

2009 Pontiac Vibe

2009 ENGINE Engine Mechanical - 1.8L (LAY) - Vibe

2009 ENGINE**Engine Mechanical - 1.8L (LAY) - Vibe****SPECIFICATIONS****FASTENER TIGHTENING SPECIFICATIONS**

Application	Specification	
	Metric	English
Air Cleaner Case Bolt	7.0 N.m	62 lb in
Air Tube	10 N.m	7 lb ft
Battery Carrier Bolt	13 N.m	9 lb ft
Battery Clamp		
• Bolt	17 N.m	12 lb ft
• Nut	3.5 N.m	31 lb in
Battery Terminal	5.4 N.m	48 lb in
Camshaft Bearing Cap Bolt to Camshaft Housing	16 N.m	12 lb ft
Camshaft Bearing Cap Bolt to Cylinder Head	27 N.m	20 lb ft
Camshaft Housing Bolt	27 N.m	20 lb ft
Camshaft Oil Control Valve Bolt	10 N.m	7 lb ft
Camshaft Position Sensor Bolt	10 N.m	7 lb ft
Camshaft Timing Exhaust Gear Bolt		
• With SST	39 N.m	29 lb ft
• Without SST	54 N.m	40 lb ft
Camshaft Timing Gear Assembly Bolt	54 N.m	40 lb ft
Clutch Release Cylinder Assembly Bolt		
• Bolt A, B	12 N.m	9 lb ft
• Bolt C	8.0 N.m	71 lb in
Connecting Rod Cap Bolt		
• 1st	20 N.m	15 lb ft
• 2nd	Turn 90°	
Chain Tensioner Plate Bolt	10 N.m	7 lb ft
Crankshaft Bearing Cap to Cylinder Block		
• 1st	40 N.m	30 lb ft
• 2nd	Turn 90°	
Crankshaft Position Sensor Bolt	10 N.m	7 lb ft
Crankshaft Pulley Bolt	190 N.m	140 lb ft
Cylinder Block Water Drain Cock	13-20 N.m	9-15 lb ft

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Cylinder Head Bolt

• 1st	49 N.m	36 lb ft
• 2nd	Turn 90°	
• 3rd	Turn 45°	
Cylinder Head Cover Bolt	10 N.m	7 lb ft
Drive Plate and Ring Gear Bolt		
• 1st	88 N.m	65 lb ft
• 2nd	Turn 90°	
Drive Plate and Ring Gear Nut	28 N.m	21 lb ft
Engine Coolant Temperature	20 N.m	15 lb ft
Engine Hanger Bolt	43 N.m	32 lb ft
Engine Mounting Bracket RH to Engine Mounting Insulator RH		
• Nut A	95 N.m	70 lb ft
• Nut B	52 N.m	38 lb ft
• Bolt	95 N.m	70 lb ft
Engine Mounting Bracket RH Bolt	51 N.m	37 lb ft
Engine Mounting Insulator LH to Engine Mounting Bracket Bolt	52 N.m	38 lb ft
Engine Mounting Insulator LH to Body Bolt	56 N.m	41 lb ft
Engine Mounting Insulator RH to Body Bolt	52 N.m	38 lb ft
Engine Oil Pressure Switch Assembly	15 N.m	11 lb ft
Exhaust Manifold Nut	21 N.m	16 lb ft
Exhaust Manifold Stay Bolt	43 N.m	32 lb ft
Exhaust Manifold Stay Nut	43 N.m	32 lb ft
Fan Belt Adjusting Bar Bolt	19 N.m	14 lb ft
Fan Belt Adjusting Bar Nut	19 N.m	14 lb ft
Flywheel Sub-Assembly Bolt	49 N.m	36 lb ft
Front Engine Mounting Bracket Bolt	73 N.m	54 lb ft
Front Engine Mounting Insulator Bolt	81 N.m	60 lb ft
Ignition Coil Assembly Bolt	10 N.m	7 lb ft
Intake Manifold Nut	28 N.m	21 lb ft
Knock Control Sensor	20 N.m	15 lb ft
No. 1 Chain Tensioner Assembly Bolt	10 N.m	7 lb ft
No. 1 Chain Vibration Damper Bolt	21 N.m	16 lb ft
No. 1 Exhaust Manifold Heat Insulator Bolt	12 N.m	9 lb ft
No. 1 Generator Bracket Bolt	21 N.m	16 lb ft
No. 1 Oil Nozzle Sub-Assembly Bolt	10 N.m	7 lb ft
No. 1 Ventilation Case Bolt	10 N.m	7 lb ft
No. 1 Water By-Pass Pipe Bolt	21 N.m	16 lb ft

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No. 2 Chain Vibration Damper Bolt

• With SST	5.5 N.m	48 lb in
• Without SST	10 N.m	7 lb ft
No. 2 Oil Pan Sub-Assembly Bolt	10 N.m	7 lb ft
No. 2 Straight Screw Plug	44 N.m	33 lb ft
Oil Drain Plug	37 N.m	27 lb ft
Oil Filter Bracket Bolt	26 N.m	19 lb ft
Oil Level Dipstick Guide Bolt	21 N.m	16 lb ft
Oil Pan Drain Plug	37 N.m	27 lb ft
Oil Pump Assembly Bolt	21 N.m	16 lb ft
Oil Pump Drive Shaft Gear Bolt	28 N.m	21 lb ft
Radiator Pipe Bolt	8.8 N.m	78 lb in
Radiator Reserve Tank Bolt	7.0 N.m	62 lb in
Radio Setting Condenser Bolt	10 N.m	7 lb ft
Rear Engine Mounting Bracket Bolt	65 N.m	50 lb ft
Rear Engine Mounting Insulator Bolt	52 N.m	38 lb ft
Stiffening Crankcase Assembly Bolt	21 N.m	16 lb ft
Spark Plug	20 N.m	15 lb ft
Stud Bolt to Crankcase	5.0 N.m	44 lb in
Stud Bolt to Cylinder Head		
• Bolt A	9.5 N.m	84 lb in
• Bolt B	9.5 N.m	84 lb in
Stud Bolt to No. 1 Ventilation Case	10 N.m	7 lb in
Timing Chain Cover		
• Bolt A	26 N.m	19 lb in
• Bolt B	51 N.m	38 lb in
• Bolt C	51 N.m	38 lb in
• Bolt D	10 N.m	7 lb in
• Bolt E	26 N.m	19 lb in
Ventilation Valve Bolt	20 N.m	15 lb in
Water Inlet Bolt	10 N.m	7 lb in
Water Inlet Housing Bolt	21 N.m	16 lb in
Water Pump Bolt	24 N.m	17 lb in
Wire Harness Bracket to Cylinder Head	52 N.m	38 lb in

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English

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V-Belt Deflection

• New Belt	7.5-8.6 mm	0.30-0.34 in
• Used Belt	8.0-10.0 mm	0.32-0.39 in

V-Belt Tension

• New Belt	637-735 N.m	143-165 lb ft
• Used Belt	392-588 N.m	88-132 lb ft

Ignition Timing - With terminals TC and CG of DLC3 connected

8-12° BTDC at idle

Idle Speed

600-700 RPM

Compression

• Compression Pressure	1373 kPa	199 psi
• Minimum Pressure	1079 kPa	157 psi
• Difference between each cylinder	98 kPa	14 psi

Oil Pump Drive Socket - Minimum Sprocket Diameter (With Chain)

48.2 mm

1.898 in

Oil Pump Drive Shaft Socket - Minimum Sprocket Diameter (With Chain)

48.8 mm

1.921 in

Crankshaft Timing Sprocket - Minimum Sprocket Diameter (With Chain)

51.1 mm

2.012 in

Chain Tensioner Slipper - Maximum Wear

1.0 mm

0.039 in

Chain Vibration Damper - Maximum Wear

1.0 mm

0.039 in

Chain Tensioner Plate - Maximum Wear

1.0 mm

0.039 in

Cylinder Head Set Bolt

• Standard Bolt Length	146.8-148.2 mm	5.7795-5.8346 in
• Maximum Bolt Length	149.2 mm	5.874 in
• Standard Outside Diameter	9.77-9.96 mm	0.3846-0.3921 in
• Minimum Outside Diameter	9.4 mm	0.3701 in

Ring Pin (Cylinder Head) - Protrusion

6.5-7.5 mm

0.26-0.30 in

Ring Pin (Crankcase) - Protrusion

3 mm

0.12 in

No. 1 Camshaft Bearing - Dimension A-B

0.7 mm or less

0.0276 in or less

No. 2 Camshaft Bearing - Dimension A

1.05-1.75 mm

0.0413-0.0689 in

Camshaft Housing - Seal Diameter

3.5-4.0 mm

0.138-0.158 in

Chain Sub-Assembly - Maximum Chain Elongation

115.2 mm

4.535 in

No. 2 Chain Sub-Assembly - Maximum Chain Elongation

102.1 mm

4.019 in

Camshaft Timing Gear Assembly - Minimum Gear or Sprocket Diameter (With Chain)

96.8 mm

3.811 in

Camshaft Timing Exhaust Gear Assembly - Minimum Gear or Sprocket Diameter (With Chain)

96.8 mm

3.811 in

Camshaft (Intake)

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• Maximum Circle Runout	0.04 mm	0.0016 in
• Standard Cam Lobe Height	42.816-42.916 mm	1.6857-1.6896 in
• Maximum Can Lobe Height	42.666 mm	1.6798 in
• No. 1 Journal Diameter	34.449-34.465 mm	1.3563-1.3569 in
• Other Journal Diameter	22.949-22.965 mm	0.9035-0.9041 in
• Standard Thrust Clearance - Intake	0.06-0.155 mm	0.0024-0.0061 in
• Maximum Thrust Clearance - Intake	0.17 mm	0.0067 in
Standard Oil Clearance		
• Camshaft No. 1 Journal	0.03-0.063 mm	0.0012-0.0025 in
• Camshaft Other Journals	0.035-0.072 mm	0.0014-0.0028 in
• Maximum Oil Clearance Camshaft No. 1 Journal	0.085 mm	0.0033 in
• Maximum Oil Clearance Camshaft Other Journals	0.09 mm	0.0035 in
Camshaft No. 2 (Exhaust)		
• Maximum Circle Runout	0.04 mm	0.0016 in
• Standard Cam Lobe Height	44.336-44.436 mm	1.7455-1.7494 in
• Minimum Can Lobe Height	44.186 mm	1.7396 in
• No. 1 Journal Diameter	34.449-34.465 mm	1.3563-1.3569 in
• Other Journal Diameter	22.949-22.965 mm	0.9035-0.9041 in
• Standard Thrust Clearance - Exhaust	0.06-0.155 mm	0.0024-0.0061 in
• Standard Thrust Clearance - Exhaust	0.17 mm	0.0067 in
Standard Oil Clearance		
• Camshaft No. 1 Journal	0.03-0.079 mm	0.0012-0.0031 in
• Camshaft Other Journals	0.035-0.072 mm	0.0014-0.0028 in
• Maximum Oil Clearance Camshaft No. 1 Journal	0.085 mm	0.0033 in
• Maximum Oil Clearance Camshaft Other Journal	0.09 mm	0.0035 in
• Exhaust Manifold - Maximum Warp	0.70 mm	0.028 in
Cylinder Head		
• Cylinder Block Side - Maximum Warp	0.05 mm	0.0020 in
• Intake Manifold Side - Maximum Warp	0.10 mm	0.0039 in
• Exhaust Manifold Side - Maximum Warp	0.10 mm	0.0039 in
Compression Spring		
• Free Length	53.36 mm	2.1008 in
• Maximum Deviation	1.0 mm	0.0394 in
Intake Valve		

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• Standard Overall Length	109.34 mm	4.3047 in
• Minimum Overall Length	108.84 mm	4.2850 in
• Valve Stem Diameter	5.470-5.485 mm	0.2154-0.2159 in
• Standard Margin Thickness	1.0 mm	0.0394 in
• Minimum Margin Thickness	0.50 mm	0.0197 in
• Valve Seat Width	1.0-1.4 mm	0.039-0.055 in
Exhaust Valve		
• Standard Overall Length	108.25 mm	4.2618 in
• Minimum Overall Length	107.75 mm	4.2421 in
• Valve Stem Diameter	5.465-5.480 mm	0.2152-0.2157 in
• Standard Margin Thickness	1.01 mm	0.0398 in
• Minimum Margin Thickness	0.50 mm	0.0197 in
• Valve Seat Width	1.0-1.4 mm	0.039-0.55 in
Intake Valve Guide Bush		
• Bush Inside Diameter	5.510-5.530 mm	0.2169-0.2177 in
• Standard Bush Oil Clearance	0.025-0.060 mm	0.0010-0.0024 in
• Maximum Bush Oil Clearance	0.080 mm	0.0031 in
Bush Bore Diameter		
• Use STD	10.285-10.306 mm	0.4049-0.4057 in
• Use O/S 0.05	10.335-10.356 mm	0.4069-0.4077 in
• Protrusion Height (Bush)	9.9-10.3 mm	0.3898-0.4055 in
• Standard Oil Clearance	0.025-0.060 mm	0.0010-0.0024 in
Exhaust Valve Guide Bush		
• Bush Inside Diameter	5.510-5.530 mm	0.2169-0.2177 in
• Standard Oil Clearance	0.030-0.065 mm	0.0012-0.0026 in
• Maximum Oil Clearance	0.085 mm	0.0033 in
Bush Bore Diameter		
• Use STD	10.285-10.306 mm	0.4049-0.4057 in
• Use O/S 0.05	10.335-10.356 mm	0.4069-0.4077 in
• Protrusion Height	11.15-11.55 mm	0.4390-0.4547 in
• Standard Oil Clearance	0.030-0.065 mm	0.0012-0.0026 in
• Protrusion Height (Ring Pin)	6.5-7.5 mm	0.26-0.30 in
• Valve Seat Width	1.0-1.4 mm	0.039-0.055 in
Connecting Rod		

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• Standard Oil Clearance	0.03-0.062 mm	0.0012-0.0024 in
• Maximum Oil Clearance	0.07 mm	0.0028 in
• Standard Oil Clearance	0.016-0.039 mm	0.0006-0.0015 in
• Maximum Oil Clearance	0.05 mm	0.0020 in
Connecting Rod Bearing Thickness		
• Mark 1	1.489-1.493 mm	0.0586-0.0588 in
• Mark 2	1.494-1.497 mm	0.0588-0.0589 in
• Mark 3	1.498-1.501 mm	0.0590-0.0591 in
• Connecting Rod Small End Bore Diameter	20.012-20.021 mm	0.7879-0.7882 in
Connecting Rod Large End Bore Diameter (Reference)		
• Mark A	20.012-20.015 mm	0.7879-0.7880 in
• Mark B	20.016-20.018 mm	0.7880-0.7881 in
• Mark C	20.019-20.021 mm	0.7881-0.7882 in
Connecting Rod Small End Bore Diameter (Resistance)		
• Mark 1	47.000-47.008 mm	1.8504-1.8507 in
• Mark 2	47.009-47.016 mm	1.8507-1.8510 in
• Mark 3	47.017-47.024 mm	1.8510-1.8513 in
Crankshaft Pin Diameter		
• Mark 1	43.992-44.000 mm	1.7320-1.7323 in
• Mark 2	43.992-44.000 mm	1.7320-1.7323 in
• Mark 3	43.992-44.000 mm	1.7320-1.7323 in
• Standard Oil Clearance	0.005-0.011 mm	0.0002-0.0004 in
• Maximum Oil Clearance	0.014 mm	0.0006 in
• Maximum Rod Out-of-Alignment per 100 mm (3.94 in)	0.05 mm	0.0020 in
• Maximum Rod twist per 100 mm (3.94 in)	0.15 mm	0.0059 in
Cylinder Block		
• Maximum Warp	0.05 mm	0.0020 in
• Standard Cylinder Bore Diameter	80.500-80.513 mm	3.1693-3.1698 in
• Maximum Cylinder Bore Diameter	80.633 mm	3.1745 in
• Protrusion Height (Ring Pin)	7.5-8.5 mm	0.295-0.335 in
Protrusion Height (Straight Pin)		
• Pin A	18.5-19.5 mm	0.729-0.768 in
• Pin B	5.0-7.0 mm	0.197-0.276 in
	11-13 mm	0.433-0.512 in

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• Pin C		
• Pin D	5.0-7.0 mm	0.197-0.276 in
• Pin E	5.0-6.0 mm	0.197-0.236 in
• No. 1 Ventilation Case - Seal Packing	2.0 mm	0.0787 in
Piston		
• Standard Piston Diameter	80.461-80.471 mm	3.1677-3.1681 in
• Standard Piston Oil Clearance	0.029-0.052 mm	0.0011-0.0020 in
• Maximum Piston Oil Clearance	0.09 mm	0.0035 in
• Piston Pin Bore Diameter	20.006-20.015 mm	0.7876-0.7880 in
Piston Pin Bore Diameter (Reference)		
• Mark A	20.006-20.009 mm	0.7876-0.7878 in
• Mark B	20.010-20.012 mm	0.7878-0.7879 in
• Mark C	20.013-20.015 mm	0.7879-0.7880 in
Piston Ring		
Ring Groove Clearance		
• No. 1 Ring	0.020-0.070 mm	0.0008-0.0028 in
• No. 2 Ring	0.020-0.060 mm	0.0008-0.0024 in
• Oil Ring	0.020-0.065 mm	0.0008-0.0026 in
Standard End Gap		
• No. 1 Ring	0.2-0.3 mm	0.0079-0.0118 in
• No. 2 Ring	0.3-0.5 mm	0.0118-0.0197 in
• Oil Ring	0.1-0.4 mm	0.0039-0.0157 in
Maximum End Gap		
• No. 1 Ring	0.5 mm	0.0197 in
• No. 2 Ring	0.7 mm	0.0276 in
• Oil Ring	0.7 mm	0.0276 in
Piston Pin		
• Piston Pin Diameter	20.004-20.013 mm	0.7876-0.7879 in
Piston Pin Diameter (Resistance)		
• Mark A	20.004-20.007 mm	0.7876-0.7877 in
• Mark B	20.008-20.010 mm	0.7877-0.7878 in
• Mark C	20.011-20.013 mm	0.7878-0.7879 in
• Standard Oil Clearance	-0.001-0.005 mm	-0.00004-0.0002 in
• Maximum Oil Clearance	0.010 mm	0.0004 in
Connecting Rod Bolt		

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• Standard Diameter	6.6-6.7 mm	0.2598-0.2638 in
• Minimum Diameter	6.4 mm	0.252 in
Crankshaft		
• Standard Thrust Clearance	0.04-0.14 mm	0.0016-0.0055 in
• Maximum Thrust Clearance	0.18 mm	0.0071 in
• Thrust Washer Thickness	2.43-2.48 mm	0.0957-0.0976 in
Cylinder Block Main Journal Bore Diameter (Reference)		
• Mark 0	52.000-52.003 mm	2.0472-2.0474 in
• Mark 1	52.003-52.005 mm	2.0474-2.0474 in
• Mark 2	52.005-52.007 mm	2.0474-2.0475 in
• Mark 3	52.007-52.010 mm	2.0475-2.0476 in
• Mark 4	52.010-52.012 mm	2.0476-2.0477 in
• Mark 5	52.012-52.014 mm	2.0477-2.0478 in
• Mark 6	52.014-52.016 mm	2.0478-2.0479 in
Main Journal Diameter	47.988-48.000 mm	1.8893-1.8898 in
• Maximum Taper and Distortion	0.004 mm	0.0002 in
Main Journal Diameter (Reference)		
• Mark 0	47.999-48.000 mm	1.8897-1.8898 in
• Mark 1	47.997-47.998 mm	1.8896-1.8897 in
• Mark 2	47.995-47.996 mm	1.8896-1.8896 in
• Mark 3	47.993-47.994 mm	1.8895-1.8895 in
• Mark 4	47.991-47.992 mm	1.8894-1.8894 in
• Mark 5	47.988-47.990 mm	1.8893-1.8894 in
Crankshaft Journal Diameter (Reference)		
• Mark 0	47.999-48.000 mm	1.8897-1.8898 in
• Mark 1	47.997-47.998 mm	1.8896-1.8897 in
• Mark 2	47.995-47.996 mm	1.8896-1.8896 in
• Mark 3	47.993-47.994 mm	1.8895-1.8895 in
• Mark 4	47.991-47.992 mm	1.8894-1.8894 in
• Mark 5	47.988-47.990 mm	1.8893-1.8894 in
Standard Main Bearing Center Wall Thickness (Reference)		
• Mark 1	1.994-1.997 mm	0.0785-0.0786 in
• Mark 2	1.998-2.000 mm	0.0787-0.0787 in
• Mark 3	2.001-2.003 mm	0.0788-0.0789 in

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• Mark 4	2.004-2.006 mm	0.0789-0.0790 in
• Maximum Circle Runout	0.03 mm	0.0012 in
• Standard Oil Clearance	0.016-0.039 mm	0.0006-0.0015 in
• Maximum Oil Clearance	0.050 mm	0.0020 in
• Crank Pin Diameter	43.992-44.000 mm	1.7320-1.7323 in
• Maximum Taper and Distortion	0.004 mm	0.0002 in
Crankshaft Bearing Cap Set Bolt		
• Standard Diameter	84.3-85.7 mm	3.3189-3.3740 in
• Minimum Diameter	86.7 mm	3.4134 in
Crankshaft Bearing		
• Dimension A	0.5-1.0 mm	0.020-0.039 in
• Dimension A-B	0.5 mm or less	0.0197 in or less

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Reviewing the description and operation information will help you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the description and operation information will also help you determine if the condition described by the customer is normal operation. Refer to **Symptoms - Engine Mechanical** in order to identify the correct procedure for diagnosing the system and where the procedure is located.

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions.

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

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the Engine. Refer to **Checking Aftermarket Accessories**.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Check for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM,

ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.

- Compare the engine sounds, if applicable, to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

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

Symptom List

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

- **Diagnostic Starting Point - Engine Mechanical**
- **Symptoms - Engine Mechanical**
- **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**
- **Oil Consumption Diagnosis**
- **Oil Leak Diagnosis**
- **Drive Belt Chirping, Squeal, and Whine Diagnosis**
- **Drive Belt Rumbling and Vibration Diagnosis**
- **Drive Belt Falls Off and Excessive Wear Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

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

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misfire condition.	
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required.
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body.	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
Improperly installed or damaged MAP sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
Damage to the MAP sensor housing and/or O-ring seal	Replace the intake manifold.
Worn or faulty lifters The lifters may be worn on the camshaft or the valve tip surfaces or the lifters may be bleeding down	Replace the lifters.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	• Perform an oil pressure test. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn Piston Rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. • Inspect the cylinders for a loss of compression. • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.
A damaged crankshaft reluctor wheel	Replace the sensor and/or crankshaft as required.

A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage.
Systems with electronic communication, DIS or coil per cylinder and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

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

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.

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Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking or worn lifters	Replace as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

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

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

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

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

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
High valve lifter leak down rate	Replace the lifters as required.
Worn crankshaft thrust bearing	• Inspect the thrust bearing and crankshaft. • Repair or replace as required.
Damaged or faulty oil filter by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

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Cause	Correction
Low oil pressure	• Perform an oil pressure test. • Repair or replace as required.
Improper lubrication to the valve train	Inspect the following components, and repair or replace as required: • Restricted oil filter • The valve lifter • The valve lifter bore • The oil filter bypass valve • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or damaged valve lifter bore	Repair or replace as required.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft and valve lifters as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
Stuck Valves Carbon on the valve stem or valve seat may cause the valve to stay open	Inspect the following components, and repair as required: • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	• Perform an oil pressure test. • Repair or replace damaged components as required.
Worn accessory drive components Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	• Inspect the accessory drive system. • Repair or replace as required.
Loose or damaged crankshaft balancer	

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	• Inspect the crankshaft balancer. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Oil pump screen loose, damaged or restricted	• Inspect the oil pump screen. • Repair or replace as required.
Excessive piston-to-cylinder bore clearance	• Inspect the piston and cylinder bore. • Repair as required.
Excessive piston pin-to-bore clearance	• Inspect the piston, piston pin, and the connecting rod. • Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin and connecting rod installation Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	• Verify the pistons, piston pins and connecting rods are installed correctly. • Repair as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	• Perform an oil pressure test. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls.
Loose torque converter bolts	• Inspect the torque converter bolts and

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	flywheel. • Repair as required.
Cracked flywheel, automatic transmission	• Inspect the flywheel bolts and flywheel. • Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

ENGINE COMPRESSION TEST

Perform a compression test in order to determine the cylinder compression pressure. Use a compression test in order to diagnose lack of power, excessive oil consumption, or poor fuel economy.

NOTE: This engine is equipped with an aluminum cylinder head. Allow the engine to cool before removing spark plugs. Removing the spark plugs from an engine at operating temperature may damage the spark plug threads in the cylinder head. Also be sure to clean any dirt or debris from around spark plug holes prior to removing spark plugs.

IMPORTANT: The engine should be at room temperature.

1. Verify that the battery is fully charged.

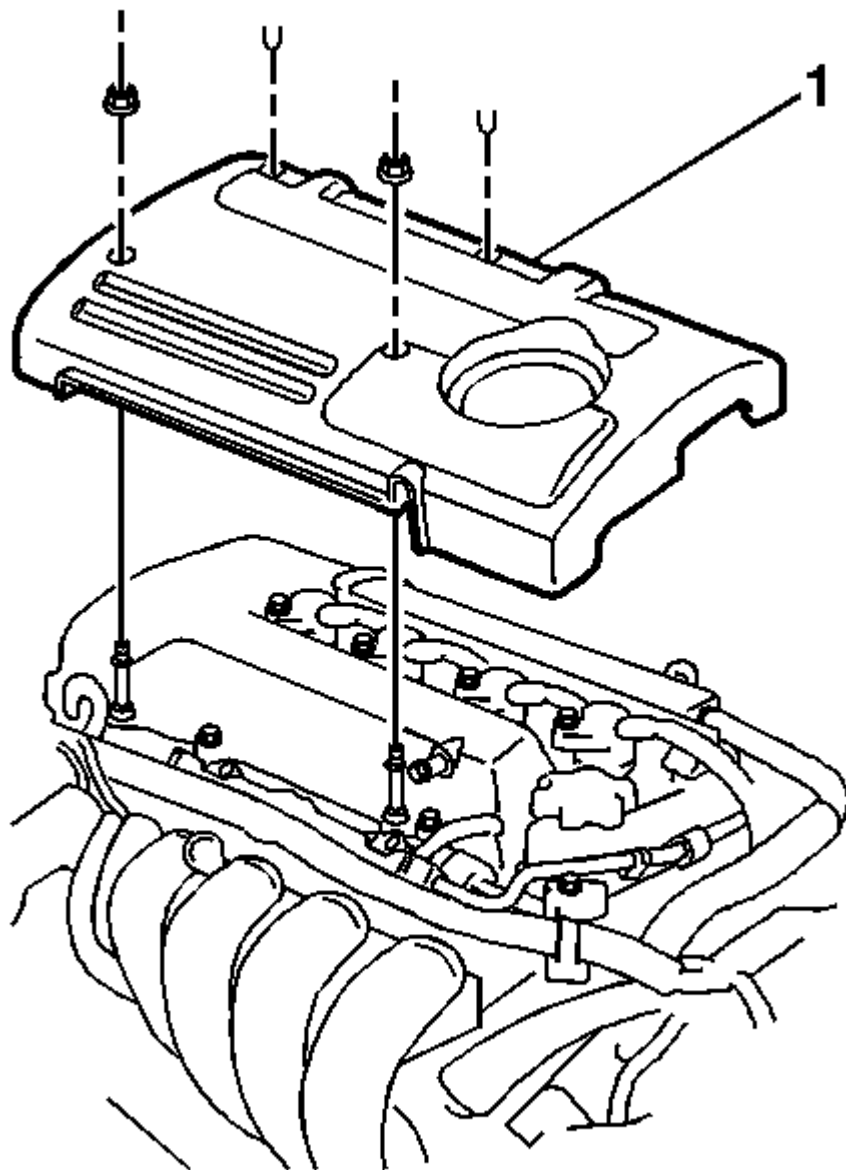


Fig. 1: View Of Engine Top Cover, Plastic Retainers & Fasteners
Courtesy of GENERAL MOTORS CORP.

2. Remove the 2 engine cover fasteners.
3. Remove the 2 engine cover plastic retainers.
4. Remove the engine cover (1) from the engine.

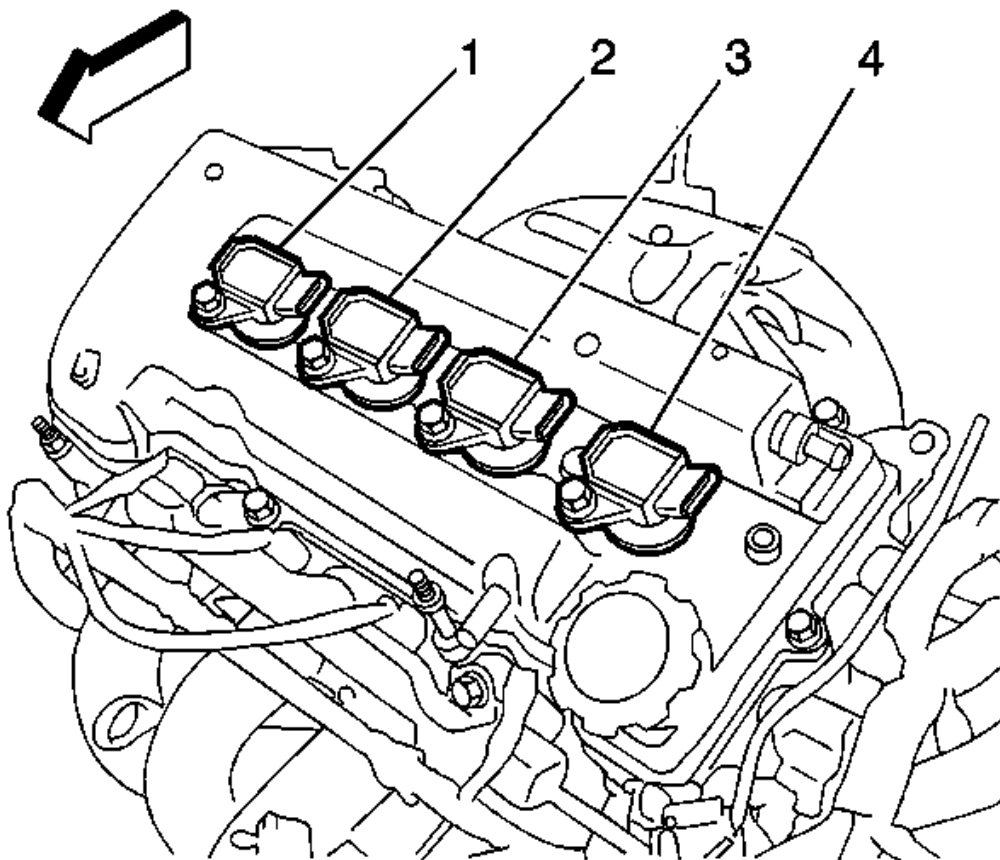


Fig. 2: Identifying Ignition Coils

Courtesy of GENERAL MOTORS CORP.

5. Remove the four ignition coils (1-4) from the cylinder head cover.
6. Remove the spark plugs from the cylinder head.

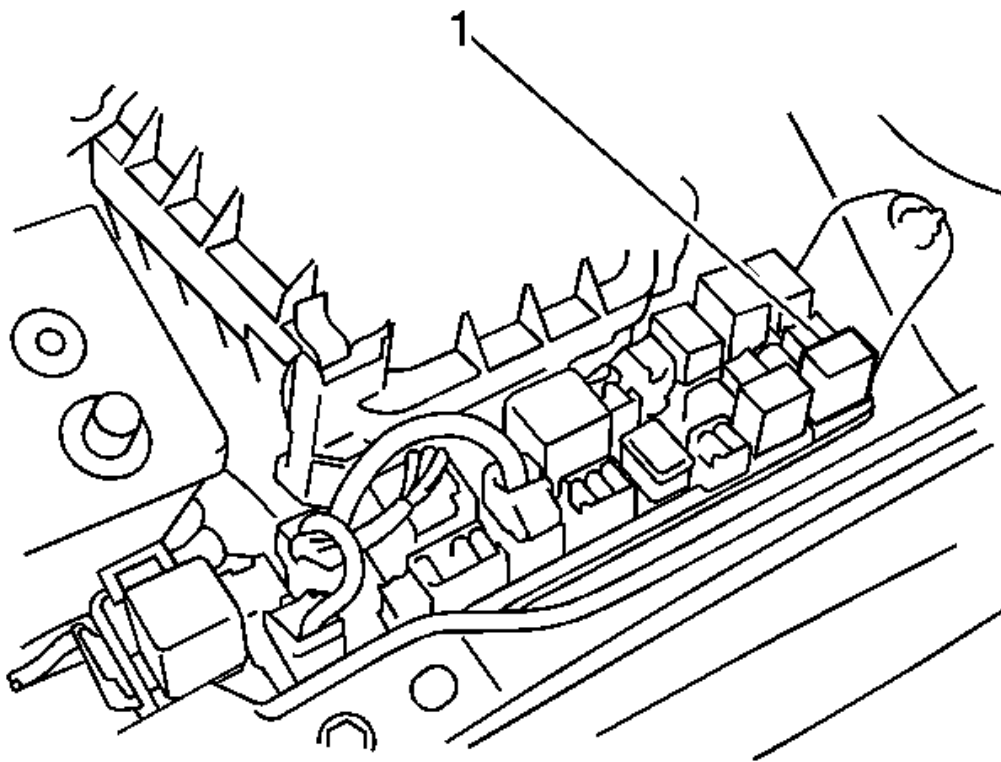


Fig. 3: Identifying EFI Main Relay
Courtesy of GENERAL MOTORS CORP.

7. Remove the EFI Main Relay (1) from the Fuse/Relay Block 1.

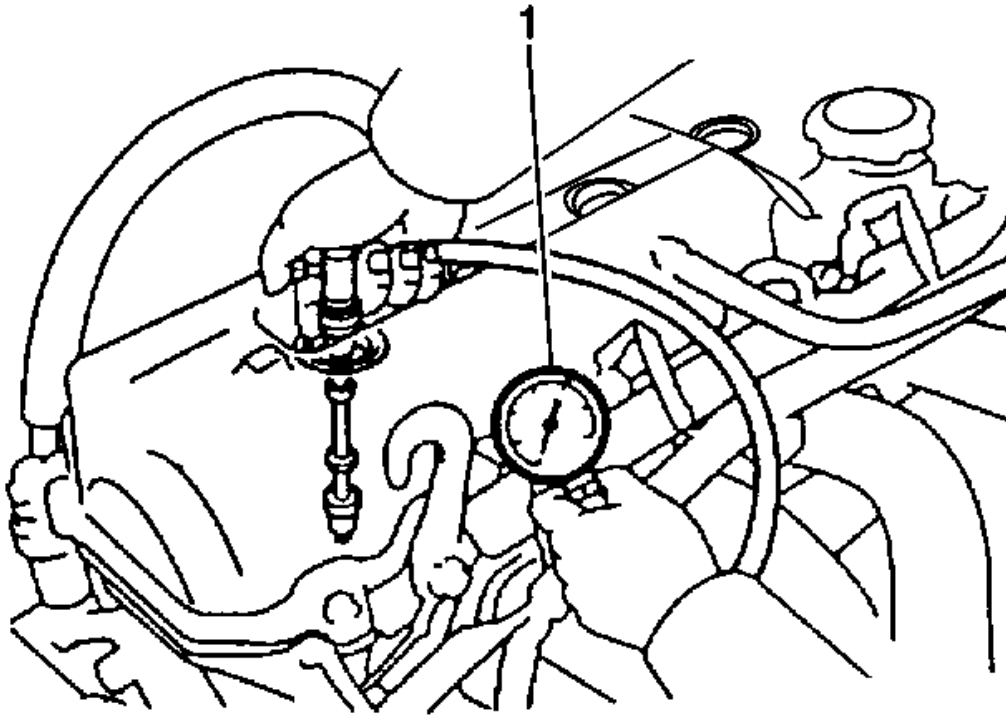


Fig. 4: View Of Compression Gage
Courtesy of GENERAL MOTORS CORP.

8. Install a compression gage into a spark plug hole.
9. Depress the clutch pedal (on vehicles that are equipped with a manual transmission).
10. Depress the accelerator pedal to the floor for a wide open throttle.
11. Crank the engine through four compression strokes for each cylinder being tested.

IMPORTANT: The maximum allowable compression pressure difference between any two cylinders is 100 kPa (15 psi).

12. Measure the highest pressure reading on the compression gage.
 - The standard compression pressure is 1,300 kPa (218 psi).
 - The minimum allowable compression pressure is 1,000 kPa (145 psi).
13. Repeat the compression test procedures for the remaining three cylinders.
14. Remove the compression gage from the engine.
15. Install the four spark plugs.

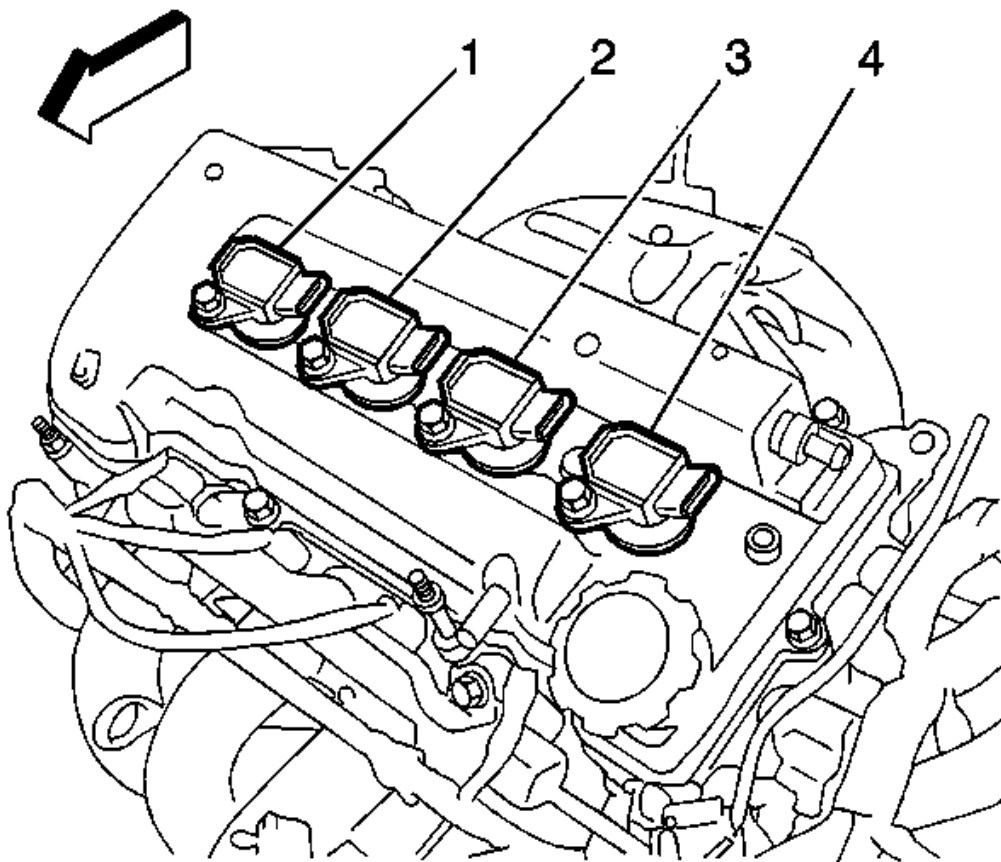


Fig. 5: Identifying Ignition Coils
Courtesy of GENERAL MOTORS CORP.

16. Install the four ignition coils (1-4) to the cylinder head cover.

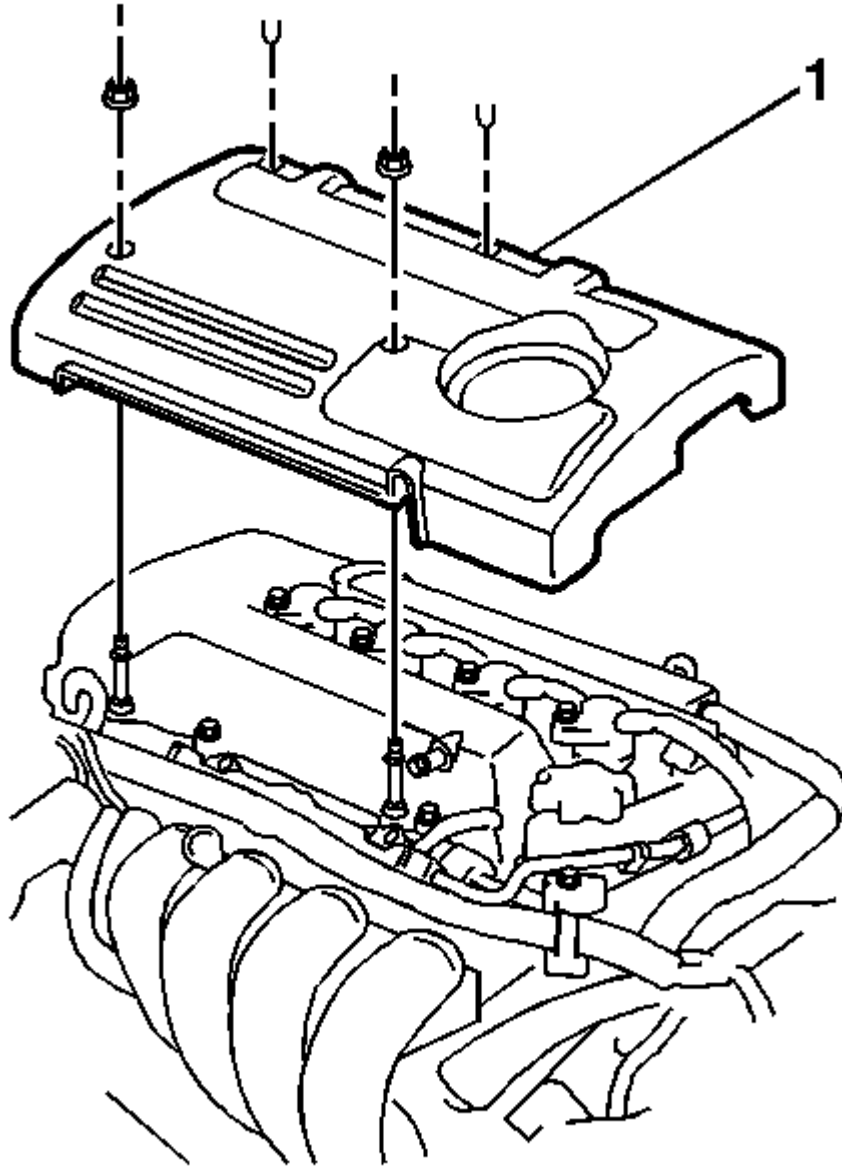


Fig. 6: View Of Engine Top Cover, Plastic Retainers & Fasteners
Courtesy of GENERAL MOTORS CORP.

17. Position the engine cover (1) to the engine.

NOTE: Refer to FASTENER CAUTION .

18. Install the 2 engine cover fasteners.

Tighten: Tighten the engine cover fasteners to 7 N.m (62 lb in).

19. Install the 2 engine cover plastic retainers.

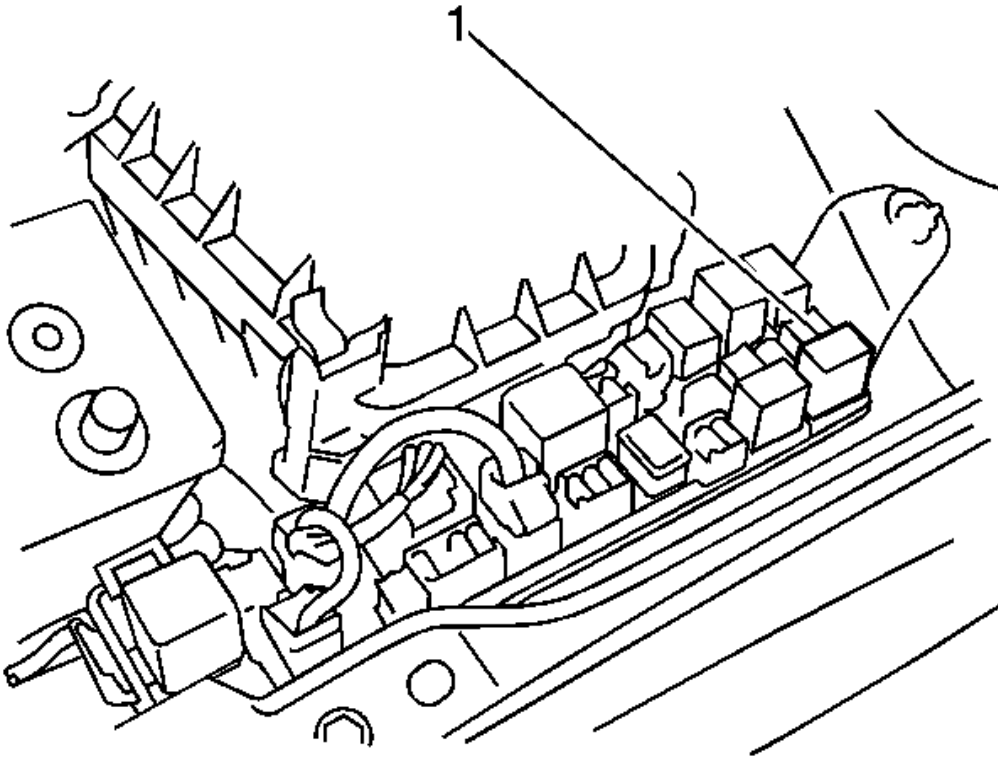


Fig. 7: Identifying EFI Main Relay
Courtesy of GENERAL MOTORS CORP.

20. Reconnect the EFI Main Relay (2) to the Fuse/Relay Block 1.
21. Inspect for the following conditions:

- Normal operation

The pistons, piston rings and valves are operating normally if the cylinder compression pressure increases quickly and evenly to the compression standard (1,300 kPa [218 psi]).

- Faulty piston rings

The following actions indicate that the piston rings are faulty:

- The cylinder compression is low on the first stroke.
- The cylinder compression increases on the following strokes but does not reach the compression standard.
- Faulty valves

The following actions indicate that the valves are faulty:

- The cylinder compression is low on the first stroke.
- The cylinder compression does not increase on the following strokes.

CYLINDER LEAKAGE TEST

Tools Required

J 35667-A Cylinder Head Leakdown Tester or equivalent

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

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

Test Procedure

CAUTION: Refer to BATTERY DISCONNECT WARNING .

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs.
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Install the **J 35667-A** , or equivalent.

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

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

OIL CONSUMPTION DIAGNOSIS

Excessive oil consumption, not due to leaks, is the use of 1.9L (2 qts) or more of engine oil within 3 200 kilometers (2,000 mi). The causes of excessive oil consumption include the following conditions:

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

OIL PRESSURE DIAGNOSIS AND TESTING

1. Warm up the engine, then stop the engine and wait for 5 minutes.

IMPORTANT: Do not fill to above the full level mark.

2. Check that the engine oil level is between the low level and full level marks on the level gauge. If low, check for leakage and add oil up to the full level mark.
3. Check the oil for deterioration, water, discoloring or thinning.

If the quality is visibly poor, replace the oil.

4. Disconnect the oil pressure switch connector.

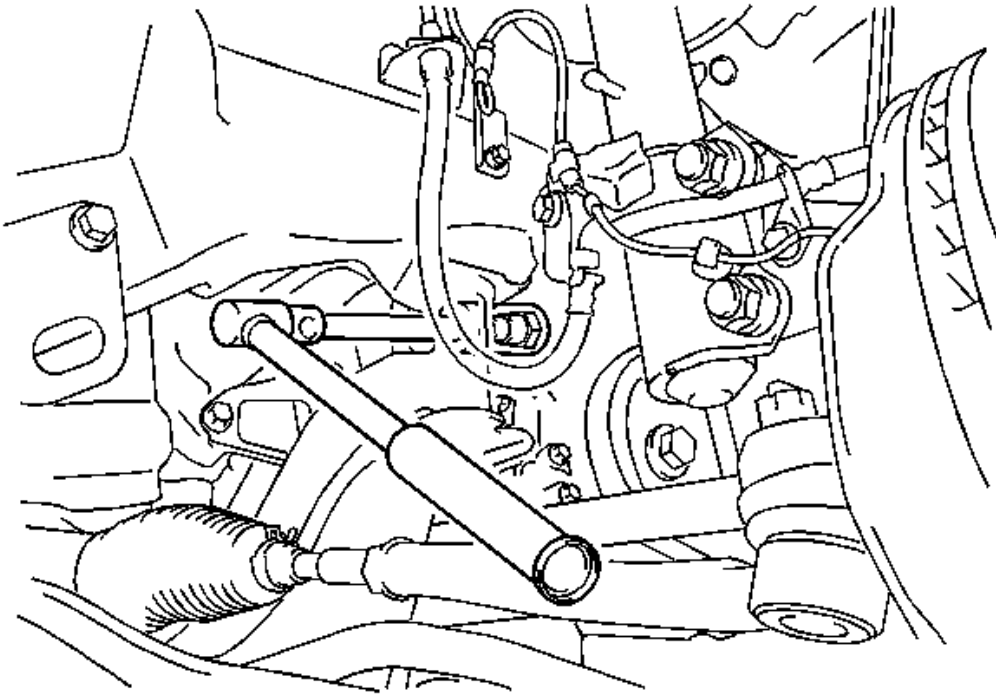


Fig. 8: Identifying Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

5. Using a 24 mm deep socket wrench, remove the oil pressure switch.

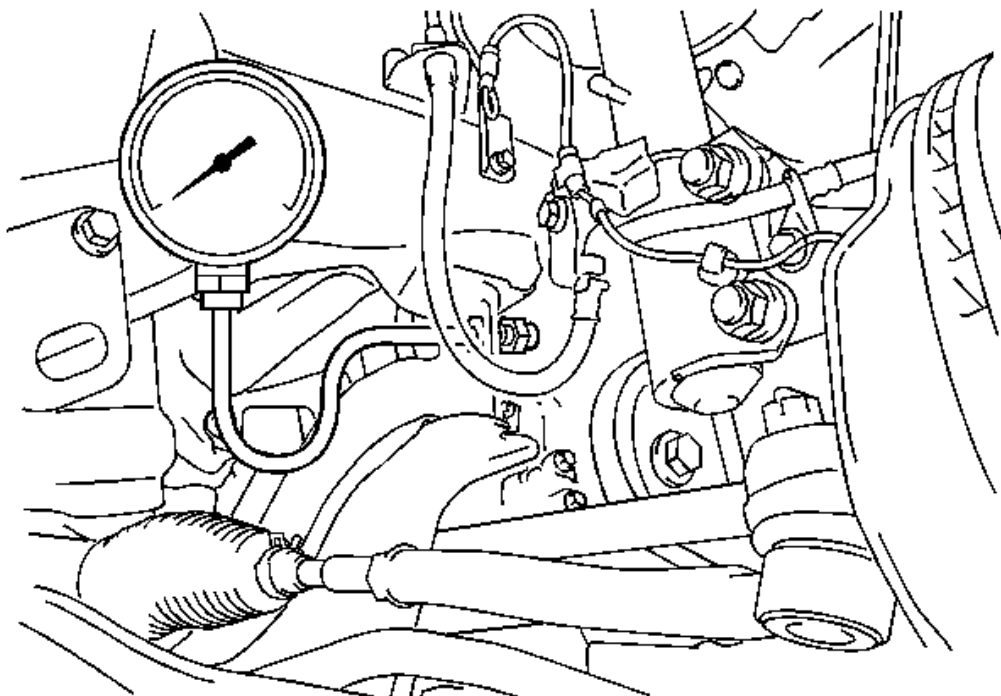


Fig. 9: View Of Oil Pressure Gauge
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pressure gauge.
7. Warm up the engine.
8. Remove the oil pressure gauge.
9. Check the oil pressure.

Specification:

- At Idle - 25 kPa (3.6 psi) or more
 - At 3,000 RPM - 150-550 kPa (22-80 psi)
10. If the oil pressure is not as specified, check the oil pump.

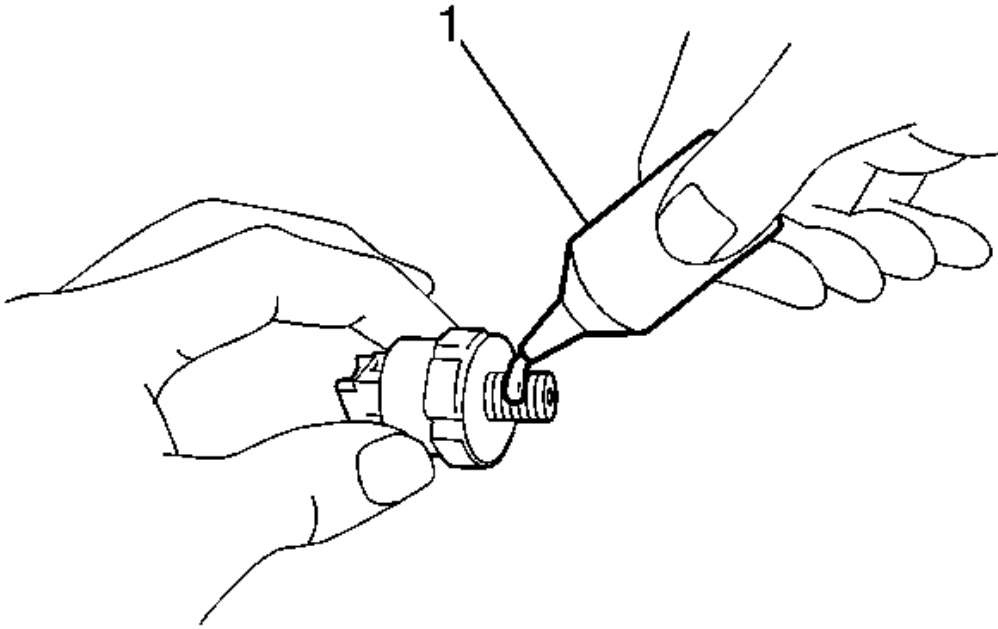


Fig. 10: Applying Adhesive To Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

11. Apply adhesive Three Bond 1344 or equivalent. to 2 or 3 threads of the oil pressure switch.

NOTE: Refer to **FASTENER CAUTION** .

12. Using a 24 mm deep socket wrench, install the oil pressure switch.

Tighten: Tighten to 15 N.m (11 lb ft).

IMPORTANT: Do not start the engine for at least 1 hour after installation

13. Connect the oil pressure switch connector.
14. Check for engine oil leaks.

OIL LEAK DIAGNOSIS

Use one of the following methods in order to locate a fluid oil leak.

Finding the Leak

1. Determine if the fluid is one of the following types:
 - Engine oil
 - Automatic transmission fluid
 - Power steering fluid
2. Use the following steps in order to determine the location of the fluid leak:
 1. Run the vehicle at normal operating temperature.
 2. Park the vehicle over a large sheet of paper.
 3. After several minutes, observe the drops of fluid that fall on the paper.

Use the drops on the paper in order to determine the location of the leak.

3. Visually inspect around the suspected component.

Inspect around the gasket mating surfaces for leaks.

Use a mirror in order to find leaks in areas that are difficult to reach.

4. If you cannot locate the leak, use one of the following items in order to clean the suspected area:
 - A degreaser
 - Steam
 - A spray solvent
5. Thoroughly dry the area.
6. Operate the vehicle for several miles at normal operating temperature and varying speeds.
7. Visually inspect the suspected component.

If you still cannot locate the leak, use the powder method or the black light and dye method in order to locate the leak.

Powder Method

Perform the following steps in order to diagnose the leak:

1. Clean the suspected area.
2. Apply an aerosol-type powder (such as foot powder) to the suspected area.
3. Operate the vehicle under normal operating conditions.
4. Visually inspect the suspected component.

Trace the leak path over the white powder surface to the source.

Tools Required

- **J 28428-E** High Intensity Black Light
- **J 28431-6** Fluorescent Oil Additive

Black Light and Dye Method

IMPORTANT: Follow the manufacturer's instructions that are included with the J 28431-6 .

1. Pour the specified amount of **J 28431-6** into the leaking component.

Refer to the manufacturer's instructions for the proper amount of oil additive.

2. Operate the vehicle under normal operating conditions.
3. Shine the **J 28428-E** onto the suspected area.

The **J 28431-6** fluid will appear as a yellow path leading to the source of the oil leak.

Repairing the Leak

After you find the source of the leak, determine the cause of the leak. This action will enable you to properly repair the faulty component.

Gaskets

Inspect for a bent sealing flange. Repair the surface if the sealing flange is bent. A new gasket will not repair the leak.

Inspect for the following conditions before repairing a leak:

- An incorrect fluid level
- High pressure
- Malfunctions in the crankcase ventilation system
- Improperly tightened fasteners
- Dirty or damaged threads on the fasteners
- Warped flanges or sealing surfaces
- Scratches, burrs or other damage to the sealing surface
- A damaged or worn gasket
- Cracking or porosity of the component
- An improper sealant

Seals

Inspect for the following conditions before repairing a leak:

- An incorrect fluid level
- High pressure
- Malfunctions in the crankcase ventilation system

- Any of the following conditions on the seal bore:
 - Scratches
 - Burrs
 - Nicks
- A damaged or worn seal
- Improper installation
- A cracked component
- Inspect the shaft surface for the following conditions:
 - Scratches
 - Nicks
 - Damage
- A loose or worn bearing

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.

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

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- The noise may be caused by an accessory drive component failed bearing.

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to <u>Symptoms - Engine Mechanical</u>
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to <u>Drive Belt Replacement</u>. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to <u>Symptoms - Engine Mechanical</u>	Go to Step 4
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Does the belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to Step 20	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 20	Go to Step 8
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 20	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	NOTE: Refer to <u>FASTENER CAUTION</u> . 1. Tighten any loose fasteners. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition? If diagnosing a whine noise and the condition still		

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	exist, proceed to Diagnostic Aids.	Go to Step 20	Go to Step 14
14	Test the drive belt tensioner for proper operation. Did you find and correct the condition?	Go to Step 20	Go to Step 15
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to Step 20	Go to Step 16
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 20	Go to Step 17
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 20	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to Step 20	Go to Step 19
19	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> . 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

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of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt or felt as a lump in the belt.

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

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

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

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

Step	Action	Yes	No
NOTE: Refer to <u>BELT DRESSING CAUTION</u> .			
DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle • Heard once per revolution of the drive belt or a pulley • Rumbling may be caused from: ○ Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove ○ The separation of the drive belt ○ A damaged drive belt			
DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to <u>Symptoms - Engine Mechanical</u>
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to <u>Symptoms - Engine Mechanical</u>	Go to Step 4
	Inspect the drive belts for wear, damage, separation,		

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4	sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. 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	-
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	NOTE: Refer to <u>FASTENER CAUTION</u> . 1. Tighten any loose fasteners. 2. Replace improper or missing fasteners. Did you complete the repair?	Go to Step 13	-
11	Inspect for a bent water pump shaft. Did you find and correct the condition?	Go to Step 13	Go to Step 12
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 13	Go to <u>Diagnostic Aids</u> .
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS**Diagnostic Aids**

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

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

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

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

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will probably cause the drive

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belt to make a noise or to fall off.

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

Test Description

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

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

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

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

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

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

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

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

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

Step	Action	Yes	No
NOTE: Refer to <u>BELT DRESSING CAUTION</u> .			
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 <u>Symptoms - Engine Mechanical</u>
2	If diagnosing excessive wear, proceed to step 13. If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to Step 3	Go to Step 4

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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	NOTE: Refer to <u>FASTENER CAUTION</u> . 1. Tighten any loose fasteners. 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
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

DRIVE BELT REPLACEMENT

On-Vehicle Inspection

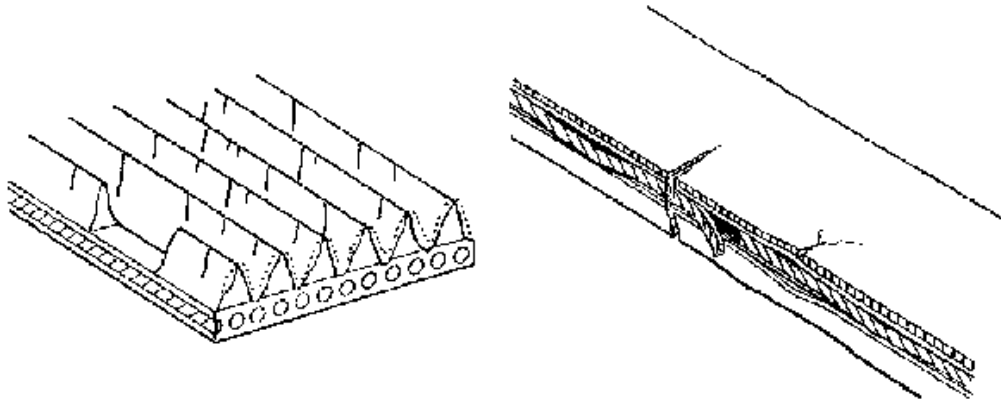


Fig. 11: Inspecting Drive Belt

Courtesy of GENERAL MOTORS CORP.

1. Inspect the V-ribbed belt for wear, cracks or other signs of damage.

If any of the following defects is found, replace the V-ribbed belt.

- The belt is cracked.
- The belt is worn out to the extent that wires are exposed.
- The belt has chunks missing from the ribbed grooves.

IMPORTANT: Check by hand to confirm that the belt has not slipped out of the grooves on the bottom to the pulley. If it has slipped out, replace the V-ribbed belt. Install a new V-ribbed belt correctly.

**CORRECT****INCORRECT**

Fig. 12: Ensuring Belt Fits Properly In Ribbed Grooves
Courtesy of GENERAL MOTORS CORP.

2. Check that the belt fits properly in the ribbed grooves.

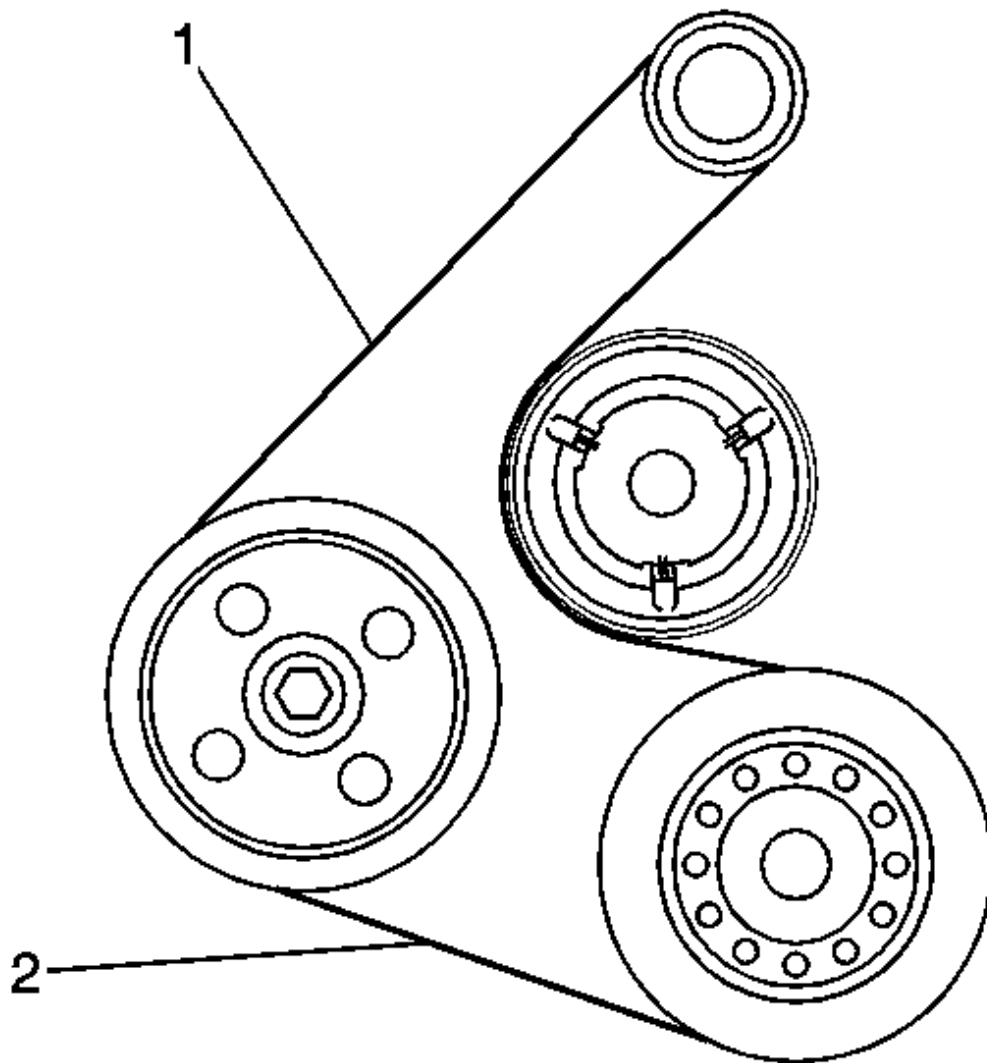


Fig. 13: Checking Belt Routing & Deflection
Courtesy of GENERAL MOTORS CORP.

3. Check the V belt deflection and tension.

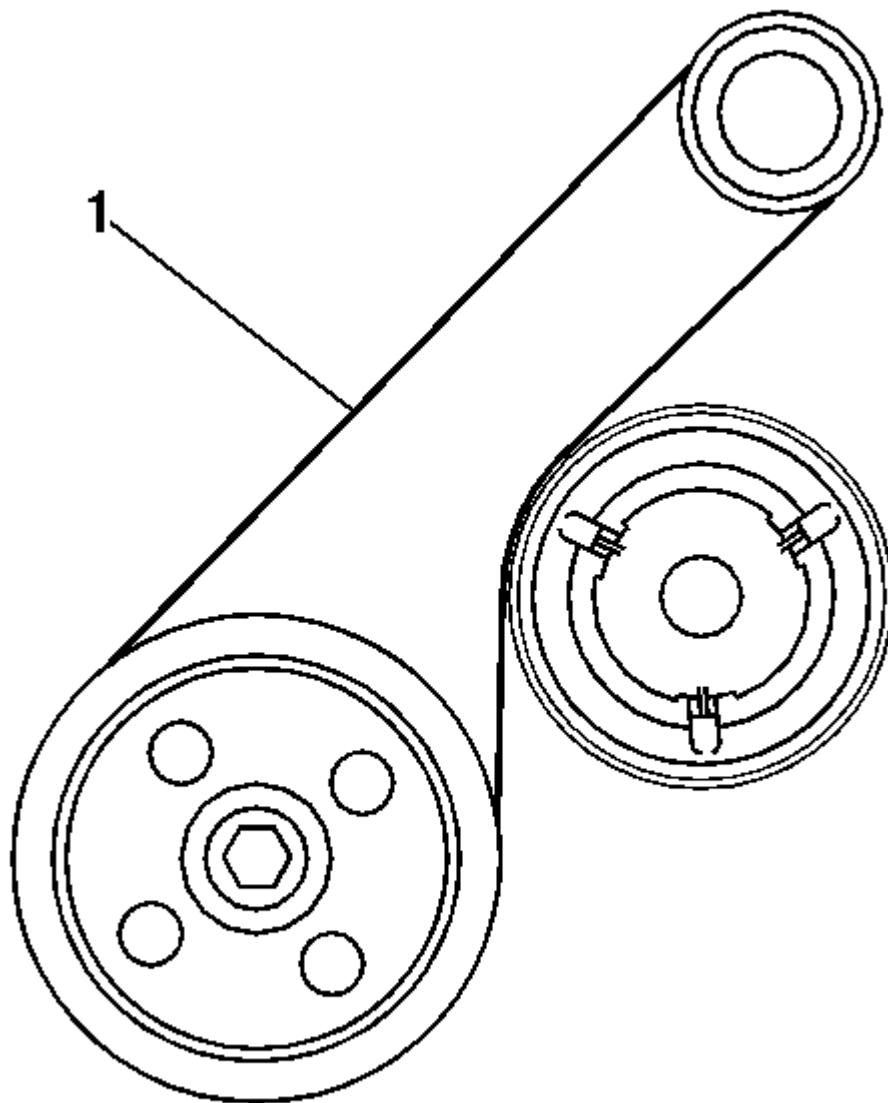


Fig. 14: Checking Belt Deflection

Courtesy of GENERAL MOTORS CORP.

4. If the belt deflection is not as specified, adjust it.
 - When inspecting the V belt deflection, apply 98 N (10 kgf) tensile force to it.
 - After installing a new belt, run the engine for approximately 5 minutes and then re-adjust the tension to (new belt) specifications.
 - Check the V-ribbed belt deflection and tension at the specified point.

- V-ribbed belt tension and deflection should be checked after 2 revolutions of the engine.
- V-ribbed belt tension and deflection should be checked at TDC crank angle and cold condition.
- When adjusting a belt, adjust its deflection and tension to the intermediate values of the specification.
- When reinstalling a belt which has been used for over 5 minutes, adjust its deflection and tension to the used belt specification.
- When using a belt tension gauge, confirm its accuracy by using a master gauge first.
- If using a sonic tension meter: Input data for sonic tension meter

Specification:

- Weight: 15 g/rib*m
- Width: 6 ribs
- Span: 188 mm (7.40 in) (w/ A/C)
- Span: 282 mm (11.1 in) (without A/C)

Removal Procedure

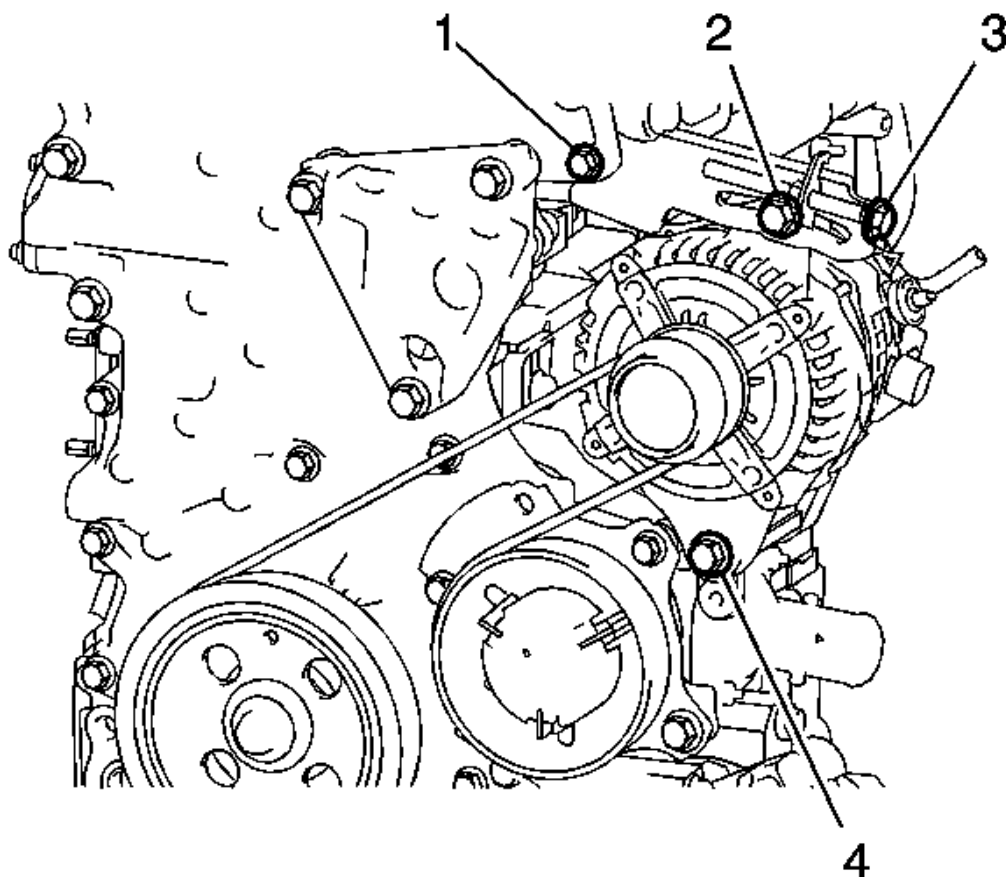


Fig. 15: View Of Engine Cover Attachments
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine cover. Refer to **Engine Cover Replacement**
2. Remove the engine under cover RH.
3. Remove the V-ribbed belt.

IMPORTANT: Do not loosen bolt D.

1. Loosen bolts A and B.
2. Loosen bolt C, then remove the V-ribbed belt.

Installation Procedure

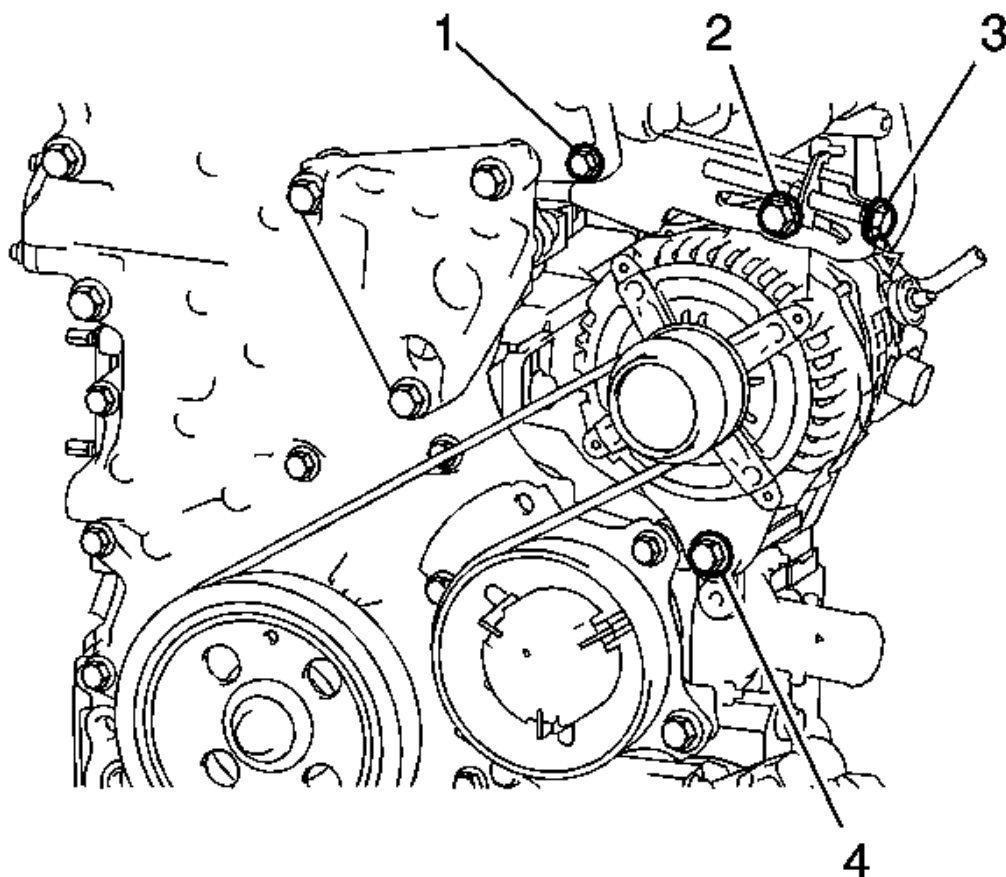


Fig. 16: View Of Engine Cover Attachments
Courtesy of GENERAL MOTORS CORP.

1. Install the V-ribbed belt

NOTE: Refer to Drive Belt Replacement.

IMPORTANT: Confirm that bolt D is not loosened.

2. Adjust the V-ribbed belt
 1. Turn bolt C to adjust the tension of the V-ribbed belt.
 2. Tighten bolts A and B.

Tighten:

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- Tighten bolt A to 19 N.m (14 lb ft).
 - Tighten bolt B to 43 N.m (32 lb ft).
3. Inspect the V-ribbed belt.
 4. Install the engine under cover RH.
 5. Install the engine cover. Refer to **Engine Cover Replacement**.

Item	Specified Condition
Deflection	
• New belt	7.5-8.6 mm (0.296- 0.338 in)
• Used belt	8.0-10.0 mm (0.315- 0.397 in)
Tension	
• New belt	637-735 N (143-165 lb)
• Used belt	392-588 N (88-132 lb)

ENGINE COVER REPLACEMENT

Removal Procedure

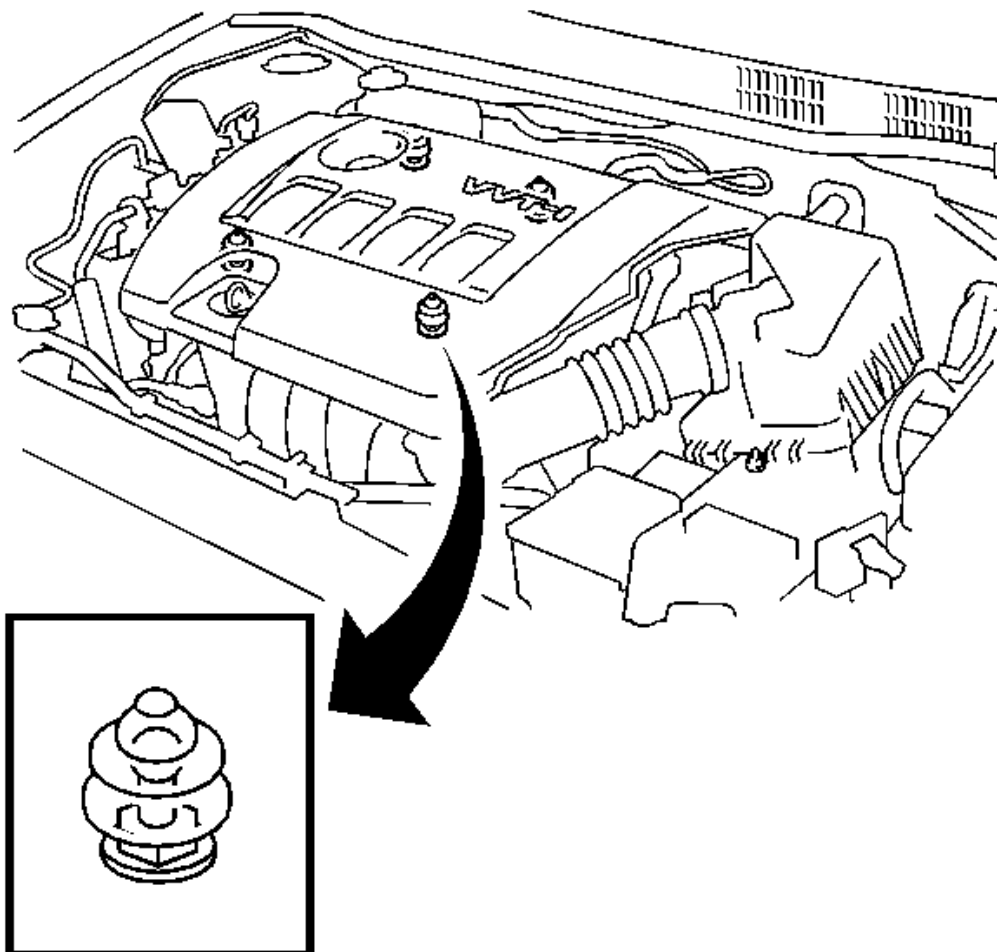


Fig. 17: View Of Engine & Rear Clips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Attempting to disengage both front and rear clips at the same time may cause the cover to break.

1. Hold the rear of the cover and raise it to disengage the two fasteners on the rear of the cover. Continue to raise the cover to disengage the two fasteners on the front of the cover.
2. Remove the engine cover.

Installation Procedure

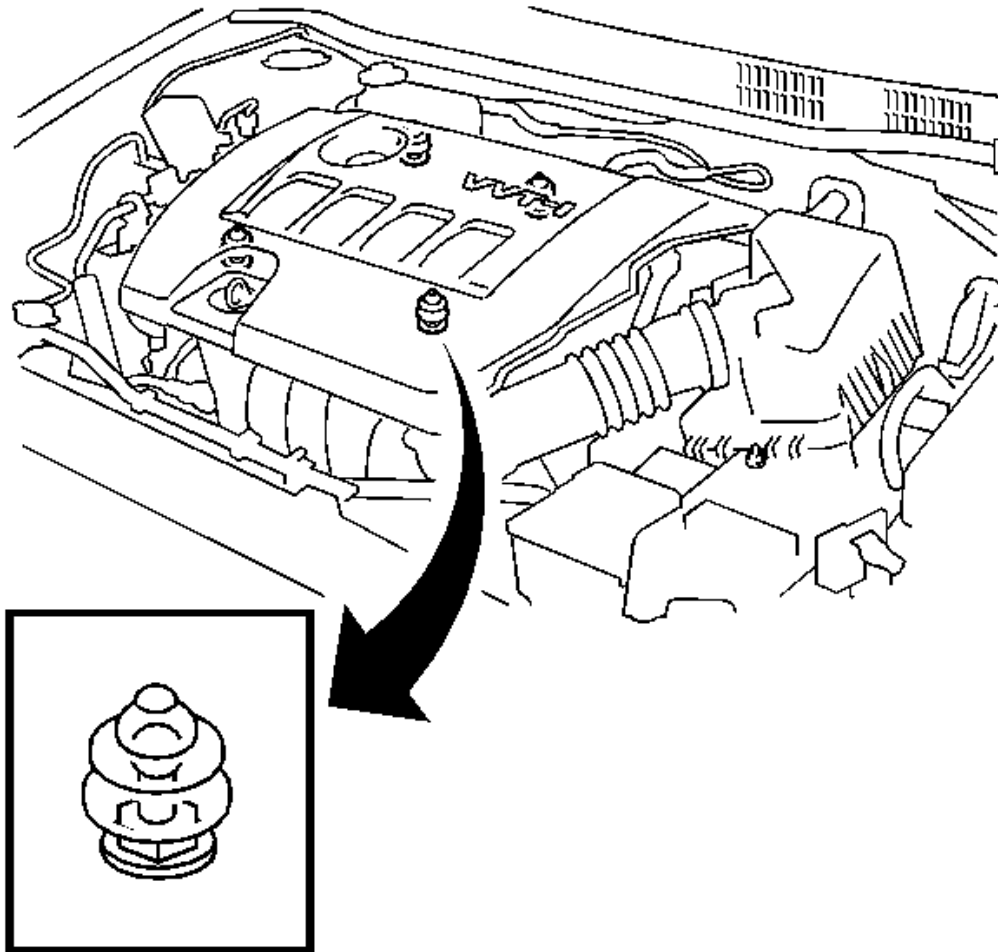


Fig. 18: View Of Engine & Rear Clips
Courtesy of GENERAL MOTORS CORP.

1. Position The engine cover and engage the two front fasteners.
2. Engage the two fasteners on the rear of the cover.

ENGINE SUPPORT FIXTURE

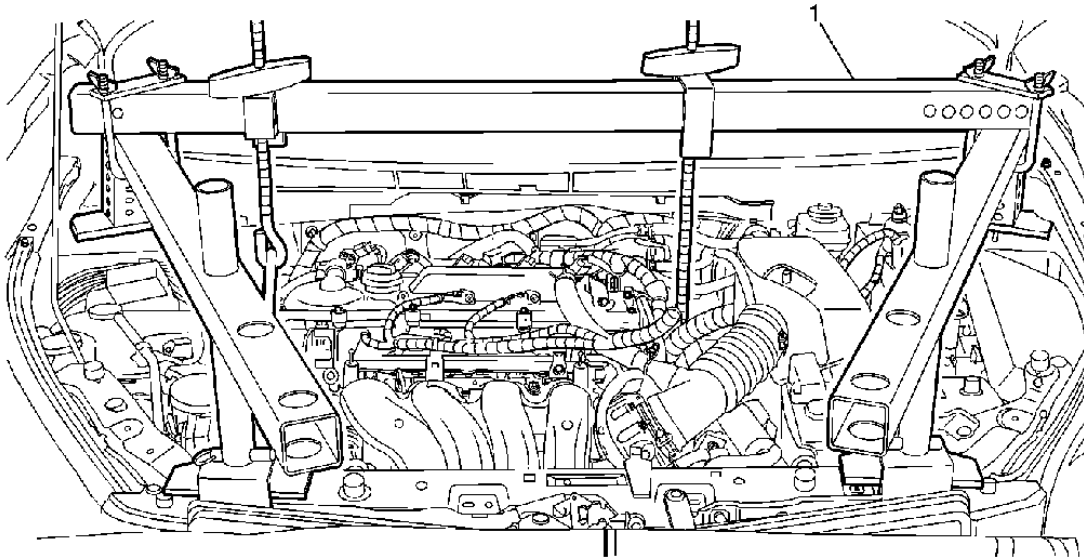


Fig. 19: View Of Engine Support Fixture
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Assemble the Engine Support Fixture. Tip: As shown in the illustration. Special Tools • J-28467-B: Universal Engine Support Fixture • J-28467-4: Engine Support Bracket • J-36462-A: Engine Support Adapter Leg Set • J-36857: Engine Lift Bracket

ENGINE MOUNT INSPECTION

IMPORTANT: It is the design intent of the torque axis mounting systems to allow more engine movement than other mounting systems. Do not replace any torque axis mounts for excessive engine movement. Replace them if damage exists on the mount or rubber.

1. Raise the engine enough to apply slight tension on the engine mount.
2. Replace the engine mount if any of the following conditions exist:
 - The hard rubber surface is covered with heat cracks.
 - The rubber split through the center.
3. Lower the engine.
4. Check the engine mount fastener torque.

ENGINE MOUNT REPLACEMENT

Removal Procedure

WARNING: Refer to Battery Disconnect Warning in the Preface section.

1. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection And Connection .
2. Raise and properly support the engine. Refer to Engine Support Fixture.

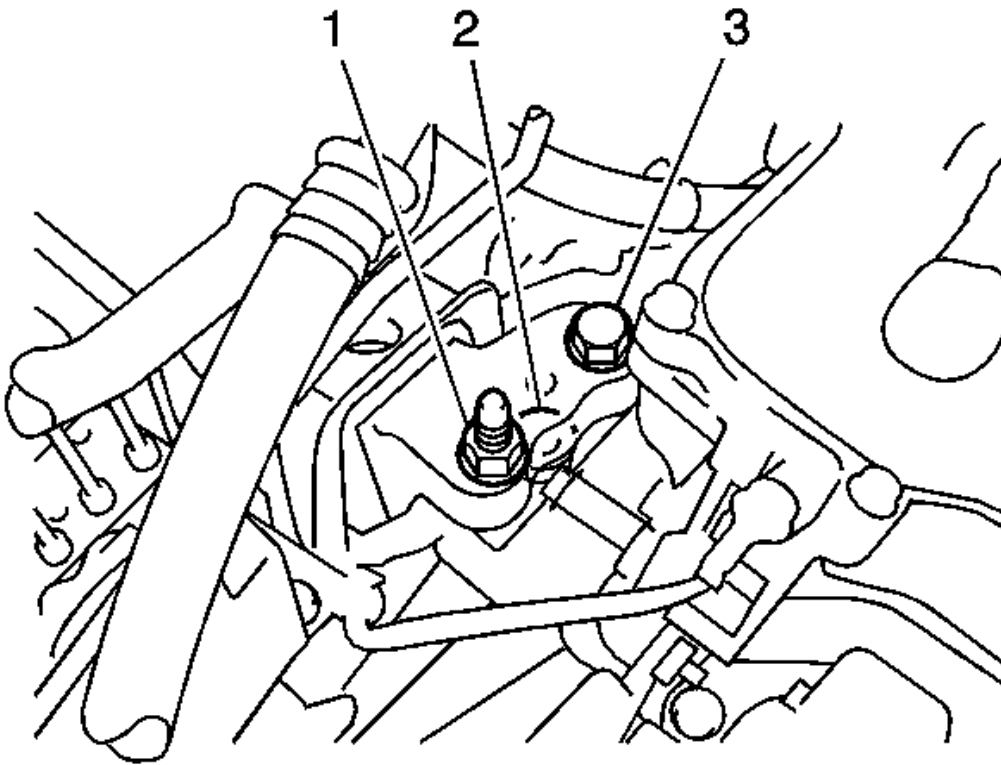


Fig. 20: Identifying Engine Mounting Insulator Bolts - Right Side
Courtesy of GENERAL MOTORS CORP.

3. Remove the bolt and 2 nuts (1, 2), and separate the engine mounting insulator RH.

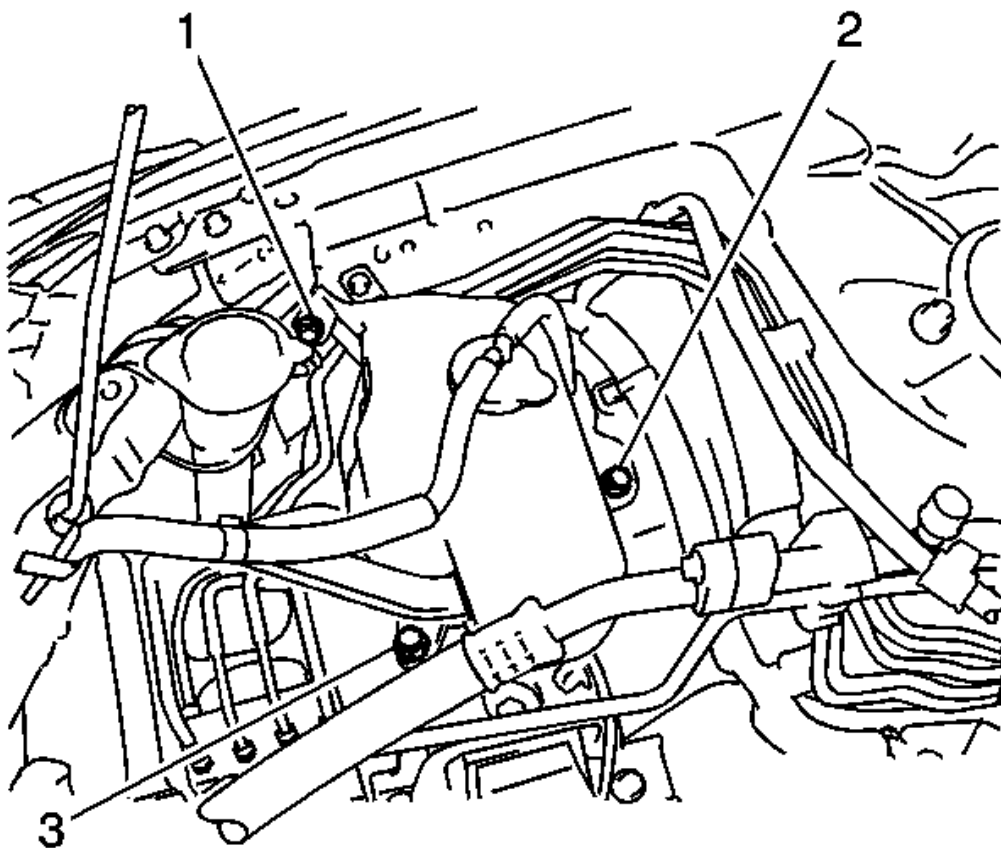


Fig. 21: View Of Radiator Surge Tank Assembly Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the 3 bolts (1-3) and radiator reserve tank.

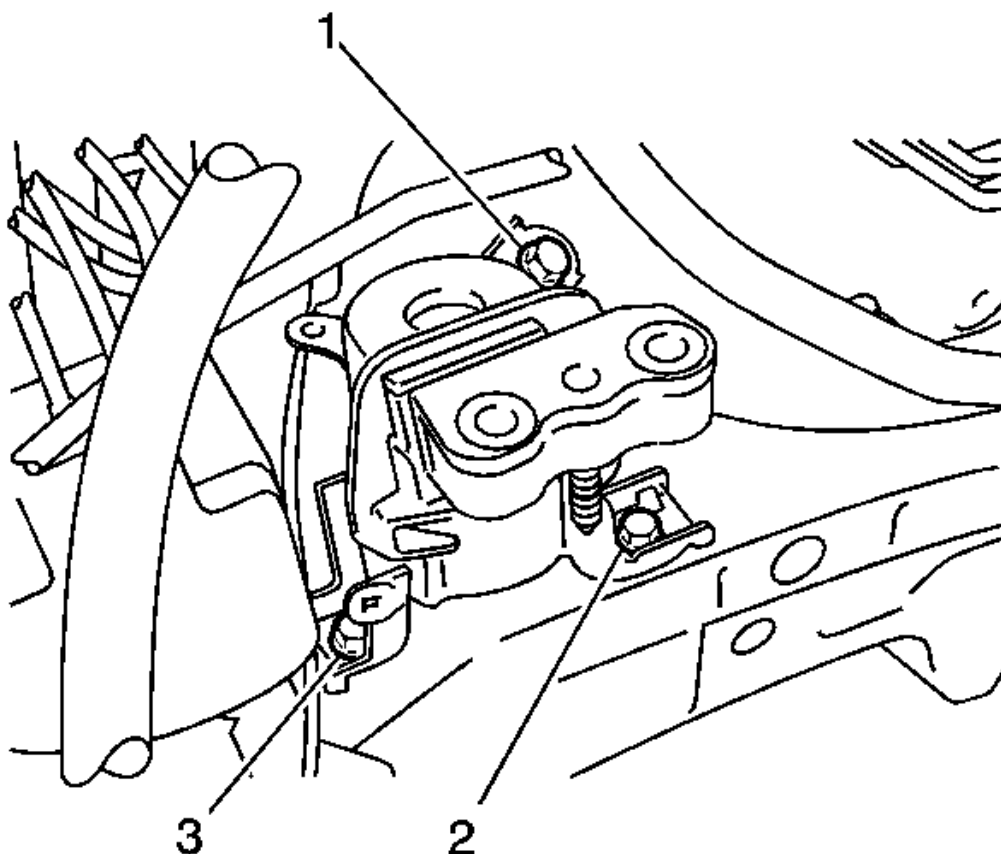


Fig. 22: View Of Engine Mounting Insulator Bolts - Right Side
Courtesy of GENERAL MOTORS CORP.

NOTE: Perform this procedure only when replacement of the engine mounting insulator is necessary.

5. Remove the 3 bolts (1-3) and engine mounting insulator RH.

Installation Procedure

CAUTION: Refer to Fastener Caution

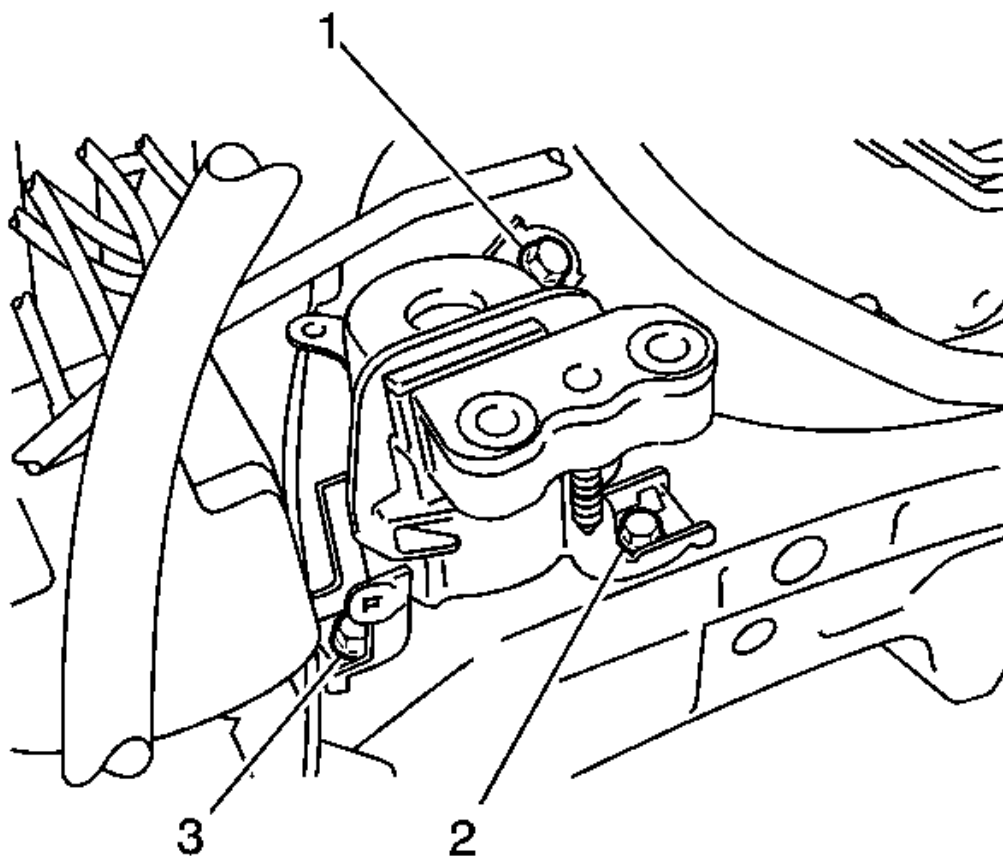


Fig. 23: View Of Engine Mounting Insulator Bolts - Right Side
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mounting insulator RH with the 3 bolts (1-3).

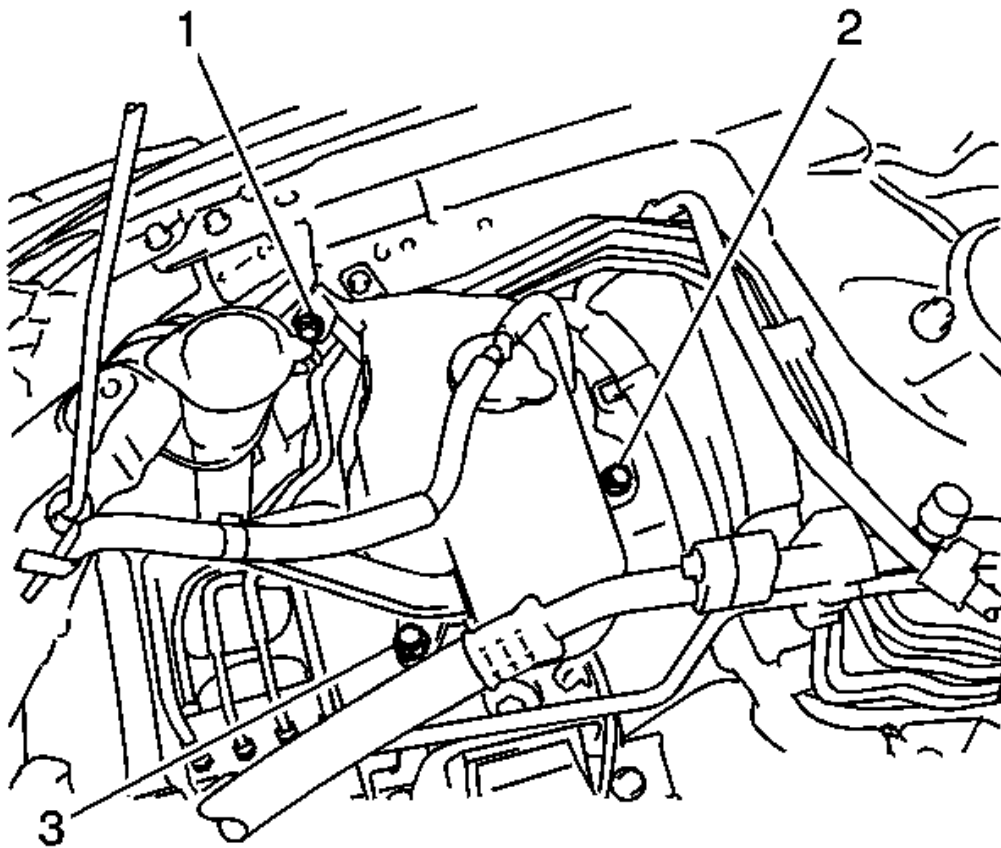


Fig. 24: View Of Radiator Surge Tank Assembly Bolts
Courtesy of GENERAL MOTORS CORP.

Tighten

Tighten the bolts to 52 N.m (38 lb ft).

2. Install the radiator reserve tank with the 3 bolts (1-3).

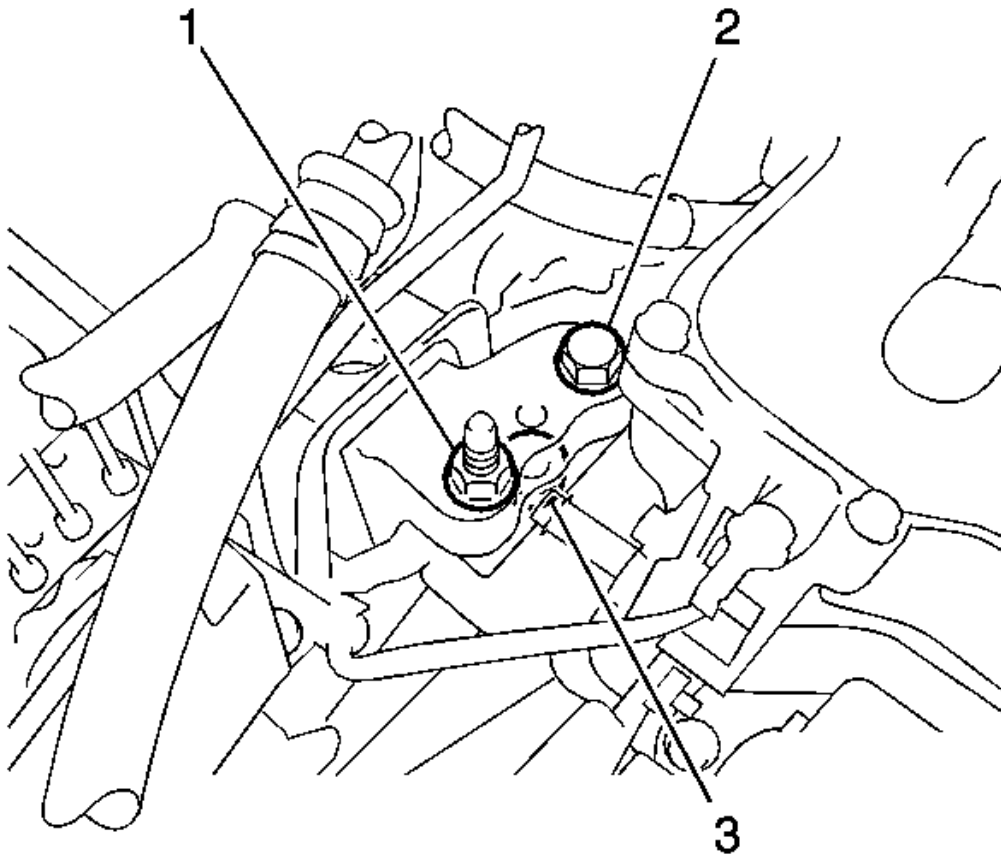


Fig. 25: Identifying Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

Tighten

Tighten the bolts to 7.0 N.m (62 lb in).

3. Install the engine mounting insulator RH with the bolt and 2 nuts.

Tighten

- Tighten the nut 1 to 95 N.m (70 lb ft)
 - Tighten the nut 2 to 52 N.m (38 lb ft)
 - Tighten the bolt 3 to 95 N.m (70 lb ft)
4. Remove the engine support fixture.
 5. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection And Connection** .

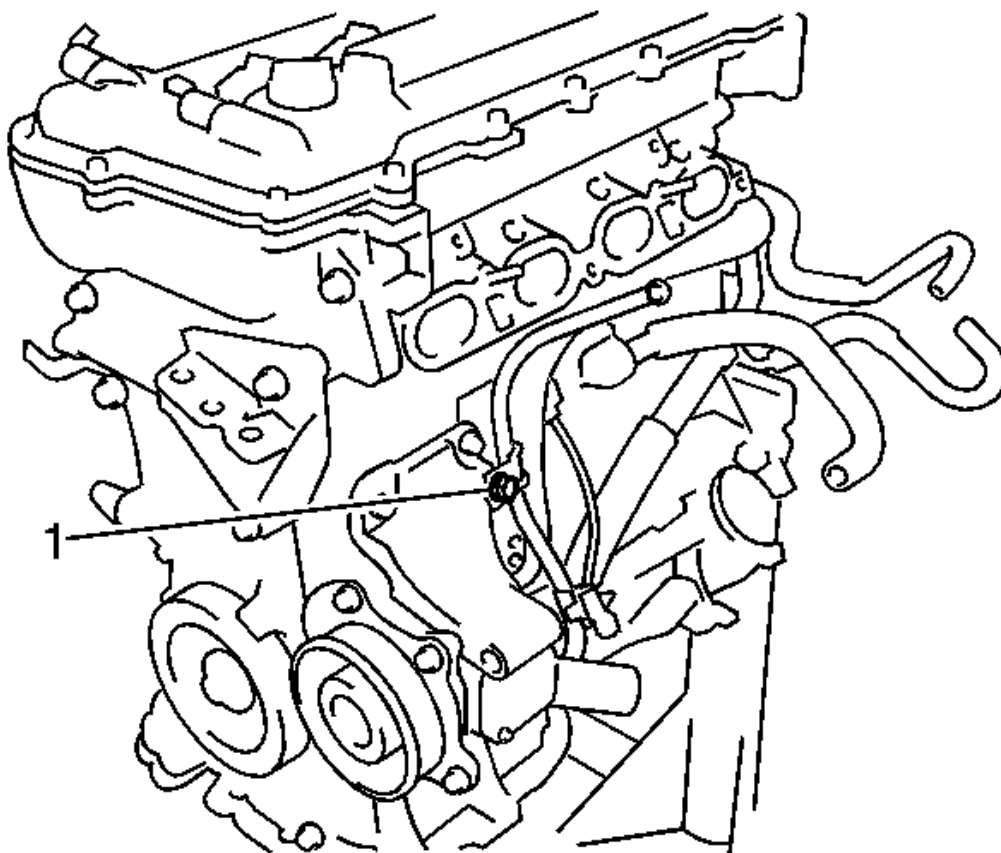
OIL LEVEL INDICATOR AND TUBE REPLACEMENT**Removal Procedure**

Fig. 26: Identifying Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator from the guide tube.
2. Remove the guide tube bolt from the cylinder block.
3. Remove the guide tube from the cylinder block.

Installation Procedure

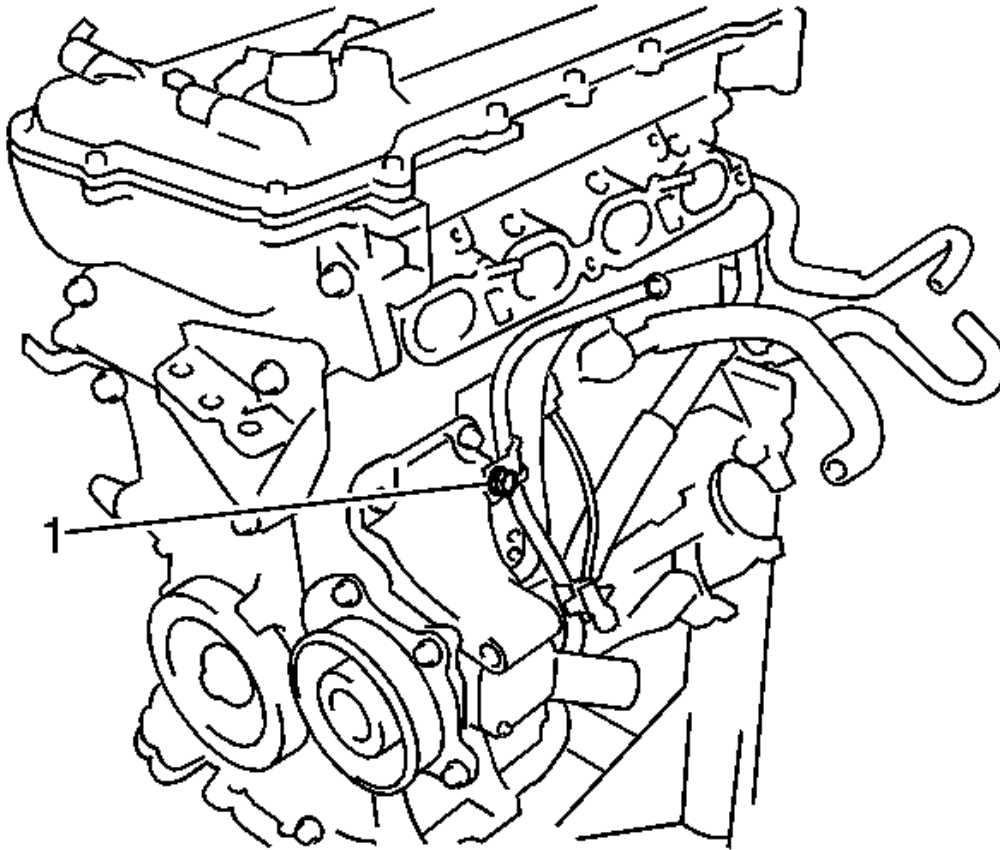


Fig. 27: Identifying Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Use new engine oil in order to coat the new guide tube seal.

CAUTION: Refer to Fastener Caution .

2. Install the new guide tube seal (1) to the guide tube. Secure the guide tube to the cylinder block using one bolt and tighten to 14 N.m (10 lb ft).
3. Install the oil level indicator to the guide tube.

ENGINE BLOCK HEATER REPLACEMENT (AUTOMATIC TRANSMISSION)

Removal Procedure

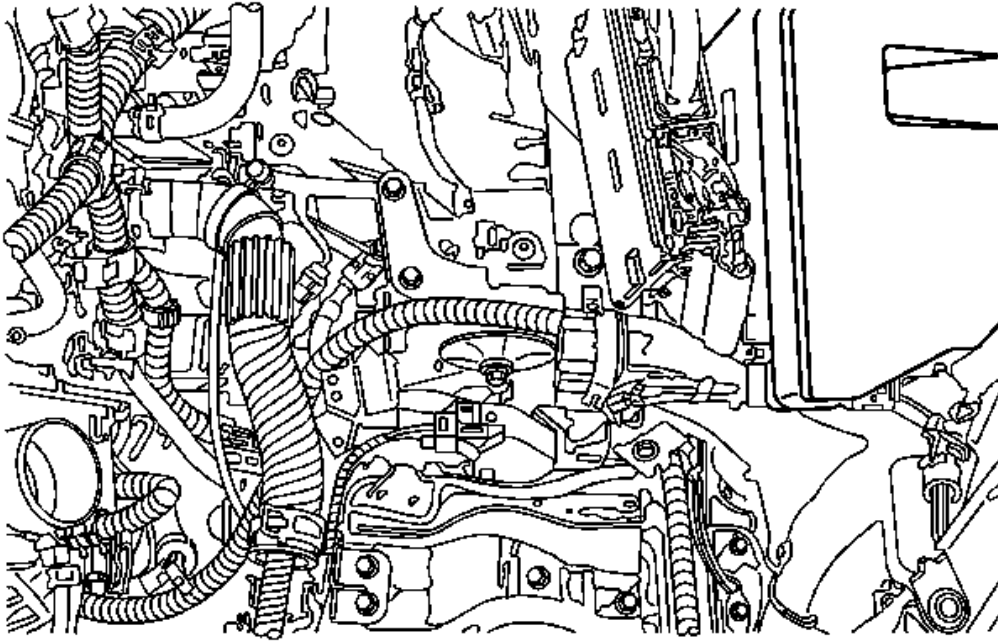


Fig. 28: Identifying Engine Block Heater Harness Plug Bundle
Courtesy of GENERAL MOTORS CORP.

1. Unclip the engine block heater harness plug bundle from the resonator attachment flange.

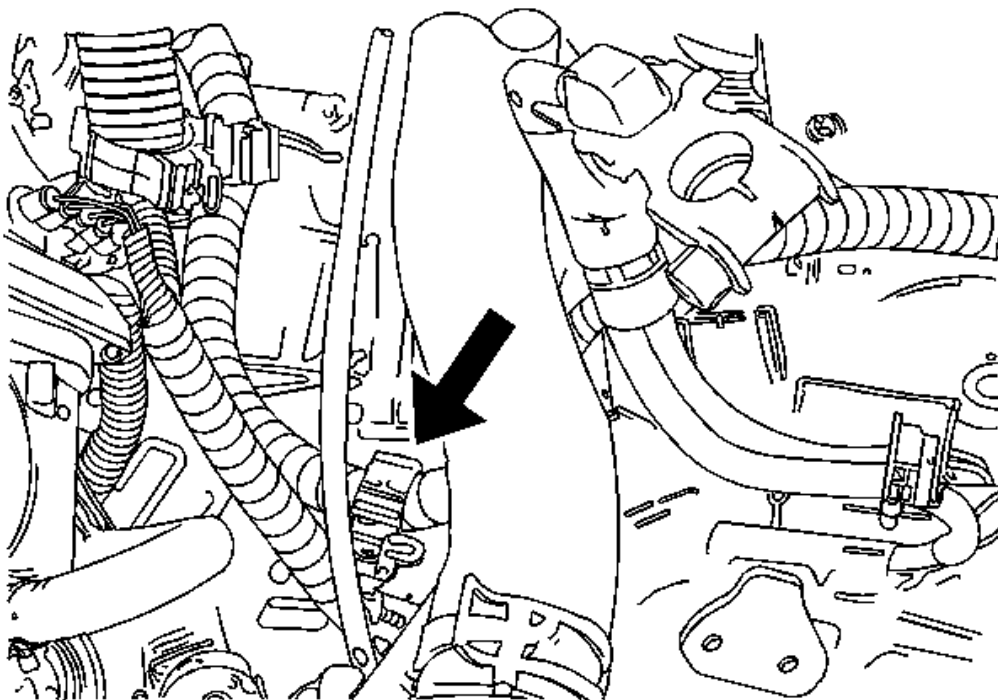


Fig. 29: Identifying Engine Block Heater Harness Retainer
Courtesy of GENERAL MOTORS CORP.

2. Detach the engine block heater harness retainer from the neutral safety switch harness.

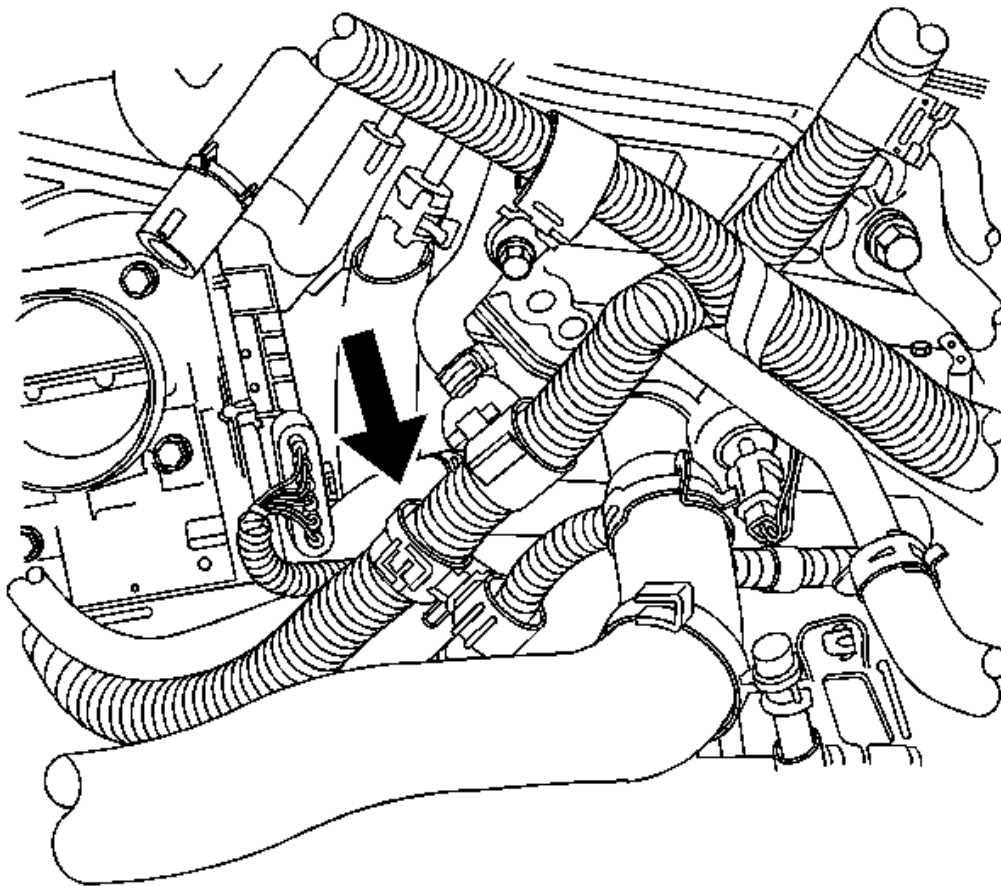


Fig. 30: View Of Engine Block Heater Harness Retainer
Courtesy of GENERAL MOTORS CORP.

3. Detach the engine block heater harness retainer from the engine harness.

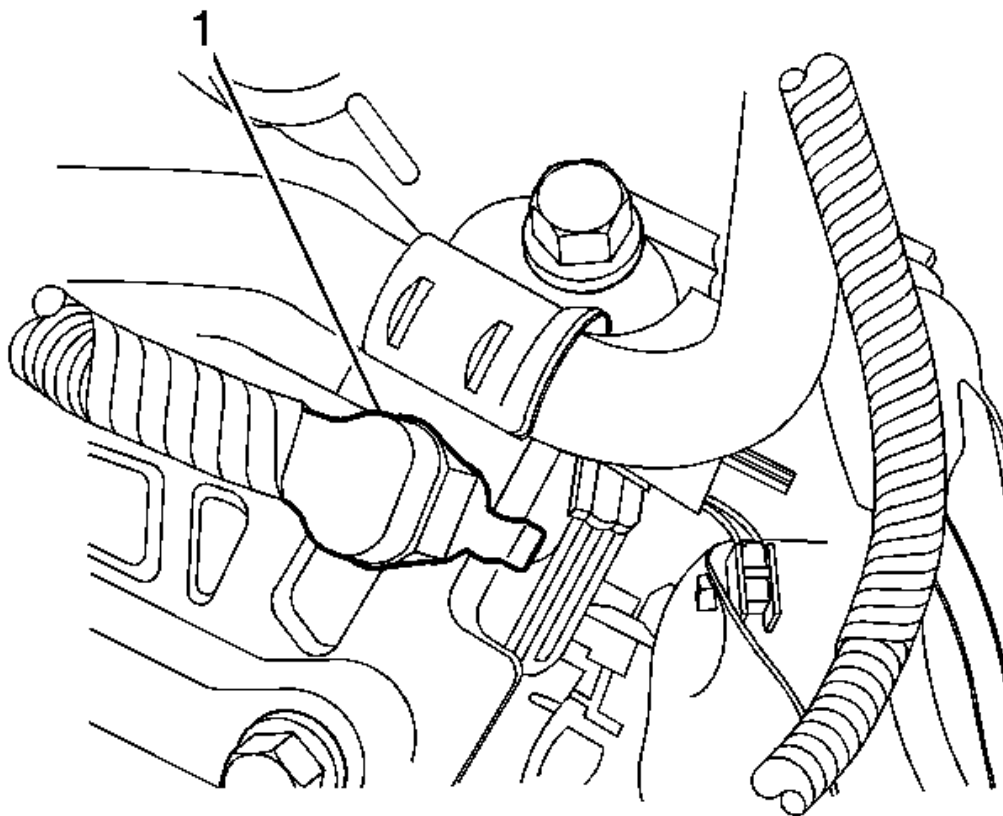


Fig. 31: Locating Engine Block Heater Element Retaining Clip
Courtesy of GENERAL MOTORS CORP.

4. Disengage the engine block heater element retaining clip from the engine block and remove the engine block heater assembly.

Installation Procedure

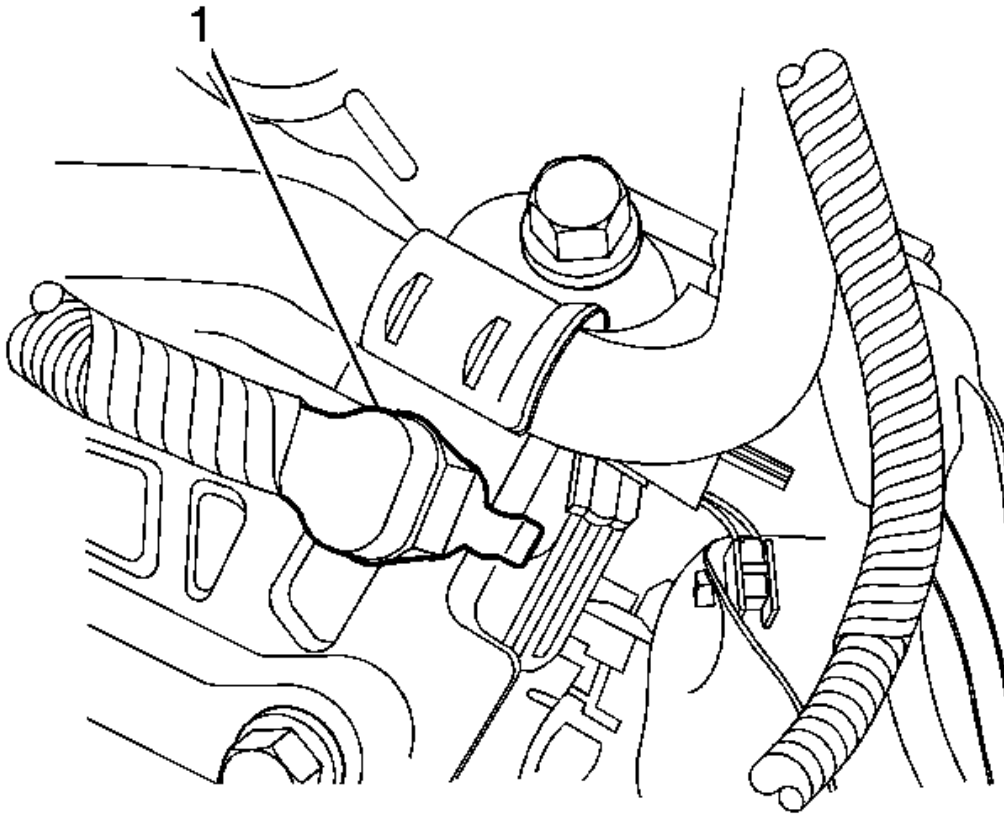


Fig. 32: Locating Engine Block Heater Element Retaining Clip
Courtesy of GENERAL MOTORS CORP.

NOTE: Visually inspect that the engine block heater harness plug is fully seated onto the element. Ensure the heating element is fully inserted into the engine block and the retaining clip is engaged. An audible click will be heard when clip is locked in position.

1. Completely insert the engine block heater element into the engine block cavity in the nine o'clock position.

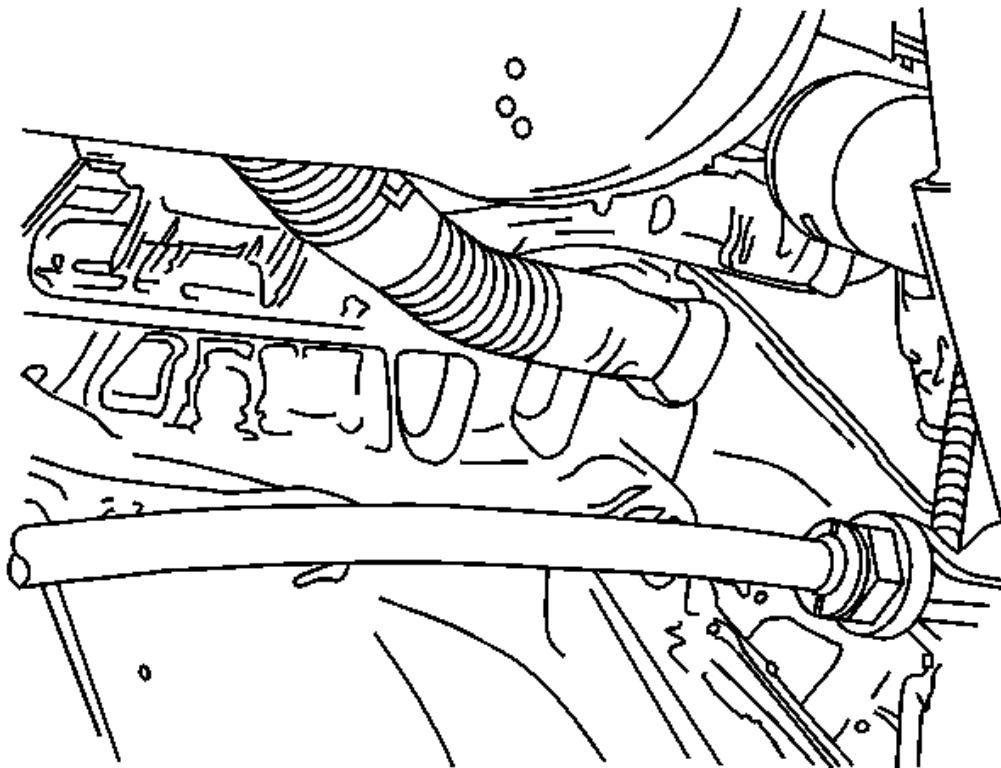


Fig. 33: Routing Engine Block Heater Harness
Courtesy of GENERAL MOTORS CORP.

2. Route the engine block heater harness towards the front of the engine.

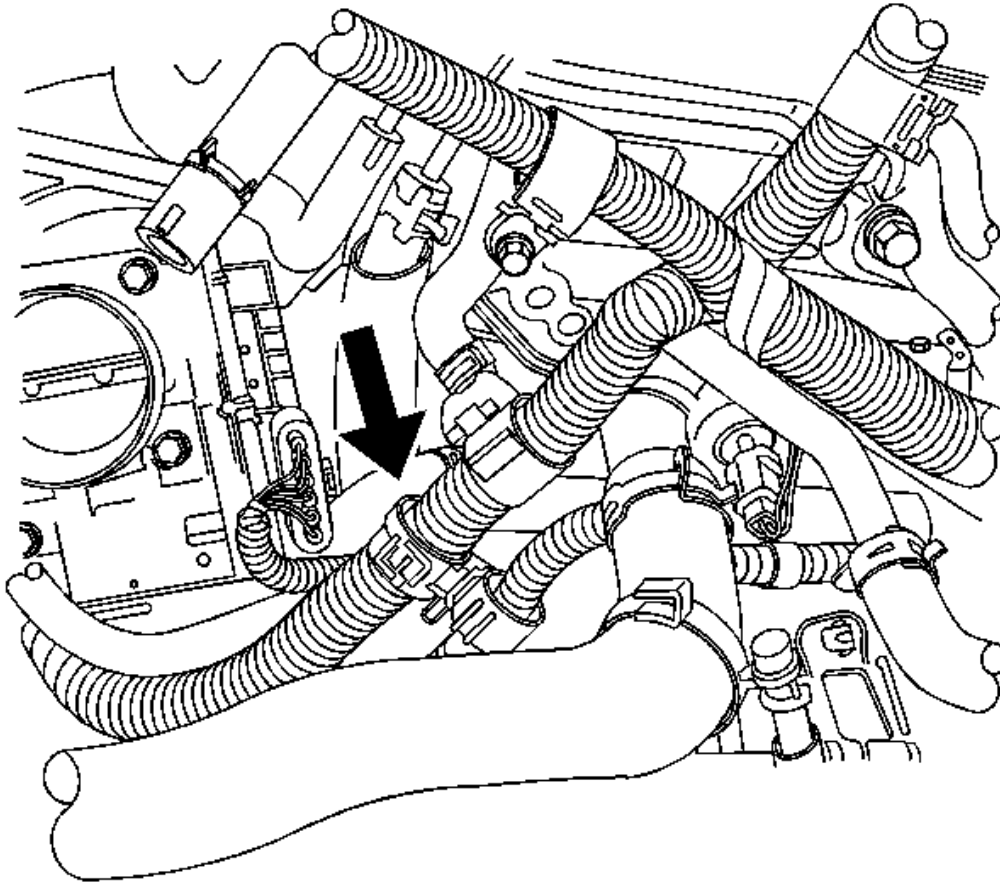


Fig. 34: View Of Engine Block Heater Harness Retainer
Courtesy of GENERAL MOTORS CORP.

NOTE: **Locate the retaining clip close to the throttle body branch. Ensure the engine block heater harness clip is fully attached to the conduit of the engine harness. An audible click will be heard when fully seated.**

3. Attach the engine block heater harness clip, nearest the heating element, between the engine main wiring harness bracket and the throttle body branch.

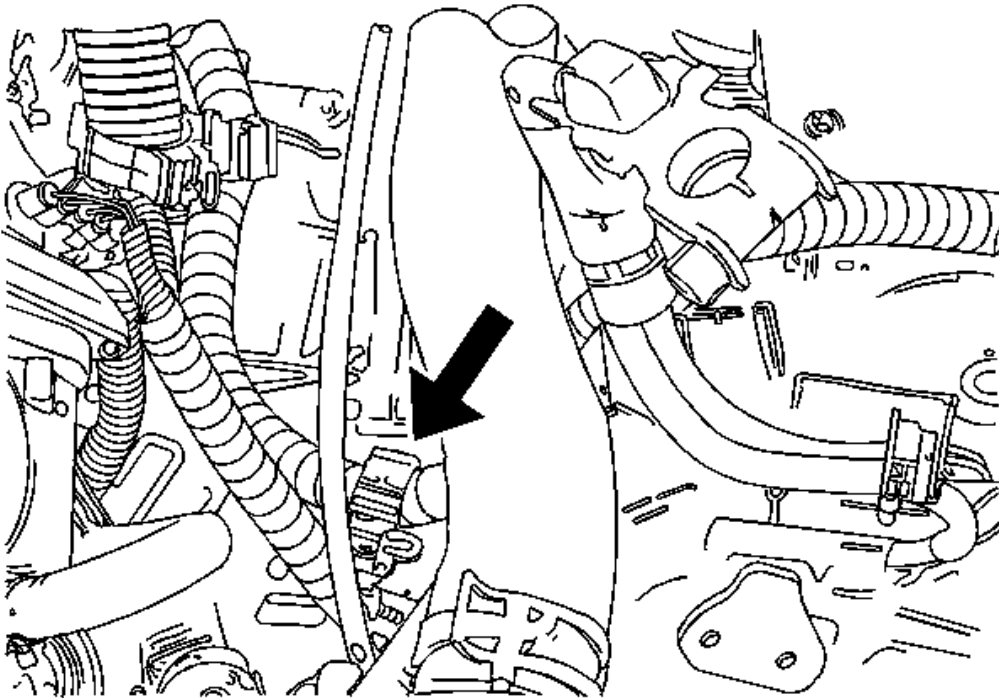


Fig. 35: Identifying Engine Block Heater Harness Retainer

Courtesy of GENERAL MOTORS CORP.

4. Route the engine block heater harness downward towards the bottom of the engine.
5. Route the engine block heater harness below the transmission shift cable.

NOTE: **Ensure the engine block heater harness clip is fully attached to the conduit of the neutral safety switch harness. An audible click will be heard when fully seated.**

6. Attach the engine block heater harness retaining clip to the neutral safety switch harness branch bracket.
7. Route the engine block heater harness over the battery harness protector and away from the air cleaner.

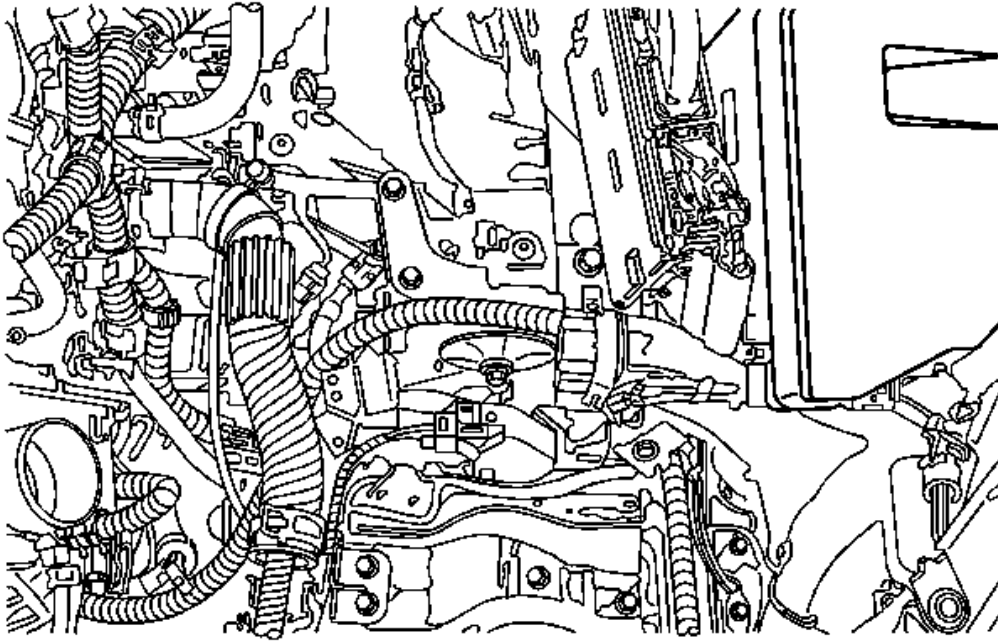


Fig. 36: Identifying Engine Block Heater Harness Plug Bundle
Courtesy of GENERAL MOTORS CORP.

8. Route the engine block heater harness under the air inlet. Then bring the harness upward along the air inlet towards the fender.

NOTE: When installation is completed, ensure the engine block heater harness plug bundle is stowed between the resonator and the fender.

9. Clip the engine block heater harness plug bundle to the resonator attachment flange close to the neck.

ENGINE BLOCK HEATER REPLACEMENT (MANUAL TRANSMISSION)

Removal Procedure

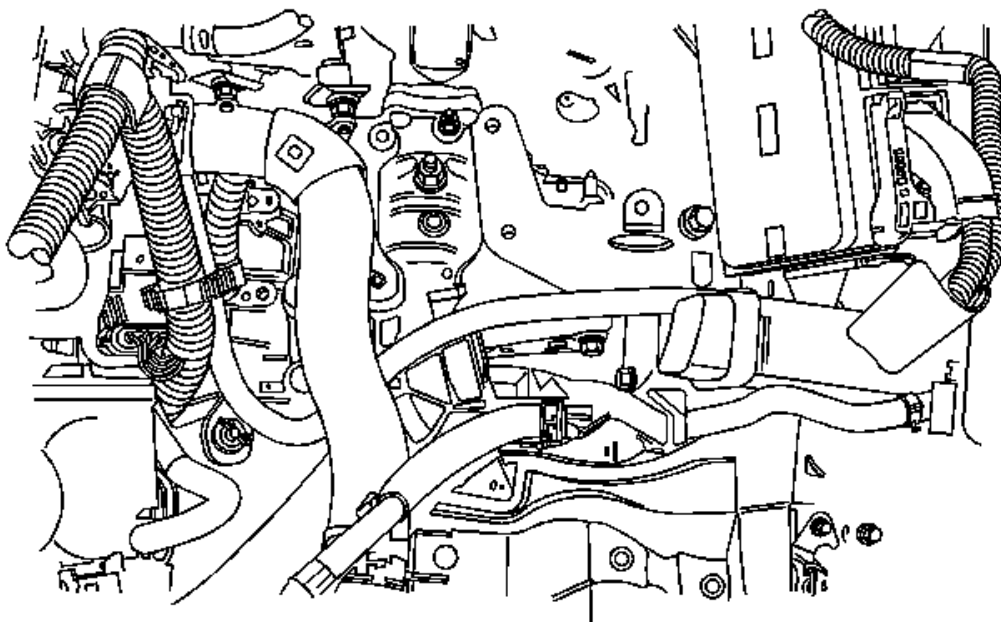


Fig. 37: View Of Engine Block Heater Harness Plug Bundle
Courtesy of GENERAL MOTORS CORP.

1. Unclip the engine block heater harness plug bundle from the resonator attachment flange.

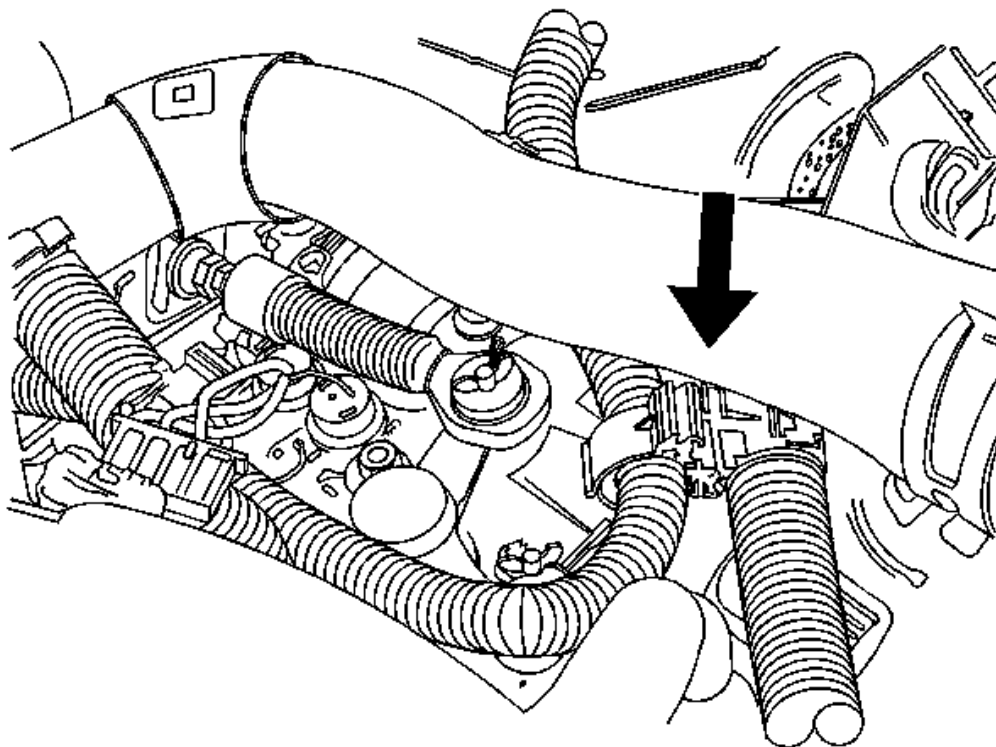


Fig. 38: View Of Engine Block Heater Harness Retainer
Courtesy of GENERAL MOTORS CORP.

2. Detach the engine block heater harness retainer from the battery harness.

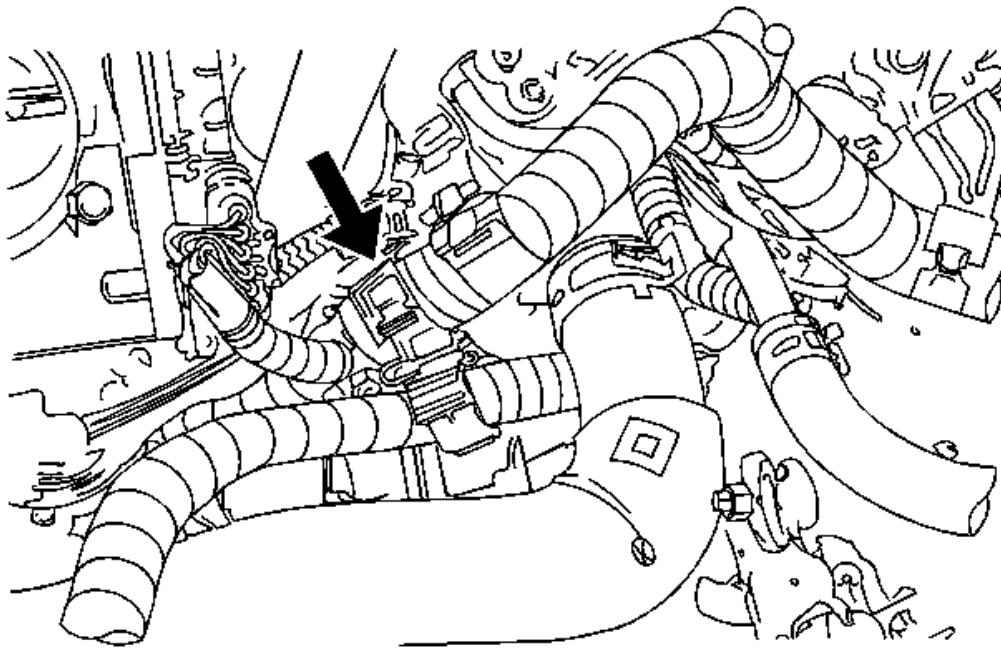


Fig. 39: Locating Engine Block Heater Harness Retainer
Courtesy of GENERAL MOTORS CORP.

3. Detach the engine block heater harness retainer from the engine harness.

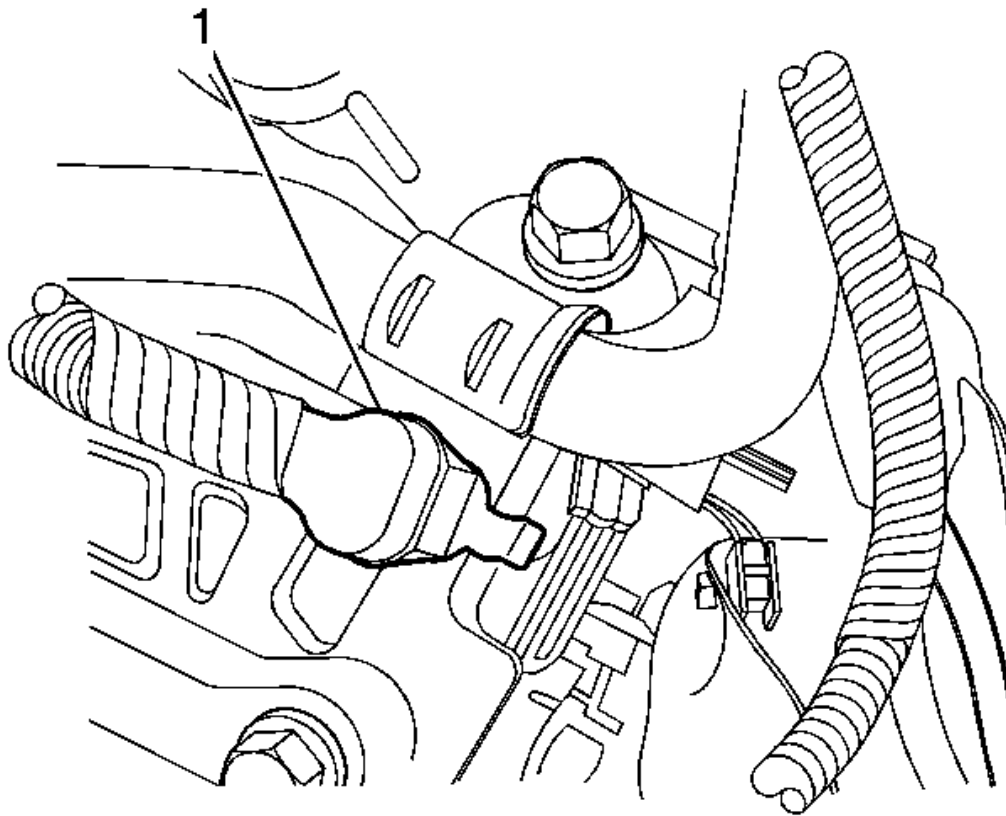


Fig. 40: Locating Engine Block Heater Element Retaining Clip
Courtesy of GENERAL MOTORS CORP.

4. Disengage the engine block heater element retaining clip from the engine block and remove the engine block heater assembly.

Installation Procedure

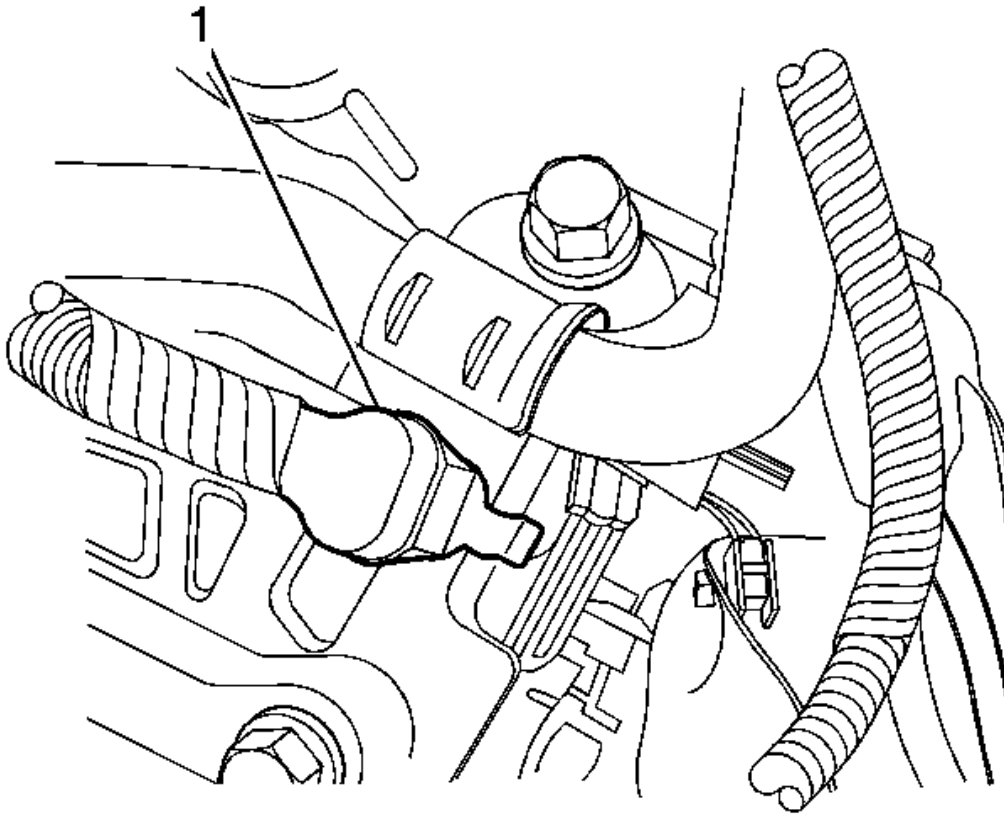


Fig. 41: Locating Engine Block Heater Element Retaining Clip
Courtesy of GENERAL MOTORS CORP.

NOTE: Visually inspect that the engine block heater harness plug is fully seated onto the element. Ensure the heating element is fully inserted into the engine block and the retaining clip is engaged. An audible click will be heard when clip is locked in position.

1. Completely insert the engine block heater element into the engine block cavity in the nine o'clock position.

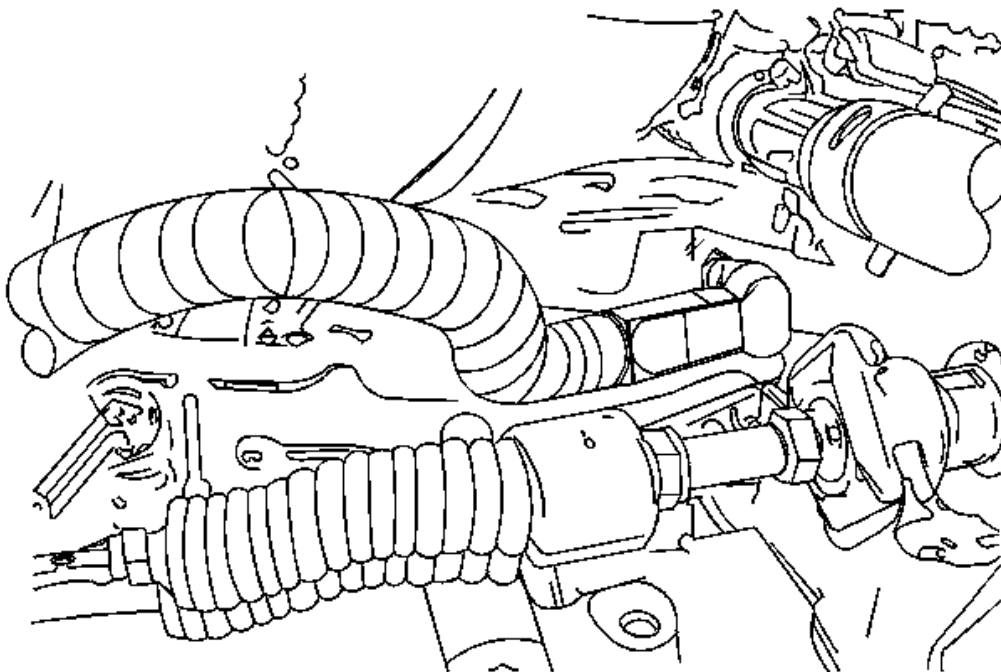


Fig. 42: Routing Of Engine Block Heater Harness
Courtesy of GENERAL MOTORS CORP.

2. Route the engine block heater harness towards the front of the engine.

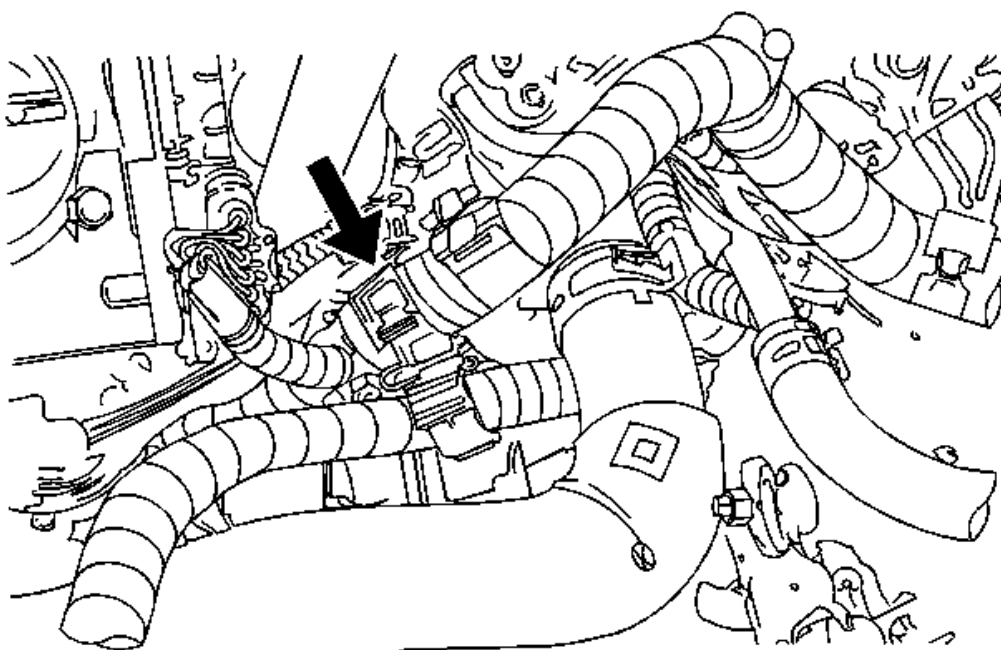


Fig. 43: Locating Engine Block Heater Harness Retainer
Courtesy of GENERAL MOTORS CORP.

NOTE: Locate the retaining clip close to the throttle body branch. Ensure the engine block heater harness clip is fully attached to the conduit of the engine harness. An audible click will be heard when fully seated.

3. Attach the engine block heater harness clip, nearest the heating element, between the engine main wiring harness bracket and the throttle body branch.

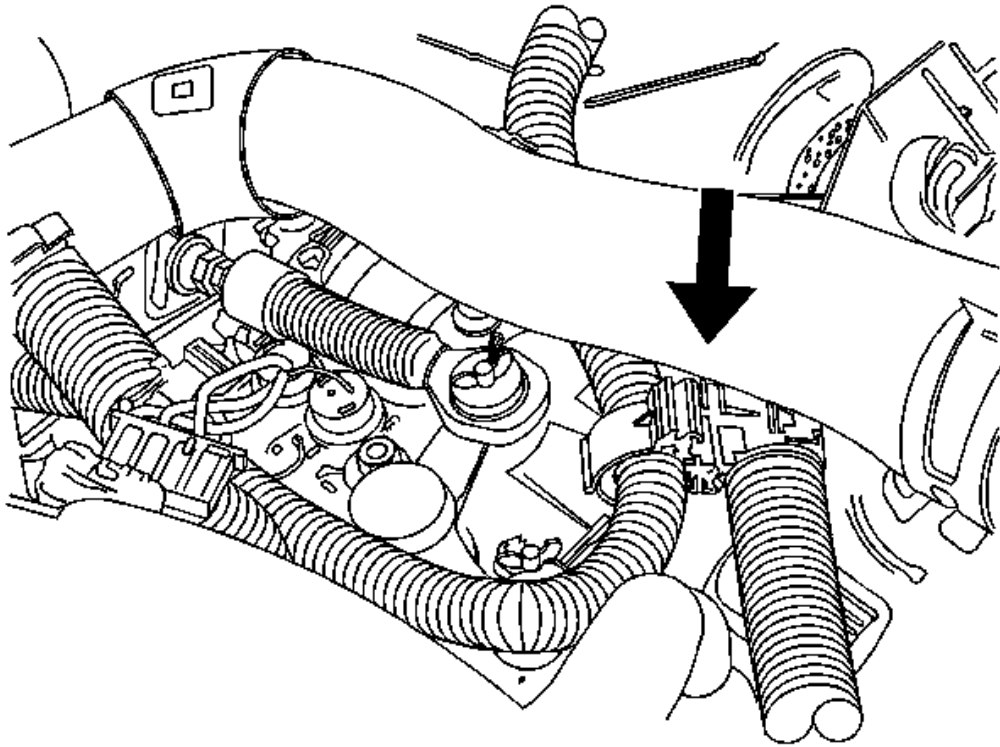


Fig. 44: View Of Engine Block Heater Harness Retainer
Courtesy of GENERAL MOTORS CORP.

4. Route the engine block heater harness under the heater hose.

NOTE: **Ensure the engine block heater harness clip is fully attached to the conduit of the battery harness. An audible click will be heard when fully seated.**

5. Route the engine block heater harness below the battery tray bracket and along the battery harness.
6. Rotate the clip downwards away from the radiator hose to prevent contact.

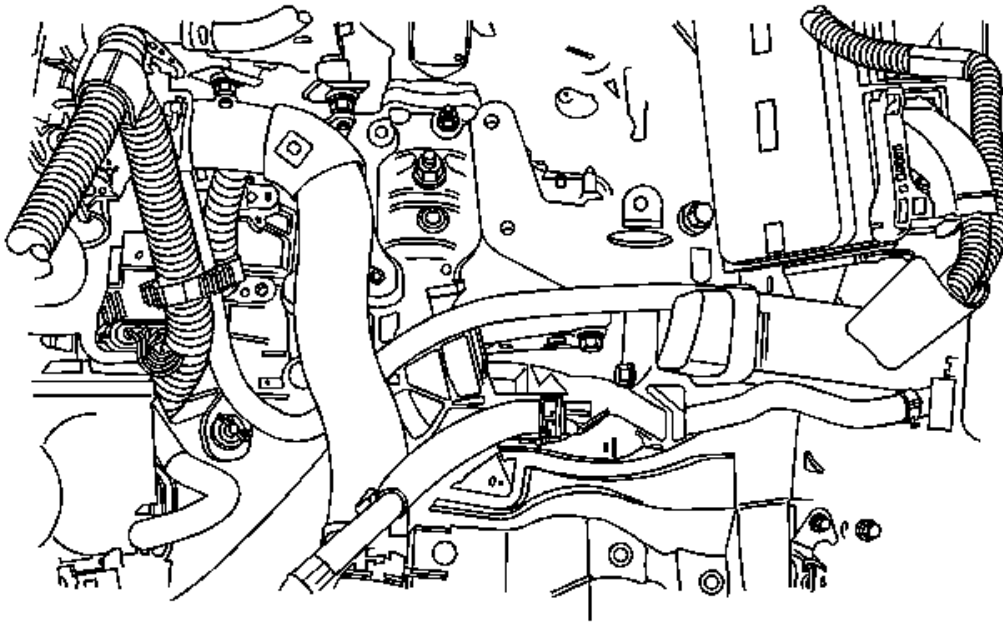


Fig. 45: View Of Engine Block Heater Harness Plug Bundle
Courtesy of GENERAL MOTORS CORP.

7. Route the engine block heater harness over the battery harness protector and away from the air cleaner.
8. Route the engine block heater harness under the air inlet. Then bring the harness upward along the air inlet.

NOTE: When installation is completed, ensure the engine block heater harness plug bundle is stowed between the resonator and the fender.

9. Clip the engine block heater harness plug bundle to the resonator attachment flange close to the neck.

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

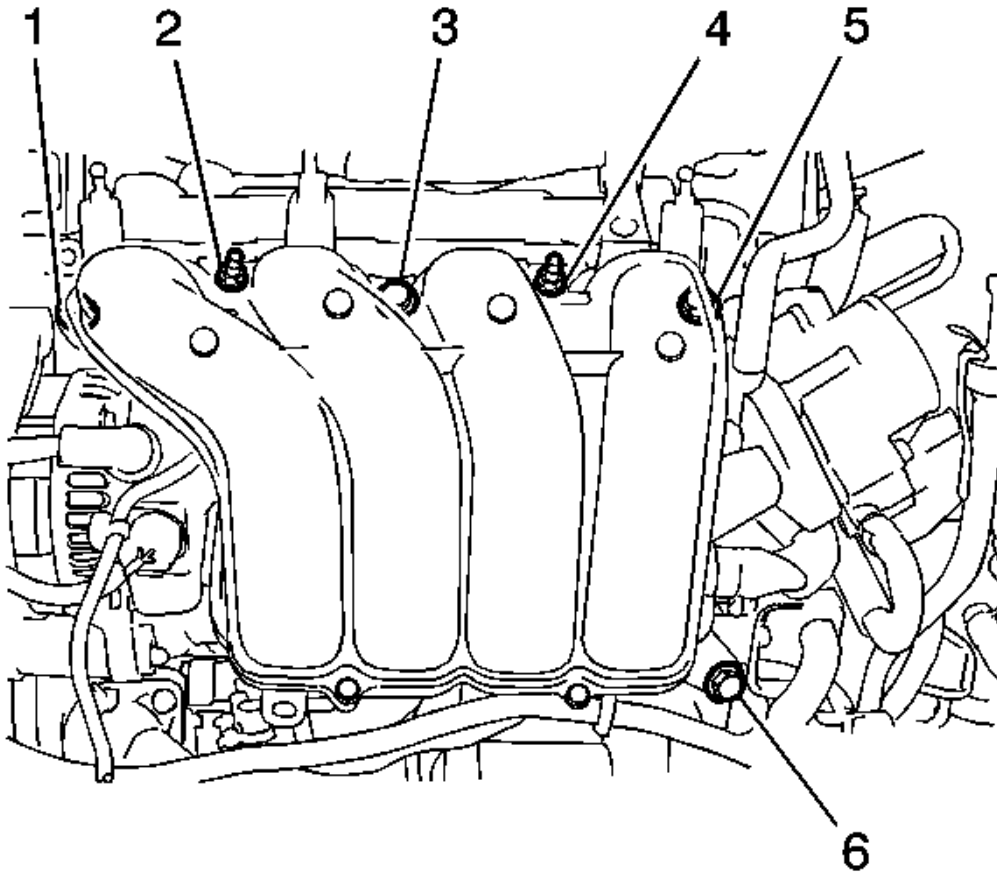


Fig. 46: Identifying Intake Manifold Bolt Loosening/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

1. Drain the engine coolant.
2. Remove the engine cover.
3. Remove the air cleaner cap sub-assembly with hose.
4. Remove the throttle body assembly.
5. Remove the intake manifold.
6. Remove the bolt and wire harness bracket.
7. Disconnect the 3 hoses.
8. Remove the 4 bolts, 2 nuts, intake manifold stay and intake manifold.

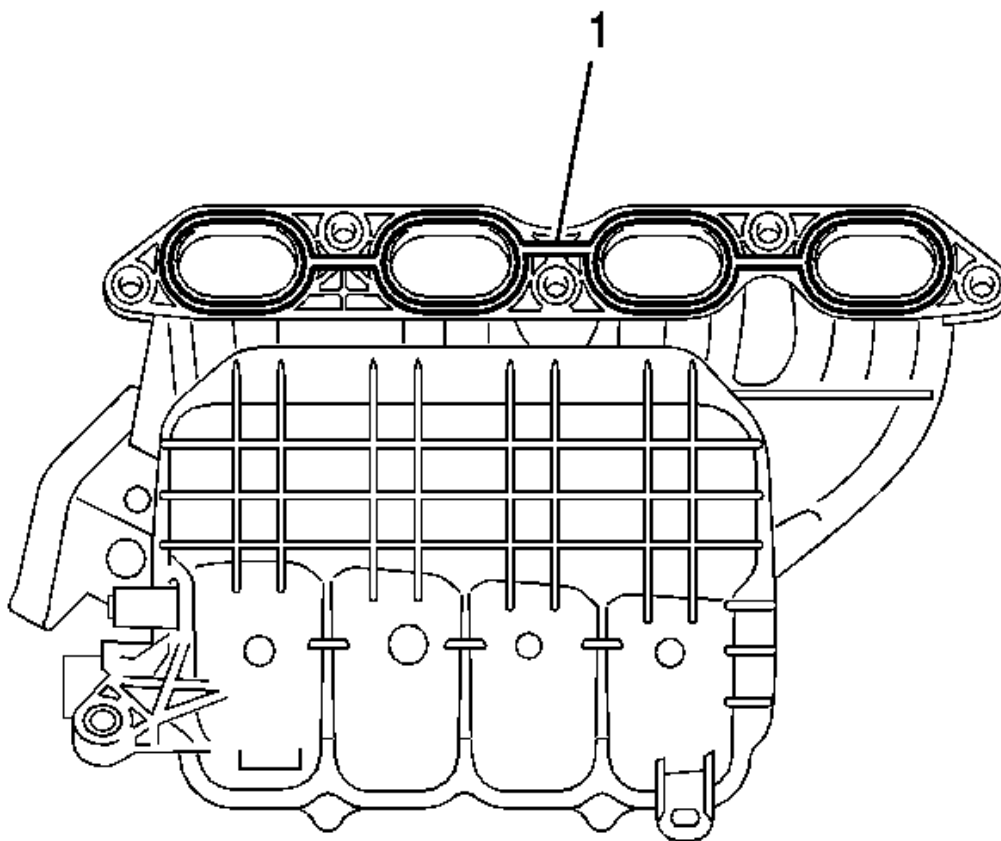


Fig. 47: View Of Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

9. Remove the gasket from the intake manifold.
10. Remove the bolt and bracket.
11. Using a TORX® socket E6, remove the 2 stud bolts from the intake manifold.

Installation Procedure

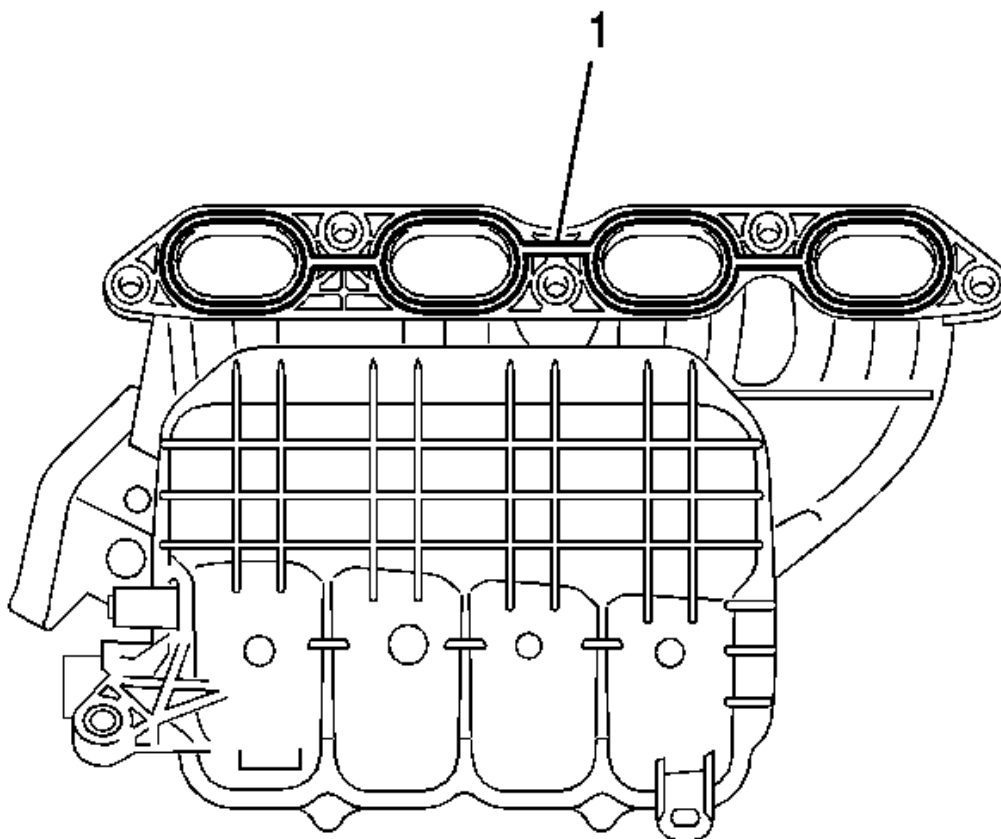


Fig. 48: View Of Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the intake manifold.

NOTE: Refer to FASTENER CAUTION .

2. Using a TORX® socket E6, install the 2 stud bolts to the intake manifold.

Tighten: Tighten the bolts to 5.0 N.m (44 lb in).

3. Connect the bracket with the bolt.

Tighten: Tighten the bolt to 10 N.m (8 lb ft).

4. Install a new gasket into the intake manifold.

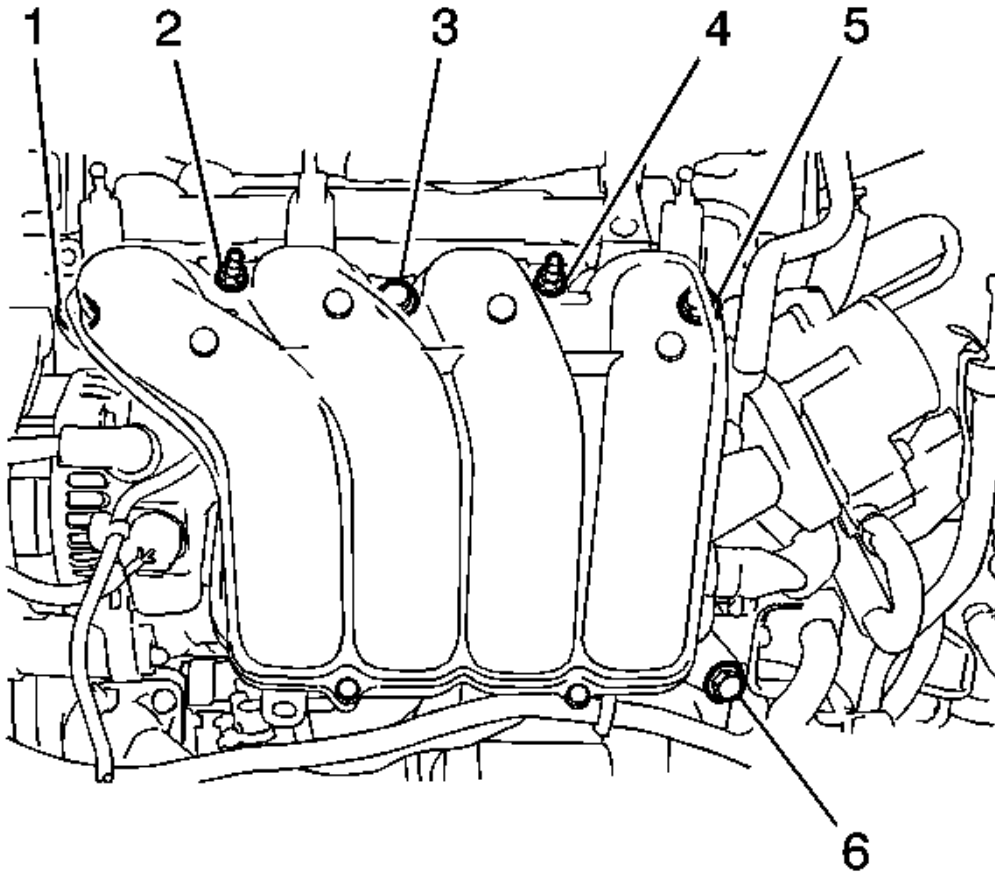


Fig. 49: Identifying Intake Manifold Bolt Loosening/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

5. Install the intake manifold and intake manifold stay with the 4 bolts and 2 nuts.

Tighten: Tighten the bolts to 28 N.m (21 lb ft).

6. Connect the 3 hoses.
7. Connect the wire harness bracket with the bolt.

Tighten: Tighten the bolt to 10 N.m (8 lb ft).

8. Install the throttle body assembly.
9. Install the air cleaner cap sub-assembly with hose.
10. Install the engine cover.

11. Add the engine coolant.
12. Inspect for coolant leak.

INTAKE CAMSHAFT AND VALVE LIFTER REPLACEMENT

Removal Procedure

1. Remove the engine assembly with transaxle. Refer to **Engine Replacement**.
2. Install the engine stand.
3. Remove the intake manifold.
4. Remove the fuel tube sub-assembly.
5. Remove the fuel delivery pipe sub-assembly.
6. Remove the fuel injector assembly.
7. Remove the ignition coil assembly.
8. Remove the oil level dipstick sub-assembly. Refer to **Oil Level Indicator and Tube Replacement**
9. Remove the No. 1 exhaust manifold heat insulator.
10. Remove the manifold stay.
11. Remove the exhaust manifold.
12. Remove the ventilation hose.
13. Remove the No. 3 water by-pass hose.
14. Remove the No. 1 water by-pass pipe.
15. Remove the water by-pass hose.
16. Remove the inlet water hose.
17. Remove the inlet water.
18. Remove the thermostat.
19. Remove the radio setting condenser.
20. Remove the cylinder head cover sub-assembly.
21. Set the No. 1 cylinder to TDC/compression.
22. Remove the crankshaft pulley.
23. Remove the No. 1 chain tensioner assembly.
24. Remove the timing chain cover sub-assembly.
25. Remove the timing chain cover oil seal.
26. Remove chain tensioner slipper.
27. Remove the No. 1 chain vibration damper.
28. Remove chain sub-assembly.
29. Remove the No. 2 chain vibration damper.

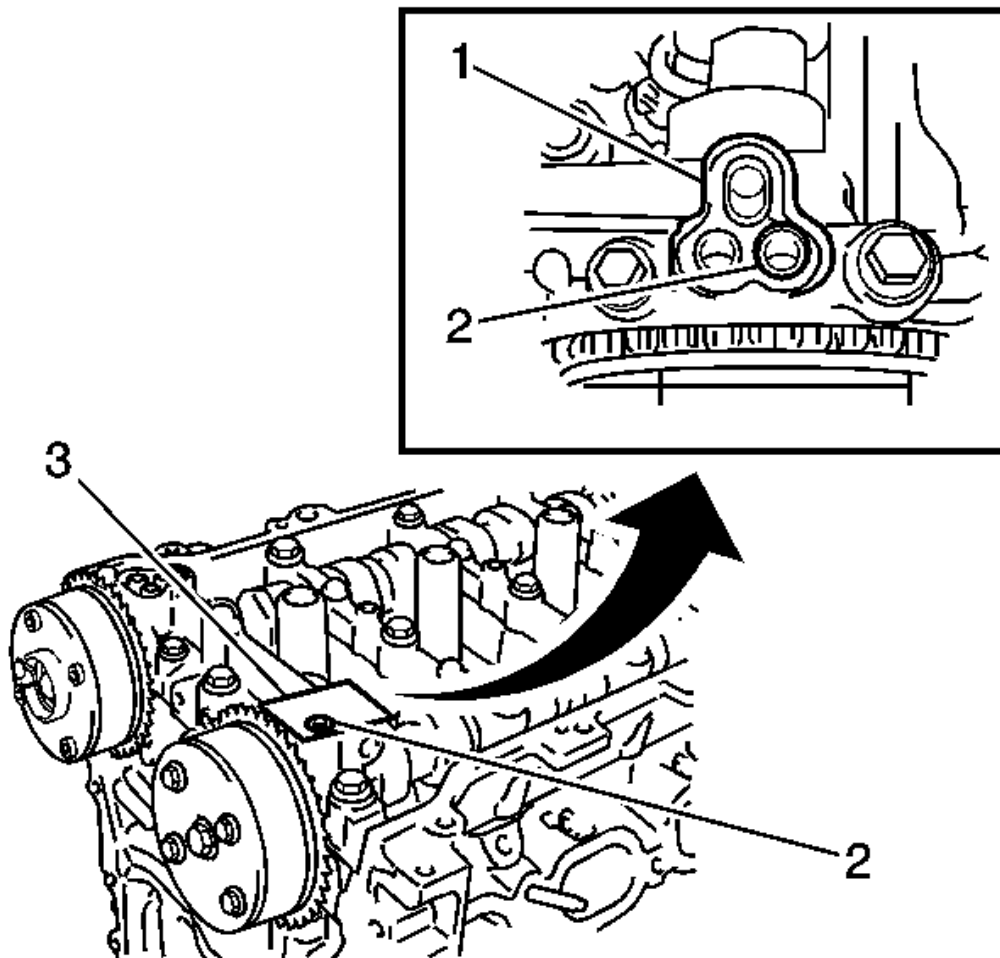


Fig. 50: Identifying Camshaft Timing Gear Assembly
Courtesy of GENERAL MOTORS CORP.

30. Inspect the camshaft timing gear assembly.
31. Check the lock of the camshaft timing gear.

IMPORTANT: Be sure to cover the oil hole completely because air leaks due to insufficient sealing will prevent the lock pin from being released.

32. After cleaning and degreasing the VVT oil hole on the intake side of the No. 1 camshaft bearing cap, completely seal the oil hole with adhesive tape or equivalent as shown in the illustration to prevent air from leaking.
33. Prick a hole in the tape covering the oil hole as shown.

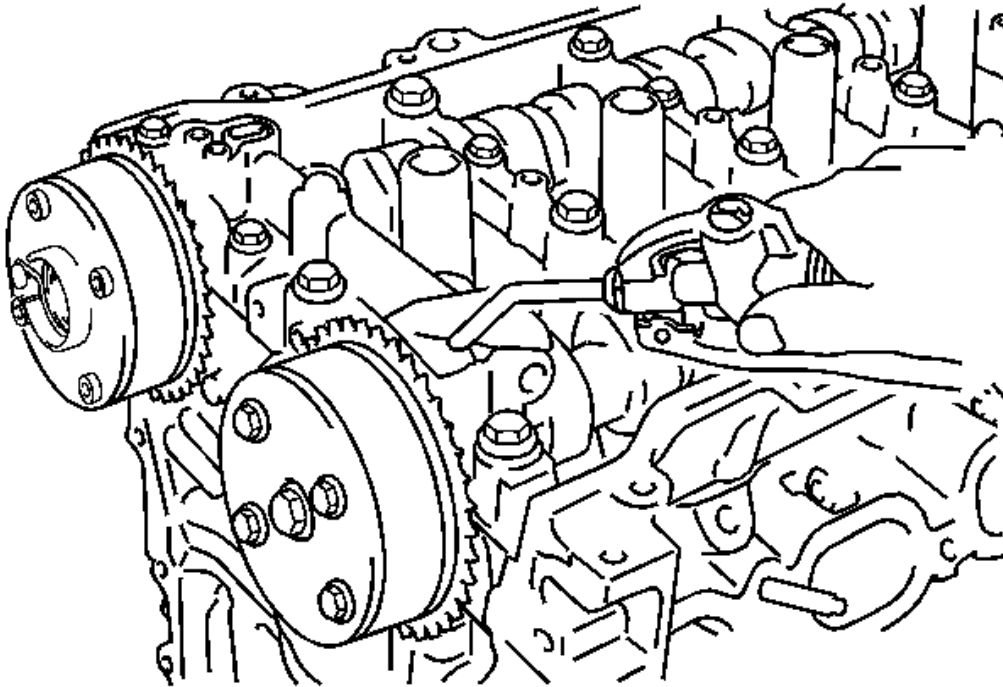


Fig. 51: Checking For Air Leaks
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- If air leaks out, reattach the adhesive tape.
- Cover the oil hole with a shop rag or piece of cloth when applying air pressure to prevent oil from spraying.

34. Apply approximately 150 kPa (22 psi) of air pressure to the hole pricked in procedure A to release the lock pin.

IMPORTANT: Depending on the air pressure applied, the camshaft timing gear assembly may turn in the advanced direction without assistance by hand.

35. Forcibly turn the camshaft timing gear assembly in the advanced direction (counterclockwise).

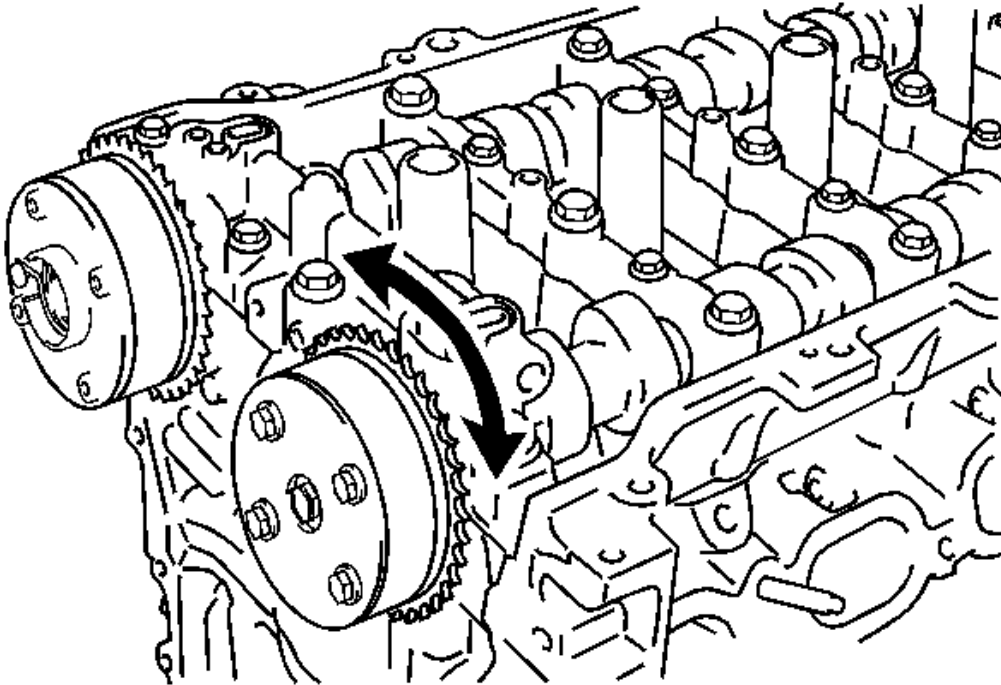


Fig. 52: Checking Camshaft Timing Gear Assembly For Smooth Turning Ability
Courtesy of GENERAL MOTORS CORP.

36. Turn the camshaft timing gear assembly within its movable range (26.5-28.5°) 2 or 3 times without turning it to the most retarded position. Make sure that the camshaft timing gear assembly turns smoothly.
37. Remove the adhesive tape from the No. 1 camshaft bearing cap.
38. Inspect the camshaft timing exhaust gear assembly.
39. Check the lock of the camshaft timing exhaust gear.

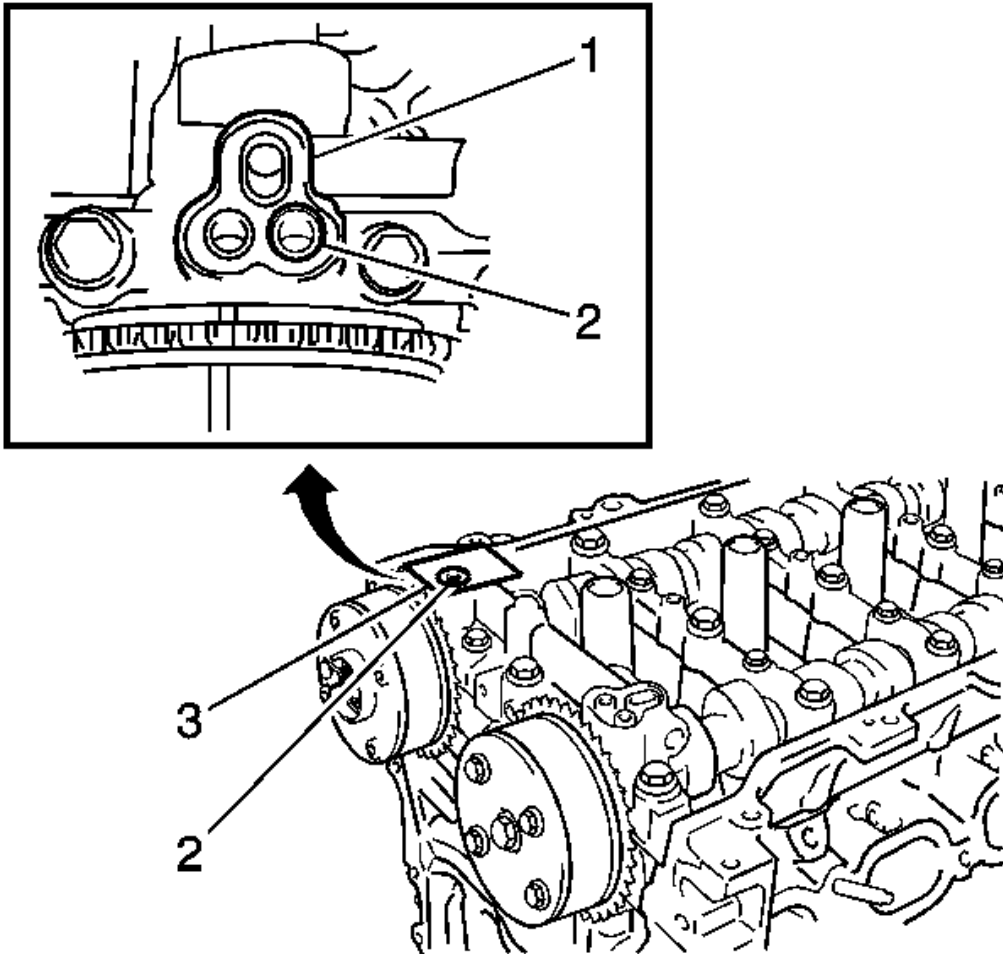


Fig. 53: View Of Sealing Oil Hole With Tape
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be sure to cover the oil hole completely because air leaks due to insufficient sealing will prevent the lock pin from being released.

40. After cleaning and degreasing the VVT oil hole on the exhaust side of the No. 1 camshaft bearing cap, completely seal the oil hole with adhesive tape or equivalent as shown in the illustration to prevent air from leaking.
41. Prick a hole in the tape covering the oil hole as shown.

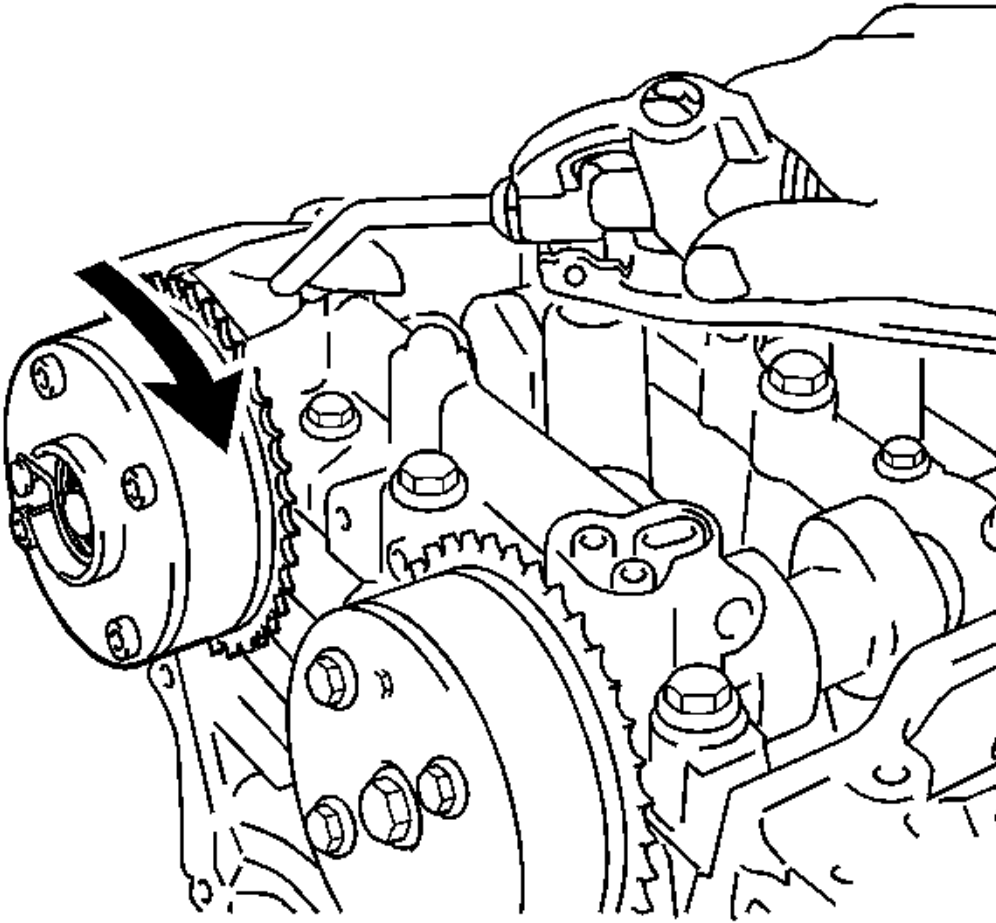


Fig. 54: Applying Shop Air To Hole In Tape

Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- If air leaks out, reattach the adhesive tape.
- Cover the oil hole with a shop rag or piece of cloth when applying air pressure to prevent oil from spraying.

42. Apply approximately 200 kPa (28 psi) of air pressure to the hole pricked in procedure B to release the lock pin.

IMPORTANT:

- Be sure to keep the camshaft timing exhaust gear in the retard direction using a screwdriver. If the gear is released, it will return to the most advanced position automatically due to force from the

spring.

- **Do not damage the camshaft timing exhaust gear.**

43. Using a screwdriver with its tip wrapped with tape, forcibly turn the camshaft timing exhaust gear in the retard direction (clockwise).

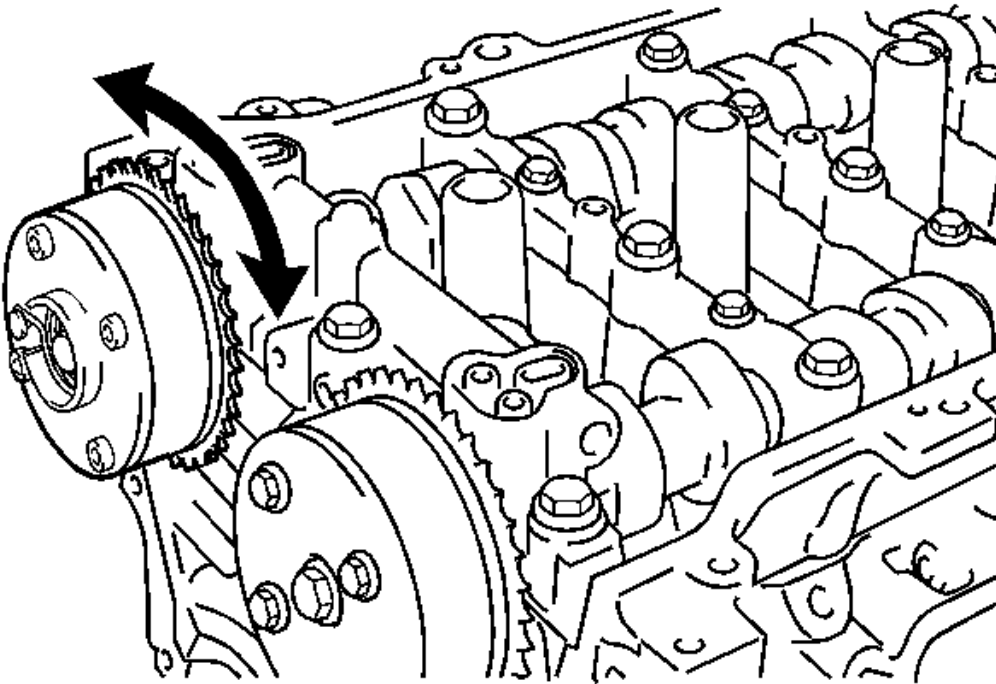


Fig. 55: Turning Camshaft Timing Exhaust Gear Within Movable Range
Courtesy of GENERAL MOTORS CORP.

44. Using a screwdriver with its tip wrapped with tape, turn the camshaft timing exhaust gear within its movable range (19 to 21 degrees) 2 or 3 times without turning it to the most advanced position. Make sure that the camshaft timing exhaust gear turns smoothly.
45. Remove the adhesive tape from the No. 1 camshaft bearing cap.

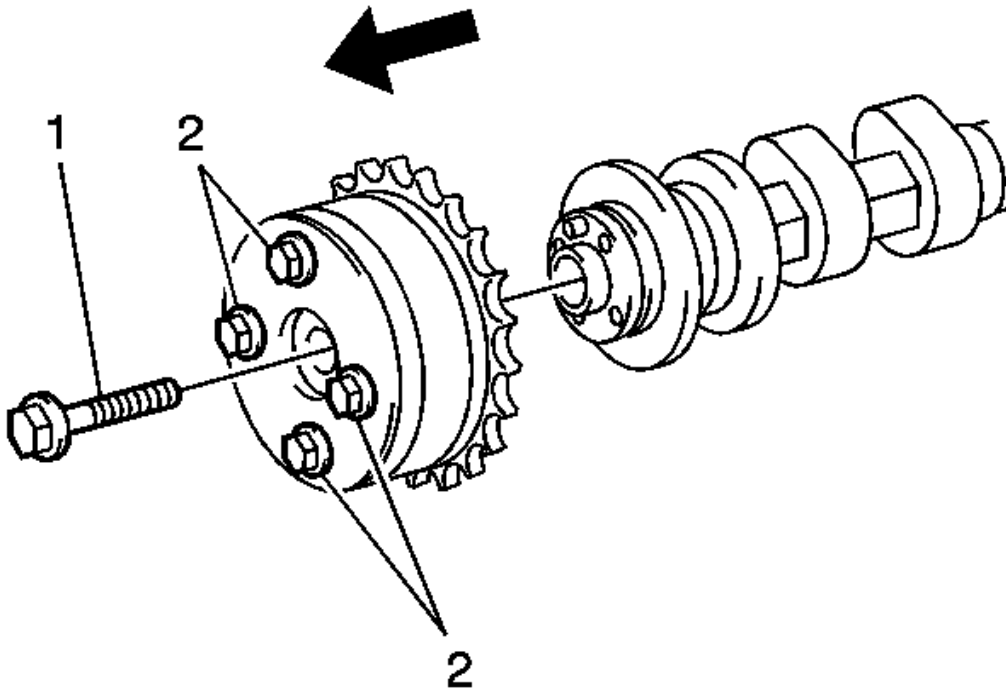


Fig. 56: View Of Camshaft Timing Gear & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Before removing the camshaft timing gear, make sure that the lock pin has been released.
- Be sure not to remove the other 4 bolts.
- Keep the camshaft timing gear assembly horizontal while removing it from the camshaft.

46. Remove the flange bolt while holding the hexagonal portion of the camshaft, and then remove the camshaft timing gear assembly.

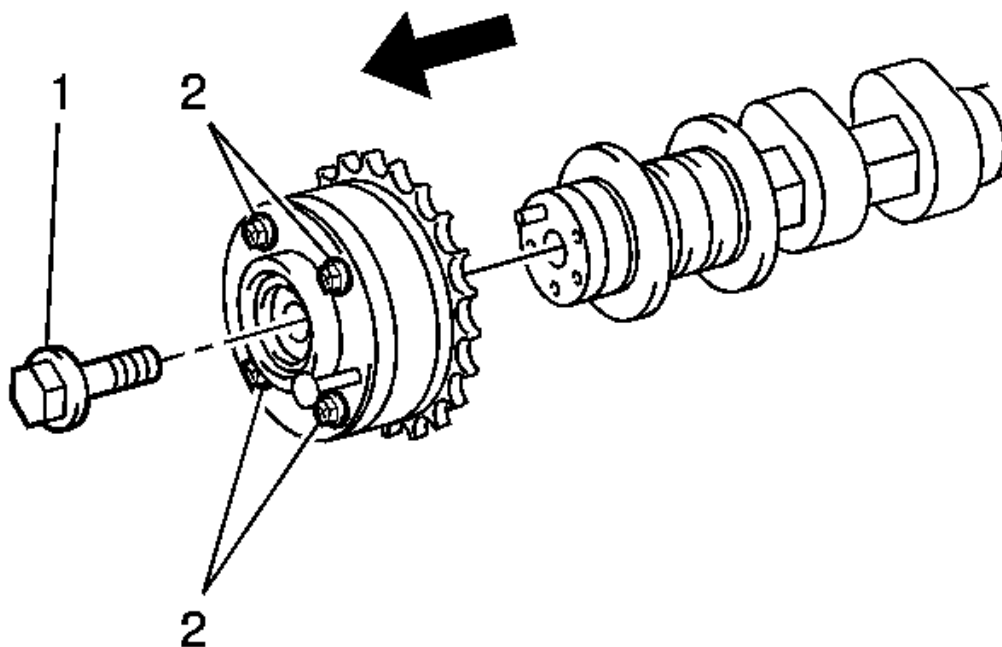


Fig. 57: View Of Camshaft Timing Gear & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Be sure not to remove the other 4 bolts.
- Keep the camshaft timing exhaust gear assembly horizontal while removing it from the camshaft.

47. Remove the flange bolt while holding the hexagonal portion of the camshaft, and then remove the camshaft timing exhaust gear assembly.

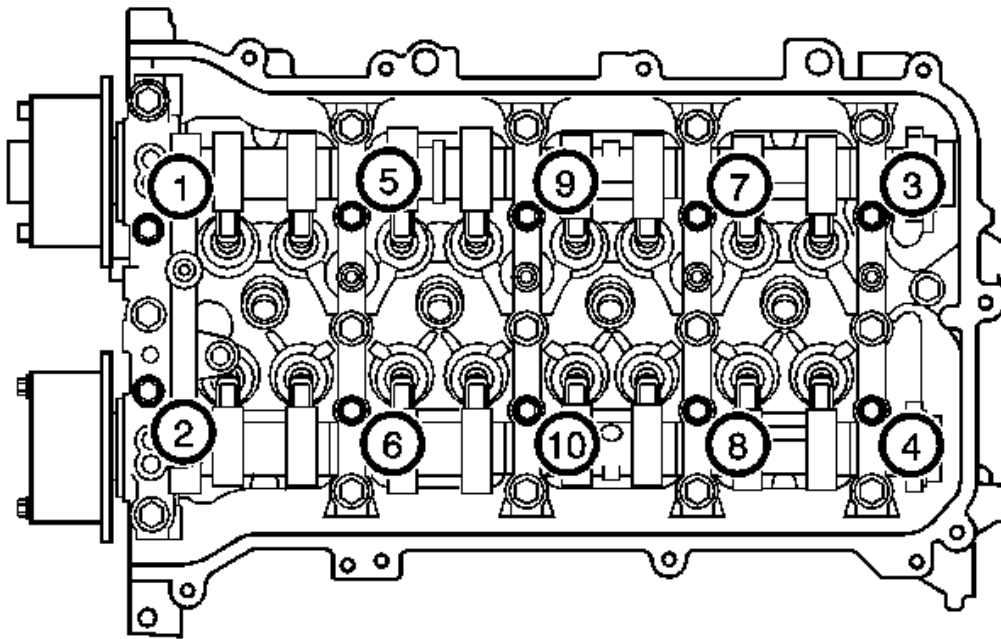


Fig. 58: Identifying Camshaft Bearing Cap Bolt Removal/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

48. Remove camshaft bearing cap-Uniformly loosen and remove the 10 bearing cap bolts in the sequence shown in the illustration.

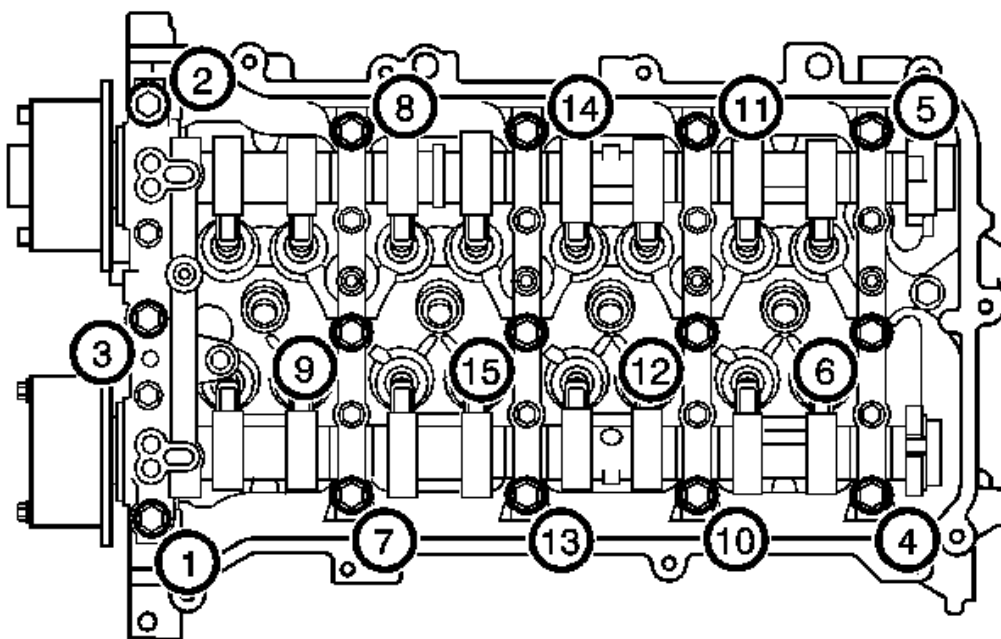


Fig. 59: View Of Camshaft Bearing Cap Bolt Removal/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Uniformly loosen the bolts while keeping the camshaft level.

49. Uniformly loosen and remove the 15 bearing cap bolts in the sequence shown in the illustration.

IMPORTANT: Arrange the removed parts in the correct order.

50. Remove the 5 bearing caps.

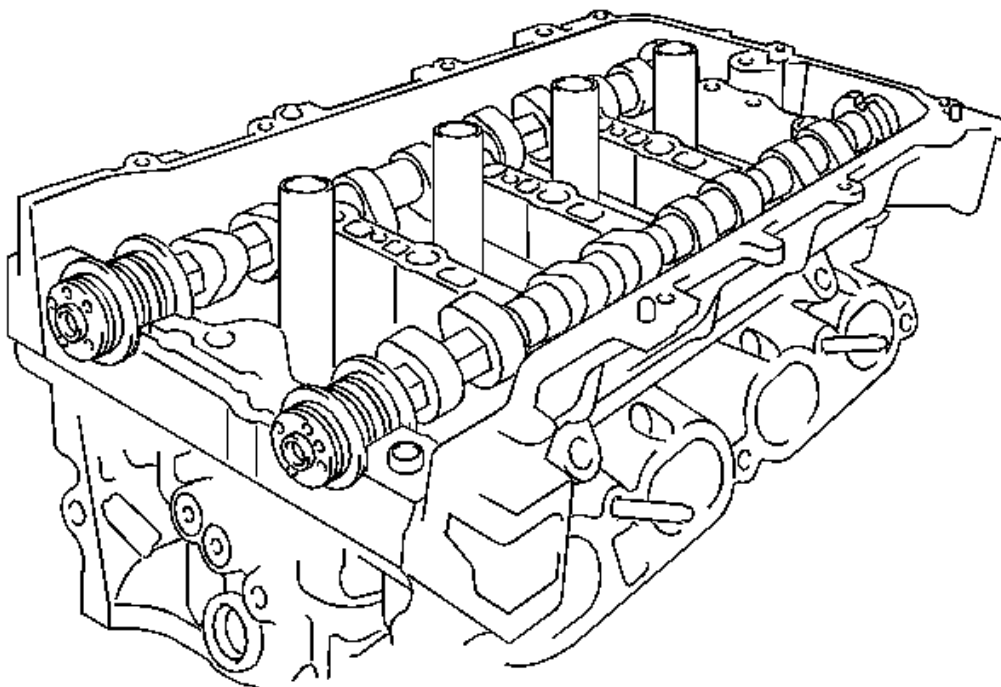


Fig. 60: View Of Cylinder Head & Camshafts
Courtesy of GENERAL MOTORS CORP.

51. Remove the camshaft.

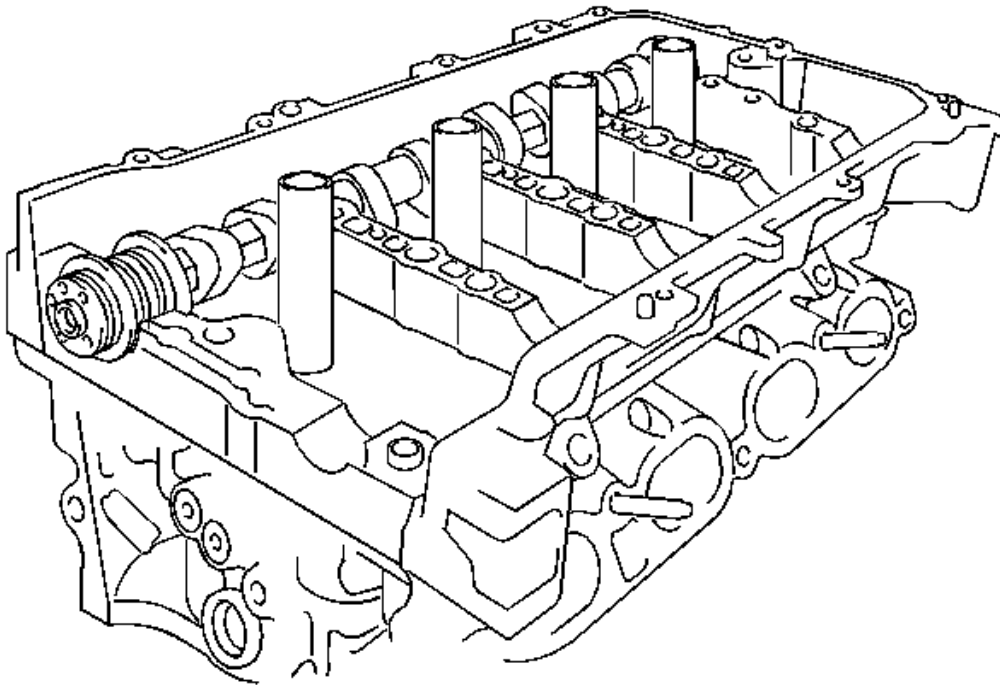


Fig. 61: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

52. Remove the No. 2 camshaft.
53. Remove the No. 1 valve rocker arm subassembly.
54. Remove the valve lash adjuster assembly.

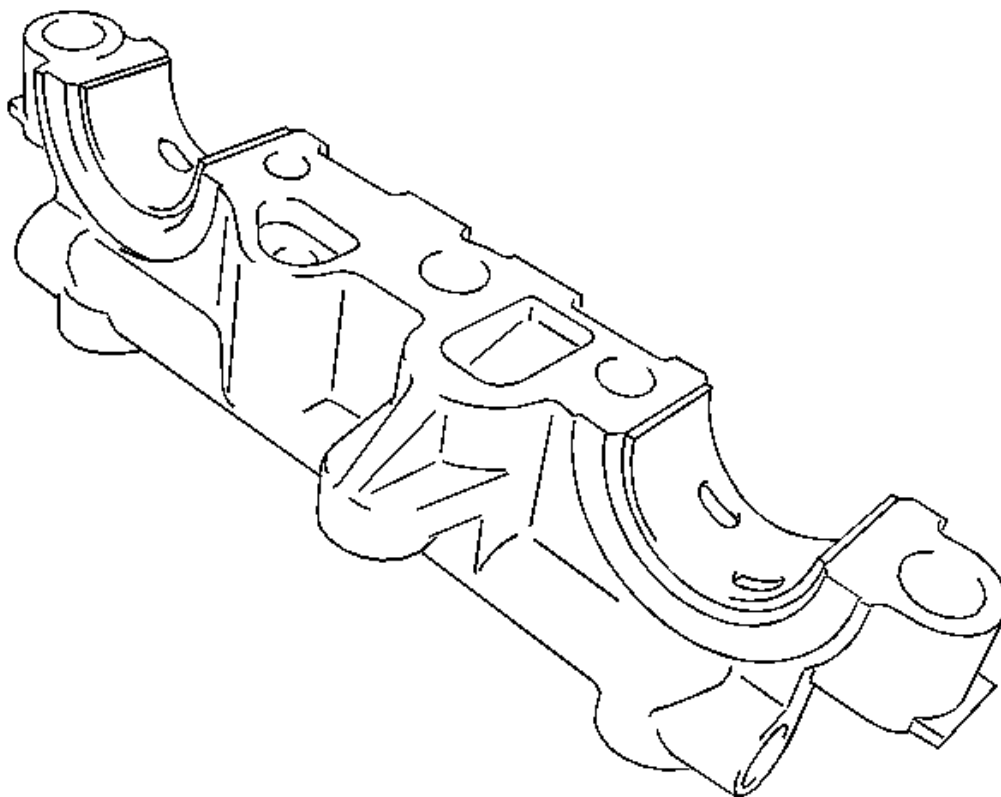


Fig. 62: View Of Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

55. Remove the 2 No. 1 camshaft bearings.

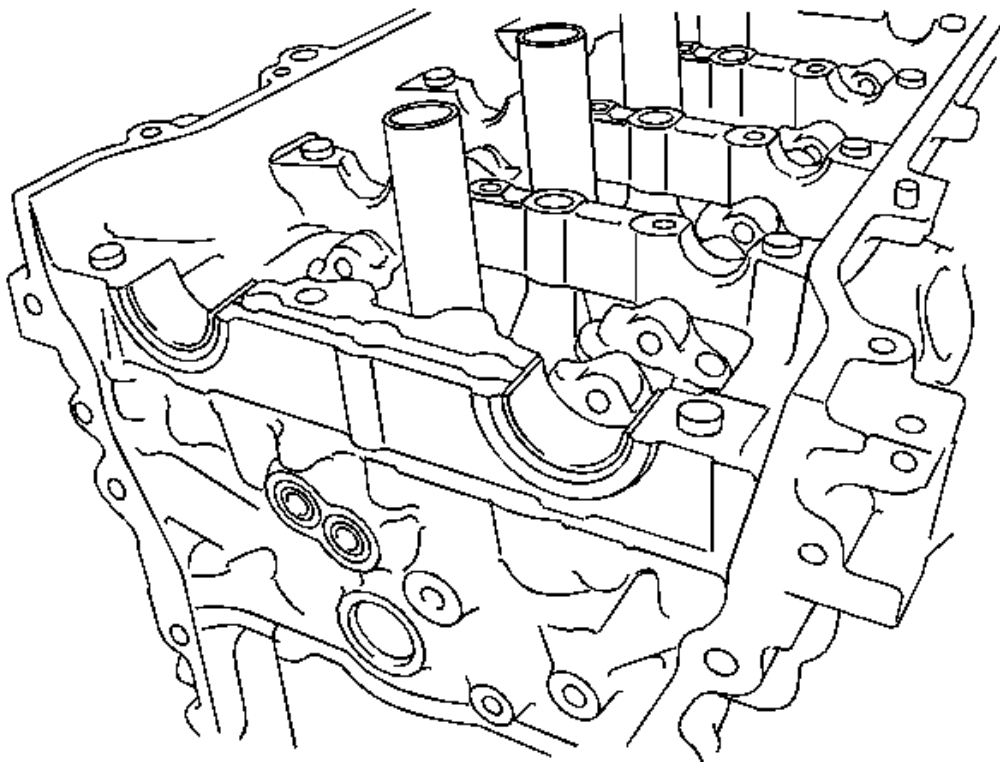


Fig. 63: Identifying Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

56. Remove the 2 No. 2 camshaft bearings.

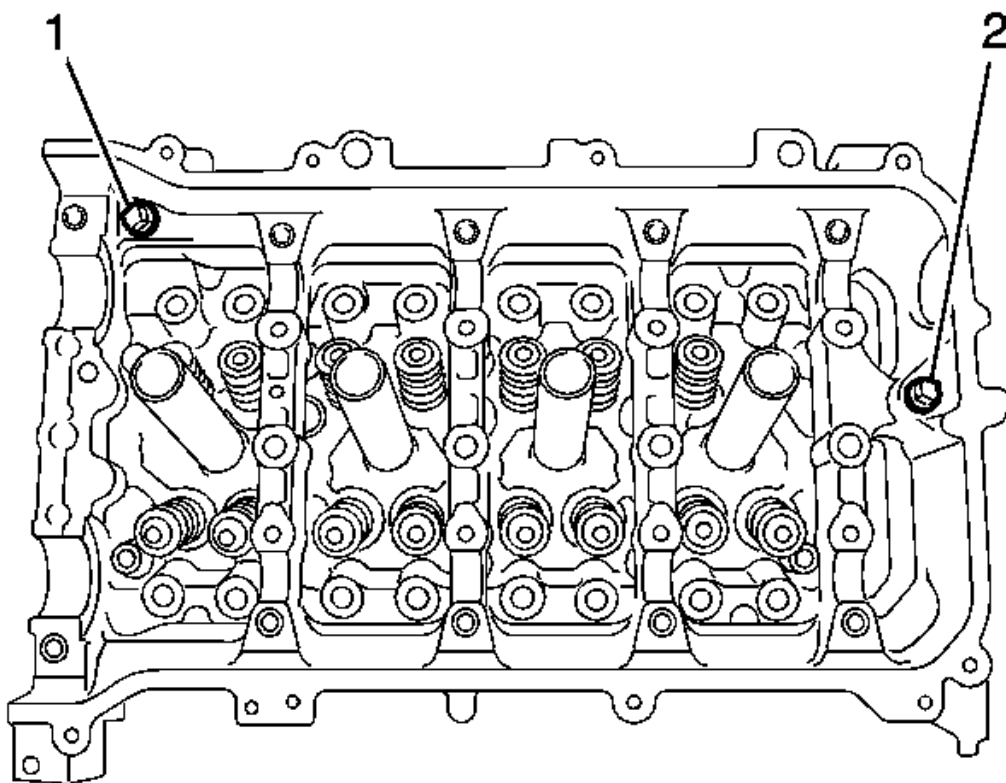


Fig. 64: Identifying 2 Bolts

Courtesy of GENERAL MOTORS CORP.

