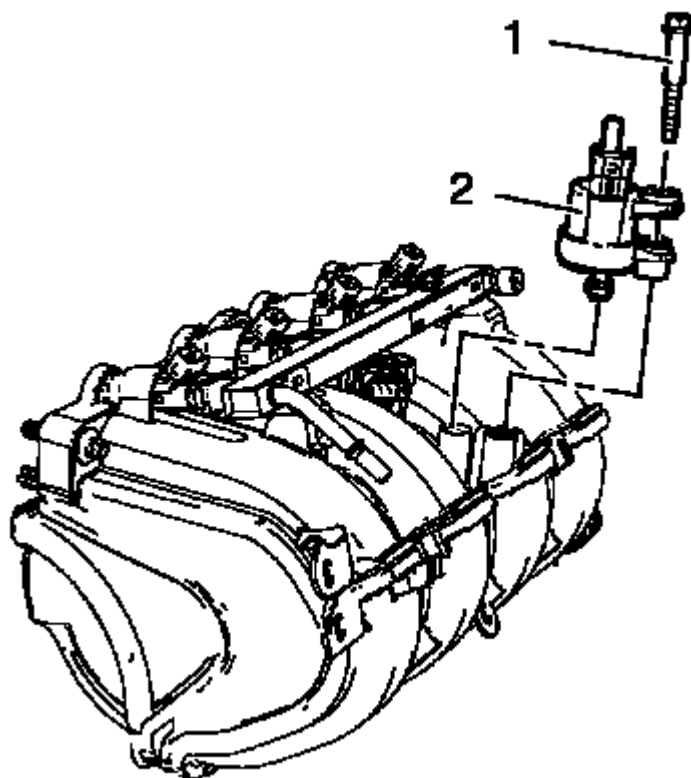


Fig. 230: Evaporative Emission Canister Purge Solenoid Valve And Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Install the evaporative emission canister purge solenoid valve (2) to the intake manifold.
9. Install the evaporative emission canister purge solenoid valve bolt (1) and tighten.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

- **EN-470-B** Angular Torque Wrench.
- **GE-571-B** Dial Gauge.

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

Crankshaft End Play, Check

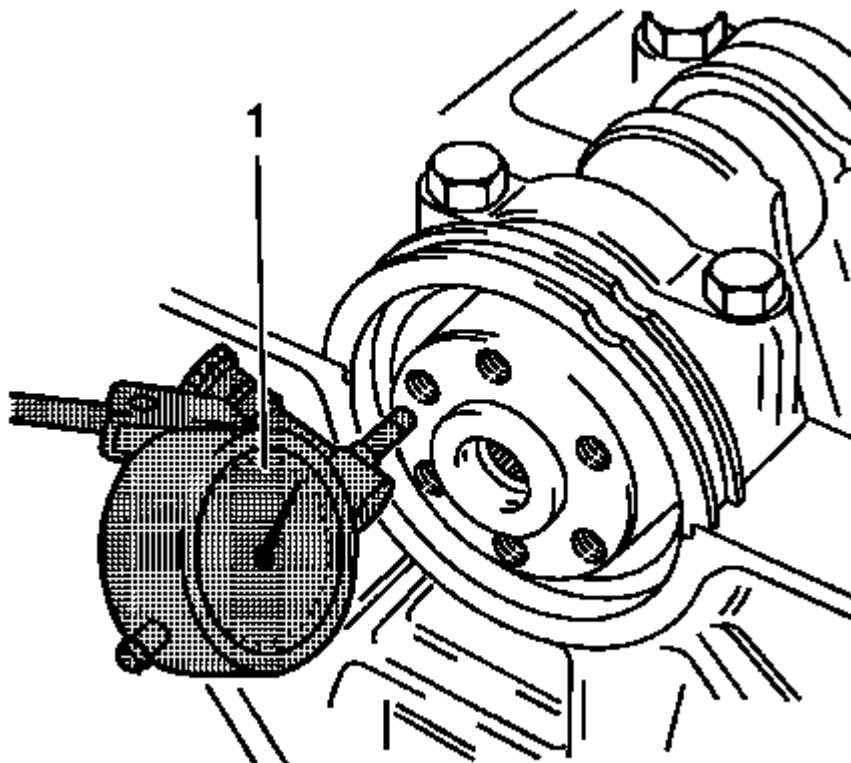


Fig. 231: Gauge Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: Crankshaft attached with crankshaft bearing caps.

1. Install the **GE-571-B** gauge (1).
 - Install the holder on the front of the engine block.
 - Place the dial gauge plunger against the crankshaft and adjust.
2. Measure the longitudinal play of the crankshaft.
 - Move the crankshaft in the longitudinal direction.
 - Permissible crankshaft end play 0.100-0.202 mm (0.0039-0.0080 in).
3. Remove the **GE-571-B** gauge.

Crankshaft Out-of-Round, Check

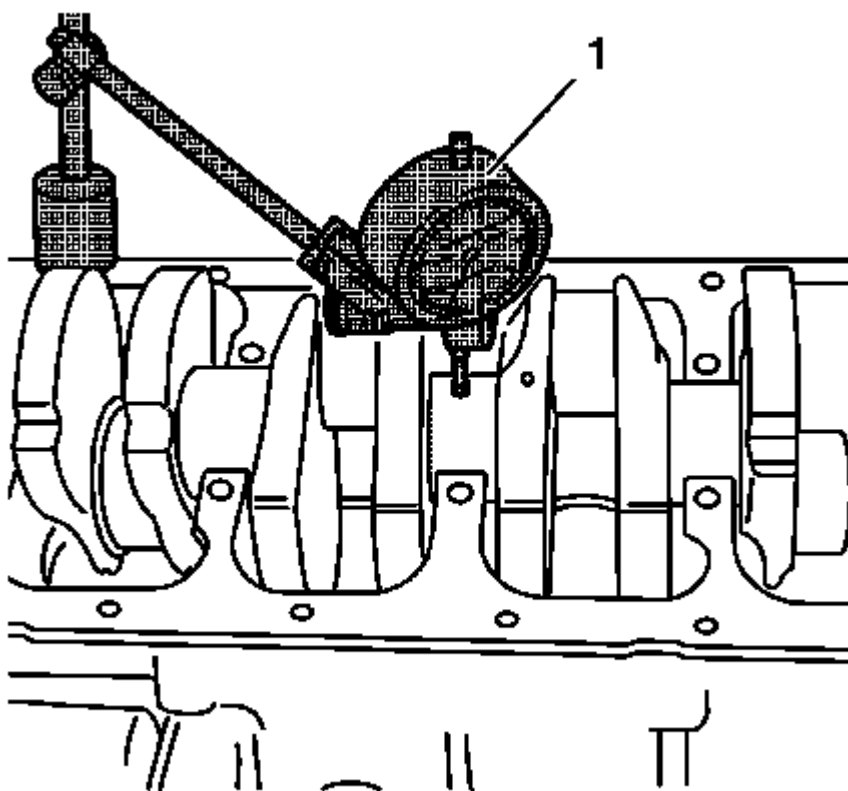


Fig. 232: Gauge Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: Crankshaft removed.

1. Insert the crankshaft in the engine block.
2. Install the **GE-571-B** gauge (1).
 - Attach holder to the engine block.
 - Place the dial gauge plunger against the crankshaft bearing journal and adjust.
3. Check the rotational play of the crankshaft.
 - Turn the crankshaft evenly.
 - Maximum permissible rotational play 0.03 mm (0.001 in).
4. Remove the **GE-571-B** gauge.

Check Crankshaft Bearing Clearance (With Plastigage)

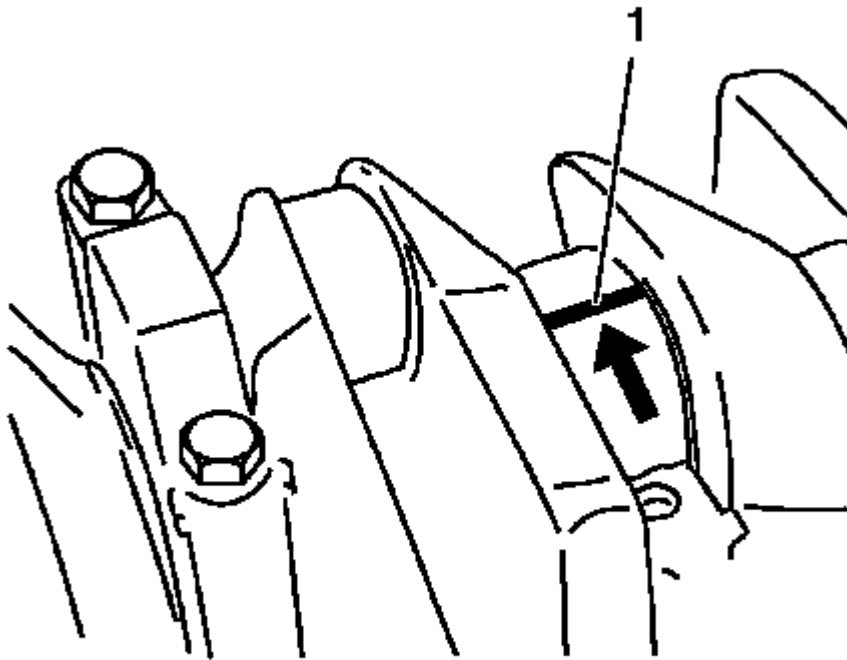


Fig. 233: Plastigage On Bearing Journal
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Crankshaft removed.**
- **Do not rotate the crankshaft.**

1. Lay out plastigage. Refer to electronic parts catalog to find the recommended plastigage.

Lay out plastigage (flexible plastic thread) around the entire width of the crankshaft bearing journal (1).

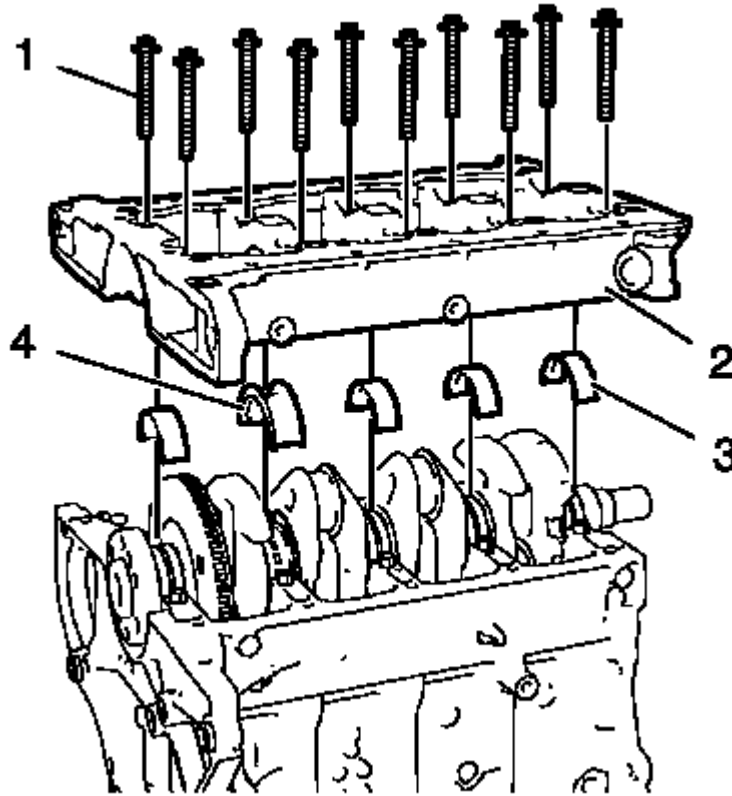


Fig. 234: Crankshaft Bearing Cap Tie Plate
Courtesy of GENERAL MOTORS COMPANY

NOTE: The bolts can be reused for checking the crankshaft bearing play.

2. Install the 4 lower crankshaft bearings (3) and the lower crankshaft thrust bearing (4).
3. Install the crankshaft bearing cap tie plate (2).
4. Install the 10 inner crankshaft bearing cap tie plate bolts (1).

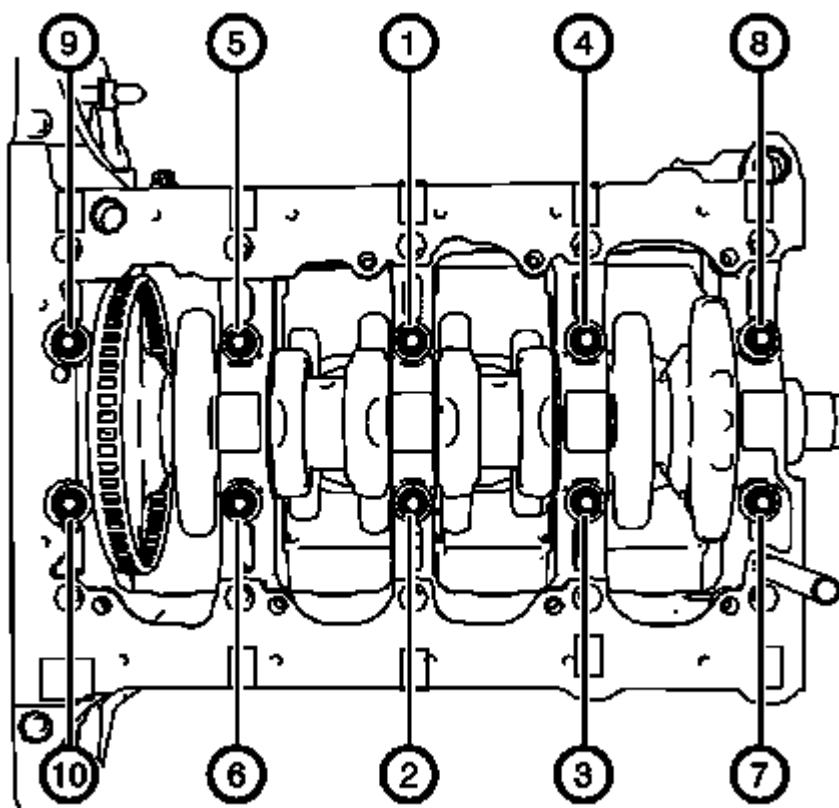


Fig. 235: Inner Crankshaft Bearing Cap Tie Plate Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

5. Tighten the 10 inner crankshaft bearing cap tie plate bolts in a sequence as shown and in the following order:
 1. Tighten the inner crankshaft bearing cap tie plate bolts to 25 N.m (18 lb ft).
 2. Tighten the inner crankshaft bearing cap tie plate bolts an additional 60°. Use **EN-470-B** wrench.
 3. Tighten the inner crankshaft bearing cap tie plate bolts an additional 15°. Use **EN-470-B** wrench.
6. Remove the crankshaft bearing cap tie plate bolts and the crankshaft bearing cap tie plate.

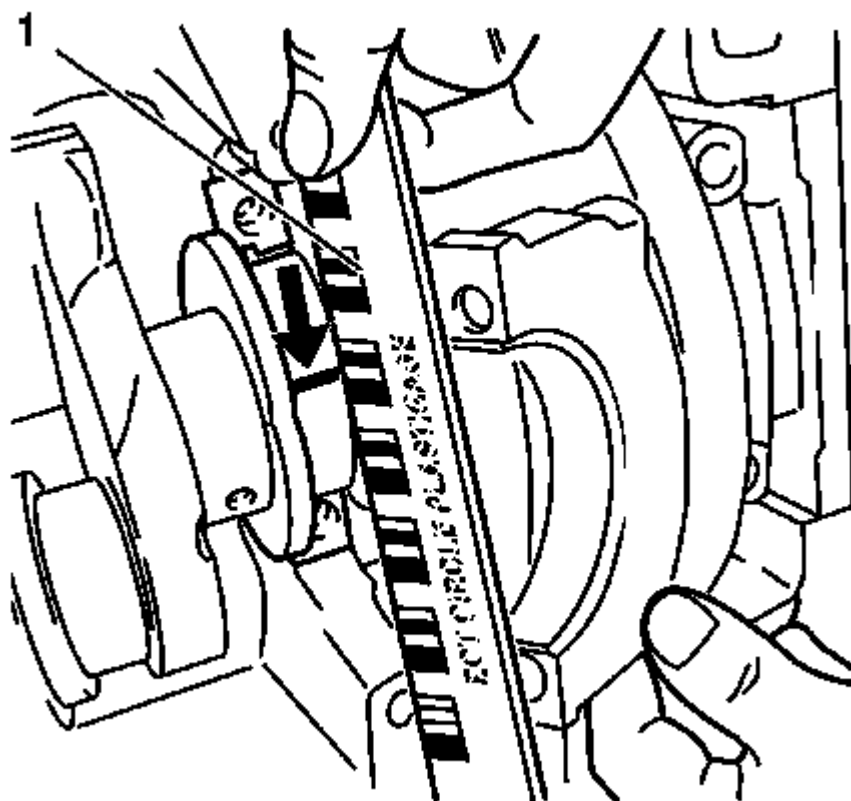


Fig. 236: Measuring Crankshaft Bearing Play Using Measuring Scale
Courtesy of GENERAL MOTORS COMPANY

NOTE: When reading the value, do not confuse millimeters and inches on the measuring scale.

7. Measure the crankshaft bearing play.
 - Compare the width of the flattened plastic thread (arrow) to the measuring scale (1).
 - The crankshaft bearing play should be 0.007-0.031 mm (0.00028-0.00122 in).

Check Crankshaft Bearing Clearance (With Micrometer Gauge Internal Measuring Device)

NOTE: The bolts can be reused for checking the crankshaft bearing play.

1. Install and tighten the crankshaft bearing cap tie plate and the crankshaft bearings as shown above.

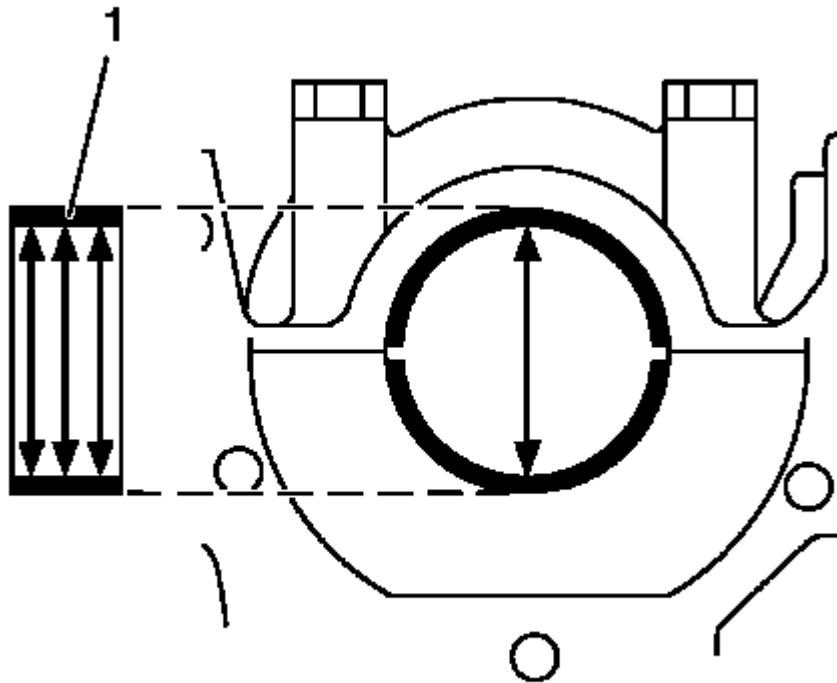


Fig. 237: Crankshaft Bearing Diameter Measuring Points
Courtesy of GENERAL MOTORS COMPANY

2. Measure the crankshaft bearing diameter at 3 points.

Measure in areas as shown (1) with an internal measuring device.

Calculate the average crankshaft bearing diameter.

Formula: 1. result + 2. result + 3. result / 3.

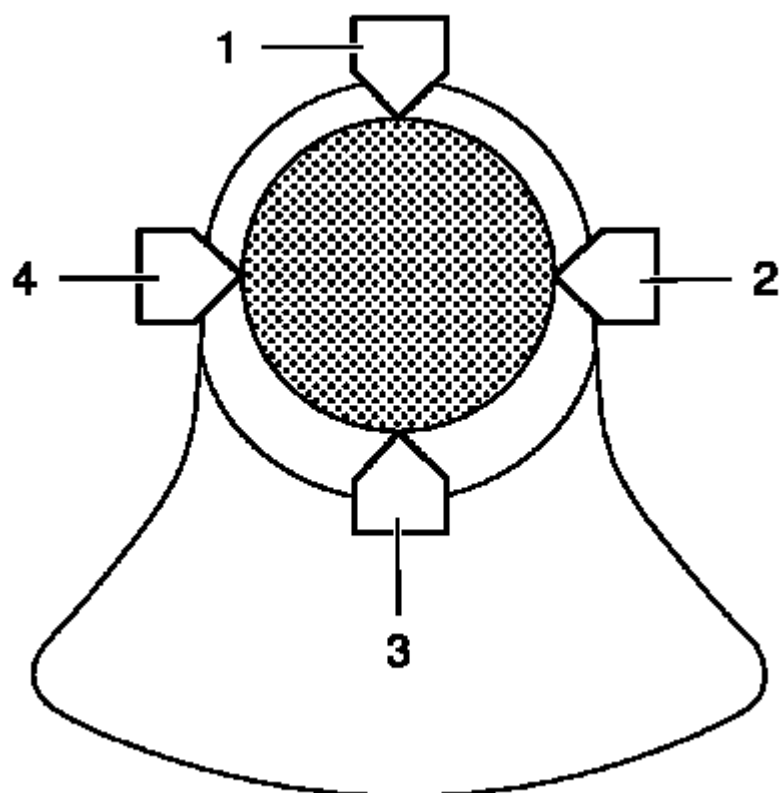


Fig. 238: Connecting Rod Journal Diameter Points
Courtesy of GENERAL MOTORS COMPANY

3. Measure the crankshaft bearing journal diameter at 2 points between (1) and (3) and between (2) and (4) with the micrometer gauge.
4. Calculate the average crankshaft bearing journal diameter.

Formula: 1. result + 2. result / 2.

5. Determine the crankshaft bearing play.

Calculation formula: average crankshaft bearing diameter minus average crankshaft bearing journal diameter.

6. The crankshaft bearing play should be 0.007-0.031 mm (0.00028-0.00122 in).

ENGINE FRONT COVER AND OIL PUMP CLEANING AND INSPECTION

Engine Front Cover Cleaning Procedure

1. Clean the engine front cover sealing surface.

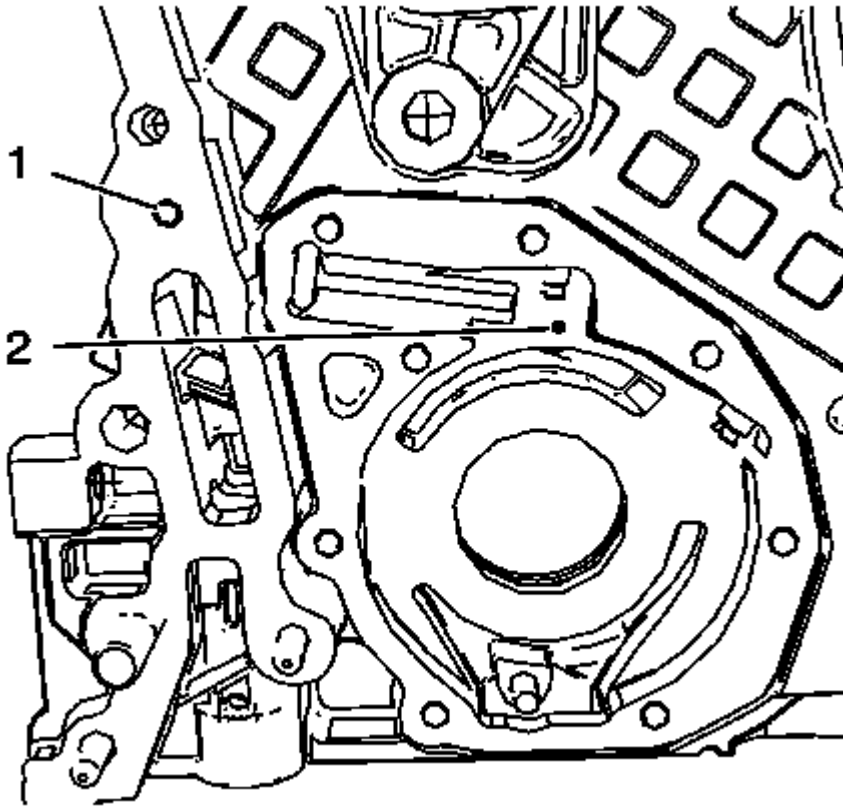


Fig. 239: Oil Gallery Bores

Courtesy of GENERAL MOTORS COMPANY

WARNING: Wear safety glasses when using compressed air in order to prevent eye injury.

CAUTION: To ensure proper engine lubrication, clean clogged or contaminated oil galleries in an approved solvent and with compressed air. Failure to clean oil galleries may cause engine damage.

2. Clean the shown oil gallery with solvent and compressed air. Blow compressed air from bore (2) to bore (1).

Engine Front Cover Visual Inspection

Inspect the engine front cover for cracks, scratches and damage.

Oil Pump Visual Inspection and Measurement

1. Inspect the oil pump cover and the engine front cover for flatness.
2. Inspect the oil pump vanes, the oil pump vane rotor, the oil pump vane rings and the oil pump slide for localized flatting.

3. Inspect the oil pump slide pivot pin for firm seat.

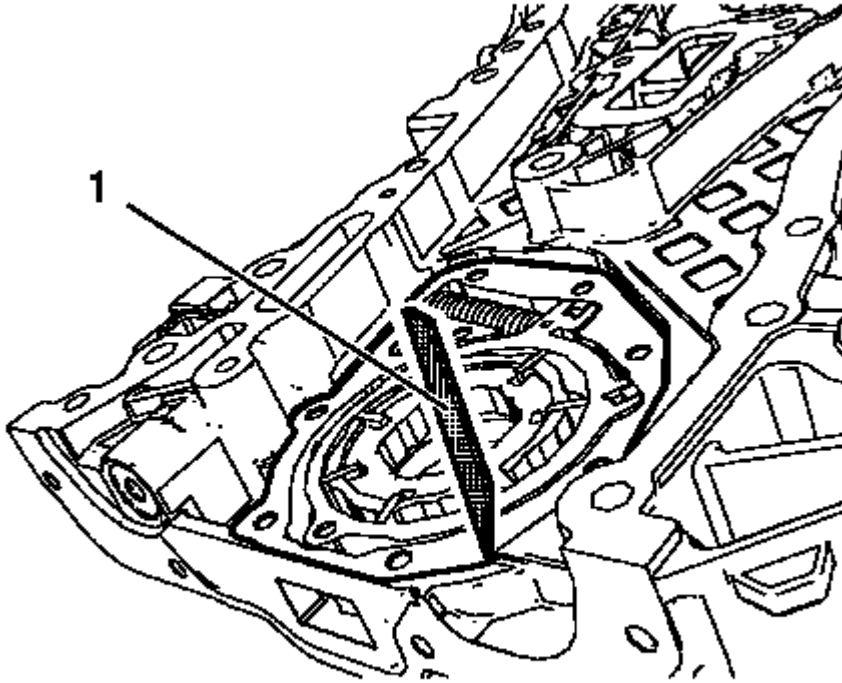


Fig. 240: Straight Edge Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: Oil pump components are installed.

4. Measure the oil pump axial clearances. Use a straight edge (1) and a feeler gauge.
 1. The maximal axial clearance between engine front cover and oil pump vane rotor should be 0.1 mm (0.004 in).
 2. The maximal axial clearance between engine front cover and oil pump vane should be 0.09 mm (0.0035 in).
 3. The maximal axial clearance between engine front cover and oil pump vane ring should be 0.4 mm (0.016 in).
 4. The maximal axial clearance between engine front cover and oil pump slide should be 0.08 mm (0.0031 in).
 5. The maximal axial clearance between engine front cover and oil pump slide seal should be 0.09 mm (0.0035 in).

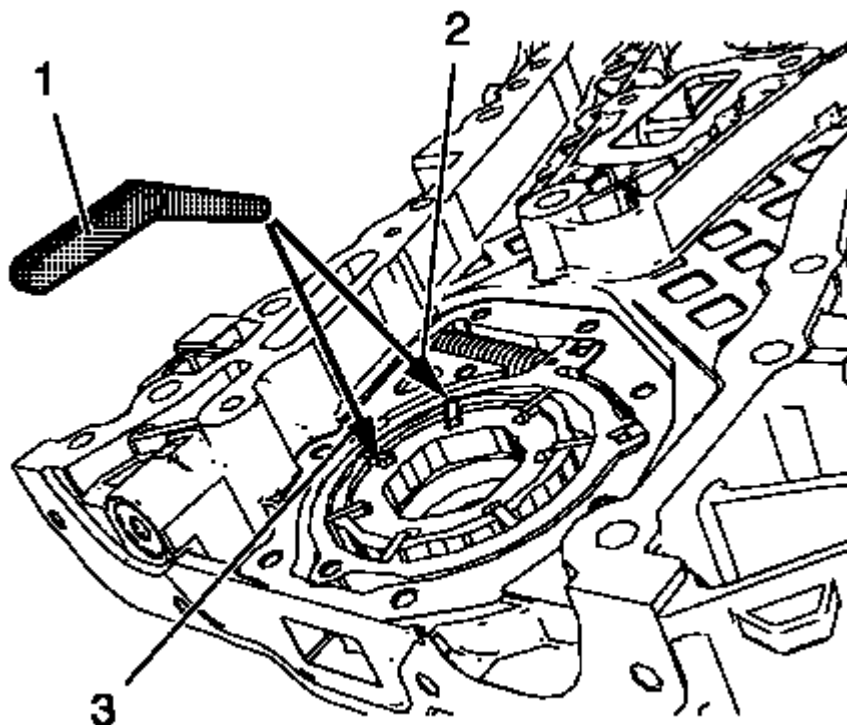


Fig. 241: Feeler Gauge, Oil Pump Slide And Oil Pump Vane
Courtesy of GENERAL MOTORS COMPANY

5. Measure the oil pump radial clearance. Use a feeler gauge (1). Measure the clearance between oil pump vane rotor and oil pump vane (3).

The maximal clearance should be 0.05 mm (0.002 in).

6. Measure the clearance between oil pump vane and oil pump slide (2).

The maximal clearance should be 0.2 mm (0.008 in).

