Cadillac XLR
(2007-2008)



- Update Version -

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2007 TRANSMISSION

Automatic Transmission - 6L50/6L80/6L90 - XLR

SYMPTOMS - AUTOMATIC TRANSMISSION

IMPORTANT: Use the symptom tables only if the following conditions are met:

- **Refer to Diagnostic Starting Point - Vehicle .**
- **There are no DTCs set.**
- **The control modules can communicate via the serial data link.**
- **Review the system operation in order to familiarize yourself with the system functions. Refer to Transmission General Description and Transmission Component and System Description .**

VISUAL/PHYSICAL INSPECTION

Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

INTERMITTENT

Faulty electrical connections or wiring may be the cause of intermittent conditions. Refer to **Testing for Intermittent Conditions and Poor Connections** .

SYMPTOM LIST

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

- Fluid Diagnosis
  - **Transmission Fluid Checking**
  - **Fluid Pressure High or Low**
  - **Automatic Transmission Fluid Leaks**
  - **Fluid Leak Diagnosis**
- Noise and Vibration Diagnosis
  - **Whine/Growl Noise That Changes with Vehicle Speed**
  - **Noise in First or Reverse Gear**
  - **Noise in First, Second, Third, Fourth, Fifth or Reverse Gear**
  - **Noise in First, Second, Sixth or Reverse Gear**
  - **Noise in Second or Sixth Gear**
  - **Noise During 3-4 or 4-3 Shifts**
  - **Noise in Fourth, Fifth or Sixth Gear**

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    - **Vibration**
    - **Vibration in Second, Third, Fourth, Fifth or Sixth Gear**
    - **Flexplate/Torque Converter Vibration Test**
    - **Noise and Vibration Analysis**
- Range Performance Diagnosis
    - **No Park or Drive**
    - **No Drive in All Ranges**
    - **No Reverse Gear**
    - **No Drive or Reverse Gear**
- Shift Quality Feel Diagnosis
    - **Harsh Garage Shift**
    - **Harsh, Soft, Delayed or Slipping First or Reverse Gear**
    - **Harsh, Soft, Delayed or Slipping 1-2-3-4 Shift**
    - **Harsh, Soft, Delayed or Slipping 4-5-6 Shift**
    - **Harsh, Soft, Delayed or Slipping Third, Fifth or Reverse Gear**
    - **Harsh, Soft, Delayed or Slipping Second or Sixth Gear**
- Shift Pattern
    - **No First Gear**
    - **No First and Reverse Gears**
    - **No First, Second, Third and Fourth Gear**
    - **No First, Second, Third, Fourth, Fifth or Reverse Gear**
    - **No Second and Sixth Gear**
    - **No First, Second, Sixth or Reverse Gear**
    - **No Fourth, Fifth and Sixth Gear**
    - **No Third, Fifth and Reverse Gear**
    - **Stuck in Second or Sixth Gear**
    - **Stuck in First or Reverse Gear**
- Torque Converter Diagnosis
    - **Torque Converter Diagnosis**
    - **No Torque Converter Clutch Apply**
    - **No Torque Converter Clutch Release**
- Symptom Not Found or No Symptom Detected
    - **Transmission Fluid Checking**
    - **Road Test**
    - **Line Pressure Check**

CONTROL SOLENOID VALVE AND TRANSMISSION CONTROL MODULE

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ASSEMBLY INSPECTION

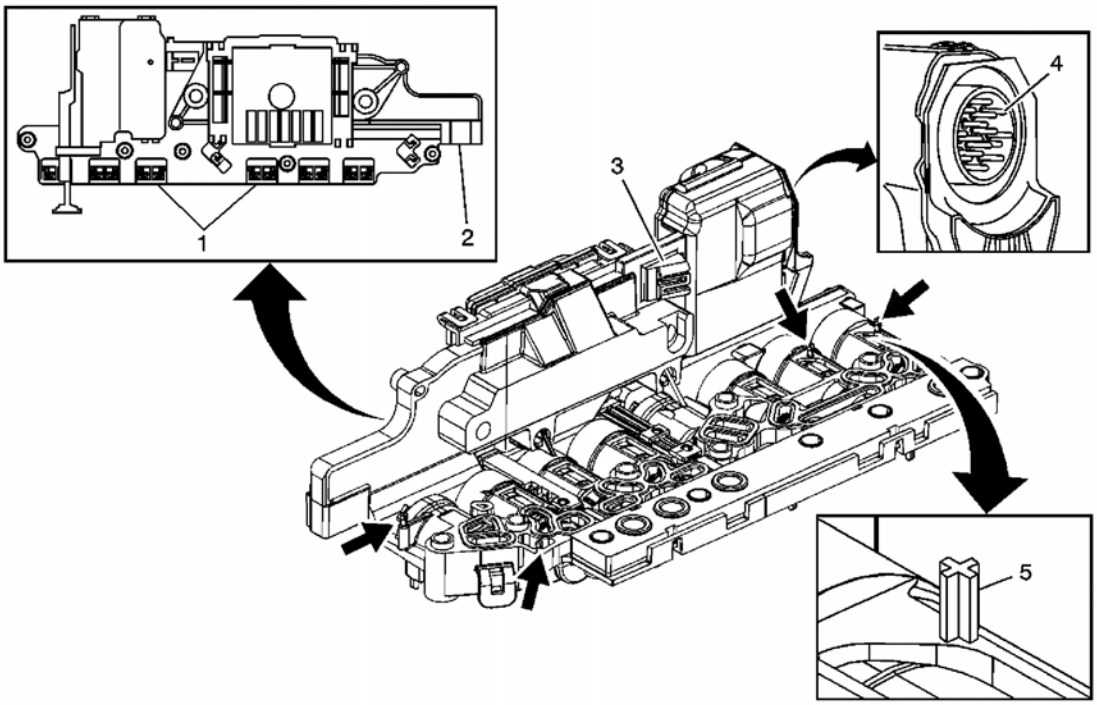


Fig. 1: Identifying Control Solenoid Valve & Transmission Control Module Assembly
Courtesy of GENERAL MOTORS CORP.

1. Inspect the control solenoid (w/body and TCM) valve assembly connectors and pins (2, 3, 4) for the following conditions:
   - Damage
   - Bent pins
   - Debris
   - Broken retaining tab
   - Contamination
2. Ensure no metallic debris is inside the connectors near the terminal pins.
3. Inspect the control solenoid (w/body and TCM) valve assembly solenoid leads (1) for contamination or metallic debris.
4. Inspect the 4 control solenoid (w/body and TCM) valve assembly filter plate retaining tabs (5) for cracks and ensure proper tension when filter plate is attached.

CONTROL SOLENOID VALVE AND TRANSMISSION CONTROL MODULE ASSEMBLY INPUT SHAFT SPEED/OUTPUT SHAFT SPEED INPUT TEST

TOOLS REQUIRED

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- **J 35616** GM-Approved Terminal Test Kit. See **Special Tools** .
- **J 38522** Variable Signal Generator

TEST PROCEDURE

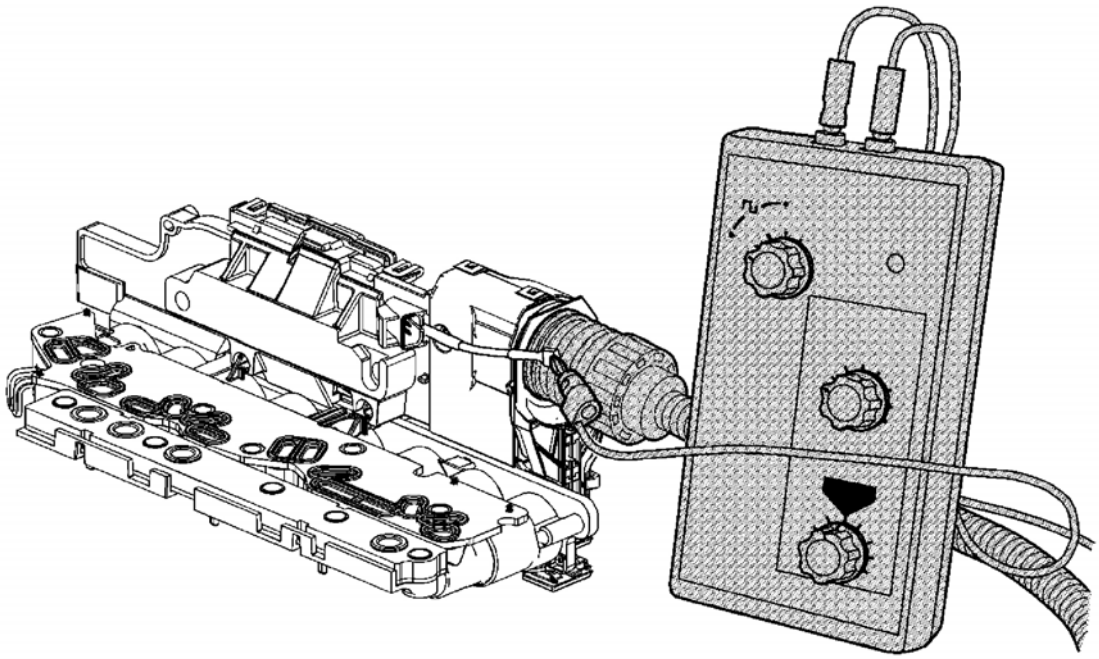


Fig. 2: Testing Using J 35616
Courtesy of GENERAL MOTORS CORP.

The purpose of this test is to provide a simulated input/output speed sensor (ISS/OSS) signal to the control solenoid (w/body and TCM) valve assembly ISS/OSS input circuits.

1. Disconnect the ISS/OSS wiring harness connector from the control solenoid (w/body and TCM) valve assembly.
2. Using the **J 35616** , connect the **J 38522** to the affected ISS or OSS signal circuit on the control solenoid (w/body and TCM) valve assembly. See **Special Tools** .
    1. Set the **J 38522** Signal to 5 volts, the Frequency to 120 and the Percent Duty Cycle to 50.
    2. Ignition On, observe either the scan tool parameter ISS Signal or OSS Signal.
    3. The signal parameter should display between 100-400 RPM.

- If the signal display is not in this range, the control solenoid (w/body and TCM) valve assembly is not reading the input signal correctly and is faulty.

CONTROL SOLENOID VALVE AND TRANSMISSION CONTROL MODULE ASSEMBLY CLEANING

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The control solenoid (w/body and TCM) valve assembly cleaning procedure is a specific software based routine, which resides in the TCM. This procedure is activated by the scan tool and is used to cycle the solenoids and valves in the control solenoid valve assembly in an attempt to dislodge debris and free up the valves after a performance diagnostic trouble code (DTC) has set. The transmission fluid is drained and refilled with new fluid and then the cleaning procedure is performed. When the cleaning procedure is completed, the DTC enable criteria is run again and retested to see if the DTC concern has been corrected.

IMPORTANT: The fluid pan must be removed in order to drain the fluid.

1. Drain and refill the transmission fluid. Refer to **Automatic Transmission Fluid, Fluid Pan and/or Filter Replacement** .
2. Operate the transmission to achieve 70°-90°C (158°-194°F).
3. With a scan tool, select the Service Cleaning Procedure. Initiate the cleaning procedure.
4. When the cleaning procedure is completed, shut OFF the ignition for 30 seconds.

CONTROL SOLENOID VALVE AND TRANSMISSION CONTROL MODULE ASSEMBLY SOLENOID PERFORMANCE TEST

TOOLS REQUIRED

DT-47825 Control Solenoid Test Plate. See **Special Tools** .

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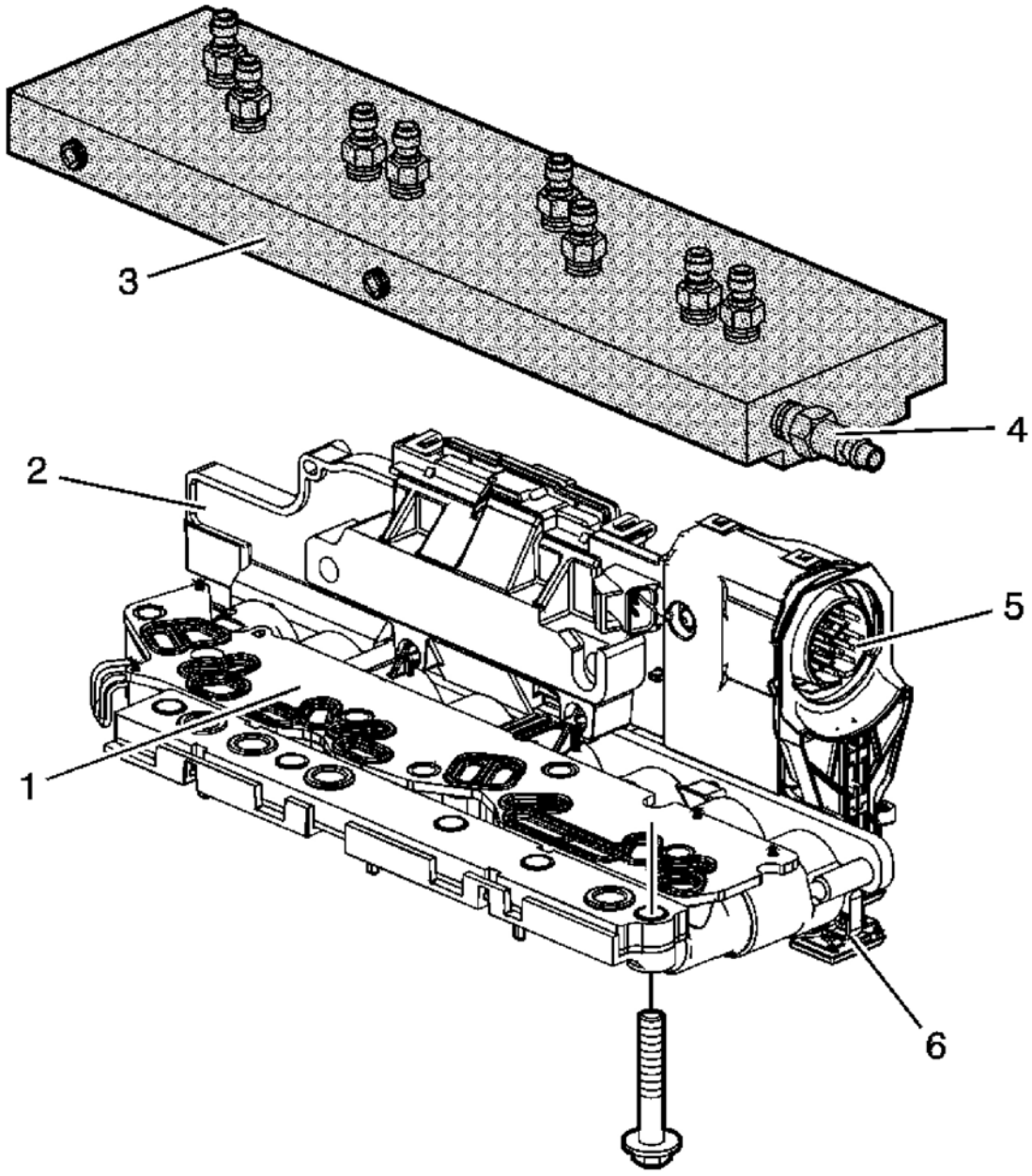


Fig. 3: View Of Control Solenoid (w/Body & TCM) Valve Assembly With Control Solenoid Test Plate
Courtesy of GENERAL MOTORS CORP.

The purpose of this procedure is to test the functionality of the control solenoid (w/body and TCM) valve assembly solenoids for a gross stuck open or stuck closed condition. **DT-47825** is bolted to the control solenoid (w/body and TCM) valve assembly on the valve body mounting surface. Pressurized air is passed into the aluminum test block, through the control solenoid (w/body and TCM) valve assembly solenoid passage and back to a pressure gage on the test block. The pressure gage indicates open if air pressure is passed through the solenoid or closed if the solenoid is unable to pass air through. A scan tool is used to command the solenoids ON and OFF. While watching the pressure gage, one can determine the valve functionality. The recommended

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shop air pressure for this test is 90-100 psi.

1. Remove the control solenoid (w/body and TCM) valve assembly from the transmission.
2. Bolt the **DT-47825** to the control solenoid (w/body and TCM) valve assembly on the valve body mounting surface. See **Special Tools** . Use the bolts and washers supplied with the tool to attach the test block. Tighten the bolts to 5 N.m (44 lb in).
3. Install the pressure gage to the affected solenoid air port. Reference component to air port table.
4. Connect the shop air pressure line to the **DT-47825** air psi inlet port. See **Special Tools** .

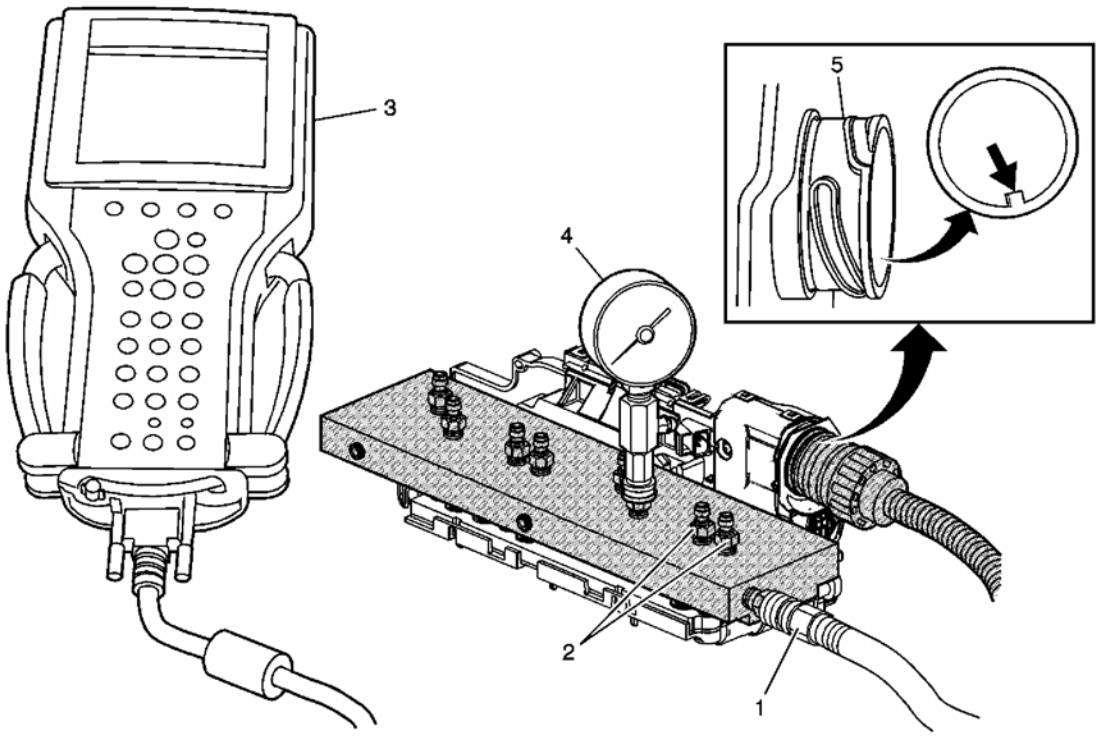


Fig. 4: Identifying Solenoid Testing Procedure
Courtesy of GENERAL MOTORS CORP.

5. Ignition ON, with a scan tool command the solenoid in question On and Off. Watch the air pressure gage and look for the change in pressure as you command the valve On and Off. The valve should allow air pressure to flow through the valve port to the gage with a result of pressure reading on the gage. If the valve is stuck closed, no pressure change will occur. Command the solenoid valve On and Off several times to determine the state of the solenoid valve in question. Release the air pressure in the gage between pressurization tests.

Control Solenoid (w/Body & TCM) Valve Assembly Solenoid Performance Test Block To Component Identification

COMPONENT	PORT ON TEST BLOCK	Key On, Engine Off (KOEO) Normal State

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PC Solenoid 1	G	No PSI flow to gauge
PC Solenoid 2	C	No PSI flow to gauge
PC Solenoid 3	A	Full PSI flow to gauge
PC Solenoid 4	B	No PSI flow to gauge
PC Solenoid 5	F	No PSI flow to gauge
Shift Solenoid 1	H	Full PSI flow to gauge
Shift Solenoid 2	D	No PSI flow to gauge
TCC PC Solenoid	E	No PSI flow to gauge

IMPORTANT: With the key on engine off (KOEO), the TCM will normally cycle some of the transmission solenoids On and Off to facilitate keeping the ports and solenoids clean and free of debris. This dither function is a normal activity and will cause the valves to cycle open and closed quickly when the TCM is powered up. This can cause the psi gage to flicker high and low as the valves open and close. This may cause some air to exit the ports where the psi gage is not connected as those solenoids cycle on and off.

Drain the TCM of excess transmission fluid before attaching to test block and use caution when attaching air to test block air inlet.

SERVICE FAST LEARN ADAPTS

Service Fast Learn Adapts is a procedure for 6 speed automatic transmissions in which a series of tests are run to allow the transmission control module (TCM) to learn individual clutch characteristics. Once the clutch data is learned, Service Fast Learn Adapts translates it into the adaptive data cells, which the TCM uses for clutch control during shifts. The scan tool provides initiation of the Service Fast Learn Adapts procedure. This procedure is to be used following transmission repair.

The Service Fast Learn Adapts procedure must be performed when one of the following repairs have been made to the vehicle. Failure to perform the procedure after one of the following repairs may result in poor transmission performance, as well as transmission DTCs being set:

- Transmission internal service/overhaul
- Valve body repair or replacement
- Control solenoid (w/body and TCM) valve assembly replacement
- TCM software/calibration update
- Any service in response to a shift quality concern

IMPORTANT: Ensure the following conditions are met before performing the Service Fast Learn Adapts procedure:

- **Drive wheels are blocked**
- **Parking brake is applied**

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- **Service brake is applied**
- **Zero percent throttle and no external engine RPM control**
- **Transmission fluid temperature (TFT) is between 70-100°C (158-212°F)**
- **Transmission gear selector has been cycled from Park to Reverse 3 times in order to purge air from the reverse clutches.**

1. Use the scan tool to navigate to Service Fast Learn Adapts by selecting the following commands:
    1. F3: Special Function
    2. F1: Transmission Output Controls
    3. Service Fast Learn Adapts

IMPORTANT: If at any time during the procedure, required conditions are not met, Service Fast Learn Adapts may abort and the process may need to be started again from the beginning.

2. Use the scan tool to perform the Service Fast Learn Adapts procedure.

IMPORTANT: There are 3 stages required to successfully complete the Service Fast Learn Adapts procedure:

1. **PARK test setup**
2. **DRIVE mode**
3. **REVERSE mode**

These stages are automatically initiated and controlled by the scan tool. As the procedure is being performed, the scan tool data display will provide operator instructions. Follow the scan tool instructions as required. The following are brief descriptions of each of the 3 different stages.

PARK TEST SETUP

While the transmission is in PARK, Service Fast Learn Adapts will prepare for test cycles. The test preparation will include the diagnostic criteria checks, safety checks, vehicle status checks and then will perform internal transmission test preparation functions such as clutch air purging. The scan tool will instruct the operator to select park and apply the brake only.

DRIVE MODE

CAUTION: Block the wheels before selecting DRIVE. While in DRIVE, if the Scan Tool loses communication or becomes disconnected, the vehicle could move forward. Failure to block the wheels could result in personal injury or property damage.

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Once the PARK setup has completed, the scan tool instructs the driver to select DRIVE. Once DRIVE is selected, the TCM engages the individual clutches to learn the clutch volume, full feed fill thresholds and pressure offsets. The TCM will only cycle through this test once. Running the Service Fast Learn Adapts procedure multiple times will give the same results and is not necessary.

REVERSE MODE

CAUTION: Block the wheels before selecting REVERSE. While in REVERSE, if the Scan Tool loses communication or becomes disconnected, the vehicle could move backward. Failure to block the wheels could result in personal injury or property damage.

Next, the scan tool instructs the driver to select REVERSE. The TCM engages the individual clutches to learn the clutch volume, full feed fill thresholds and pressure offsets. The TCM will only cycle through this test one time. Running the Service Fast Learn Adapts procedure multiple times will give the same results.

IMPORTANT: When the Service Fast Learn Adapts procedure is completed, the transmission will remain in a neutral state.

3. Once the procedure is complete, shut OFF the engine and power down the TCM. You will lose communication to the scan tool.

4. Restart the engine. This will complete the Service Fast Learn Adapts procedure.

Troubleshooting

If the Service Fast Learn Adapts will not run and the above stated conditions have been met, ensure the following:

- TFT is between 70-100°C (158-212°F).
- Brakes and brake switch are functioning properly.
- No active DTCs.
- Closed throttle and engine RPM increases above 1500 RPM while in Park Test Setup or at entrance of the test modes.
- Park/Neutral position switch is properly adjusted and functioning.
- Line pressure control is able to provide 1000 kPa and is within specifications.
- Vehicle is not moving or vibrating excessively.
- Clutches are properly assembled.

TRANSMISSION FLUID CHECK

This procedure checks both the transmission fluid level, as well as the condition of the fluid itself. Since the transmission on this vehicle is not equipped with a fill tube and dipstick, a tube in the bottom pan is used to set the fluid level.

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NOTE: The transmission fluid level must be checked when the transmission fluid temperature (TFT) is between 30-50°C (86-122°F). If the TFT is not within this range, operate the vehicle or allow the fluid to cool as required. Setting the fluid level with a TFT outside this range will result in either an under or over-filled transmission. TFT>50°C under-filled, TFT<30°C=over-filled. An under-filled transmission will cause premature component wear or damage. An over-filled transmission will cause fluid to discharge out the vent tube, fluid foaming or pump cavitation.

1. Observe the TFT using the driver information center (DIC) or a scan tool.
2. Start and idle the engine.
3. Depress the brake pedal and move the shift lever through each gear range. Pause for at least 3 seconds in each range. Move the shift lever back to PARK. Ensure the engine RPM is low (500-800 RPM).
4. Allow the engine to idle for at least 1 minute.
5. Raise the vehicle on a hoist. The vehicle must be level, with the engine running and the shift lever in the PARK range.

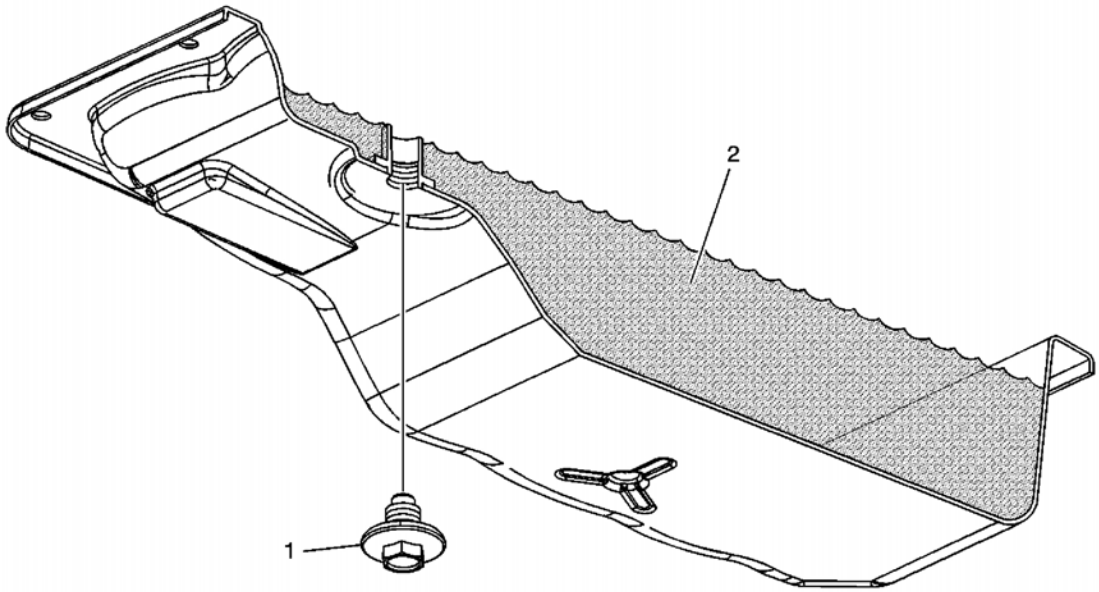


Fig. 5: Locating Transmission Oil Level Check Plug
Courtesy of GENERAL MOTORS CORP.

NOTE: THE ENGINE MUST BE RUNNING when the trans oil level check plug is removed or excessive fluid loss will occur, resulting in an under-filled condition. An under-filled transmission will cause premature component wear or damage.

IMPORTANT: Continue to monitor the TFT. If the TFT is not within the specified values,

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reinstall the trans oil level check plug and repeat the previous steps.

6. Remove the trans oil level check plug (1) from the transmission fluid pan. Allow any fluid (2) to drain.
   - If the fluid is flowing as a steady stream, wait until the fluid begins to drip.
   - If no fluid comes out, add fluid until fluid drips out. Refer to **Transmission Fluid Fill Procedure**.
7. Inspect the fluid color. The fluid should be red or dark brown.
   - If the fluid color is very dark or black and has a burnt odor, inspect the fluid and inside of the bottom pan for excessive metal particles or other debris. A small amount of "friction" material in the bottom pan is a "normal" condition. If large pieces and/or metal particles are noted in the fluid or bottom pan, flush the oil cooler and cooler lines and overhaul the transmission. If there are no signs of transmission internal damage noted, replace the fluid filter assembly, repair the oil cooler and flush the cooler lines.
   - Fluid that is cloudy or milky or appears to be contaminated with water indicates engine coolant or water contamination. Refer to **Engine Coolant/Water in Transmission**.
8. Replace the trans oil level check plug and tighten to 25 N.m (18 lb ft).
9. Inspect for external leaks. Refer to **Fluid Leak Diagnosis**.
10. Reset the oil life monitor only if the fluid was changed.

TRANSMISSION FLUID FILL PROCEDURE

NOTE: Use Dexron VI transmission fluid only. Failure to use the proper fluid may result in transmission internal damage.

Perform this procedure for vehicles with transmissions that are not equipped with a fill tube and dipstick. Based on accessibility, transmission fluid may be added through the fluid fill tube plug assembly (1) hole or through the oil level check plug (2) hole in the bottom of the transmission fluid pan.

TOOLS REQUIRED

- **DT 47784** Transmission Fluid Fill Pan Adapter. See **Special Tools** .
- **J 45096** Transmission Oil Cooling System Flush and Flow Test Tool. See **Special Tools** .
- **J 45096-30** Transmission Cooler Flush Adapters. See **Special Tools** .
- **J 45096-40** Transflow Oil Fill Adapter. See **Special Tools** .

FILL PROCEDURE

Fill Tube Plug Method

NOTE: Before removing the transmission fluid fill tube plug assembly, thoroughly clean around the plug to prevent dirt or contaminants from entering the transmission during plug removal. Use compressed air to dislodge any caked dirt that may be stuck on and around the plug area. Use a mirror to confirm the area is free of dirt before removing the plug. Failure to clean

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around the plug may result in transmission contamination.

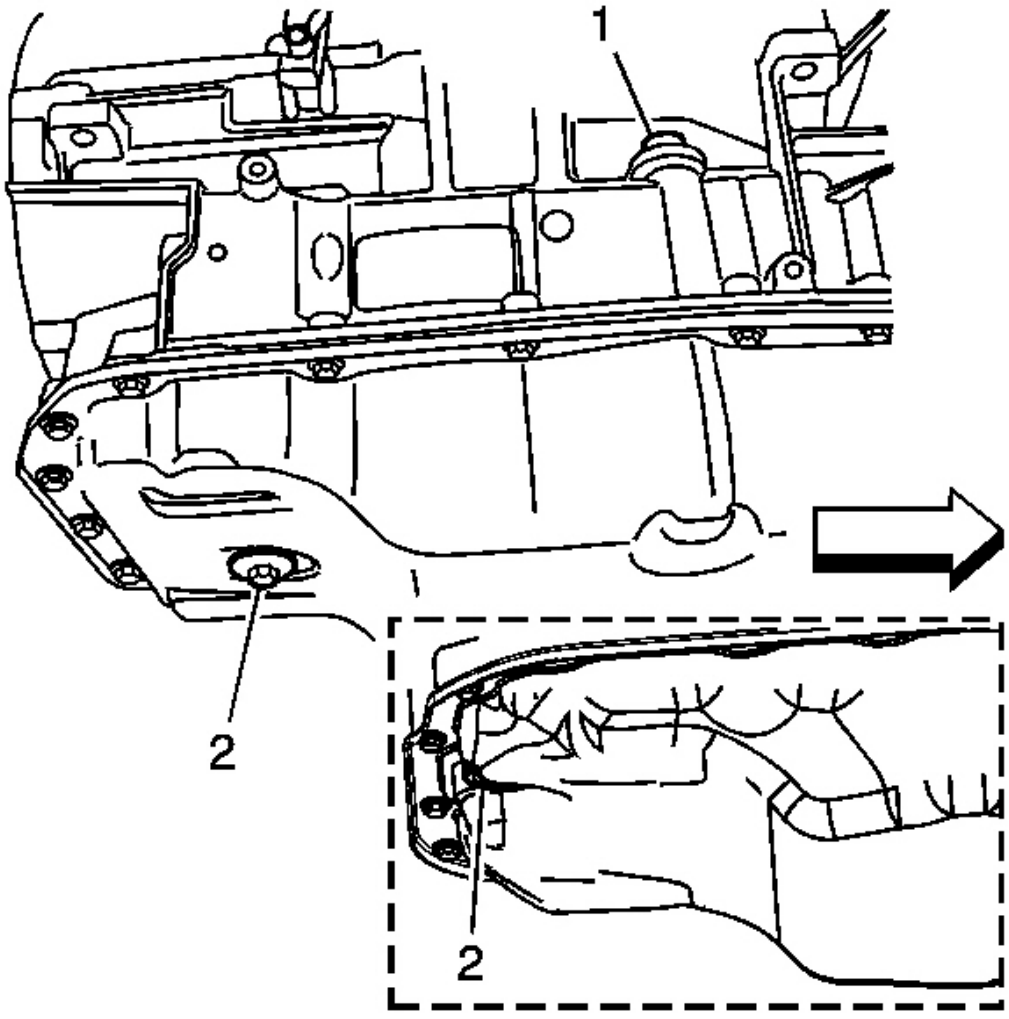


Fig. 6: Identifying Fluid Fill Tube Plug
Courtesy of GENERAL MOTORS CORP.

NOTE: **Before removing the transmission fluid fill tube plug assembly, thoroughly clean around the plug to prevent dirt or contaminants from entering the transmission during plug removal. Use compressed air to dislodge any caked dirt that may be stuck on and around the plug area. Use a mirror to confirm the area is free of dirt before removing the plug. Failure to clean around the plug may result in transmission contamination.**

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1. Clean around the fluid fill tube plug.

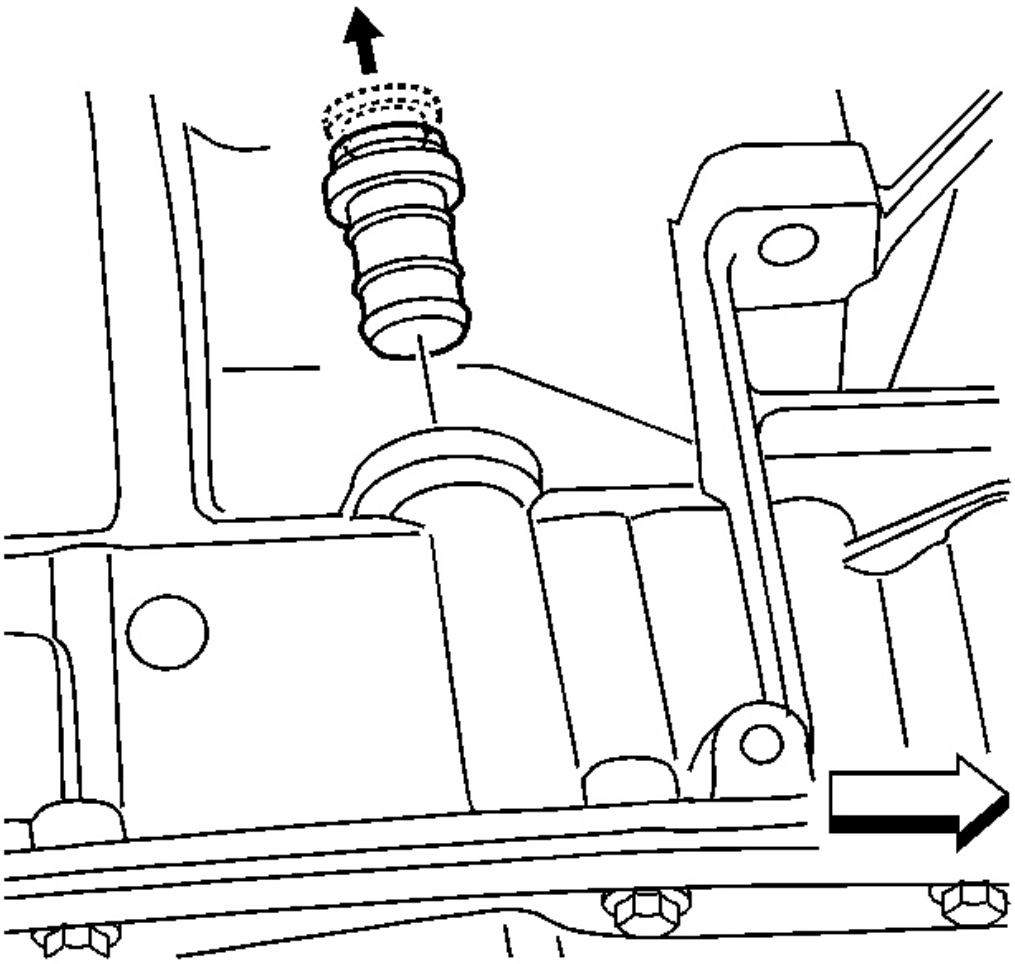


Fig. 7: Unlocking The Fill Tube Plug By Lifting The Plunger
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It may be necessary to use a long pair of 90 degree needle nose pliers to lift the plunger and remove the plug assembly.

2. Unlock the fill tube plug by lifting the plunger. Once the plunger is lifted, remove the entire plug assembly.
3. Determine the approximate amount of fluid needed to fill the transmission, based on the repair performed. Refer to **Fluid Capacity Specifications** . To avoid an under-fill condition, slightly overfill the

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transmission and then allow the extra fluid to drain during the fluid checking procedure.

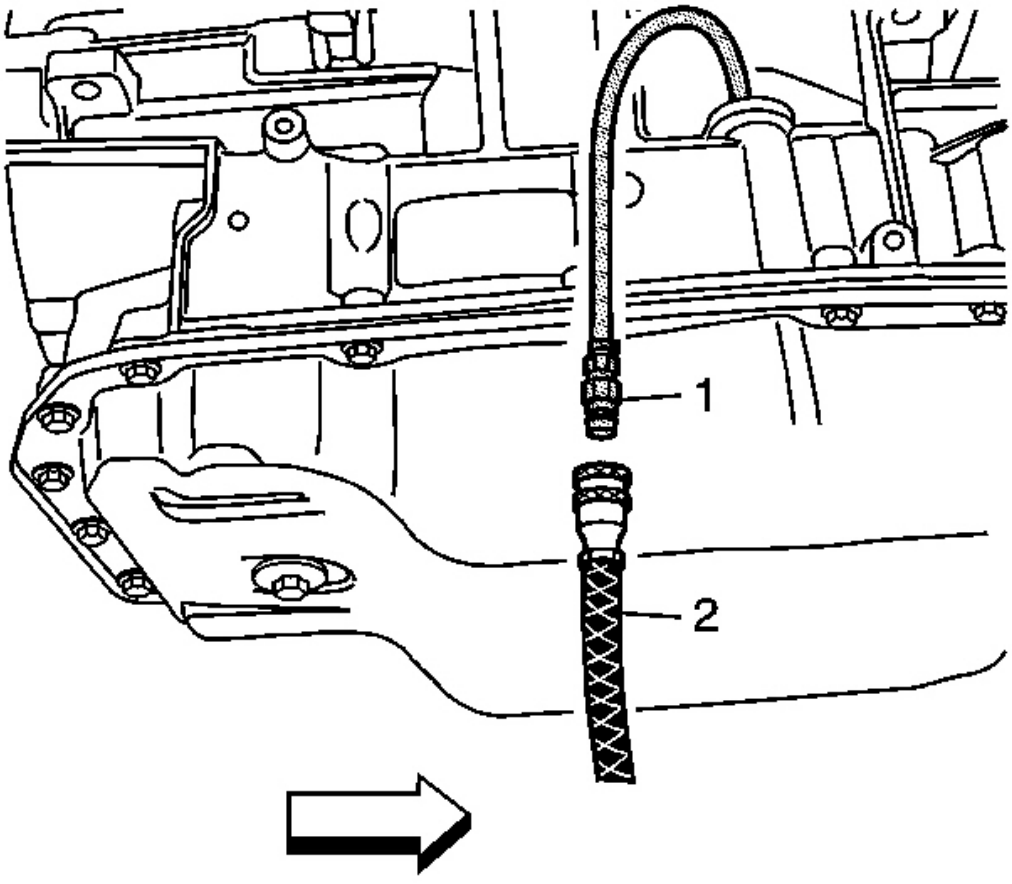


Fig. 8: Adding Transmission Fluid Through The Fill Tube Plug Opening
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The J 45096 is being utilized as a convenient method to pump the fluid into the bottom pan. See Special Tools . A suitable hand pump may also be used instead. When using the J 45096 , monitor the display panel to determine the amount of fluid being pumped from the tool supply tank into the transmission.

4. Using the **J 45096-40** (1) and the **J 45096** (2) or a suitable hand pump, add transmission fluid through the fill tube plug opening. See **Special Tools** . Refer to **Automatic Transmission Oil Cooler Flushing and Flow Test (J 45096)** for complete **J 45096** operating instructions. See **Special Tools** . Use the FLOW position on the main function switch to pump the fluid.

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5. Check the fluid level. Refer to **Transmission Fluid Checking**.

Check Plug Method

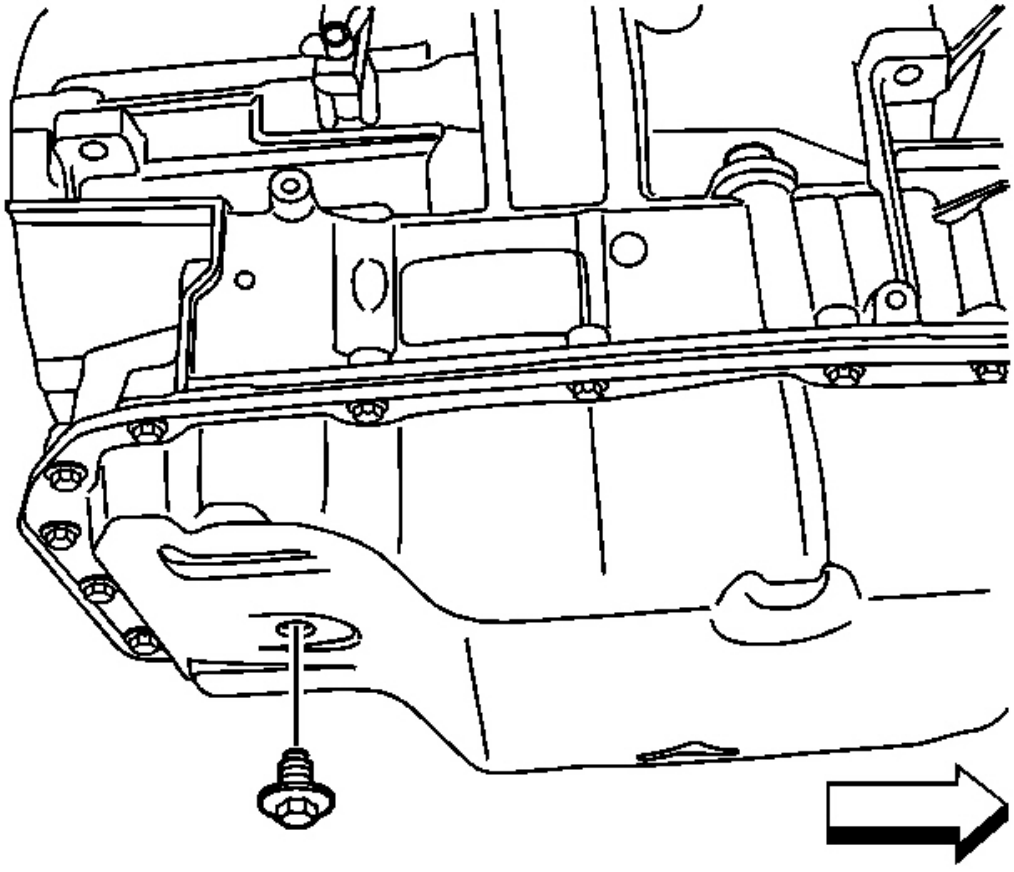


Fig. 9: Identifying Oil Level Check Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When the oil level check plug is removed with the engine OFF, transmission fluid may drain from the hole.

1. Remove the oil level check plug.

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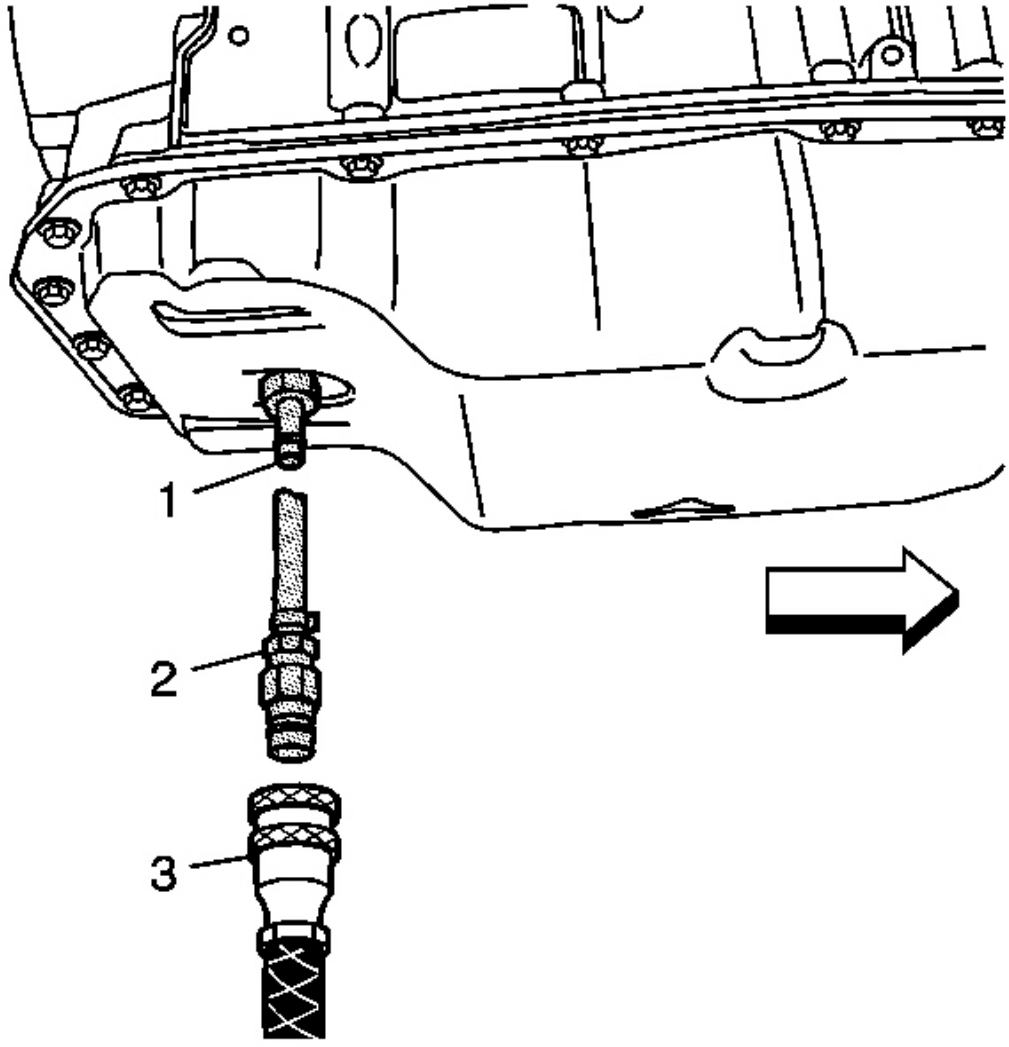


Fig. 10: Pumping Fluid Into The Bottom Pan
Courtesy of GENERAL MOTORS CORP.

2. Install the **DT 47784** (1) and, if necessary, one adapter from the **J 45096-30** (2). See **Special Tools** .
3. Determine the approximate amount of fluid needed to fill the transmission, based on the repair performed. Refer to **Fluid Capacity Specifications** . To avoid an under-fill condition, slightly overfill the transmission and then allow the extra fluid to drain during the fluid checking procedure.

IMPORTANT: The J 45096 is being utilized as a convenient method to pump the fluid into the bottom pan. A suitable hand pump may also be used instead.

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When using the J 45096, monitor the display panel to determine the amount of fluid being pumped from the tool supply tank into the transmission.

4. Using the **DT 47784** (1), **J 45096-30** (2) and the **J 45096** (3), add transmission fluid through the check plug hole. See **Special Tools** . Refer to **Automatic Transmission Oil Cooler Flushing and Flow Test (J 45096)** for complete J 45096 operating instructions. Use the FLOW position on the main function switch to pump the fluid.

IMPORTANT: Failure to start the engine and move the shift lever through the gear ranges before removing the DT 47784 and J 45096-30 from the bottom pan will result in an excess amount of fluid draining from the check plug hole. See Special Tools . This may lead to an under-fill condition.

5. Start the engine and move the shift lever through each gear range. Pause for at least 3 seconds in each gear range.
6. With the engine still running, remove the **DT 47784** (1), **J 45096-30** (2) and **J 45096** (3) and then check the fluid level. See **Special Tools** . Refer to **Transmission Fluid Checking**.

LINE PRESSURE CHECK

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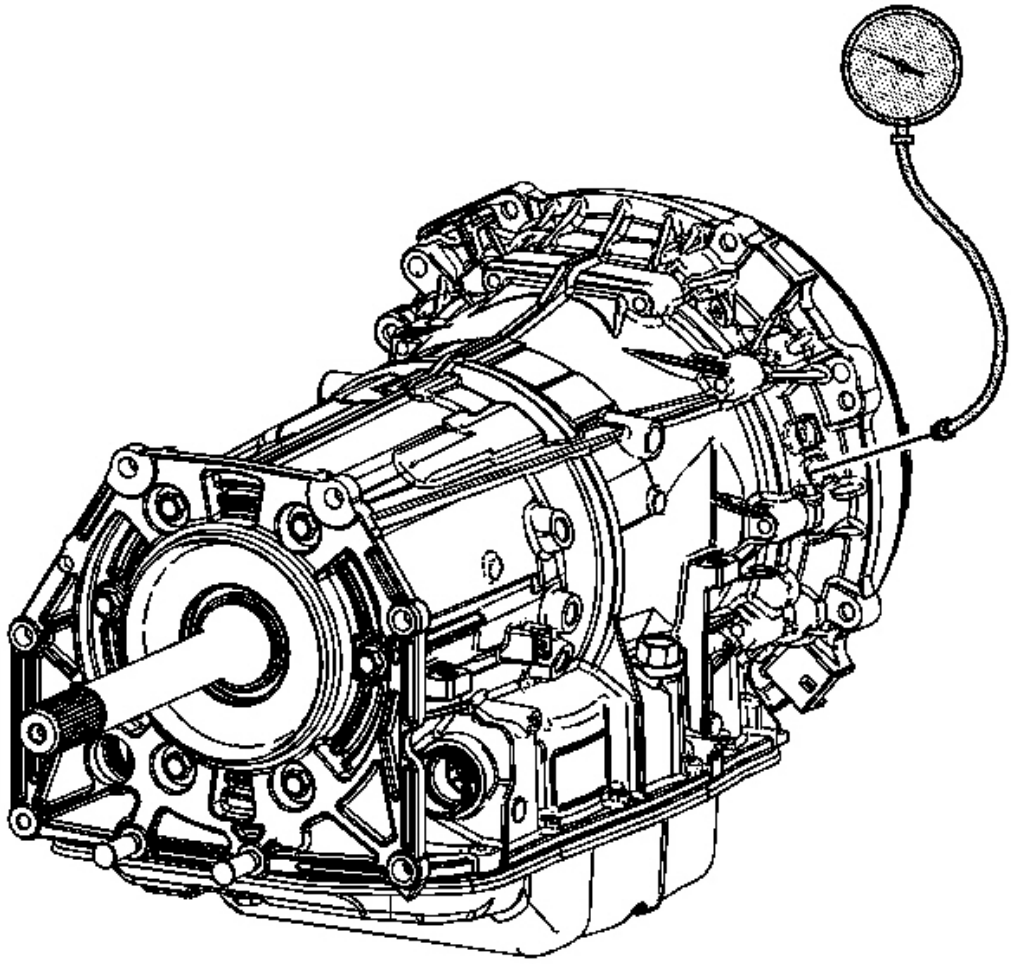


Fig. 11: Identifying J 21867 Pressure Gage
Courtesy of GENERAL MOTORS CORP.

TOOLS REQUIRED

J 21867 Pressure Gage

CHECK PROCEDURE

CAUTION: Keep the brakes applied at all times in order to prevent unexpected vehicle motion. Personal injury may result if the vehicle moves unexpectedly.

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1. Install a scan tool.
2. Start the engine.
3. Inspect the transmission for the proper fluid level. Refer to **Transmission Fluid Checking**.
4. Use the scan tool to inspect for any active or stored diagnostic trouble codes.
5. Inspect the manual linkage at the transmission for proper function.
6. Turn the engine OFF.

IMPORTANT: You may need to remove or disconnect components in order to gain access to the transmission line pressure test hole plug.

7. Remove the line pressure test hole plug.
8. Install the **J 21867** .
9. Access the Scan Tool Transmission Output Controls for the Line PC Solenoid.
10. Start the engine.

IMPORTANT: In order to achieve accurate line pressure readings, the following procedure must be performed at least 3 times in order to gather uniform pressure readings.
The scan tool is only able to control the line PC solenoid in PARK and NEUTRAL with engine speeds below 1500 RPM. This protects the clutches from extreme high or low line pressures.

11. Use the scan tool to increase and decrease the Line PC Solenoid in increments of approximately 100 kPa (15 psi). The scan tool commands the increment values automatically.
12. Allow the pressure to stabilize between increments.
13. Compare your pressure readings on the scan tool to those indicated on the **J 21867** .
14. If the pressure readings vary greatly, refer to **Fluid Pressure High or Low**.
15. Turn the engine OFF.
16. Remove the **J 21867** .

NOTE: Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Fasteners requiring replacement or fasteners requiring the use of thread locking compound or sealant are identified in the service procedure. Do not use paints, lubricants or corrosion inhibitors on fasteners or fastener joint surfaces unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems.

17. Install the line pressure test hole plug.

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Tighten: Tighten the pressure plug to 11 N.m (97 lb in).

ROAD TEST

IMPORTANT: The Road Test Procedure should be performed only as part of the Symptom Diagnosis. Refer to Symptoms - Automatic Transmission.

The following test provides a method of evaluating the condition of the automatic transmission. The test is structured so that most driving conditions would be achieved. The test is divided into the following parts:

- Electrical Function Check
- Upshift Control and Torque Converter Clutch (TCC) Apply
- Part Throttle Detent Downshifts
- Manual Downshifts
- Coasting Downshifts
- Manual Gear Range Selection
  - REVERSE
  - Driver Shift Control

IMPORTANT: Complete the test in the sequence given. Incomplete testing cannot guarantee an accurate evaluation.

Before the road test, ensure the following:

- The engine is performing properly.
- Transmission fluid level is correct. Refer to **Transmission Fluid Checking**.
- Tire pressure is correct.

During the road test:

- Perform the test only when traffic conditions permit.
- Operate the vehicle in a controlled, safe manner.
- Observe all traffic regulations.
- View the scan tool data while conducting this test.

  Take along qualified help in order to operate the vehicle safely.

- Observe any unusual sounds or smells.

After the road test, check the following:

- Inspect for proper transmission fluid level. Refer to **Transmission Fluid Checking**.

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- Inspect for any diagnostic trouble codes (DTCs) that may have set during the testing. Refer to the applicable DTC.
- Monitor the scan tool data for any abnormal readings or data.
- Inspect for fluid leaks. Refer to **Fluid Leak Diagnosis**.

ELECTRICAL FUNCTION CHECK

Perform this procedure first in order to ensure the electronic transmission components are functioning properly. If these components are not checked, a simple electrical condition could be misdiagnosed.

1. Connect the scan tool.
2. Ensure the gear selector is in PARK and set the parking brake.
3. Start the engine.
4. Verify that the following scan tool data can be obtained and is functioning properly.

   Refer to **Scan Tool Data List** for typical data values. Data that is questionable may indicate a concern.

   - Engine Speed
   - Transmission ISS
   - Transmission OSS
   - Vehicle Speed
   - IMS
   - Commanded Gear
   - Gear Ratio
   - Line PC Sol. Pressure Cmd.
   - TCC Brake Switch
   - ECT, Engine Data List
   - Trans. Fluid Temp.
   - TCM Temperature
   - Calc. Throttle Position
   - Ignition Voltage
   - TFP Switch 1
   - TFP Switch 3
   - TFP Switch 4
   - TFP Switch 5
   - PC Sol. 2 Pressure Cmd.
   - PC Sol. 3 Pressure Cmd.
   - PC Sol. 4 Pressure Cmd.
   - PC Sol. 5 Pressure Cmd.

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- Shift Solenoid 1
- Shift Solenoid 2
- TCC PC Sol. Duty Cycle
- TCC Slip Speed

5. Monitor the TCC Brake Switch parameter while applying and releasing the brake pedal. The scan tool should display:
   - Open when the brake pedal is applied.
   - Closed when the brake pedal is released.
6. Check the garage shifts.
   1. Apply the brake pedal and ensure the parking brake is set.
   2. Move the gear selector through the following ranges:
      1. PARK to REVERSE
      2. REVERSE to NEUTRAL
      3. NEUTRAL to DRIVE
   3. Pause 2 to 3 seconds in each gear position.
   4. Verify the gear engagements are immediate and not harsh.

IMPORTANT: Harsh engagement may be caused by any of the following conditions:

- **High engine idle speed-Compare engine idle speed to desired idle speed.**
- **Commanded low pressure control (PC) solenoid current-Investigate PC Sol. Pressure Cmd. kPa (psi) for all solenoids. High pressure will cause harsh shifts.**
- **A default condition caused by certain DTCs that result in maximum line pressure to prevent clutch slippage.**

IMPORTANT: Soft or delayed engagement may be caused by any of the following conditions:

- **Low idle speed-Compare engine idle speed to desired idle speed.**
- **Low fluid level**
- **Commanded high PC solenoid current-Investigate PC Sol. Pressure Cmd. kPa (psi) for all solenoids. Low pressure will cause soft or delayed shifts.**
- **Cold transmission fluid temperature (TFT)-Use the scan tool to determine TFT.**
- **Selector linkage-Inspect and adjust as necessary.**

7. Monitor transmission range on the scan tool, engine data list.

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1. Apply the brake pedal and ensure the parking brake is set.
2. Move the gear selector through all ranges.
3. Pause 2 to 3 seconds in each range.
4. Return gear selector to PARK.
5. Verify that all selector positions match the scan tool display.

8. Check throttle position input.
    1. Apply the brake pedal and ensure the parking brake is set.
    2. Ensure the gear selector is in PARK.
    3. Monitor the scan tool Calc. Throttle Position while increasing and decreasing engine speed with the throttle pedal. The scan tool Calc. Throttle Position percentage should increase and decrease with engine speed.

If any of the above checks do not perform properly, record the result for reference after completion of the road test.

UPSHIFT CONTROL AND TORQUE CONVERTER CLUTCH (TCC) APPLY

The TCM calculates the upshift points based primarily on 2 inputs: throttle position and vehicle speed. When the TCM determines that conditions are met for a shift to occur, the TCM commands the shift by closing or opening the ground circuit for the appropriate solenoid.

Perform the following steps:

1. Refer to **Shift Speed** table in this section and choose a throttle position of 12.5 percent or 25 percent. All throttle positions shown should be tested to cover the normal driving range.
2. Monitor the following scan tool parameters:
    - Calc. Throttle Position
    - Vehicle Speed
    - Engine Speed
    - Transmission ISS
    - Transmission OSS
    - Commanded Gear
    - TCC PC Sol. Pressure Cmd.
    - TCC Pressure Actual
    - TCC Slip Speed
    - TFP Switch 1
    - TFP Switch 3
    - TFP Switch 4
    - TFP Switch 5
    - PC Sol. 2 Pressure Cmd.

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- PC Sol. 3 Pressure Cmd.
- PC Sol. 4 Pressure Cmd.
- PC Sol. 5 Pressure Cmd.
- Shift Solenoid 1 and 2

3. Place the gear selector in the DRIVE position.
4. Accelerate the vehicle using the chosen throttle position. Hold the throttle steady.
5. As the transmission upshifts, there should be a noticeable shift feel or engine speed change within 1 to 2 seconds of the commanded gear change. The TCC feel may not be noticeable. Look for 100-300 RPM engine speed change.
6. Compare the shift speeds to the Shift Speed table. Refer to **Shift Speed** . Shift speeds may vary slightly due to TFT or other operating variables, including hydraulic delays in responding to electronic controls.
   - Note any harsh, soft or delayed shifts or slipping.
   - Note any noise or vibration.

IMPORTANT: This transmission is equipped with an electronically controlled capacity clutch (ECCC), which does not allow the clutch to fully lock to the torque converter cover. The clutch maintains a small amount of slippage, approximately 20 RPM, in 2nd, 3rd, 4th, 5th and 6th gears, depending on the vehicle application. ECCC was developed to reduce the possibility of noise, vibration or chuggle caused by TCC apply. Full lockup is available at highway speeds on some applications.

IMPORTANT: The TCC will not engage until the engine is in closed loop operation and the vehicle speed is as shown in the Shift Speed table. Refer to Shift Speed . The vehicle must be in a near-cruise condition, not accelerating or coasting and on a level road surface.

7. Monitor TCC PC solenoid current while driving and make sure the current rises when the TCC is commanded to apply.
   - When the TCC applies there should be a noticeable drop in engine speed and a drop in slip speed to below 100 RPM. If the TCC apply can not be detected:
     - Check for DTCs.
     - Refer to **Torque Converter Diagnosis**.
   - Apply and release the brake pedal. The TCC will release on most applications.

PART THROTTLE DETENT DOWNSHIFT

1. Place the gear selector in the DRIVE position.
2. Accelerate the vehicle to 64-88 km/h (40-55 mph) in 6th gear.
3. Quickly increase throttle angle to between 25-30 percent.
4. Verify the following:

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- The TCC releases.
- The transmission downshifts immediately.

MANUAL DOWNSHIFTS

Manual downshift testing is not required for vehicles equipped with Driver Shift Control (DSC). The TCM and shift solenoids will automatically override DSC downshifts to protect the transmission from damage.

Coasting Downshifts

1. Place the gear selector in the DRIVE position.
2. Accelerate the vehicle to 6th gear with the TCC applied.
3. Release the throttle and apply the brakes
4. Verify the following:
   - The TCC releases (on most applications).
   - Downshifts occur as commanded.

MANUAL GEAR RANGE SELECTION

This application does not utilize manual forward gear ranges.

Reverse

Perform the following test using a 10-15 percent throttle position.

1. With the vehicle stopped, move the gear selector to REVERSE.
2. Slowly accelerate the vehicle.
3. Verify that there is no noticeable slip, noise or vibration.

Driver Shift Control (DSC)

Refer to the owner's manual for specific instructions on DSC. The TCM will upshift automatically when maximum engine speed is achieved and will protect from any downshift which may cause excessive engine RPMs.

TORQUE CONVERTER DIAGNOSIS

The torque converter clutch (TCC) is applied by fluid pressure, which is controlled by a TCC pressure control (PC) solenoid. This solenoid is part of the control solenoid valve assembly, which is located inside the automatic transmission assembly. The solenoid is controlled through a combination of computer controlled switches and sensors.

TORQUE CONVERTER STATOR

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The torque converter stator roller clutch can have 2 different malfunctions.

- The stator assembly freewheels in both directions.
- The stator assembly remains locked up at all times.

POOR ACCELERATION AT LOW SPEED

If the stator is freewheeling at all times, the vehicle tends to have poor acceleration from a standstill. At speeds above 50-55 km/h (30-35 mph), the vehicle may act normally. For poor acceleration, you should first determine that the exhaust system is not blocked and the transmission is in First gear when starting out.

If the engine freely accelerates to high RPM in NEUTRAL, you can assume that the engine and the exhaust system are normal. Check for poor performance in DRIVE and REVERSE to help determine if the stator is freewheeling at all times.

POOR ACCELERATION AT HIGH SPEED

If the stator is locked up at all times, performance is normal when accelerating from a standstill. Engine RPM and vehicle speed are limited or restricted at high speeds. Visual examination of the converter may reveal a blue color from overheating.

If the converter has been removed, you can check the stator roller clutch by inserting a finger into the splined inner race of the roller clutch and trying to turn the race in both directions. You should be able to freely turn the inner race clockwise, but you should have difficulty in moving the inner race counterclockwise or you may be unable to move the race at all.

NOISE

IMPORTANT: Do not confuse this noise with pump whine noise, which is usually noticeable in PARK, NEUTRAL and all other gear ranges. Pump whine will vary with line pressure.

You may notice a torque converter whine when the vehicle is stopped and the transmission is in DRIVE or REVERSE. This noise will increase as you increase the engine RPM. The noise will stop when the vehicle is moving or when you apply the torque converter clutch, because both halves of the converter are turning at the same speed.

Perform a stall test to make sure the noise is actually coming from the converter:

1. Place your foot on the brake.
2. Put the gear selector in DRIVE.

NOTE: You may damage the transmission if you depress the accelerator for more than 6 seconds.

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3. Depress the accelerator to approximately 1,200 RPM for no more than six seconds.

A torque converter noise will increase under this load.

TORQUE CONVERTER CLUTCH SHUDDER

The key to diagnosing torque converter clutch (TCC) shudder is to note when it happens and under what conditions.

TCC shudder which is caused by the transmission should only occur during the apply or the release of the converter clutch. Shudder should never occur after the TCC plate is fully applied.

IF SHUDDER OCCURS DURING TCC APPLY OR RELEASE

If the shudder occurs while the TCC is applying, the problem can be within the transmission or the torque converter. Something is causing one of the following conditions to occur:

- Something is not allowing the clutch to become fully engaged.
- Something is not allowing the clutch to release.
- The clutch is releasing and applying at the same time.

One of the following conditions may be causing the problem to occur:

- Leaking turbine shaft seals
- A restricted release orifice
- A distorted clutch or housing surface due to long converter bolts
- Defective friction material on the TCC plate

IF SHUDDER OCCURS AFTER TCC HAS APPLIED

If shudder occurs after the TCC has applied, most of the time there is nothing wrong with the transmission.

The TCC is not likely to slip after the TCC has been applied. Engine problems may go unnoticed under light throttle and load, but they become noticeable after the TCC apply when going up a hill or accelerating. This is due to the mechanical coupling between the engine and the transmission.

Once TCC is applied, there is no torque converter (fluid coupling) assistance. Engine or driveline vibrations could be unnoticeable before TCC engagement.

Inspect the following components in order to avoid misdiagnosis of TCC shudder. An inspection will also avoid the unnecessary disassembly of a transmission or the unnecessary replacement of a torque converter.

- Spark plugs-Inspect for cracks, high resistance or a broken insulator.
- Plug wires-Look in each end. If there is red dust (ozone) or a black substance (carbon) present, then the wires are bad. Also look for a white discoloration of the wire. This indicates arcing during hard

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acceleration.

- Coil-Look for a black discoloration on the bottom of the coil. This indicates arcing while the engine is misfiring.
- Fuel injector-The filter may be plugged.
- Vacuum leak-The engine will not get a correct amount of fuel. The mixture may run rich or lean depending on where the leak occurs.
- EGR valve-The valve may let in too much or too little unburnable exhaust gas and could cause the engine to run rich or lean.
- MAP/MAF sensor-Like a vacuum leak, the engine will not get the correct amount of fuel for proper engine operation.
- Carbon on the intake valves-Carbon restricts the proper flow of air/fuel mixture into the cylinders.
- Flat cam-Valves do not open enough to let the proper fuel/air mixture into the cylinders.
- Oxygen sensor-This sensor may command the engine too rich or too lean for too long.
- Fuel pressure-This may be too low.
- Engine mounts-Vibration of the mounts can be multiplied by TCC engagement.
- Axle joints-Check for vibration.
- TP Sensor-The TCC apply and release depends on the TP Sensor in many engines. If the TP Sensor is out of specification, TCC may remain applied during initial engine loading.
- Cylinder balance-Bad piston rings or poorly sealing valves can cause low power in a cylinder.
- Fuel contamination-This causes poor engine performance.

Replace the torque converter if any of the following conditions exist:

- External leaks appear in the hub weld area.
- The converter hub is scored or damaged.
- The converter pilot is broken, damaged or fits poorly into the crankshaft.
- You discover steel particles after flushing the cooler and the cooler lines.
- The pump is damaged or you discover steel particles in the converter.
- The vehicle has TCC shudder and/or no TCC apply. Replace the torque converter only after all hydraulic and electrical diagnoses have been made. The converter clutch material may be glazed.
- The converter has an imbalance which cannot be corrected. Refer to **Flexplate/Torque Converter Vibration Test**.
- The converter is contaminated with engine coolant which contains antifreeze or water.
- An internal failure occurs in the stator roller clutch.
- You notice excessive end play.
- Overheating produces heavy debris in the clutch or converter ballooning.
- You discover steel particles or clutch lining material in the fluid filter or on the magnet, when no internal parts in the unit are worn or damaged. This condition indicates that lining material came from the converter.

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Do not replace the torque converter if you discover any of the following symptoms:

- The oil has an odor or the oil is discolored, even though metal or clutch facing particles are not present.
- The threads in one or more of the converter bolt holds are damaged. Correct the condition with a new thread inset.
- Transmission failure did not display evidence of damaged or worn internal parts, steel particles or clutch plate lining material in the unit and inside the fluid filter.
- The vehicle has been exposed to high mileage only. An exception may exist where the lining of the torque converter clutch dampener plate has seen excess wear by vehicles operated in heavy and/or constant traffic, such as taxi, delivery or police use.

FLEXPLATE/TORQUE CONVERTER VIBRATION TEST

ISOLATING VIBRATION

NOTE: Some engine/transaxle combinations cannot be balanced in this manner due to restricted access or limited clearances between the torque converter bolts and the engine. Ensure that the bolts do not bottom out in the lug nuts or the torque converter cover which could dent and cause internal damage.

To isolate and correct a flywheel or torque converter vibration, separate the torque converter from the flywheel to determine if vibration is in the engine or transmission.

1. With the engine at idle speed and the transmission in PARK or NEUTRAL, observe the vibration.
2. Turn the engine OFF.
3. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the transmission converter cover bolts and the cover.
5. Mark the relationship of the converter to the flywheel.
6. Remove the bolts attaching the converter to the flywheel.
7. Slide the torque converter away from the flywheel.
8. Rotate the flywheel and torque converter to inspect for defects or missing balance weights.
9. Lower the vehicle.
10. With the engine at idle speed and the transmission in PARK or NEUTRAL, observe the vibration. Refer to **Diagnostic Starting Point - Vibration Diagnosis and Correction** .
11. Turn the engine OFF.

INDEXING TORQUE CONVERTER

To determine and correct a torque converter vibration, the following procedure may have to be performed several times to achieve the best possible torque converter to flywheel balance.

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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2. Rotate the torque converter one bolt position.

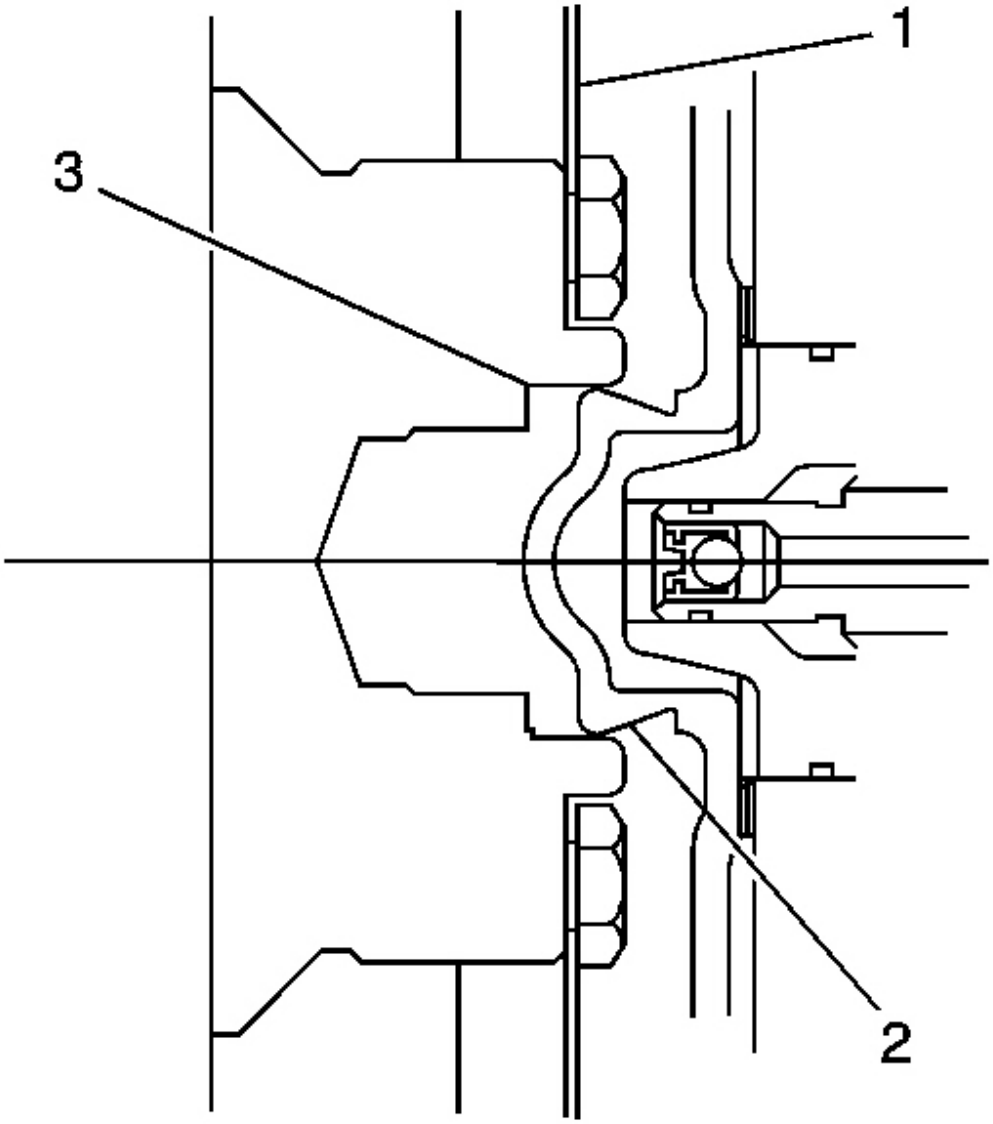


Fig. 12: View Of Torque Converter Hub In Engine Crankshaft
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3. Align the torque converter hub (2) in the engine crankshaft (3) and install the torque converter to flywheel bolts.

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4. Lower the vehicle.
5. With the engine at idle speed and the transmission in PARK or NEUTRAL, observe the vibration. Refer to **Noise and Vibration Analysis**.

   Repeat this procedure until you obtain the best possible balance.

6. Install the transmission converter cover bolts and the cover.

VIBRATION

Vibration

Checks	Causes
Lug bolts for the Torque Converter (1)	Inspect for loose torque converter (1) lug bolts.
Input Sun Gear Thrust Washer (55)	Inspect for wear or damage.
Turbine Shaft Thrust Bearing Assembly (57)	Inspect for wear or damage.
2-6 and 3-5-R Clutch Hub Thrust Bearing Assembly (65)	Inspect the bearing for wear or damage.
Output Carrier Assembly (68)	• Inspect the carrier assembly for damaged pinion gears, thrush washers, pins and rollers. • Inspect for a worn or damaged center support roller bearing assembly (485). • Inspect for damaged thrust bearings (486, 488). • Inspect the carrier assembly for damaged output carrier rear sun gear thrust bearing (captured).
Output Carrier Thrust Bearing Assembly (69)	Inspect the bearing for wear or damage.
Output Shaft Thrust Bearing Assembly (71)	Inspect the bearing for wear or damage.
1-2-3-4 Clutch Hub Thrust Bearing Assembly (63)	Inspect the bearing for wear or damage.
Turbine Shaft Thrust Bearing Assembly (57)	Inspect the bearing for wear or damage.

NOISE AND VIBRATION ANALYSIS

A noise or vibration that is noticeable when the vehicle is in motion MAY NOT be the result of the transmission.

If noise or vibration is noticeable in PARK and NEUTRAL with the engine at idle, but is less noticeable as RPM increases, the cause may be from poor engine performance.

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- Vibration may also be caused by a small amount of water inside the converter.
- Inspect the tires for the following conditions:
  - Uneven wear
  - Imbalance
  - Mixed sizes
  - Mixed radial and bias ply
- Inspect the suspension components for the following conditions:
  - Alignment wear or damage
  - Loose fasteners
  - Driveline damage or wear
- Inspect the engine and transmission mounts for damage and loose bolts.
- Inspect the transmission case mounting holes for the following conditions:
  - Missing bolts, nuts and studs
  - Stripped threads
  - Cracks
- Inspect the flywheel for the following conditions:
  - Missing or loose bolts
  - Cracks
  - Imbalance
- Inspect the torque converter for the following conditions:
  - Missing or loose bolts or lugs
  - Missing or loose balance weights
  - Imbalance caused by heat distortion or fluid contamination

WHINE/GROWL NOISE THAT CHANGES WITH VEHICLE SPEED

Whine/Growl Noise That Changes with Vehicle Speed

Checks	Causes
2-6 and 3-5-R Clutch Hub Thrust Bearing Assembly (65)	Inspect the bearing for wear or damage.
Output Carrier Assembly (68)	• Inspect the carrier assembly for damaged pinion gears, thrust washers, pins and rollers. • Inspect for a damaged center support roller bearing assembly (485). • Inspect for damaged thrust bearings (486, 488). • Inspect for damaged sun gears (487, 489). • Inspect the carrier assembly for damaged output carrier rear sun gear thrust bearing (captured).

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	• Inspect for damaged or stripped splines on the output carrier assembly.
Output Carrier Thrust Bearing Assembly (69)	Inspect the bearing for wear or damage.
Output Shaft Assembly (70)	• Inspect for damaged internal gears (495, 497). • Inspect the output carrier bushing (498) for damage or wear.
Output Shaft Thrust Bearing Assembly (71)	Inspect the bearing for wear or damage.
Input Sun Gear Thrust Washer (55)	Inspect the washer for wear or damage.
Input Sun Gear Thrust Bearing (54)	Inspect the bearing for wear or damage.
Input Sun Gear (53)	Inspect for spline wear or damage.
Input Carrier Assembly (52)	Inspect the carrier assembly for damaged pinion gears, thrust washers, pins and rollers.
1-2-3-4 Clutch Hub Thrust Bearing Assembly (63)	Inspect the bearing for wear or damage.
2-6 and 3-5-R Clutch (with Output Carrier Outer Sun Gear Shaft) Hub Assembly (64)	Inspect the output carrier inner sun gear shaft bushings (60 and 62) for damage or wear.
Turbine Shaft Thrust Bearing Assembly (57)	Inspect the bearing for wear or damage.
Fluid Filter Assembly (26)	• Inspect for damaged or restricted fluid filter assembly (26) • Inspect for damaged fluid filter seal assembly (25) or improper sealing interface (leaks, fluid aeration).
Automatic Transmission Fluid Pump Seal (5)	Inspect for worn or damaged seal.

NOISE IN FIRST OR REVERSE GEAR

Noise in First or Reverse Gear

Checks	Causes
Center Support with 2-6 Low and Reverse Clutch Assembly (67)	• Inspect for damaged or worn low and reverse clutch plates (463-465). • Inspect for damaged low and reverse clutch backing plate (462). Inspect for worn splines on backing plate. • Inspect for damaged low and reverse clutch backing plate retaining ring (461). • Inspect for damaged low and reverse clutch piston assembly (470), spring (469), spring retaining ring (466) and center support assembly (459). • Inspect for damaged low clutch sprag assembly (467). Holding the sprag assembly with the retaining ring facing up and the inner race of the sprag assembly fixed, the outer race

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	should freewheel counterclockwise. • Inspect for cut, worn or damaged low clutch sprag seal (468).
Output Carrier Assembly (68)	Inspect for damaged or stripped splines on the output carrier assembly.

NOISE IN FIRST, SECOND, THIRD, FOURTH, FIFTH OR REVERSE GEAR

Noise in First, Second, Third, Fourth, Fifth or Reverse Gear

Checks	Causes
Input Carrier Assembly (52)	Inspect thrust washers, pinion gears and pins for wear or damage.
Input Sun Gear (53)	Inspect for damaged sun gear.
1-2-3-4 and 3-5-R Clutch Assembly (51)	Inspect for worn or damaged clutch bearing (428).

NOISE IN FIRST, SECOND, SIXTH OR REVERSE GEAR

Noise in First, Second, Sixth or Reverse Gear

Checks	Causes
Center Support with 2-6 Low and Reverse Clutch Assembly (67)	Inspect for worn or damaged output carrier outer sun gear shaft front and rear bushings (458 and 460).
Output Carrier Assembly (68)	Inspect for a worn or damaged center support roller bearing assembly (485).

NOISE IN SECOND OR SIXTH GEAR

Noise in Second or Sixth Gear

Checks	Causes
Center Support with 2-6 Low and Reverse Clutch Assembly (67)	• Inspect for damaged or worn output carrier outer sun gear shaft front bushing (458). • Inspect for damaged or worn output carrier outer sun gear shaft rear bushing (460). • Inspect for damaged 2-6 clutch backing plate (451). Inspect for worn splines on backing plate. • Inspect for damaged 2-6 clutch backing plate retaining ring (450). • Inspect for damaged 2-6 clutch piston assembly (457), spring (456), retaining ring (455) and center support assembly (459).

NOISE DURING 3-4 OR 4-3 SHIFTS

Noise During 3-4 or 4-3 Shifts

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Checks	Causes
4-5-6 Clutch (with Output Carrier Shaft and Dampener) Hub Assembly (58)	• Inspect hub assembly (475), dampener (476) and apply plate (477) for wear or damage. • Inspect for damaged or worn 4-5-6 clutch backing plate (432).

NOISE IN FOURTH, FIFTH OR SIXTH GEAR

Noise in Fourth, Fifth or Sixth Gear

Checks	Causes
Input Sun Gear Thrust Washer (55)	Inspect for wear or damage.
Turbine Shaft Thrust Bearing Assembly (57)	Inspect for wear or damage.
4-5-6 Clutch (with Output Carrier Shaft and Dampener) Hub Assembly (58)	• Inspect for damaged or worn 4-5-6 clutch backing plate (432). • Inspect for improper selective 4-5-6 clutch backing plate retaining ring (431).

CLUTCH PLATE DIAGNOSIS

COMPOSITION PLATES

Dry the plates and inspect the plates for the following conditions:

- Pitting
- Flaking
- Delamination-splitting or separation of bonded clutch material
- Wear
- Glazing
- Cracking
- Charring
- Chips or metal particles embedded in the lining

Replace a composition plate which shows any of these conditions.

STEEL PLATES

Wipe the plates dry and check the plates for heat discoloration. If the surfaces are smooth, even if color smear is indicated, you can reuse the plate. If the plate is discolored with heat spots or if the surface is scuffed, replace the plate.

CAUSES OF BURNED CLUTCH PLATES

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The following conditions can result in a burned clutch plate:

- Incorrect usage of clutch or apply plates
- Engine coolant or water in the transmission fluid
- A cracked clutch piston
- Damaged or missing seals
- Low line pressure
- Valve body conditions
  - The valve body face is not flat.
  - Porosity is between channels.
  - The valve bushing clips are improperly installed.
  - The checkballs are misplaced.
- The Teflon® seal rings are worn or damaged.

ENGINE COOLANT/WATER IN TRANSMISSION

NOTE: The antifreeze or water will deteriorate the seals, gaskets and the glue that bonds the clutch material to the pressure plate. Both conditions may cause damage to the transmission.

If antifreeze or water has entered the transmission, perform the following:

1. Disassemble the transmission.
2. Replace all of the rubber type seals. The coolant will attack the seal material which will cause leakage.
3. Replace the composition-faced clutch plate assemblies. The facing material may separate from the steel center portion.
4. Replace all of the nylon parts - washers.
5. Replace the torque converter.
6. Thoroughly clean and rebuild the transmission, using new gaskets and oil filter.
7. Flush the cooler lines after the transmission cooler has been properly repaired or replaced.

FLUID LEAK DIAGNOSIS

GENERAL METHOD

1. Verify that the leak is transmission fluid.
2. Thoroughly clean the suspected leak area.
3. Operate the vehicle for 24 km (15 mi) or until normal operating temperatures are reached.
4. Park the vehicle over clean paper or cardboard.
5. Shut OFF the engine.

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6. Look for fluid spots on the paper.
7. Make the necessary repairs.

POWDER METHOD

1. Thoroughly clean the suspected leak area with solvent.
2. Apply an aerosol type powder, such as foot powder, to the suspected leak area.
3. Operate the vehicle for 24 km (15 mi) or until normal operating temperatures are reached.
4. Shut OFF the engine.
5. Inspect the suspected leak area.
6. Trace the leak path through the powder in order to find the source of the leak.
7. Make the necessary repairs.

DYE AND BLACK LIGHT METHOD

A fluid dye and black light kit is available from various tool manufacturers.

1. Follow the manufacturer's instructions in order to determine the amount of dye to use.
2. Detect the leak with the black light.
3. Make the necessary repairs.

FIND THE CAUSE OF THE LEAK

Pinpoint the leak and trace the leak back to the source. You must determine the cause of the leak in order to repair the leak properly. For example, if you replace a gasket, but the sealing flange is bent, the new gasket will not repair the leak. You must also repair the bent flange. Before you attempt to repair a leak, check for the following conditions and make repairs as necessary:

Gaskets

- Fluid level/pressure is too high
- Plugged vent or drain-back holes
- Improperly tightened fasteners
- Dirty or damaged threads
- Warped flanges or sealing surface
- Scratches, burrs or other damage to the sealing surface
- Damaged or worn gasket
- Cracking or porosity of the component
- Improper sealant used, where applicable
- Incorrect gasket

Seals

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- Fluid level/pressure is too high
- Plugged vent or drain-back holes
- Damaged seal bore
- Damaged or worn seal
- Improper installation
- Cracks in component
- Manual or output shaft surface is scratched, nicked or damaged
- Loose or worn bearing causing excess seal wear

POSSIBLE POINTS OF FLUID LEAKS

Transmission Oil Pan

- Incorrectly tightened oil pan bolts
- Improperly installed or damaged oil pan gasket
- Damaged oil pan or mounting face
- Incorrect oil pan gasket

Case Leak

- Damaged vehicle speed sensor seal
- Damaged manual shaft seal
- Loose or damaged oil cooler connector fittings
- Worn or damaged propeller shaft oil seal
- Loose line pressure pipe plug
- Porous casting warped torque converter housing

Leak at the Torque Converter End

- Converter leak in the weld area
- Converter seal lip cut. Check the converter hub for damage
- Converter seal bushing moved forward and damaged
- Converter seal garter spring missing from the seal
- Porous casting of the transmission case or the oil pump

Leak at the Vent Pipe

- Overfilled system
- Water or coolant in the fluid; The fluid will appear milky
- Transmission case porous
- Incorrect fluid level indicator

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- Plugged vent
- Drain-back holes plugged
- Mispositioned oil pump to case gasket, if equipped

Leak at the Case Extension

- Output shaft seal assembly - located in the case
- Output shaft seal assembly - located in the case extension

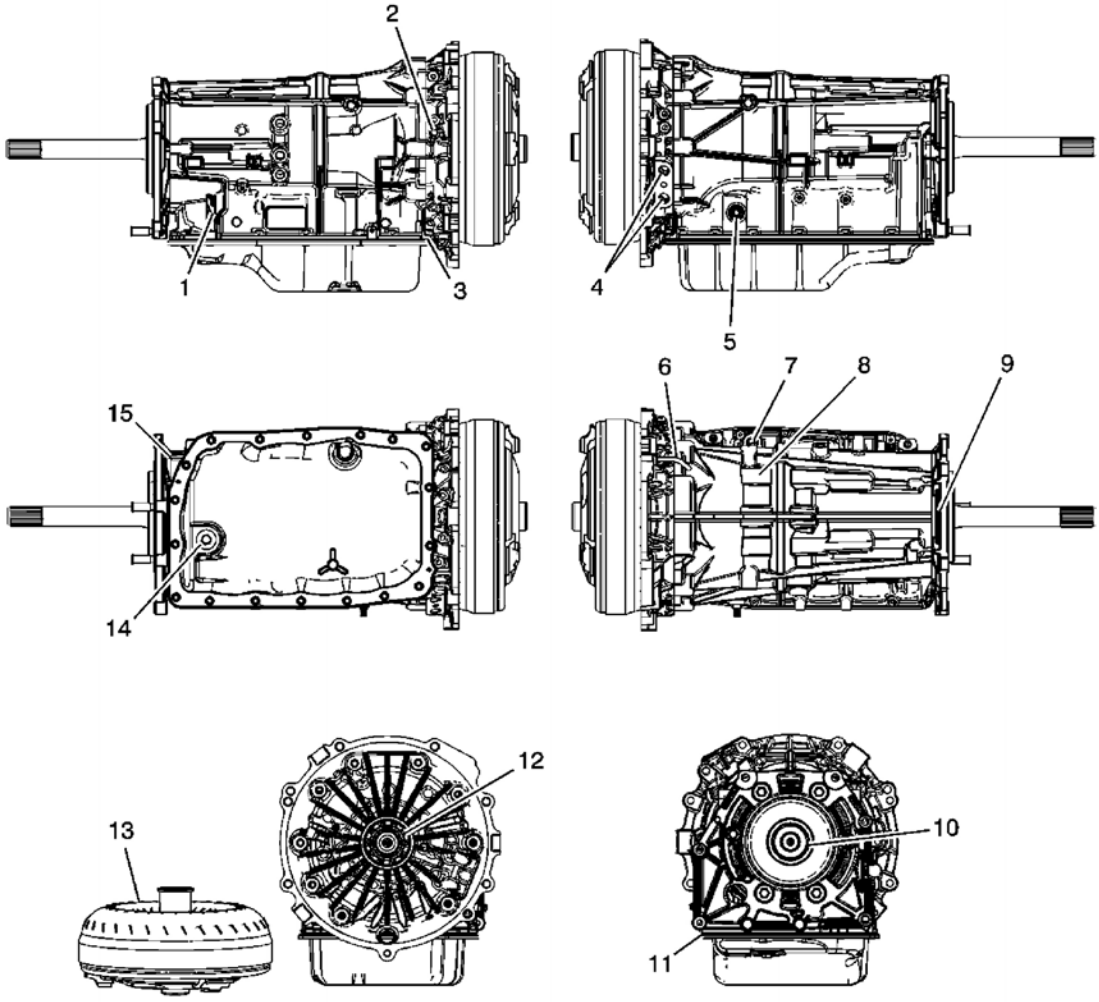


Fig. 13: Leak Inspection Points
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 41

Callout	Component Name
1	Automatic Transmission Electrical Connector Passage Sleeve

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2	Line Pressure Test Hole Plug
3	Converter Housing to Case Joint
4	Trans Fluid Cooler Pipe Fitting Seals
5	Manual Shift Shaft Seal
6	Automatic Transmission Vent Pipe
7	Fluid Fill Tube Plug Assembly
8	Transmission Case Assembly
9	Output Shaft Seal Assembly - Case
10	Output Shaft Seal Assembly - Case Extension
11	A/Trans Fluid Pan Gasket
12	Torque Converter Fluid Seal Assembly
13	Torque Converter Assembly
14	Trans Oil Level Check Plug
15	Case Extension to Case Joint

CASE POROSITY REPAIR

Some external leaks are caused by case porosity in non-pressurized areas. You can usually repair these leaks with the transmission in the vehicle.

1. Thoroughly clean the area to be repaired with a cleaning solvent. Air dry the area.

CAUTION: Epoxy adhesive may cause skin irritations and eye damage. Read and follow all information on the container label as provided by the manufacturer.

2. Using instructions from the manufacturer, mix a sufficient amount of an epoxy to make the repair.
3. While the transmission case is still hot, apply the epoxy. You can use a clean, dry soldering acid brush to clean the area and also to apply the epoxy cement. Make certain that the area to be repaired is fully covered.
4. Allow the epoxy cement to cure for three hours before starting the engine.
5. Repeat the fluid leak diagnosis procedures.

AUTOMATIC TRANSMISSION OIL COOLER FLUSHING AND FLOW TEST (J 45096)

GM studies indicate that plugged or restricted transmission oil coolers and pipes cause insufficient transmission lubrication and elevated operating temperatures which can lead to premature transmission failure. Many repeat repair cases could have been prevented by following published procedures for transmission oil cooler flushing and flow checking. This procedure includes flow checking and flushing the auxiliary transmission oil cooler, if equipped.

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IMPORTANT: Use the J 45096 or equivalent to flush and flow test the transmission oil cooler and the oil cooler pipes after the transaxle is removed for repairs. See Special Tools .

Only GM Goodwrench DEXRON®VI automatic transmission fluid should be used when doing a repair on a GM transmission.

Time allowance for performing the cooler flow checking and flushing procedure has been included in the appropriate labor time guide operations since the 1987 model year. The service procedure steps for oil cooler flushing and flow testing are as follows:

COOLER FLOW CHECK AND FLUSHING STEPS

1. Machine Set-up
2. Determine Minimum Flow Rate
3. Back Flush
4. Forward Flush
5. Flow Test
6. Code Recording Procedure
7. Clean-up

TOOLS REQUIRED

- **J 45096** Transmission Oil Cooling System Flush and Flow Test Tool. See **Special Tools** .
- **J 45096-30** Transmission Cooler Flush Adapter. See **Special Tools** .
- Shop air supply with water/oil filters, regulator and pressure gage - minimum 90 psi
- Eye protection
- Rubber gloves

MACHINE SET-UP

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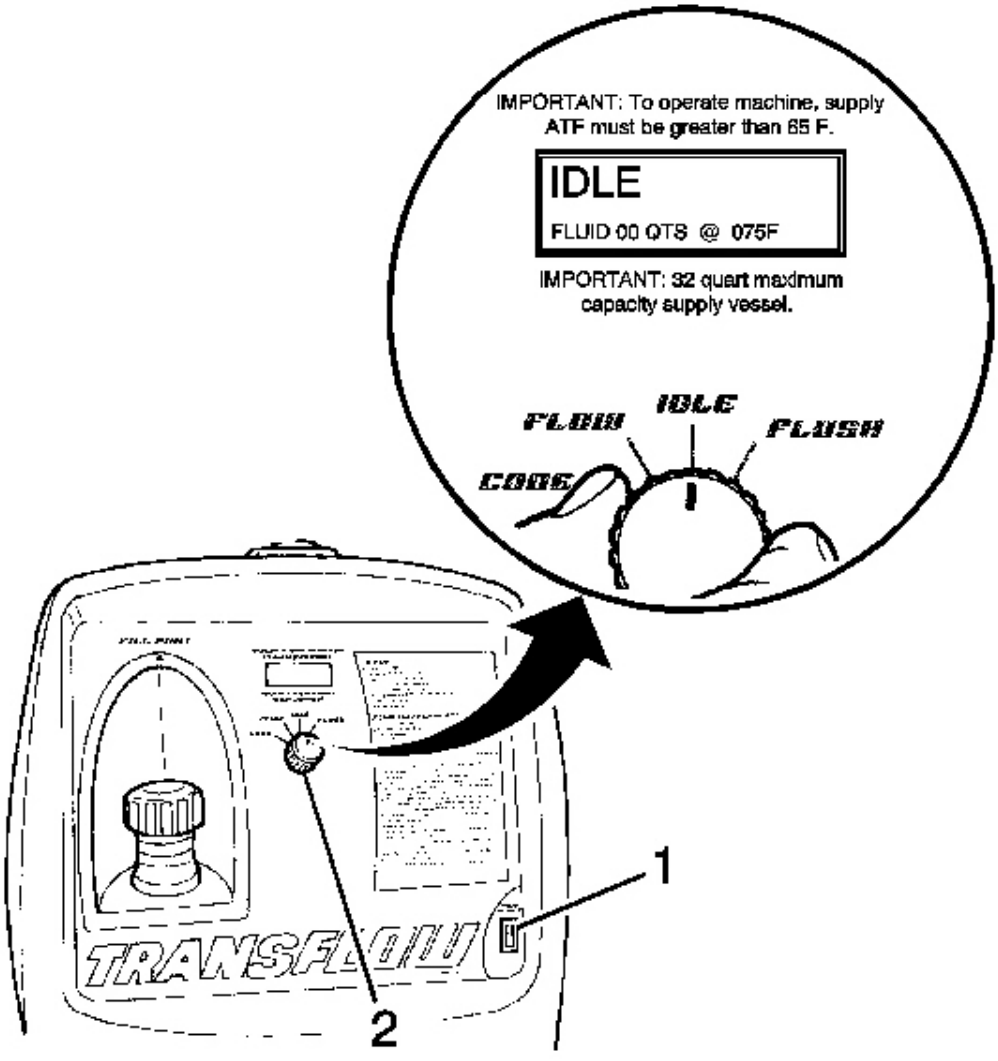


Fig. 14: View Of Main Power Switch & Main Function Switch
Courtesy of GENERAL MOTORS CORP.

1. Verify that the main power switch (1) is in the OFF position.
2. Place the main function switch (2) in the IDLE position.

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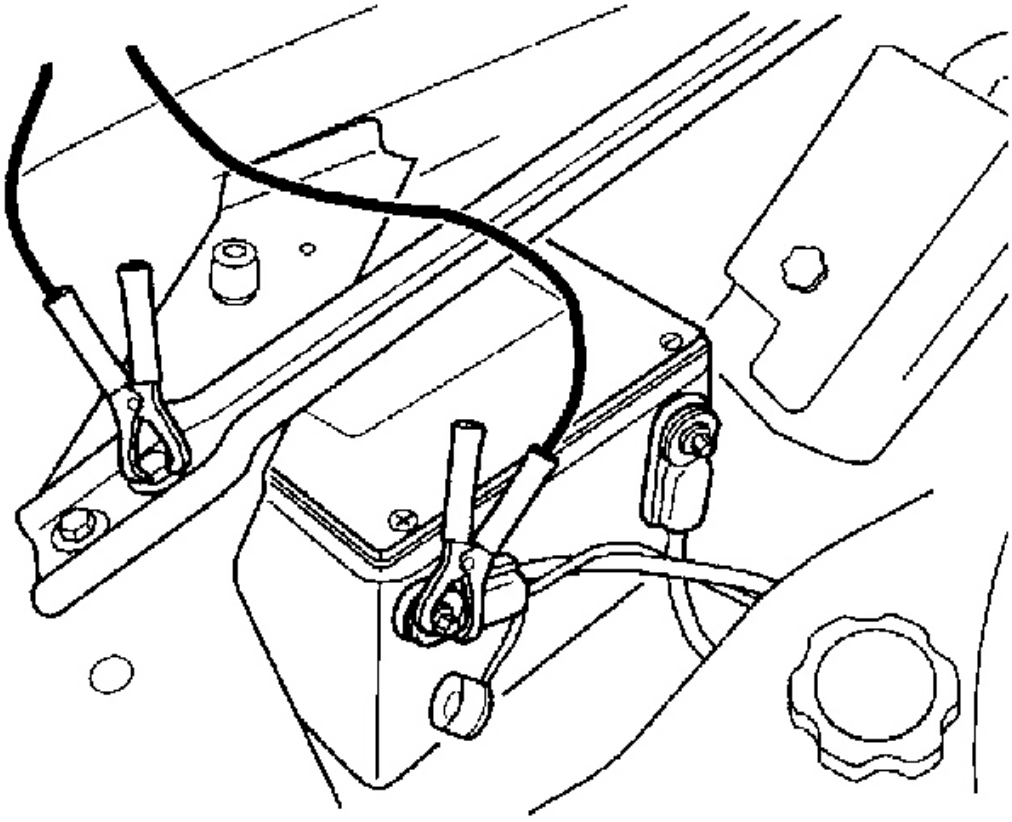


Fig. 15: Connecting To 12V DC Power Source
Courtesy of GENERAL MOTORS CORP.

3. Connect **J 45096** to the vehicle 12V DC power source by connecting the red battery clip to the positive, +, battery post on the vehicle and connect the negative lead to a known good chassis ground. See **Special Tools** .
4. Turn the main power switch to the ON position.

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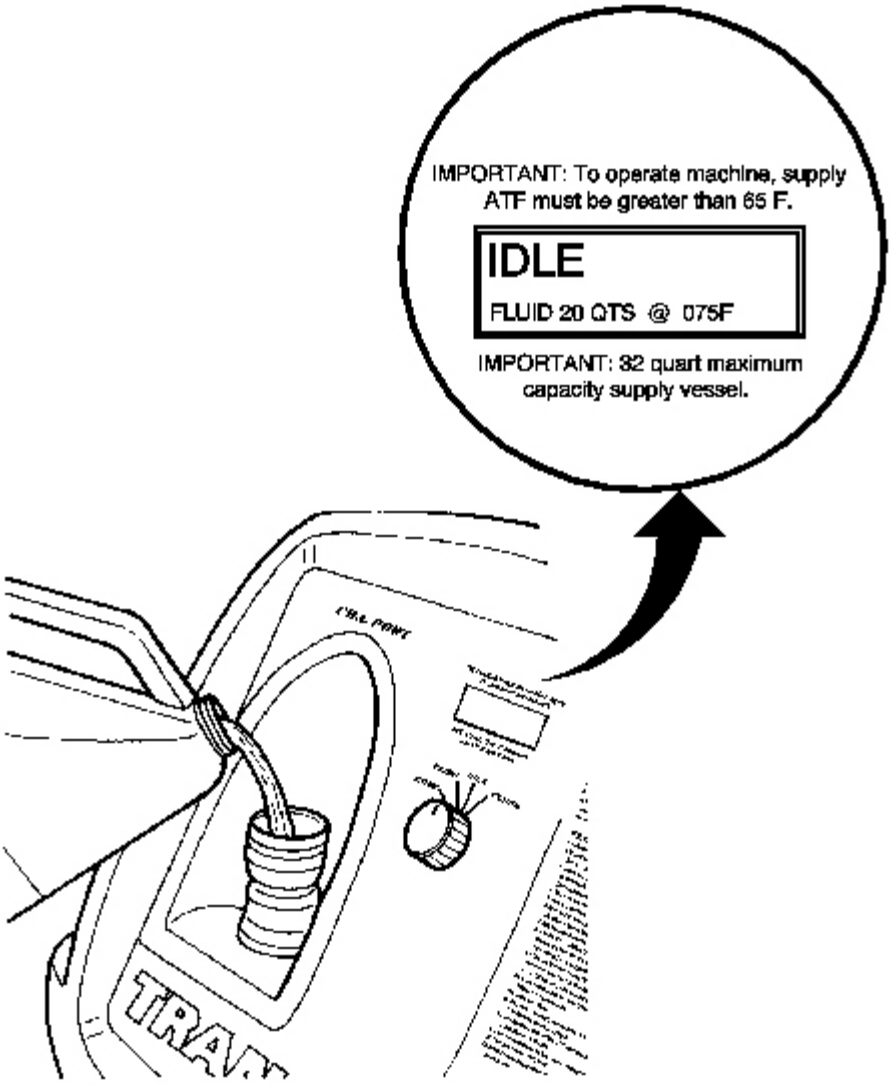


Fig. 16: Filling Supply Tank With Transmission Fluid
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not overfill the supply vessel. Damage to the unit may result. To verify the fluid level, view the LCD screen display while filling the unit, to ensure the fluid level does not exceed 30 L (32 qt).

5. Fill the supply tank with Dexron®VI through the fill port.

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6. Reinstall and tighten the fill cap.

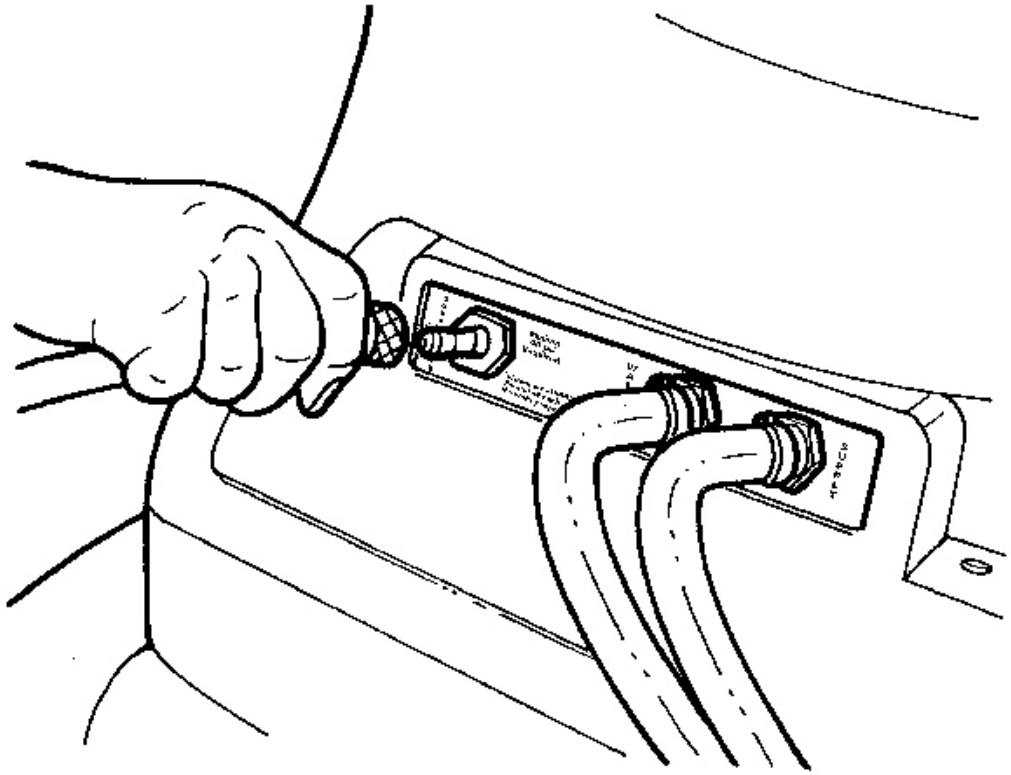


Fig. 17: Applying Shop Air Supply Hose To Quick-Disconnect
Courtesy of GENERAL MOTORS CORP.

7. Connect a shop air supply hose to the quick-disconnect on the rear panel marked SUPPLY AIR.

DETERMINE MINIMUM FLOW RATE

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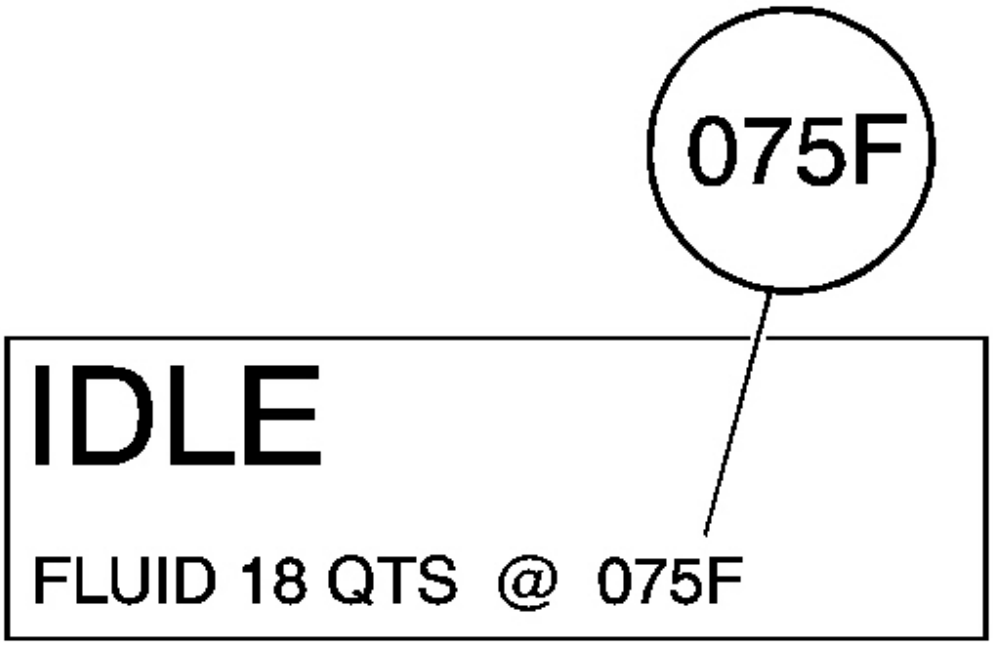


Fig. 18: Identifying Machine Display Of Automatic Transmission Fluid Temperature
Courtesy of GENERAL MOTORS CORP.

1. From the machine display, identify the temperature of the automatic transmission fluid that is stored in the supply vessel of **J 45096** . See **Special Tools** .

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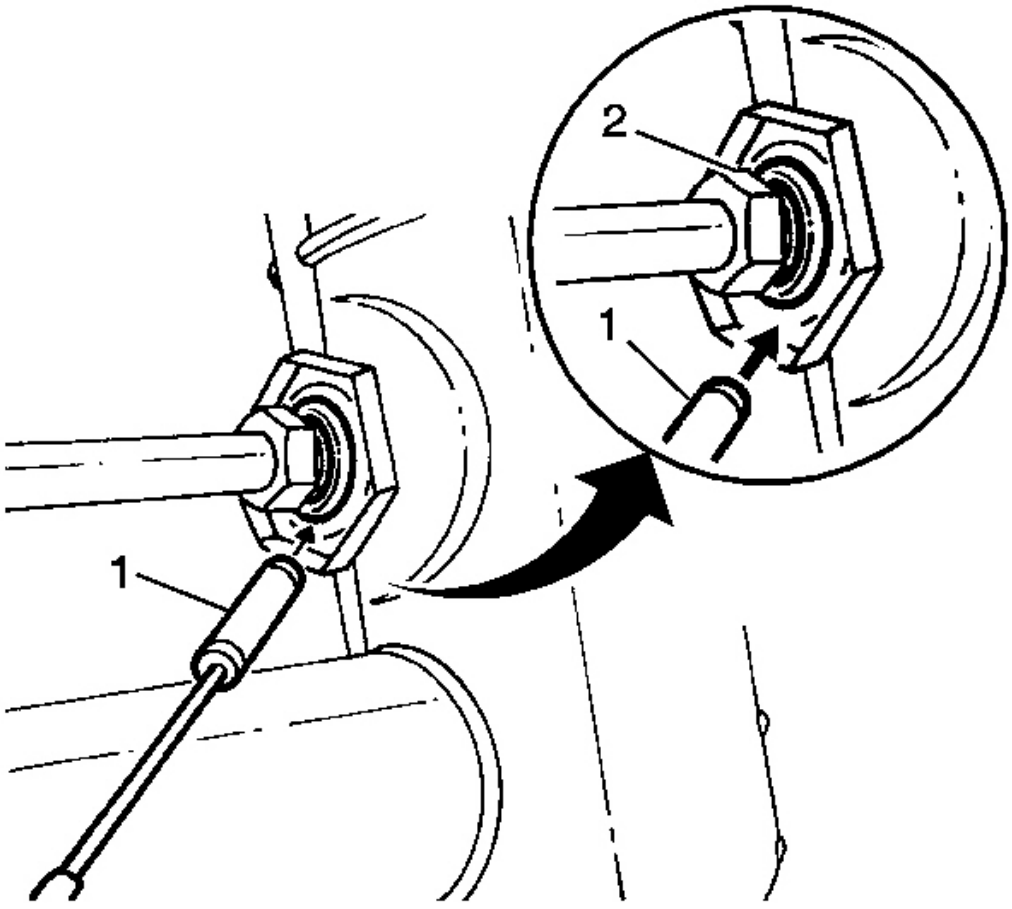


Fig. 19: Identifying Transmission Oil Cooler Metal Composition
Courtesy of GENERAL MOTORS CORP.

2. Determine whether the transmission oil cooler is steel or aluminum by using a magnet (1) at the cooler flange (2) at the radiator.
3. Refer to the table below. Using the temperature from step 1, locate on either the Steel MINIMUM Flow Rate table or the Aluminum MINIMUM Flow Rate table the minimum flow rate in gallons per minutes (GPM). Record the minimum flow rate in GPMs and the supply fluid temperature for further reference.

Example:

- Fluid temperature: 75°F
- Cooler type: Steel

The MINIMUM flow rate for this example would be 0.8 GPM.

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4. Inspect transmission oil cooler lines for damage or kinks that could cause restricted oil flow. Repair as needed and refer to the appropriate GM service manual procedures.

Minimum Flow Rate in Gallons Per Minute (gpm)

Temperature Range	Steel	Aluminum
65 - 66°F	0.6 gpm	0.5 gpm
67 - 70°F	0.7 gpm	0.6 gpm
71 - 75°F	0.8 gpm	0.7 gpm
76 - 80°F	0.9 gpm	0.8 gpm
81 - 84°F	1.0 gpm	0.9 gpm
85 - 89°F	1.1 gpm	1.0 gpm
90 - 94°F	1.2 gpm	1.1 gpm
95 - 98°F	1.3 gpm	1.2 gpm
99 - 103°F	1.4 gpm	1.3 gpm
104 - 108°F	1.5 gpm	1.4 gpm
109 - 112°F	1.6 gpm	1.5 gpm
113 - 117°F	1.7 gpm	1.6 gpm
118 - 120°F	1.8 gpm	1.7 gpm

BACK FLUSH PROCEDURE

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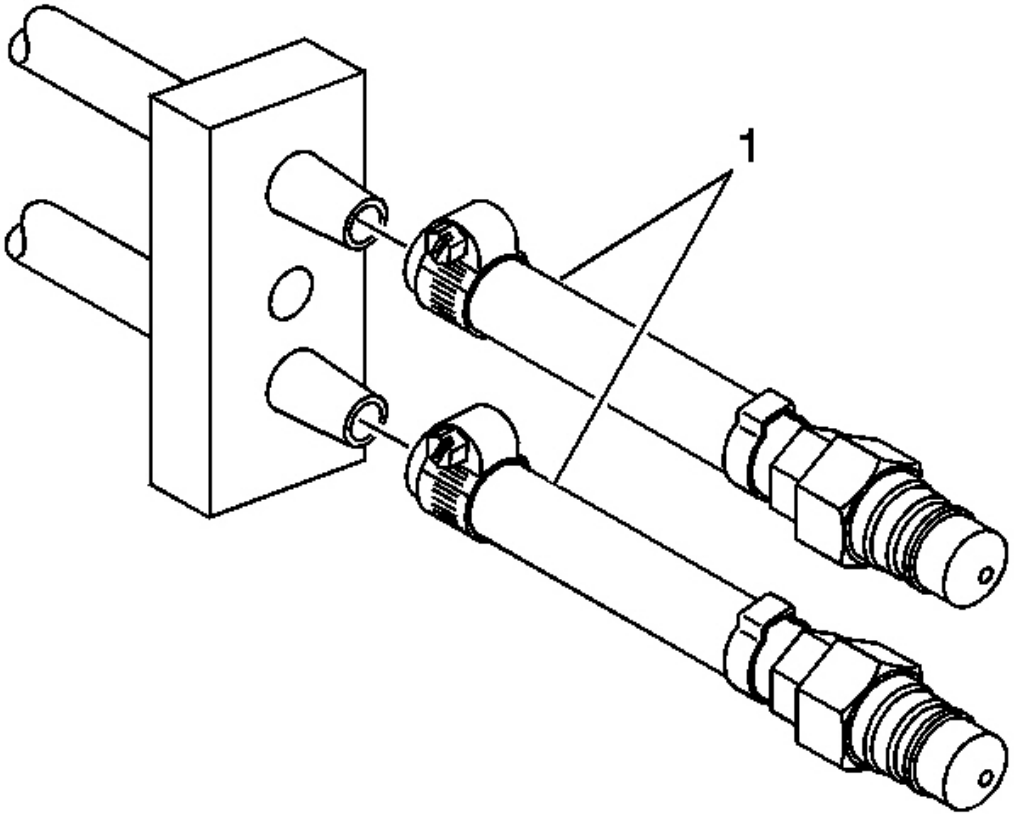


Fig. 20: Identifying Transmission Oil Cooler Supply And Return Lines
Courtesy of GENERAL MOTORS CORP.

1. Connect the **J 45096-30** (1) to the vehicle transmission oil cooler supply and return lines at the transmission. See **Special Tools** .

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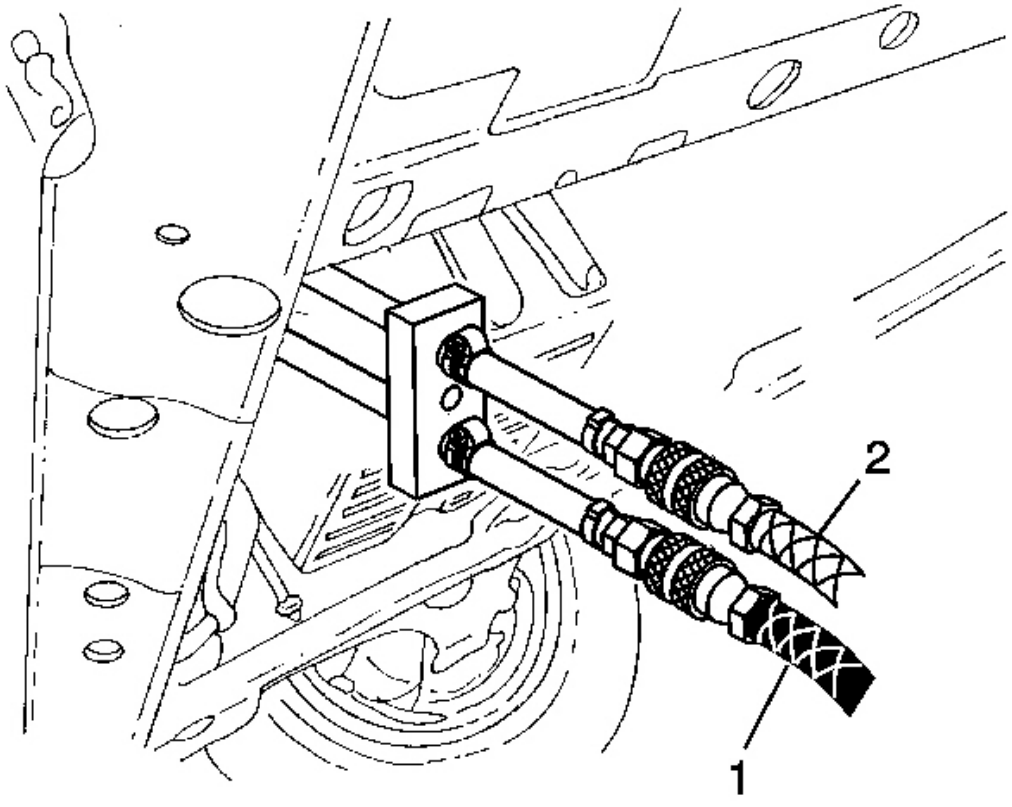


Fig. 21: Identifying Black Supply Hose & Clear Waste Hose
Courtesy of GENERAL MOTORS CORP.

2. Connect the black supply hose (1) to the return line, top connector of the transmission and the clear waste hose (2) to the feed line, bottom connector of the transmission, to the vehicle cooler lines. This is the reverse flow - backflush direction.

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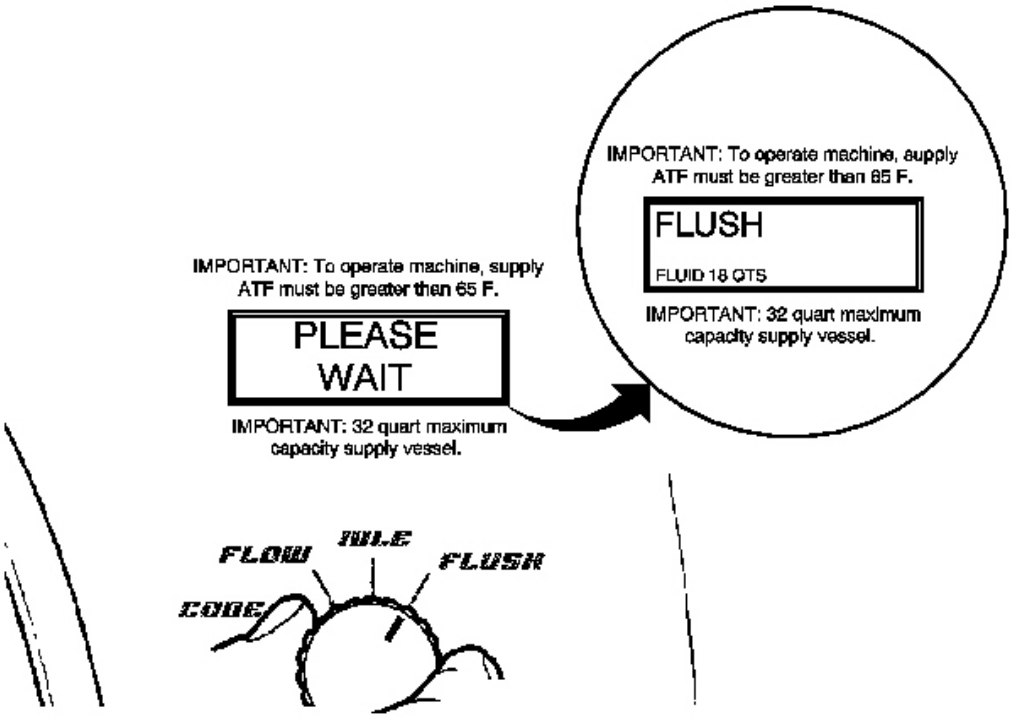


Fig. 22: Setting Main Function Switch To FLUSH Position
Courtesy of GENERAL MOTORS CORP.

3. Turn the main function switch to the FLUSH position. Allow the machine to operate for 30 seconds.

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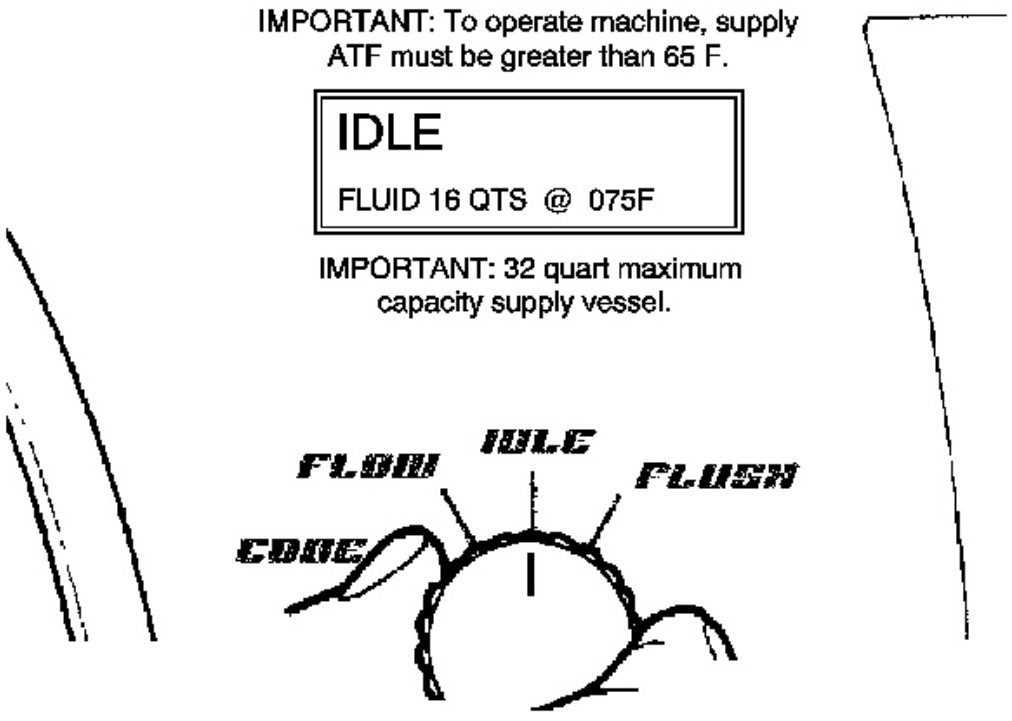


Fig. 23: Setting Main Function Switch To IDLE Position
Courtesy of GENERAL MOTORS CORP.

4. Turn the main function switch to the IDLE position and allow the supply vessel pressure to dissipate.

FORWARD FLUSH

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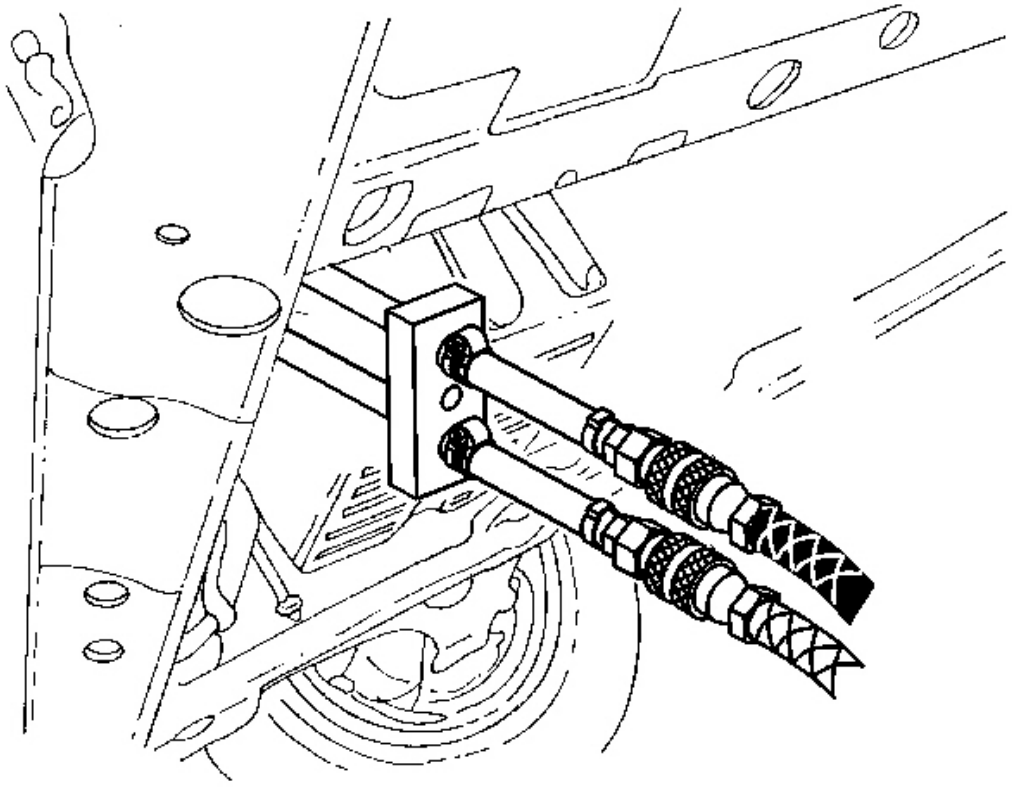


Fig. 24: Identifying Black Supply Hose & Clear Waste Hose
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the supply and waste hoses from the vehicle cooler lines. Reverse the supply and waste hoses to provide a normal flow direction.

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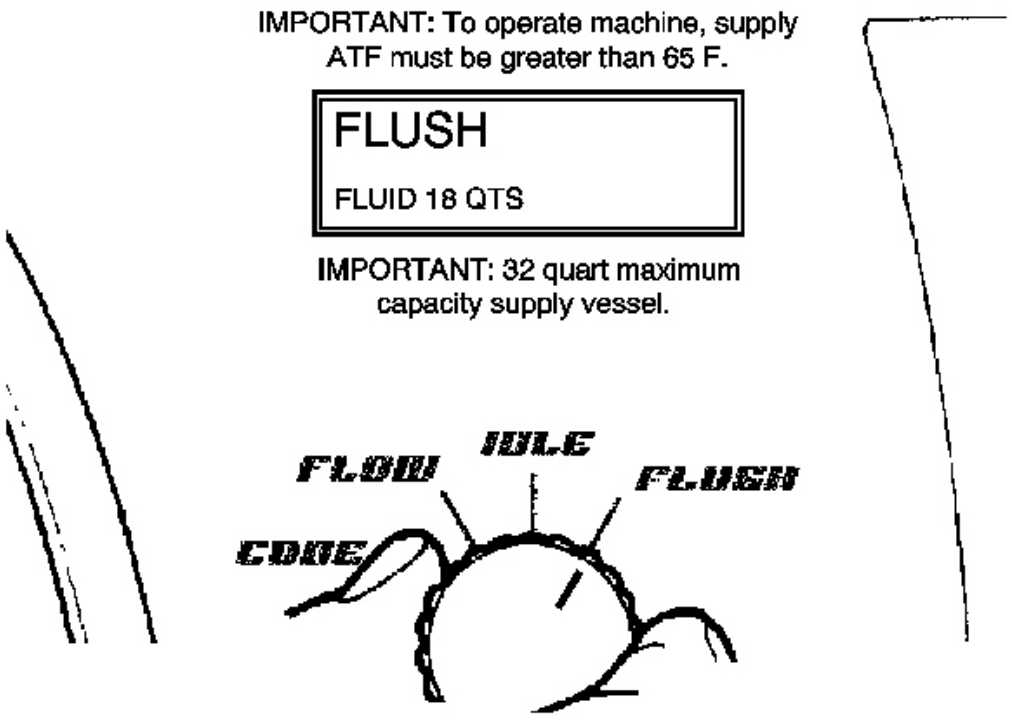


Fig. 25: Setting Main Function Switch To FLUSH Position
Courtesy of GENERAL MOTORS CORP.

2. Turn the main function switch to the FLUSH position and allow machine to operate for 30 seconds.

FLOW TEST

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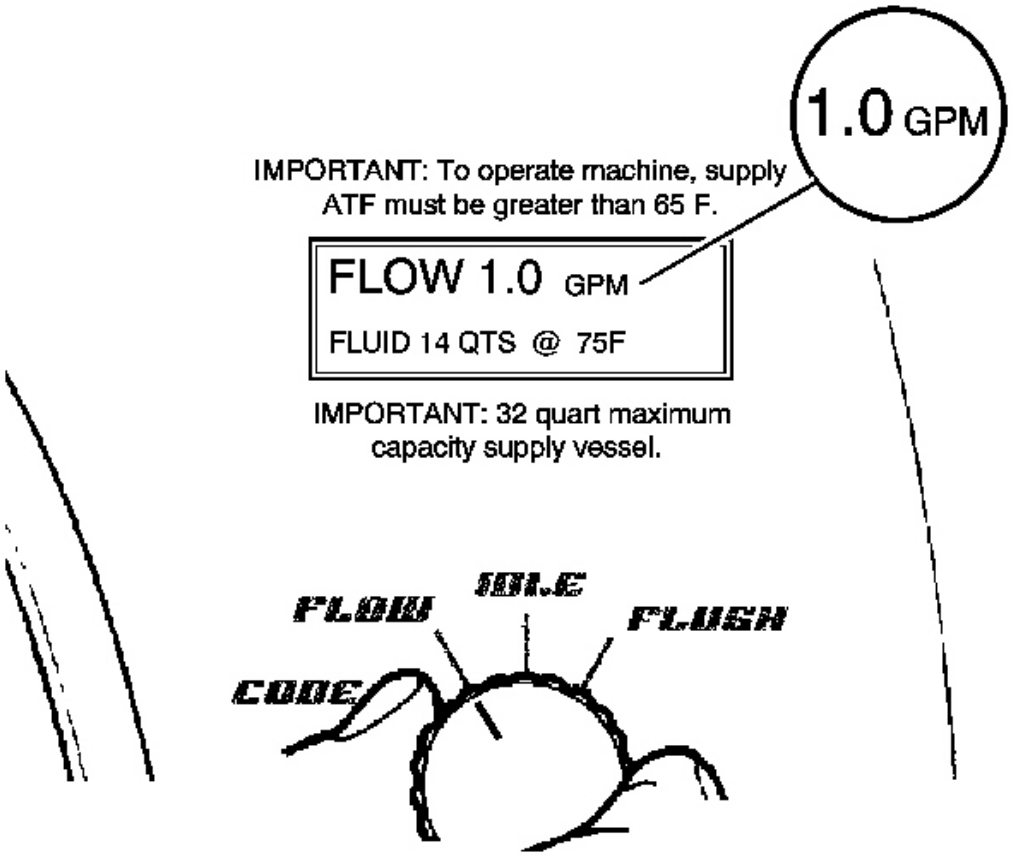


Fig. 26: Setting Main Function Switch To FLOW Position
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the flow rate is less than 0.5 gpm, the LCD displays an error message. Refer to the Troubleshooting section of the operation manual.

1. Turn the main function switch to the FLOW position and allow the oil to flow for 15 seconds. Observe and note the flow rate; this is the TESTED flow rate.
2. Compare the TESTED flow rate to the MINIMUM flow rate information previously recorded.
   - If the TESTED flow rate is equal to or greater than the MINIMUM flow rate recorded, the oil cooling system is functioning properly. Perform Code Recording Procedure.
   - If the TESTED flow rate is less than the MINIMUM flow rate previously recorded, repeat the back flush and forward flush procedures.
3. If the TESTED flow rate is less than the MINIMUM flow rate after the second test, perform Code Recording Procedure.

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1. Replace the transmission oil cooler.
2. Reconnect supply and waste hoses to the cooler lines in the normal flow direction. Perform Flow Test.
3. Perform Code Recording Procedure.

CODE RECORDING PROCEDURE

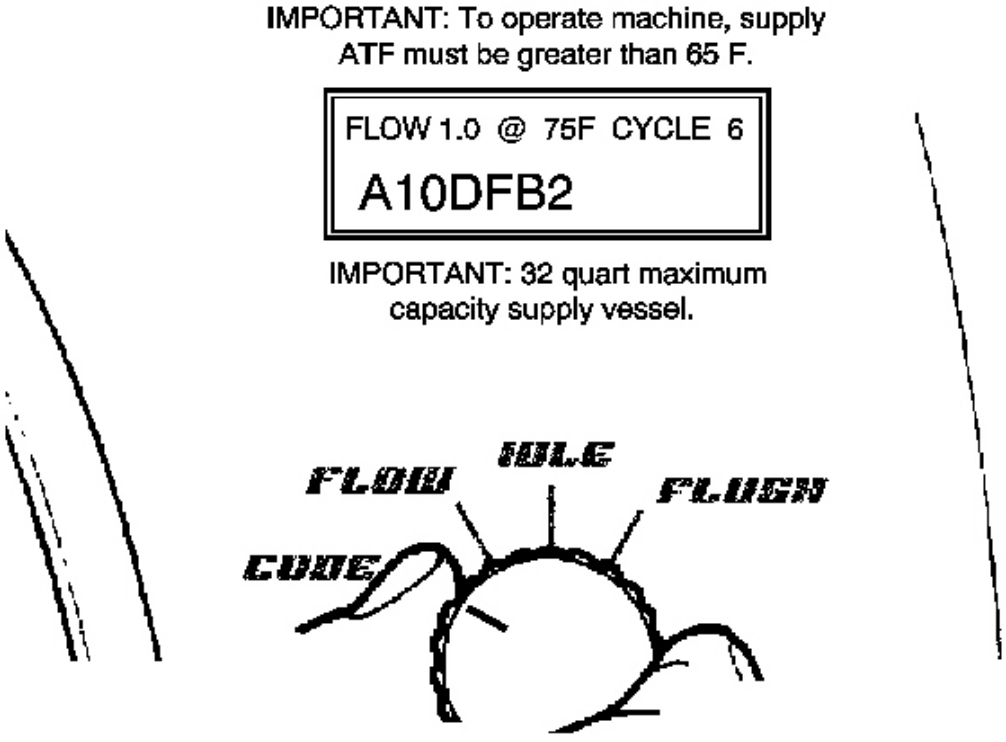


Fig. 27: Setting Main Function Switch To CODE Position
Courtesy of GENERAL MOTORS CORP.

1. Turn the main function switch to the CODE position.

IMPORTANT:

- **If power is interrupted prior to the recording of the seven-character code, the code will be lost and the flow rate test will need to be repeated.**
- **The flow test must run for a minimum of 8-10 seconds and be above 0.5 GPM for a code to be generated.**

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2. Record TESTED flow rate, temperature, cycle and seven-character flow code information on repair order.

CLEAN-UP

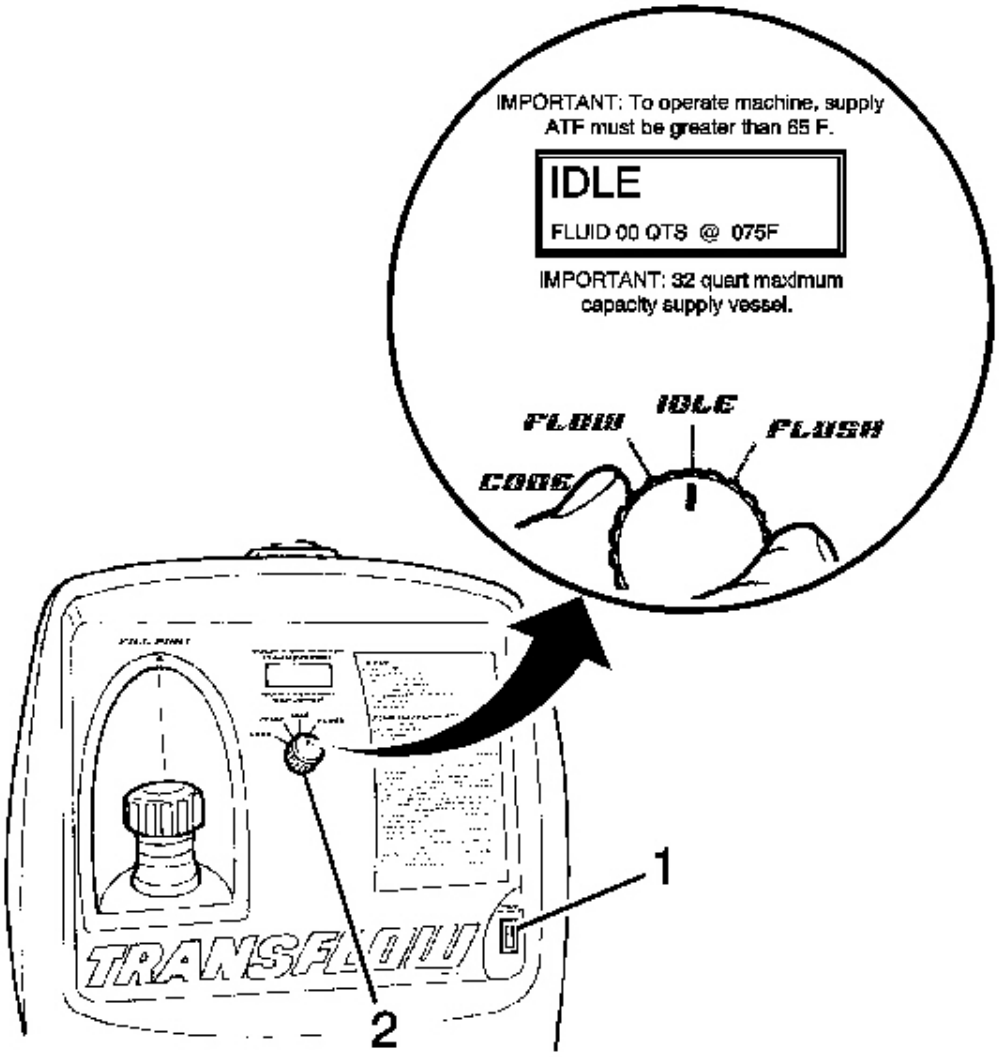


Fig. 28: View Of Main Power Switch & Main Function Switch
Courtesy of GENERAL MOTORS CORP.

1. Turn the main function switch (2) to the IDLE position and allow the supply vessel pressure to dissipate.
2. Turn the main power switch (1) to the OFF position.

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IMPORTANT: A small amount of water may drain from the bottom of the unit when the air supply is disconnected. This is a normal operation of the built-in water separator.

3. Disconnect the supply and waste hoses and the 12-volt power source from the vehicle.

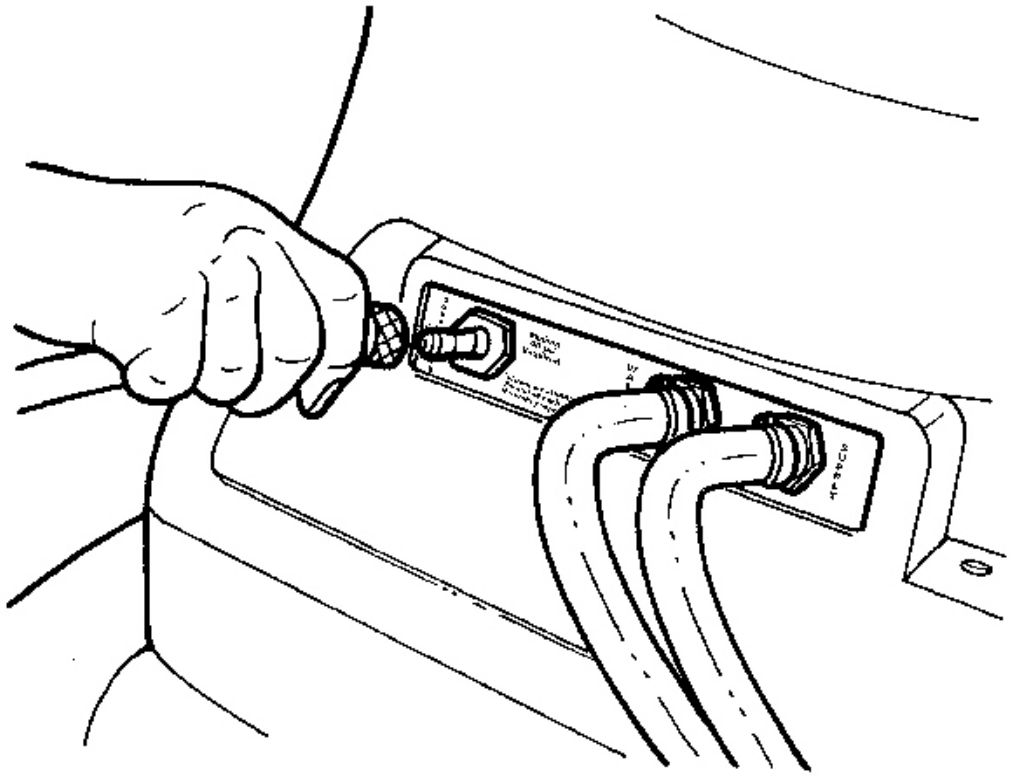


Fig. 29: Applying Shop Air Supply Hose To Quick-Disconnect
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the air supply hose from **J 45096** . See **Special Tools** .
5. Dispose of the waste ATF in accordance with all applicable federal, state and local requirements.

AUTOMATIC TRANSMISSION FLUID LEAKS

Automatic Transmission Fluid Leaks

Checks	Causes
Torque Converter (1)	Inspect for damage.

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Torque Converter Housing (203)	Inspect for porosity or damage.
Automatic Transmission Fluid Pump Seal (5)	Inspect for cut, wear or damage.

NO PARK OR DRIVE

No Park or Drive

Checks	Causes
Output Shaft Assembly (70)	Inspect for a broken or damaged output shaft. Inspect for worn splines.

HARSH GARAGE SHIFT

Harsh Garage Shift

Checks	Causes
1-2-3-4 and 3-5-R Clutch Assembly (51)	Inspect for damaged or worn 1-2-3-4 clutch plates (408-410).

NO DRIVE IN ALL RANGES

No Drive in All Ranges

Checks	Causes
4-5-6 (with Turbine Shaft) Clutch Assembly (56)	• Inspect for damaged or worn 4-5-6 clutch backing plate (432). • Inspect for damaged 4-5-6 clutch (with turbine shaft) housing assembly (441).
Output Carrier Assembly (68)	• Inspect the carrier assembly for damaged pinion gears, thrust washers, pins and rollers. • Inspect for damaged thrust bearings (486 and 488). • Inspect for damaged sun gears (487 and 489). • Inspect the carrier assembly for damaged output carrier rear sun gear thrust bearing (captured).
Output Carrier Thrust Bearing Assembly (69)	Inspect the bearing for wear or damage.
Output Shaft Assembly (70)	Inspect for damaged internal gears (495 and 497).
Input Sun Gear Thrust Washer (55)	Inspect the washer for wear or damage.
Input Sun Gear Thrust Bearing (54)	Inspect the bearing for wear or damage.
Input Sun Gear (53)	Inspect for spline wear or damage.
Input Carrier Assembly (52)	Inspect carrier assembly for damaged pinion gears, thrust washers, pins and rollers.
Turbine Shaft Thrust Bearing	Inspect the bearing for wear or damage.

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Assembly (57)	
Fluid Filter Assembly (26)	• Inspect for damaged or restricted fluid filter assembly (26). • Inspect for damaged fluid filter seal assembly (25) or improper sealing interface, leaks and fluid aeration.
Automatic Transmission Fluid Pump Seal (5)	Inspect for worn or damaged seal.

NO DRIVE OR REVERSE GEAR

No Drive or Reverse Gear

Checks	Causes
4-5-6 (with Turbine Shaft) Clutch Assembly (56)	• Inspect for damaged 4-5-6 clutch (with turbine shaft) housing assembly (441). • Inspect for damaged or distorted turbine shaft.
1-2-3-4 Clutch (with Output Carrier Inner Sun Gear Shaft) Hub Assembly (61)	Inspect for damaged or distorted shaft on hub assembly.
2-6 and 3-5-R Clutch (with Output Carrier Outer Sun Gear Shaft) Hub Assembly (64)	• Inspect for damaged or distorted shaft on hub assembly. • Inspect the output carrier inner sun gear shaft bushings (60 and 62) for damage or wear.

NO FIRST GEAR

No First Gear

Checks	Causes
Center (with 2-6 Low and Reverse Clutch) Support Assembly (67)	• Inspect for damaged low clutch sprag assembly (467). Holding the sprag assembly with the retaining ring facing up and the inner race of the sprag assembly fixed, the outer race should freewheel counterclockwise. • Inspect for cut, worn or damaged low clutch sprag seal (468).

NO FIRST AND REVERSE GEARS

No First and Reverse Gears

Checks	Causes
Center (with 2-6 Low and Reverse Clutch) Support Assembly (67)	• Inspect for damaged or worn low and reverse clutch plates (463 and 465). • Inspect for damaged low and reverse clutch backing plate (462). Inspect for worn splines on backing plate. • Inspect for damaged low and reverse clutch backing plate retaining ring (461).

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	• Inspect for damaged low and reverse clutch piston assembly (470), spring (469), spring retaining ring (466) and center support assembly (459). • Inspect for damaged low clutch sprag assembly (467). Holding the sprag assembly with the retaining ring facing up and the inner race of the sprag assembly fixed, the outer race should freewheel counterclockwise. • Inspect for cut, worn or damaged low clutch sprag seal (468).
Output Carrier Assembly (68)	Inspect for damaged or stripped splines on the output carrier assembly.

HARSH, SOFT, DELAYED OR SLIPPING FIRST OR REVERSE GEAR

Harsh, Soft, Delayed or Slipping First or Reverse Gear

Checks	Causes
Center (with 2-6 Low and Reverse Clutch) Support Assembly (67)	• Inspect for damaged or worn low and reverse clutch plates (463 and 465). • Inspect for damaged low and reverse clutch backing plate (462). Inspect for worn splines on backing plate. • Inspect for damaged low and reverse clutch backing plate retaining ring (461). • Inspect for damaged low and reverse clutch piston assembly (470), spring (469), spring retaining ring (466) and center support assembly (459). • Inspect for damaged low clutch sprag assembly (467). Holding the sprag assembly with the retaining ring facing up and the inner race of the sprag assembly fixed, the outer race should freewheel counterclockwise. • Inspect for cut, worn or damaged low clutch sprag seal (468).

STUCK IN FIRST OR REVERSE GEAR

Stuck in First or Reverse Gear

Checks	Causes
Center (with 2-6 Low and Reverse Clutch) Support Assembly (67)	• Inspect for damaged or worn low and reverse clutch plates (463 and 465). • Inspect for damaged low and reverse clutch backing plate (462). Inspect for worn splines on backing plate. • Inspect for damaged low and reverse clutch backing plate retaining ring (461). • Inspect for damaged low and reverse clutch piston assembly (470), spring (469), spring retaining ring (466) and center

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	support assembly (459). • Inspect for damaged low clutch sprag assembly (467). Holding the sprag assembly with the retaining ring facing up and the inner race of the sprag assembly fixed, the outer race should freewheel counterclockwise. • Inspect for cut, worn or damaged low clutch sprag seal (468).

NO FIRST, SECOND, THIRD AND FOURTH GEAR

No First, Second, Third and Fourth Gear

Checks	Causes
1-2-3-4 and 3-5-R Clutch Assembly (51)	• Inspect for damaged or worn 1-2-3-4 clutch plates (408-410). • Inspect for damaged 1-2-3-4 clutch piston (414), piston housing (417), spring (413) and dam assembly (412). • Inspect for damaged 1-2-3-4 clutch piston dam retaining ring (411). • Inspect for cut, worn or damaged 1-2-3-4 clutch piston seal (416), inner seal (423) and housing seals (424 and 425). • Inspect for improper selective 1-2-3-4 clutch backing plate retaining ring (429). • Inspect for damaged 1-2-3-4 clutch backing plate (407). Inspect for worn splines on the backing plate.
1-2-3-4 Clutch (with Output Carrier Inner Sun Gear Shaft) Hub Assembly (61)	Inspect for damaged splines on the hub assembly.

HARSH, SOFT, DELAYED OR SLIPPING 1-2-3-4 SHIFT

Harsh, Soft, Delayed or Slipping 1-2-3-4 Shift

Checks	Causes
1-2-3-4 and 3-5-R Clutch Assembly (51)	• Inspect for damaged or worn 1-2-3-4 clutch plates (408-410). • Inspect for damaged 1-2-3-4 clutch piston (414), piston housing (417), spring (413) and dam assembly (412). • Inspect for damaged 1-2-3-4 clutch piston dam retaining ring (411). • Inspect for cut, worn or damaged 1-2-3-4 clutch piston seal (416), inner seal (423) and housing seals (424 and 425). • Inspect for improper selective 1-2-3-4 clutch backing plate retaining ring (429). • Inspect for damaged 1-2-3-4 clutch backing plate (407). Inspect for worn splines on the backing plate.

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NO FIRST, SECOND, THIRD, FOURTH, FIFTH OR REVERSE GEAR

No First, Second, Third, Fourth, Fifth or Reverse Gear

Checks	Causes
1-2-3-4 and 3-5-R Clutch Assembly (51)	• Inspect for improper selective 3-5-R clutch backing plate retaining ring (400). • Inspect for improper selective 1-2-3-4 clutch backing plate retaining ring (429). • Inspect for worn or damaged clutch bearing (428).

NO FIRST, SECOND, SIXTH OR REVERSE GEAR

No First, Second, Sixth or Reverse Gear

Checks	Causes
Center (with 2-6 Low and Reverse Clutch) Support Assembly (67)	• Inspect for a damaged center support assembly (459). • Inspect for worn or damaged output carrier outer sun gear shaft front and rear bushing (458 and 460).
Center Support Retaining Ring (66)	Inspect for damage.
Output Carrier Assembly (68)	Inspect for a worn or damaged center support roller bearing assembly (485).
2-6 and 3-5-R Clutch Hub Thrust Bearing Assembly (65)	Inspect the bearing for wear or damage.

NO SECOND AND SIXTH GEAR

No Second and Sixth Gear

Checks	Causes
Center (with 2-6 Low and Reverse Clutch) Support Assembly (67)	• Inspect for damaged or worn 2-6 clutch plates (452 and 454). • Inspect for damaged 2-6 clutch backing plate (451). Inspect for worn splines on backing plate. • Inspect for damaged 2-6 clutch backing plate retaining ring (450). • Inspect for damaged 2-6 clutch piston assembly (457), spring (456), retaining ring (455) and center support assembly (459).

HARSH, SOFT, DELAYED OR SLIPPING SECOND OR SIXTH GEAR

Harsh, Soft, Delayed or Slipping Second or Sixth Gear

Checks	Causes
Center (with 2-6 Low and Reverse Clutch) Support Assembly (67)	• Inspect for damaged or worn 2-6 clutch plates (452 and 454).

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	• Inspect for damaged 2-6 clutch backing plate (451). Inspect for worn splines on backing plate. • Inspect for damaged 2-6 clutch backing plate retaining ring (450). • Inspect for damaged 2-6 clutch piston assembly (457), spring (456), retaining ring (455) and center support assembly (459).

STUCK IN SECOND OR SIXTH GEAR

Stuck in Second or Sixth Gear

Checks	Causes
Center (with 2-6 Low and Reverse Clutch) Support Assembly (67)	• Inspect for damaged or worn 2-6 clutch plates (452 and 454). • Inspect for damaged 2-6 clutch backing plate (451). Inspect for worn splines on backing plate. • Inspect for damaged 2-6 clutch backing plate retaining ring (450). • Inspect for damaged 2-6 clutch piston assembly (457), spring (456), retaining ring (455) and center support assembly (459).

VIBRATION IN SECOND, THIRD, FOURTH, FIFTH OR SIXTH GEAR

Vibration in Second, Third, Fourth, Fifth or Sixth Gear

Checks	Causes
4-5-6 Clutch (with Output Carrier Shaft and Dampener) Hub Assembly (58)	Inspect hub assembly (475), dampener (476) and apply plate (477) for wear or damage.

NO THIRD, FIFTH AND REVERSE GEAR

No Third, Fifth and Reverse Gear

Checks	Causes
1-2-3-4 and 3-5-R Clutch Assembly (51)	• Inspect for damaged or worn 3-5-R clutch plates (402-404). • Inspect for damaged 3-5-R clutch piston (421), apply ring (405) and spring (420). • Inspect for cut, worn or damaged 3-5-R clutch piston dam O-ring seal (418), inner seal (419) and outer seal (422). • Inspect for improper selective 3-5-R clutch backing plate retaining ring (400). • Inspect for damaged 3-5-R clutch backing plate (401). Inspect for worn splines on the backing plate.

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HARSH, SOFT, DELAYED OR SLIPPING THIRD, FIFTH OR REVERSE GEAR

Harsh, Soft, Delayed or Slipping Third, Fifth or Reverse Gear

Checks	Causes
1-2-3-4 and 3-5-R Clutch Assembly (51)	• Inspect for damaged or worn 3-5-R clutch plates (402-404). • Inspect for damaged 3-5-R clutch piston (421), apply ring (405) and spring (420). • Inspect for cut, worn or damaged 3-5-R clutch piston dam O-ring seal (418), inner seal (419) and outer seal (422). • Inspect for improper selective 3-5-R clutch backing plate retaining ring (400). • Inspect for damaged 3-5-R clutch backing plate (401). Inspect for worn splines on the backing plate.

NO FOURTH, FIFTH AND SIXTH GEAR

No Fourth, Fifth and Sixth Gear

Checks	Causes
4-5-6 (with Turbine Shaft) Clutch Assembly (56)	• Inspect for damaged or worn clutch plates (433-435). • Inspect for damaged piston (439), piston dam (437), dam retaining ring (436) and clutch spring (438). • Inspect for improper selective 4-5-6 clutch backing plate retaining ring (431). • Inspect for cut, worn or damaged turbine shaft fluid seal rings (442). • Inspect for damaged or distorted turbine shaft.
Control Valve Upper Body Assembly (304)	Inspect the 1/Reverse band and 4-5-6 clutch regulator valve (327) and spring (326) for wear or damage.
4-5-6 Clutch (with Output Carrier Shaft and Dampener) Hub Assembly (58)	Inspect the hub assembly (475), dampener (476) and apply plate (477) for wear or damage.
Output Carrier Assembly (68)	Inspect for damaged or stripped internal splines on the output carrier assembly.

HARSH, SOFT, DELAYED OR SLIPPING 4-5-6 SHIFT

Harsh, Soft, Delayed or Slipping 4-5-6 Shift

Checks	Causes
4-5-6 (with Turbine Shaft) Clutch Assembly (56)	• Inspect for damaged or worn clutch plates (433-435). • Inspect for damaged piston (439), piston dam (437), dam retaining ring (436) and clutch spring (438).

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	• Inspect for improper selective 4-5-6 clutch backing plate retaining ring (431). • Inspect for cut, worn or damaged turbine shaft fluid seal rings (442).

NO TORQUE CONVERTER CLUTCH APPLY

No Torque Converter Clutch Apply

Checks	Causes
Torque Converter Assembly (1)	Diagnose torque converter for possible internal damage.
Fluid Pump Cover Assembly (219)	• Inspect for worn, damaged or sticking converter feed limit valve (220) and spring (221). • Inspect for worn, damaged or sticking TCC control valve (227) and spring (226). • Inspect for damaged stator shaft.
Control Valve Lower Body Assembly (307)	Inspect for worn, damaged or sticking torque converter clutch (TCC) regulator apply valve (355).
4-5-6 (with Turbine Shaft) Clutch Assembly (56)	• Inspect for damaged turbine shaft. • Inspect for damaged turbine shaft O-ring seal.

NO TORQUE CONVERTER CLUTCH RELEASE

No Torque Converter Clutch Release

Checks	Causes
Torque Converter Assembly (1)	Diagnose torque converter for possible internal damage.
Fluid Pump Cover Assembly (219)	• Inspect for worn, damaged or sticking converter feed limit valve (220) and spring (221). • Inspect for worn, damaged or sticking torque converter clutch (TCC) control valve (227) and spring (226).
Control Valve Lower Body Assembly (307)	Inspect for worn, damaged or sticking TCC regulator apply valve (355).

NO REVERSE GEAR

No Reverse Gear

Checks	Causes
Control Valve Upper Body Assembly (304)	• Inspect for worn, damaged or sticking 3-5 reverse regulator valve (336) and valve spring (326). • Inspect for damaged or missing #5 checkball.
Control Valve Lower Body	Inspect for worn, damaged or sticking clutch select solenoid valve 3

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Assembly (307)	(352) and valve spring (353).

FLUID PRESSURE HIGH OR LOW

Fluid Pressure High or Low

Checks	Causes
Torque Converter Housing with Fluid Pump Assembly (2)	• Inspect for worn, sticking or damaged pressure regulator valve (233). • Inspect for worn, sticking or damaged pressure regulator valve outer spring (234). • Inspect for worn, sticking or damaged pressure regulator valve inner spring (235). • Inspect for worn, sticking or damaged isolator valve (236) and sleeve (237). • Inspect for worn, sticking or damaged pressure relief ball valve (225). • Inspect for worn, sticking or damaged pressure relief ball valve spring (224). • Inspect for damaged or porous pump cover assembly (219). Inspect for pump surfaces not flat. • Inspect for excessive fluid pump rotor (217) clearance or damage. Ensure proper selective rotor is being utilized. • Inspect for damaged fluid pump slide (212). Ensure proper selective slide is being utilized. • Inspect for worn, sticking or damaged fluid pump slide outer spring (211). • Inspect for worn or damaged fluid pump slide seal (213), seal support (214), pivot pin (215), fluid seal ring (209) and O-ring seal (210). • Inspect for worn or damaged fluid pump vane rings (207) and rotor guide (208).
Control Valve Upper Body Assembly (321)	• Inspect for worn, sticking or damaged actuator feed limit valve (325) and spring (324). • Inspect for worn, sticking or damaged clutch boost valve (329) and spring (330).
Fluid Filter Assembly (26)	• Inspect for damaged or restricted fluid filter assembly (26). • Inspect for damaged fluid filter seal assembly (25).

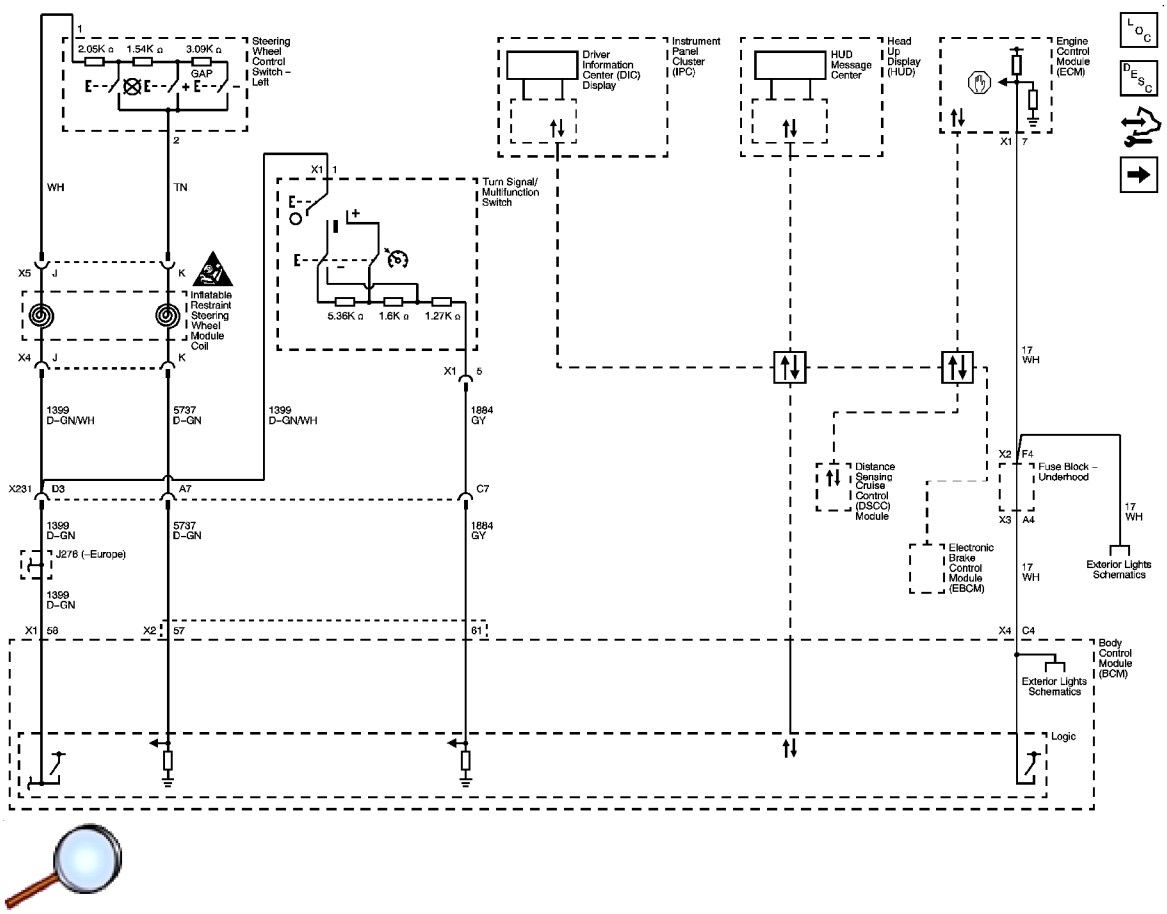
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Fastener Tightening Specifications

Application	Specification	
	Metric	English
Distance sensing cruise control (DSCC) module bracket mounting bolts	25 N·m	18 lb ft
DSCC module mounting bolts	10 N·m	7 lb ft

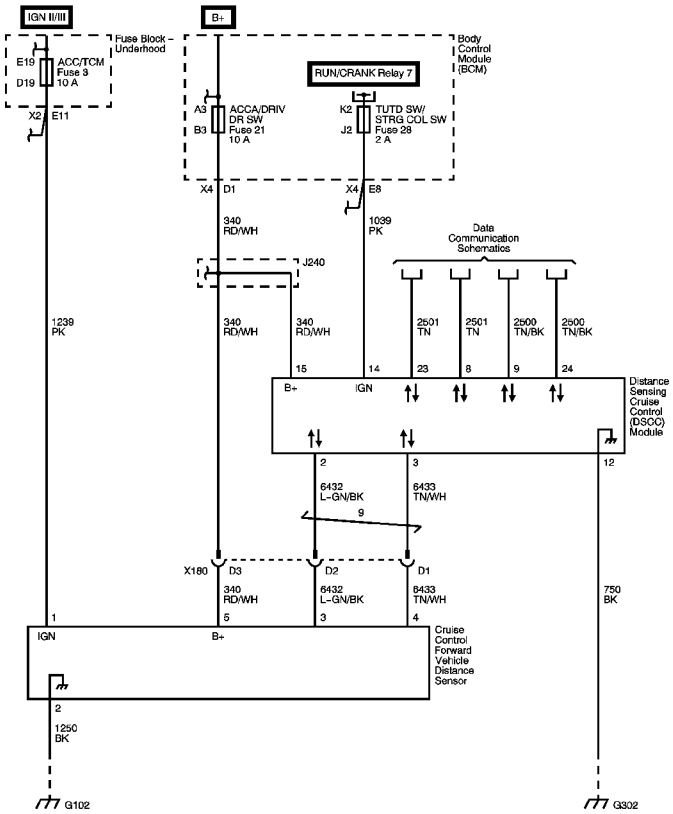
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Driver Controls



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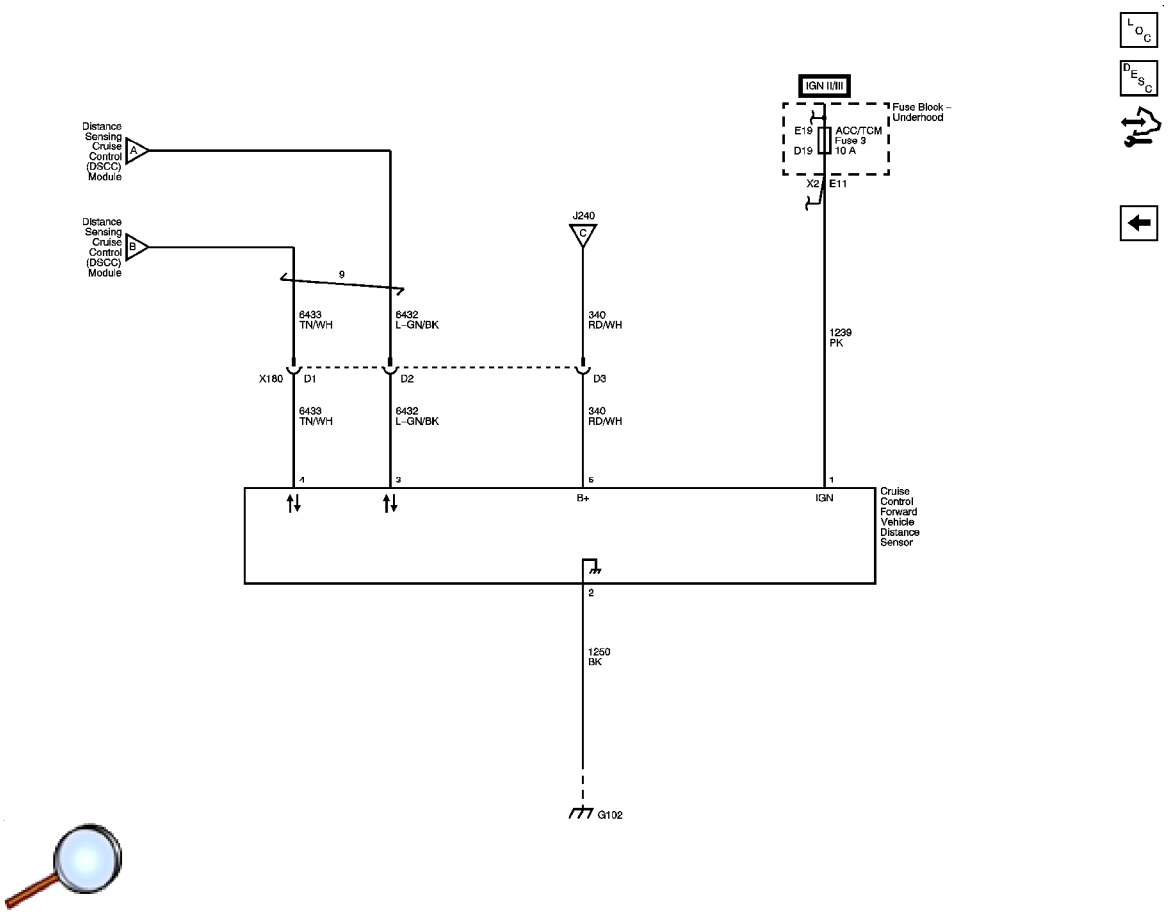
Computer Controls and Indicators



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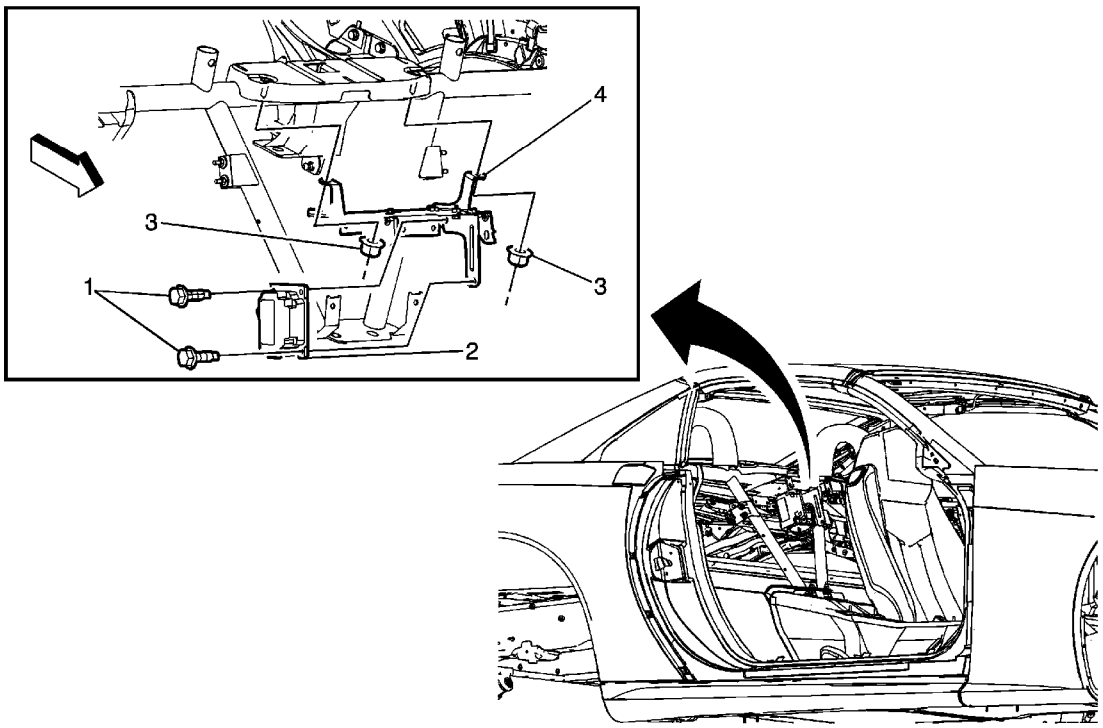
Forward Looking Sensor



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Distance Sensing Cruise Control Module Replacement



Callout	Component Name
Preliminary Procedure Remove the rear window panel assembly. Refer to Rear Window Panel Trim Replacement .	
1	Cruise Control Module Bolt (Qty: 2) **Notice:** Refer to Fastener Notice in the Preface section. **Tighten** 3 N·m (27 lb in)
2	Cruise Control Module **Tip** Disconnect the electrical connector and remove from the bracket. Refer to Control Module References for programming and setup information.
3	Cruise Control Module Bracket Nut (Qty: 2) **Tighten** 3 N·m (27 lb in)

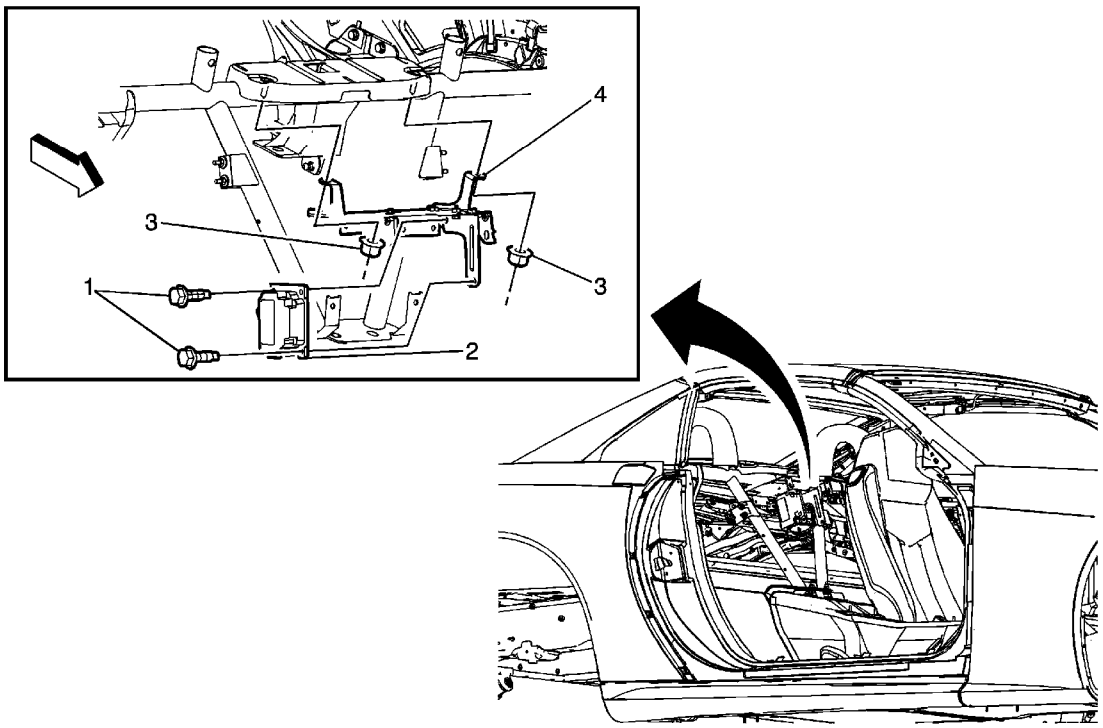
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4	Cruise Control Module Bracket

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Distance Sensing Cruise Control Bracket Replacement



Callout	Component Name
Preliminary Procedure Remove the rear window panel assembly. Refer to Rear Window Panel Trim Replacement .	
1	Cruise Control Module Bolt (Qty: 2) **Notice:** Refer to Fastener Notice in the Preface section. **Tighten** 3 N·m (27 lb in)
2	Cruise Control Module **Tip** Disconnect the electrical connector and remove from the bracket. Refer to Control Module References for programming and setup information.
3	Cruise Control Module Bracket Nut (Qty: 2) **Tighten** 3 N·m (27 lb in)

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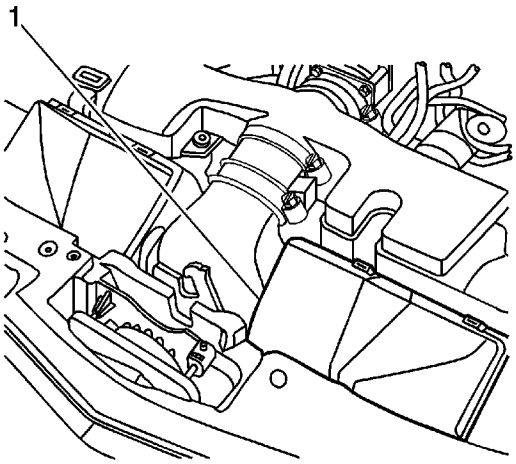
4	Cruise Control Module Bracket

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Cruise Control Vehicle Distance Module Sensor Replacement

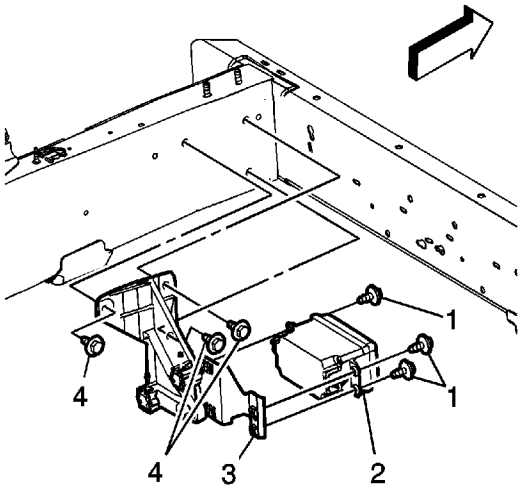
Removal Procedure

1. Open the hood.





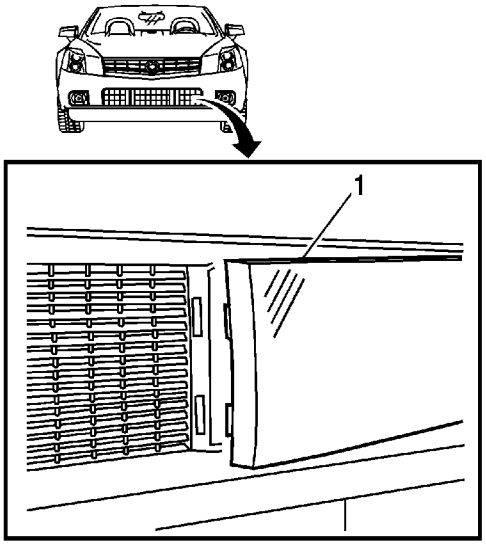
2. Remove the left front section (1) of the air cleaner assembly.



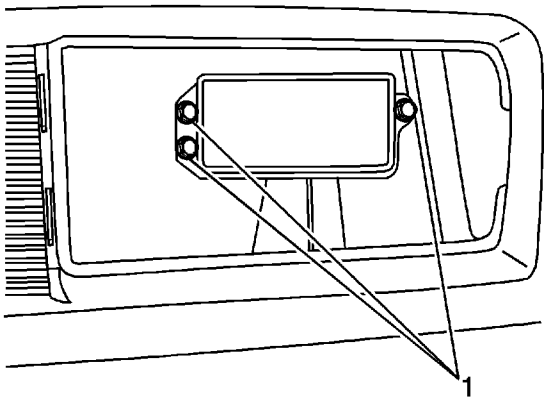


3. Disconnect the electrical connector from the vehicle distance module sensor assembly (2).

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4. Remove the sensor assembly from the fascia (1).

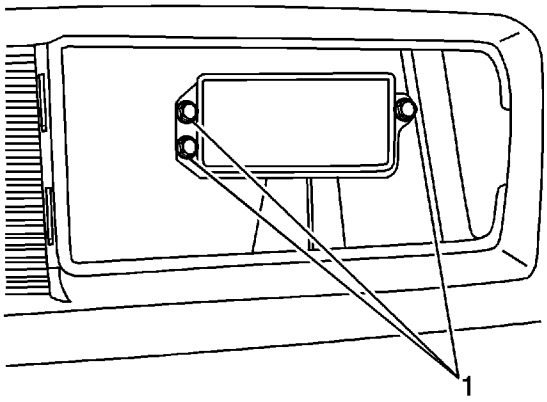


5. Remove the three bolts (1) attaching the sensor assembly to the bracket.

Installation Procedure

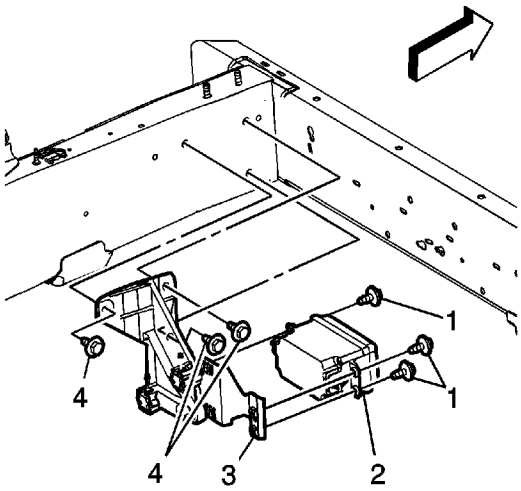
1. Position the sensor assembly to the bracket.

   Notice: Refer to Fastener Notice in the Preface section.

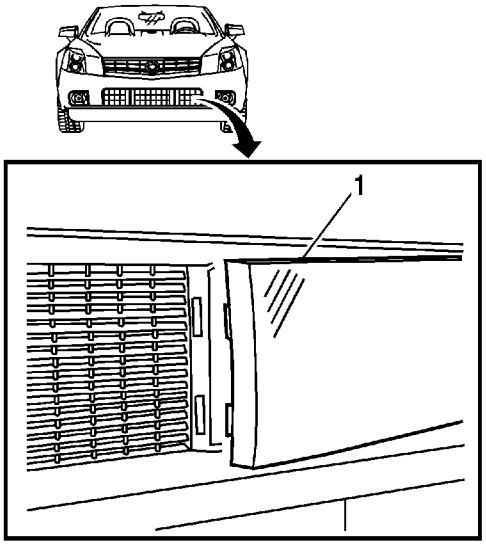


2. Hand tighten the three bolts that attach the sensor assembly to the bracket.

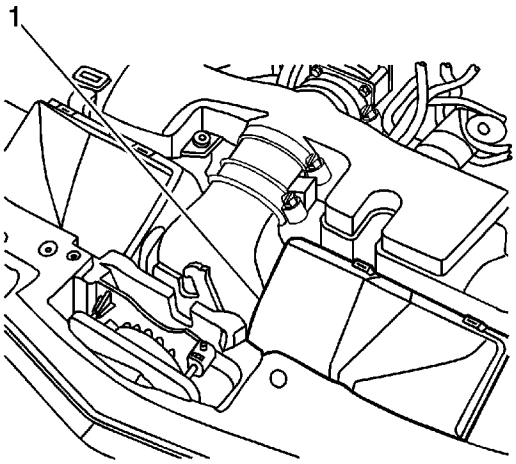
Tighten
Tighten the bolt to 10 N·m (7 lb ft).