57. Remove the 2 bolts.

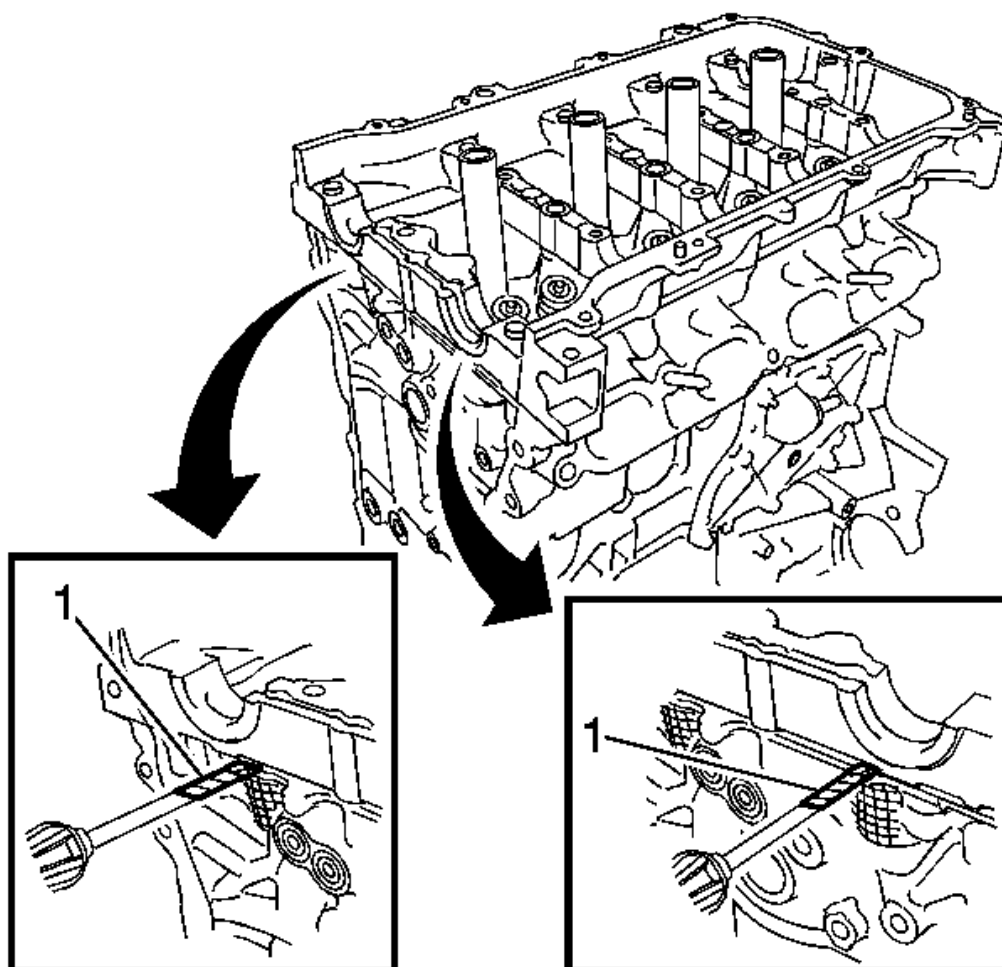


Fig. 65: View Of Camshaft Housing Sub-Assembly
 Courtesy of GENERAL MOTORS CORP.

58. Remove the camshaft housing sub-assembly. Remove the 2 bolts and pry between the cylinder head and camshaft housing with a screwdriver.

IMPORTANT: Tape the screwdriver tip before use.

59. Inspect the No. 1 valve rocker arm sub-assembly.
60. Inspect the valve lash adjuster assembly.

Installation Procedure

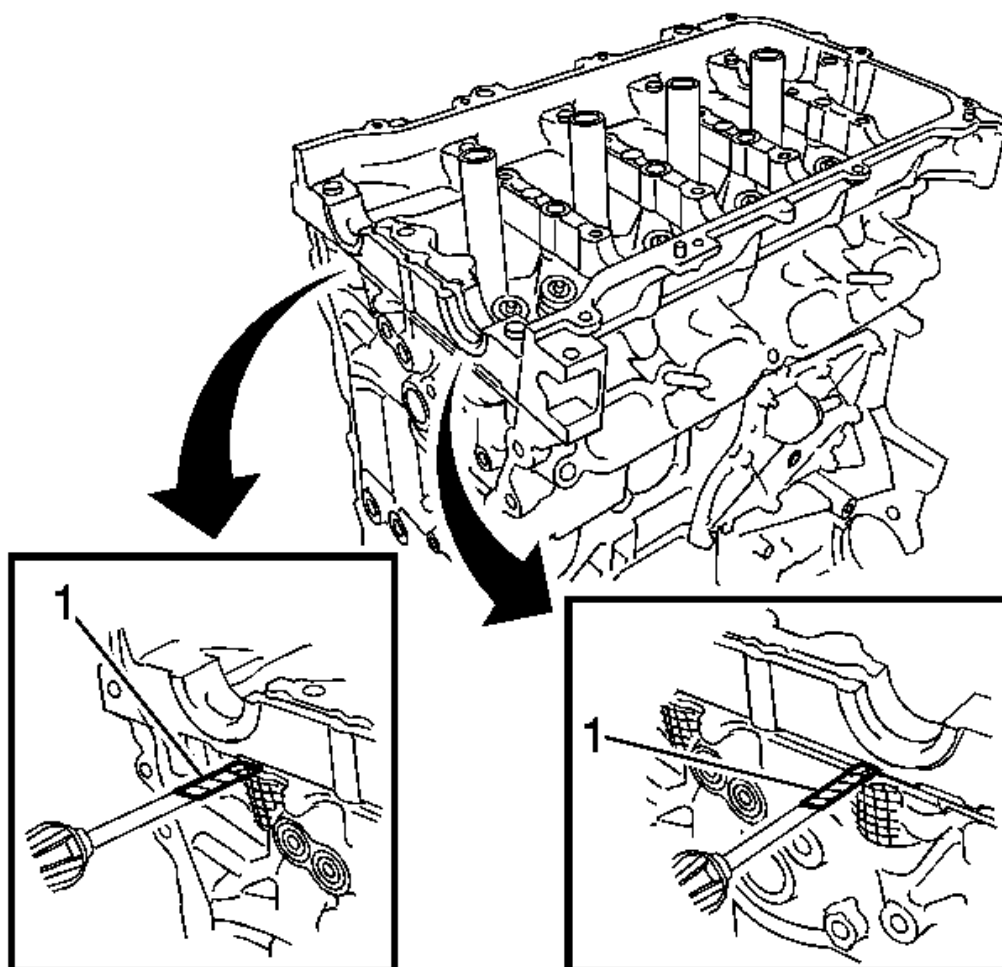


Fig. 66: View Of Camshaft Housing Sub-Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the valve lash adjuster assembly.
2. Install the No. 1 valve rocker arm subassembly.
3. Install the 2 No. 1 camshaft bearings after cleaning both surfaces of the bearings.

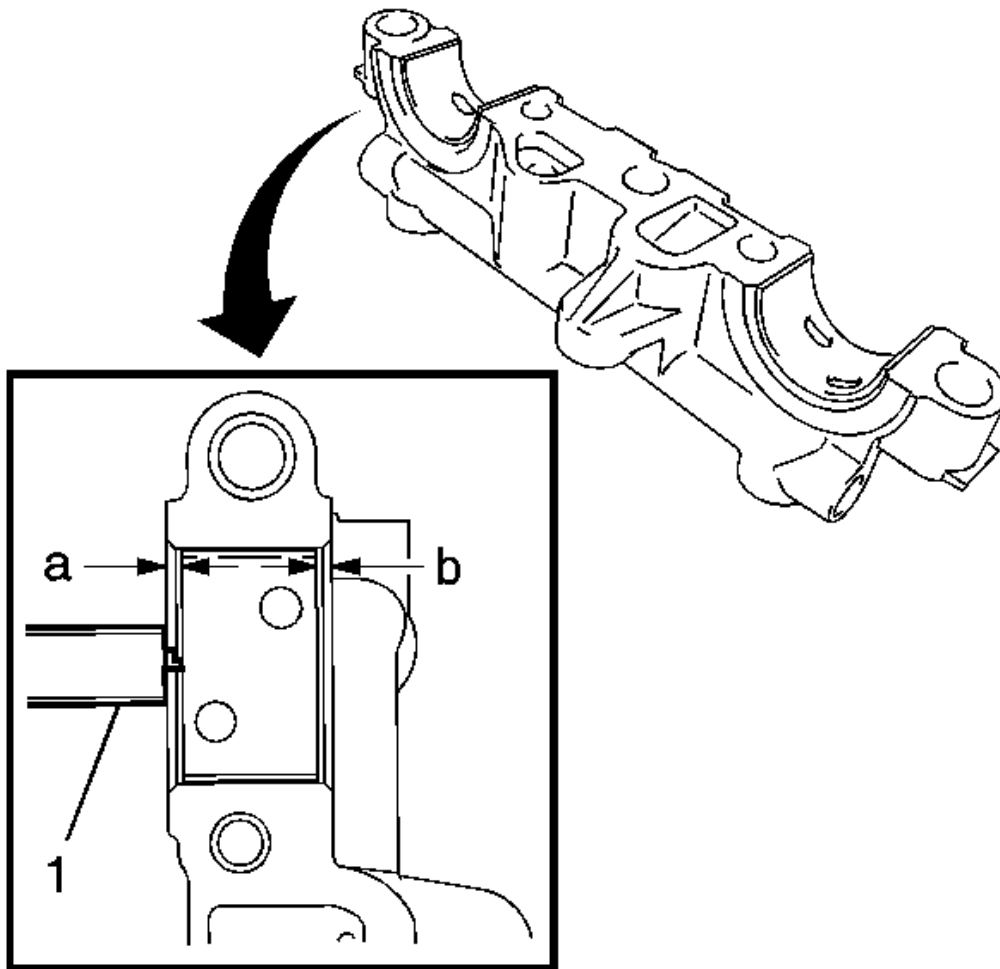


Fig. 67: Measuring Distance Between Bearing Cap Edge & Camshaft Bearing Edge
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Position the bearings to the center of the bearing cap by measuring dimensions A and B.

4. Using vernier calipers, measure the distance between the bearing cap edge and the camshaft bearing edge.

Specification: Dimension (A-B): 0.7 mm (0.0276 in) or less

5. Clean both surfaces of the bearings.
6. Install the 2 No. 2 camshaft bearings.

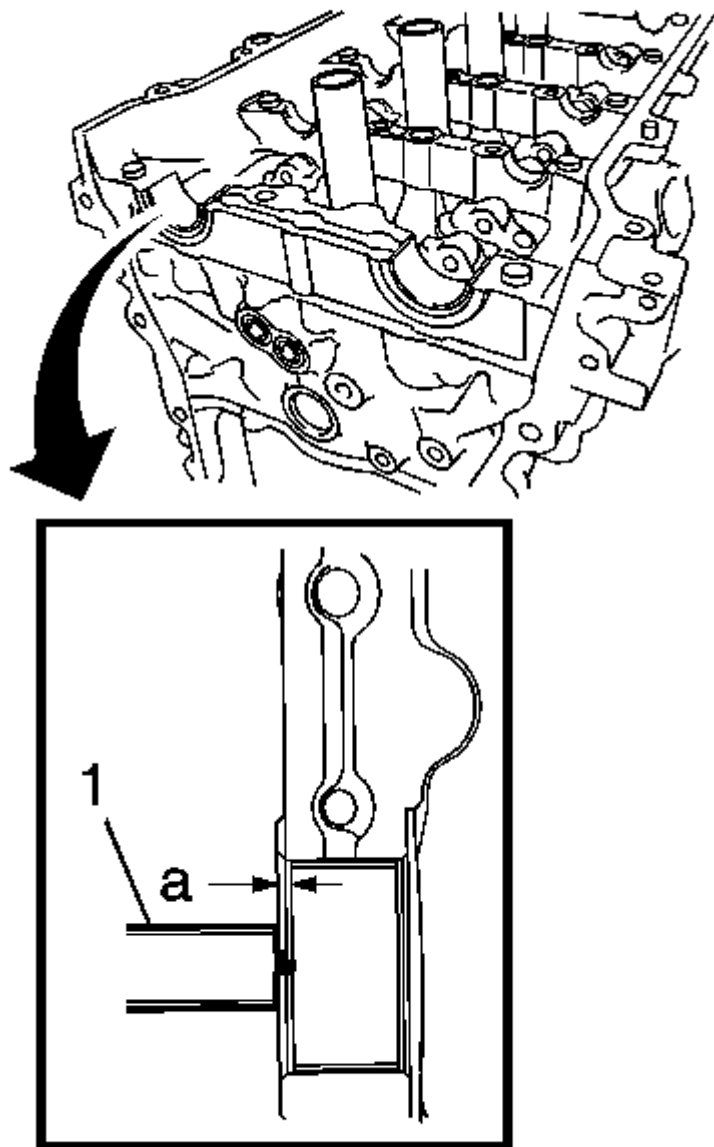


Fig. 68: Measuring Distance Between Bearing Cap Edge & Camshaft Bearing Edge
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Position the bearings to the center of the bearing cap by measuring dimension A.

7. Using vernier calipers, measure the distance between the bearing cap edge and the camshaft bearing edge.

Specification: Dimension (A): 1.05-1.75 mm (0.0413-0.0689 in.)

8. Clean the camshaft journals.
9. Apply a light coat of engine oil to the camshaft journals, camshaft housings and bearing caps.

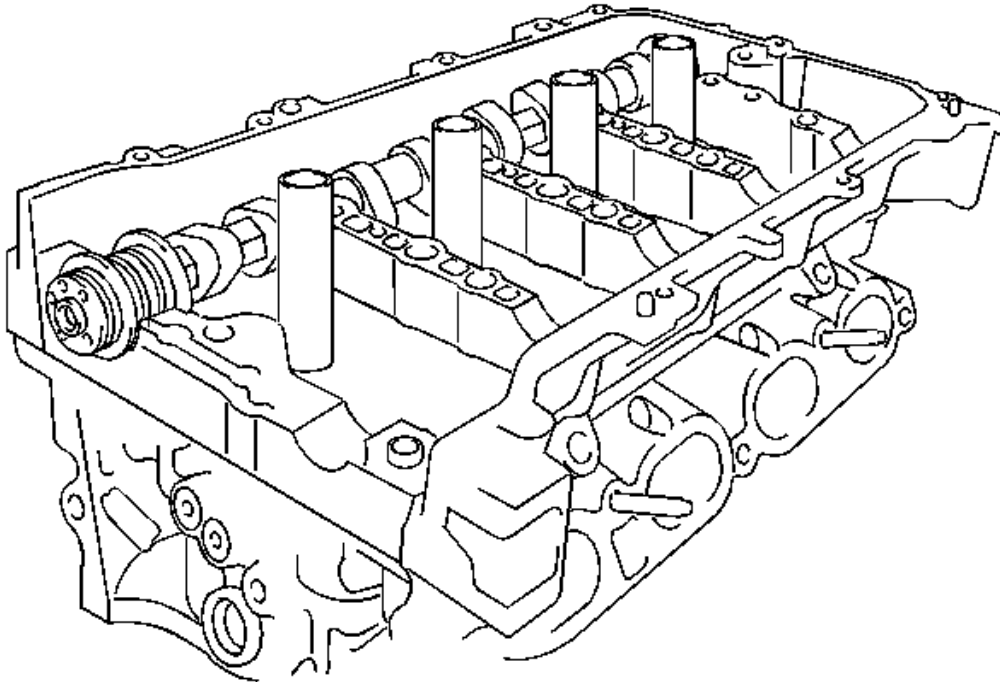


Fig. 69: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

10. Install the No. 2 camshaft to the camshaft housing.
11. Clean the camshaft journals.
12. Apply a light coat of engine oil to the camshaft journals, camshaft housings and bearing caps.

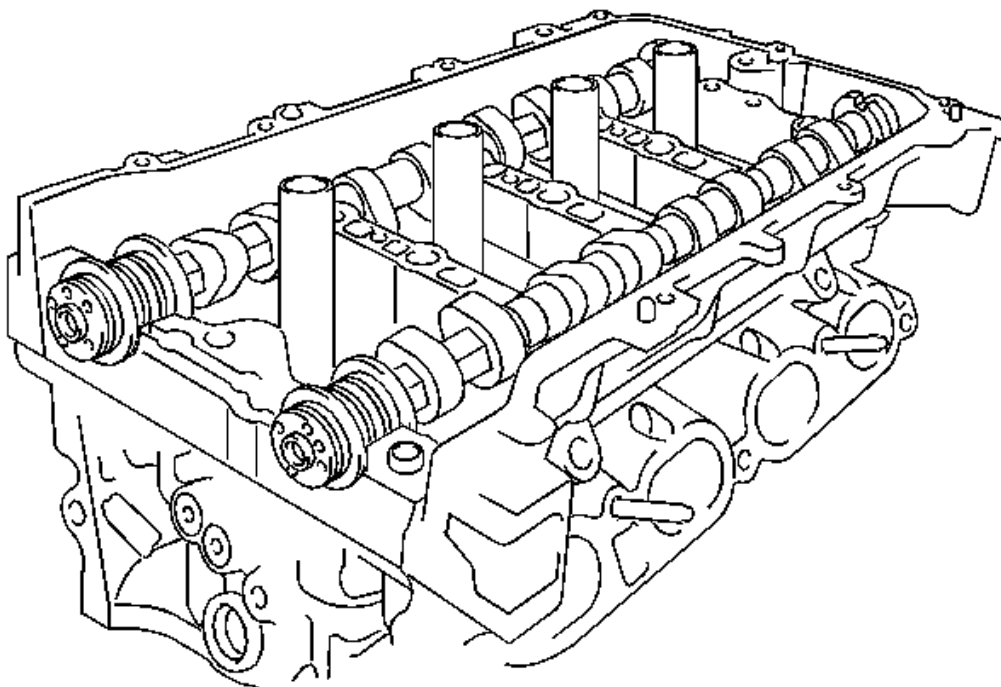


Fig. 70: View Of Cylinder Head & Camshafts
Courtesy of GENERAL MOTORS CORP.

13. Install the camshaft to the camshaft housing.
14. Apply engine oil to the camshaft journals, camshaft housings and bearing caps.

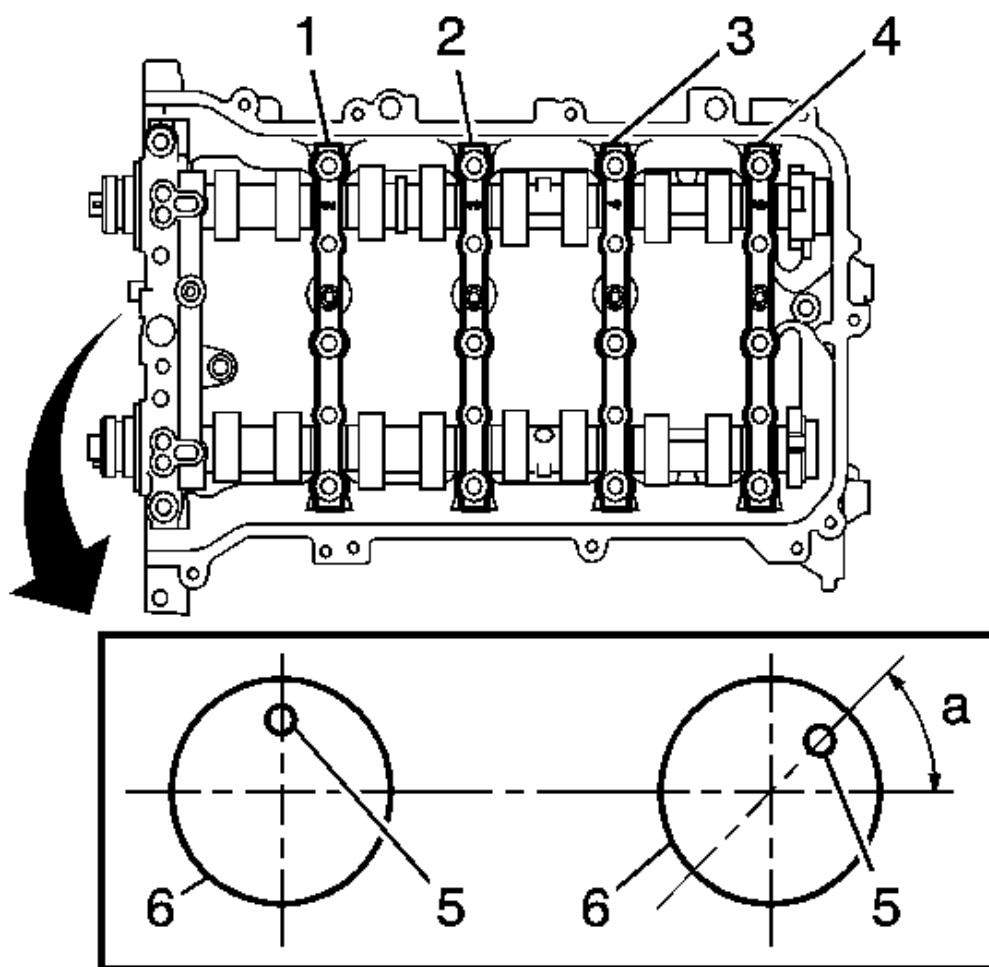


Fig. 71: Locating Marks & Numbers On Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure that the knock pin of the camshaft is positioned as shown in the illustration.

15. Make sure of the marks and numbers on the camshaft bearing caps and place them in each proper position and direction.

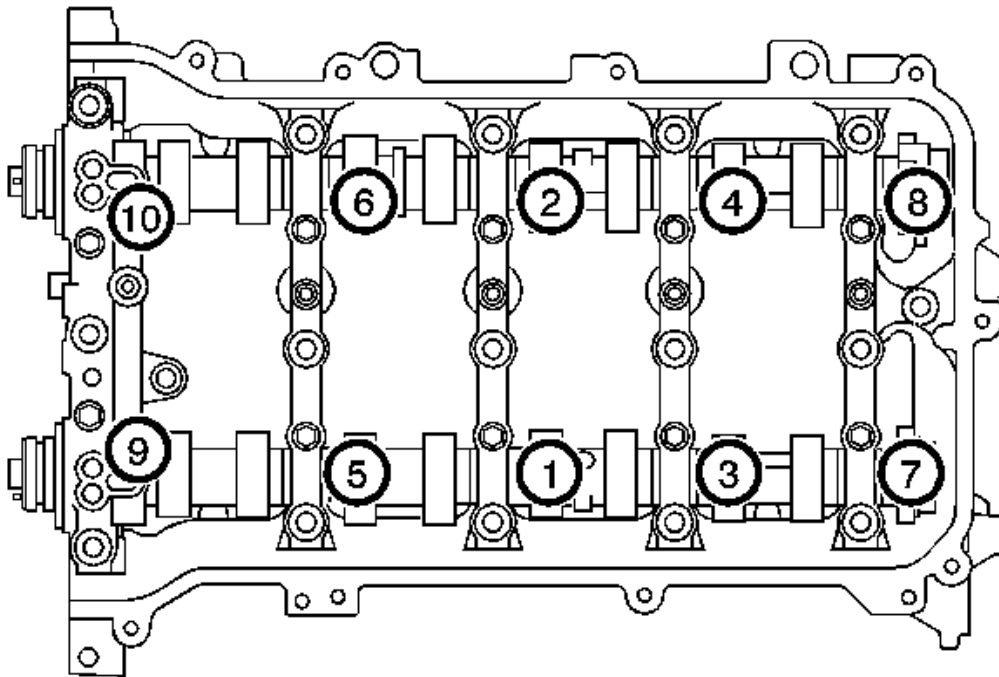


Fig. 72: Identifying Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to **FASTENER CAUTION** .

16. Install the 10 bolts in the order.

Tighten: Tighten the bolts to 16 N.m (12 lb ft).

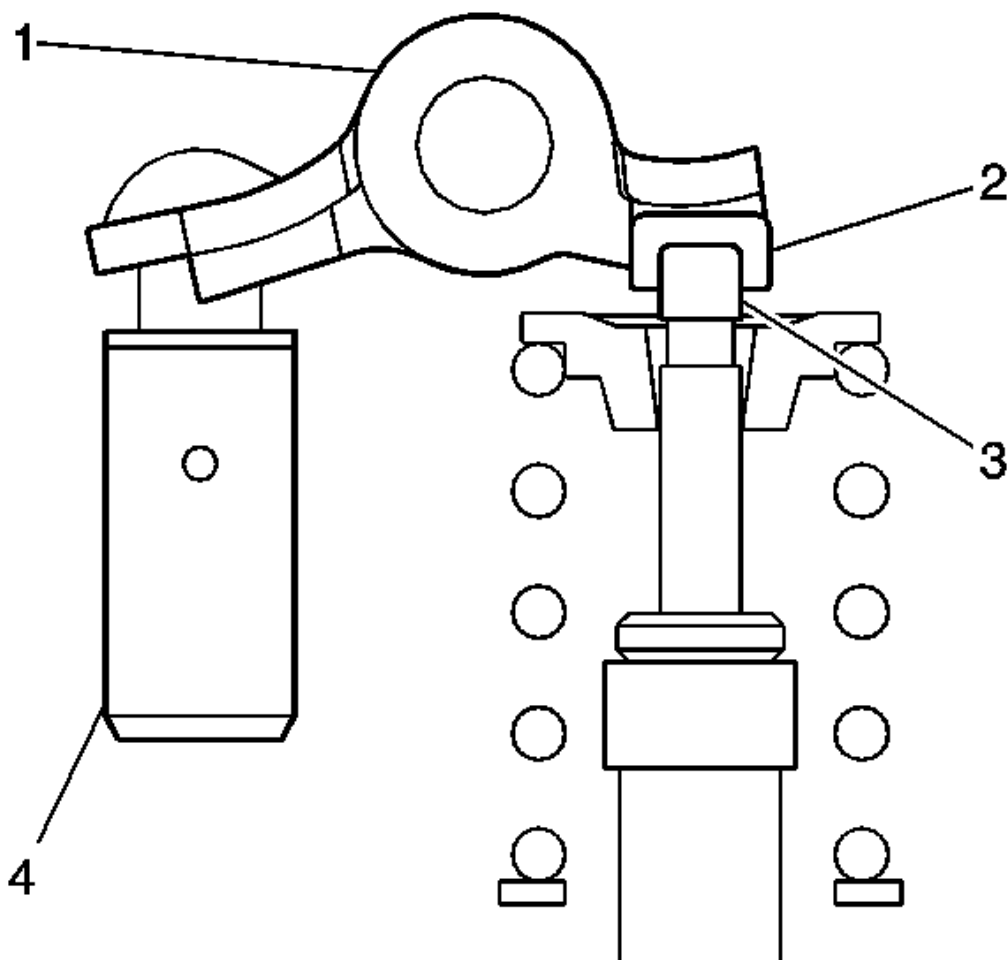


Fig. 73: View Of Correct Rocker Arm Installation
Courtesy of GENERAL MOTORS CORP.

17. Install the camshaft housing sub-assembly.
18. Make sure that the valve rocker arm is installed as shown in the illustration.

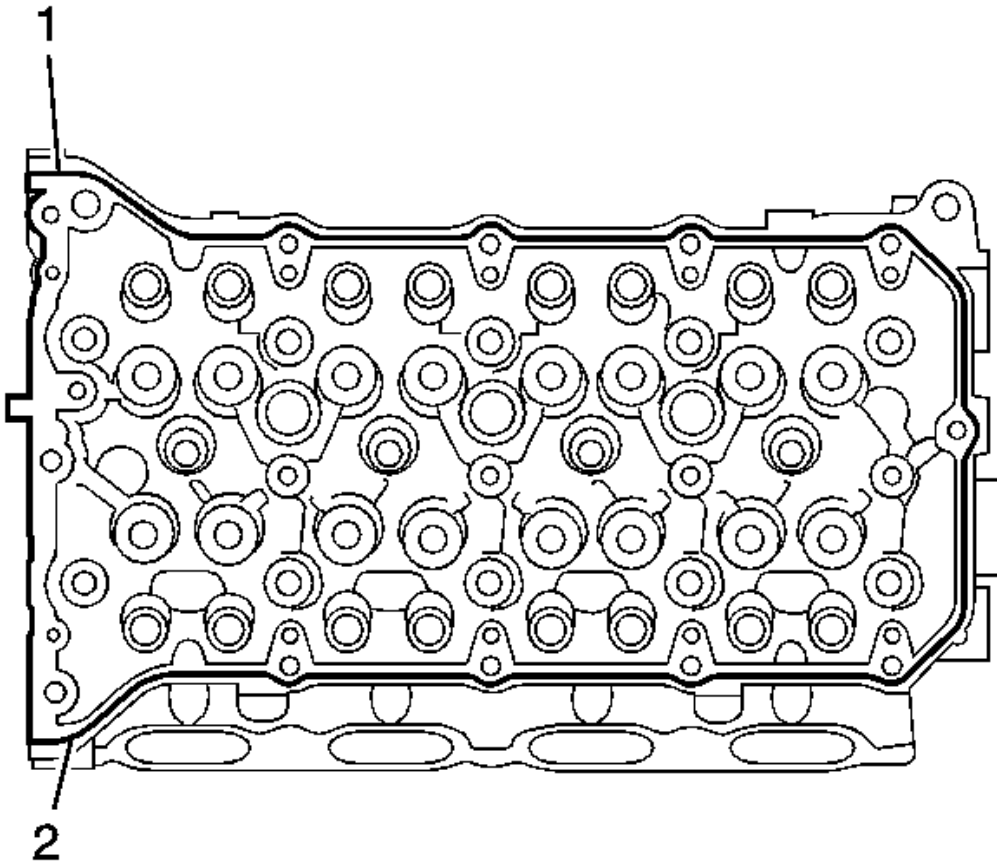


Fig. 74: Applying Adhesive To Cylinder Head
 Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Remove any oil from the contact surface.
- Install the camshaft housing sub-assembly within 3 minutes and tighten the bolts within 15 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after installing.

19. Apply seal packing Three Bond 1207B or equivalent Bead diameter: 3.5-4.0 mm (0.138-0.158 in) in a continuous bead.

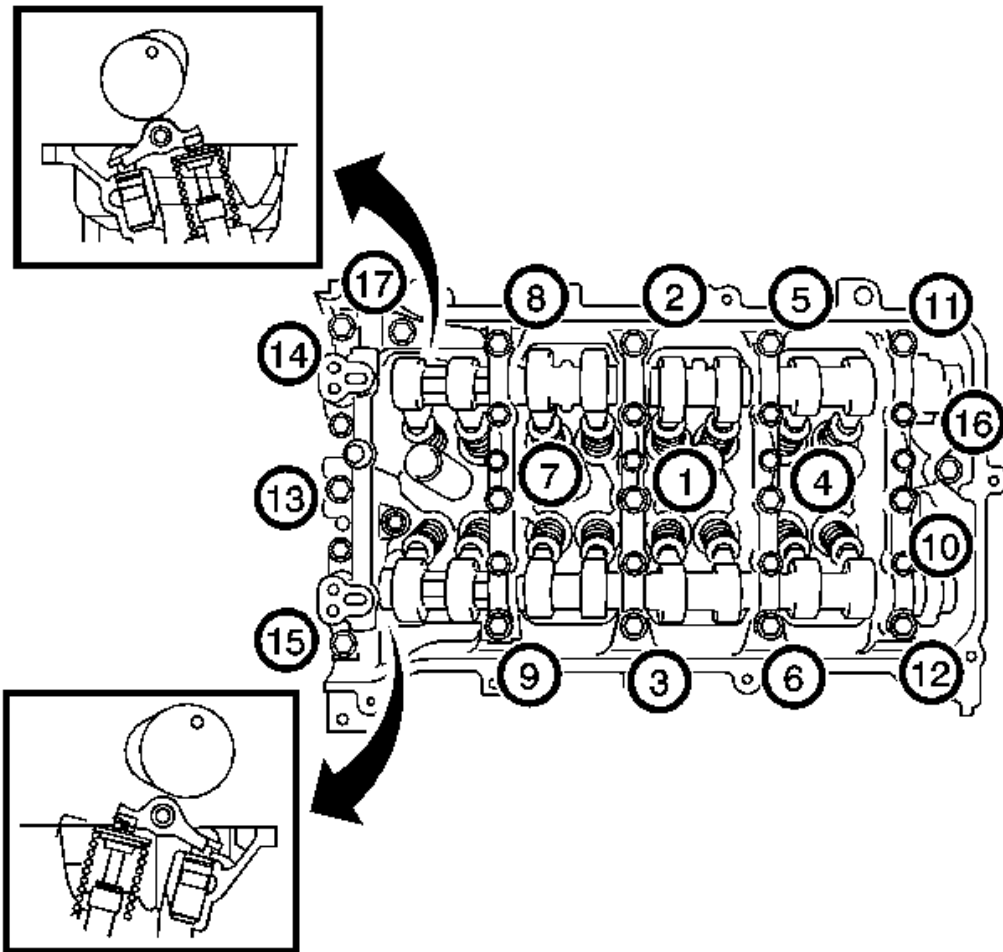


Fig. 75: View Of Setting Camshafts
Courtesy of GENERAL MOTORS CORP.

20. Set the camshaft and No. 2 camshaft.

IMPORTANT:

- After installing the camshaft housing, make sure that the cam lobes are positioned.
- If any of the bolts are loosened during installation, remove the camshaft housing, clean the installation surfaces, and reapply seal packing.
- If the camshaft housing is removed because any of the bolts are loosened during installation, make sure that the previously applied seal packing does not enter any oil passages.

- After installing the camshaft housing, wipe off any seal packing that seeped out from between the housing and the cylinder head.

21. Install the camshaft housing and tighten the 17 bolts in the order.

Tighten: Tighten the bolts to 27 N.m (20 lb ft).

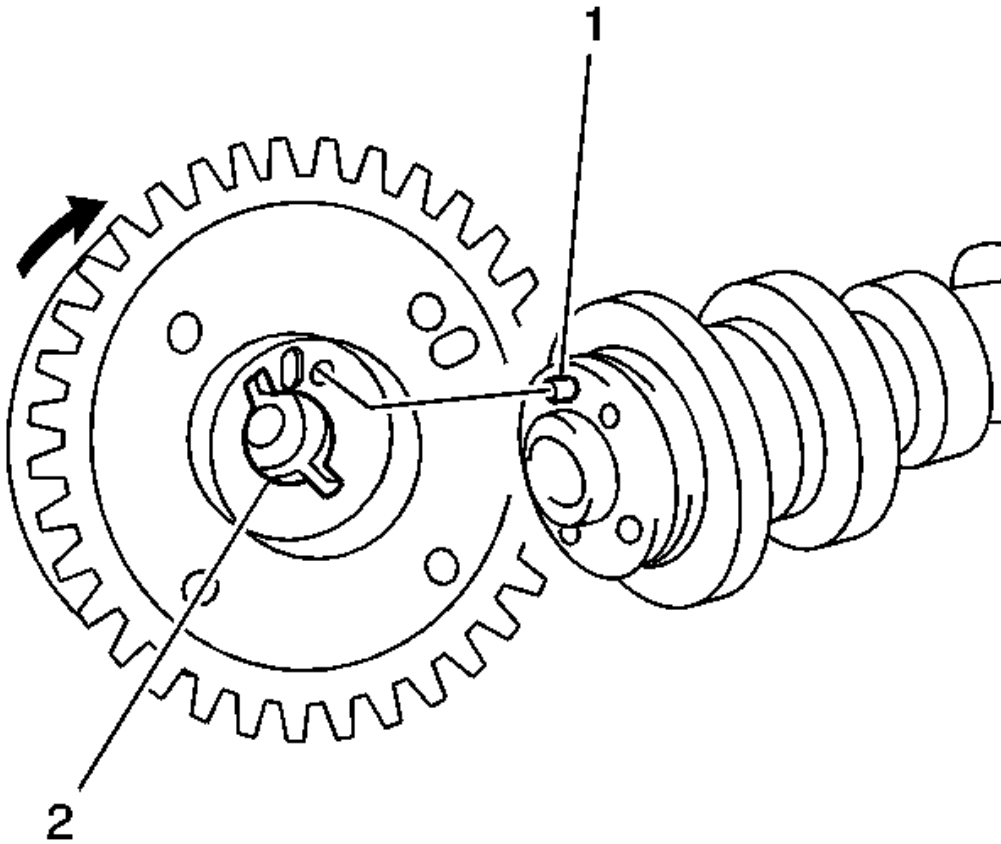


Fig. 76: View Of Camshaft Timing Gear Assembly
Courtesy of GENERAL MOTORS CORP.

22. Install camshaft timing gear assembly.
23. Check that the knock pin is installed on the camshaft.

IMPORTANT: Do not forcefully push in the camshaft timing gear assembly. This may cause the camshaft knock pin tip to damage the installation surface of the camshaft timing gear assembly.

24. Put the camshaft timing gear and camshaft together with the straight pin and key groove misaligned, as shown in the illustration.

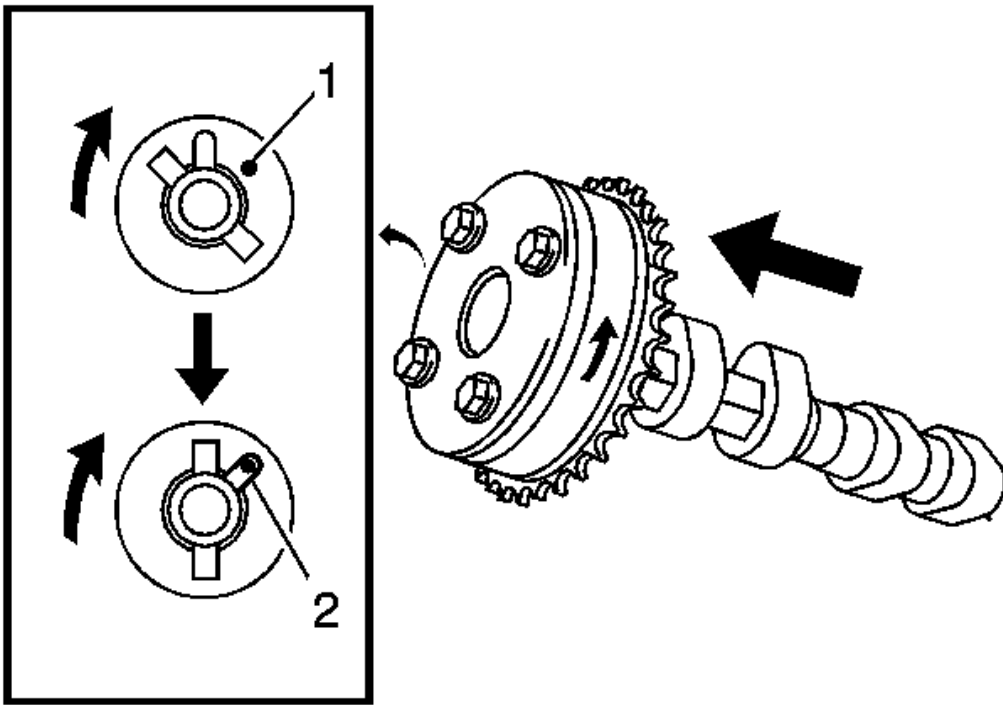


Fig. 77: View Of Turning Camshaft Gear
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not turn the camshaft timing gear in the retard direction (clockwise).

25. Turn the camshaft timing gear as shown in the illustration while pushing it gently against the camshaft. Push further at the position where the pin fits into the groove.

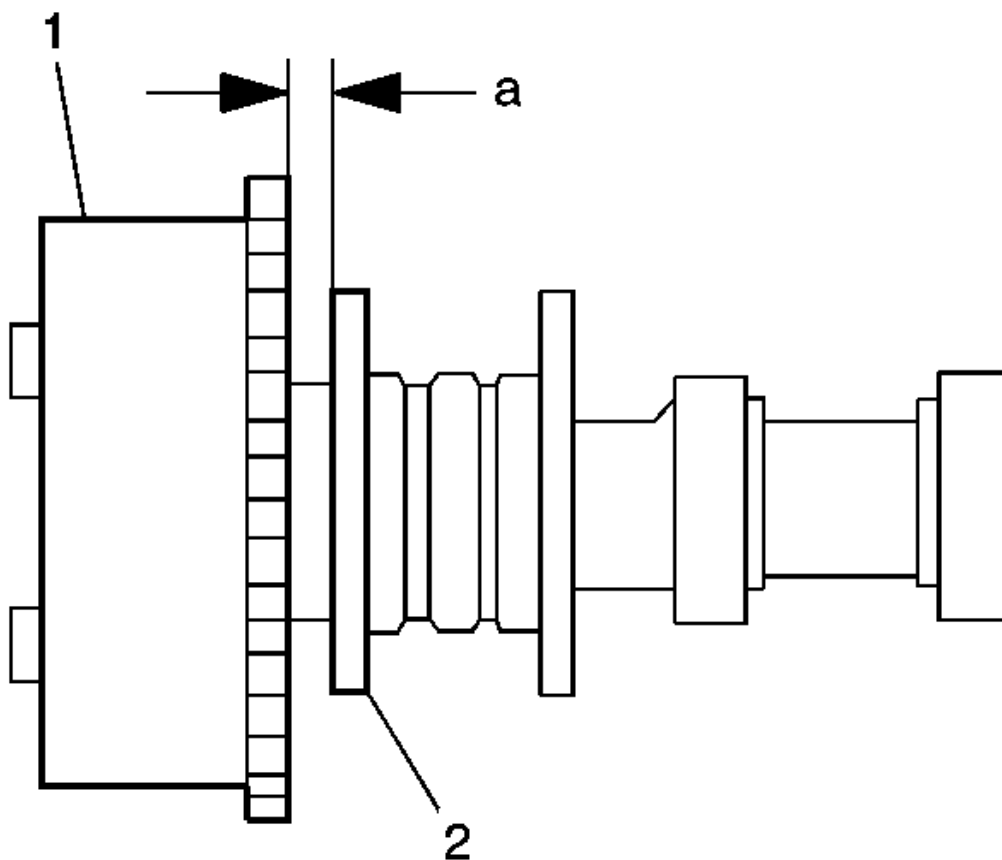


Fig. 78: Identifying Clearance Between Gear & Camshaft
Courtesy of GENERAL MOTORS CORP.

26. Measure the clearance between the gear and the camshaft.

Specification: Clearance: 0.1-0.4 mm (0.004-0.016 in.)

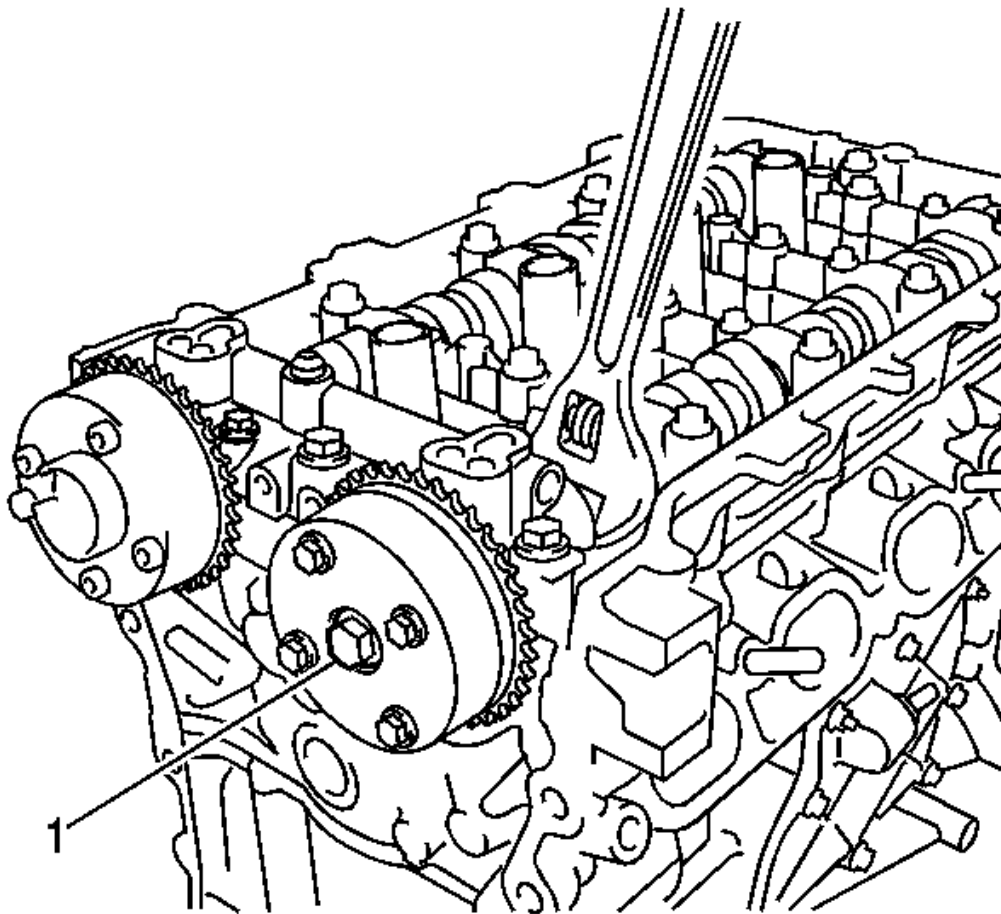


Fig. 79: View Of Tightening Camshaft Timing Gear
Courtesy of GENERAL MOTORS CORP.

27. Install the flange bolt with the camshaft timing gear fixed in place.

Tighten: Tighten the bolt to 54 N.m (40 lb ft).

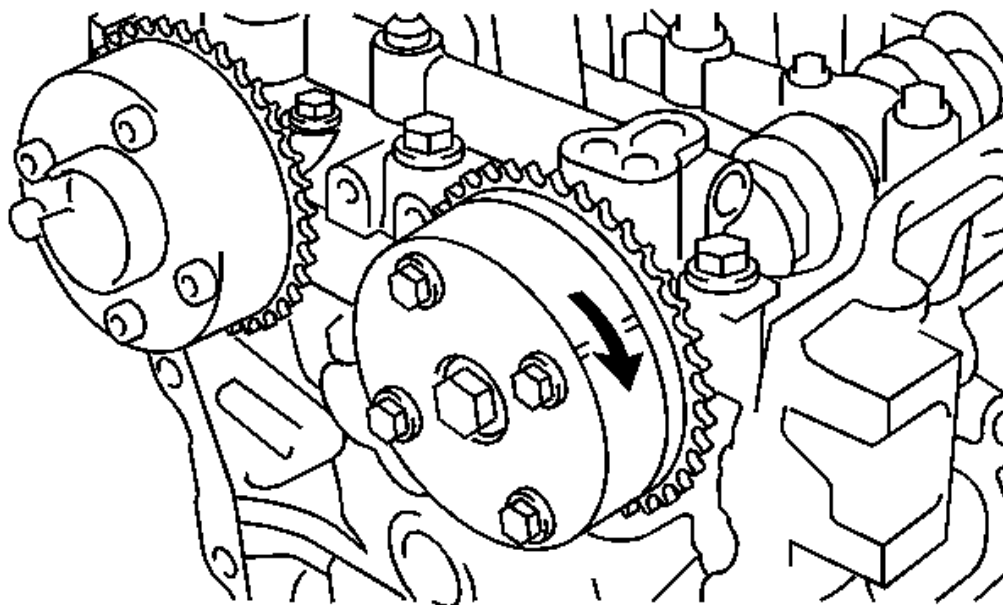


Fig. 80: Checking Camshaft Timing Gear Movement
Courtesy of GENERAL MOTORS CORP.

28. Check that the camshaft timing gear can move in the retard direction (clockwise) and is locked in the most retarded position.
29. Install the camshaft timing exhaust gear assembly.
30. Check that the knock pin is installed on the camshaft.

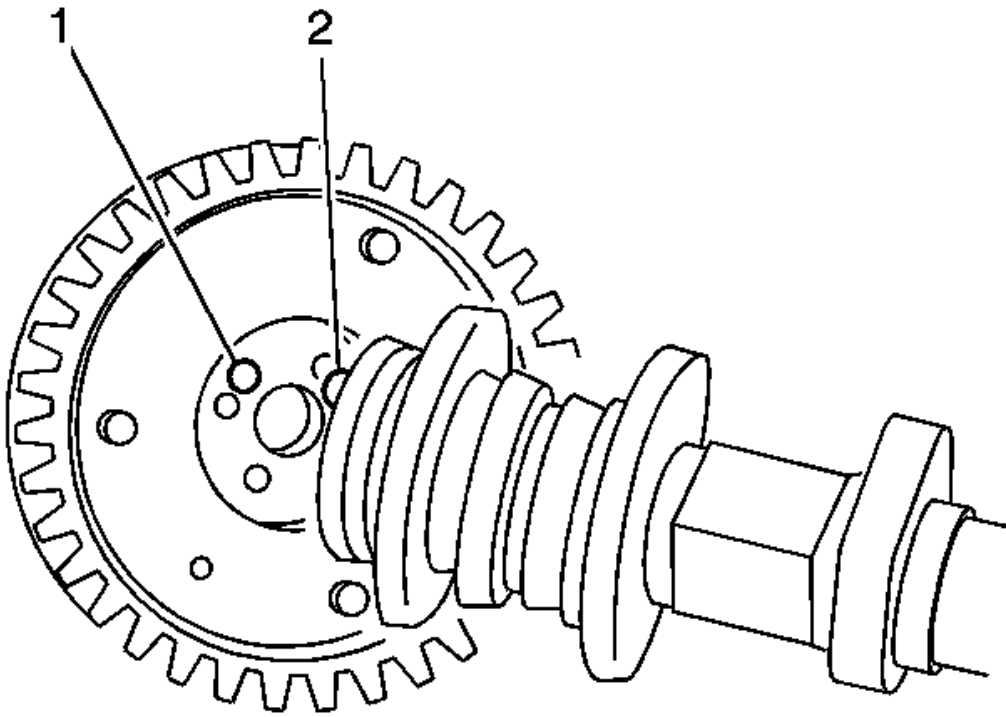


Fig. 81: View Of Camshaft Timing Exhaust Gear & Camshaft
Courtesy of GENERAL MOTORS CORP.

31. Put the camshaft timing exhaust gear and camshaft together by aligning the key groove and straight pin.

IMPORTANT: Be sure not to turn the camshaft timing exhaust gear in the retard direction (clockwise).

32. Lightly press the gear against the camshaft, and turn the gear. Push further at the position where the pin enters the groove.
33. Check that there is no clearance between the gear flange and the camshaft.

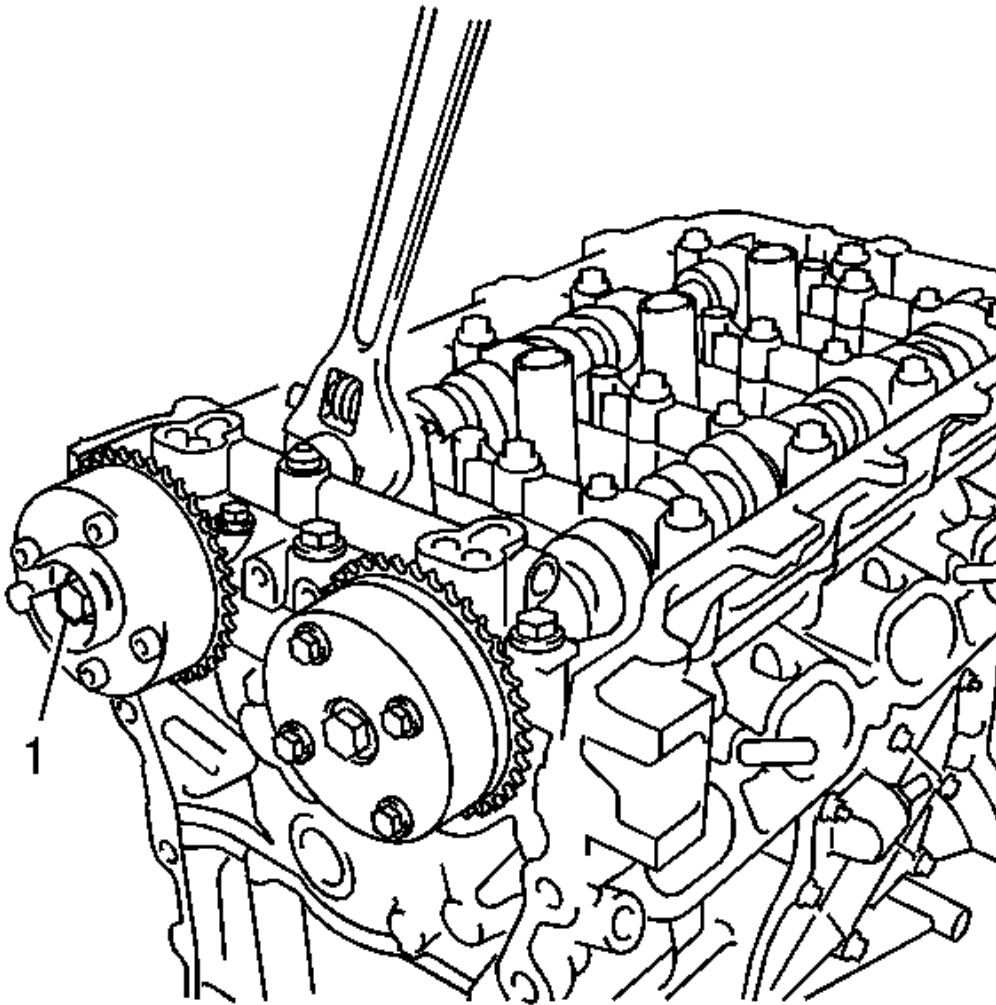


Fig. 82: View Of Tightening Flange Bolt With Camshaft Timing Exhaust Gear Fixed
 Courtesy of GENERAL MOTORS CORP.

34. Install the flange bolt with the camshaft timing exhaust gear fixed.

Tighten: Tighten the bolt to 54 N.m (40 lb ft).

35. Make sure that the camshaft timing exhaust gear is locked.
36. Install the No. 1 chain vibration damper.
37. Install the No. 2 chain vibration damper.
38. Install the chain sub-assembly.

39. Install the chain tensioner slipper.
40. Install the timing chain cover oil seal.
41. Install the timing chain cover sub-assembly.
42. Install the crankshaft pulley.
43. Install the No. 1 chain tensioner assembly.
44. Install the cylinder head cover sub-assembly.
45. Install the radio setting condenser.
46. Install the thermostat.
47. Install the inlet water.
48. Install the inlet water hose.
49. Install the water by-pass hose.
50. Install the No. 1 water by-pass pipe.
51. Install the No. 3 water by-pass hose.
52. Install the ventilation hose.
53. Inspect the exhaust manifold.
54. Install the exhaust manifold.
55. Install the manifold stay.
56. Install the No. 1 exhaust manifold heat insulator.
57. Install the oil level dipstick sub-assembly. Refer to **Oil Level Indicator and Tube Replacement**.
58. Install the ignition coil assembly.
59. Install the fuel injector assembly.
60. Install the No. 1 delivery pipe spacer.
61. Install the fuel delivery pipe sub-assembly.
62. Install the fuel tube sub-assembly.
63. Install the intake manifold.
64. Remove the engine stand.
65. Install the engine assembly with transaxle. Refer to **Engine Replacement**.

EXHAUST CAMSHAFT AND VALVE LIFTER REPLACEMENT

Removal Procedure

1. Remove the engine assembly with transaxle. Refer to **Engine Replacement**.
2. Install the engine stand.
3. Remove the intake manifold.
4. Remove the fuel tube sub-assembly.
5. Remove the fuel delivery pipe sub-assembly.
6. Remove the fuel injector assembly.
7. Remove the ignition coil assembly.

8. Remove the oil level dipstick sub-assembly. Refer to **Oil Level Indicator and Tube Replacement**
9. Remove the No. 1 exhaust manifold heat insulator.
10. Remove the manifold stay.
11. Remove the exhaust manifold.
12. Remove the ventilation hose.
13. Remove the No. 3 water by-pass hose.
14. Remove the No. 1 water by-pass pipe.
15. Remove the water by-pass hose.
16. Remove the inlet water hose.
17. Remove the inlet water.
18. Remove the thermostat.
19. Remove the radio setting condenser.
20. Remove the cylinder head cover sub-assembly.
21. Set the No. 1 cylinder to TDC/compression.
22. Remove the crankshaft pulley.
23. Remove the No. 1 chain tensioner assembly.
24. Remove the timing chain cover sub-assembly.
25. Remove the timing chain cover oil seal.
26. Remove chain tensioner slipper.
27. Remove the No. 1 chain vibration damper.
28. Remove chain sub-assembly.
29. Remove the No. 2 chain vibration damper.

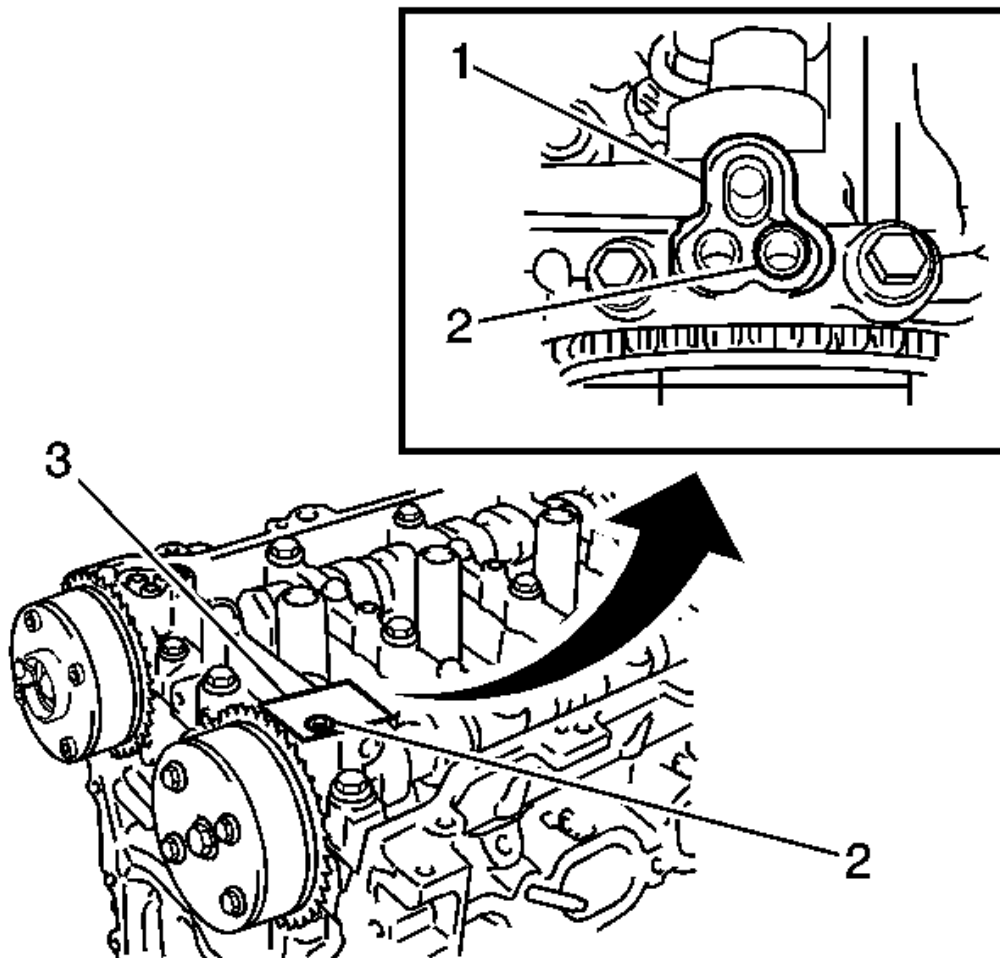


Fig. 83: Identifying Camshaft Timing Gear Assembly
Courtesy of GENERAL MOTORS CORP.

30. Inspect the camshaft timing gear assembly.
31. Check the lock of the camshaft timing gear.

IMPORTANT: Be sure to cover the oil hole completely because air leaks due to insufficient sealing will prevent the lock pin from being released.

32. After cleaning and degreasing the VVT oil hole on the intake side of the No. 1 camshaft bearing cap, completely seal the oil hole with adhesive tape or equivalent as shown in the illustration to prevent air from leaking.
33. Prick a hole in the tape covering the oil hole as shown.

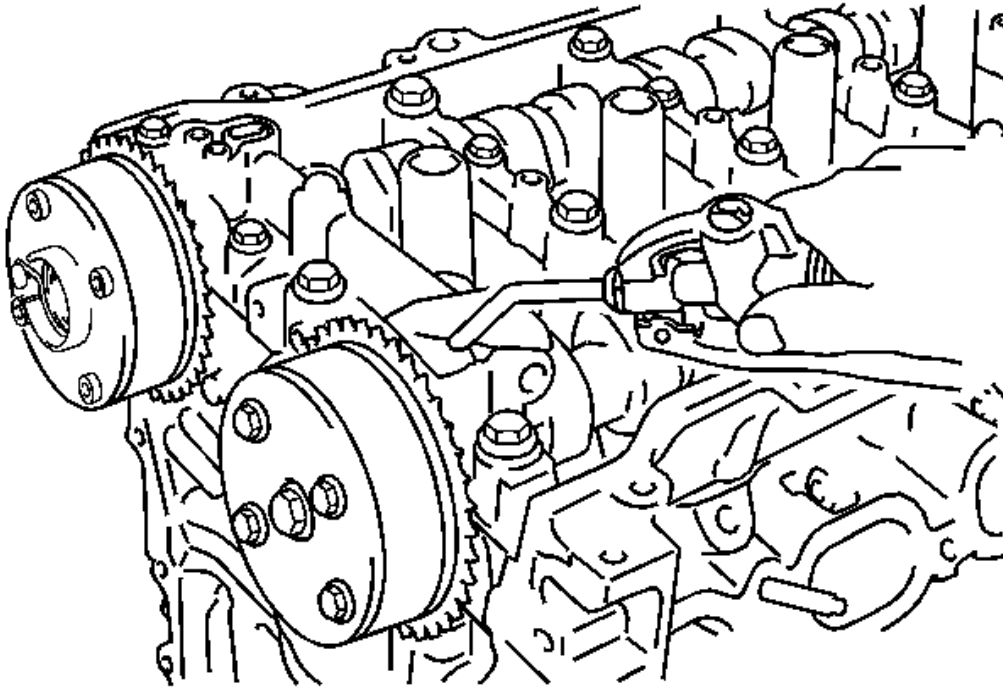


Fig. 84: Checking For Air Leaks
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- If air leaks out, reattach the adhesive tape.
- Cover the oil hole with a shop rag or piece of cloth when applying air pressure to prevent oil from spraying.

34. Apply approximately 150 kPa (22 psi) of air pressure to the hole pricked in procedure A to release the lock pin.

IMPORTANT: Depending on the air pressure applied, the camshaft timing gear assembly may turn in the advanced direction without assistance by hand.

35. Forcibly turn the camshaft timing gear assembly in the advanced direction (counterclockwise).

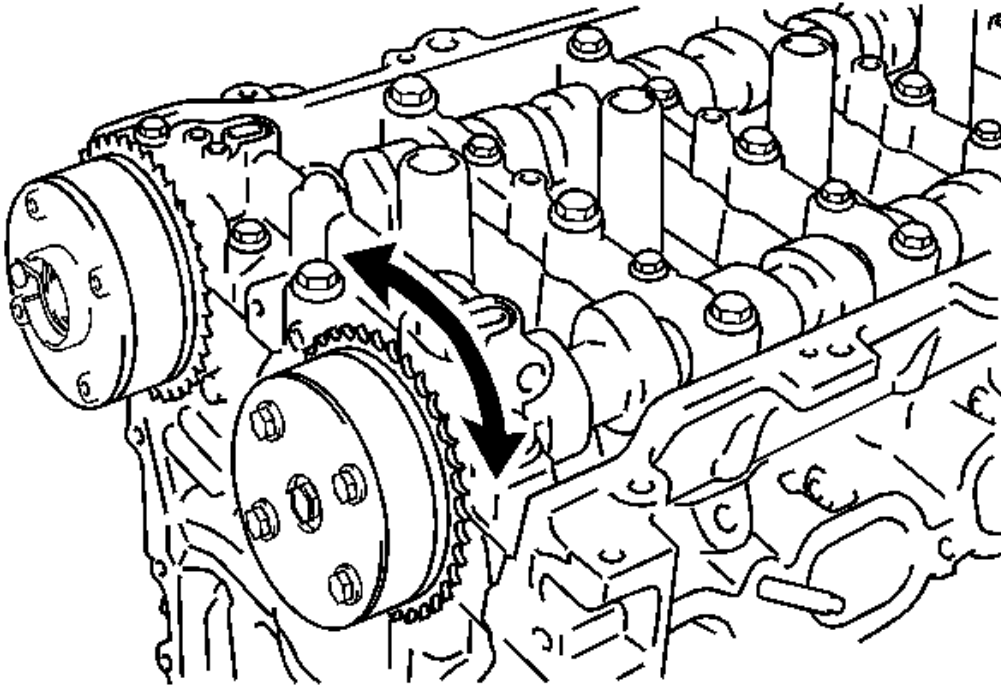


Fig. 85: Checking Camshaft Timing Gear Assembly For Smooth Turning Ability
Courtesy of GENERAL MOTORS CORP.

36. Turn the camshaft timing gear assembly within its movable range (26.5-28.5°) 2 or 3 times without turning it to the most retarded position. Make sure that the camshaft timing gear assembly turns smoothly.
37. Remove the adhesive tape from the No. 1 camshaft bearing cap.
38. Inspect the camshaft timing exhaust gear assembly.
39. Check the lock of the camshaft timing exhaust gear.

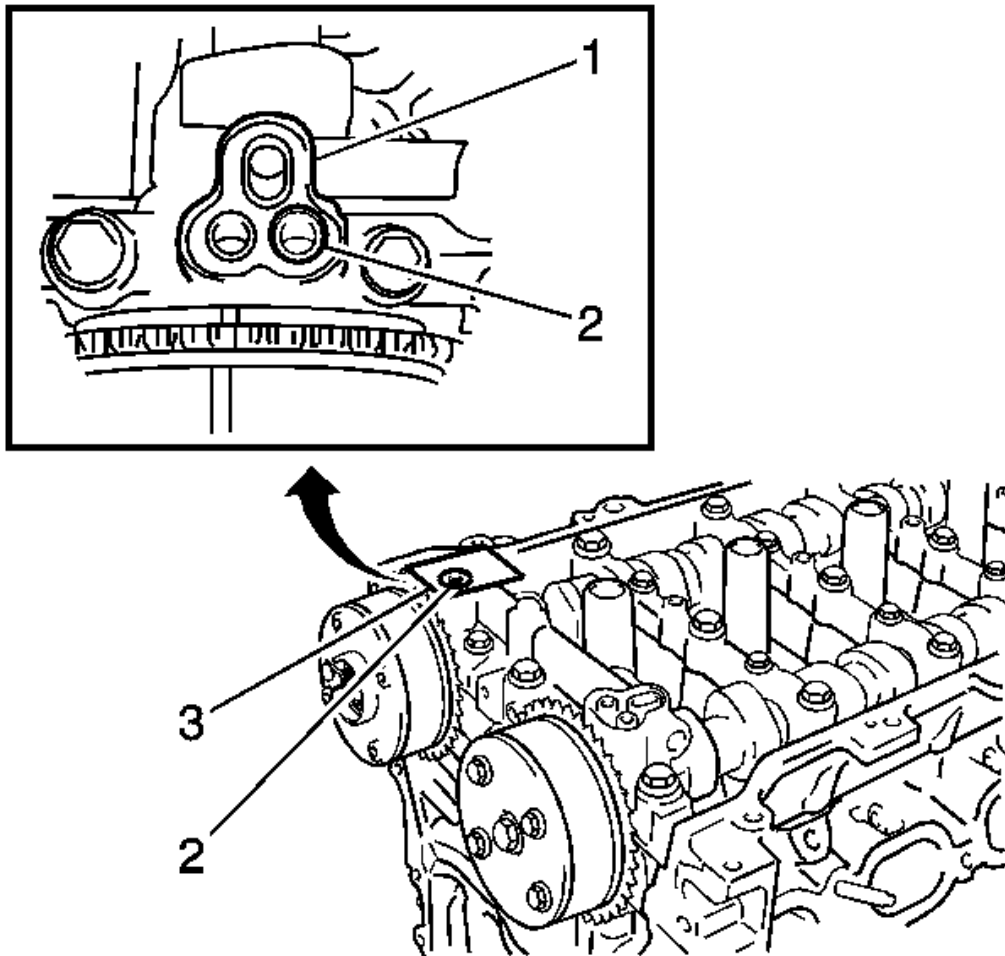


Fig. 86: View Of Sealing Oil Hole With Tape
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be sure to cover the oil hole completely because air leaks due to insufficient sealing will prevent the lock pin from being released.

40. After cleaning and degreasing the VVT oil hole on the exhaust side of the No. 1 camshaft bearing cap, completely seal the oil hole with adhesive tape or equivalent as shown in the illustration to prevent air from leaking.
41. Prick a hole in the tape covering the oil hole as shown.

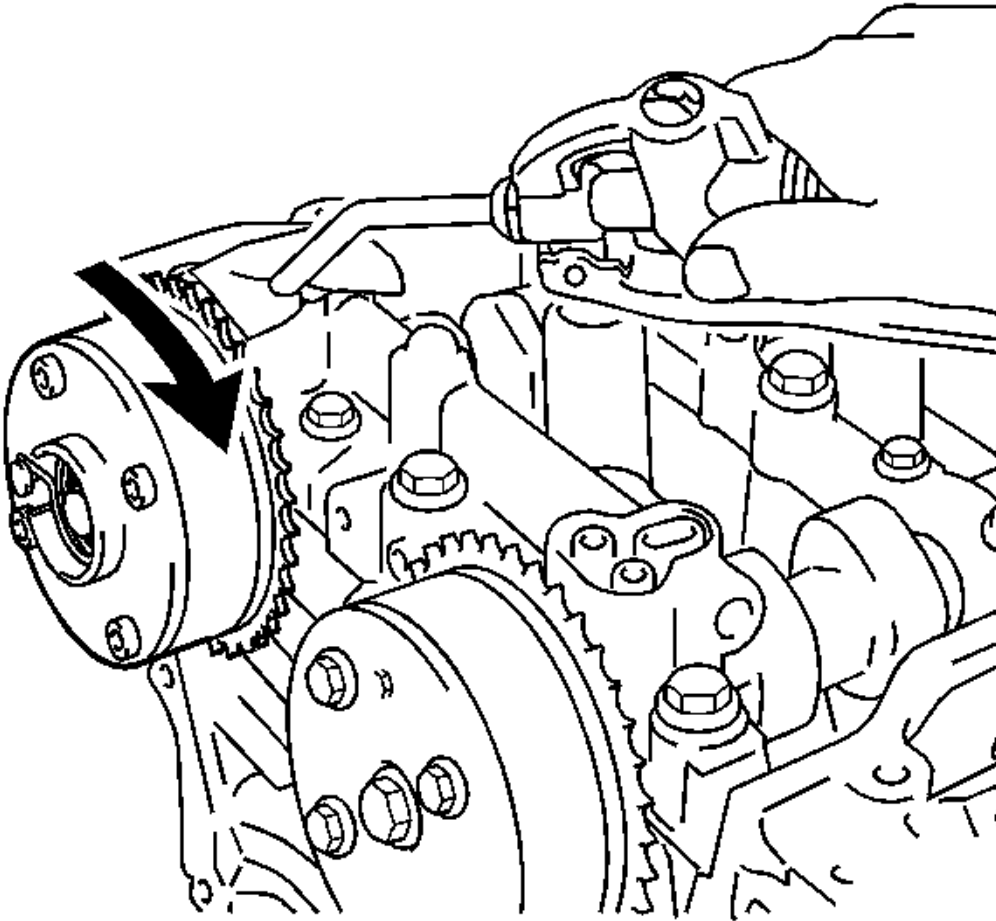


Fig. 87: Applying Shop Air To Hole In Tape

Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- If air leaks out, reattach the adhesive tape.
- Cover the oil hole with a shop rag or piece of cloth when applying air pressure to prevent oil from spraying.

42. Apply approximately 200 kPa (28 psi) of air pressure to the hole pricked in procedure B to release the lock pin.

IMPORTANT:

- Be sure to keep the camshaft timing exhaust gear in the retard direction using a screwdriver. If the gear is released, it will return to the most advanced position automatically due to force from the

spring.

- **Do not damage the camshaft timing exhaust gear.**

43. Using a screwdriver with its tip wrapped with tape, forcibly turn the camshaft timing exhaust gear in the retard direction (clockwise).

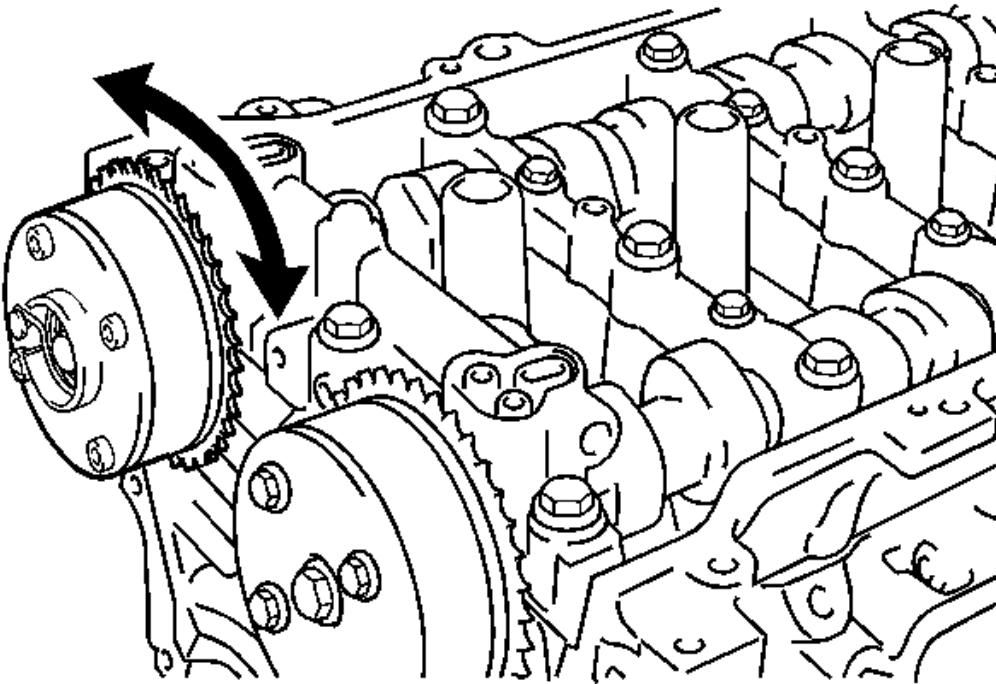


Fig. 88: Turning Camshaft Timing Exhaust Gear Within Movable Range
Courtesy of GENERAL MOTORS CORP.

44. Using a screwdriver with its tip wrapped with tape, turn the camshaft timing exhaust gear within its movable range (19 to 21 degrees) 2 or 3 times without turning it to the most advanced position. Make sure that the camshaft timing exhaust gear turns smoothly.
45. Remove the adhesive tape from the No. 1 camshaft bearing cap.

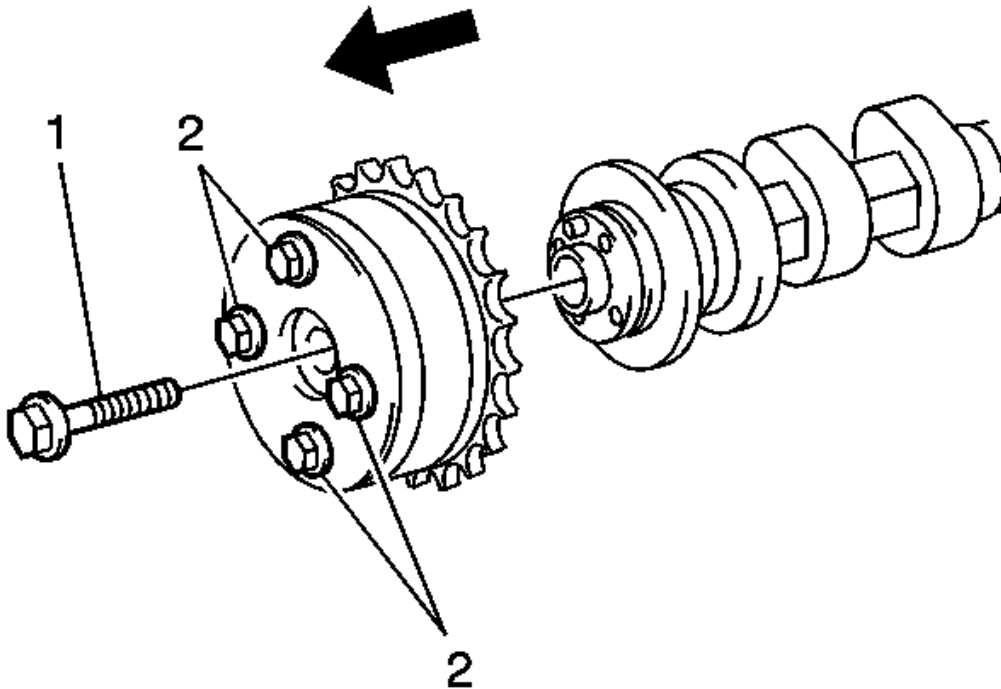


Fig. 89: View Of Camshaft Timing Gear & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Before removing the camshaft timing gear, make sure that the lock pin has been released.
- Be sure not to remove the other 4 bolts.
- Keep the camshaft timing gear assembly horizontal while removing it from the camshaft.

46. Remove the flange bolt while holding the hexagonal portion of the camshaft, and then remove the camshaft timing gear assembly.

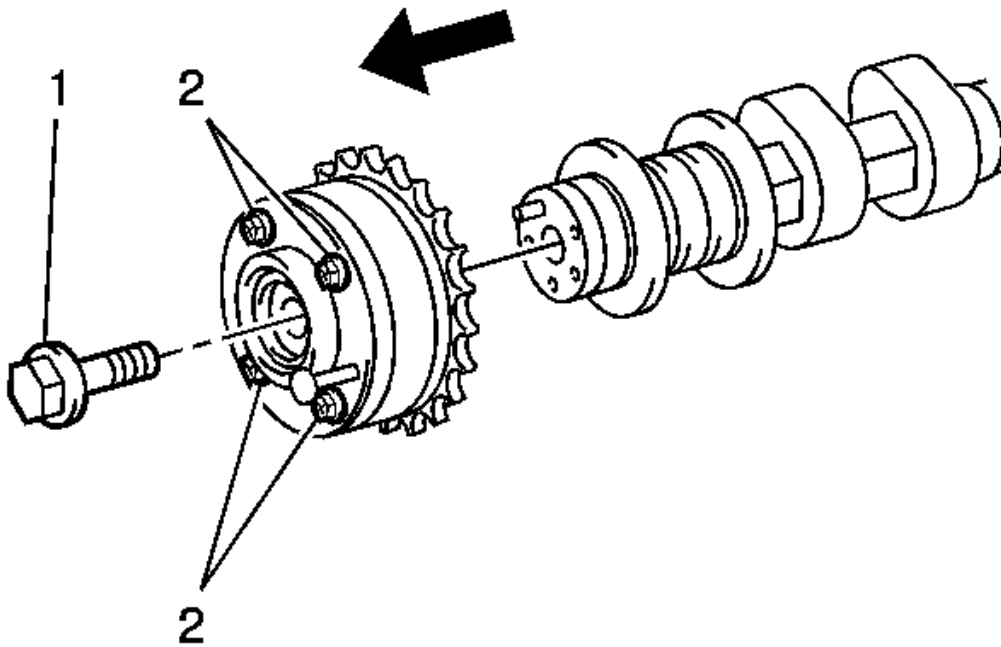


Fig. 90: View Of Camshaft Timing Gear & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Be sure not to remove the other 4 bolts.
- Keep the camshaft timing exhaust gear assembly horizontal while removing it from the camshaft.

47. Remove the flange bolt while holding the hexagonal portion of the camshaft, and then remove the camshaft timing exhaust gear assembly.

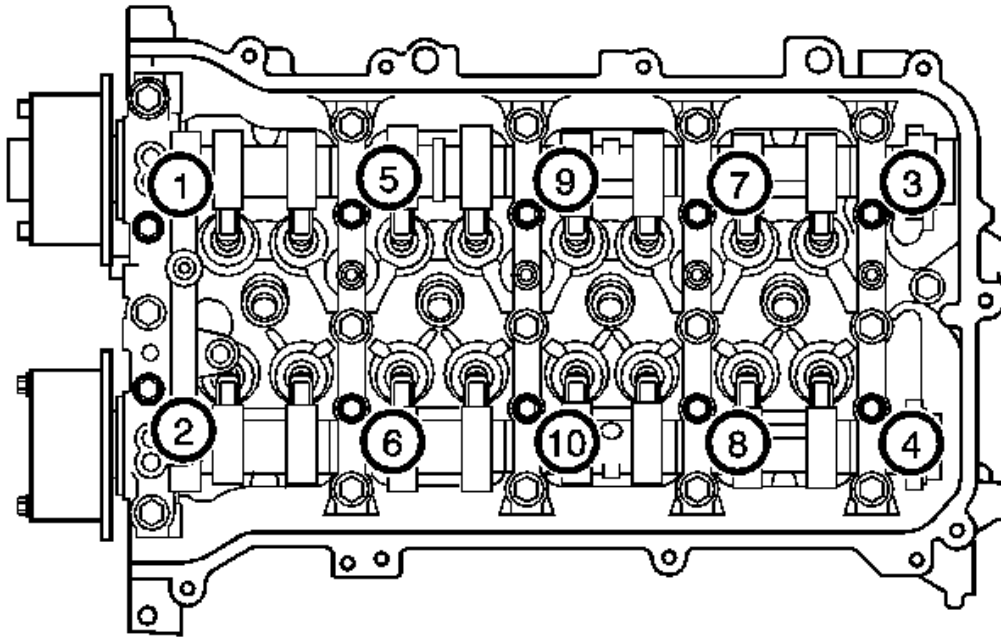


Fig. 91: Identifying Camshaft Bearing Cap Bolt Removal/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

48. Remove camshaft bearing cap-Uniformly loosen and remove the 10 bearing cap bolts in the sequence shown in the illustration.

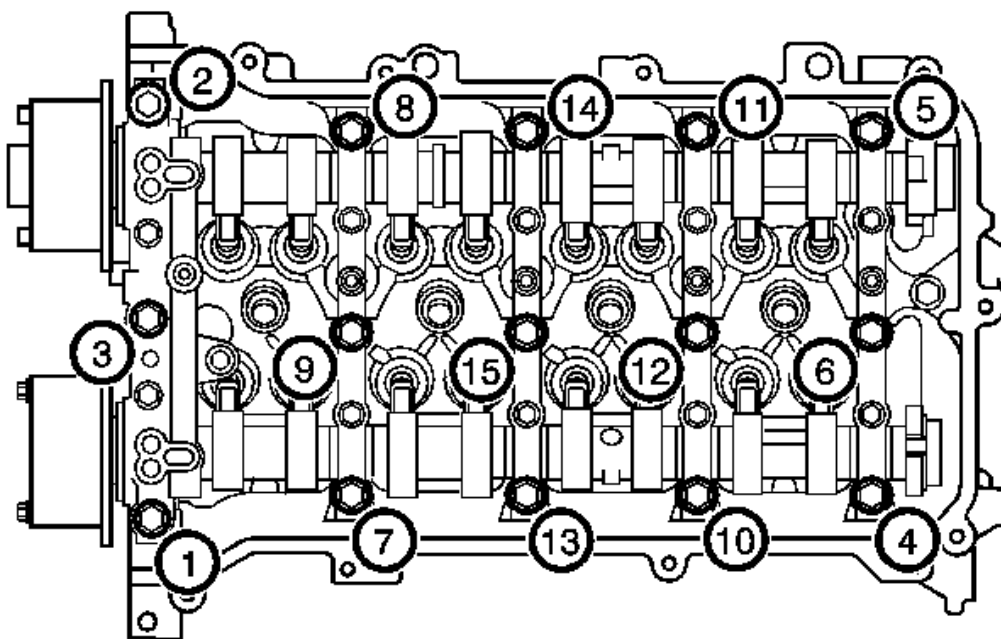


Fig. 92: View Of Camshaft Bearing Cap Bolt Removal/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Uniformly loosen the bolts while keeping the camshaft level.

49. Uniformly loosen and remove the 15 bearing cap bolts in the sequence shown in the illustration.

IMPORTANT: Arrange the removed parts in the correct order.

50. Remove the 5 bearing caps.

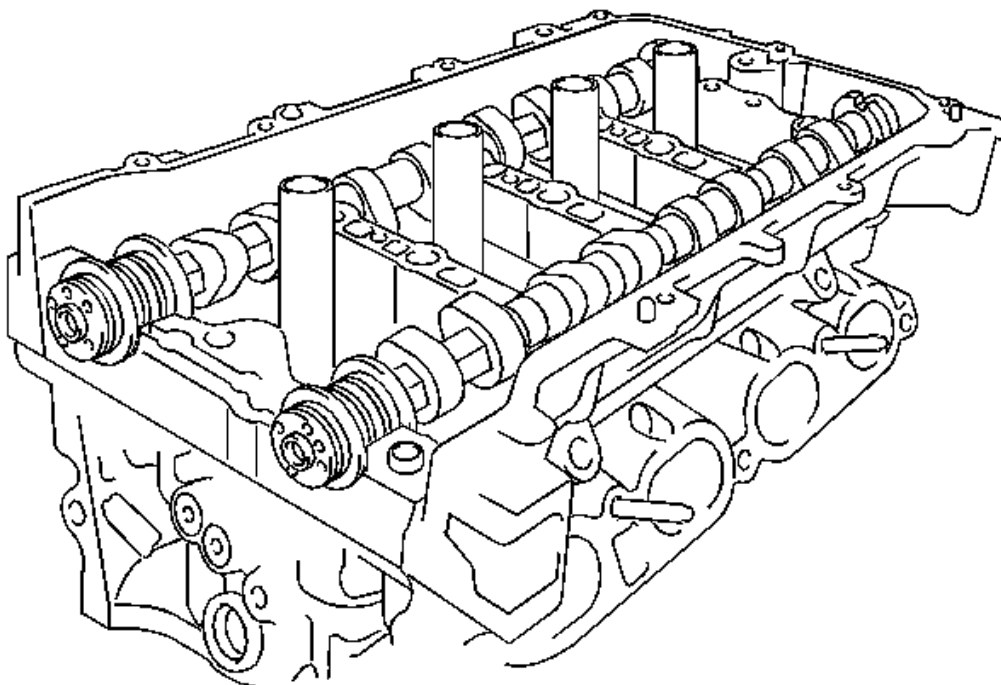


Fig. 93: View Of Cylinder Head & Camshafts
Courtesy of GENERAL MOTORS CORP.

51. Remove the camshaft.

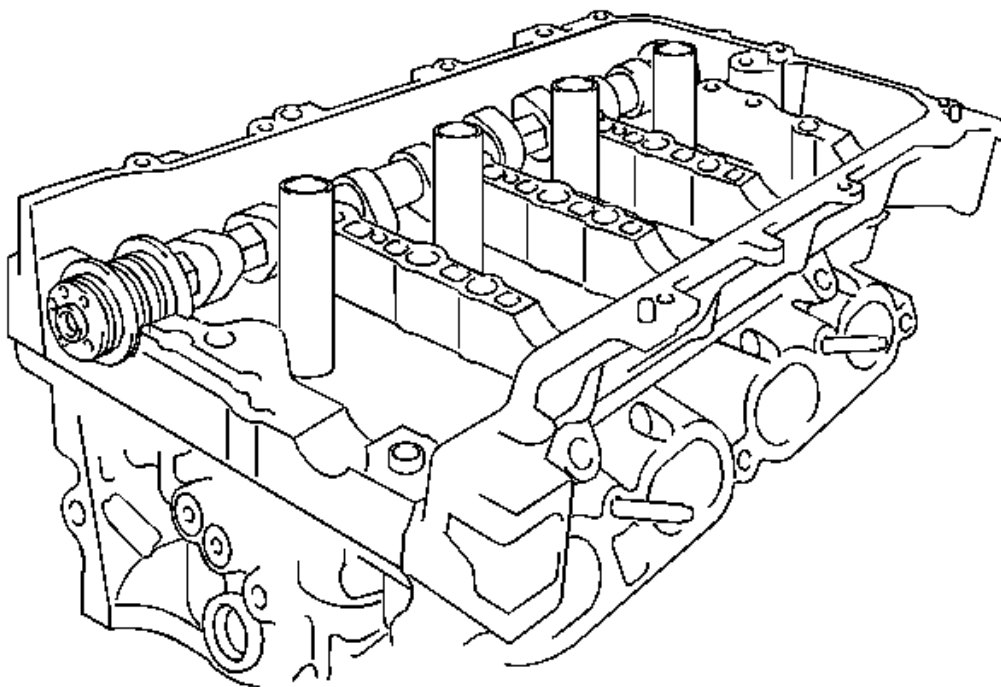


Fig. 94: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

52. Remove the No. 2 camshaft.
53. Remove the No. 1 valve rocker arm subassembly.
54. Remove the valve lash adjuster assembly.

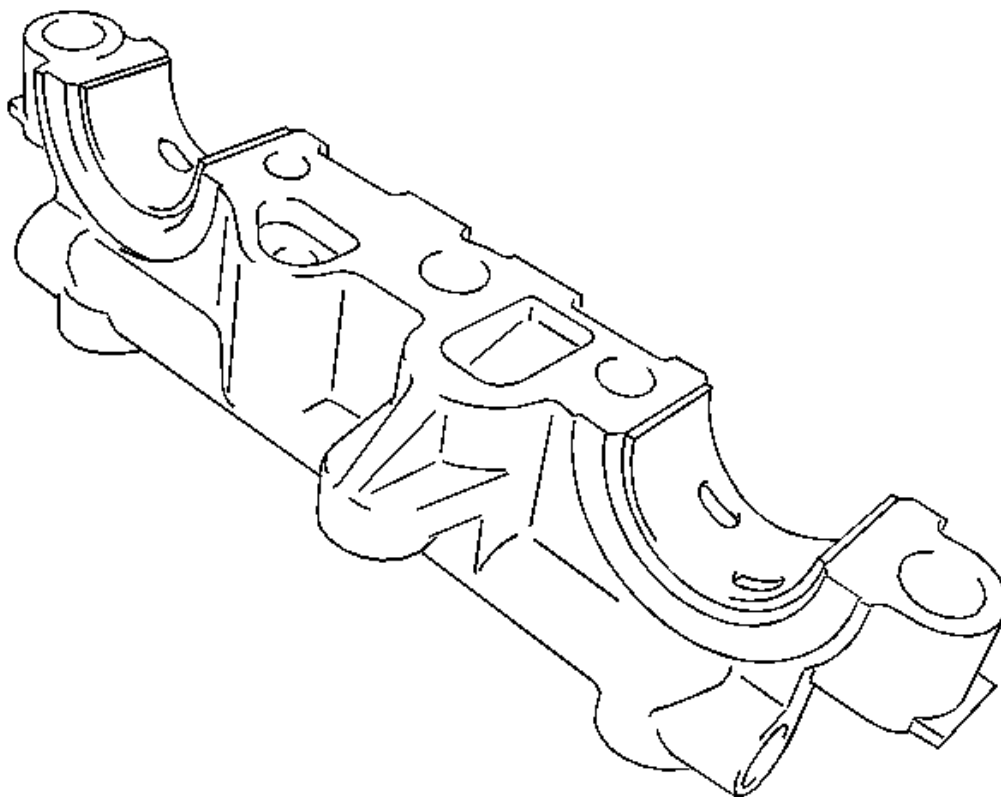


Fig. 95: View Of Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

55. Remove the 2 No. 1 camshaft bearings.

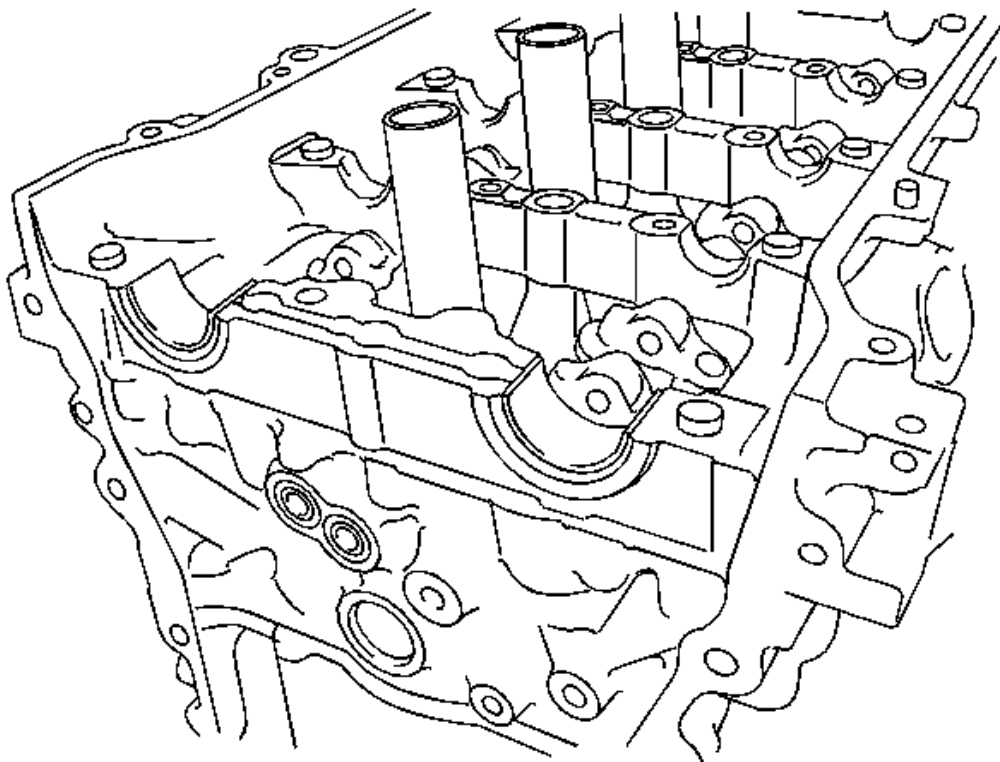


Fig. 96: Identifying Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

56. Remove the 2 No. 2 camshaft bearings.

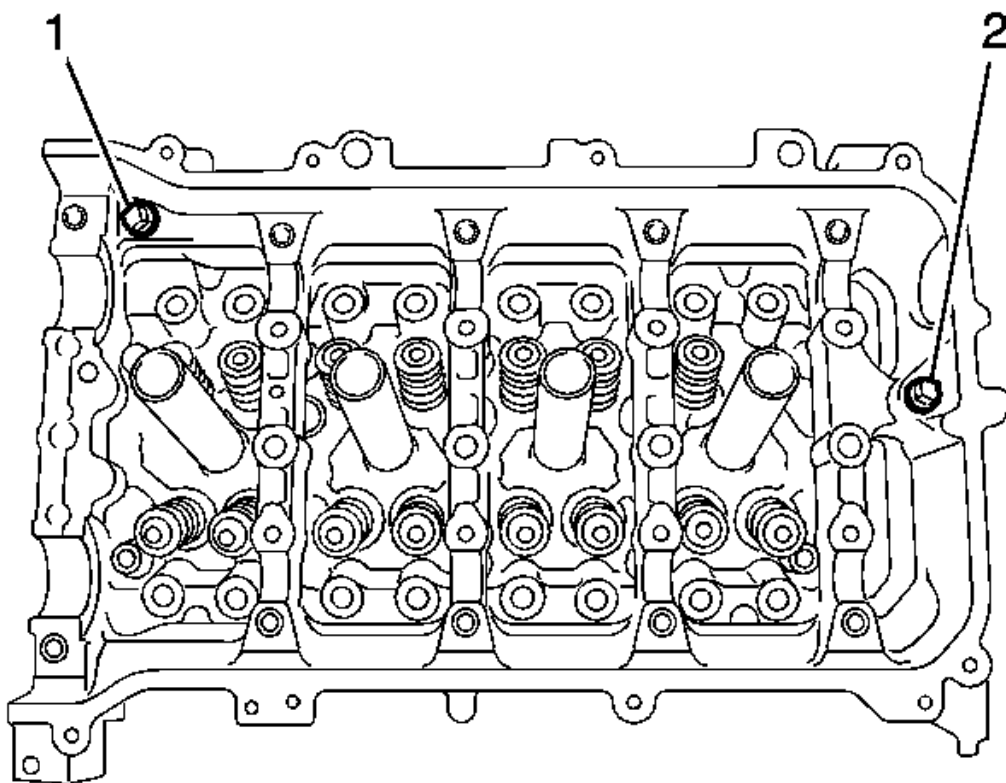


Fig. 97: Identifying 2 Bolts

Courtesy of GENERAL MOTORS CORP.

57. Remove the 2 bolts.

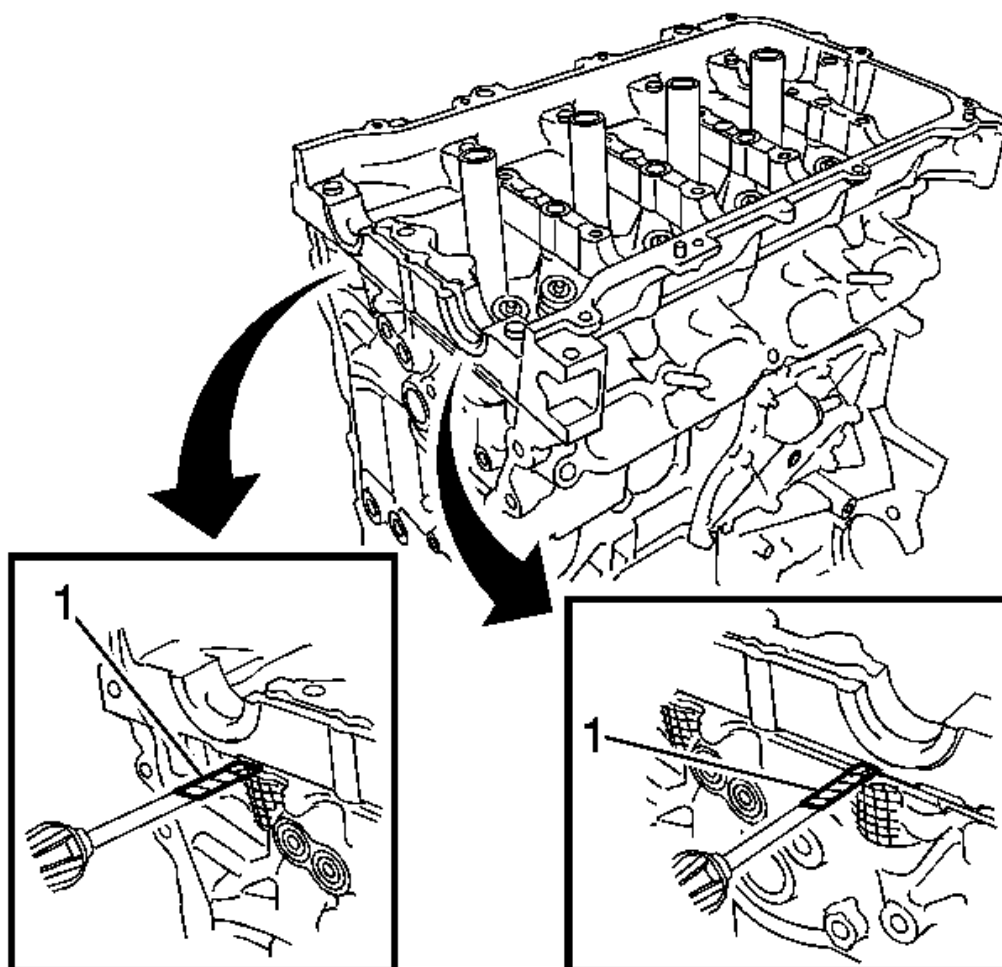


Fig. 98: View Of Camshaft Housing Sub-Assembly
 Courtesy of GENERAL MOTORS CORP.

58. Remove the camshaft housing sub-assembly. Remove the 2 bolts and pry between the cylinder head and camshaft housing with a screwdriver.

IMPORTANT: Tape the screwdriver tip before use.

59. Inspect the No. 1 valve rocker arm sub-assembly.
60. Inspect the valve lash adjuster assembly.

Installation Procedure

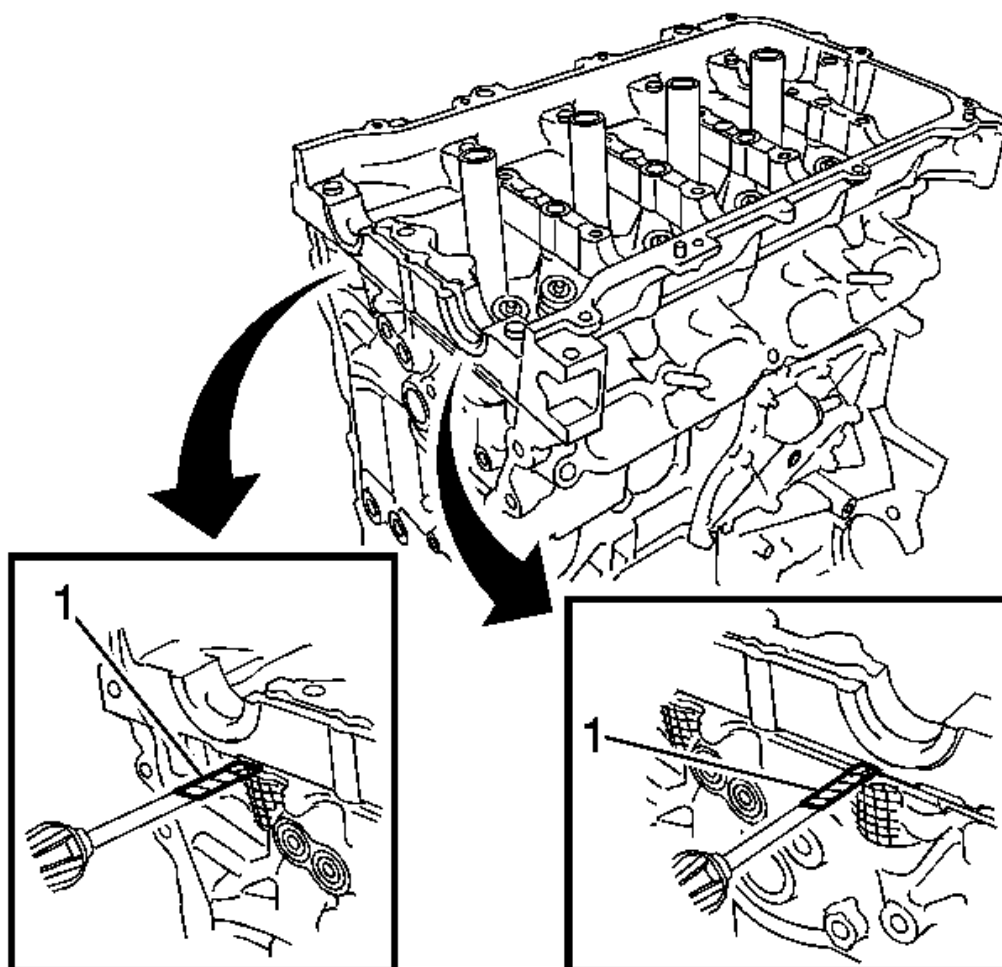


Fig. 99: View Of Camshaft Housing Sub-Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the valve lash adjuster assembly.
2. Install the No. 1 valve rocker arm subassembly.
3. Install the 2 No. 1 camshaft bearings after cleaning both surfaces of the bearings.

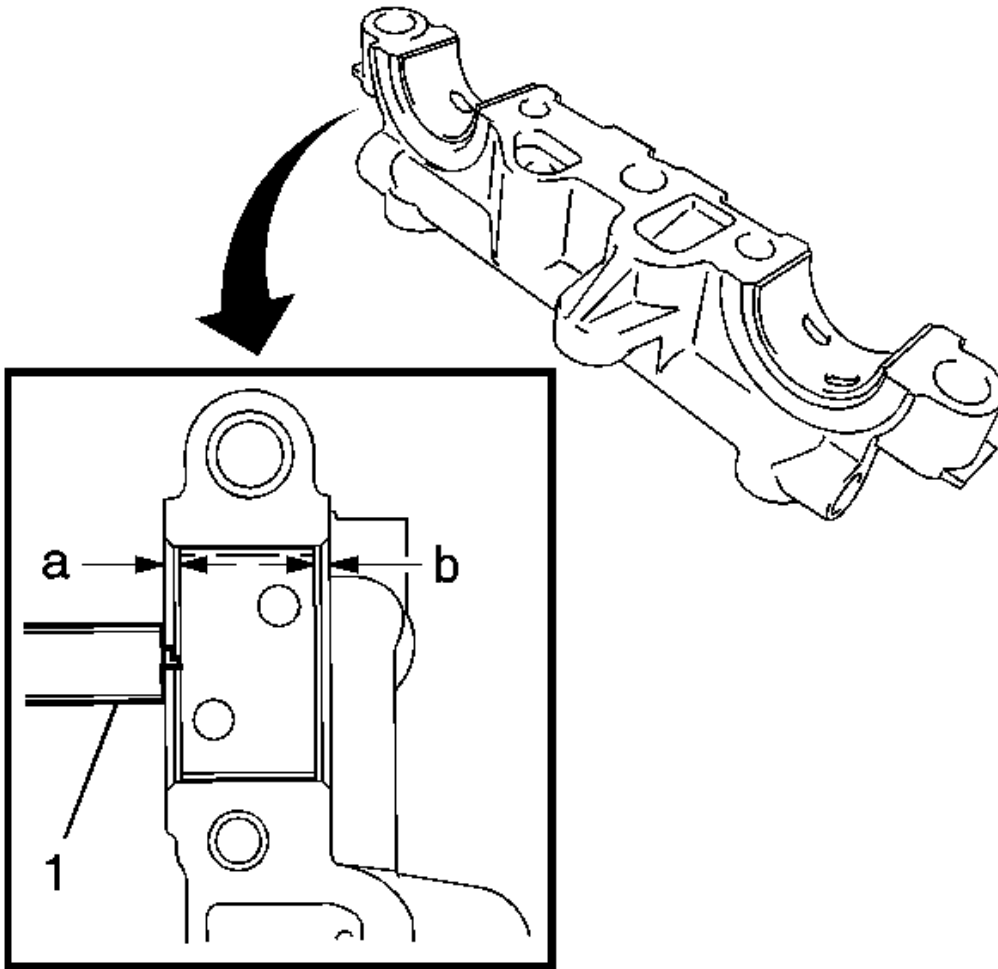


Fig. 100: Measuring Distance Between Bearing Cap Edge & Camshaft Bearing Edge
 Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Position the bearings to the center of the bearing cap by measuring dimensions A and B.

4. Using vernier calipers, measure the distance between the bearing cap edge and the camshaft bearing edge.

Specification: Dimension (A-B): 0.7 mm (0.0276 in) or less

5. Clean both surfaces of the bearings.
6. Install the 2 No. 2 camshaft bearings.

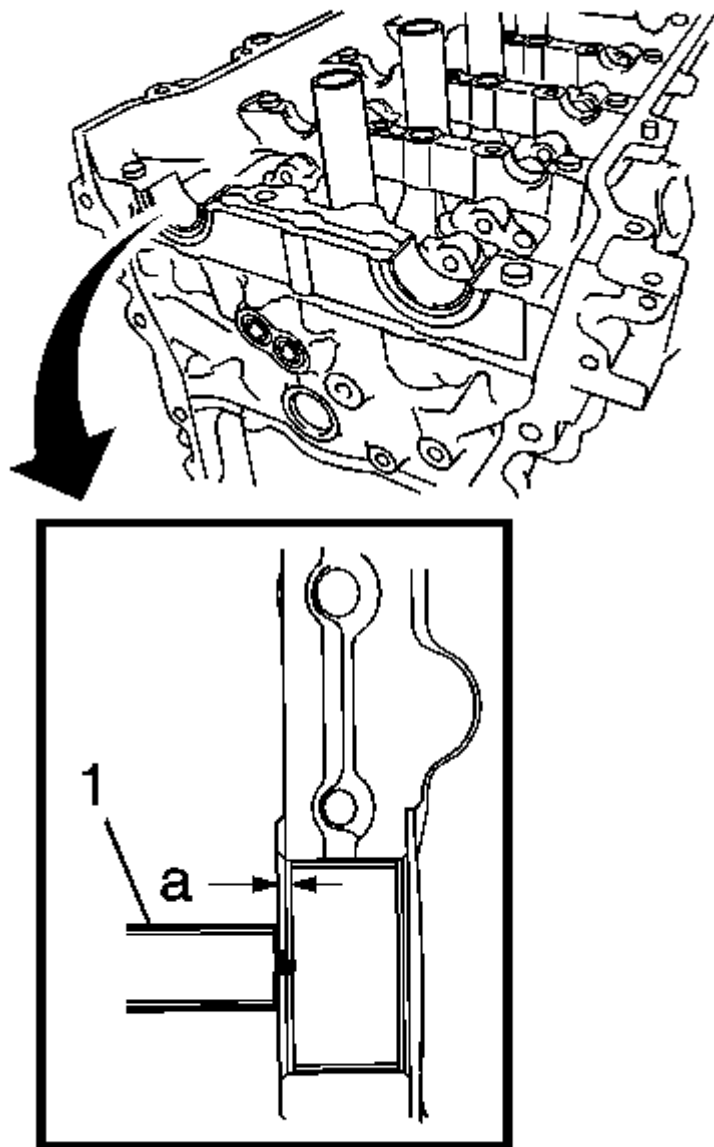


Fig. 101: Measuring Distance Between Bearing Cap Edge & Camshaft Bearing Edge
 Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Position the bearings to the center of the bearing cap by measuring dimension A.

7. Using vernier calipers, measure the distance between the bearing cap edge and the camshaft bearing edge.

Specification: Dimension (A): 1.05-1.75 mm (0.0413-0.0689 in.)

8. Clean the camshaft journals.
9. Apply a light coat of engine oil to the camshaft journals, camshaft housings and bearing caps.

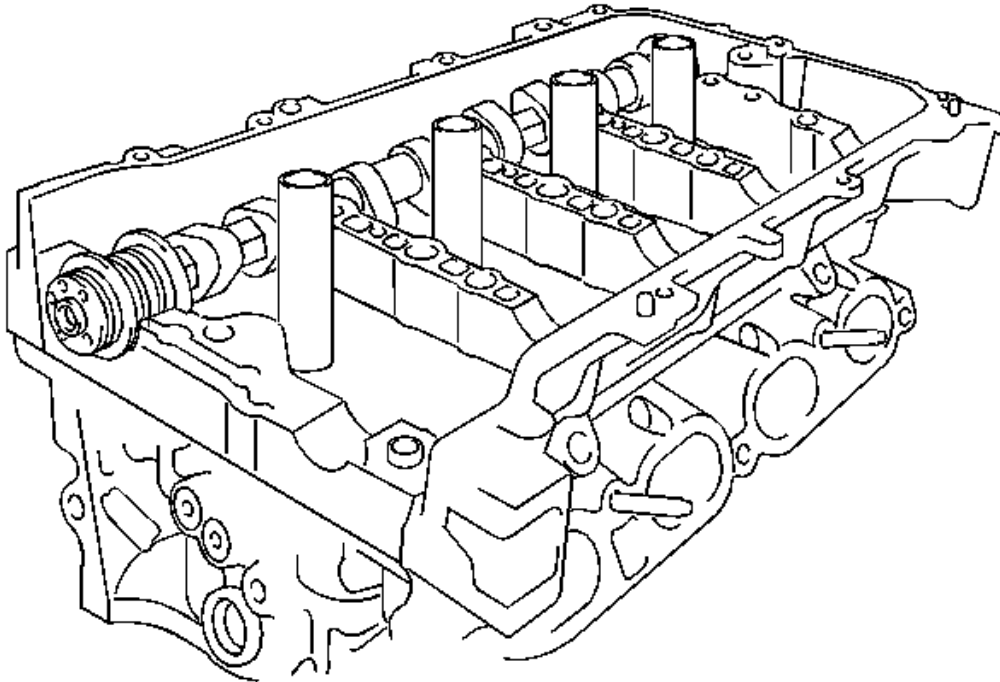


Fig. 102: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

10. Install the No. 2 camshaft to the camshaft housing.
11. Clean the camshaft journals.
12. Apply a light coat of engine oil to the camshaft journals, camshaft housings and bearing caps.

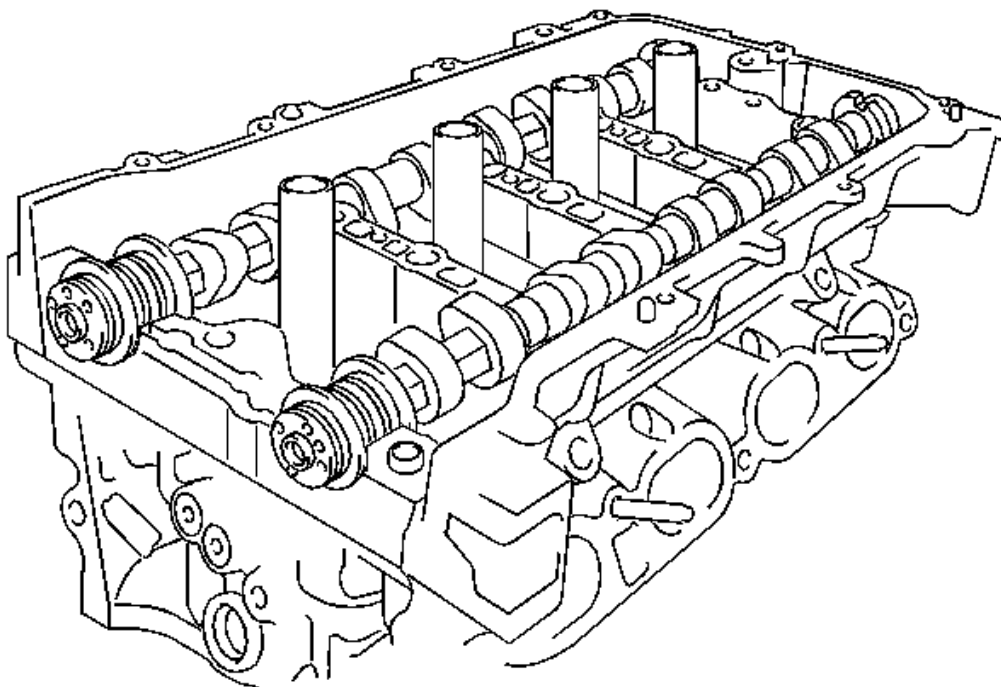


Fig. 103: View Of Cylinder Head & Camshafts
Courtesy of GENERAL MOTORS CORP.

13. Install the camshaft to the camshaft housing.
14. Apply engine oil to the camshaft journals, camshaft housings and bearing caps.

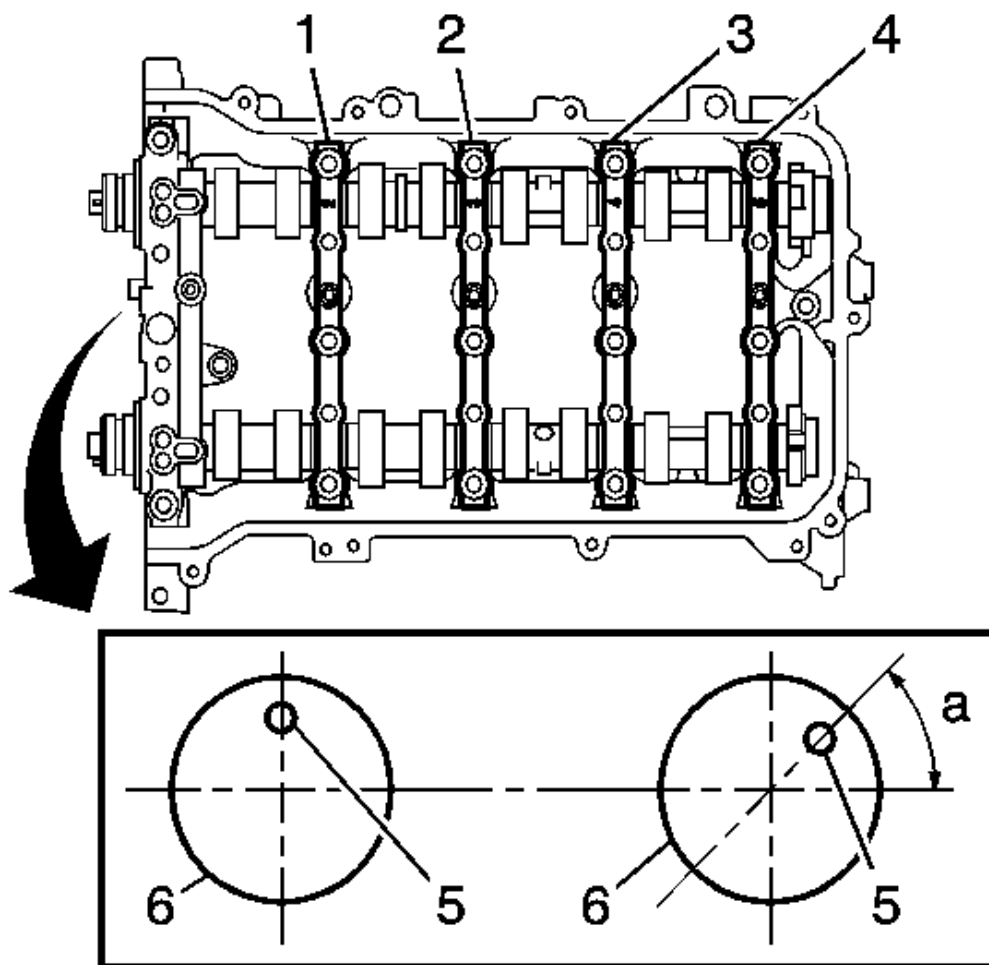


Fig. 104: Locating Marks & Numbers On Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure that the knock pin of the camshaft is positioned as shown in the illustration.

15. Make sure of the marks and numbers on the camshaft bearing caps and place them in each proper position and direction.

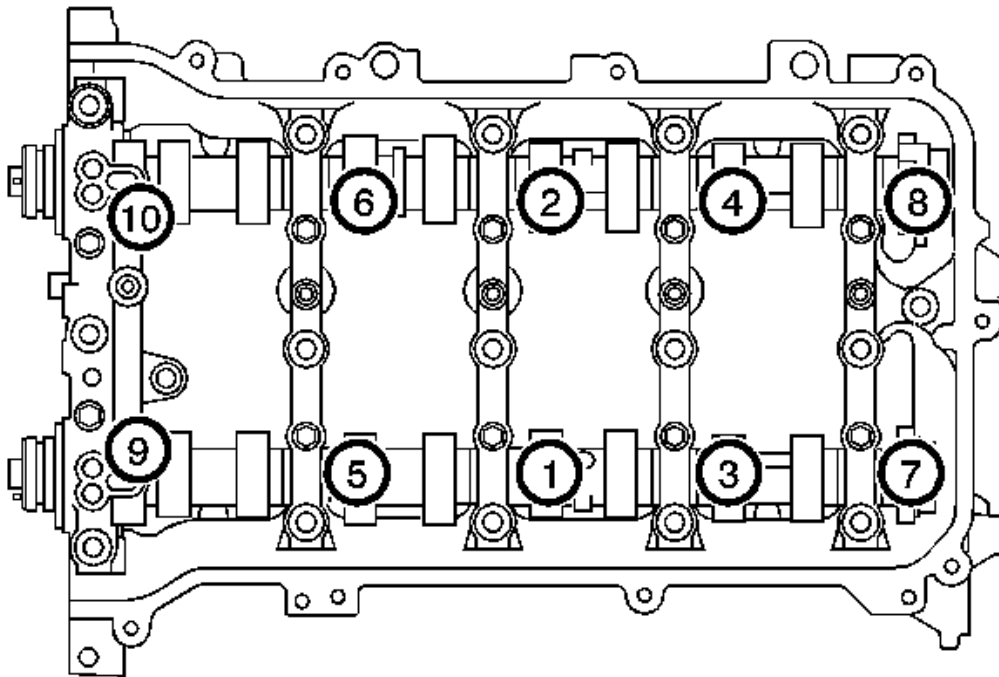


Fig. 105: Identifying Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to **FASTENER CAUTION** .

16. Install the 10 bolts in the order.

Tighten: Tighten the bolts to 16 N.m (12 lb ft).

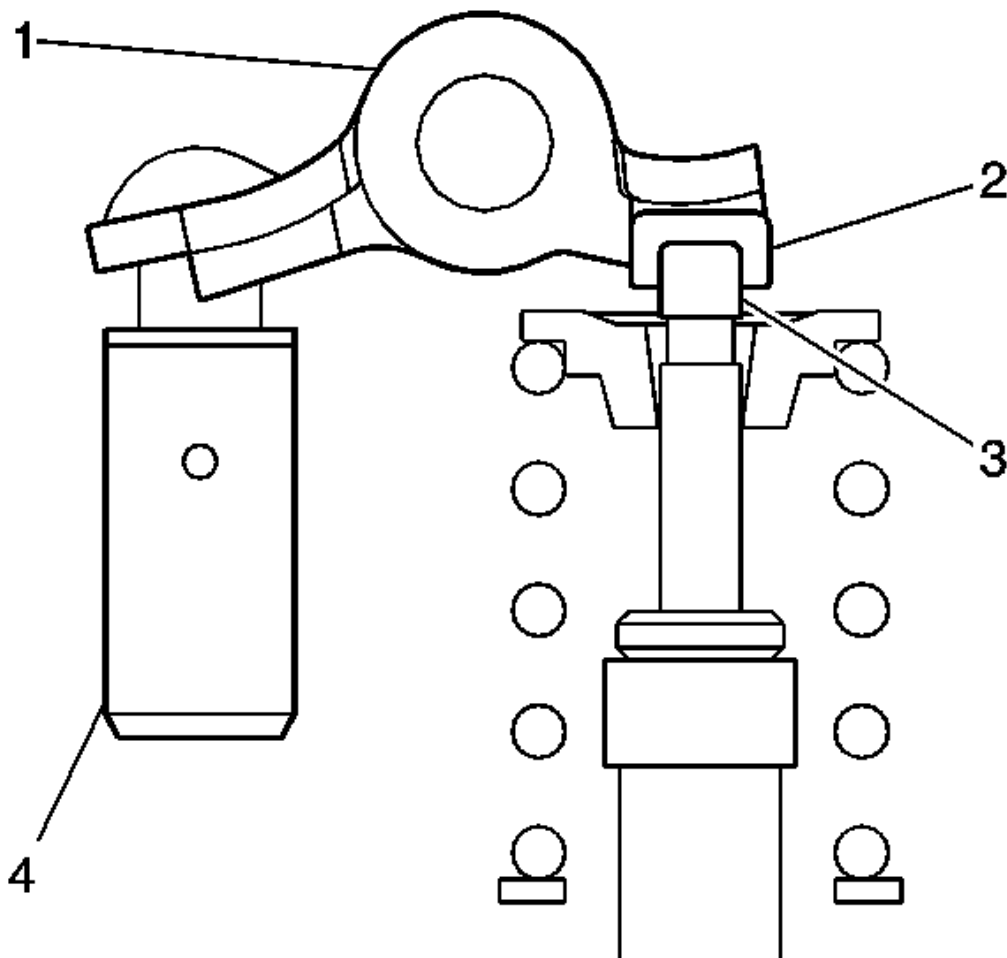


Fig. 106: View Of Correct Rocker Arm Installation
Courtesy of GENERAL MOTORS CORP.

17. Install the camshaft housing sub-assembly.
18. Make sure that the valve rocker arm is installed as shown in the illustration.

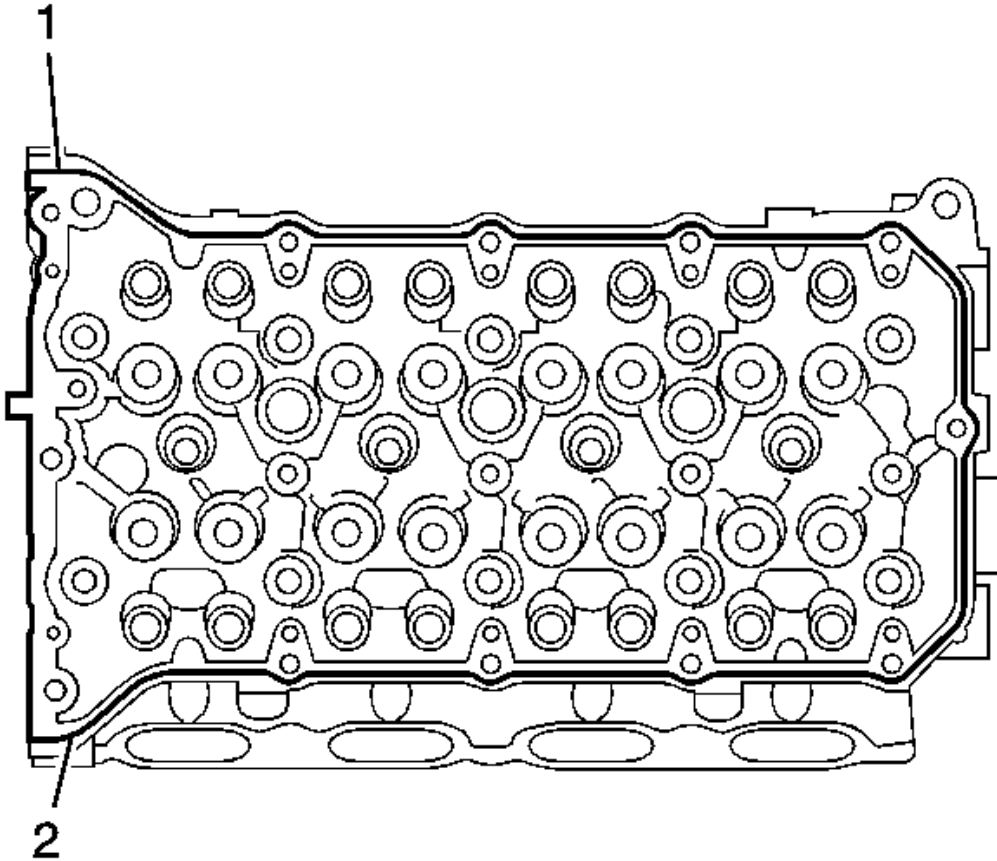


Fig. 107: Applying Adhesive To Cylinder Head
 Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Remove any oil from the contact surface.
- Install the camshaft housing sub-assembly within 3 minutes and tighten the bolts within 15 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after installing.

19. Apply seal packing Three Bond 1207B or equivalent Bead diameter: 3.5-4.0 mm (0.138-0.158 in) in a continuous bead.

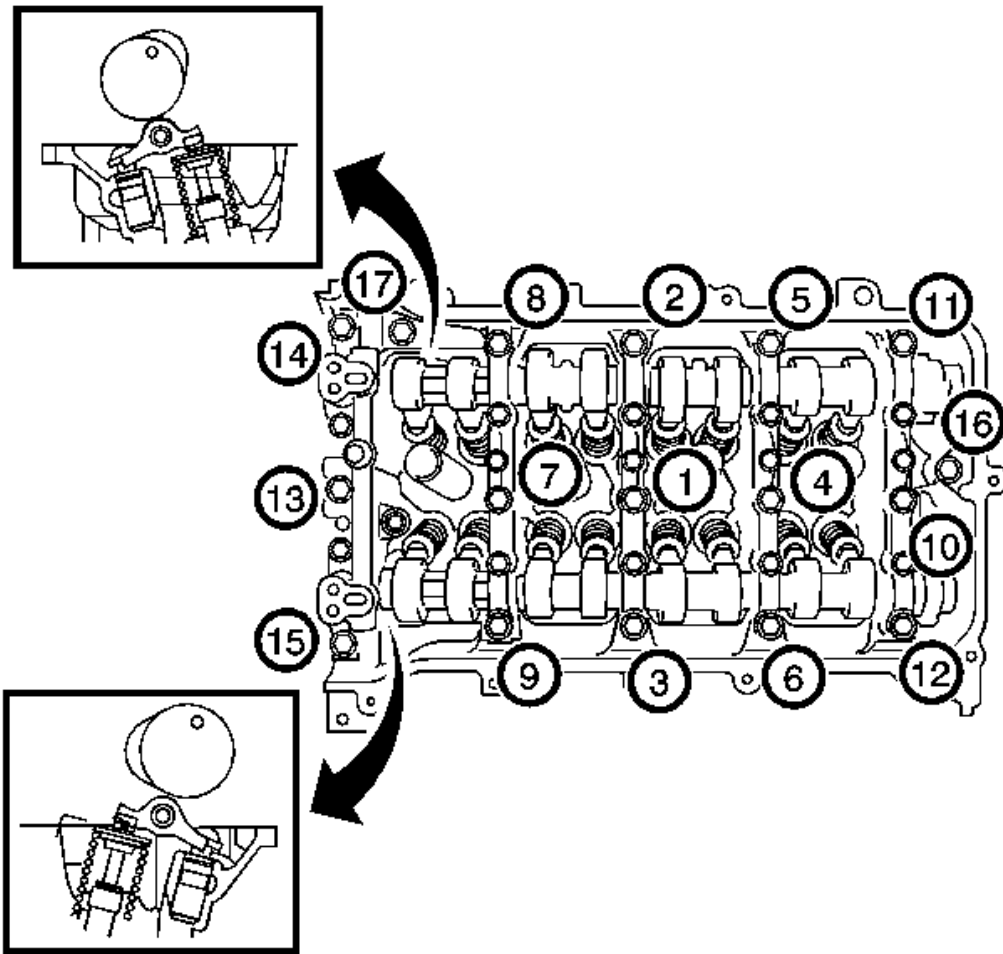


Fig. 108: View Of Setting Camshafts
Courtesy of GENERAL MOTORS CORP.

20. Set the camshaft and No. 2 camshaft.

IMPORTANT:

- After installing the camshaft housing, make sure that the cam lobes are positioned.
- If any of the bolts are loosened during installation, remove the camshaft housing, clean the installation surfaces, and reapply seal packing.
- If the camshaft housing is removed because any of the bolts are loosened during installation, make sure that the previously applied seal packing does not enter any oil passages.

- After installing the camshaft housing, wipe off any seal packing that seeped out from between the housing and the cylinder head.

21. Install the camshaft housing and tighten the 17 bolts in the order.

Tighten: Tighten the bolts to 27 N.m (20 lb ft).

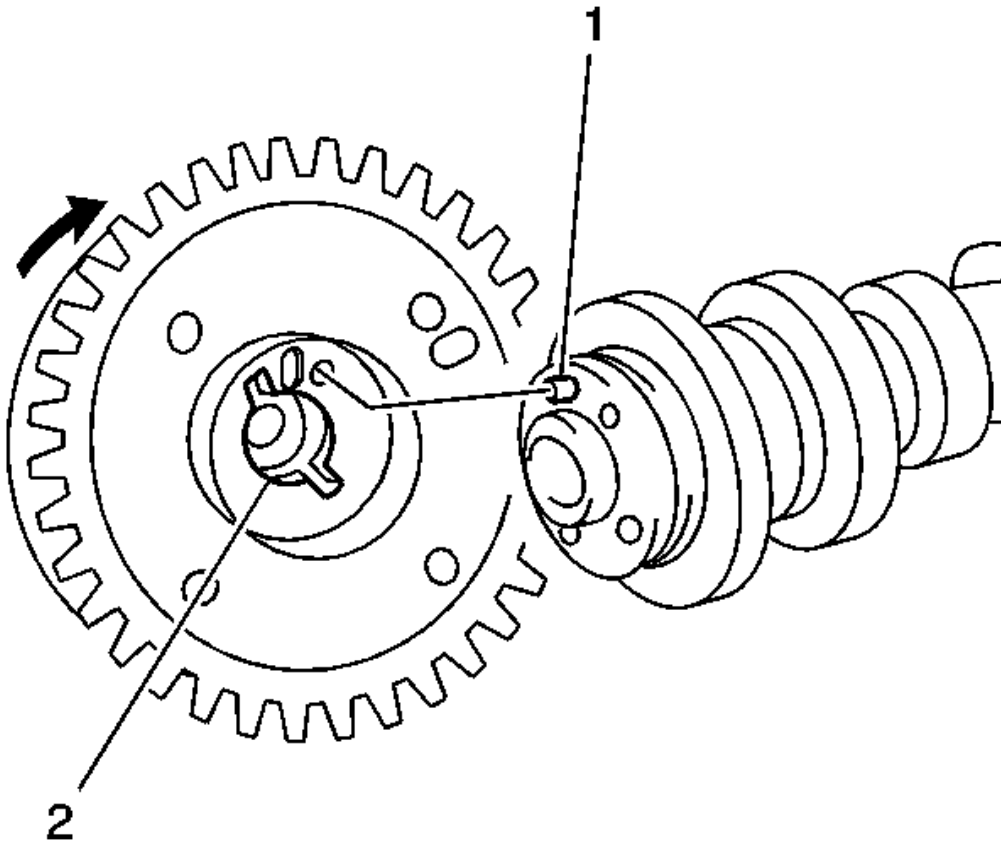


Fig. 109: View Of Camshaft Timing Gear Assembly
Courtesy of GENERAL MOTORS CORP.

22. Install camshaft timing gear assembly.
23. Check that the knock pin is installed on the camshaft.

IMPORTANT: Do not forcefully push in the camshaft timing gear assembly. This may cause the camshaft knock pin tip to damage the installation surface of the camshaft timing gear assembly.

24. Put the camshaft timing gear and camshaft together with the straight pin and key groove misaligned, as shown in the illustration.

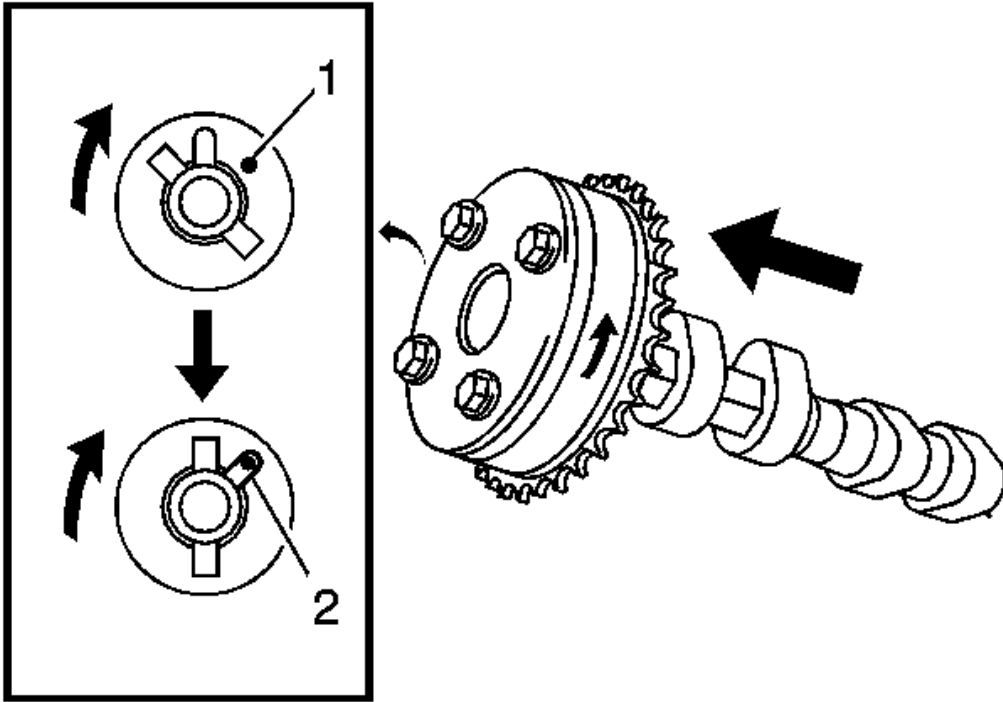


Fig. 110: View Of Turning Camshaft Gear
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not turn the camshaft timing gear in the retard direction (clockwise).

25. Turn the camshaft timing gear as shown in the illustration while pushing it gently against the camshaft. Push further at the position where the pin fits into the groove.

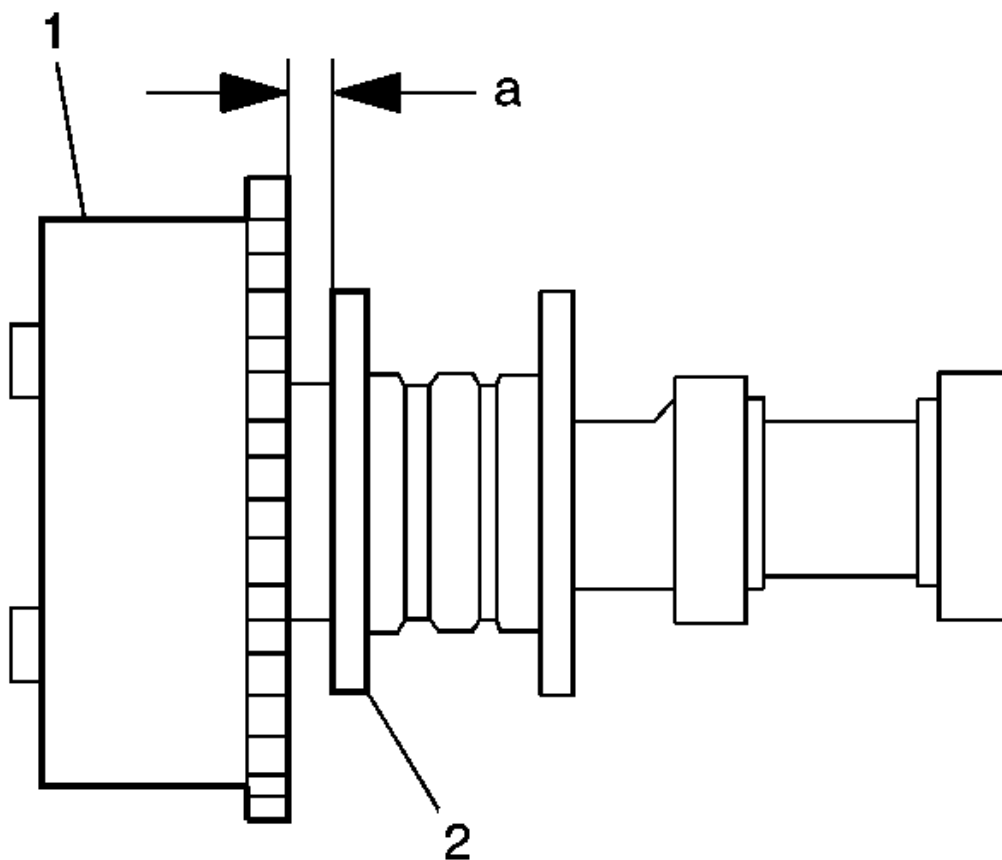


Fig. 111: Identifying Clearance Between Gear & Camshaft
Courtesy of GENERAL MOTORS CORP.

26. Measure the clearance between the gear and the camshaft.

Specification: Clearance: 0.1-0.4 mm (0.004-0.016 in.)

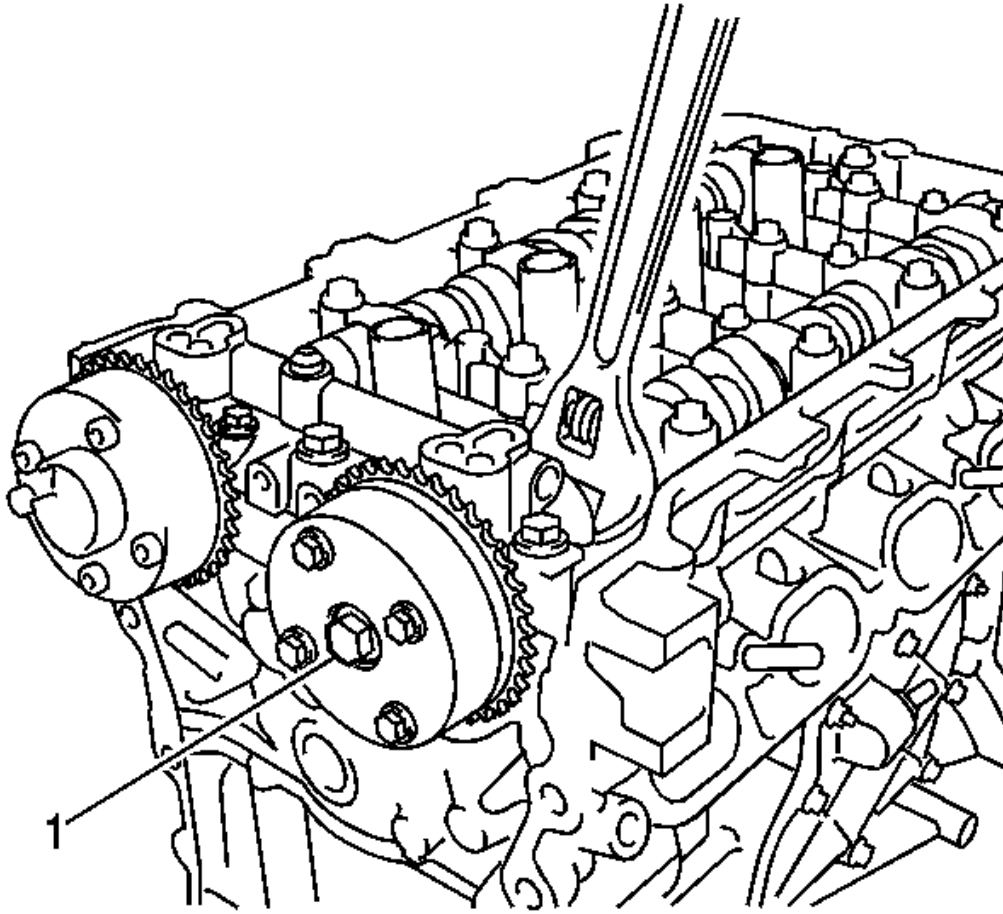


Fig. 112: View Of Tightening Camshaft Timing Gear
Courtesy of GENERAL MOTORS CORP.

27. Install the flange bolt with the camshaft timing gear fixed in place.

Tighten: Tighten the bolt to 54 N.m (40 lb ft).

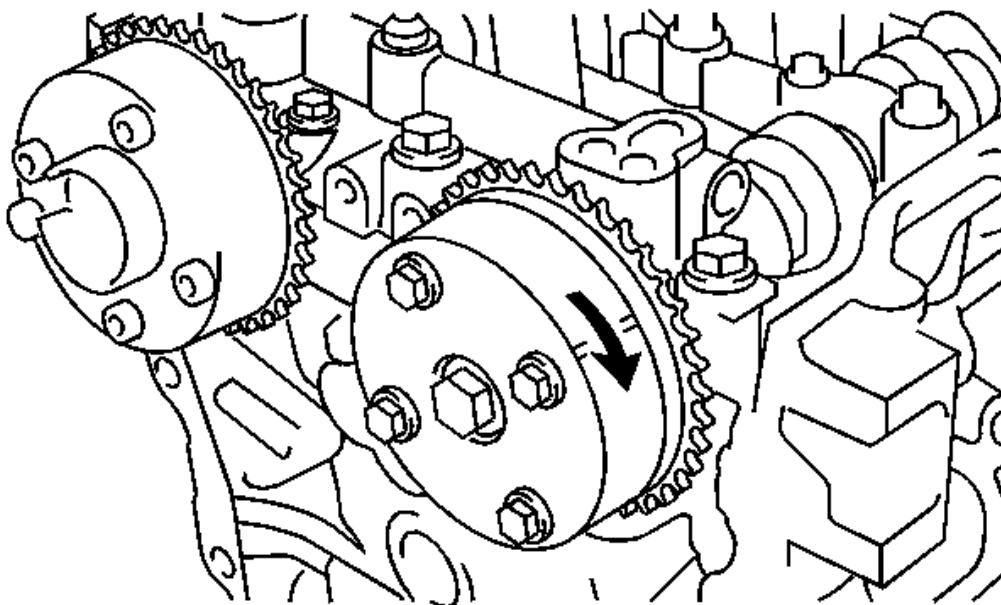


Fig. 113: Checking Camshaft Timing Gear Movement
Courtesy of GENERAL MOTORS CORP.

28. Check that the camshaft timing gear can move in the retard direction (clockwise) and is locked in the most retarded position.
29. Install the camshaft timing exhaust gear assembly.
30. Check that the knock pin is installed on the camshaft.

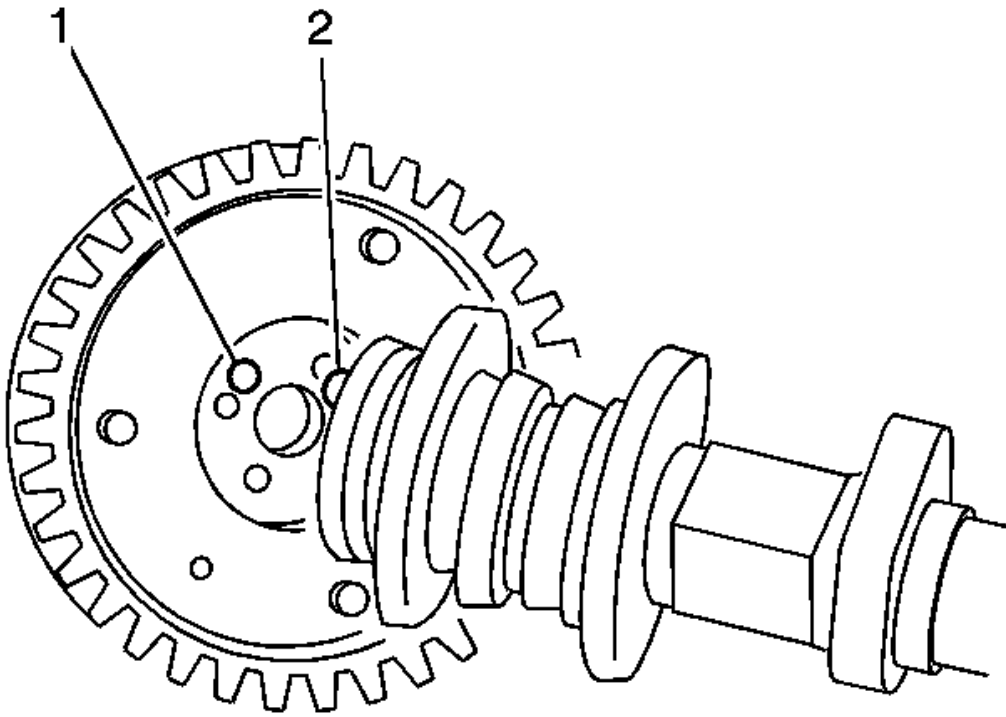


Fig. 114: View Of Camshaft Timing Exhaust Gear & Camshaft
Courtesy of GENERAL MOTORS CORP.

31. Put the camshaft timing exhaust gear and camshaft together by aligning the key groove and straight pin.

IMPORTANT: Be sure not to turn the camshaft timing exhaust gear in the retard direction (clockwise).

32. Lightly press the gear against the camshaft, and turn the gear. Push further at the position where the pin enters the groove.
33. Check that there is no clearance between the gear flange and the camshaft.

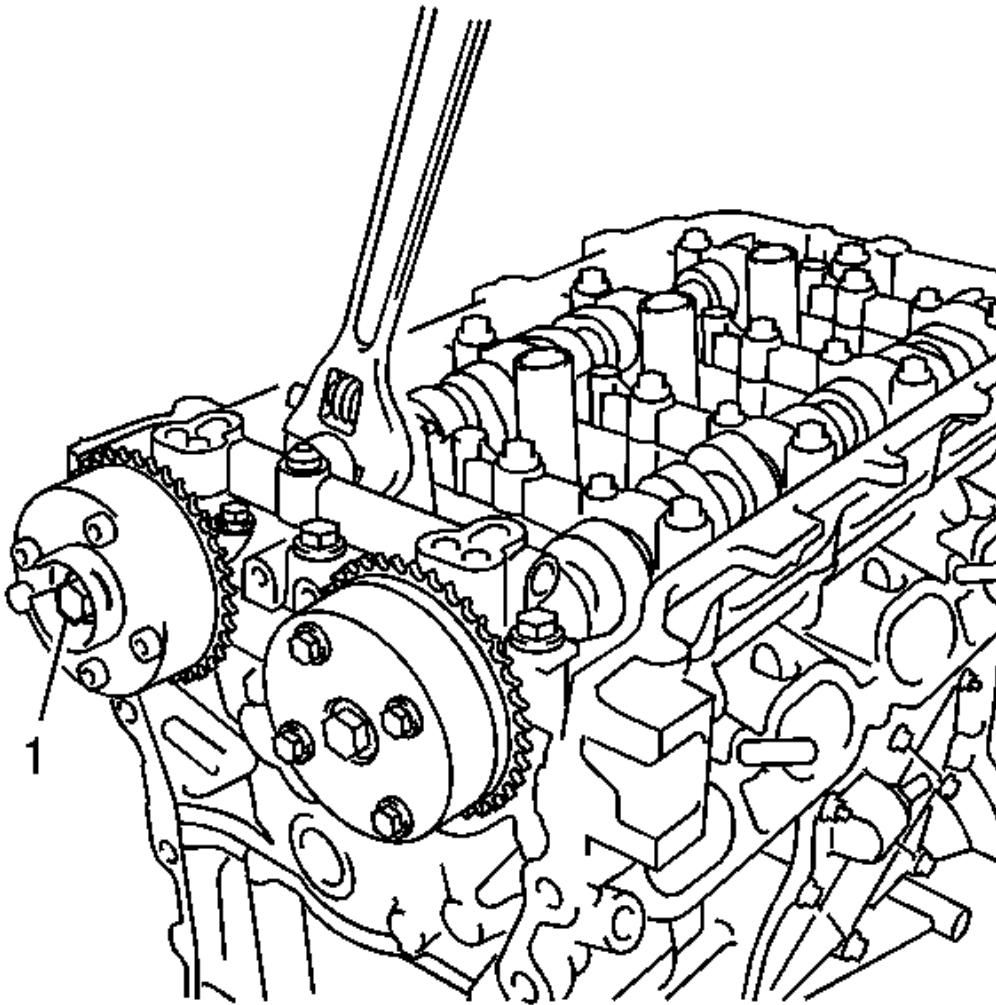


Fig. 115: View Of Tightening Flange Bolt With Camshaft Timing Exhaust Gear Fixed
Courtesy of GENERAL MOTORS CORP.

34. Install the flange bolt with the camshaft timing exhaust gear fixed.

Tighten: Tighten the bolt to 54 N.m (40 lb ft).

35. Make sure that the camshaft timing exhaust gear is locked.
36. Install the No. 1 chain vibration damper.
37. Install the No. 2 chain vibration damper.
38. Install the chain sub-assembly.

39. Install the chain tensioner slipper.
40. Install the timing chain cover oil seal.
41. Install the timing chain cover sub-assembly.
42. Install the crankshaft pulley.
43. Install the No. 1 chain tensioner assembly.
44. Install the cylinder head cover sub-assembly.
45. Install the radio setting condenser.
46. Install the thermostat.
47. Install the inlet water.
48. Install the inlet water hose.
49. Install the water by-pass hose.
50. Install the No. 1 water by-pass pipe.
51. Install the No. 3 water by-pass hose.
52. Install the ventilation hose.
53. Inspect the exhaust manifold.
54. Install the exhaust manifold.
55. Install the manifold stay.
56. Install the No. 1 exhaust manifold heat insulator.
57. Install the oil level dipstick sub-assembly. Refer to **Oil Level Indicator and Tube Replacement**.
58. Install the ignition coil assembly.
59. Install the fuel injector assembly.
60. Install the No. 1 delivery pipe spacer.
61. Install the fuel delivery pipe sub-assembly.
62. Install the fuel tube sub-assembly.
63. Install the intake manifold.
64. Remove the engine stand.
65. Install the engine assembly with transaxle. Refer to **Engine Replacement**.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Removal Procedure

1. Remove the front wheel RH.
2. Remove the engine under cover RH.
3. Remove the engine cover. Refer to **Drive Belt Replacement**.
4. Remove the V-ribbed belt.

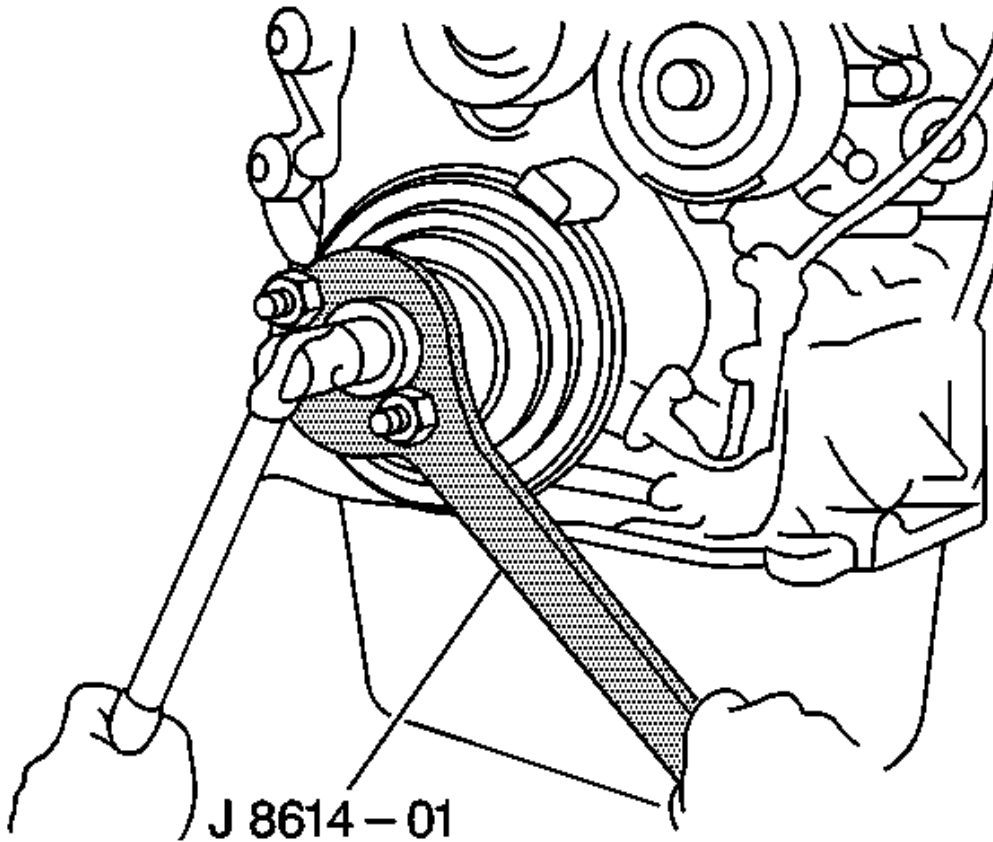


Fig. 116: View Of Crankshaft Pulley & Special Tool
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft pulley.
6. Using SST, hold the pulley in place and loosen the pulley bolt.

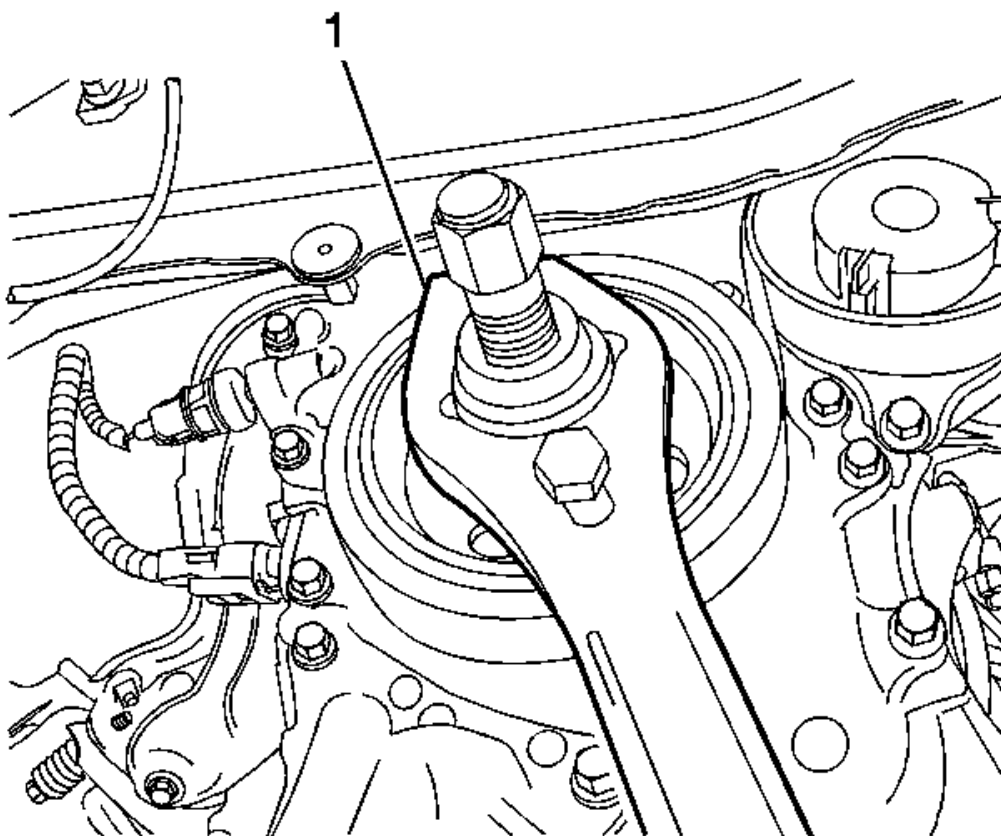


Fig. 117: View Of Crankshaft Pulley & Pulley Bolt Removal
Courtesy of GENERAL MOTORS CORP.

7. Using SST, remove the crankshaft pulley and pulley bolt.
8. Remove the timing chain cover oil seal.
9. Using a knife, cut off the lip of the oil seal.

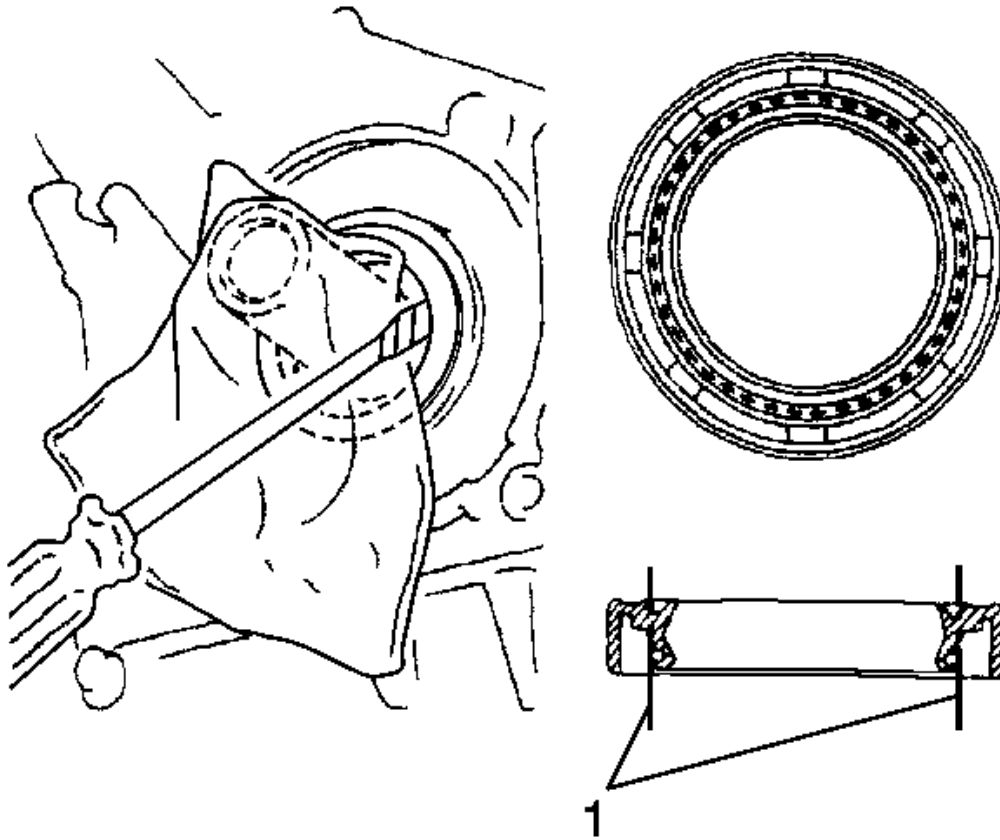


Fig. 118: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: After removing, check the crankshaft for nicks or burrs. Smooth the surface with 400-grit sandpaper.

10. Using a screwdriver with its tip wrapped with tape, pry out the oil seal.

Installation Procedure

1. Install the timing chain cover oil seal.

IMPORTANT: Keep the lip free from foreign matter.

2. Apply MP grease to the lip of a new oil seal.

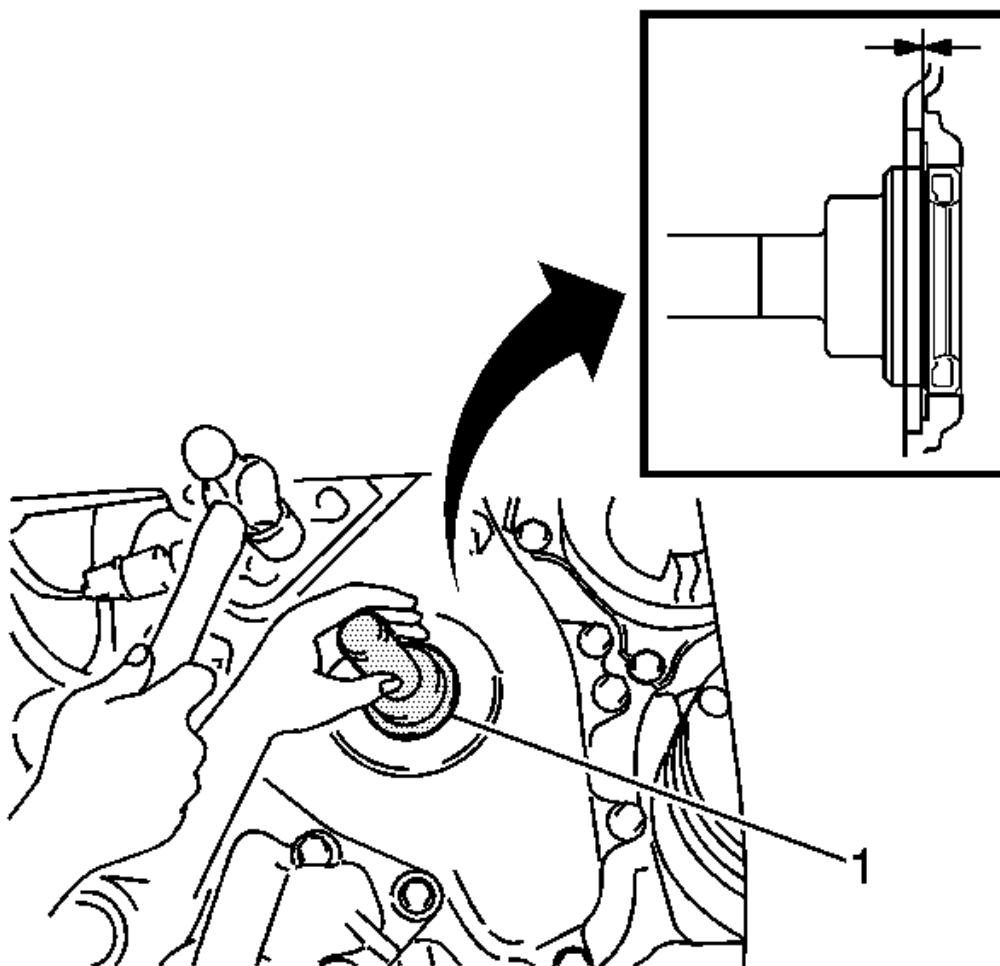


Fig. 119: View Of Crankshaft Front Oil Seal Installation
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Wipe off extra grease from the crankshaft.

3. Using SST and a hammer, tap in the oil seal until its surface is flush with the rear oil seal retainer edge.
4. Install the crankshaft pulley.
5. Align the pulley set key with the key groove of the pulley.

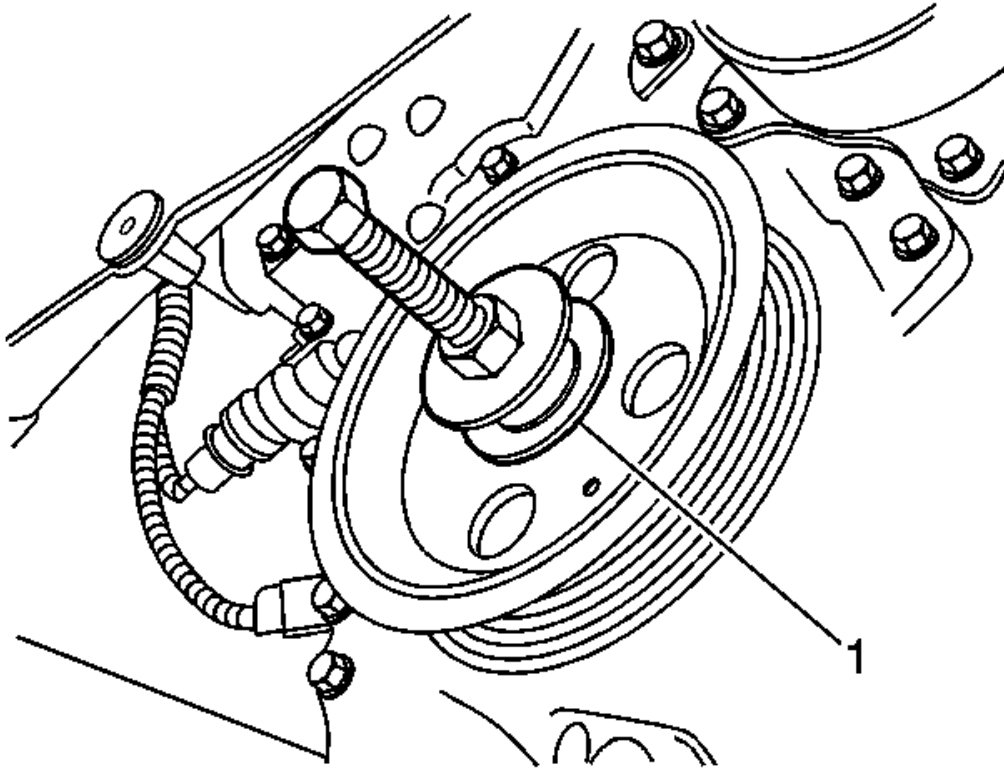


Fig. 120: View Of Tightening Crankshaft Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to **FASTENER CAUTION** .

6. Using SST, hold the pulley in place and tighten the bolt.

Tighten: Tighten the bolt to 190 N.m (140 lb ft)

7. Install the V-ribbed belt. Refer to **Drive Belt Replacement**.
8. Adjust the V-ribbed belt.
9. Inspect the V-ribbed belt.
10. Add the engine oil.
11. Inspect for engine oil leaks.
12. Install the engine cover. Refer to **Engine Cover Replacement**.
13. Install the engine under cover RH.
14. Install the front wheel RH.

CAMSHAFT COVER REPLACEMENT**Removal Procedure**

1. Remove the engine cover.

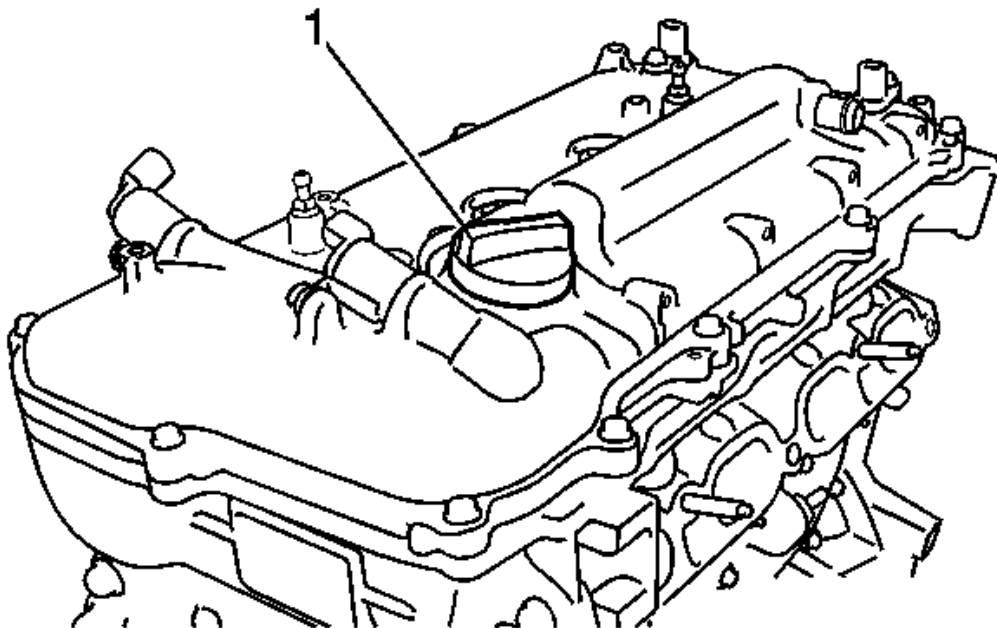


Fig. 121: Identifying Oil Filler Cap
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filler cap.

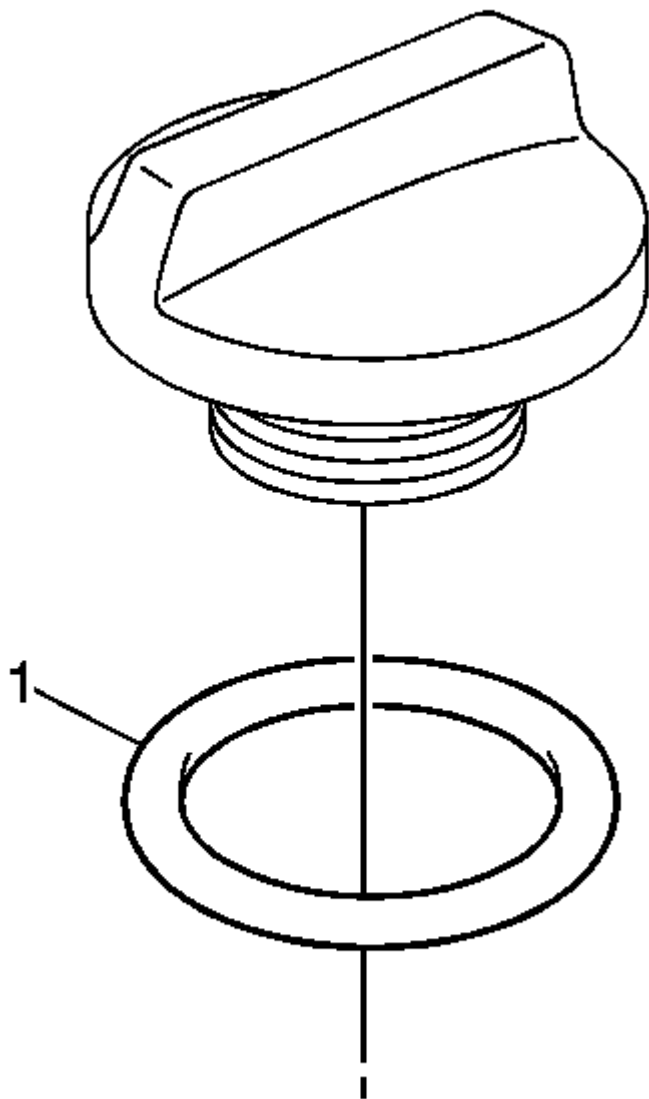


Fig. 122: View Of Oil Filler Cap
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filler cap gasket.

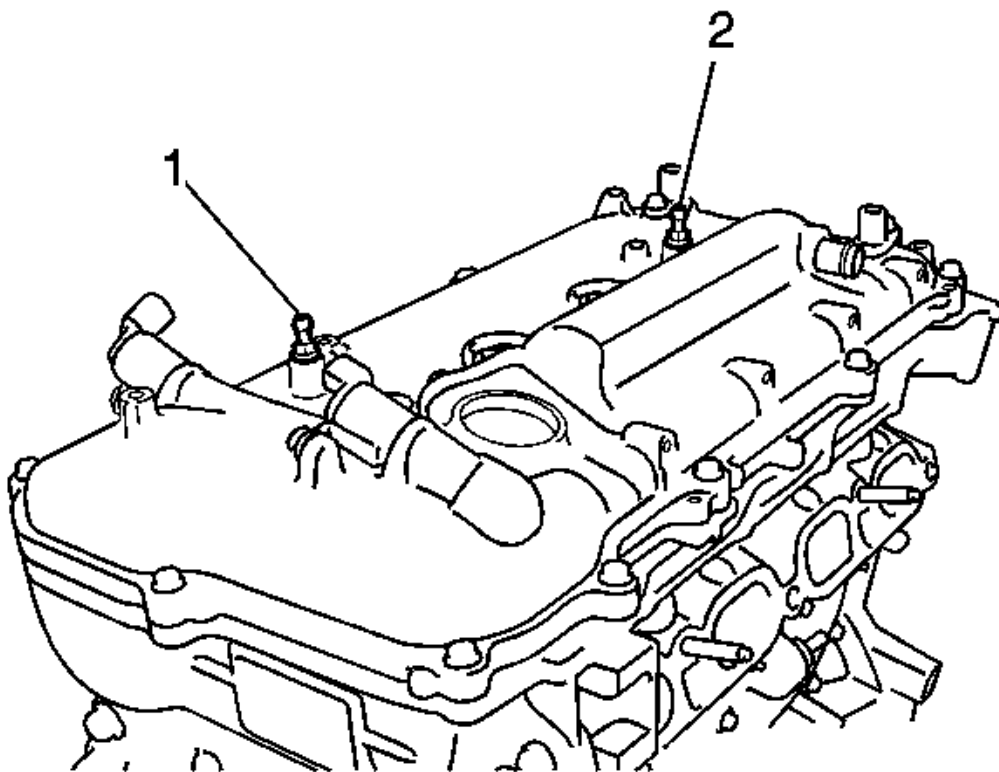


Fig. 123: View Of Engine Cover Joints
Courtesy of GENERAL MOTORS CORP.

4. Remove the 2 engine cover joints.

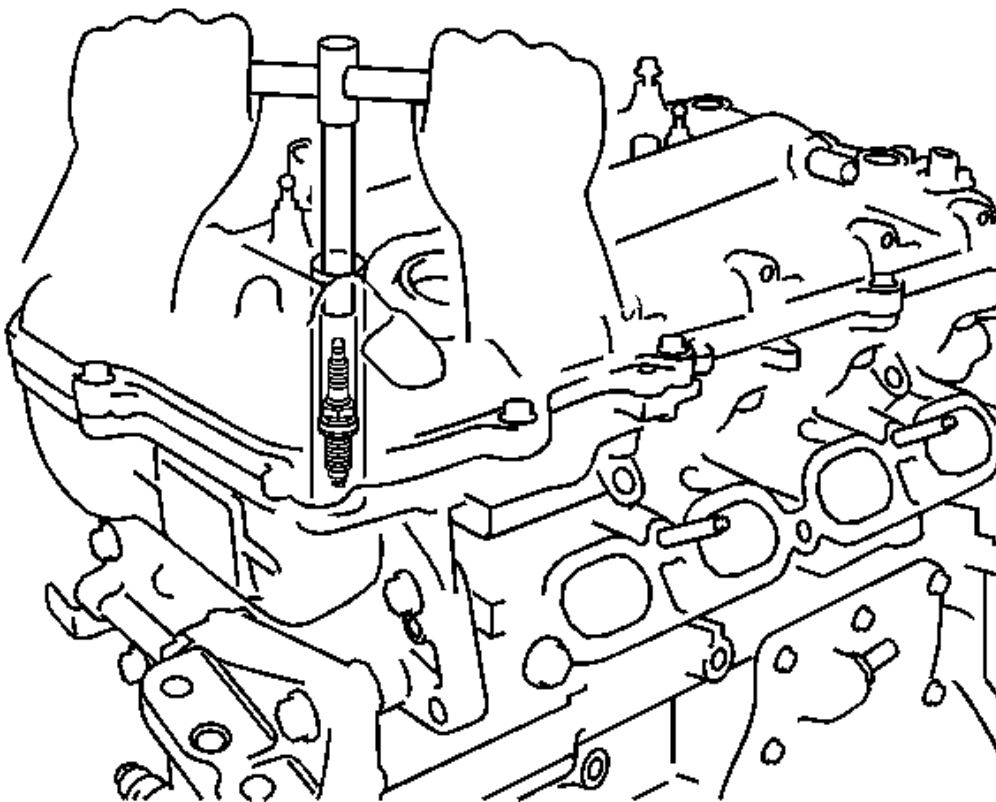


Fig. 124: View Of Spark Plug Removal/Installation
Courtesy of GENERAL MOTORS CORP.

5. Using a 14 mm spark plug wrench, remove the 4 spark plugs.

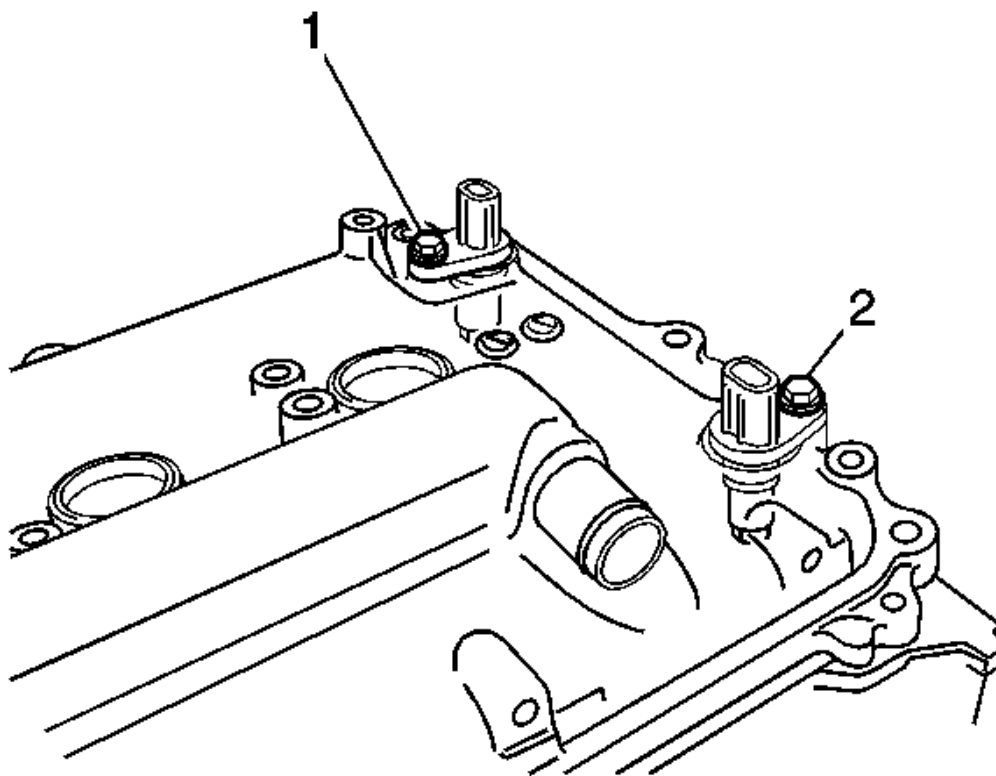


Fig. 125: Identifying Camshaft Position Sensors
Courtesy of GENERAL MOTORS CORP.

6. Remove the 2 bolts and 2 camshaft position sensors.

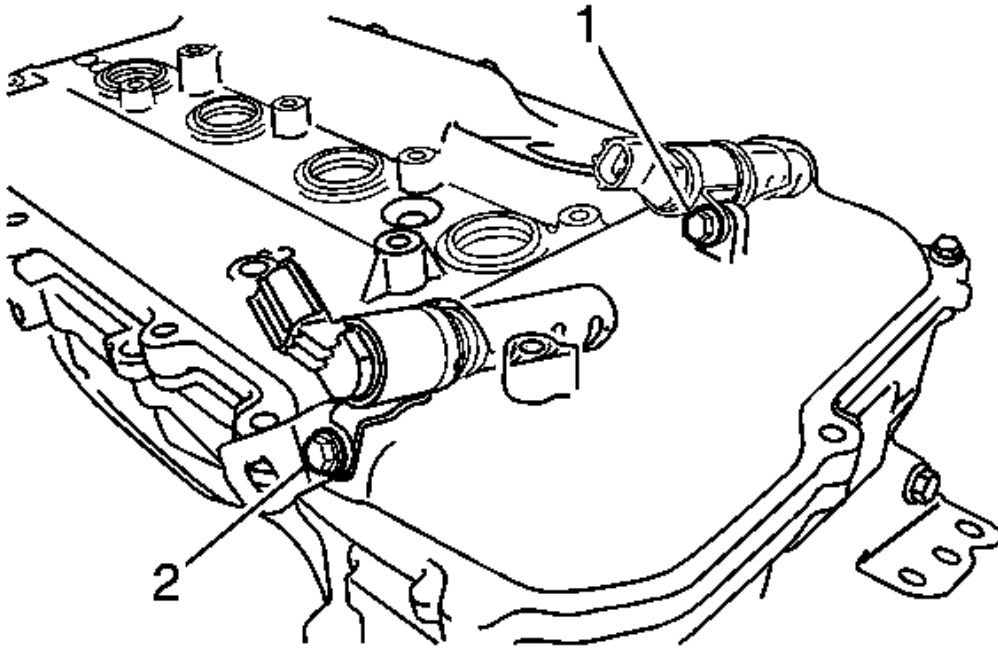


Fig. 126: Identifying Oil Camshaft Timing Control Valves, Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the 2 bolts, O-rings, bracket and 2 oil camshaft timing control valves.

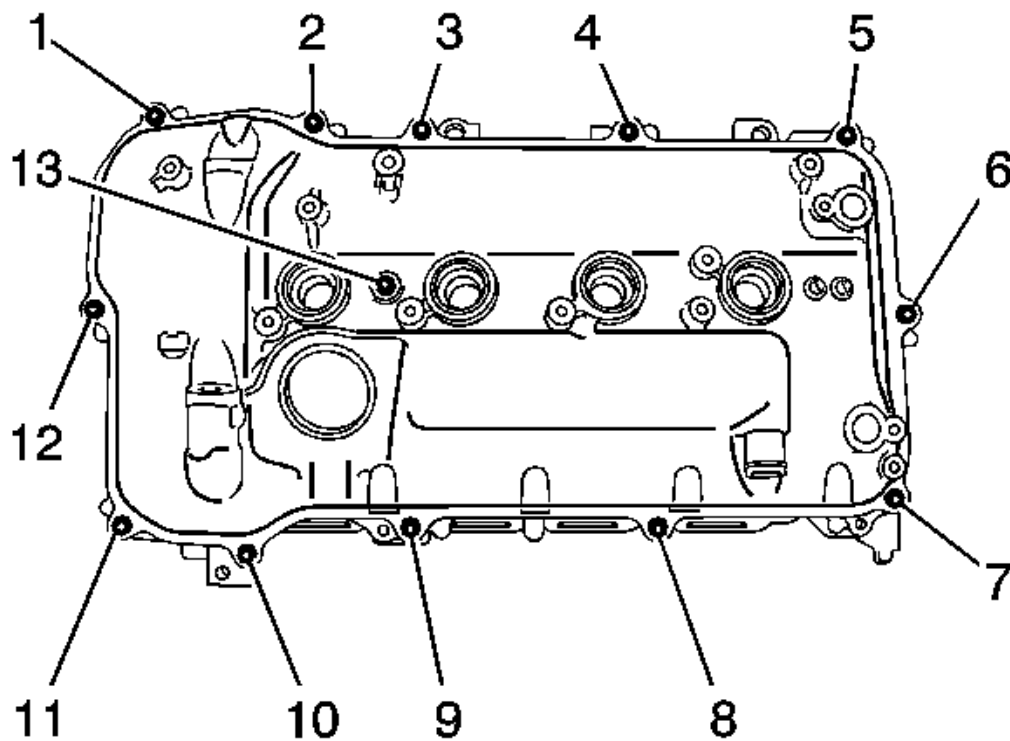


Fig. 127: Identifying Cylinder Head Cover Bolt Loosening/Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

8. Remove the 13 bolts, seal washer and cylinder head cover.

Installation Procedure

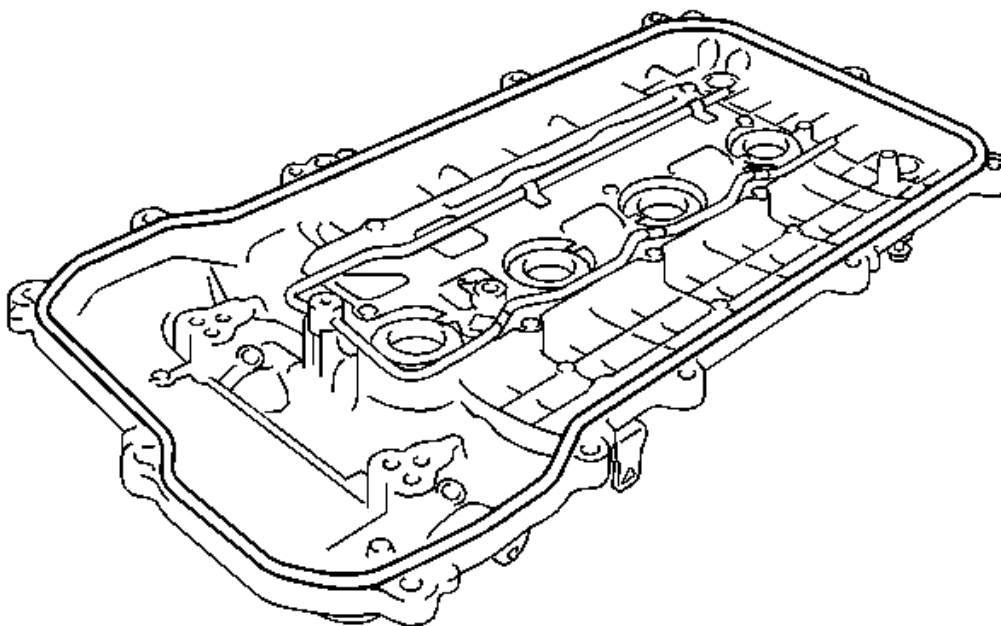


Fig. 128: View Of Cylinder Head Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a new gasket to the cylinder head cover.

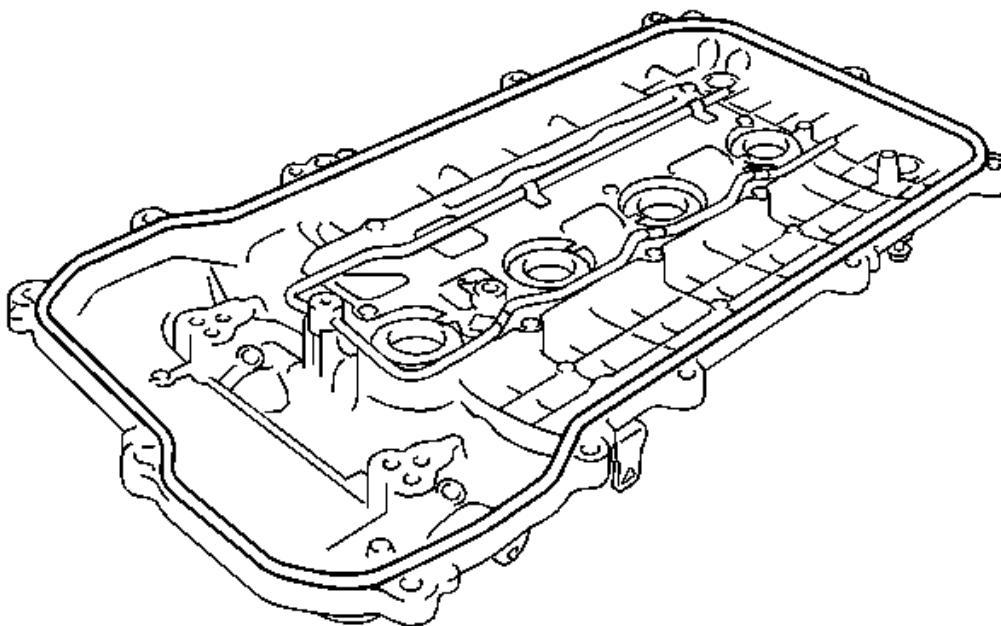


Fig. 129: View Of Cylinder Head Cover Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install a new gasket to the cylinder head cover.

IMPORTANT:

- Remove any oil from the contact surfaces.
- Install the cylinder head cover within 3 minutes and tighten the bolts within 15 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after the installation.

3. Apply Three Bond 1207B or equivalent seal packing.

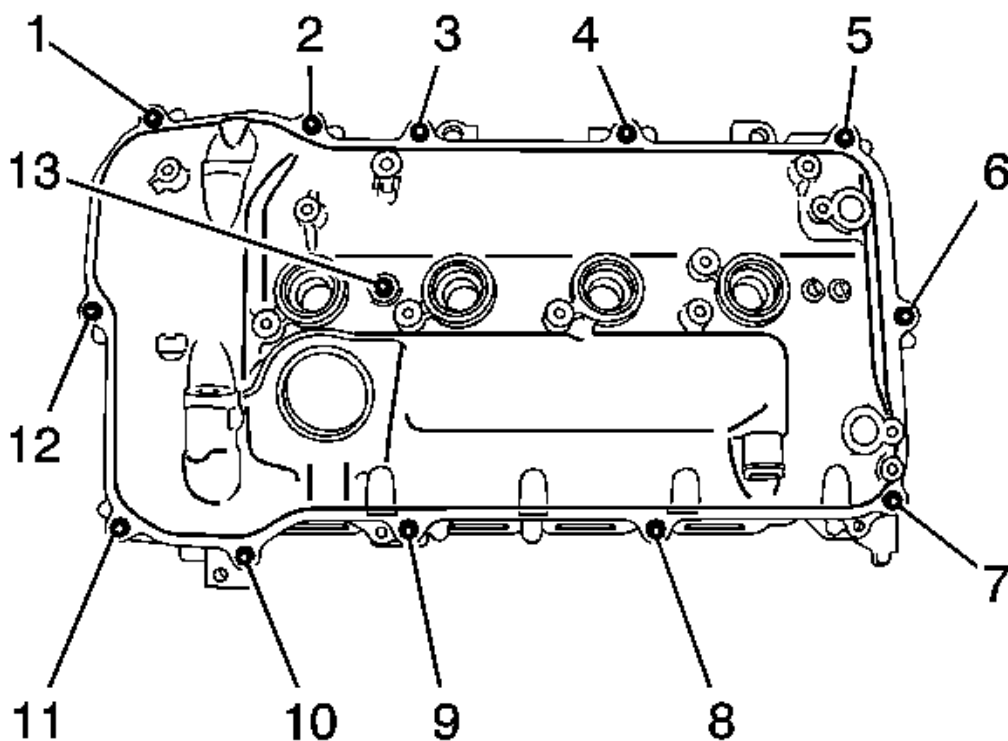


Fig. 130: Identifying Cylinder Head Cover Bolt Loosening/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Install the cylinder head cover with a new seal washer and the 13 bolts and tighten to 10 N.m (7 lb ft).

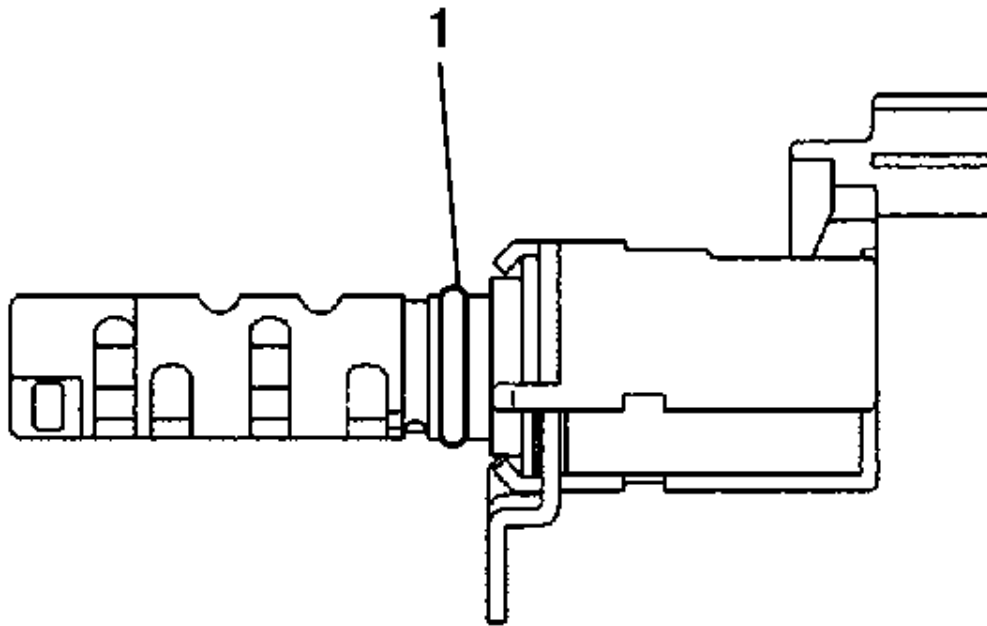


Fig. 131: View Of Camshaft Timing Oil Control Valve Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the camshaft timing oil control valve assembly.
6. Apply a light coat of engine oil to a new O-ring, then install it onto the camshaft timing oil control valve.

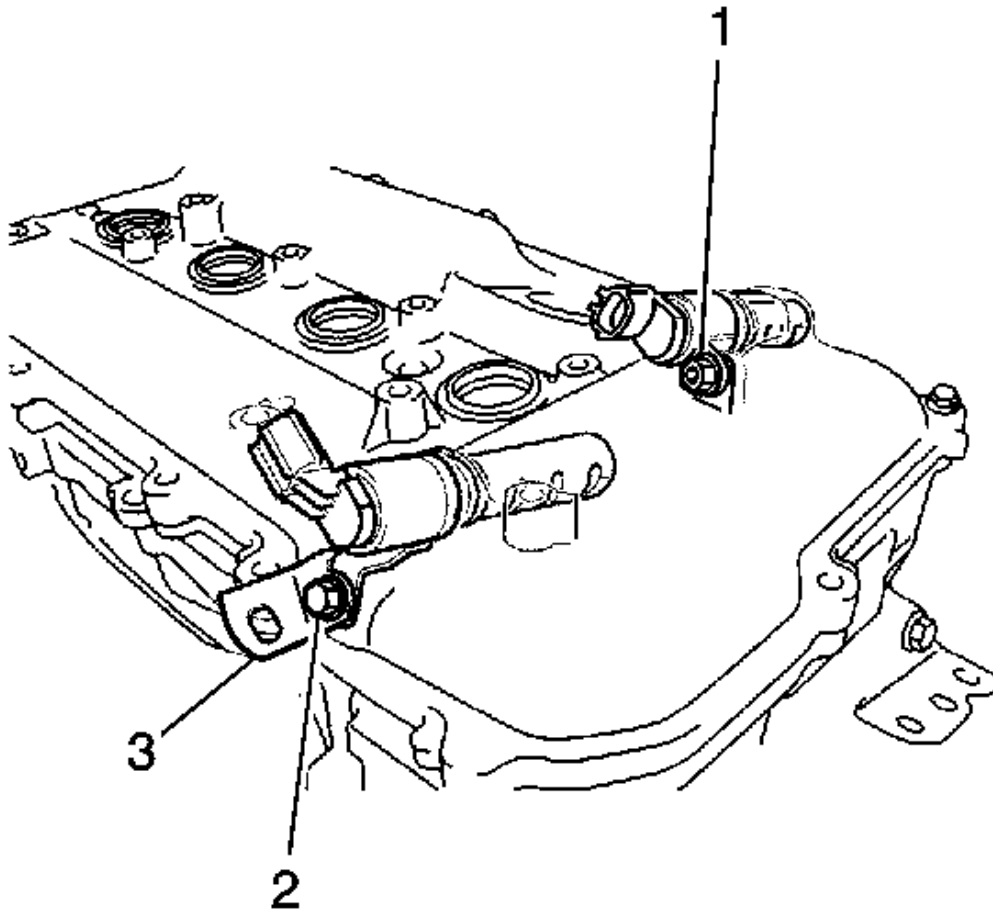


Fig. 132: View Of Camshaft Timing Oil Control Valves, Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the 2 camshaft timing oil control valves and bracket with the 2 bolts and tighten to 10 N.m (7 lb ft).

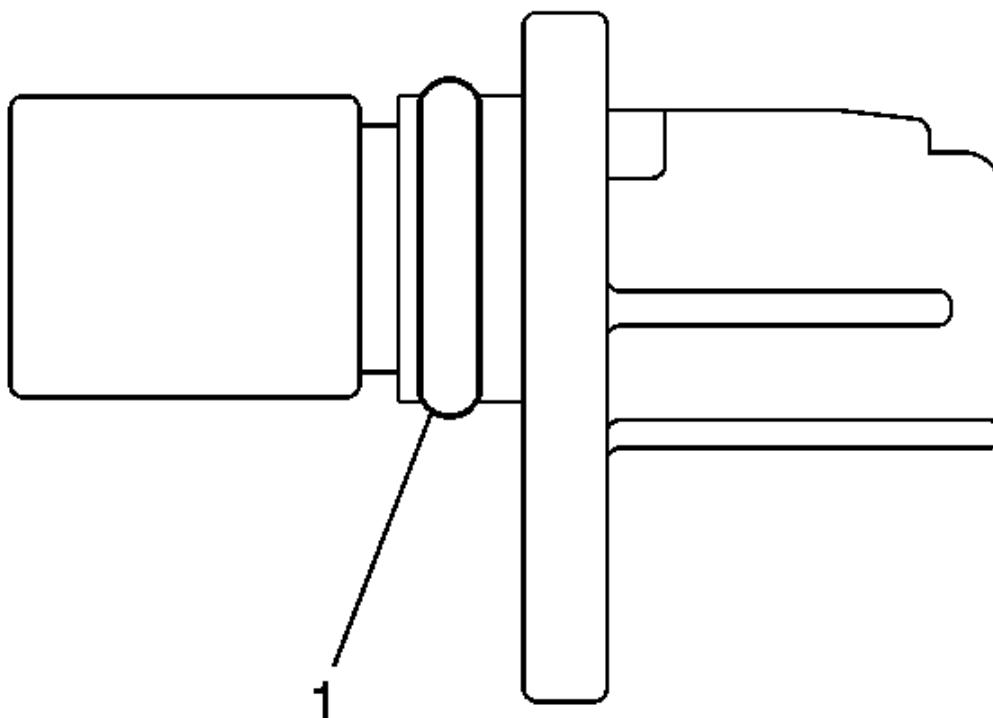


Fig. 133: Identifying Camshaft Position Sensor & O-Ring
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft position sensor.
9. Apply a light coat of engine oil to the O-ring of the sensor.

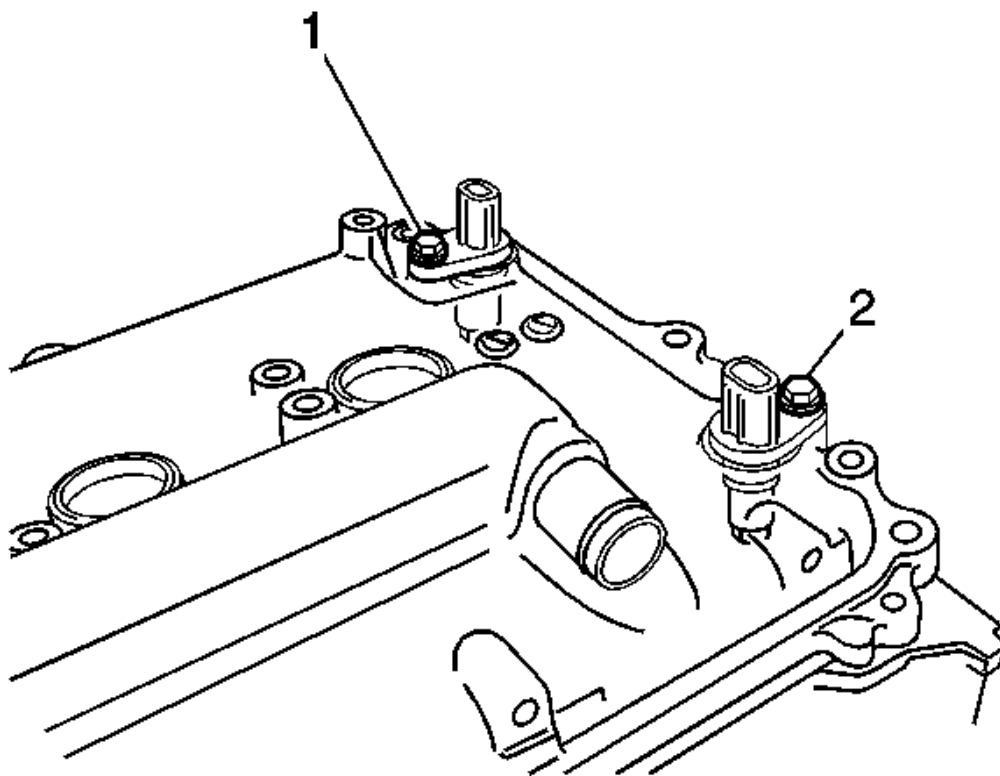


Fig. 134: Identifying Camshaft Position Sensors
Courtesy of GENERAL MOTORS CORP.

10. Install the 2 sensors with the 2 bolts and tighten to 10 N.m (7 lb ft).

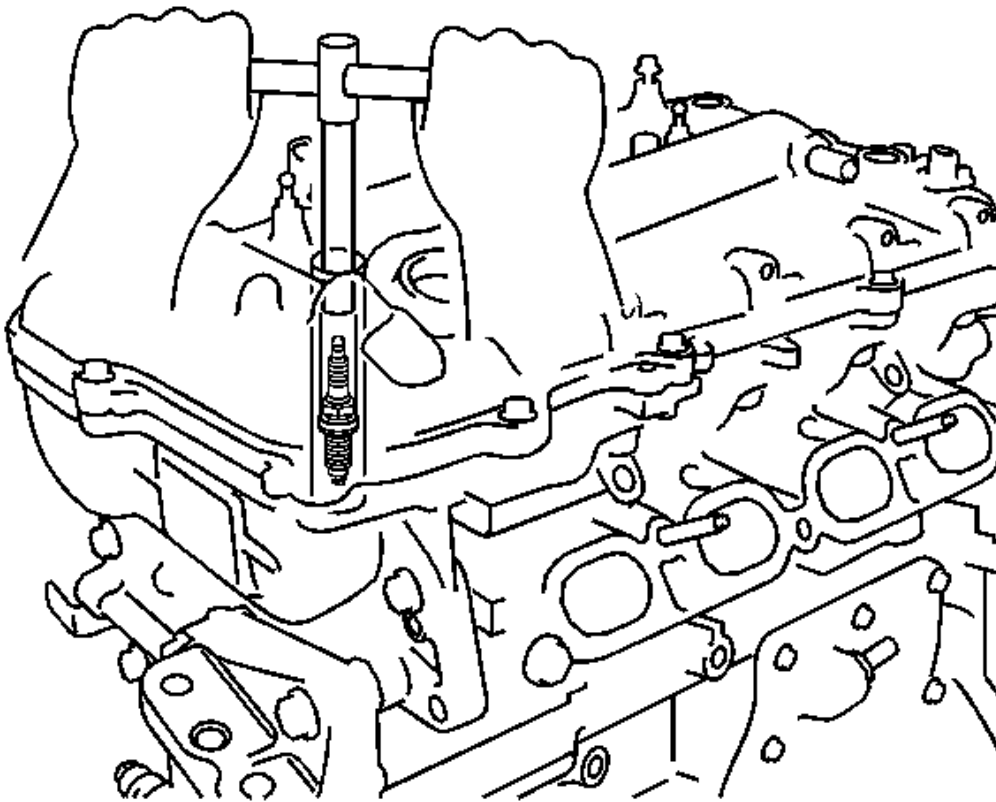


Fig. 135: View Of Spark Plug Removal/Installation
Courtesy of GENERAL MOTORS CORP.

11. Using a 14 mm spark plug wrench, install the 4 spark plugs and tighten to 20 N.m (15 lb ft).

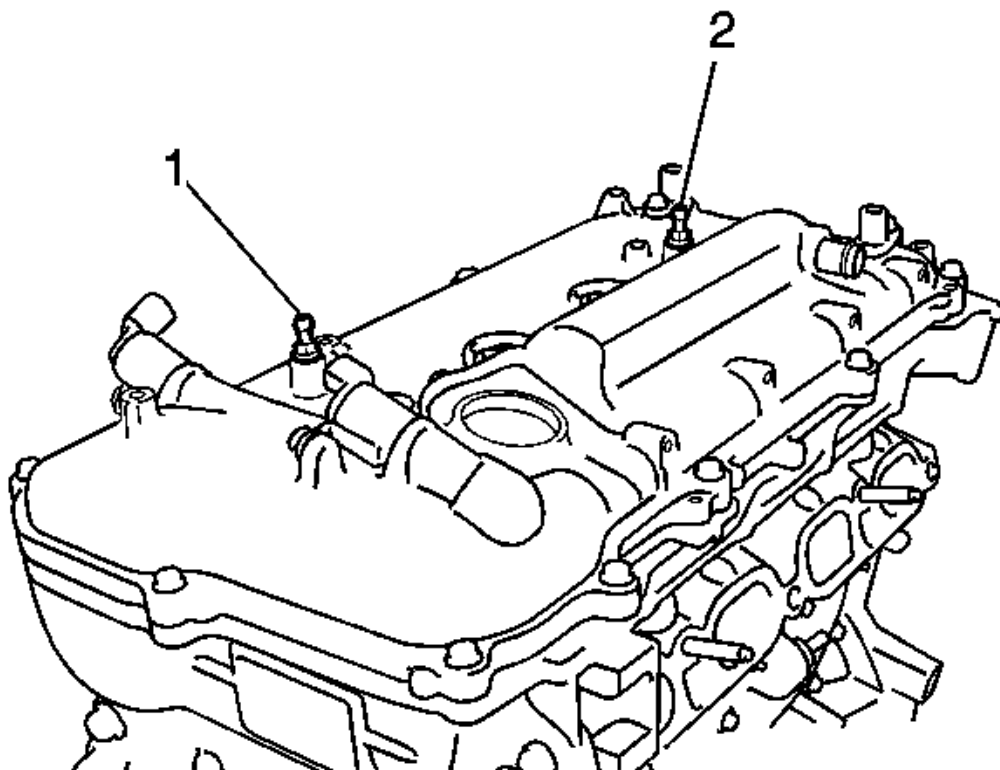


Fig. 136: View Of Engine Cover Joints
Courtesy of GENERAL MOTORS CORP.

12. Install the 2 engine cover joints and tighten to 10 N.m (7 lb ft).

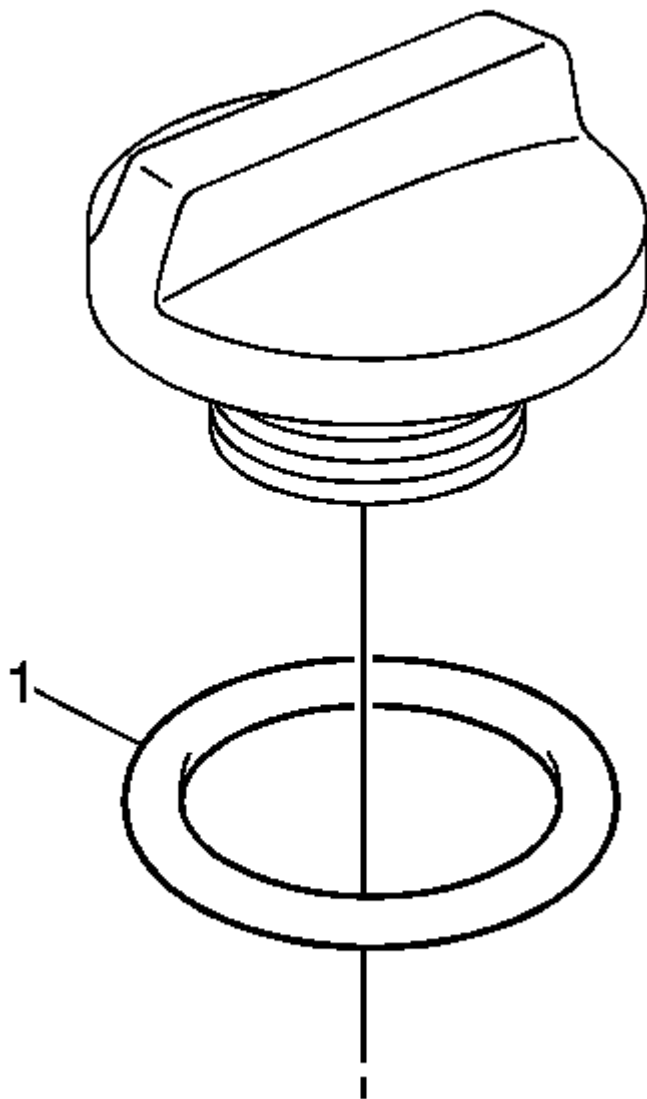


Fig. 137: View Of Oil Filler Cap
Courtesy of GENERAL MOTORS CORP.

13. Install the oil filler cap gasket.

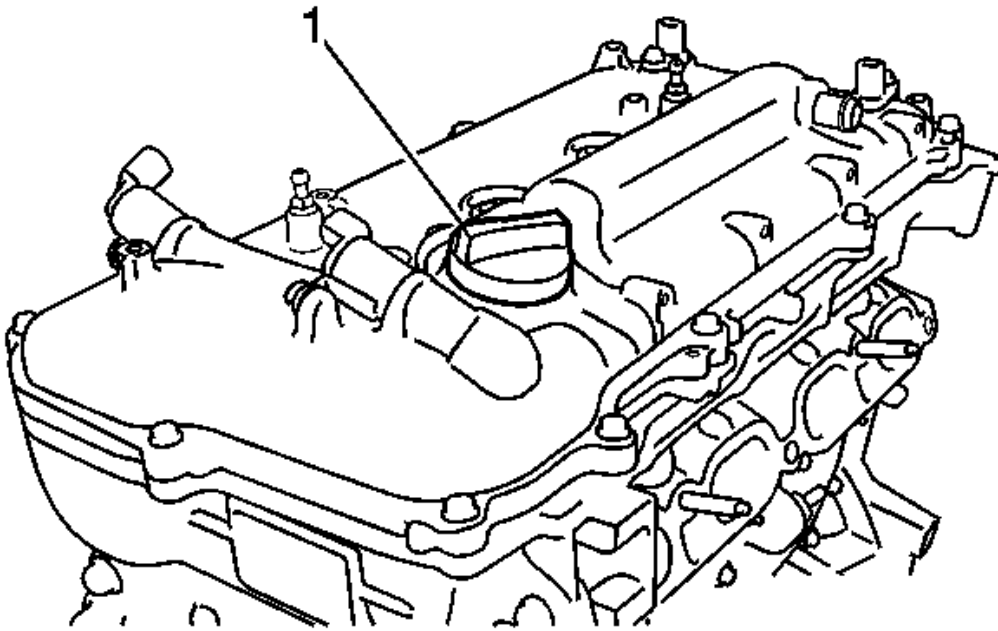


Fig. 138: Identifying Oil Filler Cap
Courtesy of GENERAL MOTORS CORP.