ENGINE FRONT COVER AND OIL PUMP DISASSEMBLE

Engine Front Cover Disassemble

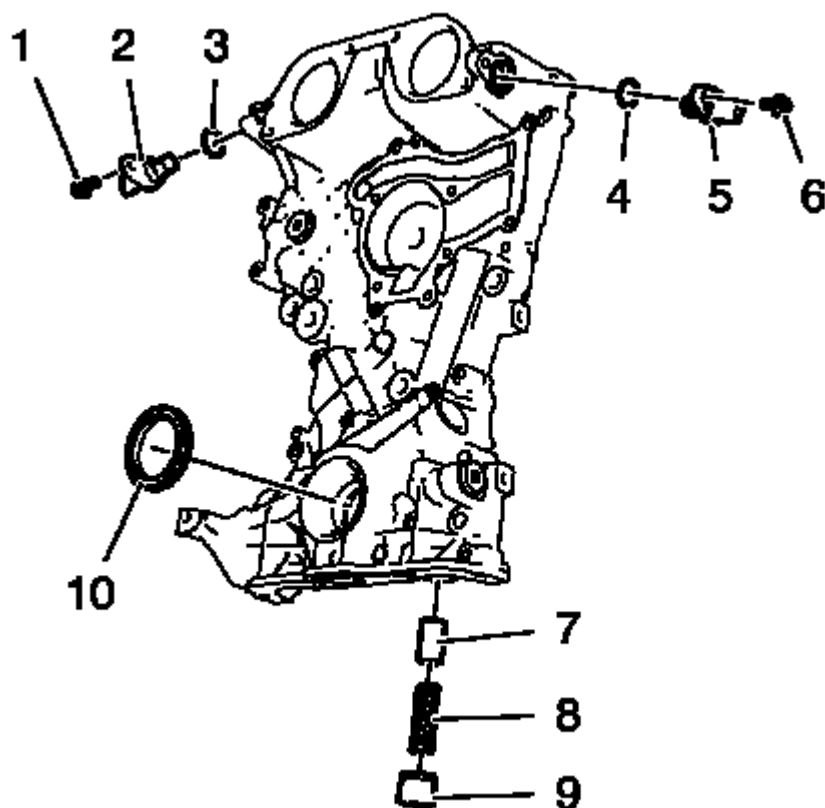


Fig. 242: Engine Front Cover Components

Courtesy of GENERAL MOTORS COMPANY

1. Remove the intake camshaft position sensor bolt (1).
2. Remove the intake camshaft position sensor (2) and the seal ring (3).
3. Remove the exhaust camshaft position sensor bolt (6).
4. Remove the exhaust camshaft position sensor (5) and the seal ring (4).
5. Remove the oil pressure relief valve (7, 8 and 9)
6. Remove the crankshaft front oil seal (10).

Oil Pump Removal

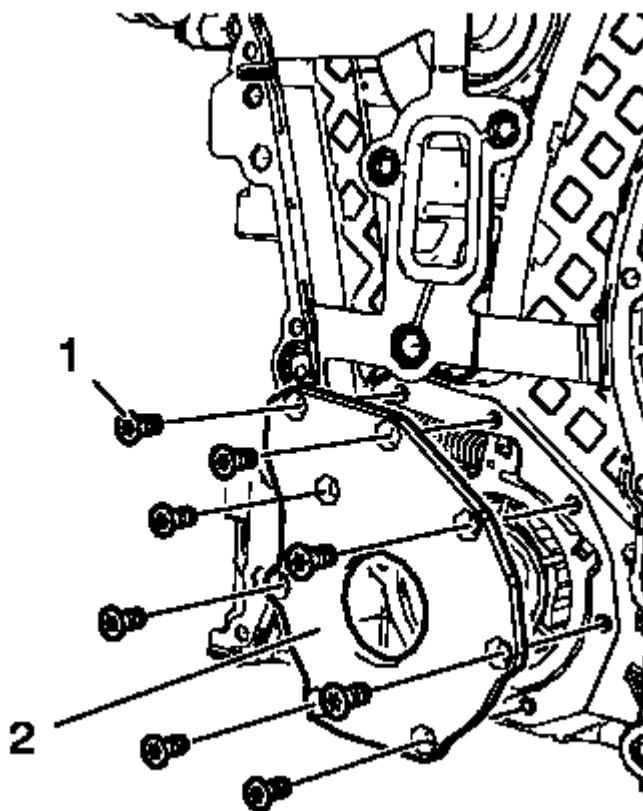


Fig. 243: Engine Oil Pump Cover And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the 8 oil pump cover bolts (1).
2. Remove the oil pump cover (2).

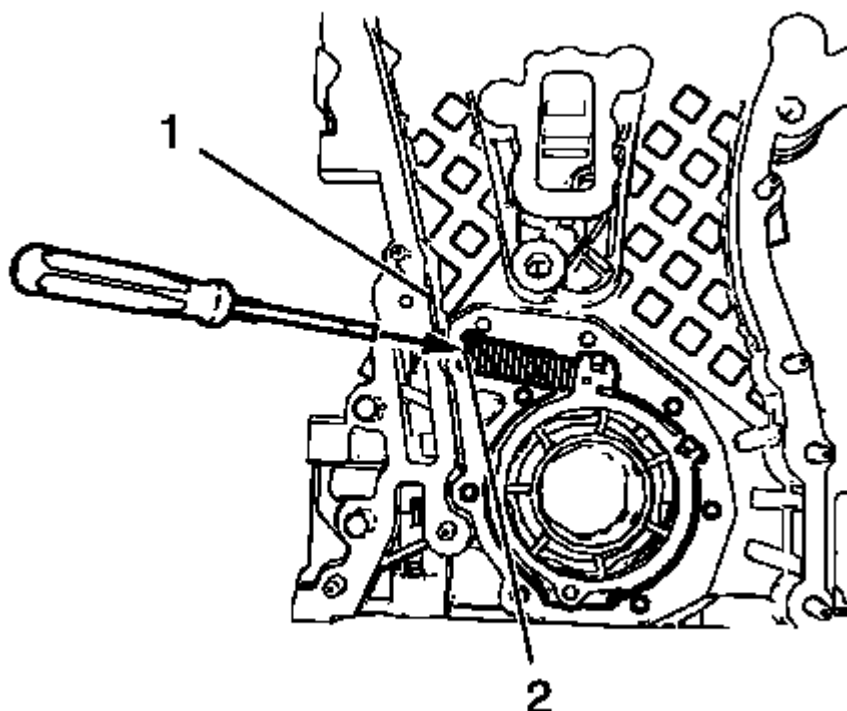


Fig. 244: Oil Pump Slide Spring Windings And Engine Front Cover Edge
Courtesy of GENERAL MOTORS COMPANY

WARNING: Before removing the spring, cover the spring with a towel to prevent the spring from flying and possibly causing damage or personal injury.

NOTE: Position a screw driver between the oil pump slide spring windings (2).

3. Protect the engine front cover edge (1) with a suitable piece of plastic.
4. Compress the oil pump slide spring with a screw driver and remove the oil pump slide spring along with the oil pump slide spring pin.

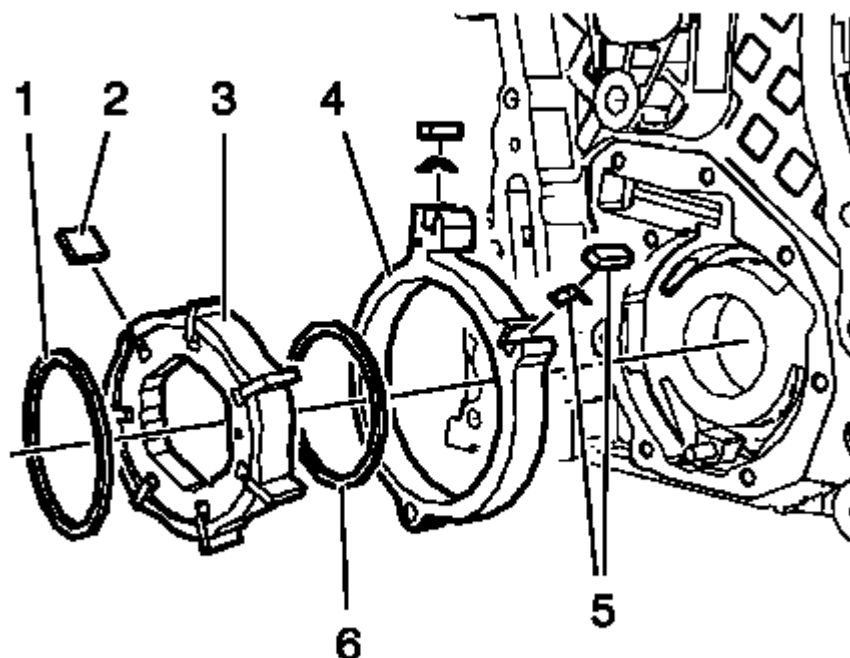


Fig. 245: Engine Oil Pump Components

Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the installation position of the oil pump components.

5. Remove the oil pump components in the following order:
 1. Outer oil pump vane ring (1).
 2. Oil pump vane rotor (3) and the 7 oil pump vanes (2).
 3. Inner oil pump vane ring (6).
 4. Oil pump slide (4) and the 2 oil pump slide seals with the 2 oil pump slide seal springs (5).

OIL PAN CLEANING AND INSPECTION

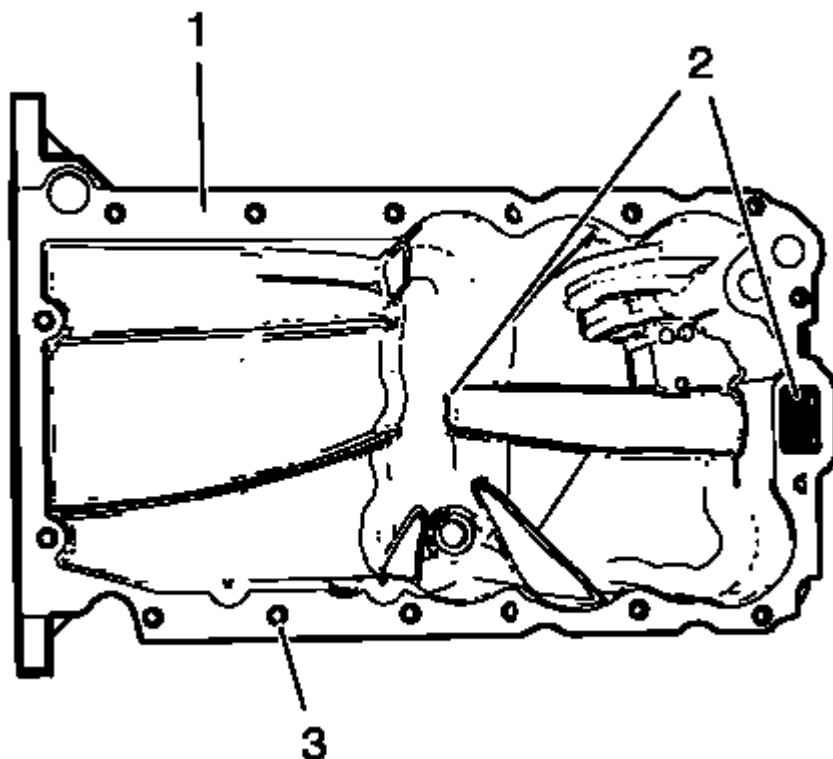


Fig. 246: Oil Pan Cleaning Areas

Courtesy of GENERAL MOTORS COMPANY

WARNING: Wear safety glasses when using compressed air in order to prevent eye injury.

CAUTION: To ensure proper engine lubrication, clean clogged or contaminated oil galleries in an approved solvent and with compressed air. Failure to clean oil galleries may cause engine damage.

1. Clean the oil suction gallery (2) with compressed air. Ensure that there are no remains of dirt or old gasket material.
2. Remove all remains of old gasket material from sealing surface (1) and screw bores (3).
3. Clean the sealing surfaces from dirt and grease.
4. Inspect the sealing surface for cracks and damage.

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

- **EN-470-B** Angular Torque Wrench.

- **EN-658-1** Installer from **EN-658** Kit.
- **EN-235-6** Installer from **EN-235-D** Kit.

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

1. Lubricate crankshaft, crankshaft bearings and crankshaft bearing cap tie plate with engine oil.

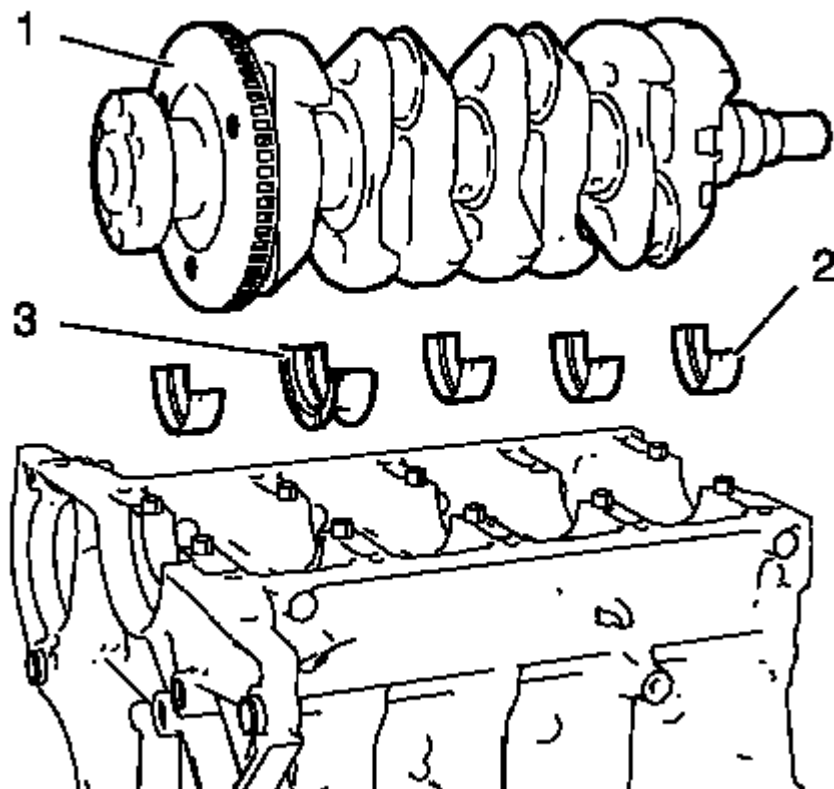


Fig. 247: Crankshaft, Upper Crankshaft Bearings And Upper Crankshaft Thrust Bearing
Courtesy of GENERAL MOTORS COMPANY

2. Install the 4 upper crankshaft bearings (2) and the crankshaft thrust bearing (3).
3. Install the crankshaft (1).

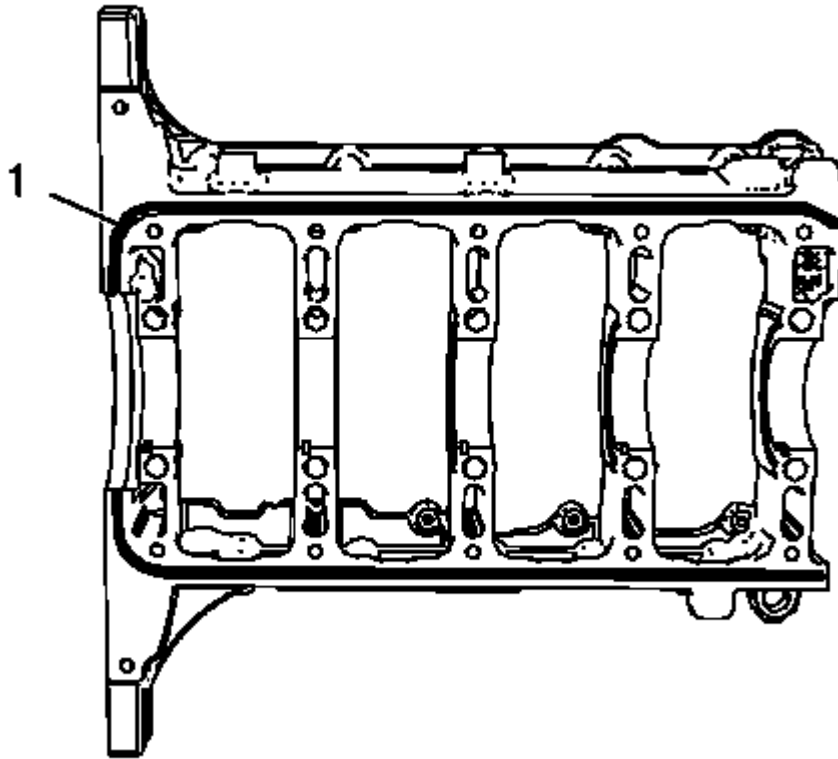


Fig. 248: Sealing Compound Application Area
Courtesy of GENERAL MOTORS COMPANY

NOTE: Refer to the electronic parts catalogue to find a suitable sealing compound.

4. Apply sealing compound (1) to the outer rim of the groove on the crankshaft bearing cap tie plate. The thickness of the sealing bead should be 2 mm (0.0787 in).

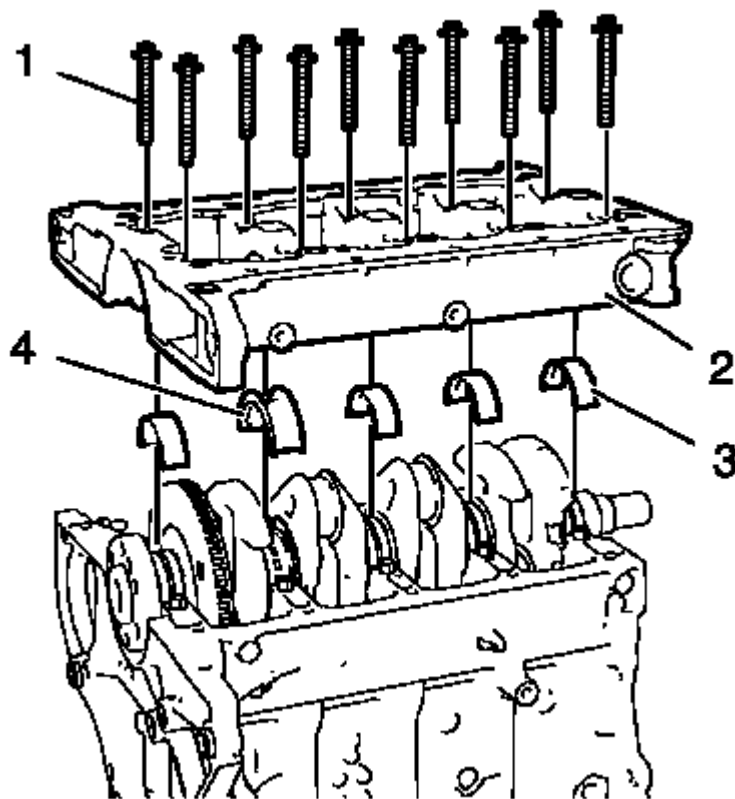


Fig. 249: Crankshaft Bearing Cap Tie Plate
Courtesy of GENERAL MOTORS COMPANY

NOTE: The complete installation procedure should be done in 10 minutes.

5. Install the 4 lower crankshaft bearings (3) and the lower crankshaft thrust bearing (4).
6. Install the crankshaft bearing cap tie plate (2).

NOTE: Do not reuse the old bolts.

7. Install the 10 inner crankshaft bearing cap tie plate bolts (1).

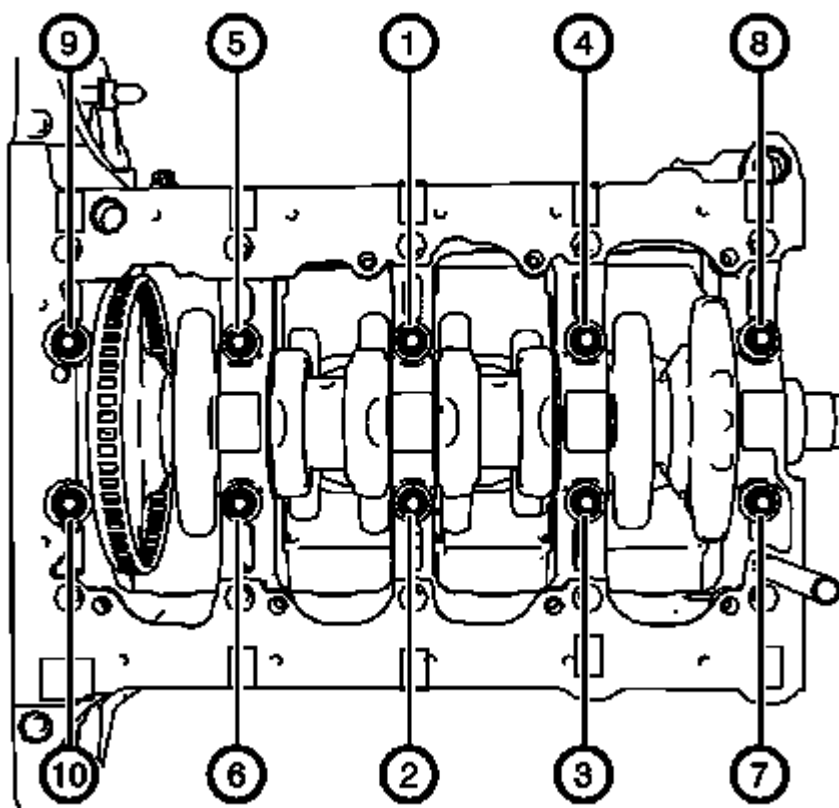


Fig. 250: Inner Crankshaft Bearing Cap Tie Plate Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

8. Tighten the 10 NEW inner crankshaft bearing cap tie plate bolts in a sequence as shown and in the following order:
 1. Tighten the inner crankshaft bearing cap tie plate bolts to 25 N.m (18 lb ft).
 2. Tighten the inner crankshaft bearing cap tie plate bolts an additional 60°. Use **EN-470-B** wrench.
 3. Tighten the inner crankshaft bearing cap tie plate bolts an additional 15°. Use **EN-470-B** wrench.

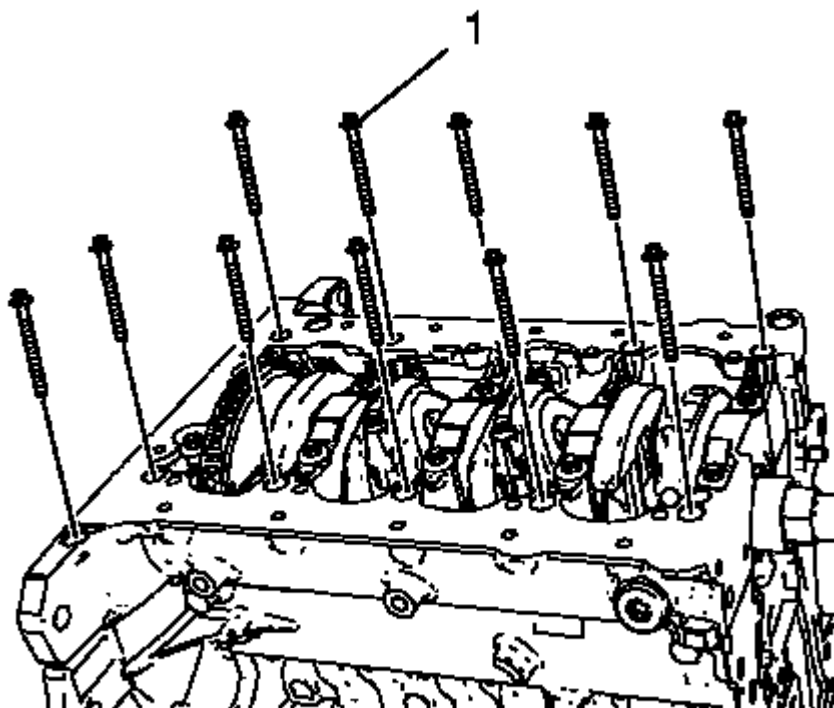


Fig. 251: Outer Crankshaft Bearing Cap Tie Plate Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not reuse the old bolts.

9. Install the 12 NEW outer crankshaft bearing cap tie plate bolts (1) and tighten in the following order:
 1. Tighten the outer crankshaft bearing cap tie plate bolts to 10 N.m (89 lb in).
 2. Tighten the outer crankshaft bearing cap tie plate bolts an additional 60°. Use **EN-470-B** wrench.
 3. Tighten the outer crankshaft bearing cap tie plate bolts an additional 15°. Use **EN-470-B** wrench.

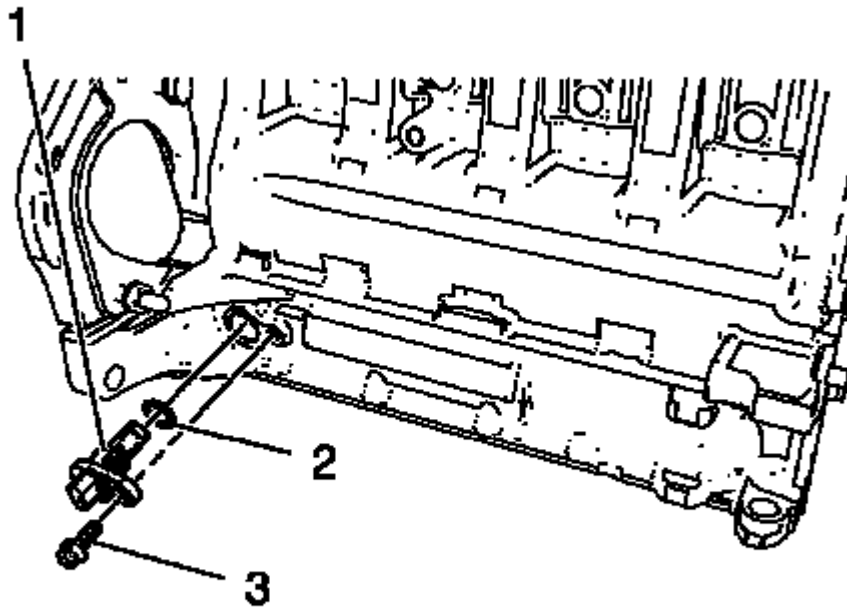


Fig. 252: Crankshaft Position Sensor, Bolt And Seal Ring
Courtesy of GENERAL MOTORS COMPANY

10. Install the crankshaft position sensor (1) and a NEW crankshaft position sensor seal ring (2).
11. Install the crankshaft position sensor bolt (3) and tighten to 8 N.m (71 lb in).

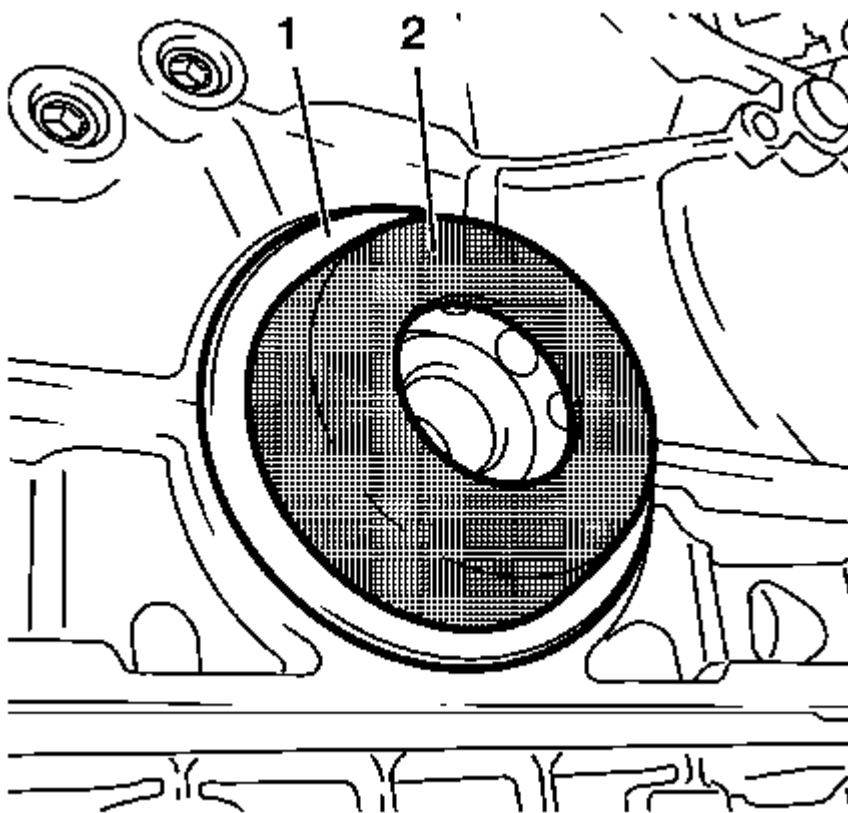


Fig. 253: Crankshaft Rear Oil Seal And Installer
Courtesy of GENERAL MOTORS COMPANY

NOTE: Lubricate the crankshaft rear oil seal.

12. Install the crankshaft rear oil seal (1) with **EN-235-6** installer (2).

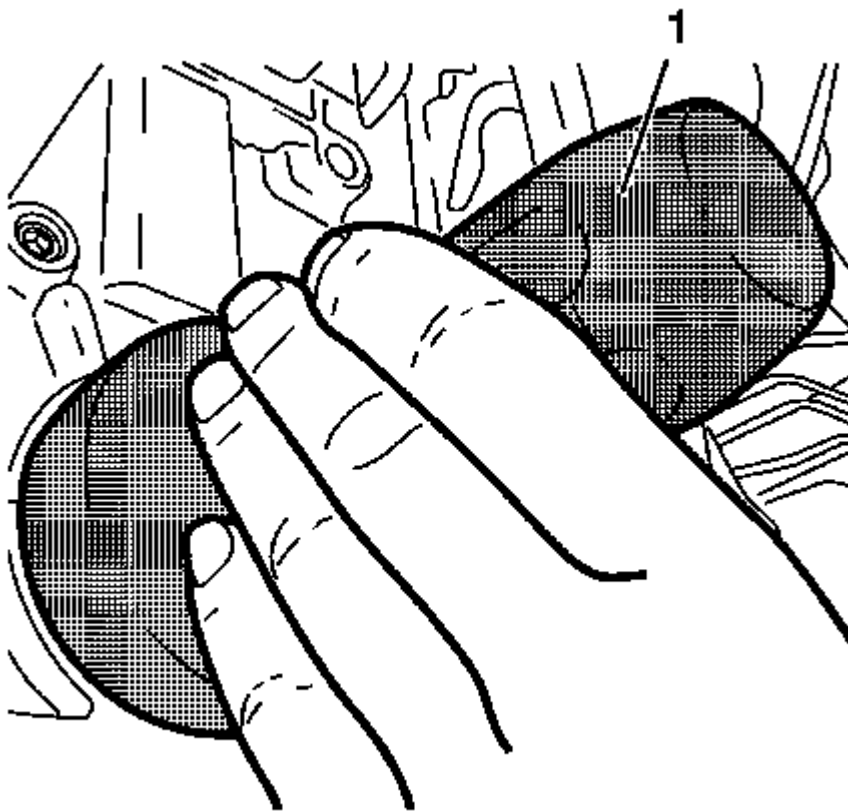


Fig. 254: Installer Tool

Courtesy of GENERAL MOTORS COMPANY

13. Use EN-658-1 installer (1) to strike the crankshaft rear oil seal.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Special Tools

EN-470-B Angular Torque Wrench.