3. Connect the electrical connector to the sensor assembly (2).



4. Install the sensor assembly cover to the fascia (1).



5. Install the left front section (1) of the air cleaner assembly.
6. Close the hood.

Important: After replacing the sensor assembly the next steps are necessary for the ACC system to perform properly.

7. With the scan tool, change the Automatic Alignment Learn Status Parameter in the DSCC module scan tool data list to Not Aligned after replacing the sensor assembly . This allows the new sensor assembly to automatically align to the vehicle during normal customer driving. Refer to Control Module References
8. Performance of the ACC system may be degraded after sensor assembly replacement. Normal customer driving will correct the performance of the ACC system. Refer to Cruise

Control Description and Operation

9. Refer to Control Module References

Distance Sensing Cruise Control Aiming

1. Place a bubble level on top of the radar. Adjust the vertical control until the radar is level.
2. For horizontal adjustment:
   2.1. Measure the back of the horizontal adjuster.
   2.2. Adjust the horizontal until 6 mm (0.25 in) of the adjuster is sticking out behind the radar.
3. At this point the radar will do an automatic adjustment to align the radar. Use a Tech 2 and check the Auto Alignment Learn Status. The Tech 2 should indicate Aligned. If not, proceed to step 4.
4. Use a Tech 2 and the Adaptive Cruise Control Horizontal Adjustment Table. Using the Tech 2 Alignment Error, adjust the horizontal until the alignment error is between -2.5 and +2.5 degrees.
5. Cycle the ignition. Use a Tech 2 and check the Auto Alignment Learn Status. The Tech 2 should indicate Aligned. If not, repeat step 4 until aligned.

Adaptive Cruise Control Horizontal Adjustment Table

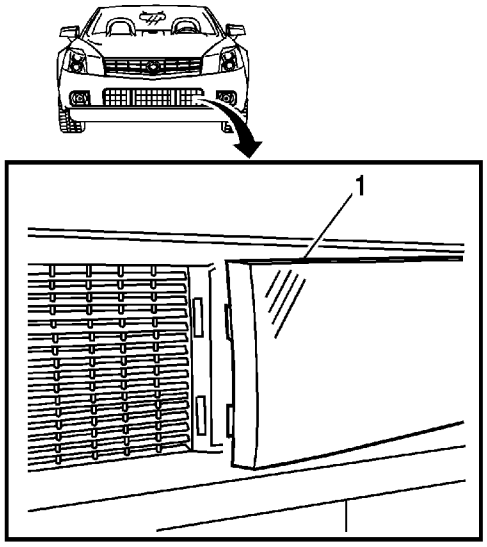
Tech 2 Alignment Error - Degrees		Number of Turns of Adjuster RHT (Right-Hand Turn) LHT (Left-Hand Turn)	
Lower Limit	Upper Limit		
-5.85	-5.549	9 ½	RHT
-5.55	-5.249	9	RHT
-5.25	-4.949	8 ½	RHT
-4.95	-4.649	8	RHT
-4.65	-4.349	7 ½	RHT
-4.35	-4.049	7	RHT
-4.05	-3.749	6 ½	RHT
-3.75	-3.449	6	RHT
-3.45	-3.149	5 ½	RHT
-3.15	-2.849	5	RHT
-2.85	-2.549	4 ½	RHT
-2.55	-2.249	4	RHT
-2.25	-1.949	3 ½	RHT
-1.95	-1.649	3	RHT
-1.65	-1.349	2 ½	RHT
-1.35	-1.049	2	RHT
-1.05	-0.749	1 ½	RHT
-0.75	-0.449	1	RHT
-0.45	-0.149	½	RHT
-0.15	0.149	0	--
0.15	0.449	½	LHT

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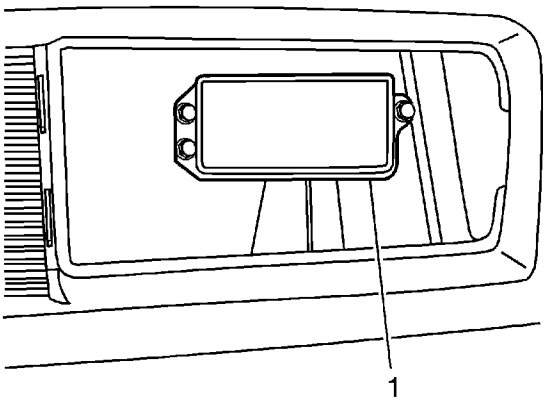
0.45	0.749	1	LHT
0.75	1.049	1 ½	LHT
1.05	1.349	2	LHT
1.35	1.649	2 ½	LHT
1.65	1.949	3	LHT
1.95	2.249	3 ½	LHT
2.25	2.549	4	LHT
2.55	2.849	4 ½	LHT
2.85	3.149	5	LHT
3.15	3.449	5 ½	LHT
3.45	3.749	6	LHT
3.75	4.049	6 ½	LHT
4.05	4.349	7	LHT
4.35	4.649	7 ½	LHT
4.65	4.949	8	LHT
4.95	5.249	8 ½	LHT
5.25	5.549	9	LHT
5.55	5.849	9 ½	LHT

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Distance Sensing Cruise Control Maintenance

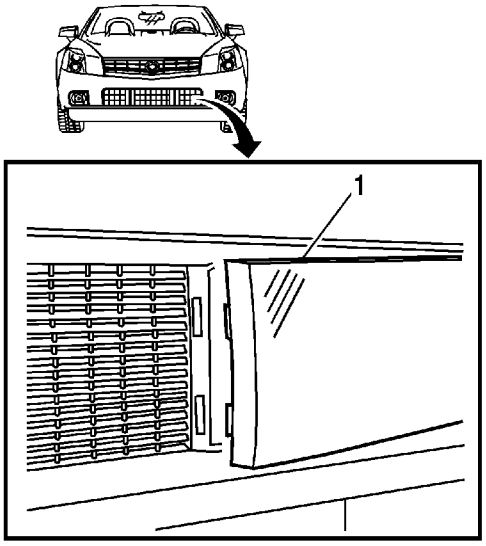


1. Remove the distance sensing cruise control (DSCC) module cover from the fascia (1).
2. Clean the surfaces of the inner and outer DSCC module cover with a 50/50 mixture of isopropyl alcohol and water by volume on a dampened lint free cloth.



3. With the same solution, clean the outer surface of the DSCC module (1).

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4. Install the DSCC module cover to the fascia (1).

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2007 ENGINE

Engine Controls and Fuel - 4.4L - XLR

SYMPTOMS - ENGINE CONTROLS

DIAGNOSTIC INSTRUCTIONS

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- **Strategy Based Diagnosis**
- **Diagnostic Procedure Instructions**

SYMPTOMS DESCRIPTION

Symptoms covers conditions that are not covered by DTCs. Certain conditions can cause multiple symptoms. These conditions are listed together under Symptoms Testing. Conditions that may only cause specific symptoms are listed separately under Additional Symptoms Testing. Perform the Symptoms Testing before using the Additional Symptoms Testing.

SYMPTOMS DEFINITION

Backfire

The fuel ignites in the intake manifold or in the exhaust system, making a loud popping noise.

Cuts Out, Misses

A steady pulsation or jerking that follows engine speed, which is usually more pronounced as the engine load increases. This condition is not normally felt above 1500 RPM or 48 km/h (30 mph). The exhaust has a steady spitting sound at idle or at low speed.

Detonation/Spark Knock

A mild to severe ping which usually occurs worse while under acceleration. The engine makes sharp metallic knocks that change with throttle opening.

Dieseling, Run-On

The engine continues to run after the key is turned OFF, but runs very rough.

Hard Start

The engine cranks OK, but does not start for a long time. The vehicle does eventually run or may start but immediately stall.

Hesitation, Sag, Stumble

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A momentary lack of response as the accelerator is pushed down. This condition can occur at any vehicle speed. This condition is usually more pronounced when first trying to make the vehicle move, as from a stop. This condition may cause the engine to stall in severe conditions.

Lack of Power, Sluggishness or Sponginess

The engine delivers less than expected power. Little or no increase in vehicle speed when the accelerator pedal is pushed down part way.

Poor Fuel Economy

Fuel economy, as measured by an actual road test, is noticeably lower than expected. Also, the fuel economy is noticeably lower than it was on this vehicle at one time, as previously shown by an actual road test.

Rough, Unstable or Incorrect Idle and Stalling

The engine runs unevenly at idle. If severe, the engine or the vehicle may shake. Engine idle speed may vary. Either condition may be severe enough to stall the engine.

Surges/Chuggles

An engine power variation under steady throttle or cruise. Feels like the vehicle speeds up and slows down with no change in the accelerator pedal position.

SYMPTOMS VERIFICATION

Before using the Symptom tables, perform the following inspections:

- Ensure that the engine control module (ECM) and malfunction indicator lamp (MIL) are operating correctly.
- Ensure that there are no diagnostic trouble codes (DTCs) that are stored.
- Ensure that the scan tool data is within a normal operating range. Refer to **Scan Tool Data List** .
- Verify the customer concern.
- Perform the Visual/Physical Inspection in this section. The visual/physical inspection is extremely important and can lead to correcting a condition without additional testing. It may also help reveal the cause of an intermittent condition.

Identifying Intermittent Conditions

Many intermittent conditions occur with harness or connector movement due to engine torque, rough pavement, vibration or physical movements of a component. Refer to the following for a list of issues that may cause an intermittent condition:

- Moisture and water intrusion in connectors, terminals and components

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- Incomplete connector mating
- Poor terminal contact
- High circuit or component resistance-High resistance can include any resistance, regardless of the amount, which can interrupt the operation of the component.
- Harness that is too short or tight.
- Wire insulation that is chaffed or cut.
- High or low ambient temperature
- High or low engine coolant temperatures
- High underhood temperatures
- Heat build up in component or circuit due to circuit resistance, poor terminal contact or high electrical load
- High or low system voltage
- High vehicle load conditions
- Rough road surfaces
- Electro-magnetic interference (EMI)/circuit interference from relays, solenoids or other electrical surge
- Incorrect installation of aftermarket, add on accessories

Visual/Physical Check

- Ensure that the control module grounds are clean, tight and correctly located. Refer to **Power and Grounding Schematic Icons** and **Power and Grounding Connector End Views** .
- Ensure that the vacuum hoses are not split, kinked and properly connected, as shown on the Vehicle Emission Control Information label. Refer to Emission Hose Routing Diagram. Refer to **Evaporative Emissions Hose Routing Diagram** .
- Ensure that the air filter is clean and free from restrictions.
- Ensure that there is no water intrusion in connectors terminals and components.
- Inspect the air intake ducts for the following conditions:
  - Collapsed
  - Damaged areas
  - Looseness
  - Incorrect installation
  - Leaking
- Inspect for air leaks at the throttle body mounting area, the mass air flow (MAF) sensor and intake manifold sealing surfaces.
- Inspect the wiring harness for the following conditions:
  - Poor connections
  - Pinches
  - Cuts
- Inspect for loose, damaged, unseated or missing sensors/components.

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- Inspect the terminals for corrosion and correct contact.

SYMPTOMS TESTING

Backfire, Cuts Out/Misses, Detonation/Spark Knock, Dieseling/Run-On, Hard Start, Hesitation/Sag/Stumble, Lack of Power/Sluggishness/Sponginess, Poor Fuel Economy, Rough, Unstable or Incorrect Idle and Stalling or Surges/Chuggles

- Test the fuel system for the following:
  - The fuel system for correct operation volume and pressure. Refer **Fuel System Diagnosis**
  - The fuel injectors for proper operation. Refer to **Fuel Injector Diagnosis (w/J39021 or w/Tech 2)** or **Fuel Injector Diagnosis (w/CH47976)**.
  - The fuel quality condition. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
- Test ignition system for the following:
  - Proper ignition system operation - Refer to **Electronic Ignition (EI) System Diagnosis**.
  - Spark plugs - Refer to **Spark Plug Inspection** .
  - Spark plugs for correct application - Refer to **Ignition System Specifications** .
- Inspect for the following conditions
  - The proper operation of the transmission torque converter clutch (TCC). The scan tool should indicate an engine speed drop when the TCC is commanded ON. Refer to **Torque Converter Diagnosis** .
  - The proper operation of the A/C compressor.
  - Items that can cause an engine to run lean or rich. Refer to **DTC P0171, P0172, P0174 or P0175** .
  - The crankshaft position (CKP) sensor for proper operation
  - The proper operation of the knock sensor (KS) system
  - Inspect the exhaust system. Refer to **Symptoms - Engine Exhaust** .
  - Electromagnetic interference (EMI) on the reference circuit can cause a misfire condition. You can usually detect EMI with a scan tool by monitoring the engine speed parameter. A sudden increase in the engine speed parameter with little change in actual engine speed indicates that EMI is present. Inspect the high voltage components near the ignition control circuit if a condition exists.
  - The crankcase ventilation valve for proper operation.
  - Inspect for a clean throttle body. Coking on the throttle body can cause a symptom. Refer to **Throttle Body Service**
  - The proper operation of the evaporative emission (EVAP) canister purge solenoid.
  - The proper operation of the engine cooling system - Refer to **Symptoms - Engine Cooling**
- Inspect the engine for the following mechanical failures:

  Refer to **Symptoms - Engine Mechanical** .

  - Excessive oil in the combustion chamber or leaking valve seals
  - Oil Consumption

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  - Incorrect cylinder compression
  - Sticking or leaking valves
  - Worn camshaft lobes
  - Incorrect valve timing
  - Worn rocker arms
  - Broken valve springs
  - Excessive carbon buildup in the combustion chambers-Clean the chambers with top engine cleaner. Follow the instructions on the can.
  - Incorrect engine parts
- If the above conditions do not address the symptom, refer to the additional symptoms tests.

ADDITIONAL SYMPTOMS TESTS

Hard Start

- Verify that the engine coolant temperature (ECT) has not shifted in value. Refer to **Temperature Versus Resistance** .
- Verify the engine electrical system for correct operation. Refer to **Symptoms - Engine Electrical** .
- Verify that the driver is using the correct starting procedure as described in the owners manual.
- Verify that there is adequate fuel.
- Inspect for excessive crankshaft endplay that will cause the crankshaft position (CKP) sensor reluctor wheel to move out of alignment with the CKP sensor. Refer to **Crankshaft and Bearings Cleaning and Inspection** .

Hesitation, Sag, Stumble

- Inspect the mass air flow (MAF) sensor for obstruction, contamination and damage. Refer to **Mass Airflow Sensor/Intake Air Temperature Sensor Replacement**
- Test the generator. Refer to **Symptoms - Engine Electrical** . Repair the charging system if the generator output voltage is less than 9 volts or more than 16 volts.
- Inspect for excessive crankshaft endplay that will cause the crankshaft position (CKP) sensor reluctor wheel to move out of alignment with the CKP sensor. Refer to **Crankshaft and Bearings Cleaning and Inspection** .

Poor Fuel Economy

- Heavy loads being carried or towed
- Acceleration rate too much or too often
- Inspect the brake system for brake drag.
- Inspect for incorrect operation of the speedometer.
- Verify that the engine coolant temperature (ECT) has not shifted in value. Refer to **Temperature Versus Resistance** .

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- Inspect the mass air flow (MAF) sensor for obstruction, contamination and damage. Refer to **Mass Airflow Sensor/Intake Air Temperature Sensor Replacement** .
- Inspect for foreign material accumulation in the throttle bore and for carbon deposits on the throttle plate and shaft. Also inspect for throttle body tampering.

Detonaton/Spark Knock

- Test for an engine overheating condition. Refer to **Symptoms - Engine Cooling** .
- Verify that the engine coolant temperature (ECT) has not shifted in value. Refer to **Temperature Versus Resistance** .
- If there are no engine mechanical faults, fill the fuel tank with a known high quality fuel that meets the vehicle minimum octane requirements.

Lack of Power, Hesitation or Cut Out

- Inspect the engine electrical system for correct operation. Refer to **Symptoms - Engine Electrical** .
- Verify that each injector harness is connected to the correct injector.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination and damage. Refer to **Mass Airflow Sensor/Intake Air Temperature Sensor Replacement** .

Rough, Unstable or Incorrect Idle and Stalling

- Inspect the mass air flow (MAF) sensor for obstruction, contamination and damage. Refer to **Mass Airflow Sensor/Intake Air Temperature Sensor Replacement** .
- Inspect the engine mounts. Refer to **Engine Mount Inspection** .
- Inspect the intake and exhaust manifolds for casting flash.

Surges/Chuggles

- Inspect the mass air flow (MAF) sensor for obstruction, contamination and damage. Refer to **Mass Airflow Sensor/Intake Air Temperature Sensor Replacement** .
- Test the heated oxygen sensors (HO2S). The HO2S should respond quickly to a change in throttle position. If the HO2S do not respond to different throttle positions, inspect for contamination from fuel, silicon or the incorrect use of RTV sealant. The sensors may have a white powdery coating and result in a high, but false, signal voltage, which gives a rich exhaust indication. The ECM reduces the amount of fuel delivered to the engine, causing a driveability condition.
- Verify that each injector harness is connected to the correct injector.

BOOST CONTROL SYSTEM DIAGNOSIS

DIAGNOSTIC INSTRUCTIONS

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

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- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

CIRCUIT DESCRIPTION

Supercharger boost pressure is regulated under certain conditions to prevent engine and drive train damage. When the engine is operating under high boost conditions, the engine control module (ECM) can limit boost pressure to 83 kPa (12 psi) or less.

The ECM disables boost under the following conditions:

- When reverse gear is selected.
- When an intercooler pump failure is detected.
- When the intake air temperature (IAT) sensor 2 becomes excessively high, equal to or greater than 120.5° C (248°F) boost pressure is limited to 145 kPa (7 psi). The ECM commands the boost control solenoid to 62 percent duty cycle (DC).
- When the engine coolant temperature (ECT) exceeds a predetermined threshold.
- When drivetrain abuse is detected.
- When vehicle speeds exceed 256 km/h (159 mph) in second, third and fourth gears only, after 150 seconds boost is limited to a predetermined threshold.
- When the intake cam phasers are inoperable, boost pressure is limited to 145 kPa (7 psi), ECM commands the boost control solenoid to 62 percent DC.

The ECM controls boost pressure by a pulse-width ground signal to the boost control solenoid. The boost control solenoid is a normally open valve. Under most conditions, the ECM commands the boost control solenoid to operate at a 99-100 percent DC. This keeps the boost control solenoid valve closed and allows only inlet vacuum from the supercharger plenum to the bypass valve actuator to control the position of the bypass valve. At idle, engine vacuum is applied to the upper side of the bypass valve actuator, counteracting spring tension to hold the bypass valve open. When the engine load is increased, the engine vacuum is decreased, causing the spring in the bypass valve actuator to overcome the applied vacuum, closing the bypass valve and allowing the boost pressure to increase. The bypass valve starts to close when the vacuum measure is 250 mm Hg (10 in Hg) and is fully closed at 90 mm Hg (3.5 in Hg). When reduced boost pressure is desired, the ECM commands the boost control solenoid to operate at a 0 percent DC, but may command a partial duty cycle, approximately 62 percent, depending on the operating conditions. This opens the boost control solenoid and allows boost pressure to enter the bypass valve actuator at the lower side to counteract the spring tension, opening the bypass valve and re-circulating excess boost pressure back into the supercharger inlet.

REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Description and Operation

- **Supercharger Description and Operation**

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- **Boost Control System Description**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

- **Scan Tool Data List**
- **Scan Tool Data Definitions**
- **Scan Tool Output Controls**

Special Tools Required

J 35555 Metal Mityvac. See **Special Tools** .

CIRCUIT/SYSTEM VERIFICATION

1. Review the vacuum schematics in the Boost Control System Description. Refer to **Boost Control System Description** .
2. Ignition OFF, visually and physically inspect the supercharger components for any of the following conditions:

   Inspect the vacuum lines for:

   - Cracking
   - Loose fit
   - Improper connections
   - Improper routing
3. Inspect the following components for damage and for proper connections, adjustments and installation:
   - The bypass valve actuator
   - The boost control solenoid
   - The bypass valve lever
   - The bypass valve cable - Refer to **Supercharger Cleaning and Inspection** .
4. Verify that the charge air cooler (CAC) coolant level is full.
5. Ignition ON, command the CAC coolant pump ON and OFF with a scan tool. Listen for the CAC coolant pump to turn ON and OFF with each command.
   - If the CAC coolant pump does not turn ON and OFF refer to **Supercharger Intercooler Relay Diagnosis**.
6. Engine running, command the supercharger bypass (SCB) solenoid from 0 to 90% with a scan tool. Observe the operation of the bypass valve, it should move as the DC percentages are varied.
7. Verify there are no vacuum leaks at the supercharger manifold gaskets and supercharger intake plenum.

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CIRCUIT/SYSTEM TESTING

1. Ignition OFF, disconnect the boost source hose from the boost control solenoid, connect the **J 35555** to the boost source hose. See **Special Tools** .
2. Engine running, observe the gage on the **J 35555** for a reading equal to or greater then 15 inch Hg. See **Special Tools** .
    - If less than 15 inch Hg, repair the boost vacuum source hose or the intake manifold port for a restriction or blockage.
3. Ignition OFF, connect the vacuum source hose to the boost solenoid.
4. Disconnect the boost signal hose from the bottom port of the bypass valve actuator and connect the **J 35555** to the boost signal hose. See **Special Tools** .
5. Engine running, observe the gage on the **J 35555** for a reading of 0-1 inch Hg. See **Special Tools** .
    - If greater than the specified range, replace the boost control solenoid.
6. Engine running, command the boost control solenoid to 0% DC with a scan tool. Observe the gage on the **J 35555** for a reading equal to or greater than 15 inch Hg. See **Special Tools** .
    - If less than the specified range, test the boost signal hose for a restriction or blockage. If the boost signal hose tests normal, replace the boost control solenoid.
7. Disconnect the inlet vacuum signal hose from the top of the bypass valve actuator and connect **J 35555** to the inlet vacuum signal hose. See **Special Tools** .
8. Engine running, observe the gage on the **J 35555** for a reading equal to or greater than 15 inch Hg. See **Special Tools** .
    - If less than 15 inch Hg, repair the inlet vacuum signal hose or the intake manifold port for a restriction or blockage.

COMPONENT TESTING

1. Ignition OFF, disconnect the inlet vacuum signal hose from the top of the bypass valve actuator.
2. Connect **J 35555** to the inlet vacuum signal port at the bypass valve actuator. See **Special Tools** .
3. Slowly apply 15 inch Hg of vacuum while observing the bypass valve actuator. the bypass valve actuator and cable should retract.
    - If the bypass valve actuator and cable do not retract, inspect the bypass valve and bypass valve actuator linkage for binding, sticking or damage. If the bypass valve, cable and linkage operate normally, replace the bypass valve actuator.
4. Connect the inlet vacuum signal hose to the top of the bypass valve actuator.
5. Disconnect the boost signal hose from the bottom of the bypass valve actuator and connect **J 35555** to the boost signal port on the bypass valve actuator. See **Special Tools** .
6. Start and idle the engine in park.
7. Slowly apply vacuum until you reach 20 inch Hg and observe the bypass valve actuator. The bypass valve actuator should extend.
    - If the bypass valve actuator does not extend, inspect the bypass valve and linkage for binding, sticking or damage. If the bypass valve and linkage operate normally, replace the bypass valve actuator.

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REPAIR PROCEDURES

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- **Supercharger Bypass Regulator Solenoid Valve Replacement**
- **Supercharger Bypass Valve Actuator Replacement**

SUPERCHARGER INTERCOOLER RELAY DIAGNOSIS

DIAGNOSTIC INSTRUCTIONS

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- **Strategy Based Diagnosis**
- **Diagnostic Procedure Instructions**

CIRCUIT DESCRIPTION

The supercharger intercooler relay is a normally open relay. The relay armature is held in the open position by spring tension. The ignition 1 voltage is supplied directly to the relay coil and to the armature contact when the ignition is ON or the engine is running. The engine control module (ECM) supplies the ground path to the relay coil control circuit via an internal integrated circuit called an output driver module (ODM). When the engine is running, the ECM commands the relay ON and the relay coil creates an electromagnetic field. This electromagnetic field overcomes the spring tension and pulls the armature contact into the stationary contact of the relay load circuit. The closing of the relay contacts allow current to flow from the battery to the supercharger intercooler pump. When the ignition switch is turned to the OFF position, power is interrupted to the output driver module in the ECM and the relay electromagnetic field collapses. This allows the spring tension to separate the relay armature contact from the relay load circuit contact, which interrupts current flow to the supercharger intercooler pump.

DIAGNOSTIC AIDS

- A slight resistance of 1-4 ohms on the B+ or ground circuits to the CAC coolant pump or the CAC coolant pump relay may inhibit the supercharger coolant pump operation.
- This test procedure assumes that the vehicle battery has passed a load test and is completely charged. Refer to **Battery Inspection/Test** .
- When disconnecting electrical connectors or removing fuses and relays from a fuse block, always inspect the component electrical terminals for corrosion and the mating electrical terminals for correct tension.

REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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- **Engine Control Module Connector End Views**
- **Engine Controls Connector End Views**

Description and Operation

- **Supercharger Description and Operation**
- **Boost Control System Description**

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**
- **Electrical Center Identification Views**

Scan Tool Reference

- **Scan Tool Data List**
- **Scan Tool Data Definitions**
- **Scan Tool Output Controls**

Special Tools Required

J 43244 Relay Puller Pliers

CIRCUIT/SYSTEM VERIFICATION

1. Ignition ON, command the CAC Coolant Pump ON and OFF with a scan tool. Listen for the CAC coolant pump to turn ON and OFF with each command.
2. Verify that the charge air cooler (CAC) coolant level is full. Refer to **Cooling System Leak Testing** , **Charge Air Cooling System Coolant Level Inspection** and **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .

CIRCUIT/SYSTEM TESTING

1. Ignition OFF, disconnect the CAC coolant pump relay.
2. Ignition ON, verify that a test lamp does not illuminate between the control circuit and ground.
    - If the test lamp illuminates, test the control circuit for a short to voltage.
3. Verify that a test lamp illuminates between the coil voltage supply circuit and ground.
    - If the test lamp does not illuminate, test the B+ coil supply circuit for a short to ground or an open/high resistance.
4. Verify that a test lamp illuminates between the B+ switch supply circuit and ground.

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- If the test lamp does not illuminate, test the B+ switch supply circuit for an open/high resistance. If the circuit tests normal and the B+ switch supply circuit fuse is open, test the CAC pump voltage supply circuit for a short to ground.

5. Disconnect the harness connector at the CAC coolant pump.
6. Test for less than 2 ohm of resistance between the CAC coolant pump ground circuit terminal 1 and ground.
   - If greater than the specified range, test the ground circuit for an open/high resistance.
7. Connect the harness connector at the CAC coolant pump.
8. Connect a 10A fused jumper wire between the B+ switch circuit and the CAC coolant pump voltage supply circuit. Verify that CAC coolant pump is activated.
   - If the CAC coolant pump does not activate, test the CAC coolant voltage supply circuit for an open/high resistance. If the circuit tests normal, test the CAC coolant pump motor. Refer to **Component Testing**.
9. Connect a test lamp between the B+ coil supply circuit and the CAC relay control circuit.
10. Command the CAC coolant pump ON and OFF with a scan tool. The test lamp should turn ON and OFF when changing between commanded states.
    - If the test lamp is always ON, test the control circuit for a short to ground. If the circuit tests normal, replace the ECM.
    - If the test lamp is always OFF, test the control circuit for an open/high resistance. If the circuit tests normal, replace the ECM.
11. If all circuits test normal, test the CAC coolant pump relay. Refer to **Component Testing**.

COMPONENT TESTING

Coolant Pump Relay

1. Ignition OFF, disconnect the CAC coolant pump relay.
2. Test between the normally-closed switch terminals, if any, for 0 ohms.
3. Test between the normally-open switch terminals for infinite ohms.
4. Test between each switch terminal and either coil terminal for infinite ohms.
5. Connect the relay coil terminals to ground and fused power to energize the relay.
6. Test between each switch terminal and each coil terminal for 0 volts.
7. Test between the normally-closed switch terminals, if any, for infinite ohms.
8. Test between the normally-open switch terminals for 0 ohms.
   - If the relay fails any of the above tests, replace the supercharger coolant pump relay.

CAC Pump Dynamic Test

1. Install a 10A fused jumper wire between the B+ terminal 2 and 12 volts.
2. Install a jumper wire between the ground terminal 1 and ground.
3. Observe for the CAC pump to activate.

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- If the CAC pump does not activate, replace the CAC coolant pump.

REPAIR PROCEDURES

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

- **Control Module References** for ECM replacement, setup and programming
- **Underhood Electrical Center or Junction Block Replacement**
- **Coolant Pump Replacement - Charge Air Cooler**

MALFUNCTION INDICATOR LAMP (MIL) DIAGNOSIS

DIAGNOSTIC INSTRUCTIONS

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

CIRCUIT/SYSTEM DESCRIPTION

Ignition voltage is supplied to the malfunction indicator lamp (MIL). The engine control module (ECM) turns the MIL ON by applying a ground to the MIL control circuit.

REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

- **Engine Control Module Connector End Views**
- **Engine Controls Connector End Views**

Electrical Information Reference

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

Scan Tool Reference

- **Scan Tool Data List**

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- **Scan Tool Data Definitions**
- **Scan Tool Output Controls**

CIRCUIT/SYSTEM VERIFICATION

1. Ignition ON, the MIL should turn ON and OFF when commanded with a scan tool.
2. Ignition ON, observe the scan tool MIL Circuit Status parameter. The reading should indicate Incomplete and continue to indicate Incomplete when commanding the MIL ON and OFF.

CIRCUIT/SYSTEM TESTING

1. Ignition OFF, disconnect the harness at the instrument panel cluster (IPC).
2. Ignition ON, verify that a test lamp illuminates between the ignition circuit and ground.
    - If the test lamp does not illuminate, test the ignition circuit for a short to ground or an open/high resistance. If the circuit tests normal and the ignition circuit fuse is open, replace the IPC.
3. Connect a test lamp between the control circuit and the ignition circuit.
4. Command the MIL ON and OFF with a scan tool. The test lamp should turn ON and OFF when changing between the commanded states.
    - If the test lamp is always ON, test the control circuit for a short to ground. If the circuit tests normal, replace the ECM.
    - If the test lamp is always OFF, test the control circuit for a short to voltage or an open/high resistance. If the circuit tests normal, replace the ECM.
5. If all circuits test normal, replace the IPC.

REPAIR PROCEDURES

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- **Instrument Cluster Replacement**
- **Control Module References** for instrument panel cluster replacement, setup and programming

ENGINE CRANKS BUT DOES NOT RUN

DIAGNOSTIC INSTRUCTIONS

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- **Strategy Based Diagnosis**
- **Diagnostic Procedure Instructions**

CIRCUIT/SYSTEM DESCRIPTION

This Engine Cranks but Does Not Run is an organized approach to identify a condition which causes the engine to crank but not start. This diagnostic directs the technician to the appropriate system diagnosis.

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This diagnostic assumes the system voltage levels are adequate for starter motor operation. Refer to **Battery Inspection/Test** and **Engine Cranks Slowly** . Fuel level and fuel quality should be determined for correct diagnosis.

REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

- **Engine Control Module Connector End Views**
- **Engine Controls Connector End Views**

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**
- **Starting System Description and Operation**

Scan Tool Reference

Scan Tool Data List

Special Tools Required

J 34730-1A Fuel Pressure Gage. See **Special Tools** .

CIRCUIT/SYSTEM VERIFICATION

Attempt to start the engine. The engine should start and run.

CIRCUIT/SYSTEM TESTING

1. Crank the engine for up to 30 seconds.
2. Observe the Engine DTC information with a scan tool.
    - If DTCs P0033, P0102, P0171, P0201-P0208, P0230, P0335, P0336, P0340, P0403, P0404, P0443, P0601, P0602, P0603, P0604, P0606, P0607, P060D, P062F, P0641, P0651, P0685, P0689, P0690, P1516, P1682, P2610 are set, refer to **Diagnostic Trouble Code (DTC) List - Vehicle** to diagnose those DTCs.
3. Install a spark tester.
4. Crank the engine for 15 seconds. Spark should be observed from the Spark Tester.

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- If spark is not observed refer to **Electronic Ignition (EI) System Diagnosis**.

IMPORTANT: Additional DTCs may set when using the fuel pump output control.

5. Command the fuel pump ON and OFF. Fuel pump should energize when commanded ON and De-energize when commanded OFF
   - If the fuel pump does not respond refer to **Fuel System Diagnosis**.
6. Turn OFF the ignition.
7. Install the **J 34730-1A** Fuel Pressure Gage. See **Special Tools** . Turn ON the ignition and command the fuel pump ON while observing the **J 34730-1A** . See **Special Tools** . Refer to **Fuel Pressure Gage Installation and Removal** . The fuel pressure should be between 384-425 kPa (55-61 psi).
   - If the fuel pressure is not within 384-425 kPa (55-61 psi), refer to **Fuel System Diagnosis**.
8. Inspect for the following conditions:
   - Compare the actual engine coolant temperature to the ECT parameter.
   - Air filter and air intake system for restrictions and obstructions
   - Test the fuel for contamination. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
   - Inspect the spark plugs. Refer to **Spark Plug Inspection** .
   - Test the exhaust system for restrictions. Refer to **Restricted Exhaust** .
   - Engine mechanical conditions such as worn timing chain gears, low compression, etc. - Refer to **Engine Compression Test** .

REPAIR PROCEDURES

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

FUEL PUMP ELECTRICAL CIRCUIT DIAGNOSIS

DIAGNOSTIC INSTRUCTIONS

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

DIAGNOSTIC FAULT INFORMATION

Fuel Pump Electrical Circuit Diagnosis

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Battery Voltage - Relay Switch Side	1	2	-	-
Fuel Pump Supply Voltage	1	2	3	-
Fuel Pump Relay Control	P0230	P0230	P0230	-

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Fuel Pump Relay Ground	P0230	P0230	P0230	-
Fuel Pump Ground	-	[2]	-	-

[1] Open fuel pump fuse, cranks no start
[2] Cranks no start
[3] Fuel pump operates continuously, then discharged battery

CIRCUIT/SYSTEM DESCRIPTION

The control module enables the fuel pump relay when the ignition switch is turned ON. The control module will disable the fuel pump relay within 2 seconds unless the control module detects ignition reference pulses. The control module continues to enable the fuel pump relay as long as ignition reference pulses are detected. The control module disables the fuel pump relay within 2 seconds if ignition reference pulses cease to be detected and the ignition remains ON.

DIAGNOSTIC AIDS

The following conditions may cause the fuel pump fuse to open:

- The fuse is faulty.
- There is an intermittent short to ground in the supply voltage circuit of the fuel pump.
- The fuel pump has an intermittent internal condition.

REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

- **Engine Control Module Connector End Views**
- **Engine Controls Connector End Views**
- **Electrical Center Identification Views**

Electrical Information Reference

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

Scan Tool Reference

- **Scan Tool Data List**

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- **Scan Tool Data Definitions**
- **Scan Tool Output Controls**

Special Tools Required

J 43244 Relay Puller Pliers

CIRCUIT/SYSTEM VERIFICATION

With the ignition ON, engine OFF, command the fuel pump relay ON and OFF several times using the scan tool output control function. You should either hear or feel the relay click and the fuel pump should turn ON and OFF with each command.

- If the fuel pump operates continuously, test for a faulty relay or a short to voltage in the supply voltage circuit of the fuel pump.

CIRCUIT/SYSTEM TESTING

1. With the ignition OFF, remove the fuel pump relay from the electrical center.
2. With the ignition ON, engine OFF, probe the control circuit of the fuel pump relay with a test lamp that is connected to a good ground. Command the fuel pump relay ON and OFF with a scan tool. The test lamp should turn ON and OFF with each command.
    - If the test lamp does not turn ON and OFF, test for an open or a short to ground in the fuel pump relay control circuit, an intermittent or a poor connection at the engine control module (ECM) or a faulty ECM.
    - If the test lamp remains illuminated with each command, test for a short to voltage in the control circuit of the fuel pump relay, an intermittent or a poor connection at the ECM or a faulty ECM.
3. Connect a test lamp between the control circuit of the fuel pump relay and the ground circuit of the fuel pump relay. Command the fuel pump relay ON and OFF with a scan tool.
    - If the test lamp does not turn ON and OFF, repair the open or the high resistance in the ground circuit of the fuel pump relay.
    - If the test lamp does turn ON and OFF, test for an intermittent and for a poor connection at the fuel pump relay or a faulty fuel pump relay.
4. Inspect the fuel pump fuse.
    - If the fuel pump fuse is open, test for a short to ground in the supply voltage circuit of the fuel pump or a faulty fuel sender.
5. With the ignition ON, engine OFF, probe the battery positive voltage circuit of the fuel pump relay with a test lamp that is connected to a good ground.
    - If the test lamp does not illuminate, repair the open in the battery positive voltage circuit.
6. Connect a 15A fused jumper wire between the battery positive voltage circuit of the fuel pump relay and the supply voltage circuit of the fuel pump.
    - If the fuel pump operates, test for an intermittent or poor connection at the fuel pump relay or a faulty fuel pump relay.

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- If the fuel pump does not operate, test for an open or high resistance in the supply voltage circuit of the fuel pump, an open or high resistance in the ground circuit of the fuel pump, an intermittent or poor connection at the fuel sender cover or a faulty fuel sender.

REPAIR PROCEDURES

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- **Control Module References** for ECM replacement, setup and programming
- **Fuel Tank Module Replacement - Left Side**

FUEL SYSTEM DIAGNOSIS

DIAGNOSTIC INSTRUCTIONS

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- **Strategy Based Diagnosis**
- **Diagnostic Procedure Instructions**

CIRCUIT/SYSTEM DESCRIPTION

The control module enables the fuel pump relay when the ignition switch is turned ON. The control module will disable the fuel pump relay within 2 seconds unless the control module detects ignition reference pulses. The control module continues to enable the fuel pump relay as long as ignition reference pulses are detected. The control module disables the fuel pump relay within 2 seconds if ignition reference pulses cease to be detected and the ignition remains ON.

The fuel system is a semi-returnless design. The fuel pressure regulator is a part of the fuel sender assembly, eliminating the need for a return pipe from the engine. A semi-returnless fuel system reduces the internal temperature of the fuel tank by not returning hot fuel from the engine to the fuel tank. Reducing the internal temperature of the fuel tank results in lower evaporative emissions.

The fuel tank stores the fuel supply. The fuel pump is an electric pump that is attached to the primary fuel tank module assembly. The fuel pump also supplies fuel to the siphon jet pump, also attached to the primary fuel tank module. The siphon jet pump draws fuel from the secondary side of the fuel tank to the primary side of the fuel tank. The fuel pump is designed to provide fuel at a pressure above the pressure that is needed by the fuel injectors. A fuel pressure regulator which is also located in the fuel tank, is attached to the primary fuel tank module. The fuel pressure regulator keeps the fuel available to the fuel injectors at a regulated pressure. Unused fuel is returned from the fuel filter to the fuel tank by a separate fuel return pipe.

REFERENCE INFORMATION

Electrical Information Reference

- **Circuit Testing**

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

Scan Tool Reference

- **Scan Tool Data List**
- **Scan Tool Data Definitions**
- **Scan Tool Output Controls**

Special Tools Required

- **CH-48027** Digital Fuel Pressure Gage. See **Special Tools** .
- **J 37287** Fuel Line Shut-off Adapter. See **Special Tools** .

CIRCUIT/SYSTEM VERIFICATION

1. Turn OFF the ignition.
2. Relieve the fuel pressure. Refer to **Fuel Pressure Relief** .
3. Disconnect the chassis fuel hose from the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
4. Install the **J 37287** between the chassis fuel hose and the fuel rail. See **Special Tools** .
5. Open the valve on the **J 37287** . See **Special Tools** .
6. Turn ON the ignition, with the engine OFF.
7. Command the fuel pump relay ON with a scan tool.
8. Bleed the air from the **CH-48027** . See **Special Tools** .
9. Command the fuel pump relay ON and then OFF with a scan tool.
10. Close the fuel feed pipe shut-off valve.
11. Monitor the **CH-48027** for one minute. See **Special Tools** .
    - If the fuel pressure remains constant, replace the fuel sender assembly.
    - If the fuel pressure does not remain constant, locate and replace the leaking fuel injectors.

CIRCUIT/SYSTEM TESTING

IMPORTANT:

- **Inspect the fuel system for damage or external leaks before proceeding.**
- **Verify that adequate fuel is in the fuel tank before proceeding.**

1. Turn ON the ignition, with the engine OFF.
2. Command the fuel pump relay ON with a scan tool.
    - If the fuel pump does not operate, refer to **Fuel Pump Electrical Circuit Diagnosis**.

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3. Turn OFF the ignition.
4. Turn OFF all accessories.
5. Install a **CH-48027** . See **Special Tools** . Refer to **Fuel Pressure Gage Installation and Removal** .
6. Turn ON the ignition, with the engine OFF.

IMPORTANT:

- **The fuel pump relay may need to be commanded ON a few times in order to obtain the highest possible fuel pressure.**
- **DO NOT start the engine.**

7. Command the fuel pump relay ON with a scan tool.
8. Observe the **CH-48027** with the fuel pump commanded ON. See **Special Tools** . The fuel pressure should be 380-410 kPa (55-60 psi).
    - If the fuel pressure is less than 380 kPa (55 psi), inspect for a restricted fuel feed pipe, poor connections at the harness connectors and ground circuits of the fuel pump or a faulty fuel sender assembly.
    - If the fuel pressure is more than 410 kPa (60 psi), replace the fuel sender assembly.

IMPORTANT: The fuel pressure may vary slightly when the fuel pump stops operating. After the fuel pump stops operating, the fuel pressure should stabilize and remain constant.

9. Monitor the **CH-48027** for 1 minute. See **Special Tools** . The fuel pressure should not decrease more than 34 kPa (5 psi).
    - If the fuel pressure decreases more than 34 kPa (5 psi), refer to **Circuit/System Testing**.
10. Relieve the fuel pressure to 69 kPa (10 psi).
11. Monitor the **CH-48027** for 5 minutes. See **Special Tools** . The fuel pressure should not decrease more than 14 kPa (2 psi).
    - If the fuel pressure decreases more than 14 kPa (2 psi), replace the fuel sender assembly.
12. Remove the **CH-48027** . See **Special Tools** . Refer to **Fuel Pressure Gage Installation and Removal** .
13. Operate the vehicle within the conditions to reproduce the original symptoms.
14. Monitor the O2 and the Fuel Trim parameters with a scan tool.
    - If the scan tool parameters indicate a lean condition, inspect for a restricted fuel feed pipe, poor connections at the harness connectors and ground circuits of the fuel pump or a faulty fuel sender assembly.
    - If the scan tool parameters do not indicate a lean condition, go to **Symptoms - Engine Controls**.

REPAIR PROCEDURES

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- **Fuel Injector and Fuel Rail Replacement**

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- **Fuel Tank Module Replacement - Left Side**

FUEL INJECTOR DIAGNOSIS (W/J39021 OR W/TECH 2)

DIAGNOSTIC INSTRUCTIONS

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

CIRCUIT/SYSTEM DESCRIPTION

The control module enables the appropriate fuel injector pulse for each cylinder. The ignition voltage is supplied directly to the fuel injectors. The control module controls each fuel injector by grounding the control circuit via a solid state device called a driver. A fuel injector coil winding resistance that is too high or too low will affect the engine driveability. A fuel injector control circuit DTC may not set, but a misfire may be apparent. The fuel injector coil windings are affected by temperature. The resistance of the fuel injector coil windings will increase as the temperature of the fuel injector increases.

When performing the fuel injector balance test, the scan tool is first used to energize the fuel pump relay. The fuel injector tester or the scan tool is then used to pulse each injector for a precise amount of time, allowing a measured amount of the fuel to be injected. This causes a drop in the system fuel pressure that can be recorded and used to compare each injector.

DIAGNOSTIC AIDS

- Monitoring the misfire current counters or misfire graph, may help to isolate the fuel injector that is causing the condition.
- Operating the vehicle over a wide temperature range may help isolate the fuel injector that is causing the condition.
- Perform the fuel injector coil test within the conditions of the customer's concern. A fuel injector condition may only be apparent at a certain temperature or under certain conditions.

REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

- **Engine Control Module Connector End Views**
- **Engine Controls Connector End Views**

Electrical Information Reference

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

Scan Tool Reference

- **Scan Tool Data List**
- **Scan Tool Data Definitions**
- **Scan Tool Output Controls**

Special Tools Required

- **CH-48027** Digital Pressure Gage. See **Special Tools** .
- **J 39021** Fuel Injector Coil and Balance Tester. See **Special Tools** .
- **J 44602** Injector Test Adapter. See **Special Tools** .

COMPONENT TESTING

Fuel Injector Coil Test

Verify the resistance of each fuel injector with one of the following methods:

- If the engine coolant temperature (ECT) sensor is between 10-32°C (50-90°F), the resistance of each fuel injector should be 11-14 ohms.
  - If the injectors measure OK, perform the AFIT Test Procedure.
  - If not within the specified range, replace the fuel injector.
- If the ECT sensor is not between 10-32°C (50-90°F), measure and record the resistance of each fuel injector with a DMM. Subtract the lowest resistance value from the highest resistance value. The difference between the lowest value and the highest value should be equal to or less than 3 ohms.
  - If the difference is equal to or less than 3 ohms, perform the AFIT Test Procedure.
  - If the difference is more than 3 ohms, add all of the fuel injector resistance values to obtain a total resistance value. Divide the total resistance value by the number of fuel injectors to obtain an average resistance value. Subtract the lowest individual fuel injector resistance value from the average resistance value. Compute the difference between the highest individual fuel injector resistance value and the average resistance value. Replace the fuel injector that displays the greatest resistance difference above or below the average.

IMPORTANT:

- **DO NOT perform this test if the engine coolant temperature (ECT) is above 94°C (201°F). Irregular fuel pressure readings may result due to hot soak fuel boiling.**
- **Verify that adequate fuel is in the fuel tank before proceeding with this diagnostic.**

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- **Before proceeding with this test review the User Manual CH 48027-5 for Safety Information and Instructions.**

Fuel Injector Balance Test-Fuel Pressure Test

1. Install a fuel pressure gage. Refer to **Fuel Pressure Gage Installation and Removal** .
2. Turn ON the ignition, with the engine OFF.

IMPORTANT:

- **The fuel pump relay may need to be commanded ON a few times in order to obtain the highest possible fuel pressure.**
- **DO NOT start the engine.**

3. Command the fuel pump relay ON with a scan tool.
4. Observe the fuel pressure gage with the fuel pump commanded ON. The fuel pressure should be 380-414 kPa (55-60 psi).
   - If the fuel pressure is not 380-414 kPa (55-60 psi), refer to **Fuel System Diagnosis**.
5. Monitor the fuel pressure gage for one minute. The fuel pressure should not decrease more than 34 kPa (5 psi).
   - If the fuel pressure decreases more than 34 kPa (5 psi), refer to **Fuel System Diagnosis**.
6. Perform the Fuel Injector Balance Test with Special Tool or the Fuel Injector Balance Test with Tech 2.

Fuel Injector Balance Test with Special Tool

1. Set the amperage supply selector switch on the fuel injector tester to the Balance Test 0.5-2.5 amp position.
2. Connect the **J 39021** to a fuel injector with a **J 44602** . See **Special Tools** .
3. Command the fuel pump relay ON and then OFF three times with a scan tool. On the last command, as the fuel pressure begins to slowly degrade and stabilize, select a fuel pressure within 34 kPa (5 psi) of the maximum pump pressure. Record this fuel pressure. This is the starting pressure at which you will pulse each injector.
4. Command the fuel pump relay ON one more time and energize the fuel injector by depressing the Push to Start Test button on the **J 39021** at the previously selected pressure. See **Special Tools** .
5. After the injector stops pulsing, select Min from the Display Mode and record the Min pressure.

IMPORTANT: New test results will not be recorded if the Min/Max results are not cleared after each injector is tested.

6. Clear the Min/Max results.
7. Select Normal from the Display Mode.
8. Repeat steps 2 and 4 through 7 for each fuel injector.
9. Perform the Pressure Drop Calculation.

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Fuel Injector Balance Test with Tech 2

1. Command the fuel pump relay ON and then OFF three times with a scan tool. On the last command, as the fuel pressure begins to slowly degrade and stabilize, select a fuel pressure within 34 kPa (5 psi) of the maximum pump pressure. Record this fuel pressure. This is the starting pressure at which you will pulse each injector.
2. With a scan tool, select the Fuel Injector Balance Test function within the Special Functions menu.
3. Select an injector to be tested.
4. Press Enter to prime the fuel system.
5. Energize the fuel injector by depressing the Pulse Injector button on the scan tool at the previously selected pressure.
6. After the injector stops pulsing, select Min from the Display Mode on the **CH-48027** and record the Min pressure. See **Special Tools** .

IMPORTANT: New test results will not be recorded if the Min/Max results are not cleared after each injector is tested.

7. Clear the Min/Max results on the **CH-48027** . See **Special Tools** .
8. Select Normal from the Display Mode on the **CH-48027** . See **Special Tools** .
9. Press Enter on the scan tool to bring you back to the Select Injector screen.
10. Repeat steps 3 through 9 for each fuel injector.
11. Perform the Pressure Drop Calculation.

Pressure Drop Calculation

1. Subtract the minimum pressure from the starting pressure for one fuel injector. The result is the pressure drop value.
2. Obtain a pressure drop value for each fuel injector.
3. Add all of the individual pressure drop values except for the injector suspected of being faulty. This is the total pressure drop.
4. Divide the total pressure drop by the number of fuel injectors that were added together. This is the average pressure drop. The difference between any individual pressure drop and the average pressure drop should not be more than 20 kPa (3 psi).
    - If the difference between any individual pressure drop and the average pressure drop is more than 20 kPa (3 psi), replace the fuel injector.

REPAIR PROCEDURES

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

Fuel Injector and Fuel Rail Replacement

FUEL INJECTOR DIAGNOSIS (W/CH47976)

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DIAGNOSTIC INSTRUCTIONS

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

CIRCUIT/SYSTEM DESCRIPTION

The control module enables the appropriate fuel injector pulse for each cylinder. The ignition voltage is supplied directly to the fuel injectors. The control module controls each fuel injector by grounding the control circuit via a solid state device called a driver. A fuel injector coil winding resistance that is too high or too low will affect the engine driveability. A fuel injector control circuit DTC may not set, but a misfire may be apparent. The fuel injector coil windings are affected by temperature. The resistance of the fuel injector coil windings will increase as the temperature of the fuel injector increases.

The **CH-47976** Active Fuel Injector Tester (AFIT) is used to test the fuel pump, fuel system leak down and the fuel injectors. Following the User Guide, CH 47976-11 and the on screen prompts or selections, will indicate the steps required to perform each of the available tests. The tester will perform all of the tests automatically and display results of the test. The results can also be down loaded for storage and printing.

REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

- **Engine Control Module Connector End Views**
- **Engine Controls Connector End Views**

Electrical Information Reference

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

Special Tools Required

CH-47976 Active Fuel Injector Tester (AFIT)

COMPONENT TESTING

Fuel Injector Coil Test

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Verify the resistance of each fuel injector with one of the following methods:

- If the engine coolant temperature (ECT) sensor is between 10-32°C (50-90°F), the resistance of each fuel injector should be 11-14 ohms.
  - If the resistance of any fuel injector is not 11-14 ohms, replace the fuel injector.
- If the ECT sensor is not between 10-32°C (50-90°F), measure and record the resistance of each fuel injector with a DMM. Subtract the lowest resistance value from the highest resistance value. The difference between the lowest value and the highest value should be equal to or less than 3 ohms.
  - If the difference is equal to or less than 3 ohms, refer to **AFIT Test Procedure** for further diagnosis of the fuel injectors.
  - If the difference is more than 3 ohms, add all of the fuel injector resistance values to obtain a total resistance value. Divide the total resistance value by the number of fuel injectors to obtain an average resistance value. Subtract the lowest and the highest individual fuel injector resistance values from the average resistance value. Replace the fuel injector that displays the greatest resistance difference above or below the average.

AFIT Test Procedure

IMPORTANT: DO NOT perform this test if the engine coolant temperature (ECT) is above 94° C (201°F). Irregular fuel pressure readings may result due to hot soak fuel boiling.

IMPORTANT: Verify that adequate fuel is in the fuel tank before proceeding with this diagnostic.

1. Turn OFF all accessories.
2. Turn OFF the ignition.
3. Install the AFIT. Refer to the AFIT User Guide.
4. Turn ON the AFIT and select the vehicle.
5. Turn ON the ignition and perform the Injector Test.
   - If the AFIT aborts testing due to fuel pressure or fuel leak down, refer to **Fuel System Diagnosis**.
6. View the test results.
   - If any injector exceeds the recommended tolerance, replace the injector(s).

REPAIR PROCEDURES

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

Fuel Injector and Fuel Rail Replacement

ALCOHOL/CONTAMINANTS-IN-FUEL DIAGNOSIS

DIAGNOSTIC INSTRUCTIONS

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

TEST DESCRIPTION

Water contamination in the fuel system may cause driveability conditions such as hesitation, stalling, no start or misfires in one or more cylinders. Water may collect near a single fuel injector at the lowest point in the fuel injection system and cause a misfire in that cylinder. If the fuel system is contaminated with water, inspect the fuel system components for rust or deterioration.

Ethanol concentrations of greater than 10 percent can cause driveability conditions and fuel system deterioration. Fuel with more than 10 percent ethanol could result in driveability conditions such as hesitation, lack of power, stalling or no start. Excessive concentrations of ethanol used in vehicles not designed for it may cause fuel system corrosion, deterioration of rubber components and fuel filter restriction.

REFERENCE INFORMATION

Special Tools Required

J 44175 Fuel Composition Tester. See **Special Tools** .

SYSTEM VERIFICATION

The fuel sample should be drawn from the bottom of the tank so that any water present in the tank will be detected. The sample should be bright and clear.

- If the sample appears cloudy or contaminated with water, as indicated by a water layer at the bottom of the sample, perform the Particulate Contaminants in Fuel Testing Procedure.
- If alcohol contamination is suspected, perform the Alcohol in Fuel Testing procedure.

ALCOHOL IN FUEL TESTING WITH SPECIAL TOOL

1. Test the fuel composition using **J 44175** and Instruction Manual. See **Special Tools** .
2. If water appears in the fuel sample, clean the fuel system.
3. Subtract 50 from the reading on the DMM in order to obtain the percentage of alcohol in the fuel sample.
4. If the fuel sample contains more than 15 percent ethanol, add fresh, regular gasoline to the vehicle's fuel tank.
5. Test the fuel composition.
6. If testing shows the ethanol percentage is still more than 15 percent, replace the fuel in the vehicle.

ALCOHOL IN FUEL TESTING WITHOUT SPECIAL TOOL

1. Using a 100 ml (3.38 oz.) specified cylinder with 1 ml (0.034 oz.) graduation marks, fill the cylinder with

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fuel to the 90 ml (3.04 oz.) mark.

2. Add 10 ml (0.34 oz.) of water in order to bring the total fluid volume to 100 ml (3.38 oz.) and install a stopper.
3. Shake the cylinder vigorously for 10-15 seconds.
4. Carefully loosen the stopper in order to release the pressure.
5. Re-install the stopper and shake the cylinder vigorously again for 10-15 seconds.
6. Put the cylinder on a level surface for approximately 5 minutes in order to allow adequate liquid separation. If alcohol is present in the fuel, the volume of the lower layer, which would now contain both alcohol and water, will be more than 10 ml (0.34 oz.). For example, if the volume of the lower layer is increased to 15 ml (0.51 oz.), this indicates at least 5 percent alcohol in the fuel. The actual amount of alcohol may be somewhat more because this procedure does not extract all of the alcohol from the fuel.

PARTICULATE CONTAMINANTS IN FUEL TESTING PROCEDURE

1. Using an approved fuel container, draw approximately 0.5 liter (0.53 qt) of fuel.
2. Place the container on a level surface for approximately 5 minutes in order to allow settling of the particulate contamination. Particulate contamination will show up in various shapes and colors. Sand will typically be identified by a white or light brown crystals. Rubber will appear as black and irregular particles.
3. Observe the fuel sample. If any physical contaminants or water are present, clean the fuel system.

REPAIR PROCEDURES

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

Alcohol/Contaminants-in-Fuel Diagnosis

ELECTRONIC IGNITION (EI) SYSTEM DIAGNOSIS

DIAGNOSTIC INSTRUCTIONS

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

CIRCUIT/SYSTEM DESCRIPTION

The ignition system uses individual ignition coil/module assemblies for each cylinder. The engine control module (ECM) controls the individual coils by transmitting timing pulses on the ignition control (IC) circuit of each ignition coil/module to enable a spark event. Each ignition coil/module has the following circuits:

- An ignition voltage circuit
- A ground circuit
- An IC control circuit

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- A low reference circuit

REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

- **Engine Controls Connector End Views**
- **Engine Control Module Connector End Views**

Electrical Information Reference

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

Scan Tool Reference

- **Scan Tool Data List**
- **Scan Tool Output Controls**

Special Tools Required

J 26792 Spark Tester. See **Special Tools** .

CIRCUIT/SYSTEM VERIFICATION

Observe the Engine Controls Schematic for the ignition coils/modules and review the Ignition System Specifications to verify the following:

- The ignition coil/modules are correctly connected
- The proper firing order
- The proper spark plug type
- The proper spark plug gap and torque

Refer to **Ignition System Specifications** .

CIRCUIT/SYSTEM TESTING

IMPORTANT: Verify that the engine is in good mechanical condition before continuing with

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this diagnostic.

1. Turn OFF the ignition.
2. Inspect the fuse that supplies voltage to the ignition coil/modules.
   - If the fuse is open, then test the spliced circuits and the individual ignition coil/modules for a short to ground.
3. Disconnect the affected ignition coil/module.
4. Connect a test lamp between the ignition coil/module ignition 1 voltage circuit and a good ground.
5. With the test lamp still connected, measure for battery voltage between the ignition 1 voltage circuit and a good ground.
   - If the voltage is not within 1 volt of battery voltage, repair the high resistance or the open in the ignition 1 voltage circuit.
6. Turn OFF the ignition and all electrical accessories. Allow sufficient time for all of the control modules to power down before taking a resistance measurement.
7. Measure for a proper value of less than 5 ohms of resistance between the ground circuit of the affected ignition coil/module and a good ground.
   - If the resistance is more than 5 ohms, repair the high resistance or the open in the ground circuit.
8. Exchange the affected ignition coil/module with the ignition coil/module of a good cylinder.
9. Start the engine and observe the scan tool.
   - If the misfire transfers with the suspect ignition coil/module, replace as needed.
   - If the misfire does not transfer with the suspect ignition coil/module, observe the component testing procedures below and replace the spark plug if needed.

COMPONENT TESTING

- Use the Spark Plug Inspection procedure to verify the integrity of the spark plugs. Refer to **Spark Plug Inspection** .
- Use the **J 26792** Spark Tester to verify the output of each ignition coil/module. See **Special Tools** .

REPAIR PROCEDURES

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- **Ignition Coil Replacement - Bank 1**
- **Ignition Coil Replacement - Bank 2**
- **Spark Plug Replacement**

INSPECTION/MAINTENANCE (I/M) SYSTEM CHECK

DIAGNOSTIC INSTRUCTIONS

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

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- **Strategy Based Diagnosis**
- **Diagnostic Procedure Instructions**

DESCRIPTION

Several states require that a vehicle pass on-board diagnostic (OBD) system tests and the inspection/maintenance (I/M) emission inspection in order to renew vehicle registration. This is accomplished by viewing the I/M System Status display on a scan tool. Using a scan tool, the technician can observe the I/M System Status in order to verify that the vehicle meets the criteria that comply with the local area requirements.

CONDITIONS FOR UPDATING THE I/M SYSTEM STATUS

Each system monitor requires at least one and sometimes several diagnostic tests. The result of each test is reported by a diagnostic trouble code (DTC). A system monitor is complete when either all of the DTCs composing the monitor have Run and Passed or when any one of the DTCs comprising the monitor has illuminated the malfunction indicator lamp (MIL). Once the system monitor is complete, the I/M System Status display will indicate YES in the Completed column.

For example, when the HO2S Heater Status indicates YES, either all of the oxygen sensor heater tests have passed or one of the tests has illuminated the MIL. If the vehicle has four heated oxygen sensors, either all four heater circuit tests have passed or one of the heater circuit tests has illuminated the MIL. The I/M System Status will indicate NO under the Completed column when any of the required tests for that system have not run. The following is a list of conditions that would set the I/M System Status indicator to NO:

- The vehicle is new from the factory and has not yet been driven through the necessary drive conditions to complete the tests.
- The battery has been disconnected or discharged below operating voltage.
- The control module power or ground has been interrupted.
- The control module has been reprogrammed.
- The control module DTCs have been cleared.

MONITORED EMISSION CONTROL SYSTEMS

The OBD II System monitors all emission control systems that are on-board. The OBD II regulations require monitoring of the following:

- The air conditioning system
- The catalytic converter efficiency
- Comprehensive component monitoring-Emission related inputs and outputs
- The evaporative emission (EVAP) system
- The fuel delivery system
- Heated catalyst monitoring
- Misfire monitoring

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- The oxygen sensor system (O2S or HO2S)
- The oxygen sensor heater system (HO2S heater)
- The AIR system

For the specific DTCs required for each system, refer to **Inspection/Maintenance (I/M) System DTC Table** . Systems such as fuel delivery, misfire and comprehensive components may not be listed in a system status list. These tests run continuously and do not require an I/M System Status indicator.

CIRCUIT/SYSTEM VERIFICATION

Review the I/M System Status indicators. All I/M System Status indicators should report YES.

CIRCUIT/SYSTEM TESTING

IMPORTANT: Many DTC related repairs will instruct the technician to clear the DTC information. Clearing the DTC will reset the I/M System Status indicators to NO. Performing the I/M Complete System Set Procedure will set each of the I/M System Status indicators to YES.

1. Observe the Engine DTC information with a scan tool.
   - If a DTC is set that would prevent the I/M System Status tests from completing, diagnose that DTC before continuing. Refer to **Inspection/Maintenance (I/M) System DTC Table** .
2. Review applicable service bulletins for software updates that would prevent the I/M System Status tests from completing.
   - If a control module re-program or other repair is required, perform the **Inspection/Maintenance (I/M) Complete System Set Procedure**.
3. Observe the I/M System Status indicators.
   - If any I/M System Status indicators report NO, perform the **Inspection/Maintenance (I/M) Complete System Set Procedure**.

INSPECTION/MAINTENANCE (I/M) COMPLETE SYSTEM SET PROCEDURE

DIAGNOSTIC INSTRUCTIONS

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

DESCRIPTION

The purpose of the inspection/maintenance (I/M) complete system set procedure is to satisfy the enable criteria necessary to execute all of the I/M readiness diagnostics and complete the trips for those particular diagnostics. When all I/M monitored diagnostic tests are completed, the I/M system status indicators are set to YES.

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Perform the I/M complete system set procedure if any I/M system status indicators are set to NO.

CONDITIONS FOR MEETING A COLD START

- The ignition voltage between 11-18 volts.
- The barometric pressure (BARO) is more than 75 kPa.
- The start-up engine coolant temperature (ECT) is between 4-30°C (39-86°F).
- The start-up intake air temperature (IAT) is between 4-30°C (39-86°F).
- The difference between the IAT and the ECT is 6°C (10.8°F).
- The ambient air temperature is between 4-30°C (39-86°F).
- Fuel level is between 15-85 percent.
- Vehicle has NOT been refueled since the last cold start ignition cycle

CIRCUIT/SYSTEM VERIFICATION

Review the Inspection/Maintenance (I/M) System Status indicators. All I/M System Status indicators should report YES.

INSPECTION/MAINTENANCE (I/M) SYSTEM SET PROCEDURE

IMPORTANT: Whenever the ignition is turned ON, ignition positive voltage is supplied to the heated oxygen sensor (HO2S) heaters. After verifying the enable criteria, turn OFF the ignition for approximately 5 minutes to allow the sensors to cool before continuing with the test. Once the engine is started, do NOT turn the engine OFF for the remaining portion of the set procedure.

1. Ensure that the vehicle meets the conditions for a cold start listed above.
    - If the EVAP I/M System Status indicator displays NO, perform the EVAP Service bay test if applicable.
    - If the EVAP Service bay test is NOT available, it may take up to 6 drive cycles, with 17 hours between drive cycles for the EVAP I/M System Status Indicator to transition to YES.

      The EVAP I/M System Status indicator requires several drive and 17 hour key OFF cycles to complete before the indicator will transition.

    - If the O2S Heater System Status indicator displays NO, ensure that the ignition has been turned OFF for at least 10 hours.
2. Turn OFF all accessories; HVAC system, other electrical loads, including aftermarket/add-on equipment, etc. and open the hood.
3. Set the vehicle parking brake and ensure the vehicle is in park for automatic transmission or neutral for manual transmission.
4. Turn the ignition ON with the engine OFF for 1 minute.

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5. Start and idle the engine for 2 minutes and until 65°C (149°F) is achieved.
6. Run the engine for 6.5 minutes within the following conditions:
   - MAF parameter between 4-30 g/s
   - Engine speed steady between 1,000-3,000 RPM
7. Return the engine to idle for 1 minute.
8. Apply and hold brake pedal and shift to Drive for automatic or apply clutch pedal for manual and operate the vehicle within the following conditions for 2 minutes:
   - Depress the accelerator pedal until TP Sensor angle is more than 2 percent.
   - MAF signal between 15-30 g/s
   - RPM steady between 1,200-2,000 RPM

IMPORTANT: Do NOT touch the accelerator pedal until told to do so. A change in TP Sensor angle or an increase in engine speed may invalidate this portion of the test.

9. Release the accelerator pedal and shift the vehicle to Park for automatic or Neutral and release clutch pedal for manual and allow the engine to idle for 2 minutes.
10. Quickly depress the accelerator pedal until TP Sensor Angle is more than 8 percent and return to idle, repeat 3 times.
11. Allow engine to idle for at least 2 minutes.

CAUTION: Refer to Road Test Caution .

12. Close the hood, release the parking brake and drive vehicle at 24 km/h (15 mph) or slower for 2 minutes.
13. Continue to drive the vehicle for at least 5.5 miles between 45-112 km/h (28-70 mph) with the vehicle reaching at least 80 km/h (50 mph).
14. Release the accelerator pedal for at least 3 seconds. This will allow the vehicle to enter the decel fuel cut off. Repeat 4 more times.
15. Depress the accelerator pedal until the TP Sensor angle is between 3-20 percent and maintain for 1 minute.
16. Safely stop the vehicle, with the engine in drive for automatic or neutral with the clutch pedal depressed and parking brake applied for manual. Allow the vehicle to idle for 2 minutes.

IMPORTANT: Do NOT disturb the vehicle or turn ON the ignition until told to do so. Disturbing the vehicle may invalidate this portion of the test.

17. Shift the vehicle to park for automatic and neutral for manual. Turn OFF the ignition and exit the vehicle. Do NOT disturb the vehicle for 45 minutes.
18. Observe the Inspection/Maintenance (I/M) System Status with a scan tool. All of the I/M System Status indicators should display YES.

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- If the EVAP I/M System Status indicator displays NO turn OFF the ignition for 17 hours, ensure that the vehicle meets the conditions for a cold start and repeat steps 13-18 three more times or until the EVAP I/M System Status indicator transitions to YES. If the indicator continues to display NO, refer to the **Inspection/Maintenance (I/M) System DTC Table** to identify the DTCs that did not run.

- If any of the I/M System Status indicators display NO, refer to the **Inspection/Maintenance (I/M) System DTC Table** for the indicator which did not display YES. The I/M System DTC Table identifies the DTCs associated with each I/M System Status Indicator.

INSPECTION/MAINTENANCE (I/M) SYSTEM DTC TABLE

DIAGNOSTIC INSTRUCTIONS

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- **Strategy Based Diagnosis**
- **Diagnostic Procedure Instructions**

Inspection/Maintenance (I/M) System DTC Table

System	DTCs Required to Set System Status to YES
If an I/M System Status indicator did NOT update to YES during the **Inspection/Maintenance (I/M) Complete System Set Procedure**, review each indicator and reference this table to determine each DTC associated with the I/M System Status Indicator. Each DTC listed below has specific conditions that must be met for the diagnostic to run. Included within the conditions are additional DTCs which, if set, may inhibit the DTCs listed below from running. Reviewing and operating the vehicle within the Conditions for Running for each DTC listed below will allow the I/M System Status Indicators to transition to YES.	
Catalyst	**DTC P0420 or P0430**
EVAP	**DTC P0442** **DTC P0446** **DTC P0455** **DTC P0496**
Oxygen Sensor	**DTC P0030, P0036, P0053, P0054, P0135 or P0141** **DTC P0050, P0056, P0059, P0060, P0155 or P0161** **DTC P0131, P0132, P0137 or P0138** **DTC P0133, P0134, P0140, P1133, P2A00 or P2A01** **DTC P0151, P0152, P0157 or P0158** **DTC P0153, P0154, P0160, P1153, P2A03 or P2A04**

SERVICE BAY TEST

DIAGNOSTIC INSTRUCTIONS

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

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- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

DESCRIPTION

The purpose of the evaporative emission (EVAP) Service Bay Test is to aid in resetting the EVAP inspection/maintenance (I/M) system status. For this vehicle that is equipped with the engine off natural vacuum (EONV) diagnostic, the Service Bay Test uses the scan tool to initiate the control module's regular sequence of EVAP system DTC tests, but with different enable criteria. By using the Service Bay Test the I/M indicator can be set without the need for multiple cold soaks.

The scan tool displays for the Service Bay Test are based on the events that occur within the following three categories:

- The engine running portion of the tests-The vehicle must remain at rest, in Park or in Neutral, during this portion of the test. This test inspects for large leaks, a leaking purge valve and/or vent system restrictions. The scan tool will display test progress or the reason for an abort or failure.
- Drive cycle-The scan tool will display time and distance needed to warm the fuel.
- Ignition OFF-During this portion of the test, the engine controller will remain active for up to 45 minutes when the ignition is turned OFF to allow control of the EVAP vent valve and run the EONV test. The engine controller inspects for small leaks during this period by monitoring fuel tank pressure or vacuum. If the system is sealed, there will be a pressure or vacuum change. Pressure or vacuum changes that are less than the calibrated values indicate a leak.

When the EVAP diagnostics are initiated by the Service Bay Test, the scan tool will indicate if the enable conditions listed below are not met or will display a specific reason if the test aborts. When complete, the display will indicate that the tests passed or failed.

CONDITIONS FOR RUNNING THE TEST

The following conditions must be met in order to enable the Service Bay Test:

- The battery voltage is between 11-18 volts.
- The engine coolant temperature (ECT) is less than 70°C (158°F) at start-up.
- The EVAP I/M system status indicator is set to NO.
- The fuel level is 15-85 percent capacity and cannot be refueled during the tests.
- There are no DTCs displayed.
- The vehicle must be driven for the time and distance specified on the scan tool.
- The ambient air temperature is between 0-40°C (32-104°F)
- The ignition must remain OFF during the engine OFF portion of the test and the vehicle must remain at rest.

TEST PROCEDURE

IMPORTANT: If the Service Bay Test aborts or fails a DTC will NOT be set.

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1. Install a scan tool.
2. Select the Service Bay Test with the scan tool.

CAUTION: Refer to Road Test Caution .

3. Follow the instructions on the scan tool.
   - If the test aborts, correct the condition for running the test and then retest.
   - If the test fails, repair the vehicle for the condition indicated by the failure message on the scan tool.
4. Verify that the EVAP I/M system status is set to YES.

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2007 ENGINE

Engine Cooling - XLR

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Auxiliary Transmission Oil Cooler Brace bolts	22 N.m	16 lb ft
Auxiliary Transmission Oil Cooler Bracket Nuts	8 N.m	6 lb ft
Charge Air Coolant Cap Bolts	10 N.m	89 lb in
Coolant Heater Cord Clip Bolt	32 N.m	24 lb ft
Drain Cock	2 N.m	18 lb in
Engine Cooling Fan Module Screw	6 N.m	53 lb in
Fan Shroud to Radiator Bolts	5 N.m	44 lb in
Generator Cooling Hose Assembly to Generator Bolt	27 N.m	20 lb ft
Generator Cooling Inlet Hose Fitting	25 N.m	18 lb ft
Radiator Air Baffle Screws	2.5 N.m	22 lb in
Radiator Front Air Deflector Bolts	2.5 N.m	22 lb in
Radiator Front Air Deflector Upper Mounting Screws	2.5 N.m	22 lb in
Radiator Support Bolts	9 N.m	80 lb in
Surge Tank Nuts	8 N.m	71 lb in
Thermostat Housing Bolt (LC3)	10 N.m	89 lb in
Thermostat Housing Bolt (LH2)	10 N.m	89 lb in
Water Outlet Housing Bolts (LC3, LH2)	25 N.m	18 lb ft
Water Pump Bolts (LC3)	10 N.m	89 lb in
Water Pump Bolts (LH2)	30 N.m	22 lb ft
Water Pump Pulley Bolts (LC3)	12 N.m	106 lb in
Water Pump Pulley Bolts (LH2)	10 N.m	89 lb in

SCHEMATIC AND ROUTING DIAGRAMS

ENGINE COOLING SCHEMATICS

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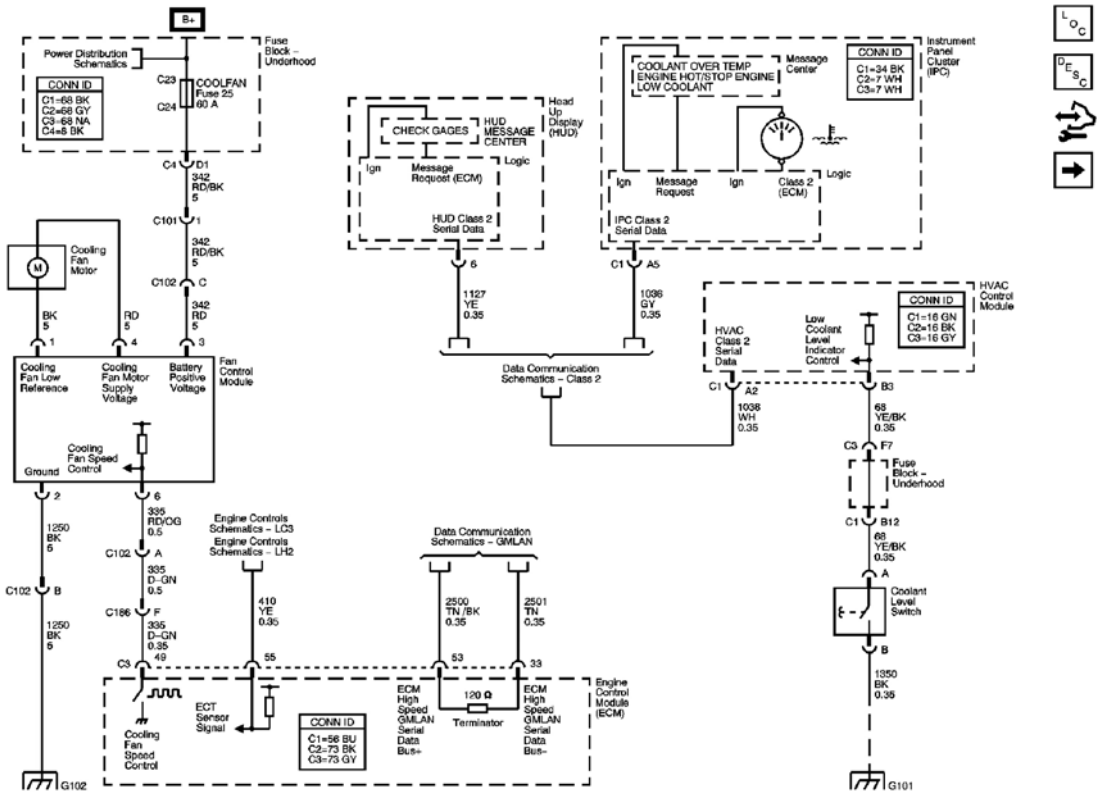


Fig. 1: Engine Cooling Schematic - 4.4L
Courtesy of GENERAL MOTORS CORP.

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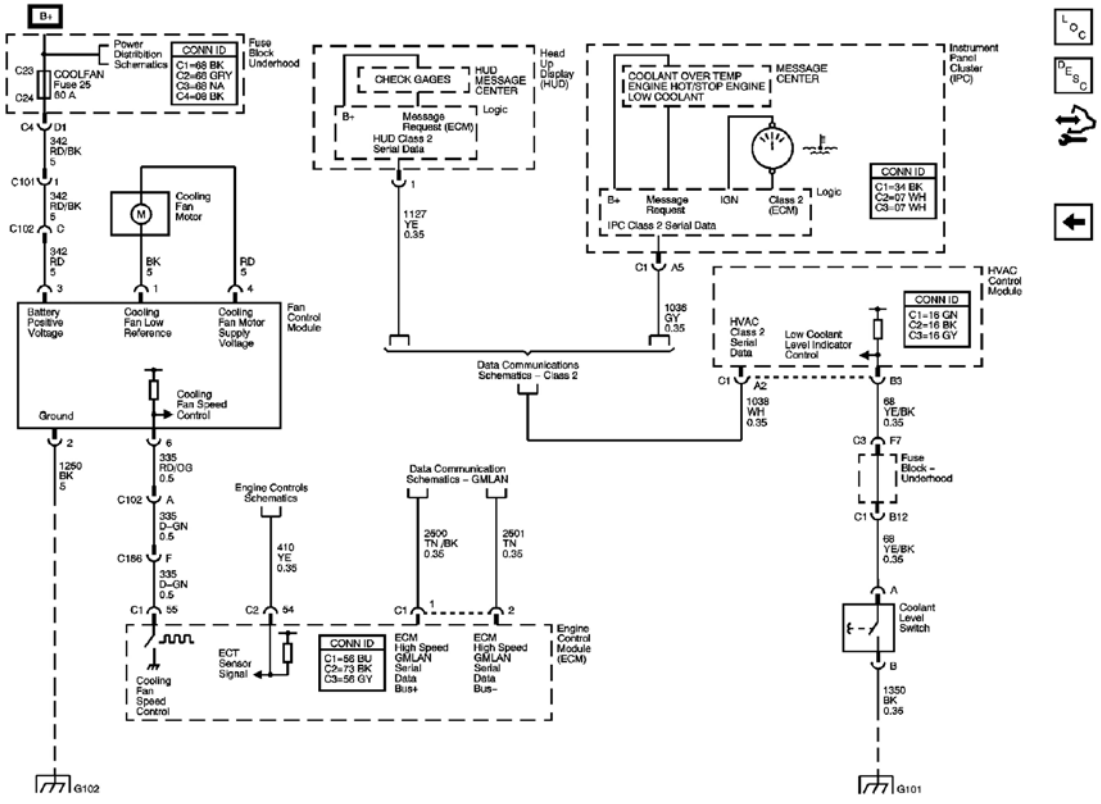


Fig. 2: Engine Cooling Schematic - 4.6L
Courtesy of GENERAL MOTORS CORP.

COMPONENT LOCATOR

COOLING SYSTEM COMPONENT VIEWS

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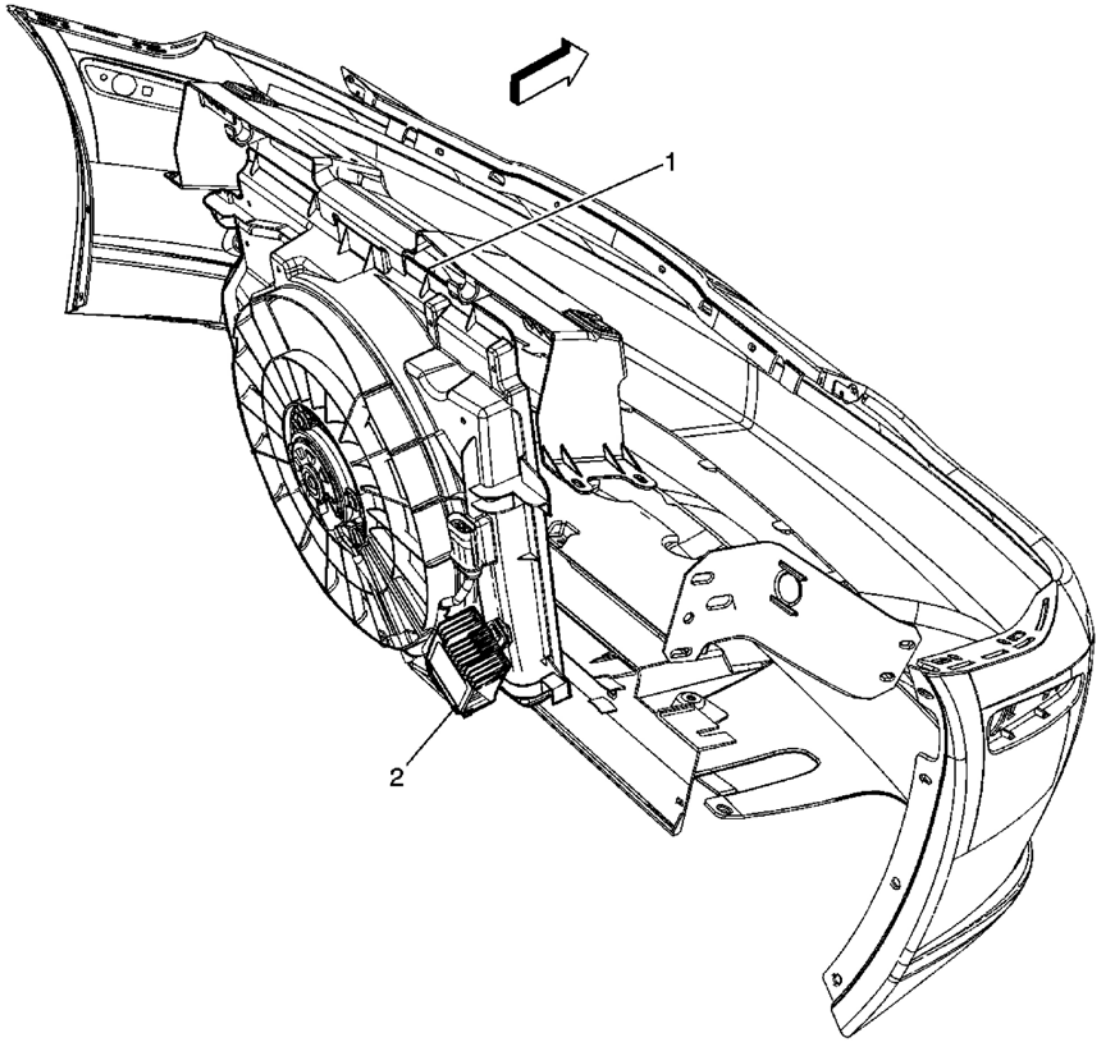


Fig. 3: View Of Front Engine Compartment Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 3

Callout	Component Name
1	Cooling Fan Motor
2	Fan Control Module

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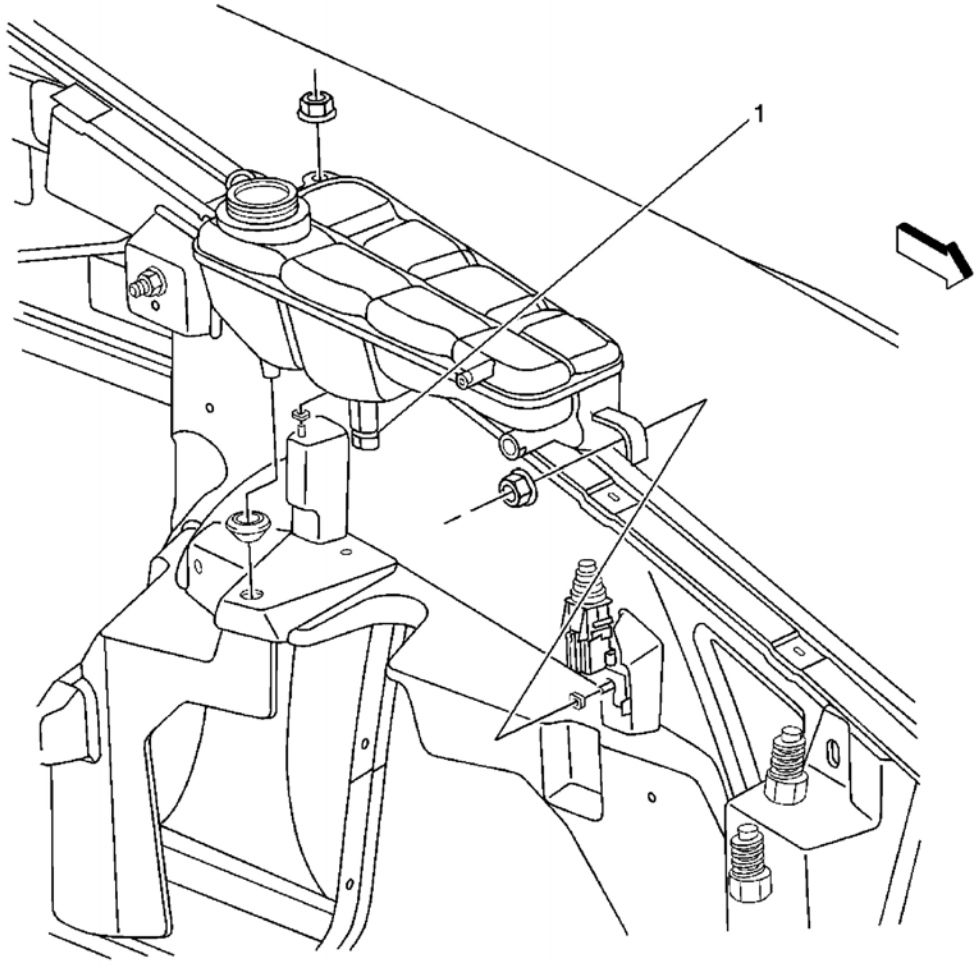


Fig. 4: Locating Coolant Level Switch - Left Side Of Engine Compartment
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 4

Callout	Component Name
1	Coolant Level Switch

COOLING SYSTEM CONNECTOR END VIEWS

Coolant Level Switch

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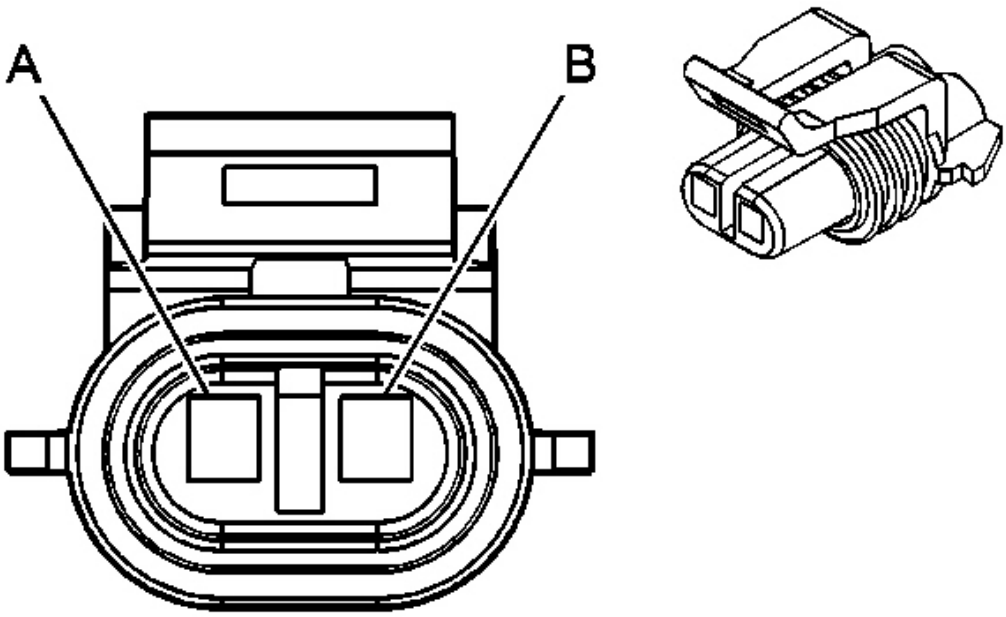


Fig. 5: Coolant Level Switch Connector End View
Courtesy of GENERAL MOTORS CORP.

Coolant Level Switch Connector Parts Information

Connector Part Information

- OEM: 12052641
- Service: 12102747
- Description: 2-Way F Metri-Pack 150 Series (BK)

Terminal Part Information

- Terminal/Tray: See Terminal Repair Kit
- Core/Insulation Crimp: See Terminal Repair Kit
- Release Tool/Test Probe: See Terminal Repair Kit

Coolant Level Switch Connector Terminal Identification

Pin	Wire Color	Circuit No.	Function
A	YE/BK	68	Low Coolant Level Indicator Control
B	BK	1350	Ground

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Fan Control Module

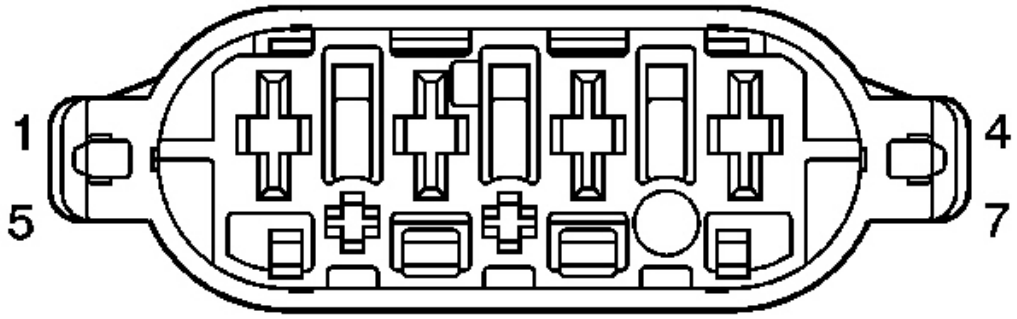


Fig. 6: Fan Control Module Connector End View
Courtesy of GENERAL MOTORS CORP.

Fan Control Module Connector Parts Information

Connector Part Information

- OEM: 9440194
- Service: See Catalog
- Description: 7-Way F (BK)

Terminal Part Information

- Pins: 1, 2, 3, 4, 6
- Terminal/Tray: See Terminal Repair Kit
- Core/Insulation Crimp: See Terminal Repair Kit
- Release Tool/Test Probe: See Terminal Repair Kit

Fan Control Module Connector Terminal Identification

Pin	Wire Color	Circuit No.	Function
1	BK	-	Cooling Fan Low Reference
2	BK	1250	Ground
3	RD	342	Battery Positive Voltage
4	RD	-	Cooling Fan Motor Supply Voltage
5	-	-	Not Used
6	RD/OG	335	Cooling Fan Speed Control
7	-	-	Not Used

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DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC CODE INDEX

DIAGNOSTIC CODE INDEX

DTC	Description
DTC P1258	Engine Coolant Overtemperature Protection Mode Active
DTC P1482	Cooling Fan Speed Output Circuit Malfunction

DIAGNOSTIC STARTING POINT - ENGINE COOLING

Begin the system diagnosis with the **Diagnostic System Check - Vehicle** . The Diagnostic System Check will provide the following information:

- The identification of the control modules which command the system
- The ability of the control modules to communicate through the serial data circuit
- The identification of any stored diagnostic trouble codes (DTCs) and their status

The use of the Diagnostic System Check will identify the correct procedure for diagnosing the system and where the procedure is located.

SCAN TOOL OUTPUT CONTROLS

Scan Tool Output Controls

Scan Tool Output Control	Additional Menu Selection(s)	Description
Cooling Fan Command	Output Control/Cooling Fan	The scan tool displays the Commanded fan state in 10% increments. This allows you to communicate with the ECM and activate or deactivate the cooling fan speeds manually.

SCAN TOOL DATA LIST

Scan Tool Data List

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
Operating Conditions & Ignition Switch in RUN/Engine running/Automatic Transmission in PARK/Air Conditioner is OFF			
ECT	Cooling/HVAC Data	°C/°F	Varies
Cooling Fan Motor Command	Cooling/HVAC Data	%	0%
Cooling Fan Command	Cooling/HVAC Data	%	0%
FC Circuit Status	Cooling/HVAC Data	OK/Open/Short/Invalid State	OK

SCAN TOOL DATA DEFINITIONS

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Cooling Fan Motor Command

The percent of PWM duty cycle requested from the ECM.

Cooling Fan Command

The percent of engine cooling fan commanded.

ECT

The scan tool displays -40 to +151°C (-40 to +304°F). The engine coolant temperature (ECT) sensor is mounted in the coolant stream. The powertrain control module (PCM) applies 5 volts to the ECT sensor circuit. The sensor is a thermistor which changes internal resistance as temperature changes. When the sensor is cold, internal resistance high, the PCM monitors a high signal voltage and interprets it as a cold engine. As the sensor warms, internal resistance decreases, the voltage signal decreases and the PCM interprets the lower voltage as a warm engine.

DTC P1258

DTC Descriptor

DTC P1258

Engine Coolant Overtemperature - Protection Mode Active

Diagnostic Fault Information

Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

Circuit/System Description

The engine control module (ECM) uses the engine coolant temperature (ECT) sensor to monitor the engine for an over-termperature condition. This condition occurs when the coolant temperature is above a calibrated value for a calibrated length of time. The ECM will disable half of the cylinders by turning OFF the fuel injectors. By disabling half of cylinders, the ECM is able to reduce the temperature of the coolant.

Conditions for Running the DTC

- The engine is running.
- DTC P0116, P0117, P0118 or P0128 are not set.

Conditions for Setting the DTC

Coolant temperature more than 131°C (267.8°F) for more than 7 seconds.

Action Taken When the DTC Sets

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- DTC P1258 is a type A DTC.
- The engine will operate in the Overheated Engine Protection Operating Mode.
- The instrument panel (IP) will illuminate the coolant indicator lamp and the driver information center (DIC), if equipped, may display a message.

Conditions for Clearing the DTC

DTC P1258 is a type A DTC.

Reference Information

Description and Operation

- **Cooling System Description and Operation**
- **Instrument Cluster Description and Operation**
- **Indicator/Warning Message Description and Operation**
- **Audible Warnings Description and Operation**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Engine Cooling

- **Scan Tool Data List**
- **Scan Tool Data Definitions**
- **Scan Tool Output Controls**

Circuit/System Verification

IMPORTANT: If DTC P1482 is set, diagnose that DTC first.

1. Observe the engine coolant level. The engine coolant level should be within operating range. Refer to Capacities - Approximate Fluid and Engine Coolant in the Owner's Manual.
2. Ensure that the vehicle has the correct engine coolant, with correct concentration and is not old, contaminated or contains additives. Refer to Recommended Fluids and Lubricants in the Owner's Manual.
3. Inspect the cooling system for the following:
    - Cooling system leaks
    - Kinked or pinched hoses, especially at the radiator
    - Loose, missing or damaged radiator air seals or deflectors
    - The radiator and A/C condenser for any air flow obstructions or bent fins-Refer to **Symptoms -**

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Engine Cooling.

IMPORTANT: A small delay occurs before the ECM changes the cooling fan speed.

4. Command the cooling fans in both low and high speed.
   - If the cooling fans do not operate in both speeds, refer to **Cooling Fan Inoperative**.

Circuit/System Testing

1. Test the thermostat for correct operation. Refer to **Thermostat Diagnosis**.
2. Test the engine cooling system for overheating. Refer to **Engine Overheating**.
3. Inspect the water pump and coolant flow for correct operation. Refer to **Water Pump Replacement (LH2)** or **Water Pump Replacement (LC3)**.
4. Inspect the engine mechanical for worn/leaking/cracked cylinder heads and engine block. Refer to **Coolant in Combustion Chamber** and **Coolant in Engine Oil** for the 4.4L engine or **Coolant in Combustion Chamber** and **Coolant in Engine Oil** for the 4.6L engine.

Repair Procedures

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

DTC P1482

DTC Descriptor

DTC P1482

Cooling Fan Speed Output Circuit

Diagnostic Fault Information

Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

DTC P1482

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Cooling Fan Speed Control	P1482	P1482	P1482	-
Cooling Fan Motor Supply Voltage	-	-	-	-
Cooling Fan Low Reference	-	-	-	-
Battery Positive Voltage	-	-	-	-
Ground	-	-	-	-

Circuit/System Description

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The engine cooling fan is a variable speed fan. The engine control module (ECM) controls the fan speed by sending a pulse width modulated signal to the cooling fan speed control module. The cooling fan control module varies the voltage drop across the engine cooling fan motor in relation to the pulse width modulated signal. The cooling fan speed is affected by many different conditions and can be adjusted from 10 to 90 percent duty cycle (PWM). 90 percent is considered high fan speed. When multiple cooling speed requests are received the ECM uses the highest cooling fan speed of all the requests. During normal fan ON operation the control circuit voltage will be low and near battery voltage when the fan is OFF.

Conditions for Running the DTC

- The battery voltage is between 9-18 volts.
- The engine speed is greater than 400 RPM.

Conditions for Setting the DTC

- The commanded state of the output driver module (ODM) and the actual state of the control circuit do not match.
- The condition is present for more than 5 seconds.

Action Taken When the DTC Sets

DTCs P1482 is Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P1482 is Type B DTCs.

Diagnostic Aids

1. Cooling fan duty cycle starts when engine coolant temperature reaches approximately 95°C (204°F) and reaches high speed at temperatures above 113°C (235°F).
2. Cooling fan duty cycle starts when A/C pressure reaches approximately 1100 kPa (160 Psi) and reaches high speed at A/C pressures above 2480 kPa (360 psi)
3. At engine oil temperatures above approximately 150°C (302°F) the cooling fan duty cycle will be commanded to high speed.
4. At transmission oil temperatures above approximately 132°C (270°F) the cooling fan duty cycle will be commanded to high speed.
5. After the vehicle is shut OFF if the engine coolant temperature at key-off is greater than 113°C (235°F) or the A/C pressure is greater than 1720 kPa (249 psi) the cooling fan duty cycle is set to 50 percent, low speed. If the coolant temperature drops below 110°C (230°F) and the A/C pressure drops below 1660 kPa (241 psi) the fan will shut OFF. The fans will automatically shut OFF after 2 min. regardless of coolant temperature.

Reference Information

Schematic Reference

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Engine Cooling Schematics

Connector End View Reference

- **Engine Control Module Connector End Views** for 4.4L engine
- **Engine Controls Connector End Views** for 4.6L engine
- **Engine Control Module Connector End Views** for 4.4L engine
- **Engine Controls Connector End Views** for 4.6L engine
- **Electrical Center Identification Views**

Description and Operation

Cooling Fan Description and Operation

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

- **Scan Tool Data List**
- **Scan Tool Data Definitions**
- **Scan Tool Data List**

Circuit/System Verification

Ignition ON, command the cooling fan ON and OFF with a scan tool. Observe that the cooling fan turns ON and OFF with each command.

Circuit/System Testing

IMPORTANT: Circuit/System Verification must be performed first or misdiagnosis may result.

1. Ignition OFF, disconnect the engine harness connector from the cooling fan speed control module.
2. Ignition OFF, install a test lamp between the cooling fan speed control circuit terminal and B+. The lamp should be OFF.
    - If the lamp is ON, test the cooling fan speed control circuit for a short to ground. If the circuit tests

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normal, replace the ECM.

3. Ignition ON, command the cooling fan speed from 0-100 percent with a scan tool. The brightness of the lamp should change with the commanded states.
    - If the lamp brightness does not change correctly, test the cooling fan speed control circuit for a short to voltage or an open/high resistance. If the circuit tests normal, replace the ECM.
4. Ignition OFF, disconnect the cooling fan harness connector at the cooling fan speed control module.
5. Connect a jumper wire between the fan ground circuit terminal and ground. Connect a 30A fused jumper wire between the positive terminal at the battery and the fan voltage supply circuit terminal and verify fan activation.
    - If the cooling fan does not activate, replace the cooling fan.
6. Ignition OFF, measure between the cooling fan speed control module ground circuit terminal at the harness connector and ground for less than 1 ohm of resistance.
7. Install appropriately fused jumpers in the power and ground circuits between the cooling fan speed control module harness connector terminals and the cooling fan harness connector terminals. The fan should activate at full speed.
    - If the fan does not activate correctly, test the cooling fan speed control module voltage supply circuit for a short to ground or an open/high resistance. If the circuit tests normal and it's fuse is open, replace the cooling fan speed control module.
8. If the ECM, fan and all circuits test normal, replace the cooling fan speed control module.

Repair Procedures

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

Control Module References for ECM replacement, setup and programming

SYMPTOMS - ENGINE COOLING

IMPORTANT: The following steps must be completed before using the symptom tables.

Perform the **Diagnostic System Check - Vehicle** before using the Symptom Tables in order to verify that all of the following are true:

1. There are no DTCs set.
2. The control modules can communicate via the serial data link.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect cooling system operation. Refer to **Checking Aftermarket Accessories** .
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

Intermittent

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Faulty electrical connections or wiring may be the cause of intermittent conditions. Refer to **Testing for Intermittent Conditions and Poor Connections** .

Symptom List

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

- **Cooling Fan Always On**
- **Cooling Fan Inoperative**
- **Coolant Heater Inoperative**
- **Loss of Coolant (LC3)** or **Loss of Coolant (LH2)**
- **Thermostat Diagnosis**
- **Engine Fails To Reach Normal Operating Temperature**

LOW ENGINE COOLANT INDICATOR ALWAYS ON

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- **Strategy Based Diagnosis**
- **Diagnostic Procedure Instructions**

Diagnostic Fault Information

Low Engine Coolant Indicator Always On

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Coolant Level Switch Signal	Lamp ON	Lamp OFF	-	-
Ground	-	Lamp OFF	-	-

Circuit/System Description

The low engine coolant level indicator lamp on the instrument panel cluster (IPC) is controlled by the body control module (BCM) through the low speed GM LAN Serial Data line to the engine control module (ECM). When the engine coolant level switch is closed for 30 seconds or longer indicating low coolant, the BCM will signal the ECM to turn ON the coolant level lamp. The lamp will also illuminate for approximately 3 seconds during the display test at the start of each ignition cycle.

Reference Information

Schematic Reference

Engine Cooling Schematics

Connector End View Reference

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Cooling System Connector End Views

Description and Operation

Cooling System Description and Operation

Electrical Information Reference

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

DTC Type Definitions

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

- **Scan Tool Data List**
- **Scan Tool Output Controls**

Circuit/System Verification

1. Turn ON the ignition with the engine OFF.
2. Command the instrument cluster indicators ON and OFF with a scan tool.
3. The low coolant indicator lamp should turn ON and OFF on command.
4. The low coolant indicator should be OFF with the engine coolant at the proper level.

Circuit/System Testing

IMPORTANT: Circuit/System Verification must be performed before performing the Circuit/System Testing.

1. Turn ON the ignition with the engine OFF.
2. Verify that the low coolant indicator turns ON and OFF with each command when the instrument cluster indicators are commanded ON and OFF with a scan tool.
    - If the low coolant level indicator does NOT turn OFF, test for poor connections at the IPC or a faulty IPC.
3. Ignition ON, disconnect the coolant level switch.
    - If the low coolant level indicator turns OFF with the switch disconnected, replace the coolant level switch.
    - If the low coolant level indicator does not turn OFF with the switch disconnected, test the signal circuit of the coolant level switch for a short to ground.

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- If the signal circuit tests normal, inspect for poor connections at the BCM or a faulty BCM.

Repair Procedures

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- **Surge Tank Replacement**
- **Control Module References**
- **Instrument Cluster Replacement**

Repair Verification

Verify that the low coolant indicator is OFF with the engine coolant at the proper level.

COOLING FAN ALWAYS ON

Circuit/System Description

The engine cooling fan is a variable speed fan. The engine control module (ECM) controls the fan speed by sending a pulse width modulated signal to the cooling fan speed control module. The cooling fan control module varies the voltage drop across the engine cooling fan motor in relation to the pulse width modulated signal. The cooling fan speed is affected by many different conditions and can be adjusted from 10 to 90 percent duty cycle (PWM). 90 percent is considered high fan speed. When multiple cooling speed requests are received the ECM uses the highest cooling fan speed of all the requests. During normal fan ON operation the control circuit voltage will be low and near battery voltage when the fan is OFF.

Reference Information

Schematic Reference

Engine Cooling Schematics

Connector End View Reference

Cooling System Connector End Views

Description and Operation

Cooling Fan Description and Operation

Electrical Information Reference

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

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Circuit/System Verification

Ignition ON, command the cooling fan ON and OFF with a scan tool. Observe that the cooling fan turns ON and OFF with each command.

Circuit/System Testing

1. Ignition OFF, disconnect the cooling fan control module.
2. Ignition ON, observe that the fan is not activated.
    - If the fan is not activated, replace the cooling fan control module.
    - If the fan is activated, test the fan voltage supply circuit for a short to voltage.

Repair Verification

1. Ignition ON, verify with a scan tool that the control module is not commanding fan activation.
2. Ignition ON, observe that the fans are not activated.

COOLING FAN INOPERATIVE

Diagnostic Fault Information

Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

Circuit/System Description

The engine cooling fan is a variable speed fan. The engine control module (ECM) controls the fan speed by sending a pulse width modulated signal to the cooling fan speed control module. The cooling fan control module varies the voltage drop across the engine cooling fan motor in relation to the pulse width modulated signal. The cooling fan speed is affected by many different conditions and can be adjusted from 10 to 90 percent duty cycle (PWM). 90 percent is considered high fan speed. When multiple cooling speed requests are received the ECM uses the highest cooling fan speed of all the requests. During normal fan ON operation the control circuit voltage will be low and near battery voltage when the fan is OFF.

Diagnostic Aids

The ECM has the capability of providing command to the fan relays even while a scan tool output control is being used. Always refer to the fan control command parameters on the scan tool to know which fans are being commanded on by the ECM.

Reference Information

Schematic Reference

Engine Cooling Schematics

Description and Operation

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Cooling Fan Description and Operation

Connector End View Reference

- **Engine Controls Connector End Views** for the 4.4L engine and **Engine Controls Connector End Views** for the 4.6L engine
- **Engine Control Module Connector End Views** for the 4.4L engine and **Engine Control Module Connector End Views** for the 4.6L engine
- **Electrical Center Identification Views**

Electrical Information Reference

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

Scan Tool Reference

- **Cooling System Connector End Views**
- **Scan Tool Data List** for the 4.4L engine and **Scan Tool Data List** for the 4.6L engine
- **Scan Tool Data Definitions** for the 4.4L engine and **Scan Tool Data Definitions** for the 4.6L engine
- **Scan Tool Output Controls** for the 4.4L engine and **Scan Tool Output Controls** for the 4.6L engine

Circuit/System Verification

Ignition ON, command the cooling fan ON and OFF with a scan tool. Observe that the cooling fan turns ON and OFF with each command.

Circuit/System Testing

1. Ignition OFF, disconnect the cooling fan control module.
2. Connect a jumper wire between the fan ground circuit terminal and ground.
3. Connect a 30A fused jumper wire between the positive terminal at the battery and the fan voltage supply circuit terminal and verify fan activation.
    - If the fan does not activate, test the fan voltage supply circuit for a short to ground or an open/high resistance. If the circuit tests normal, test the fan ground circuit for an open/high resistance. If the fan did not activate and the circuits test normal, replace the fan.
4. Ignition ON, connect the 30A fused jumper wire between the fan control module voltage supply circuit terminal and the fan voltage supply circuit terminal and verify fan activation.
    - If the fan does not activate, test the fan control module voltage supply circuit for a short to ground or an open/high resistance. If the circuit tests normal and its fuse is open, test all connected components and replace as necessary.
5. If the fan and all circuits test normal, replace the fan control module.

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Repair Procedures

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

Cooling Fan Motor Replacement - Electric

Repair Verification

Ignition ON, command the fan relay ON and OFF with a scan tool. Observe that the fan turns ON and OFF with each command.

ENGINE OVERHEATING

Engine Overheating

Step	Action	Yes	No
1	Inspect for a missing or damaged radiator, upper or lower baffle, and/or radiator air deflector. Is the baffle and/or deflector missing or damaged?	Go to **Step 8**	Go to **Step 2**
2	Inspect for a loss of coolant. Is there a loss of coolant?	Go to **Step 3**	Go to **Step 4**
3	Fill the system to the specified level. Refer to **Loss of Coolant (LC3)** or **Loss of Coolant (LH2)**. Does the engine overheat?	Go to **Step 4**	System OK
4	Inspect for low coolant protection. Is the coolant to the correct concentration?	Go to **Step 5**	Go to **Step 8**
5	Inspect for a loss of cooling system pressure. Is there a loss of system pressure?	Go to **Step 8**	Go to **Step 6**
6	Inspect for a faulty engine coolant temperature (ECT) sensor. Refer to **DTC P0128** for the 4.4L (LC3) engine or **DTC P0128** for the 4.6L (LH2) engine. Is the sensor operating properly?	Go to **Step 7**	Go to **Step 8**
7	Inspect for a cracked coolant surge tank or a leaking hose. Is the coolant surge tank cracked or is the hose leaking?	Go to **Step 8**	Go to **Step 3**
8	Repair or install new parts as necessary, then retest. Does the engine overheat?	Go to **Step 9**	System OK
9	Inspect for incorrect drive belt tension. Is the belt tension correct?	Go to **Step 10**	Go to **Step 8**
10	1. Remove the water pump. Refer to **Water Pump Replacement (LH2)** or **Water Pump Replacement (LC3)**. 2. Inspect for a damaged water pump		

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	driveshaft. Is the water pump driveshaft damaged or is the seal leaking?	Go to **Step 8**	Go to **Step 11**
11	Inspect for obstructed radiator air flow or bent radiator fins. Is the radiator air flow obstructed?	Go to **Step 8**	Go to **Step 12**
12	Inspect for blocked cooling system passages. Are the cooling system passages blocked?	Go to **Step 8**	Go to **Step 13**
13	Inspect for inoperative cooling fans. Refer to **Cooling Fan Inoperative**. Are the cooling fans and the motors operating correctly?	Go to **Step 14**	Go to **Step 8**
14	Inspect the thermostat. Refer to **Thermostat Diagnosis**. Is the thermostat stuck in the closed position?	Go to **Step 15**	Go to **Step 16**
15	Replace the thermostat. Refer to **Thermostat Replacement (LC3)** or **Thermostat Replacement (LH2)**. Does the engine overheat?	Go to **Step 16**	System OK
16	Inspect the radiator cooling capacity. Is the proper sized radiator being used on the vehicle?	Go to **Step 3**	Go to **Step 17**
17	Consult the current parts catalog and replace the radiator. Refer to **Radiator Replacement**. Is the repair complete?	System OK	-

LOSS OF COOLANT (LC3)

Loss of Coolant (LC3)

Step	Action	Yes	No
DEFINITION: The cooling system is losing coolant either internally or externally.			
1	Were you sent here from Symptoms or another diagnostic table?	Go to **Step 2**	Go to **Symptoms - Engine Cooling**
2	Repair any present DTCs. Refer to **Diagnostic Starting Point - Engine Cooling**. Is the action complete?	Go to **Step 3**	-
3	Inspect the coolant level at the surge tank. Is the coolant at the proper level?	Go to **Step 4**	Go to **Step 5**
4	Inspect the charge air cooling system coolant level. Is the coolant at the proper level?	Go to **Step 7**	Go to **Step 6**
5	Fill the cooling system to the proper level. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System**		

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	(Static Fill). Is the action complete?	Go to **Step 4**	-
6	Fill the charge air cooling system to the proper level. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**. Is the action complete?	Go to **Step 7**	-
7	If the engine is suspected to have a coolant leak into a cylinder, the coolant can hydraulically lock the engine. Does the engine crankshaft rotate?	Go to **Step 8**	Go to **Step 27**
8	Engine overheating can cause a loss of coolant. Is the engine overheating?	Go to **Step 28**	Go to **Step 9**
9	Extended operation with a low coolant level can cause engine internal component failure. Is the engine knocking?	Go to **Step 30**	Go to **Step 10**
10	Visually inspect the hoses, pipes and hose clamps at the following locations: • Radiator - Charge Air Cooler • Pump - Charge Air Cooler • Charge Air Cooler Are any of the hoses, clamps or pipes leaking?	Go to **Step 23**	Go to **Step 11**
11	Visually inspect the following components: • Radiator - Charge Air Cooler • Pump - Charge Air Cooler • Charge Air Cooler • Charge Air Coolant Cap Are any of the listed components leaking?	Go to **Step 23**	Go to **Step 12**
12	1. Pressure test the charge air cooling system. Refer to **Cooling System Leak Testing**. 2. With the cooling system pressurized, visually inspect the components listed in steps 10 and 11. Are any leaks present?	Go to **Step 23**	Go to **Step 13**
	Visually inspect the hoses, pipes and hose clamps at the following locations:		

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13	• Surge Tank • Throttle Body • Water Pump • Generator • Heater Core • Radiator Are any of the hoses, clamps or pipes leaking?	Go to **Step 23**	Go to **Step 14**
14	Visually inspect the following components: • Block heater • Coolant Pressure Cap • Core Plugs • Cylinder Head Gaskets • Cylinder Heads • Engine Block • Radiator • Thermostat housing • Water pump Are any of the listed components leaking?	Go to **Step 23**	Go to **Step 15**
15	1. Pressure test the cooling system. Refer to **Cooling System Leak Testing**. 2. With the cooling system pressurized, visually inspect the components listed in steps 13 and 14. Are any leaks present?	Go to **Step 23**	Go to **Step 16**
16	Pressure test the coolant pressure cap. Refer to **Pressure Cap Testing**. Does the coolant pressure cap hold pressure?	Go to **Step 17**	Go to **Step 24**
17	1. Apply the parking brake. 2. Ensure the vehicle is in PARK. 3. Start and idle the engine until it reaches normal operating temperature. 4. Inspect for heavy white smoke coming out of the exhaust pipe. Is a heavy white smoke present from the exhaust		

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	pipe?	Go to **Step 18**	Go to **Step 19**
18	Coolant in the exhaust system creates a distinctive, burning coolant odor in the exhaust. Condensation in the exhaust system can cause an odorless white smoke during engine warm up. Does the white smoke have a burning coolant type odor?	Go to **Step 29**	Go to **Step 19**
19	With the engine idling, inspect the surge tank. Does the surge tank discharge coolant while the engine is idling?	Go to **Step 31**	Go to **Step 20**
20	Inspect for the following conditions: • A coolant smell inside of the vehicle. • Coolant in the HVAC module drain tube. • Coolant on the vehicle floor covering near the HVAC module. Is coolant present?	Go to **Step 25**	Go to **Step 21**
21	Inspect the engine oil for a gray/white milky substance. Is there a milky substance in the engine oil ?	Go to **Step 29**	Go to **Step 22**
22	Inspect the transmission oil fluid for a gray/white milky substance. Does the transmission fluid contain a gray/white milky substance?	Go to **Step 26**	Go to **Step 32**
23	Repair or replace the leaking component. Refer to the appropriate repair. Is the repair complete?	Go to **Step 32**	-
24	Replace the coolant pressure cap. Is the repair complete?	Go to **Step 32**	-
25	Replace the heater core. Refer to **Heater Core Replacement** . Is the repair complete?	Go to **Step 32**	-
26	1. Replace the radiator. Refer to **Radiator Replacement**. 2. Service the transmission. Refer to **Engine Coolant/Water in Transmission** . Is the repair complete?	Go to **Step 32**	-
27	Repair the engine no crank condition. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate** . Is the repair complete?	Go to **Step 32**	-

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28	Repair the engine overheating condition. Refer to **Engine Overheating**. Is the repair complete?	Go to **Step 32**	-
29	Repair the engine internal coolant leak. Refer to **Coolant in Combustion Chamber** or **Coolant in Engine Oil** . Is the repair complete?	Go to **Step 32**	-
30	Repair the engine knock. Refer to **Lower Engine Noise, Regardless of Engine Speed** . Is the repair complete?	Go to **Step 32**	-
31	Repair the combustion pressure in the cooling system problem. Refer to **Cylinder Leakage Test** . Is the repair complete?	Go to **Step 32**	-
32	Operate the system in order to verify the repair. Did you find and correct the condition?	System OK	Go to **Step 2**

LOSS OF COOLANT (LH2)

Loss of Coolant (LH2)

Step	Action	Yes	No
DEFINITION: The cooling system is losing coolant either internally or externally.			
1	Were you sent here from Symptoms or another diagnostic table?	Go to **Step 2**	Go to **Symptoms - Engine Cooling**
2	Repair any present DTCs. Refer to **Diagnostic Starting Point - Engine Cooling**. Is the action complete?	Go to **Step 3**	-
3	Inspect the coolant level at the surge tank. Is the coolant at the proper level?	Go to **Step 5**	Go to **Step 4**
4	Fill the cooling system to the proper level. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**. Is the action complete?	Go to **Step 5**	-
5	If the engine is suspected to have a coolant leak into a cylinder, the coolant can hydraulically lock the engine. Does the engine crankshaft rotate?	Go to **Step 6**	Go to **Step 22**
6	Engine overheating can cause a loss of coolant. Is the engine overheating?	Go to **Step 23**	Go to **Step 7**
7	Extended operation with a low coolant level can cause engine internal component failure. Is the engine knocking?	Go to **Step 25**	Go to **Step 8**
	Visually inspect the hoses, pipes and hose clamps at the following locations:		

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8	• Surge Tank • Throttle Body • Water Pump • Heater Core • Radiator Are any of the hoses, clamps or pipes leaking?	Go to **Step 18**	Go to **Step 9**
9	Visually inspect the following components: • Block heater • Coolant Pressure Cap • Core Plugs • Cylinder Head Gaskets • Cylinder Heads • Engine Block • Radiator • Thermostat housing • Water pump Are any of the listed components leaking?	Go to **Step 18**	Go to **Step 10**
10	1. Pressure test the cooling system. Refer to **Cooling System Leak Testing**. 2. With the cooling system pressurized, visually inspect the components listed in steps 8 and 9. Are any leaks present?	Go to **Step 18**	Go to **Step 11**
11	Pressure test the coolant pressure cap. Refer to **Pressure Cap Testing**. Does the coolant pressure cap hold pressure?	Go to **Step 12**	Go to **Step 19**
12	1. Apply the parking brake. 2. Ensure the vehicle is in PARK. 3. Start and idle the engine until it reaches normal operating temperature. 4. Inspect for heavy white smoke coming out of the exhaust pipe. Is a heavy white smoke present from the exhaust		

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	pipe?	Go to **Step 13**	Go to **Step 14**
13	Coolant in the exhaust system creates a distinctive, burning coolant odor in the exhaust. Condensation in the exhaust system can cause an odorless white smoke during engine warm up. Does the white smoke have a burning coolant type odor?	Go to **Step 24**	Go to **Step 14**
14	With the engine idling, inspect the surge tank. Does the surge tank discharge coolant while the engine is idling?	Go to **Step 26**	Go to **Step 15**
15	Inspect for the following conditions: • A coolant smell inside of the vehicle. • Coolant in the HVAC module drain tube. • Coolant on the vehicle floor covering near the HVAC module. Is coolant present?	Go to **Step 20**	Go to **Step 16**
16	Inspect the engine oil for a gray/white milky substance. Is there a milky substance in the engine oil ?	Go to **Step 24**	Go to **Step 17**
17	Inspect the transmission oil fluid for a gray/white milky substance. Does the transmission fluid contain a gray/white milky substance?	Go to **Step 21**	Go to **Step 27**
18	Repair or replace the leaking component. Refer to the appropriate repair. Is the repair complete?	Go to **Step 27**	-
19	Replace the coolant pressure cap. Is the repair complete?	Go to **Step 27**	-
20	Replace the heater core. Refer to **Heater Core Replacement** . Is the repair complete?	Go to **Step 27**	-
21	1. Replace the radiator. Refer to **Radiator Replacement**. 2. Service the transmission. Refer to **Engine Coolant/Water in Transmission** . Is the repair complete?	Go to **Step 27**	-
22	Repair the engine no crank condition. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate** .		

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	Is the repair complete?	Go to **Step 27**	-
23	Repair the engine overheating condition. Refer to **Engine Overheating**. Is the repair complete?	Go to **Step 27**	-
24	Repair the engine internal coolant leak. Refer to **Coolant in Combustion Chamber** or **Coolant in Engine Oil** . Is the repair complete?	Go to **Step 27**	-
25	Repair the engine knock. Refer to **Lower Engine Noise, Regardless of Engine Speed** . Is the repair complete?	Go to **Step 27**	-
26	Repair the combustion pressure in the cooling system problem. Refer to **Cylinder Leakage Test** . Is the repair complete?	Go to **Step 27**	-
27	Operate the system in order to verify the repair. Did you find and correct the condition?	System OK	Go to **Step 2**

THERMOSTAT DIAGNOSIS

Use one of the following procedures in testing for a malfunctioning thermostat.

Tools Required

J 24731 Tempilstick. See **Special Tools**.

Thermostat Test Procedure Using Tempilsticks

The coolant thermostat can be tested using a temperature (tempil) stick. The temperature stick is a pencil like device. It has a wax material containing certain chemicals which melt at a given temperature. Temperature sticks can be used to determine a thermostat's operating range, by rubbing 87°C (188°F) and 97°C (206°F) sticks on the thermostat housing.

1. Use a tempilstick in order to find the opening and the closing temperatures of the coolant thermostat.
   - J 24731-188 tempilstick melts at 87°C (188°F). The thermostat should begin to open.
   - J 24731-206 tempilstick melts at 97°C (206°F). The thermostat should be fully open.
2. Replace the coolant thermostat if it does not operate properly between this temperature range.

Thermostat Test Procedure Using Glycol

Inspect the operation of the thermostat by hanging the thermostat on a hook in a 33 percent glycol solution.

In order to inspect if the thermostat valve is opening properly, perform the following test:

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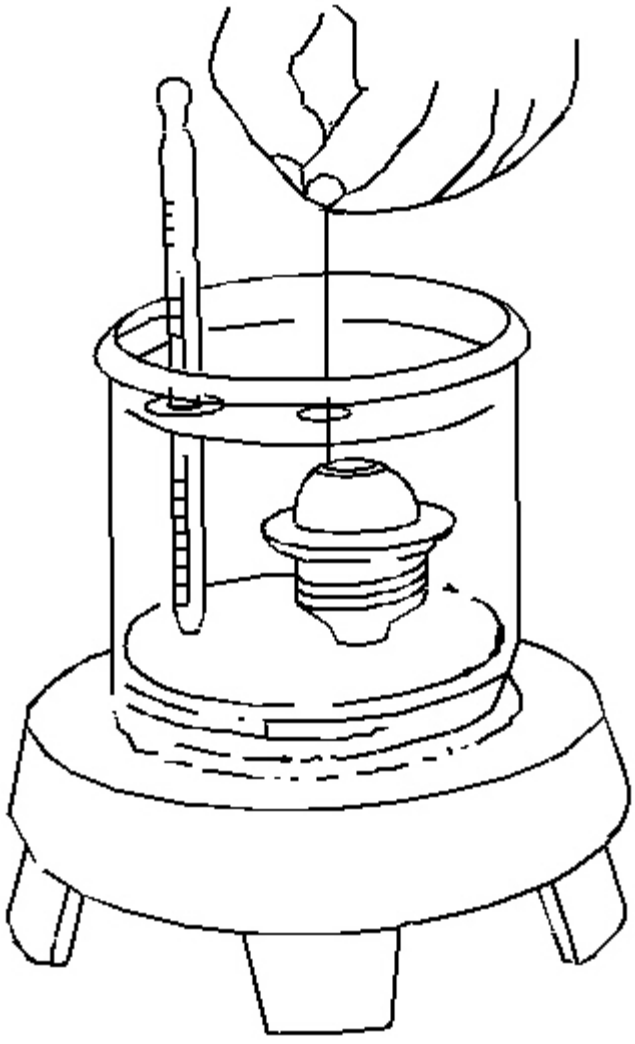


Fig. 7: View Of Thermostat Test Procedure Using Glycol
Courtesy of GENERAL MOTORS CORP.

1. Completely submerge the thermostat in a glycol solution. The solution should be 11°C (22°F) above the temperature indicated on the thermostat valve.
2. Thoroughly agitate the solution. Under these conditions, the thermostat valve should open.

In order to inspect if the thermostat valve is closing properly, perform the following test:

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1. Completely submerge the thermostat in a glycol solution. The solution should be 6°C (10°F) below the temperature indicated on the thermostat valve.
2. Thoroughly agitate the solution. Under these conditions, the thermostat valve should close completely.

COOLANT HEATER INOPERATIVE

Circuit/System Description

The optional coolant heater operates using 110 volt AC external power and is designed to warm the coolant in the engine block area for improved starting in very cold weather. There is an internal thermal switch in the power cord that prevents operation above -18°C (0°F). The coolant heater helps reduce fuel consumption when a cold engine is warming up. The unit is equipped with a detachable AC power cord. A weather shield on the cord is provided to protect the plug when not in use.

Reference Information

Electrical Information Reference

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

Circuit/System Testing

IMPORTANT: The power supply cord will read open due to an internal thermal switch if the ambient temperature is above -18°C (0°F).

1. Test the engine coolant heater for an open or short to ground.
    - If open or shorted, replace the heater.
2. If the heater tests normal, replace the coolant heater power cord.

Repair Procedures

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

Coolant Heater Replacement - Left Side

Coolant Heater Cord Replacement

ENGINE FAILS TO REACH NORMAL OPERATING TEMPERATURE

Engine Fails To Reach Normal Operating Temperature

Step	Action	Yes	No

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1	Check the level of the coolant in the coolant surge tank. Is the coolant in the surge tank at the proper level?	Go to **Step 3**	Go to **Step 2**
2	Add engine coolant as necessary. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**. Does the engine still fail to reach normal operating temperature?	Go to **Step 3**	System OK
3	Check if the thermostat is stuck open. Is the thermostat stuck in the open position?	Go to **Step 5**	Go to **Step 4**
4	Check to see if the correct type of thermostat was installed. Was the incorrect thermostat installed?	Go to **Step 5**	System OK
5	Replace the thermostat. Refer to **Thermostat Replacement (LC3)** or **Thermostat Replacement (LH2)**. Does the engine still fail to reach normal operating temperature?	-	System OK

PRESSURE CAP TESTING

Tools required

- **J 24460-01** Cooling System Pressure Tester. See **Special Tools**.
- **J 42401** Radiator Cap/Surge Tank Test Adapter. See **Special Tools**.

Pressure Cap Testing

CAUTION: To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if radiator cap or surge tank cap is removed while the engine and radiator are still hot.

1. Remove the pressure cap.
2. Wash the pressure cap sealing surface with water.

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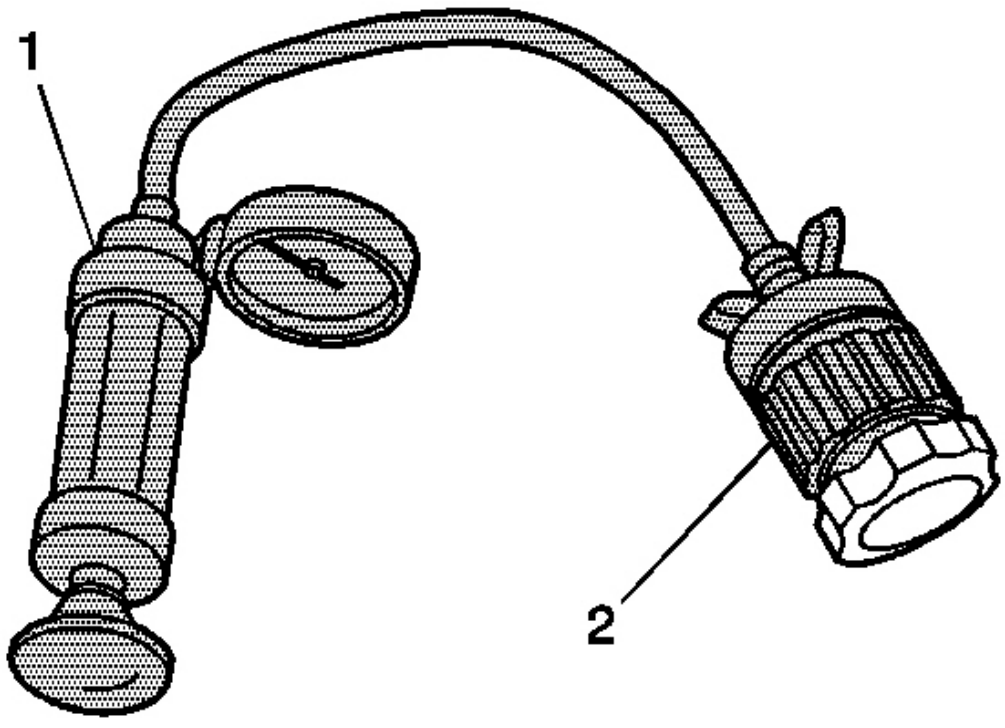


Fig. 8: Identifying Pressure Cap Testing Tool J 42401
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 24460-01** (1) with **J 42401** (2) in order to test the pressure cap. See **Special Tools**.
4. Test the pressure cap for the following conditions:
   - Pressure release when the **J 24460-01** exceeds the pressure rating of the pressure cap. See **Special Tools**.
   - Maintain the rated pressure for at least 10 seconds.

     Note the rate of pressure loss.
5. Replace the pressure cap under the following conditions:
   - The pressure cap does not release pressure which exceeds the rated pressure of the cap.
   - The pressure cap does not hold the rated pressure.

COOLING SYSTEM LEAK TESTING

Tools Required

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- **J 24460-01** Cooling System Pressure Tester. See **Special Tools**.
- **J 42401** Radiator Cap/Surge Tank Test Adapter. See **Special Tools**.

Cooling System Leak Testing

CAUTION: Under pressure, the temperature of the solution in the radiator can be considerably higher, without boiling. Removing the radiator cap while the engine is hot (pressure is high), will cause the solution to boil instantaneously, with explosive force. The solution will spew out over the engine, fenders and the person removing the cap. Serious bodily injury may result. Flammable antifreeze, such as alcohol, is not recommended for use at any time. Flammable antifreeze could cause a serious fire.

CAUTION: In order to help avoid being burned, do not remove the radiator cap while the engine and the radiator are hot. Scalding fluid and steam can be blown out under pressure if the cap is removed too soon.

1. Remove the pressure cap.
2. Test the operation of the pressure cap. Refer to **Pressure Cap Testing**.
3. Wash the pressure cap mating surface with water.

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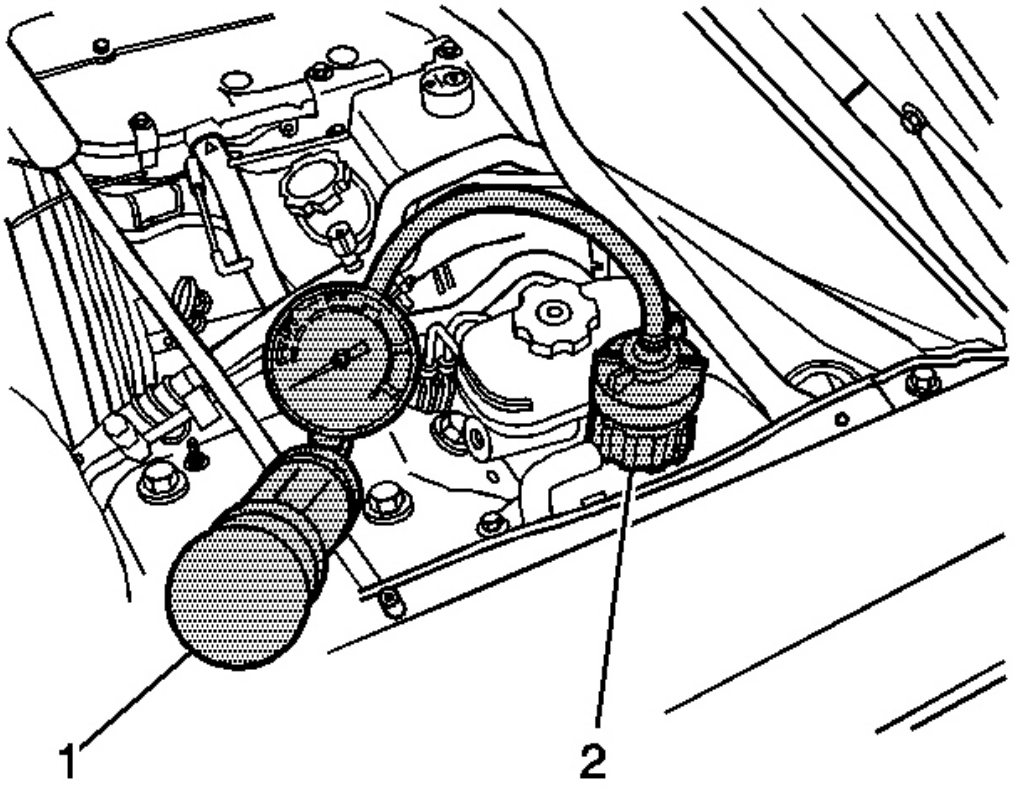


Fig. 9: Testing Cooling System Pressure Using J 24460-01 & J 42401
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 24460-01** (1) with **J 42401** (2) in order to apply pressure to the cooling system. See **Special Tools**.

   Do not exceed the pressure cap rating.

5. The cooling system should hold the rated pressure for at least 2 minutes.

   Observe the gage for any pressure loss.

6. Repair any leaks as required.

COOLING SYSTEM LEAK TESTING (CHARGE AIR COOLING)

Tools Required

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- **J 24460-01** Cooling System Pressure Tester. See **Special Tools**.
- **GE-47844** Charge Air Cooling System Pressure Test Adapter. See **Special Tools**.

Test Procedure

1. Install the manifold sight shield. Refer to **INTAKE MANIFOLD SIGHT SHIELD REPLACEMENT** for the 4.4L engine.

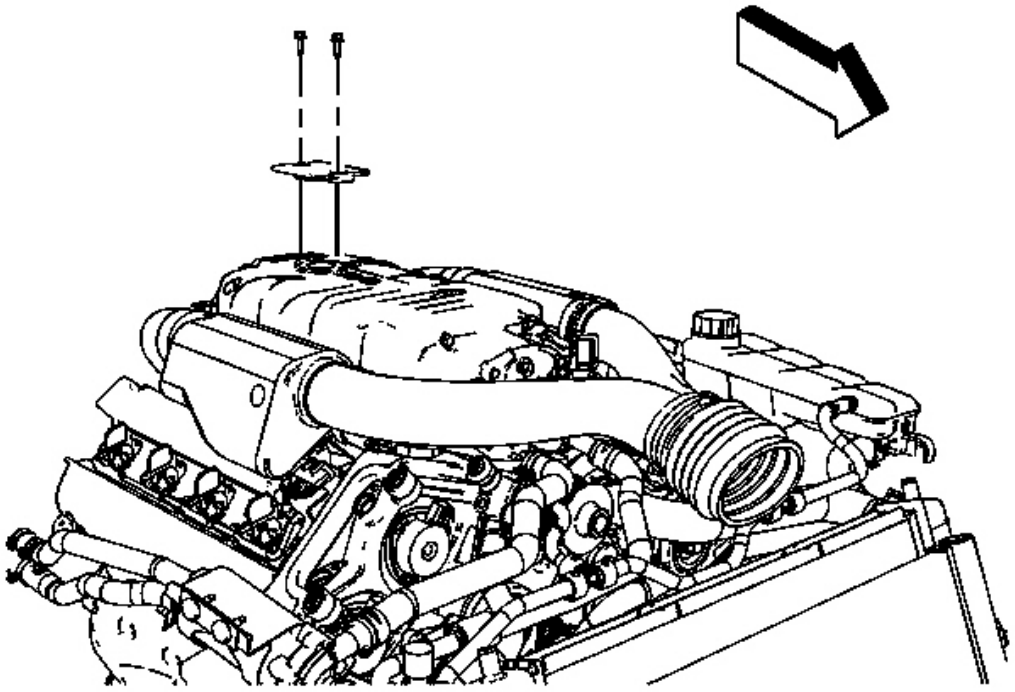


Fig. 10: Identifying Charge Air Coolant Cap Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It is normal to have a very small pocket of air at the top of the system below the fill cap on a properly filled charge air cooling system.

2. Remove the charge air coolant cap.

NOTE: Refer to Fastener Notice .

3. Install the **GE-47844** onto the charge air cooler cap port.

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Tighten: Tighten the bolts to 10 N.m (89 lb in).

4. Use the **J 24460-01** with **GE-47844** in order to apply pressure to the cooling system. Do not exceed 34 kPa (5 psi).
5. The cooling system should hold 34 kPa (5 psi) at least 2 minutes. Observe the gage for any pressure loss.
6. Repair any leaks as required.
7. Remove the **GE-47844** from the charge air cooler cap port.

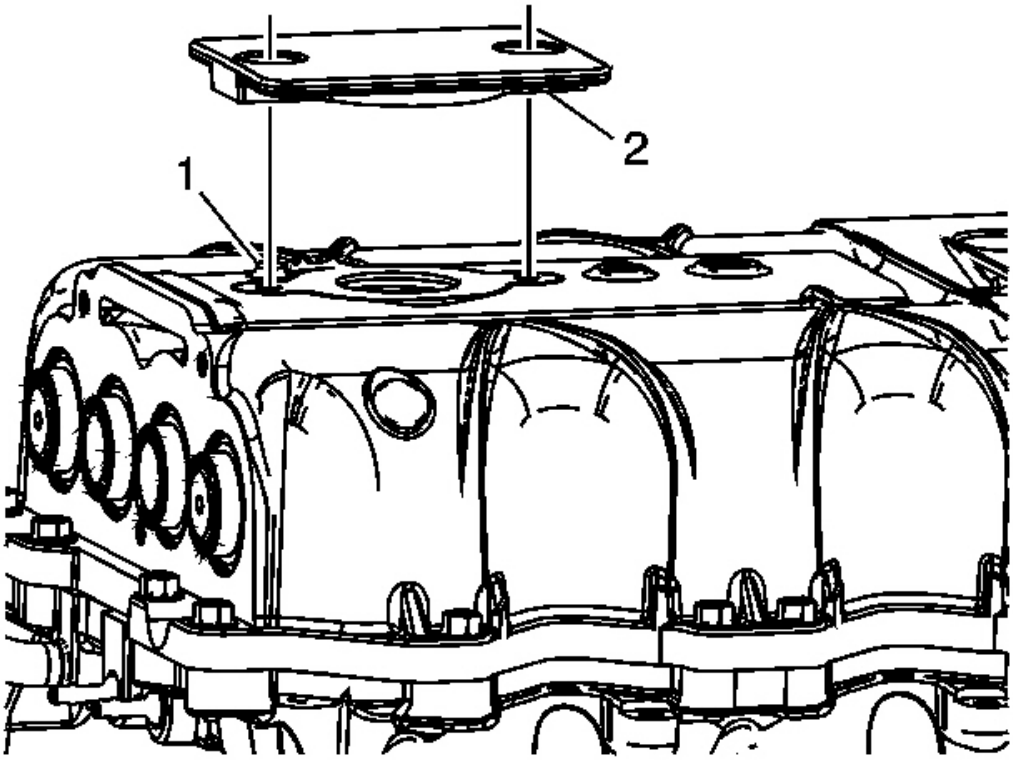


Fig. 11: View Of Charge Air Cooler Cooling Fill Cap
Courtesy of GENERAL MOTORS CORP.

8. Install the charge air cooler cooling fill cap.
9. Ensure the charge air cooler cooling fill cap is installed in the proper orientation:
   - The alignment boss (1) is at the rear of the charge air cooler manifold.
   - The alignment boss (2) is at the front of the charge air cooler cooling filling cap.

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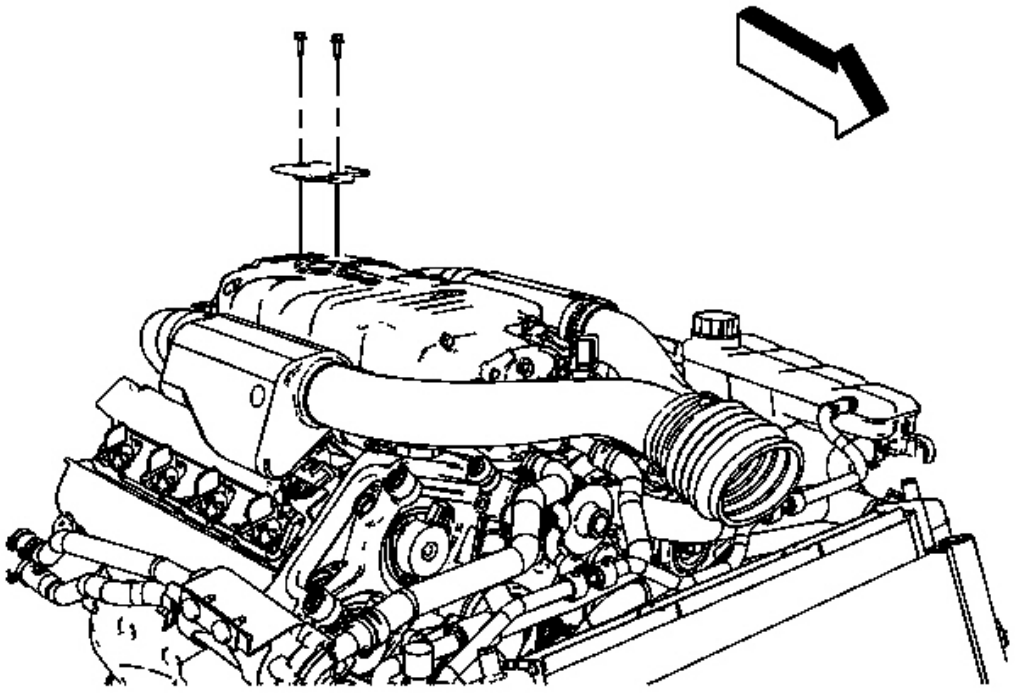


Fig. 12: Identifying Charge Air Coolant Cap Bolts
Courtesy of GENERAL MOTORS CORP.

10. Install the charge air coolant cap bolts.

    Tighten: Tighten the bolts to 10 N.m (89 lb in).

11. Install the manifold sight shield. Refer to **INTAKE MANIFOLD SIGHT SHIELD REPLACEMENT** for the 4.4L engine.

REPAIR INSTRUCTIONS

DRAINING AND FILLING COOLING SYSTEM (GE 47716)

Tools Required

- **J 26568** Coolant and Battery Fluid Tester. See **Special Tools**.
- **J 42401** Radiator Cap and Surge Tank Test Adapter. See **Special Tools**.
- **GE-47716** Vac N Fill Coolant Refill Tool. See **Special Tools**.

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Draining Procedure

CAUTION: With a pressurized cooling system, the coolant temperature in the radiator can be considerably higher than the boiling point of the solution at atmospheric pressure. Removal of the surge tank cap, while the cooling system is hot and under high pressure, causes the solution to boil instantaneously with explosive force. This will cause the solution to spew out over the engine, the fenders and the person removing the cap. Serious bodily injury may result.

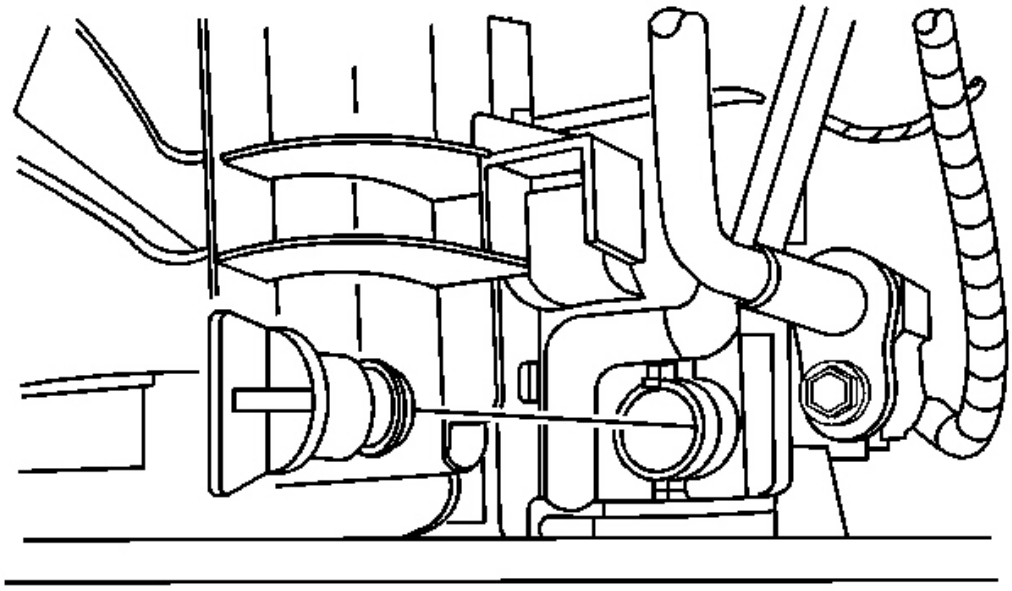


Fig. 13: Identifying Radiator Drain Cock
Courtesy of GENERAL MOTORS CORP.

CAUTION: To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if radiator cap or surge tank cap is removed while the engine and radiator are still hot.

1. Remove the coolant pressure cap.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Place a drain pan under the drain cock.
4. Remove the radiator drain cock.

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5. Drain the cooling system.
6. Lower the vehicle.
7. Inspect the coolant.
8. Follow the appropriate procedure based on the condition of the coolant.
    - Normal in appearance-Follow the filling procedure.
    - Discolored-Follow the flush procedure. Refer to **Flushing (Charge Air Cooling)** or **Flushing (Powertrain)**.

Vac N Fill Procedure

1. Install the **J 42401** onto the coolant surge tank. See **Special Tools**.

CAUTION: To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if radiator cap or surge tank cap is removed while the engine and radiator are still hot.

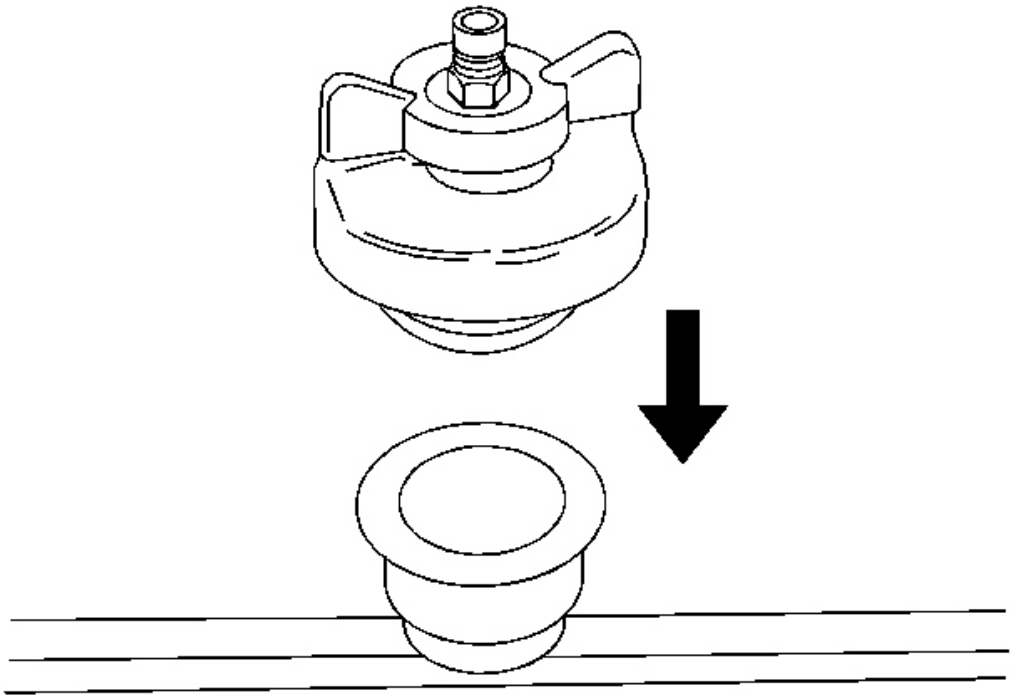


Fig. 14: Identifying Vac-N-Fill Cap
Courtesy of GENERAL MOTORS CORP.

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2. Attach the Vac N Fill cap to the **J 42401** . See **Special Tools**.

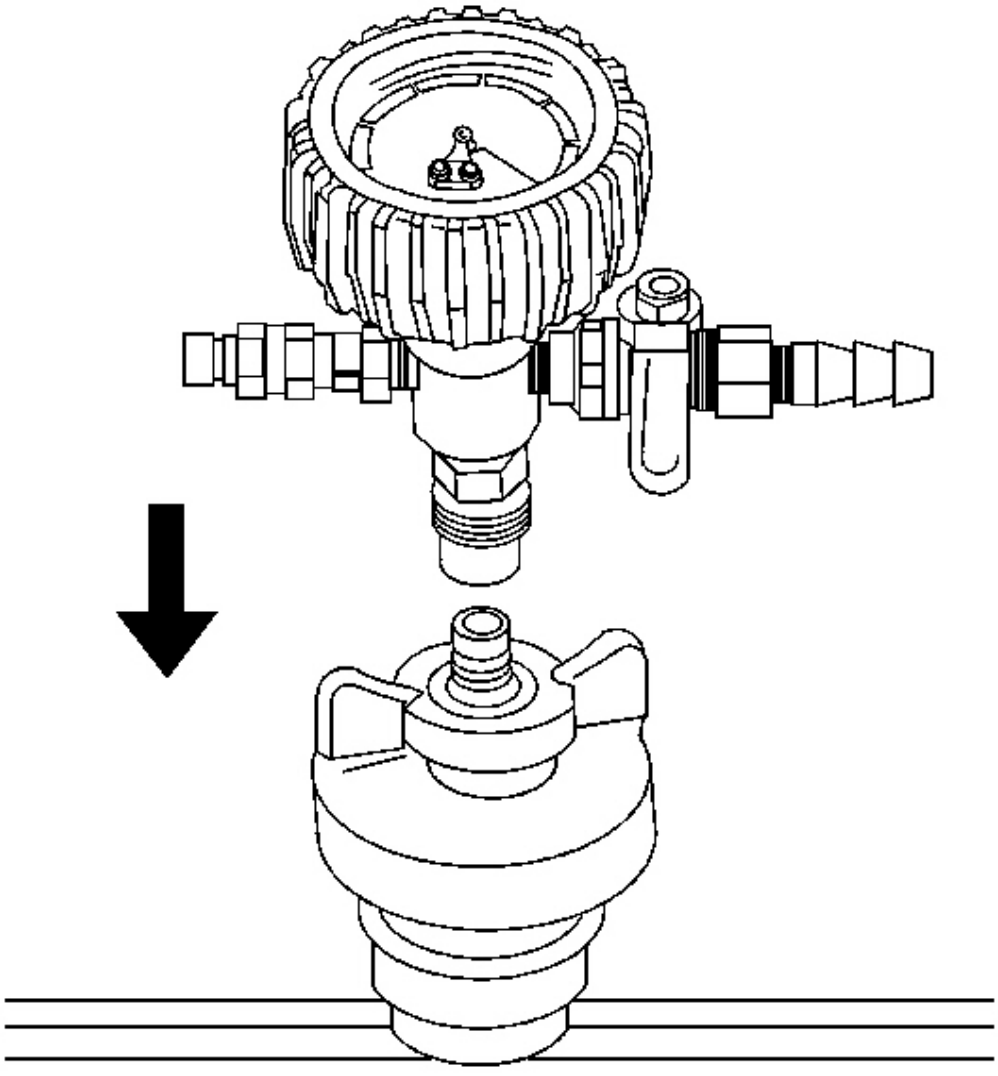


Fig. 15: View Of Vacuum Gage Assembly
Courtesy of GENERAL MOTORS CORP.

3. Attach the vacuum gage assembly to the Vac N Fill cap.

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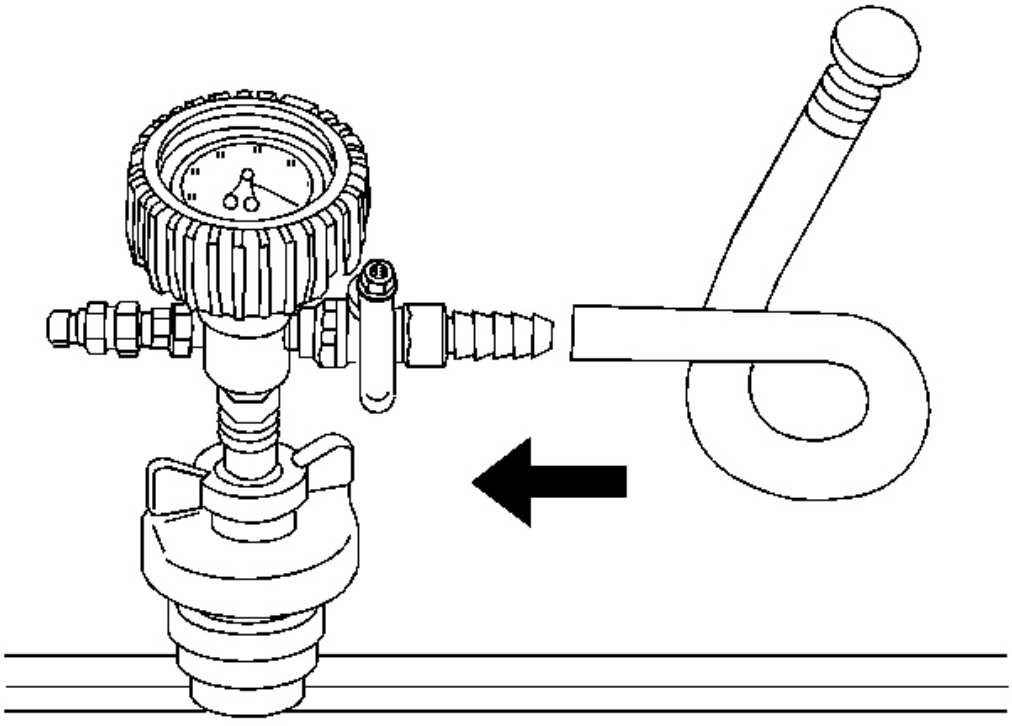


Fig. 16: Identifying Fill Hose
Courtesy of GENERAL MOTORS CORP.

4. Attach the fill hose to the barb fitting on the vacuum gage assembly.

   Ensure that the valve is closed.

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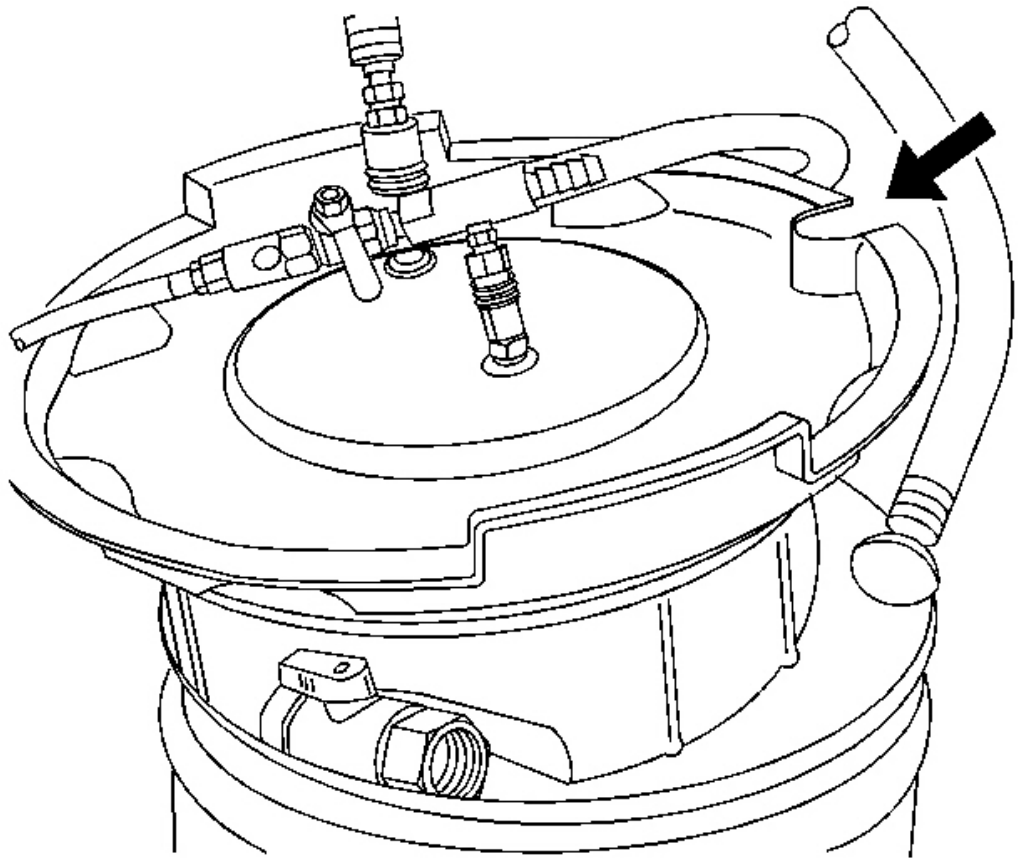


Fig. 17: View Of Graduated Reservoir & Hose
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Use a 50/50 mixture of DEX-COOL antifreeze and clean, drinkable water.**
- **Always use more coolant than necessary. This will eliminate air from being drawn into the cooling system.**

5. Pour the coolant mixture into the graduated reservoir.
6. Place the fill hose in the graduated reservoir.

IMPORTANT: Prior to installing the vacuum tank onto the graduated reservoir, ensure that the drain valve located on the bottom of the tank is closed.

7. Install the vacuum tank on the graduated reservoir with the fill hose routed through the cut-out area in the

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vacuum tank.

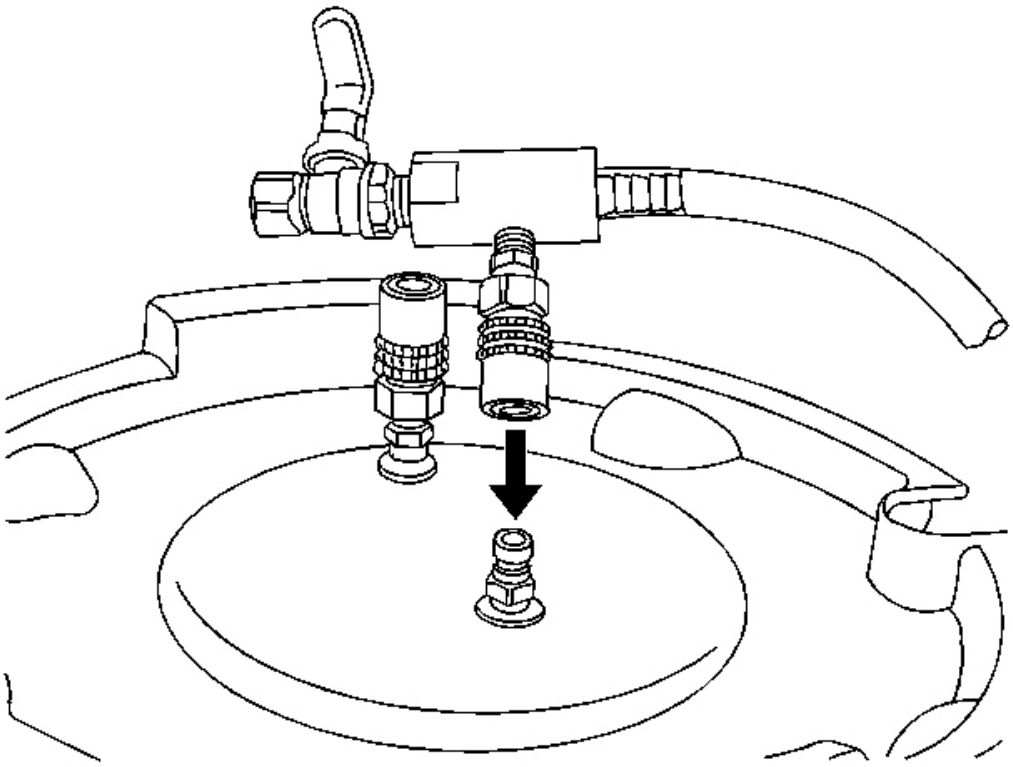


Fig. 18: Identifying Venturi Assembly
Courtesy of GENERAL MOTORS CORP.

8. Attach the venturi assembly to the vacuum tank.

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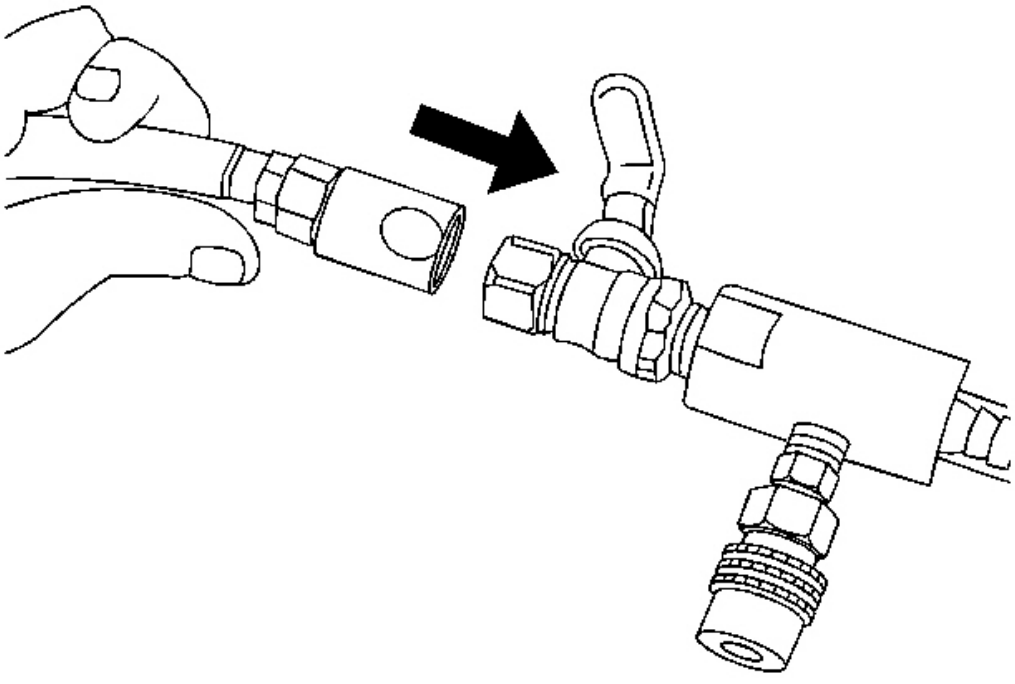


Fig. 19: View Of Shop Air Hose And Venturi Assembly
Courtesy of GENERAL MOTORS CORP.

9. Attach a shop air hose to the venturi assembly.

   Ensure the valve on the venturi assembly is closed.

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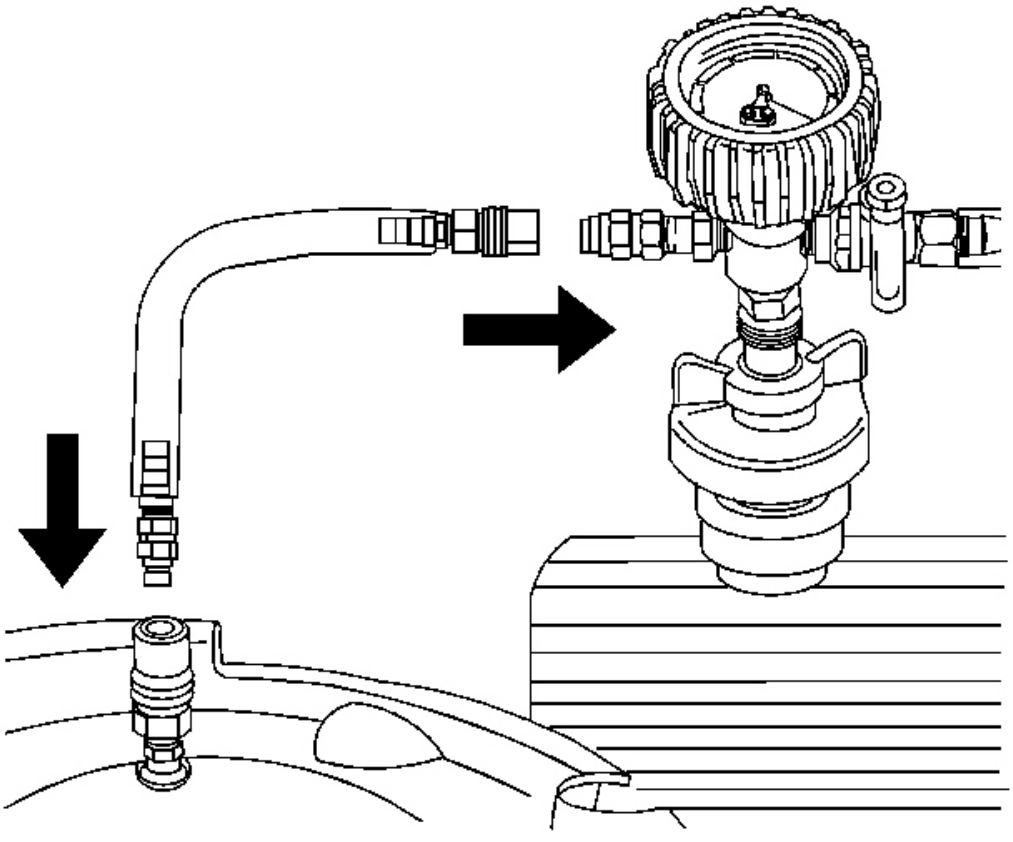


Fig. 20: Identifying Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

10. Attach the vacuum hose to the vacuum gage assembly and the vacuum tank.

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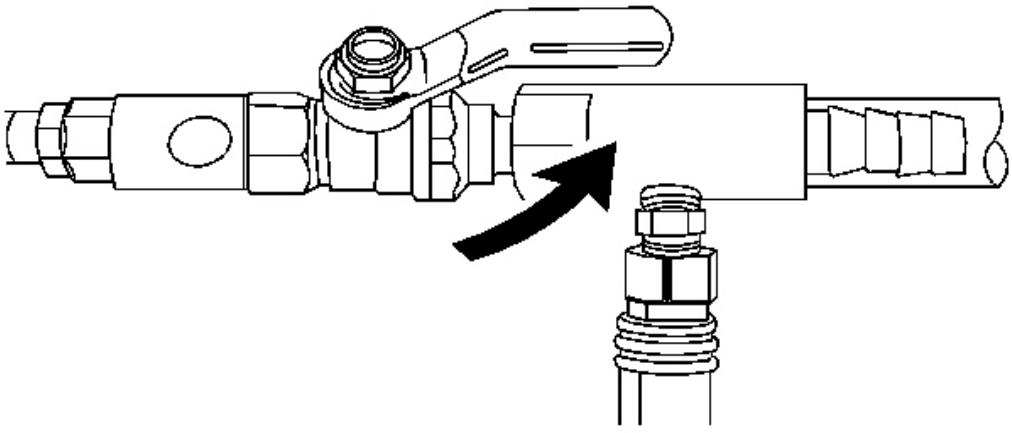


Fig. 21: Identifying Valve & Venturi Assembly
Courtesy of GENERAL MOTORS CORP.

11. Open the valve on the venturi assembly. The vacuum gage will begin to rise and a hissing noise will be present.

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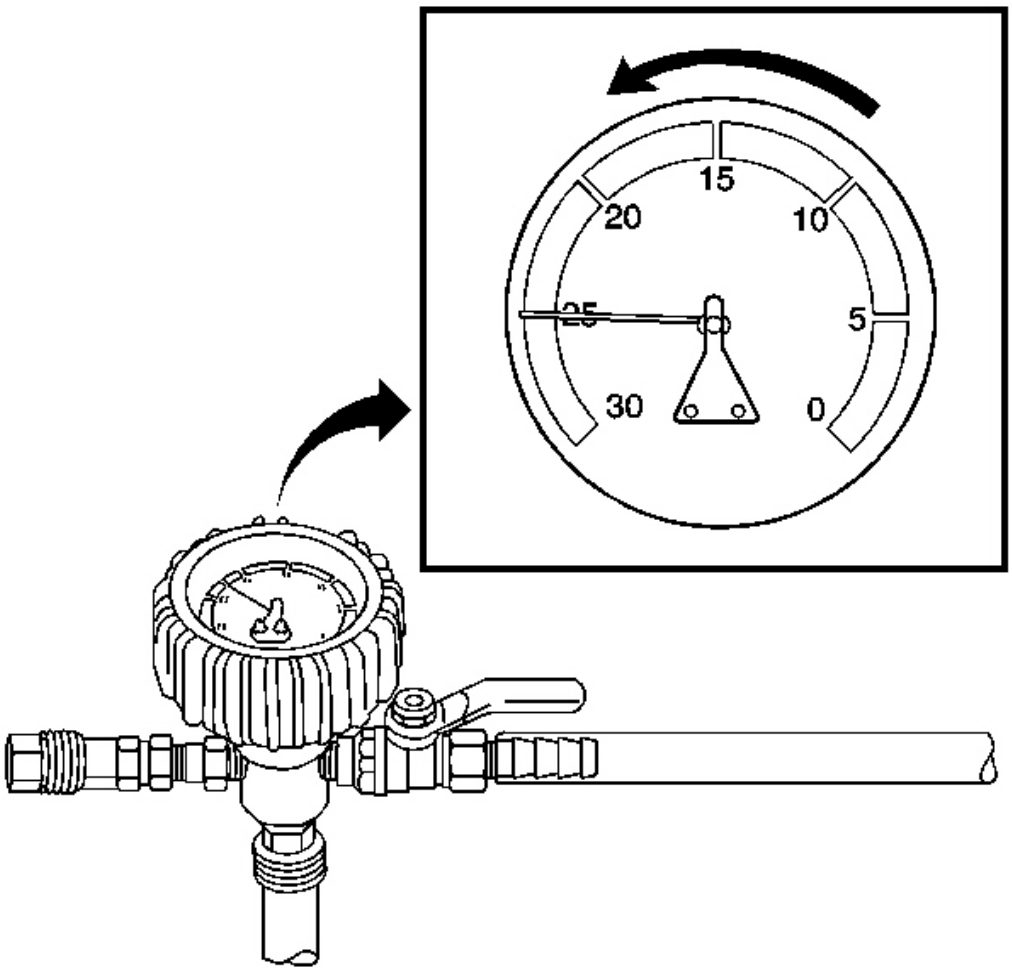


Fig. 22: Drawing Vacuum
Courtesy of GENERAL MOTORS CORP.

12. Continue to draw vacuum until the needle stops rising. This should be 610-660 mm Hg (24-26 in Hg).

    Cooling hoses may start to collapse. This is normal due to vacuum draw.

13. To aid in the fill process, position the graduated reservoir above the coolant fill port.

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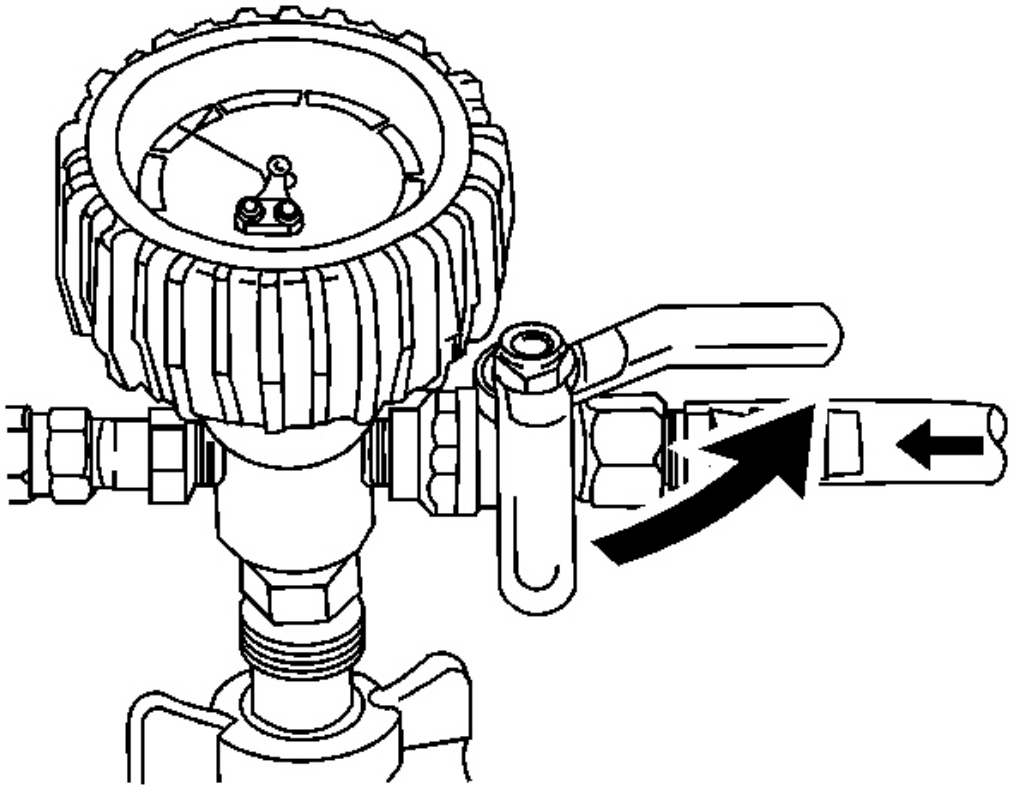


Fig. 23: Opening/Closing Valve
Courtesy of GENERAL MOTORS CORP.

14. Slowly open the valve on the vacuum gage assembly. When the coolant reaches the top of the fill hose, close the valve. This will eliminate air from the fill hose.
15. Close the valve on the venturi assembly.
16. If there is a suspected leak in the cooling system, allow the system to stabilize under vacuum and monitor for vacuum loss.

    If vacuum loss is observed, refer to **Loss of Coolant (LC3)** or **Loss of Coolant (LH2)**.

17. Open the valve on the vacuum gage assembly. The vacuum gage will drop as coolant is drawn into the system.

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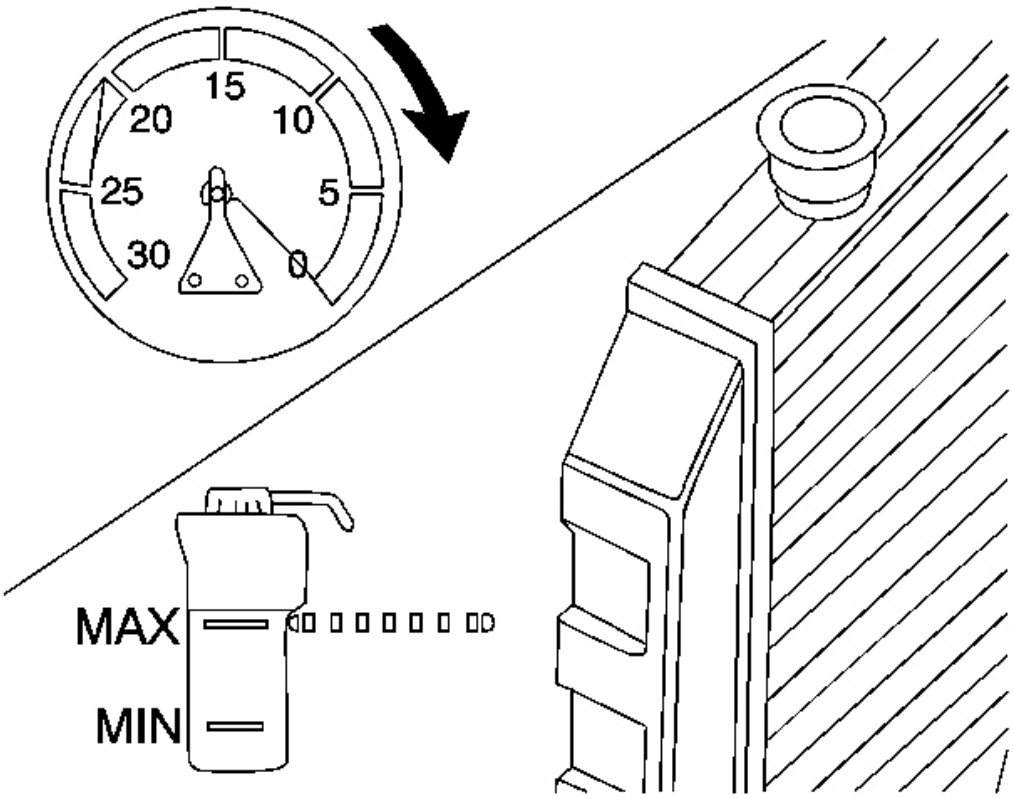


Fig. 24: Identifying Vacuum Gage Reading
Courtesy of GENERAL MOTORS CORP.

18. Once the vacuum gage reaches zero, close the valve on the vacuum gage assembly and repeat steps 11-17.
19. Detach the Vac N Fill cap from the **J 42401** . See **Special Tools**.
20. Remove the **J 42401** from the coolant surge tank. See **Special Tools**.
21. Add coolant to the system as necessary.
22. Inspect the concentration of the coolant mixture using **J 26568** . See **Special Tools**.

IMPORTANT: After filling the cooling system, the extraction hose can be used to remove excess coolant to achieve the proper coolant level.

23. Detach the vacuum hose from the vacuum gage assembly.

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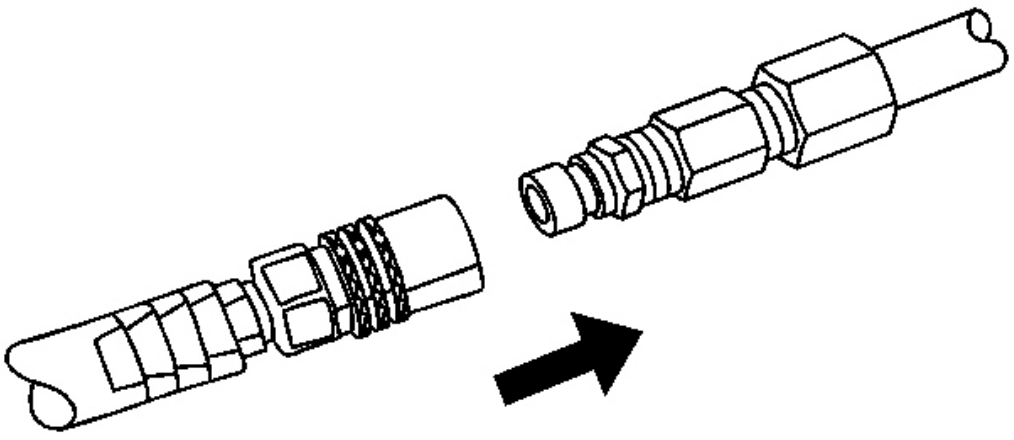


Fig. 25: Identifying Extraction Hose And Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

24. Attach the extraction hose to the vacuum hose.

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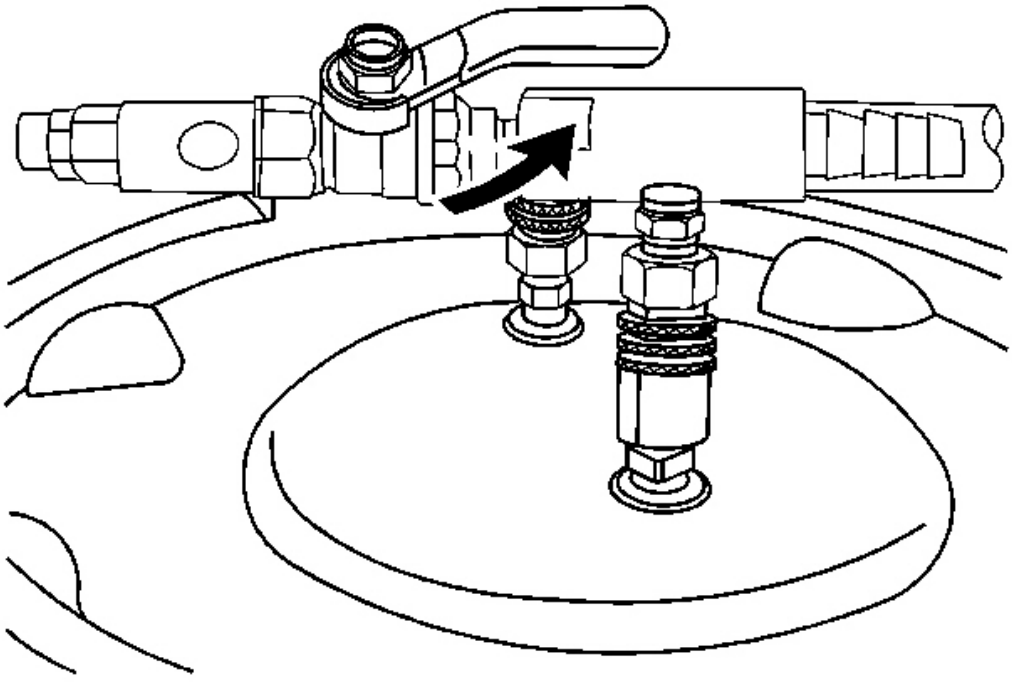


Fig. 26: Identifying Valve On Venturi Assembly
Courtesy of GENERAL MOTORS CORP.