14. Install the oil filler cap sub-assembly.
15. Install the engine cover.

CYLINDER HEAD REPLACEMENT

Removal Procedure

1. Remove the engine assembly with transaxle. Refer to **Engine Replacement**
2. Install the engine stand.
3. Remove the intake manifold.
4. Disconnect the fuel tube sub-assembly.
5. Remove the fuel delivery pipe sub-assembly.
6. Remove the fuel injector assembly.
7. Remove the ignition coil assembly.
8. Remove the oil level dipstick sub-assembly.
9. Remove the No. 1 exhaust manifold heat insulator.
10. Remove the manifold stay.

11. Remove the exhaust manifold.
12. Remove the ventilation hose.
13. Remove the No. 3 water by-pass hose.
14. Remove the No. 1 water by-pass pipe.
15. Remove the water by-pass hose.
16. Remove the inlet water hose.
17. Remove the inlet water.
18. Remove the thermostat.
19. Remove the radio setting condenser.
20. Remove the cylinder head cover sub-assembly.

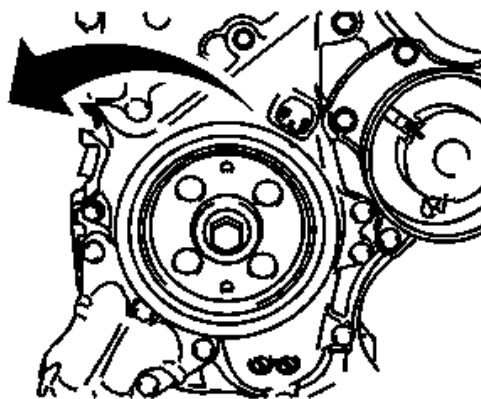
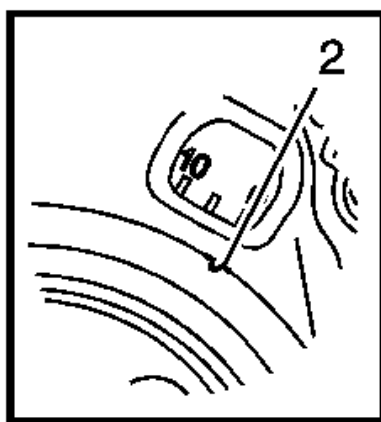
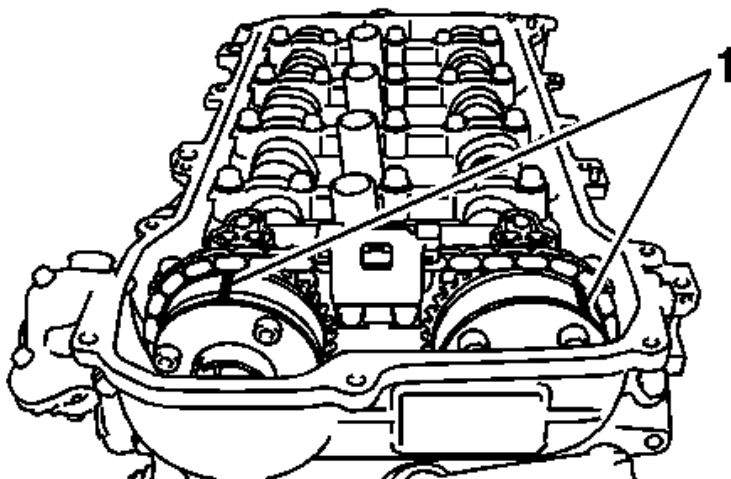


Fig. 139: Setting No. 1 Cylinder To TDC/Compression Stroke
Courtesy of GENERAL MOTORS CORP.

21. Set the No. 1 cylinder to TDC/compression.
 1. Turn the crankshaft pulley until its groove and the timing mark 0 of the timing chain cover are aligned.
 2. Check that each timing mark of the camshaft timing gear and sprocket are aligned with each timing mark located on the No. 1 and No. 2 bearing caps as shown in the illustration. If not, turn the crankshaft by 1 revolution, 360 degrees, to align the timing marks as above.
22. Remove the crankshaft pulley.
23. Remove the No. 1 chain tensioner assembly.
24. Remove the timing chain cover sub-assembly.
25. Remove the timing chain cover oil seal.

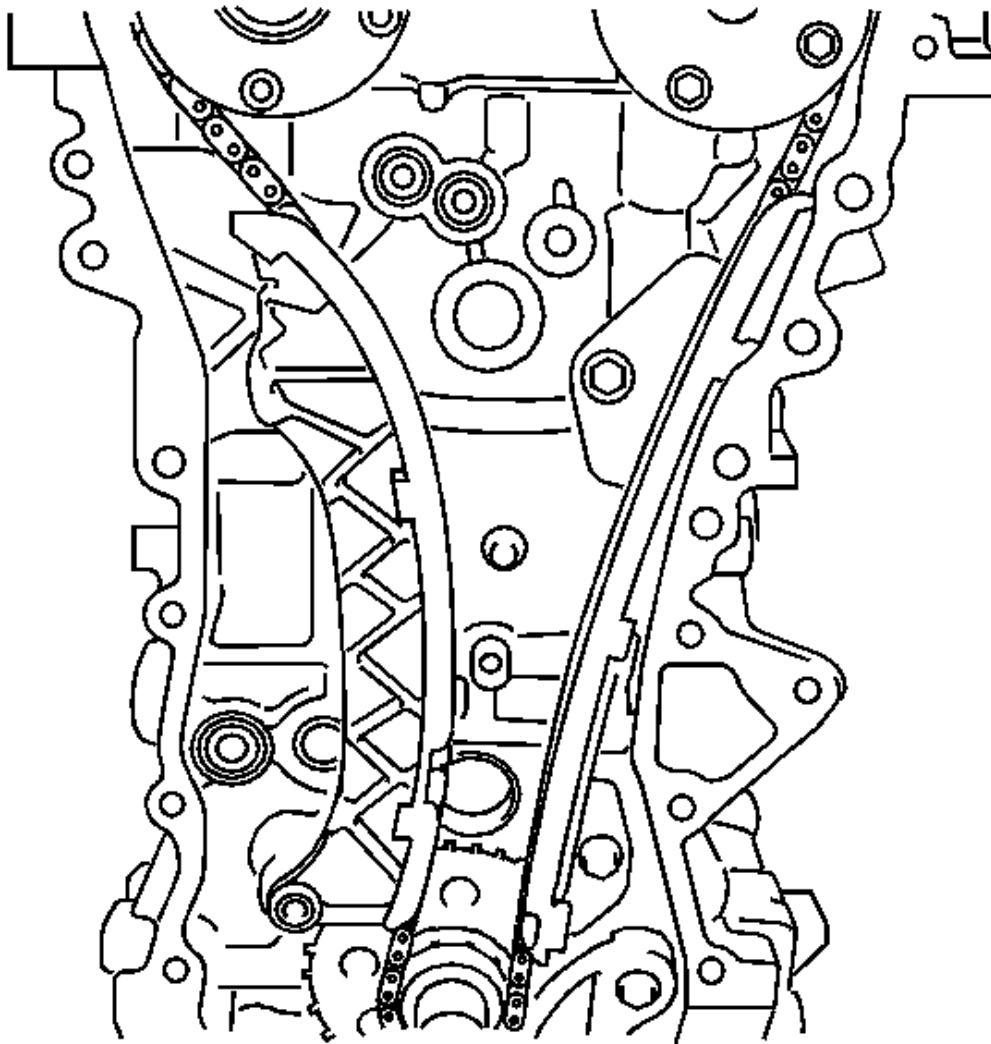


Fig. 140: Identifying Timing Chain Tensioner Slipper
Courtesy of GENERAL MOTORS CORP.

26. Remove the chain tensioner slipper.

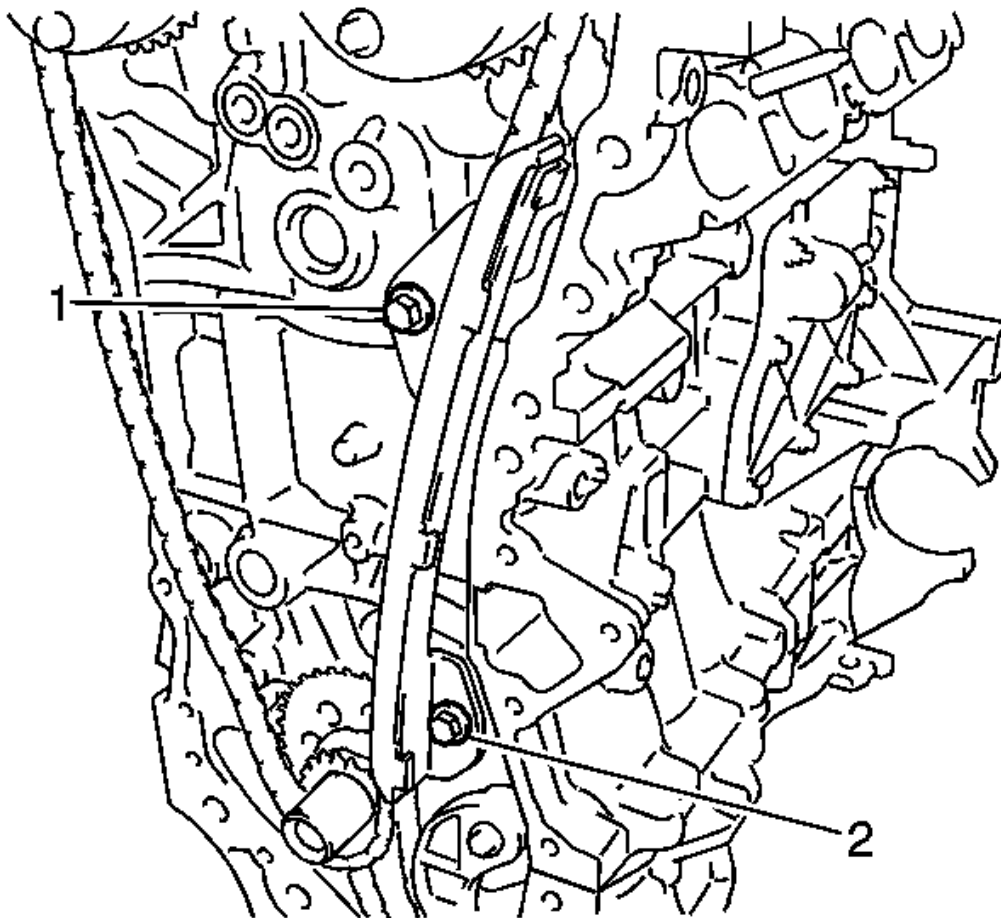


Fig. 141: Identifying Timing Chain Damper
Courtesy of GENERAL MOTORS CORP.

27. Remove the 2 bolts and No. 1 chain vibration damper.

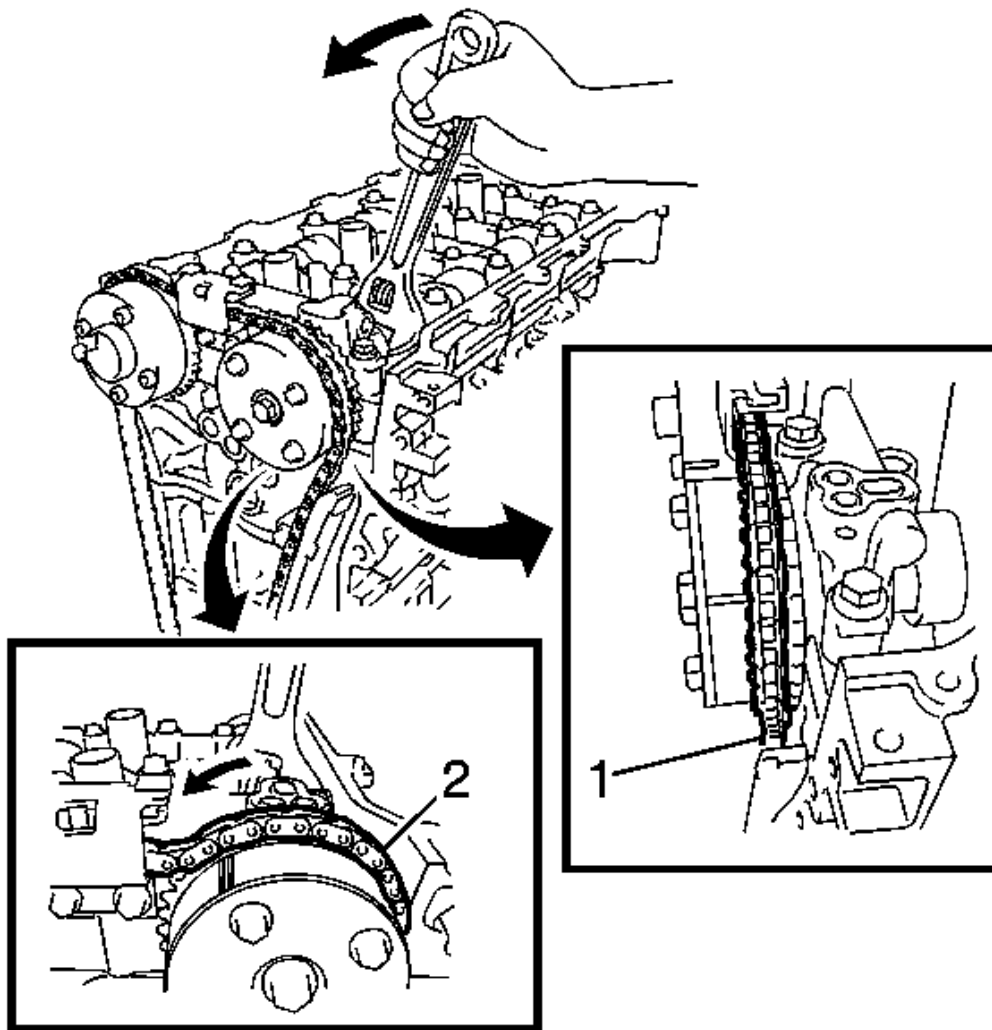


Fig. 142: View Of Timing Chain Sub-Assembly
Courtesy of GENERAL MOTORS CORP.

28. Remove the chain sub-assembly.
 1. Hold the hexagonal portion of the camshaft with a wrench and turn the camshaft timing gear assembly counterclockwise to loosen the chain between the camshaft timing gears.

IMPORTANT: Be sure to release the chain from the sprocket completely.

2. With the chain loosened, release the chain from the camshaft timing gear assembly and place it on the camshaft timing gear assembly.

3. Turn the camshaft clockwise to return it to the original position and remove the chain.
29. Remove the No. 2 chain vibration damper.
30. Inspect the camshaft timing gear assembly.
31. Inspect the camshaft timing exhaust gear assembly.
32. Remove the camshaft timing gear assembly.
33. Remove the camshaft timing exhaust gear assembly.
34. Remove the camshaft bearing cap.
35. Remove the camshaft.
36. Remove the No. 2 camshaft.
37. Remove the No. 1 camshaft bearing.
38. Remove the No. 1 valve rocker arm subassembly.
39. Remove the valve lash adjuster assembly.
40. Remove the No. 2 camshaft bearing.
41. Remove the camshaft housing sub-assembly.

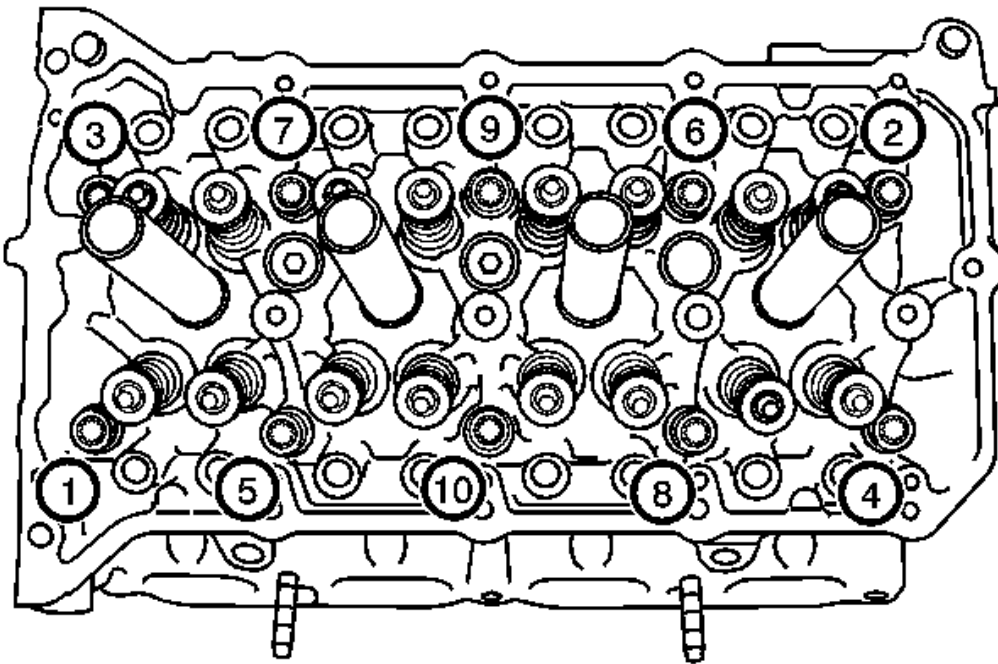


Fig. 143: Identifying Cylinder Head Bolt Loosening Sequence
Courtesy of GENERAL MOTORS CORP.

42. Remove the cylinder head sub-assembly.

IMPORTANT: Head warpage or cracking could result from removing the bolts in the wrong order.

1. Using several steps, uniformly loosen and remove the 10 cylinder head bolts and 10 plate washers with a 10 mm bi-hexagon wrench in the sequence shown.

NOTE: Be careful not to damage the contact surfaces of the cylinder head and cylinder block.

2. Using a screwdriver with its tip wrapped with tape, pry between the cylinder head and cylinder block, and remove the cylinder head.

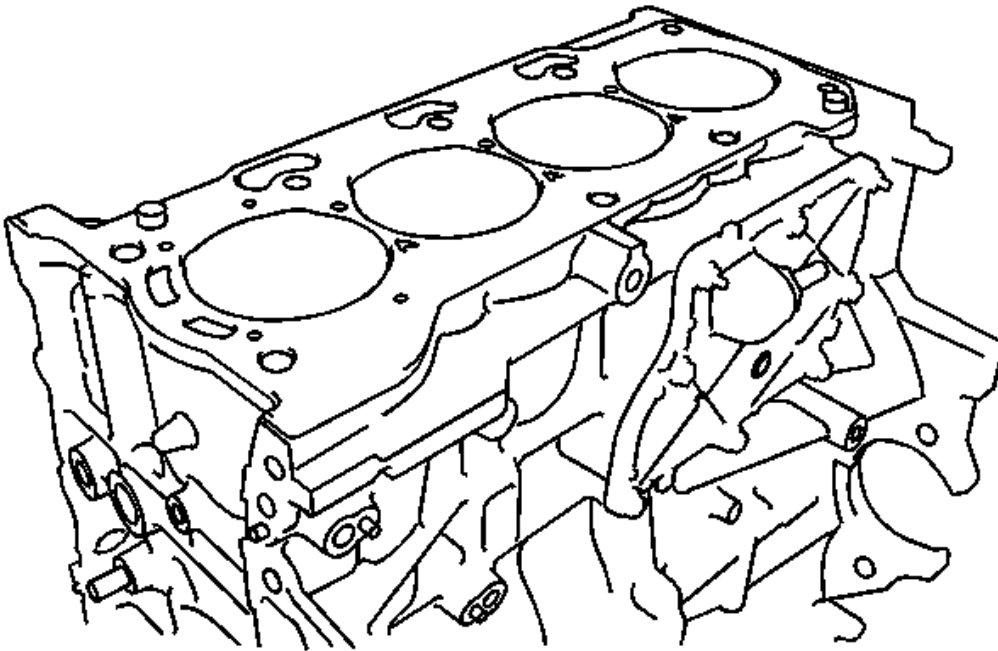


Fig. 144: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

43. Remove the cylinder head gasket.
44. Inspect the No. 1 valve rocker arm subassembly.
45. Inspect the valve lash adjuster assembly.
46. Inspect the cylinder head set bolt.

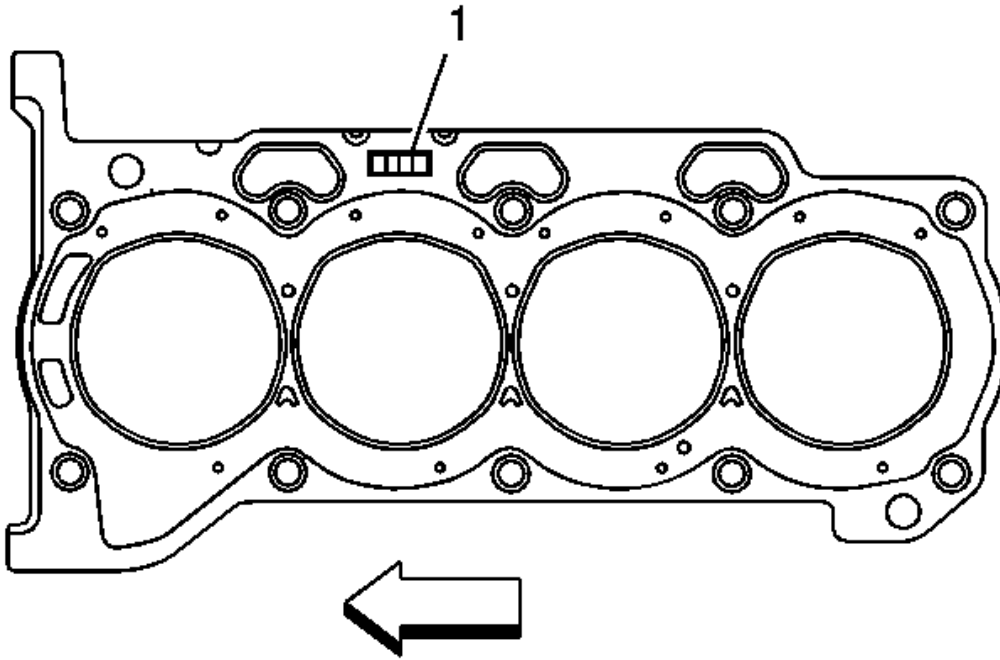
Installation Procedure

Fig. 145: Identifying Cylinder Block Contact Surface
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Remove any oil from the contact surface.
- Make sure that the gasket is installed in the correct direction.

1. Install cylinder head gasket.
2. Place a new gasket on the cylinder block surface with the Lot No. stamp facing upward.

IMPORTANT: The cylinder head bolts are tightened in 2 progressive steps.

3. Install the cylinder head sub-assembly.
4. Apply a light coat of engine oil to the bolt threads and the area beneath the bolt heads that come in contact with the washers.
5. Install the bolts and plate washers to the cylinder head.

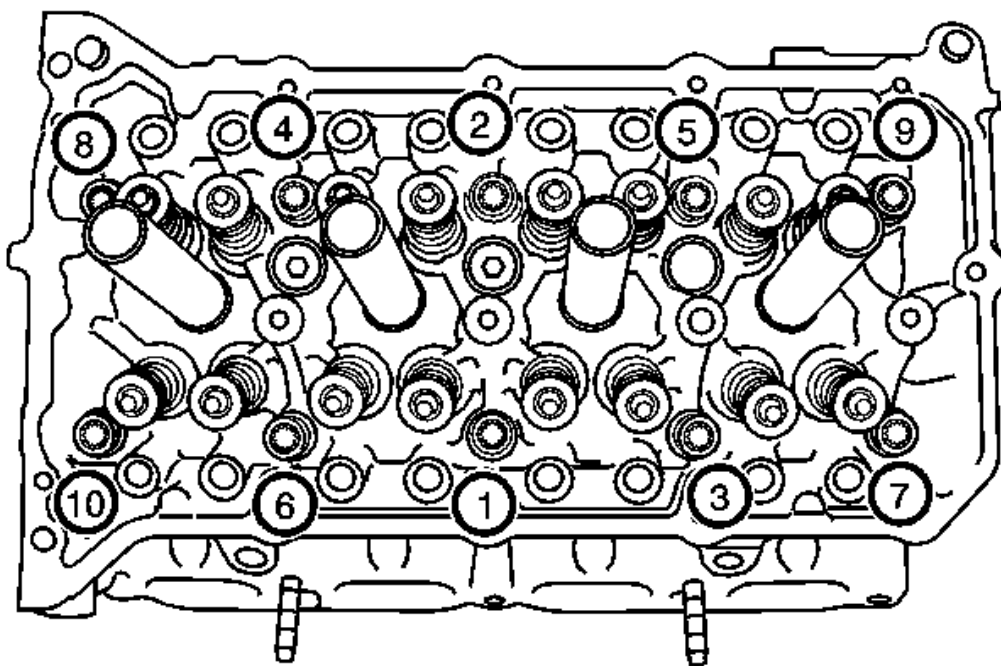


Fig. 146: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to **FASTENER CAUTION** .

6. Using several passes, uniformly install and tighten the 10 cylinder head set bolts and plate washers with a 10 mm bi-hexagon wrench in the order shown.

Tighten: Tighten to 49 N.m (36 lb ft)

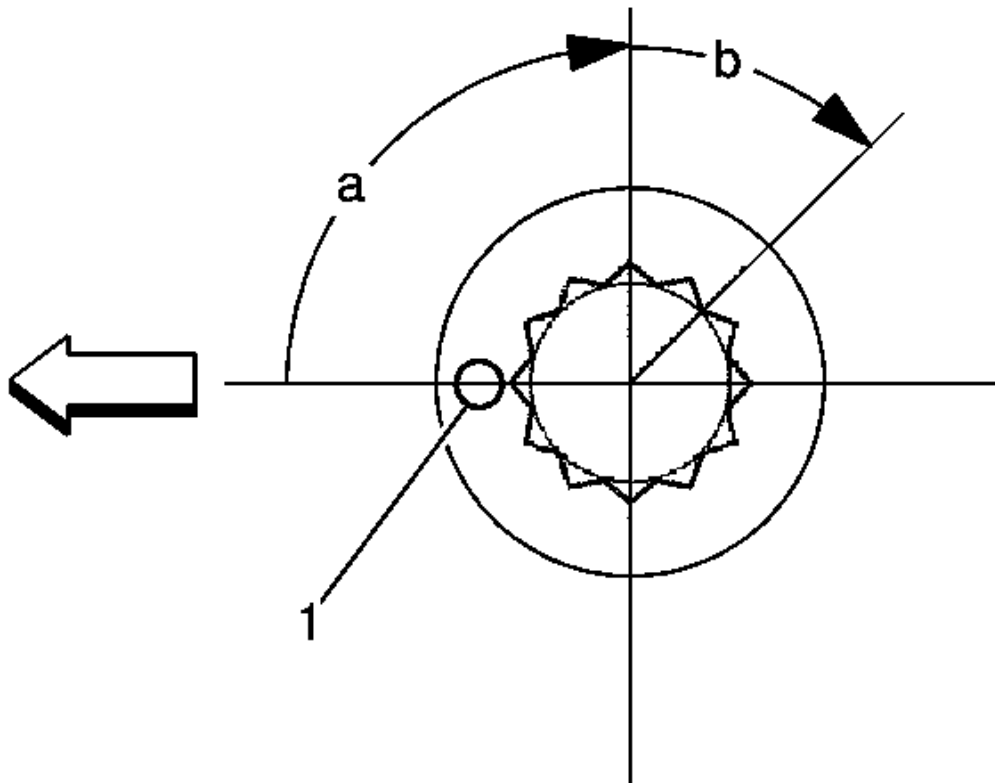


Fig. 147: Marking Front Side Of Cylinder Head Bolts For Final Tightening Pass
Courtesy of GENERAL MOTORS CORP.

7. Mark the front side of the cylinder head bolts with paint.
8. Retighten the cylinder head bolts an additional 90 degrees, then once more 45 degrees as shown in the illustration.
9. Check that the paint mark is now at a 135 degrees angle to the front.
10. Install the valve lash adjuster assembly.
11. Install the No. 1 valve rocker arm sub-assembly.
12. Install the No. 1 camshaft bearing.
13. Install the No. 2 camshaft bearing.
14. Install the No. 2 camshaft.
15. Install the camshaft.
16. Install the camshaft bearing cap.
17. Install the camshaft housing sub-assembly.

18. Install the camshaft timing gear assembly.
19. Install the camshaft timing exhaust gear assembly.

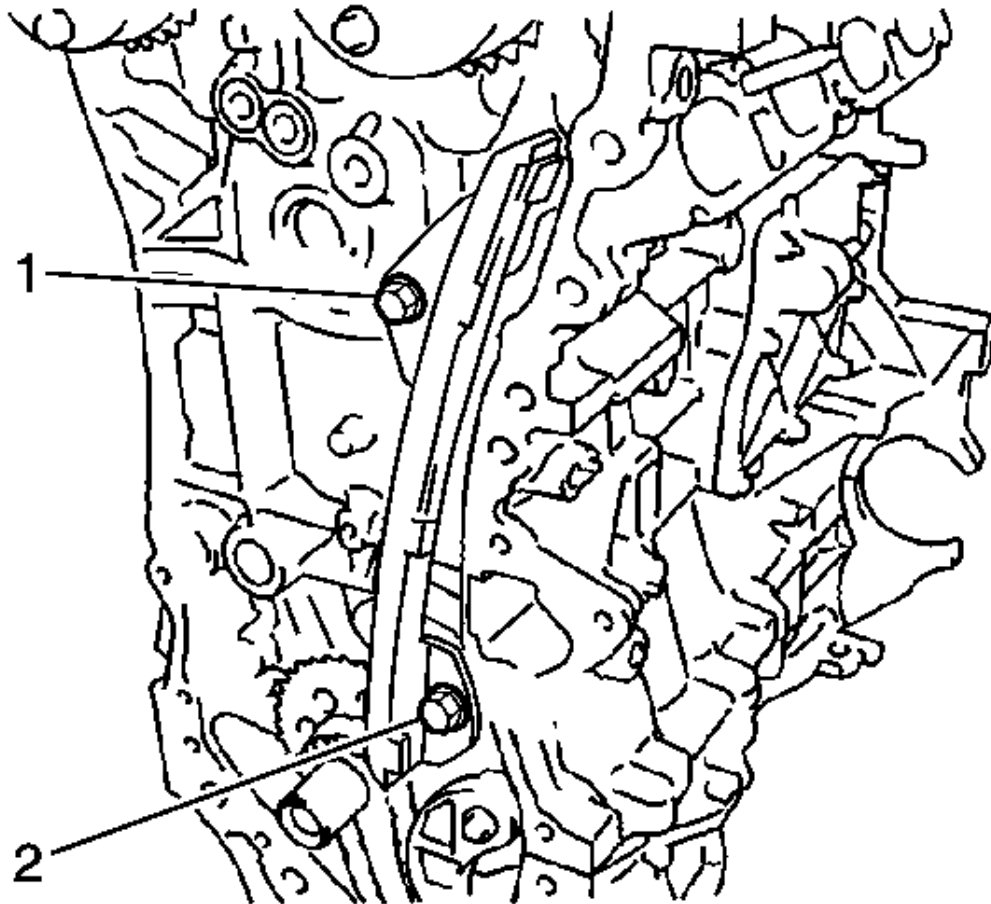


Fig. 148: Identifying No. 1 Chain Vibration Damper
Courtesy of GENERAL MOTORS CORP.

20. Install the No. 1 chain vibration damper with the 2 bolts.

Tighten: Tighten the bolts to 21 N.m (16 lb ft).

21. Install the No. 2 chain vibration damper.
22. Install the chain sub-assembly.
23. Check the No. 1 cylinder TDC/compression.

24. Hand tighten the crankshaft pulley bolt.

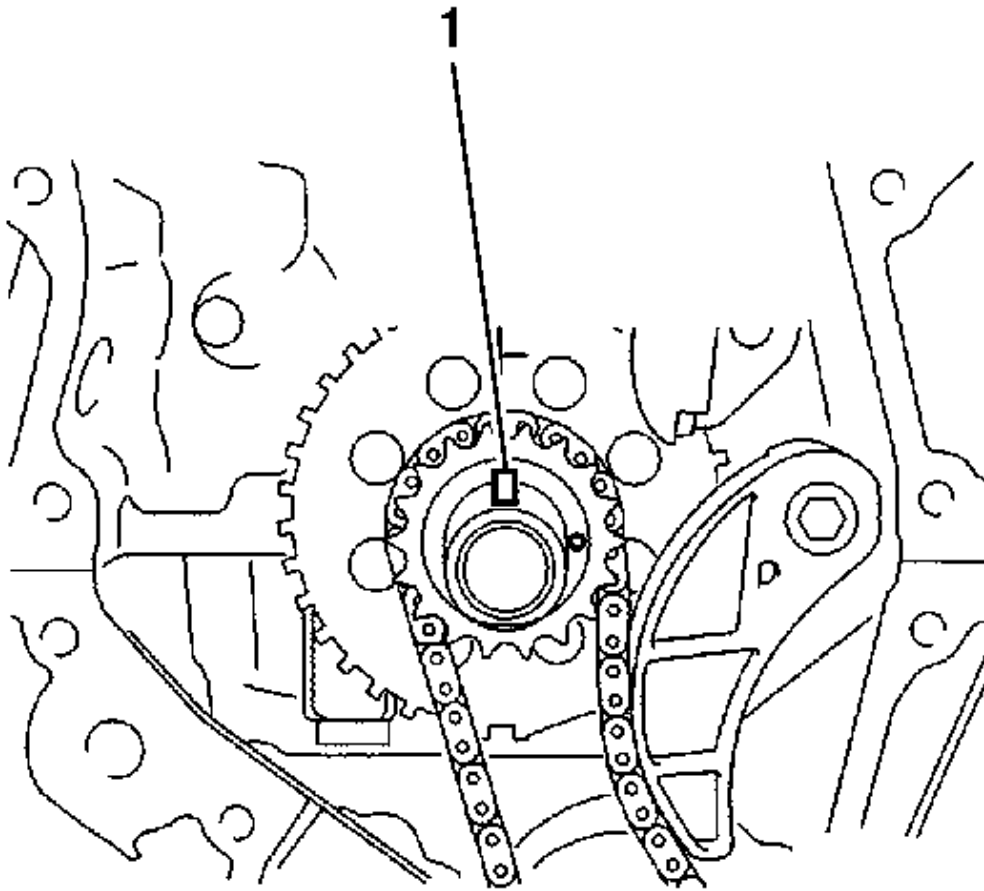


Fig. 149: Identifying Timing Gear Key
Courtesy of GENERAL MOTORS CORP.

25. Turn the crankshaft counterclockwise to position the timing gear key to the top.
26. Remove the crankshaft pulley bolt.

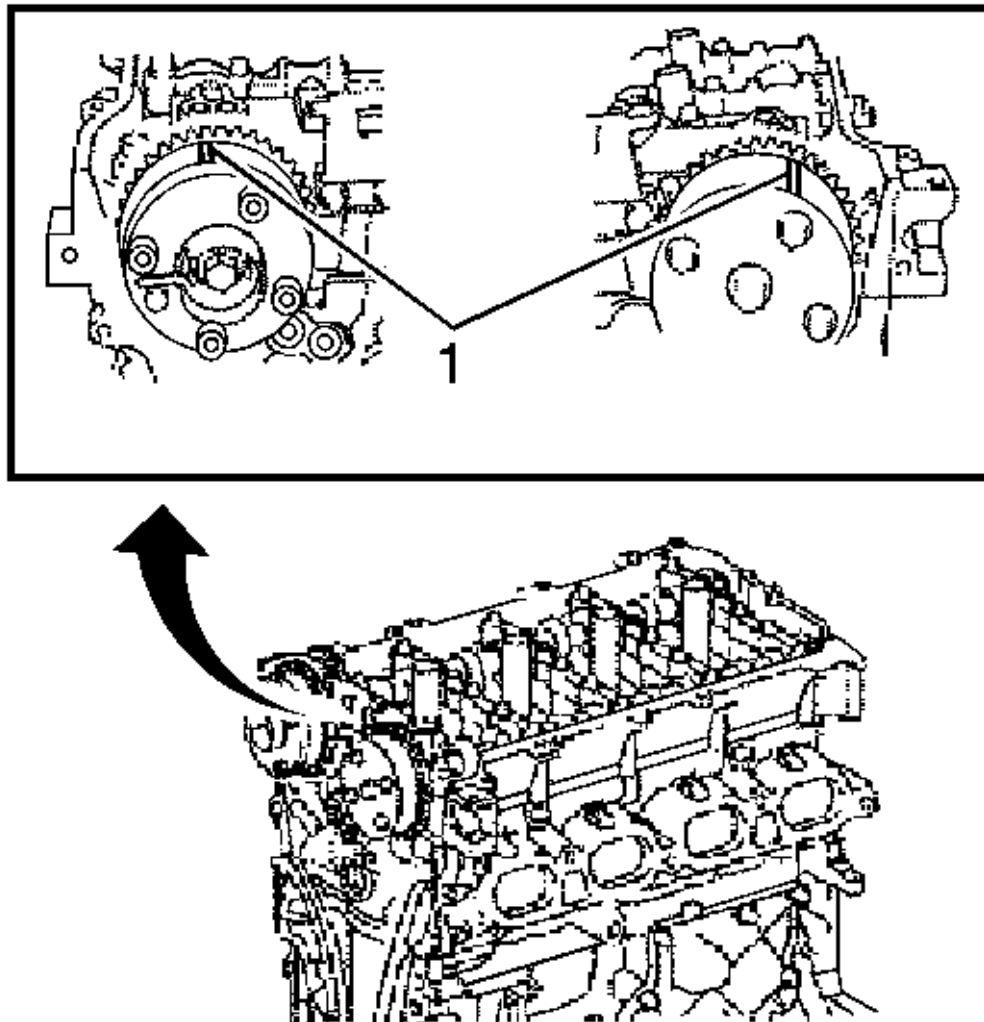


Fig. 150: Checking Timing Marks On Each Camshaft Timing Gear
Courtesy of GENERAL MOTORS CORP.

27. Check the timing marks on each camshaft timing gear.

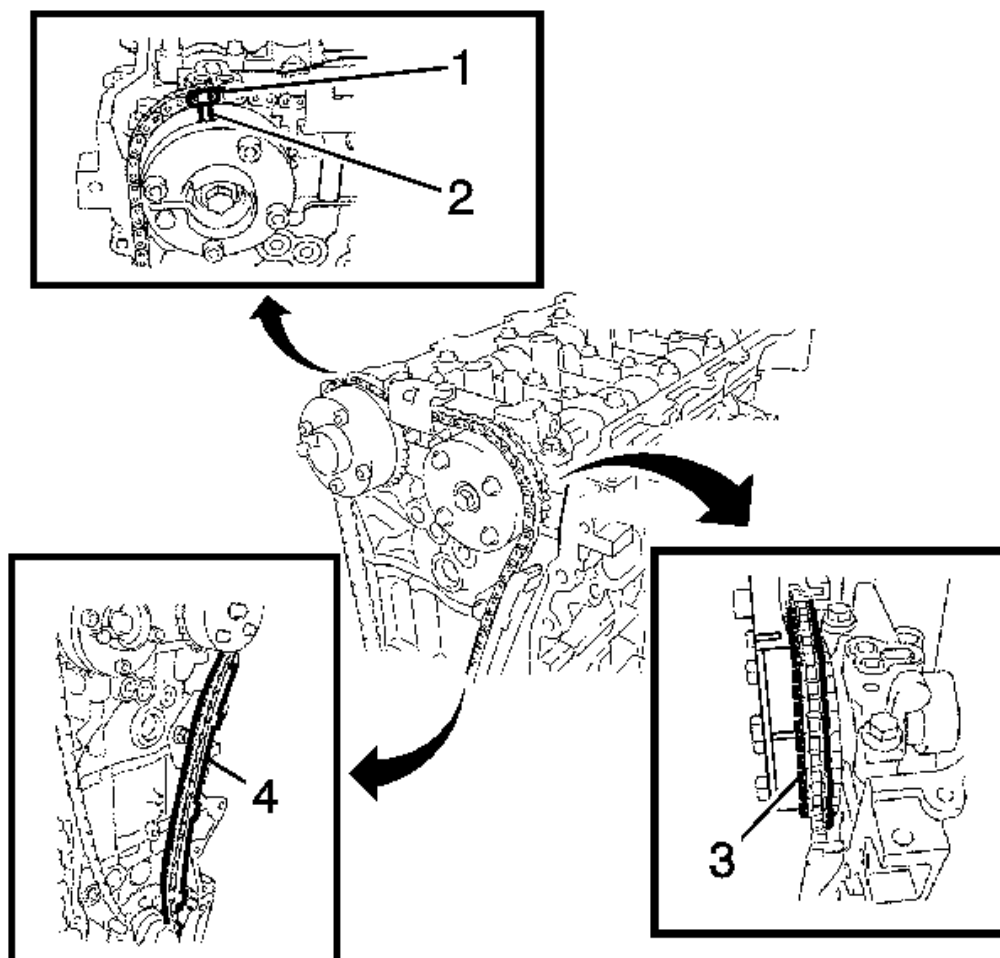


Fig. 151: View Of Properly Positioning Timing Marks
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Be sure to position the mark plate at the front of the engine.
- The mark plate on the camshaft side is colored orange.
- Do not pass the chain around the sprocket of the camshaft timing gear assembly. Only place it on the sprocket.
- Pass the chain through the No. 1 vibration damper

28. Align the mark plate, orange, with the timing mark as shown in the illustration and install the chain.

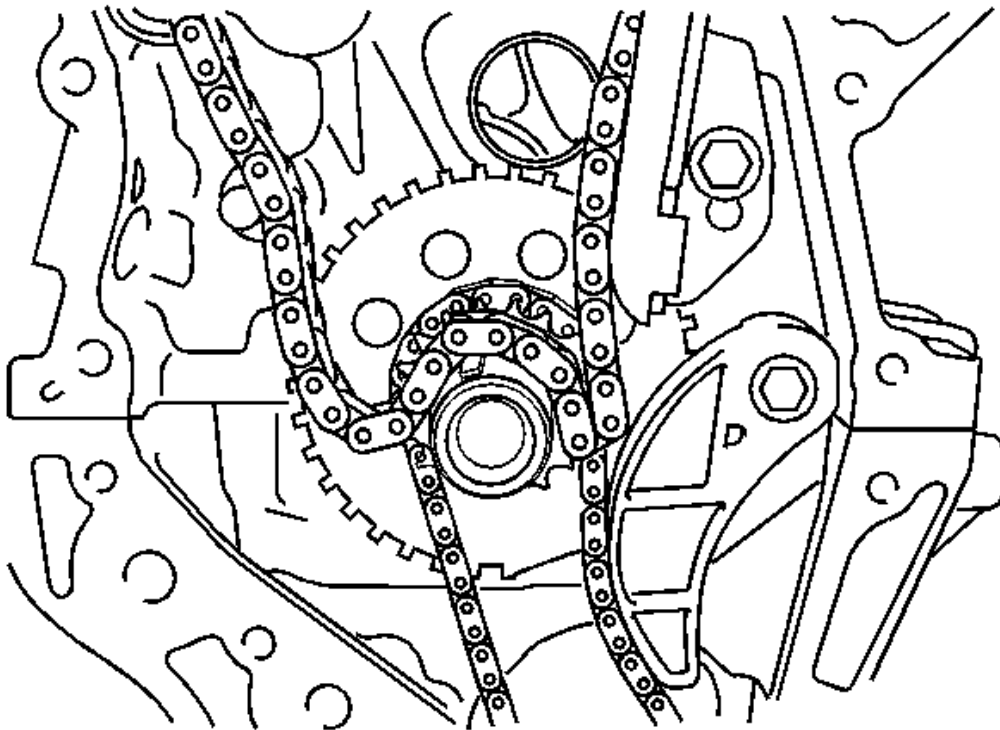


Fig. 152: View Of Correctly Placing Chain On Crankshaft
Courtesy of GENERAL MOTORS CORP.

29. Place the chain on the crankshaft without passing it around the shaft.

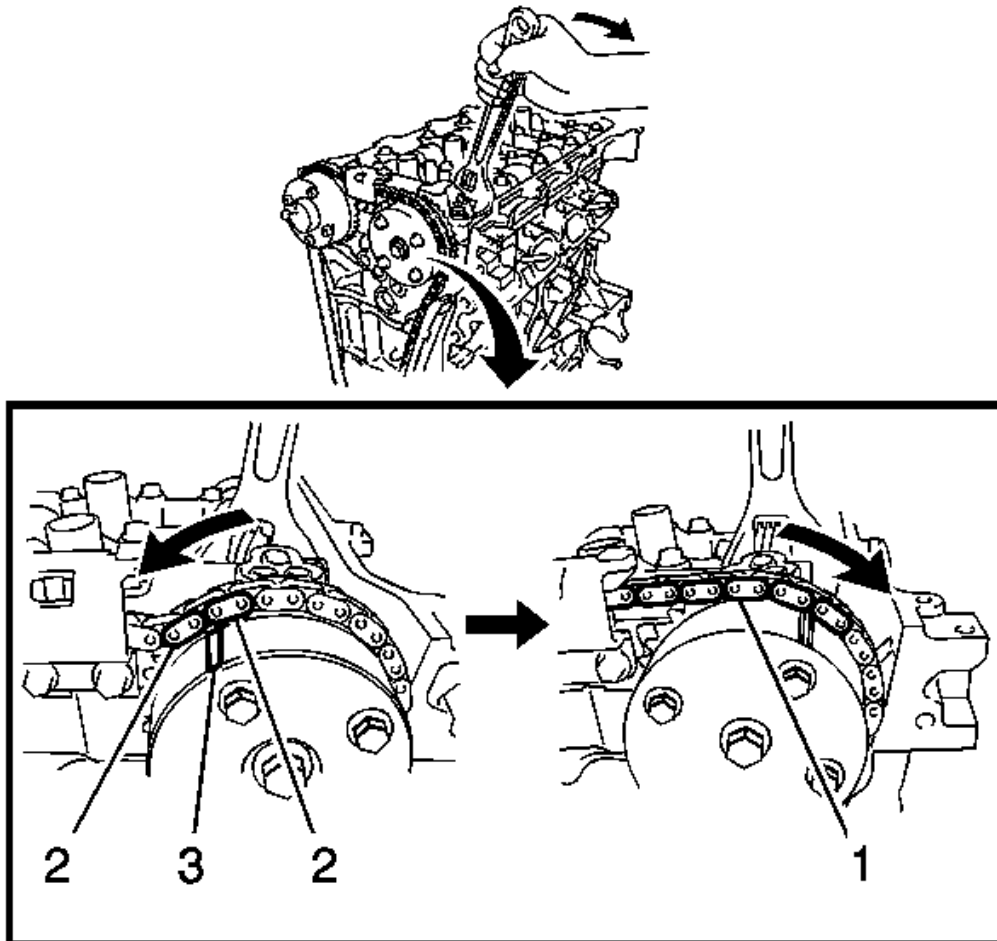


Fig. 153: Checking Marks On Plate
Courtesy of GENERAL MOTORS CORP.

- IMPORTANT:**
- Be sure to position the mark plate at the front of the engine.
 - The mark plate on the camshaft side is colored orange.

30. Hold the hexagonal portion of the camshaft with a wrench and turn the camshaft timing gear assembly counterclockwise to align the mark plate, orange, and timing mark.

IMPORTANT: To tension the chain, slowly turn the camshaft timing gear assembly clockwise to prevent the chain from being misaligned.

31. Hold the hexagonal portion of the camshaft with a wrench and turn the camshaft timing gear assembly

clockwise.

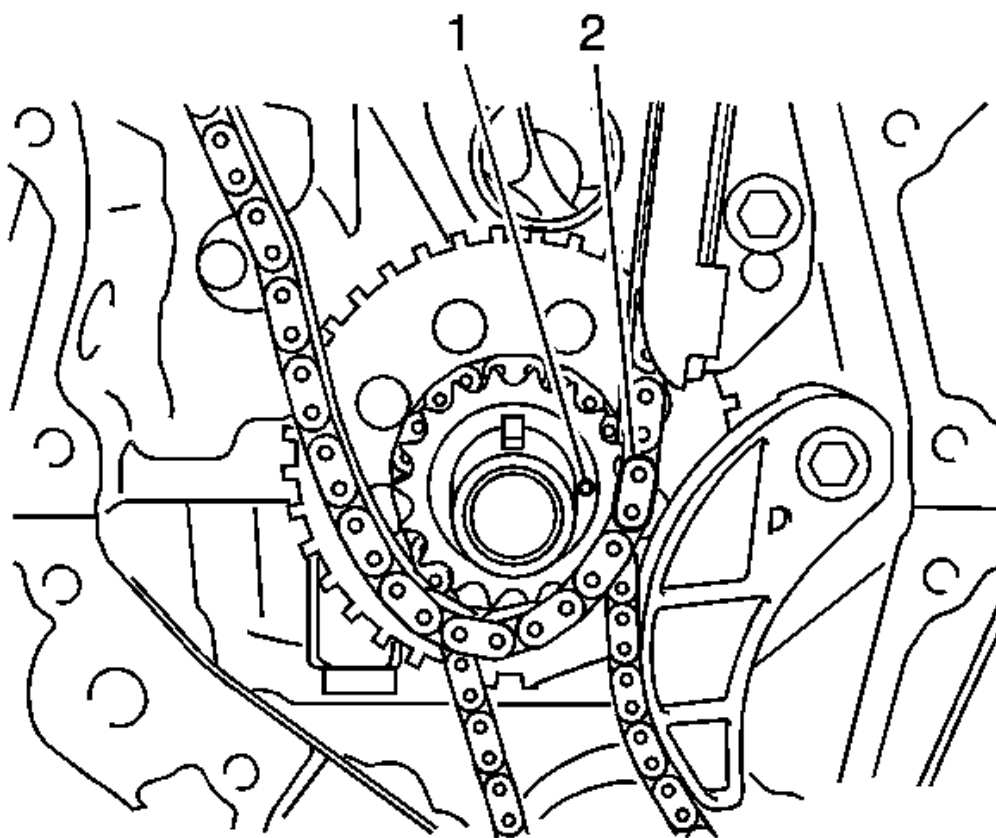


Fig. 154: Aligning Marks On Crankshaft Plate
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The mark plate on the crankshaft side is colored yellow.

32. Align the mark plate, yellow, and timing mark and install the chain to the crankshaft timing gear.
33. Recheck each timing mark at TDC/compression.

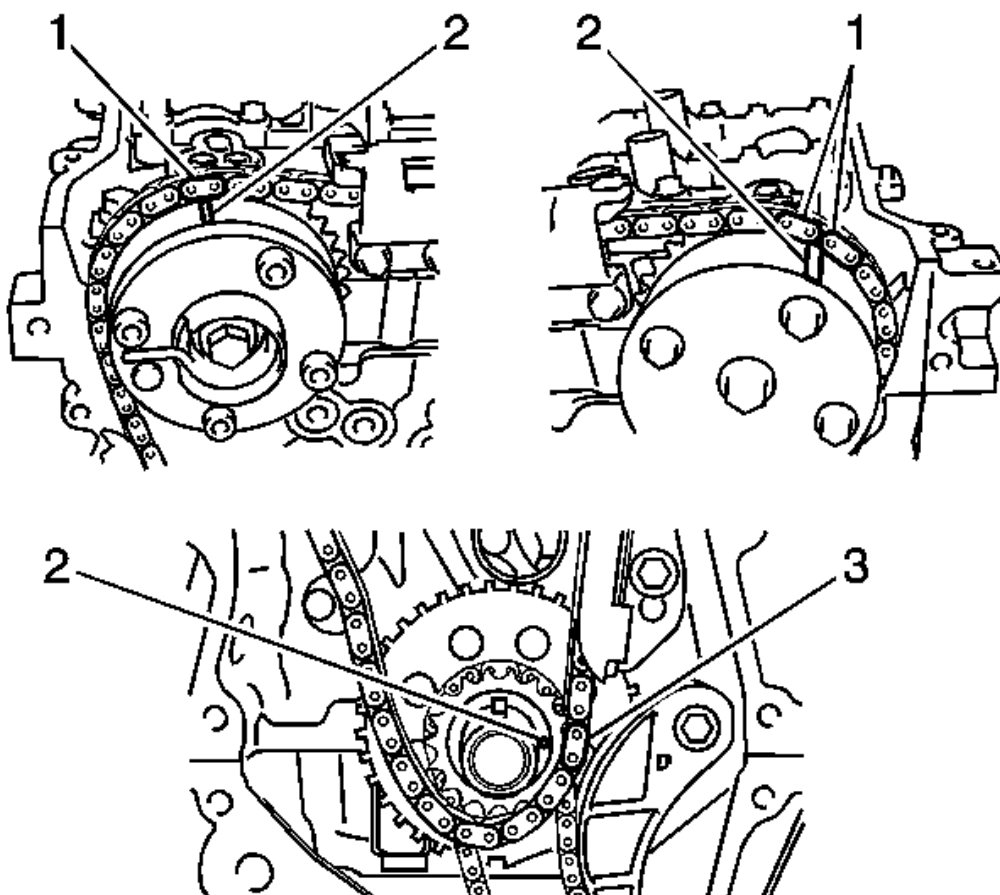


Fig. 155: View Of Chain Tensioner Slipper Installation
 Courtesy of GENERAL MOTORS CORP.

34. Install the chain tensioner slipper.

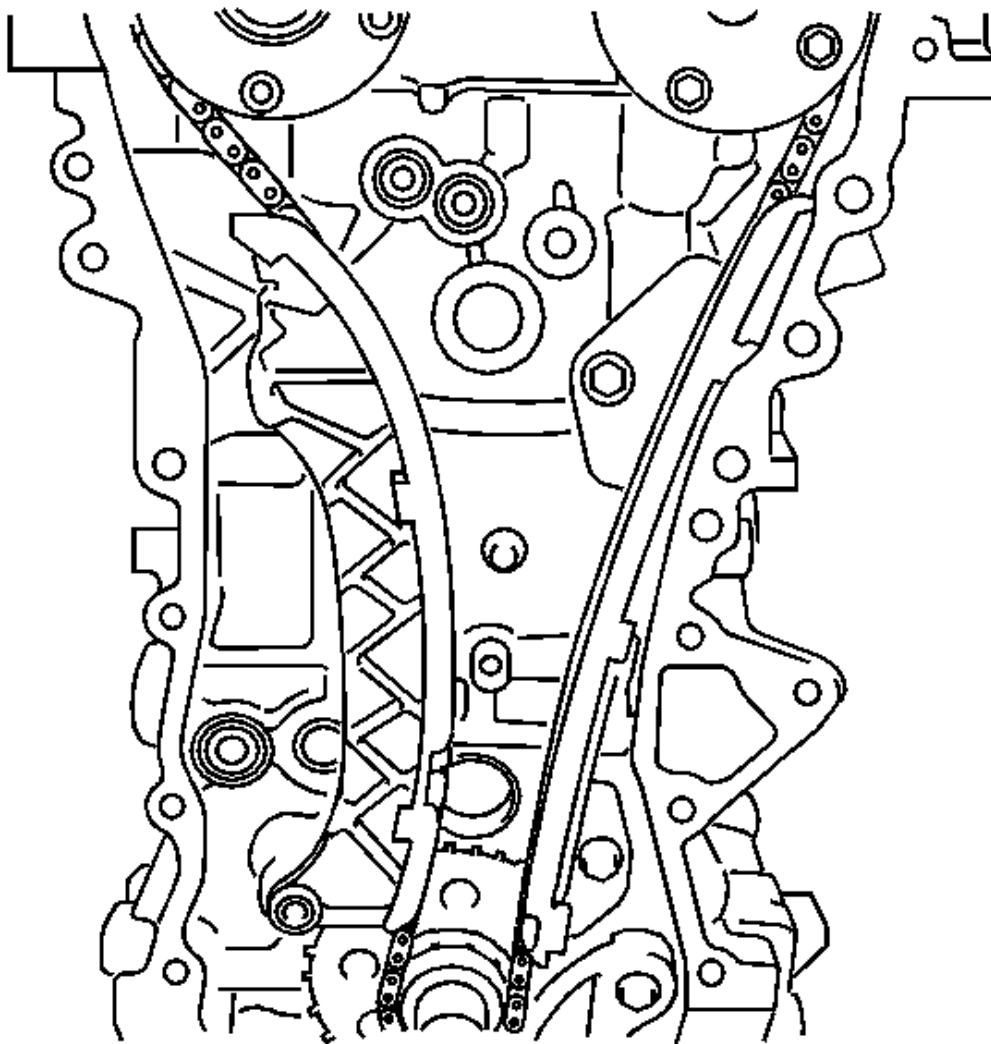


Fig. 156: Identifying Timing Chain Tensioner Slipper
Courtesy of GENERAL MOTORS CORP.

35. Install the timing chain cover oil seal.
36. Install the timing chain cover sub-assembly.
37. Install the crankshaft pulley.
38. Install the No. 1 chain tensioner assembly.
39. Install the cylinder head cover sub-assembly.
40. Install the radio setting condenser.

41. Install the thermostat.
42. Install the inlet water.
43. Install the inlet water hose.
44. Install the water by-pass hose.
45. Install the No. 1 water by-pass pipe.
46. Install the No. 3 water by-pass hose.
47. Install the ventilation hose.
48. Inspect the exhaust manifold.
49. Install the exhaust manifold.
50. Install the manifold stay.
51. Install the No. 1 exhaust manifold heat insulator.
52. Install the oil level dipstick sub-assembly.
53. Install the ignition coil assembly.
54. Install the fuel injector assembly.
55. Install the No. 1 delivery pipe spacer.
56. Install the fuel delivery pipe sub-assembly.
57. Install the fuel tube sub-assembly.
58. Install the intake manifold.
59. Remove the engine stand.
60. Install the engine assembly with transaxle. Refer to **Engine Replacement**.

OIL PUMP REPLACEMENT

Special Tools

SST 09223-22010

Removal Procedure

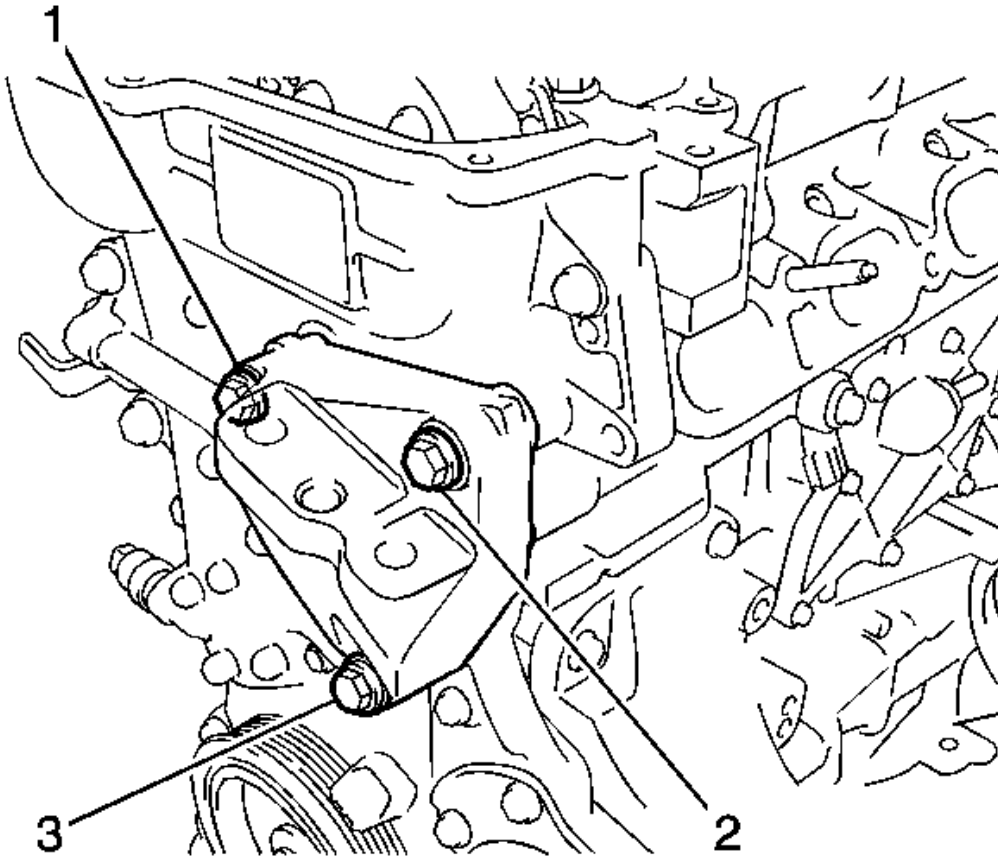


Fig. 157: Identifying Engine Mounting Bracket & Bolts
 Courtesy of GENERAL MOTORS CORP.

1. Remove the engine assembly with transaxle.
2. Install the engine stand.
3. Remove the intake manifold.
4. Disconnect the fuel tube sub-assembly.
5. Remove the fuel delivery pipe sub-assembly.
6. Remove the fuel injector assembly.
7. Remove the ignition coil assembly.
8. Remove the oil level dipstick sub-assembly.
9. Remove the No. 1 exhaust manifold heat insulator.
10. Remove the manifold stay.
11. Remove the exhaust manifold.

12. Remove the ventilation hose.
13. Remove the No. 3 water by-pass hose.
14. Remove the No. 1 water by-pass pipe.
15. Remove the water by-pass hose.
16. Remove the inlet water hose.
17. Remove the inlet water.
18. Remove the thermostat.
19. Remove the radio setting condenser.
20. Remove the cylinder head cover sub-assembly.
21. Set the No. 1 cylinder to TDC/compression.
22. Remove the crankshaft pulley.
23. Remove the No. 1 chain tensioner assembly.

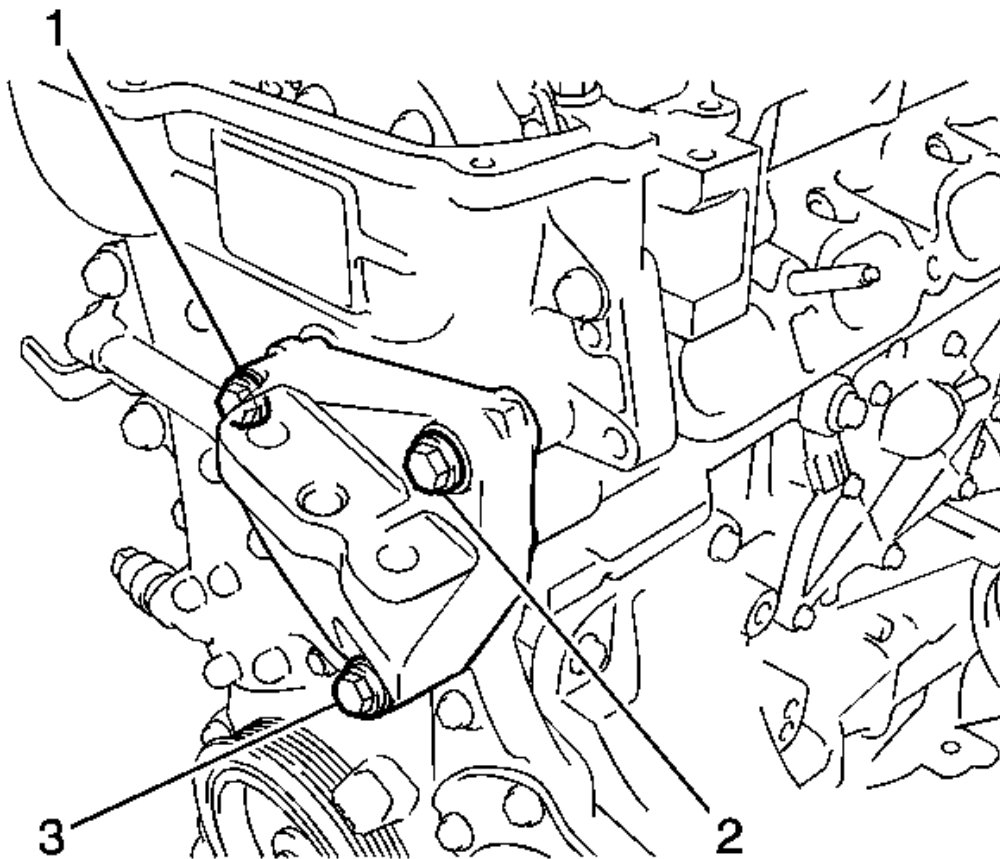


Fig. 158: Identifying Engine Mounting Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

24. Remove the timing chain cover sub-assembly.
25. Remove the 3 bolts and engine mounting bracket.

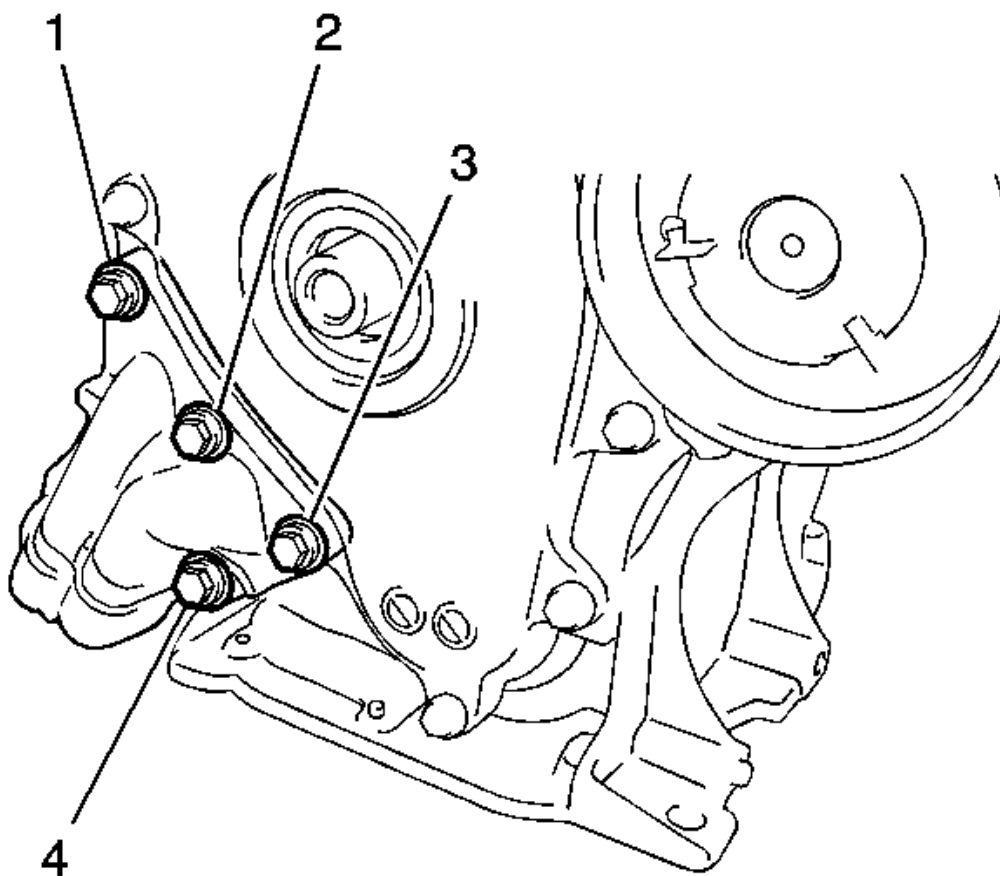


Fig. 159: Identifying Oil Filter Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

26. Remove the 4 bolts and oil filter bracket.

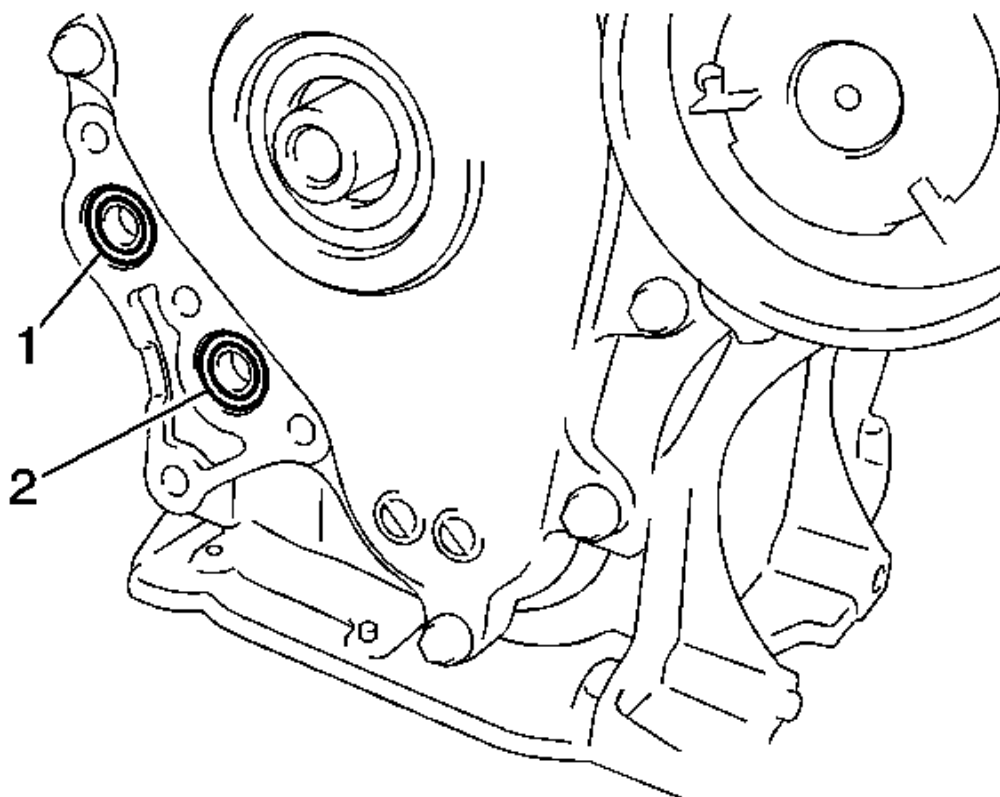


Fig. 160: View Of O-Rings

Courtesy of GENERAL MOTORS CORP.

27. Remove the 2 O-rings.

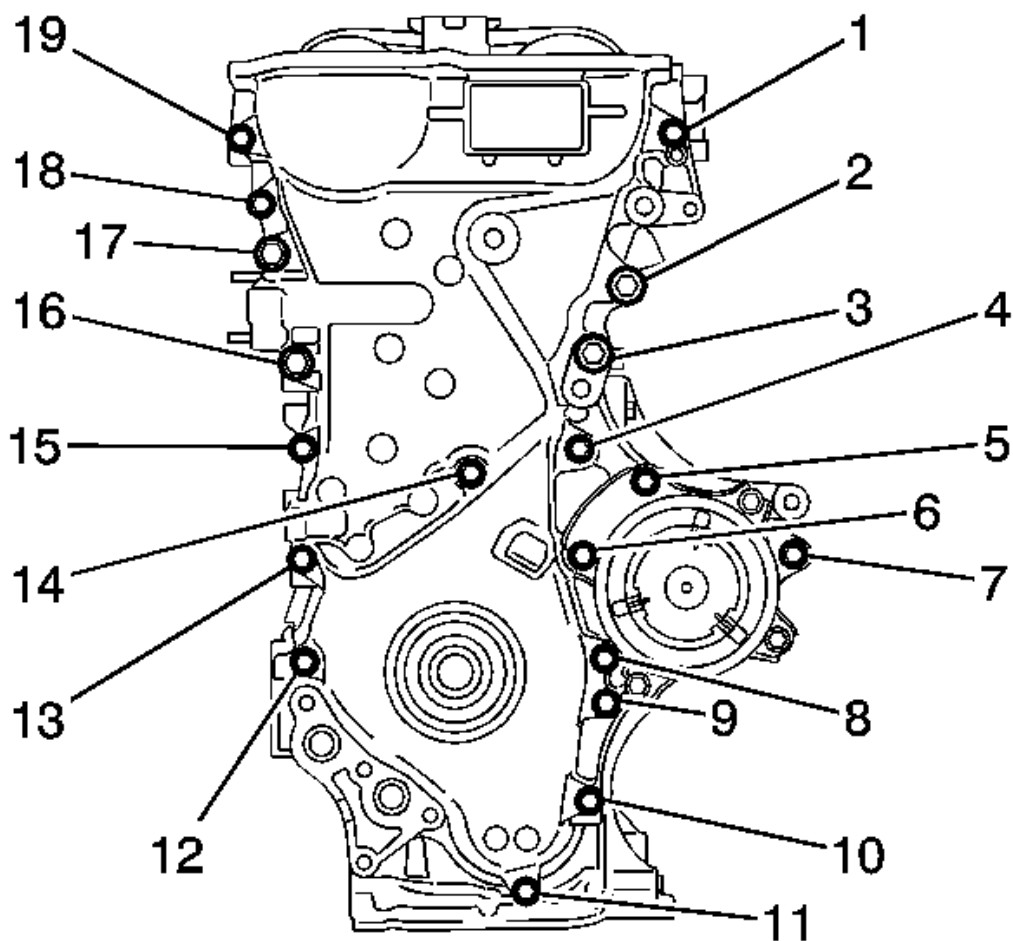


Fig. 161: Identifying Front Cover Bolt Loosening Sequence
Courtesy of GENERAL MOTORS CORP.

28. Remove the 19 bolts.

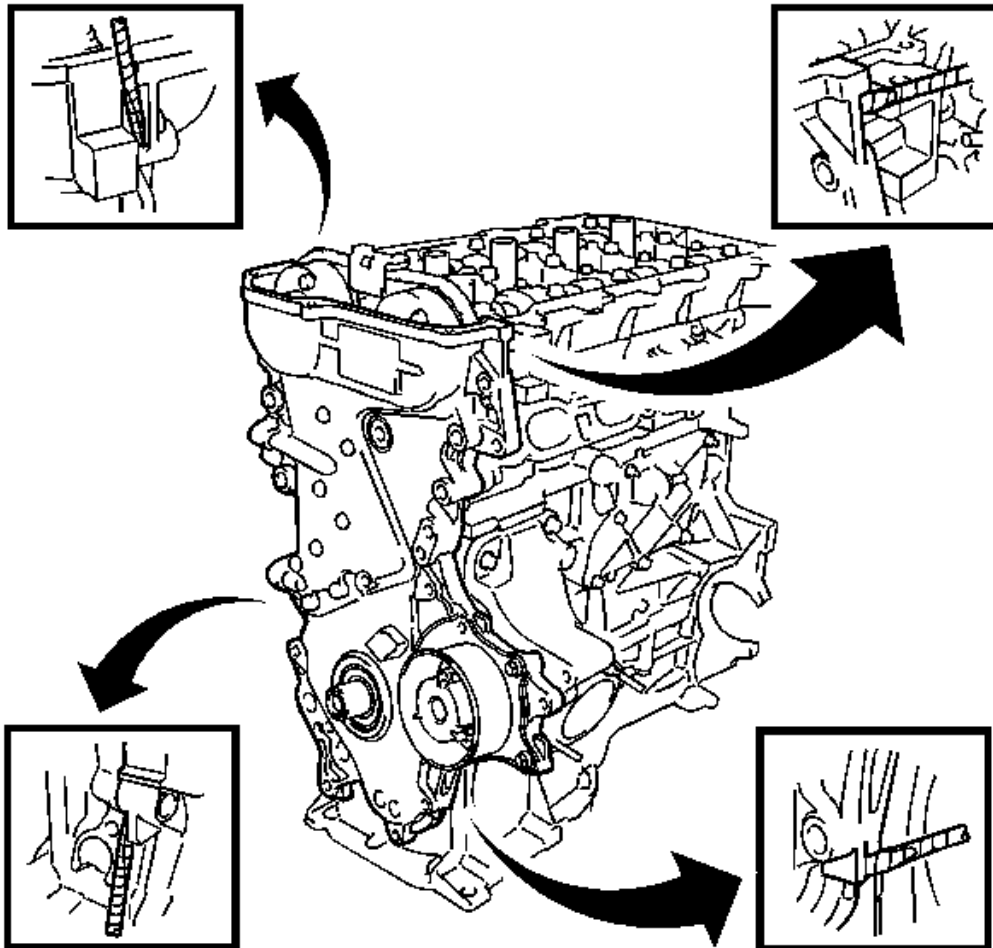


Fig. 162: View Of Timing Chain Cover
Courtesy of GENERAL MOTORS CORP.

NOTE: Be careful not to damage the contact surfaces of the timing chain cover, cylinder block, and cylinder head.

IMPORTANT: Tape the screwdriver tip before use.

29. Remove the timing chain cover by prying between the timing chain cover and cylinder head or cylinder block with a screwdriver.

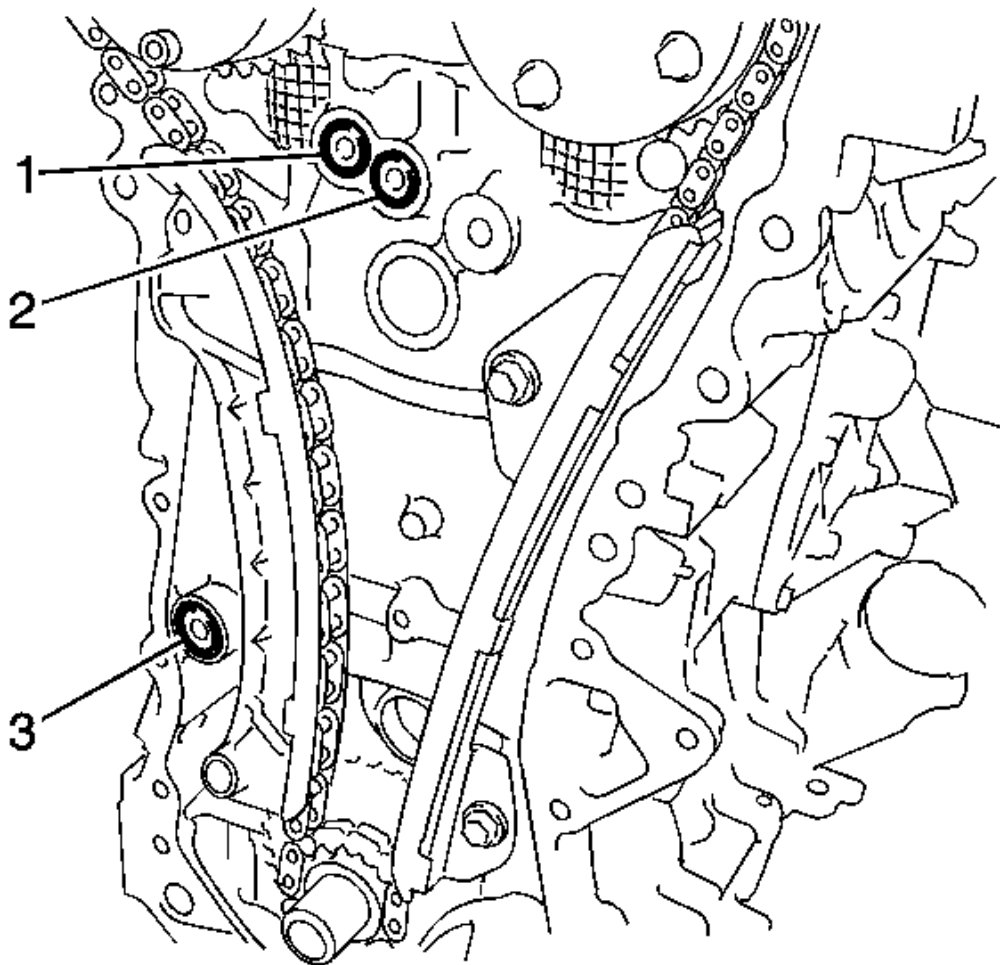


Fig. 163: Locating O-Rings

Courtesy of GENERAL MOTORS CORP.

30. Remove the 3 O-rings.

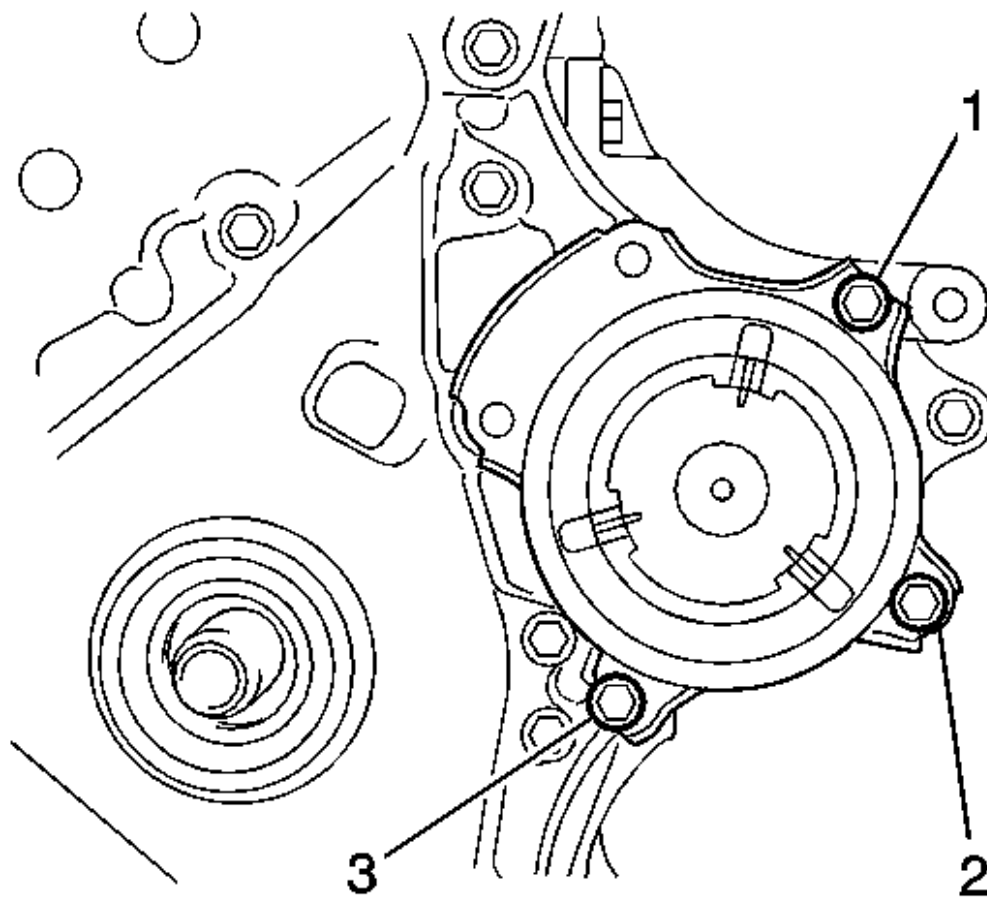


Fig. 164: View Of Water Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

31. Remove the 3 bolts and water pump.

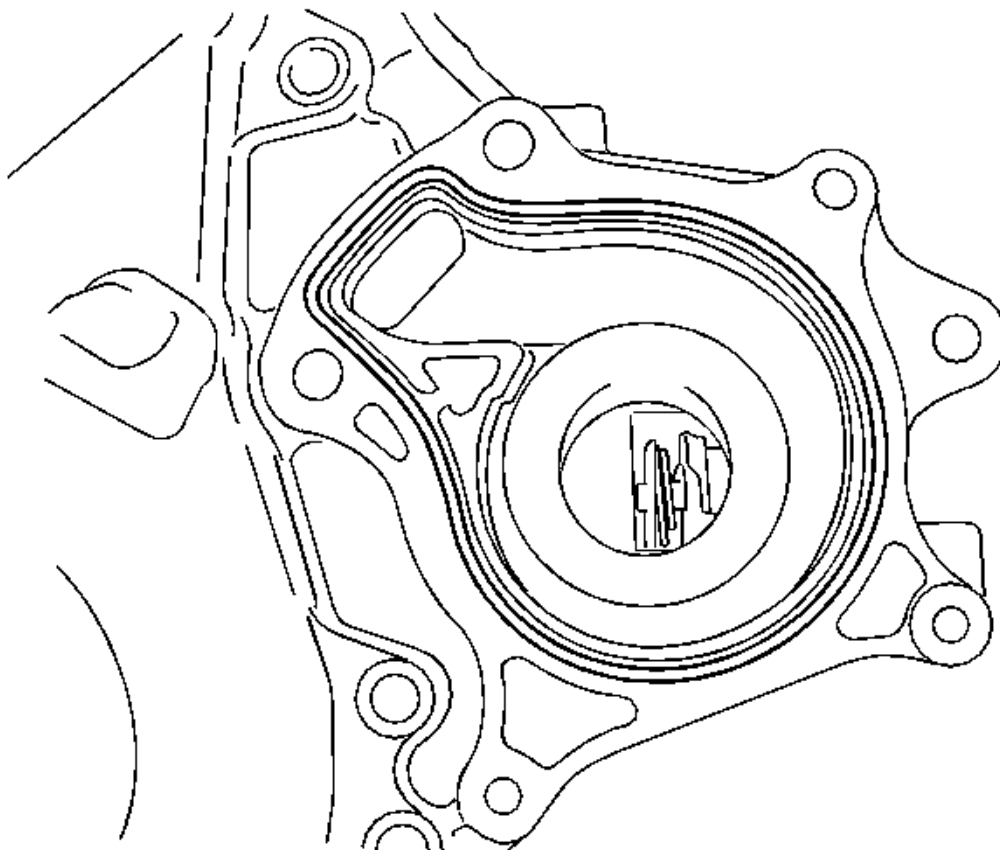


Fig. 165: View Of Water Pump Gasket
Courtesy of GENERAL MOTORS CORP.

32. Remove the gasket.

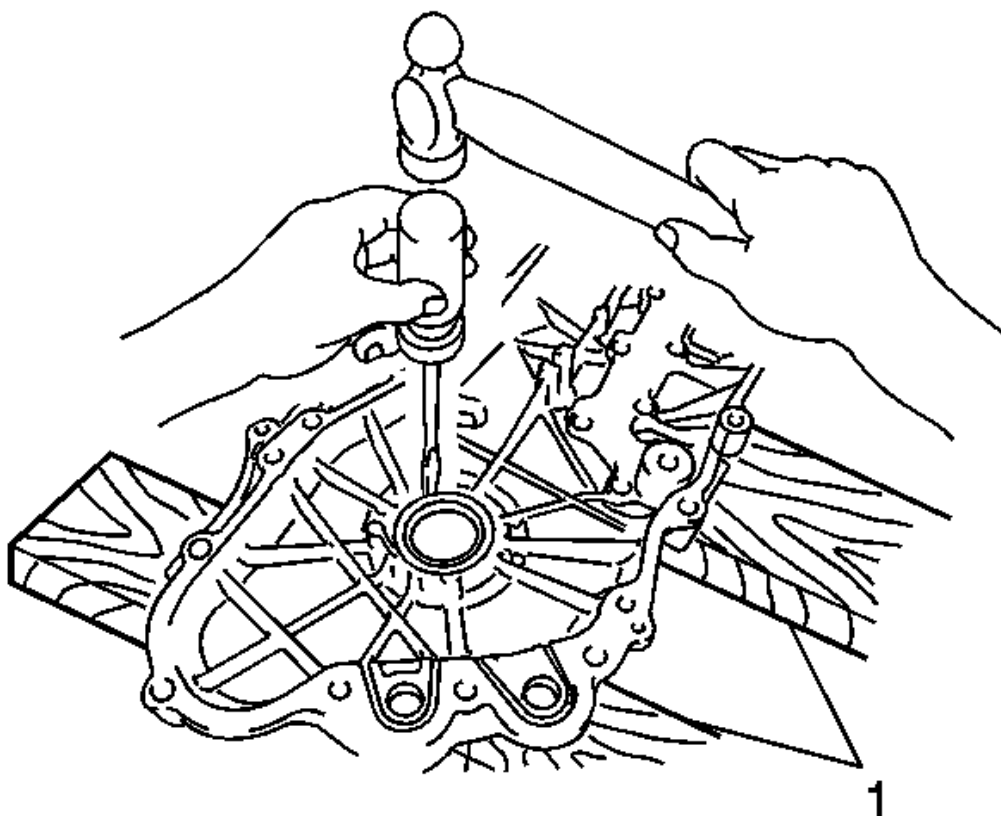


Fig. 166: View Of Chain Cover Seal Removal
Courtesy of GENERAL MOTORS CORP.

33. Place the timing chain cover on wooden blocks.

NOTE: Do not damage the surface of the oil seal press fit hole.

IMPORTANT: Tape the screwdriver tip before use.

34. Using a screwdriver, pry out the oil seal.
35. Remove the chain tensioner slipper.
36. Remove the No. 1 chain vibration damper.
37. Remove the chain sub-assembly.

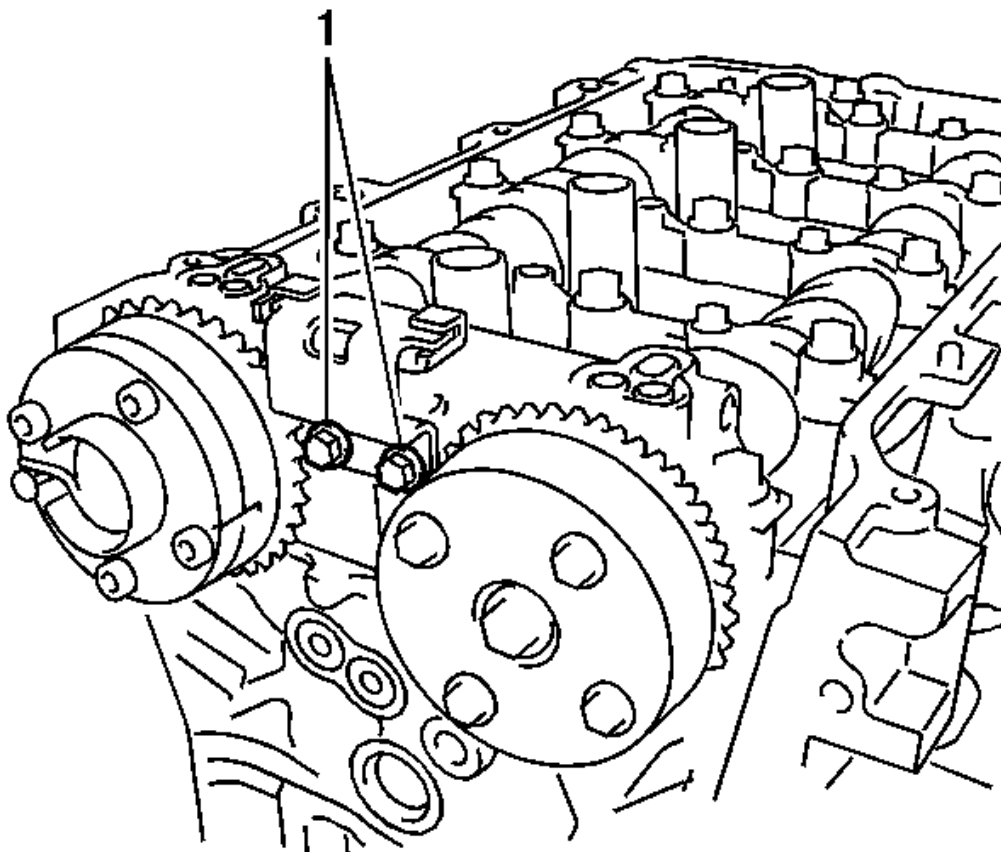


Fig. 167: Identifying Chain Vibration Damper
Courtesy of GENERAL MOTORS CORP.

38. Remove the 2 bolts and No. 2 chain vibration damper.
39. Remove the No. 2 chain sub-assembly.
40. Hand tighten the crank pulley bolt.

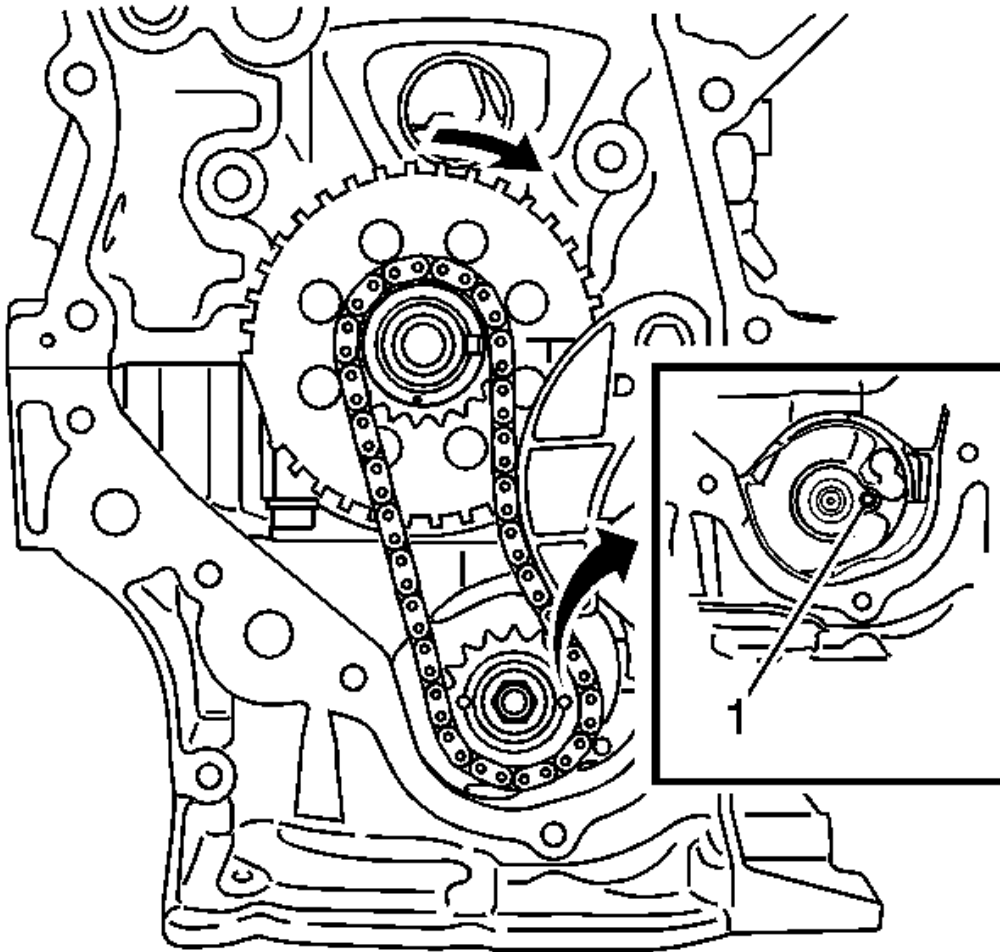


Fig. 168: Aligning Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not rotate the crankshaft more than 90°. If the crankshaft is rotated too much without the timing chain installed, the valves may hit the pistons and cause damage.

41. Turn the crankshaft 90 degrees clockwise to align the adjusting hole of the oil pump drive shaft sprocket with the groove of the oil pump.
42. Remove the crank pulley bolt.

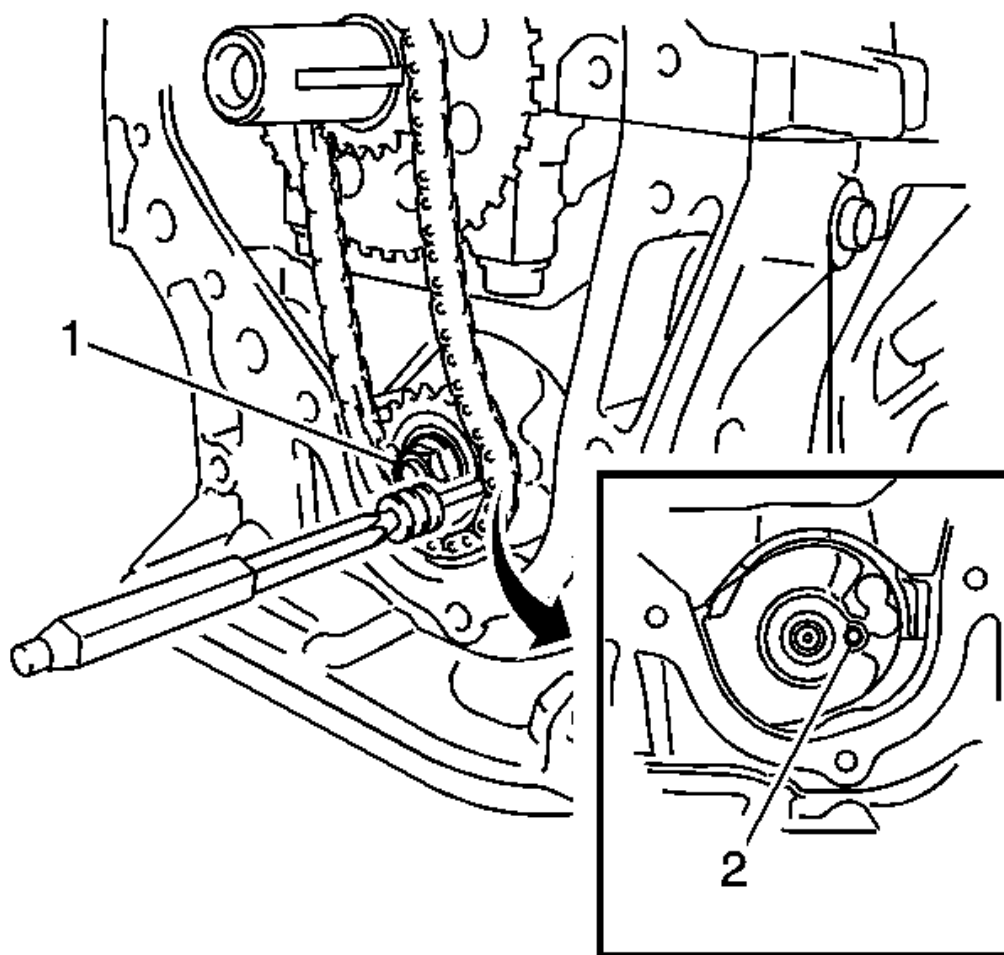


Fig. 169: Identifying Adjusting Hole
Courtesy of GENERAL MOTORS CORP.

43. Insert a pin punch (3 mm) into the adjusting hole of the oil pump drive shaft sprocket to lock the gear in position, and then remove the nut.

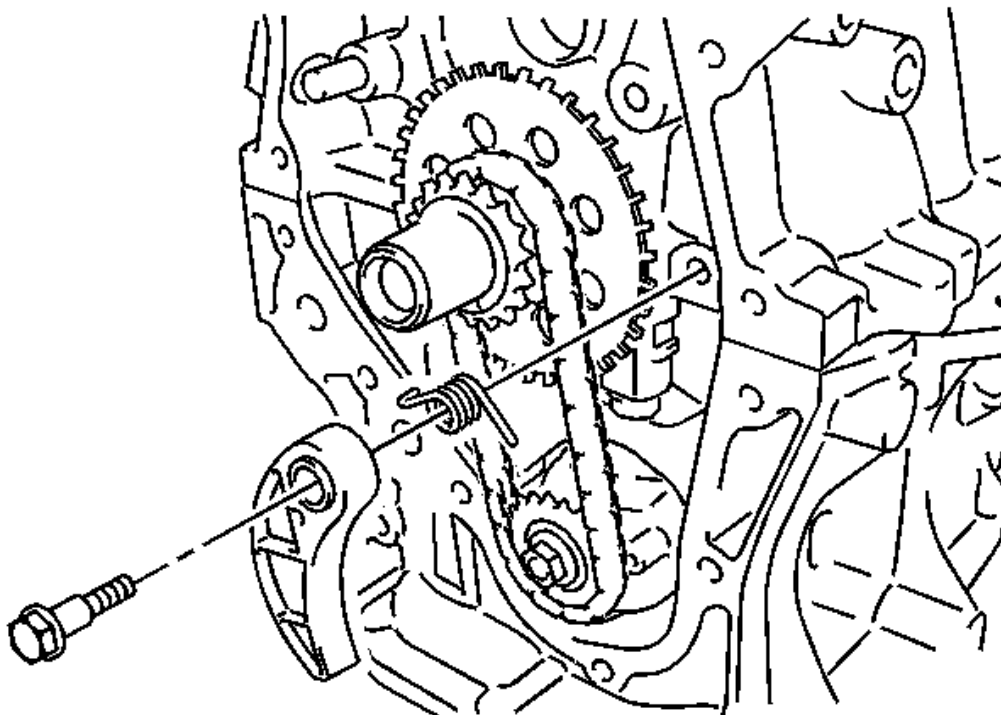


Fig. 170: View Of Chain Tensioner Plate, Spring & Bolt
Courtesy of GENERAL MOTORS CORP.

44. Remove the bolt, chain tensioner plate, and spring.

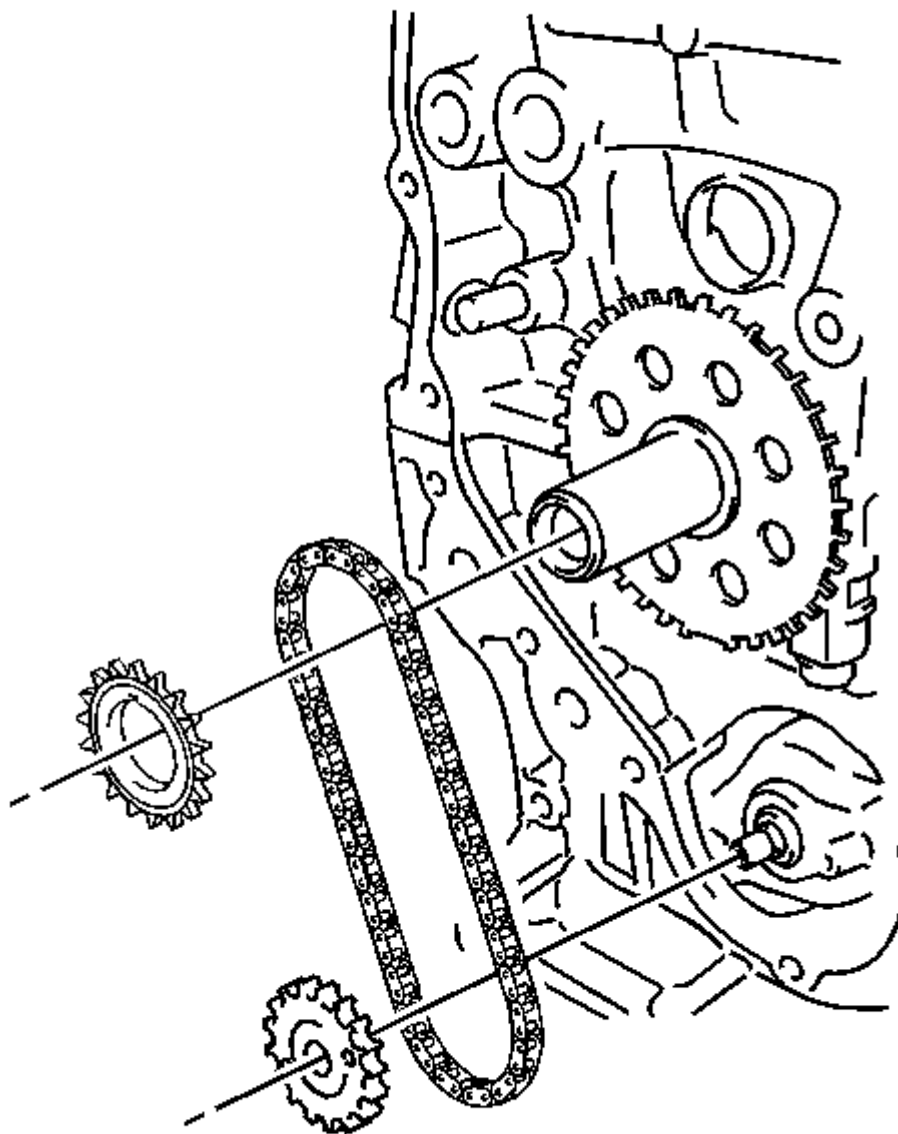


Fig. 171: View Of Crankshaft Timing Sprocket, Oil Pump Drive Shaft Gear & No. 2 Chain
Courtesy of GENERAL MOTORS CORP.

45. Remove the crankshaft timing sprocket, oil pump drive shaft gear, and No. 2 chain sub-assembly.
46. Remove No. 1 crankshaft position sensor plate.

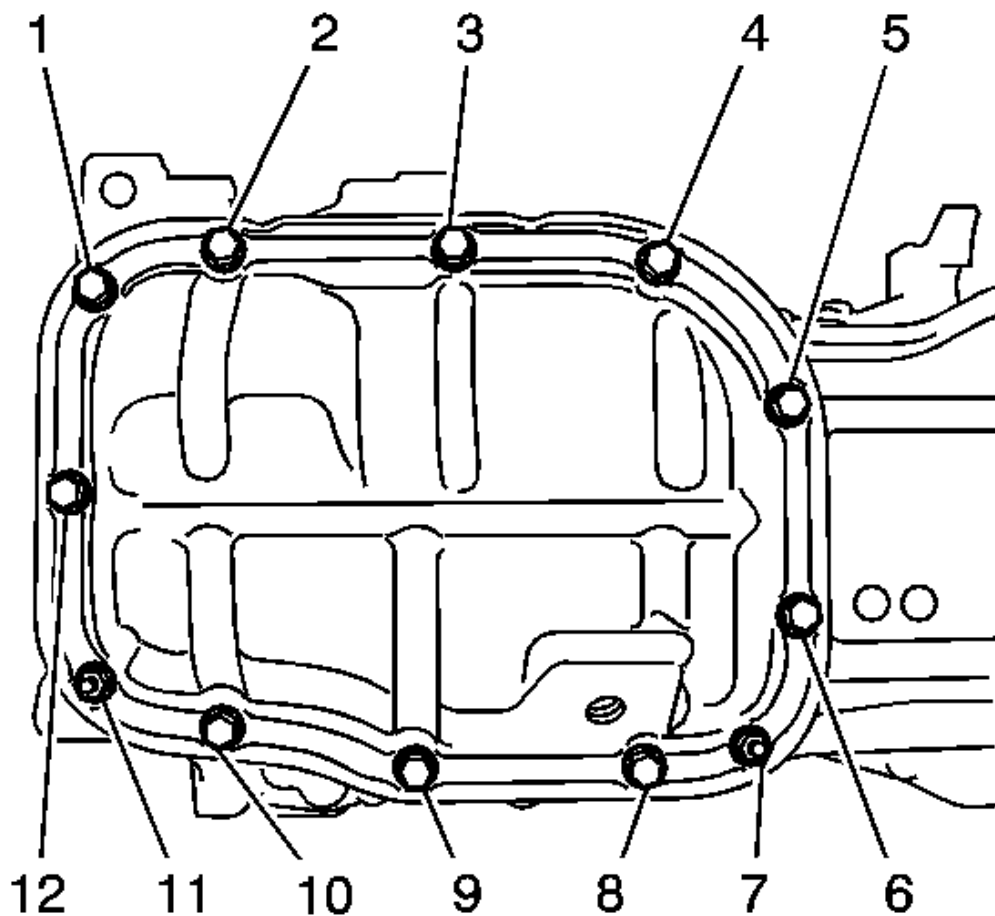


Fig. 172: Identifying No. 2 Oil Pan Bolt Loosening/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

47. Remove No. 2 oil pan sub-assembly.
48. Remove the 10 bolts and 2 nuts.

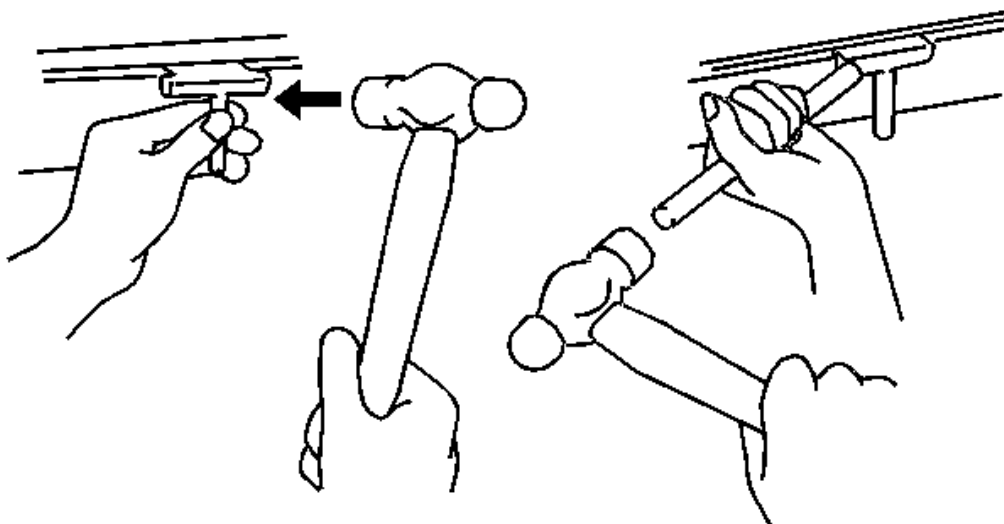


Fig. 173: Illustrating Oil Pan Removal
Courtesy of GENERAL MOTORS CORP.

NOTE: Be careful not to damage the contact surfaces of the crankcase, chain cover, and oil pan.

49. Insert the blade of oil pan seal cutter between the crankcase and oil pan. Cut through the sealer and remove the oil pan.

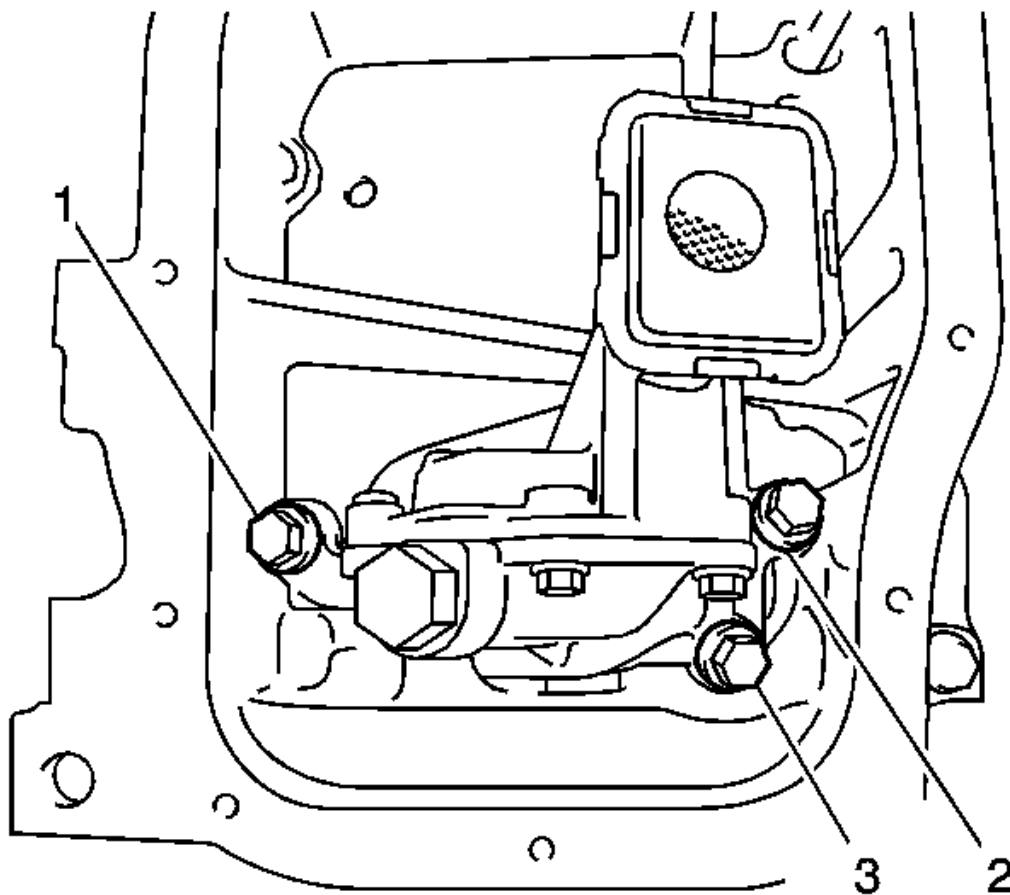


Fig. 174: Identifying Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

50. Remove the 3 bolts and oil pump.

Disassembly Procedure

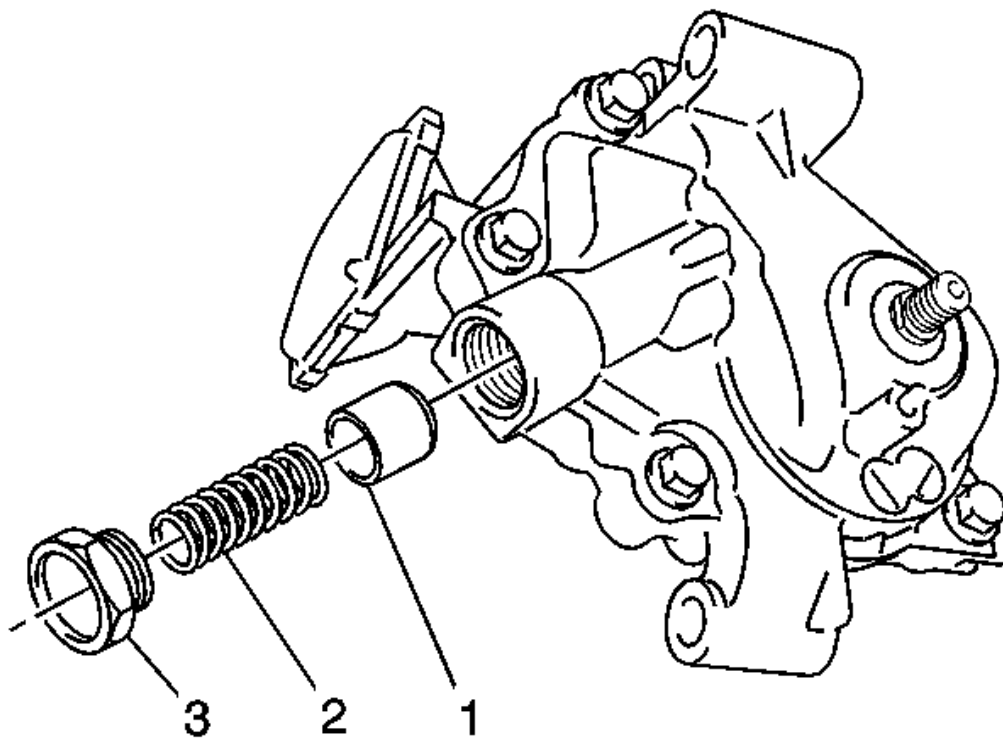


Fig. 175: Identifying Oil Pump Valve & Spring
Courtesy of GENERAL MOTORS CORP.

1. Using a 27 mm socket wrench, remove the plug.
2. Remove the valve spring and relief valve.

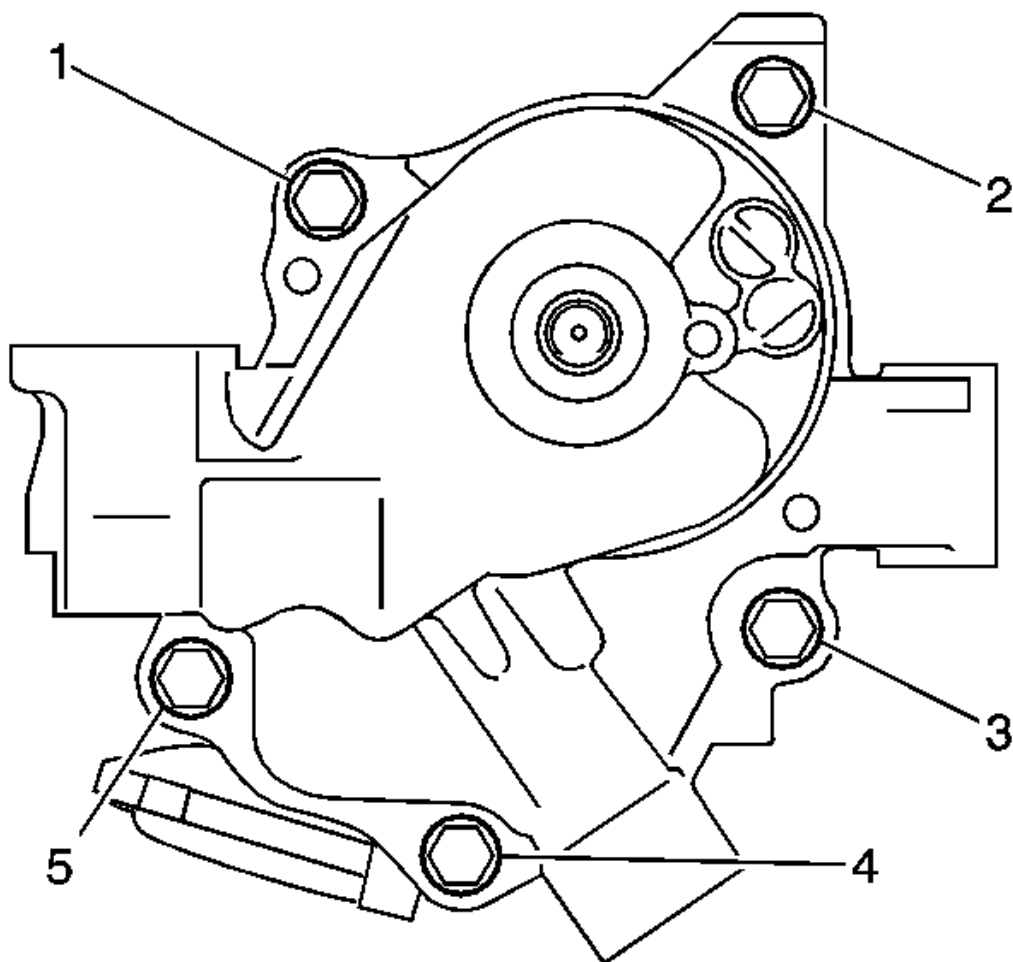


Fig. 176: Identifying Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the 5 bolts and oil pump cover.
4. Remove the oil pump drive and driven rotors from the oil pump.

Inspection Procedure

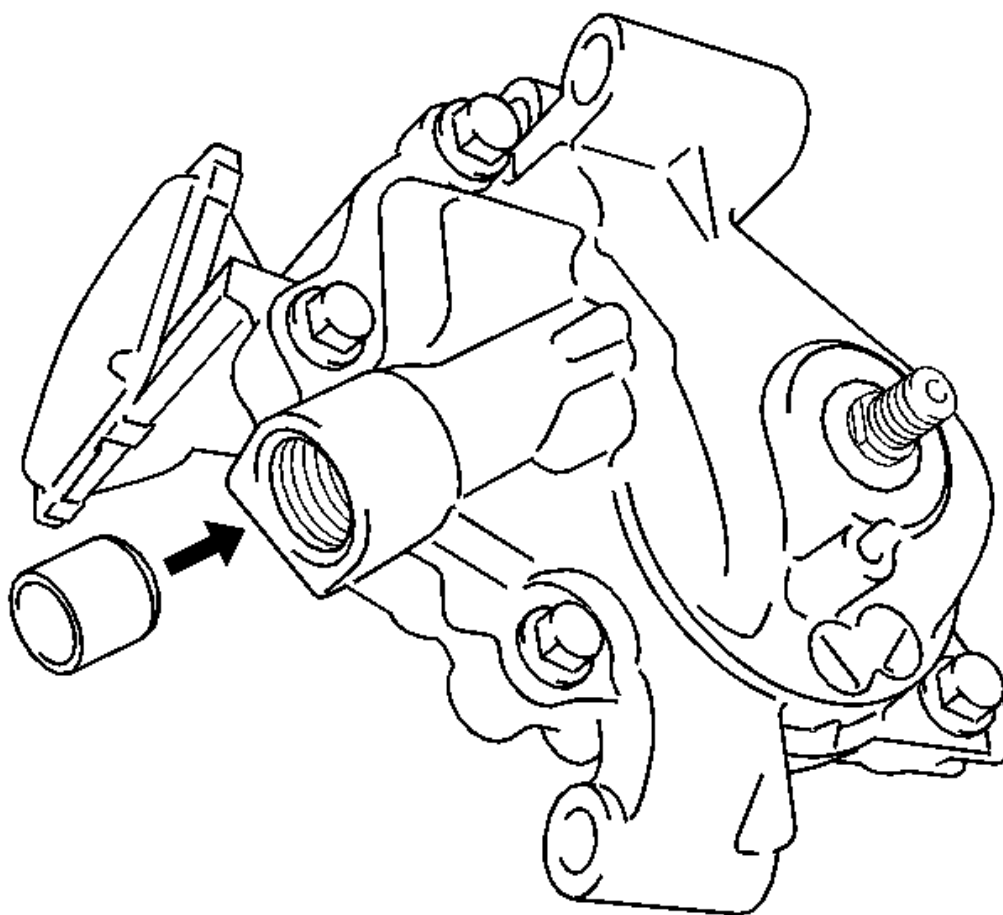


Fig. 177: Inspecting Oil Pump Relief Valve
Courtesy of GENERAL MOTORS CORP.

1. Coat the oil pump relief valve with engine oil, then check that it falls smoothly into the valve hole by its own weight.

If this does not occur, replace the oil pump.

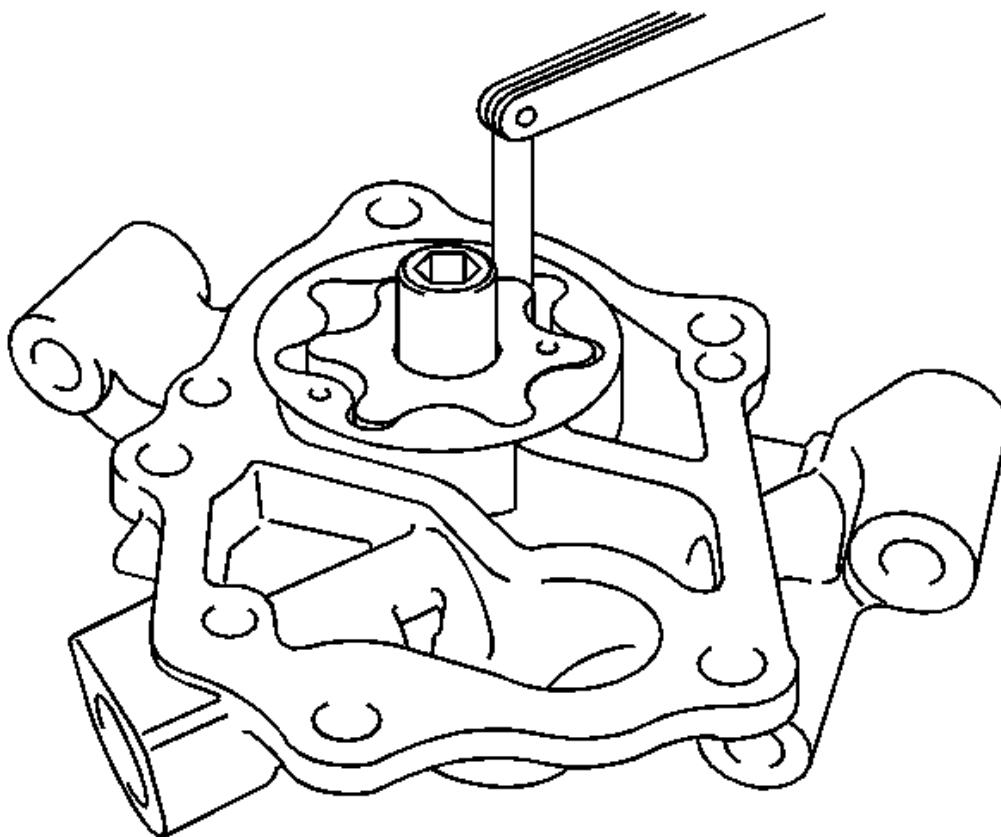


Fig. 178: Measuring Oil Pump Drive & Driven Rotor Tip Clearance
Courtesy of GENERAL MOTORS CORP.

2. Using a feeler gauge, measure the clearance between the drive and driven rotor tips.

Specification:

- Standard tip clearance: 0.08 to 0.160 mm (0.00315 to 0.00630 in)
- Maximum tip clearance: 0.35 mm (0.0138 in)

If the tip clearance is greater than the maximum, replace the oil pump.

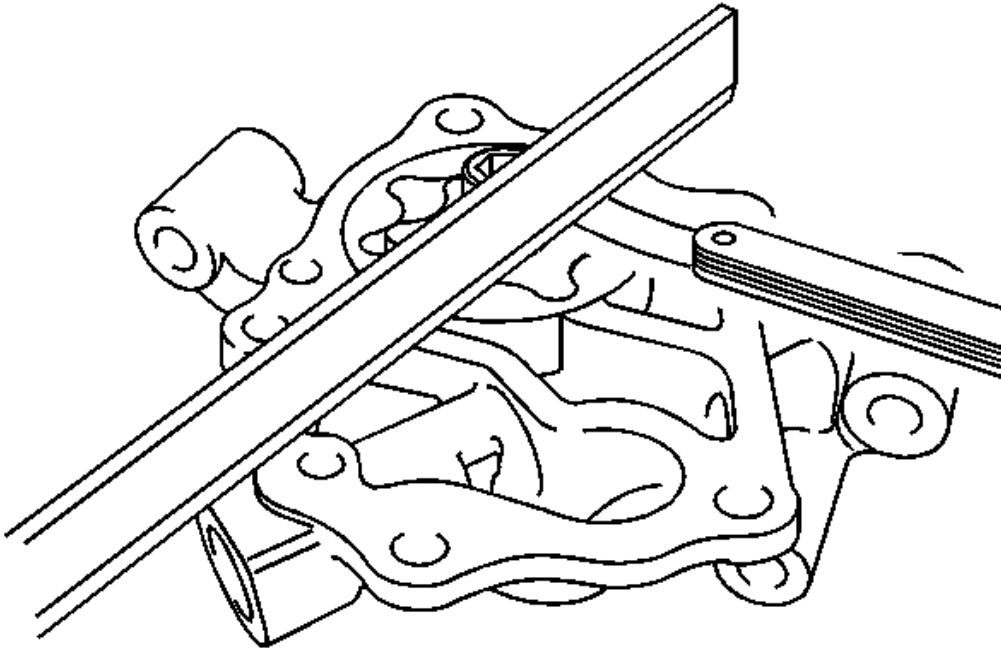


Fig. 179: Measuring Oil Pump Rotor Clearance

Courtesy of GENERAL MOTORS CORP.

3. Using a feeler gauge and precision straight edge, measure the clearance between the 2 rotors and precision straight edge.

Specification:

- Standard side clearance: 0.03 to 0.08 mm (0.00118 to 0.00315 in)
- Maximum side clearance: 0.16 mm (0.0063 in)

If the side clearance is greater than the maximum, replace the oil pump.

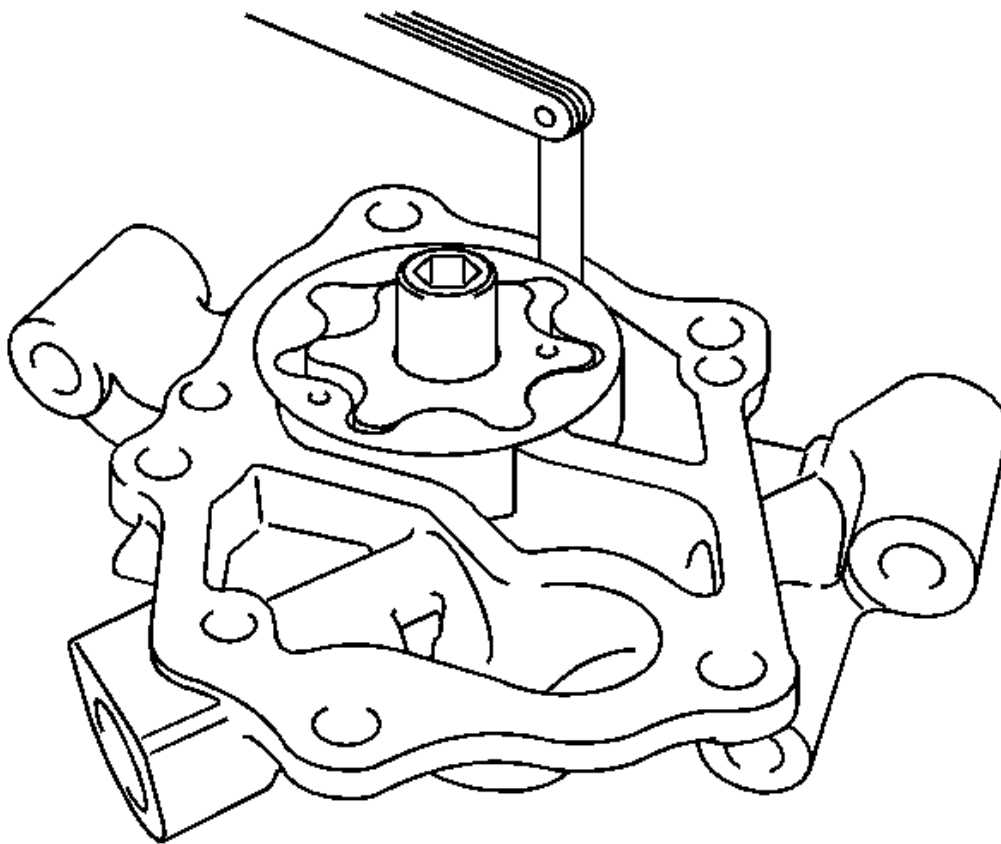


Fig. 180: Measuring Oil Pump Driven Rotor-To-Body Clearance
Courtesy of GENERAL MOTORS CORP.

4. Using a feeler gauge, measure the clearance between the driven rotor and oil pump body.

If the body clearance is greater than the maximum, replace the oil pump.

Specification:

- Standard Body Clearance: 0.12-0.19 mm (0.00472 -0.00748 in).
- Maximum Body Clearance: 0.325 mm (0.0128 in).

Reassembly Procedure

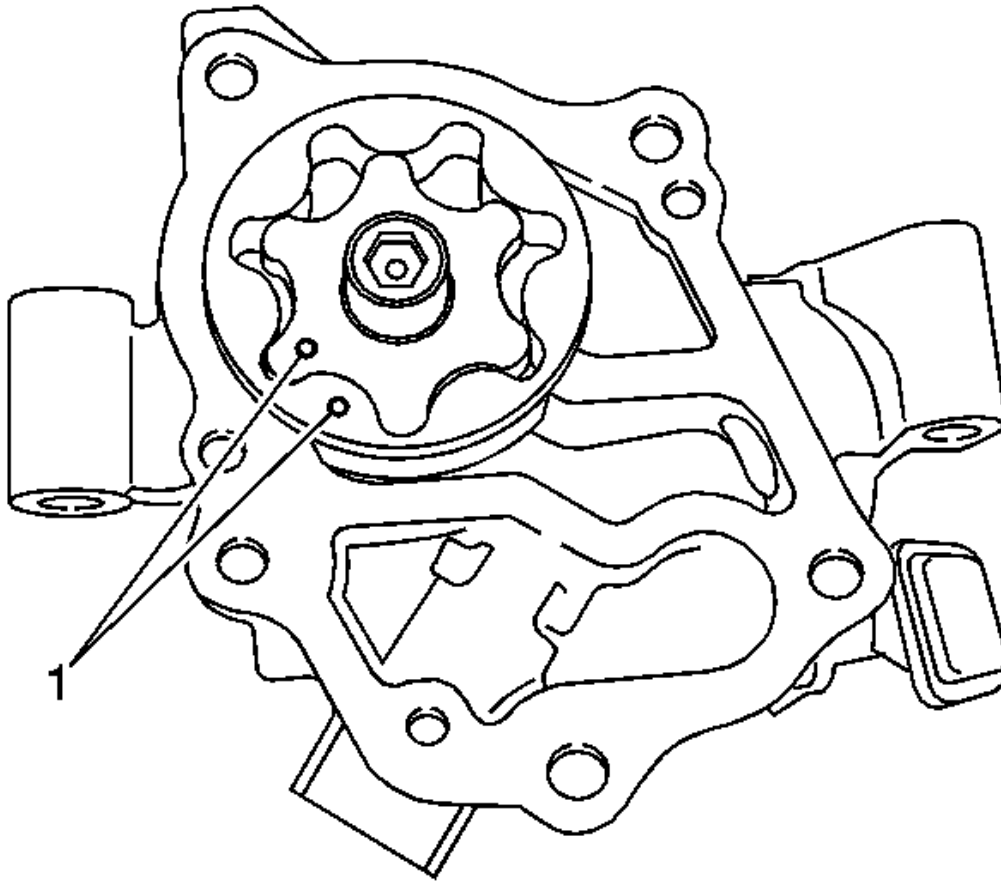


Fig. 181: Identifying Oil Pump Drive & Driven Rotors
Courtesy of GENERAL MOTORS CORP.

1. Coat the oil pump drive and driven rotors with engine oil, and place them into the oil pump with the marks facing the oil pump cover side.

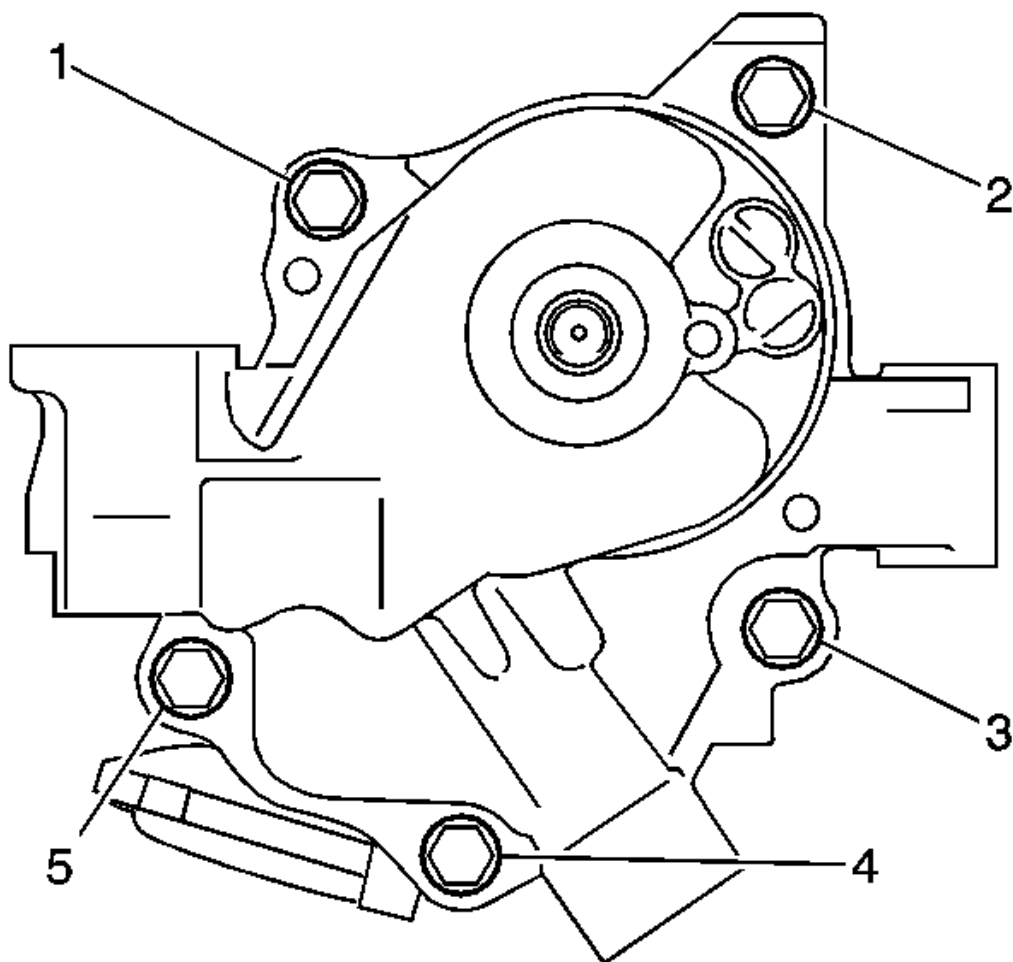


Fig. 182: Identifying Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to **FASTENER CAUTION** .

2. Install the oil pump cover with the 5 bolts.

Tighten: Tighten to 8.8 N.m (78 lb in).

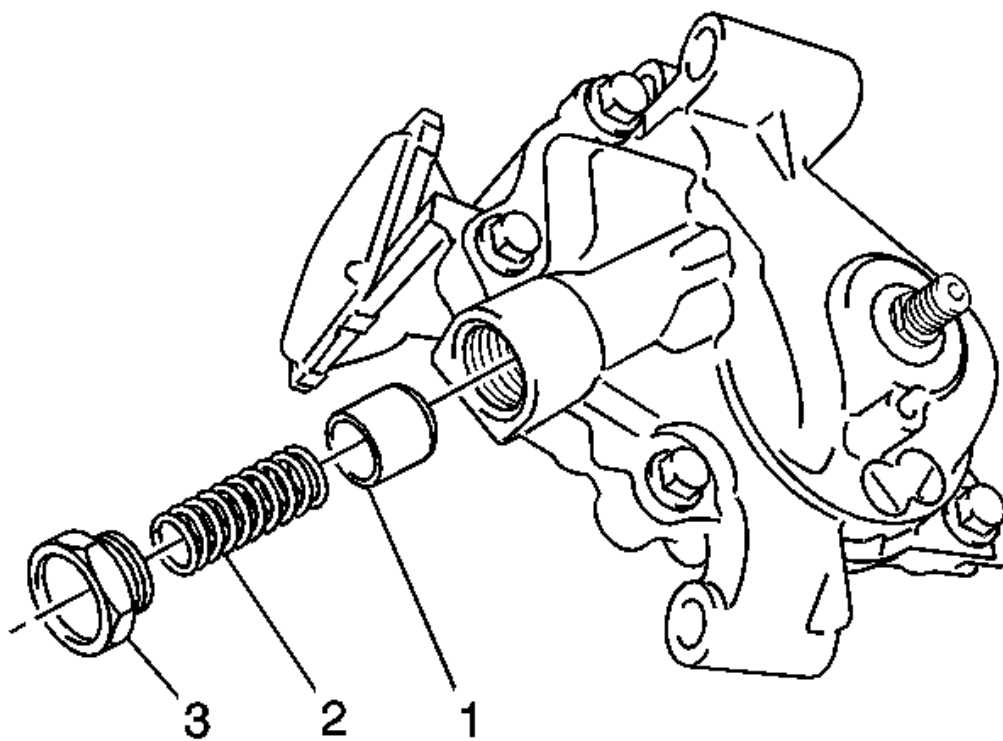


Fig. 183: Identifying Oil Pump Valve & Spring
 Courtesy of GENERAL MOTORS CORP.

3. Coat the relief valve with engine oil.
4. Insert the relief valve and spring into the pump body hole.
5. Using a 27 mm socket wrench, install the plug.

Tighten: Tighten to 49 N.m (36 lb ft).

Installation Procedure

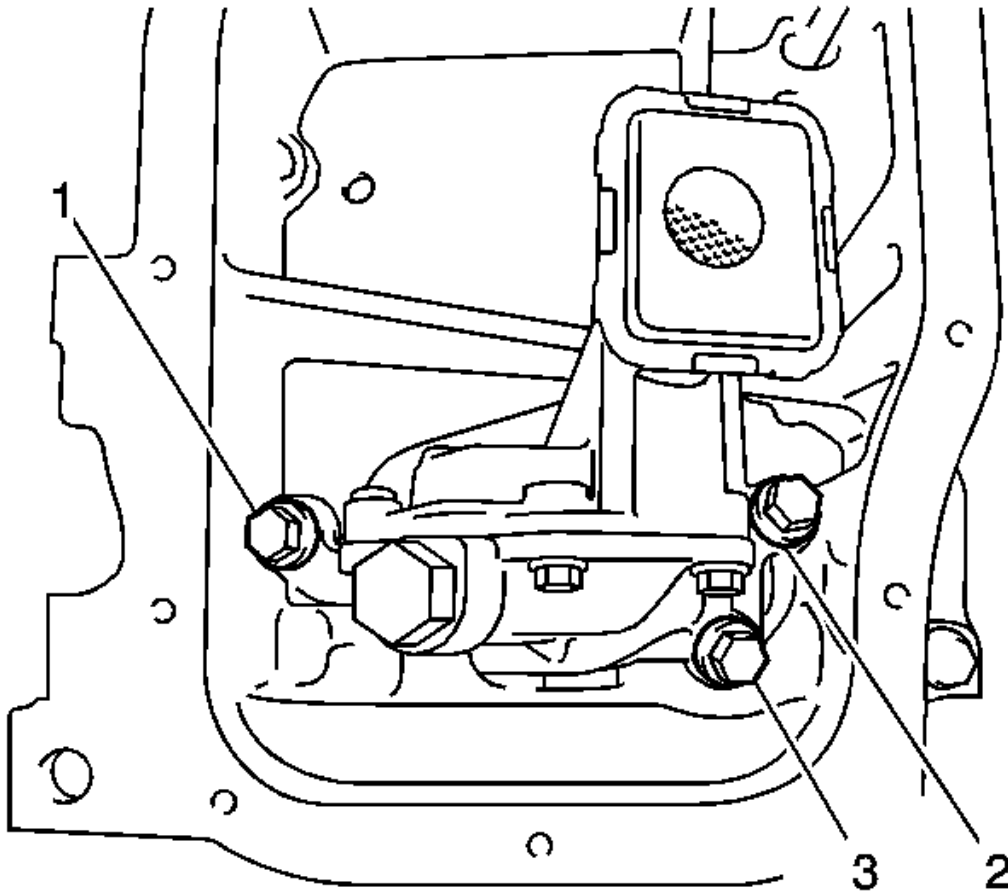


Fig. 184: Identifying Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to **FASTENER CAUTION** .

1. Install the oil pump with the 3 bolts.

Tighten: Tighten to 21 N.m (16 lb ft).

2. Remove any old packing material and be careful not to drop any oil on the contact surfaces of the cylinder block and oil pan.

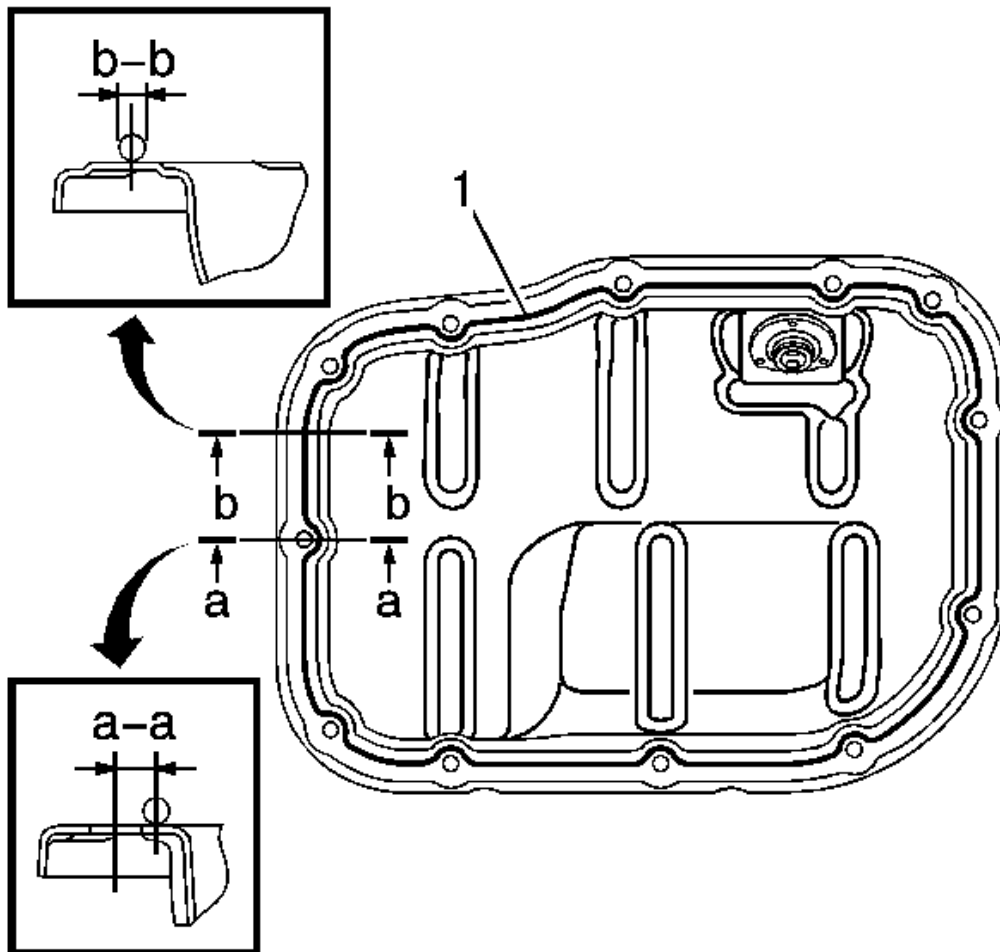


Fig. 185: View Of Oil Pump Contact Surfaces
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Remove any oil from the contact surfaces.
- Install the oil pan within 3 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after installing the oil pan.

3. Apply a continuous bead of seal packing, Toyota Genuine Seal Packing Black, Three Bond 1207B or equivalent, (Diameter 4.0 mm (0.157 in)).

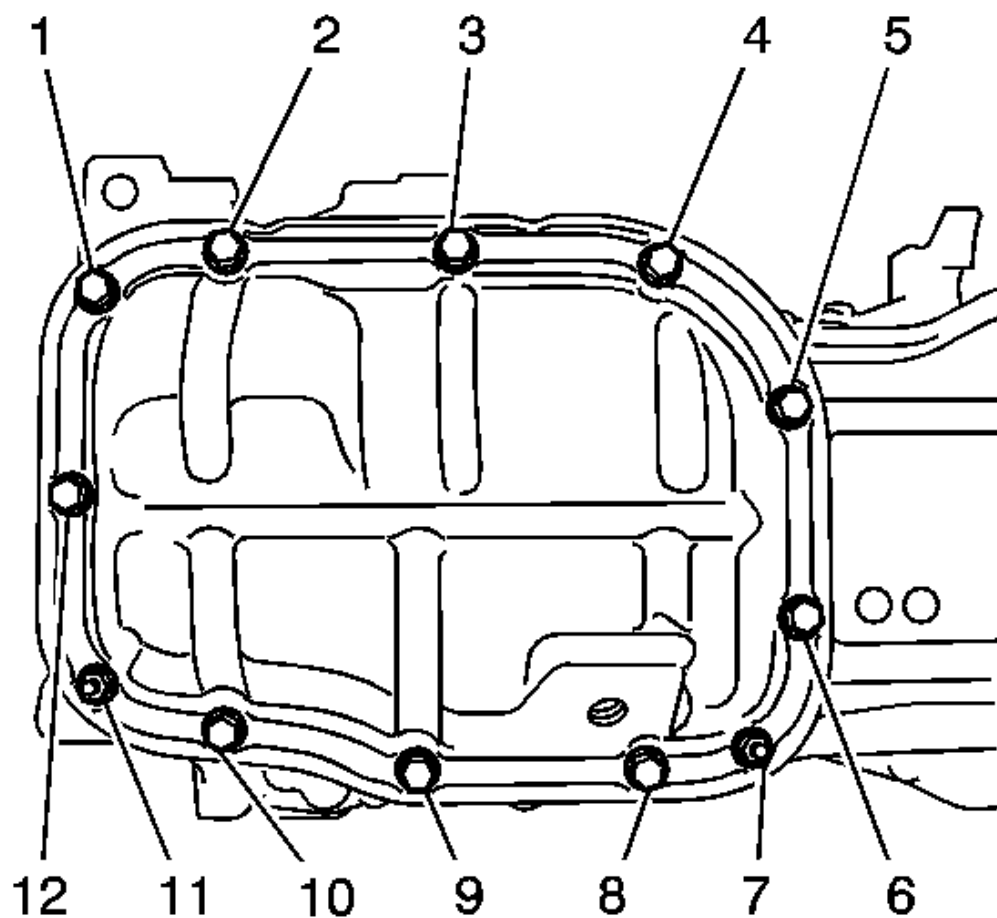


Fig. 186: Identifying No. 2 Oil Pan Bolt Loosening/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Install the No. 2 oil pan with the 10 bolts and 2 nuts.

Tighten: Tighten to 10 N.m (7 lb ft).

5. Install the No. 1 crankshaft position sensor plate.

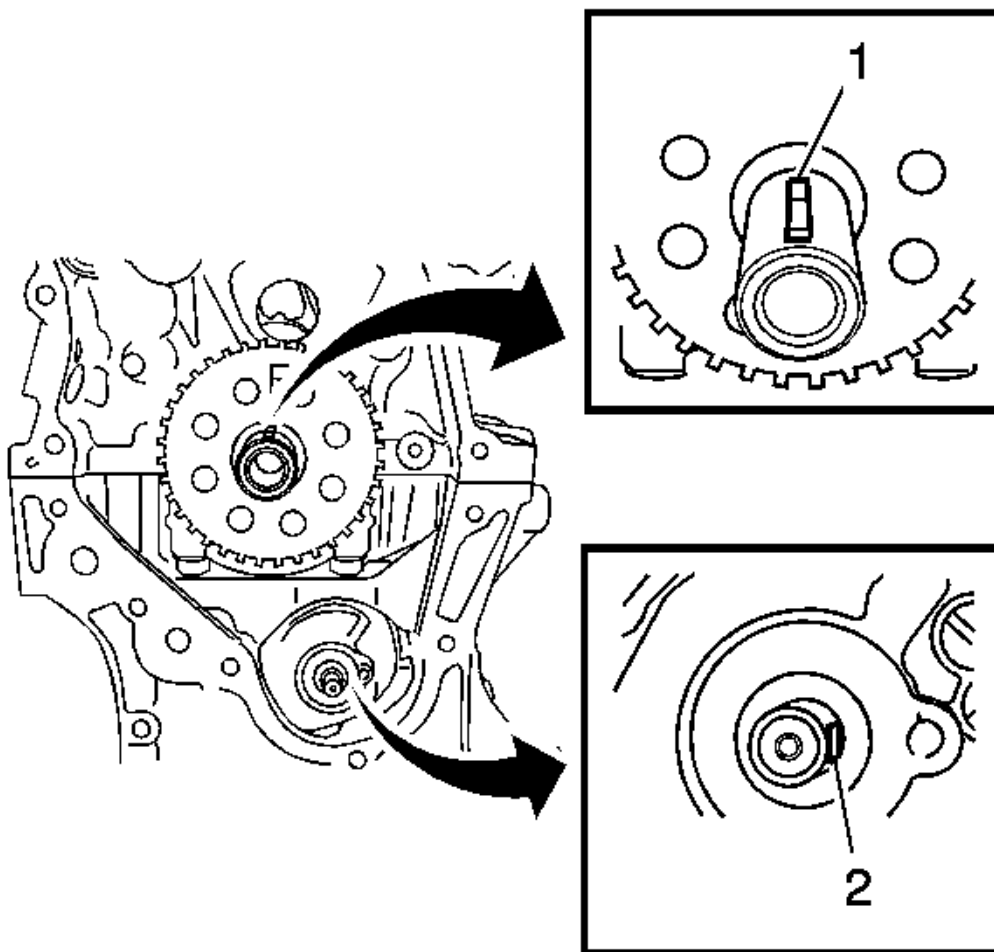


Fig. 187: Identifying Crankshaft Key
Courtesy of GENERAL MOTORS CORP.

6. Set the crankshaft key.
7. Turn the drive shaft so that the cutout faces right horizontal position.

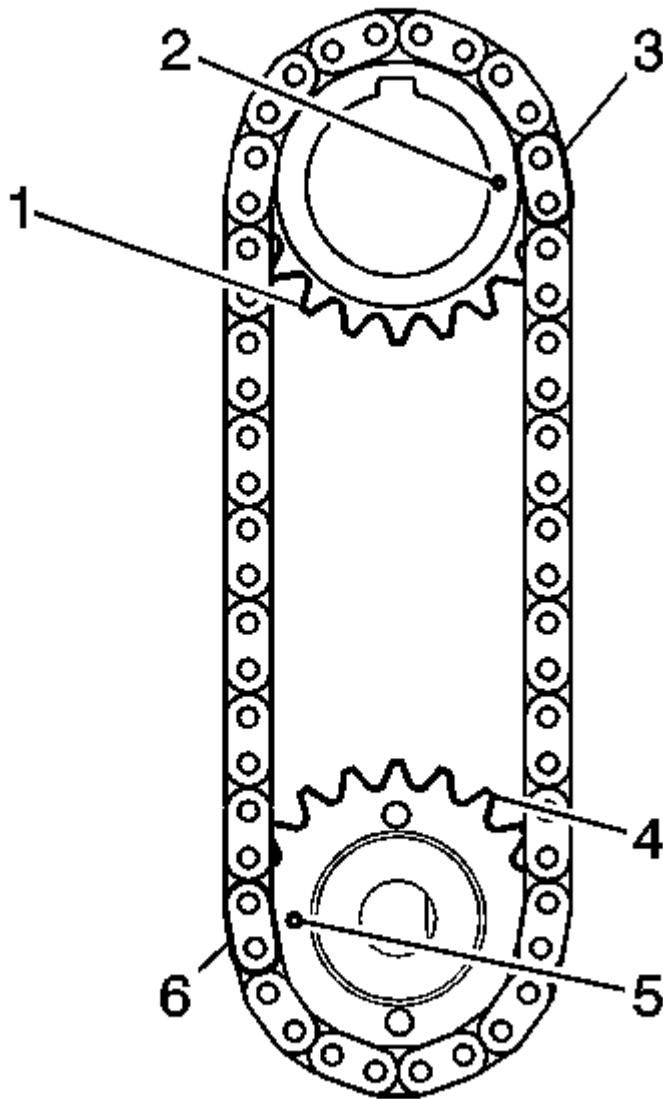


Fig. 188: View Of Aligning Link Marks With Timing Marks Of Each Gear
Courtesy of GENERAL MOTORS CORP.

8. Align the yellow mark links with the timing marks of each gear.
9. Install the sprockets onto the crankshaft and oil pump shaft with the chain on the gears.

Continuous Line Area

- Seal Packing Diameter - 3.0 mm (0.118 in)
- Application Position form Inside Seal Line - 2.5 mm (0.098 in)
- Seal Packing - Three Bond 1207B or equivalent

Dashed Line Area

- Seal Packing Diameter - 4.0 mm (0.156 in)
- Application Position form Inside Seal Line - 3.0 mm (0.118 in)
- Seal Packing - Three Bond 1207B or equivalent

10. Hand tighten the oil pump drive shaft sprocket with the nut.

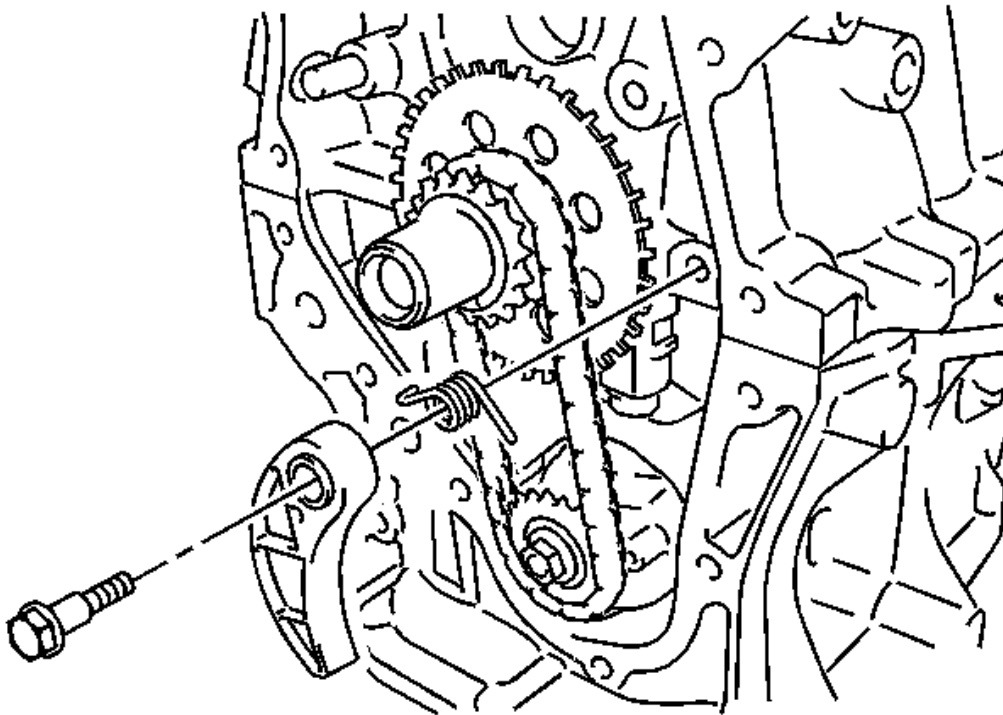


Fig. 189: View Of Chain Tensioner Plate, Spring & Bolt
Courtesy of GENERAL MOTORS CORP.

11. Insert the damper spring into the adjusting hole, and then install the chain tensioner plate with the bolt.

Tighten: Tighten to 10 N.m (7 lb ft).

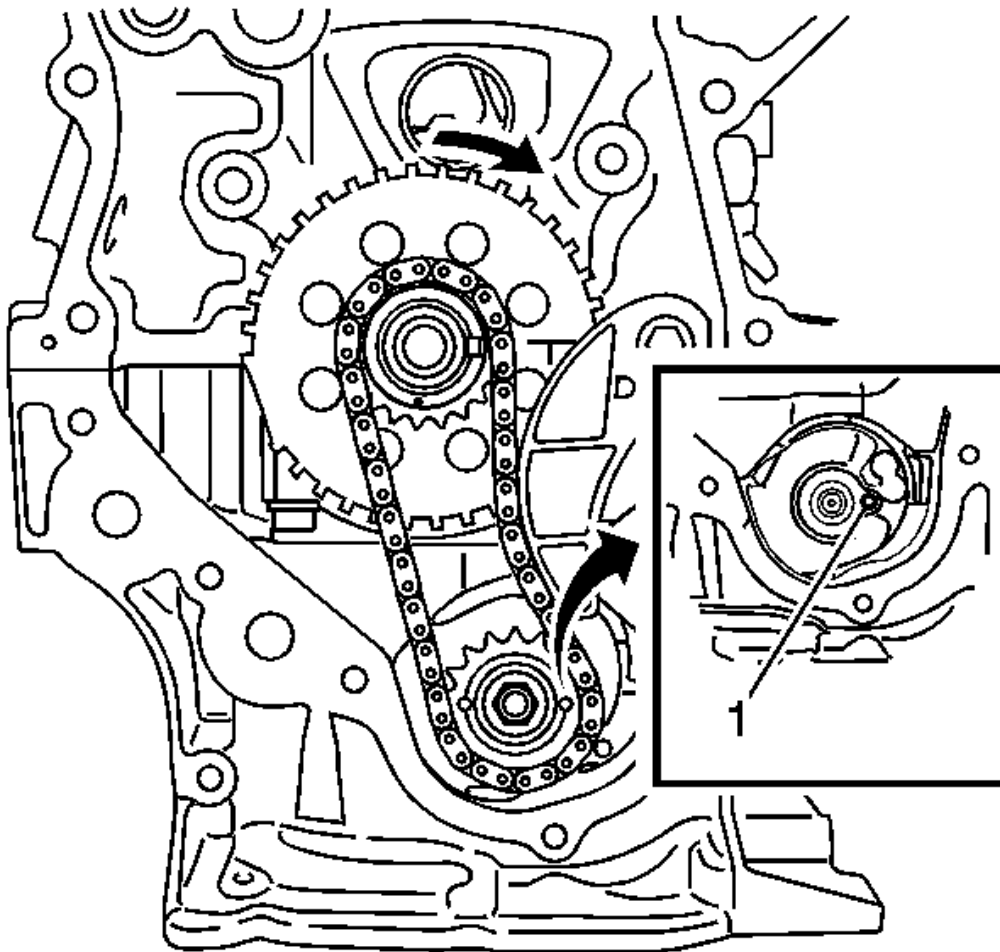


Fig. 190: Aligning Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

12. Align the adjusting hole of the oil pump drive shaft sprocket with the groove of the oil pump.

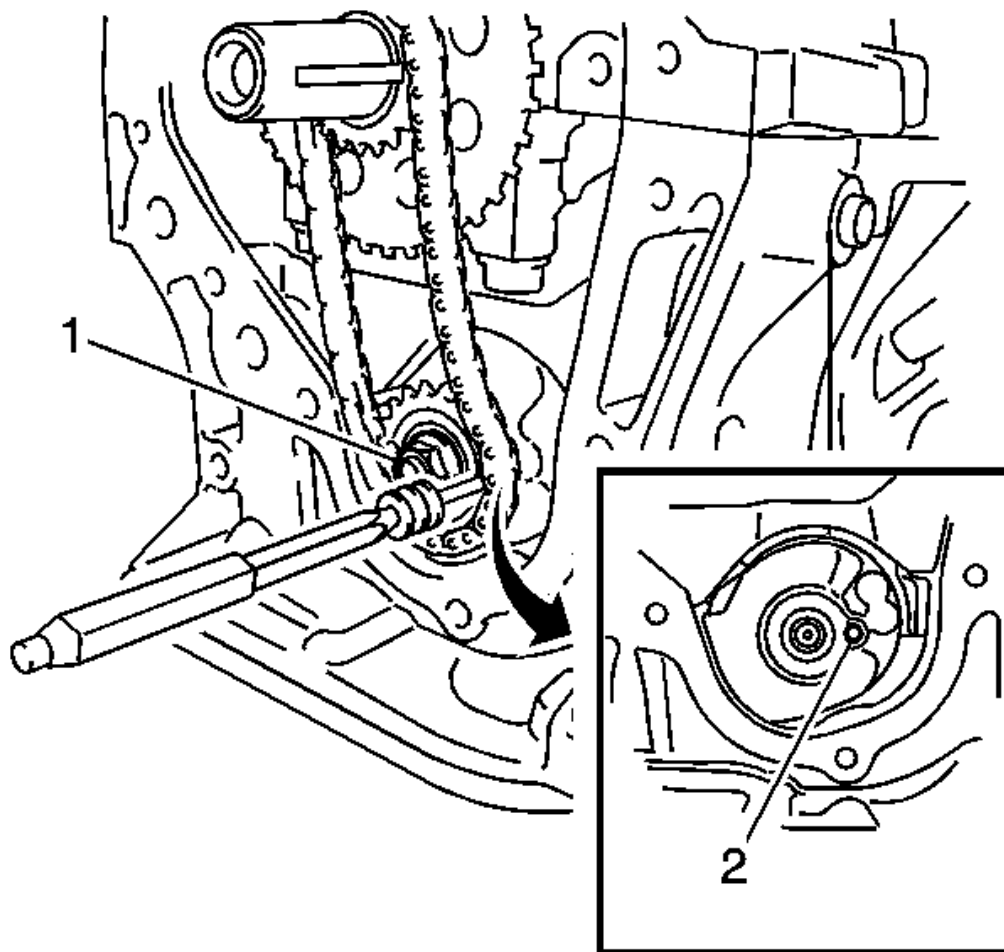


Fig. 191: Identifying Adjusting Hole
Courtesy of GENERAL MOTORS CORP.

13. Insert a pin punch (3 mm) into the adjusting hole of the oil pump drive shaft gear to lock the gear in position, and then tighten the nut.

Tighten: Tighten to 28 N.m (21 lb ft).

14. Install the No. 1 chain vibration damper.

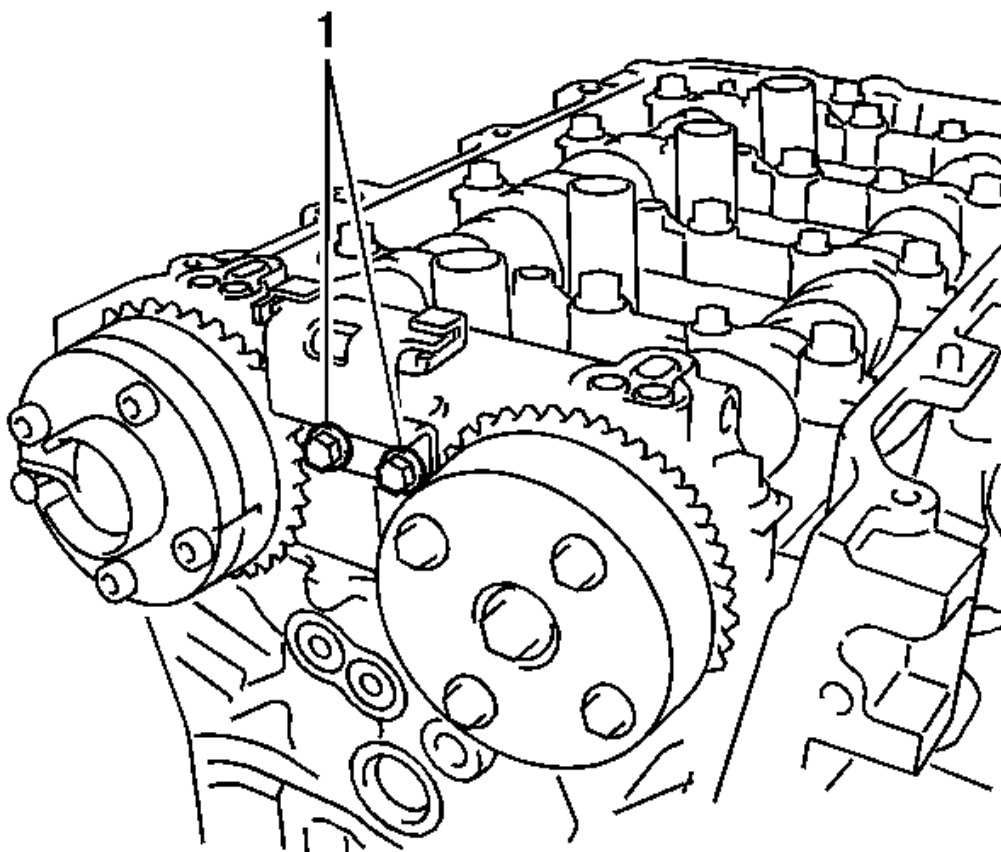


Fig. 192: Identifying Chain Vibration Damper
Courtesy of GENERAL MOTORS CORP.

15. Install the No. 2 chain vibration damper with the 2 bolts.

Tighten: Tighten to 10 N.m (7 lb ft).

16. Install the chain sub-assembly.
17. Install the chain tensioner slipper.

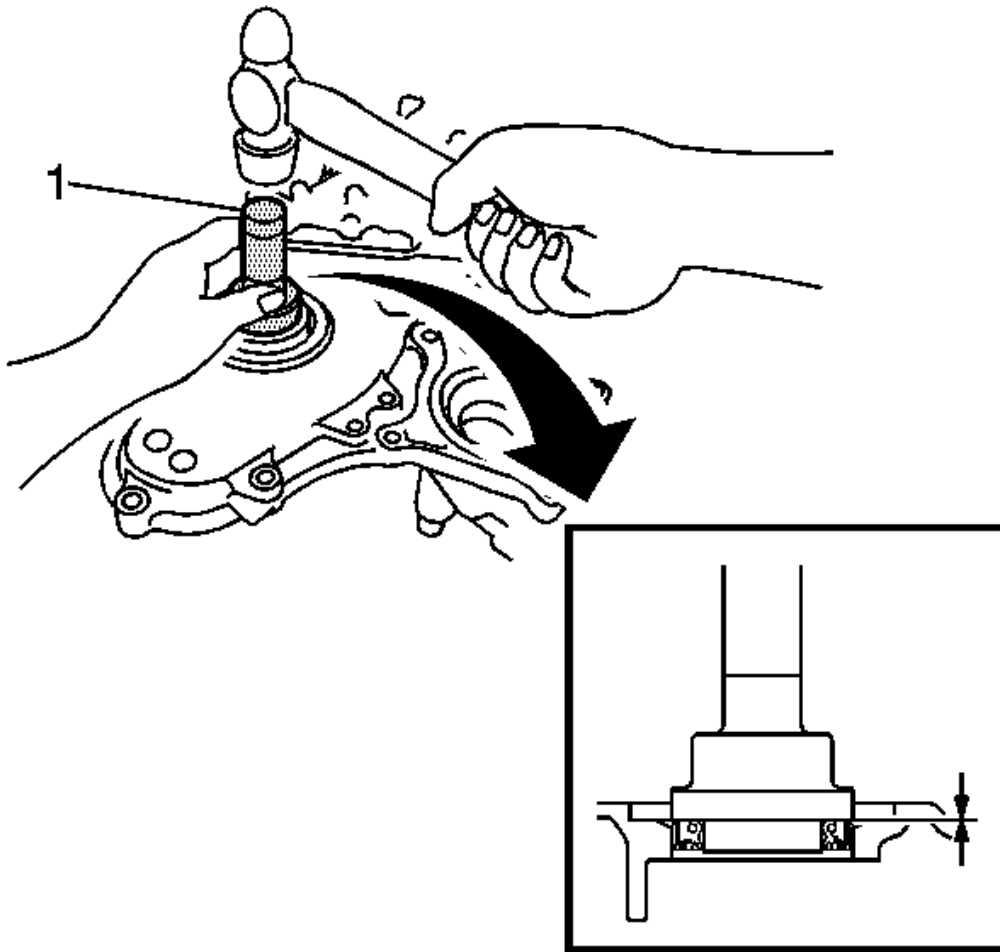


Fig. 193: Tapping In Replacement Oil Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: Keep the lip free from foreign matter. Do not tap the oil seal at an angle.

18. Using SST , tap in a new oil seal until its surface is flush with the timing chain cover sub-assembly edge.
19. Apply MP grease to the lip of the oil seal.
20. Remove any old packing (FIPG) material and be careful not to drop any oil on the contact surfaces of the timing chain cover sub-assembly, cylinder head, and cylinder block.

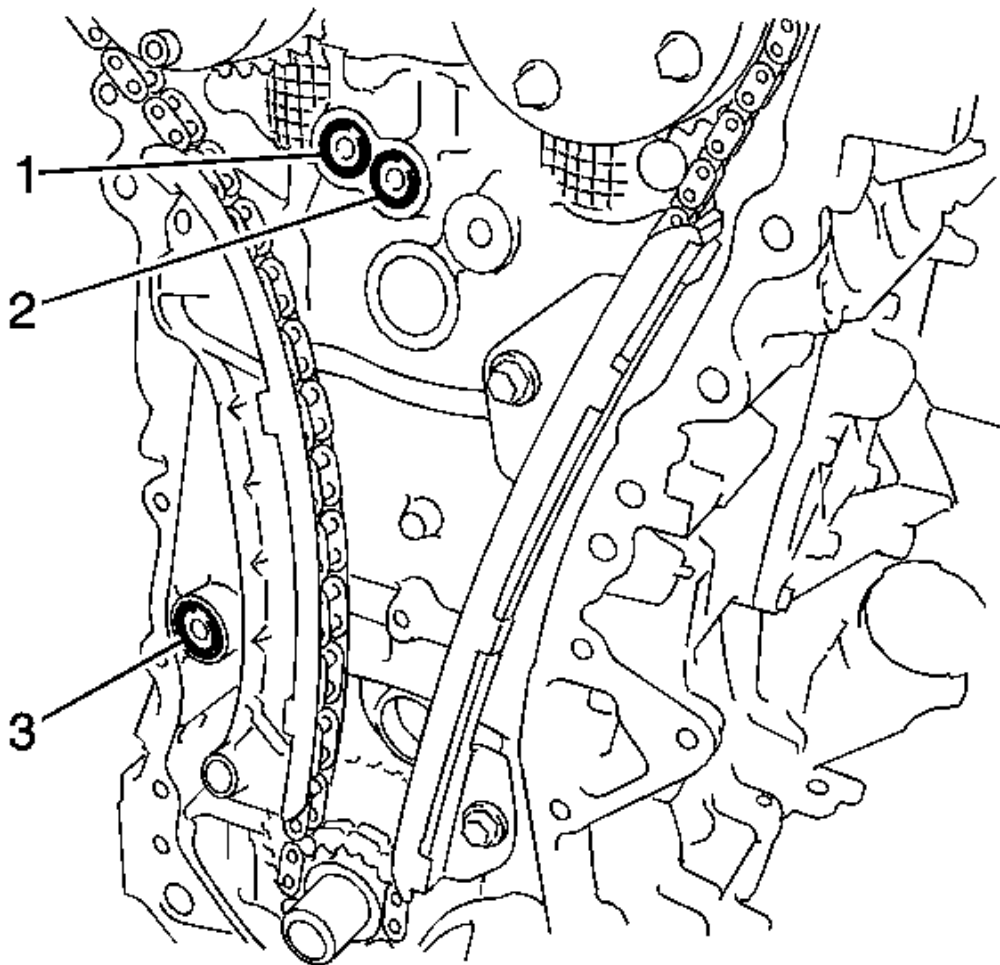


Fig. 194: Locating O-Rings

Courtesy of GENERAL MOTORS CORP.

21. Install the 3 new O-rings.
22. Apply Toyota Genuine Seal Packing Black, Three Bond 1207B or equivalent.

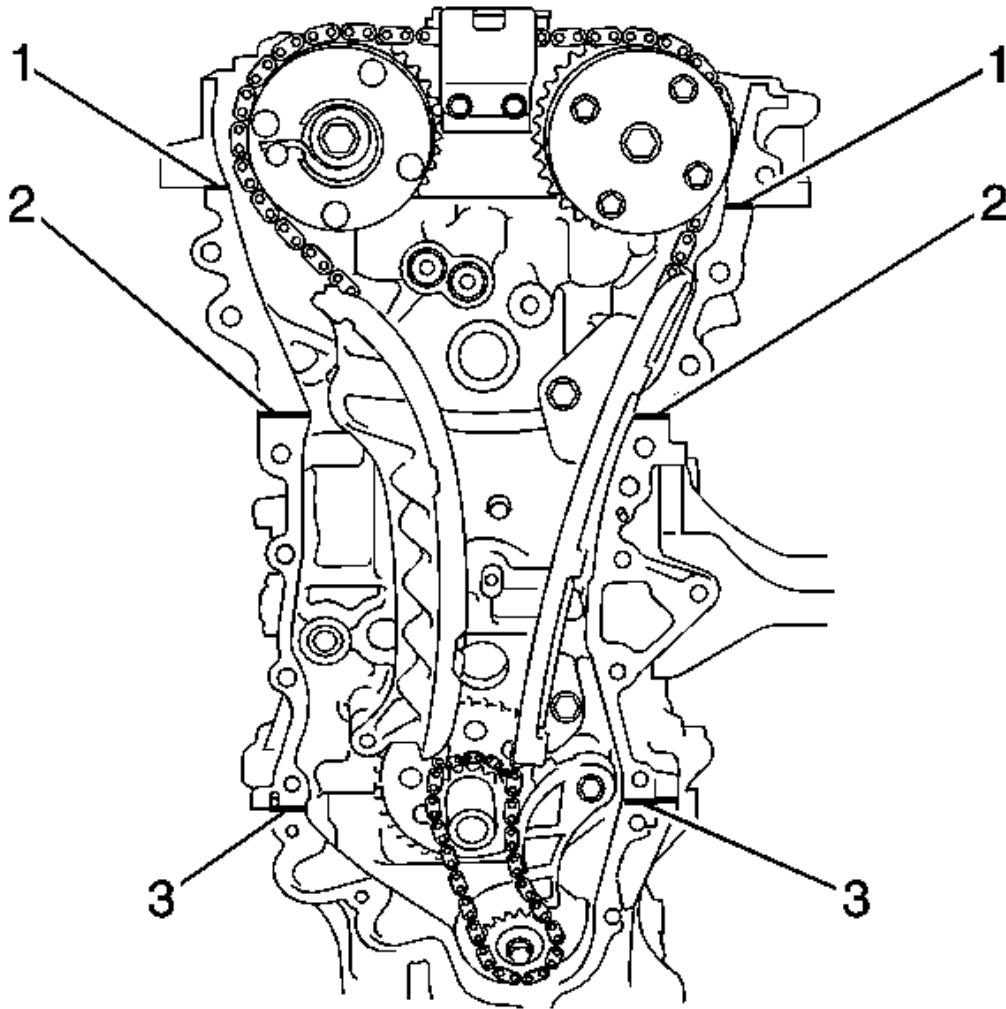


Fig. 195: View Of Chain Cover Contact Surfaces
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Remove any oil from the contact surfaces.
- Install the chain cover within 3 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after installing the timing chain cover sub-assembly.

23. Apply seal packing to the timing chain cover subassembly in a continuous line.

Specification: Seal diameter: 5.0 mm (0.196 in).

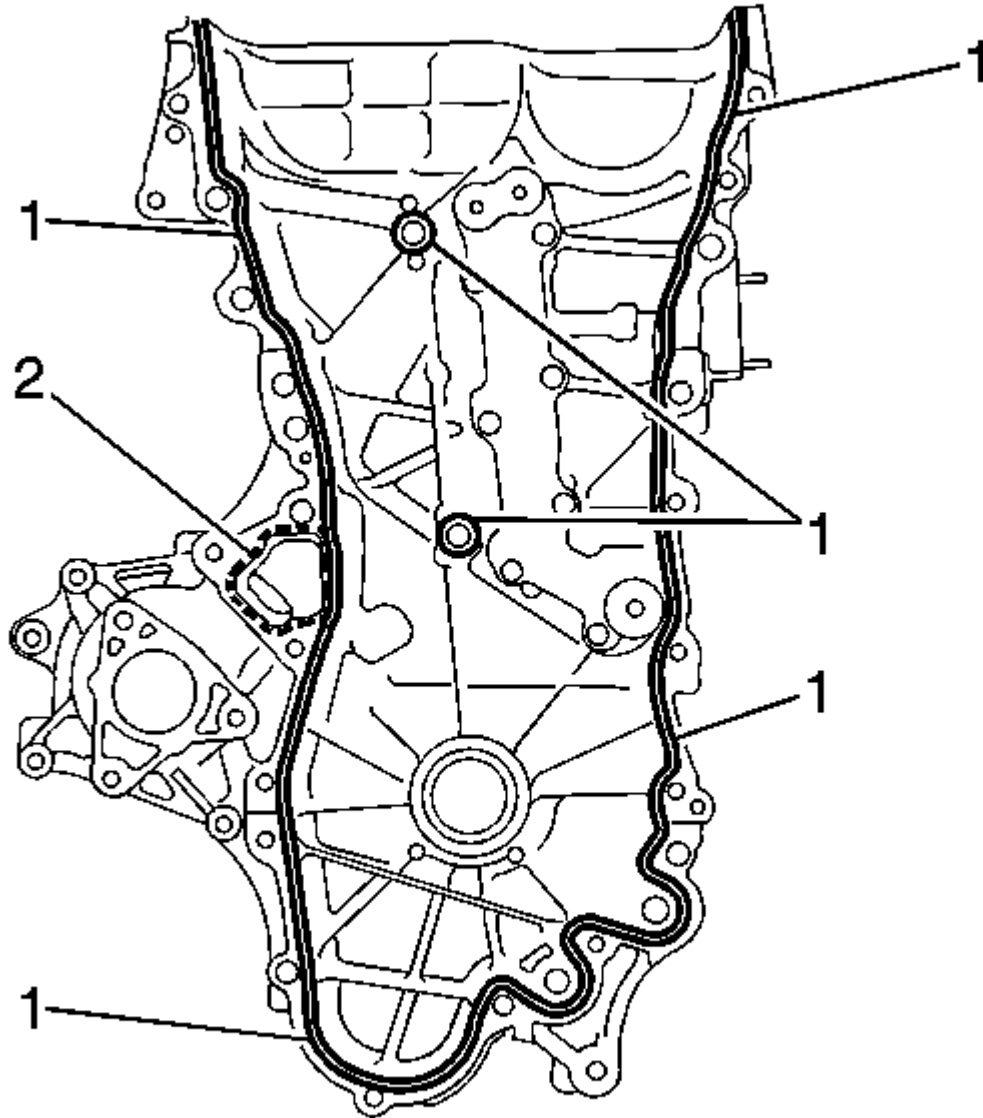


Fig. 196: Identifying Sealant Area For Timing Chain Cover
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- When the contact surfaces are wet, wipe them with oil-free cloth before applying seal packing.
- Install the timing chain cover sub-assembly within 3 minutes and tighten the bolts within 15 minutes after applying seal packing.

- **Do not start the engine for at least 2 hours after installing.**

24. Hand install the timing chain cover subassembly with the 19 bolts.

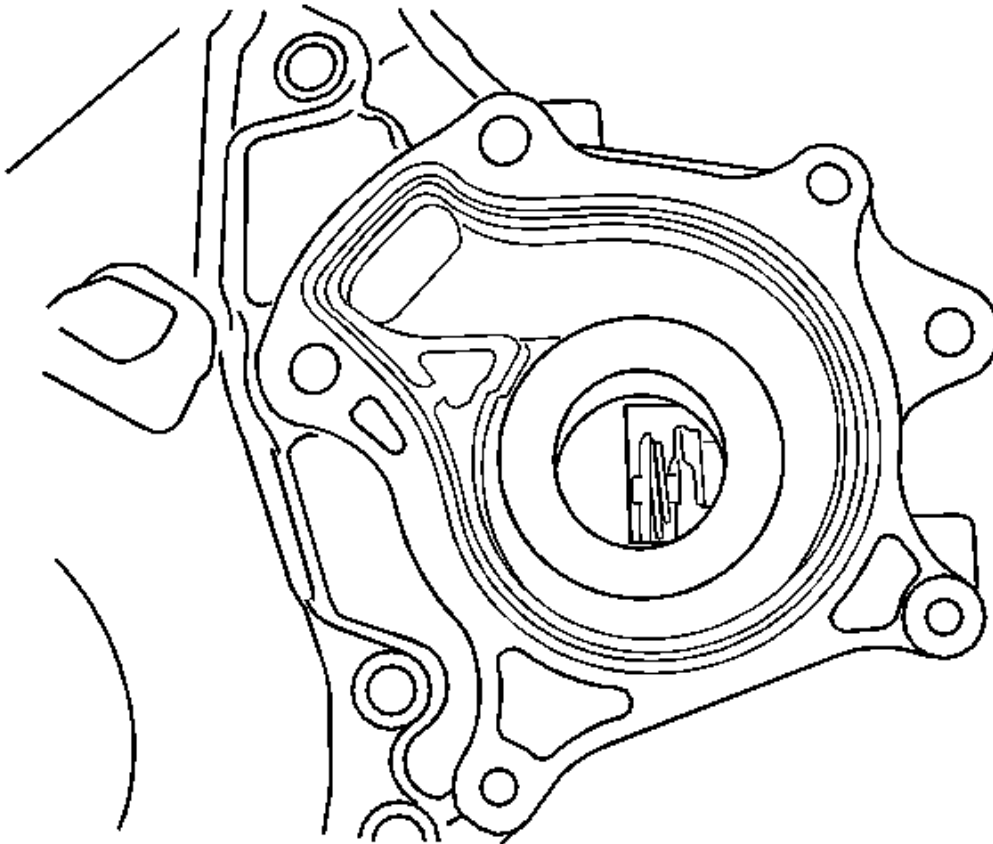


Fig. 197: Identifying Water Pump Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove any oil from the contact surfaces.

25. Install a new gasket.

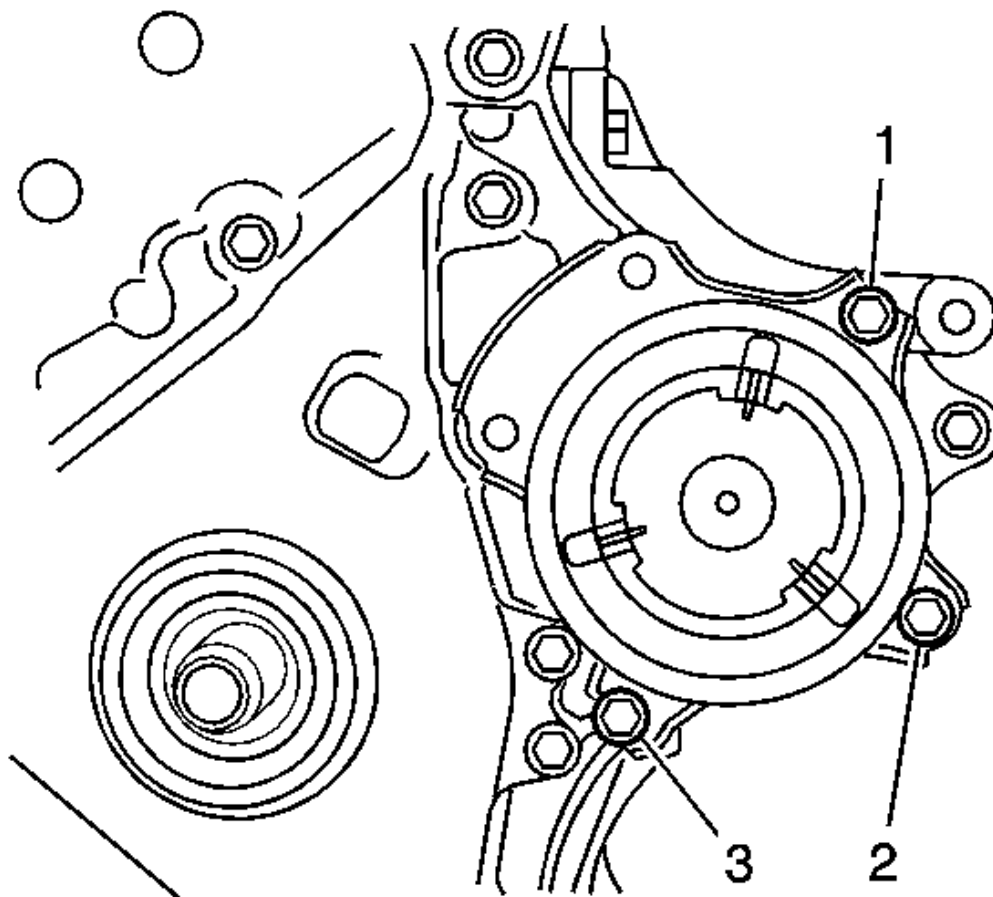


Fig. 198: Identifying Water Pump Bolts
Courtesy of GENERAL MOTORS CORP.

26. Install the water pump with the 3 bolts.

Tighten: Tighten to 24 N.m (18 lb ft).

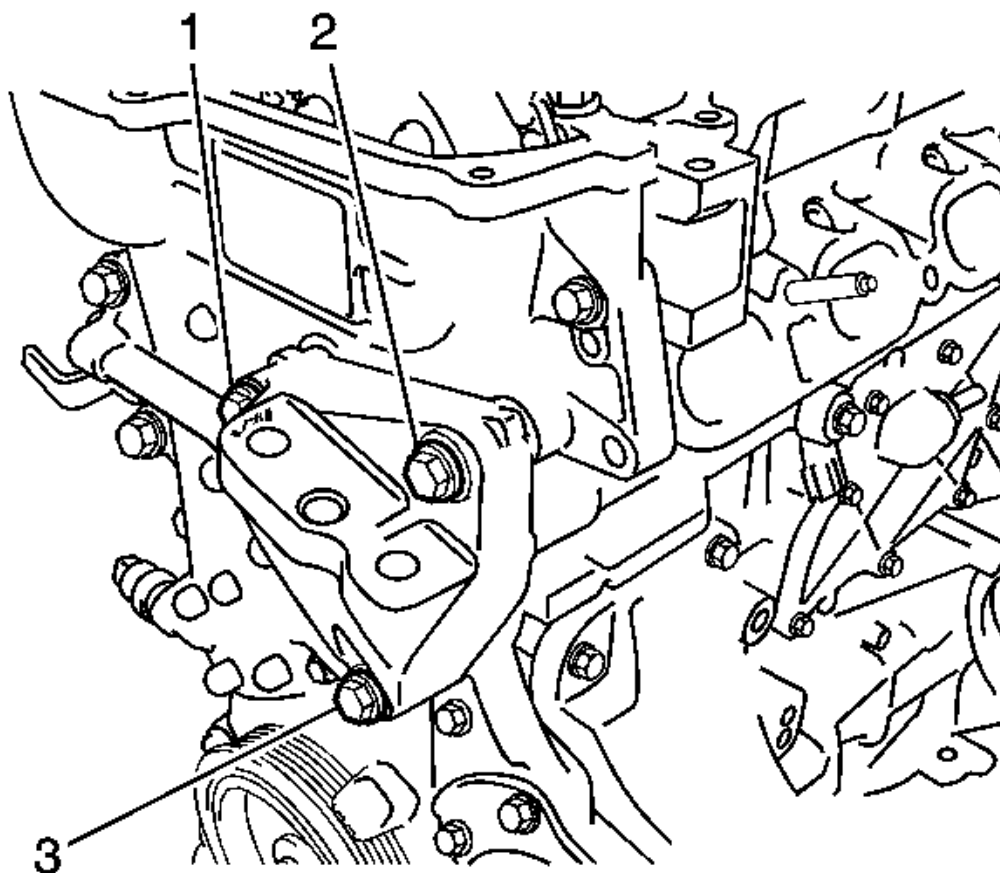


Fig. 199: Identifying Mounting Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not start the engine for at least 2 hours after installation.

27. Install the mounting bracket within 10 minutes after installing the timing chain cover sub-assembly.
28. Hand tighten the engine mounting bracket with the 3 bolts.

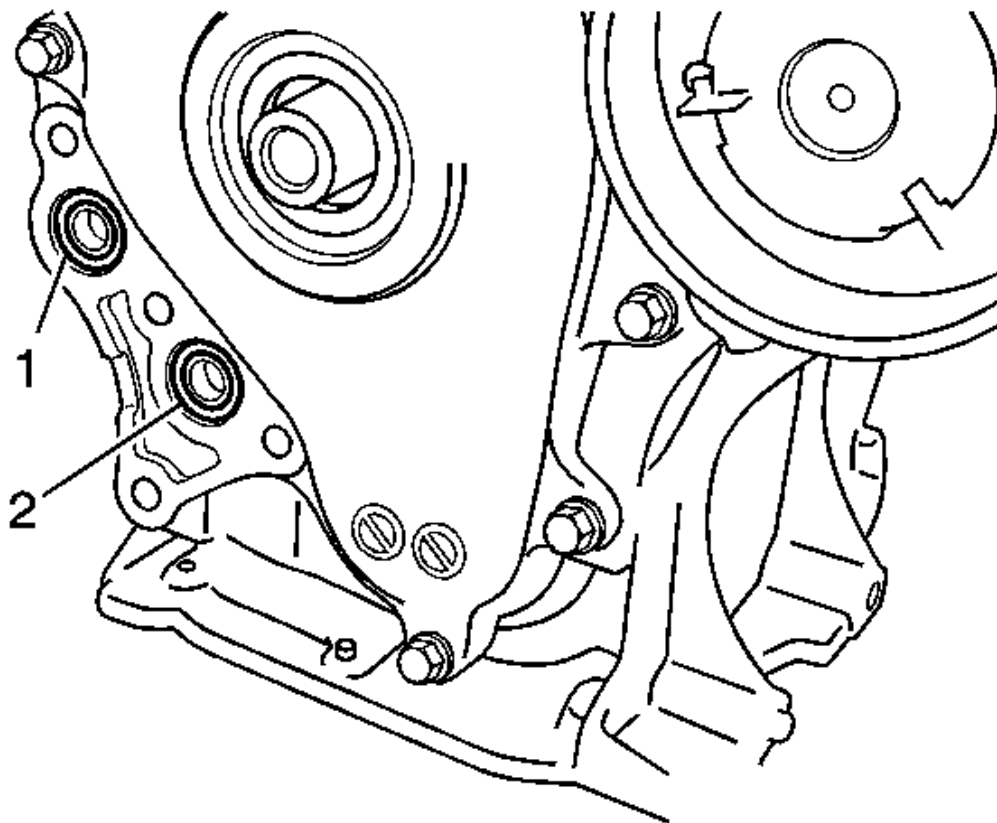


Fig. 200: Identifying 2 New O-Rings
Courtesy of GENERAL MOTORS CORP.

29. Install 2 new O-rings.

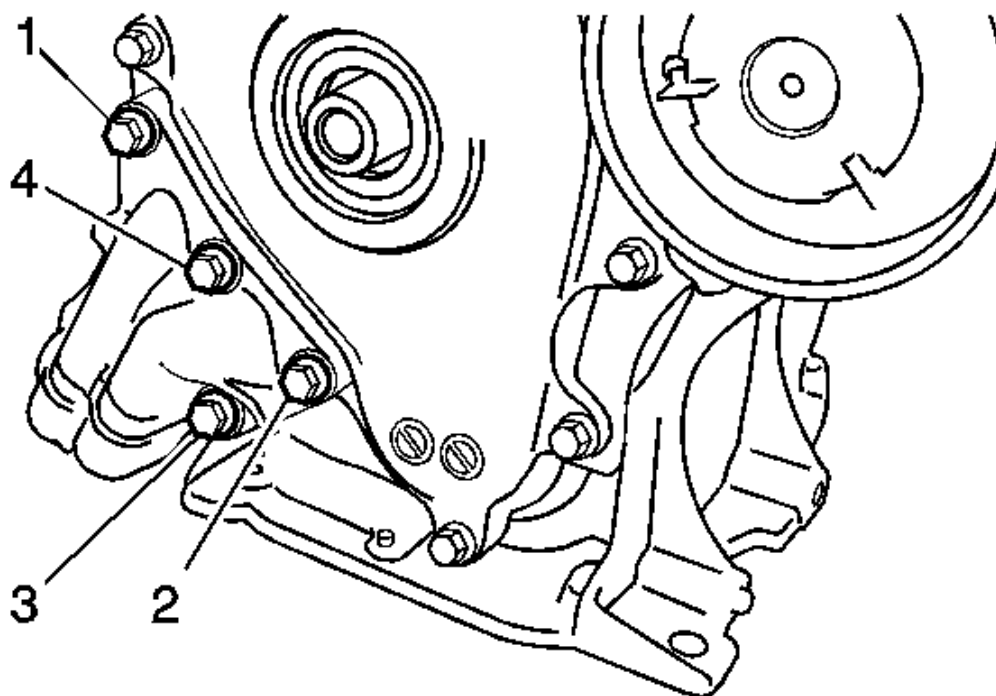


Fig. 201: Identifying Oil Filter Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not start the engine for at least 2 hours after installation.

30. Install the oil filter bracket within 10 minutes after installing the chain cover.
31. Temporarily tighten the oil filter bracket with the 4 bolts.
32. Apply Toyota Genuine Adhesive 1324, Three Bond 1324 or equivalent to the threads of the bolt E.

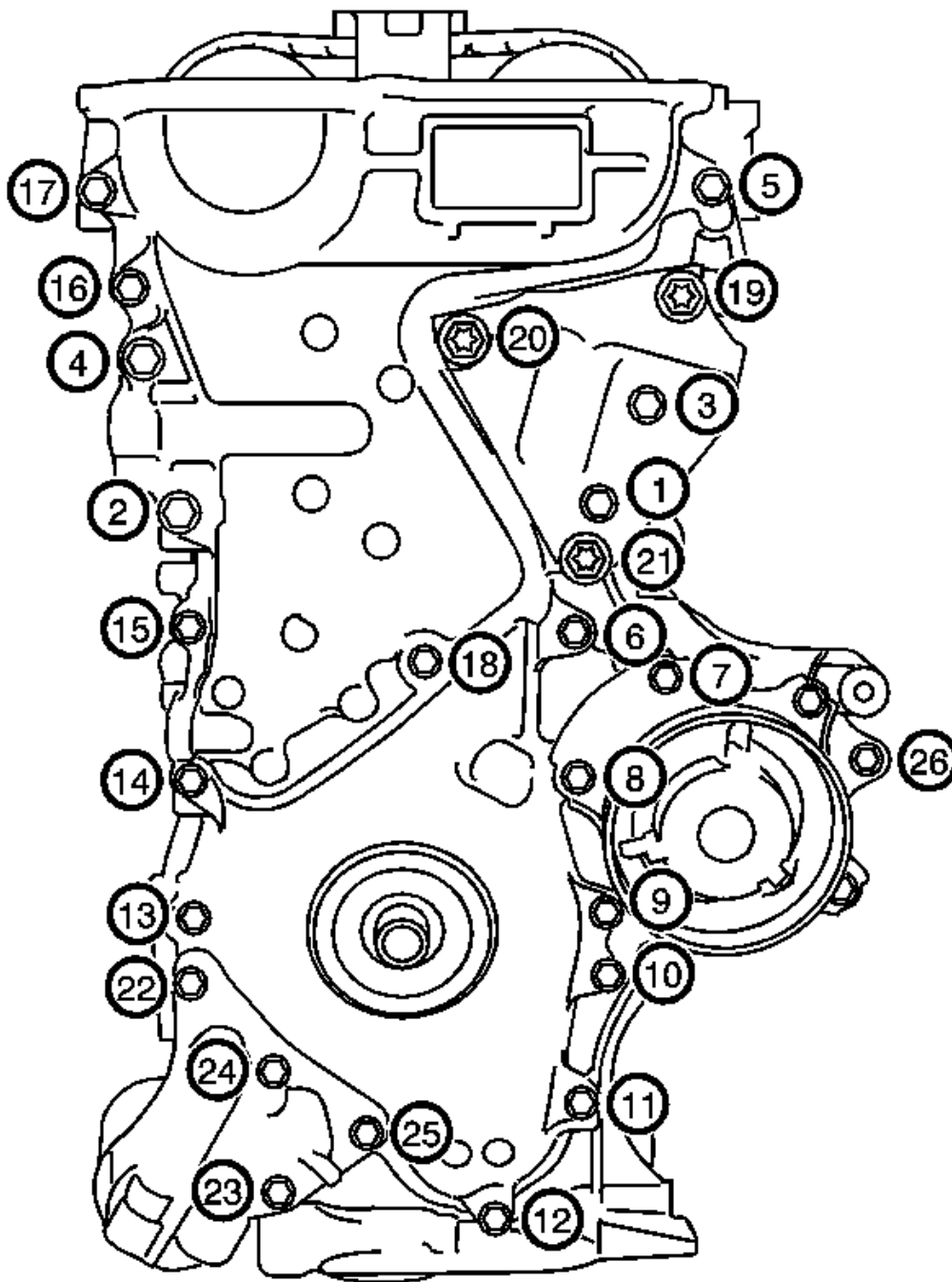


Fig. 202: Identifying Front Cover Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- When the contact surfaces are wet, wipe them with oil-free cloth before applying seal packing.
- Do not start the engine for at least 2 hours after installing

33. Install the chain cover within 3 minutes and tighten the bolts within 15 minutes after applying the seal packing.
34. Fully tighten the timing chain cover sub-assembly with the 26 bolts.

Tighten:

- Tighten the bolts A and E to 26 N.m (19 lb ft).
 - Tighten the bolts B and C to 51 N.m (37 lb ft).
 - Tighten the bolt D to 10 N.m (7 lb ft).
35. Install the crankshaft pulley.
 36. Install the No. 1 chain tensioner assembly.
 37. Install the cylinder head cover sub-assembly.
 38. Install the radio setting condenser.
 39. Install the thermostat.
 40. Install the inlet water.
 41. Install the inlet water hose.
 42. Install the water by-pass hose.
 43. Install the No. 1 water by-pass pipe.
 44. Install the No. 3 water by-pass hose.
 45. Install the ventilation hose.
 46. Inspect the exhaust manifold.
 47. Install the exhaust manifold.
 48. Install the manifold stay.
 49. Install the No. 1 exhaust manifold heat insulator.
 50. Install the oil level dipstick sub-assembly.
 51. Install the ignition coil assembly.
 52. Install the fuel injector assembly.
 53. Install the No. 1 delivery pipe spacer.
 54. Install the fuel delivery pipe sub-assembly.
 55. Install the fuel tube sub-assembly.
 56. Install the intake manifold.
 57. Remove the engine stand.
 58. Install the engine assembly with transaxle.

2009 Pontiac Vibe

2009 ENGINE Engine Mechanical - 1.8L (LAY) - Vibe

Area	Seal Packing Diameter	from Inside Seal Line	Seal Packing
Continuous Line Area	0.118 in. (3.0 mm)	0.098 in. (2.5 mm)	Toyota Genuine Seal Packing Black, Three Bond 1207B or equivalent
Dashed Line Area	0.156 in. (4.0 mm)	0.118 in. (3.0 mm)	Toyota Genuine Seal Packing Black 1282B, Three Bond 1282B or equivalent

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Removal Procedure

1. Remove the engine assembly with transaxle. Refer to **Engine Replacement**
2. Remove the transaxle assembly.
3. Remove the clutch cover assembly and disc for the manual transaxle.

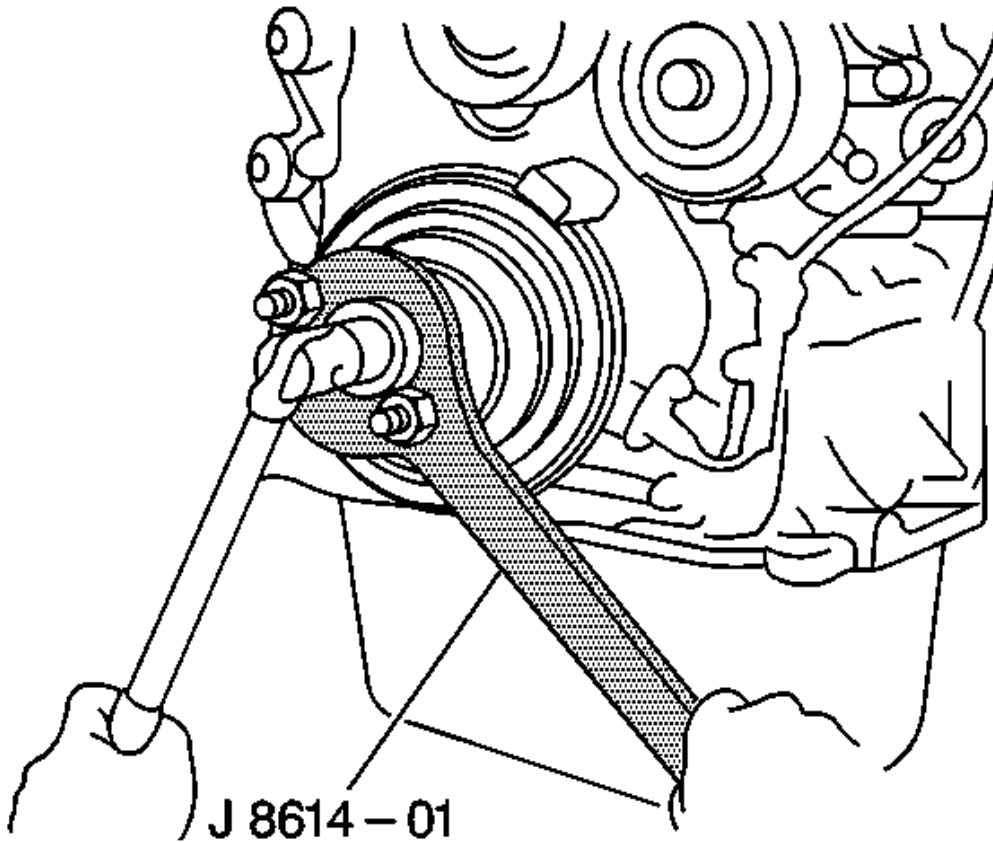


Fig. 203: View Of Crankshaft Pulley & Special Tool
Courtesy of GENERAL MOTORS CORP.

4. Remove the clutch disc assembly-for manual transaxle.
5. Using SST, hold the crankshaft.

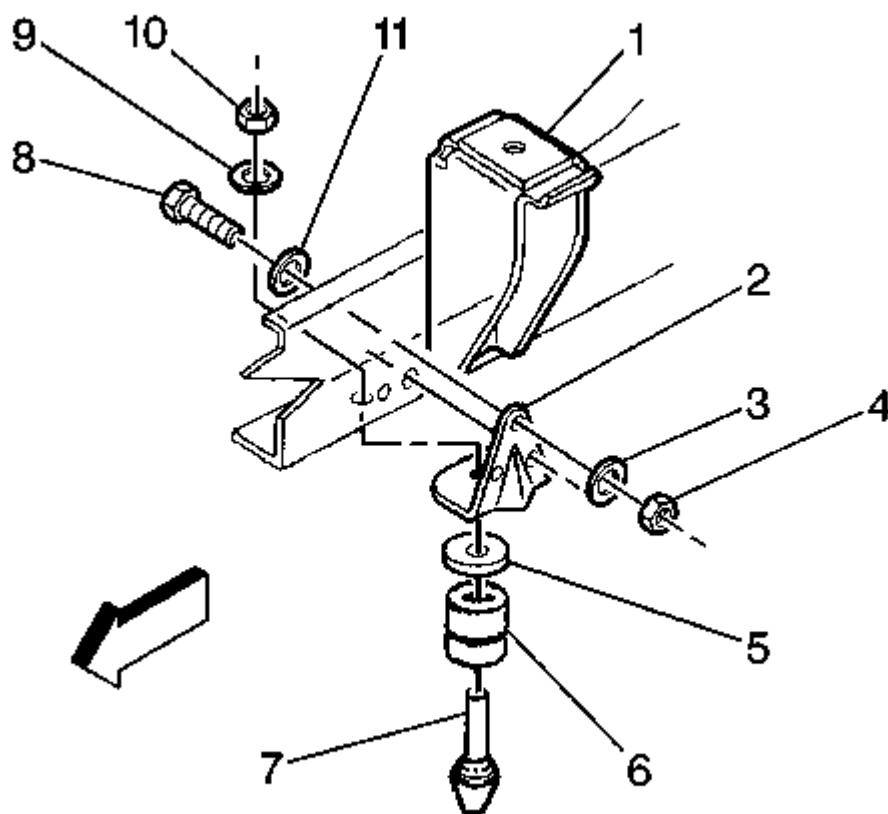


Fig. 204: Disassembled View Of Spring Bumper Assembly
 Courtesy of GENERAL MOTORS CORP.

6. Remove the 8 bolts and the flywheel.
7. Remove the drive plate and ring gear sub-assembly, if equipped with automatic transmission.
8. Using SST, hold the crankshaft.

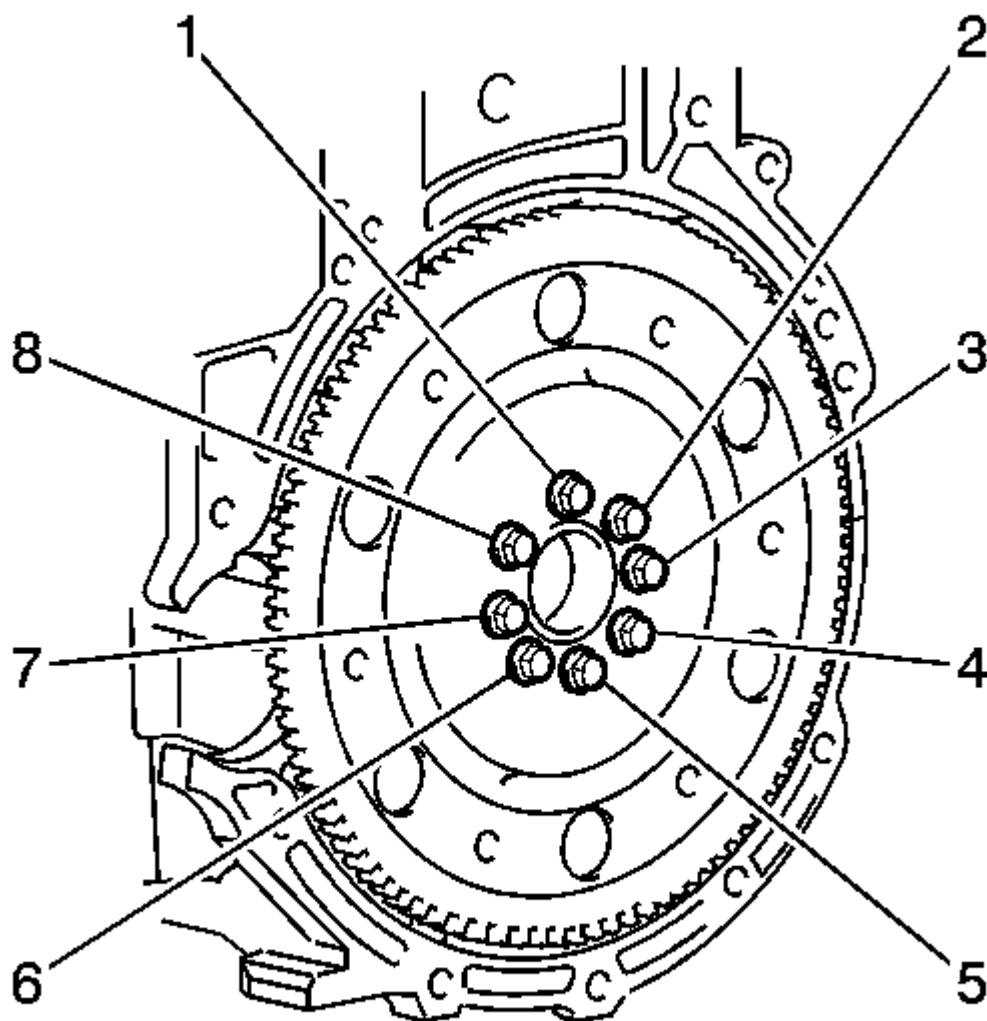


Fig. 205: Identifying Drive Plate Loosening Sequence
Courtesy of GENERAL MOTORS CORP.

9. Remove the 8 bolts, rear spacer, drive plate and front spacer.
10. Remove the rear engine oil seal.
11. Using a knife, cut off the lip of the oil seal.

NOTE: After removing, check the crankshaft for nicks or burrs. Smooth the surface with 400-grit sandpaper.