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

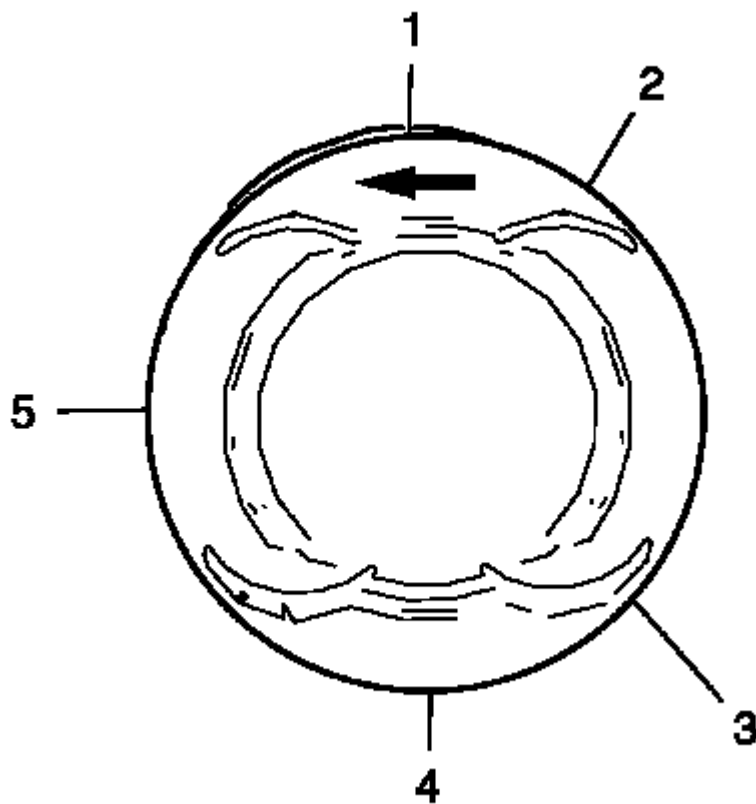


Fig. 255: Piston Ring Joint Adjustment Points
Courtesy of GENERAL MOTORS COMPANY

1. Adjust the piston ring joints as followed:
 1. Upper compression ring (1).
 2. Lower compression ring (4).
 3. Oil rings (2) or (3).
 4. Oil ring spacer (5).

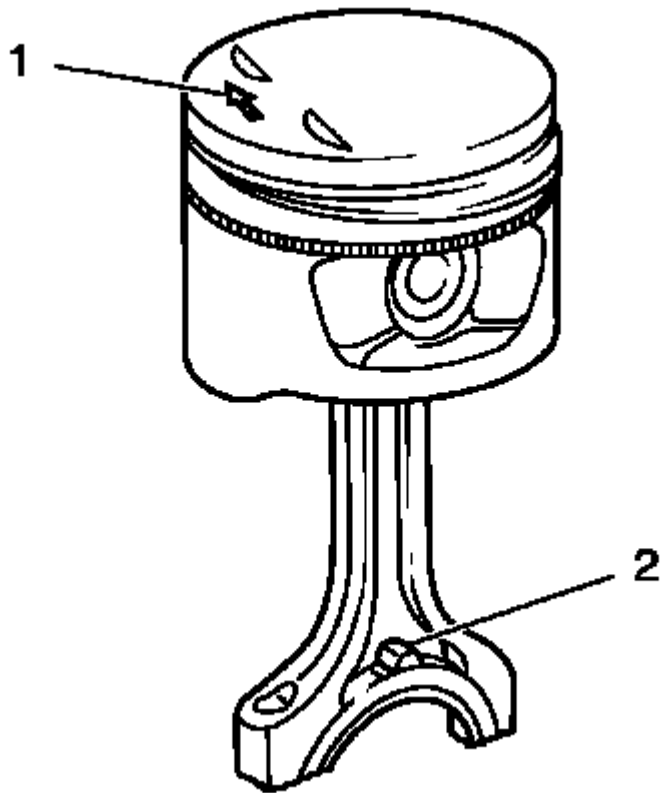


Fig. 256: Connecting Rods And Arrow On Piston Head
Courtesy of GENERAL MOTORS COMPANY

2. The arrow (1) on the piston head must point to the timing side.
3. The markings on the connecting rods (2) must point to the transmission side.

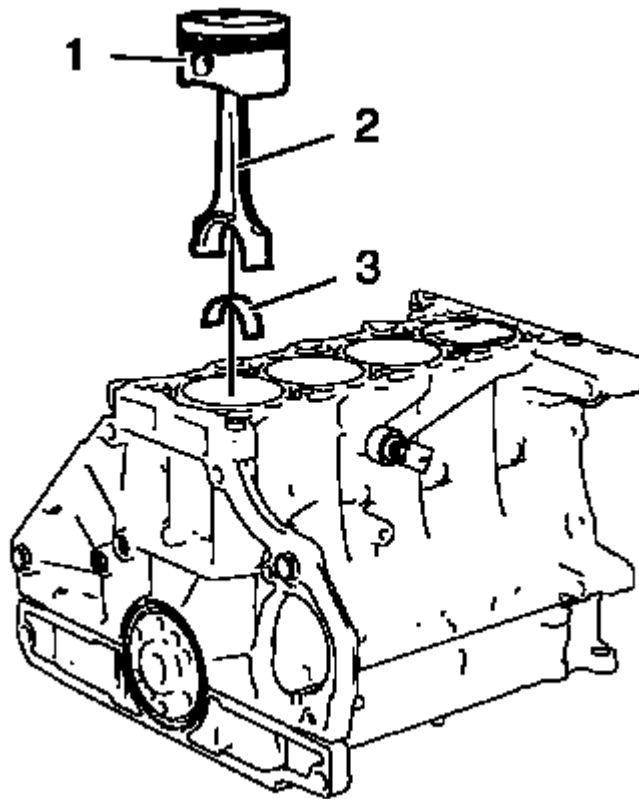


Fig. 257: Pistons, Connecting Rods And Bearings
Courtesy of GENERAL MOTORS COMPANY

4. Install a suitable piston ring compressor tool in order to compress the piston rings.
5. Install the pistons (1) in compound with connecting rods (2) and upper connecting rod bearings (3) to the engine block and to the crankshaft.

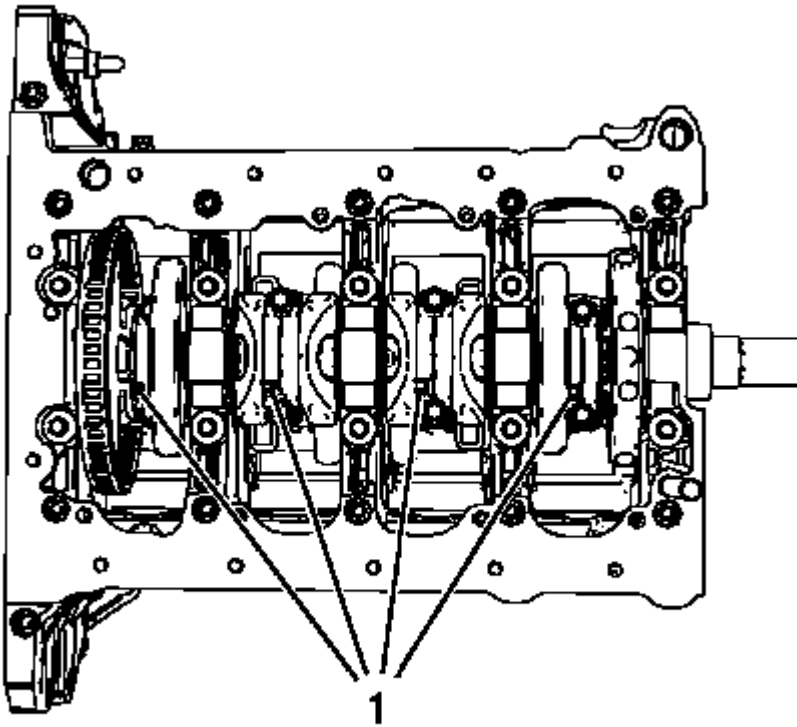


Fig. 258: Ensuring Connecting Rod Bearing Caps Point To Transmission Side
Courtesy of GENERAL MOTORS COMPANY

NOTE: The connecting rod bearing caps must be installed in their original position.

6. Verify that the flarings (1) on the connecting rod bearing caps point to the transmission side.

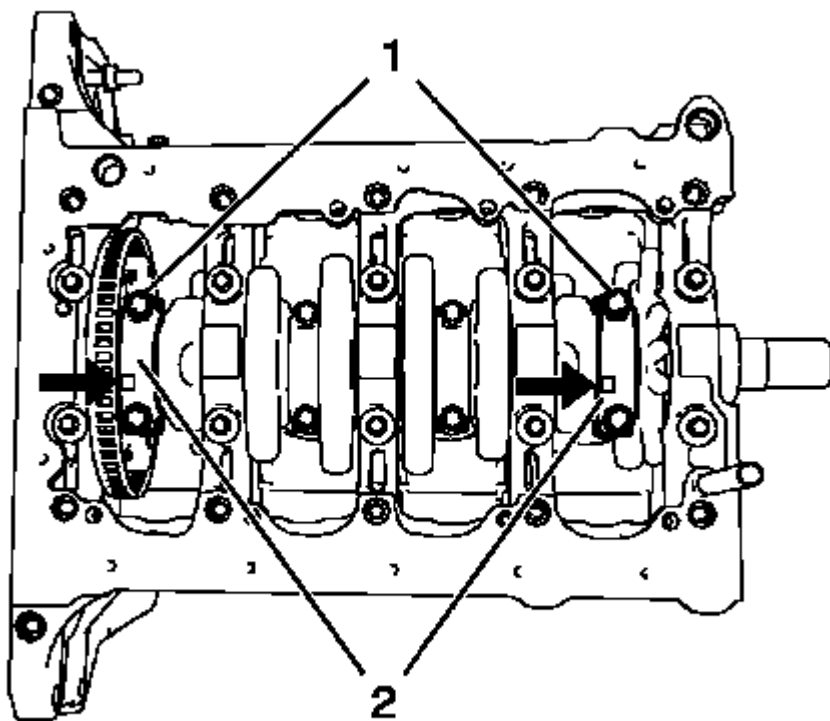


Fig. 259: Connecting Rod Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Install the 2 connecting rod bearings and the 2 connecting rod bearing caps (2) of cylinder 1 and 4.

CAUTION: Refer to Fastener Caution .

NOTE: Do not reuse the old bolts.

8. Install the 4 NEW connecting rod bearing cap bolts (1) and tighten in the following sequence:
 1. Tighten the connecting rod bearing cap bolts to 25 N.m (18 lb ft).
 2. Tighten the connecting rod bearing cap bolts an additional 45°. Use **EN-470-B** wrench.
9. Rotate the crankshaft 180°.

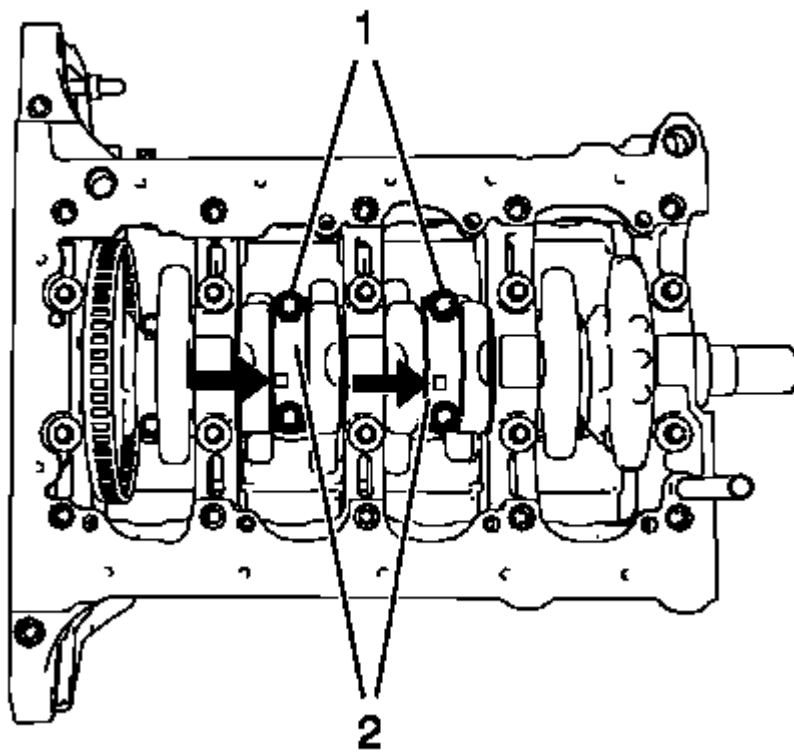


Fig. 260: Connecting Rod Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Install the 2 connecting rod bearings and the 2 connecting rod bearing caps (2) of cylinder 3 and 2.

NOTE: Do not reuse the old bolts.

11. Install the 4 connecting rod bearing cap bolts (1) and tighten in the following sequence:
 1. Tighten the connecting rod bearing cap bolts to 25 N.m (18 lb ft).
 2. Tighten the connecting rod bearing cap bolts an additional 45°. Use **EN-470-B** wrench.

CYLINDER HEAD INSTALLATION

Special Tools

EN-470-B Angular Torque Wrench.

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

WARNING: Wear safety glasses when using compressed air in order to prevent eye injury.

1. Clean the sealing surfaces and remove all remains of dirt and old gasket material from thread bores, water galleries and oil galleries.

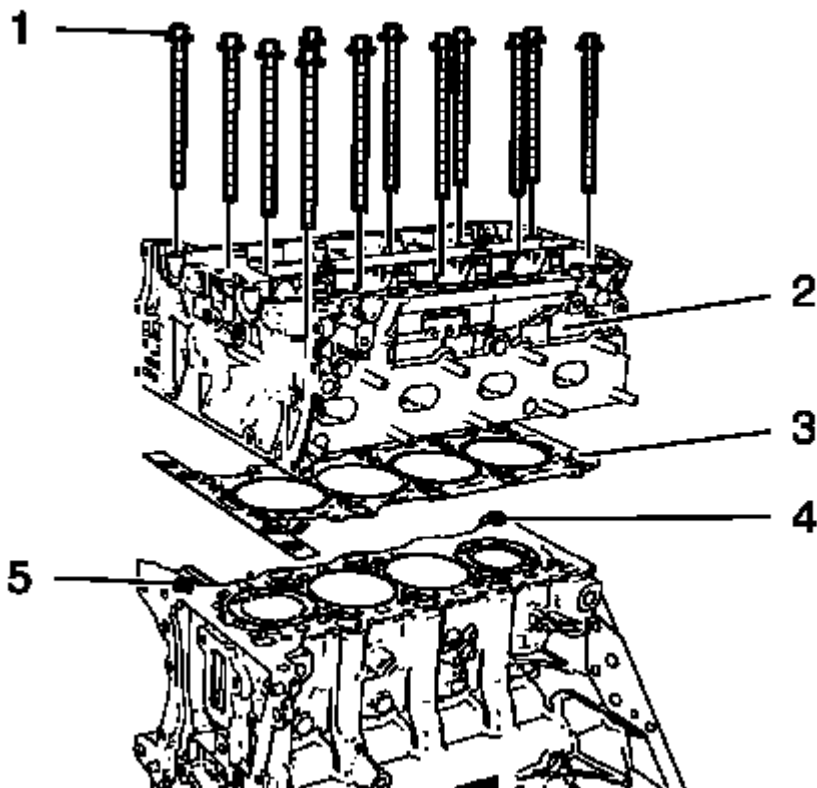
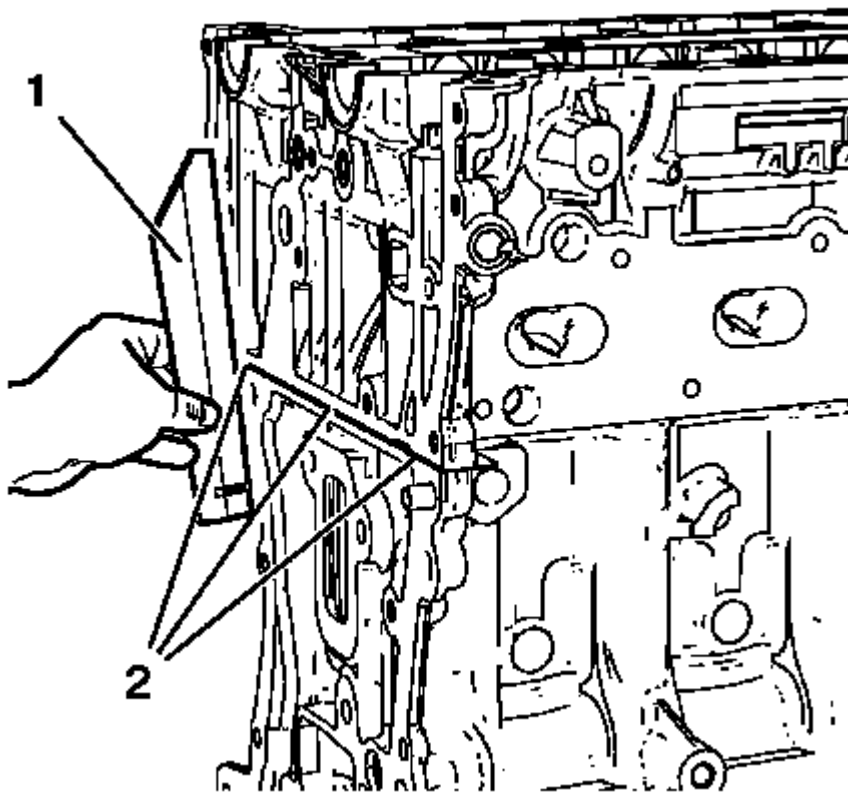


Fig. 261: Cylinder Head, Gasket, Bolts And Guide Sleeves
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the guide sleeves (4) and (5).

2. Install a NEW cylinder head gasket (3). The marking "Top" should point to the cylinder head.
3. Install the cylinder head (2).
4. Install the 12 cylinder head bolts (1) and handtighten.

**Fig. 262: Straight Edge Tool****Courtesy of GENERAL MOTORS COMPANY**

5. Lay on a straight edge (1) to engine block and cylinder head and adjust the transition in area (2) until there is no clearance between cylinder head and straight edge. Use a rubber mallet.

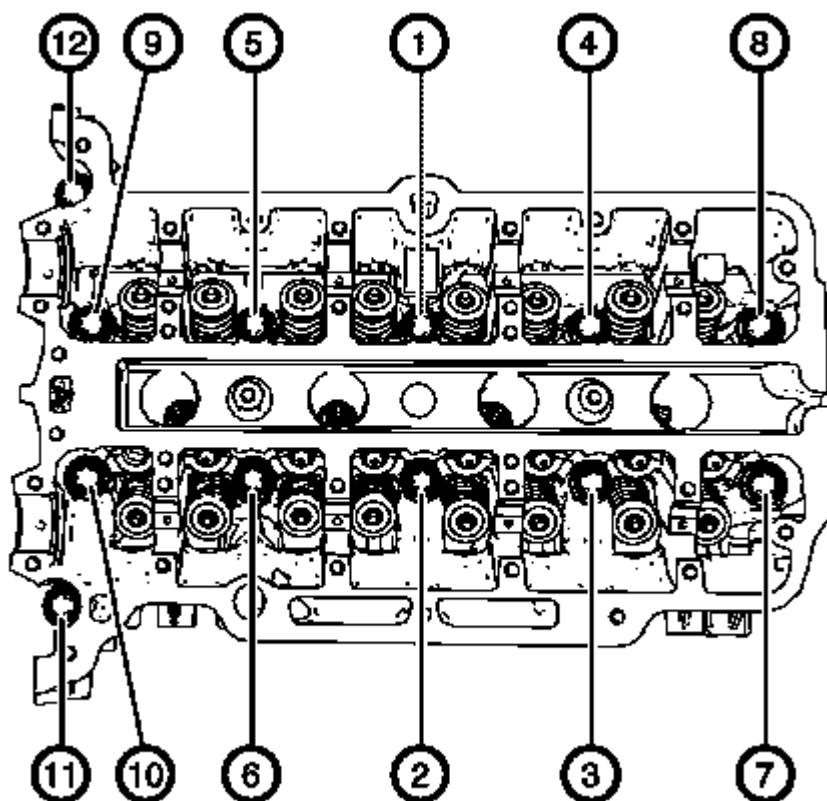


Fig. 263: Cylinder Head Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

6. Tighten the cylinder head bolts in the sequence as shown and in the following order:
 1. Tighten the cylinder head bolts to 35 N.m (26 lb ft).
 2. Tighten the cylinder head bolts an additional 180°. Use **EN-470-B** wrench.

HYDRAULIC VALVE LASH ADJUSTER INSTALLATION

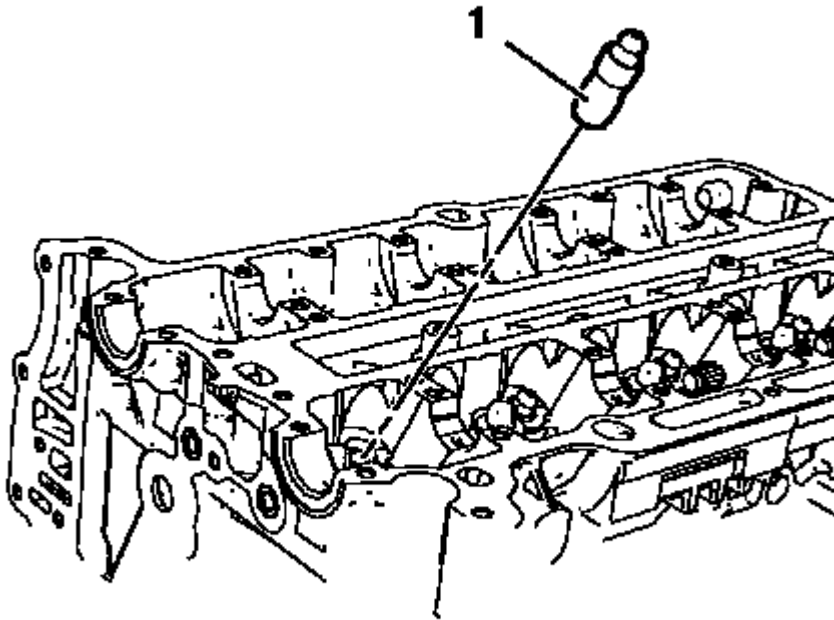


Fig. 264: Hydraulic Valve Lash Adjusters
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the installation position of the hydraulic valve lash adjusters.

1. Lubricate the hydraulic valve lash adjusters with engine oil.
2. Install the 16 hydraulic valve lash adjusters (1).

HYDRAULIC VALVE LASH ADJUSTER ARM INSTALLATION

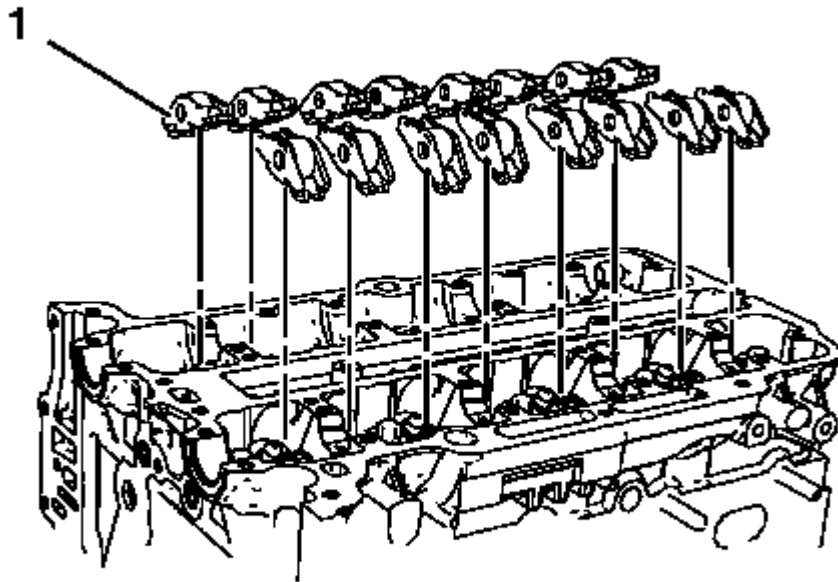


Fig. 265: Hydraulic Valve Lash Adjuster Arms
Courtesy of GENERAL MOTORS COMPANY

NOTE: Hydraulic valve lash adjuster arms should be installed in their original position.

1. Lubricate the hydraulic valve lash adjuster arms with engine oil.
2. Install the 16 hydraulic valve lash adjuster arms (1).

INTAKE CAMSHAFT INSTALLATION

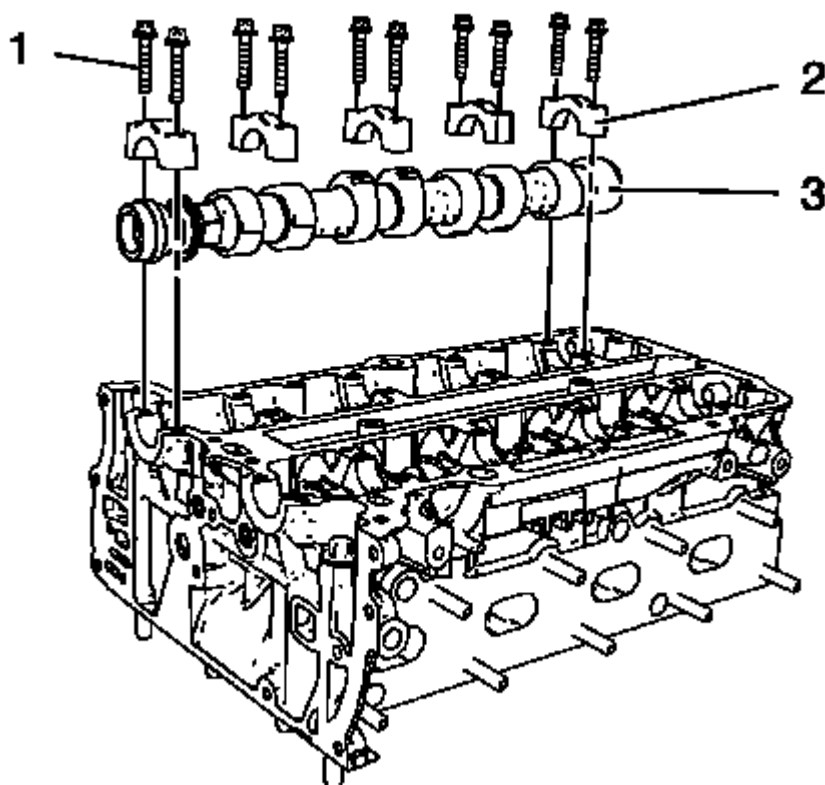


Fig. 266: Intake Camshaft, Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the markings on the camshaft bearing caps. Camshaft bearing caps should be installed in their original position.

1. Lubricate camshaft and camshaft bearing caps with engine oil.
2. Install the intake camshaft (3).
3. Install the 5 camshaft bearing caps (2).
4. Install the 10 camshaft bearing cap bolts (1) and handtighten.

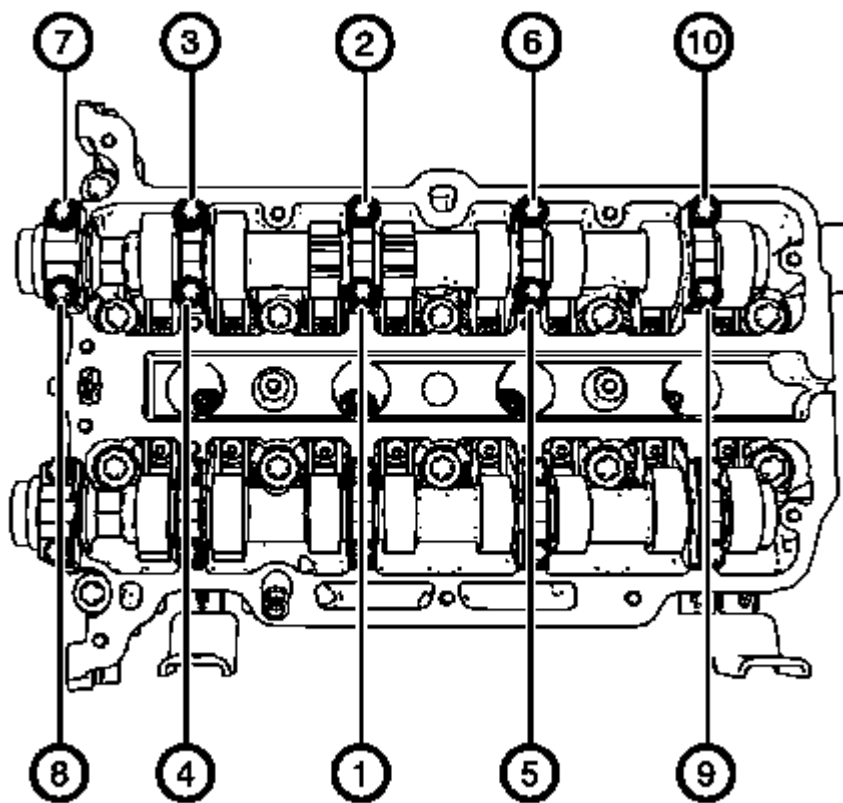


Fig. 267: Intake Camshaft Bearing Cap Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

NOTE: Tighten the camshaft bearing cap bolts one turn at a time in order to avoid shape distortion of the camshaft.