25. Open the valve on the venturi assembly to start a vacuum draw.

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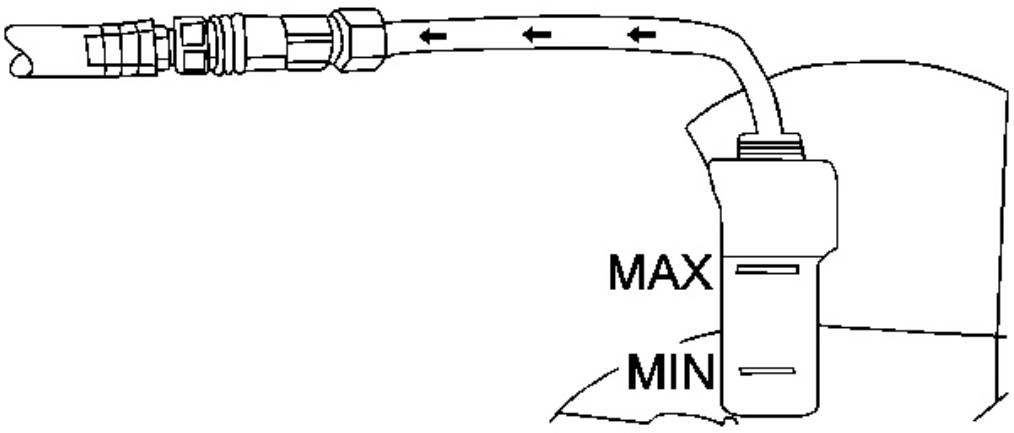


Fig. 27: Using Extraction Hose To Draw Out Coolant
Courtesy of GENERAL MOTORS CORP.

26. Use the extraction hose to draw out coolant to the proper level.
27. The vacuum tank has a drain valve on the bottom of the tank. Open the valve to drain coolant from the vacuum tank into a suitable container for disposal.
28. Install the surge tank cap.

DRAINING AND FILLING COOLING SYSTEM (STATIC FILL)

Tools Required

J 26568 Coolant and Battery Tester. See **Special Tools**.

Draining Procedure

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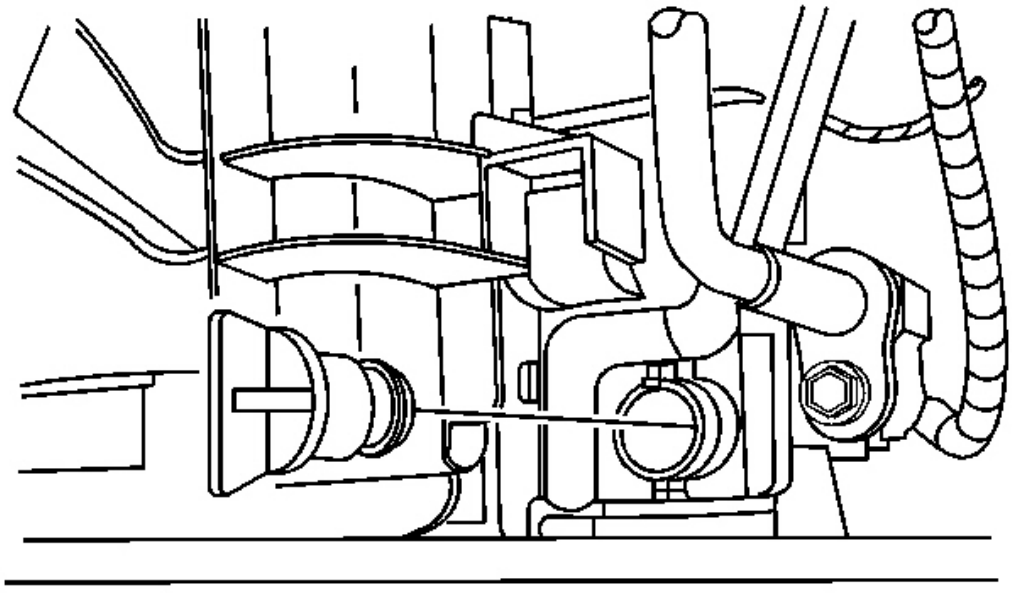


Fig. 28: Identifying Radiator Drain Cock
Courtesy of GENERAL MOTORS CORP.

CAUTION: To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if radiator cap or surge tank cap is removed while the engine and radiator are still hot.

1. Remove the coolant pressure cap.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Place a drain pan under the drain cock.
4. Remove the radiator drain cock.
5. Drain the cooling system.
6. Lower the vehicle.
7. Inspect the coolant.
8. Follow the appropriate procedure based on the condition of the coolant.
   - Normal in appearance-Follow the filling procedure.
   - Discolored-Follow the flush procedure. Refer to **Flushing (Charge Air Cooling)Flushing (Powertrain)**.

Filling Procedure

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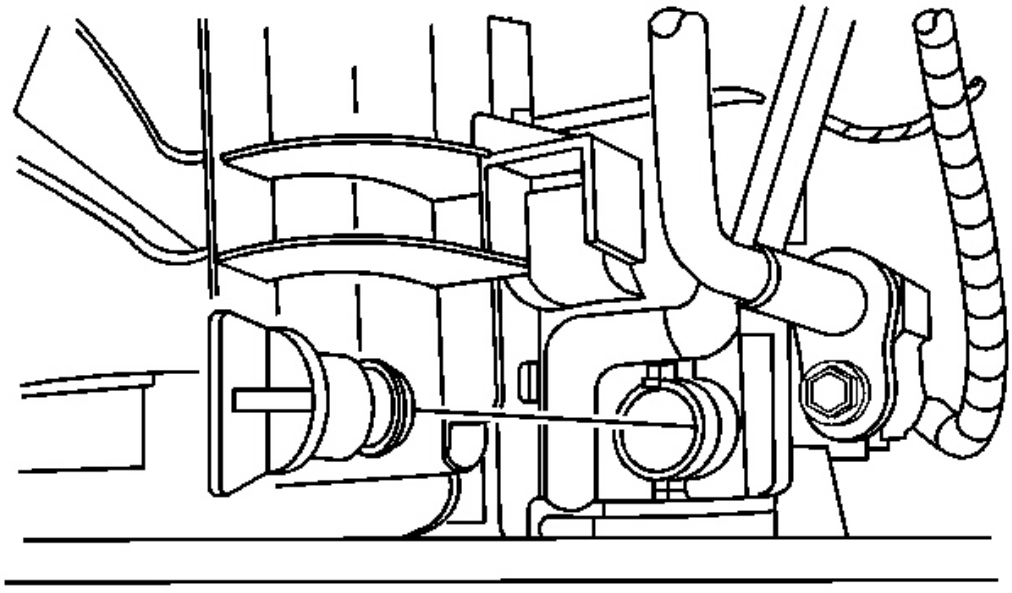


Fig. 29: Identifying Radiator Drain Cock
Courtesy of GENERAL MOTORS CORP.

NOTE: The procedure below must be followed. Improper coolant level could result in a low or high coolant level condition, causing engine damage.

1. Raise and support the vehicle.

IMPORTANT: Inspect the drain cock O-ring for signs of cracks or damage. Replace, if necessary.

2. Lubricate the drain cock O-ring with clean coolant prior to installation.

NOTE: Refer to Fastener Notice .

3. Install the radiator drain cock.

Tighten: Tighten the radiator drain cock to 2 N.m (18 lb in).

4. Lower the vehicle.

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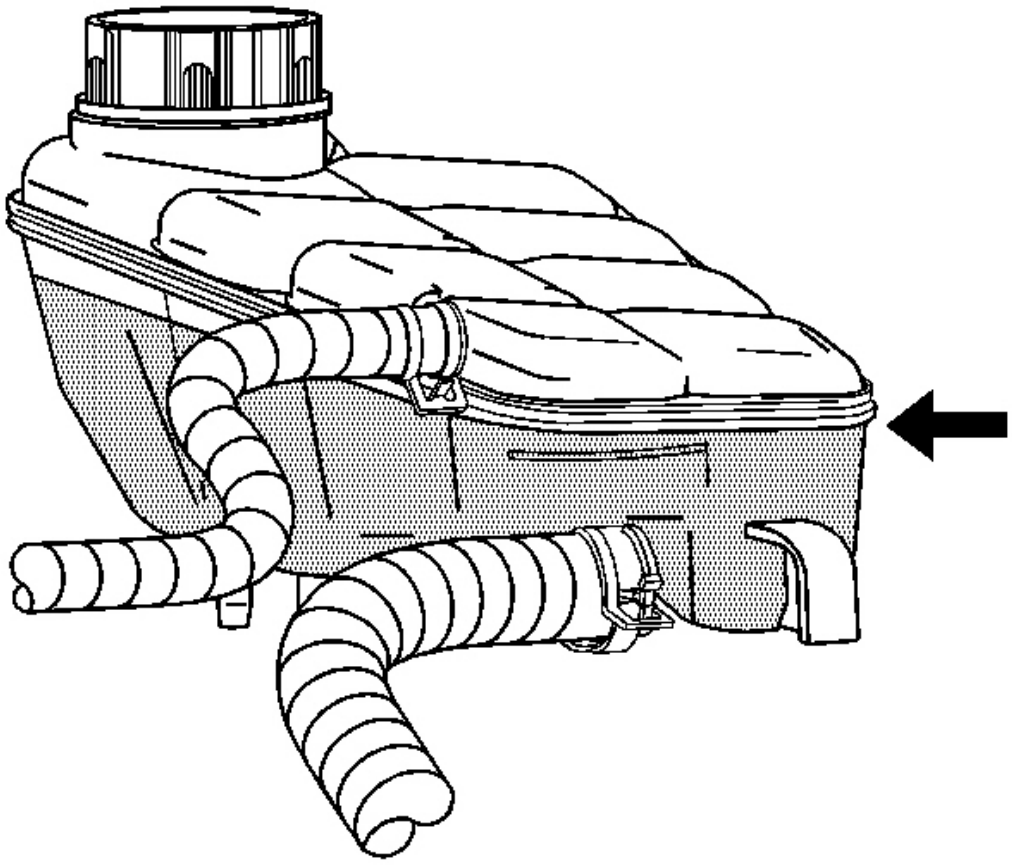


Fig. 30: Monitoring Surge Tank Coolant Level
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use a 50/50 mixture of DEX-COOL antifreeze and clean drinkable water.

5. Slowly fill the surge tank with a 50/50 coolant mixture until the coolant level reaches the base of the surge tank fill neck. Refer to **Capacities - Approximate Fluid** .

IMPORTANT: Monitor the surge tank coolant level closely. The surge tank coolant level will begin to decrease once the engine is started.

6. Start the engine and allow to the engine to idle.

   Allow the engine to idle for approximately 4 minutes.

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7. Slowly fill the coolant mixture until the level stabilizes at the base of the surge tank fill neck.
8. Run the engine between 2,000-2,500 RPM for approximately 2 minutes.
9. Allow engine to idle and add approximately 1 liter (1.1 quarts) of coolant to the surge tank.
10. Install the coolant pressure cap.
11. Turn the engine OFF.
12. Allow the engine to cool.
13. Top off the coolant as necessary.
14. Inspect the concentration of the engine coolant. Using the **J 26568** . See **Special Tools**.
15. Rinse away any excess coolant from the engine and the engine compartment.
16. Inspect the cooling system for leaks.

CHARGE AIR COOLING SYSTEM COOLANT LEVEL INSPECTION

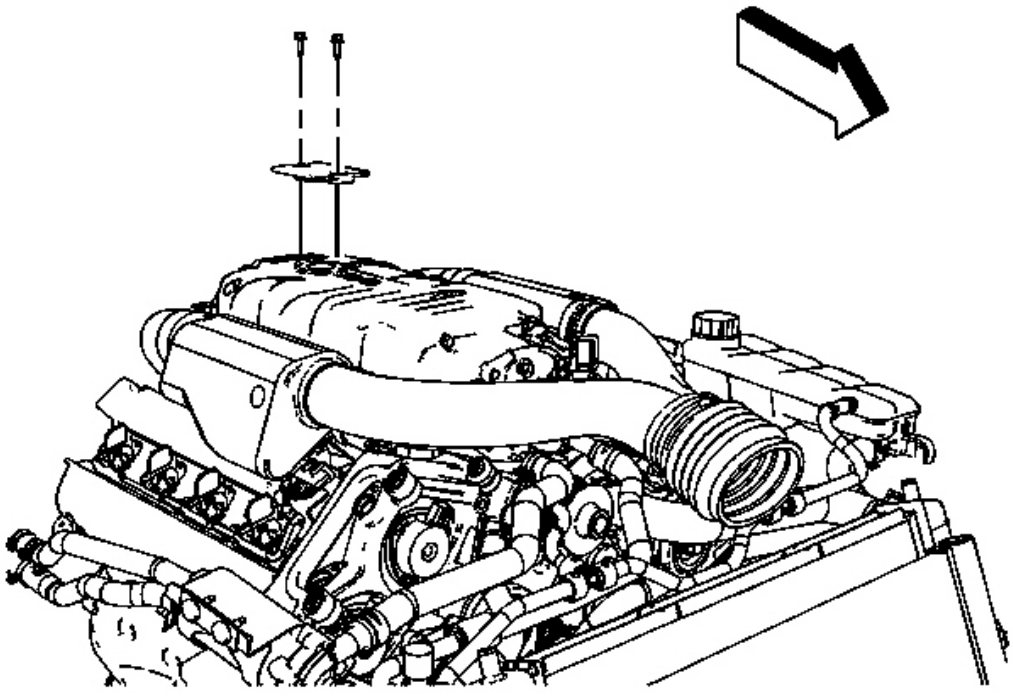


Fig. 31: Identifying Charge Air Coolant Cap Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure the intercooler system is cool and that the pump is not in the ON position.

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1. Remove the manifold sight shield. Refer to **Intake Manifold Sight Shield Replacement** .
2. Remove the charge air coolant cap.

IMPORTANT: It is normal to have a very small pocket of air at the top of the system below the fill cap on a properly filled charge air cooling system.

3. Verify that coolant is visible near to top of the opening.

IMPORTANT: Use a 50/50 mixture of DEX-COOL® antifreeze and clean drinkable water. Pour the coolant in very small amounts to avoid coolant spillage from the charge air coolant cap port or from funnel.

4. Using a small funnel, slowly fill the charge air cooling system through the charge air coolant cap port with a 50/50 coolant mixture until the level is slightly below the charge air coolant cap port. Refer to **Capacities - Approximate Fluid** .

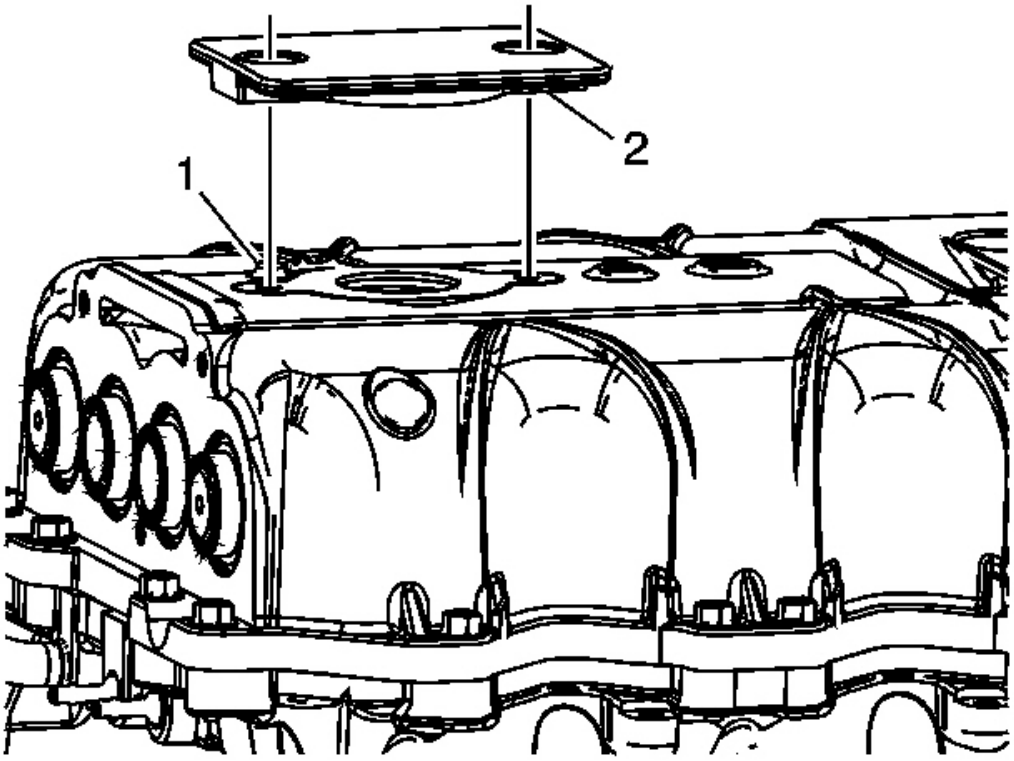


Fig. 32: View Of Charge Air Cooler Cooling Fill Cap
Courtesy of GENERAL MOTORS CORP.

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5. Ensure the charge air cooler cooling fill cap is installed in the proper orientation.
   - The alignment boss (1) is at the rear of the charge air cooler manifold.
   - The alignment boss (1) is at the front of the charge air cooler cooling filling cap.

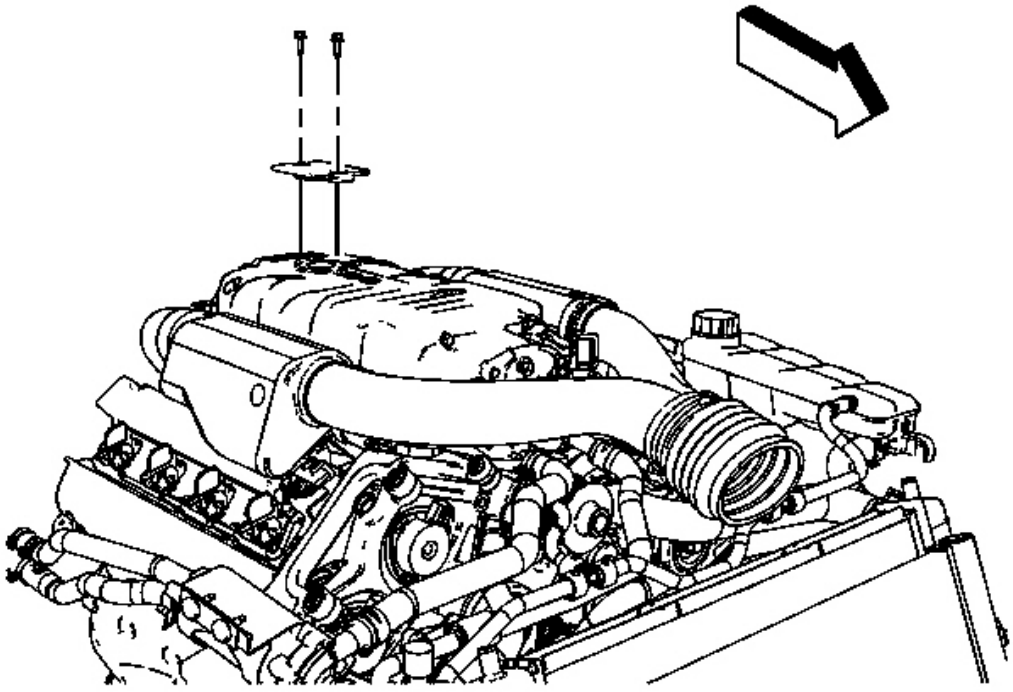


Fig. 33: Identifying Charge Air Coolant Cap Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the charge air coolant cap bolts.

   Tighten: Tighten the bolts to 10 N.m (89 lb in).

7. Install the manifold sight shield. Refer to **Intake Manifold Sight Shield Replacement** .

DRAINING AND FILLING COOLING SYSTEM - CHARGE AIR COOLING SYSTEM (STATIC FILL)

Tools Required

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- **J 26568** Coolant and Battery Tester. See **Special Tools**.
- **J 38185** Hose Clamp Pliers. See **Special Tools**.

Draining Procedure

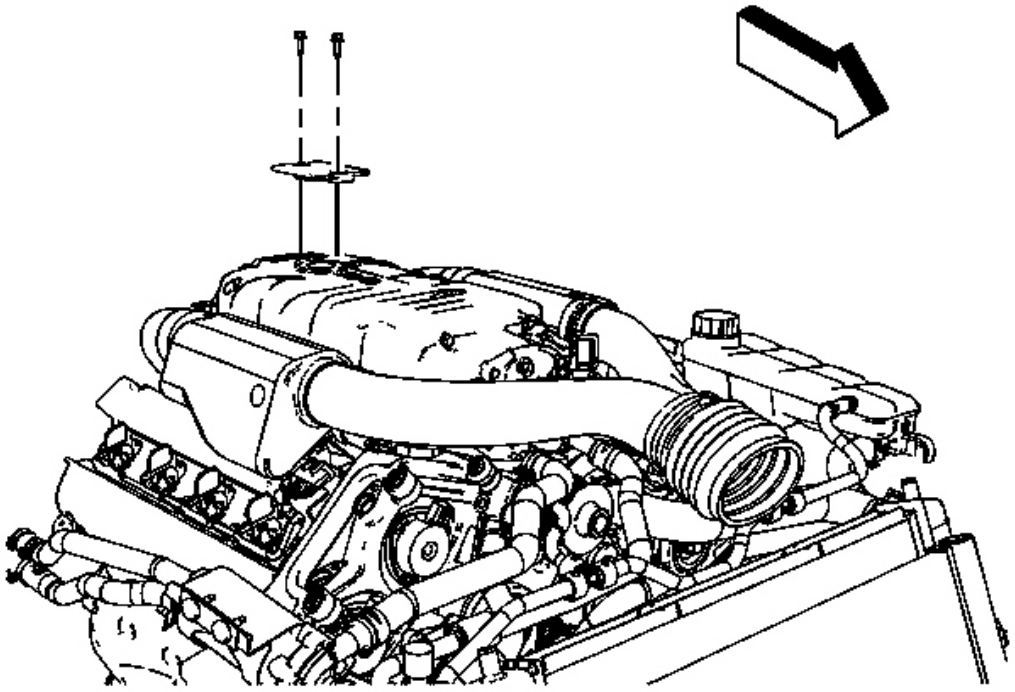


Fig. 34: Identifying Charge Air Coolant Cap Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: To avoid being burned, do not remove the charge air coolant cap while the system is hot. The cooling system will release scalding fluid and steam under pressure if charge air coolant cap is removed while the system is still hot.

IMPORTANT: Make sure the intercooler system is cool and that the pump is not in the ON position.

1. Remove the manifold sight shield. Refer to **Intake Manifold Sight Shield Replacement** .
2. Remove the charge air coolant cap.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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4. Place a drain pan under the charge air cooler radiator.

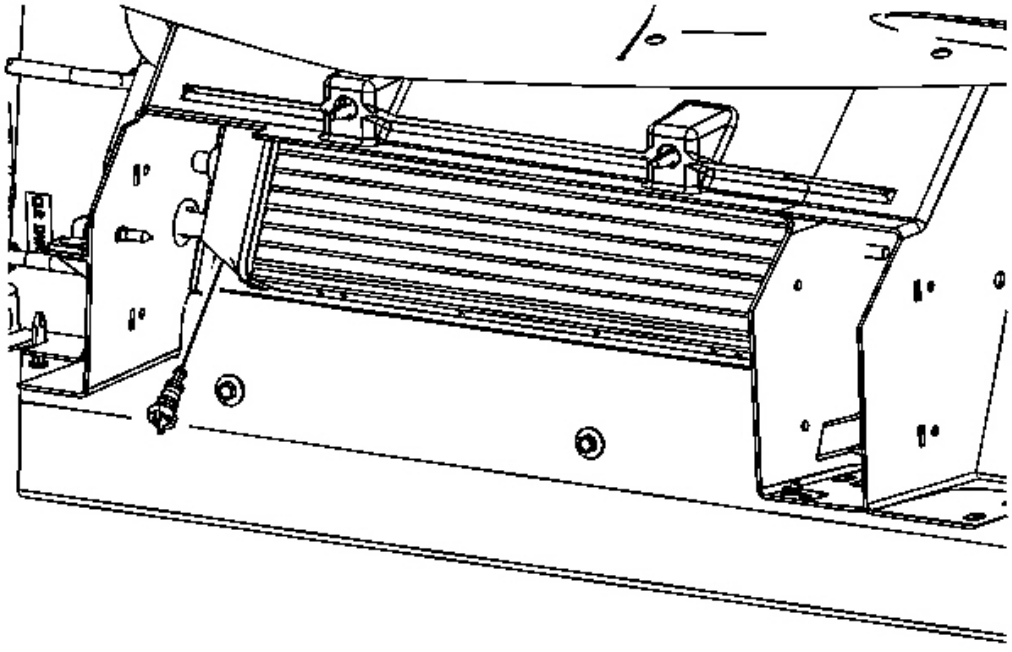


Fig. 35: Identifying Charge Air Cooler Radiator Drain Plug
Courtesy of GENERAL MOTORS CORP.

5. Remove the drain plug from the charge air cooler radiator.
6. Drain the charge air cooling system.
7. Inspect the coolant.
8. Follow the appropriate procedure based on the condition of the coolant:
   - Normal in appearance-Follow the filling procedure.
   - Discolored-Follow the flush procedure. Refer to **Flushing (Charge Air Cooling)Flushing (Powertrain)**.
9. Install the drain plug to the charge air cooler radiator.
10. Remove the drain pan from under the charge air coolant radiator.
11. Lower the vehicle.

Filling Procedure

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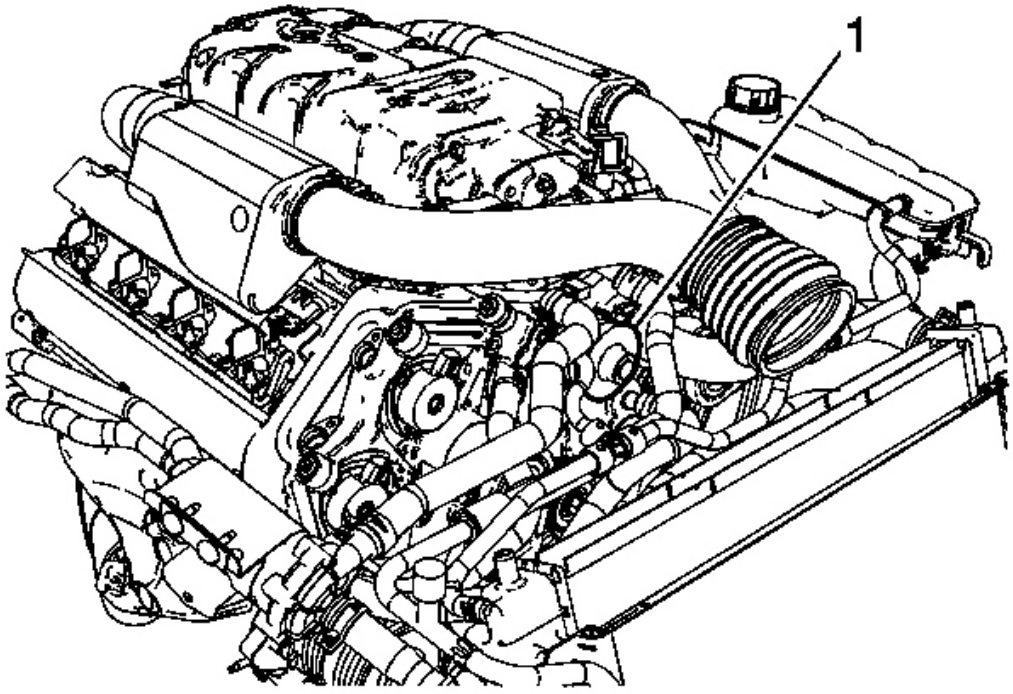


Fig. 36: Charge Air Cooler Manifold Lines
Courtesy of GENERAL MOTORS CORP.

NOTE: **The procedure below must be followed. Improper coolant level could result in poor system performance.**

IMPORTANT: **The charge air cooling system is filled through the fitting in the charge air coolant pump outlet hose.**
Be sure the coolant does not make contact with the drive belt or any other surfaces. Coolant contact will cause belt noise and require belt replacement.

1. Place a moderate amount of absorbent material below the charge air cooler manifold lines (1) to ensure that coolant does not contact the belts or other components.

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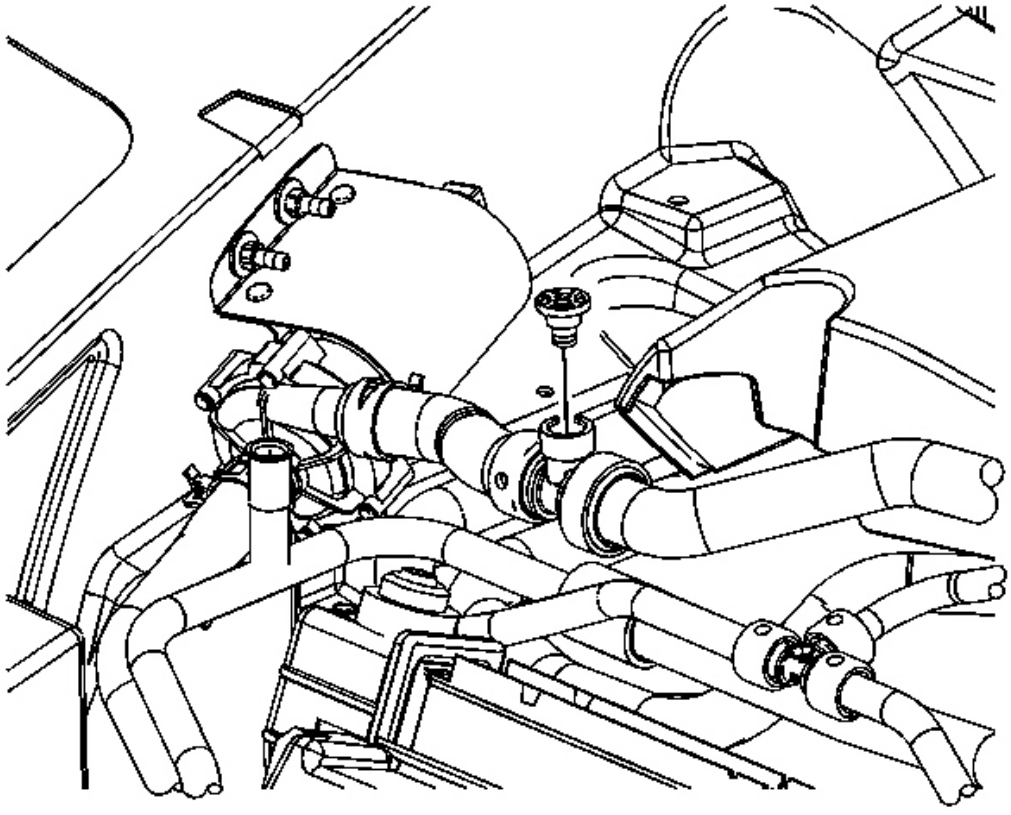


Fig. 37: View Of Charge Air Cooler Pump Outlet Hose Cap
Courtesy of GENERAL MOTORS CORP.

2. Remove the cap on the charge air cooler pump outlet hose.

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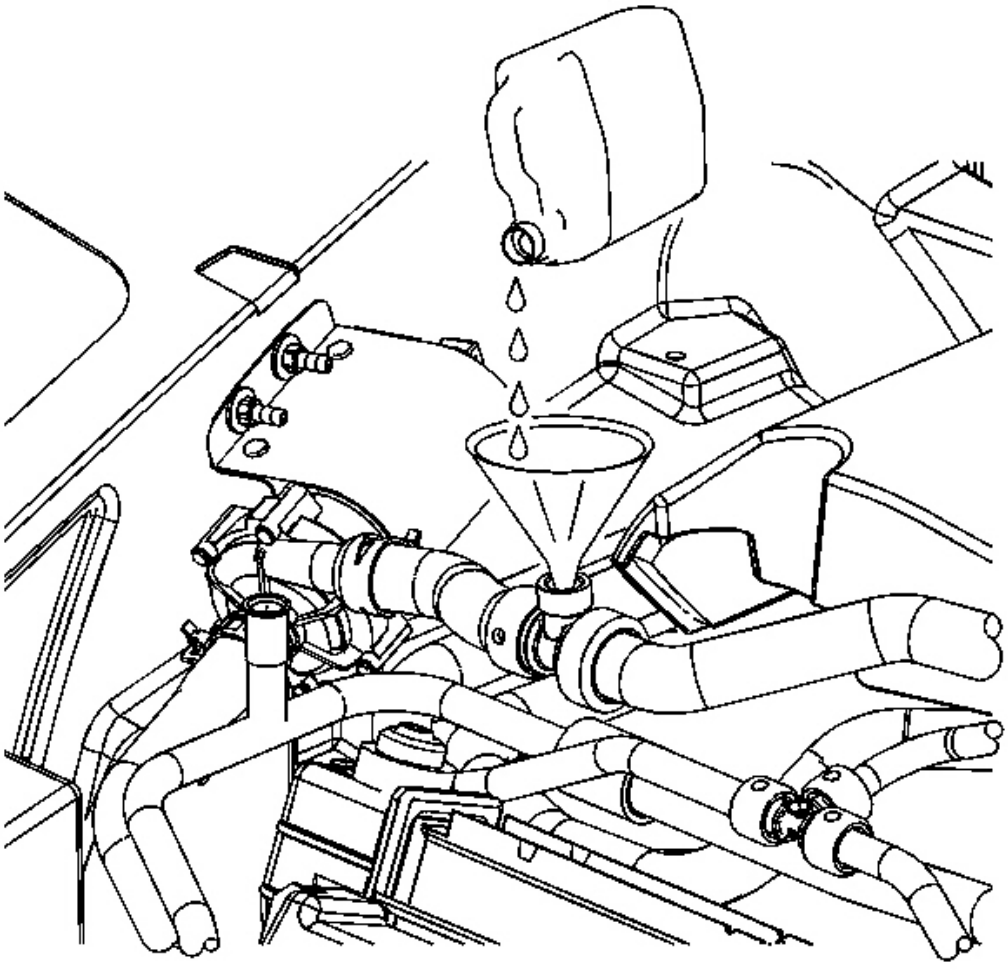


Fig. 38: Filling Charge Air Cooling System
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use a 50/50 mixture of DEX-COOL® antifreeze and clean drinkable water. Pour coolant in very small amounts to avoid coolant spillage from the charge air coolant cap port or from the funnel.

3. Using a small funnel, slowly fill the charge air cooling system through the charge air coolant cap port with a 50/50 coolant mixture until the level is slightly below the charge air coolant cap port. Refer to **Capacities - Approximate Fluid** .

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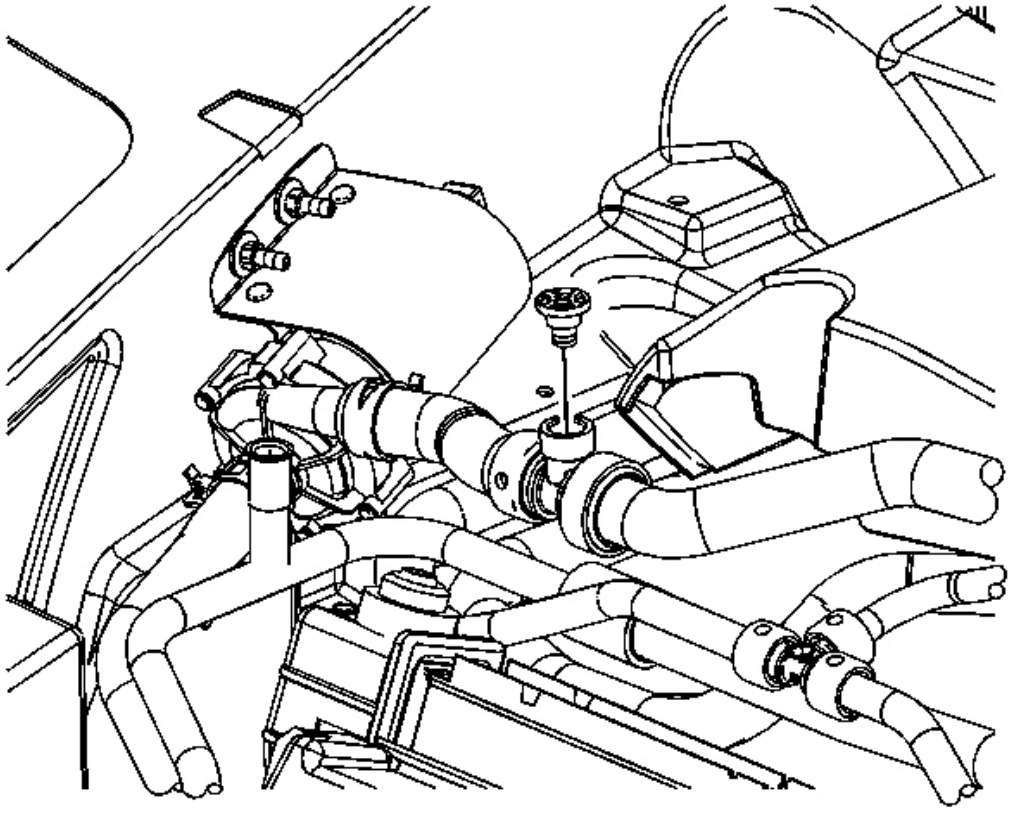


Fig. 39: View Of Charge Air Cooler Pump Outlet Hose Cap
Courtesy of GENERAL MOTORS CORP.

4. Install the cap on the charge air cooler pump outlet hose.

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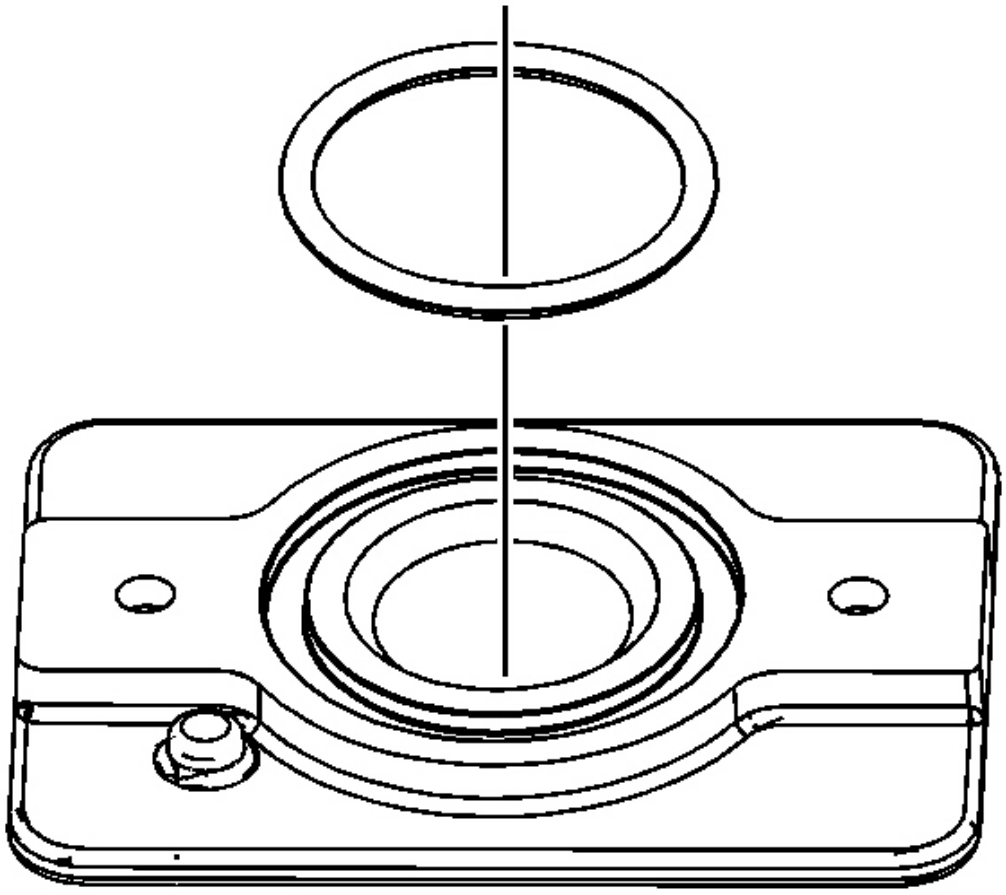


Fig. 40: View Of Charge Air Cooler Cooling Fill Cap O-Ring
Courtesy of GENERAL MOTORS CORP.

5. Install a new charge air cooler cooling fill cap O-ring.

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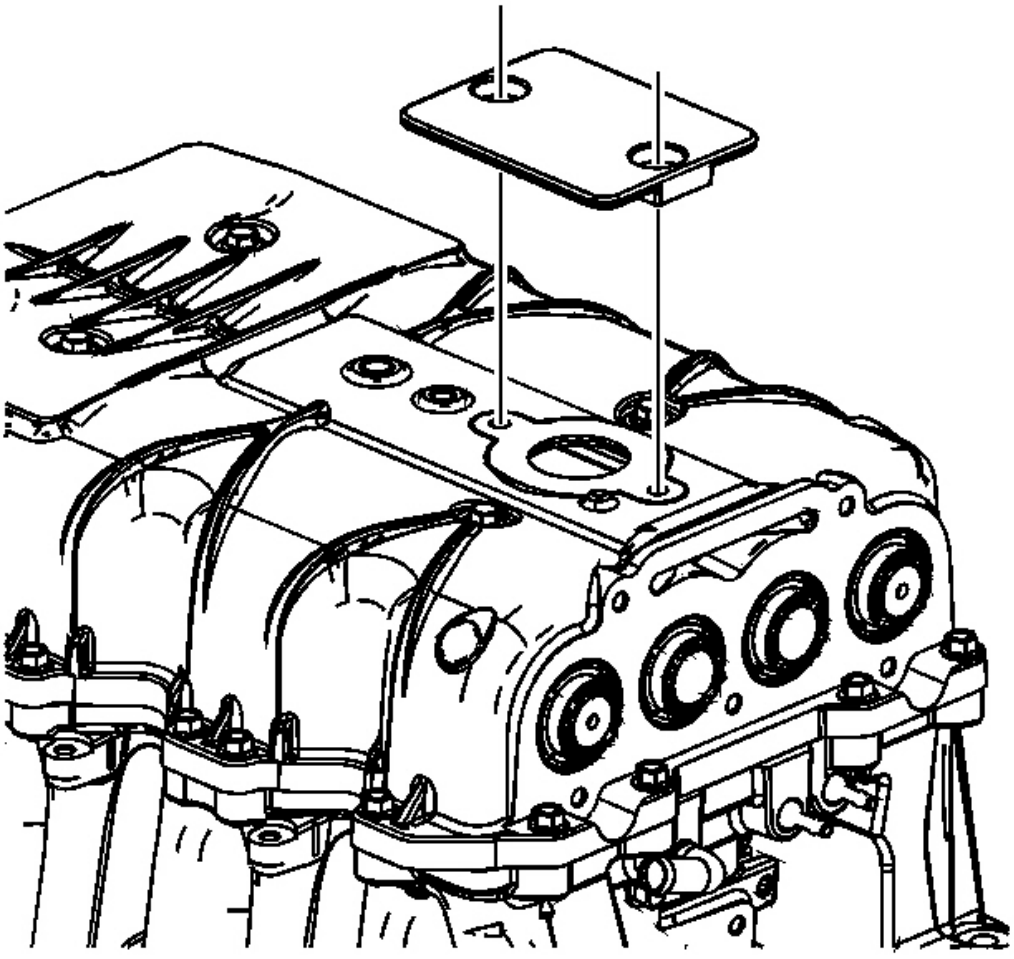


Fig. 41: View Of Charge Air Cooler Cooling Fill Cap
Courtesy of GENERAL MOTORS CORP.

6. Install a new charge air cooler cooling fill cap.

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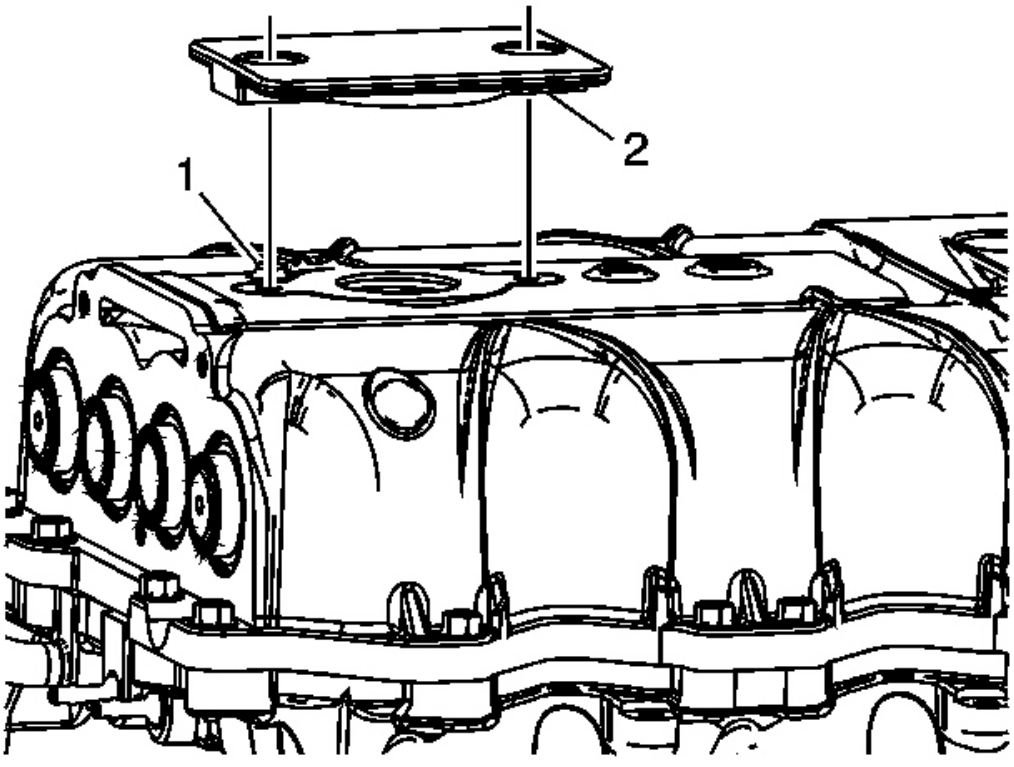


Fig. 42: View Of Charge Air Cooler Cooling Fill Cap
Courtesy of GENERAL MOTORS CORP.

7. Ensure the charge air cooler cooling fill cap is installed in the proper orientation:
    - The alignment boss (1) is at the rear of the charge air cooler manifold.
    - The alignment boss (2) is at the front of the charge air cooler cooling filling cap.

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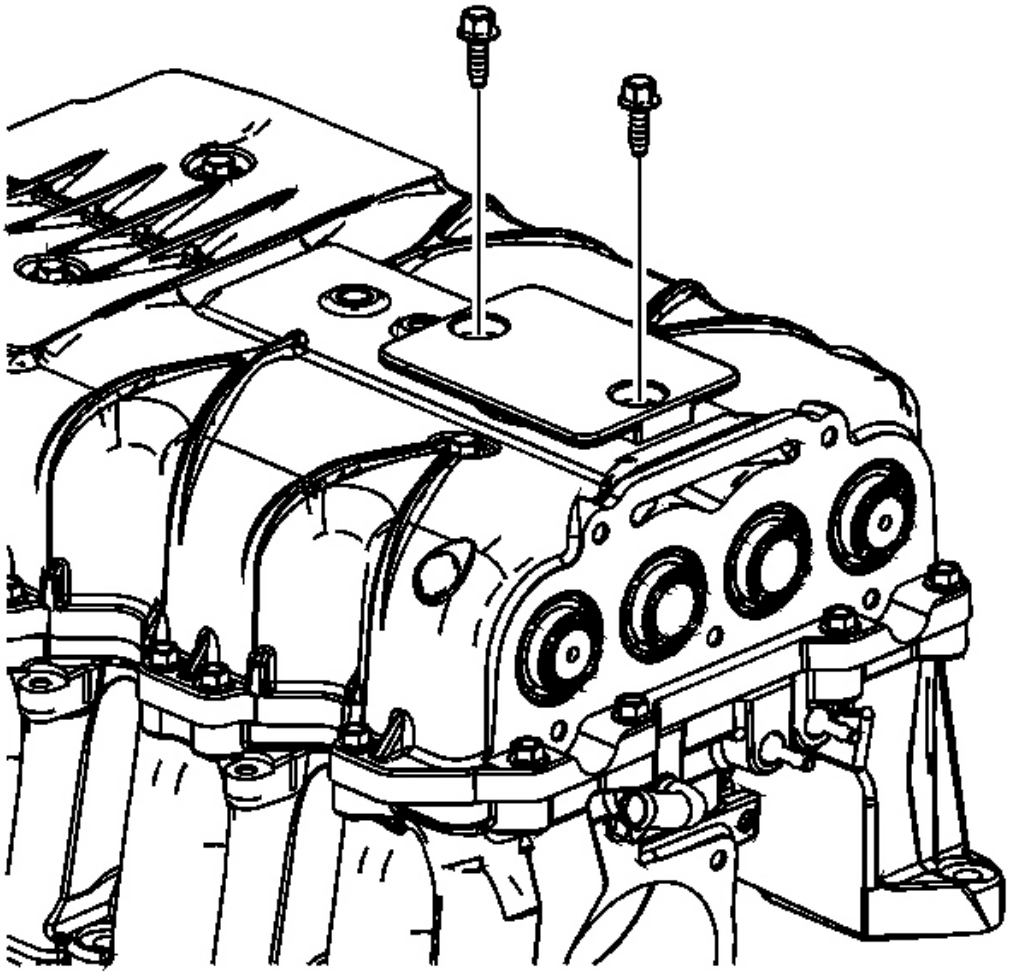


Fig. 43: View Of Charge Air Cooler Cooling Fill Cap Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Fastener Notice .**

8. Install the charge air coolant cap bolts.

Tighten: Tighten the bolts to 10 N.m (89 lb in).

IMPORTANT: Do not cycle the charge air cooling system without the charge air cooling cap in place or coolant loss will occur.

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9. Cycle the charge air cooling system ON by using the Tech 2 or by starting the engine for approximately 2 minutes.
10. Cycle the charge air cooling system OFF.
11. Remove the charge air coolant cap bolts.
12. Remove the charge air coolant cap.

IMPORTANT: It is normal to have a very small pocket of air at the top of the system below the fill cap on a properly filled charge air cooling system.

13. Ensure that coolant is almost level with the coolant cap fill port (1). Top off with a 50/50 coolant mixture through the charge air coolant cap port if necessary.

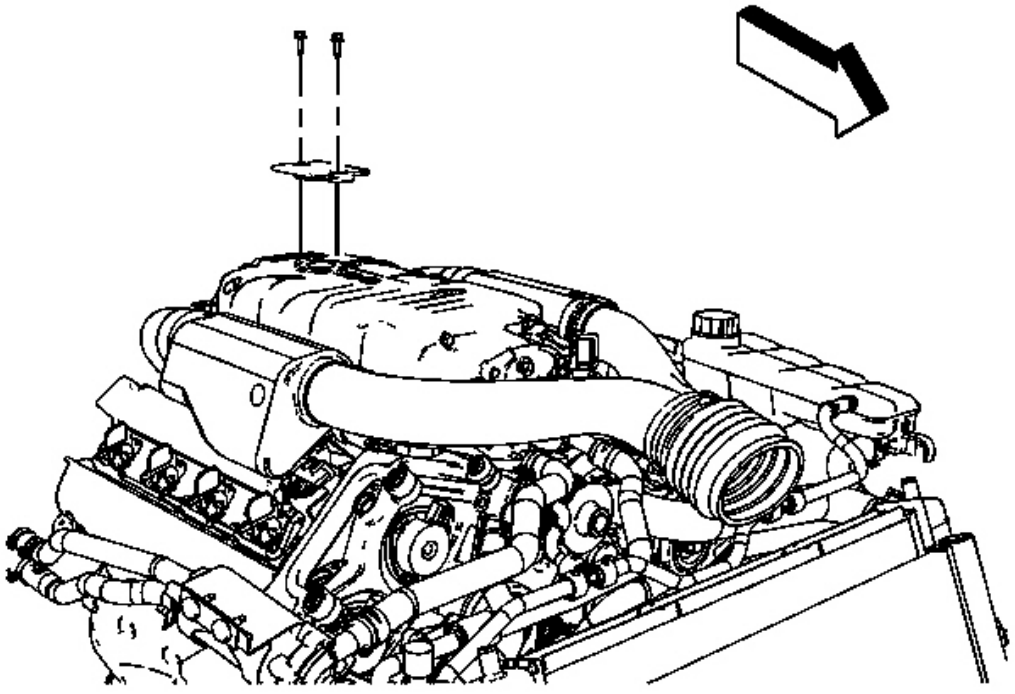


Fig. 44: Identifying Charge Air Coolant Cap Bolts
Courtesy of GENERAL MOTORS CORP.

14. Install the charge air coolant cap.
15. Install the charge air coolant cap bolts.

Tighten: Tighten the bolts to 10 N.m (89 lb in).

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16. Repeat steps 10-16 two more times to ensure the system is properly purged of air.
17. Inspect the concentration of the engine coolant, using the **J 26568** . See **Special Tools**.
18. Inspect the charge air cooling system for leaks.
19. Install the manifold sight shield. Refer to **Intake Manifold Sight Shield Replacement** .

FLUSHING (CHARGE AIR COOLING)

Flushing

IMPORTANT: Do not use a chemical flush.
Store used coolant in the proper manner, such as in a used engine coolant holding tank. Do not pour used coolant down a drain. Ethylene glycol antifreeze is a very toxic chemical. Do not dispose of coolant into the sewer system or ground water. This is illegal and ecologically unsound.
Various methods and equipment can be used to flush the charge air cooling system. If special equipment is used, such as a back flusher, follow the manufacturer's instruction.

When the charge air cooling system becomes contaminated, the system should be flushed thoroughly to remove the contaminants before any components are damaged.

1. Drain the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.
2. Follow the FILL procedure using only clean, drinkable water. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.
3. Cycle the charge air coolant pump ON with the TECH 2 for approximately 5 minutes.
4. Cycle the charge air coolant pump OFF.
5. Drain the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.
6. Repeat the procedure if necessary, until the fluid is nearly colorless.
7. Fill the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.

FLUSHING (POWERTRAIN)

Flushing

IMPORTANT: Do not use a chemical flush.
Store used coolant in the proper manner, such as in a used engine coolant holding tank. Do not pour used coolant down a drain. Ethylene glycol antifreeze is a very toxic chemical. Do not dispose of coolant into the sewer system or ground water. This is illegal and ecologically unsound.
Various methods and equipment can be used to flush the cooling system. If special equipment is used, such as a back flusher, follow the manufacturer's

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instruction. Always remove the thermostat before flushing the cooling system.

When the cooling system becomes contaminated, the cooling system should be flushed thoroughly to remove the contaminants before the engine is seriously damaged.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the surge tank. Refer to **Surge Tank Replacement**.
3. Clean and flush the surge tank with clean, drinkable water.
4. Install the surge tank. Refer to **Surge Tank Replacement**.
5. Follow the drain and fill procedure using only clean, drinkable water. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
6. Run the engine for 20 minutes.
7. Stop the engine.
8. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
9. Repeat the procedure if necessary, until the fluid is nearly colorless.
10. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

RADIATOR CLEANING (CHARGE AIR COOLING)

CAUTION: NEVER spray water on a hot radiator. The resulting steam could cause personal injury.

NOTE: The radiator fins are necessary for good heat transfer. Do not brush the fins. This may cause damage to the fins, reducing heat transfer.

IMPORTANT: Remove bugs, leaves, dirt and other debris by blowing compressed air through the engine side of the charge air coolant radiator.

- Some conditions may require the use of warm water and a mild detergent.
- Clean the A/C condenser fins.
- Clean between the A/C condenser and charge air coolant radiator.
- Clean the charge air coolant radiator cooling fins.
- Straighten any damaged cooling fins.

RADIATOR CLEANING (POWERTRAIN)

CAUTION: NEVER spray water on a hot radiator. The resulting steam could cause personal injury.

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NOTE: The radiator fins are necessary for good heat transfer. Do not brush the fins. This may cause damage to the fins, reducing heat transfer.

IMPORTANT: Remove bugs, leaves, dirt and other debris by blowing compressed air through the engine side of the radiator.

- Some conditions may require the use of warm water and a mild detergent.
- Clean the A/C condenser fins.
- Clean between the A/C condenser and radiator.
- Clean the radiator cooling fins.
- Straighten any damaged cooling fins.

SURGE TANK REPLACEMENT

Tools Required

J 38185 Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

CAUTION: To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if radiator cap or surge tank cap is removed while the engine and radiator are still hot.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

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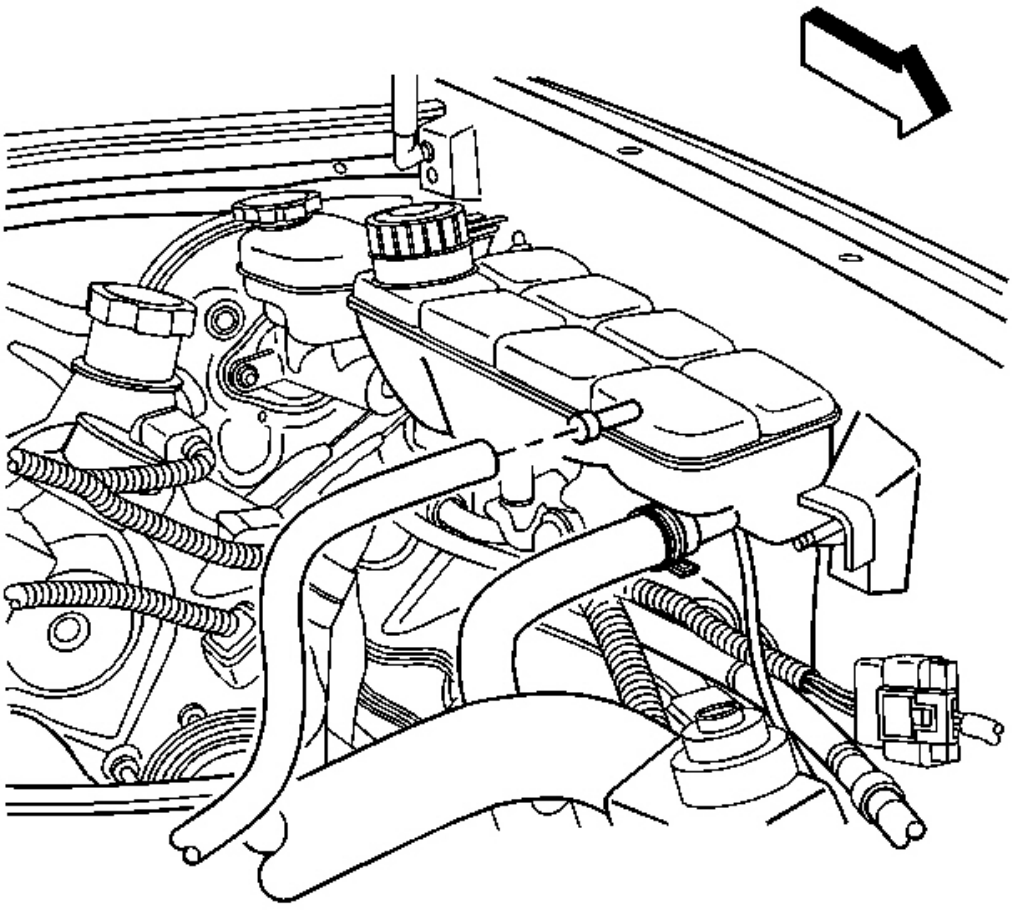


Fig. 45: View Of Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS CORP.

2. Disengage tension on the surge tank inlet hose clamp.
3. Disconnect the surge tank inlet hose from the surge tank.

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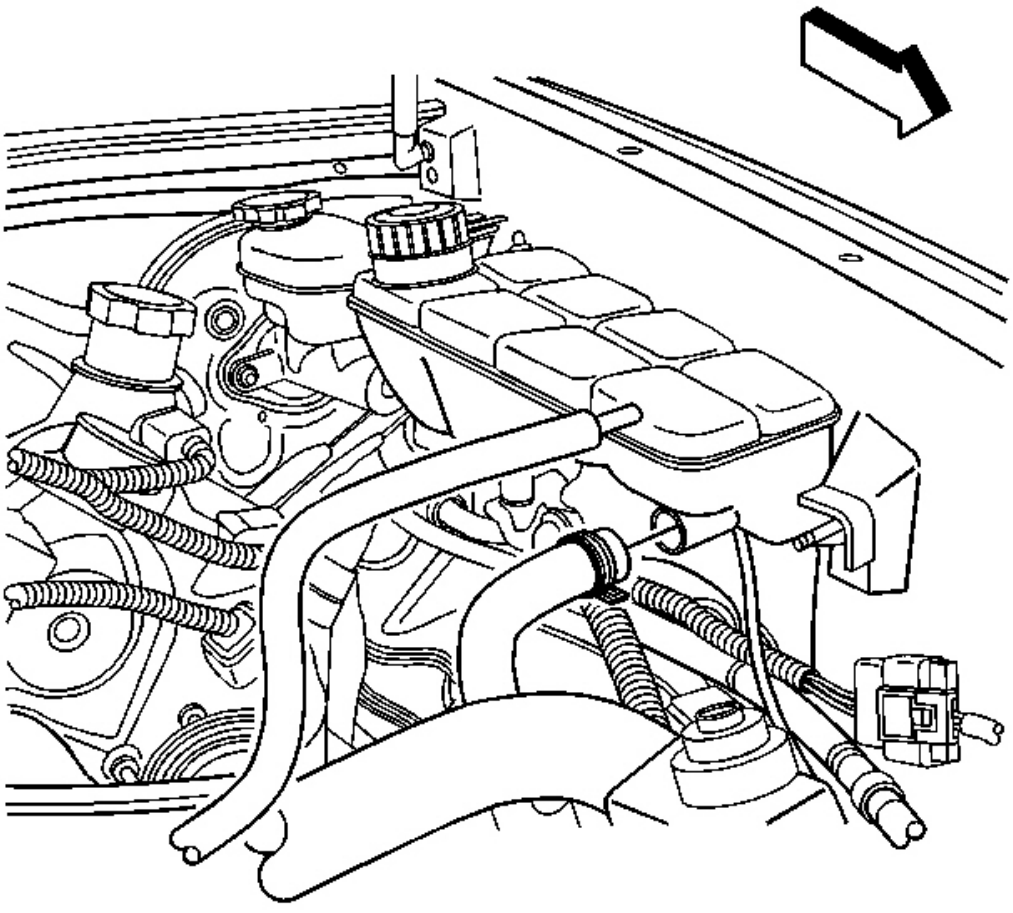


Fig. 46: Disconnecting/Connecting Surge Tank Outlet Hose
Courtesy of GENERAL MOTORS CORP.

4. Disengage tension on the surge tank outlet hose clamp using the **J 38185** . See **Special Tools**.
5. Disconnect the surge tank outlet hose from the surge tank.
6. Remove the protective cap on the surge tank upper stud.
7. Remove the surge tank upper nut.

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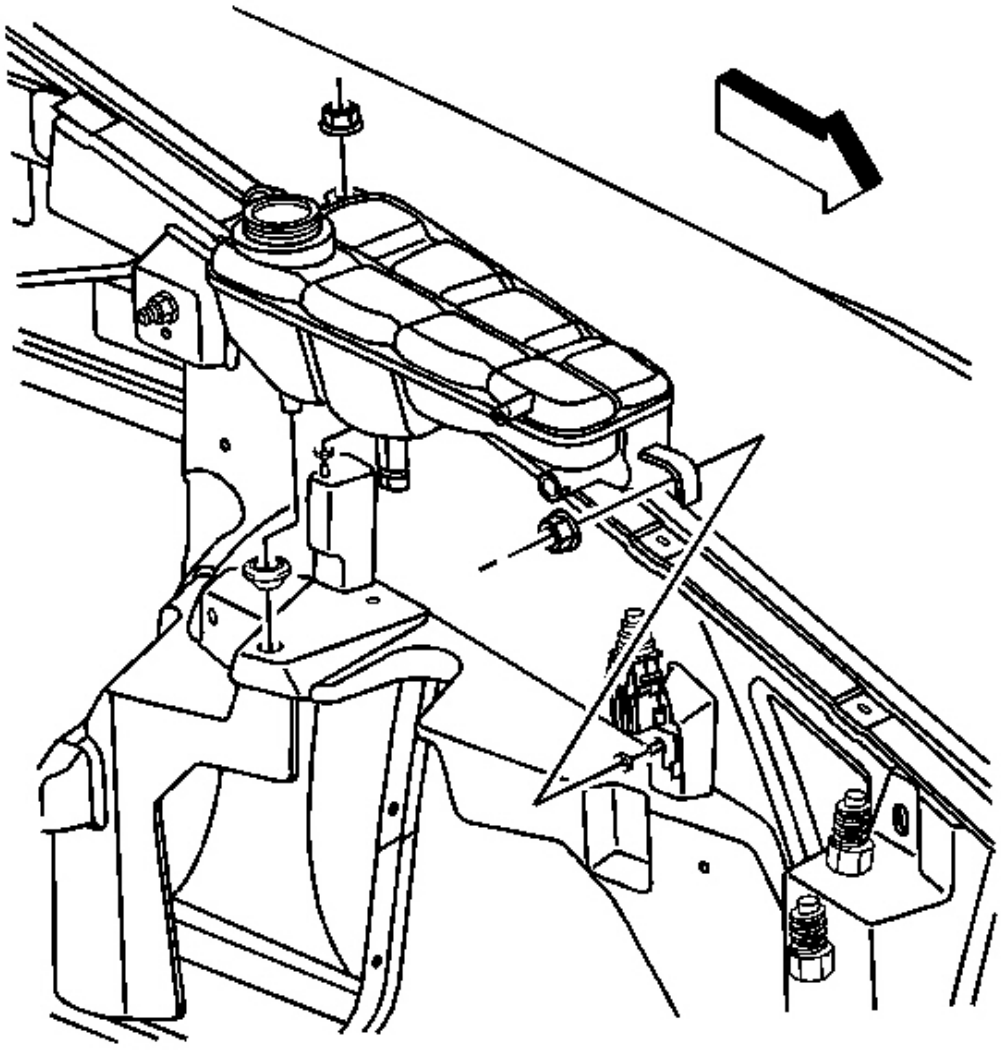


Fig. 47: View of Surge Tank
Courtesy of GENERAL MOTORS CORP.

8. Loosen the surge tank side nut.
9. Disconnect the coolant level sensor electrical connector.
10. Remove the surge tank.

Installation Procedure

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IMPORTANT: Lubricate the inside diameters of the hoses with clean coolant prior to installation.

1. Install the surge tank.

   NOTE: Refer to Fastener Notice .

2. Install the upper surge tank nut.

   Tighten: Tighten all nuts to 8 N.m (71 lb in).

3. Install the protective cap on the surge tank upper stud.

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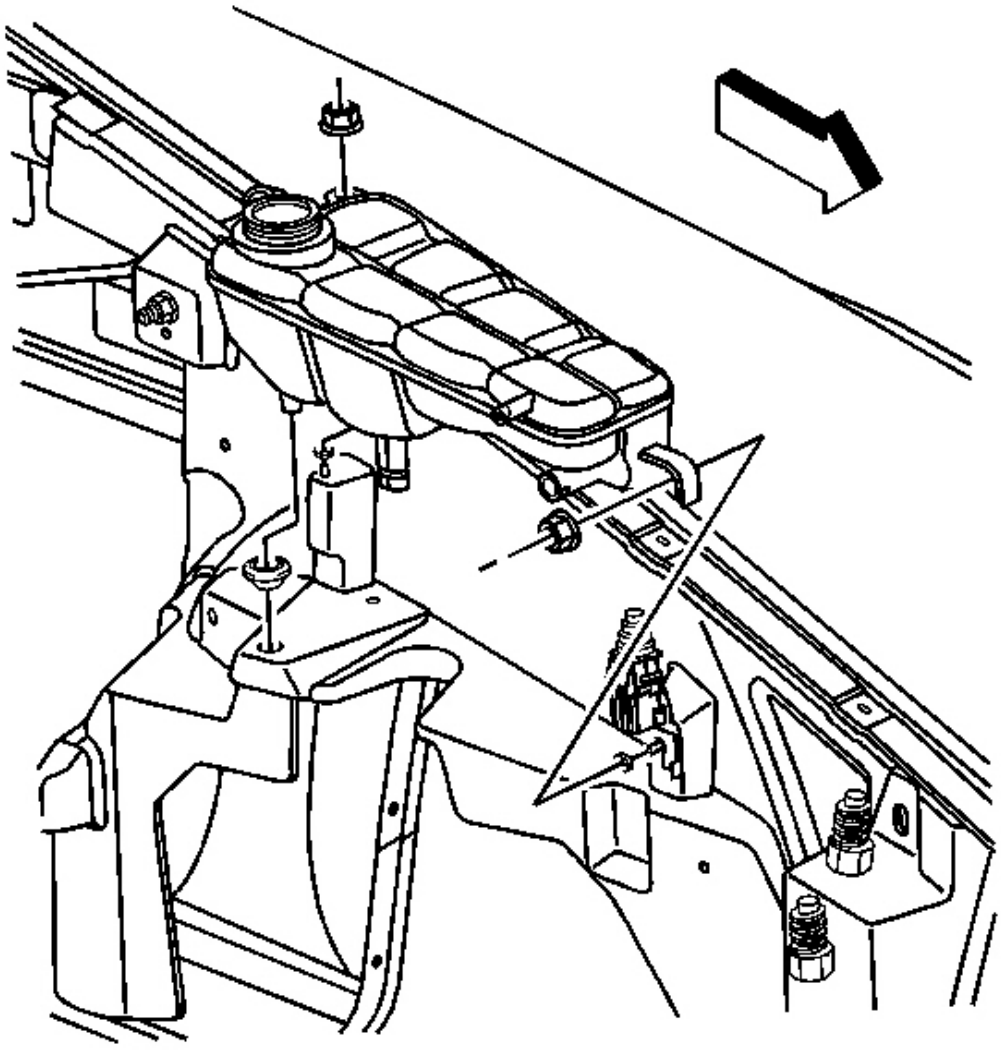


Fig. 48: View of Surge Tank
Courtesy of GENERAL MOTORS CORP.

4. Connect the coolant level sensor electrical connector.

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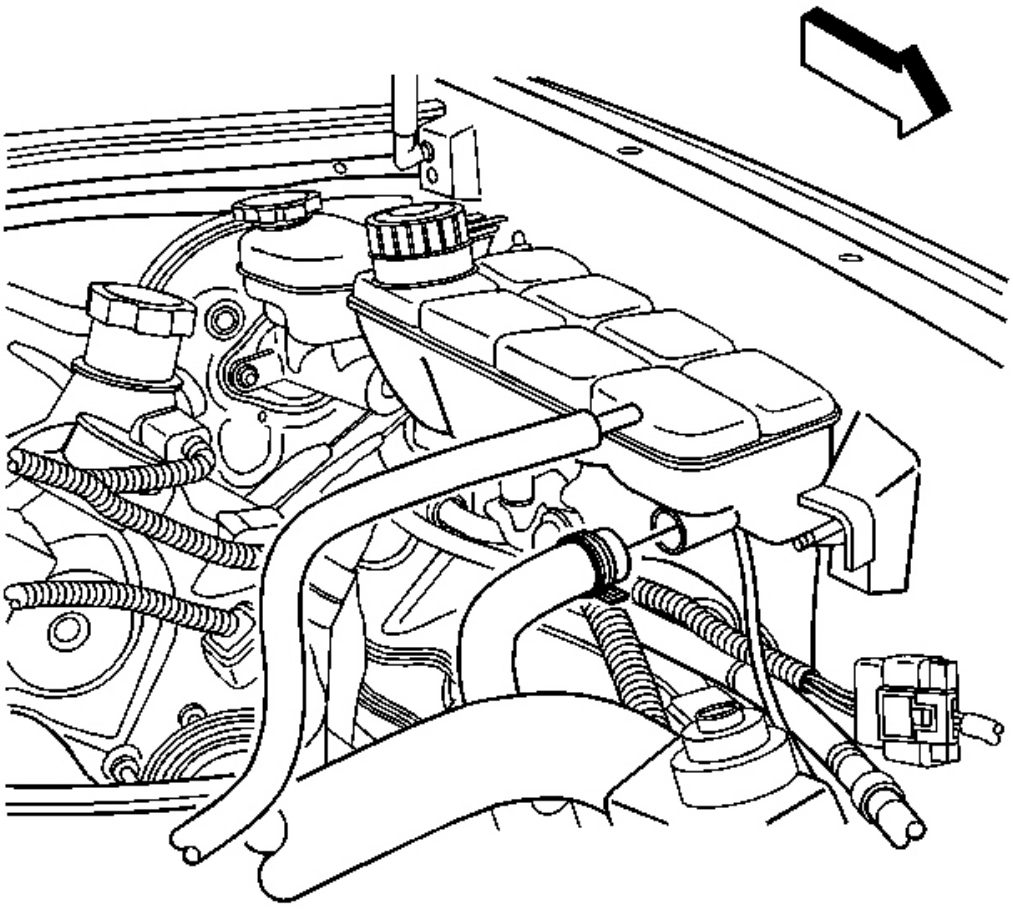


Fig. 49: Disconnecting/Connecting Surge Tank Outlet Hose
Courtesy of GENERAL MOTORS CORP.

5. Connect the surge tank outlet hose to the surge tank.
6. Engage tension on the surge tank outlet hose clamp.

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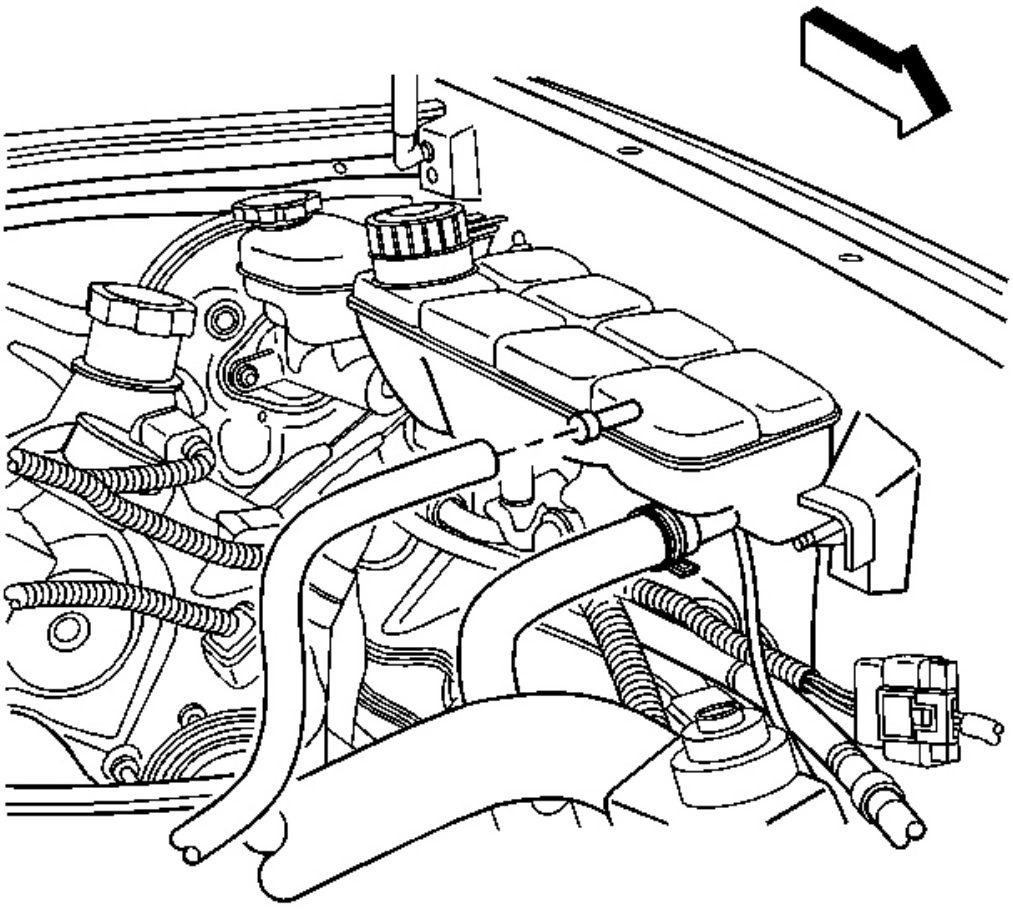


Fig. 50: View Of Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS CORP.

7. Connect the surge tank inlet hose to the surge tank.
8. Engage tension on the surge tank inlet hose clamp.
9. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

SURGE TANK HOSE/PIPE REPLACEMENT - INLET

Tools Required

J 38185 Hose Clamp Pliers. See **Special Tools**.

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Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the radiator support. Refer to **Radiator Support Replacement**.

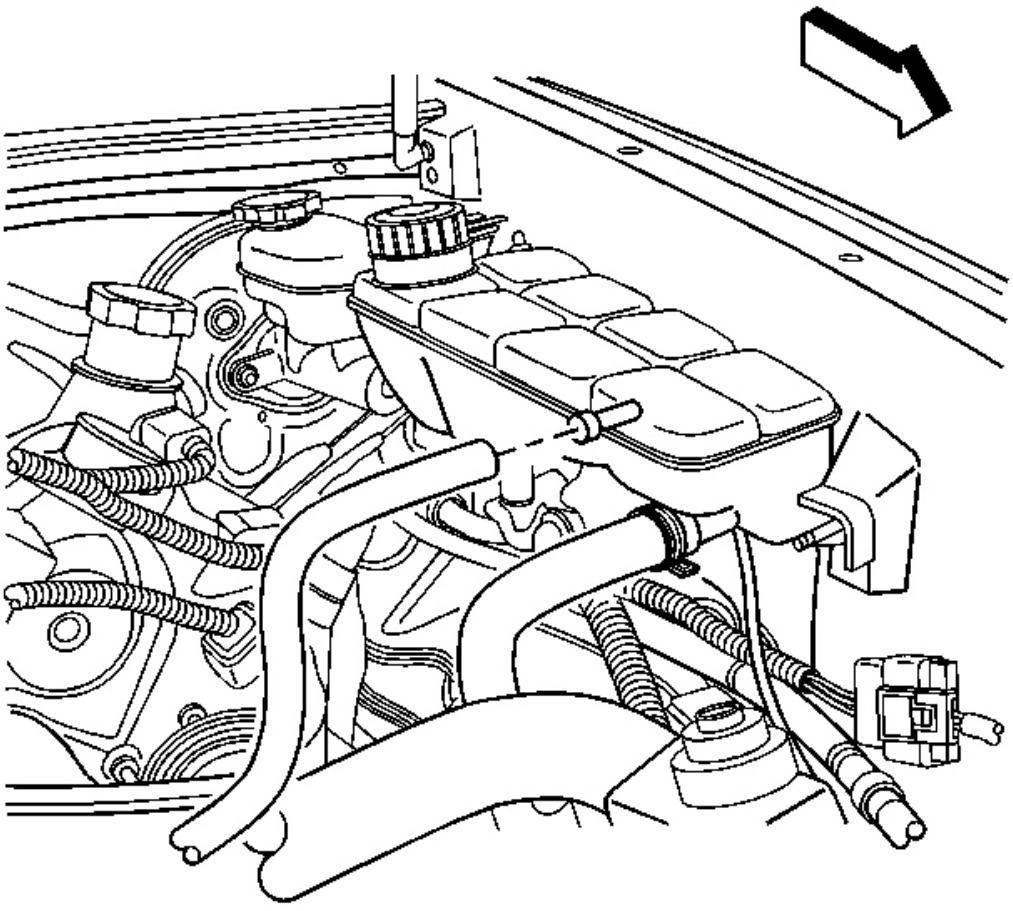


Fig. 51: View Of Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS CORP.

3. Disengage tension and reposition the surge tank inlet hose clamp at the surge tank using the **J 38185** . See **Special Tools**.
4. Disconnect the surge tank inlet hose from the surge tank.

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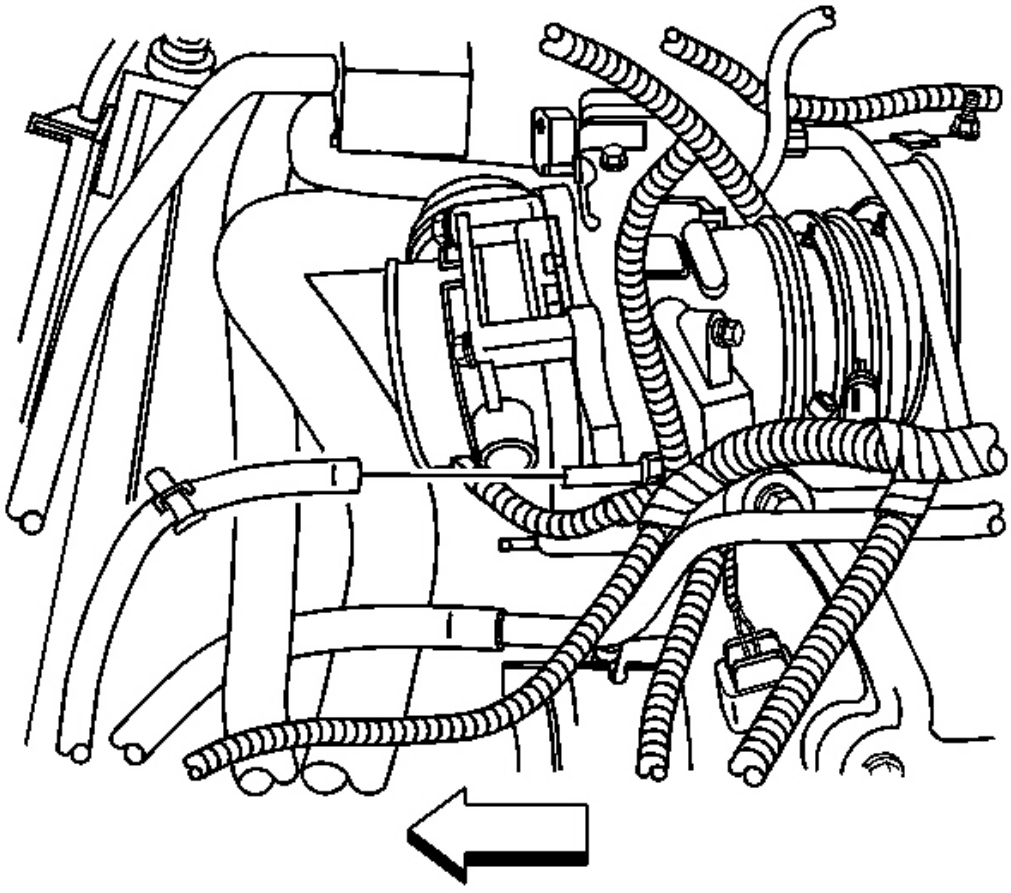


Fig. 52: Repositioning Surge Tank Inlet Hose Clamp At Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

5. Disengage tension and reposition the surge tank inlet hose clamp at the throttle body assembly using the **J 38185** . See **Special Tools**.
6. Disconnect the surge tank inlet hose from the throttle body assembly.

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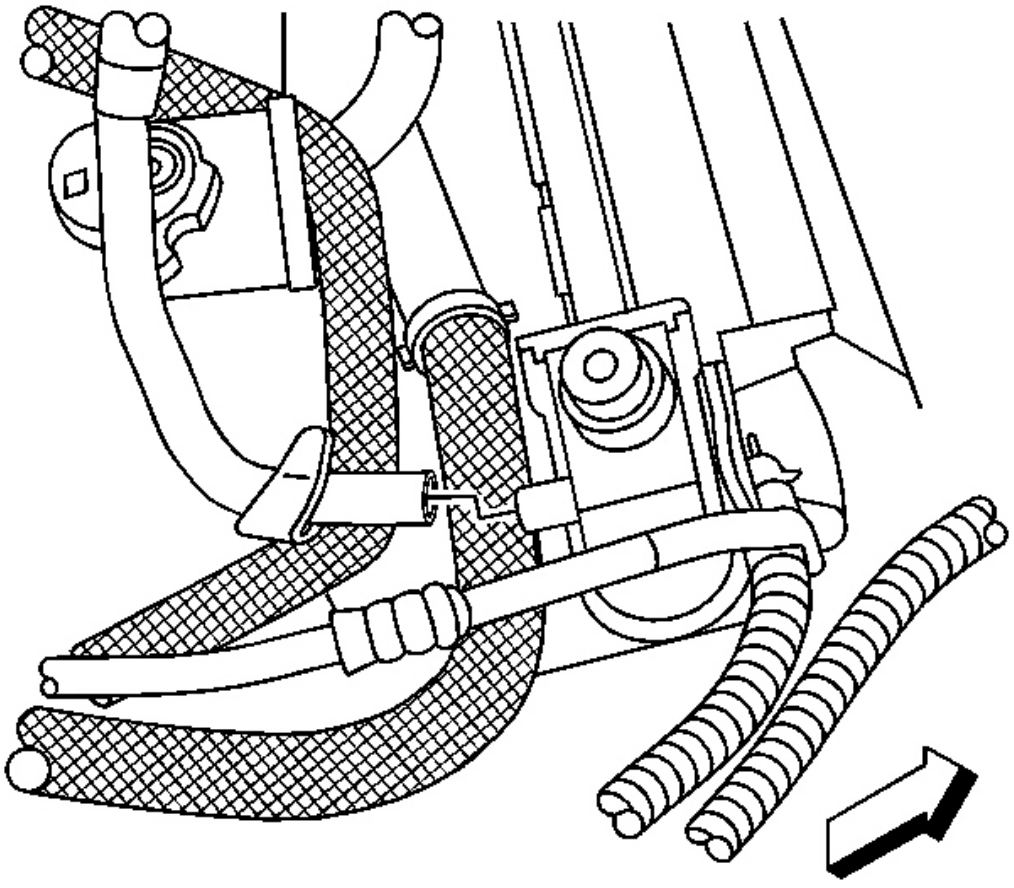


Fig. 53: Repositioning Surge Tank Inlet Hose Clamp At Radiator
Courtesy of GENERAL MOTORS CORP.

7. Disengage tension and reposition the surge tank inlet hose clamp at the radiator using the **J 38185** . See **Special Tools**.
8. Disconnect the surge tank inlet hose from the radiator.

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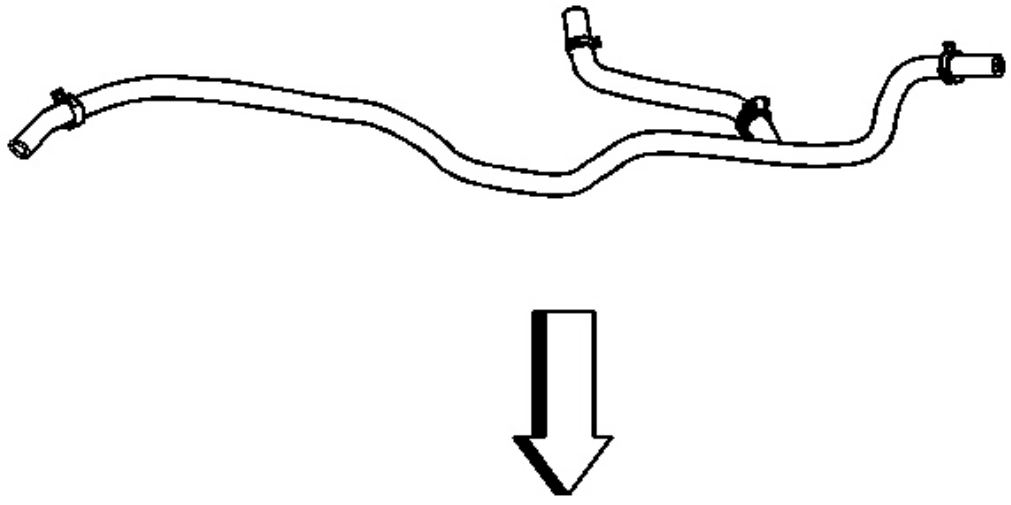


Fig. 54: Removing/Installing Surge Tank Inlet Hose Assembly
Courtesy of GENERAL MOTORS CORP.

9. Remove the surge tank inlet hose assembly from the vehicle.

Installation Procedure

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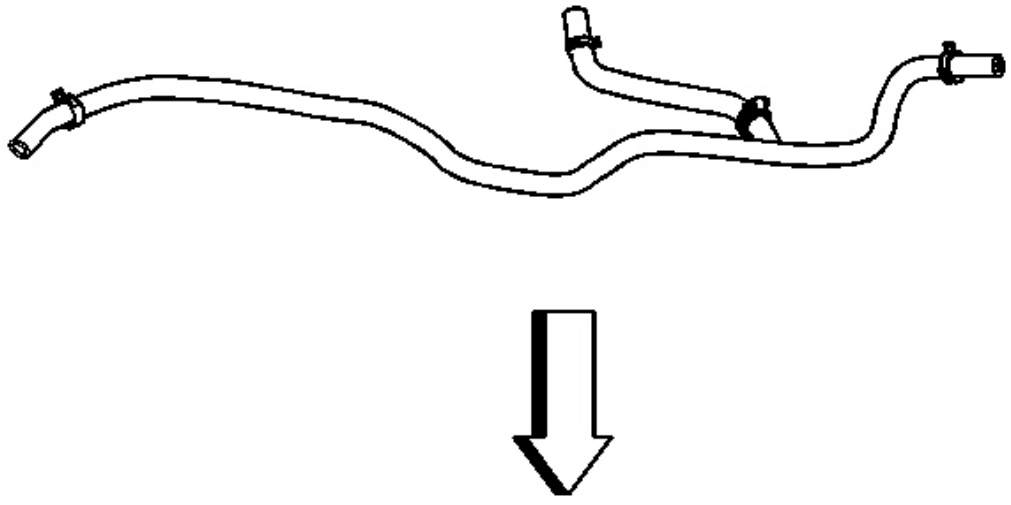


Fig. 55: Removing/Installing Surge Tank Inlet Hose Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Lubricate the inside diameters of the hoses with clean coolant prior to installation.

1. Install the surge tank inlet hose assembly to the vehicle.
2. Connect the surge tank inlet hose to the radiator.

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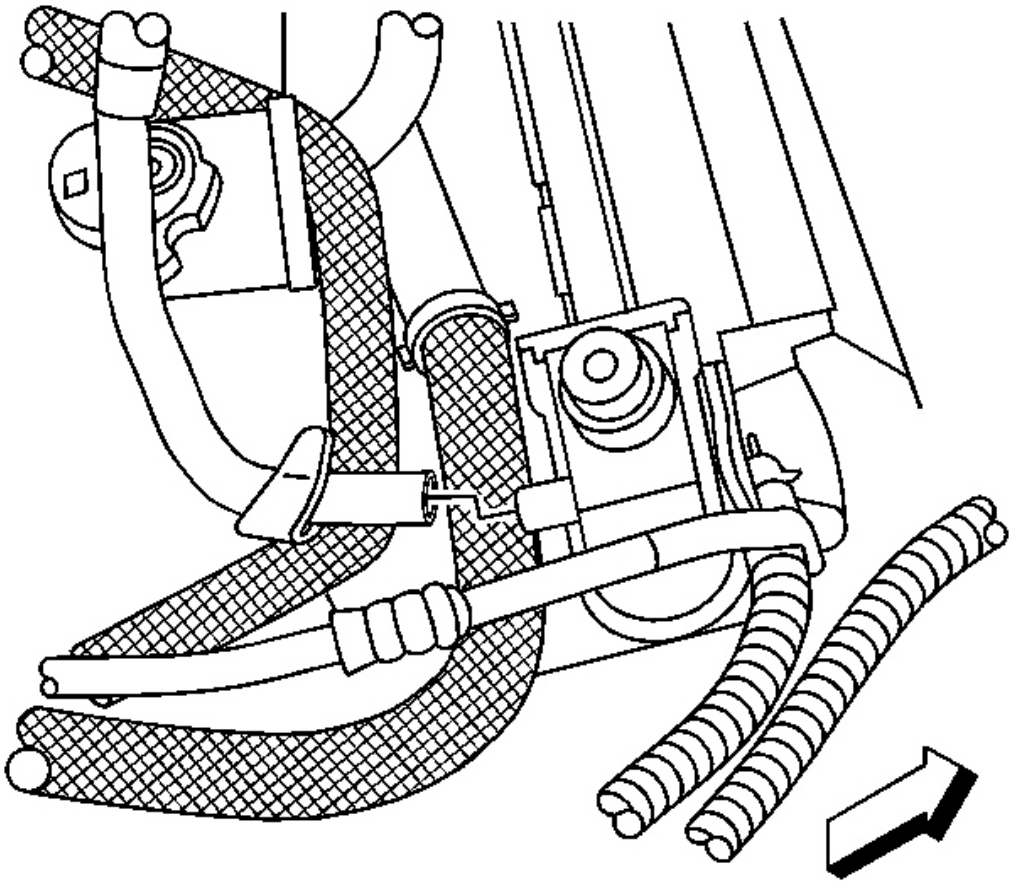


Fig. 56: Repositioning Surge Tank Inlet Hose Clamp At Radiator
Courtesy of GENERAL MOTORS CORP.

3. Disengage tension and reposition the surge tank inlet hose clamp at the radiator using the **J 38185** . See **Special Tools**.
4. Connect the surge tank inlet hose to the throttle body assembly.

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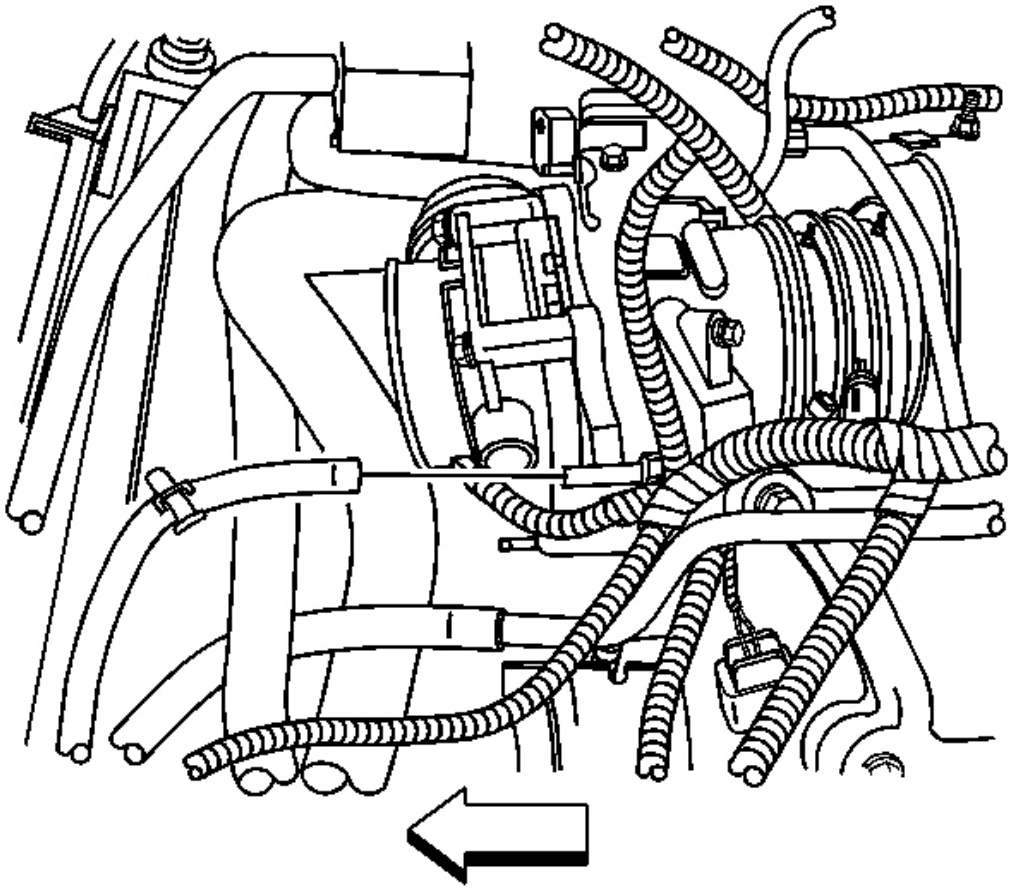


Fig. 57: Repositioning Surge Tank Inlet Hose Clamp At Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

5. Disengage tension and reposition the surge tank inlet hose clamp at the throttle body assembly using the **J 38185** . See **Special Tools**.
6. Connect the surge tank inlet hose to the surge tank.

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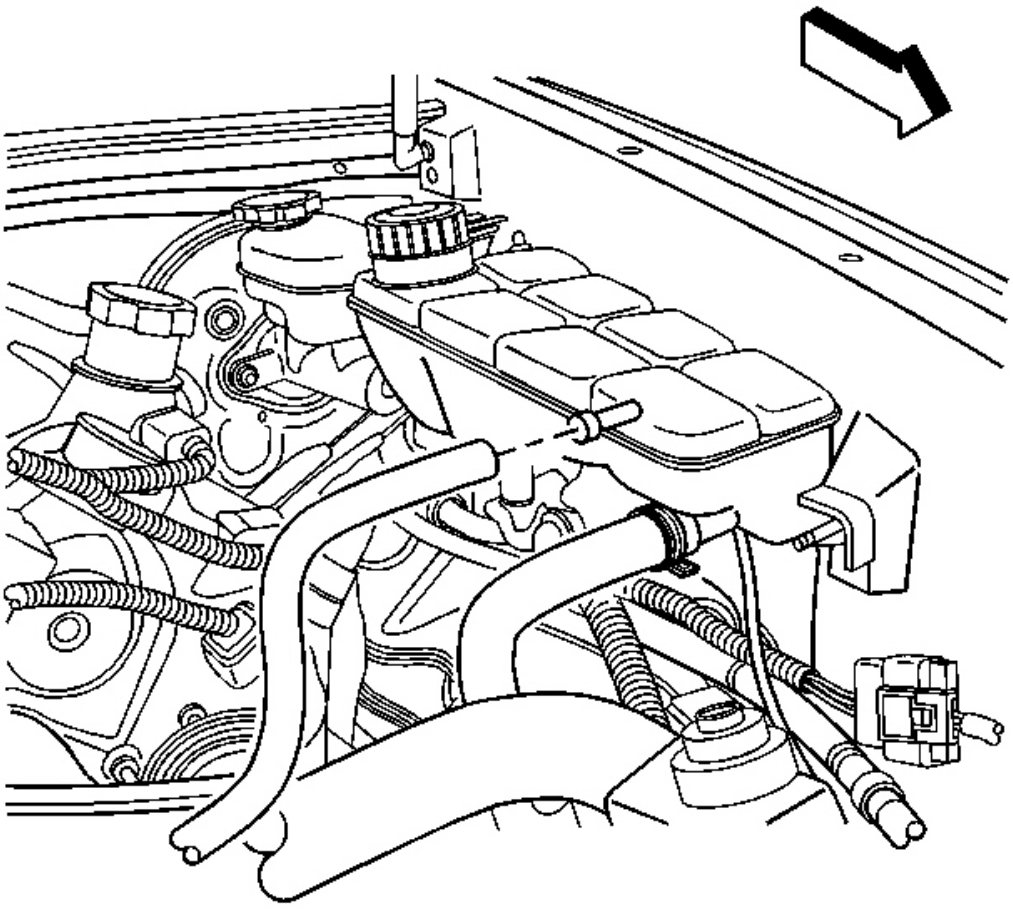


Fig. 58: View Of Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS CORP.

7. Disengage tension and reposition the surge tank inlet hose clamp at the surge tank using the **J 38185** . See **Special Tools**.
8. Install the radiator support. Refer to **Radiator Support Replacement**.
9. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

SURGE TANK HOSE/PIPE REPLACEMENT - OUTLET

Tools Required

J 38185 Hose Clamp Pliers. See **Special Tools**.

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Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the radiator support. Refer to **Radiator Support Replacement**.

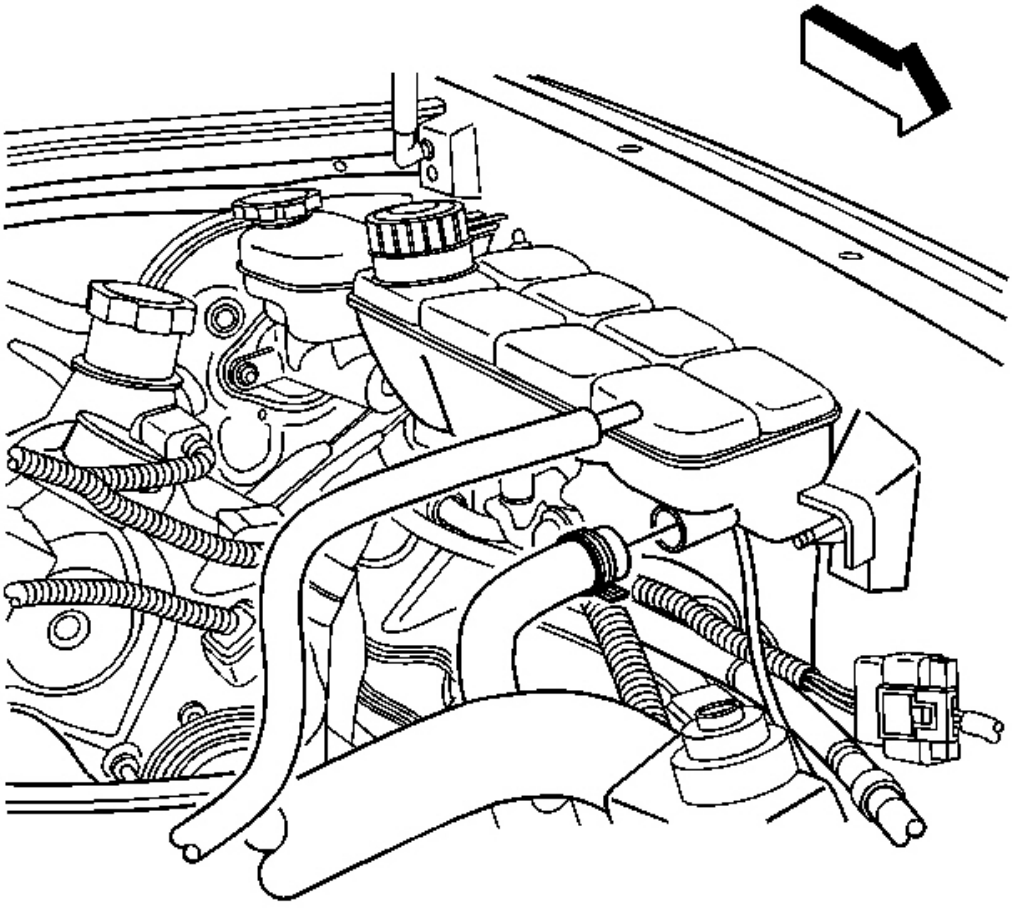


Fig. 59: Disconnecting/Connecting Surge Tank Outlet Hose
Courtesy of GENERAL MOTORS CORP.

3. Disengage tension on the surge tank outlet hose clamp at the surge tank using the **J 38185** . See **Special Tools**.
4. Disconnect the surge tank outlet hose from the surge tank.

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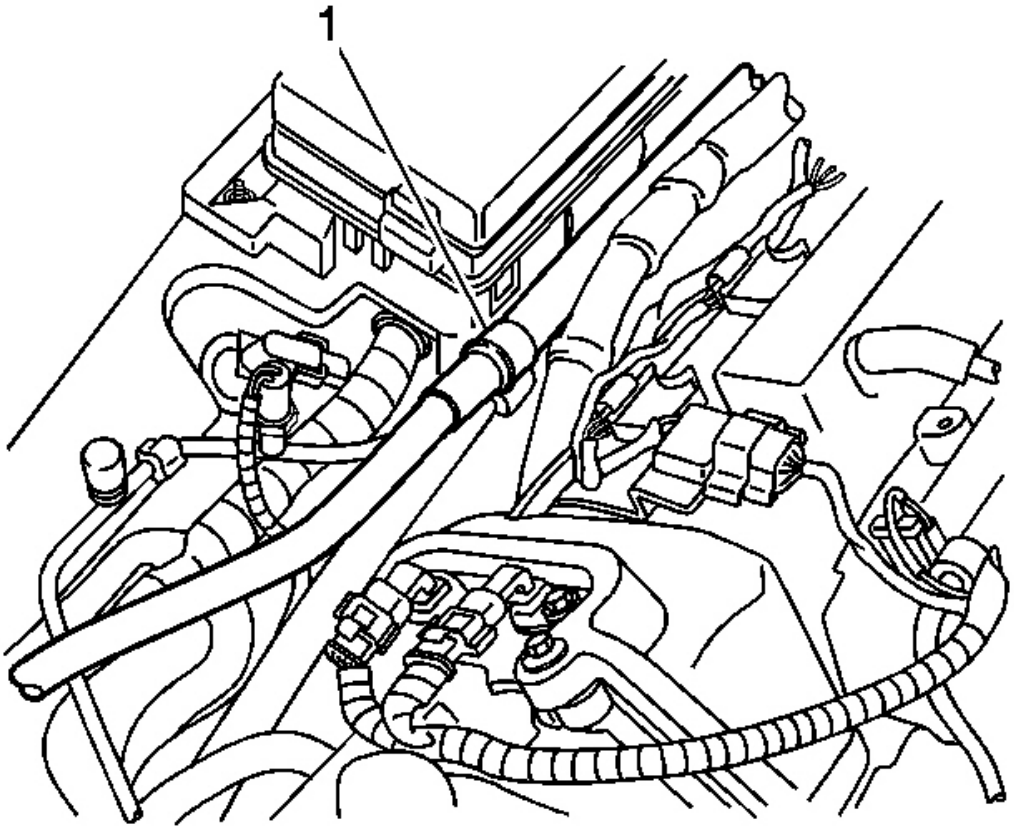


Fig. 60: View Of Underhood Junction Box Retainer Clip
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the surge tank outlet hose assembly from the support tabs on the cooling fan shroud.
6. Disconnect the surge tank outlet hose from the underhood junction box retainer clip (1).
7. Disengage tension on the surge tank outlet hose clamp at the heater pipe assembly.

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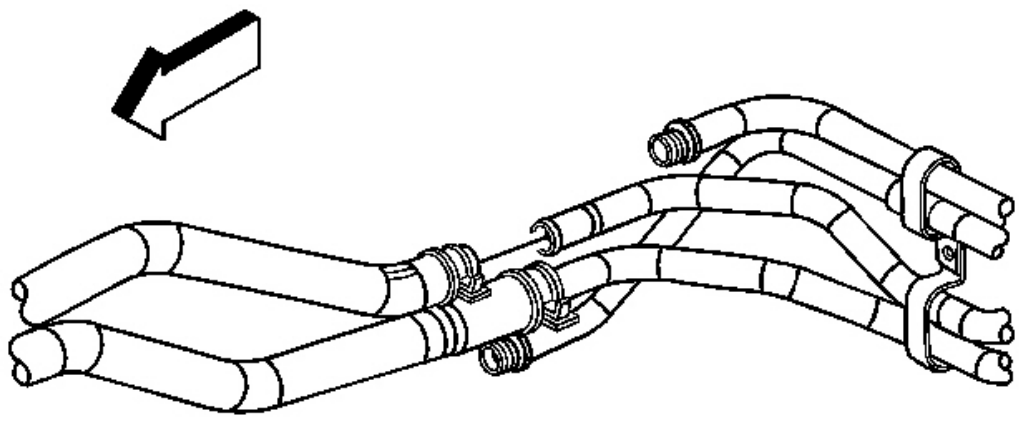


Fig. 61: Disconnecting/Connecting Surge Tank Outlet Hose From Heater Pipe Assembly
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the surge tank outlet hose from the heater pipe assembly.
9. Disengage tension on the radiator inlet hose clamp at the radiator using **J 38185** . See **Special Tools**.
10. Disconnect the radiator inlet hose from the radiator.
11. Disengage tension on the radiator inlet hose clamp at the engine using **J 38185** . See **Special Tools**.

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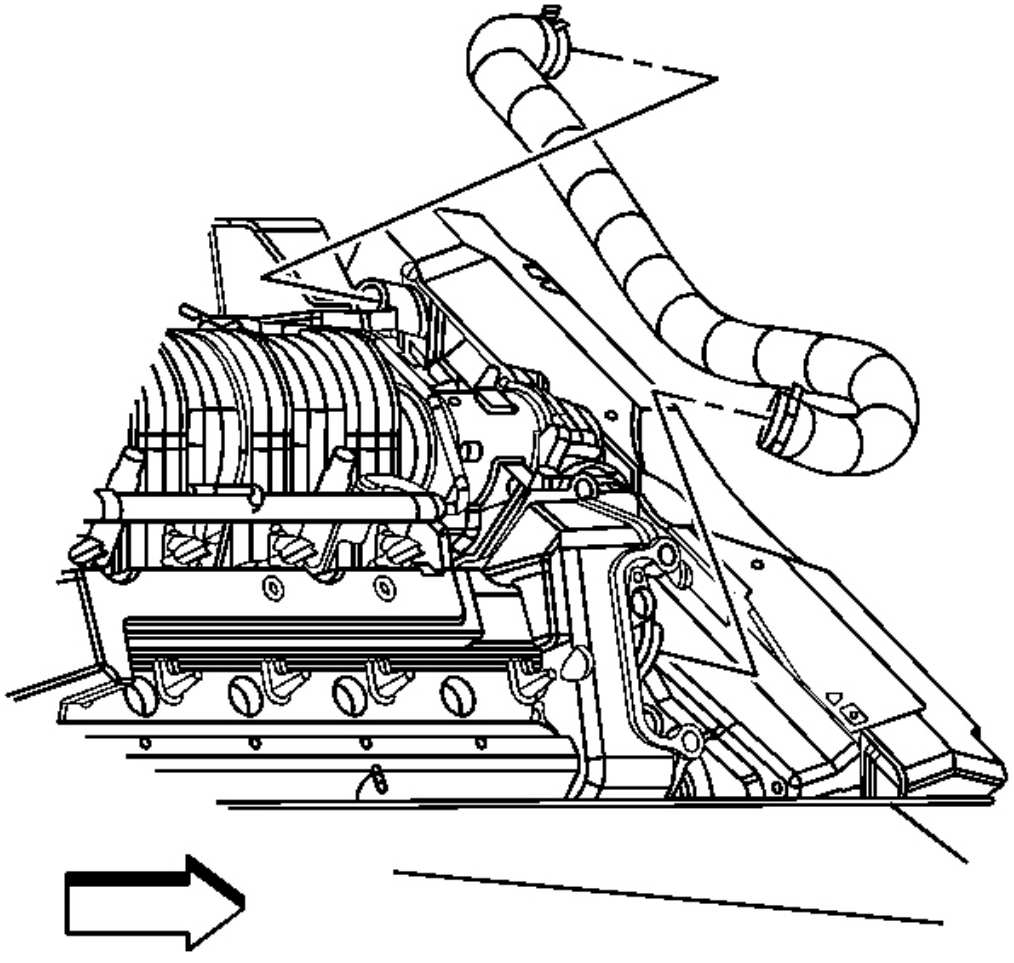


Fig. 62: Removing/Installing Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the radiator inlet hose from the engine.
13. Remove the radiator inlet hose.

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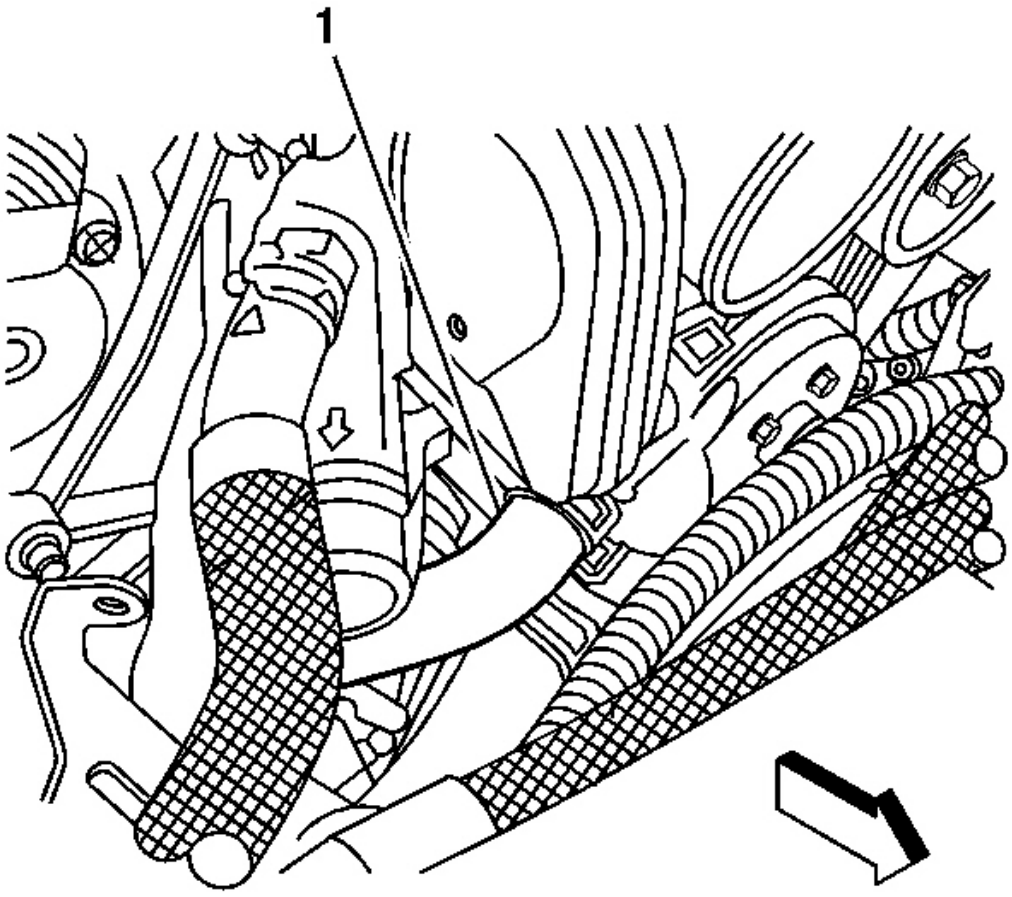


Fig. 63: View Of Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

14. Disengage tension on the surge tank outlet hose clamp at the thermostat housing (1).
15. Disconnect the surge tank outlet hose from the thermostat housing.

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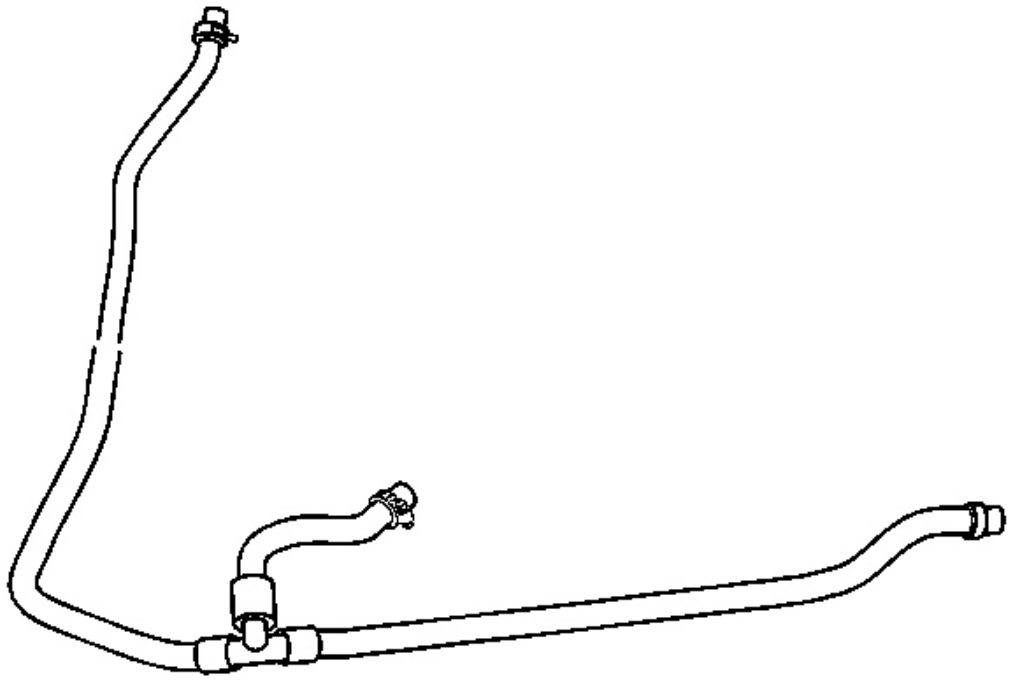


Fig. 64: Removing/Installing Surge Tank Outlet Hose Assembly
Courtesy of GENERAL MOTORS CORP.

16. Remove the surge tank outlet hose assembly from the vehicle.

Installation Procedure

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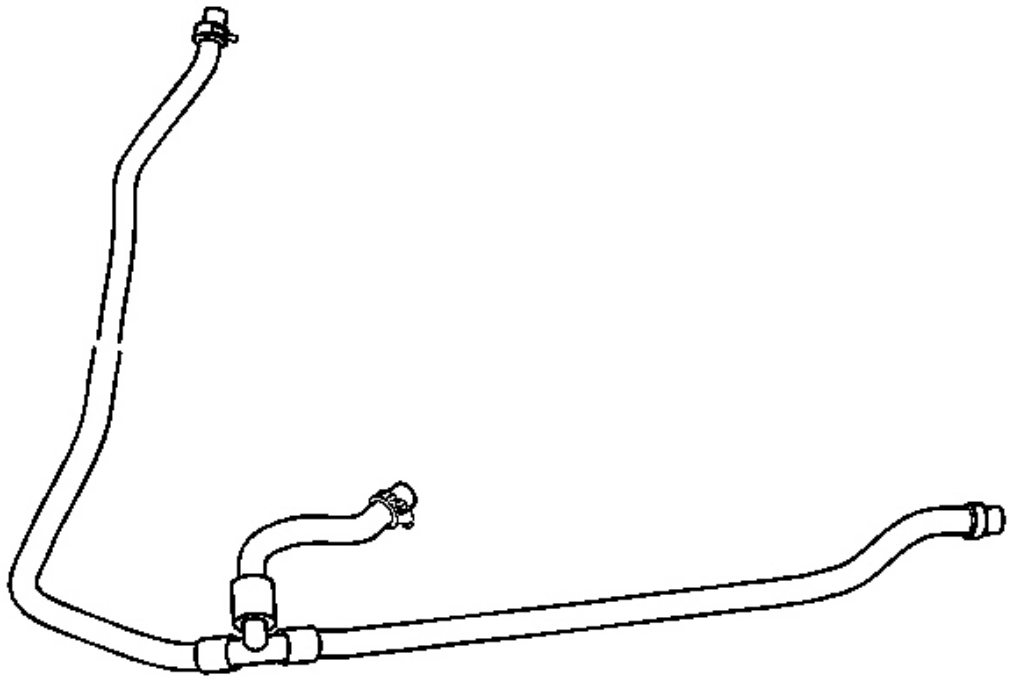


Fig. 65: Removing/Installing Surge Tank Outlet Hose Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Lubricate the inside diameters of the hoses with clean coolant prior to installation.

1. Install the surge tank outlet hose assembly to the vehicle.

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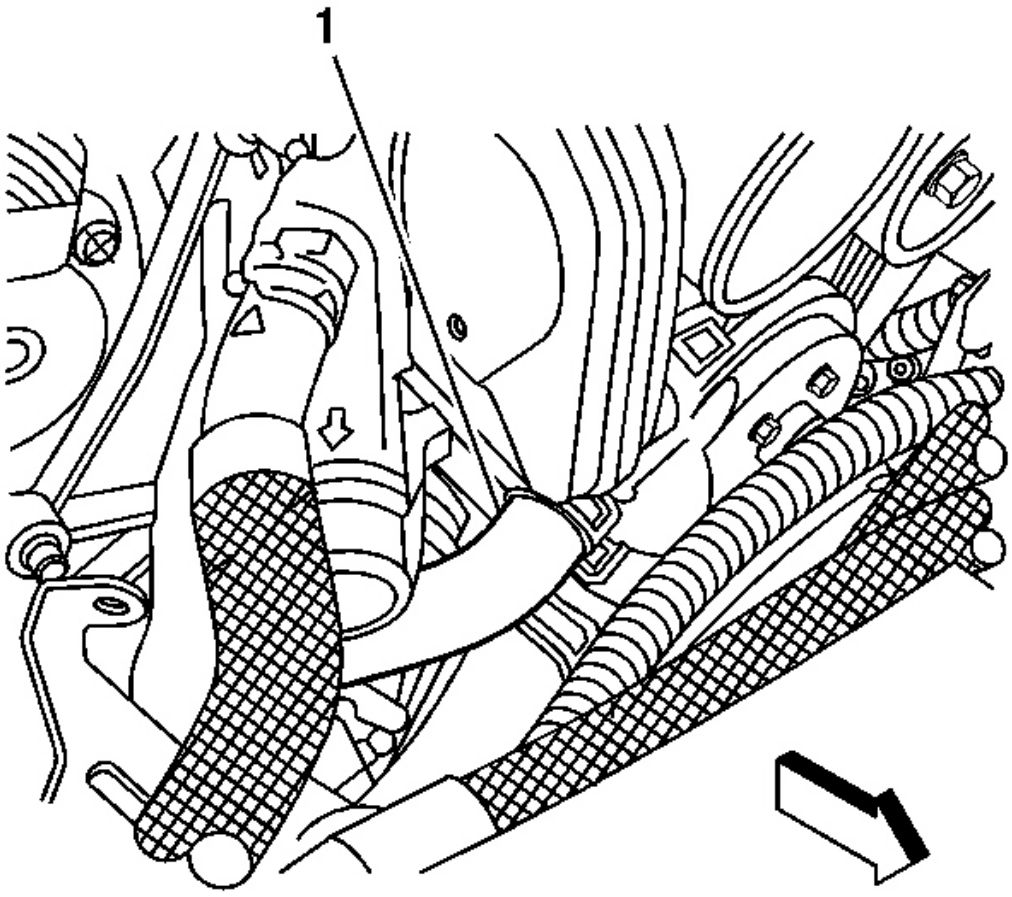


Fig. 66: View Of Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

2. Connect the surge tank outlet hose to the thermostat housing (1).
3. Engage tension on the surge tank outlet hose clamp at the thermostat housing.
4. Install the radiator inlet hose.

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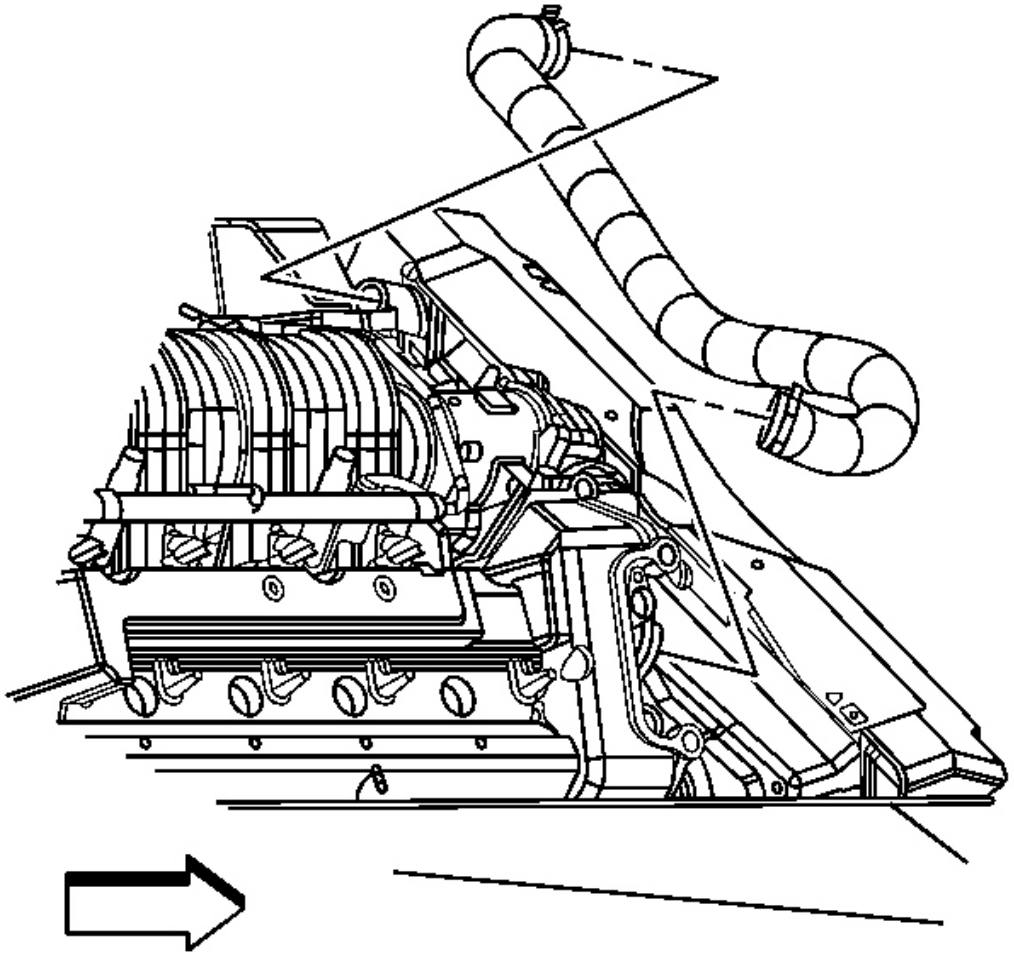


Fig. 67: Removing/Installing Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

5. Connect the radiator inlet hose to the engine.
6. Engage tension on the radiator inlet hose clamp at the engine using **J 38185** . See **Special Tools**.
7. Connect the radiator inlet hose to the radiator.
8. Engage tension on the radiator inlet hose clamp at the radiator using **J 38185** . See **Special Tools**.

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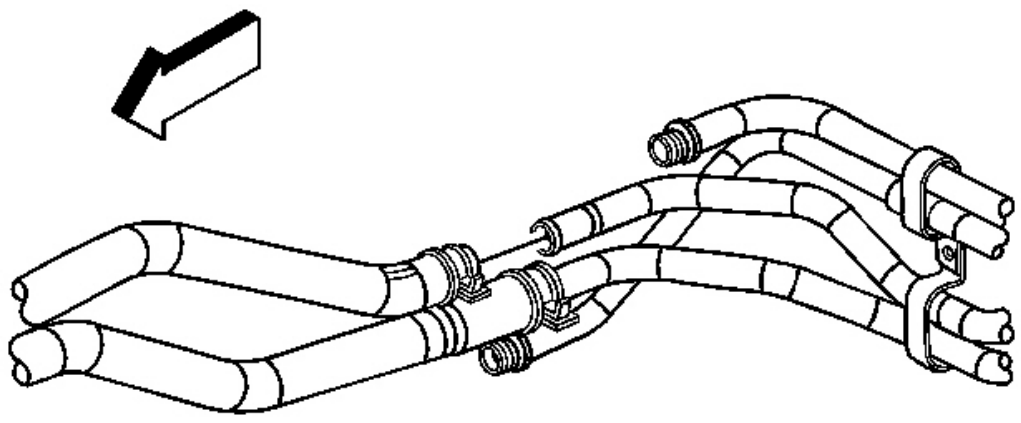


Fig. 68: Disconnecting/Connecting Surge Tank Outlet Hose From Heater Pipe Assembly
Courtesy of GENERAL MOTORS CORP.

9. Connect the surge tank outlet hose to the heater pipe assembly.
10. Engage tension on the surge tank outlet hose clamp at the heater pipe assembly.

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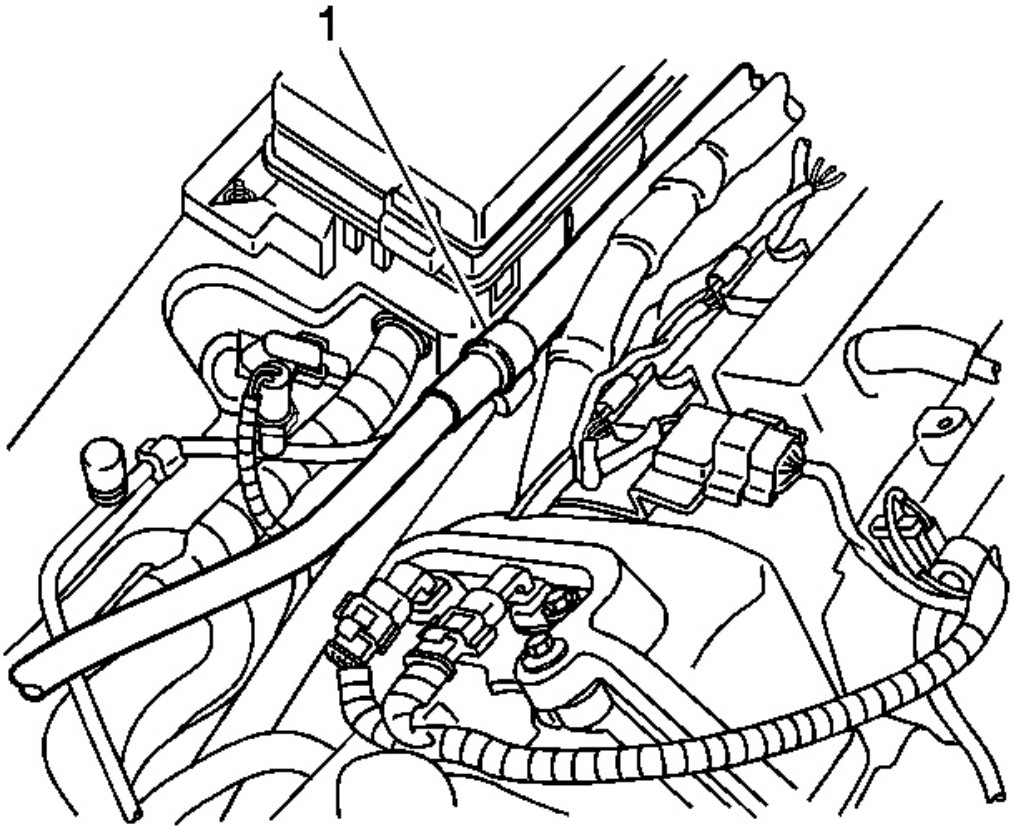


Fig. 69: View Of Underhood Junction Box Retainer Clip
Courtesy of GENERAL MOTORS CORP.

11. Connect the surge tank outlet hose to the underhood junction box retainer clip (1).
12. Connect the surge tank outlet hose assembly to the support tabs on the cooling fan shroud.

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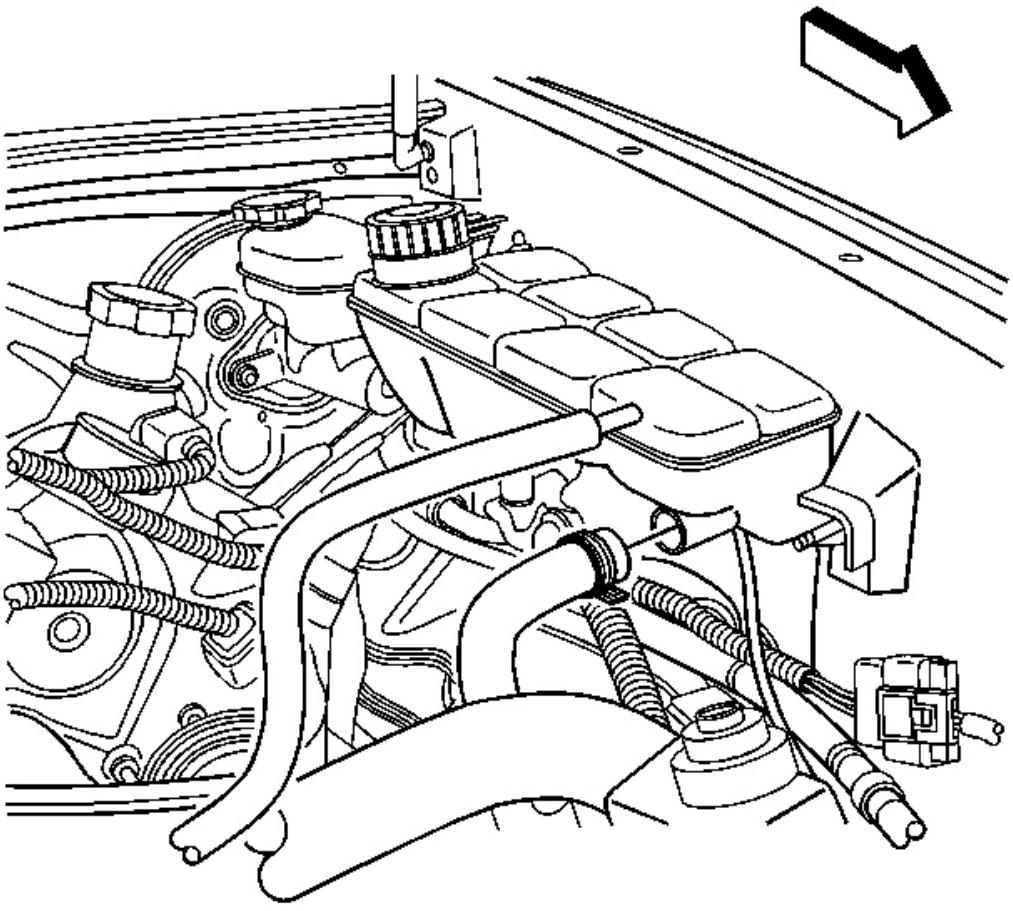


Fig. 70: Disconnecting/Connecting Surge Tank Outlet Hose
Courtesy of GENERAL MOTORS CORP.

13. Connect the surge tank outlet hose to the surge tank.
14. Engage tension on the surge tank outlet hose clamp at the surge tank using the **J 38185** . See **Special Tools**.
15. Install the radiator support. Refer to **Radiator Support Replacement**.
16. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

RADIATOR INLET HOSE REPLACEMENT

Tools Required

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J 38185 Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
3. Disengage tension on the radiator inlet hose clamp at the radiator using **J 38185** . See **Special Tools**.
4. Disconnect the radiator inlet hose from the radiator.
5. Disengage tension on the radiator inlet hose clamp at the engine using **J 38185** . See **Special Tools**.

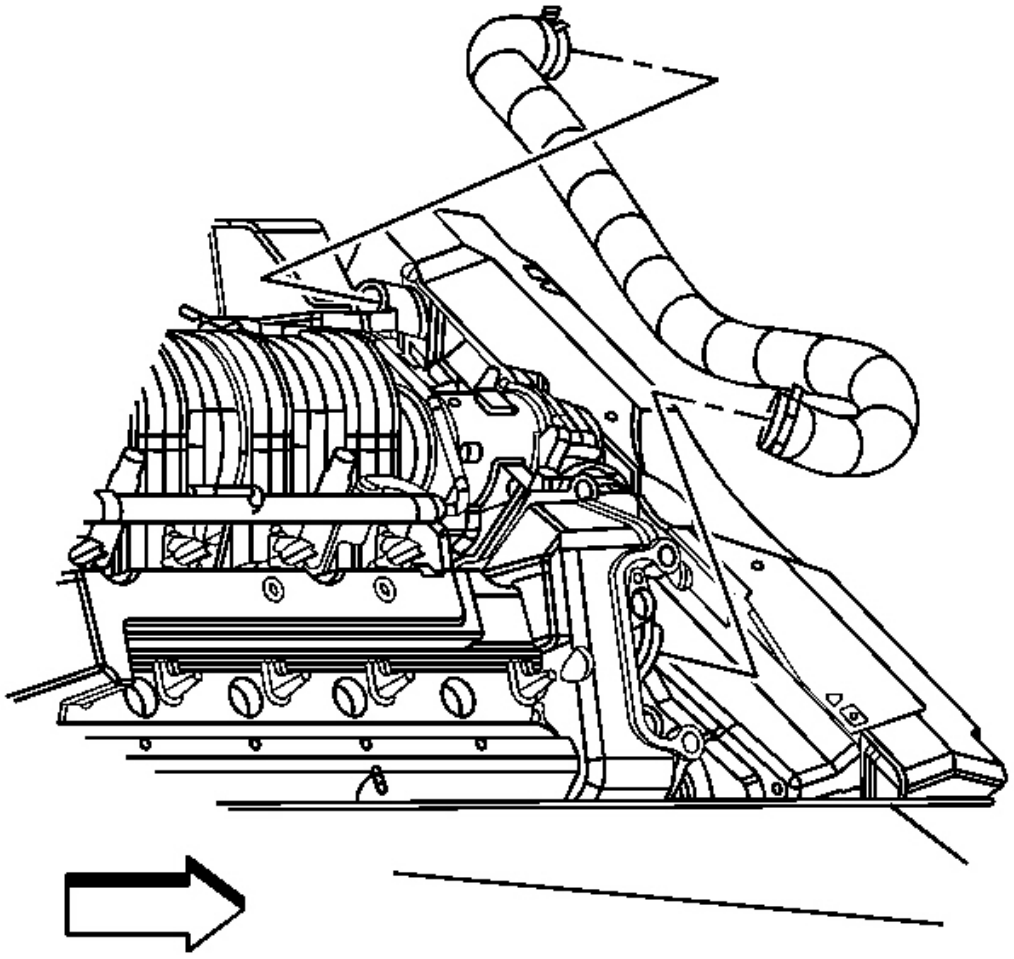


Fig. 71: Removing/Installing Radiator Inlet Hose

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Courtesy of GENERAL MOTORS CORP.

6. Disconnect the radiator inlet hose from the engine.
7. Remove the radiator inlet hose.

Installation Procedure

NOTE: Make sure the reference marks on the hoses and the radiator are lined up. A twist on the hose would place strain on the radiator fitting which could cause the fitting to crack or break.

IMPORTANT: Lubricate the inside diameters of the hose with clean coolant prior to installation.

1. Install the radiator inlet hose.

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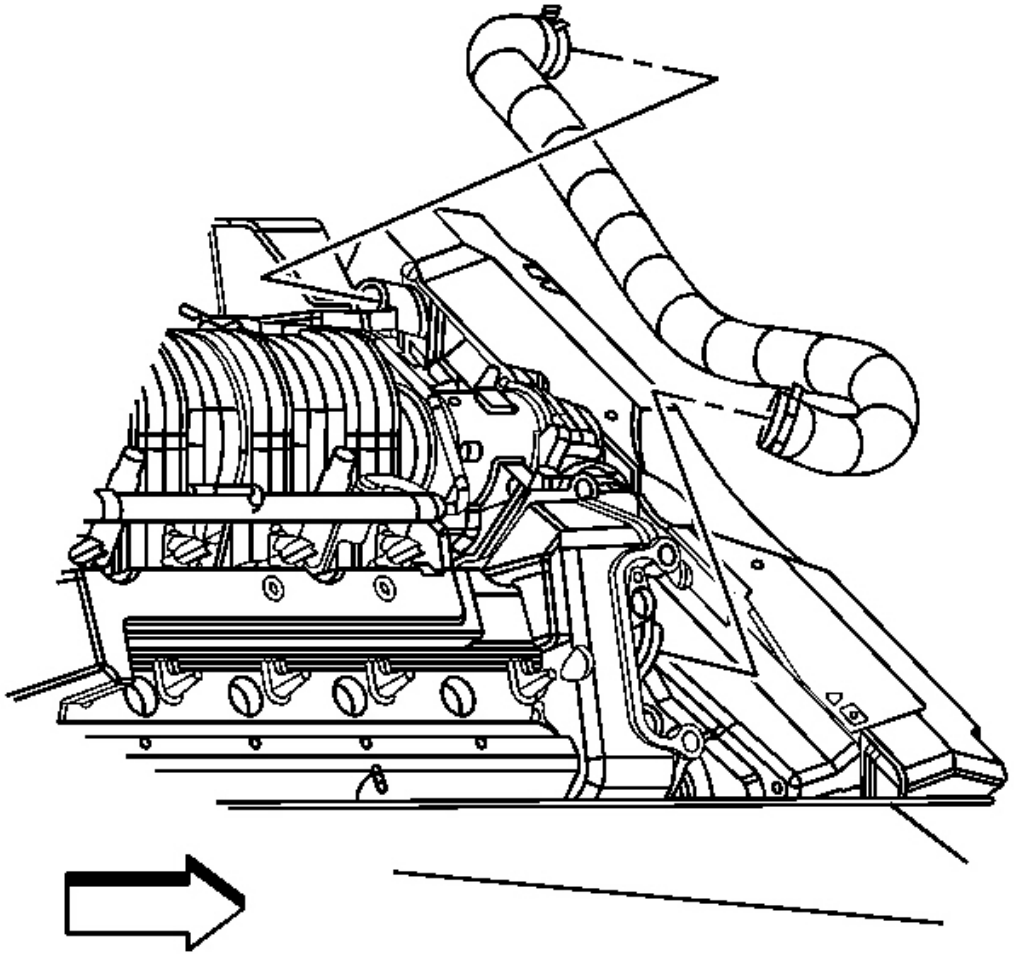


Fig. 72: Removing/Installing Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

2. Connect the radiator inlet hose to the engine.
3. Engage tension on the radiator inlet hose clamp at the engine using **J 38185** . See **Special Tools**.
4. Connect the radiator inlet hose to the radiator.
5. Engage tension on the radiator inlet hose clamp at the radiator using **J 38185** . See **Special Tools**.
6. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
7. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

RADIATOR OUTLET HOSE REPLACEMENT

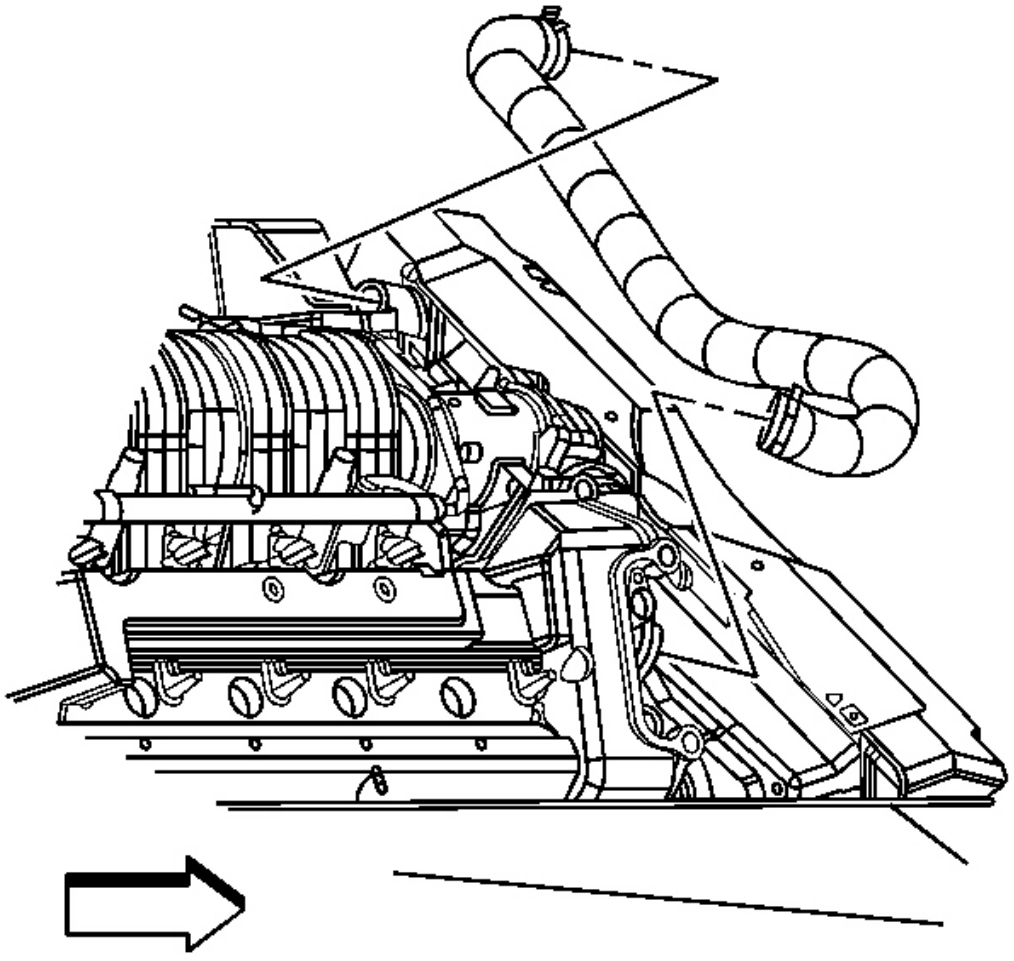
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Tools Required

J 38185 Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

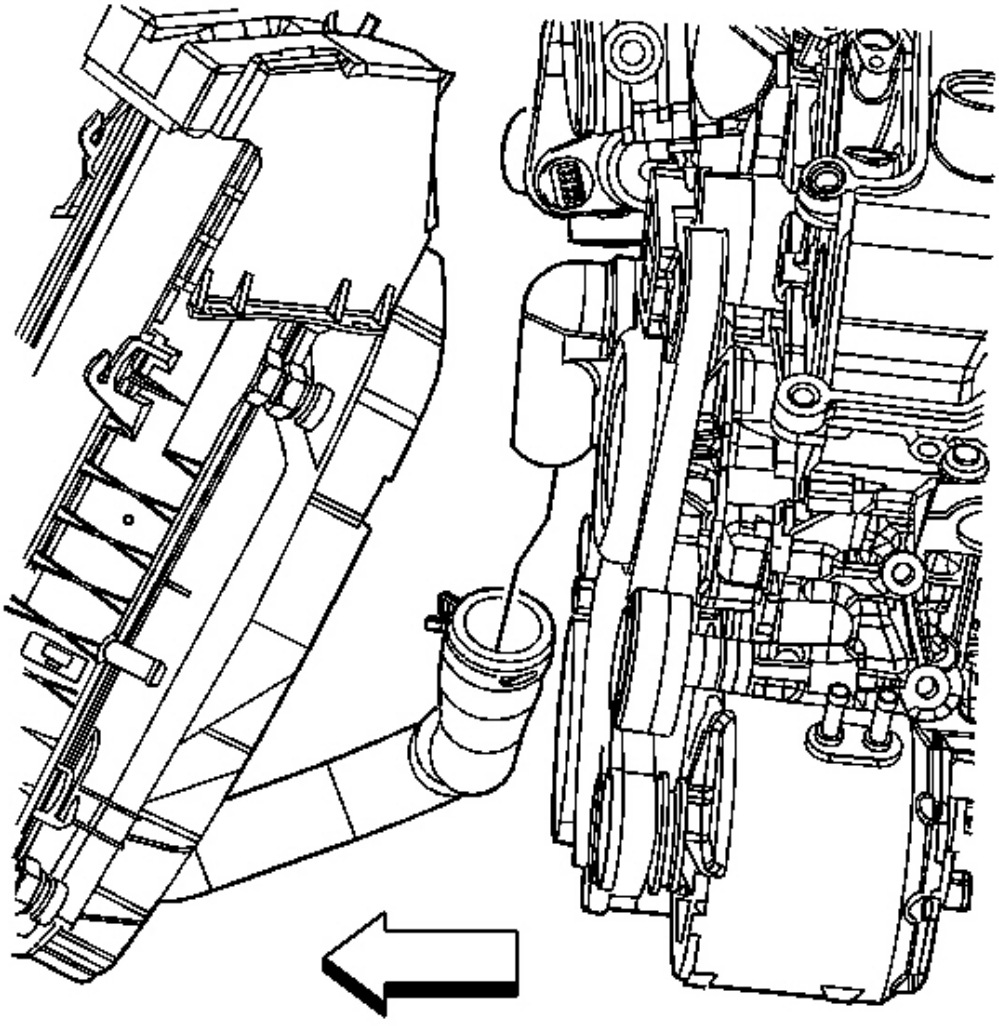
1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
3. Disengage tension on the radiator inlet hose clamp at the radiator using **J 38185** . See **Special Tools**.
4. Disconnect the radiator inlet hose from the radiator.
5. Disengage tension on the radiator inlet hose clamp at the engine using **J 38185** . See **Special Tools**.



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Fig. 73: Removing/Installing Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the radiator inlet hose from the engine.
7. Remove the radiator inlet hose.
8. Remove the remote power steering reservoir. Refer to **Remote Power Steering Fluid Reservoir Replacement** .
9. Disengage tension on the radiator outlet hose clamp at the water pump using the **J 38185** . See **Special Tools**.



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Fig. 74: Disconnecting/Connecting Radiator Outlet Hose To Water Pump
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the radiator outlet hose from the water pump.
11. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

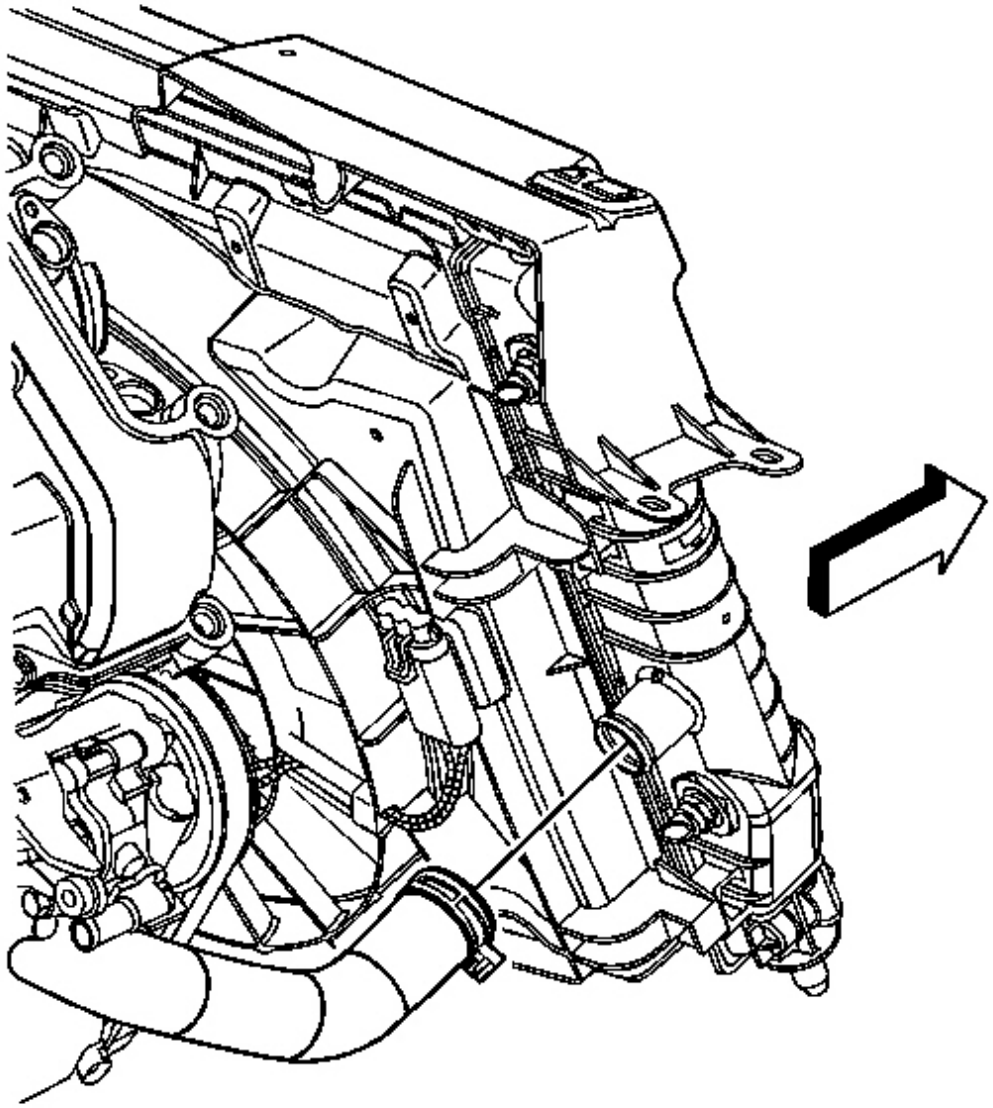


Fig. 75: Disconnecting/Connecting Radiator Outlet Hose From Radiator
Courtesy of GENERAL MOTORS CORP.

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12. Disengage tension on the radiator outlet hose clamp at the radiator using **J 38185** . See **Special Tools**.
13. Disconnect the radiator outlet hose from the radiator.
14. Remove the radiator outlet hose.

Installation Procedure

NOTE: Make sure the reference marks on the hoses and the radiator are lined up. A twist on the hose would place strain on the radiator fitting which could cause the fitting to crack or break.

IMPORTANT: Lubricate the inside diameters of the hose with clean coolant prior to installation.

1. Install the radiator outlet hose.

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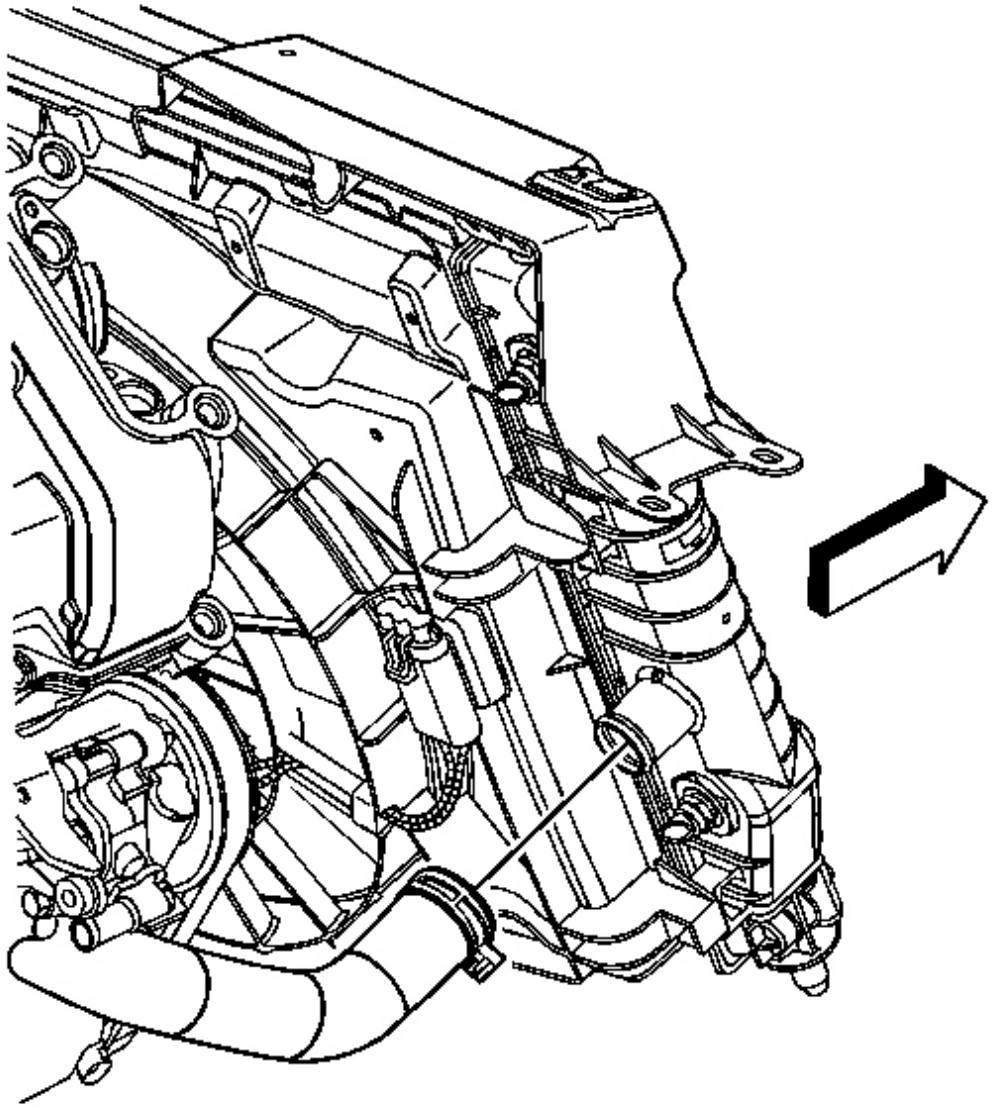


Fig. 76: Disconnecting/Connecting Radiator Outlet Hose From Radiator
Courtesy of GENERAL MOTORS CORP.

2. Connect the radiator outlet hose to the radiator.
3. Engage tension on the radiator outlet hose clamp at the radiator.
4. Lower the vehicle.

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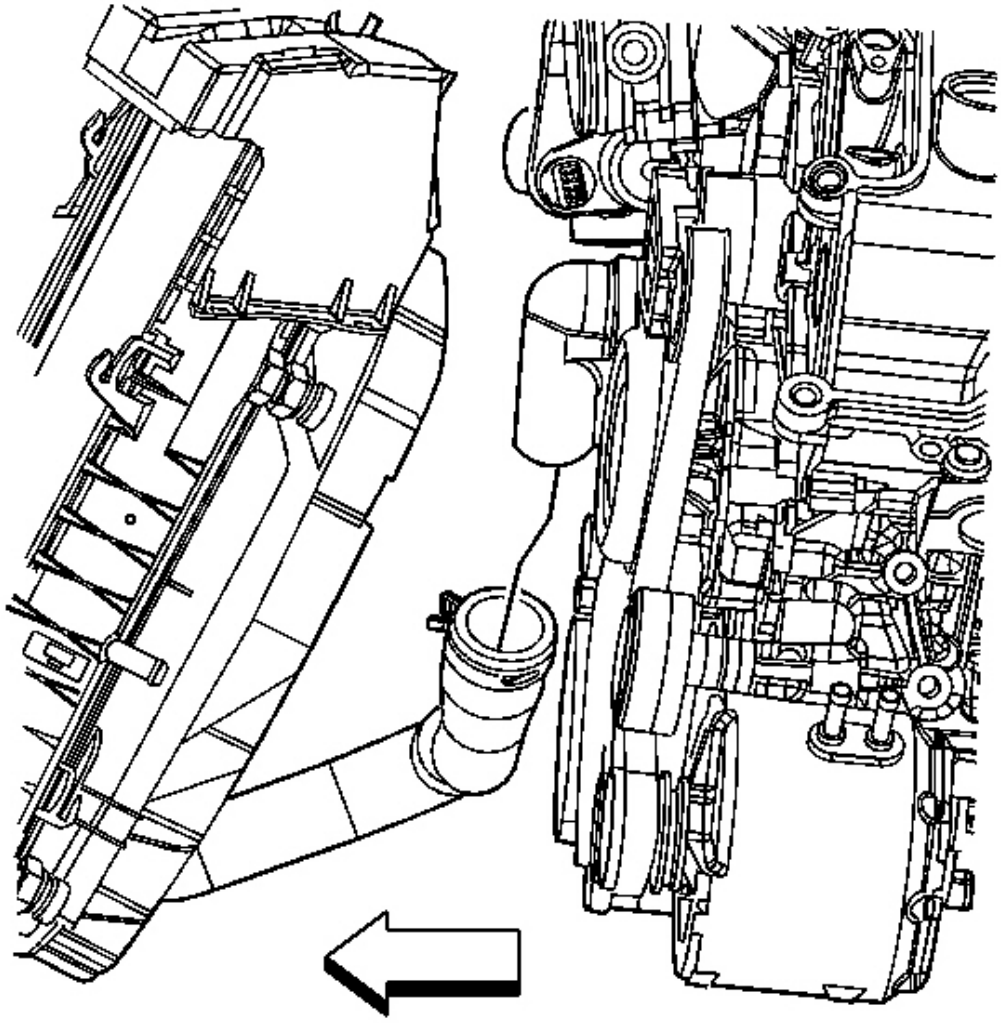


Fig. 77: Disconnecting/Connecting Radiator Outlet Hose To Water Pump
Courtesy of GENERAL MOTORS CORP.

5. Connect the radiator outlet hose to the water pump.
6. Engage tension on the radiator outlet hose clamp at the water pump.
7. Install the remote power steering reservoir. Refer to **Remote Power Steering Fluid Reservoir Replacement** .
8. Install the radiator inlet hose.

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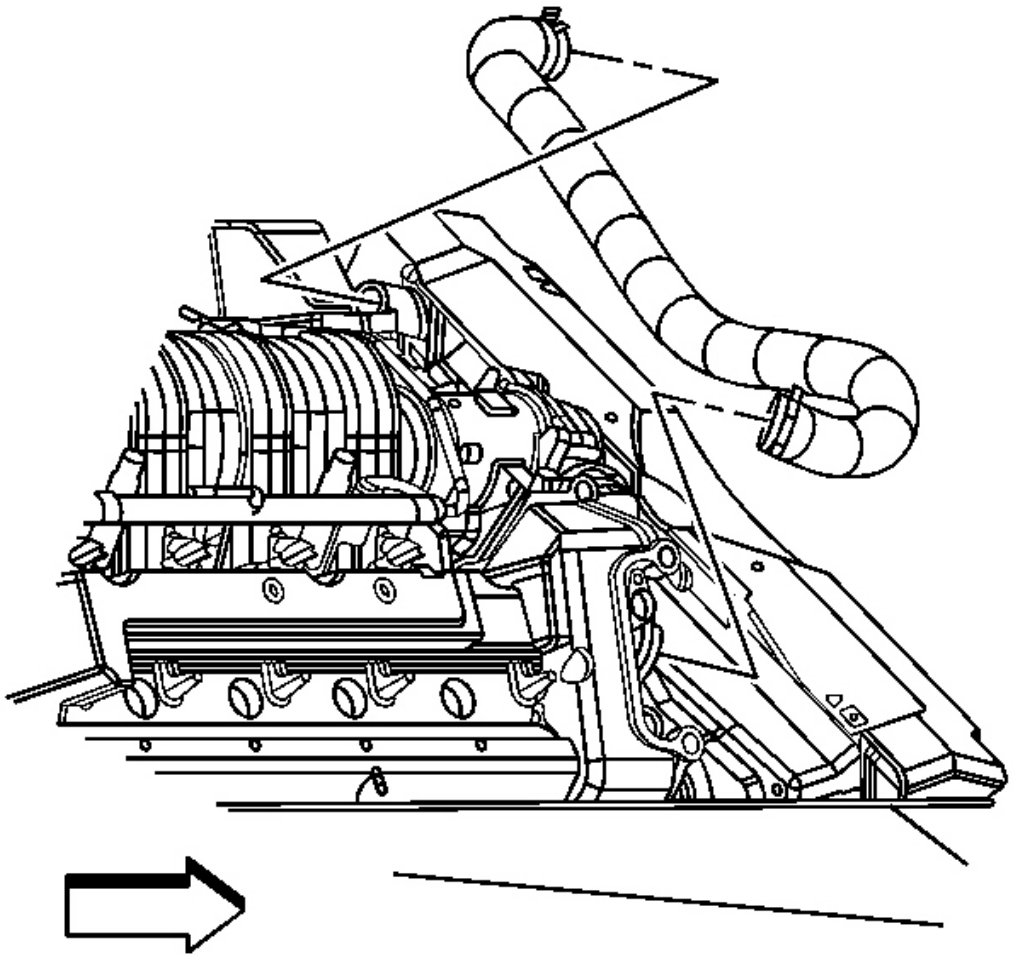


Fig. 78: Removing/Installing Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

9. Connect the radiator inlet hose to the engine.
10. Engage tension on the radiator inlet hose clamp at the engine using **J 38185** . See **Special Tools**.
11. Connect the radiator inlet hose to the radiator.
12. Engage tension on the radiator inlet hose clamp at the radiator using **J 38185** . See **Special Tools**.
13. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
14. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

CHARGE AIR COOLER INLET HOSE REPLACEMENT

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Tools Required

GE-47622 Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

1. Drain the charge air cooler cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.

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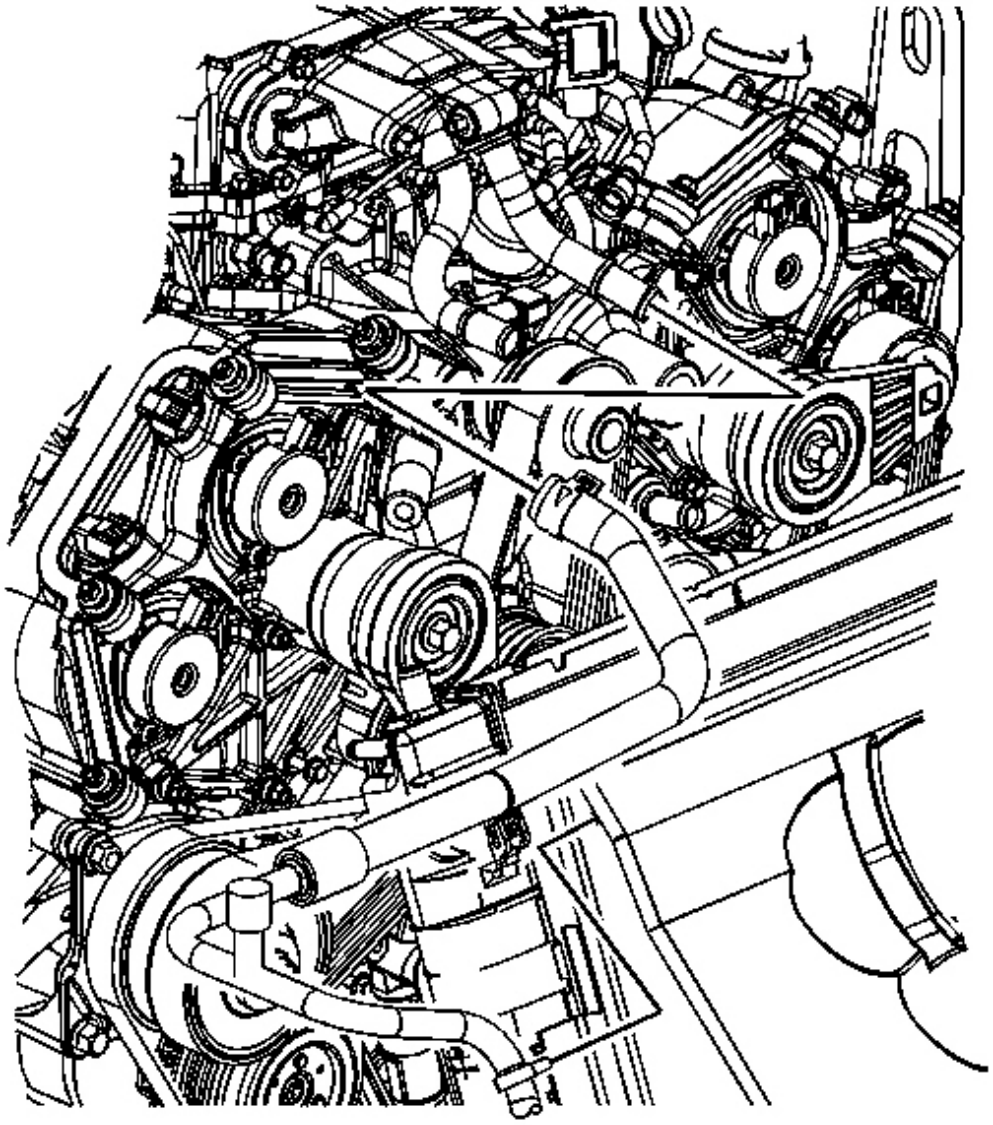


Fig. 79: Locating Charge Air Cooler Coolant Inlet Hose At Charge Air Cooler
Courtesy of GENERAL MOTORS CORP.

2. Using the **GE-47622** , reposition the charge air cooler coolant inlet hose from the charge air cooler. See **Special Tools**.
3. Remove the charge air cooler coolant inlet hose from the charge air cooler.
4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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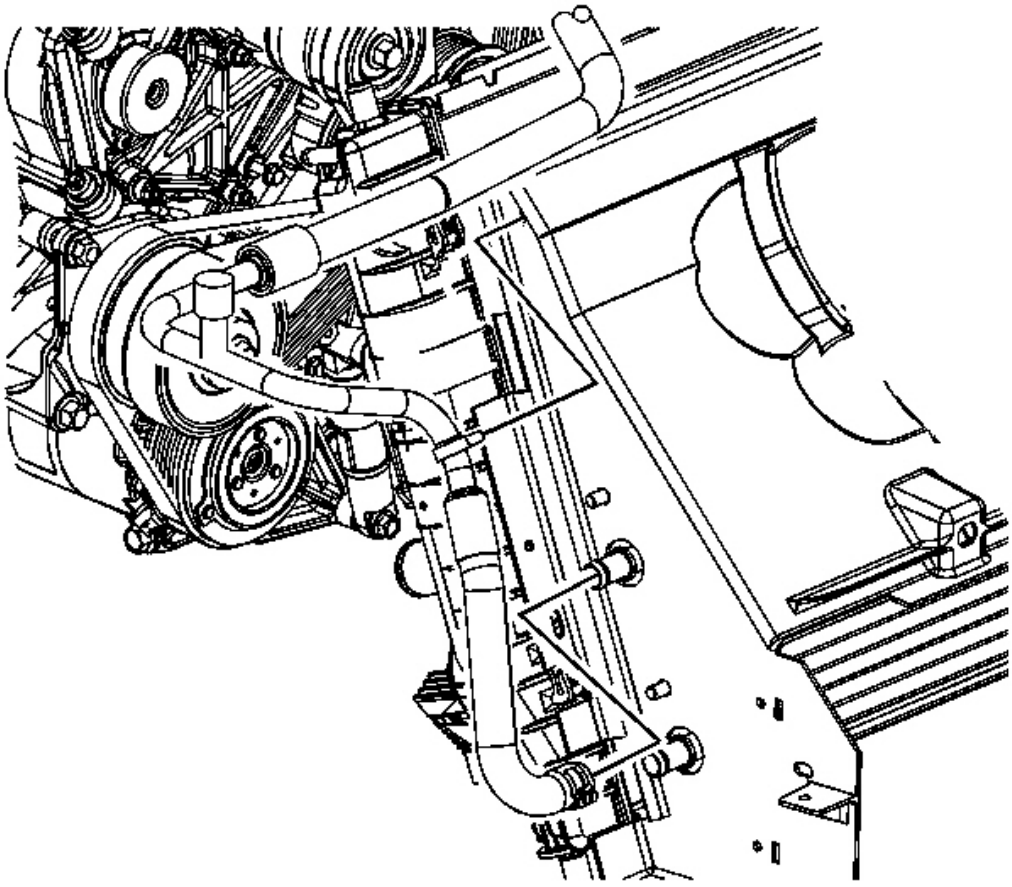


Fig. 80: Charge Air Cooler Coolant Inlet Hose
Courtesy of GENERAL MOTORS CORP.

5. Using the **GE-47622** , reposition the charge air cooler coolant inlet hose from the charge air cooler radiator. See **Special Tools**.

IMPORTANT: Note the routing of the charge air cooler coolant inlet hose to ensure proper installation.

6. Remove the charge air cooler coolant inlet hose from the charge air cooler radiator.
7. Gently pull on the charge air cooler coolant inlet hose to release the charge air cooler inlet hose retainer from the fan shroud.
8. Remove the charge air cooler coolant inlet hose from the vehicle.

Installation Procedure

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1. Install the charge air cooler coolant inlet hose to the vehicle.

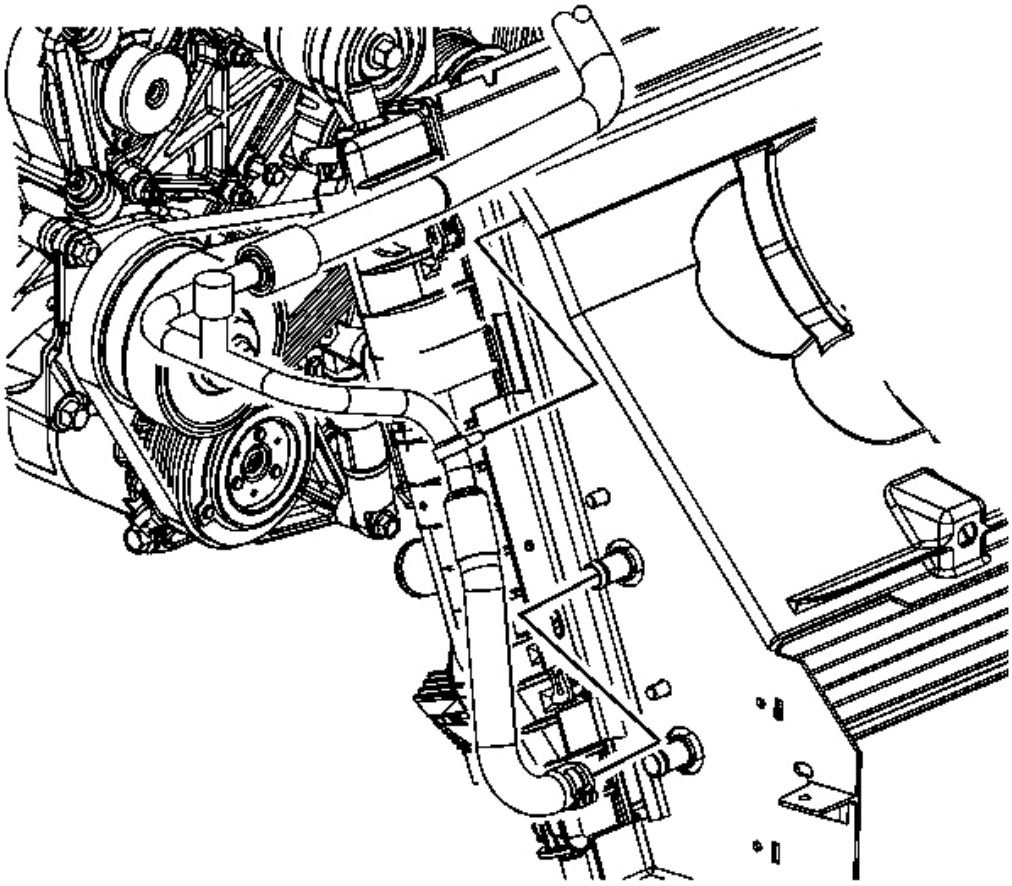


Fig. 81: Charge Air Cooler Coolant Inlet Hose
Courtesy of GENERAL MOTORS CORP.

2. Install the charge air cooler coolant inlet hose to the charge air cooler radiator.
3. Using the **GE-47622** , reposition the charge air cooler coolant inlet hose clamp at the charge air cooler radiator. See **Special Tools**.
4. Gently push the charge air cooler coolant inlet hose retainer into the hole in the fan shroud.
5. Lower the vehicle.

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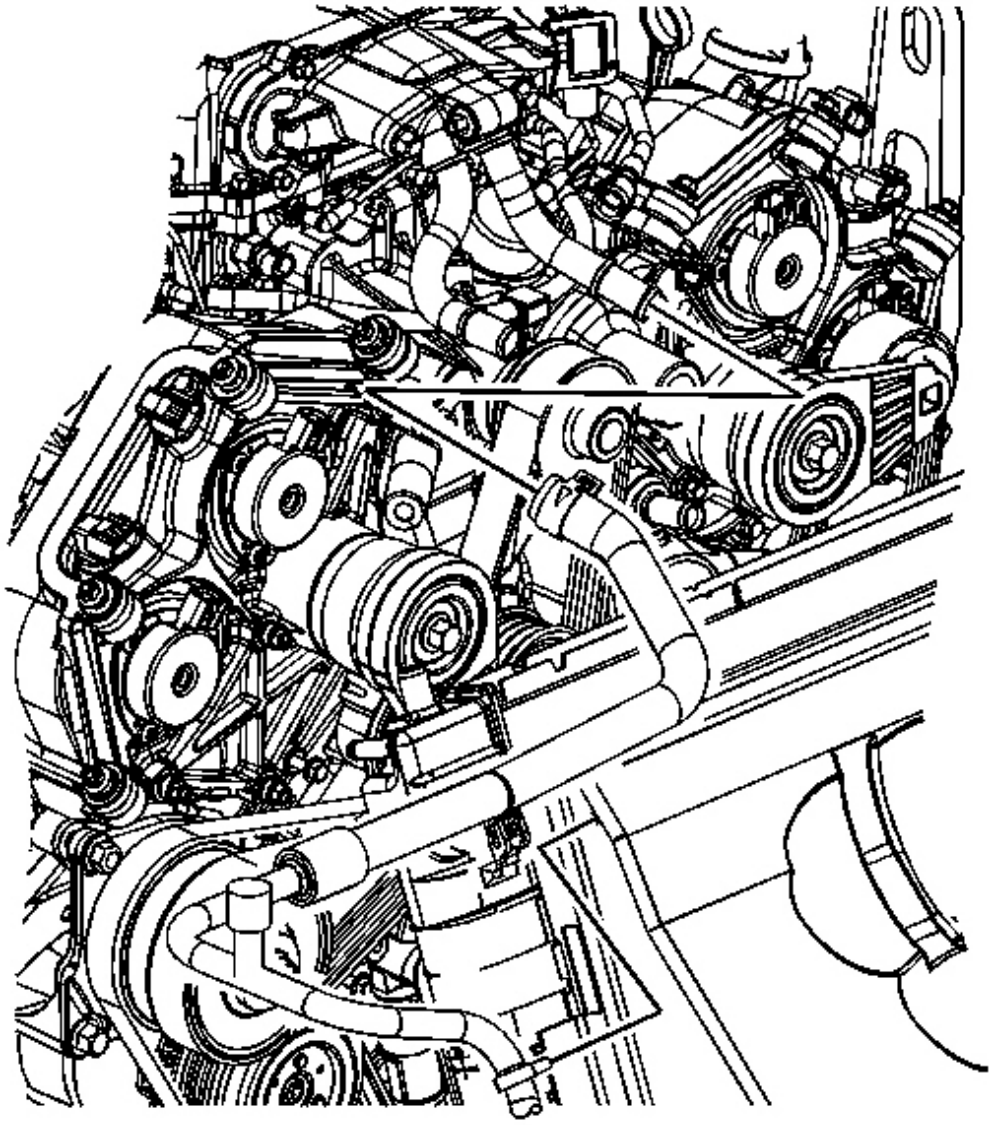


Fig. 82: Locating Charge Air Cooler Coolant Inlet Hose At Charge Air Cooler
Courtesy of GENERAL MOTORS CORP.

6. Install the charge air cooler coolant outlet hose to the charge air cooler.
7. Using the **GE-47622** , reposition the charge air cooler coolant outlet hose at the charge air cooler. See **Special Tools**.
8. Fill the charge air cooler cooling system. Refer to **Draining and Filling Cooling System - Charge Air**

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Cooling System (Static Fill).

CHARGE AIR COOLER OUTLET HOSE REPLACEMENT

Tools Required

GE-47622 Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

1. Drain the charge air cooler cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.

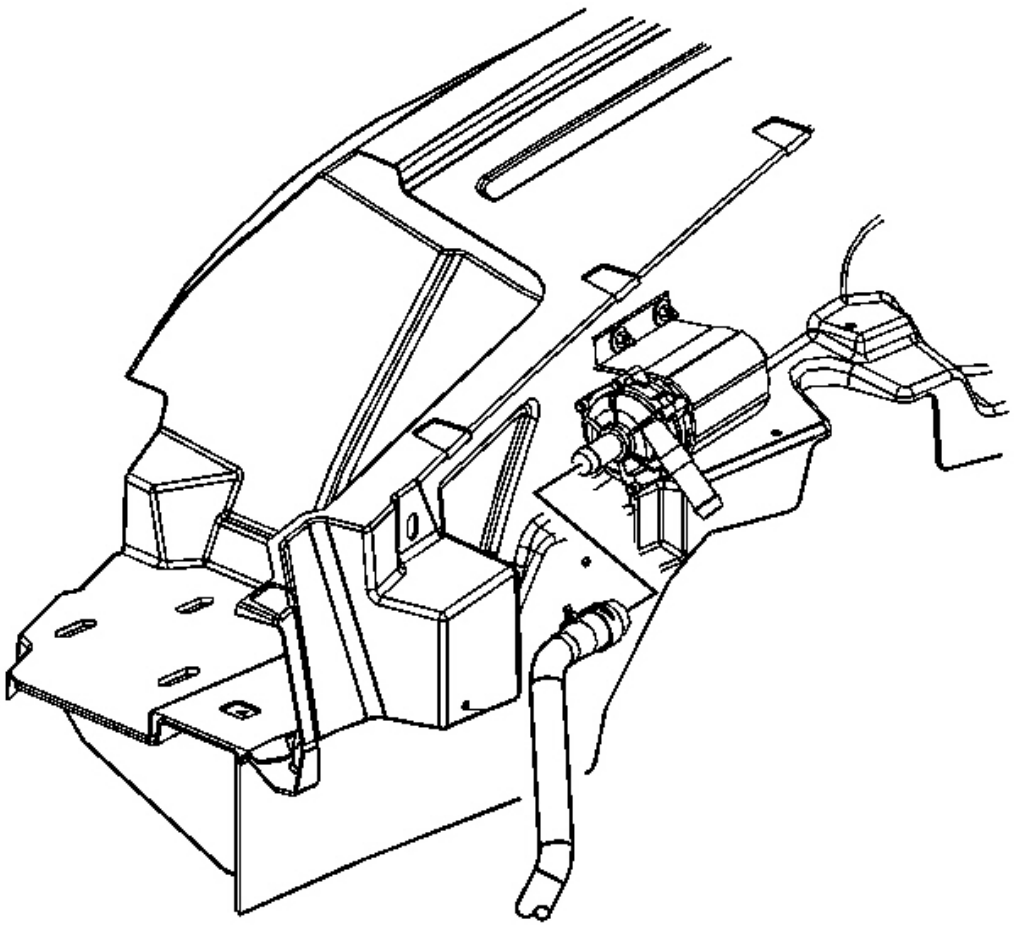


Fig. 83: View Of Charge Air Coolant Pump

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Courtesy of GENERAL MOTORS CORP.