12. Using a screwdriver with its tip wrapped with tape, pry out the oil seal.

Installation Procedure

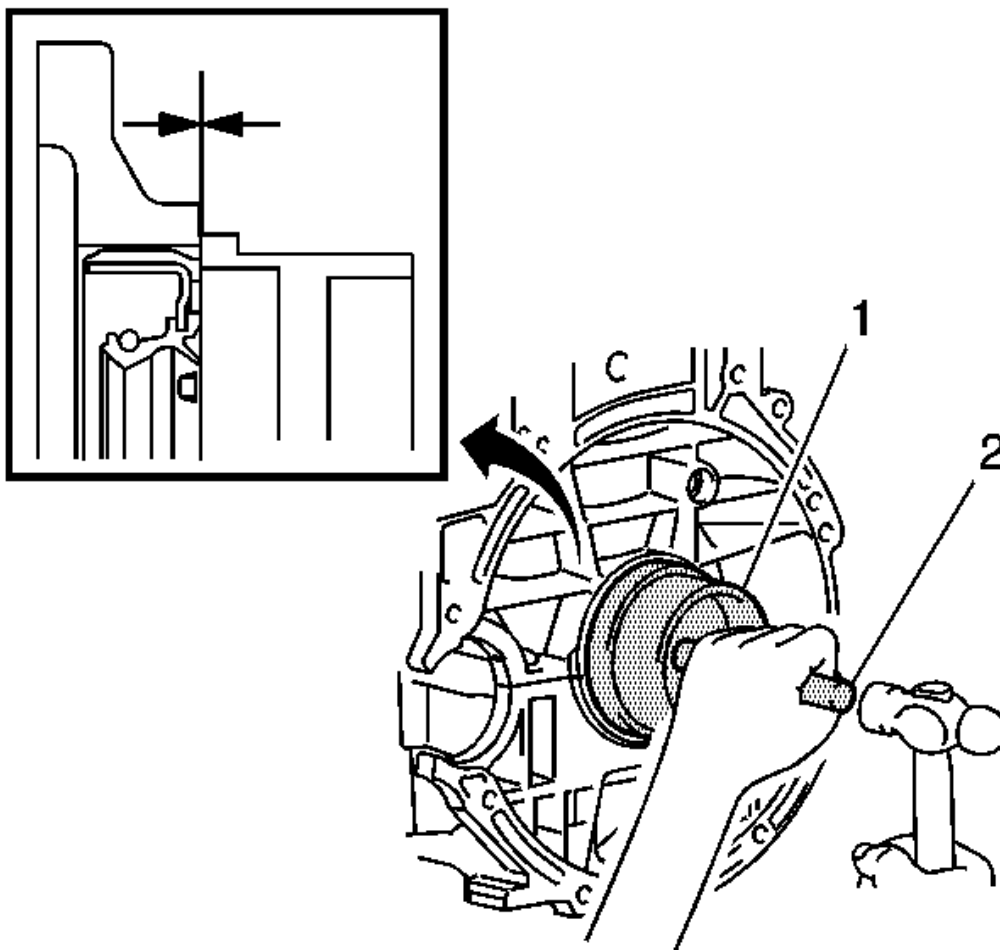


Fig. 206: Illustrating Front Cover Oil Seal Installation
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Keep the lip free from foreign matter.

1. Apply MP grease to the lip of a new oil seal.

IMPORTANT:

- Wipe any extra grease off the crankshaft.
- Do not tap the oil seal at an angle.

2. Using SST and a hammer, tap in the oil seal until its surface is flush with the rear oil seal retainer edge.

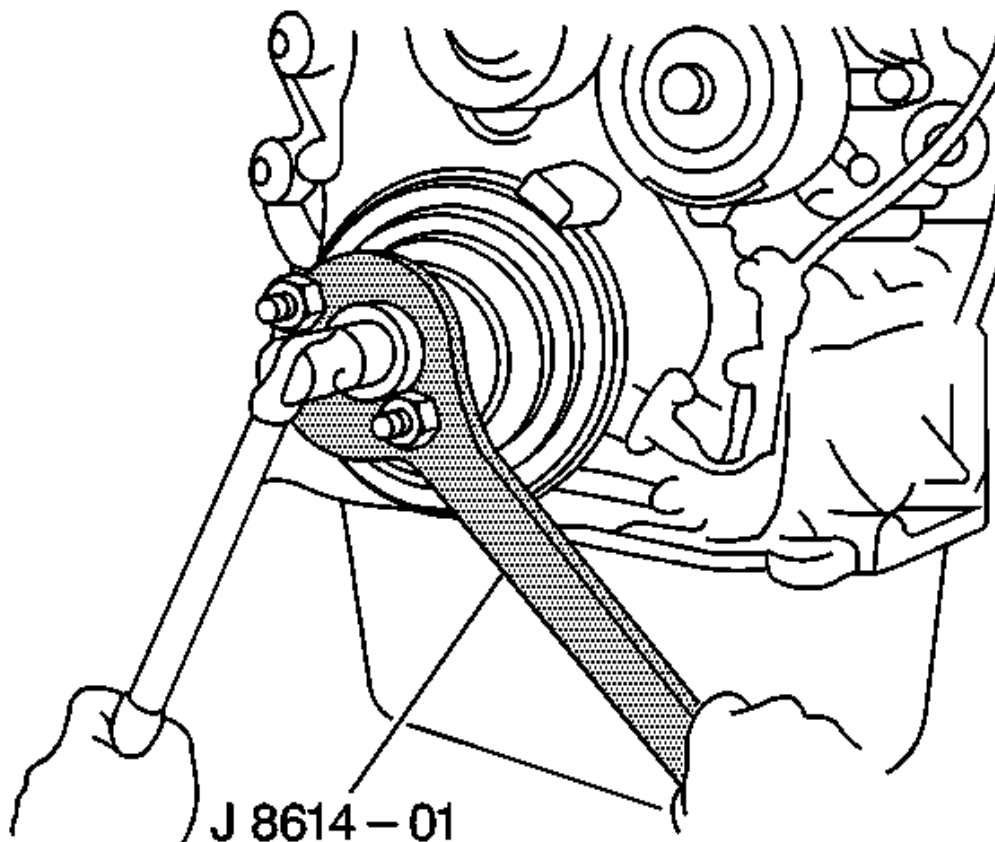


Fig. 207: View Of Crankshaft Pulley & Special Tool
Courtesy of GENERAL MOTORS CORP.

3. Install the flywheel sub-assembly for the manual transaxle.
4. Using SST, hold the crankshaft.

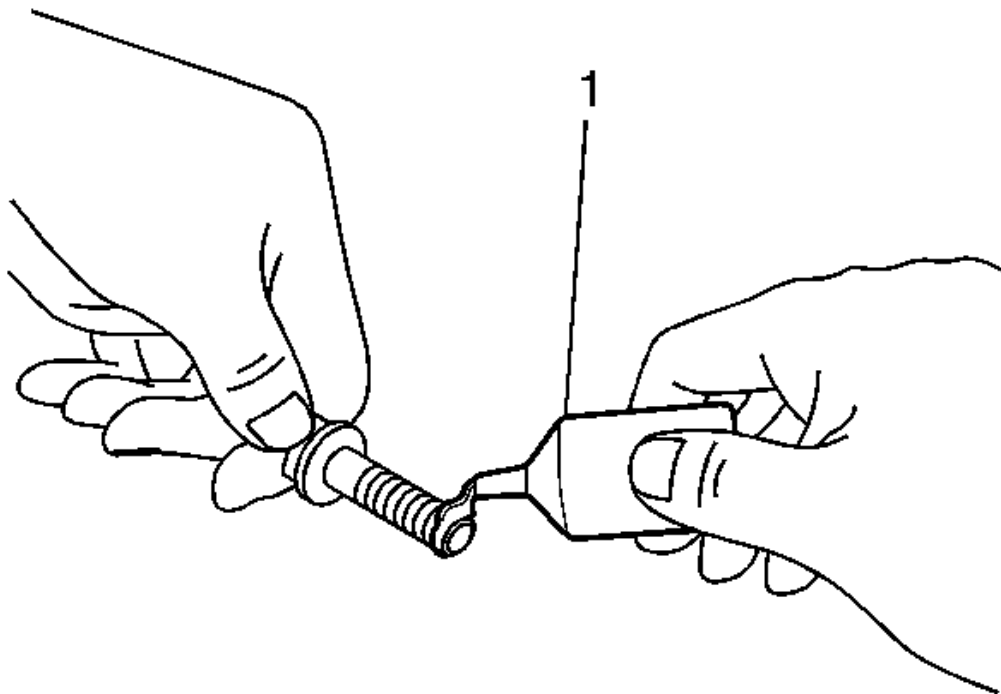


Fig. 208: Applying Adhesive To Bolt
Courtesy of GENERAL MOTORS CORP.

5. Apply adhesive Three Bond 1324 or equivalent to 2 or 3 end threads of the new bolts.

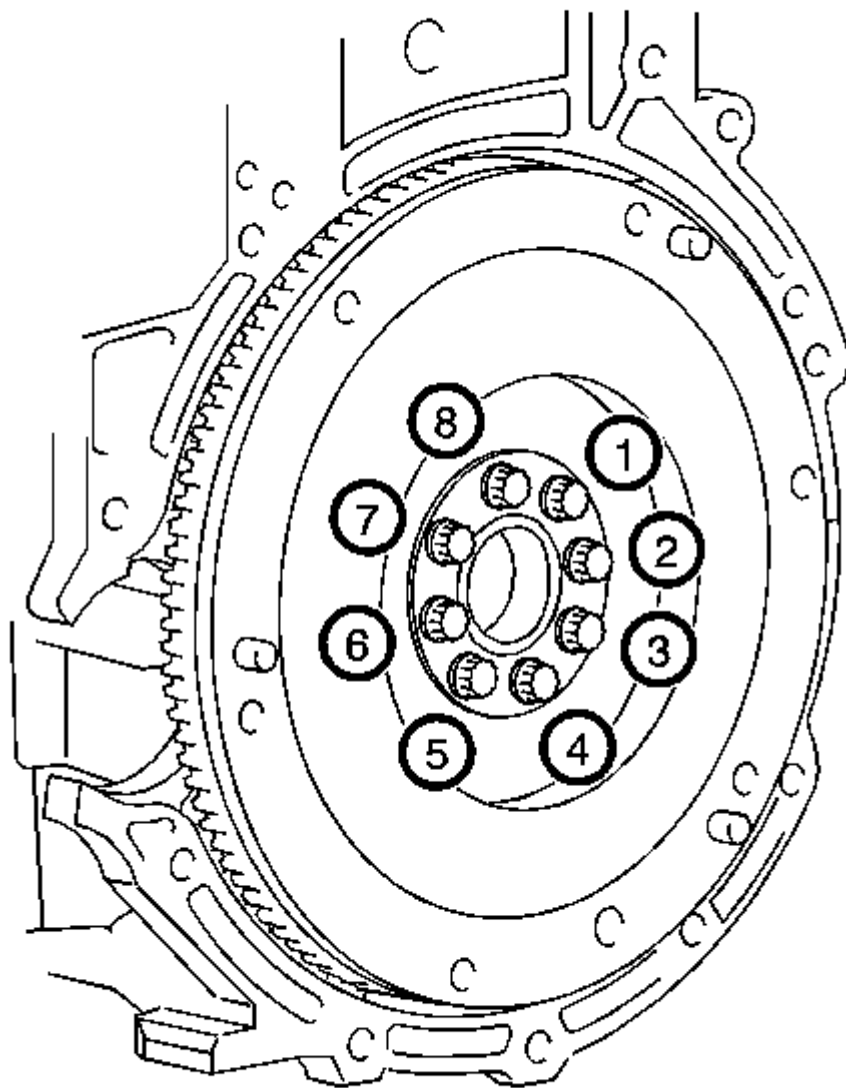


Fig. 209: Identifying Flywheel/Flexplate Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to **FASTENER CAUTION** .

6. Using several steps, uniformly install and tighten the 8 bolts in the sequence.

Tighten: Tighten the bolts to 49 N.m (36 lb ft).

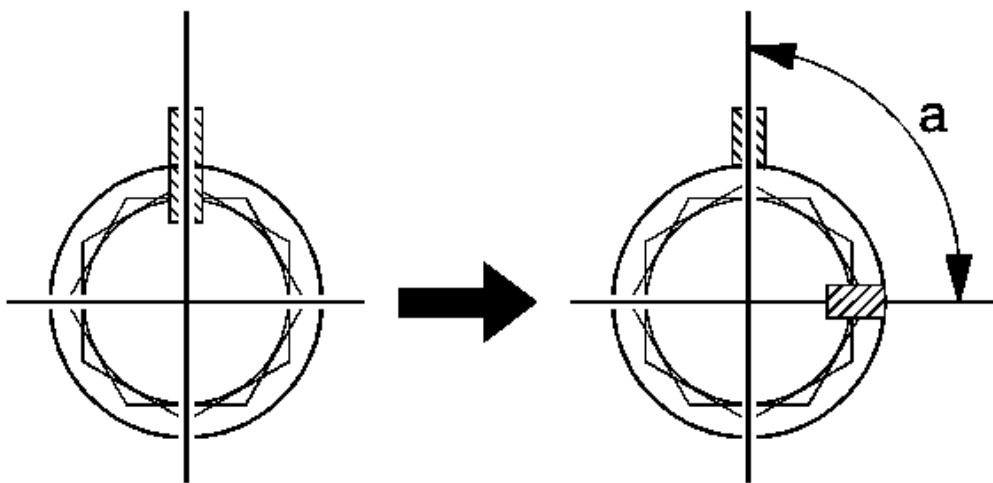


Fig. 210: Identifying Flywheel/Flexplate Tightening Final Step
Courtesy of GENERAL MOTORS CORP.

7. Mark the front of the bolts with paint.
8. Retighten the 8 bolts an additional 90 degrees in the same sequence.
9. Check that the paint marks are now at a 90 degree angle to the front.
10. Check that the crankshaft turns smoothly.

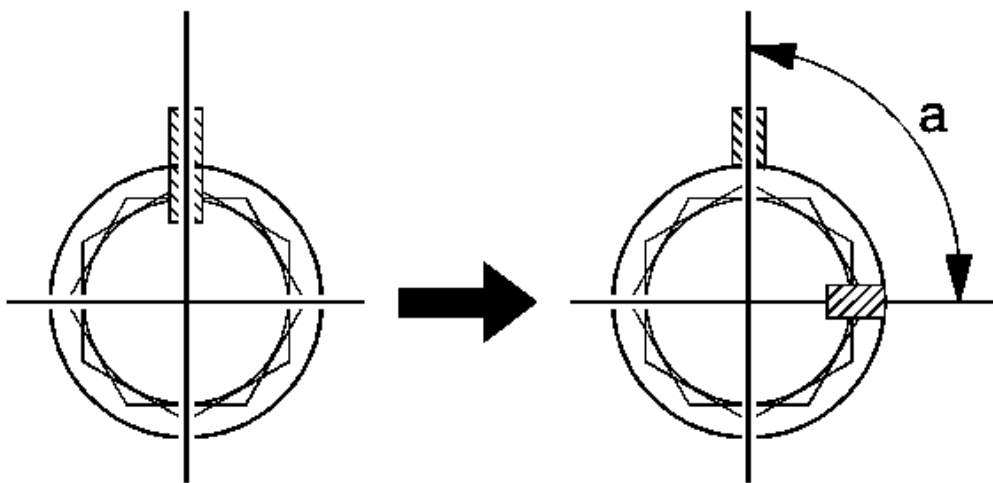


Fig. 211: Identifying Flywheel/Flexplate Tightening Final Step
Courtesy of GENERAL MOTORS CORP.

11. Install the drive plate and ring gear sub-assembly-for Automatic Transaxle.
12. Using SST, hold the crankshaft.
13. Clean the bolts and the bolt holes.
14. Apply adhesive Three Bond 1324 or equivalent to 2 or 3 threads of the bolt ends.

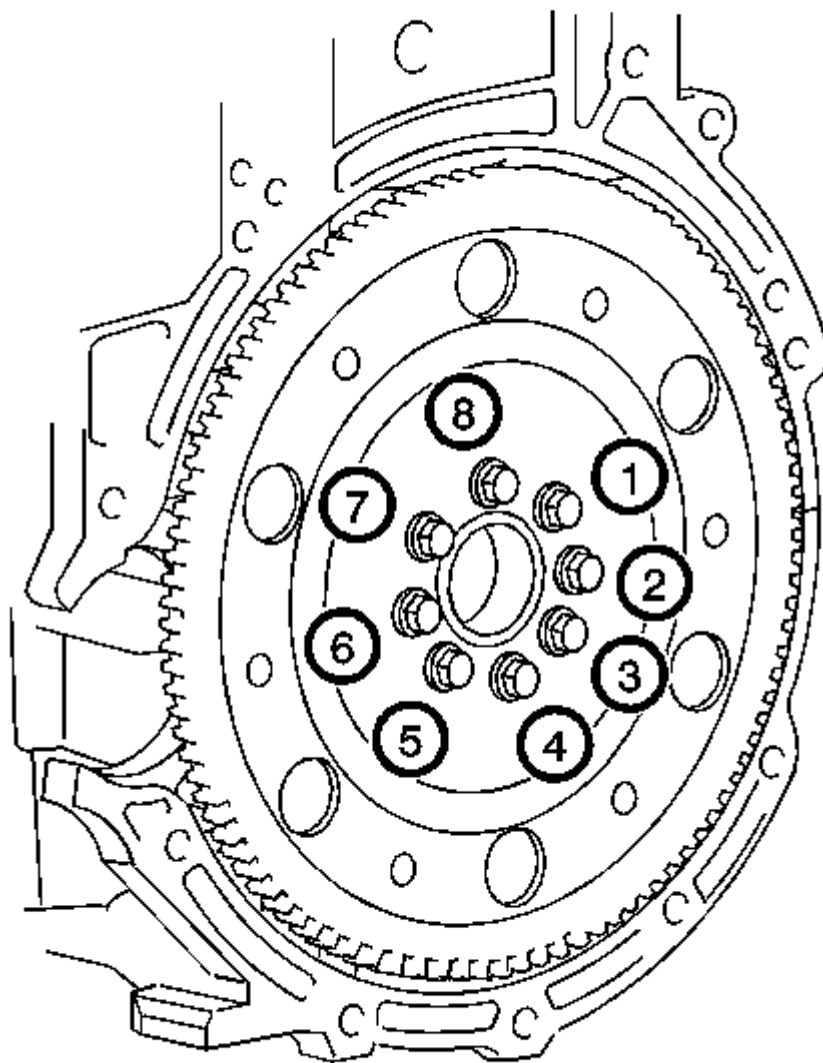


Fig. 212: View Of Front Spacer, Rear Spacer & Drive Plate Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

15. Install the front spacer, drive plate and rear spacer with the 8 bolts. uniformly tighten the 8 bolts in the sequence.

Tighten: Tighten the bolts to 88 N.m (65 lb ft).

16. Install the clutch disc assembly and clutch cover for the manual transaxle.

17. Inspect and adjust clutch cover assembly for the manual transaxle.
18. Install the manual transaxle assembly for the manual transaxle.
19. Install the automatic transaxle assembly for the automatic transaxle.
20. Install the engine assembly with transaxle. Refer to **Engine Replacement**.

ENGINE REPLACEMENT

Removal Procedure

1. Discharge the fuel system pressure. Refer to **Fuel Pressure Relief**.
2. Align the front wheels facing straight ahead.
3. Remove the front wheel.
4. Remove the engine under cover LH.
5. Remove the engine under cover RH.
6. Drain the engine coolant. Refer to **Cooling System Draining and Filling**.
7. Drain the manual transaxle oil for the manual transaxle.
8. Drain the automatic transaxle fluid for the automatic transaxle.

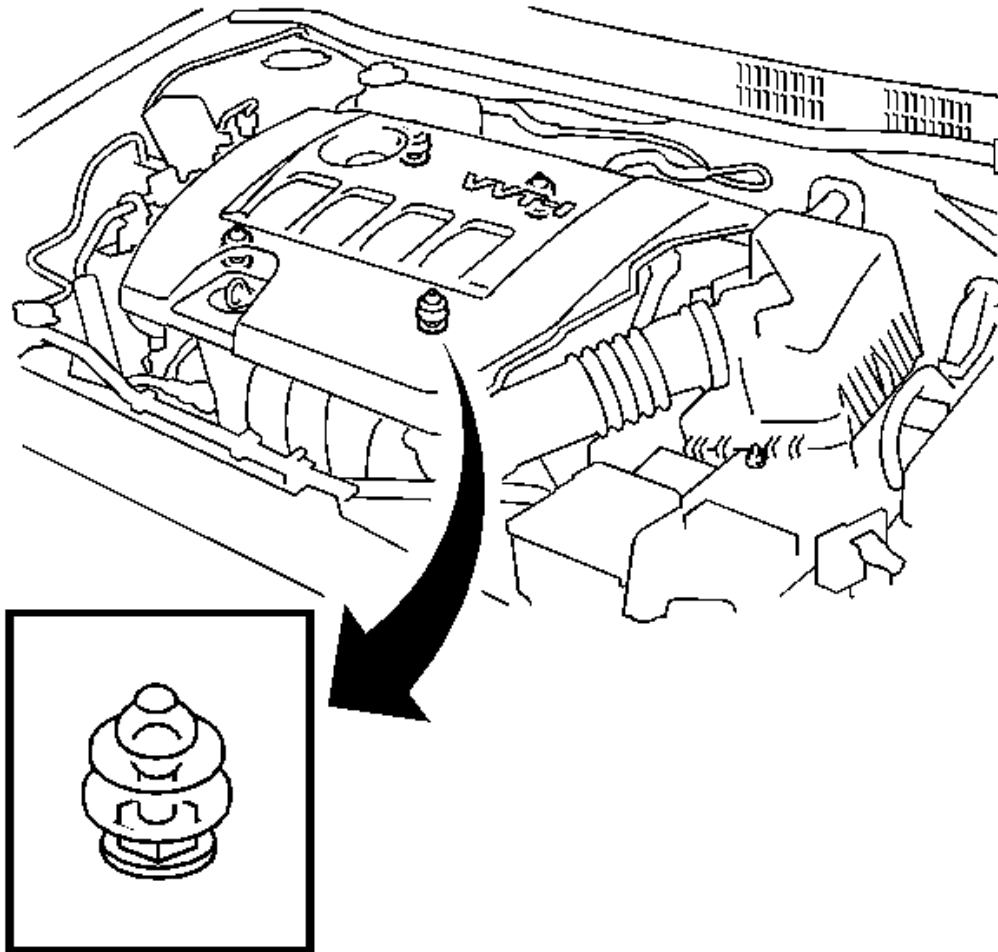


Fig. 213: View Of Engine & Rear Clips
Courtesy of GENERAL MOTORS CORP.

NOTE: Attempting to disengage both front and rear clips at the same time may cause the cover to break.

9. Remove the engine cover.

Hold the rear of the cover and raise it to disengage the 2 clips on the rear of the cover. Continue to raise the cover to disengage the 2 clips on the front of the cover and remove the cover.

10. Remove the air cleaner assembly.
11. Separate the air cleaner filter element from the air cleaner.

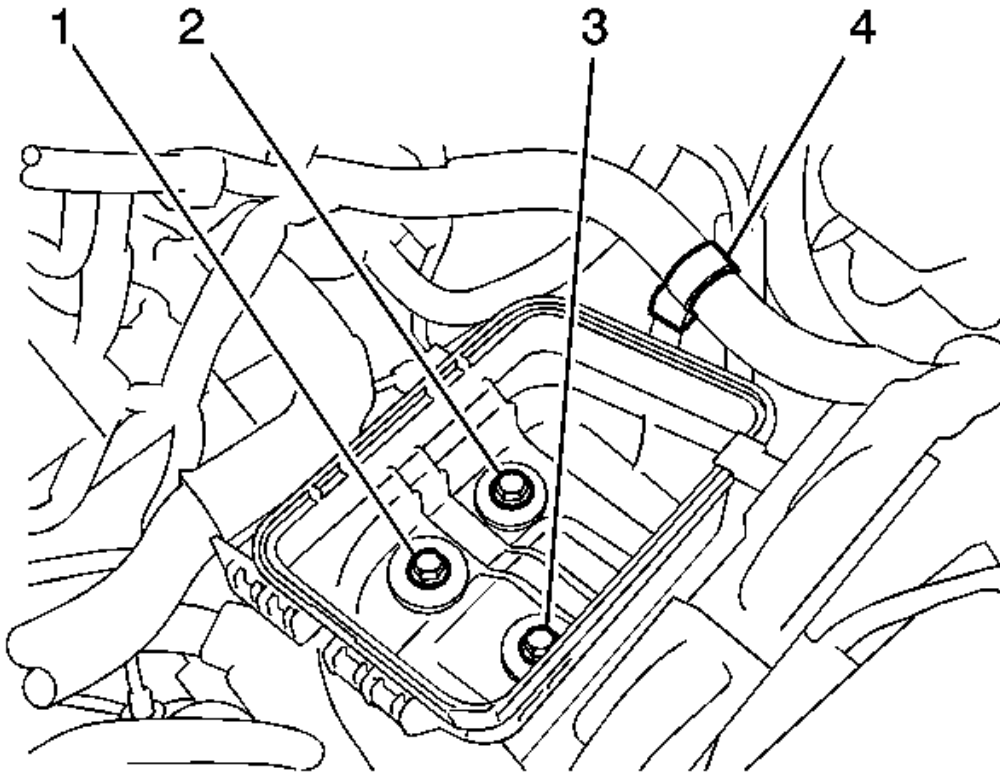


Fig. 214: Identifying Air Cleaner Case & Engine Wire Harness Clamp
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the engine wire harness clamp from air cleaner case.
13. Remove the 3 bolts and the air cleaner case.

CAUTION: Refer to BATTERY DISCONNECT WARNING .

14. Disconnect the battery cables.
15. Remove the bolt and loosen the nut.
16. Remove the battery. Refer to Battery Replacement .

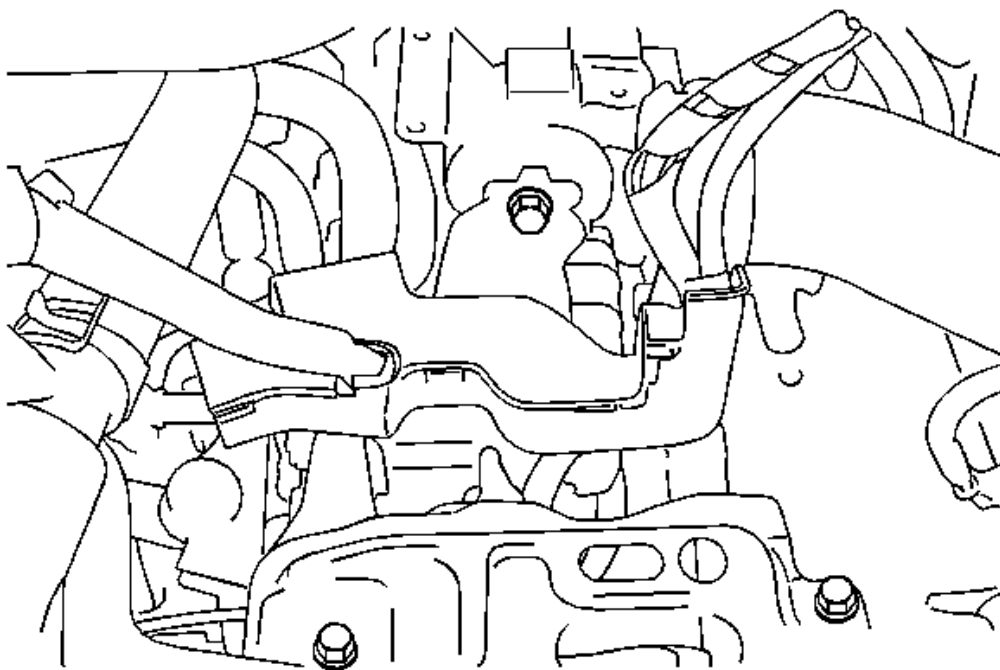


Fig. 215: Identifying Wire Harness Clamps At Battery Carrier
Courtesy of GENERAL MOTORS CORP.

17. Remove the battery carrier. Refer to **Battery Tray Replacement** .
18. Separate the 2 wire harness clamps from the battery carrier.

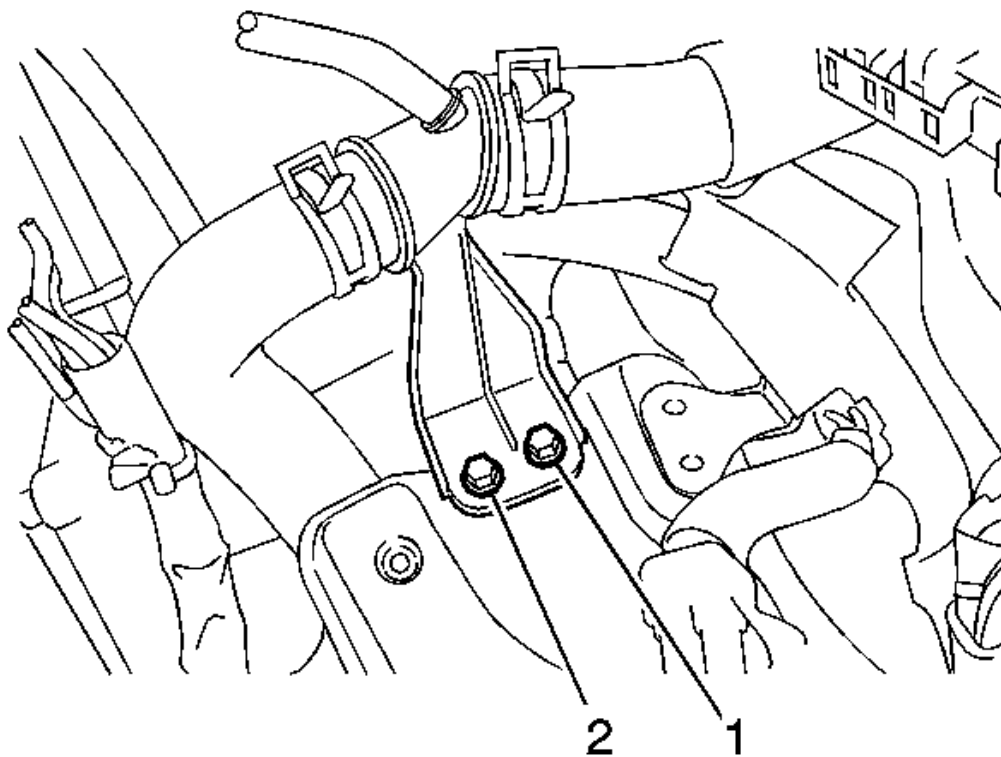


Fig. 216: Identifying Radiator Pipe Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

19. Remove the 2 bolts.
20. Separate the radiator pipe from the battery carrier.
21. Remove the 4 bolts and battery carrier.

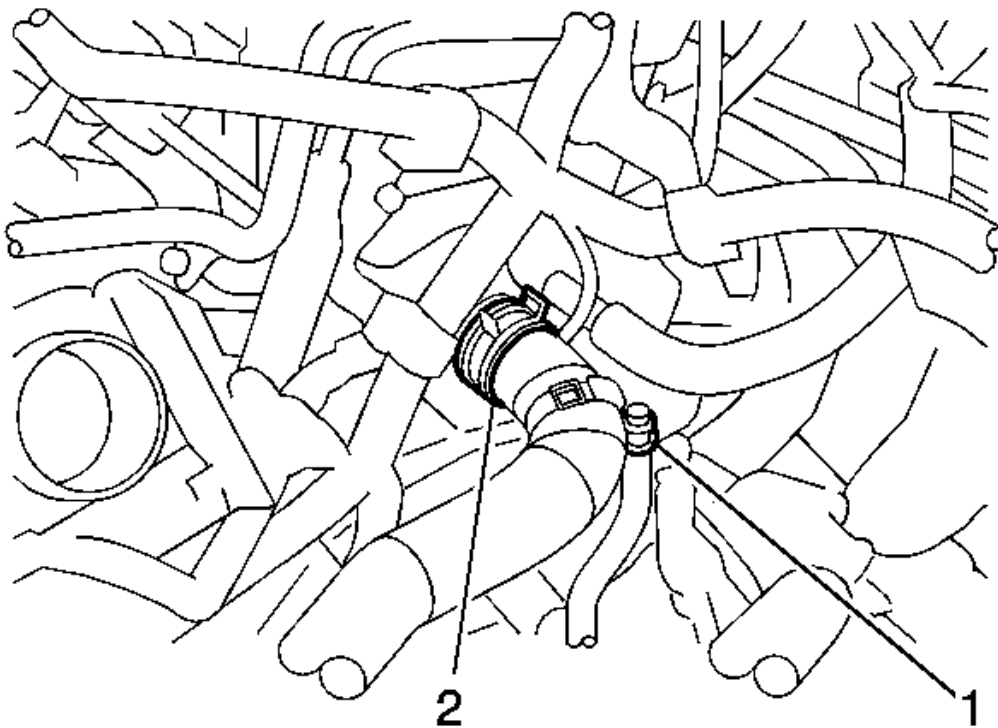


Fig. 217: Identifying Upper Radiator Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

22. Disengage the clamp (1) from the upper radiator hose.
23. Disconnect the upper radiator hose from the cylinder head.

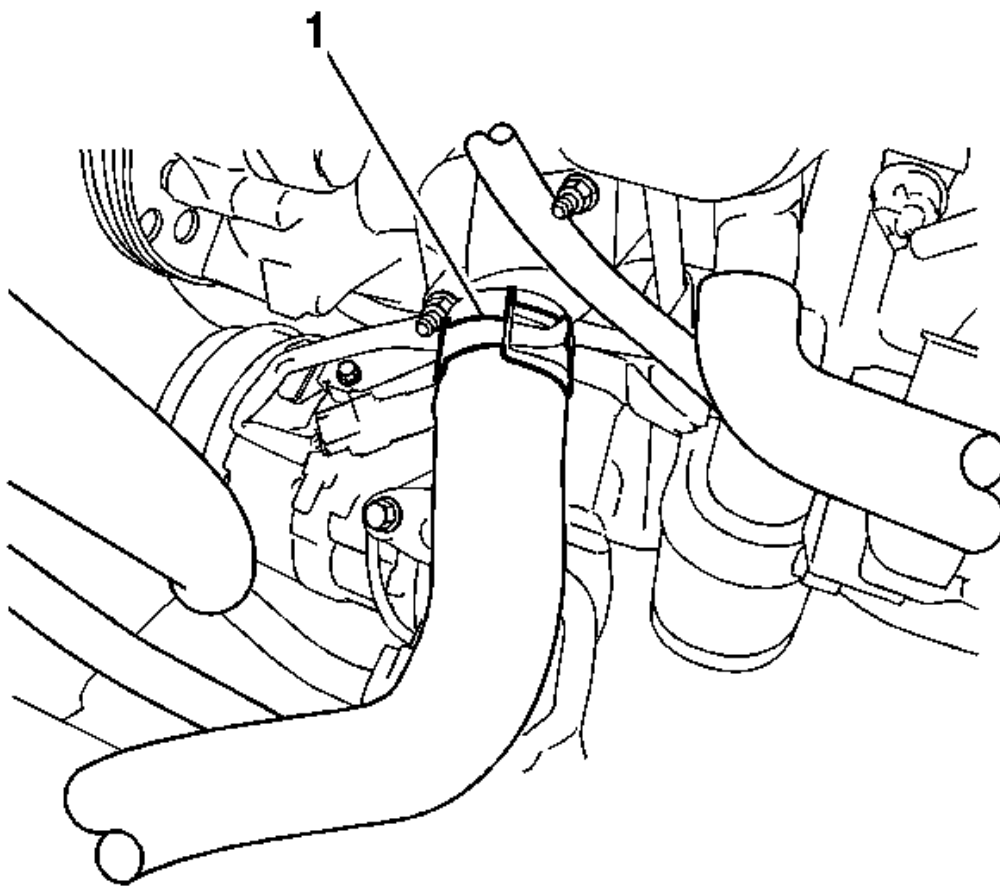


Fig. 218: Identifying Lower Radiator Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

24. Disconnect the lower radiator hose from the water inlet hose.

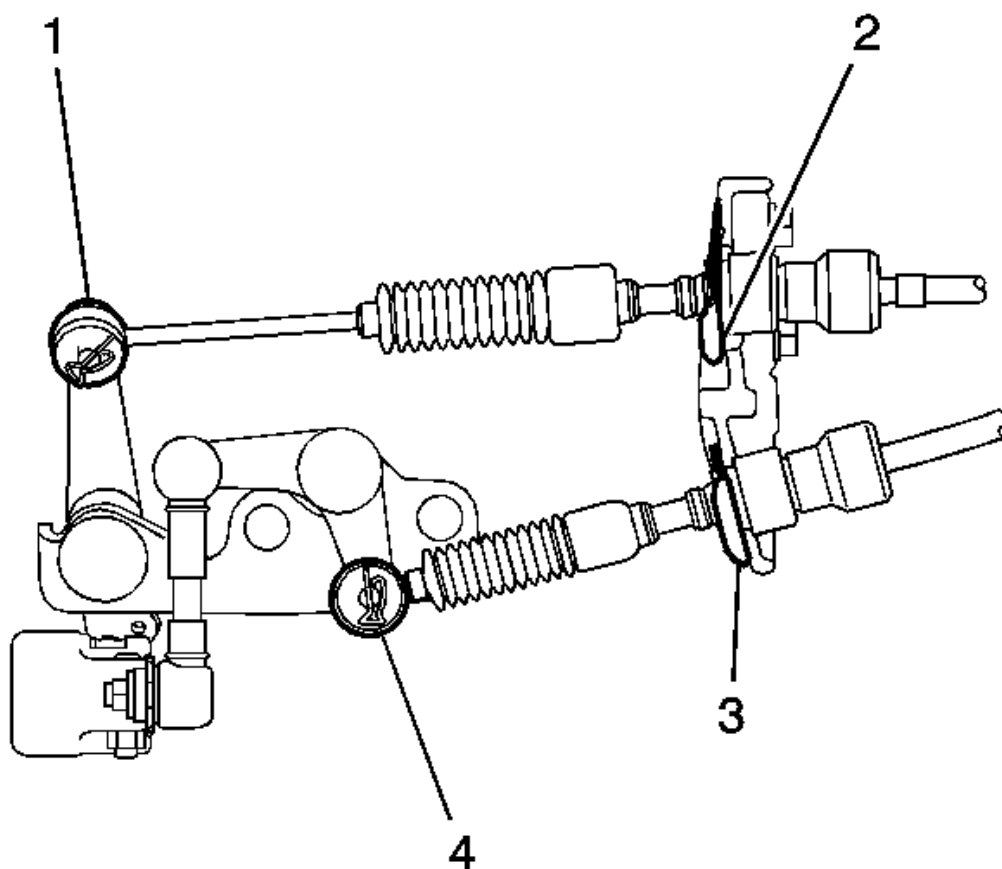


Fig. 219: Identifying Manual Transmission Shift Control Cables
Courtesy of GENERAL MOTORS CORP.

25. If equipped with manual transmission, remove the 2 clips and disconnect the 2 cables from the transaxle.
26. Remove the 2 clips and disconnect the 2 cables from the control cable bracket.

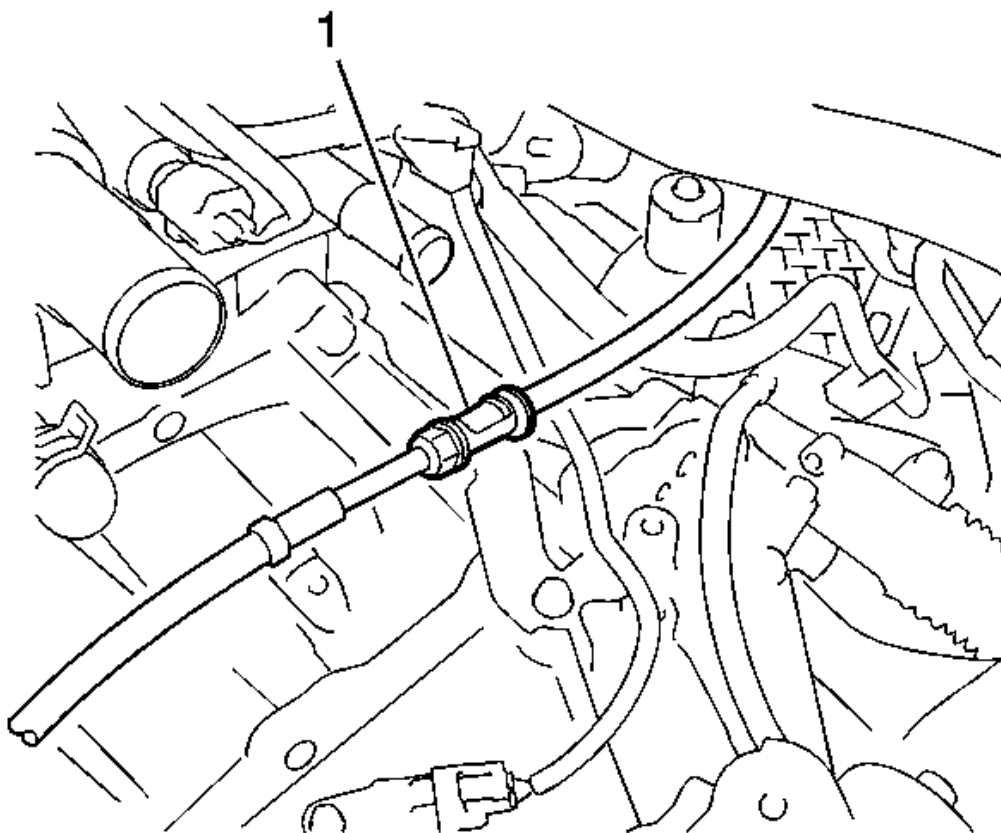


Fig. 220: Identifying Automatic Transmission Shift Control Cable
Courtesy of GENERAL MOTORS CORP.

27. If equipped with automatic transmission, disconnect the control cable from the control cable support.
28. Remove the nut and disconnect the control cable from the control shaft lever.
29. Remove the clip and disconnect the control cable from the control cable bracket.
30. Remove the bolt and disconnect the clamp of the control cable.

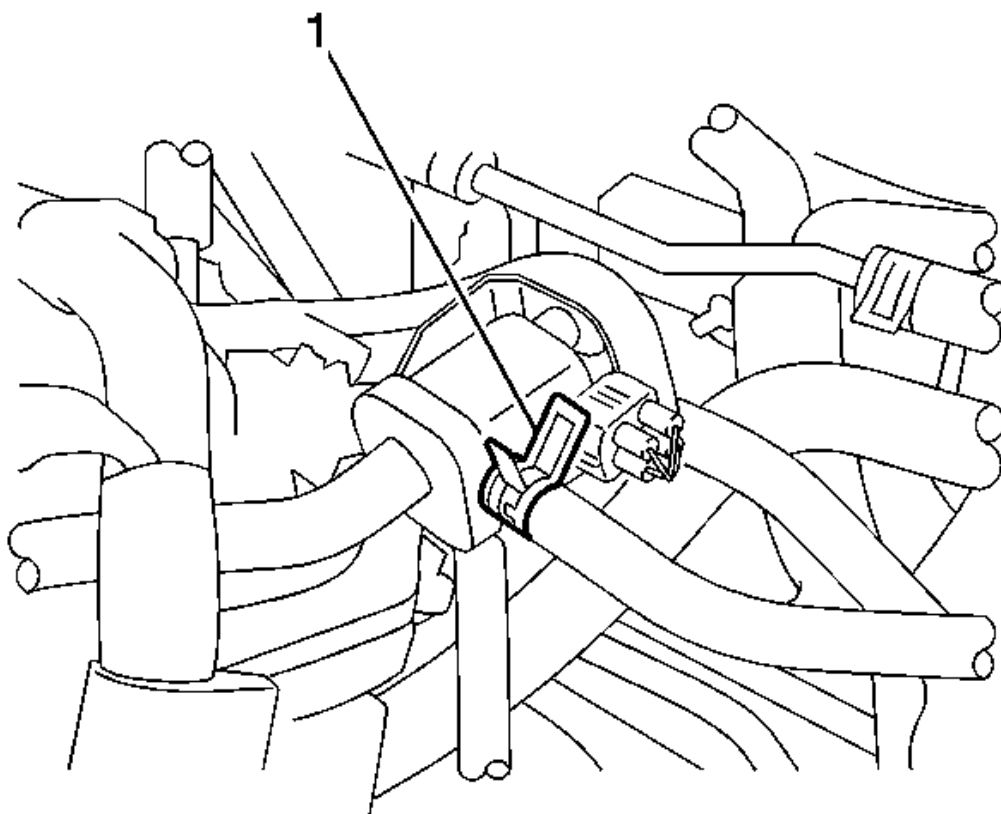


Fig. 221: Identifying Fuel Vapor Feed Hose Assembly
Courtesy of GENERAL MOTORS CORP.

31. Disconnect the fuel vapor feed hose assembly.

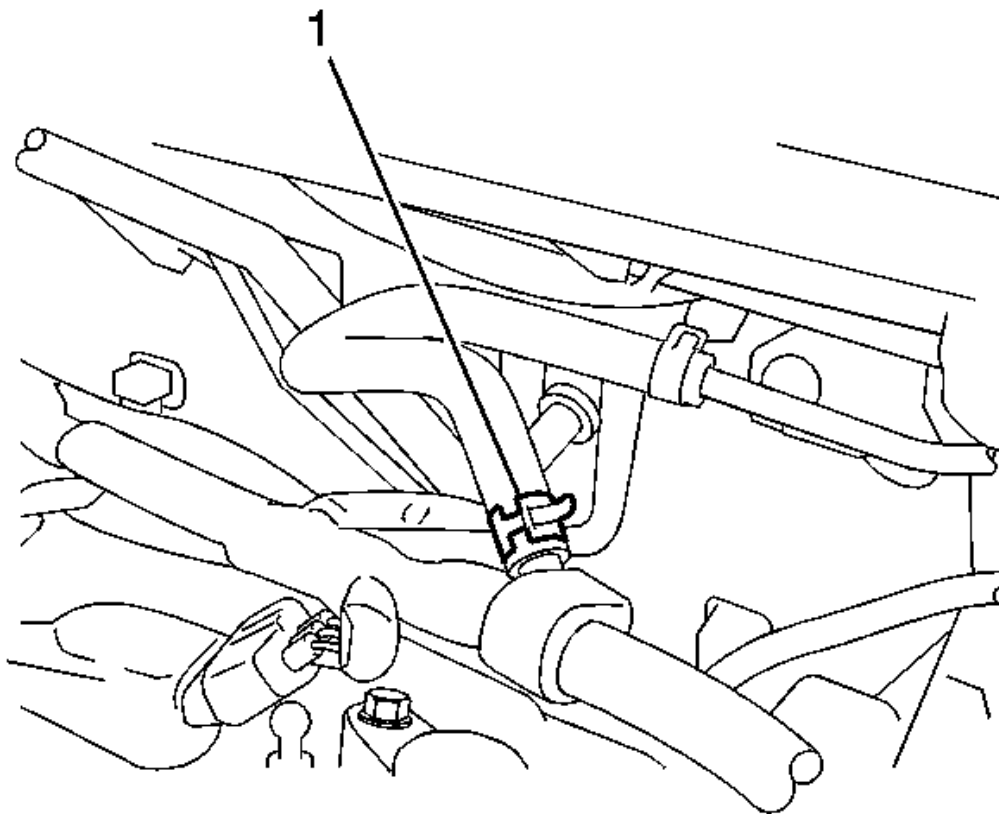


Fig. 222: Identifying Connector Tube Hose & Union
Courtesy of GENERAL MOTORS CORP.

32. Disconnect the union to connector tube hose.

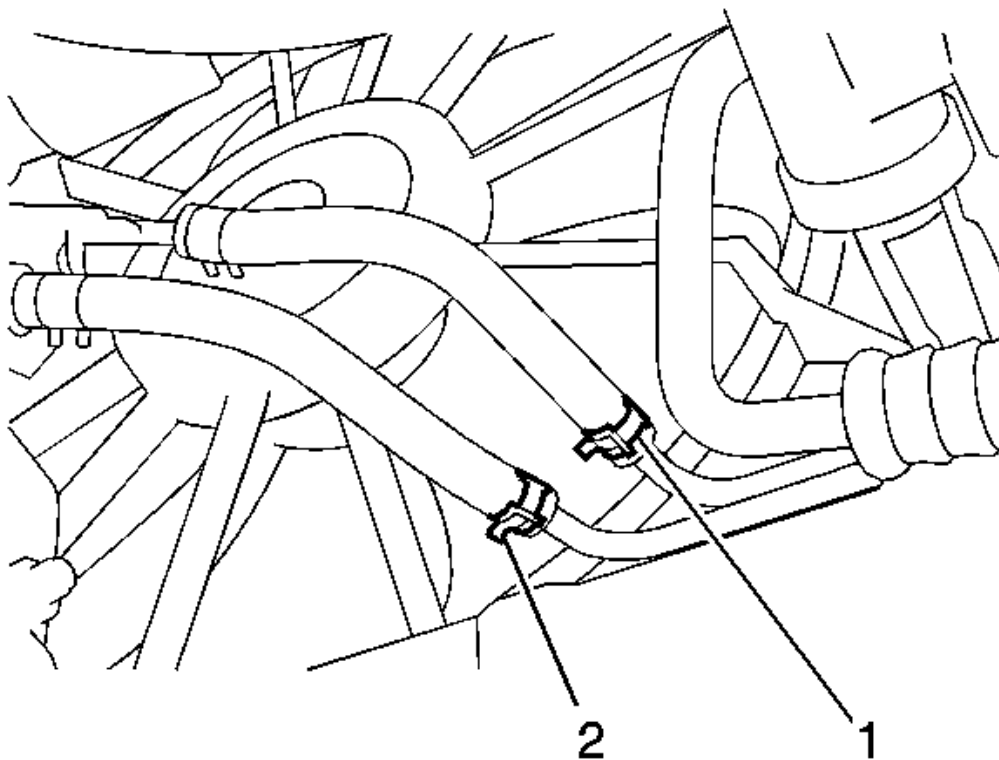


Fig. 223: Identifying Cooler Hoses & Oil Cooler Tube
Courtesy of GENERAL MOTORS CORP.

33. Disconnect the 2 oil cooler hoses from the oil cooler tube, if equipped with automatic transaxle.

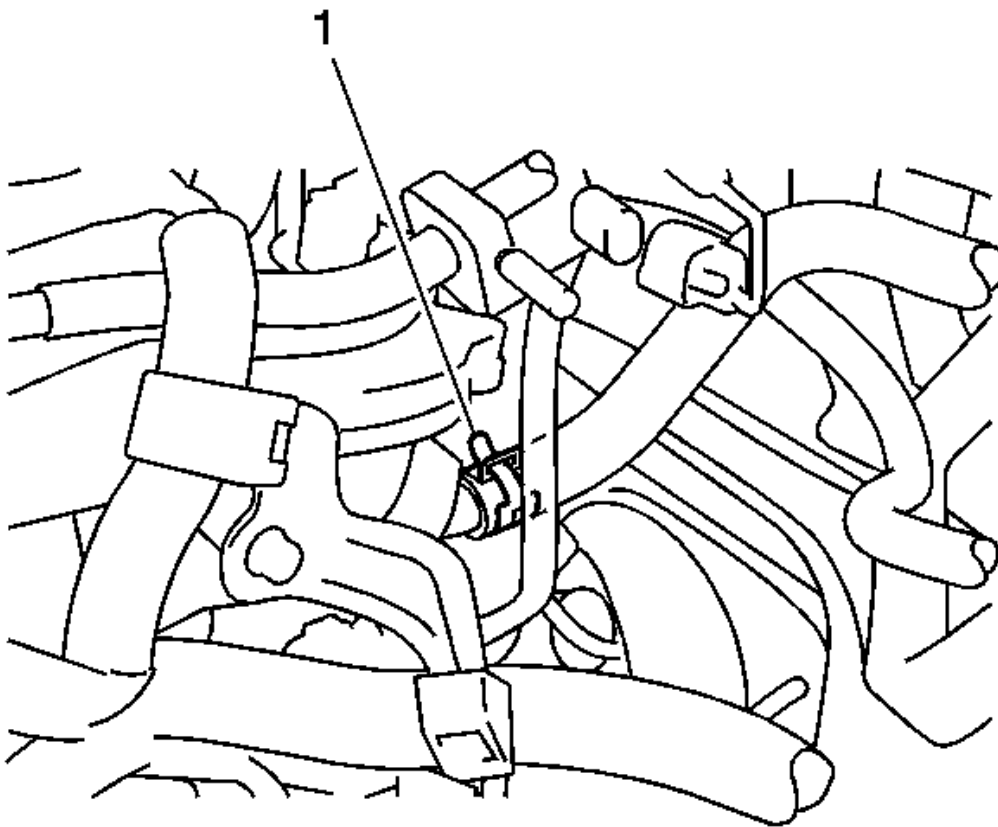


Fig. 224: Identifying Heater Outlet Hose
Courtesy of GENERAL MOTORS CORP.

34. Disconnect the outlet heater water hose from the engine.

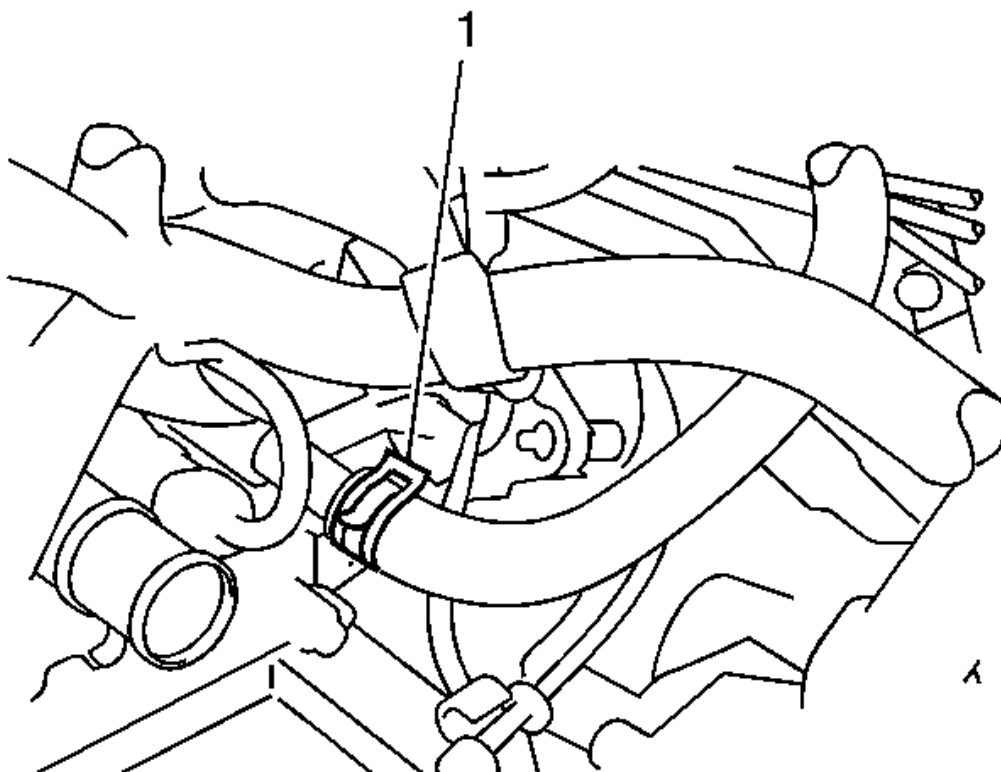


Fig. 225: Identifying Heater Inlet Hose
Courtesy of GENERAL MOTORS CORP.

35. Disconnect the inlet heater water hose from the engine.

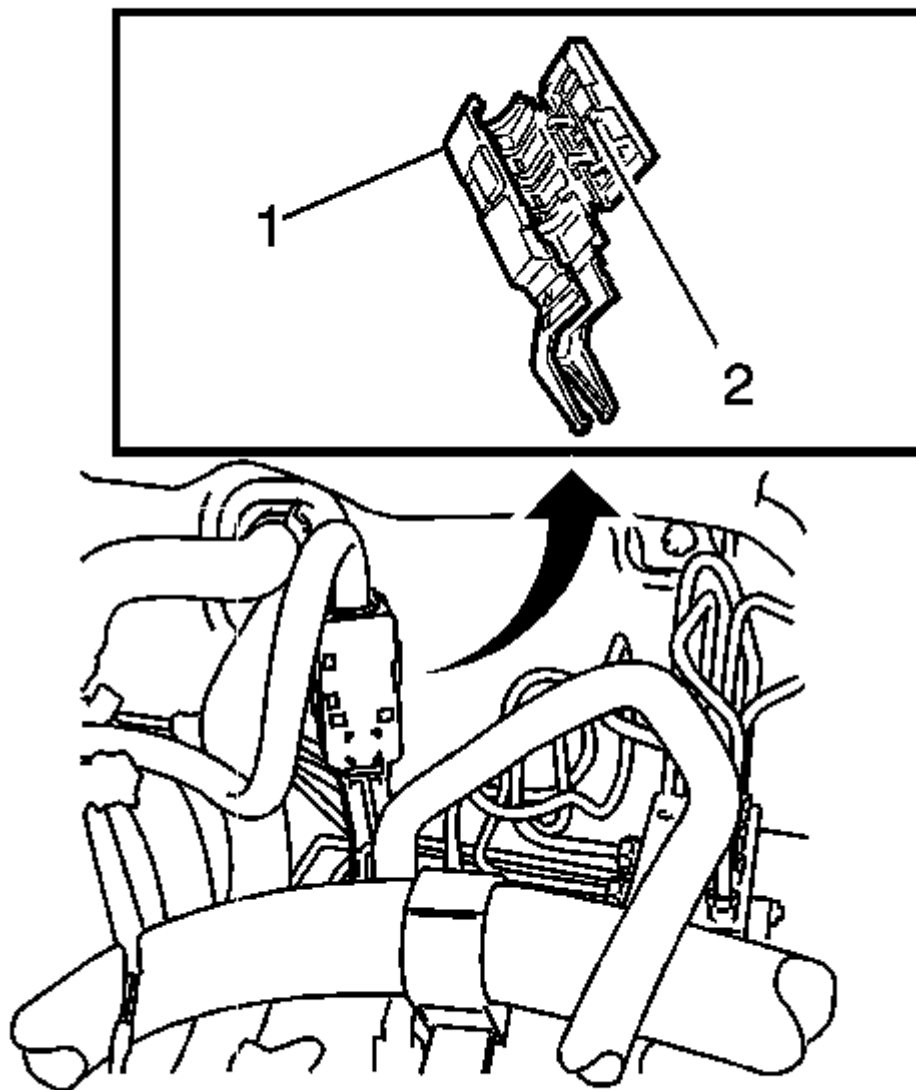


Fig. 226: Identifying No. 1 Fuel Pipe Clamp & Claw
Courtesy of GENERAL MOTORS CORP.

36. Disconnect the fuel tube sub-assembly.
37. Release the claw and remove the No. 1 fuel pipe clamp.

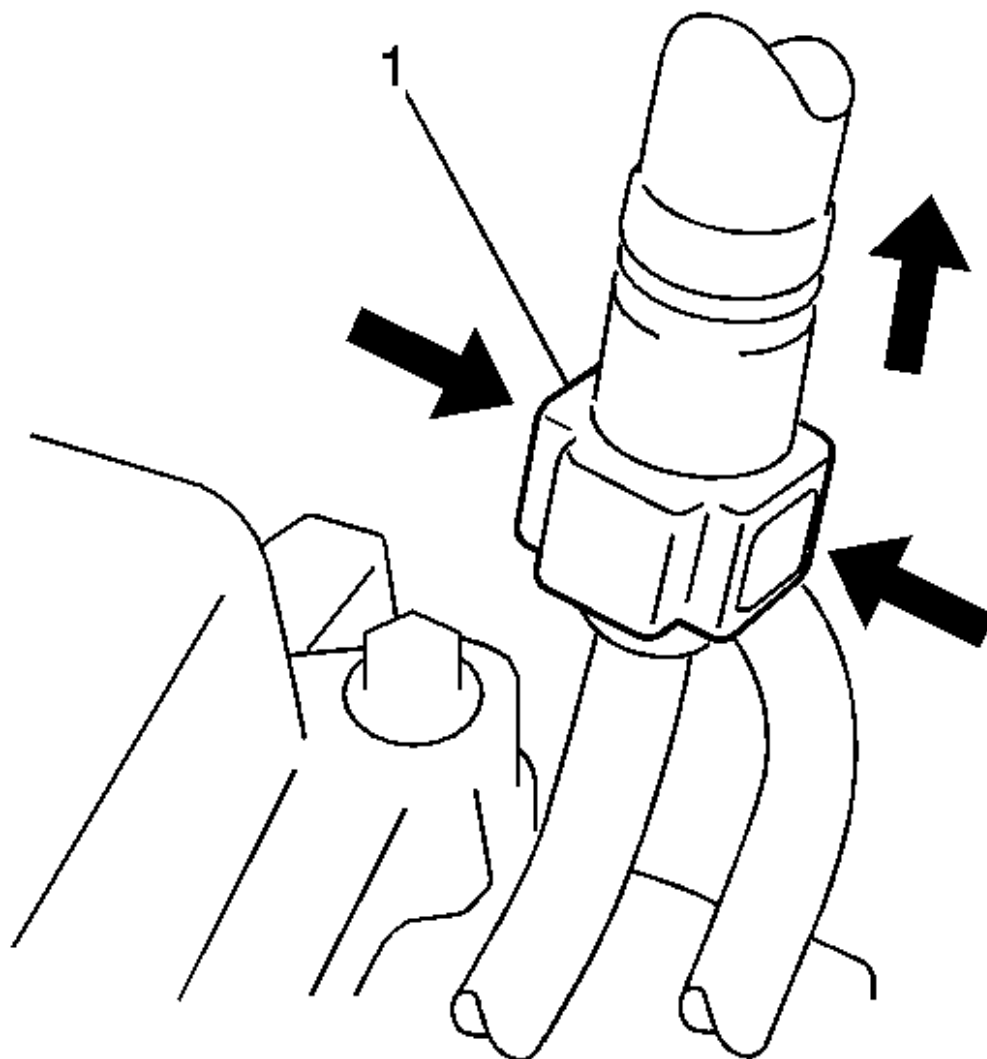


Fig. 227: View Of Fuel Tube Connector
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Remove any dirt and foreign matter from the fuel tube connector before performing this work.
- Do not allow any scratches or foreign matter on the parts when disconnecting, as the fuel tube connector has the O-rings that seal the pipe. Perform this work by hand. Do not use any tools.
- Do not forcibly bend, kink or twist the nylon tube.

- **Protect the disconnected parts by covering them with vinyl bags after disconnecting the fuel tube.**
- **If the fuel tube connector and pipe are stuck, push and pull to release them.**

38. Pinch the retainer then pull the fuel tube connector out of the pipe.
39. Remove the V-ribbed belt.
40. Remove the generator assembly.
41. Separate the compressor with pulley assembly with air conditioning system.
42. Disconnect the connector.

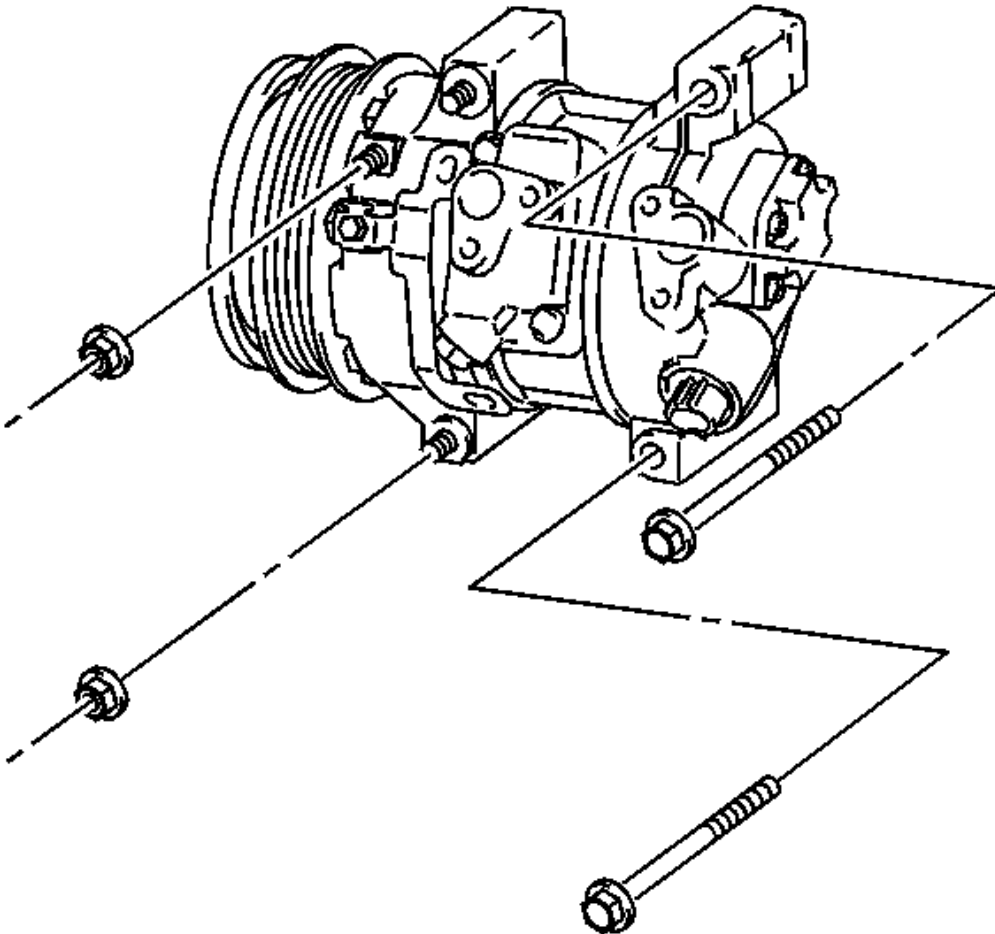


Fig. 228: Identifying A/C Compressor Bolts & Nuts

Courtesy of GENERAL MOTORS CORP.

43. Remove the 2 bolts and 2 nuts.

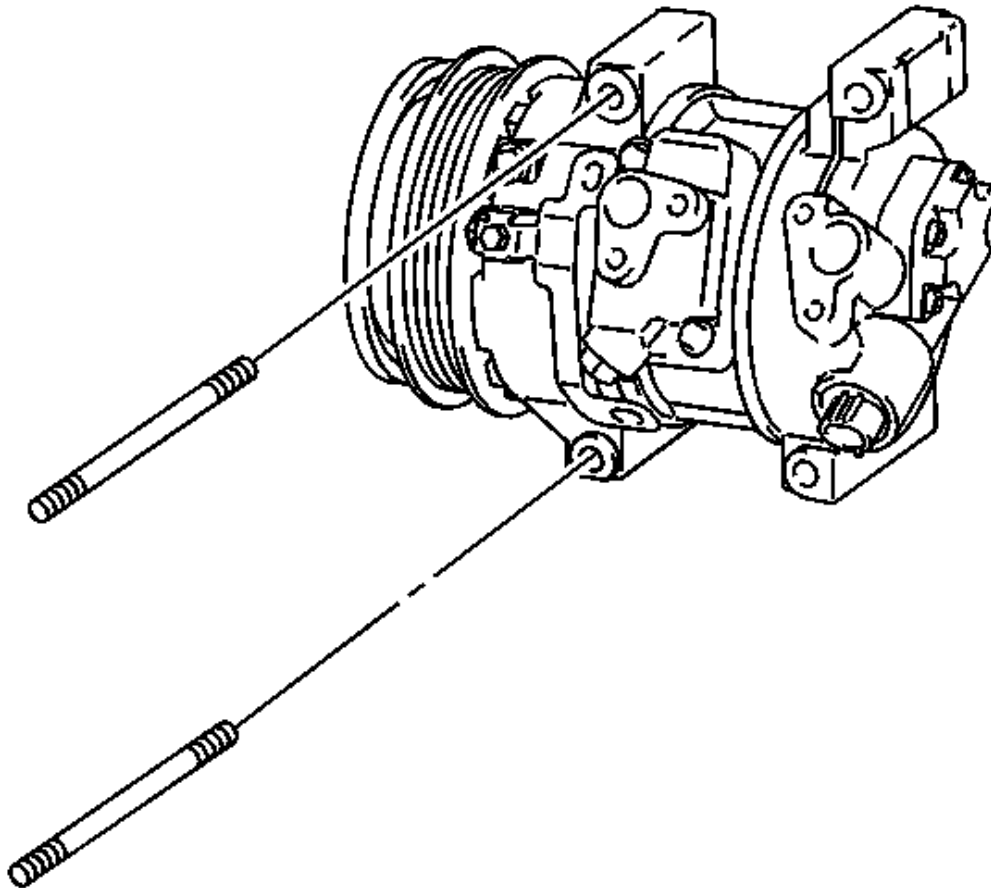


Fig. 229: Identifying A/C Compressor Studs
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Secure the compressor and hoses off to the side instead of discharging the A/C system.

44. Using a TORX socket wrench, remove the 2 stud bolts and compressor with pulley assembly.

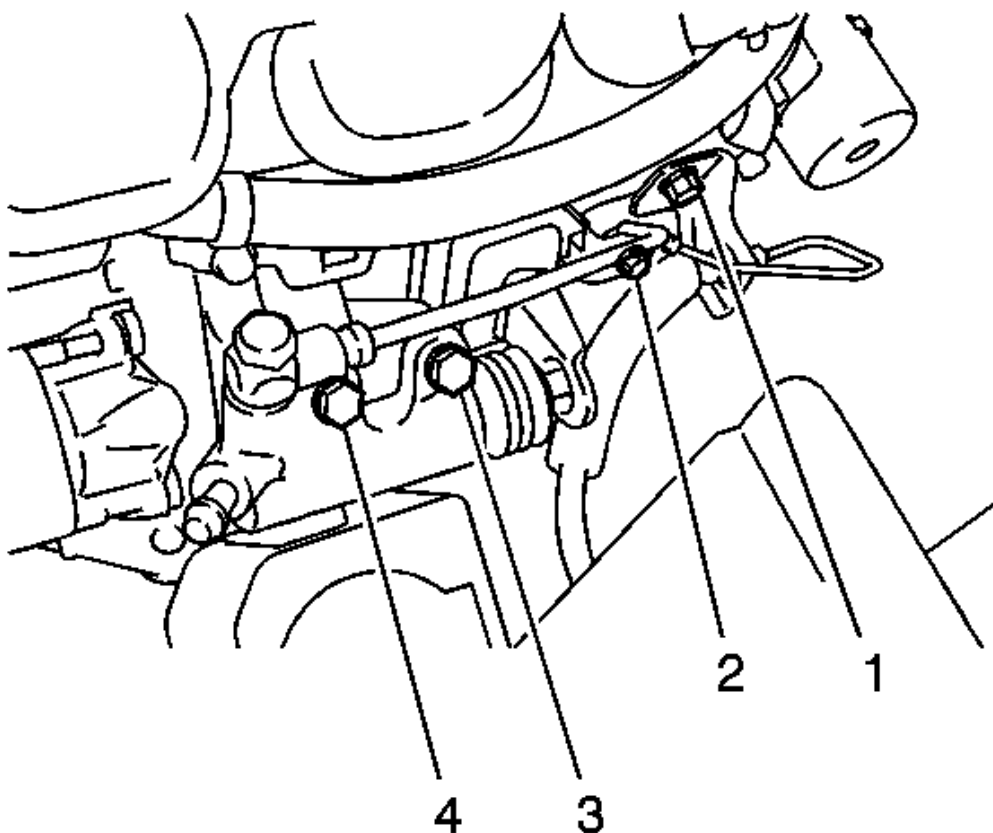


Fig. 230: Identifying Clutch Release Cylinder Assembly, Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

45. Separate the clutch release cylinder assembly-for manual transaxle.

Remove the 4 bolts and clutch tube bracket, and separate the clutch release cylinder assembly.

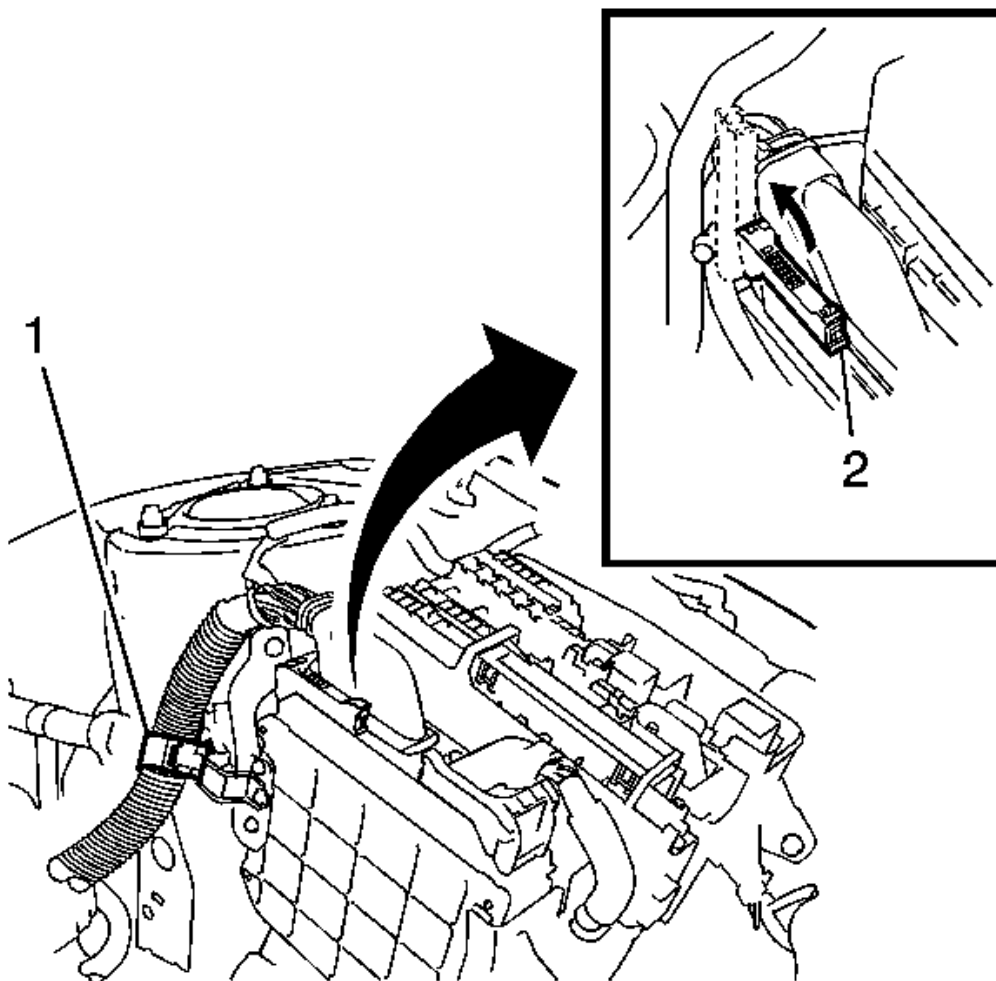


Fig. 231: View Of Lever & ECM Connector
Courtesy of GENERAL MOTORS CORP.

46. Disconnect the wire harness.
47. Pull up the lever and disconnect the ECM connector.

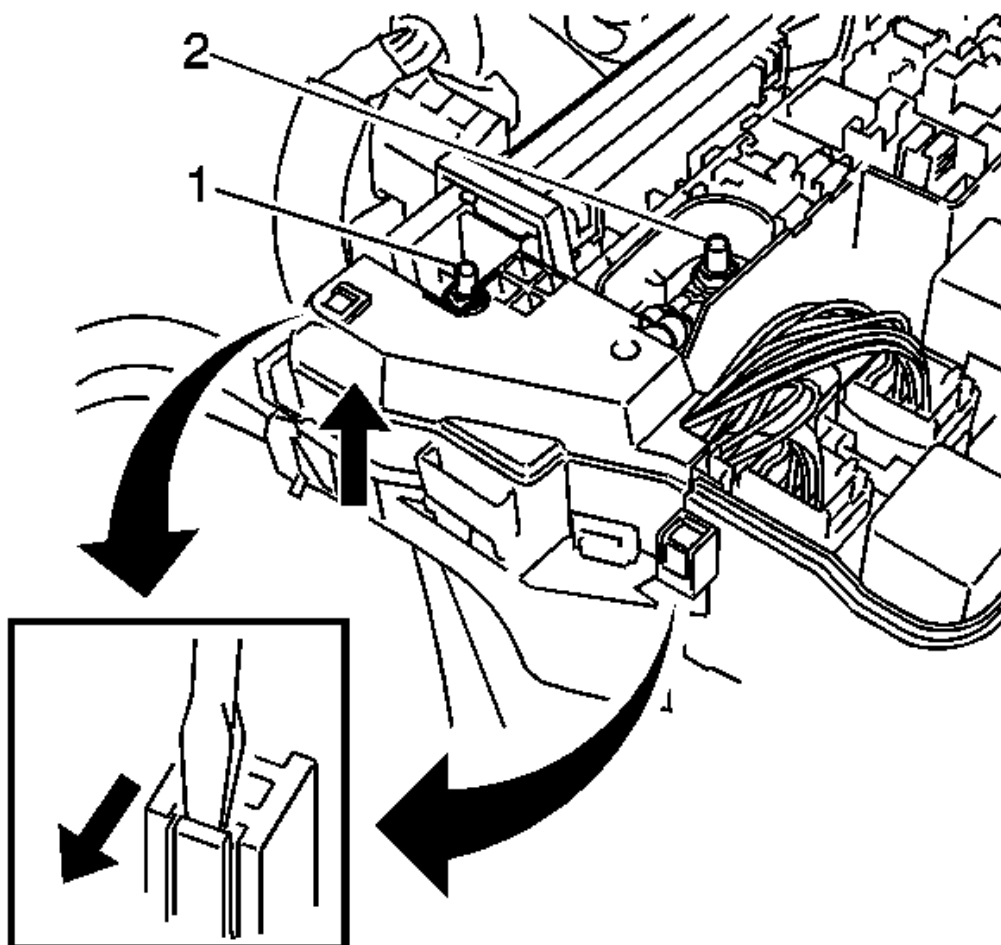


Fig. 232: Locating Engine Room Junction Block, Wire Harness & Connectors
Courtesy of GENERAL MOTORS CORP.

48. Remove the 2 nuts.
49. Remove the 3 connectors and 2 clamps from the engine room junction block and disconnect the wire harness.

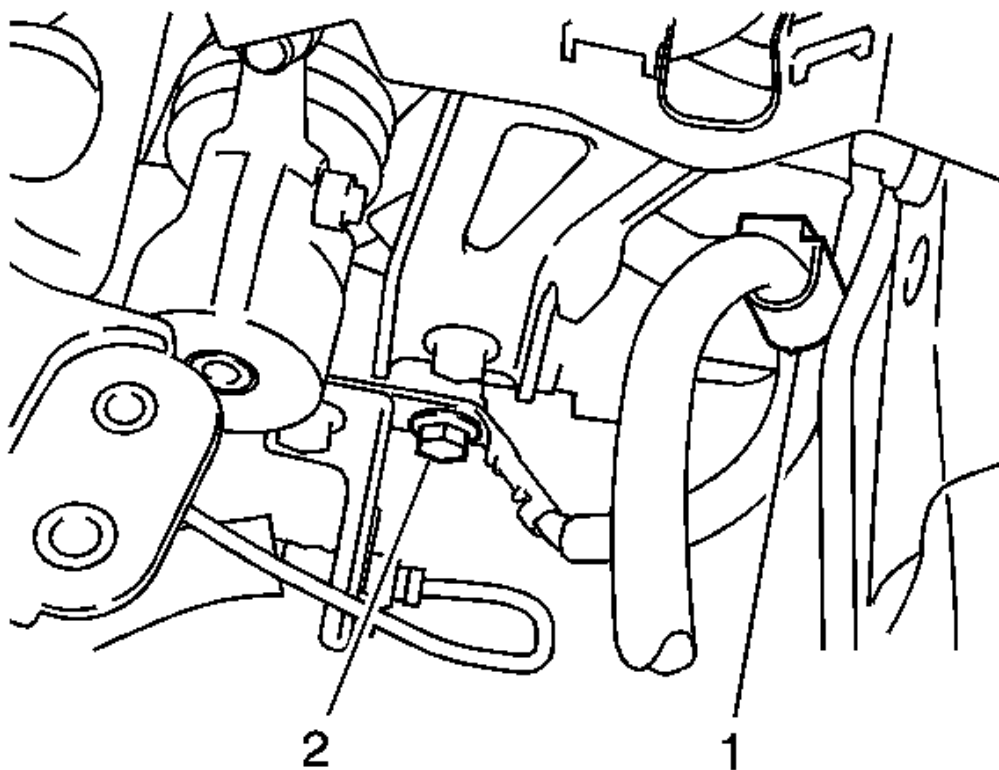


Fig. 233: View Of Bolt & Clamp (Manual Transaxle)
Courtesy of GENERAL MOTORS CORP.

50. Remove the bolt & clamp (manual transaxle)

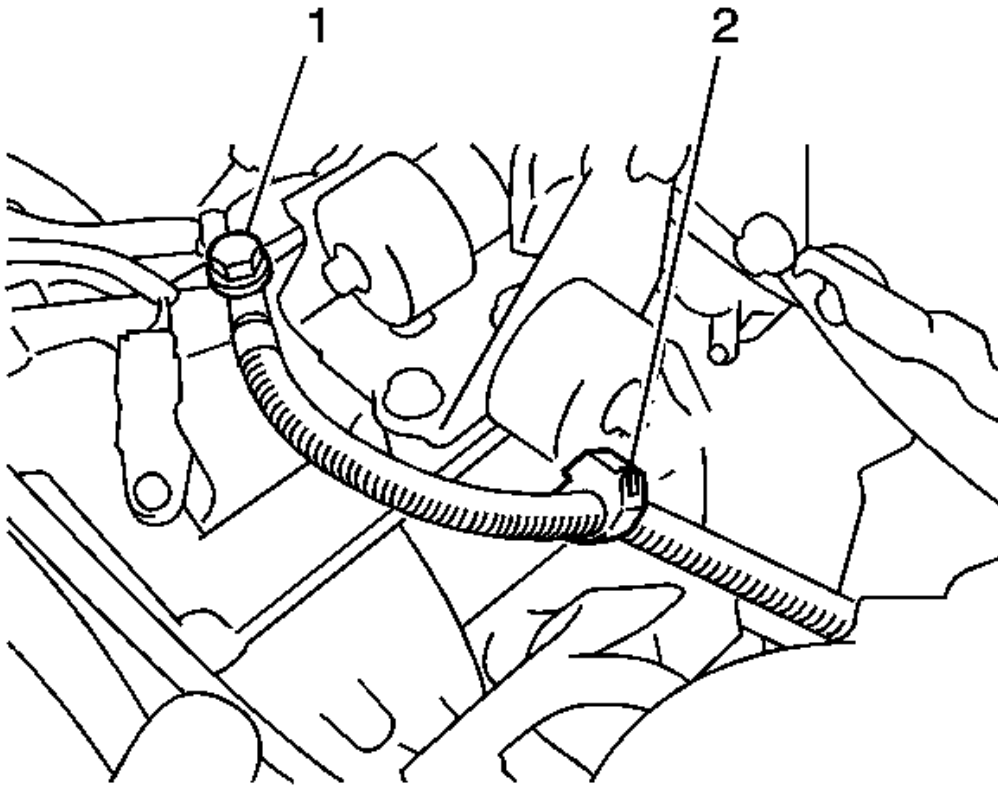


Fig. 234: Identifying Bolt & Clamp (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

51. Remove the bolt and clamp for the automatic transaxle.
52. Disconnect all the wire harnesses and connectors. Make sure that no wire harness is connected between the body and engine.
53. Secure the steering wheel.
54. Remove the column hole cover silencer sheet.
55. Separate the No. 2 steering intermediate shaft assembly.
56. Disconnect the No. 1 steering column hole cover sub-assembly.
57. Remove the front exhaust pipe assembly.
58. Remove the front axle shaft LH nut.

IMPORTANT: Perform the same procedure for the LH side.

59. Remove the front axle shaft RH nut.

60. Disconnect the front speed sensor LH.

IMPORTANT: Perform the same procedure for the LH side.

61. Disconnect the front speed sensor RH.

62. Separate the tie rod end sub-assembly LH.

IMPORTANT: Perform the same procedure for the LH side.

63. Separate the tie rod end sub-assembly RH.

64. Separate the front stabilizer link assembly LH.

IMPORTANT: Perform the same procedure for the LH side.

65. Separate the front stabilizer link assembly RH.

66. Separate the front lower No. 1 suspension arm sub-assembly LH.

IMPORTANT: Perform the same procedure for the LH side.

67. Separate the front lower No. 1 suspension arm sub-assembly RH.

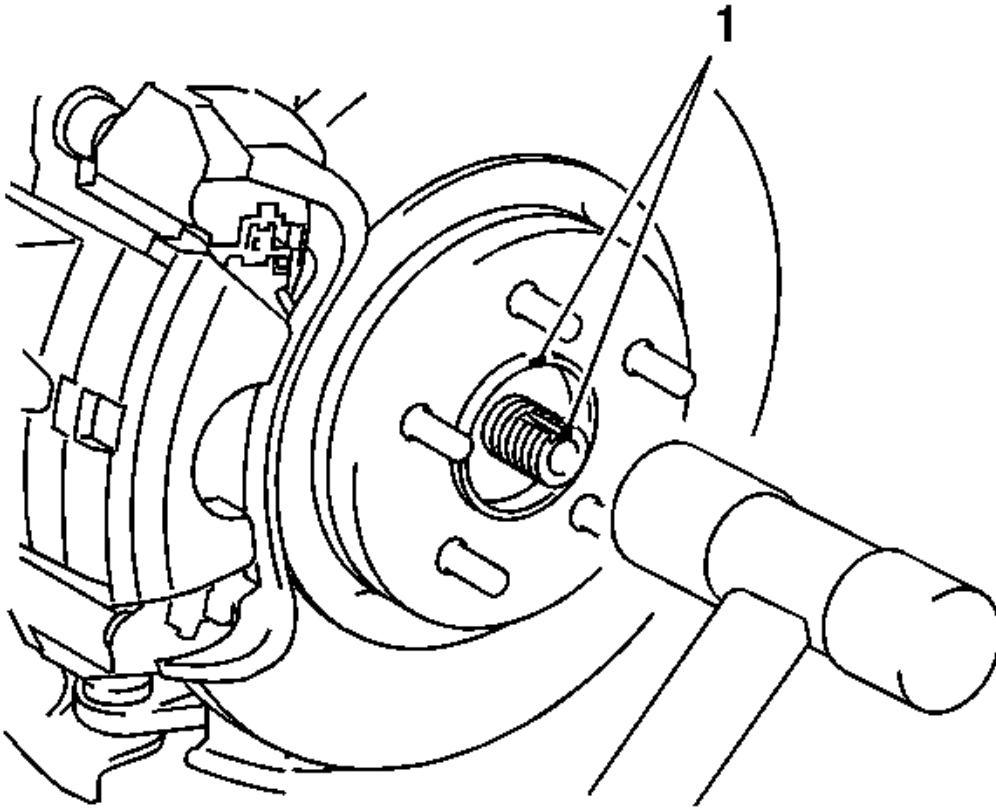


Fig. 235: View Of Axle Hub

Courtesy of GENERAL MOTORS CORP.

68. Separate the steering knuckle with axle hub LH.
 1. Put matchmarks on the drive shaft and axle hub.
 2. Using a plastic-faced hammer, disconnect the front axle assembly LH.

IMPORTANT: Perform the same procedure for the LH side.

69. Separate the steering knuckle with axle hub RH.
70. Remove the front drive shaft assembly LH. Refer to **Front Wheel Drive Shaft Replacement - Left Side**.
71. Remove the front drive shaft assembly RH. Refer to **Front Wheel Drive Shaft Replacement - Right Side**.
72. Remove the front drive shaft hole snap ring LH.
73. Remove the front drive shaft hole snap ring RH.

74. Remove the flywheel housing under cover-for automatic transaxle.
75. Remove the drive plate and torque converter clutch setting bolt-for automatic transaxle.
76. Remove the front suspension crossmember sub-assembly.
77. Remove the center engine mounting member sub-assembly.
78. Remove the engine assembly with transaxle.

IMPORTANT: Place the engine on wooden blocks or equivalent so that the engine is level.

79. Set the engine lifter.

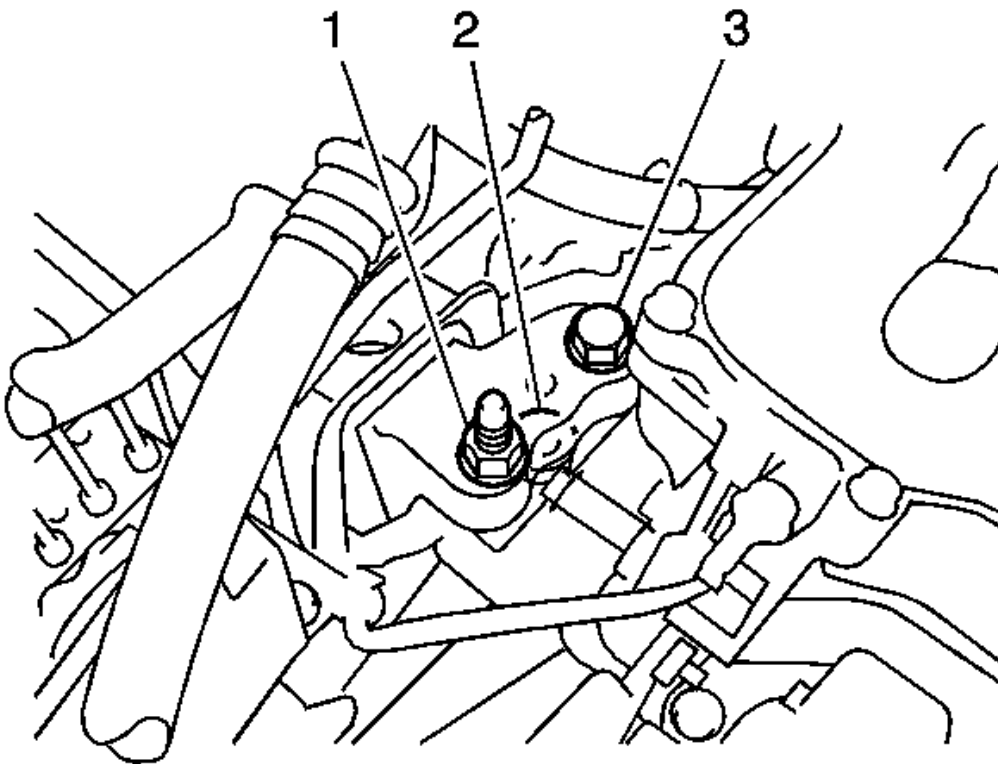


Fig. 236: Identifying Engine Mounting Insulator Bolts - Right Side
Courtesy of GENERAL MOTORS CORP.

80. Remove the bolt and 2 nuts, and separate the engine mounting insulator RH.

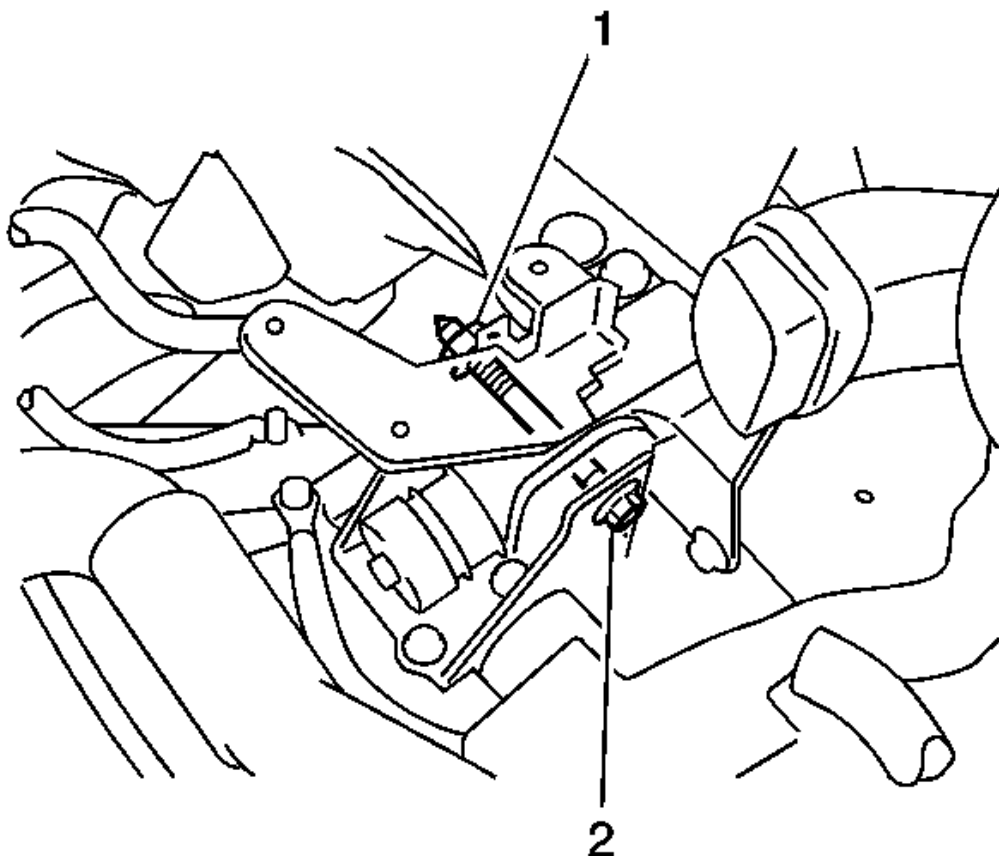


Fig. 237: Identifying Left Side Engine Mounting Insulator Through Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

81. Remove the through bolt and nut, and separate the engine mounting insulator LH.
82. Carefully remove the engine with transaxle from the vehicle.

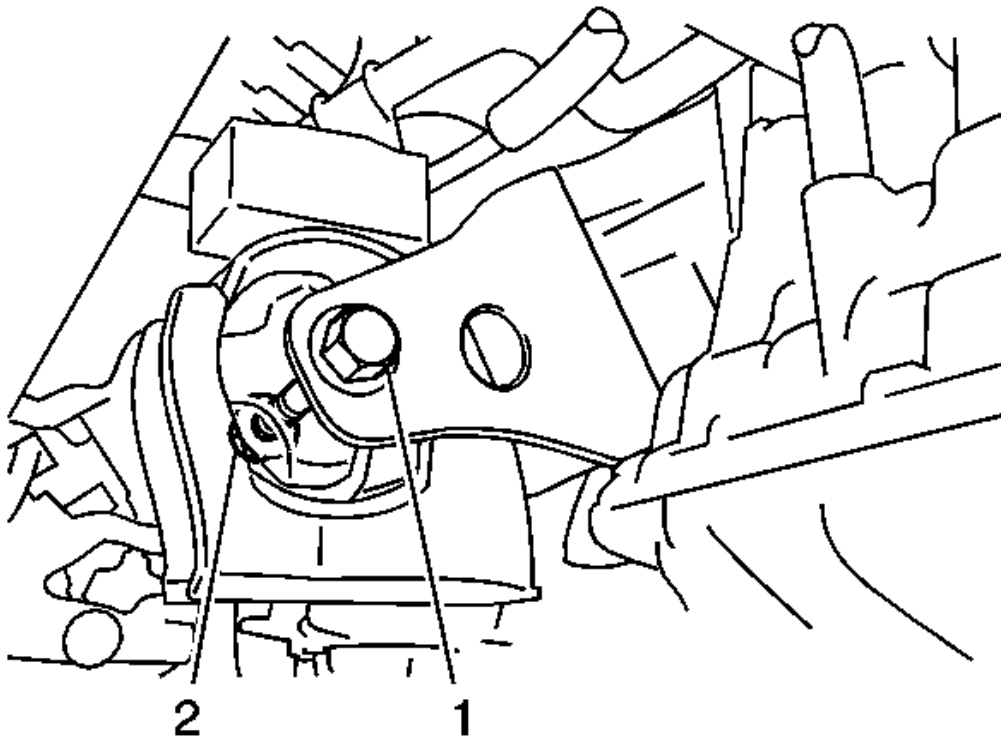


Fig. 238: Identifying Front Engine Mounting Insulator Bolt
Courtesy of GENERAL MOTORS CORP.

83. Remove the bolt and nut, and remove the front engine mounting insulator.

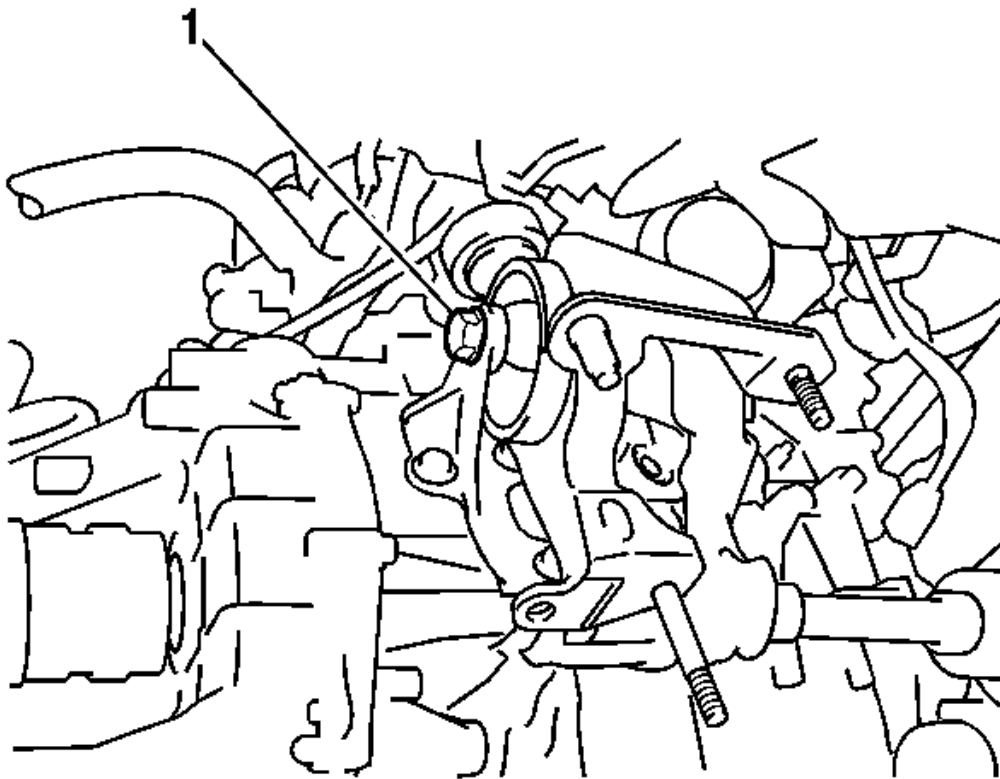


Fig. 239: Identifying Rear Engine Mounting Insulator Through Bolt
Courtesy of GENERAL MOTORS CORP.

84. Remove the through bolt and the rear engine mounting insulator.

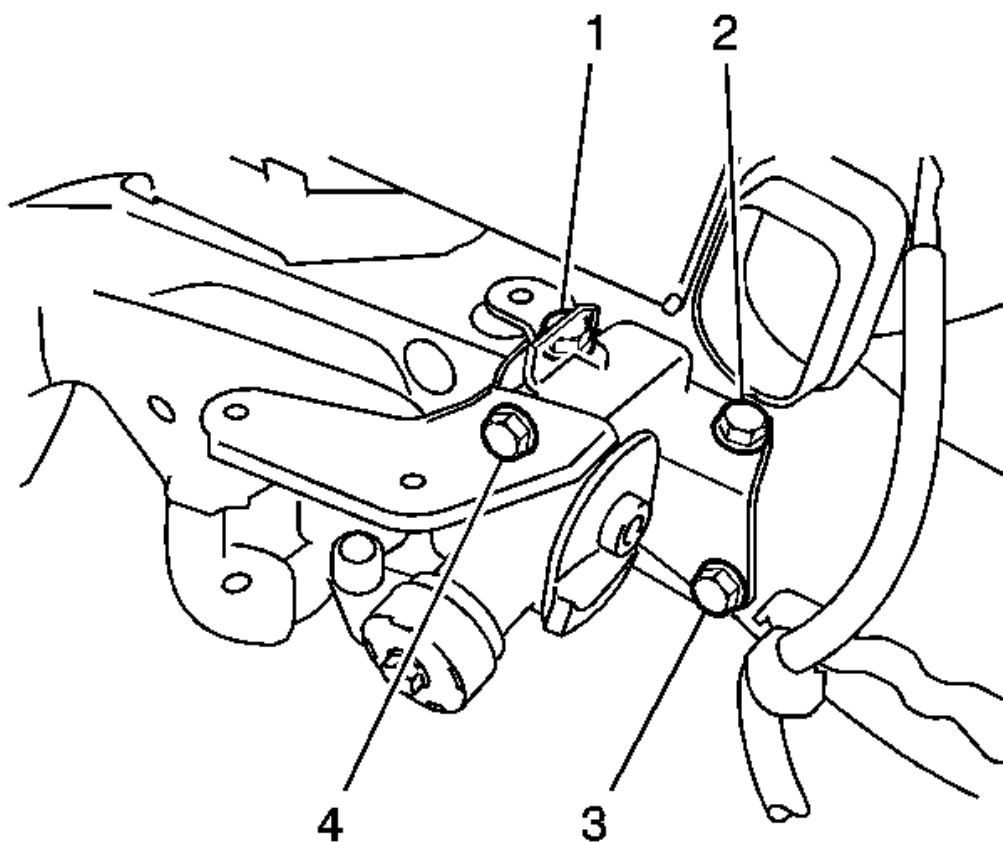


Fig. 240: Identifying Left Side Engine Mounting Insulator Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Perform this procedure only when replacement of the engine mounting insulator is necessary.

85. Remove the 4 bolts and engine mounting insulator LH.

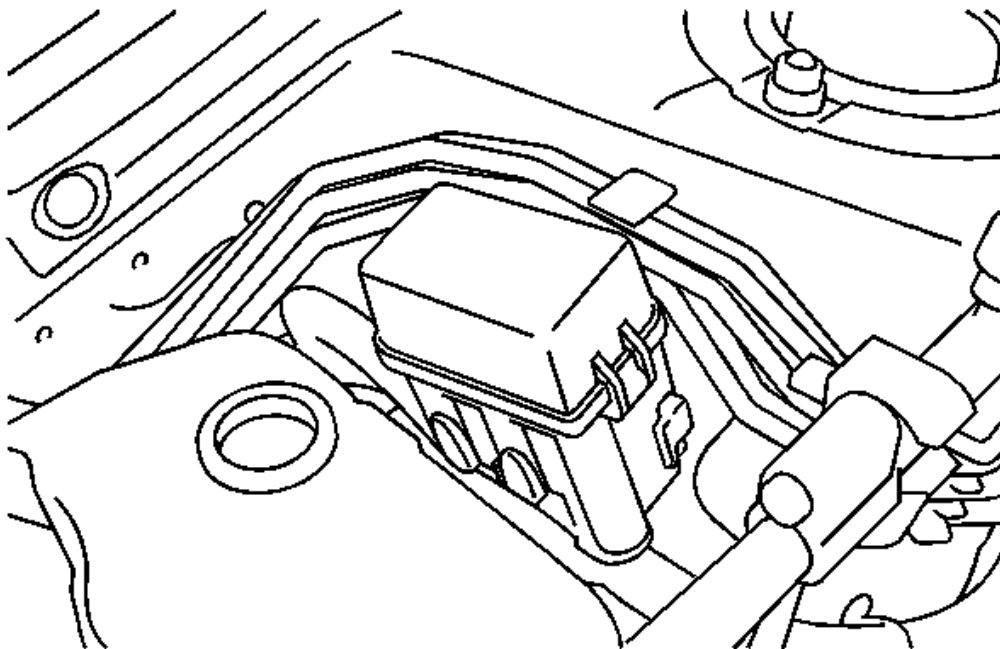


Fig. 241: Identifying Right Side Engine Mounting Insulator
Courtesy of GENERAL MOTORS CORP.

86. Remove the engine mounting insulator RH.
87. Disconnect the clamp, and release the relay block assembly.

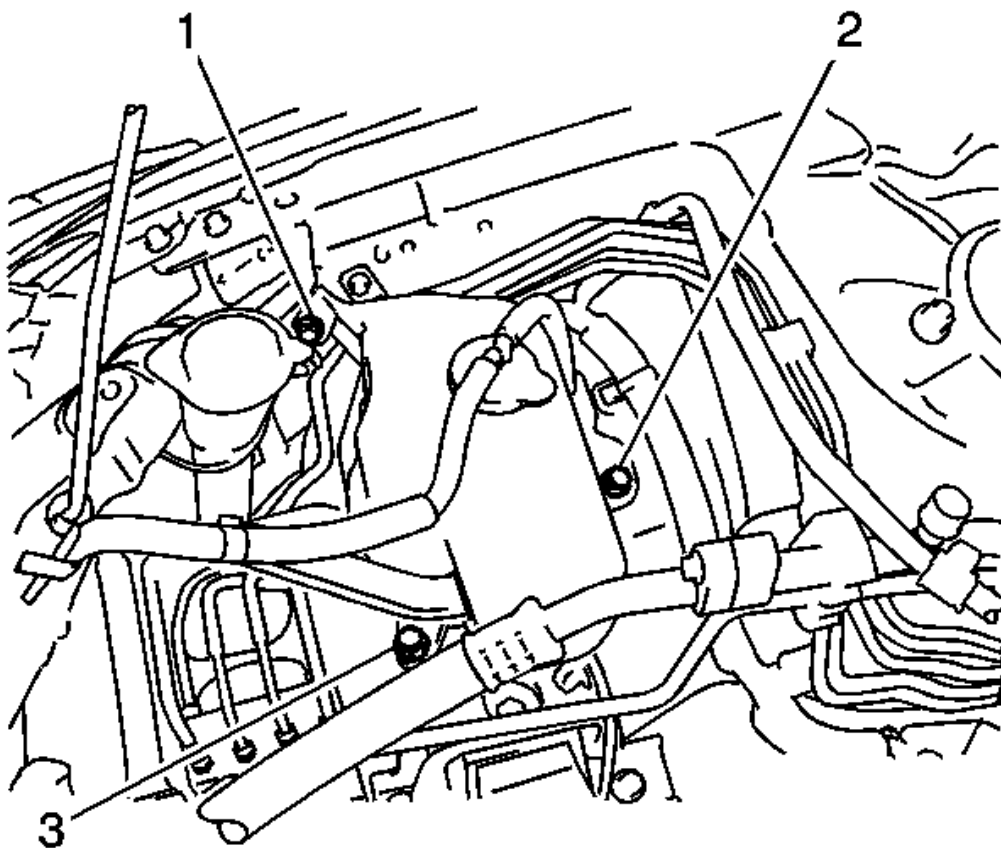


Fig. 242: View Of Radiator Surge Tank Assembly Bolts
Courtesy of GENERAL MOTORS CORP.

88. Remove the 3 bolts and radiator reserve tank.

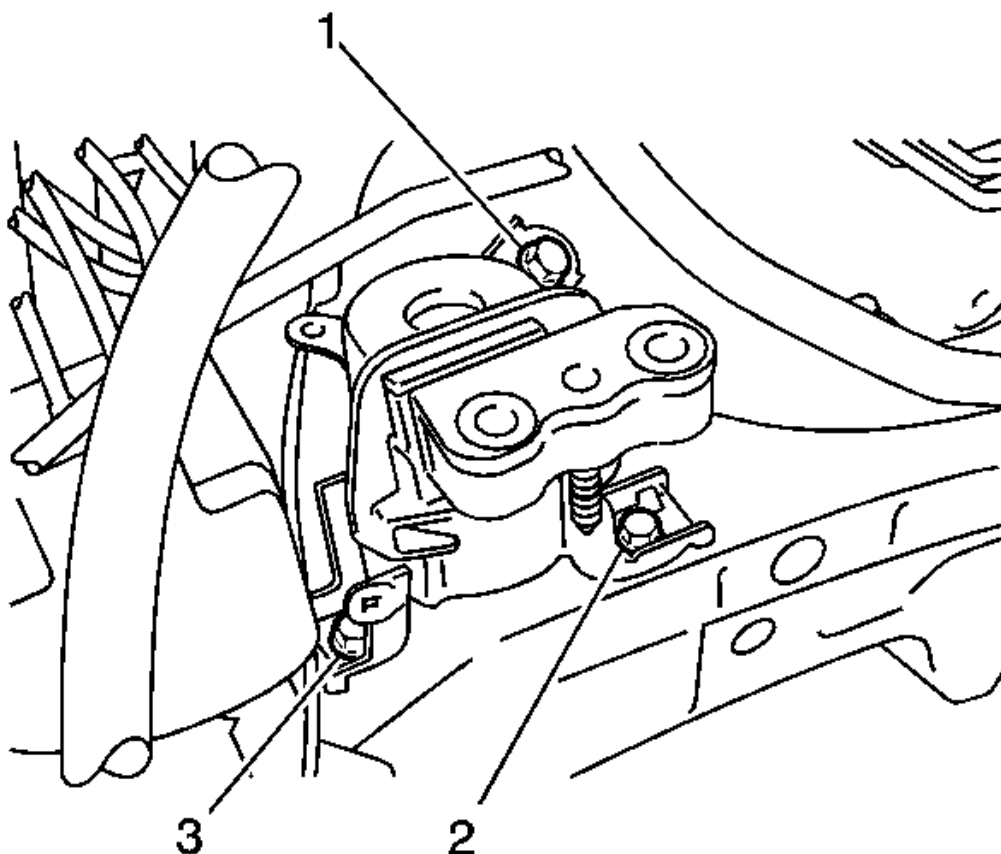


Fig. 243: View Of Engine Mounting Insulator Bolts - Right Side
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Perform this procedure only when replacement of the engine mounting insulator is necessary.

89. Remove the 3 bolts and engine mounting insulator RH.

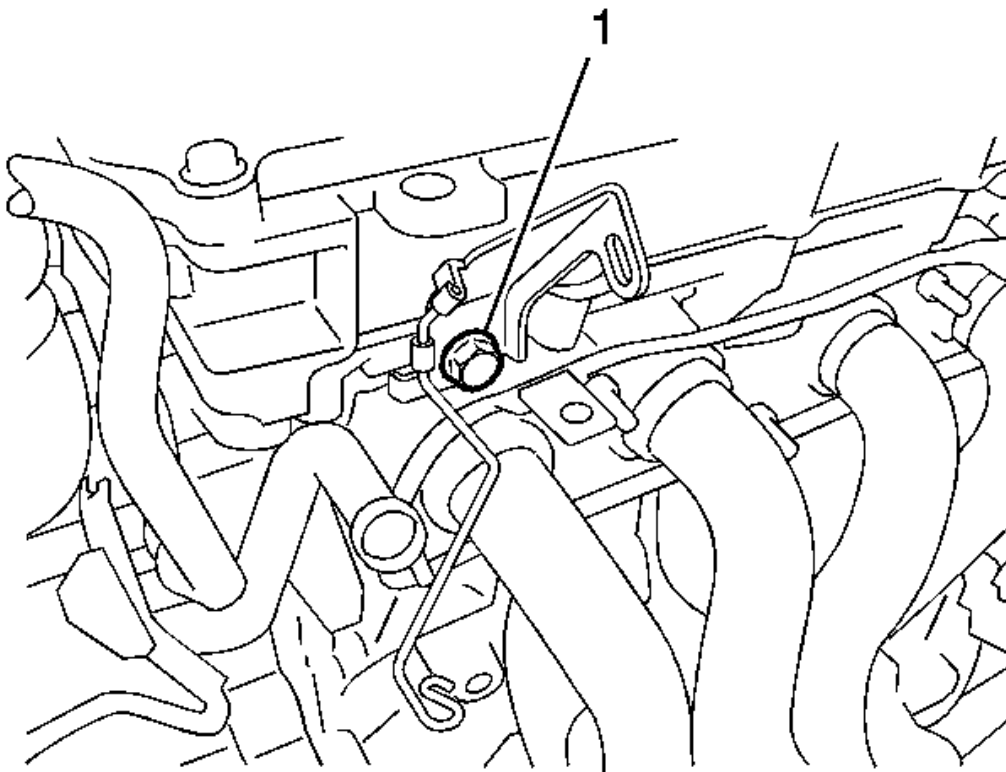


Fig. 244: Identifying Wire Harness Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

90. Remove the bolt and wire harness bracket.

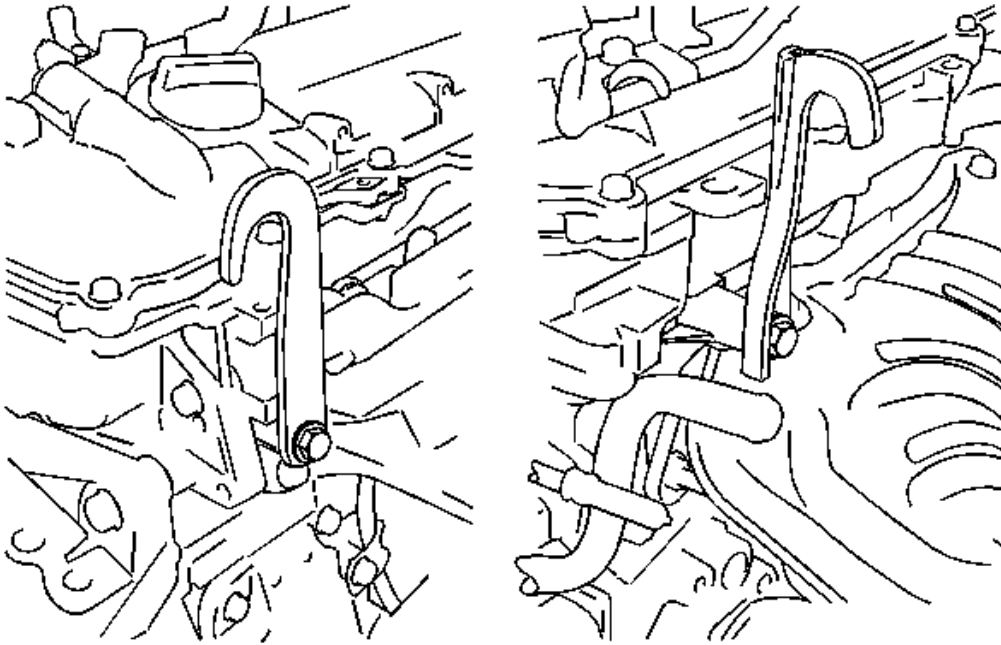


Fig. 245: View Of Installing Engine Hanger With 2 Bolts
Courtesy of GENERAL MOTORS CORP.

91. Install the 2 engine hangers with the 2 bolts.

Tighten: Tighten to 43 N.m (32 lb ft).

92. Remove the flywheel housing side cover.
93. Remove the starter assembly.
94. Remove the transaxle assembly.
95. Remove the clutch cover assembly for the manual transaxle.
96. Remove the clutch disc assembly for the manual transaxle.
97. Remove the flywheel sub-assembly for the manual transaxle.
98. Remove the drive plate and ring gear subassembly for the automatic transaxle.
99. Remove the engine wire harness.

Installation Procedure

1. Install the engine wire harness.
2. Install the flywheel sub-assembly for the manual transaxle.

3. Install the drive plate and ring gear subassembly for the automatic transaxle.
4. Install clutch disc assembly for the manual transaxle.
5. Install clutch cover assembly for the manual transaxle.
6. Inspect and adjust clutch cover assembly for the manual transaxle.
7. Install the transaxle assembly.
8. Install the starter assembly.
9. Install the flywheel housing side cover.

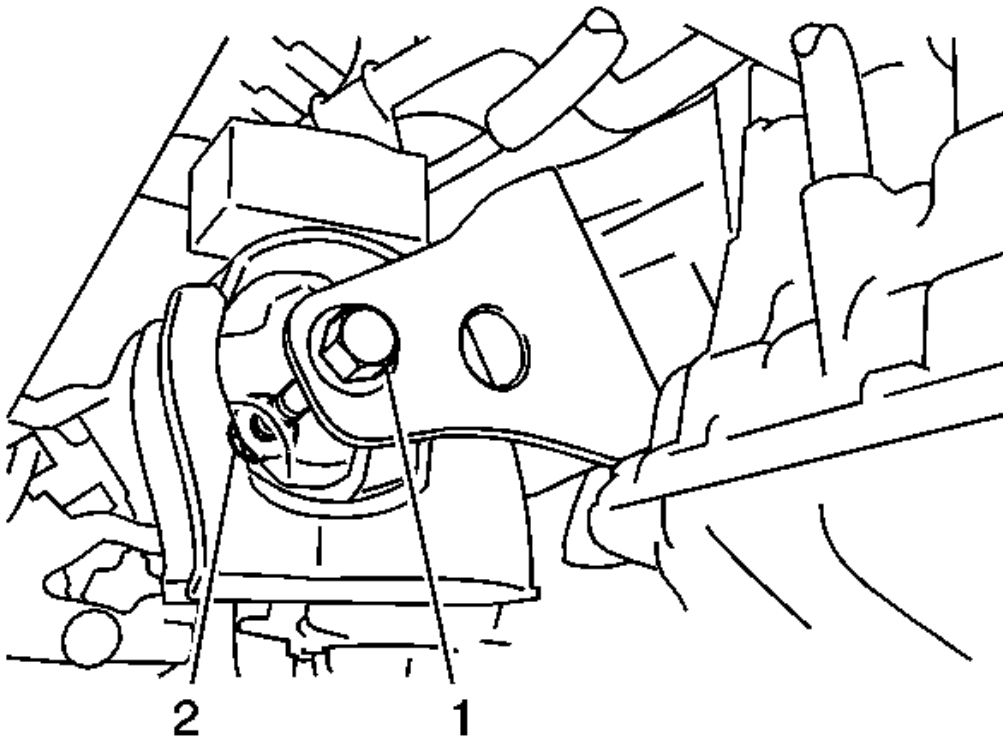


Fig. 246: Identifying Front Engine Mounting Insulator Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to **FASTENER CAUTION** .

10. Install the front engine mounting insulator with the nut and bolt.

Tighten: Tighten the nut and bolt to 73 N.m (54 lb ft).

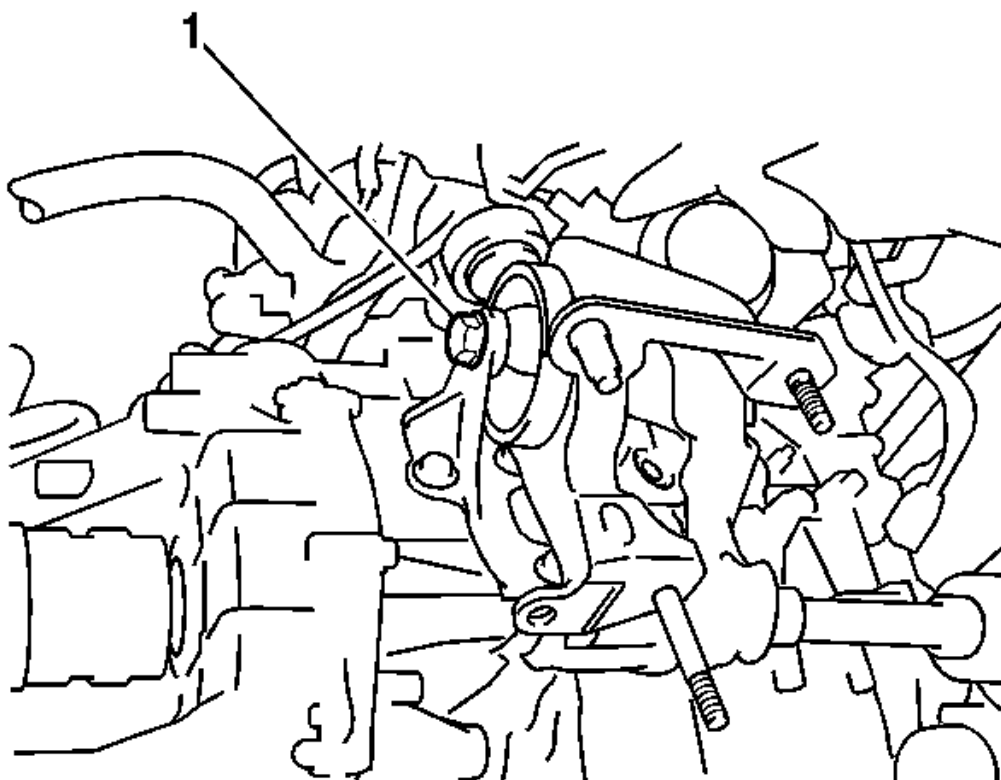


Fig. 247: Identifying Rear Engine Mounting Insulator Through Bolt
Courtesy of GENERAL MOTORS CORP.

11. Install the rear engine mounting insulator to the engine mounting bracket with the through bolt.

Tighten: Tighten the bolt to 65 N.m (50 lb ft).

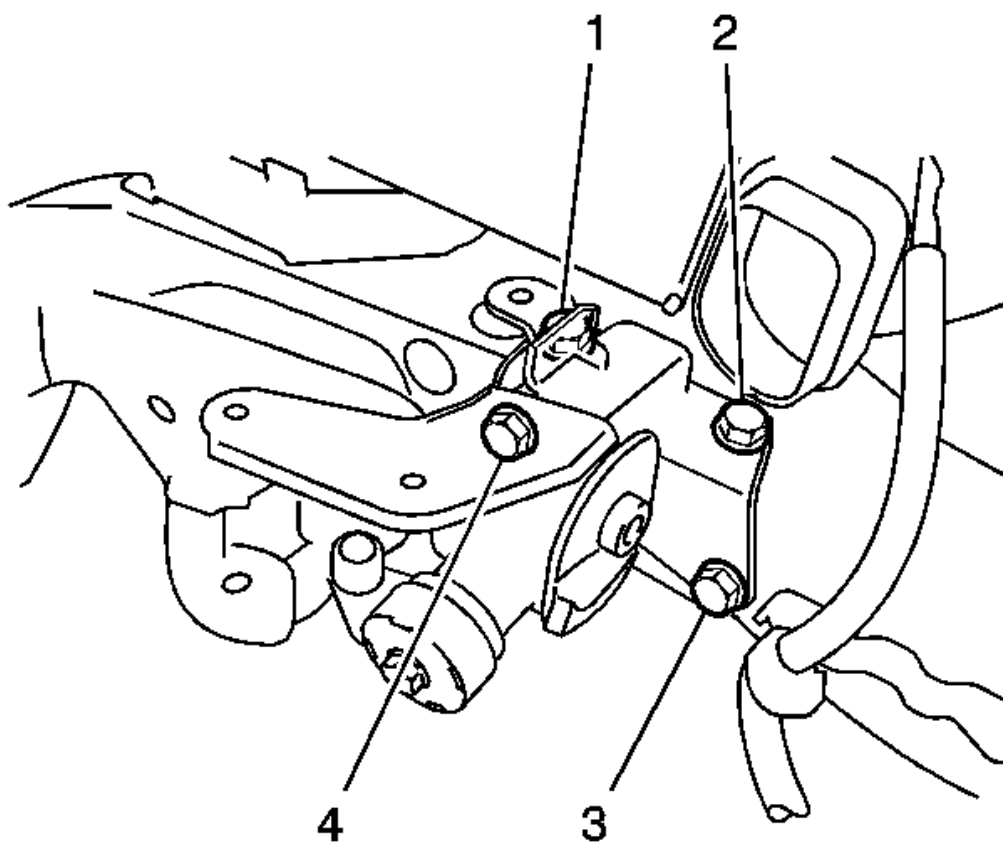


Fig. 248: Identifying Left Side Engine Mounting Insulator Bolts
Courtesy of GENERAL MOTORS CORP.

12. Temporarily install the engine mounting insulator LH with the 4 bolts.

IMPORTANT: Perform this procedure only when replacement of the engine mounting insulator is necessary.

13. Install the 4 bolts.

Tighten: Tighten the bolts to 52 N.m (38 lb ft).

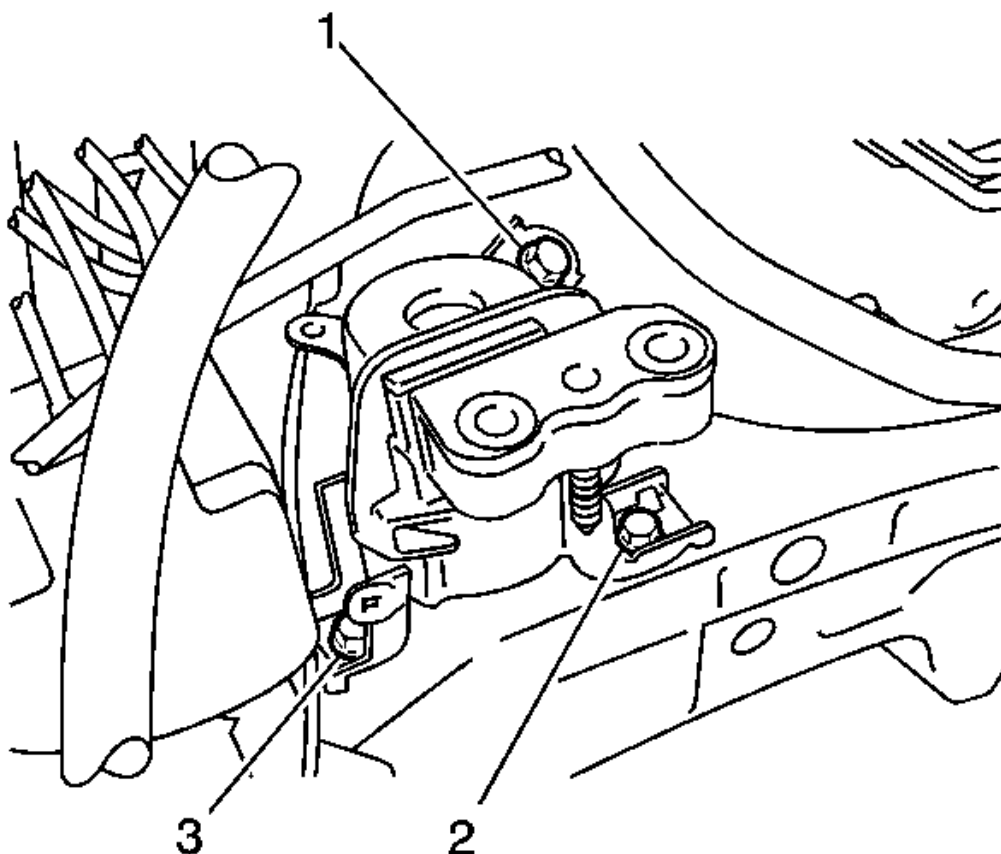


Fig. 249: View Of Engine Mounting Insulator Bolts - Right Side
Courtesy of GENERAL MOTORS CORP.

14. Install the engine mounting insulator RH with the 3 bolts.

Tighten: Tighten the bolts to 52 N.m (38 lb ft).

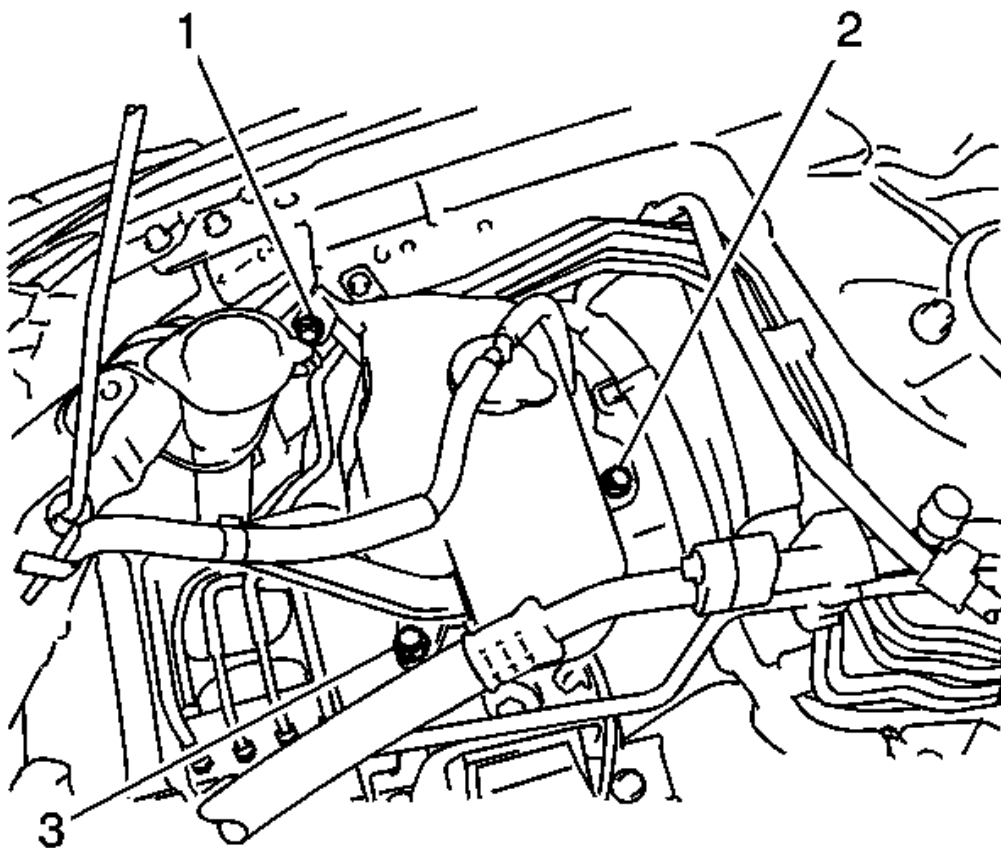


Fig. 250: View Of Radiator Surge Tank Assembly Bolts
Courtesy of GENERAL MOTORS CORP.

15. Install the radiator reserve tank with the 3 bolts.

Tighten: Tighten the bolts to 7.0 N.m (62 lb in).

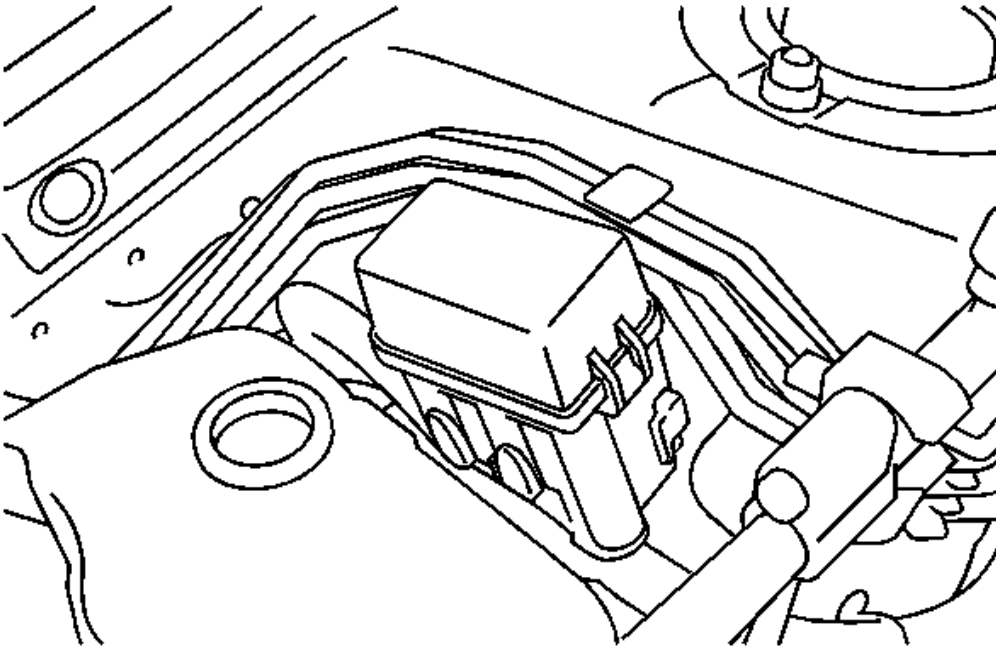


Fig. 251: Identifying Right Side Engine Mounting Insulator
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Perform this procedure only when replacement of the engine mounting insulator is necessary.

16. Install the relay block assembly.
17. Install the engine assembly with transaxle.
18. Set the engine assembly with transaxle and front suspension crossmember on the engine lifter.

IMPORTANT: Do not raise the engine more than necessary. If the engine is raised excessively, the vehicle may also be lifted up.

IMPORTANT:

- Make sure that the engine is clear of all wiring and hoses.
- While raising the engine into the vehicle, do not allow it to contact the vehicle.

19. Operate the engine lifter and lift the engine assembly with transaxle and front suspension crossmember to the position where the engine mounting insulators RH and LH can be installed.

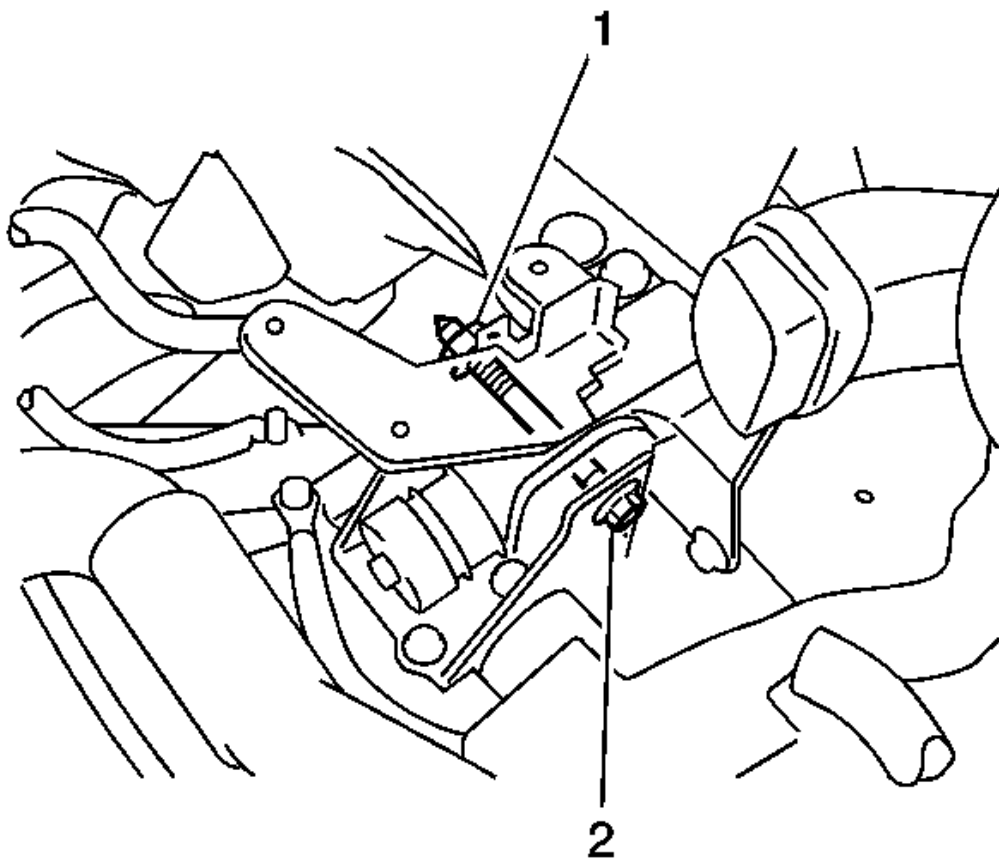


Fig. 252: Identifying Left Side Engine Mounting Insulator Through Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

20. Install the engine mounting insulator LH with the through bolt and nut.

Tighten: Tighten the bolt and nut to 56 N.m (41 lb ft).

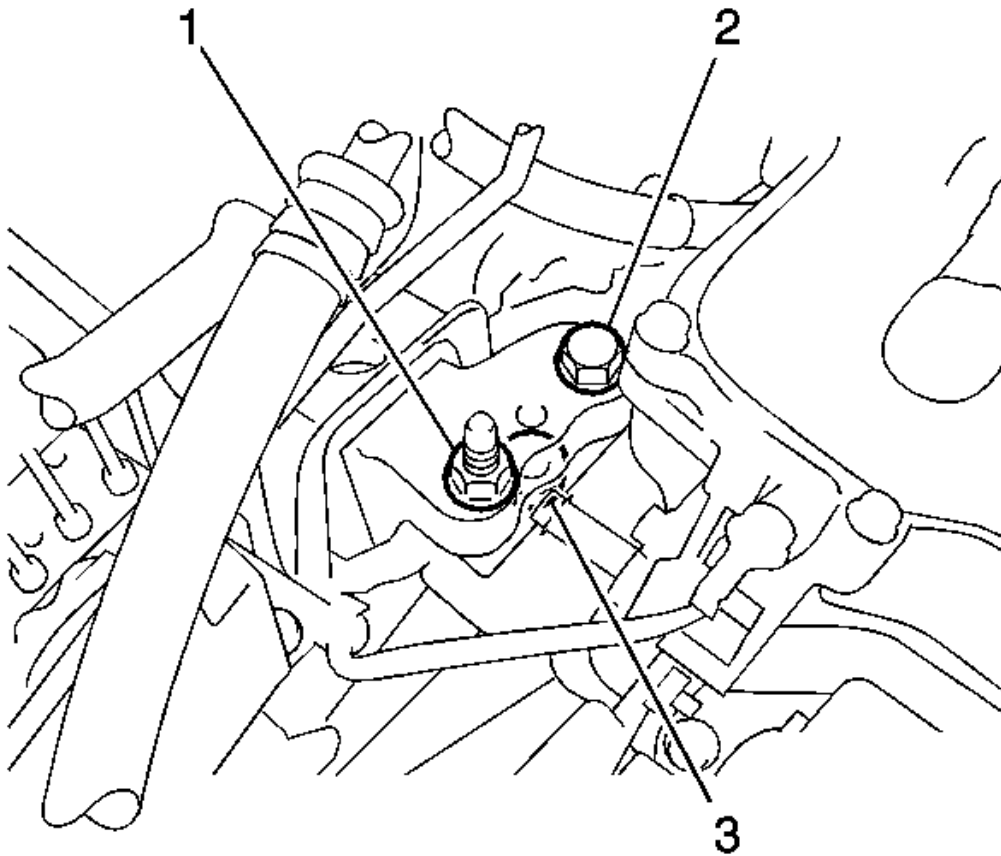


Fig. 253: Identifying Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

21. Install the engine mounting insulator RH with the bolt and 2 nuts.

Tighten:

- Tighten the nut A to 95 N.m (70 lb ft)
 - Tighten the nut B to 52 N.m (38 lb ft)
 - Tighten the bolt to 95 N.m (70 lb ft)
22. Temporarily install center engine mounting member sub-assembly.
 23. Install the front suspension crossmember sub-assembly.
 24. Fully tighten the center engine mounting member sub-assembly.
 25. Remove the 2 engine hangers with the 2 bolts.

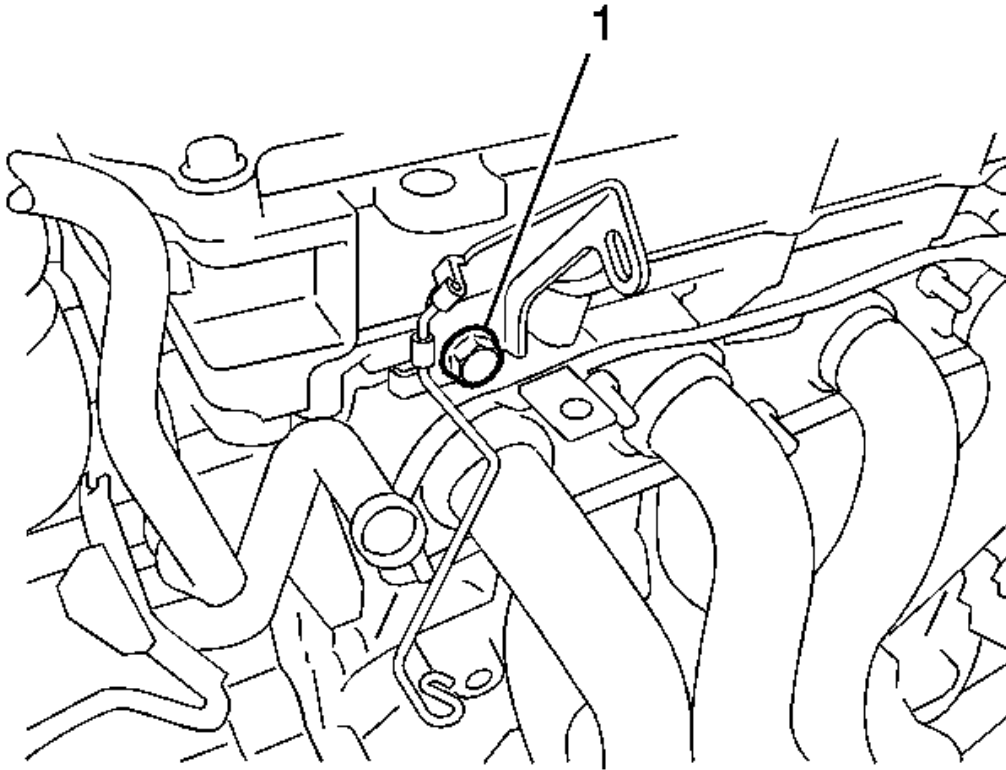


Fig. 254: Identifying Wire Harness Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

26. Install the wire harness bracket with the bolt.

Tighten: Tighten the bolt to 60 N.m (44 lb ft)

27. Install the drive plate and torque converter clutch setting bolt for the automatic transaxle.
28. Install the flywheel housing under cover for the automatic transaxle.
29. Install the front drive shaft hole snap ring LH.
30. Install the front drive shaft assembly LH. Refer to **Front Wheel Drive Shaft Replacement - Left Side** .
31. Install the front drive shaft assembly RH. Refer to **Front Wheel Drive Shaft Replacement - Right Side** .

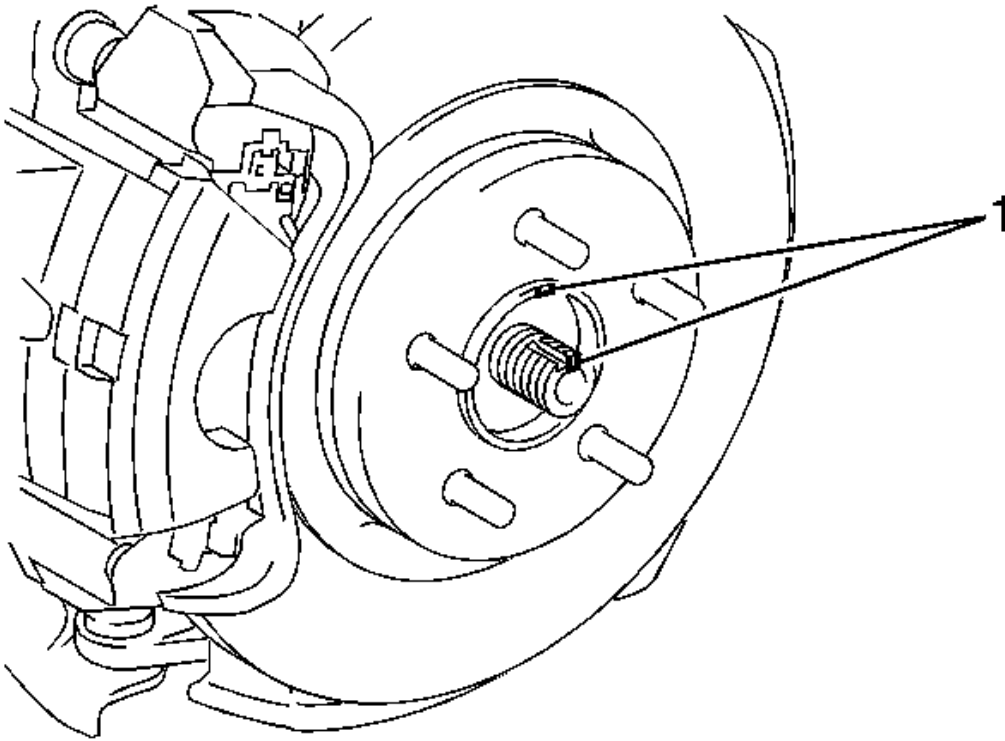


Fig. 255: Identifying Front axle Hub Nut
Courtesy of GENERAL MOTORS CORP.

32. Install the steering knuckle with axle hub LH by aligning the matchmarks and connect the front drive shaft assembly to the front axle assembly LH.

IMPORTANT: Perform the same procedure for the LH side.

33. Install the steering knuckle with axle hub RH.
34. Install the front lower No. 1 suspension arm sub-assembly LH.

IMPORTANT: Perform the same procedure for the LH side.

35. Install the front lower No. 1 suspension arm sub-assembly RH.
36. Install front stabilizer link assembly LH.

IMPORTANT: Perform the same procedure for the LH side.

37. Install the front stabilizer link assembly RH.
38. Connect the tie rod end sub-assembly LH.

IMPORTANT: Perform the same procedure for the LH side.

39. Connect the tie rod end sub-assembly RH.
40. Install the front speed sensor LH.
41. Install the front speed sensor RH.
42. Install the front axle shaft LH nut.
43. Install the front axle shaft RH nut.
44. Install the front exhaust pipe assembly.
45. Install the No. 1 steering column hole cover sub-assembly.
46. Install the No. 2 steering intermediate shaft assembly.
47. Install the column hole cover silencer sheet.

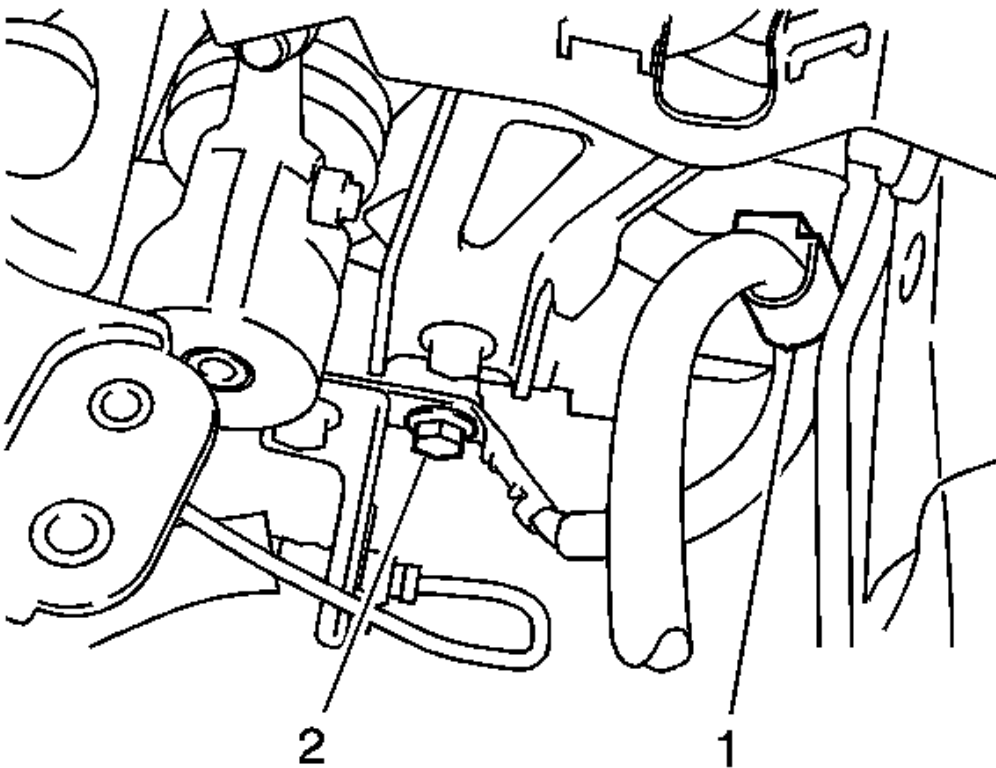


Fig. 256: View Of Bolt & Clamp (Manual Transaxle)

Courtesy of GENERAL MOTORS CORP.

48. Install the wire harness.
49. Install the ground wire to the engine compartment wire with the bolt and clamp for the manual transaxle.

Tighten: Tighten to 13 N.m (10 lb ft).

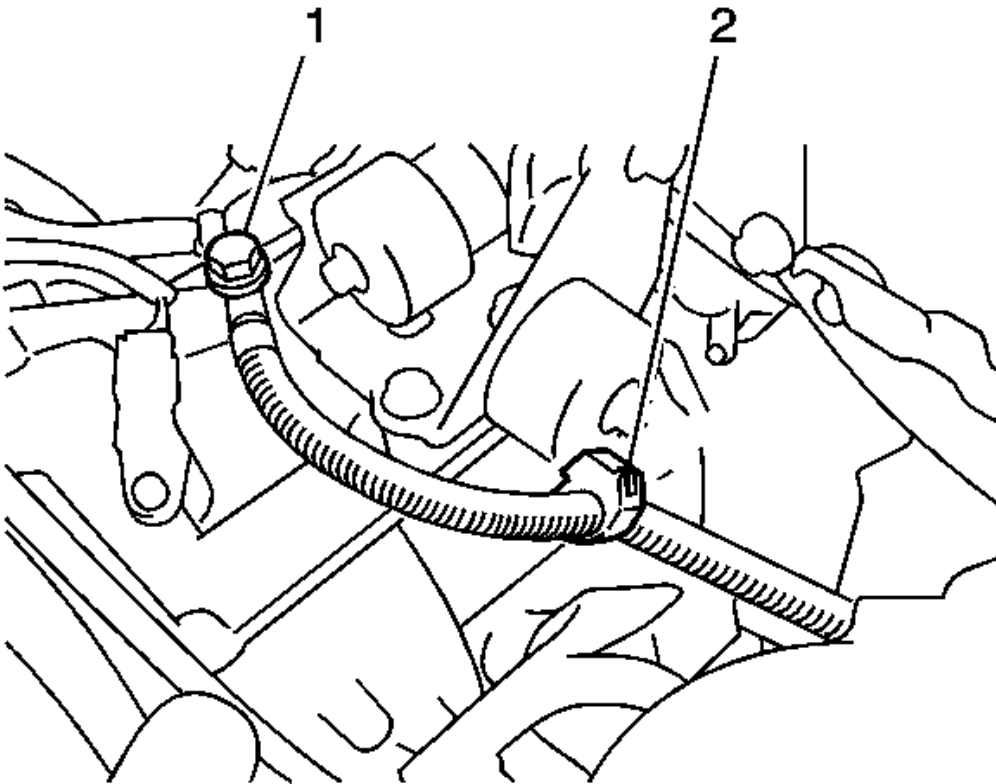


Fig. 257: Identifying Bolt & Clamp (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

50. Install the ground wire to the engine compartment wire with the bolt and clamp for the automatic transaxle.

Tighten: Tighten to 26 N.m (19 lb ft).

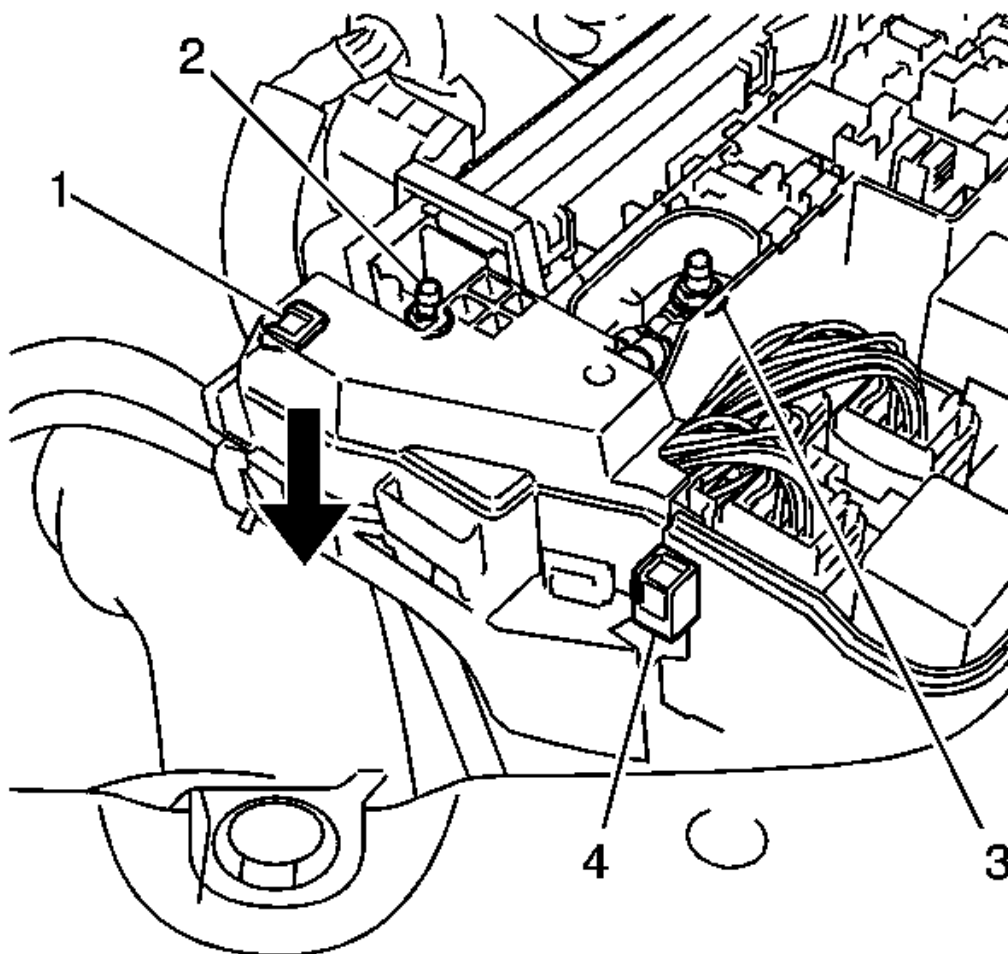


Fig. 258: Identifying Wire Harness Retainer Nuts
Courtesy of GENERAL MOTORS CORP.

51. Install the wire harness with the 2 nuts.

Tighten: Tighten the nuts to 8.4 N.m (74 lb in).

52. Connect the 3 connectors and wire harness clamp to the engine room junction block.

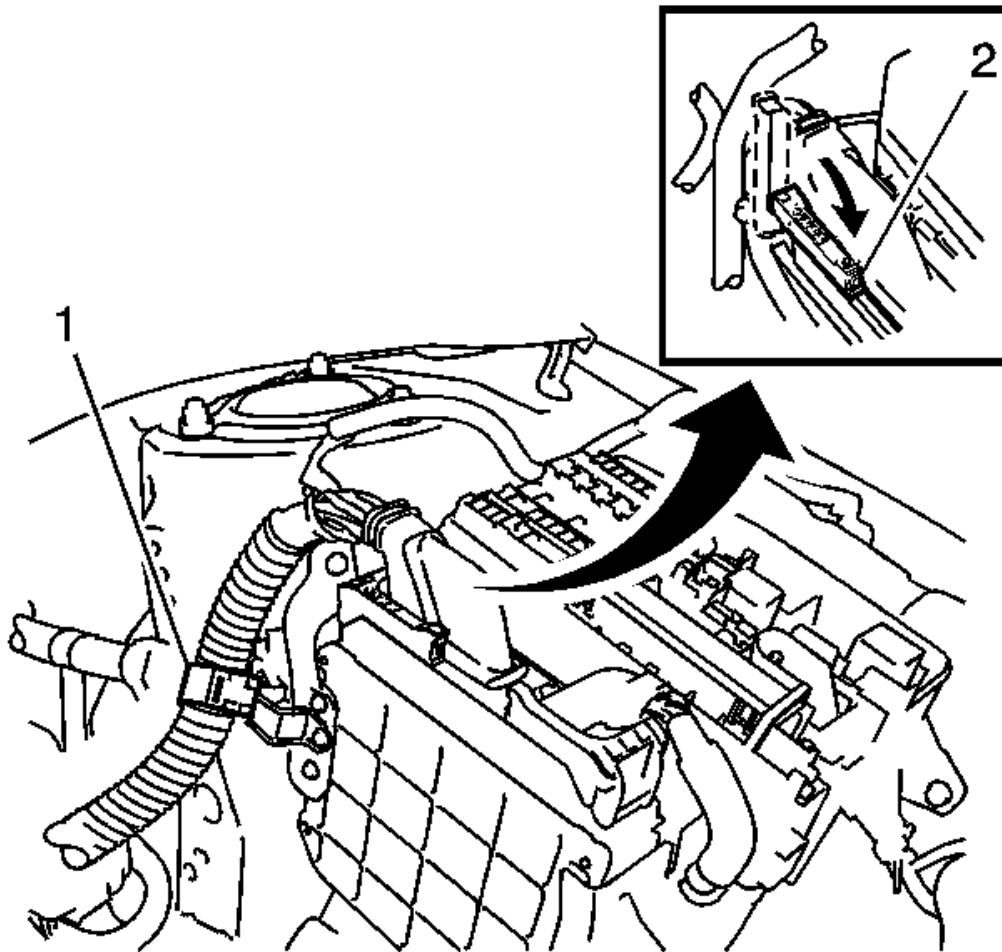


Fig. 259: Locating Engine Control Computer Connector
Courtesy of GENERAL MOTORS CORP.

53. Connect the connector to the ECU with the clamp and lock lever.

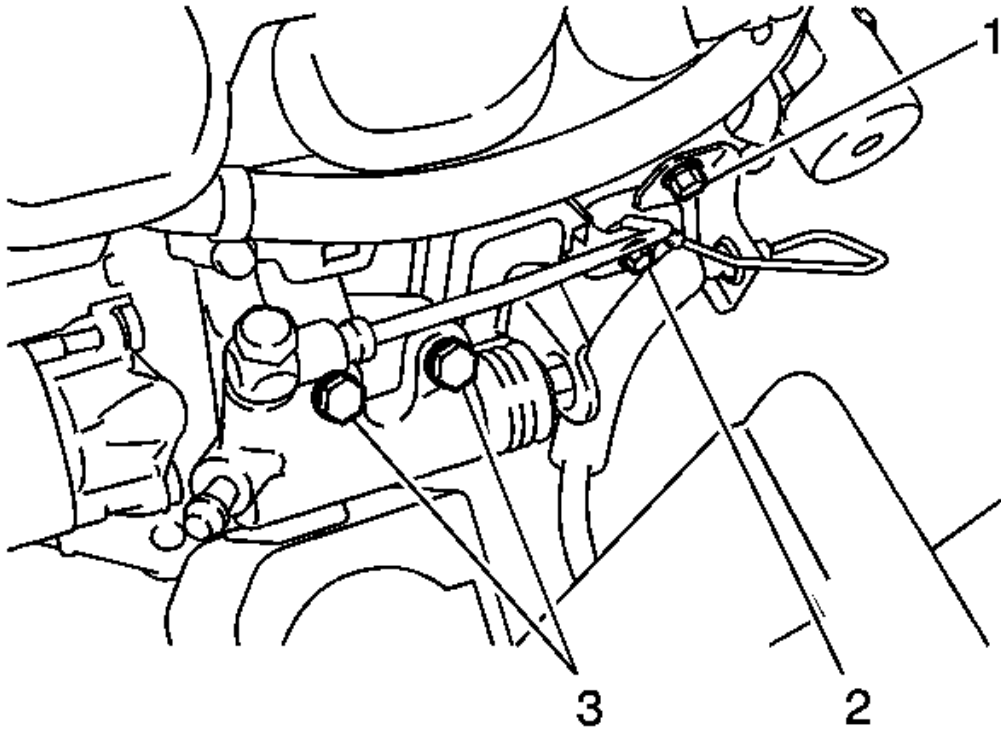


Fig. 260: Identifying Clutch Release Cylinder Assembly Bolts
Courtesy of GENERAL MOTORS CORP.

54. Install the clutch release cylinder assembly with the 5 bolts and clutch tube bracket for the manual transaxle.

Tighten:

- Tighten bolt A to 12 N.m (9 lb ft)
 - Tighten bolt B to 12 N.m (9 lb ft)
 - Tighten bolt C to 8.0 N.m (71 lb in)
55. Install the compressor with pulley assembly with air conditioning system.
56. Install the generator assembly. Refer to **Generator Replacement (1.8L)**
57. Install the V-ribbed belt. Refer to **Drive Belt Replacement**.

IMPORTANT: Align the fuel tube connector with the pipe, then push the fuel tube connector in until the retainer makes a click sound. If the connection is tight, apply a small amount of engine oil to the tip of the pipe. After connecting, pull on the pipe and connector to make sure that they are

securely connected.

58. Connect the fuel tube connector and fuel pipe.

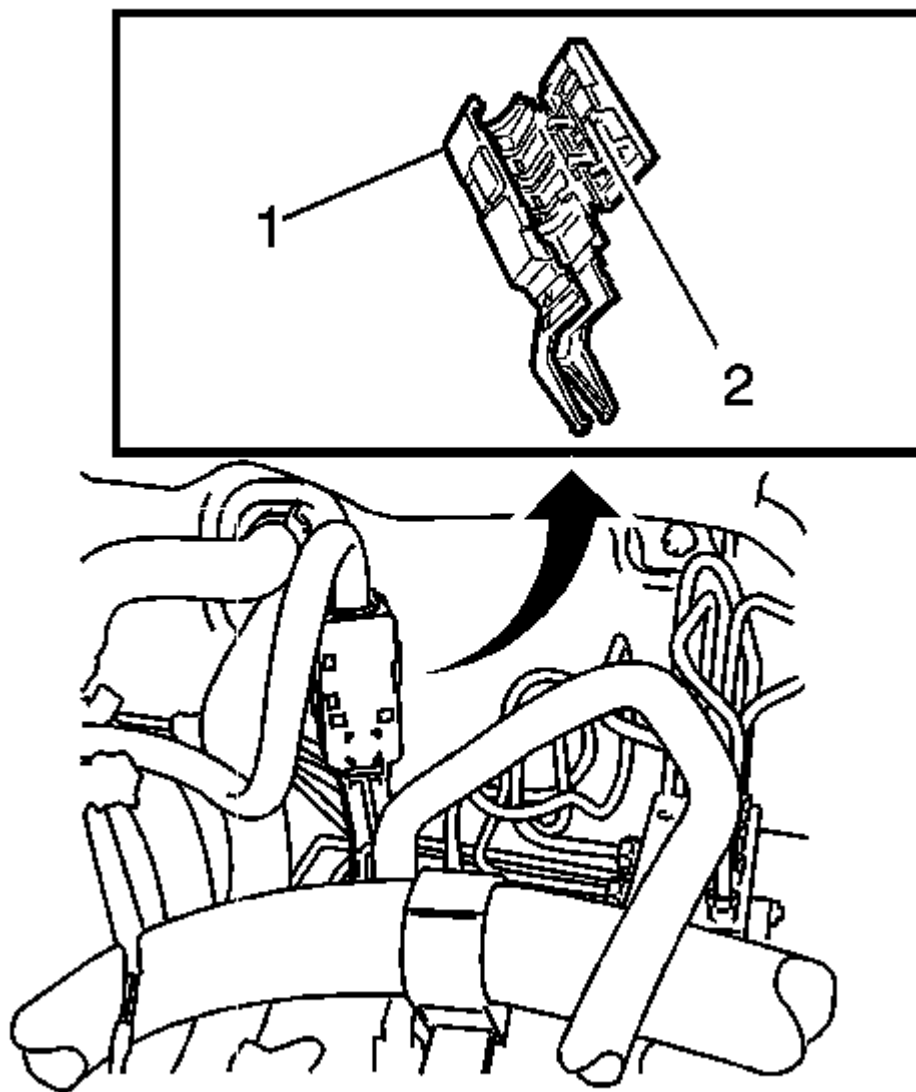


Fig. 261: Identifying No. 1 Fuel Pipe Clamp & Claw
Courtesy of GENERAL MOTORS CORP.

59. Engage the claw and install the No. 1 fuel pipe clamp.

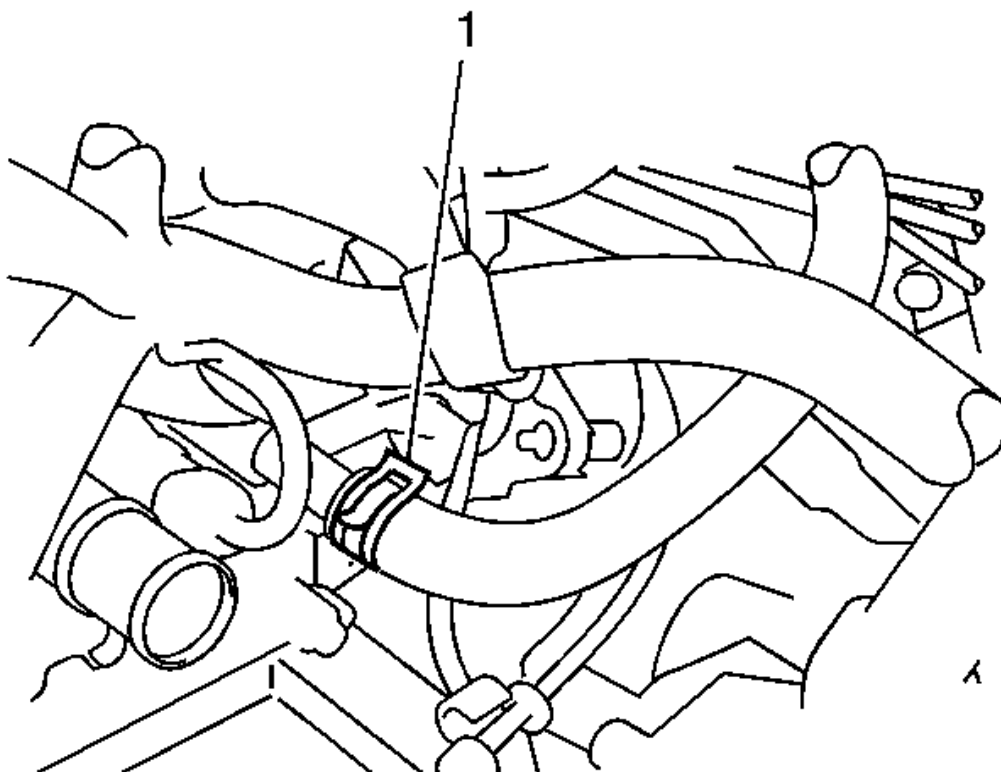


Fig. 262: Identifying Heater Inlet Hose
Courtesy of GENERAL MOTORS CORP.

60. Connect the inlet heater water hose with the clamp.

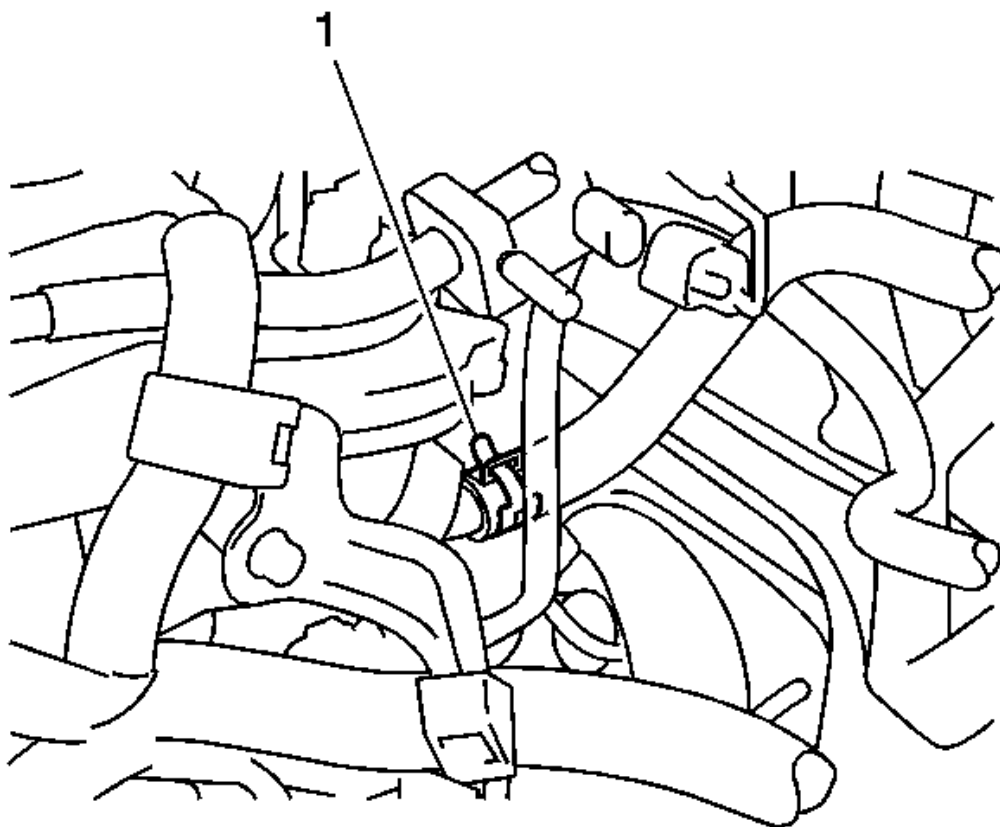


Fig. 263: Identifying Heater Outlet Hose
Courtesy of GENERAL MOTORS CORP.

61. Connect the outlet heater water hose with the clamp.
62. Connect the union to check valve hose with the clamp.

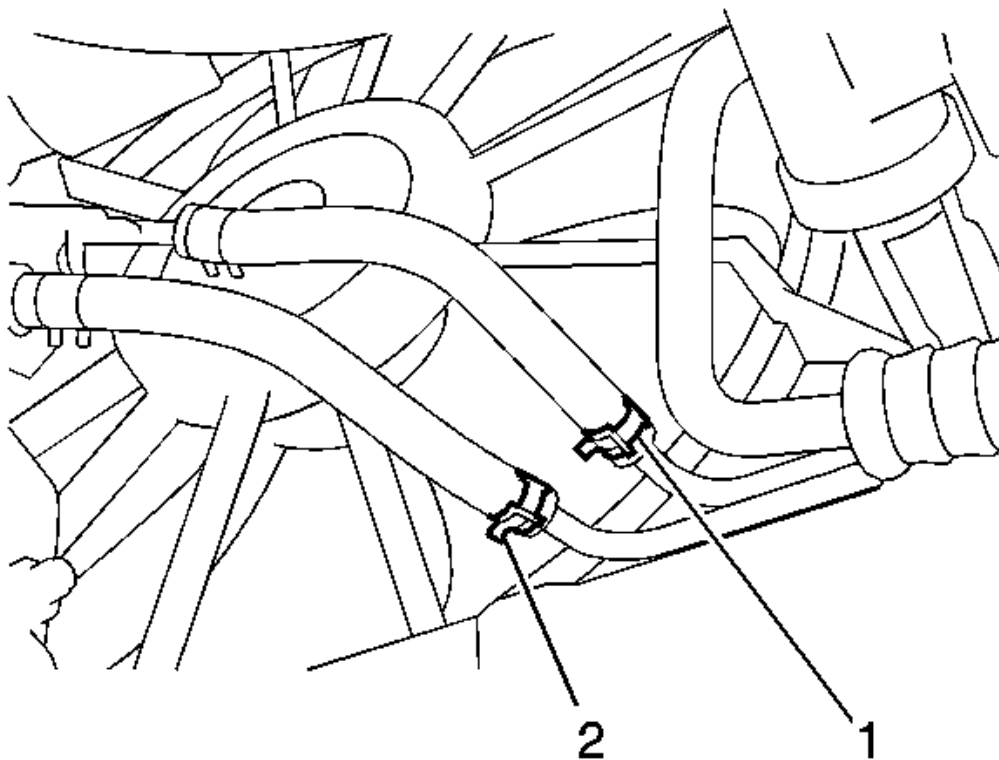


Fig. 264: Identifying Cooler Hoses & Oil Cooler Tube
Courtesy of GENERAL MOTORS CORP.

63. Connect the 2 oil cooler hoses with the clamp-for automatic transaxle.

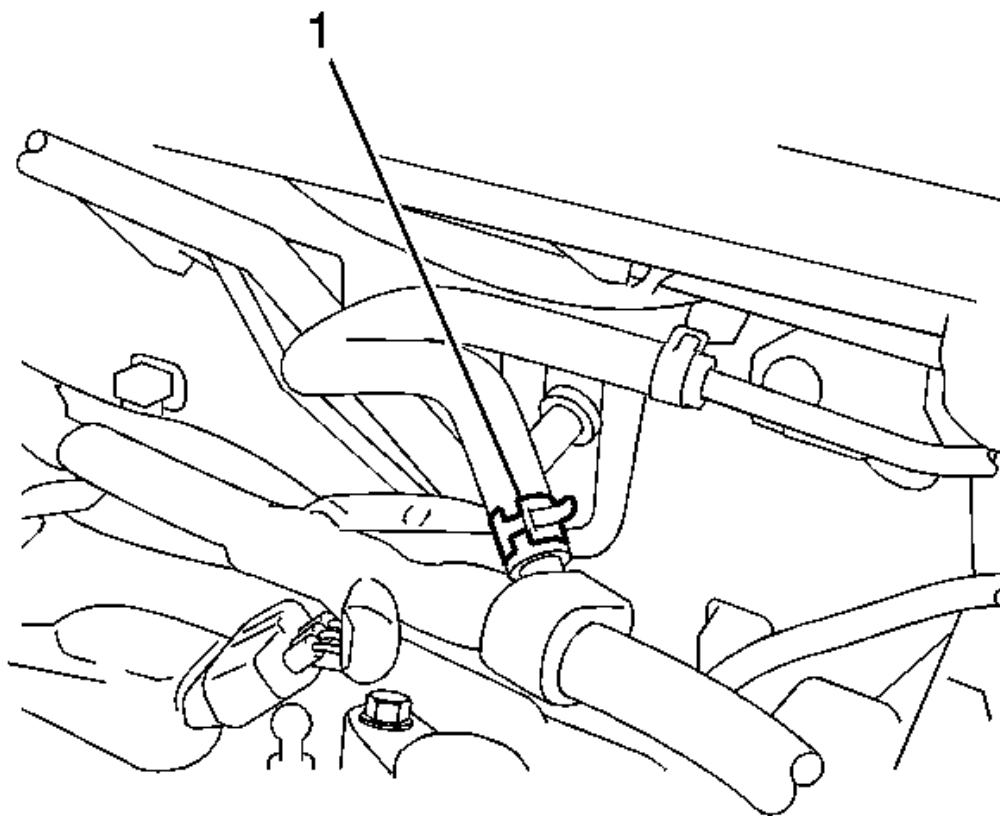


Fig. 265: Identifying Connector Tube Hose & Union
Courtesy of GENERAL MOTORS CORP.

64. Connect the union to connector tube hose.

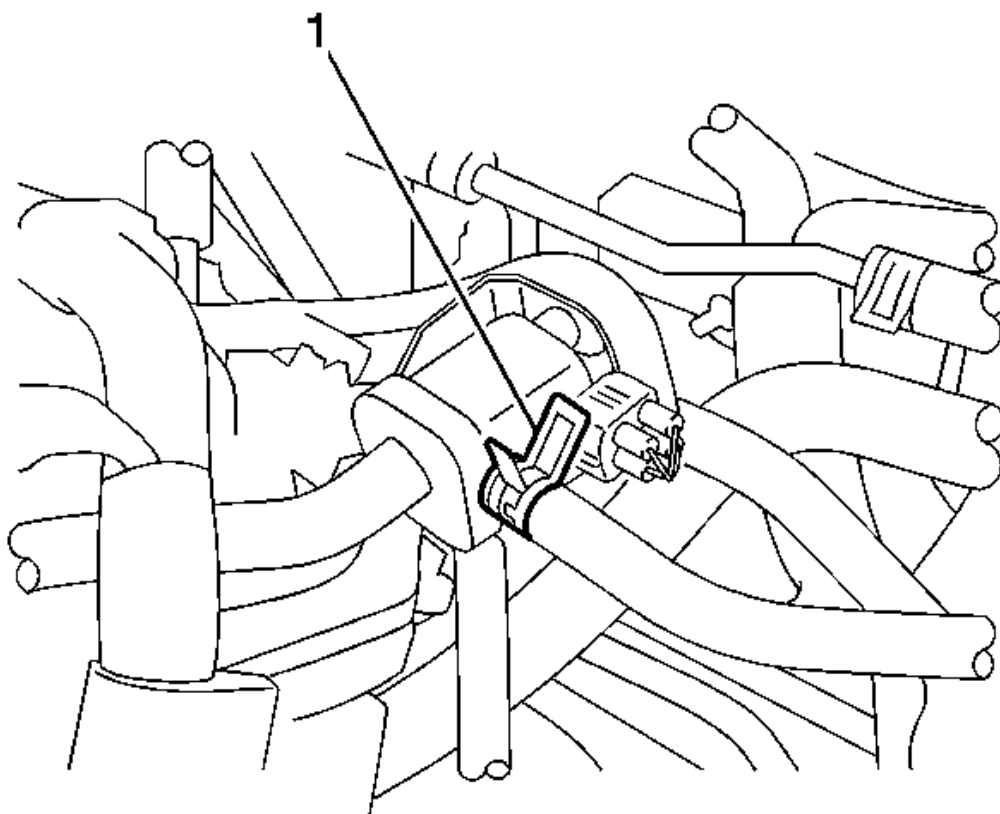


Fig. 266: Identifying Fuel Vapor Feed Hose Assembly
Courtesy of GENERAL MOTORS CORP.

65. Connect the fuel vapor feed hose assembly.

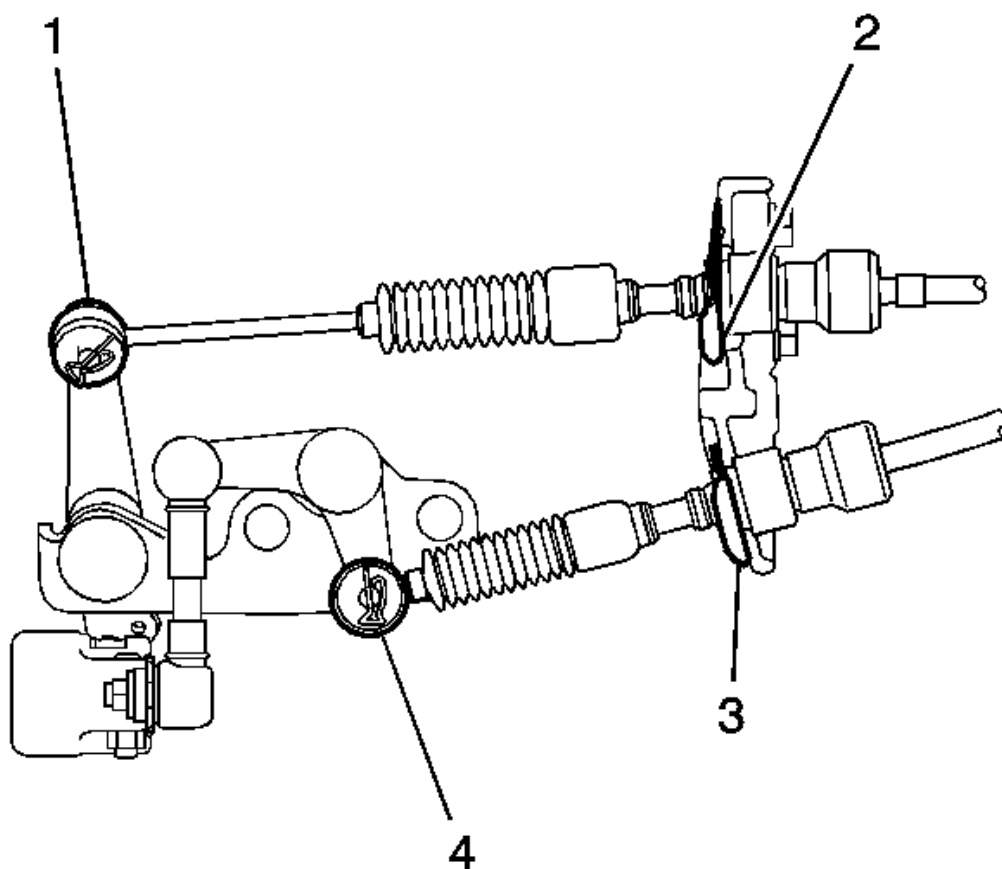


Fig. 267: Identifying Manual Transmission Shift Control Cables
Courtesy of GENERAL MOTORS CORP.

66. Install the transmission control cable to the control cable bracket with 2 new clips-for manual transaxle.
67. Install the transmission control cable to the transaxle with the 2 clips-for manual transaxle.

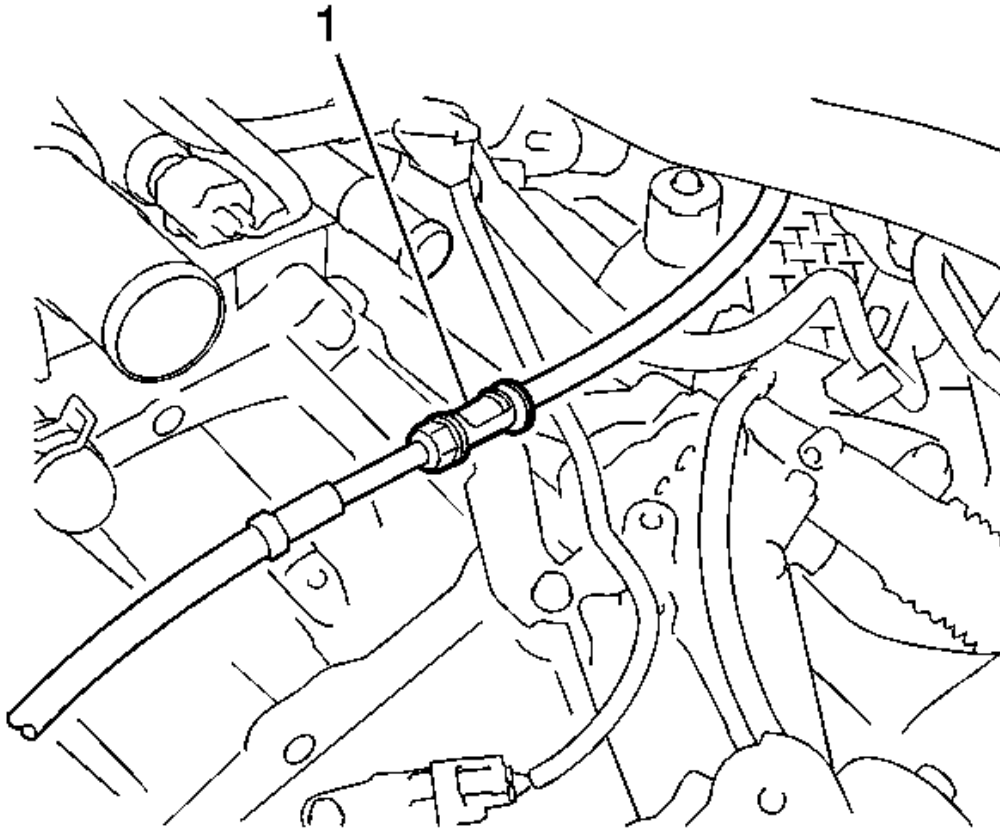


Fig. 268: Identifying Automatic Transmission Shift Control Cable
Courtesy of GENERAL MOTORS CORP.

68. If equipped with automatic transmission secure the control cable onto the control cable bracket with the clip.
69. Connect the control cable onto the control shaft lever with the nut.

Tighten: Tighten the nut to 12 N.m (9 lb ft).

70. Connect the control cable to the cable support.
71. Connect the clamp of the control cable with the bolt.

Tighten: Tighten the bolt to 12 N.m (9 lb ft).

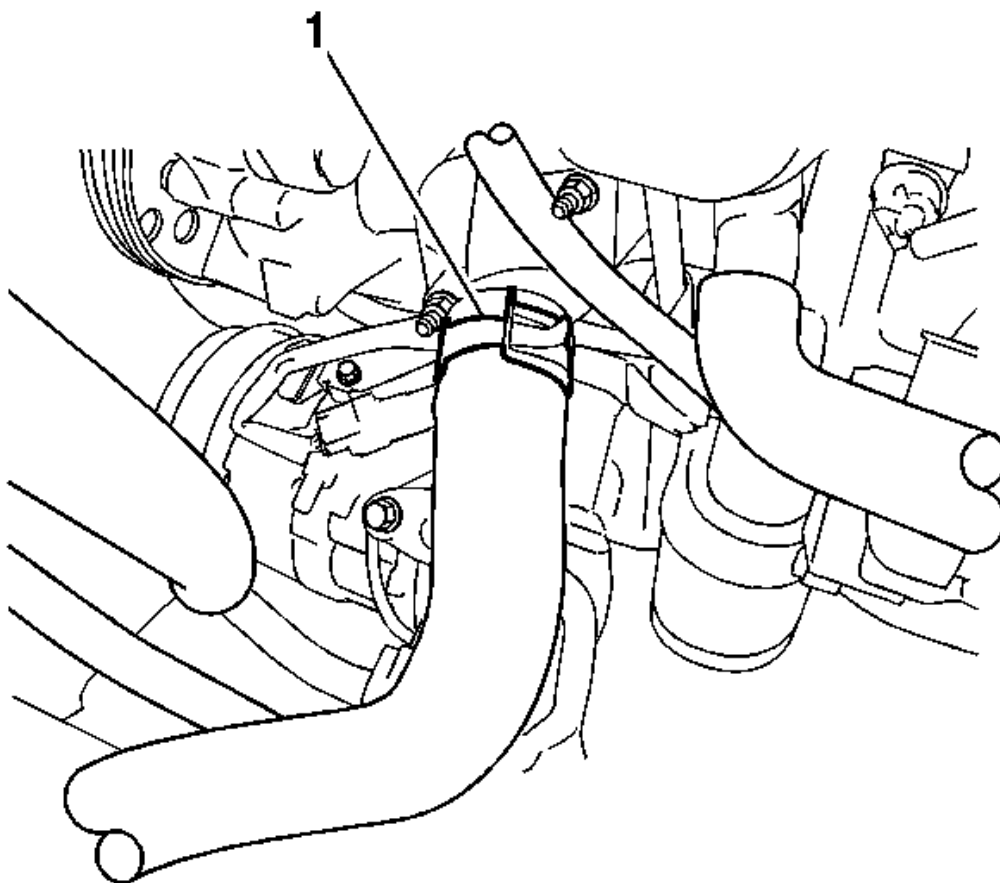


Fig. 269: Identifying Lower Radiator Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

72. Connect the No. 2 radiator hose with the clamp.

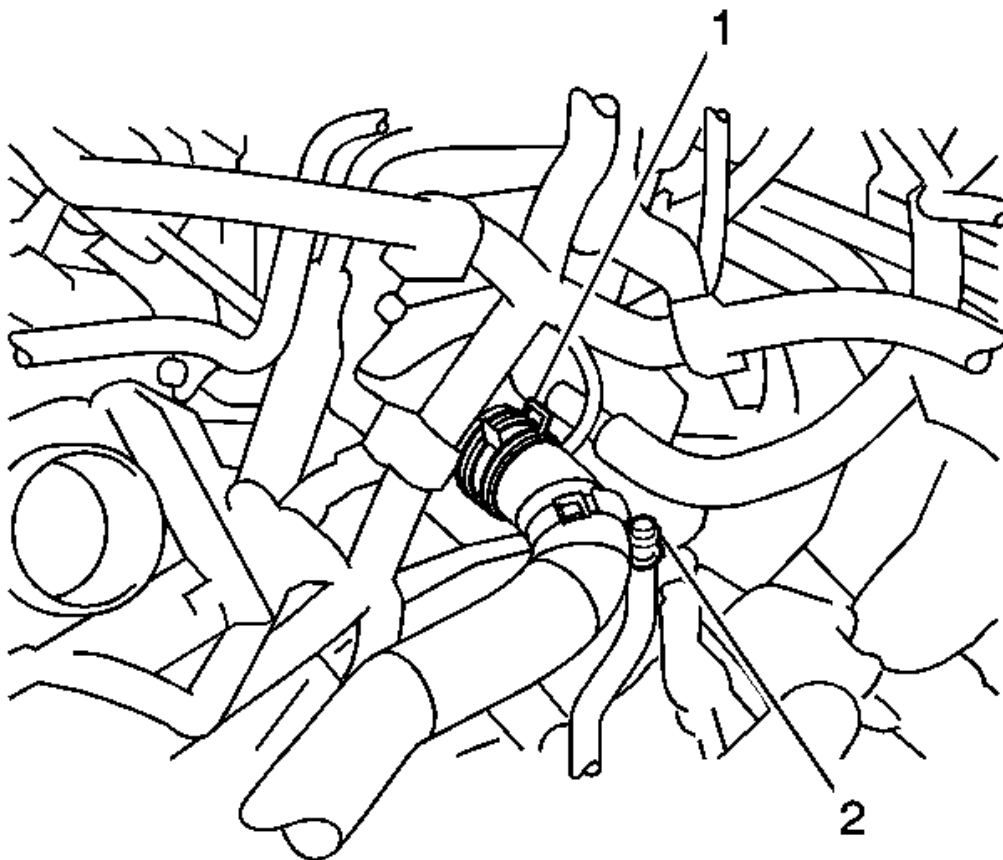


Fig. 270: Identifying Radiator Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

73. Connect the No. 1 radiator hose with the clamp.
74. Connect the clamp.
75. Install the battery carrier with the 4 bolts.

Tighten: Tighten the bolts to 19 N.m (14 lb ft).

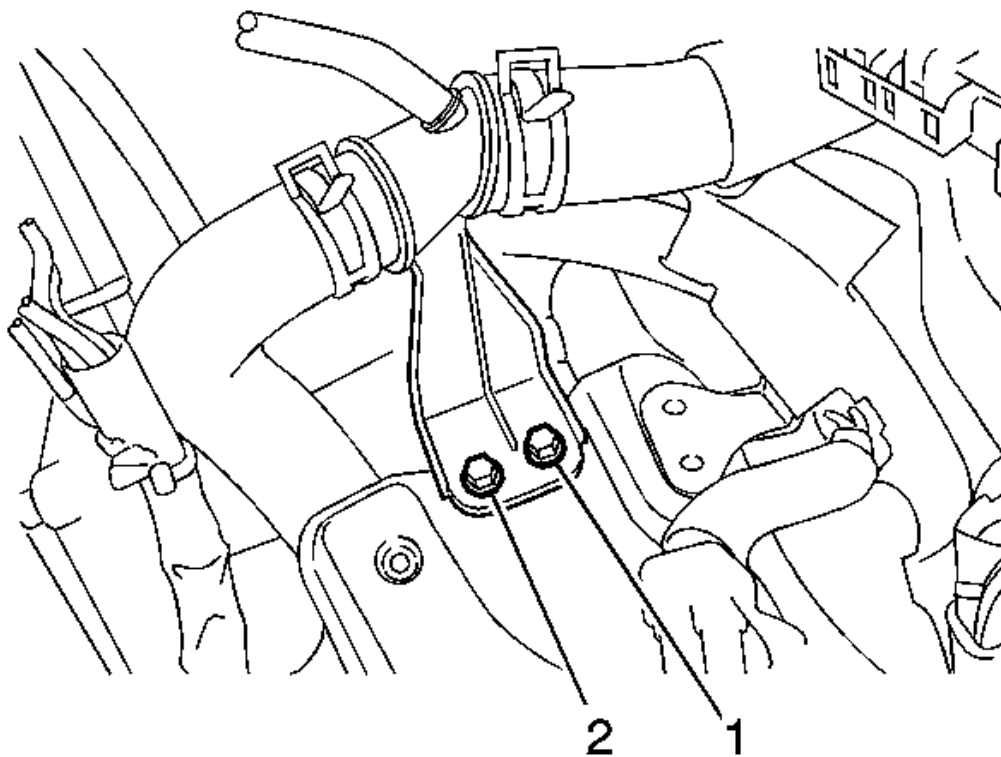


Fig. 271: Identifying Radiator Pipe Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

76. Connect the radiator pipe with the 2 bolts.

Tighten: Tighten the bolts to 8.8 N.m (78 lb in).

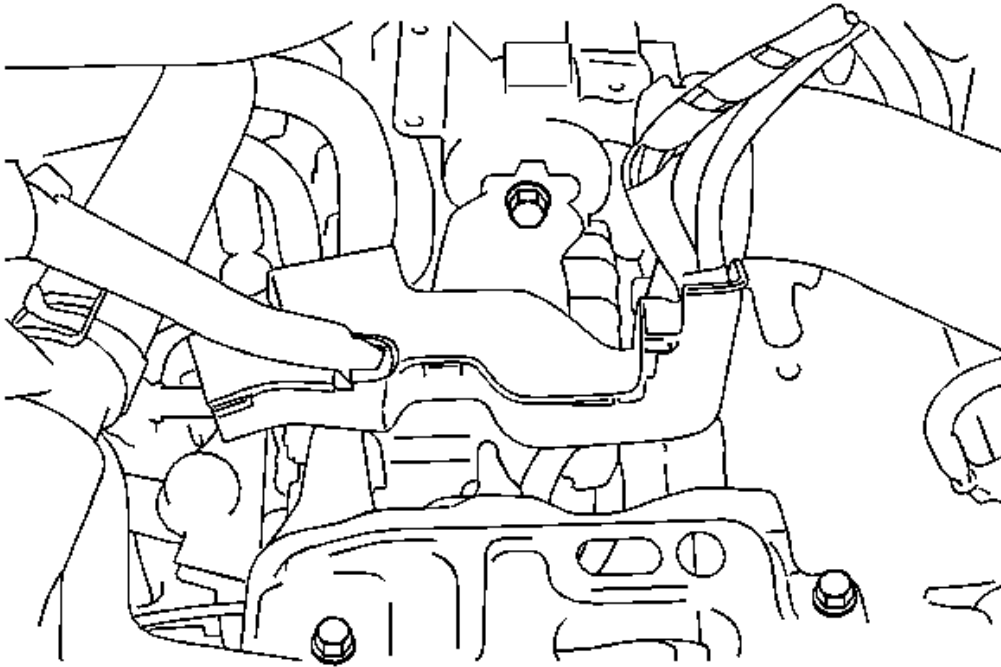


Fig. 272: Identifying Wire Harness Clamps At Battery Carrier
Courtesy of GENERAL MOTORS CORP.

77. Connect the 2 wire harness clamps.
78. Install the battery clamp with the bolt and nut.

Tighten:

- Tighten the bolts to 6.5 N.m (58 lb in).
- Tighten the nut to 3.5 N.m (31 lb in).

79. Connect the battery cables.

Tighten: Tighten to 5.4 N.m (48 lb in).

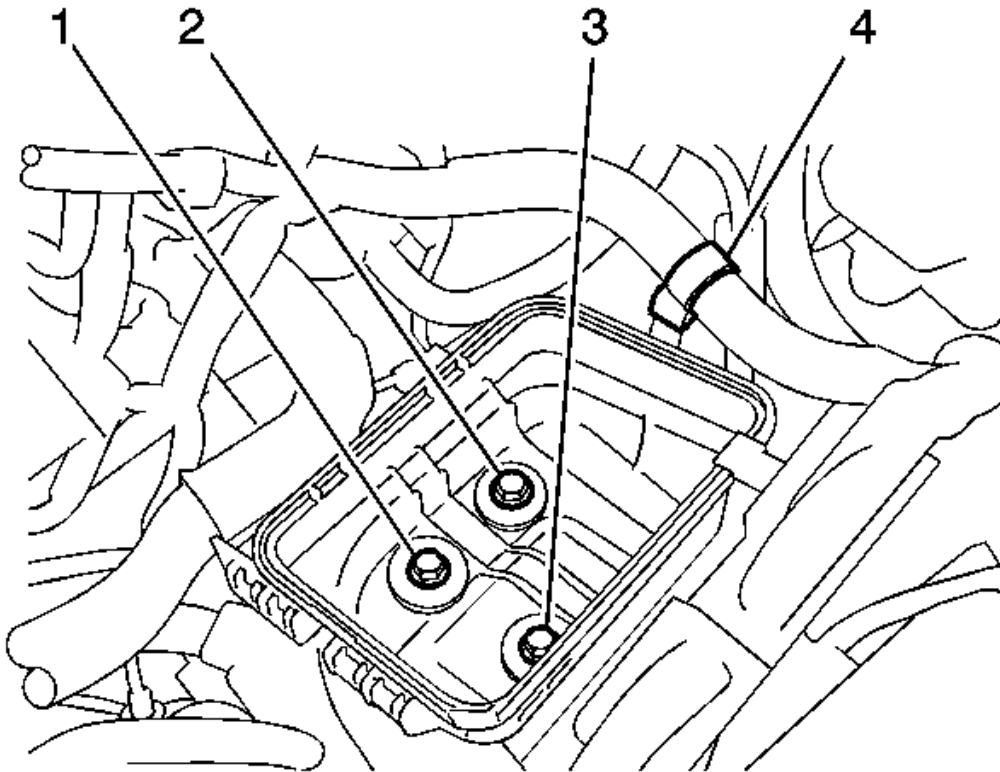


Fig. 273: Identifying Air Cleaner Case & Engine Wire Harness Clamp
Courtesy of GENERAL MOTORS CORP.

80. Install the air cleaner case with the 3 bolts.

Tighten: Tighten the bolts to 7.0 N.m (62 lb in).

81. Install the wire harness clamp to the air cleaner case.
82. Install the air cleaner assembly.
83. Add transaxle oil for the manual transaxle.
84. Add automatic transaxle fluid for the automatic transaxle.
85. Inspect transaxle fluid level for the automatic transaxle.
86. Inspect for automatic transaxle fluid leak for the automatic transaxle.
87. Inspect the shift lever position for the automatic transaxle.
88. Adjust the shift lever position for the automatic transaxle.
89. Add the engine coolant. Refer to **Cooling System Draining and Filling** .
90. Add the engine oil.

- 91. Inspect the engine oil level.
- 92. Inspect the for fuel leak.
- 93. Inspect the for engine coolant leak.
- 94. Inspect the for oil leak.
- 95. Inspect the for exhaust gas leak.
- 96. Install the engine under cover LH.
- 97. Install the engine under cover RH.
- 98. Install the front wheels.

Tighten: Tighten to 103 N.m (76 lb ft).

- 99. Inspect the ignition timing.
- 100. Inspect the engine idle speed.
- 101. Inspect the CO/HC.
- 102. Adjust the front wheel alignment. Refer to **Wheel Alignment Measurement** .

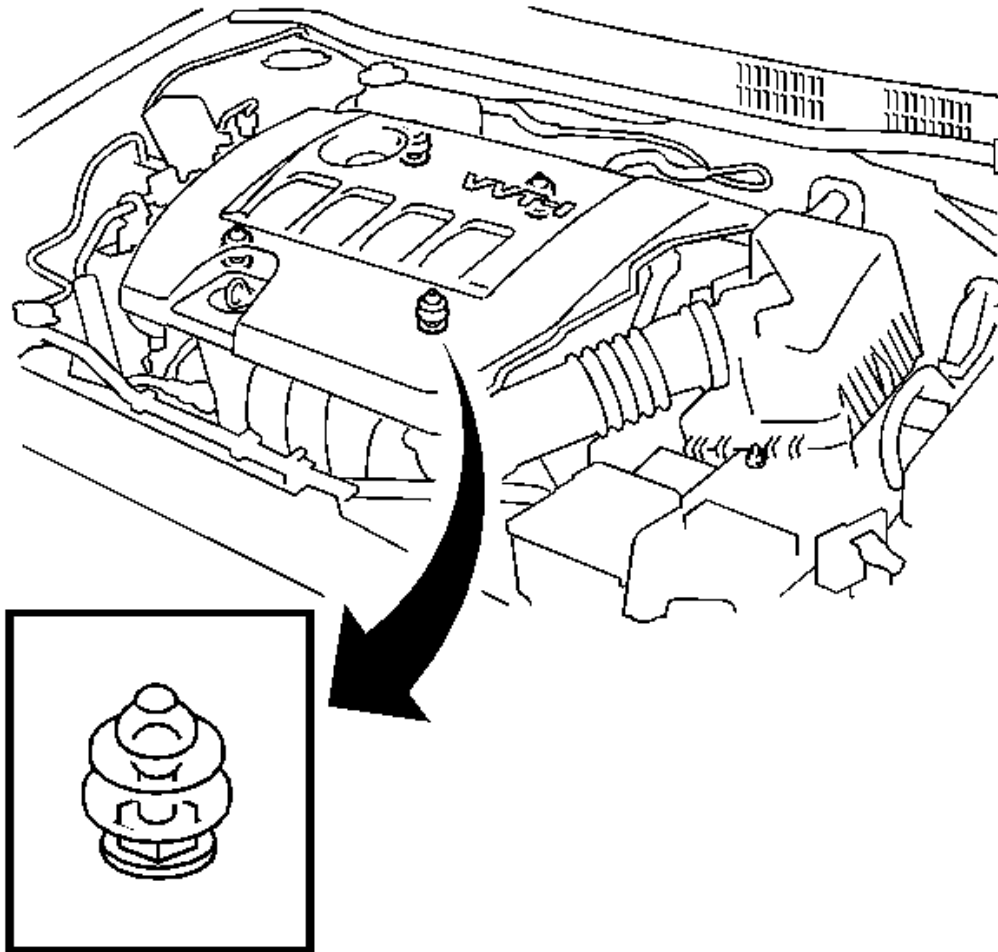


Fig. 274: View Of Engine & Rear Clips
Courtesy of GENERAL MOTORS CORP.

NOTE: Be sure to engage the clips securely. Do not apply excessive force or do not hit the cover to engage the clips. This may cause the cover to break.

103. Engage the 4 clips to install the No. 2 cylinder head cover.
104. Check the ABS speed sensor signal.

ENGINE OIL AND OIL FILTER REPLACEMENT

IMPORTANT: For environmental protection, used oil and used oil filters must be disposed of at designated disposal sites.

1. Remove the oil filler cap.
2. Remove the oil drain plug and drain the oil into a container.

NOTE: Refer to **FASTENER CAUTION** .

3. Clean and install the oil drain plug with a new gasket.

Tighten: Tighten to 37 N.m (27 lb ft).

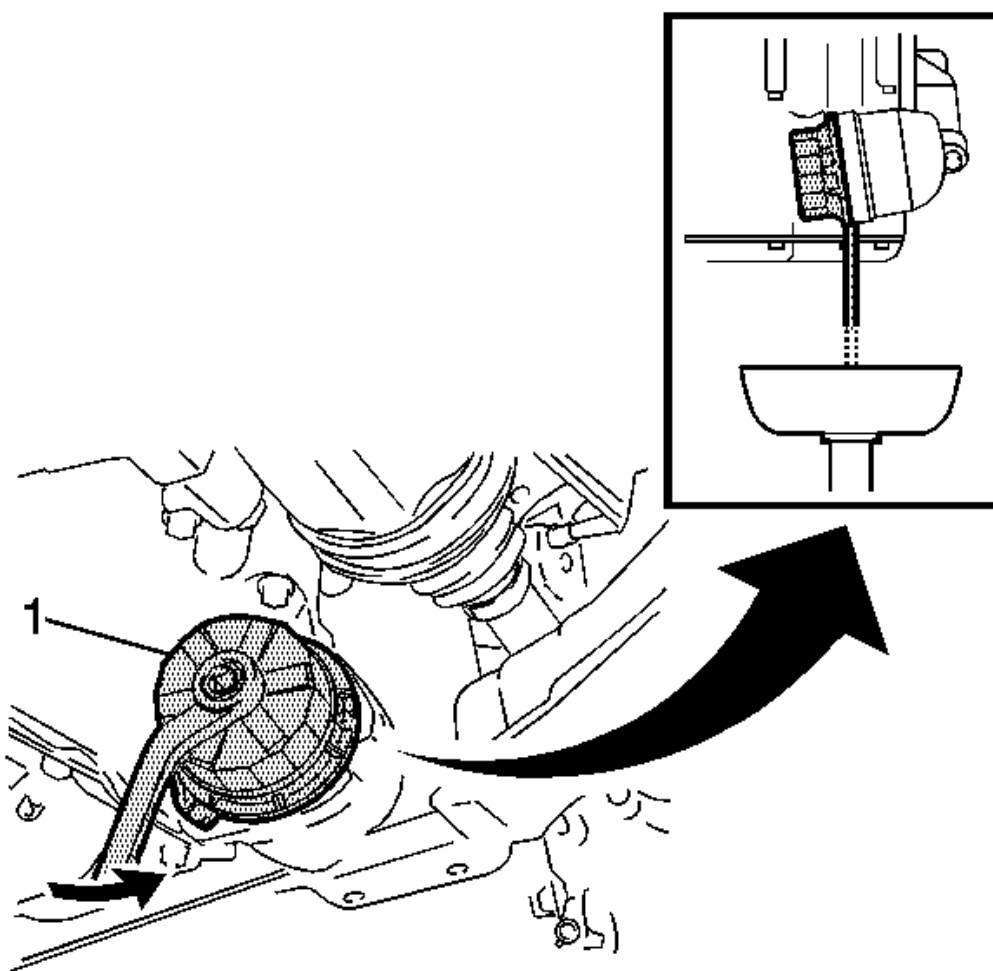


Fig. 275: Identifying Rap Type Wrench
Courtesy of GENERAL MOTORS CORP.

4. Using a strap type wrench, loosen the oil filter cap 4 revolutions, align the cap ribs vertically, and drain the remaining engine oil in the oil filter and cap.

IMPORTANT: Set a container below the oil filter cap assembly before loosening the oil filter cap.

5. Remove the oil filter cap assembly.

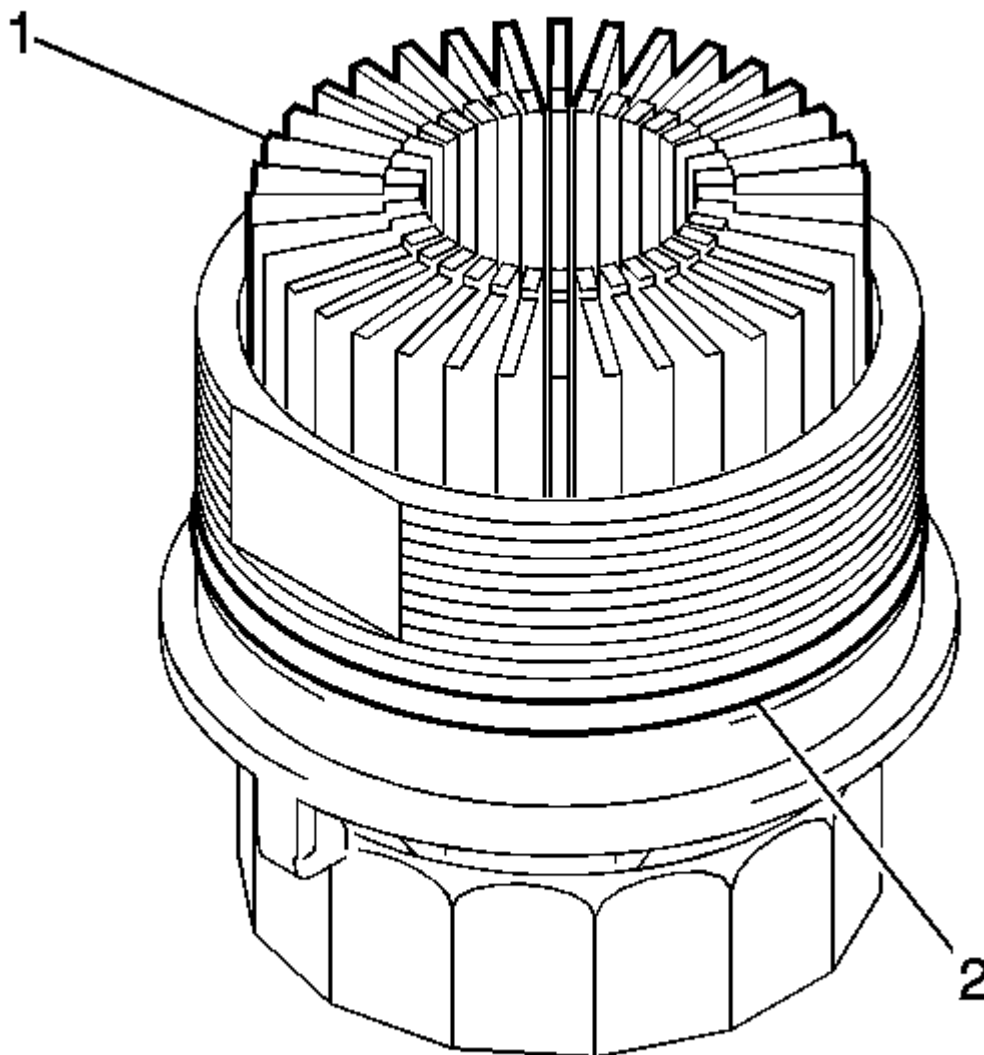


Fig. 276: View Of Oil Filter Element & O-Ring

Courtesy of GENERAL MOTORS CORP.

NOTE: Be sure to remove the O-ring (for the cap) by hand, without using any tools, to prevent damage to the groove for the O-ring on the cap.

6. Remove oil filter element and O-ring from the oil filter cap.
7. Clean the oil filter cap threads and O-ring groove.
8. Apply a small amount of engine oil to a new O-ring and install it to the oil filter cap.
9. Set a new oil filter element in the oil filter cap.
10. Remove any dirt or foreign matter from the installation surfaces.

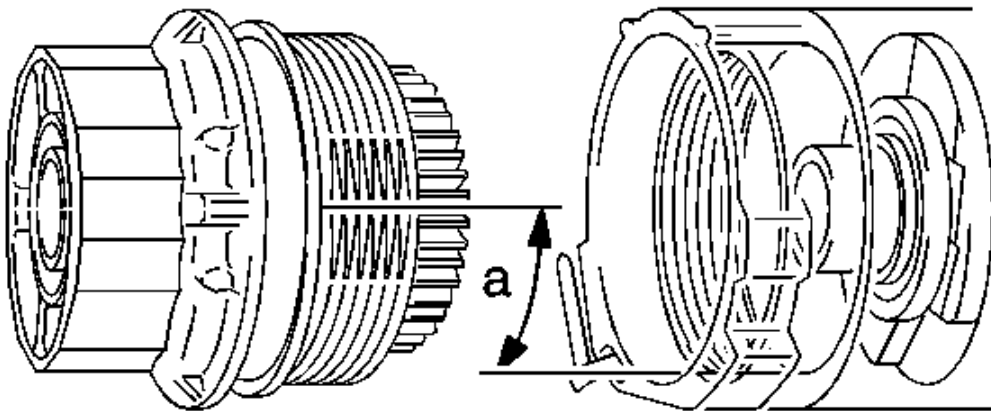


Fig. 277: Identifying Correct Tightening Procedure Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

NOTE: Make sure that the O-ring does not get caught between the parts.

11. Apply a small amount of engine oil to the O-ring of the oil filter cap assembly. Align the cutout in the oil filter cap threads 90 degrees to the grooves in the oil filter bracket and temporarily tighten the cap.

IMPORTANT: After tightening the oil filter cap assembly, check for gaps between the installation surfaces. Do not remove the oil filter bracket clip when installing the oil filter cap assembly. Do not cross thread the oil filter cap assembly.

12. Using a strap type wrench, tighten the oil filter cap assembly.

Tighten: Tighten to 25 N.m (18 lb ft).

13. Add fresh engine oil and install the oil filler cap.
14. Inspect for oil leaks.

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

1. Position an appropriate drain pan under the engine.
2. Remove the oil pan drain bolt and allow oil to drain from the oil pan.