5. Tighten the camshaft bearing cap bolts one turn at a time and in a spiral sequence as shown to 8 N.m (71 lb in).

EXHAUST CAMSHAFT INSTALLATION

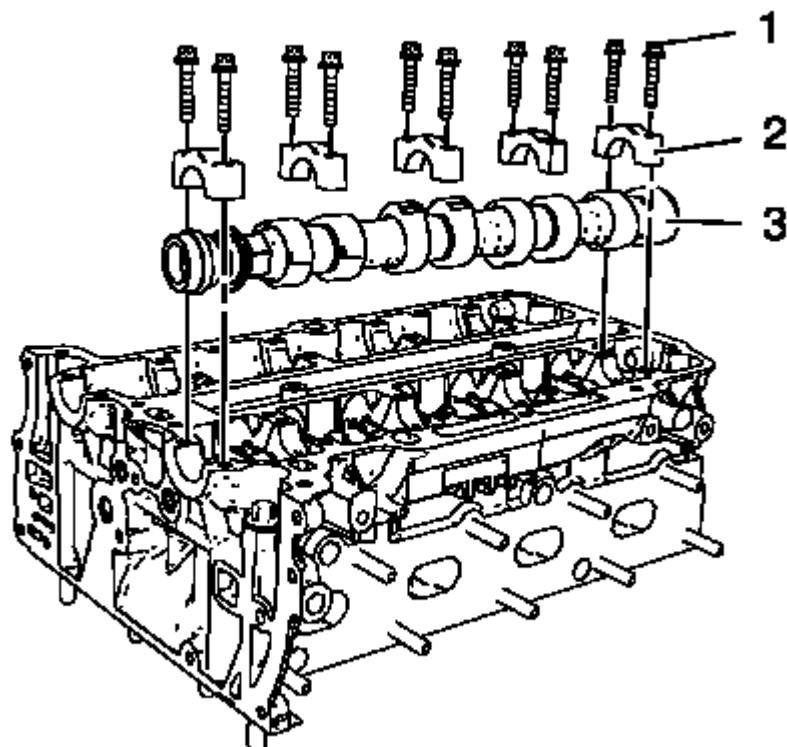


Fig. 268: Exhaust Camshaft, Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the markings on the camshaft bearing caps. Camshaft bearing caps should be installed in their original position.

1. Lubricate camshaft and camshaft bearing caps with engine oil.
2. Install the exhaust camshaft (3).
3. Install the 5 camshaft bearing caps (2).
4. Install the 10 camshaft bearing cap bolts (1) and handtighten.

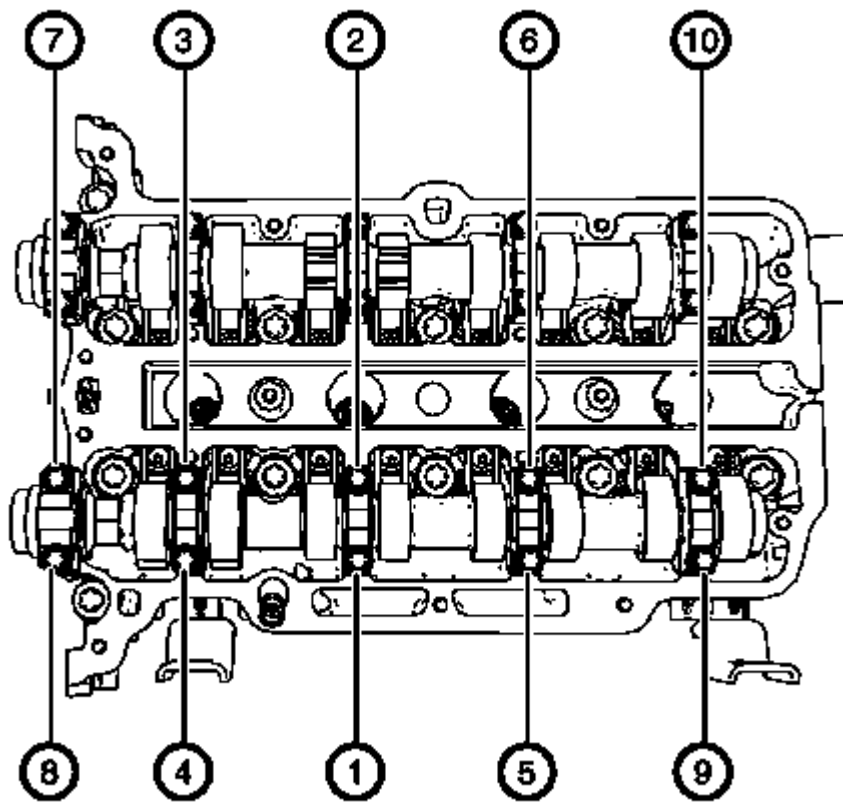


Fig. 269: Exhaust Camshaft Bearing Cap Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

NOTE: Tighten the camshaft bearing cap bolts one turn at a time in order to avoid shape distortion of the camshaft.

5. Tighten the camshaft bearing cap bolts one turn at a time and in a spiral sequence as shown to 8 N.m (71 lb in).

CAMSHAFT SPROCKET INSTALLATION

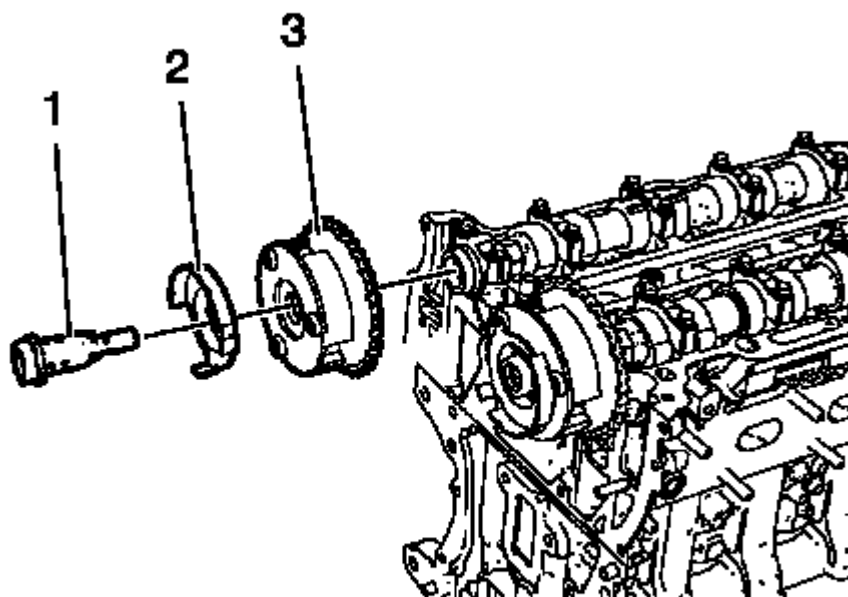


Fig. 270: Intake Camshaft Sprocket, Bolt And Intake Camshaft Position Exciter Wheel
Courtesy of GENERAL MOTORS COMPANY

1. Install the intake camshaft sprocket (3).
2. Install the intake camshaft position sensor exciter wheel (2) and the intake camshaft sprocket bolt (1), but do not tighten yet.
3. Install the exhaust camshaft sprocket.

NOTE: Tightening of camshaft sprocket bolts will be done after the engine front cover installation.

4. Install the exhaust camshaft position sensor exciter wheel and the exhaust camshaft sprocket bolt, but do not tighten yet.

TIMING CHAIN TENSIONER INSTALLATION

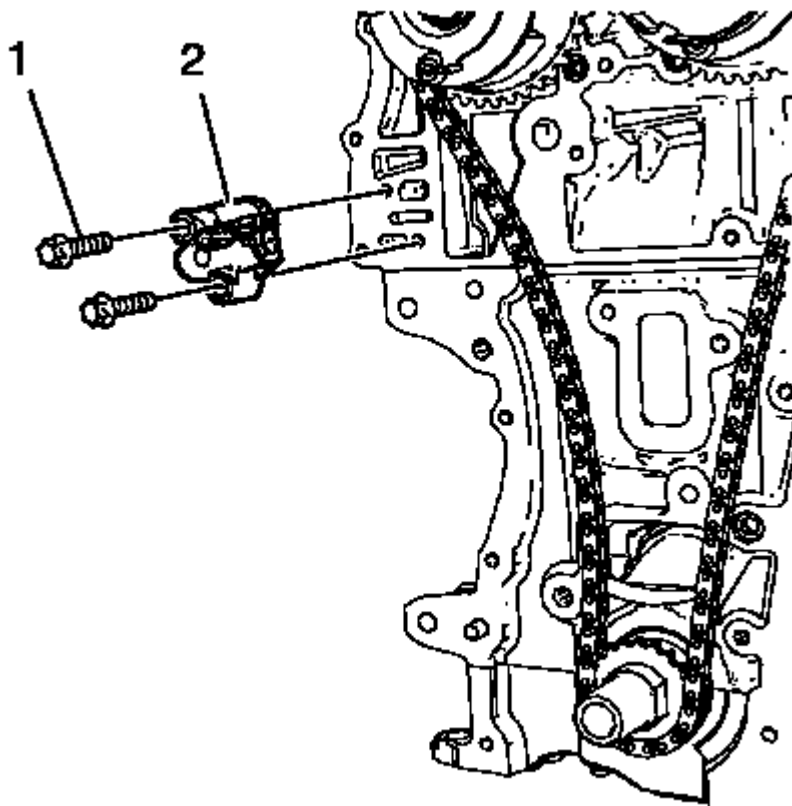


Fig. 271: Timing Chain Tensioner And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install the timing chain tensioner (2).

CAUTION: Refer to Fastener Caution .

2. Install the 2 timing chain tensioner bolts (1) and tighten to 8 N.m (71 lb in).

ENGINE FRONT COVER GASKET INSTALLATION

NOTE: The complete installation procedure should be done in 10 minutes.

1. Clean the sealing surfaces and remove all remains of old sealing compound material.

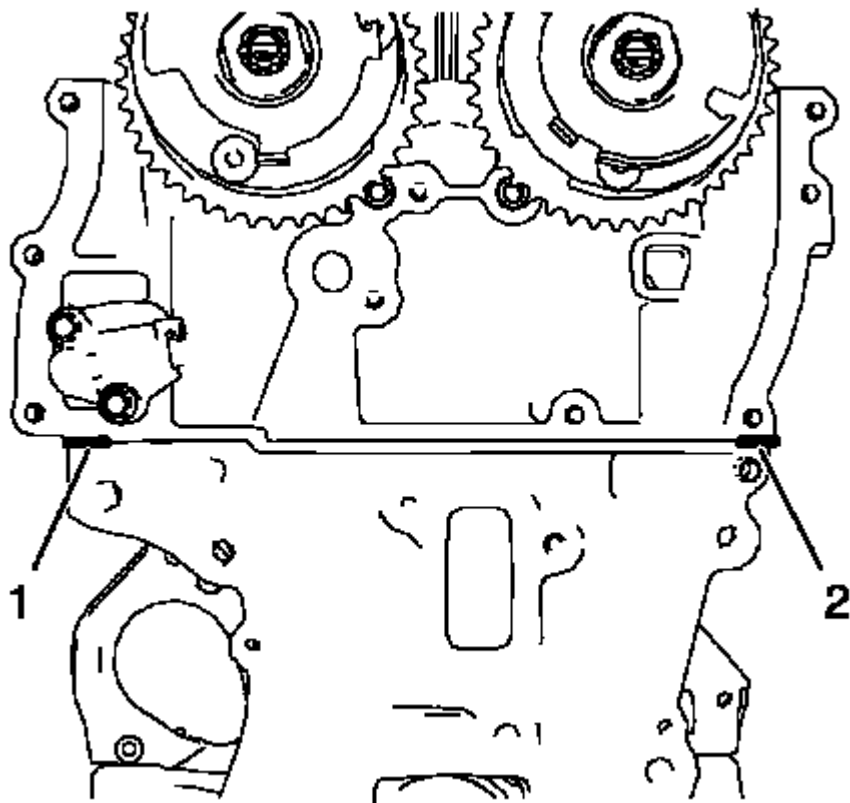


Fig. 272: Sealing Compound Application Areas
Courtesy of GENERAL MOTORS COMPANY

NOTE: Refer to electronic parts catalogue to find a suitable sealing compound.

2. Apply sealing compound to the shown areas (1) and (2). The thickness of the sealing bead should be 2 mm (0.0787 in).

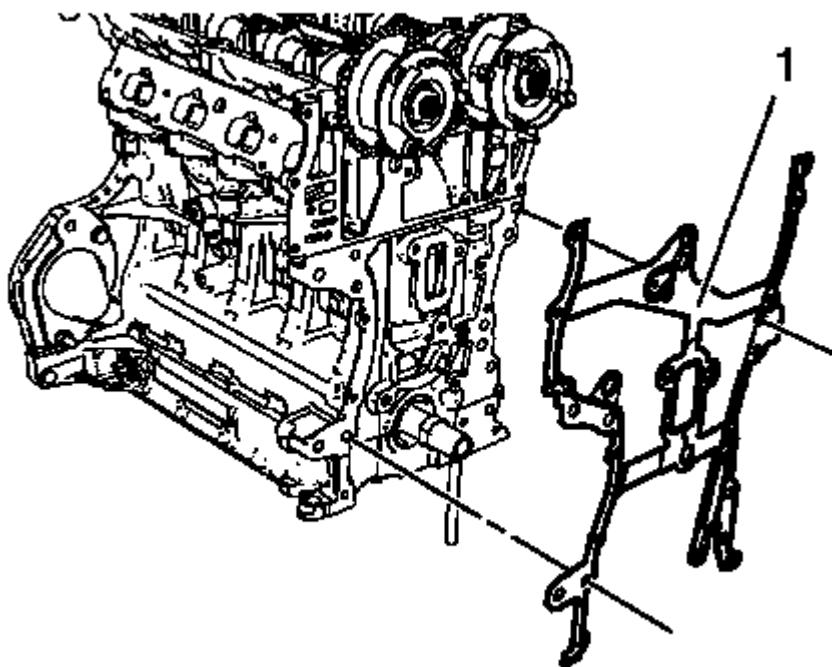


Fig. 273: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the guide sleeves.

3. Install the engine front cover gasket (1).
4. Install the timing chain. Refer to **Camshaft Timing Chain Installation**.
5. Install the engine front cover. Refer to **Engine Front Cover and Oil Pump Installation**.

CAMSHAFT TIMING CHAIN INSTALLATION

Special Tools

- **EN-952** Fixing Pin
- **EN-953-A** Fixing Tool
- **EN-955-10** Fixing Pin from **EN-955** Kit

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

1. The engine should be adjusted to TDC.
2. The crankshaft should be fixed with **EN-952** fixing pin.

3. The camshaft should be fixed with **EN-953-A** fixing tool.

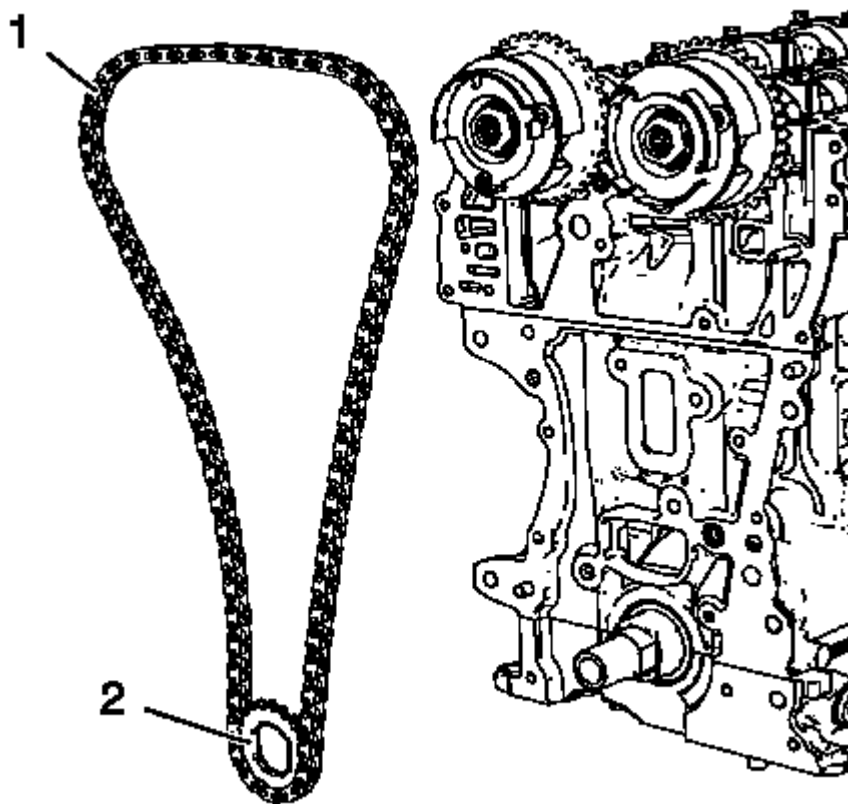


Fig. 274: Timing Chain And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

4. Install the timing chain (1) in compound with the crankshaft sprocket (2).

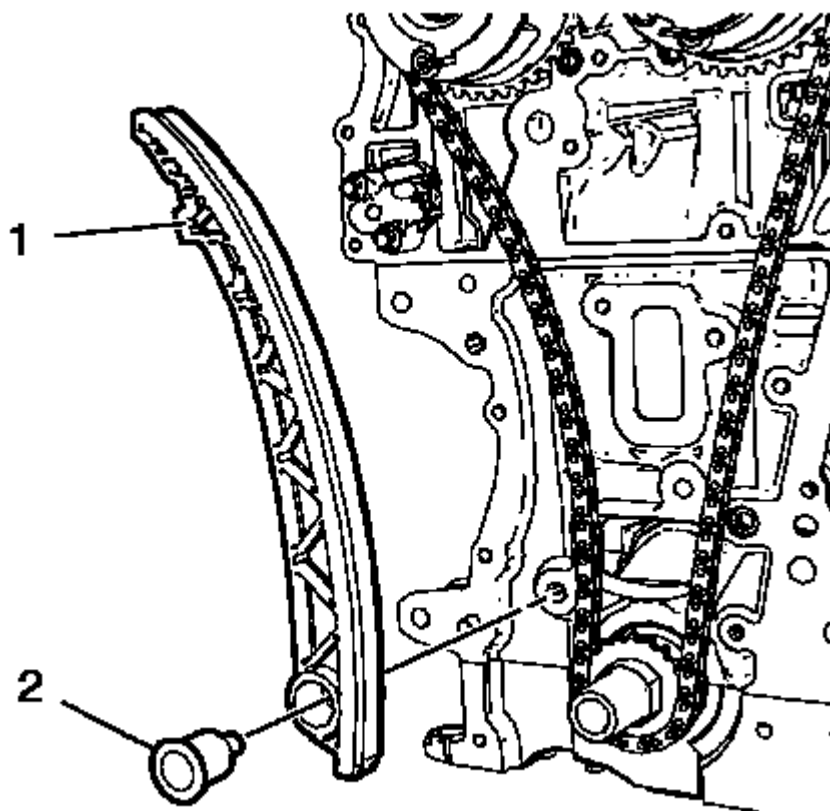


Fig. 275: Timing Chain Tensioner Shoe And Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Install the timing chain tensioner shoe (1).

CAUTION: Refer to Fastener Caution .

6. Install the timing chain tensioner shoe bolt (2) and tighten to 20 N.m (15 lb ft).

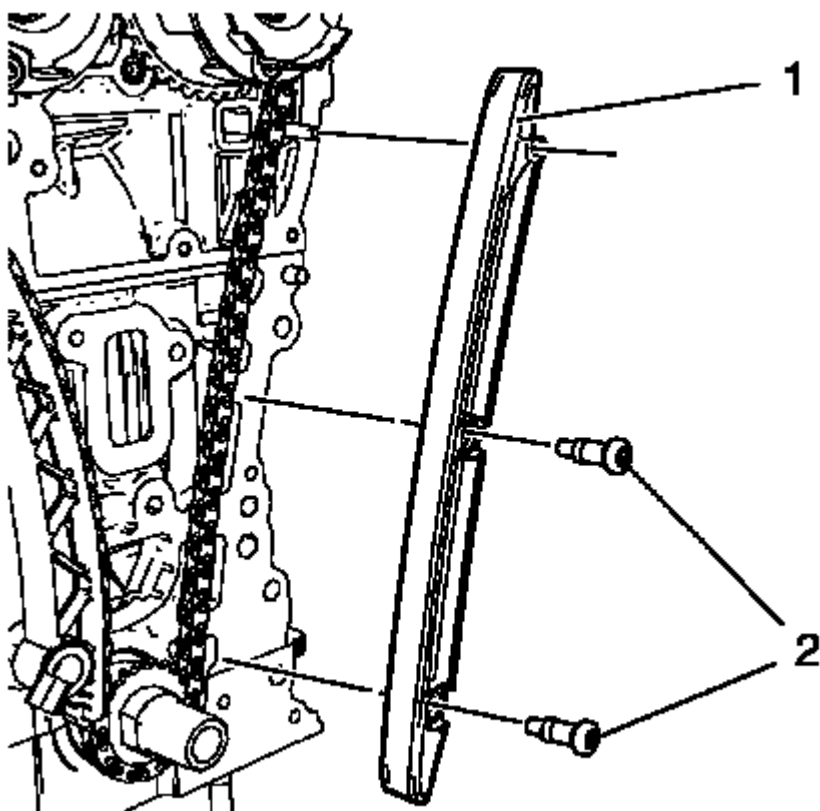


Fig. 276: Timing Chain Guide Right Side
Courtesy of GENERAL MOTORS COMPANY

7. Install the timing chain guide right side (1).
8. Install the 2 timing chain guide right side bolts (2) and tighten to 8 N.m (71 lb in).

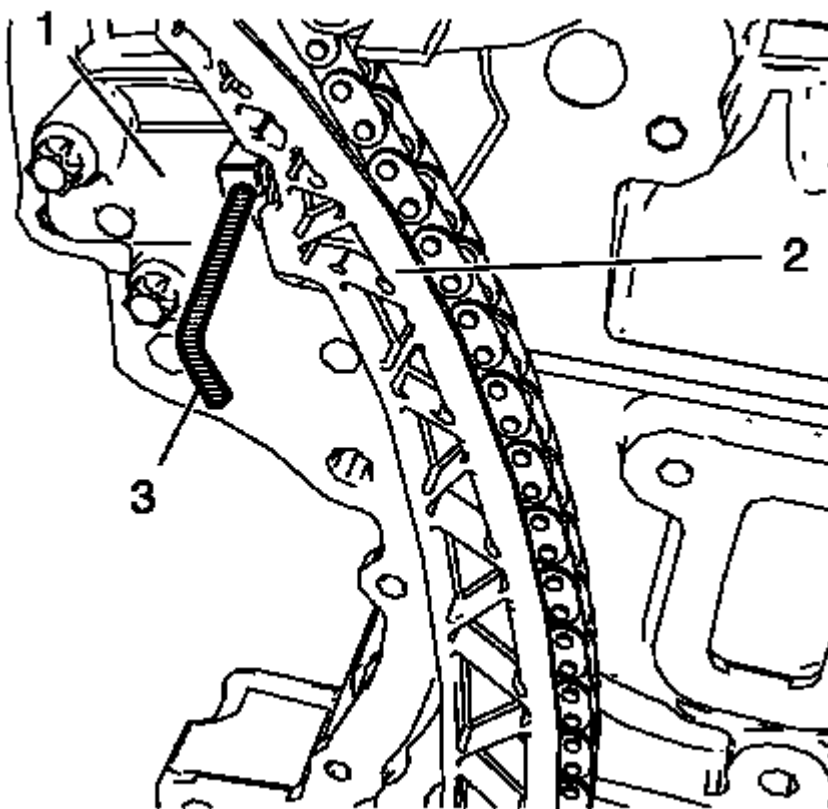


Fig. 277: Timing Chain And Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

9. Push the timing chain (2) in direction to the timing chain tensioner (1) and remove **EN-955-10** fixing pin (3).

The upper timing chain guide will be installed after the installation of the engine front cover and the fastening of the camshaft sprockets.

ENGINE FRONT COVER AND OIL PUMP INSTALLATION

Special Tools

- **EN-952** Fixing Pin
- **EN-953-A** Fixing Tool
- **EN-49977-100** Transmitter Disc Fixation
- **EN-49977-200** Fixing Tool

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

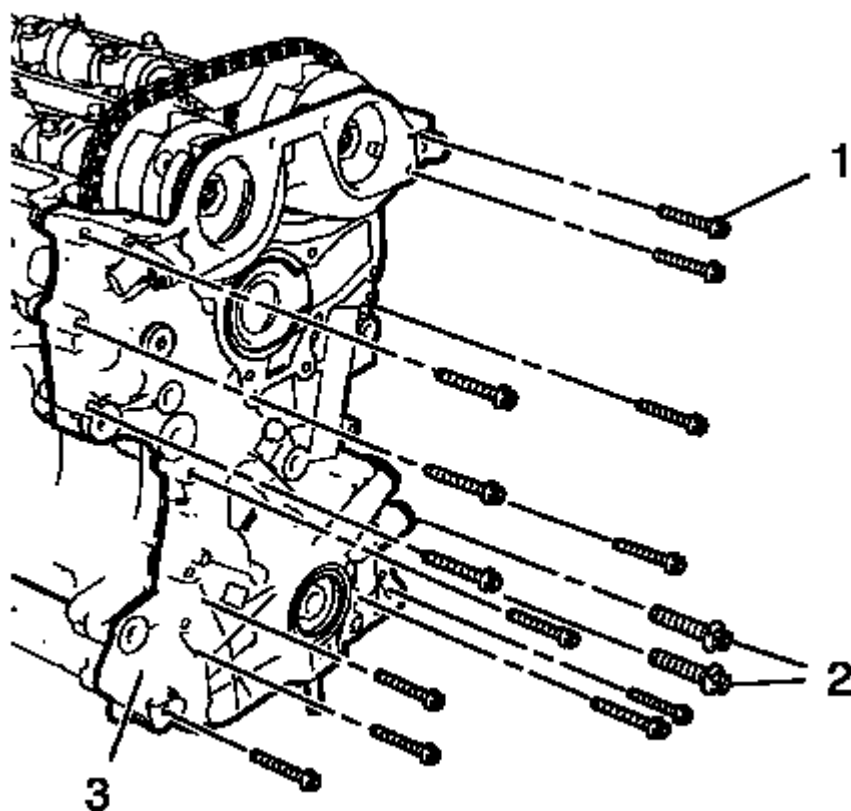


Fig. 278: M6, M10 Front Cover Bolts And Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the guide sleeves when installing engine front cover.

1. Install the engine front cover (3).
2. Install the 13 engine front cover bolts M6 (1).
3. Install the 2 engine front cover bolts M10 (2).

CAUTION: Refer to Fastener Caution .

4. Tighten the 13 engine front cover bolts M6 to 8 N.m (71 lb in).
5. Tighten the 2 engine front cover bolts M10 to 35 N.m (26 lb ft).

Camshaft Sprocket Fastening

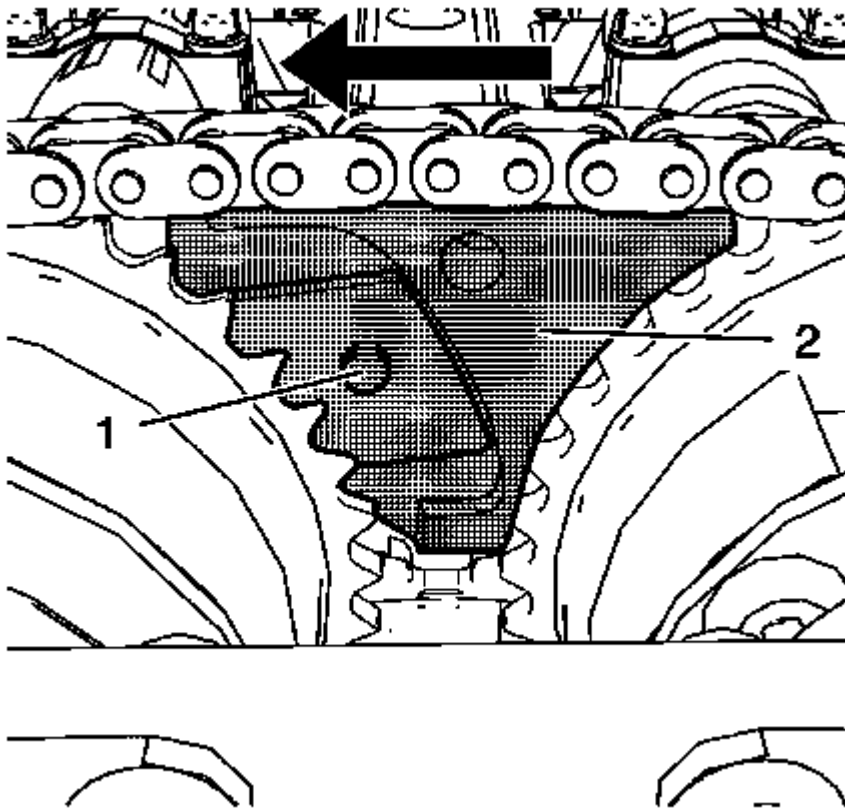


Fig. 279: Intake Camshaft Sprocket Gearing And Special Tool
Courtesy of GENERAL MOTORS COMPANY

NOTE: Push the fixing tool in the direction of the arrow to ensure it engages without clearance.

1. Install EN-49977-200 fixing tool (2) and adjust that the gearing (1) of the fixing tool engages with the intake camshaft sprocket gearing (1).

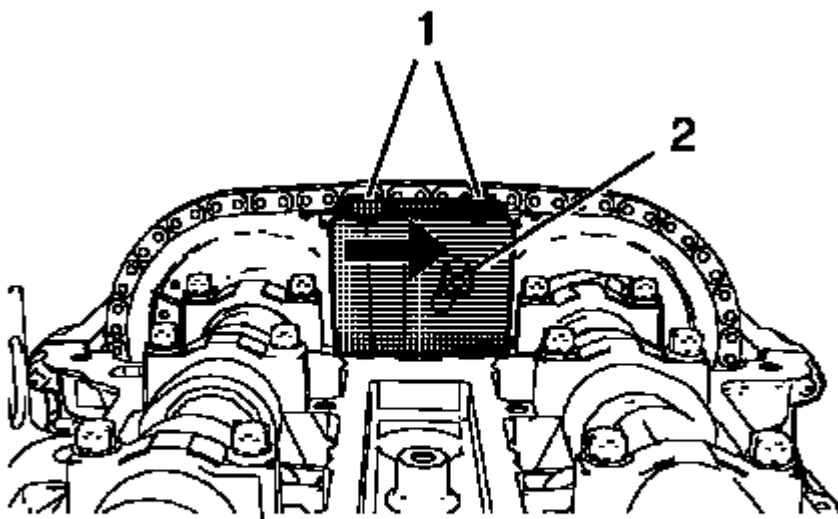


Fig. 280: Adjuster Bolt And Fastening Bolts

Courtesy of GENERAL MOTORS COMPANY

2. Tighten the 2 fastening bolts (1) of **EN-49977-200** fixing tool while pushing the fixing tool in direction of the arrow.
3. Tighten the adjuster bolt (2).