2. Using the **GE-47622** , reposition the charge air cooler coolant outlet hose from the charge air coolant pump. See **Special Tools**.
3. Remove the charge air cooler coolant outlet hose from the charge air coolant pump.
4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

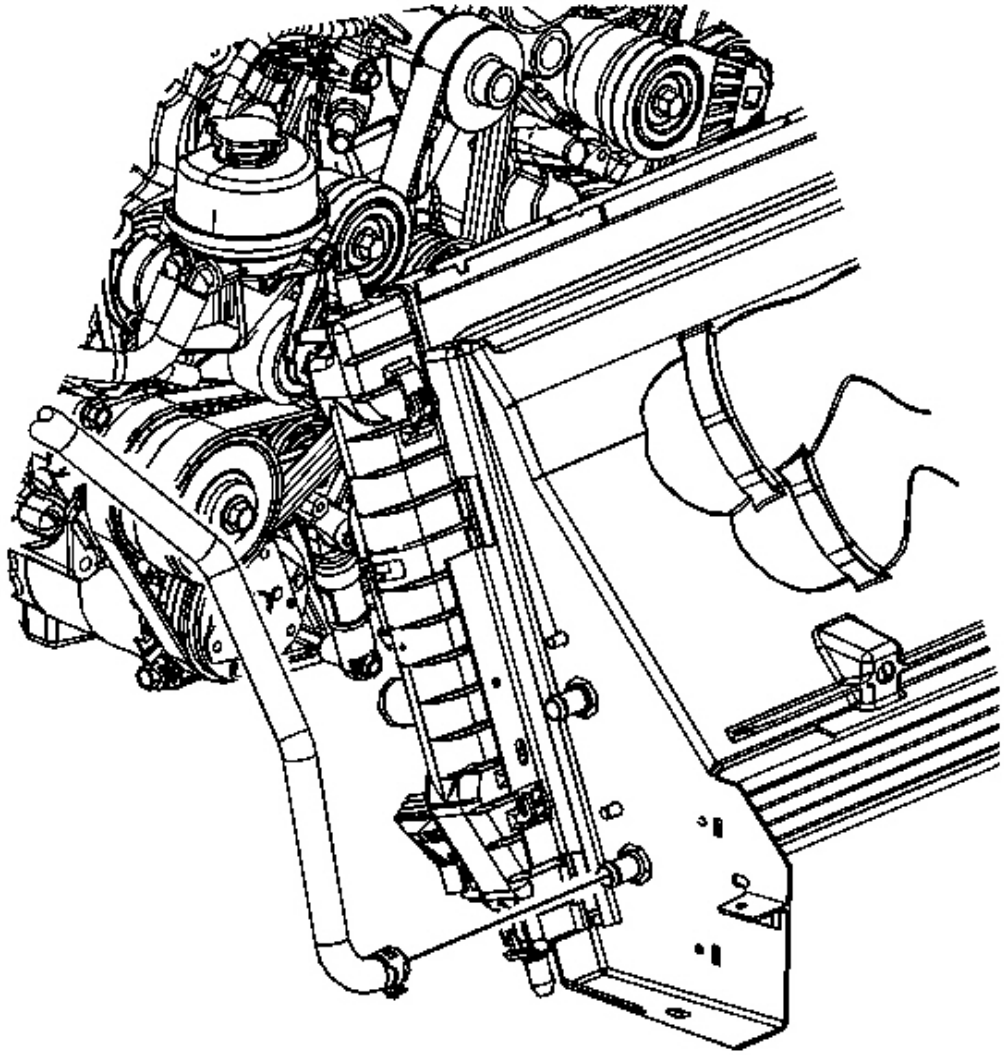


Fig. 84: Charge Air Cooler Coolant Outlet Hose
Courtesy of GENERAL MOTORS CORP.

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5. Using the **GE-47622** , reposition the charge air cooler coolant outlet hose from the charge air cooler radiator. See **Special Tools**.

IMPORTANT: Note the routing of the charge air cooler coolant outlet hose to ensure proper installation.

6. Remove the charge air cooler coolant outlet hose from the charge air cooler radiator.
7. Remove the charge air cooler coolant outlet hose from the vehicle.

Installation Procedure

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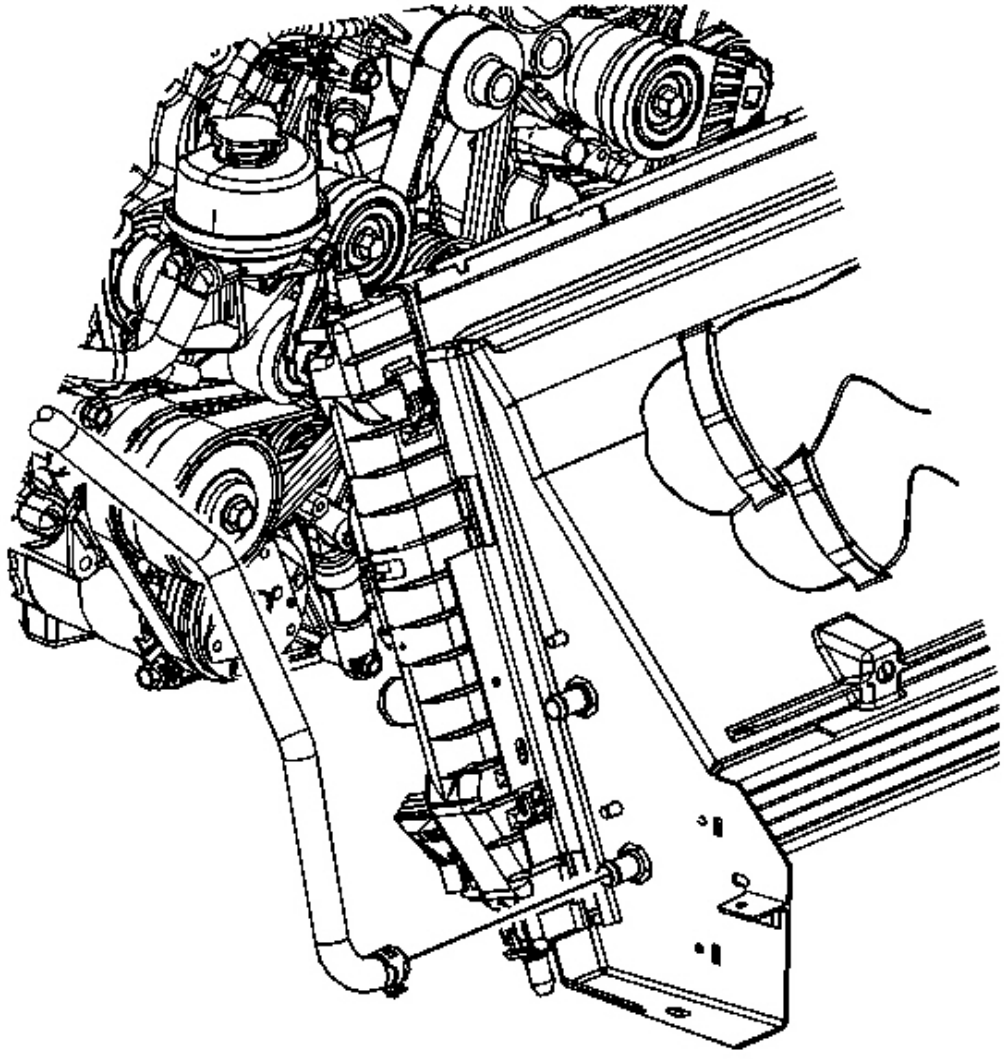


Fig. 85: Charge Air Cooler Coolant Outlet Hose
Courtesy of GENERAL MOTORS CORP.

1. Install the charge air cooler coolant outlet hose to the vehicle.
2. Install the charge air cooler coolant outlet hose to the charge air cooler radiator.
3. Using the **GE-47622** , reposition the charge air cooler coolant outlet hose clamp at the charge air cooler radiator. See **Special Tools**.
4. Lower the vehicle.

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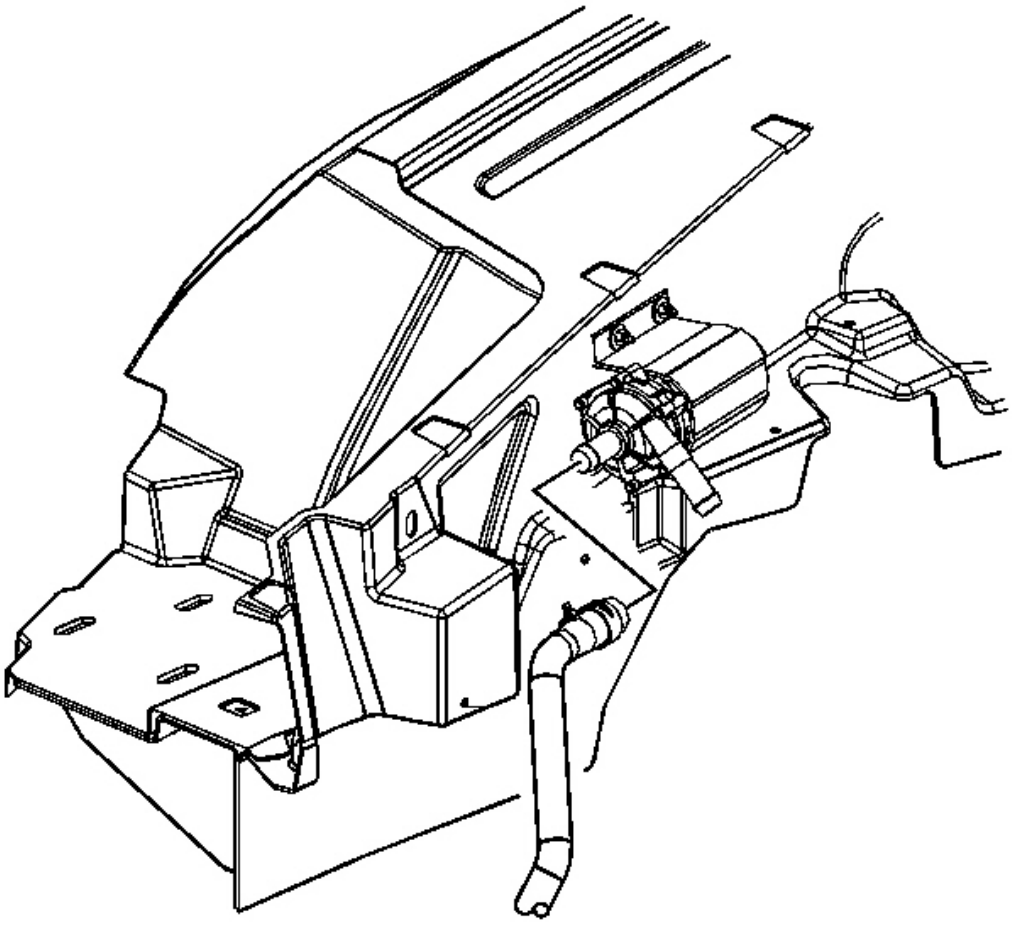


Fig. 86: View Of Charge Air Coolant Pump
Courtesy of GENERAL MOTORS CORP.

5. Install the charge air cooler coolant outlet hose to the charge air coolant pump.
6. Using the **GE-47622** , reposition the charge air cooler coolant outlet hose at the charge air coolant pump. See **Special Tools**.
7. Fill the charge air cooler cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.

GENERATOR COOLING INLET HOSE FITTING REPLACEMENT

Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and**

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Filling Cooling System (Static Fill).

2. Remove the accessory drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory** .

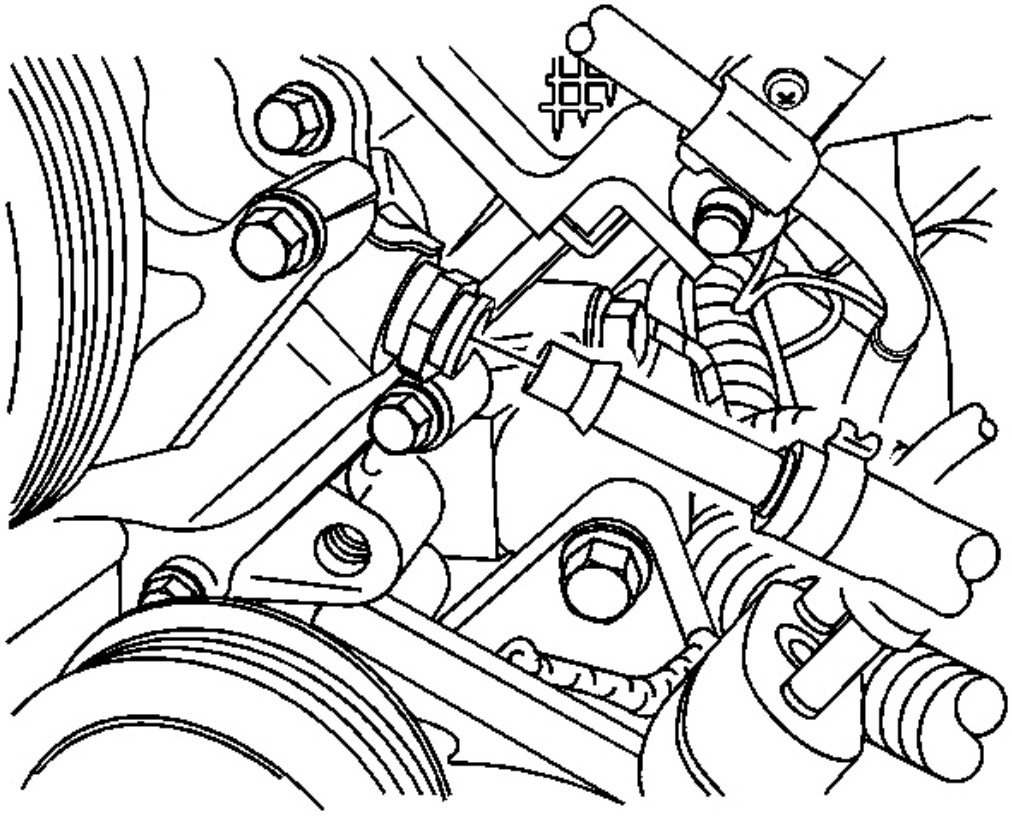


Fig. 87: Disconnecting/Connecting Generator Cooling Hose To Water Pump
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the generator cooling hose from the water pump. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.

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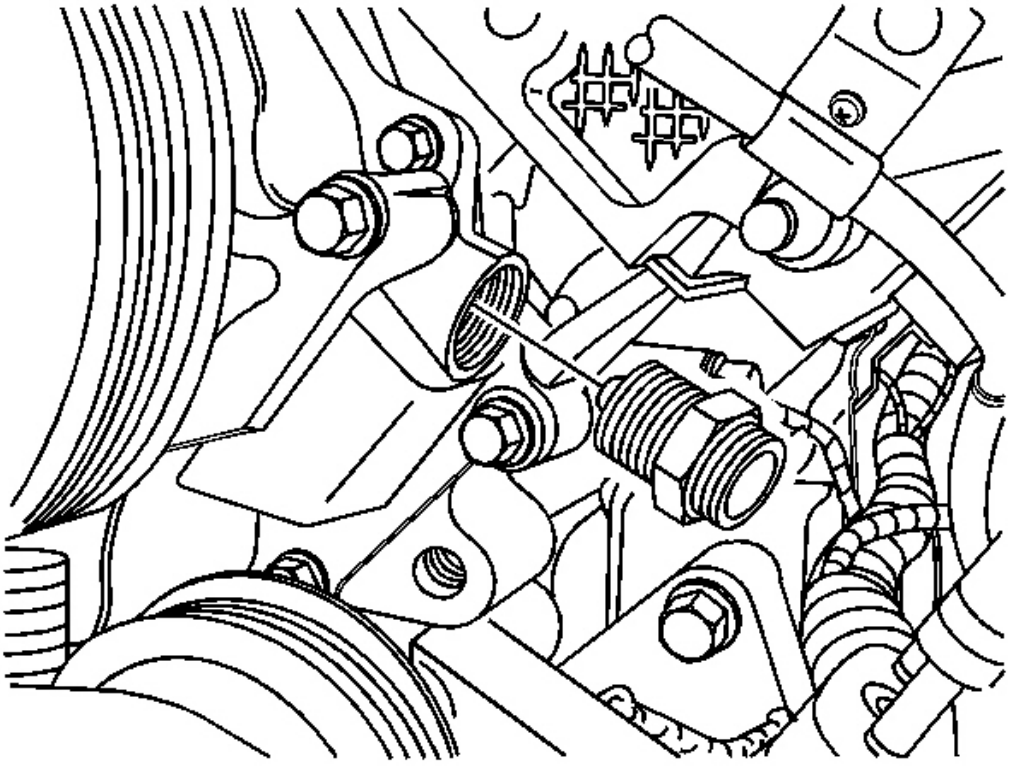


Fig. 88: Removing/Installing Generator Cooling Inlet Hose Fitting
Courtesy of GENERAL MOTORS CORP.

4. Remove the generator cooling inlet hose fitting from the vehicle.
5. Remove and discard the seal washer.

Installation Procedure

IMPORTANT: Flat washer type seals do not require lubrication.

1. Inspect the new seal washer for any signs of cracks, cuts or damage.

   Do not use a damaged seal washer.

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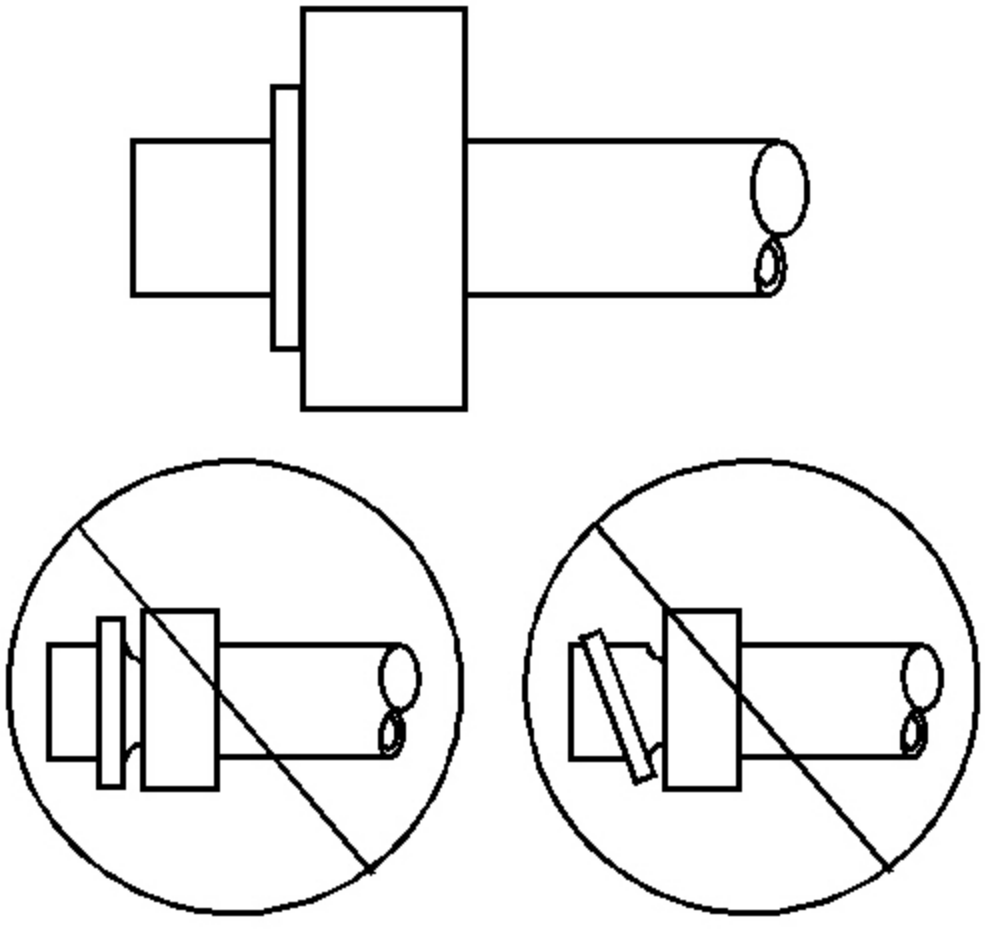


Fig. 89: Identifying Good And Bad Sealing Washer Positions
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The seal washer must completely bottom against the surface of the fitting.

2. Using a lint-free clean, dry cloth, clean the sealing surfaces at the water pump and generator cooling inlet hose fitting.

   Carefully install the new seal washer onto the generator cooling inlet hose fitting.

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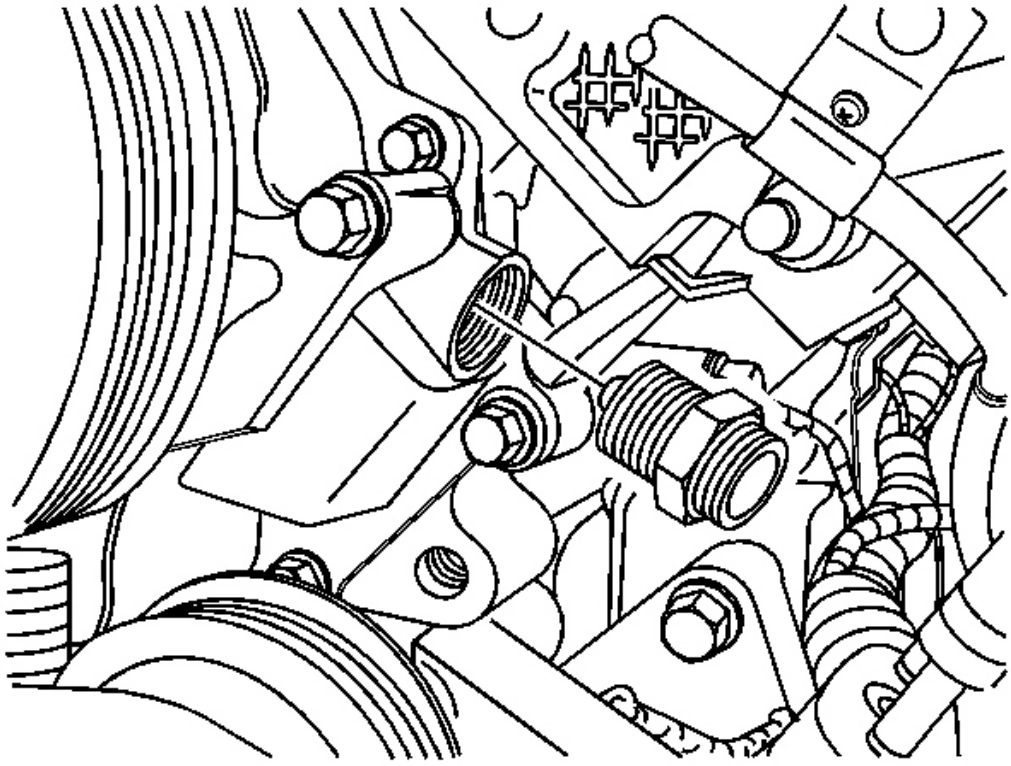


Fig. 90: Removing/Installing Generator Cooling Inlet Hose Fitting
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice.

3. Install the generator cooling inlet hose fitting to the vehicle.

   Tighten: Tighten the fitting to 25 N.m (18 lb ft).

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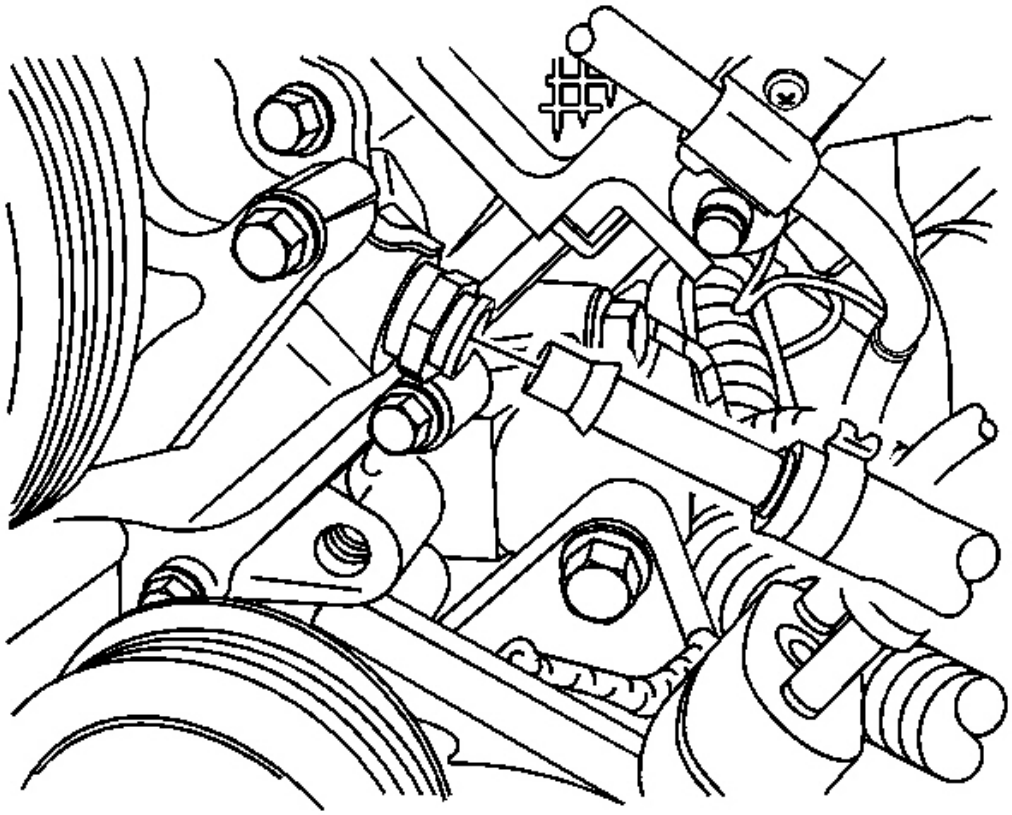


Fig. 91: Disconnecting/Connecting Generator Cooling Hose To Water Pump
Courtesy of GENERAL MOTORS CORP.

4. Connect the generator cooling hose to the water pump. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.
5. Install the accessory drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory** .
6. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

GENERATOR COOLING HOSE ASSEMBLY REPLACEMENT

Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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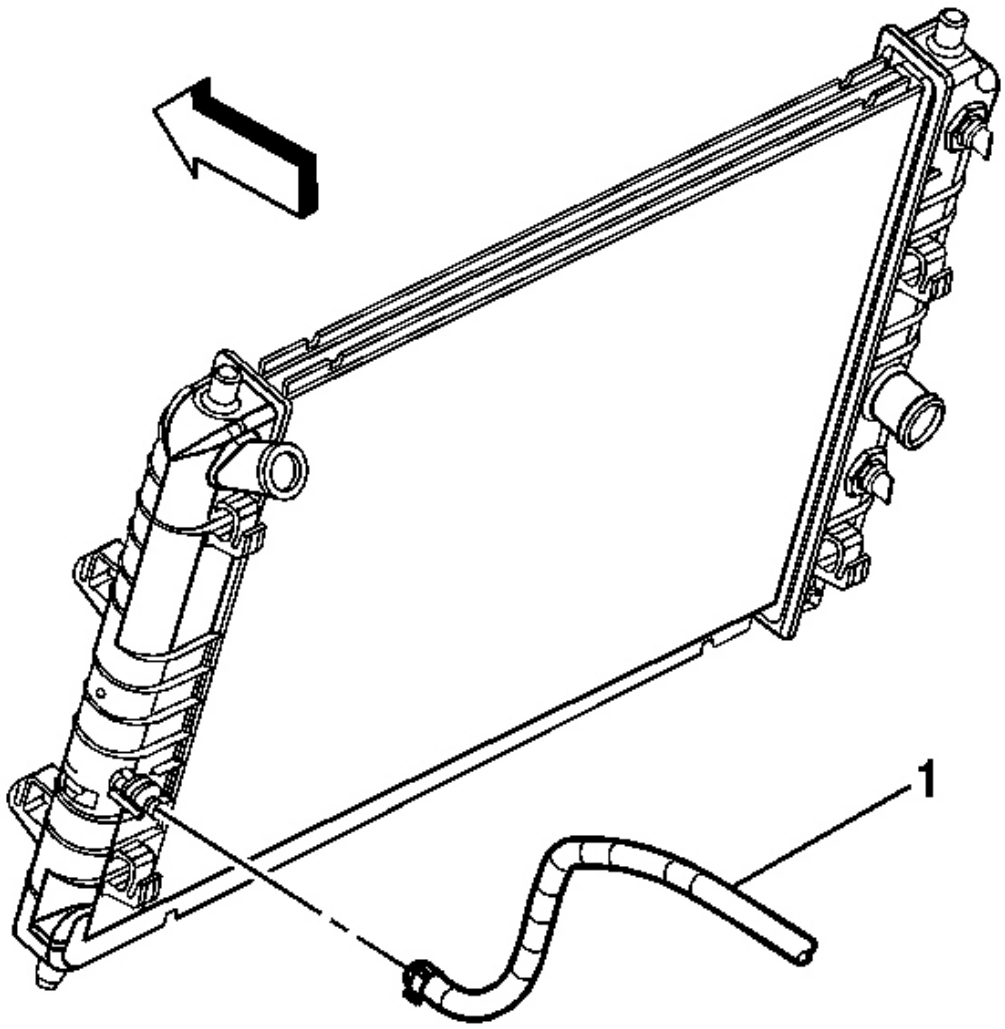


Fig. 92: Disconnecting/Connecting Generator Cooling Hose To Radiator
Courtesy of GENERAL MOTORS CORP.

3. Disengage the generator cooling hose clamp at the radiator.
4. Disconnect the generator cooling hose (1) from the radiator.
5. Lower the vehicle.
6. Remove the accessory drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory** .

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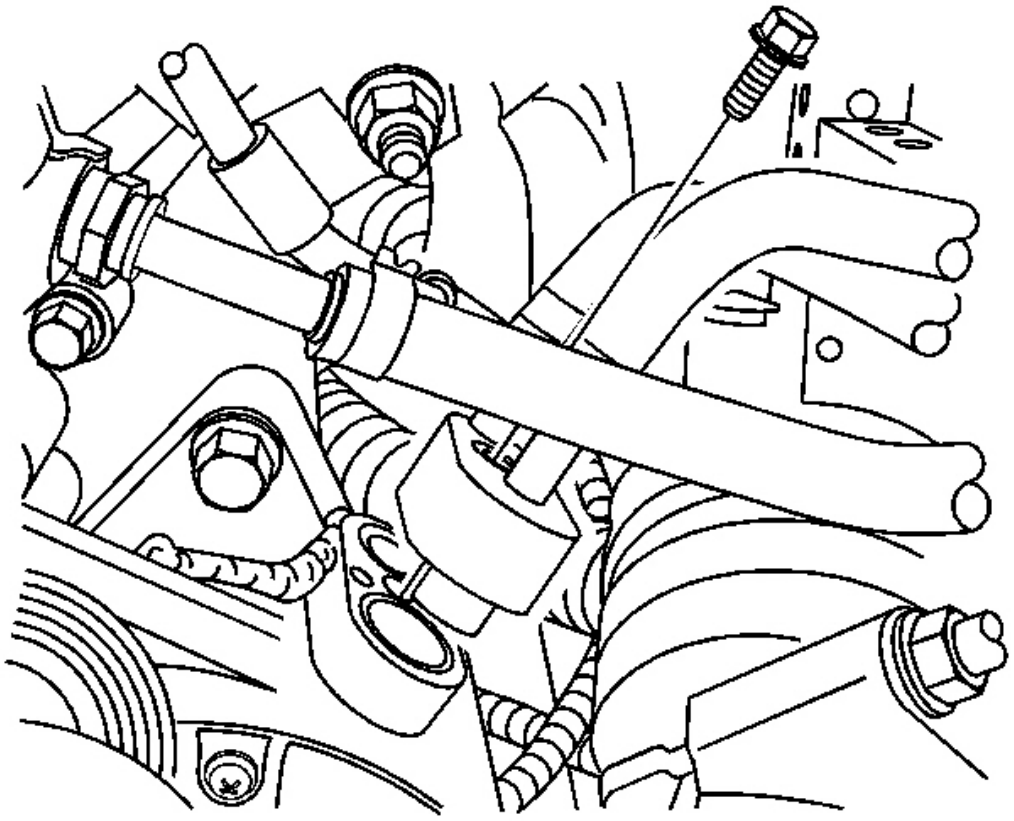


Fig. 93: Removing/Installing Generator Cooling Hose Assembly To Generator Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the generator cooling hose assembly to generator bolt.
8. Disconnect the generator cooling hose assembly from the generator.

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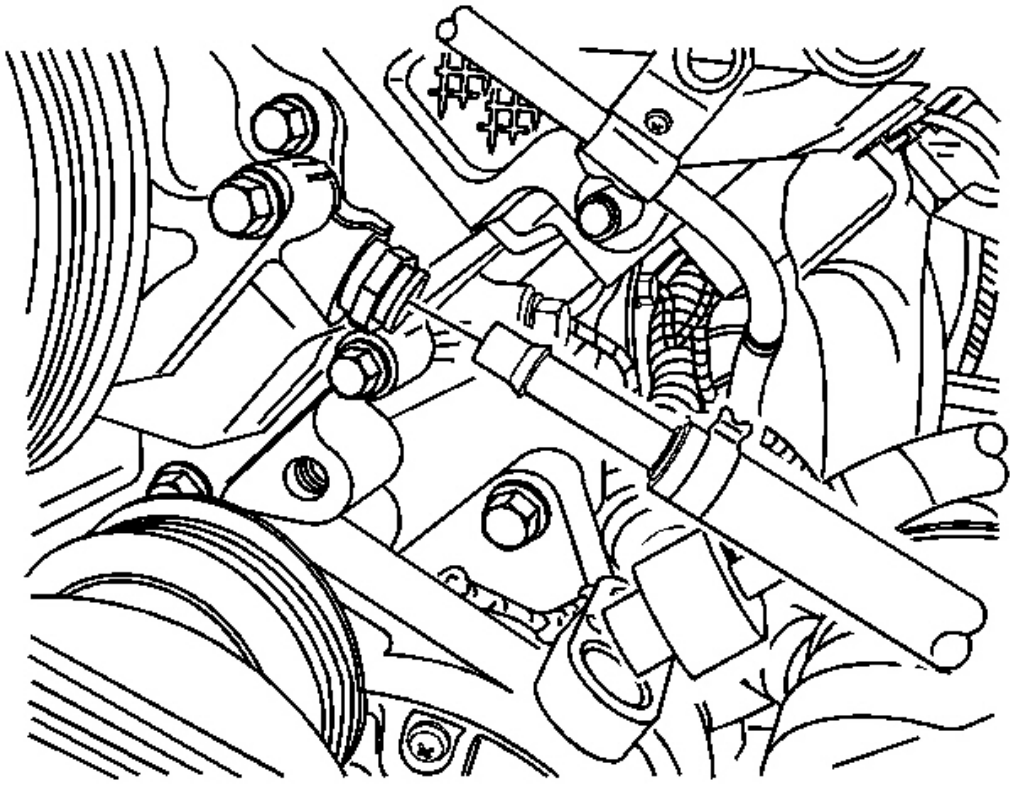


Fig. 94: Removing/Installing Generator Cooling Hose Assembly
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the generator cooling hose from the water pump. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.
10. Remove the generator cooling hose assembly from the vehicle.
11. Remove and discard the seal washers.

Installation Procedure

IMPORTANT: Flat washer type seals do not require lubrication.

1. Inspect the new seal washer for any signs of cracks, cuts or damage.

   Do not use a damaged seal washer.

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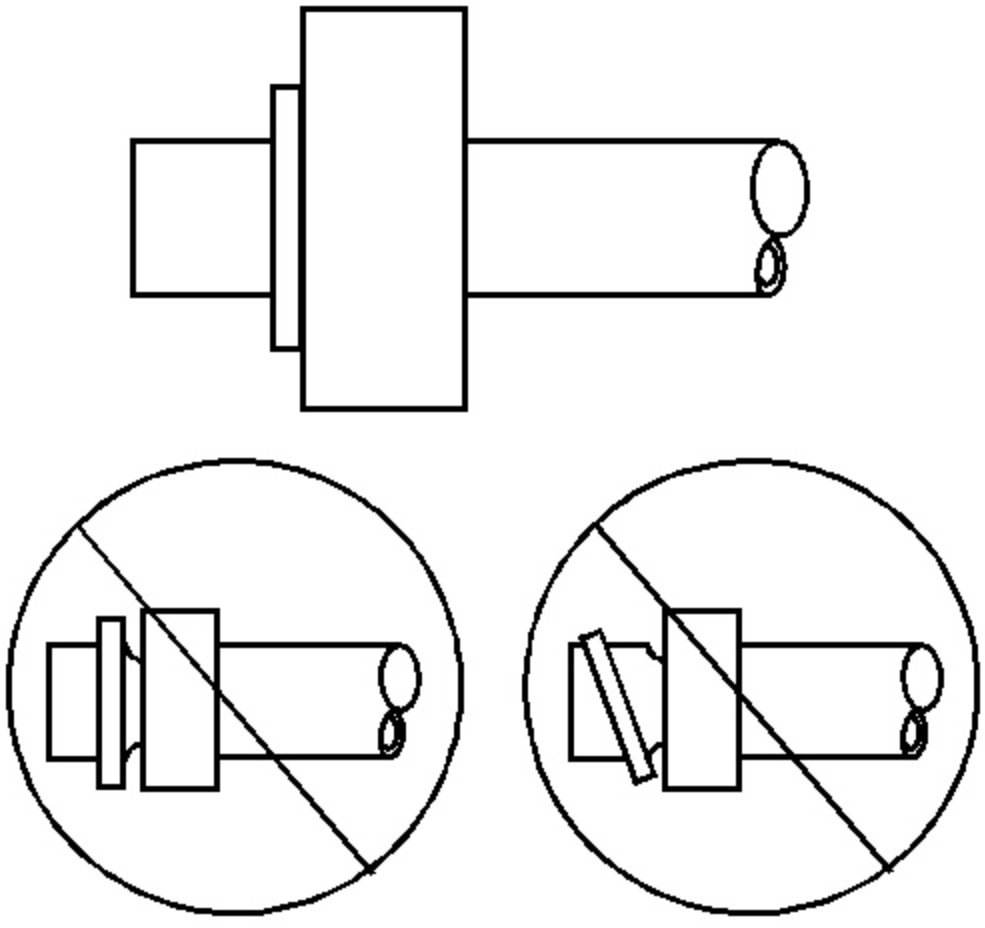


Fig. 95: Identifying Good And Bad Sealing Washer Positions
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The seal washer must completely bottom against the surface of the fitting.

2. Using a lint-free clean, dry cloth, clean the sealing surfaces at the generator and generator cooling hose assembly.

   Carefully install the new seal washers onto the generator cooling hose assembly.

3. Install the generator cooling hose assembly to the vehicle.

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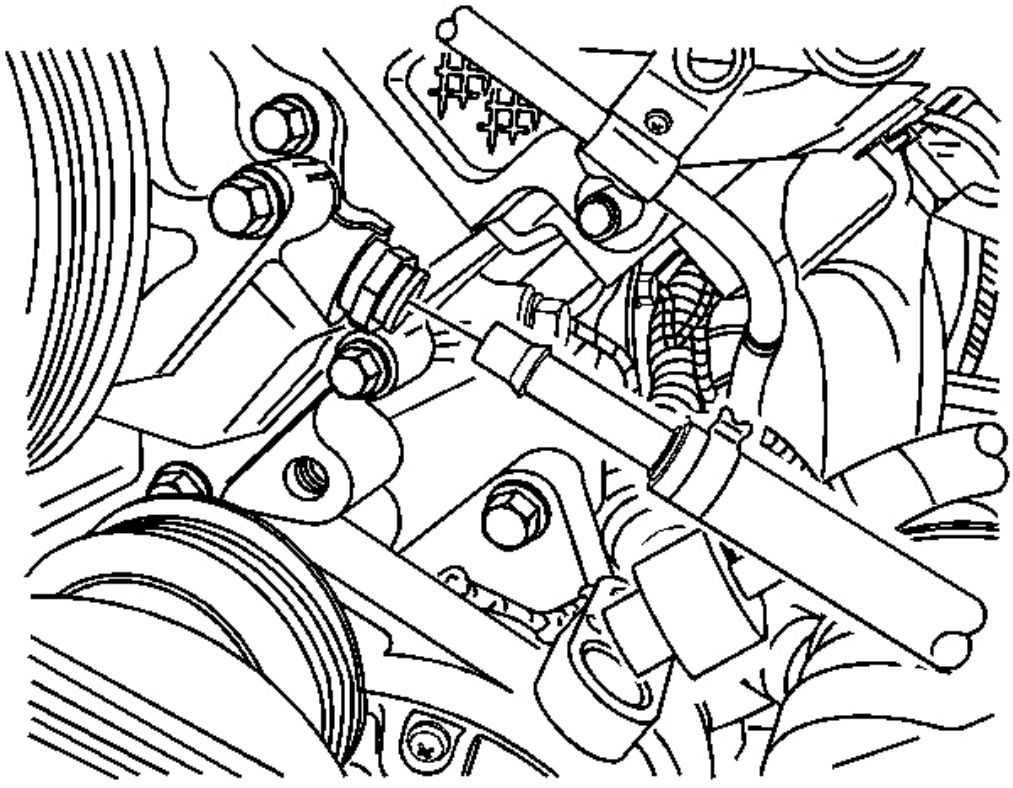


Fig. 96: Removing/Installing Generator Cooling Hose Assembly
Courtesy of GENERAL MOTORS CORP.

4. Connect the generator cooling hose to the water pump. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.
5. Connect the generator cooling hose assembly to the generator.

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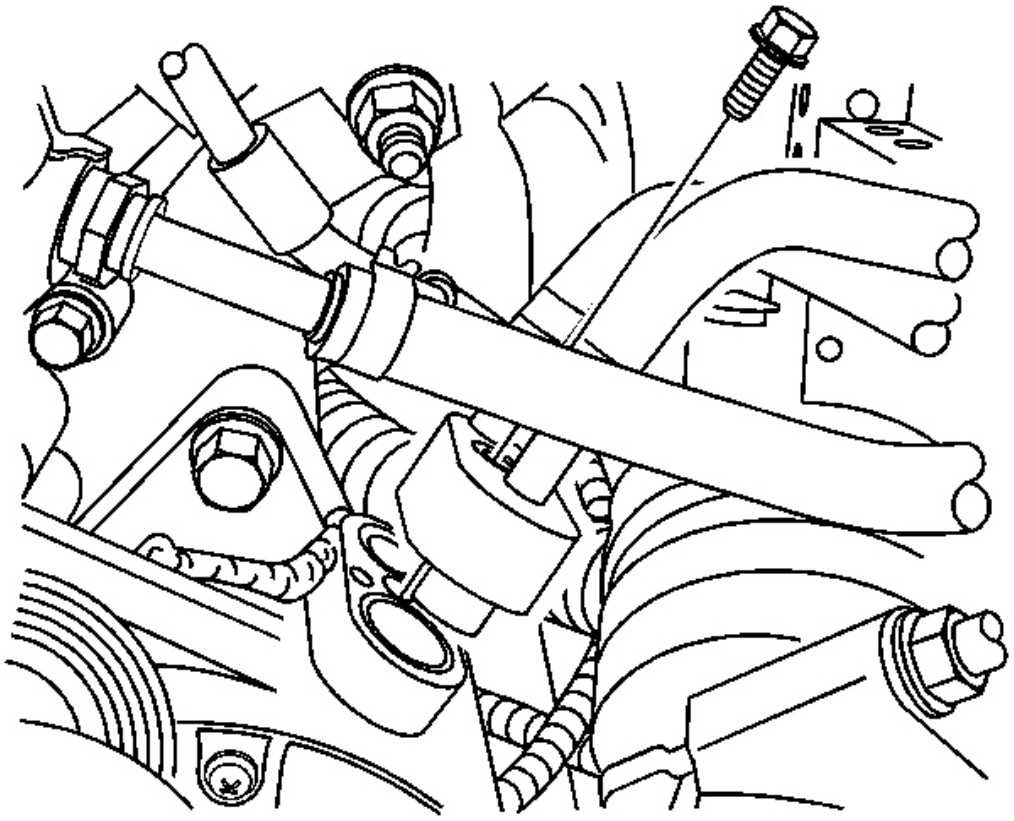


Fig. 97: Removing/Installing Generator Cooling Hose Assembly To Generator Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the generator cooling hose assembly to generator bolt.

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

7. Install the accessory drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory** .
8. Raise and support the vehicle.

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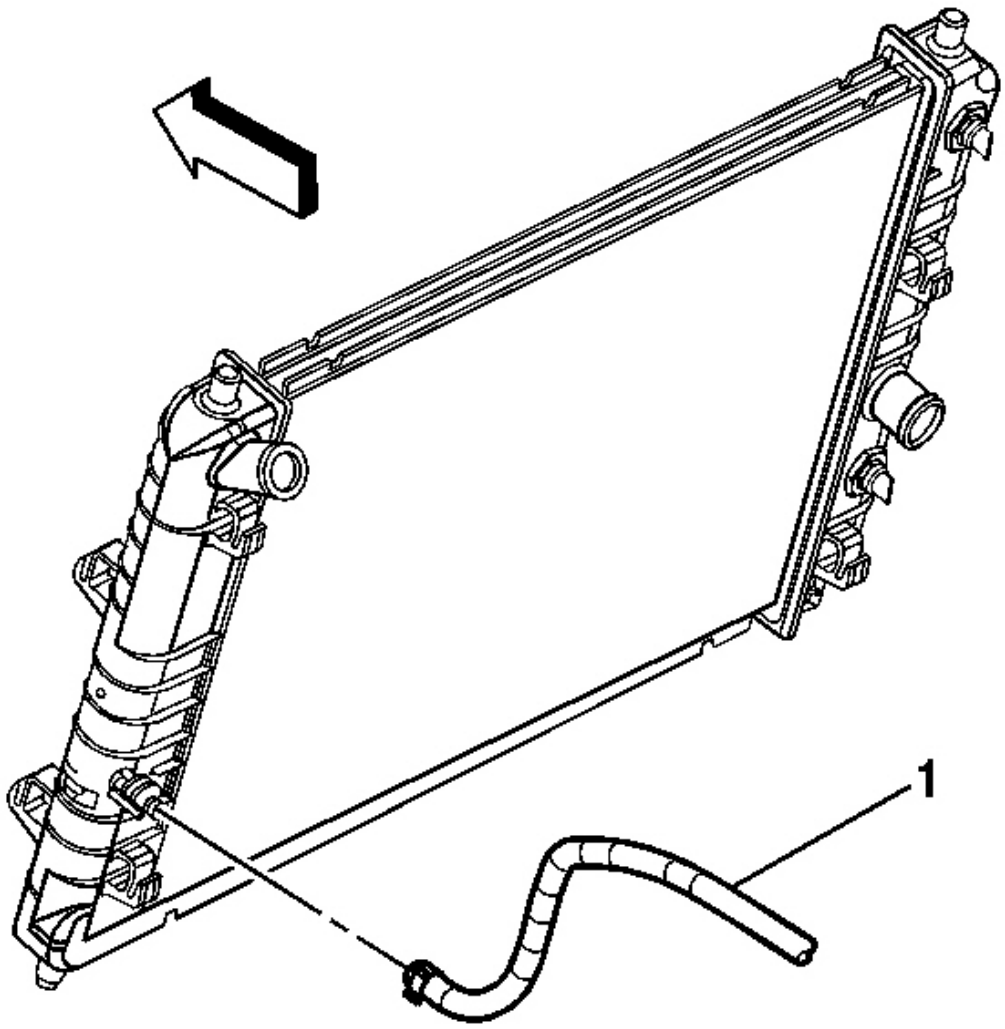


Fig. 98: Disconnecting/Connecting Generator Cooling Hose To Radiator
Courtesy of GENERAL MOTORS CORP.

9. Connect the generator cooling hose (1) to the radiator.
10. Engage the generator cooling hose clamp at the radiator.
11. Lower the vehicle.
12. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

GENERATOR COOLING PIPE/HOSE QUICK CONNECT FITTING

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Tools Required

J 41623-B Cooler Quick Connect Tool. See **Special Tools**.

Removal Procedure

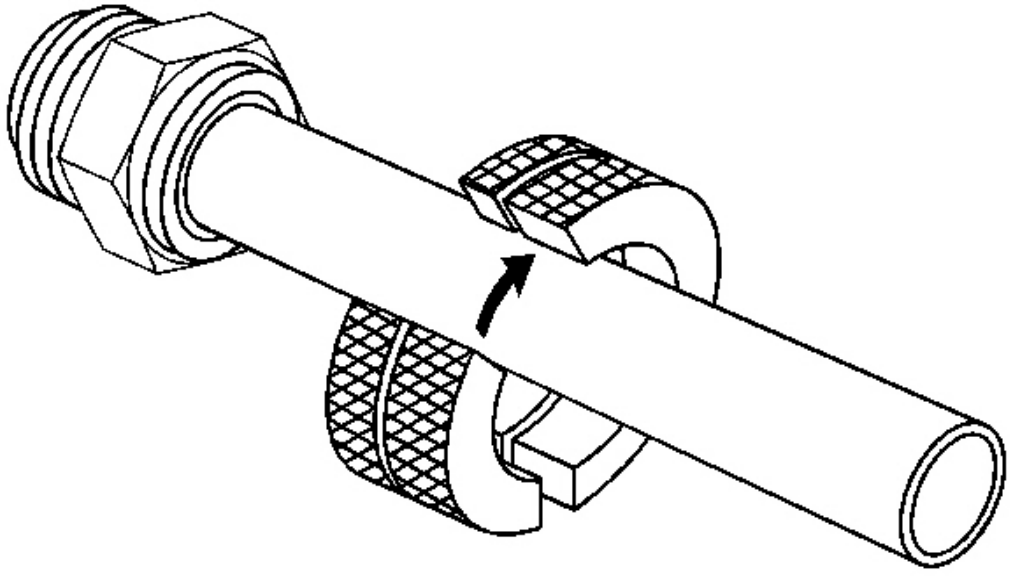


Fig. 99: Installing J 41623-B Onto Generator Cooling Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

1. Install the **J 41623-B** onto the generator cooling inlet pipe. See **Special Tools**.

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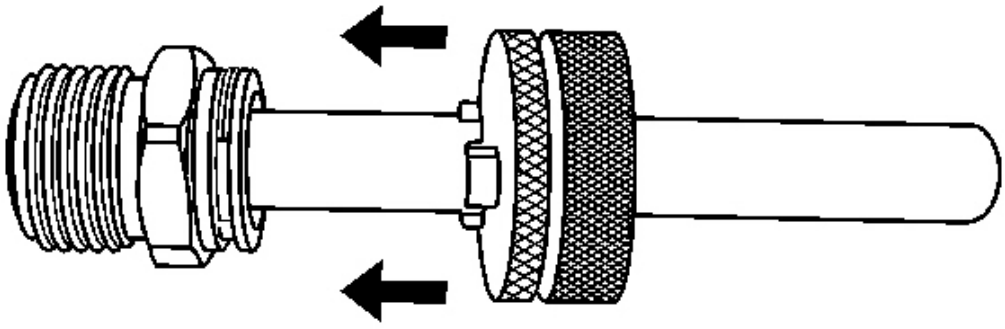


Fig. 100: Sliding J 41623-B Toward Generator Cooling Inlet Pipe Fitting
Courtesy of GENERAL MOTORS CORP.

2. Slide the **J 41623-B** toward the generator cooling inlet pipe fitting. See **Special Tools**.

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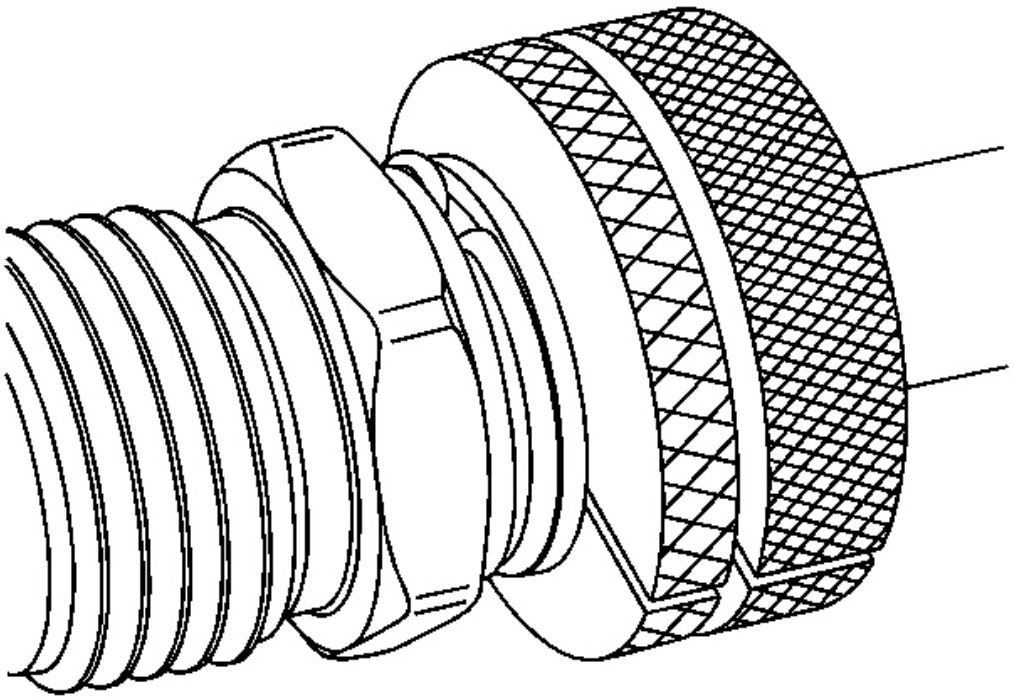


Fig. 101: Rotating J 41623-B On Coolant Pipe
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Rotate the J 41623-B to engage the generator cooling inlet pipe fitting's retainer slots. See Special Tools.
The J 41623-B should be nearly flush with the fitting. See Special Tools.

3. Connect the **J 41623-B** onto the generator cooling inlet pipe fitting. See **Special Tools**.

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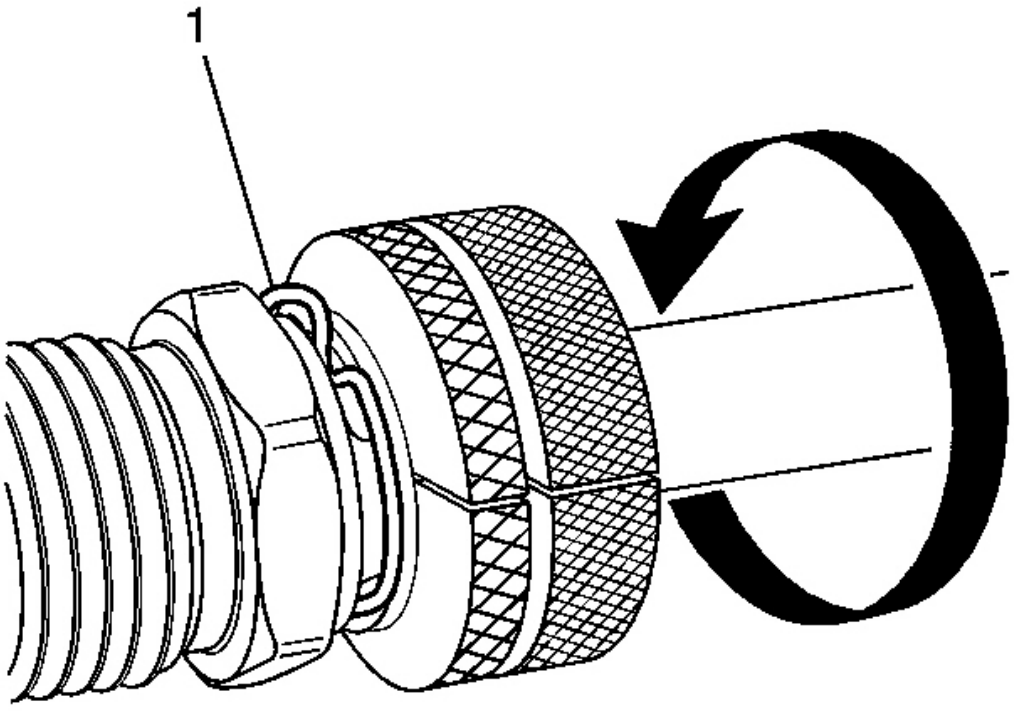


Fig. 102: Rotating J 41623-B Until Retainer Clip Rises Above Fitting Retainer Seat
Courtesy of GENERAL MOTORS CORP.

4. Rotate the **J 41623-B** until the retainer clip (1) rises above the fitting retainer seat. See **Special Tools**.

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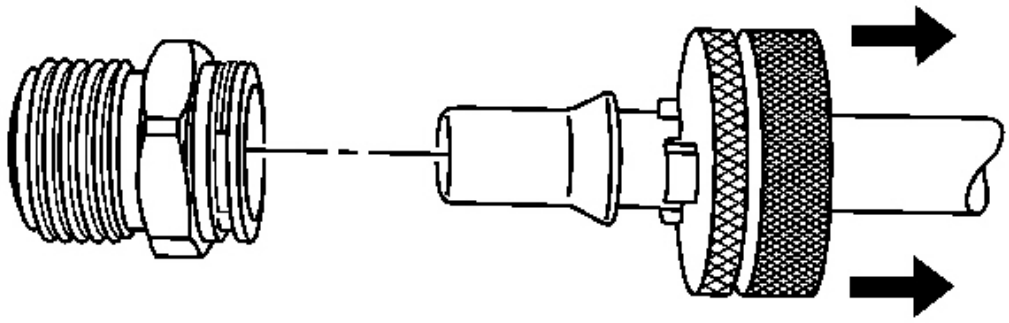


Fig. 103: Removing J 41623-B From Generator Cooling Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

5. Pull back on the generator cooling inlet pipe to disengage the pipe from the generator cooling inlet pipe fitting.
6. Remove the **J 41623-B** from the generator cooling inlet pipe. See **Special Tools**.

Installation Procedure

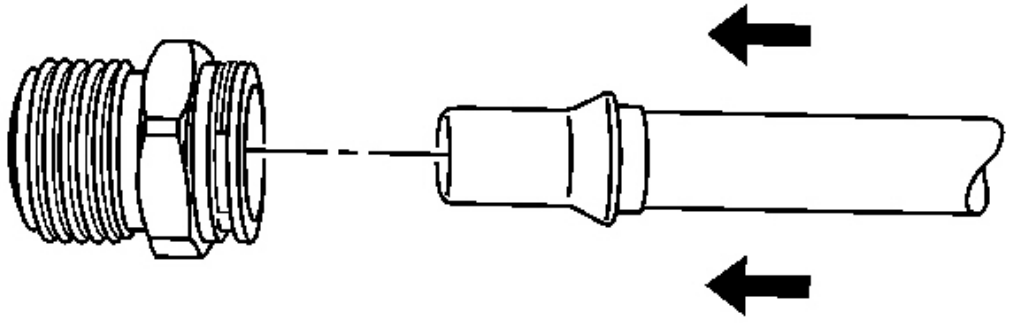


Fig. 104: Installing Generator Cooling Inlet Pipe Into Generator Cooling Inlet Pipe Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Inspect the generator cooling inlet pipe fitting and retaining clip for signs of wear or damage. Replace the components if necessary.

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1. Install the generator cooling inlet pipe into the generator cooling inlet pipe fitting.

   A distinct snap should be heard or felt when assembling the generator cooling inlet pipe to the fitting.

2. To ensure the cooler line is properly installed, give the cooler pipe a gentle pull.

ENGINE OIL COOLER CONNECTOR REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the left lower front bumper close out panel. Refer to **Front Bumper Fascia Lower Close Out Panel Replacement** .

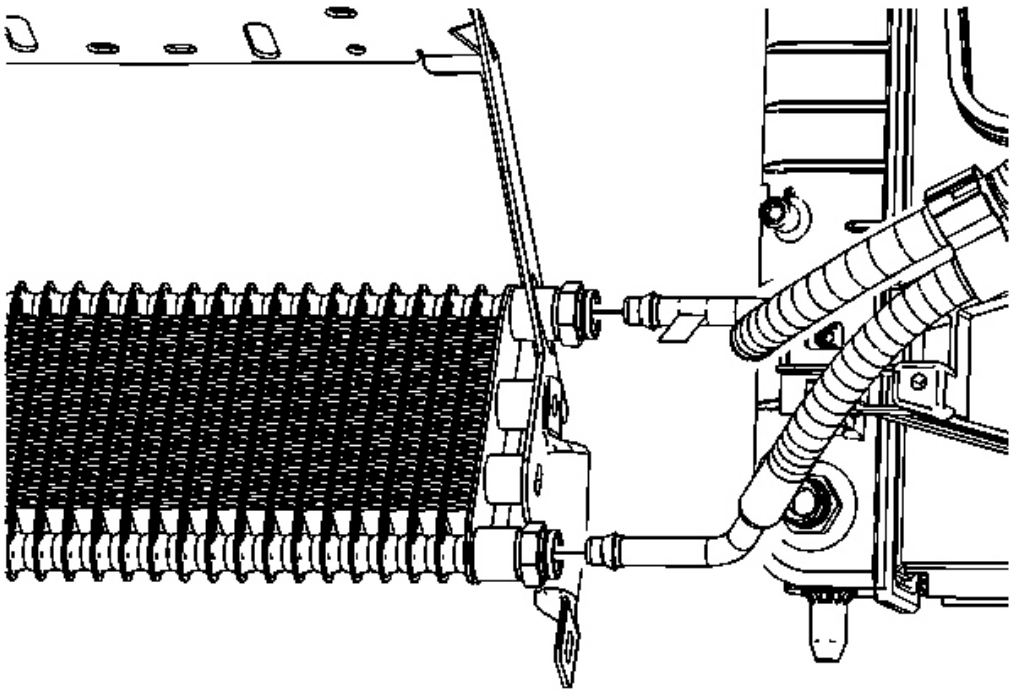


Fig. 105: View Of Engine Oil Cooler Hose/Pipe
Courtesy of GENERAL MOTORS CORP.

3. Install oil drain pan under the vehicle.
4. Remove the engine oil cooler hose/pipe from the external oil cooler. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.

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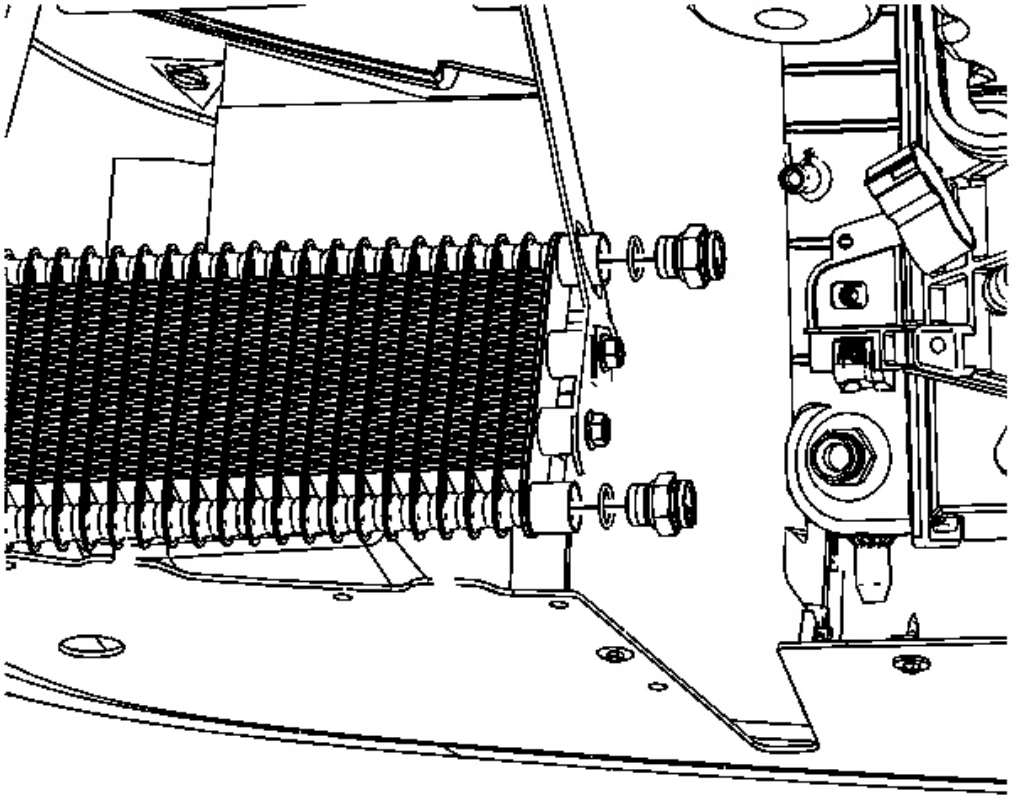


Fig. 106: View Of External Engine Oil Cooler Quick Connect Fitting
Courtesy of GENERAL MOTORS CORP.

5. Remove the external engine oil cooler quick connect fitting.
6. Remove and discard all engine oil cooler hose/pipe seals.

Installation Procedure

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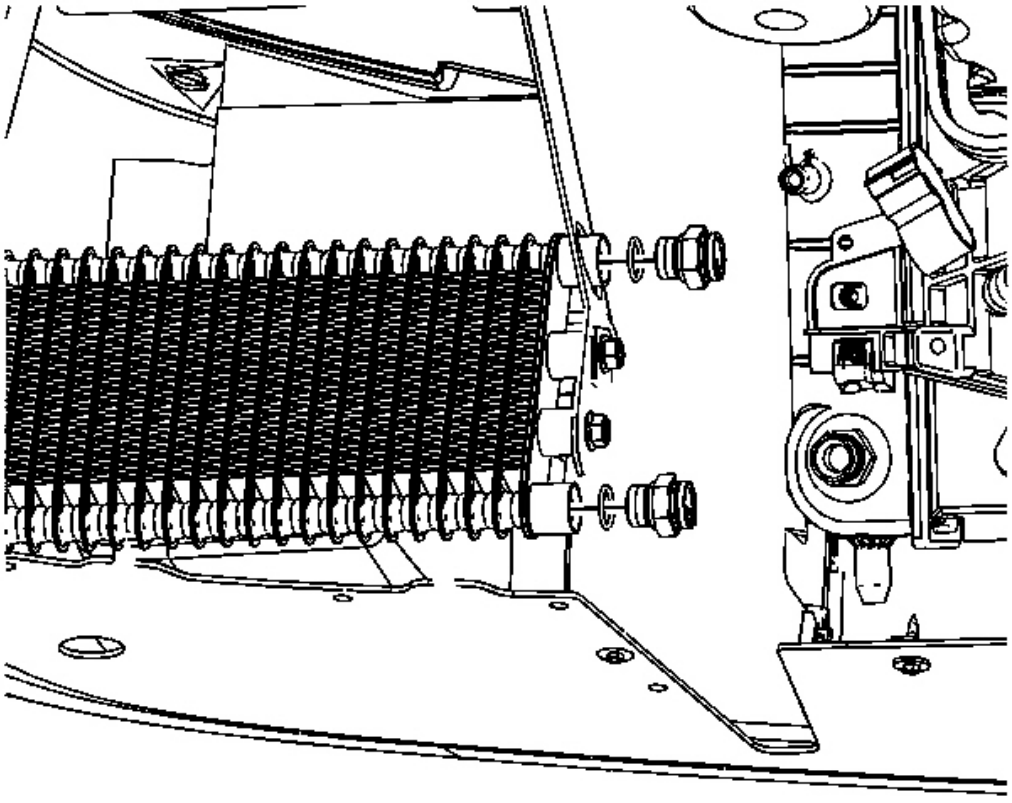


Fig. 107: View Of External Engine Oil Cooler Quick Connect Fitting
Courtesy of GENERAL MOTORS CORP.

1. Install new engine oil cooler hose/pipe seals.

   NOTE: Refer to Fastener Notice .

2. Install the external engine oil cooler quick connect fitting.

   Tighten: Tighten the fitting to 18 N.m (13 lb ft).

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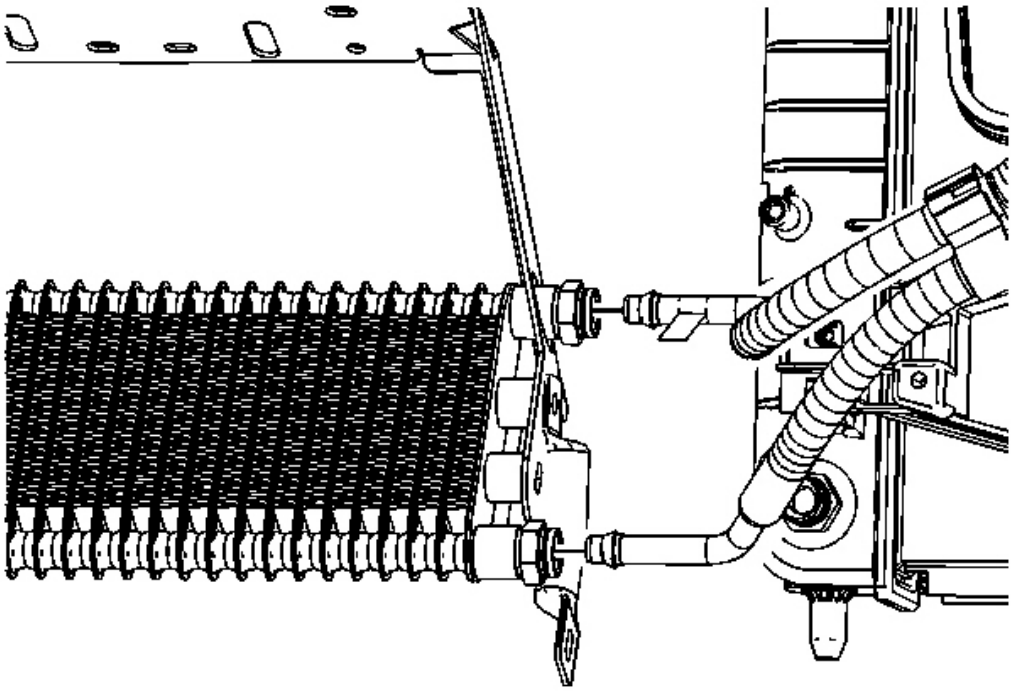


Fig. 108: View Of Engine Oil Cooler Hose/Pipe
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The quick connect fitting must be pushed on and then pulled back to verify proper connector engagement.

3. Install the engine oil cooler hose/pipes to the external oil cooler. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.
4. Remove the oil drain pan from under the vehicle.
5. Install the left lower front bumper close out panel. Refer to **Front Bumper Fascia Lower Close Out Panel Replacement** .
6. Refill the engine with oil and check for leaks.

ENGINE OIL COOLER HOSE/PIPE REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the left lower front bumper close out panel. Refer to **Front Bumper Fascia Lower Close Out**

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Panel Replacement .

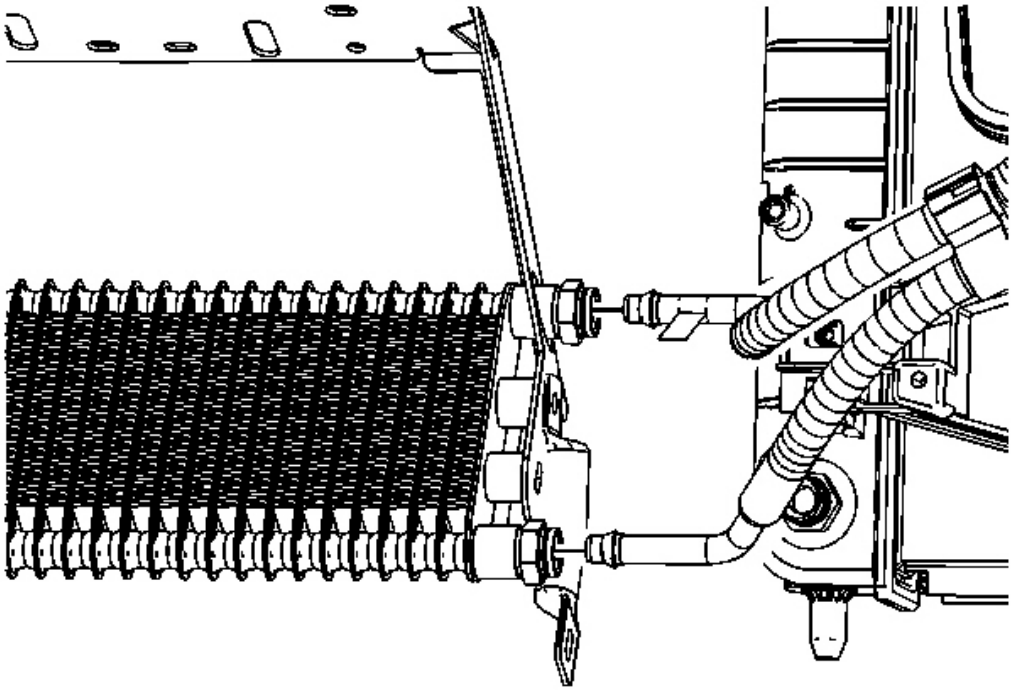


Fig. 109: View Of Engine Oil Cooler Hose/Pipe
Courtesy of GENERAL MOTORS CORP.

3. Install oil drain pan under the vehicle.
4. Remove the engine oil cooler hose/pipe from the external oil cooler. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.

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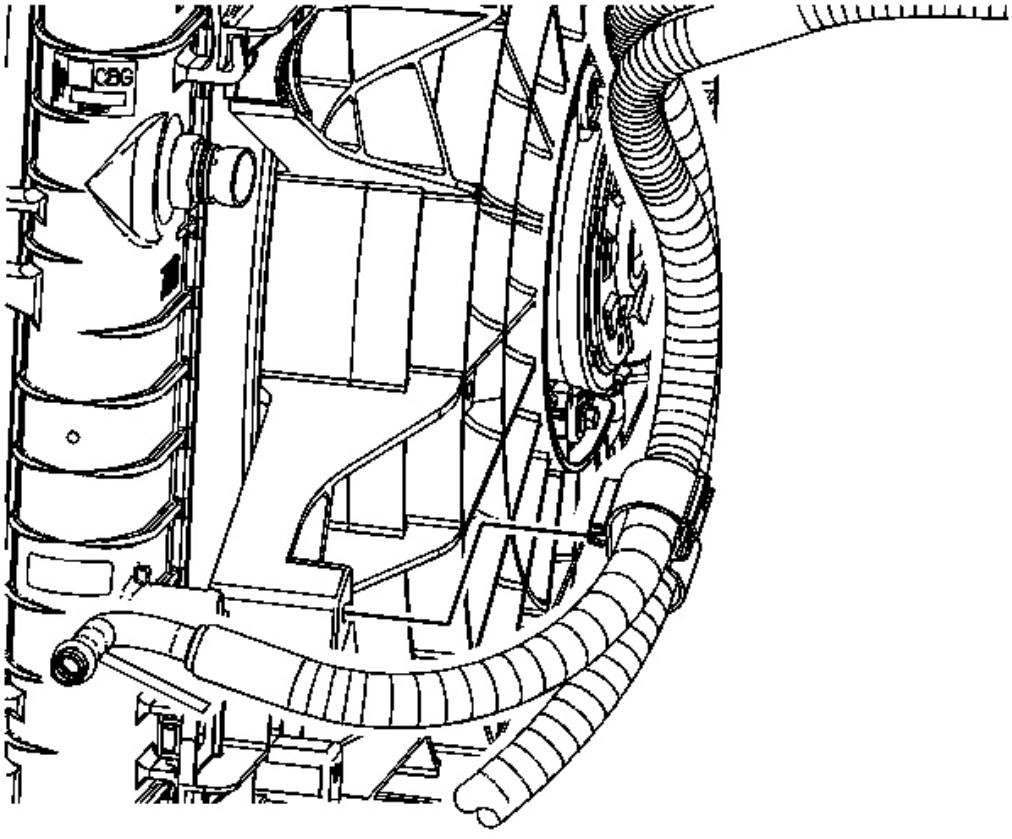


Fig. 110: View Of Engine Oil Cooler Hose/Pipe & Clip
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the engine oil cooler hose/pipe clip from the fan shroud.

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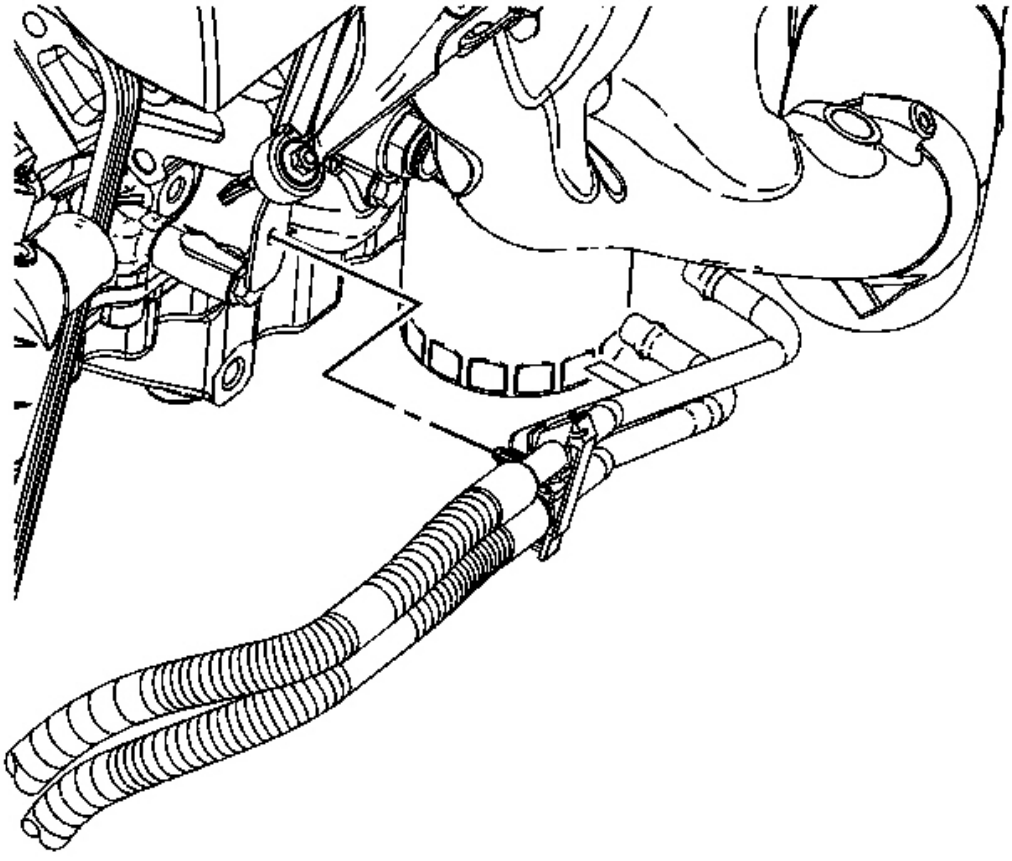


Fig. 111: View Of Engine Oil Cooler Hoses & Pipes
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the engine oil cooler hose/pipe clip from the engine.

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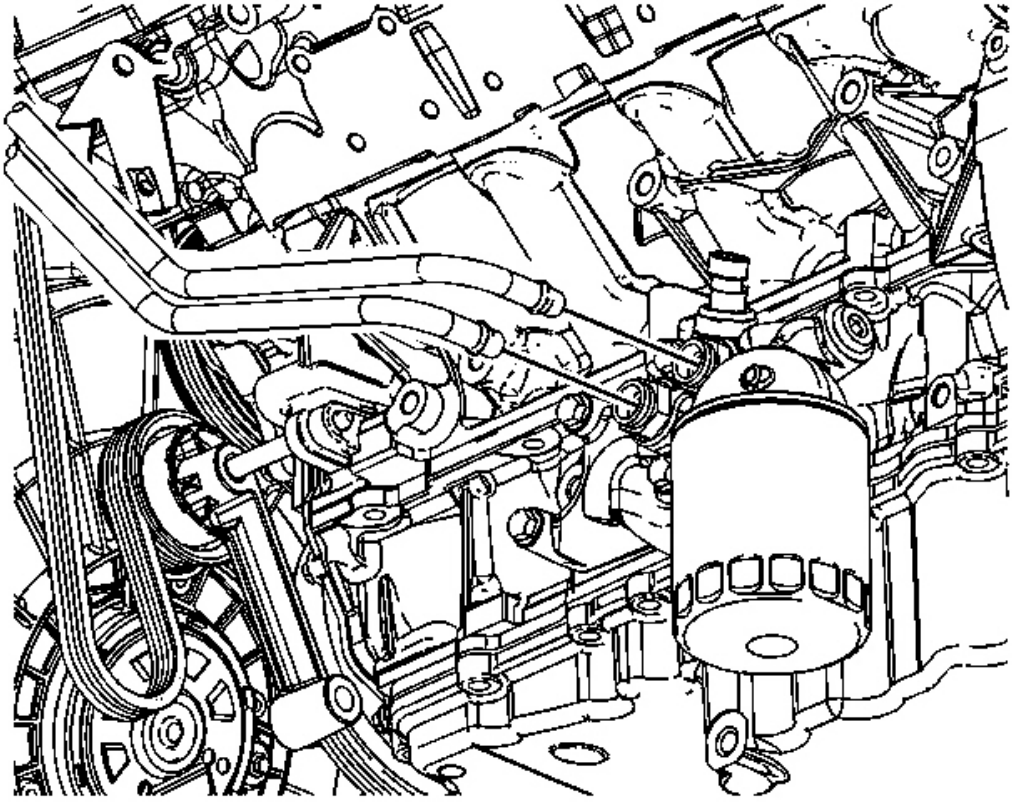


Fig. 112: View Of External Engine Oil Cooler Hose/Pipe
Courtesy of GENERAL MOTORS CORP.

7. Remove the external engine oil cooler hose/pipe from the engine. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.
8. Remove the external engine oil cooler hose/pipe from the vehicle.
9. Remove and discard all engine oil cooler hose/pipe seals.

Installation Procedure

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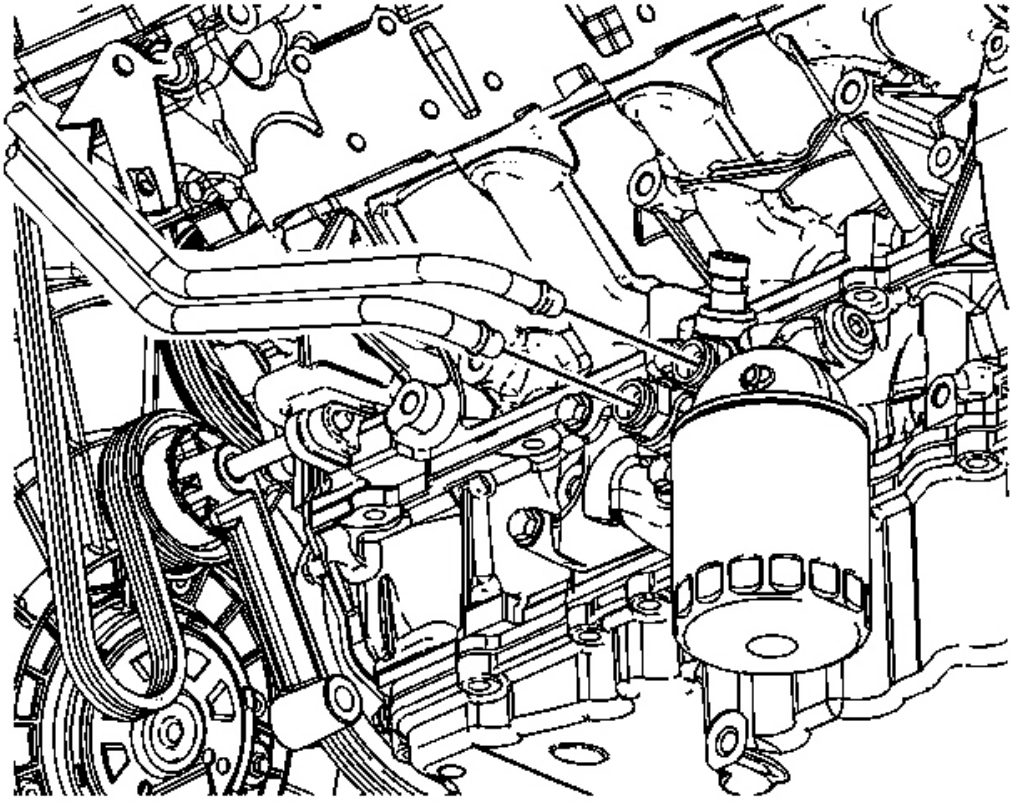


Fig. 113: View Of External Engine Oil Cooler Hose/Pipe
Courtesy of GENERAL MOTORS CORP.

1. Install new engine oil cooler hose/pipe seals.
2. Install the external engine oil cooler hose/pipe to the vehicle.

IMPORTANT: The quick connect fitting must be pushed on and then pulled back to verify proper connector engagement.

3. Install the external engine oil cooler hose/pipe to the engine. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.

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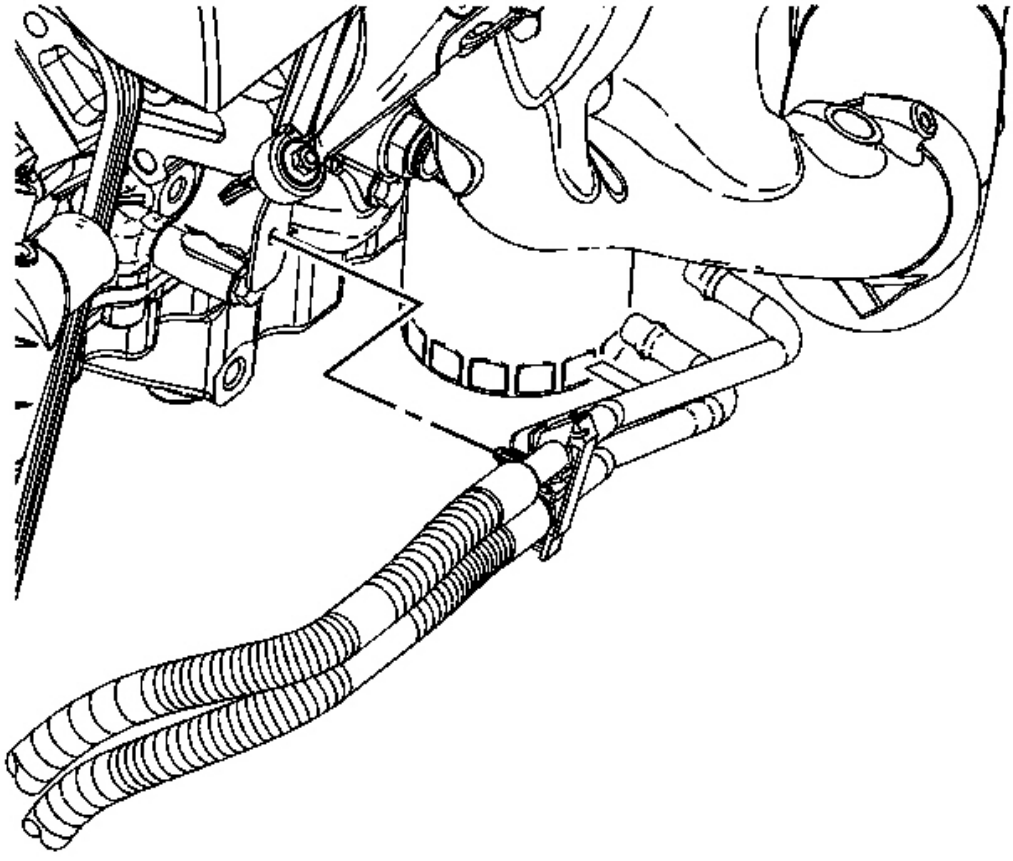


Fig. 114: View Of Engine Oil Cooler Hoses & Pipes
Courtesy of GENERAL MOTORS CORP.

4. Connect the engine oil cooler hose/pipe clip to the engine.

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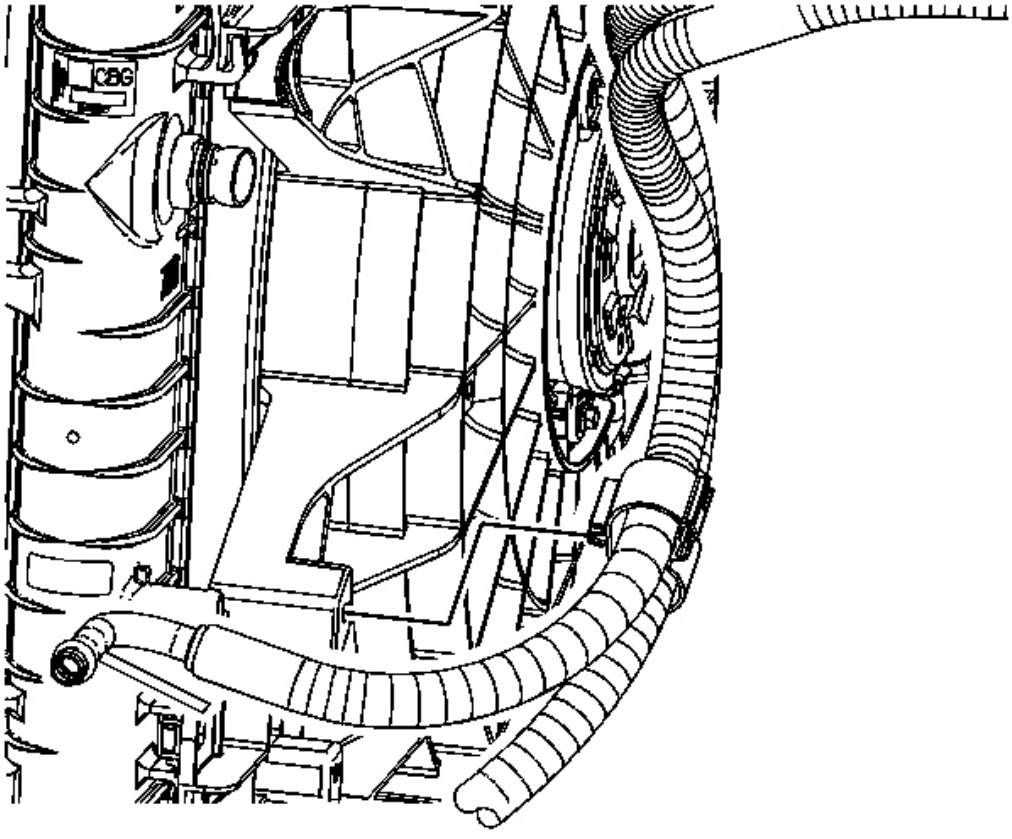


Fig. 115: View Of Engine Oil Cooler Hose/Pipe & Clip
Courtesy of GENERAL MOTORS CORP.

5. Connect the engine oil cooler hose/pipe clip to the fan shroud.

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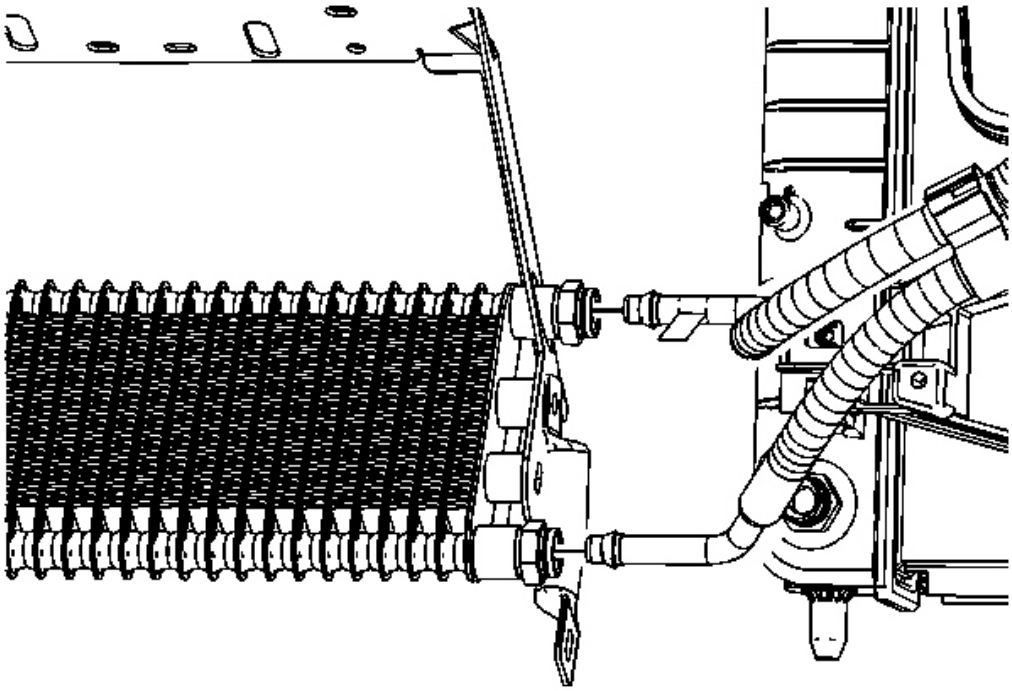


Fig. 116: View Of Engine Oil Cooler Hose/Pipe
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The quick connect fitting must be pushed on and then pulled back to verify proper connector engagement.

6. Install the engine oil cooler hose/pipes to the external oil cooler. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.
7. Remove the oil drain pan from under the vehicle.
8. Install the left lower front bumper close out panel. Refer to **Front Bumper Fascia Lower Close Out Panel Replacement** .
9. Refill the engine with oil and check for leaks.

AUXILIARY ENGINE OIL COOLER REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the left lower front bumper close out panel. Refer to **Front Bumper Fascia Lower Close Out**

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Panel Replacement .

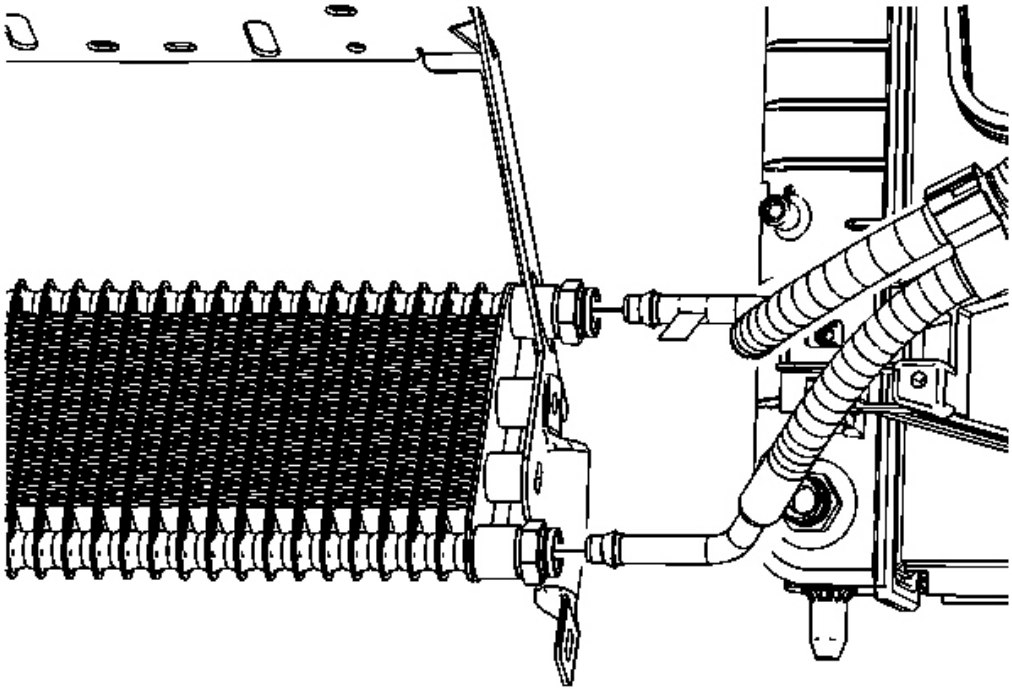


Fig. 117: View Of Engine Oil Cooler Hose/Pipe
Courtesy of GENERAL MOTORS CORP.

3. Install oil drain pan under the vehicle.
4. Remove the engine oil cooler hose/pipe from the external oil cooler. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.

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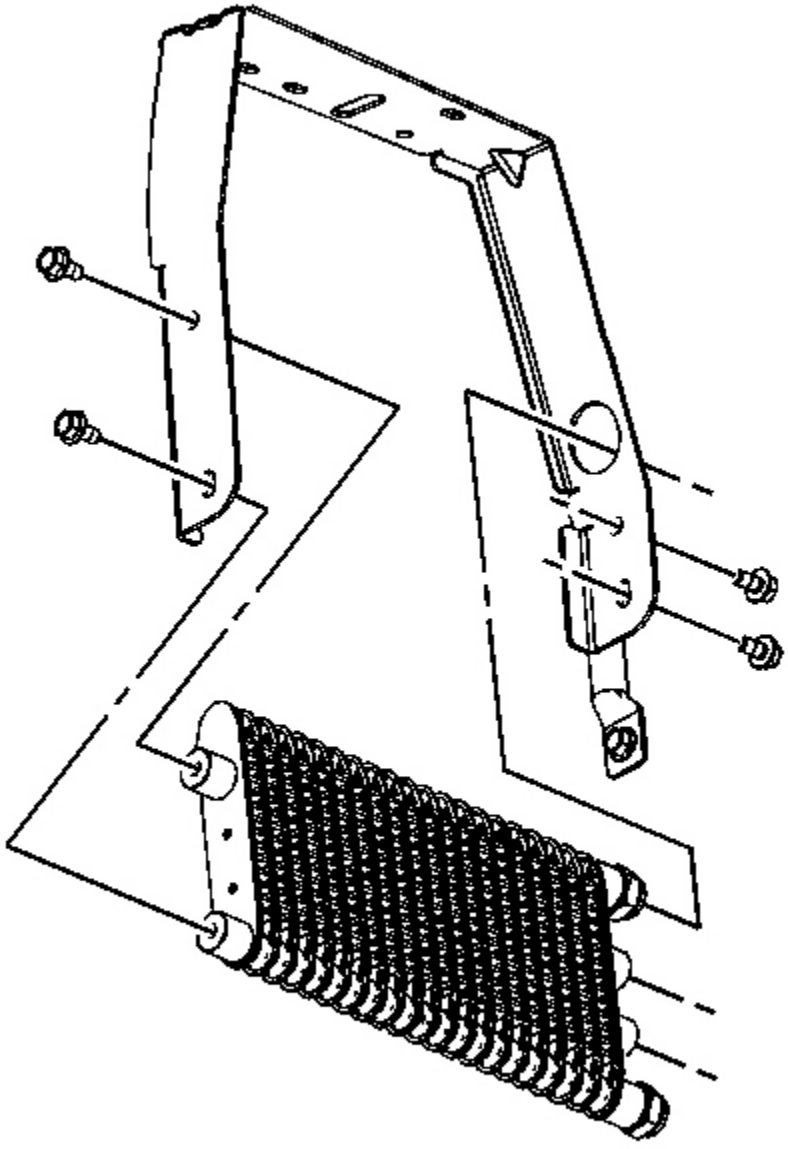


Fig. 118: View Of External Engine Oil Cooler Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the external engine oil cooler retaining bolts.
6. Remove the external engine oil cooler.
7. Remove and discard all engine oil cooler hose/pipe seals.

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Installation Procedure

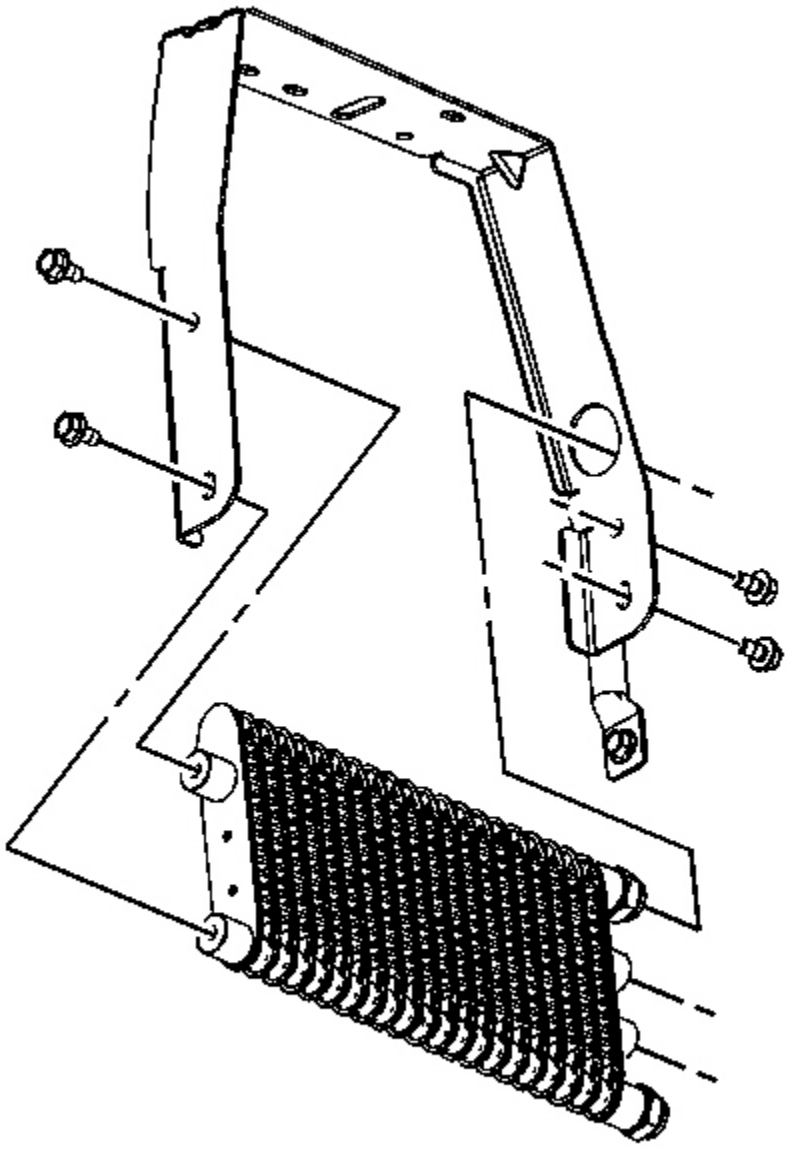


Fig. 119: View Of External Engine Oil Cooler Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install new engine oil cooler hose/pipe seals.
2. Install the external engine oil cooler.

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NOTE: **Refer to Fastener Notice .**

3. Install the external engine oil cooler retaining bolts.

   Tighten: Tighten the bolts to 10 N.m (89 lb in).

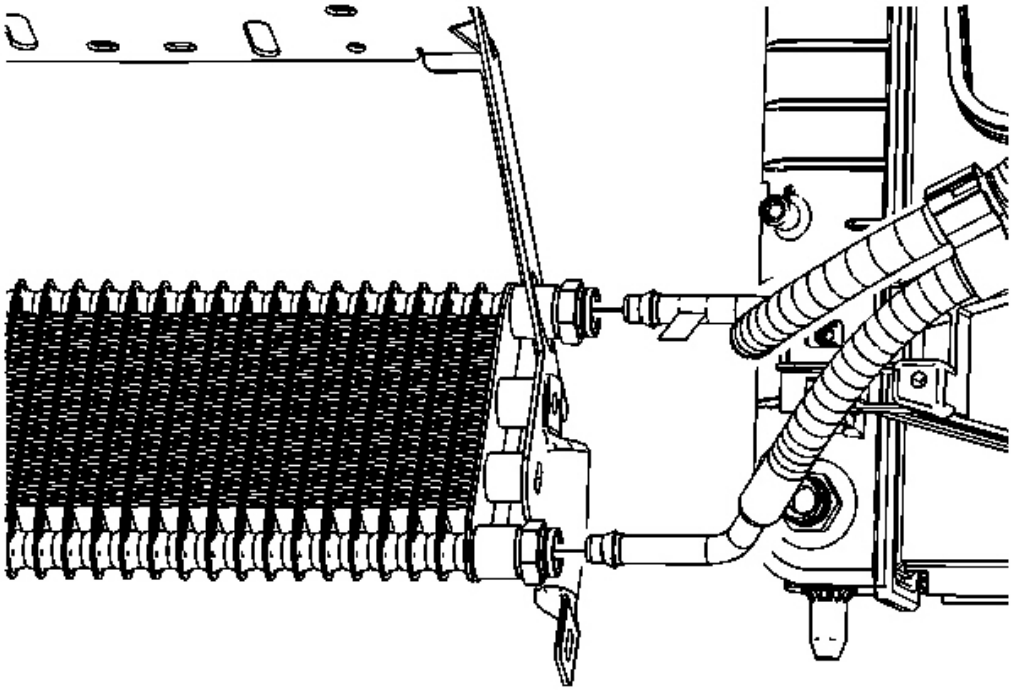


Fig. 120: View Of Engine Oil Cooler Hose/Pipe
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The quick connect fitting must be pushed on and then pulled back to verify proper connector engagement.

4. Install the engine oil cooler hose/pipes to the external oil cooler. Refer to **Generator Cooling Pipe/Hose Quick Connect Fitting**.
5. Remove the oil drain pan from under the vehicle.
6. Install the left lower front bumper close out panel. Refer to **Front Bumper Fascia Lower Close Out Panel Replacement** .
7. Refill the engine with oil and check for leaks.

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COOLING FAN AND SHROUD REPLACEMENT (W/PWM)

Removal Procedure

CAUTION: An electric fan under the hood can start up even when the engine is not running and can injure you. Keep hands, clothing and tools away from any underhood electric fan.

CAUTION: To help avoid personal injury or damage to the vehicle, a bent, cracked or damaged fan blade or housing should always be replaced.

CAUTION: Before servicing any electrical component, the ignition and start switch must be in the OFF or LOCK position and all electrical loads must be OFF, unless instructed otherwise in these procedures. If a tool or equipment could easily come in contact with a live exposed electrical terminal, also disconnect the negative battery cable. Failure to follow these precautions may cause personal injury and/or damage to the vehicle or its components.

1. Remove the radiator support. Refer to **Radiator Support Replacement**.
2. Disconnect the engine wiring harness from the cooling fan shroud.
3. Disconnect the surge tank outlet hose from the retaining clips on the cooling fan shroud.
4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
5. Remove the stabilizer shaft. Refer to **Stabilizer Shaft Replacement** .

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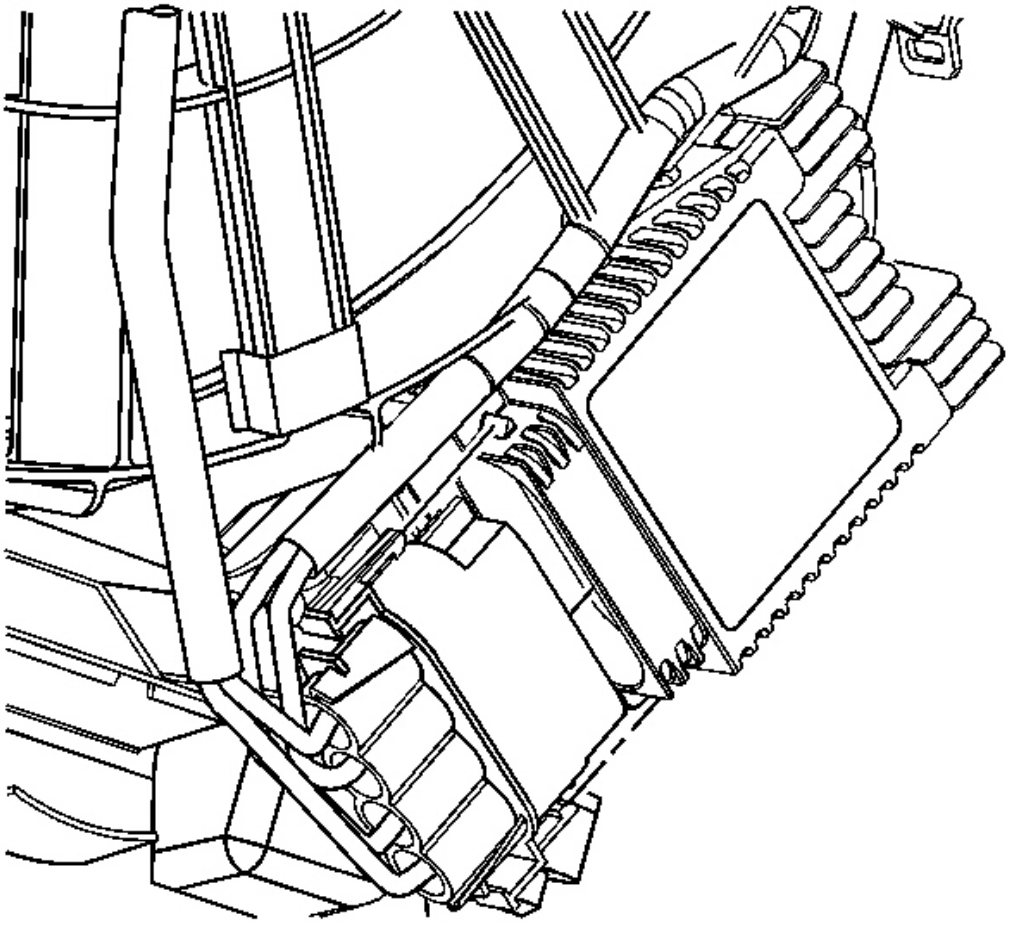


Fig. 121: View Of Cooling Fan Control Module Electrical Connector
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the cooling fan electrical connector.
7. Disconnect the lower transmission oil cooler line from the radiator. Refer to **TRANSMISSION FLUID COOLER HOSE/PIPE CONNECTOR REPLACEMENT (LOWER RADIATOR)** .

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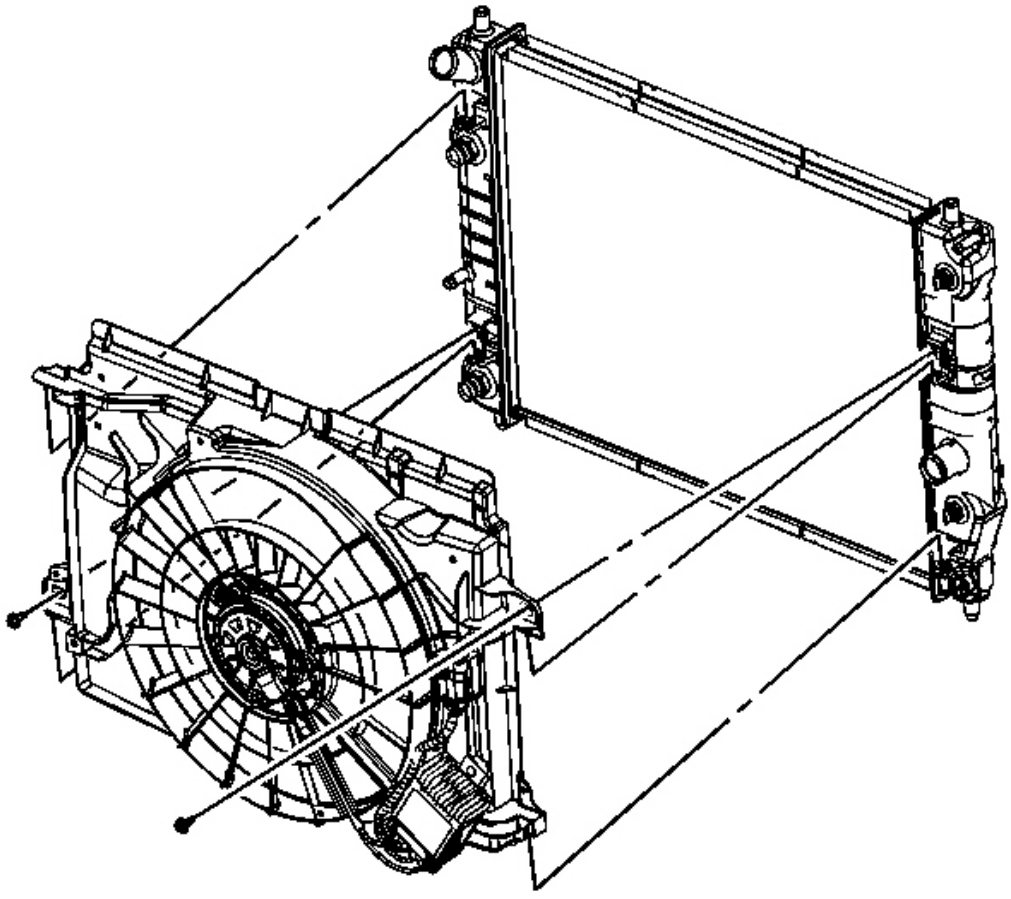


Fig. 122: View Of Fan Assembly
Courtesy of GENERAL MOTORS CORP.

8. Remove the cooling fan shroud retaining bolts.
9. Remove the cooling fan and shroud.

Installation Procedure

IMPORTANT: Ensure the cooling fan and shroud is properly seated on the radiator

1. Install the cooling fan and shroud.

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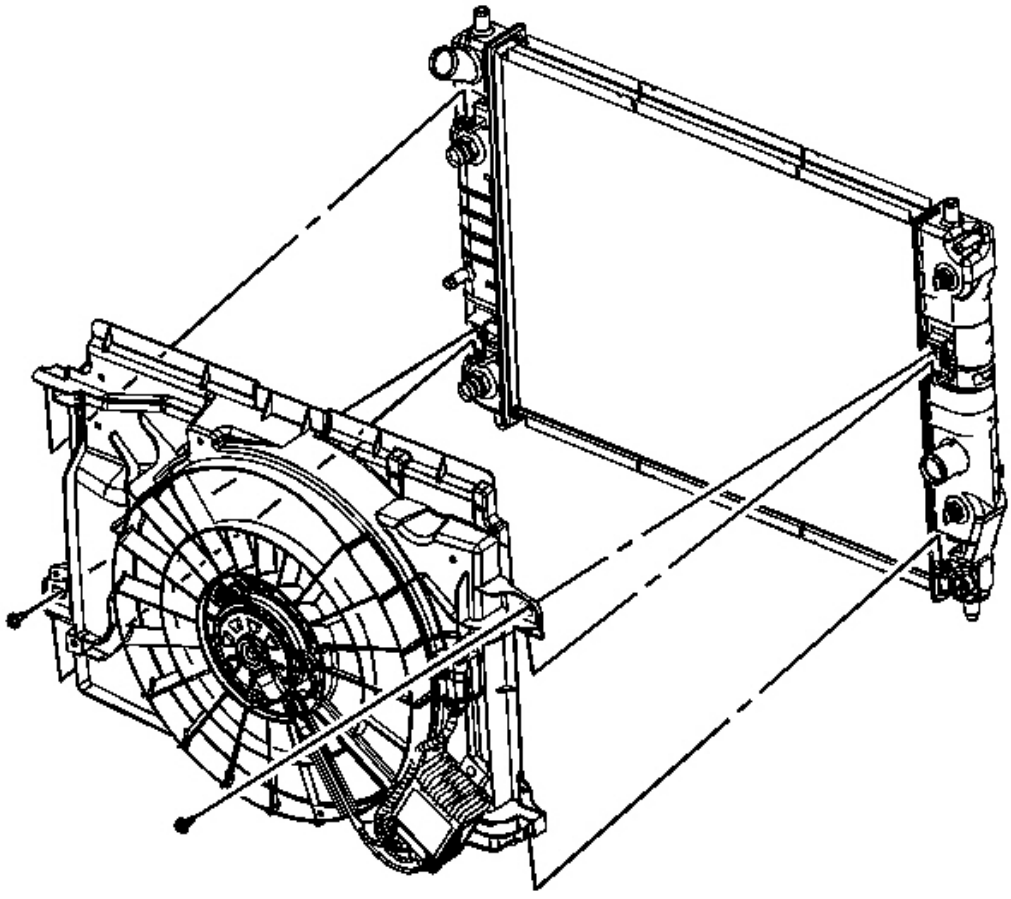


Fig. 123: View Of Fan Assembly
Courtesy of GENERAL MOTORS CORP.

2. Install the cooling fan shroud retaining bolts.

   Tighten: Tighten the bolts to 5 N.m (44 lb in).

3. Install the lower transmission oil cooler line. Refer to **TRANSMISSION FLUID COOLER HOSE/PIPE CONNECTOR REPLACEMENT (LOWER RADIATOR)** .

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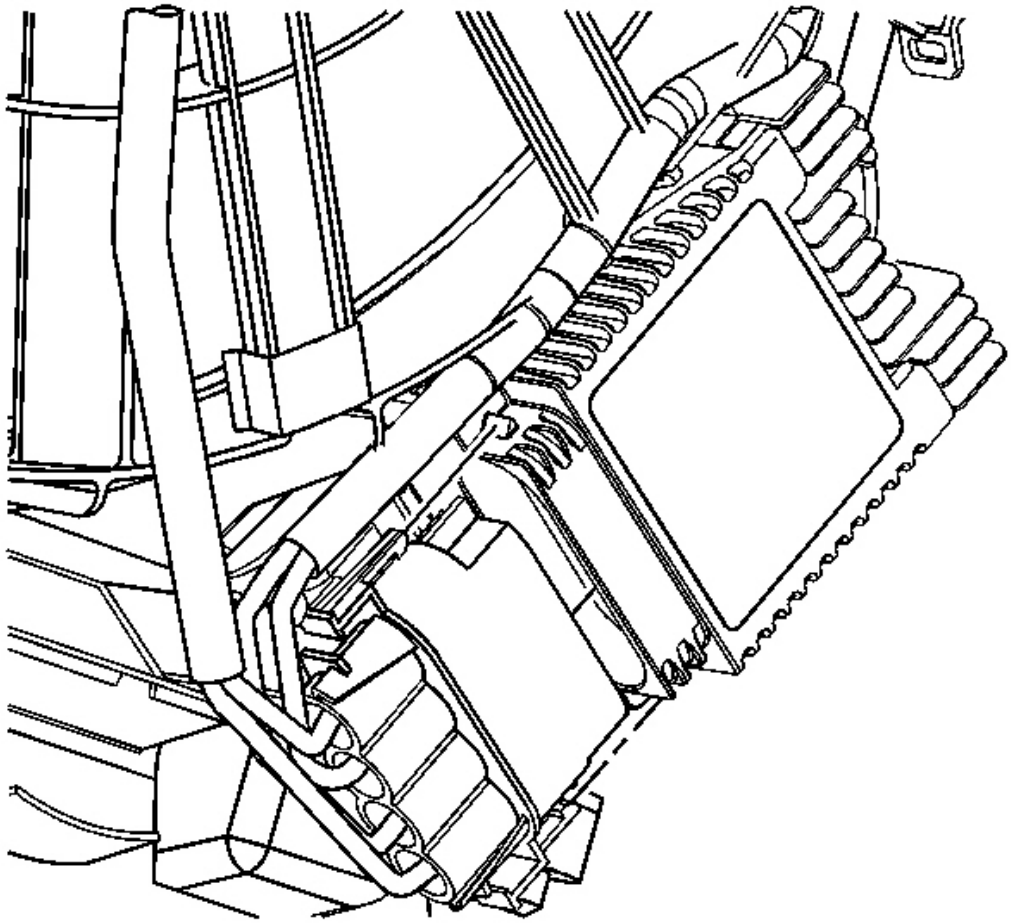


Fig. 124: View Of Cooling Fan Control Module Electrical Connector
Courtesy of GENERAL MOTORS CORP.

4. Connect the cooling fan electrical connector.
5. Install the stabilizer shaft. Refer to **Stabilizer Shaft Replacement** .
6. Lower the vehicle.
7. Connect the surge tank outlet hose to the retaining clips on the cooling fan shroud.
8. Connect the engine wiring harness to the cooling fan shroud.
9. Install the radiator support. Refer to **Radiator Support Replacement**.

COOLING FAN AND SHROUD REPLACEMENT (W/O PWM)

Removal Procedure

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CAUTION: An electric fan under the hood can start up even when the engine is not running and can injure you. Keep hands, clothing and tools away from any underhood electric fan.

CAUTION: To help avoid personal injury or damage to the vehicle, a bent, cracked or damaged fan blade or housing should always be replaced.

CAUTION: Before servicing any electrical component, the ignition and start switch must be in the OFF or LOCK position and all electrical loads must be OFF, unless instructed otherwise in these procedures. If a tool or equipment could easily come in contact with a live exposed electrical terminal, also disconnect the negative battery cable. Failure to follow these precautions may cause personal injury and/or damage to the vehicle or its components.

1. Remove the radiator support. Refer to **Radiator Support Replacement**.
2. Disconnect the engine wiring harness from the cooling fan shroud.
3. Disconnect the surge tank outlet hose from the retaining clips on the cooling fan shroud.
4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
5. Remove the stabilizer shaft. Refer to **Stabilizer Shaft Replacement** .

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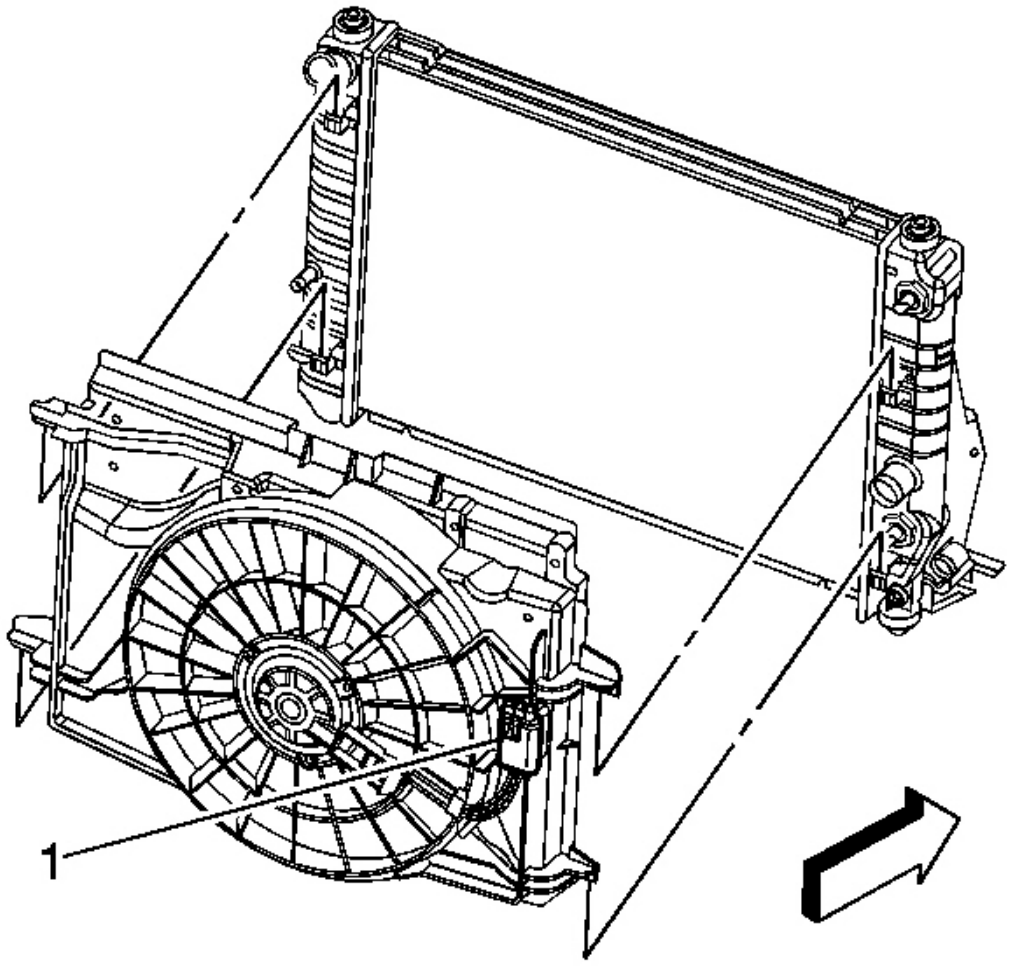


Fig. 125: Disconnecting/Connecting Cooling Fan Electrical Connector
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the cooling fan electrical connector (1).
7. Disconnect the lower transmission oil cooler line from the radiator. Refer to **TRANSMISSION FLUID COOLER HOSE/PIPE CONNECTOR REPLACEMENT (LOWER RADIATOR)** .

IMPORTANT: Lift up on the cooling fan and shroud to disengage the retaining tabs from the radiator

8. Remove the cooling fan and shroud.

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Installation Procedure

IMPORTANT: Ensure the cooling fan and shroud is properly seated on the radiator

1. Install the cooling fan and shroud.
2. Install the lower transmission oil cooler line. Refer to **TRANSMISSION FLUID COOLER HOSE/PIPE CONNECTOR REPLACEMENT (LOWER RADIATOR)** .

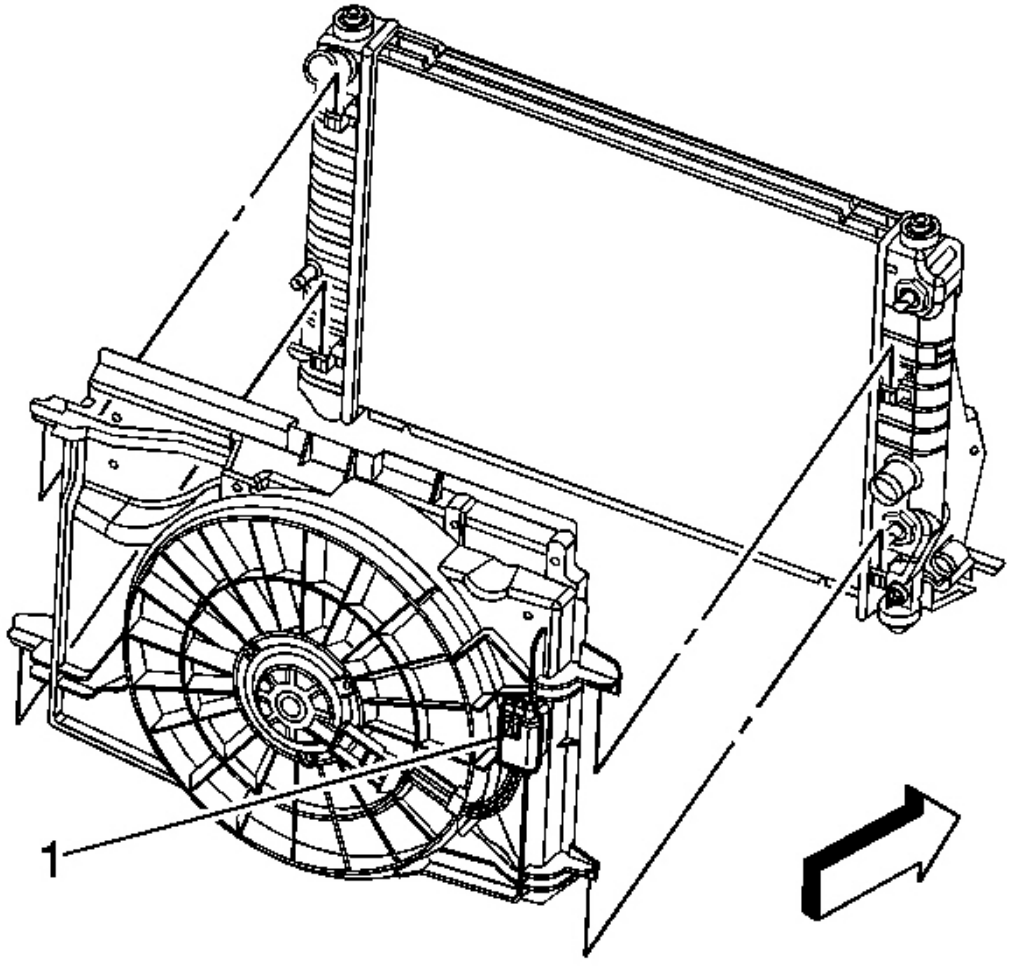


Fig. 126: Disconnecting/Connecting Cooling Fan Electrical Connector
Courtesy of GENERAL MOTORS CORP.

3. Connect the cooling fan electrical connector (1).

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4. Install the stabilizer shaft. Refer to **Stabilizer Shaft Replacement** .
5. Lower the vehicle.
6. Connect the surge tank outlet hose to the retaining clips on the cooling fan shroud.
7. Connect the engine wiring harness to the cooling fan shroud.
8. Install the radiator support. Refer to **Radiator Support Replacement**.

COOLING FAN CONTROL MODULE REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

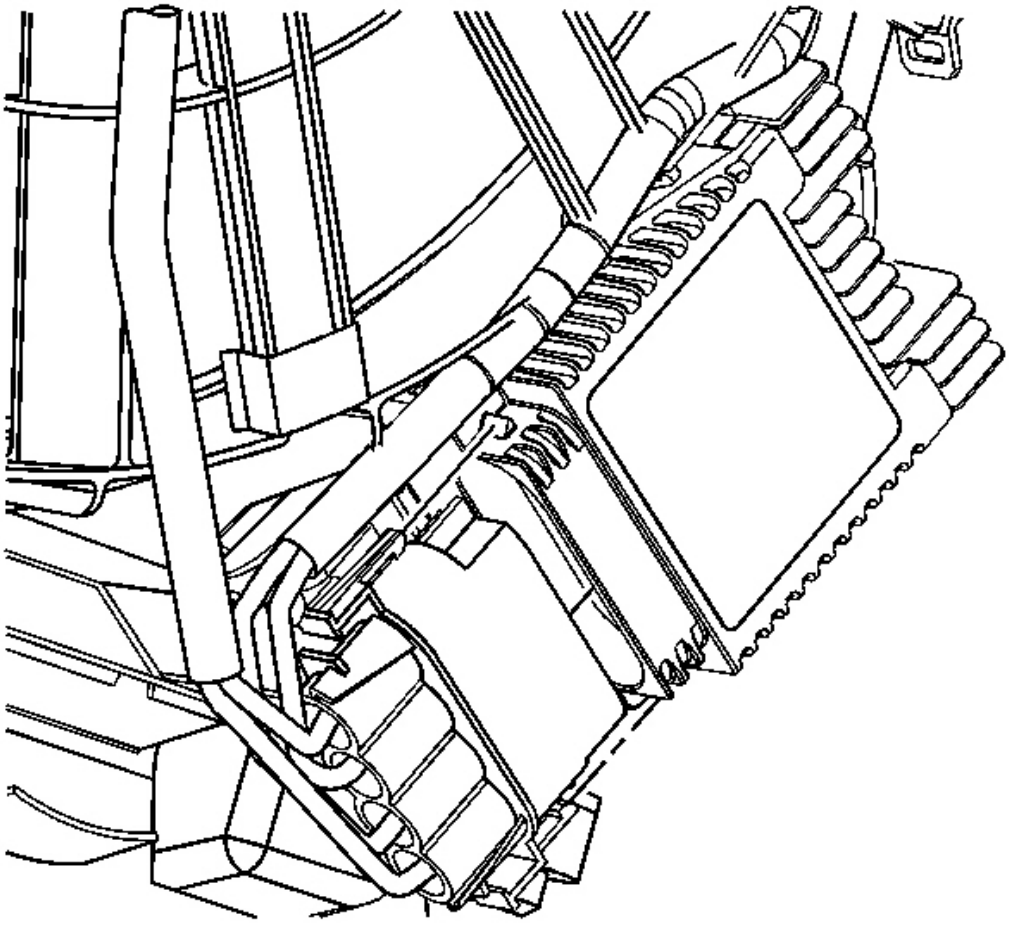


Fig. 127: View Of Cooling Fan Control Module Electrical Connector

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Courtesy of GENERAL MOTORS CORP.

2. Disconnect the cooling fan control module electrical connector.

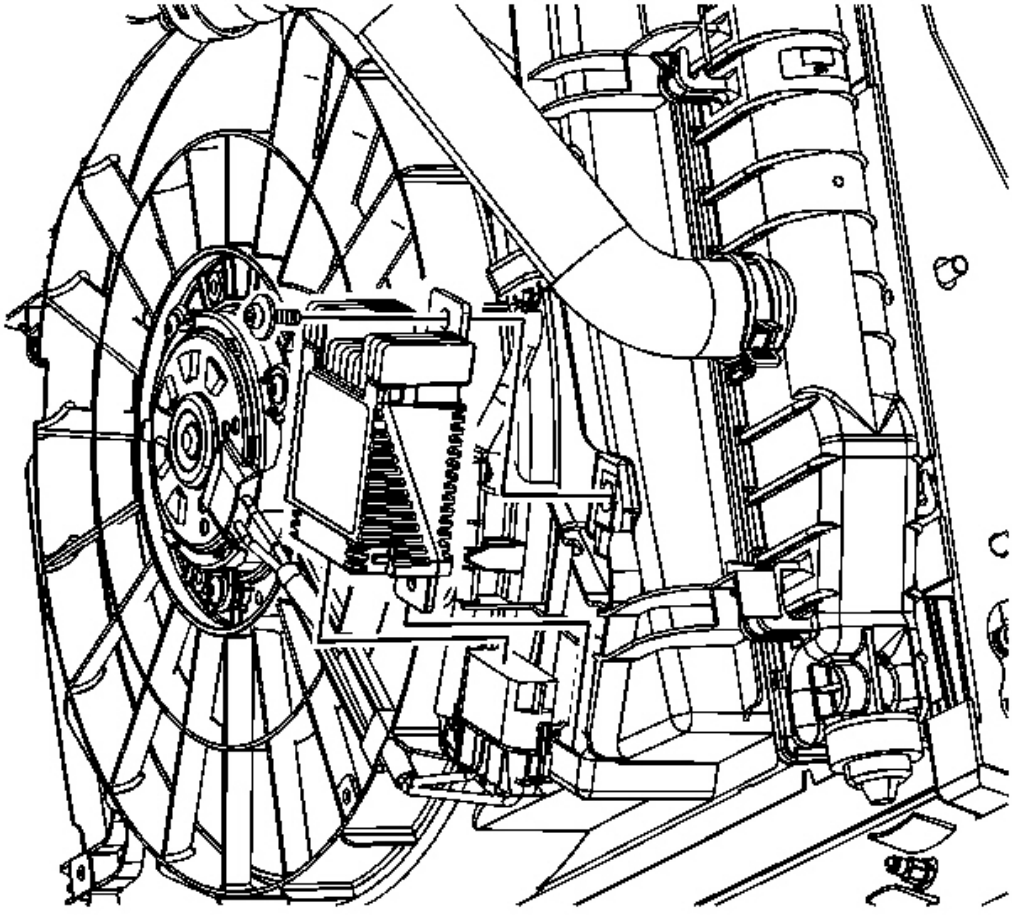


Fig. 128: View Of Cooling Fan Control Module
Courtesy of GENERAL MOTORS CORP.

3. Remove the cooling fan control module retaining bolt.
4. Remove the cooling fan control module from the vehicle.

Installation Procedure

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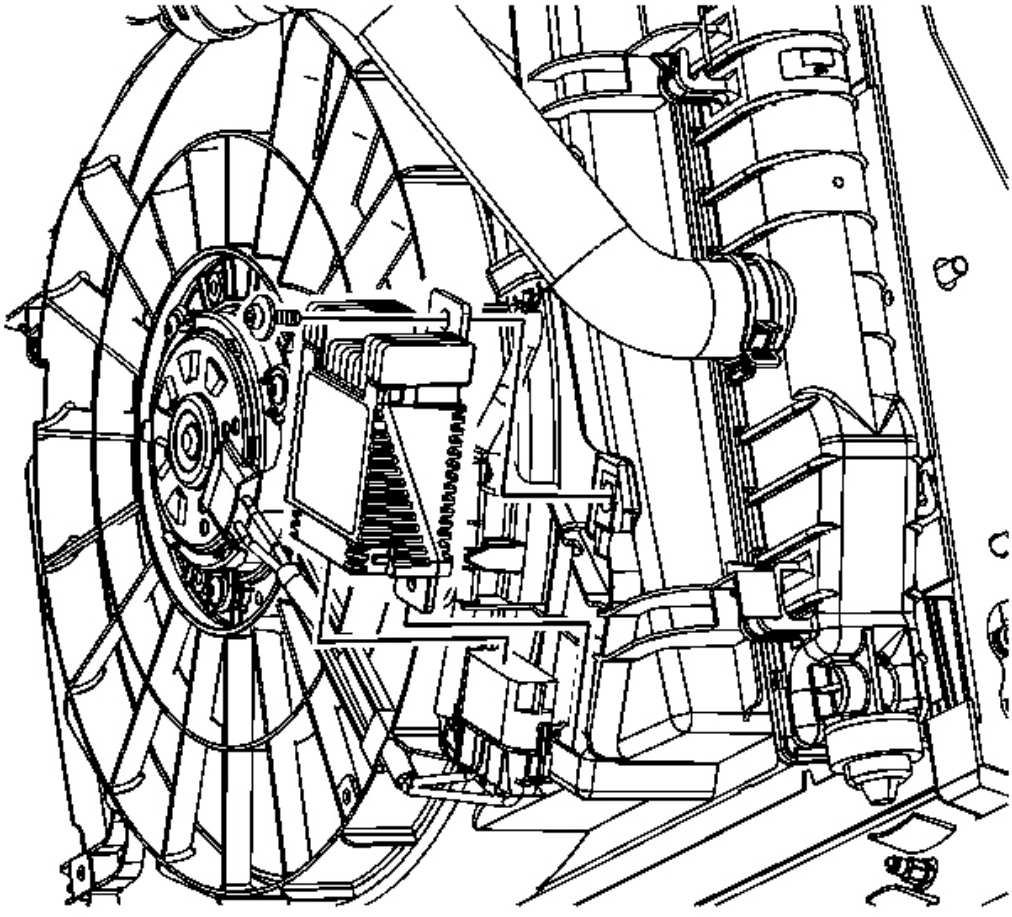


Fig. 129: View Of Cooling Fan Control Module
Courtesy of GENERAL MOTORS CORP.

1. Install the cooling fan control module to the vehicle.

   NOTE: Refer to Fastener Notice .

2. Install the cooling fan control module retaining bolt.

   Tighten: Tighten the bolt to 6 N.m (53 lb in).

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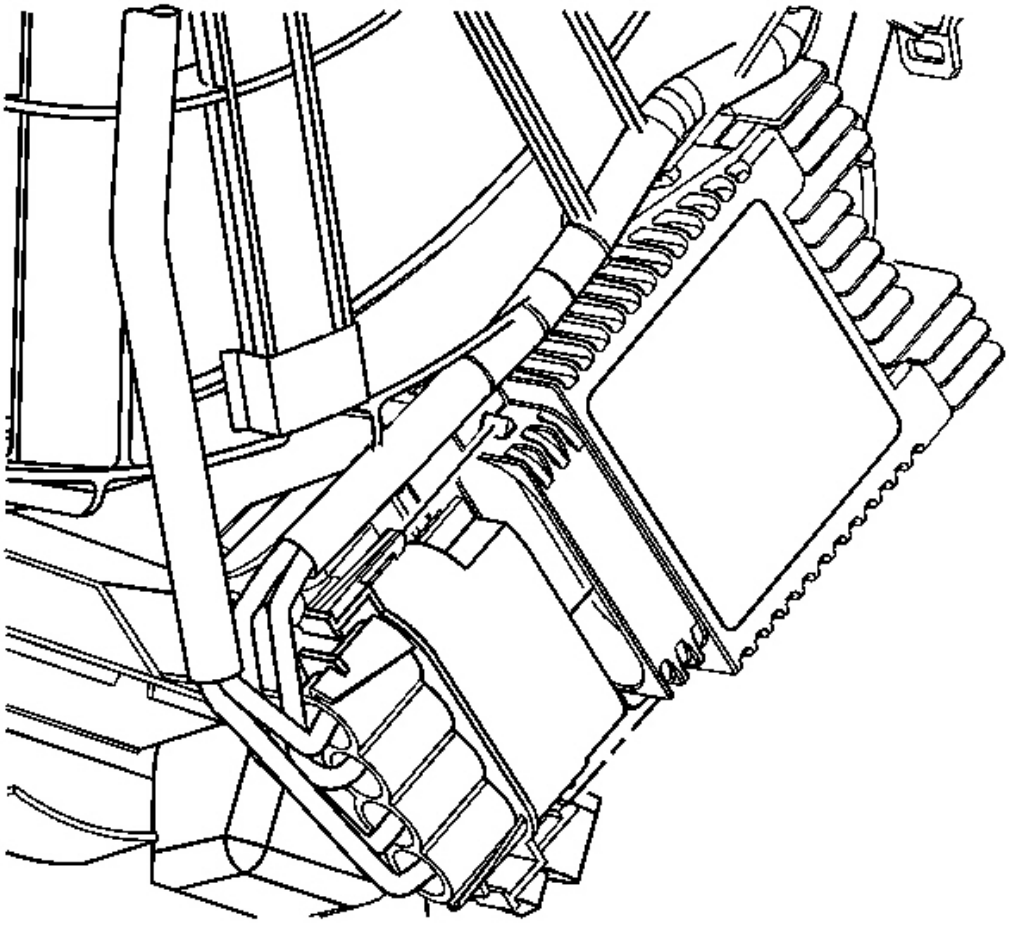


Fig. 130: View Of Cooling Fan Control Module Electrical Connector
Courtesy of GENERAL MOTORS CORP.

3. Connect the cooling fan control module electrical connector.
4. Lower the vehicle.
5. Refer to **Control Module References** for programming and setup information.

ENGINE COOLANT THERMOSTAT HOUSING REPLACEMENT (LC3)

Removal Procedure

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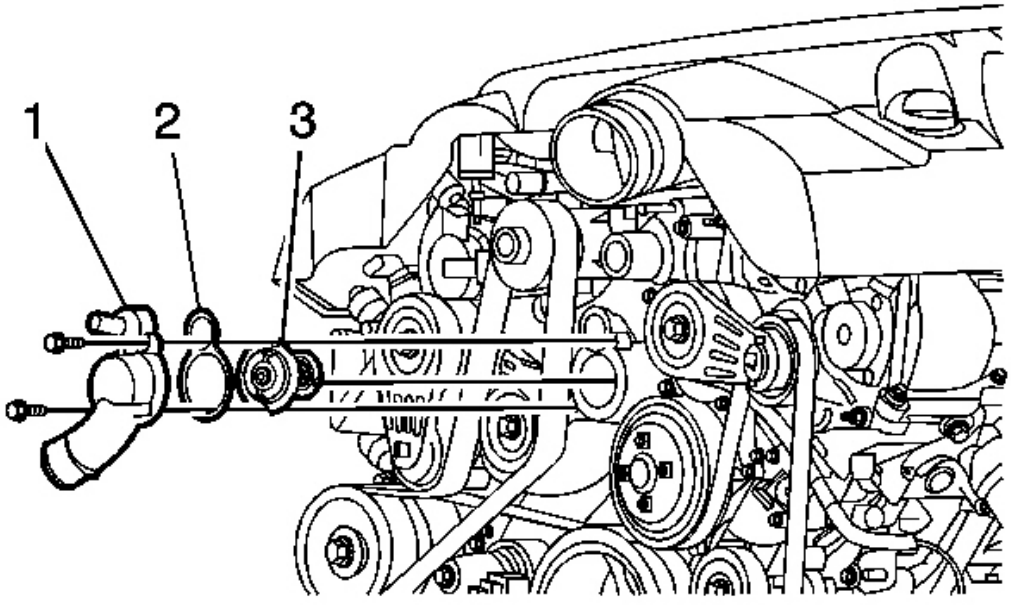


Fig. 131: View Of Thermostat Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
3. Remove the radiator hose from the thermostat housing. Refer to **Radiator Outlet Hose Replacement**.
4. Remove the heater hose from the thermostat housing.
5. Remove the thermostat housing bolts.
6. Remove the thermostat housing (1) with thermostat (3), from the water housing.
7. Remove and discard the seal ring (2).
8. Remove the thermostat from the thermostat housing.

Installation Procedure

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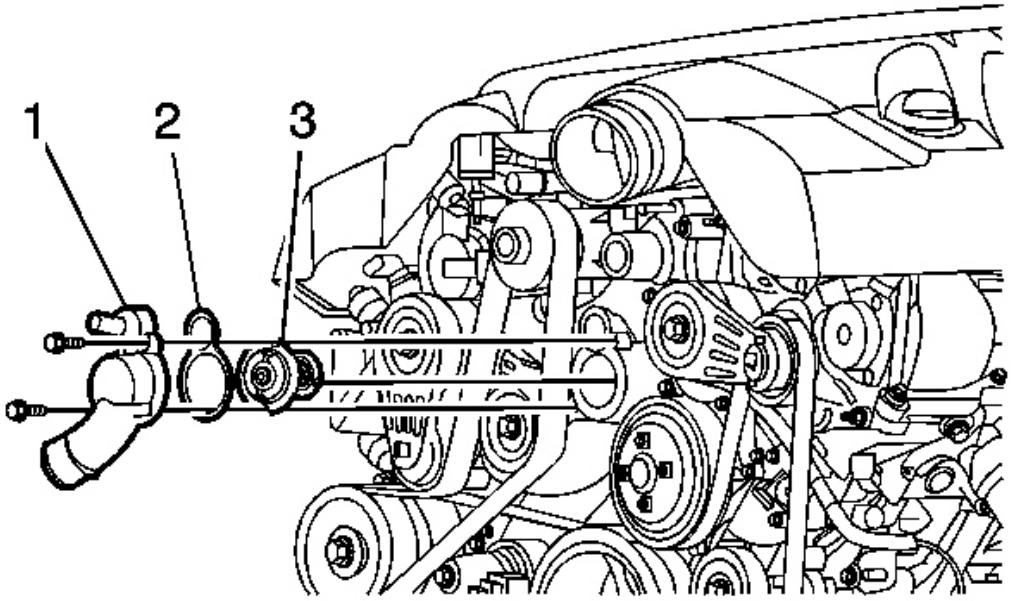


Fig. 132: View Of Thermostat Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Clean the thermostat housing and water housing sealing surfaces.
2. Install the thermostat (3) to the thermostat housing (1).
3. Install the NEW seal (2) to the thermostat housing.
4. Install the thermostat housing (1) with the thermostat (3) and the seal (2) to the water housing.

NOTE: Refer to Fastener Notice .

5. Install the thermostat housing bolts.

   Tighten: Tighten the thermostat housing bolts to 10 N.m (89 lb in).

6. Install the heater hose to the thermostat housing.
7. Install the radiator hose to the thermostat housing. Refer to **Radiator Outlet Hose Replacement**.
8. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
9. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

ENGINE COOLANT THERMOSTAT HOUSING REPLACEMENT (LH2)

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Tools Required

J 38185 Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the air outlet duct in order to gain access to the thermostat housing. Refer to **Air Cleaner Inlet Duct Replacement** .

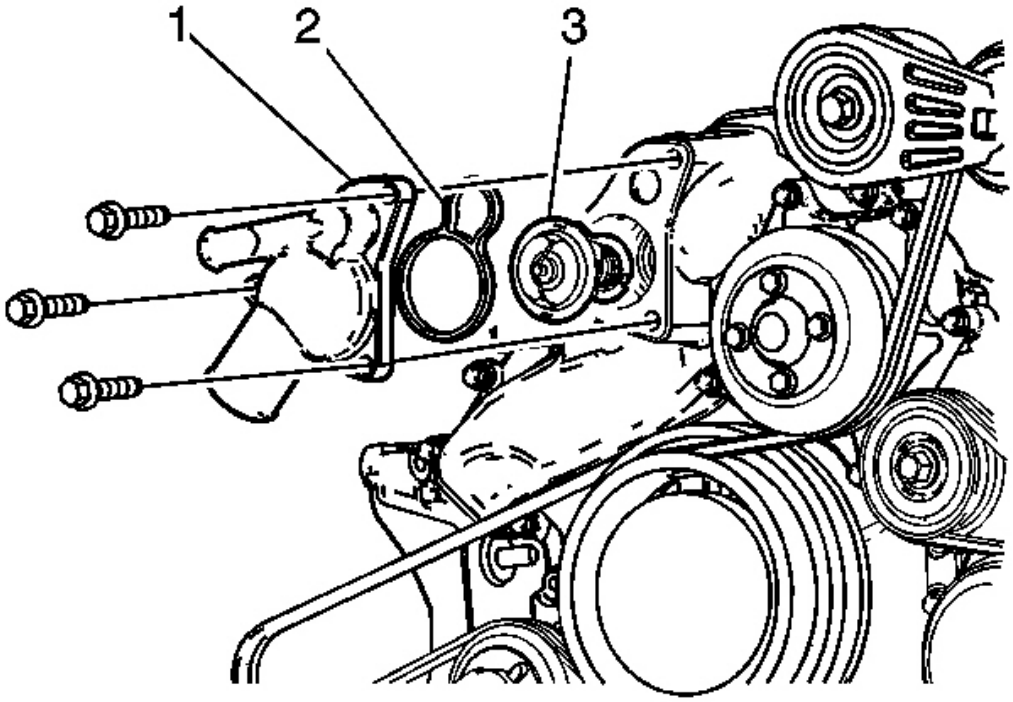


Fig. 133: View Of Exploded View Of Thermostat Assembly
Courtesy of GENERAL MOTORS CORP.

3. Remove the heater hose from the thermostat housing using a **J 38185** . See **Special Tools**.
4. Remove the coolant radiator hose from the thermostat housing. Refer to **Coolant Bypass Hose Replacement (LC3)** or **Coolant Bypass Hose Replacement (LH2)**.
5. Remove the thermostat housing bolts.
6. Remove the thermostat housing with thermostat from the engine front cover.

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7. Remove the thermostat and seal ring and discard the seal ring.

Installation Procedure

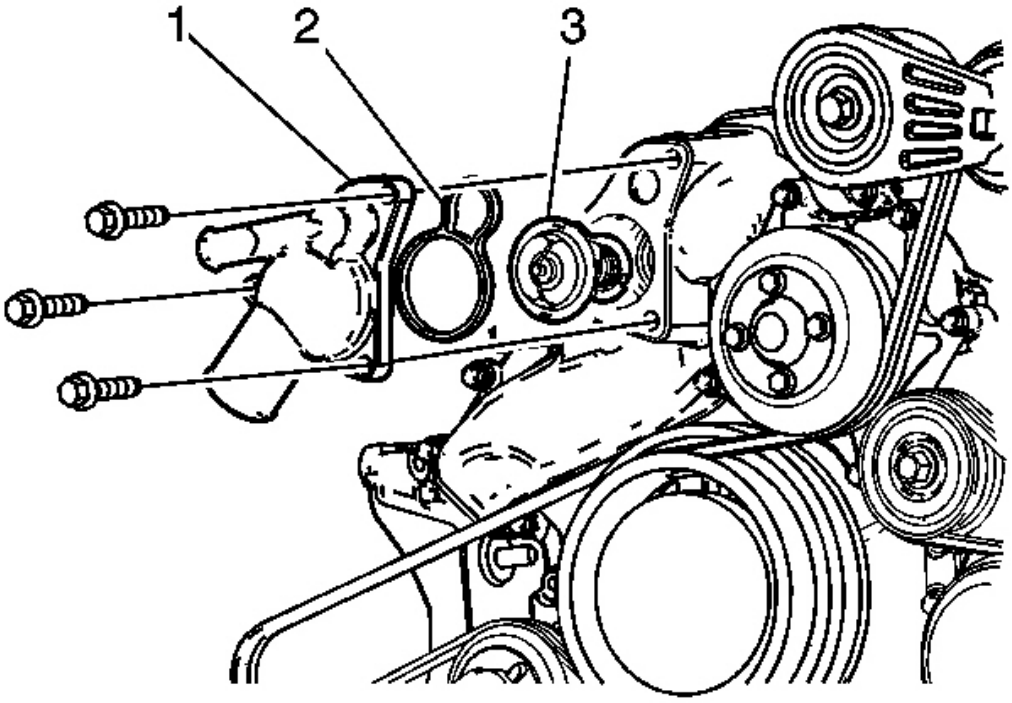


Fig. 134: View Of Exploded View Of Thermostat Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install a new seal ring on the thermostat.
2. Install the thermostat and new seal ring into the thermostat housing.
3. Install the thermostat housing with the thermostat assembly to the engine front cover.

NOTE: **Refer to Fastener Notice .**

4. Install the thermostat housing bolts.

   Tighten: Tighten the thermostat housing bolts to 20 N.m (15 lb ft).

5. Position the radiator hose over to the thermostat housing and reposition the clamp using the **J 38185** . See **Special Tools**.

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6. Install the heater hose to the thermostat housing using **J 38185** . See **Special Tools**.
7. Install the air outlet duct. Refer to **Air Cleaner Inlet Duct Replacement** .
8. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

ENGINE COOLANT THERMOSTAT REPLACEMENT (LC3)

Removal Procedure

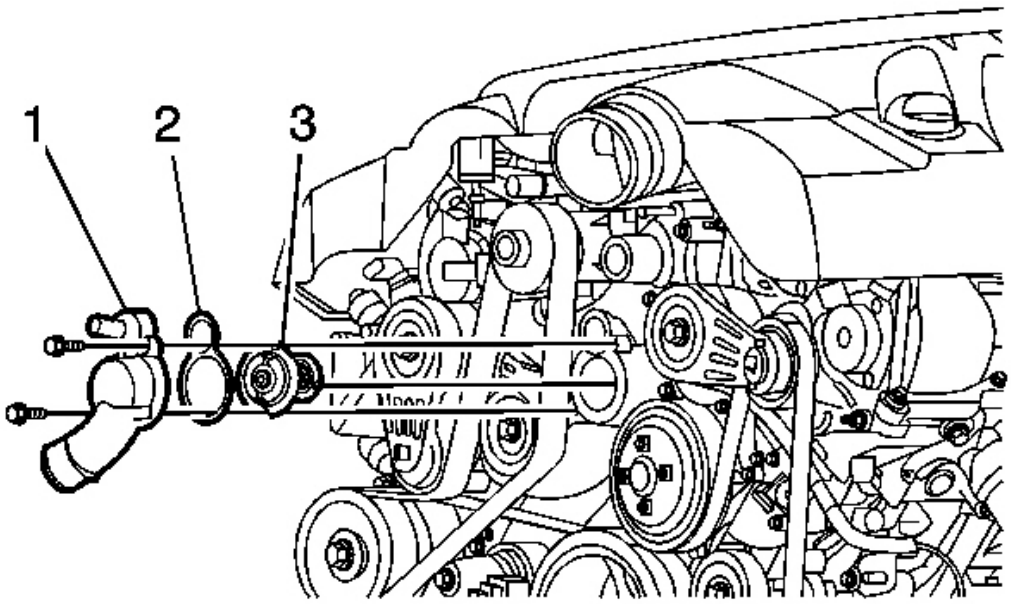


Fig. 135: View Of Thermostat Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
3. Remove the radiator hose from the thermostat housing. Refer to **Radiator Outlet Hose Replacement**.
4. Remove the heater hose from the thermostat housing.
5. Remove the thermostat housing bolts.
6. Remove the thermostat housing (1) with thermostat (3), from the water housing.
7. Remove and discard the seal ring (2).
8. Remove the thermostat from the thermostat housing.

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Installation Procedure

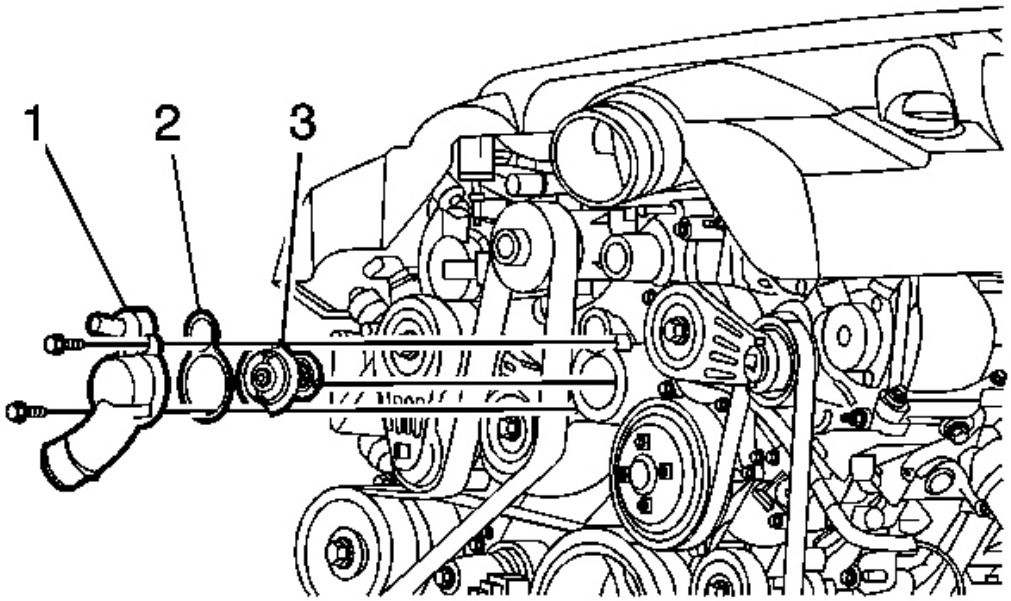


Fig. 136: View Of Thermostat Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Clean the thermostat housing and water housing sealing surfaces.
2. Install the thermostat (3) to the thermostat housing (1).
3. Install the NEW seal (2) to the thermostat housing.
4. Install the thermostat housing (1) with the thermostat (3) and the seal (2) to the water housing.

NOTE: Refer to Fastener Notice .

5. Install the thermostat housing bolts.

   Tighten: Tighten the thermostat housing bolts to 10 N.m (89 lb in).

6. Install the heater hose to the thermostat housing.
7. Install the radiator hose to the thermostat housing. Refer to **Radiator Outlet Hose Replacement**.
8. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
9. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

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ENGINE COOLANT THERMOSTAT REPLACEMENT (LH2)

Tools Required

J 38185 Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the air outlet duct in order to gain access to the thermostat housing. Refer to **Air Cleaner Inlet Duct Replacement** .

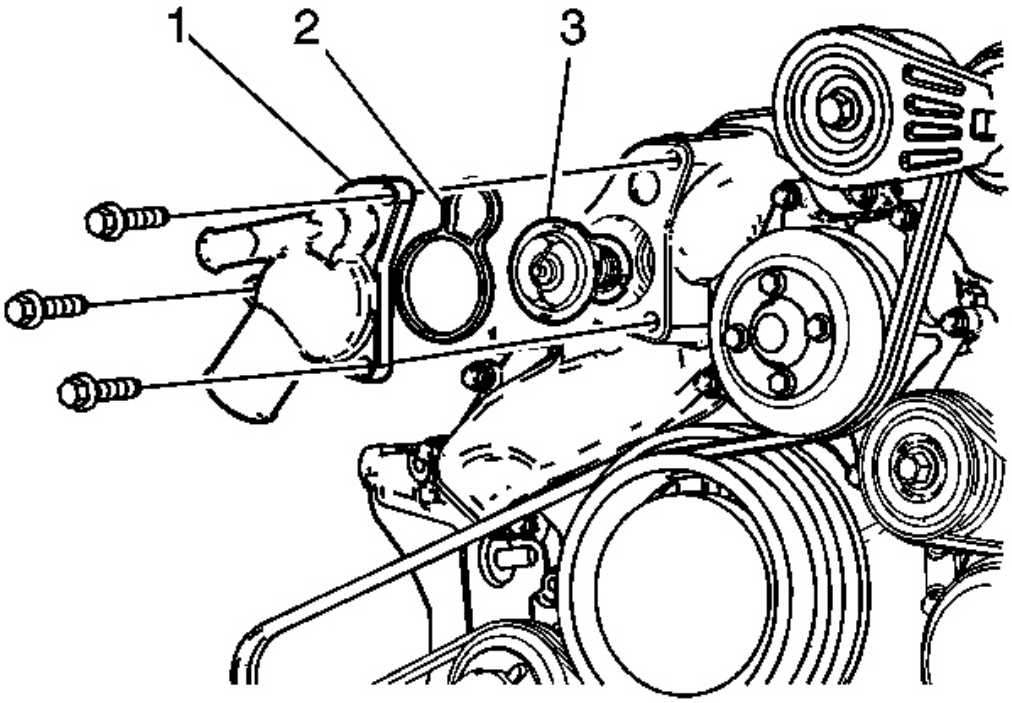


Fig. 137: View Of Exploded View Of Thermostat Assembly
Courtesy of GENERAL MOTORS CORP.

3. Remove the heater hose from the thermostat housing using a **J 38185** . See **Special Tools**.
4. Remove the coolant radiator hose from the thermostat housing. Refer to **Coolant Bypass Hose Replacement (LC3)** or **Coolant Bypass Hose Replacement (LH2)**.
5. Remove the thermostat housing bolts.

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6. Remove the thermostat housing with thermostat from the engine front cover.
7. Remove the thermostat and seal ring and discard the seal ring.

Installation Procedure

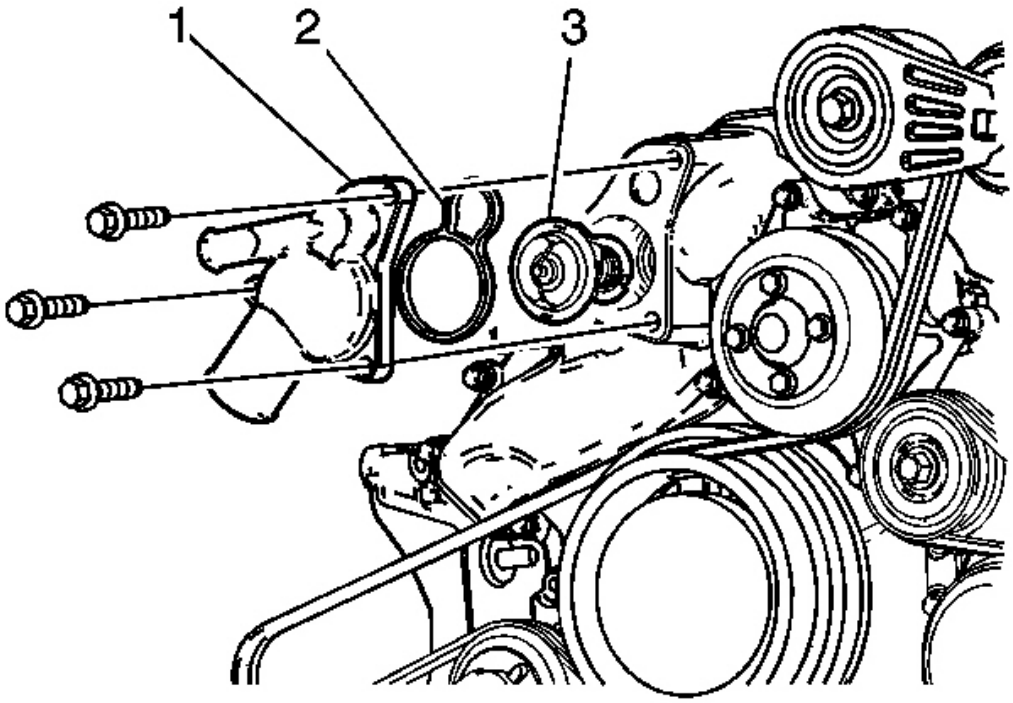


Fig. 138: View Of Exploded View Of Thermostat Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install a new seal ring on the thermostat.
2. Install the thermostat and new seal ring into the thermostat housing.
3. Install the thermostat housing with the thermostat assembly to the engine front cover.

NOTE: Refer to Fastener Notice .

4. Install the thermostat housing bolts.

   Tighten: Tighten the thermostat housing bolts to 10 N.m (89 lb in).

5. Position the radiator hose over to the thermostat housing and reposition the clamp using the **J 38185** . See

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Special Tools.

6. Install the heater hose to the thermostat housing using **J 38185** . See **Special Tools**.
7. Install the air outlet duct. Refer to **Air Cleaner Inlet Duct Replacement** .
8. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

WATER OUTLET HOUSING REPLACEMENT (LC3)

Removal Procedure

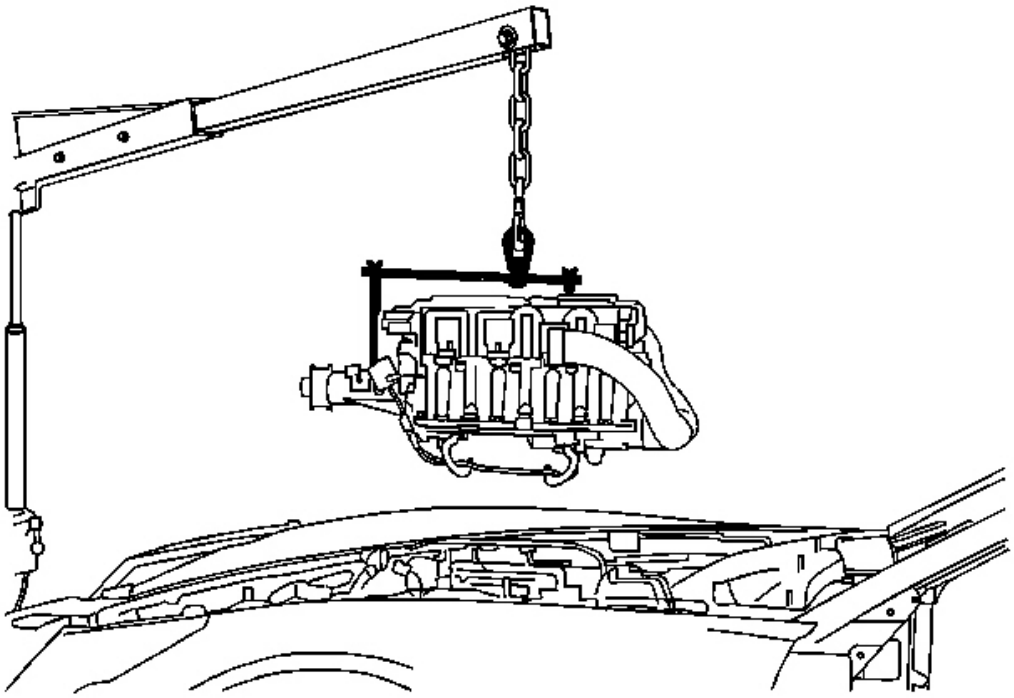


Fig. 139: View Of Supercharger Service Holding Tool Fixture
Courtesy of GENERAL MOTORS CORP.

1. Drain the engine cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Drain the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.
3. Remove the supercharger assembly. Refer to **Supercharger Replacement** .
4. Remove the supercharger belt tensioner. Refer to **Drive Belt Tensioner Replacement - Supercharger** .

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5. Remove the supercharger idler pulley. Refer to **Supercharger Belt Idler Pulley Replacement** .

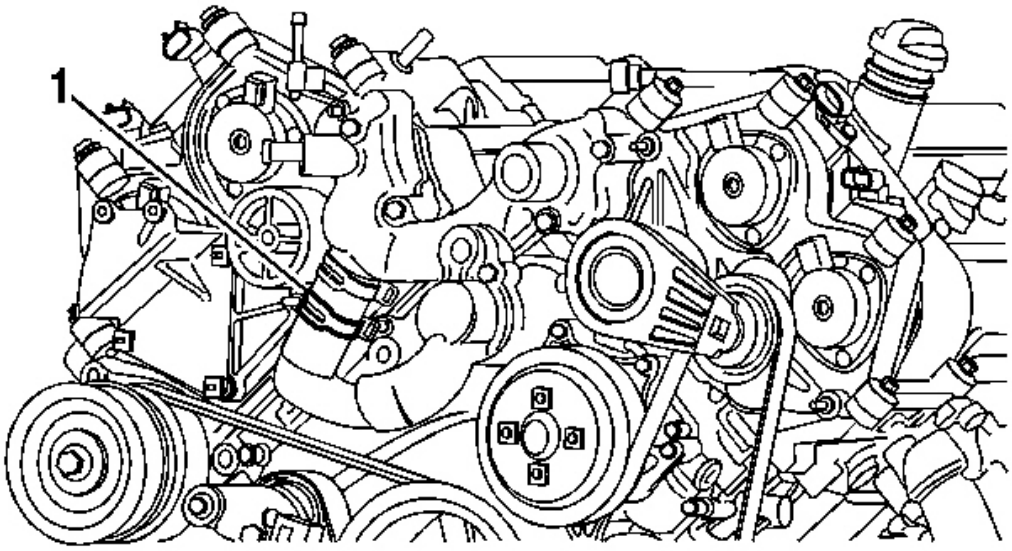


Fig. 140: View Of Bypass Hose
Courtesy of GENERAL MOTORS CORP.

6. Remove the two coolant hoses from the water outlet housing. Refer to **Surge Tank Hose/Pipe Replacement - Inlet**.
7. Remove the radiator hose from the water outlet housing. Refer to **Radiator Inlet Hose Replacement**.
8. Reposition the lower clamp on the bypass hose (1) as shown.

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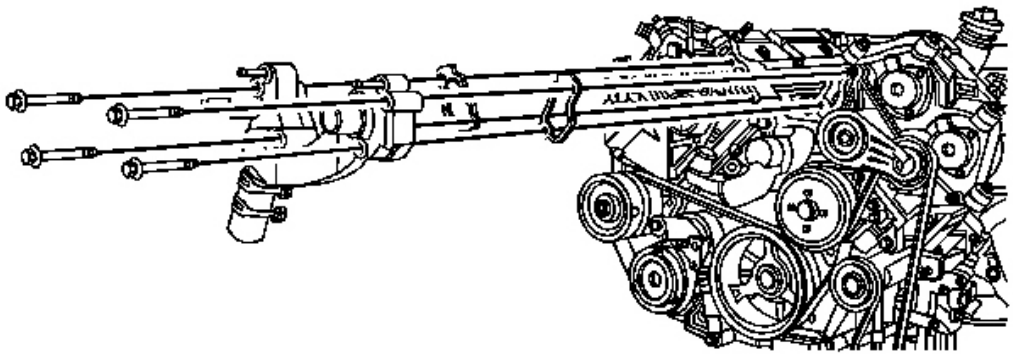


Fig. 141: View Of Water Outlet Housing
Courtesy of GENERAL MOTORS CORP.

9. Remove the bolts securing the water outlet housing to the cylinder heads.
10. Remove the water outlet housing along with the bypass hose from the engine.
11. Discard the water outlet housing gaskets.
12. Disassemble the water outlet housing if necessary. Refer to **Water Outlet Housing Disassemble**
13. Clean and inspect the water outlet housing. Refer to **Water Outlet Housing Cleaning and Inspection** .

Installation Procedure

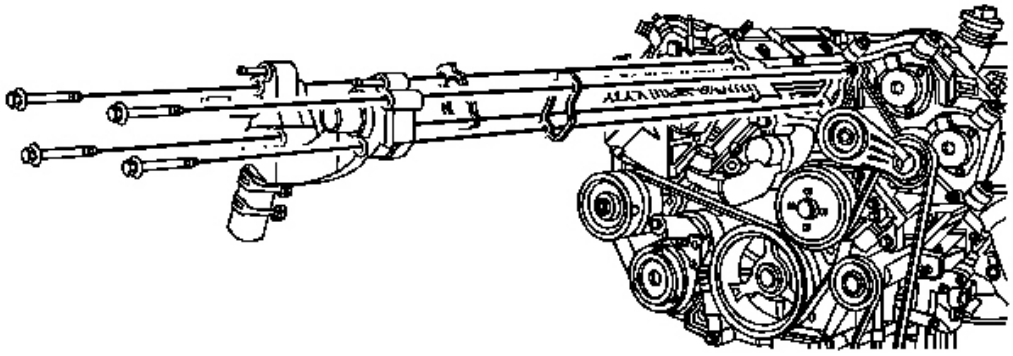


Fig. 142: View Of Water Outlet Housing

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Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Assemble the water outlet housing if necessary. Refer to **Water Outlet Housing Assemble** .
2. Install NEW water outlet housing gaskets.
3. Install the water outlet housing with bypass hose to the vehicle.
4. Install the water outlet housing bolts.

   Tighten: Tighten the water outlet housing bolts to 25 N.m (18 lb ft).

5. Install the bypass hose clamp in the proper position.
6. Install the radiator hose to the water outlet housing. Refer to **Radiator Inlet Hose Replacement**.
7. Install the two coolant hoses to the water outlet housing. Refer to **Surge Tank Hose/Pipe Replacement - Inlet**.

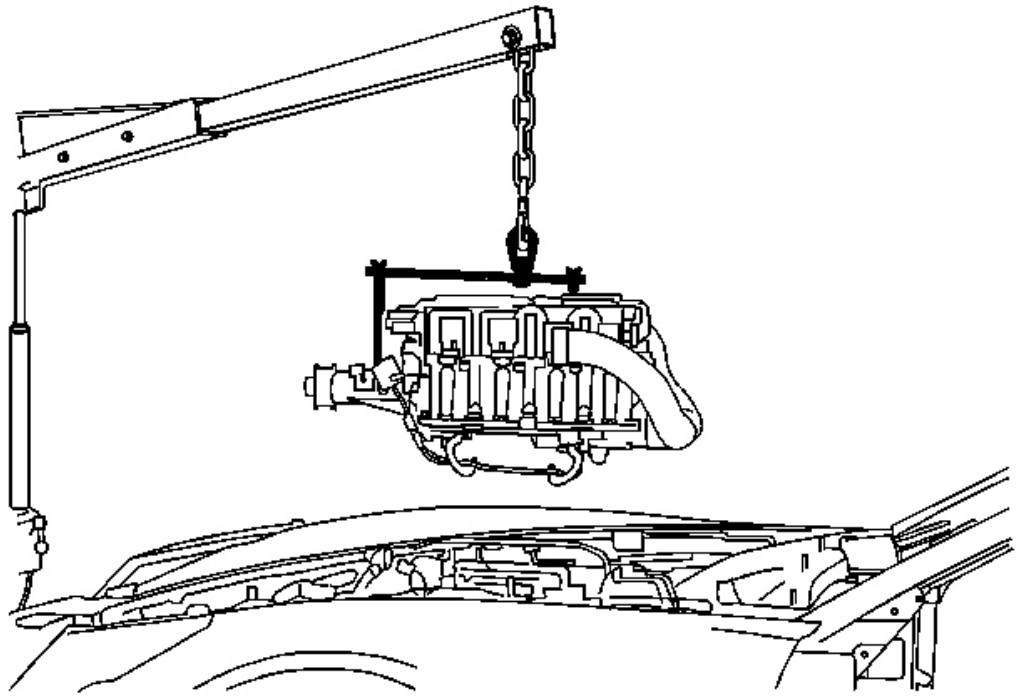


Fig. 143: View Of Supercharger Service Holding Tool Fixture
Courtesy of GENERAL MOTORS CORP.

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8. Install the supercharger idler pulley. Refer to **Supercharger Belt Idler Pulley Replacement** .
9. Install the supercharger belt tensioner. Refer to **Drive Belt Tensioner Replacement - Supercharger** .
10. Install the supercharger assembly. Refer to **Supercharger Replacement** .
11. Fill the charge air cooling system with coolant. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.
12. Fill the engine cooling system with coolant. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
13. Check the engine cooling system for leaks.
14. Check the charge air cooling system for leaks.

WATER OUTLET HOUSING REPLACEMENT (LH2)

Tools Required

J 38185 Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
3. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement** .

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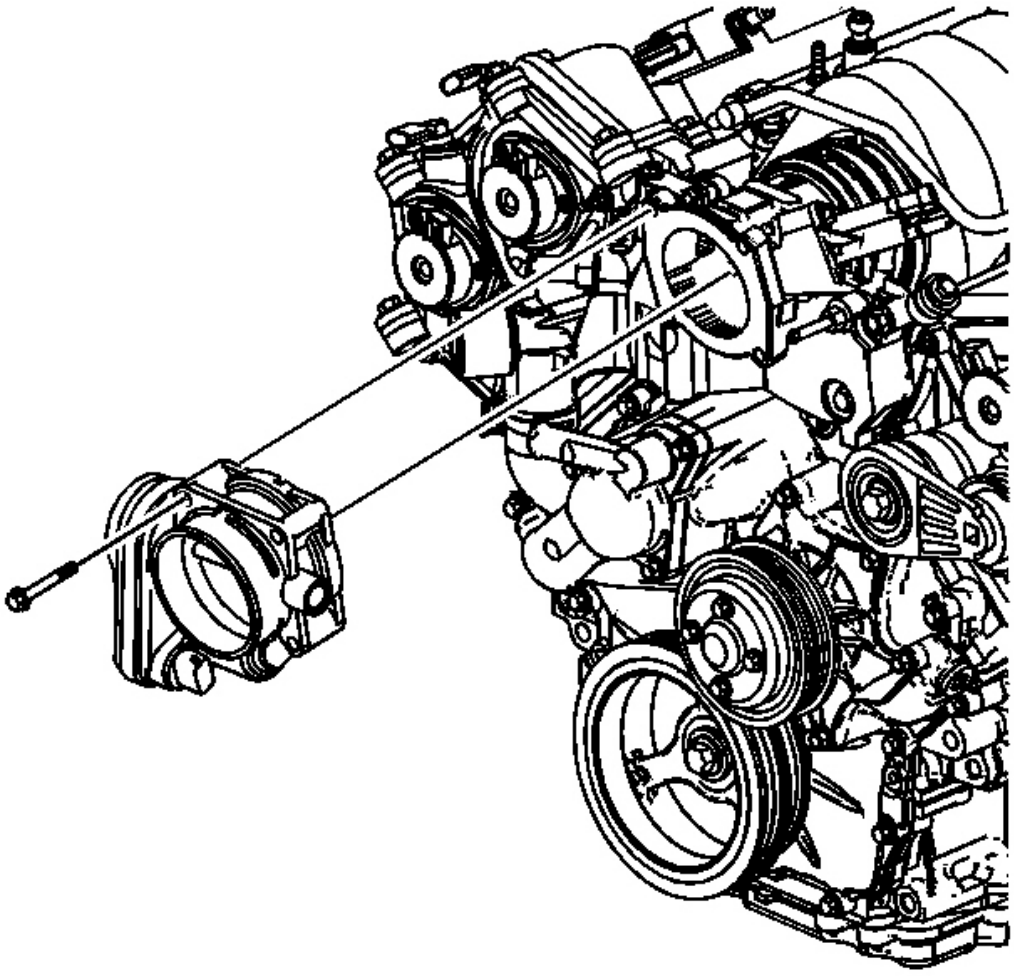


Fig. 144: View Of Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the throttle body from the water outlet housing. Refer to **Throttle Body Assembly Replacement** .
5. Remove the manifold absolute pressure (MAP) sensor. Refer to **Manifold Absolute Pressure Sensor Replacement** .
6. Remove the purge solenoid. Refer to **Evaporative Emission Canister Purge Solenoid Valve Replacement** .
7. Position the **J 38185** to the hose clamps to remove the following hoses from the water outlet housing:
   - The surge tank outlet hose
   - The radiator hose

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- The heater hose
- The bypass hose

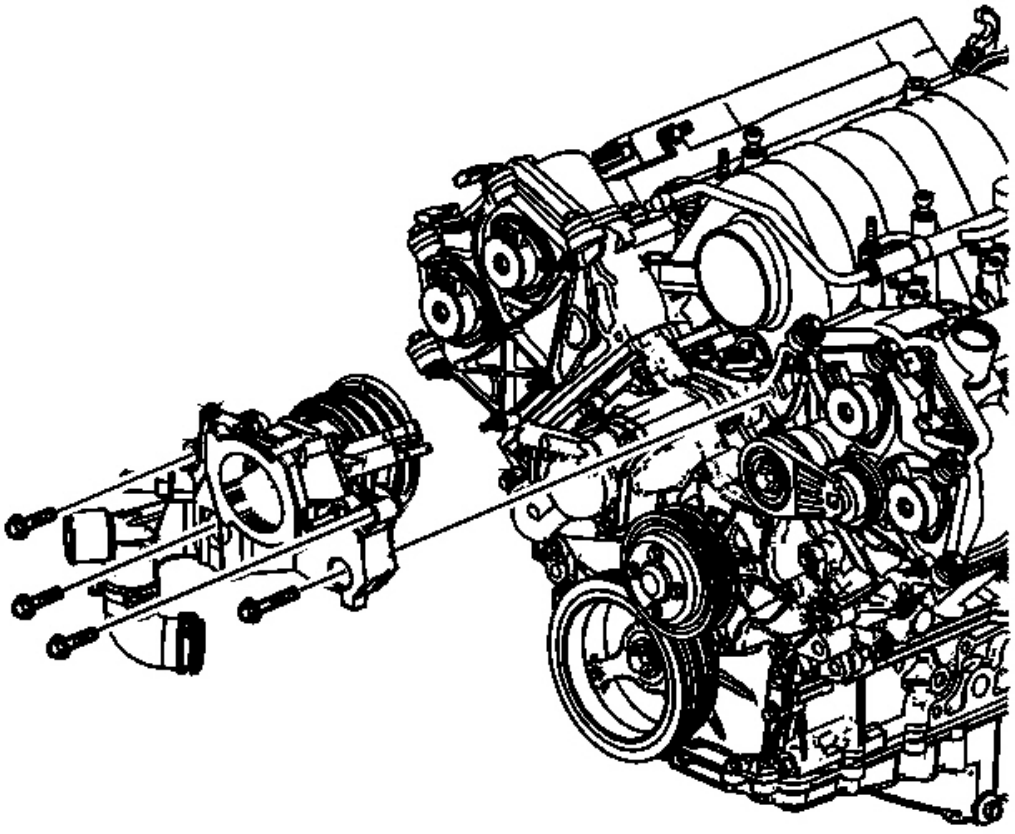


Fig. 145: View Of Water Outlet Housing
Courtesy of GENERAL MOTORS CORP.