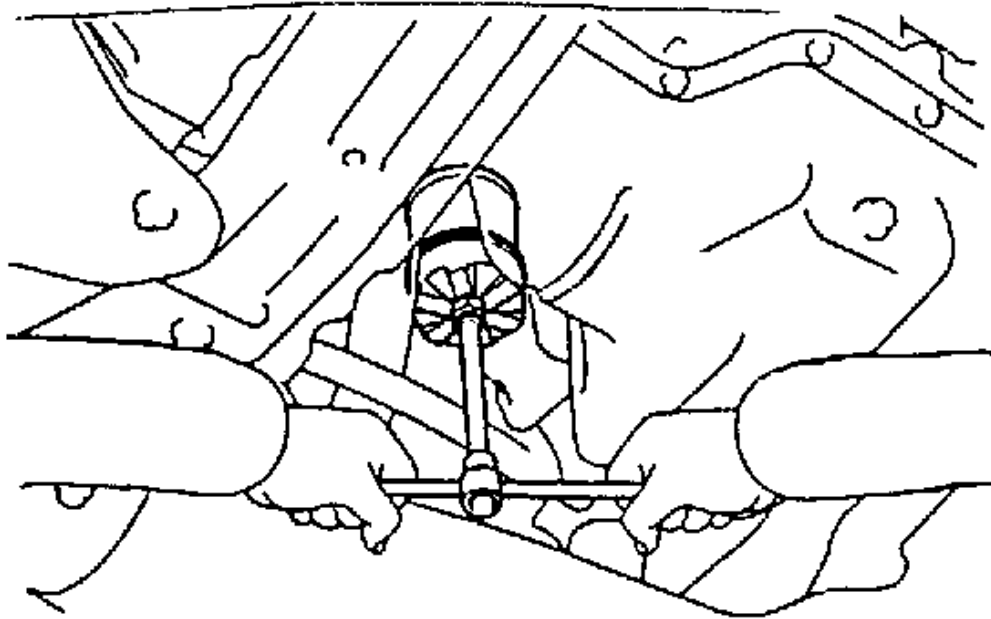


Fig. 278: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter.
4. Remove coolant jacket drain plug and allow coolant to drain from the water jacket.

CAUTION: Refer to Fastener Caution .

5. Install oil pan drain bolt and the coolant jacket plug.
 - Tighten the bolt to 35 N.m (26 lb ft).
 - Tighten the plug to 25 N.m (18 lb ft).
6. If cleaning or repairing the engine block, it is not necessary to reinstall the plugs.

ENGINE FLYWHEEL REMOVAL

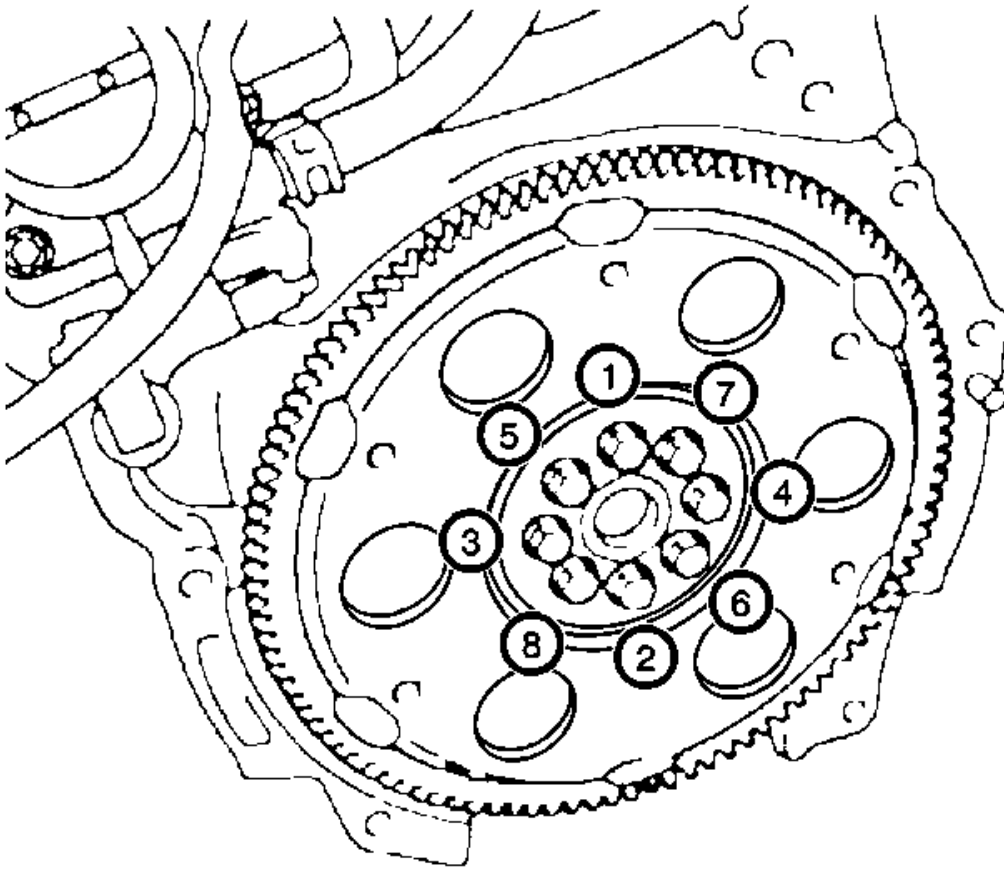


Fig. 279: Identifying Flywheel Retaining Bolt Loosening/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

1. Mark the flywheel-to-engine position.
2. Remove the 8 flywheel retaining bolts.
3. Remove the flywheel from the crankshaft.

OIL LEVEL INDICATOR AND TUBE REMOVAL

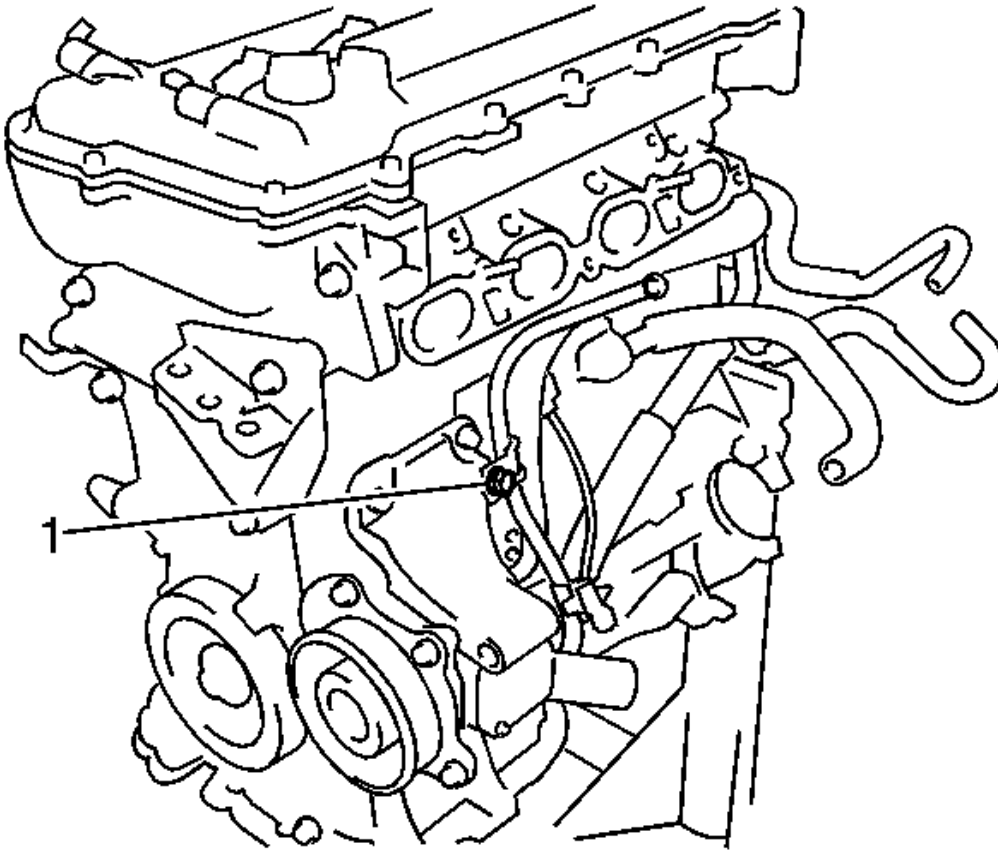


Fig. 280: Identifying Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator from the guide tube.
2. Remove the guide tube bolt from the cylinder block.
3. Remove the guide tube from the cylinder block.

EXHAUST MANIFOLD REMOVAL

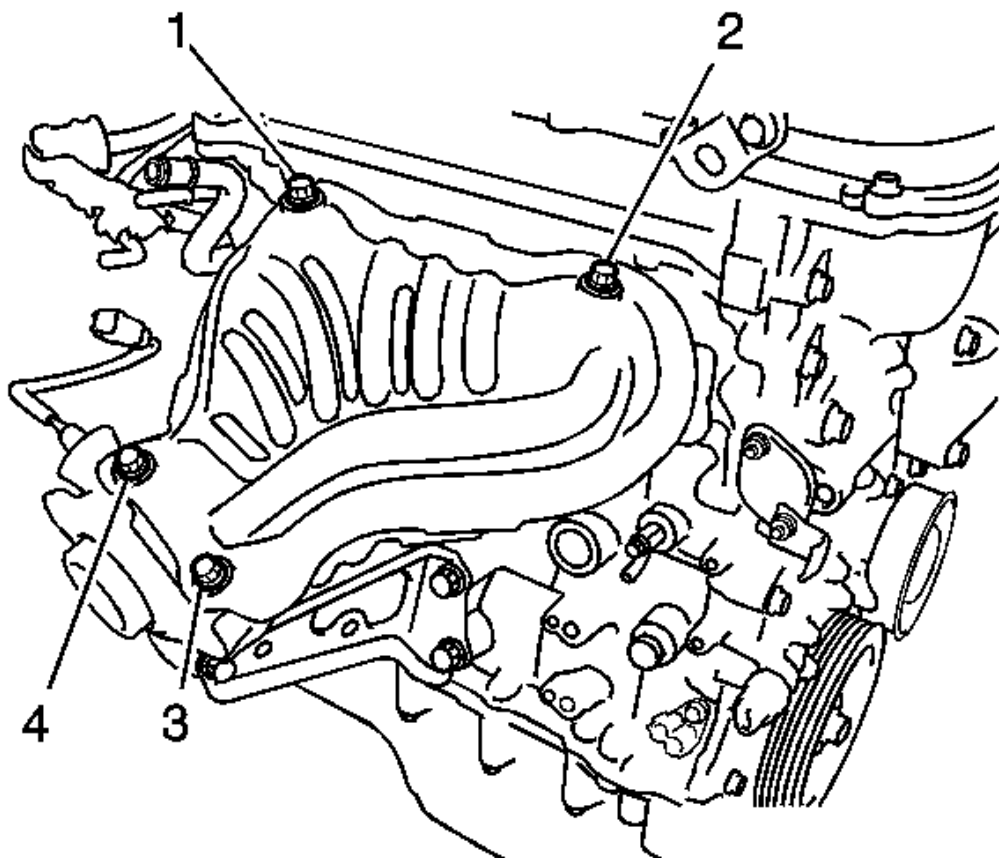


Fig. 281: Identifying Exhaust Manifold Heat Insulator Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the 4 bolts and exhaust manifold heat insulator.

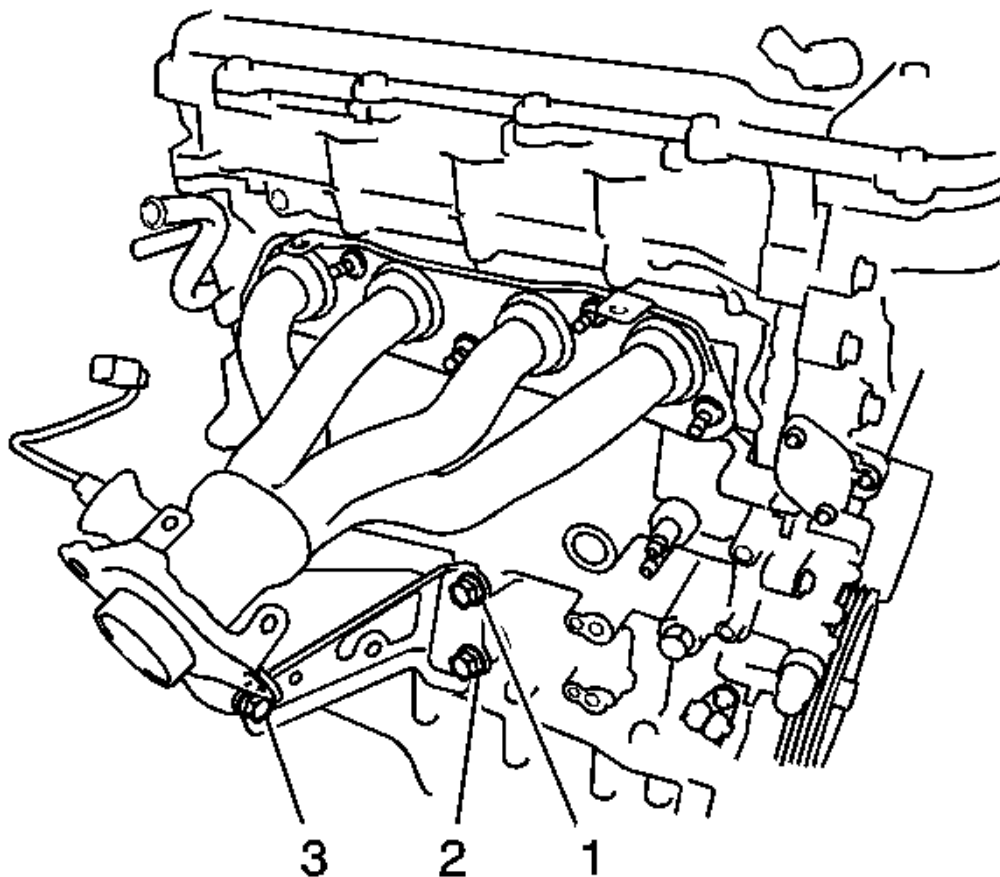


Fig. 282: Identifying Exhaust Manifold Bolts & Stay
Courtesy of GENERAL MOTORS CORP.

2. Remove the 3 bolts and manifold stay.

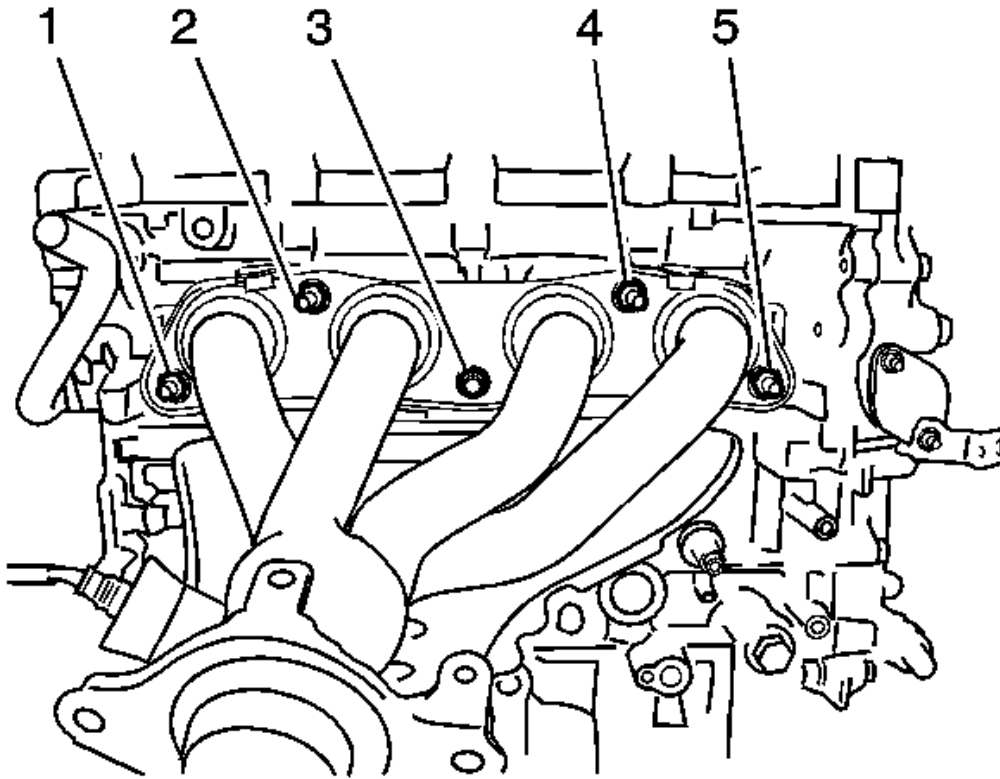


Fig. 283: Identifying Exhaust Manifold Nuts
Courtesy of GENERAL MOTORS CORP.

3. Remove the 5 nuts and exhaust manifold.

INTAKE MANIFOLD REMOVAL

1. Install the engine stand.
2. Set the engine on an engine stand.
3. Remove the engine hanger.
4. Remove the bolt and fan belt adjusting bar.
5. Remove the wire harness clamp bracket.
6. Remove the 2 bolts and disconnect the air tube.
7. Disconnect the ventilation hose from the intake manifold.

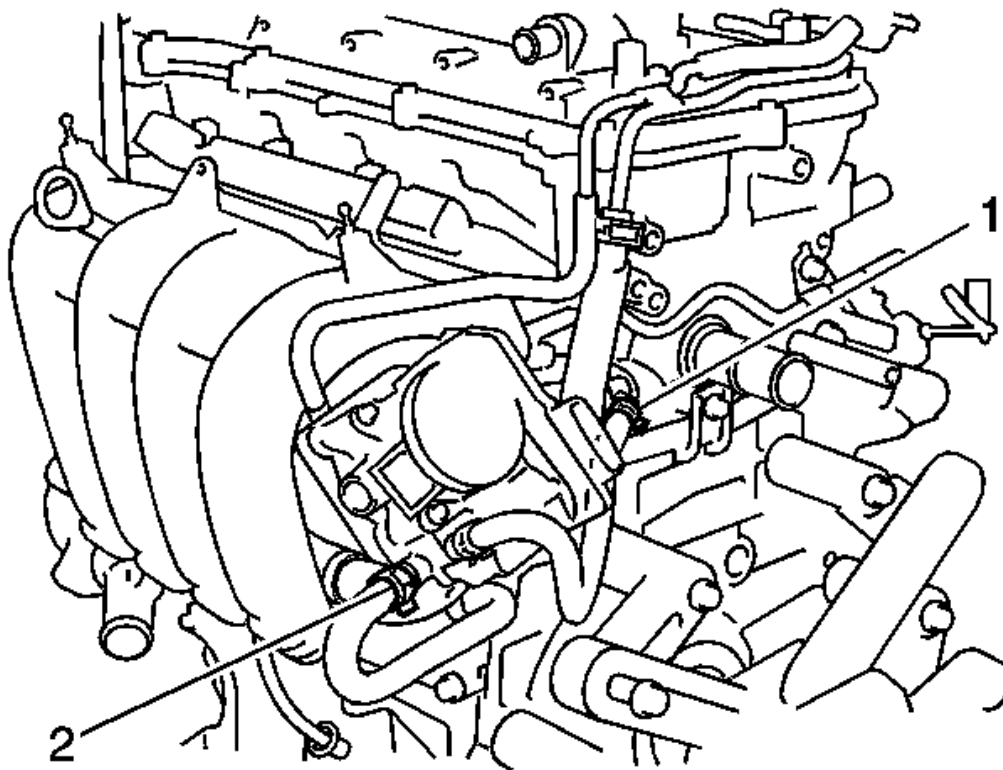


Fig. 284: Identifying Water By-Pass Hoses
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the 2 water by-pass hoses.

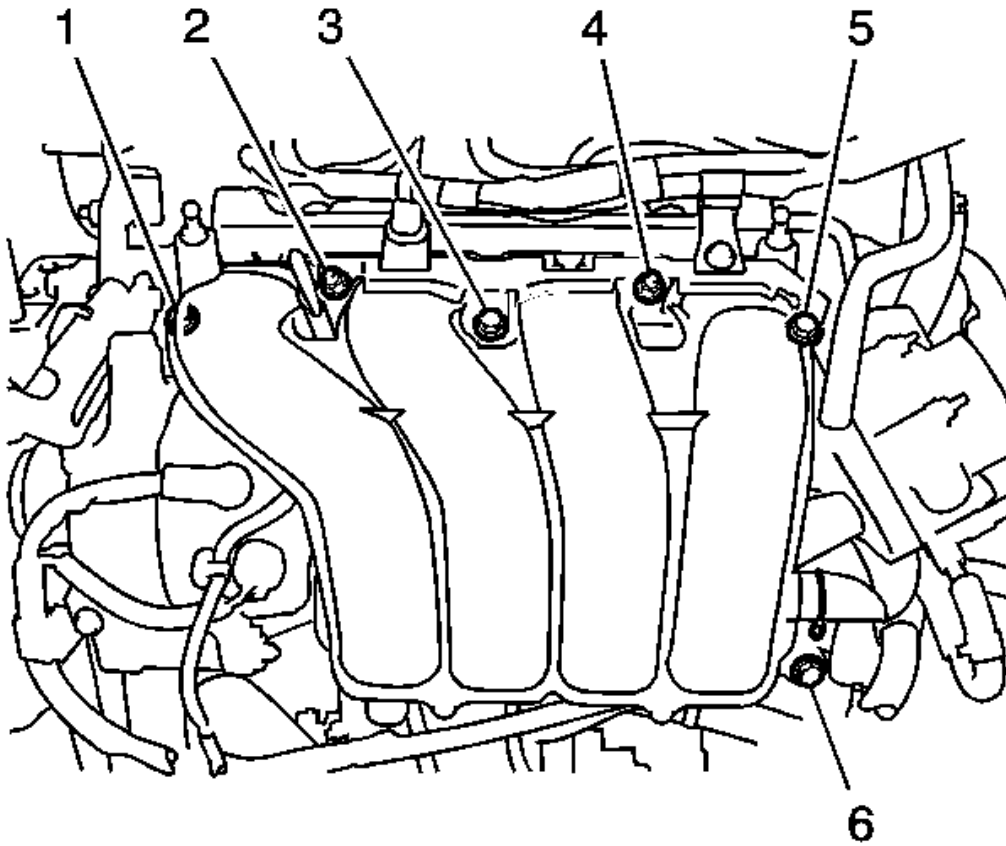


Fig. 285: Identifying Intake Manifold, Intake Manifold Stay, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

9. Remove the 4 bolts and 2 nuts, and remove the intake manifold and intake manifold stay.
10. Remove the gasket from the intake manifold.
11. Disconnect the fuel tube sub-assembly.
12. Remove the fuel delivery pipe sub-assembly.
13. Remove the fuel injector assembly.
14. Remove the 4 bolts and 4 ignition coils.

CAMSHAFT COVER REMOVAL

1. Remove the ventilation hose.

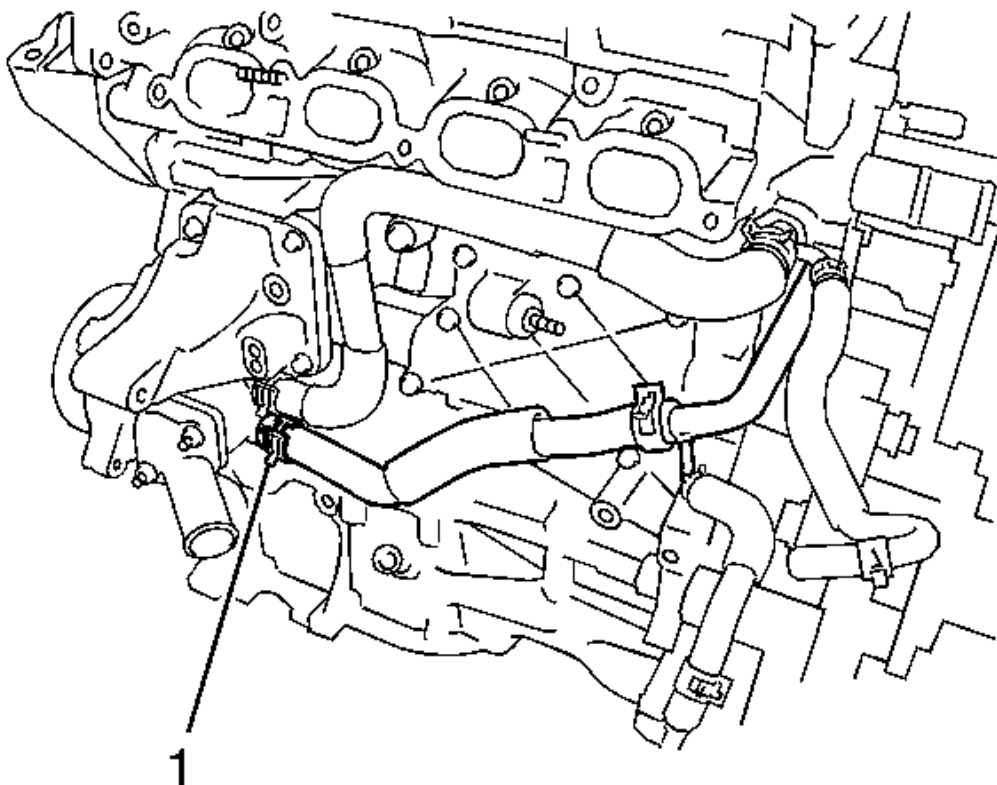


Fig. 286: Identifying By-Pass Hose & Water Inlet Housing
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the No. 3 water by-pass hose from the water inlet housing.

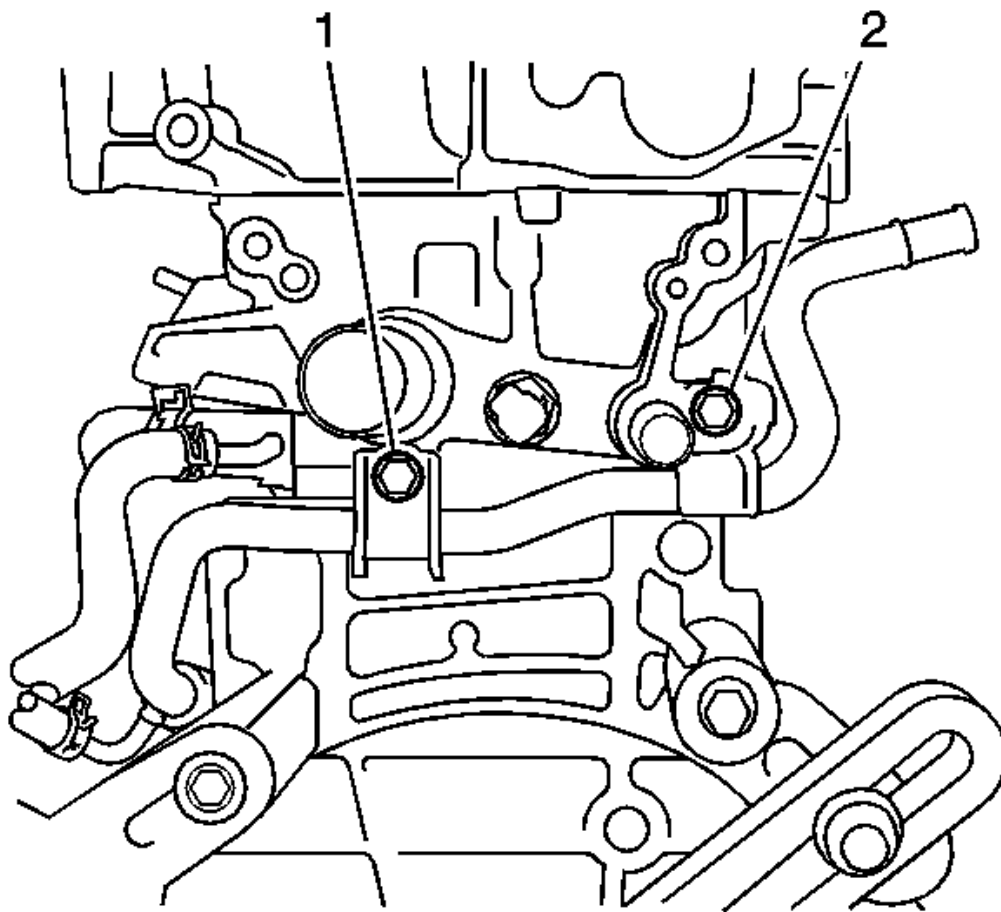


Fig. 287: View Of No. 1 Water By-Pass Pipe
Courtesy of GENERAL MOTORS CORP.

3. Remove the 2 bolts and No. 1 water by-pass pipe.
4. Remove the clamp and water by-pass hose.

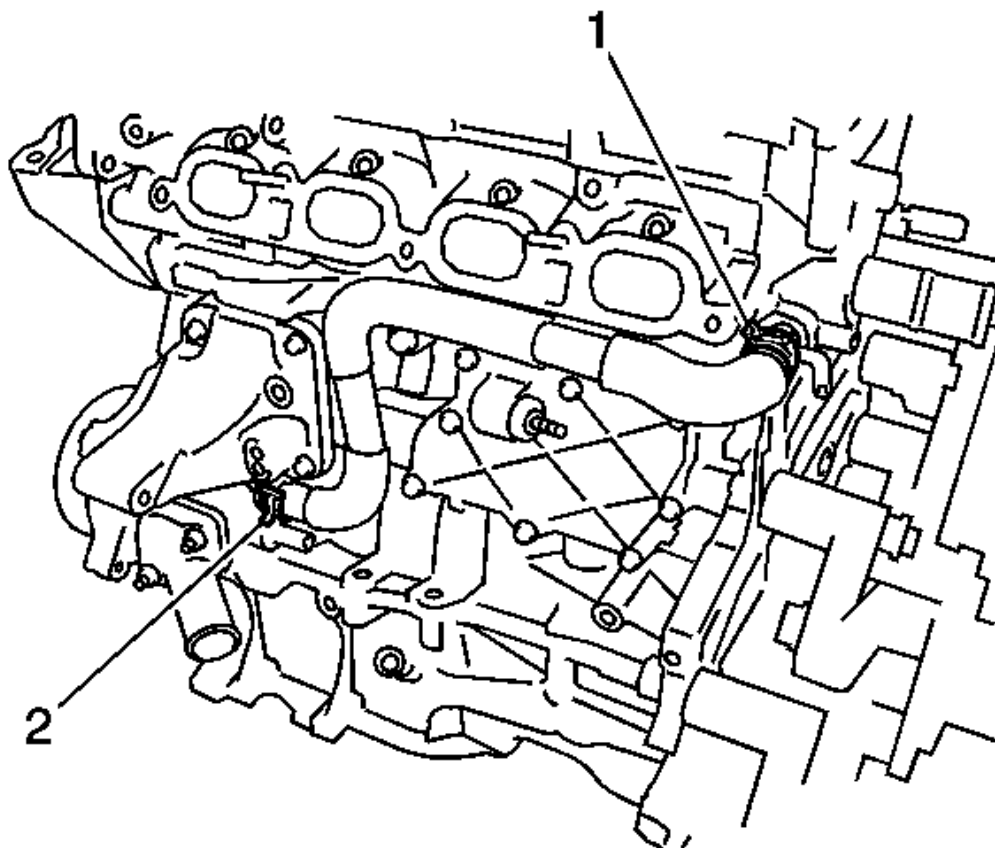


Fig. 288: Identifying Water Inlet Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

5. Remove the 2 clamps and inlet water hose.
6. Remove the inlet water.
7. Remove the thermostat.
8. Remove the bolt and radio setting condenser.

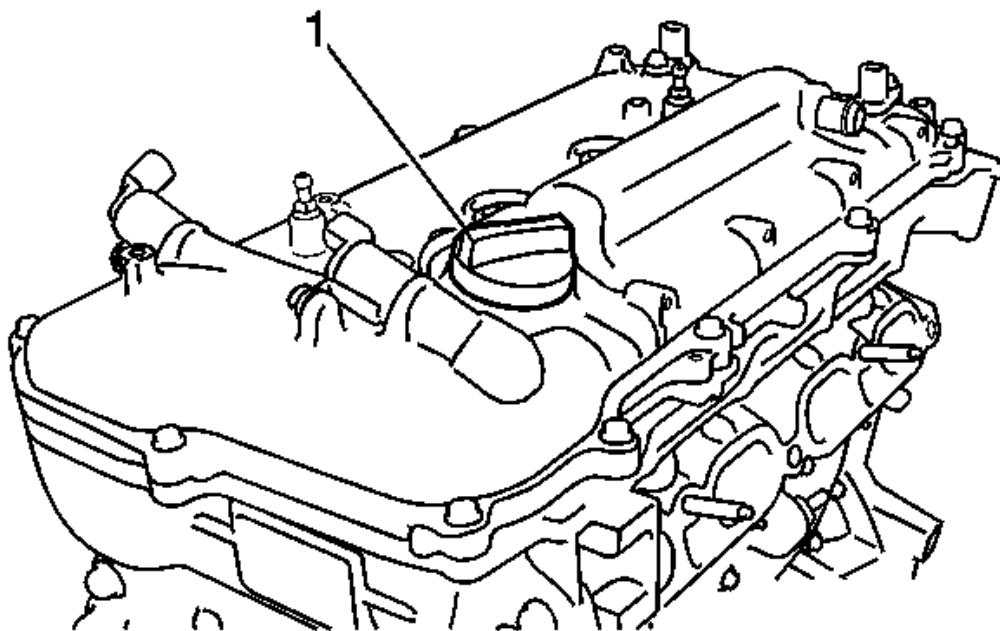


Fig. 289: Identifying Oil Filler Cap
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil filler cap.

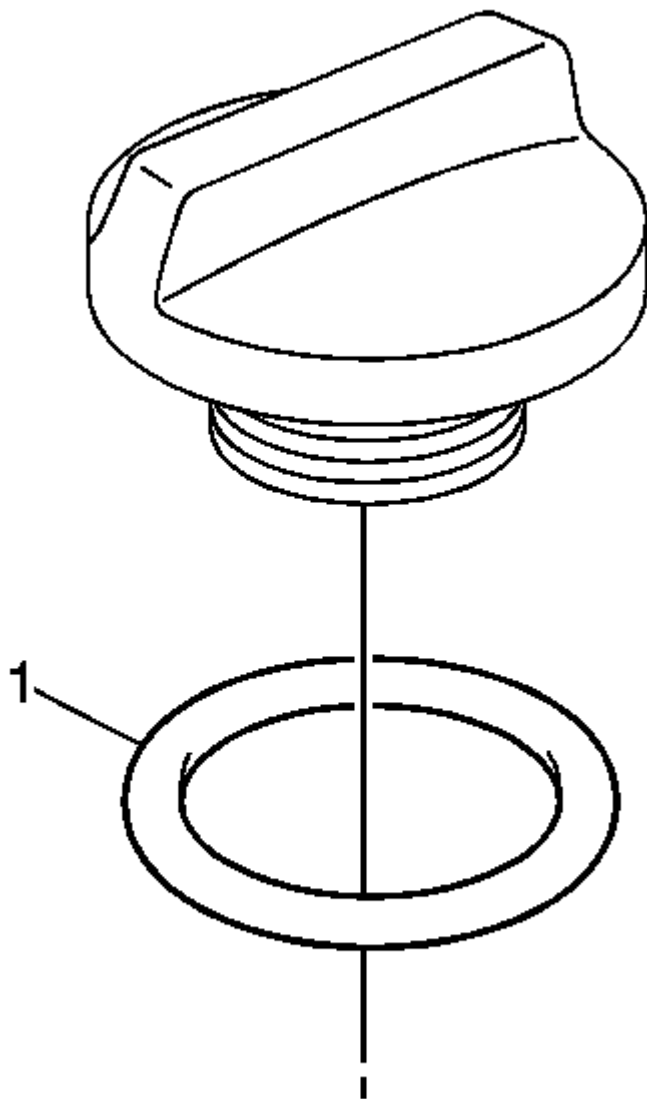


Fig. 290: View Of Oil Filler Cap
Courtesy of GENERAL MOTORS CORP.

10. Remove the oil filler cap gasket.

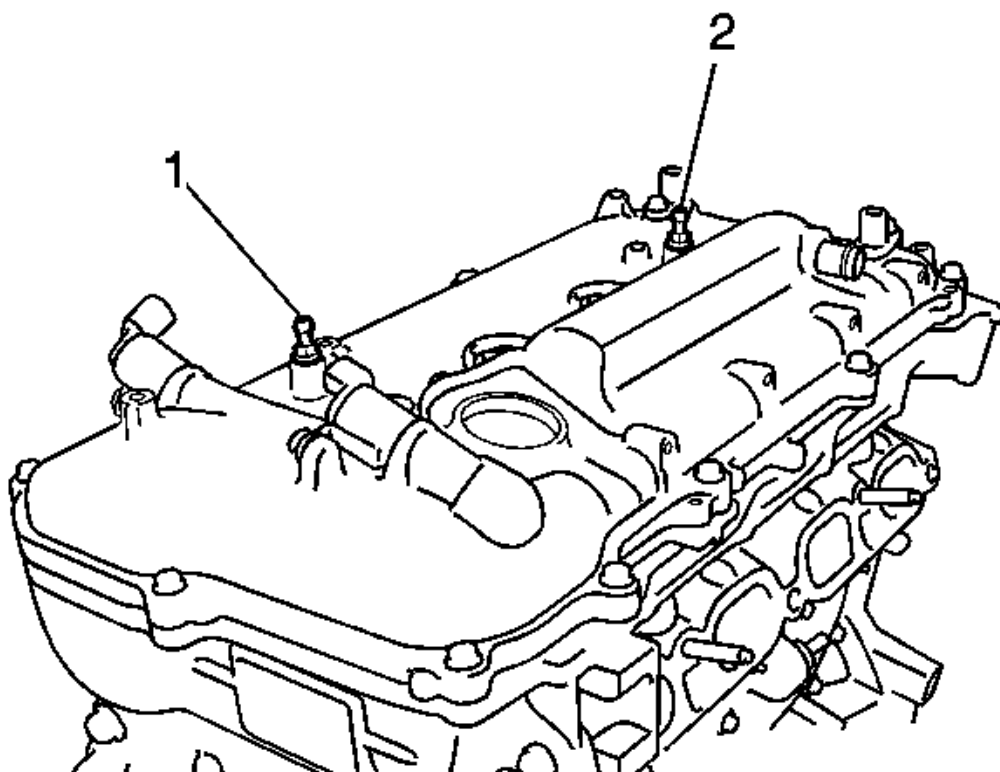


Fig. 291: View Of Engine Cover Joints
Courtesy of GENERAL MOTORS CORP.

11. Remove the 2 engine cover joints.

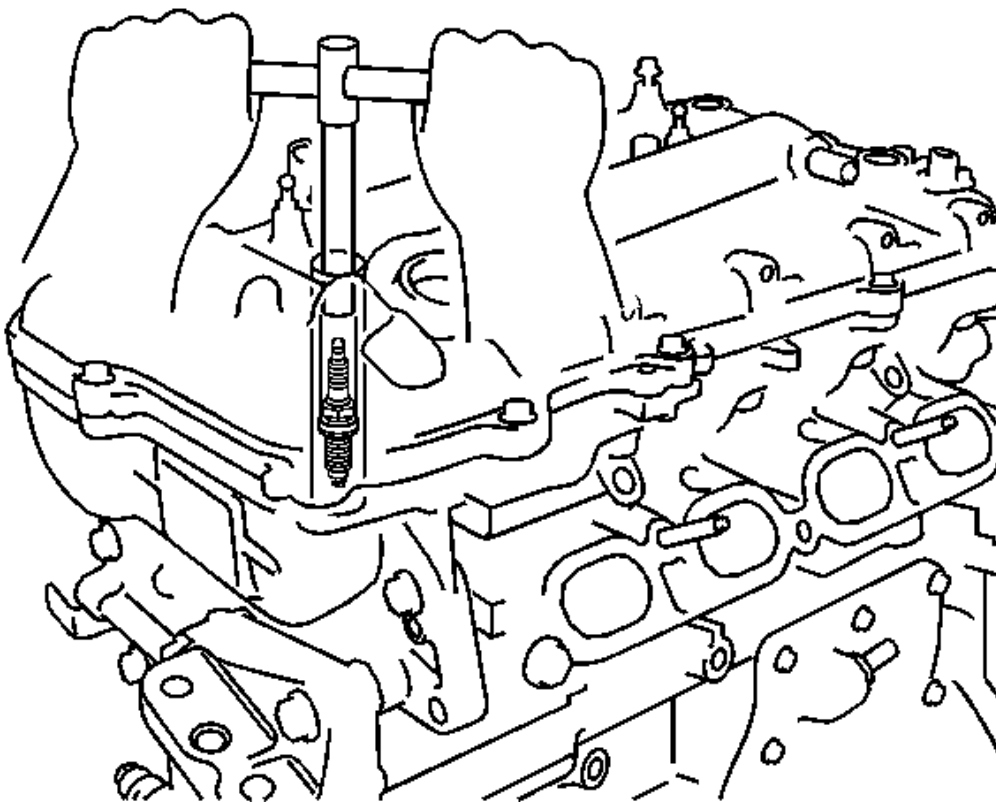


Fig. 292: View Of Spark Plug Removal/Installation
Courtesy of GENERAL MOTORS CORP.

12. Using a 14 mm spark plug wrench, remove the 4 spark plugs.

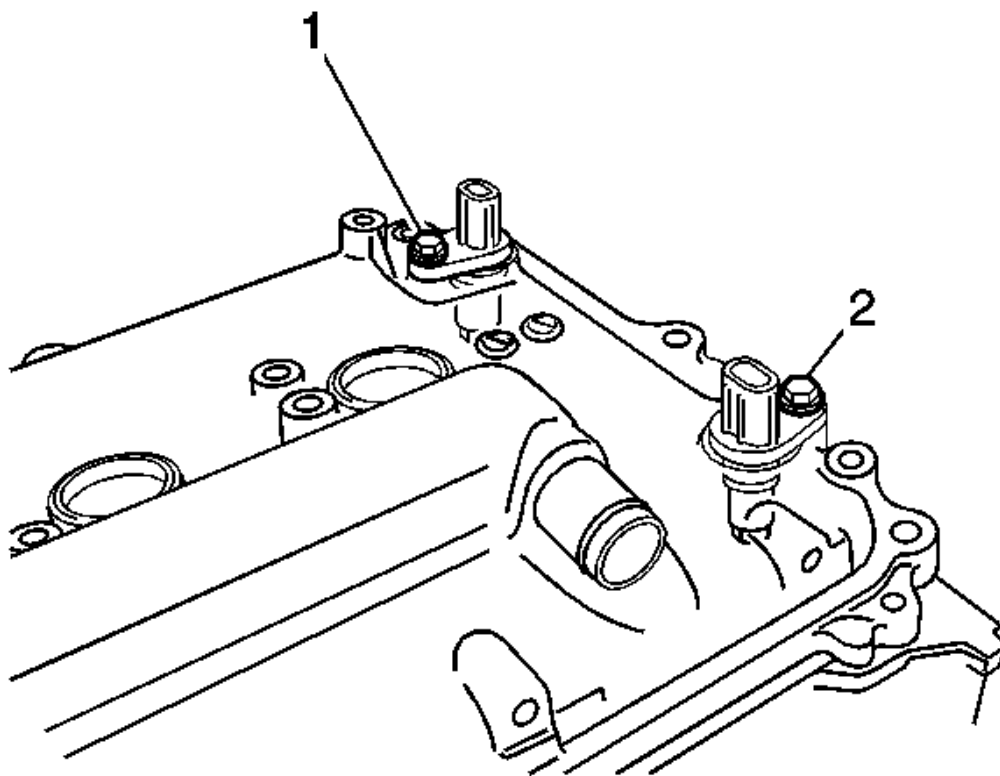


Fig. 293: Identifying Camshaft Position Sensors
Courtesy of GENERAL MOTORS CORP.

13. Remove the 2 bolts and 2 camshaft position sensors.

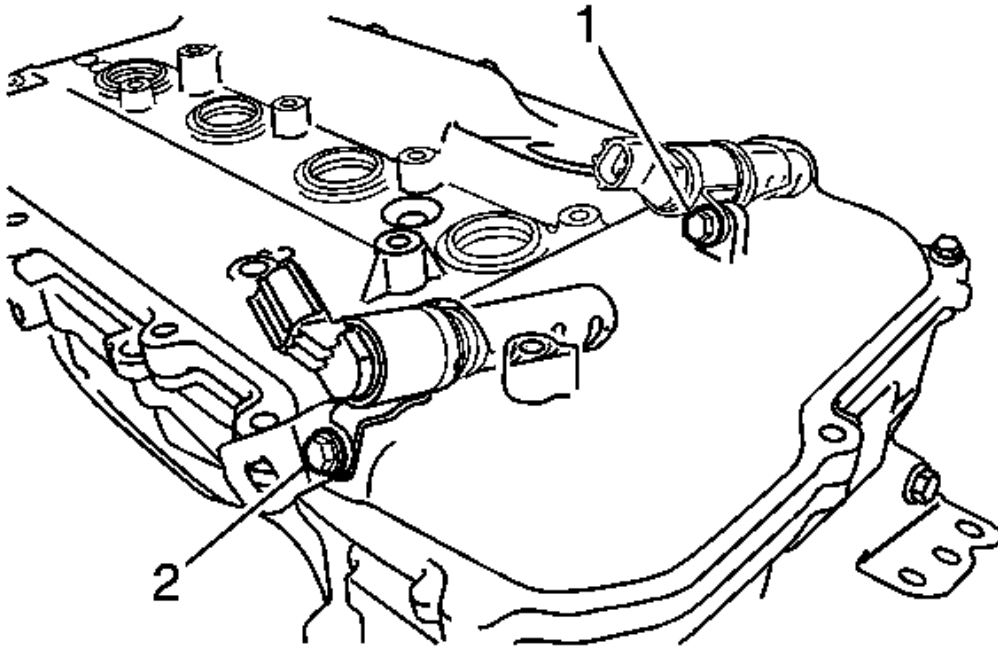


Fig. 294: Identifying Oil Camshaft Timing Control Valves, Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the 2 bolts, O-rings, bracket and 2 oil camshaft timing control valves.

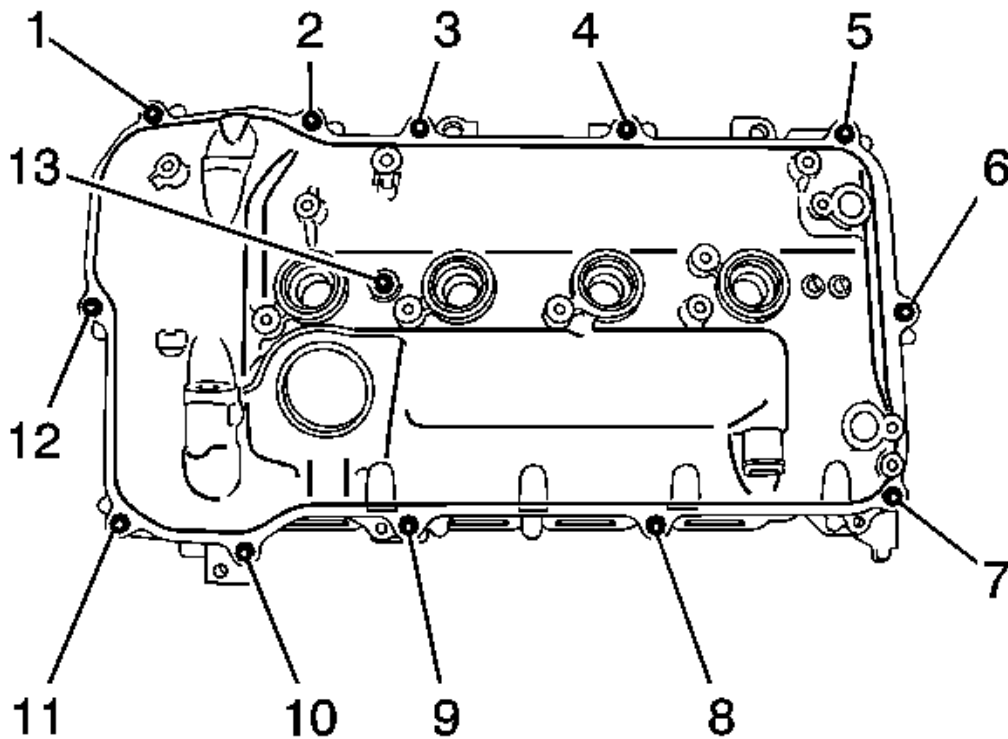


Fig. 295: Identifying Cylinder Head Cover Bolt Loosening/Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

15. Remove the 13 bolts, seal washer and cylinder head cover.

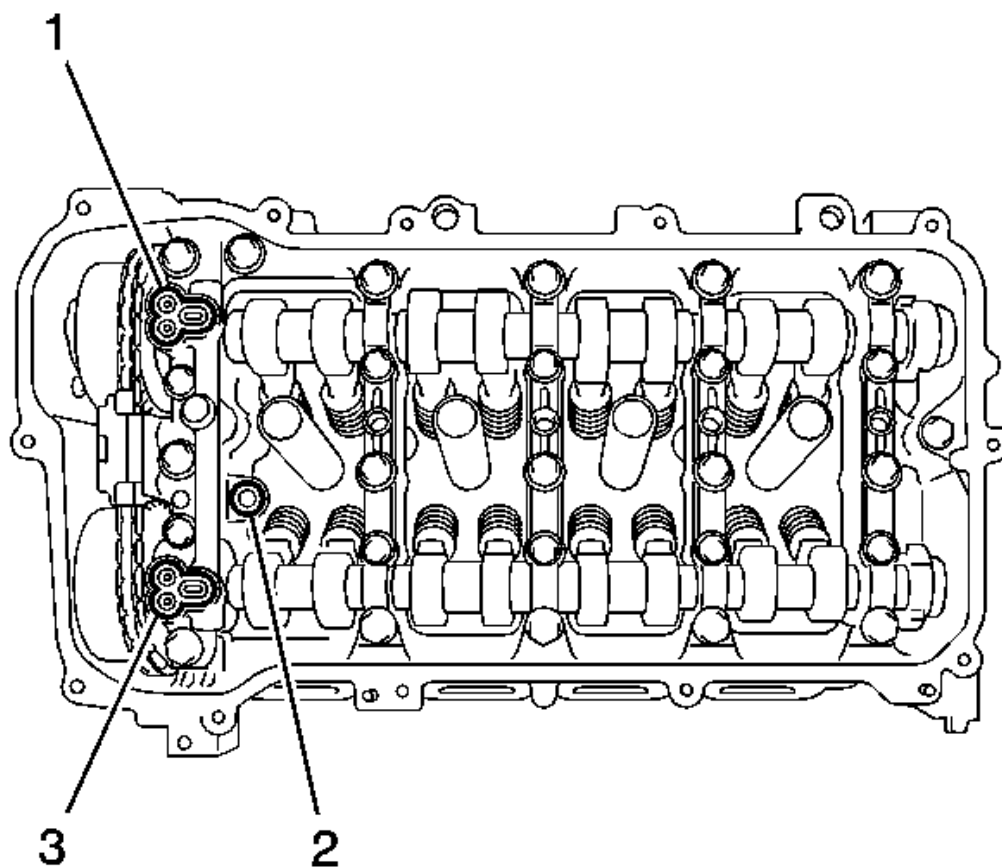


Fig. 296: Identifying Camshaft Bearing Cap Gaskets
Courtesy of GENERAL MOTORS CORP.

NOTE: Be careful not to drop any of the gaskets into the engine when removing the cylinder head cover because gaskets may stick to the cylinder head cover.

16. Remove the 3 gaskets from the camshaft bearing cap.

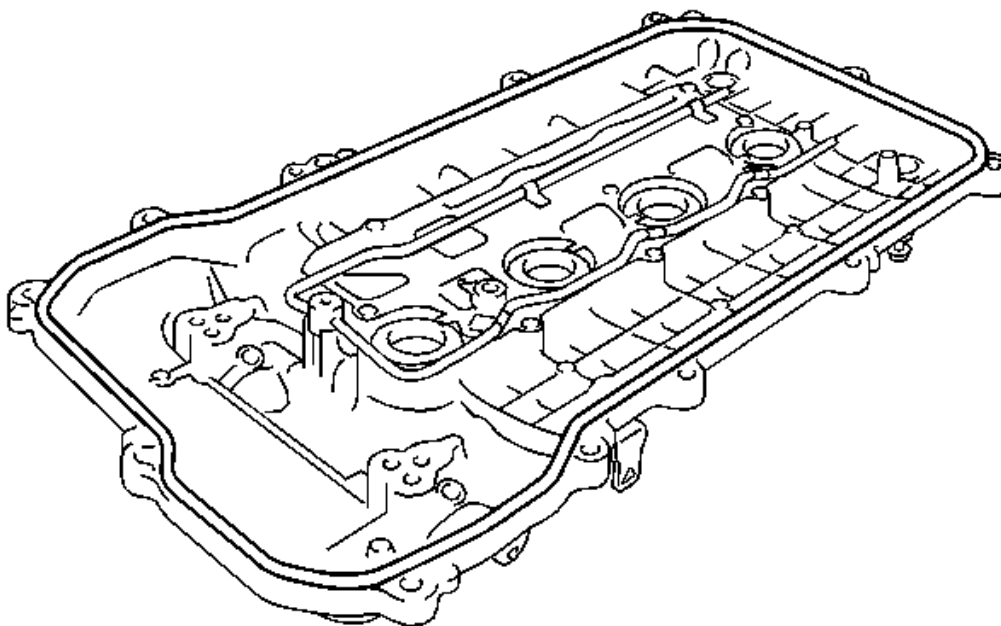


Fig. 297: View Of Cylinder Head Cover Gasket
Courtesy of GENERAL MOTORS CORP.

17. Remove the cylinder head cover gasket.

TIMING CHAIN TENSIONER REMOVAL

1. Remove the chain tensioner slipper.
2. Remove the No. 1 chain vibration damper.
3. Remove the chain sub-assembly.
4. Remove the No. 2 chain vibration damper.
5. Remove the crankshaft timing sprocket.
6. Remove the No. 2 chain sub-assembly.

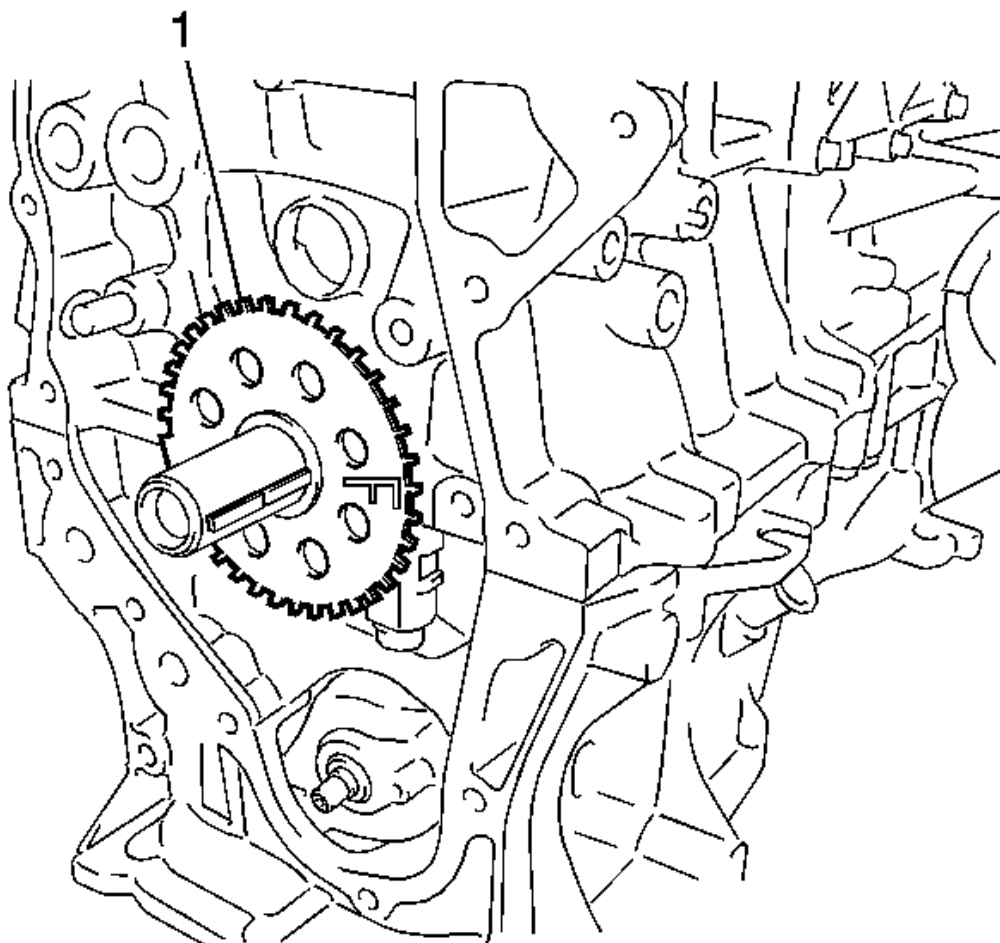


Fig. 298: Identifying No. 1 Crankshaft Position Sensor Plate
Courtesy of GENERAL MOTORS CORP.

7. Remove the No. 1 crankshaft position sensor plate.

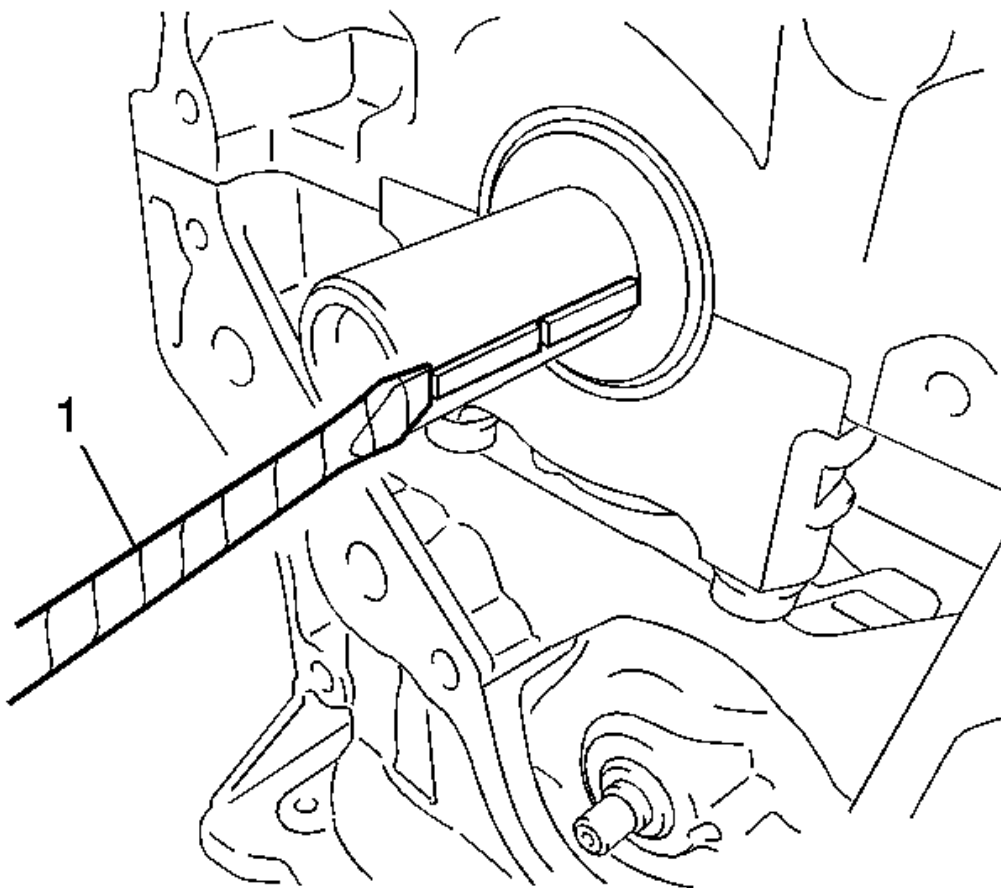


Fig. 299: Identifying Crankshaft Timing Gear Keys
Courtesy of GENERAL MOTORS CORP.

NOTE: Tape the screwdriver tip before use.

8. Using a screwdriver, remove the 2 crankshaft timing gear keys.
9. Remove the camshaft timing gear assembly.
10. Check the lock of the camshaft timing gear.

NOTE: Before removing the camshaft timing gear assembly, make sure that the lock pin has been released.

11. Release the lock pin. Refer to Camshaft Position Actuator Locking Pin Adjustment.

TIMING CHAIN HOUSING REMOVAL

1. Set No. 1 cylinder to TDC/compression.
2. Remove the crankshaft pulley.

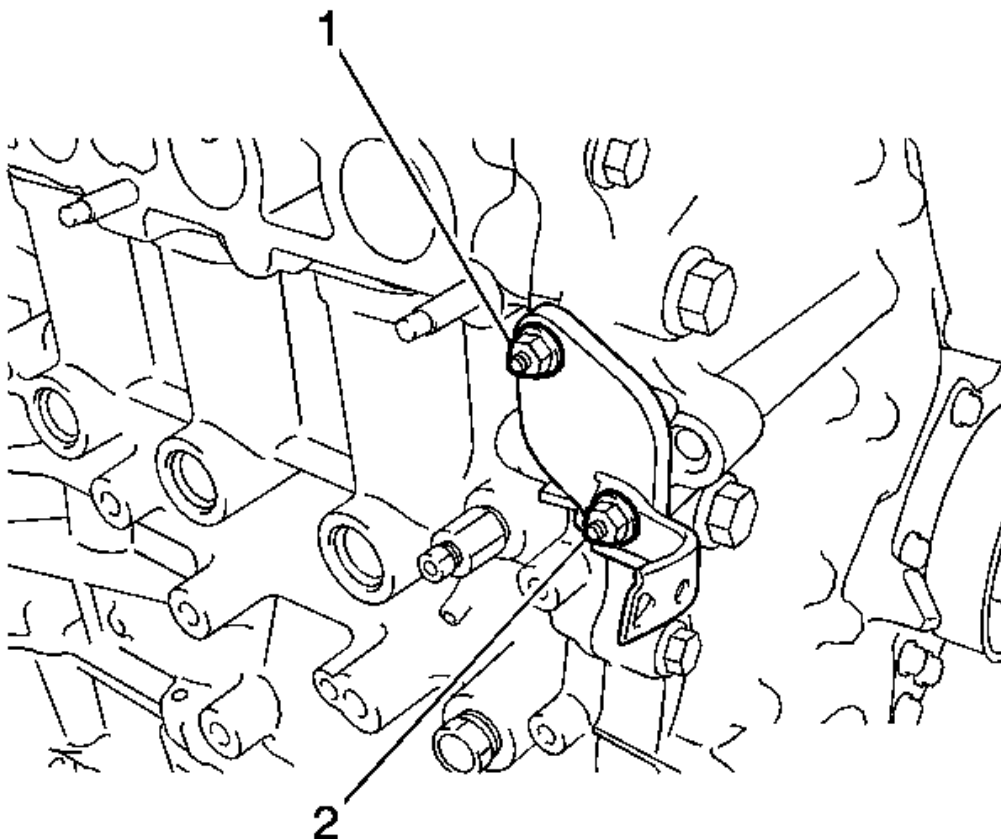


Fig. 300: Identifying Bracket, Tensioner, Gasket, Chain Tensioner Assembly & Nuts
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not turn the crankshaft without the chain tensioner installed.

3. Remove the 2 nuts, bracket, tensioner and gasket, chain tensioner assembly.

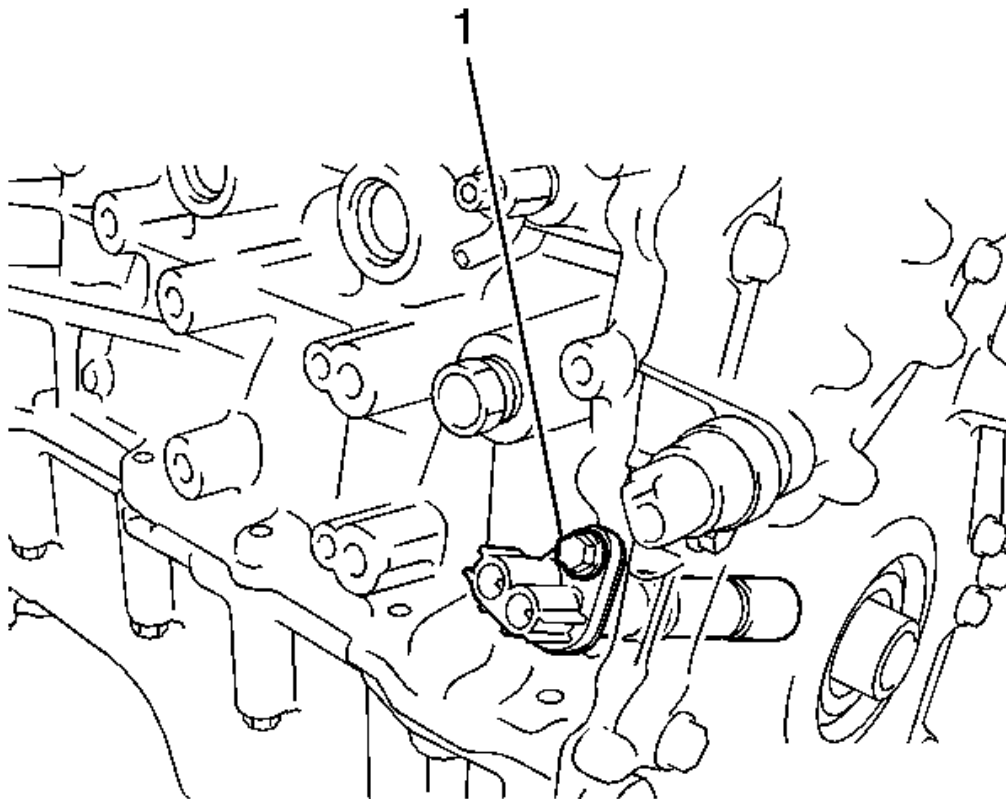


Fig. 301: Locating Crankshaft Position Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft position sensor.
5. Remove the bolt and sensor.

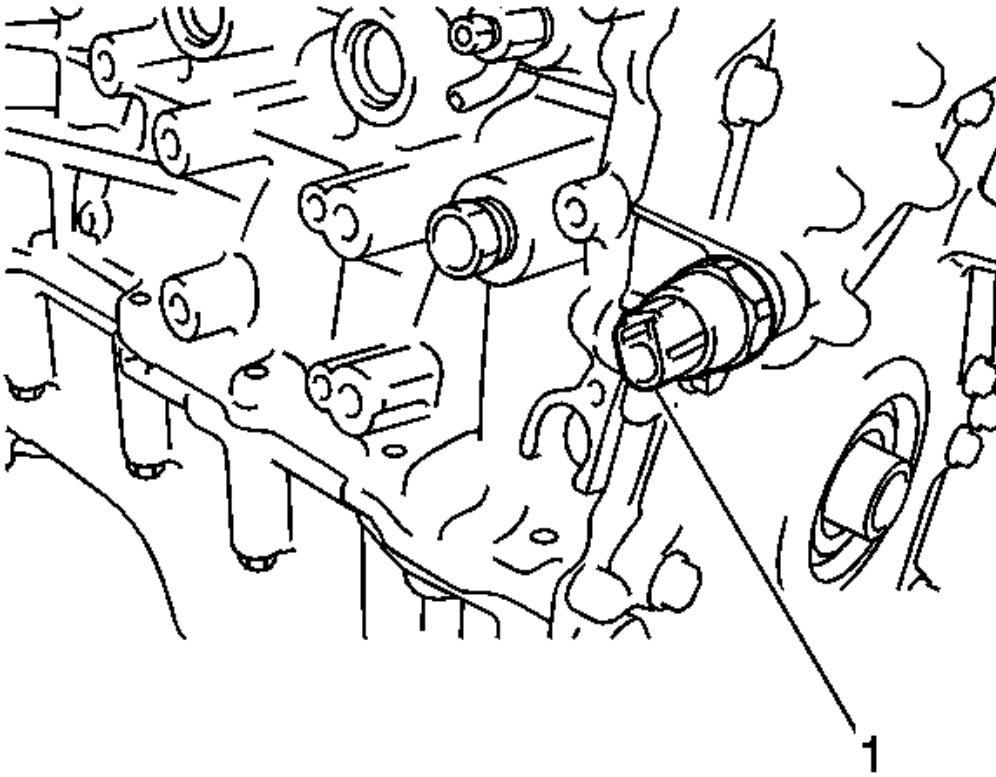


Fig. 302: Identifying Engine Oil Pressure Switch Assembly
Courtesy of GENERAL MOTORS CORP.

6. Using a 24 mm deep socket wrench, remove the engine oil pressure switch assembly.

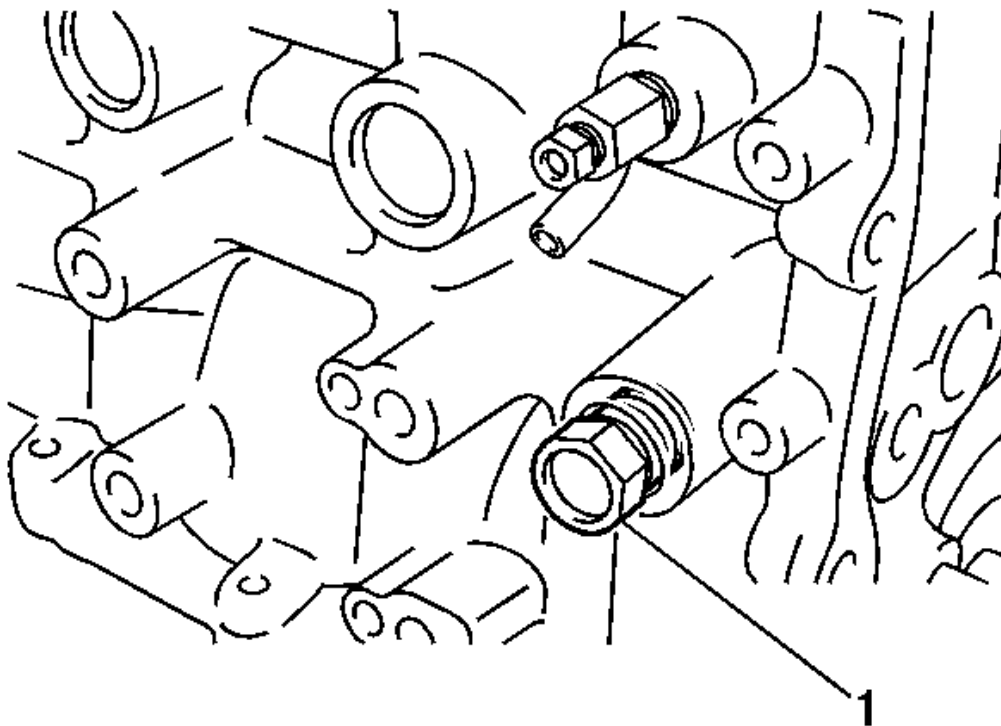


Fig. 303: Identifying 1 Taper Screw Plug
Courtesy of GENERAL MOTORS CORP.

7. Remove the No. 1 taper screw plug.

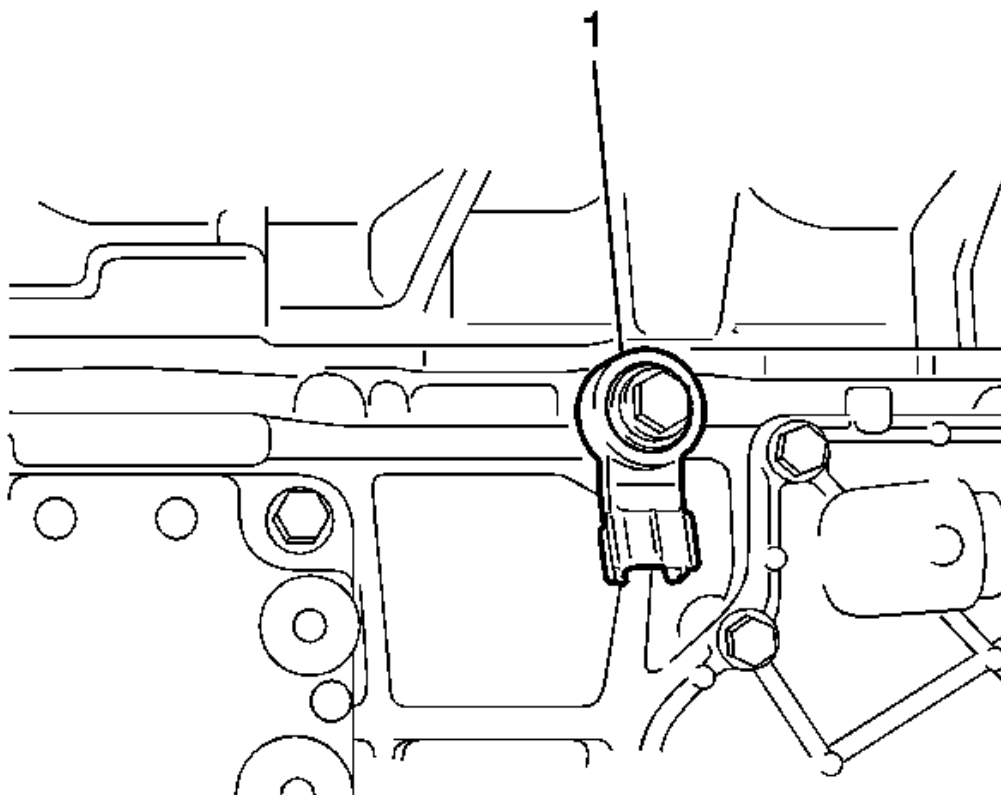


Fig. 304: Identifying Knock Control Sensor
Courtesy of GENERAL MOTORS CORP.

8. Remove the bolt and knock control sensor.

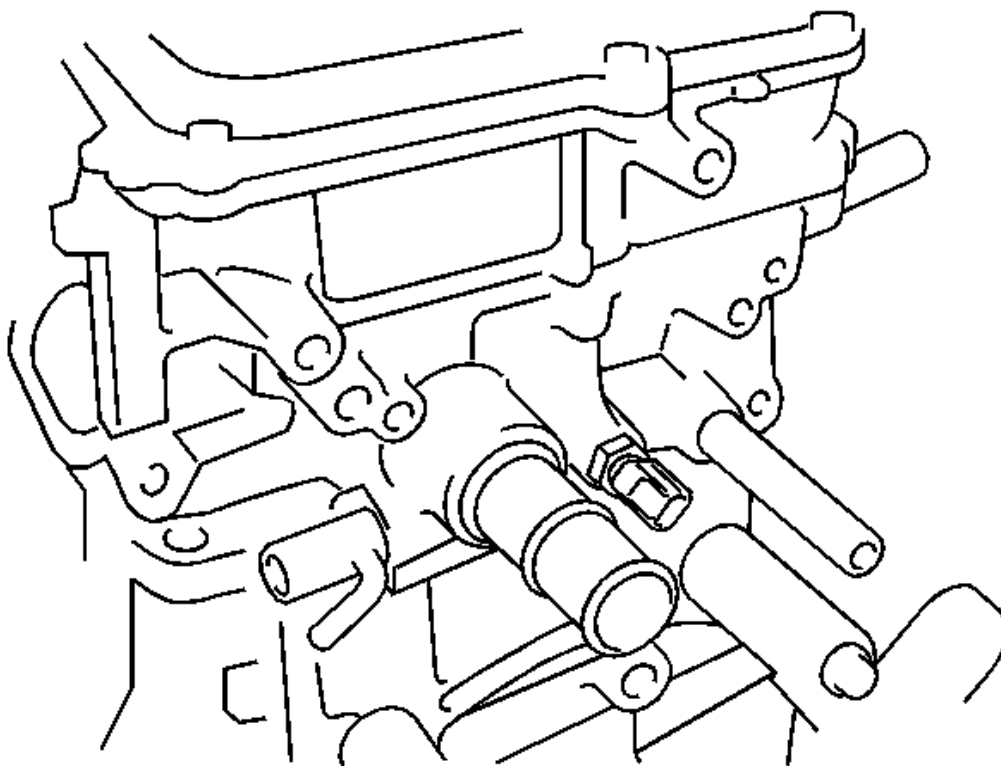


Fig. 305: Identifying Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

9. Using a 19 mm deep socket wrench, remove the engine coolant temperature sensor.
10. Remove the gasket from the engine coolant temperature sensor.
11. Remove the oil filter cap assembly.
12. Remove the timing chain cover sub-assembly.

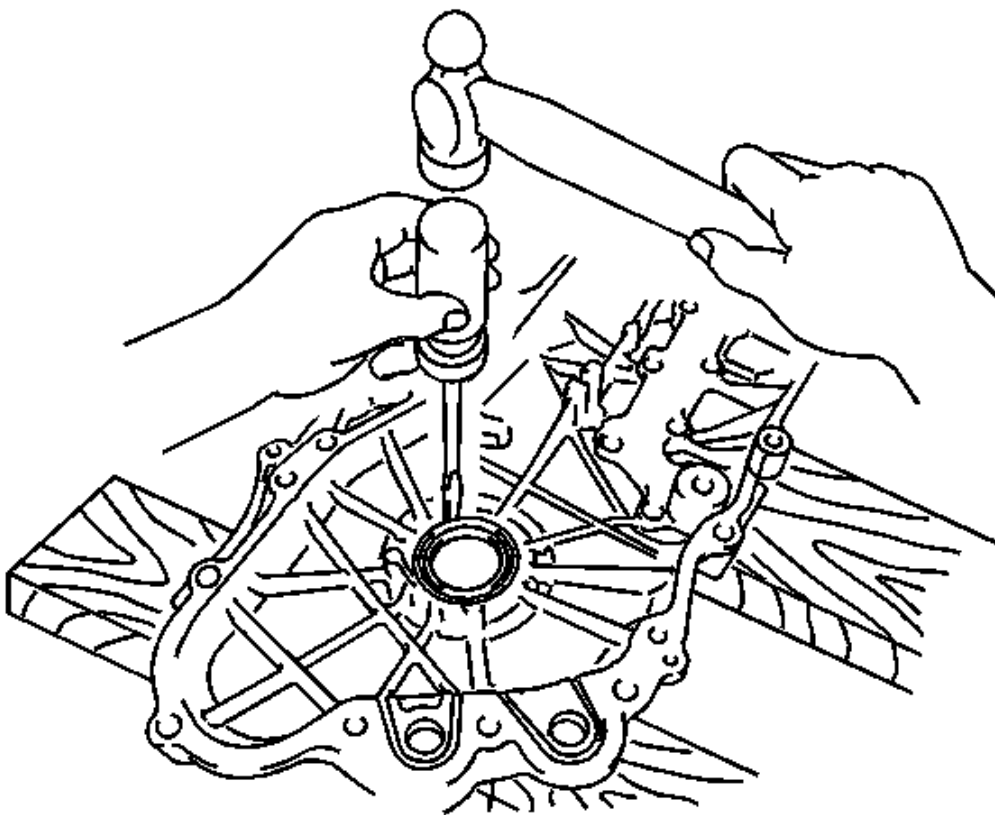


Fig. 306: Illustrating Removing Timing Chain Cover Oil Seal
Courtesy of GENERAL MOTORS CORP.

CAUTION: Be careful not to damage the timing chain cover.

NOTE: Tape the screwdriver tip before use.

13. Using a screwdriver and hammer, remove the timing chain cover oil seal.

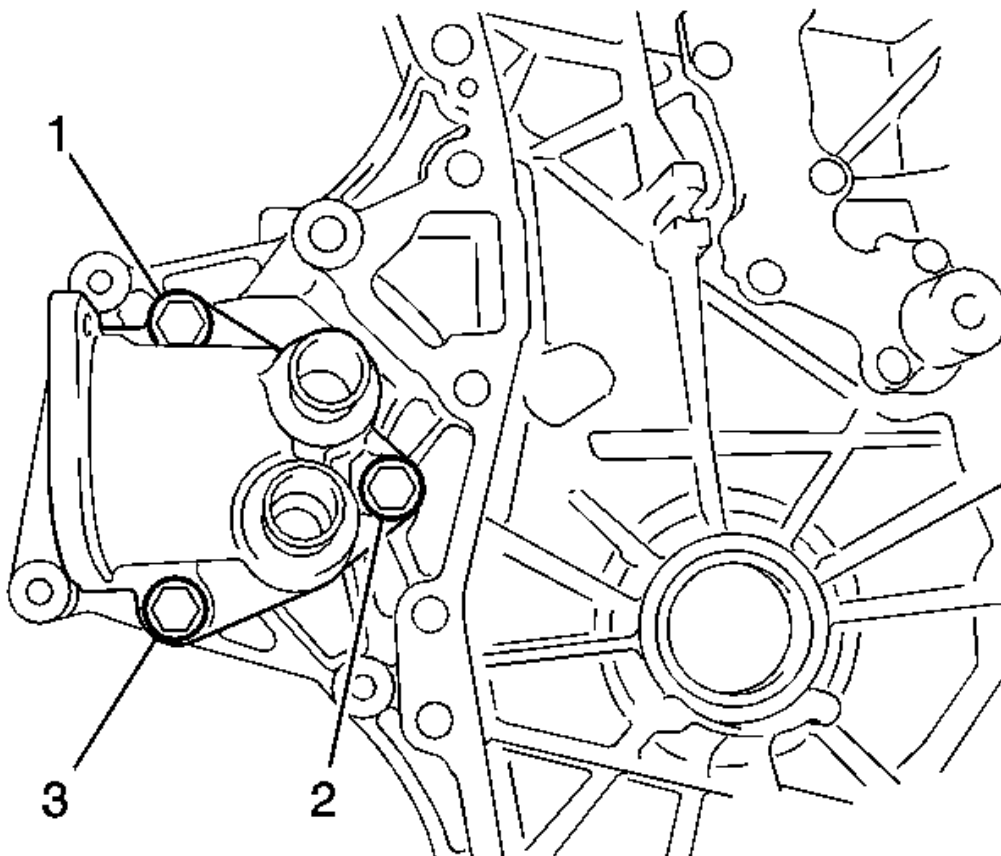


Fig. 307: Identifying Water Housing, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the 3 bolts, gasket and inlet water housing

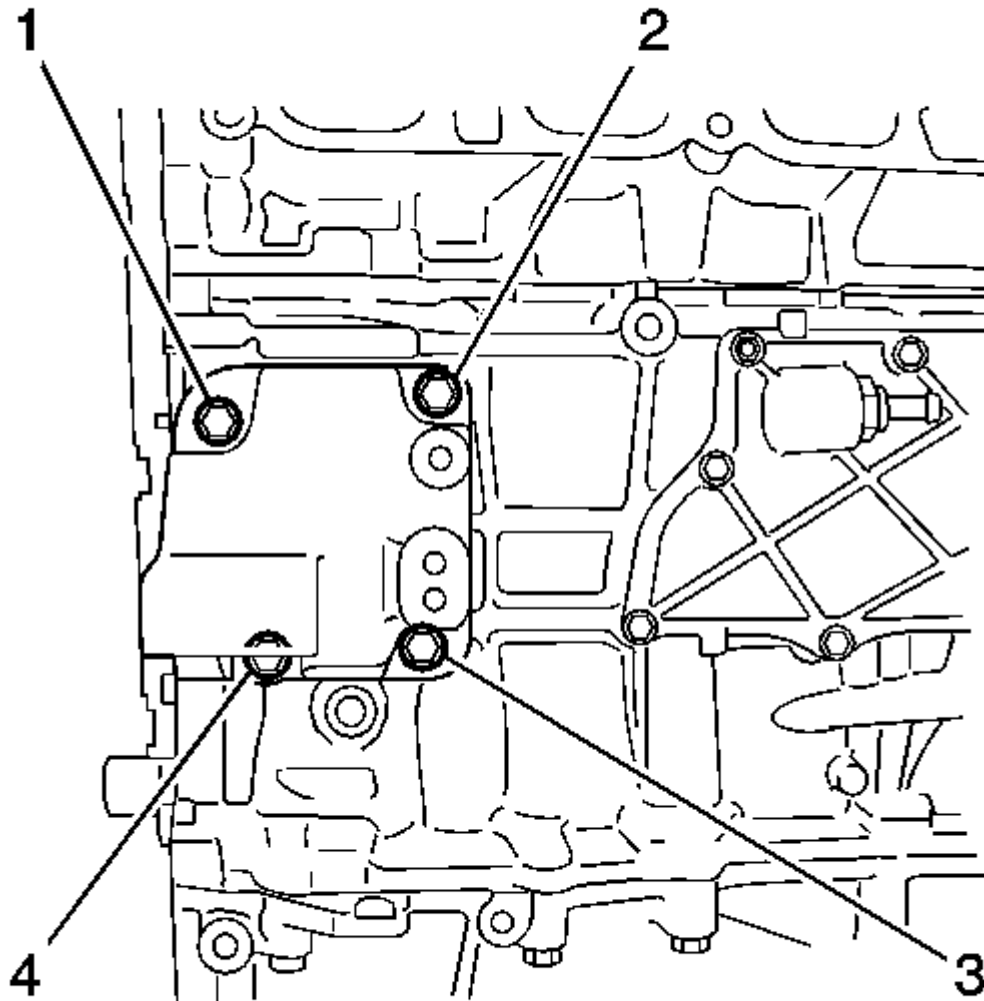


Fig. 308: Identifying Generator Bracket
Courtesy of GENERAL MOTORS CORP.

15. Remove the 4 bolts and No. 1 generator bracket.

CAMSHAFT POSITION ACTUATOR LOCKING PIN ADJUSTMENT

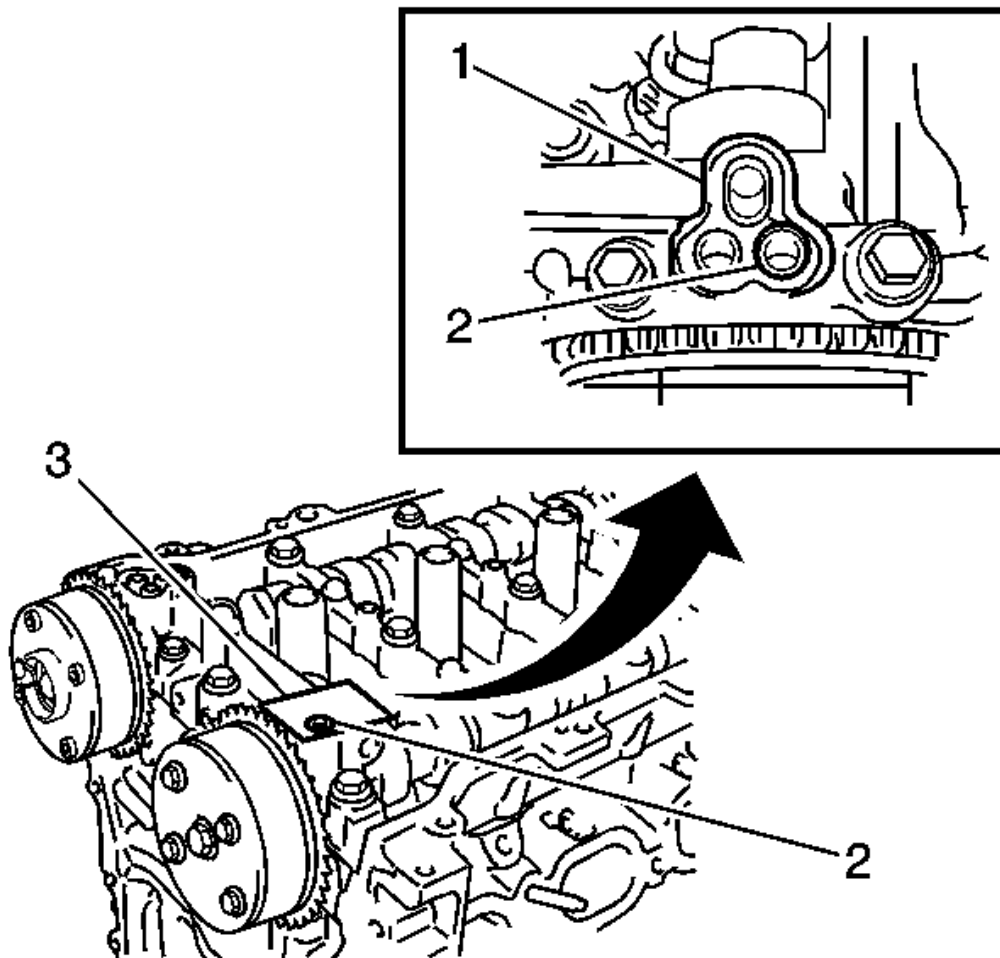


Fig. 309: Identifying Camshaft Timing Gear Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: Be sure to cover the oil hole completely because air leaks due to insufficient sealing will prevent the lock pin from being released.

1. After cleaning and degreasing the VVT oil hole on the intake side of the No. 1 camshaft bearing cap, completely seal the oil hole with adhesive tape or equivalent as shown in the illustration to prevent air from leaking.
2. Prick a hole in the tape covering the oil hole as shown in the illustration. (Procedure A)

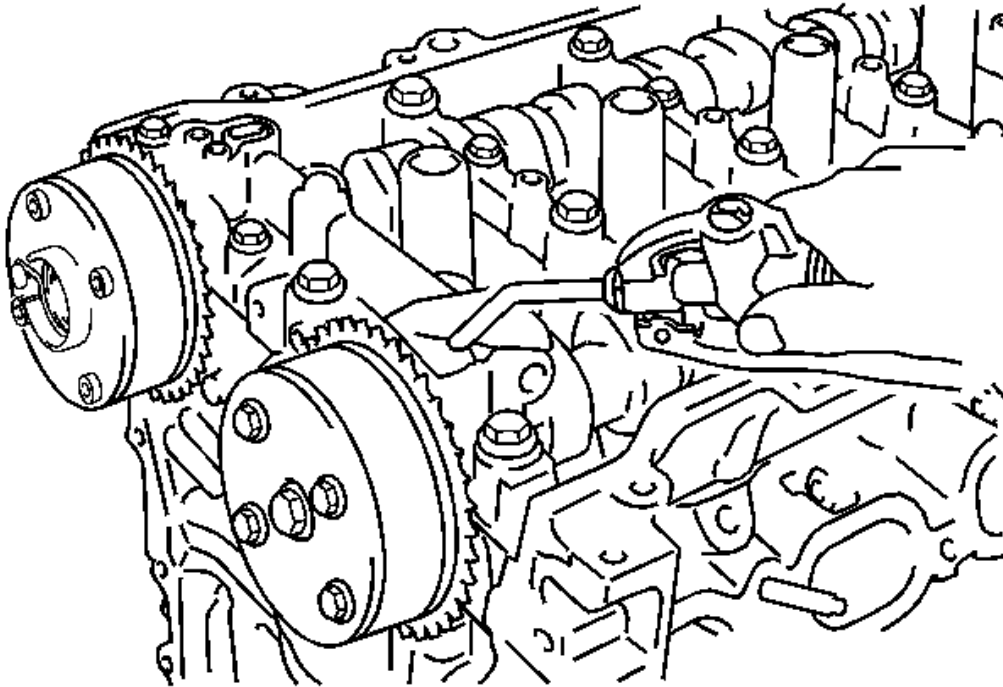


Fig. 310: Checking For Air Leaks
Courtesy of GENERAL MOTORS CORP.

NOTE:

- The camshaft timing gear assembly may be turned in the advance direction without applying any force.
- If enough air pressure cannot be applied because of air leakage from the port, releasing the lock pin may be difficult.
- If air leaks out, reattach the adhesive tape.
- Cover the oil hole with a shop rag or piece of cloth when applying air pressure to prevent oil from spraying.
- Do not lock the camshaft timing gear assembly. If it is locked, release the lock pin again.

3. Apply approximately 150 kPa (22 psi) of air pressure to the hole pricked in procedure A to release the lock pin.
4. Remove the adhesive tape from the No. 1 camshaft bearing cap.

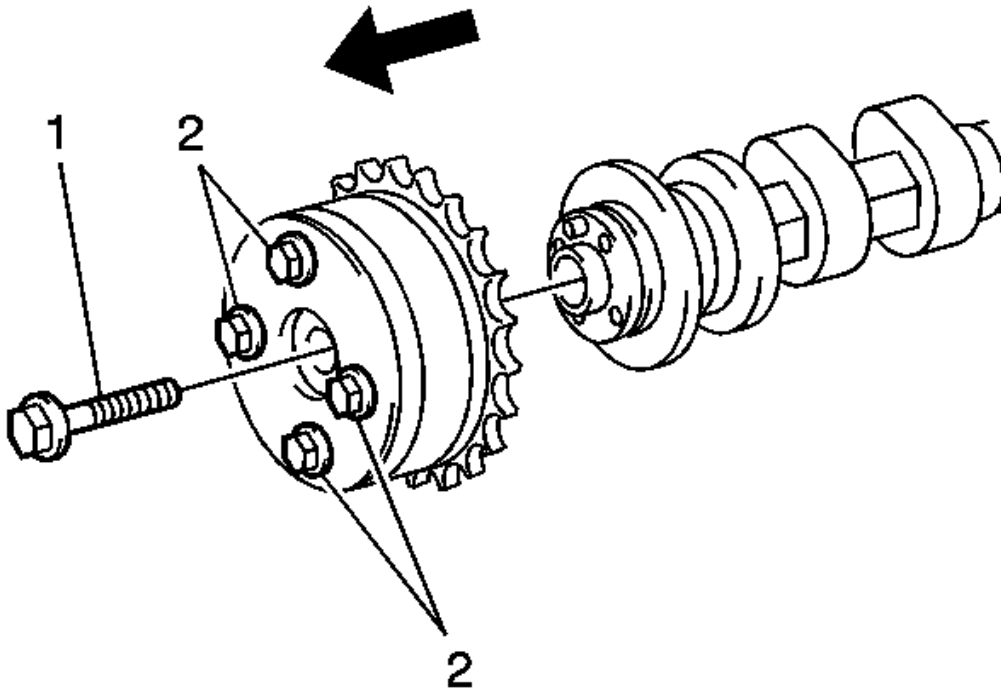


Fig. 311: View Of Camshaft Timing Gear & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Before removing the camshaft timing gear, make sure that the lock pin has been released.
- Be sure not to remove the other 4 bolts.
- Keep the camshaft timing gear assembly horizontal while removing it from the camshaft.

5. Remove the flange bolt while holding the hexagonal portion of the camshaft, and then remove the camshaft timing gear assembly.

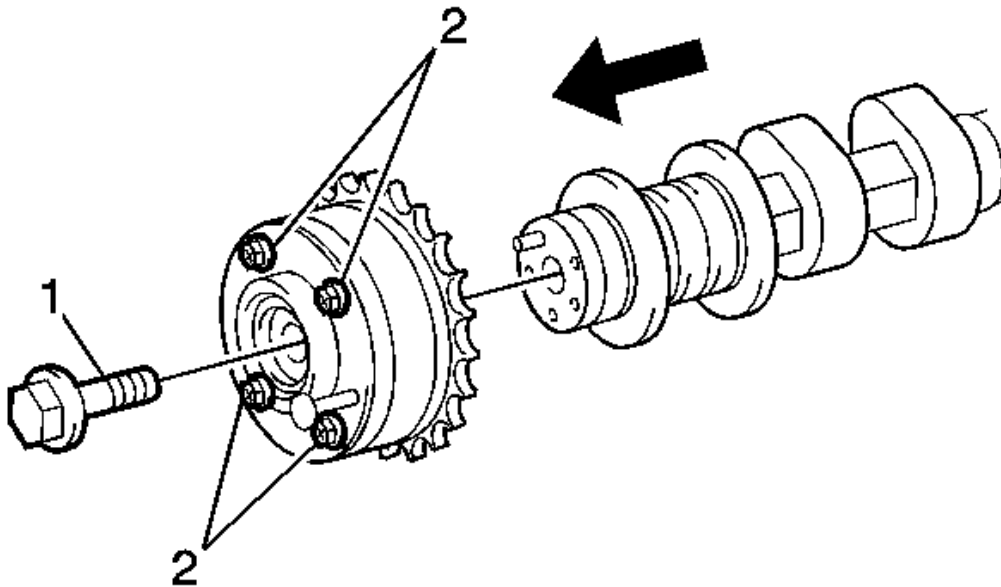


Fig. 312: View Of Exhaust camshaft Timing Gear & Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Be sure not to remove the other 4 bolts.
- Keep the camshaft timing exhaust gear assembly horizontal while removing it from the camshaft.

6. Remove the flange bolt while holding the hexagonal portion of the camshaft, and then remove the camshaft timing exhaust gear assembly.

INTAKE CAMSHAFT AND VALVE LIFTER REMOVAL

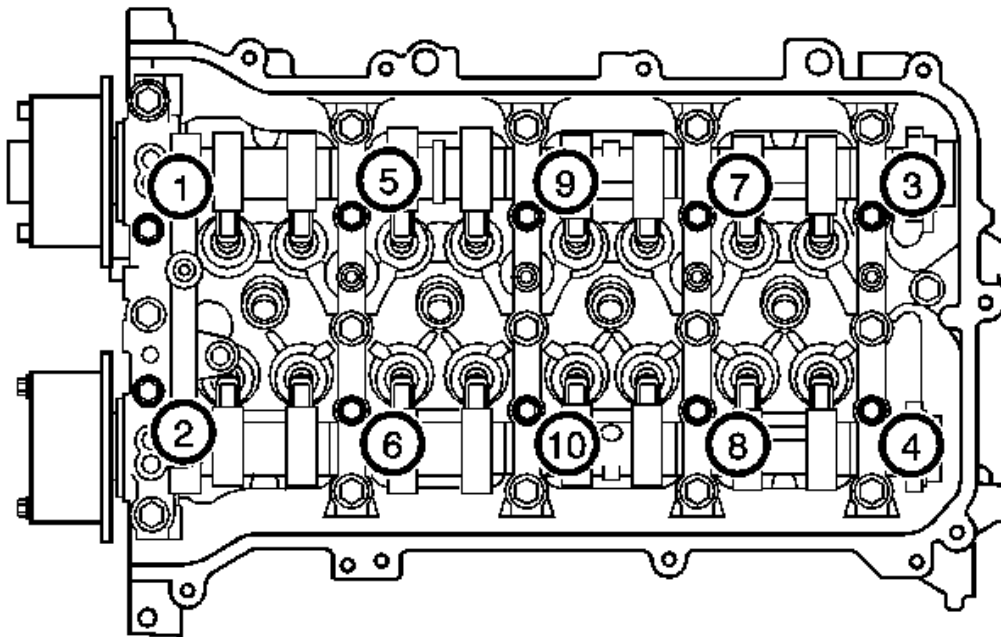


Fig. 313: Identifying Camshaft Bearing Cap Bolt Removal/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

1. Uniformly loosen and remove the 10 bearing cap bolts in the sequence shown in the illustration.

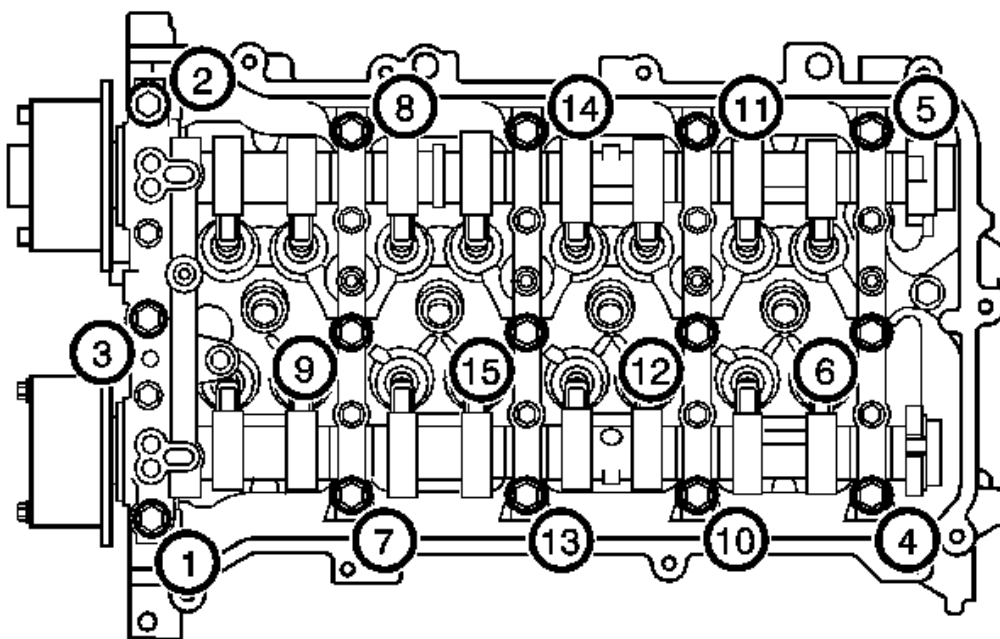


Fig. 314: View Of Camshaft Bearing Cap Bolt Removal/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

2. Uniformly loosen and remove the 15 bearing cap bolts in the sequence shown in the illustration.

NOTE: **Arrange the removed parts in the correct order.**

3. Remove the 5 bearing caps.

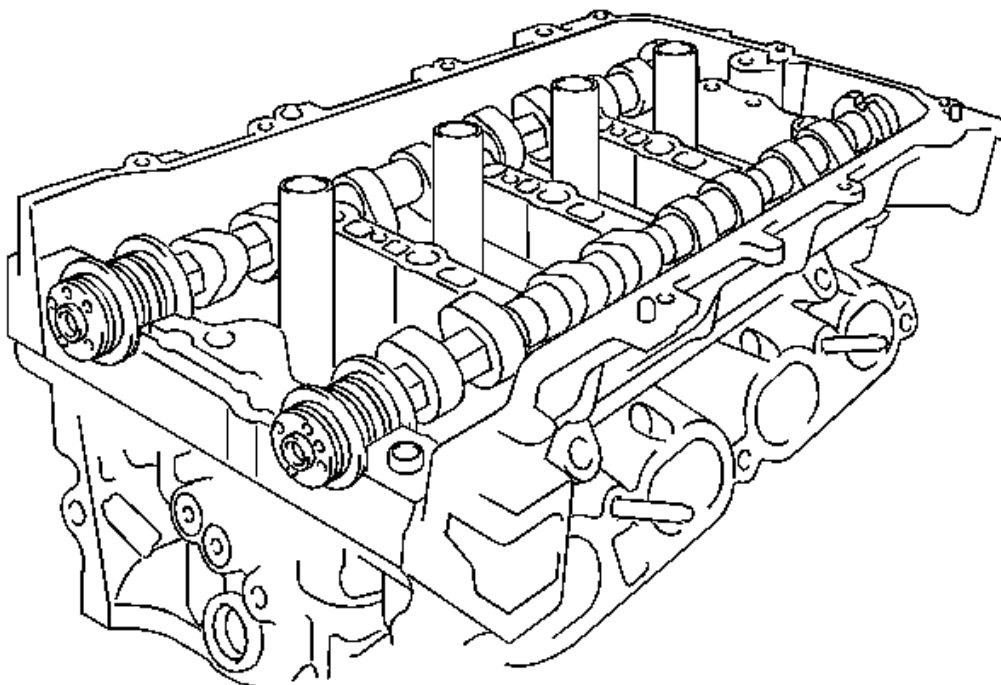


Fig. 315: View Of Cylinder Head & Camshafts
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft.

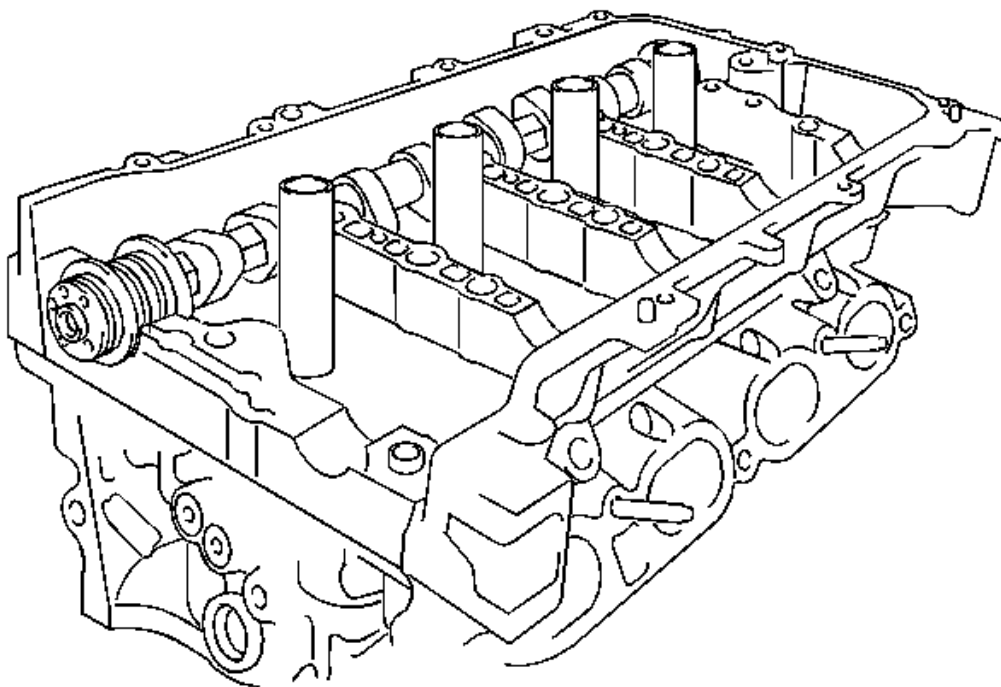


Fig. 316: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Remove the No. 2 camshaft.

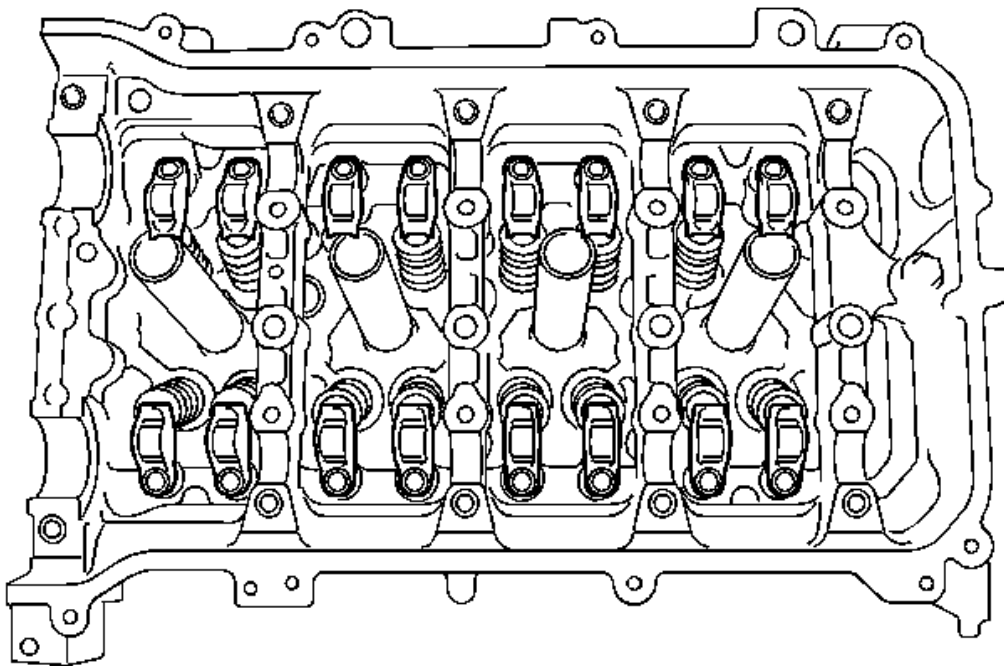


Fig. 317: Identifying Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

NOTE: Arrange the removed parts in the correct order.

6. Remove the 16 valve rocker arms.

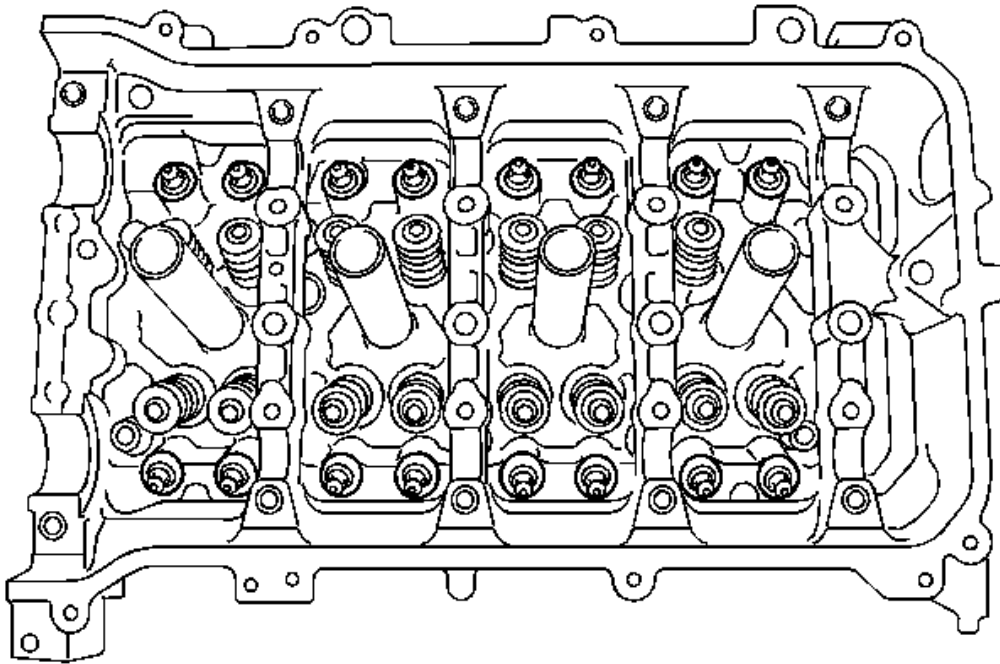


Fig. 318: Verifying Removed Parts Are In Correct Order
Courtesy of GENERAL MOTORS CORP.

NOTE: Arrange the removed parts in the correct order.

7. Remove the 16 valve lash adjusters from the cylinder head.

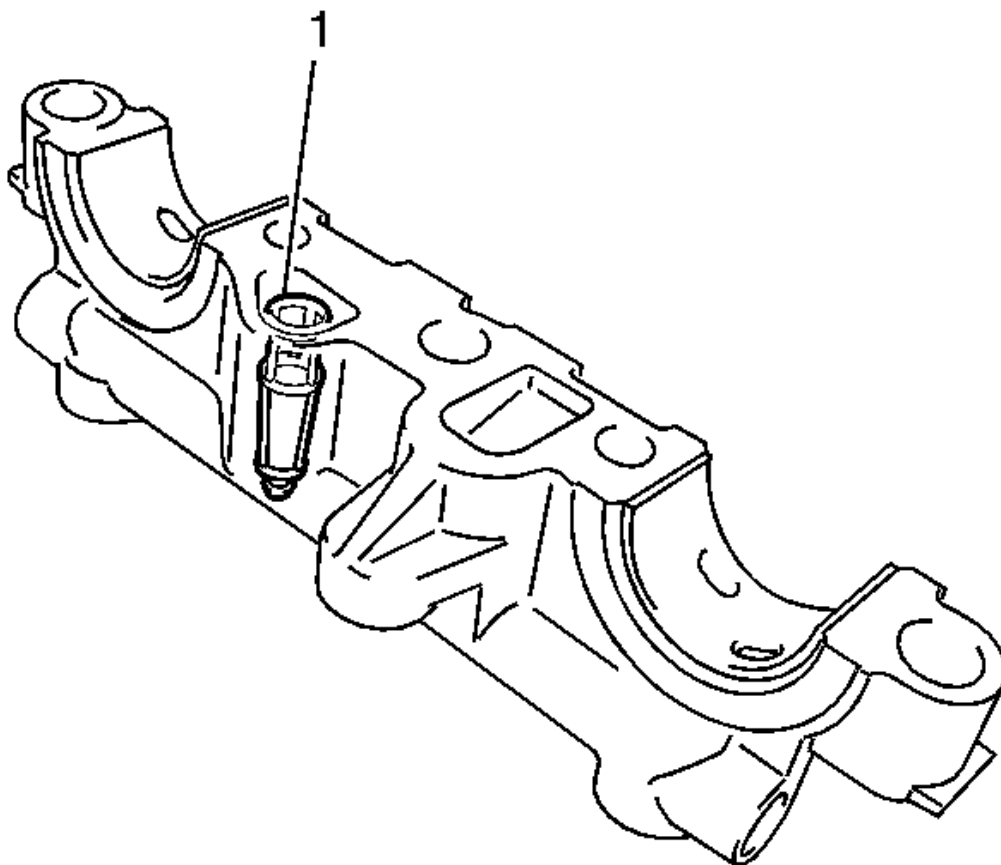


Fig. 319: Identifying Oil Control Valve Filter
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil control valve filter.

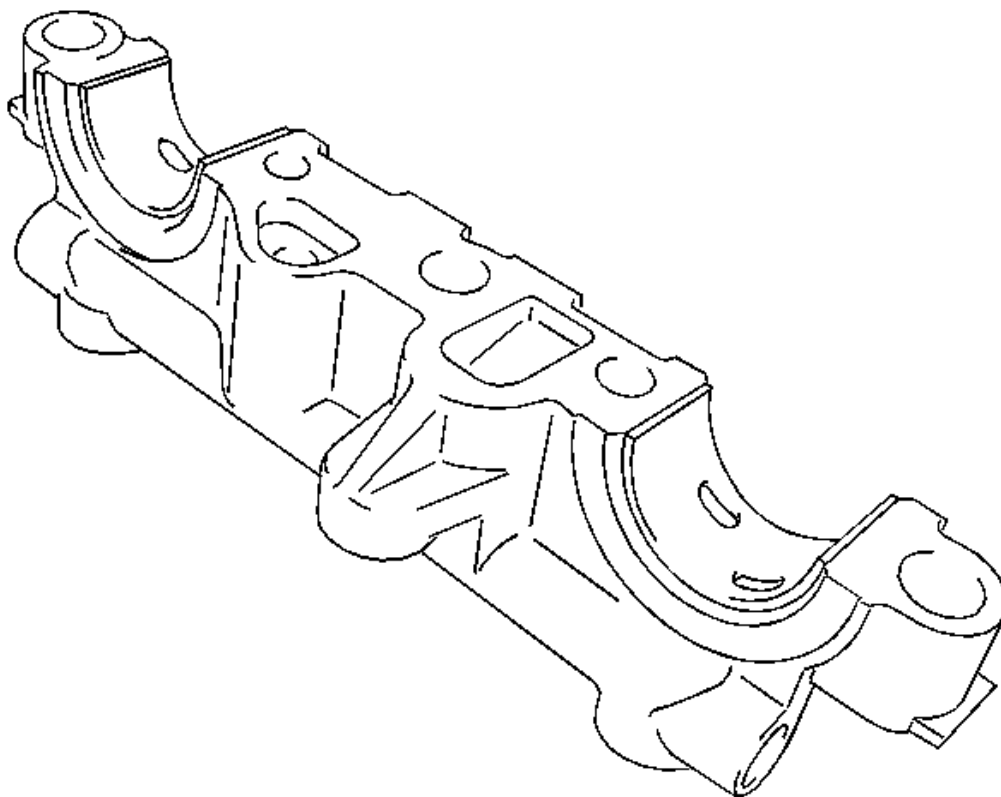


Fig. 320: View Of Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

9. Remove the 2 No. 1 camshaft bearings.

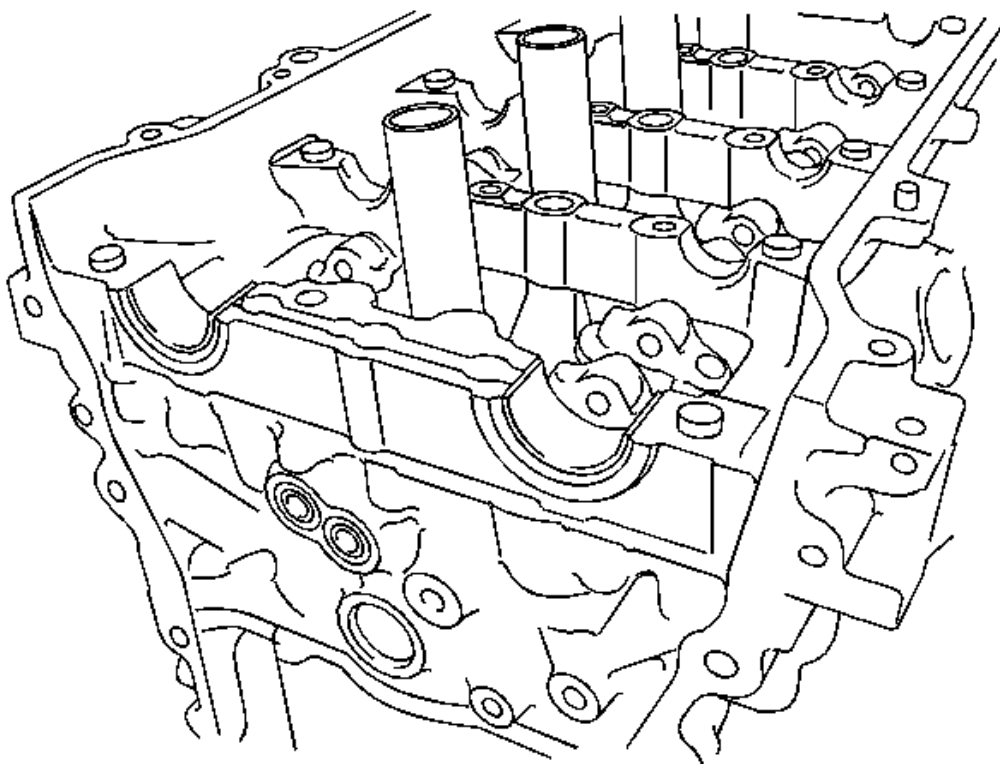


Fig. 321: Identifying Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

10. Remove the 2 No. 2 camshaft bearings.

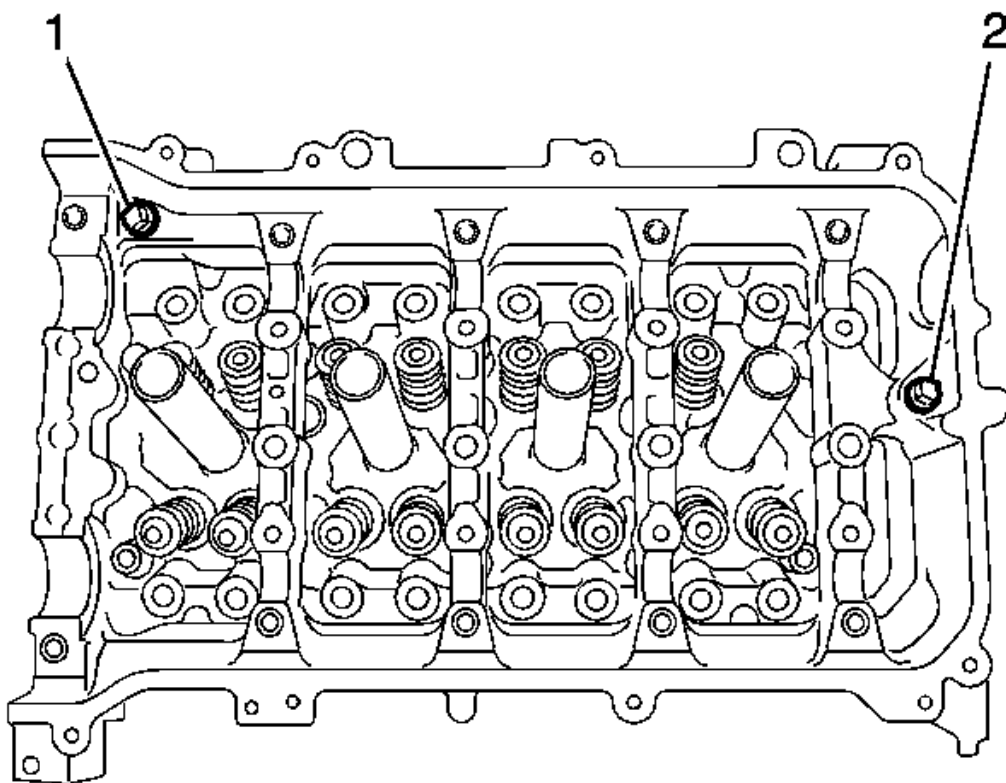


Fig. 322: Identifying 2 Bolts

Courtesy of GENERAL MOTORS CORP.

11. Remove the 2 bolts.

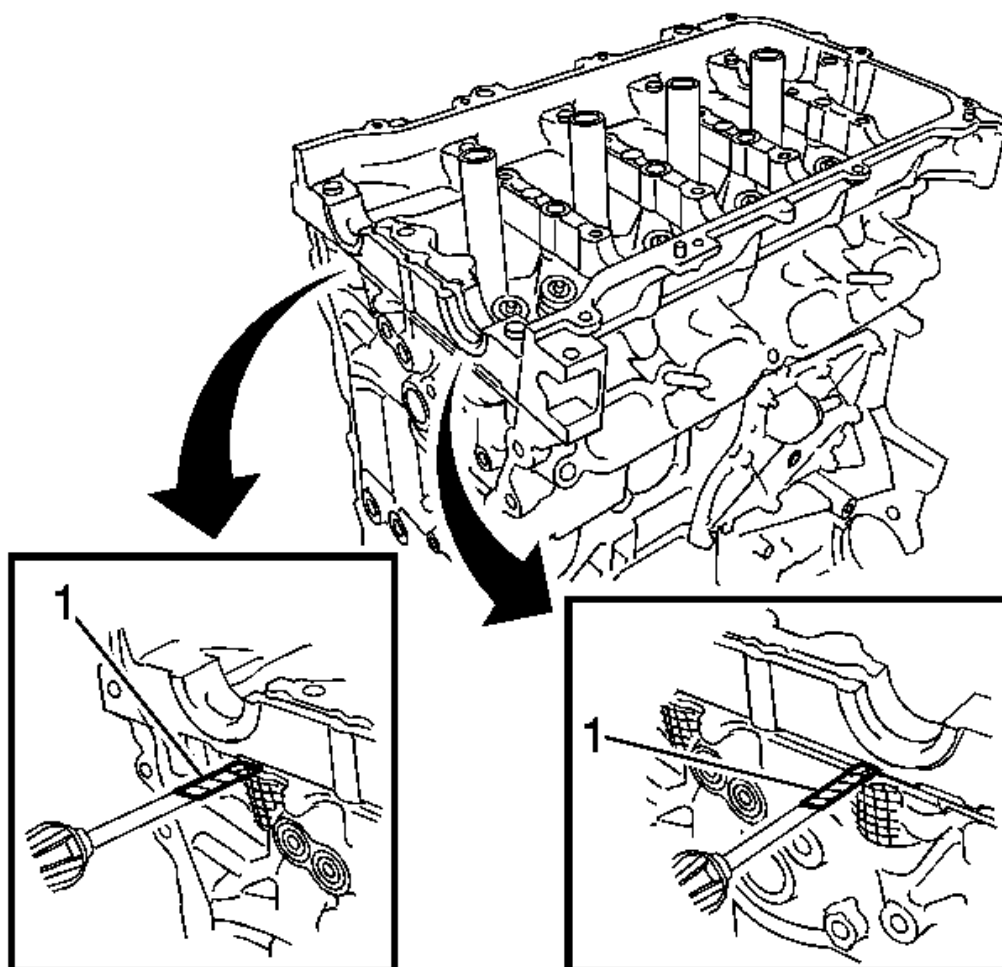


Fig. 323: View Of Camshaft Housing Sub-Assembly
 Courtesy of GENERAL MOTORS CORP.

CAUTION: Be careful not to damage the contact surfaces of the cylinder head and camshaft housing.

NOTE: Tape the screwdriver tip before use.

12. Remove the camshaft housing by prying between the cylinder head and camshaft housing with a screwdriver.
13. Remove the cylinder head sub-assembly.
14. Remove the cylinder head gasket.

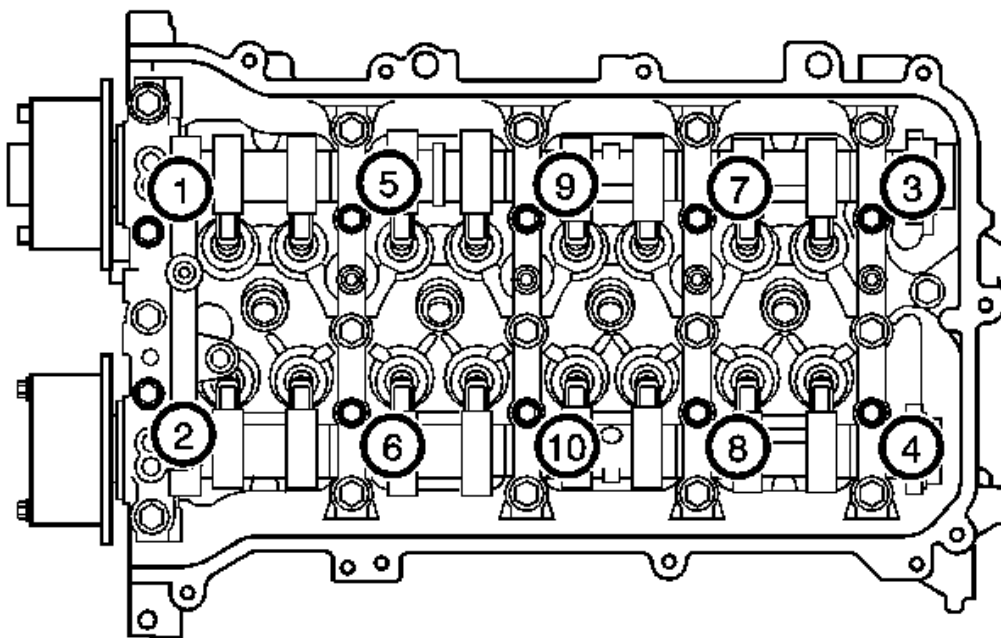
EXHAUST CAMSHAFT AND VALVE LIFTER REMOVAL

Fig. 324: Identifying Camshaft Bearing Cap Bolt Removal/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

1. Uniformly loosen and remove the 10 bearing cap bolts in the sequence shown in the illustration.

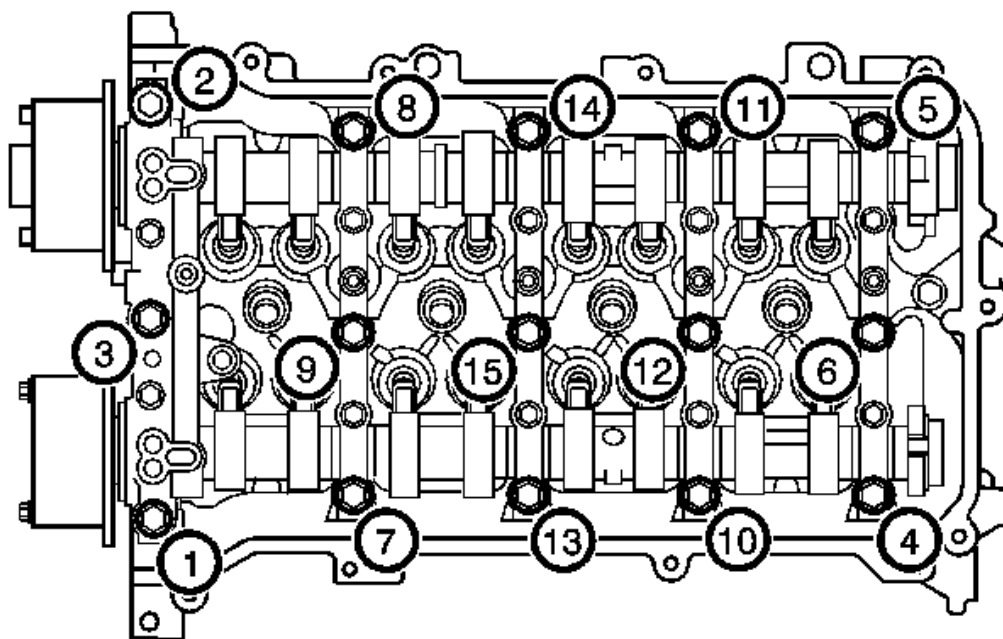


Fig. 325: View Of Camshaft Bearing Cap Bolt Removal/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

2. Uniformly loosen and remove the 15 bearing cap bolts in the sequence shown in the illustration.

NOTE: **Arrange the removed parts in the correct order.**

3. Remove the 5 bearing caps.

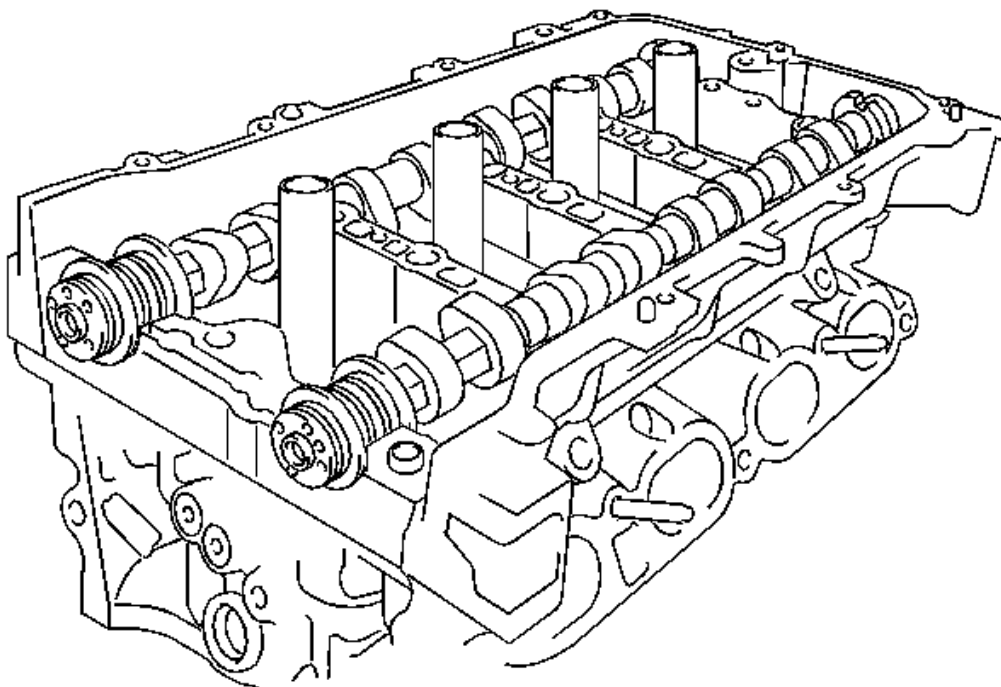


Fig. 326: View Of Cylinder Head & Camshafts
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft.

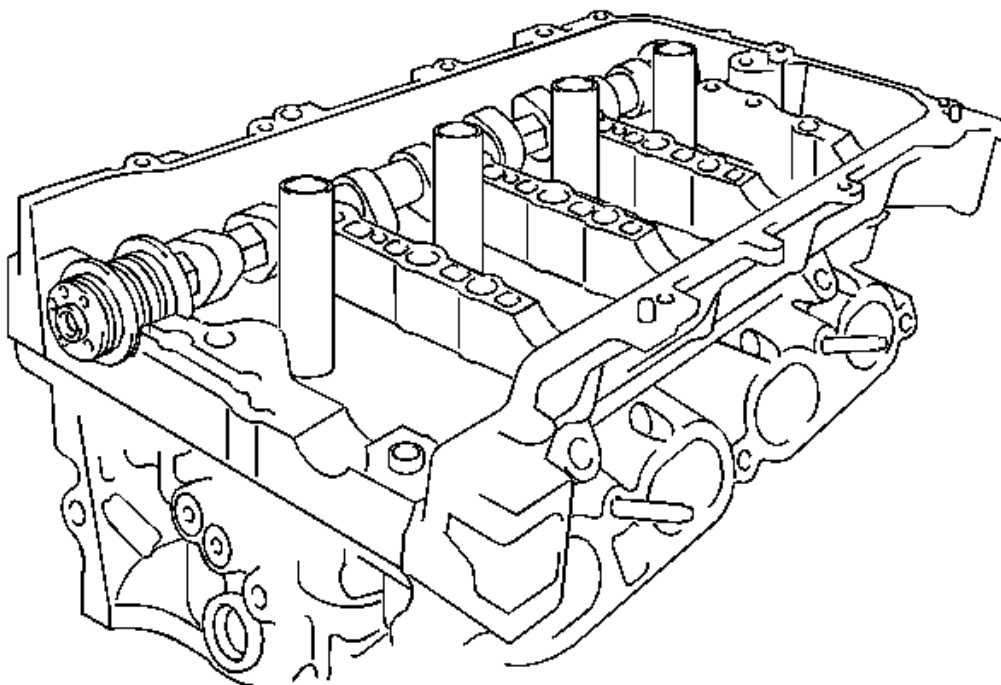


Fig. 327: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Remove the No. 2 camshaft.

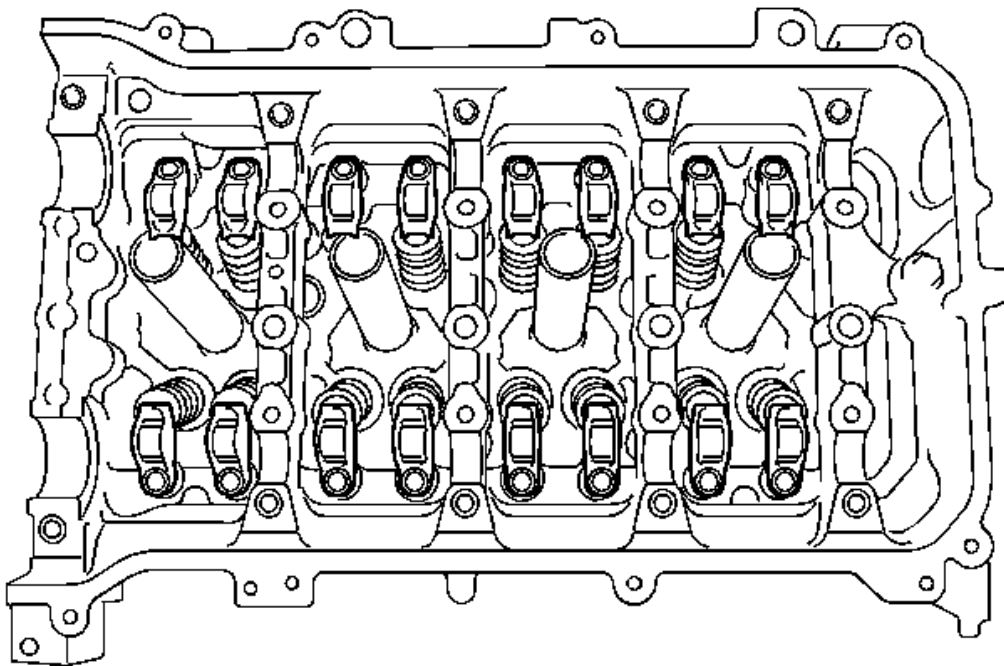


Fig. 328: Identifying Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

NOTE: **Arrange the removed parts in the correct order.**

6. Remove the 16 valve rocker arms.

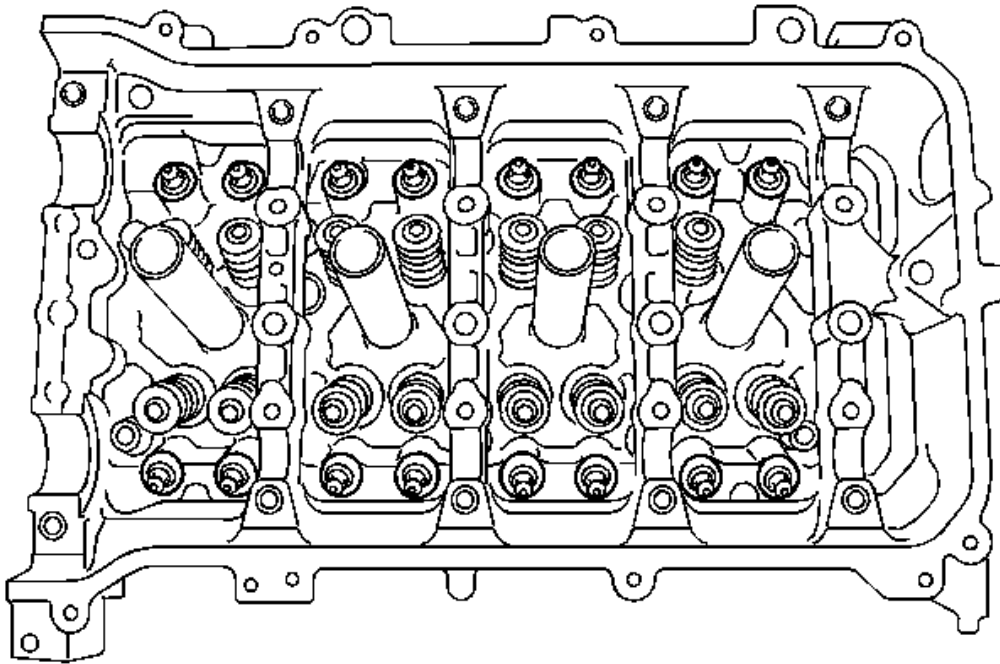


Fig. 329: Verifying Removed Parts Are In Correct Order
Courtesy of GENERAL MOTORS CORP.

NOTE: Arrange the removed parts in the correct order.

7. Remove the 16 valve lash adjusters from the cylinder head.

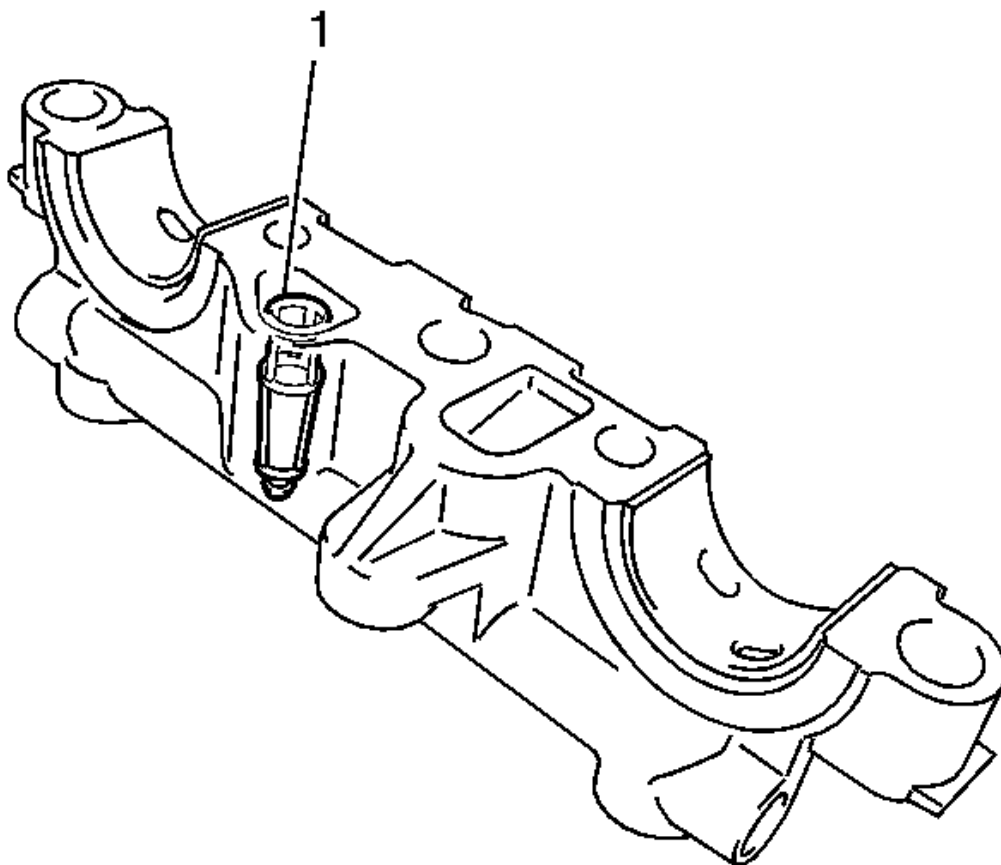


Fig. 330: Identifying Oil Control Valve Filter
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil control valve filter.

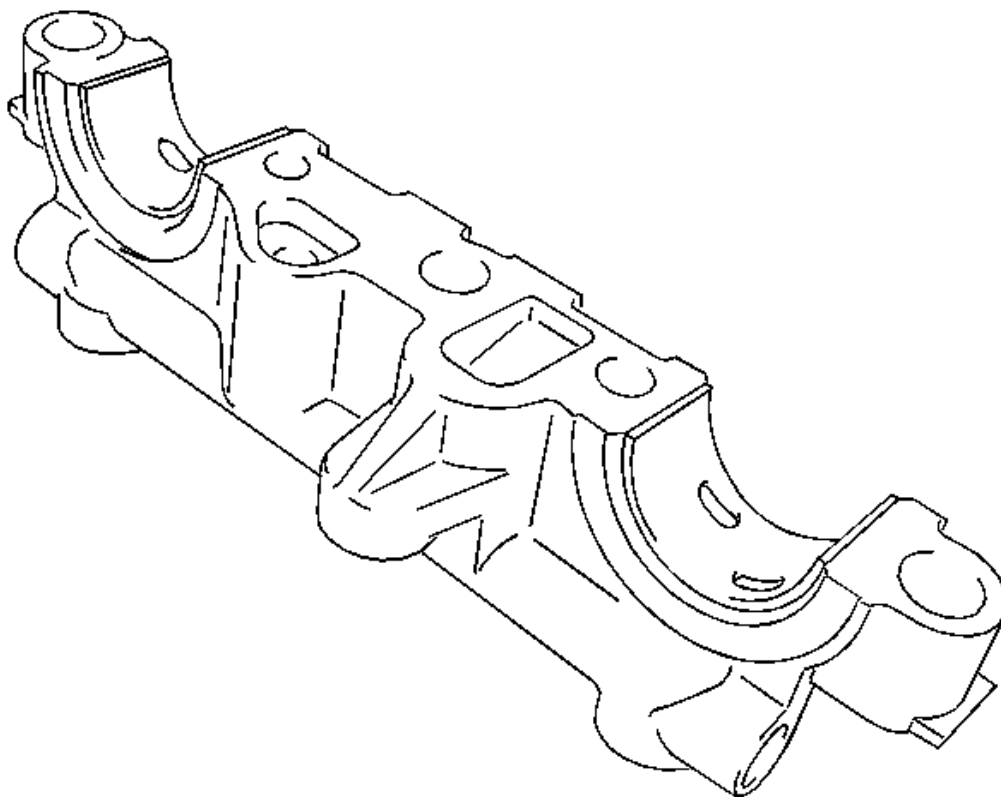


Fig. 331: View Of Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

9. Remove the 2 No. 1 camshaft bearings.

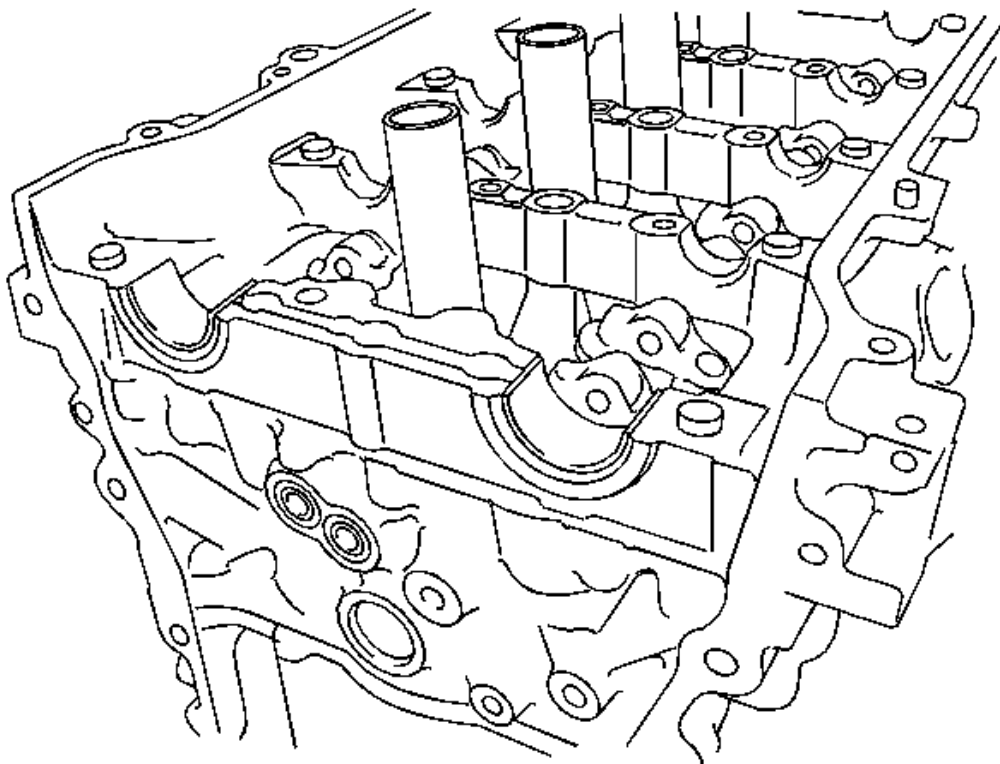


Fig. 332: Identifying Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

10. Remove the 2 No. 2 camshaft bearings.

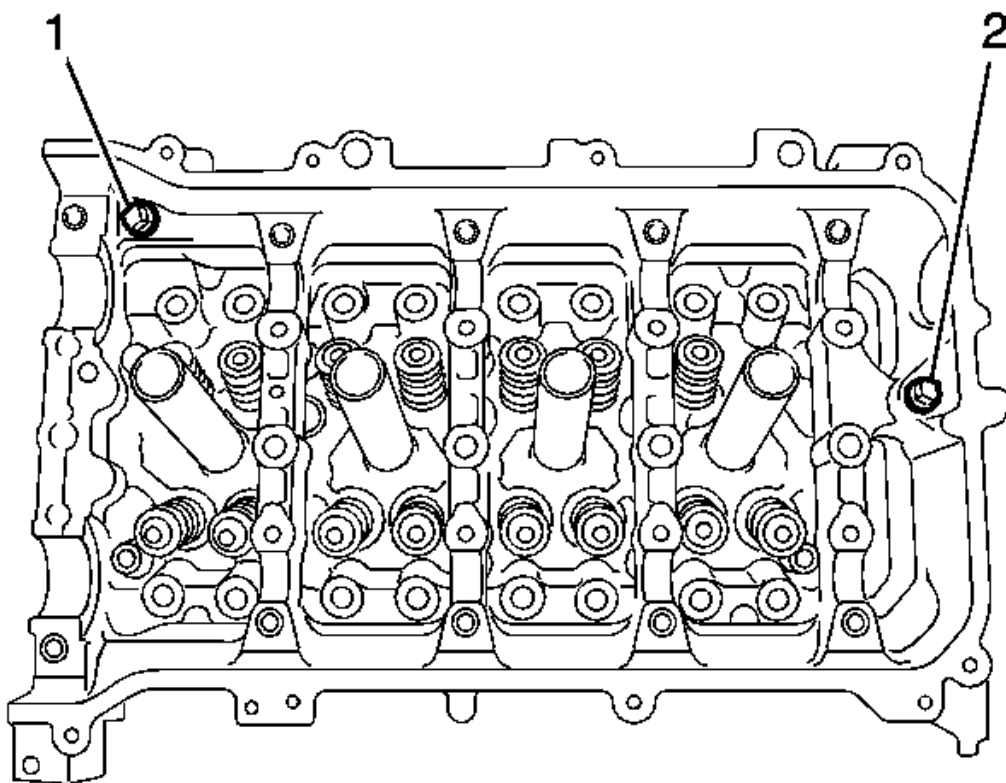


Fig. 333: Identifying 2 Bolts

Courtesy of GENERAL MOTORS CORP.

11. Remove the 2 bolts.

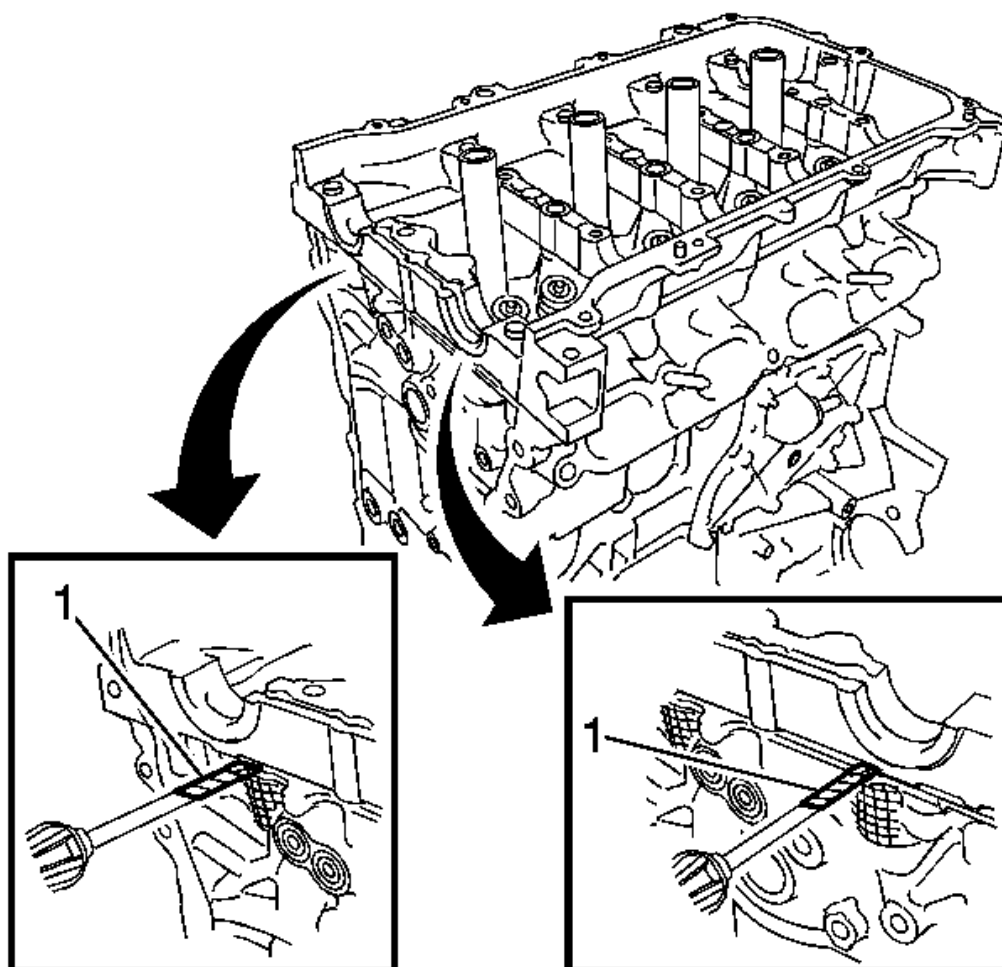


Fig. 334: View Of Camshaft Housing Sub-Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: Be careful not to damage the contact surfaces of the cylinder head and camshaft housing.

NOTE: Tape the screwdriver tip before use.

12. Remove the camshaft housing by prying between the cylinder head and camshaft housing with a screwdriver.
13. Remove the cylinder head sub-assembly.
14. Remove the cylinder head gasket.

CYLINDER HEAD REMOVAL

1. Remove the cylinder head sub-assembly.
2. Remove the cylinder head gasket.

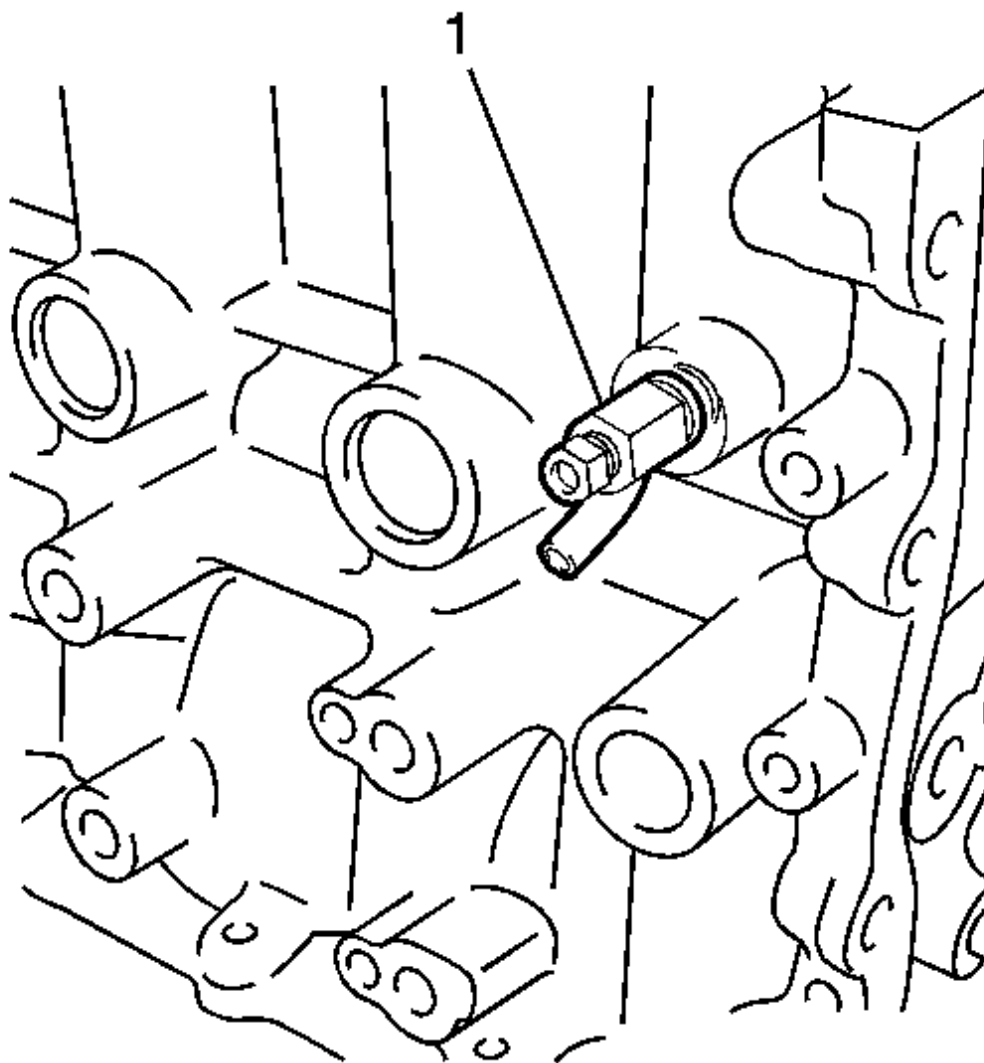
OIL PAN REMOVAL (LOWER)

Fig. 335: Identifying Water Drain Cock Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the water drain cock plug from the water drain cock sub-assembly.
2. Remove the cylinder block water drain cock subassembly from the cylinder block.

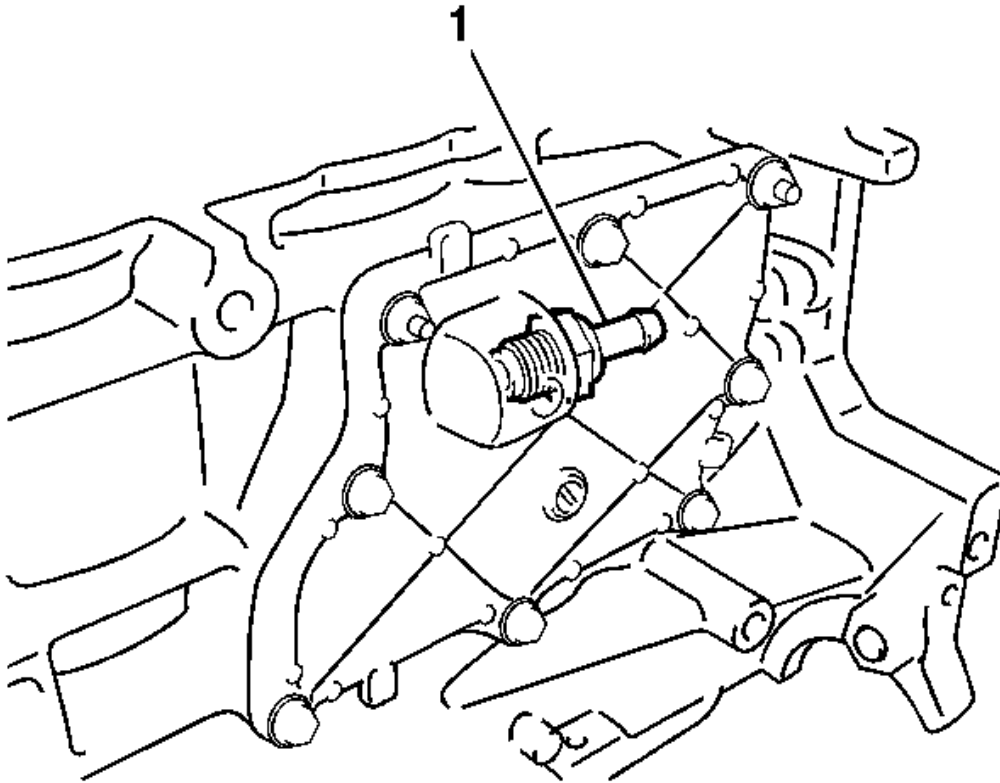


Fig. 336: Identifying Ventilation Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the ventilation valve.

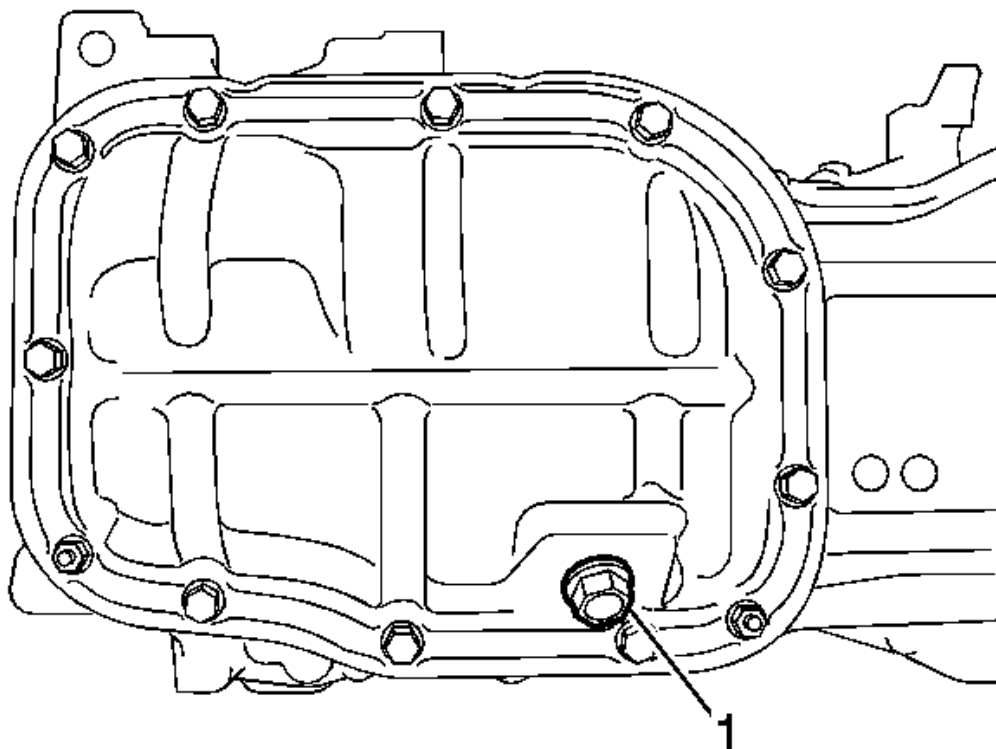


Fig. 337: Identifying Oil Pan Drain Plug & Gasket
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan drain plug and gasket.
5. Remove the No. 2 oil pan sub-assembly.

OIL PAN REMOVAL (UPPER)

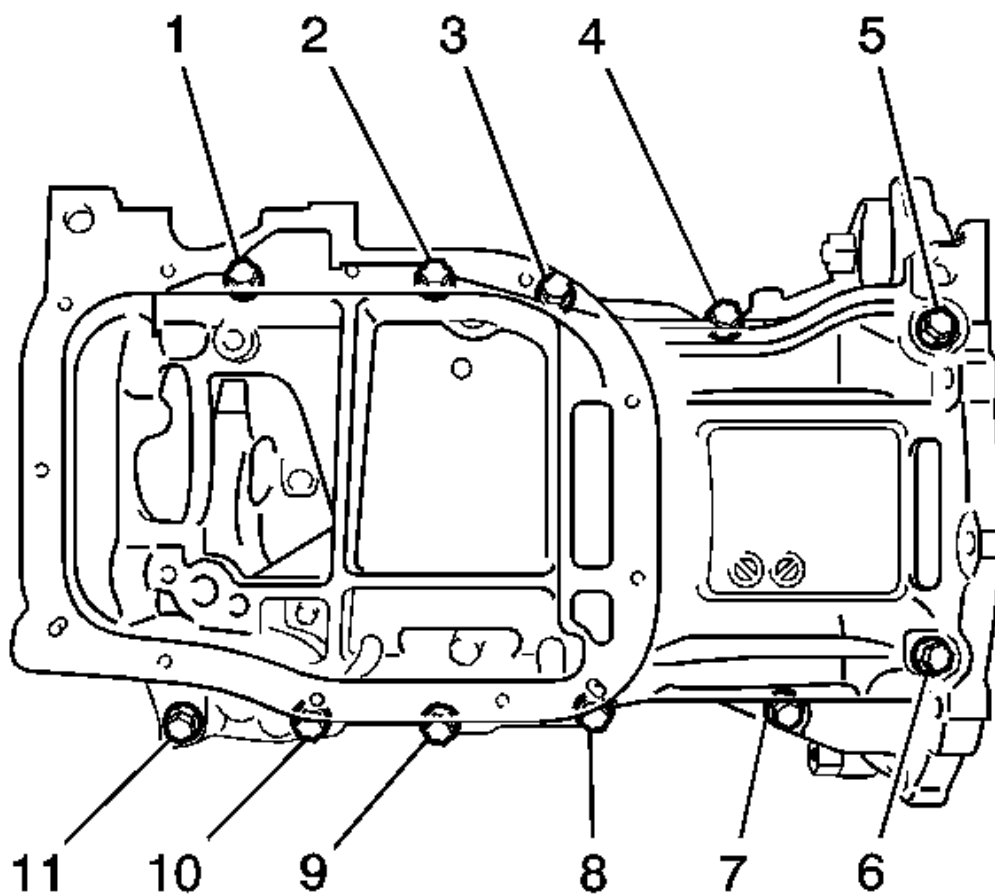


Fig. 338: Identifying Upper Oil Pan Bolt Loosening Sequence
Courtesy of GENERAL MOTORS CORP.

1. Uniformly loosen and remove the 11 bolts.

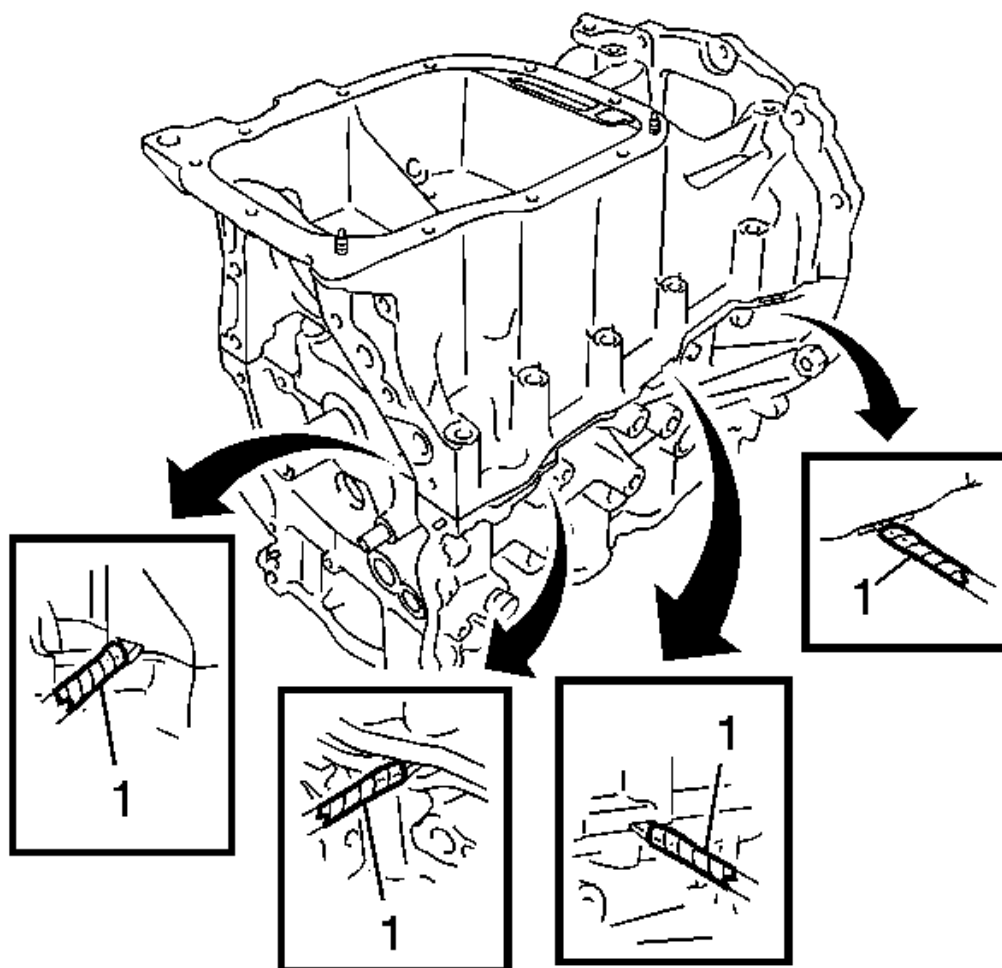


Fig. 339: Illustrating Upper Oil Pan Removal
Courtesy of GENERAL MOTORS CORP.

CAUTION: Be careful not to damage the contact surfaces of the crankcase and cylinder block.

2. Using a screwdriver, remove the stiffening crankcase by prying between the crankcase and cylinder block.

OIL PUMP REMOVAL

Remove the oil pump assembly.

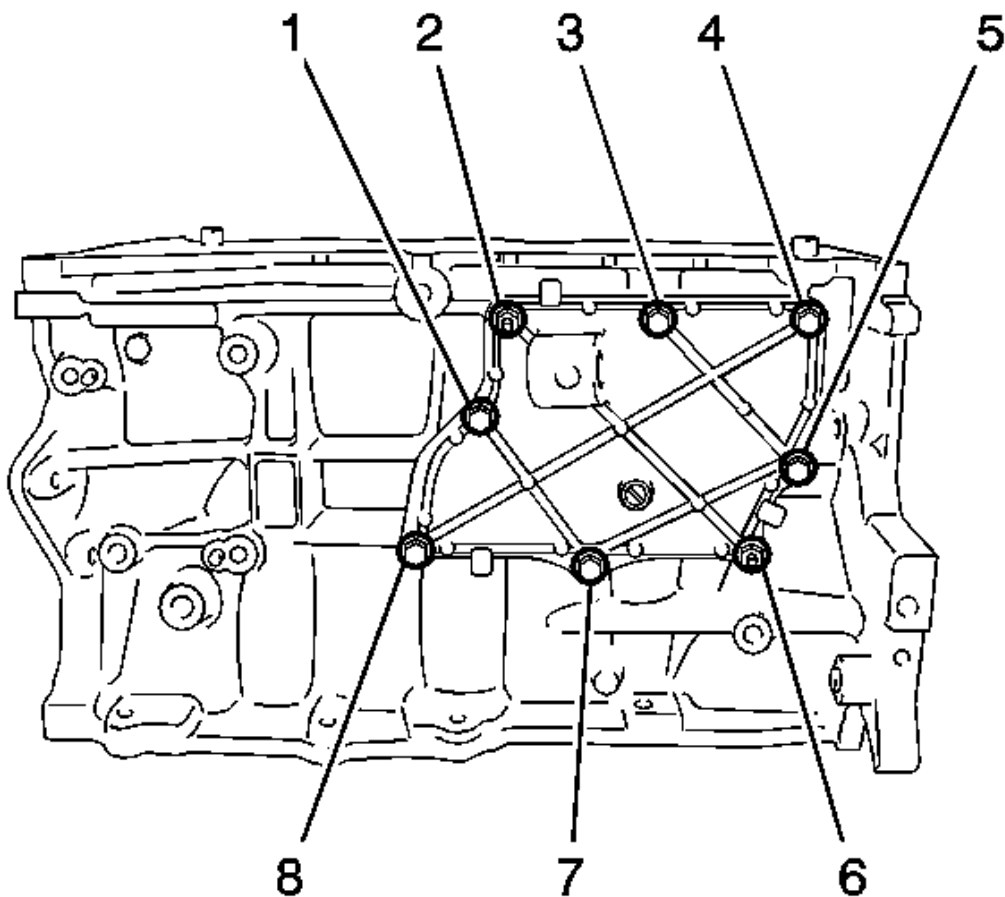
PISTON, CONNECTING ROD, AND BEARING REMOVAL

Fig. 340: View Of 6 Bolts & 2 Nuts
Courtesy of GENERAL MOTORS CORP.

1. Remove the 6 bolts and 2 nuts.

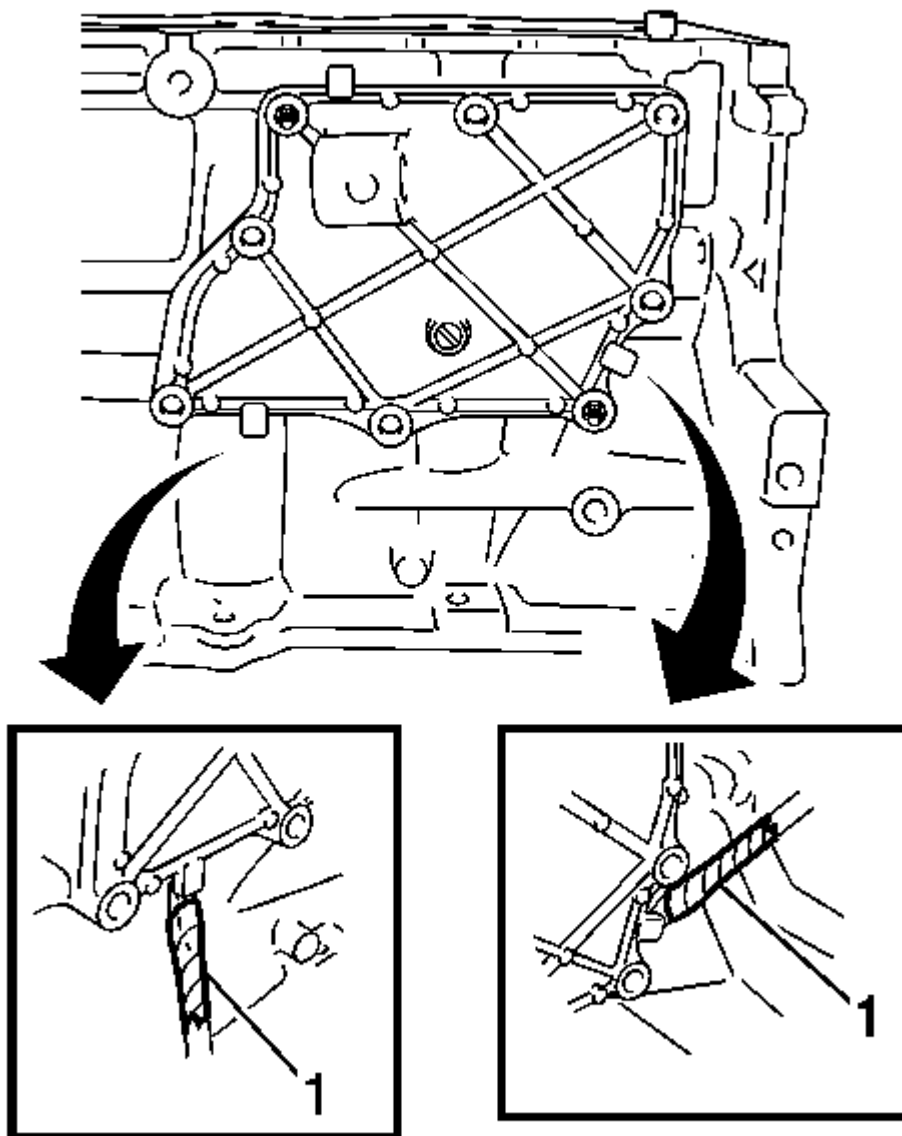


Fig. 341: Illustrating Ventilation Case Removal
Courtesy of GENERAL MOTORS CORP.

NOTE: Tape the screwdriver tip before use.

2. Remove the ventilation case by prying between the 1 ventilation case and cylinder block with a screwdriver as shown in the illustration.

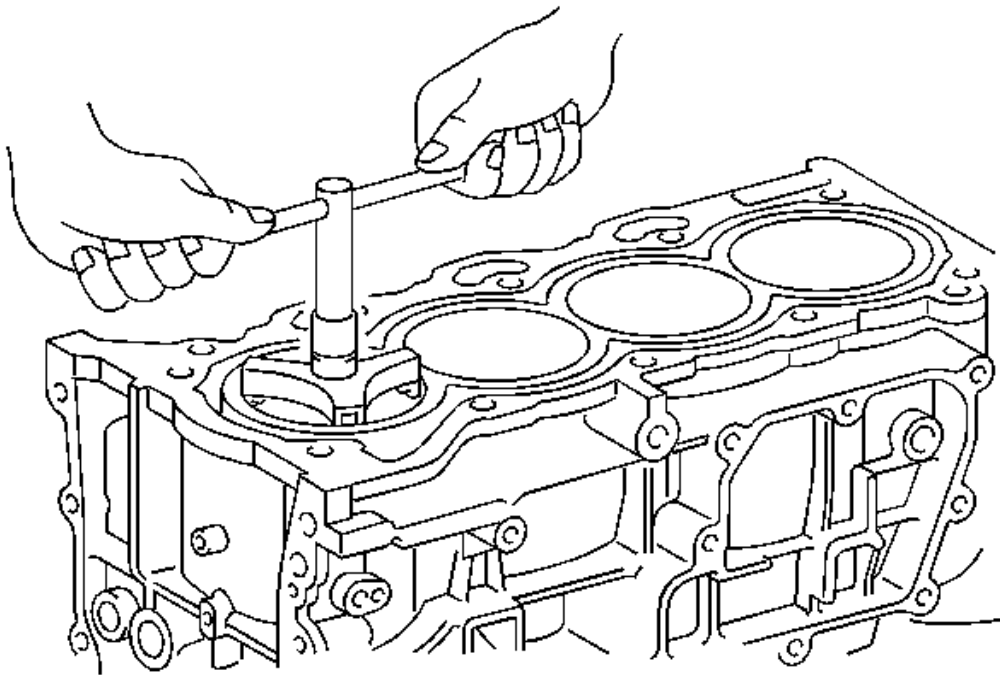


Fig. 342: View Of Reaming Piston Ring Ridge
Courtesy of GENERAL MOTORS CORP.

3. Using a ridge reamer, remove all the carbon from the top of the cylinder.

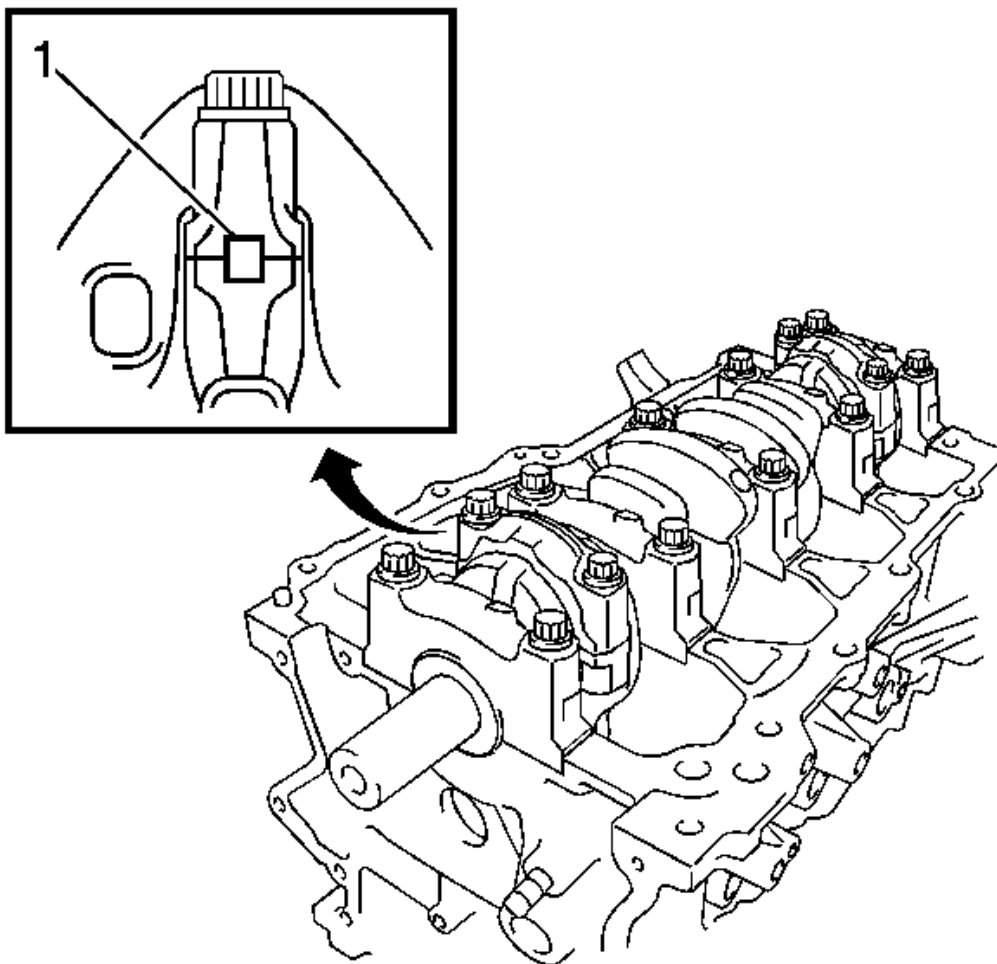


Fig. 343: Checking Matchmarks On Connecting Rod & Cap Are Aligned
Courtesy of GENERAL MOTORS CORP.

NOTE: The matchmarks on the connecting rods and caps are provided to ensure correct reassembly.

4. Check that the matchmarks on the connecting rod and cap are aligned to ensure correct reassembly.

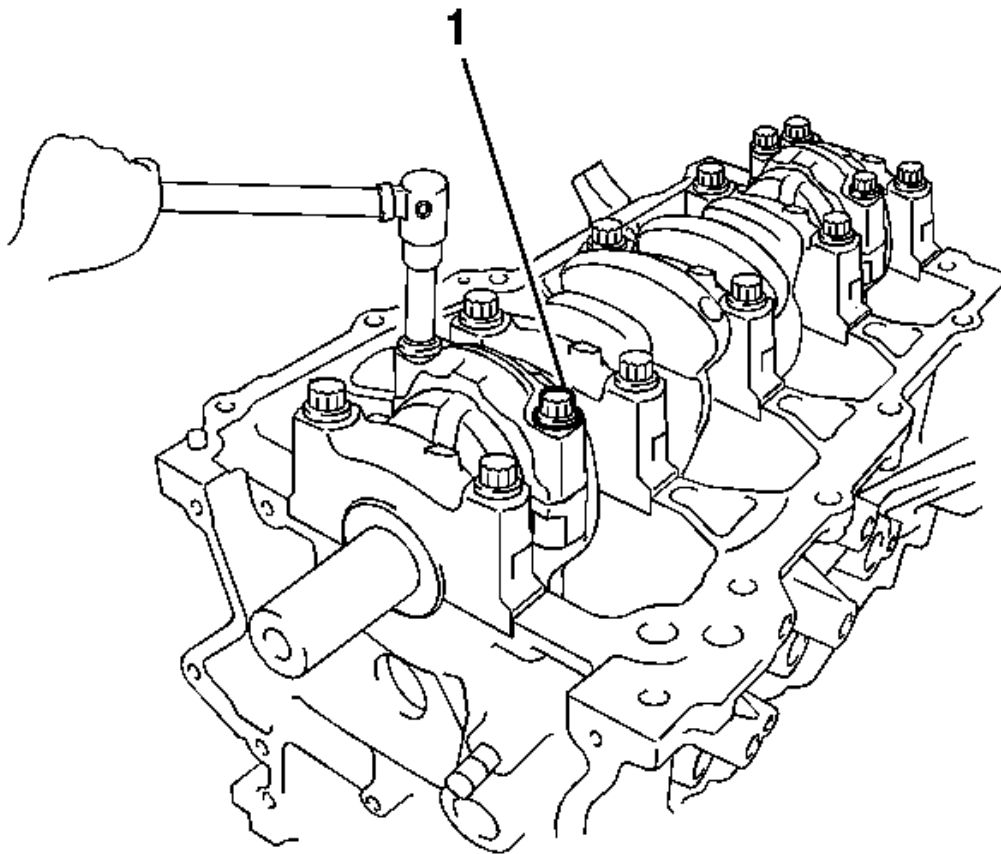


Fig. 344: Identifying Connecting Rod Cap Bolts
Courtesy of GENERAL MOTORS CORP.

5. Using SST, uniformly loosen the 2 bolts.

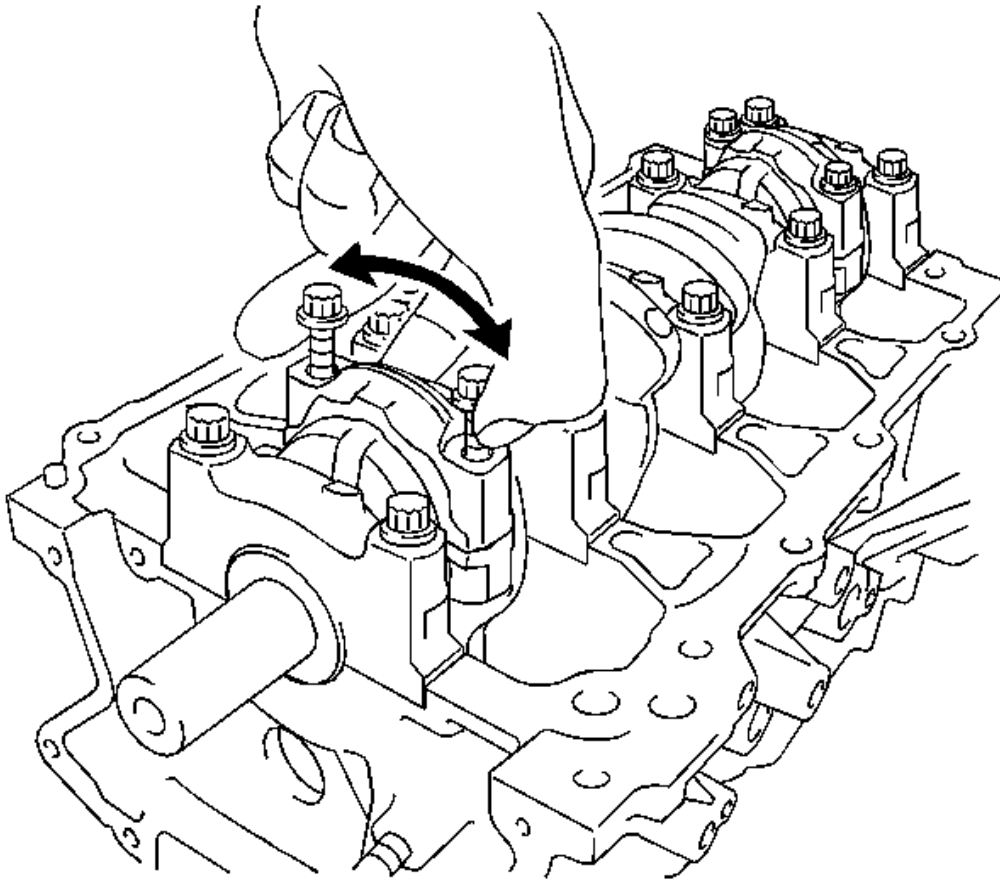


Fig. 345: View Of Connecting Rod Cap & Lower Bearing
Courtesy of GENERAL MOTORS CORP.

NOTE: **Keep the lower bearing inserted in the connecting rod cap.**

6. Using the 2 removed connecting rod cap bolts, remove the connecting rod cap and lower bearing by wiggling the connecting rod cap right and left.

NOTE: **Keep the bearing, connecting rod and cap as a set and arrange the piston and connecting rod assemblies in the correct order.**

7. Push the piston, connecting rod assembly and upper bearing through the top of the cylinder block.
8. Remove the connecting rod bearings.

CRANKSHAFT REAR OIL SEAL REMOVAL

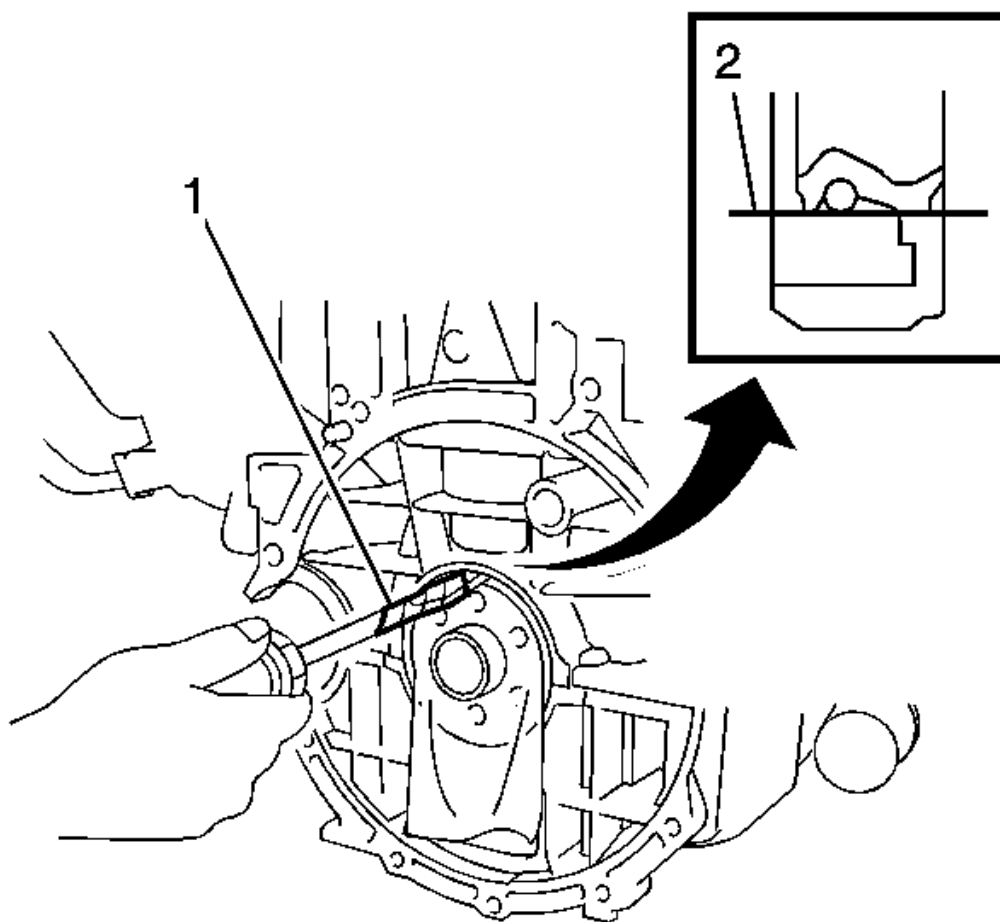


Fig. 346: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Using a knife, cut off the rear engine oil seal lip.

NOTE: After removing the oil seal, check the crankshaft for damage. If it is damaged, smooth the surface with 400-grit sandpaper.

2. Using a screwdriver with its tip taped, pry out the rear engine oil seal.

CRANKSHAFT AND BEARING REMOVAL

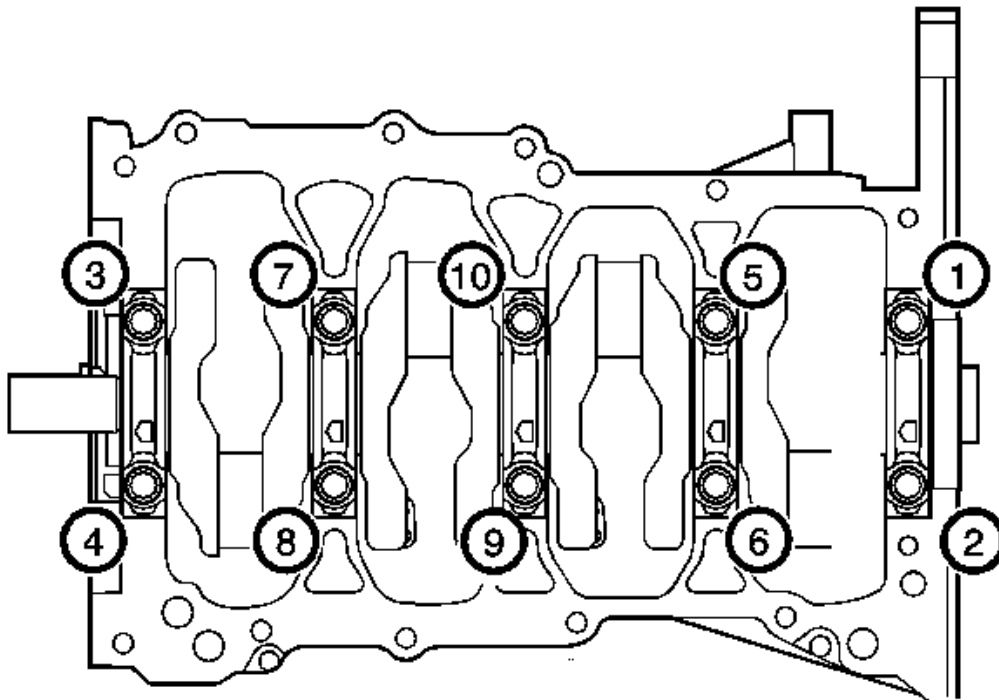


Fig. 347: Identifying Main Bearing Cap Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

1. Uniformly loosen and remove the 10 main bearing cap bolts in the sequence shown in the illustration.

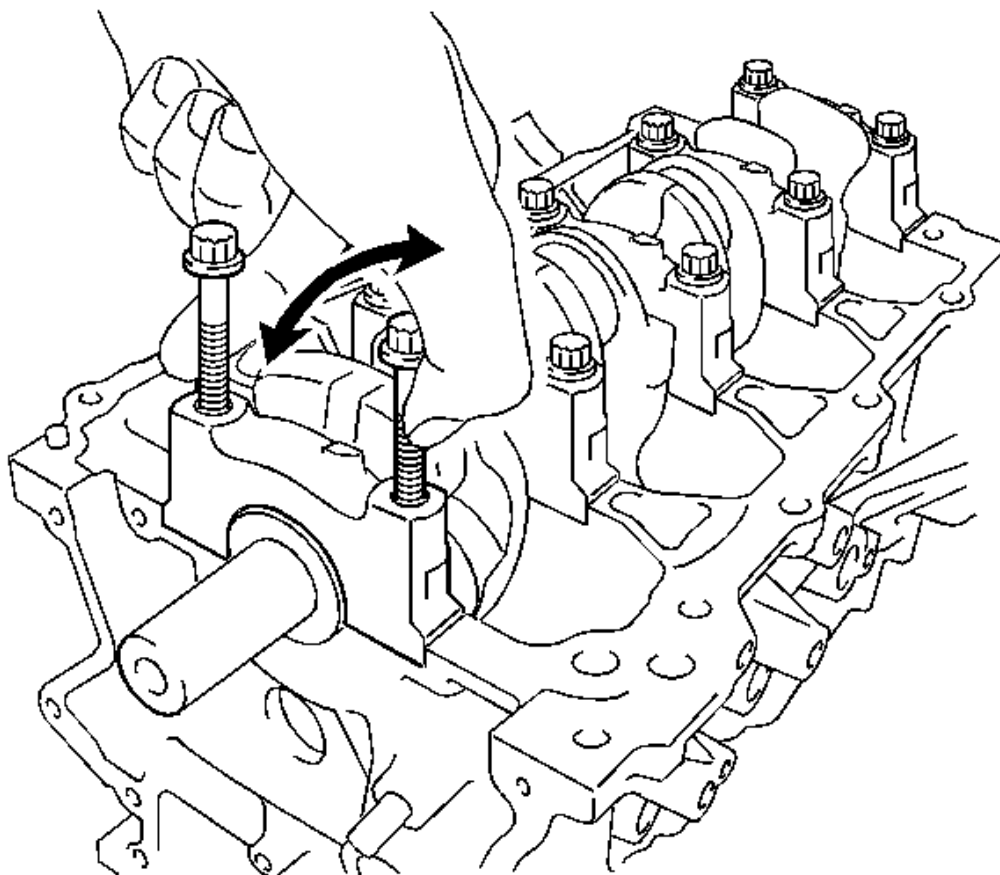


Fig. 348: View Of Main Bearing Cap & Lower Bearing
Courtesy of GENERAL MOTORS CORP.

CAUTION: Insert the bolts into the caps in turn. Ease the cap out by gently pulling up and applying force toward the front and back sides of the cylinder block as shown.

NOTE: Keep the lower bearing and main bearing cap as a set and arrange the main bearing caps in the correct order.

2. Use 2 removed main bearing cap bolts to remove the 5 main bearing caps and 5 lower bearings.
3. Lift out the crankshaft.

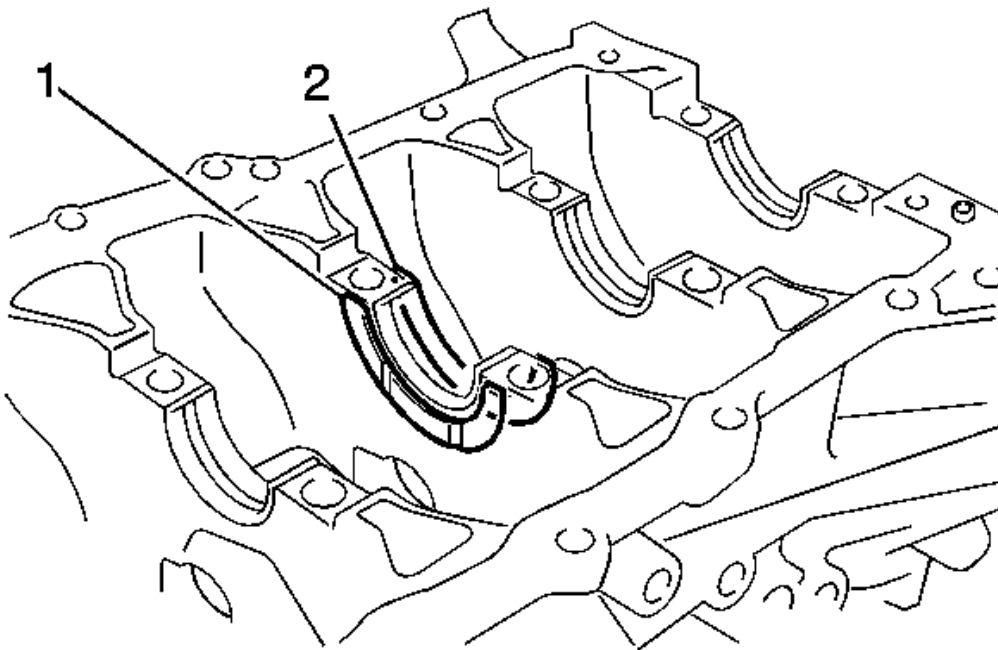


Fig. 349: Identifying Upper Crankshaft Thrust Washers

Courtesy of GENERAL MOTORS CORP.

4. Remove the upper crankshaft thrust washers from the cylinder block.

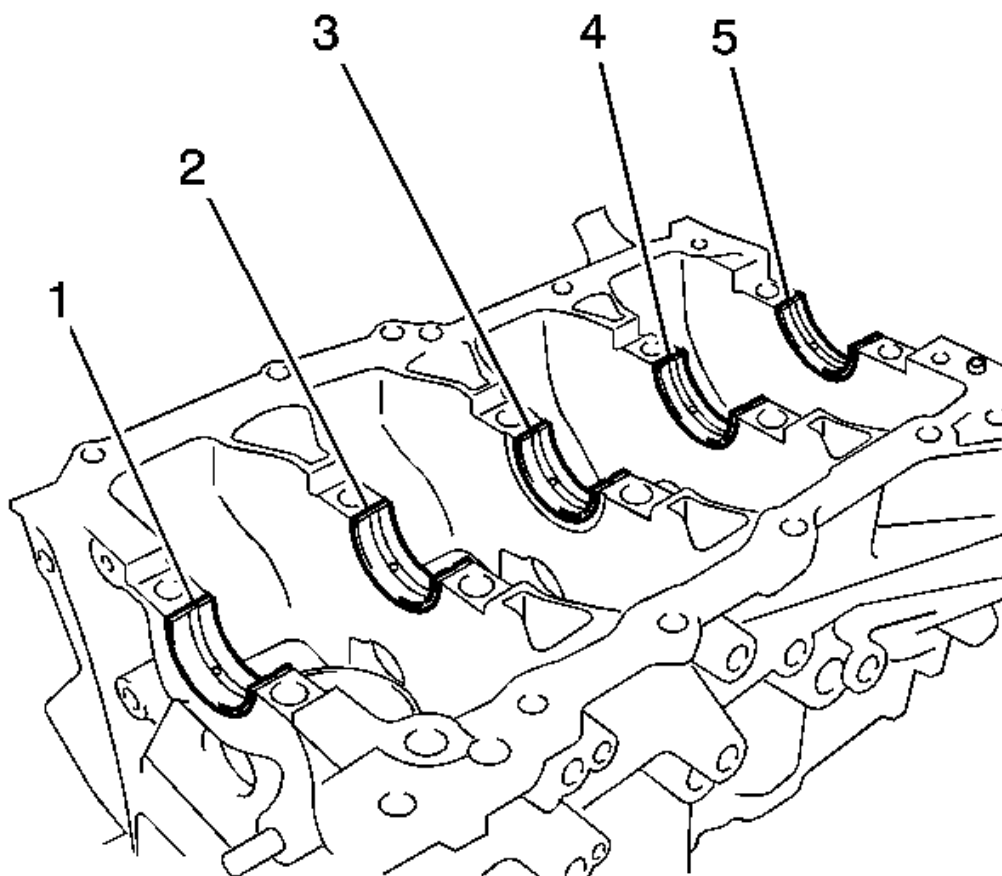


Fig. 350: Identifying Upper Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

NOTE: **Arrange the bearings in the correct order.**

5. Remove the 5 upper main crankshaft bearings from the cylinder block.

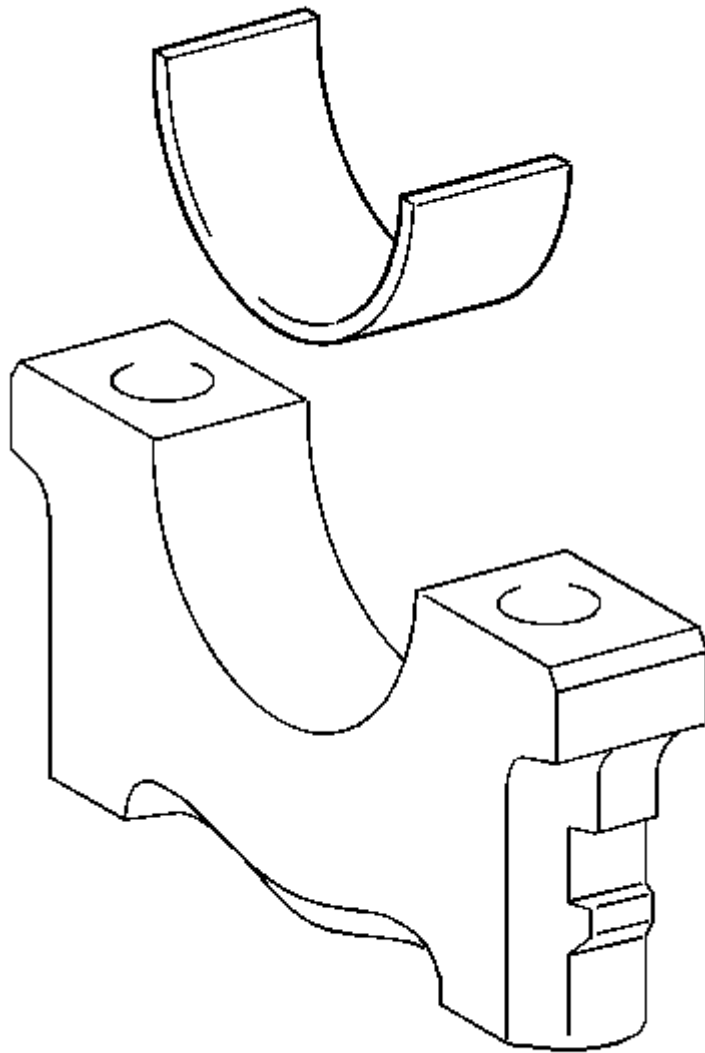


Fig. 351: View Of Lower Main Bearing & Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: **Arrange the bearings in the correct order.**

6. Remove the 5 lower main bearings from the 5 main bearing caps.

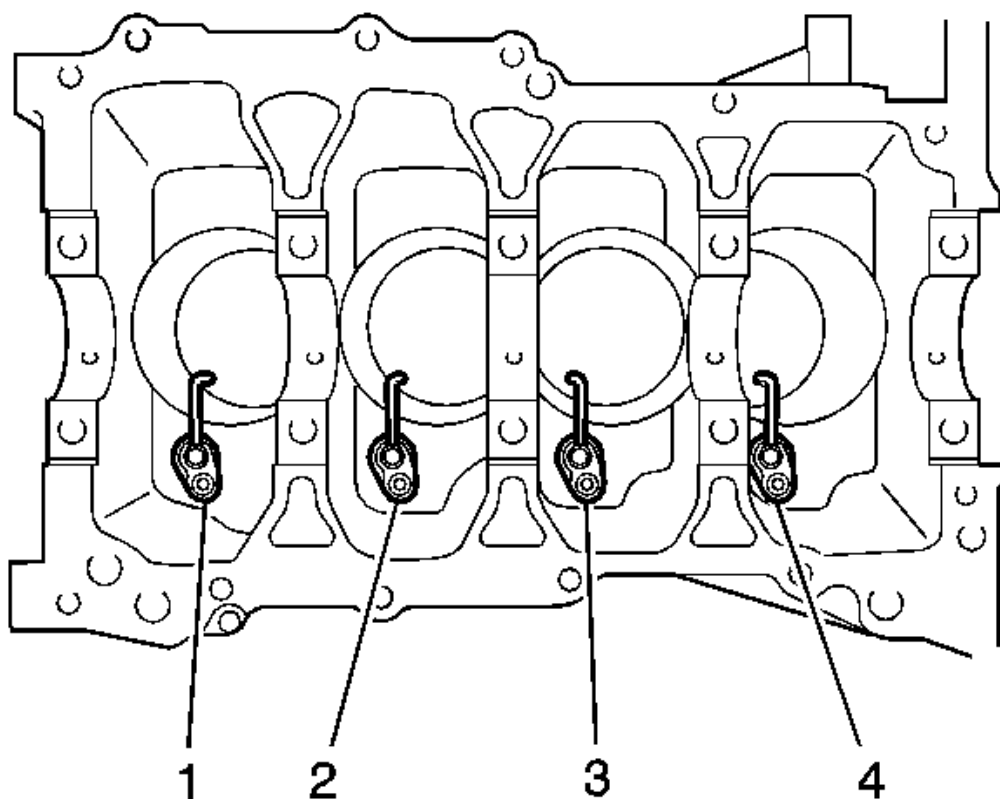


Fig. 352: Identifying Oil Nozzles

Courtesy of GENERAL MOTORS CORP.

7. Using a 5 mm socket hexagon wrench, remove the bolts and oil nozzles.

NOTE: If the cylinder is washed at high temperature, the cylinder liner will stick out beyond the cylinder block. Always wash the cylinder block at a temperature of 45°C (113°F) or less.

8. Clean cylinder block.

ENGINE BLOCK CLEANING AND INSPECTION

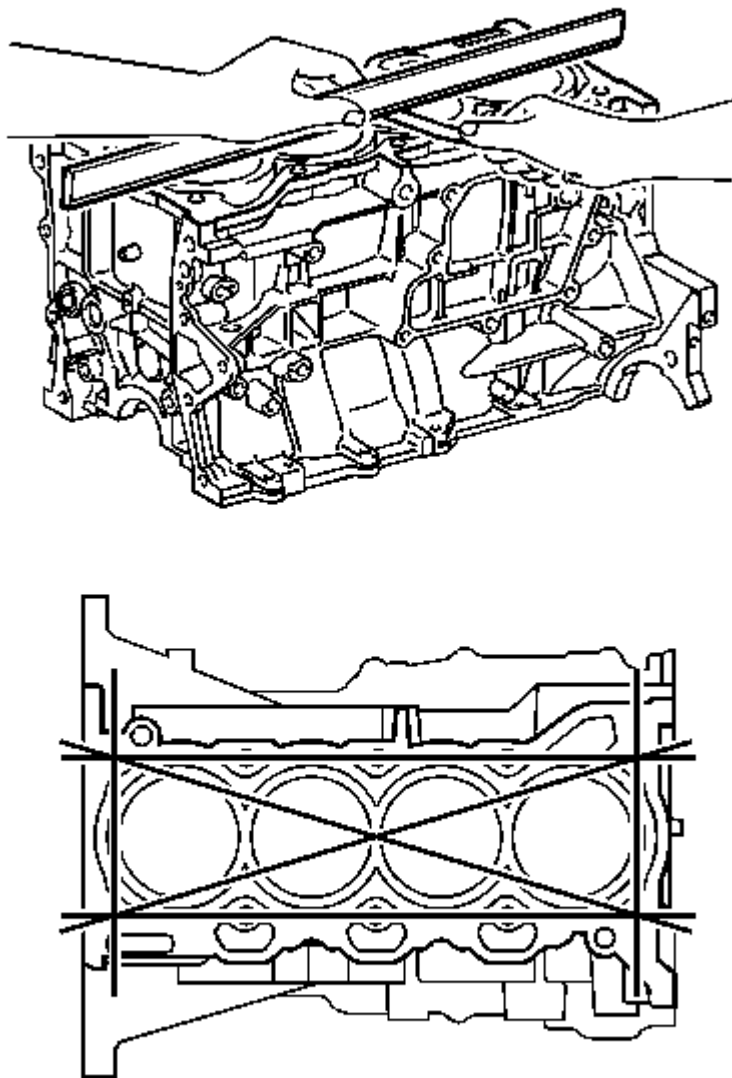


Fig. 353: Inspecting Engine Block For Flatness
Courtesy of GENERAL MOTORS CORP.

1. Inspect cylinder block for warpage.
2. Using a precision straightedge and feeler gauge, measure the warpage of the surface that is in contact with the cylinder head gasket.

Specification: Maximum warpage: 0.05 mm (0.0020 in)

3. If the warpage is greater than the maximum, replace the cylinder block.

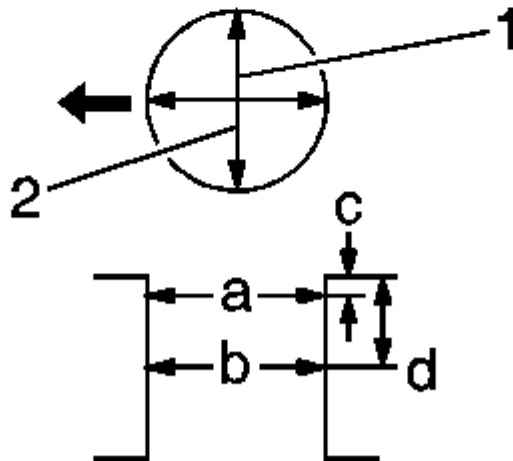
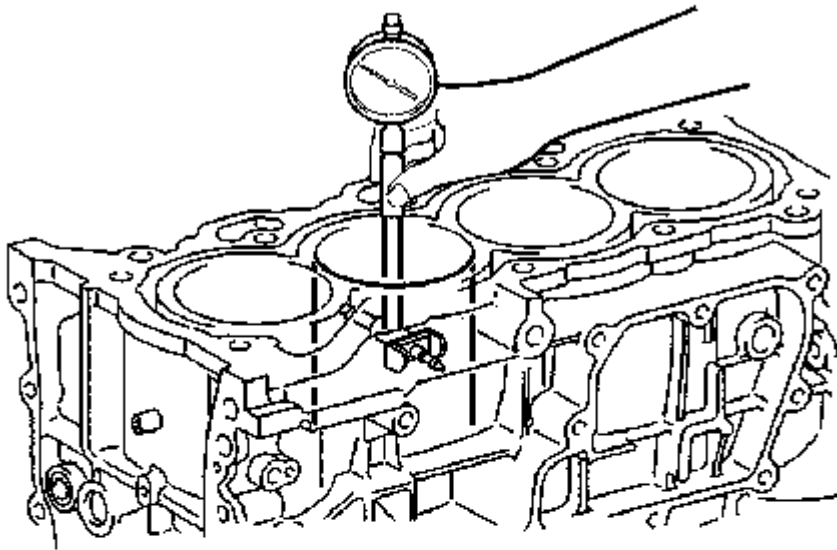


Fig. 354: Inspecting Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

4. Inspect the cylinder bore.
5. Using a cylinder gauge, measure the cylinder bore diameter at positions A and B in both thrust and axial directions.