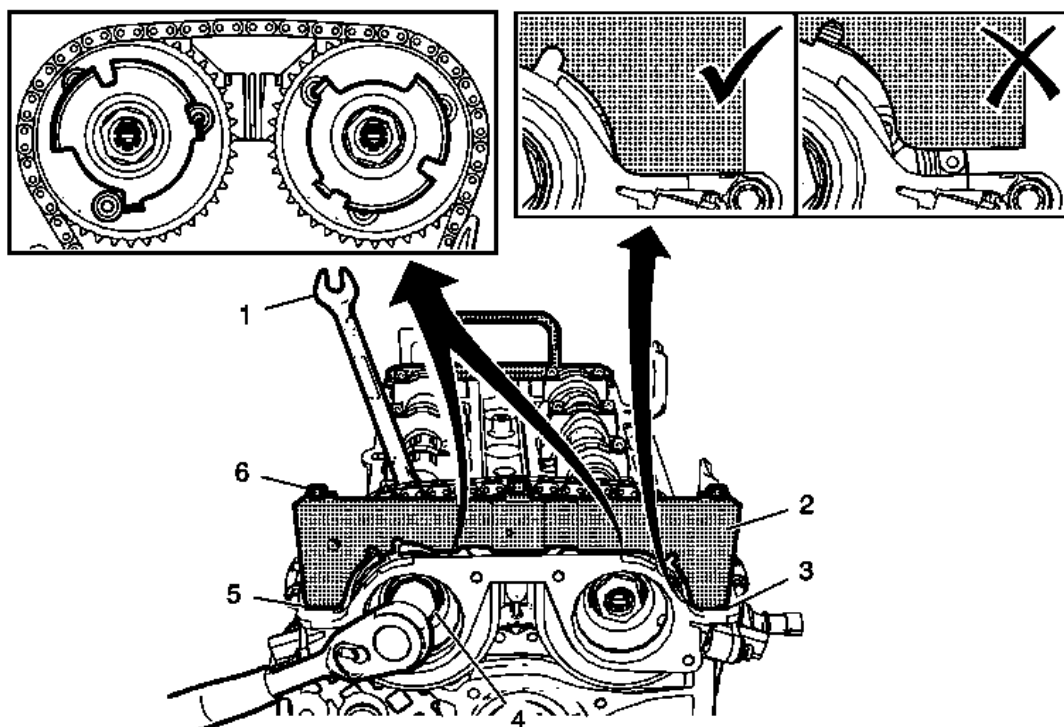


Fig. 281: Intake Camshaft Sprocket Bolt And Cylinder Head
 Courtesy of GENERAL MOTORS COMPANY

NOTE: A wrong installation position is possible. Make sure that the fixation tool is installed without clearance to the cylinder head in areas (3) and (5) and the camshaft position exciter wheels are positioned as shown.

4. Install **EN-49977-100** transmitter disc fixation (2) in order to find and fix the correct position of the camshaft position exciter wheels.
5. Tighten the fastening bolts (6) of **EN-49977-100** transmitter disc fixation.

CAUTION: Refer to Fastener Caution .

6. Tighten the intake camshaft sprocket bolt (4) while holding up the hexagon (1) of the intake camshaft to 50 N.m (37 lb ft).
7. Tighten the intake camshaft sprocket bolt (4) while holding up the hexagon (1) of the intake camshaft to an additional 60 degrees.
8. Tighten the exhaust camshaft sprocket bolt while holding up the hexagon of the exhaust camshaft to 50 N.m (37 lb ft).
9. Tighten the exhaust camshaft sprocket bolt while holding up the hexagon of the exhaust camshaft to an additional 60 degrees.
10. Remove **EN-49977-100** transmitter disc fixation and **EN-49977-200** fixing tool.

Upper timing chain guide installation

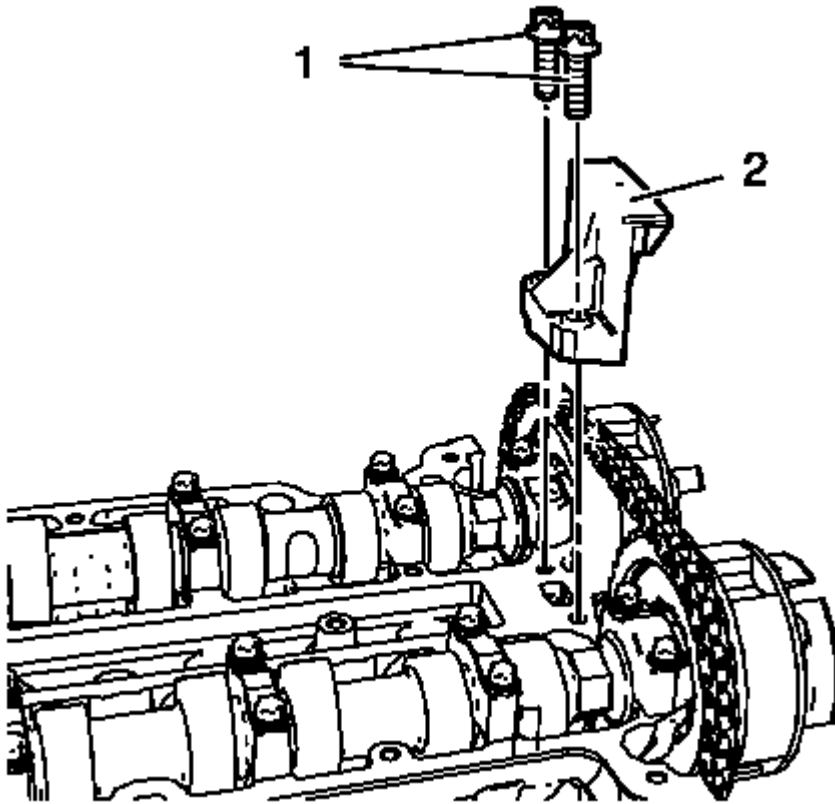


Fig. 282: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install the upper timing chain guide (2).
2. Install the 2 upper timing chain guide bolts (1) and tighten to 8 N.m (71 lb in).
3. Remove **EN-953-A** fixing tool and **EN-952** fixing pin.
4. Install crankshaft bearing cap tie plate hole plug and seal ring and tighten to 40 N.m (30 lb ft).

OIL PAN INSTALLATION

Special Tools

EN-49980 Guidance Pins

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

NOTE: Refer to electronic parts catalogue to find a suitable sealing compound.

1. Clean the sealing surfaces from old sealing material, dirt, oil and grease.

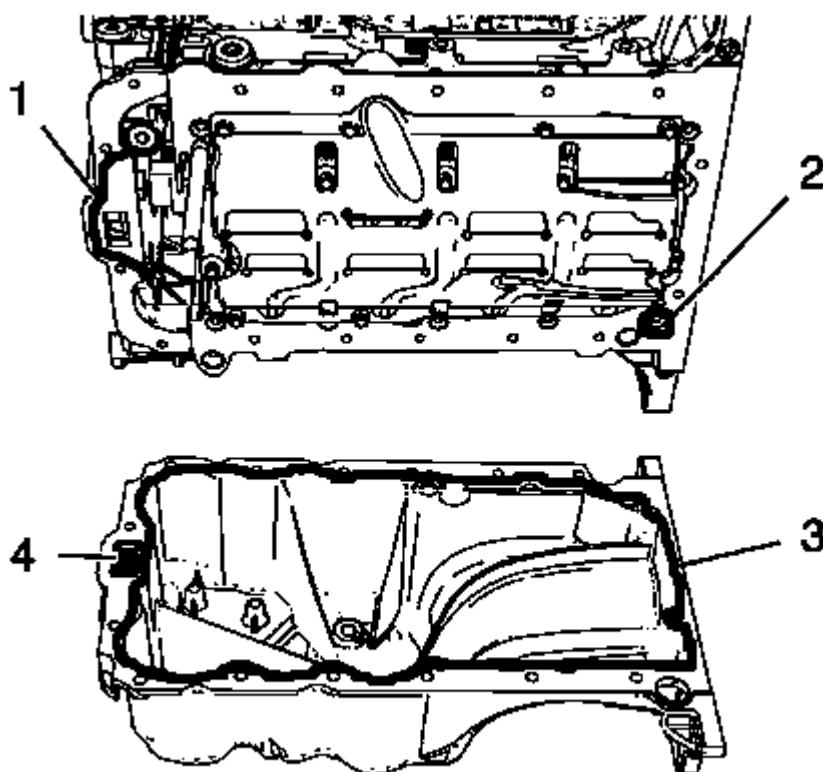


Fig. 283: Engine Front Cover, Oil Suction Gallery And Screw Bore
Courtesy of GENERAL MOTORS COMPANY

NOTE: The sealing bead should be applied close to the inner edge of the oil pan. Take care that the oil suction gallery (4) will not get contaminated with sealing compound or dirt.

2. Apply sealing compound to the oil pan. The thickness of the sealing bead (3) should be 2 mm (0.0787 in).
3. Apply sealing compound to the groove of the engine front cover (1).
4. Apply sealing compound around the screw bore (2) of the crankshaft bearing cap tie plate.
5. Install the oil pan seal rings to the grooves of the engine front cover.

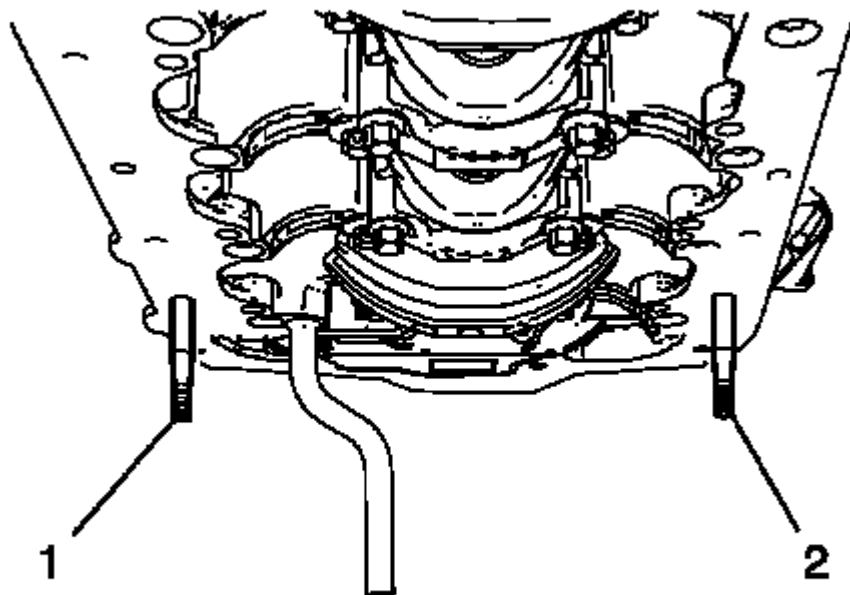


Fig. 284: Special Tools In Oil Pan Screw Bores
Courtesy of GENERAL MOTORS COMPANY

NOTE: The complete installation procedure of the oil pan should be done in 10 minutes.

6. Install the 2 **EN-49980** pins (1) and (2) to the shown oil pan screw bores.

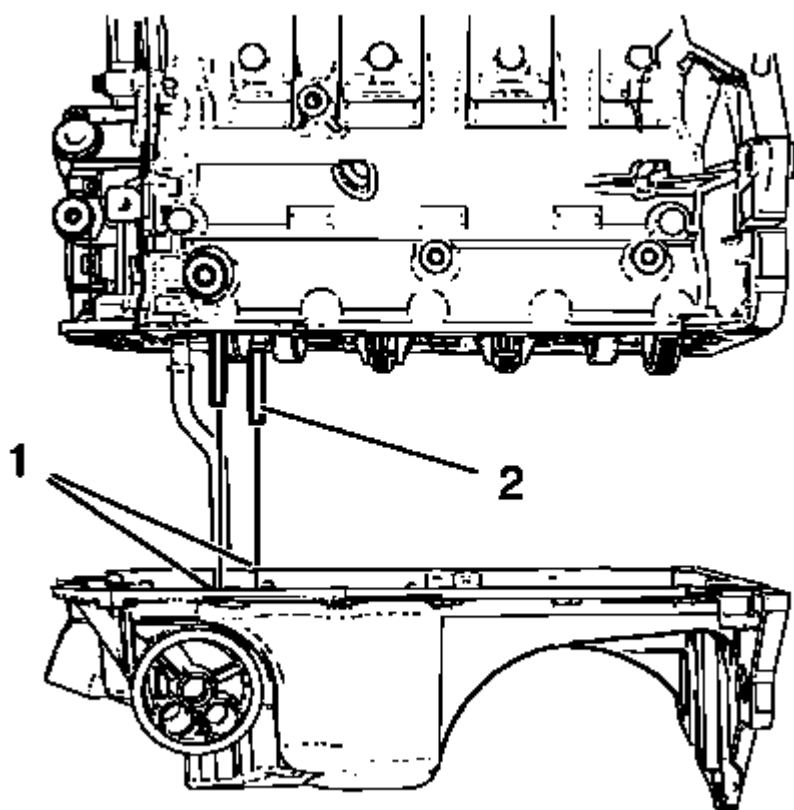


Fig. 285: Oil Pan. Guide Pins

Courtesy of GENERAL MOTORS COMPANY

NOTE: Take care not to smear the sealing bead during the installation procedure. A smeared sealing bead can cause a leak or contaminate the area around the oil suction gallery.

7. Cautiously install the oil pan. Guide the oil pan with **EN-49980** pins (2) and the equivalent screw bores (1).
8. Fix the oil pan with 4 oil pan bolts.
9. Remove **EN-49980** pins.
10. Install the remaining 12 oil pan bolts and hand tighten.

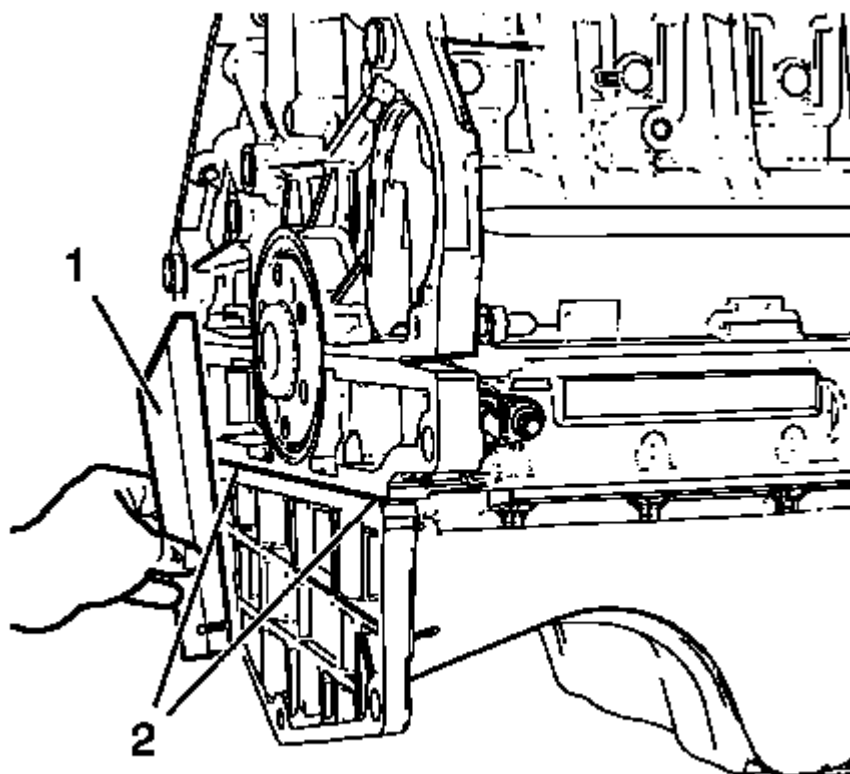


Fig. 286: Straight Edge Tool

Courtesy of GENERAL MOTORS COMPANY

11. Lay on a straight edge (1) to oil pan and engine block and adjust the transition in area (2) until there is no clearance between oil pan and straight edge. Use a rubber mallet.

CAUTION: Refer to Fastener Caution .

12. Tighten the 16 oil pan bolts to 10 N.m (89 lb in).

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE INSTALLATION

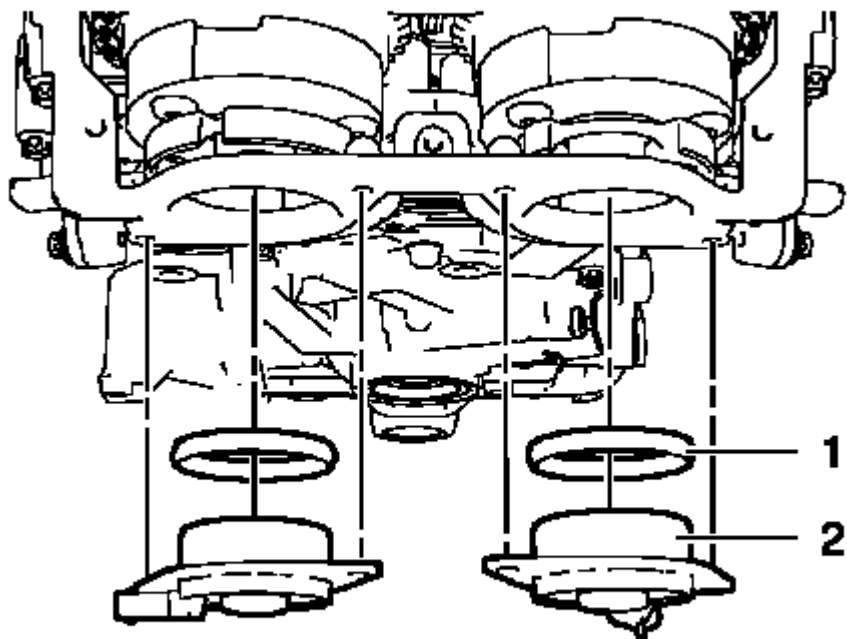


Fig. 287: Camshaft Position Actuator Solenoid Valves And Seal Rings
Courtesy of GENERAL MOTORS COMPANY

CAUTION: The camshaft position actuator solenoid valves must be kept parallel to the engine front cover during removal and installation. The camshaft position actuator solenoid valves can be damaged if they become wedged or stuck during this process.

1. Install the 2 camshaft position actuator solenoid valves (2) and the 2 seal rings (1) by carefully and evenly pressing.

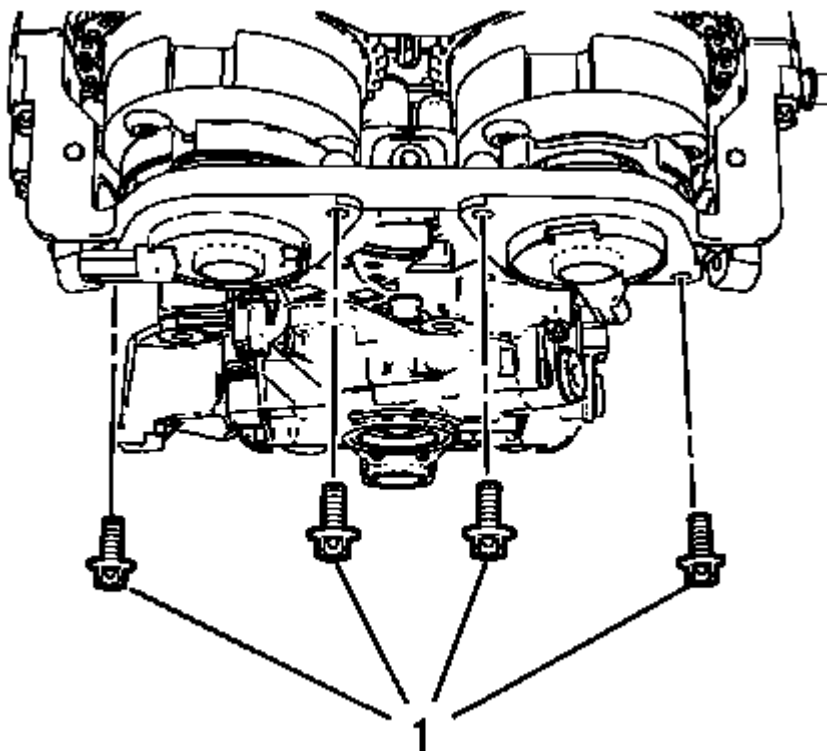


Fig. 288: Camshaft Position Actuator Solenoid Valve Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution

2. Install the 4 camshaft position actuator solenoid valve bolts (1) and tighten to 8 N.m (71 lb in).

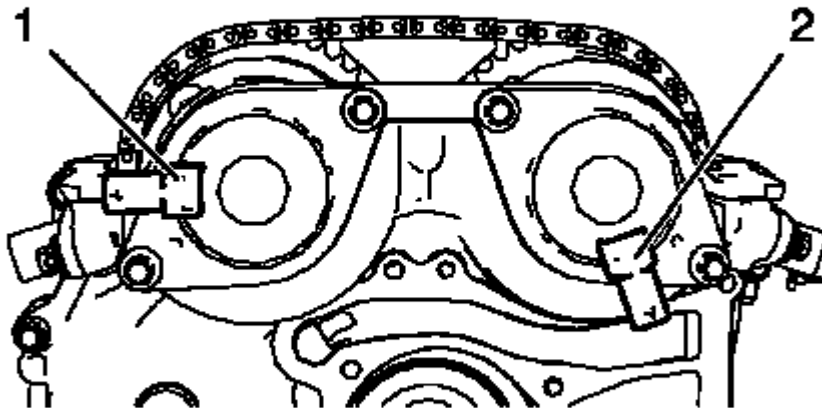


Fig. 289: Camshaft Position Actuator Solenoid Valves Proper Position
Courtesy of GENERAL MOTORS COMPANY

3. The 2 camshaft position actuator solenoid valves should be installed in the position as shown (1) and (2).

CAMSHAFT COVER INSTALLATION

1. Clean the sealing surfaces.

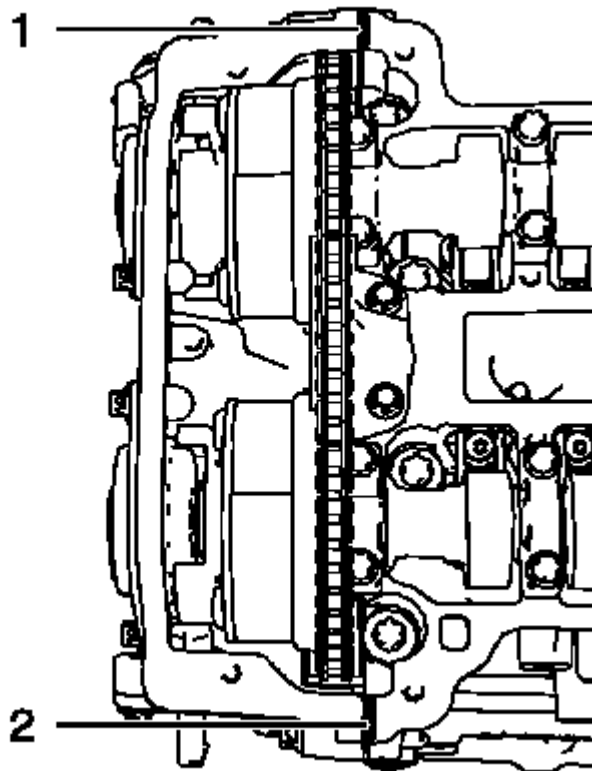


Fig. 290: Sealing Compound Application Areas
Courtesy of GENERAL MOTORS COMPANY

NOTE: The thickness of the sealing bead should be 2 mm (0.0787 in).

2. Apply sealing compound to areas (1) and (2). Refer to Adhesives, Fluids, Lubricants, and Sealers.

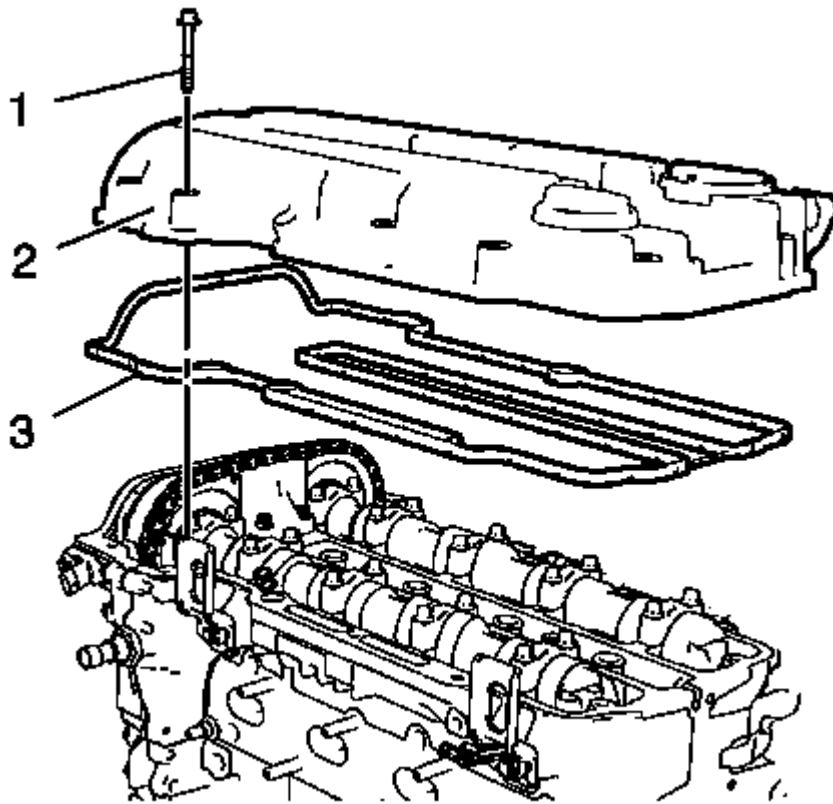


Fig. 291: Camshaft Cover And Gasket
 Courtesy of GENERAL MOTORS COMPANY

NOTE: The installation procedure should not take longer than 10 minutes.

3. Install the camshaft cover (2) and a NEW gasket (3).
4. Install the 15 camshaft cover bolts (1).

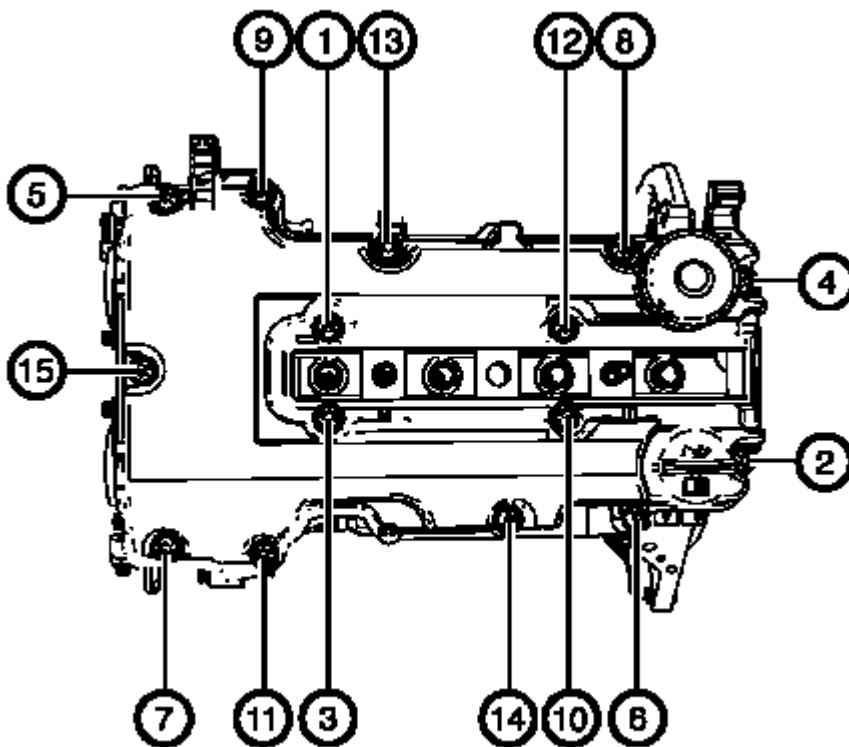


Fig. 292: Camshaft Cover Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

5. Tighten the 15 camshaft cover bolts in a sequence as shown to 8 N.m (71 lb in).

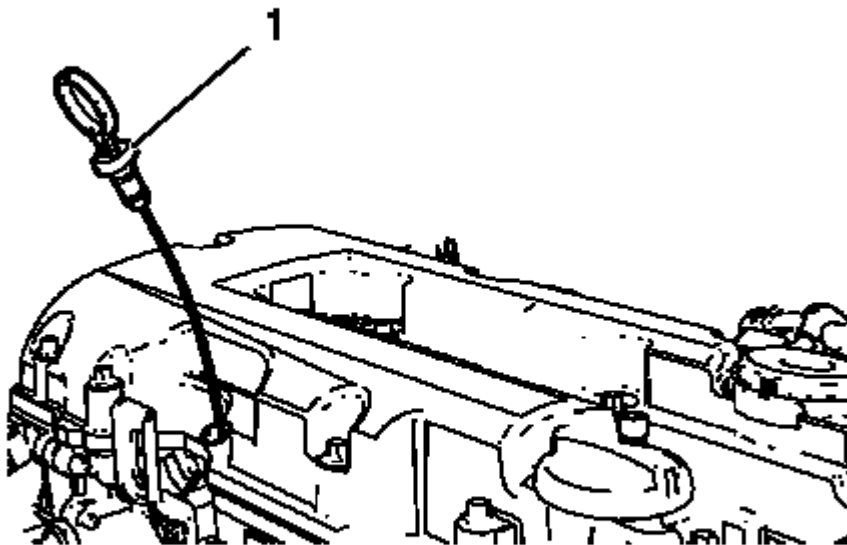


Fig. 293: Engine Oil Level Indicator

Courtesy of GENERAL MOTORS COMPANY

6. Install the oil level indicator (1).

IGNITION COIL INSTALLATION

Special Tools

EN-6009 Remover and Installer Ignition Module

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

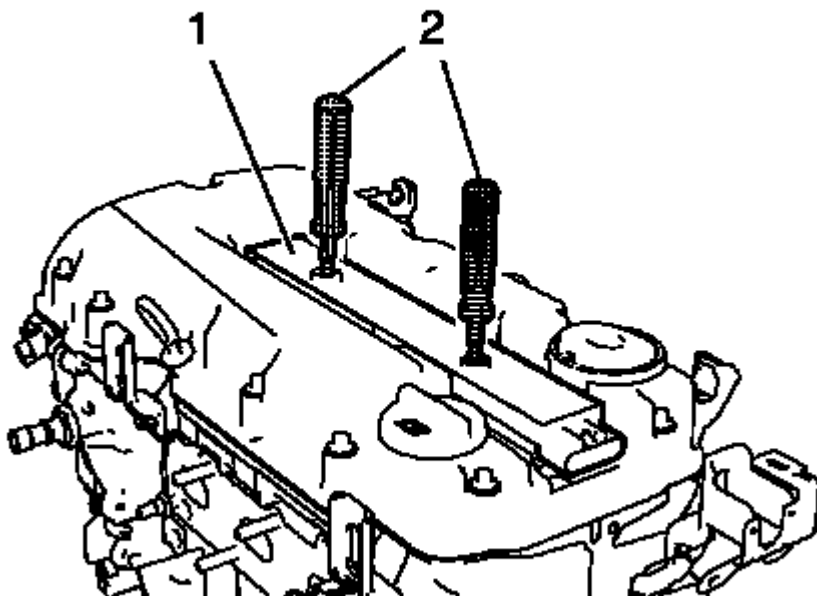


Fig. 294: Ignition Coil And Remover/Installer
Courtesy of GENERAL MOTORS COMPANY

1. Install the ignition coil (1) and remove **EN-6009** remover and installer (2).

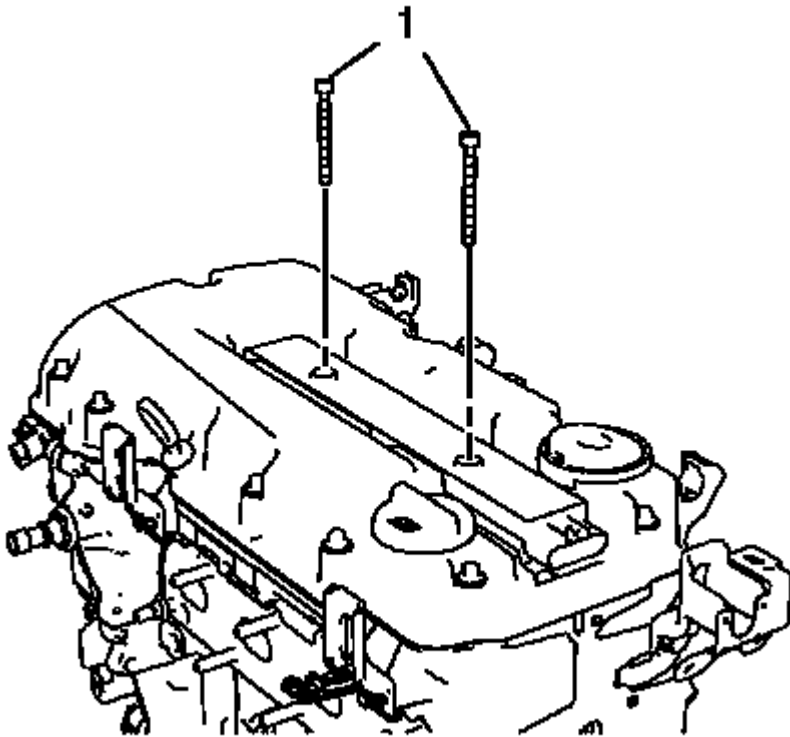


Fig. 295: Ignition Coil Bolts

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install the 2 ignition coil bolts (1) and tighten to 8 N.m (71 lb in).