8. Remove the bolts securing the water outlet housing to the cylinder heads. Discard the gasket.
9. Clean and inspect. Refer to **Water Outlet Housing Cleaning and Inspection** .
10. Remove the following components from the water outlet housing:
    - The water crossover pipe plug
    - The throttle body inlet heater hose fitting

Installation Procedure

1. Install a new water outlet housing gasket.

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2. Place the water outlet housing in position and hand start the bolts to hold the housing in place.

   NOTE: Refer to Fastener Notice .

3. Tighten the water outlet housing bolts.

   Tighten: Tighten the water outlet housing bolts to 25 N.m (18 lb ft).

4. Connect the following hoses to the water outlet housing:
   - The bypass hose
   - The heater hose
   - The radiator hose
   - The surge tank inlet hose
5. Position the **J 38185** to the hose clamps to secure the hoses to the water outlet housing. See **Special Tools**.
6. Install the purge solenoid. Refer to **Evaporative Emission Canister Purge Solenoid Valve Replacement** .

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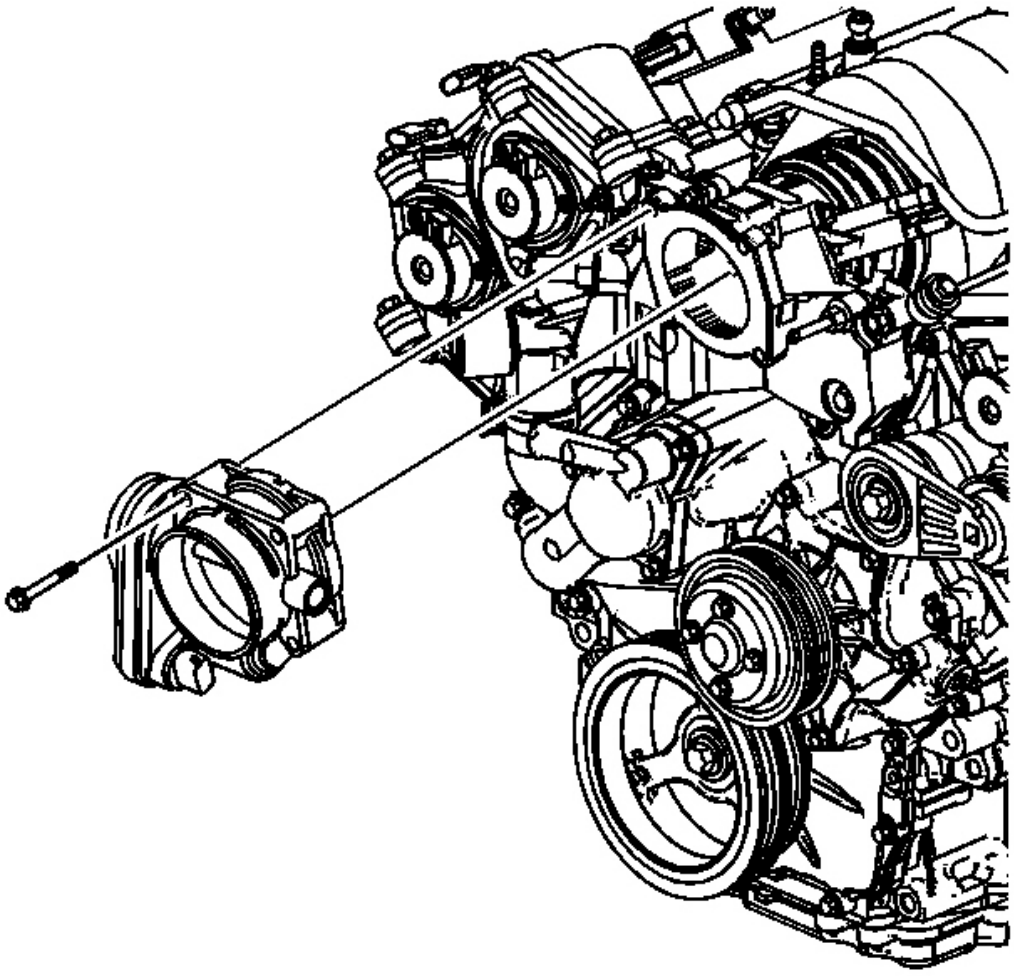


Fig. 146: View Of Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

7. Install the MAP sensor. Refer to **Manifold Absolute Pressure Sensor Replacement** .
8. Install the throttle body to the water outlet housing. Refer to **Throttle Body Assembly Replacement** .
9. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement** .
10. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
11. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

COOLANT BYPASS HOSE REPLACEMENT (LC3)

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Removal Procedure

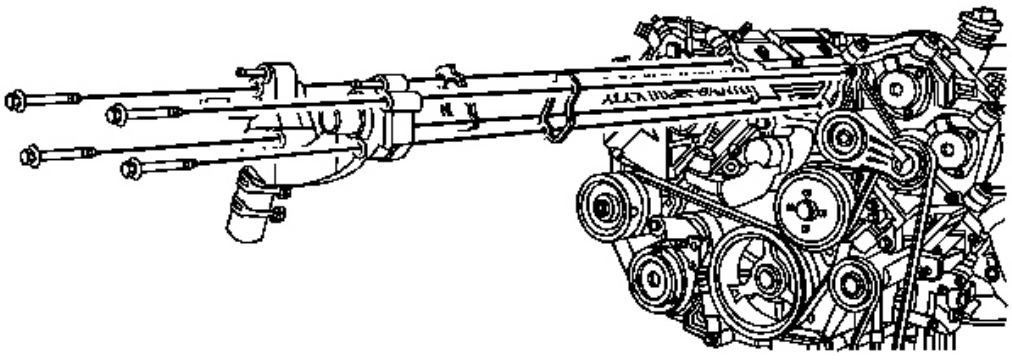


Fig. 147: View Of Water Outlet Housing
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the water outlet housing. Refer to **Water Outlet Housing Replacement (LC3)** or **Water Outlet Housing Replacement (LH2)**.

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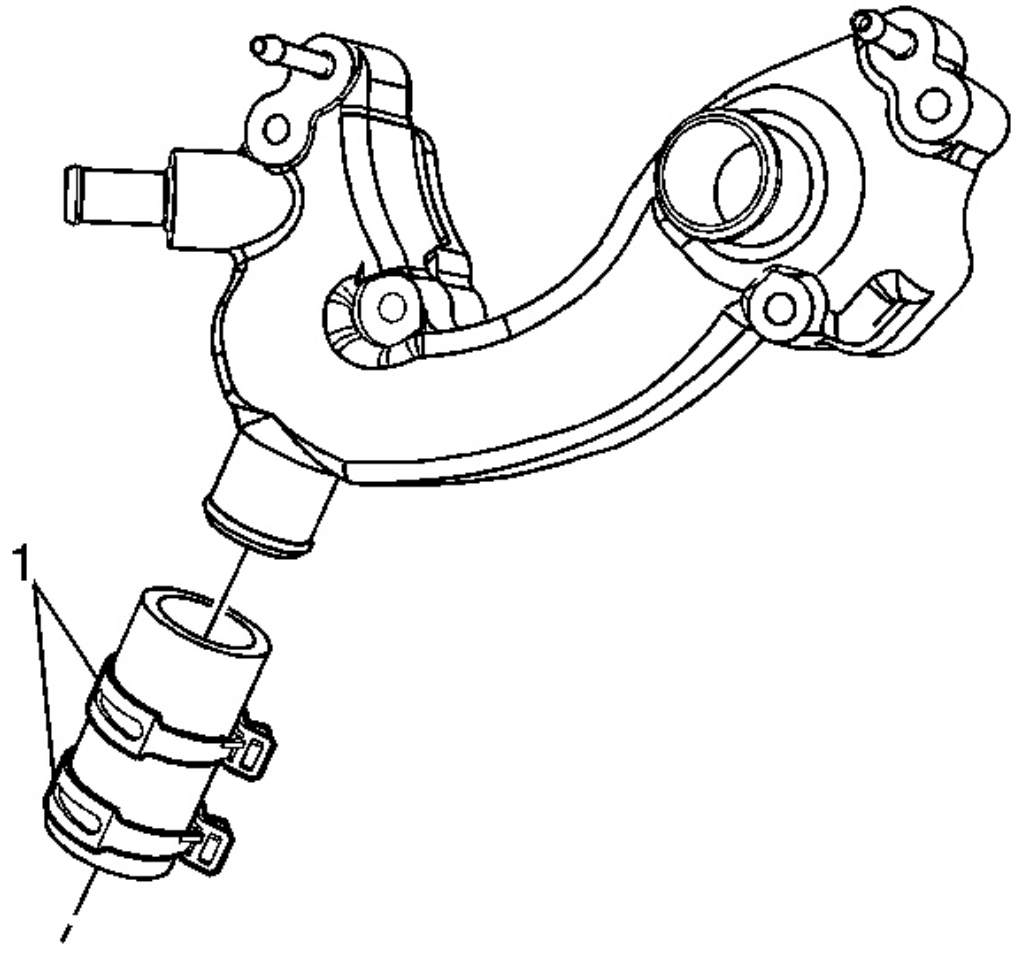


Fig. 148: View Of Bypass Hose
Courtesy of GENERAL MOTORS CORP.

3. Compress the clamps (1) as shown and remove the bypass hose from the water outlet housing.

Installation Procedure

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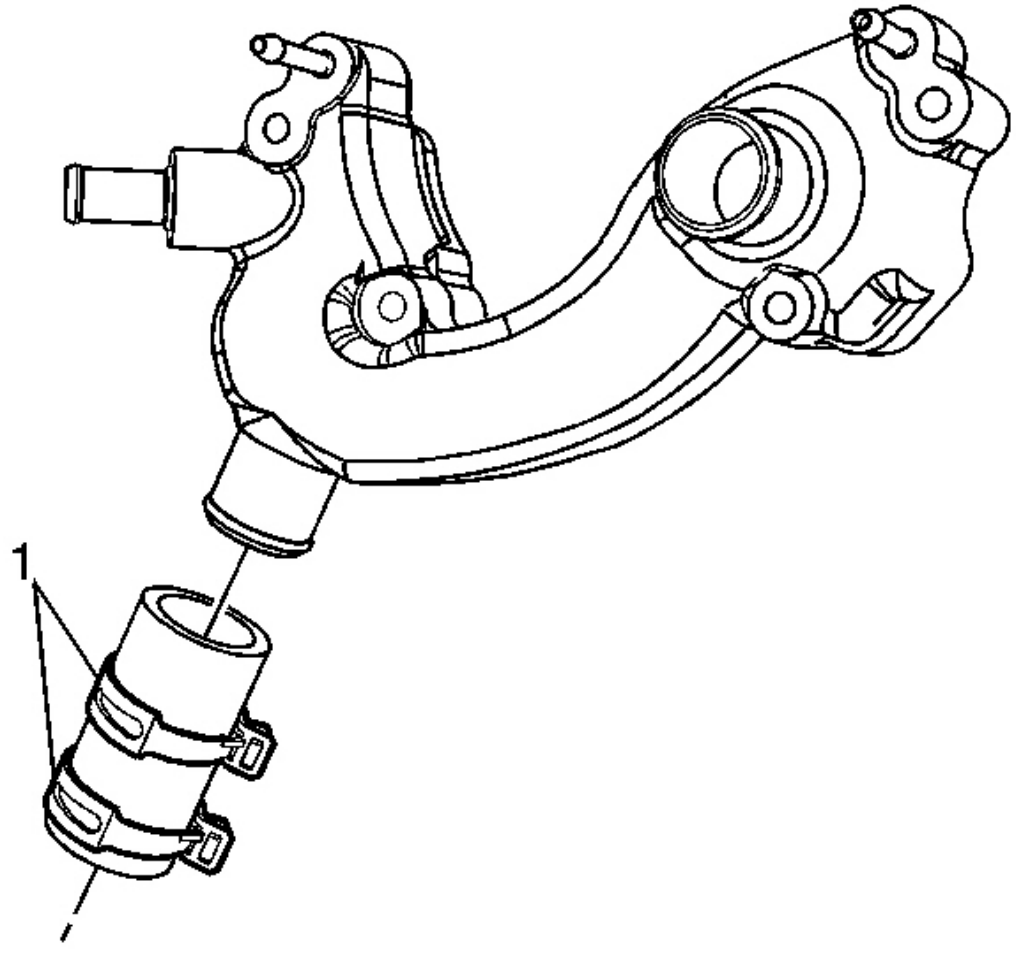


Fig. 149: View Of Bypass Hose
Courtesy of GENERAL MOTORS CORP.

1. Install the bypass hose and clamps (1) to the water outlet housing.

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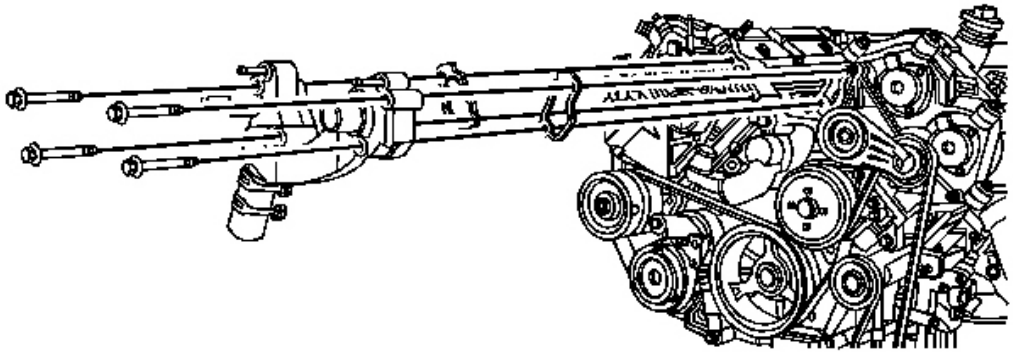


Fig. 150: View Of Water Outlet Housing
Courtesy of GENERAL MOTORS CORP.

2. Install the water outlet housing. Refer to **Water Outlet Housing Replacement (LC3)** or **Water Outlet Housing Replacement (LH2)**.
3. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
4. Check the cooling system for leaks.

COOLANT BYPASS HOSE REPLACEMENT (LH2)

Tools Required

J 38185 Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

CAUTION: To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if radiator cap or surge tank cap is removed while the engine and radiator are still hot.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the surge tank outlet hose assembly. Refer to **Surge Tank Hose/Pipe Replacement - Outlet**.

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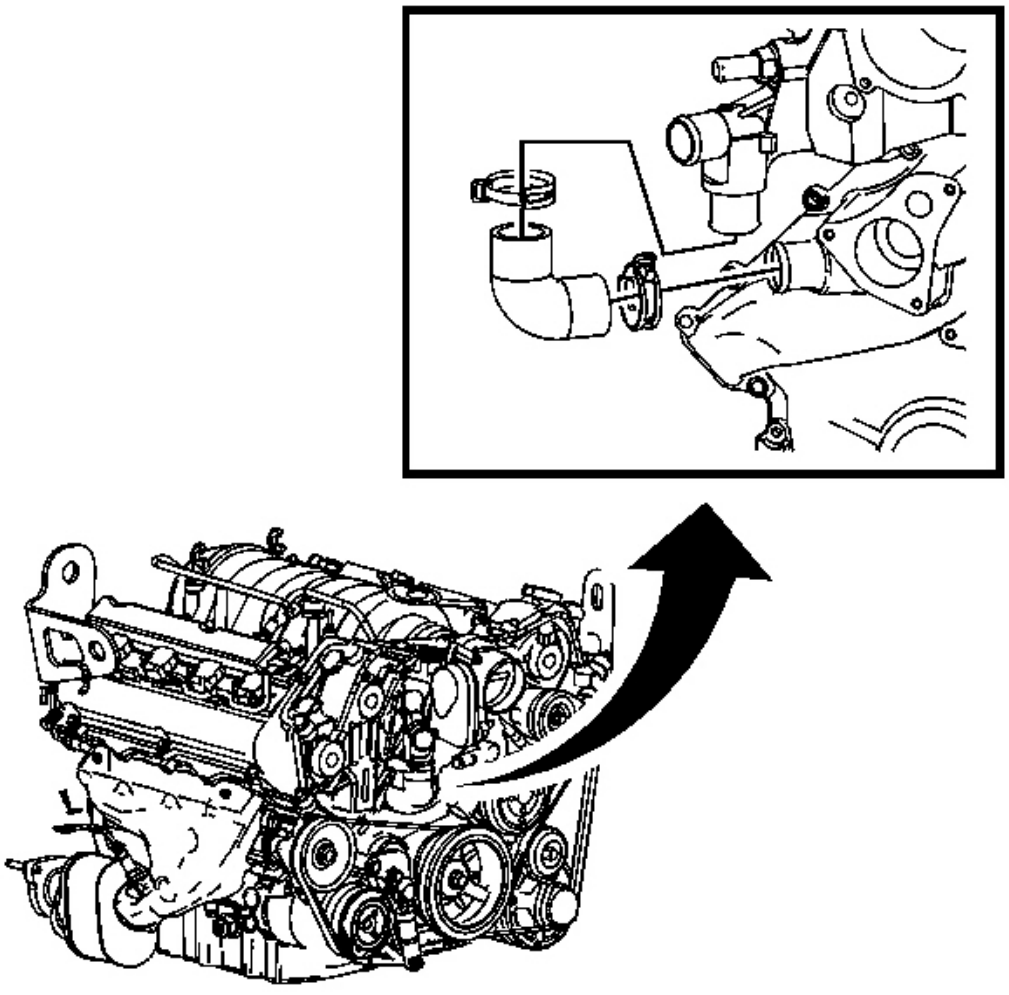


Fig. 151: View Of Upper & Lower Coolant Bypass Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

3. Disengage tension on the upper coolant bypass hose clamp using the **J 38185** . See **Special Tools**.
4. Disengage tension on the lower coolant bypass hose clamp using the **J 38185** . See **Special Tools**.
5. Remove the coolant bypass hose from the vehicle.

Installation Procedure

IMPORTANT: Lubricate the inside diameters of the hose with clean coolant prior to installation.

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1. Install the coolant bypass hose to the vehicle.

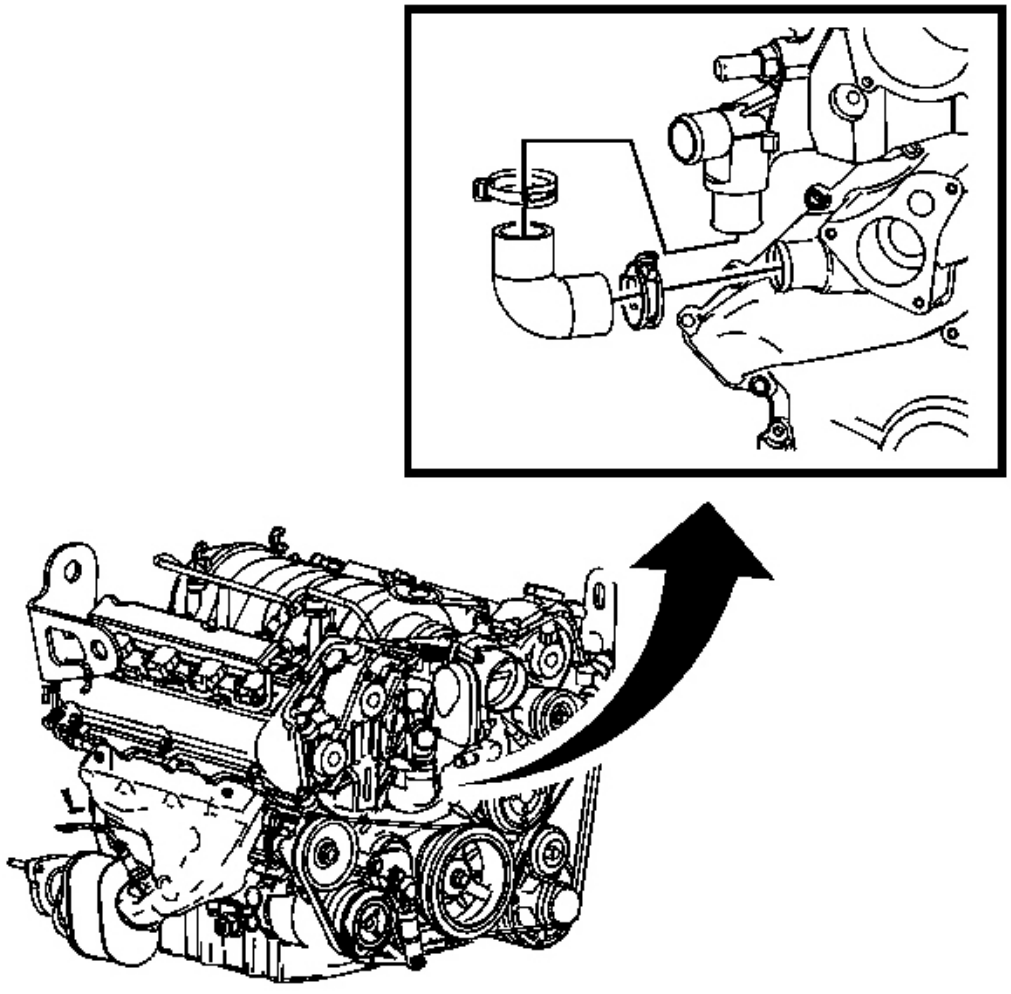


Fig. 152: View Of Upper & Lower Coolant Bypass Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

2. Position and engage tension on the lower coolant bypass hose clamp using the **J 38185** . See **Special Tools**.
3. Position and engage tension on the upper coolant bypass hose clamp using the **J 38185** . See **Special Tools**.
4. Install the surge tank outlet hose assembly. Refer to **Surge Tank Hose/Pipe Replacement - Outlet**.
5. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and**

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Filling Cooling System (Static Fill).

WATER PUMP REPLACEMENT (LH2)

Removal Procedure

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
2. Remove the drive belt. Refer to **Drive Belt Replacement** .
3. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement** .
4. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
5. Remove the water pump bolts.

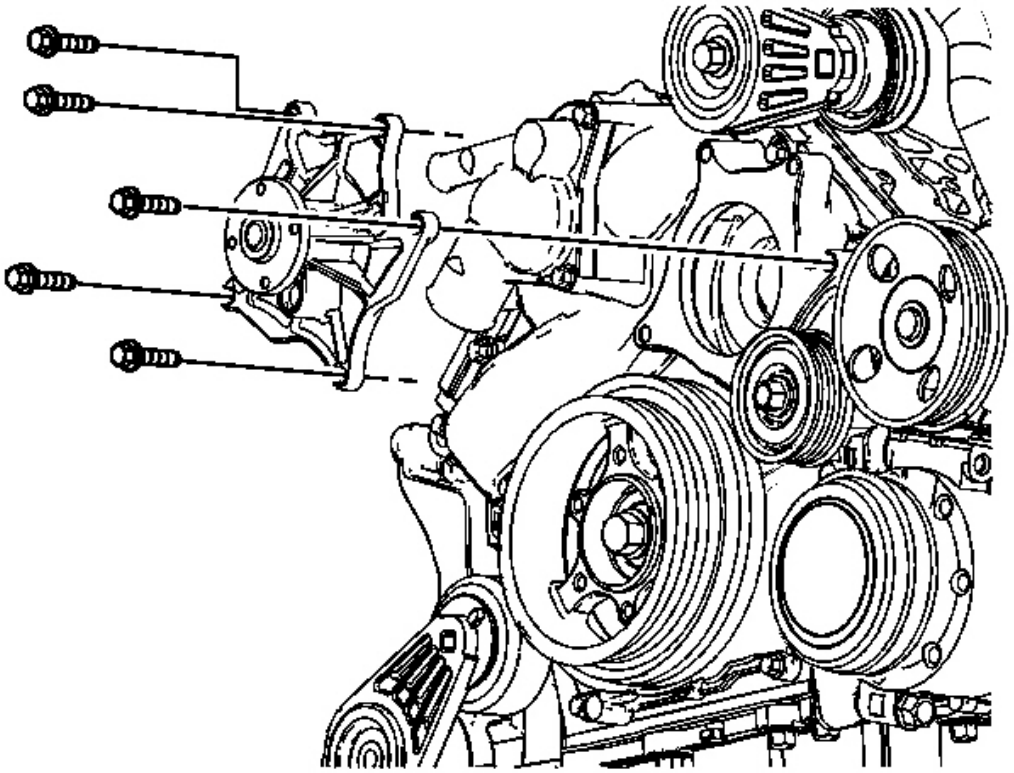


Fig. 153: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

6. Remove the water pump pulley from the water pump.

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7. Remove the water pump from the engine front cover.
8. Remove the water pump gasket and discard.
9. Clean and inspect the water pump. Refer to **Water Pump Cleaning and Inspection** .

Installation Procedure

1. Install the water pump pulley to the water pump.

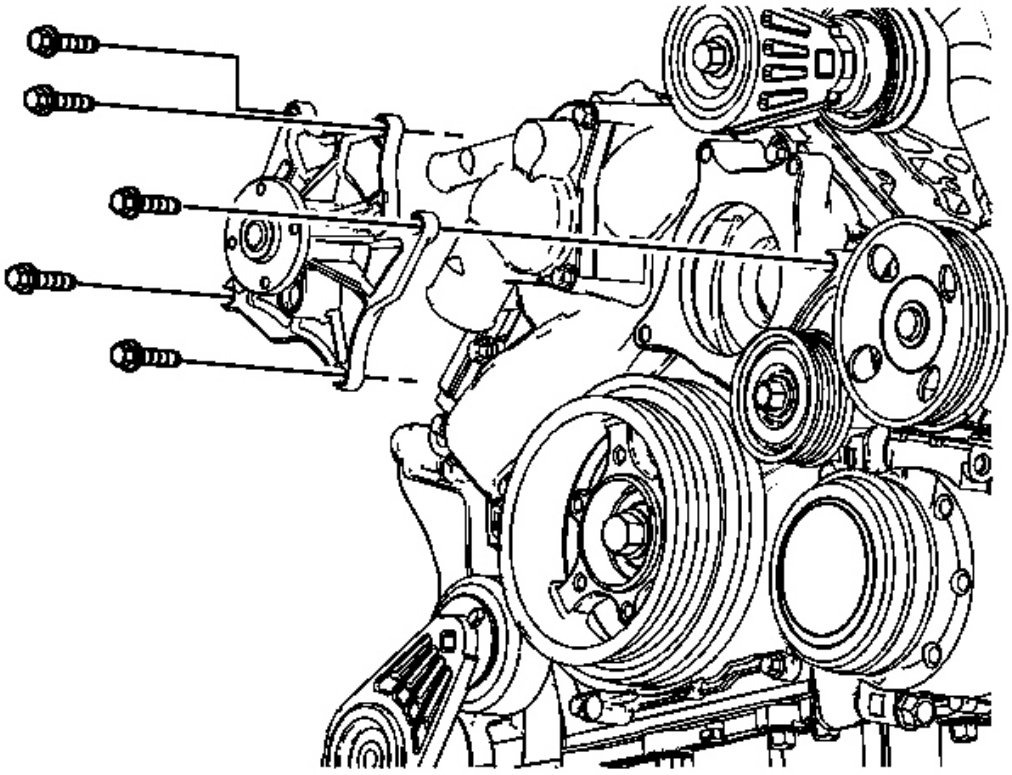


Fig. 154: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

2. Install the water pump and gaskets to the engine front cover.

NOTE: **Refer to Fastener Notice .**

3. Install the water pump pulley bolts to the water pump.

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Tighten: Tighten the water pump pulley bolts to 10 N.m (89 lb in).

4. Install the water pump bolts.

   Tighten:

   1. Tighten the water pump bolts a first pass to 15 N.m (11 lb ft).
   2. Tighten the water pump bolts a final pass to 30 N.m (22 lb ft).

5. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement** .
6. Install the drive belt. Refer to **Drive Belt Replacement** .
7. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
8. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

WATER PUMP REPLACEMENT (LC3)

Removal Procedure

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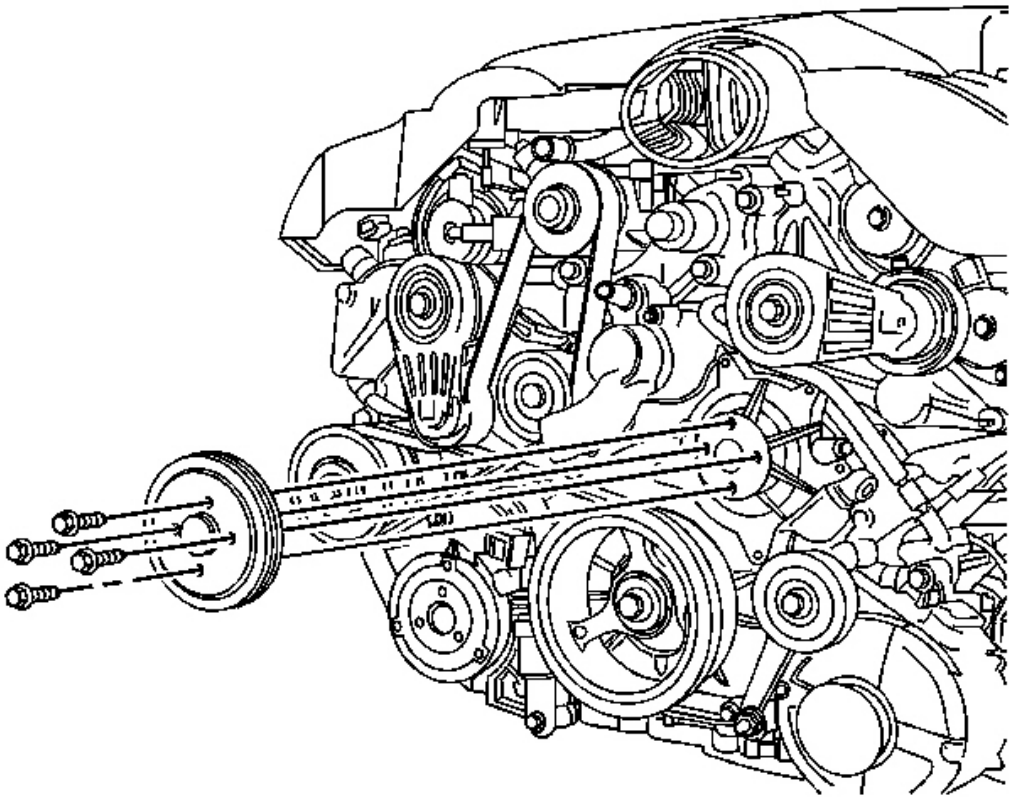


Fig. 155: View Of Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
3. Remove the water pump drive belt. Refer to **Water Pump and Generator Belt Replacement** .
4. Remove the water pump and generator drive belt tensioner. Refer to **Water Pump and Generator Drive Belt Tensioner Replacement** .
5. Remove the water pump pulley bolts.
6. Remove the water pump pulley from the water pump.

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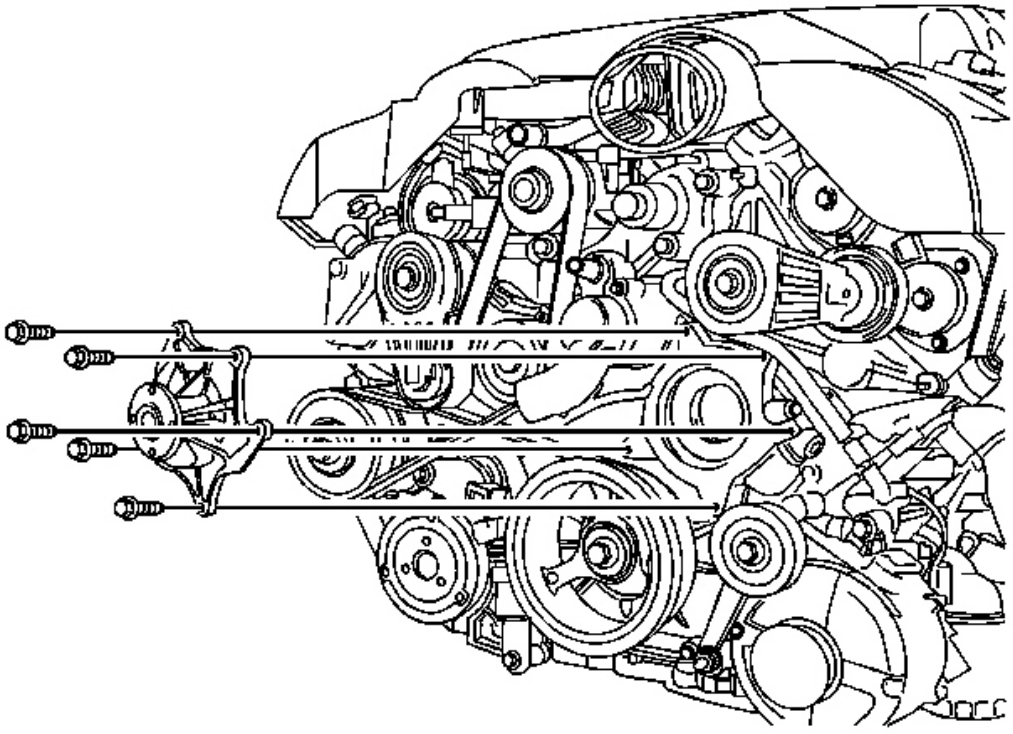


Fig. 156: Identifying Water Pump Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the water pump bolts.

IMPORTANT: Use a drain pan to collect escaping coolant.

8. Remove the water pump and seal.

   Do not reuse the seal.

9. Clean the water pump mating surfaces.
10. Clean and inspect the water pump. Refer to **Water Pump Cleaning and Inspection** .

Installation Procedure

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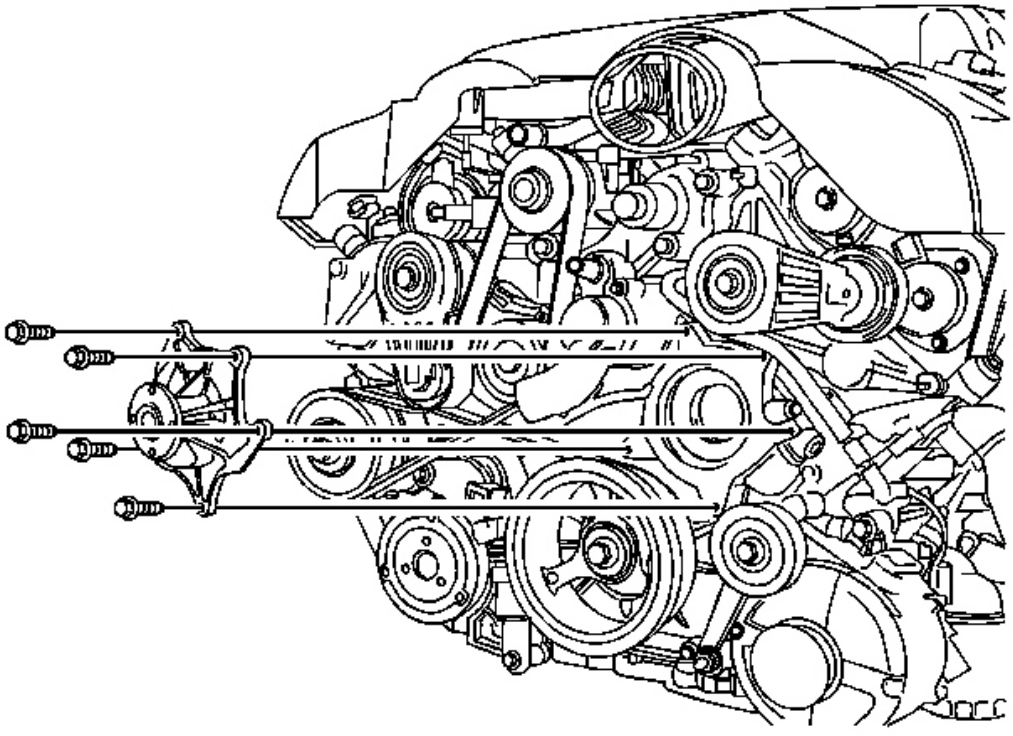


Fig. 157: Identifying Water Pump Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump and NEW seal to the engine front cover.

   NOTE: Refer to Fastener Notice .

2. Install the water pump bolts.

   Tighten: Tighten the water pump bolts to 10 N.m (89 lb in).

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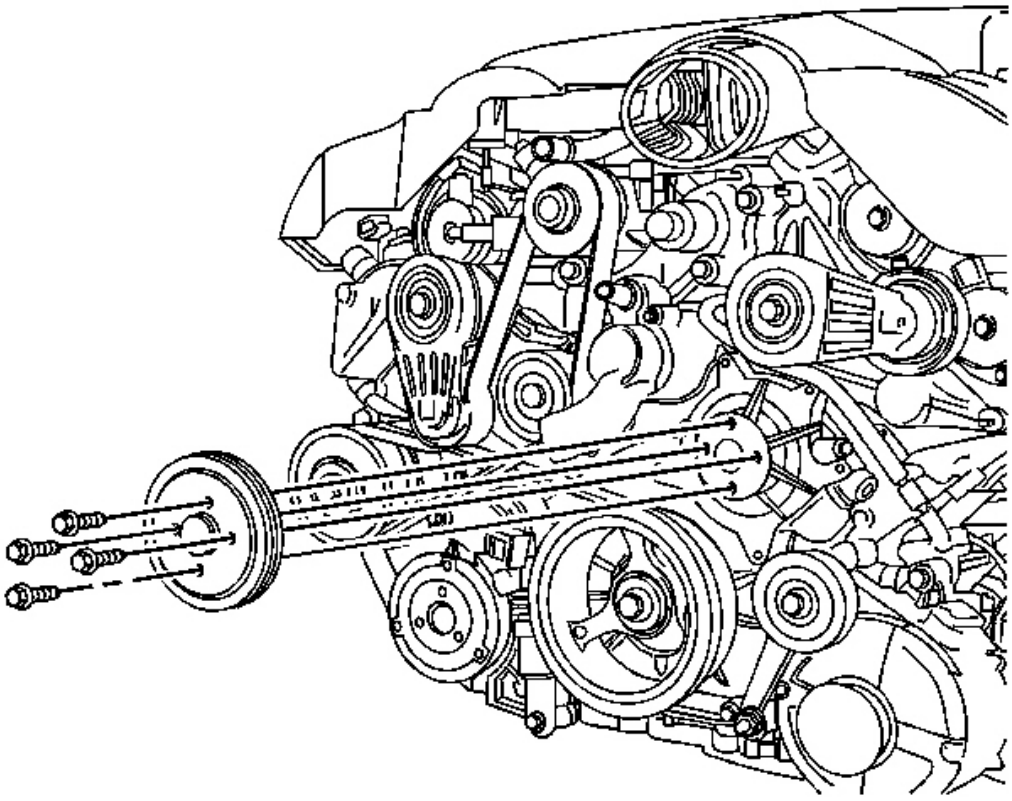


Fig. 158: View Of Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

3. Install the water pump pulley to the water pump.
4. Install the water pump pulley bolts.

   Tighten: Tighten the water pump pulley bolts to 12 N.m (106 lb in).

5. Install the water pump and generator drive belt tensioner. Refer to **Water Pump and Generator Drive Belt Tensioner Replacement** .
6. Install the water pump drive belt. Refer to **Water Pump and Generator Belt Replacement** .
7. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
8. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.

CHARGE AIR COOLER COOLANT PUMP REPLACEMENT

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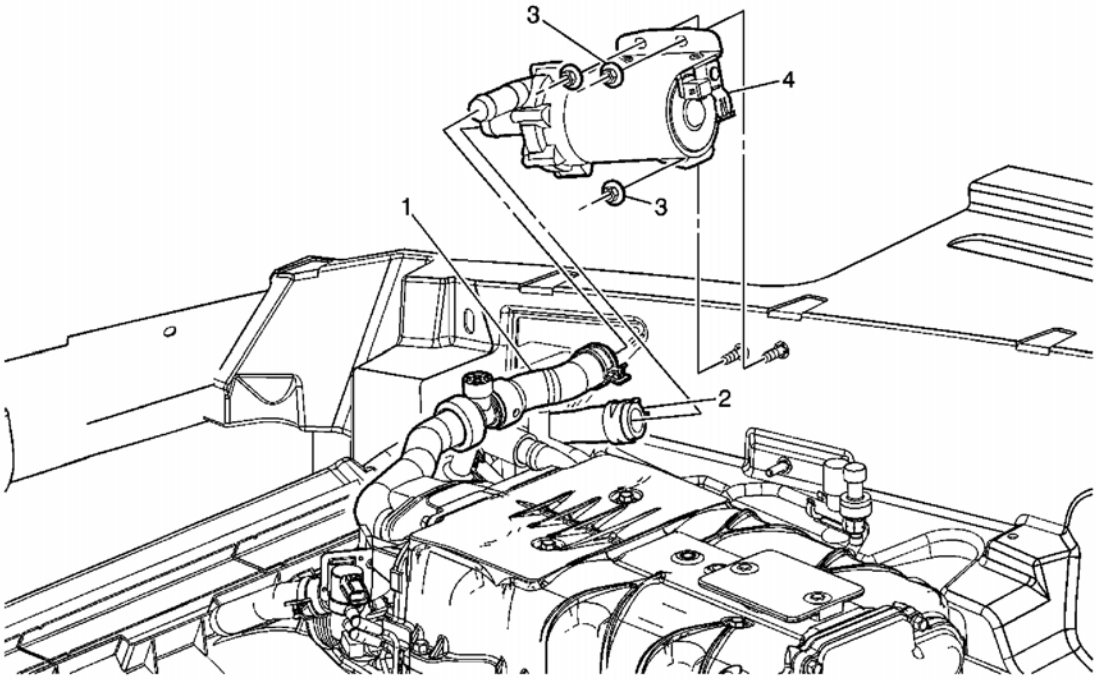


Fig. 159: View Of Air Cooler Coolant Pump
Courtesy of GENERAL MOTORS CORP.

Coolant Pump Replacement - Charge Air Cooler

Callout	Component Name
NOTE: **Refer to Fastener Notice .** **Fastener Tightening Specifications:** Refer to **Fastener Tightening Specifications**. **Preliminary Procedure** 1. Disconnect the charge air cooler coolant pump electrical connector. 2. Drain the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.	
1	Charge Air Cooler Coolant Hose Assembly, (Pump to Cooler) 1. Using **J 38185** position the air cooler coolant hose to pump hose clamp. See **Special Tools**. 2. Remove the air charge coolant hose from the charge air cooler coolant pump.
2	Charge Air Cooler Coolant Hose Assembly, (Pump to Radiator) 1. Using **J 38185** position the air cooler coolant hose to pump hose clamp. See **Special Tools**.

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	2. Remove the air charge coolant hose from the charge air cooler coolant pump.
3	Charge Air Cooler Coolant Pump Assembly Nut (Qty: 3) **Tighten:** 8 N.m (71 lb in)
4	Charge Air Cooler Coolant Pump Assembly

RADIATOR REPLACEMENT

Tools Required

- **J 39400-A** Halogen Leak Detector. See **Special Tools**.
- **J 38185** Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

1. Recover the refrigerant from the A/C system. Refer to **Refrigerant Recovery and Recharging** .
2. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
3. Remove the condenser. Refer to **Condenser Replacement** .
4. Disengage tension on the radiator inlet hose clamp at the radiator using **J 38185** . See **Special Tools**.
5. Disconnect the radiator inlet hose from the radiator.
6. Disengage tension on the radiator inlet hose clamp at the engine using **J 38185** . See **Special Tools**.

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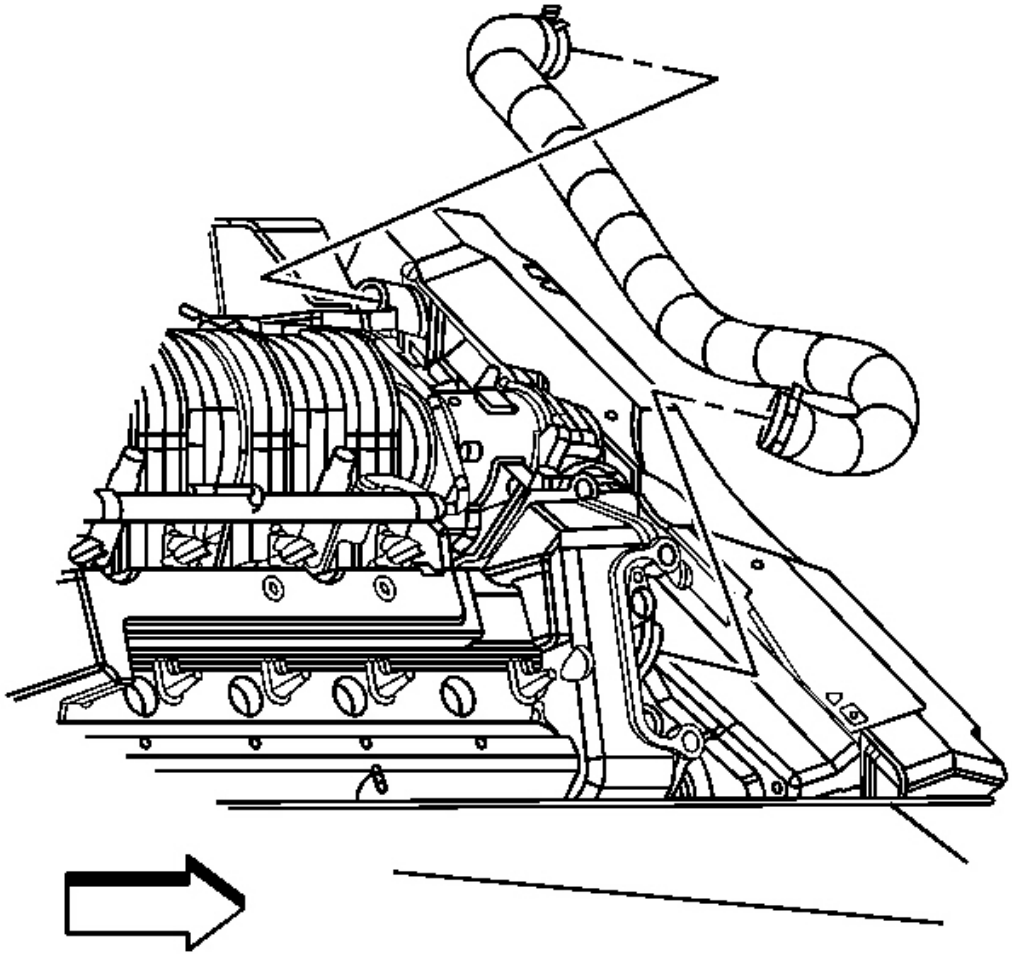


Fig. 160: Removing/Installing Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the radiator inlet hose from the engine.
8. Remove the radiator inlet hose.

IMPORTANT: Lift up on the cooling fan and shroud assembly to disengage the tabs from the radiator slots.

9. Disconnect the cooling fan and shroud assembly from the radiator.

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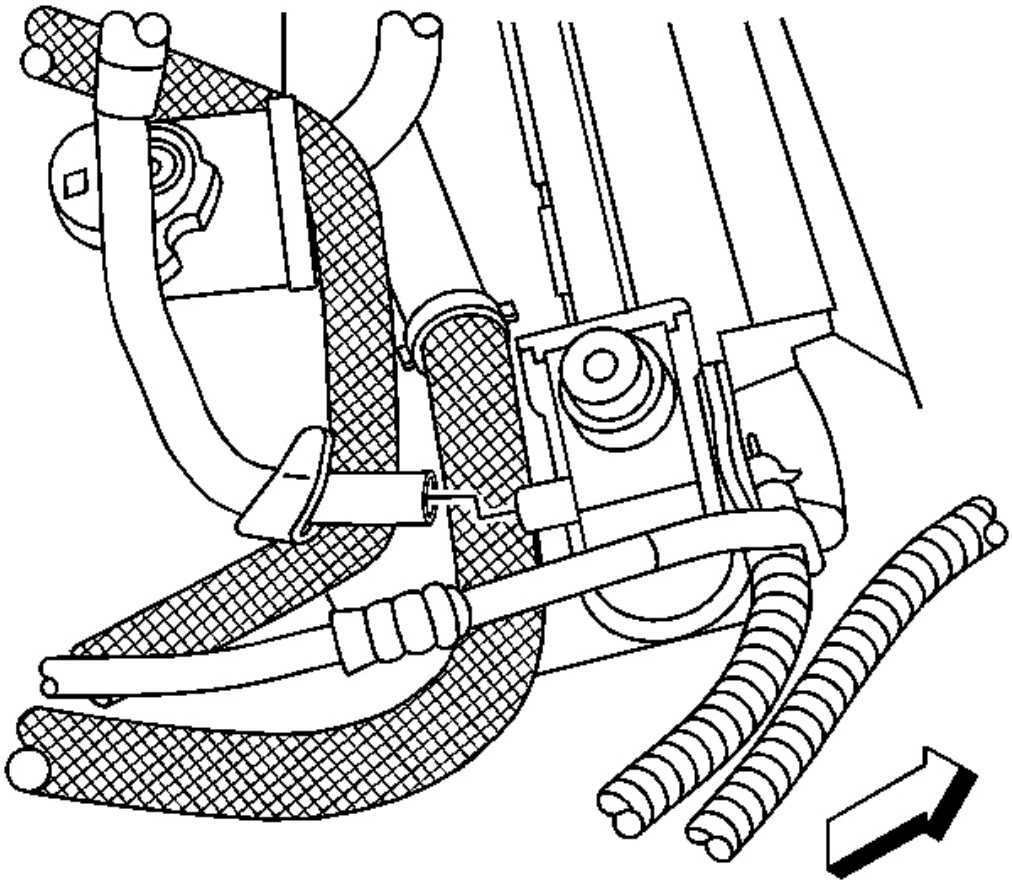


Fig. 161: Repositioning Surge Tank Inlet Hose Clamp At Radiator
Courtesy of GENERAL MOTORS CORP.

10. Disengage tension and reposition the surge tank inlet hose clamp at the radiator using **J 38185** . See **Special Tools**.
11. Disconnect the surge tank inlet hose from the radiator.
12. Disconnect the upper transmission oil cooler line from the radiator. Refer to **Transmission Fluid Cooler Upper Pipe Assembly Replacement** .
13. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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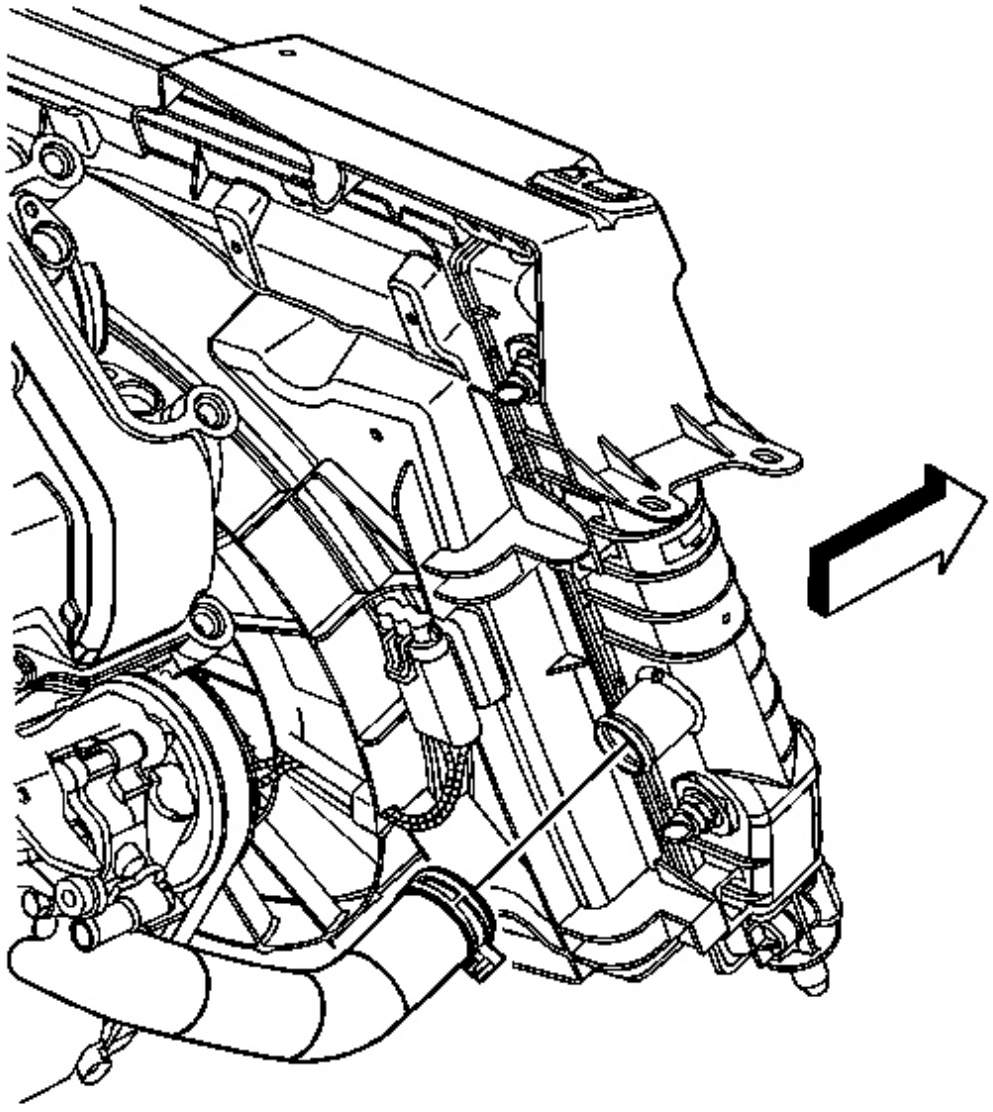


Fig. 162: Disconnecting/Connecting Radiator Outlet Hose From Radiator
Courtesy of GENERAL MOTORS CORP.

14. Disengage tension on the radiator outlet hose clamp at the radiator using the **J 38185** . See **Special Tools**.
15. Disconnect the radiator outlet hose from the radiator.
16. Disconnect the lower transmission oil cooler line from the radiator. Refer to **Transmission Fluid Cooler Lower Pipe Assembly Replacement - Transmission to Auxiliary Cooler** .

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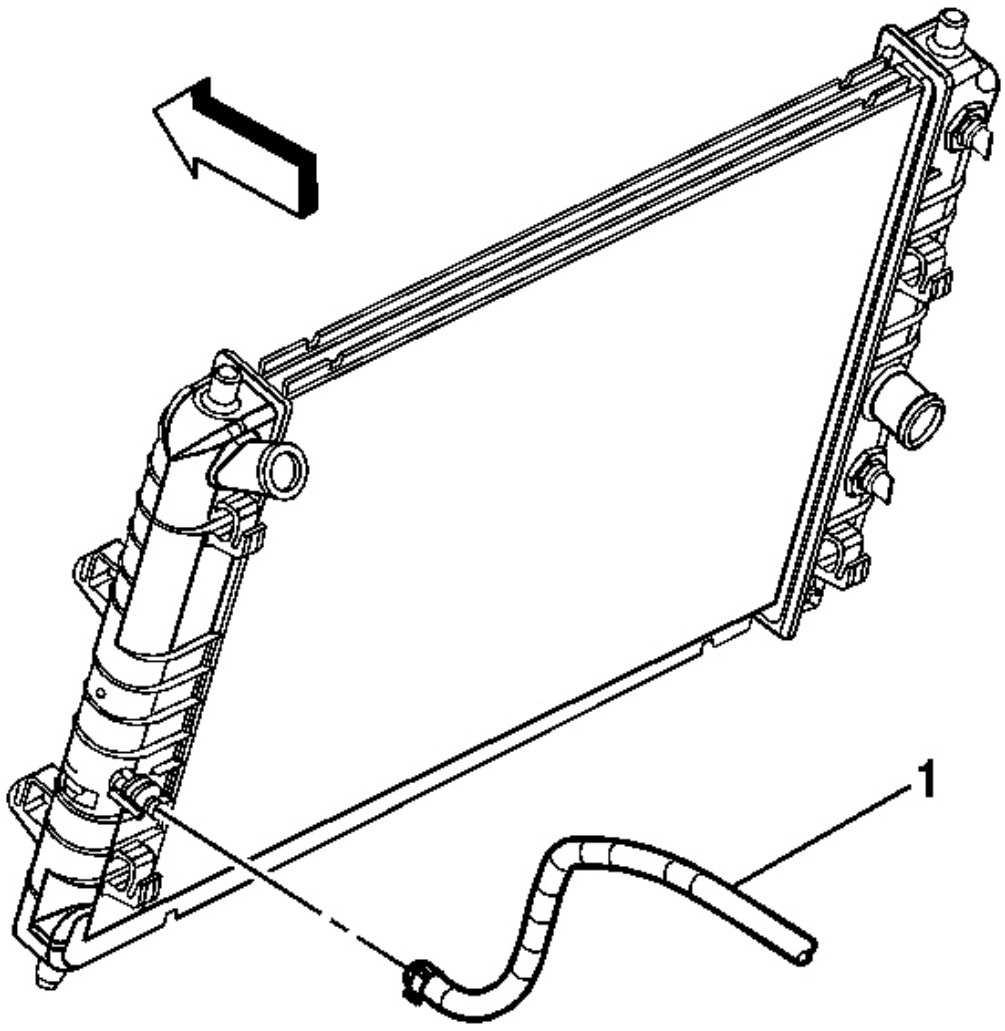


Fig. 163: Disconnecting/Connecting Generator Cooling Hose To Radiator
Courtesy of GENERAL MOTORS CORP.

17. Disengage the generator cooling hose clamp at the radiator.
18. Disconnect the generator cooling hose (1) from the radiator.
19. Lower the vehicle.
20. Remove the radiator from the vehicle.

Installation Procedure

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1. Install the radiator to the vehicle.
2. Raise the vehicle.
3. Connect the generator cooling hose (1) to the radiator.

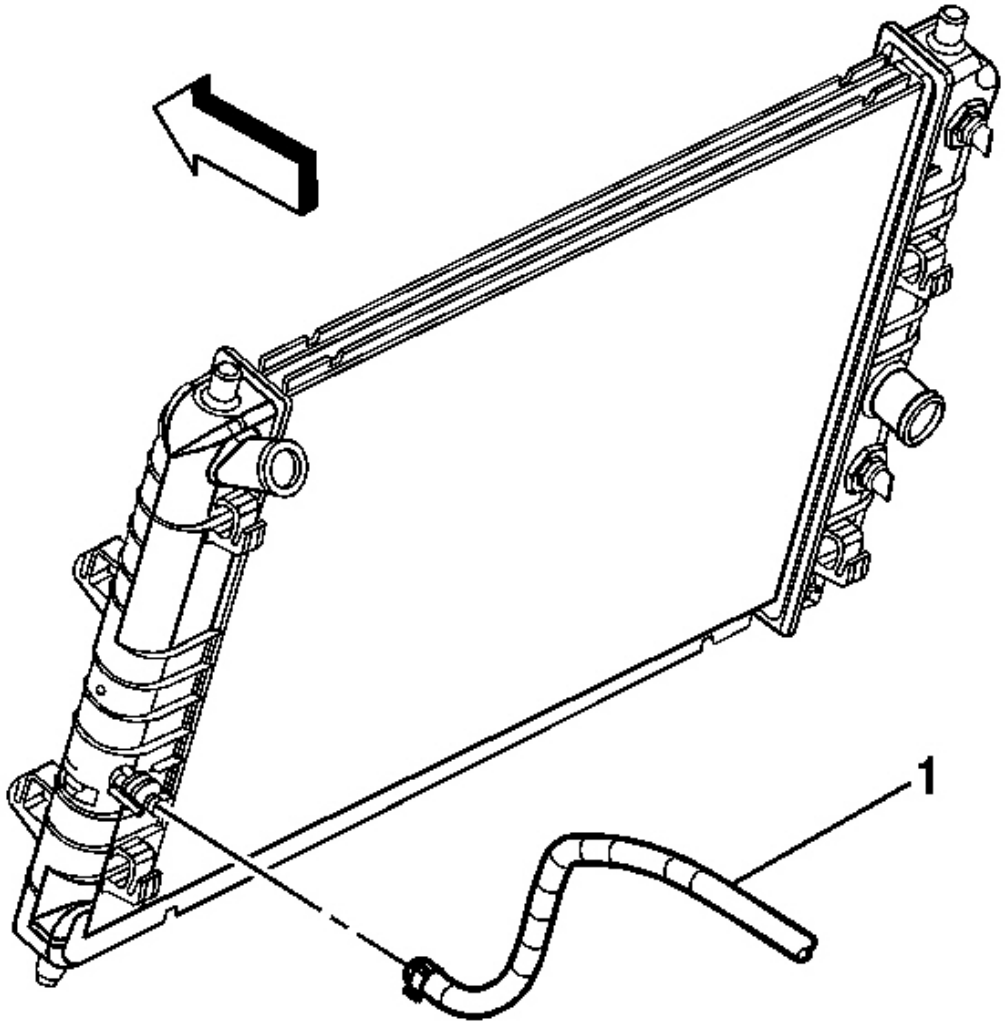


Fig. 164: Disconnecting/Connecting Generator Cooling Hose To Radiator
Courtesy of GENERAL MOTORS CORP.

4. Engage the generator cooling hose clamp at the radiator.
5. Connect the lower transmission oil cooler line to the radiator. Refer to **Transmission Fluid Cooler Lower Pipe Assembly Replacement - Transmission to Auxiliary Cooler** .

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6. Connect the radiator outlet hose to the radiator.

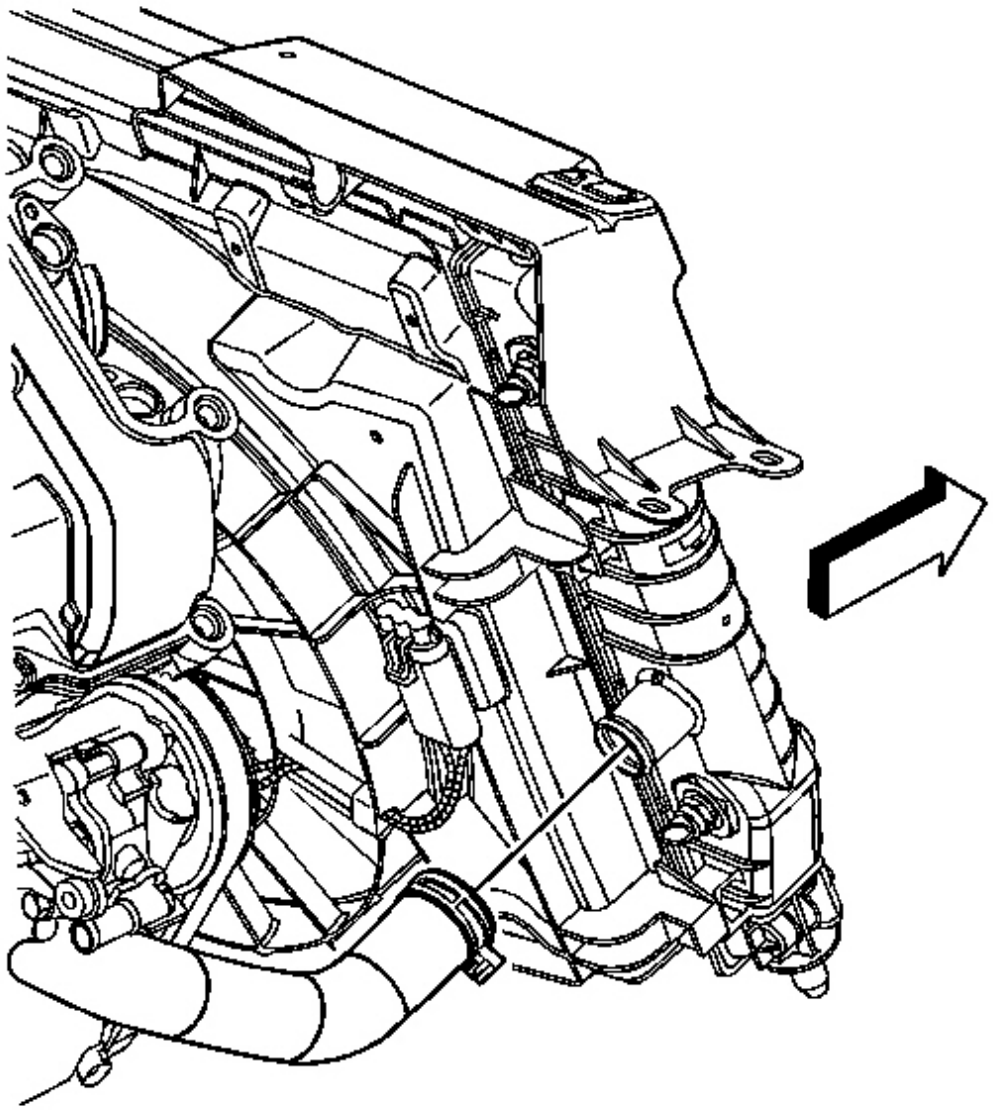


Fig. 165: Disconnecting/Connecting Radiator Outlet Hose From Radiator
Courtesy of GENERAL MOTORS CORP.

7. Engage tension on the radiator outlet hose clamp at the radiator.
8. Lower the vehicle.

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9. Connect the upper transmission oil cooler line to the radiator. Refer to **Transmission Fluid Cooler Upper Pipe Assembly Replacement** .
10. Connect the surge tank inlet hose to the radiator.

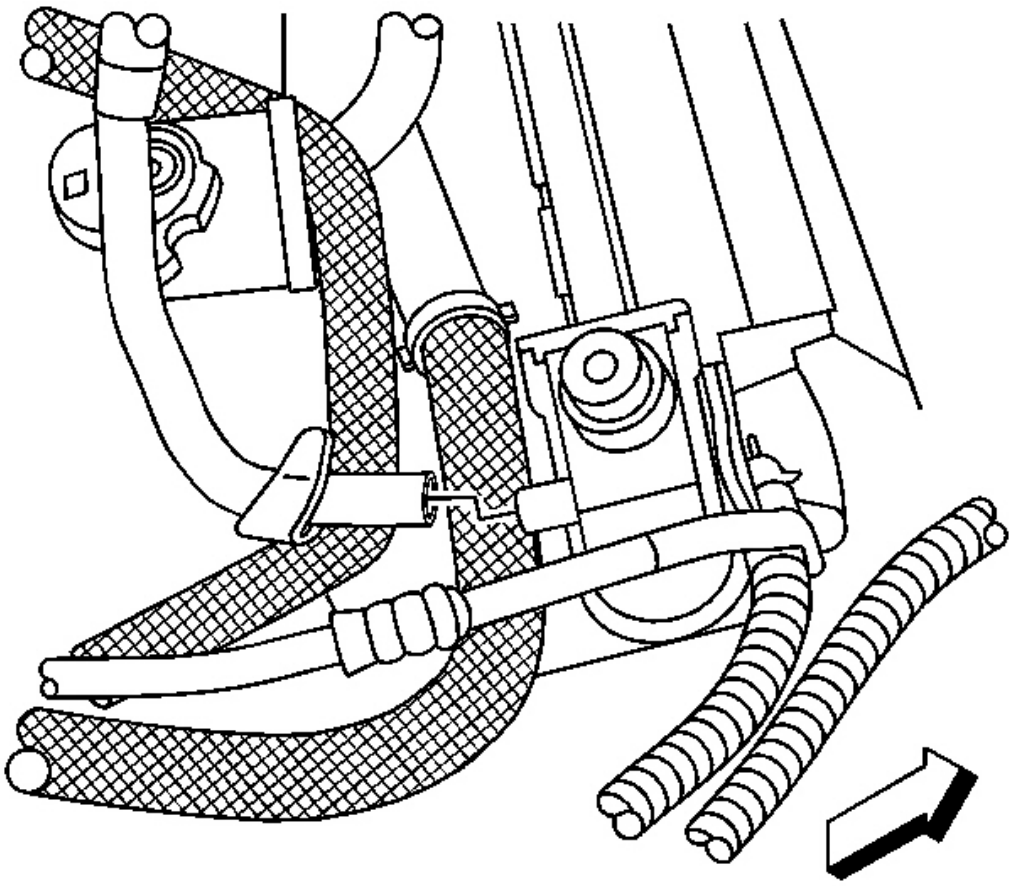


Fig. 166: Repositioning Surge Tank Inlet Hose Clamp At Radiator
Courtesy of GENERAL MOTORS CORP.

11. Engage tension on the surge tank inlet hose clamp at the radiator.

IMPORTANT: Lift up on the cooling fan and shroud assembly and engage the tabs to the radiator slots.

12. Connect the cooling fan and shroud assembly to the radiator.
13. Install the radiator inlet hose.

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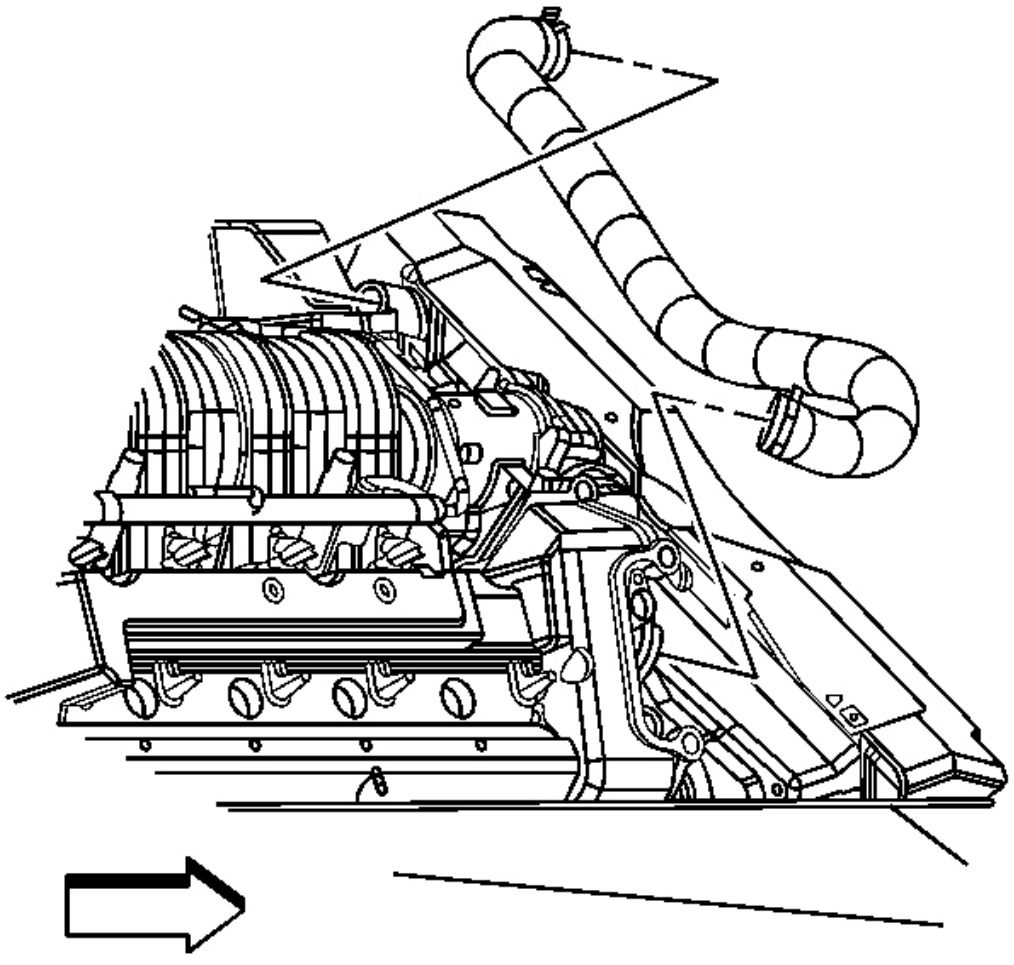


Fig. 167: Removing/Installing Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

14. Connect the radiator inlet hose to the engine.
15. Engage tension on the radiator inlet hose clamp at the engine using **J 38185** . See **Special Tools**.
16. Connect the radiator inlet hose to the radiator.
17. Engage tension on the radiator inlet hose clamp at the radiator using **J 38185** . See **Special Tools**.
18. Install the condenser. Refer to **Condenser Replacement** .
19. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)**.
20. Evacuate and recharge the A/C system. Refer to **Refrigerant Recovery and Recharging** .
21. Leak test the fittings of the component using **J 39400-A** . See **Special Tools**.

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22. Inspect the transmission fluid level. Refer to **Transmission Fluid Checking** .

CHARGE AIR COOLER RADIATOR REPLACEMENT

Tools Required

GE-47622 Hose Clamp Pliers. See **Special Tools**.

Removal Procedure

1. Drain the charge air cooler cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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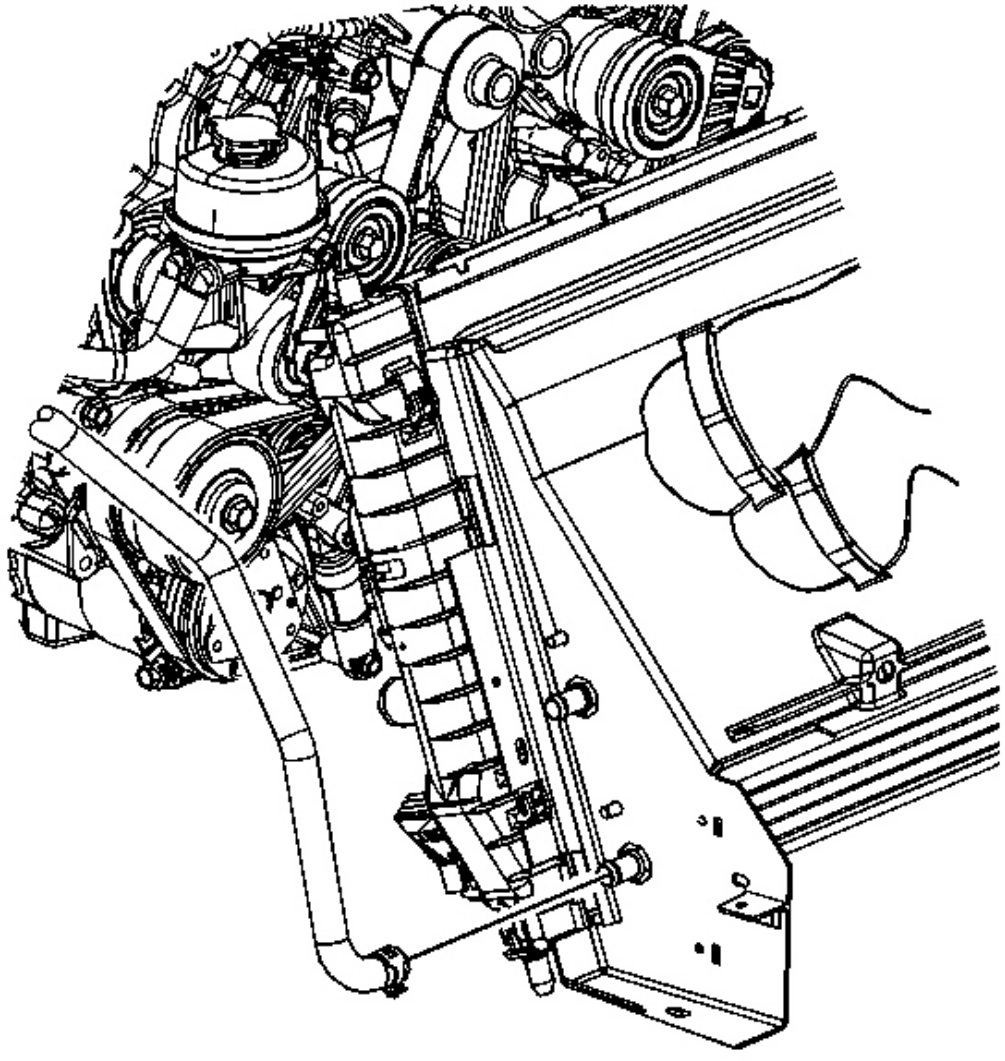


Fig. 168: View Of Charge Air Cooler Coolant Outlet Hose
Courtesy of GENERAL MOTORS CORP.

3. Using the **GE-47622** , reposition the charge air cooler coolant outlet hose from the charge air cooler radiator. See **Special Tools**.
4. Remove the charge air cooler coolant outlet hose from the charge air cooler radiator.

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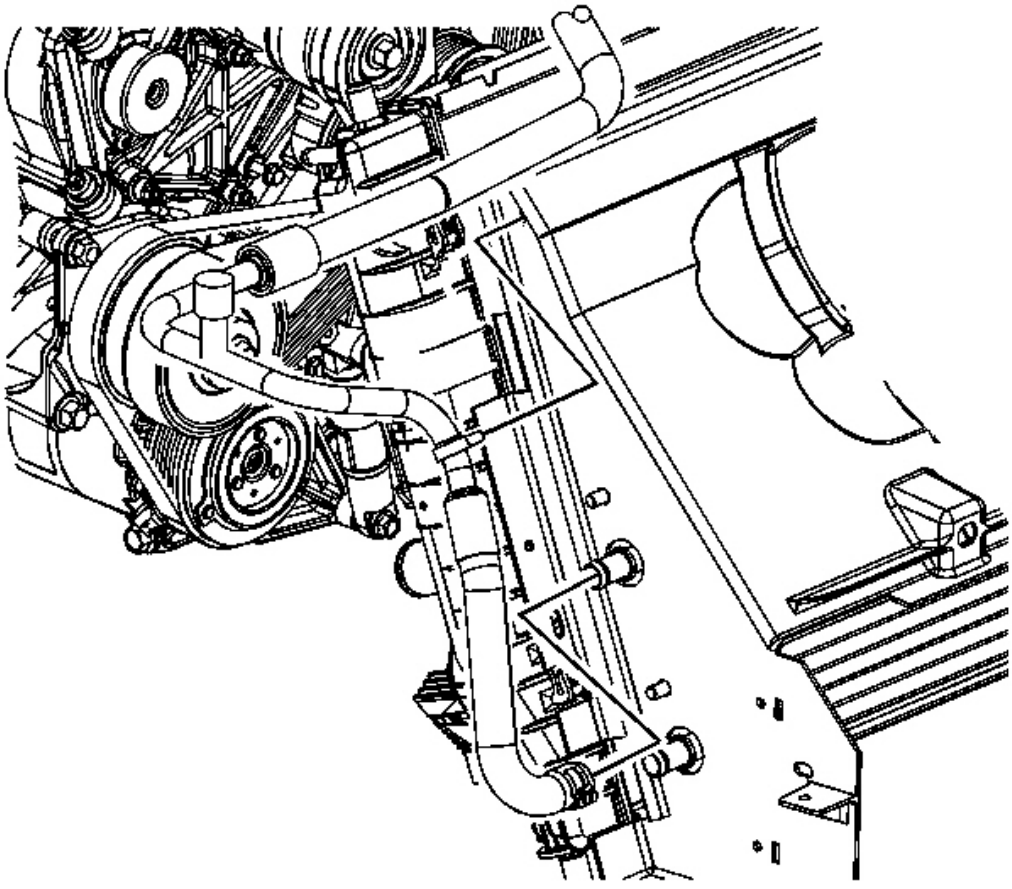


Fig. 169: View Of Charge Air Cooler Coolant Inlet Hose
Courtesy of GENERAL MOTORS CORP.

5. Using the **GE-47622** , reposition the charge air cooler coolant inlet hose from the charge air cooler radiator. See **Special Tools**.
6. Remove the charge air cooler coolant inlet hose from the charge air cooler radiator.

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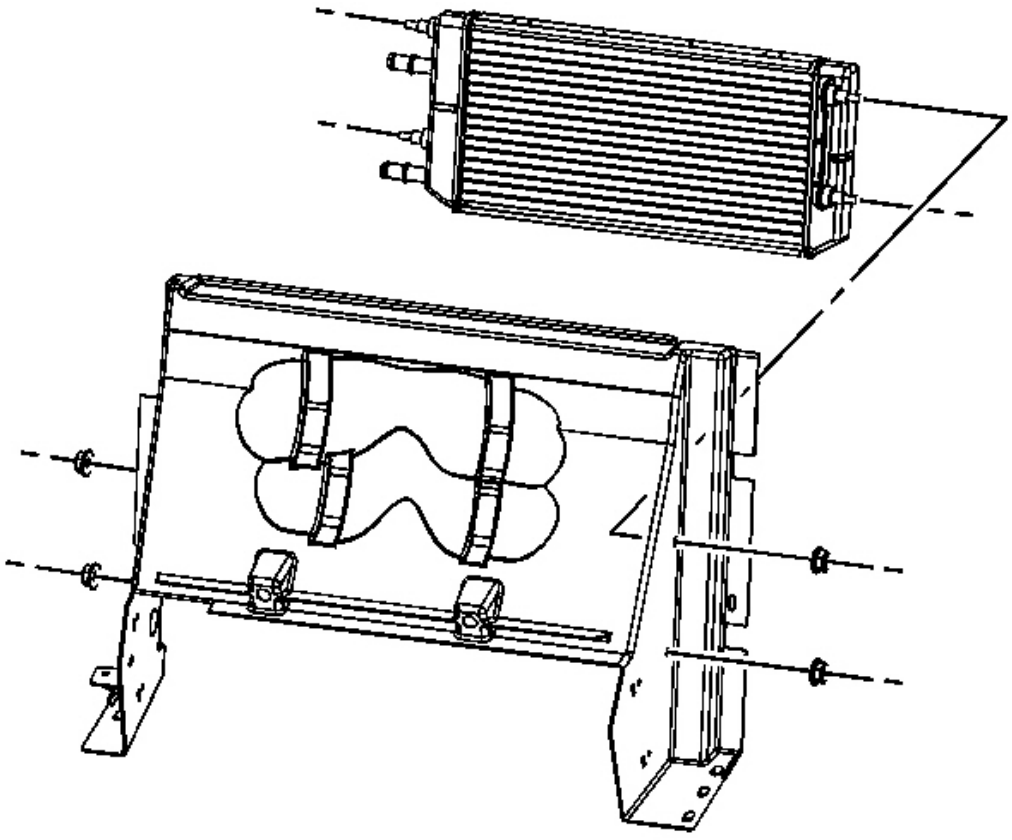


Fig. 170: View Of Charge Air Cooler Radiator
Courtesy of GENERAL MOTORS CORP.

7. Remove the charge air cooler radiator retaining nuts.
8. Remove the charge air cooler radiator from the vehicle.

Installation Procedure

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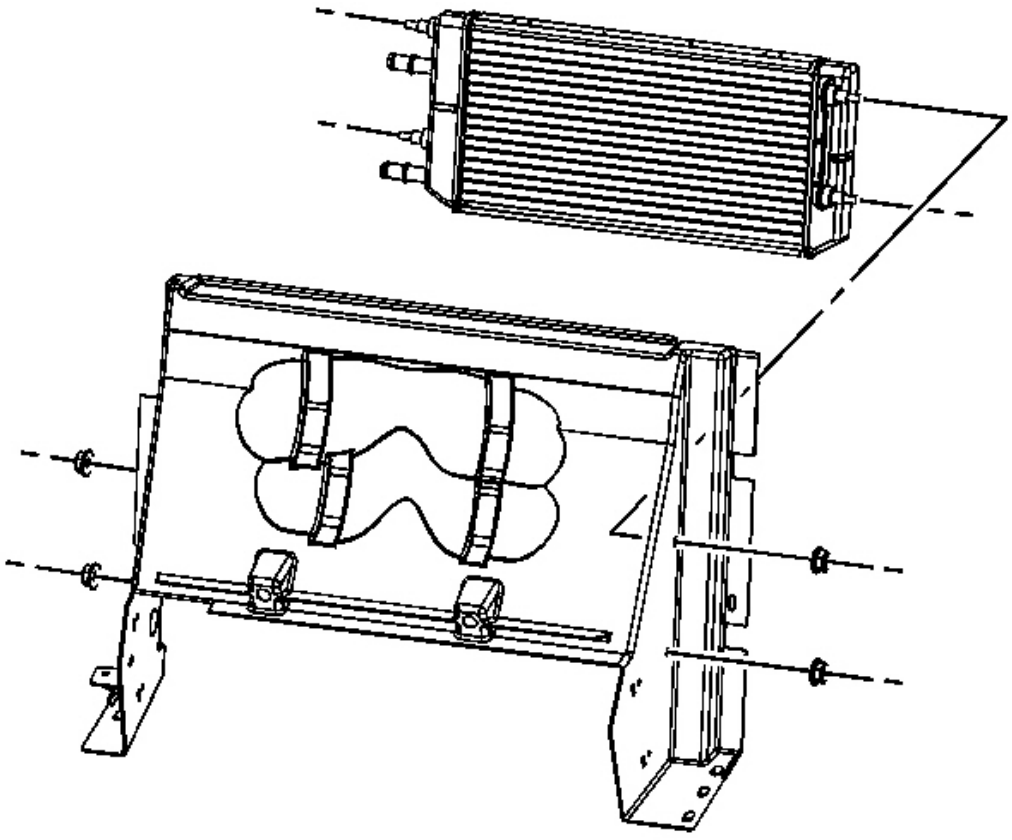


Fig. 171: View Of Charge Air Cooler Radiator
Courtesy of GENERAL MOTORS CORP.

1. Install the charge air cooler radiator to the vehicle.

   NOTE: Refer to Fastener Notice .

2. Install the charge air cooler radiator retaining nuts.

   Tighten: Tighten the nuts to 8 N.m (71 lb in)

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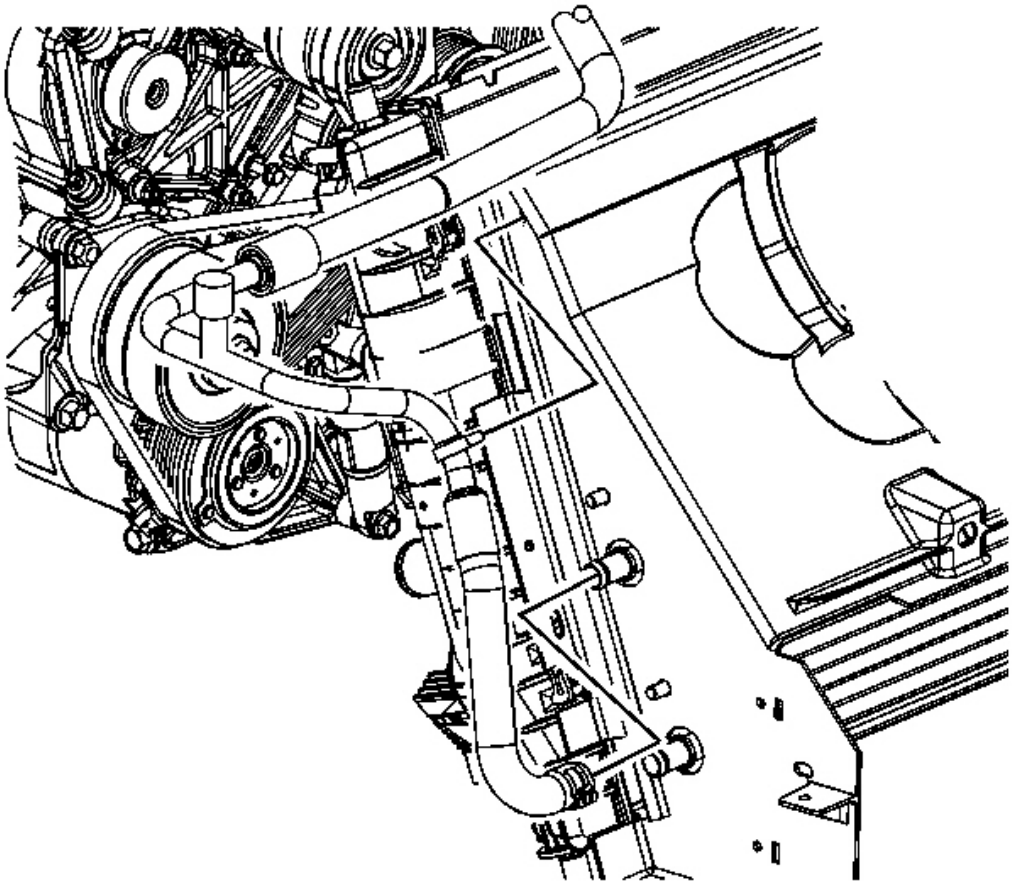


Fig. 172: View Of Charge Air Cooler Coolant Inlet Hose
Courtesy of GENERAL MOTORS CORP.

3. Install the charge air cooler coolant inlet hose to the charge air cooler radiator.
4. Using the **GE-47622** , reposition the charge air cooler coolant inlet hose clamp at the charge air cooler radiator. See **Special Tools**.

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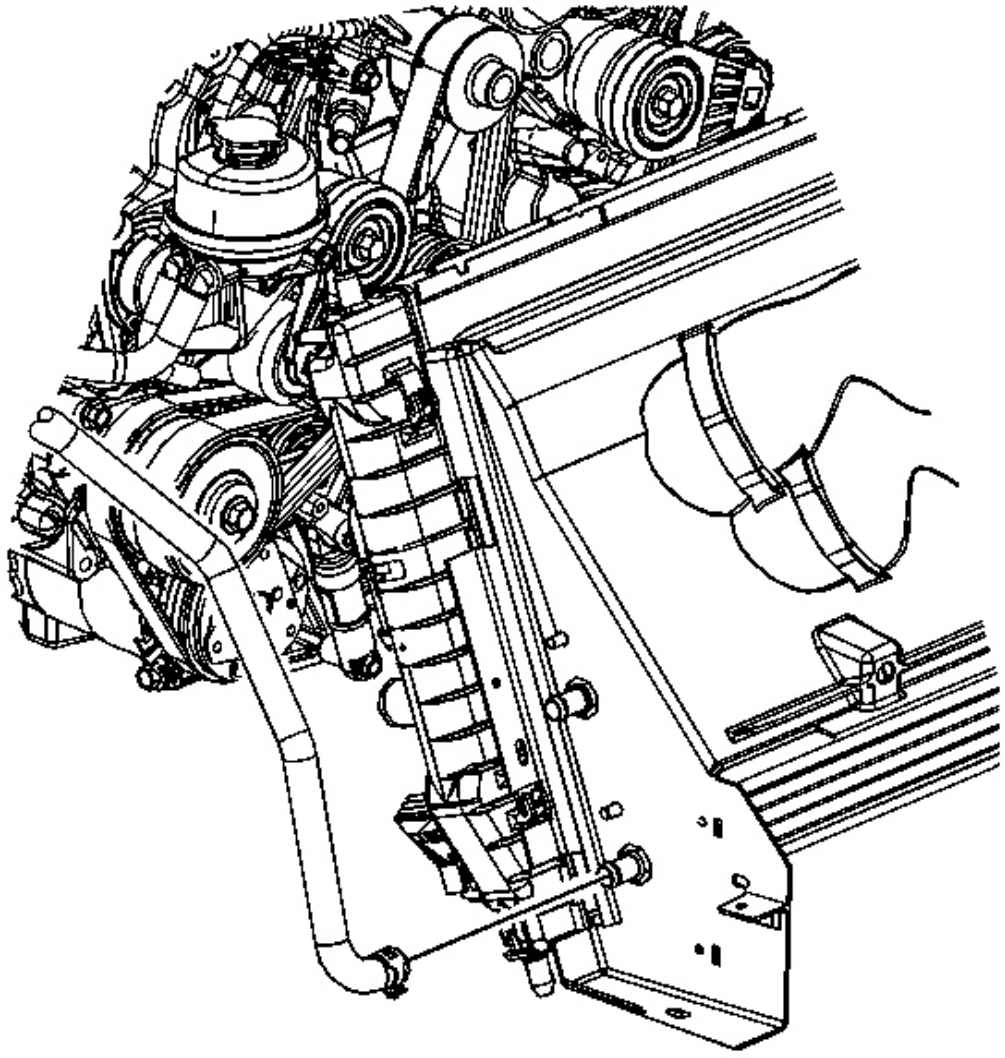


Fig. 173: View Of Charge Air Cooler Coolant Outlet Hose
Courtesy of GENERAL MOTORS CORP.

5. Install the charge air cooler coolant outlet hose to the charge air coolant radiator.
6. Using the **GE-47622** , reposition the charge air cooler coolant outlet hose at the charge air coolant radiator. See **Special Tools**.
7. Lower the vehicle.
8. Fill the charge air cooler cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)**.

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RADIATOR SUPPORT REPLACEMENT

Removal Procedure

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

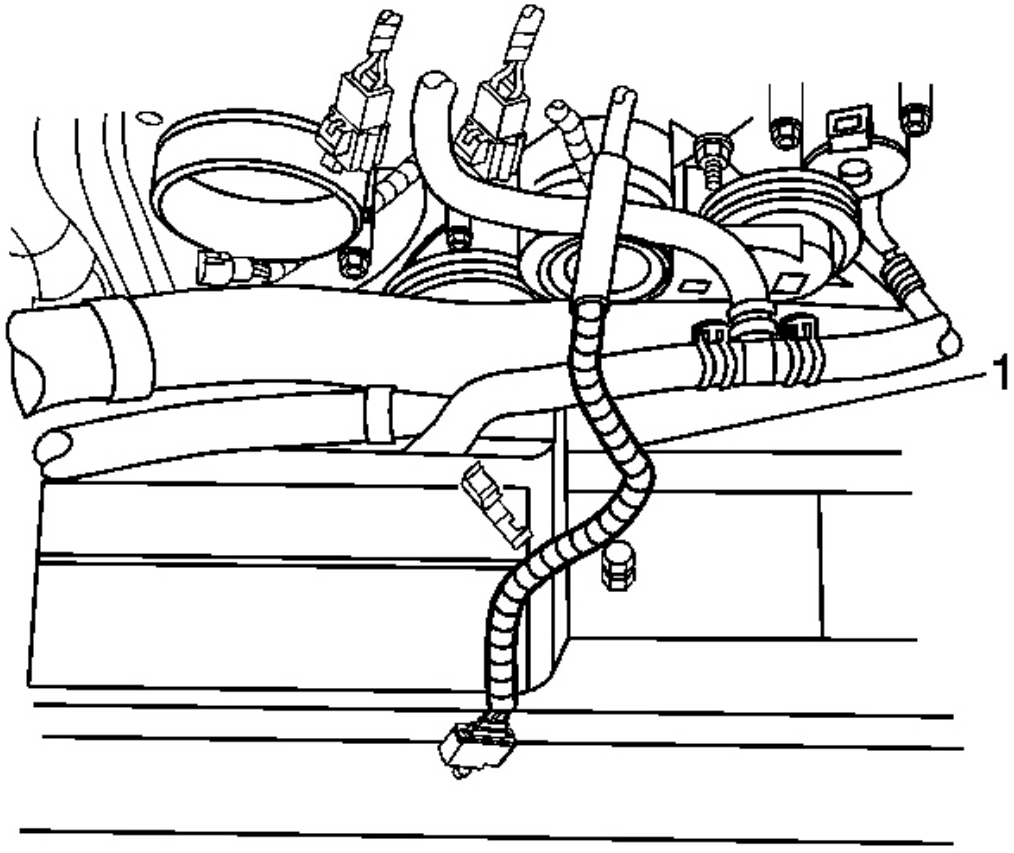


Fig. 174: Identifying Mass Air Flow Sensor Wire
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the MAF sensor wire (1) from the radiator support retainer clip.
3. Disconnect the surge tank inlet hose assembly from the radiator support tabs.

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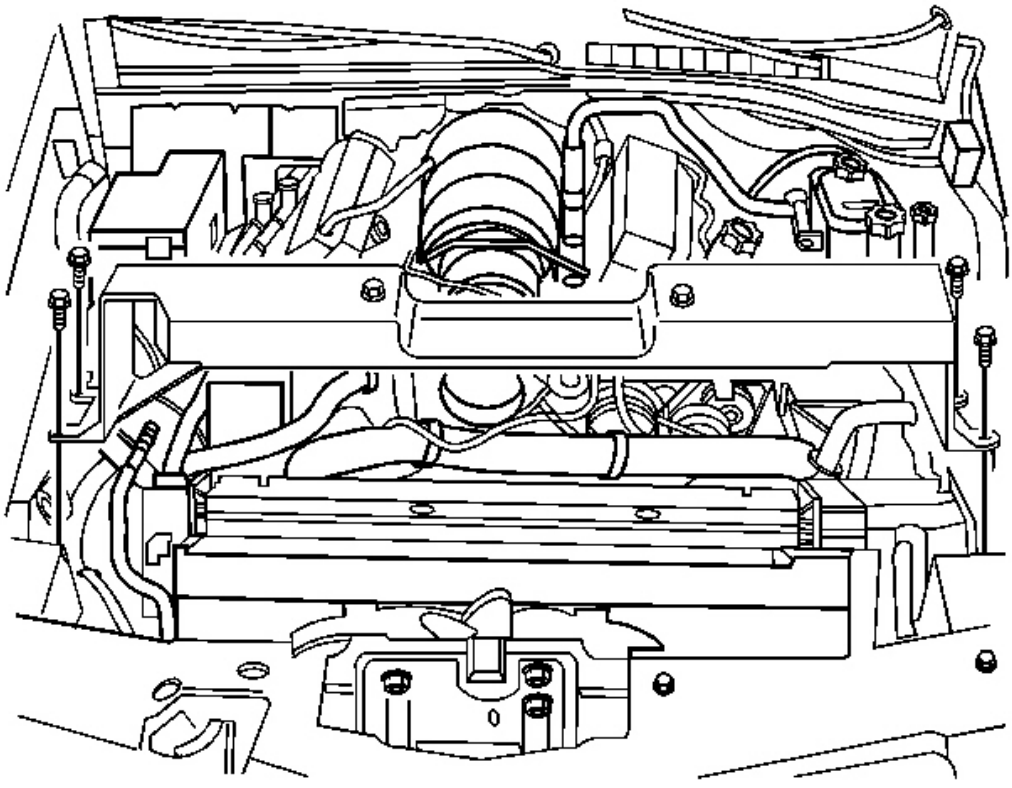


Fig. 175: Identifying Radiator Support Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the radiator support bolts.

IMPORTANT: Note the position of the radiator support in relationship to the fan shroud. This must be reassembled correctly in order to retain the fan shroud.

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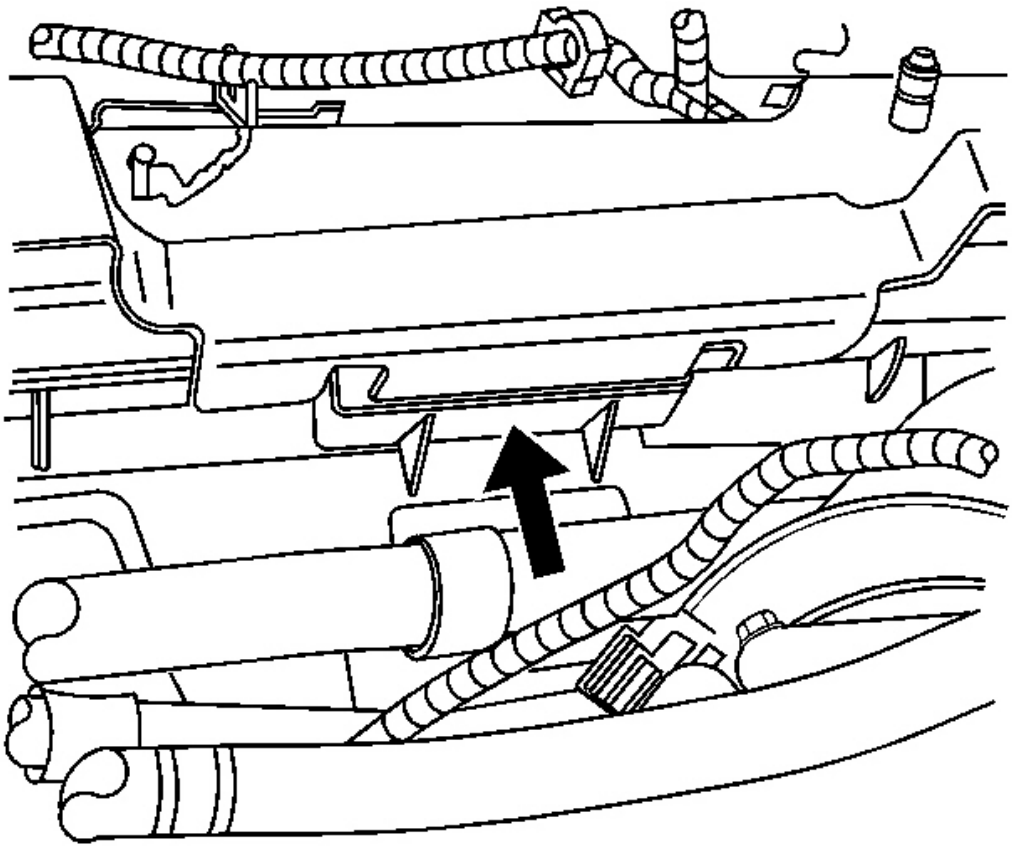


Fig. 176: Identifying Radiator Support
Courtesy of GENERAL MOTORS CORP.

5. Remove the radiator support.

Installation Procedure

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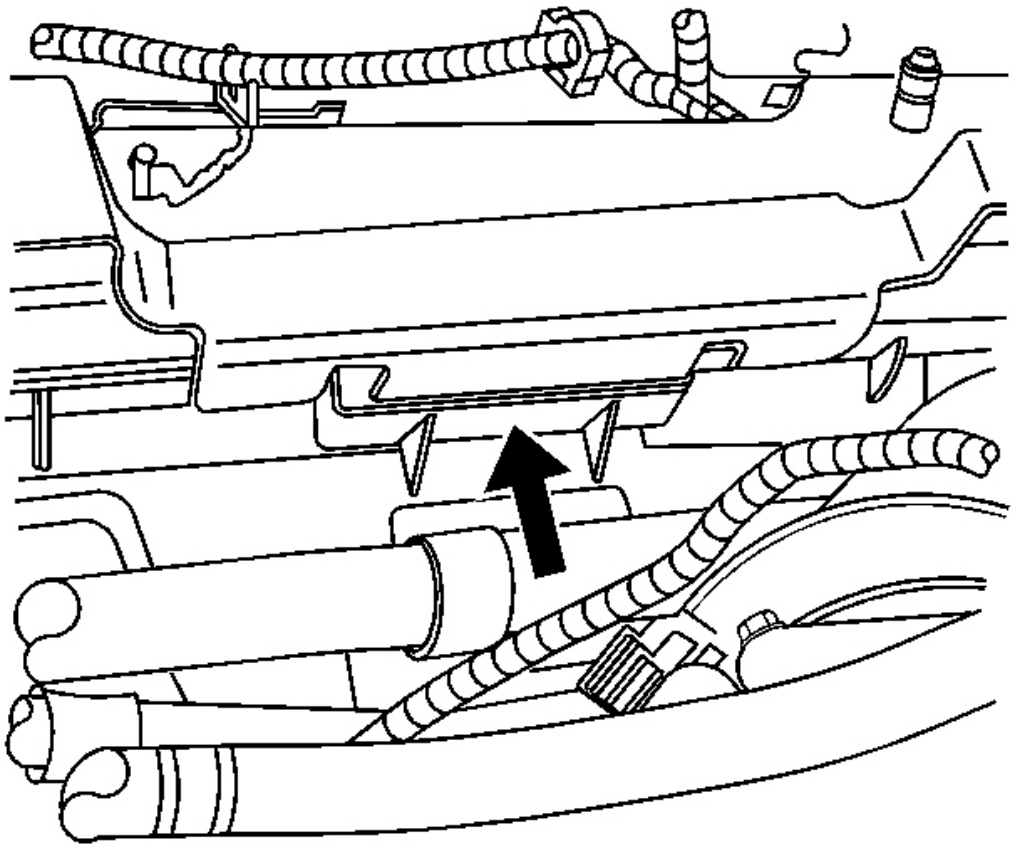


Fig. 177: Identifying Radiator Support
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Position the radiator support in the correct relationship to the fan shroud.

1. Install the radiator support.

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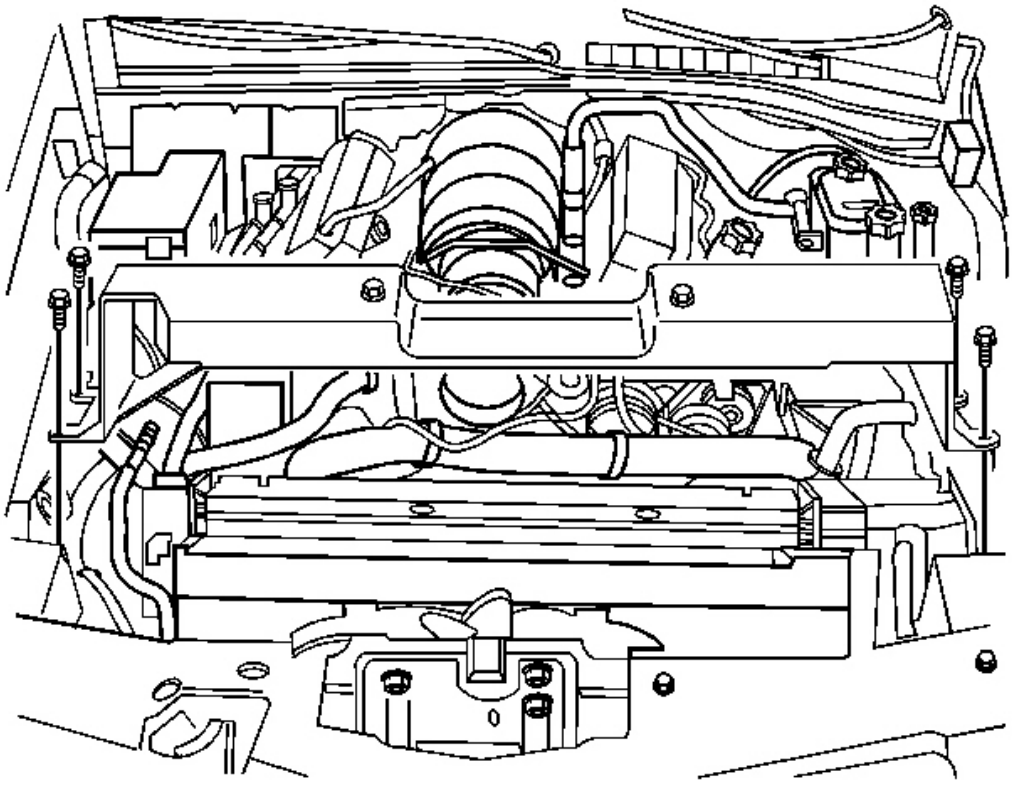


Fig. 178: Identifying Radiator Support Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

2. Install the radiator support bolts.

   Tighten: Tighten the bolts to 9 N.m (80 lb in).

3. Connect the surge tank inlet hose assembly to the radiator support tabs.

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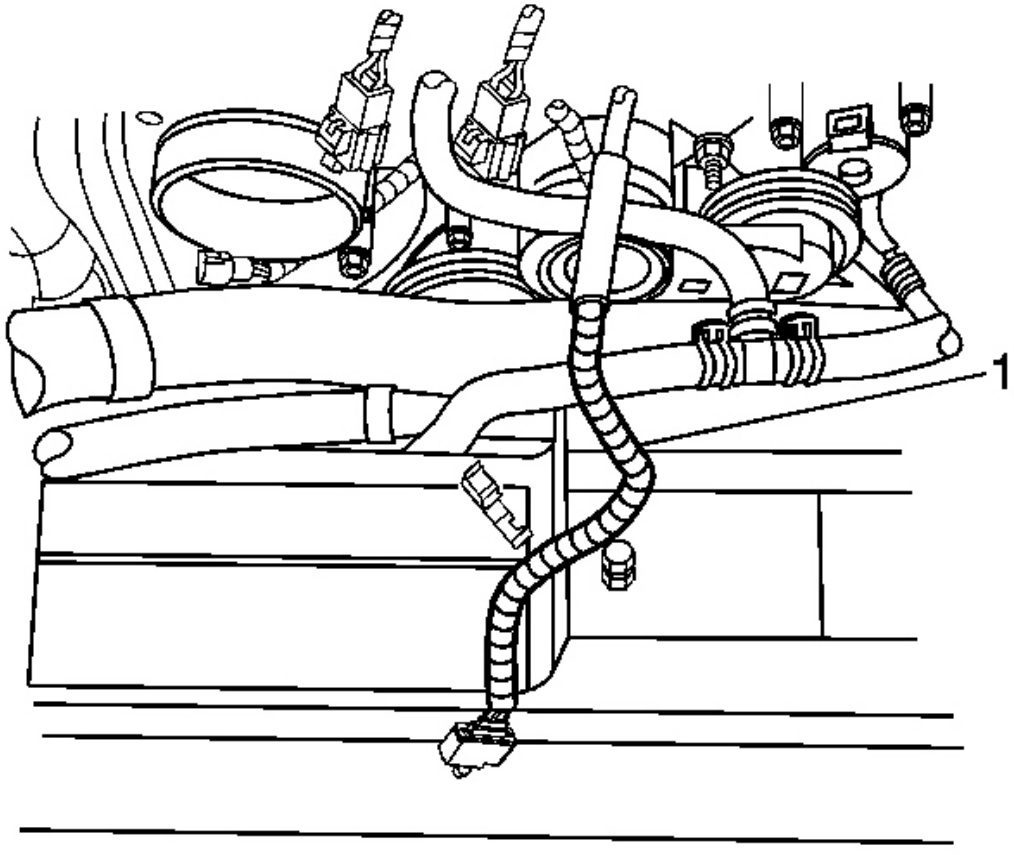


Fig. 179: Identifying Mass Air Flow Sensor Wire
Courtesy of GENERAL MOTORS CORP.

4. Connect the MAF sensor wire (1) to the radiator support retainer clip.
5. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

RADIATOR AIR BAFFLE ASSEMBLIES AND DEFLECTORS (FRONT AIR DEFLECTOR)

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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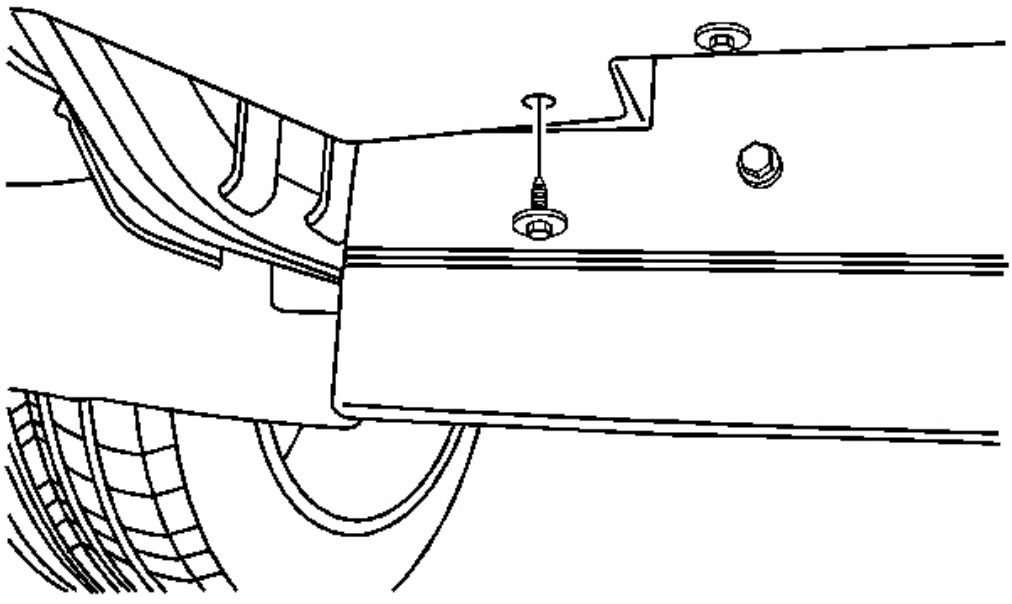


Fig. 180: Removing/Installing RH Radiator Air Baffle Lower Screw
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove the outer most front fascia screws to add additional clearance when removing the front air deflector.

2. Remove the RH radiator air baffle lower screw.

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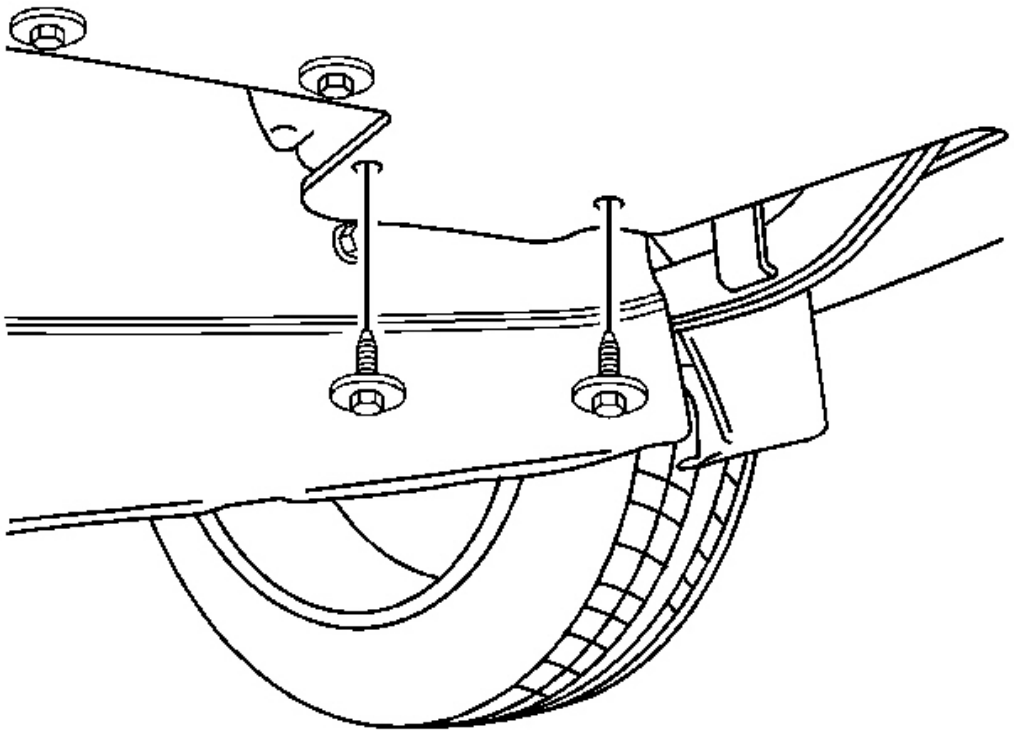


Fig. 181: Removing/Installing LH Radiator Air Baffle Lower Screws
Courtesy of GENERAL MOTORS CORP.

3. Remove the LH radiator air baffle lower screws.
4. Remove the front air deflector upper mounting screws.

Automotive-Manual.net

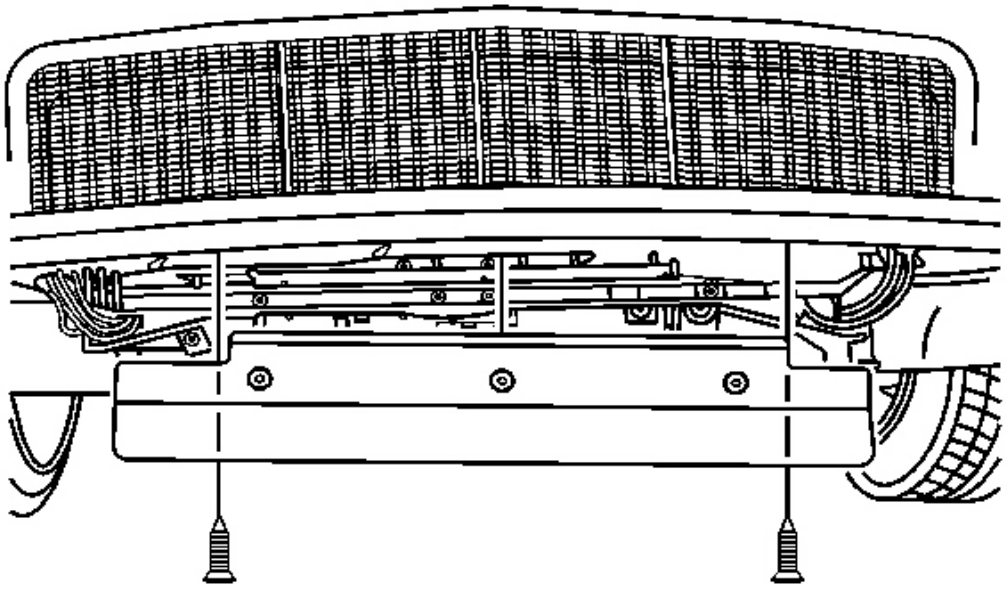


Fig. 182: Removing/Installing Front Air Deflector Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the front air deflector bolts from the frame support.
6. Remove the front air deflector.

Installation Procedure

1. Install the front air deflector.

NOTE: Refer to Fastener Notice .

Automotive-Manual.net

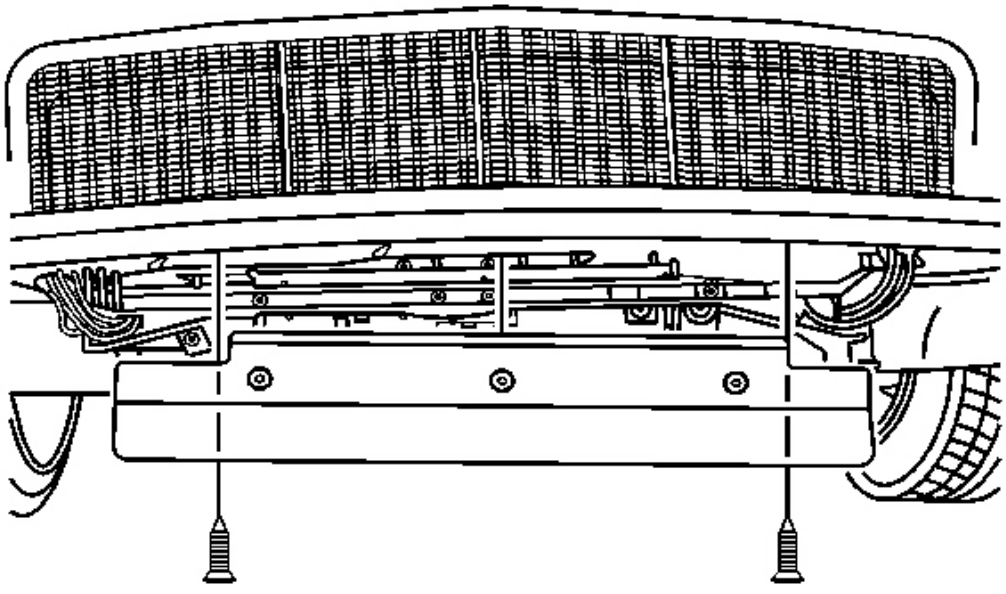


Fig. 183: Removing/Installing Front Air Deflector Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the front air deflector bolts to the frame support.

   Tighten: Tighten the bolts to 2.5 N.m (22 lb in).

3. Install the front air deflector upper mounting screws.

   Tighten: Tighten the screws to 2.5 N.m (22 lb in).

Automotive-Manual.net

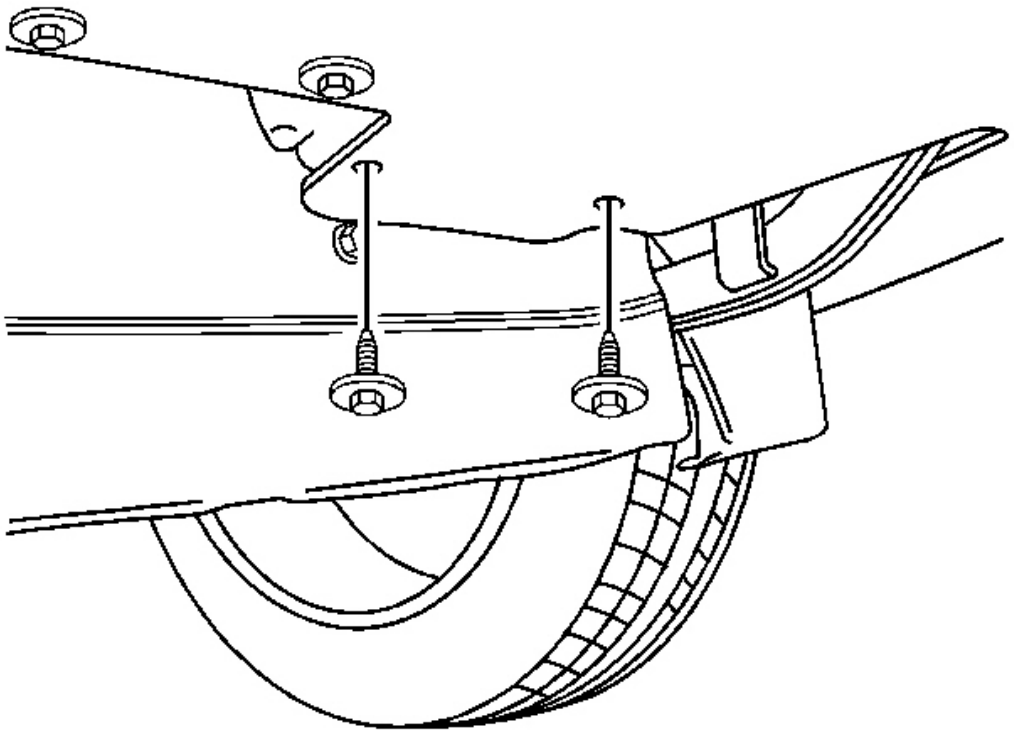


Fig. 184: Removing/Installing LH Radiator Air Baffle Lower Screws
Courtesy of GENERAL MOTORS CORP.

4. Install the LH radiator air baffle lower screws.

   Tighten: Tighten the screws to 2.5 N.m (22 lb in).

Automotive-Manual.net

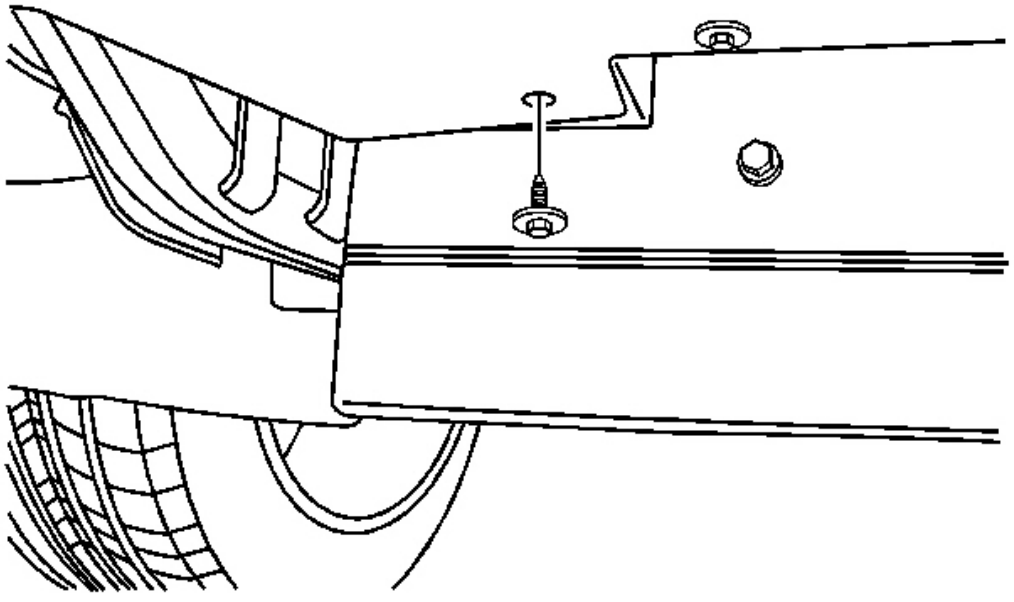


Fig. 185: Removing/Installing RH Radiator Air Baffle Lower Screw
Courtesy of GENERAL MOTORS CORP.

5. Install the RH radiator air baffle lower screw.

   Tighten: Tighten the screws to 2.5 N.m (22 lb in).

6. Lower the vehicle.

RADIATOR AIR BAFFLE ASSEMBLIES AND DEFLECTORS (RADIATOR AIR BAFFLE)

Removal Procedure

1. Remove the cruise control bracket. Refer to **Distance Sensing Cruise Control Bracket Replacement** .
2. Remove the ambient air temperature sensor. Refer to **Ambient Air Temperature Sensor Replacement** .
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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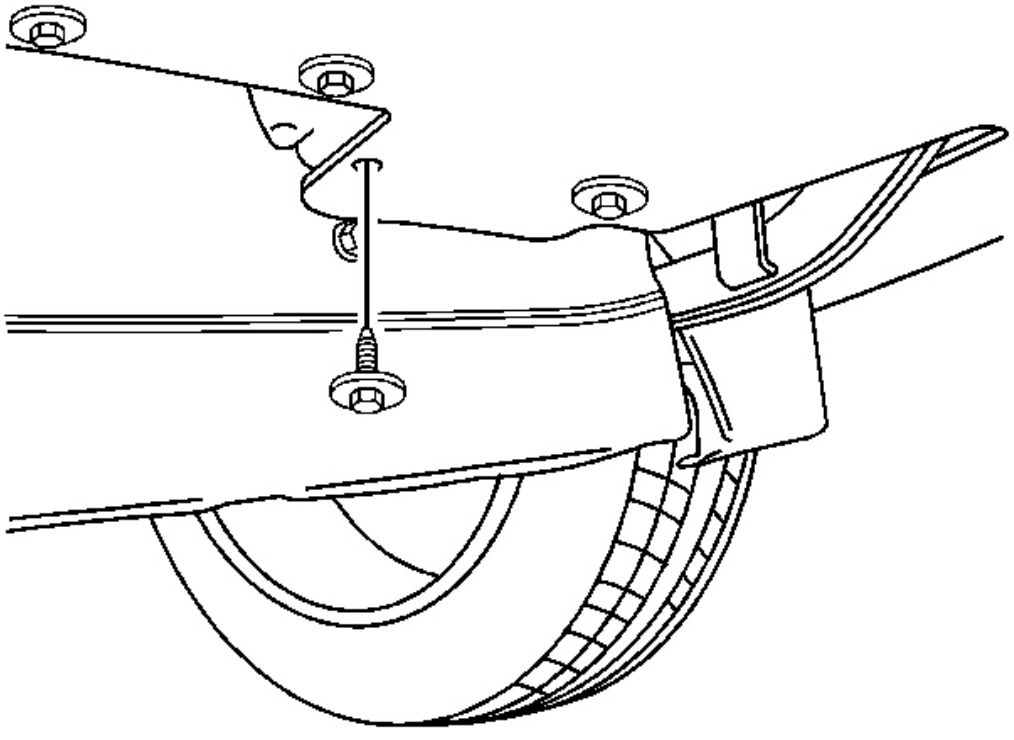


Fig. 186: Removing/Installing LH Radiator Air Baffle Lower Screws
Courtesy of GENERAL MOTORS CORP.

4. Remove the LH radiator air baffle lower screws.

Automotive-Manual.net

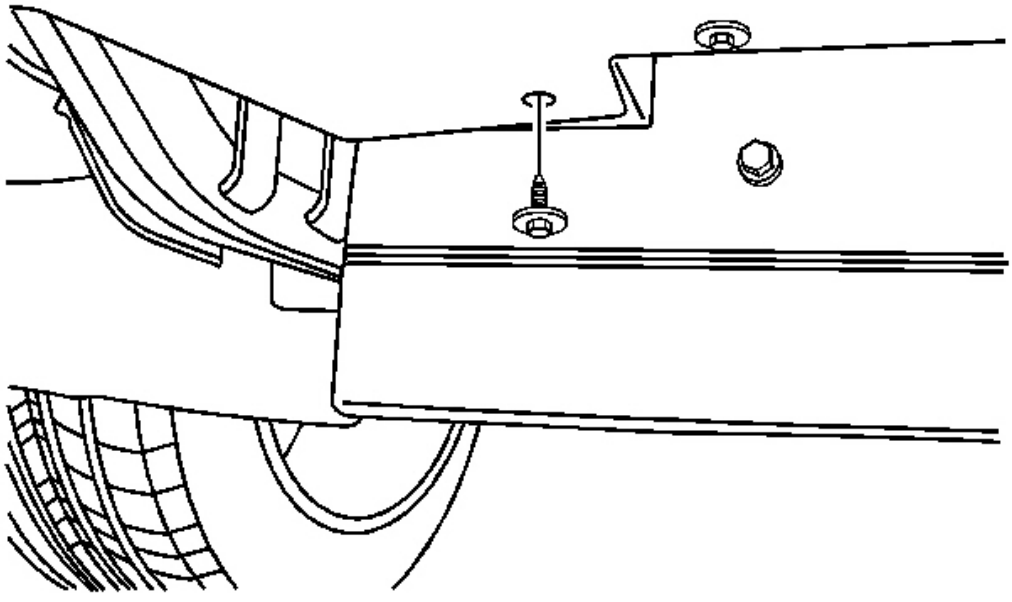


Fig. 187: Removing/Installing RH Radiator Air Baffle Lower Screw
Courtesy of GENERAL MOTORS CORP.

5. Remove the RH radiator air baffle lower screw.

Automotive-Manual.net

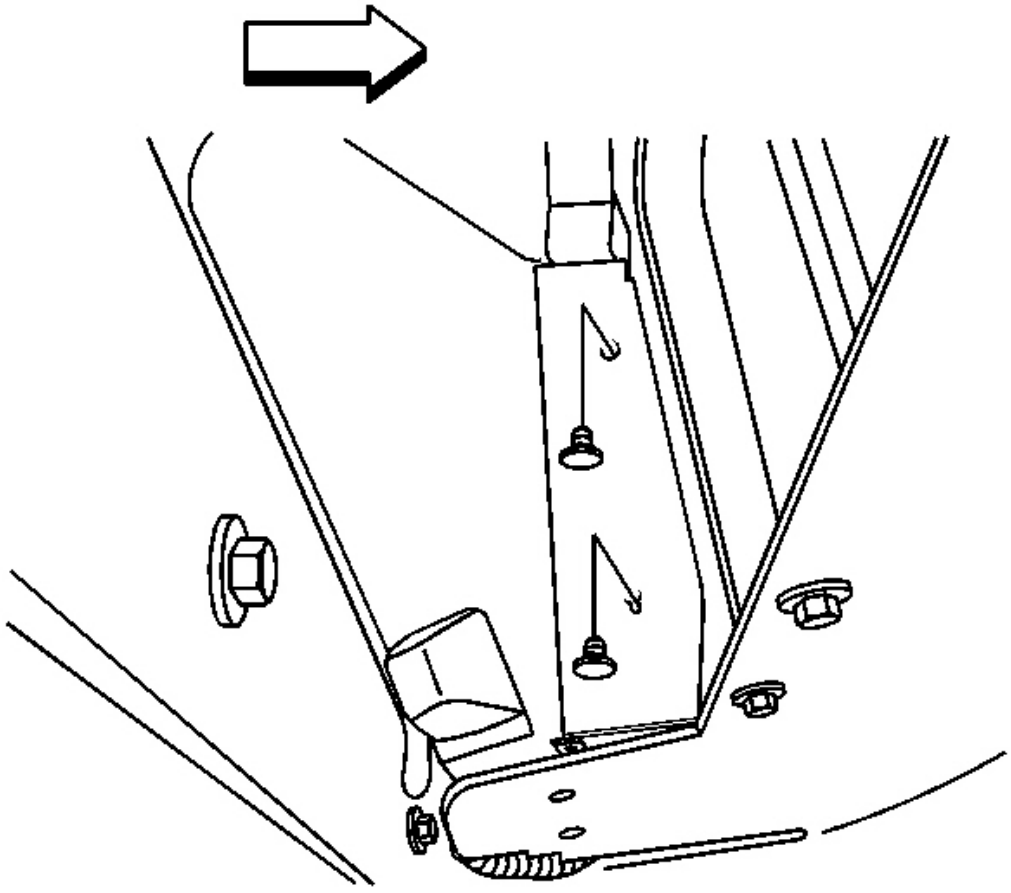


Fig. 188: Removing/Installing LH Side Air Deflector Retainer Pins
Courtesy of GENERAL MOTORS CORP.

6. Remove the LH side air deflector retainer pins.

Automotive-Manual.net

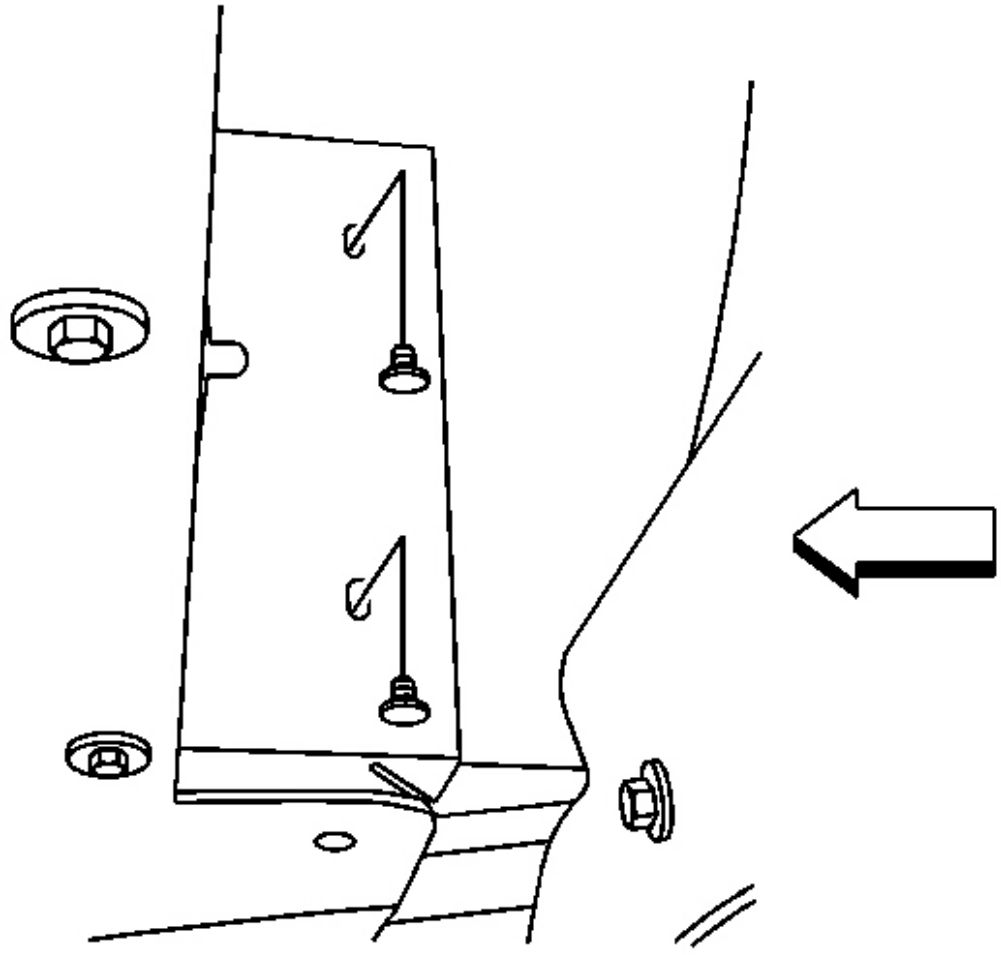


Fig. 189: Removing/Installing RH Side Air Deflector Retainer Pins
Courtesy of GENERAL MOTORS CORP.

7. Remove the RH side air deflector retainer pins.
8. Lower the vehicle.

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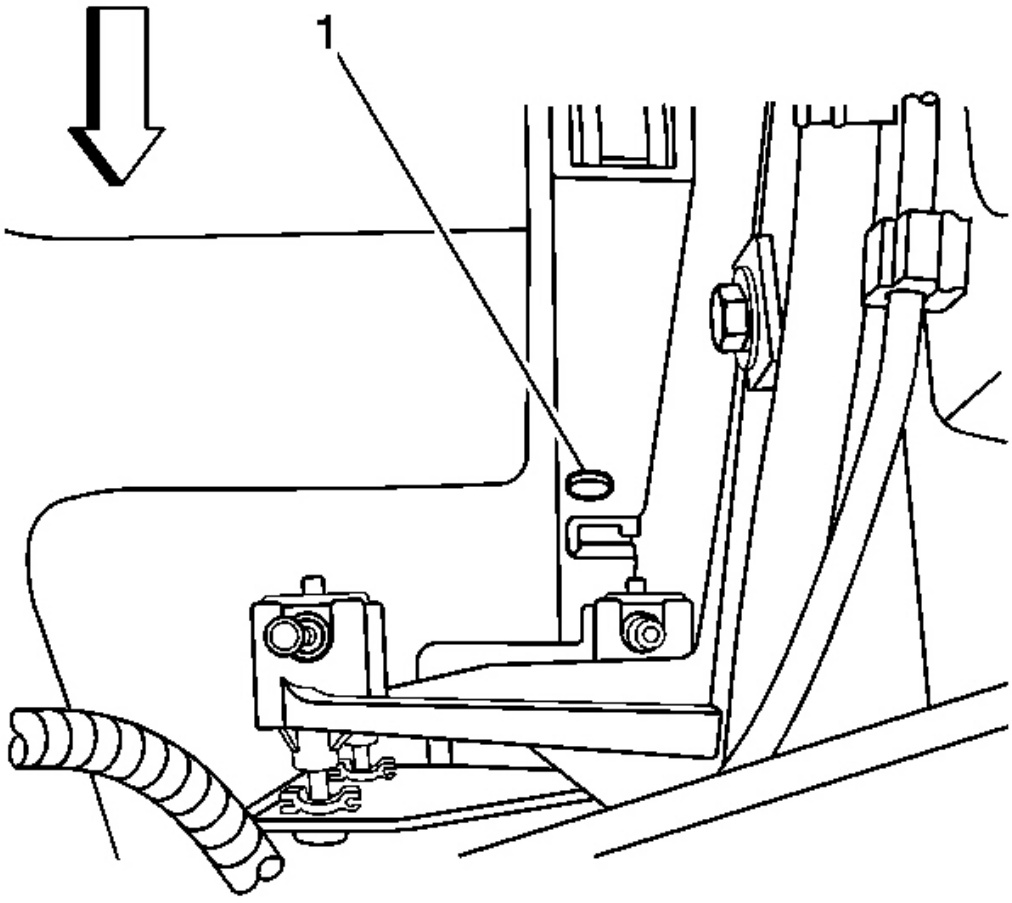


Fig. 190: Removing/Installing LH Radiator Air Baffle Upper Retainer Pin
Courtesy of GENERAL MOTORS CORP.

9. Remove the LH radiator air baffle upper retainer pin (1).

Automotive-Manual.net

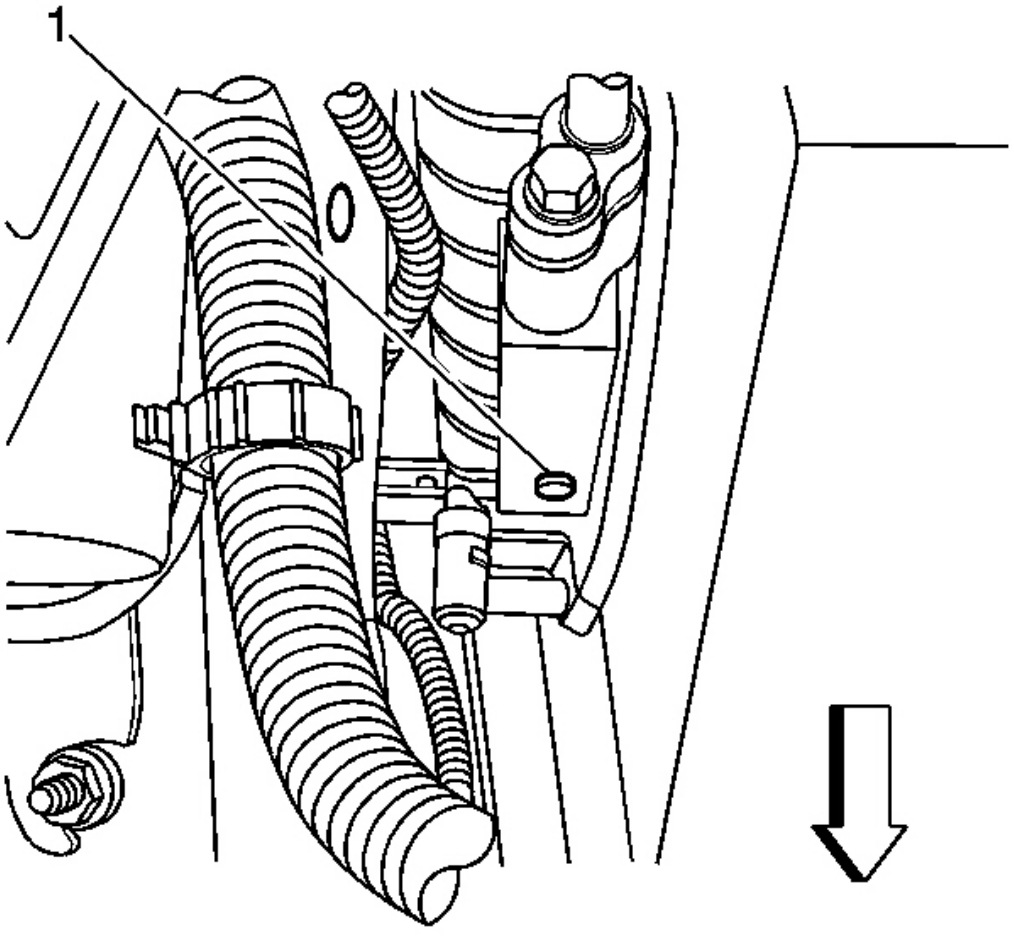


Fig. 191: Removing/Installing RH Radiator Air Baffle Upper Retainer Pin
Courtesy of GENERAL MOTORS CORP.

10. Remove the RH radiator air baffle upper retainer pin (1).

Automotive-Manual.net

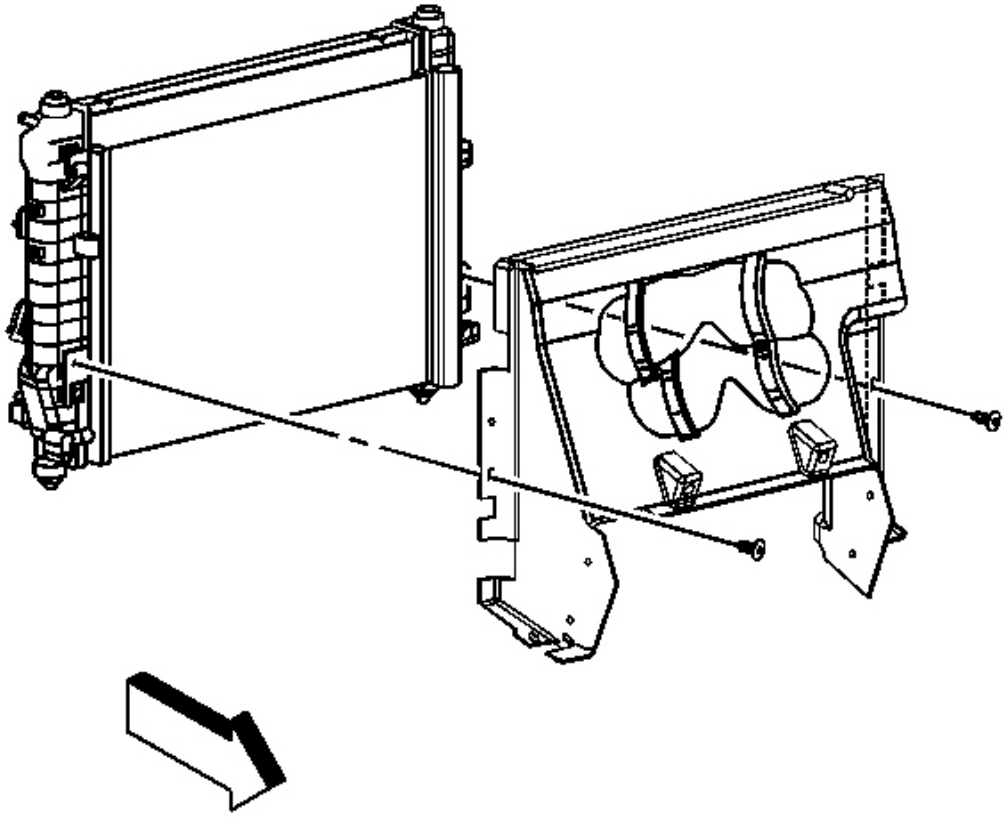


Fig. 192: Removing/Installing Radiator Air Baffle
Courtesy of GENERAL MOTORS CORP.

11. Remove the radiator air baffle.

Installation Procedure

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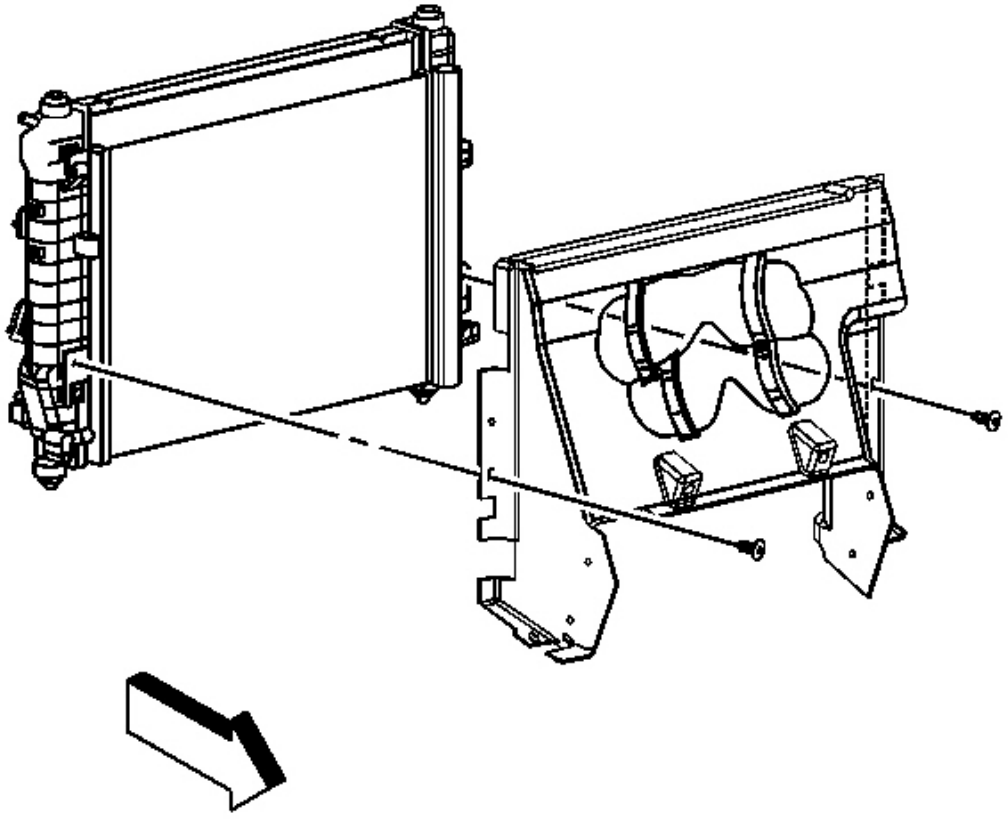


Fig. 193: Removing/Installing Radiator Air Baffle
Courtesy of GENERAL MOTORS CORP.

1. Install the radiator air baffle.

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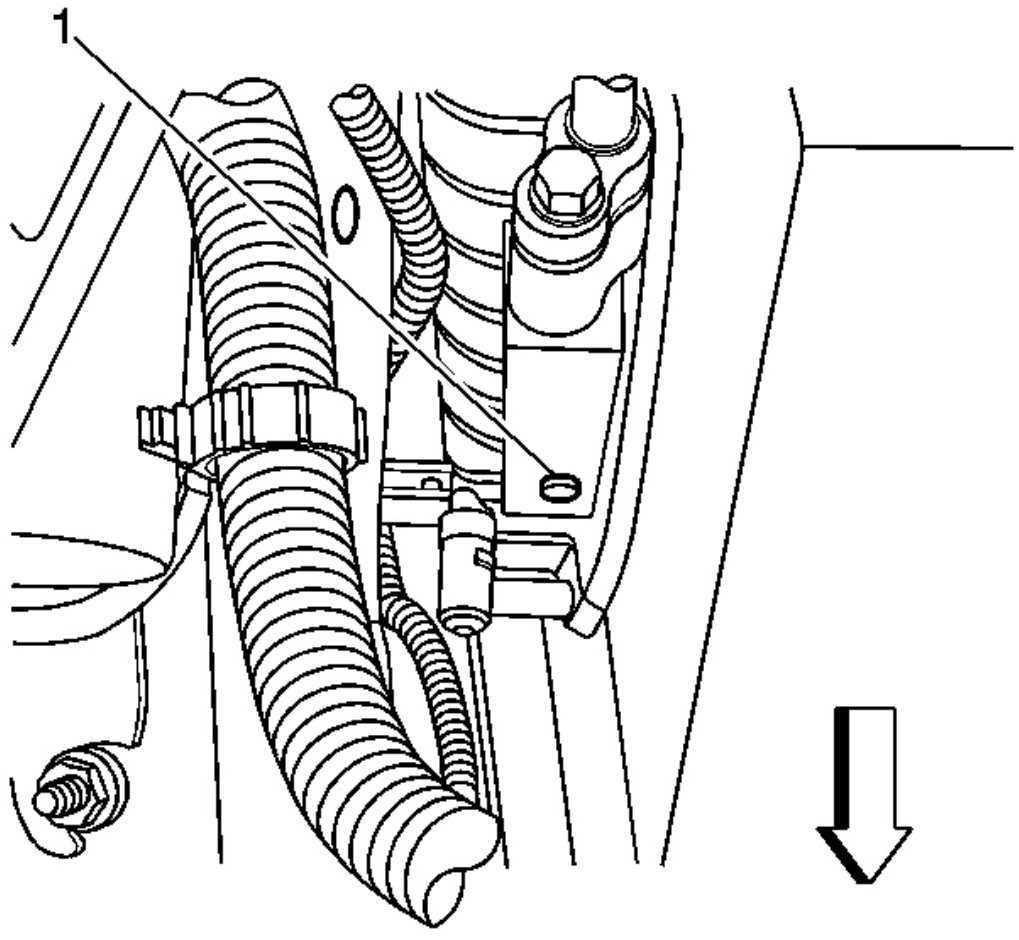


Fig. 194: Removing/Installing RH Radiator Air Baffle Upper Retainer Pin
Courtesy of GENERAL MOTORS CORP.

2. Install the RH radiator air baffle upper retainer pin (1).

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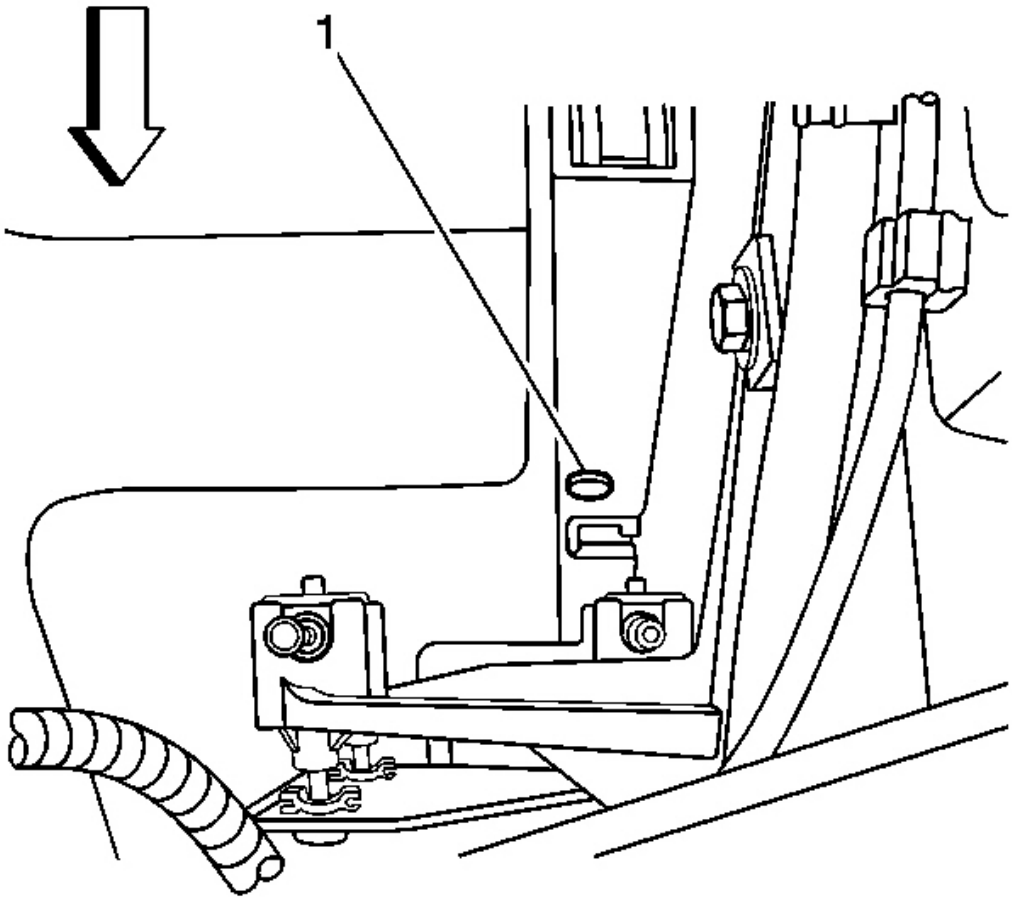


Fig. 195: Removing/Installing LH Radiator Air Baffle Upper Retainer Pin
Courtesy of GENERAL MOTORS CORP.

3. Install the LH radiator air baffle upper retainer pin (1).
4. Raise and support the vehicle.

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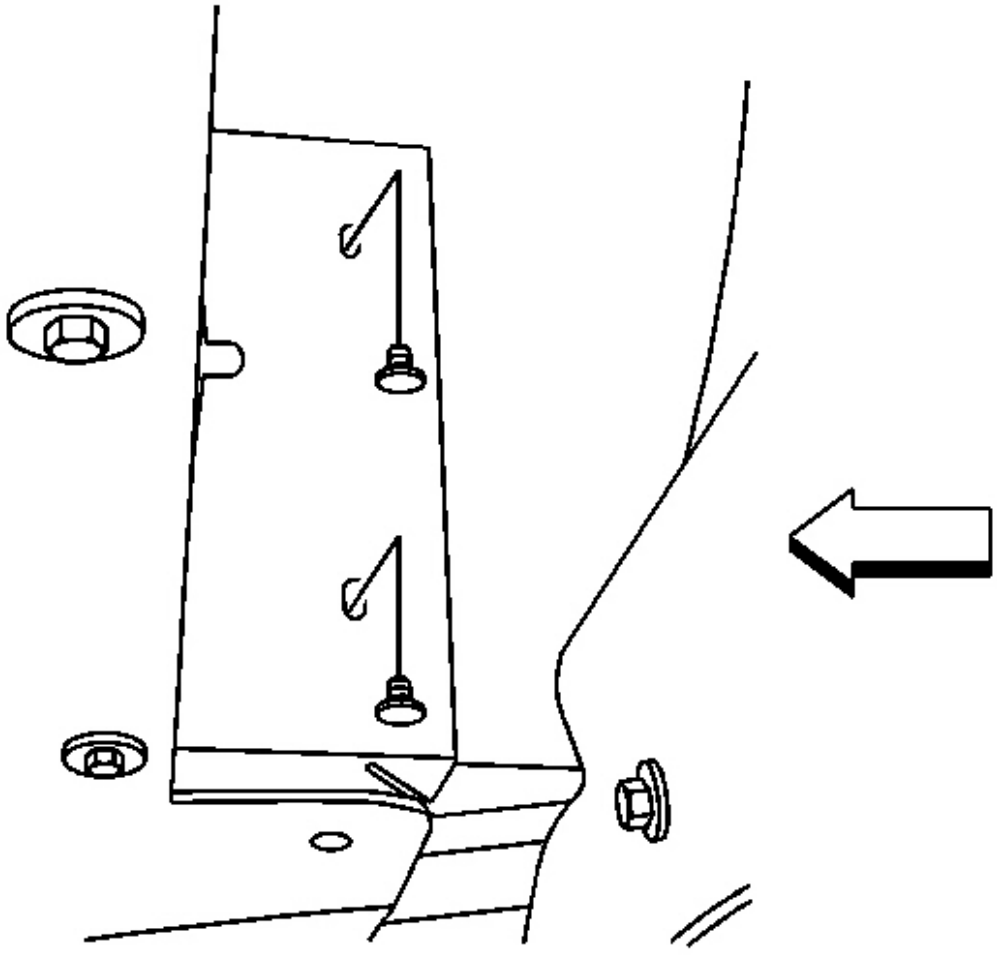


Fig. 196: Removing/Installing RH Side Air Deflector Retainer Pins
Courtesy of GENERAL MOTORS CORP.

5. Install the RH side air deflector retainer pins.

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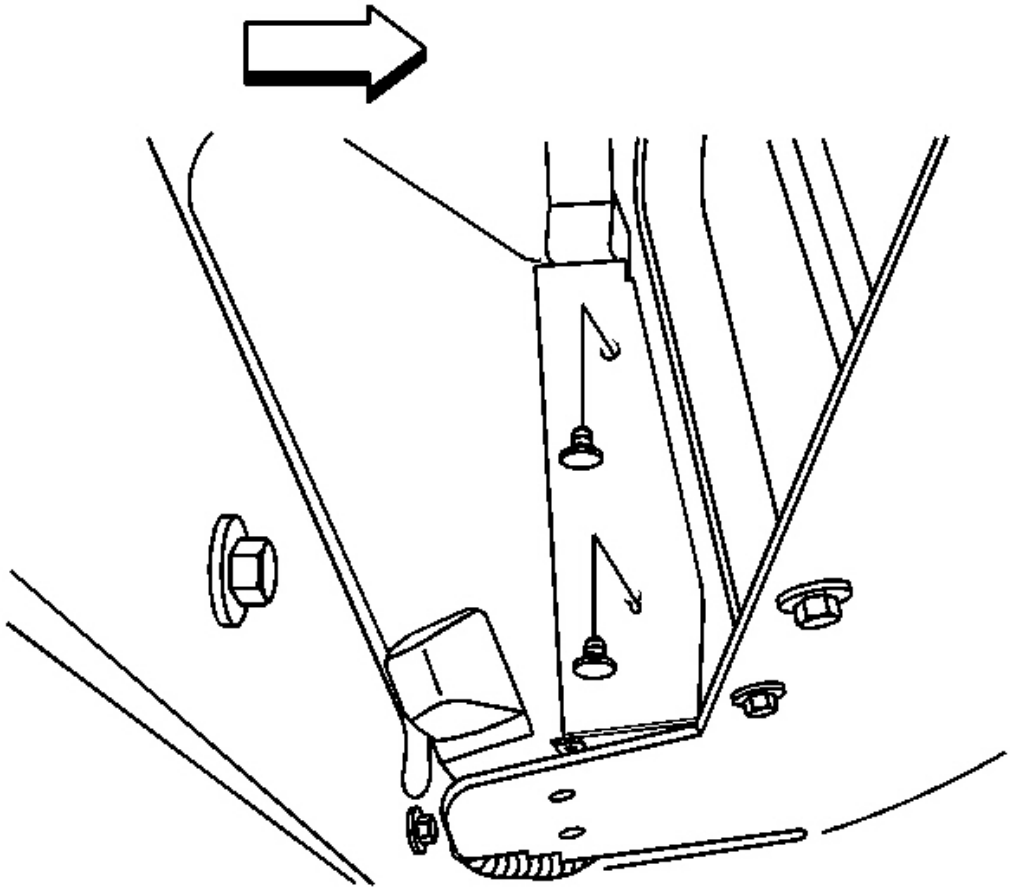


Fig. 197: Removing/Installing LH Side Air Deflector Retainer Pins
Courtesy of GENERAL MOTORS CORP.

6. Install the LH side air deflector retainer pins.

NOTE: **Refer to Fastener Notice .**

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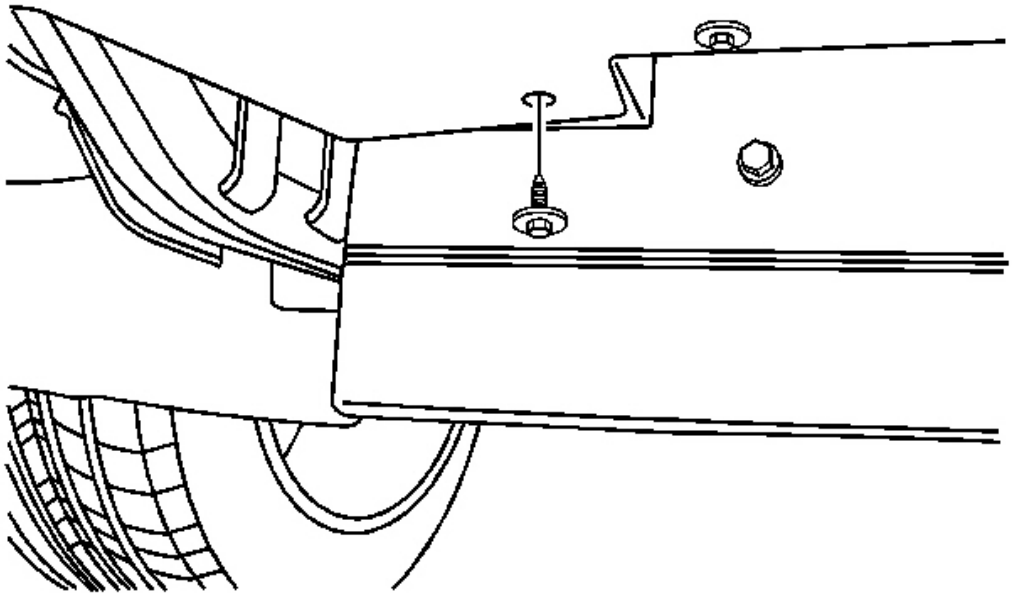


Fig. 198: Removing/Installing RH Radiator Air Baffle Lower Screw
Courtesy of GENERAL MOTORS CORP.

7. Install the RH radiator air baffle lower screw.

   Tighten: Tighten the bolt to 2.5 N.m (22 lb in).

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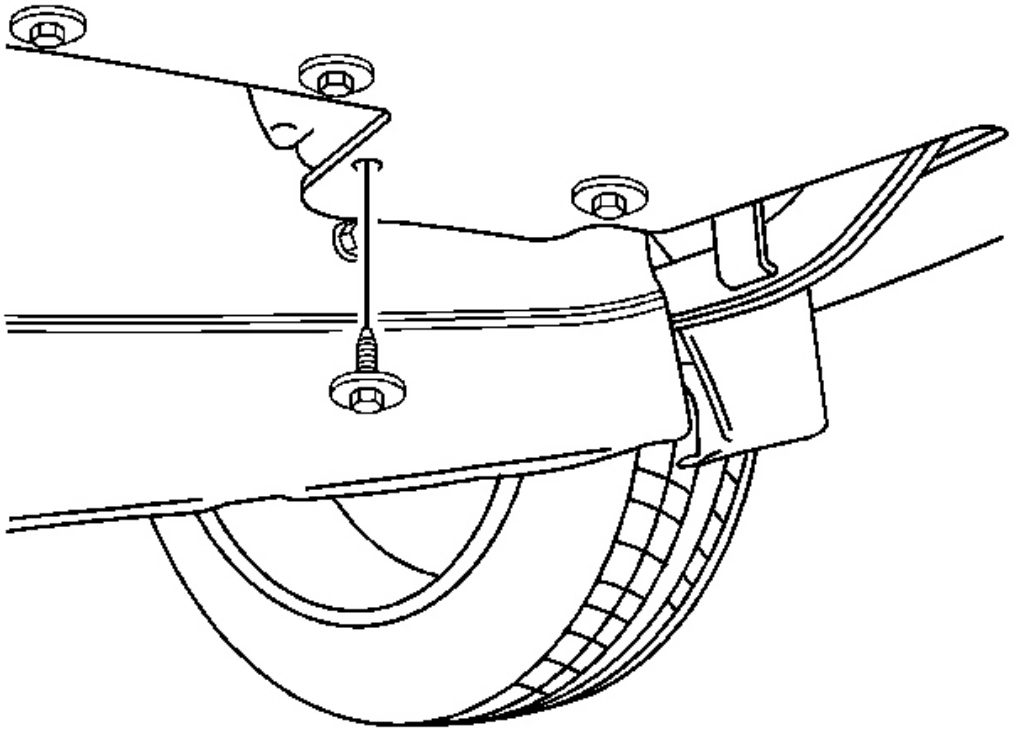


Fig. 199: Removing/Installing LH Radiator Air Baffle Lower Screws
Courtesy of GENERAL MOTORS CORP.

8. Install the LH radiator air baffle lower screws.

   Tighten: Tighten the bolts to 2.5 N.m (22 lb in).

9. Lower the vehicle.
10. Install the ambient air temperature sensor. Refer to **Ambient Air Temperature Sensor Replacement** .
11. Install the cruise control bracket. Refer to **Distance Sensing Cruise Control Bracket Replacement** .

ENGINE COOLANT HEATER REPLACEMENT - LEFT SIDE

Removal Procedure

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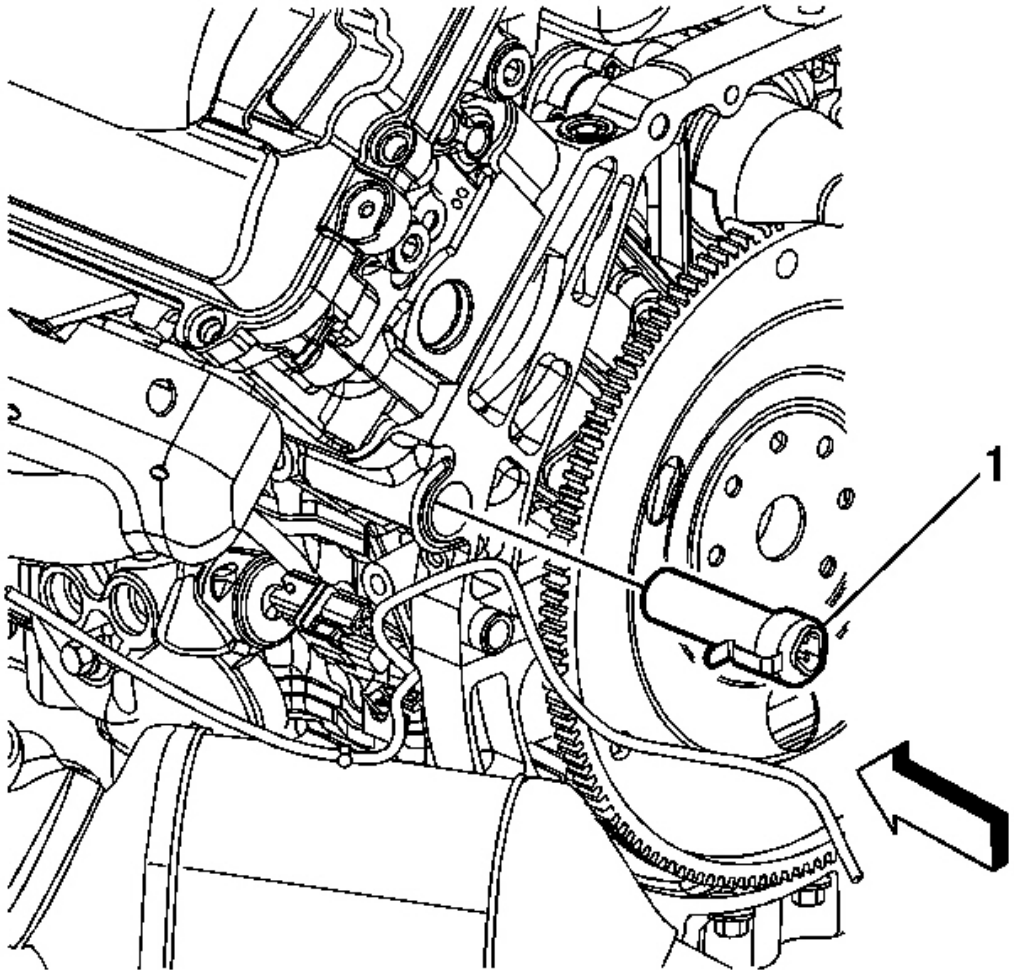


Fig. 200: View Of Coolant Heater From Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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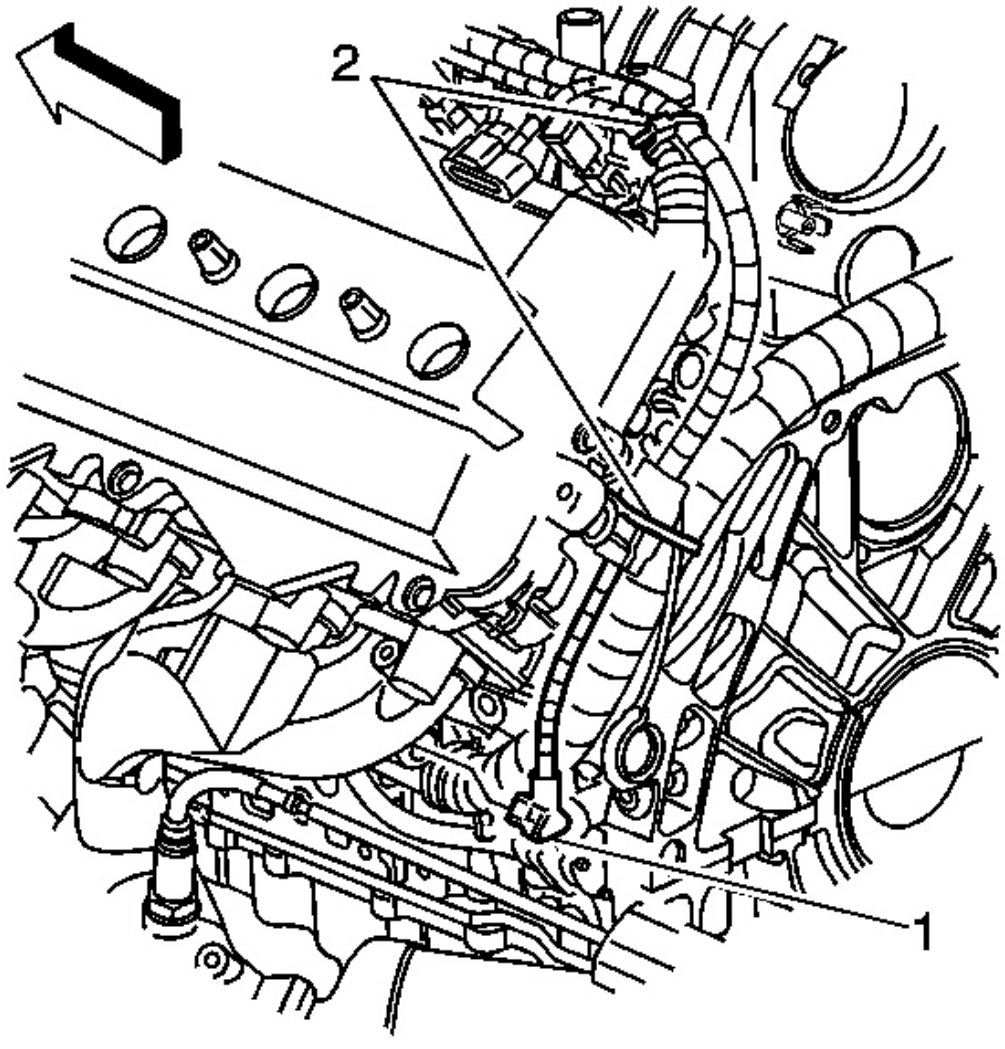


Fig. 201: Disconnecting/Connecting Coolant Heater Power Supply Cord
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the coolant heater power supply cord (1) from the coolant heater.

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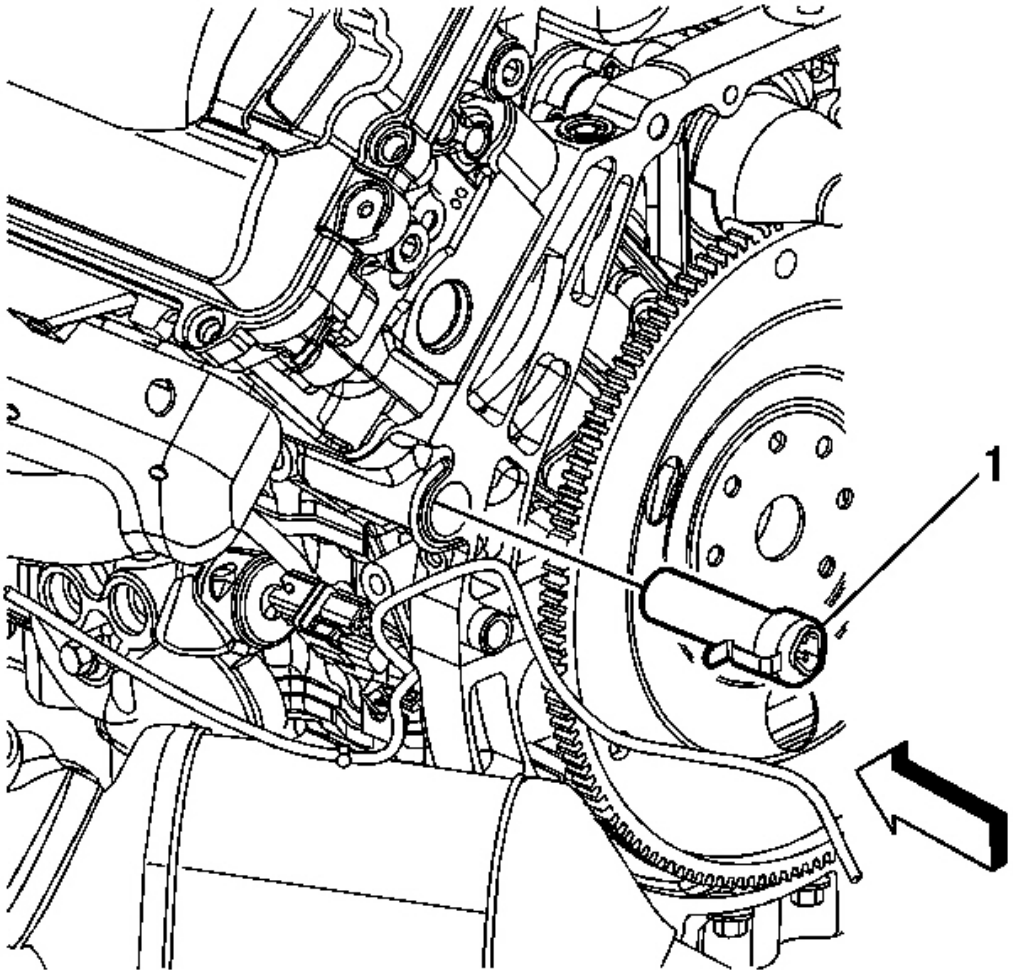


Fig. 202: View Of Coolant Heater From Engine Block
Courtesy of GENERAL MOTORS CORP.

3. Pry outward on the heater retaining clip.
4. Pull the heater (1) from the engine block.

Installation Procedure

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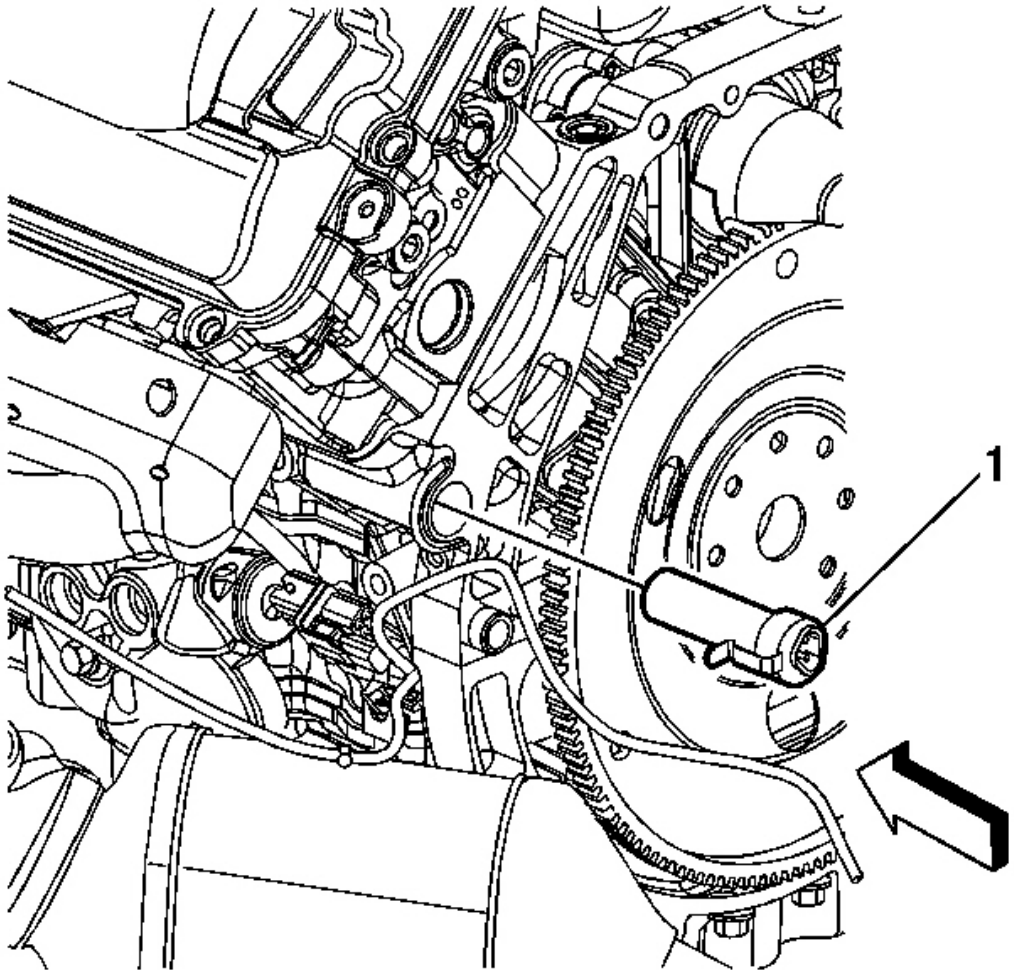


Fig. 203: View Of Coolant Heater From Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Install the coolant heater (1) into the engine block. The retaining clip should snap into place.

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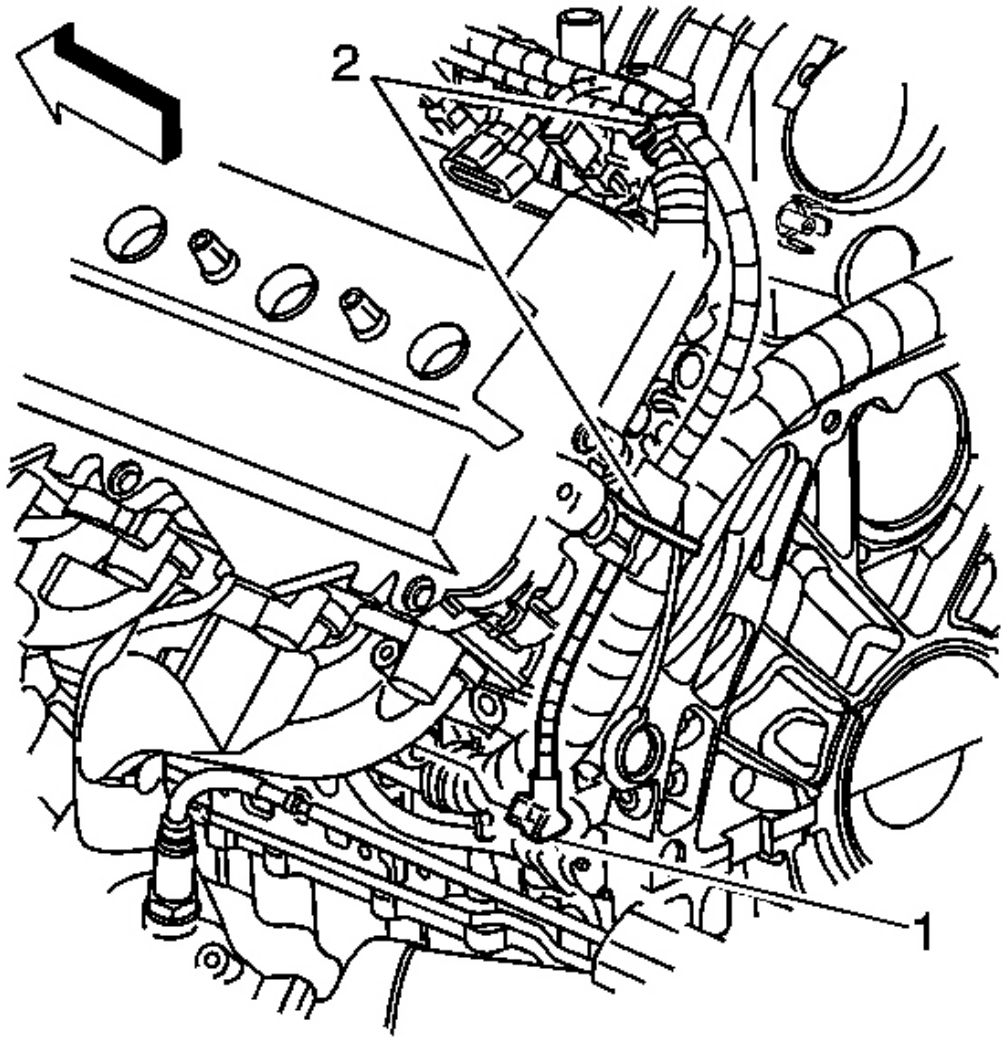


Fig. 204: Disconnecting/Connecting Coolant Heater Power Supply Cord
Courtesy of GENERAL MOTORS CORP.