Specification:

- Standard diameter: 80.500-80.513 mm (3.1693-3.1698 in)
- Maximum diameter: 80.633 mm (3.1745 in)

6. If the average diameter of the 4 positions is greater than the maximum, replace the cylinder block.

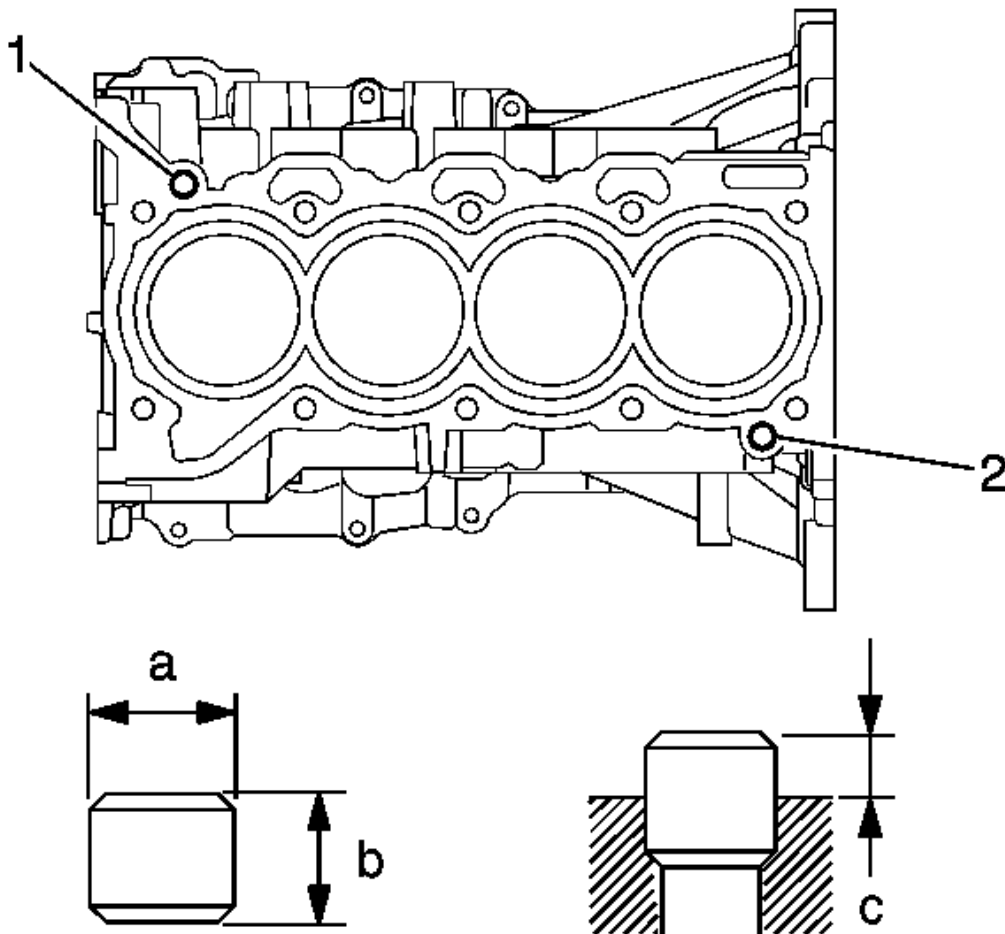


Fig. 355: Identifying Ring Pins

Courtesy of GENERAL MOTORS CORP.

NOTE: It is not necessary to remove the ring pins unless they are being replaced.

7. Remove the ring pins.
8. Using a plastic hammer, tap in the ring pins.

Specification: Standard protrusion: 7.5-8.5 mm (0.295-0.335 in)

NOTE: If any of the stud bolts is deformed or the threads are damaged, replace it.

9. Remove the stud bolts.

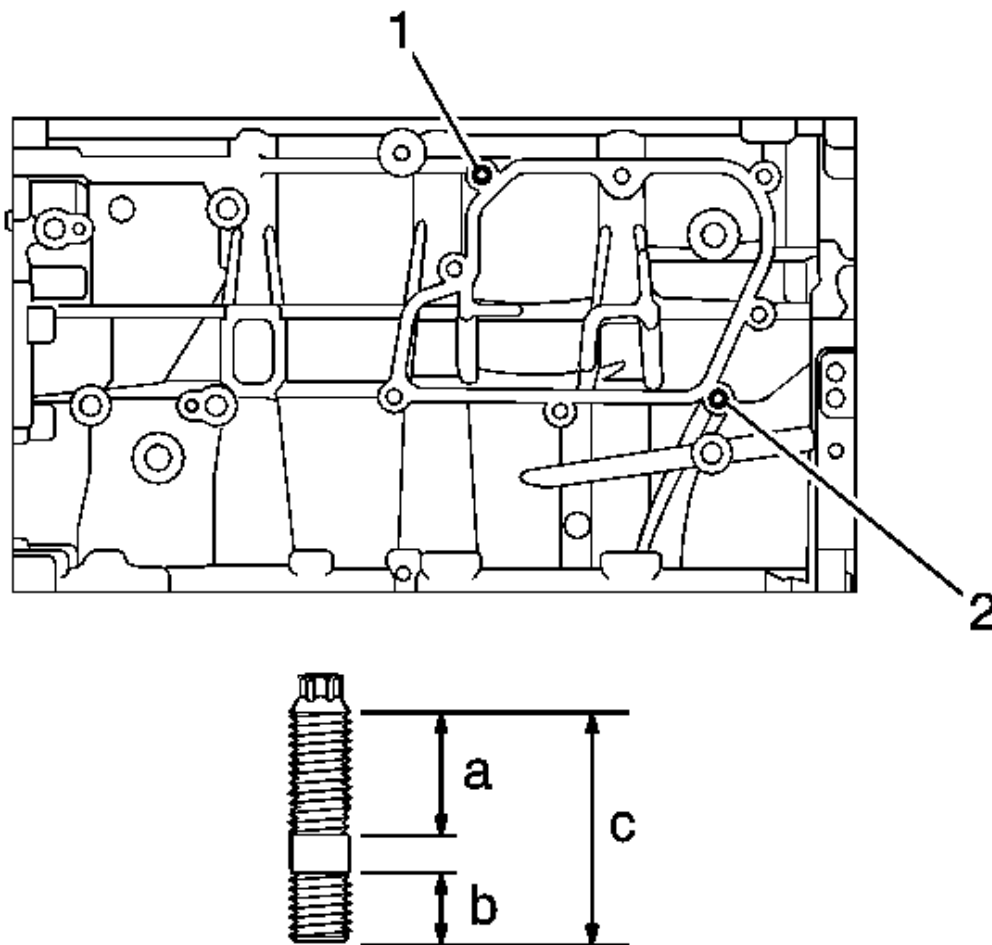


Fig. 356: Identifying Straight Pins
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

10. Using a TORX socket E6, install the stud bolts and tighten to 5.0 N.m (44 lb in).

NOTE: It is not necessary to remove the straight pins unless they are being replaced.

11. Remove the straight pins.

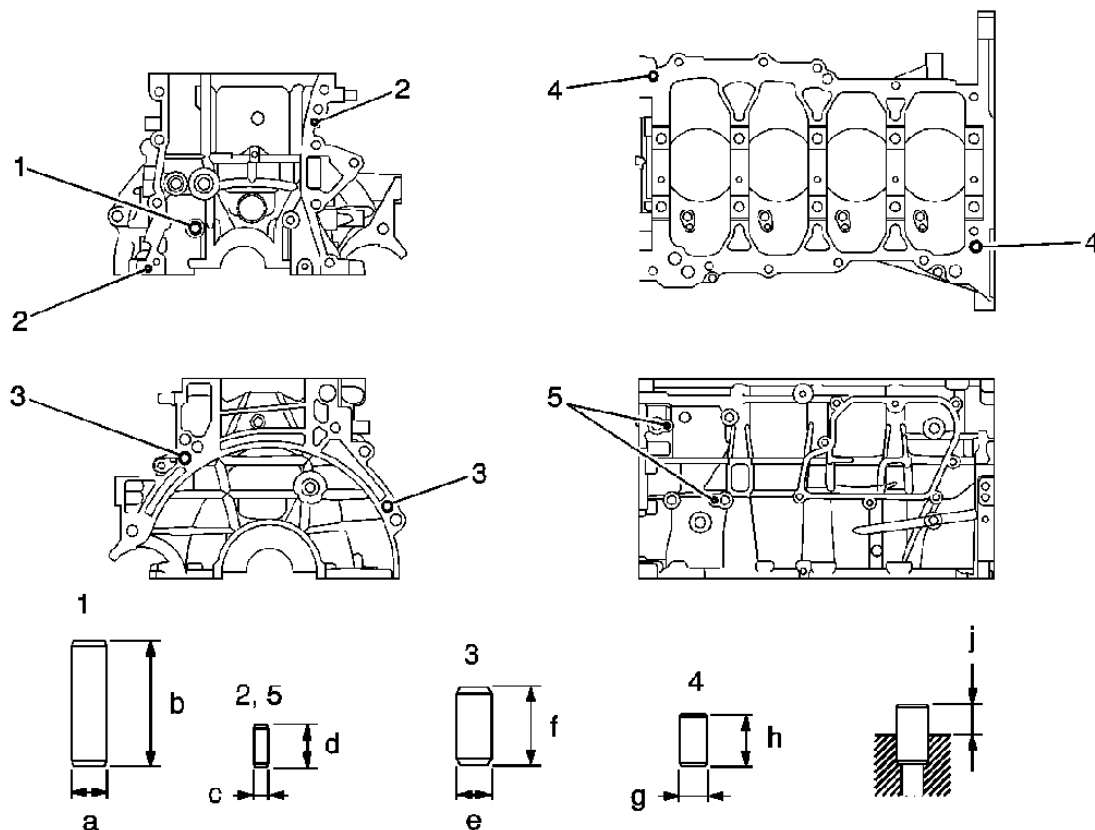


Fig. 357: Identifying Straight Pin Installation Locations
Courtesy of GENERAL MOTORS CORP.

12. Using a plastic hammer, tap in the straight pins.

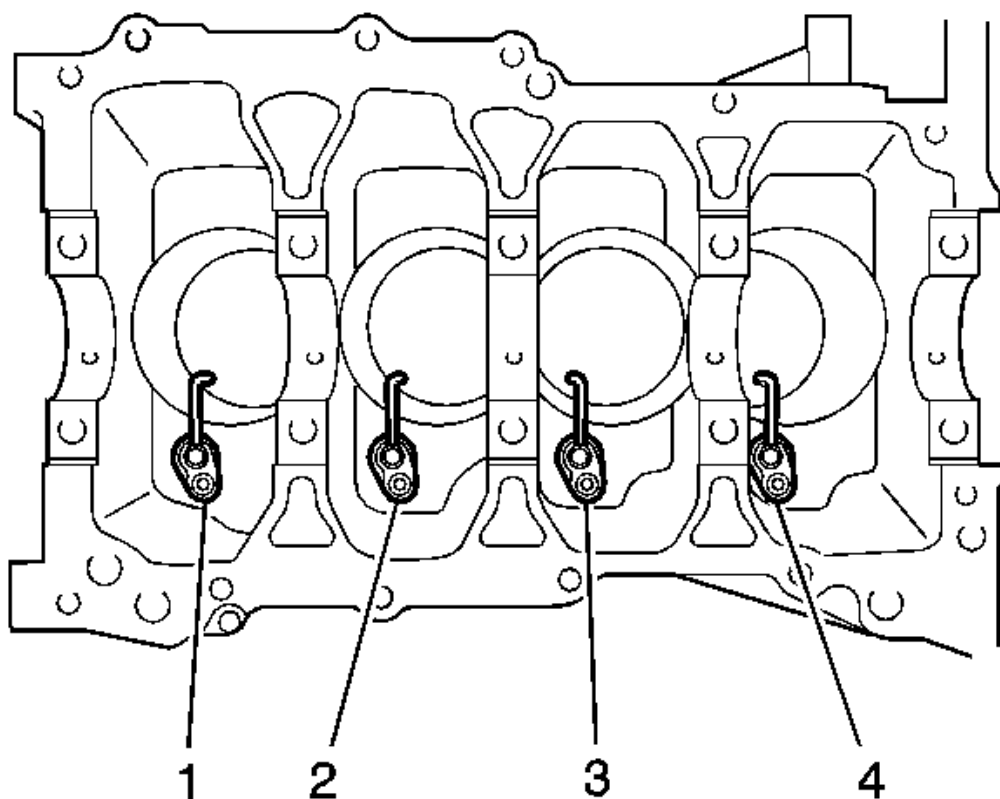


Fig. 358: Identifying Oil Nozzles
Courtesy of GENERAL MOTORS CORP.

13. Using a 5 mm socket hexagon wrench, install the oil nozzles with the bolts and tighten to 10 N.m (7 lb ft).

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

1. Inspect connecting rod thrust clearance.
2. Install the connecting rod cap.

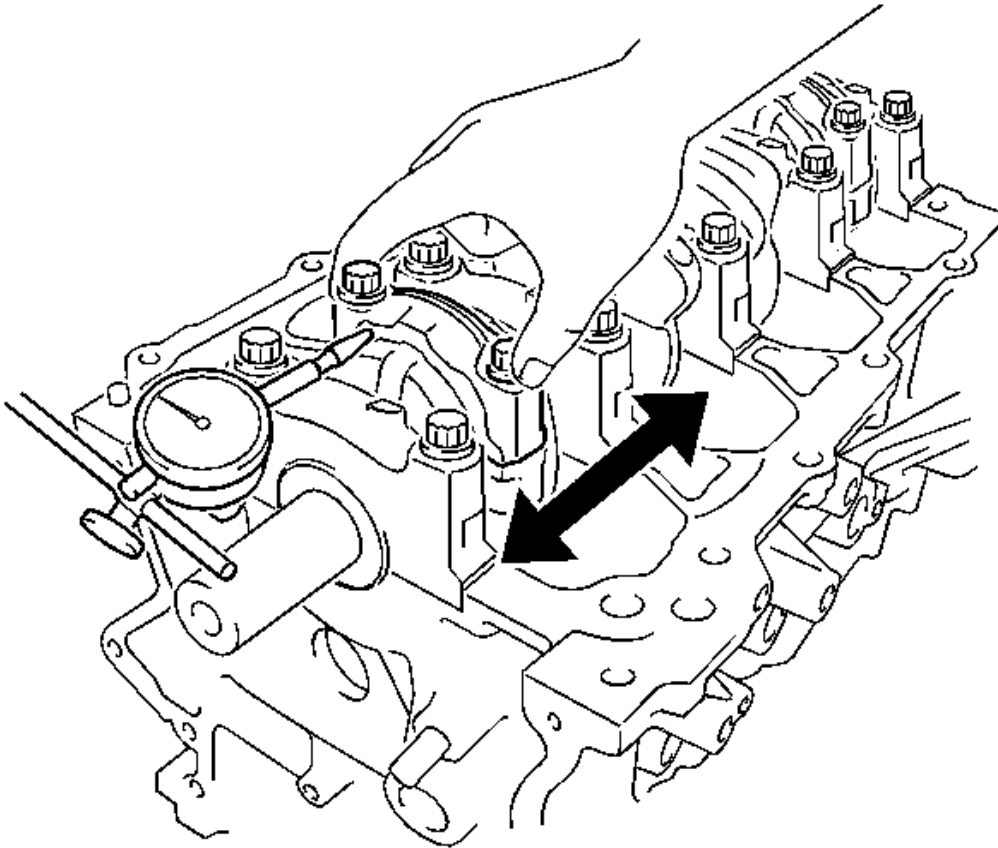


Fig. 359: Identifying Thrust Bearing Clearance
Courtesy of GENERAL MOTORS CORP.

3. Using a dial indicator, measure the thrust clearance while moving the connecting rod back and forth.

Specification:

- Standard thrust clearance: 0.160-0.342 mm (0.0063-0.0135 in)
 - Maximum thrust clearance: 0.342 mm (0.0135 in)
4. If the thrust clearance is greater than the maximum, replace the connecting rod assemblies as necessary. If necessary, replace the crankshaft.
 5. Inspect connecting rod oil clearance.
 6. Clean the crank pin and bearing.
 7. Check the crank pin and bearing for pitting and scratches.

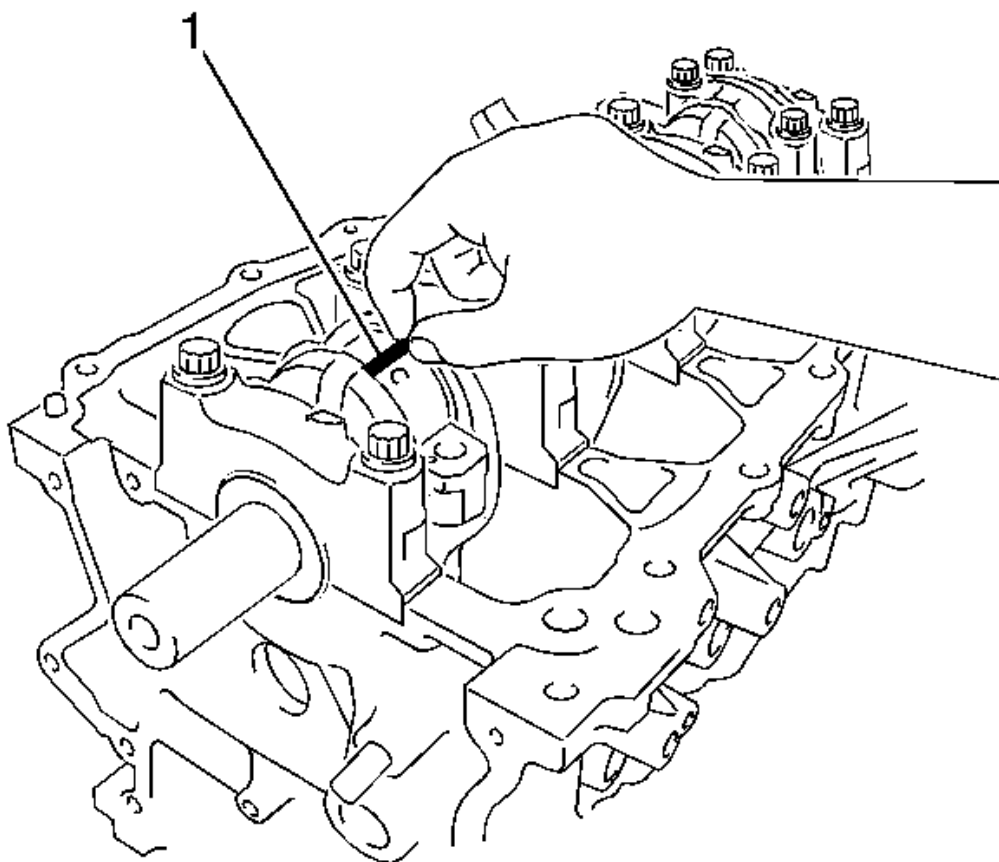


Fig. 360: View Of Measuring Clearance Using Plastigage
Courtesy of GENERAL MOTORS CORP.

8. Lay a strip of Plastigage on the crank pin.

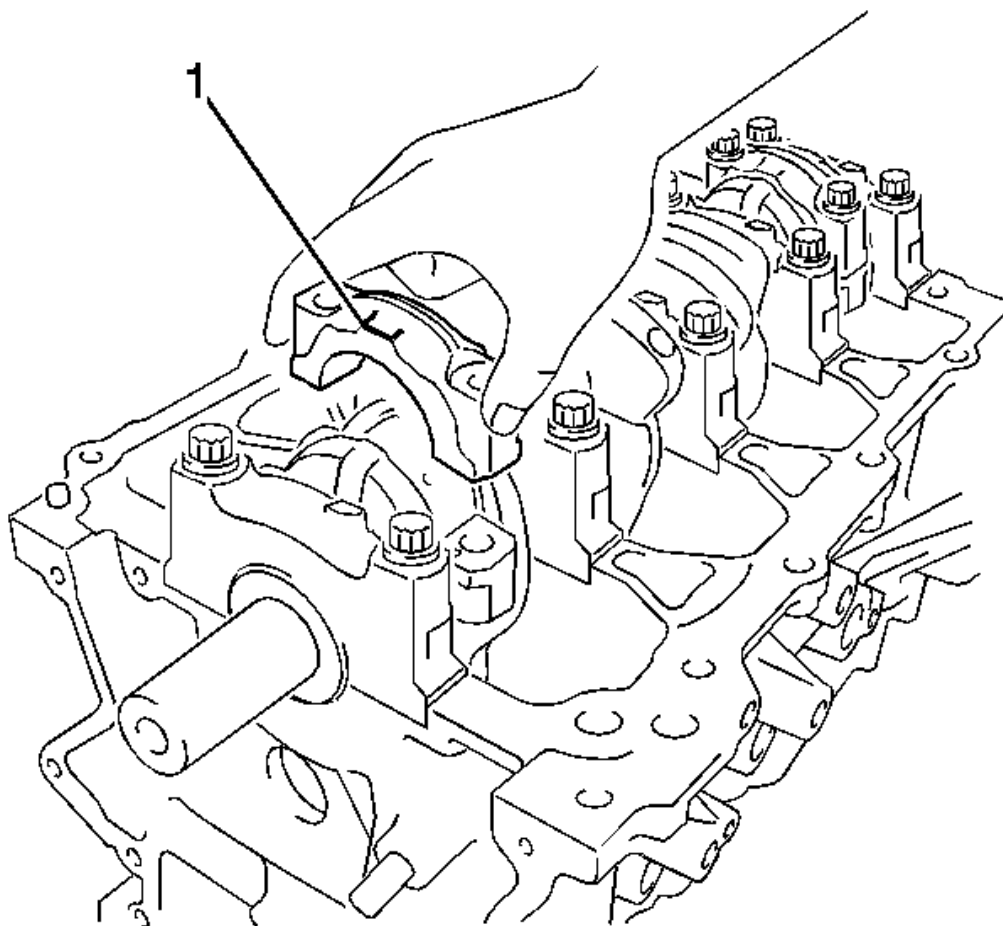


Fig. 361: Identifying Connecting Rod Cap Installation
Courtesy of GENERAL MOTORS CORP.

9. Check that the front mark of the connecting rod cap is facing forward.

NOTE: **Do not turn the crankshaft.**

10. Install the connecting rod cap.
11. Remove the 2 bolts and connecting rod cap.
12. Measure the Plastigage at its widest point.

Specification:

- Standard oil clearance: 0.030-0.062 mm (0.0012-0.0024 in)

- Maximum oil clearance: 0.07 mm (0.0028 in)

NOTE: Completely remove the Plastigage after the measurement. If replacing a bearing, replace it with one that has the same number as its respective connecting rod cap. Each bearing standard thickness is indicated by a 1, 2, or 3 mark on its surface.

13. If the oil clearance is greater than the maximum, replace the connecting rod bearings. If necessary, inspect the crankshaft.

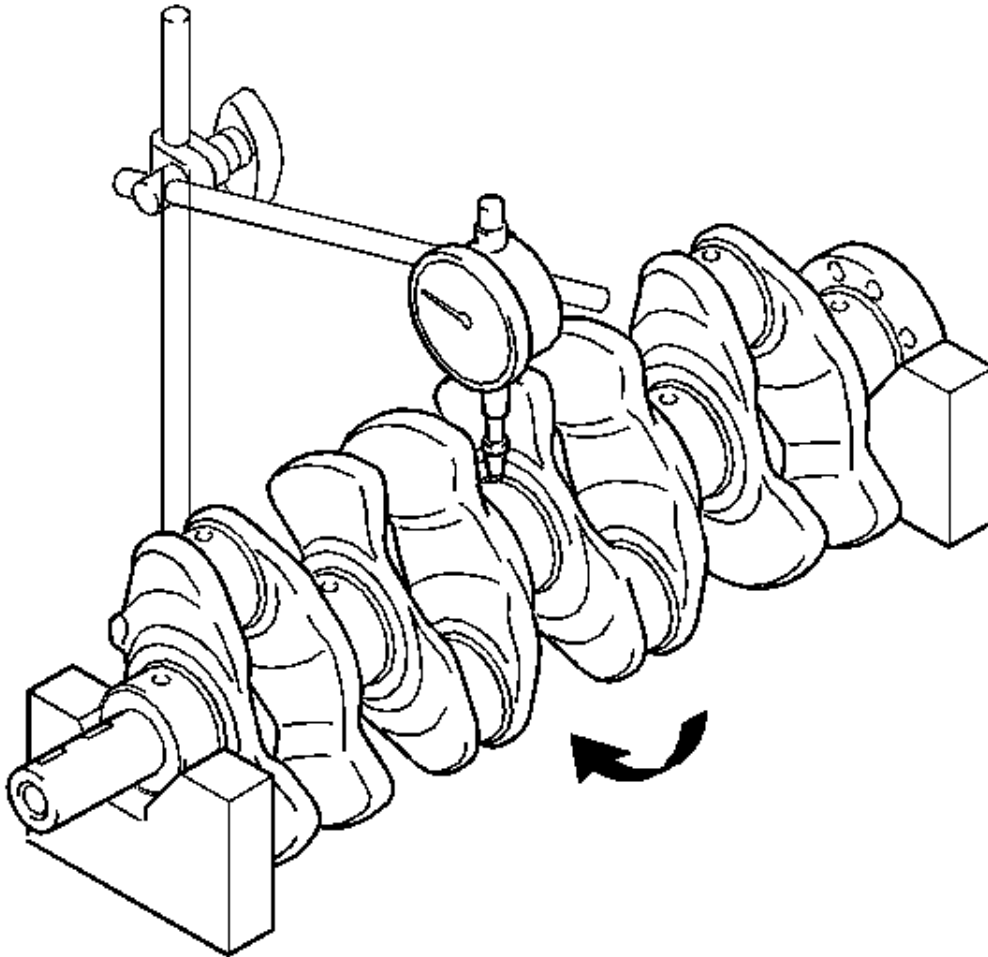


Fig. 362: Measuring Crankshaft Circle Runout
Courtesy of GENERAL MOTORS CORP.

14. Inspect the crankshaft.
15. Using a dial indicator and V-blocks, measure the circle runout as shown in the illustration.

Specification: Maximum circle runout: 0.03 mm (0.0012 in)

16. If the taper and distortion are greater than the maximum, replace the crankshaft.

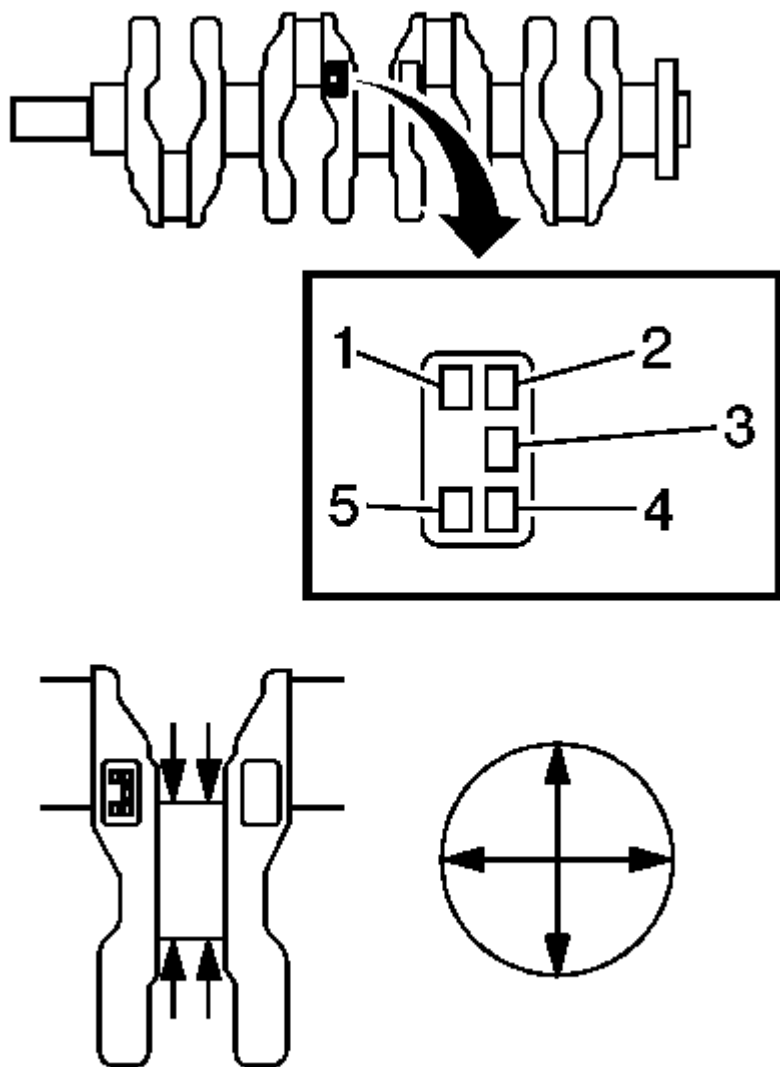


Fig. 363: Measuring Diameter Of Main Journals
Courtesy of GENERAL MOTORS CORP.

17. Using a micrometer, measure the diameter of each main journal.

Specification: Standard diameter: 47.988-48.000 mm (1.8893-1.8898 in)

18. If the diameter is not as specified, check the crankshaft oil clearance.
19. Check each main journal for taper and distortion as shown in the illustration.

Specification: Maximum taper and distortion: 0.004 mm (0.0002 in)

20. If the taper and distortion are greater than the maximum, replace the crankshaft.

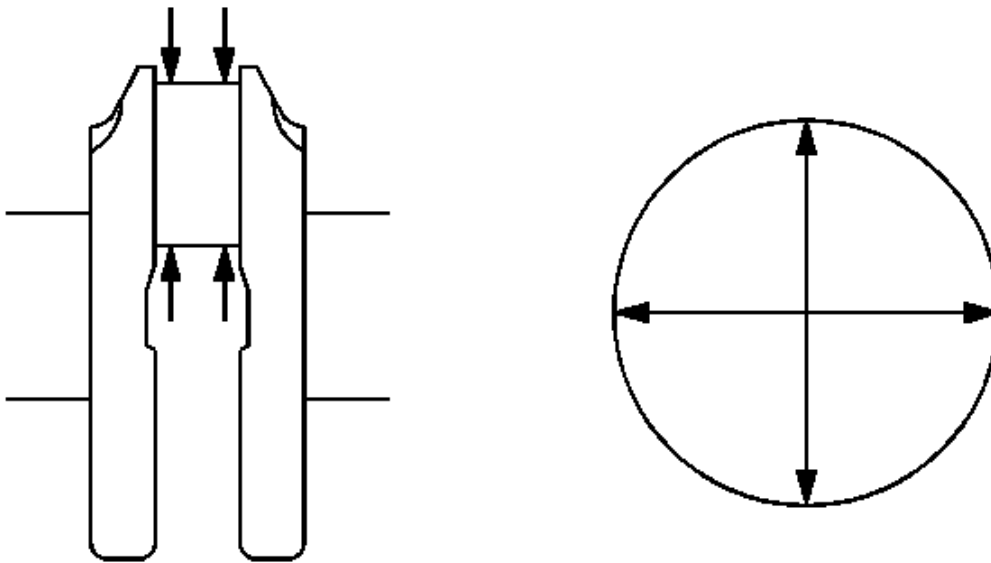


Fig. 364: Measuring Diameter Of Crank Pin
Courtesy of GENERAL MOTORS CORP.

21. Using a micrometer, measure the diameter of each crank pin.

Specification: Standard diameter: 43.992-44.000 mm (1.7320-1.7323 in)

22. If the diameter is not as specified, check the connecting rod oil clearance.
23. Inspect each crank pin for taper and distortion as shown in the illustration.

Specification: Maximum taper and distortion: 0.004 mm (0.0002 in)

24. If the taper and distortion are greater than the maximum, replace the crankshaft.
25. Inspect crankshaft thrust clearance.
26. Install the main bearing cap.

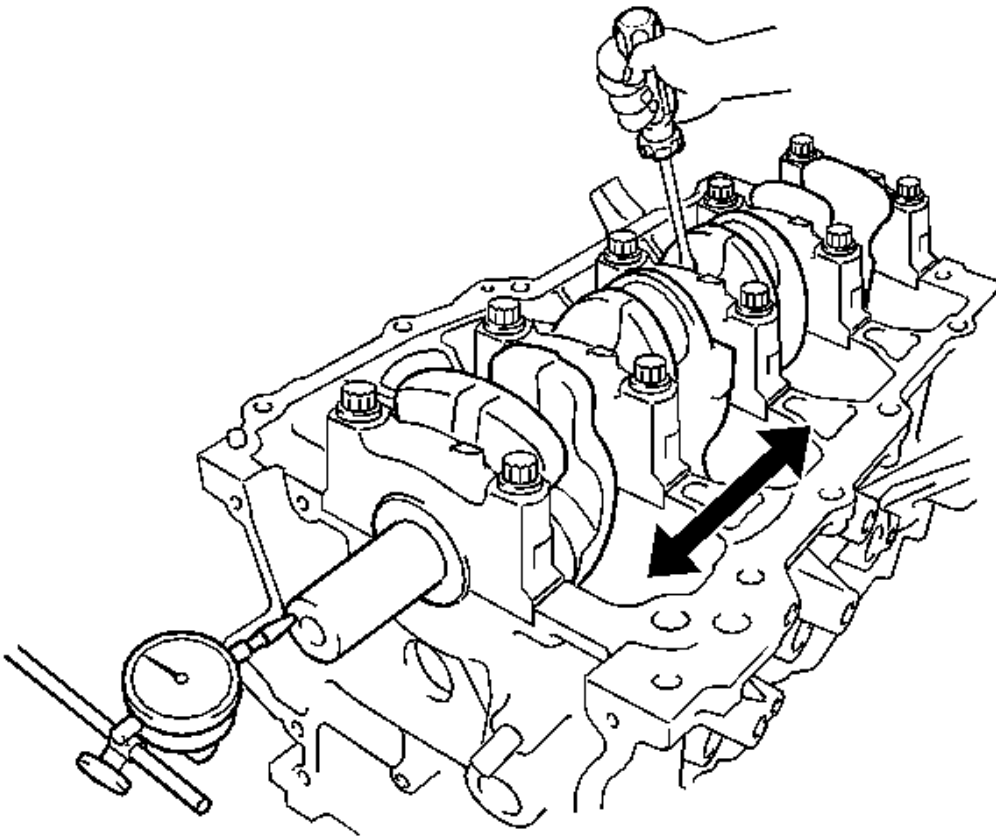


Fig. 365: Measuring Thrust Clearance While Prying Crankshaft Back & Forth
Courtesy of GENERAL MOTORS CORP.

27. Using a dial indicator, measure the thrust clearance while prying the crankshaft back and forth with a screwdriver.

Specification:

- Standard thrust clearance: 0.04- 0.14 mm (0.0016-0.0055 in)
- Maximum thrust clearance: 0.18 mm (0.0071 in)

NOTE: **The thrust washer thickness is 2.43-2.48 mm (0.0957-0.0976 in).**

28. If the thrust clearance is greater than the maximum, replace the thrust washers as a set.
29. Inspect the crankshaft oil clearance.
30. Check the crank journal and bearing for pitting and scratches.
31. Install the crankshaft bearing.
32. Place the crankshaft on the cylinder block.

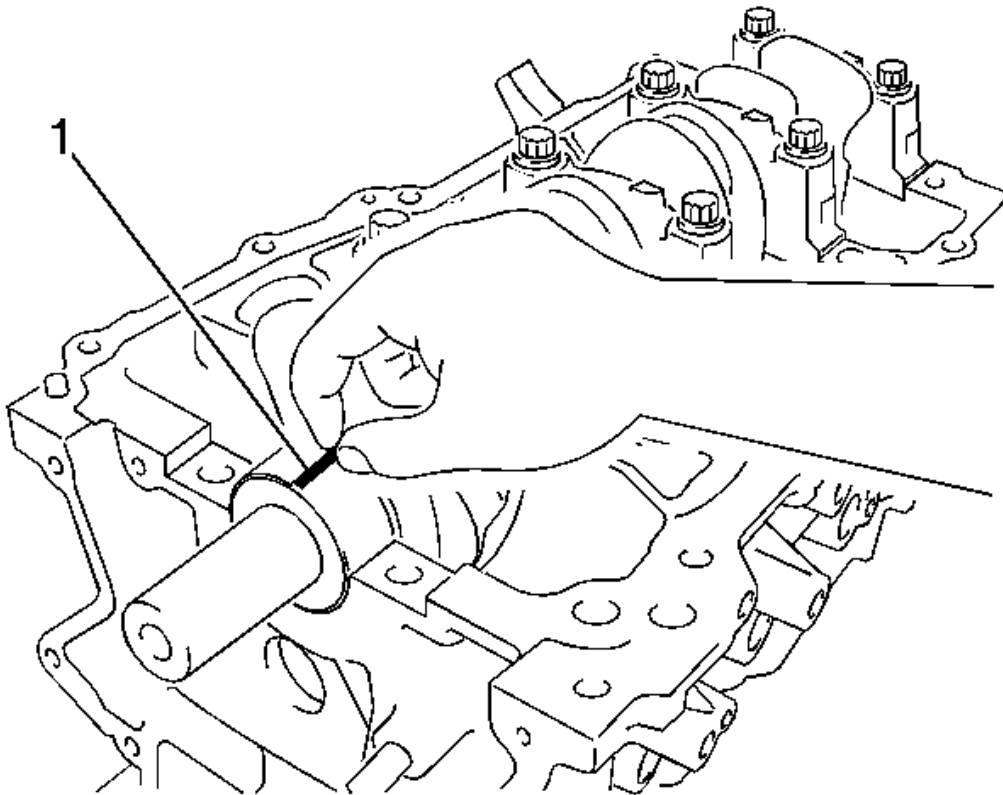


Fig. 366: View Of Measuring Journal Clearance Using Plastigage
Courtesy of GENERAL MOTORS CORP.

33. Lay a strip of Plastigage across each journal.

NOTE: **A number is marked on each main bearing cap to indicate the installation position.**

34. Examine the front marks and numbers and install the bearing caps on the cylinder block

NOTE: Do not turn the crankshaft.

35. Install the main bearing cap.
36. Remove the main bearing caps.

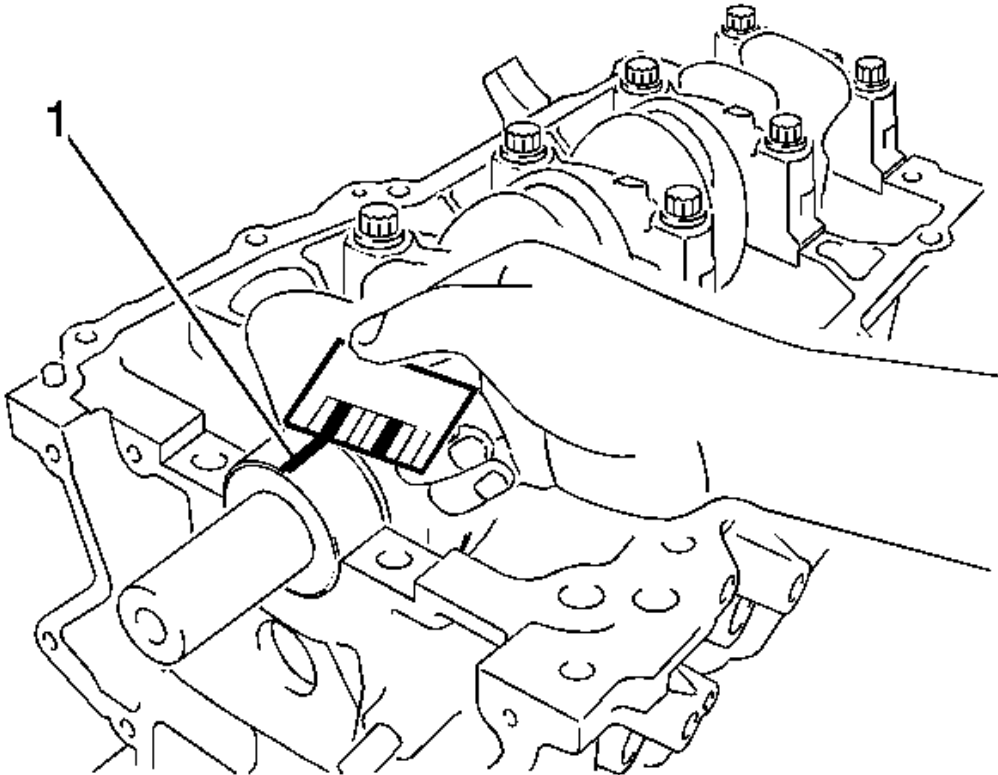


Fig. 367: View Of Measuring Plastigage At Widest Point
Courtesy of GENERAL MOTORS CORP.

37. Measure the Plastigage at its widest point.

Specification:

- Standard oil clearance: 0.016-0.039 mm (0.0006-0.0015 in)
- Maximum oil clearance: 0.050 mm (0.0020 in)

NOTE:

- Remove the Plastigage completely after the measurement.
- If replacing a bearing, select a new one with the same number. If the number of the bearing cannot be determined, calculate the correct

bearing number by adding together the numbers imprinted on the cylinder block and crankshaft. Then select a new bearing with the calculated number according to the chart below. There are 4 sizes of standard bearings, marked 1, 2, 3 and 4 accordingly.

- **EXAMPLE:** Cylinder block 3 + Crankshaft 5 = Total number 8 (Use bearing 3)

38. If the oil clearance is greater than the maximum, replace the crankshaft bearing. If necessary, replace the crankshaft.

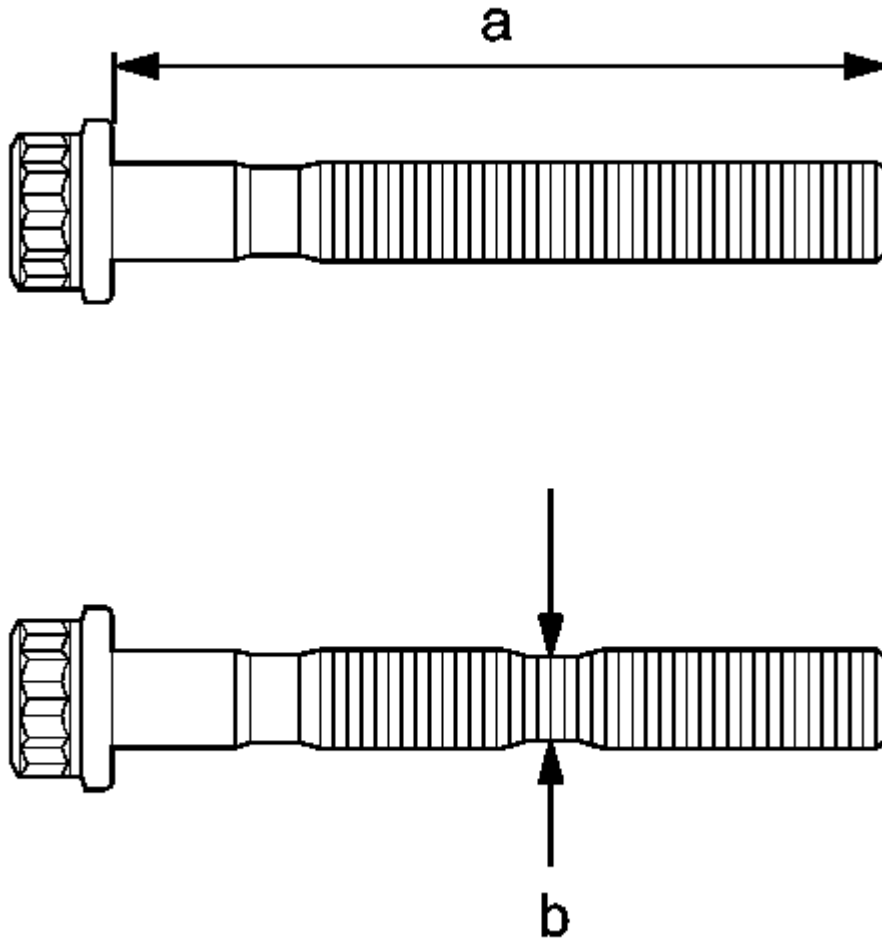


Fig. 368: Inspecting Cylinder Head Set Bolt
Courtesy of GENERAL MOTORS CORP.

39. Inspect the cylinder head set bolt.
40. Using vernier calipers, measure the tension portion diameter of the bolts.

Specification:

- Standard bolt length: 84.3-85.7 mm (3.3189-3.3740 in)
- Maximum bolt length: 86.7 mm (3.4134 in)

41. If the bolt length is greater than the maximum, replace the bolt.

NOTE: **Using a straightedge, visually check for thinner areas of the threaded part of the crankshaft bearing cap bolt.**

42. Using vernier calipers, measure the minimum diameter of the elongated thread at the measuring point.

Specification:

- Standard outside diameter: 9.77-9.96 mm (0.3846-0.3921 in)
- Minimum outside diameter: 9.1 mm (0.3583 in)

43. If the diameter is less than the minimum, replace the bolt.

NOTE: **If there is damage or clogging, replace the oil nozzle.**

44. Check the oil nozzles for damage or clogging.

PISTON AND CONNECTING ROD DISASSEMBLE

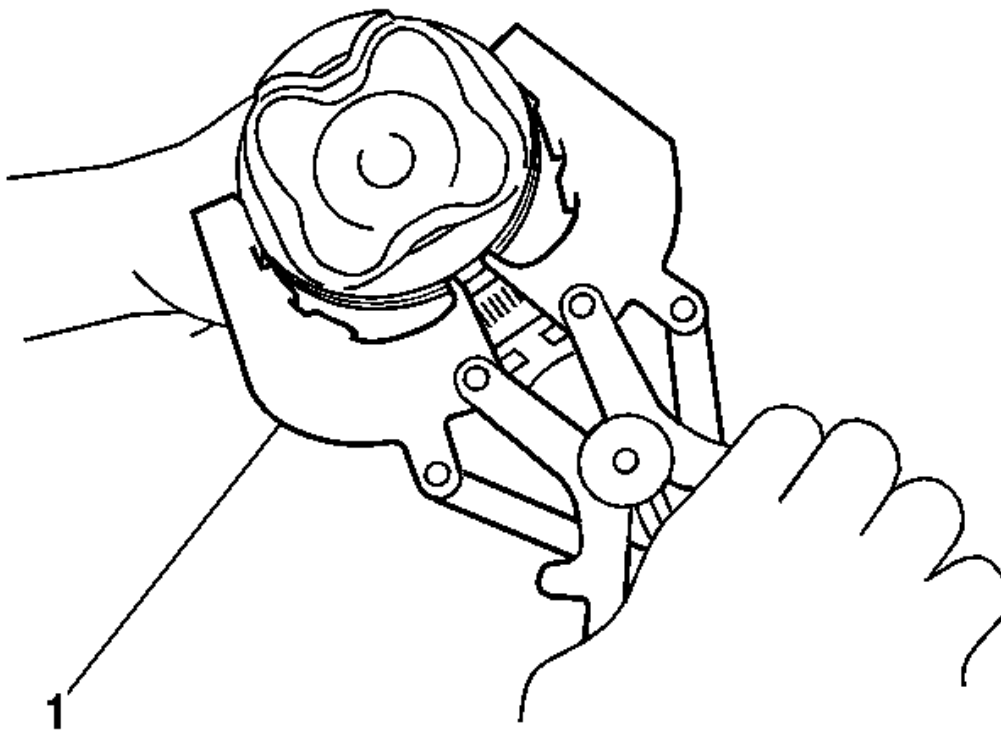


Fig. 369: Using A Piston Ring Expander
Courtesy of GENERAL MOTORS CORP.

1. Using a piston ring expander, remove the 2 compression rings.
2. Remove the oil ring rail and oil ring expander by hand.

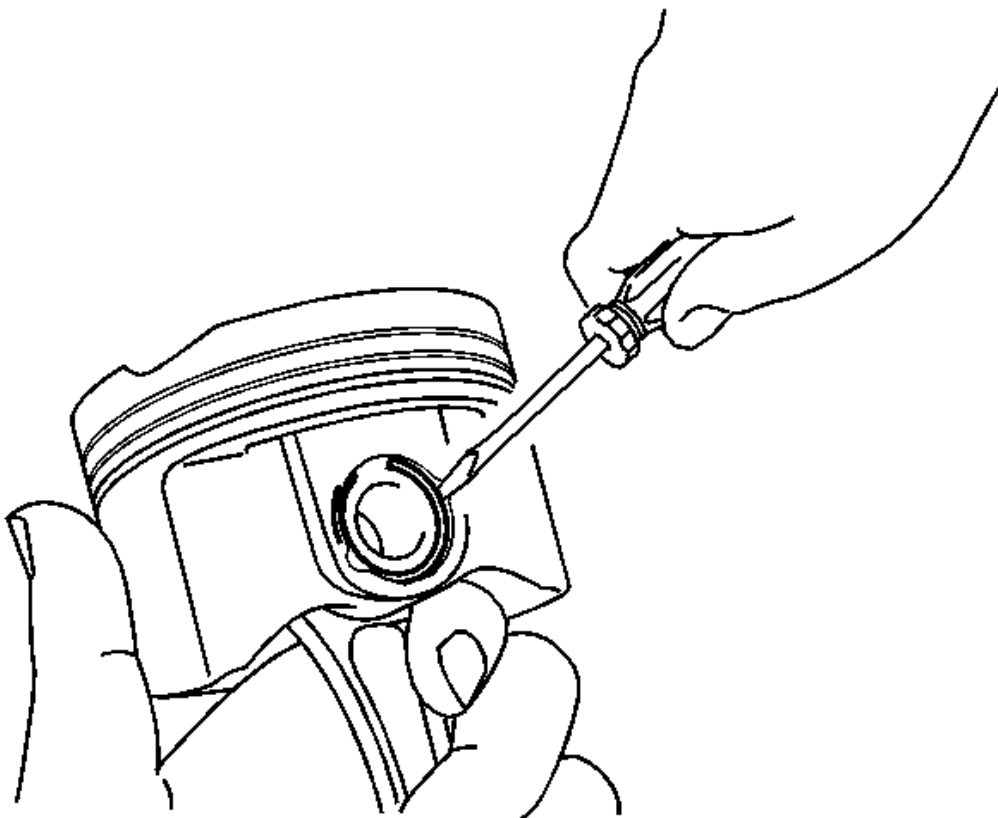


Fig. 370: Identifying Snap Ring
Courtesy of GENERAL MOTORS CORP.

3. Using a screwdriver, pry out the 2 snap rings.

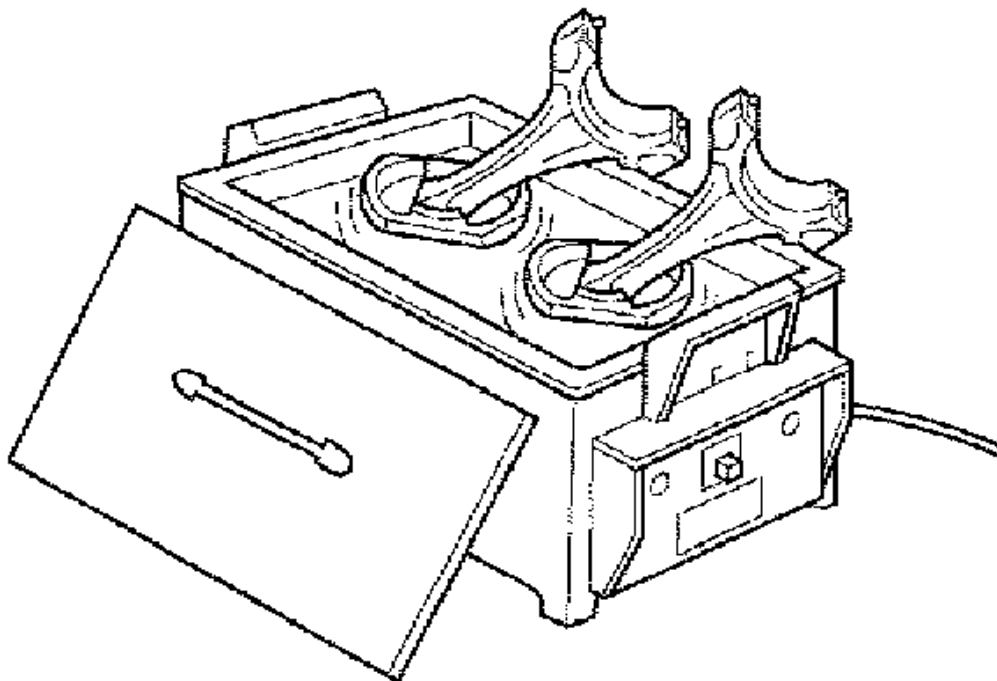


Fig. 371: View Of Heating Pistons
Courtesy of GENERAL MOTORS CORP.

4. Gradually heat each piston to approximately 80-90°C (176-194°F).

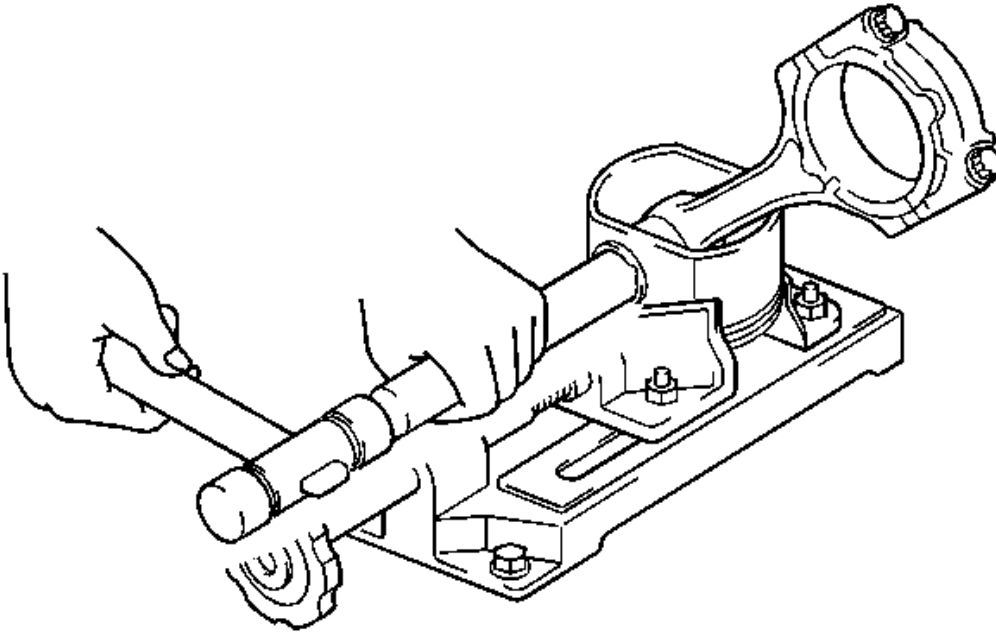


Fig. 372: View Of Piston Pin Removal Procedure
Courtesy of GENERAL MOTORS CORP.

NOTE: The piston and pin are a matched set and arrange the pistons, pins, rings, connecting rods and bearings in the correct order.

5. Using a plastic hammer and brass bar, lightly tap out the piston pin and remove the connecting rod.

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

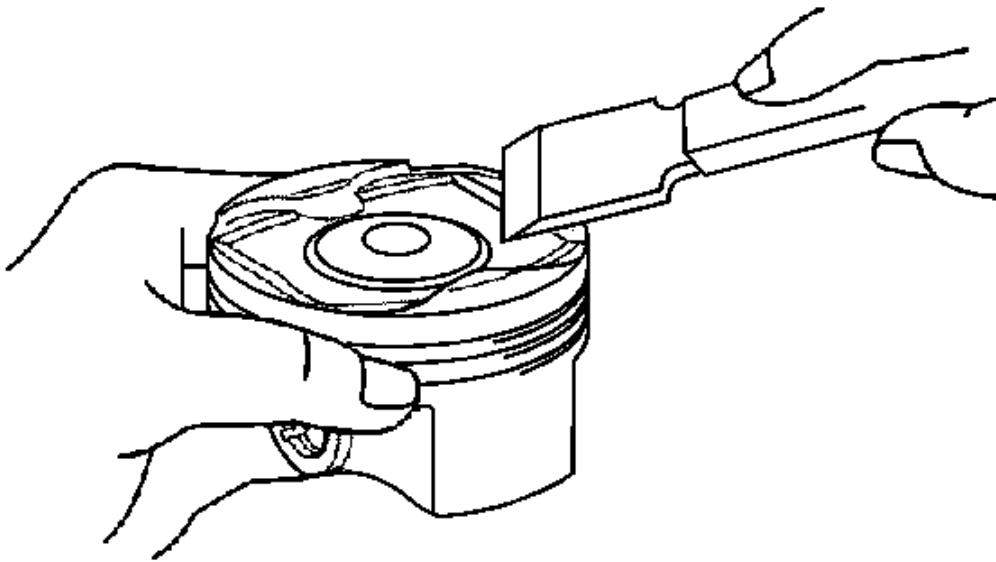


Fig. 373: Illustrating Carbon Removal
Courtesy of GENERAL MOTORS CORP.

1. Inspect the piston.
2. Using a gasket scraper, remove the carbon from the top of the piston.

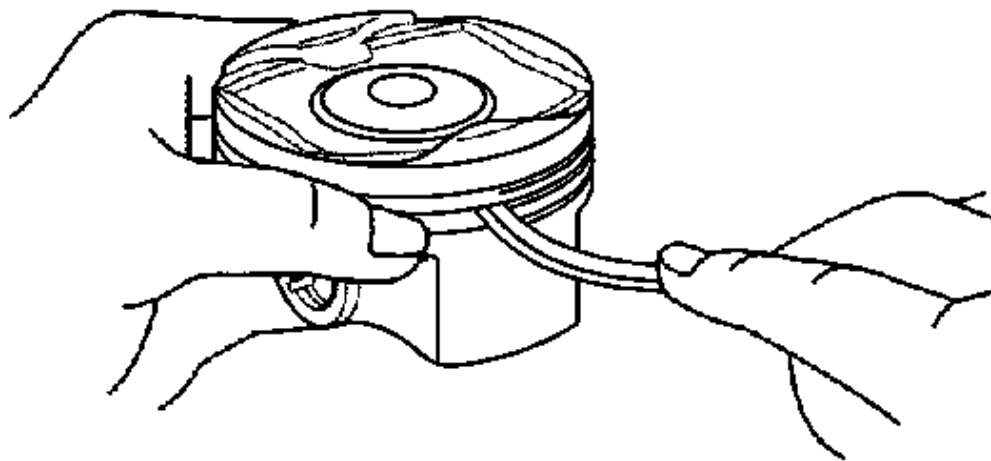


Fig. 374: Illustrating Cleaning Piston Ring Groove
Courtesy of GENERAL MOTORS CORP.

3. Using a groove cleaning tool or broken ring, clean the piston ring grooves.

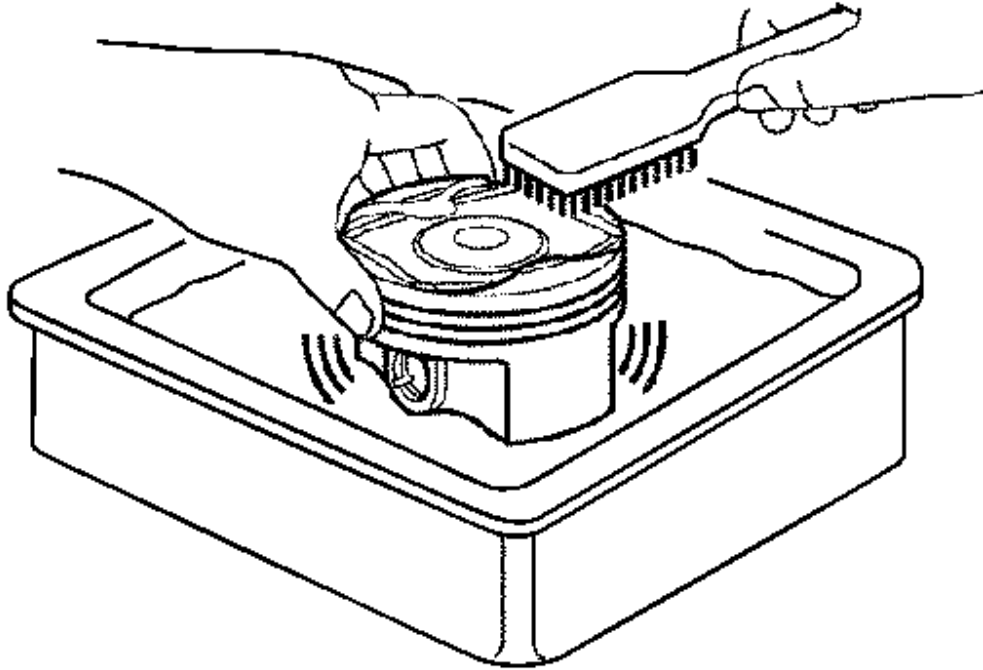


Fig. 375: Using Solvent & Brush To Clean Piston
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use a wire brush.

4. Using a brush and solvent, thoroughly clean the piston.
5. Using a micrometer, measure the piston diameter at right angles to the piston pin hole, and at a point 12.6 mm (0.4961 in) from the piston head.

Specification: Standard piston diameter: 80.461-80.471 mm (3.1677-3.1681 in)

6. If the diameter is not as specified, replace the piston.
7. Inspect piston oil clearance.
8. Subtract the piston diameter measurement from the cylinder bore diameter measurement.

Specification:

- Standard oil clearance: 0.029-0.052 mm (0.0011-0.0020 in)
- Maximum oil clearance: 0.09 mm (0.0035 in)

9. If the oil clearance is greater than the maximum, replace all the pistons. If necessary, replace the cylinder block.

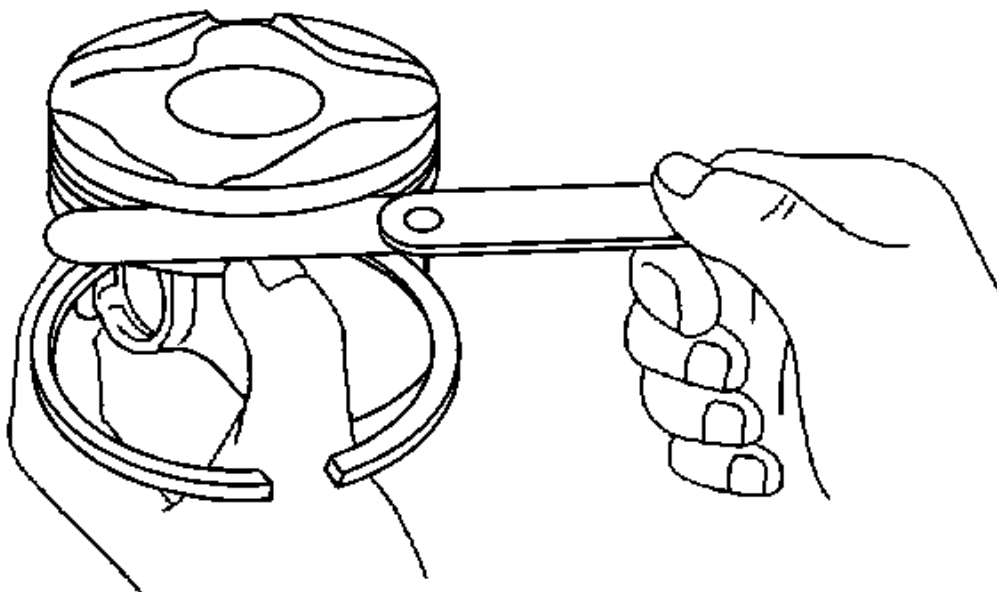


Fig. 376: Measuring Ring-To-Piston Wall Clearance
Courtesy of GENERAL MOTORS CORP.

10. Using a feeler gauge, measure the clearance between a new piston ring and the wall of the ring groove.
11. If the groove clearance is not as specified, replace the piston.

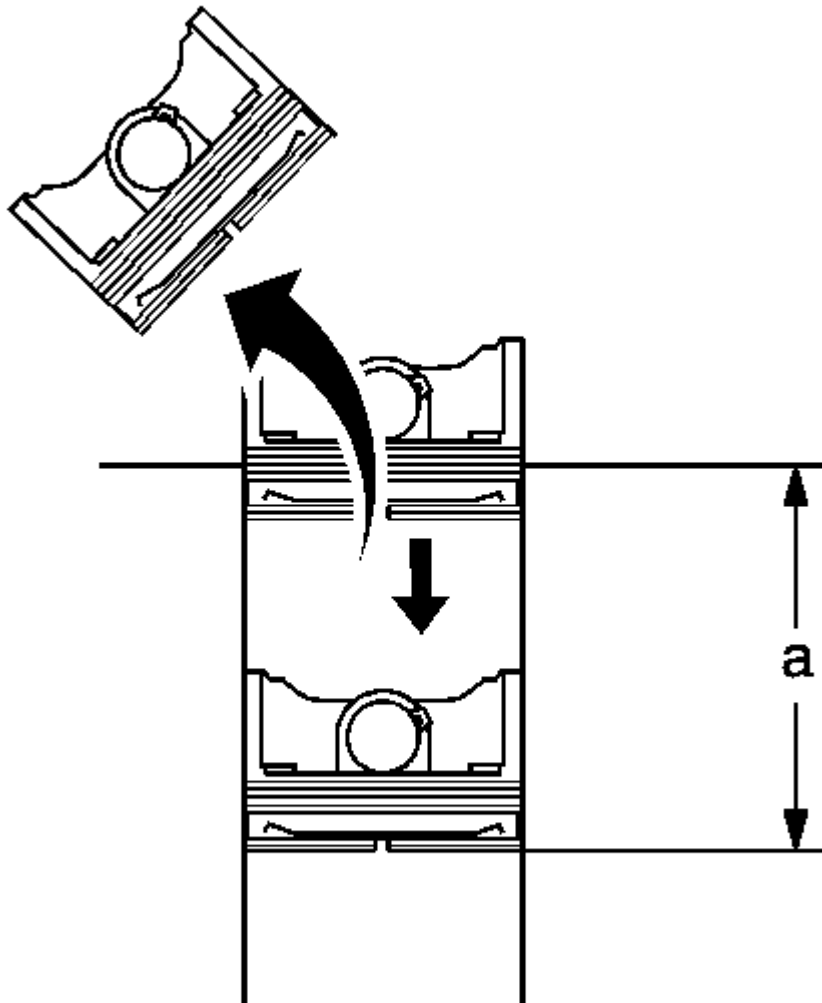


Fig. 377: View Of Pushing Piston Ring Beyond Bottom Of Normal ring travel
Courtesy of GENERAL MOTORS CORP.

12. Using a piston, push the piston ring a little beyond the bottom of the ring travel, 50 mm (1.97 in) from the top of the cylinder block.

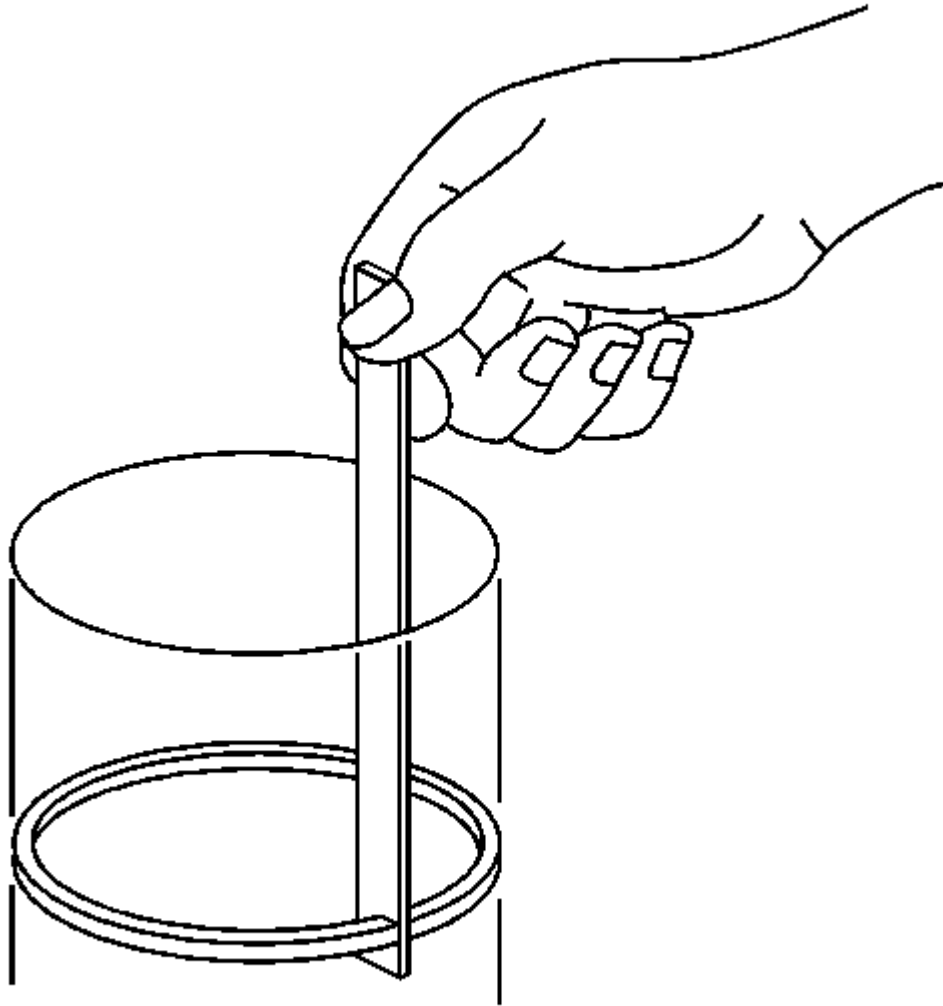


Fig. 378: Measuring Ring End Gap
Courtesy of GENERAL MOTORS CORP.

13. Using a feeler gauge, measure the end gap.
14. If the end gap is greater than the maximum, replace the piston ring. If the end gap is greater than the maximum, even with a new piston ring, replace the cylinder block.

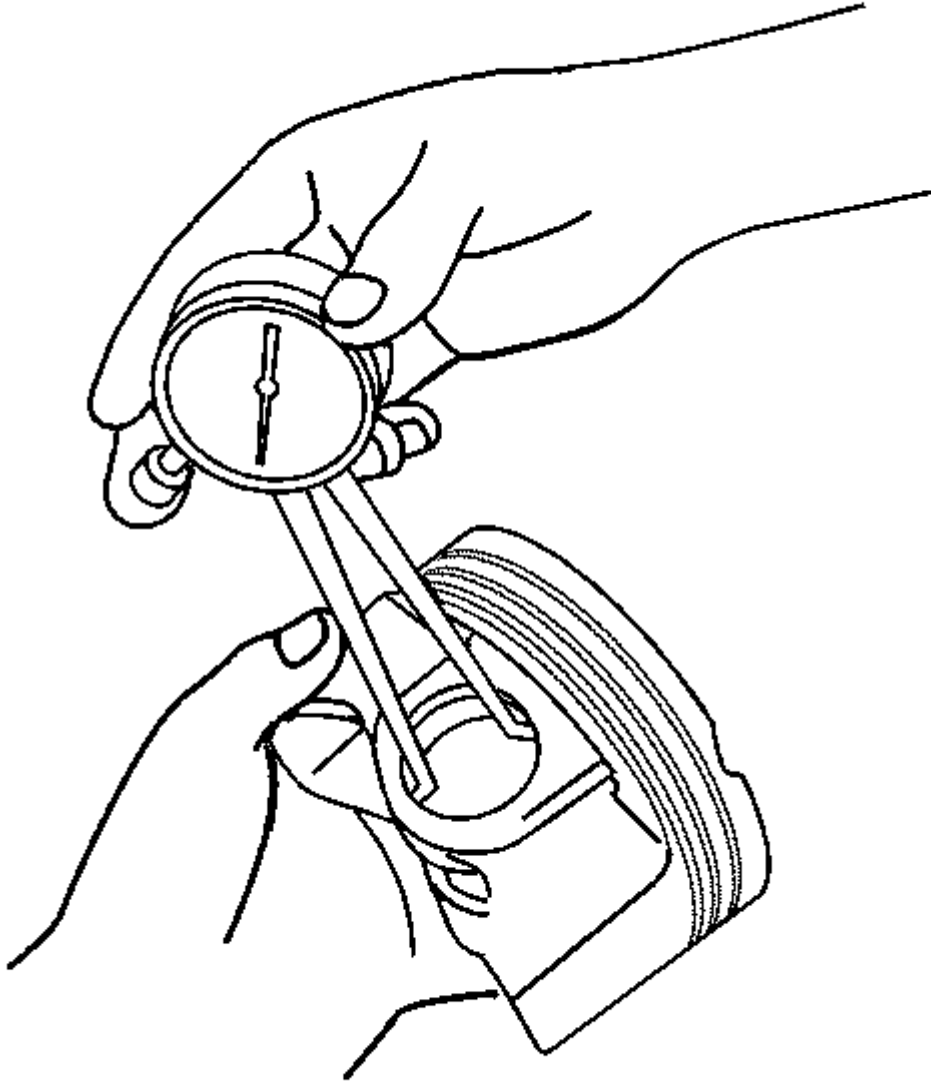


Fig. 379: Measuring Piston Pin Bore Diameter
Courtesy of GENERAL MOTORS CORP.

15. Using a caliper gauge, measure the piston pin bore diameter.

Specification: Standard piston pin bore diameter: 20.006-20.015 mm (0.7876-0.7880 in)

16. If the diameter is not as specified, replace the piston.

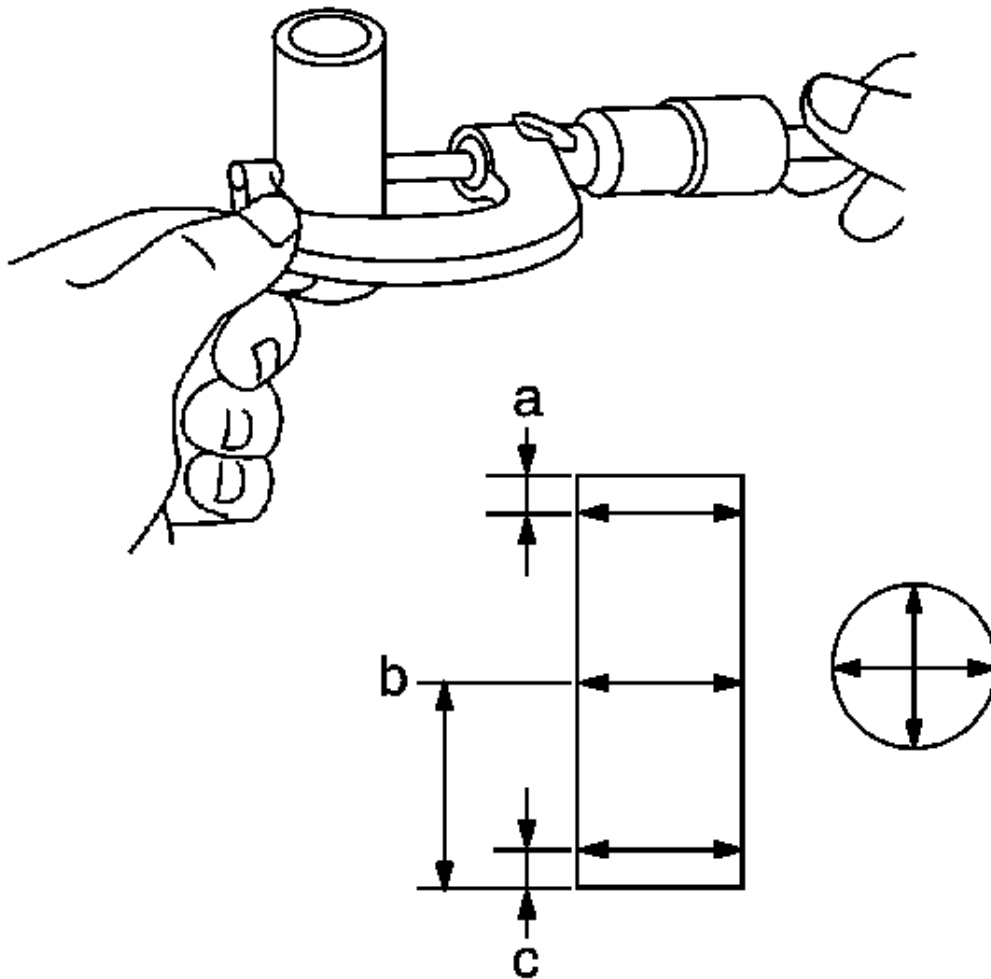


Fig. 380: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

17. Using a micrometer, measure the piston pin diameter.

Specification: Standard piston pin diameter: 20.004-20.013 mm (0.7876-0.7879 in)

18. If the diameter is not as specified, replace the piston pin.

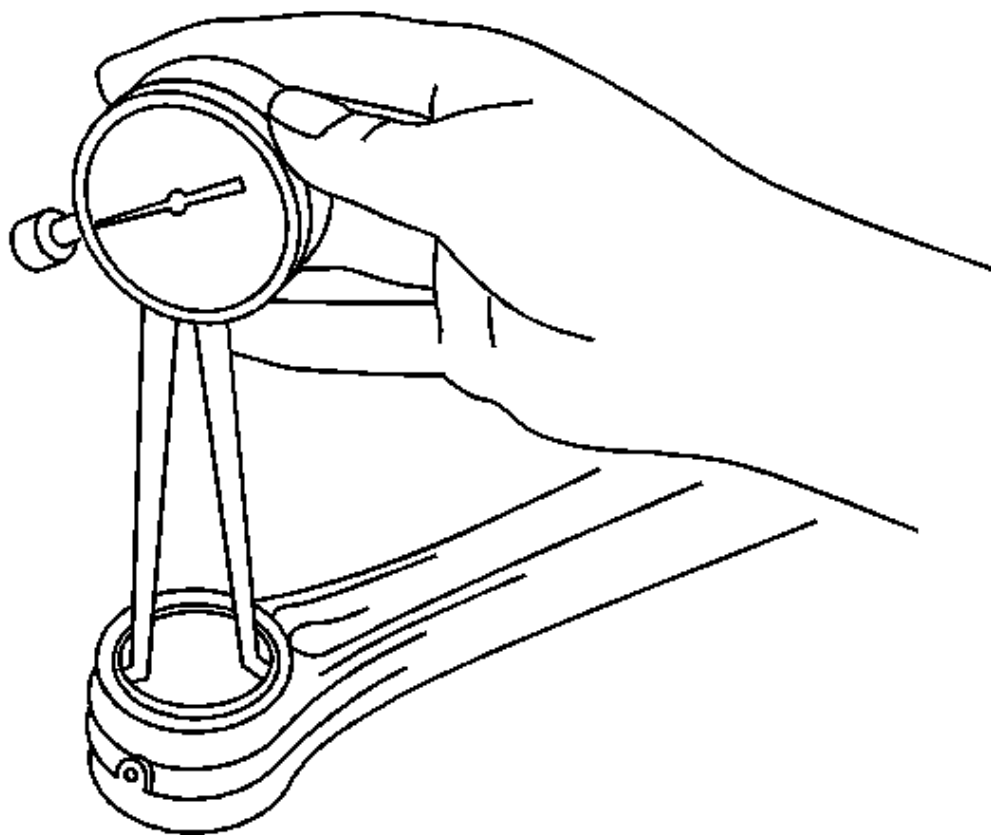


Fig. 381: Measuring Connecting Rod Pin Bore Diameter
Courtesy of GENERAL MOTORS CORP.

19. Using a caliper gauge, measure the connecting rod small end bore diameter.

Specification: Standard connecting rod small end bore diameter: 20.012-20.021 mm (0.7879-0.7882 in)

20. If the diameter is not as specified, replace the connecting rod.

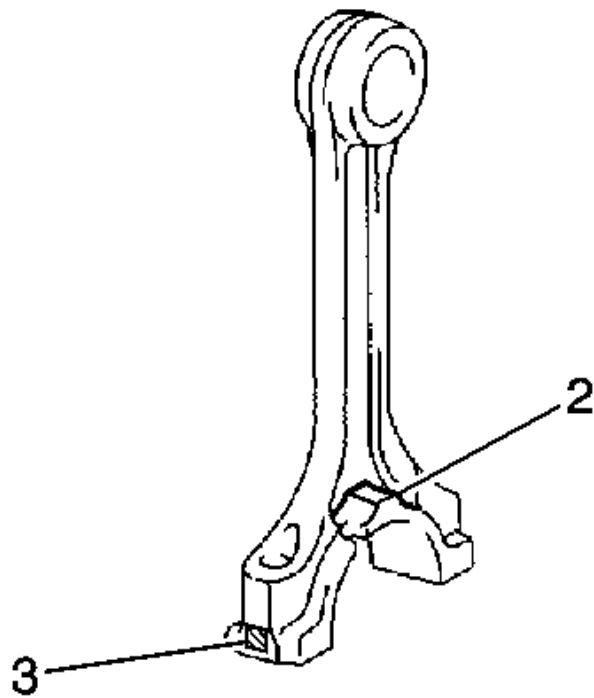
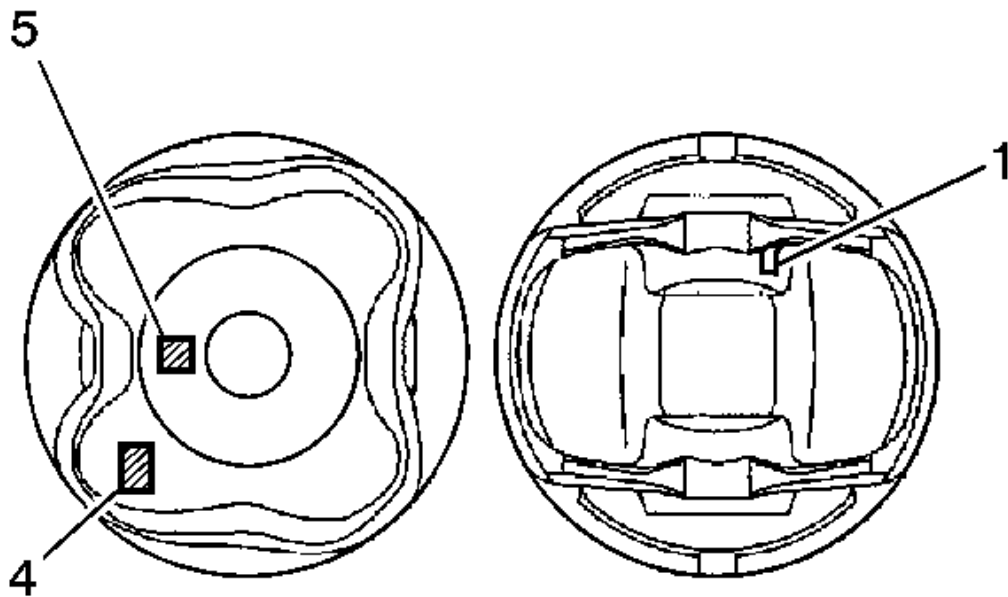


Fig. 382: View Of Measuring Pin Bore Diameter Minus Pin Diameter
Courtesy of GENERAL MOTORS CORP.

21. Subtract the piston pin diameter measurement from the piston pin bore diameter measurement.

Specification:

- Standard oil clearance: -0.001 to +0.005 mm (-0.00004 to +0.0002 in)
- Maximum oil clearance: 0.010 mm (0.0004 in)

22. If the oil clearance is greater than the maximum, replace the connecting rod. If necessary, replace the piston and piston pin as a set.

23. Subtract the piston pin diameter measurement from the connecting rod small end bore diameter measurement.

Specification:

- Standard oil clearance: 0.00-0.011 mm (0.0002-0.0004 in)
- Maximum oil clearance: 0.014 mm (0.0006 in)

24. If the oil clearance is greater than the maximum, replace the connecting rod. If necessary, replace the connecting rod and piston pin as a set.

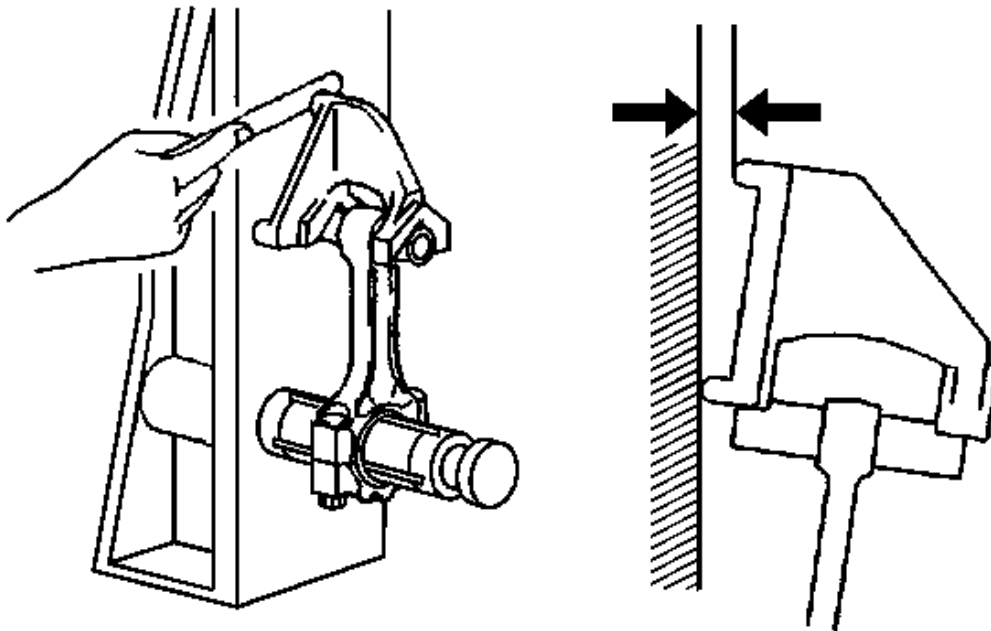


Fig. 383: Checking Connecting Rod Alignment
Courtesy of GENERAL MOTORS CORP.

25. Using a connecting rod aligner and feeler gauge, check the connecting rod alignment.
26. Check for misalignment.

Specification: Maximum misalignment: 0.05 mm (0.0020 in) per 100 mm (3.94 in)

27. If the misalignment is greater than the maximum, replace the connecting rod.

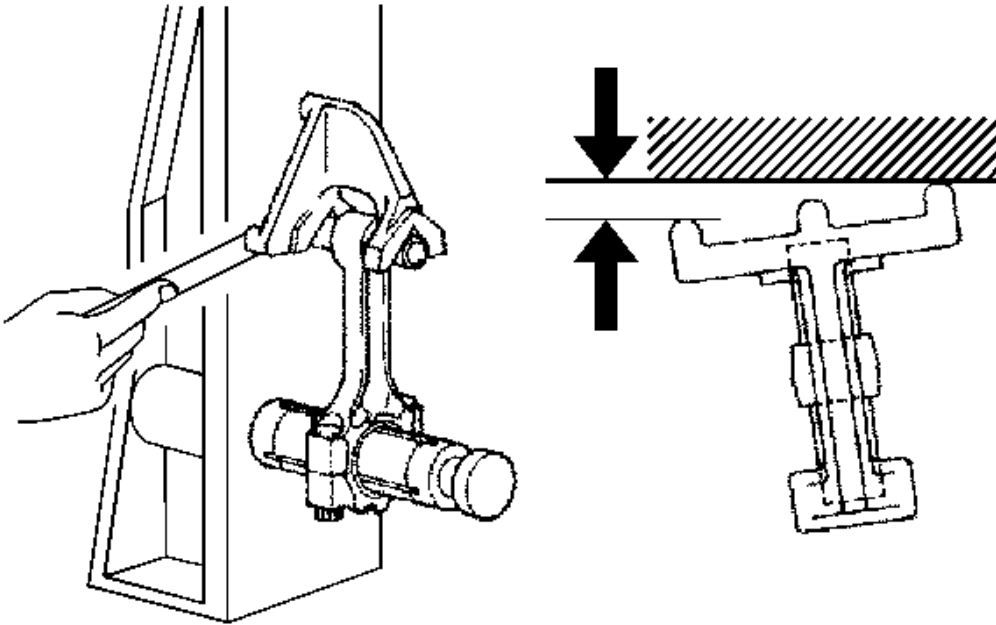


Fig. 384: Checking Connecting Rod Twist
Courtesy of GENERAL MOTORS CORP.

28. Check for twist.

Specification: Maximum twist: 0.15 mm (0.0059 in) per 100 mm (3.94 in)

29. If the twist is greater than the maximum, replace the connecting rod.

PISTON AND CONNECTING ROD ASSEMBLE

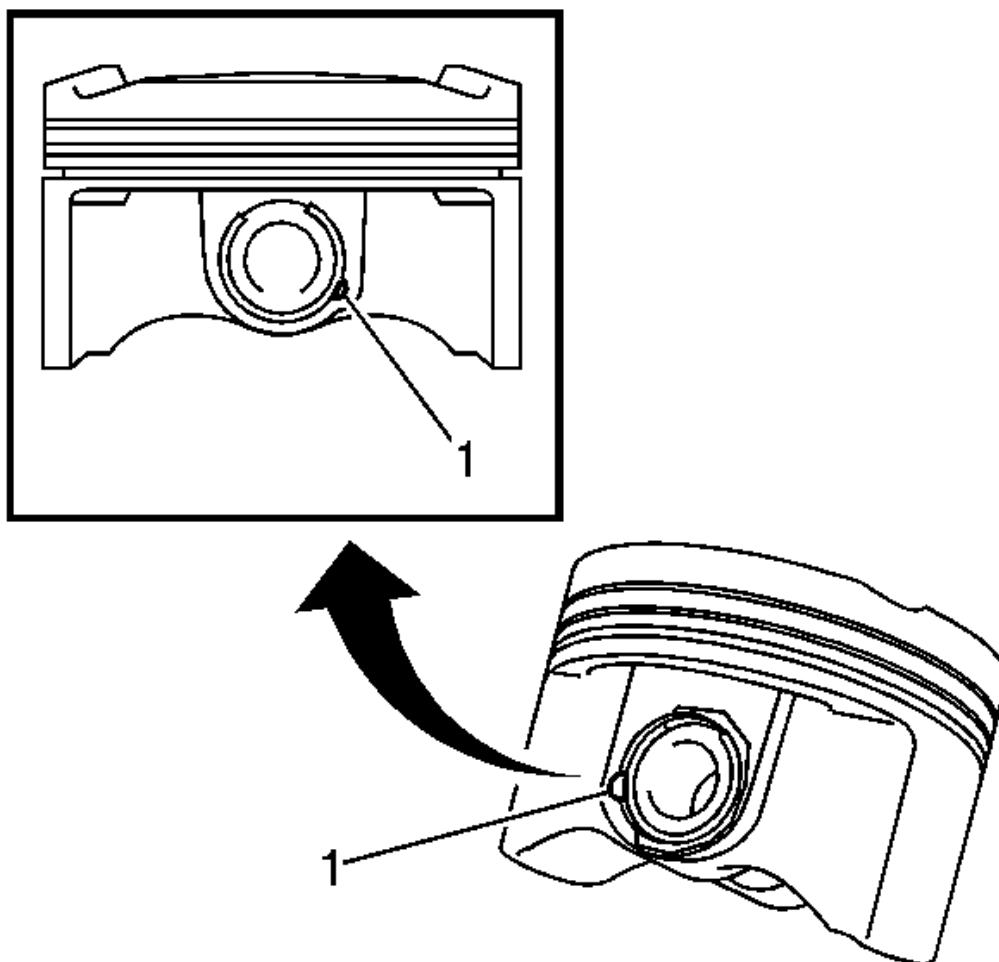


Fig. 385: Identifying Piston Pin Snap Ring
Courtesy of GENERAL MOTORS CORP.

NOTE: Make sure that the end gap of the snap ring is not aligned with the pin hole cutout portion of the piston.

1. Using a screwdriver, install a new snap ring at one end of the piston pin hole.
2. Gradually heat the piston to approximately 80-90°C (176-194°F).

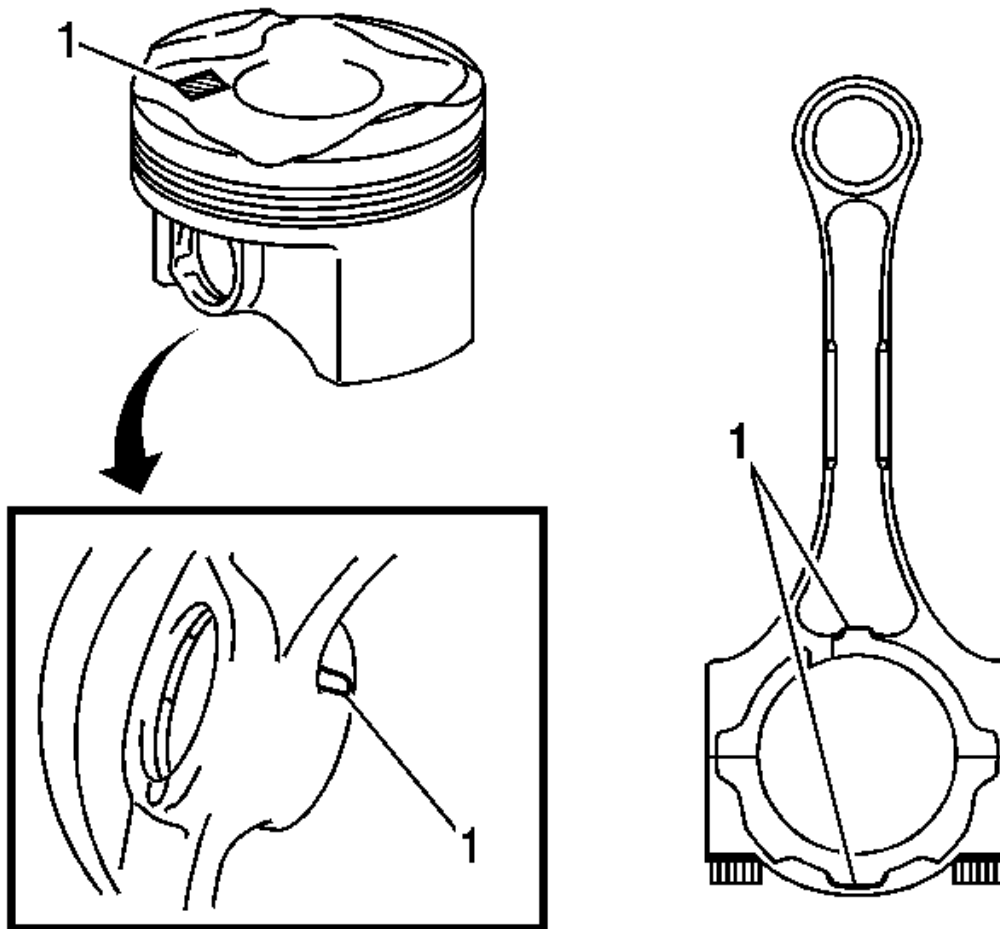


Fig. 386: Aligning Front Marks Of Piston & Connecting Rod

Courtesy of GENERAL MOTORS CORP.

NOTE: The piston and pin are a matched set.

3. Align the front marks of the piston and connecting rod, and push in the piston with your thumb.

NOTE: Make sure that the end gap of the snap ring is not aligned with the pin hole cutout portion of the piston.

4. Using a screwdriver, install a new snap ring on the other end of the piston pin hole.

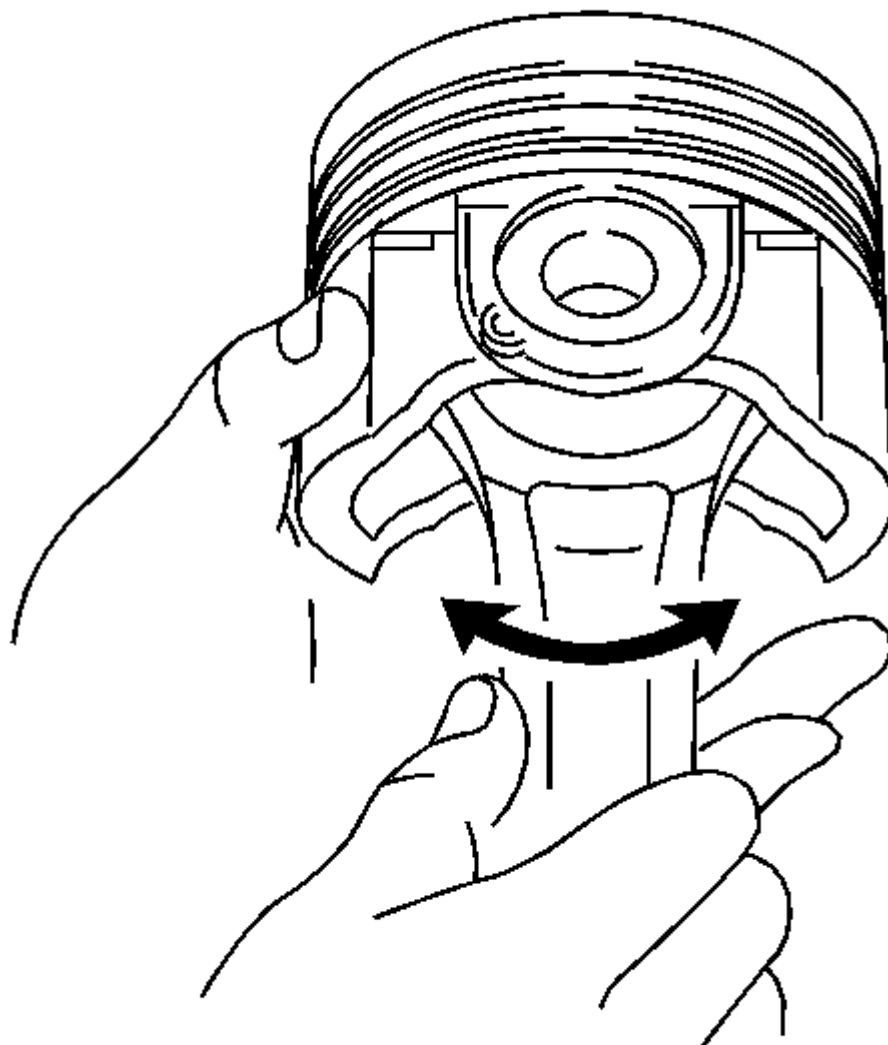


Fig. 387: Checking For Proper Connecting Rod Movement
Courtesy of GENERAL MOTORS CORP.

5. Check the fitting condition between the piston and piston pin by trying to move the piston back and forth on the piston pin.

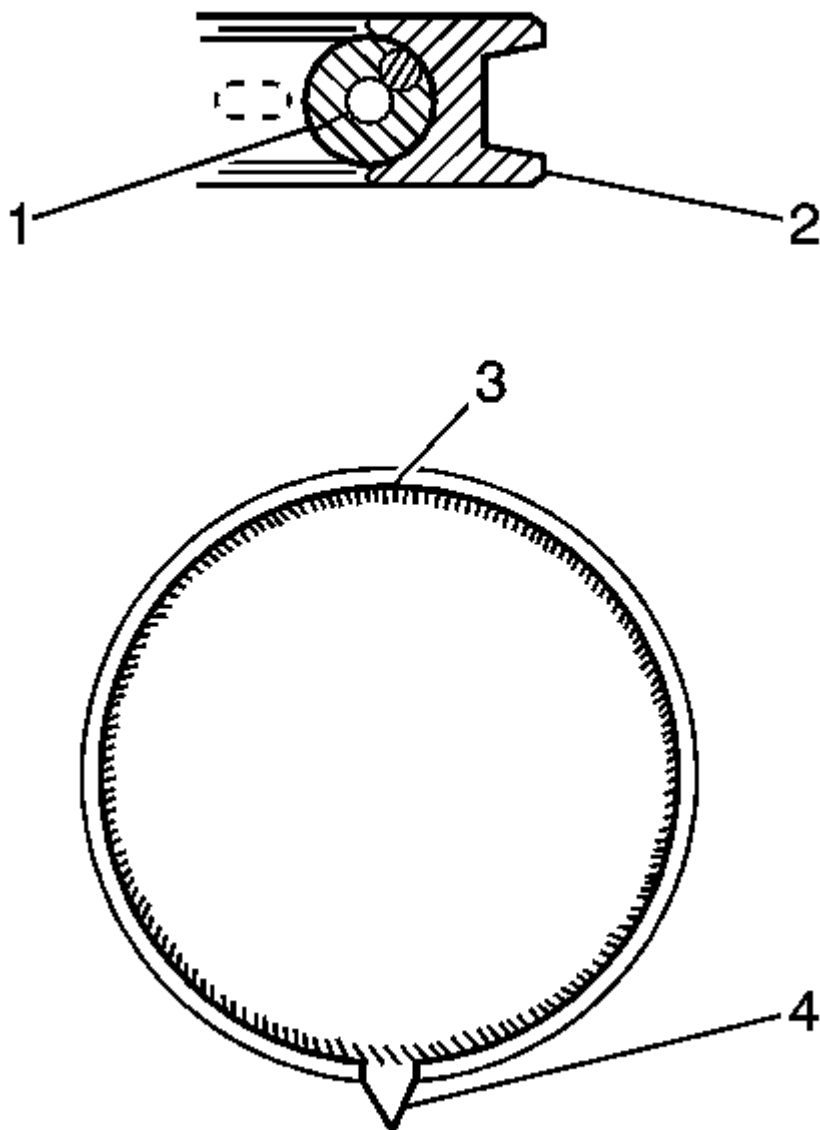


Fig. 388: View Of Oil Control Ring

Courtesy of GENERAL MOTORS CORP.

NOTE:

- Install the expander and oil ring so that their ring ends are at opposite sides.
- Securely install the expander to the inner groove of the oil ring.

6. Install the oil ring expander and oil ring rail by hand.

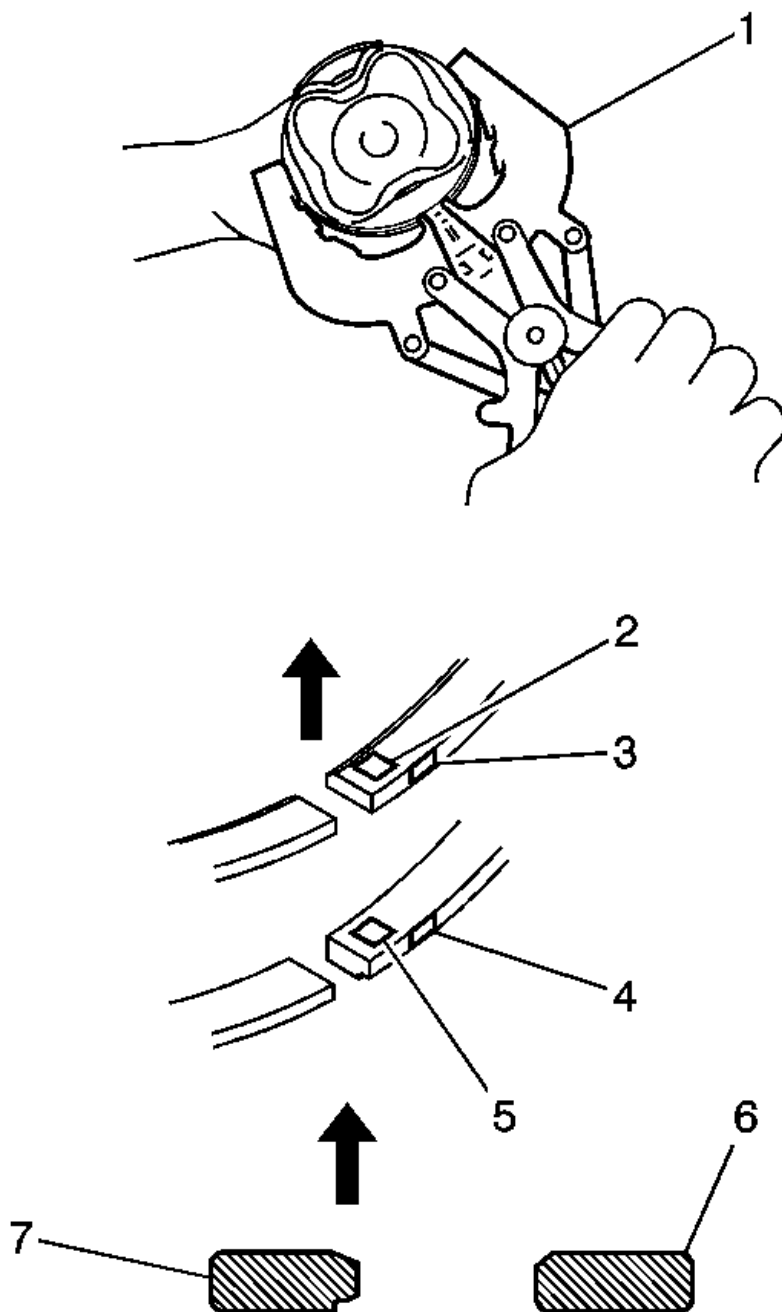


Fig. 389: View Of Proper Compression Ring Installation
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Install the compression ring No. 1 with the code mark (A1) facing upward.
- Install the compression ring No. 2 with the code mark (A2) facing upward.
- Paint marks can only be checked on new piston rings. When reusing piston rings, check each piston ring profile in order to install them into the correct positions.

7. Using a piston ring expander, install the 2 compression rings so that the paint marks are positioned as shown in the illustration.

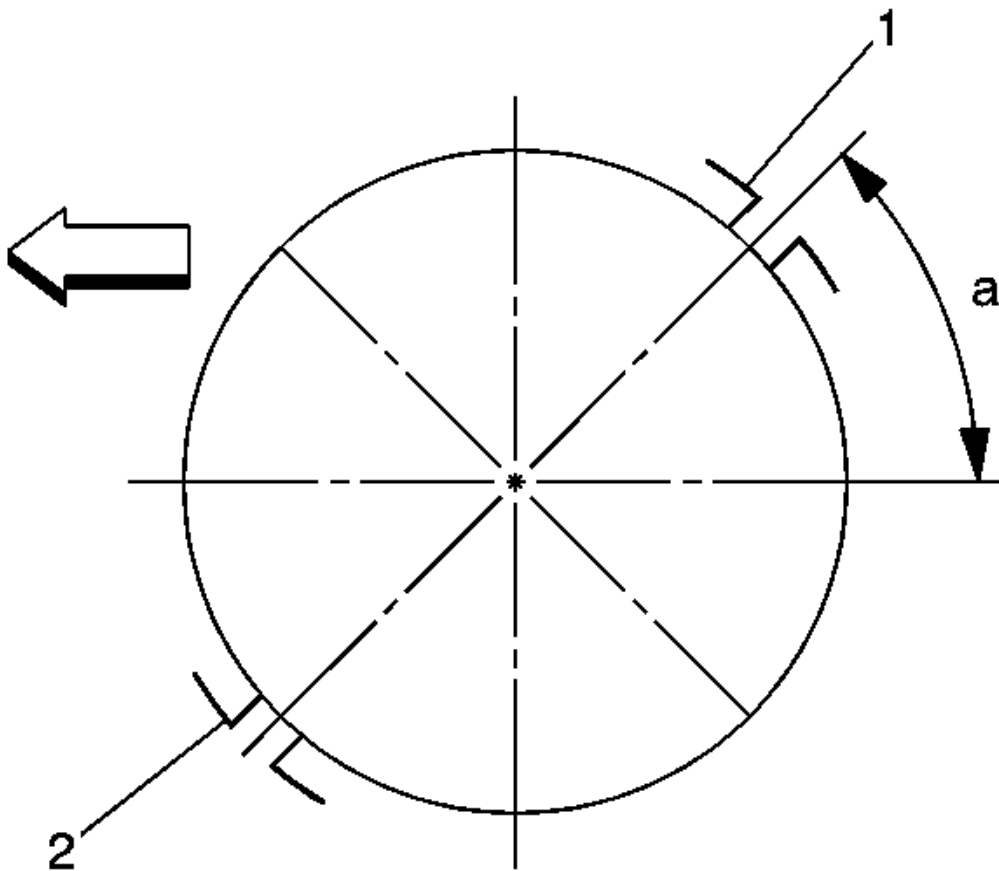


Fig. 390: Identifying Proper Piston Ring Positioning
Courtesy of GENERAL MOTORS CORP.

8. Position the piston rings so that the ring ends are as shown in the illustration.

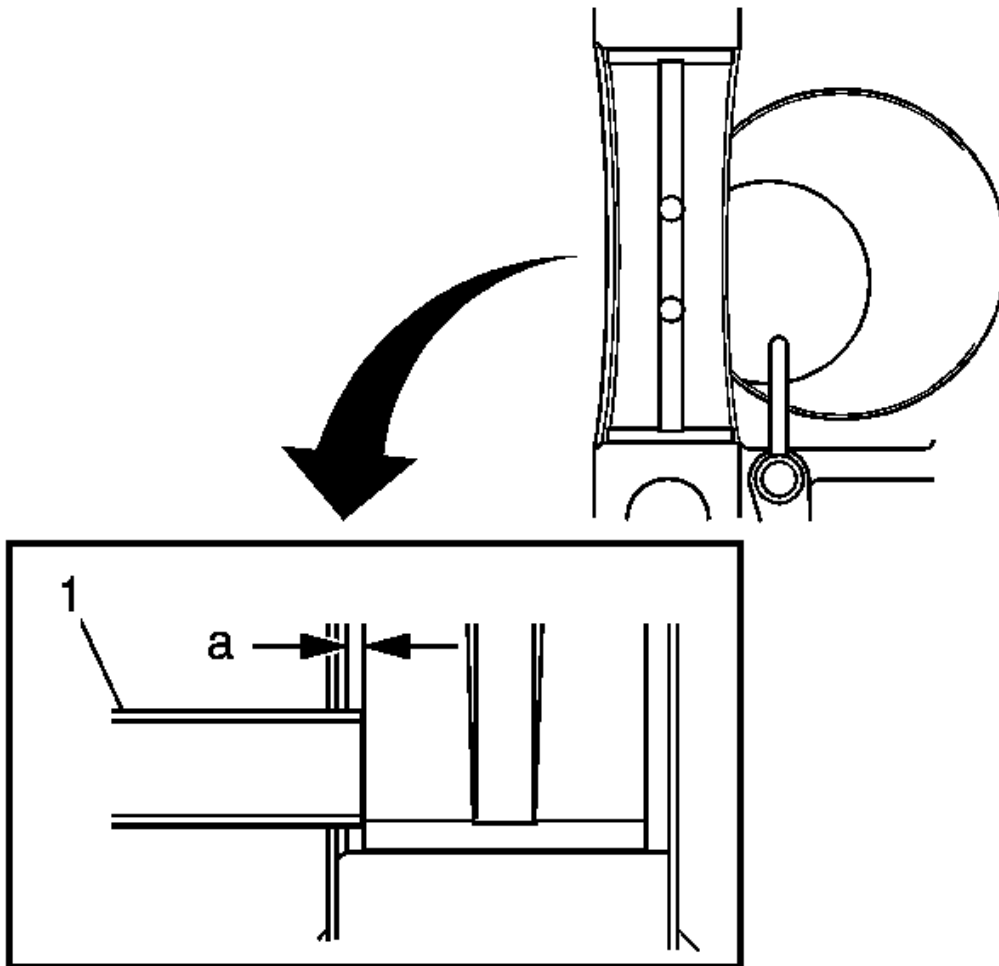


Fig. 391: View Of Upper Bearing Installation (Except No. 3 Journal)
 Courtesy of GENERAL MOTORS CORP.

9. Install the upper bearing (for except No. 3 journal).
10. Install the upper bearing with an oil groove on the cylinder block.

NOTE: Do not apply engine oil to the bearings or the contact surfaces. Dimension (A): 0.5 to 1.0 mm (0.020 to 0.039 in)

11. Using a scale, measure the distance between the cylinder block edge and the upper bearing edge.

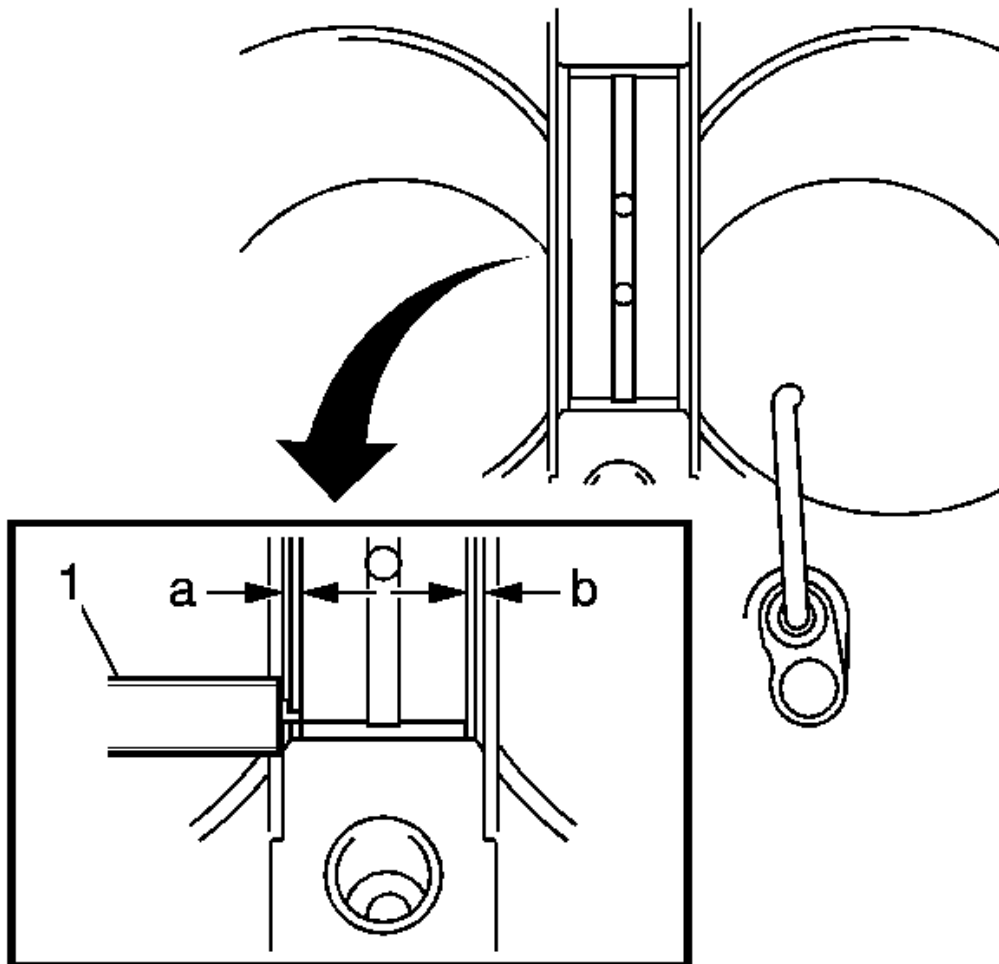


Fig. 392: Identifying Upper Bearing With An Oil Groove On Cylinder Block
Courtesy of GENERAL MOTORS CORP.

12. Install the upper bearing with an oil groove on the cylinder block.

NOTE: Do not apply engine oil to the bearings or the contact surfaces. Dimension (A - B): 0.5 mm (0.0197 in) or less.

13. Using vernier calipers, measure the distance between the cylinder block edge and the upper bearing edge.
14. Install the lower bearing onto the bearing cap.

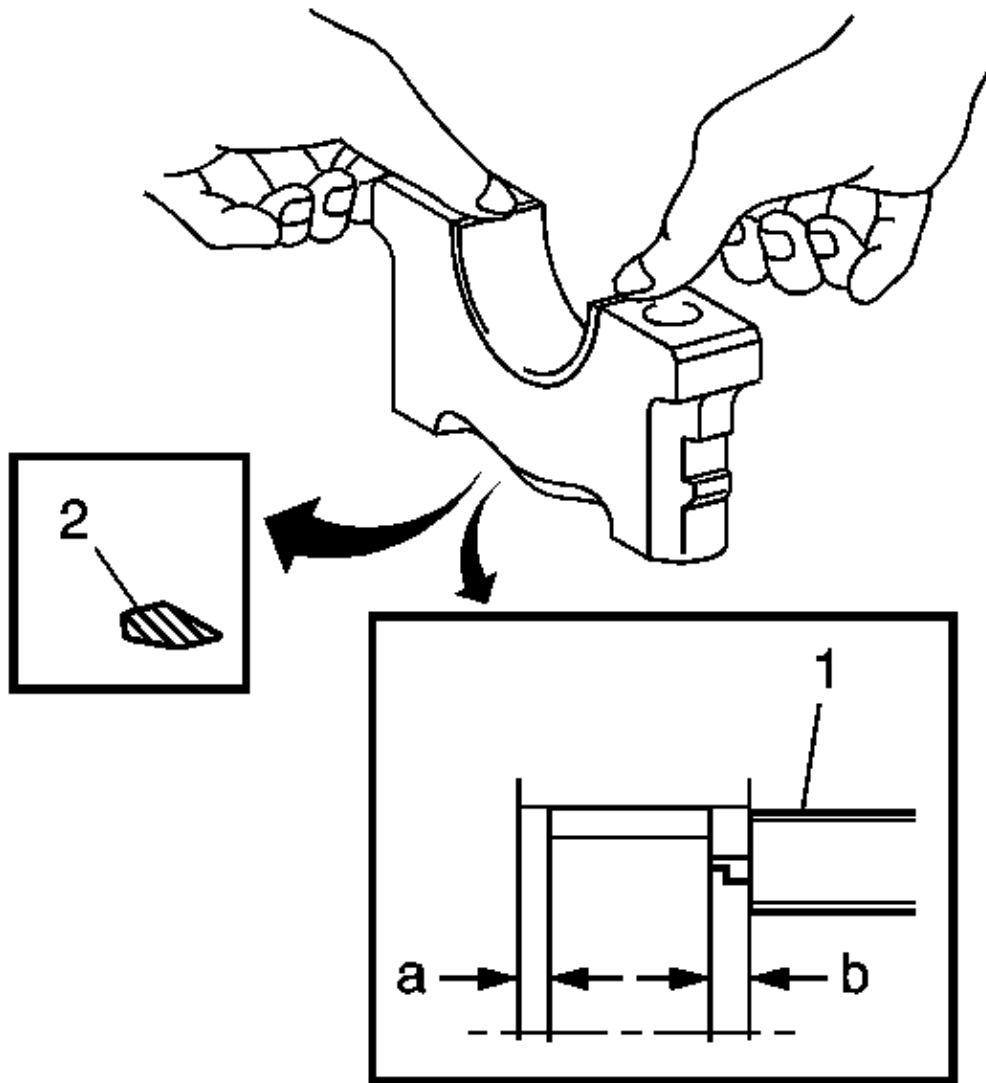


Fig. 393: Measuring Distance Between Bearing Cap Edge & Lower Bearing Edge
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not apply engine oil to the bearings or the contact surfaces.

15. Using vernier calipers, measure the distance between the bearing cap edge and the lower bearing edge.

Dimension (A - B): 0.5 mm (0.0197 in) or less

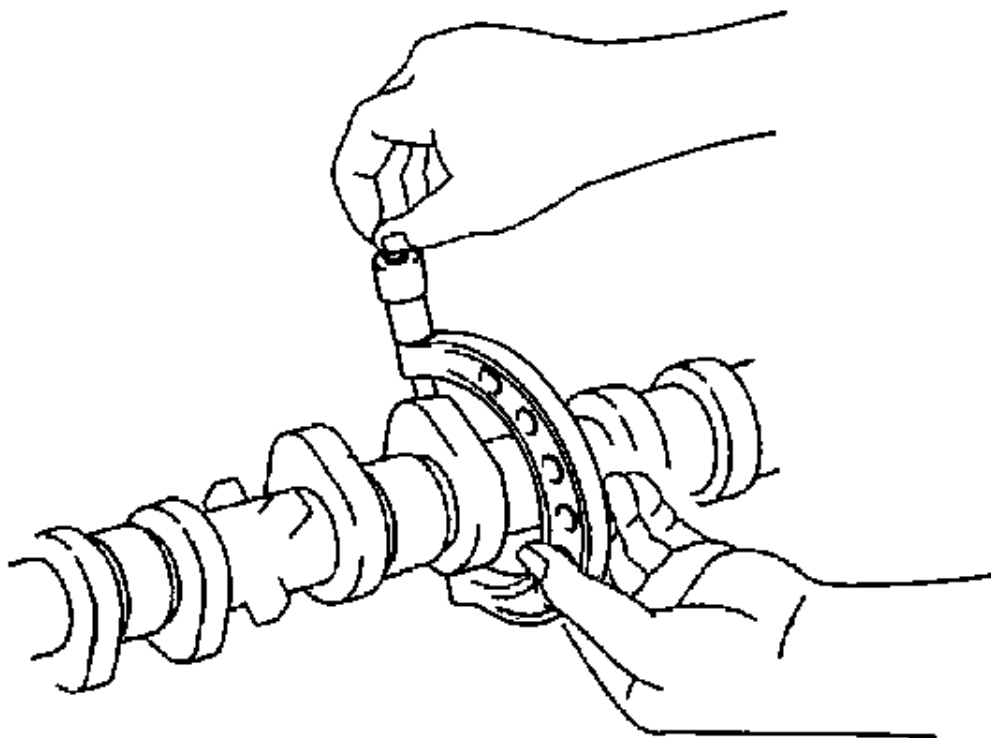
CAMSHAFT CLEANING AND INSPECTION

Fig. 394: Inspecting Cam Lobes
Courtesy of GENERAL MOTORS CORP.

1. Inspect the cam lobes.
2. Using a micrometer, measure the cam lobe height.

If the cam lobe height is less than the minimum, replace the camshaft.

Specification:

- Standard cam lobe height - 42.816 to 42.916 mm (1.6857 to 1.6896 in).
- Minimum cam lobe height - 42.666 mm (1.6798 in).

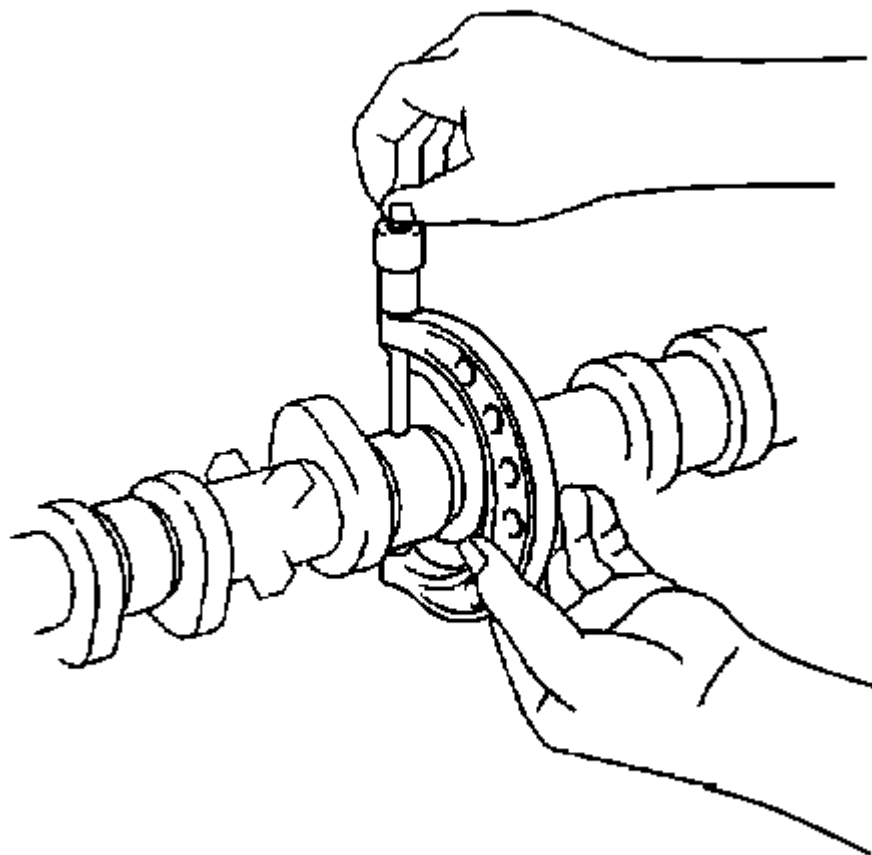


Fig. 395: Inspecting Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

3. Inspect the camshaft journals.
4. Using a micrometer, measure the journal diameter.

Place the No. 2 camshaft on V-blocks.

If the journal diameter is not as specified, check the oil clearance.

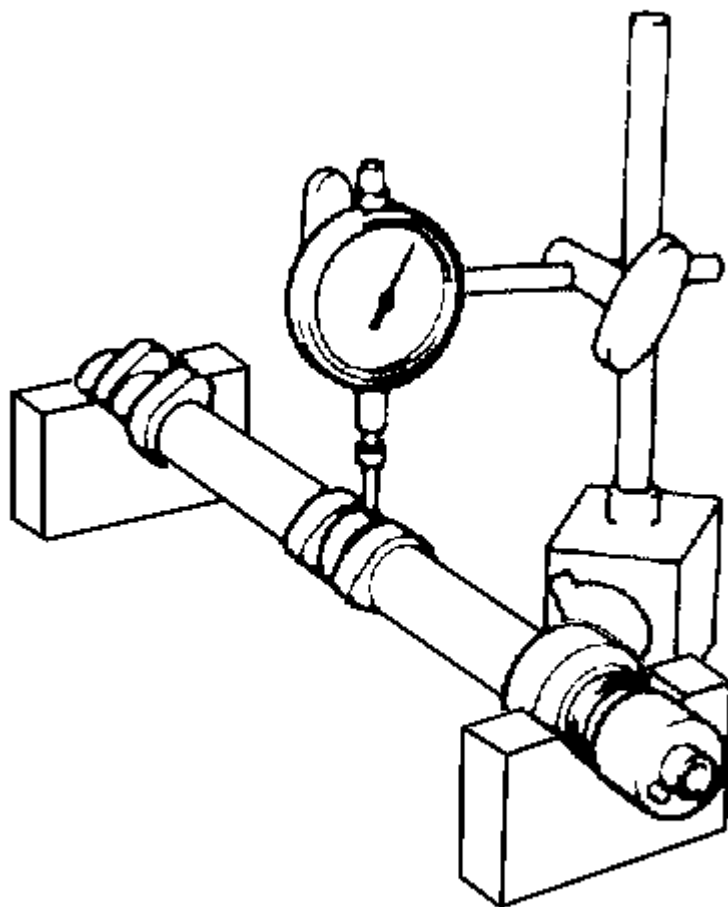


Fig. 396: Inspecting Camshaft For Runout
Courtesy of GENERAL MOTORS CORP.

5. Inspect the No. 2 camshaft for runout.
6. Place the No. 2 camshaft on V-blocks.
7. Using a dial indicator, measure the circle runout at the center journal.

If the circle runout is greater than the maximum, replace the No. 2 camshaft.

Specification: Maximum circle runout - 0.04 mm (0.0016 in).

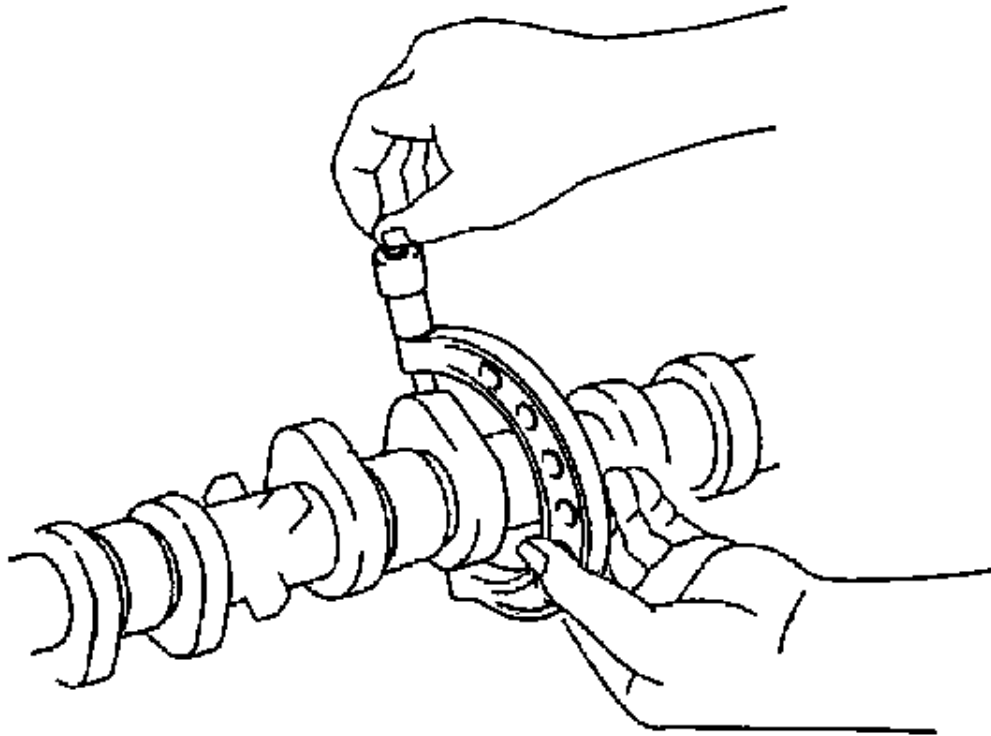


Fig. 397: Inspecting Cam Lobes
Courtesy of GENERAL MOTORS CORP.

8. Inspect the cam lobes.
9. Using a micrometer, measure the cam lobe height.

If the cam lobe height is less than the minimum, replace the No. 2 camshaft.

Specification:

- Standard cam lobe height - 44.336 to 44.436 mm (1.7455 to 1.7494 in).
- Minimum cam lobe height - 44.186 mm (1.7396 in).

10. Inspect the camshaft journals.
11. Using a micrometer, measure the journal diameter.

If the journal diameter is not as specified, check the oil clearance.

VALVE LIFTER AND GUIDE CLEANING AND INSPECTION

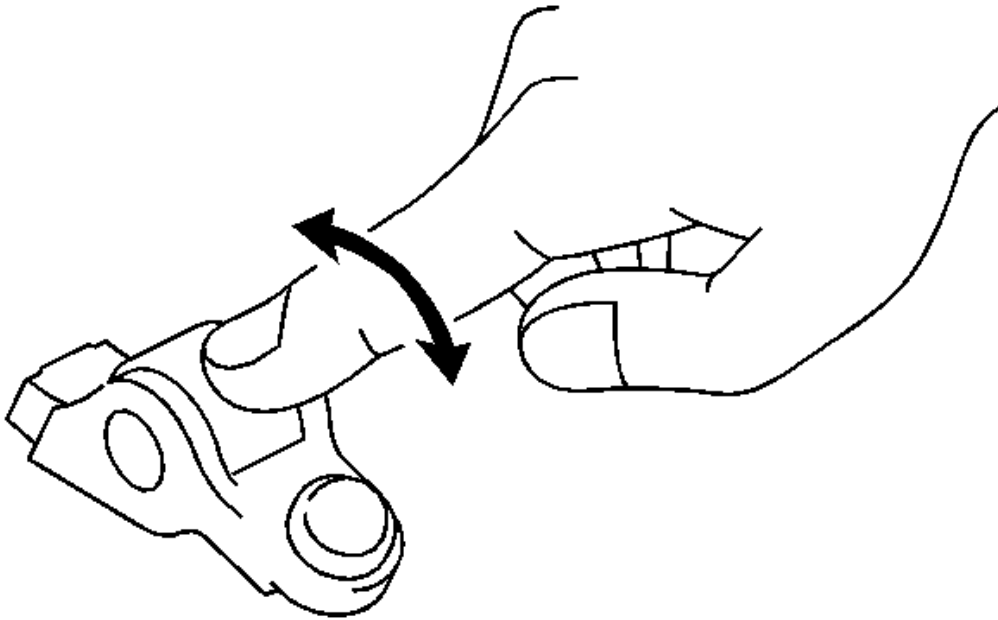


Fig. 398: Inspecting Valve Rocker Arm Subassembly
Courtesy of GENERAL MOTORS CORP.

1. Inspect No. 1 valve rocker arm subassembly.

NOTE: If the roller does not turn smoothly, replace the valve rocker arm sub-assembly.

2. Turn the roller by hand to check that it turns smoothly.

NOTE: Keep the lash adjuster free of dirt and foreign matter. Only use clean engine oil.

3. Inspect valve lash adjuster assembly.

CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

1. Install the camshaft timing gear.
2. Check the lock of the camshaft timing gear and confirm it is locked.

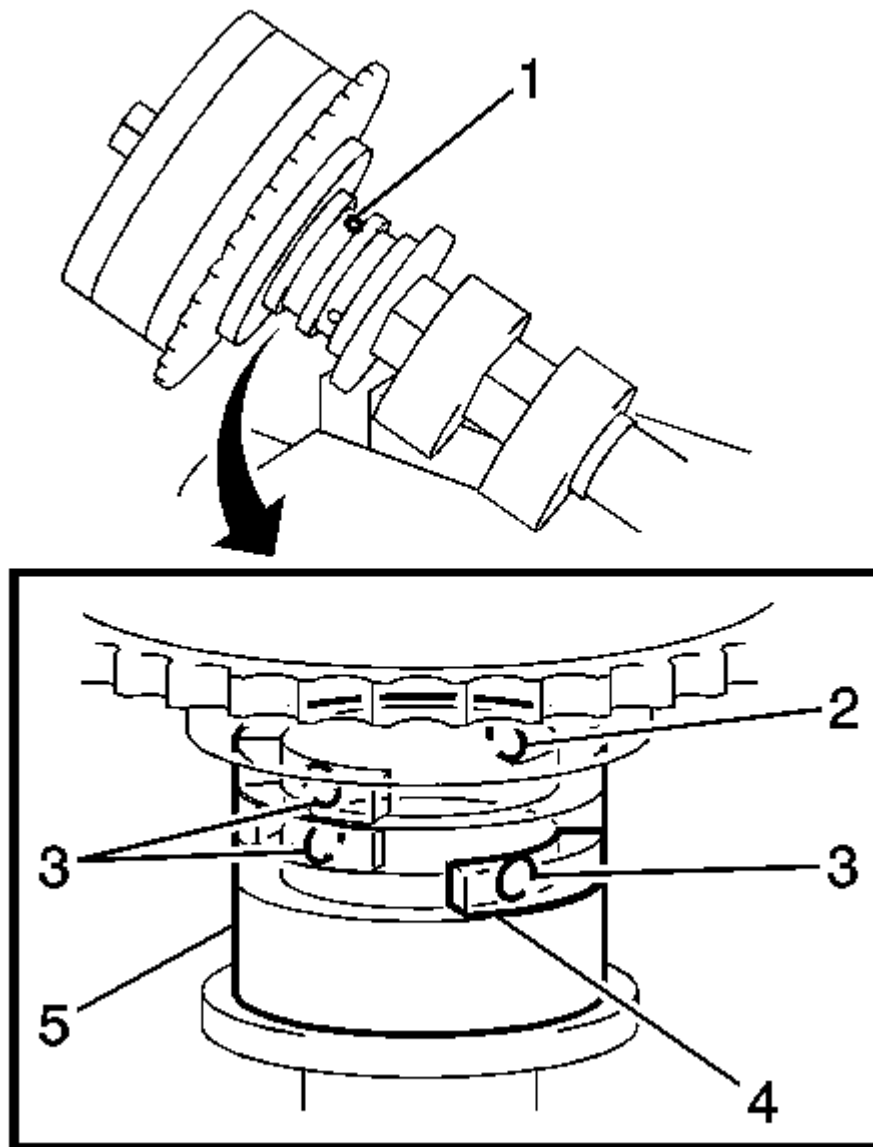


Fig. 399: Locating Lock Pin

Courtesy of GENERAL MOTORS CORP.

3. Release the lock pin.

NOTE: There are 4 oil paths in the groove of the camshaft. Plug three of the paths with pieces of rubber.

4. Cover the 4 oil paths of the cam journal with vinyl tape as shown in the illustration.
5. Prick a hole in the tape placed on the advance side path. Prick a hole in the tape placed on the retard side path, on the opposite side to that of the advance side path, as shown in the illustration.

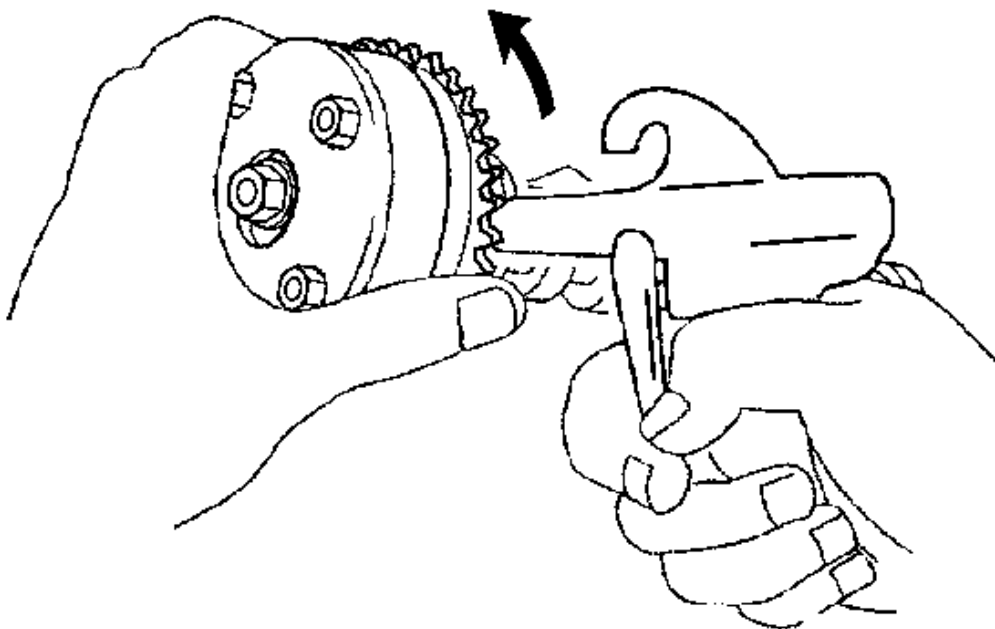


Fig. 400: Applying Air Pressure To Clean Sprocket
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Cover the paths with a piece of cloth when applying pressure to keep oil from splashing.
- Do not lock the camshaft timing gear assembly. If it is locked, release the lock pin again.
- The camshaft timing gear assembly may be turned in the advance direction without applying any force.
- If enough air pressure cannot be applied because of air leakage from the port, releasing the lock pin may be difficult.

6. While applying approximately 150 kPa (22 psi) of air pressure to the oil paths, forcibly turn the camshaft timing gear assembly in the advance direction (counterclockwise).

NOTE:

Do not lock the camshaft timing gear assembly. If it is locked, release the

lock pin again.

7. Turn the camshaft timing gear within its movable range (26.5-28.5 degrees) 2 or 3 times, but do not turn it to the most retarded position. Make sure that the gear turns smoothly.
8. Inspect the camshaft timing exhaust gear assembly.
9. Install the camshaft timing gear.
10. Make sure that the camshaft timing exhaust gear is locked.

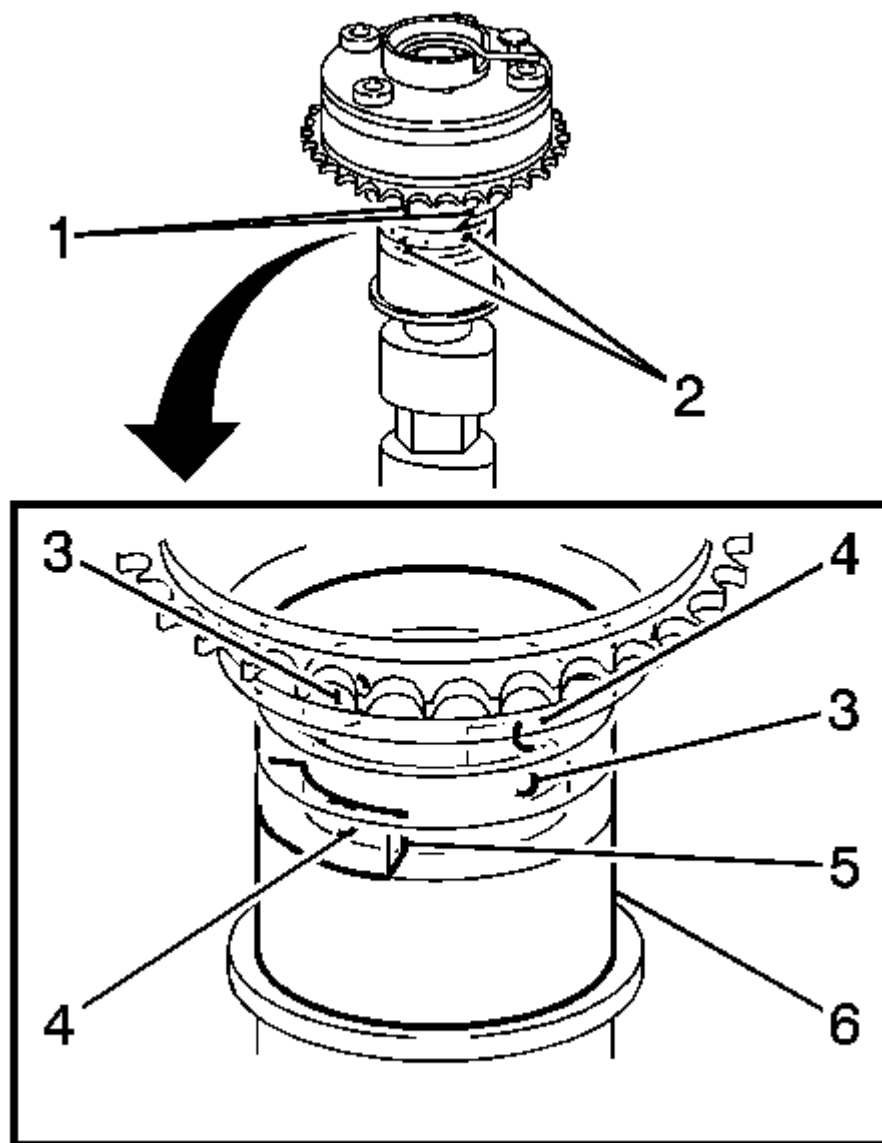


Fig. 401: Identifying Lock Pin
Courtesy of GENERAL MOTORS CORP.

11. Release the lock pin.

NOTE: The 4 oil paths are provided in the grooves. Plug 2 paths with rubber pieces.

12. Cover the 4 oil paths of the cam journal with vinyl tape as shown in the illustration.
13. Prick a hole in the tape placed on the advance side path. Prick a hole in the tape placed on the retard side path, on the opposite side to that of the advance side path, as shown in the illustration.

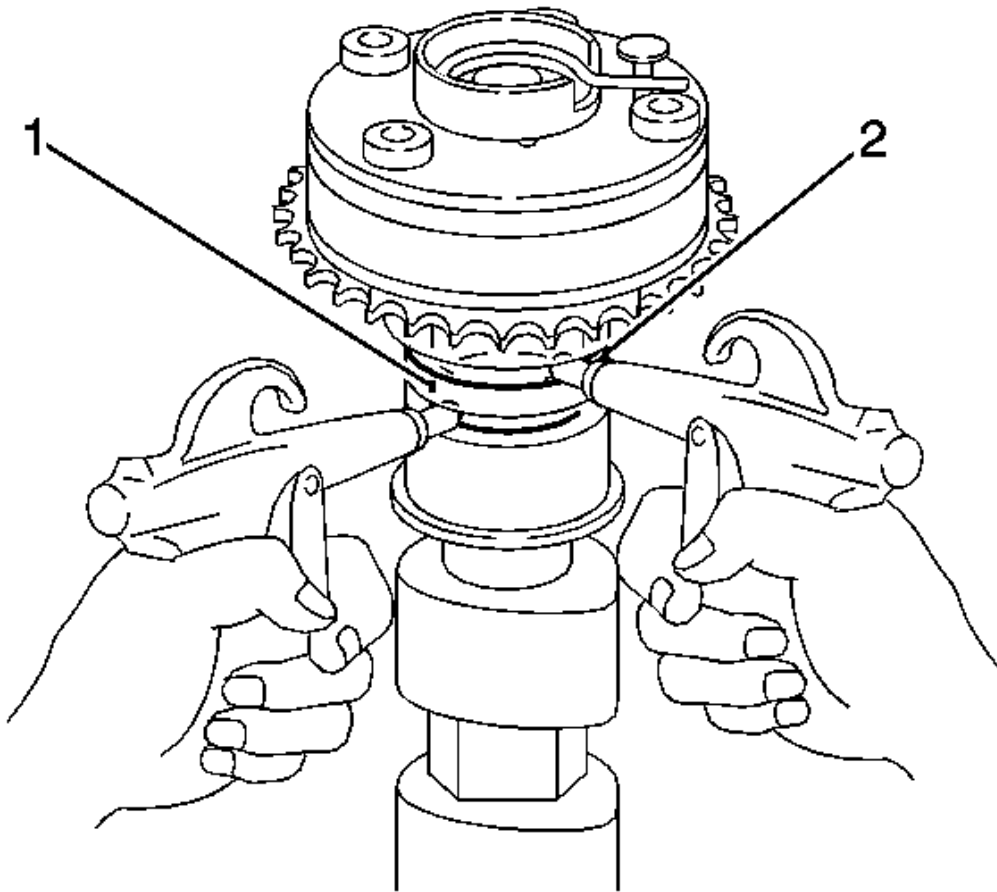


Fig. 402: View Of Sprocket Assembly Cleaning With Compressed Air
Courtesy of GENERAL MOTORS CORP.

NOTE: Cover the paths with a piece of cloth when applying pressure to keep oil from splashing.

14. Apply approximately 200 kPa (28 psi) of air pressure to the 2 paths (the advance side path and the retard side path).

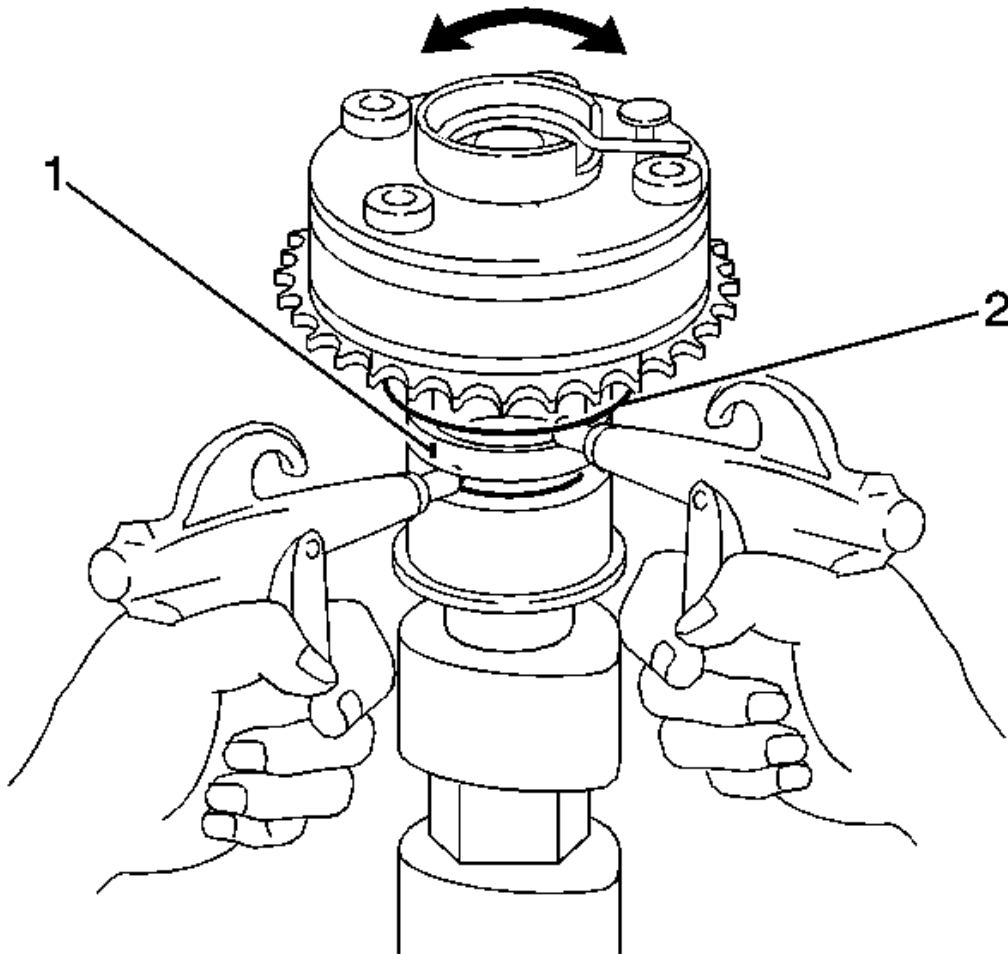


Fig. 403: Ensuring Camshaft Timing Exhaust Gear Turns In Retard Direction
Courtesy of GENERAL MOTORS CORP.

NOTE: The lock pin is released and the camshaft timing exhaust gear turns in the retard direction.

15. Make sure that the camshaft timing exhaust gear turns in the retard direction when reducing the air pressure applied to the advance side path.

NOTE: Be sure to release the air pressure from the advance side path first. If the air pressure of the retard side path is released first, the camshaft timing exhaust gear may abruptly shift in the advance direction and break the lock pin or other parts.

16. When the camshaft timing exhaust gear moves to the most retarded position, release the air pressure from the advance side path, and then release the air pressure from the retard side path.

NOTE: When the air pressure is released from the advance side path and then from the retard side path, the gear automatically returns to the most advanced position due to the advance assist spring operation and locks. Gradually release the air pressure from the retard side path before performing the smooth rotation check.

17. Turn the camshaft timing exhaust gear within its movable range (19-21 degrees) 2 or 3 times, but do not turn it to the most advanced position. Make sure that the gear turns smoothly.
18. Make sure that the camshaft timing exhaust gear is locked at the most advanced position.

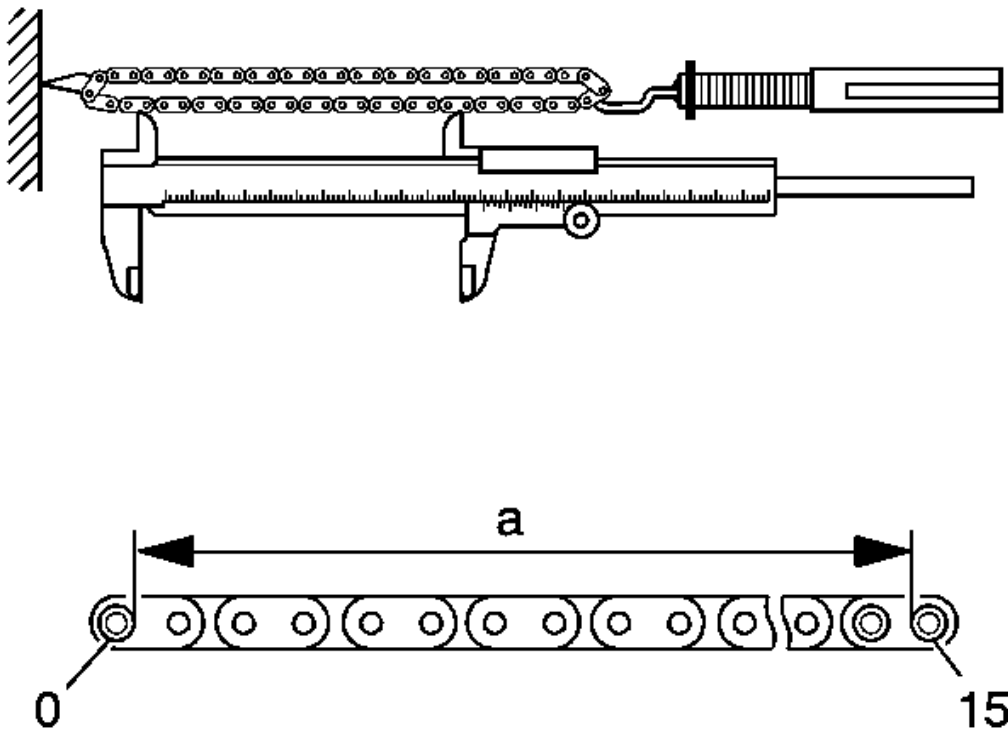


Fig. 404: Checking Maximum Chain Elongation
Courtesy of GENERAL MOTORS CORP.

19. Pull the chain with a force of 147 N (33 lb ft) as shown in the illustration.

NOTE: Perform the measurement at 3 random places. Use the average of the

measurements. If the average elongation is greater than the maximum, replace the chain.

20. Using vernier calipers, measure the length of 15 links.

Specification: Maximum Chain Elongation - 115.2 mm (4.535 in).

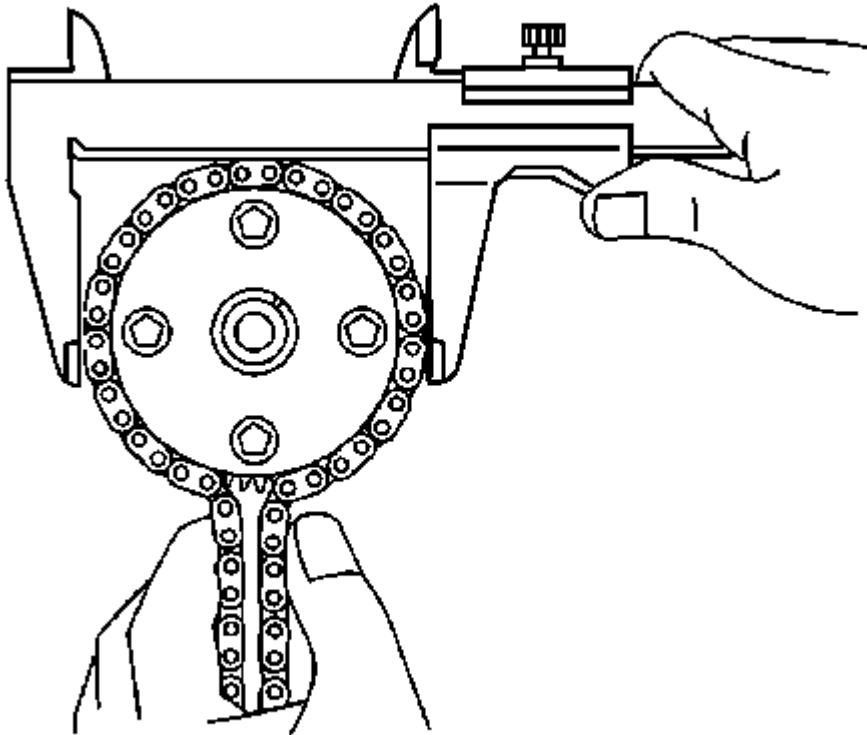


Fig. 405: Inspecting Camshaft Timing Gear Assembly
Courtesy of GENERAL MOTORS CORP.

21. Inspect the camshaft timing gear assembly.
22. Place the chain around the gear.

NOTE: The vernier calipers must be in contact with the chain rollers when measuring.

23. Using vernier calipers, measure the diameter of the gear and chain.

If the diameter is less than the minimum, replace the chain and gear.

Specification: Minimum gear diameter (with chain) - 96.8 mm (3.811 in).

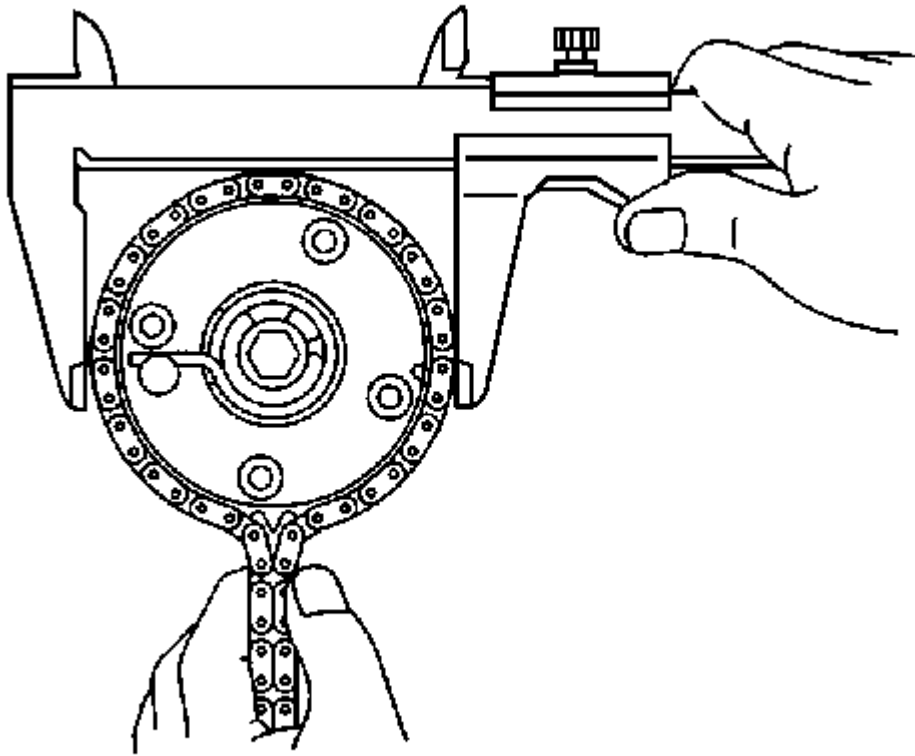


Fig. 406: Measuring Diameter Of Sprocket & Chain
Courtesy of GENERAL MOTORS CORP.

24. Inspect camshaft timing exhaust gear assembly
25. Place the chain around the sprocket.

NOTE: The vernier calipers must be in contact with the chain rollers when measuring.

26. Using vernier calipers, measure the diameter of the sprocket and chain.

If the diameter is less than the minimum, replace the chain and sprocket.

Specification: Minimum sprocket diameter (with chain) - 96.8 mm (3.811 in).

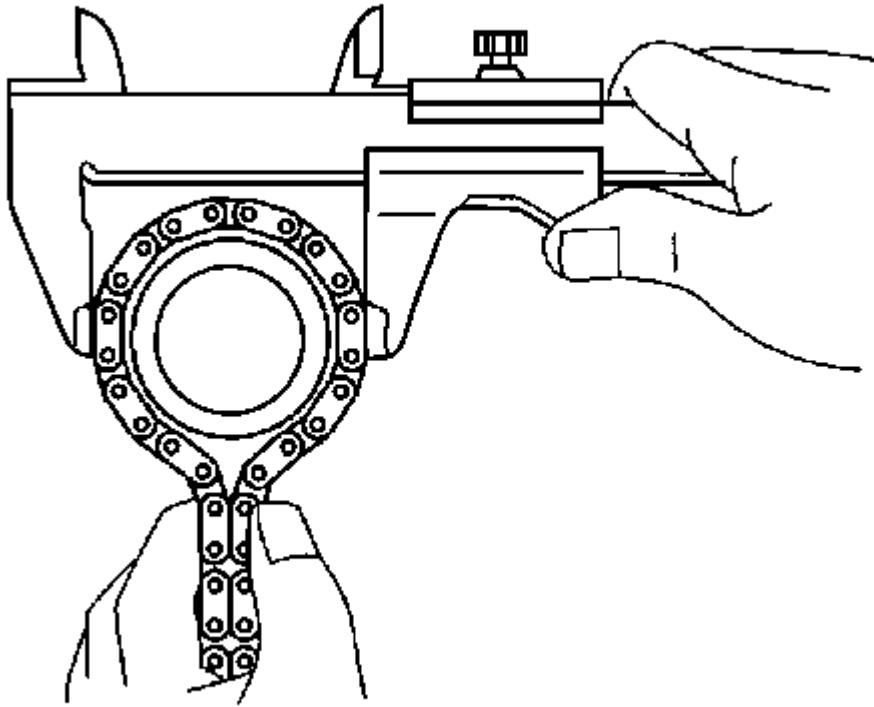


Fig. 407: Inspecting Oil Pump Drive Gear
Courtesy of GENERAL MOTORS CORP.

27. Inspect crankshaft timing gear.
28. Place the chain around the gear.

NOTE: **The vernier calipers must be in contact with the chain rollers when measuring.**

29. Using vernier calipers, measure the diameter of the gear and chain.

If the diameter is less than the minimum, replace the chain and gear.

Specification: Minimum gear diameter (with chain) - 51.1 mm (2.012 in).

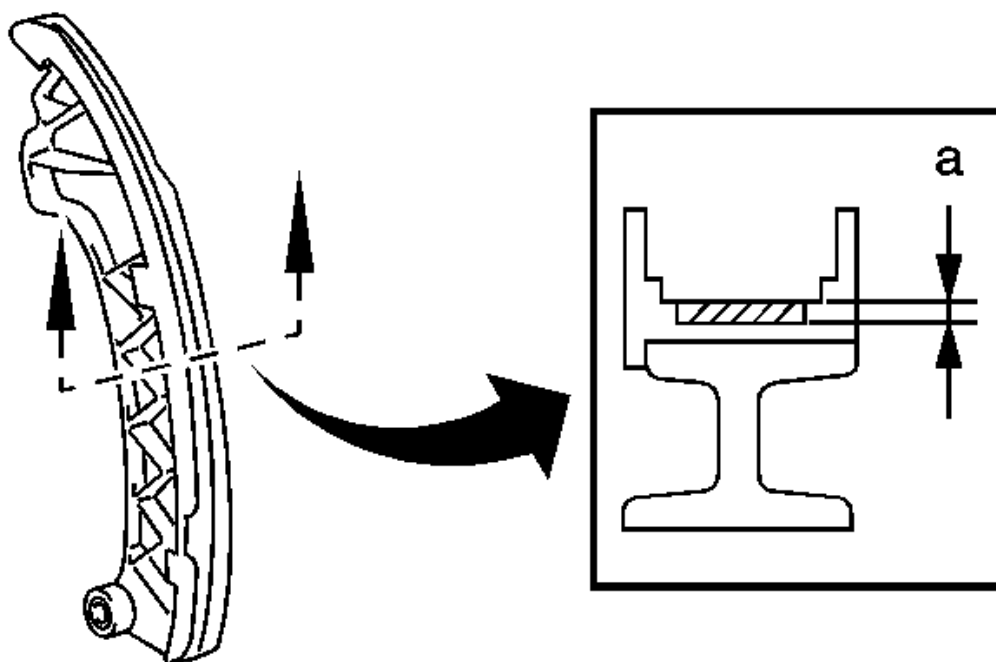


Fig. 408: View Of Tensioner Slipper
Courtesy of GENERAL MOTORS CORP.

30. Inspect chain tensioner slipper.
31. Using vernier calipers, measure the tensioner slipper wear.

If the wear is greater than the maximum, replace the chain tensioner slipper.

Specification: Maximum wear - 1.0 mm (0.039 in).

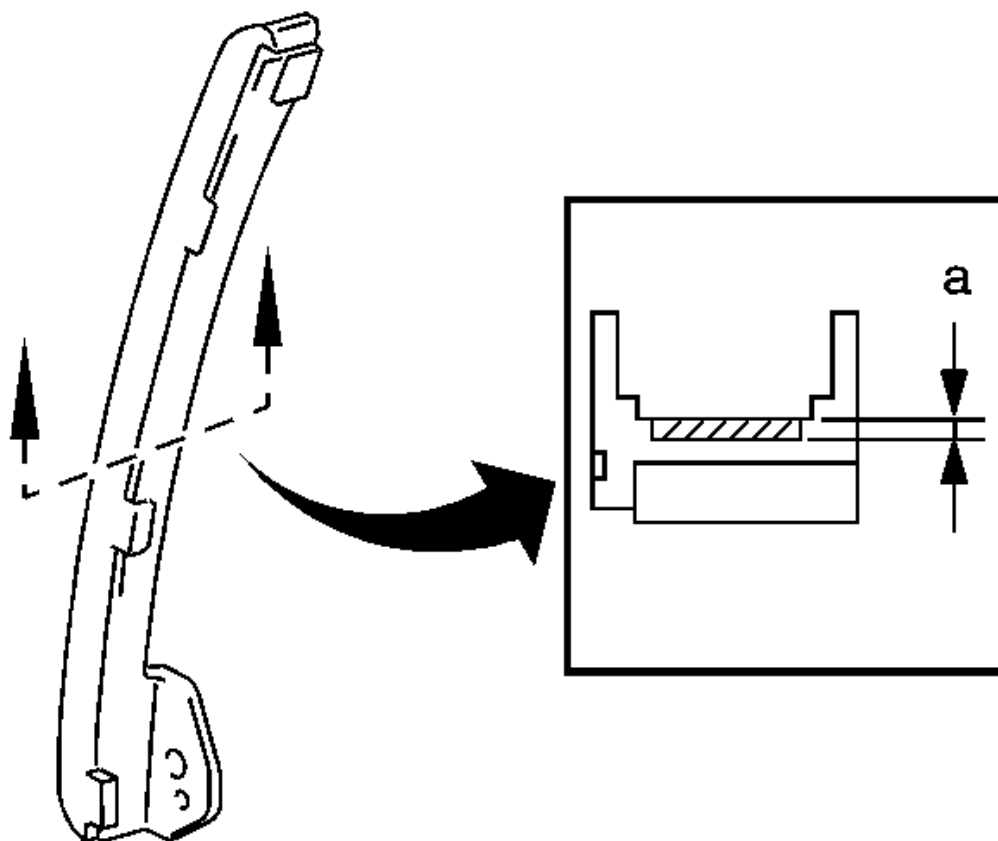


Fig. 409: View Of Chain Vibration Damper
Courtesy of GENERAL MOTORS CORP.

32. Inspect No. 1 chain vibration damper.
33. Using vernier calipers, measure the vibration damper wear.

If the wear is greater than the maximum, replace the No. 1 chain vibration damper.

Specification: Maximum wear - 1.0 mm (0.039 in).

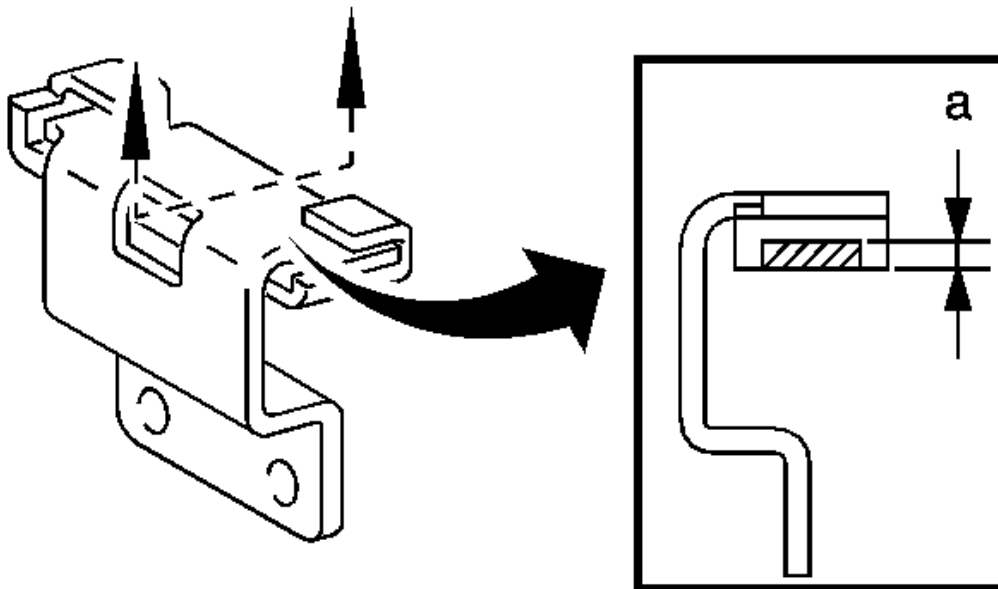


Fig. 410: View Of Chain Vibration Damper
Courtesy of GENERAL MOTORS CORP.

34. Inspect No. 2 chain vibration damper.
35. Using vernier calipers, measure the vibration damper wear.

If the wear is greater than the maximum, replace the No. 2 chain vibration damper.

Specification: Maximum wear - 1.0 mm (0.039 in).

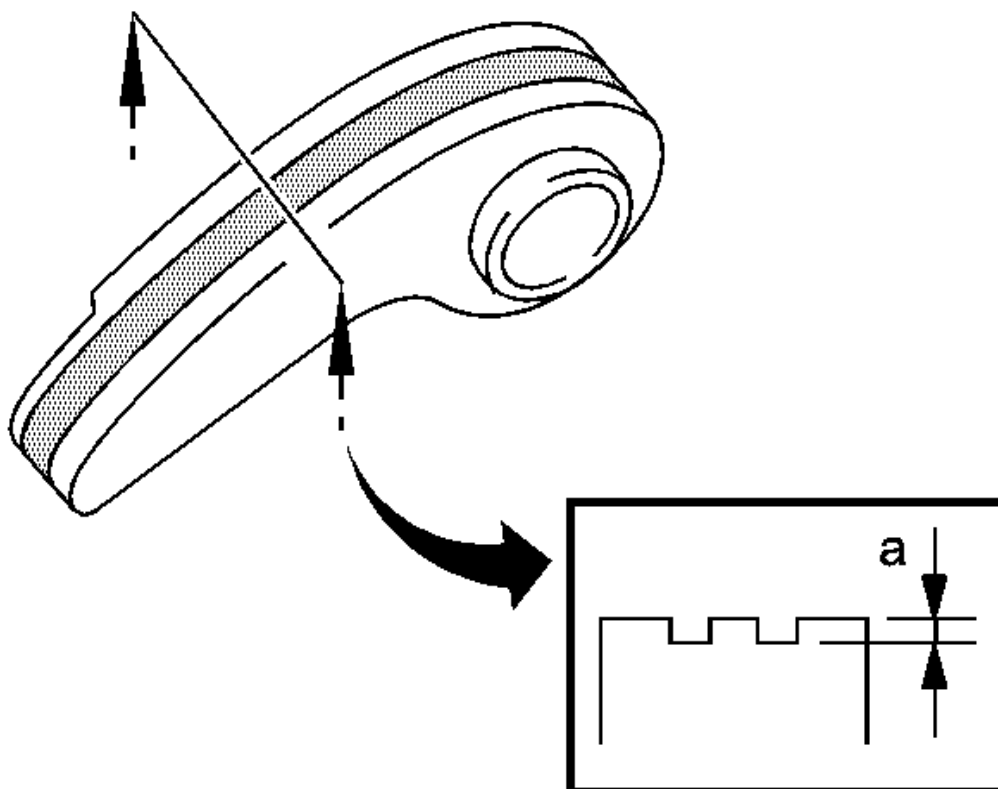


Fig. 411: Inspecting Chain Tensioner Plate
Courtesy of GENERAL MOTORS CORP.

36. Inspect chain tensioner plate.
37. Using vernier calipers, measure the chain tensioner plate wear.

If the wear is greater than the maximum, replace the chain tensioner plate.

Specification: Maximum wear - 1.0 mm (0.039 in).

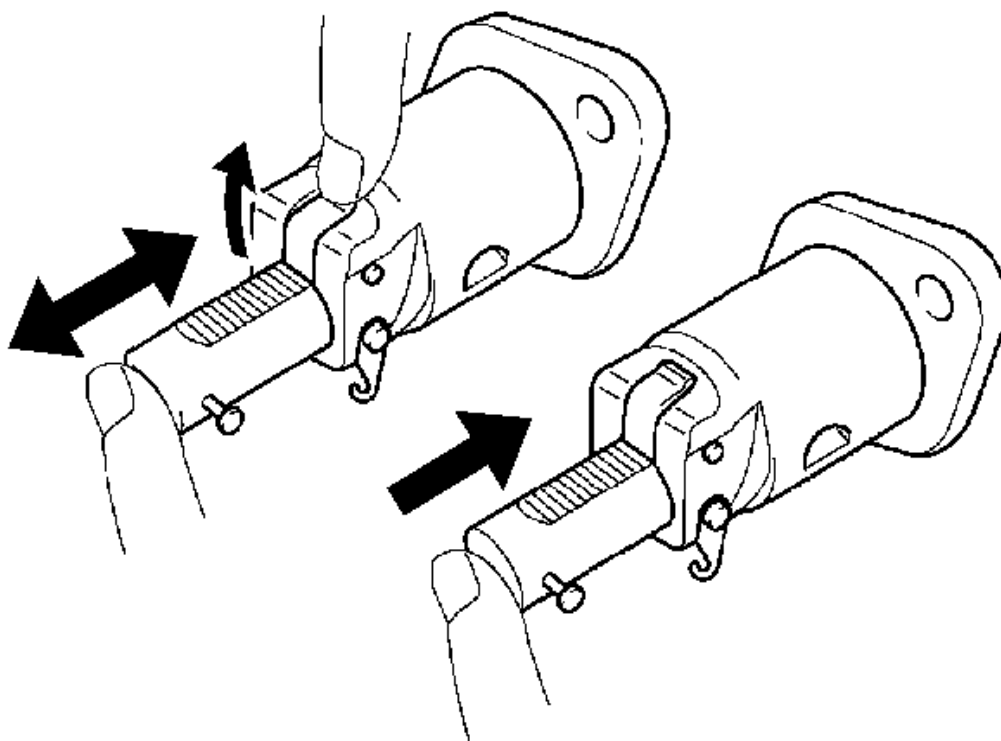


Fig. 412: Inspecting Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

38. Inspect No. 1 chain tensioner.
39. Check that the plunger moves smoothly when the ratchet pawl is raised with your finger.
40. Release the ratchet pawl, then check that the plunger is locked in place by the ratchet pawl and does not move when pushed with your finger.

CYLINDER HEAD DISASSEMBLE

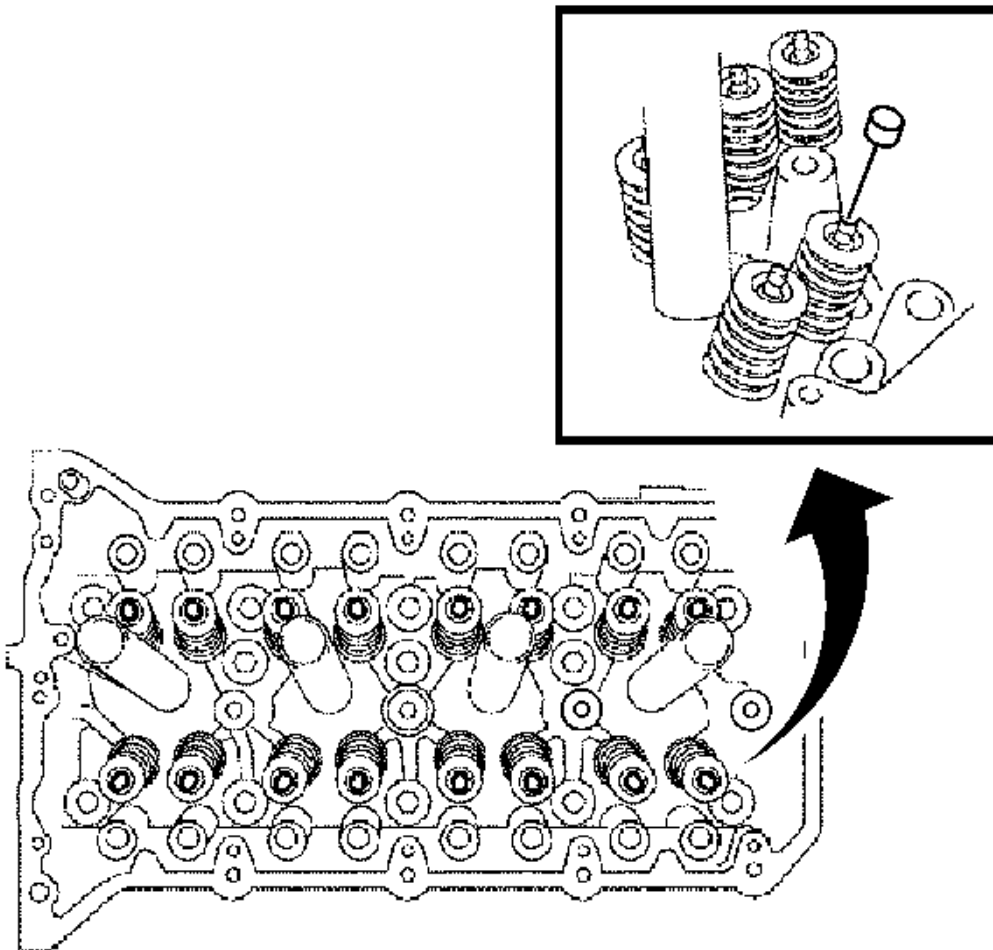


Fig. 413: Identifying Valve Stem Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Arrange the removed parts in the correct order.

1. Remove the valve stem caps from the cylinder heads.

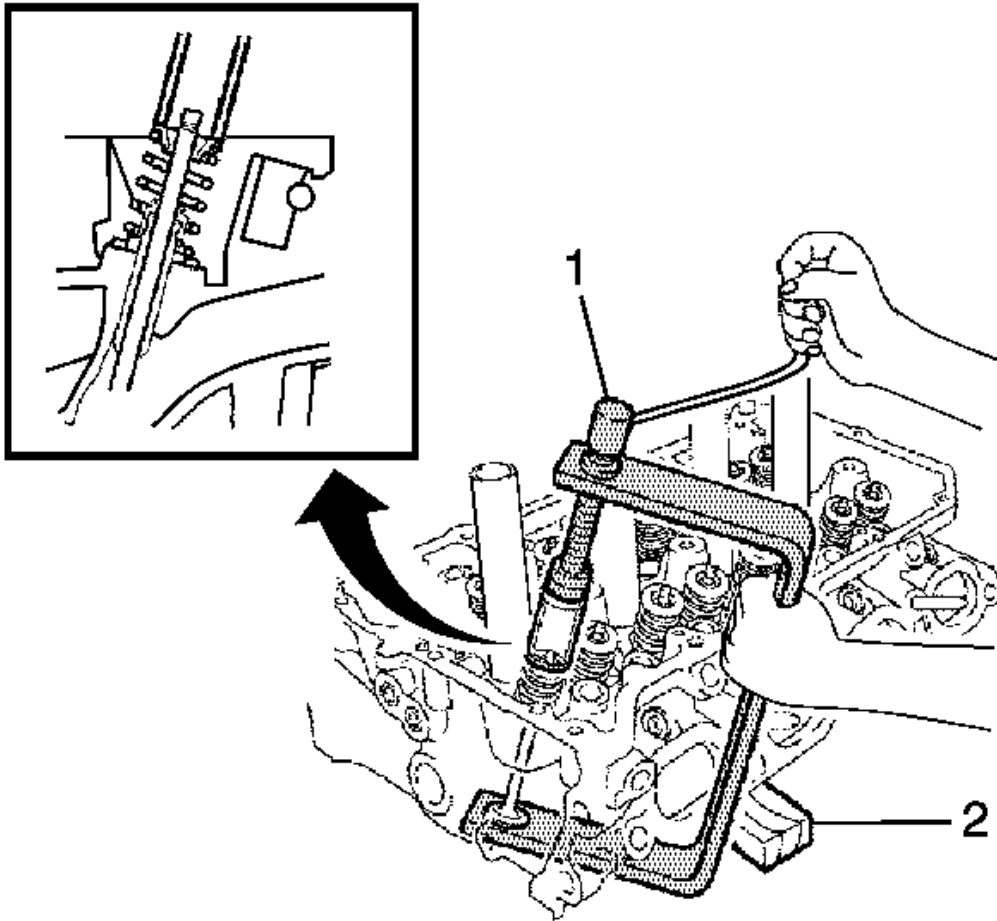


Fig. 414: View Of Compressing Valve Spring & Removing/Installing Valve Retainer Locks
 Courtesy of GENERAL MOTORS CORP.

2. Remove the intake valve.

IMPORTANT: Arrange the removed parts in the correct order.

3. Using SST and wooden blocks, compress and remove the valve retainer locks.

IMPORTANT: Arrange the removed parts in the correct order.

4. Remove the retainer, valve spring and intake valve.

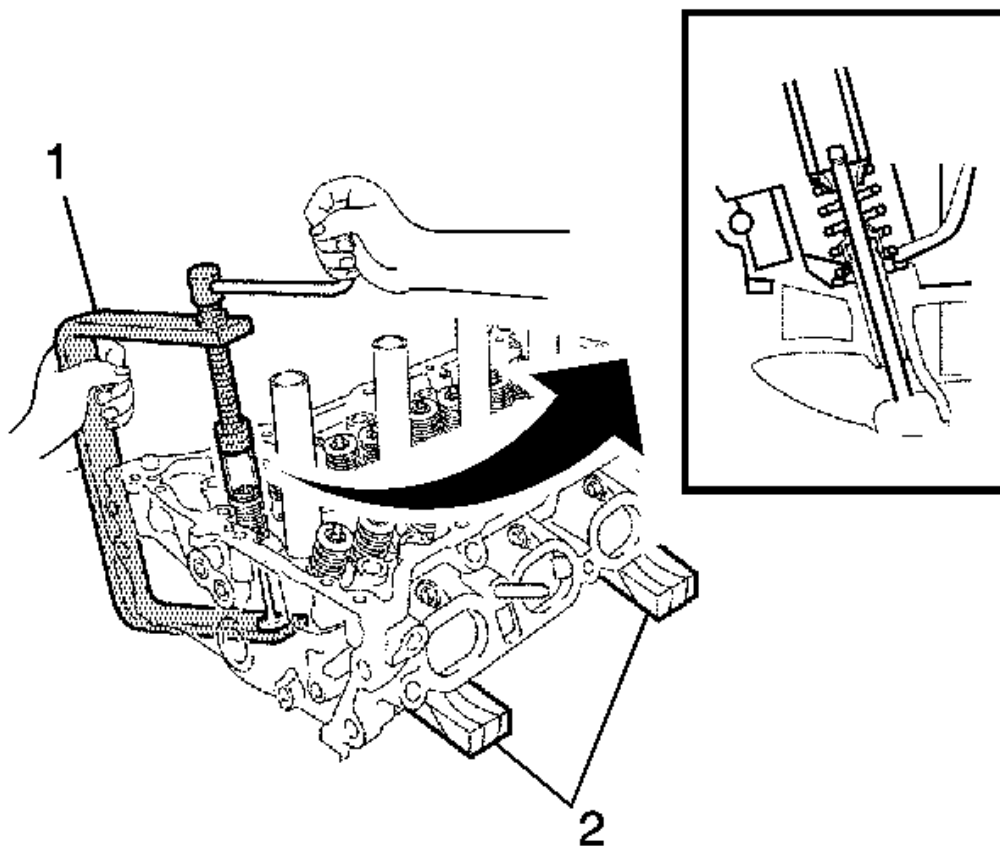


Fig. 415: Identifying Valve Springs & Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Arrange the removed parts in the correct order.

5. Using SST and wooden blocks, compress and remove the exhaust valve retainer locks.

IMPORTANT: Arrange the removed parts in the correct order.

6. Remove the retainer, valve spring and exhaust valve.

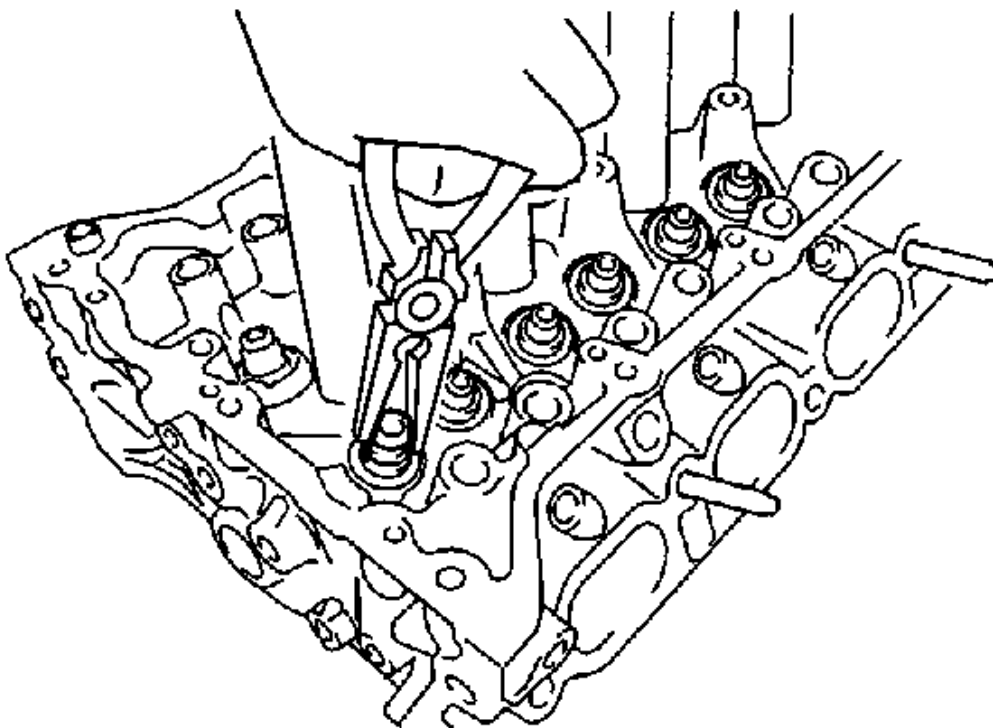


Fig. 416: View Of Valve Stem Oil Seal Removal
Courtesy of GENERAL MOTORS CORP.

7. Using needle-nose pliers, remove the valve stem oil seals.

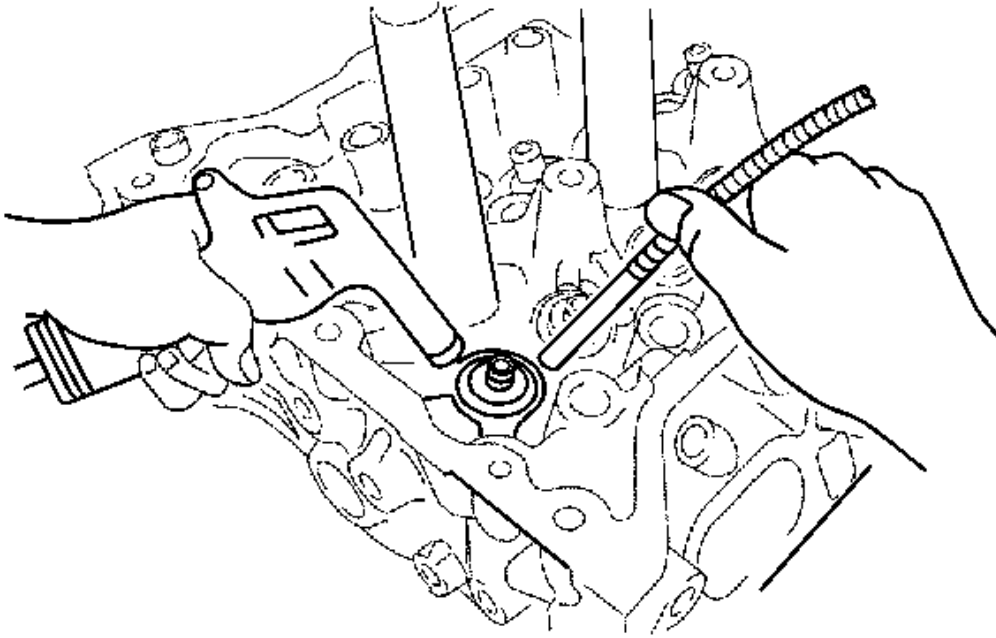


Fig. 417: View Of Valve Spring Seat Removal
Courtesy of GENERAL MOTORS CORP.

8. Using compressed air and a magnetic pick-up tool, remove the valve spring seats by blowing air onto them.

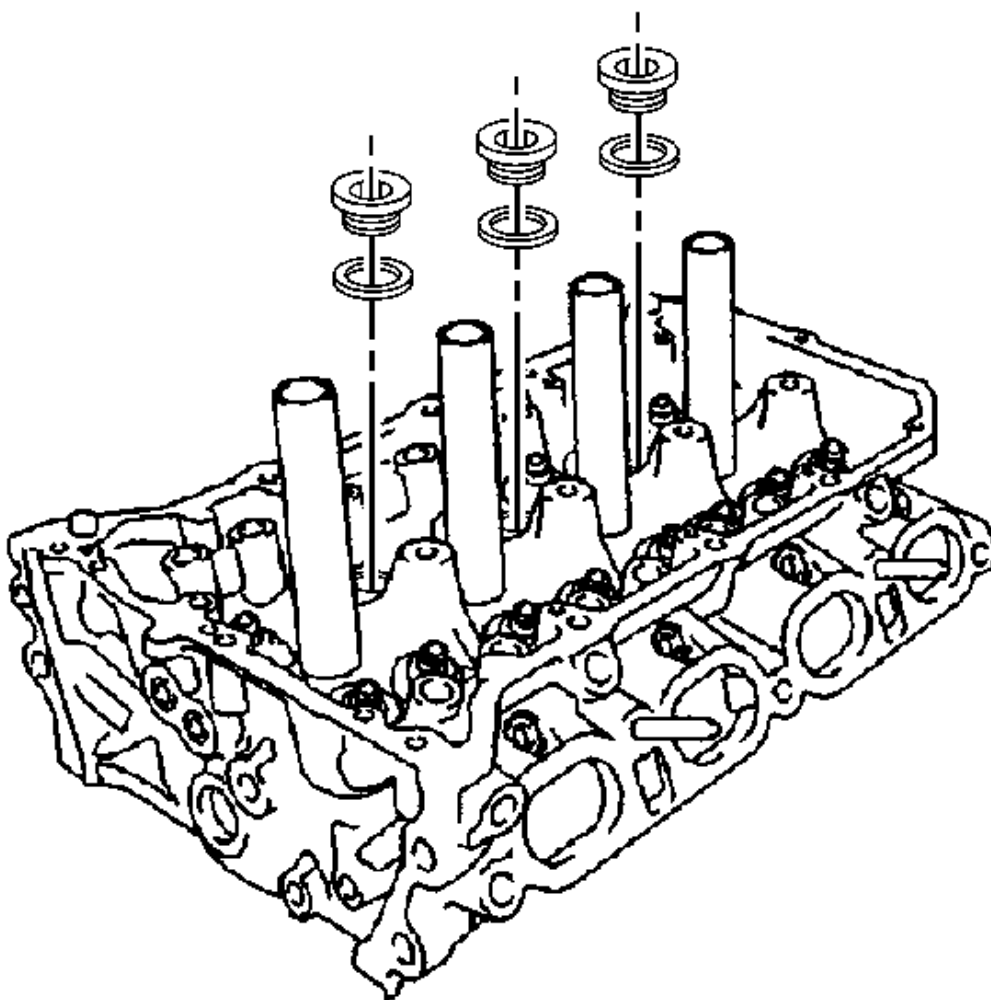


Fig. 418: View Of Straight Screw Plugs & Gaskets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If water leaks from any of the straight screw plugs or if the plug is corroded, replace it.

9. Using a 10 mm straight hexagon wrench, remove the 3 No. 2 STRAIGHT screw plugs and 3 gaskets.

CYLINDER HEAD CLEANING AND INSPECTION

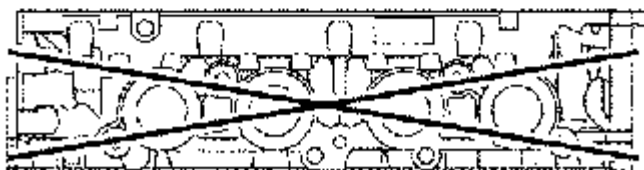
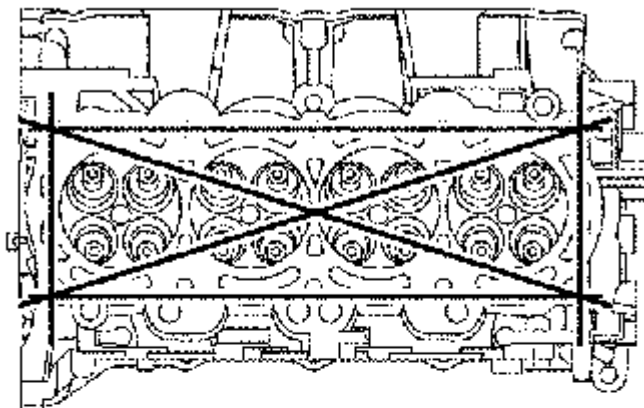


Fig. 419: Inspecting Cylinder Head For Flatness
Courtesy of GENERAL MOTORS CORP.

1. Inspect cylinder head for flatness.
2. Using a precision straight edge and a feeler gauge, measure the surfaces contacting the cylinder block and the manifolds for warpage.
3. If the warpage is greater than the maximum, replace the cylinder head.

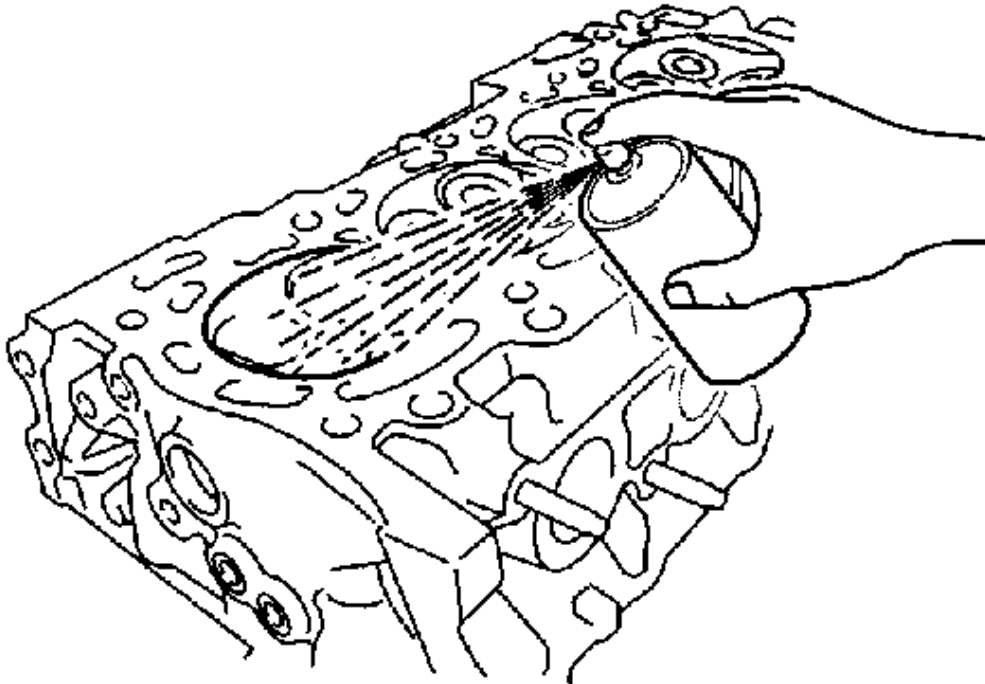


Fig. 420: Inspecting Intake/Exhaust Ports For Cracks
Courtesy of GENERAL MOTORS CORP.

4. Using a dye penetrant, check the intake ports, exhaust ports and cylinder surface for cracks. If cracked, replace the cylinder head.

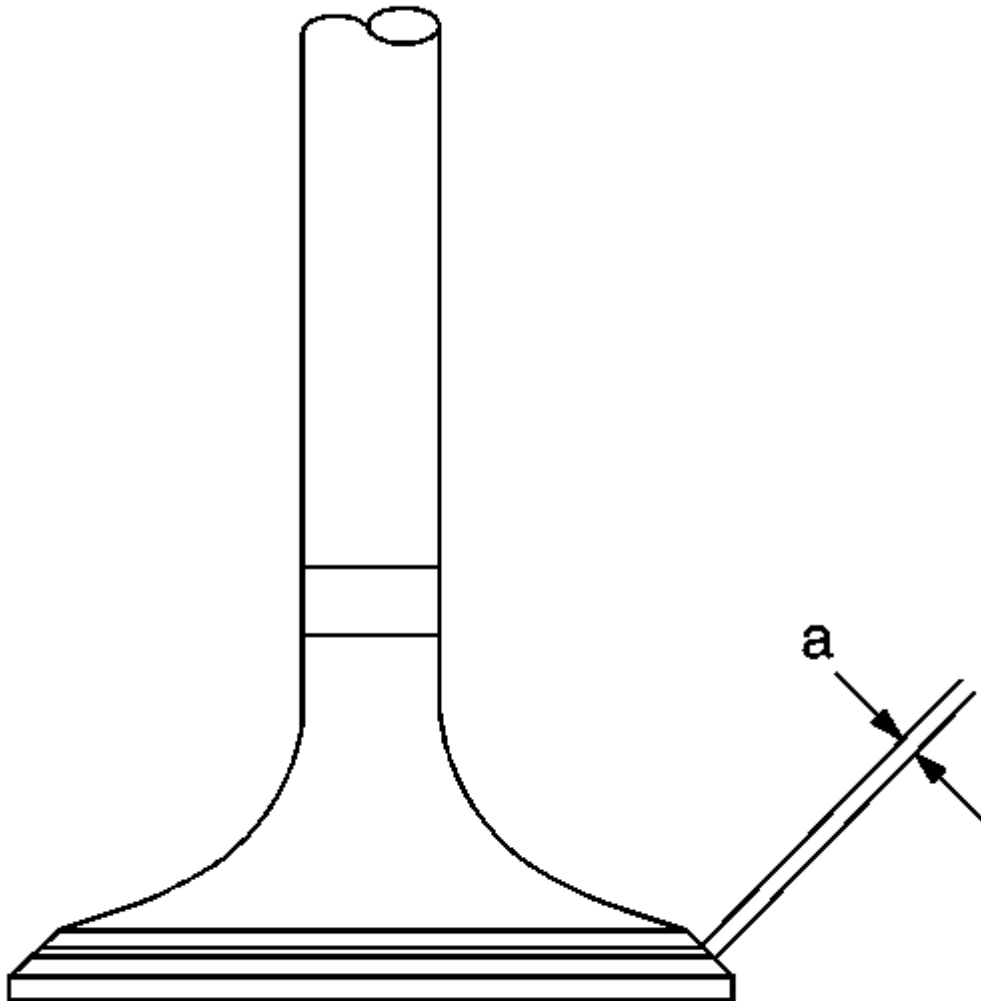


Fig. 421: Identifying Valve Face
Courtesy of GENERAL MOTORS CORP.

5. Apply a light coat of Prussian blue to the valve face.
6. Lightly press the valve face against the valve seat.
7. Check the valve face and valve seat according to the following procedure:
 1. If Prussian blue appears 360 degrees around the valve face, the valve face is concentric. If not, replace the valve.
 2. If Prussian blue appears 360 degrees around the valve seat, the guide and valve face are concentric. If not, resurface the valve seat.

3. Check that the valve seat contact is in the middle of the valve face with the valve seat width between 1.0 and 1.4 mm (Intake side - 0.039 to 0.055 in).
4. Check that the valve seat contact is in the middle of the valve face with the valve seat width between 1.0 and 1.4 mm (Exhaust side - 0.039 to 0.055 in).
8. Install the camshafts.

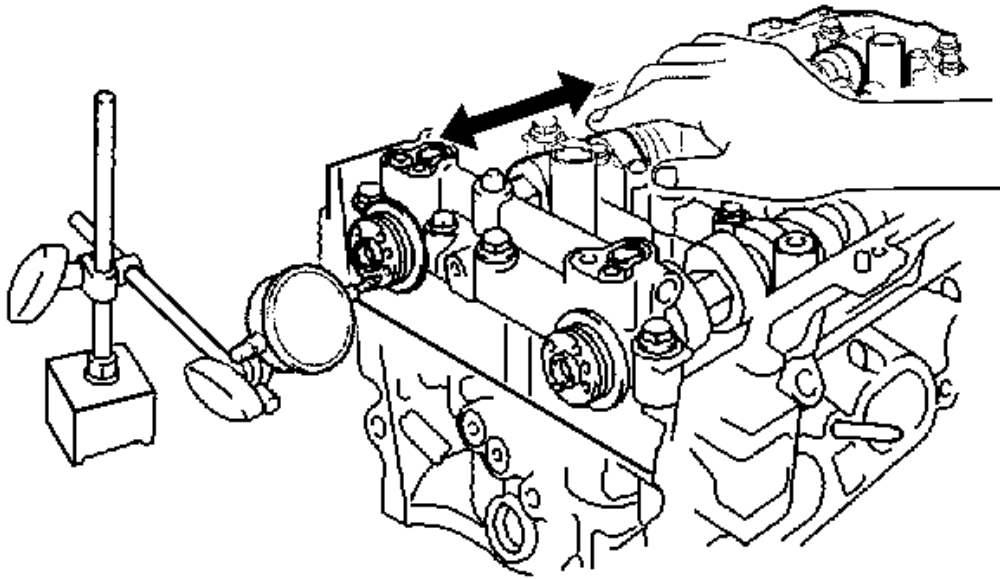


Fig. 422: Measuring Thrust Clearance While Moving Camshaft Back & Forth
Courtesy of GENERAL MOTORS CORP.

9. Using a dial indicator, measure the thrust clearance while moving the camshaft back and forth.
10. If the thrust clearance is greater than the maximum, replace the camshaft housing. If the thrust surface is damaged, replace the camshaft.
11. Inspect camshaft oil clearance.
12. Clean the bearing caps and camshaft journals.
13. Place the camshafts on the camshaft housing.

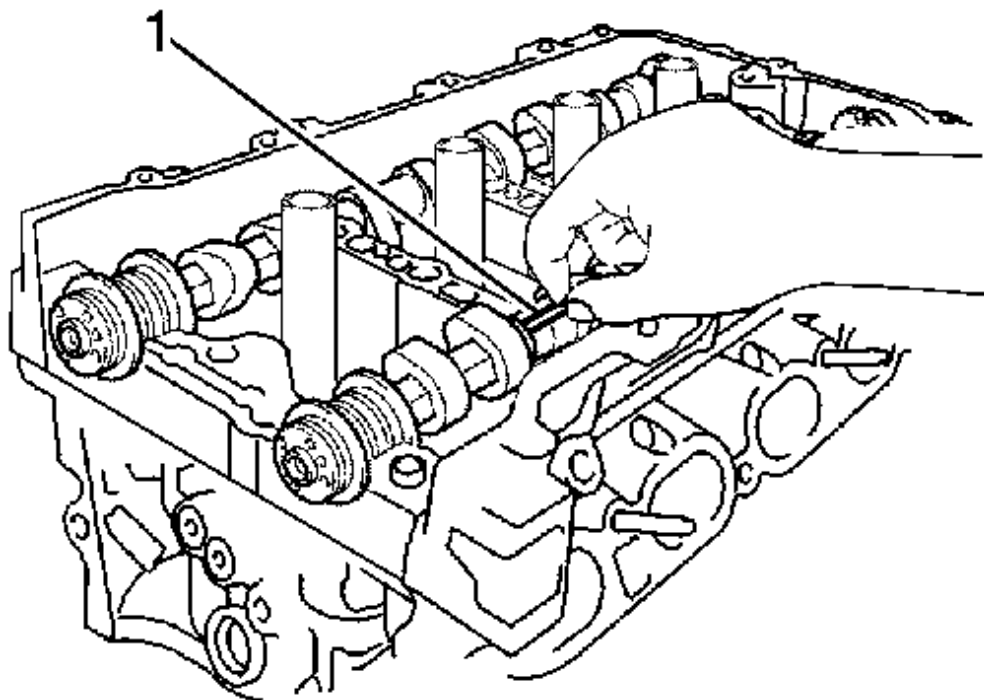


Fig. 423: Applying Plastigage Across Camshaft Journal
Courtesy of GENERAL MOTORS CORP.

14. Lay a strip of Plastigage across each of the camshaft journals.

NOTE: **Do not turn the camshaft.**

15. Install the bearing caps.
16. Remove the bearing caps.

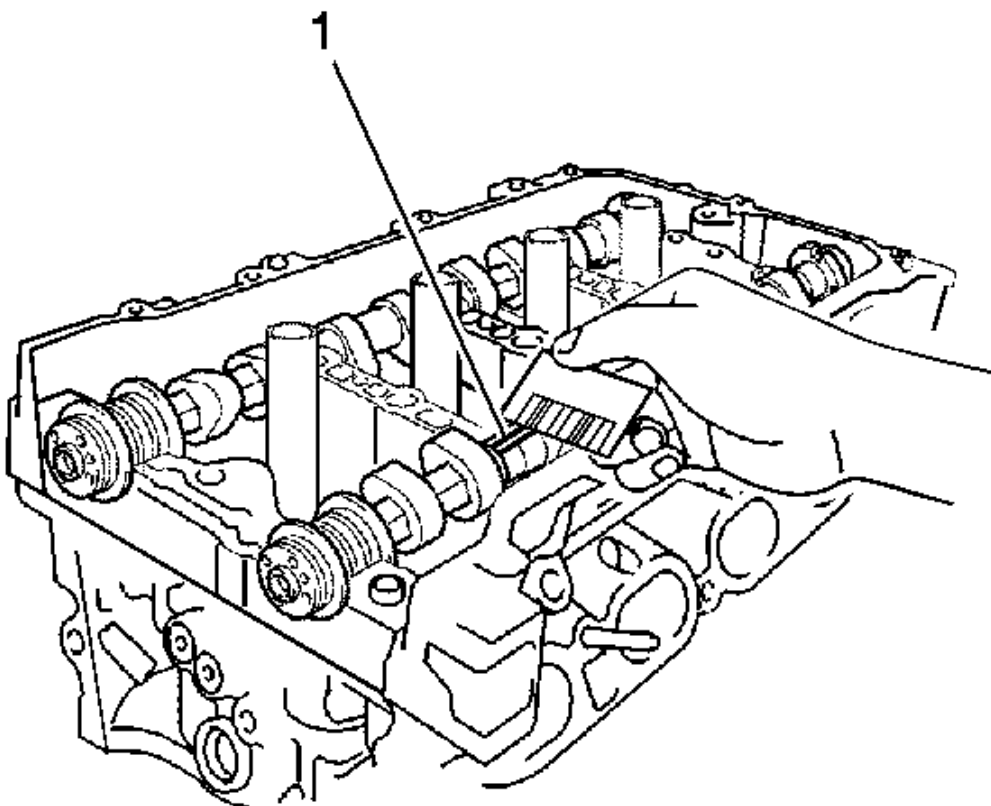


Fig. 424: Measuring Plastigage At Widest Point
Courtesy of GENERAL MOTORS CORP.

NOTE: Completely remove the Plastigage after the inspection.

17. Measure the Plastigage at its widest point.
18. If the oil clearance is greater than the maximum, replace the camshaft. If necessary, replace the cylinder head.

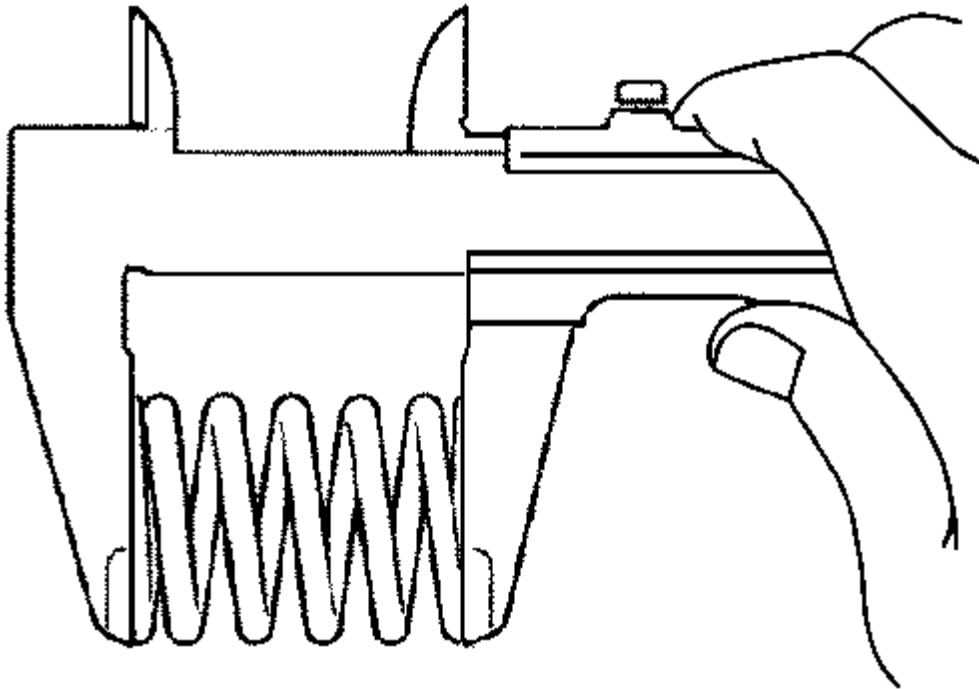


Fig. 425: Inspecting Compression Spring
Courtesy of GENERAL MOTORS CORP.

19. Inspect compression spring.
20. Using vernier calipers, measure the free length of the valve spring.

Specification: Free length: 53.36 mm (2.1008 in)

21. If the free length is not as specified, replace the valve spring.

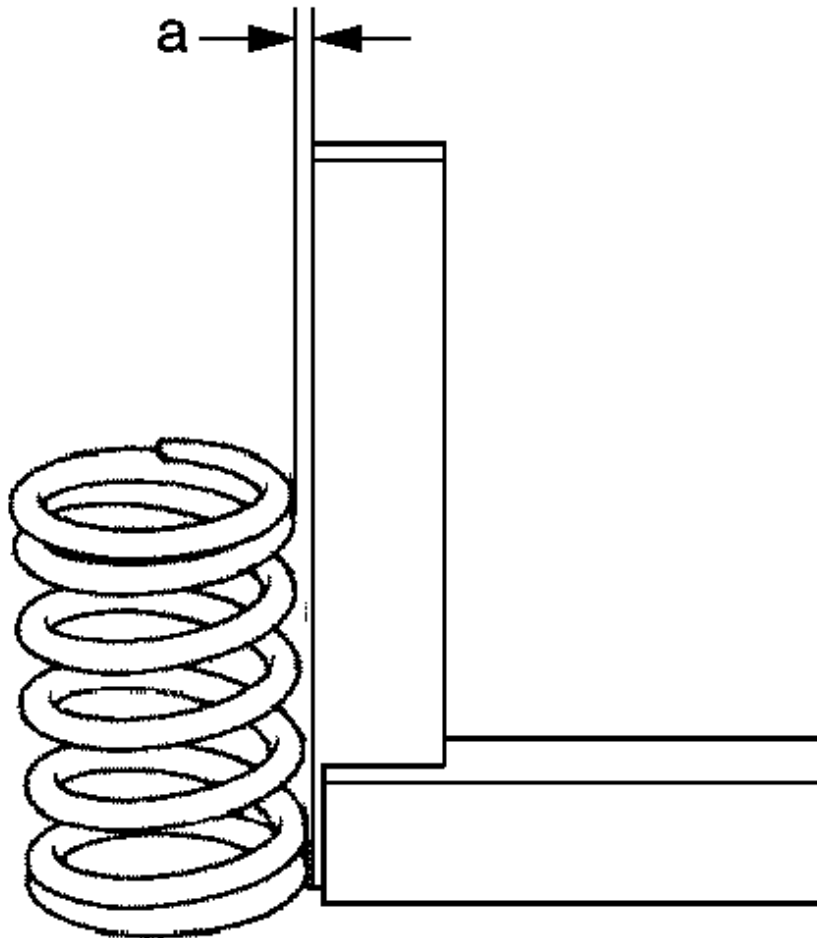


Fig. 426: Measuring Spring Deviation
Courtesy of GENERAL MOTORS CORP.