OIL FILTER INSTALLATION

Special Tools

EN-726-A Oil Filter Wrench

For equivalent regional tools, refer to Special Tools.

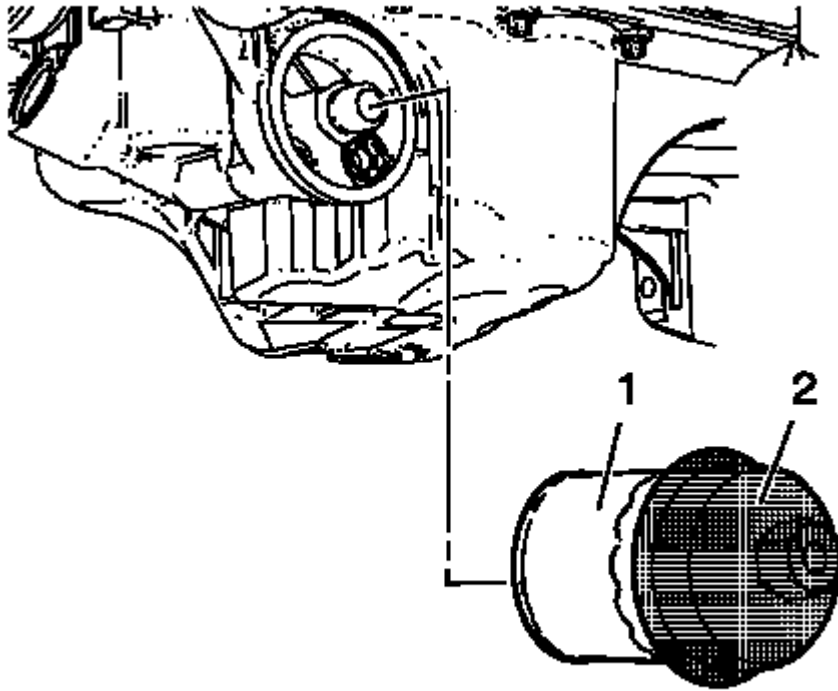


Fig. 296: Oil Filter And Wrench

Courtesy of GENERAL MOTORS COMPANY

1. Install the **EN-726-A** wrench (2) to the oil filter (1).

CAUTION: Refer to Fastener Caution .

2. Install the oil filter to the oil pan and tighten to 20 N.m (15 lb ft).
3. Remove the **EN-726-A** wrench.

INTAKE MANIFOLD INSTALLATION

1. Clean the sealing surfaces.

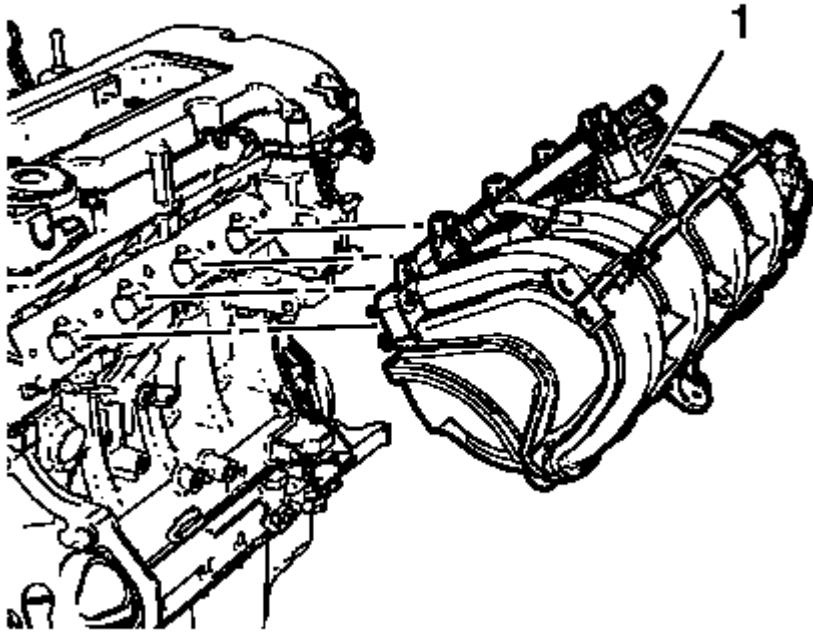


Fig. 297: Intake Manifold

Courtesy of GENERAL MOTORS COMPANY

2. Install the intake manifold (1) along with the intake manifold gasket.

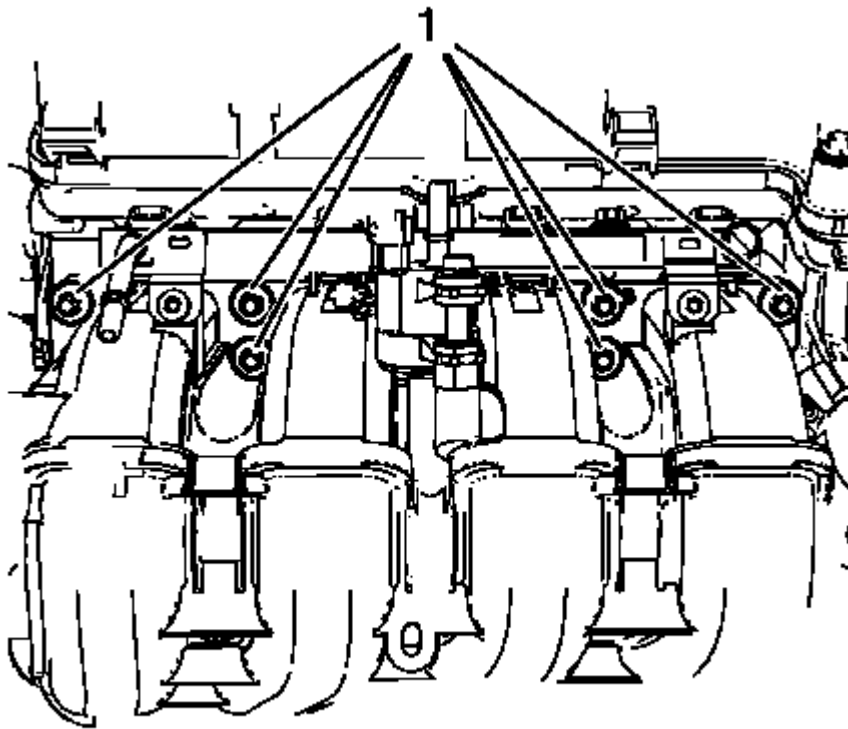


Fig. 298: Intake Manifold Bolts

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. Install the 6 intake manifold bolts (1) and tighten to 20 N.m (15 lb ft).

THROTTLE BODY INSTALLATION

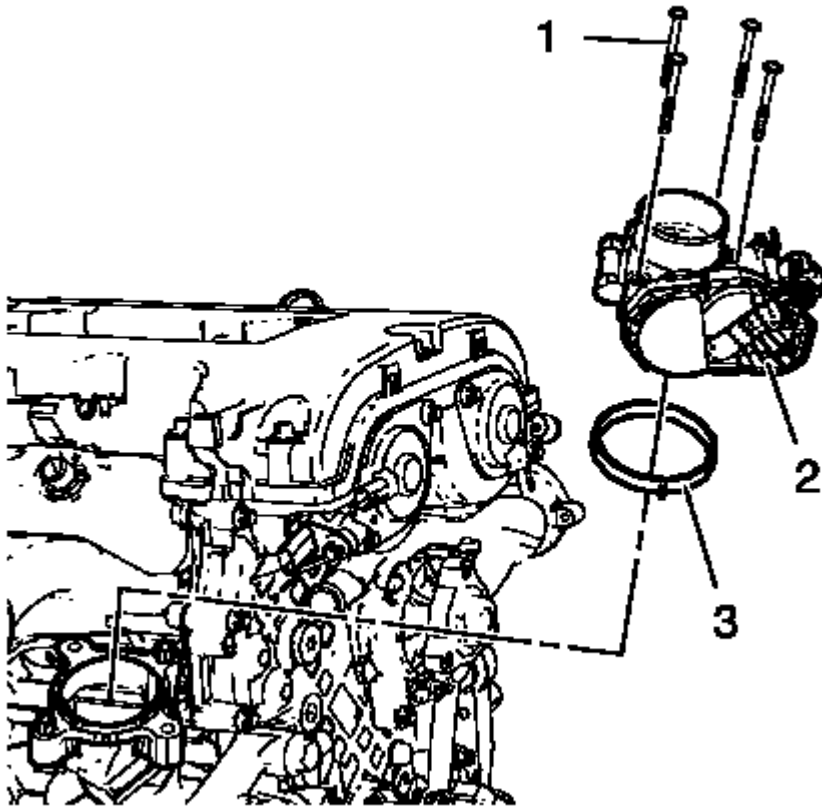


Fig. 299: Throttle Body And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Install the throttle body (2) and a NEW throttle body seal ring (3)

CAUTION: Refer to Fastener Caution .

2. Install the 4 throttle body bolts (1) and tighten to 9 N.m (80 lb in).

WATER PUMP INSTALLATION

1. Clean the sealing surfaces.

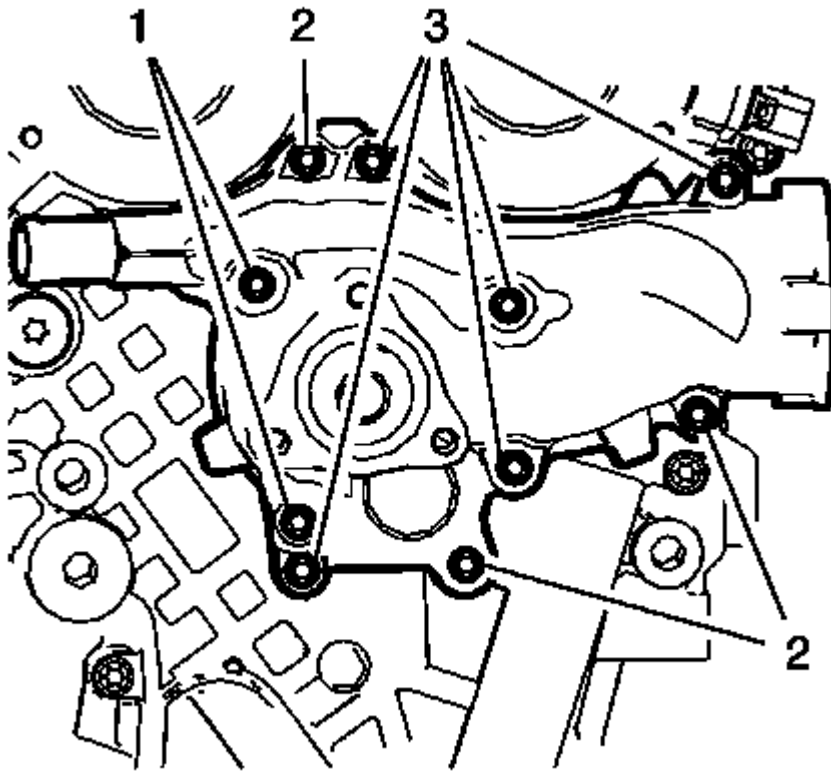


Fig. 300: Water Pump And Engine Front Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

2. The water pump and engine front cover bolts are located as followed:
 - Engine front cover special bolt without cone end 60 mm (2.362 in) (1).
 - Engine front cover standard bolt with cone end 52 mm (2.047 in) (2).
 - Water pump bolt 25 mm (0.984 in) (3).

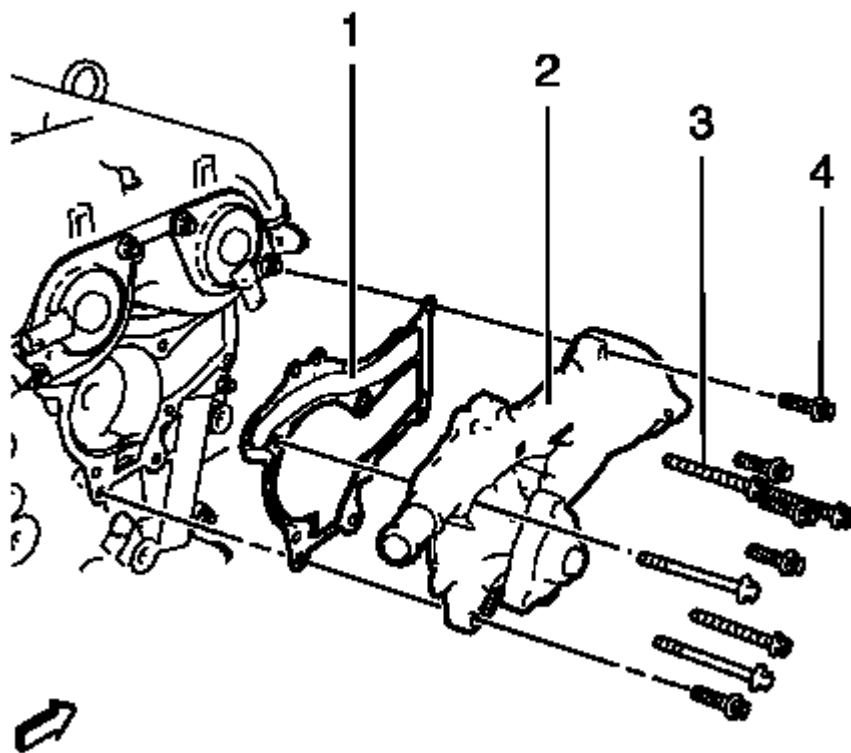


Fig. 301: Water Pump, Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

3. Install the water pump (2) and a NEW water pump gasket (1).

CAUTION: Refer to Fastener Caution .

4. Install the 5 water pump bolts (4) and the 5 long engine front cover bolts (3) and tighten in a cross sequence to 8 N.m (71 lb in).

CRANKSHAFT BALANCER INSTALLATION

Special Tools

- EN-49979 Crankshaft Shock Mount Retainer.
- EN-956-1 Extension
- EN-470-B Angular Torque Wrench

For equivalent regional tools, refer to Special Tools.

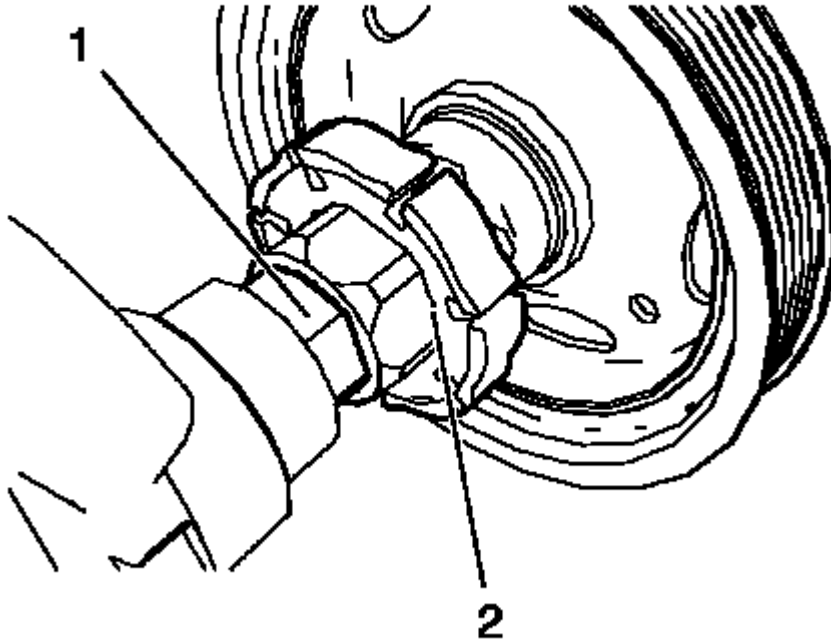


Fig. 302: Engine Oil Pump Rotor And Crankshaft
Courtesy of GENERAL MOTORS COMPANY

NOTE: The crankshaft balancer flange must fit to the hexagon of the oil pump rotor (2) and to the dihedral of the crankshaft (1).

1. Install the crankshaft balancer by cautious reciprocating and pressing.

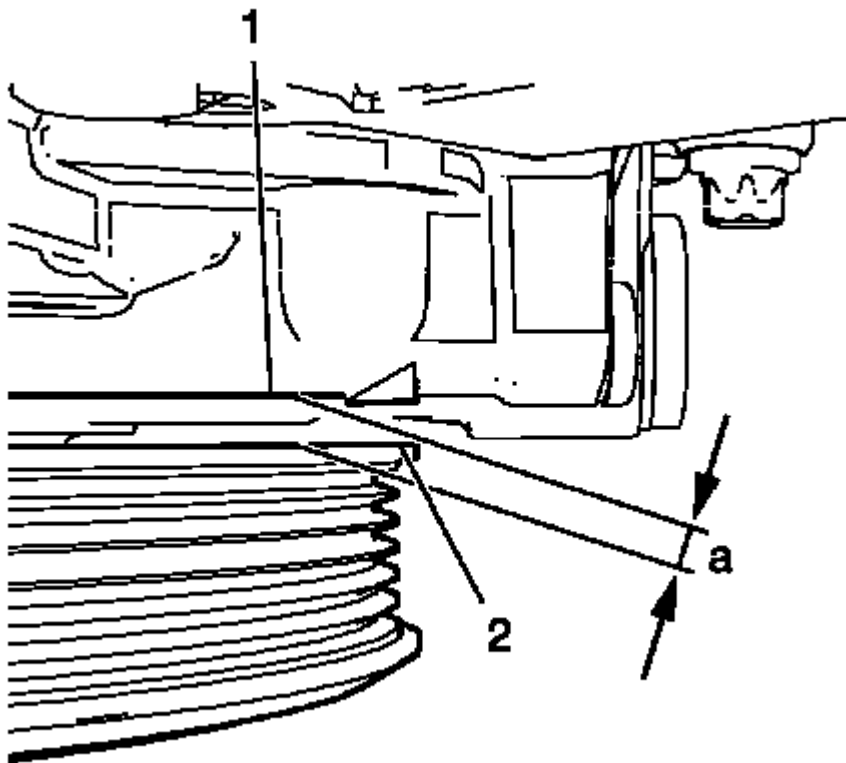


Fig. 303: Engine Front Cover And Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

2. Measure the distance *a* between the crankshaft balancer (2) and the mark on the engine front cover (1). The distance *a* should be 4.5 mm (0.1772 in).
3. Install the crankshaft balancer bolt.

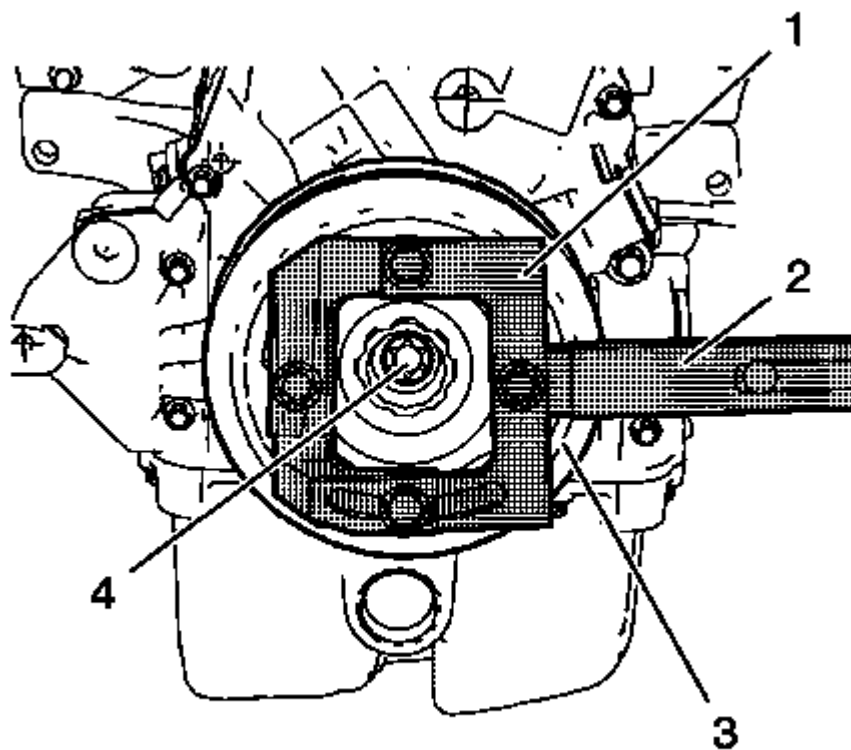


Fig. 304: Crankshaft Balancer, Retainer And Extension
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

4. Tighten the crankshaft balancer bolt (4) to while fixing the crankshaft balancer (3) with **EN-49979** retainer (1) and **EN-956-1** extension (2) in the following order:
 1. Tighten the crankshaft balancer bolt to 150 N.m (111 lb ft).
 2. Tighten the crankshaft balancer bolt to an additional 60°. Use **EN-470-B** wrench.

WATER PUMP PULLEY INSTALLATION

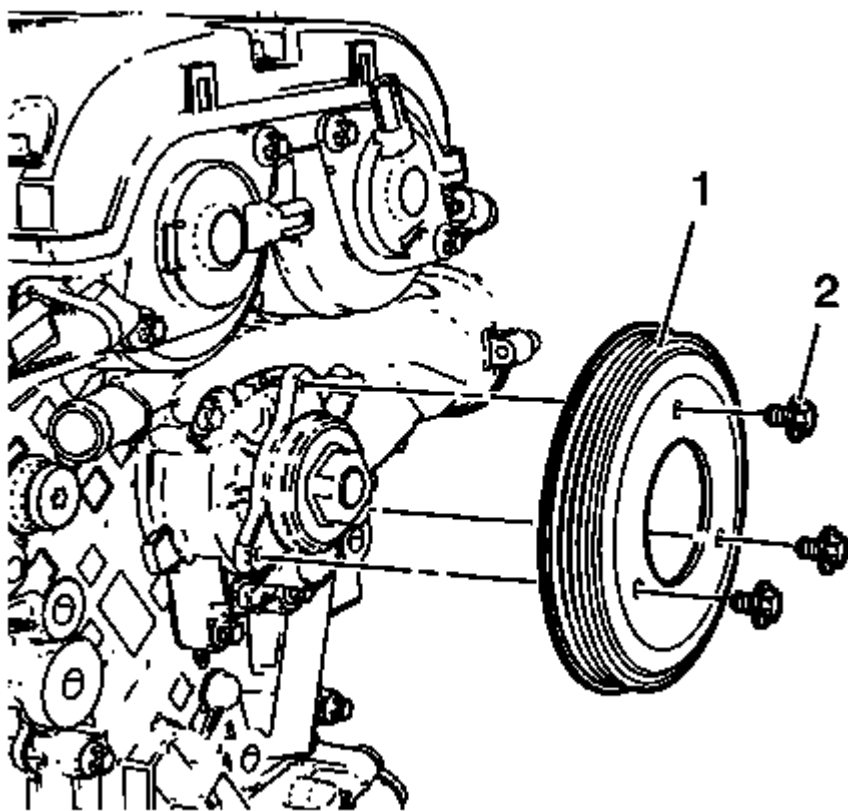


Fig. 305: Water Pump Pulley

Courtesy of GENERAL MOTORS COMPANY

1. Install the water pump pulley (1).
2. Install the 3 water pump pulley bolts (2).

CAUTION: Refer to Fastener Caution .

3. Tighten the 3 water pump pulley bolts (2) to 10 N.m (89 lb in) while holding up the water pump pulley hub with a spanner.

AIR CONDITIONING COMPRESSOR BRACKET INSTALLATION

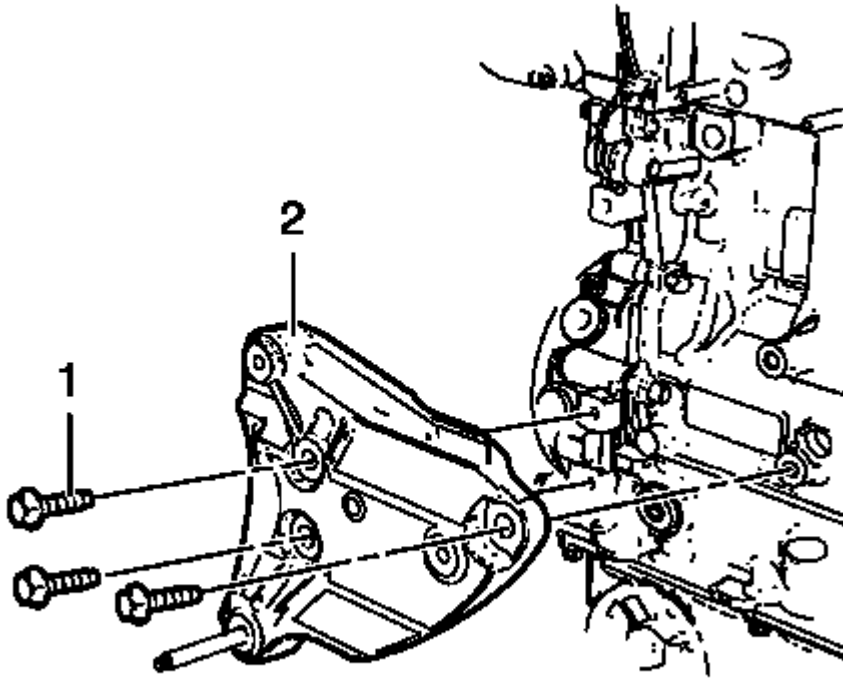


Fig. 306: Air Conditioning Compressor Bracket
Courtesy of GENERAL MOTORS COMPANY

1. Install the air conditioning compressor bracket (2).

CAUTION: Refer to Fastener Caution .

2. Install the 3 air conditioning compressor bracket bolts (1) and tighten to 22 N.m (16 lb ft).

WATER PUMP BELT INSTALLATION

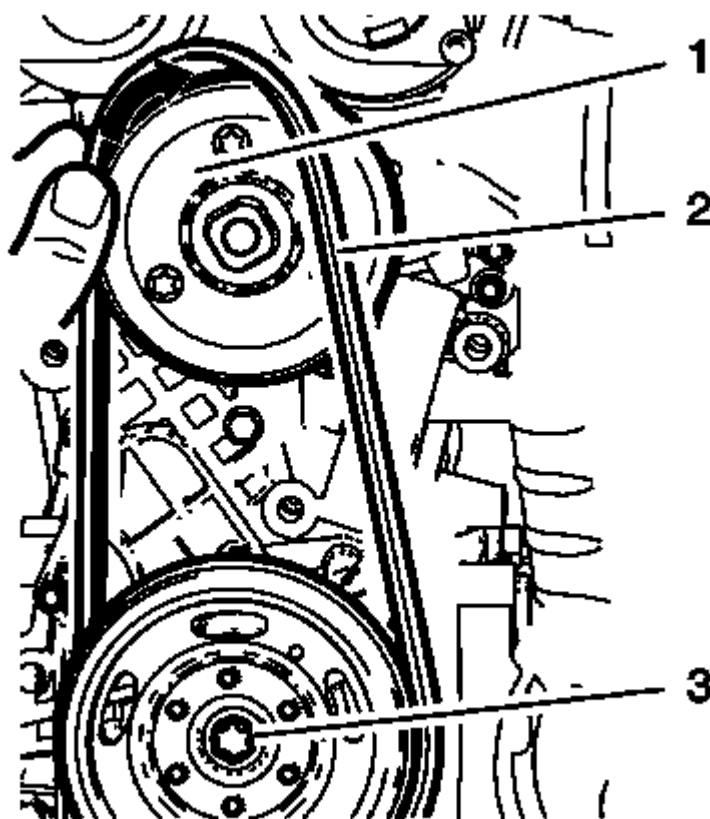


Fig. 307: Water Pump Belt And Water Pump Pulley
Courtesy of GENERAL MOTORS COMPANY

1. Pre-install the water pump belt (2) to the crankshaft balancer.
2. Guide the water pump belt (2) over the water pump pulley (1) and push it with the thumb in the water pump pulley groove.
3. Slowly rotate the crankshaft by means of the crankshaft balancer bolt (3) to install the water pump belt while pushing the belt in the water pump pulley groove.
4. Rotate the crankshaft and check proper seat of the water pump belt in the grooves of the water pump pulley and the crankshaft balancer.