2. Connect the electrical connector to the coolant heater.
3. Lower the vehicle. Refer to **Lifting and Jacking the Vehicle** .

ENGINE COOLANT HEATER CORD REPLACEMENT

Removal Procedure

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1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

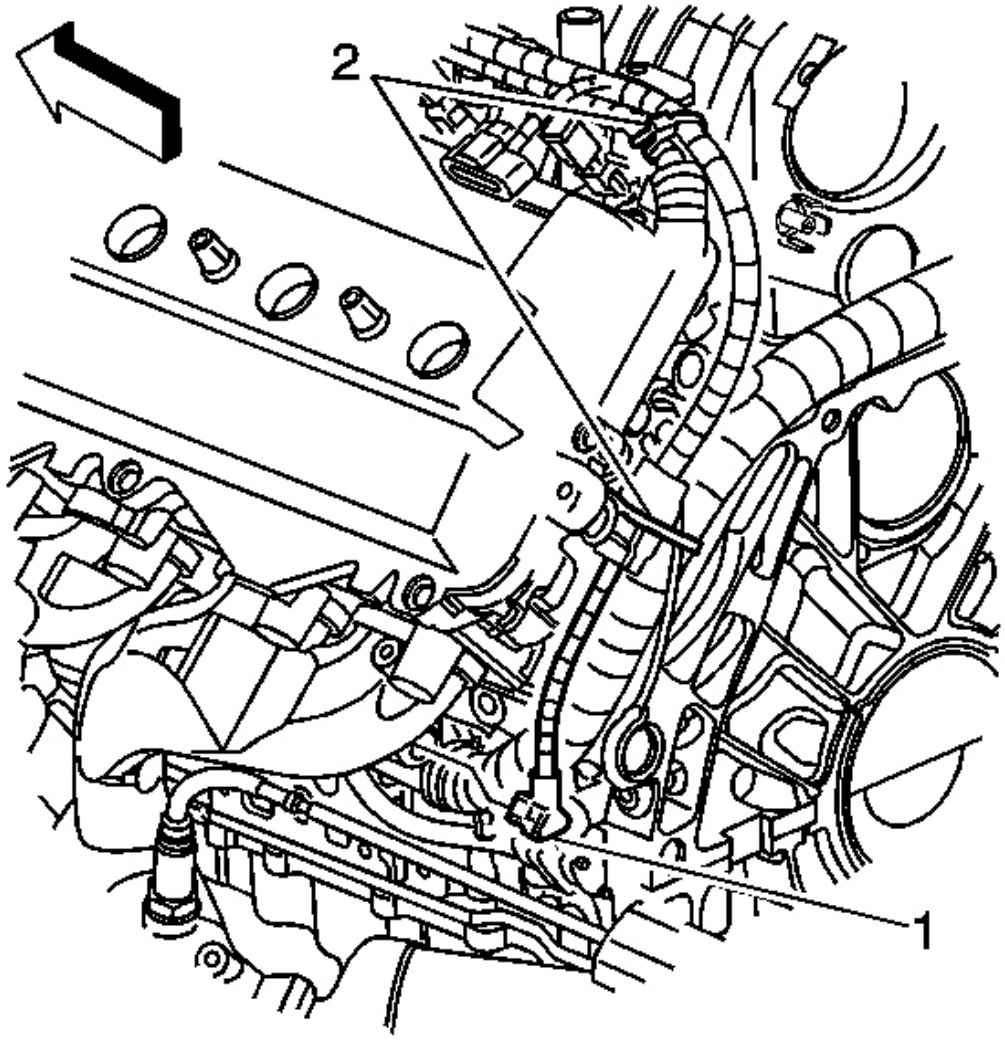


Fig. 205: Disconnecting/Connecting Coolant Heater Power Supply Cord
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the engine coolant heater cord from the engine coolant heater.
3. Lower the vehicle.
4. Disconnect the coolant heater cord clips from the wiring harness conduit.
5. Remove the engine coolant heater cord.

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Installation Procedure

1. Position the coolant heater power supply cord to the engine.
2. Route the coolant heater cord along the engine wiring harness conduit.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

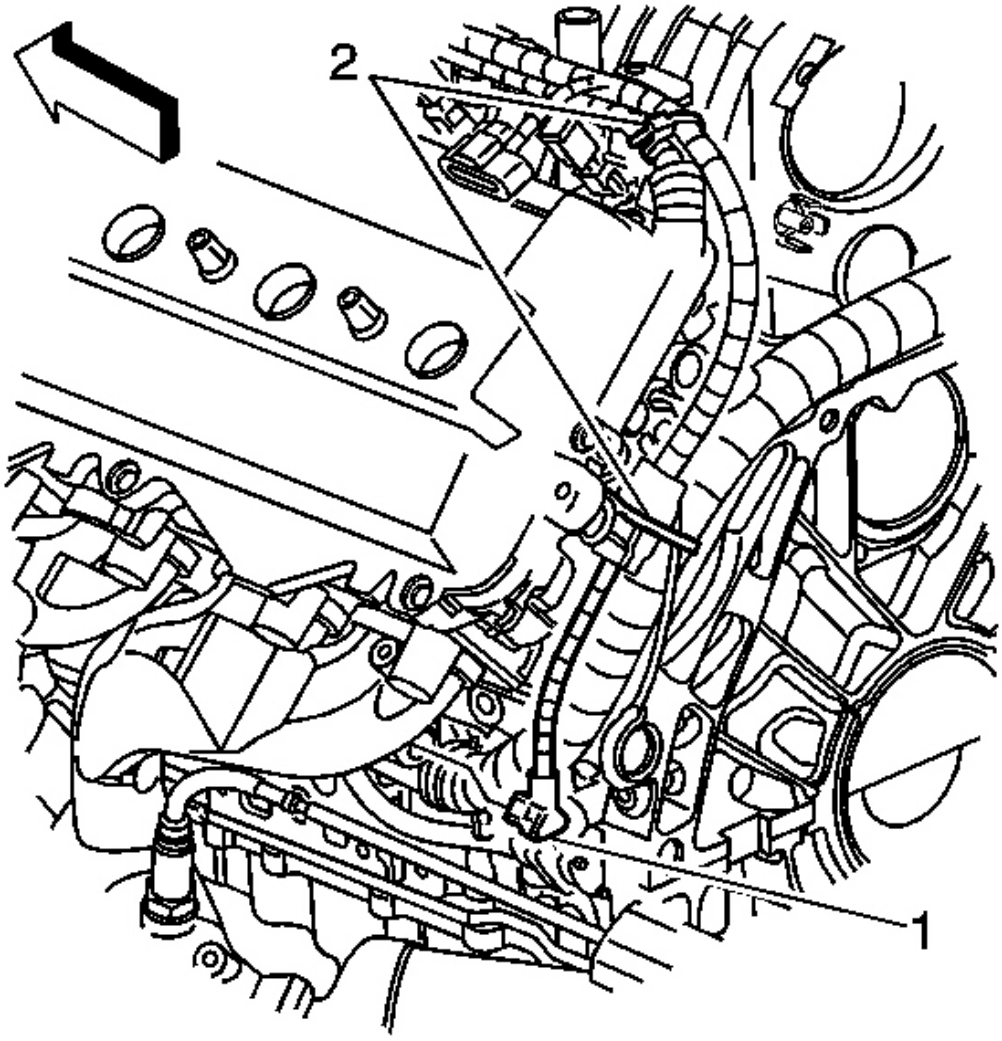


Fig. 206: Disconnecting/Connecting Coolant Heater Power Supply Cord
Courtesy of GENERAL MOTORS CORP.

4. Connect the coolant heater power cord to the heater.

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5. Secure the coolant heater cord clip to the coolant cord.
6. Lower the vehicle.
7. Secure the coolant heater cord clips to the engine wiring harness conduit.

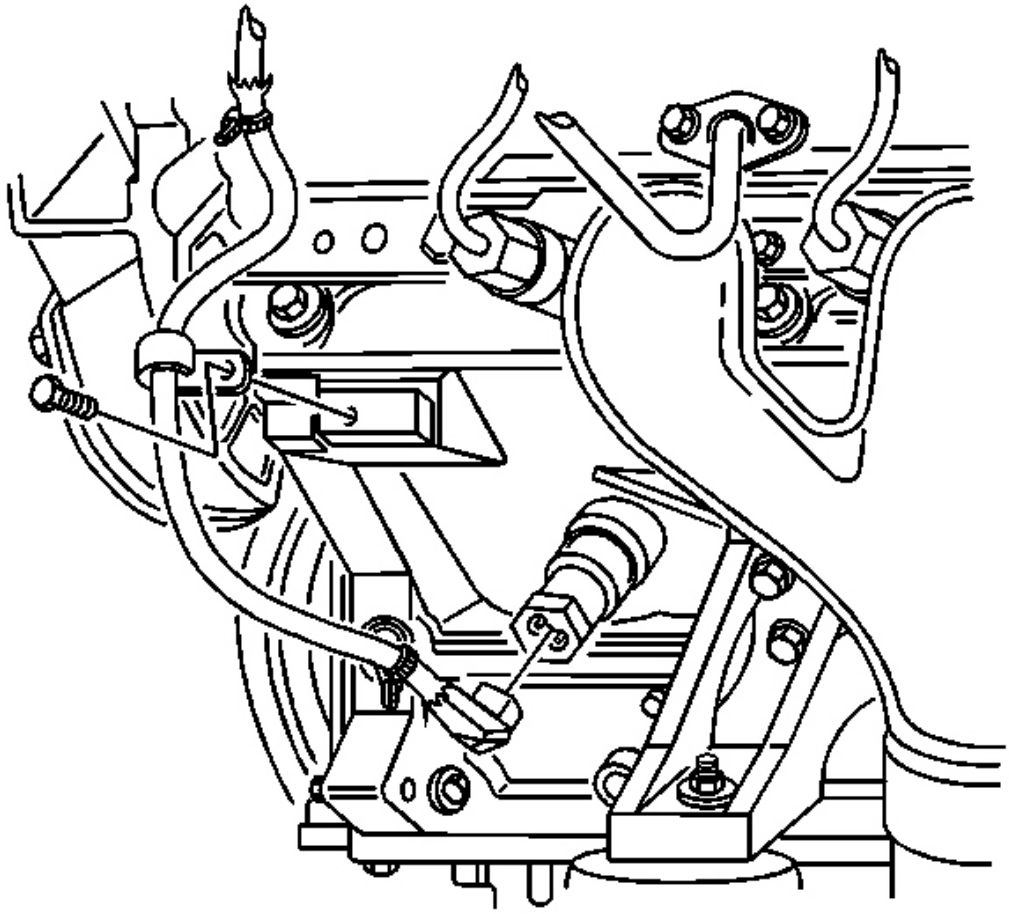


Fig. 207: Identifying Engine Coolant Heater Cord Clip Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

8. Install the engine coolant heater cord to the engine coolant heater.
9. Position the engine coolant heater cord clip and install the bolt.

Tighten: Tighten the engine coolant heater cord clip bolt to 32 N.m (24 lb ft).

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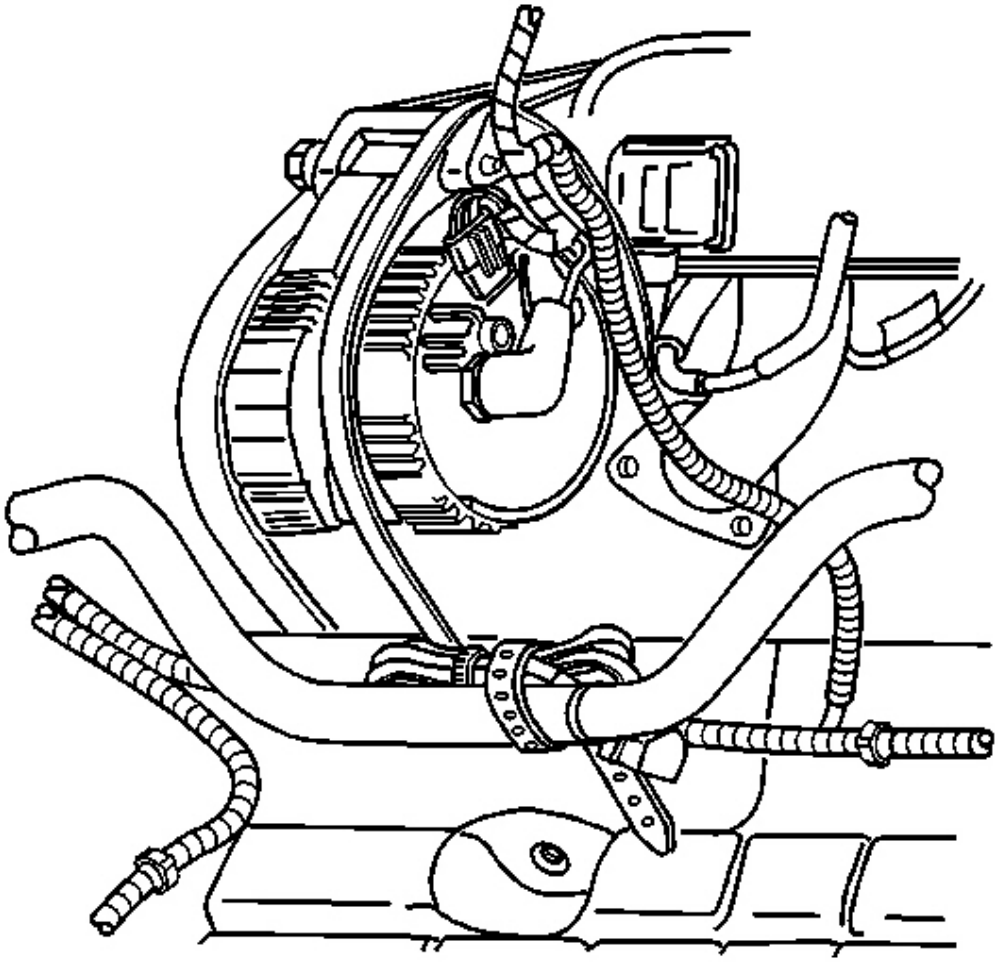


Fig. 208: Proper Routing Of Engine Coolant Heater Cord Over Generator
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The engine coolant heater cord must not contact the engine, pipes, manifold or any moving parts. Always keep the electrical cord neatly rolled up with the plug end of the cord tucked into the center of the coil and secured in place with the supplied tie straps.

10. Route the engine coolant heater cord over the generator.
11. Coil the engine coolant heater cord into a bundle and secure the bundle to the secondary air injection hose pump with the strap.

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DESCRIPTION AND OPERATION

COOLING FAN DESCRIPTION AND OPERATION

Cooling Fan Control - Variable Speed Single Fan System

The engine cooling fan is a variable speed fan. The ECM controls the fan speed by sending a pulse width modulated signal to the cooling fan control module. The cooling fan control module varies the voltage drop across the cooling fan motor in relation to the pulse width modulated signal.

Cooling fan speed is effected by many different conditions and can be adjusted from 10% to 90% duty cycle (PWM), 90% is considered high speed fan. When multiple cooling fan speed requests are received the ECM uses the highest cooling fan speed of all the requests. The ECM commands the cooling fan ON under the following conditions:

- Cooling fan duty cycle starts when engine coolant temperature reaches approximately 95°C (204°F) and reaches high speed at temperatures above 113°C (235°F).
- Cooling fan duty cycle starts when A/C pressure reaches approximately 1100 kPa (160 psi) and reaches high speed at A/C pressures above 2480 kPa (360 psi).
- At engine oil temperatures above approximately 150°C (302°F) the cooling fan duty cycle will be commanded to high speed.
- At transmission oil temperatures above approximately 132°C (270°F) the cooling fan duty cycle will be commanded to high speed.
- After the vehicle is shut OFF if the engine coolant temperature at key-off is greater than 113°C (235°F) or the A/C pressure is greater than 1720 kPa (249 psi) the cooling fan duty cycle is set to 50%, low speed. If the coolant temperature drops below 110°C (230°F) and the A/C pressure drops below 1660 kPa (241 psi) the fan will shut OFF. The fans will automatically shut OFF after 2 min. regardless of coolant temperature.

COOLING SYSTEM DESCRIPTION AND OPERATION

Cooling Fan Control - Variable Speed Single Fan System

The engine cooling fan is a variable speed fan. The ECM controls the fan speed by sending a pulse width modulated signal to the cooling fan control module. The cooling fan control module varies the voltage drop across the cooling fan motor in relation to the pulse width modulated signal.

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- At transmission oil temperatures above approximately 132°C (270°F) the cooling fan duty cycle will be commanded to high speed.
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Low Coolant Message

The engine cooling system contains an engine coolant level switch to alert the driver in the event of a low coolant level. When the engine coolant level in the surge tank falls below a certain level, the coolant level switch opens. When the HVAC control module detects an open level on the coolant level indicator control circuit for at least 10 seconds, it will send a message to the IPC requesting display of the LOW COOLANT message. There is approximately a 10 second delay before the HVAC control module sends a class 2 message, to prevent the message from being displayed due to coolant sloshing in the surge tank. After the LOW COOLANT message has been triggered the message will be displayed for that entire ignition cycle.

Engine Coolant Indicator(s)

COOLANT OVER TEMP

The IPC illuminates the COOLANT OVER TEMP indicator in the message center when the following occurs:

- The PCM detects that the engine coolant temperature exceeds 124°C (256°F). The IPC receives a class 2 message from the PCM indicating the high coolant temperature.
- The IPC will also illuminate the CHECK GAGES indicator and a chime sounds when this condition exists.

Cooling System

The cooling system's function is to maintain an efficient engine operating temperature during all engine speeds and operating conditions. The cooling system is designed to remove approximately one-third of the heat produced by the burning of the air-fuel mixture. When the engine is cold, the system cools slowly or not at all. This allows the engine to warm quickly.

Cooling Cycle

Coolant is drawn from the radiator outlet and into the water pump inlet by the water pump. Some coolant will then be pumped from the water pump, to the heater core, then back to the water pump. This provides the passenger compartment with heat and defrost.

Coolant is also pumped through the water pump outlet and into the engine block. In the engine block, the coolant circulates through the water jackets surrounding the cylinders where it absorbs heat.

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The coolant is then forced through the cylinder head gasket openings and into the cylinder heads. In the cylinder heads, the coolant flows through the water jackets surrounding the combustion chambers and valve seats, where it absorbs additional heat.

Coolant is also directed to the throttle body. There it circulates through passages in the casting. During initial start up, the coolant assists in warming the throttle body. During normal operating temperatures, the coolant assists in keeping the throttle body cool.

From the cylinder heads, the coolant is then forced to the thermostat. The flow of coolant will either be stopped at the thermostat until the engine is warmed or it will flow through the thermostat and into the radiator where it is cooled and the coolant cycle is completed.

Operation of the cooling system requires proper functioning of all cooling system components. The cooling system consists of the following components:

Coolant

The engine coolant is a solution made up of a 50-50 mixture of DEX-COOL and clean drinkable water. The coolant solution carries excess heat away from the engine to the radiator, where the heat is dissipated to the atmosphere.

Radiator

The radiator is a heat exchanger. It consists of a core and two tanks. The aluminum core is a crossflow tube and fin design. This is a brazed tube with convoluted louvered fin design. Separate tubes and fins are stacked together with a manifold at each end. The entire assembly is then brazed forming a homogeneous unified structure. The fins allow for efficient heat transfer from the coolant to the atmosphere. The inlet and outlet tanks are molded with a high temperature, glass reinforced nylon plastic. The tank and gasket is supplied as an assembly with silicone gasket attached to the tank. The tanks are clamped to the core with clinch tabs. The tabs are part of the aluminum header at each end of the core. The radiator also has a drain cock which is located in the bottom of the passenger side tank. The drain cock includes the drain cock and drain cock seal.

The radiator removes heat from the coolant passing through it. The fins on the core absorb heat from the coolant passing through the tubes. As air passes between the fins, it absorbs heat and cools the coolant.

During vehicle use, the coolant heats and expands. The coolant that is displaced by this expansion flows into the surge tank. As the coolant circulates, air is allowed to exit. Coolant without bubbles absorbs heat much better than coolant with bubbles.

Pressure Cap

The pressure cap is a cap that seals and pressurizes the cooling system. It contains a blow off or pressure valve and a vacuum or atmospheric valve. The pressure valve is held against its seat by a spring and protects the radiator by relieving pressure if it exceeds 18 psi. The vacuum valve is held against its seat by a spring, which permits opening of the valve to relieve vacuum created in the cooling system as it cools off. The vacuum, if not relieved, could cause the radiator hoses to collapse.

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The pressure cap allows pressure in the cooling system to build up. As the pressure builds, the boiling point of the coolant goes up as well. Therefore, the coolant can be safely run at a temperature higher than the boiling point of the coolant at atmospheric pressure. The hotter the coolant is, the faster the heat moves from the radiator to the cooler passing air. However, if the pressure exceeds the strength of the spring, the pressure valve rises so that the excess pressure can escape. When the engine cools down, the temperature of the coolant drops and a vacuum is created in the cooling system. This vacuum causes the vacuum valve to open, allowing outside air into the cooling system. This equalizes the pressure in the cooling system with atmospheric pressure, thus preventing the radiator hoses from collapsing.

Surge Tank

The surge tank is a plastic tank with a pressure cap mounted to it. The tank is mounted at a point higher than all other coolant passages. The surge tank provides an air space in the cooling system. The air space allows the coolant to expand and contract. The surge tank also provides a coolant fill point and a central air bleed location.

During vehicle use, the coolant heats and expands. The coolant that is displaced by this expansion flows into the surge tank. As the coolant circulates, air is allowed to exit. This is an advantage to the cooling system. Coolant without bubbles absorbs heat much better than coolant with bubbles.

Air Baffles and Seals

The cooling system uses deflectors, air baffles and air seals to increase system cooling. Deflectors are installed under the vehicle to redirect airflow beneath the vehicle to flow through the radiator and increase cooling. Air baffles are also used to direct airflow into the radiator and increase cooling. Air seals prevent air from bypassing the radiator and A/C condenser. Air seals also prevent recirculation of the air for better hot weather cooling and A/C condenser performance.

Water Pump

The water pump is a centrifugal vane impeller type pump. The pump consists of a housing with coolant inlet and outlet passages and an impeller. The impeller is a flat plate mounted on the pump shaft with a series of flat or curved blades or vanes. When the impeller rotates, the coolant between the vanes is thrown outward by centrifugal force. The impeller shaft is supported by one or more sealed bearings. These sealed bearings never need to be lubricated. With a sealed bearing, grease cannot leak out and dirt and water cannot get in.

The purpose of the water pump is to circulate coolant throughout the cooling system. The water pump is driven by the crankshaft via the drive belt.

Thermostat

The thermostat is a coolant flow control component. It's purpose is to regulate the operating temperature of the engine. It utilizes a temperature sensitive wax-pellet element. The element connects to a valve through a piston. When the element is heated, it expands and exerts pressure against a rubber diaphragm. This pressure forces the valve to open. As the element is cooled, it contracts. This contraction allows a spring to push the valve closed.

When the coolant temperature is below 91°C (195°F), the thermostat valve remains closed. This prevents circulation of the coolant to the radiator and allows the engine to warm up quickly. After the coolant temperature reaches 91°C (195°F), the thermostat valve will open. The coolant is then allowed to circulate

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through the thermostat to the radiator where the engine heat is dissipated to the atmosphere. The thermostat also provides a restriction in the cooling system, even after it has opened. This restriction creates a pressure difference which prevents cavitation at the water pump and forces coolant to circulate through the engine block.

Transmission Oil Cooler

The transmission oil cooler is a heat exchanger. It is located inside the right side end tank of the radiator. The transmission fluid temperature is regulated by the temperature of the engine coolant that surrounds the oil cooler as the transmission fluid passes down through the cooler.

The transmission oil pump, pumps the fluid through the transmission oil cooler feed line to the oil cooler. The fluid then flows down through the cooler while the engine coolant absorbs heat from the fluid. The fluid is then pumped through the transmission oil cooler return line, to the transmission.

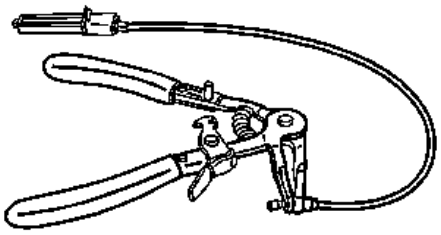
Coolant Heater

The optional engine coolant heater (RPO K05) is rated at 400 watts and supplies 1365 btu/hr. The engine coolant heater operates using 110-volt AC external power and is designed to warm the coolant in the engine block area for improved starting in very cold weather -29°C (-20°F). The coolant heater helps reduce fuel consumption when a cold engine is warming up. The unit is equipped with a detachable AC power cord. A weather shield on the cord is provided to protect the plug when not in use.

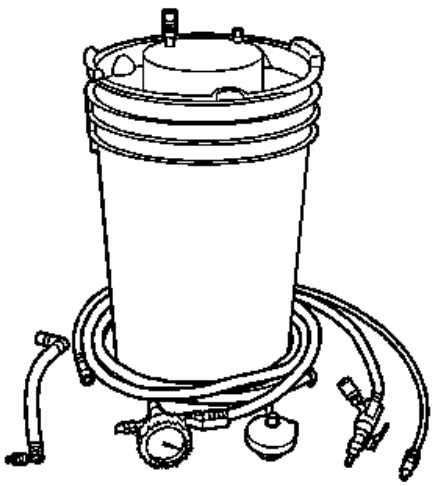
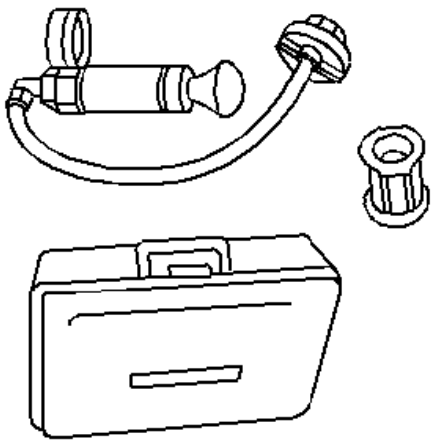
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

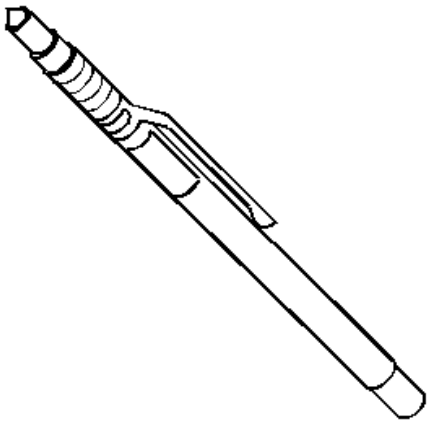
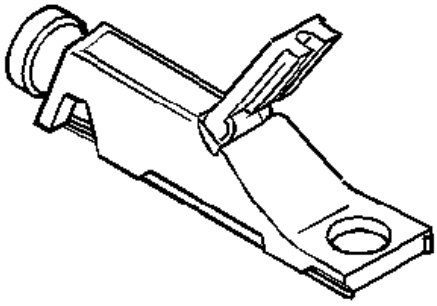
Special Tools

Illustration	Tool Number/Description
	GE 47622 Hose Clamp Pliers

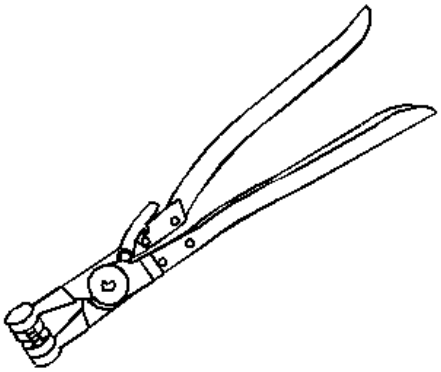
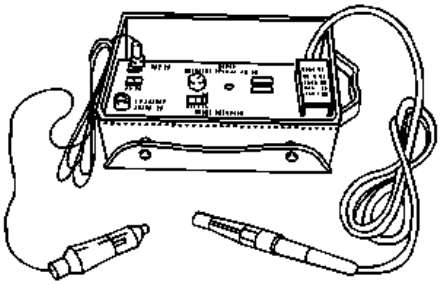
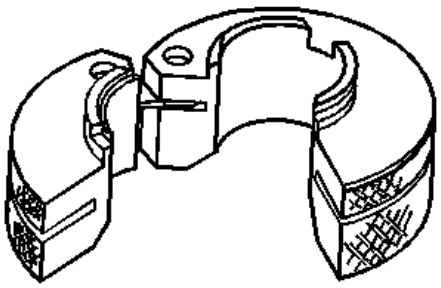
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	GE 47716 Vac N Fill Coolant Refill Tool
	J 24460-01 Cooling System Pressure Tester

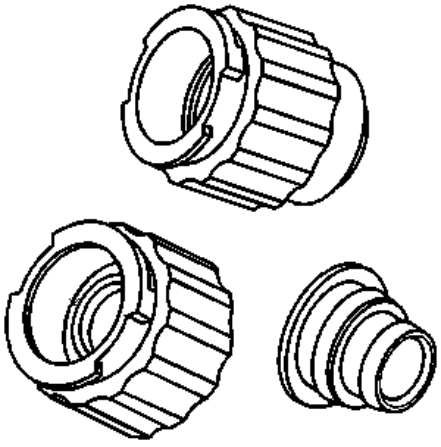
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	J 24731 Tempilstick
	J 26568 Coolant and Battery Fluid Tester
	J 38185 Hose Clamp Pliers

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	J 39400-A Halogen Leak Detector
	J 41623-B Cooler Quick Connect Tool

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	J 42401 Radiator Cap and Surge Tank Test Adapter

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2007 ENGINE

Engine Electrical - XLR

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Battery Cable to Battery Bolt	17 N.m	13 lb ft
Battery Negative Cable to Engine Block Bolt	25 N.m	18 lb ft
Battery Negative Cable to Shock Tower Bolt	10 N.m	89 lb in
Battery Positive Cable to Starter Terminal Nut (LC3)	12 N.m	106 lb in
Battery Positive Cable to Starter Terminal Nut (LH2)	10 N.m	89 lb in
Battery Positive Cable to Underhood Fuse Block Nut	15 N.m	11 lb ft
Battery Retainer Bolt	18 N.m	13 lb ft
Battery Tray Bolt	12 N.m	106 lb in
Generator Bolt	50 N.m	37 lb ft
Generator Bracket Bolt	50 N.m	37 lb ft
Generator Output Battery Terminal Nut	10 N.m	89 lb in
Ground Strap to Cam Cover Bolt	10 N.m	89 lb in
Ground Strap to Cylinder Head Bolt	25 N.m	18 lb ft
Starter Motor Bolt	30 N.m	22 lb ft
Starter Solenoid S Terminal Nut	4 N.m	35 lb in

BATTERY USAGE

Battery Usage

Application	Specification
Cold Cranking Amperage (CCA)	590 A
Reserve Capacity	110 Minutes
Replacement Model Number	86-3YR

GENERATOR USAGE

Generator Usage

Application	Specification
Generator Model	Hitachi H-LC
Rated Output	150 Amps
Load Test Output	105 Amps

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SCHEMATIC AND ROUTING DIAGRAMS

STARTING AND CHARGING SCHEMATICS

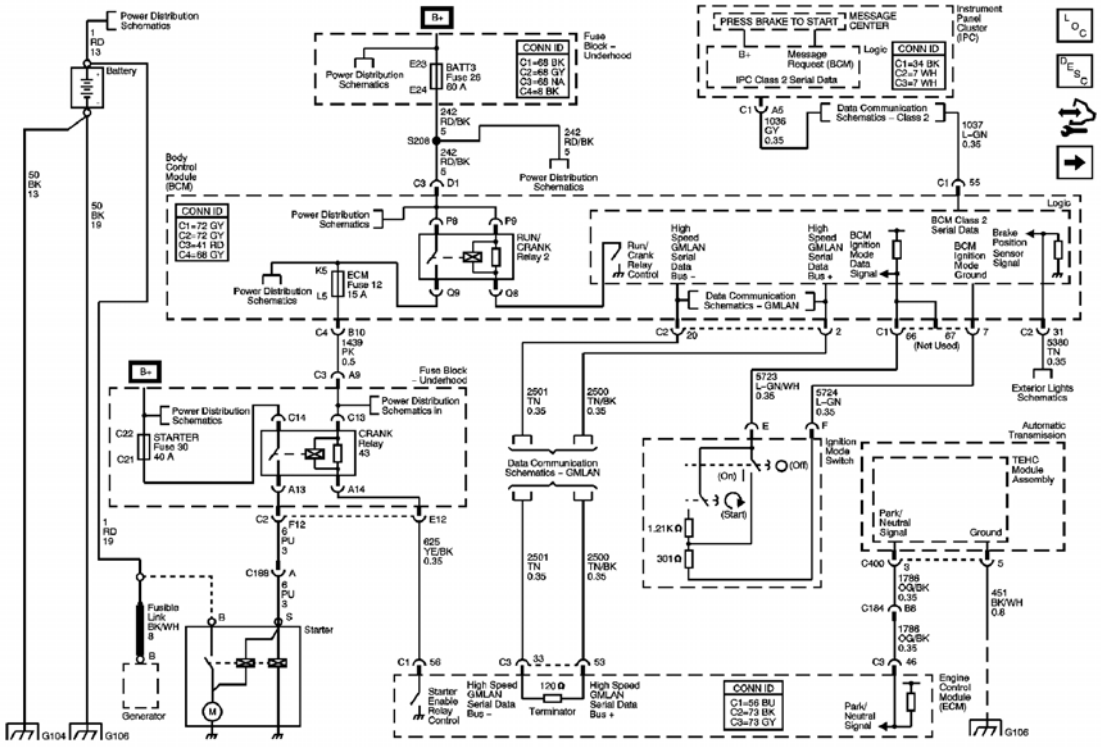


Fig. 1: Starting System Schematic
Courtesy of GENERAL MOTORS CORP.

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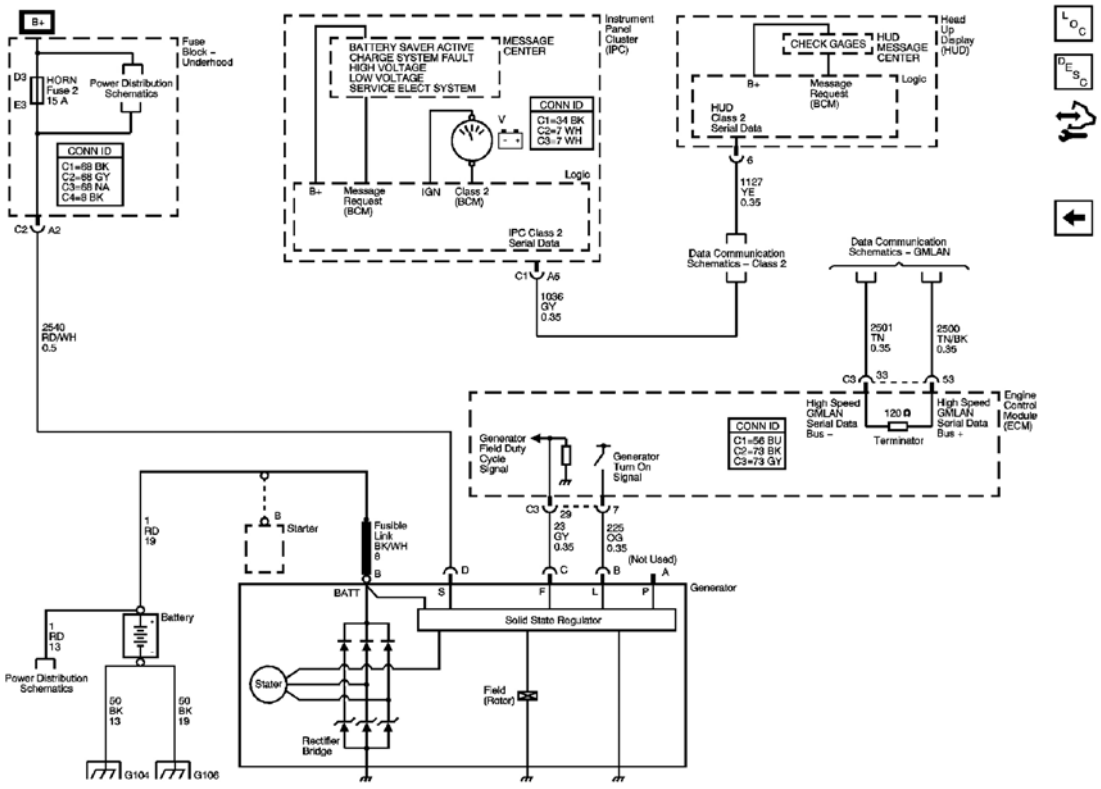


Fig. 2: Charging System Schematic
Courtesy of GENERAL MOTORS CORP.

COMPONENT LOCATOR

ENGINE ELECTRICAL COMPONENT VIEWS

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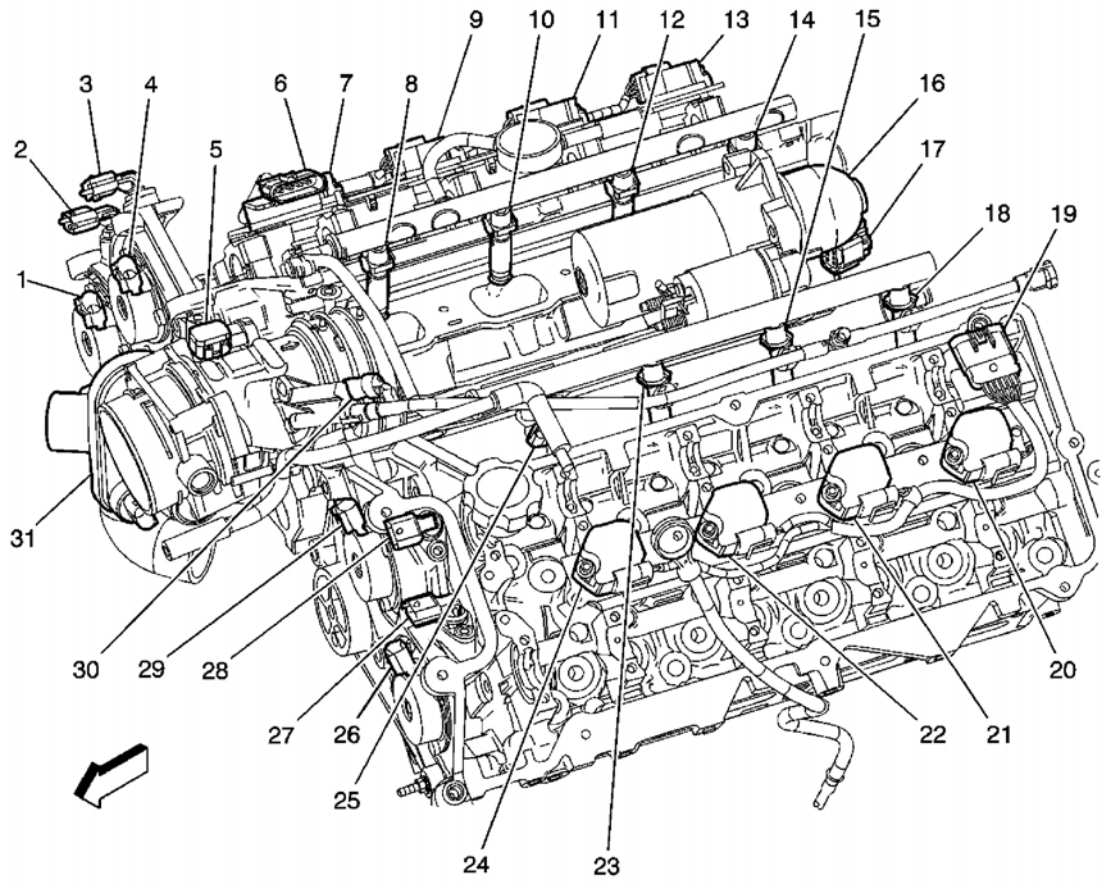


Fig. 3: Top Of Engine (LH2) Component View
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 3

Callout	Component Name
1	Camshaft Position (CMP) Actuator Solenoid Bank 1 Exhaust
2	Camshaft Position (CMP) Sensor Bank 1 Exhaust
3	Camshaft Position (CMP) Sensor Bank 1 Intake
4	Camshaft Position (CMP) Actuator Solenoid Bank 1 Intake
5	Manifold Absolute Pressure (MAP) Sensor
6	C140
7	Ignition Coil/Module 1
8	Fuel Injector 1
9	Ignition Coil/Module 3
10	Fuel Injector 3
11	Ignition Coil/Module 5
12	Fuel Injector 5
13	Ignition Coil/Module 7

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14	Fuel Injector 7
15	Fuel Injector 6
16	Starter
17	C148
18	Fuel Injector 8
19	C139
20	Ignition Coil/Module 8
21	Ignition Coil/Module 6
22	Ignition Coil/Module 4
23	Fuel Injector 4
24	Ignition Coil/Module 2
25	Fuel Injector 2
26	Camshaft Position (CMP) Actuator Solenoid Bank 2 Exhaust
27	Camshaft Position (CMP) Sensor Bank 2 Exhaust
28	Camshaft Position (CMP) Sensor Bank 2 Intake
29	Camshaft Position (CMP) Actuator Solenoid Bank 2 Intake
30	Evaporative Emission (EVAP) Canister Purge Valve
31	Throttle Body Assembly

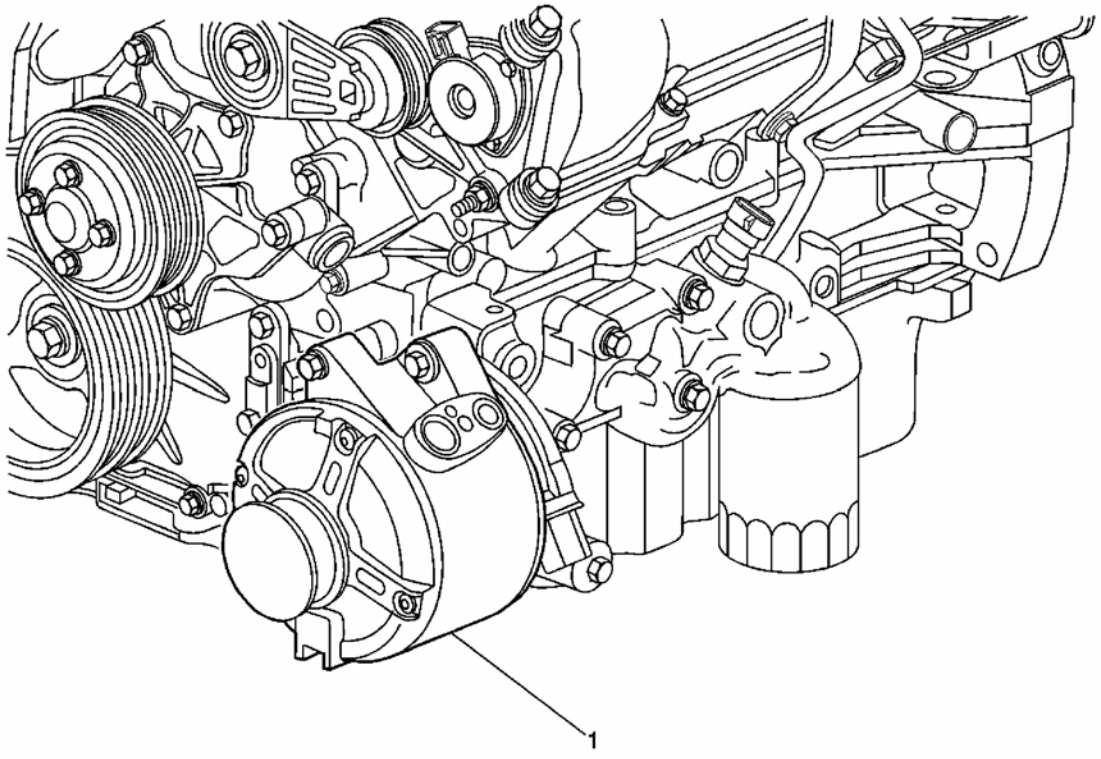


Fig. 4: Lower LF Of Engine Component View
Courtesy of GENERAL MOTORS CORP.

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Callouts For Fig. 4

Callout	Component Name
1	Generator

ENGINE ELECTRICAL CONNECTOR END VIEWS

Generator

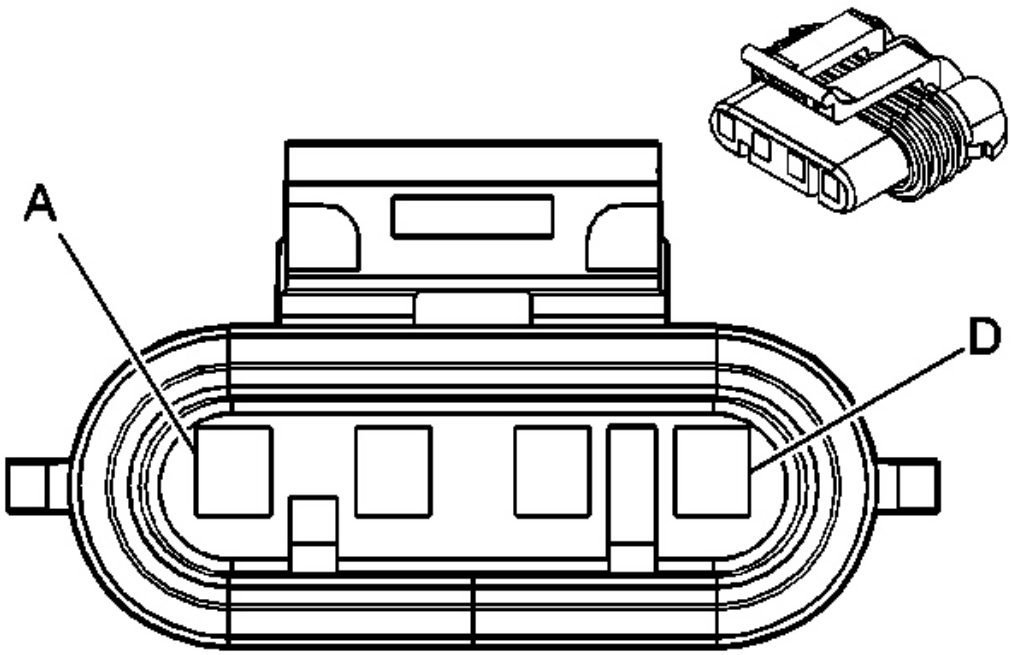


Fig. 5: Generator Connector End View
Courtesy of GENERAL MOTORS CORP.

Generator Connector Parts Information

Connector Part Information

- OEM: 12186568
- Service: See Catalog
- Description: 4-Way F Metri-Pack 150 Series (BK)

Terminal Part Information

- Pins: B, C, D

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- Terminal/Tray: 12048074/2
- Core/Insulation Crimp: E/1
- Release Tool/Test Probe: 12094429/J-35616-2A (GY)

Generator Connector Terminal Identification

Pin	Wire Color	Circuit No.	Function
A	-	-	Not Used
B	OG	225	Generator Turn On Signal
C	GY	23	Generator Field Duty Cycle Signal
D	RD/WH	2540	Battery Positive Voltage

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC CODE INDEX

DIAGNOSTIC CODE INDEX

DTC	Description
DTC B1325	Device Power 1 Circuit Voltage
DTC B1327	Device Power 1 Circuit Low
DTC B1328	Device Power 1 Circuit High
DTC C0800	Device Power 1 Circuit Voltage Above/Below Threshold
DTC C0895	Battery Voutside Of Normal Range
DTC C0899	Ignition Voltage To ECBM Less Than 9 Volts
DTC C0900	System Voltage Greater Than 16 Volts
DTC C0914	ACM Dectects System Voltage Less Than 8.5 Volts
DTC P0562	System Voltage Low
DTC P0563	System Voltage High
DTC P0615	Starter Relay Control Circuit
DTC P0621	Generator L-Terminal Circuit
DTC P0622	Generator F-Terminal Circuit
DTC P1668	Generator L-Terminal Control Circuit

DIAGNOSTIC STARTING POINT - ENGINE ELECTRICAL

Begin the system diagnosis with **Diagnostic System Check - Vehicle** . The Diagnostic System Check - Vehicle will provide the following information:

- The identification of the control modules which command the system
- The ability of the control modules to communicate through the serial data circuit
- The identification of any stored diagnostic trouble codes (DTCs) and their status

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The use of the Diagnostic System Check - Vehicle will identify the correct procedure for diagnosing the system and where the procedure is located.

SCAN TOOL OUTPUT CONTROLS

Scan Tool Output Controls

Scan Tool Output Control	Additional Menu Selection(s)	Description
Engine Output Controls	GEN L-Terminal	The engine control module (ECM) commands the generator OFF by removing the 5-volt reference signal from the L terminal of the voltage regulator when you select Off. The generator will then stop generating an output voltage.
Engine Output Controls	Starter Relay	The ECM commands the Crank Relay OFF by removing the ground from the control circuit the Crank Relay when you select OFF. Voltage will then stop flowing through the switch of the Crank Relay.

SCAN TOOL DATA LIST

Body Control Module (BCM)

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
Ignition ON/Engine Running			
Battery Voltage Signal	Data	Volts	13.9 Volts
Ignition Mode Switch	Data	IDLE/ACC/OFF/CRANK	IDLE

Engine Control Module (ECM) 4.4L (LC3)

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
Ignition ON/Engine OFF			
Crank Request Signal	Engine Electrical	Yes/No	No
GEN F-Terminal Signal	Engine Electrical	%	0%
GEN L-Terminal Signal Command	Engine Electrical	On/Off	Off
GEN L-Terminal Circuit Status	Engine Electrical	Incomplete/Short Gnd/Open/Short to B+/OK	OK
Ignition 1 Signal	Engine Electrical	Volts	Varies
PNP Switch	Engine Electrical	Park/Neutral/In Gear	Park
Starter Relay Command	Engine Electrical	On/Off	Off
Starter Relay Circuit Status	Engine Electrical	Incomplete/Short Gnd/Open/Short to B+/OK	OK

Engine Control Module (ECM) 4.6L (LH2)

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value

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Ignition ON/Engine OFF			
Crank Request Signal	Engine Electrical	Yes/No	No
GEN F-Terminal Signal	Engine Electrical	%	0%
GEN L-Terminal Signal Command	Engine Electrical	On/Off	Off
Ignition 1 Signal	Engine Electrical	Volts	Varies
PNP Switch	Engine Electrical	Park/Neutral/In Gear	Park
Starter Relay Command	Engine Electrical	On/Off	Off
Starter Relay Circuit Status	Engine Electrical	Fault/Indeterminate/OK	OK

Sensing and Diagnostic Module (SDM)

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
Ignition ON/Engine Running			
Battery Voltage Signal	Data	Volts	13.9 Volts

Transmission Control Module (TCM)

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
Ignition ON/Transmission in Park			
IMS	Data	Park, Park/Reverse, Reverse, Reverse/Neutral, Neutral, Neutral/Drive 4, Drive 4, Drive 4/Drive 3, Drive 3, Drive 3/Drive 2, Drive 2, Drive 2/Drive 1, Drive 1, INVALID, OPEN	Park

SCAN TOOL DATA DEFINITIONS

Battery Voltage Signal

The scan tool displays 0-20 Volts. The scan tool displays the voltage as received by the module or the 72-08 battery voltage message from the body control module (BCM) over class 2 lines.

Crank Request Signal

The scan tool displays Yes/No. The scan tool displays No until the ignition is placed into the START position then Yes is displayed.

GEN F-Terminal Signal

The scan tool displays 0-100%. The scan tool displays 0-10% until the engine is started and the engine control module (ECM) receives a signal from the generator then OK is displayed.

GEN L-Terminal Signal Command

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The scan tool displays On/Off. The scan tool displays Off until the engine is running, then the ECM supplies the percentage value varies depending on electrical loads

Ignition 1 Signal

The scan tool displays 0-20 Volts. The scan tool displays the voltage as received on the Ignition 1 circuit to the ECM.

IMS

The scan tool displays Park, Park/Reverse, Reverse, Reverse/Neutral, Neutral, Neutral/Drive 4, Drive 4, Drive 4/Drive 3, Drive 3, Drive 3/Drive 2, Drive 2, Drive 2/Drive 1, Drive 1, INVALID and OPEN. The scan tool displays the physical position of the internal mode switch (IMS) of the transmission.

Starter Relay Command

The scan tool displays ON/OFF. The scan tool displays Off until engine start has been requested, then it reads On.

Starter Relay Control Circuit

The scan tool displays Fault/OK/Invalid State. The scan tool displays Fault until the starter relay control circuit is grounded then OK is displayed.

DTC B1325

Circuit Description

The body control module (BCM) monitors the battery voltage through the battery voltage signal circuit. Refer to **Body Control System Schematics** .

DTC Descriptor

This diagnostic procedure supports the following DTC:

DTC B1325 Device Power 1 Circuit Voltage

Conditions for Running the DTC

The voltage supplied to the BCM is in the range of 7-26 volts.

Conditions for Setting the DTC

B1325 Type 03

- The BCM detects a system voltage below 9 volts.
- The above condition is present at least 5 seconds.

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B1325 Type 07

- The BCM detects a system voltage above 18 volts.
- The above condition is present at least 5 seconds.

Action Taken When the DTC Sets

- The BCM immediately disables all outputs when a high voltage condition was detected, with the exception of GMLAN and Run/Crank relay that are disabled after a 3 minutes delay.
- The setting of other DTCs is inhibited.

Conditions for Clearing the DTC

- A current DTC clears when the malfunction is no longer present.
- A history DTC clears when the module ignition cycle counter reaches the reset threshold, without a repeat of the malfunction.

Diagnostic Aids

- The following may cause an intermittent:
  - A damaged terminal
  - A backed out terminal
  - A poor terminal tension
  - A chafed wire
  - A broken wire inside the insulation
- When diagnosing an intermittent short or an open, manipulate the wire harness while watching the test equipment for changes.

DTC B1325

Step	Action	Values	Yes	No
Schematic Reference: Body Control System Schematics				
1	Did you perform the Diagnostic System Check - Vehicle?	-	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. With a scan tool, observe the Battery Voltage Signal parameters in the body control module (BCM) data list.	9-18 V		

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	Is the Battery Voltage Signal parameter displayed in the specified range?		Go to **Step 3**	Go to **Step 4**
3	Is the DTC set as a current DTC?	-	Go to **Step 7**	Go to Diagnostic Aids
4	1. Disconnect the BCM harness connectors. 2. Measure the voltage between the Battery Voltage Signal circuit at the BCM harness connector and a good ground. Is the measured value in the specified range?	9-18 V	Go to **Step 6**	Go to **Step 5**
5	Test the Battery Voltage Signal circuit for a short to ground or an open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 9**	Go to **Charging System Test**
6	Test the all of ground circuits of the BCM for an open or high resistance. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 9**	Go to **Step 7**
7	Inspect for poor connections at the module harness connectors. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	-	Go to **Step 9**	Go to **Step 8**
8	Replace the BCM. Refer to **Control Module References** for replacement, setup and programming. Did you complete the replacement?	-	Go to **Step 9**	-
9	Operate the system in order to verify the repair. Did you find and correct the condition?	-	System OK	Go to **Step 2**

DTC B1327

Circuit Description

The control modules on this vehicle monitor system voltage through the battery positive voltage circuits. Damage to components and incorrect data can occur when the voltage is out of range. This vehicle has multiple modules that will set this DTC. For more information on which modules refer to **Diagnostic Trouble Code**

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(DTC) List - Vehicle

DTC Descriptor

This diagnostic procedure supports the following DTC:

DTC B1327 Device Power 1 Circuit Low

Conditions for Running the DTC

This DTC shall run only if the module has power, ground and the ignition is not in START mode. This DTC shall execute regardless of the battery voltage.

Conditions for Setting the DTC

- This DTC shall be set as current when the voltage falls below 9 volts for 1.2 seconds.
- When the vehicle exits START, the module shall delay checking the voltage for 2 seconds.

Action Taken When the DTC Sets

- A message shall be sent out to notify all other modules of low battery voltage.
- The modules disable the setting of U codes and other DTCs.

Conditions for Clearing the DTC

- The DTC will clear current status when the voltage is greater than 9.5 volts for 1.2 seconds.
- A history DTC will clear after 50 consecutive ignition cycles, if the condition for the malfunction is no longer present.
- Use a scan tool.

DTC B1327

Step	Action	Values	Yes	No
Schematic Reference: Starting and Charging Schematics or **Power Distribution Schematics** **Connector End View Reference: Master Electrical Component List**				
1	Did you perform the Diagnostic System Check - Vehicle?	-	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Install a scan tool. 2. Operate the vehicle within the Conditions for Running DTC B1327. Does the scan tool indicate that DTC B1327 is current in more than one module?	-	Go to **Step 6**	Go to **Step 3**

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3	1. Turn ON the ignition, with the engine OFF. 2. With a scan tool, observe the Battery Voltage Signal parameter in the body control module (BCM) data list. Does the voltage measure greater than the specified value?	9.4 V	Go to **Step 11**	Go to **Step 4**
4	1. Turn OFF the ignition. 2. Disconnect the BCM. 3. Turn ON the ignition, with the engine OFF. 4. Measure the voltage between the battery positive voltage circuit of the BCM and the ground circuit of the BCM. Does the voltage measure greater than the specified value?	9.4 V	Go to **Step 5**	Go to **Battery Inspection/Test**
5	Measure the voltage between the battery positive voltage circuit of the BCM and a good ground. Does the voltage measure greater than the specified value?	9.4 V	Go to **Step 9**	Go to **Step 8**
6	1. Turn OFF the ignition. 2. Disconnect the harness connector of the module setting the DTC B1327. 3. Measure the voltage between the battery positive voltage circuit of the module setting the DTC B1327 and the ground circuit of the module setting the DTC B1327. Does the voltage measure greater than the specified value?	9.4 V	Go to **Step 10**	Go to **Step 7**
7	Measure the voltage between the battery positive voltage circuit of the BCM or module setting DTC B1327 and a good ground. Does the voltage measure greater than the specified value?	9.4 V	Go to **Step 9**	Go to **Step 8**
	Test the battery positive voltage circuit			

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8	of the BCM or module setting DTC B1327 for a high resistance or an open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 12**	Go to **Step 10**
9	Test the ground circuit of the BCM or module setting DTC B1327 for a high resistance or an open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 12**	Go to **Step 10**
10	Inspect for poor connections at the harness connector of the BCM or module setting DTC B1327. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	-	Go to **Step 12**	Go to **Step 11**
11	Replace the affected module setting DTC B1327. Refer to **Control Module References** for replacement, setup and programming. Did you complete the replacement?	-	Go to **Step 12**	-
12	1. Use the scan tool in order to clear the DTCs. 2. Operate the vehicle within the Conditions for Running the DTC. Does the DTC reset?	-	Go to **Step 3**	System OK

DTC B1328

Circuit Description

The control modules on this vehicle monitor system voltage through the battery positive voltage circuits. Damage to components and incorrect data can occur when the voltage is out of range. This vehicle has multiple modules that will set this DTC. For more information on which modules refer to **Diagnostic Trouble Code (DTC) List - Vehicle**

DTC Descriptor

This diagnostic procedure supports the following DTC:

DTC B1328 Device Power 1 Circuit High

Conditions for Running the DTC

This DTC shall run only if the module has power, ground and the ignition is not in START mode. This DTC

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shall execute regardless of the battery voltage.

Conditions for Setting the DTC

This DTC shall be set as current when the voltage raises above 16 volts for 1.2 seconds.

Action Taken When the DTC Sets

- A message shall be sent out to notify all other modules of high battery voltage.
- The modules disable the setting of U codes and other DTCs.

Conditions for Clearing the DTC

- The DTC will clear current status when the voltage is less than 15.5 volts for 1.2 seconds.
- A history DTC will clear after 50 consecutive ignition cycles if the condition for the malfunction is no longer present.
- Use a scan tool.

DTC B1328

Step	Action	Values	Yes	No
1	Did you perform the Diagnostic System Check - Vehicle?	-	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Install a scan tool. 2. Operate the vehicle within the conditions for running DTC B1328. Does the scan tool indicate that DTC B1328 is current in more than one module?	-	Go to **Step 4**	Go to **Step 3**
3	With a scan tool, observe the Battery Voltage Signal parameter in the body control module (BCM). Does the scan tool indicate that the voltage is greater than the specified value?	16 V	Go to **Step 5**	Go to **Charging System Test**
4	With a scan tool, observe the Battery Voltage Signal parameter in the affected module. Does the scan tool indicate that the voltage is greater than the specified value?	16 V	Go to **Step 5**	Go to **Charging System Test**
5	Replace the affected module. Refer to **Control Module References** for replacement, setup and programming. Did you complete the replacement?	-	Go to **Step 6**	-

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6	1. Use the scan tool in order to clear the DTCs. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC reset?	-	Go to **Step 2**	System OK

DTC C0800

DTC Descriptor

DTC C0800 03

Device Power 1 Circuit Voltage Below Threshold

DTC C0800 07

Device Power 1 Circuit Voltage Above Threshold

Circuit/System Description

The adaptive cruise module (ACM) monitors the ignition 1 voltage circuit to determine if the voltage is within the normal operating range. When the ACM detects that the ignition 1 voltage is below 9.2 V or above 16 V, the DTC C0800 sets.

Conditions for Running the DTC

C0800 03 and 07

- Ignition is in RUN.
- Vehicle moving at a speed greater than 40.2 km/h (25 mph).

Conditions for Setting the DTC

C0800 03

- The ACM detects that the ignition 1 voltage is less than 9.2 volts.
- The above condition is present for 7 seconds.

C0800 07

- The ACM detects that the ignition 1 voltage is greater than 16 volts.
- The above condition is present for 7 seconds.

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Action Taken When the DTC Sets

C0800 03 and 07

The following actions occur:

- Loss of adaptive cruise function.
- Cruise Not Ready indicator illuminates in the DIC.

Conditions for Clearing the DTC

- The DTC becomes history when the fault is no longer present.
- A History DTC clears after 100 malfunction free ignition cycles.
- The ACM receives a clear code command from the scan tool.

Diagnostic Aids

Using the Failure Records data may help locate an intermittent condition. If you cannot duplicate the DTC, the information in the Failure Records can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can help determine how many ignition cycles that the diagnostic test reported a pass and/or a fail.

Reference Information

Schematic Reference

Cruise Control Schematics (Adaptive Cruise) or **Cruise Control Schematics (Conventional Cruise)**

Connector End View Reference

Master Electrical Component List

Electrical Information Reference

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

Scan Tool Reference

Scan Tool Data List

Circuit/System Verification

1. Ignition ON, verify that DTC P0562, P0563 in the ECM and/or B1325 in the BCM are not current.
    - If one of those DTCs is found as a current DTC, refer to **Diagnostic Trouble Code (DTC) List -**

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Vehicle .

2. Verify that DTC C0800 is current in the scan tool.
   - If the DTC is not current, refer to **Charging System Test**.
   - If the DTC is current, go to **Circuit/System Testing**.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector of the adaptive cruise module (ACM).
2. Ignition ON, test for greater than 9.2 volts between the ignition 1 voltage circuit terminal 14 and ground.
   - If less than the specified value, test the voltage circuit for an open/high resistance.
3. Ignition ON, test for greater than 9.2 volts between the ignition 1 voltage circuit terminal 14 and the ground circuit terminal 12.
   - If less than the specified value, test the ground circuit for an open/high resistance.
4. Engine ON, test for less than 16 volts between the ignition 1 voltage circuit terminal 14 and ground.
   - If greater than the specified value, test the voltage circuit for a short to voltage. If the circuit tests normal, refer to **Charging System Test**.
5. If all circuits test normal, test or replace the ACM.

Repair Procedures

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

Control Module References for ACM replacement, setup and programming.

DTC C0895

DTC Descriptor

DTC C0895

Device Voltage

Diagnostic Fault Information

Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

Circuit/System Description

Voltage is supplied to the electronic suspension control (ESC) module in the battery positive voltage circuit and the ignition voltage circuit. The ESC module monitors the supplied voltage to determine if it is within a valid operating range.

Conditions for Running the DTC

Ignition is ON.

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Conditions for Setting the DTC

The DTC is set when the battery voltage is outside the normal range of 9-15.5 volts.

Action Taken When the DTC Sets

Disable All Functionality

Conditions for Clearing the DTC

The DTC is saved as history when the ESC module no longer sees battery voltage outside the normal range of 9-15.5 volts. The DTC will clear if the fault does not return after 50 consecutive ignition cycles.

Diagnostic Aids

DTC C0895 may set when the vehicle is placed on a battery charger, on fast charge, for a long period of time. It may also be set by an intermittent charging system malfunction.

Reference Information

Schematic Reference

Electronic Suspension Control Schematics

Connector End View Reference

Electronic Suspension Control Connector End Views

Electrical Information Reference

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

Circuit/System Testing

1. If the DTC is history, refer to **Charging System Test**.
2. If the DTC is current, turn ON the ignition and with a DMM, measure the voltage between the battery positive voltage circuits of the ESC module and the ground circuits of the ESC module.
    - If the voltage is within 9.5-15 volts, replace the ESC module.
    - If the voltage is not within 9.5-15 volts, measure the voltage between the battery positive voltage circuits of the ESC module and a separate good ground.
    - If the voltage is within 9.5-15 volts, test the battery positive ground circuits of the ESC module for high resistance or an open and repair as necessary.

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Repair Procedures

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

Control Module References for ESC module replacement, setup and programming

DTC C0899

DTC Descriptor

DTC C0899

Device Voltage Low

Diagnostic Fault Information

Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

DTC C0899

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition 1 Signal	C0899	C0899	-	-

Circuit/System Description

The electronic brake control module (EBCM) monitors the ignition voltage level available for system operation. A low voltage condition prevents the system from operating properly.

Conditions for Running the DTC

Ignition is ON.

Conditions for Setting the DTC

This fault will be set if the ignition voltage to EBCM is less than 9 volts for 100 msec.

Action Taken When the DTC Sets

- Traction Control System (TCS) and Vehicle Stability Enhancement System (VSES) for the duration of the ignition cycle.
- The TCS indicator turns ON.
- The DIC displays the Service Stability System message.

Conditions for Clearing the DTC

- The condition for the DTC is no longer present.

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- The EBCM automatically clears the history DTC when a current DTC is not detected in 100 consecutive drive cycles.

Reference Information

Schematic Reference

Antilock Brake System Schematics

Connector End View Reference

Antilock Brake System Connector End Views

Electrical Information Reference

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

Scan Tool Reference

- **Scan Tool Data List**
- **Scan Tool Data Definitions**

Circuit/System Testing

1. Measure and record the voltage at the battery terminals. With scan tool, observe the battery voltage signal parameter. Verify that battery terminal voltage and battery voltage signal readings do not differ more than 1 volt.
    - If more than 1 volt, test the battery positive voltage and ground circuits of the EBCM for an open/high resistance or replace the EBCM.
2. Go to **Charging System Test**.

Repair Procedures

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

Control Module References for EBCM replacement, setup and programming.

DTC C0900

DTC Descriptor

DTC C0900

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Device Voltage High

Diagnostic Fault Information

Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

Circuit/System Description

The electronic brake control module (EBCM) monitors the ignition voltage. If the voltage level is too high, damage may result in the system. When a high voltage condition is detected the EBCM turns OFF the system relay which removes battery voltage from the solenoid valves and pump motor.

Conditions for Running the DTC

Ignition is ON.

Conditions for Setting the DTC

The system voltage is greater than 16 volts for 100 msec.

Action Taken When the DTC Sets

- Traction Control System (TCS) and Vehicle Stability Enhancement System (VSES) disabled for the duration of the ignition cycle.
- ABS disabled if ignition voltage exceeds 19.5 volts.
- The TCS indicator turns ON.
- The Antilock Brake System (ABS) indicator turns ON if voltage exceeds 19.5 volts.
- The driver information center (DIC) displays the Service Stability System message.

Conditions for Clearing the DTC

- The condition for the DTC is no longer present.
- The EBCM automatically clears the history DTC when a current DTC is not detected in 100 consecutive drive cycles.

Reference Information

Schematic Reference

Antilock Brake System Schematics

Connector End View Reference

Antilock Brake System Connector End Views

Electrical Information Reference

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

Scan Tool Reference

- **Scan Tool Data List**
- **Scan Tool Data Definitions**

Diagnostic Aids

- A possible cause of this DTC could be overcharging with a battery charger or jump starting.
- A high voltage value in multiple modules indicates a concern in the charging system.

Circuit/System Verification

1. If the DTC is history, refer to **Charging System Test**.
2. Start the engine, record the voltage at the battery terminals. Observe the battery voltage signal parameter in the EBCM data list. Voltages should not differ by more than 1 volt.
    - If more than 1 volt, replace the EBCM.

Repair Procedures

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

Control Module References for EBCM replacement, setup and programming.

DTC C0914

DTC Descriptor

DTC C0914 03

Device Voltage Reference Output 1 Circuit Voltage Below Threshold

Diagnostic Fault Information

IMPORTANT: Always perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.

DTC C0914

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance

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Battery Voltage Signal	C0914	C0914	-	-

Circuit/System Description

The adaptive cruise module (ACM) monitors the system voltage to ensure that the voltage stays within the proper range. Damage to components and incorrect data may occur when the voltage is out of range.

Conditions for Running the DTC

- The vehicle speed is above 8 km/h (5 mph).
- The system voltage is between 9.0-18 volts.

Conditions for Setting the DTC

The ACM detects a system voltage below 8.5 volts for 1 second.

Action Taken When the DTC Sets

- The ACM will command the RADAR NOT READY warning message to be illuminated on the driver information center (DIC).
- The Cruise Control will be disabled.

Conditions for Clearing the DTC

- The history DTC will clear after 40 consecutive warm-up cycles have occurred without a malfunction.
- Using the scan tool Clear DTC Information function can clear the DTC.
- The System Voltage is greater than 9.0 volts.

Reference Information

Schematic Reference

Cruise Control Schematics (Adaptive Cruise) or **Cruise Control Schematics (Conventional Cruise)**

Connector End View Reference

Cruise Control Connector End Views

Electrical Information Reference

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

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Circuit/System Testing

1. Disconnect the ACM and measure and record the voltage of the battery supply voltage circuit and the ground circuit of the ACM then measure the voltage across battery terminals and compare it with the first reading. Verify that the battery and battery supply voltage circuit do not differ more than 0.8 volts.
    - If more than 0.8 volts test the battery supply voltage, ground circuits of the ACM for high resistance or replace the ACM.
2. Go to **Charging System Test**.

Repair Procedures

IMPORTANT: Always perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Control Module References for ACM replacement, setup and programming.

DTC P0562

Circuit Description

The engine control module (ECM) checks the system voltage to make sure that the voltage stays within the proper range. Damage to components and incorrect input can occur when the voltage is out of range. The ECM monitors the system voltage over an extended length of time. If the ECM detects an excessively low system voltage, DTC P0562 will set.

DTC Descriptor

This diagnostic procedure supports the following DTC:

DTC P0562 System Voltage Low

Conditions for Running the DTC

- Engine speed above 1500 RPM.
- System voltage between 9.5-18 volts.

Conditions for Setting the DTC

The ECM detects a system voltage below 10 volts for 5 seconds.

Action Taken When the DTC Sets

- The ECM will command a message to be displayed.
- The ECM will not illuminate the malfunction indicator lamp (MIL).
- The ECM will store conditions which were present when the DTC set as Fail Records data only.

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Conditions for Clearing the DTC

- The ECM will command the message OFF after one trip in which the diagnostic test has been run and passed.
- The history DTC will clear after 40 consecutive warm-up cycles have occurred without a malfunction.
- The DTC can be cleared by using the scan tool Clear DTC Information function.

DTC P0562

Step	Action	Values	Yes	No
Schematic Reference: Engine Controls Schematics for the 4.6L (LH2) engine, **Starting and Charging Schematics** or **Engine Controls Schematics** for the 4.4L (LC3) engine **Connector End View Reference: Engine Control Module Connector End Views** for the 4.6L (LH2) engine, **Engine Control Module Connector End Views** for the 4.4L (LC3) engine or **Power and Grounding Connector End Views**				
1	Did you perform the Diagnostic System Check - Vehicle?	-	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Install a scan tool. 2. Start the engine. 3. Raise the engine speed above 1,500 RPM. 4. With a scan tool, observe the Ignition 1 Signal parameter in the engine control module (ECM) data list. Does the scan tool indicate that the Ignition 1 Signal parameter is greater than the specified range?	10.5 V	Go to **Step 6**	Go to **Step 3**
3	Using a scan tool compare the Battery Voltage Signal parameter in the body control module (BCM) data list with the Ignition 1 Signal parameter in the ECM data list. Is the Battery Voltage and Ignition 1 Signal parameter readings different by more than the value specified?	0.5 V	Go to **Step 4**	Go to **Charging System Test**
4	Test the battery positive voltage circuit of the ECM for a high resistance. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 7**	Go to **Step 5**
5	Inspect for poor connections at the harness connector of the ECM. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** .	-		

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	Did you find and correct the condition?		Go to **Step 7**	Go to **Step 6**
6	Replace the ECM. Refer to **Control Module References** for replacement, setup and programming. Did you complete the replacement?	-	Go to **Step 7**	-
7	1. Review and record the scan tool Fail Records data. 2. Use the scan tool in order to clear the DTC. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. 4. Using the scan tool, observe the Specific DTC Information for DTC P0562 until the test runs. Does the scan tool indicate that DTC P0562 failed this ignition?	-	Go to **Step 2**	System OK

DTC P0563

Circuit Description

The engine control module (ECM) checks the system voltage to make sure that the voltage stays within the proper range. Damage to components and incorrect input can occur when the voltage is out of range. The ECM monitors the system voltage over an extended length of time. If the ECM detects an excessively high system voltage, DTC P0563 will set.

DTC Descriptor

This diagnostic procedure supports the following DTC:

DTC P0563 System Voltage High

Conditions for Running the DTC

- Engine speed above 1,500 RPM.
- System voltage between 9.5-18 volts.

Conditions for Setting the DTC

The ECM detects a system voltage above 16 volts for less than one second.

Action Taken When the DTC Sets

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- The ECM will command a message to be displayed.
- The ECM will not illuminate the malfunction indicator lamp (MIL).
- The ECM will store conditions which were present when the DTC set as Fail Records data only.

Conditions for Clearing the DTC

- The ECM will command the message OFF after one trip in which the diagnostic test has been run and passed.
- The history DTC will clear after 40 consecutive warm-up cycles have occurred without a malfunction.
- The DTC can be cleared by using the scan tool Clear DTC Information function.

DTC P0563

Step	Action	Values	Yes	No
Schematic Reference: Engine Controls Schematics for the 4.6L (LH2) engine, **Starting and Charging Schematics** or **Engine Controls Schematics** for the 4.4L (LC3) engine **Connector End View Reference: Engine Control Module Connector End Views** for the 4.6L (LH2) engine, **Engine Control Module Connector End Views** for the 4.4L (LC3) engine or **Power and Grounding Connector End Views**				
1	Did you perform the Diagnostic System Check - Vehicle?	-	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Install a scan tool. 2. Start the engine. 3. Raise the engine speed above 1,500 RPM. 4. With a scan tool, observe the Ignition 1 Signal parameter in the engine control module (ECM) data list. Does the scan tool indicate that the Ignition 1 Signal parameter is less than the specified range?	16 V	Go to **Step 4**	Go to **Step 3**
3	Using a scan tool compare the Battery Voltage parameter in the body control module (BCM) data list with the Ignition 1 Signal parameter in the ECM data list. Is the Battery Voltage and Ignition 1 Signal parameter readings different by more than the value specified?	0.5 V	Go to **Step 4**	Go to **Charging System Test**
4	Replace the ECM. Refer to **Control Module References** for replacement, setup and programming.	-		-

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	Is the action complete?		Go to **Step 5**	
5	1. Review and record the scan tool Fail Records data. 2. Use the scan tool in order to clear the DTC. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. 4. Using the scan tool, observe the Specific DTC Information for DTC P0563 until the test runs. Does the scan tool indicate that DTC P0563 failed this ignition?	-	Go to **Step 2**	System OK

DTC P0615

Circuit Description

The engine control module (ECM) supplies a ground path for the crank relay when start enable has been requested. The ECM monitors this circuit for conditions that are incorrect for the commanded state. If the ECM detects an improper circuit condition, crank relay DTC P0615 will set.

DTC Descriptor

This diagnostic procedure supports the following DTC:

DTC P0615 Starter Relay Control Circuit

Conditions for Running the DTC

System voltage is between 9-16 volts.

Conditions for Setting the DTC

- The ECM detects an improper voltage level on the control circuit that controls the crank relay.
- The condition exists for at least 2 seconds.

Action Taken When the DTC Sets

- The ECM will not illuminate the malfunction indicator lamp (MIL)
- The ECM will store the conditions present when the DTC set as Failure Records data only.

Conditions for Clearing the MIL/DTC

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- The history DTC will clear after 40 consecutive warm-up cycles have occurred without a malfunction.
- The DTC can be cleared by using the scan tool Clear DTC Information function.

Diagnostic Aids

Ignition system DTCs set with the ignition switch in the START position if the crank relay or the starter is inoperative. When the ECM enables starter operation, the ECM also initiates the diagnostic test routines for DTCs P0335, P0340 and P0385. If a condition exists which prevents the engine from cranking, the ECM will not receive signal input from the crankshaft position (CKP) and camshaft position (CMP) sensors and the DTCs will set.

Reviewing the Failure Records vehicle mileage since the diagnostic test last failed may assist in diagnosing the condition. The information may help determine how often the condition that set the DTC occurs.

Test Description

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

2: Listen for an audible click when the crank relay operates. Press the ignition switch back and forth from the ON to START positions. Repeat this as necessary.

3: This step tests for voltage at the coil side of the crank relay. The ECM IGN fuse supplies power to the coil side of the crank relay.

4: This step verifies that the ECM is providing ground to the crank relay.

5: This step tests if ground is constantly being applied to the crank relay.

DTC P0615

Step	Action	Yes	No
Schematic Reference: Engine Controls Schematics for the 4.6L (LH2) engine, **Starting and Charging Schematics** or **Engine Controls Schematics** for the 4.4L (LC3) engine **Connector End View Reference: Engine Control Module Connector End Views** for the 4.6L (LH2) engine, **Engine Control Module Connector End Views** for the 4.4L (LC3) engine or **Power and Grounding Connector End Views**			
1	Did you perform the Diagnostic System Check - Vehicle?	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Press the ignition back and forth from the ON to START positions. Does the crank relay click with each command?	Go to **Step 3**	Go to **Starter Solenoid Does Not Click**
	1. Turn OFF the ignition. 2. Remove the crank relay.		

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3	3. Turn ON the ignition, with the engine OFF. 4. Probe the battery positive voltage of the crank relay coil circuit with a test lamp that is connected to a good ground. Does the test lamp illuminate?	Go to **Step 4**	Go to **Step 8**
4	1. Connect a test lamp between the control circuit of the crank relay and the battery positive voltage of the crank relay coil circuit. 2. Turn the ignition back and forth from the ON to START positions. Does the test lamp turn ON and OFF with each command?	Go to **Step 6**	Go to **Step 5**
5	Test the control circuit of the crank relay for a short to voltage or an open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	Go to **Step 11**	Go to **Step 7**
6	Inspect for poor connections at the crank relay. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 11**	Go to **Step 9**
7	Inspect for poor connections at the engine control module (ECM). Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 11**	Go to **Step 10**
8	Repair the battery positive voltage circuit of the crank relay. Refer to **Connector Repairs** . Did you complete the repair?	Go to **Step 11**	-
9	Replace the crank relay. Did you complete the replacement?	Go to **Step 11**	-
10	Replace the ECM. Refer to **Control Module References** for replacement, setup and programming. Did you complete the replacement?	Go to **Step 11**	-
11	1. Review and record scan tool Failure Records data. 2. Clear the DTCs. 3. Operate vehicle within the Failure Records conditions as noted.		

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	4. Using a scan tool, monitor the Specific DTC Information for DTC P0615. Does the scan tool indicate DTC P0615 failed this ignition?	Go to **Step 2**	System OK

DTC P0621

Circuit Description

The engine control module (ECM) uses the generator turn on signal circuit to control the load of the generator on the engine. A high side driver in the ECM applies a voltage to the voltage regulator. This signals the voltage regulator to turn the field circuit ON and OFF. When the ECM turns ON the high side driver, the voltage regulator turns ON the field circuit. When the ECM turns OFF the high side driver, the voltage regulator turns OFF the field circuit.

The ECM monitors the state of the generator turn on signal circuit. The ECM should detect a low generator turn on signal circuit voltage when the key is ON and the engine is OFF or when the charging system malfunctions. With the engine running, the ECM should detect a high generator turn on signal circuit. The ECM performs key ON and RUN tests to determine the status of the generator turn on signal circuit. During the key ON test, if the ECM detects a high generator turn on signal circuit voltage, DTC P0621 will set. DTC P0621 will also set if, during the RUN test, the ECM detects a low generator turn on signal circuit. When the DTC sets, the ECM will send a serial data message to the drivers information center (DIC) to display a warning message.

DTC Descriptor

This diagnostic procedure supports the following DTC:

DTC P0621 Generator L-Terminal Circuit

Conditions for Running the DTC

Key ON Test

- No generator, crankshaft position (CKP) sensors or camshaft position (CMP) sensor DTCs are set.
- The key is in the RUN position.
- The engine is not running.

Run Test

- No generator, CKP sensors or CMP sensor DTCs are set.
- The engine is running.

Conditions for Setting the DTC

- During the key ON test, the ECM detects a high signal voltage on the generator turn on signal circuit for

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at least 5 seconds.

- During the RUN test, the ECM detects a low signal voltage on the generator turn on signal circuit for at least 15 seconds.

Action Taken When the DTC Sets

- The ECM will not illuminate the malfunction indicator lamp (MIL).
- The ECM will store the conditions present when the DTC set as Fail Records data only.

Conditions for Clearing the MIL/DTC

- The history DTC will clear after 40 consecutive warm-up cycles have occurred without a malfunction.
- The DTC can be cleared by using the scan tool Clear DTC Information function.

Diagnostic Aids

On vehicles equipped with a sense circuit to the voltage regulator, this circuit is used as a reference to control system voltage. The sense circuit must operating correctly for the charging system to operate properly. All the circuits at the generator should be tested for proper operation before replacing components. Refer to the schematic to confirm if the vehicle being serviced uses the sense circuit as part of the charging system.

DTC P0621

Step	Action	Yes	No
Schematic Reference: Starting and Charging Schematics **Connector End View Reference: Engine Control Module Connector End Views** for the 4.4L (LC3) engine or **Engine Electrical Connector End Views**			
1	Did you perform the Diagnostic System Check - Vehicle?	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Install a scan tool. 2. Start the engine. 3. With a scan tool, monitor the DTC information for DTC P0621. Does the scan tool indicate that DTC P0621 has passed?	Go to **Testing for Intermittent Conditions and Poor Connections**	Go to **Step 3**
3	With a scan tool, monitor the DTC information for DTC P0621 and DTC P0622. Does the scan tool indicate that DTC P0621 and DTC P0622 have failed?	Go to **Step 6**	Go to **Step 4**
4	Test the generator turn on signal circuit for a short to voltage or an open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	Go to **Step 8**	Go to **Step 5**

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5	Inspect for poor connections at the harness connector of the engine control module (ECM). Refer to **Connector Repairs** . Did you find and correct the condition?	Go to **Step 8**	Go to **Step 7**
6	Repair the high resistance or open in the battery positive voltage sense circuit of the generator. Refer to **Wiring Repairs** . Did you complete the repair?	Go to **Step 8**	-
7	**IMPORTANT:** **The replacement ECM must be programmed.** Replace the ECM. Refer to **Control Module References** for replacement, setup and programming.Did you complete the replacement?	Go to **Step 8**	-
8	1. Review and record the scan tool Fail Records data. 2. Use the scan tool in order to clear the DTC. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. 4. Using the scan tool, observe the Specific DTC Information for DTC P0621 until the test runs. Does the scan tool indicate that DTC P0621 failed this ignition?	Go to **Step 2**	System OK

DTC P0622

Circuit Description

The engine control module (ECM) uses the generator field duty cycle signal circuit to monitor the duty cycle of the generator. The generator field duty cycle signal circuit connects to the high side of the field winding in the generator. A pulse width modulated (PWM) high side driver in the voltage regulator turns the field winding ON and OFF. The ECM uses the PWM signal input to determine the generator load on the engine. This allows the ECM to adjust the idle speed to compensate for high electrical loads.

The ECM monitors the state of the generator field duty cycle signal circuit. When the key is in the RUN position and the engine is OFF, the ECM should detect a duty cycle near 0 percent. However, when the engine is running, the duty cycle should be between 5 percent and 100 percent. The ECM monitors the PWM signal using a key ON test and a RUN test. During the tests, if the ECM detects an out of range PWM signal, DTC P0622 will set. When the DTC sets, the ECM will send a serial data message to the drivers information center (DIC) to display a warning message.

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DTC Descriptor

This diagnostic procedure supports the following DTC:

DTC P0622 Generator F-Terminal Circuit

Conditions for Running the DTC

Key ON Test

- No generator, crankshaft position (CKP) sensors or camshaft position (CMP) sensor DTCs are set.
- The key is in the RUN position.
- The engine is not running.

Run Test

- No generator, CKP sensors or CMP sensor DTCs are set.
- The engine is less than 3,000 RPM.

Conditions for Setting the DTC

- During the key ON test, the ECM detects a PWM signal greater than 65 percent for at least 5 seconds.
- During the RUN test, the ECM detects a PWM signal less than 5 percent for at least 15 seconds.

Action Taken When the DTC Sets

- The ECM will not illuminate the malfunction indicator lamp (MIL).
- The ECM will store the conditions present when the DTC set as Fail Records data only.

Conditions for Clearing the MIL/DTC

- The history DTC will clear after 40 consecutive warm-up cycles have occurred without a malfunction.
- The DTC can be cleared by using the scan tool Clear DTC Information function.

DTC P0622

Step	Action	Values	Yes	No
Schematic Reference: Starting and Charging Schematics **Connector End View Reference: Engine Control Module Connector End Views** for the 4.4L (LC3) engine or **Engine Electrical Connector End Views**				
1	Did you perform the Diagnostic System Check - Vehicle?	-	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
	1. Install a scan tool.			

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2	2. Start the engine. 3. With a scan tool, observe the GEN - F Terminal Signal parameter in the ECM data list. Does the scan tool indicate that the GEN - F Terminal Signal parameter is within the specified range?	5-95%	Go to **Step 3**	Go to **Step 4**
3	With the scan tool, command the generator OFF. Does the GEN - F Terminal Signal equal the specified value?	0%	Go to **Testing for Intermittent Conditions and Poor Connections**	Go to **Step 4**
4	1. Turn OFF the ignition. 2. Disconnect the generator connector. 3. Connect test lamp to battery positive voltage. 4. Turn ON the ignition, with the engine OFF. 5. Probe the F-Terminal in the generator connector. 6. Observe the GEN - F Terminal Signal parameter in the ECM data list. Is the GEN - F Terminal Signal parameter near the specified value?	100%	Go to **Charging System Test**	Go to **Step 5**
5	Test the generator field duty cycle signal circuit for a short or open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 8**	Go to **Step 6**
6	Inspect for poor connections at the harness connector of the engine control module (ECM). Refer to **Connector Repairs** . Did you find and correct the condition?	-	Go to **Step 8**	Go to **Step 7**
7	**IMPORTANT:** **The replacement ECM must be programmed.** Replace the ECM. Refer to **Control Module References** for replacement,	-		-

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	setup and programming.Did you complete the replacement?		Go to **Step 8**	
8	1. Review and record the scan tool Fail Records data. 2. Use the scan tool in order to clear the DTC. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. 4. Using the scan tool, observe the Specific DTC Information for DTC P0622 until the test runs. Does the scan tool indicate that DTC P0622 failed this ignition?	-	Go to **Step 2**	System OK

DTC P1668

Circuit Description

The engine control module (ECM) uses the generator turn-on signal circuit to control the voltage output of the generator. When a different voltage is desired, the ECM will change the pulse width modulation (PWM) signal to the voltage regulator via the generator turn-on signal circuit. This causes the voltage regulator to the voltage output of the generator. The ECM has fault detection circuitry which monitors the state of the generator turn-on signal circuit. If the fault detection circuit senses a voltage other than what is expected, this DTC will set. The voltage regulator also contains fault detection circuitry. If the regulator detects a problem, the regulator will ground the generator turn-on signal circuit, pulling the voltage low. This also causes the ECM to set the DTC.

DTC Descriptor

This diagnostic procedure supports the following DTC:

DTC P1668 Generator L-Terminal Control Circuit

Conditions for Running the DTC

Ignition ON Test

- The ignition is in the ON position for 5 seconds.
- The engine is OFF.

Engine Run Test

- The engine is running.
- The engine speed is less than 3,000 RPM.

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Conditions for Setting the DTC

Ignition ON Test

- The ECM detects a high signal voltage on the generator turn on signal circuit for at least 5 seconds.
- The engine must be started.

During the RUN test, the ECM detects a low signal voltage on the generator turn on signal circuit for at least 5 seconds.

Action Taken When the DTC Sets

- The ECM sends a class 2 message to the instrument panel cluster (IPC) to illuminate the charge indicator and/or turn on a message.
- The ECM will not illuminate the malfunction indicator lamp (MIL).
- The ECM will store the conditions present when the DTC set as Fail Records data only.

Conditions for Clearing the MIL/DTC

- The history DTC will clear after 40 consecutive warm-up cycles have occurred without a malfunction.
- The DTC can be cleared by using the scan tool Clear DTC Information function.

DTC P1668

Step	Action	Value	Yes	No
Schematic Reference: Starting and Charging Schematics or **Engine Controls Schematics** **Connector End View Reference: Engine Control Module Connector End Views**				
1	Did you perform the Diagnostic System Check - Vehicle?	-	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Wait 5 seconds. 4. Start the engine. 5. With a scan tool, monitor the DTC information for DTC P1668. Does the scan tool indicate that DTC P1668 has passed?	-	Go to **Testing for Intermittent Conditions and Poor Connections**	Go to **Step 3**
	1. Turn OFF the engine. 2. Disconnect the generator harness connector.			

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3	3. Start the engine. 4. With a DMM measure the pulse width modulation (PWM) signal between the generator turn on signal circuit and ground. Is the PWM signal within the specified value?	15-87%	Go to **Step 5**	Go to **Step 4**
4	Test the generator turn on signal circuit for a short or open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 10**	Go to **Step 7**
5	Test the generator battery positive voltage output circuit for a high resistance or open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 10**	Go to **Step 6**
6	Inspect for poor connections at the harness connector of the generator. Refer to **Connector Repairs** . Did you find and correct the condition?	-	Go to **Step 10**	Go to **Step 8**
7	Inspect for poor connections at the harness connector of the engine control module (ECM). Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	-	Go to **Step 10**	Go to **Step 9**
8	Replace the generator. Refer to **Generator Replacement (LH2)** or **Generator Replacement (LC3)**. Did you complete the replacement?	-	Go to **Step 10**	-
9	Replace the ECM. Refer to **Control Module References** for replacement, setup and programming. Did you complete the replacement?	-	Go to **Step 10**	-
10	1. Use the scan tool in order to clear the DTCs. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC reset?	-	Go to **Step 3**	System OK

SYMPTOMS - ENGINE ELECTRICAL

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IMPORTANT: The following steps must be completed before using the symptom tables.

- Perform **Diagnostic System Check - Vehicle** , before using the Symptom Tables in order to verify that all of the following are true:
  - There are no DTCs set.
  - The control modules can communicate via the serial data link.
- Review the system descriptions and operations in order to familiarize yourself with the system functions. Refer to one of the following system operations:
  - **Battery Description and Operation**
  - **Charging System Description and Operation**
  - **Load Shed System Description and Operation**
  - **Starting System Description and Operation**

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the starting and charging systems. Refer to **Checking Aftermarket Accessories** .
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

Intermittent

Faulty electrical connections or wiring may be the cause of intermittent conditions. Refer to **Testing for Intermittent Conditions and Poor Connections** .

Symptom List

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

- **Battery Inspection/Test**
- **Battery Electrical Drain/Parasitic Load Test**
- **Battery Common Causes of Failure**
- **Charging System Test**
- **Charge Indicator Always On**
- **Charge Indicator Inoperative**
- **Generator Noise Diagnosis**
- **Starter Solenoid Does Not Click**
- **Starter Solenoid Clicks, Engine Does Not Crank**
- **Engine Cranks Slowly**
- **Starter Motor Noise Diagnosis**

BATTERY INSPECTION/TEST

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Tools Required

J 42000 Battery Tester. See **Special Tools**.

Diagnostic Aids

IMPORTANT:

- **Failure to properly understand the battery and its function could lead to a misdiagnosis and unneeded repairs. Refer to Battery Description and Operation and Battery Common Causes of Failure for more information.**
- **If testing an AGM battery with the J 42000 , add 100 to the CCA rating of the battery and enter that amount into the tester when prompted for the CCA rating. For instance, if the AGM batteries CCA rating is 500 amps, enter 600 into the J 42000 . See Special Tools. Perform this modification only if the J 42000 does not ask if you are testing an AGM battery. If these instructions are not followed when testing an AGM battery, an invalid test result and invalid test code will be obtained on the J 42000 .**
- **The battery test using the J 42000 requires correct connections to the battery terminals. See Special Tools. A failure to obtain the correct connections during the test may result in a failed test on a good battery.**
- **When the J 42000 inquires " has the battery been charged", answer yes only if the battery has been charged on this visit to the dealership. See Special Tools.**

Follow these instructions in order to avoid an incorrect diagnosis because of connections:

- If testing the vehicle with the battery cables still connected, wiggle the **J 42000** clips on the terminal bolt. See **Special Tools**. This may cut through any coating or through any oxidation that may be present on the bolt.

  Even new bolts contain a protective coating that may insulate or cause a resistance in the test circuit.

- If correct connections to the battery terminal bolts in the vehicle are in doubt, perform the following steps:
  1. Disconnect the negative battery cable.
  2. Disconnect the positive battery cable.
  3. Install the test adapters on the terminals.
  4. Follow the instructions for an Out-of-Vehicle test.
- If the tester displays a REPLACE BATTERY or BAD CELL-REPLACE result for a battery tested in the vehicle with the battery cables connected, perform the following steps:
  1. Disconnect the negative battery cable.
  2. Disconnect the positive battery cable.
  3. Install the tester adapters.
  4. Follow the instructions for an Out-of-Vehicle test.

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5. Replace the battery only if the Out-of-Vehicle test shows a REPLACE BATTERY or BAD CELL-REPLACE result. This prevents battery replacements that are due only to faulty battery cable connections.

- Use the correct terminal adapters.

  Do not use any common bolts or a combination of bolts, nuts and or washers as adapters when testing the battery.

  Use the test adapters that are provided with the **J 42000** or P/N 12303040 terminal adapters. See **Special Tools**. If the adapters that are provided with the **J 42000** require replacement, use P/N 12303040. Any other adapter may not contact the correct areas of the battery terminal, causing a resistance that may result in an invalid battery test result.

Battery Inspection/Test

Step	Action	Values	Yes	No
CAUTION: **Refer to Battery Disconnect Caution .** **IMPORTANT:** **Always write the test code displayed by the tester on the repair order for any warranty purposes. The number is a unique code that describes the test data for a particular battery at a particular time. The test code may occasionally repeat when you retest the same battery. More often, each test will result in a different code. If the battery is replaced due to failing the test, only an Out-of-Vehicle test code is valid for warranty purposes.**				
1	Inspect the battery for a cracked, broken or damaged case, which may be indicated by battery acid leakage. Is the battery OK?	-	Go to **Step 2**	Go to **Step 15**
2	Compare the cold cranking amperage (CCA) and reserve capacity (RC) and/or amp hour (AH) rating of the battery to the original battery or original equipment (OE) specification. Refer to **Battery Usage**. Does the battery meet or exceed the specifications?	-	Go to **Step 3**	Go to **Step 15**
3	1. Turn OFF the ignition. 2. Attempt to rotate the negative battery cable connector clockwise with light finger pressure.	-		

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	Does the negative connector rotate?		Go to **Step 4**	Go to **Step 5**
4	Use a torque wrench in order to verify the torque to loosen the negative battery terminal bolt. Is the torque above the specified value?	10 N.m (88 lb in)	Go to **Step 9**	Go to **Step 8**
5	Attempt to rotate the positive battery cable connector clockwise with light finger pressure. Does the positive connector rotate?	-	Go to **Step 7**	Go to **Step 6**
6	**IMPORTANT:** **Ensure that all of the electrical loads are turned OFF.** 1. Install the **J 42000** Battery Tester. See **Special Tools**. 2. Follow the directions supplied with the tester for an In-Vehicle test. 3. Follow any directions displayed on the tester. 4. If the tester calls for charging the battery, refer to **Battery Charging**. Did the tester pass the battery?	-	Go to **Step 14**	Go to **Step 8**
7	Use a torque wrench in order to verify the torque to loosen the positive battery terminal bolt. Is the torque above the specified value?	10 N.m (88 lb in)	Go to **Step 10**	Go to **Step 8**
8	1. Disconnect the negative battery cable. 2. Disconnect the positive battery cable. 3. Clean and wire brush the lead face of both battery terminals and the metal contact rings in both cable connectors. 4. Remove the bolts from the cable connectors in order to provide access to the	-		

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	connector rings as needed. 5. If either of the battery terminals or the cable rings are excessively damaged or corroded, replace as needed. Did you complete the repair?		Go to **Step 11**	-	
9	1. Disconnect the negative battery cable. 2. Inspect for the following conditions and repair as needed: • The cable bolt is too long or deformed at the end • There is foreign material present inside the nut in the battery terminal • Damage to the battery terminal face or cable connector ring Did you complete the repair?	Go to **Step 10**			-
10	1. Disconnect the positive battery cable. 2. Inspect for the following conditions and repair as needed: • The cable bolt is too long or deformed at the end • There is foreign material present inside the nut in the battery terminal • Damage to the battery terminal face or cable connector ring Did you complete the repair?	-	Go to **Step 11**	-	
	IMPORTANT: **Ensure that both battery cables**				

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11	**are disconnected and proper adapters are installed in the battery terminals.** 1. Install the **J 42000** . See **Special Tools**. 2. Follow the directions supplied with the tester for an Out-of-Vehicle test. 3. Follow any directions displayed on the tester. 4. If the tester calls for charging the battery, refer to **Battery Charging**. Did the tester pass the battery?	-	Go to **Step 12**	Go to **Step 15**	
12	1. Press the CODE button on the **J 42000** . See **Special Tools**. 2. For warranty purposes, write the displayed code on the repair order. Did you complete this action?	Go to **Step 13**			-
13	1. Connect the positive battery cable to the batteries positive terminal. **NOTE:** **Refer to Fastener Notice .** 2. Tighten the positive battery cable bolt to the specified value. 3. Connect the negative battery cable to the battery negative terminal. 4. Tighten the negative battery cable bolt to the specified value. Are the cable bolts properly tightened?	17 N.m (13 lb ft)	Battery OK	-	
	1. Press the CODE button on				

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14	the **J 42000** . See **Special Tools**. 2. For warranty purposes, write the displayed code on the repair order. Did you complete the replacement?	Battery OK			-
15	Replace the battery. Refer to **Battery Replacement**. Did you complete the replacement?	-	Battery OK	-	

BATTERY CHARGING

Tools Required

J 42000 Battery Tester. See **Special Tools**.

- For best results, use an automatic taper-rate battery charger with a voltage capability of 16 volts.
- The charging area should be well ventilated.
- Do not charge a battery that appears to be frozen. Allow the battery to warm to room temperature and test it using the **J 42000** before charging. See **Special Tools**.

Charging Time Required

The time required to charge a battery will vary depending upon the following factors:

- The battery charger capacity-The higher the charger's amperage, the less time it will take to charge the battery.
- The state-of-charge of the battery-A completely discharged battery requires more than twice as much charging time as a half charged battery. In a discharged battery with a voltage below 11 volts, the battery has a very high internal resistance and may only accept a very low current at first. Later, as the charging current causes the acid content to increase in the electrolyte, the charging current will increase. Extremely discharged batteries may not activate the reversed voltage protection in some chargers. Refer to the manufacturers instructions for operating this circuitry.
- The temperature of the battery-The colder the battery is, the more time it takes to recharge the battery. The charging current accepted by a cold battery is very low at first. As the battery warms, the charging current will increase.

Charging Procedure

NOTE: Turn OFF the ignition when connecting or disconnecting the battery cables, the battery charger or the jumper cables. Failure to do so may damage the PCM or other electronic components.

NOTE: Refer to Fastener Notice .

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When charging side-terminal batteries with the battery cables connected, connect the charger to the positive cable bolt and to a ground located away from the battery. When charging side-terminal batteries with the battery cables disconnected, install the battery side terminal adapters and connect the charger to the adapters.

Tighten: Tighten the battery side terminal adapters to 15 N.m (11 lb ft).

Use the following procedure to charge the battery:

1. Turn OFF the charger.
2. Ensure that all of the battery terminal connections are clean and tight.
3. Connect the charger positive lead to the battery positive terminal on the battery or fuse block - underhood.

NOTE: Do not connect the negative charger lead to the housings of other vehicle electrical accessories or equipment. The action of the battery charger may damage such equipment.

4. Connect the negative charger lead to a solid engine ground or to a ground stud in the engine compartment that is connected directly to the battery negative terminal, but away from the battery. If the negative battery cable is disconnected and a terminal adapter is being used, connect directly to the adapter.
5. Turn ON the charger and set to the highest setting for normal charging.
6. Inspect the battery every half hour after starting the battery charger.
   - Charge the battery until the taper-rate charger indicates that the battery is fully charged.
   - Estimate the battery temperature by feeling the side of the battery. If it feels hot to the touch or its temperature is over 45°C (125°F), discontinue charging and allow the battery to cool before resuming charging.
7. After charging, test the battery. Refer to **Battery Inspection/Test**.

BATTERY ELECTRICAL DRAIN/PARASITIC LOAD TEST

Tools Required

J 38758 Parasitic Draw Test Switch. See **Special Tools**.

Diagnostic Aids

- Be sure to rule out any possible obvious influences, such as customer error or aftermarket equipment.
- Customer driving habits, such as regular short trips. This does not allow enough time to properly charge the battery. Refer to **Battery Description and Operation**.
- Verify that the battery and charging system are in proper working order. Refer to **Battery Charging** and **Charging System Test**.
- A battery discharging for no apparent reason while the vehicle is parked can be caused by an intermittent draw, such as a module waking up or a continuous draw, such as a dome light or stuck relay.
- Some systems and modules such as OnStar® and regulated voltage control (RVC), if equipped, are designed to wake-up, perform a task and go back asleep at regular intervals. Refer to **Body Control**

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System Description and Operation for the system or modules description and operation.

- Remote keyless entry (RKE) will wake up due to an outside input. Refer to **Keyless Entry System Description and Operation** .
- The graph below indicates roughly how many days a 690 CCA battery with at 110 min. RC (60.5 AH) starting at 80 percent state of charge will last with a constant current draw until it reaches 50 percent state of charge. Differences in battery temperature and ratings will affect the results:

Battery Electrical Drain/Parasitic Load Test

Current Drain	Days
25 mA	30.5
50 mA	16.5
75 mA	11
100 mA	8.25
250 mA	3.3
500 mA	1.65
750 mA	1
1 A	0.8
2 A	0.4

NOTE: Do not turn the parasitic draw test switch to the OFF position with the engine running. Damage will occur to the vehicle's electrical system.

NOTE: The test switch must be in the ON position when removing the fuses in order to maintain continuity in the electrical system. This avoids damaging the digital multimeter due to accidental overloading, such as a door being opened to change a fuse.

IMPORTANT: The switch knob (1) on the J 38758 is marked ON and OFF. See Special Tools. When the switch knob is in the ON position, the circuit is closed and electrical current will pass through the switch. When the switch knob is in the OFF position, the circuit is open and electrical current will not pass through the switch.

CAUTION: Refer to Battery Disconnect Caution .

1. Disconnect the battery negative cable from the battery negative terminal.
2. Install the male end of the **J 38758** to the battery ground terminal. See **Special Tools**.
3. Turn the **J 38758** knob to the OFF position. See **Special Tools**.
4. Install the battery negative cable to the female end of the **J 38758** . See **Special Tools**.
5. Turn the **J 38758** knob to the ON position. See **Special Tools**.
6. Road test the vehicle and activate ALL of the accessories, including the radio and air conditioning. This

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may take up to 30 minutes.

7. Park the vehicle. Turn the ignition switch to the OFF position and remove the ignition switch key.
8. Connect a 10A fused jumper wire to the test switch tool terminals.
9. Turn the **J 38758** knob to the OFF position. See **Special Tools**. The current now flows through the jumper wire.
10. Wait 1 minute. If the fuse blows, install an inductive ammeter and go to **step 20** .
11. Remove the fused jumper wire.
12. Set a digital multimeter to the 10A scale.
13. Connect the digital multimeter to the test switch tool terminals.
14. Turn the **J 38758** knob to the OFF position. See **Special Tools**. The current flows now through the digital multimeter.
15. Wait 1 minute. Check and record the current reading.
    1. When there is a current reading on 2A or less, turn the **J 38758** knob to the ON position. See **Special Tools**. The electrical current will now pass through the switch.
    2. Then switch the digital multimeter down to the 2A scale for a more accurate reading when the **J 38758** knob is turned OFF. See **Special Tools**.
16. Turn the **J 38758** knob to the OFF position. See **Special Tools**. Wait 15 minutes for most vehicles.
17. Check and record the current reading.
18. Note the battery Reserve Capacity (Amp Hour rating). Refer to **Battery Usage**.
    1. Divide the reserve capacity by 4 (Amp hour rating by 2.4).
    2. Compare this to the multimeter milliampere reading taken in the previous step. The parasitic current drain should not exceed this number. Example: If a battery has a reserve capacity of 100 minutes, (60 A/H) the current drain should not exceed 25 mA.
19. If excessive current drain is not found at this time and there are no other apparent causes, complete the following:
    1. Using the MIN/MAX function of the digital multimeter, monitor the parasitic drain overnight or during the day. This will determine if something has been activated during that time frame.

       NOTE: The test switch must be in the ON position when removing the fuses in order to maintain continuity in the electrical system. This avoids damaging the digital multimeter due to accidental overloading, such as a door being opened to change a fuse.

       IMPORTANT: Removing fuses, relays and connectors to determine the failure area may wake up modules. You must wait for these modules to go to sleep or use the sleep function on the scan tool.

    2. When the vehicle has an unacceptable amount of parasitic current drain, remove each fuse one at a time until the current drain falls to an acceptable level. This will indicate which circuit is causing the drain. Refer to **Power Distribution Schematics** to diagnose exactly which part of the suspect circuit is causing the parasitic drain. In some cases a non-fused circuit or component, such as a relay, is the cause of excessive parasitic current drain.

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3. Repeat the parasitic current drain test procedure after any repair has been completed to make sure that the parasitic current drain is at an acceptable level.
4. When the cause of the excessive current drain has been located and repaired, remove the **J 38758** . See **Special Tools**.

20. Connect the battery negative cable to the battery negative terminal.

BATTERY COMMON CAUSES OF FAILURE

A battery is not designed to last forever. With proper care, however, the battery will provide years of good service. If the battery tests good but still fails to perform well, the following are some of the more common causes:

- A vehicle accessory was left on overnight.
- The driving speeds have been slow with frequent stops, stop-and-go driving, with many electrical accessories in use, particularly air conditioning, headlights, wipers, heated rear window, cellular telephone, etc.
- The electrical load has exceeded the generator output, particularly with the addition of aftermarket equipment.
- Existing conditions in the charging system, including the following possibilities:
  - A slipping belt
  - A bad generator
- The battery has not been properly maintained, including a loose battery hold down or missing battery insulator if used.
- There are mechanical conditions in the electrical system, such as a short or a pinched wire, attributing to power failure. Refer to **General Electrical Diagnosis** .

Electrolyte Freezing

The freezing point of electrolyte depends on its specific gravity. A fully charged battery will not freeze until the ambient temperature gets below -54°C (-65°F). However, a battery with a low state of charge may freeze at temperatures as high as -7°C (20°F). Since freezing may ruin a battery, the battery should be protected against freezing by keeping it properly charged. As long as the green eye is visible in the hydrometer, the freezing point of the battery will be somewhere below -32°C (-25°F).

Battery Protection During Vehicle Storage

Certain devices on the vehicle maintain a small continuous current drain, parasitic load, on the battery. A battery that is not used for an extended period of time will discharge. Eventually permanent damage will result. Discharged batteries will also freeze in cold weather. Refer to **Battery Inspection/Test**.

In order to maintain the battery state of charge while storing the vehicle for more than 30 days:

1. Ensure that the green dot is visible in the built-in hydrometer.

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CAUTION: Refer to Battery Disconnect Caution .

2. Disconnect the battery ground cable to protect the battery from discharge by parasitic current drains.

When the battery cannot be disconnected:

1. Maintain a high state of charge.
2. Establish a regular schedule for recharging the battery every 20-45 days.

A battery that has remained in a discharged state for a long period of time is difficult to recharge or may be permanently damaged.

JUMP STARTING IN CASE OF EMERGENCY

CAUTION: Batteries produce explosive gases. Batteries contain corrosive acid. Batteries supply levels of electrical current high enough to cause burns. Therefore, in order to reduce the risk of personal injury while working near a battery, observe the following guidelines:

- **Always shield your eyes.**
- **Avoid leaning over the battery whenever possible.**
- **Do not expose the battery to open flames or sparks.**
- **Do not allow battery acid to contact the eyes or the skin.**
  - **Flush any contacted areas with water immediately and thoroughly.**
  - **Get medical help.**

NOTE: This vehicle has a 12 volt, negative ground electrical system. Make sure the vehicle or equipment being used to jump start the engine is also 12 volt, negative ground. Use of any other type of system will damage the vehicle's electrical components.

1. Position the vehicle with the booster battery so that the jumper cables will reach.
   - Do not let the 2 vehicles touch.
   - Make sure that the jumper cables do not have loose ends or missing insulation.
2. Place an automatic transmission in PARK. If equipped with a manual transmission, place in NEUTRAL and block the wheels.
3. Turn OFF all electrical loads on both vehicles that are not needed.
4. Turn OFF the ignition on both vehicles.

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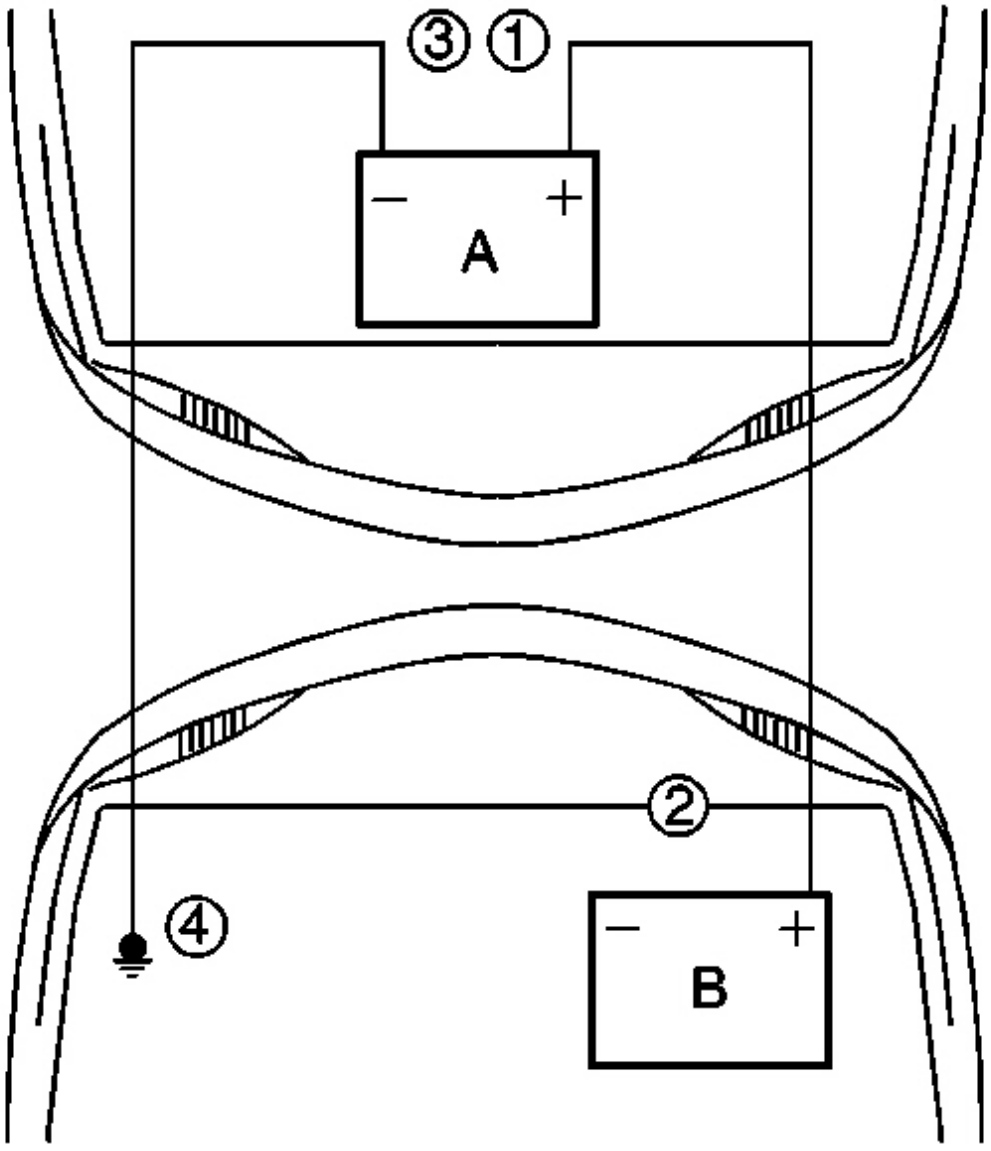


Fig. 6: Identifying Proper Jumper Cable Connection
Courtesy of GENERAL MOTORS CORP.

5. Connect the red positive (+) cable to the battery positive (+) terminal (2) of the vehicle with the discharged battery.

   Use a remote positive (+) terminal if the vehicle has one.

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6. Connect the red positive (+) cable to the positive (+) terminal (1) of the booster battery.

   Use a remote positive (+) terminal if the vehicle has one.

7. Connect the black negative (-) cable to the negative (-) terminal (3) of the booster battery.

   CAUTION: Do not connect a jumper cable directly to the negative terminal of a discharged battery to prevent sparking and possible explosion of battery gases.

8. The final connection is made to a heavy, unpainted metal engine part (4) of the vehicle with the discharged battery.

   This final attachment must be at least 46 cm (18 in) away from the dead battery.

9. Start the engine of the vehicle that is providing the boost.

   NOTE: Never operate the starter motor more than 15 seconds at a time without pausing in order to allow it to cool for at least 2 minutes. Overheating will damage the starter motor.

10. Crank the engine of the vehicle with the discharged battery.
11. The black negative (-) cable must be first disconnected from the vehicle that was boosted (4).
12. Disconnect the black negative (-) cable from the negative (-) terminal (3) of the booster battery.

    NOTE: Do not let the cable end touch any metal. Damage to the battery and other components may result.

13. Disconnect the red positive (+) cable from the positive (+) terminal (1) of the booster battery.
14. Disconnect the red positive (+) cable from the remote positive (+) terminal (2) of the vehicle with the discharged battery.

CHARGING SYSTEM TEST

Charging System Test

Step	Action	Values	Yes	No
1	Did you perform the Diagnostic System Check - Vehicle?	-	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	**IMPORTANT:** **The battery must be above a 70 percent state of charge. Refer to Battery Charging.**	-		

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	Did you perform the Battery Inspection Test?		Go to **Step 3**	Go to **Battery Inspection/Test**
3	1. Install a scan tool. 2. Start the engine. 3. With a scan tool, command the GEN-L Terminal OFF and ON. 4. Observe the Ignition 1 Signal parameter. Does the voltage change with each command?	-	Go to **Step 4**	Go to **Step 8**
4	1. Turn ON the following accessories: • Headlights (high beams) • A/C on Max • Blower fan (on high) • Heated seats (if equipped) 2. With a scan tool, observe the Ignition 1 Signal parameter in the engine data list. 3. Increase engine speed to 2,500 RPM. Is the voltage within the specified value?	12-15.5 V	Go to **Step 5**	Go to **Step 6**
5	1. Turn OFF all accessories. 2. Turn OFF the ignition. **CAUTION:** **Make sure that the load is completely turned off before connecting or disconnecting a carbon pile load tester to the battery. Otherwise, sparking could ignite battery gasses which are extremely flammable and may explode violently.** 3. Connect a carbon pile tester to the vehicle. **IMPORTANT:** **When measuring generator output current, be sure the**	-		

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	inductive probe encircles the generator output wire. 4. Connect an inductive ammeter probe to the output circuit of the generator. 5. Start the engine. 6. With a scan tool, command the GEN-L Terminal ON. 7. Increase engine speed to 2,500 RPM. 8. Adjust the carbon pile as necessary in order to obtain the maximum current output. Is the generator output greater than or equal to the load test value as specified in Generator Usage?		Generator OK	Go to **Step 7**
6	Is the voltage measured greater than 15.5 volts?	-	Go to **Step 12**	Go to **Step 7**
7	1. Leave the vehicle accessories ON or maintain load test value. 2. Maintain engine speed at 2,500 RPM. 3. Measure the voltage of the battery. 4. Measure the voltage between the generator output terminal and the generator metal housing Is the voltage measured of the generator within 0.2 volts of the battery voltage?	-	Go to **Step 14**	Go to **Step 9**
8	1. Turn ON the ignition, with the engine OFF. 2. Disconnect the generator harness connector. 3. Measure the voltage between the generator turn on signal circuit and ground. 4. With a scan tool, command the GEN-L Terminal ON and OFF. Does the voltage measure greater than the first value ON and near the second	4.7 V 0 V		

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	value OFF?		Go to **Step 14**	Go to **Step 11**
9	1. Maintain the engine speed at 2,500 RPM and continue to operate the generator at the load test value. 2. Measure the voltage drop from the battery negative terminal to the metal housing of the generator. Refer to **Circuit Testing** and **Wiring Repairs** . Is the voltage measured less than the specified value?	0.5 V	Go to **Step 10**	Go to **Step 15**
10	1. Maintain the engine speed at 2,500 RPM and continue to operate the generator at the load test value. 2. Measure the voltage drop from the output terminal of the generator to the positive terminal on the battery. Refer to **Circuit Testing** and **Wiring Repairs** . Is the voltage measured less than the specified value?	0.2 V	Go to **Step 14**	Go to **Step 16**
11	Test the generator turn on signal circuit for a short or an open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 19**	Go to **Step 13**
12	Test the generator battery voltage sense circuit, if equipped, for an open or high resistance. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 19**	Go to **Step 14**
13	Inspect for poor connections at the harness connector of the engine control module (ECM). Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	-	Go to **Step 19**	Go to **Step 17**
14	Inspect for poor connections at the generator. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	-	Go to **Step 19**	Go to **Step 18**
	Repair the high resistance or open in the ground circuit of the generator. Refer to			

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15	**Wiring Repairs** . Did you complete the repair?	-	Go to **Step 19**	-
16	Repair the high resistance or open in the generator output circuit. Refer to **Wiring Repairs** . Did you complete the repair?	-	Go to **Step 19**	-
17	Replace the ECM. Refer to **Control Module References** for replacement, setup and programming. Did you complete the replacement?	-	Go to **Step 19**	-
18	Replace the generator. Refer to **Generator Replacement (LH2)** or **Generator Replacement (LC3)**. Did you complete the replacement?	-	Go to **Step 19**	-
19	Operate the vehicle in order to verify the repair. Did you correct the condition?	-	Generator OK	Go to **Step 2**

CHARGE INDICATOR ALWAYS ON

Charge Indicator Always On

Step	Action	Value(s)	Yes	No
Schematic Reference: Starting and Charging Schematics **Connector End View Reference: Engine Electrical Connector End Views**				
1	Did you perform the Diagnostic System Check - Vehicle ?	-	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Start the engine. 2. Turn OFF all accessories. Does the battery charge indicator remain illuminated?	-	Go to **Step 3**	Go to **Testing for Intermittent Conditions and Poor Connections**
3	1. Install a scan tool. 2. Start the engine. 3. Turn OFF all accessories. 4. Increase engine speed to 1,500 RPM. 5. With a scan tool, observe the Battery Voltage parameter in the body control module (BCM) data list, engine control module (ECM)/powertrain control module	0.9-1.1 V		

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	(PCM) data list and the instrument panel cluster (IPC) data list. 6. Compare the voltages. Are all of the voltages within the specified range?		Go to **Step 4**	Go to **Step 5**
4	Are the voltages displayed within the specified range?	11-16 V	Go to **Step 5**	Go to **Charging System Test**
5	Test the battery positive voltage and ground circuits of the affected module for a high resistance or open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	-	Go to **Step 8**	Go to **Step 6**
6	Inspect for poor connections at the harness connector of the affected module. Refer to **Connector Repairs** . Did you find and correct the condition?	-	Go to **Step 8**	Go to **Step 7**
7	Replace the affected module. Refer to **Control Module References** for replacement, setup and programming. 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 2**

CHARGE INDICATOR INOPERATIVE

Charge Indicator Inoperative

Step	Action	Yes	No
1	Did you perform the Diagnostic System Check - Vehicle?	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Turn OFF the ignition. 2. Turn ON the ignition, with the engine OFF. 3. Observe the battery charge indicator on the instrument cluster (IPC) during the bulb check. Does the battery charge indicator illuminate during the bulb check?	Go to **Testing for Intermittent Conditions and Poor Connections**	Go to **Step 3**
3	Replace the IPC. Refer to **Control Module References** for replacement, setup and programming.		

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	Did you complete the repair?	Go to **Step 4**	-
4	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 2**

GENERATOR NOISE DIAGNOSIS

Diagnostic Aids

Noise from a generator may be due to electrical or mechanical noise. Electrical noise or magnetic whine usually varies with the electrical load placed on the generator and is a normal operating characteristic of all generators. When diagnosing a noisy generator, it is important to remember that loose or misaligned components around the generator may transmit the noise into the passenger compartment and that replacing the generator may not solve the problem.

Generator Noise Diagnosis

Step	Action	Yes	No
1	Test the generator for proper operation. Refer to **Charging System Test**. Is the generator operating properly?	Go to **Step 2**	Go to **Step 11**
2	1. Start the engine. Verify that the noise can be heard. 2. Turn OFF the engine. 3. Disconnect the harness connector from the generator. 4. Start the engine. 5. Listen for the noise. Has the noise stopped?	Go to **Step 11**	Go to **Step 3**
3	1. Turn OFF the engine. 2. Remove the drive belt. Refer to **Drive Belt Replacement** for the 4.6L (LH2) engine or **Water Pump and Generator Belt Replacement** for the 4.4L (LC3) engine. 3. Spin the generator pulley by hand. Does the generator shaft spin smoothly and without any roughness or grinding noise?	Go to **Step 4**	Go to **Step 11**
4	Inspect the generator for a loose pulley and/or pulley nut. Is the generator pulley or pulley nut loose?	Go to **Step 11**	Go to **Step 5**
	1. Loosen all of the generator mounting bolts. 2. Tighten the generator mounting bolts to specifications and in the proper sequence,		

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5	if necessary. Refer to **Generator Replacement (LH2)** or **Generator Replacement (LC3)**. 3. Install the drive belt. Refer to **Drive Belt Replacement** for the 4.6L (LH2) engine or **Water Pump and Generator Belt Replacement** for the 4.4L (LC3) engine. 4. Start the engine. Has the noise decreased or stopped?	System OK	Go to **Step 6**
6	Inspect the generator for the following conditions: • Strained or stretched electrical connections. • Hoses or other vehicle equipment resting on the generator, which may cause the noise to be transmitted into the passenger compartment Are any electrical connections pulling on the generator or are any hoses, etc. resting on the generator?	Go to **Step 7**	Go to **Step 8**
7	1. Reroute the electrical connections to relieve the tension. 2. Reroute the hoses, etc. away from the generator. 3. Start the engine. Has the noise decreased or stopped?	System OK	Go to **Step 8**
8	Inspect the drive belt for proper tension. Refer to **Drive Belt Tensioner Diagnosis** for the 4.6L (LH2) engine or **Drive Belt Tensioner Diagnosis** for the 4.4L (LC3) engine Is the drive belt loose?	Go to **Step 9**	Go to **Step 10**
9	1. Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement** for the 4.6L (LH2) engine or **Water Pump and Generator Drive Belt Tensioner Replacement** for the 4.4L (LC3) engine. 2. Start the engine. Has the noise decreased or stopped?	System OK	Go to **Step 11**

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10	Compare the vehicle with a known good vehicle. Do both vehicles make the same noise?	System OK	Go to **Step 11**
11	**IMPORTANT:** **If no definite generator problems were found, be sure that all other possible sources of objectionable noise are eliminated before replacing the generator. Replacing the generator may not change the noise level if the noise is a normal characteristic of the generator or the generator mounting.** Replace the generator. Refer to **Generator Replacement (LH2)** or **Generator Replacement (LC3)**.Has the noise decreased or stopped?	Go to **Step 12**	-
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 2**

STARTER SOLENOID DOES NOT CLICK

Starter Solenoid Does Not Click

Step	Action	Yes	No
Schematic Reference: Starting and Charging Schematics **Connector End View Reference: Power and Grounding Connector End Views**			
1	Did you perform the Diagnostic System Check - Vehicle?	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	Apply the brake and press the Start button. Does the engine crank?	Go to **Testing for Intermittent Conditions and Poor Connections**	Go to **Step 3**
3	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF, Are DTCs B2515,C0277,C0278,P0615,P0616,P0617,P1875 Current?	Go to **Diagnostic Trouble Code (DTC) List - Vehicle**	Go to **Step 4**
4	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. With a scan tool, observe the starter relay command parameter in the engine control module (ECM) data list. 4. Apply the brake and press the Start button.		

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	Does the scan tool display ON?	Go to **Step 6**	Go to **Step 5**
5	1. Turn ON the ignition, with the engine OFF. 2. Verify that the transmission is in Park or Neutral. 3. With a scan tool, observe the PNP switch parameter in the engine control module (ECM) data list. Does the scan tool display Park/Neutral?	Go to **Step 6**	Go to **Diagnostic Trouble Code (DTC) List - Vehicle**
6	Apply the brake and press the Start button. Do you hear the crank relay click?	Go to **Step 9**	Go to **Step 7**
7	1. Turn OFF the ignition. 2. Disconnect the crank relay. 3. Turn ON the ignition, with the engine OFF. 4. Connect a test lamp between the battery positive voltage circuit of the crank relay coil and a good ground. Does the test lamp illuminate?	Go to **Step 8**	Go to **Step 17**
8	1. Connect a test lamp between the battery positive voltage circuit of the crank relay coil and the control circuit of the crank relay. 2. Apply the brake and press the Start button. Does the test lamp illuminate?	Go to **Step 9**	Go to **Step 13**
9	1. Turn OFF the ignition. 2. Disconnect the crank relay. 3. Connect a test lamp between the battery positive voltage circuit of the crank relay switch circuit and a good ground. Does the test lamp illuminate?	Go to **Step 10**	Go to **Step 18**
10	**IMPORTANT:** **Ensure the parking brake is applied and the transmission is in park equipped with an automatic transmission or neutral on a manual transmission.** Connect a 30-amp fused jumper between the battery positive voltage circuit of the crank relay switch circuit and the supply voltage circuit of the starter solenoid.Does the engine crank?	Go to **Step 14**	Go to **Step 11**
11	Does the fuse in the jumper open?	Go to **Step 19**	Go to **Step 12**

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12	Test the supply voltage circuit of the starter solenoid for a high resistance or open. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	Go to **Step 23**	Go to **Step 15**
13	Test the control circuit of the crank relay for an open or short to battery voltage. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	Go to **Step 23**	Go to **Step 16**
14	Inspect for poor connections at the crank relay. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 23**	Go to **Step 20**
15	Inspect for poor connections at the starter solenoid. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 23**	Go to **Step 21**
16	Inspect for poor connections at the harness connector of the ECM. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 23**	Go to **Step 22**
17	Repair an open or high resistance in the battery positive voltage circuit of the crank relay coil. Refer to **Wiring Repairs** . Did you complete the repair?	Go to **Step 23**	-
18	Repair the open or high resistance in the battery positive voltage circuit of the crank relay switch. Refer to **Wiring Repairs** . Did you complete the repair?	Go to **Step 23**	-
19	Repair the short to ground in the supply voltage circuit of the starter solenoid. Refer to **Wiring Repairs** . Did you complete the repair?	Go to **Step 23**	-
20	Replace the crank relay. Did you complete the replacement?	Go to **Step 23**	-
21	Replace the starter motor. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)**. Did you complete the replacement?	Go to **Step 23**	-
22	Replace the engine control module (ECM). Refer to **Control Module References** for replacement, setup and programming. Did you complete the replacement?	Go to **Step 23**	-
23	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 2**

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STARTER SOLENOID CLICKS, ENGINE DOES NOT CRANK

Starter Solenoid Clicks, Engine Does Not Crank

Step	Action	Yes	No
Schematic Reference: Starting and Charging Schematics Connector End View Reference: Master Electrical Component List			
1	Did you perform the Diagnostic System Check - Vehicle?	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	Apply the brake and press the start button. Did the starter solenoid click?	Go to **Step 3**	Go to **Starter Solenoid Does Not Click**
3	Inspect the engine and belt drive system for mechanical binding, seized engine or seized generator. Does the engine move freely?	Go to **Step 4**	• Go to **Engine Will Not Crank - Crankshaft Will Not Rotate** for the 4.6L (LH2) engine • Go to **Engine Will Not Crank - Crankshaft Will Not Rotate** for the 4.4L (LC3) engine
4	Test the battery positive cable between the battery and the starter solenoid for high resistance. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	Go to **Step 8**	Go to **Step 5**
5	Test the ground circuit between the battery and the starter motor for a high resistance. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	Go to **Step 8**	Go to **Step 6**
6	Inspect for poor connections at the starter. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 8**	Go to **Step 7**
7	Replace the starter. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)**. Did you complete the replacement?	Go to **Step 8**	-

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8	Operate the system for which the symptom occurred. Did you correct the condition?	System OK	Go to **Step 2**

ENGINE CRANKS SLOWLY

Inspect the following items:

- Battery-Perform the Battery Inspection/Test. Refer to **Battery Inspection/Test**.
- Wiring-Inspect the wiring for damage. Inspect all connections to the starter motor, the solenoid, the battery and all ground connections. Refer to **Circuit Testing** , **Wiring Repairs** , **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** .
- Engine-Verify that the engine is not seized.

If the battery, the wiring and the engine are functioning properly and the engine continues to crank slowly, replace the starter motor. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)**.

STARTER MOTOR NOISE DIAGNOSIS

Diagnostic Aids

Inspect the flywheel ring gear for damage or unusual wear.

Starter Motor Noise Diagnosis

Step	Action	Yes	No
1	Did you perform the Diagnostic System Check - Vehicle?	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	Start the engine. Does the starter operate normally?	Go to **Testing for Intermittent Conditions and Poor Connections**	Go to **Step 3**
3	Start the engine while listening to the starter motor turn. Is there a loud "whoop", that may sound like a siren if the engine is revved while the starter is engaged, after the engine starts, but while the starter is still held in the engaged position?	Go to **Step 6**	Go to **Step 4**
4	Do you hear a "rumble", a "growl", or, in some cases, a "knock" as the starter is coasting down to a stop after starting the engine?	Go to **Step 7**	Go to **Step 5**
5	**IMPORTANT:** **This is often diagnosed as a starter drive gear hang-in or a weak solenoid.**		

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	When the engine is cranked, do you hear a high-pitched whine after the engine cranks and starts normally?	Go to **Step 8**	Go to **Step 7**
6	Inspect the flywheel ring gear for the following: • Chipped gear teeth • Missing gear teeth • Milled teeth Is the flywheel bent or does it have damaged teeth?	Go to **Step 8**	Go to **Step 7**
7	1. Remove the starter motor. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)**. 2. Inspect the starter motor bushings and clutch gear. Does the clutch gear have chipped or milled teeth or worn bushings?	Go to **Step 9**	Go to **Step 10**
8	Replace the flywheel. Refer to **Engine Flywheel Replacement** for the 4.6L (LH2) engine or **Engine Flywheel Replacement** for the 4.4L (LC3) engine. Did you complete the replacement?	Go to **Step 10**	-
9	Replace the starter motor. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)**. Did you complete the replacement?	Go to **Step 10**	-
10	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

REPAIR INSTRUCTIONS

BATTERY NEGATIVE CABLE DISCONNECTION AND CONNECTION

Removal Procedure

CAUTION: When performing service on or near the SIR components or the SIR system must be disabled. Refer to SIR DISABLING AND ENABLING . SIR Disabling and Enabling. Failure to observe the correct procedure could cause deployment of the SIR components, personal injury or unnecessary SIR system repairs.

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1. Record all of the vehicle preset radio stations.
2. Record the radio Theftlock® code (if applicable). Refer to **Radio/Audio System Description and Operation** .
3. Turn OFF all the lamps and the accessories.
4. Make sure the ignition switch is in the OFF position.

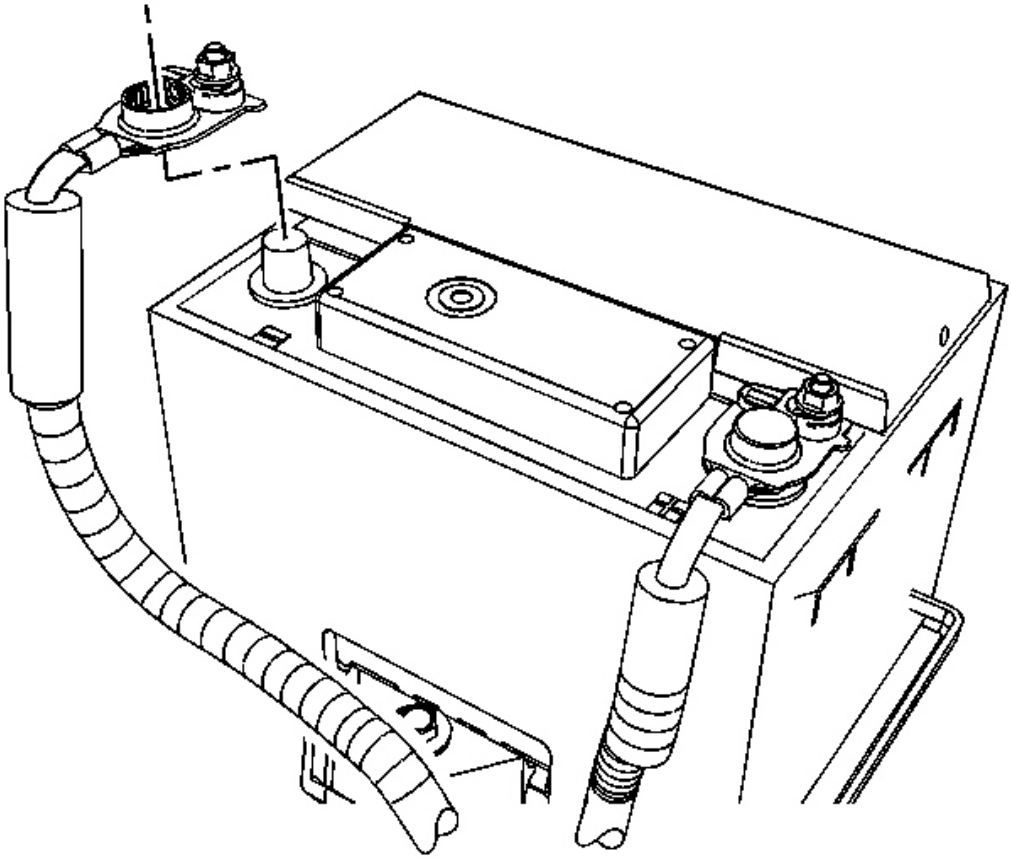


Fig. 7: Disconnecting Battery Negative Cable From Battery
Courtesy of GENERAL MOTORS CORP.

5. Loosen the negative battery cable to the battery nut and disconnect the battery negative cable from the battery.

Installation Procedure

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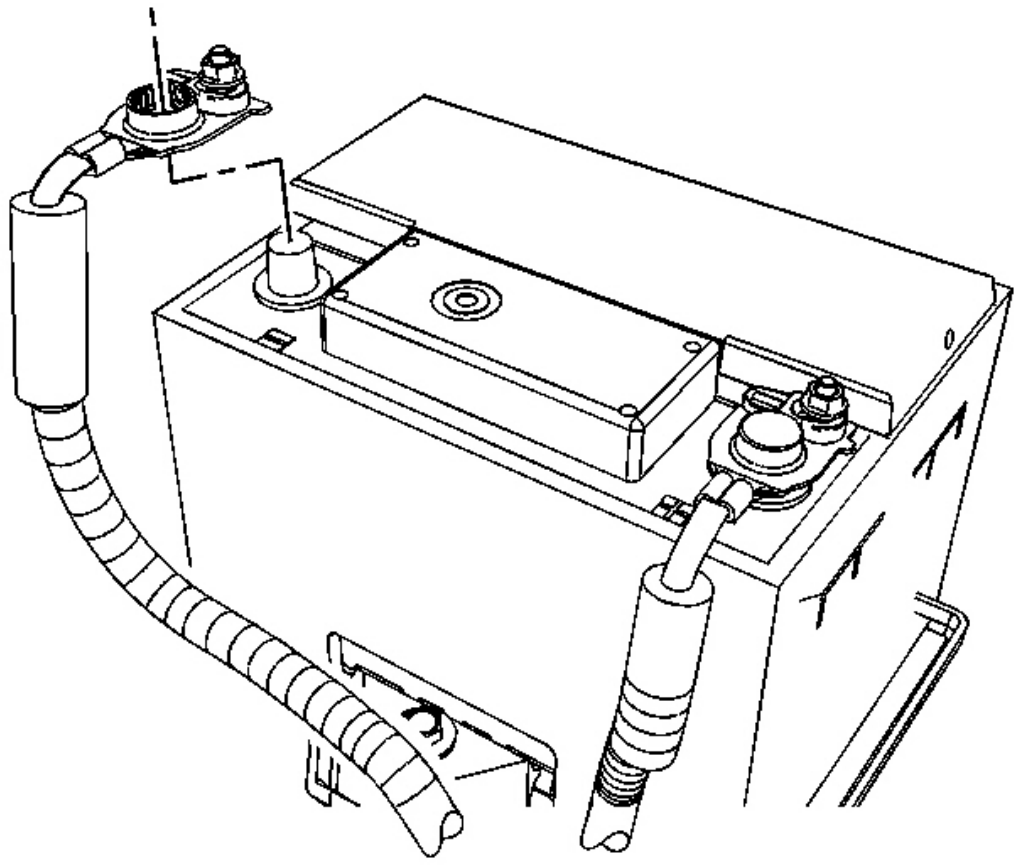


Fig. 8: Disconnecting Battery Negative Cable From Battery
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

IMPORTANT: Clean any existing oxidation from the contact surface of the battery cable using a wire brush before installing the battery cable to the battery.

1. Connect the battery negative cable to the battery.

   Tighten: Tighten the negative battery cable to battery nut to 8 N.m (71 lb in).

2. Unlock the Theftlock® radio (if applicable).
3. Program the radio stations back into the radio as recorded at the beginning of the procedure.
4. Set the clock to the current time. Refer to **Radio/Audio System Description and Operation** .

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5. Reinitialize both power windows. Refer to **Power Window Reinitialization** .

BATTERY POSITIVE AND NEGATIVE CABLE REPLACEMENT (LC3)

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to **Battery Negative Cable Disconnection and Connection**.

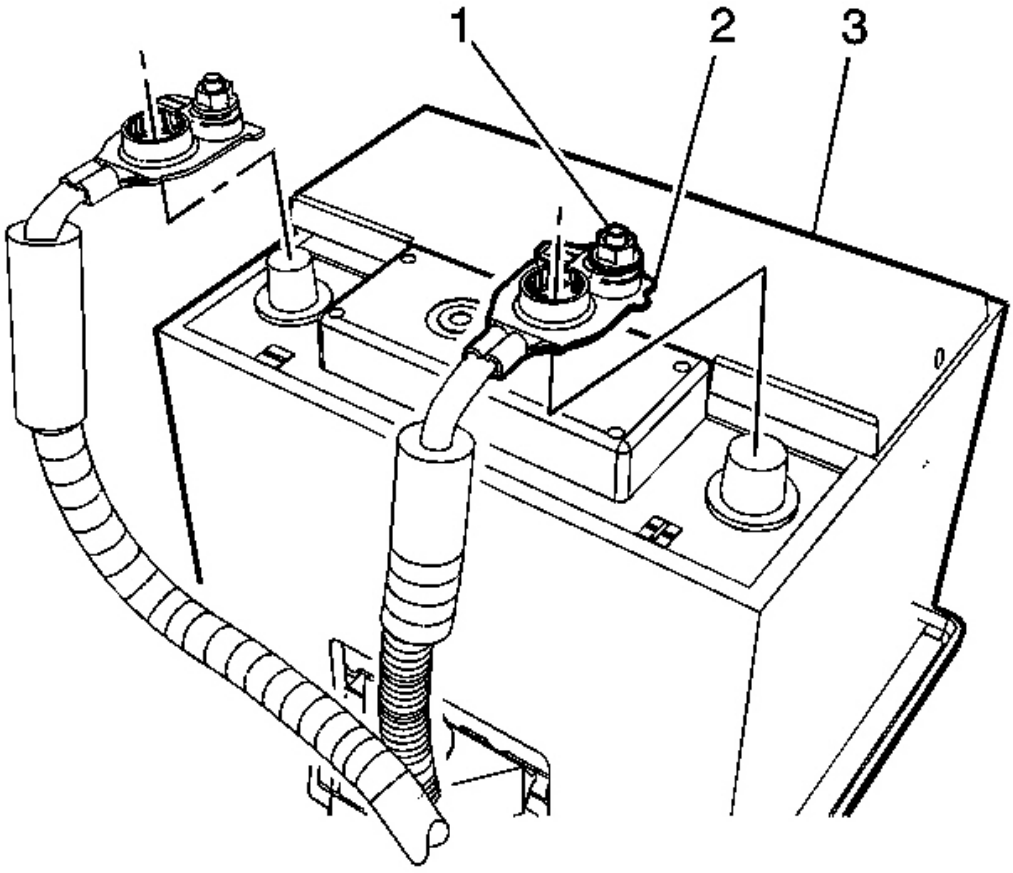


Fig. 9: View Of Battery Cable Terminals
Courtesy of GENERAL MOTORS CORP.

2. Loosen the battery positive cable nut (1) and disconnect the battery positive cable (2) from the battery (3).
3. Open the stud cover on the fuse/relay center.
4. Remove the battery positive cable nut and disconnect the battery positive cable lead from the fuse/relay

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center stud.

5. Remove the battery cable clips.
6. Remove the battery negative cable to frame rail nut and disconnect the battery negative cable from the frame rail stud.

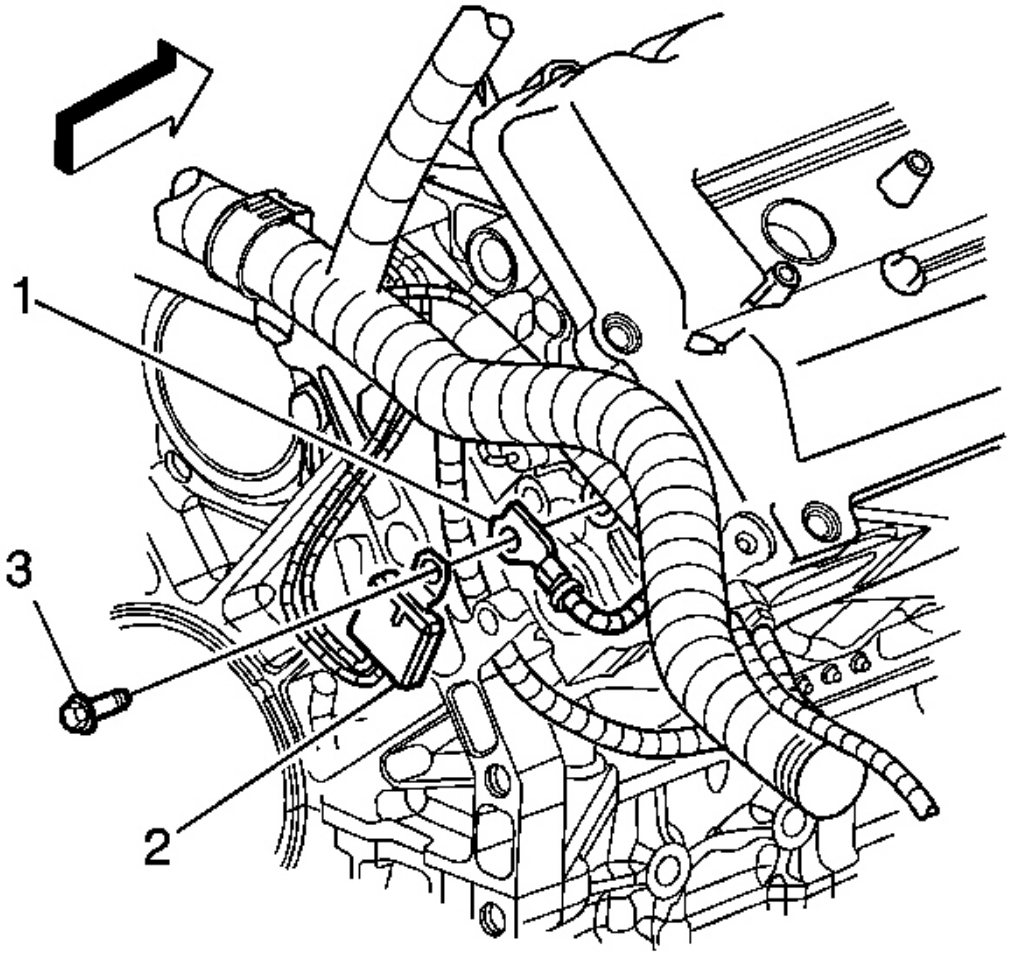


Fig. 10: View Of Battery Cable Bolt & Engine Harness Ground Pack
Courtesy of GENERAL MOTORS CORP.

7. Remove the battery cable bolt (3) securing the battery negative cable (1) and engine harness ground pack (2) to the right rear cylinder head.
8. Remove the supercharger. Refer to **Supercharger Replacement** .

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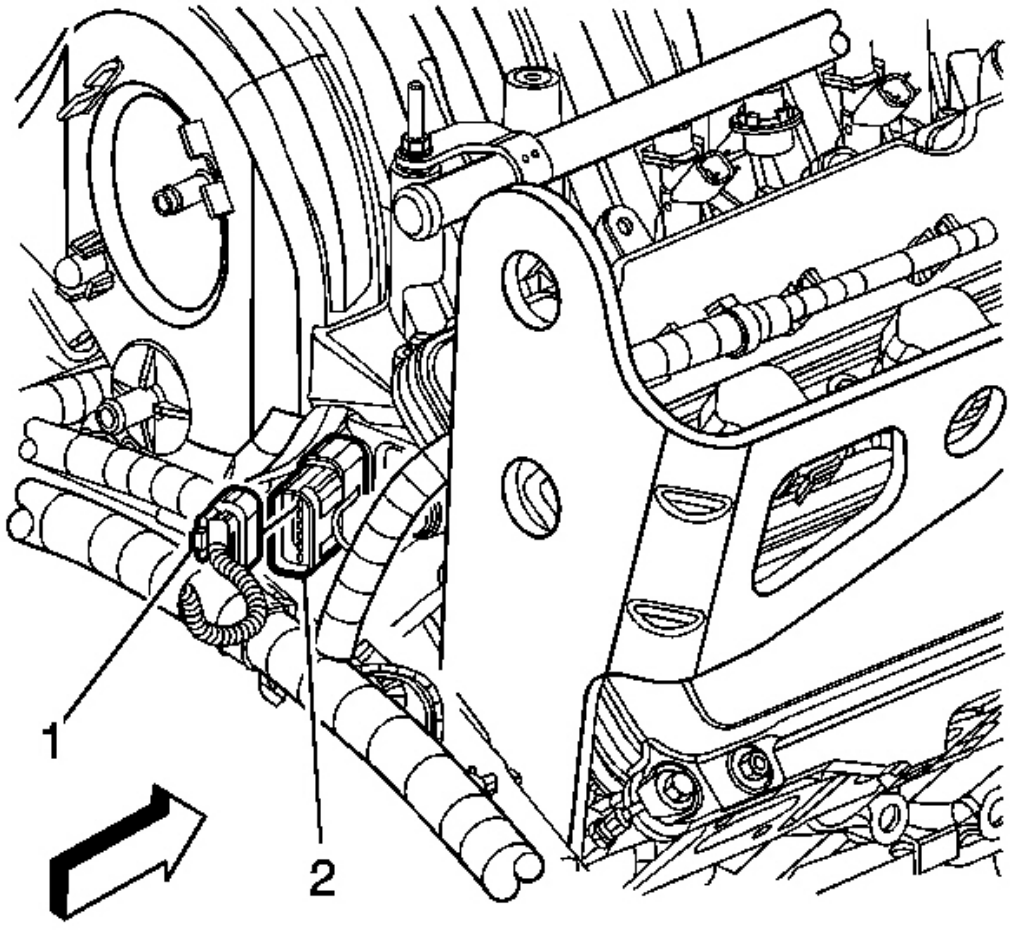


Fig. 11: View Of Jumper Harness & Engine Harness
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the starter jumper wiring harness (2) from the engine harness connector (1).

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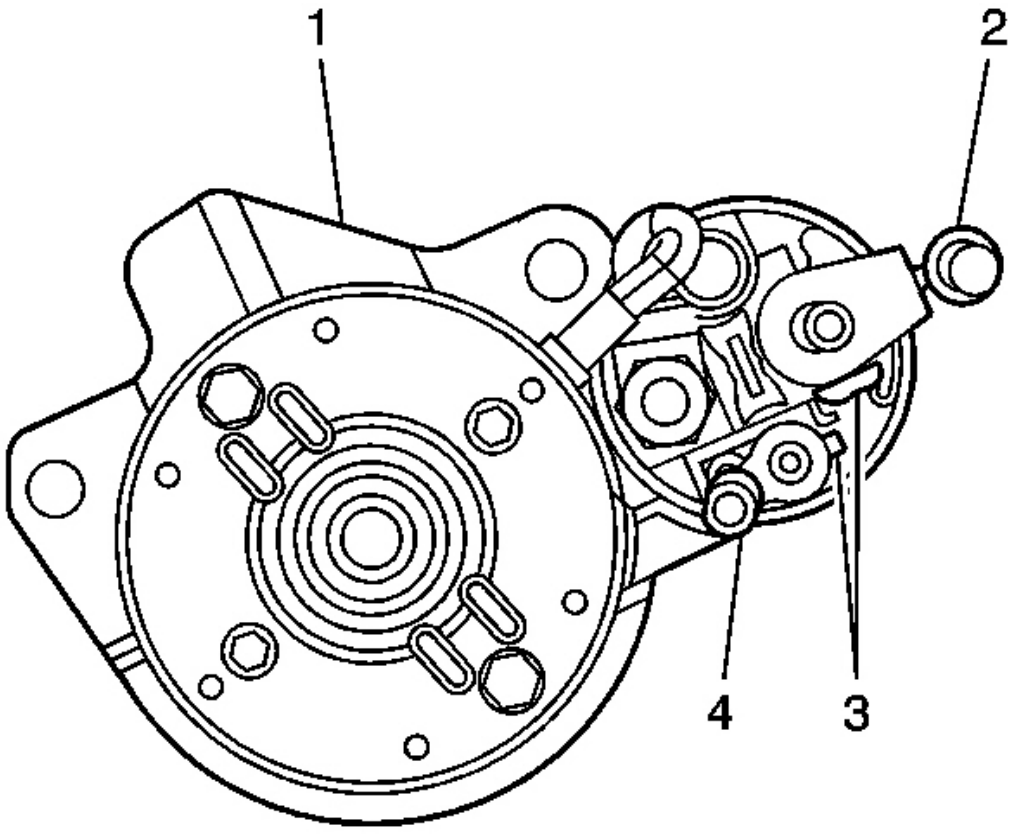


Fig. 12: View Of Starter Motor & Connections
Courtesy of GENERAL MOTORS CORP.

10. Remove the positive battery cable terminal nut and disconnect the terminals (2) from the starter solenoid.

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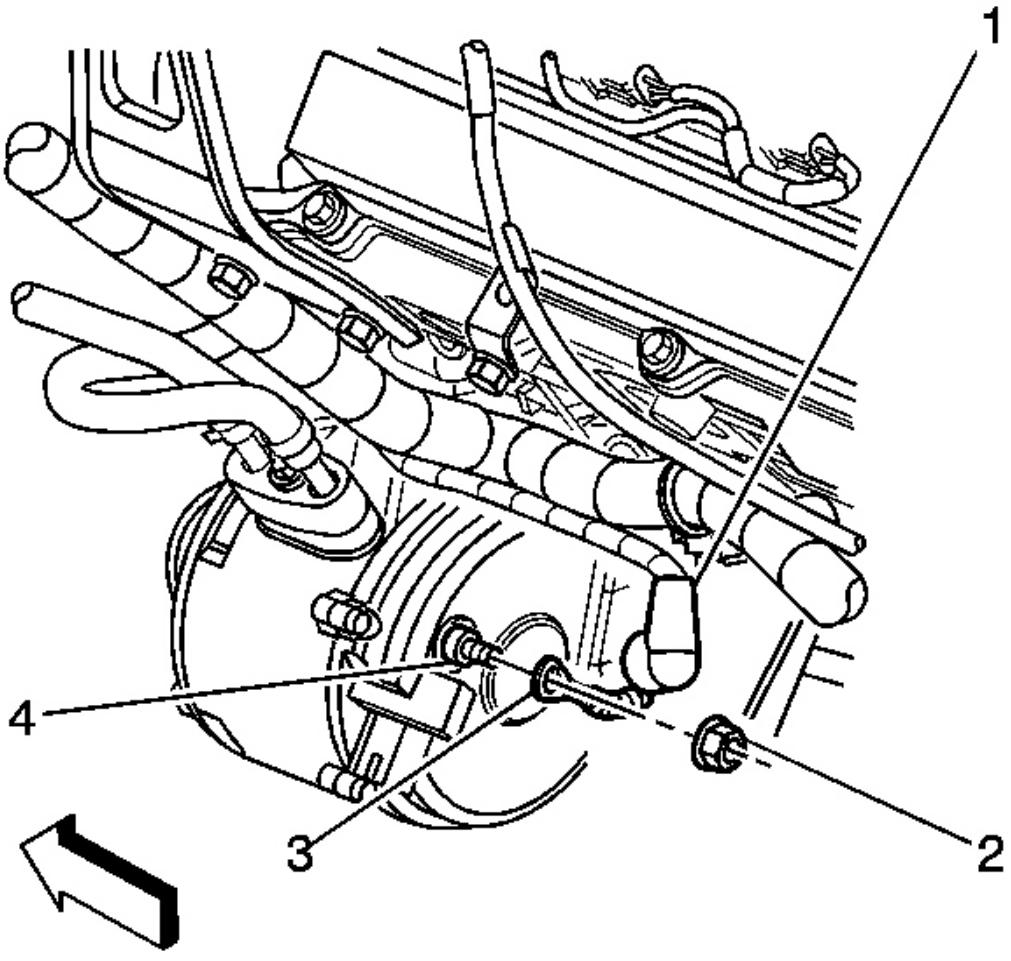


Fig. 13: View Of Battery Positive/Starter Cable Terminal & Nut
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the battery positive/starter cable from the generator:
    1. Slide the boot (1) back along the cable.
    2. Remove the battery positive/starter cable nut (2).
    3. Remove the battery positive/starter cable terminal (3) from the stud (4).

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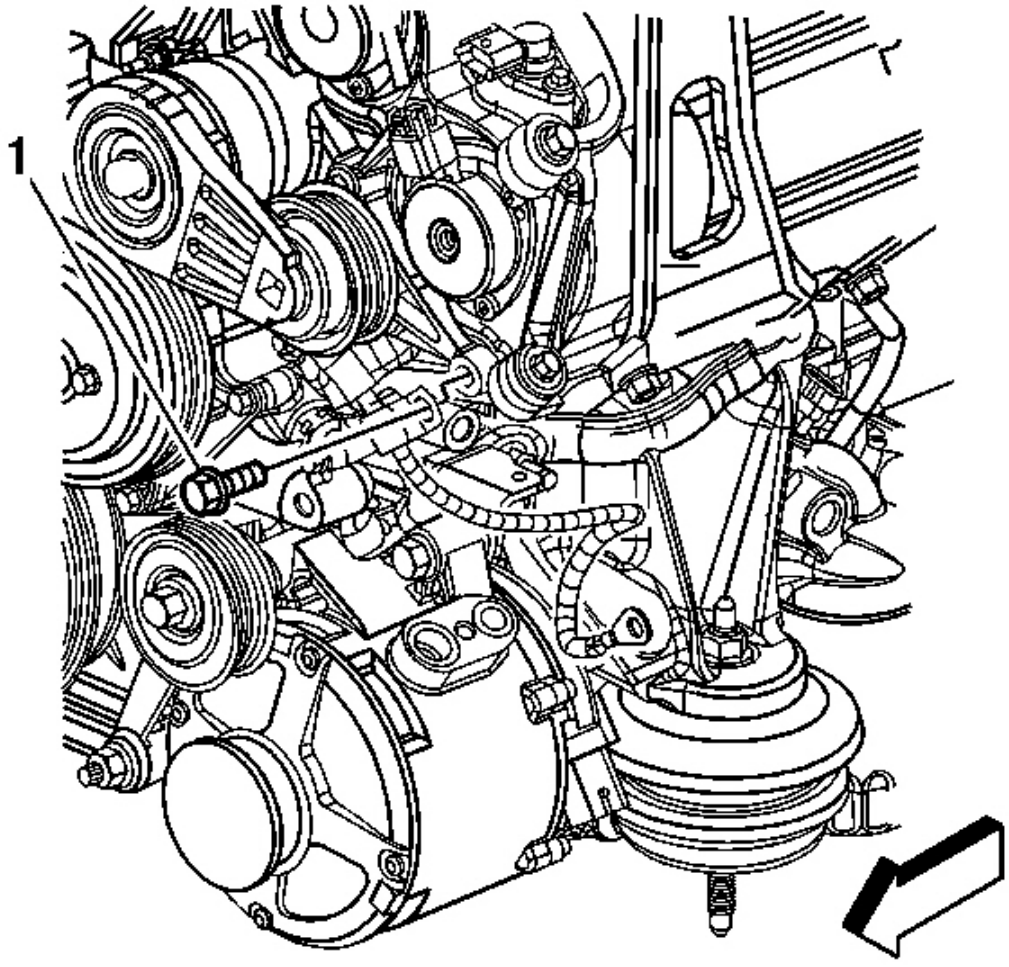


Fig. 14: View Of Cable & Clip Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

12. Remove the positive battery cable routing clip bolt (1) securing the cable and clip to the front of the engine.
13. Remove the battery positive and negative cable assembly.

Installation Procedure

1. Install the battery positive and negative cable assembly.

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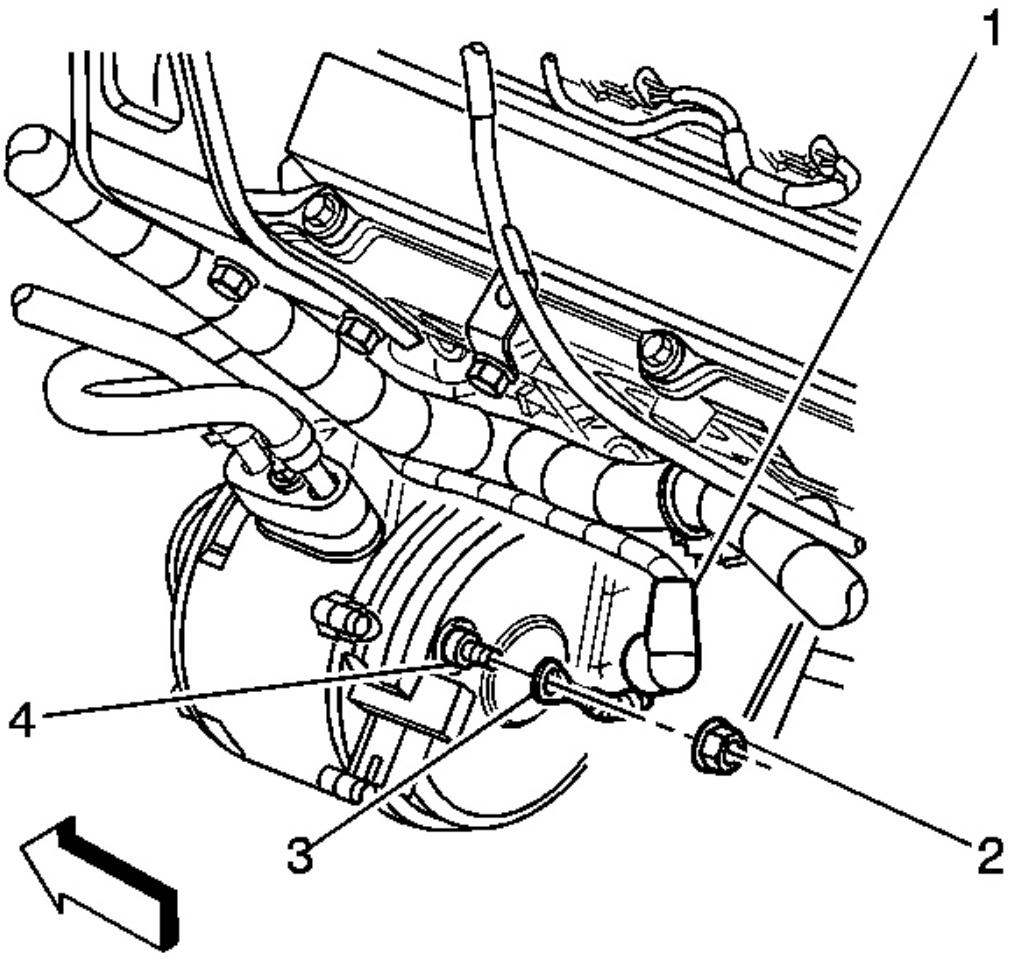


Fig. 15: View Of Battery Positive/Starter Cable Terminal & Nut
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

2. Connect the battery positive/starter/generator cable to the generator.
    1. Install the cable terminal (3) on the generator stud (4). The wire should be between the 2 and 4 o'clock position.
    2. Install the terminal nut (2).

    Tighten: Tighten the generator nut to 20 N.m (15 lb ft).

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3. Slide the boot (1) back into place over the stud (4) and the nut (2).

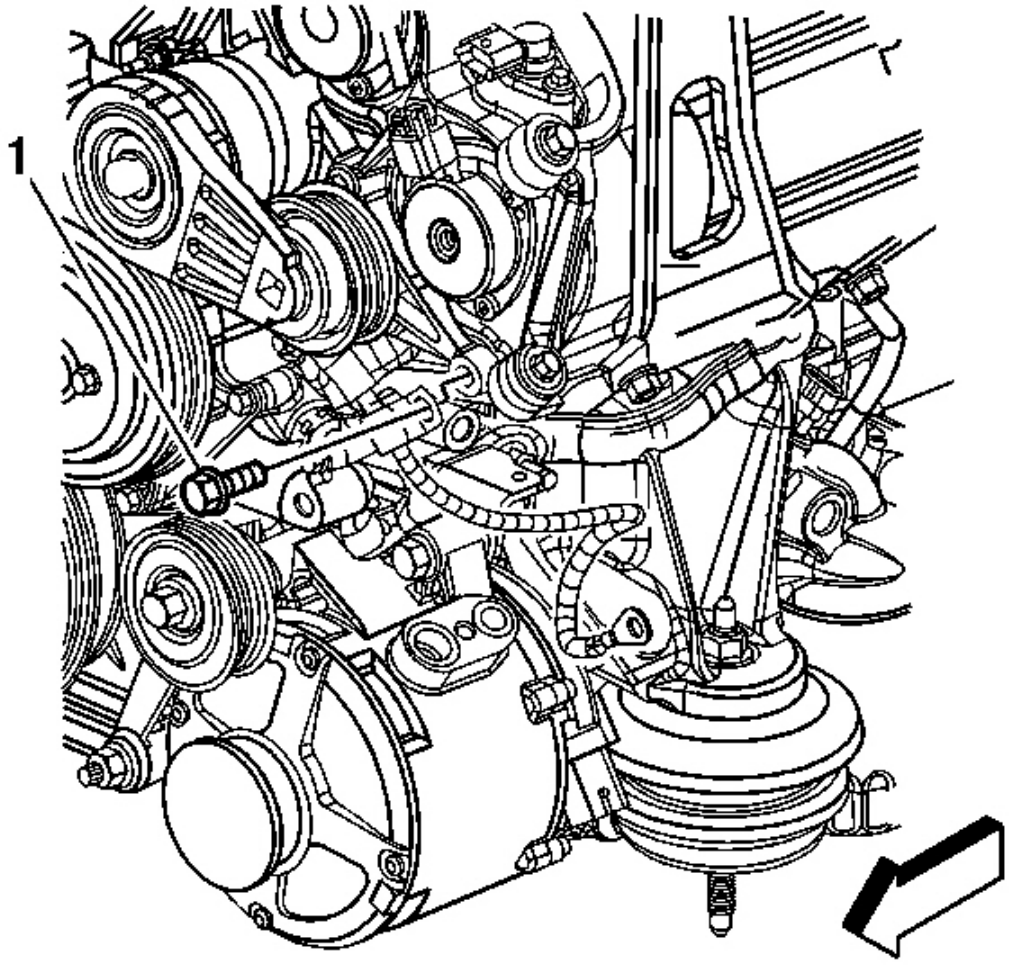


Fig. 16: View Of Cable & Clip Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

3. Install the positive battery cable routing clip bolt (1) into the cable retaining clip and attach to the front of the engine.

   Tighten: Tighten the bolt to 35 N.m (26 lb ft).

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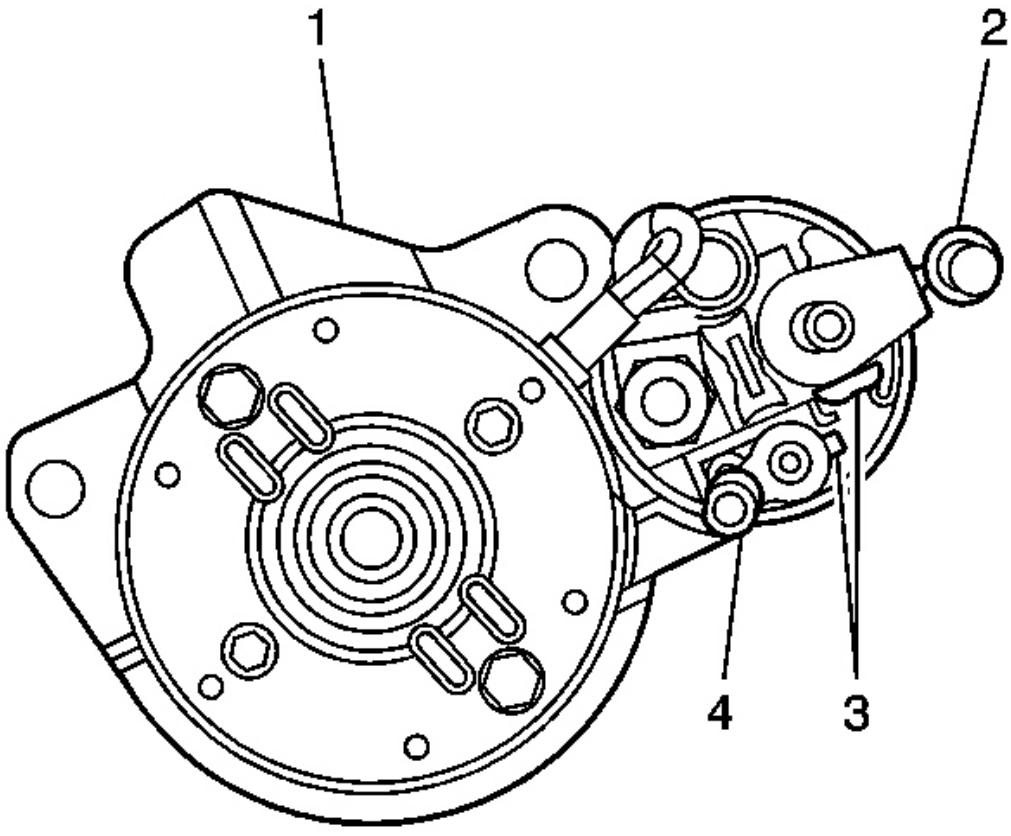


Fig. 17: View Of Starter Motor & Connections
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the engine harness leads are positioned on the solenoid prior to the positive cable terminal being installed.

4. Install the battery positive cable terminals and nut to the starter solenoid.

   Tighten:

   - Tighten the large nut (2) to 12 N.m (106 lb in).
   - Tighten the small nut to 4 N.m (35 lb in).

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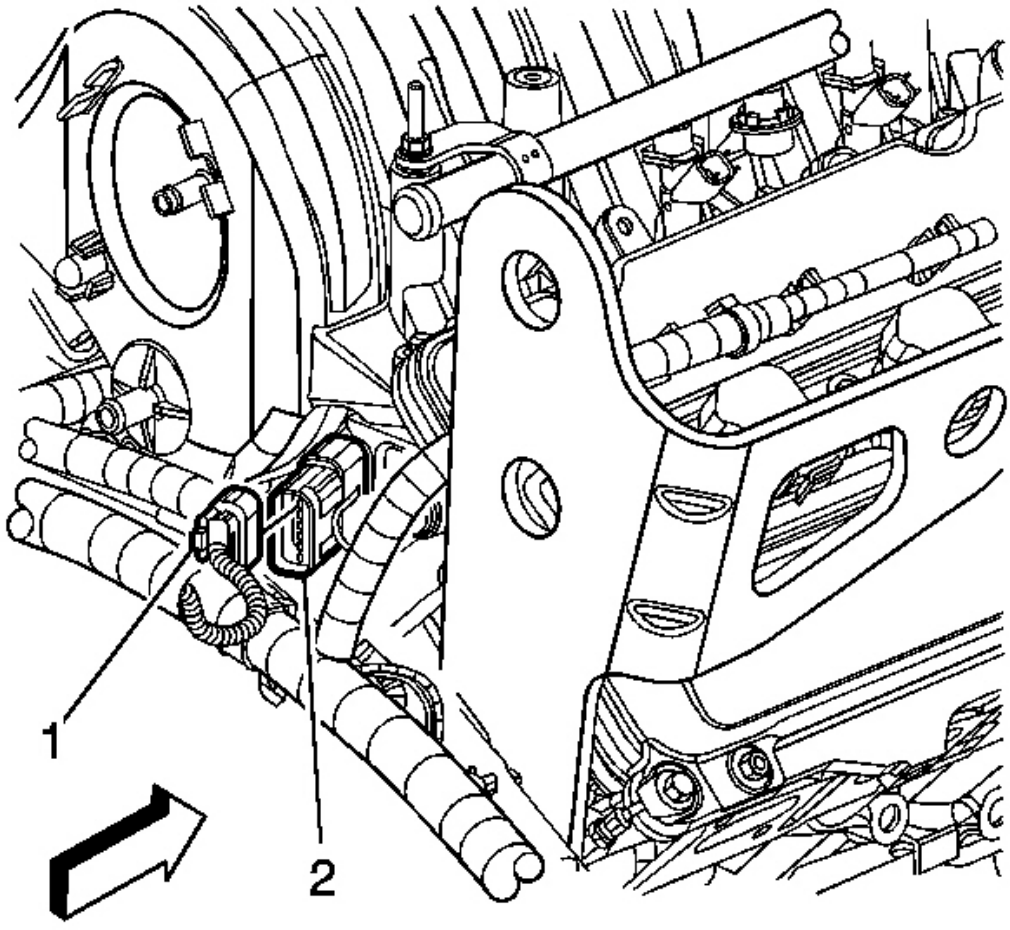


Fig. 18: View Of Jumper Harness & Engine Harness
Courtesy of GENERAL MOTORS CORP.

5. Connect the starter jumper wiring harness (2) to the engine harness connector (1).
6. Install the supercharger. Refer to **Supercharger Replacement** .

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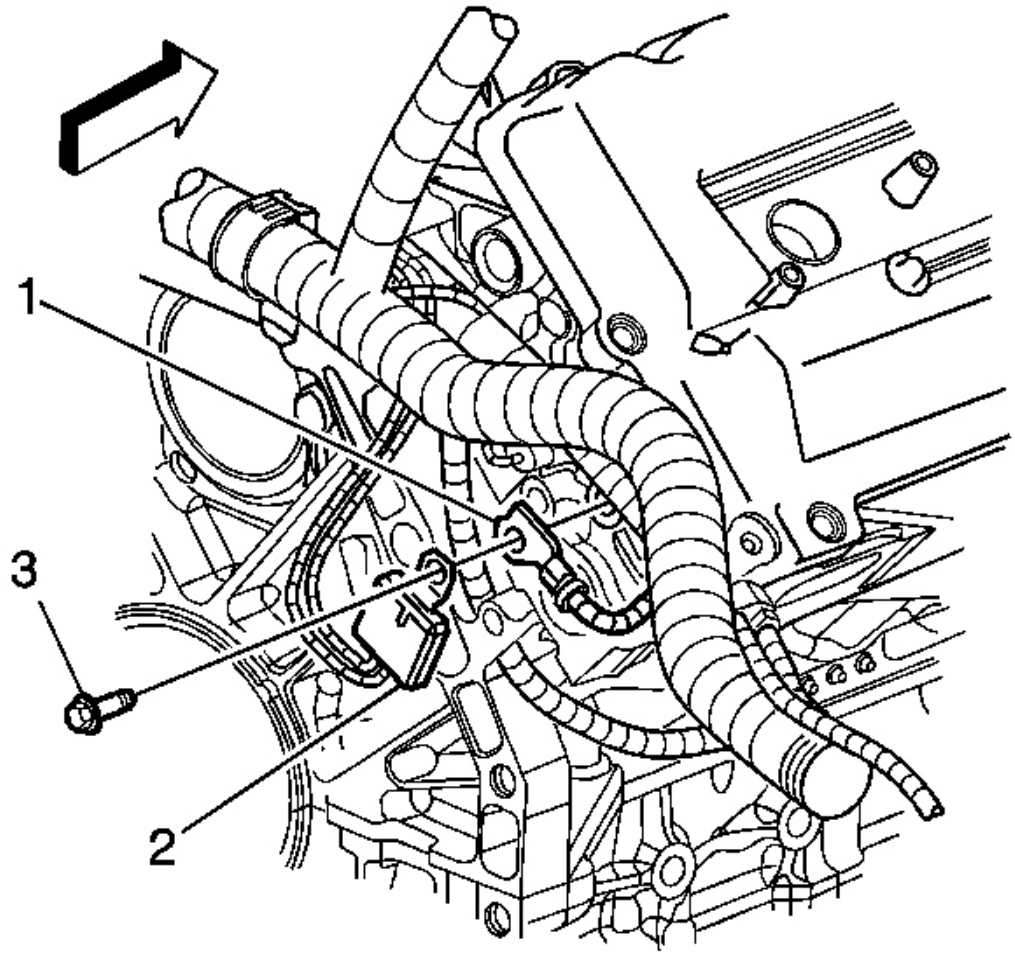


Fig. 19: View Of Battery Cable Bolt & Engine Harness Ground Pack
Courtesy of GENERAL MOTORS CORP.

7. Position the battery negative cable (1) and engine harness ground pack (2) to the right rear cylinder head and install the battery cable bolt (3).

   Tighten: Tighten the battery negative cable routing clip bolt to 35 N.m (26 lb ft).

8. Position the battery negative cable to frame rail stud and install the negative battery cable to frame rail nut.

   Tighten: Tighten the battery negative cable to frame rail nut to 11 N.m (97 lb in).

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9. Install the battery clips.
10. Position the positive battery cable lead to the fuse/relay center stud and install the positive battery cable nut.

    Tighten: Tighten the positive battery cable nut to 12 N.m (106 lb in).

11. Close the stud cover on the fuse/relay center.

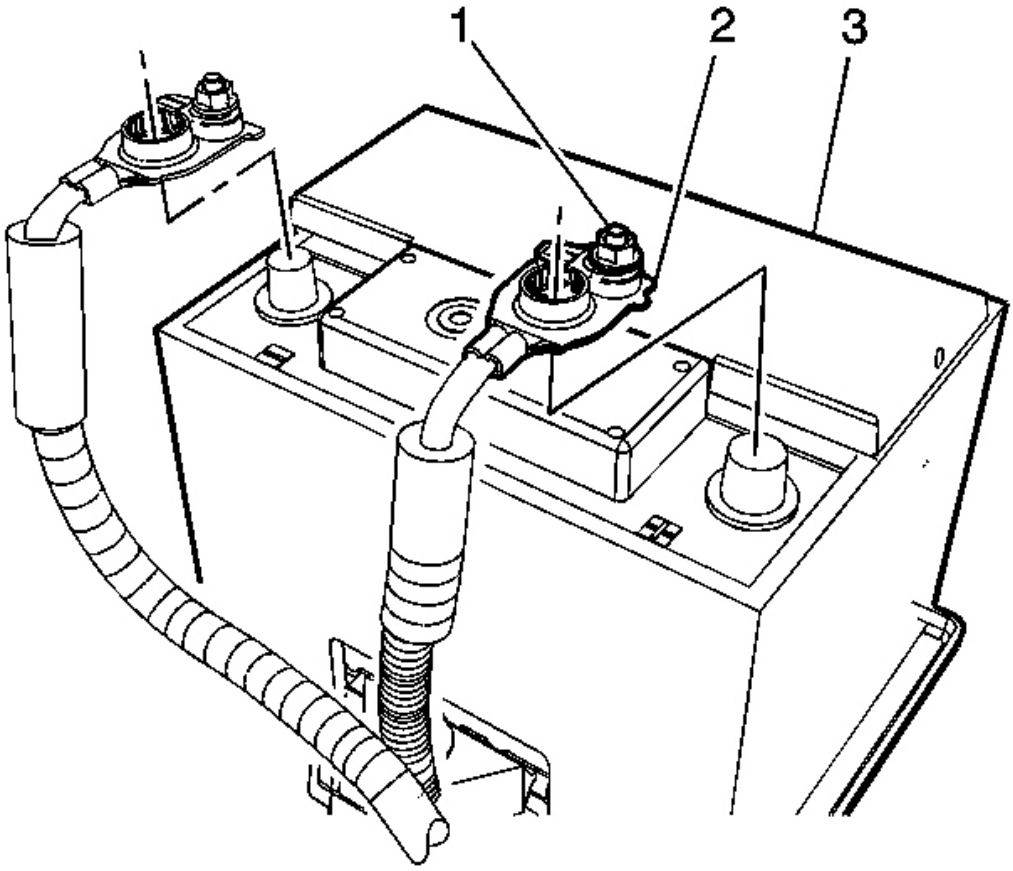


Fig. 20: View Of Battery Cable Terminals
Courtesy of GENERAL MOTORS CORP.

12. Connect the positive battery cable (2) to the battery (3) and tighten the nut (1).

    Tighten: Tighten the positive battery cable nut to 8 N.m (71 lb in).

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13. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

BATTERY POSITIVE AND NEGATIVE CABLE REPLACEMENT (LH2)

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to **Battery Negative Cable Disconnection and Connection**.

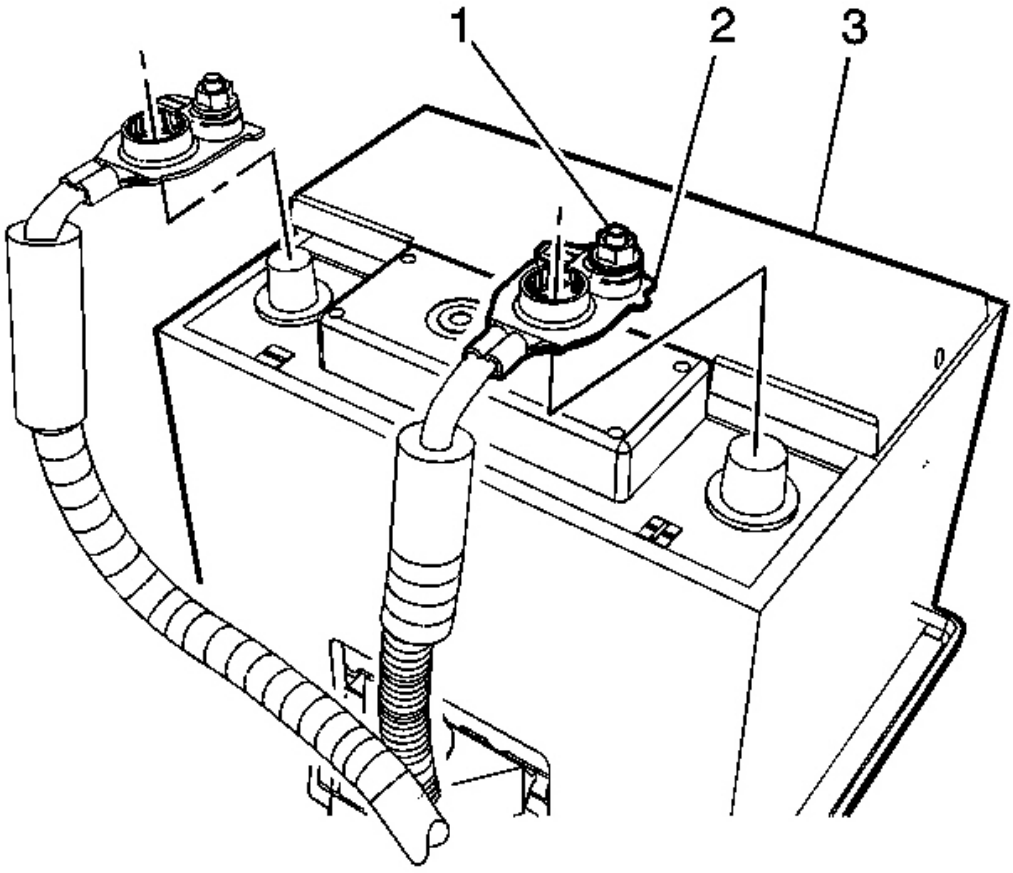


Fig. 21: View Of Battery Cable Terminals
Courtesy of GENERAL MOTORS CORP.