22. Using a steel square, measure the deviation of the valve spring.

Specification: Maximum deviation: 1.0 mm (0.0394 in)

23. If the deviation is greater than the maximum, replace the valve spring.

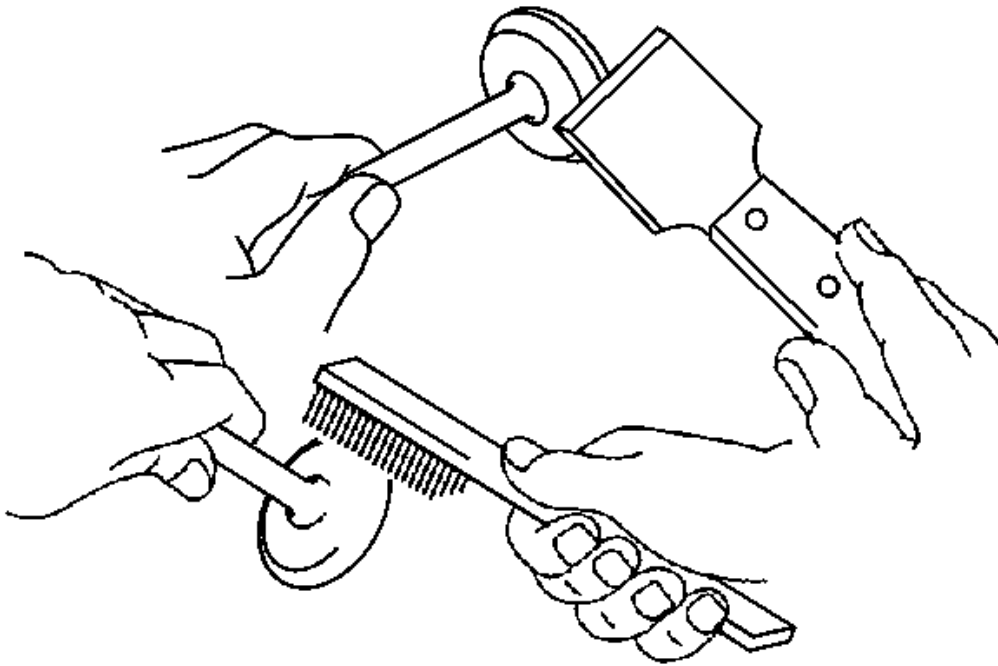


Fig. 427: Cleaning & Inspecting Valve
Courtesy of GENERAL MOTORS CORP.

24. Inspect intake valve.
25. Using a gasket scraper and wire brush, scrape off any carbon on the valve head.

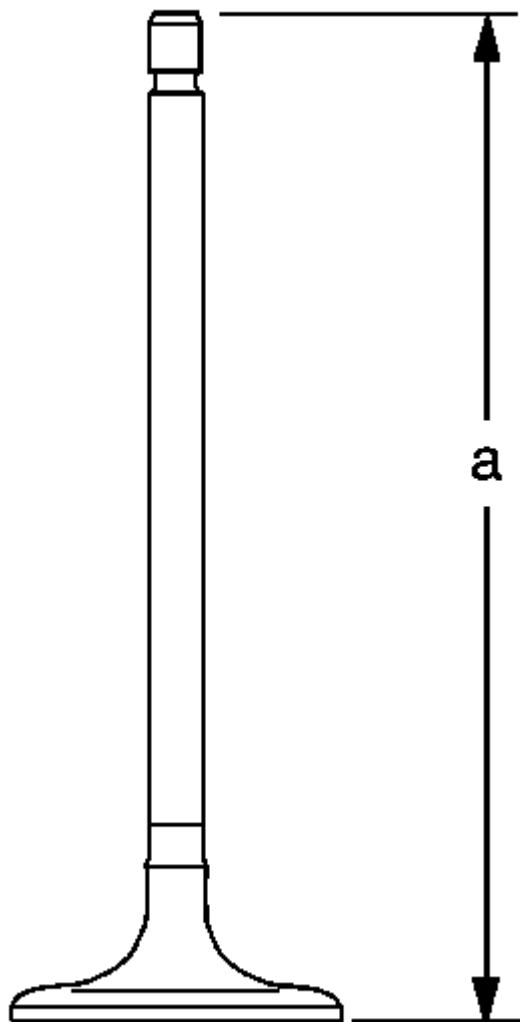


Fig. 428: Measuring Overall Valve Length
Courtesy of GENERAL MOTORS CORP.

26. Using vernier calipers, measure the overall length of the valve.

Specification:

- Standard overall length: 109.34 mm (4.3047 in).
- Minimum overall length: 108.84 mm (4.2850 in).

27. If the overall length is less than the minimum, replace the valve.

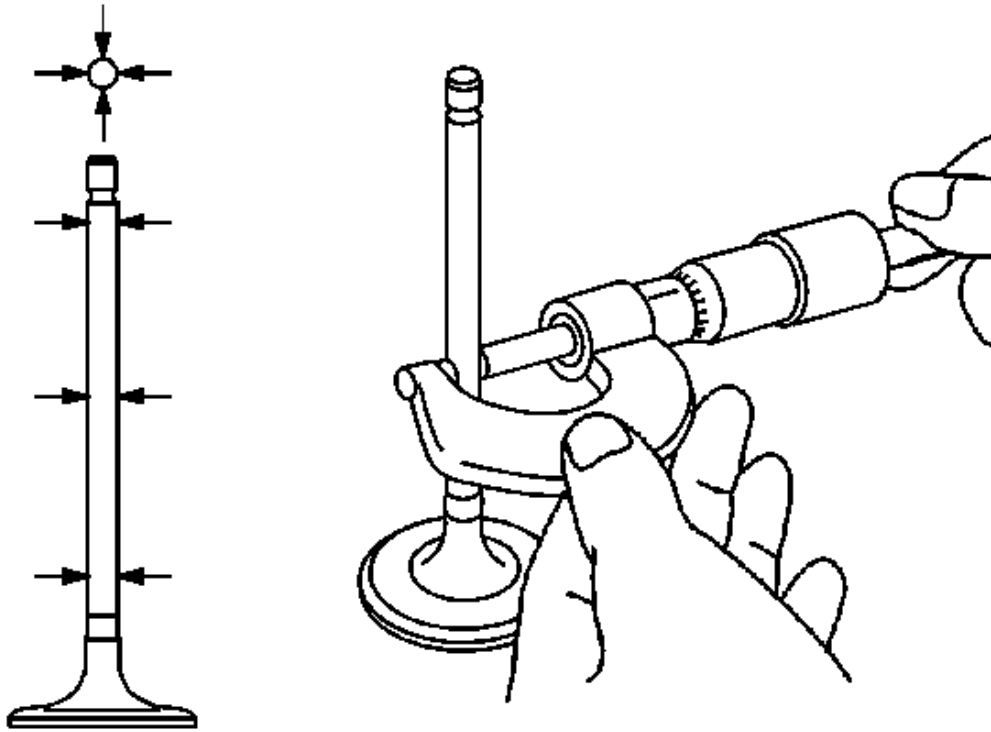


Fig. 429: Measuring Valve Stem Using Micrometer
Courtesy of GENERAL MOTORS CORP.

28. Using a micrometer, measure the diameter of the valve stem.

Specification: Valve stem diameter: 5.470 to 5.485 mm (0.2154 to 0.2159 in)

29. If the valve stem diameter is not as specified, check the oil clearance.

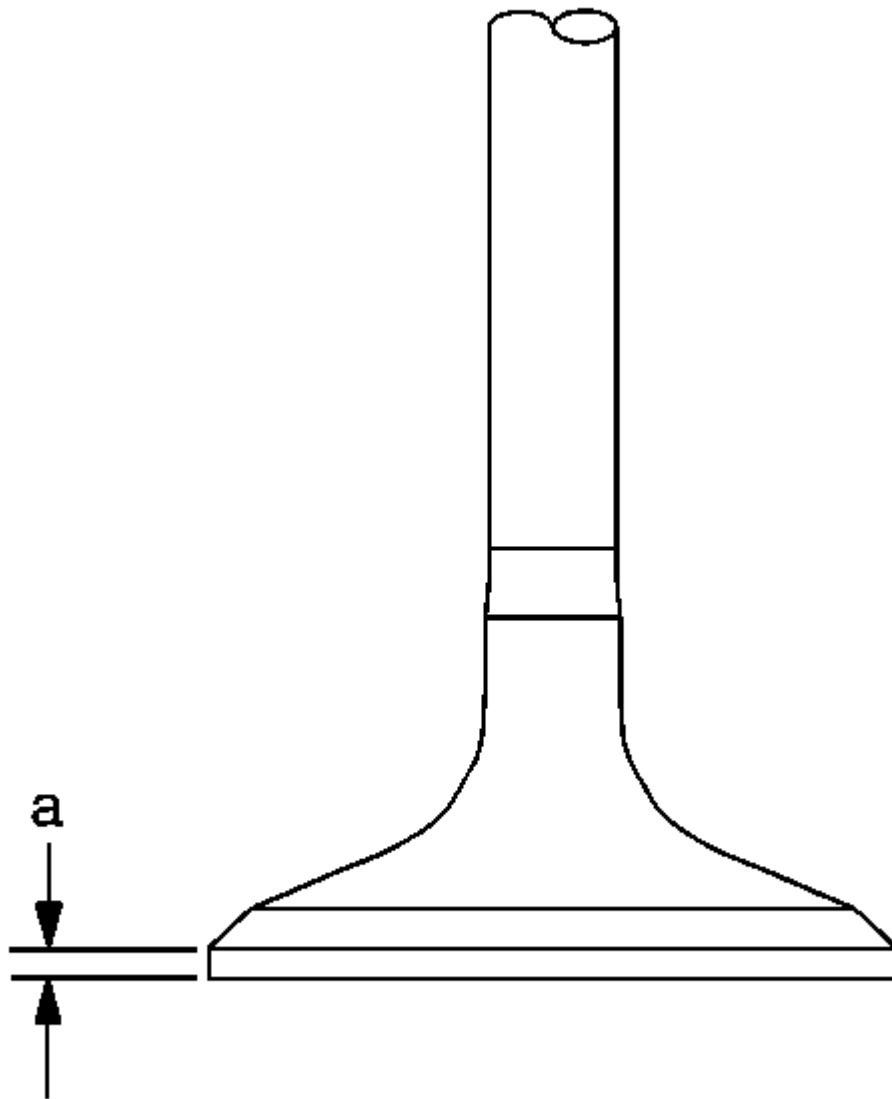


Fig. 430: Identifying Valve Head Margin Thickness
Courtesy of GENERAL MOTORS CORP.

30. Using vernier calipers, measure the valve head margin thickness.

Specification:

- Standard margin thickness: 1.0 mm (0.0394 in)
- Minimum margin thickness: 0.5 mm (0.0197 in)

31. If the margin thickness is less than the minimum, replace the valve.

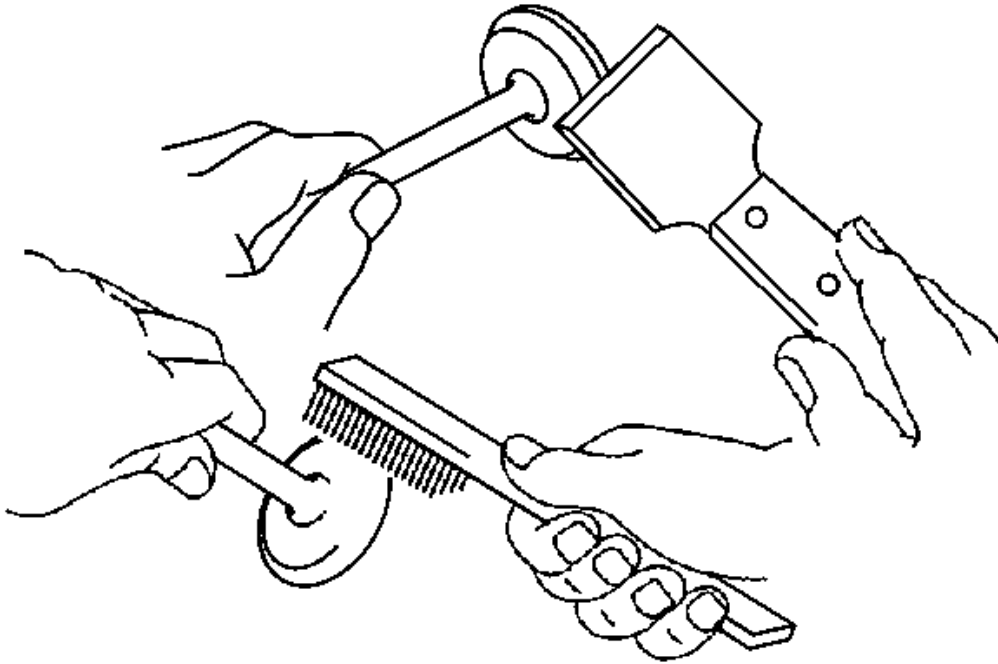


Fig. 431: Cleaning & Inspecting Valve
Courtesy of GENERAL MOTORS CORP.

32. Inspect the exhaust valve.
33. Using a gasket scraper and wire brush, scrape off any carbon on the valve head.

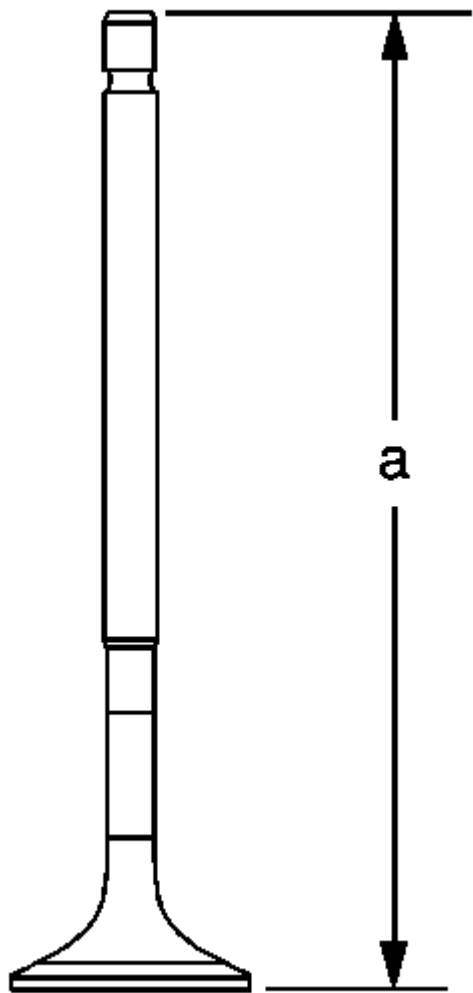


Fig. 432: Measuring Overall Valve Length
Courtesy of GENERAL MOTORS CORP.

34. Using vernier calipers, measure the overall length of the valve.

Specification:

- Standard overall length: 109.34 mm (4.3047 in)
- Minimum overall length: 108.84 mm (4.2850 in)

35. If the overall length is less than the minimum, replace the valve.

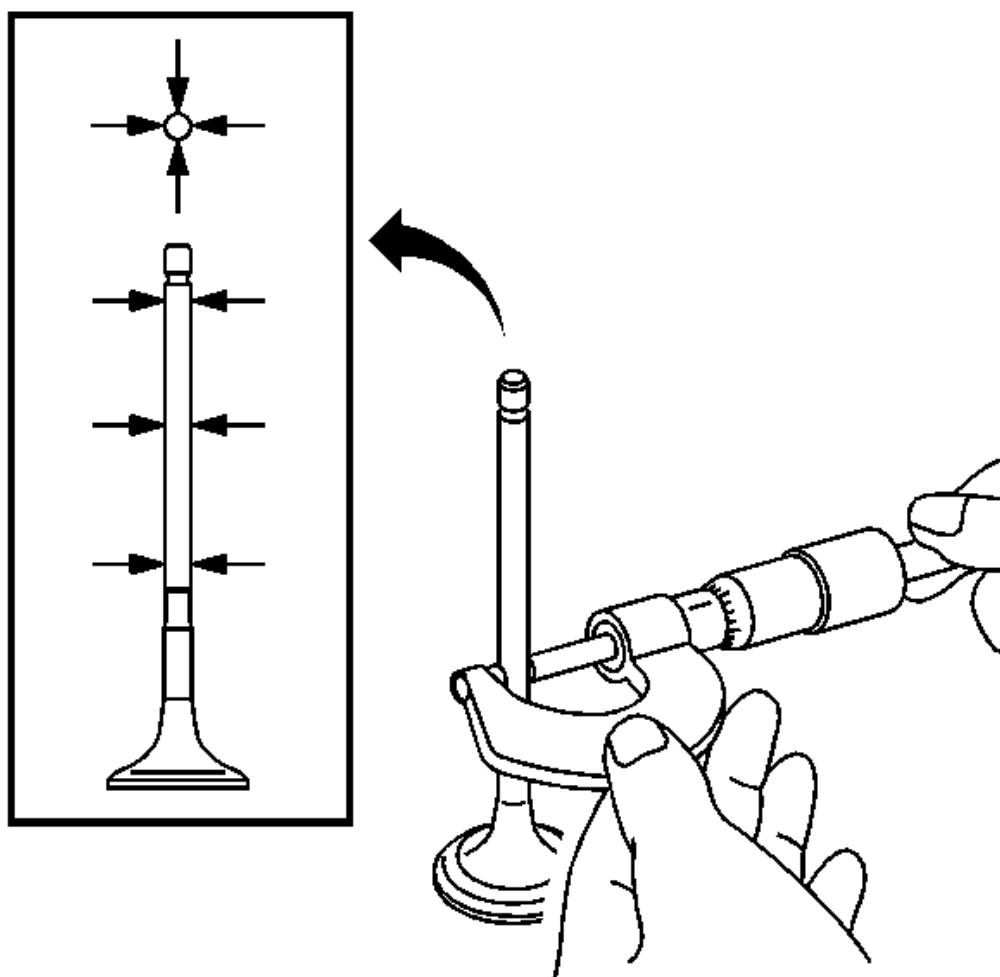


Fig. 433: Measuring Valve Stem Using Micrometer
Courtesy of GENERAL MOTORS CORP.

36. Using a micrometer, measure the diameter of the valve stem.

Specification: Valve stem diameter: 5.470 to 5.485 mm (0.2154 to 0.2159 in)

37. If the valve stem diameter is not as specified, check the oil clearance.

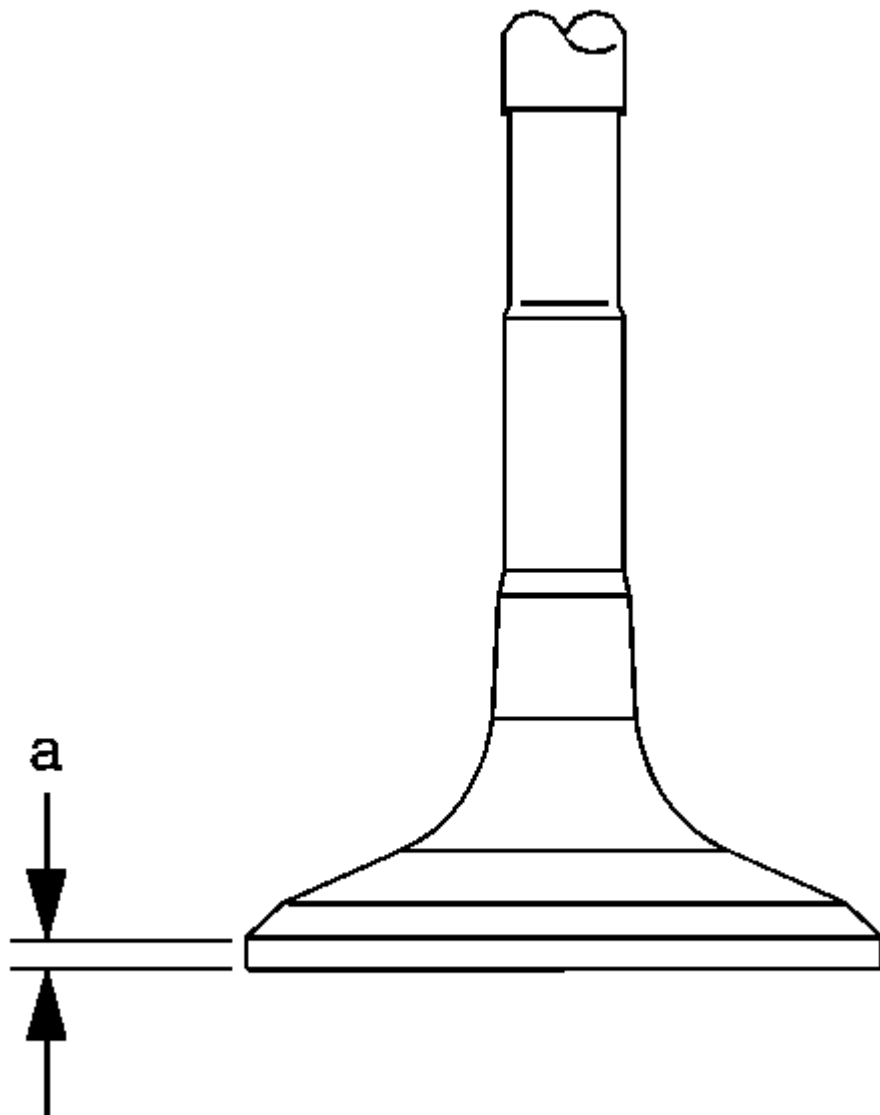


Fig. 434: Measuring Valve Head Margin
Courtesy of GENERAL MOTORS CORP.

38. Using vernier calipers, measure the valve head margin thickness.

Specification:

- Standard margin thickness: 1.0 mm (0.0394 in)
- Minimum margin thickness: 0.5 mm (0.0197 in)

39. If the margin thickness is less than the minimum, replace the valve.

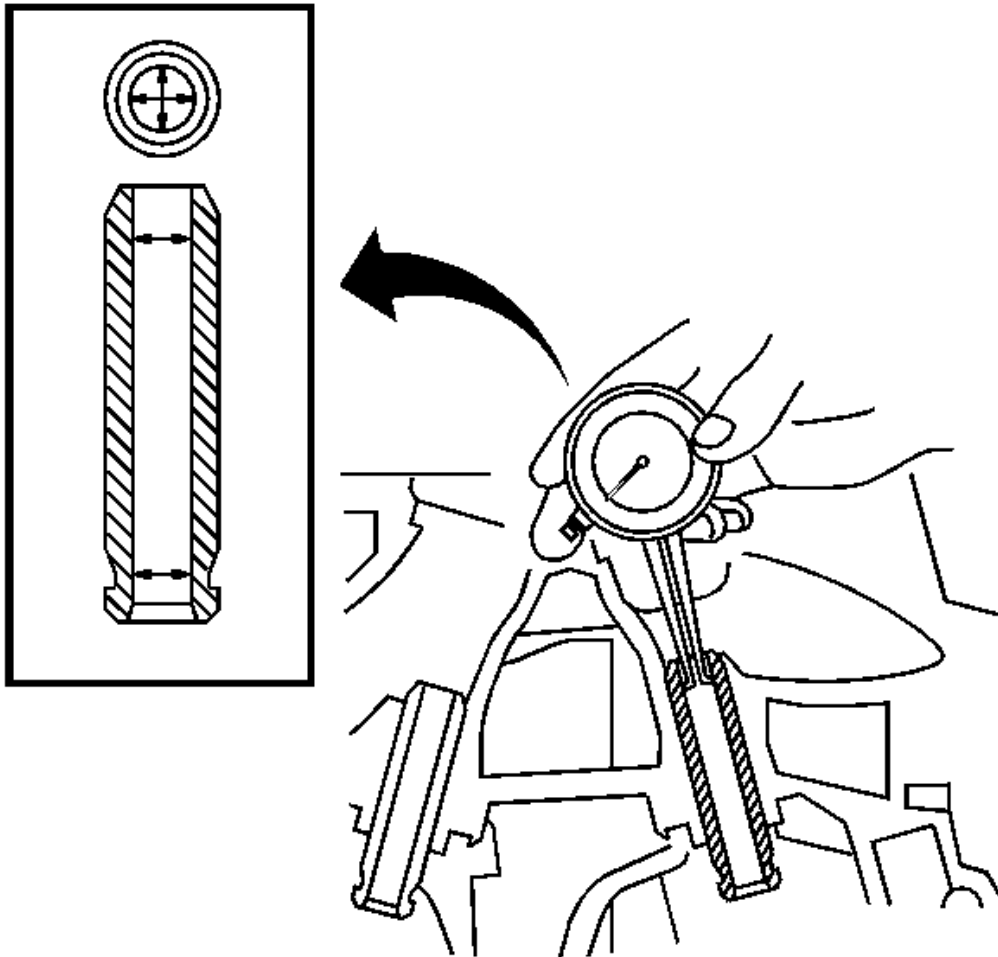


Fig. 435: Inspecting Valve Guide Bush Oil Clearance
Courtesy of GENERAL MOTORS CORP.

40. Inspect valve guide bush oil clearance.
41. Using a caliper gauge, measure the inside diameter of the guide bush.

Specification: Bushing inside diameter: 5.510 to 5.530 mm (0.2169 to 0.2177 in)

42. Subtract the valve stem diameter measurement from the guide bush inside diameter measurement.
43. If the clearance is greater than the maximum, replace the valve and guide bush.

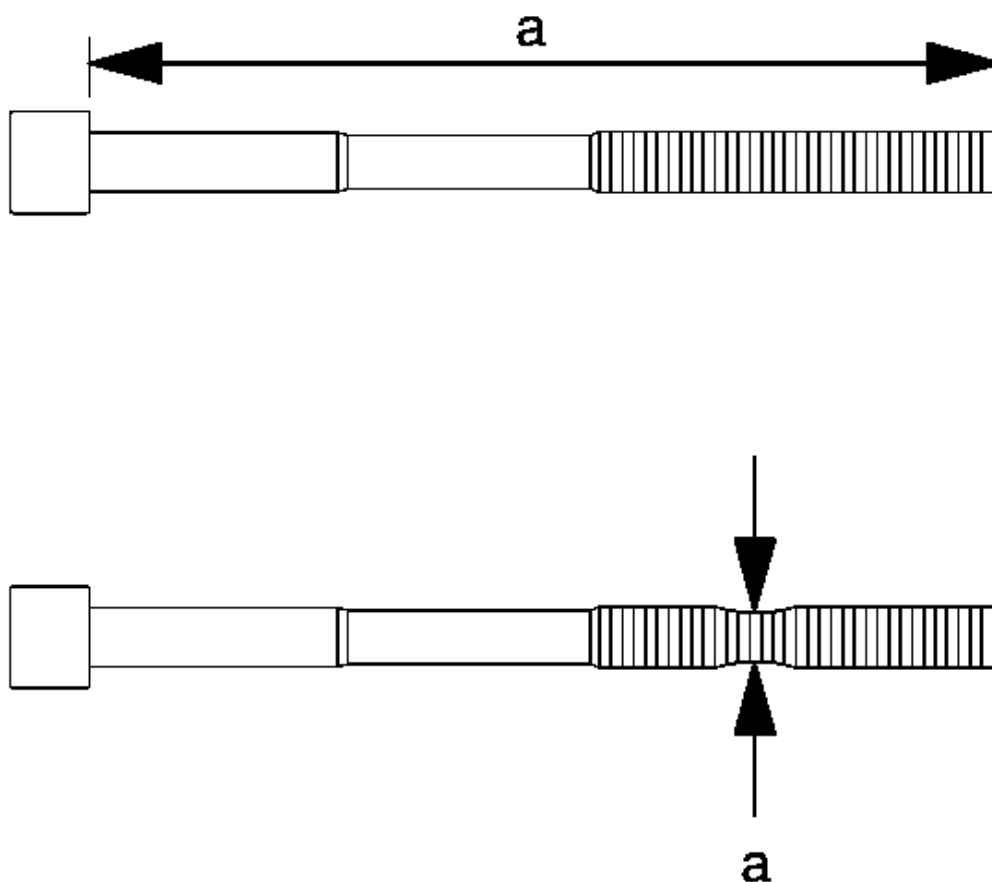


Fig. 436: Inspecting Cylinder Head Set Bolt
Courtesy of GENERAL MOTORS CORP.

44. Inspect the cylinder head set bolt.

Using vernier calipers, measure the length of the cylinder head set bolt from the seat to the end.

If the bolt length is greater than the maximum, replace the cylinder head set bolt.

Specification:

- Standard bolt length: 146.8-148.2 mm (5.7795-5.8346 in)
- Maximum bolt length: 149.2 mm (5.874 in)

NOTE: Using a straightedge, visually check the thinner areas of the threaded part of the cylinder head set bolt.

2009 Pontiac Vibe

2009 ENGINE Engine Mechanical - 1.8L (LAY) - Vibe

45. Using vernier calipers, measure the minimum diameter of the elongated thread at the measuring point.

If the diameter is less than the minimum, replace the cylinder head set bolt.

Specification: Maximum warpage: 0.7 mm (0.028 in)

Maximum Warpage

Item	Specified Condition
Cylinder block side	0.05 mm (0.0020 in)
Intake manifold side	0.10 mm (0.0039 in)
Exhaust manifold side	0.10 mm (0.0039 in)

Standard Thrust Clearance

Item	Specified Condition
Intake	0.06 to 0.155 mm (0.0024 to 0.0061 in)
Exhaust	0.06 to 0.155 mm (0.0024 to 0.0061 in)

Maximum Thrust Clearance

Item	Specified Condition
Intake	0.17 mm (0.0067 in)
Exhaust	0.17 mm (0.0067 in)

Standard Oil Clearance

Item	Specified Condition
Camshaft No. 1 journal	0.085 mm (0.0033 in)
Camshaft other journals	0.09 mm (0.0035 in)

Maximum Oil Clearance

Item	Specified Condition
Intake	0.080 mm (0.0031 in)
Exhaust	0.085 mm (0.0033 in)

VALVE GUIDE REAMING, AND VALVE AND SEAT GRINDING

Valve Guides

1. Replace intake valve guide bush.
2. Heat the cylinder head to 80-100°C (176-212°F).
3. Place the cylinder head on wooden blocks.

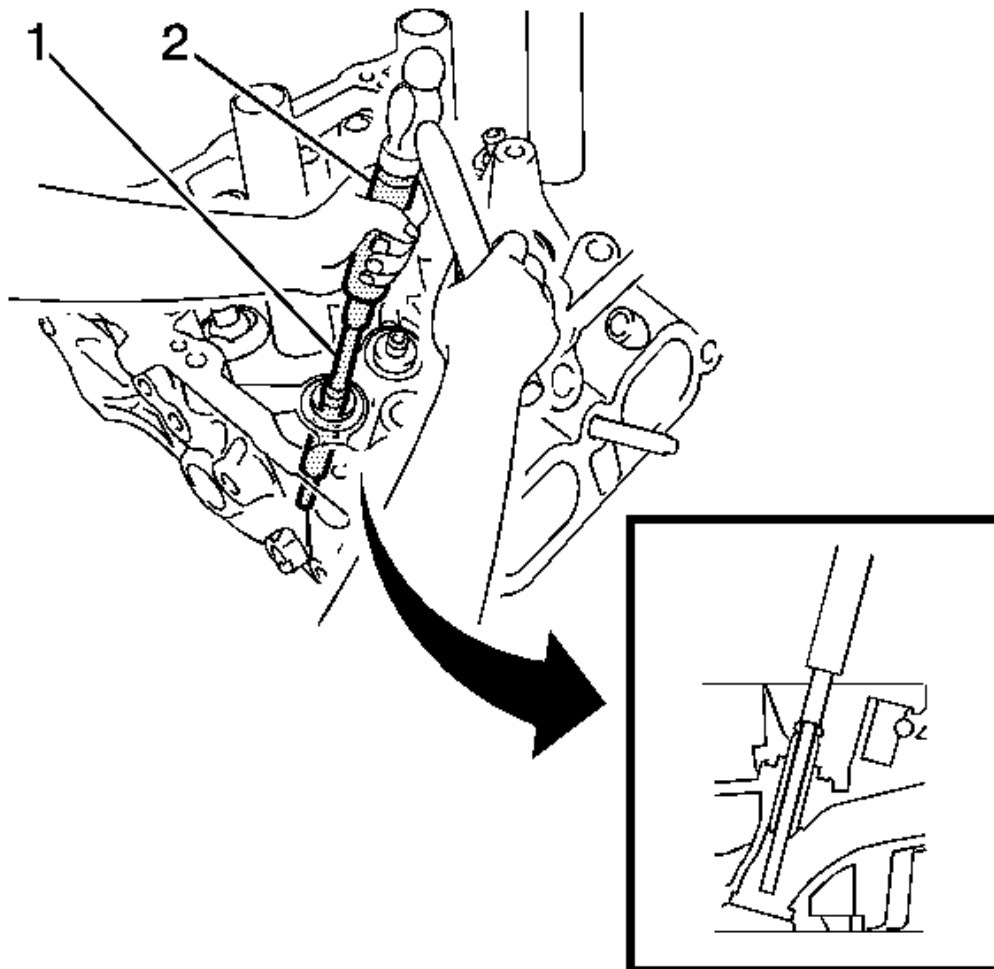


Fig. 437: Tapping Out Guide Bush
Courtesy of GENERAL MOTORS CORP.

4. Using SST and a hammer, tap out the guide bush.

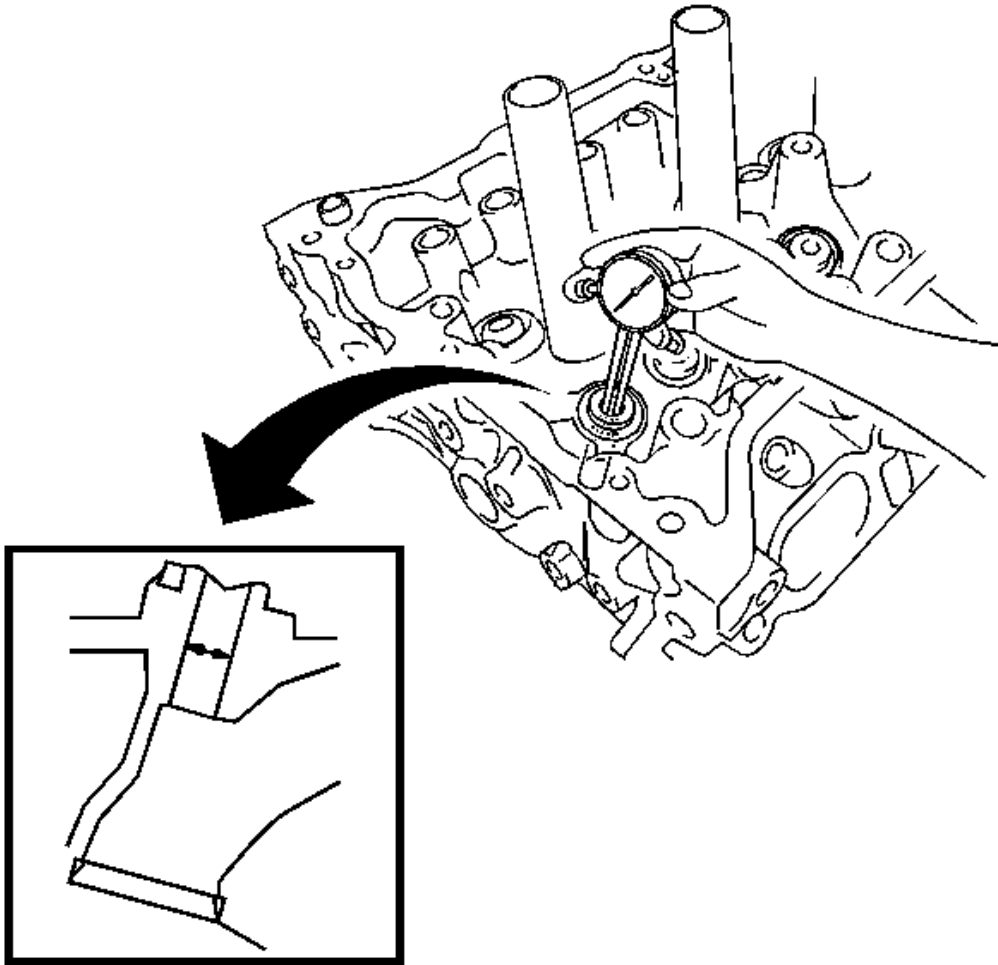


Fig. 438: Measuring Bush Bore Diameter
Courtesy of GENERAL MOTORS CORP.

5. Using a caliper gauge, measure the bush bore diameter of the cylinder head.

Specification: Cylinder bore diameter: 10.285 to 10.306 mm (0.4049 to 0.4057 in)

6. Select a new guide bush (STD or O/S 0.05).
7. If the bush bore diameter of the cylinder head is greater than 10.306 mm (0.4057 in), machine the bush bore to the dimension of 10.335 to 10.356 mm (0.4069 to 0.4077 in) to install an O/S 0.05 valve guide bush. If the bush bore diameter of the cylinder head is greater than 10.356 mm (0.4077 in), replace the cylinder head.
8. Heat the cylinder head to 80-100°C (176-212°F).

9. Place the cylinder head on wooden blocks.

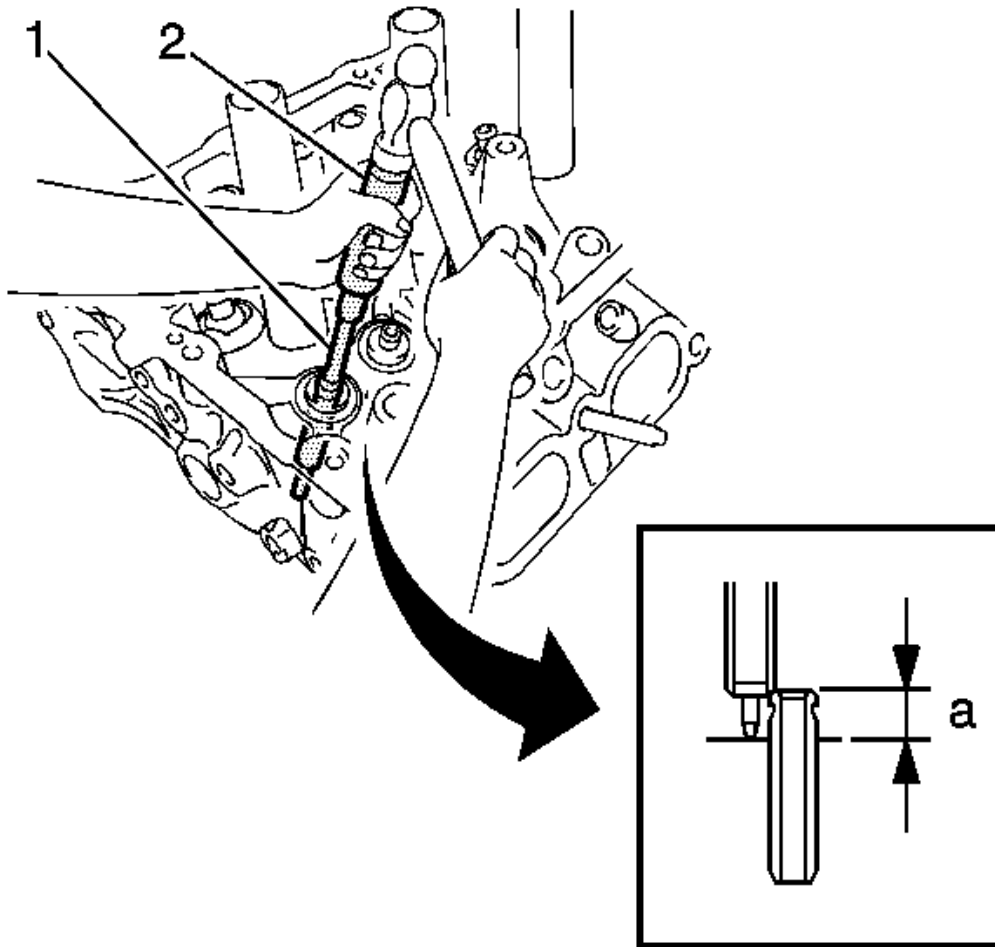


Fig. 439: Tapping In Guide Bush
Courtesy of GENERAL MOTORS CORP.

10. Using SST and a hammer, tap in a new guide bush to the specified protrusion height.

Specification: Protrusion height: 9.9-10.3 mm (0.3898-0.4055 in)

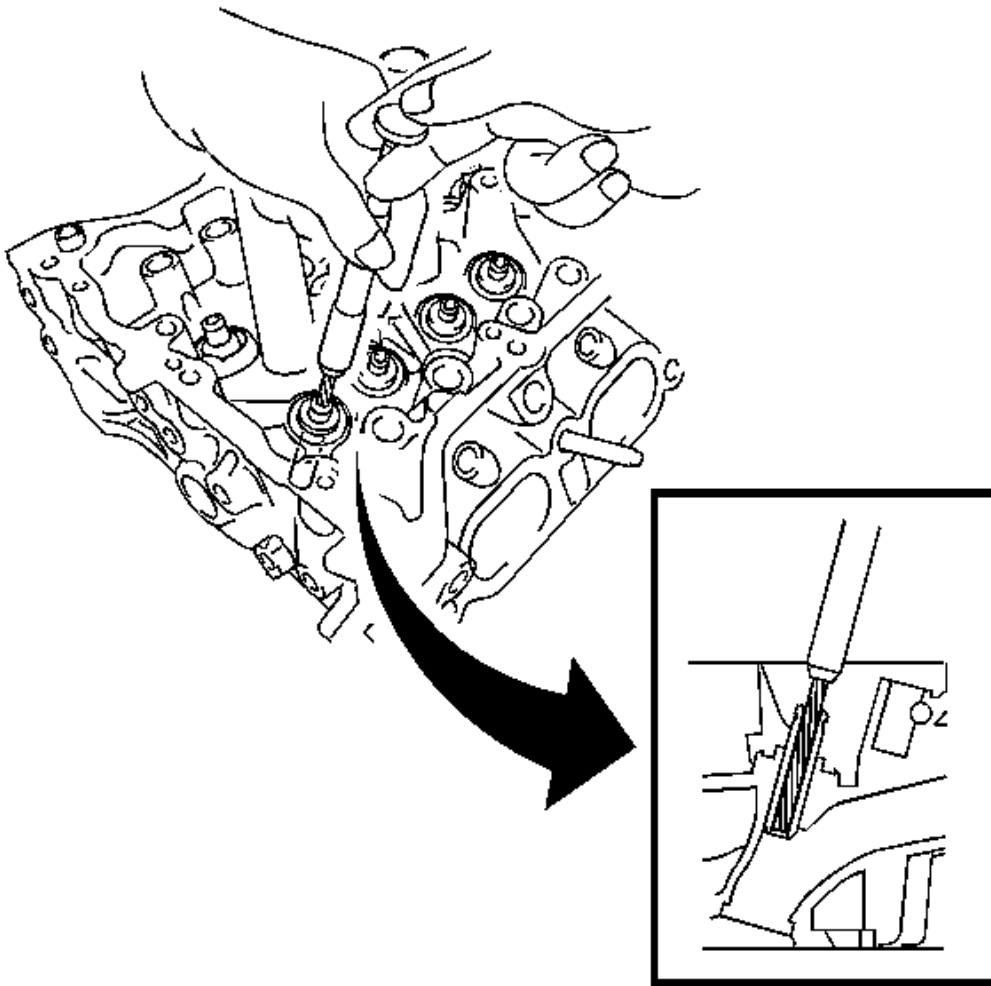


Fig. 440: Reaming Guide Bush
Courtesy of GENERAL MOTORS CORP.

11. Using a sharp 5.5 mm reamer, ream the guide bush to obtain the standard clearance between the guide bush and valve stem.

Specification: Standard oil clearance: 0.025-0.060 mm (0.0010-0.0024 in)

12. Replace the exhaust valve guide bush.
13. Heat the cylinder head to 80-100°C (176-212°F).
14. Place the cylinder head on wooden blocks.

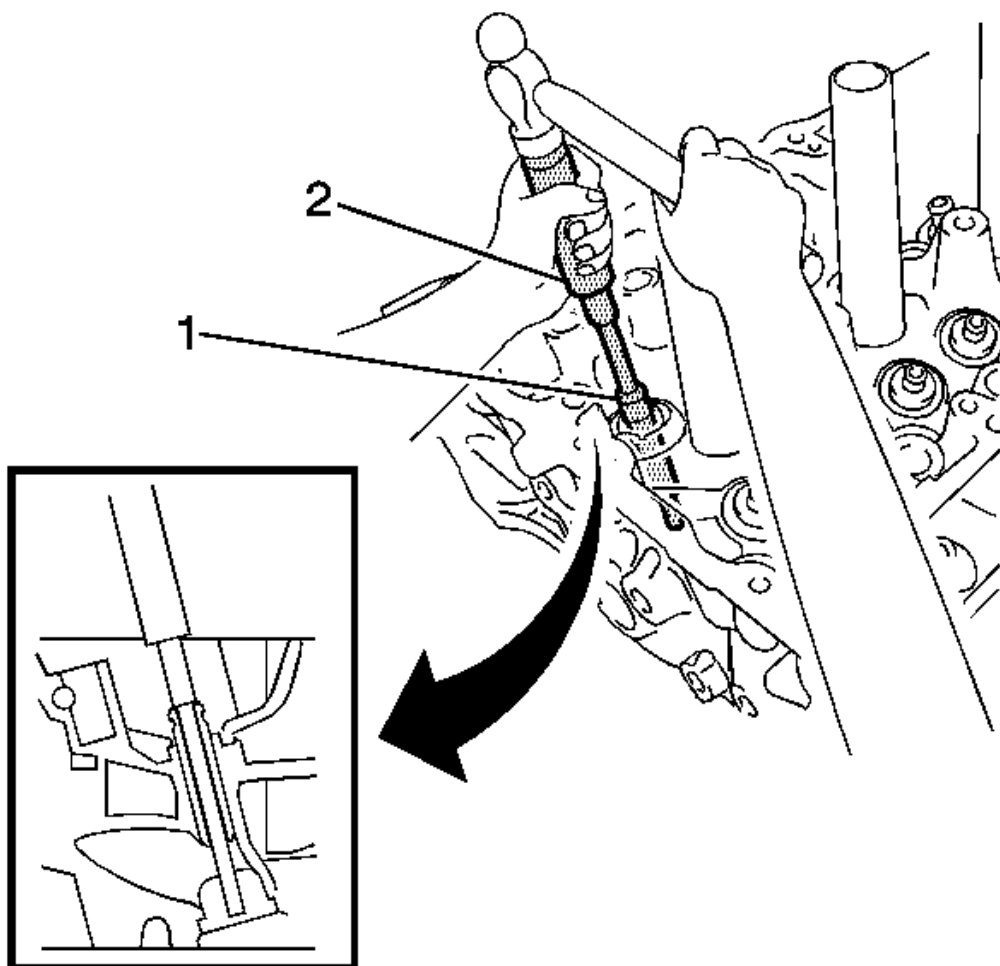


Fig. 441: Tapping Out Guide Bush
Courtesy of GENERAL MOTORS CORP.

15. Using SST and a hammer, tap out the guide bush.

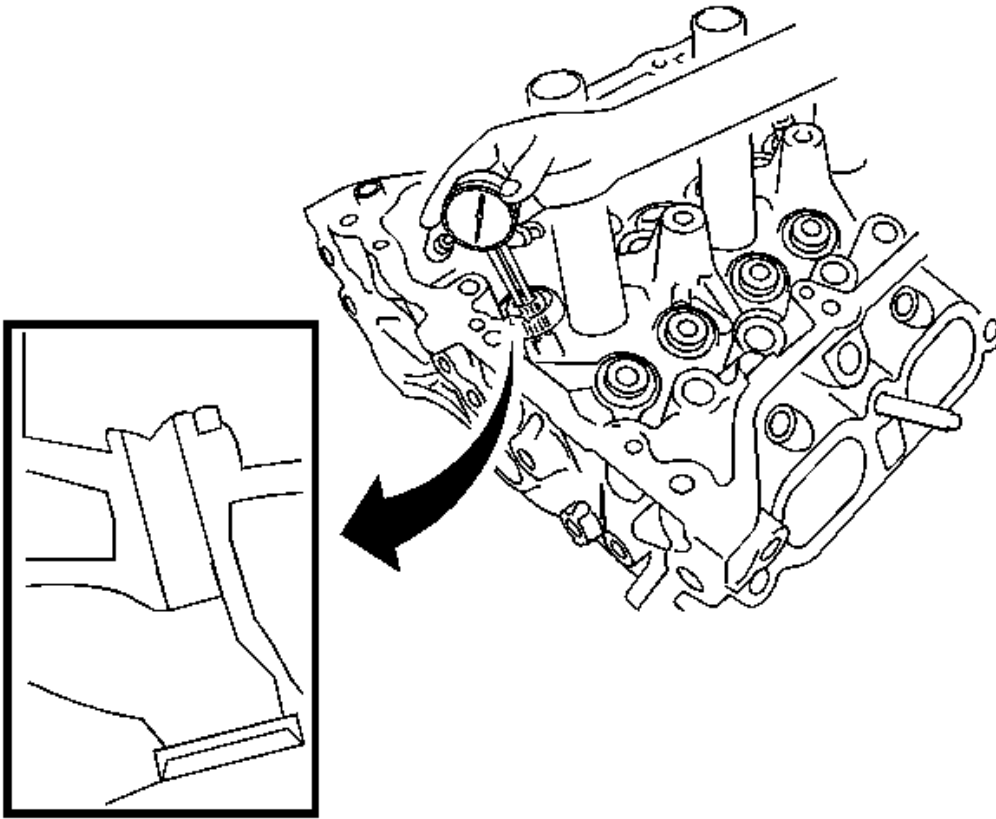


Fig. 442: Measuring Bush Bore Diameter
Courtesy of GENERAL MOTORS CORP.

16. Using a caliper gauge, measure the bush bore diameter of the cylinder head.

Diameter: 10.285-10.306 mm (0.4049-0.4057 in) Select a new guide bush (STD or O/S 0.05)

17. If the bush bore diameter of the cylinder head is greater than 10.306 mm (0.4057 in), machine the bush bore to the dimension of 10.335 to 10.356 mm (0.4069 to 0.4077 in) to install an O/S 0.05 valve guide bush. If the bush bore diameter of the cylinder head is greater than 10.356 mm (0.4077 in), replace the cylinder head.
18. Heat the cylinder head to 80-100°C (176-212°F).
19. Place the cylinder head on wooden blocks.

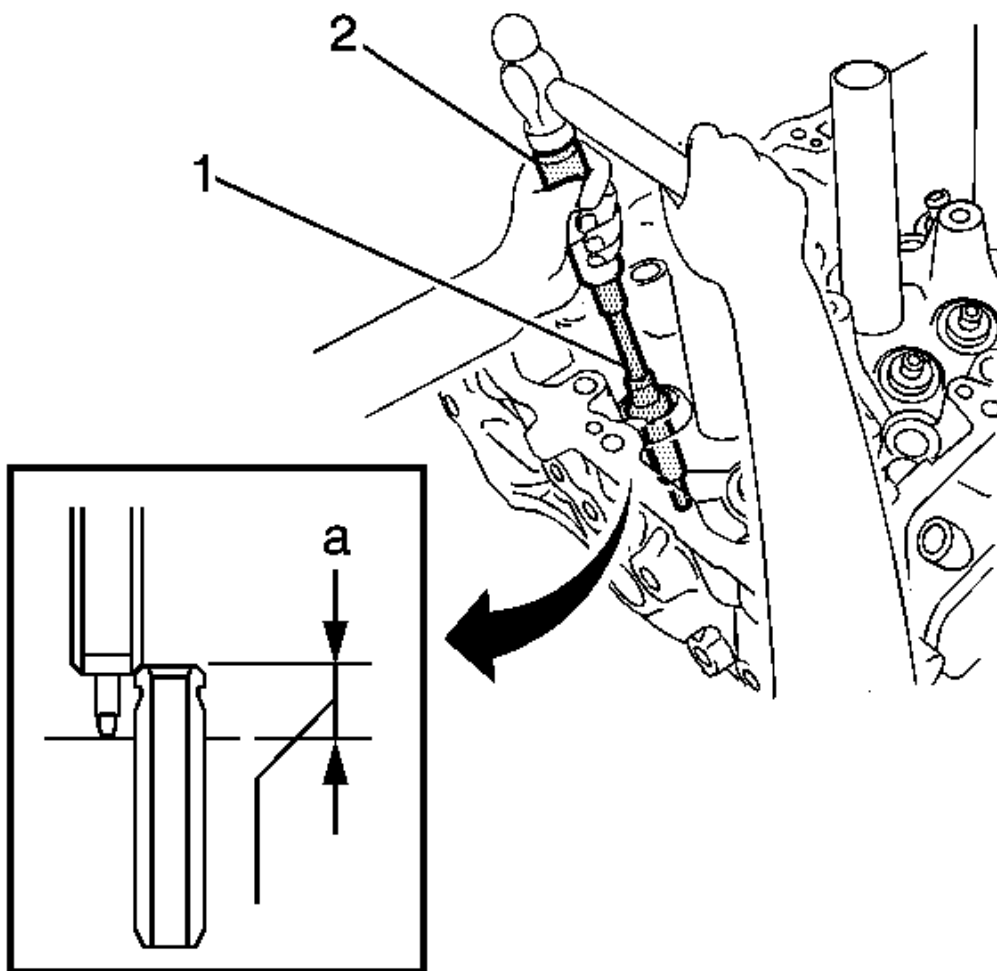


Fig. 443: Tapping In Guide Bush
Courtesy of GENERAL MOTORS CORP.

20. Using SST and a hammer, tap in a new guide bush to the specified protrusion height.

Specification: Protrusion height: 11.15-11.55 mm (0.4390-0.4547 in.)

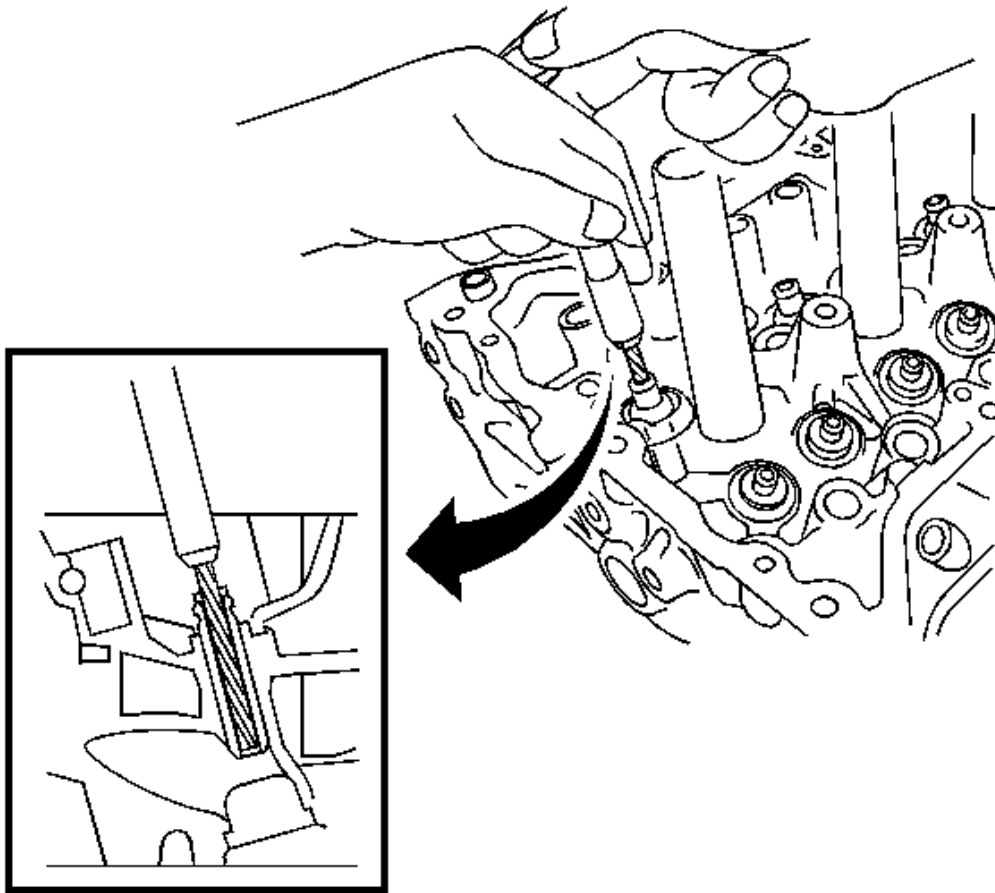


Fig. 444: Reaming Guide Bush

Courtesy of GENERAL MOTORS CORP.

21. Using a sharp 5.5 mm reamer, ream the guide bush to obtain the standard clearance between the guide bush and valve stem.

Specification: Standard oil clearance: 0.030- 0.065 mm (0.0012-0.0026 in)

IMPORTANT: It is not necessary to remove the ring pins unless they are being replaced.

22. Remove the ring pins.

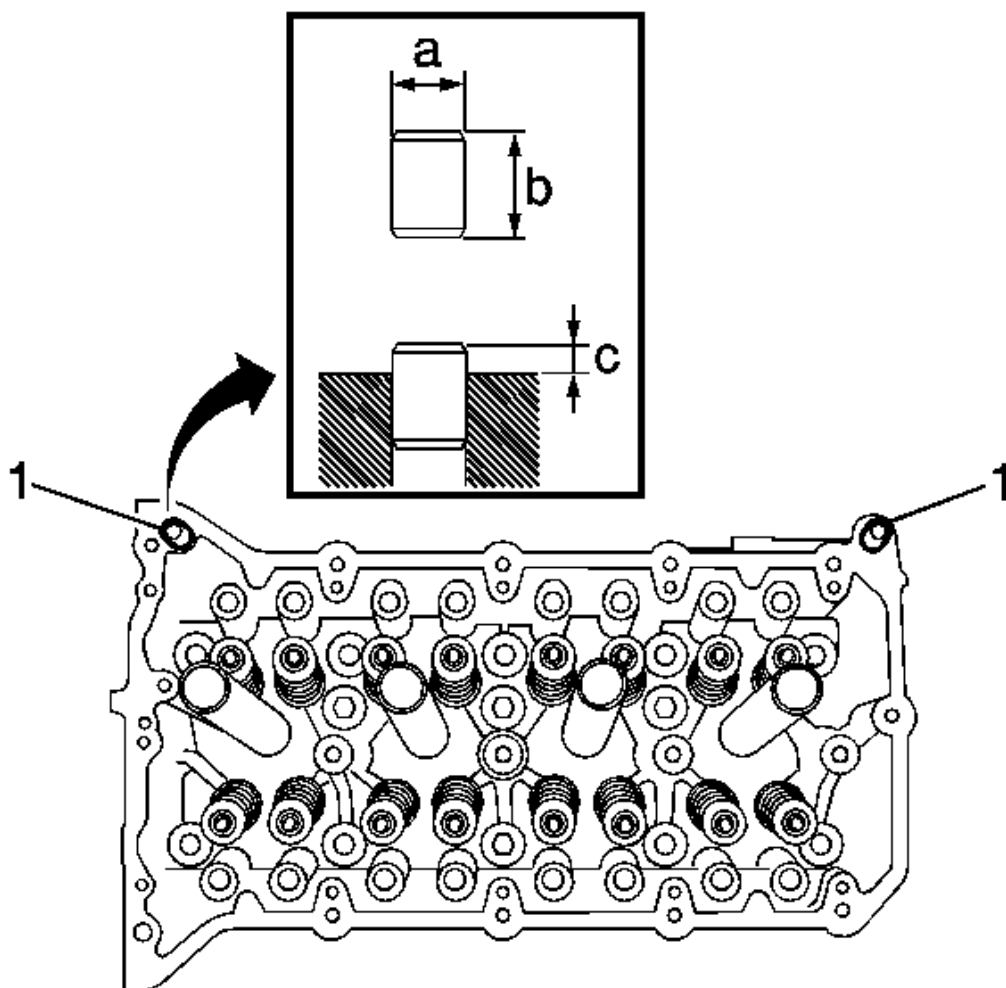


Fig. 445: Tapping In New Ring Pins To Specified Protrusion Height
Courtesy of GENERAL MOTORS CORP.

23. Using a plastic-faced hammer, tap in new ring pins to the specified protrusion height.

Specification: Protrusion height: 6.5-7.5 mm (0.26-0.30 in)

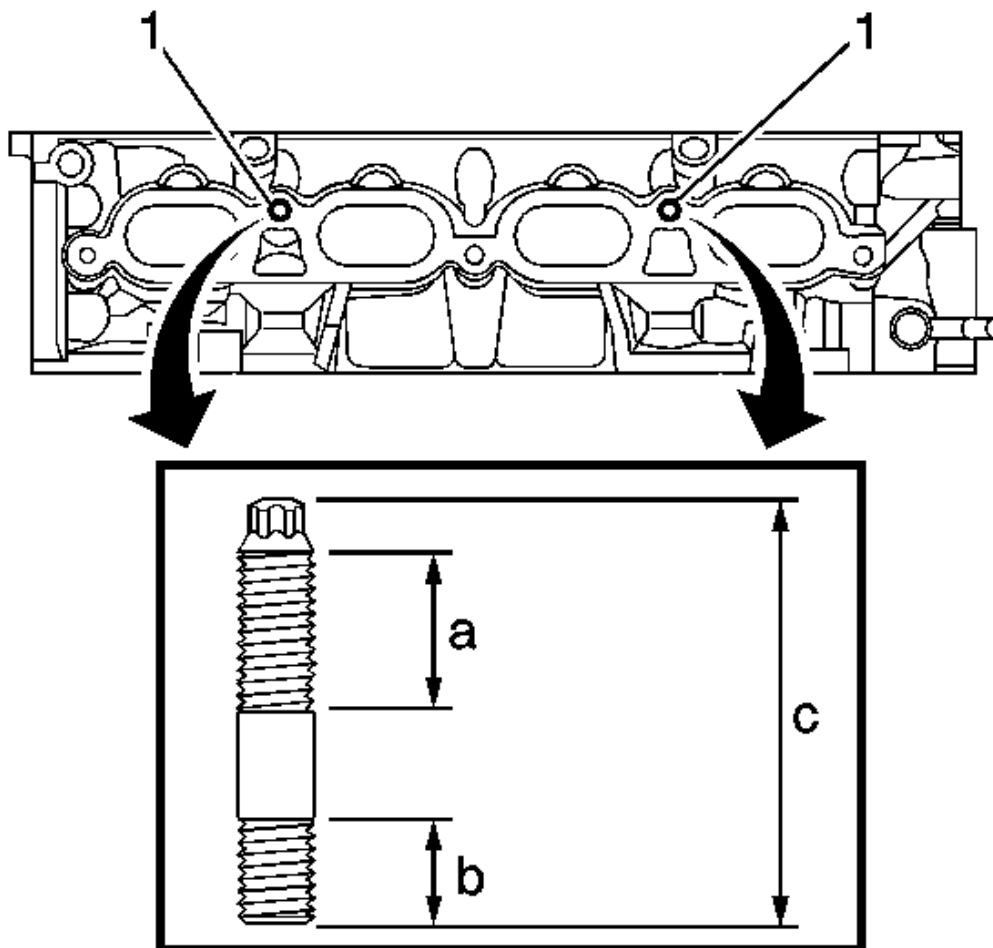


Fig. 446: Locating Stud Bolts

Courtesy of GENERAL MOTORS CORP.

NOTE: If any of the stud bolts is deformed or the threads are damaged, replace it.

24. Remove the stud bolts.

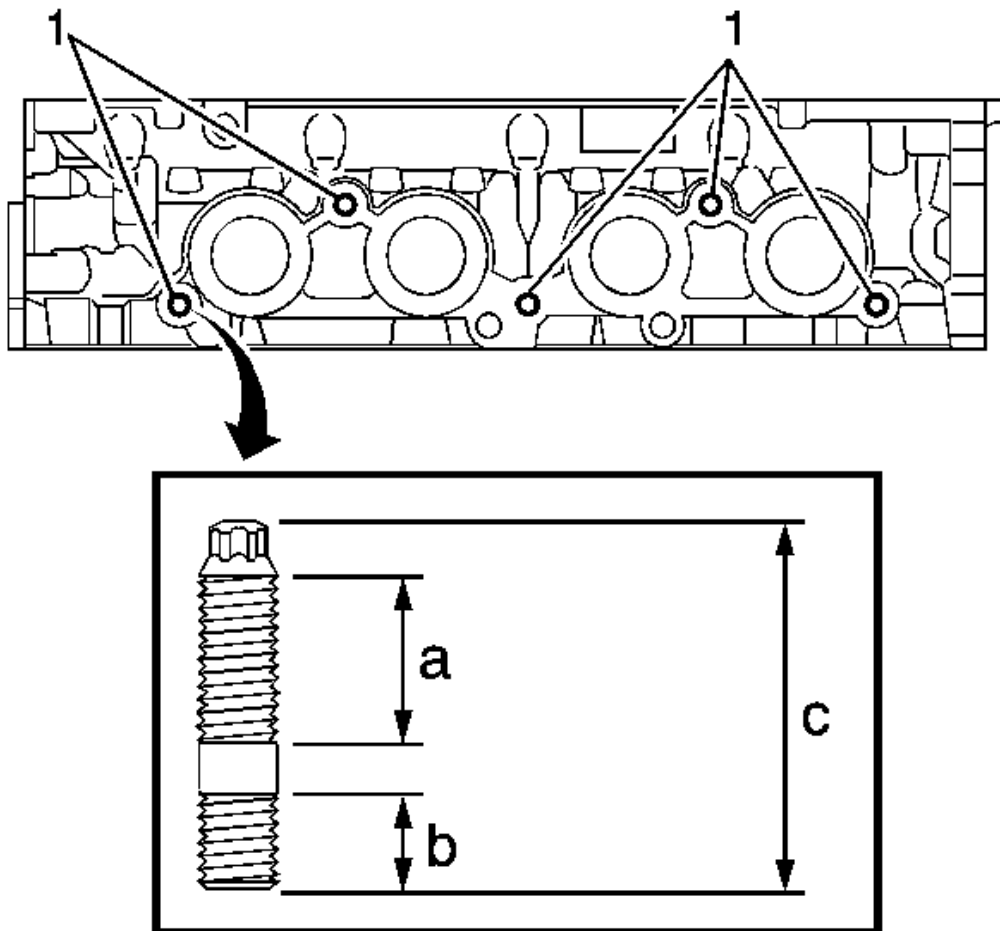


Fig. 447: View Of Stud Bolt Installation
Courtesy of GENERAL MOTORS CORP.

25. Using an E8 TORX socket, install the stud bolts.

Tighten: Tighten the bolts to 9.5 N.m (84 lb in).

Intake and Exhaust Valves

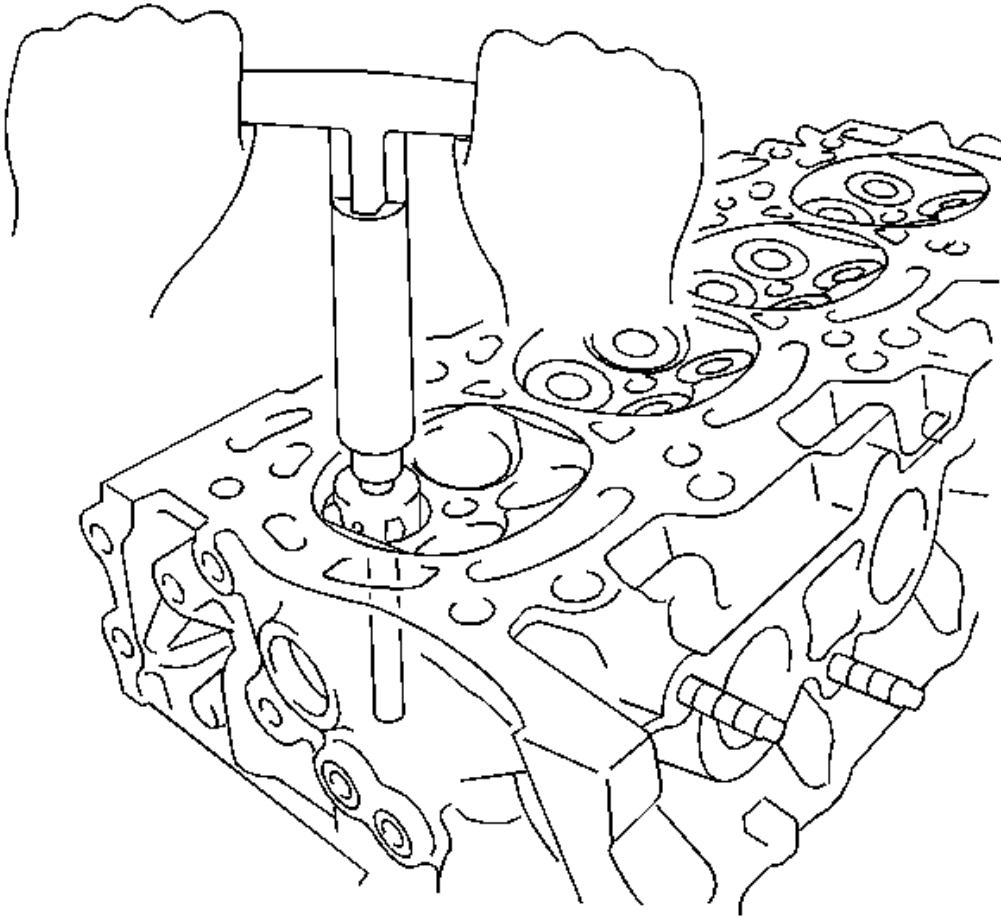


Fig. 448: View Of Valve Seat Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Repair the seat while checking the seating position.
- Keep the lip free of foreign matter.

1. Using a 45 degree cutter, resurface the valve seat so that the valve seat width is more than the specification.

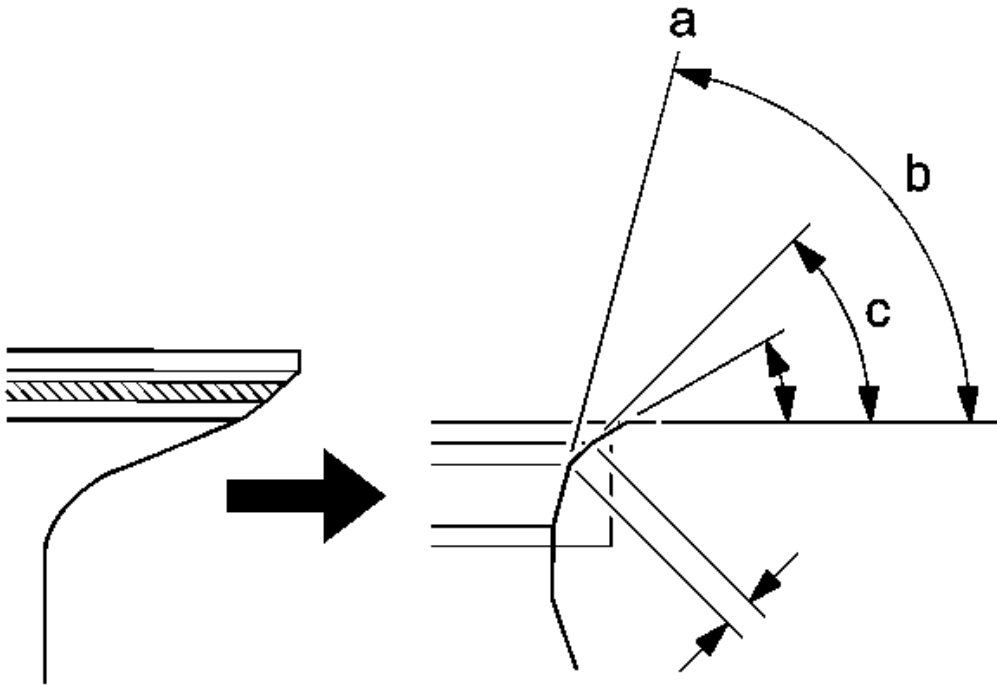


Fig. 449: Identifying Valve Face Angles
 Courtesy of GENERAL MOTORS CORP.

- Using 30 degree and 75 degree cutters, correct the valve seat so that the valve contacts the entire circumference of the seat. The contact should be in the center of the valve seat, and the valve seat width should be maintained within the specified range around the entire circumference of the seat.
- Handrub the valve and valve seat with an abrasive compound.
- Check the valve seating position.

Select A New Guide Bush (STD or O/S 0.05)

Bush Size	Bush Bore Diameter
STD	10.285 to 10.306 mm (0.4049 to 0.4057 in)
O/S 0.05	10.335 to 10.356 mm (0.4069 to 0.4077 in)

Valve Seat Width

Item	Specified Condition
Intake Side	1.0 to 1.4 mm (0.039 to 0.055 in)
Exhaust Side	1.0 to 1.4 mm (0.039 to 0.055 in)

CYLINDER HEAD ASSEMBLE

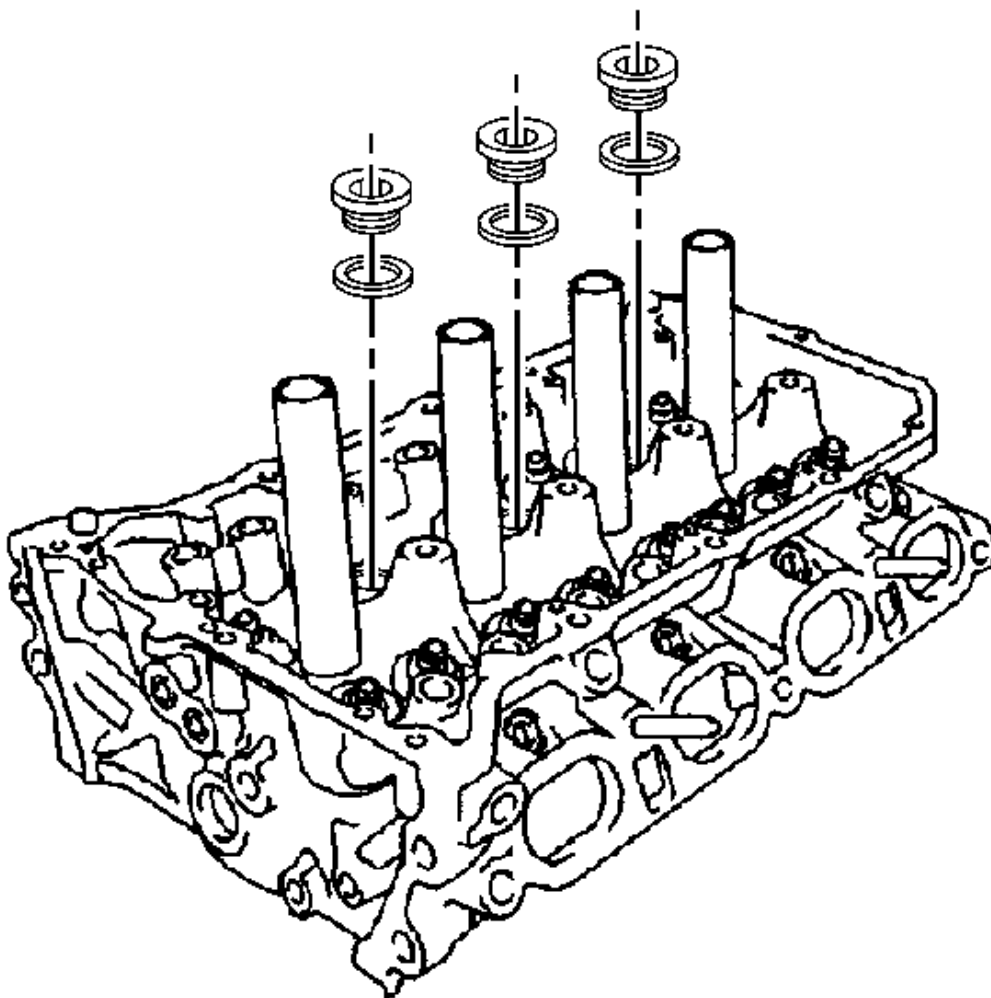


Fig. 450: View Of Straight Screw Plugs & Gaskets
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to **FASTENER CAUTION** .

1. Using a 10 mm straight hexagon wrench, install 3 new gaskets and the 3 No. 2 straight screw plugs.

Tighten: Tighten to 44 N.m (33 lb ft).

2. Install the valve spring seats to the cylinder head.

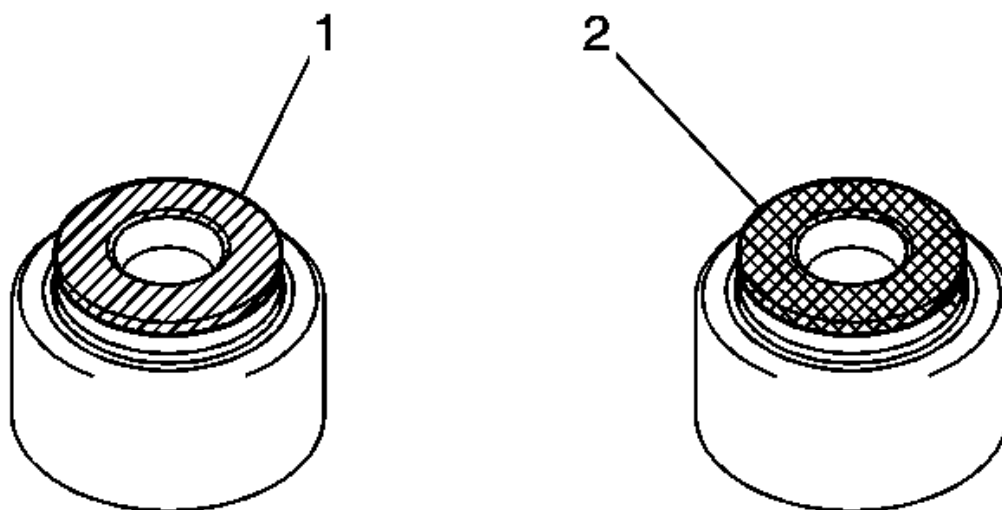


Fig. 451: View Of Valve Stem Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. Install valve stem oil seal.

IMPORTANT: Pay close attention when installing the intake and exhaust oil seals. Installing the intake oil seal into the exhaust side or installing the exhaust oil seal to the intake side may cause installation problems later.

IMPORTANT: The intake valve oil seal is gray and the exhaust valve oil seal is black.

4. Apply a light coat of engine oil to a new oil seal.

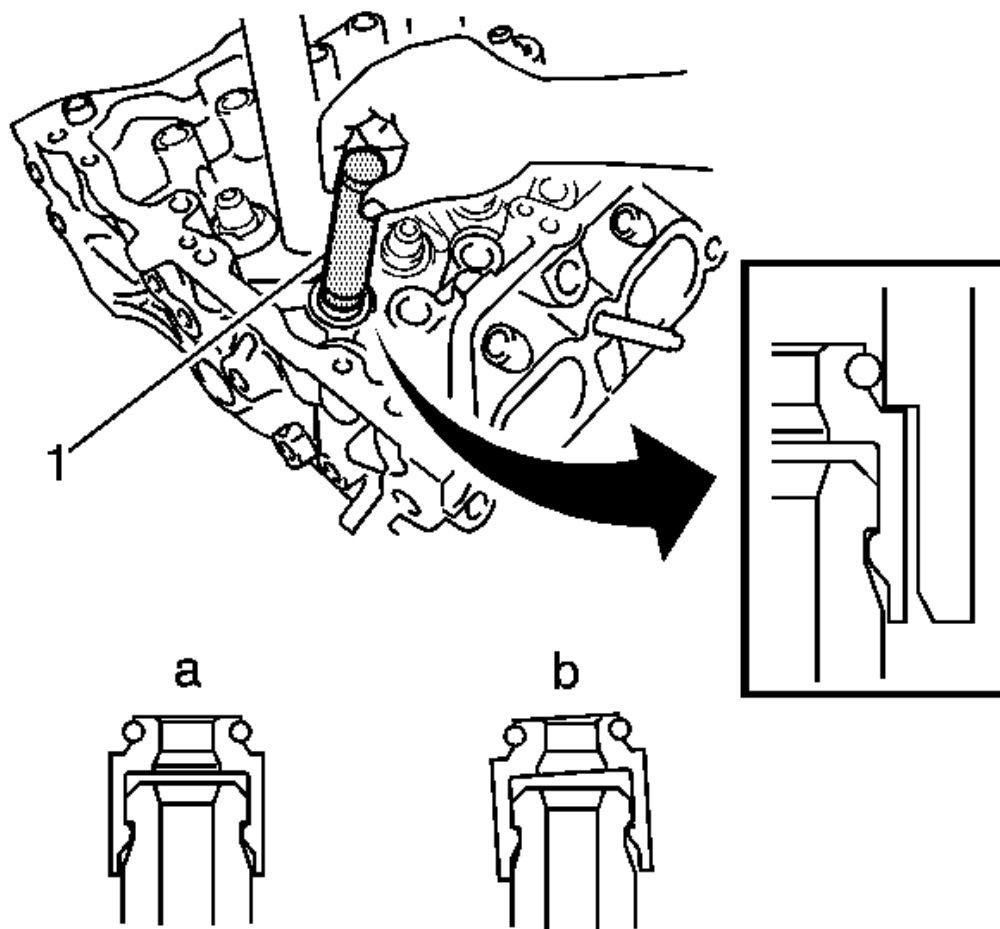


Fig. 452: View Of Valve Stem Oil Seal Installation

Courtesy of GENERAL MOTORS CORP.

NOTE: Failure to use SST will cause the oil seal to be damaged or improperly seated.

5. Using SST, push in the oil seal.

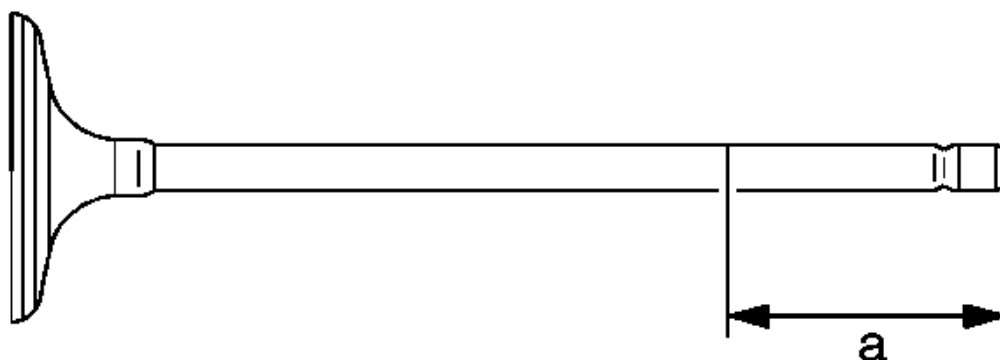


Fig. 453: Identifying Valve Stem Lubrication Area
Courtesy of GENERAL MOTORS CORP.

6. Sufficiently apply engine oil to the tip area of the intake valve shown in the illustration.

IMPORTANT: Install the same parts in the same combination to the original locations.

7. Install the valve, compression spring and spring retainer to the cylinder head.

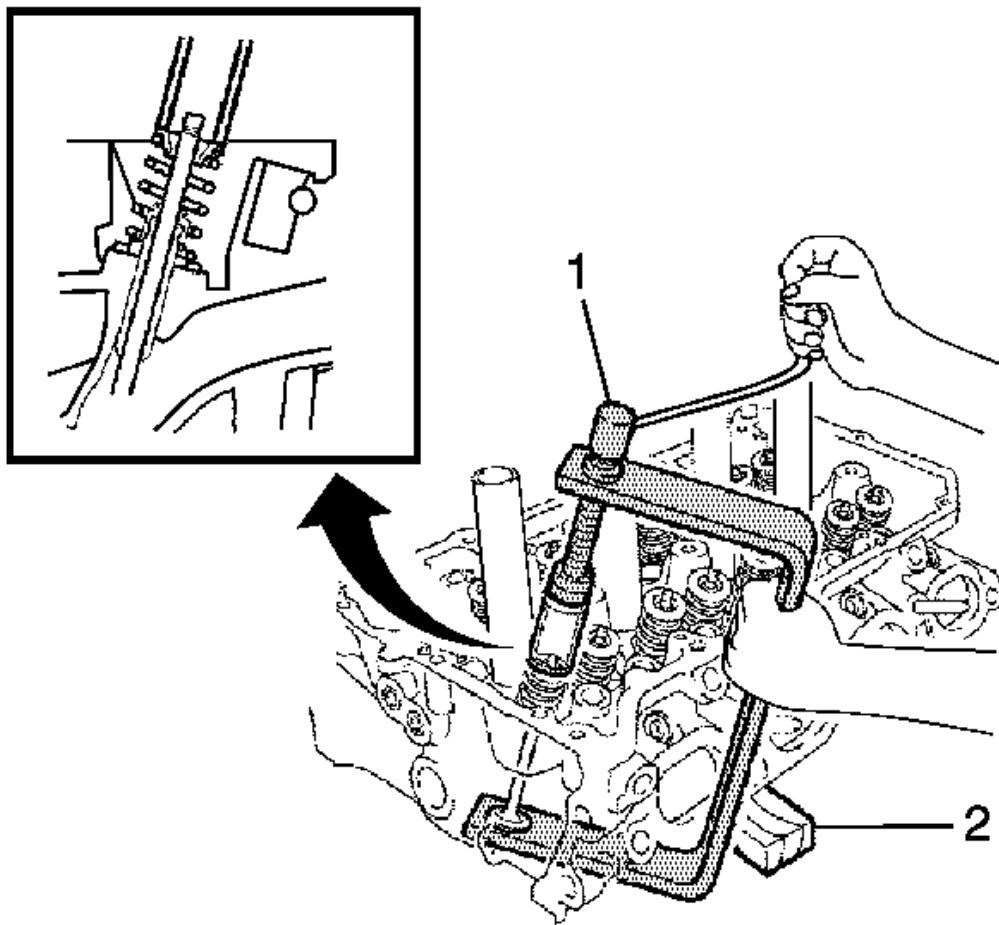


Fig. 454: View Of Compressing Valve Spring & Removing/Installing Valve Retainer Locks
 Courtesy of GENERAL MOTORS CORP.

8. Using SST and wooden blocks, compress the spring and install the 2 retainer locks.

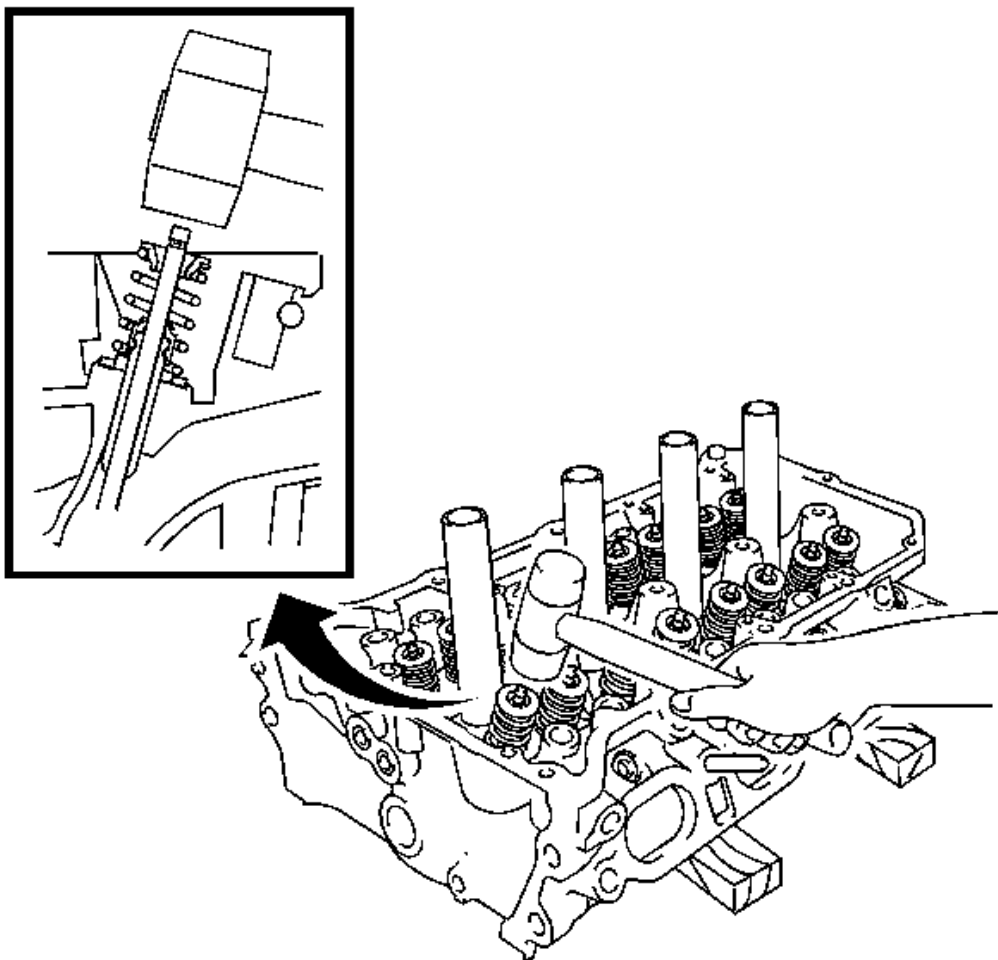


Fig. 455: Ensuring Proper Valve Component Fit
Courtesy of GENERAL MOTORS CORP.

NOTE: Be careful not to damage the valve stem tip and retainer.

9. Using a plastic-faced hammer, lightly tap the valve stem tip to ensure a proper fit.

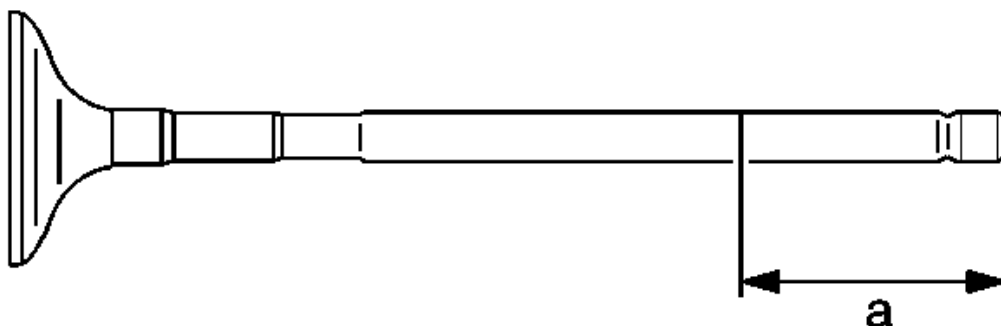


Fig. 456: Identifying Valve Stem Lubrication Area
Courtesy of GENERAL MOTORS CORP.

10. Sufficiently apply engine oil to the tip area of the exhaust valve.

IMPORTANT: Install the same parts in the same combination to the original locations.

11. Install the exhaust valve, compression spring and spring retainer to the cylinder head.

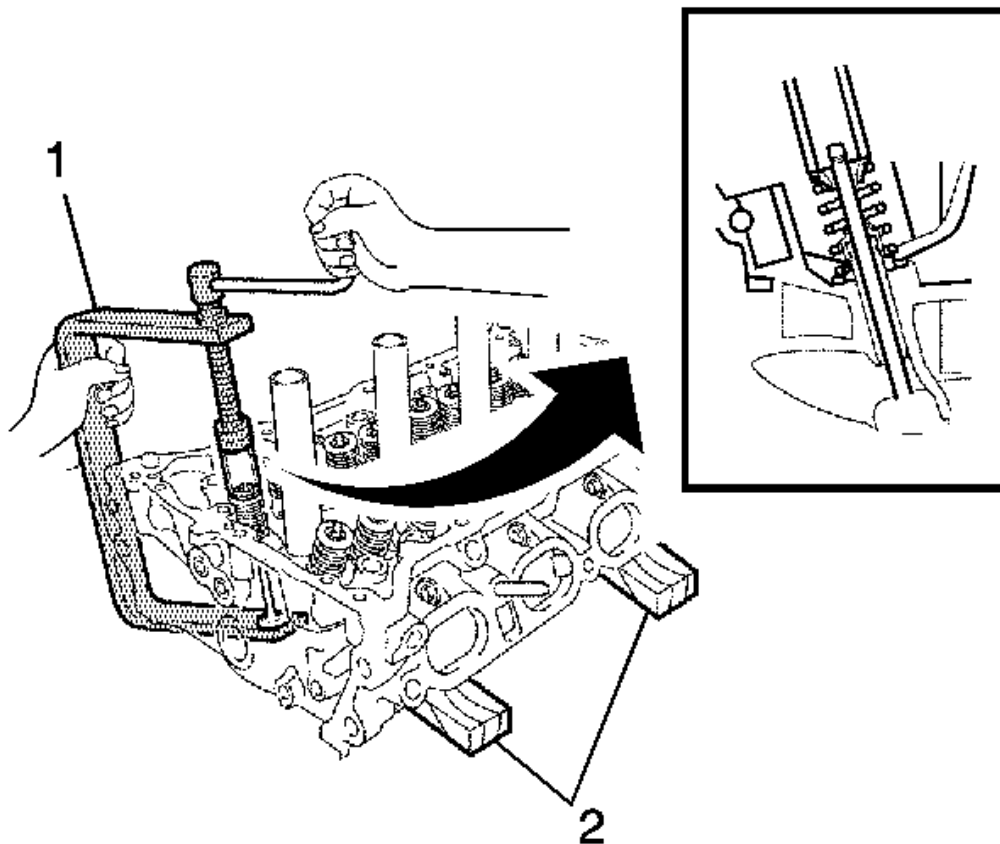


Fig. 457: Identifying Valve Springs & Components
Courtesy of GENERAL MOTORS CORP.

12. Using SST and wooden blocks, compress the spring and install the 2 retainer locks.

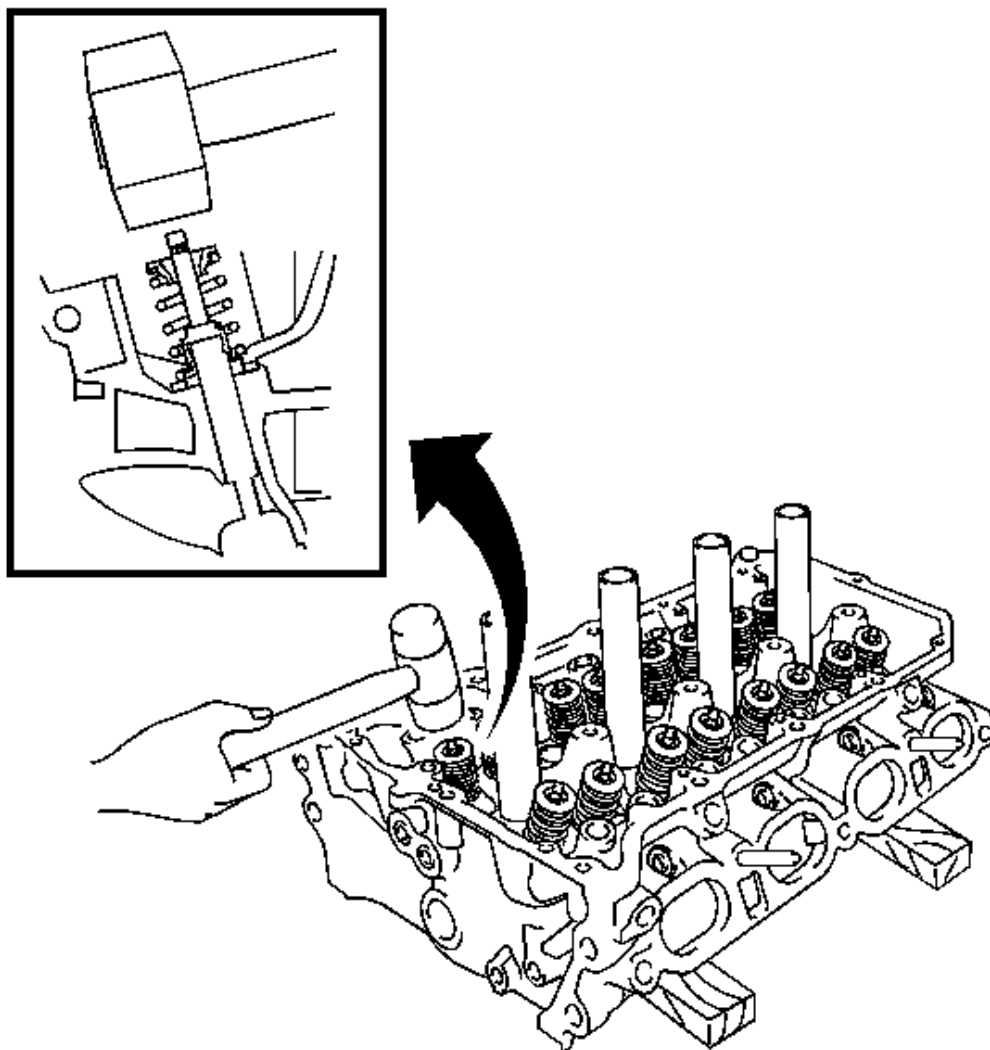


Fig. 458: Ensuring Proper Valve Component Fit
Courtesy of GENERAL MOTORS CORP.

NOTE: Be careful not to damage the valve stem tip and retainer.

13. Using a plastic-faced hammer, lightly tap the valve stem tip to ensure a proper fit.
14. Apply a light coat of engine oil to the valve stem caps.
15. Install the valve stem caps to the cylinder head.

OIL PUMP CLEANING AND INSPECTION

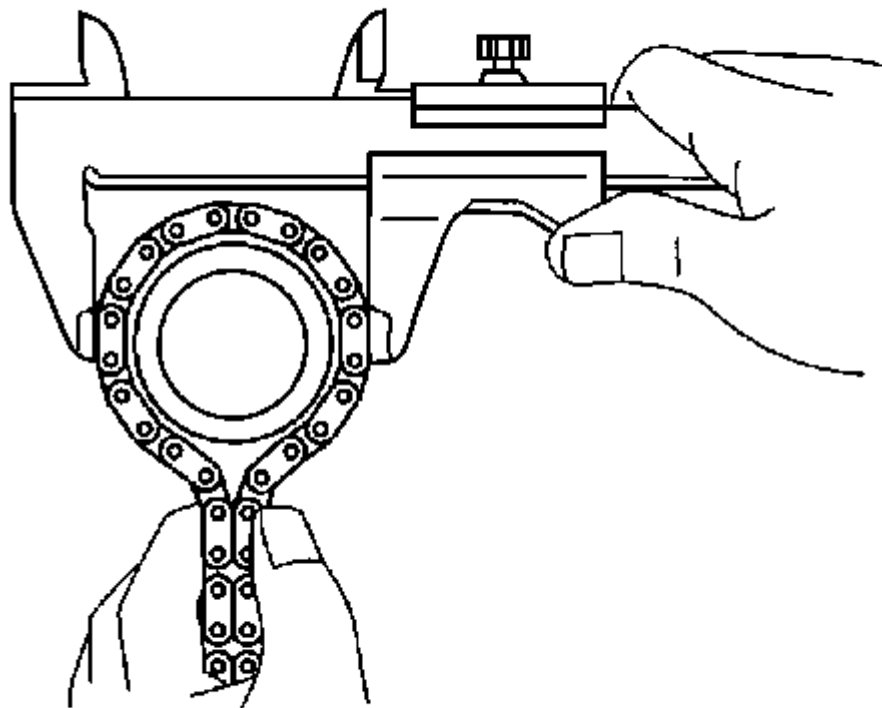


Fig. 459: Inspecting Oil Pump Drive Gear
Courtesy of GENERAL MOTORS CORP.

1. Inspect oil pump drive gear.
2. Place the chain around the gear.

NOTE: The vernier calipers must be in contact with the chain rollers when measuring.

3. Using vernier calipers, measure the diameter of the gear and chain.

If the diameter is less than the minimum, replace the chain and gear.

Specification: Minimum gear diameter w/chain - 48.2 mm (1.898 in).

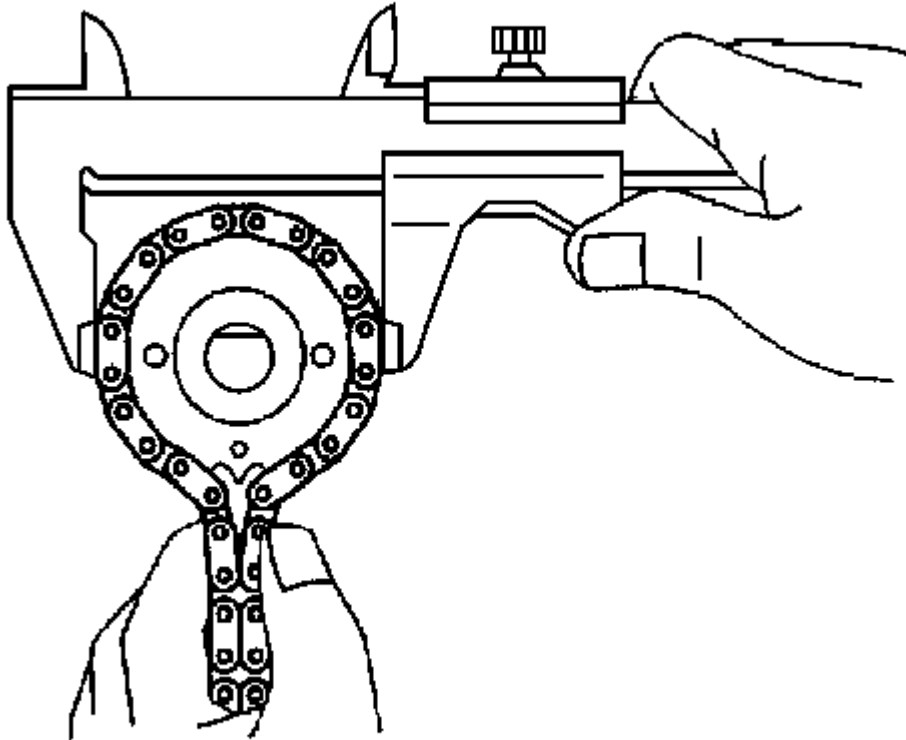


Fig. 460: Measuring Diameter Of Gear & Chain
 Courtesy of GENERAL MOTORS CORP.

4. Inspect the oil pump drive shaft gear.
5. Place the chain around the gear.

NOTE: The vernier calipers must be in contact with the chain rollers when measuring.

6. Using vernier calipers, measure the diameter of the gear and chain.

If the diameter is less than the minimum, replace the chain and gear.

Specification: Minimum gear diameter (with chain) - 48.8 mm (1.921 in).

EXHAUST MANIFOLD CLEANING AND INSPECTION

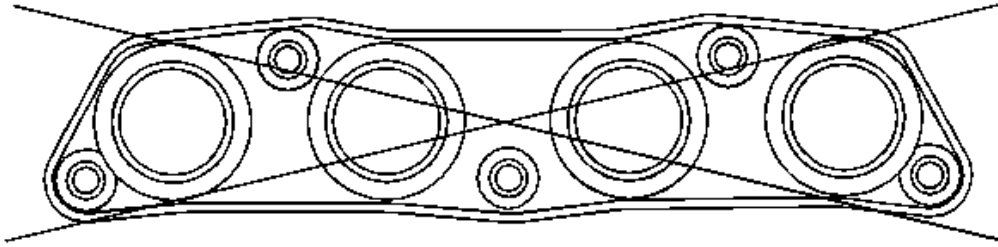


Fig. 461: Inspecting Exhaust Manifold For Warpage
Courtesy of GENERAL MOTORS CORP.

1. Inspect exhaust manifold.

NOTE: If the warpage is greater than the maximum, replace the manifold.

2. Using a precision straightedge and feeler gauge, measure the warpage on the contact surface of the cylinder head.

Specification: Maximum warpage: 0.7 mm (0.028 in)

Standard Journal Diameter

Journal Position	Specified Condition
No. 1	34.449 to 34.46 mm (1.3563 to 1.3569 in)
Other	22.949 to 22.965 mm (0.9035 to 0.9041 in)

SERVICE PRIOR TO ASSEMBLY

1. Remove the 2 ring pins.

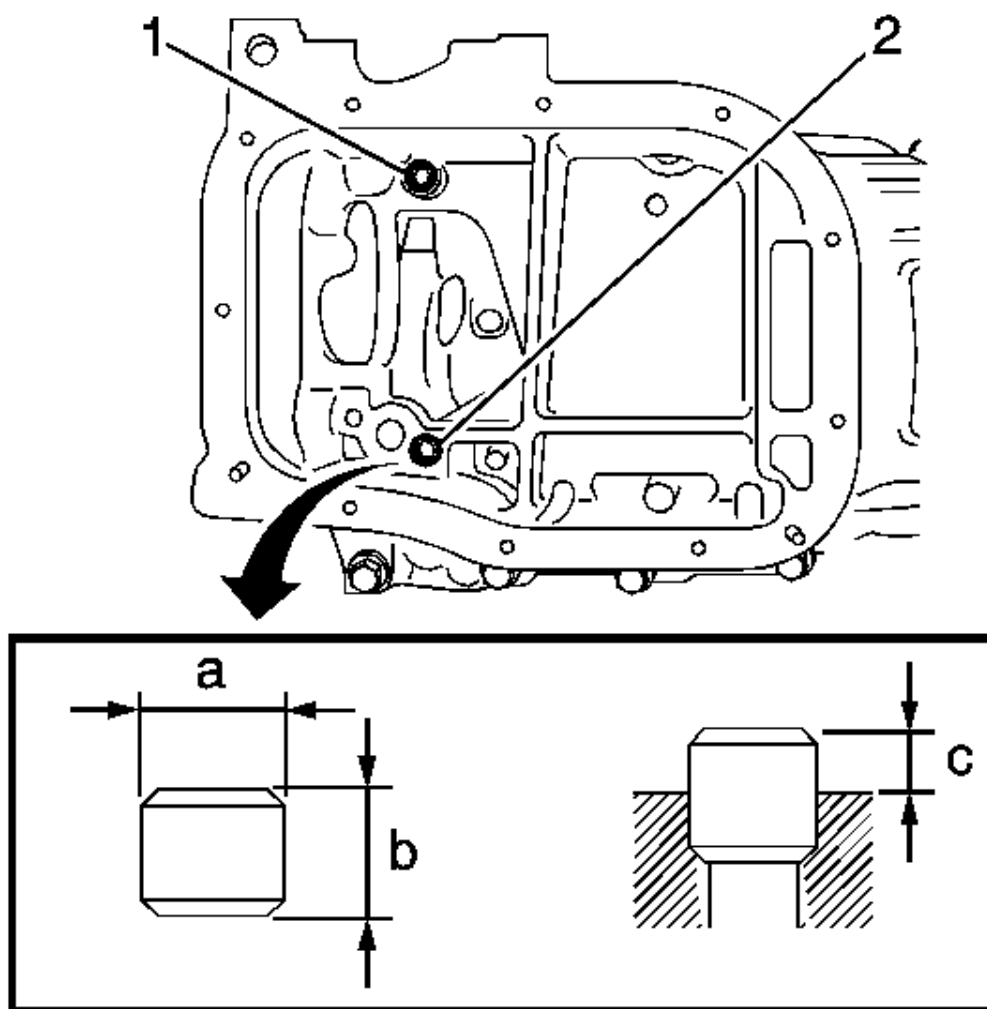


Fig. 462: View Of Ring Pins-To-Crankcase Installation
Courtesy of GENERAL MOTORS CORP.

2. Install 2 new ring pins to the crankcase.

Specification: Standard protrusion - 3 mm (0.12 in).

3. Remove the 2 stud bolts from the crankcase.

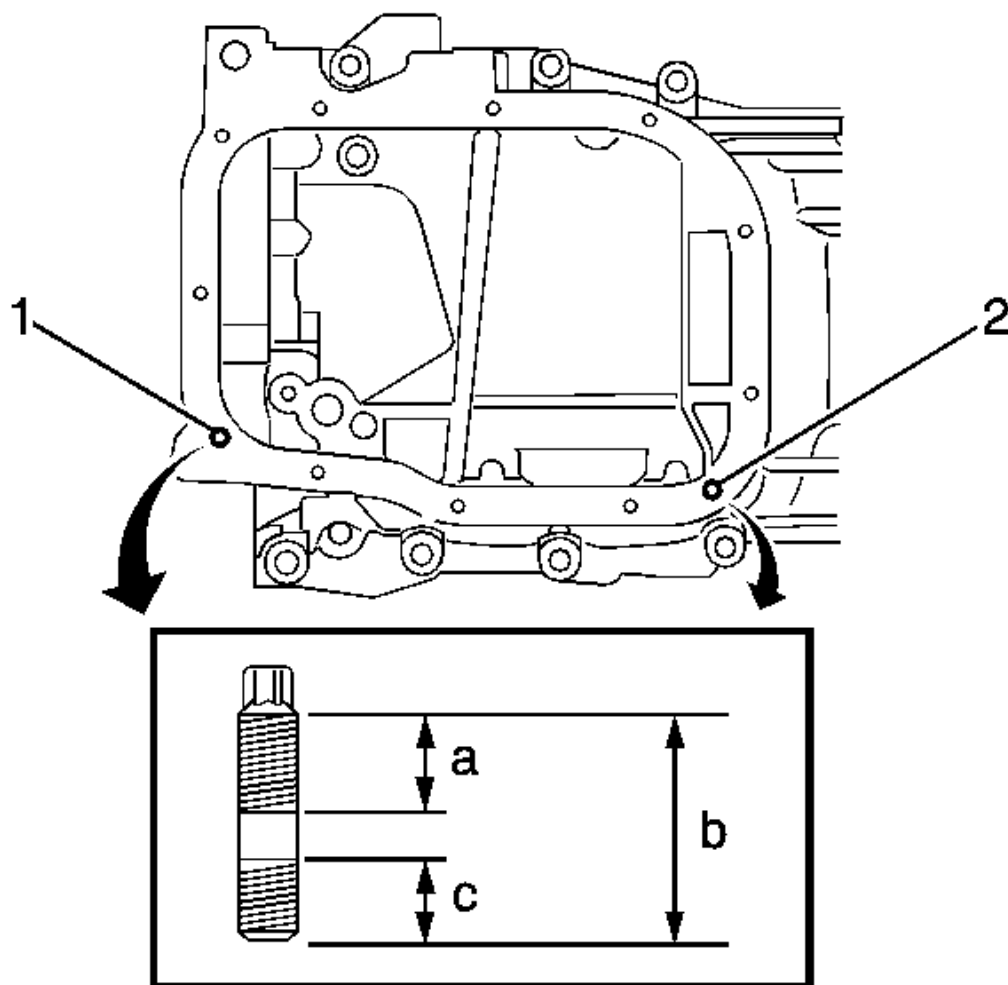


Fig. 463: View Of Stud Bolt Installation
Courtesy of GENERAL MOTORS CORP.

4. Using a TORX socket E5, install the 2 stud bolts as shown in the illustration.

Tighten: Tighten the bolts to 5.0 N.m (44 lb in).

5. Remove the 2 stud bolts from the water inlet housing.

CAUTION: Refer to Fastener Caution .

6. Using a TORX socket E5, install the 2 stud bolts and tighten to 5.0 N.m (44 lb in).

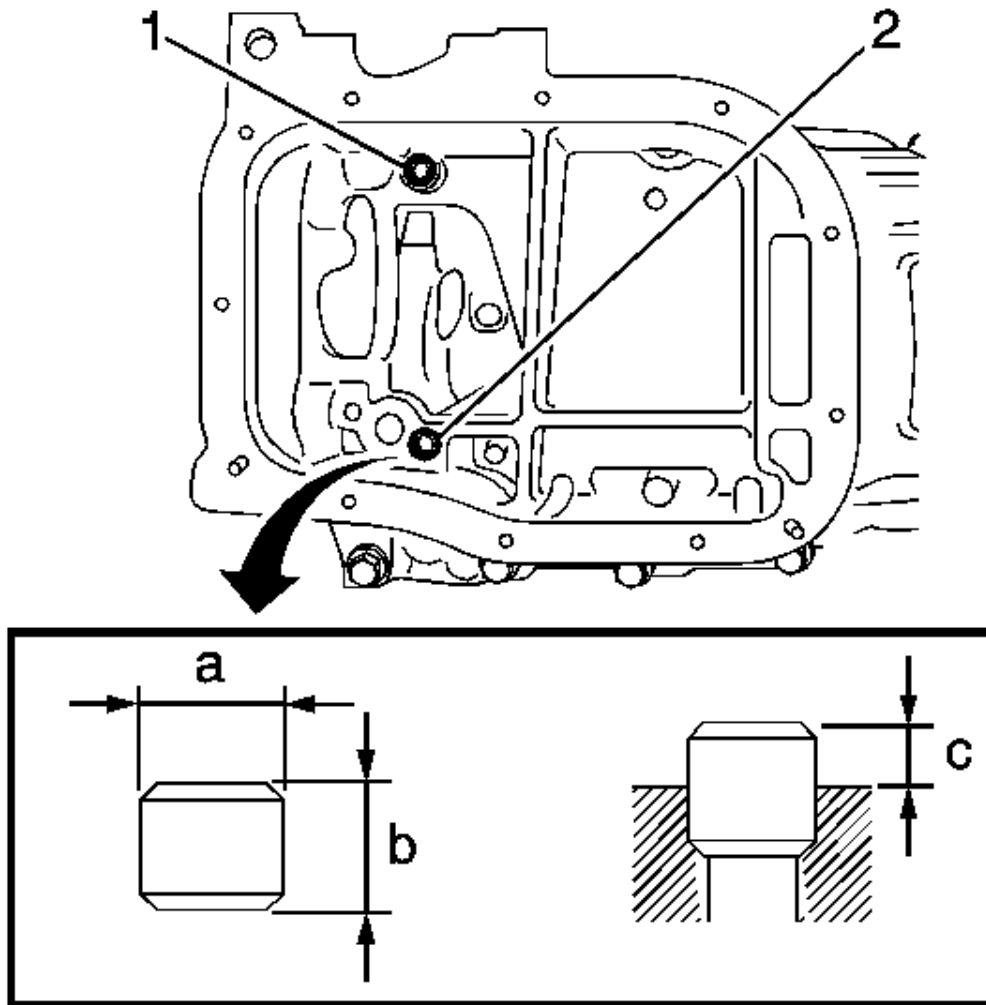


Fig. 464: View Of Ring Pins-To-Crankcase Installation
Courtesy of GENERAL MOTORS CORP.

7. Replace the spark plug tube gasket.

NOTE: Do not deform the claws of the baffle plate more than necessary.

8. Pry up the claws of the ventilation baffle plate.

NOTE:

- Prevent the plug tube gaskets from being deformed as much as possible. The removed gaskets will be used when reinstalling the gaskets.
- Do not damage the connection of the cylinder head cover.

9. Remove the 4 gaskets from the cylinder head covers.

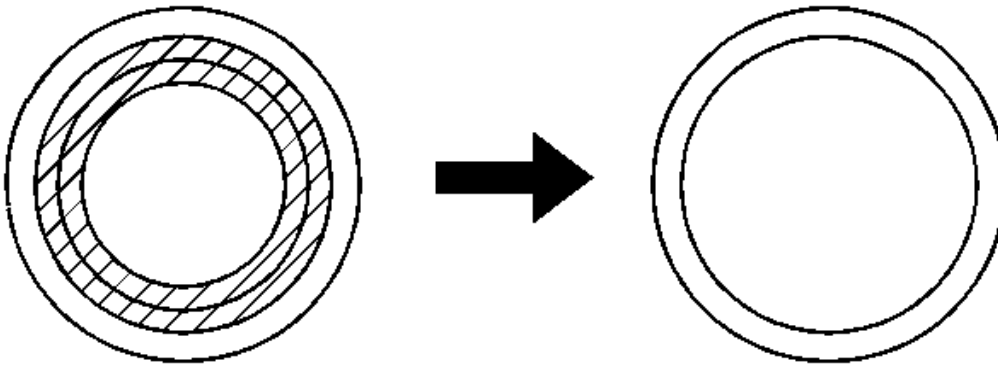


Fig. 465: View Of Sealing Part Of Plug Tube Gasket
Courtesy of GENERAL MOTORS CORP.

10. Using a cutter, cut off the sealing part of the removed plug tube gasket.

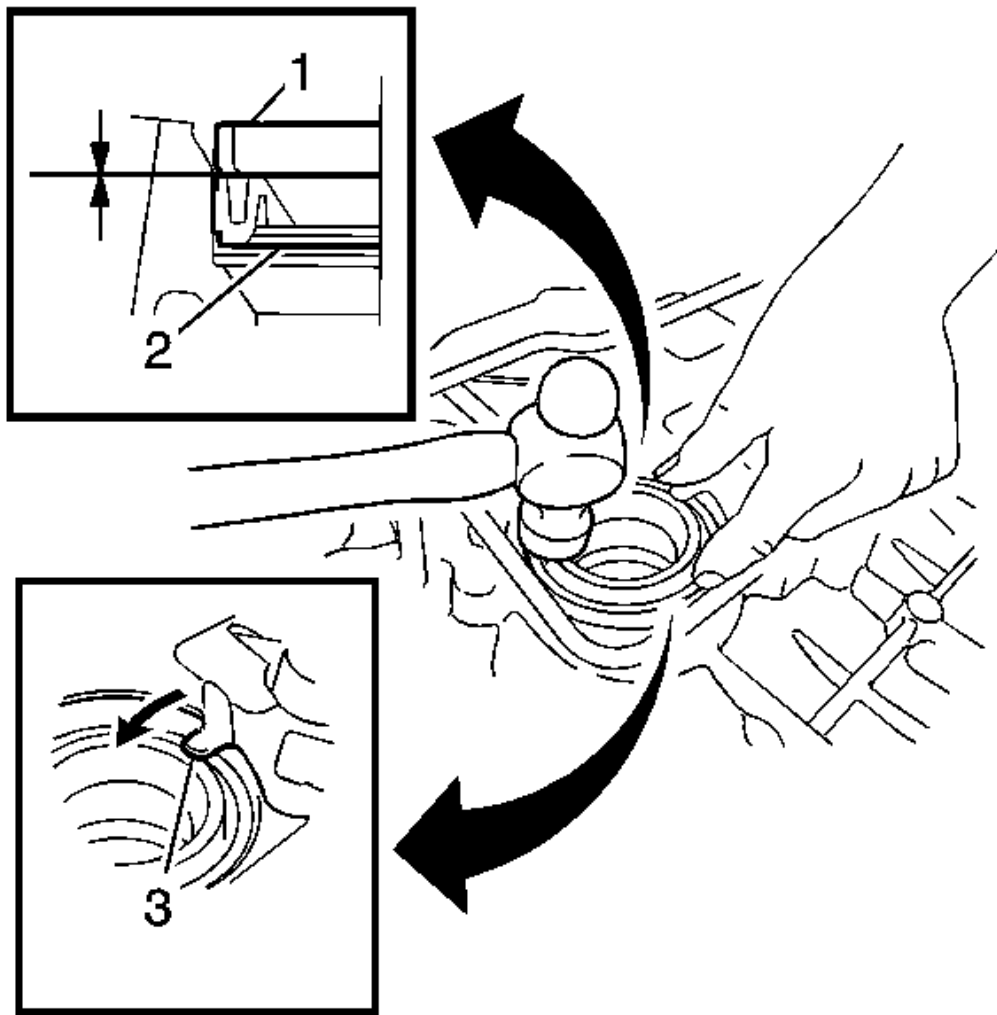


Fig. 466: Identifying Proper Gasket Positioning
Courtesy of GENERAL MOTORS CORP.

NOTE: If a plug tube gasket that will be used to install a new gasket is deformed, and cannot be positioned on a new gasket, correct the deformation using pliers.

NOTE:

- Keep the lip free of foreign matter.
- Do not tap on the oil seal at an angle.

11. Using a plug tube gasket which has had the sealing part cut off, uniformly press in a new plug tube gasket

all the way.

12. Return the claws of the ventilation baffle plate to their original positions.

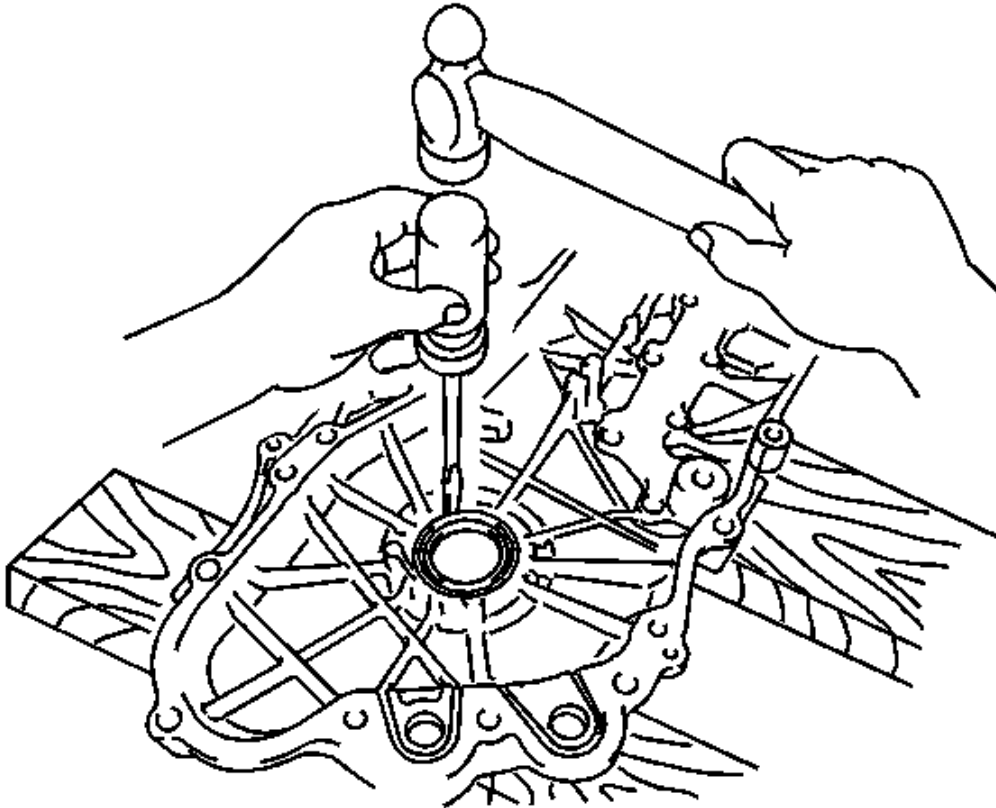


Fig. 467: Illustrating Removing Timing Chain Cover Oil Seal
Courtesy of GENERAL MOTORS CORP.

13. Replace the timing chain cover oil seal.

CAUTION: Be careful not to damage the timing chain cover oil seal.

NOTE: Tape the screwdriver tip before use.

14. Remove the oil seal, using a screwdriver and hammer.

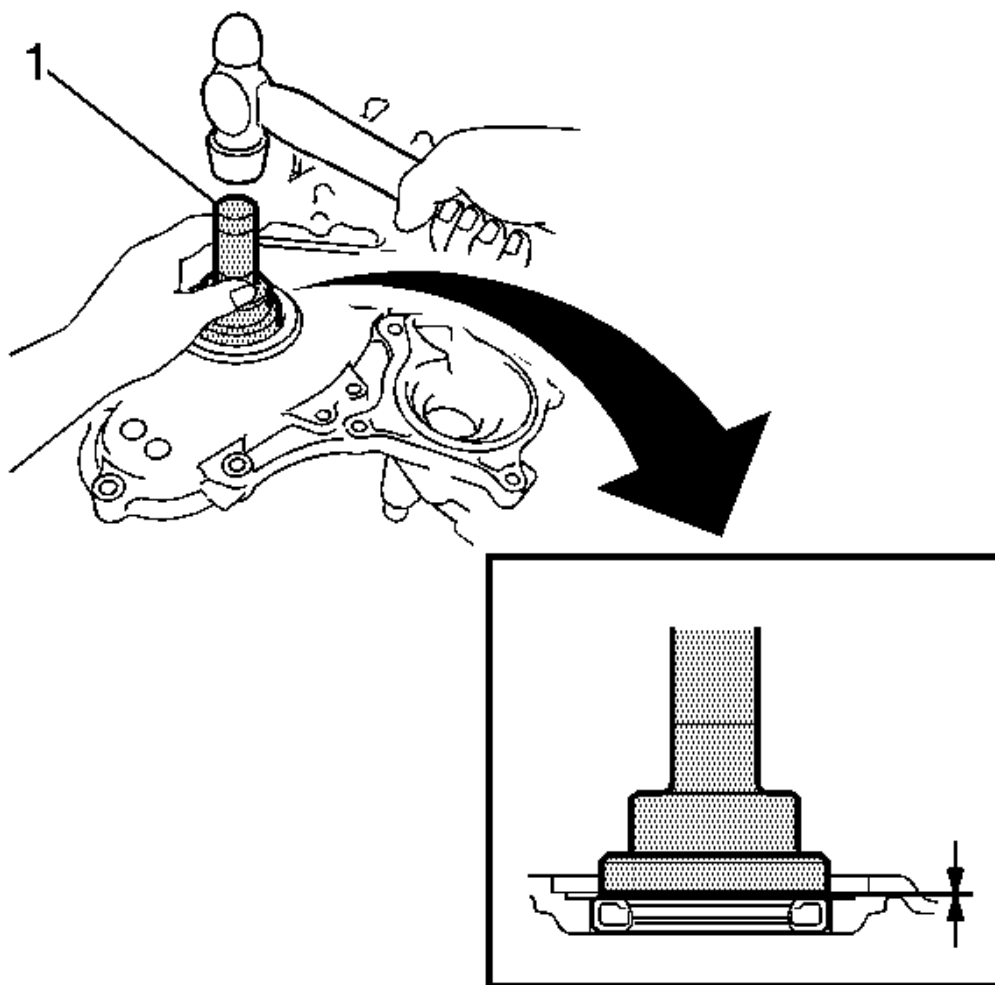


Fig. 468: View Of Proper Oil Seal Installation
Courtesy of GENERAL MOTORS CORP.

15. Using SST, tap in a new oil seal until its surface is flush with the timing gear case edge.

NOTE:

- Keep the lip free of foreign matter.
- Do not tap on the oil seal at an angle.
- Make sure that the oil seal edge does not stick out of the timing chain cover.

16. Apply a light coat of MP grease to the lip of the oil seal.

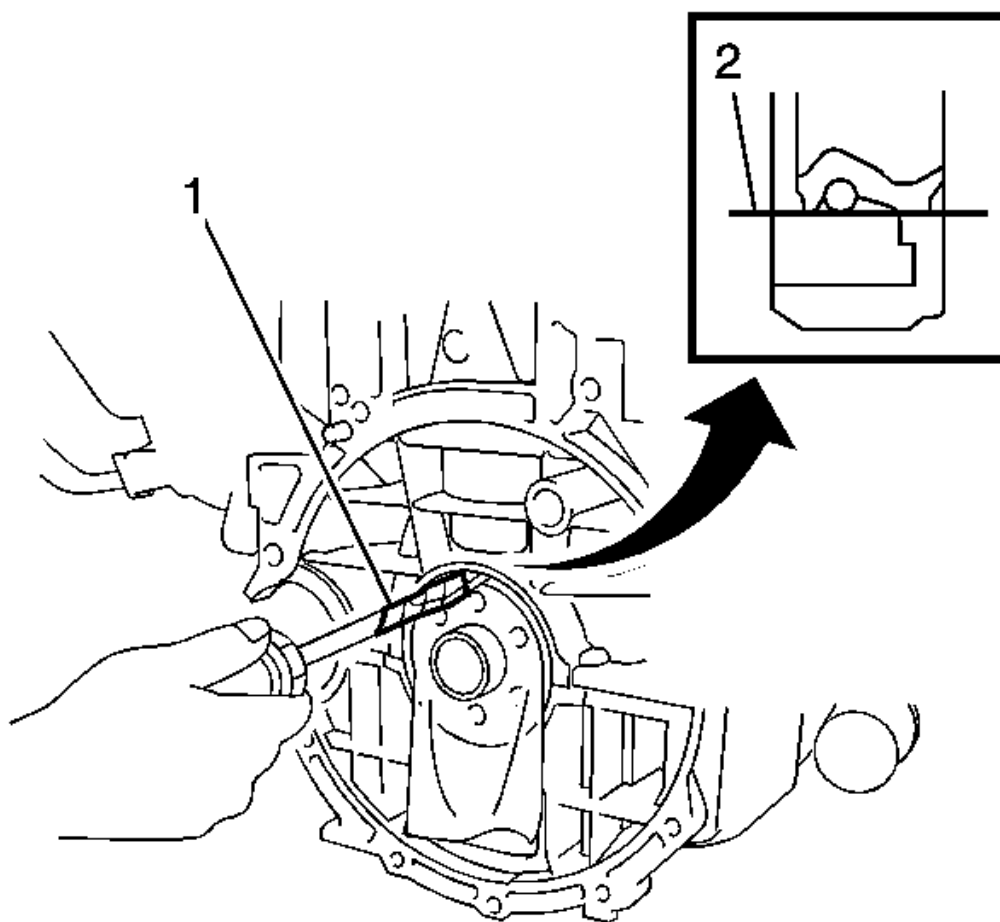


Fig. 469: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

17. Replace rear engine oil seal.
18. Using a knife, cut off the oil seal lip.

CAUTION: After removing the oil seal, check the crankshaft for damage. If it is damaged, smooth the surface with 400-grit sandpaper.

19. Using a screwdriver with its tip taped, pry out the oil seal.

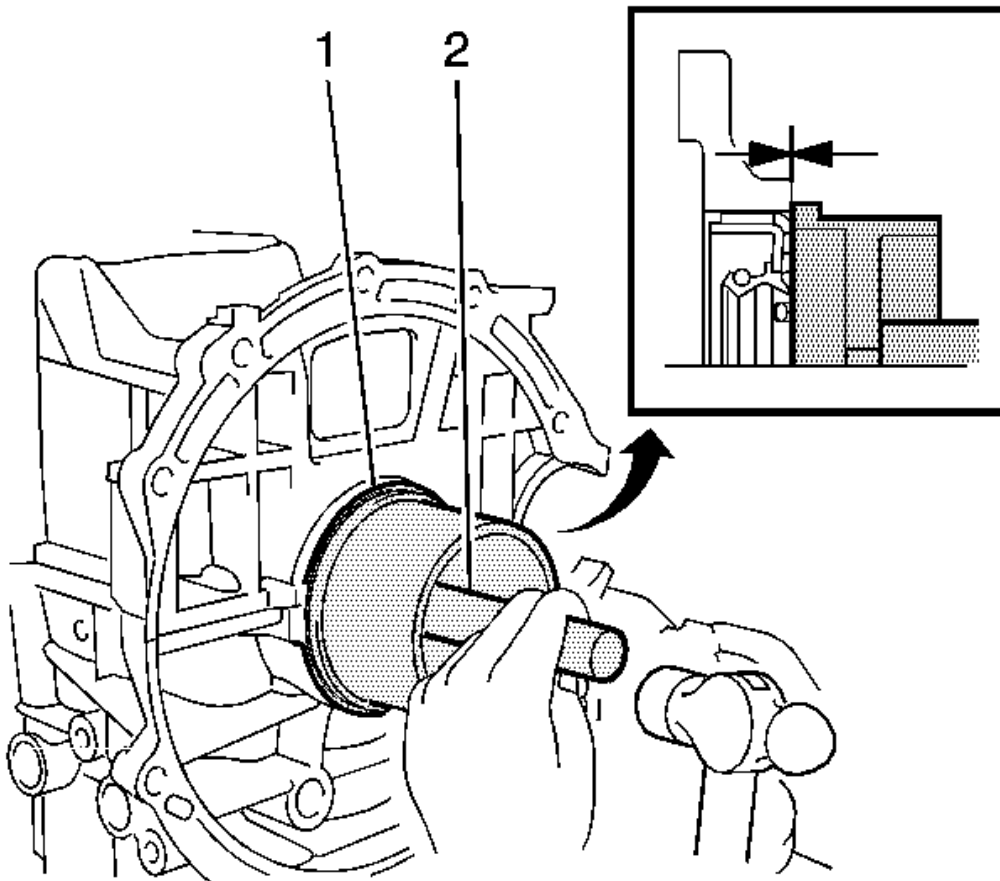


Fig. 470: View Of Proper Oil Seal Cleaning & Installation
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Keep the lip free of foreign matter.
- Do not tap on the oil seal at an angle.

20. Using SST and a hammer, evenly tap the oil seal until its surface is flush with the rear oil seal retainer edge.

NOTE:

Wipe off extra grease on the crankshaft.

21. Apply MP grease to a new oil seal lip.

CRANKSHAFT AND BEARING INSTALLATION

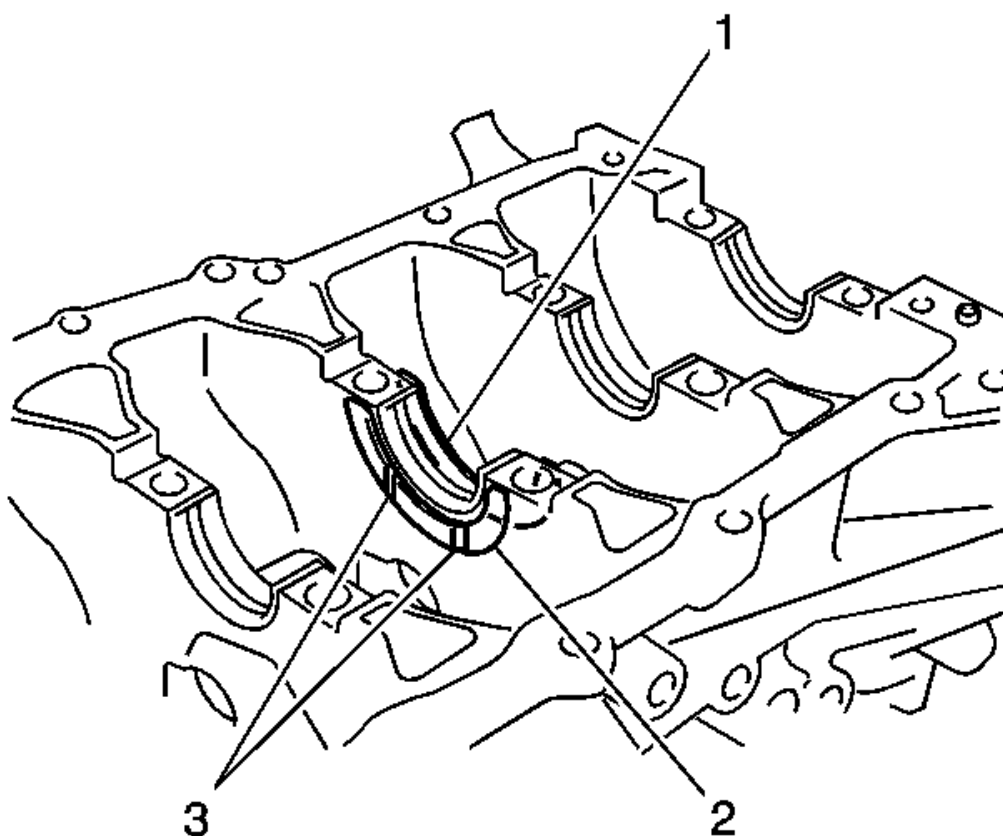


Fig. 471: View Of Upper Crankshaft Thrust Washers
Courtesy of GENERAL MOTORS CORP.

1. Install the 2 upper crankshaft thrust washers under the No. 3 journal of the cylinder block with the oil grooves facing outward.
2. Apply the engine oil to the crankshaft thrust washer.
3. Apply the engine oil to the upper bearing and install the crankshaft on the cylinder block.
4. Apply the engine oil to the lower bearing.

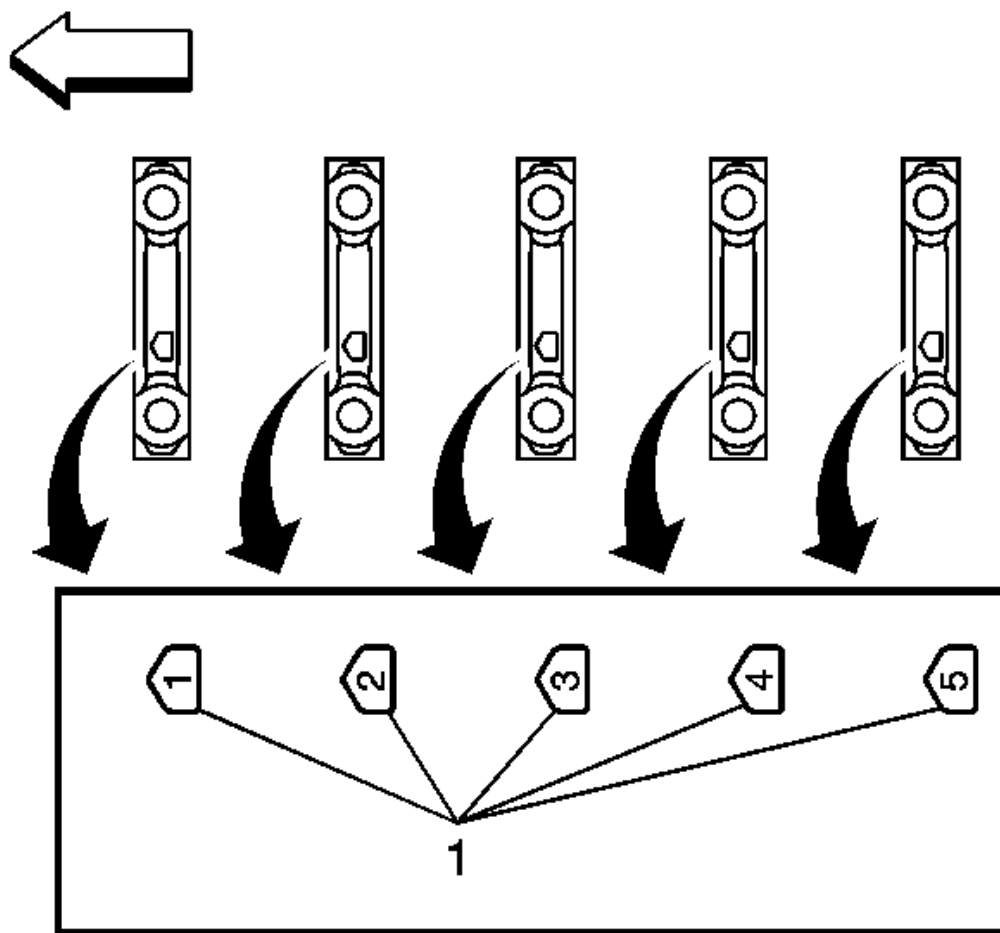


Fig. 472: Identifying Main Bearing Cap & Block Marks

Courtesy of GENERAL MOTORS CORP.

5. Examine the number marks and install the bearing caps on the cylinder block.
6. Apply a light coat of engine oil to the threads and under the bearing cap bolts.

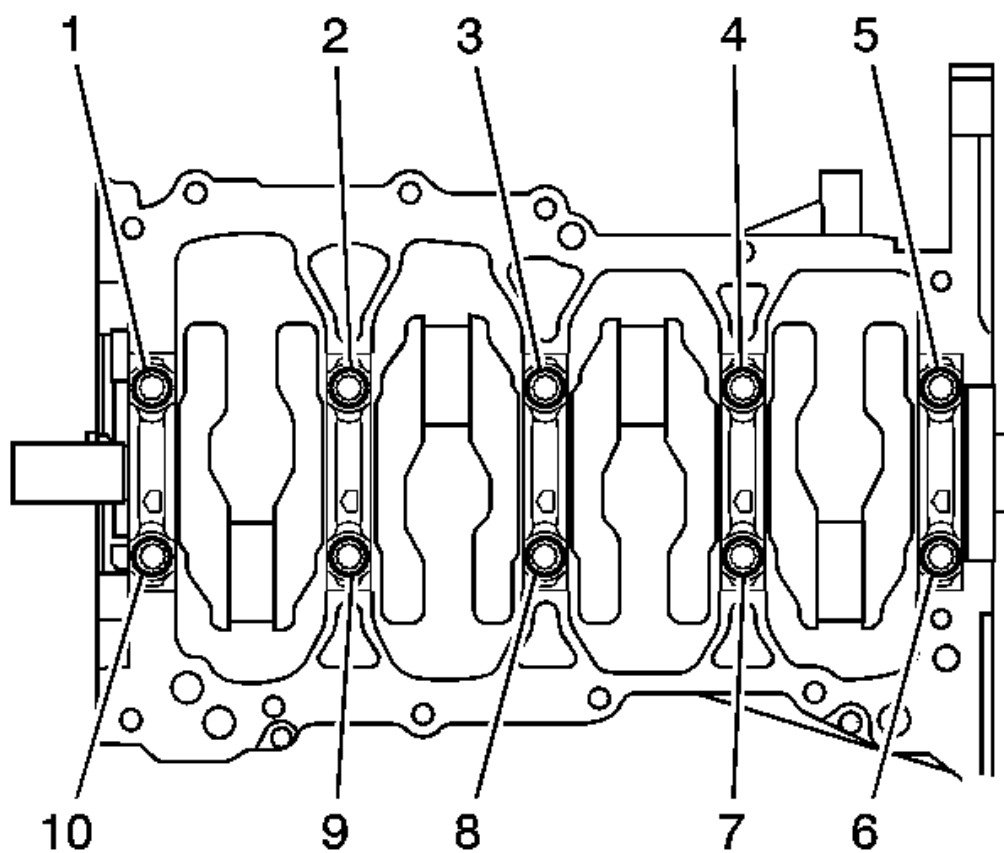


Fig. 473: Identifying Main Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

7. Temporarily install the 10 main bearing cap bolts.

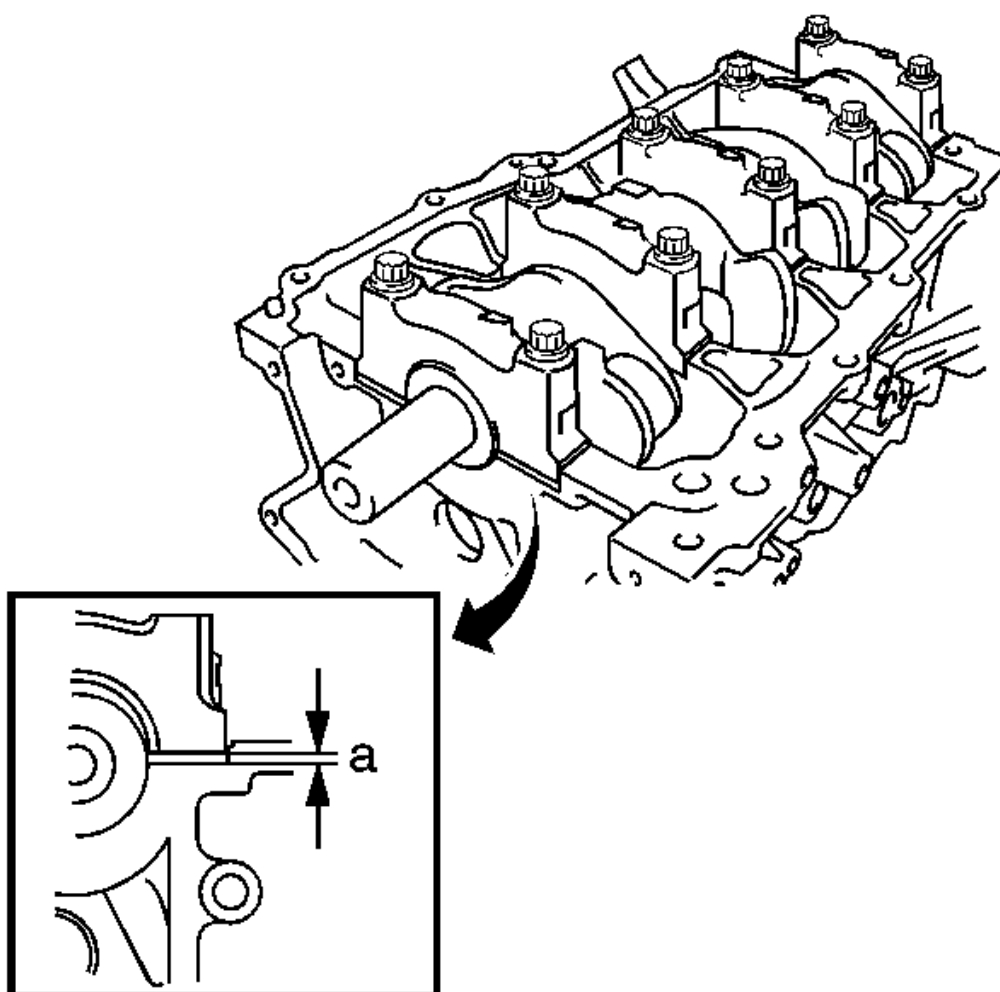


Fig. 474: Loosely Installing Main Bearing Cap By Hand
Courtesy of GENERAL MOTORS CORP.

8. Insert the main bearing cap with your hand until the clearance between the main bearing cap and the cylinder block is less than 5 mm (0.20 in) using the 2 internal bearing cap bolts as guides.

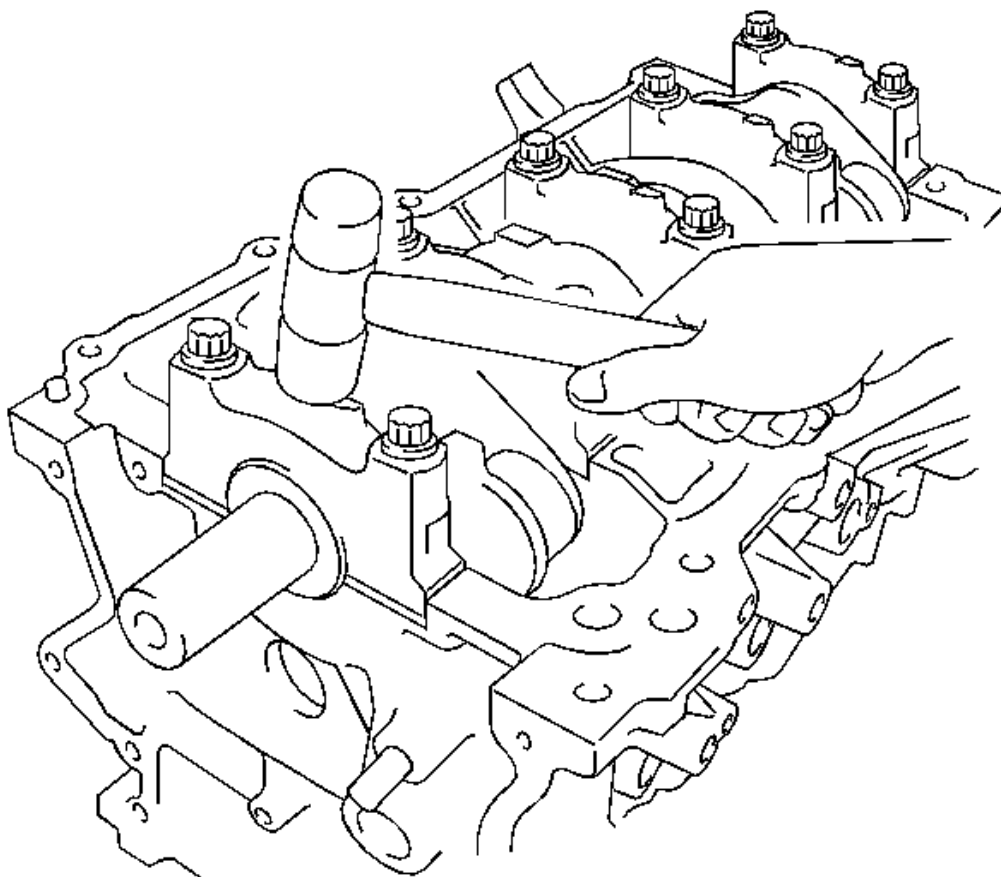


Fig. 475: Tapping Bearing Cap To Ensure Proper Fit
Courtesy of GENERAL MOTORS CORP.

9. Using a plastic hammer, lightly tap the bearing cap to ensure a proper fit.

NOTE: The main bearing cap bolts are tightened in 2 progressive steps.

10. Install the crankshaft bearing cap bolts.

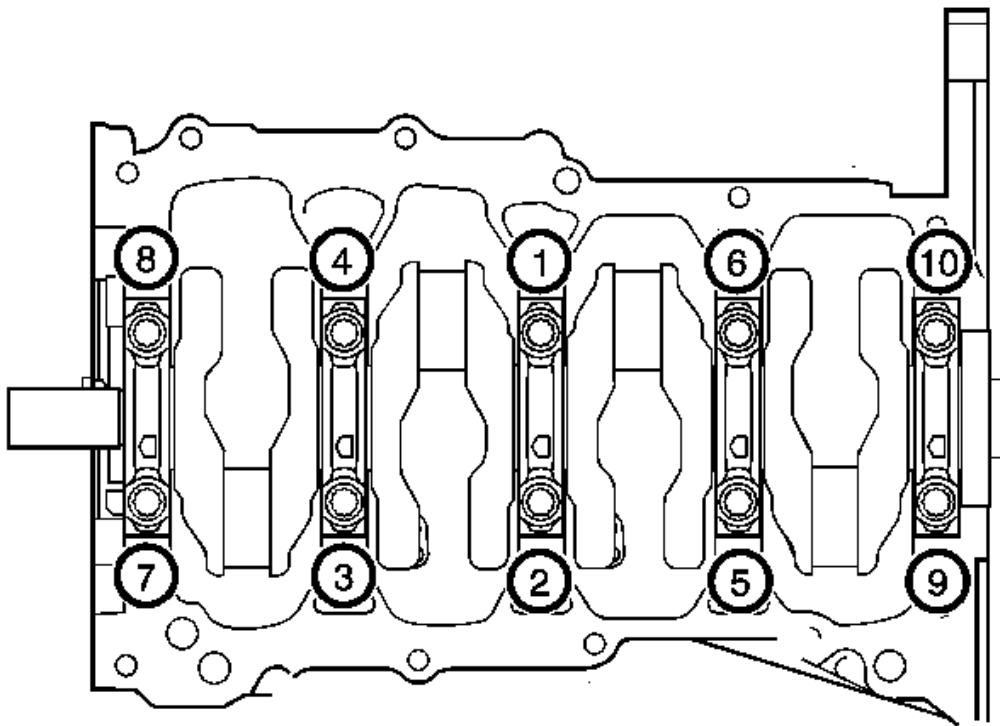


Fig. 476: Identifying Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

11. Install and uniformly tighten the 10 main bearing cap bolts in sequence to 40 N.m (30 lb ft).

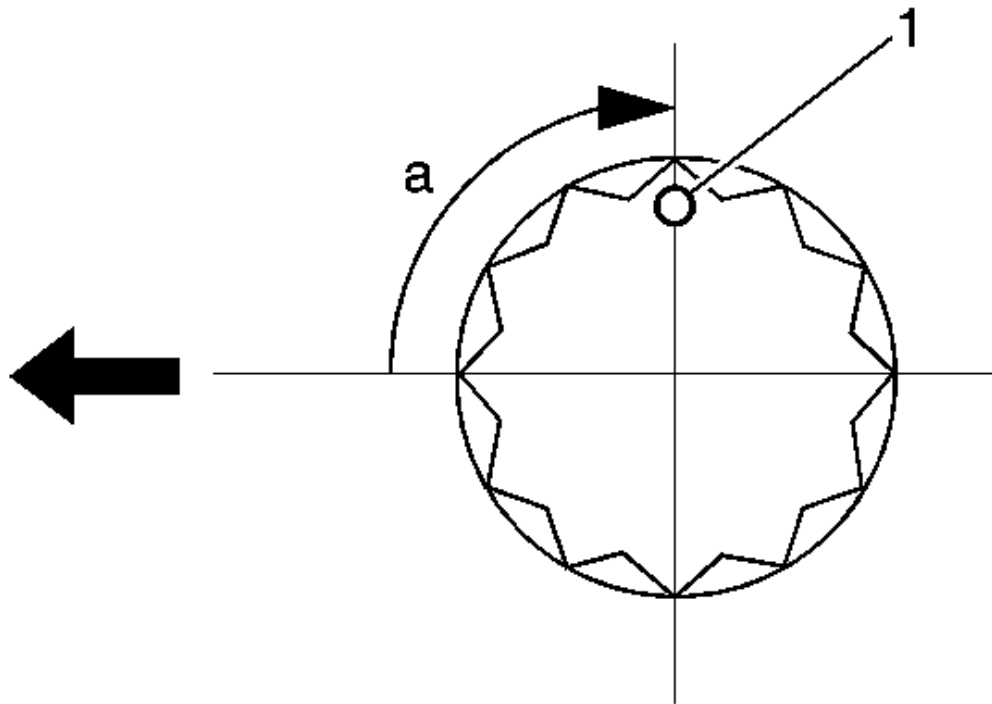


Fig. 477: Identifying Bearing Cap Bolt Tightening Final Step
Courtesy of GENERAL MOTORS CORP.

12. Mark the front of the bearing cap bolts with paint.
13. Further tighten the bearing cap bolts an additional 90 degree in the numerical order shown in the previous illustration.
14. Check that the paint mark is now at a 90 degree angle to the front.
15. Check that the crankshaft turns smoothly.
16. Check the crankshaft thrust clearance. Refer to **Crankshaft and Bearing Cleaning and Inspection**.

CRANKSHAFT REAR OIL SEAL INSTALLATION

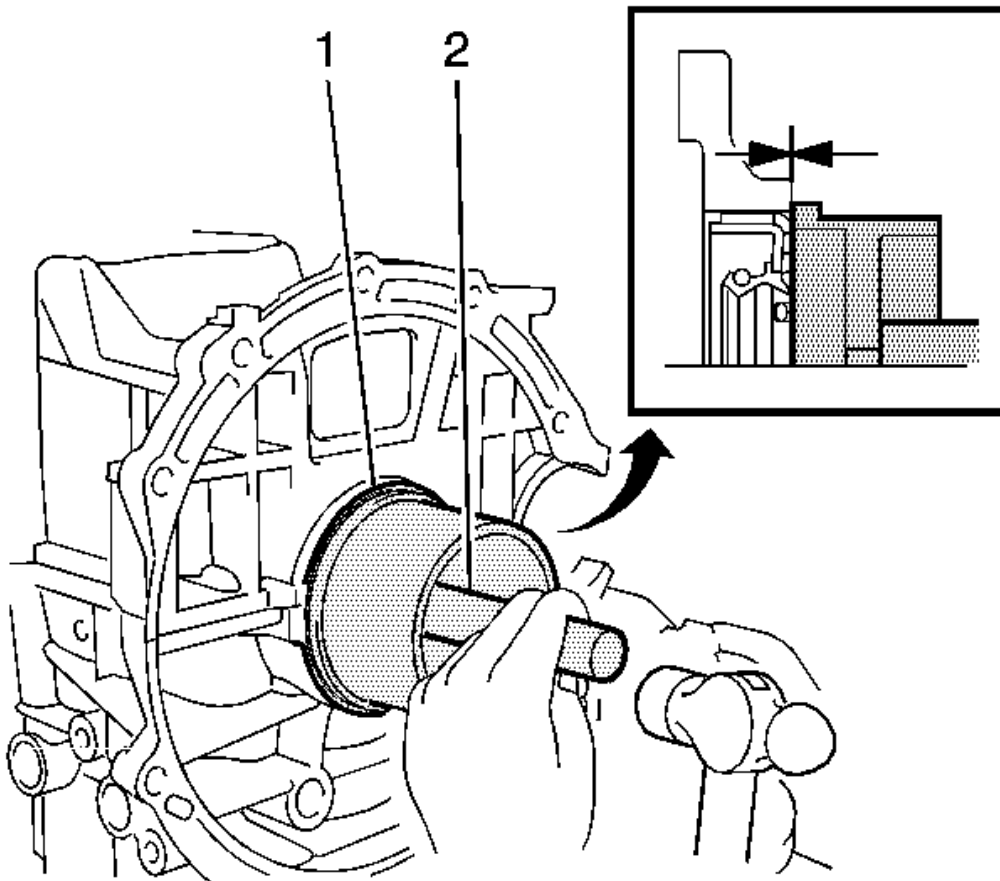


Fig. 478: View Of Proper Oil Seal Cleaning & Installation
 Courtesy of GENERAL MOTORS CORP.

NOTE:

- Keep the lip free of foreign matter.
- Do not tap on the oil seal at an angle.

1. Install the rear engine oil seal.
2. Using SST and a hammer, evenly tap the oil seal until its surface is flush with the rear oil seal retainer edge.

NOTE:

Wipe off extra grease on the crankshaft.

3. Apply MP grease to a new oil seal lip.
4. Install the oil pump assembly.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

1. Install the connecting rod bearing to the connecting rod and bearing cap.

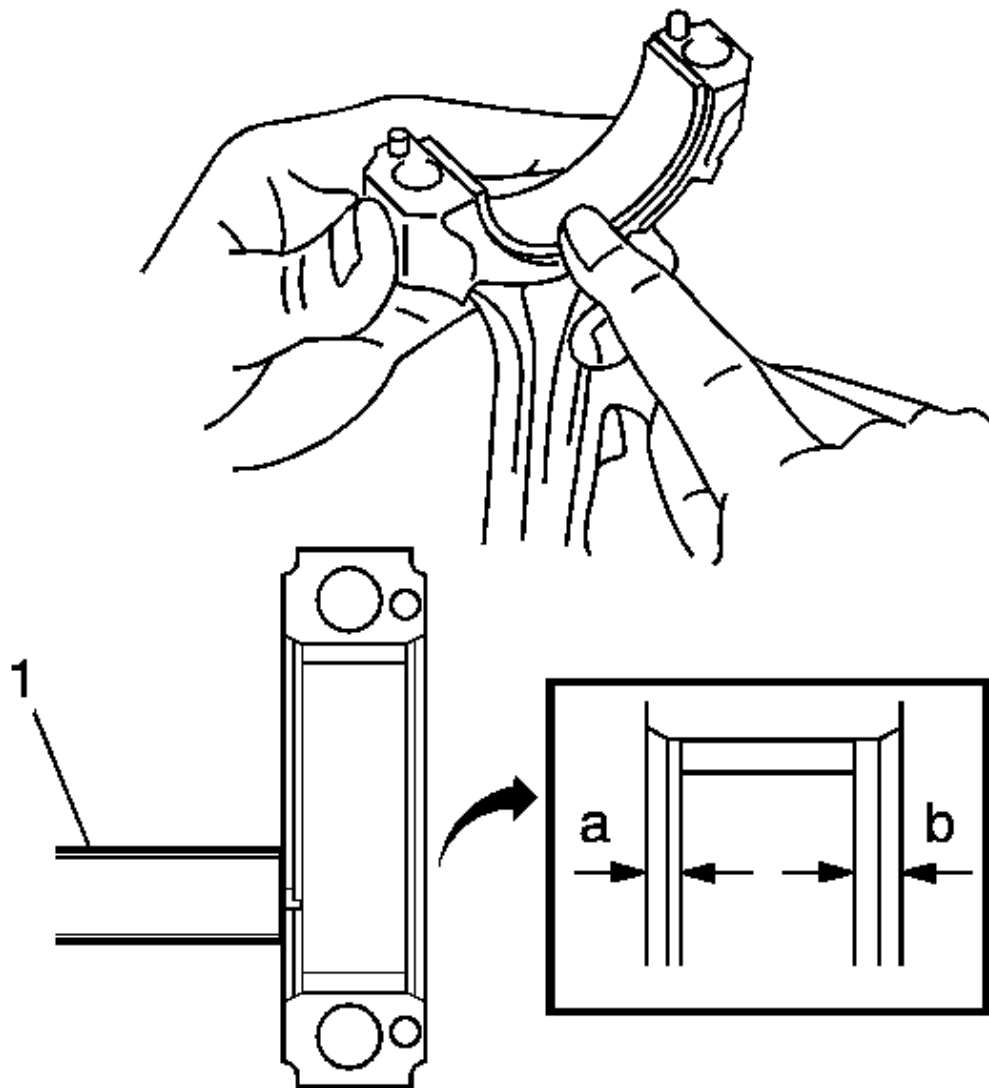


Fig. 479: Measuring Distance Between Connecting Rod & Bearing Cap Edges & Connecting Rod Bearing Edge

Courtesy of GENERAL MOTORS CORP.

NOTE: Do not apply engine oil to the bearings or the contact surfaces.

2. Using vernier calipers, measure the distance between the connecting rod and bearing cap edges and the connecting rod bearing edge.

Specification: Dimension (A - B): 0.7 mm (0.0276 in) or less

3. Apply engine oil to the cylinder walls, the pistons, and the surfaces of the connecting rod bearings.

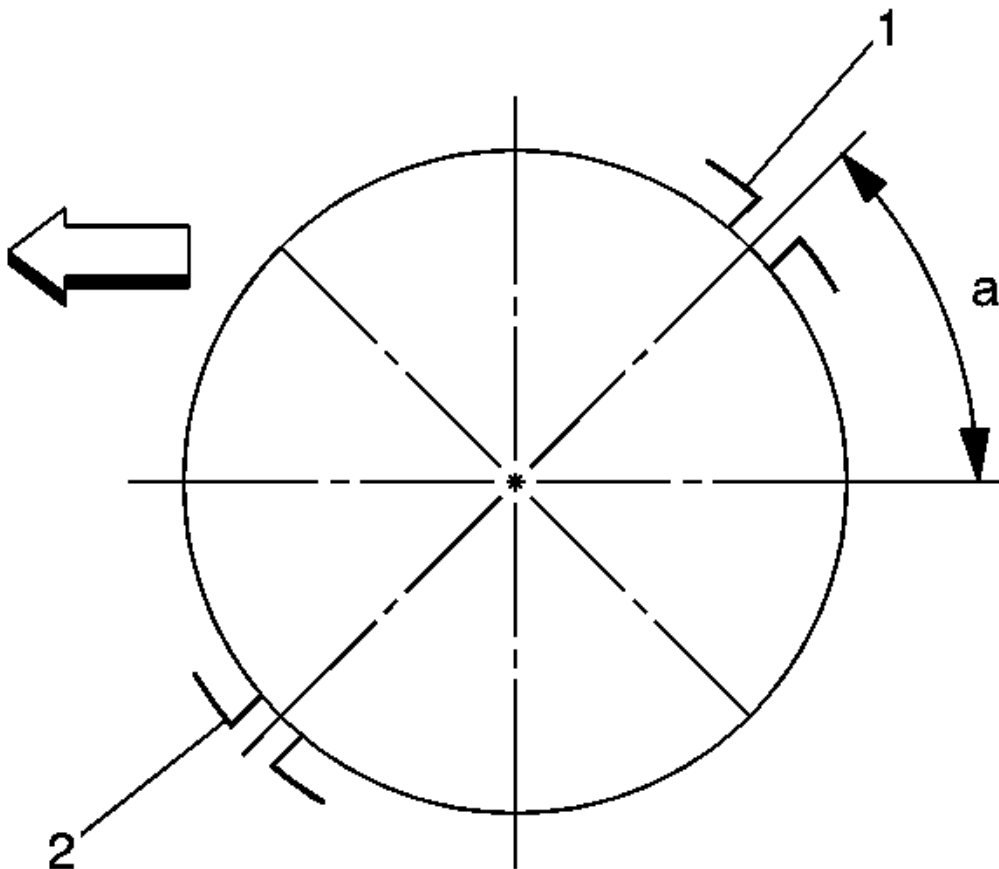


Fig. 480: Identifying Proper Piston Ring Positioning
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not align the ring ends.

4. Position the piston rings so that the ring ends are as shown in the illustration.

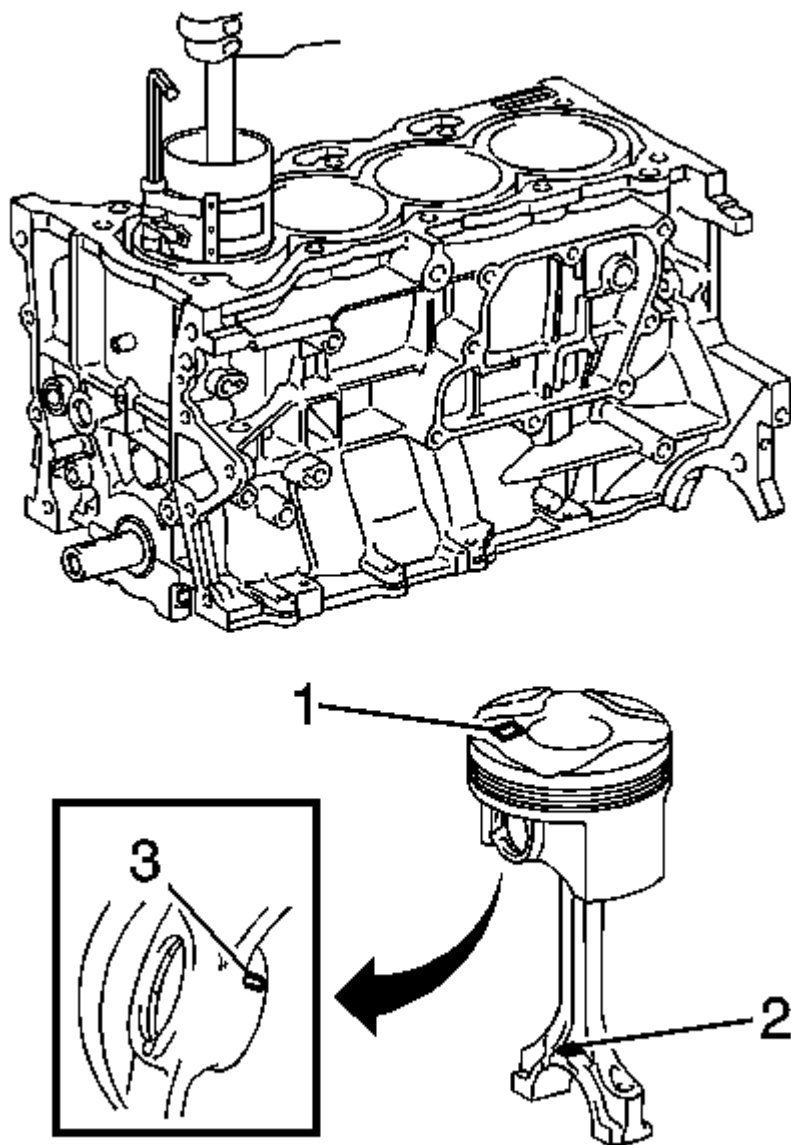


Fig. 481: View Of Piston & Rod Installation Into Block
 Courtesy of GENERAL MOTORS CORP.

NOTE:

- When inserting the piston with connecting rod, do not allow it to make contact with the oil nozzle.
- Match the numbered connecting rod cap with the connecting rod.

5. Using a piston ring compressor, push the correctly numbered piston and connecting rod assembly into the cylinder with the front mark of the piston facing forward.

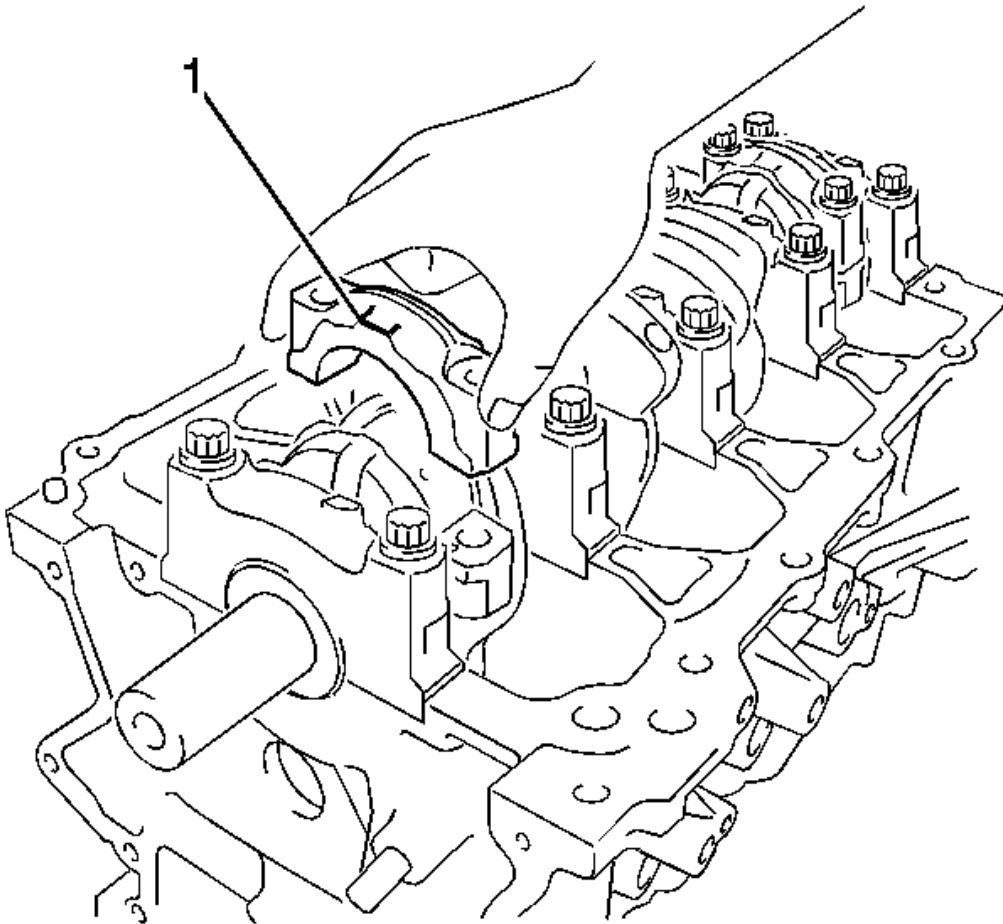


Fig. 482: Identifying Connecting Rod Cap Installation
Courtesy of GENERAL MOTORS CORP.

6. Check that the protrusion of the connecting rod cap is facing in the correct direction.
7. Apply a light coat of engine oil to the threads and under the heads of the connecting rod cap bolts.

NOTE: **The connecting rod cap bolts should be tightened in 2 progressive steps.**

8. Install the connecting rod cap bolts.

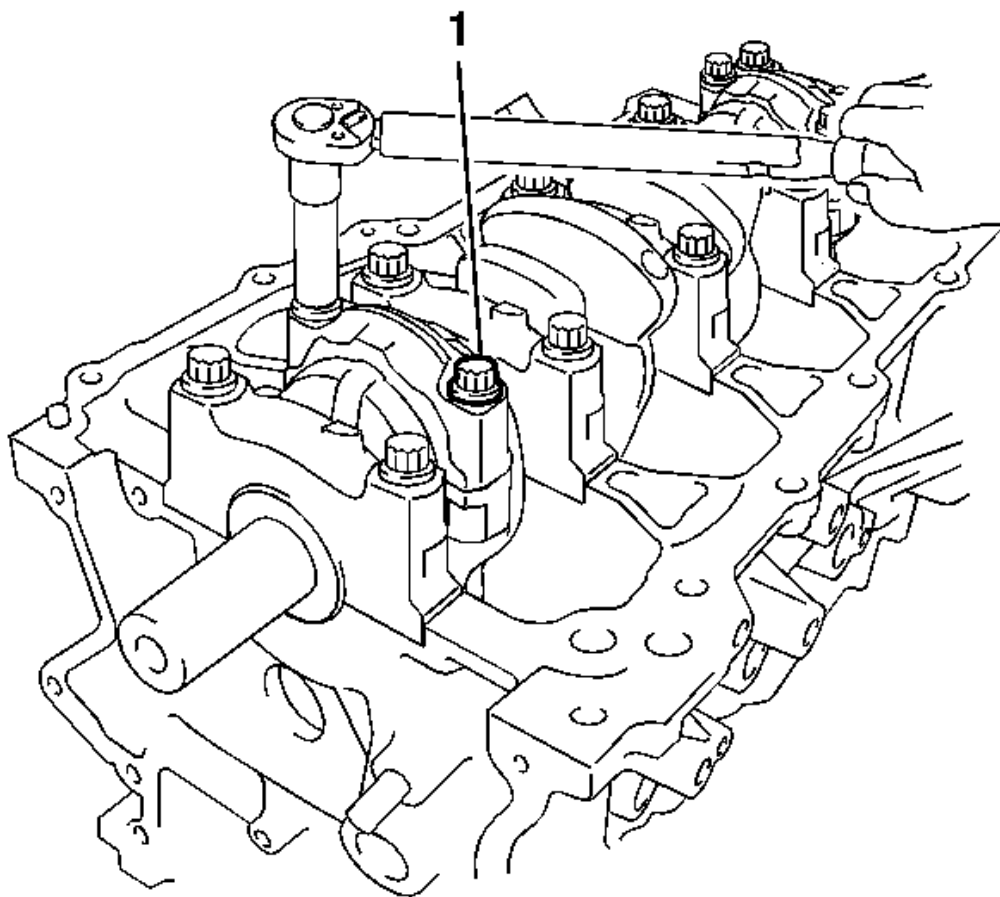


Fig. 483: Identifying Connecting Rod Cap Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

9. Using **SST** , install and alternately tighten the bolts of the connecting rod cap in several steps to 20 N.m (15 lb ft).

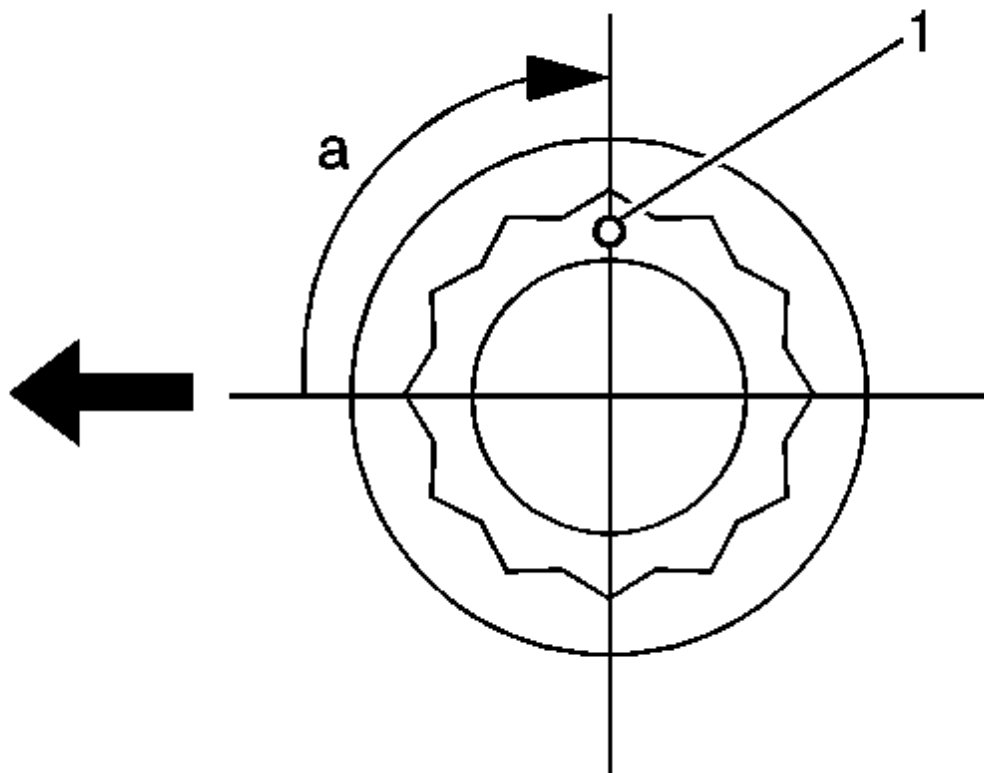


Fig. 484: Identifying Connecting Rod Cap Bolt Tightening Final Step
Courtesy of GENERAL MOTORS CORP.

10. Mark the front of the connecting rod cap bolts with paint.
11. Further tighten the cap bolts an additional 90 degrees as shown.
12. Check that the crankshaft turns smoothly.
13. Check the connecting rod thrust clearance.

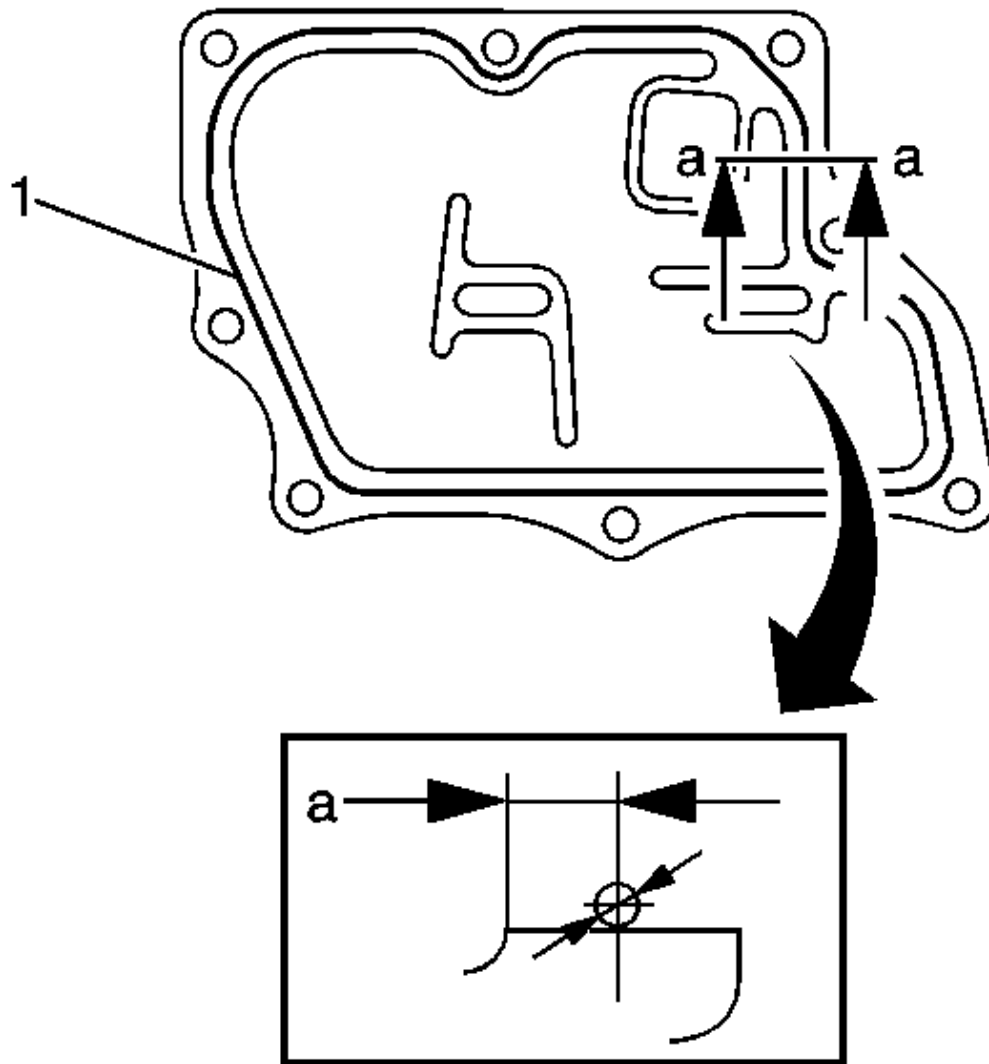


Fig. 485: Identifying Ventilation Case Contact Surface
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Remove any oil from the contact surface.
- Install the No. 1 ventilation case within 3 minutes and tighten the bolts and nuts within 15 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after installing.

14. Apply Three Bond 1207B or equivalent Bead diameter: 2.0 mm (0.0787 in) seal packing in a continuous

bead as shown in the illustration.

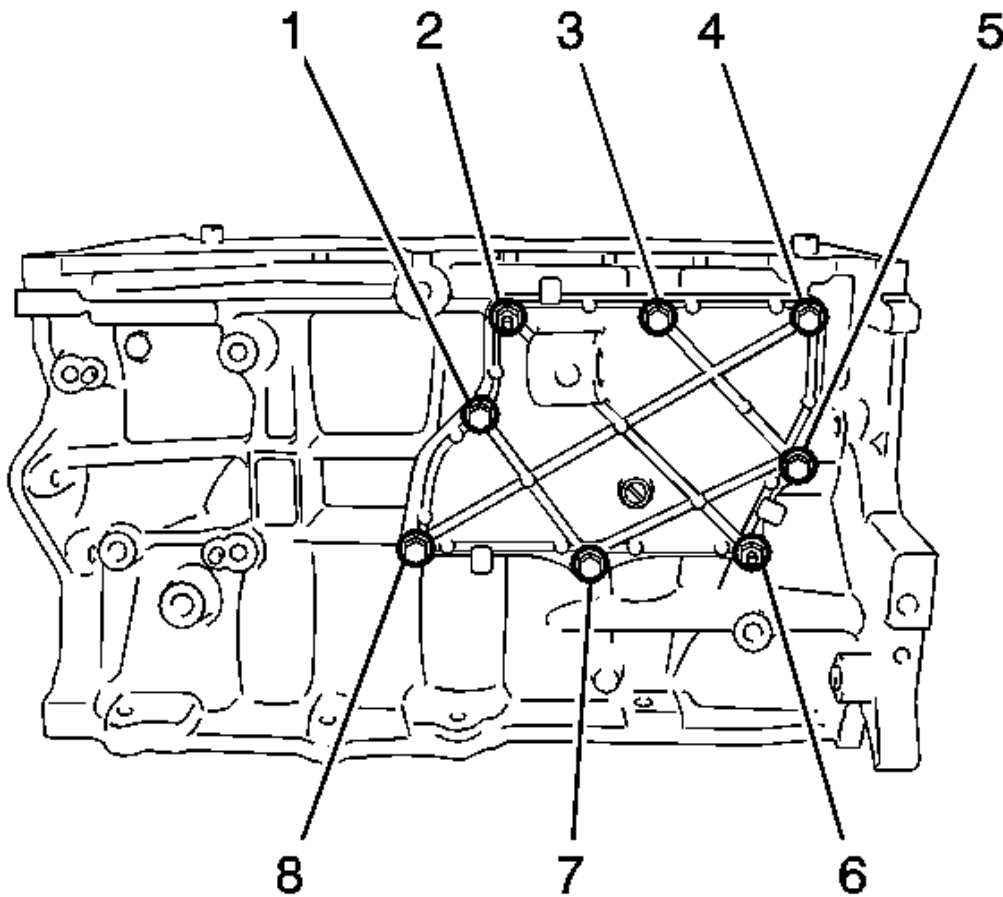


Fig. 486: View Of 6 Bolts & 2 Nuts
Courtesy of GENERAL MOTORS CORP.

15. Install the No. 1 ventilation case with the 6 bolts and 2 nuts and tighten to 10 N.m (7 lb ft).

CYLINDER HEAD INSTALLATION

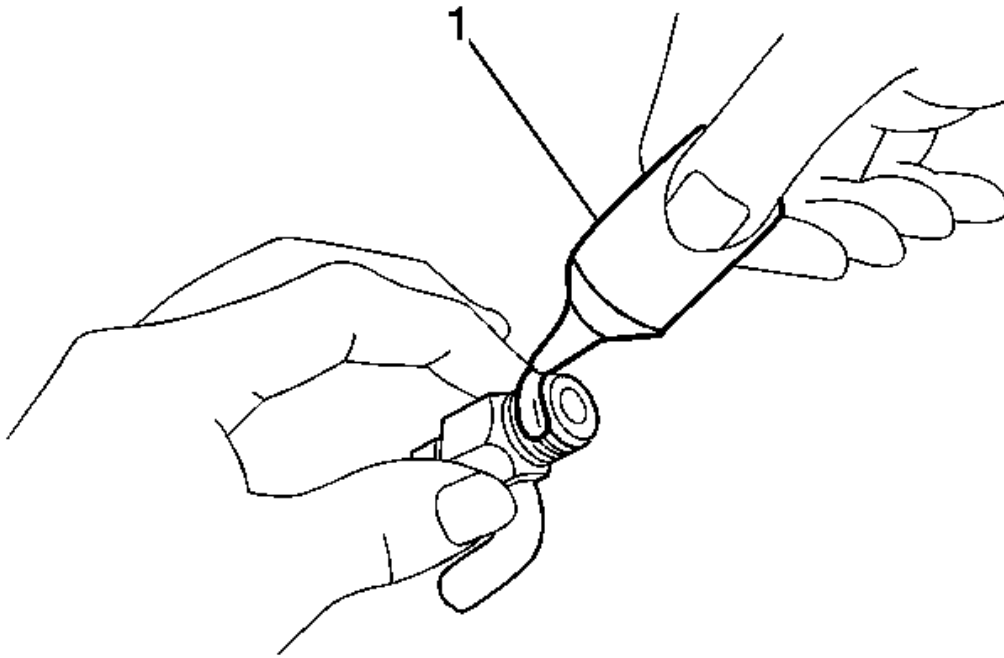


Fig. 487: Applying Sealant To Block Water Drain Cock Sub-Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install cylinder block water drain cock sub-assembly.
2. Apply Three Bond 1344 or equivalent adhesive to the threads of the drain cock.

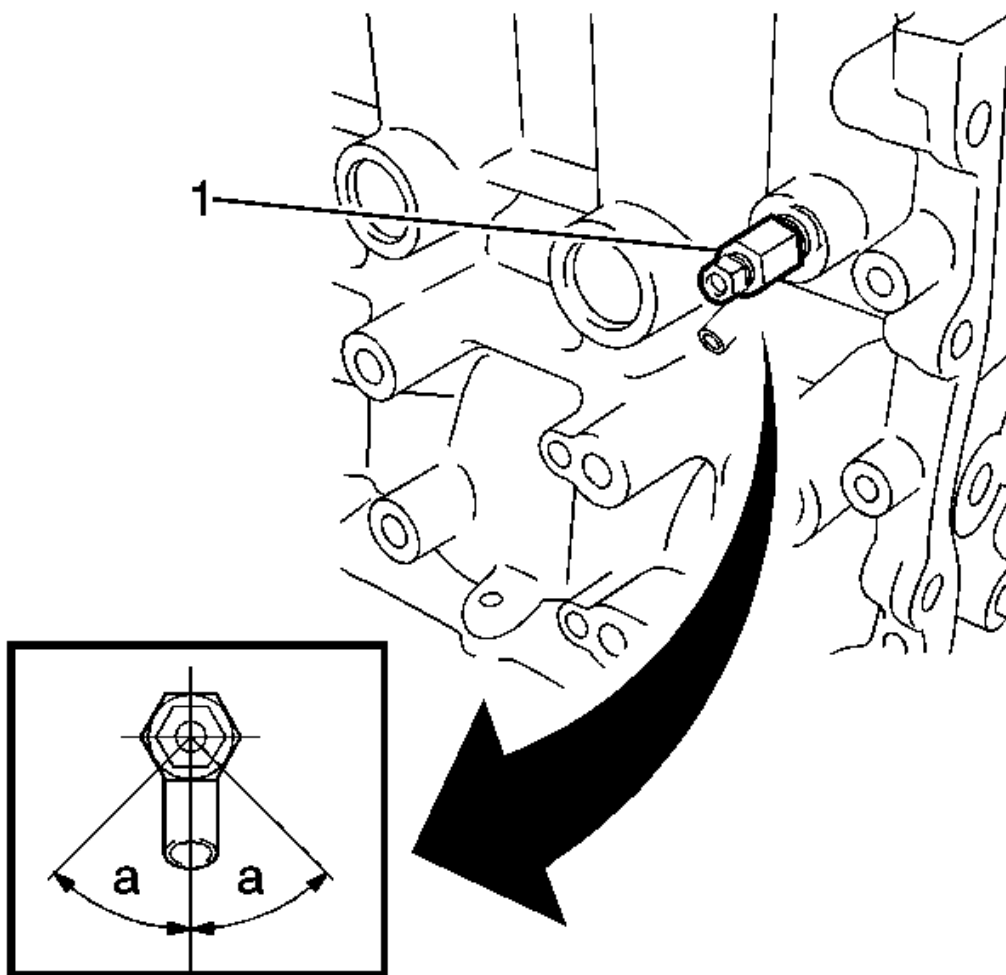


Fig. 488: View Of Water Drain Cock Installation
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE:

- Do not rotate the drain cock more than 1 revolution (360 degrees) after tightening it to the specified torque.
- Install the water drain cock within 3 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after installing the water

drain cock.

3. Install the water drain cock and tighten to 20 N.m (15 lb ft)
4. Install the water drain cock plug to the water drain cock and tighten to 13 N.m (9 lb ft)

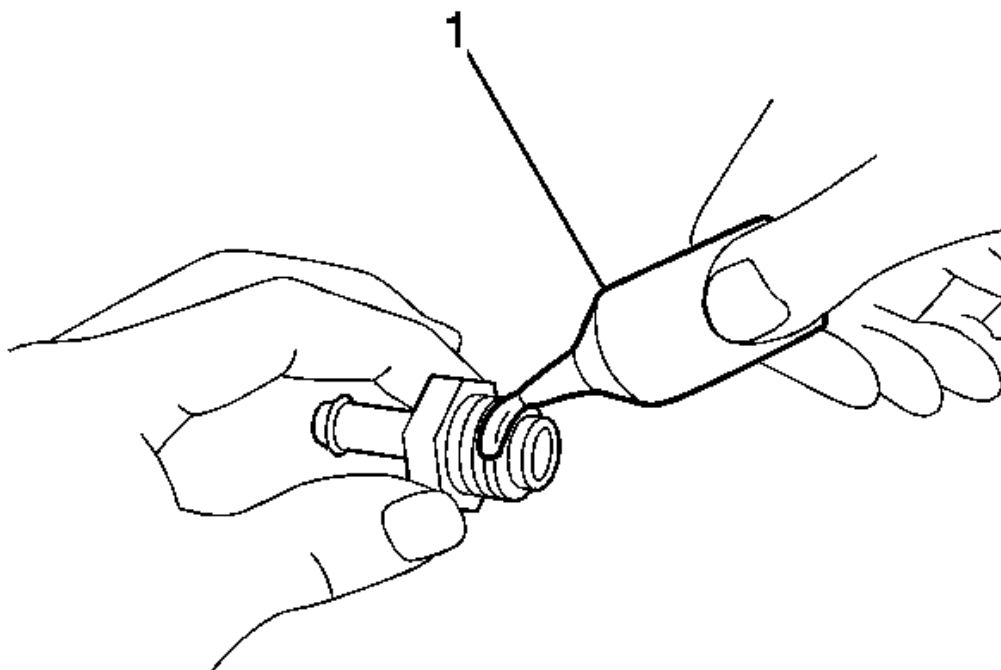


Fig. 489: Applying Adhesive To Threads Of Ventilation Valve Sub-Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the ventilation valve sub-assembly.
6. Apply Three Bond 1324 or equivalent adhesive to the threads of the ventilation valve.

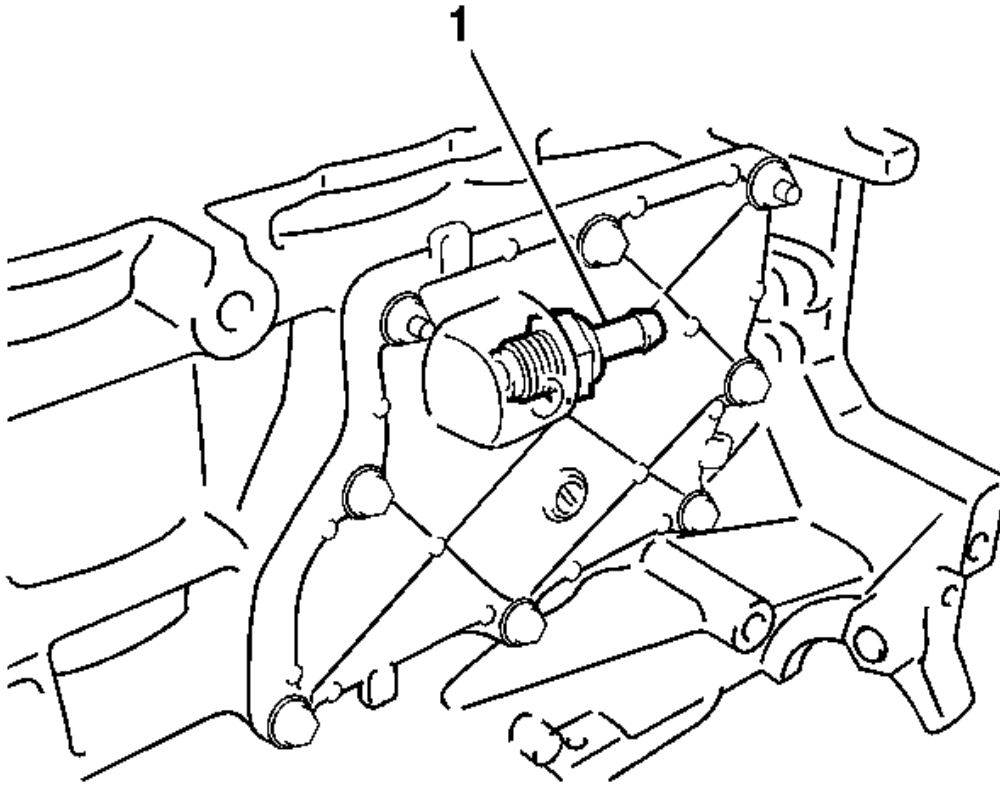


Fig. 490: Identifying Ventilation Valve
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Install the crankcase within 3 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after installing the ventilation valve.

7. Install the ventilation valve and tighten to 20 N.m (15 lb ft).
8. Install the cylinder head gasket.
9. Install the cylinder head sub-assembly.

INTAKE CAMSHAFT AND VALVE LIFTER INSTALLATION

NOTE:

- Keep the lash adjuster free of dirt and foreign matter.
- Only use clean engine oil.

1. Install the valve lash adjuster assembly.
2. Place the lash adjuster into a container filled with engine oil.

NOTE: Install the lash adjuster to the same place it was removed from.

3. Install the lash adjusters.
4. Install the No. 1 valve rocker arm subassembly
5. Apply engine oil to the lash adjuster tip and valve stem cap end.

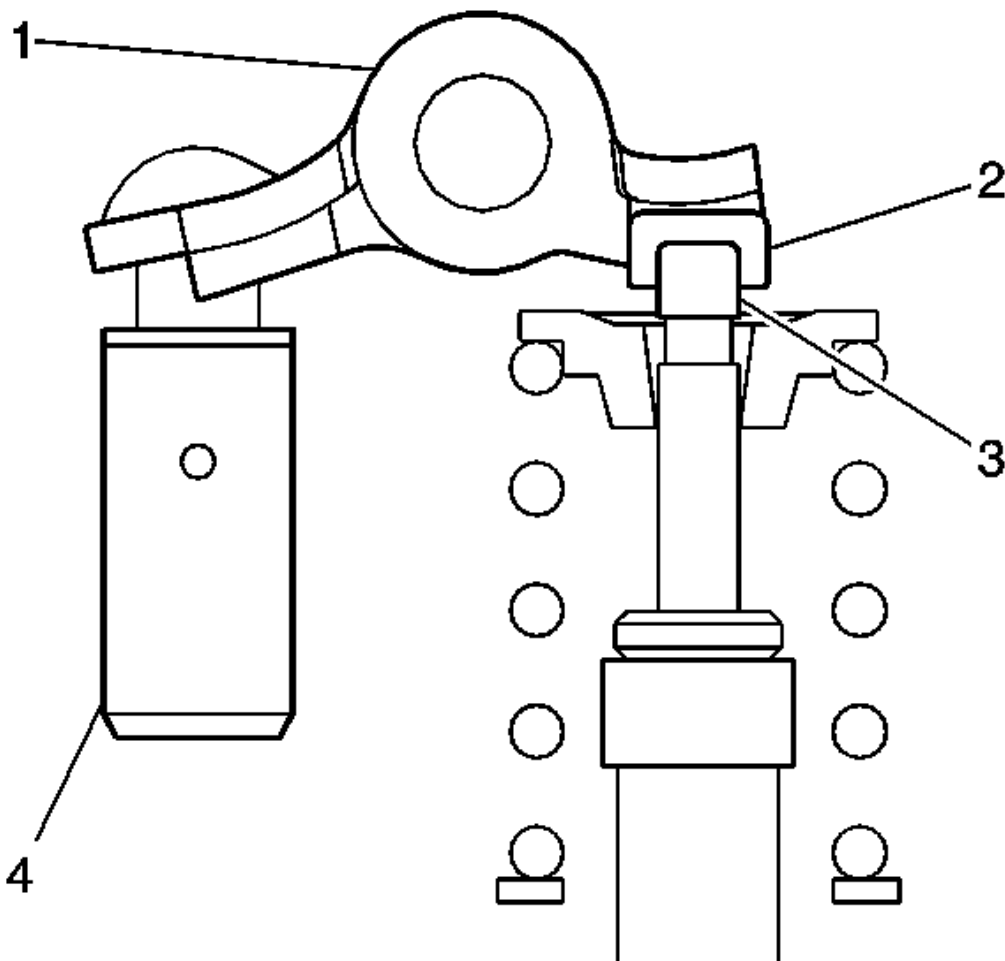


Fig. 491: View Of Correct Rocker Arm Installation
Courtesy of GENERAL MOTORS CORP.

6. Make sure that the valve rocker arms are installed.
7. Clean both surfaces of the bearings.
8. Install the 2 No. 1 camshaft bearings.

NOTE: Position the bearings to the center of the bearing cap by measuring dimensions A and B.

9. Using vernier calipers, measure the distance between the bearing cap edge and the camshaft bearing edge.

Specification: Dimension A - B: 0.7 mm (0.0276 in) or less

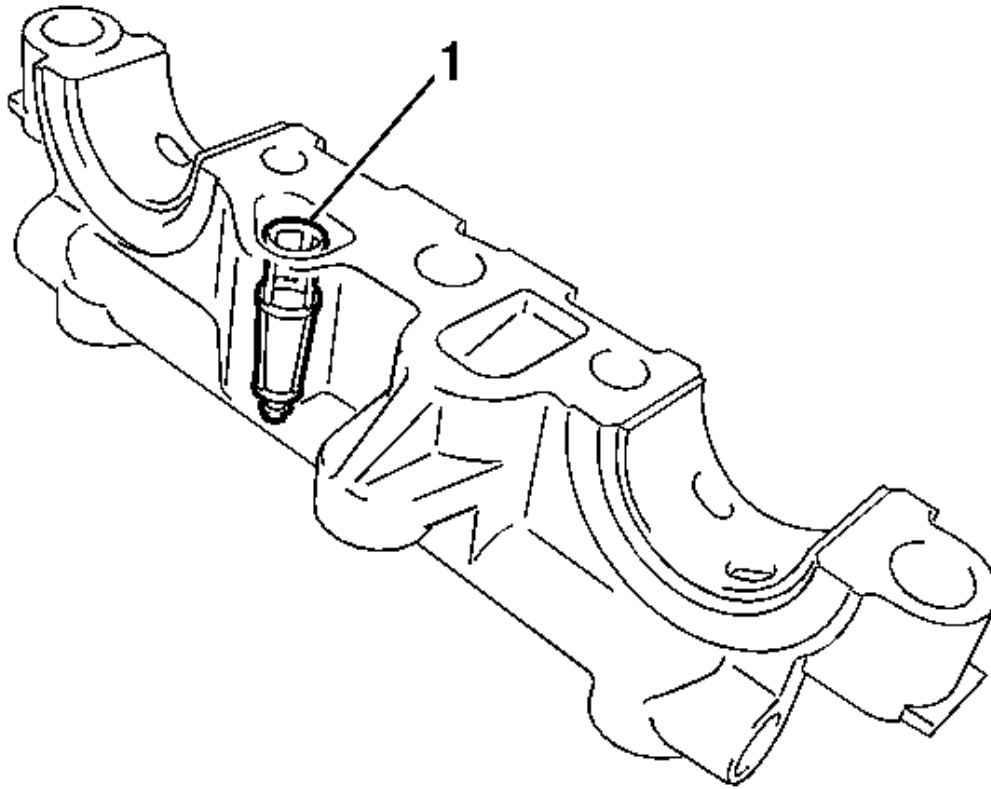


Fig. 492: Identifying oil control valve filter
Courtesy of GENERAL MOTORS CORP.

10. Install the oil control valve filter.
11. Clean both surfaces of the bearings.

12. Install the 2 No. 2 camshaft bearings.

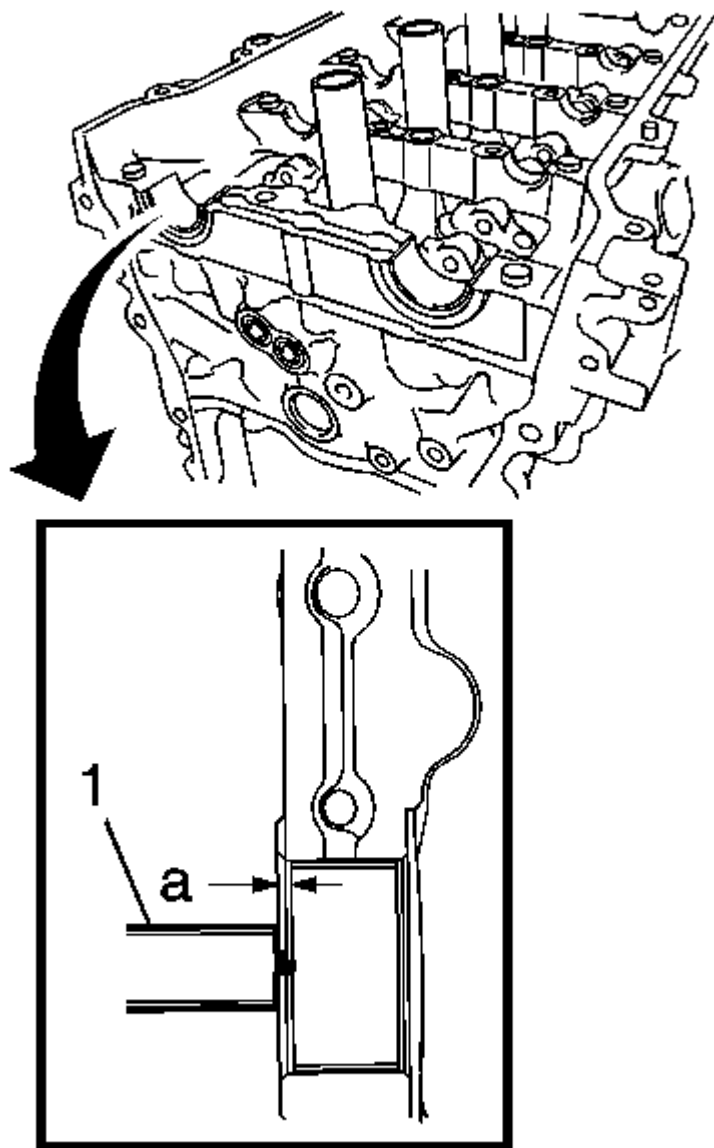


Fig. 493: Measuring Distance Between Bearing Cap Edge & Camshaft Bearing Edge
 Courtesy of GENERAL MOTORS CORP.

NOTE: Position the bearings to the center of the bearing cap by measuring dimension A.

13. Using vernier calipers, measure the distance between the bearing cap edge and the camshaft bearing edge.

Specification: Dimension A: 1.05 to 1.75 mm (0.041 to 0.069 in)

14. Clean the camshaft journals.
15. Apply a light coat of engine oil to the camshaft journals, camshaft housings and bearing caps.

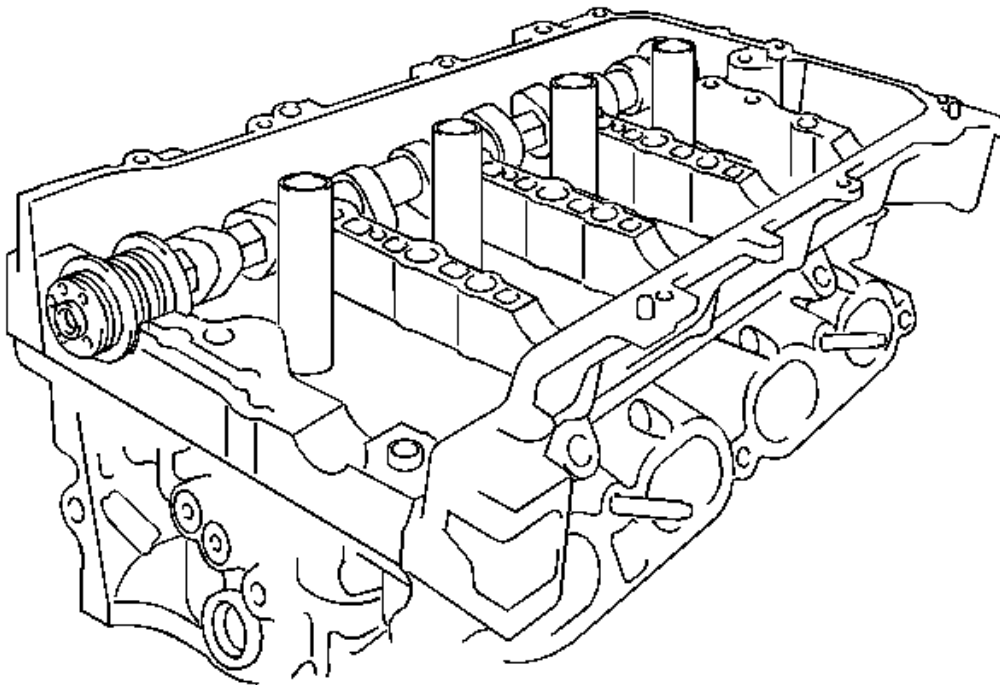


Fig. 494: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

16. Install the No. 2 camshaft to the camshaft housing.
17. Clean the camshaft journals.
18. Apply a light coat of engine oil to the camshaft journals, camshaft housing.

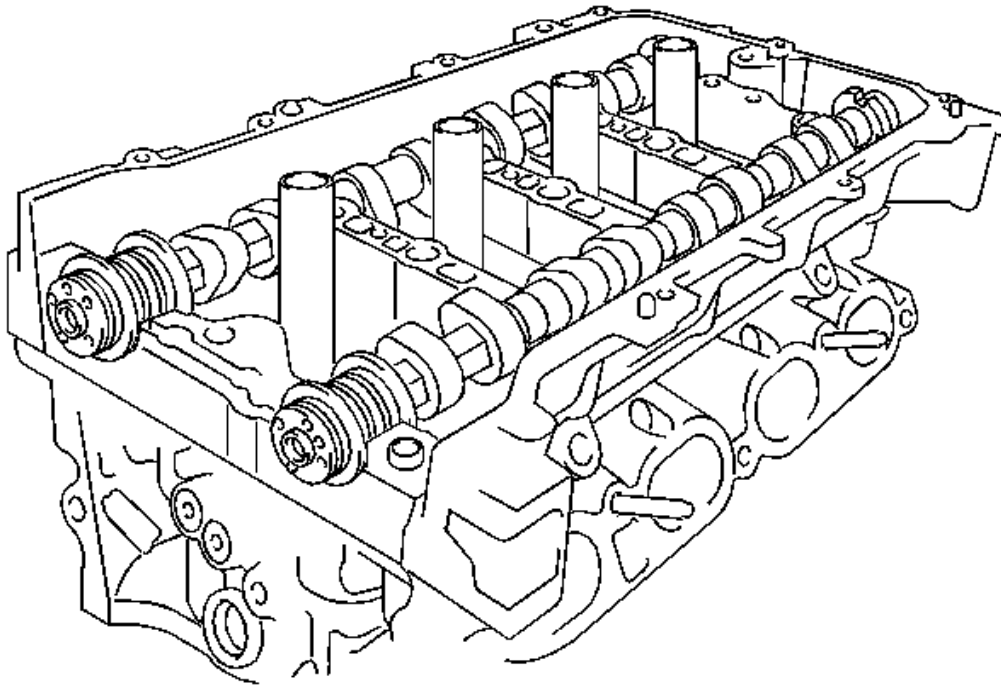


Fig. 495: View Of Cylinder Head & Camshafts
Courtesy of GENERAL MOTORS CORP.

19. Install the camshaft to the camshaft housing.
20. Install the camshaft bearing cap.
21. Apply the engine oil to the bearing caps.

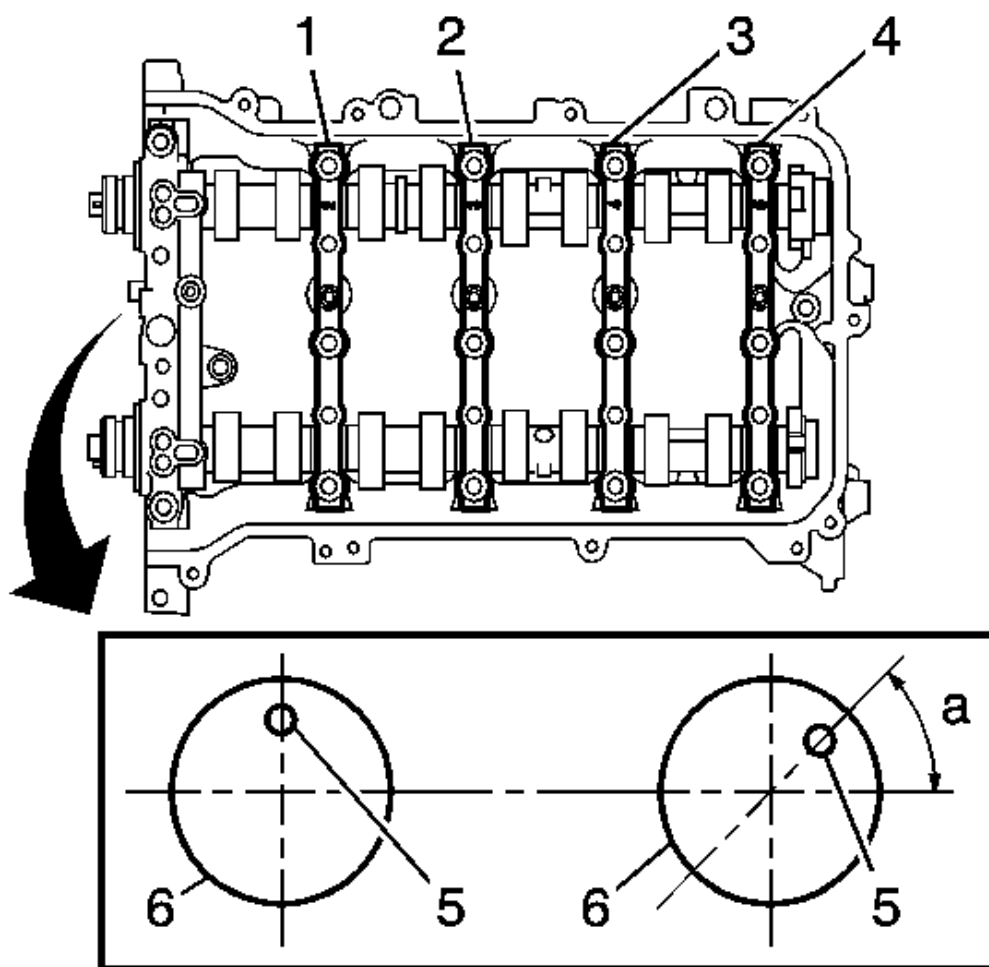


Fig. 496: Locating Marks & Numbers On Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

NOTE:

Make sure that the knock pin of the camshaft is positioned as shown.

22. Make sure of the marks and numbers on the camshaft bearing caps and place them in each proper position and direction.