WATER OUTLET INSTALLATION

1. Clean the sealing surfaces.

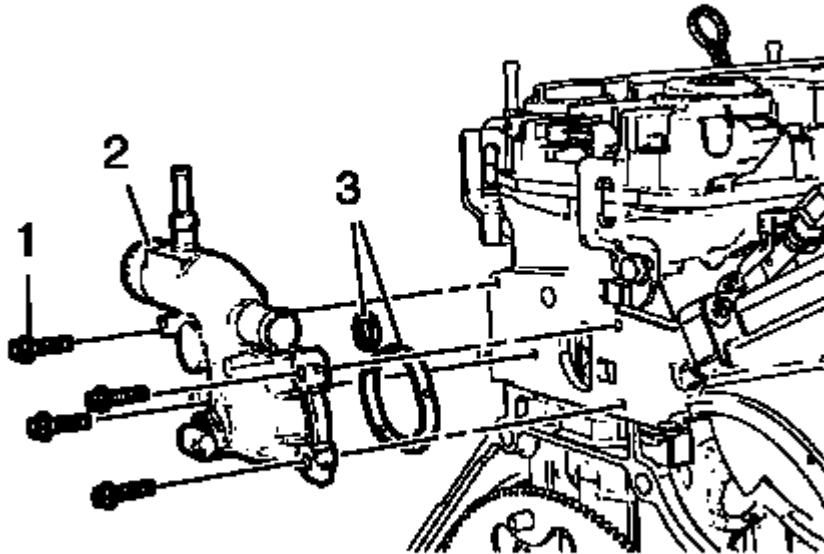


Fig. 308: Water Outlet

Courtesy of GENERAL MOTORS COMPANY

2. Install the water outlet (2) and 2 NEW water outlet seal rings (3).

CAUTION: Refer to Fastener Caution .

3. Install the 4 water outlet bolts (1) and tighten to 8 N.m (71 lb in).

ENGINE COOLANT THERMOSTAT HOUSING INSTALLATION

1. Clean the sealing surfaces.

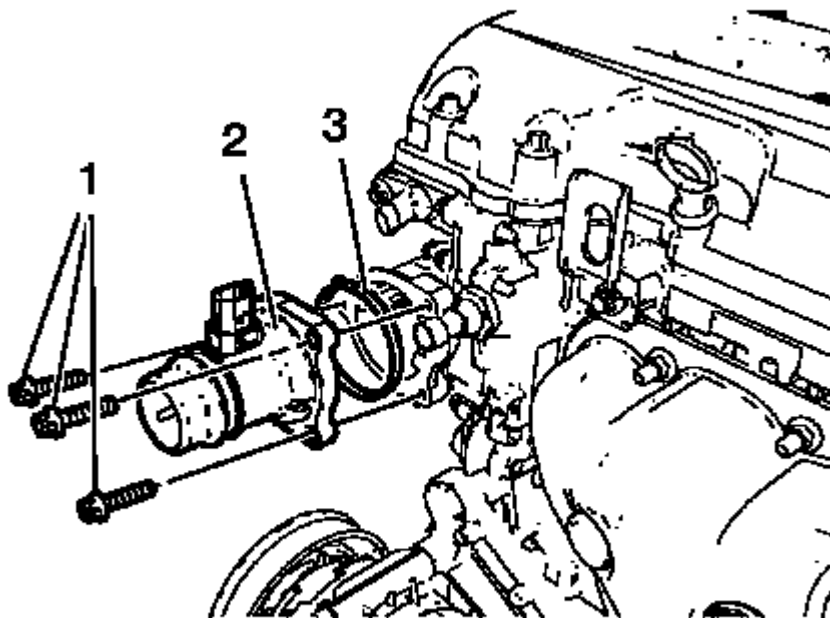


Fig. 309: Engine Coolant Thermostat Housing And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install the engine coolant thermostat housing (2) and a NEW engine coolant thermostat housing seal ring (3).

CAUTION: Refer to Fastener Caution .

3. Install the 3 engine coolant thermostat housing bolts (1) and tighten to 8 N.m (71 lb in).

EXHAUST MANIFOLD INSTALLATION

1. Clean the exhaust manifold and the cylinder head sealing surfaces from old gasket material.

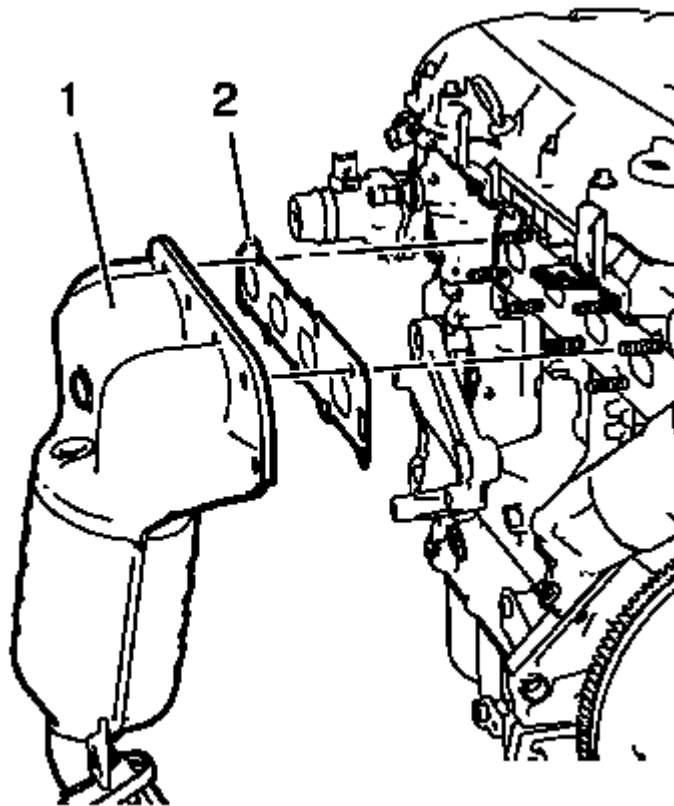


Fig. 310: Exhaust Manifold And Gasket

Courtesy of GENERAL MOTORS COMPANY

2. Install a NEW exhaust manifold gasket (2).
3. Install the exhaust manifold (1).

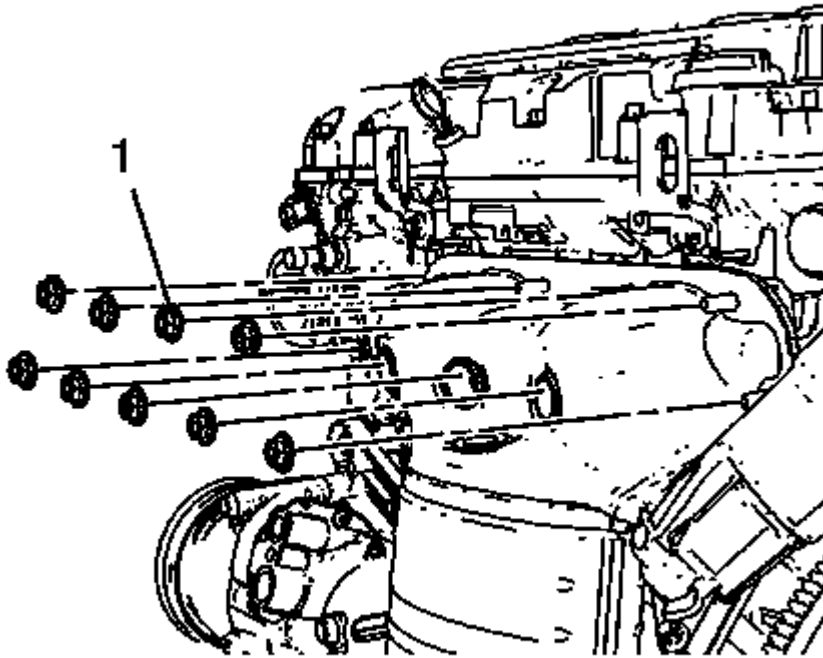


Fig. 311: Exhaust Manifold Nuts

Courtesy of GENERAL MOTORS COMPANY

4. Install the 9 exhaust manifold nuts (1) and handtighten.

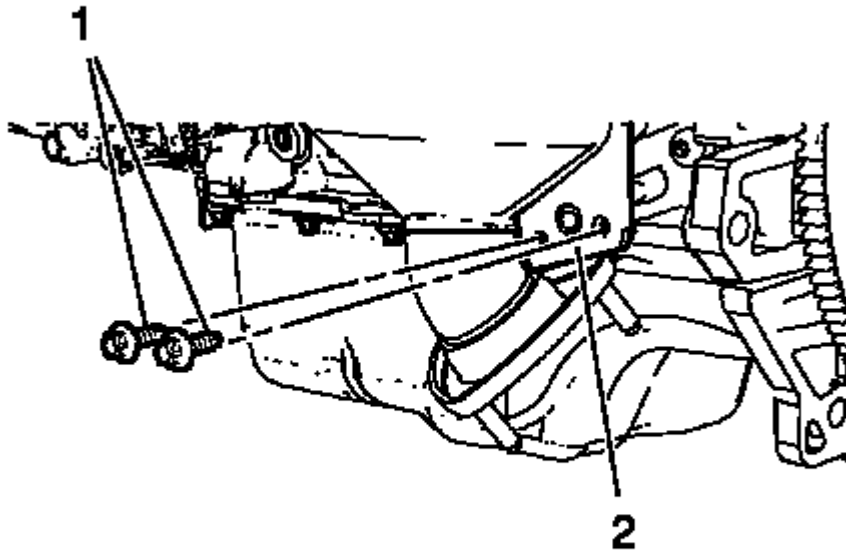


Fig. 312: Catalytic Converter Bracket And Bolts
 Courtesy of GENERAL MOTORS COMPANY

5. Install the 2 catalytic converter bracket bolts (1) to the catalytic converter bracket (2).

CAUTION: Refer to Fastener Caution .

6. Tighten the 9 exhaust manifold nuts to 22 N.m (16 lb ft).
7. Tighten the 2 catalytic converter bracket bolts to 10 N.m (89 lb in).

ENGINE LIFT BRACKET INSTALLATION

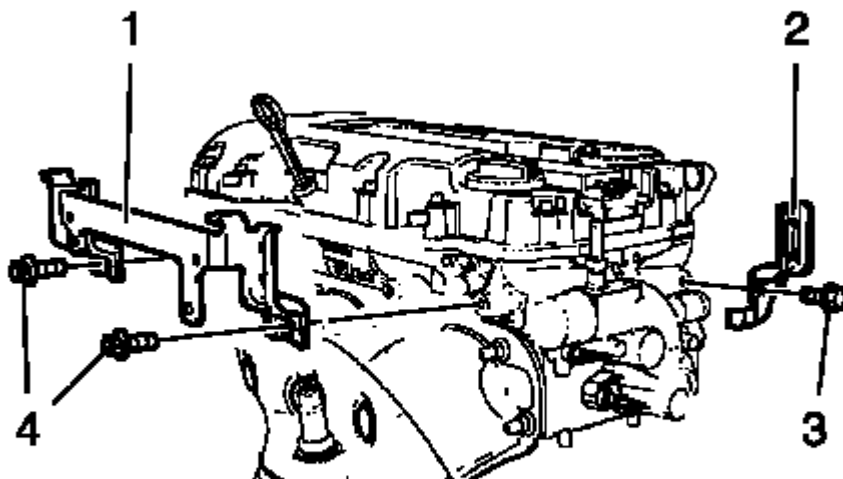


Fig. 313: Sidewise Engine Lift Bracket And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Install the engine lift bracket (1).

CAUTION: Refer to Fastener Caution .

2. Install the 2 engine lift bracket bolts (4) and tighten to 22 N.m (16 lb ft).
3. Install the sidewise engine lift bracket (2).
4. Install the sidewise engine lift bracket bolt (3) and tighten to 22 N.m (16 lb ft).

ENGINE MOUNT BRACKET INSTALLATION

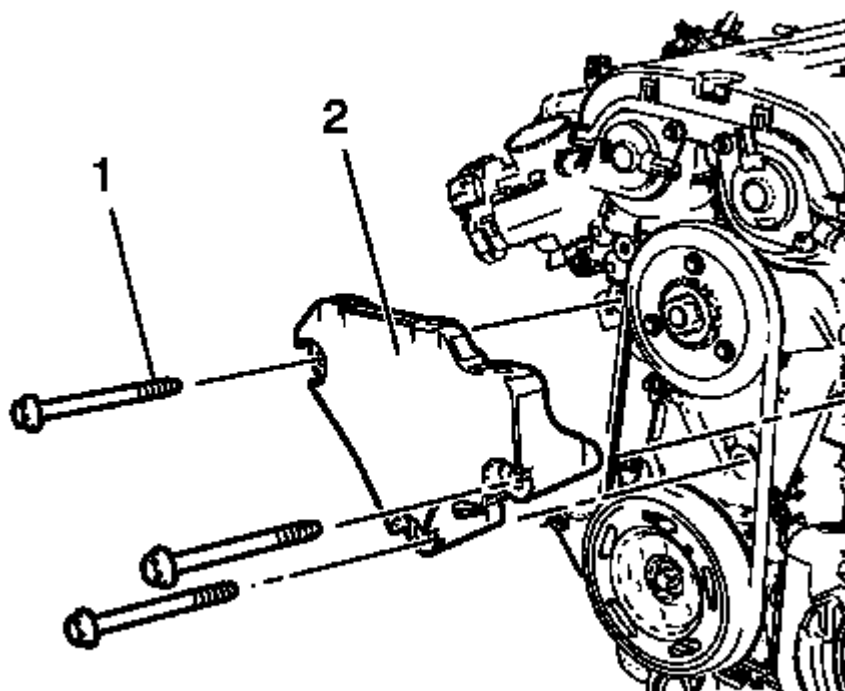


Fig. 314: Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install the engine mount bracket (2).

CAUTION: Refer to Fastener Caution .

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

2. Install the 3 engine mount bracket bolts and tighten to 60 N.m (44 lb ft) + 45-60°.

ENGINE FRONT COVER AND OIL PUMP ASSEMBLE

Oil Pump Installation

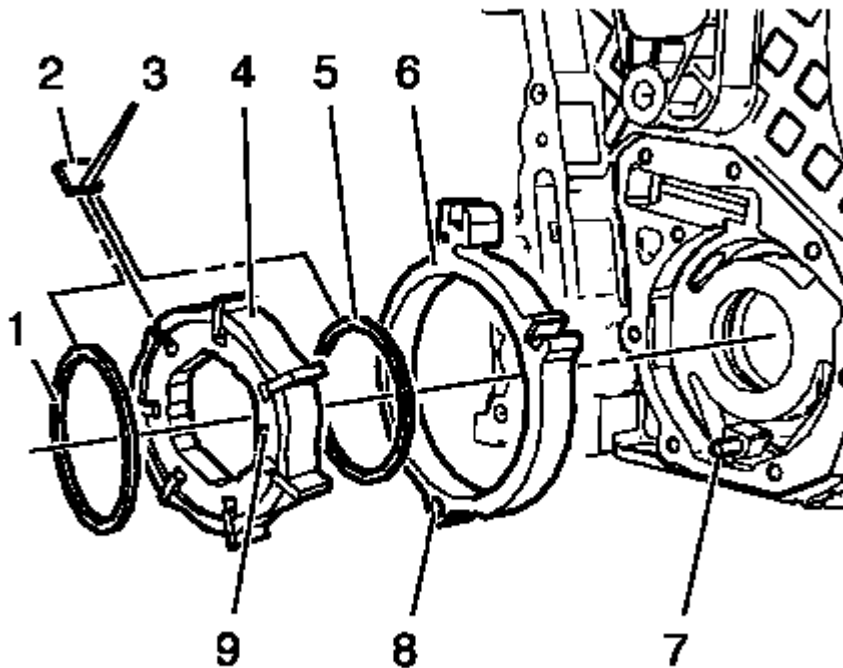


Fig. 315: Oil Pump Components

Courtesy of GENERAL MOTORS COMPANY

NOTE: Oil pump slide spring pin and oil pump slide spring, as well as slide seal and slide seal spring can be ordered as single parts. All other oil pump components can only be ordered as a replacement kit.

1. Install the oil pump components in the following order:

NOTE: The bore (8) in the oil pump slide must fit smooth-running and without clearance to the oil pump slide pivot pin (7)

1. Install the oil pump slide (6).
2. Install the inner oil pump vane ring (5).

NOTE: Mind the installation position of the oil pump vane rotor (4). The mark (9) must point to direction of the oil pump cover.

3. Install the oil pump vane rotor (4).

NOTE: Mind the localized flattings (3) on the oil pump vanes (2) caused by

the oil pump vane rings. The localized flattings must point to the oil pump vane rotor.

4. Install the 6 oil pump vanes (2).
5. Install the outer oil pump vane ring (1).

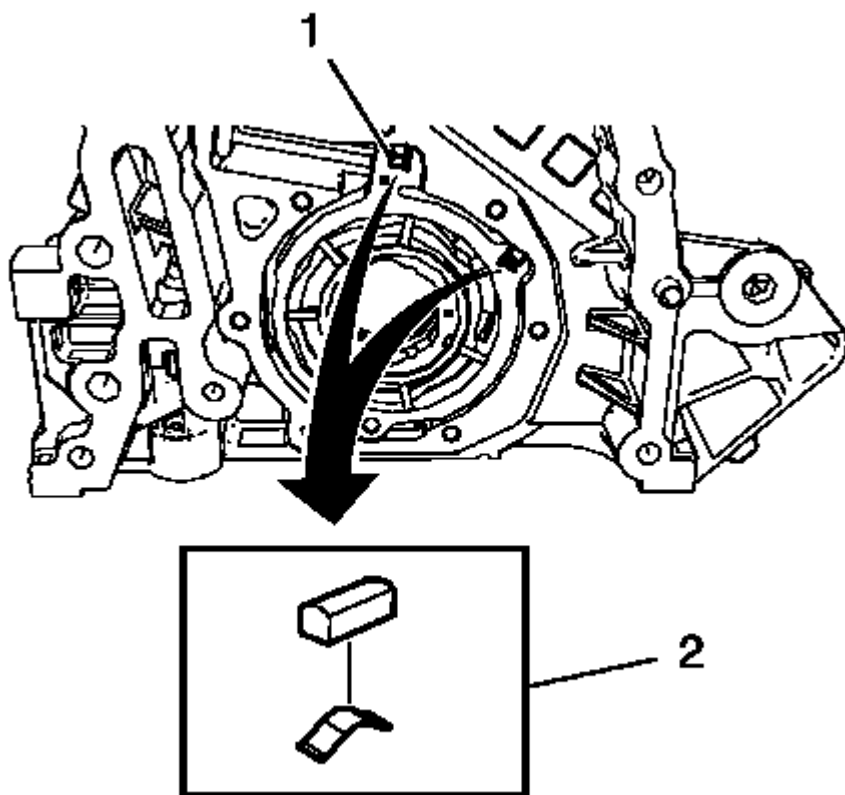


Fig. 316: Oil Pump Slide Seal Springs And Grooves
Courtesy of GENERAL MOTORS COMPANY

2. Install the 2 oil pump slide seals and the 2 oil pump slide seal springs (2) in the position as shown to the 2 grooves (1) of the oil pump slide.

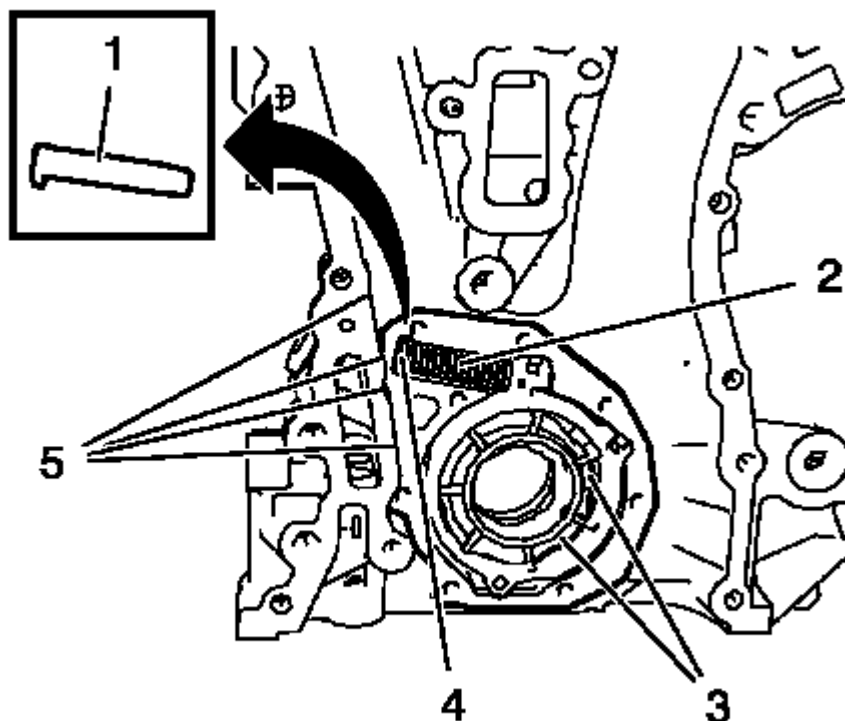


Fig. 317: Oil Pump Slide Spring, Pin, Chambers And Front Cover Edge
Courtesy of GENERAL MOTORS COMPANY

3. Protect the engine front cover edge (5) with a suitable piece of plastics.

NOTE: The length of the removed oil pump slide spring (2) should be 76.5 mm (3.0118 in).

4. Install the oil pump slide spring pin along with the oil pump slide spring (4). Use a screwdriver to compress the oil pump slide spring. The flat side of oil pump slide spring pin must face upwards.
5. Measure the oil pump clearances to ensure a correct installation of the oil pump components. Refer to Engine Front Cover and Oil Pump Cleaning and Inspection.
6. Lubricate the oil pump vanes, the oil pump vane rotor, the oil pump slide spring and the area (3) with engine oil.
7. Inspect the oil pump slide spring mechanism for practicability.

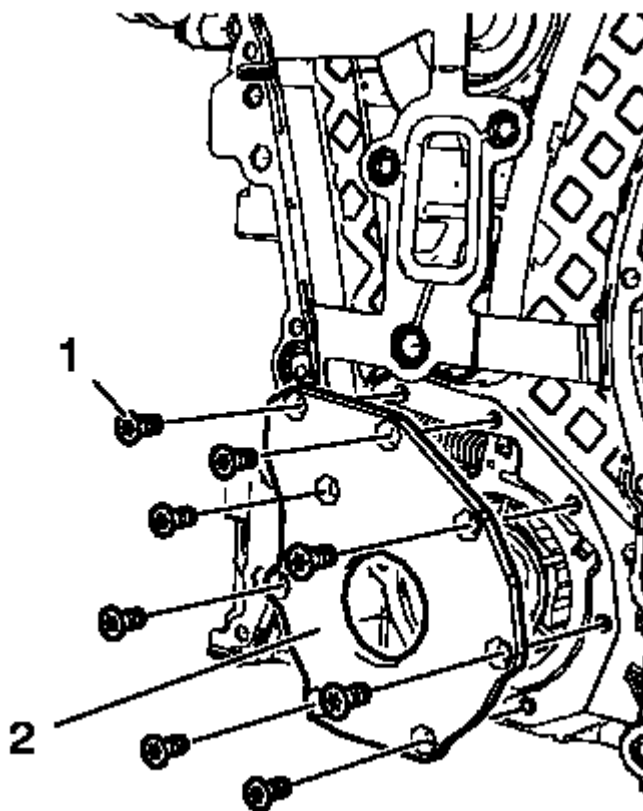


Fig. 318: Engine Oil Pump Cover And Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Install the oil pump cover (2) and the 8 oil pump cover bolts (1).

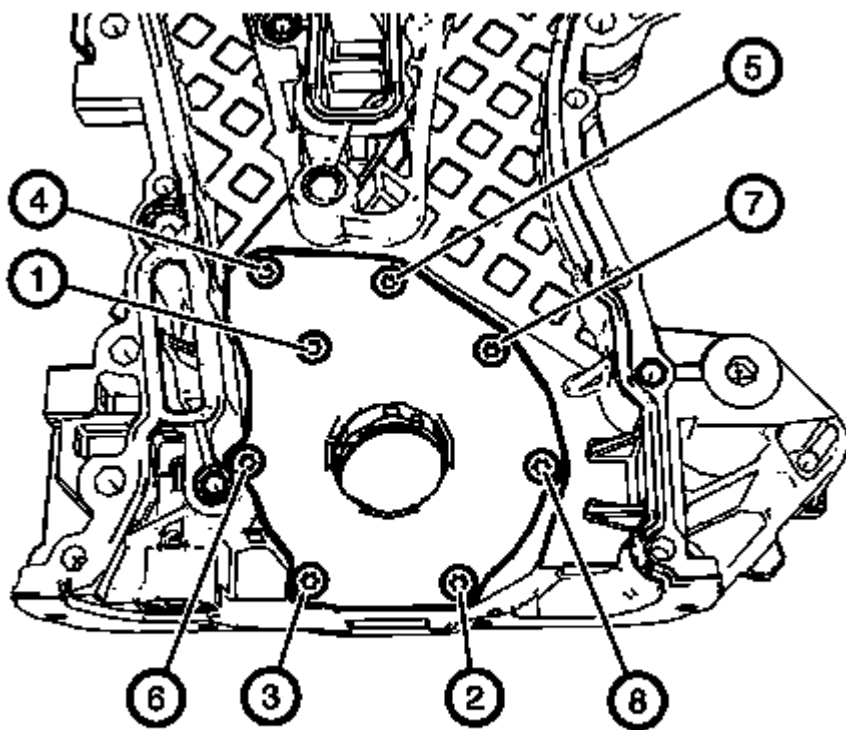


Fig. 319: Oil Pump Cover Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

9. Tighten the oil pump cover bolts in a sequence as shown to 8 N.m (71 lb in).

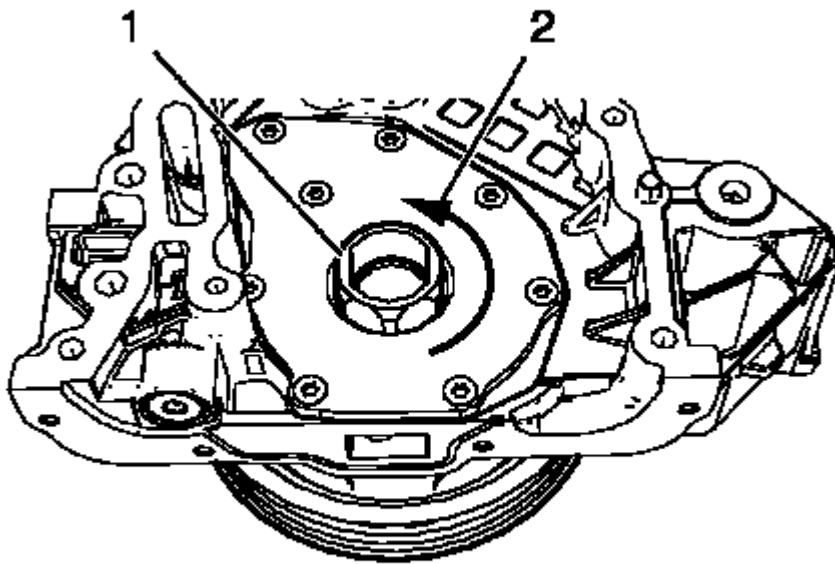


Fig. 320: Crankshaft Balancer

Courtesy of GENERAL MOTORS COMPANY

10. Install the crankshaft balancer (1) and rotate in shown direction (2) in order to inspect the function of the oil pump mechanism. Crankshaft balancer should be rotated easily.

Engine Front Cover Assemble

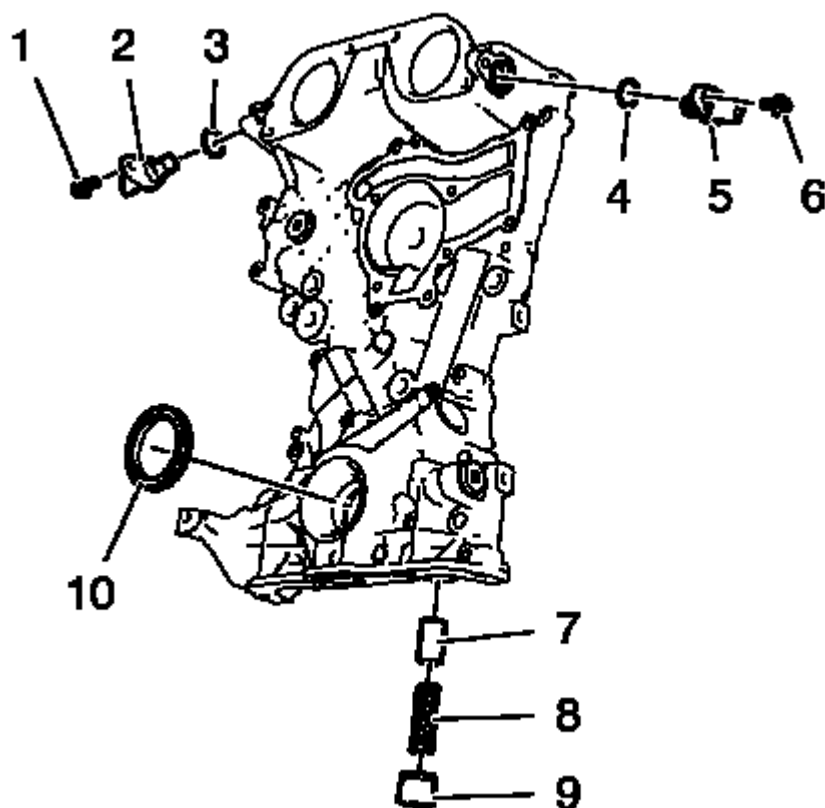


Fig. 321: Engine Front Cover Components

Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft front oil seal (10).
2. Install the oil pressure relief valve (7), (8) and (9) and tighten to 50 N.m (37 lb ft).
3. Install the exhaust camshaft position sensor (5) and the seal ring (4).
4. Install the exhaust camshaft sensor bolt (6) and tighten to 6 N.m (53 lb in).
5. Install the intake camshaft position sensor (2) and the seal ring (3).
6. Install the intake camshaft sensor bolt (1) and tighten to 6 N.m (53 lb in).