2. Loosen the battery positive cable nut (1) and disconnect the battery positive cable (2) from the battery (3).
3. Open the stud cover on the fuse/relay center.
4. Remove the battery positive cable nut and disconnect the battery positive cable lead from the fuse/relay

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center stud.

5. Remove the battery cable clips.
6. Remove the battery negative cable to frame rail nut and disconnect the battery negative cable from the frame rail stud.

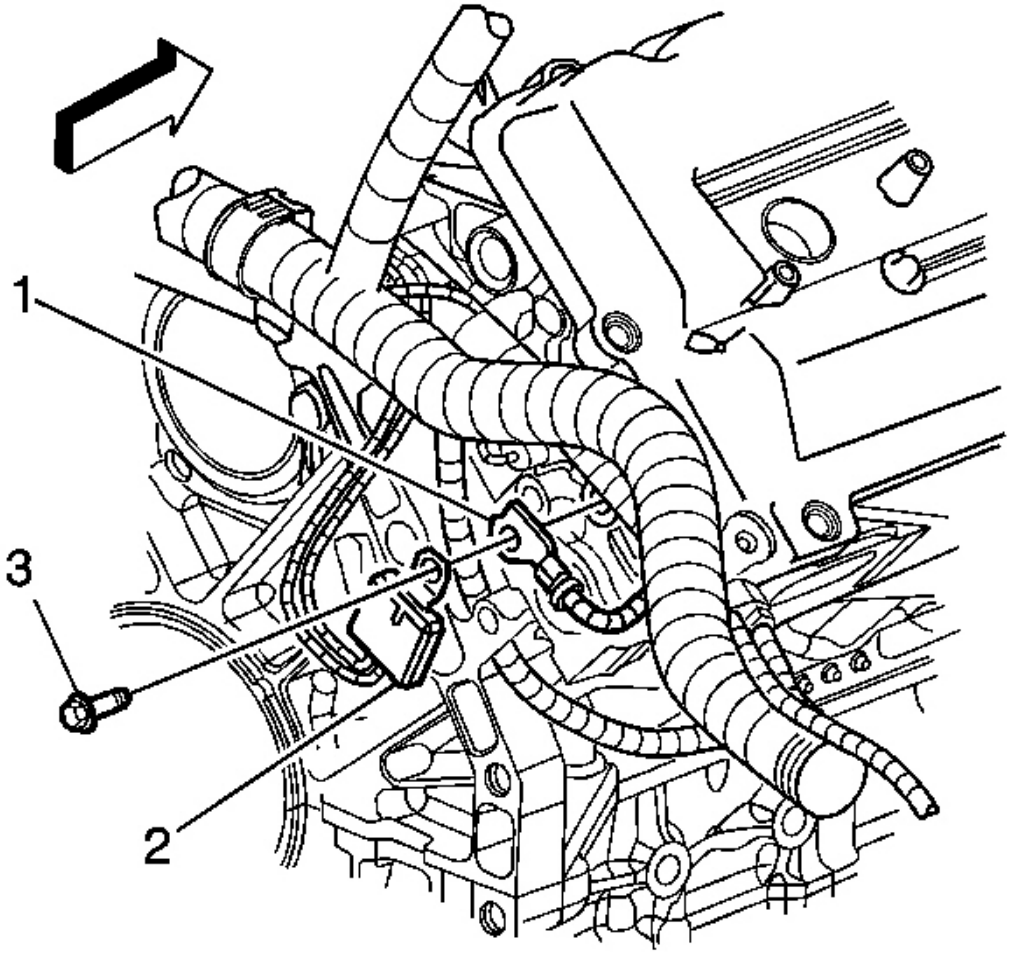


Fig. 22: View Of Battery Cable Bolt & Engine Harness Ground Pack
Courtesy of GENERAL MOTORS CORP.

7. Remove the battery cable bolt (3) securing the battery negative cable (1) and engine harness ground pack (2) to the right rear cylinder head.
8. Remove the intake manifold. Refer to **Intake Manifold Replacement** .

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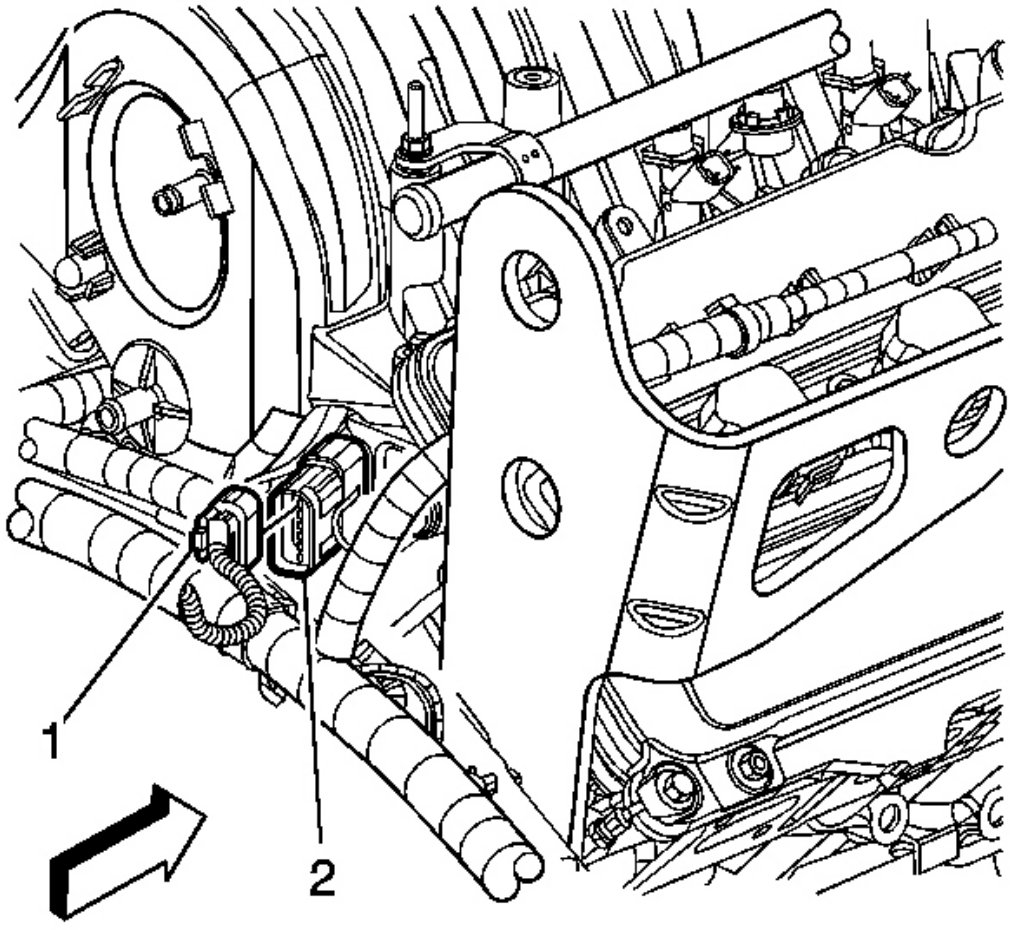


Fig. 23: View Of Jumper Harness & Engine Harness
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the starter jumper wiring harness (2) from the engine harness connector (1).

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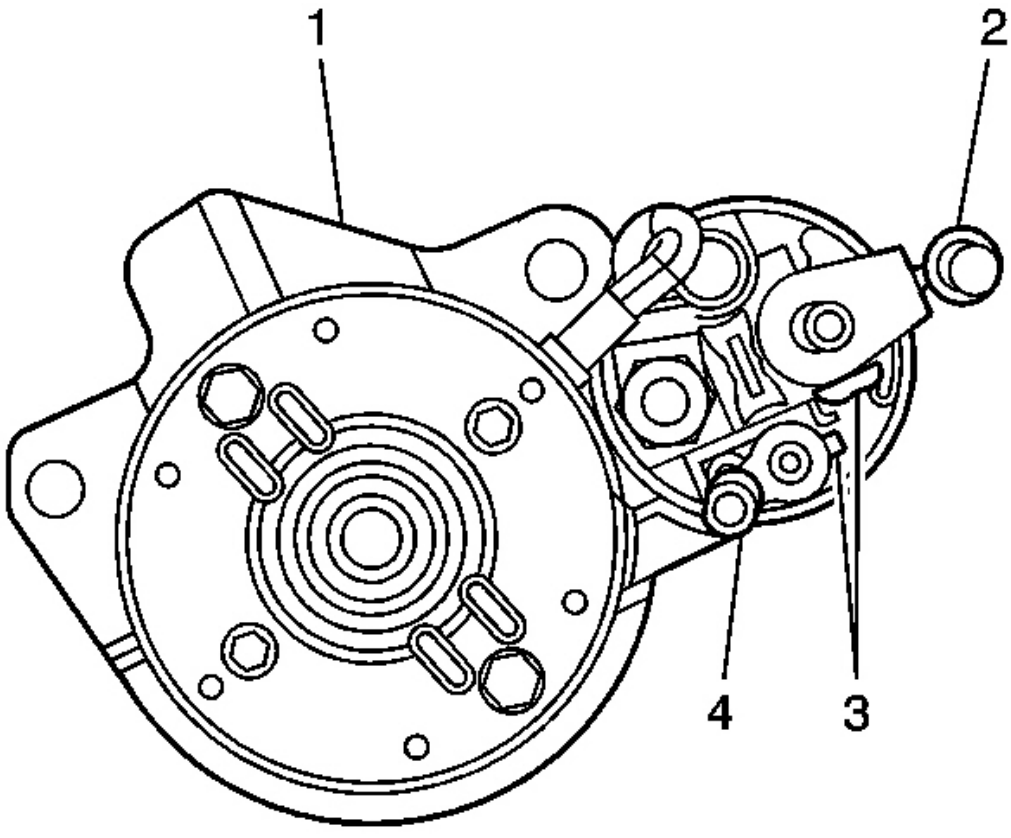


Fig. 24: View Of Starter Motor & Connections
Courtesy of GENERAL MOTORS CORP.

10. Remove the positive battery cable terminal nut and disconnect the terminals (2) from the starter solenoid.

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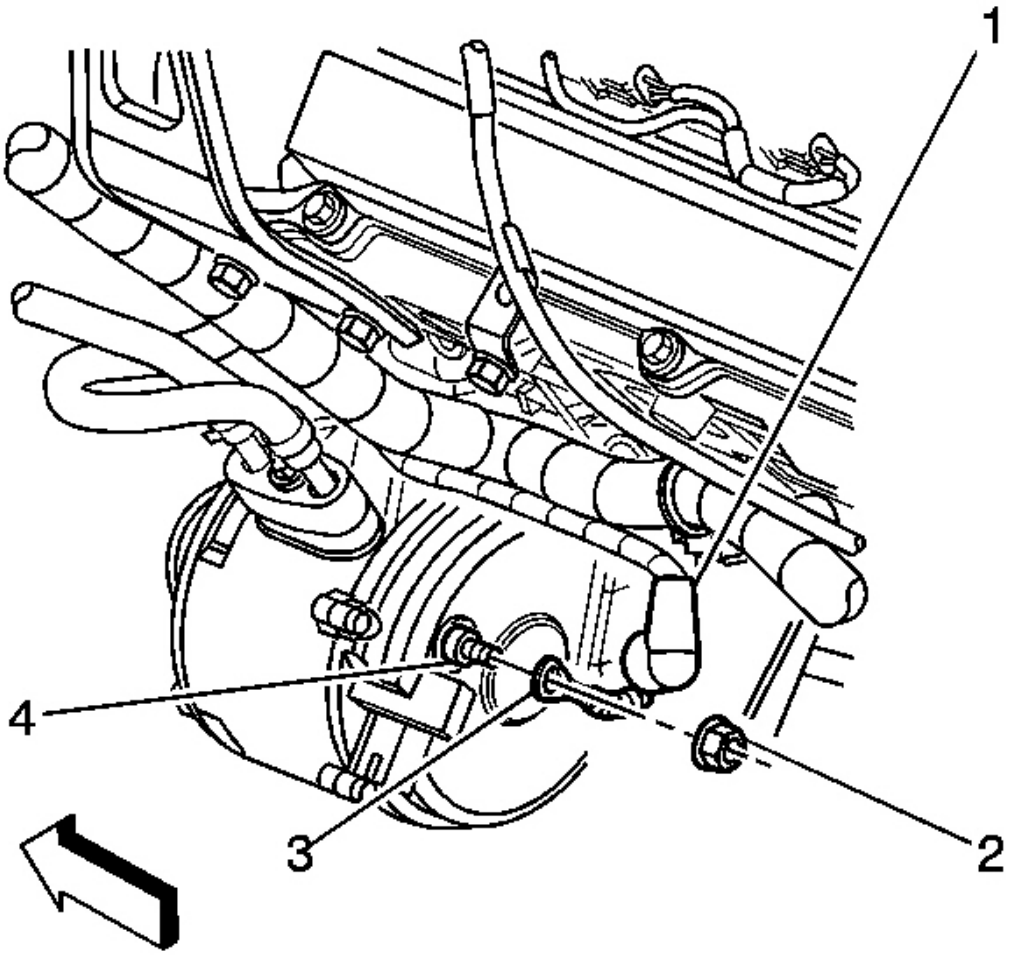


Fig. 25: View Of Battery Positive/Starter Cable Terminal & Nut
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the battery positive/starter cable from the generator:
    1. Slide the boot (1) back along the cable.
    2. Remove the battery positive/starter cable nut (2).
    3. Remove the battery positive/starter cable terminal (3) from the stud (4).

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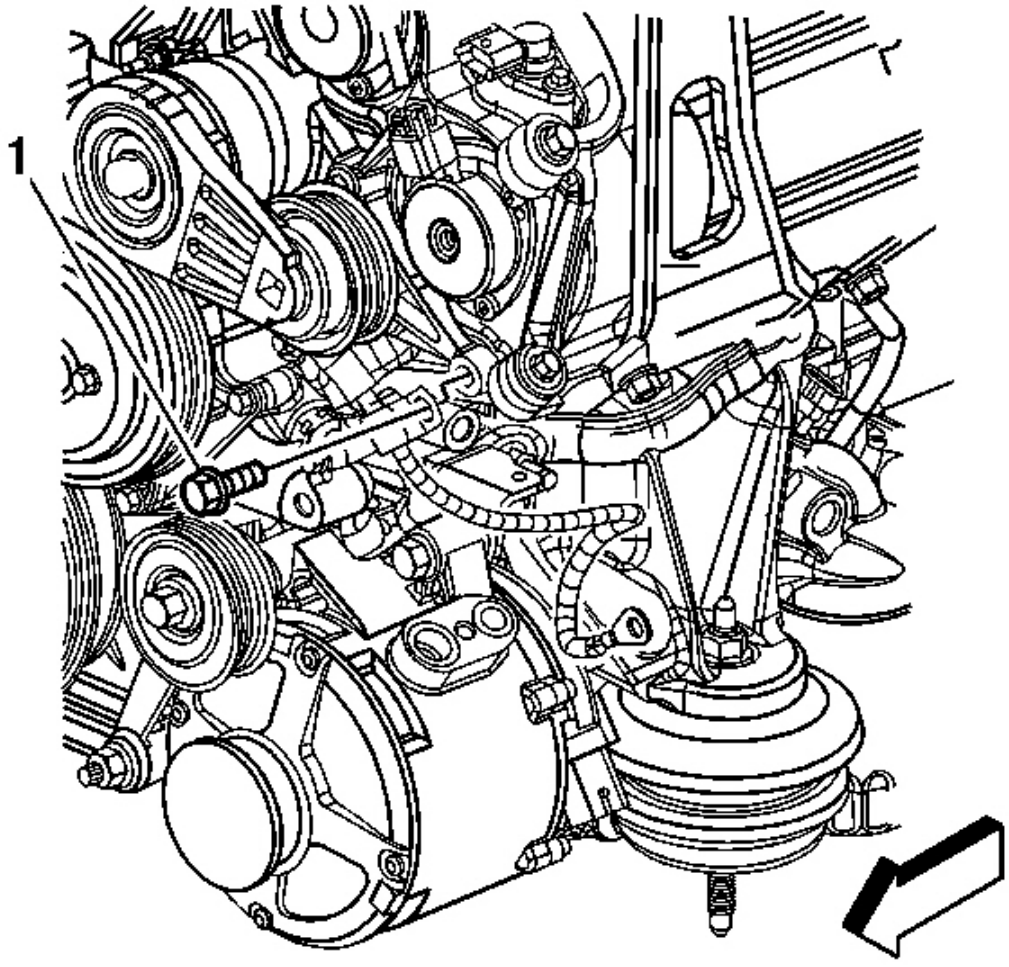


Fig. 26: View Of Cable & Clip Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

12. Remove the positive battery cable routing clip bolt (1) securing the cable and clip to the front of the engine.
13. Remove the battery positive and negative cable assembly.

Installation Procedure

1. Install the battery positive and negative cable assembly.

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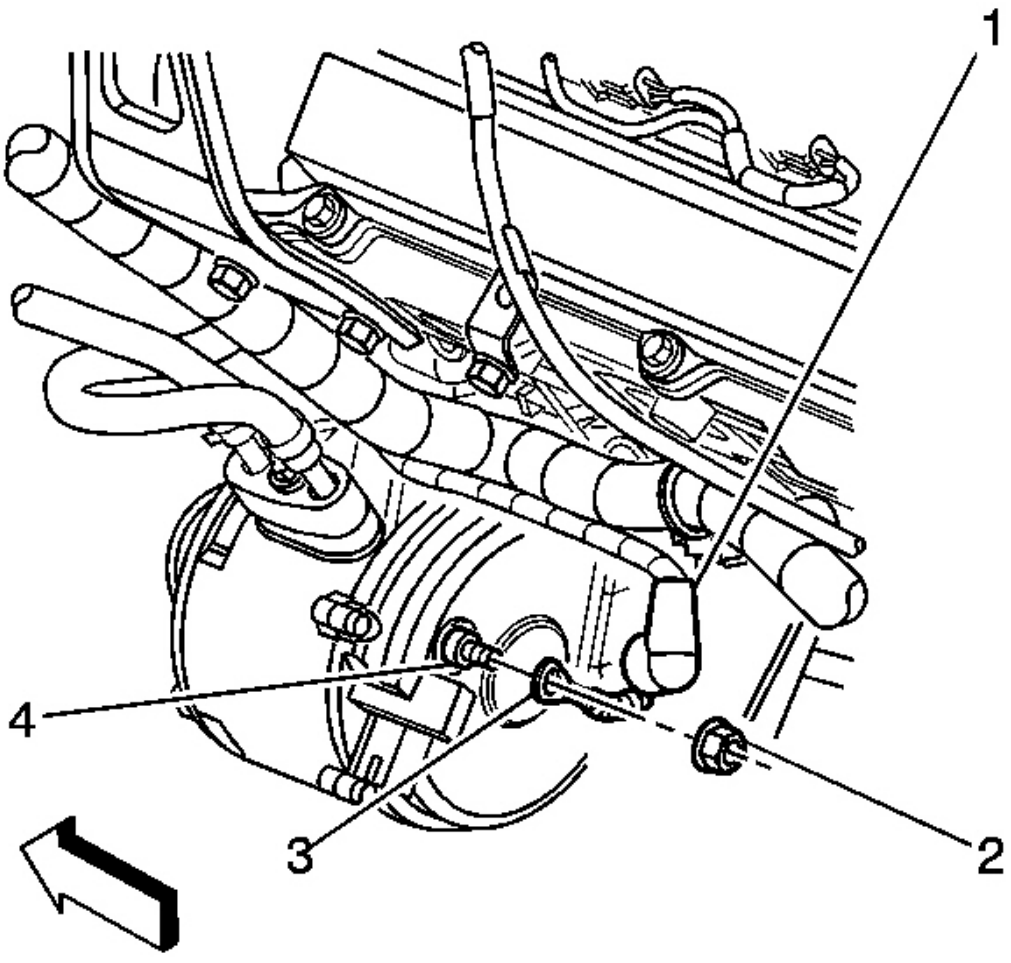


Fig. 27: View Of Battery Positive/Starter Cable Terminal & Nut
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

2. Connect the battery positive/starter/generator cable to the generator.
    1. Install the cable terminal (3) on the generator stud (4). The wire should be between the 2 and 4 o'clock position.
    2. Install the terminal nut (2).

    Tighten: Tighten the generator nut to 20 N.m (15 lb ft).

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3. Slide the boot (1) back into place over the stud (4) and the nut (2).

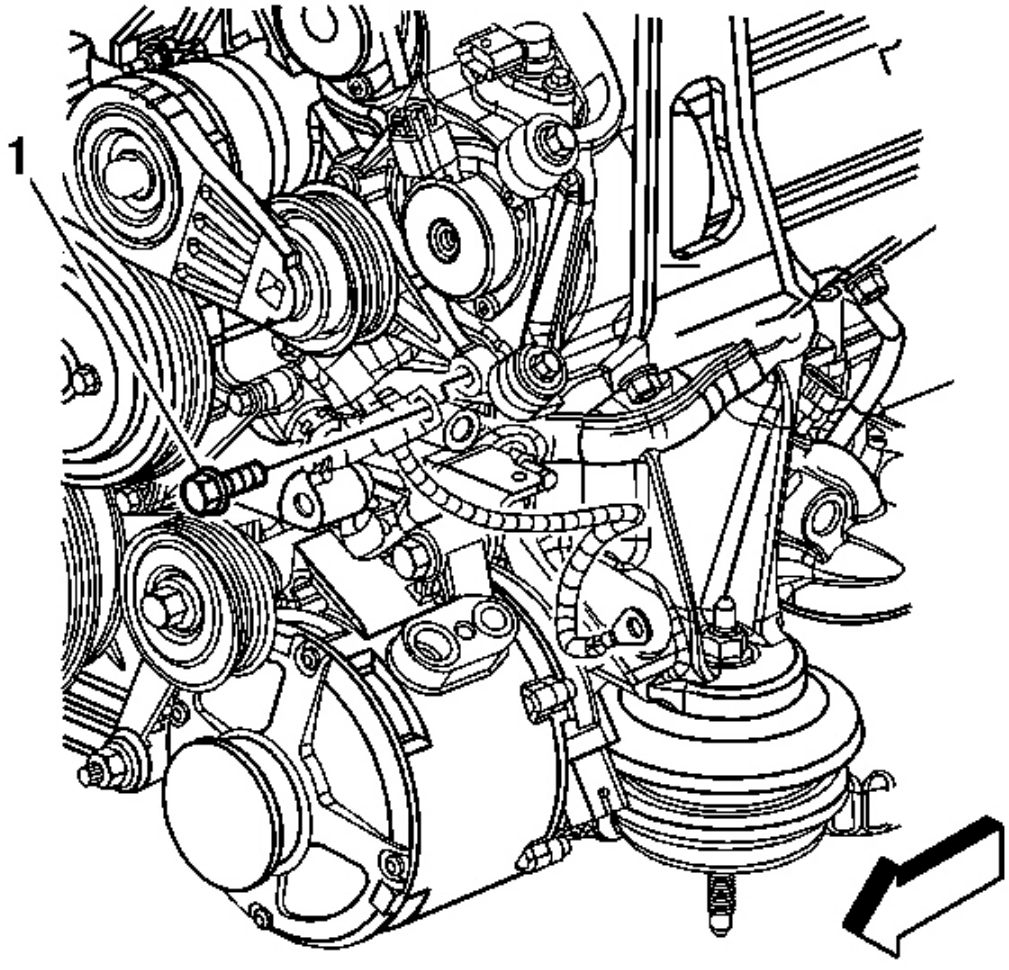


Fig. 28: View Of Cable & Clip Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

3. Install the positive battery cable routing clip bolt (1) into the cable retaining clip and attach to the front of the engine.

   Tighten: Tighten the bolt to 35 N.m (26 lb ft).

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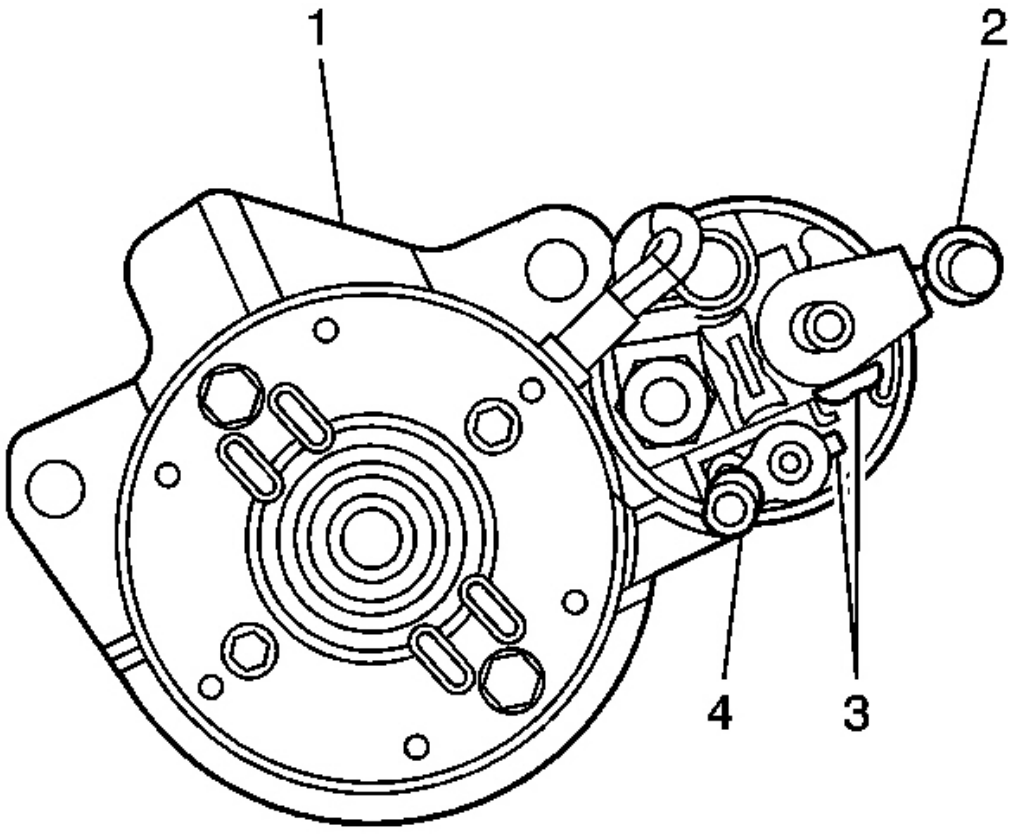


Fig. 29: View Of Starter Motor & Connections
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the engine harness leads (2) are positioned on the solenoid prior to the positive cable terminal being installed.

4. Install the battery positive cable terminals and nut to the starter solenoid.

   Tighten:

   - Tighten the large nut (2) to 12 N.m (106 lb in).
   - Tighten the small nut to 4 N.m (35 lb in).

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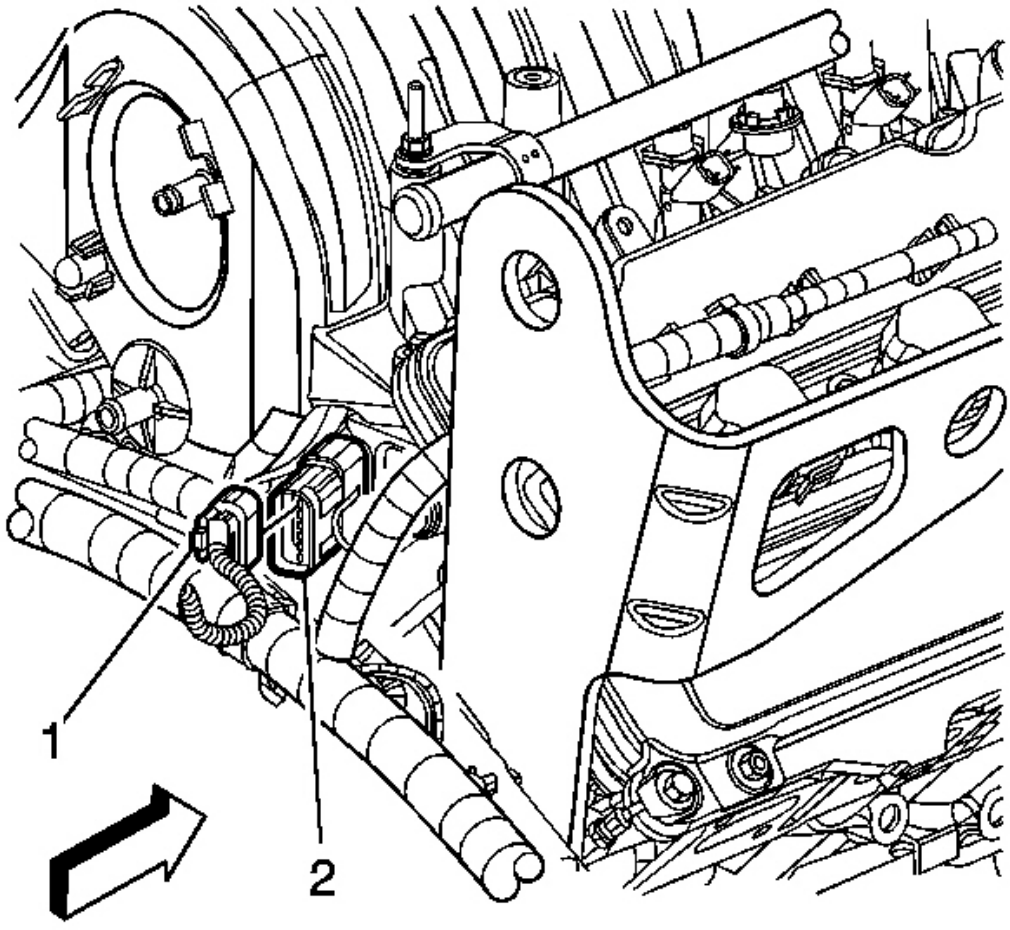


Fig. 30: View Of Jumper Harness & Engine Harness
Courtesy of GENERAL MOTORS CORP.

5. Connect the starter jumper wiring harness (2) to the engine harness connector (1).
6. Install the intake manifold. Refer to **Intake Manifold Replacement** .

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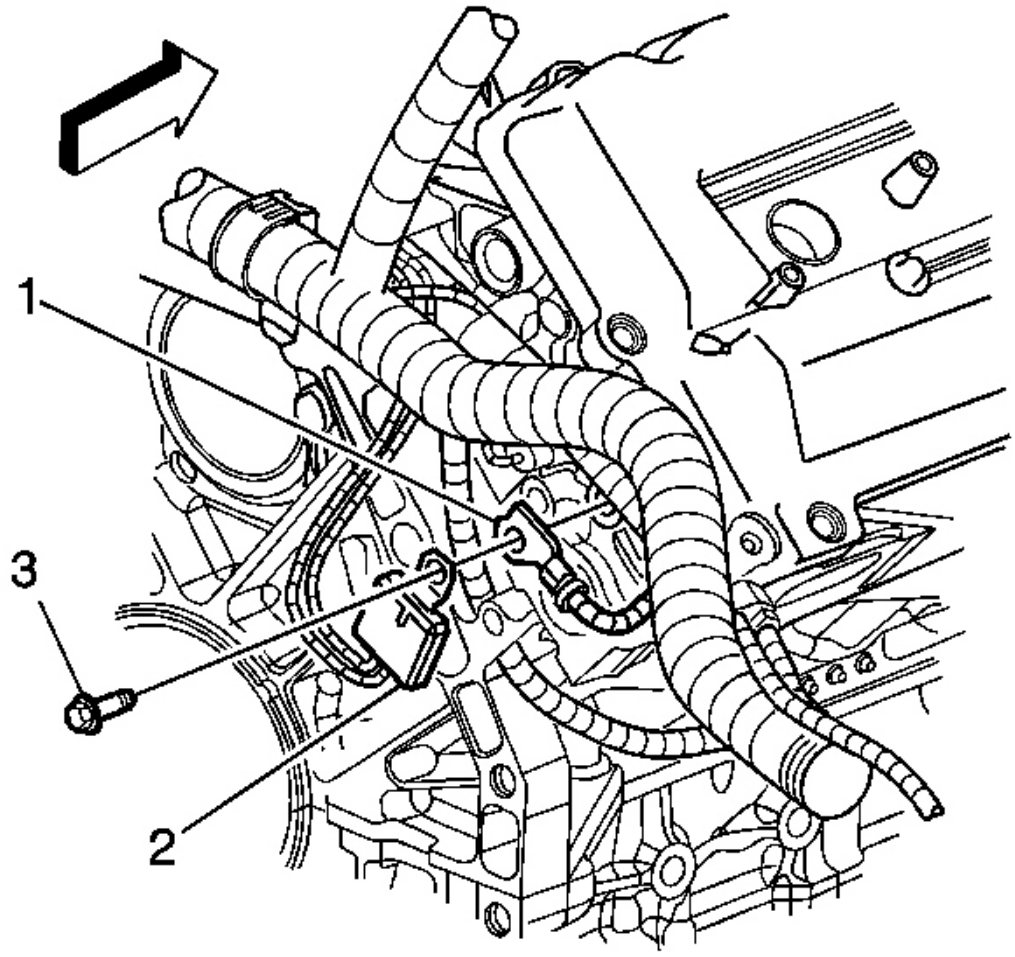


Fig. 31: View Of Battery Cable Bolt & Engine Harness Ground Pack
Courtesy of GENERAL MOTORS CORP.

7. Position the battery negative cable (1) and engine harness ground pack (2) to the right rear cylinder head and install the battery cable bolt (3).

   Tighten: Tighten the battery positive cable routing clip bolt to 35 N.m (26 lb ft).

8. Position the battery negative cable to frame rail stud and install the negative battery cable to frame rail nut.

   Tighten: Tighten the battery negative cable to frame rail nut to 11 N.m (97 lb in).

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9. Install the battery clips.
10. Position the positive battery cable lead to the fuse/relay center stud and install the positive battery cable nut.

    Tighten: Tighten the positive battery cable nut to 12 N.m (106 lb in).

11. Close the stud cover on the fuse/relay center.

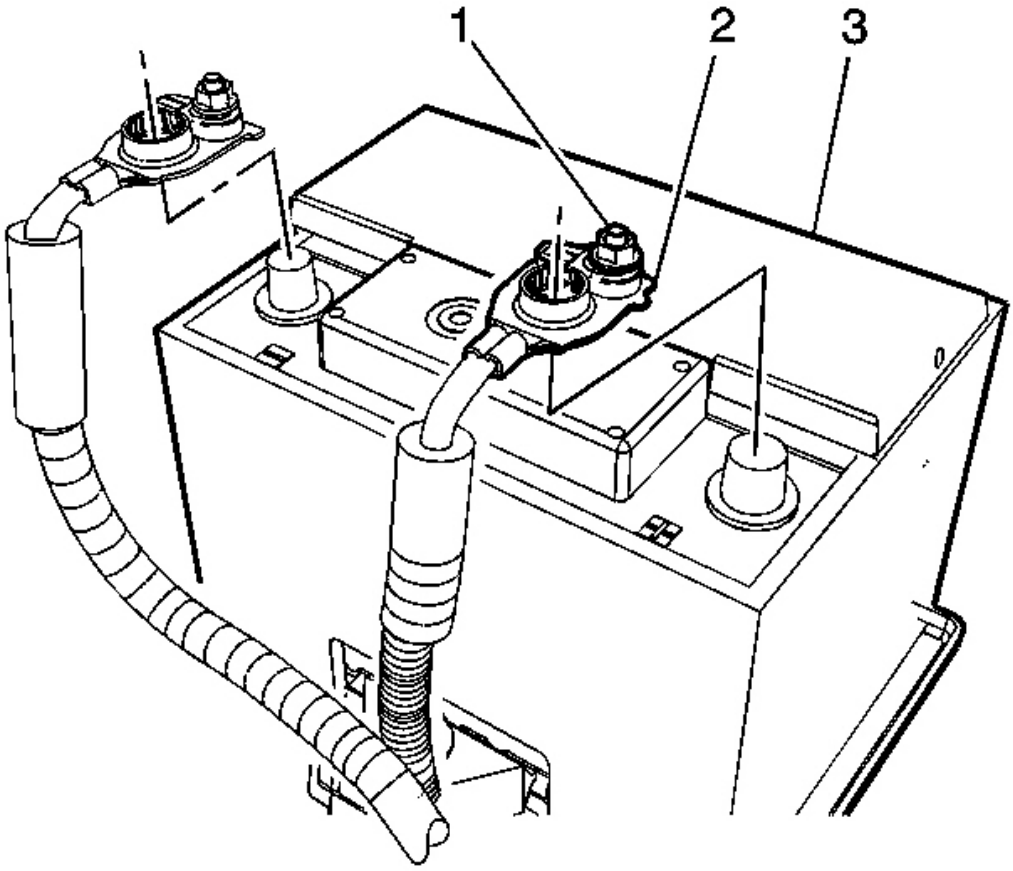


Fig. 32: View Of Battery Cable Terminals
Courtesy of GENERAL MOTORS CORP.

12. Connect the positive battery cable (2) to the battery (3) and tighten the nut (1).

    Tighten: Tighten the positive battery cable nut to 8 N.m (71 lb in).

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13. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

BATTERY REPLACEMENT

Removal Procedure

CAUTION: Refer to Battery Disconnect Caution .

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

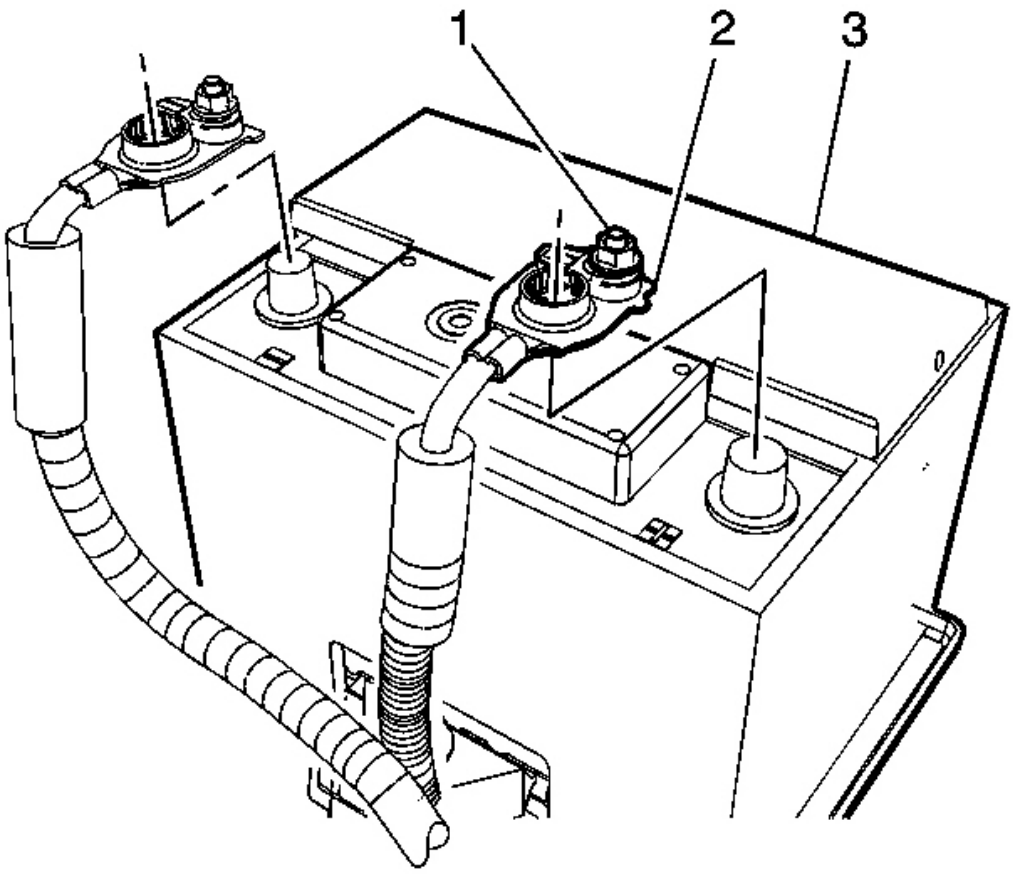


Fig. 33: View Of Battery Cable Terminals
Courtesy of GENERAL MOTORS CORP.

2. Loosen the positive battery cable to the battery nut (1) and disconnect the positive battery cable (2) from

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the battery (3).

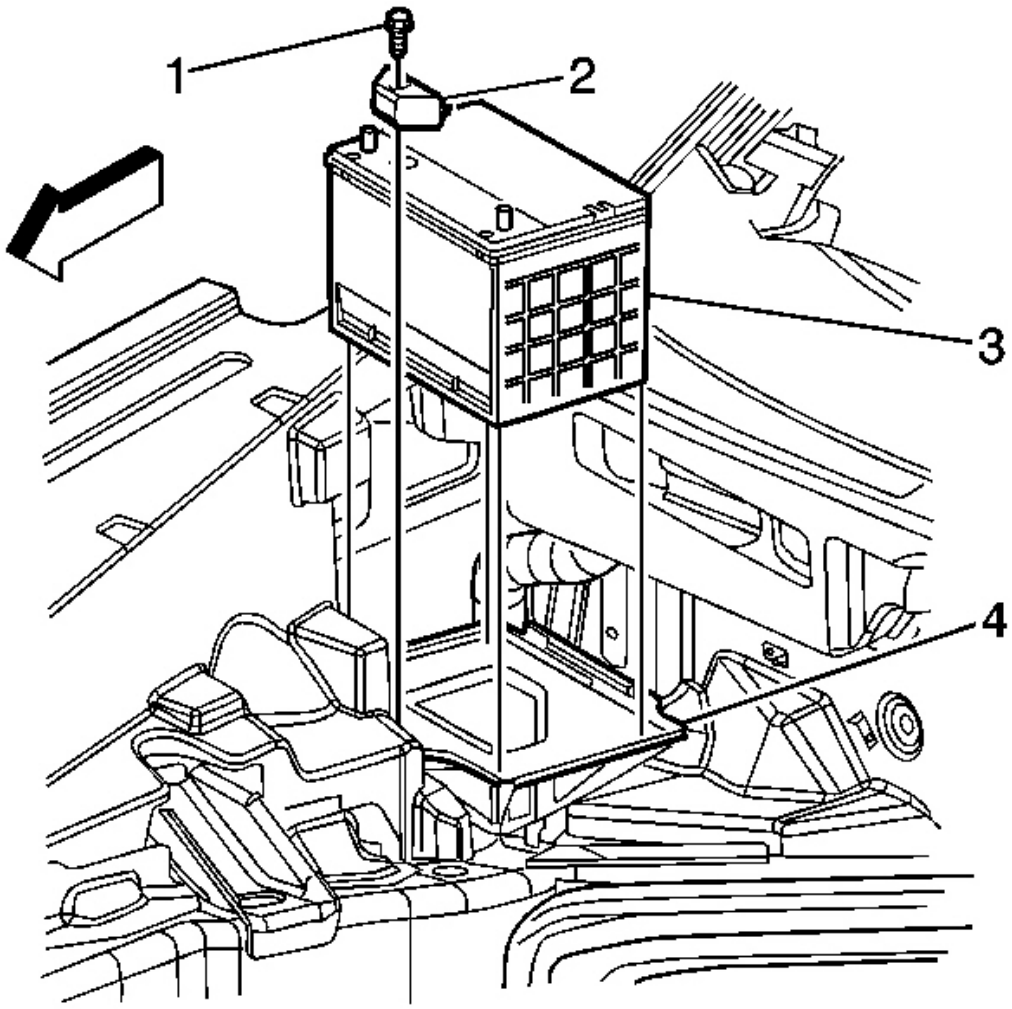


Fig. 34: View Of Battery & Retainer
Courtesy of GENERAL MOTORS CORP.

3. Remove the battery hold down retainer bolt (1) and retainer (2).
4. Remove the battery.

Installation Procedure

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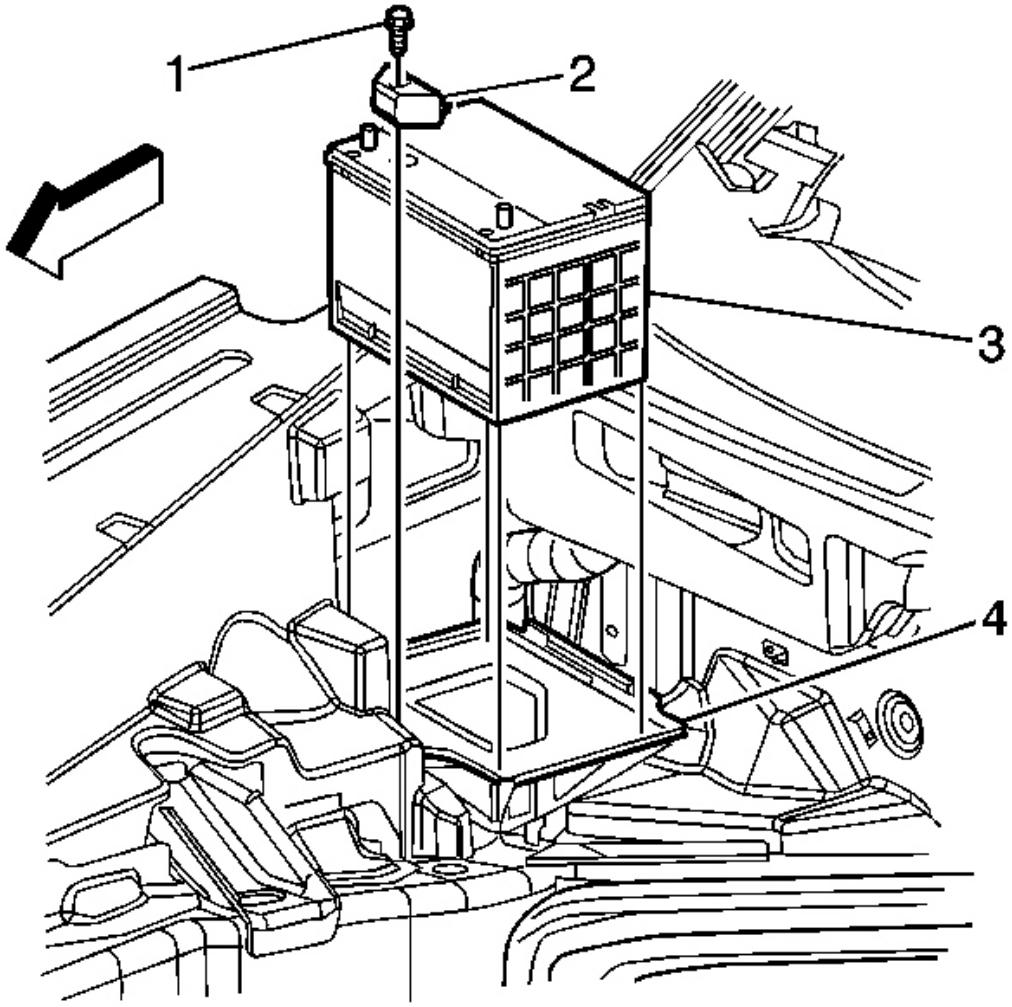


Fig. 35: View Of Battery & Retainer
Courtesy of GENERAL MOTORS CORP.

1. Install the battery (3).

NOTE: **Refer to Fastener Notice .**

2. Install the battery hold down retainer (2) and bolt (1).

Tighten: Tighten the battery hold down retainer bolt to 18 N.m (13 lb ft).

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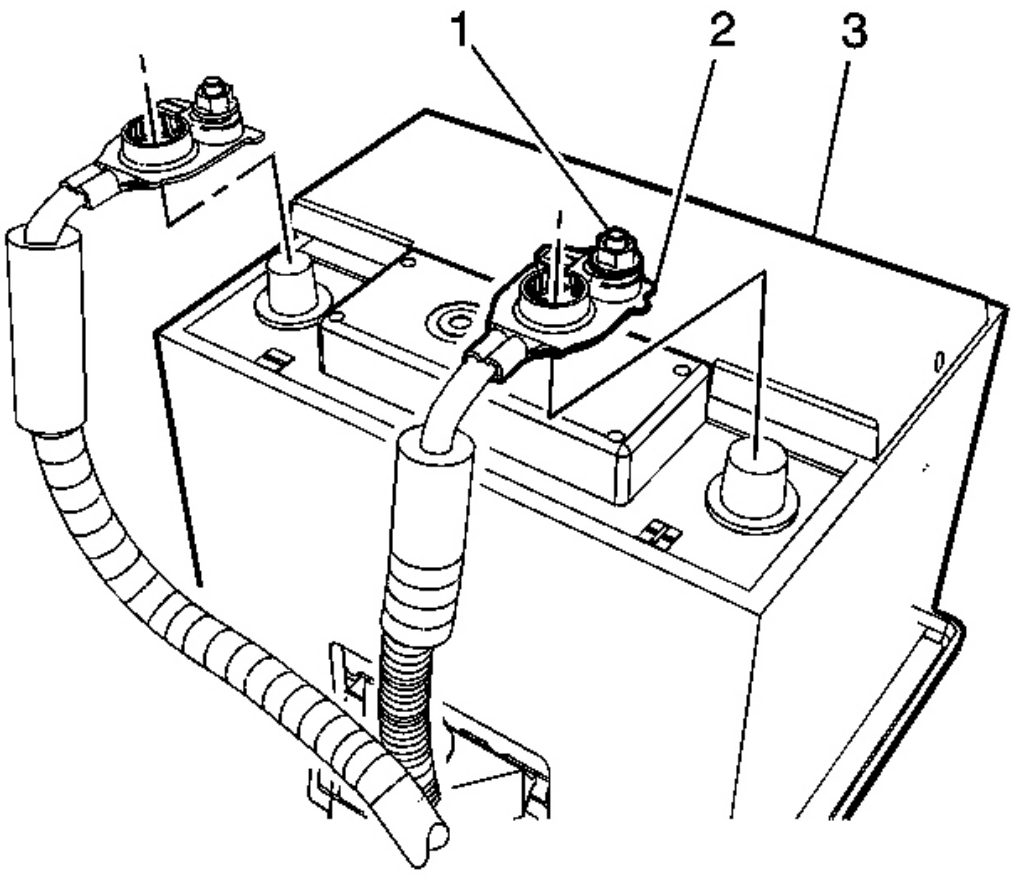


Fig. 36: View Of Battery Cable Terminals
Courtesy of GENERAL MOTORS CORP.

3. Connect the positive battery cable (2) to the battery (3).

   Tighten: Tighten the positive battery cable to battery nut to 8 N.m (71 lb in).

4. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

BATTERY TRAY REPLACEMENT

Removal Procedure

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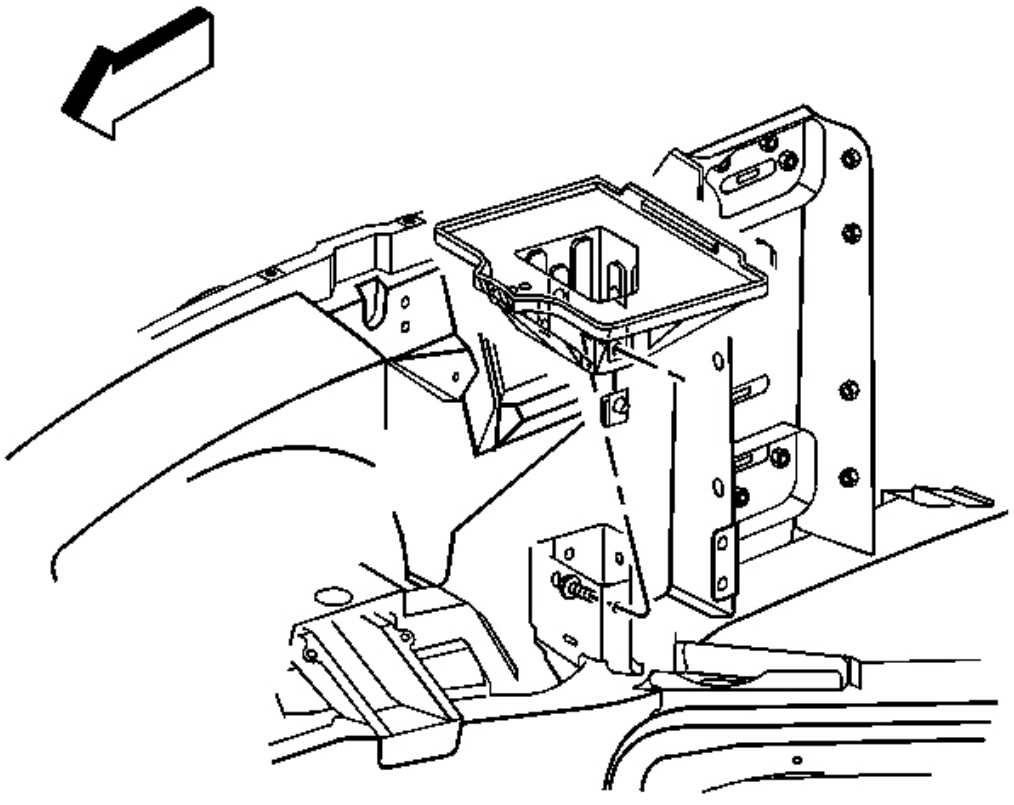


Fig. 37: View Of Battery Tray
Courtesy of GENERAL MOTORS CORP.

1. Remove the battery. Refer to **Battery Replacement**.
2. Remove the battery tray bolts.
3. Remove the battery tray.

Installation Procedure

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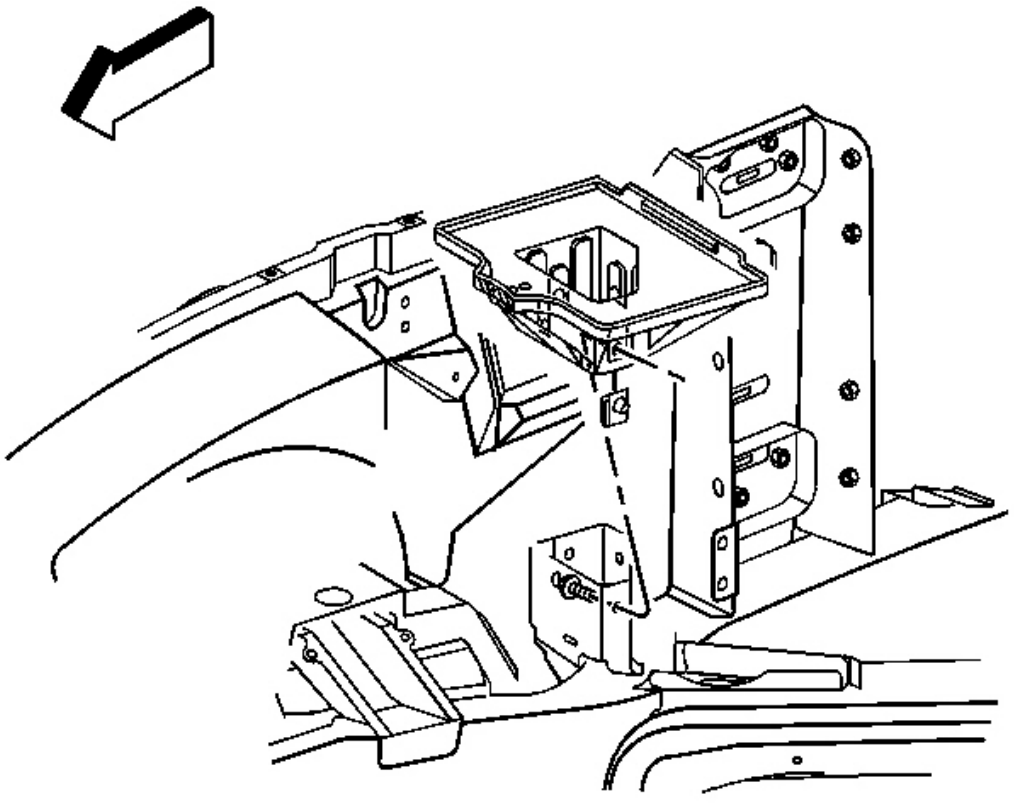


Fig. 38: View Of Battery Tray
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

1. Install the battery tray.
2. Install the battery tray bolts.

   Tighten: Tighten the battery tray bolts to 12 N.m (106 lb in).

3. Install the battery. Refer to **Battery Replacement**.

STARTER MOTOR REPLACEMENT (LC3)

Removal Procedure

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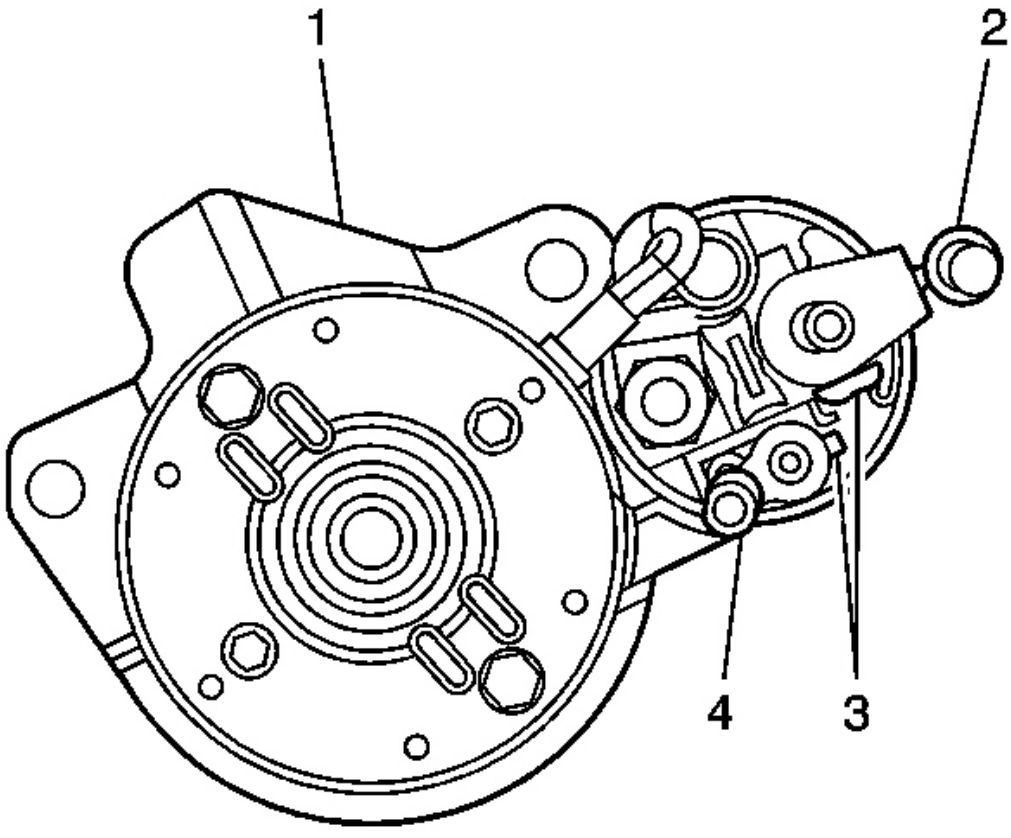


Fig. 39: View Of Starter Motor & Connections
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Remove the supercharger assembly. Refer to **Supercharger Replacement** .
3. Disconnect the battery positive cable from the starter.
4. Disconnect the wire from the S terminal (4) on the starter.

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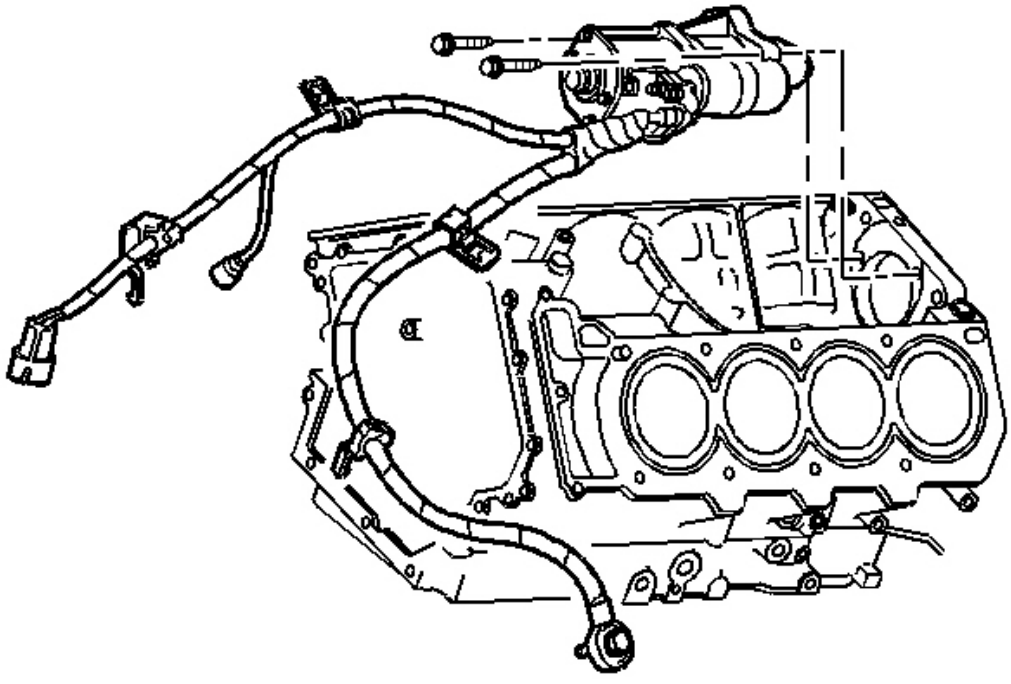


Fig. 40: View Of Starter Motor - LH2
Courtesy of GENERAL MOTORS CORP.

5. Remove the starter motor bolts.
6. Remove the starter motor.

Installation Procedure

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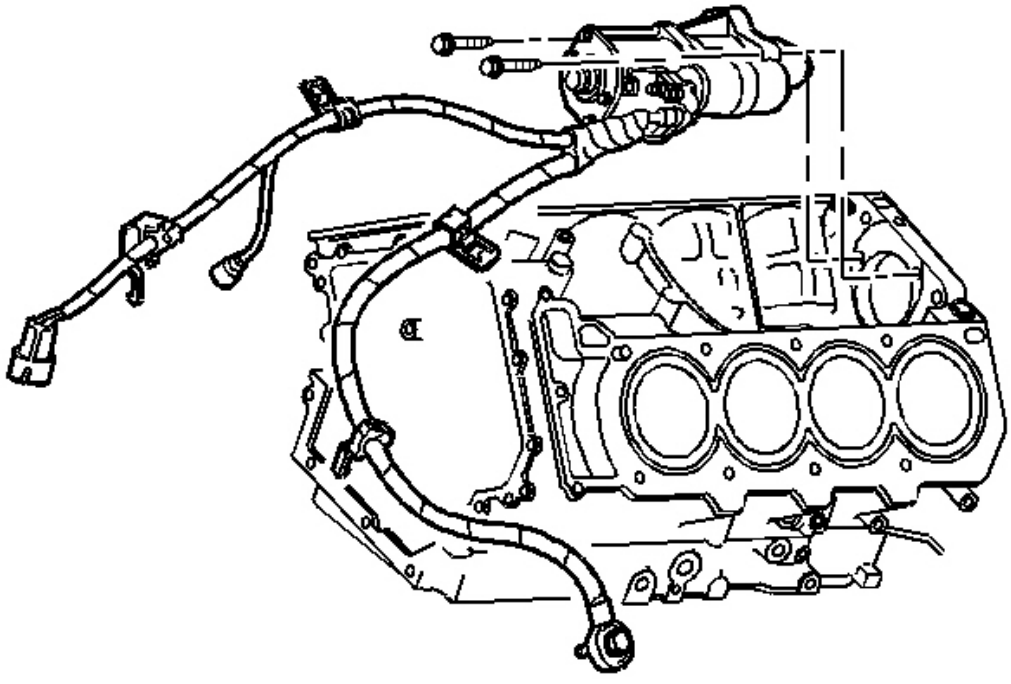


Fig. 41: View Of Starter Motor - LH2
Courtesy of GENERAL MOTORS CORP.

1. Install the starter motor.

   NOTE: Refer to Fastener Notice .

2. Install the starter motor bolts.

   Tighten: Tighten the bolts to 30 N.m (22 lb ft).

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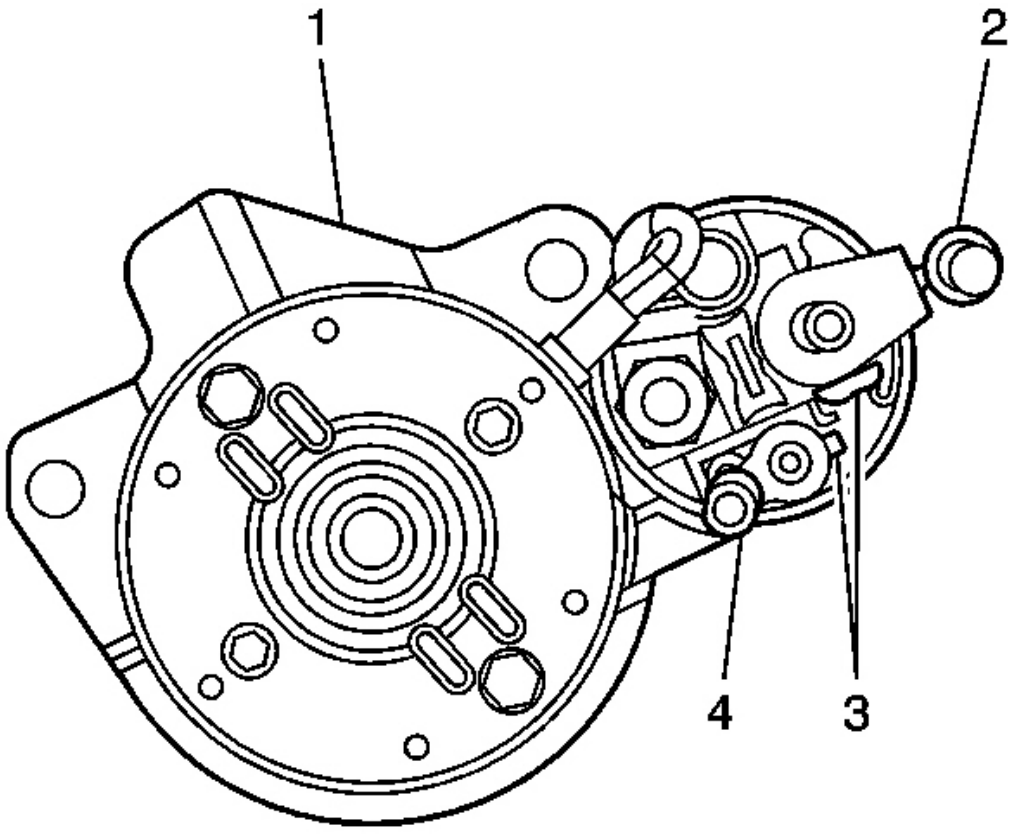


Fig. 42: View Of Starter Motor & Connections
Courtesy of GENERAL MOTORS CORP.

3. Connect the wire and nut to the S terminal (4) on the starter.

   Tighten: Tighten the nut to 4 N.m (35 lb in).

4. Connect the battery positive cable and nut to the starter terminal.

   Tighten: Tighten the nut to 12 N.m (106 lb in).

5. Install the supercharger assembly. Refer to **Supercharger Replacement** .
6. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.

STARTER MOTOR REPLACEMENT (LH2)

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Removal Procedure

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Remove the intake manifold. Refer to **Intake Manifold Replacement** .

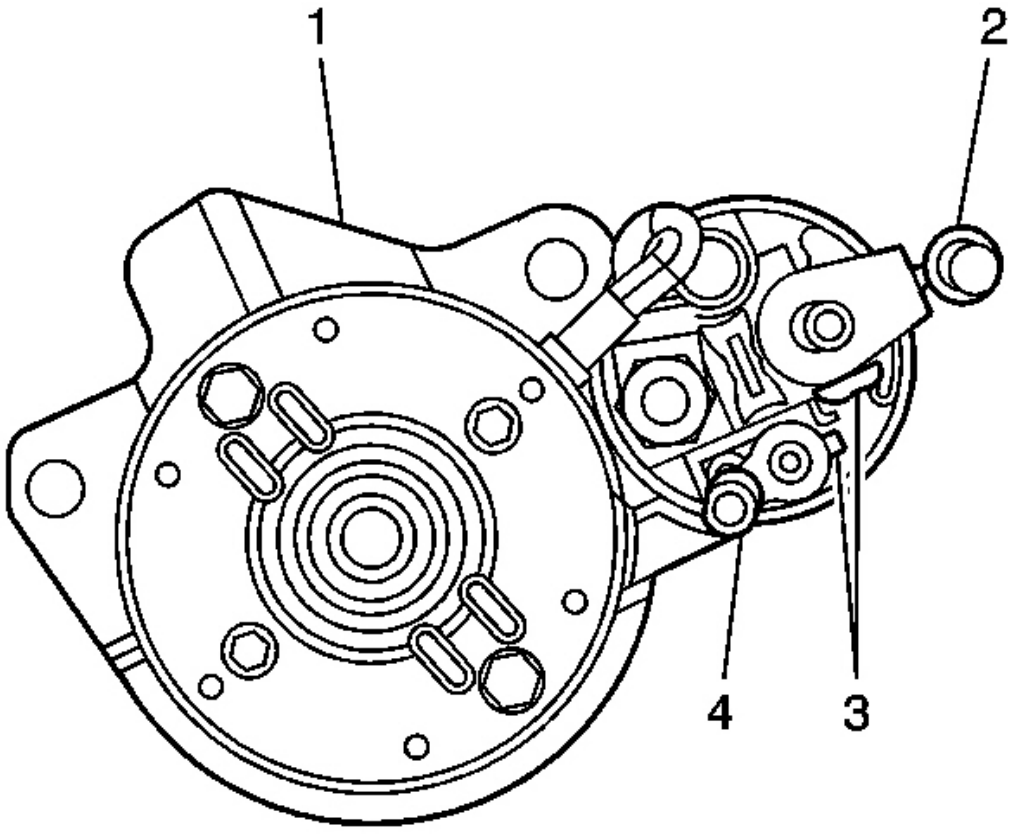


Fig. 43: View Of Starter Motor & Connections
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the BAT cable from the starter.
4. Disconnect the wire from the S terminal (4) on the starter.

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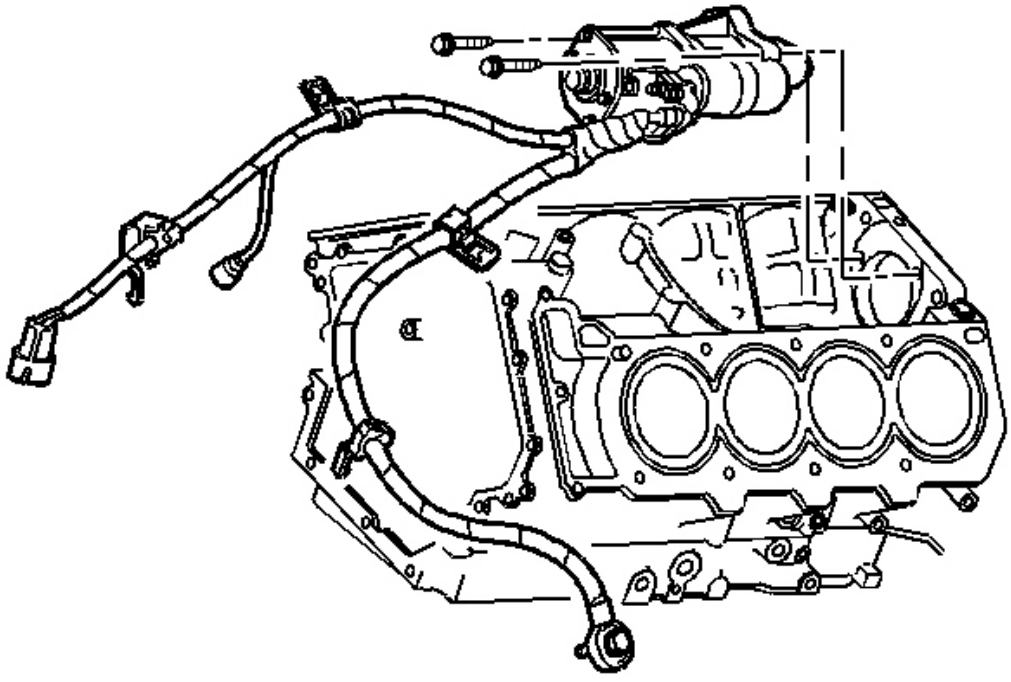


Fig. 44: View Of Starter Motor - LH2
Courtesy of GENERAL MOTORS CORP.

5. Remove the 2 starter motor mounting bolts.
6. Remove the starter motor.

Installation Procedure

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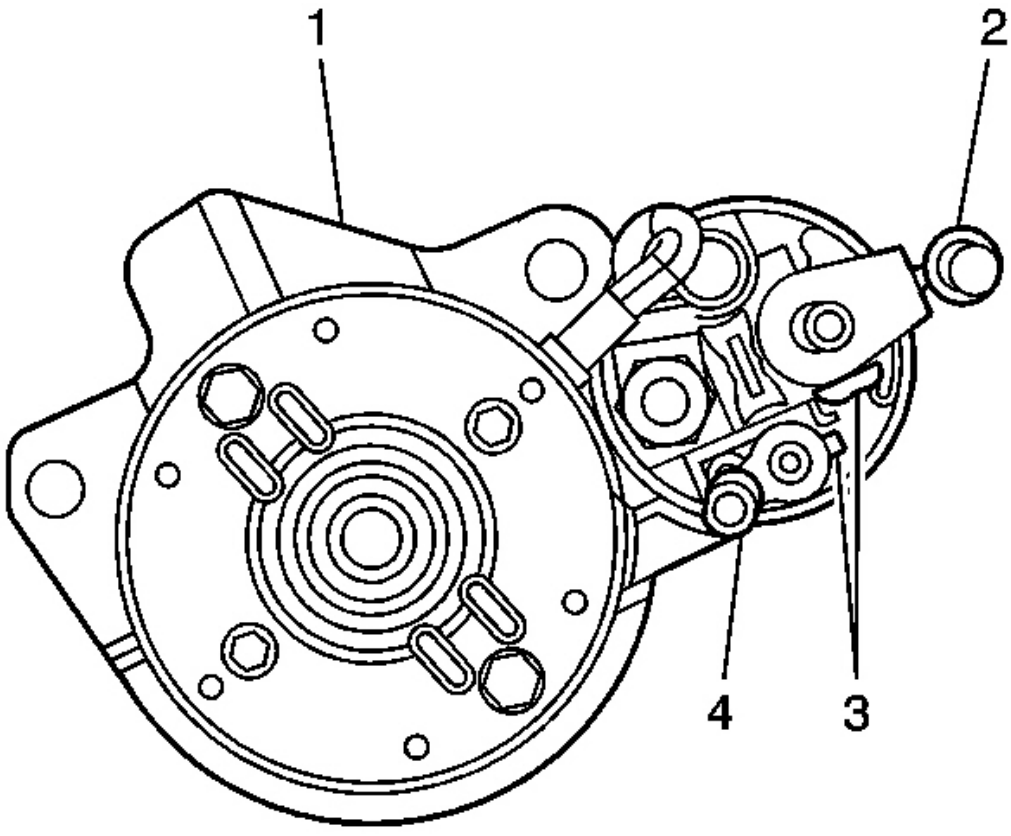


Fig. 45: View Of Starter Motor & Connections
Courtesy of GENERAL MOTORS CORP.

1. Install the starter motor.

   NOTE: Refer to Fastener Notice .

2. Install the starter motor mounting bolts.

   Tighten: Tighten the starter motor mounting bolts to 30 N.m (22 lb ft).

3. Connect the starter motor S terminal wire (4).

   Tighten: Tighten the starter solenoid S terminal nut to 4 N.m (35 lb in).

4. Connect the starter motor BAT terminal wire.

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Tighten: Tighten the battery cable to starter terminal nut to 12 N.m (106 lb in).

5. Install the intake manifold. Refer to **Intake Manifold Replacement** .
6. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.

GENERATOR REPLACEMENT (LH2)

Removal Procedure

CAUTION: Refer to Battery Disconnect Caution .

1. Remove the drive belt. Refer to **Drive Belt Replacement** .
2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
3. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)** .
4. Remove the front suspension crossmember. Refer to **Front Suspension Crossmember Replacement** .

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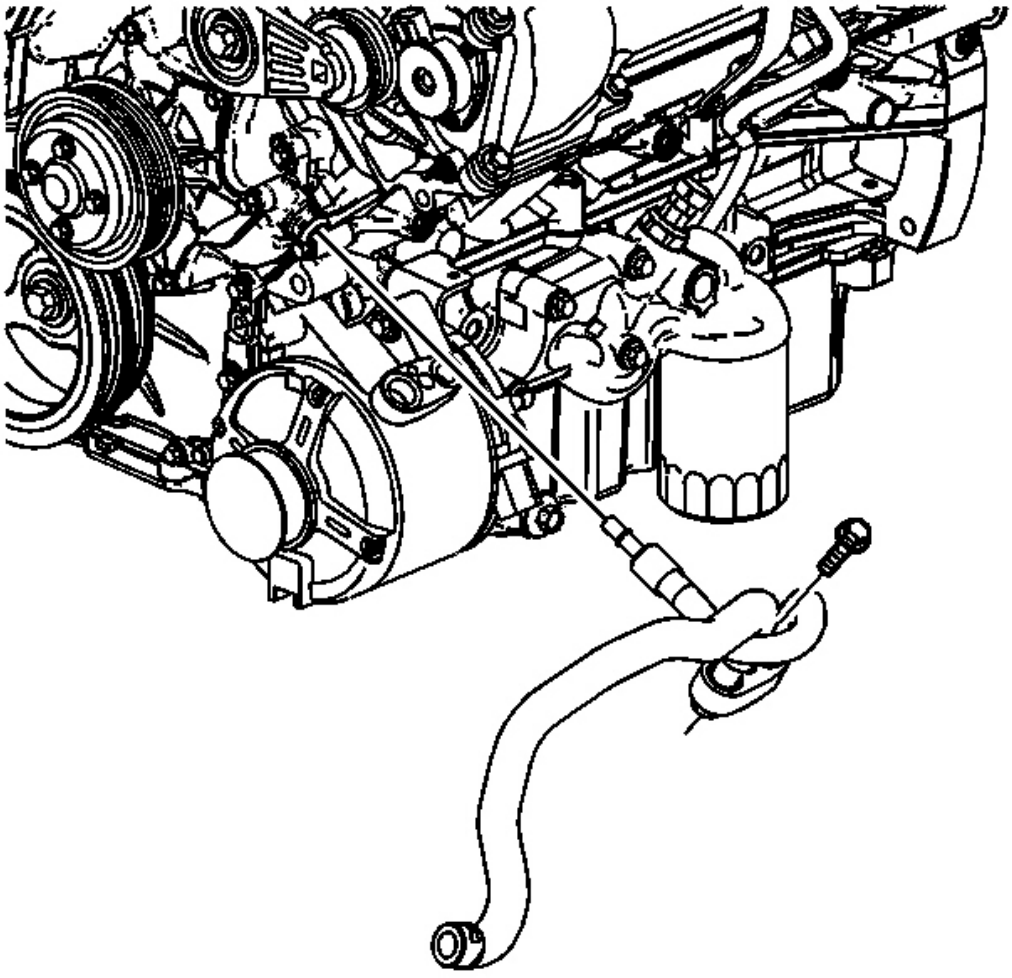


Fig. 46: View Of Generator Coolant Hose Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the bolt from the generator coolant hose assembly on the generator.
6. Disconnect the generator coolant hose assembly from the generator port.

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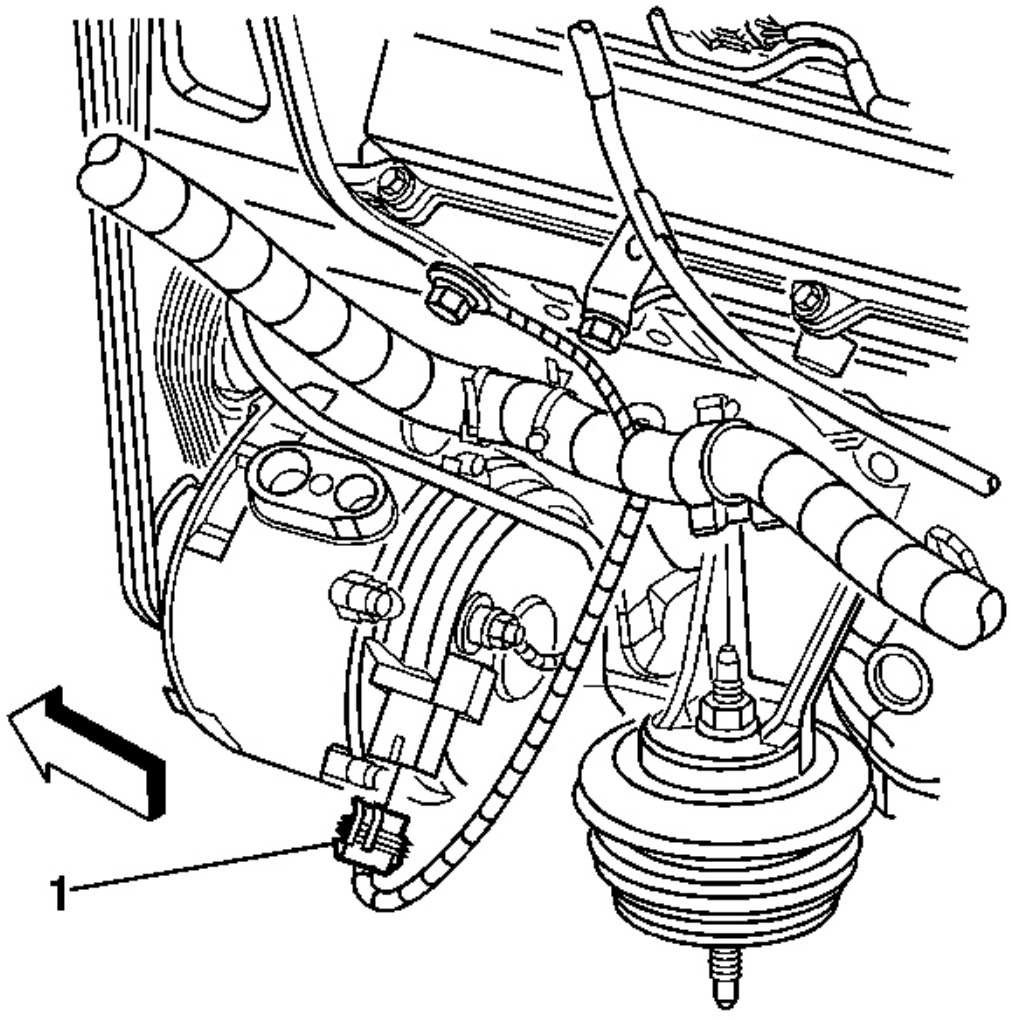


Fig. 47: View Of Generator Electrical Connector
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the generator electrical connector (1).

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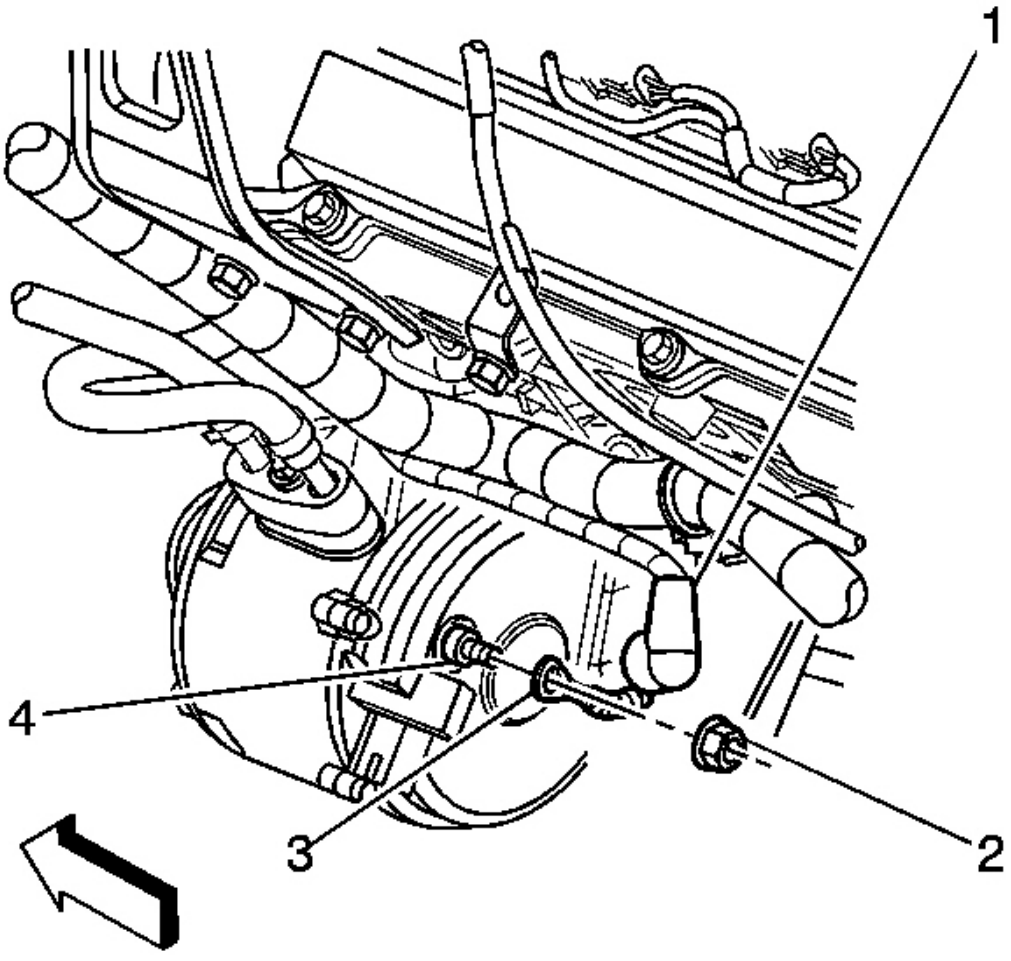


Fig. 48: View Of Battery Positive/Starter Cable Terminal & Nut
Courtesy of GENERAL MOTORS CORP.

8. Remove the starter cable terminal from the generator:
    1. Slide the boot (1) back along the cable.
    2. Remove the starter cable nut (2).
    3. Remove the starter cable terminal (3) from the stud (4).

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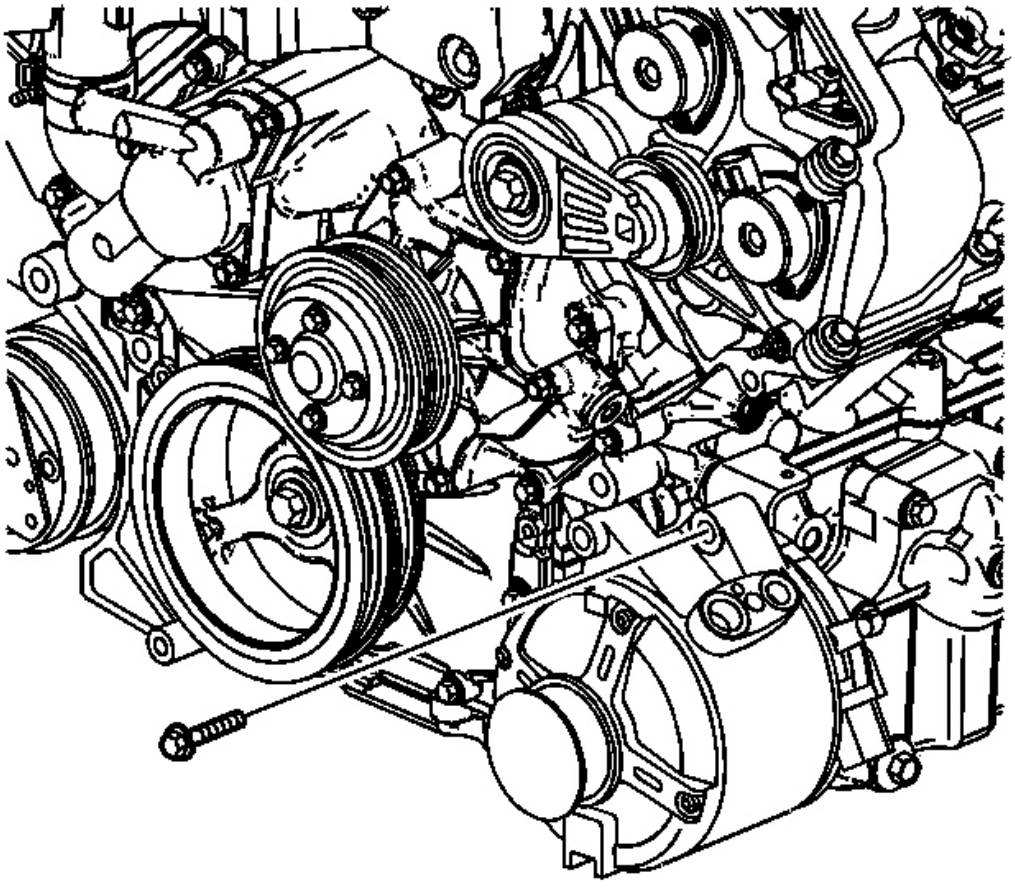


Fig. 49: View Of Front Upper Generator Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper generator bolt from the generator.

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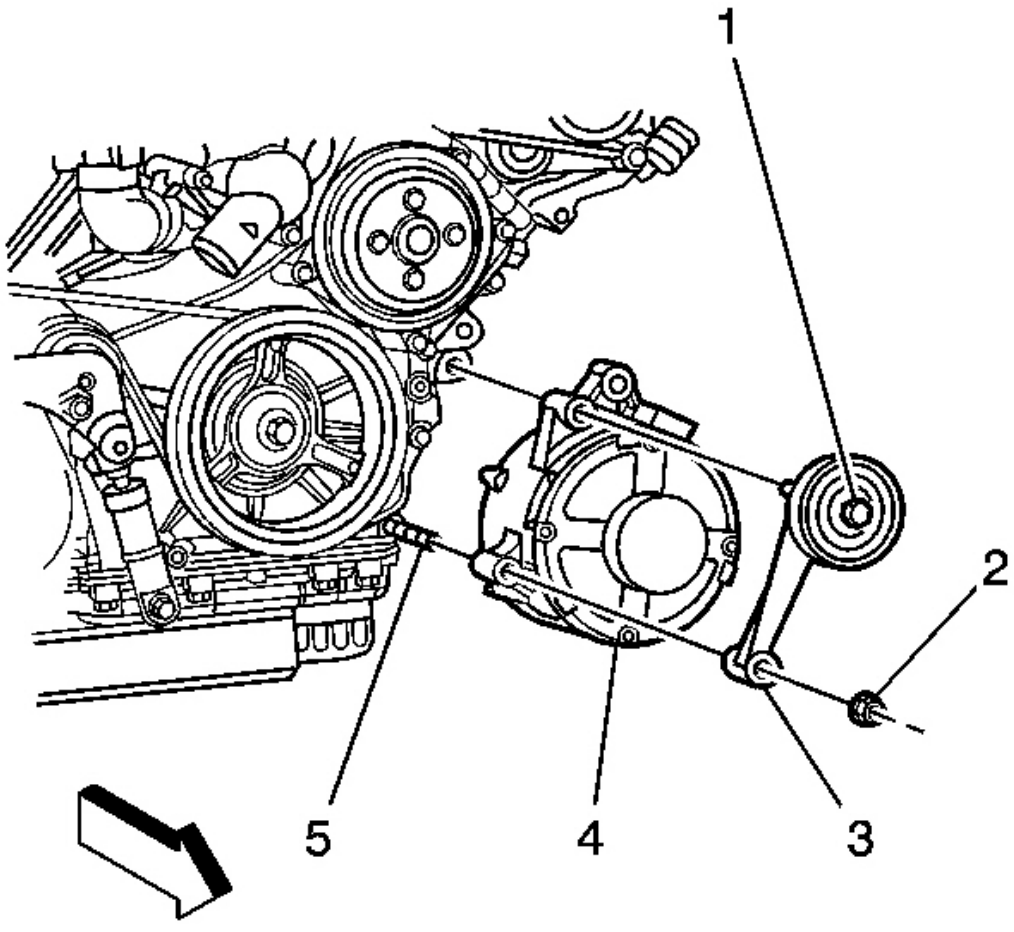


Fig. 50: View Of Generator & Idler Pulley Assembly
Courtesy of GENERAL MOTORS CORP.

10. Remove the idler pulley thru-bolt (1).
11. Remove the idler pulley nut (2).
12. Remove the idler pulley assembly (3).
13. Remove the generator (4).

Installation Procedure

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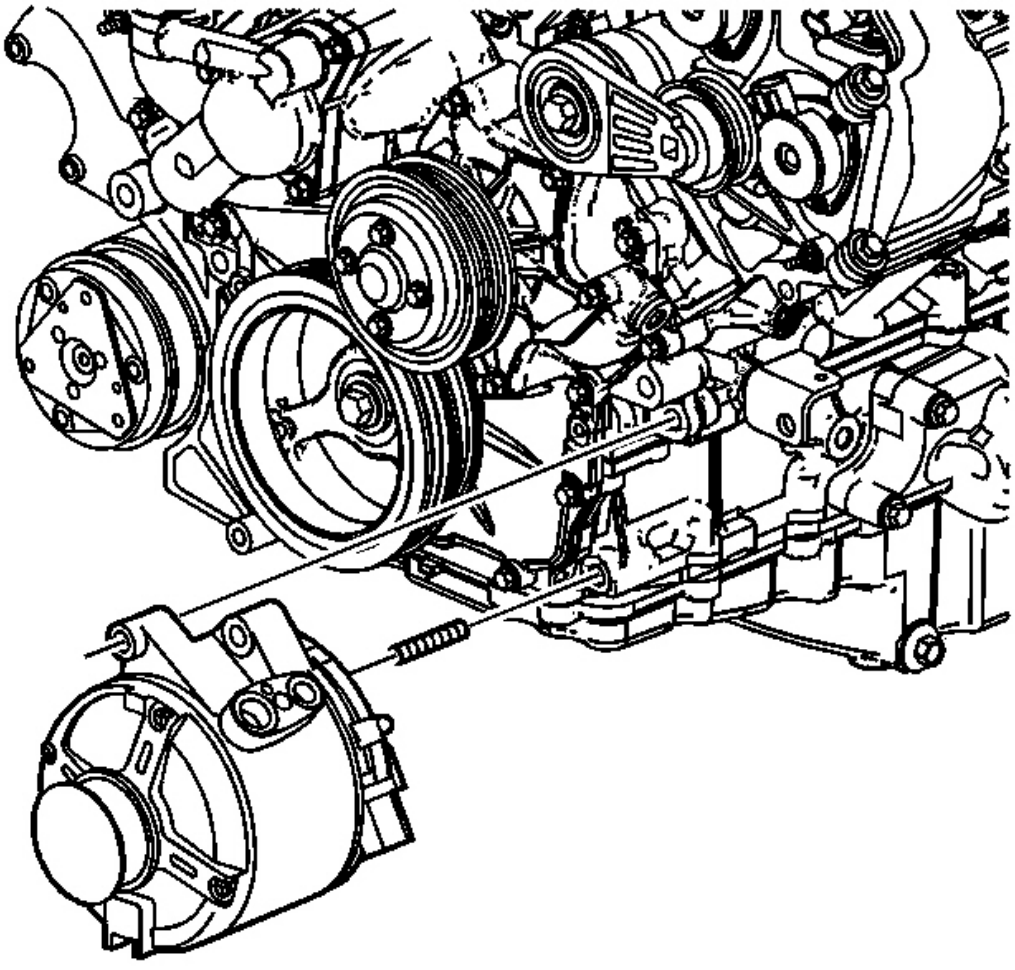


Fig. 51: View Of Generator & Mounting Stud
Courtesy of GENERAL MOTORS CORP.

1. Install the generator.

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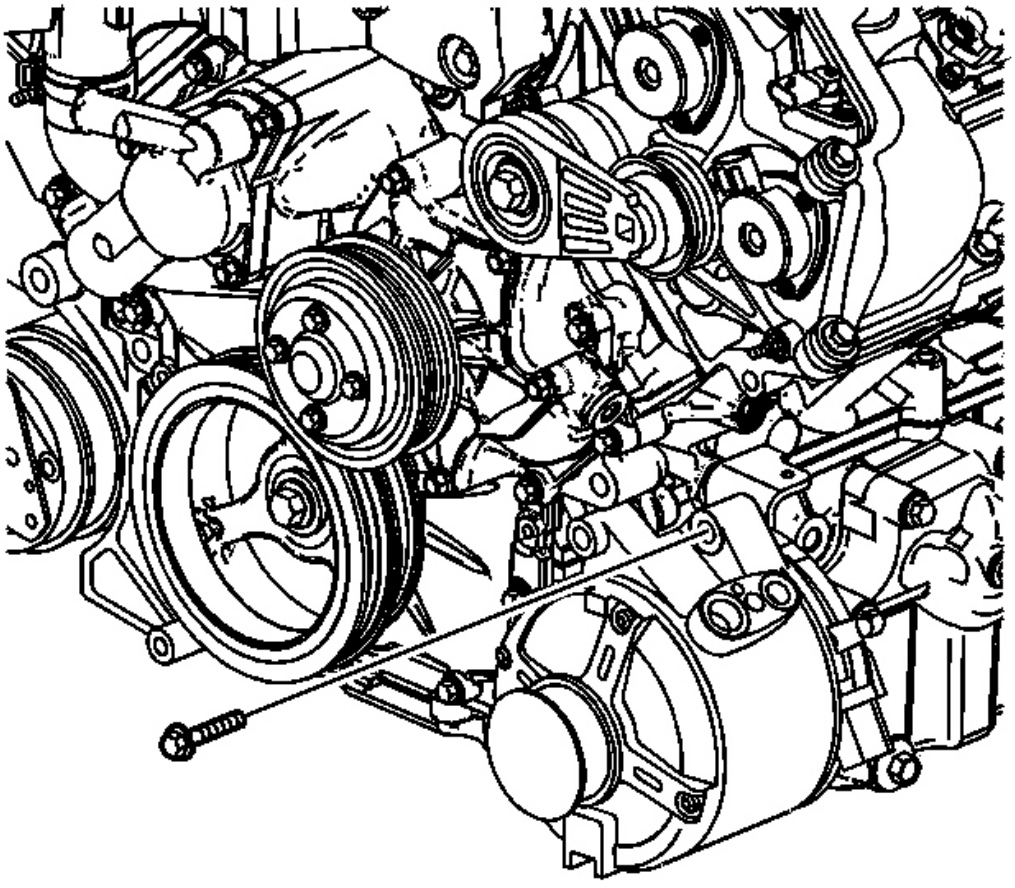


Fig. 52: View Of Front Upper Generator Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install the upper generator bolt.

   Tighten: Tighten the generator bolts to 50 N.m (37 lb ft).

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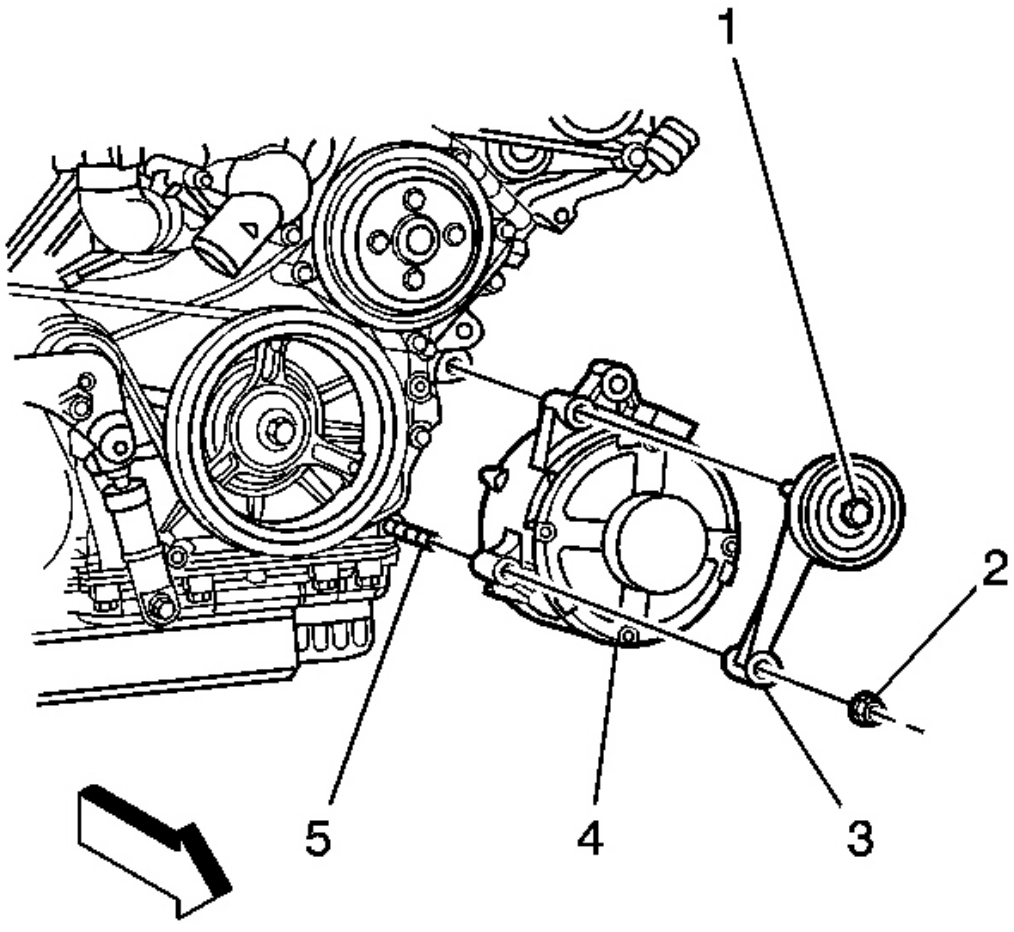


Fig. 53: View Of Generator & Idler Pulley Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the idler pulley assembly (3) and bolt (1).
4. Install the nut (2).

Tighten the generator fasteners to the following torque values:

Tighten:

1. Tighten the idler pulley bolt (1) to 50 N.m (37 lb ft).
2. Tighten the idler pulley nut (2) to 50 N.m (37 lb ft).

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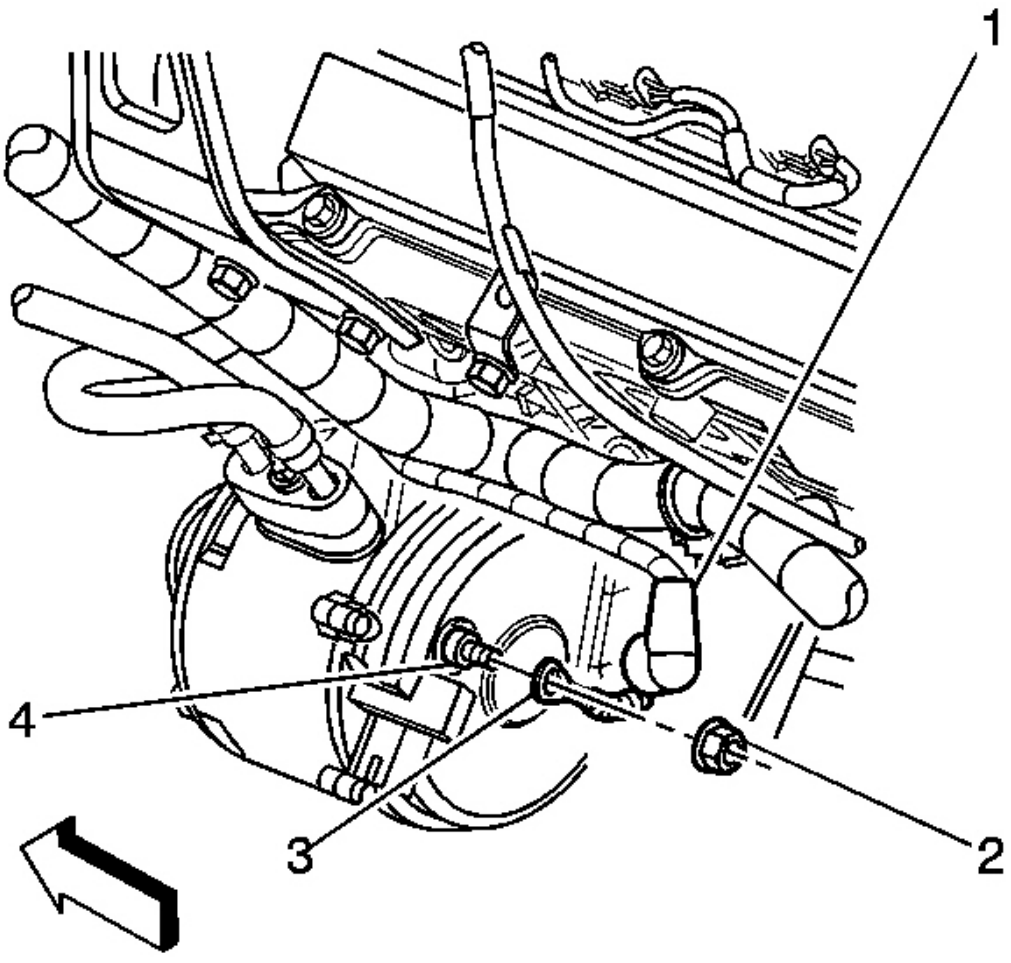


Fig. 54: View Of Battery Positive/Starter Cable Terminal & Nut
Courtesy of GENERAL MOTORS CORP.

5. Install the starter cable terminal to the generator:
    1. Install the starter cable terminal to the stud.
    2. Install the starter cable nut (2).

        Tighten: Tighten the starter cable nut to 20 N.m (15 lb ft).

    3. Slide the boot (1) over the generator stud (4).
6. Position the generator coolant hose assembly to the generator and secure with the bolt.

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

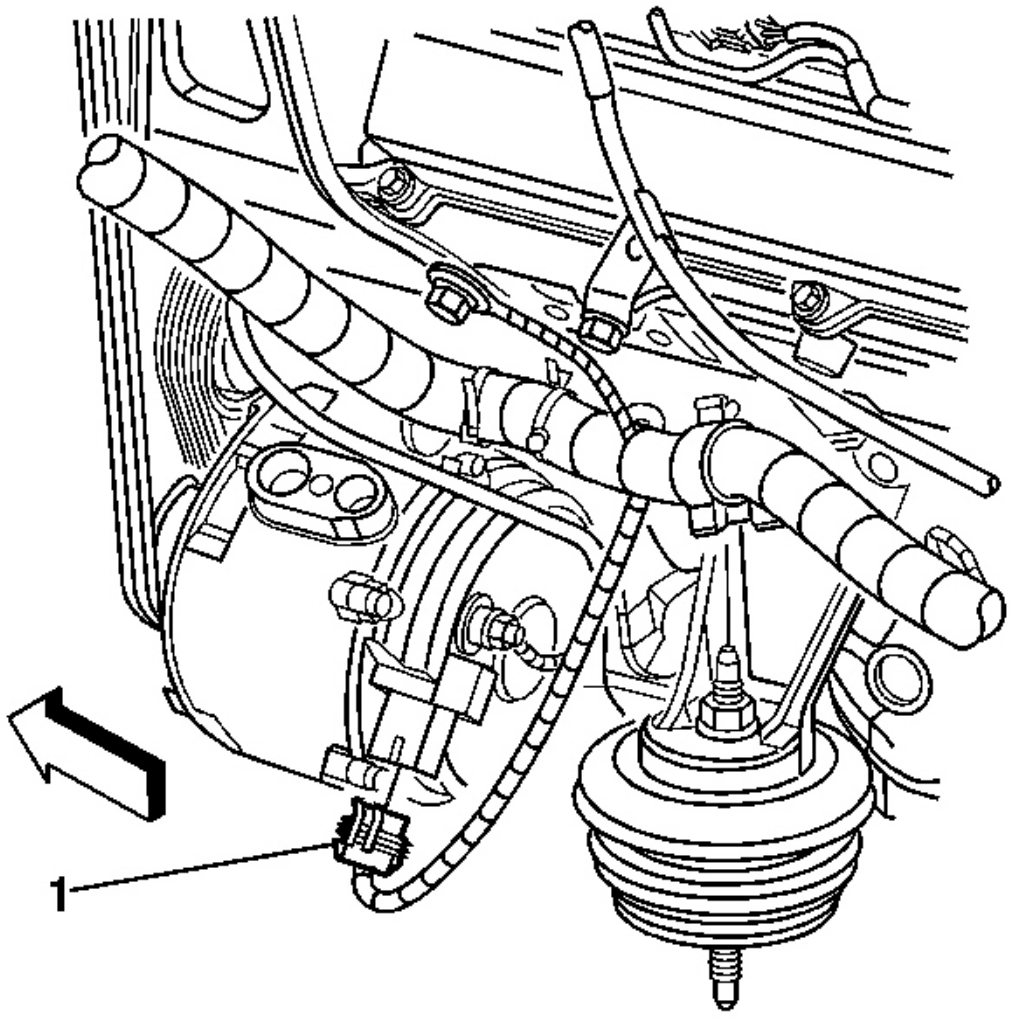


Fig. 55: View Of Generator Electrical Connector
Courtesy of GENERAL MOTORS CORP.

7. Connect the generator electrical connector (1).
8. Install the front suspension crossmember. Refer to **Front Suspension Crossmember Replacement** .
9. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)** .
10. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

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11. Install the drive belt. Refer to **Drive Belt Replacement** .

GENERATOR REPLACEMENT (LC3)

Removal Procedure

CAUTION: Refer to Battery Disconnect Caution .

1. Remove the generator drive belt. Refer to **DRIVE BELT REPLACEMENT** .
2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
3. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)** .
4. Remove the front suspension crossmember. Refer to **Front Suspension Crossmember Replacement** .

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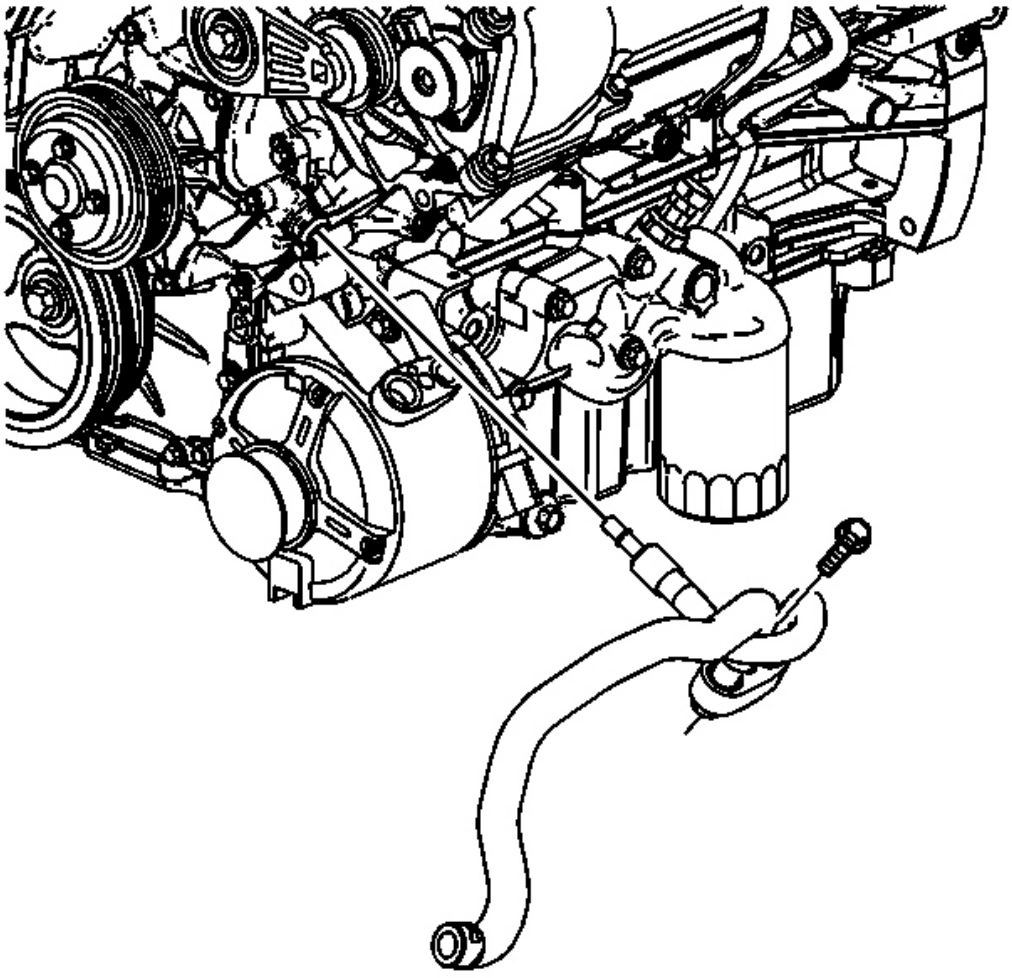


Fig. 56: View Of Generator Coolant Hose Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the bolt from the generator coolant hose assembly on the generator.
6. Disconnect the generator coolant hose assembly from the generator port.

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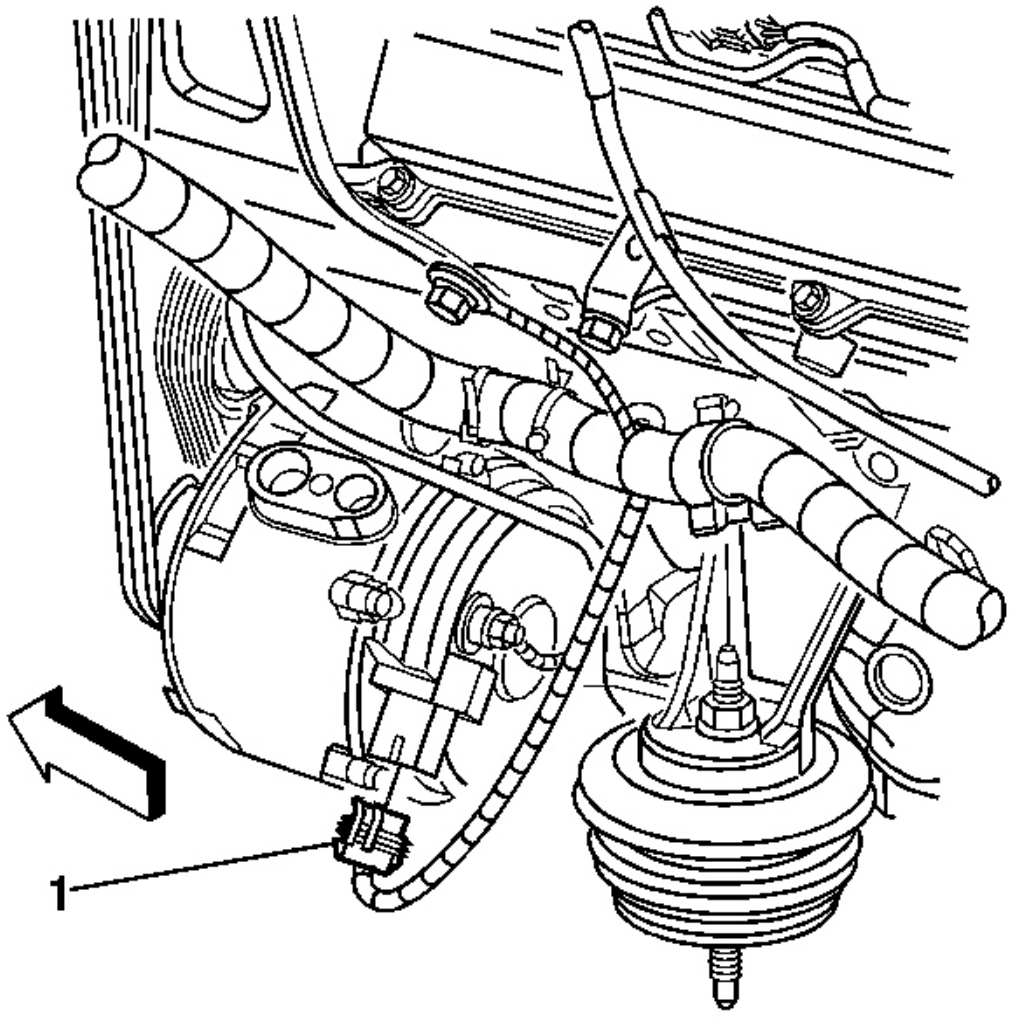


Fig. 57: View Of Generator Electrical Connector
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the generator electrical connector (1).

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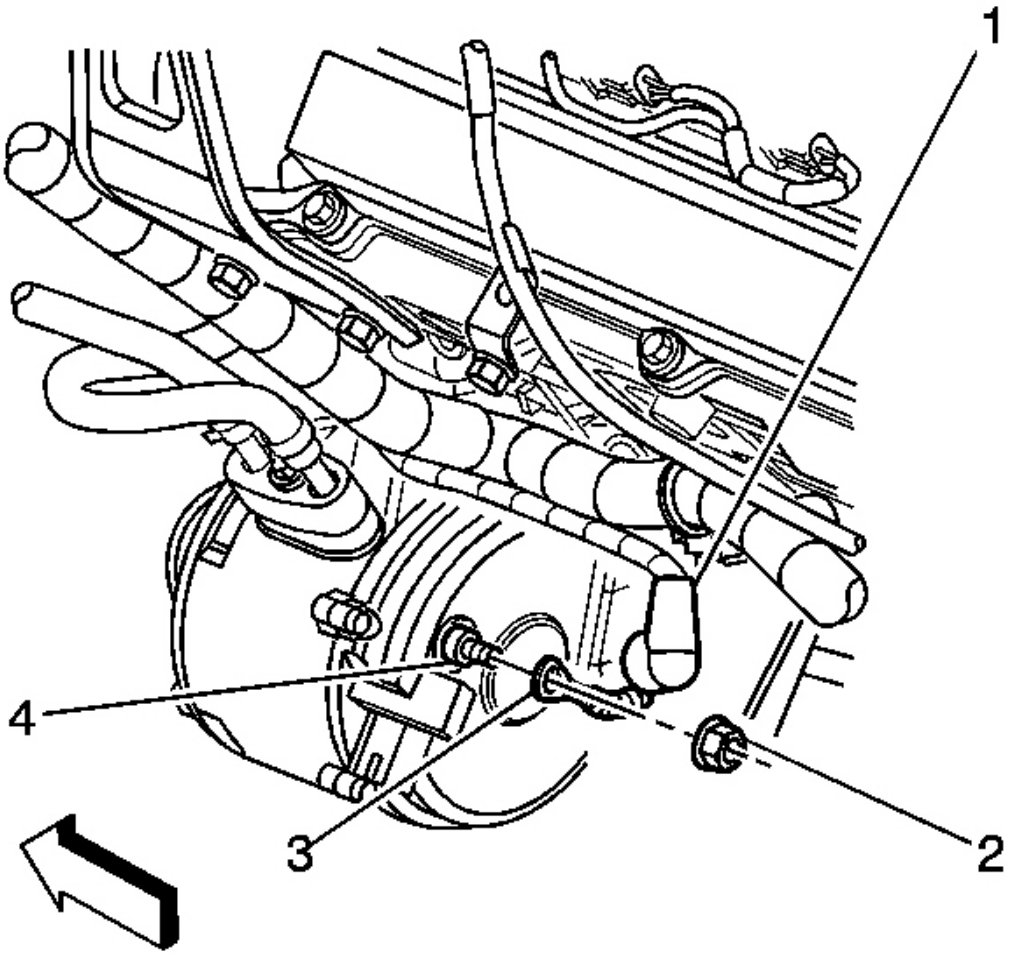


Fig. 58: View Of Battery Positive/Starter Cable Terminal & Nut
Courtesy of GENERAL MOTORS CORP.

8. Remove the starter cable terminal from the generator:
    1. Slide the boot (1) back along the cable.
    2. Remove the starter cable nut (2).
    3. Remove the starter cable terminal (3) from the stud (4).

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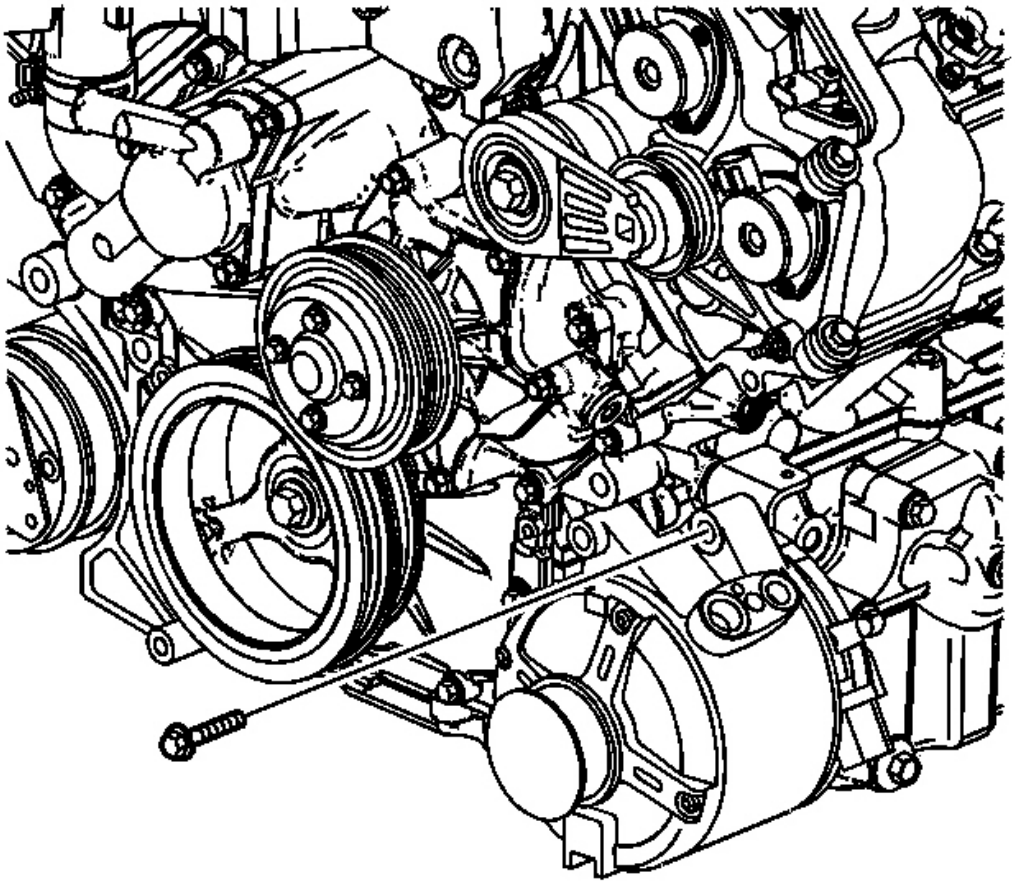


Fig. 59: View Of Front Upper Generator Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper generator bolt from the generator.

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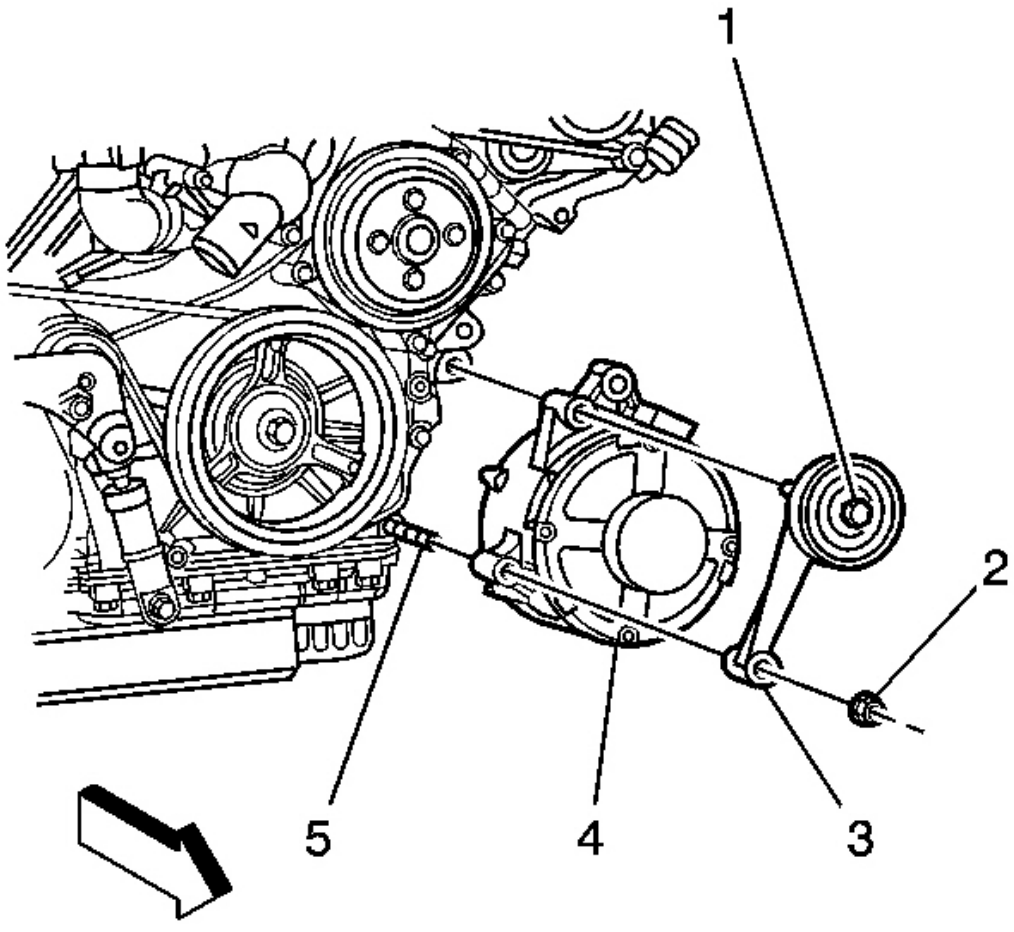


Fig. 60: View Of Generator & Idler Pulley Assembly
Courtesy of GENERAL MOTORS CORP.

10. Remove the idler pulley thru-bolt (1).
11. Remove the idler pulley nut (2).
12. Remove the idler pulley assembly (3).
13. Remove the generator (4).

Installation Procedure

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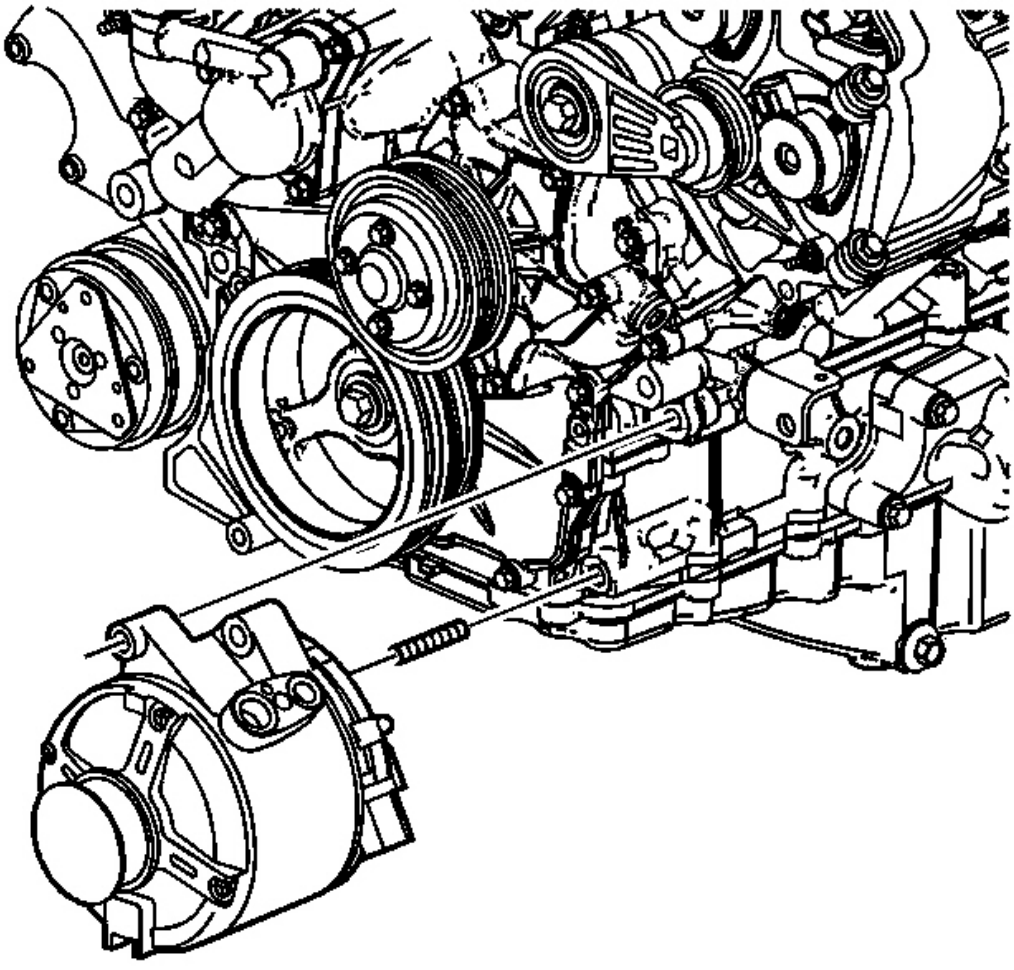


Fig. 61: View Of Generator & Mounting Stud
Courtesy of GENERAL MOTORS CORP.

1. Install the generator.

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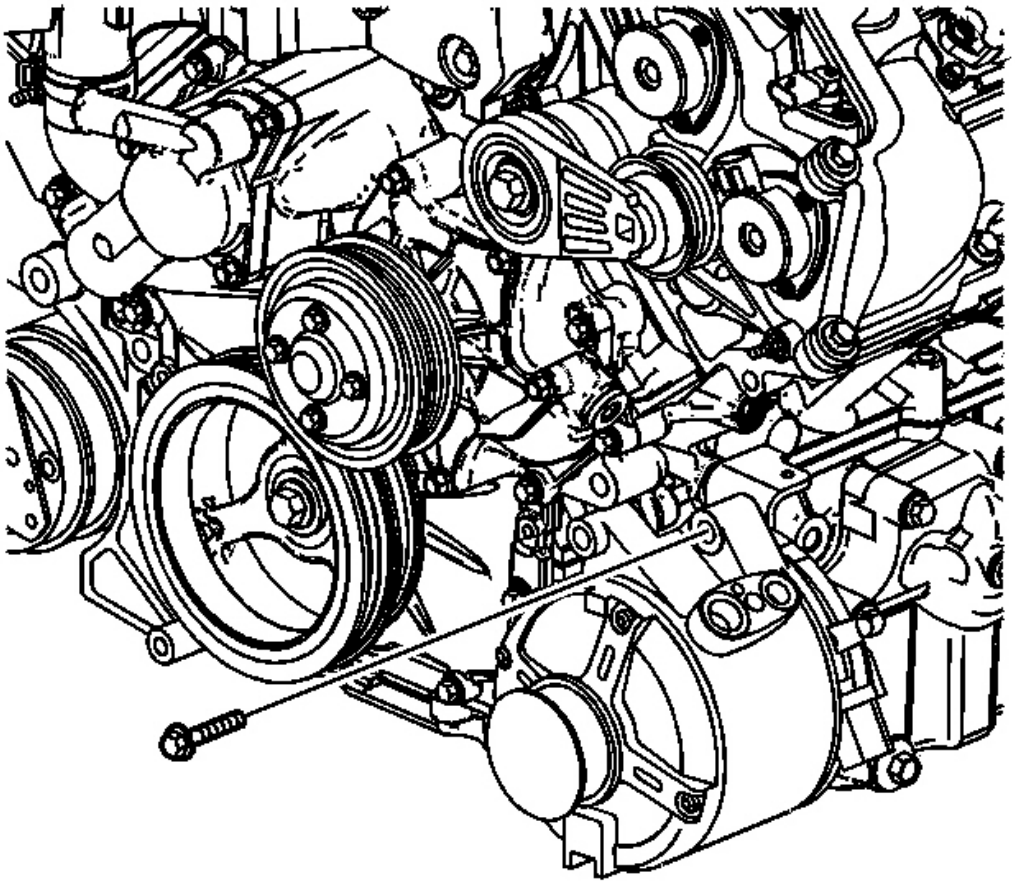


Fig. 62: View Of Front Upper Generator Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install the upper generator bolt.

   Tighten: Tighten the generator bolts to 50 N.m (37 lb ft).

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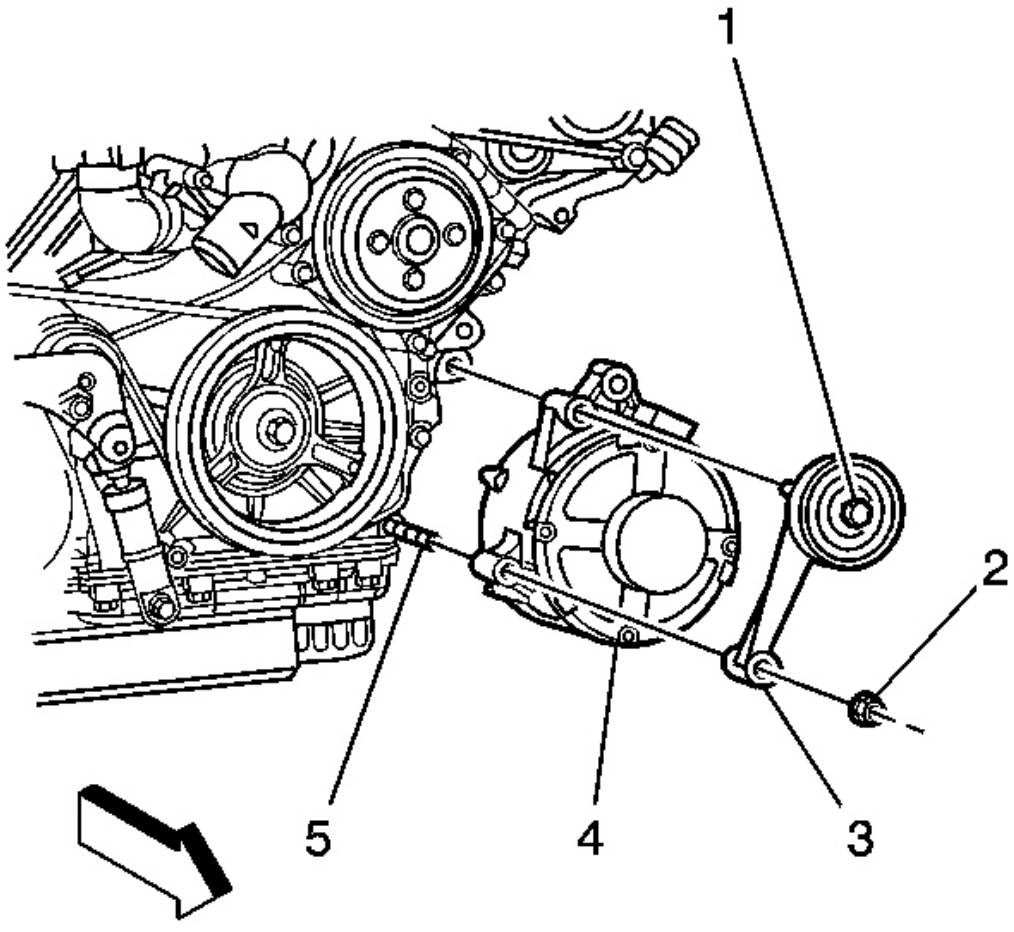


Fig. 63: View Of Generator & Idler Pulley Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the idler pulley assembly (3) and bolt (1).
4. Install the nut (2).

Tighten the generator fasteners to the following torque values:

Tighten:

1. Tighten the idler pulley bolt (1) to 50 N.m (37 lb ft).
2. Tighten the idler pulley nut (2) to 50 N.m (37 lb ft).

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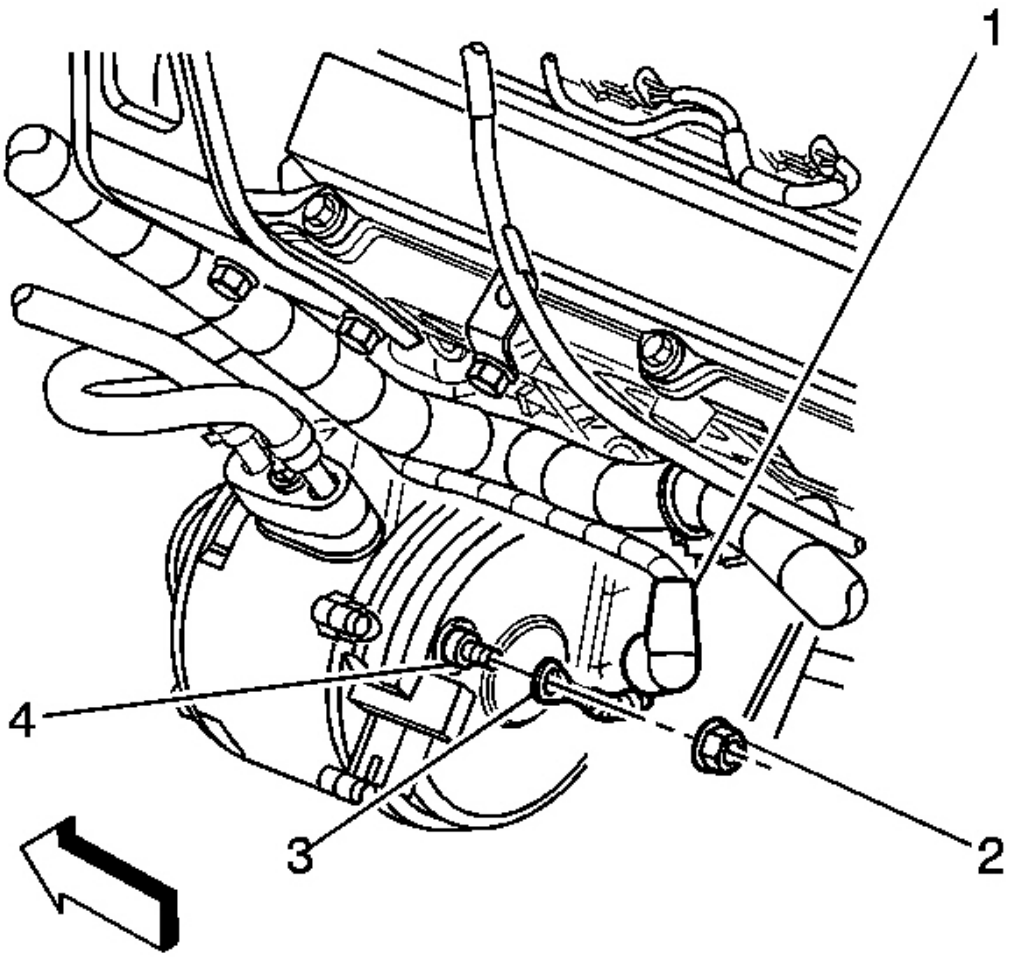


Fig. 64: View Of Battery Positive/Starter Cable Terminal & Nut
Courtesy of GENERAL MOTORS CORP.

5. Install the starter cable terminal to the generator:
    1. Install the starter cable terminal to the stud.
    2. Install the starter cable nut (2).

        Tighten: Tighten the starter cable nut to 20 N.m (15 lb ft).

    3. Slide the boot (1) over the generator stud (4).
6. Position the generator coolant hose assembly to the generator and secure with the bolt.

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

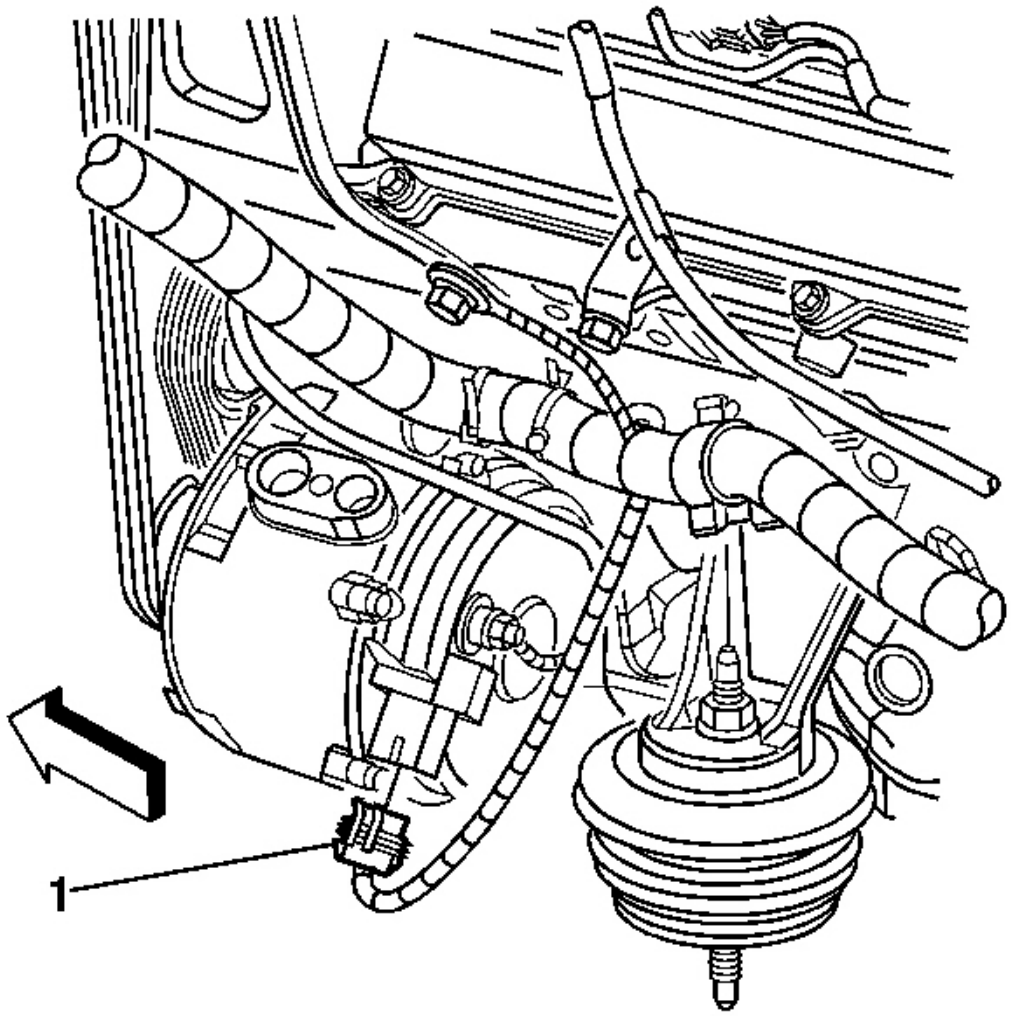


Fig. 65: View Of Generator Electrical Connector
Courtesy of GENERAL MOTORS CORP.

7. Connect the generator electrical connector (1).
8. Install the front suspension crossmember. Refer to **Front Suspension Crossmember Replacement** .
9. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)** .
10. Connect the negative battery cable (2). Refer to **Battery Negative Cable Disconnection and Connection**.

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11. Install the generator drive belt. Refer to **DRIVE BELT REPLACEMENT** .

DESCRIPTION AND OPERATION

BATTERY DESCRIPTION AND OPERATION

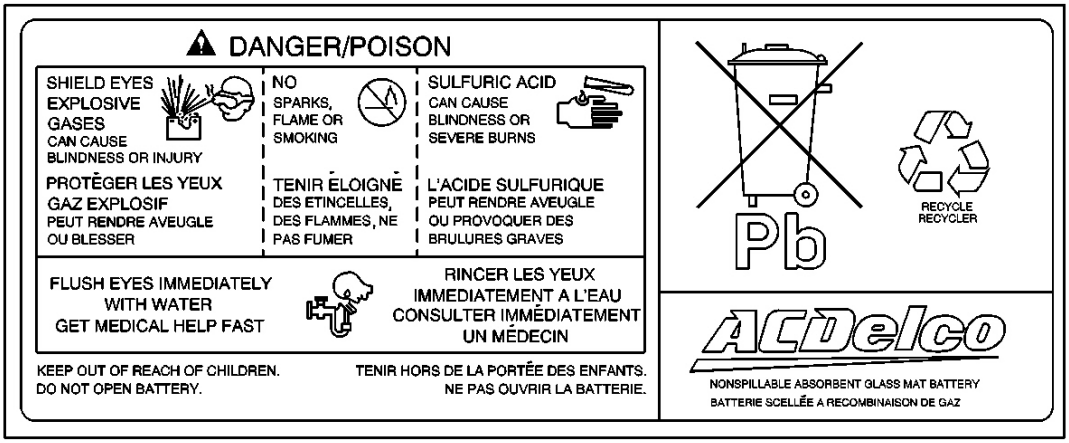


Fig. 66: Battery Warning Label
Courtesy of GENERAL MOTORS CORP.

CAUTION: Batteries produce explosive gases, contain corrosive acid and supply levels of electrical current high enough to cause burns. Therefore, to reduce the risk of personal injury when working near a battery:

- **Always shield your eyes and avoid leaning over the battery whenever possible.**
- **Do not expose the battery to open flames or sparks.**
- **Do not allow the battery electrolyte to contact the eyes or the skin. Flush immediately and thoroughly any contacted areas with water and get medical help.**
- **Follow each step of the jump starting procedure in order.**
- **Treat both the booster and the discharged batteries carefully when using the jumper cables.**

IMPORTANT: Because of the materials used in the manufacture of automotive lead-acid batteries, dealers and service shops that handle them are subject to various regulations issued by OSHA, EPA, DOT and various state or local agencies. Other regulations may also apply in other locations. Always know and follow these regulations when handling batteries.

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Batteries that are no longer wanted must be disposed of by an approved battery recycler and must never be thrown in the trash or sent to a landfill.

Batteries that are not part of the vehicle itself, not the battery under the hood, must only be transported on public streets for business purposes via approved hazardous material transportation procedures.

Battery storage, charging and testing facilities in repair shops must meet various requirements for ventilation, safety equipment, material segregation, etc.

The maintenance-free battery is standard. There are no vent plugs in the cover. The battery is completely sealed except for 2 small vent holes in the side. These vent holes allow the small amount of gas that is produced in the battery to escape.

The battery has 3 functions as a major source of energy:

- Engine cranking
- Voltage stabilizer
- Alternate source of energy with generator overload

The battery specification label, example below, contains information about the following:

- The test ratings
- The original equipment catalog number
- The recommended replacement model number

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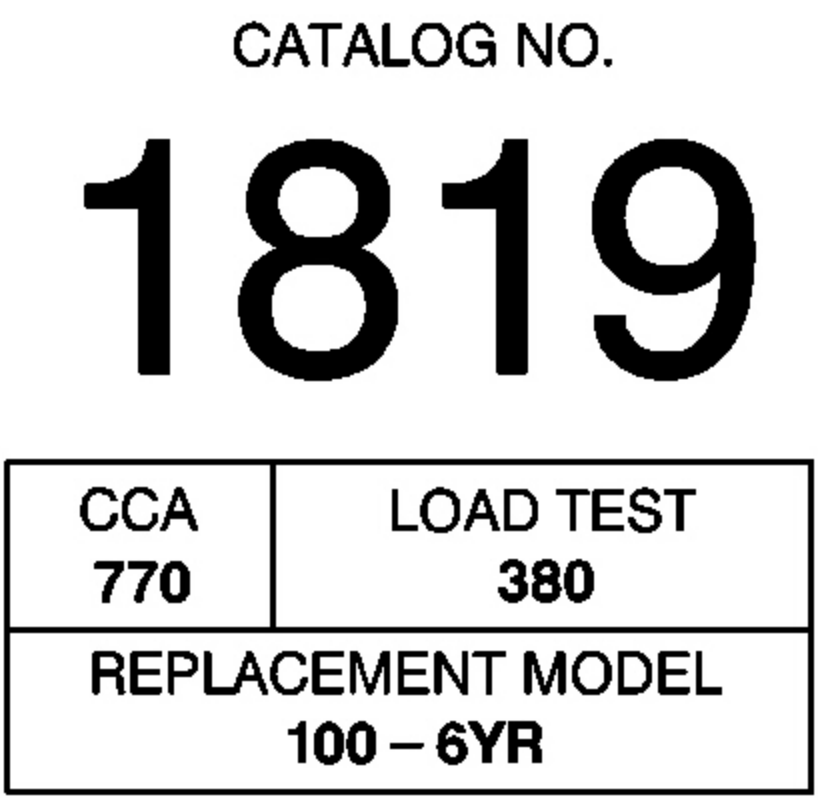


Fig. 67: View Of Battery Specification Label
Courtesy of GENERAL MOTORS CORP.

Battery Ratings

A battery may have 3 ratings:

- Amp hour
- Reserve capacity
- Cold cranking amperage

When a battery is replaced, use a battery with similar ratings. Refer to the battery specification label on the original battery or refer to **Battery Usage**.

Amp Hour

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The amp hour rating of a battery is the amount of time it takes a fully charged battery, being discharged at a constant rate of 1 amperes and a constant temperature of 27°C (80°F), to reach a terminal voltage of 10.5 volts. Refer to **Battery Usage** for the amp hour rating of the original equipment battery.

Reserve Capacity

Reserve capacity is the amount of time in minutes it takes a fully charged battery, being discharged at a constant rate of 25 amperes and a constant temperature of 27°C (80°F), to reach a terminal voltage of 10.5 volts. Refer to **Battery Usage** for the reserve capacity rating of the original equipment battery.

Cold Cranking Amperage

The cold cranking amperage is an indication of the ability of the battery to crank the engine at cold temperatures. The cold cranking amperage rating is the minimum amperage the battery must maintain for 30 seconds at -18°C (0°F) while maintaining at least 7.2 volts. Refer to **Battery Usage** for the cold cranking amperage rating for this vehicle.

CHARGING SYSTEM DESCRIPTION AND OPERATION

Generator

The generator features the following major components:

- The delta stator
- The rectifier bridge
- The rotor with slip rings and brushes
- A conventional pulley
- The regulator

The slip ring and the frame are liquid cooled.

The generator features permanently lubricated bearings. Service should only include tightening of mount components. Otherwise, replace the generator as a complete unit.

Regulator

The voltage regulator controls the rotor field current in order to limit the system voltage. When the field current is on, the regulator switches the current on and off at a rate of 400 cycles per second in order to perform the following functions:

- Radio noise control
- Obtain the correct average current needed for proper system voltage control

At high speeds, the on-time may be 10 percent with the off-time at 90 percent. At low speeds, the on-time may be 90 percent and the off-time 10 percent.

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Circuit Description

The generator provides voltage to operate the vehicle's electrical system and to charge its battery. A magnetic field is created when current flows through the rotor. This field rotates as the rotor is driven by the engine, creating an AC voltage in the stator windings. The AC voltage is converted to DC by the rectifier bridge and is supplied to the electrical system at the battery terminal.

When the engine is running, the generator turn-on signal is sent to the generator from the engine control module (ECM), turning on the regulator. The generator's voltage regulator controls current to the rotor, thereby controlling the output voltage. The rotor current is proportional to the electrical pulse width supplied by the regulator. When the engine is started, the regulator senses generator rotation by detecting AC voltage at the stator through an internal wire. Once the engine is running, the regulator varies the field current by controlling the pulse width. This regulates the generator output voltage for proper battery charging and electrical system operation. The generator F terminal is connected internally to the voltage regulator and externally to the ECM. When the voltage regulator detects a charging system problem, it grounds this circuit to signal the ECM that a problem exists. The ECM monitors the generator field duty cycle signal circuit. The system voltage sense circuit receives B+ voltage that is Hot At All Times through the HORN/ALT SENSE fuse in the underhood junction block. This voltage is used by the regulator as the reference for system voltage control. On vehicles that use a sense circuit connected to the voltage regulator, this circuit must be operating properly for the charging system to work correctly, when there is a charging system concern all circuits at the generator should be tested.

Charging System Messages

The driver information center (DIC) displays a charging system message the when the following occurs:

- The engine control module (ECM) detects that the generator output is less than 11 volts or greater than 16 volts. The DIC receives a class 2 message from the ECM requesting illumination of the charge charging system message.
- The instrument panel cluster (IPC) determines that the system voltage is less than 11 volts or greater than 16 volts. The IPC receives a class 2 message from the body control module (BCM) indicating the system voltage.

CHARGE SYSTEM FAULT

The DIC displays the CHARGE SYSTEM FAULT message when the ECM detects a malfunction with the generator output. The IPC receives a message from the ECM requesting illumination.

BATTERY SAVER ACTIVE

The DIC displays the BATTERY SAVER ACTIVE message when the BCM reduces or disables the performance of some vehicle systems in order to reduce the load on the charging system. The DIC receives a message from the BCM requesting illumination.

VOLTAGE HIGH

The DIC displays the VOLTAGE HIGH message when the IPC determines that the system voltage is greater

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than 16 volts. The IPC receives a message from the BCM indicating the system voltage.

VOLTAGE LOW

The DIC displays the VOLTAGE LOW message when the IPC determines that the system voltage is less than 11 volts. The IPC receives a message from the BCM indicating the system voltage.

SERVICE CHARGING SYS

The DIC displays the SERVICE CHARGING SYS message when the ECM detects a malfunction with the generator output. The IPC receives a message from the ECM requesting illumination.

STARTING SYSTEM DESCRIPTION AND OPERATION

The starter motors on this vehicle are non-repairable. It has pole pieces that are arranged around the armature. Both solenoid windings are energized. The pull-in winding circuit is completed to the ground through the starter motor. The windings work together magnetically to pull and hold in the plunger. The plunger moves the shift lever. This action causes the starter drive assembly to rotate on the armature shaft spline as it engages with the flywheel ring gear on the engine. Moving at the same time, the plunger also closes the solenoid switch contacts in the starter solenoid. Full battery voltage is applied directly to the starter motor and it cranks the engine.

As soon as the solenoid switch contacts close, current stops flowing thorough the pull-in winding because battery voltage is applied to both ends of the windings. The hold-in winding remains energized; its magnetic field is strong enough to hold the plunger, shift lever, starter drive assembly and solenoid switch contacts in place to continue cranking the engine. When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened.

When the engine control module (ECM) sees an engine run flag, the ground is removed from the control circuit of the crank relay. The switch side of the crank relay opens and battery voltage is removed from the starter solenoid S terminal. Current flows from the motor contacts through both windings to the ground at the end of the hold-in winding. However, the direction of the current flow through the pull-in winding is now opposite the direction of the current flow when the winding was first energized.

The magnetic fields of the pull-in and hold-in windings now oppose one another. This action of the windings, along with the help of the return spring, causes the starter drive assembly to disengage and the solenoid switch contacts to open simultaneously. As soon as the contacts open, the starter circuit is turned off.

Circuit Description

Pressing the Start switch sends a discrete input to the body control module (BCM) notifying it that engine start has been requested. The BCM then verifies that the brake pedal has been depressed with a discrete input from the break pedal switch and that the key fob, with the correct code, is in the vehicle. After this information has been verified the BCM grounds the control side of the RUN/CRANK Relay closing the switch side of it and allowing battery positive voltage to flow from the BATT 3 fuse through the RUN/CRANK Relay switch, ECM Fuse to the battery positive voltage side of the crank relay coil. The BCM also sends a high speed GMLAN message to the ECM requesting engine start. The ECM will then verify that the internal mode switch (IMS) is in Park of Neutral. After this has been verified the ECM grounds the control circuit of the CRANK relay closing

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the CRANK relay switch circuit and allowing battery positive voltage to flow through the STARTER Fuse, the CRANK relay switch to the S terminal of the Starter solenoid cranking the engine. Ground is supplied through the engine block.

LOAD SHED SYSTEM DESCRIPTION AND OPERATION

Electrical Load Management

Electrical load management is designed to maintain battery voltage and covers more than load-shed. The body control module (BCM) will request increases in idle speed from the engine control module (ECM), when the vehicle is in park or neutral, as well as turn off loads in order to manage the electrical system and preserve the vehicle electrical power availability. The BCM calculates the battery temperature, voltage and charging rate at all times while the engine is running.

The BCM calculates the battery temperature by factoring in:

- The current intake manifold air temperature compared to the last temperature recorded when the ignition switch was turned OFF
- The current battery voltage compared to the last battery voltage recorded when the ignition switch was turned OFF
- The length of time since the last battery temperature calculation

If the calculated battery temperature is below -15°C (+5°F), the PMM institutes steps to control the load.

The BCM calculates the voltage of the battery by making constant voltage measurements and using the measurements to calculate the true battery voltage. If the BCM detects a low voltage, the BCM institutes steps to control the load.

The BCM calculates the net charge rate on the electrical system by making constant voltage measurements and using the measurements to calculate the charge rate in amp/hours. If the BCM detects a negative charge rate, equal to a discharge from the battery, the PMM institutes steps to control the load.

The BCM will either request an increase in the engine idle speed from the ECM or the BCM will turn off loads, called the load-shed function, in order to preserve the vehicle electrical system operation. The criteria used by the BCM to regulate this electrical load management are outlined below:

Load Shed System Description and Operation

Function	Battery Temperature Calculation	Battery Voltage Calculation	Amp-hour Calculation	Action Taken
Idle Boost 1 Start	Less Than -15°C (5° F)	-	-	First level Idle boost requested
Idle Boost 1 Start	-	-	Battery has a net loss of 0.6 AH	First level Idle boost requested
Idle Boost 1 End	Greater Than -15°C	-	Battery has a net loss of less than 0.2	First level Idle boost

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	(5°F)		AH	request cancelled
Idle Boost 1 End	-	14.0 V	Battery has a net loss of less than 0.2 AH	First level Idle boost request cancelled
Load Shed 1 Start	-	-	Battery has a net loss of 1.6 AH	Controlled outputs cycled OFF for 20% of their cycle
Load Shed 1 End	-	-	Battery has a net loss of less than 0.8 AH	Clear Load Shed 1
Idle Boost 2 Start	-	-	Battery has a net loss of 5.0 AH	Second level Idle boost requested
Idle Boost 2 End	-	-	Battery has a net loss of less than 2.0 AH	Second level Idle boost request cancelled
Idle Boost 3 Start	-	-	Battery has a net loss of 10.0 AH	Third level Idle boost requested
Idle Boost 3 Start	-	-	-	Third level Idle boost requested
Idle Boost 3 End	-	Greater Than 13.0 V	Battery has a net loss of less than 6.0 AH	Third level Idle boost request cancelled
Load Shed 2 Start	-	Less Than 10.9 V	Battery has a net loss of 20.0 AH	Controlled outputs cycled OFF for 100% of their cycle, Battery Indicator or Battery Saver Indicator ON request sent
Load Shed 2 End	-	Greater Than 13.0 V	battery has a net loss of less than 10.5 AH	Clear Load Shed 2

Each load management function, either idle boost or load-shed, is discrete. No two functions are implemented at the same time.

During each load management function, the BCM checks the battery temperature, battery voltage and amp-hour calculations and determines if the BCM should implement a different power management function.

The highest loads on the electrical system are the resistance load of heating elements. The BCM controls the heating elements in the outside rear view mirrors, the rear window and the heated seats, either directly or by sending messages to any module controlling power to these devices.

The second highest load on the electrical system are the blowers used in the HVAC system. The BCM will send messages to the HVAC system controller that will result in reducing the blower operation on vehicles equipped

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with automatic HVAC systems.

Idle Boost Functions

The BCM sends a serial data request to the ECM to increase the idle speed. The ECM then adjusts the idle speed by using a special program and idle speed ramp calculations in order to prevent driveability and safety concerns. The idle speed boost and cancel function will vary from vehicle to vehicle and from one moment to another on the same vehicle. This happens because the ECM responds to changes in the inputs from the sensors used to control the powertrain.

Load Shed System Description and Operation

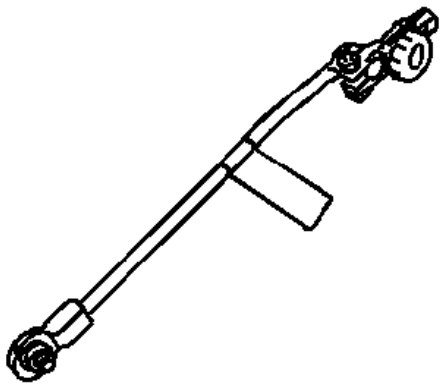
Load Shed Level	Affected Systems	Action Taken
Load-Shed Level 0	No systems affected	Normal operation
Load-Shed Level 1	Heated Outside Rear View Mirrors, Heated Rear Window/Rear Window Defrost, Heated Seats	Cycled at 80% duty cycle, OFF for 4 of every 20 second cycle. Indicator and timer not affected.
	Message Center, Instrument Cluster	No messages or indicators are displayed. Data (DPID) indicating that the Load-Shed 1 was entered is stored and may be accessed with a scan tool. DPID will reset after 40 ignition switch cycles with no repeated load-shed 1 action or with a battery disconnection.
Load-Shed Level 2	Heated Outside Rear View Mirrors, Heated Rear Window/Rear Window Defrost, Heated Seats	Turned OFF. Indicator and timer are not affected. The indicators and timers are controlled by the BCM. The operator must turn ON system when load-shed level is exited. System will not respond to operator input until current load-shed level is exited. This system will respond to only one Load-Shed Level 2 command per ignition switch cycle.
	Message Center, Instrument Cluster	"Battery Saver Action" message is displayed. Charge indicator is illuminated. Data (DPID) indicating that the Load-Shed Level 2 was entered is stored and may be accessed with a scan tool. DPID will reset after 40 ignition switch cycles with no repeated Load-Shed 2 actions or with a battery disconnection.

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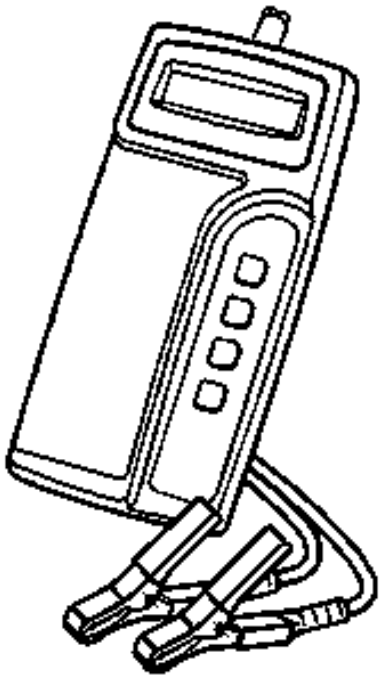
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Special Tools

Illustration	Tool Number/Description
	J 38758 Parasitic Draw Test Switch
	J 42000 Battery Tester

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2007 ENGINE

Engine Exhaust - XLR

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Exhaust Down Pipe Hanger to Bell Housing	50 N.m	37 lb ft
Exhaust Manifold Bolts and Nuts	25 N.m	18 lb ft
Exhaust Manifold Hanger Bolt	50 N.m	37 lb ft
Exhaust Muffler Hanger Nut	16 N.m	12 lb ft
Exhaust Manifold Heat Shield Bolt	10 N.m	89 lb in
Exhaust Manifold Pipe to H-Pipe Nut	20 N.m	15 lb ft
Exhaust Manifold Stud	6 N.m	53 lb in
Exhaust Manifold Stud to Cylinder Head	6 N.m	53 lb in
Exhaust Manifold Stud/Nut and Bolt Torque	25 N.m	18 lb ft
Exhaust Pipe Brace Lower Bolt	50 N.m	37 lb ft
Exhaust Pipe Hanger Bolt	50 N.m	37 lb ft
Intermediate Pipe to Muffler Clamps	44 N.m	32 lb ft
Oxygen Sensors	42 N.m	30 lb ft

SCHEMATIC AND ROUTING DIAGRAMS

EXHAUST SYSTEM SCHEMATICS

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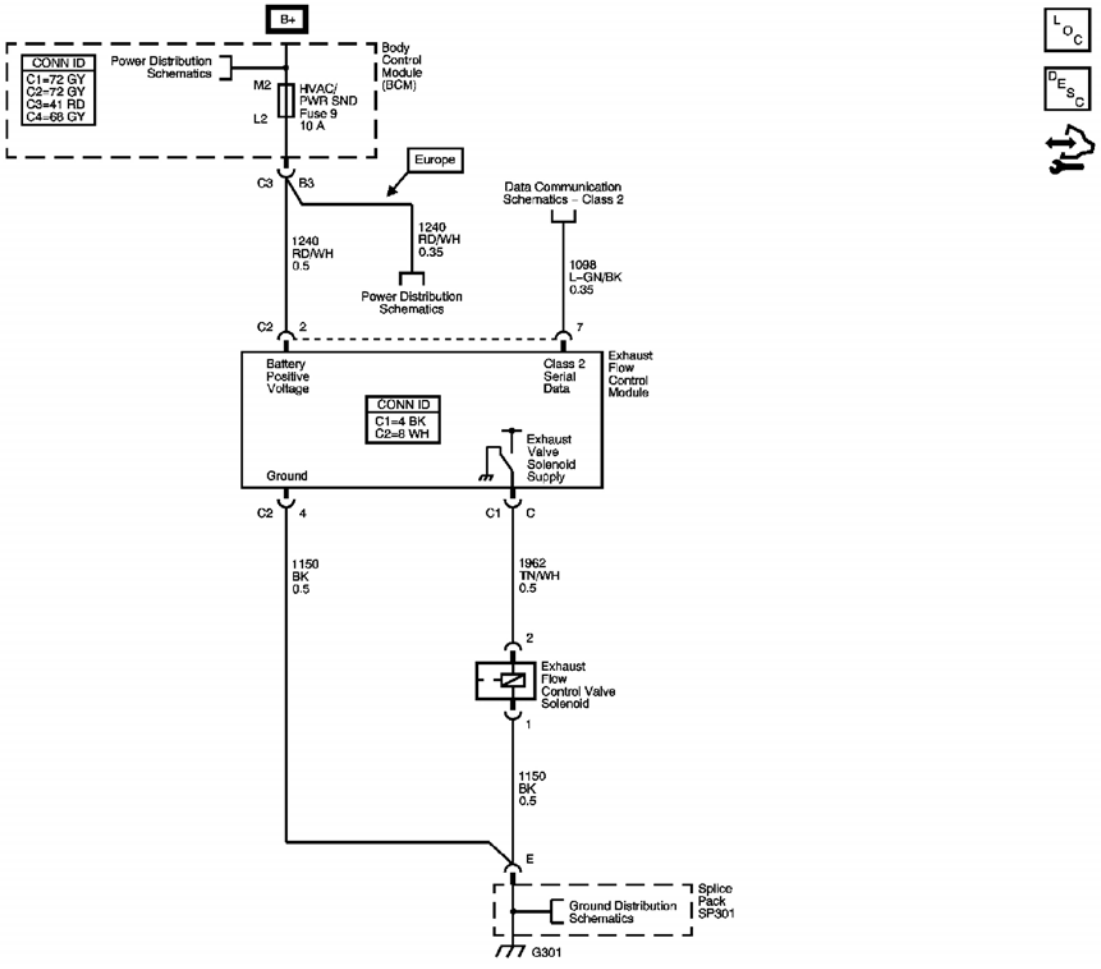


Fig. 1: Exhaust System Schematic
Courtesy of GENERAL MOTORS CORP.

COMPONENT LOCATOR

EXHAUST SYSTEM COMPONENT VIEWS

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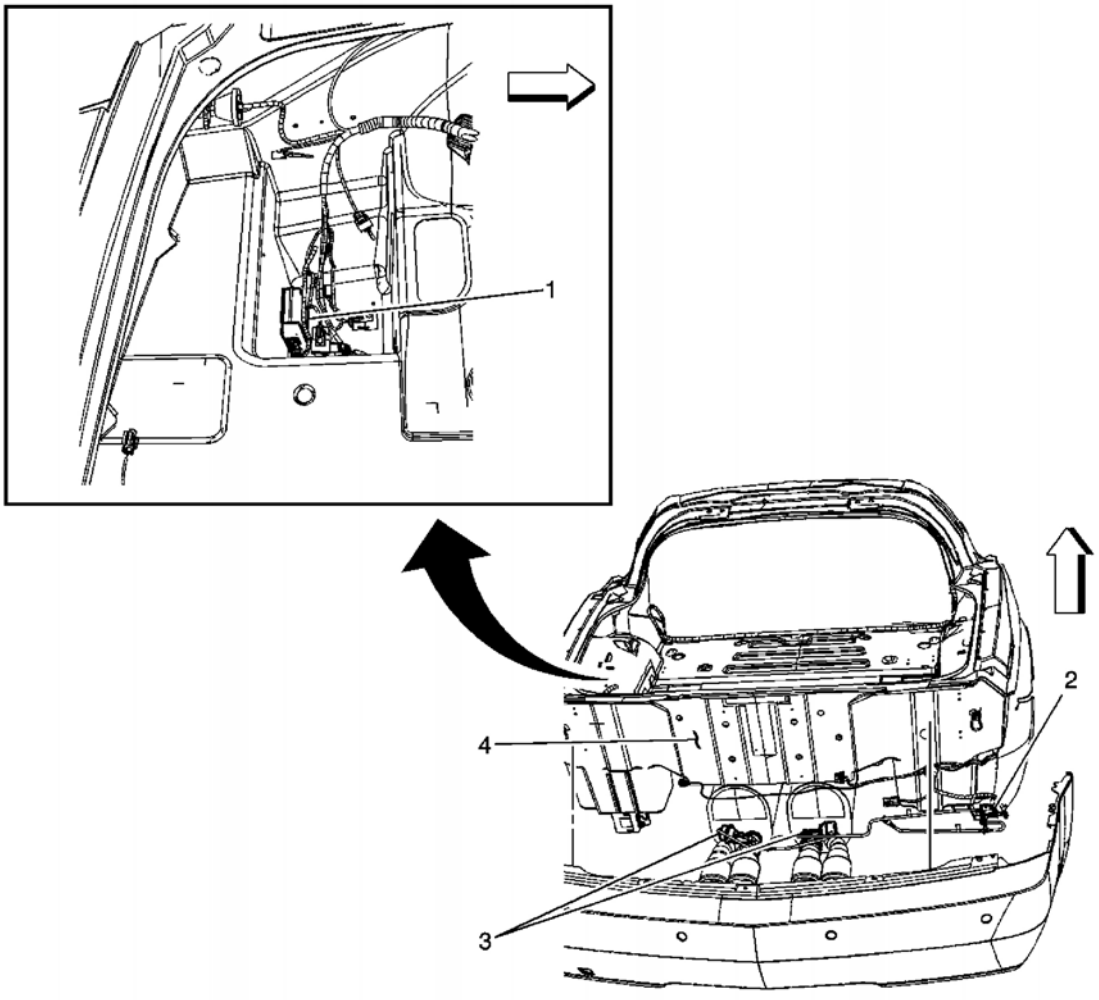


Fig. 2: Rear Exhaust System Component View
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 2

Callout	Component Name
1	Exhaust Flow Control Module
2	Exhaust Flow Control Solenoid
3	Exhaust Control Valves
4	Rear Compartment Panel

EXHAUST SYSTEM CONNECTOR END VIEWS

Exhaust Flow Control Module C1

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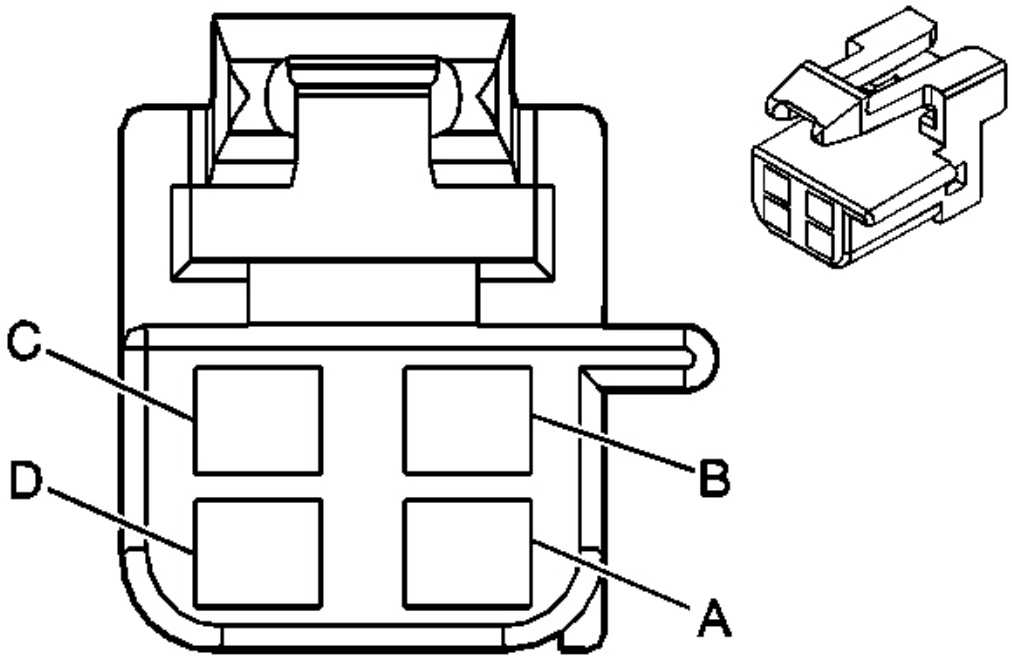


Fig. 3: Exhaust Flow Control Module C1 Connector End View
Courtesy of GENERAL MOTORS CORP.

Exhaust Flow Control Module C1 Connector Parts Information

Connector Part Information

- OEM: 12064760
- Service: 12085208
- Description: 4-Way F Metri-Pack 150 Series (BK)

Terminal Part Information

- Terminal/Tray: 12064971/5
- Core/Insulation Crimp: E/C
- Release Tool/Test Probe: 12094429/J-35616-2A (GY)

Exhaust Flow Control Module C1 Connector Terminal Identification

Pin	Wire Color	Circuit No.	Function
A-B	-	-	Not Used
C	TN/WH	1962	Exhaust Valve Solenoid Supply

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D	-	-	Not Used

Exhaust Flow Control Module C2

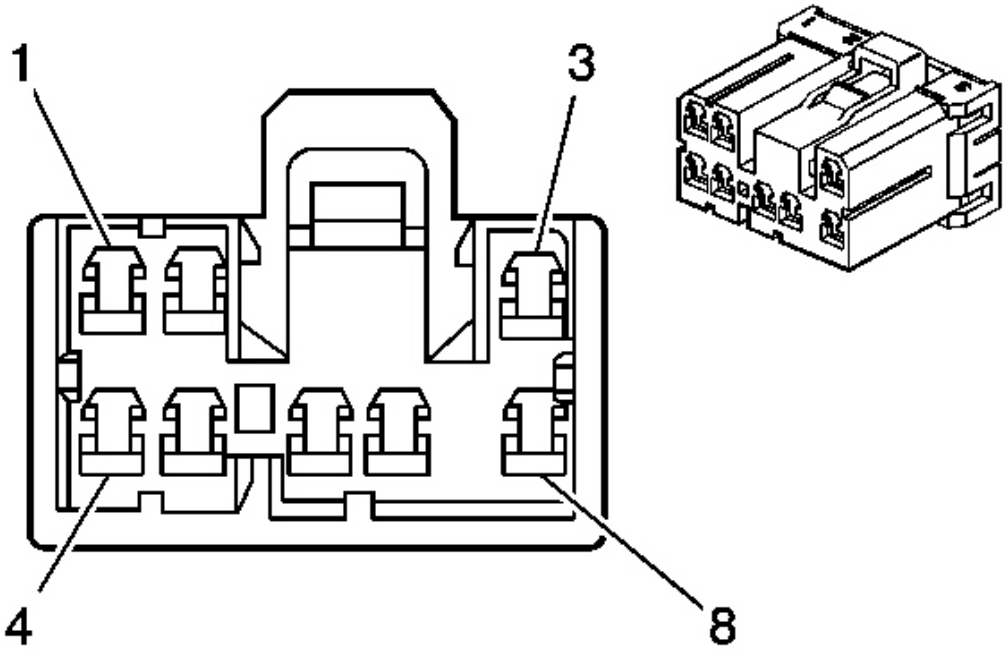


Fig. 4: Exhaust Flow Control Module C2 Connector End View
Courtesy of GENERAL MOTORS CORP.

Exhaust Flow Control Module C2 Connector Parts Information

Connector Part Information

- OEM: 12196605
- Service: 88953352
- Description: 8-Way F 070 Series (WH)

Terminal Part Information

- Terminal/Tray: 173630-7/7
- Core/Insulation Crimp: E/4
- Release Tool/Test Probe: 15315247/J-35616-33 (YE)

Exhaust Flow Control Module C2 Connector Terminal Identification

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Pin	Wire Color	Circuit No.	Function
1	-	-	Not Used
2	RD/WH	1240	Battery Positive Voltage
3	-	-	Not Used
4	BK	1150	Ground
5-6	-	-	Not Used
7	L-GN/BK	1098	Class 2 Serial Data
8	-	-	Not Used

Exhaust Flow Control Valve Solenoid

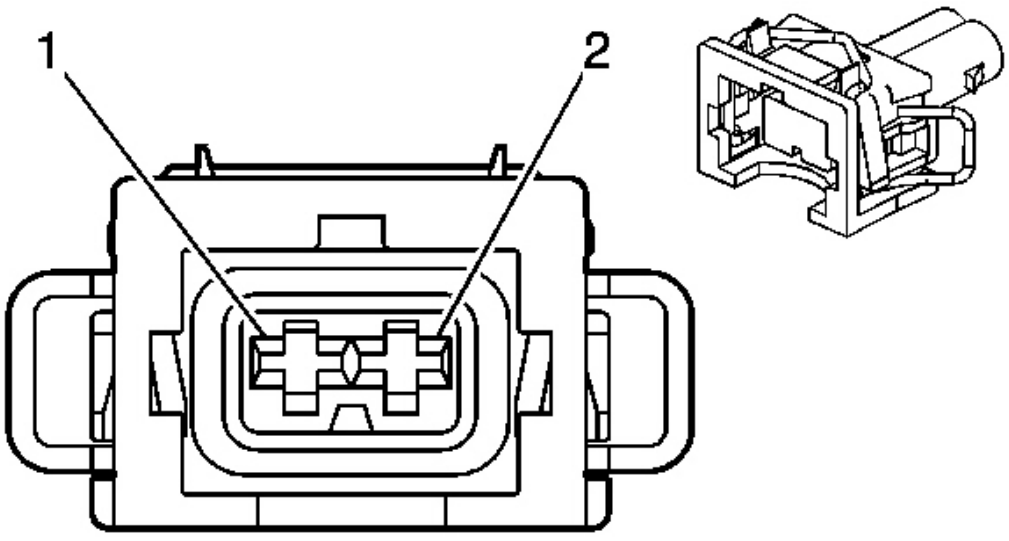


Fig. 5: Exhaust Flow Control Valve Solenoid Connector End View
Courtesy of GENERAL MOTORS CORP.

Exhaust Flow Control Valve Solenoid Connector Parts Information

Connector Part Information

- OEM: 12131678
- Service: 89046833
- Description: 2-Way F Mini-Timer Series (BK)

Terminal Part Information

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- Terminal/Tray: 60012941/21
- Core/Insulation Crimp: See Terminal Repair Kit
- Release Tool/Test Probe: 12122378/J-35616-4A (PU)

Exhaust Flow Control Valve Solenoid Connector Terminal Identification

Pin	Wire Color	Circuit No.	Function
1	BK	1150	Ground
2	TN/WH	1962	Exhaust Valve Solenoid Supply

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE EXHAUST

Begin the system diagnosis by reviewing the system Description and Operation. Reviewing the information will help you determine the correct symptom diagnostic procedure when a malfunction exists. It will also help you determine if the condition described by the customer is normal operation. Refer to **Symptoms - Engine Exhaust** in order to identify the correct procedure for diagnosing the system.

SCAN TOOL OUTPUT CONTROLS

Scan Tool Output Controls

Scan Tool Output Control	Additional Menu Selections	Description
EFC System Enable/Disable	-	Enables or disables the system after EFCM replacement or per customer request
Exhaust Valve Command	-	Commands the exhaust flow control valve vacuum solenoid ON or OFF

SCAN TOOL DATA LIST

Scan Tool Data List

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
Ignition ON/engine OFF or engine ON			
Battery Voltage	EFCM Data	Volts	8-16
Engine Run	EFCM Data	Yes/No	Varies
Exhaust Valve Command	EFCM Data	On/Off	Varies
Power Mode	EFCM Data	Off/RAP/Acc/On/Crank	Varies
System Enabled	EFCM Data	Yes/No	Varies
System Mode Status	EFCM Data	Normal/Comp	Varies
Throttle Position	EFCM Data	%	Varies
Vehicle Speed	EFCM Data	kph/mph	Varies

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SCAN TOOL DATA DEFINITIONS

Battery Voltage

The scan tool displays 0-30 volts. The voltage measured between the modules battery positive voltage circuit and ground circuit.