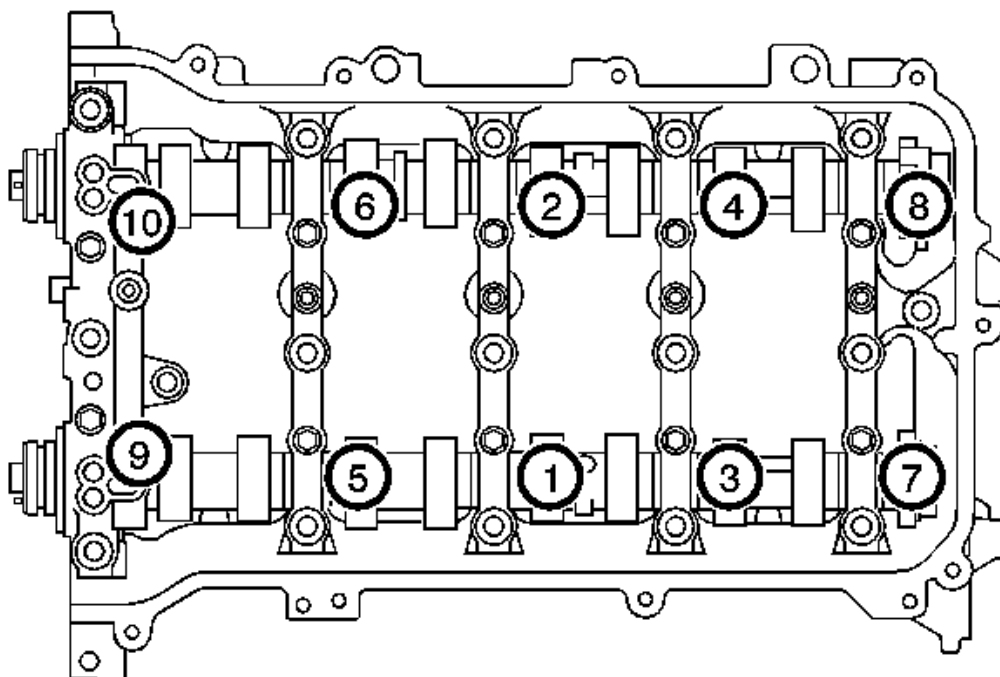


Fig. 497: Identifying Camshaft Bearing Cap Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

23. Install the 10 bolts and tighten in sequence to 16 N.m (12 lb ft).

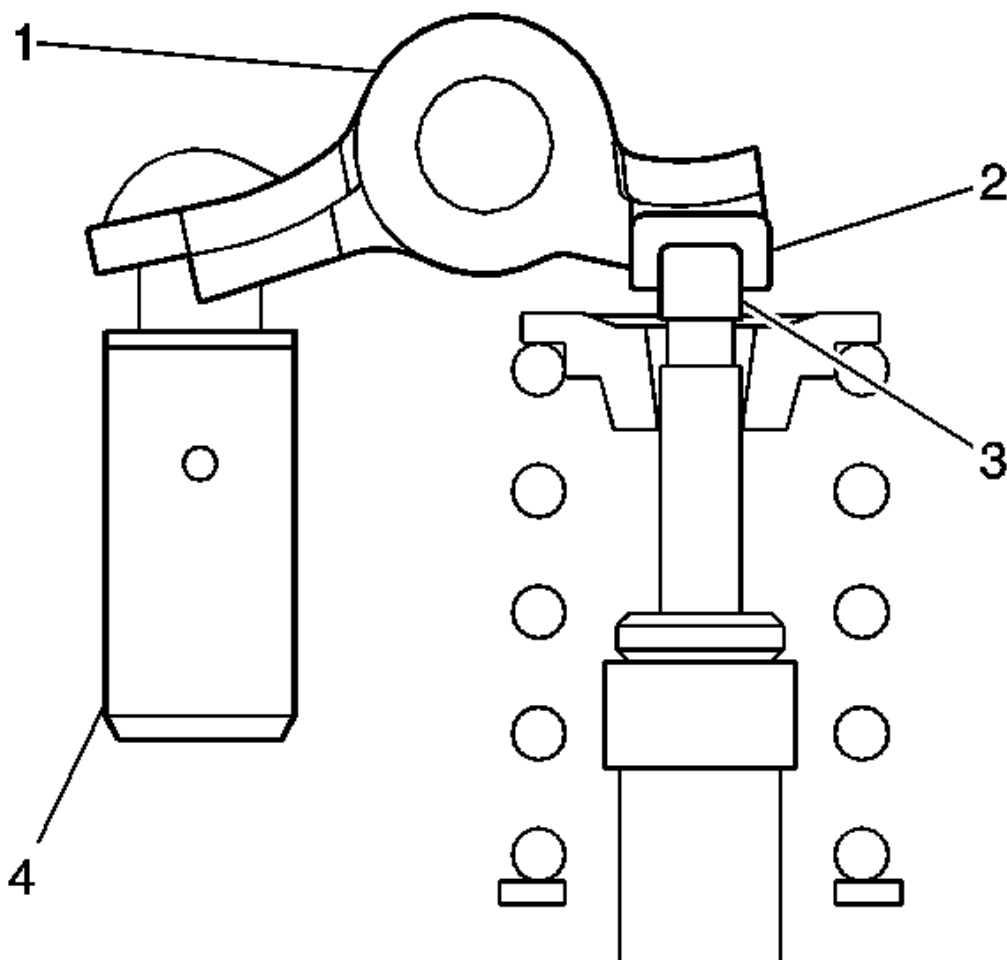


Fig. 498: View Of Correct Rocker Arm Installation
Courtesy of GENERAL MOTORS CORP.

24. Install the camshaft housing sub-assembly.
25. Make sure that the valve rocker arm is installed.

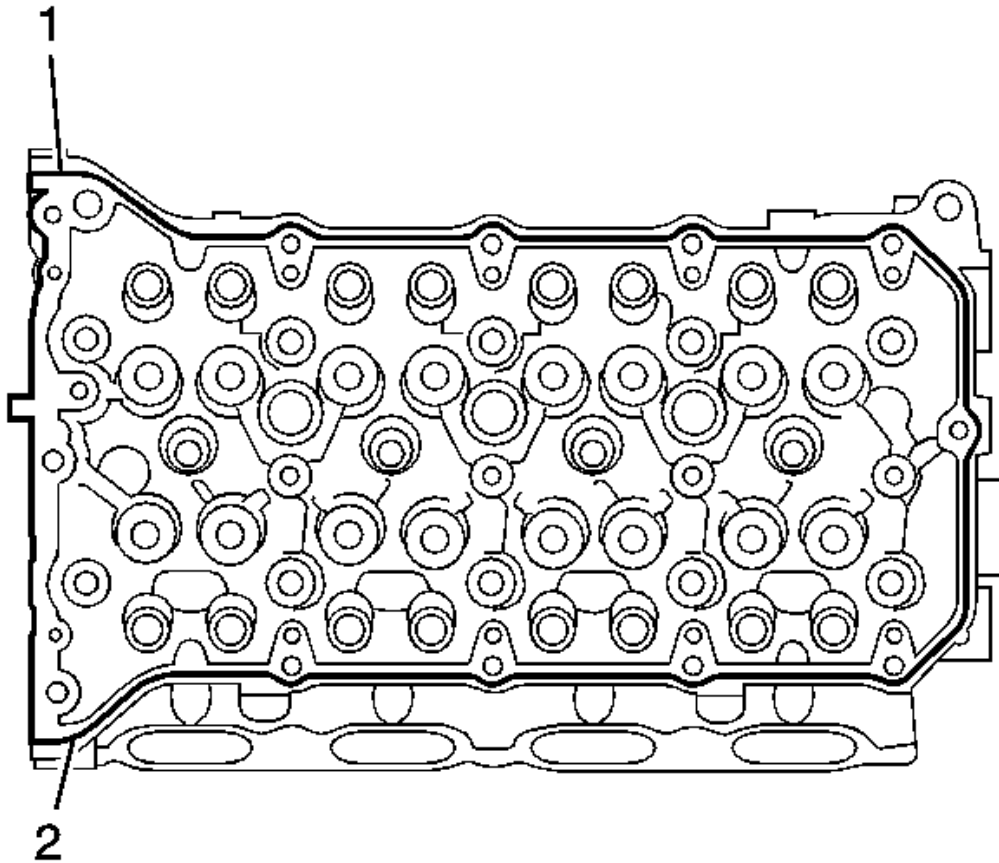


Fig. 499: Applying Adhesive To Cylinder Head
 Courtesy of GENERAL MOTORS CORP.

NOTE:

- Remove any oil from the contact surface.
- Install the camshaft housing sub-assembly within 3 minutes and tighten the bolts within 15 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after installing.

26. Apply Three Bond 1207B or equivalent, seal packing in a continuous bead.

Specification: Bead diameter: 3.5 to 4.0 mm (0.138 to 0.158 in)

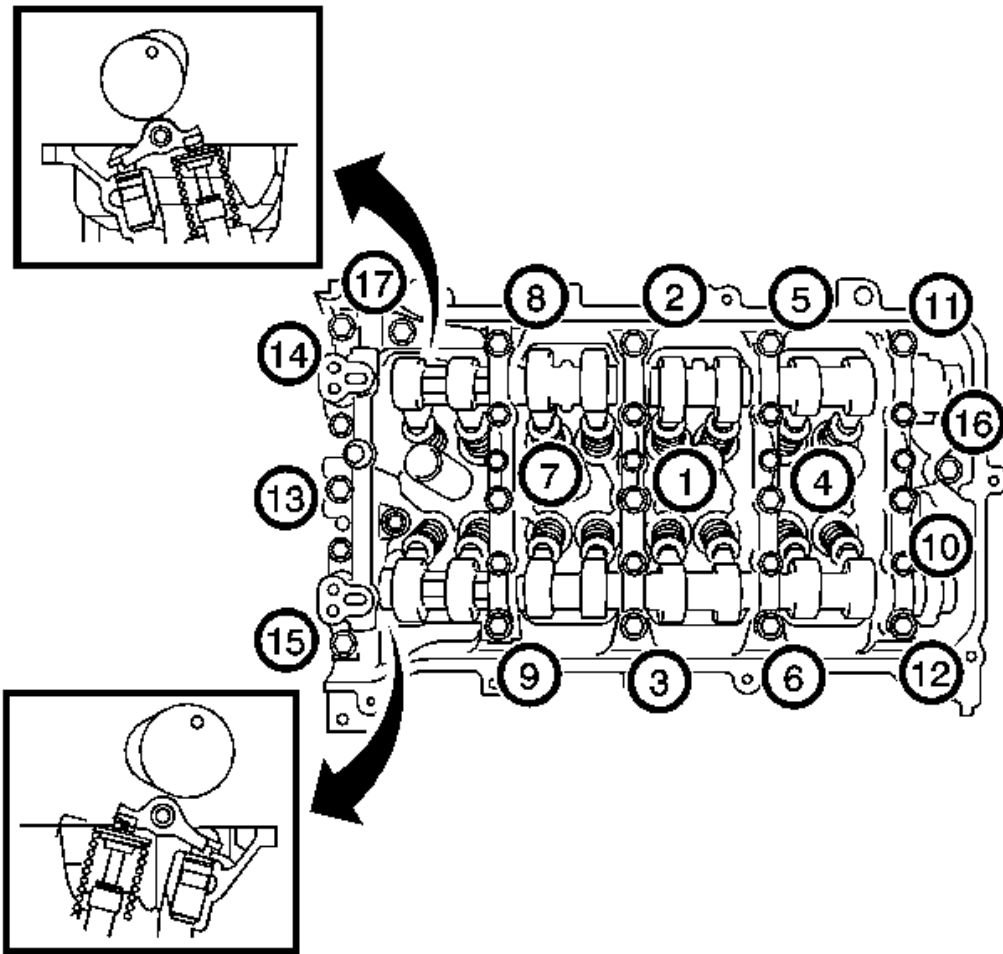


Fig. 500: View Of Setting Camshafts
Courtesy of GENERAL MOTORS CORP.

27. Set the camshaft and No. 2 camshaft.

NOTE:

- After installing the camshaft housing, make sure that the cam lobes are positioned as shown.
- If any of the bolts are loosened during installation, remove the camshaft housing, clean the installation surfaces, and reapply seal packing.
- If the camshaft housing is removed because any of the bolts are loosened during installation, make sure that the previously applied seal packing does not enter any oil passages.

- After installing the camshaft housing, wipe off any seal packing that seeped out from between the housing and the cylinder head.

28. Install the camshaft housing and 17 bolts and tighten in sequence to 27 N.m (20 lb ft).
29. Install the camshaft timing gear assembly.
30. Check that the knock pin is installed on the camshaft.

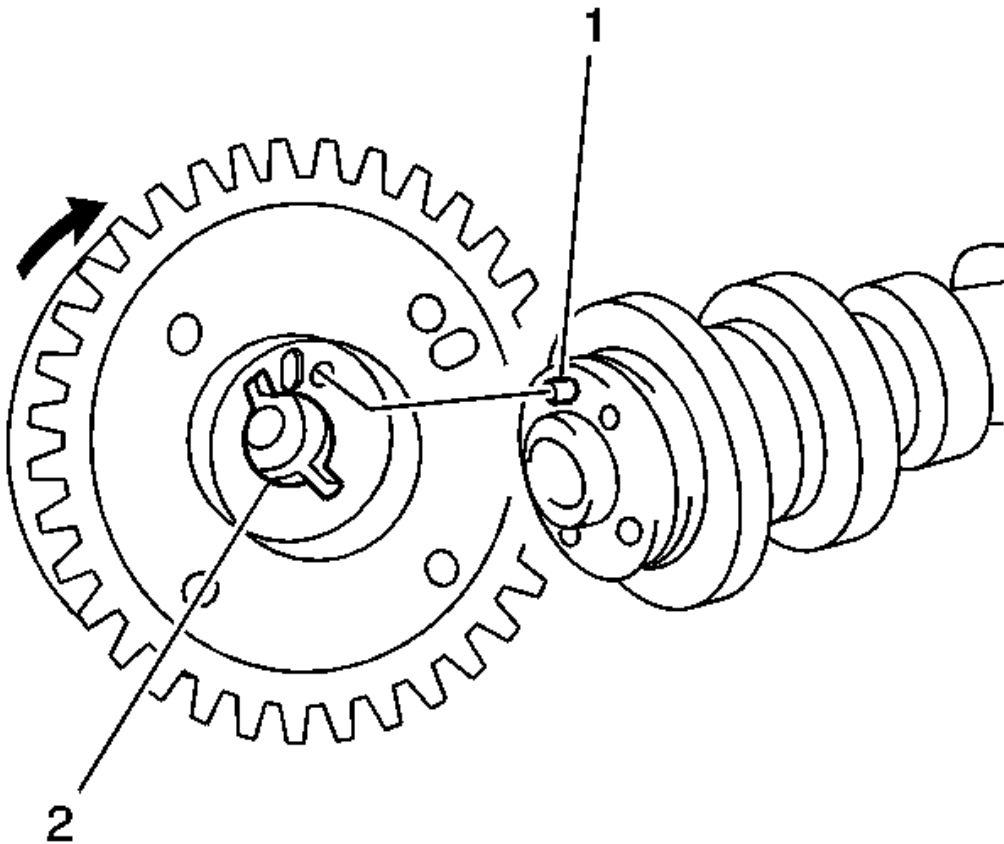


Fig. 501: View Of Camshaft Timing Gear Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not forcefully push in the camshaft timing gear assembly. This may cause the camshaft knock pin tip to damage the installation surface of the camshaft timing gear assembly.

31. Put the camshaft timing gear and camshaft together with the straight pin and key groove misaligned.

NOTE: Do not turn the camshaft timing gear in the retard direction (clockwise).

32. Turn the camshaft timing gear, while pushing it gently against the camshaft. Push further at the position where the pin fits into the groove.

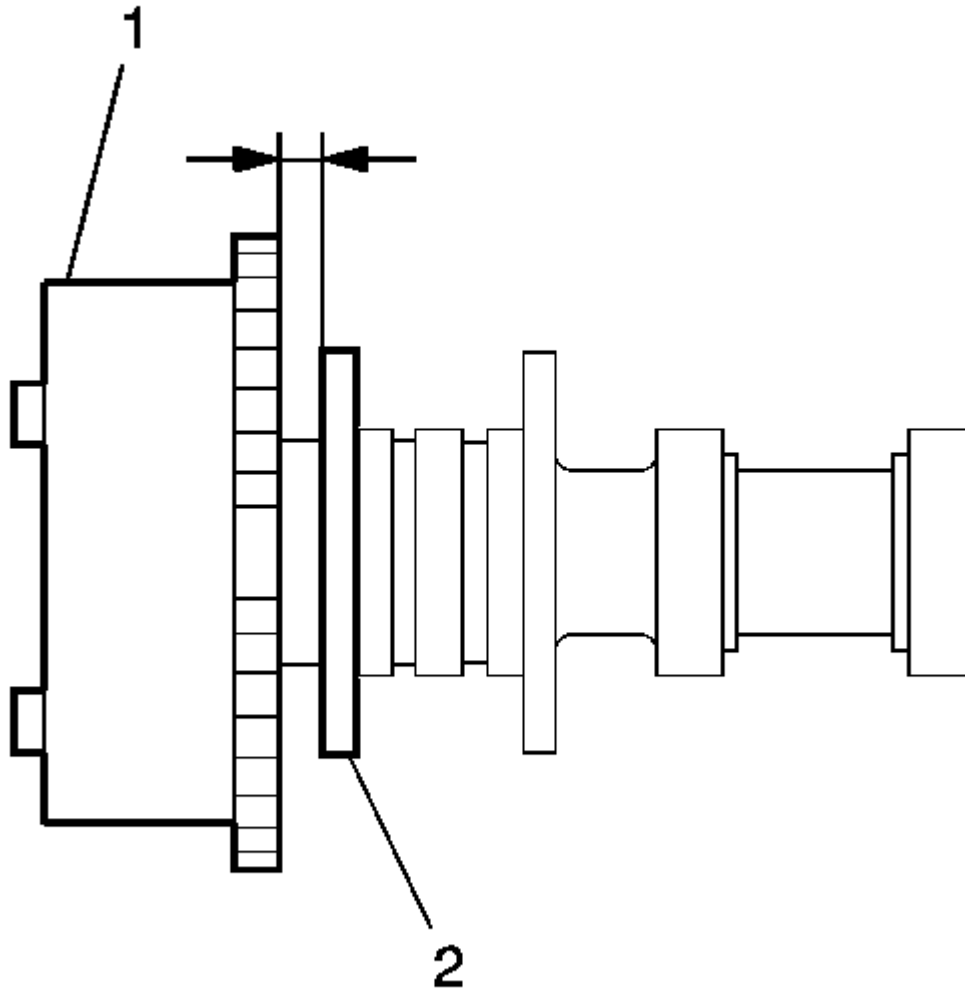


Fig. 502: Measuring Clearance Between Gear & Camshaft
Courtesy of GENERAL MOTORS CORP.

33. Measure the clearance between the gear and the camshaft.

Specification: Clearance: 0.1-0.4 mm (0.004-0.016 in)

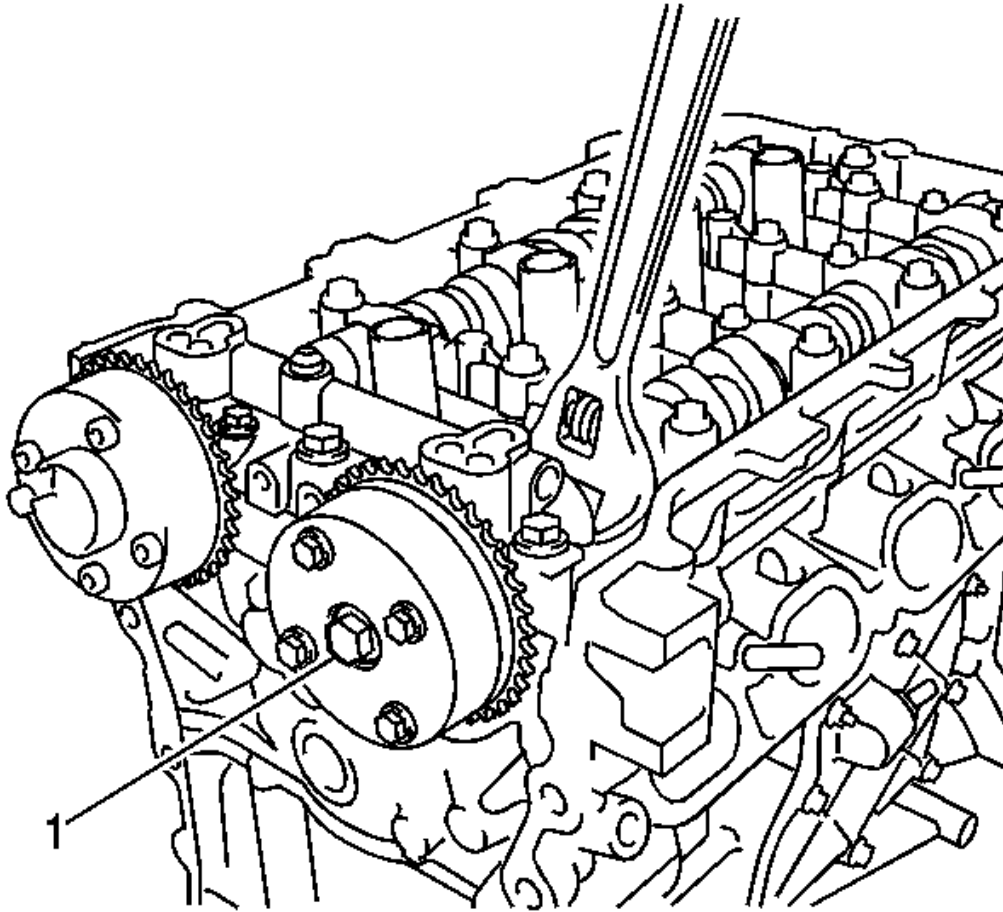


Fig. 503: View Of Tightening Camshaft Timing Gear
Courtesy of GENERAL MOTORS CORP.

34. Install the flange bolt with the camshaft timing gear fixed in place and tighten to 54 N.m (40 lb ft).

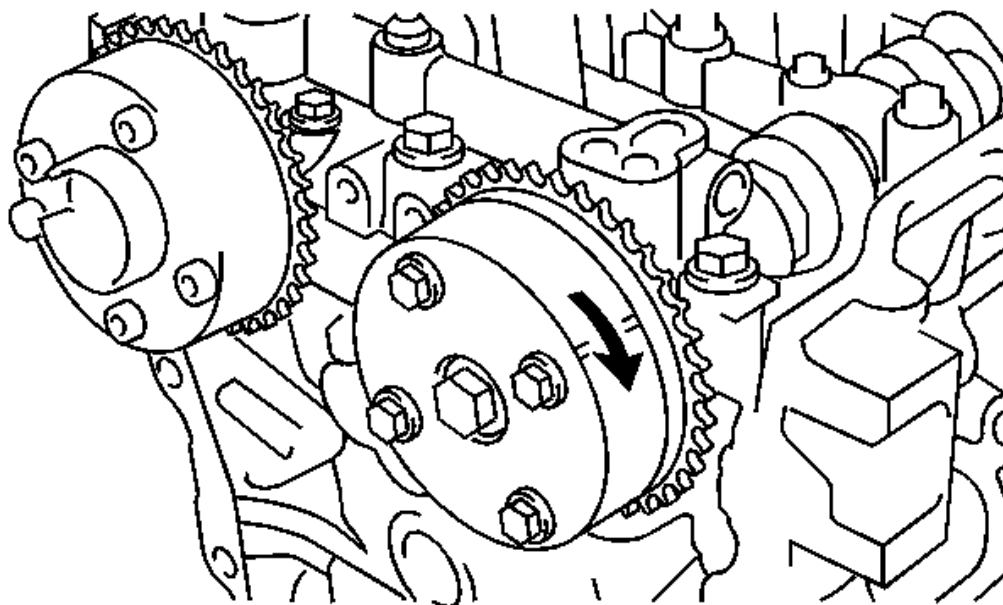


Fig. 504: Checking Camshaft Timing Gear Movement
Courtesy of GENERAL MOTORS CORP.

35. Check that the camshaft timing gear can move in the retard direction (clockwise) and locks in the most retarded position.
36. Install the camshaft timing exhaust gear assembly.
37. Check that the knock pin is installed on the camshaft.

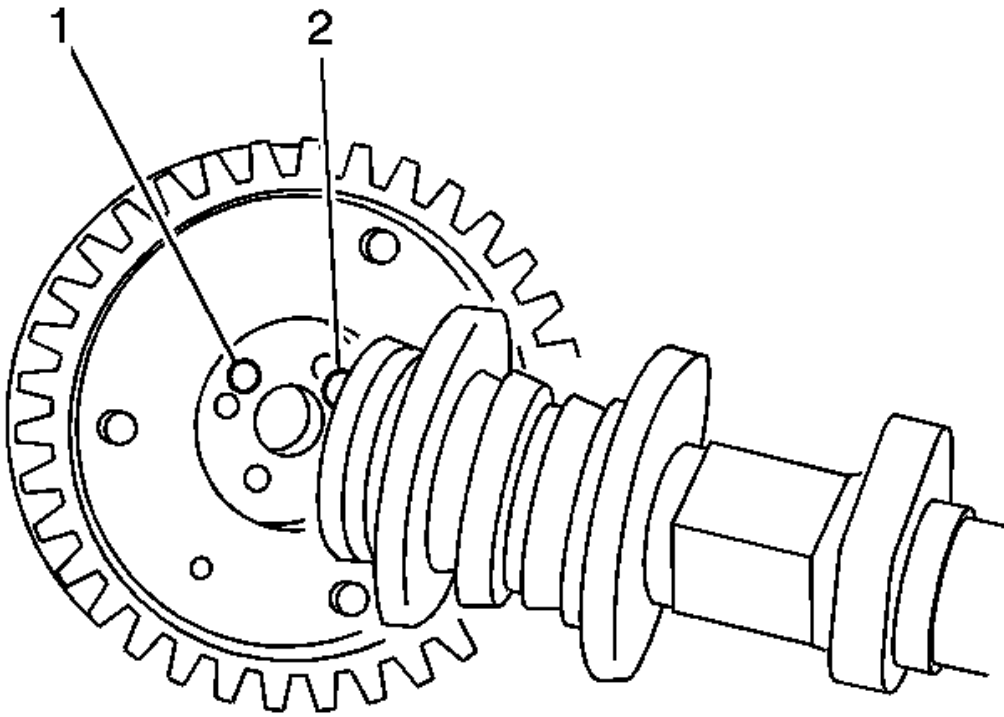


Fig. 505: View Of Camshaft Timing Exhaust Gear & Camshaft
Courtesy of GENERAL MOTORS CORP.

38. Put the camshaft timing exhaust gear and camshaft together by aligning the key groove and straight pin.

NOTE: Be sure not to turn the camshaft timing exhaust gear in the retard direction (clockwise).

39. Lightly press the gear against the camshaft, and turn the gear. Push further at the position where the pin enters the groove.
40. Check that there is no clearance between the gear flange and the camshaft.

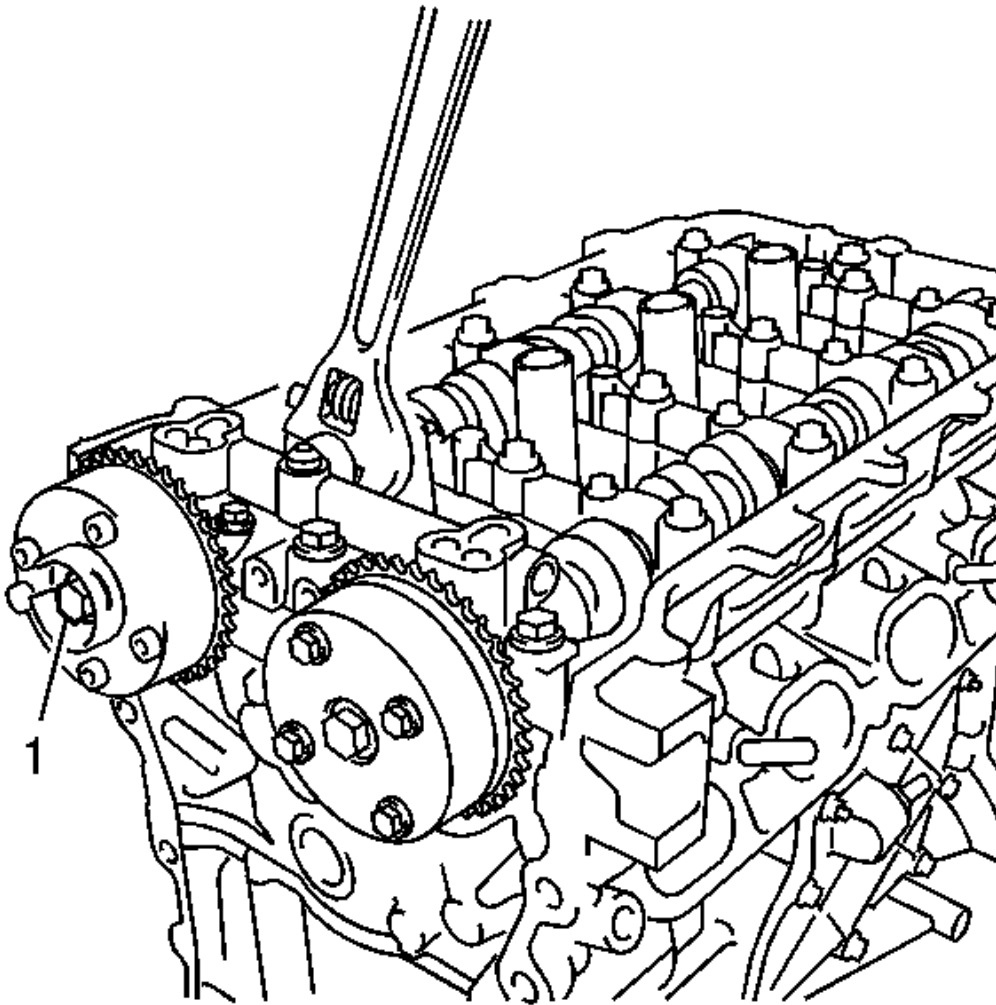


Fig. 506: View Of Tightening Flange Bolt With Camshaft Timing Exhaust Gear Fixed
Courtesy of GENERAL MOTORS CORP.

41. Install the flange bolt with the camshaft timing exhaust gear fixed and tighten to 54 N.m (40 lb ft).
42. Make sure that the camshaft timing exhaust gear is locked.

EXHAUST CAMSHAFT AND VALVE LIFTER INSTALLATION

NOTE:

- Keep the lash adjuster free of dirt and foreign matter.
- Only use clean engine oil.

1. Install the valve lash adjuster assembly.
2. Place the lash adjuster into a container filled with engine oil.

NOTE: Install the lash adjuster to the same place it was removed from.

3. Install the lash adjusters.
4. Install the No. 1 valve rocker arm subassembly
5. Apply engine oil to the lash adjuster tip and valve stem cap end.

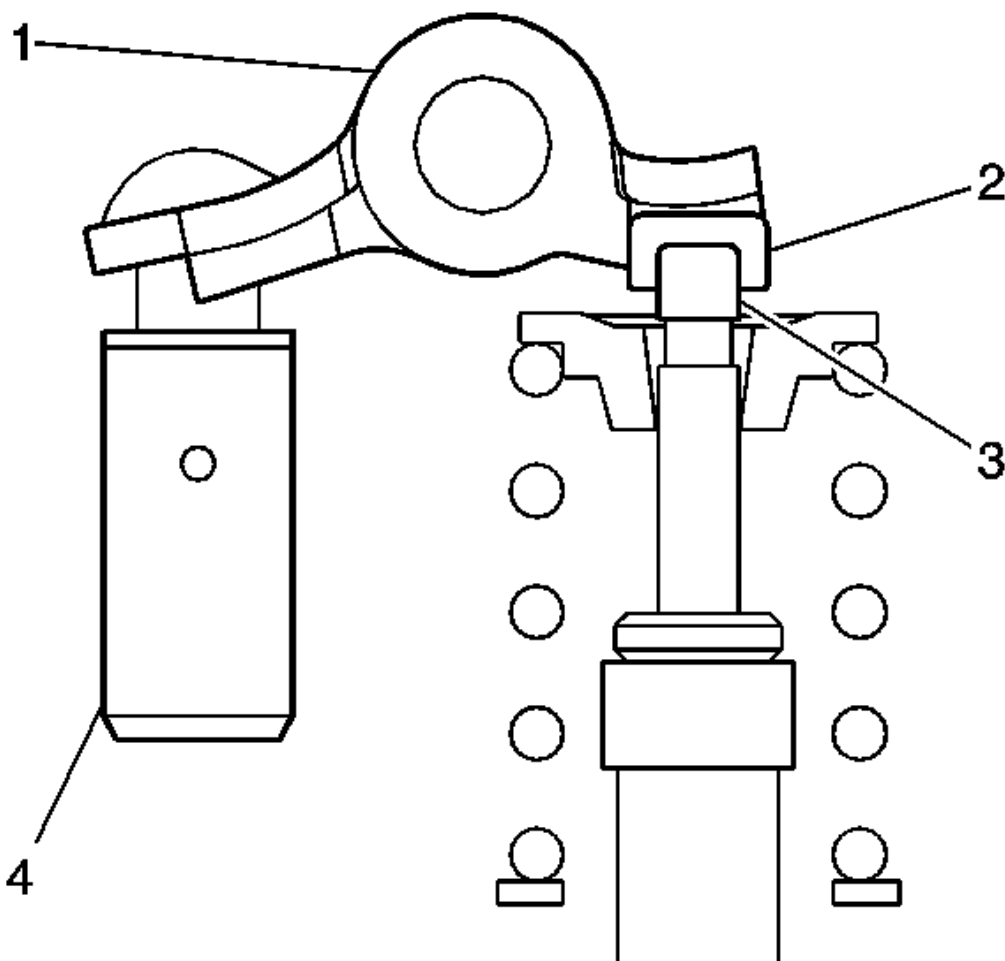


Fig. 507: View Of Correct Rocker Arm Installation
Courtesy of GENERAL MOTORS CORP.

6. Make sure that the valve rocker arms are installed as shown in the illustration.
7. Clean both surfaces of the bearings.
8. Install the 2 No. 1 camshaft bearings.

NOTE: Position the bearings to the center of the bearing cap by measuring dimensions A and B.

9. Using vernier calipers, measure the distance between the bearing cap edge and the camshaft bearing edge.

Specification: Dimension A - B: 0.7 mm (0.0276 in) or less

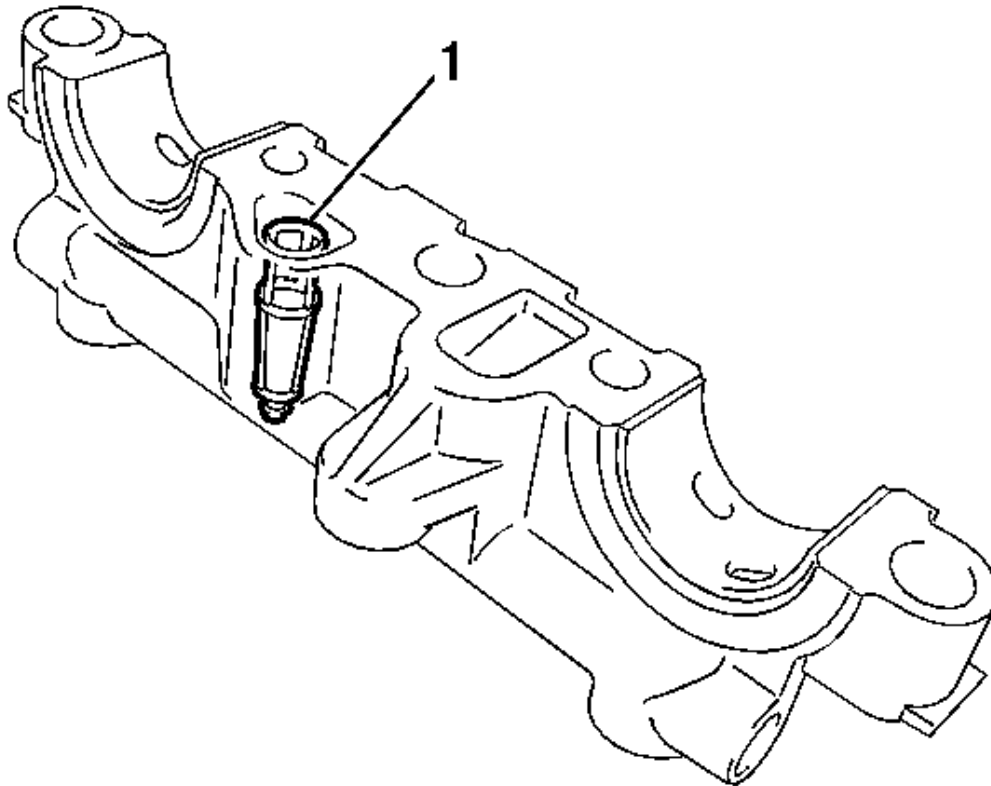


Fig. 508: Identifying oil control valve filter
Courtesy of GENERAL MOTORS CORP.

10. Install the oil control valve filter.
11. Clean both surfaces of the bearings.

12. Install the 2 No. 2 camshaft bearings.

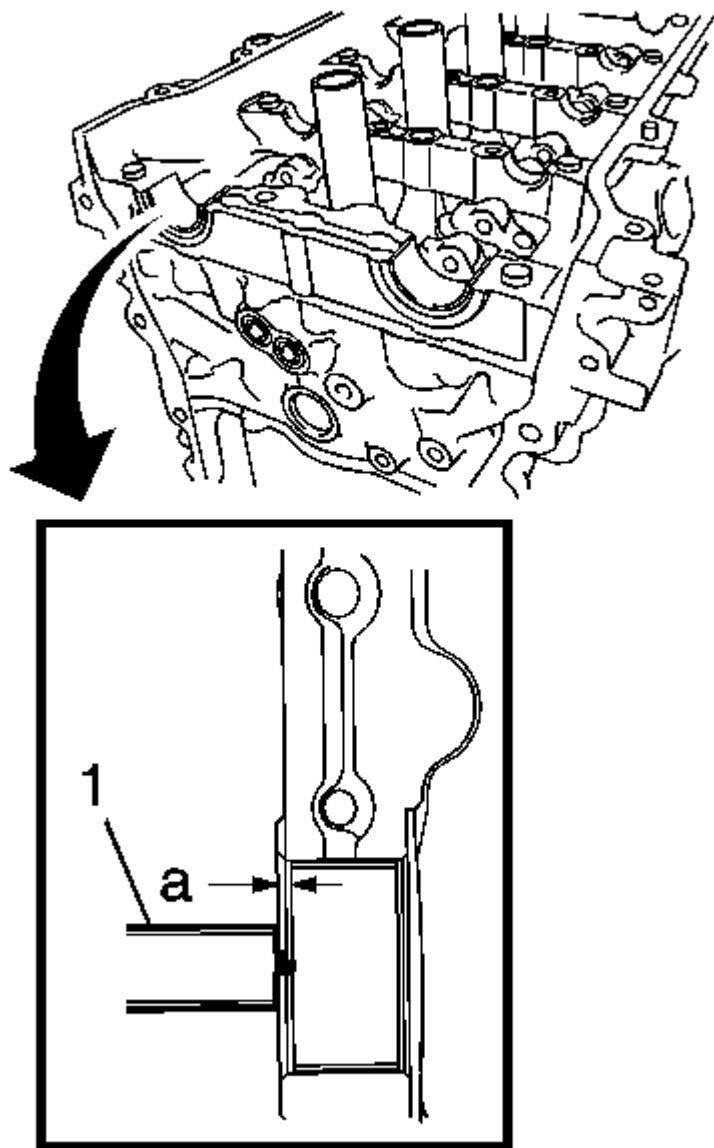


Fig. 509: Measuring Distance Between Bearing Cap Edge & Camshaft Bearing Edge
Courtesy of GENERAL MOTORS CORP.

NOTE: Position the bearings to the center of the bearing cap by measuring dimension A.

13. Using vernier calipers, measure the distance between the bearing cap edge and the camshaft bearing edge.

Specification: Dimension A: 1.05 to 1.75 mm (0.041 to 0.069 in)

14. Clean the camshaft journals.
15. Apply a light coat of engine oil to the camshaft journals, camshaft housings and bearing caps.

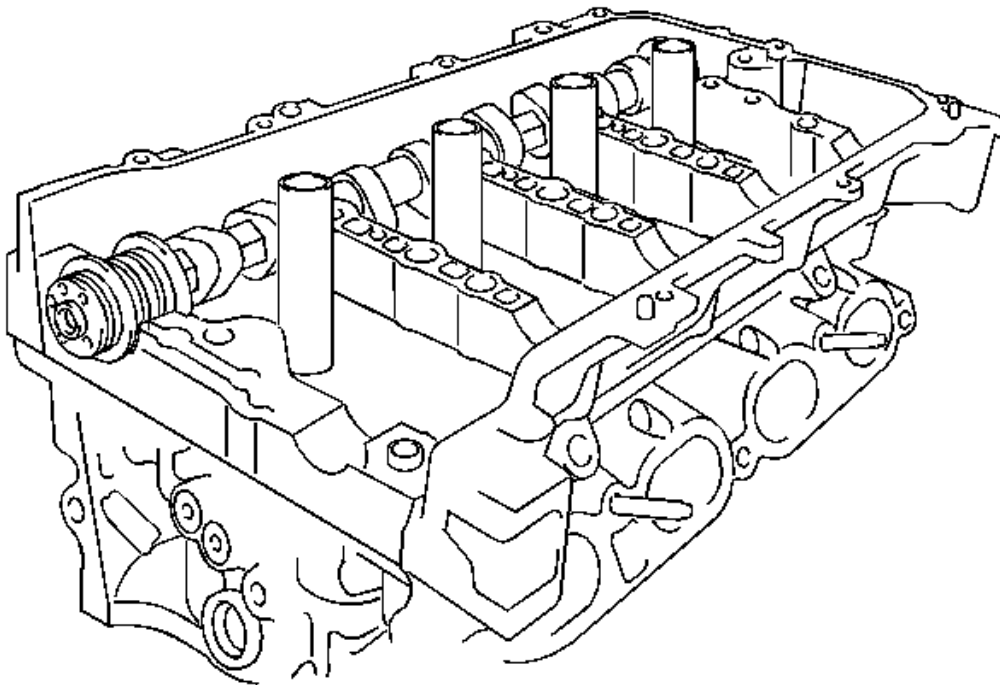


Fig. 510: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

16. Install the No. 2 camshaft to the camshaft housing.
17. Clean the camshaft journals.
18. Apply a light coat of engine oil to the camshaft journals, camshaft housing.

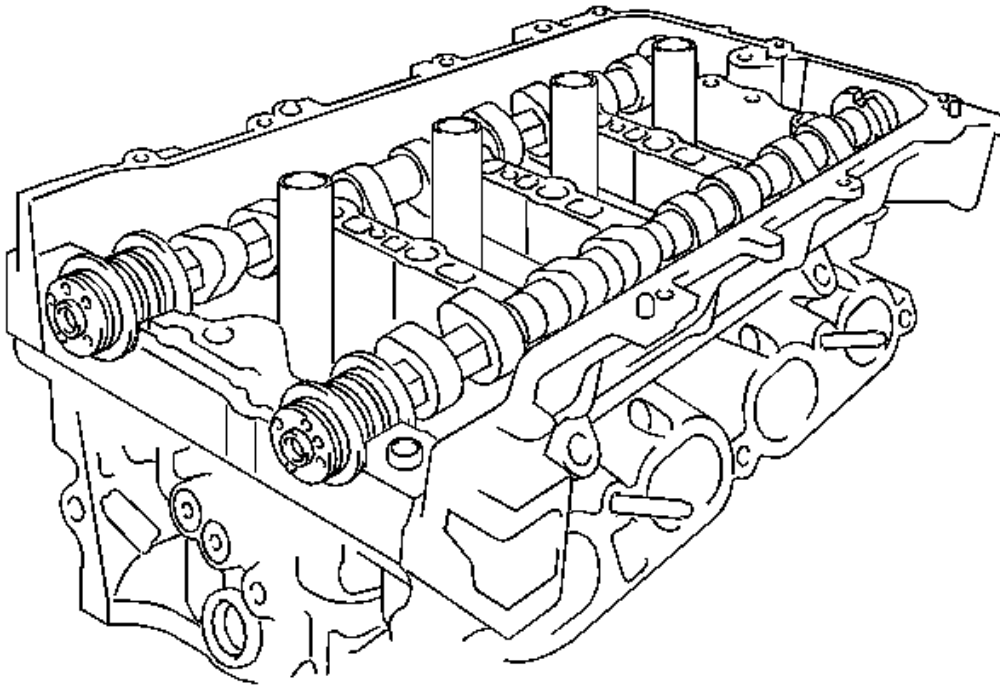


Fig. 511: View Of Cylinder Head & Camshafts
Courtesy of GENERAL MOTORS CORP.

19. Install the camshaft to the camshaft housing.
20. Install the camshaft bearing cap.
21. Apply the engine oil to the bearing caps.

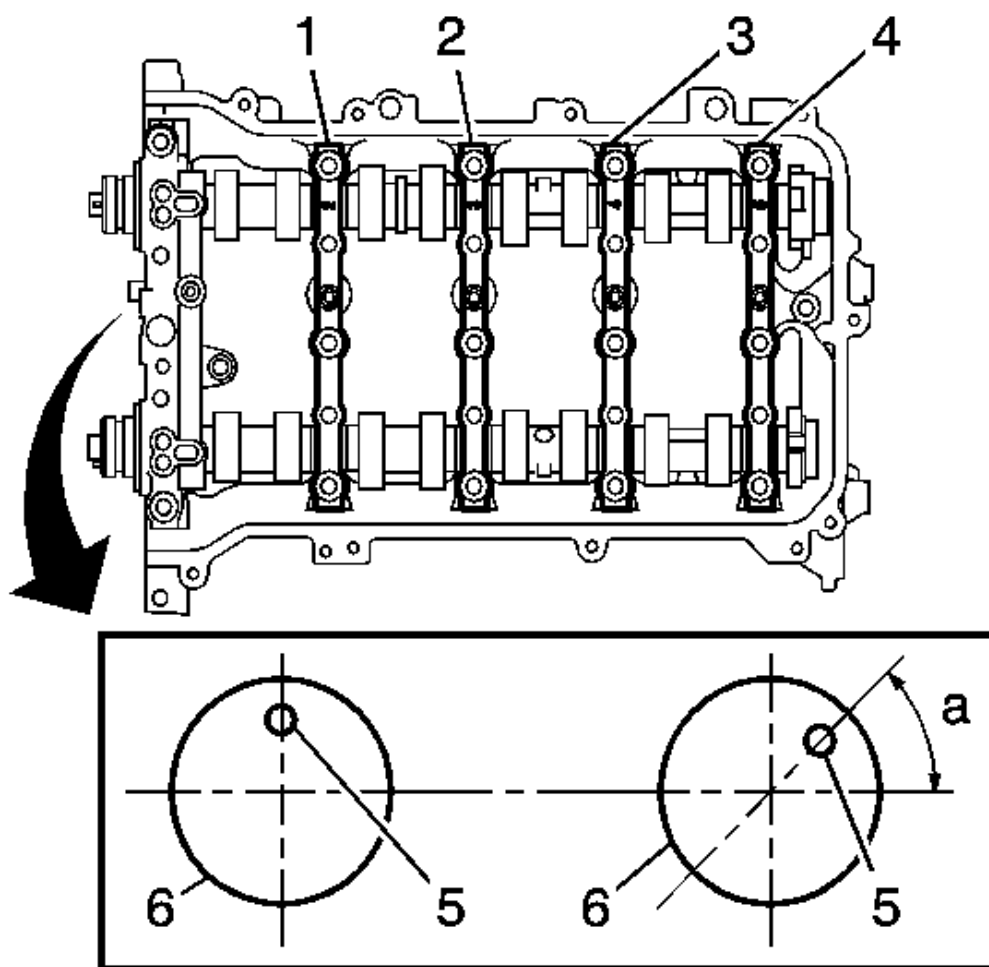


Fig. 512: Locating Marks & Numbers On Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

NOTE:

Make sure that the knock pin of the camshaft is positioned as shown in the illustration.

22. Make sure of the marks and numbers on the camshaft bearing caps and place them in each proper position and direction.

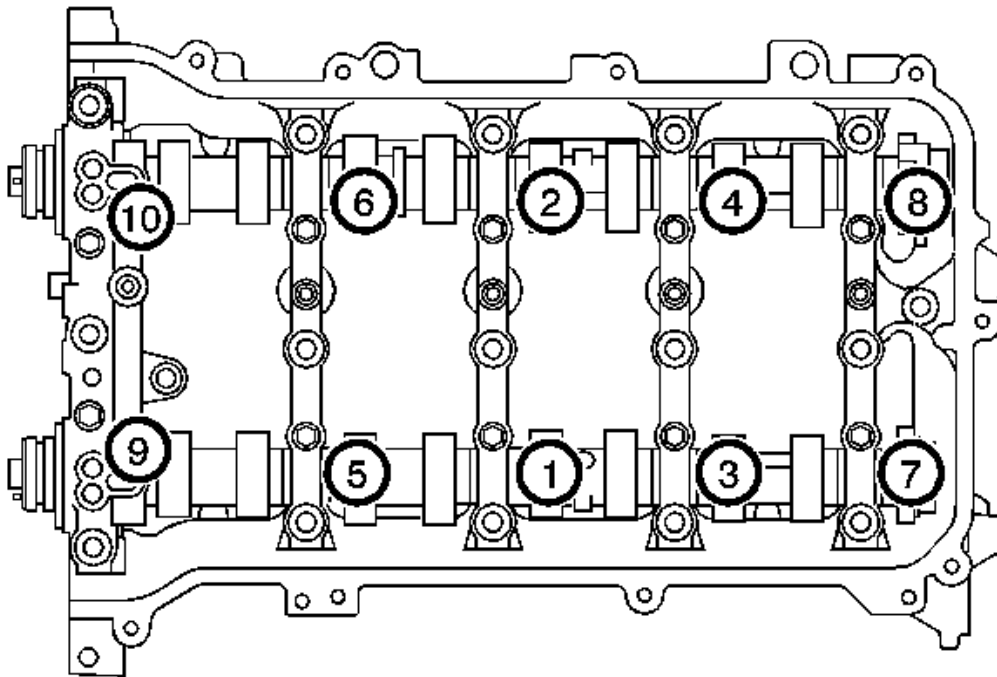


Fig. 513: Identifying Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

23. Install the 10 bolts and tighten in sequence to 16 N.m (12 lb ft).

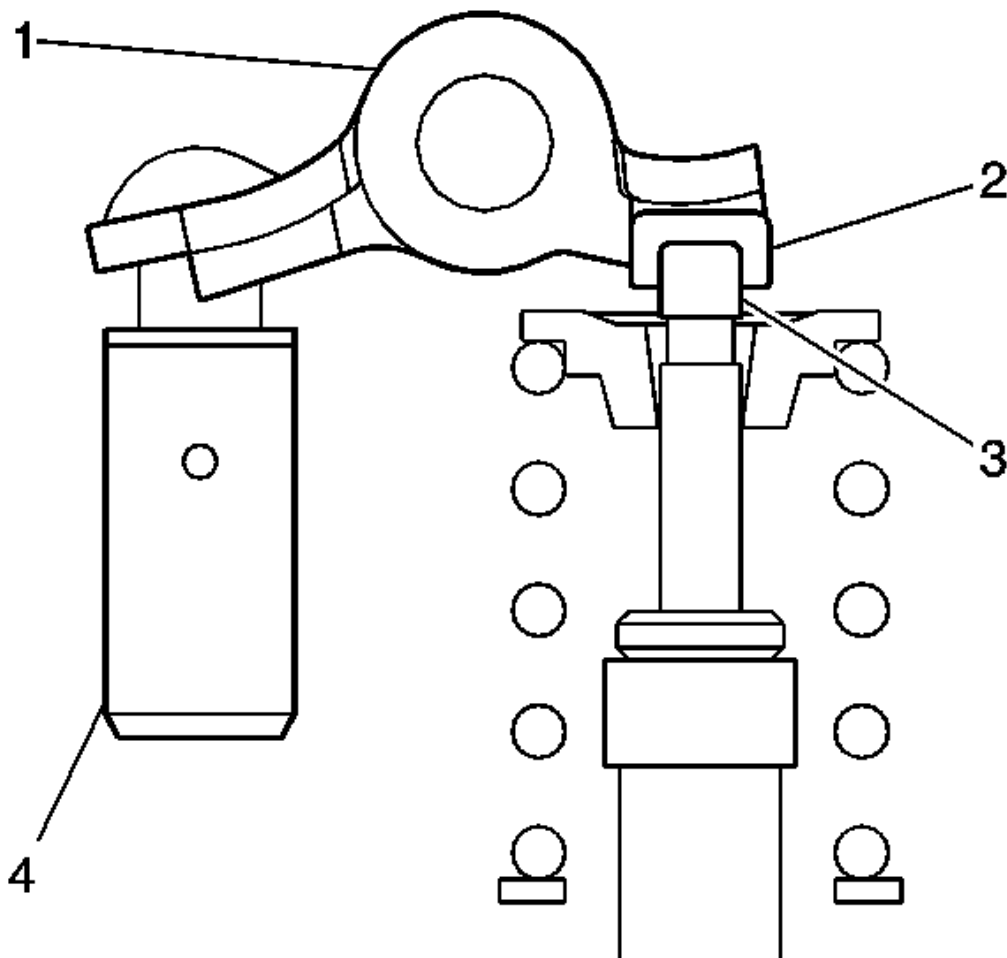


Fig. 514: View Of Correct Rocker Arm Installation
Courtesy of GENERAL MOTORS CORP.

24. Install the camshaft housing sub-assembly.
25. Make sure that the valve rocker arm is installed.

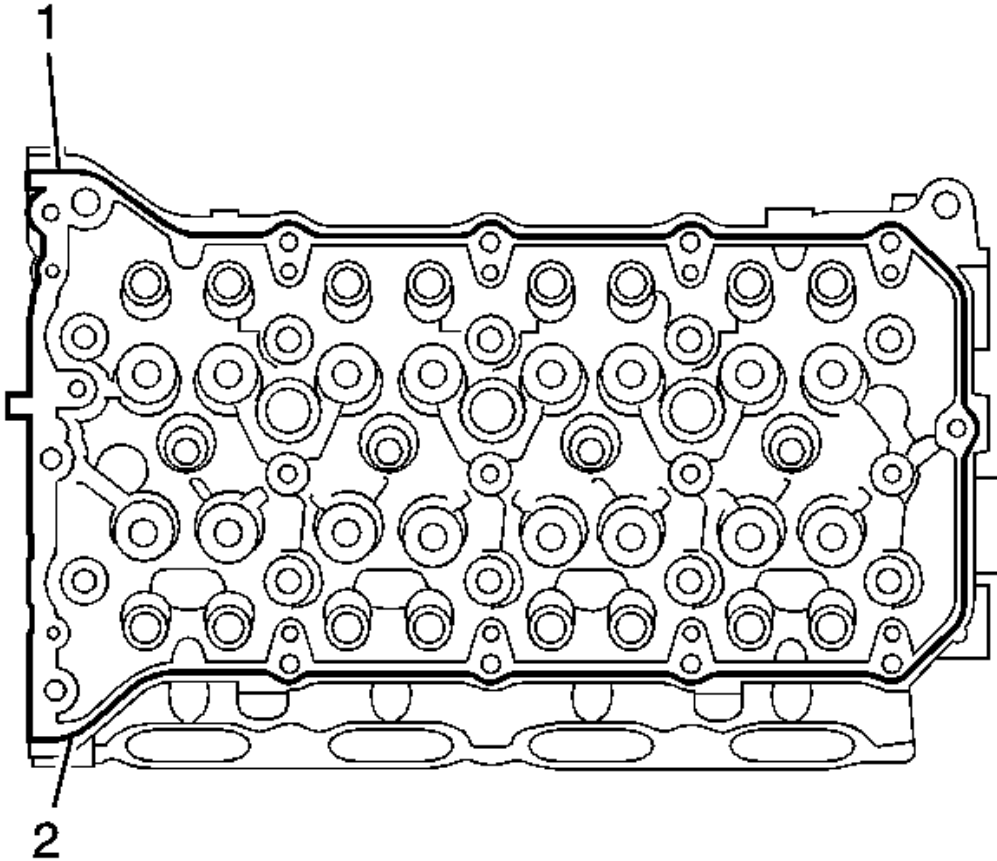


Fig. 515: Applying Adhesive To Cylinder Head
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Remove any oil from the contact surface.
- Install the camshaft housing sub-assembly within 3 minutes and tighten the bolts within 15 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after installing.

26. Apply Three Bond 1207B or equivalent, seal packing in a continuous bead.

Specification: Bead diameter: 3.5 to 4.0 mm (0.138 to 0.158 in)

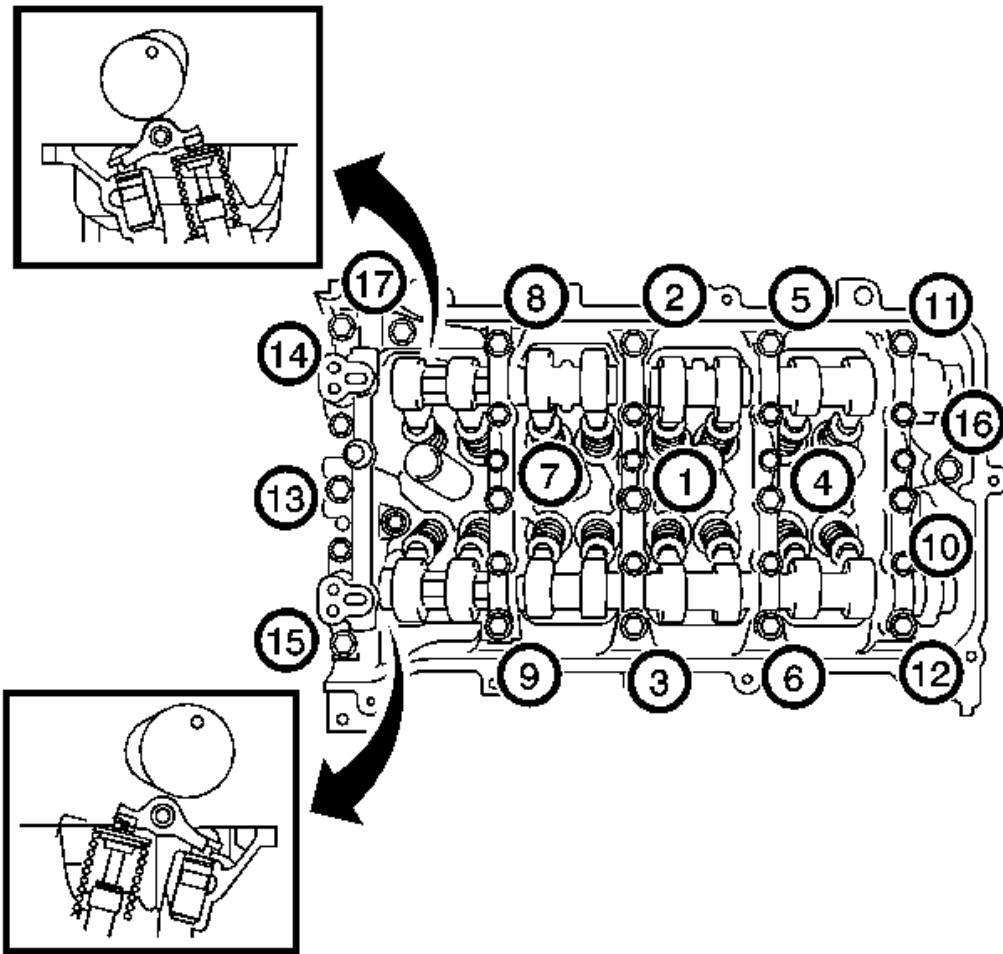


Fig. 516: View Of Setting Camshafts
Courtesy of GENERAL MOTORS CORP.

27. Set the camshaft and No. 2 camshaft as shown in the illustration.

NOTE:

- After installing the camshaft housing, make sure that the cam lobes are positioned as shown in the illustration.
- If any of the bolts are loosened during installation, remove the camshaft housing, clean the installation surfaces, and reapply seal packing.
- If the camshaft housing is removed because any of the bolts are loosened during installation, make sure that the previously applied seal packing does not enter any oil passages.

- After installing the camshaft housing, wipe off any seal packing that seeped out from between the housing and the cylinder head.

28. Install the camshaft housing and 17 bolts and tighten in sequence to 27 N.m (20 lb ft).
29. Install the camshaft timing gear assembly.
30. Check that the knock pin is installed on the camshaft.

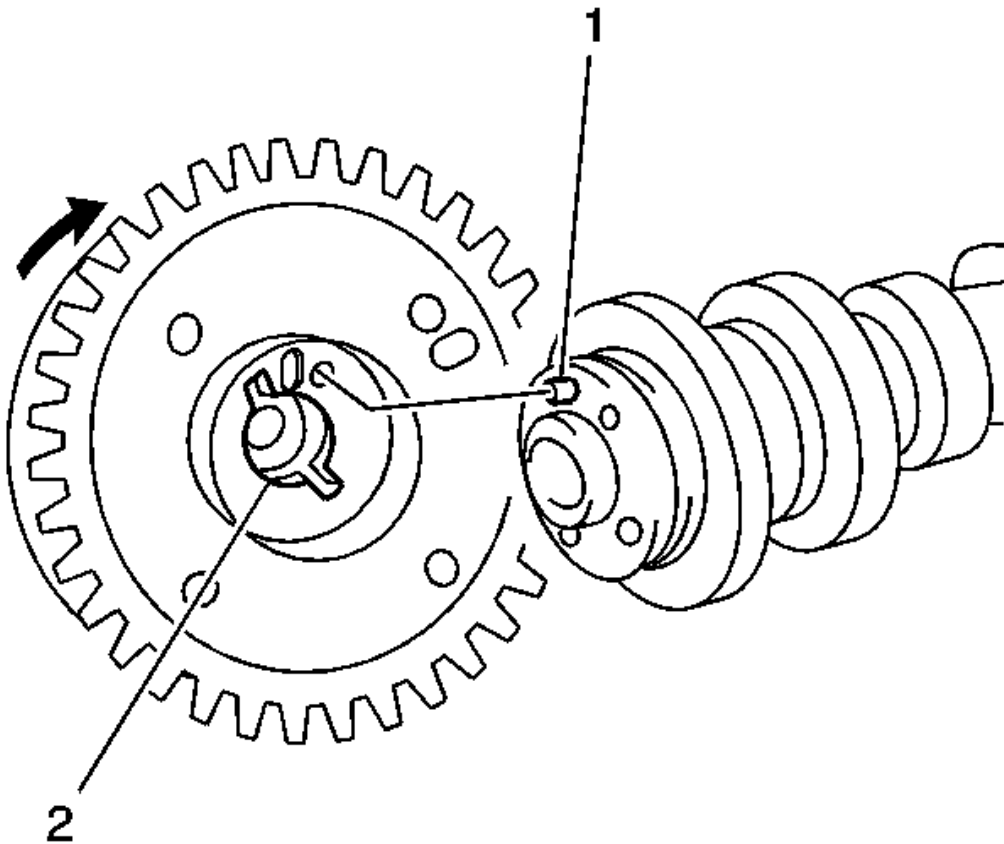


Fig. 517: View Of Camshaft Timing Gear Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not forcefully push in the camshaft timing gear assembly. This may cause the camshaft knock pin tip to damage the installation surface of the camshaft timing gear assembly.

31. Put the camshaft timing gear and camshaft together with the straight pin and key groove misaligned, as shown in the illustration.

NOTE: Do not turn the camshaft timing gear in the retard direction (clockwise).

32. Turn the camshaft timing gear as shown in the illustration while pushing it gently against the camshaft. Push further at the position where the pin fits into the groove.

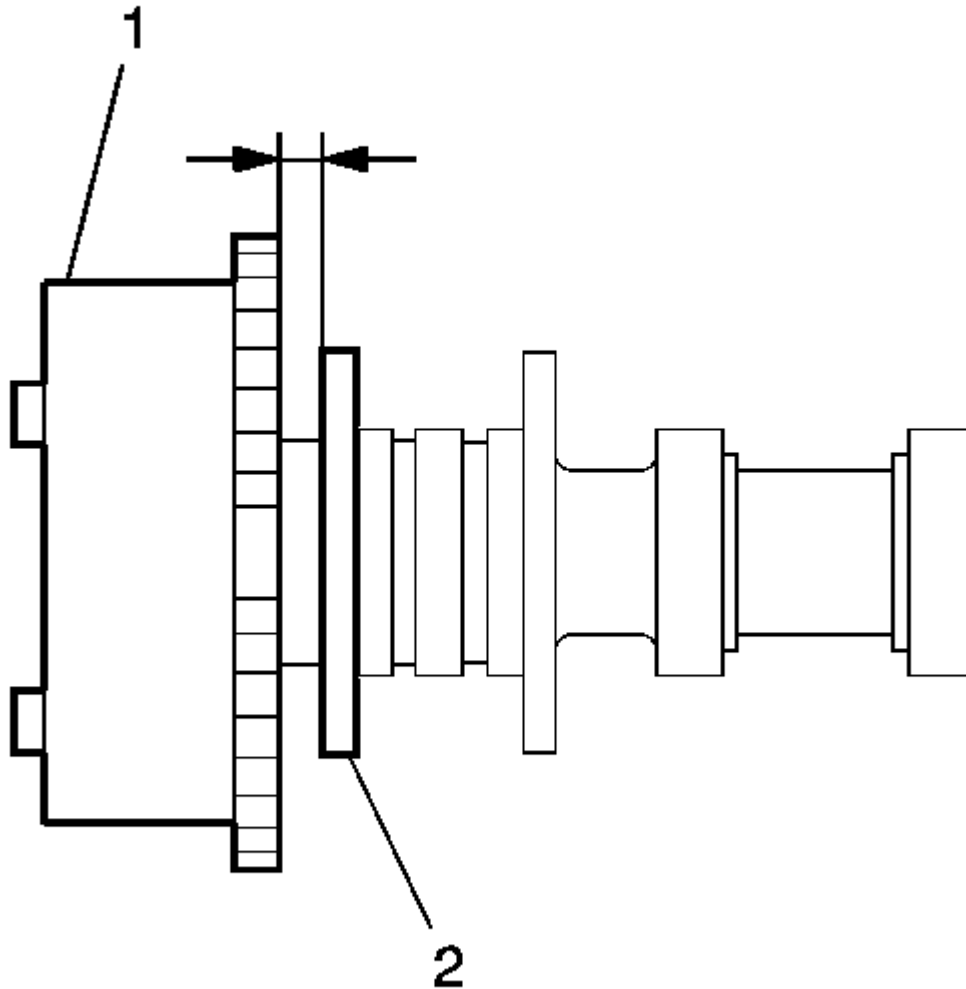


Fig. 518: Measuring Clearance Between Gear & Camshaft
Courtesy of GENERAL MOTORS CORP.

33. Measure the clearance between the gear and the camshaft.

Specification: Clearance: 0.1-0.4 mm (0.004-0.016 in)

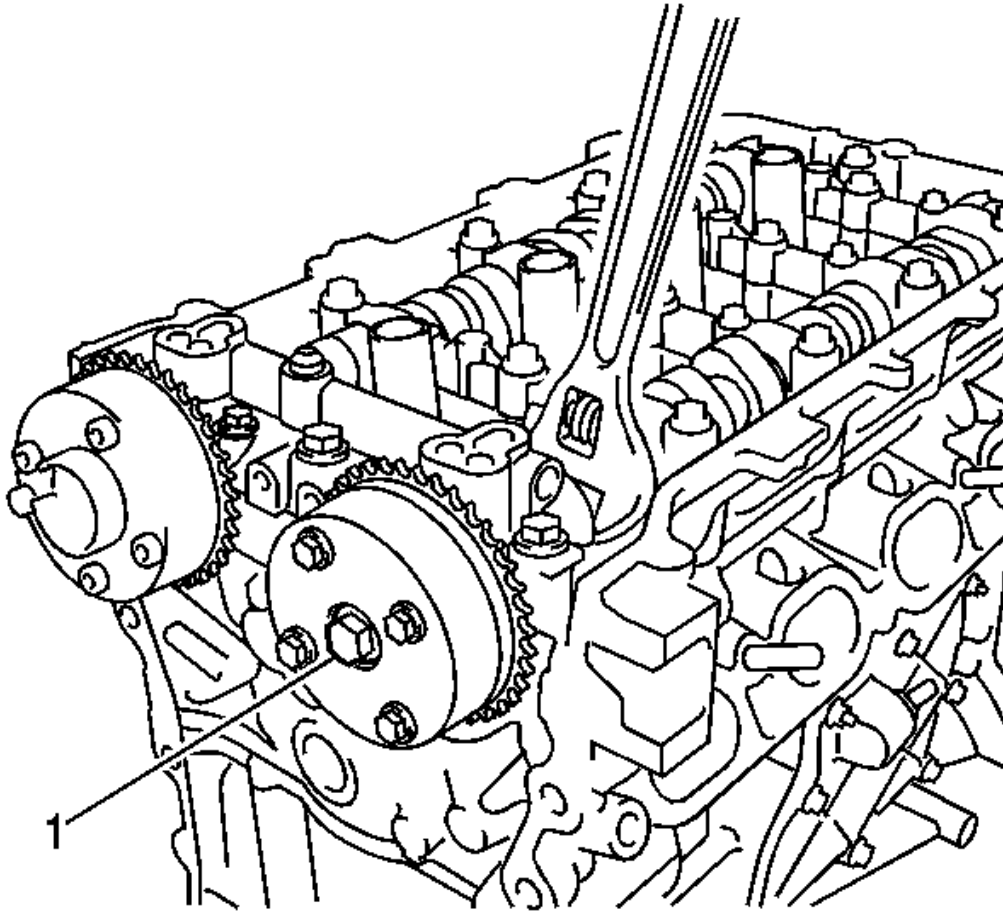


Fig. 519: View Of Tightening Camshaft Timing Gear
Courtesy of GENERAL MOTORS CORP.

34. Install the flange bolt with the camshaft timing gear fixed in place and tighten to 54 N.m (40 lb ft).

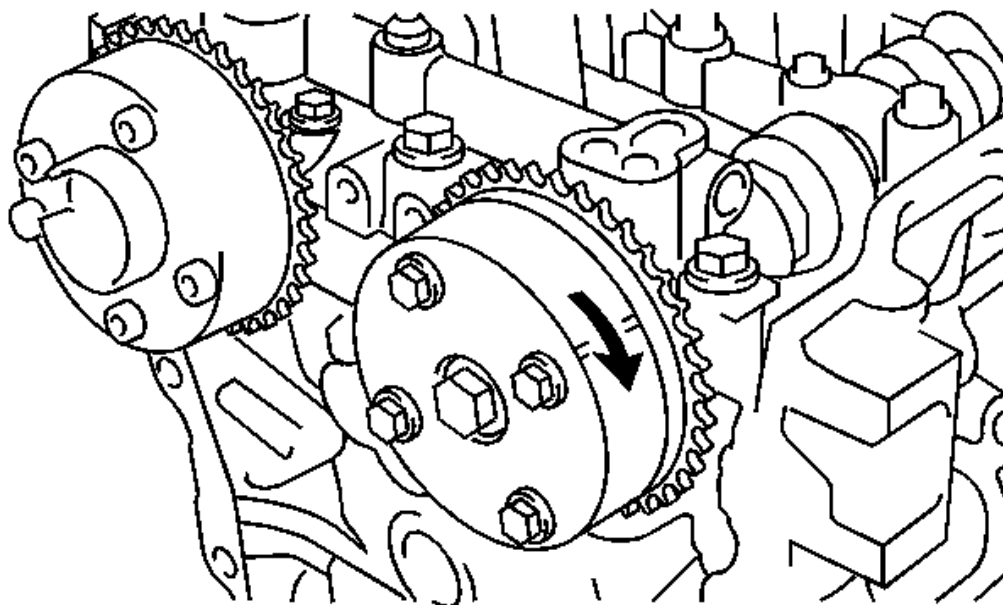


Fig. 520: Checking Camshaft Timing Gear Movement
Courtesy of GENERAL MOTORS CORP.

35. Check that the camshaft timing gear can move in the retard direction (clockwise) and locks in the most retarded position.
36. Install the camshaft timing exhaust gear assembly.
37. Check that the knock pin is installed on the camshaft.

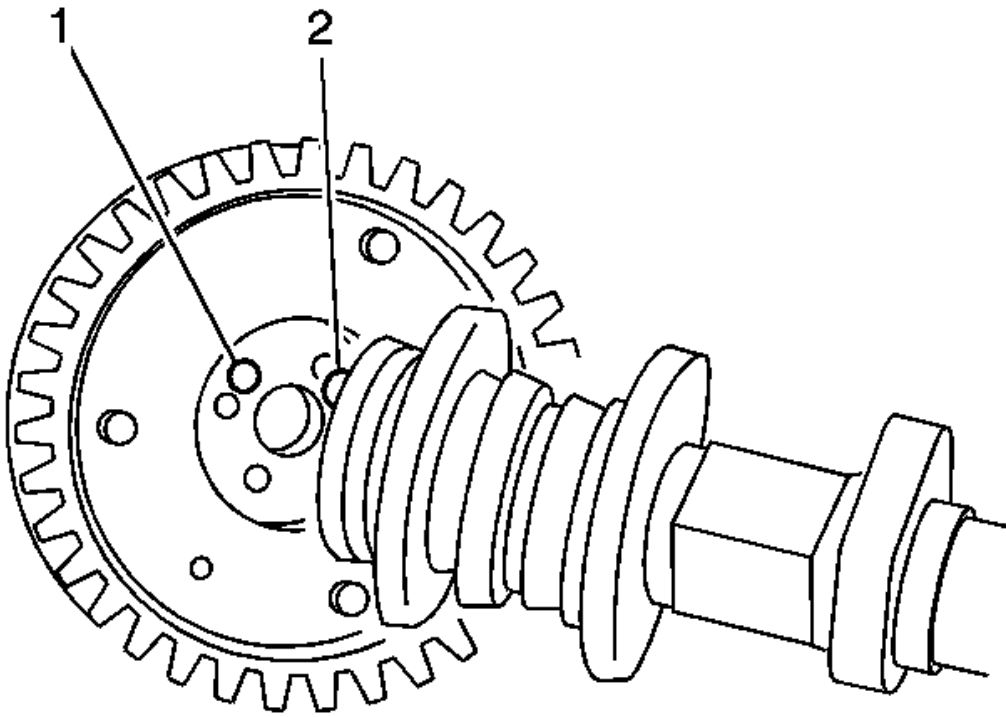


Fig. 521: View Of Camshaft Timing Exhaust Gear & Camshaft
Courtesy of GENERAL MOTORS CORP.

38. Put the camshaft timing exhaust gear and camshaft together by aligning the key groove and straight pin.

NOTE: Be sure not to turn the camshaft timing exhaust gear in the retard direction (clockwise).

39. Lightly press the gear against the camshaft, and turn the gear. Push further at the position where the pin enters the groove.
40. Check that there is no clearance between the gear flange and the camshaft.

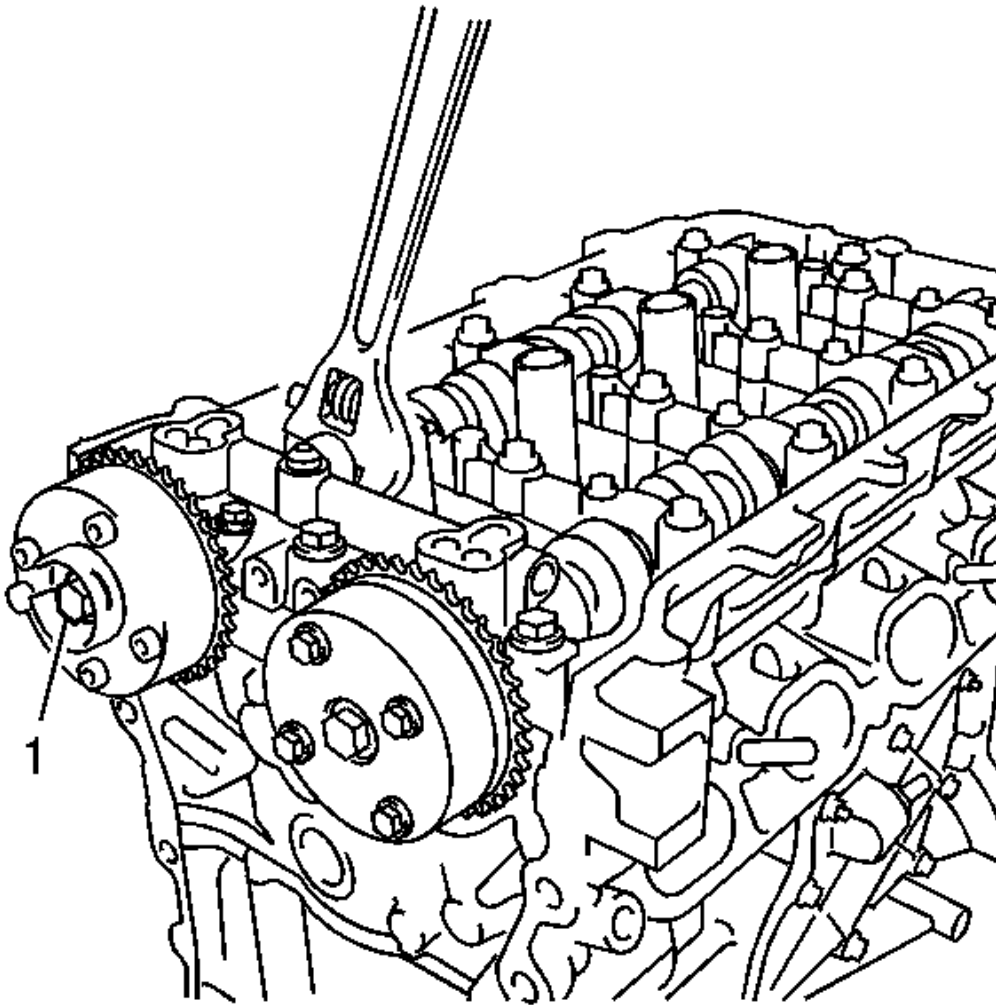


Fig. 522: View Of Tightening Flange Bolt With Camshaft Timing Exhaust Gear Fixed
Courtesy of GENERAL MOTORS CORP.

41. Install the flange bolt with the camshaft timing exhaust gear fixed and tighten to 54 N.m (40 lb ft).
42. Make sure that the camshaft timing exhaust gear is locked.

TIMING CHAIN HOUSING INSTALLATION

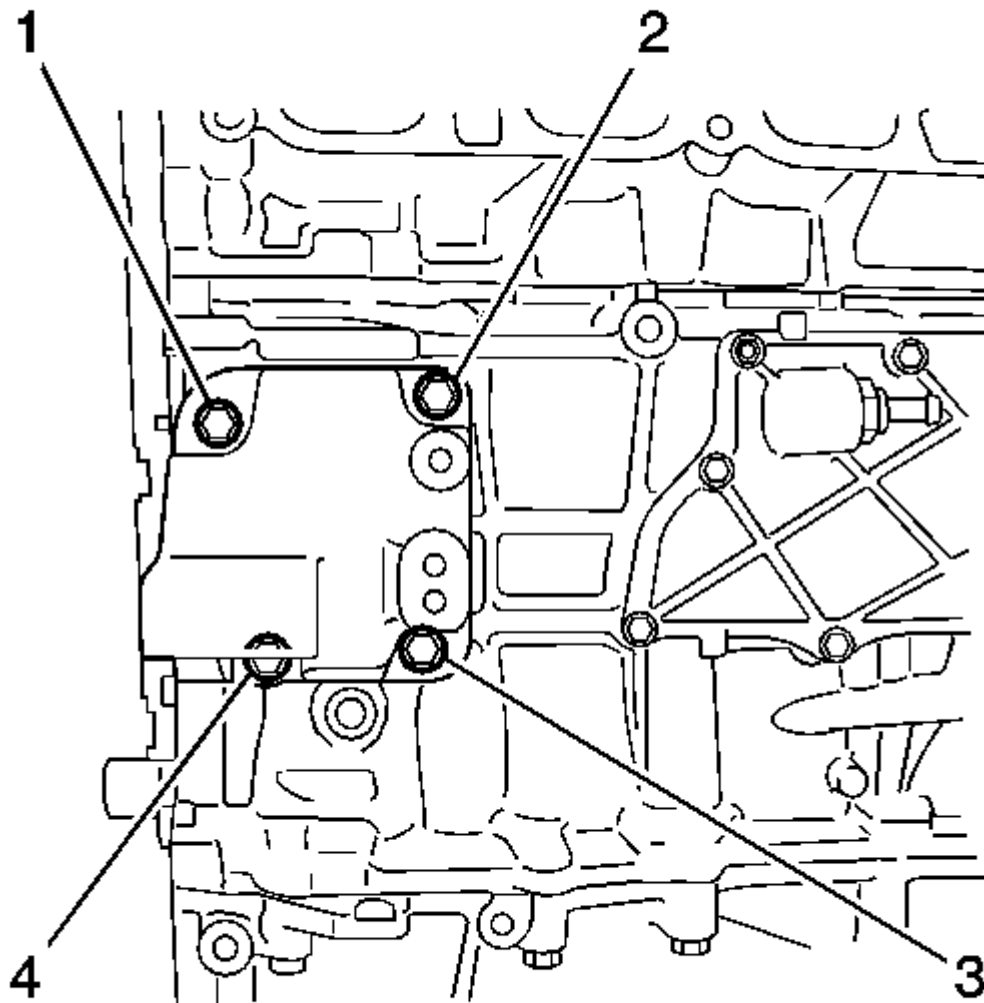


Fig. 523: Identifying Generator Bracket
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the No. 1 generator bracket with the 4 bolts and tighten to 21 N.m (16 lb ft).

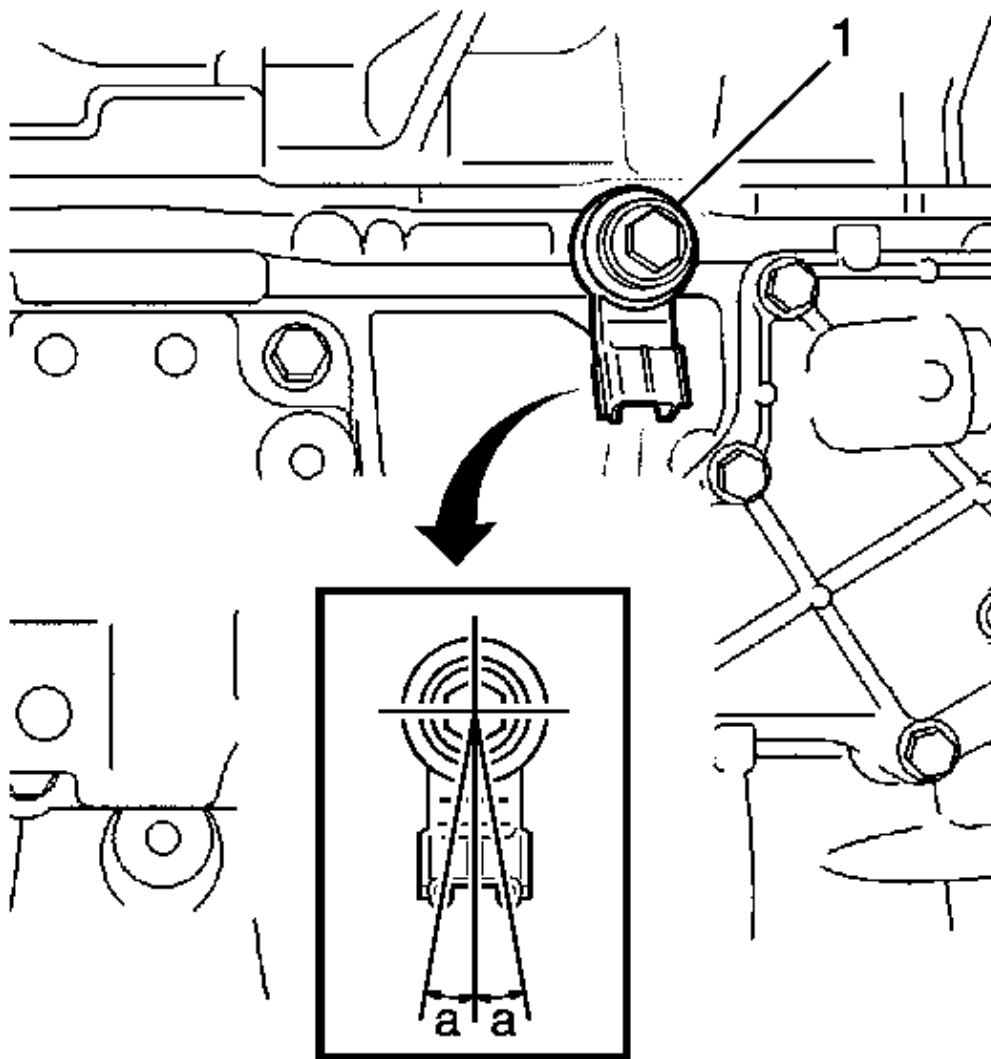


Fig. 524: View Of Inlet Water Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the inlet water housing with the 3 bolts and tighten to 21 N.m (16 lb ft).

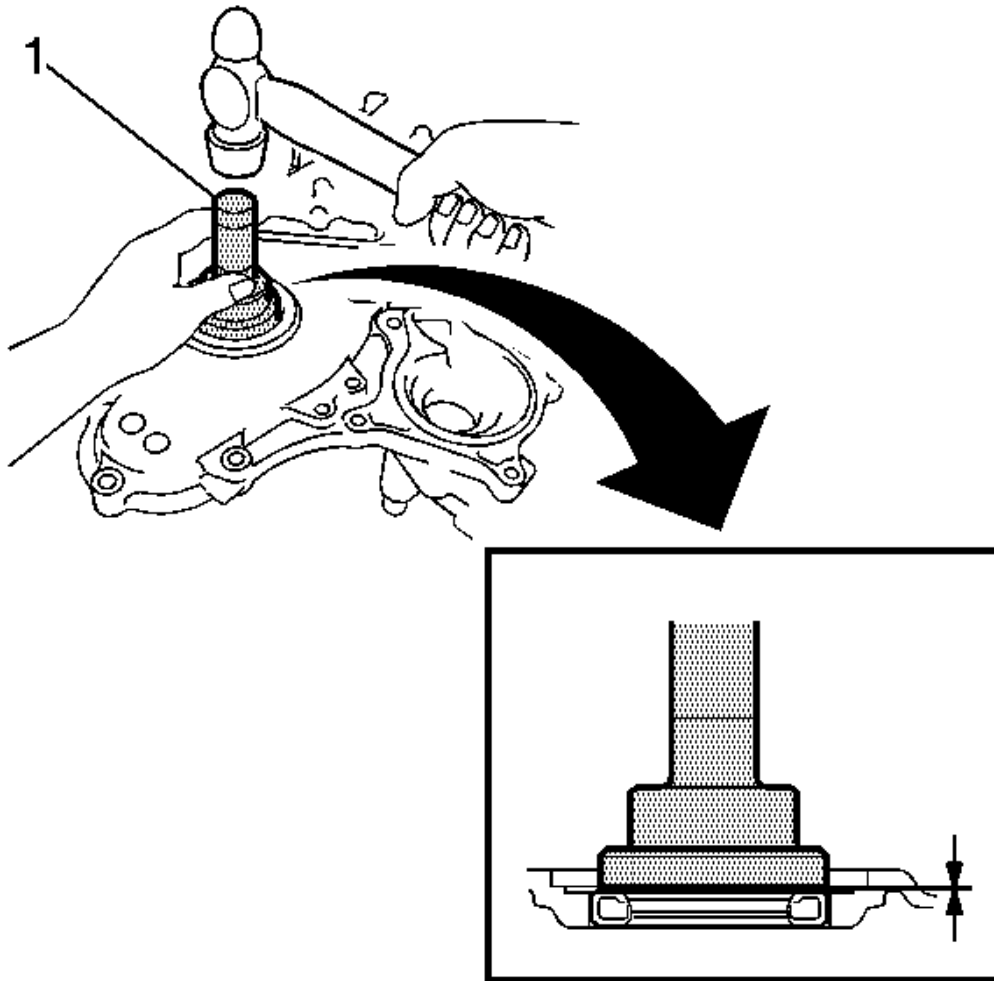


Fig. 525: View Of Proper Oil Seal Installation
 Courtesy of GENERAL MOTORS CORP.

3. Install the timing chain cover oil seal.
4. Using SST, tap in a new oil seal until its surface is flush with the timing gear case edge.

NOTE: Keep the lip free of foreign matter. Do not tap on the oil seal at an angle. Make sure that the oil seal edge does not stick out of the timing chain cover.

5. Apply a light coat of MP grease to the lip of the oil seal.
6. Install the timing chain cover sub-assembly.

7. Install the crankshaft pulley.

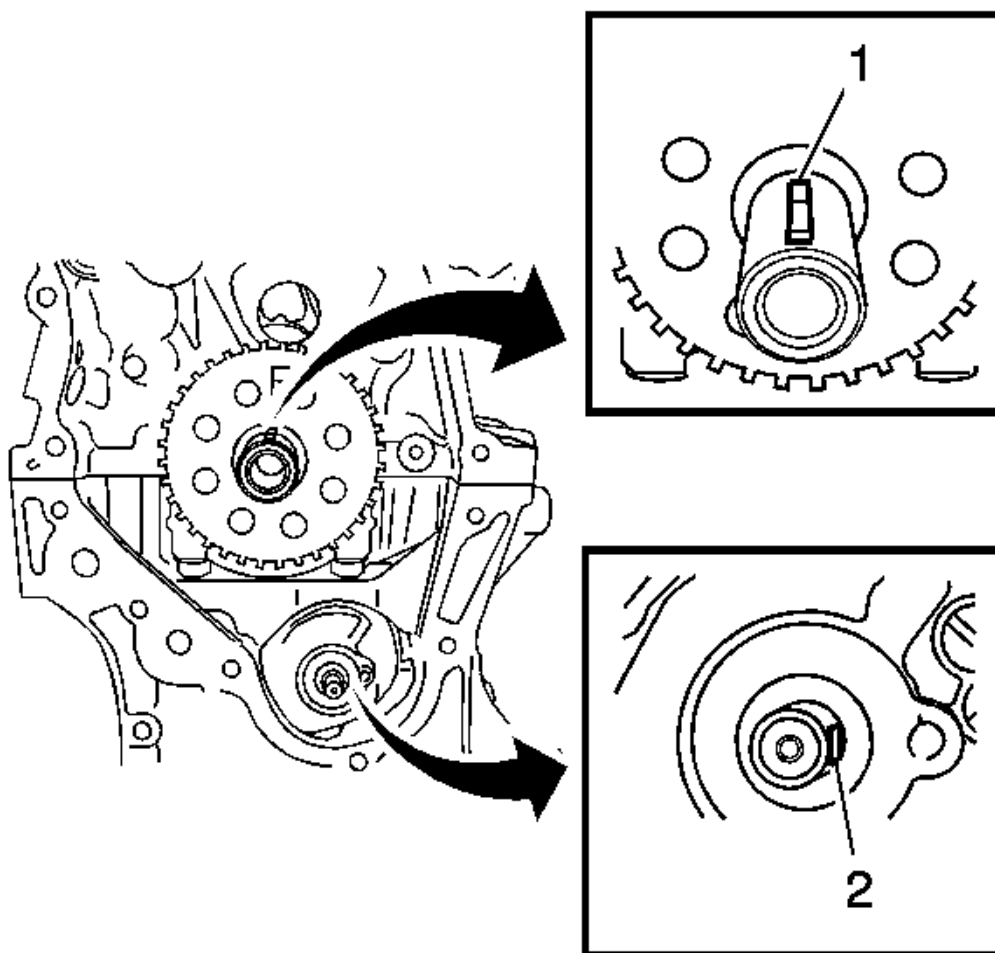


Fig. 526: Identifying Crankshaft Key
Courtesy of GENERAL MOTORS CORP.

8. Install the engine oil pressure switch assembly.
9. Apply Three Bond 1344 or equivalent adhesive to 2 or 3 threads of the oil pressure switch.

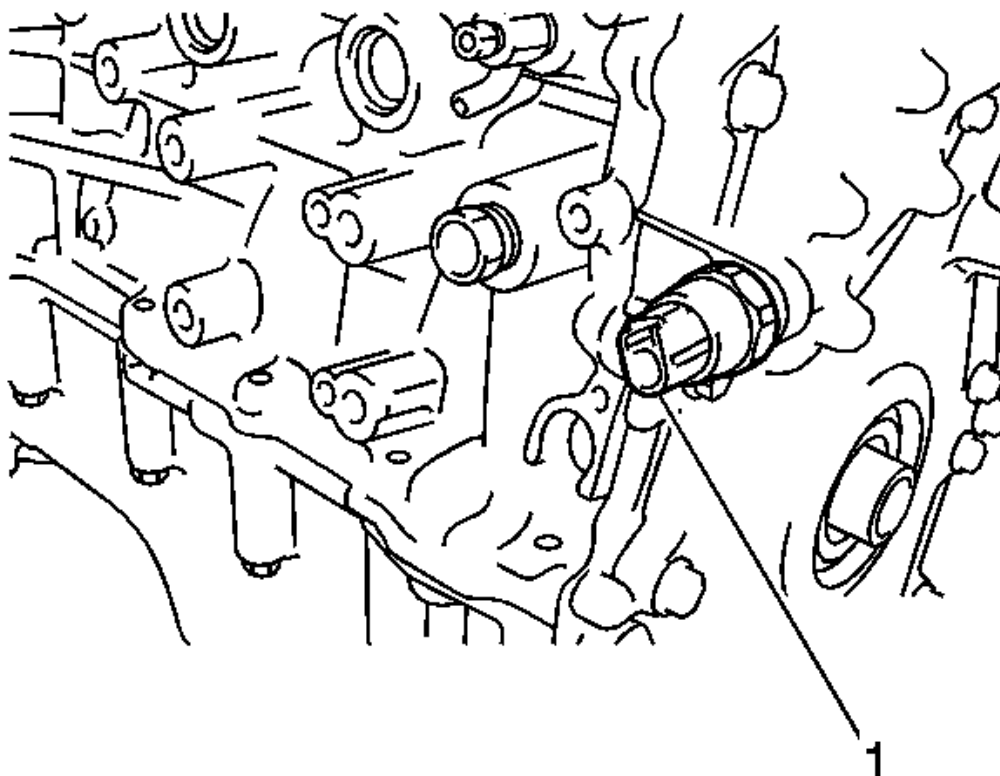


Fig. 527: Identifying Engine Oil Pressure Switch Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Install the oil pressure switch within 3 minutes after applying adhesive.
- Do not start the engine within 1 hour after installation.

10. Using a 24 mm deep socket wrench, install the oil pressure switch and tighten to 15 N.m (11 lb ft).

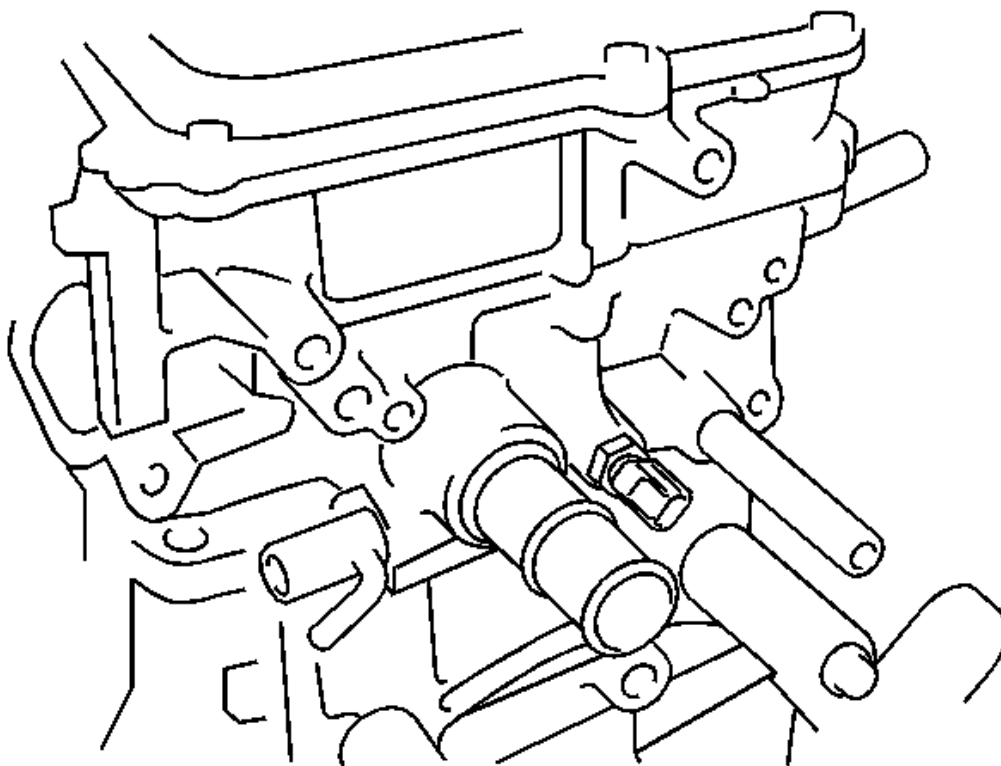


Fig. 528: Identifying Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

11. Install the engine coolant temperature sensor.
12. Install a new gasket to the engine coolant temperature sensor.
13. Using a 19 mm deep socket wrench, install the temperature sensor and tighten to 20 N.m (15 lb ft).

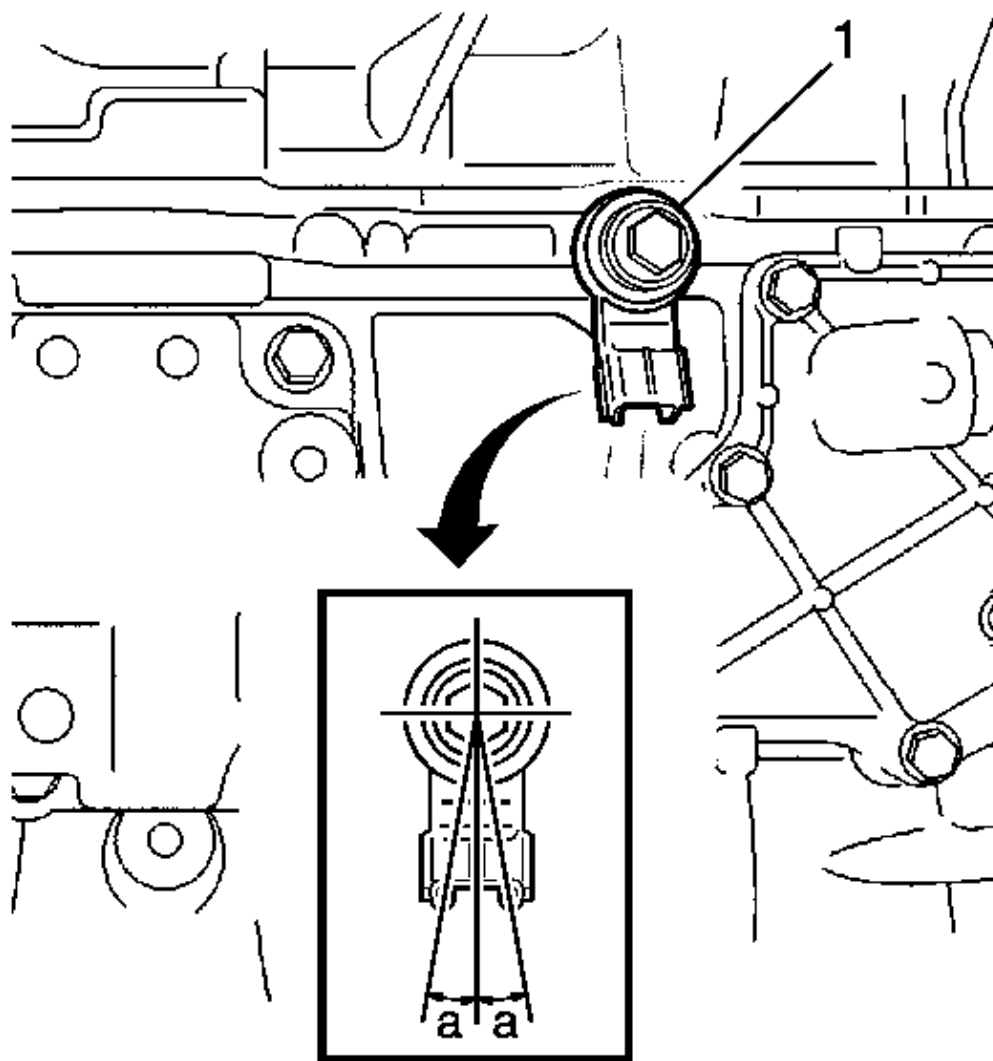


Fig. 529: View Of Inlet Water Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Make sure that the knock control sensor is in the correct position.

14. Install the knock control sensor with the bolt and tighten to 21 N.m (16 lb ft).

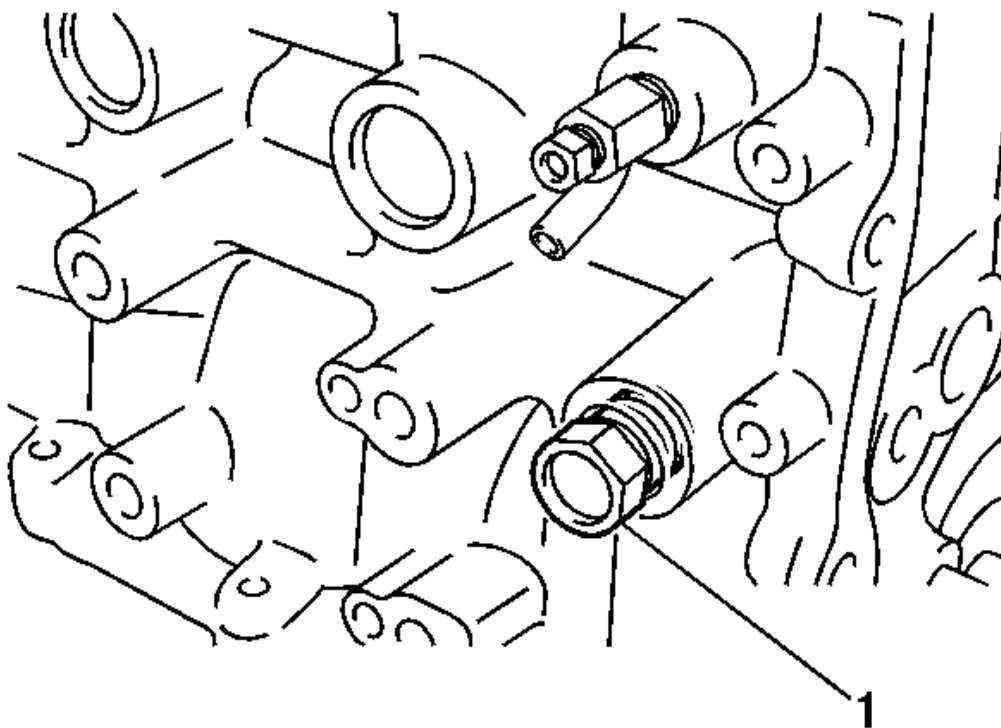


Fig. 530: Identifying 1 Taper Screw Plug
Courtesy of GENERAL MOTORS CORP.

15. Install the No. 1 taper screw plug.

NOTE:

- Install the plug within 3 minutes after applying adhesive.
- Do not start the engine within 1 hour after installation.

16. Apply Three Bond 1324 or equivalent adhesive to 2 or 3 threads of the plug, and install the plug and tighten to 43 N.m (32 lb ft).

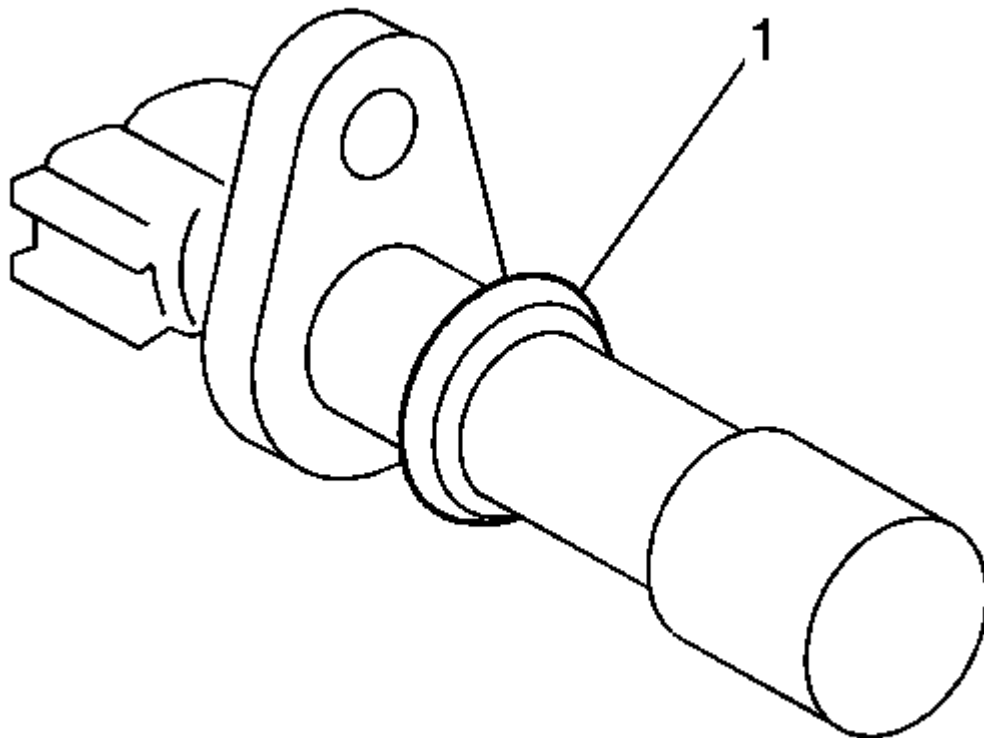


Fig. 531: View Of Crankshaft Position Sensor & O-Ring
Courtesy of GENERAL MOTORS CORP.

17. Install the crankshaft position sensor.
18. Apply a light coat of engine oil to the O-ring of the sensor.

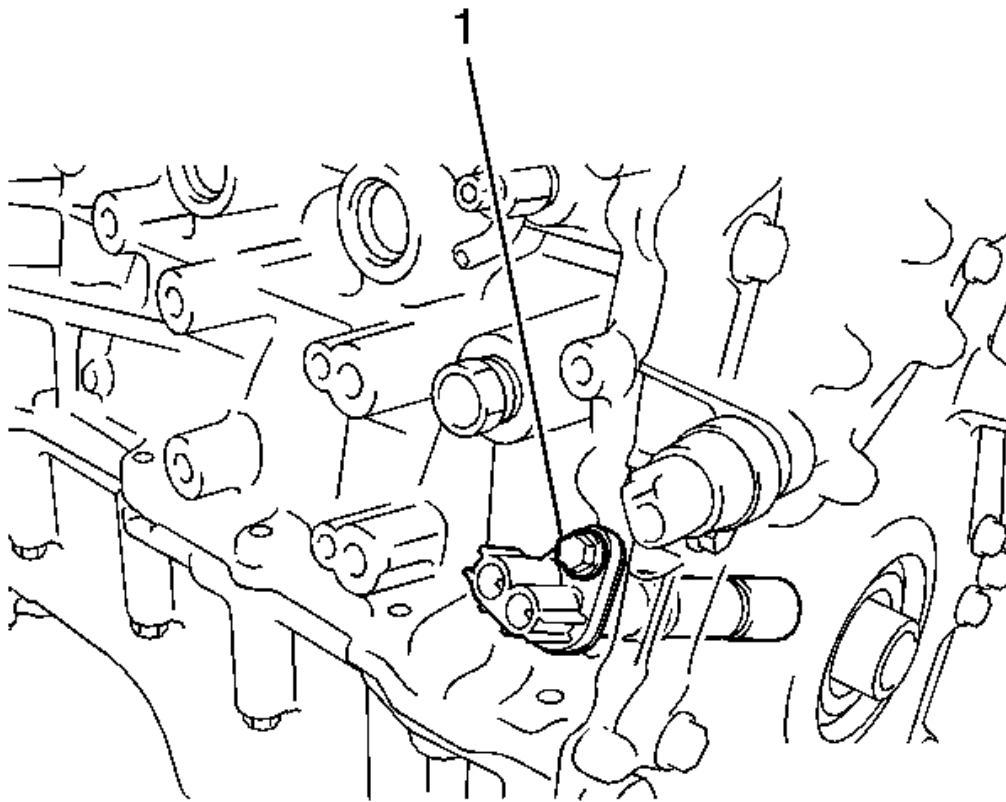


Fig. 532: Locating Crankshaft Position Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

19. Install the crankshaft position sensor with the bolt and tighten to 10 N.m (7 lb ft).

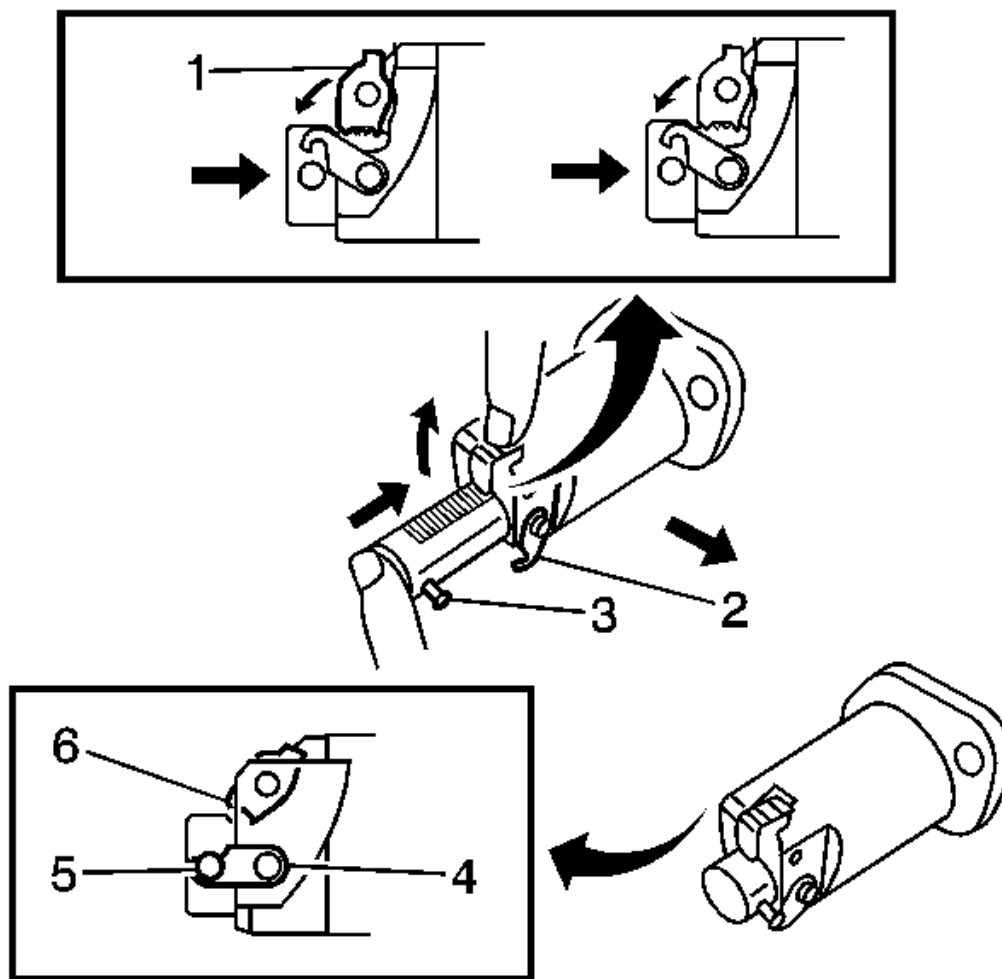


Fig. 533: View Of Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

20. Install the No. 1 chain tensioner assembly.

NOTE: Make sure that the cam engages the first tooth of the plunger to allow the hook to pass over the pin.

21. Release the ratchet pawl, then fully push in the plunger and engage the hook to the pin so that the plunger is in the position shown in the illustration.

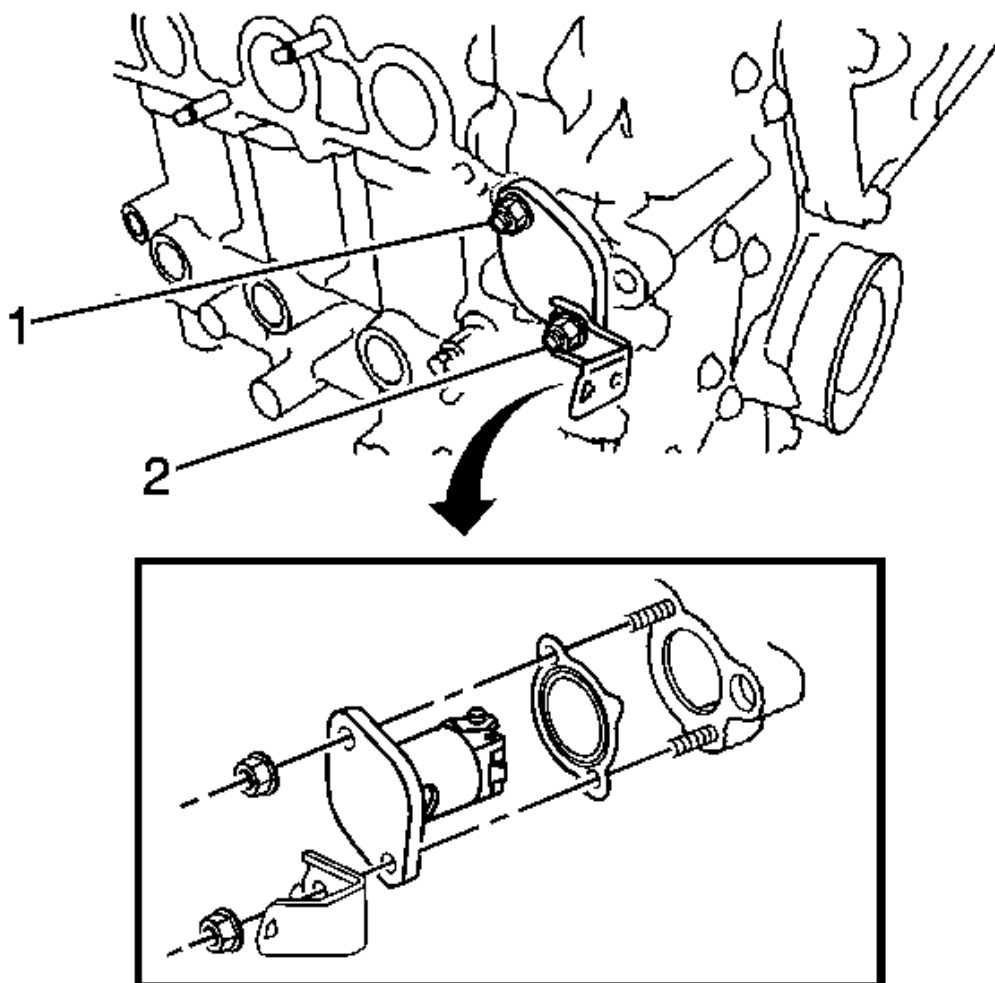


Fig. 534: Identifying No. 1 Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: If the hook releases the plunger while the chain tensioner is being installed, engage the hook again.

22. Install a new gasket, bracket and the No. 1 chain tensioner with the 2 nuts and tighten to 10 N.m (7 lb ft).

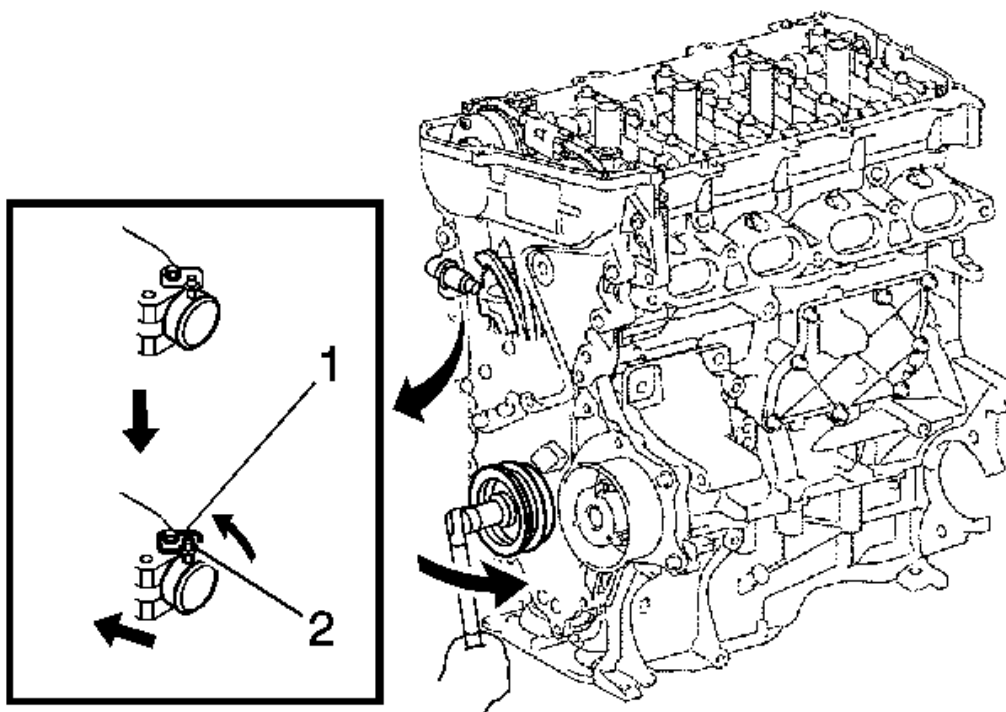


Fig. 535: View Of Turning Crankshaft Counterclockwise
Courtesy of GENERAL MOTORS CORP.

23. Turn the crankshaft counterclockwise, then disconnect the plunger knock pin from the hook.

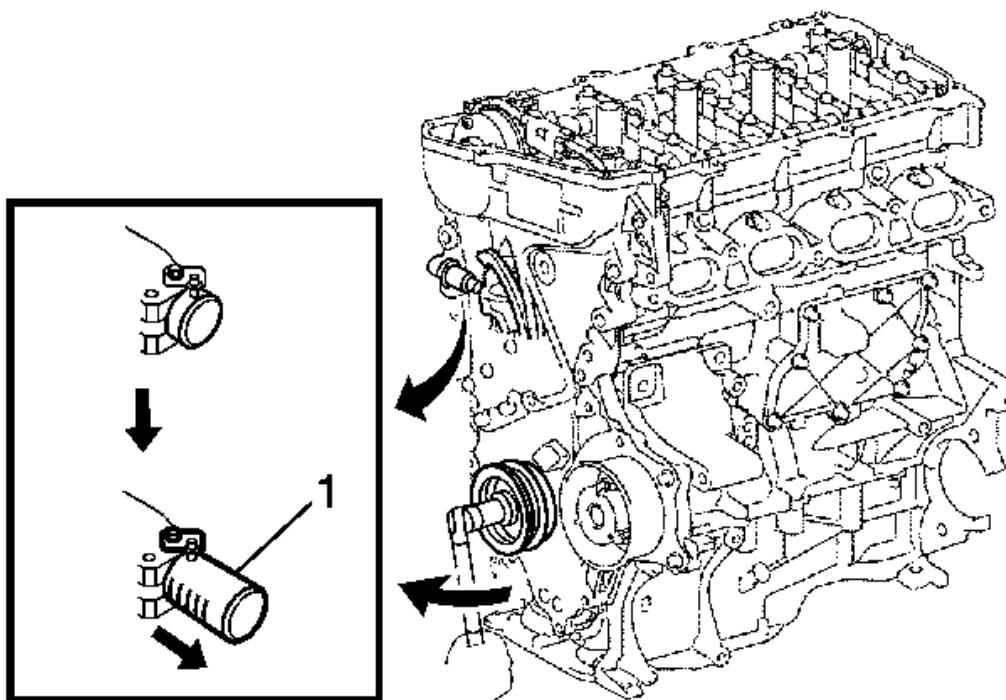


Fig. 536: Checking For Plunger Extension
Courtesy of GENERAL MOTORS CORP.

24. Turn the crankshaft clockwise, then check that the plunger is extended.
25. Install the oil filter cap assembly.

TIMING CHAIN TENSIONER INSTALLATION

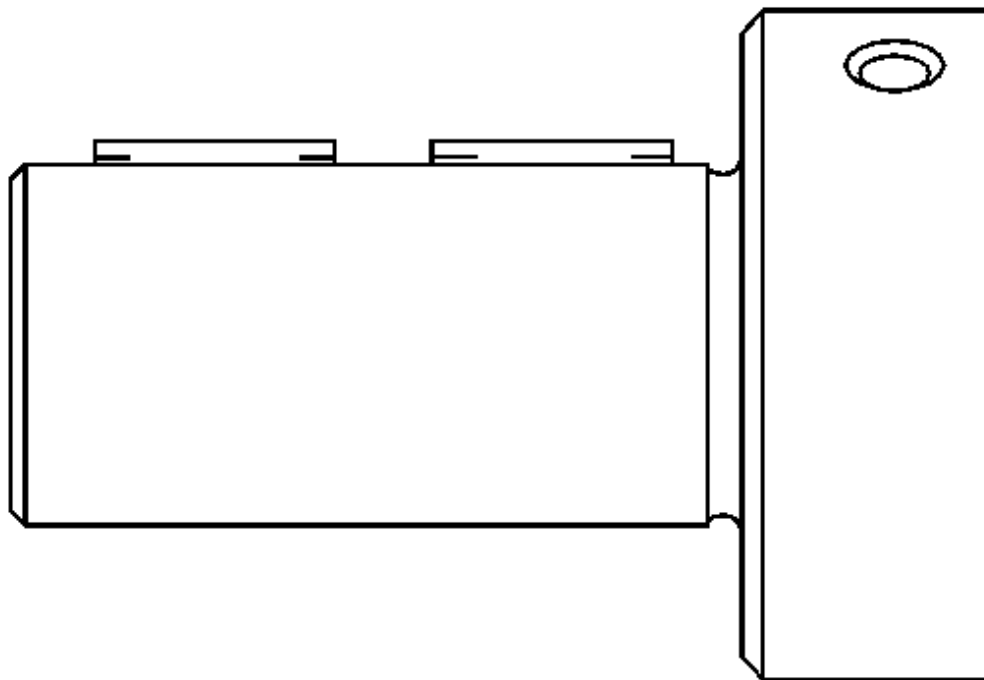


Fig. 537: View Of Crankshaft Timing Gear Keys

Courtesy of GENERAL MOTORS CORP.

NOTE: Tap in the crankshaft timing gear keys until they contact the crankshaft as shown in the illustration.

1. Using a plastic-faced hammer, tap in the 2 crankshaft timing gear keys.

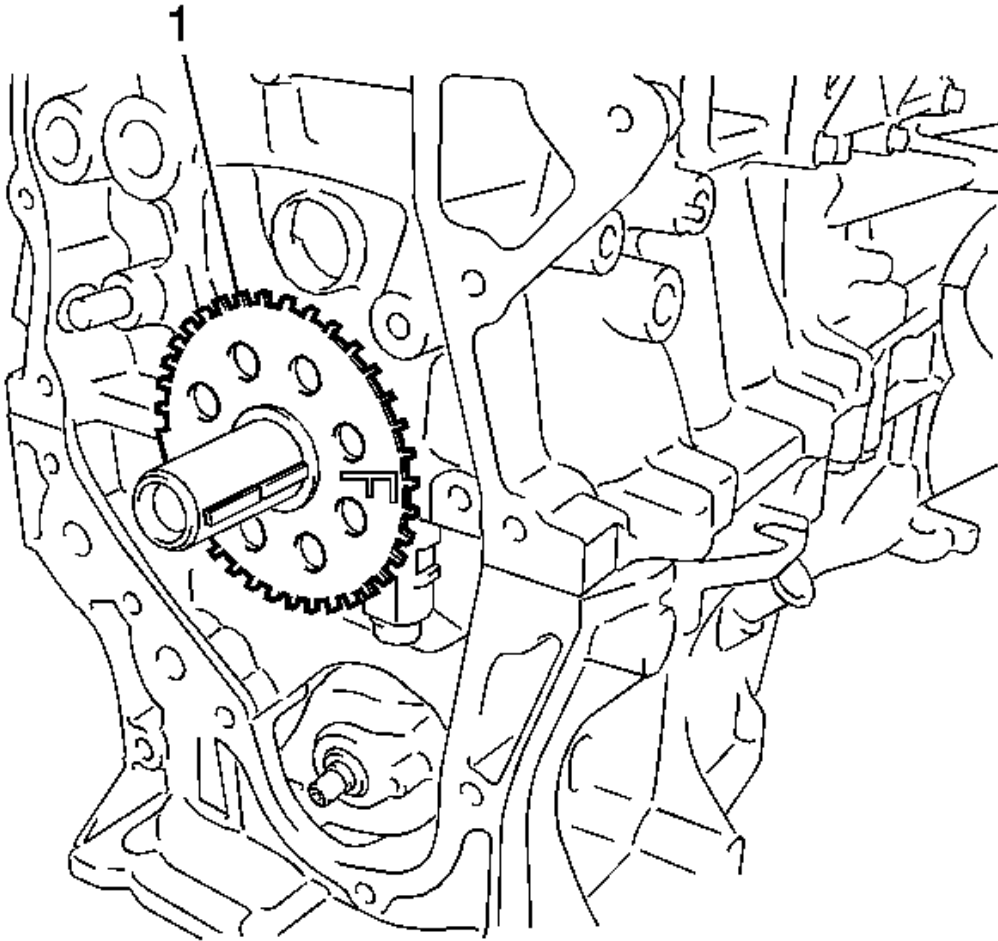


Fig. 538: Identifying No. 1 Crankshaft Position Sensor Plate
Courtesy of GENERAL MOTORS CORP.

2. Install the No. 1 crankshaft position sensor plate with the F mark facing forward.
3. Install the No. 2 chain sub-assembly.
4. Install the crankshaft timing sprocket.
5. Install the No. 1 chain vibration damper.
6. Install the No. 2 chain vibration damper.
7. Install the chain sub-assembly.
8. Install the chain tensioner slipper.

CAMSHAFT COVER INSTALLATION

1. Install the cylinder head cover sub-assembly.

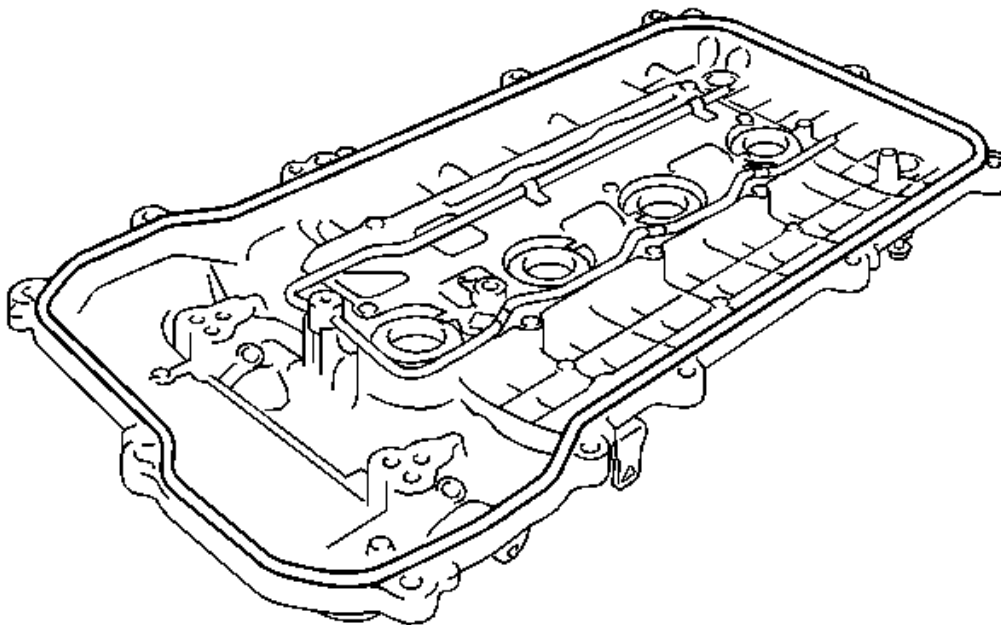


Fig. 539: View Of Cylinder Head Cover Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install a new gasket to the cylinder head cover.

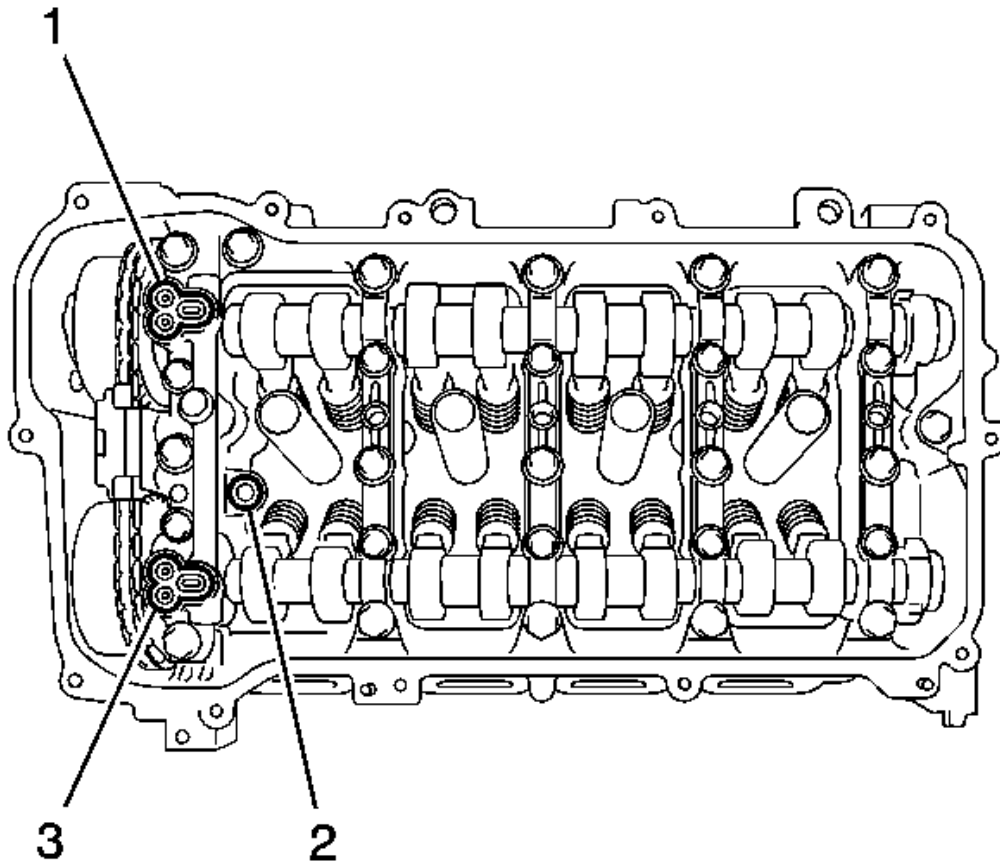


Fig. 540: Identifying Camshaft Bearing Cap Gaskets
Courtesy of GENERAL MOTORS CORP.

3. Install 3 new gaskets to the No. 1 camshaft bearing cap.

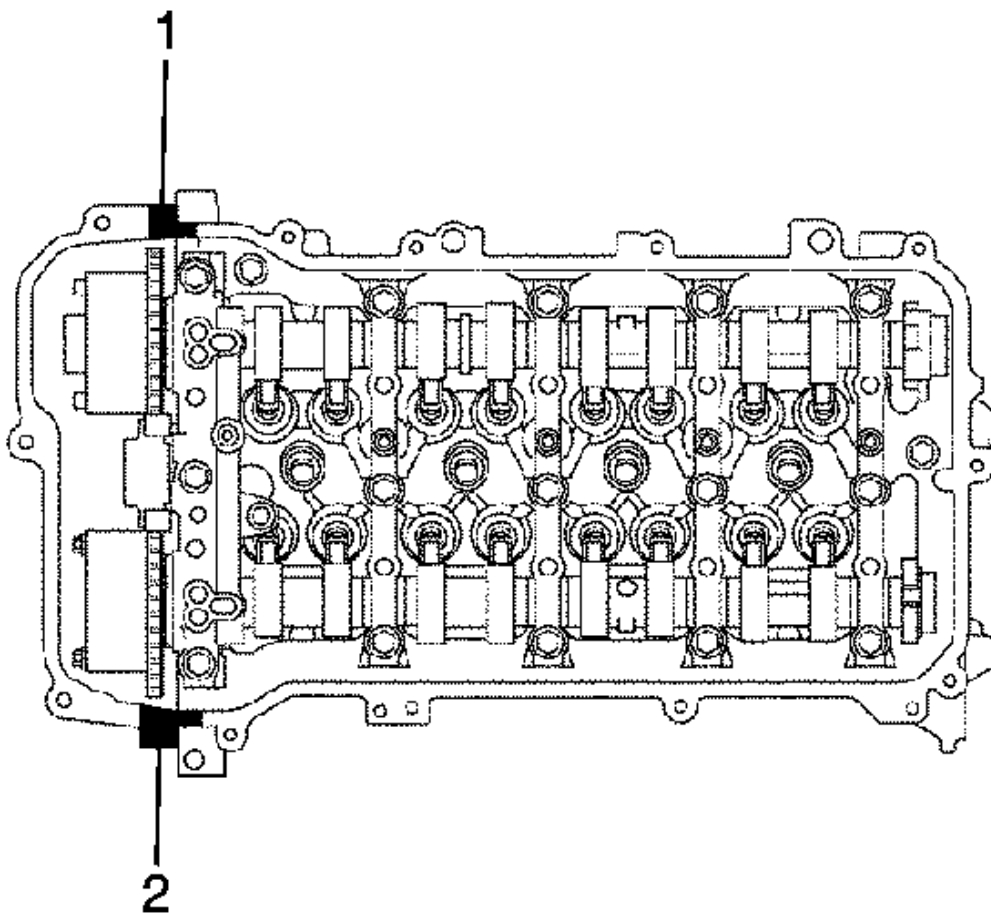


Fig. 541: Identifying Cylinder Head Cover Sealant Locations
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Remove any oil from the contact surfaces.
- Install the cylinder head cover within 3 minutes and tighten the bolts within 15 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after the installation.

4. Apply Three Bond 1207B or equivalent seal packing.

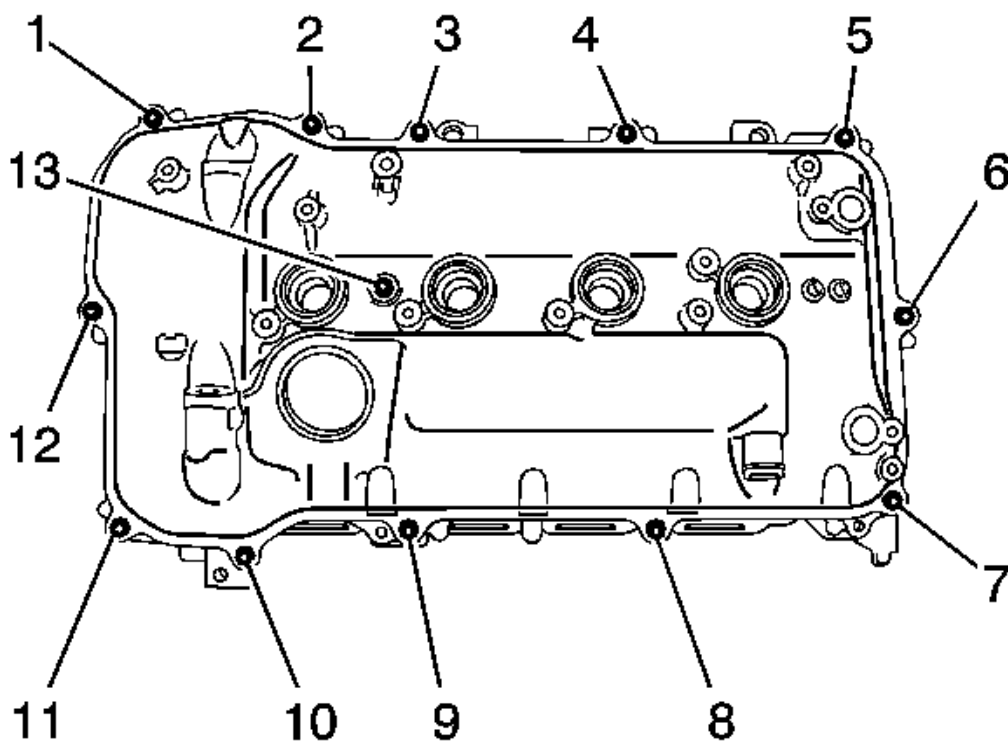


Fig. 542: Identifying Cylinder Head Cover Bolt Loosening/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

5. Install the cylinder head cover with a new seal washer and the 13 bolts and tighten to 10 N.m (7 lb ft).

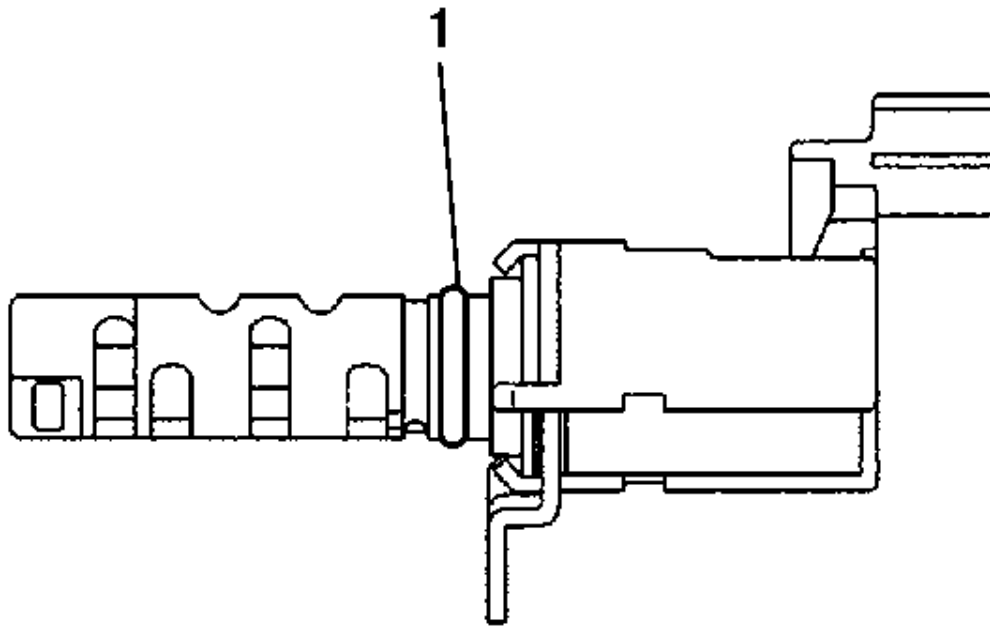


Fig. 543: View Of Camshaft Timing Oil Control Valve Assembly
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft timing oil control valve assembly.
7. Apply a light coat of engine oil to a new O-ring, then install it onto the camshaft timing oil control valve.

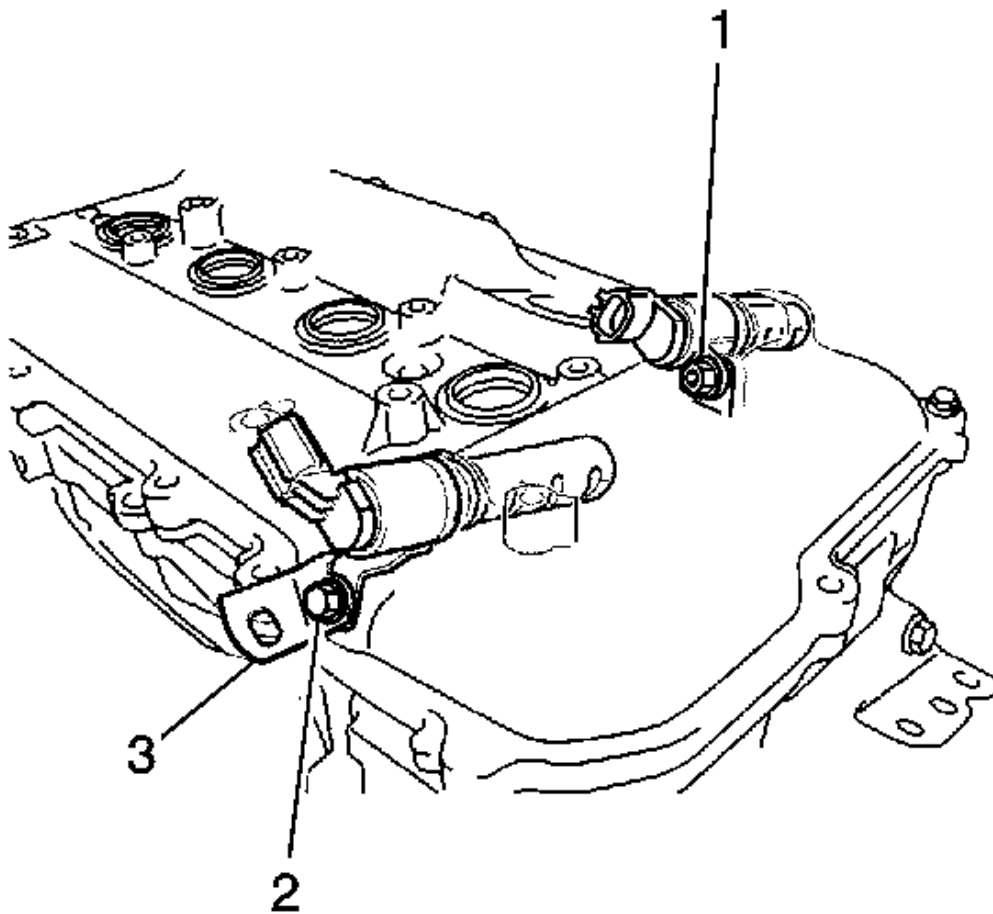


Fig. 544: View Of Camshaft Timing Oil Control Valves, Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the 2 camshaft timing oil control valves and bracket with the 2 bolts and tighten to 10 N.m (7 lb ft).

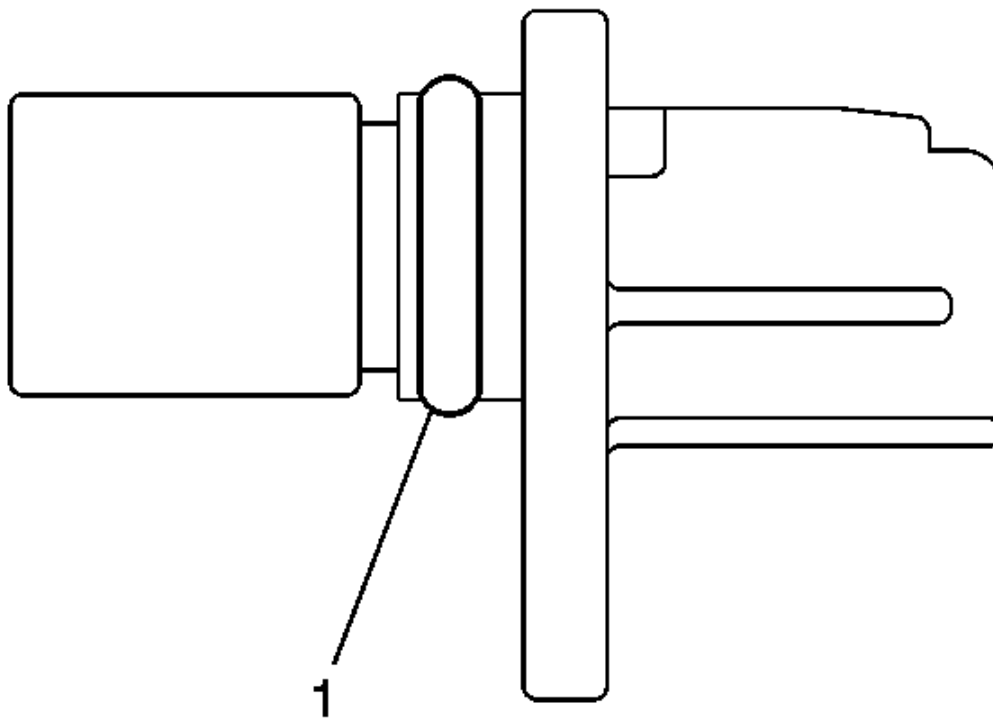


Fig. 545: Identifying Camshaft Position Sensor & O-Ring
Courtesy of GENERAL MOTORS CORP.

9. Install the camshaft position sensor.
10. Apply a light coat of engine oil to the O-ring of the sensor.

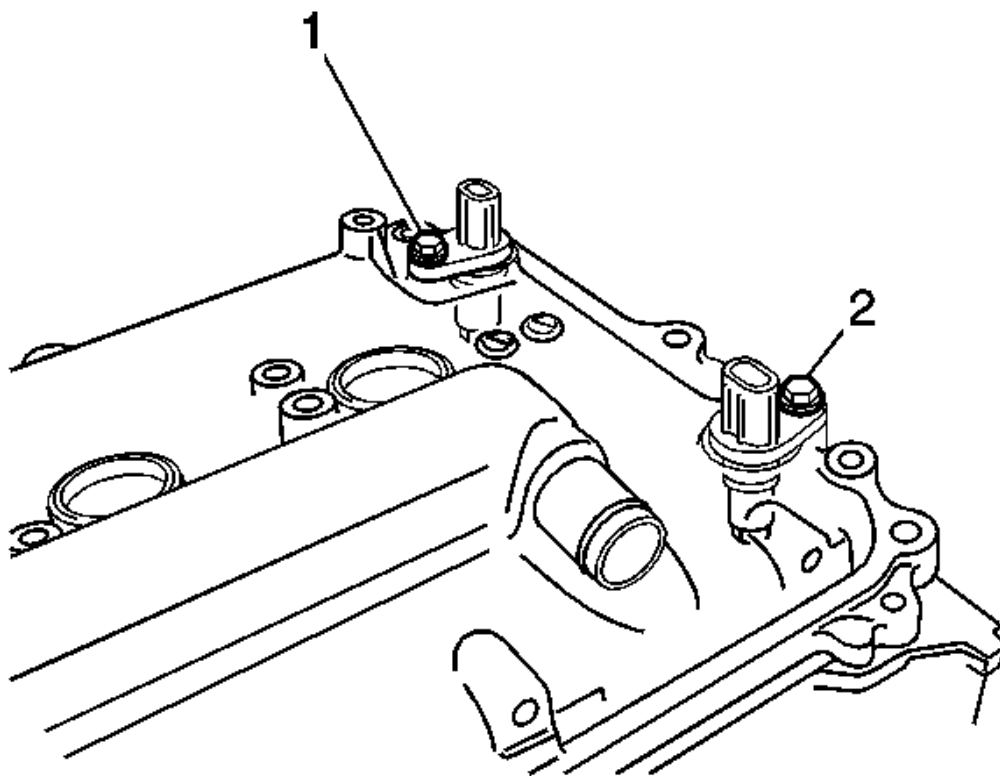


Fig. 546: Identifying Camshaft Position Sensors
Courtesy of GENERAL MOTORS CORP.

11. Install the 2 sensors with the 2 bolts and tighten to 10 N.m (7 lb ft).

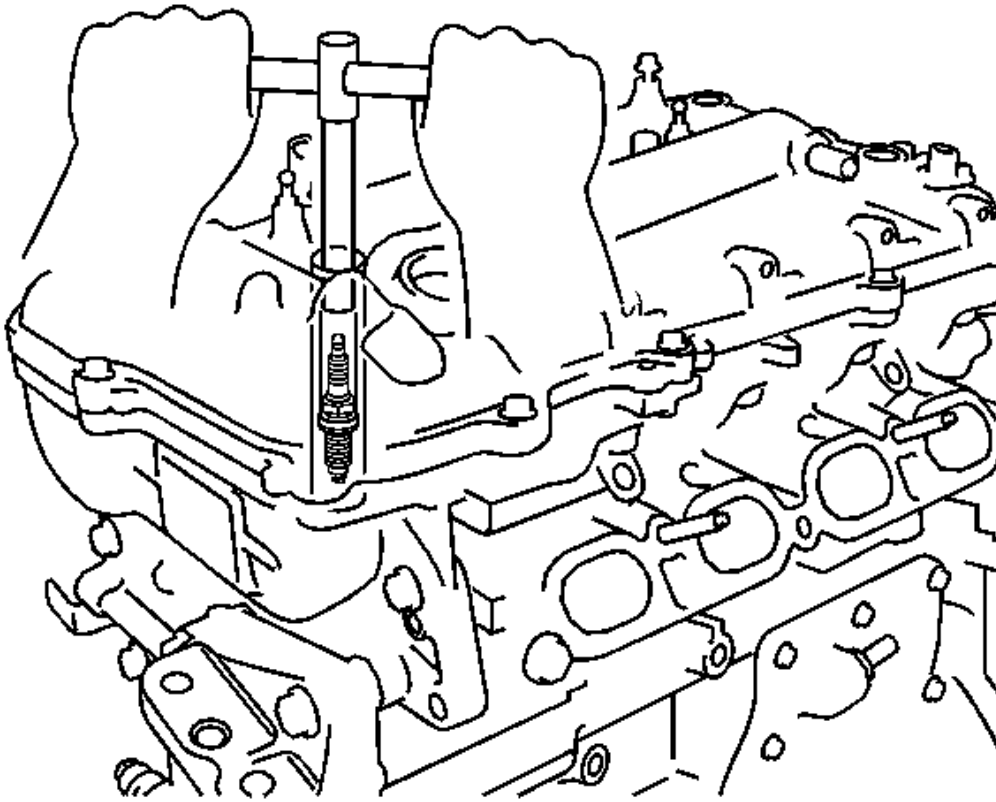


Fig. 547: View Of Spark Plug Removal/Installation
Courtesy of GENERAL MOTORS CORP.

12. Using a 14 mm spark plug wrench, install the 4 spark plugs and tighten to 20 N.m (15 lb ft).

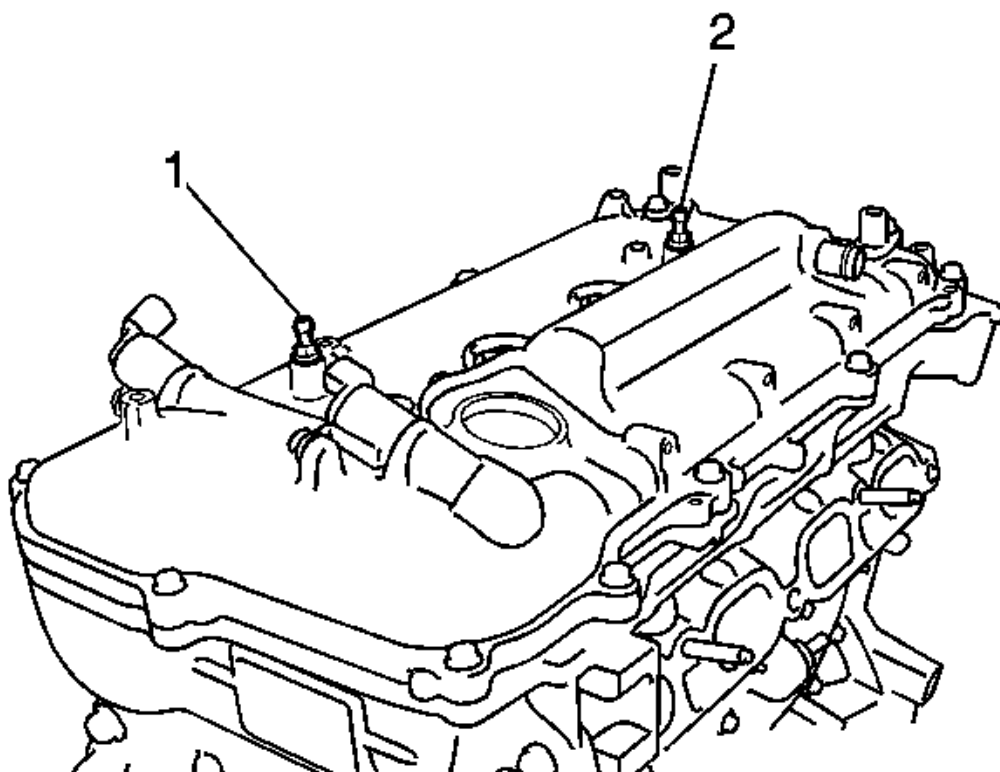


Fig. 548: View Of Engine Cover Joints
Courtesy of GENERAL MOTORS CORP.

13. Install the 2 engine cover joints and tighten to 10 N.m (7 lb ft).

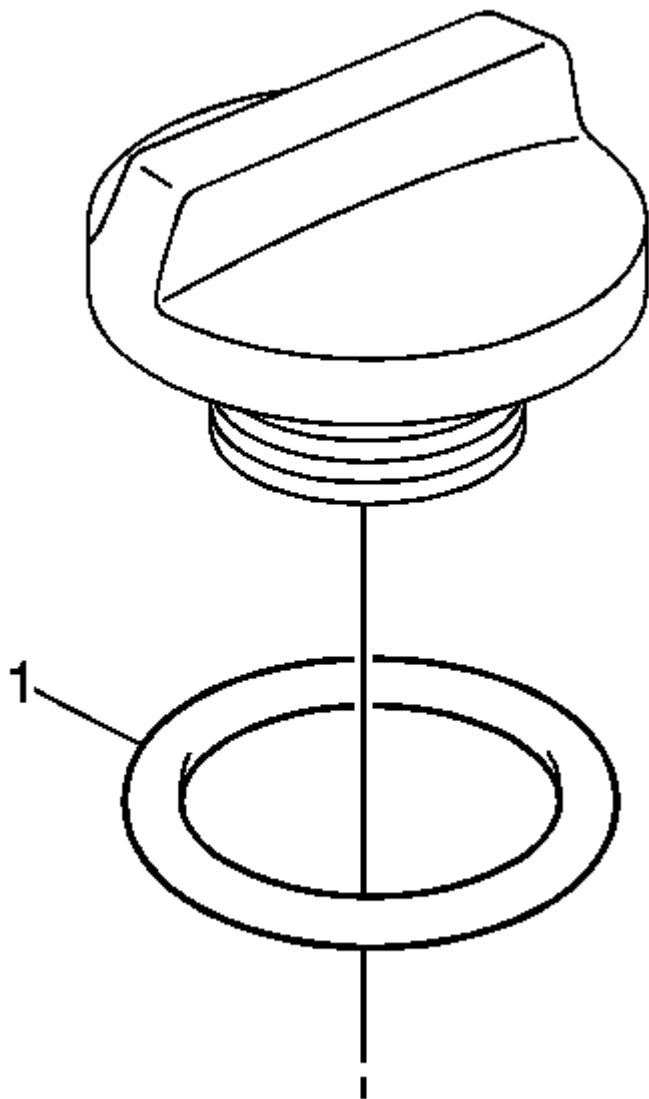


Fig. 549: View Of Oil Filler Cap
Courtesy of GENERAL MOTORS CORP.

14. Install the oil filler cap gasket.

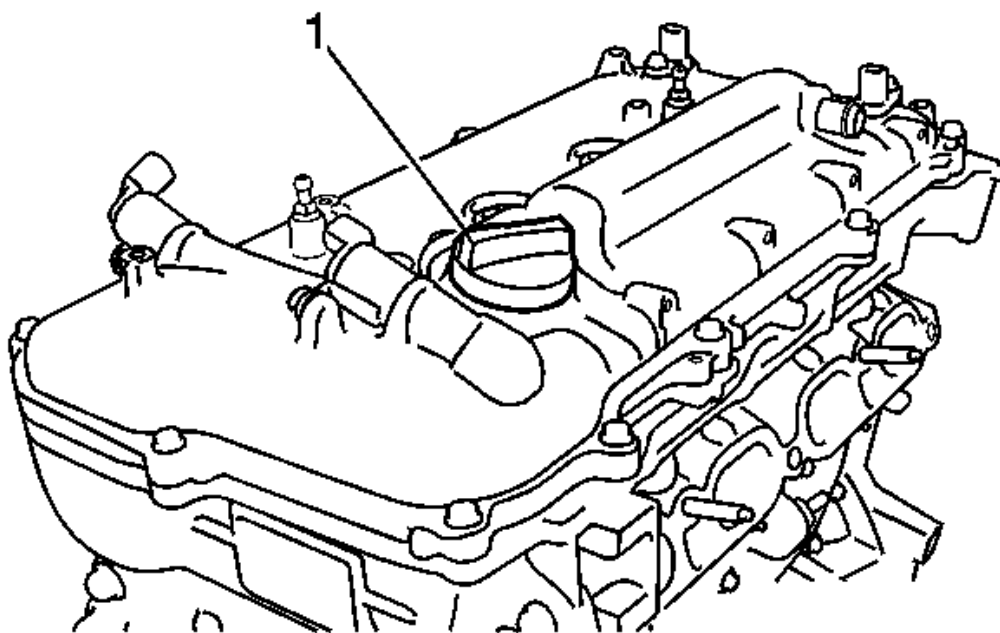


Fig. 550: Identifying Oil Filler Cap
Courtesy of GENERAL MOTORS CORP.

15. Install the oil filler cap sub-assembly.

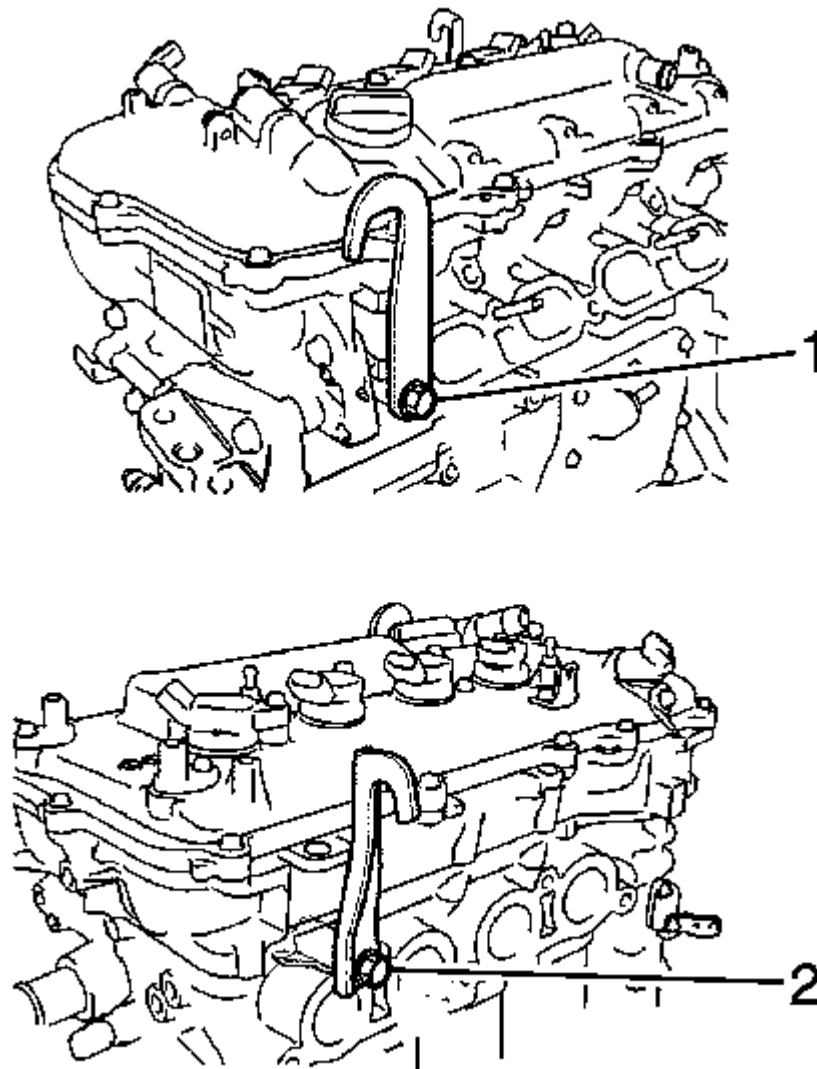


Fig. 551: View Of Engine Hangers
Courtesy of GENERAL MOTORS CORP.

16. Install the 2 engine hangers with the 2 bolts and tighten to 43 N.m (32 lb ft).

OIL PAN INSTALLATION (UPPER)

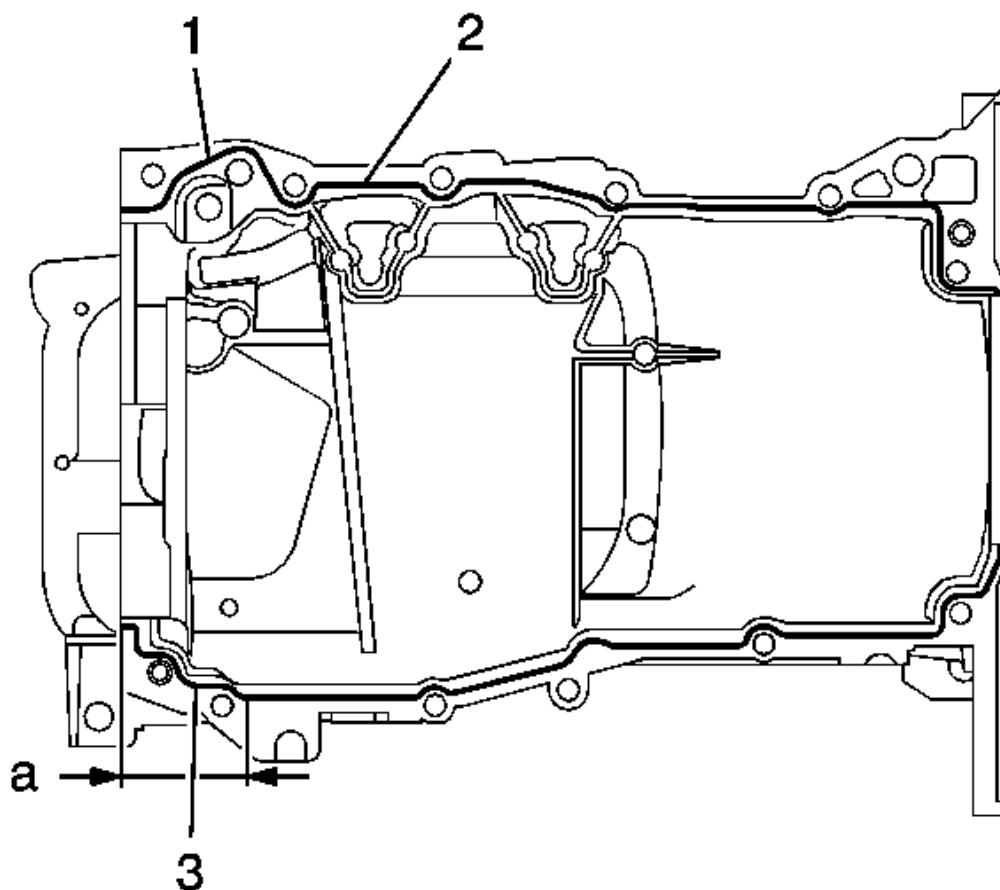


Fig. 552: View Of Upper Oil Pan

Courtesy of GENERAL MOTORS CORP.

NOTE:

- Remove any oil from the contact surface.
- Install the crankcase within 3 minutes after applying seal packing.
- Do not start the engine for at least 2 hours after installing the stiffening crankcase.

1. Apply Three Bond 1207B or equivalent, in a continuous bead (diameter: 2.5 mm (0.098 in)) to the places shown.

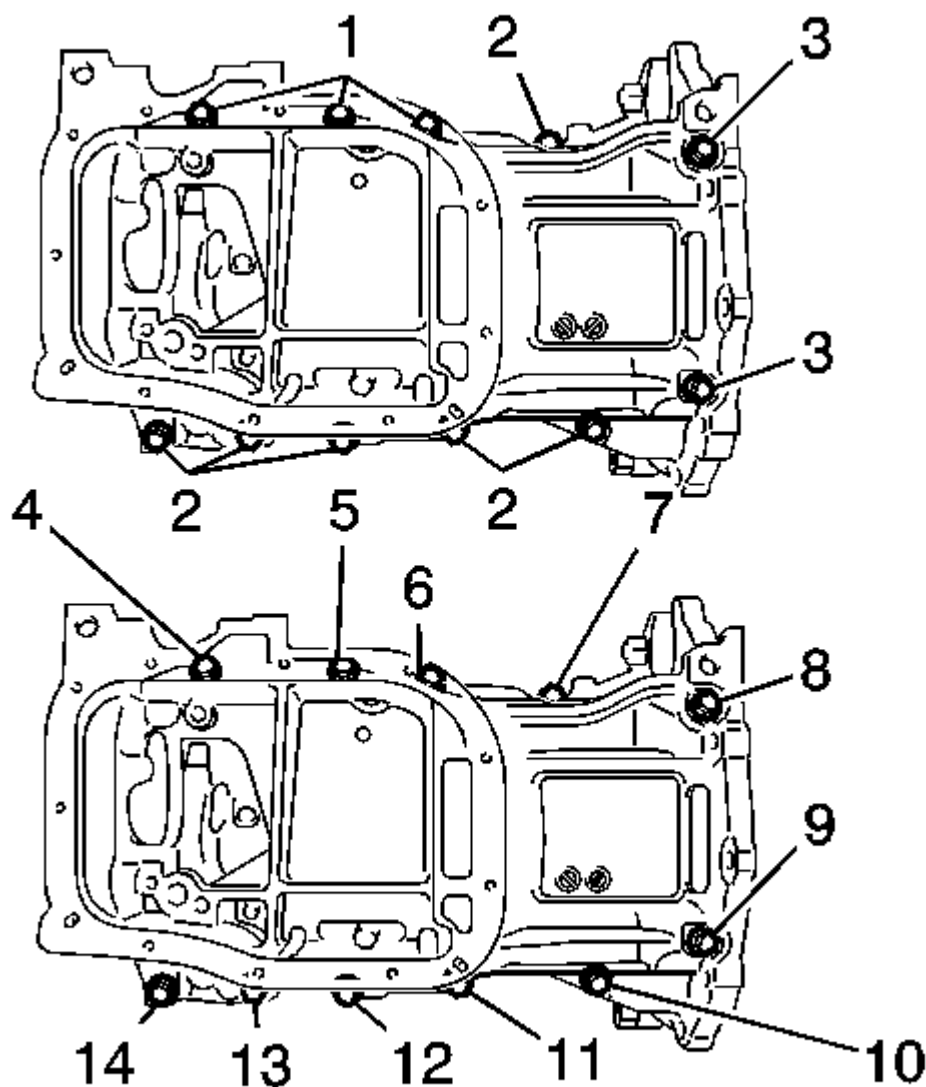


Fig. 553: Identifying Upper Oil Pan Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

2. Install the stiffening crankcase with the 11 bolts and tighten to 21 N.m (16 lb ft).
3. Check the torque for bolts 1 and 2 and tighten to 21 N.m (16 lb ft).

4. Wipe off any excess seal packing with a clean piece of cloth.

OIL PAN INSTALLATION (LOWER)

1. Install the No. 2 oil pan sub-assembly.

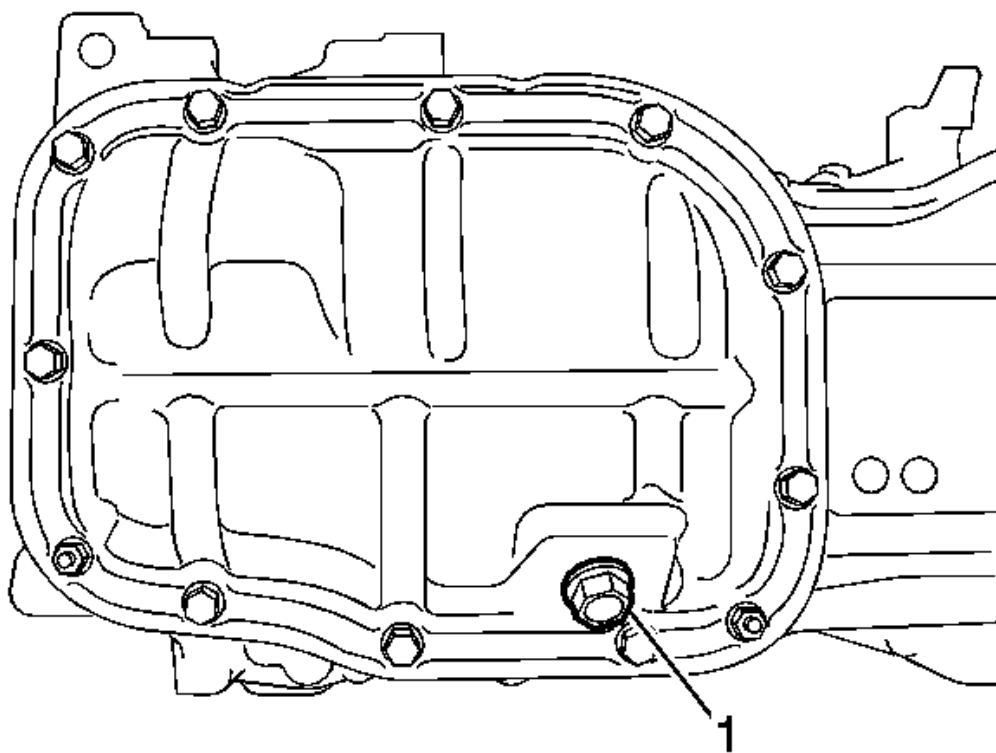


Fig. 554: Identifying Oil Pan Drain Plug & Gasket
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

2. Install a new gasket and the oil pan drain plug and tighten to 37 N.m (27 lb ft).

INTAKE MANIFOLD INSTALLATION

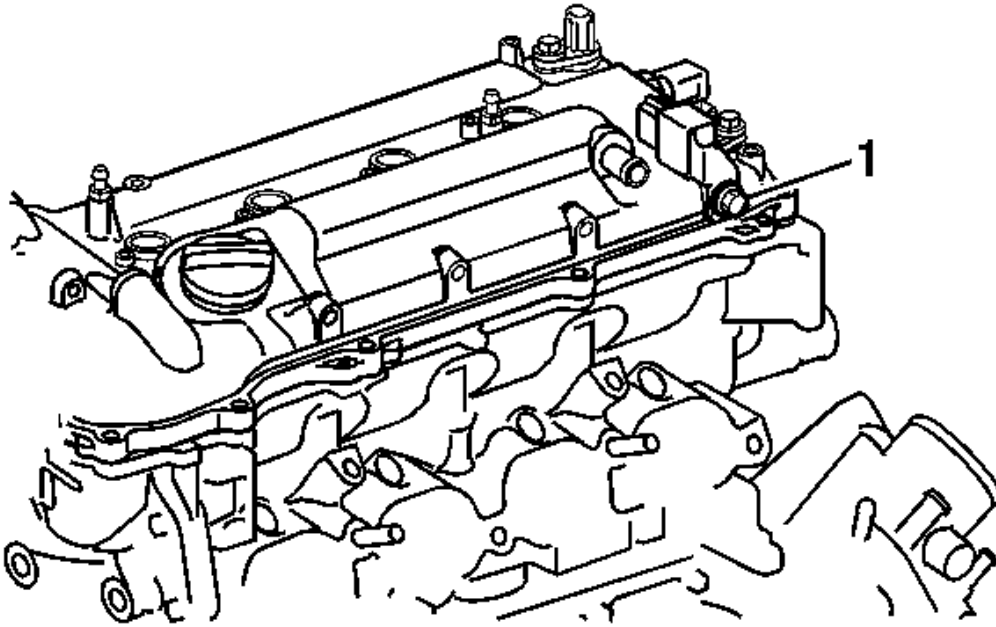


Fig. 555: Identifying Intake Manifold

Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the radio setting condenser with the bolt and tighten to 10 N.m (7 lb ft).
2. Install the thermostat.
3. Install the inlet water.

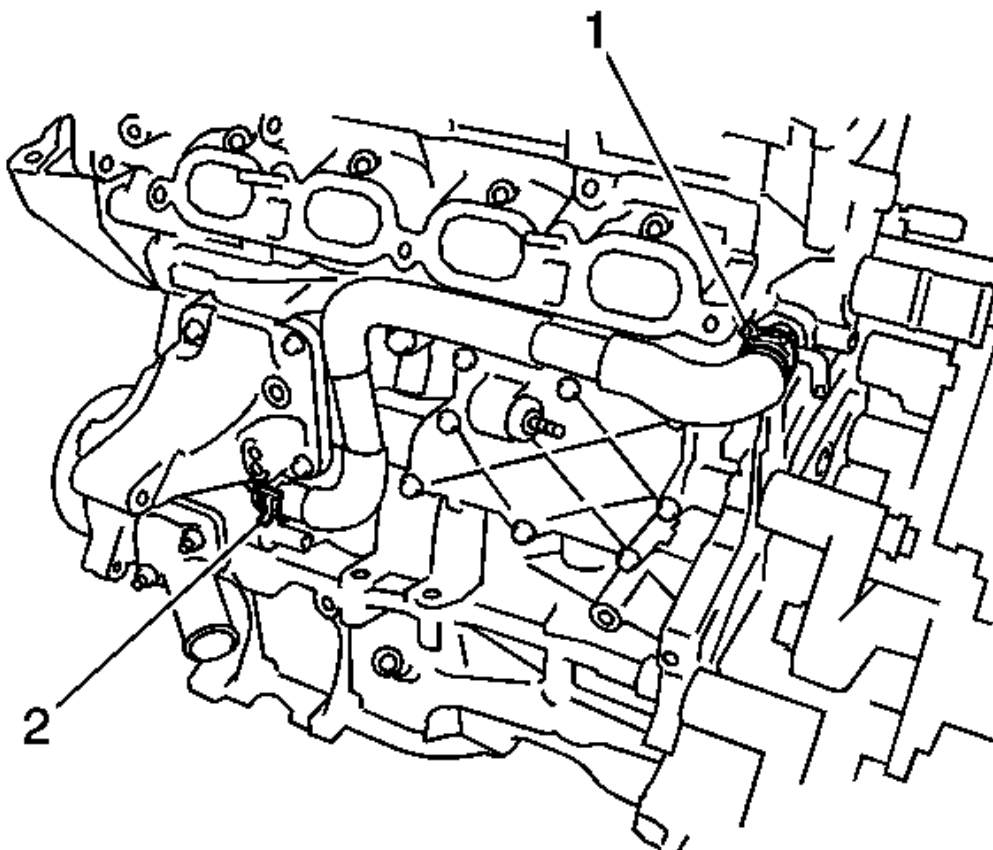


Fig. 556: Identifying Water Inlet Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

4. Install the inlet water hose with the 2 clamps.
5. Install the water by-pass hose with the clamp.

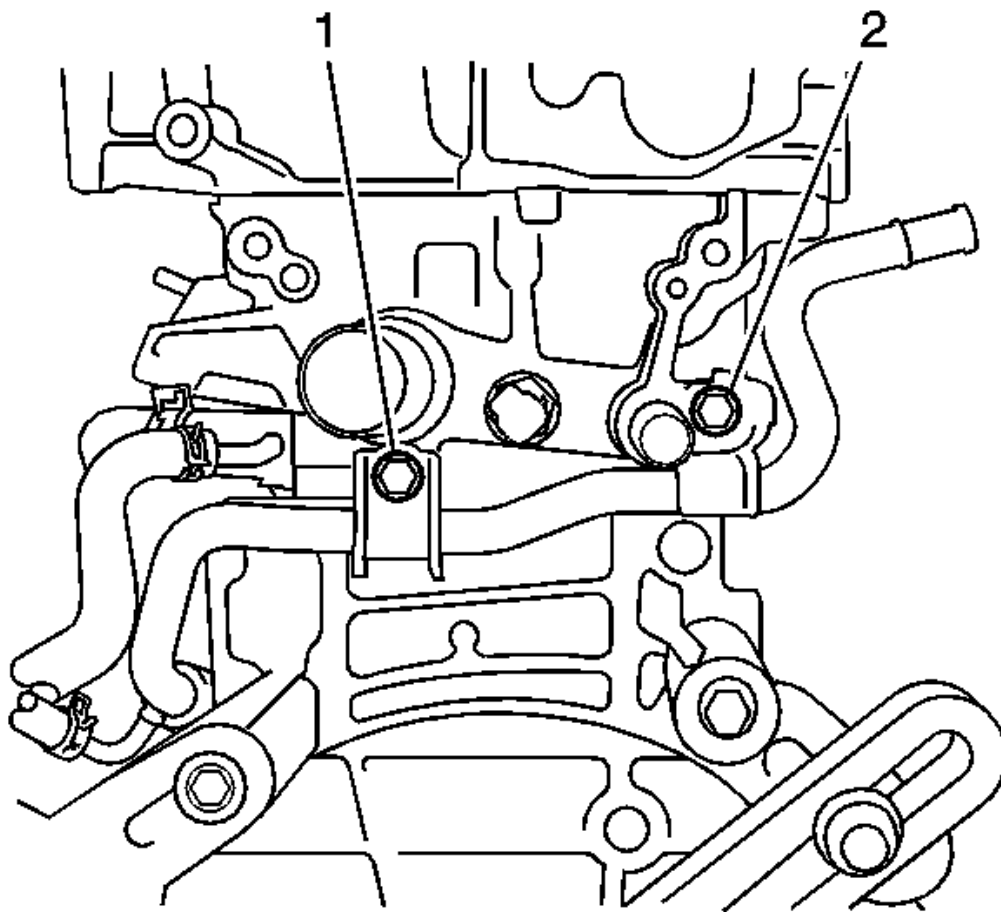


Fig. 557: View Of No. 1 Water By-Pass Pipe
Courtesy of GENERAL MOTORS CORP.

6. Install the No. 1 water by-pass pipe with the 2 bolts and tighten to 21 N.m (16 lb ft).

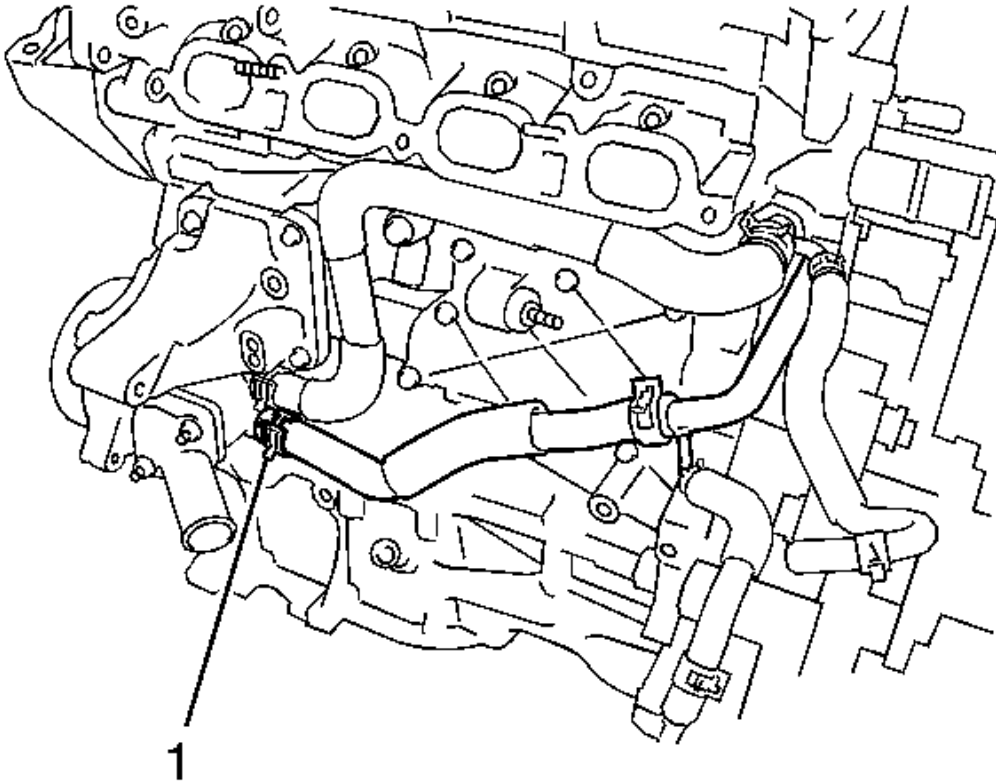


Fig. 558: Identifying By-Pass Hose & Water Inlet Housing
Courtesy of GENERAL MOTORS CORP.

7. Connect the No. 3 water by-pass hose to the inlet water housing.
8. Install the ventilation hose.
9. Install the 4 ignition coils with the 4 bolts and tighten to 10 N.m (7 lb ft).
10. Install the fuel injector assembly.
11. Install the No. 1 delivery pipe spacer.
12. Install the fuel delivery pipe sub-assembly.
13. Connect the fuel tube sub-assembly.
14. Install a new gasket to the intake manifold.

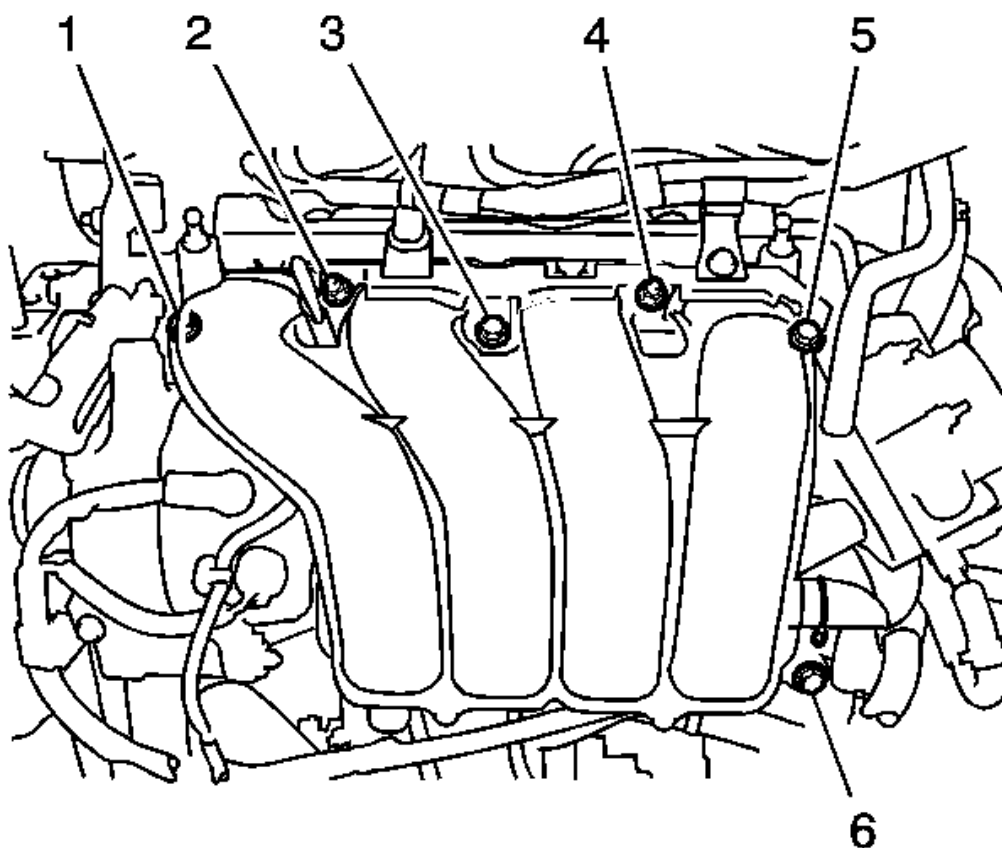


Fig. 559: Identifying Intake Manifold, Intake Manifold Stay, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

15. Install the intake manifold and intake manifold stay with the 4 bolts and 2 nuts and tighten to 28 N.m (21 lb ft).

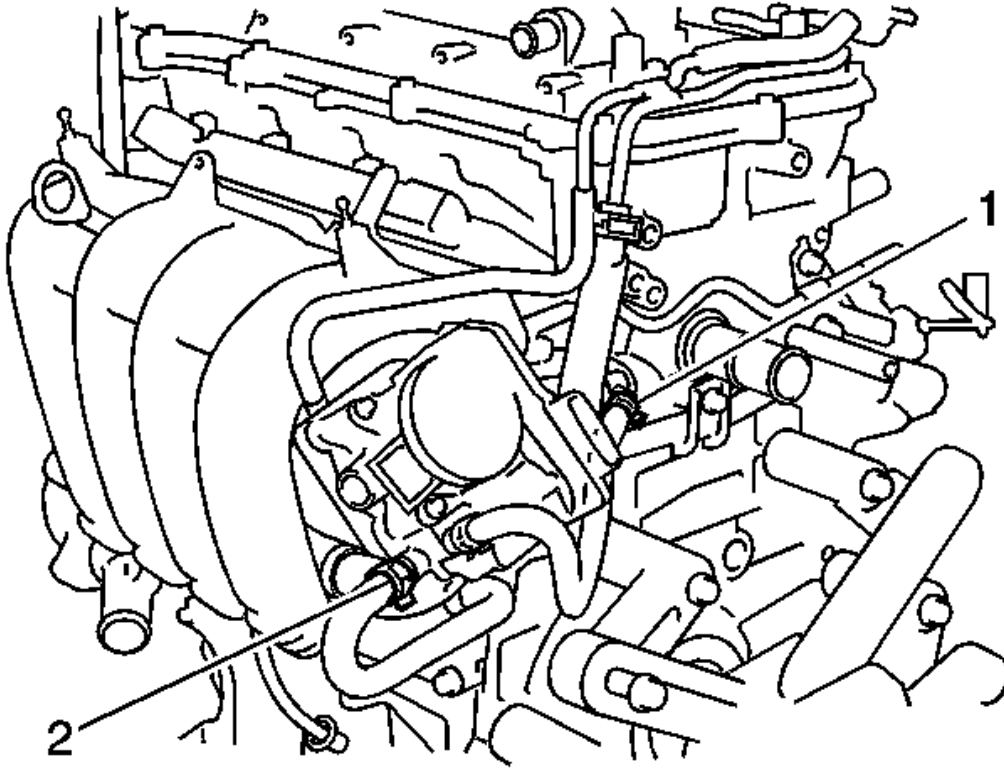


Fig. 560: Identifying Water By-Pass Hoses
Courtesy of GENERAL MOTORS CORP.

16. Connect the 2 water by-pass hoses.
17. Connect the ventilation hose to the intake manifold.
18. Install the air tube with the 2 bolts and tighten to 10 N.m (7 lb ft).
19. Install the wire harness bracket and tighten to 10 N.m (7 lb ft).
20. Install the bolt and fan belt adjusting bar and tighten to 19 N.m (14 lb ft).
21. Install the engine hanger.
22. Remove the engine stand.
23. Attach the engine to the sling device with the chain block.
24. Remove the engine from the engine stand.

EXHAUST MANIFOLD INSTALLATION

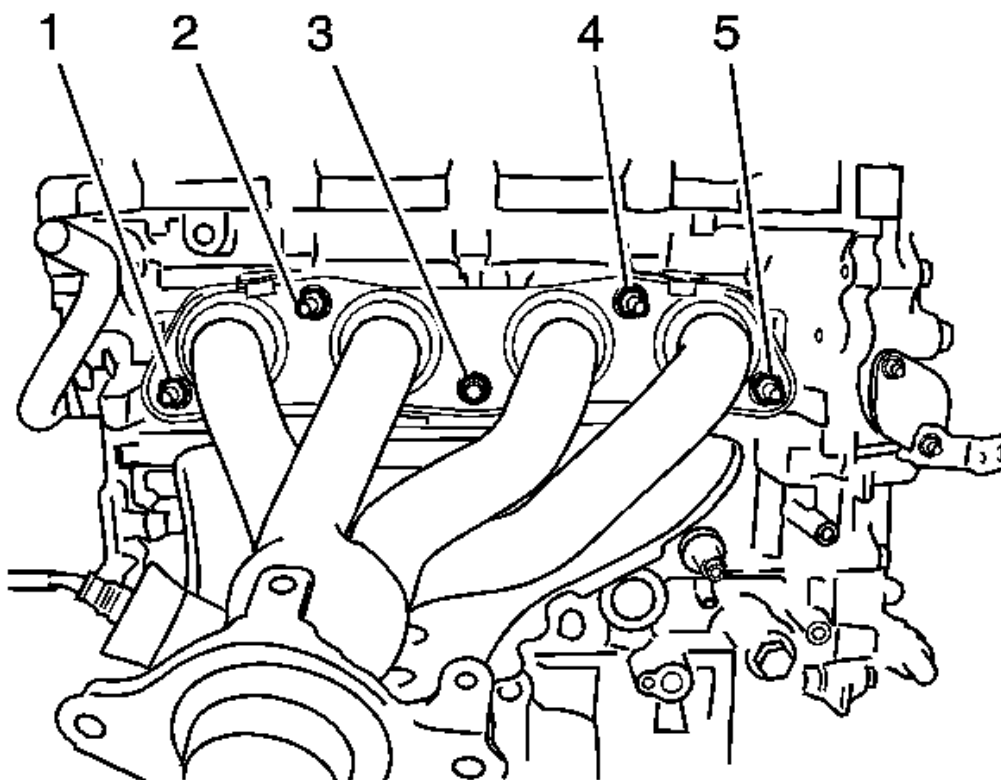


Fig. 561: Identifying Exhaust Manifold Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install a new gasket onto the exhaust manifold.

CAUTION: Refer to Fastener Caution .

2. Install the exhaust manifold with the 5 nuts and tighten to 21 N.m (16 lb ft).

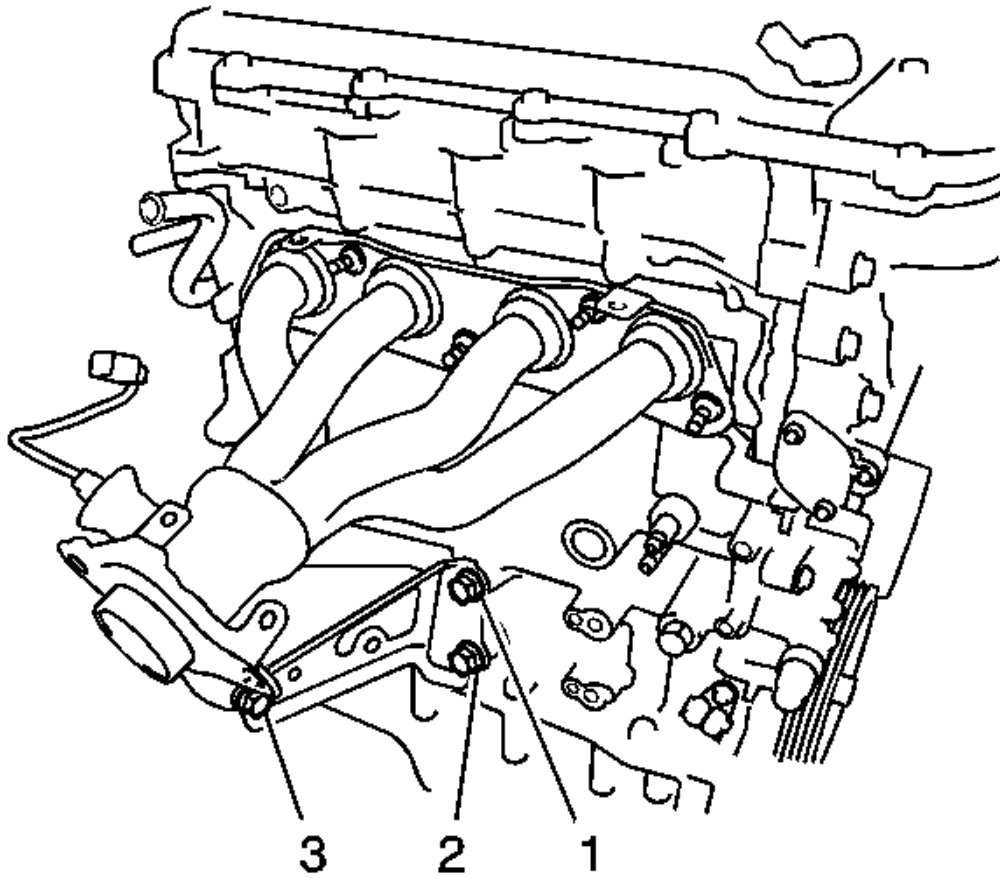


Fig. 562: Identifying Exhaust Manifold Bolts & Stay
Courtesy of GENERAL MOTORS CORP.

3. Install the manifold stay with the 3 bolts and tighten to 43 N.m (32 lb ft).

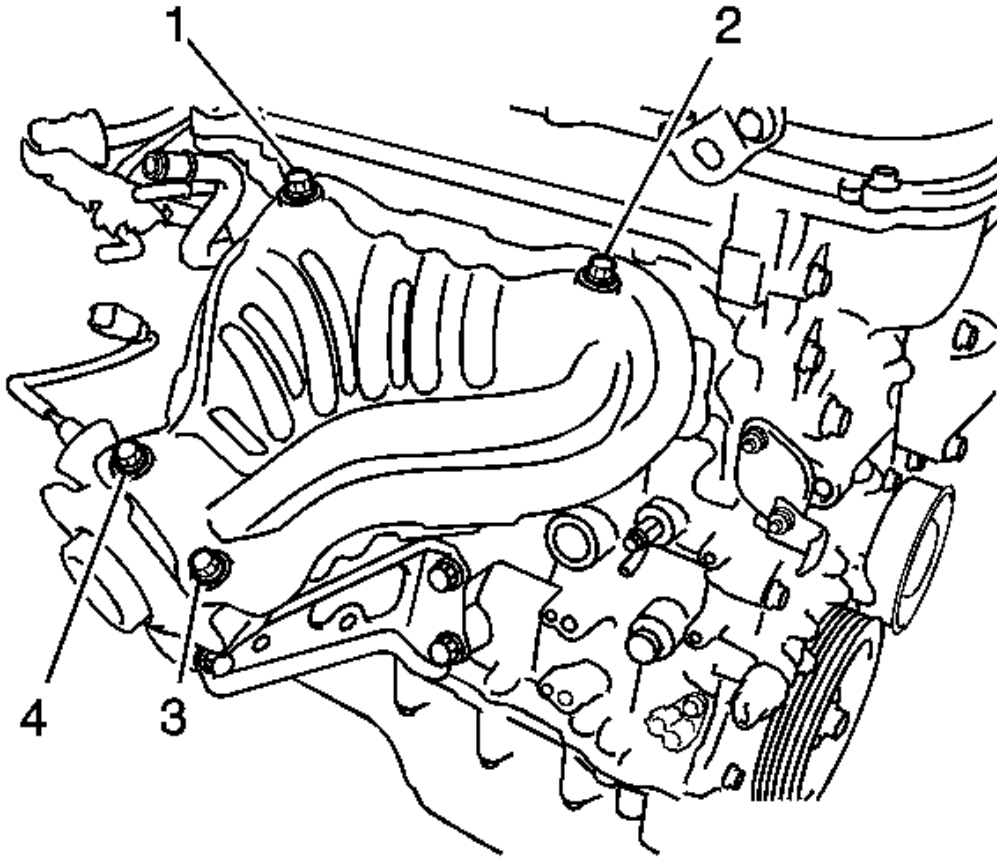


Fig. 563: Identifying Exhaust Manifold Heat Insulator Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install No. 1 exhaust manifold heat insulator with the 4 bolts and tighten to 12 N.m (9 lb ft).

OIL LEVEL INDICATOR AND TUBE INSTALLATION

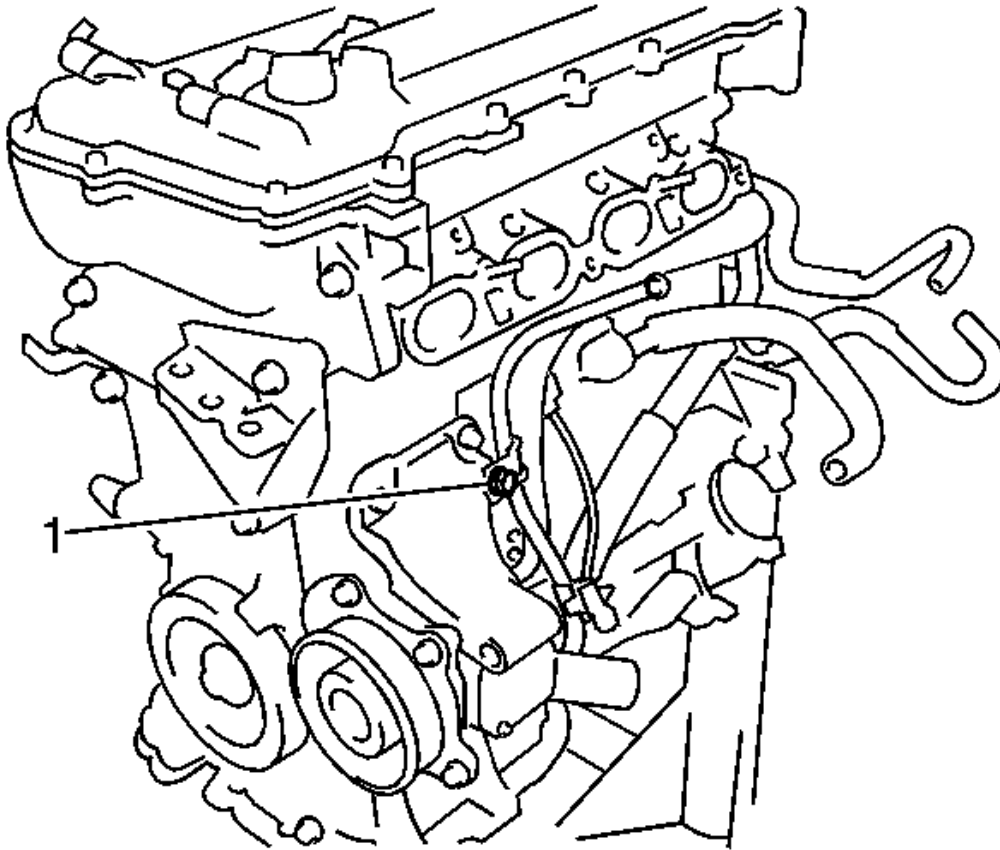


Fig. 564: Identifying Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Use new engine oil in order to coat the new guide tube seal.

CAUTION: Refer to Fastener Caution .

2. Install the new guide tube seal (1) to the guide tube. Secure the guide tube to the cylinder block using one bolt and tighten to 14 N.m (10 lb ft).
3. Install the oil level indicator to the guide tube.

ENGINE FLYWHEEL INSTALLATION

Special Tools

J 36660-A: Torque Angle Meter**Installation Procedure**

1. Install the flywheel to the crankshaft. Align the flywheel-to-engine marks.

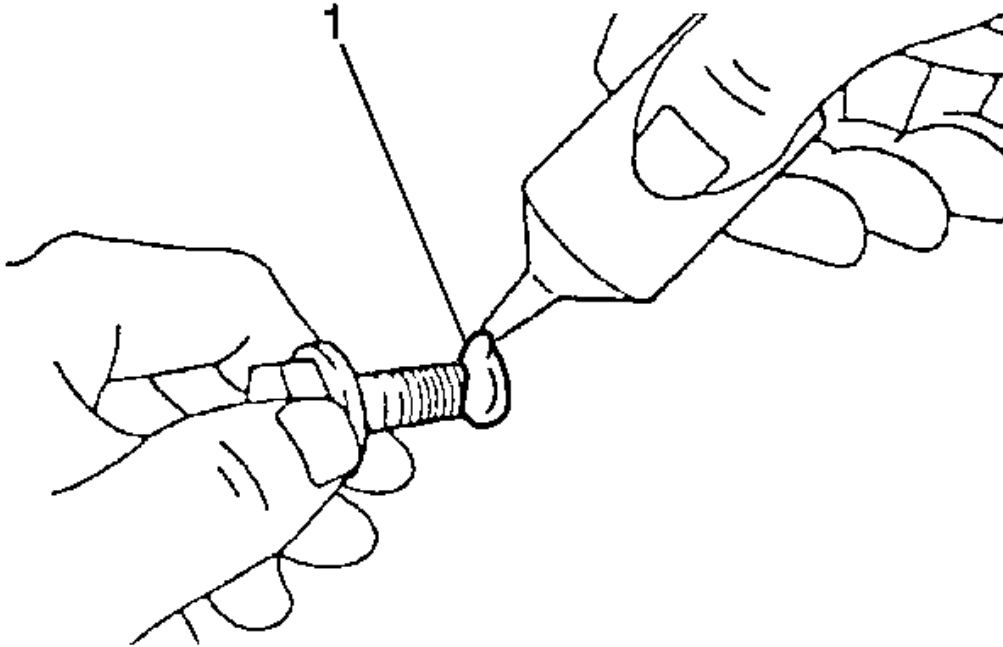


Fig. 565: Applying Sealant To Flywheel Retaining Bolt Threads
Courtesy of GENERAL MOTORS CORP.

CAUTION: Apply the proper amount of the sealant to the fastener when assembling this component. Excessive use of the sealant can prohibit the component from being assembled properly or allow the fastener to loosen. A component or fastener that is not assembled properly can loosen or fall off leading to extensive engine damage.

2. Apply GM P/N 12345493 (Canadian P/N 10953488) or the equivalent, to the flywheel retaining bolt threads (1).

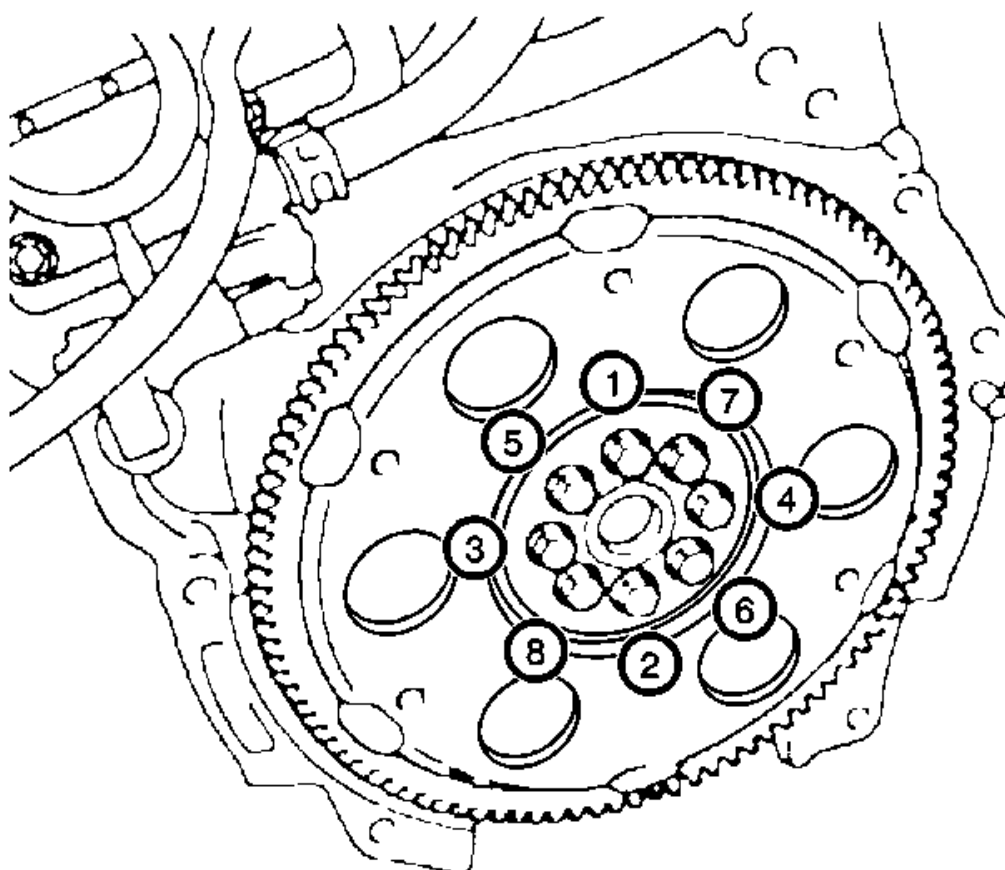


Fig. 566: Identifying Flywheel Retaining Bolt Loosening/Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. For vehicles equipped with an automatic transmission, install the flywheel retaining bolts (1-8) to the crankshaft and tighten in sequence to 83 N.m (61 lb ft).

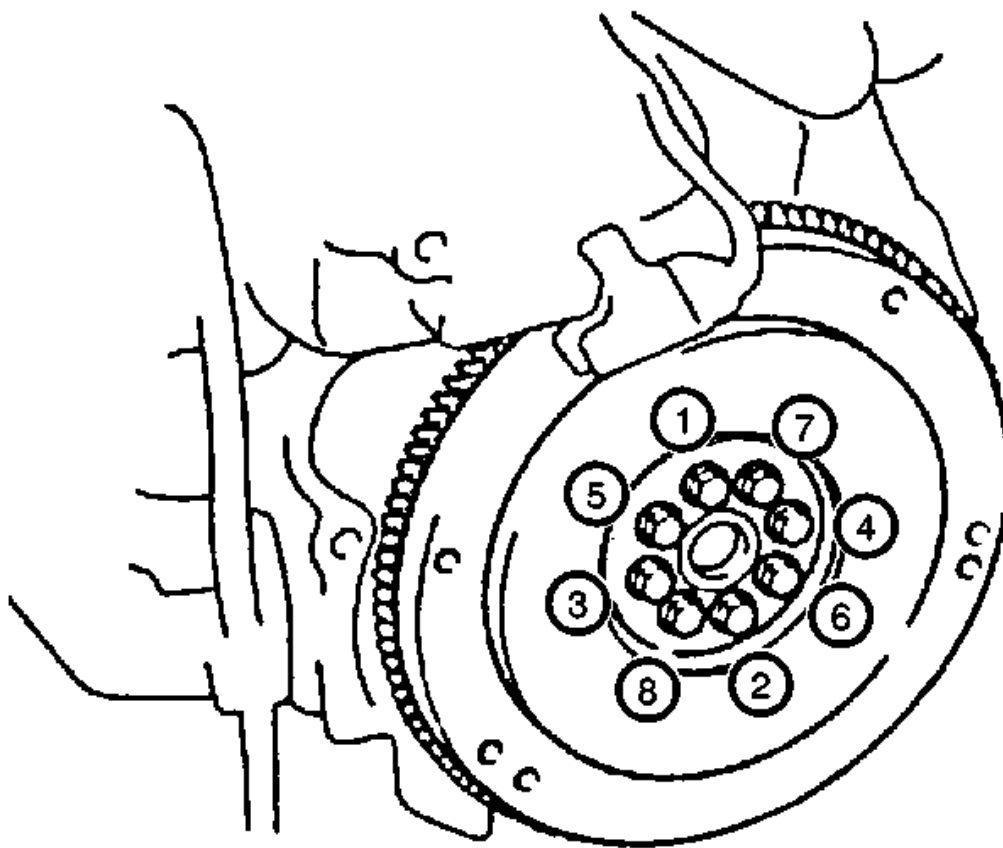


Fig. 567: Identifying Flywheel Retaining Bolt Removal/Installation Sequence
Courtesy of GENERAL MOTORS CORP.

4. For vehicles equipped with a manual transmission, install the 8 flywheel retaining bolts to the crankshaft and tighten the bolts to 49 N.m (36 lb ft).

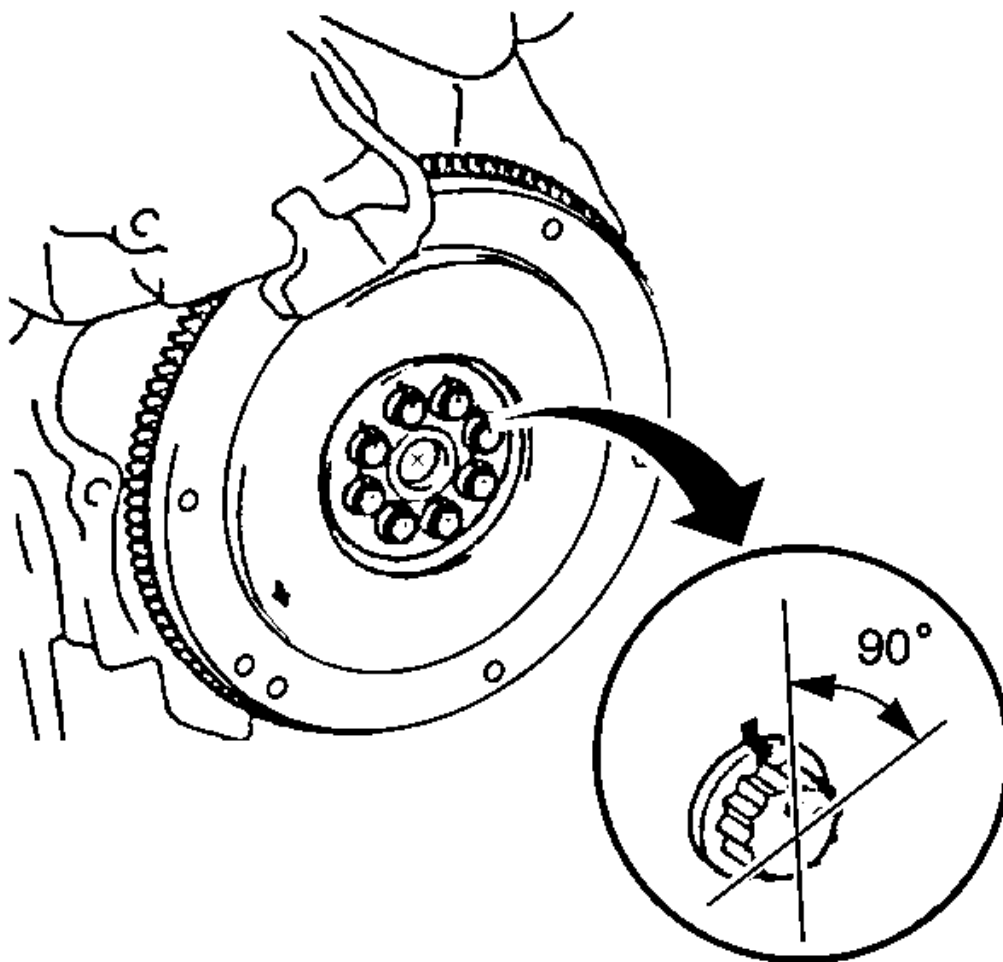


Fig. 568: Tightening Flywheel Bolts Additional 90 Degrees
Courtesy of GENERAL MOTORS CORP.

5. Perform the final torque on the manual transmission flywheel retaining bolts.

After the proper torque of 49 N.m (36 lb ft) has been reached, use a **J 36660-A** meter and tighten the flywheel bolts an additional 90 degrees.