WATER PUMP BELT REMOVAL

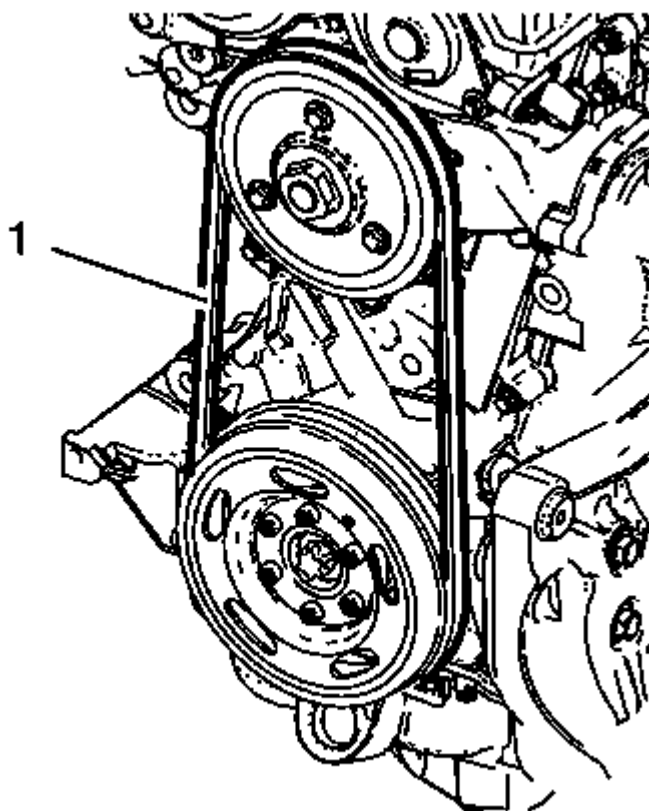


Fig. 322: Water Pump Belt

Courtesy of GENERAL MOTORS COMPANY

1. Cut the water pump belt (1) with a suitable cutting tool.
2. Remove the water pump belt.

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

Special Tools

- **EN-49979** Crankshaft Shock Mount Retainer.
- **EN-956-1** Extension.

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

1. Install **EN-49979** retainer to **EN-956-1** extension.

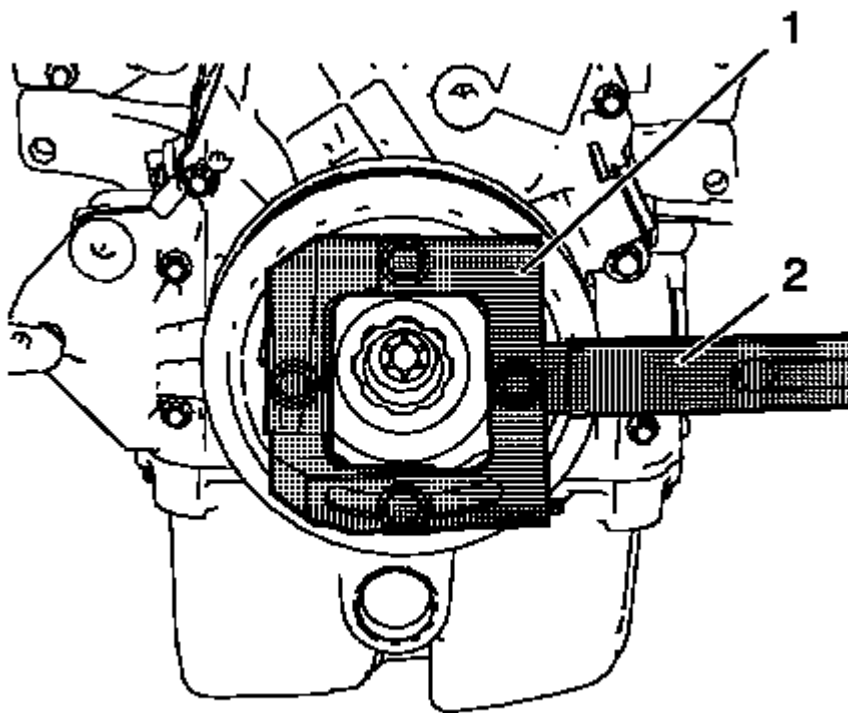


Fig. 323: Crankshaft Balancer And Special Tool
Courtesy of GENERAL MOTORS COMPANY

2. Install **EN-49979** retainer (1) in compound with **EN-956-1** extension (2) to the crankshaft balancer as shown.

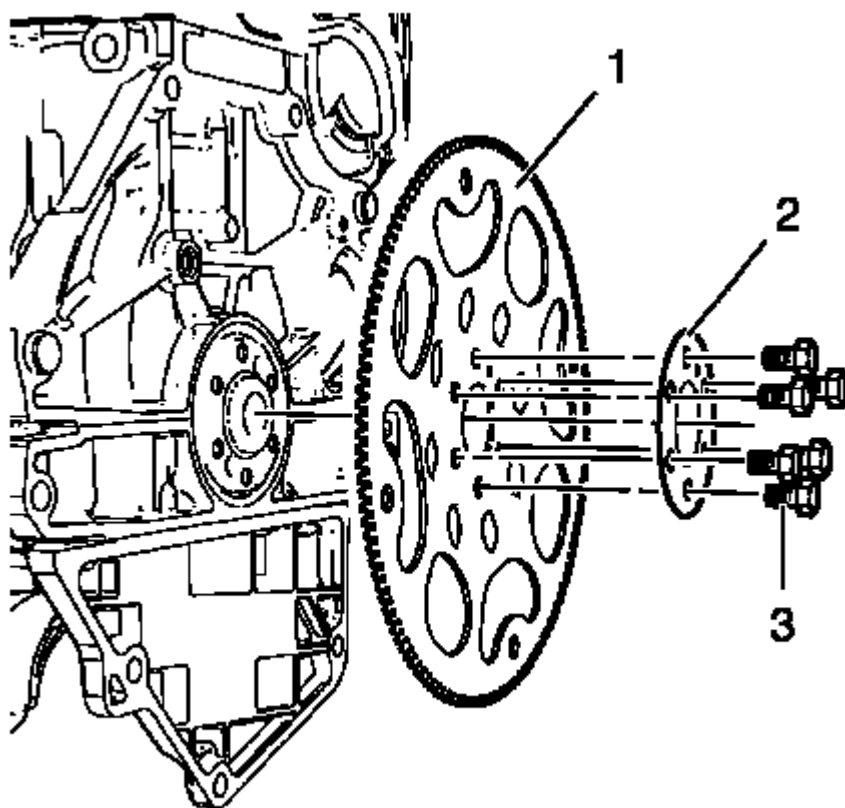


Fig. 324: Flex Plate And Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Loosen the 6 flex plate bolts (3) while holding up the crankshaft balancer.
4. Remove the 6 flex plate bolts and the flex plate bolt washer (2).
5. Remove the flex plate (1).

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

EN-8087 Cylinder Bore Gauge

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

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant.
2. Clean all the following areas with solvent:
 - Sealing surfaces
 - Cooling passages
 - Oil passages

3. Clean all threaded and through holes with solvent.

WARNING: Wear safety glasses when using compressed air in order to prevent eye injury.

4. Dry the engine block with compressed air.

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 engine block assembly must be replaced.
2. Inspect all sealing and mating surfaces for damage, repair or replace the engine block assembly if necessary.
3. Inspect all threaded and through holes for damage or excessive debris.
4. Inspect all bolts for damage, if damaged replace with NEW bolts only.
5. 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.
6. Inspect the engine block for cracks. Do not repair any cracks. If cracks are found, the cylinder block assembly must be replaced.

Measuring Procedure

Engine Block Flatness Inspection

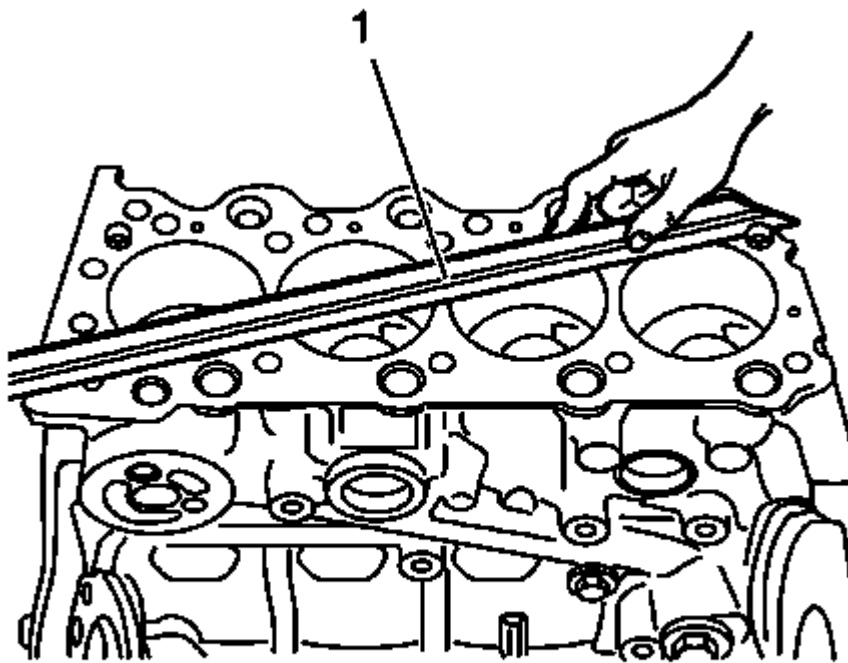


Fig. 325: Inspecting Engine Block For Distortion Using Straight Edge
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the engine block as shown for distortion. Use a straightedge (1).

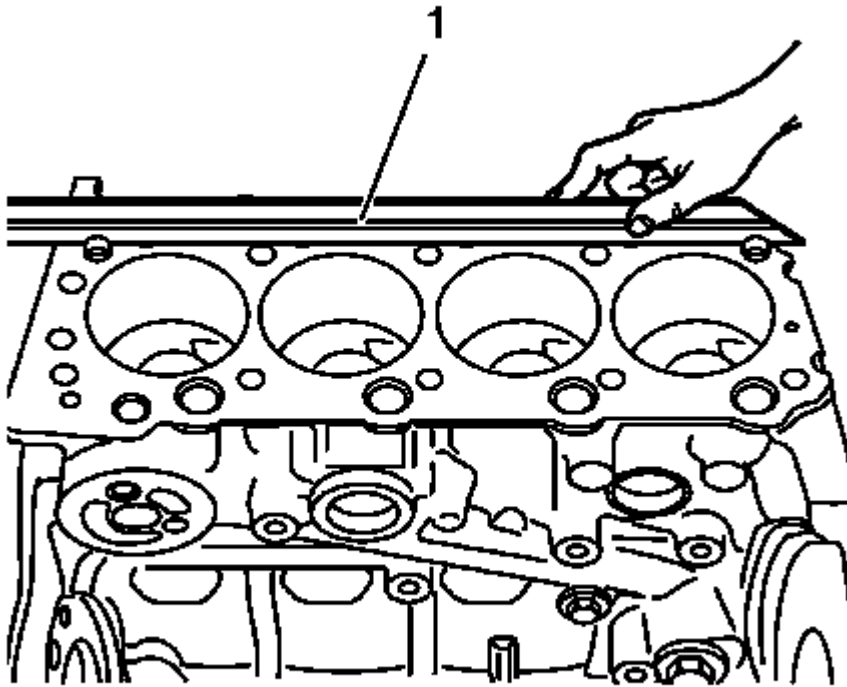


Fig. 326: Inspecting Engine Block For Deflection Using Straight Edge
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the engine block as shown for deflection. Use a straightedge (1).

Cylinder bore and crankshaft bearing bore

NOTE: Old bolts can be used for the measuring procedure.

1. Install the crankshaft bearing cap tie plate and tighten.

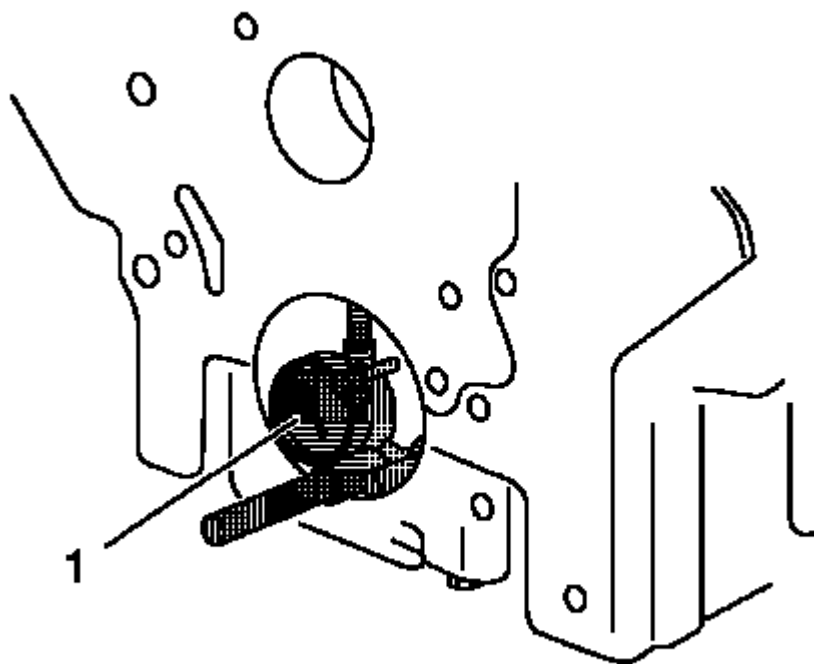


Fig. 327: Measuring Bearing Bore Concentricity And Alignment Using Gauge Tool
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the crankshaft main bearing bores. Use the **EN-8087** gauge (1) to measure the bearing bore concentricity and alignment. Refer to **Engine Mechanical Specifications** to find the permitted values.
3. Replace the engine block and crankshaft bearing cap tie plate if the crankshaft bearing bores are out of specification.

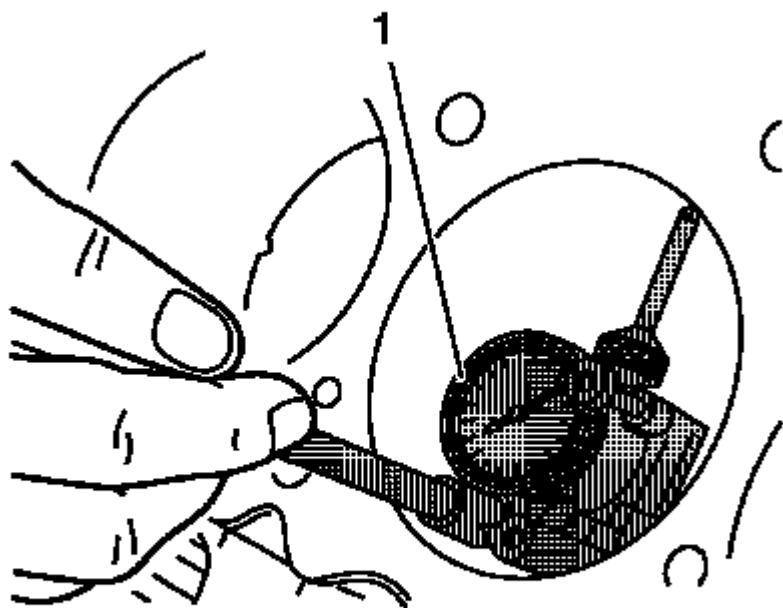


Fig. 328: Inspecting Cylinder Bore
Courtesy of GENERAL MOTORS COMPANY

4. Inspect the cylinder bores using the **EN-8087** gauge (1). Inspect for the following items:
 - Wear
 - Taper
 - Runout
 - Ridging
5. Refer to **Engine Mechanical Specifications** to find the permitted values.
6. If the cylinder bores are out of specification, replace the engine block.
7. Remove the crankshaft bearing cap tie plate.

AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

Special Tools

- **EN-49979** Crankshaft Shock Mount Retainer.
- **EN-956-1** Extension.
- **EN-470-B** Angular Torque Wrench.

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

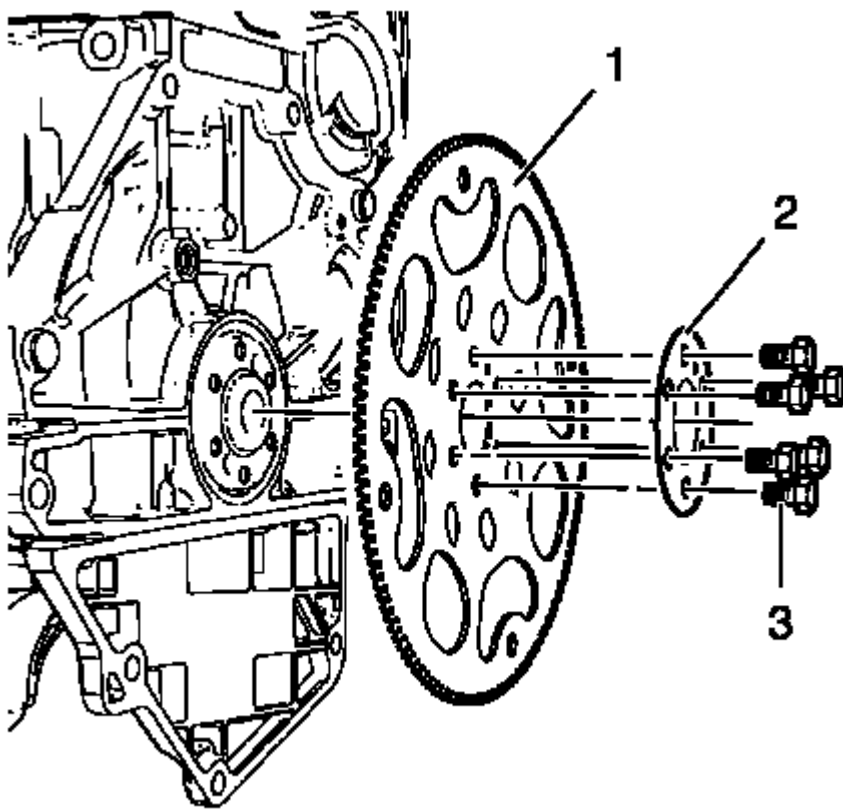


Fig. 329: Flex Plate And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Install the flex plate (1).
2. Install the flex plate bolt washer (2) and the 6 flex plate bolts (3).
3. Install **EN-49979** retainer to **EN-956-1** extension.

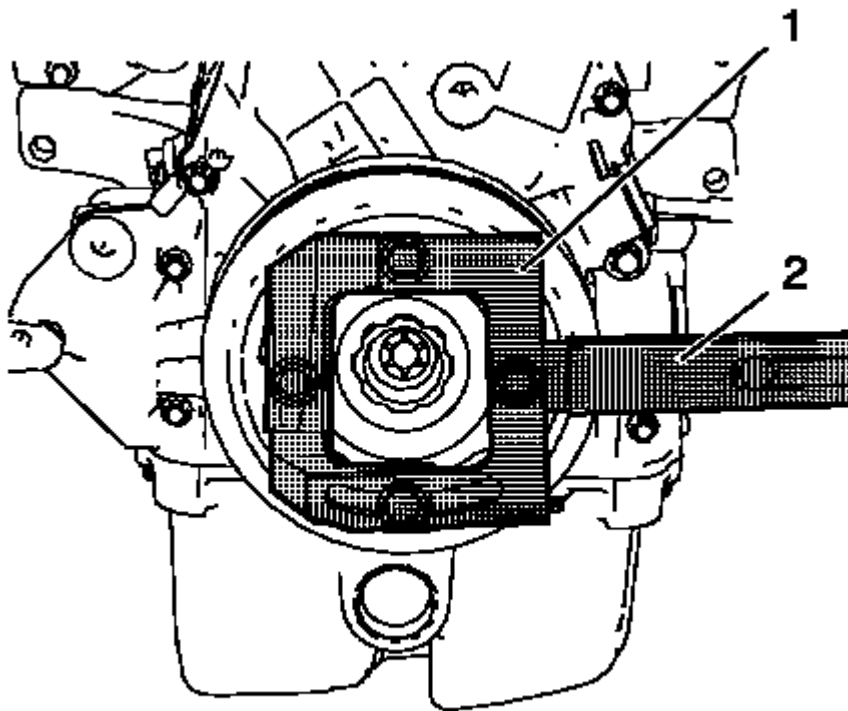


Fig. 330: Crankshaft Balancer And Special Tool
Courtesy of GENERAL MOTORS COMPANY

4. Install **EN-49979** retainer (1) in compound with **EN-956-1** extension (2) to the crankshaft balancer as shown.

CAUTION: Refer to Fastener Caution .

5. Tighten the 6 flex plate bolts to 35 N.m (26 lb ft).
6. Tighten the 6 flex plate bolts to an additional 30°. Use **EN-470-B** wrench.
7. Tighten the 6 flex plate bolts to an additional 15°. Use **EN-470-B** wrench.

DESCRIPTION AND OPERATION

ENGINE COMPONENT DESCRIPTION

Cylinder Block

The cylinder block is a hollow frame structured in-line 4 cylinder. The block has 5 crankshaft bearings with the thrust bearing located on the third bearing from the front of the engine.

Crankshaft

The crankshaft is a steel crankshaft. It is supported in 5 main journals with main bearings which have oil clearance for lubrication. The 3rd bearing which controls the proper axial end play of the crankshaft.

Oil Pump

The engine is equipped with a variable oil pump. The oil pump is integrated into the engine front cover and provides different oil pressure values depending on the engine speed.

Oil Pan

The oil pan is a structural aluminum oil pan with transmission attachment points. The oil suction gallery for the oil pump is integrated into the oil pan.

Piston and Connecting Rod

The pistons are aluminum pistons. The connecting rods are made of fractured steel. The piston pin is floating in piston bore and shrunk in connecting rod.

Cylinder Head

This cylinder head is a double over head camshaft (DOHC) type and has 2 camshafts that open 4 valves per cylinder with hydraulic valve lash adjusters and hydraulic valve lash adjuster arms. The cylinder head is made of cast aluminum alloy for strength and hardness while remaining light weight. The combustion chamber of the cylinder head is designed for increasing of squish and swirl efficiency to help maximize gasoline combustion efficiency.

Camshaft Drive with Variable Camshaft Timing

A timing chain is used for camshaft drive. There is a tensioner to control the tension of the chain. The engine is equipped with a variable camshaft timing system. The camshaft adjuster will readjust itself depending on the engine speed. The valve timing readjusts to reduce fuel consumption and provides optimal power and torque. The variable camshaft timing makes an exhaust gas recirculation unnecessary.

Intake Manifold

The intake manifold provides the air flow passage to the combustion chambers through the throttle body. The intake manifold along with the throttle body have an effect on engine torque, power, noise, driveability, emission, fuel economy and performance. The intake manifold is made of plastic for better strength with maintaining a light weight.

Exhaust Manifold

The exhaust manifold is located to the cylinder head and channels the exhaust gas out of the combustion chamber. It is designed to endure on high pressure and high temperature. The exhaust manifold includes the catalytic converter.

LUBRICATION DESCRIPTION

General Lubrication Description

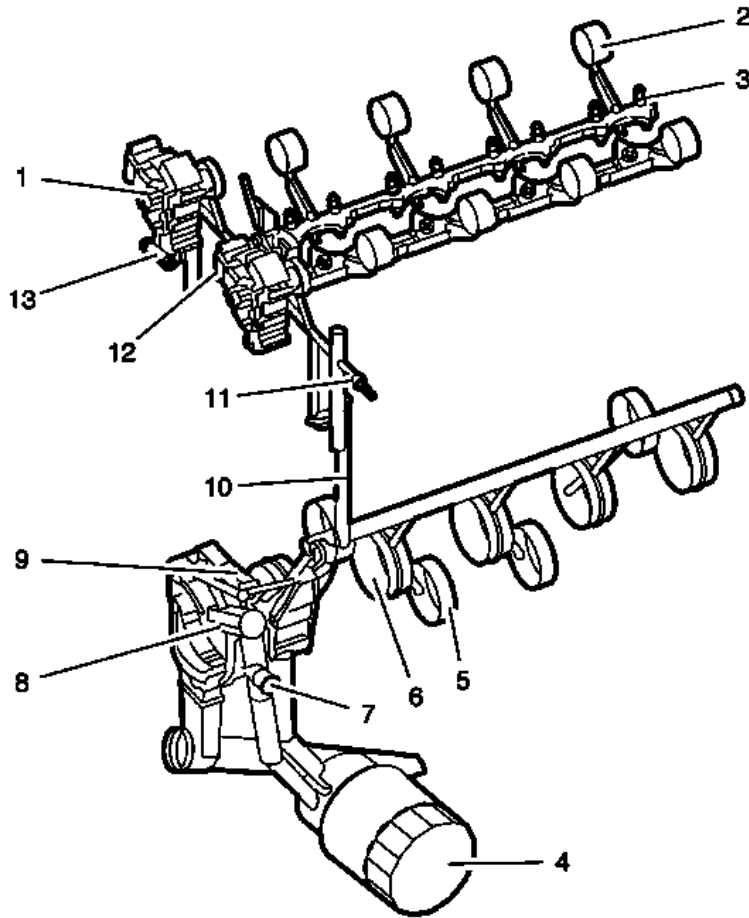


Fig. 331: Engine Lubrication System
 Courtesy of GENERAL MOTORS COMPANY

Oil is applied under pressure to the crankshaft bearings (6), connecting rod bearings (5), camshaft bearings (2) and hydraulic lash adjusters (3). In addition the variable oil pump (8), variable camshaft phaser (1), and hydraulic chain tensioner (13) are supplied with pressurized oil. Oil is sucked from the oil pan through the fixed screen into the variable vane type oil pump. The pump is integrated in the front cover and directly driven by the crank shaft. Also integrated into the front cover is a pressure relieve valve (7) that opens when the oil pressure is too high at a cold start. When that valve is open some oil flows directly into the oil pan. Normally the pressurized oil passes into the engine oil gallery leading to the oil filter (4). The oil is cleaned by passing the filter from the outer to the inner side of the filter. Then the oil flows into the main oil gallery. A filter by-pass valve in the oil filter ensures continues oil flow in case the oil filter should be restricted by more than 1.7 bar. From the oil filter the oil is distributed to the crankshaft bearings, oil pump displacement control chamber (9) and cylinder head feed (10). The connecting rod bearings are supplied by oil flow passages through the crankshaft connecting the main journals to the rod journals. A groove around each upper main bearing furnishes




oil to the drilled crankshaft passages. In the cylinder head the oil is distributed to the variable camshaft phasers, chain tensioner, oil pressure switch (11) and through the restrictor orifice (12) into the camshaft feed oil gallery. From there the hydraulic valve lifters and camshaft bearings are supplied with oil.

Variable Oil Pump Description

The engine is equipped with a variable displacement vane oil pump. It is indirectly regulated by the oil pressure out of the main oil gallery. The purpose of this indirect regulation is to keep a defined maximal pressure in the main oil gallery independently of the individual pressure drop between the pump outlet and the main gallery inlet and the individual oil flow to the consumers (bearing clearances differ, wear differs, •••) The purpose of the variable displacement is to reduce the power consumption of the pump to reduce the overall fuel consumption of the engine. The oil flow of a static displacement oil pump is linear to the speed of the pump. This would lead to a too high oil pressure after a certain engine speed (ca. 1000 rpm at cold oil temperature, ca. 3000 rpm at hot oil temperatures). To reduce that high oil pressure normal pumps have a relieve valve: a portion of the pressurized, already pumped oil is fed back to the intake of the pump. This is waste of power. The oil flow of a Variable Displacement Vane Pump (VDVP) as used in Fam 0 Gen 3 is linear to the speed and to the excentricity of the rotor to the slide. The slide is moveable, so it is possible to reduce the oil flow for a given speed by reducing the excentricity. With a lower flow the oil pressure is reduced; pump oil flow equals now engine oil flow.

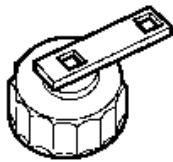
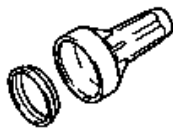
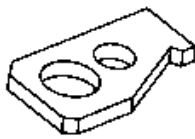
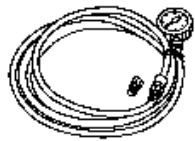
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number / Description
	207649 Rod Hairpins
	547324 Flange Screws
	EN-194-E KM-194-E Spark Plug Key
	EN-470-B KM-470-B J-45059 Angular Torque Wrench

2013 Chevrolet Volt

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EN-498-B
KM-498-B
Pressure Gauge

EN-652
DT-652
KM-652
Flywheel Holder

EN-658
KM-658
J-35264
Installer

EN-663
KM-663
Installer

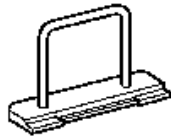
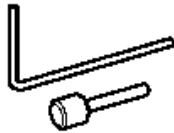
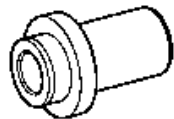
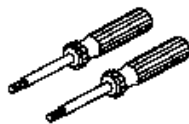
EN-726-A
KM-726-A
J-29142
Oil Filter Wrench

EN-840
KM-840
Pliers / Remover

EN-952
KM-952
Fixing Tool Crankshaft

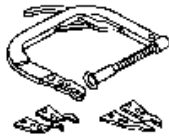
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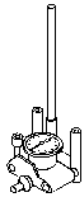
EN-953-1
Fixing Tool CamshaftEN-955
KM-955
Locking PinsEN-956-1
KM-956-1
ExtensionEN-958
KM-958
Valve Stem Seal InstallerEN-960
KM-960
InstallerEN-6009
KM-6009
Remover / InstallerEN-6179
KM-6179
Installer / RemoverEN-6216
MKM-6216
Dial Gauge

2013 Chevrolet Volt

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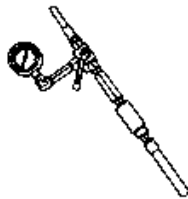
EN-8062
J-8062
Valve Spring Compressor



EN-8087
J-8087
Cylinder Bore Gauge



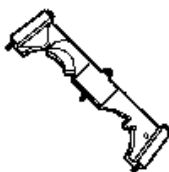
EN-45000
KM-J-45000
J-45000
Remover Oil Seal



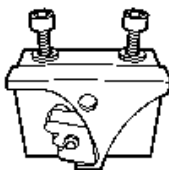
EN-48248
Cylinder Compression Pressure Gauge



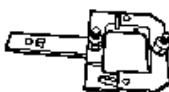
EN-48488
KM-956
Holding Wrench



EN-49977-100
Fixation Sensor Disks and Camshafts



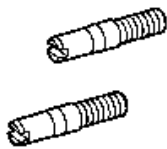
EN-49977-200
Fixing Tool



EN-49979
Retainer Shock Mount Crankshaft

2013 Chevrolet Volt

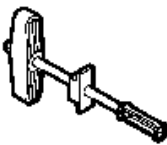
2013 ENGINE Engine Mechanical - 1.4L (LUU) - Volt



EN-49980
Guidance Pins Oil Pan



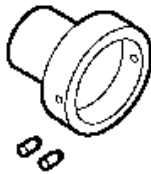
EN-50717-1
Stands



EN-50717-2
Compressor



GE-571-B
MKM-571-B
Dial Gauge



J-8062-5
Adapter



J-43649-2
Rods