Engine Run

This parameter displays if engine is ON or OFF.

Exhaust Valve Command

This parameter displays if the exhaust flow control solenoid is being commanded ON or OFF.

Power Mode

This parameter displays what position has been selected by the ignition switch, (Run, Accessory, Crank, Retained Accessory Power or Off).

System Enabled

This parameter displays Yes or No. Yes indicates the Exhaust Flow Control system has been enabled. No indicates the system is disabled

System Mode Status

This parameter displays Normal or Comp. Normal indicates exhaust flow is bypassing the mufflers less frequently and at higher engine RPMs. Comp indicates exhaust flow is bypassing the mufflers more frequently and at lower engine RPMs

Throttle Position

This parameter displays the angle of the throttle position (TP) sensor in percent. This information is calculated by the control module using the signal from the throttle position sensor. The scan tool will display a low percentage when the throttle plates are closed. The scan tool will display a high percentage when the throttle plates are fully open.

Vehicle Speed

This parameter indicates the vehicle speed calculated by the control module based on an input from the vehicle speed sensor (VSS).

DTC P166A

Diagnostic Instructions

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- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- **Strategy Based Diagnosis**
- **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P166A

Exhaust Control Valve Control Circuit

Diagnostic Fault Information

IMPORTANT: Always perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.

DTC P166A

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Exhaust Valve Solenoid Supply Voltage	P166A	1	P166A	-
Ground	1	1	1	-
1. Exhaust Vibration/Noise - Exhaust Flow Control System Malfunction				

Circuit/System Description

Exhaust tail pipe flow valve control module receives throttle position sensor and RPM information via serial data from powertrain control module (PCM). The exhaust tail pipe flow valve control module uses this information to determine if to command exhaust tail pipe flow control valve solenoid ON or OFF. When commanded OFF the exhaust tail pipe flow control valve solenoid allows vacuum to flow to close exhaust valve.

Conditions for Running the DTC

- The ignition is ON.
- Ignition voltage is greater than 8 volts.

Conditions for Setting the DTC

- Exhaust tail pipe flow valve control module detects short to voltage on exhaust valve solenoid supply voltage circuit.
- Exhaust tail pipe flow valve control module detects short to ground on exhaust valve solenoid supply voltage circuit.

Action Taken When the DTC Sets

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Exhaust flow control valve defaults to open.

Conditions for Clearing the DTC

The condition for setting the DTC is no longer present and the DTC is cleared with a scan tool.

Reference Information

Schematic Reference

Exhaust System Schematics

Connector End View Reference

Exhaust System Connector End Views

Electrical Information Reference

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

Scan Tool Reference

Scan Tool Data List for exhaust tail pipe flow valve control module

Circuit/System Testing

1. Ignition OFF, disconnect the exhaust tail pipe flow control valve solenoid connector.
2. Ignition ON, measure for 0 volts between the exhaust tail pipe flow control valve solenoid supply voltage circuit and ground.
    - If over 0 volts, test for short to voltage in exhaust valve solenoid supply voltage circuit.
3. Ignition ON, use scan tool to command exhaust flow control relay ON, measure for 10 volts or above between the exhaust tail pipe flow control valve solenoid supply voltage circuit and ground.
    - If under 10 volts, test for short to ground in exhaust valve solenoid supply voltage circuit.
4. If all circuits test normal replace the exhaust tail pipe flow valve control module.

Repair Procedures

IMPORTANT: Always perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Control Module References for exhaust tail pipe flow valve control module replacement, setup and programming.

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SYMPTOMS - ENGINE EXHAUST

- Review the Exhaust System Description and Operation in order to familiarize yourself with the system functions. Refer to **Exhaust System Description**.
- All diagnostics on a vehicle should follow a logical process. Strategy Based Diagnostics is a uniform approach for repairing all systems. The diagnostic flow chart is the place to start when repairs are necessary and may always be used in order to resolve a system problem. For a detailed explanation, refer to **Strategy Based Diagnosis** .

Visual/Physical Inspection

- Inspect for aftermarket or non-OEM devices such as, but not limited too; tailpipe extensions, headers and exhaust cutouts. This could affect the operation and proper performance of the exhaust system.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, engine temperature, engine load and frequency of concern.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause any symptom.

Intermittent

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

Symptom List

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

- Loss of power-Refer to **Restricted Exhaust**.
- Poor acceleration-Refer to **Restricted Exhaust**.
- Poor fuel economy-Refer to **Restricted Exhaust**.
- Excessive smoke - Refer to **Restricted Exhaust**.
- Exhaust hissing noise - Refer to **Exhaust Leakage**.
- Exhaust popping noise - Refer to **Exhaust Leakage**.
- Exhaust rattle noise - Refer to **Exhaust Noise**.
- Loud exhaust noise - Refer to **Exhaust Noise**.
- Exhaust buzz, groan, hum noise - Refer to **Exhaust Noise**.

RESTRICTED EXHAUST

Diagnostic Aids

CAUTION: Refer to Hot Exhaust System Caution .

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For dual exhaust systems a quick check of exhaust flow will help determine which side of the exhaust system is restricted. The side that has less exhaust flow is the side that will be suspect and diagnosis should begin there.

Test Description

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

4: The exhaust system has very low back pressure under normal conditions. If the exhaust system is restricted, a significant increase in the exhaust pressure is noticed on the **J 35314-A** . See **Special Tools**. Removing the HO2S sensor may set a DTC. When finishing this diagnostic table, be sure to clear all codes.

5: This step will isolate the catalytic converter from the remainder of the exhaust system.

8: Confirming that the condition has been fixed is essential. If the symptom still exists and the vehicle has a dual exhaust system, proceed to Step 2 and repeat diagnostic procedure on the opposite exhaust pipe.

Restricted Exhaust

Step	Action	Value(s)	Yes	No
1	Did you verify the customers complaint?	-	Go to **Step 2**	-
2	Did you review the exhaust symptoms diagnostic information and perform the necessary inspections?	-	Go to **Step 3**	Go to **Symptoms - Engine Exhaust**
3	Is the system equipped with dual exhaust?	-	Go to **Diagnostic Aids**	Go to **Step 4**
4	1. Remove the HO2S that is in front of and closest to the catalytic converter. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1** or **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1** . 2. Install the **J 35314-A** Exhaust Back Pressure Gage in place of the HO2S sensor. See **Special Tools**. 3. Start the engine. 4. Increase and monitor the engine speed at 2,000 RPM. 5. Observe the exhaust system back pressure reading on the gauge. Does the reading exceed the specified value?	14 kPa (2 psi)	Go to **Step 5**	Go to **Step 8**
	1. Turn the engine off and place the			

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5	ignition in the lock position. 2. Remove the **J 35314-A** . See **Special Tools**. 3. Re-install the HO2S sensor. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1** or **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1** . 4. Remove the post-catalyst HO2S sensor. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2** or **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2** . 5. Install the **J 35314-A** in place of the post HO2S sensor. See **Special Tools**. 6. Start the engine. 7. Increase and monitor the engine speed at 2,000 RPM. 8. Observe the exhaust system back pressure reading on the gage. Does the reading exceed the specified value?	14 kPa (2 psi)	Go to **Step 6**	Go to **Step 7**
6	Inspect the exhaust system for the following conditions: • Damage in the exhaust pipe • Debris in the exhaust pipe • Muffler or internal failure • Two-layer exhaust pipe separation Did you find and correct the condition?	-	Go to **Step 8**	-
7	Replace the catalytic converter. Did you find and correct the condition?	-	Go to **Step 8**	-
	1. Remove the **J 35314-A** . See **Special Tools**. 2. Reinstall the post-catalyst HO2S sensor. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2** or **Heated Oxygen**			

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8	**Sensor Replacement - Bank 2 Sensor 2** . 3. Clear any codes. 4. Road test the vehicle in order to verify the repair. Did you correct the condition?	-	System OK	Go to **Step 2**

EXHAUST LEAKAGE

Exhaust Leakage

Problem	Action
CAUTION: **Refer to Hot Exhaust System Caution .** DEFINITION: An exhaust leak may show stains at the area of the leak. The leak may be felt by holding a hand close to the suspected areas or using a smoke pencil. The leak may make a popping or hissing noise.Refer to **Symptoms - Engine Exhaust** prior to beginning this table.	
Misaligned or improperly installed exhaust system components	1. Align and tighten the components to the specifications. Refer to **Fastener Tightening Specifications**. 2. Ensure the exhaust hangers are in the proper locations and not loose.
Exhaust leaks at the following connections: • Exhaust manifold to pipe • Flanges • Pipe clamps	Tighten the components to the specifications. Refer to **Fastener Tightening Specifications**.
Seals or gaskets leaking: • Exhaust manifold to cylinder head • Exhaust pipes to exhaust manifold • AIR connections to the exhaust manifold or cylinder head	Replace the leaking seal or gasket. Refer to the affected components procedure for service.
Irregularities at the mating surfaces on the flange connections	Repair as required or replace the affected component. Refer to the affected components procedure for service.
Exhaust manifold cracked or broken	Replace the exhaust manifold. Refer to one of the following procedures:

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	• **Exhaust Manifold Replacement - Left Side** • **Exhaust Manifold Replacement - Right Side**
Exhaust system component connection welds leaking	Replace the leaking component. Refer to the affected component's procedure for service.
Muffler damaged or leaking at the seams	Replace the affected muffler. Refer to one of the following procedures: • **Muffler Replacement - Left Side** • **Muffler Replacement - Right Side**

EXHAUST NOISE

Exhaust Noise

Condition	Action
CAUTION: **Refer to Hot Exhaust System Caution .** DEFINITION: An audible or physical noise due to a faulty component or damaged components causing a loose or misaligned exhaust system resulting in a rattle or vibration noise (buzz, groan, hum).Refer to **Symptoms - Engine Exhaust** prior to beginning this table.	
Popping or hissing noise	Exhaust leak-Refer to **Exhaust Leakage**.
Loud exhaust	1. Compare to a known good vehicle. 2. Inspect for a damaged or failed muffler. 3. Replace the faulty muffler. Refer to one of the following procedures: • **Muffler Replacement - Left Side** • **Muffler Replacement - Right Side**
External rattle or vibration noise	1. Inspect for a bent or loose hanger, loose heat shield or loose clamp. 2. Inspect for a exhaust pipe causing interference. 3. Repair or replace the affected component. Refer to the affected component's service procedure.
Internal rattle	1. Test the components by tapping with a rubber mallet to confirm a rattle. 2. Replace the faulty catalytic converter, resonator or muffler. Refer to one of the following procedures: • **Muffler Replacement - Left Side** • **Muffler Replacement - Right Side**

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EXHAUST VIBRATION/NOISE - EXHAUST FLOW CONTROL SYSTEM MALFUNCTION

Diagnostic Fault Information

IMPORTANT: Always perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.

Exhaust Vibration/Noise - Exhaust Flow Control System Malfunction

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Exhaust Valve Solenoid Supply Voltage	P166A	1	P166A	-
Ground	1	1	1	-
1. Exhaust Vibration/Noise - Exhaust Flow Control System Malfunction				

Circuit/System Description

Exhaust tail pipe flow valve control module receives throttle position sensor and RPM information via serial data from powertrain control module (PCM). The exhaust tail pipe flow valve control module uses this information to determine if to command exhaust tail pipe flow control valve solenoid ON or OFF. When commanded OFF the exhaust tail pipe flow control valve solenoid allows vacuum to flow to close exhaust valve.

Reference Information

Schematic Reference

Exhaust System Schematics

Connector End View Reference

Exhaust System Connector End Views

Electrical Information Reference

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

Scan Tool Reference

Scan Tool Data List for exhaust tail pipe flow valve control module

Circuit/System Testing

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1. Ignition OFF, disconnect the exhaust tail pipe flow control valve solenoid connector.
2. Ignition ON, use scan tool to command exhaust flow control relay ON, measure for 10 volts or above between the exhaust tail pipe flow control valve solenoid supply voltage circuit and ground.
    - If under 10 volts, test for open/high resistance in exhaust tail pipe flow control valve solenoid supply voltage circuit. If circuit test normal replace the exhaust tail pipe flow valve control module.
3. Connect a test lamp between the exhaust tail pipe flow control valve solenoid supply voltage circuit and ground circuit. Verify that the test lamp illuminates.
    - If the test lamp does not illuminate, test the ground circuit for open or high resistance.
4. If all circuits test normal replace the exhaust tail pipe flow control valve solenoid.

Repair Procedures

IMPORTANT: Always perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- **Exhaust Tail Pipe Flow Control Valve Solenoid Replacement**
- **Control Module References** for exhaust tail pipe flow valve control module replacement, setup and programming.

REPAIR INSTRUCTIONS

EXHAUST MANIFOLD REPLACEMENT - LEFT SIDE

Removal Procedure

1. Remove the powertrain. Refer to **Powertrain Removal and Installation** .

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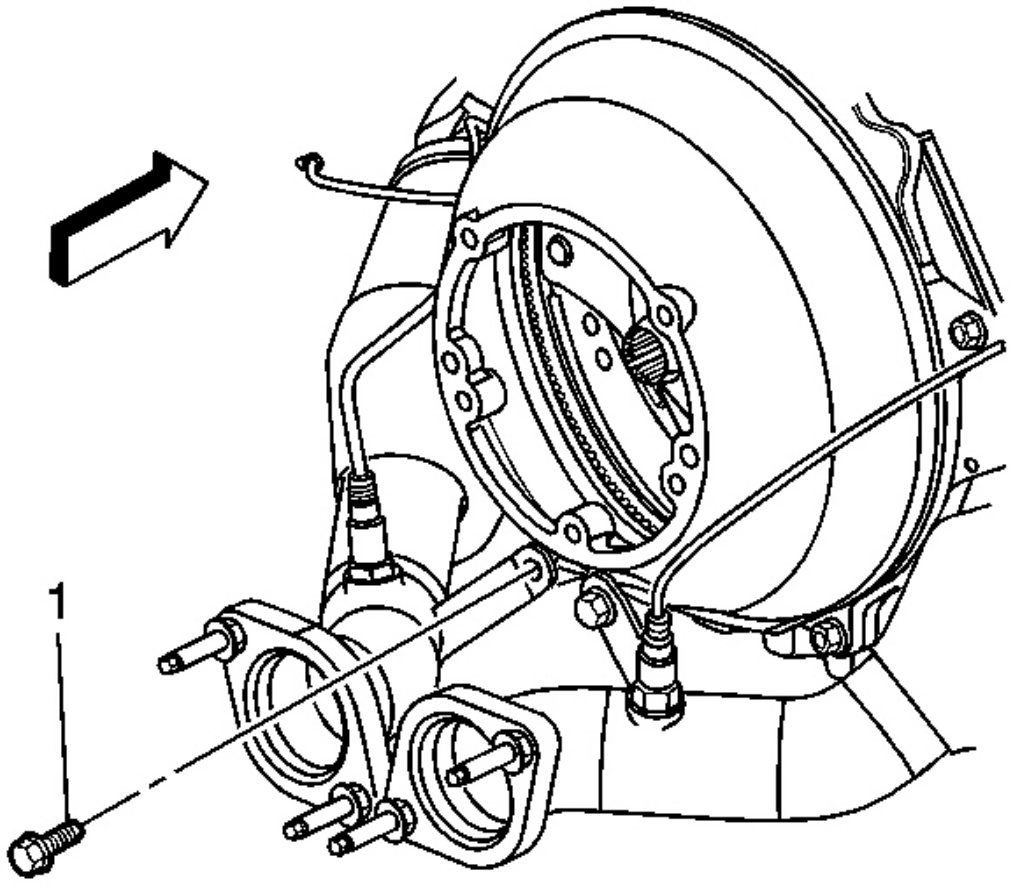


Fig. 6: View Of Exhaust Manifold & Catalytic Converter Assembly Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the exhaust manifold and catalytic converter assembly bolt securing the pipe to the bell housing.
3. Remove the connector position assurance (CPA) lock for the oxygen sensors.

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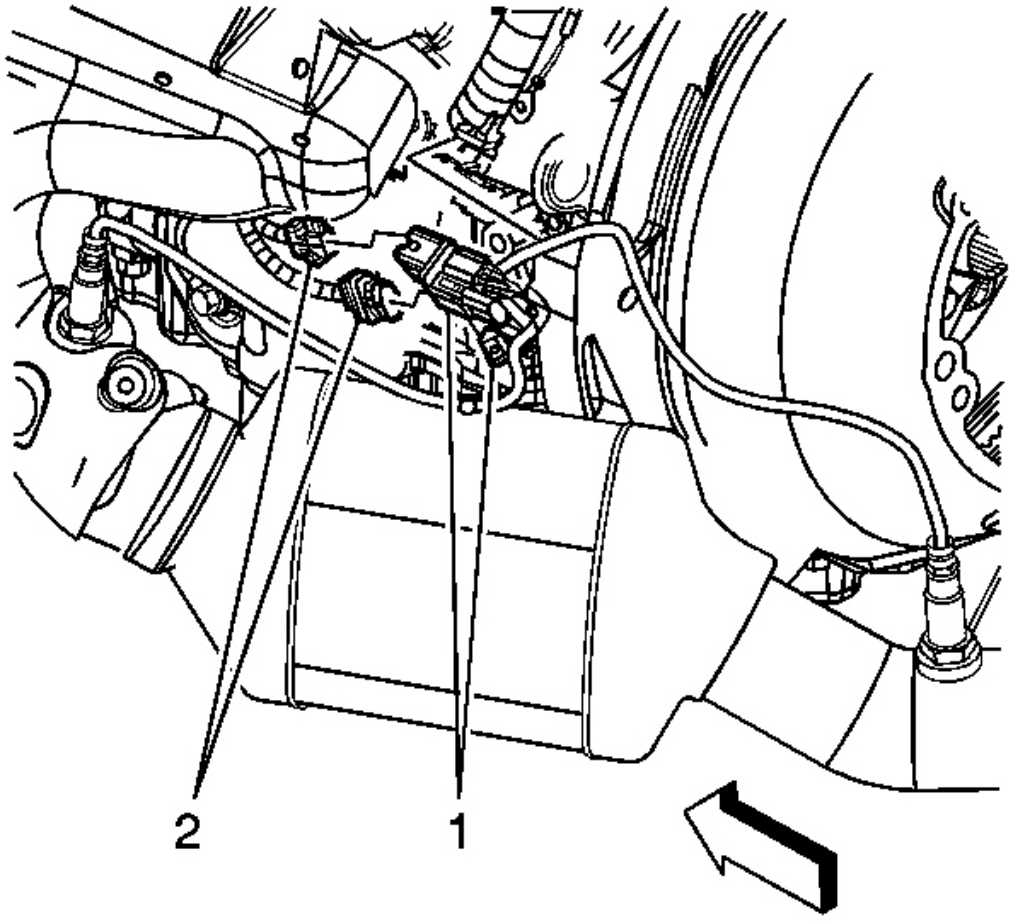


Fig. 7: View Of Oxygen Sensor Electrical Connectors - Left
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the oxygen sensor electrical connectors (1, 2).

NOTE: **Refer to Oxygen Sensor Notice .**

5. Remove the oxygen sensors.

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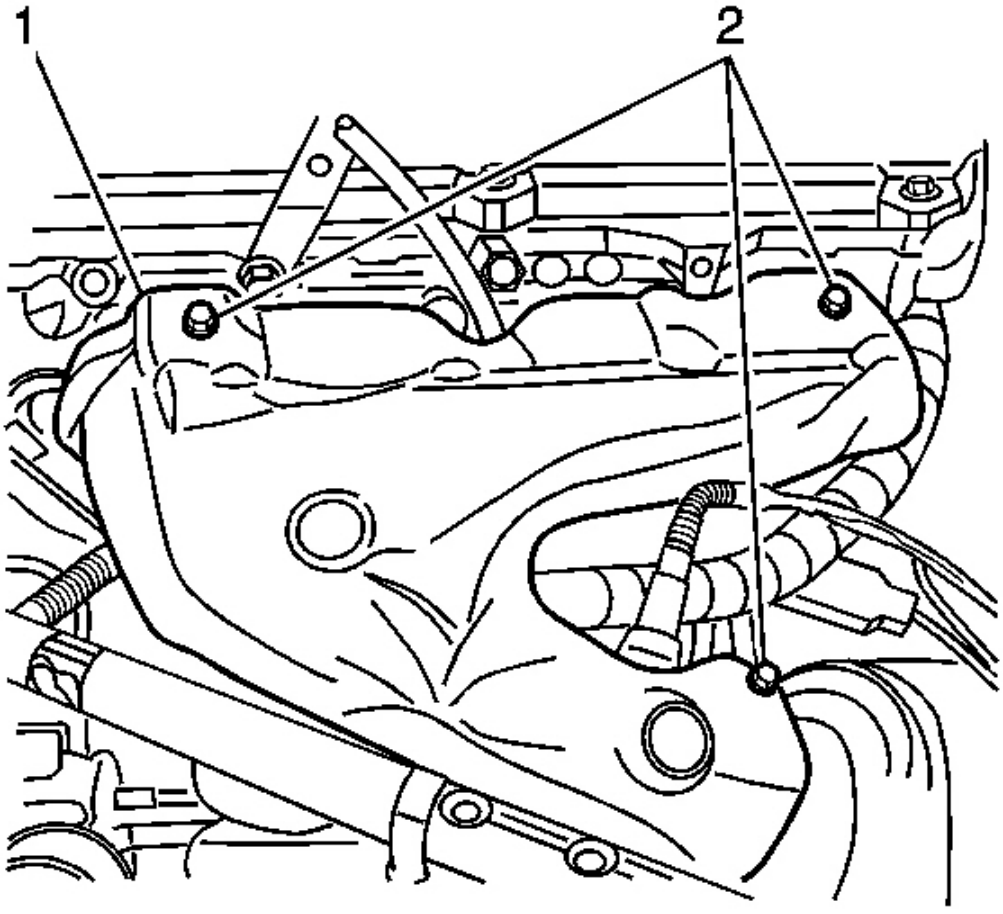


Fig. 8: View Of Left Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

6. Remove the left exhaust manifold heat shield bolts (2).
7. Remove the left exhaust manifold heat shield (1).

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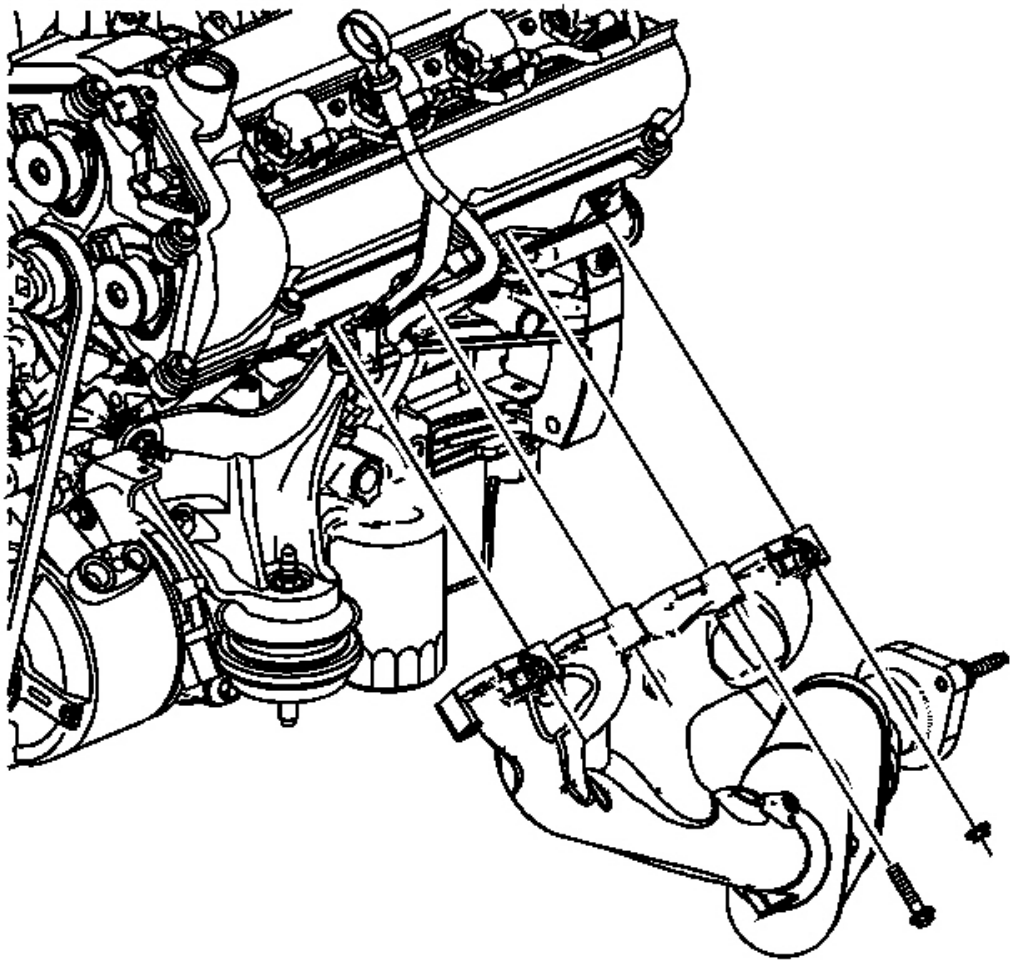


Fig. 9: View Of Left Exhaust Manifold, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

8. Remove the exhaust manifold bolts and nuts.
9. Remove the exhaust manifold.

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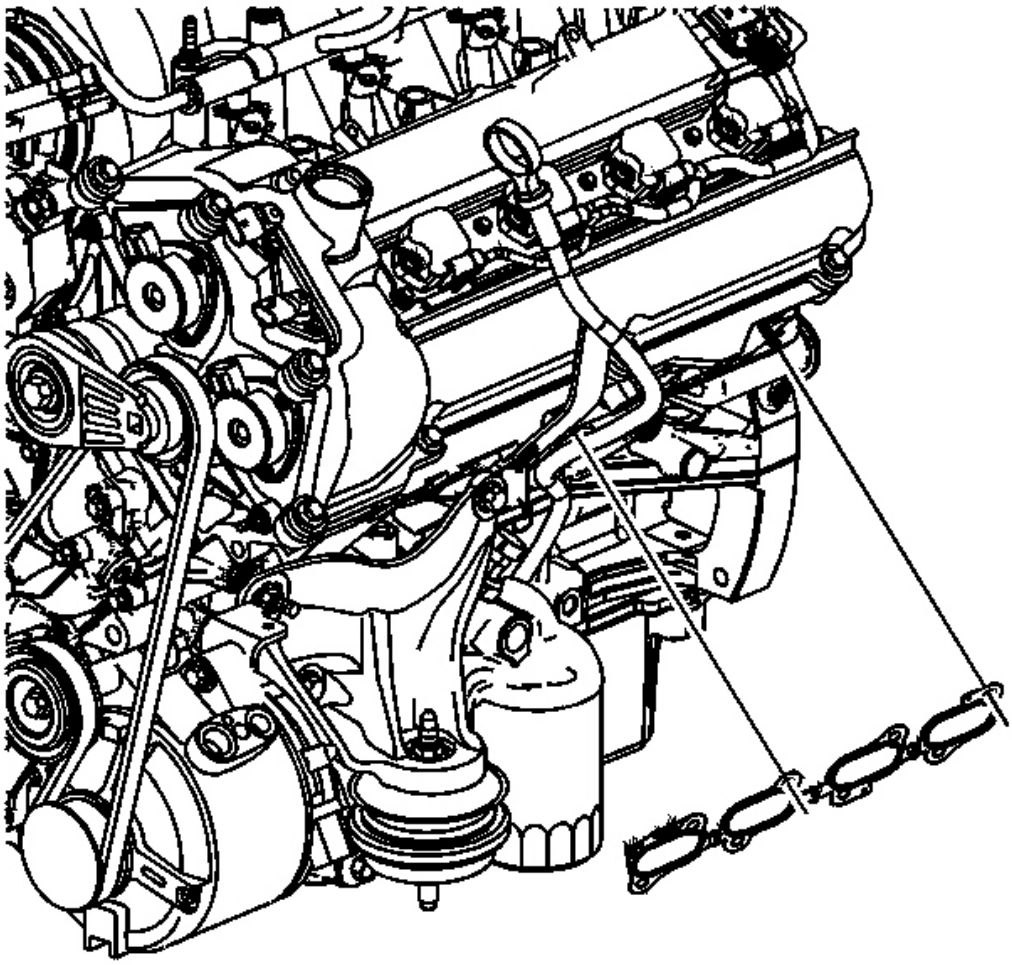


Fig. 10: View Of Left Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

10. Remove the left exhaust manifold gasket.
11. Discard the gasket.

Installation Procedure

IMPORTANT: Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may effect vehicle emissions and/or On-Board Diagnostics (OBD) II system performance. The cylinder head exhaust manifold bolt hole threads must be cleaned and free of debris or threadlocking material.

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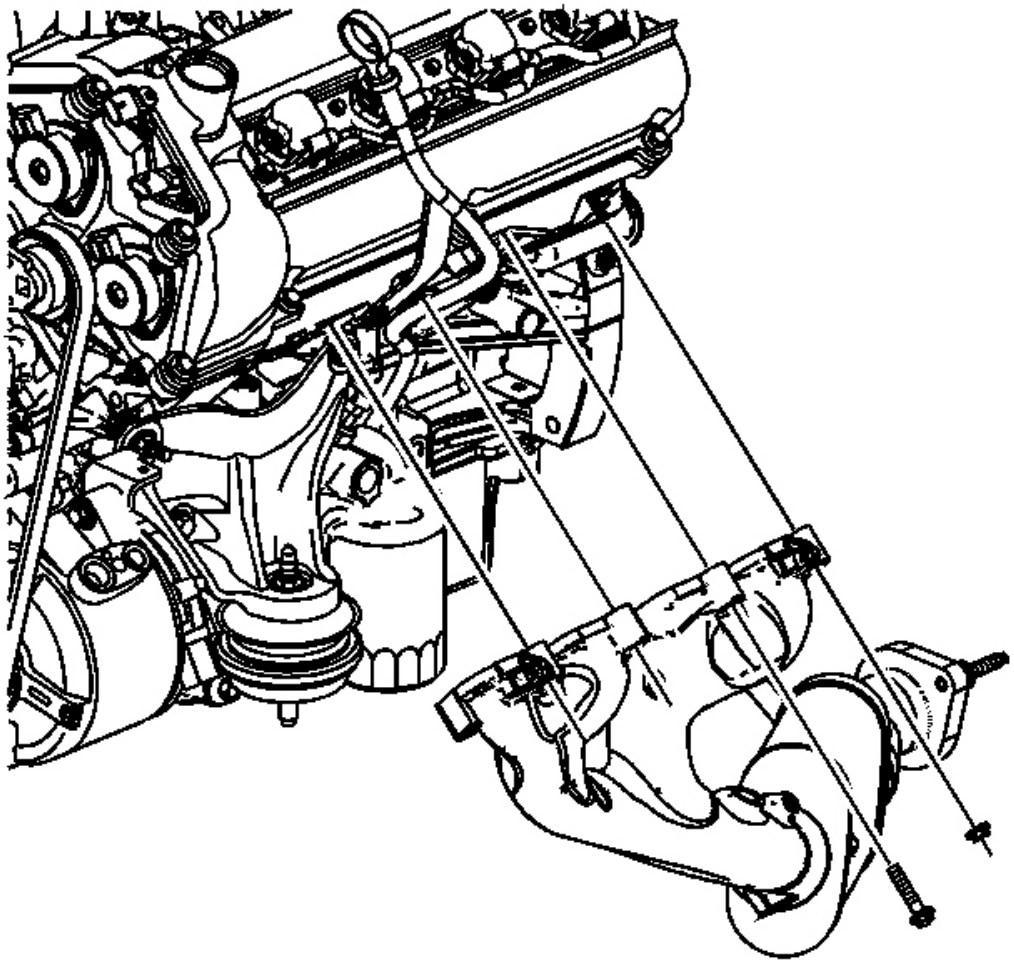


Fig. 11: View Of Left Exhaust Manifold, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953489) or equivalent to the threads of the exhaust manifold bolts and studs.

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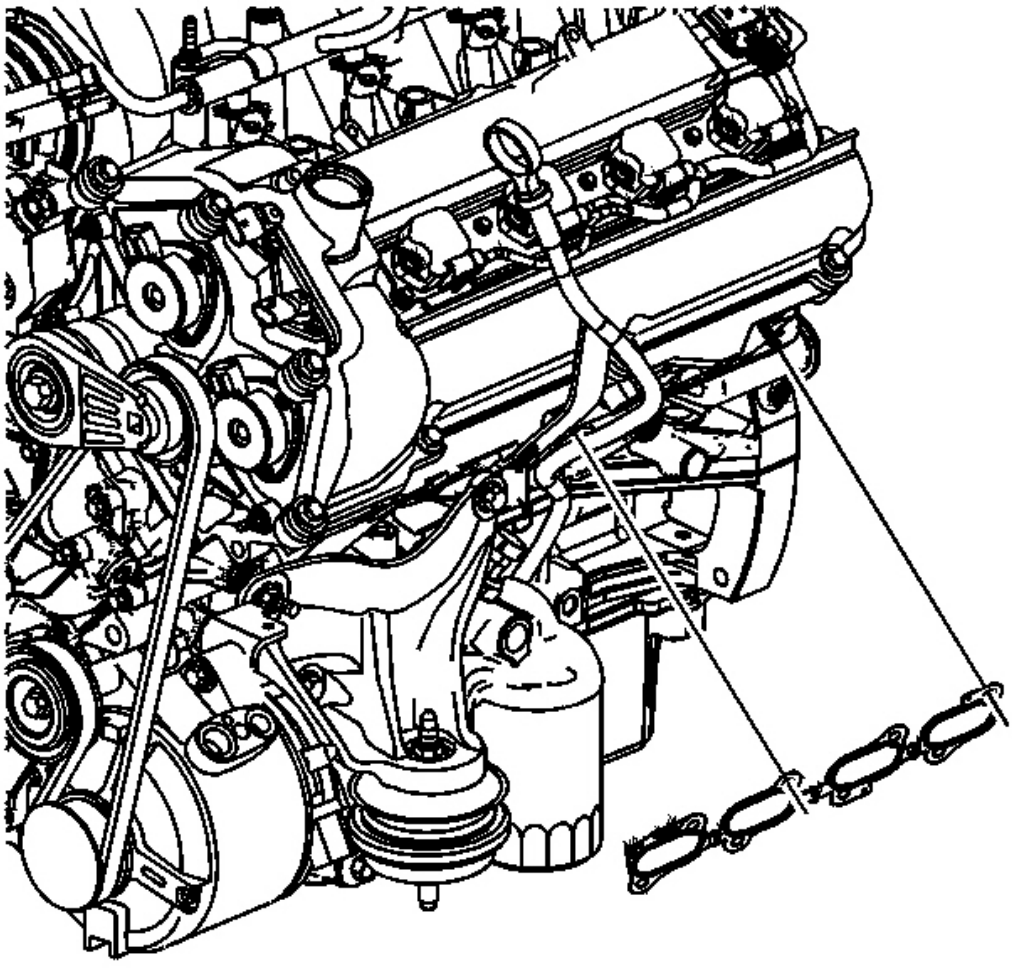


Fig. 12: View Of Left Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

2. Position the exhaust manifold and a NEW gasket into place.

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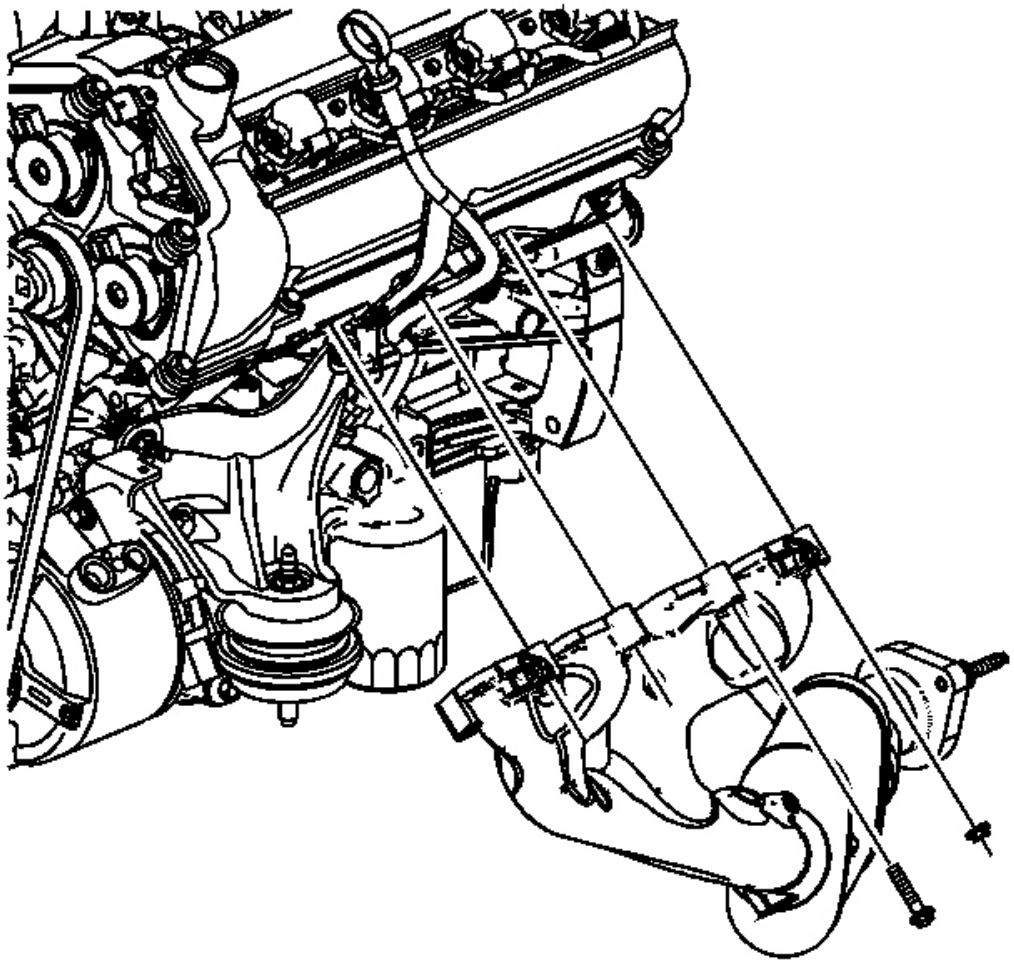


Fig. 13: View Of Left Exhaust Manifold, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the exhaust manifold bolts and nuts.

   Tighten: Tighten the exhaust manifold bolts and nuts to 25 N.m (18 lb ft). Tighten the exhaust manifold bolts and nuts beginning with the center two nuts. Alternate from side-to-side, working toward the outside bolts and nuts.

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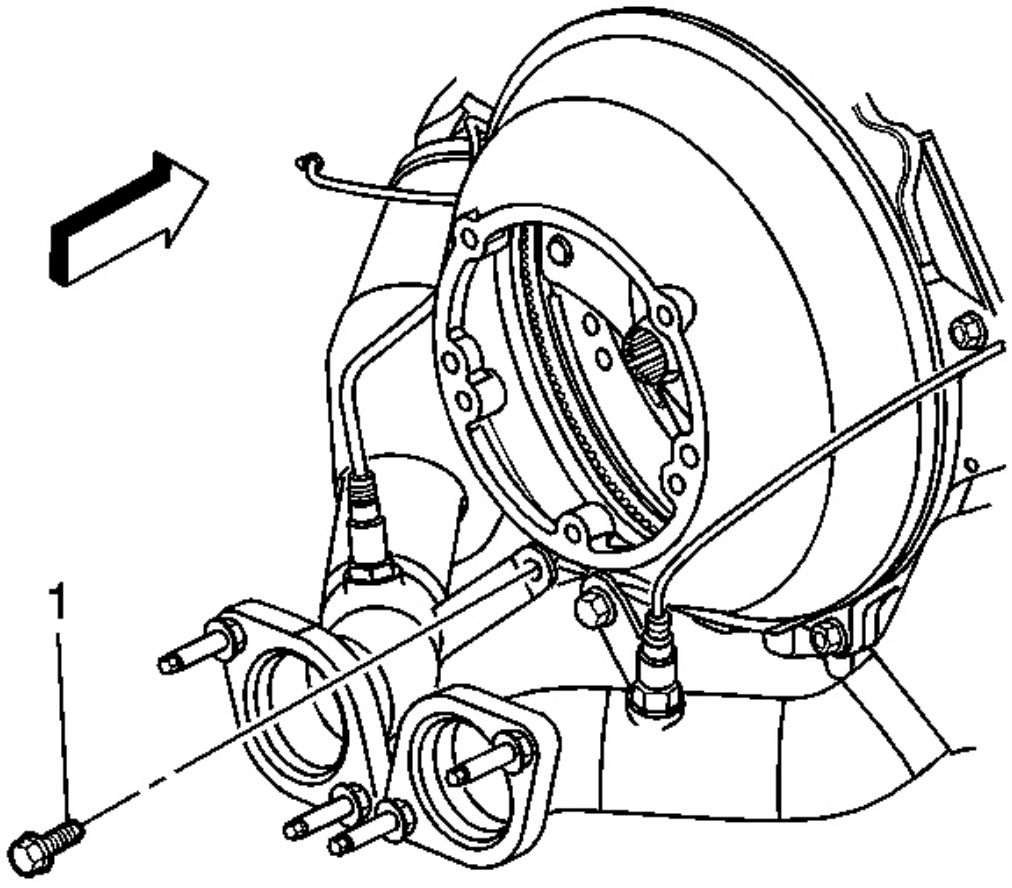


Fig. 14: View Of Exhaust Manifold & Catalytic Converter Assembly Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust manifold catalytic converter hanger bolt to the bell housing.

   Tighten: Tighten the exhaust hanger bolt to 50 N.m (37 lb ft).

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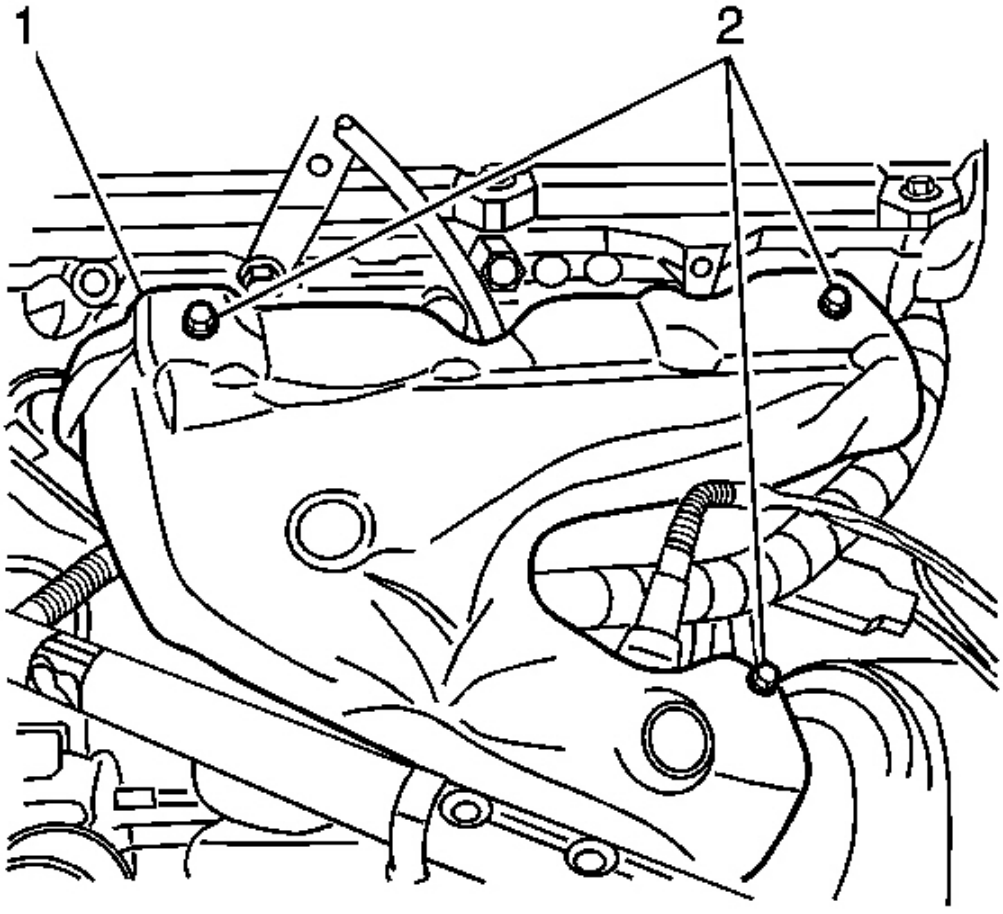


Fig. 15: View Of Left Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

5. Install the left exhaust manifold heat shield (1) and bolts (2).

   Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

6. Apply anti-sieze compound GM P/N 12377953 or equivalent to the threads of the oxygen sensors.

   NOTE: Refer to Oxygen Sensor Notice .

7. Install the oxygen sensors.

   Tighten: Tighten the oxygen sensors to 42 N.m (30 lb ft).

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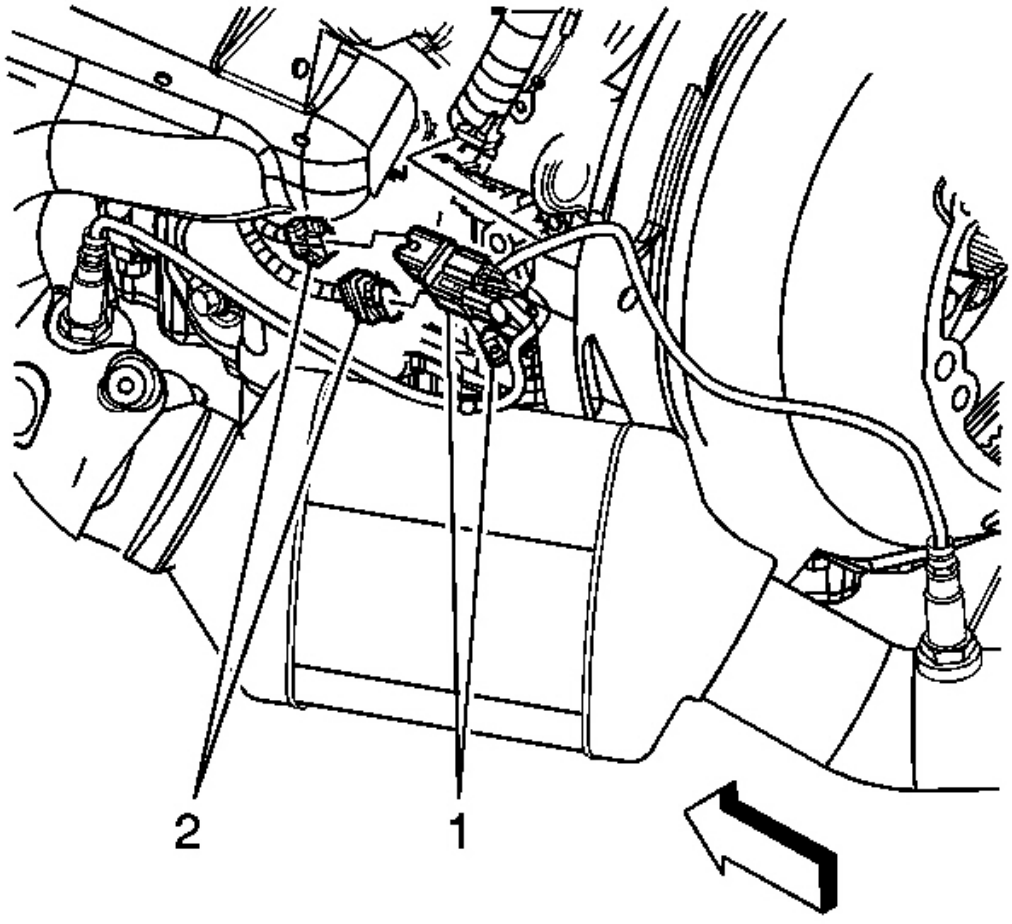


Fig. 16: View Of Oxygen Sensor Electrical Connectors - Left
Courtesy of GENERAL MOTORS CORP.

8. Connect the oxygen sensor electrical connectors.
9. Install the CPA locks.
10. Install the powertrain. Refer to **Powertrain Removal and Installation** .

EXHAUST MANIFOLD REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Remove the powertrain. Refer to **Powertrain Removal and Installation** .

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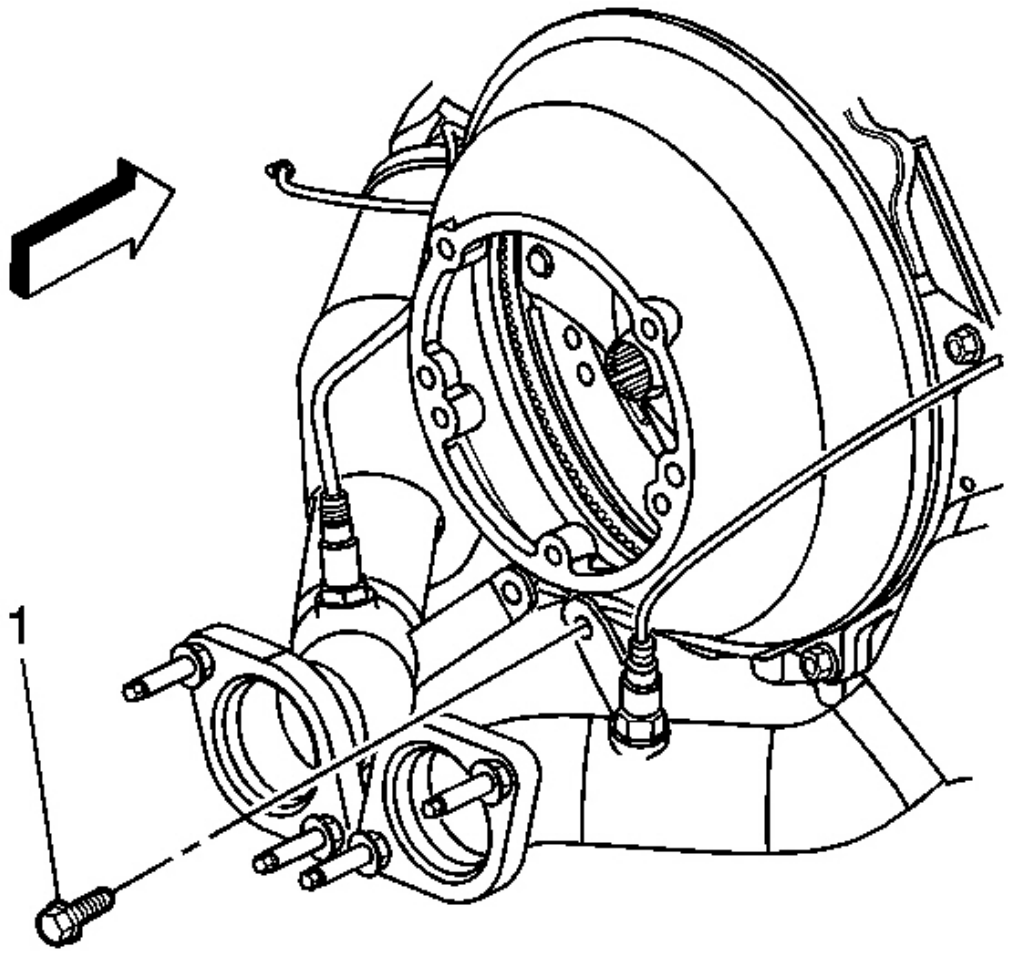


Fig. 17: View Of Catalytic Converter Pipe-To-Bell Housing Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolt securing the catalytic converter pipe to the bell housing.
3. Remove the connector position assurance (CPA) lock for the oxygen sensor.

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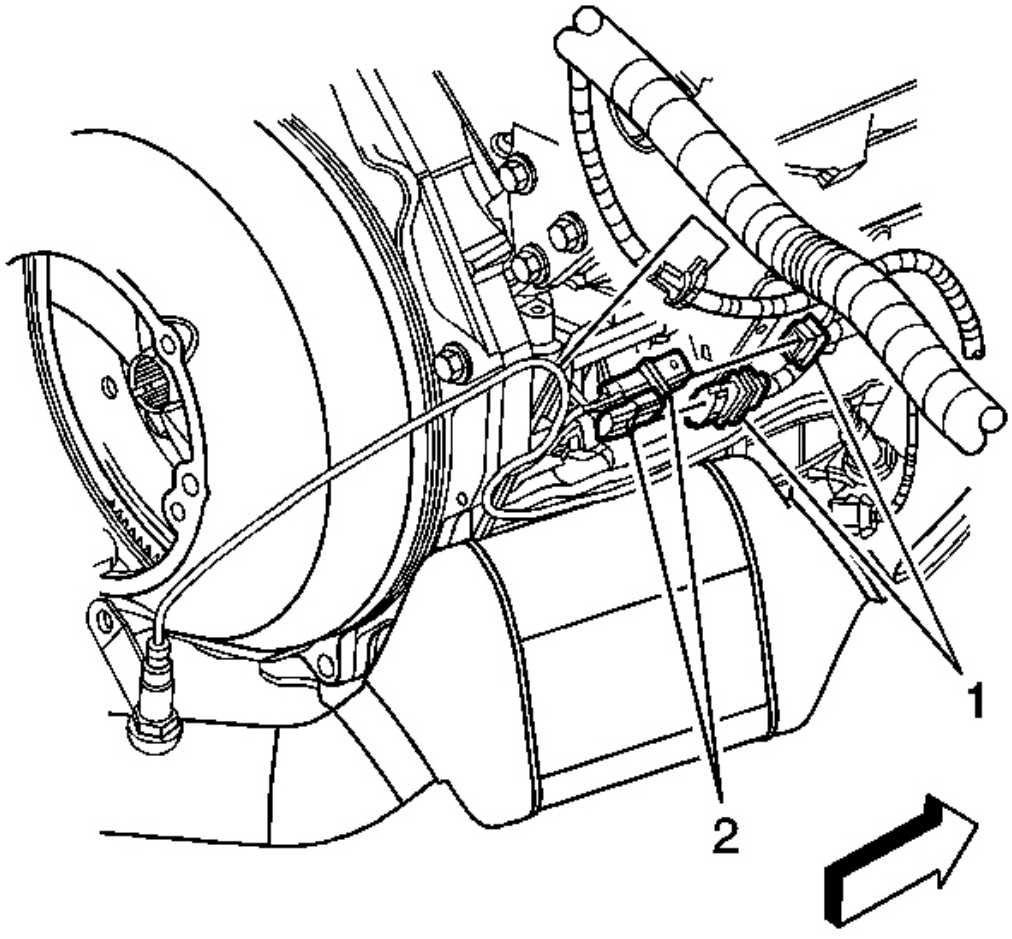


Fig. 18: View Of Oxygen Sensor Electrical Connectors - Right
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the oxygen sensor electrical connectors (1, 2).

NOTE: **Refer to Oxygen Sensor Notice .**

5. Remove the oxygen sensors.

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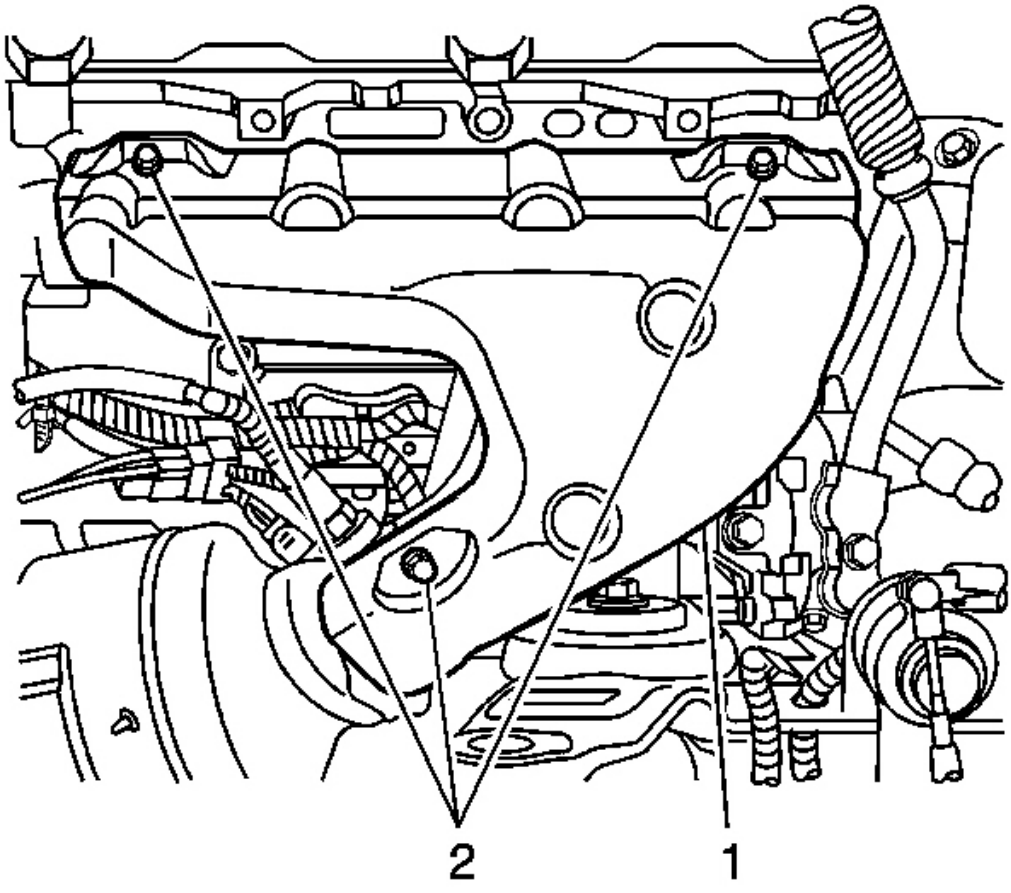


Fig. 19: View Of Right Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

6. Remove the right exhaust manifold heat shield bolts (2).
7. Remove the right exhaust manifold heat shield (1).

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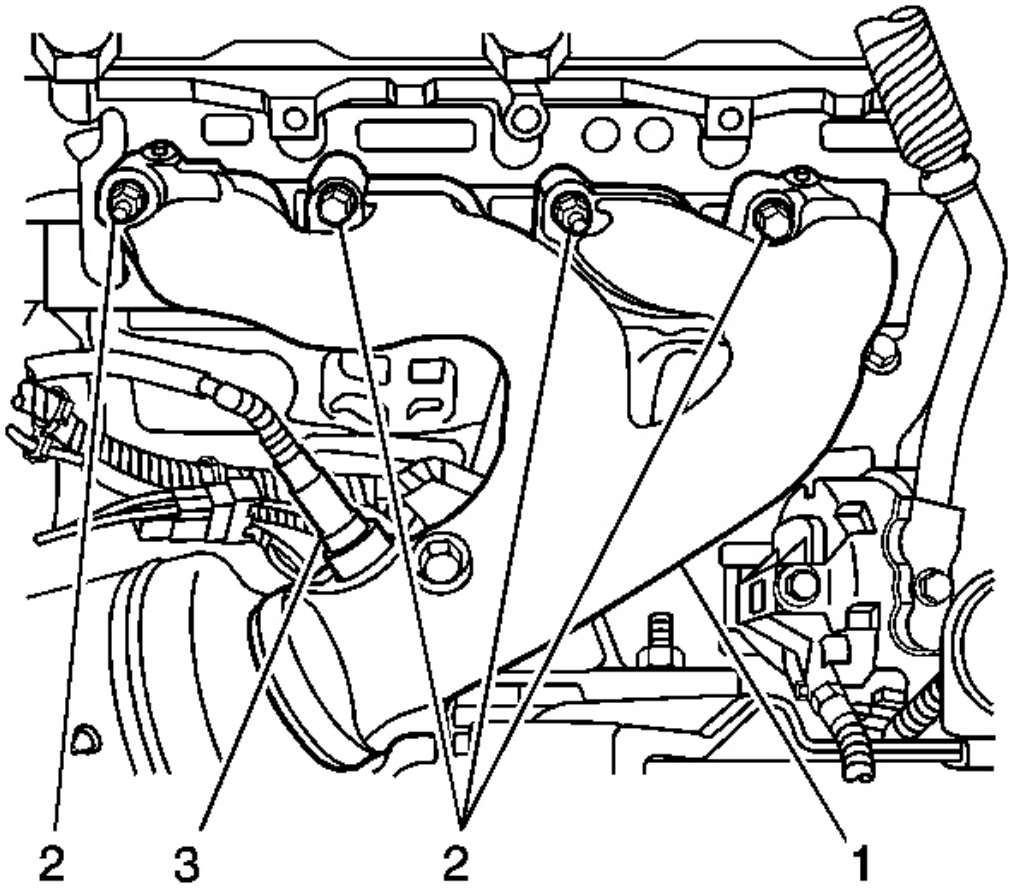


Fig. 20: View Of Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

8. Remove the exhaust manifold bolts and nuts (2).
9. Remove the exhaust manifold and old gasket. Discard the gasket.

Installation Procedure

IMPORTANT: Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may effect vehicle emissions and/or On-Board Diagnostics (OBD) II system performance. The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.

1. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488) or

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equivalent to the threads of the exhaust manifold bolts and studs.

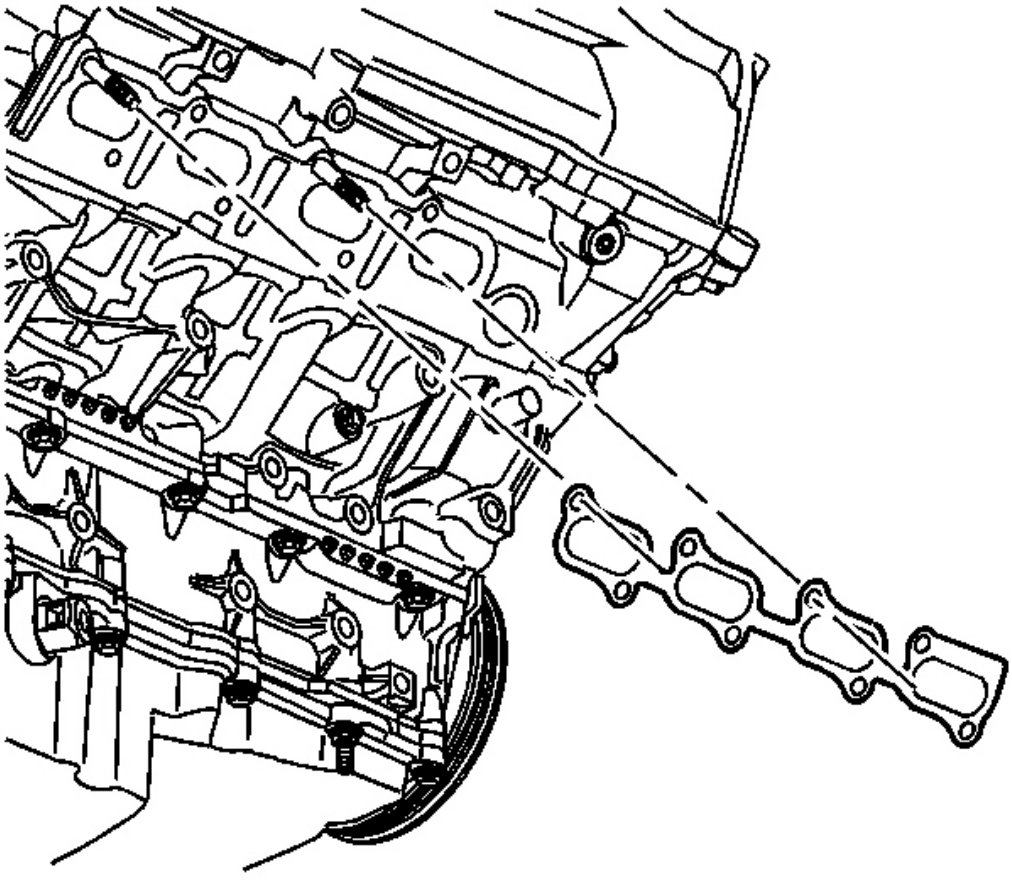


Fig. 21: View Of Right Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

2. Position the exhaust manifold and a NEW gasket into place.

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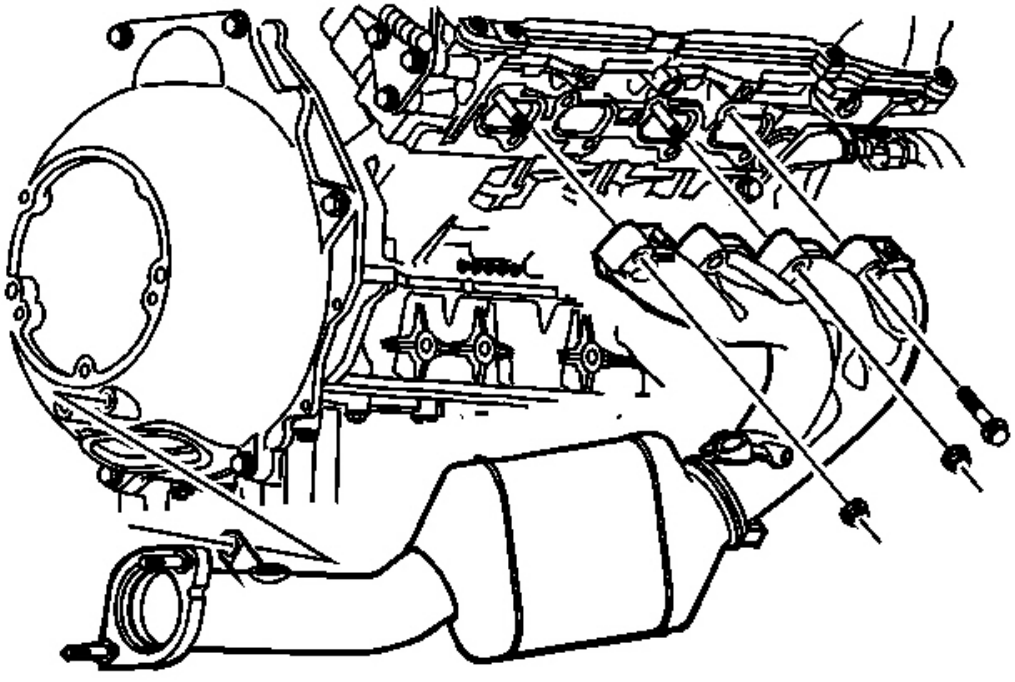


Fig. 22: View Of Right Exhaust Manifold, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the exhaust manifold bolts and nuts.

   Tighten: Tighten the exhaust manifold bolts and nuts to 25 N.m (18 lb ft). Tighten the exhaust manifold bolts and nuts beginning with the center two nuts. Alternate from side-to-side, working toward the outside bolts and nuts.

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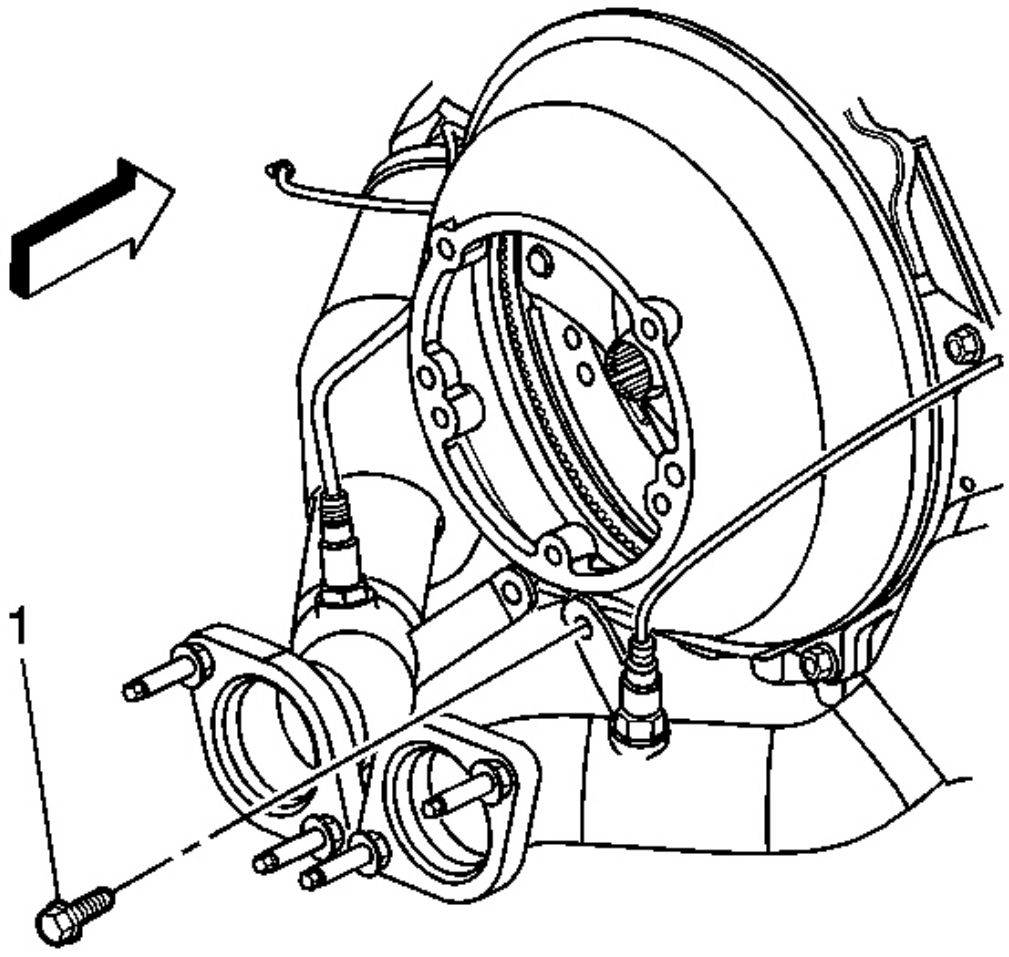


Fig. 23: View Of Catalytic Converter Pipe-To-Bell Housing Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust manifold and catalytic converter bolt securing the pipe to the bell housing.

   Tighten: Tighten the exhaust hanger bolt to 50 N.m (37 lb ft).

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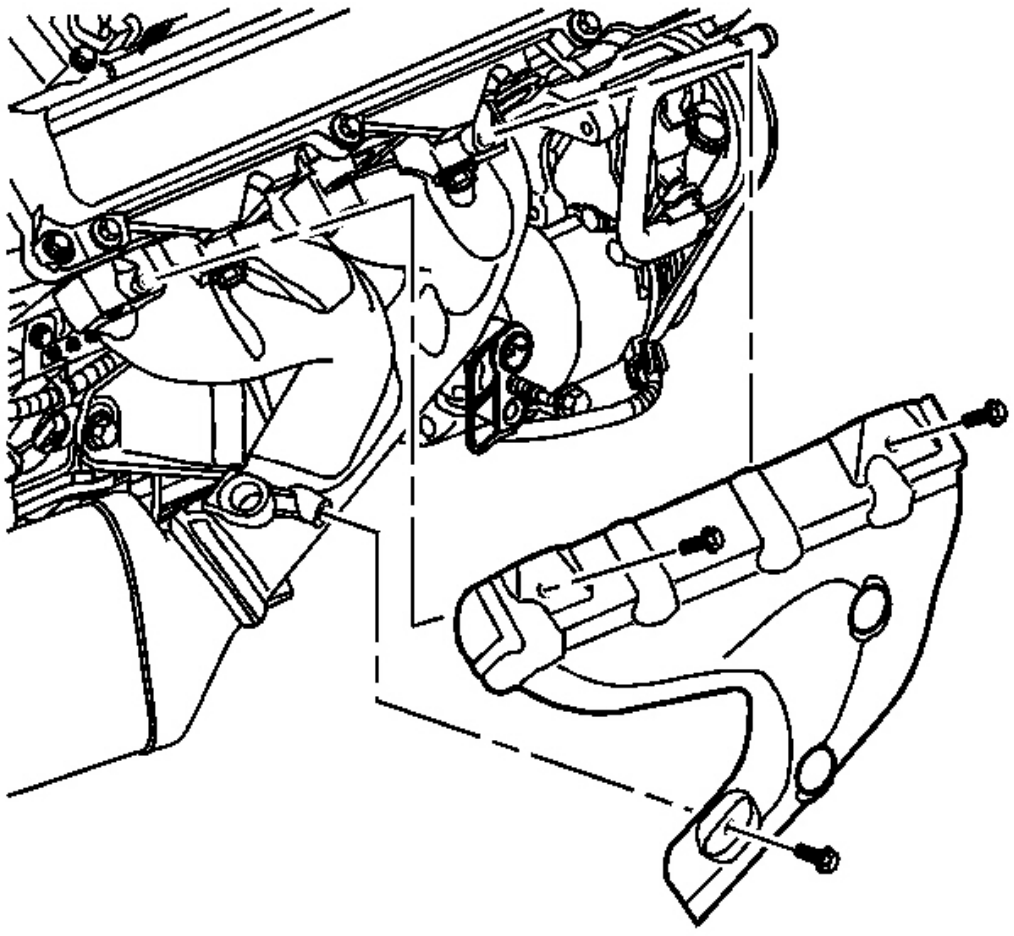


Fig. 24: View Of Right Exhaust Manifold Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the right exhaust manifold heat shield and bolts.

   Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

6. Apply anti-sieze compound GM P/N 12377953 or equivalent to the threads of the oxygen sensors.

   NOTE: Refer to Oxygen Sensor Notice .

7. Install the oxygen sensors.

   Tighten: Tighten the oxygen sensors to 42 N.m (30 lb ft).

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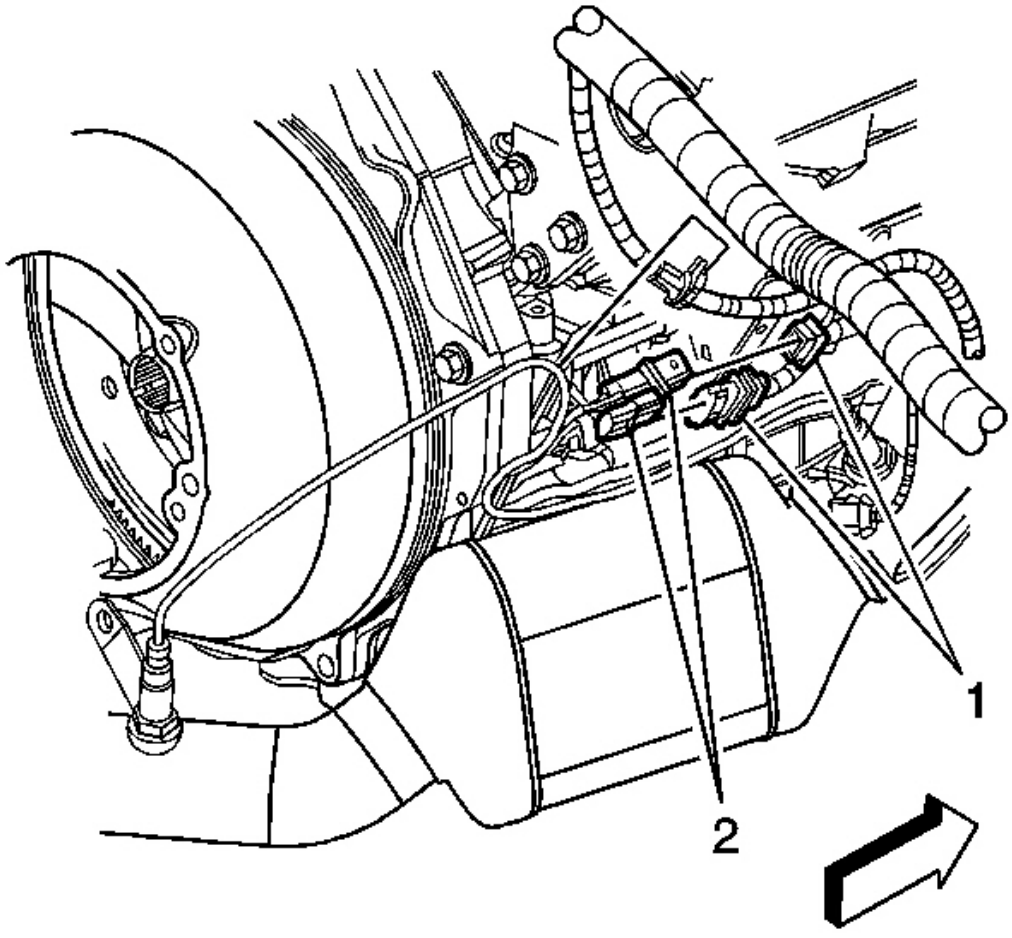


Fig. 25: View Of Oxygen Sensor Electrical Connectors - Right
Courtesy of GENERAL MOTORS CORP.

8. Connect the oxygen sensor electrical connectors.
9. Install the CPA locks.
10. Install the powertrain. Refer to **Powertrain Removal and Installation** .

EXHAUST SEAL REPLACEMENT

Removal Procedure

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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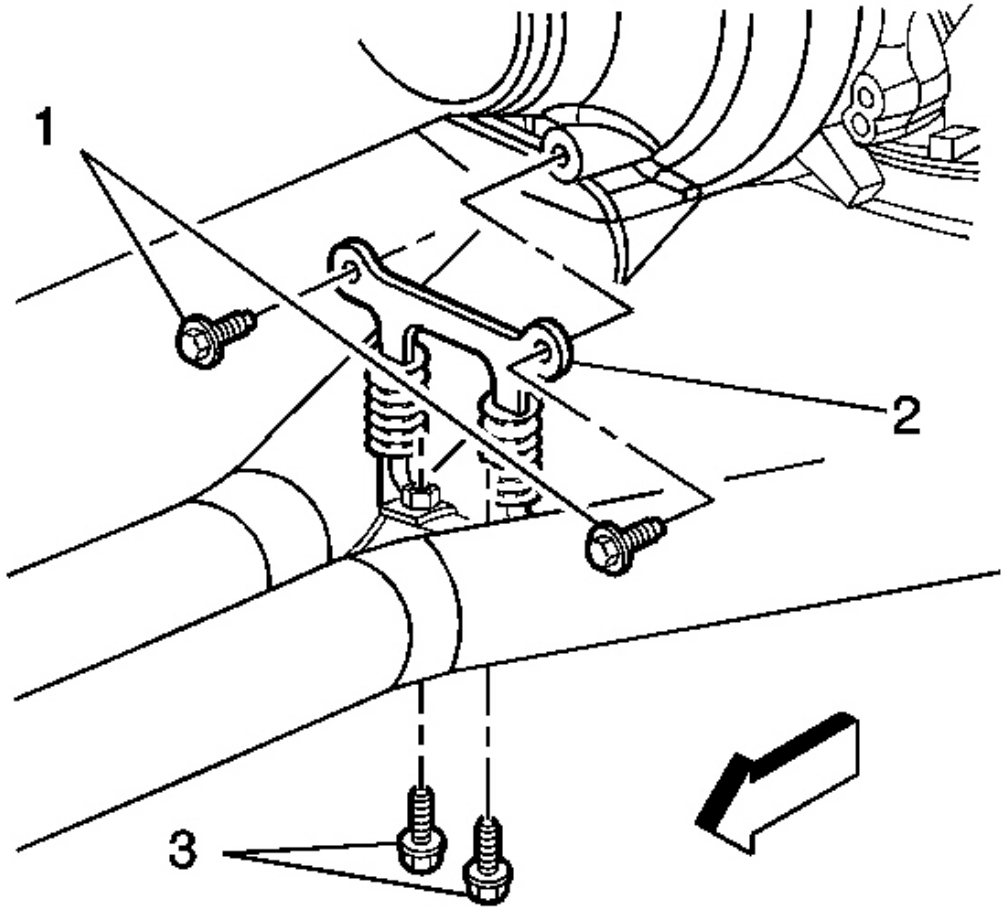


Fig. 26: View Of Intermediate Exhaust Pipe Hanger
Courtesy of GENERAL MOTORS CORP.

2. Remove the intermediate exhaust pipe hanger lower bolts (3).

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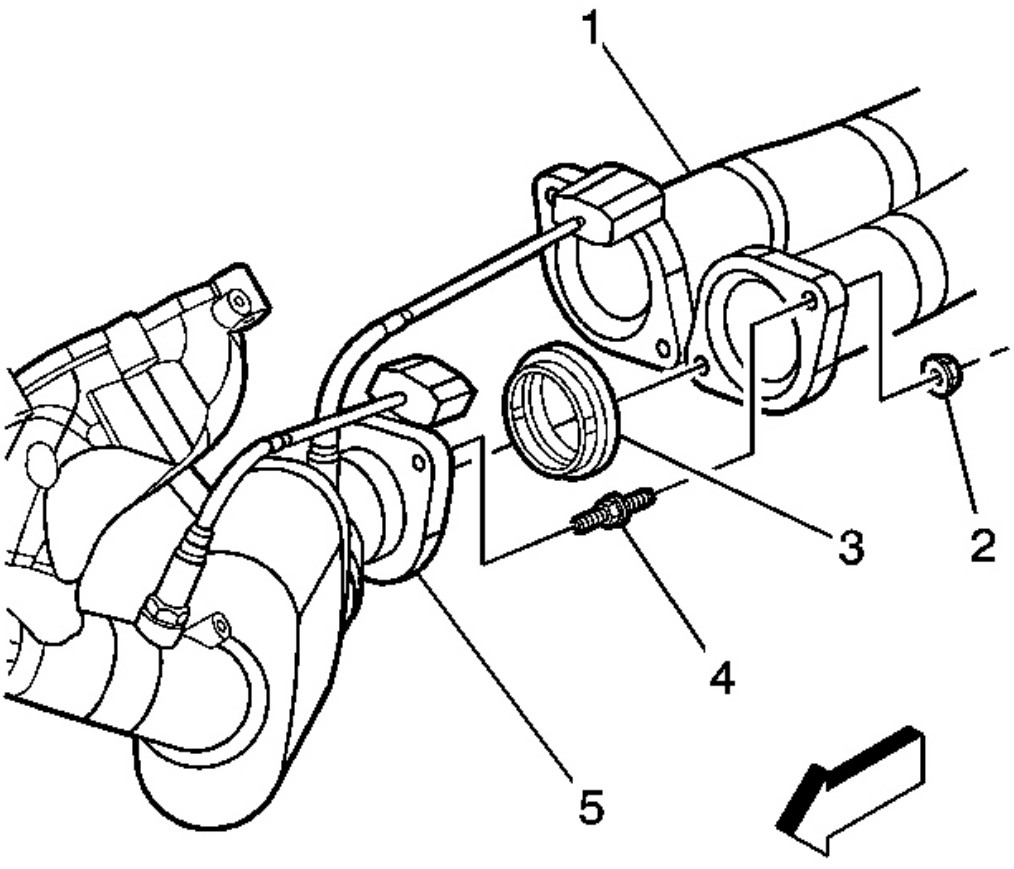


Fig. 27: View Of Intermediate Exhaust Pipe, Exhaust Manifold Nuts & Exhaust Seal
Courtesy of GENERAL MOTORS CORP.

3. Remove the left and right exhaust manifold nuts (2).
4. Lower the front of the intermediate exhaust pipe (1).
5. Remove the exhaust seal (3).

Installation Procedure

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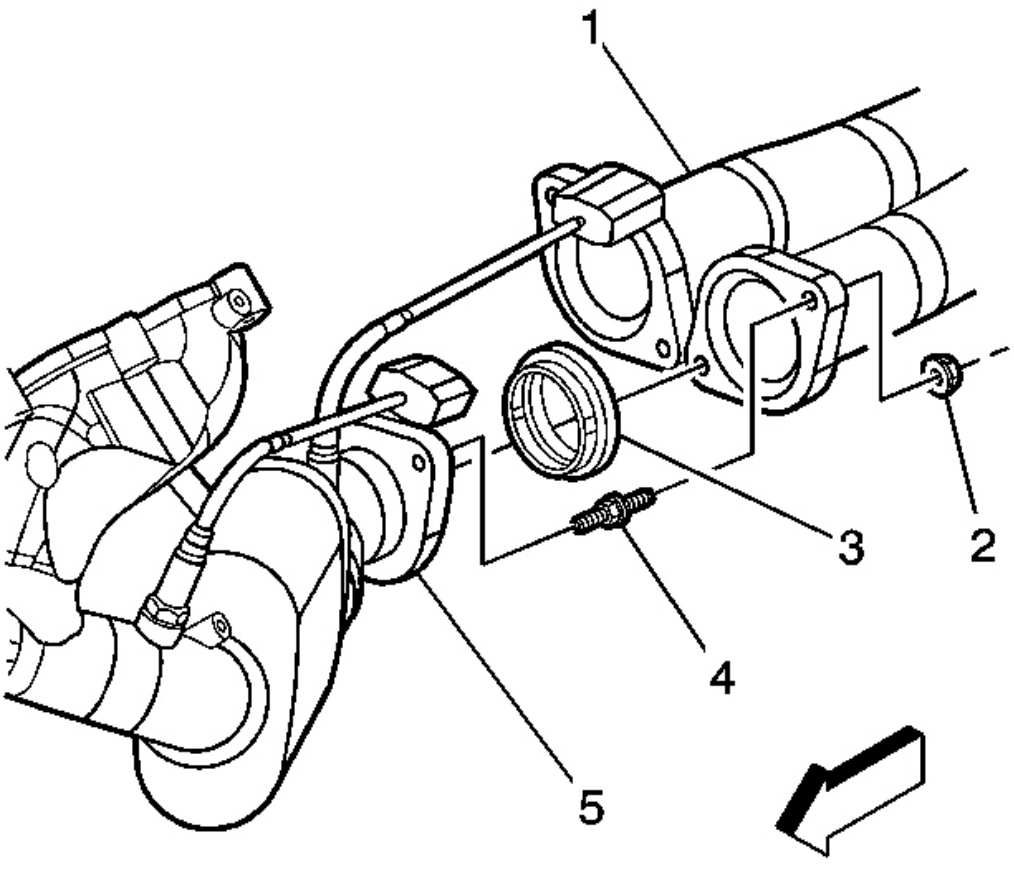


Fig. 28: View Of Intermediate Exhaust Pipe, Exhaust Manifold Nuts & Exhaust Seal
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW exhaust seal (3).
2. Raise the front of the intermediate exhaust pipe (1).

NOTE: **Refer to Fastener Notice .**

3. Install the left and right exhaust manifold nuts (2).

Tighten: Tighten the exhaust manifold nuts to 20 N.m (15 lb ft).

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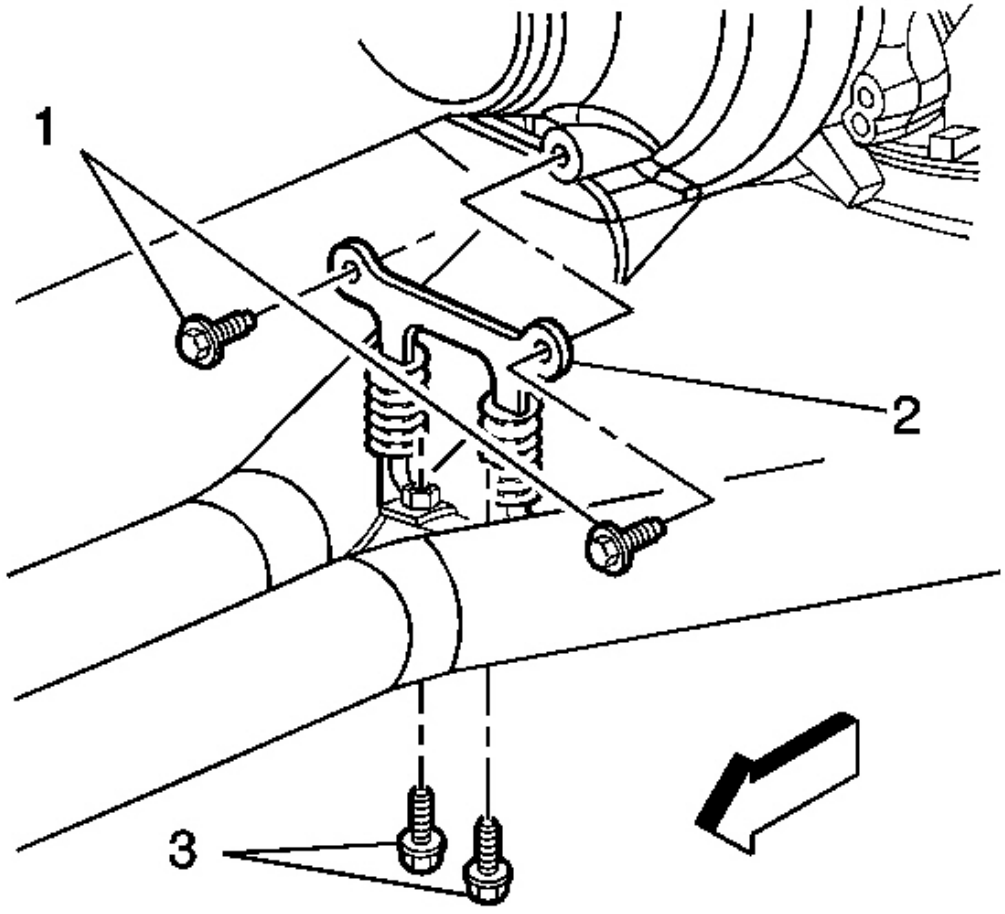


Fig. 29: View Of Intermediate Exhaust Pipe Hanger
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust pipe hanger lower bolts (3).

   Tighten: Tighten the exhaust pipe hanger bolts to 50 N.m (37 lb ft).

5. Lower the vehicle.

INTERMEDIATE PIPE REPLACEMENT

Removal Procedure

CAUTION: Refer to Exhaust Service Caution .

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CAUTION: Refer to Protective Goggles and Glove Caution .

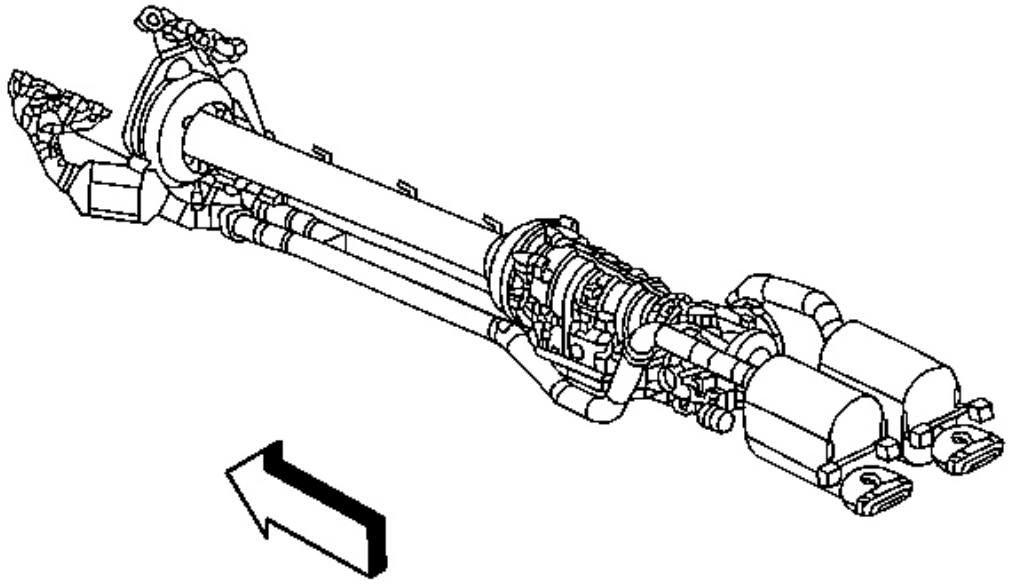


Fig. 30: View Of Exhaust System
Courtesy of GENERAL MOTORS CORP.

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Install adjustable jack stands under the front and rear of the intermediate pipe.

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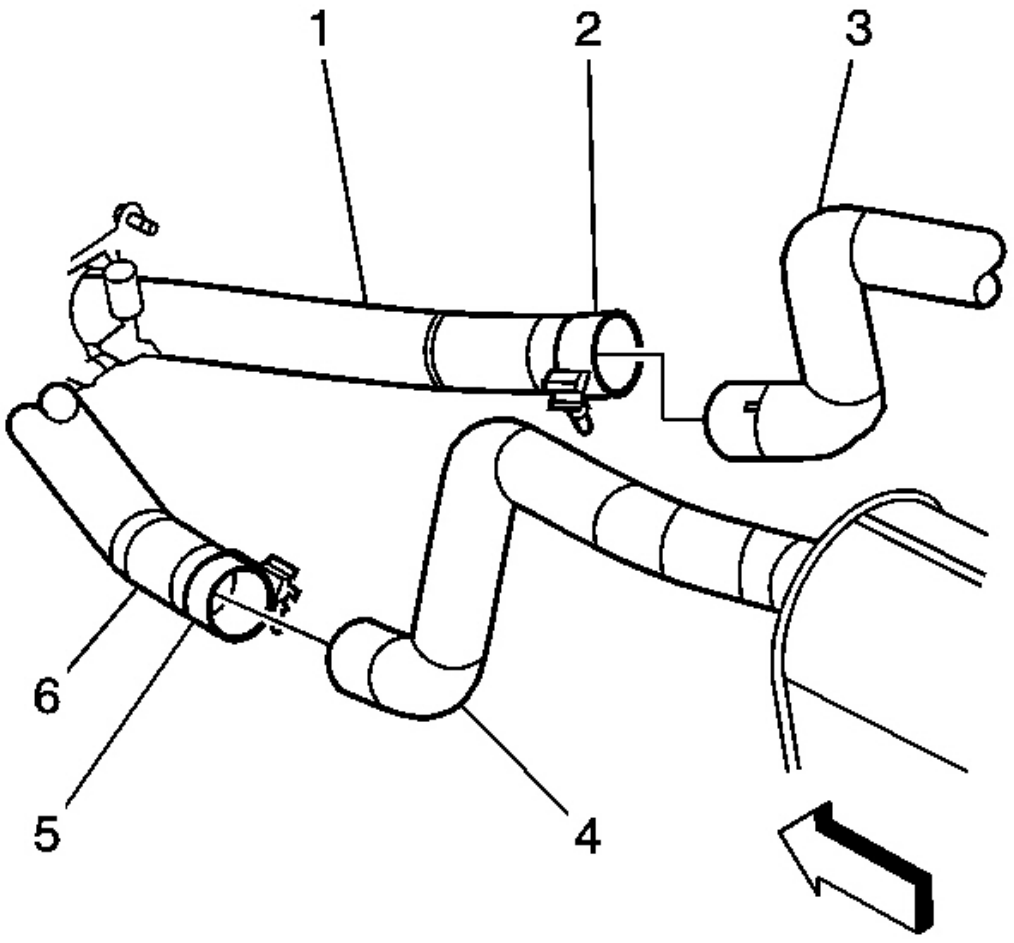


Fig. 31: View Of Exhaust Muffler Band Clamps
Courtesy of GENERAL MOTORS CORP.

3. Loosen the exhaust muffler band clamps (2, 5).
4. Separate the left and right tailpipe/muffler assemblies from the intermediate pipe.

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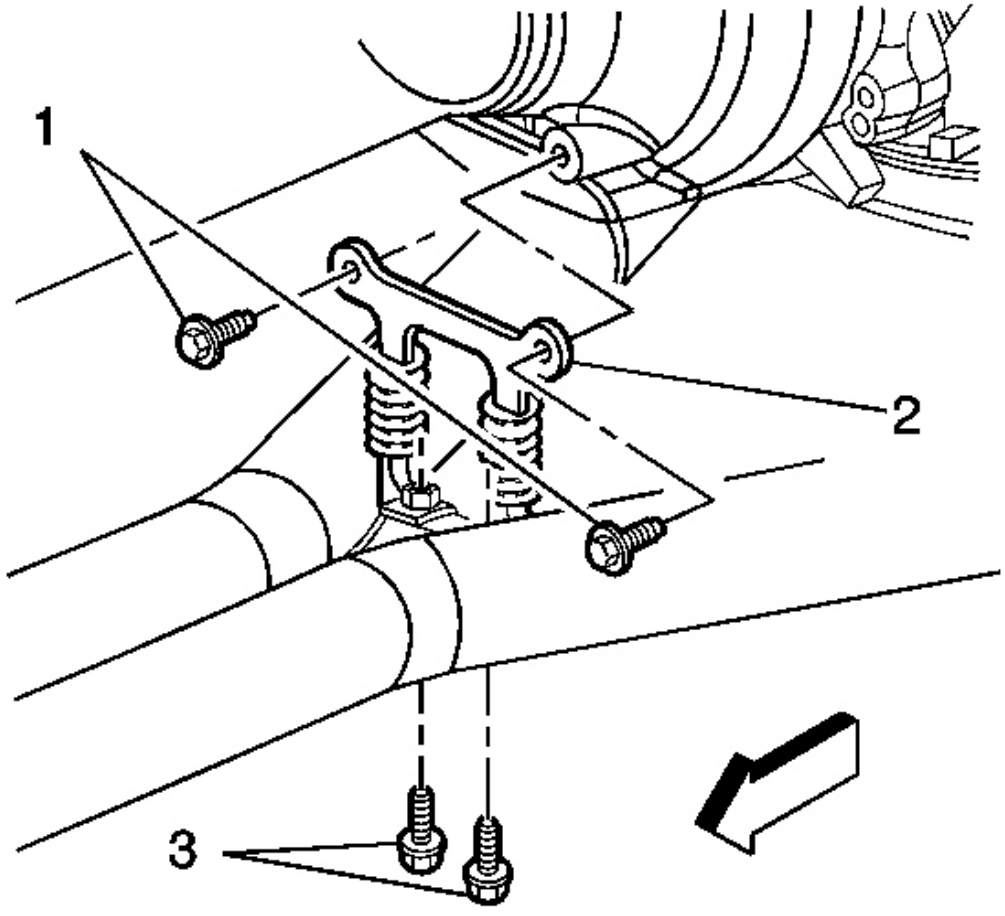


Fig. 32: View Of Intermediate Exhaust Pipe Hanger
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust pipe hanger lower bolts (3).

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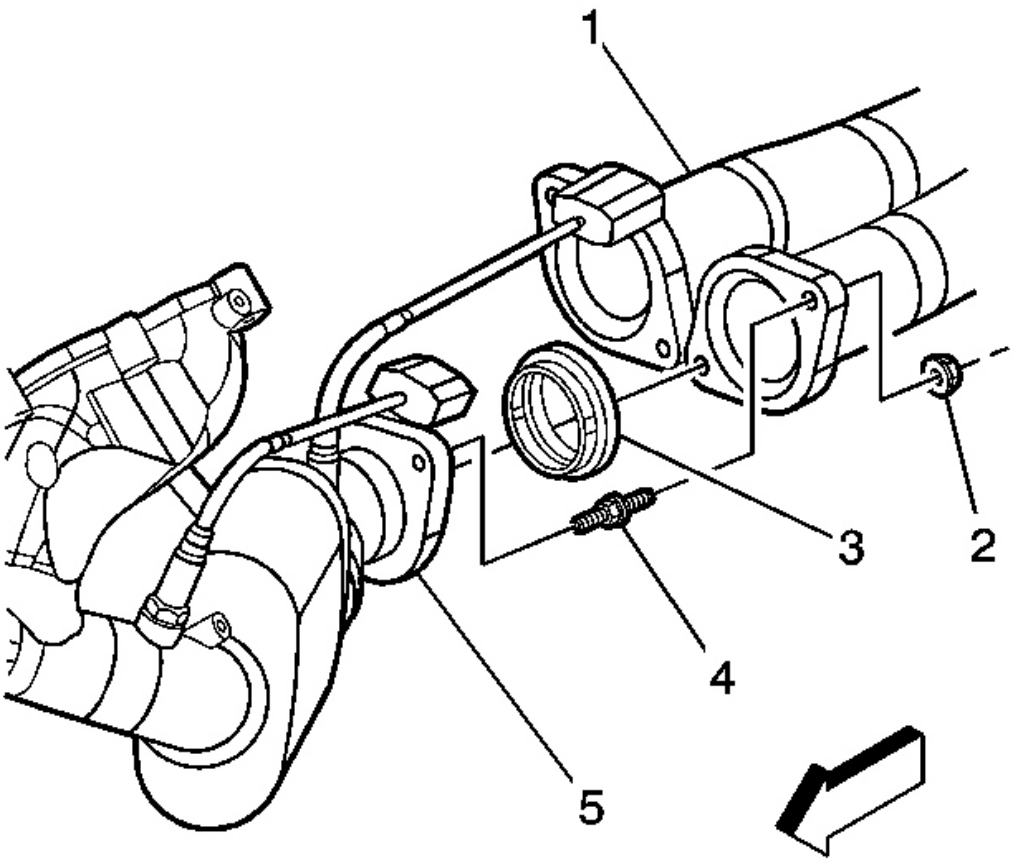


Fig. 33: View Of Intermediate Exhaust Pipe, Exhaust Manifold Nuts & Exhaust Seal
Courtesy of GENERAL MOTORS CORP.

6. Remove the exhaust manifold nuts (2).
7. Lower the jack stands.
8. Remove the intermediate pipe from the jack stands.

Installation Procedure

NOTE: Refer to Exhaust System Inspection Notice .

IMPORTANT: If reinstalling the original intermediate pipe, the tail pipe/muffler band clips must be replaced. Mark the position of the band clips on the intermediate exhaust pipe. Remove the band clips by grinding the welds. Install new band clips on the intermediate pipe. Position the new band clips using the alignment

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mark created previously.

1. Install the intermediate pipe to the jack stands.
2. Raise the jack stands in order to position the intermediate pipe.

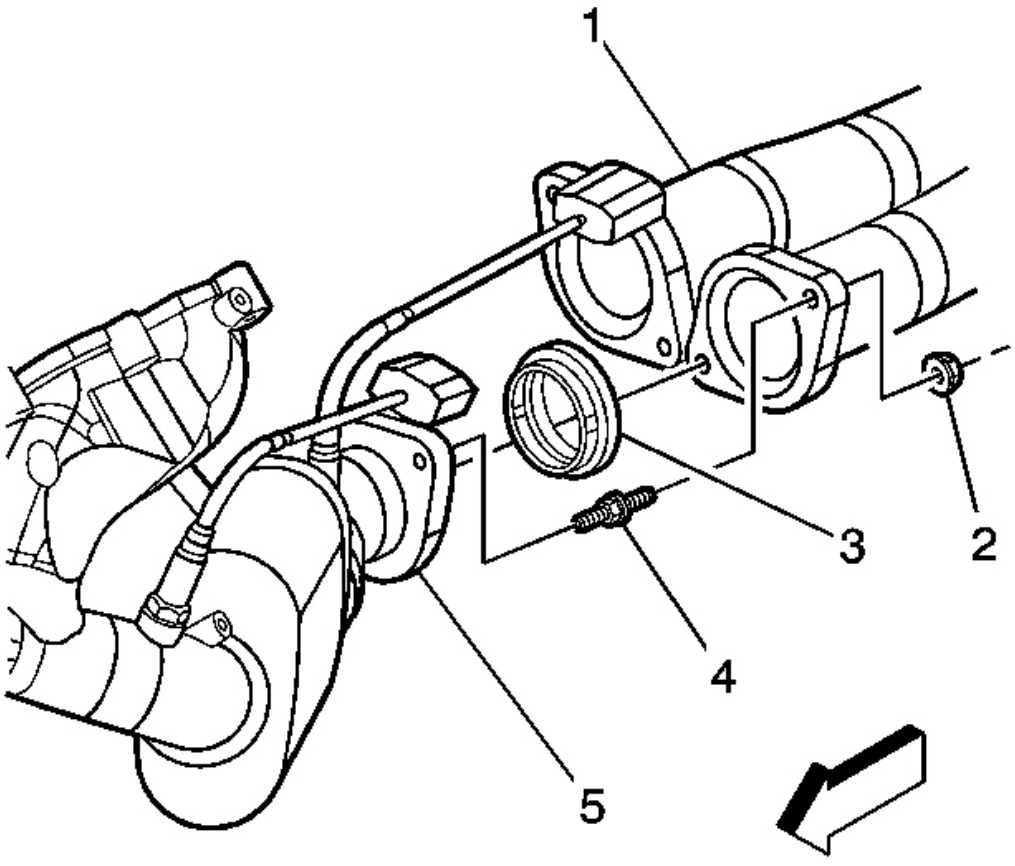


Fig. 34: View Of Intermediate Exhaust Pipe, Exhaust Manifold Nuts & Exhaust Seal
Courtesy of GENERAL MOTORS CORP.

3. Install ALL exhaust clamps and bolts until snug to ensure correct alignment of the intermediate pipe.
4. Remove the adjustable jack stands.

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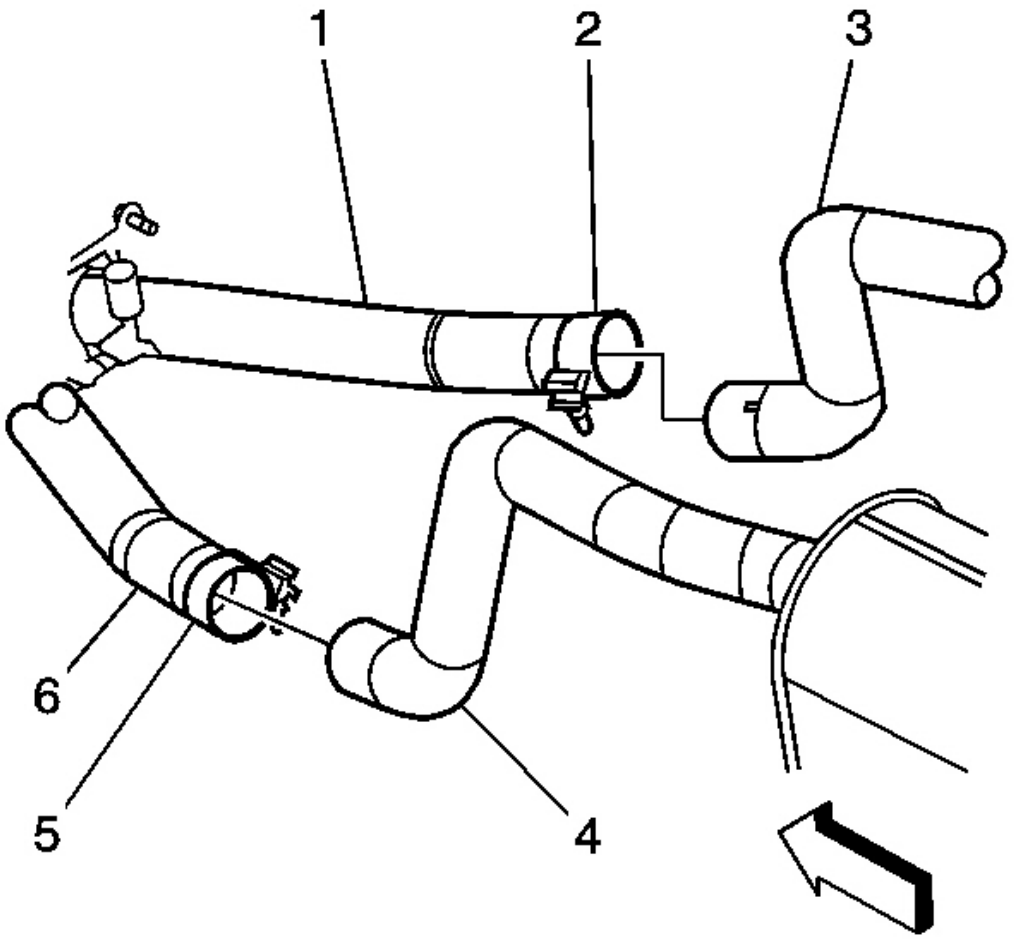


Fig. 35: View Of Exhaust Muffler Band Clamps
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

5. Tighten the exhaust muffler clamps (2, 5).

   Tighten: Tighten the exhaust clamps bolts to 44 N.m (32 lb ft).

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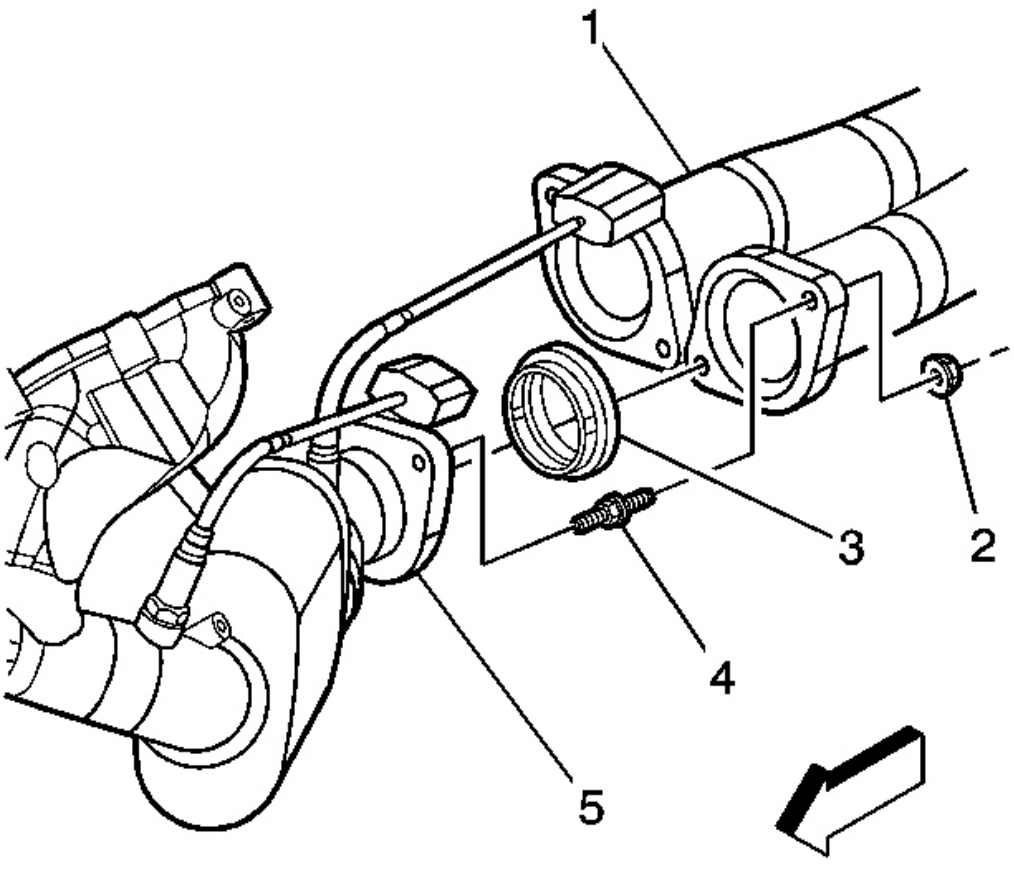


Fig. 36: View Of Intermediate Exhaust Pipe, Exhaust Manifold Nuts & Exhaust Seal
Courtesy of GENERAL MOTORS CORP.

6. Tighten the exhaust manifold nuts (2).

   Tighten: Tighten the exhaust manifold nuts to 20 N.m (15 lb ft).

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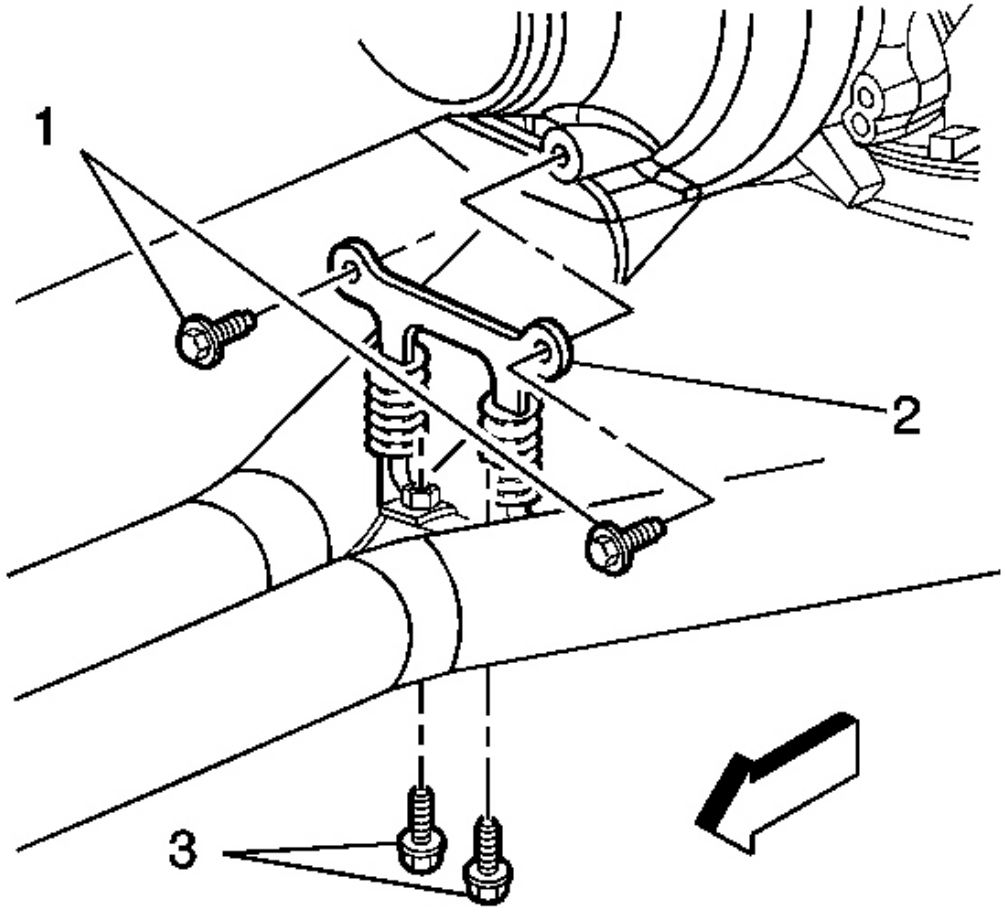


Fig. 37: View Of Intermediate Exhaust Pipe Hanger
Courtesy of GENERAL MOTORS CORP.

7. Tighten the exhaust pipe hanger lower bolts (3).

   Tighten: Tighten the exhaust pipe hanger bolts to 50 N.m (37 lb ft).

8. Lower the vehicle.

EXHAUST HANGER MOUNTING BRACKET REPLACEMENT

Removal Procedure

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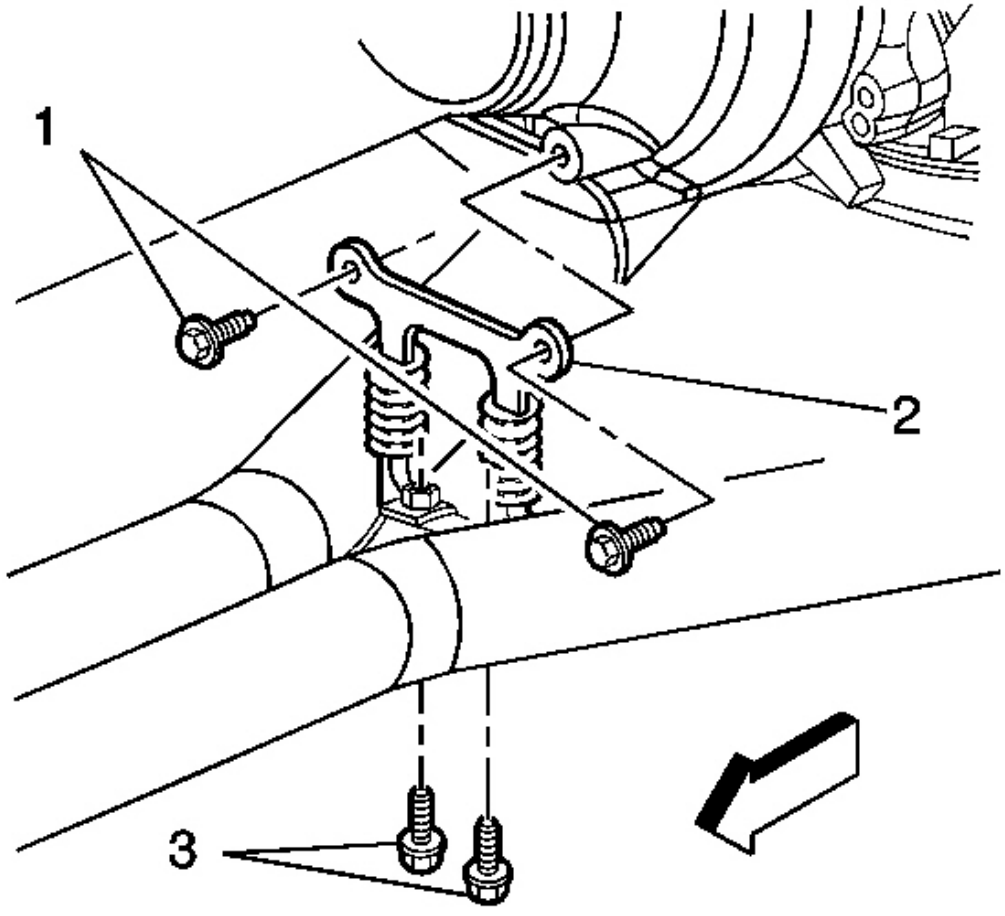


Fig. 38: View Of Intermediate Exhaust Pipe Hanger
Courtesy of GENERAL MOTORS CORP.

1. Remove the intermediate exhaust pipe. Refer to **Intermediate Pipe Replacement**.
2. Remove the upper exhaust pipe hanger bolts (1).
3. Remove the exhaust pipe hanger.

Installation Procedure

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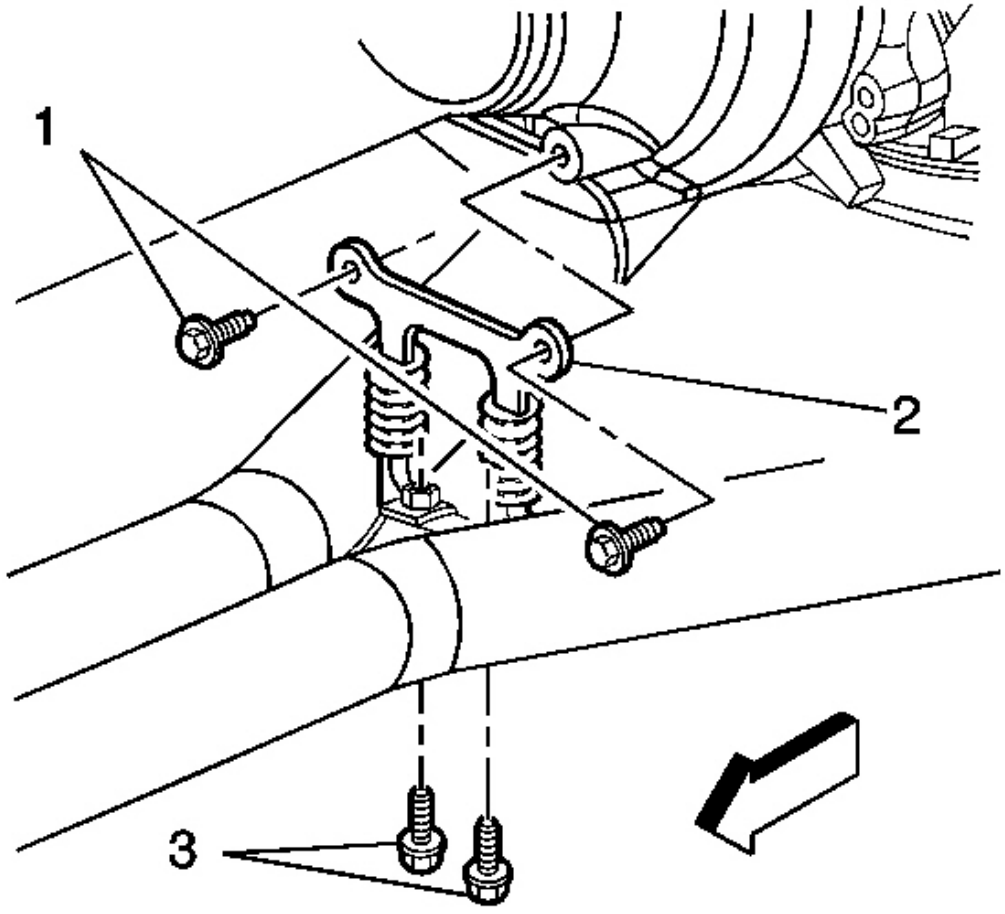


Fig. 39: View Of Intermediate Exhaust Pipe Hanger
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust pipe hanger.

   NOTE: Refer to Fastener Notice .

2. Install the upper exhaust pipe hanger bolts (1).

   Tighten: Tighten the exhaust pipe hanger bolts to 50 N.m (37 lb ft).

3. Install the intermediate exhaust pipe. Refer to **Intermediate Pipe Replacement**.

MUFFLER REPLACEMENT - LEFT SIDE

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Removal Procedure

CAUTION: Refer to Exhaust Service Caution .

CAUTION: Refer to Protective Goggles and Glove Caution .

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

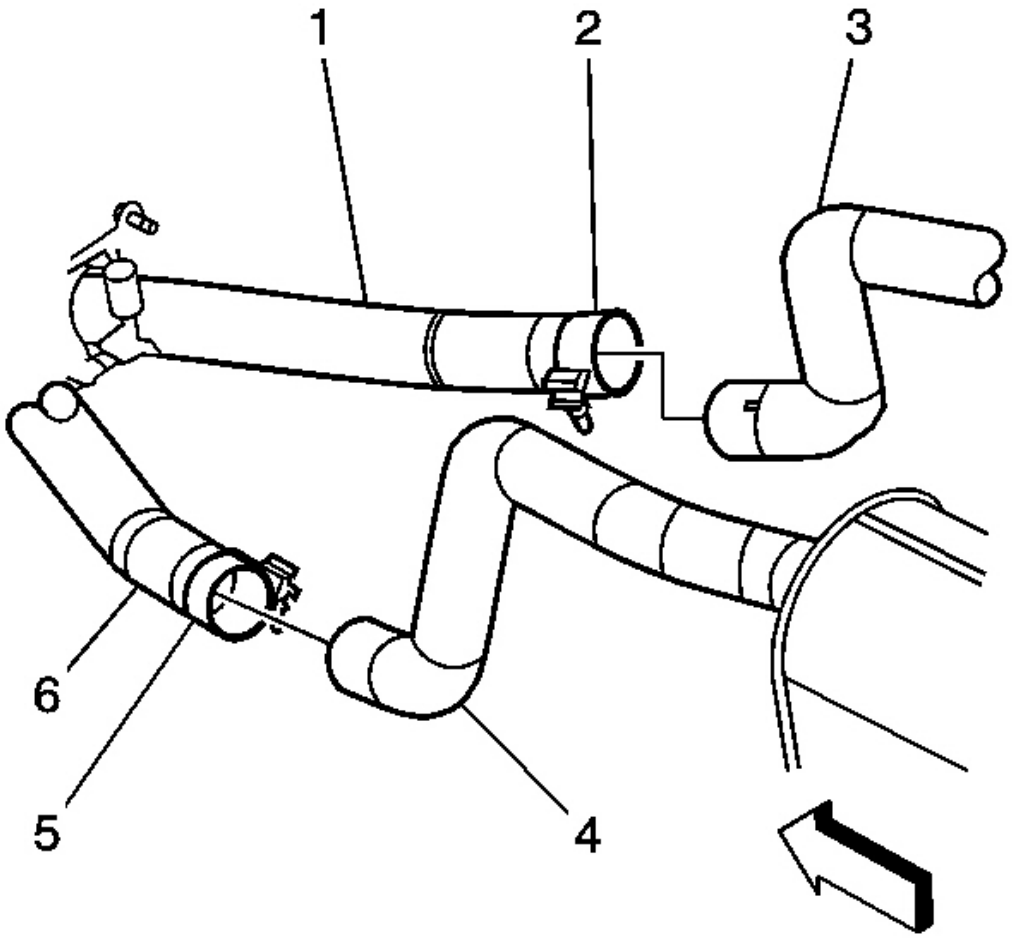


Fig. 40: View Of Exhaust Muffler Band Clamps
Courtesy of GENERAL MOTORS CORP.

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2. Loosen the left exhaust muffler clamp (5).

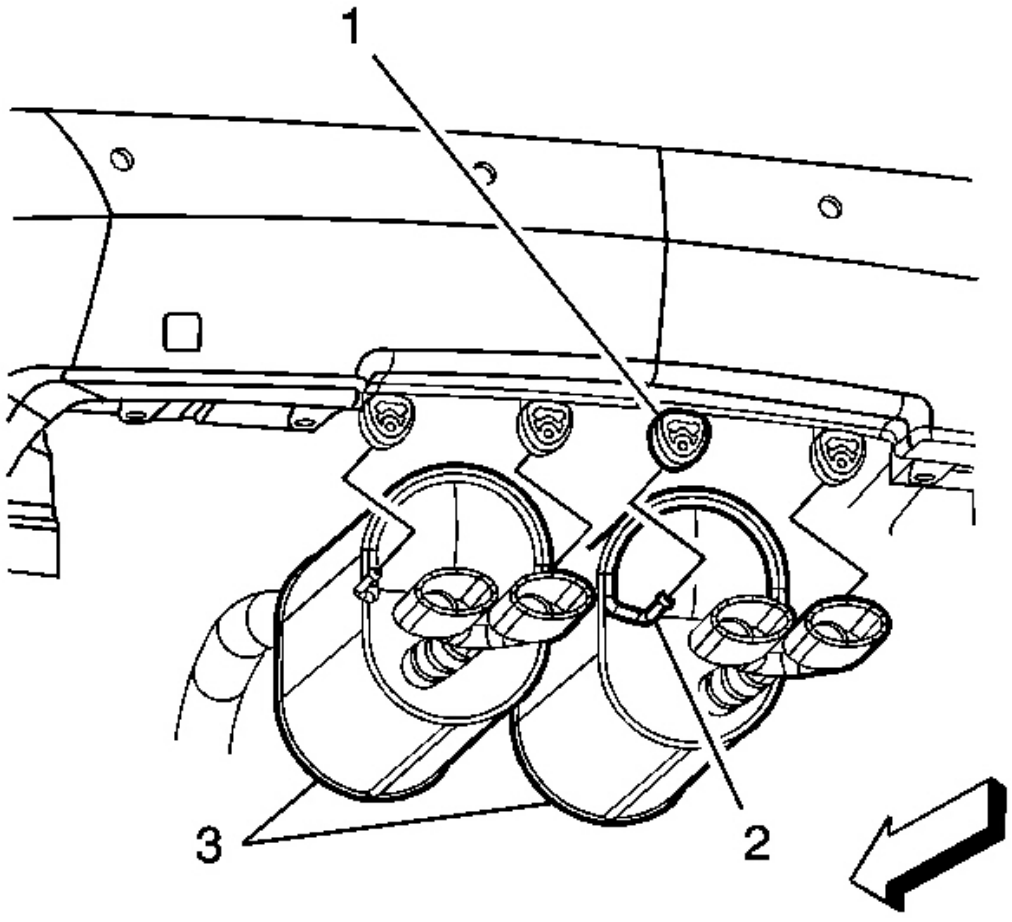


Fig. 41: View Of Mufflers
Courtesy of GENERAL MOTORS CORP.

3. Slide the muffler out from the hanger (1).
4. Remove the left muffler.

Installation Procedure

NOTE: Refer to Exhaust System Inspection Notice .

1. Mark the position of the muffler band clamp (5) on the intermediate exhaust pipe.

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2. Remove the muffler band clamp from the intermediate exhaust pipe by grinding the weld.
3. Install a new muffler band clamp on the intermediate exhaust pipe.

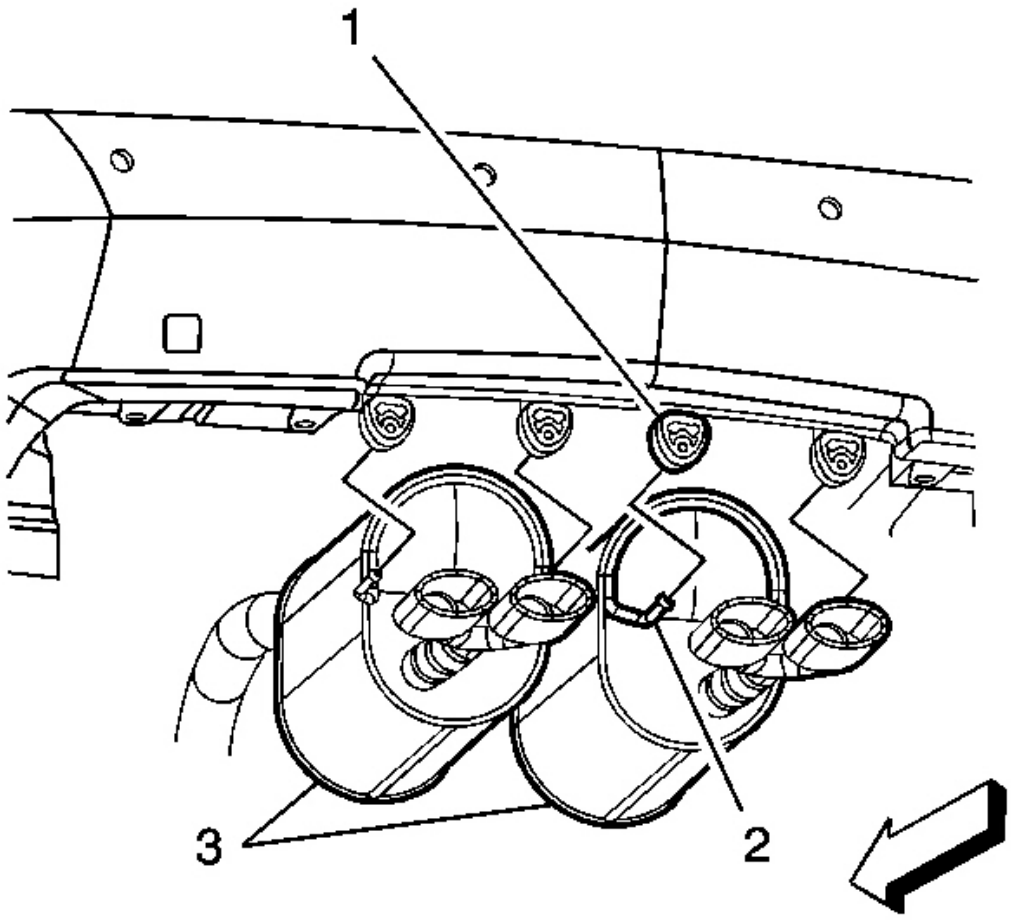


Fig. 42: View Of Mufflers
Courtesy of GENERAL MOTORS CORP.

4. Install the left muffler.
5. Slide the muffler into the hanger (1).

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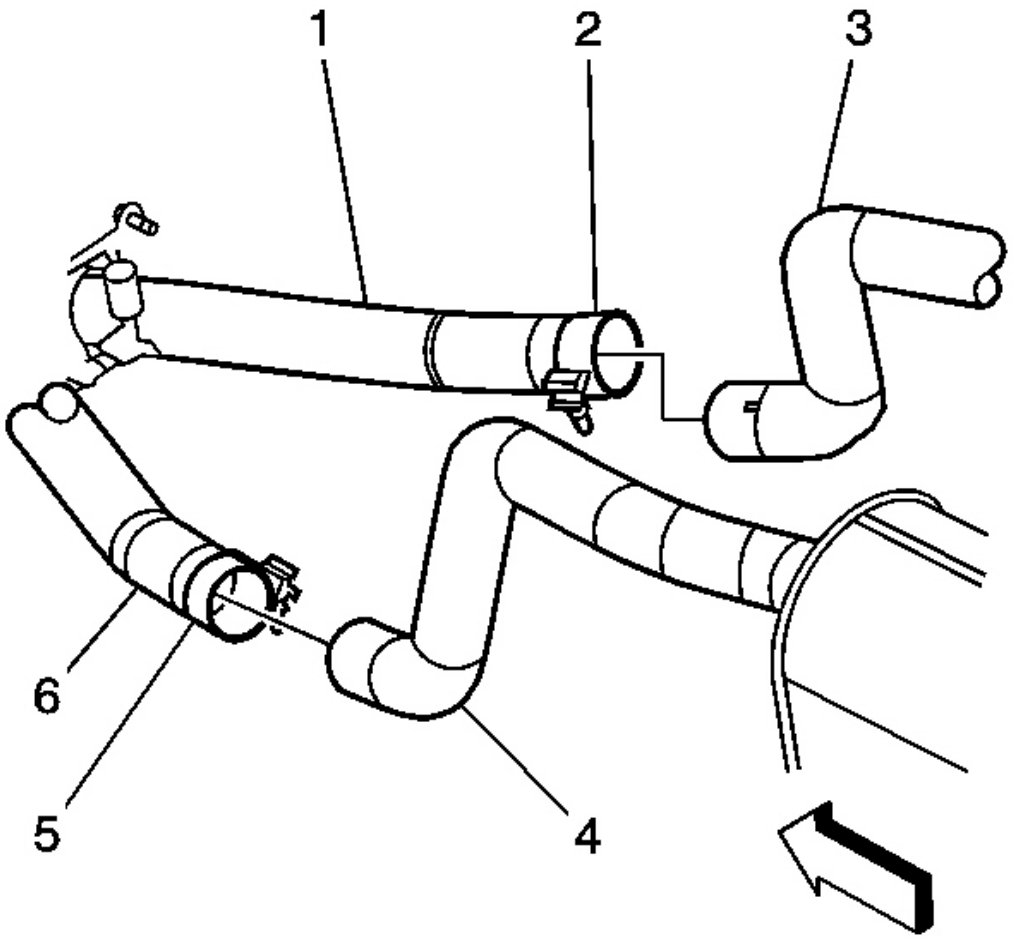


Fig. 43: View Of Exhaust Muffler Band Clamps
Courtesy of GENERAL MOTORS CORP.

6. Position the new muffler band clamp (5) on the intermediate exhaust pipe using the alignment mark created previously. The muffler band clamp bolt must not be positioned below the exhaust pipe.

NOTE: **Refer to Fastener Notice .**

7. Tighten the right side exhaust muffler clamp.

Tighten: Tighten the exhaust muffler clamp to 44 N.m (32 lb ft).

8. Lower the vehicle.

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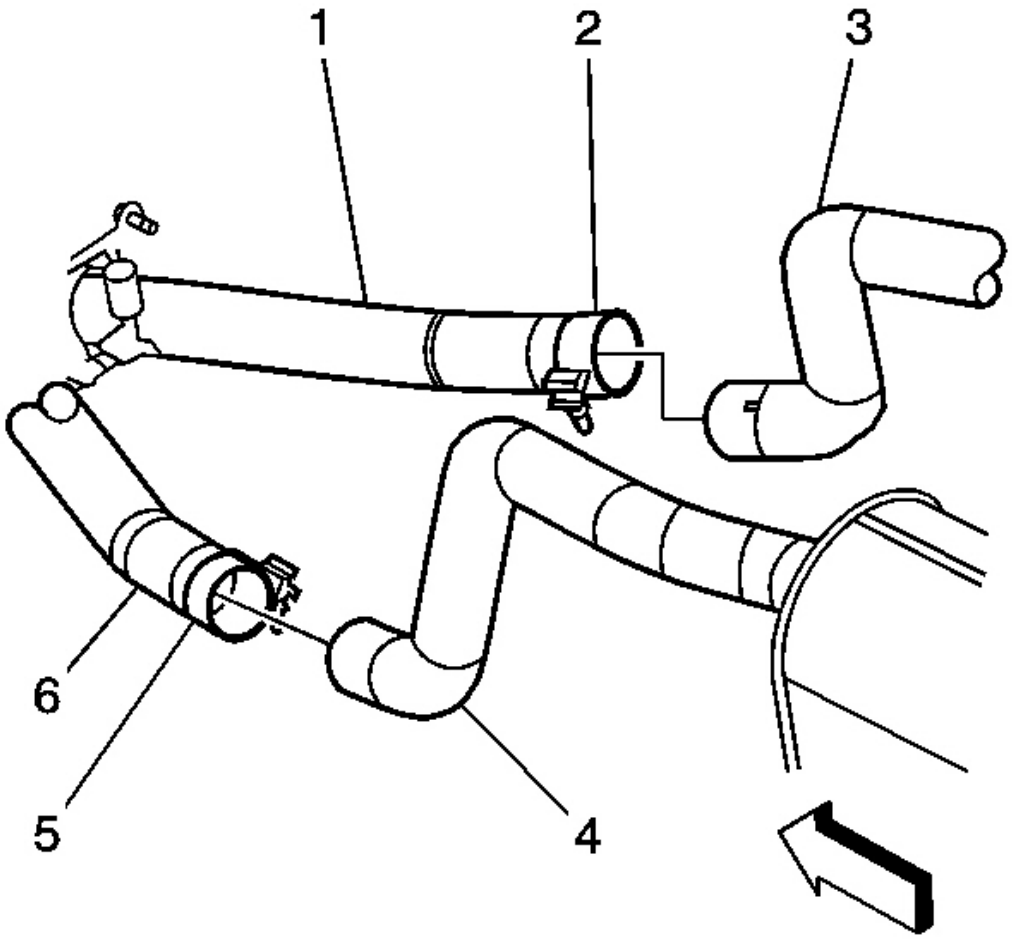
MUFFLER REPLACEMENT - RIGHT SIDE

Removal Procedure

CAUTION: Refer to Exhaust Service Caution .

CAUTION: Refer to Protective Goggles and Glove Caution .

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .



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Fig. 44: View Of Exhaust Muffler Band Clamps
Courtesy of GENERAL MOTORS CORP.

2. Loosen the right side exhaust muffler clamp (2).

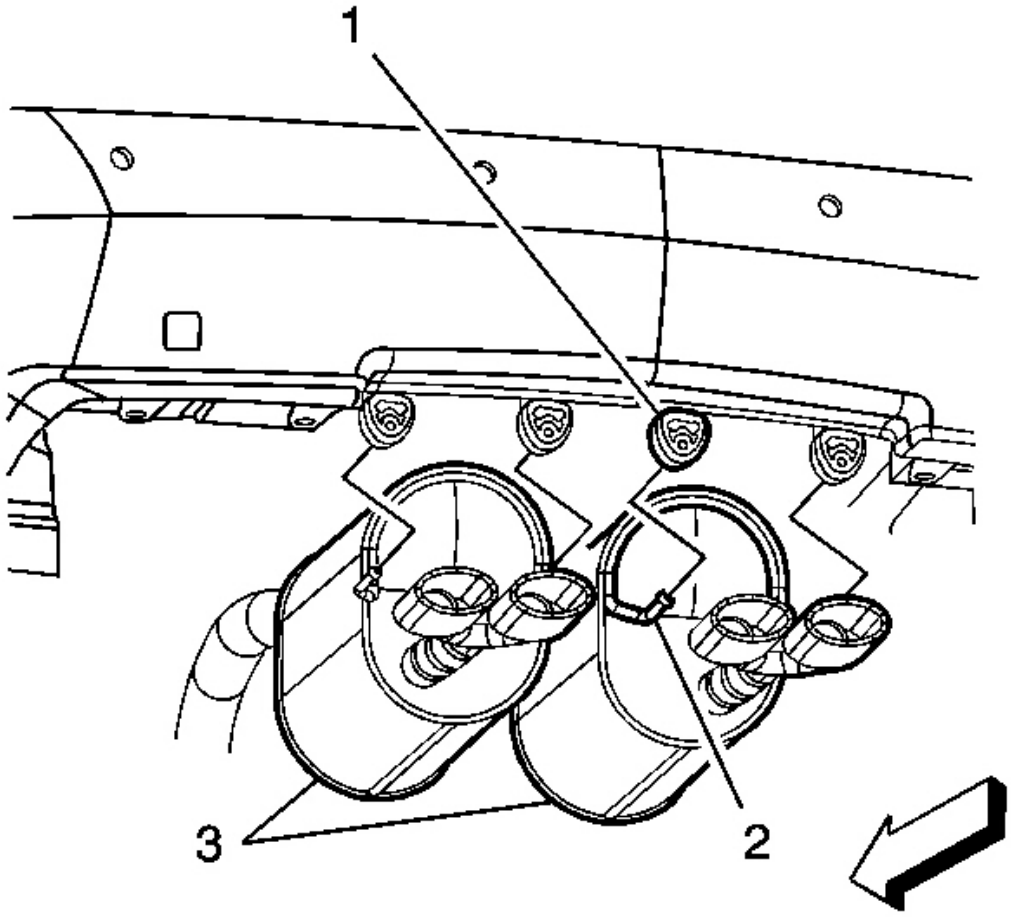


Fig. 45: View Of Mufflers
Courtesy of GENERAL MOTORS CORP.

3. Slide the muffler out from the hanger (1).
4. Remove the right muffler.

Installation Procedure

NOTE: Refer to Exhaust System Inspection Notice .

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1. Mark the position of the muffler band clamp (2) on the intermediate exhaust pipe.
2. Remove the muffler band clamp from the intermediate exhaust pipe by grinding the weld.
3. Install a new muffler band clamp on the intermediate exhaust pipe.
4. Install the right muffler.

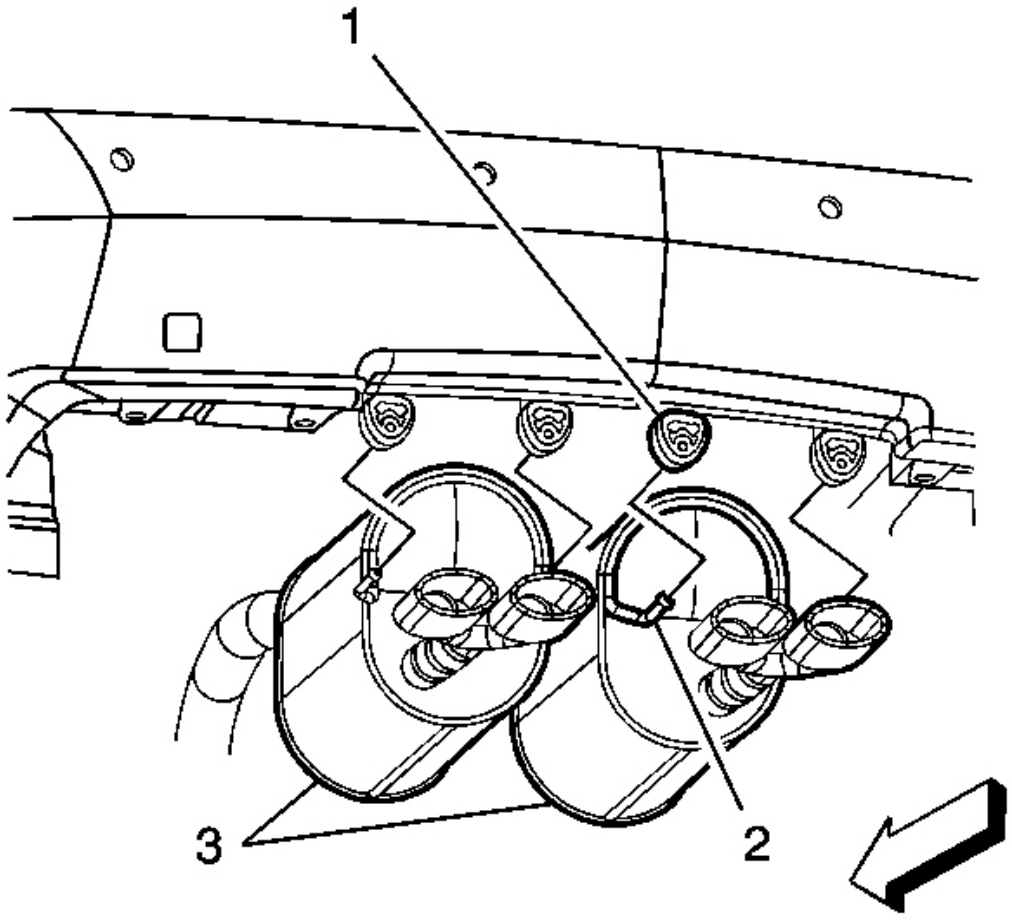


Fig. 46: View Of Mufflers
Courtesy of GENERAL MOTORS CORP.

5. Slide the muffler into the hanger.

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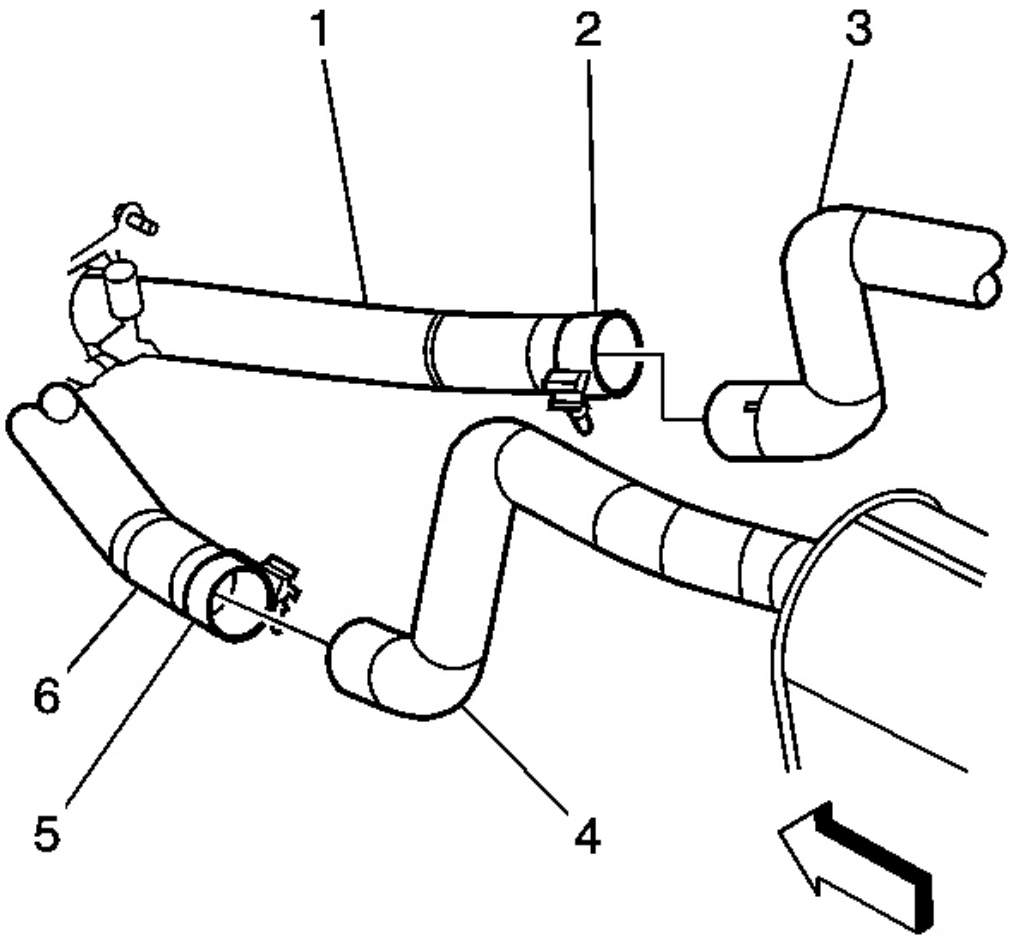


Fig. 47: View Of Exhaust Muffler Band Clamps
Courtesy of GENERAL MOTORS CORP.

6. Position the new muffler band clamp (2) on the intermediate exhaust pipe using the alignment mark created previously. The muffler band clamp bolt must not be positioned below the exhaust pipe.

NOTE: **Refer to Fastener Notice .**

7. Tighten the right side exhaust muffler clamp.

Tighten: Tighten the exhaust muffler clamp to 44 N.m (32 lb ft).

8. Lower the vehicle.

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EXHAUST TAIL PIPE FLOW CONTROL VACUUM CHECK VALVE AND HOSE REPLACEMENT

Removal Procedure

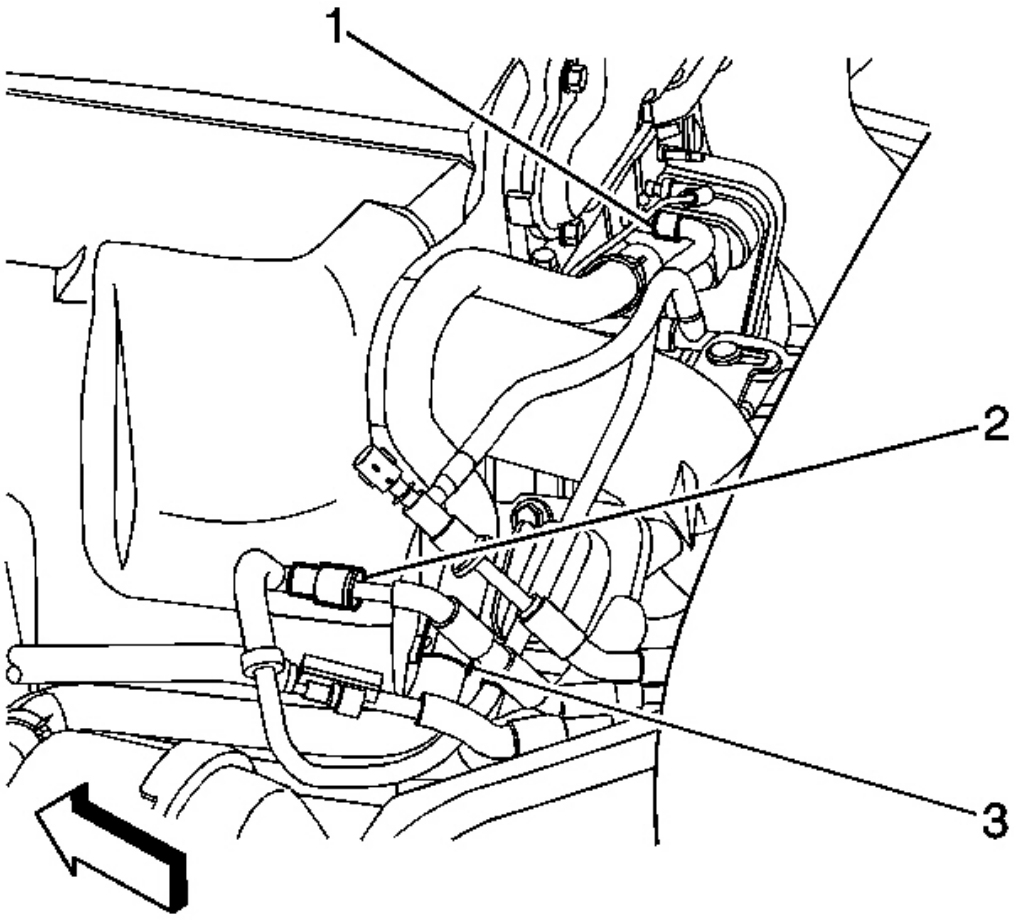


Fig. 48: Identifying Quick Connect Fitting
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the quick connect fitting (2) at the front of dash. Refer to **Plastic Collar Quick Connect Fitting Service** .
2. Disconnect the vacuum line fitting (1) from the rear of the supercharger.
3. Remove the vacuum line from the retainer (3).
4. Remove the exhaust flow control vacuum check valve and engine compartment vacuum line from the vehicle.

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Installation Procedure

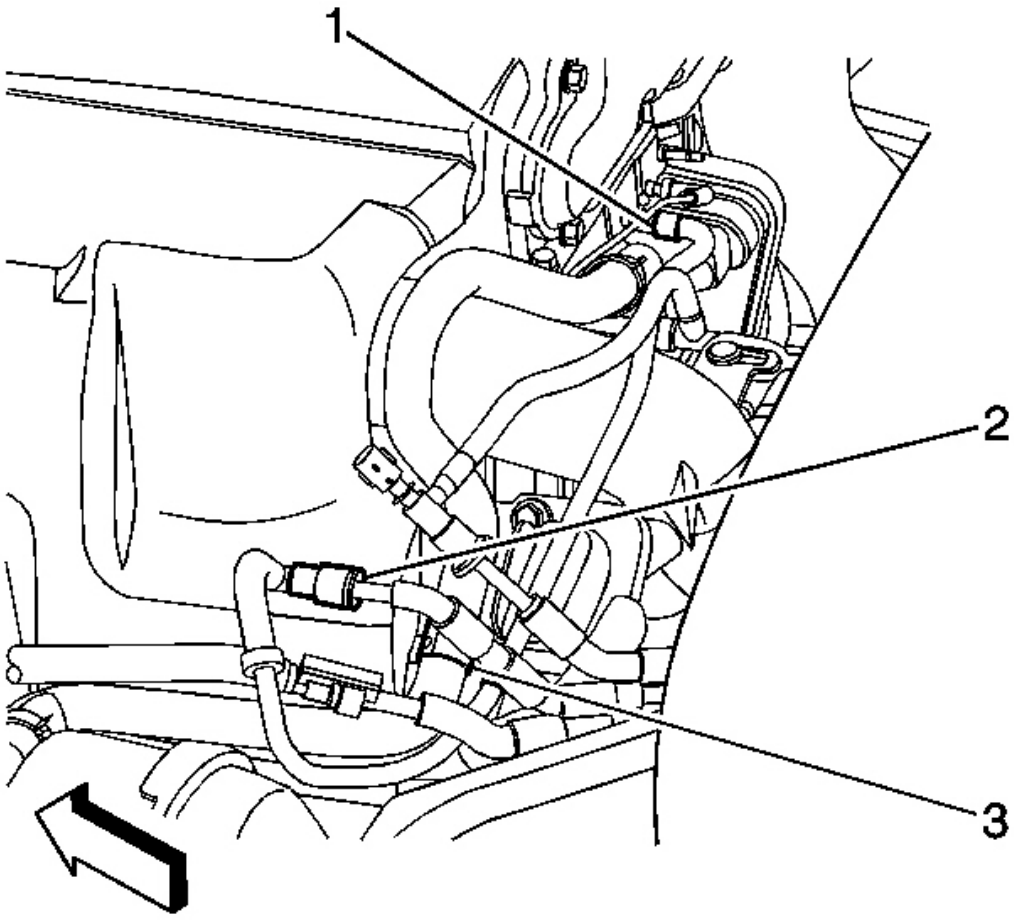


Fig. 49: Identifying Quick Connect Fitting
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust flow control vacuum check valve and engine compartment vacuum line to the vehicle.
2. Install the vacuum line to the retainer (3).
3. connect the vacuum line fitting (1) to the rear of the supercharger.
4. Connect the quick connect fitting (2) at the front of dash. Refer to **Plastic Collar Quick Connect Fitting Service** .

EXHAUST TAIL PIPE FLOW VALVE VACUUM PIPE RESERVOIR TANK REPLACEMENT

Removal Procedure

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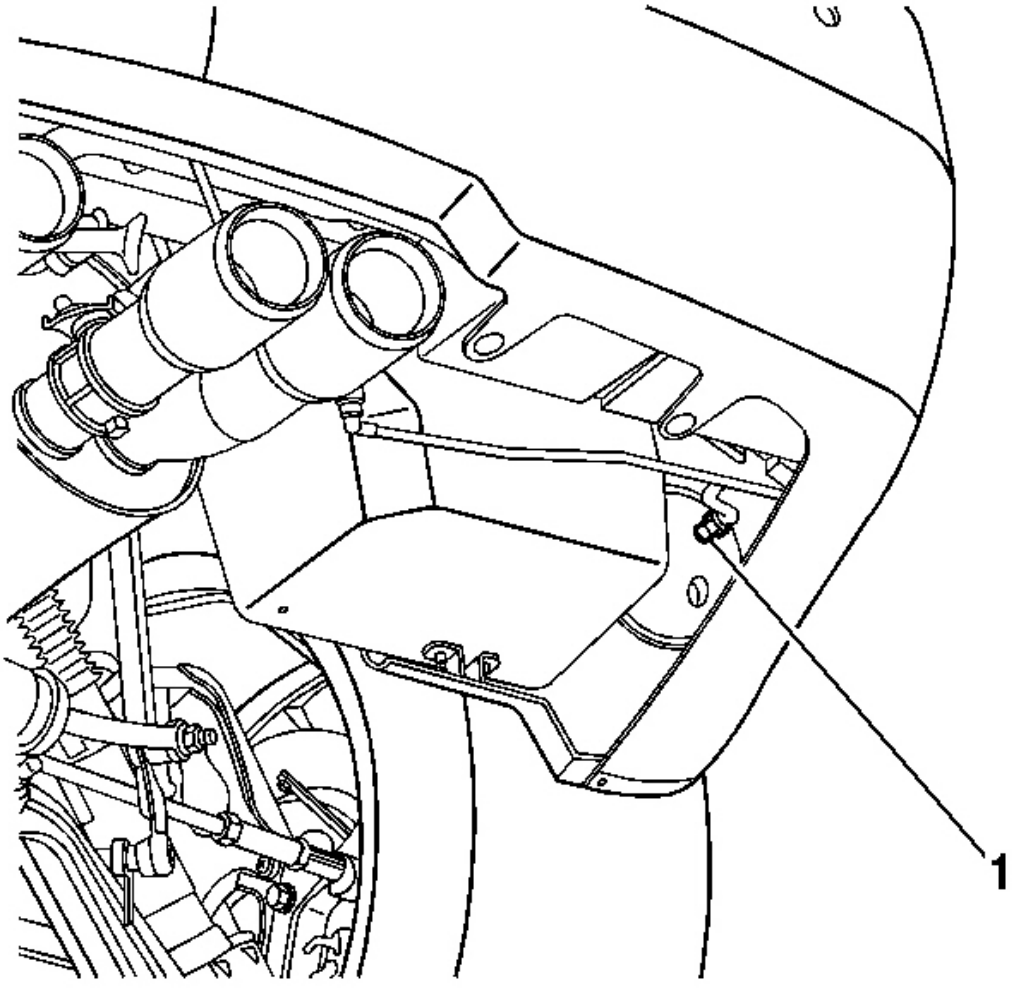


Fig. 50: Identifying Vacuum Pipe & Reservoir Tank
Courtesy of GENERAL MOTORS CORP.

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Disconnect the vacuum line (1) from the vacuum tank located behind the right rear quarter panel.
3. Remove the right rear tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** .
4. Remove the right rear wheel house liner. Refer to **Wheelhouse Liner Panel Replacement - Rear** .

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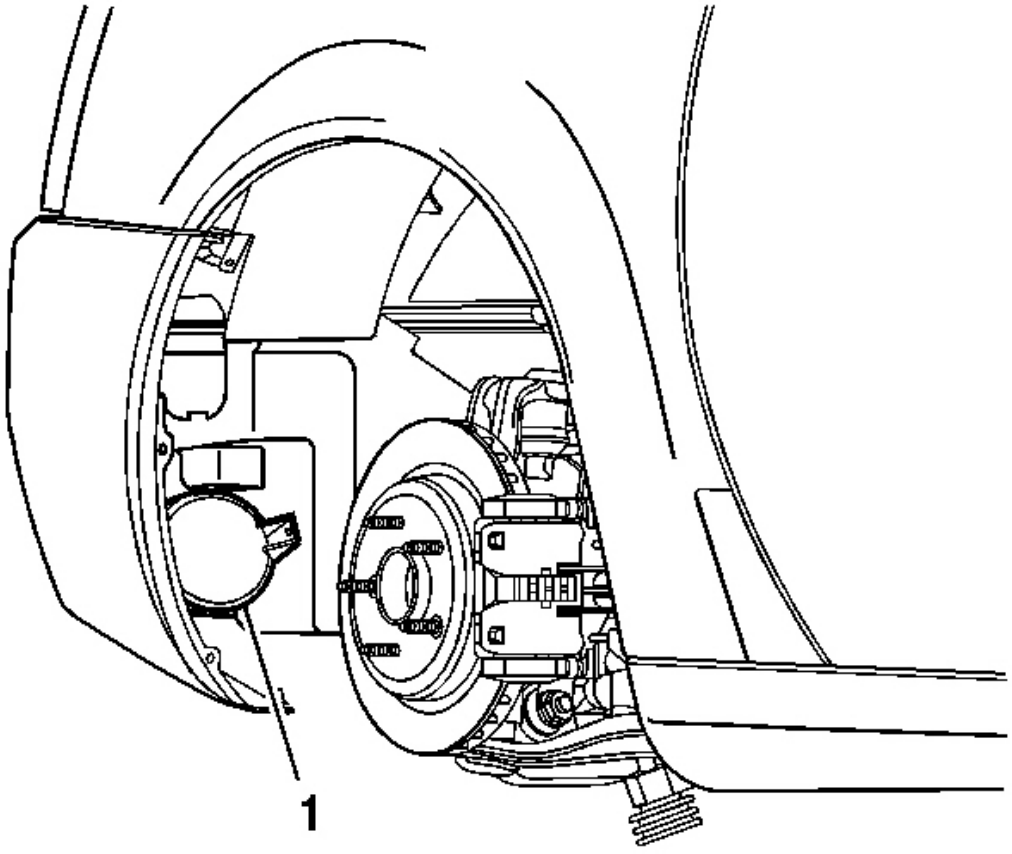


Fig. 51: Locating Vacuum Tank
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark the location of the vacuum tank before removal. Wear gloves while removing the vacuum tank.

5. If the vacuum tank is not damaged, grasp the vacuum tank and break it free from the rear compartment panel. If the vacuum tank is broken, use suitable tools for removal.
6. Remove the vacuum tank from the rear compartment panel.

Installation Procedure

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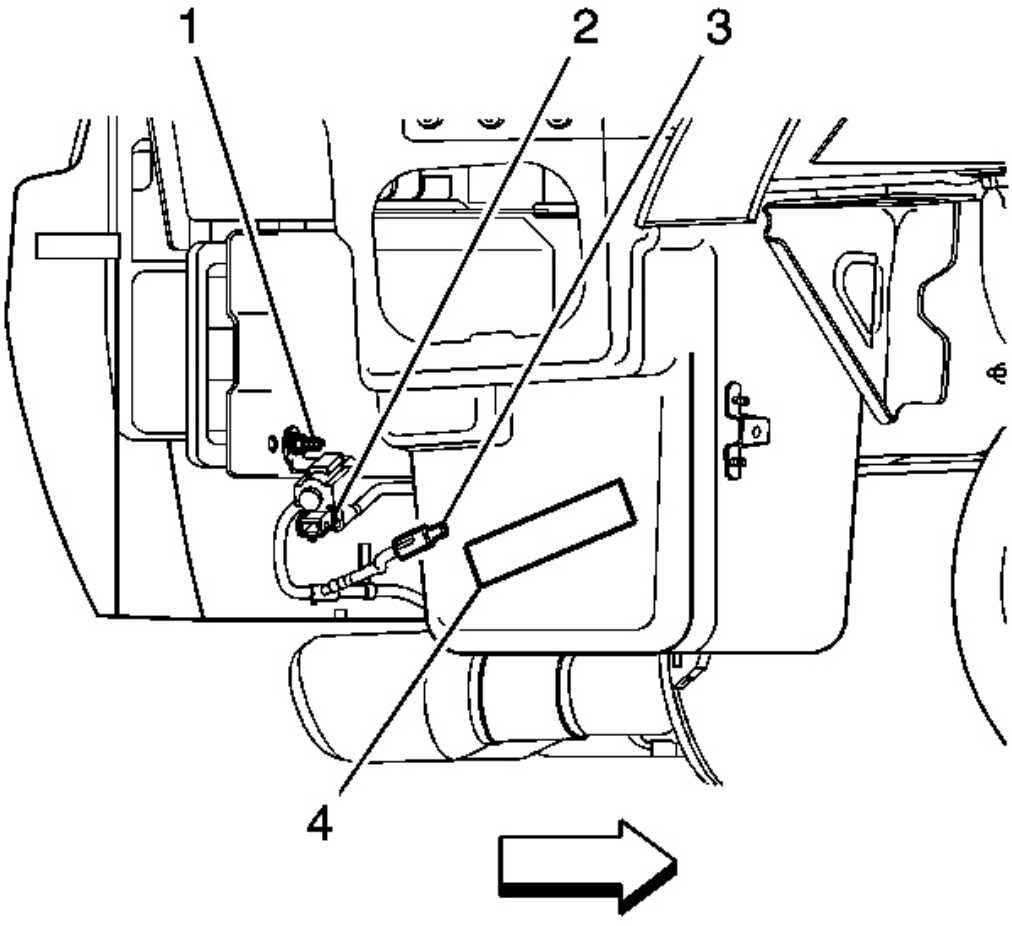


Fig. 52: Identifying Vacuum Tank Mounts
Courtesy of GENERAL MOTORS CORP.

1. Clean the area of the rear compartment panel where the vacuum tank mounts (4). Use an abrasive wheel if necessary.
2. Clean the rear compartment panel and the vacuum tank mounting surface with an alcohol based cleaner.
3. Apply two part epoxy GM P/N 89020330 (Canadian P/N 89020332) or equivalent to the mounting surface of the vacuum tank.
4. Install the vacuum tank to the vehicle in the location shown (4). Ensure that the vacuum line will reach the vacuum tank.
5. Hold the tank in position with masking tape while the epoxy dries.
6. Allow the epoxy to dry for thirty minutes before removing the masking tape.

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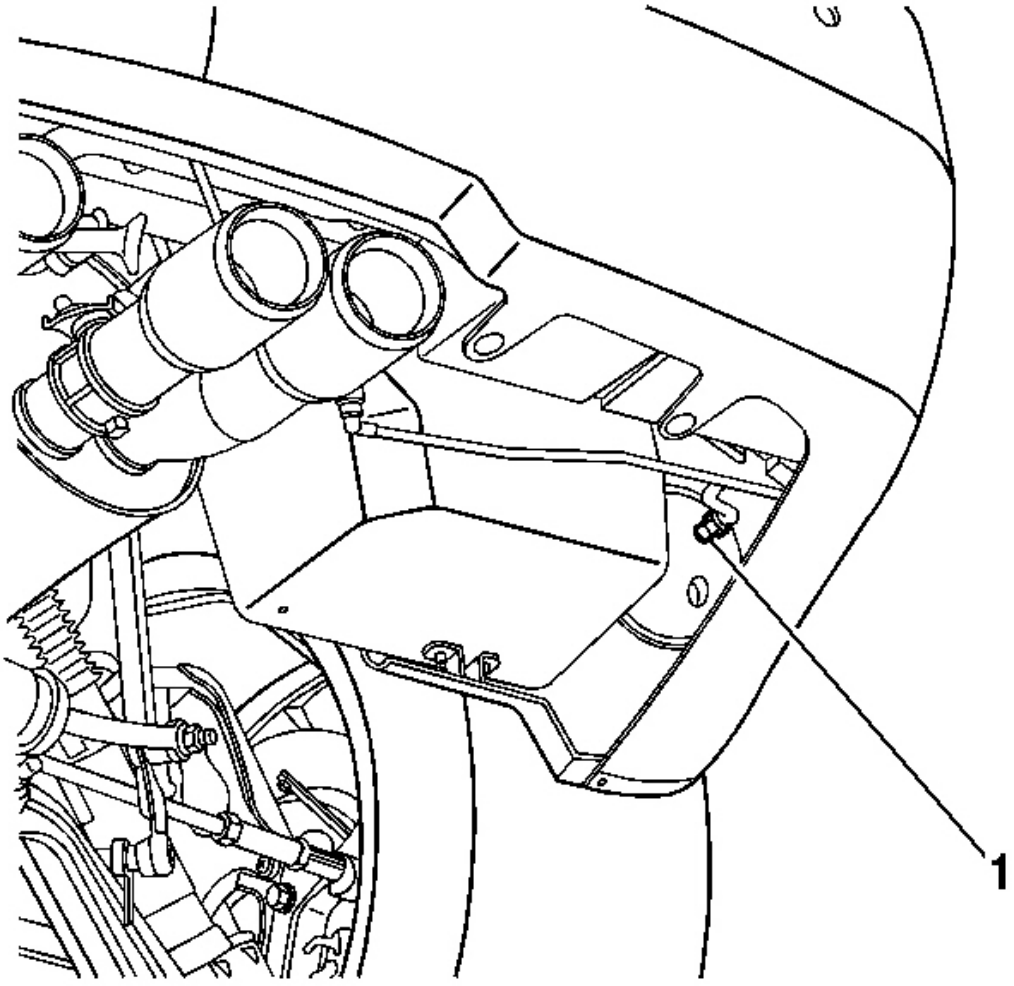


Fig. 53: Identifying Vacuum Pipe & Reservoir Tank
Courtesy of GENERAL MOTORS CORP.

7. Connect the vacuum line (1) to the vacuum tank.
8. Install the wheel house liner. Refer to **Wheelhouse Liner Panel Replacement - Rear** .
9. Install the tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** .
10. Lower the vehicle.

EXHAUST TAIL PIPE FLOW VALVE VACUUM PIPE REPLACEMENT - CHASSIS FRONT

Removal Procedure

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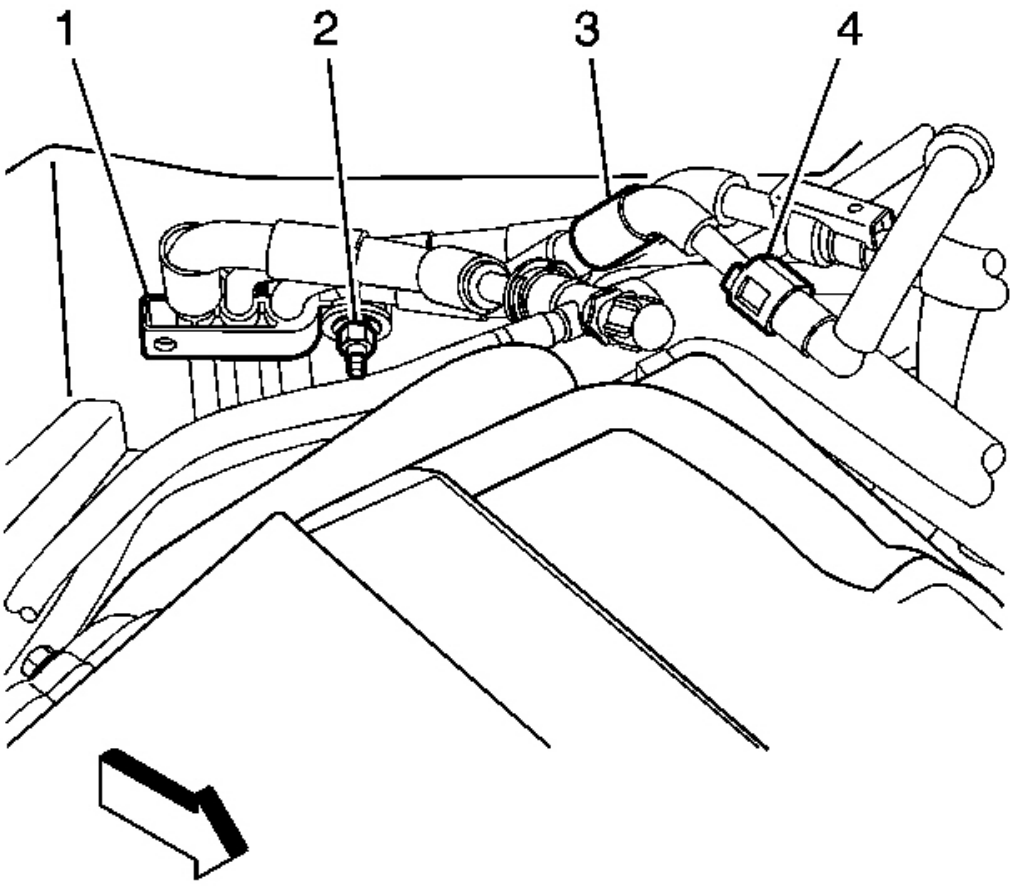


Fig. 54: Locating Quick Connect Fitting
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement** .
2. Disconnect the quick connect fitting (4) at the front of dash. Refer to **Plastic Collar Quick Connect Fitting Service** .
3. Disconnect the chassis fuel bundle retainer (1) from the upper front of dash mounting stud.
4. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
5. Remove the exhaust intermediate pipe. Refer to **Intermediate Pipe Replacement**.

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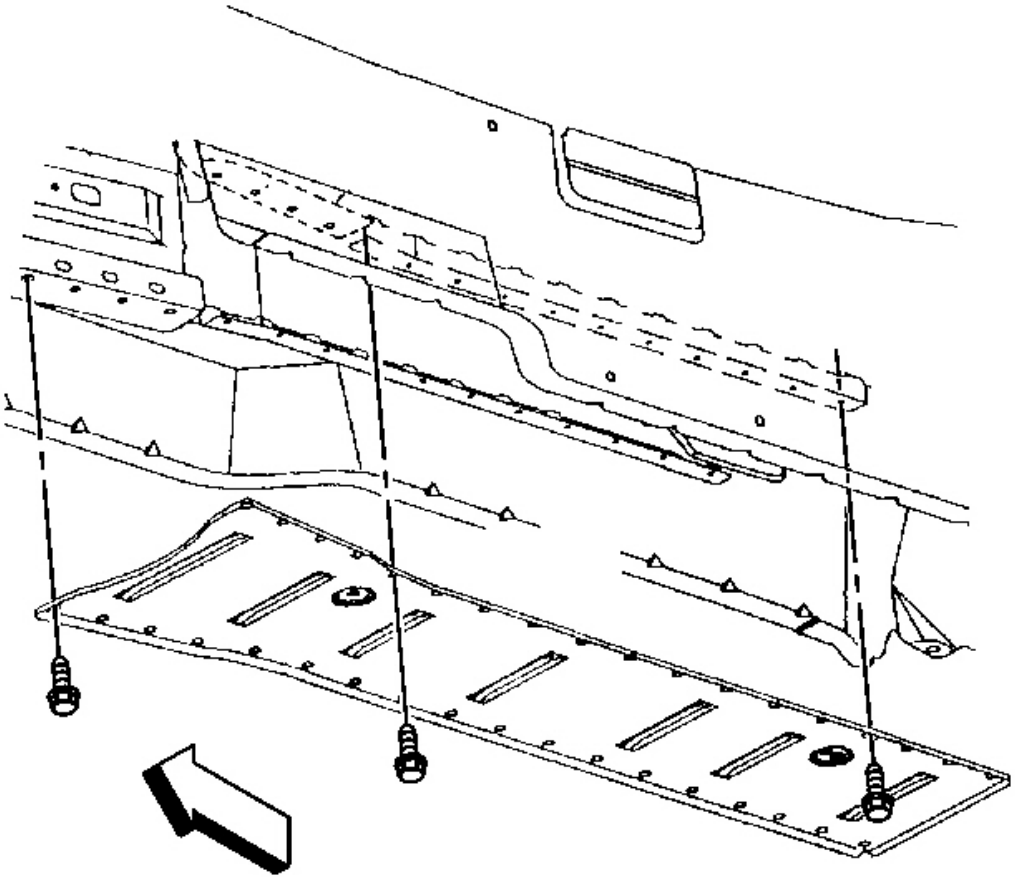


Fig. 55: View Of Driveline Tunnel Closeout Panel & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the driveline closeout panel. Refer to **Driveline Tunnel Closeout Panel Replacement** .

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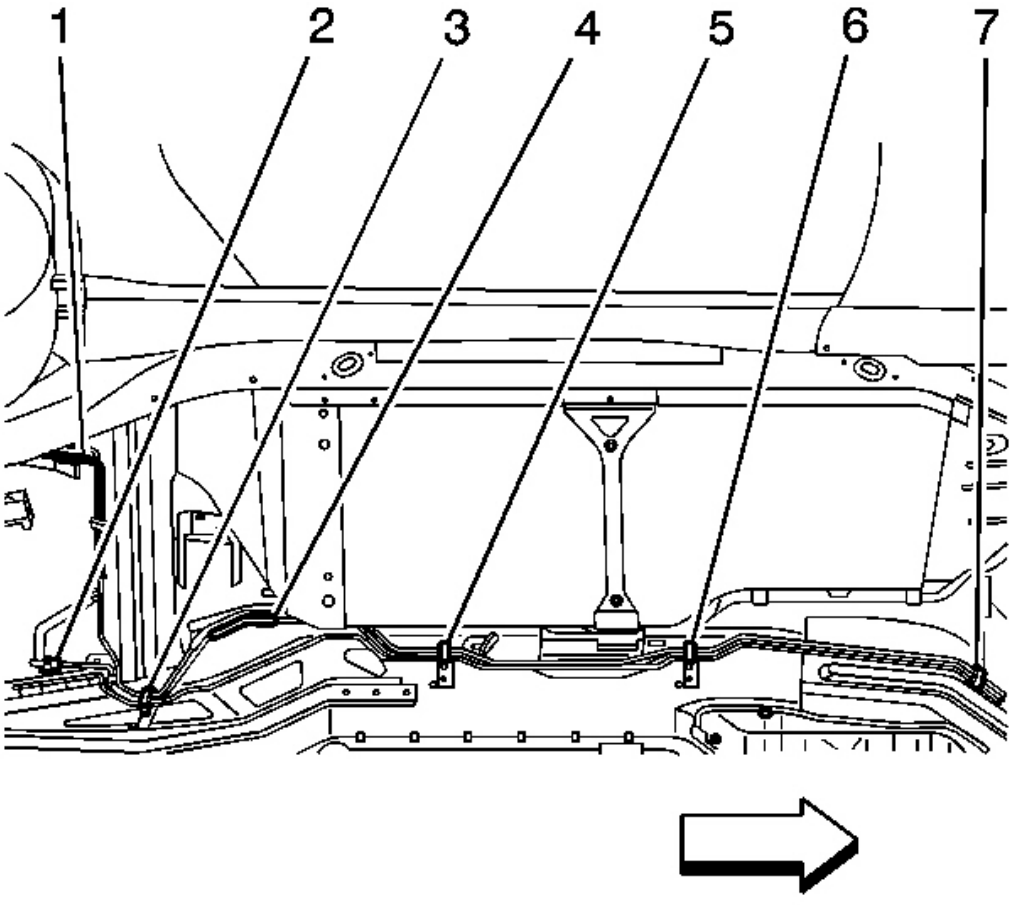


Fig. 56: Identifying Underbody Retainers
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the front chassis vacuum line from the underbody retainers (3,5,6 and 7).
8. Disconnect the front chassis vacuum line quick connect fitting (2) located on the left side of the vehicle, forward of the rear drive module. Refer to **Plastic Collar Quick Connect Fitting Service** .
9. Remove the front chassis vacuum line from the vehicle.

Installation Procedure

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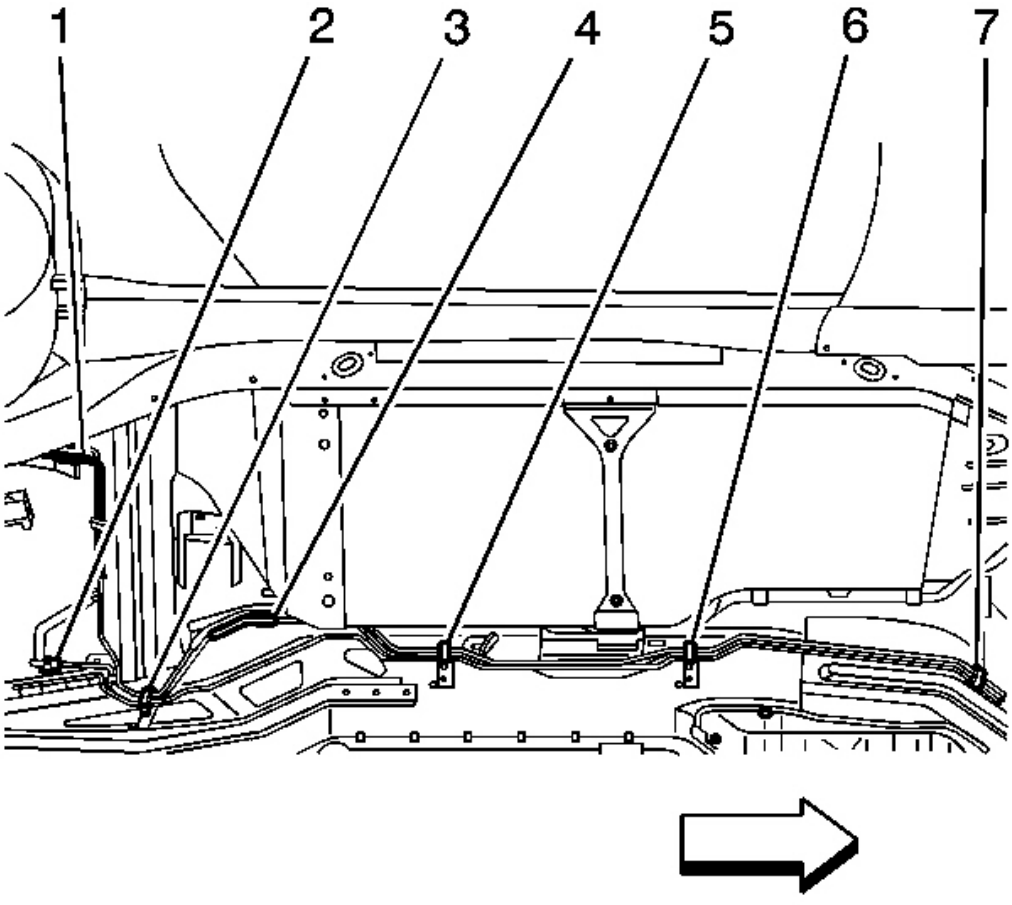


Fig. 57: Identifying Underbody Retainers
Courtesy of GENERAL MOTORS CORP.

1. Install the front chassis vacuum line to the vehicle.
2. Connect the front chassis vacuum line quick connect fitting (2). Refer to **Plastic Collar Quick Connect Fitting Service** .
3. Install the front chassis vacuum line to the underbody retainers (3,5,6 and 7).

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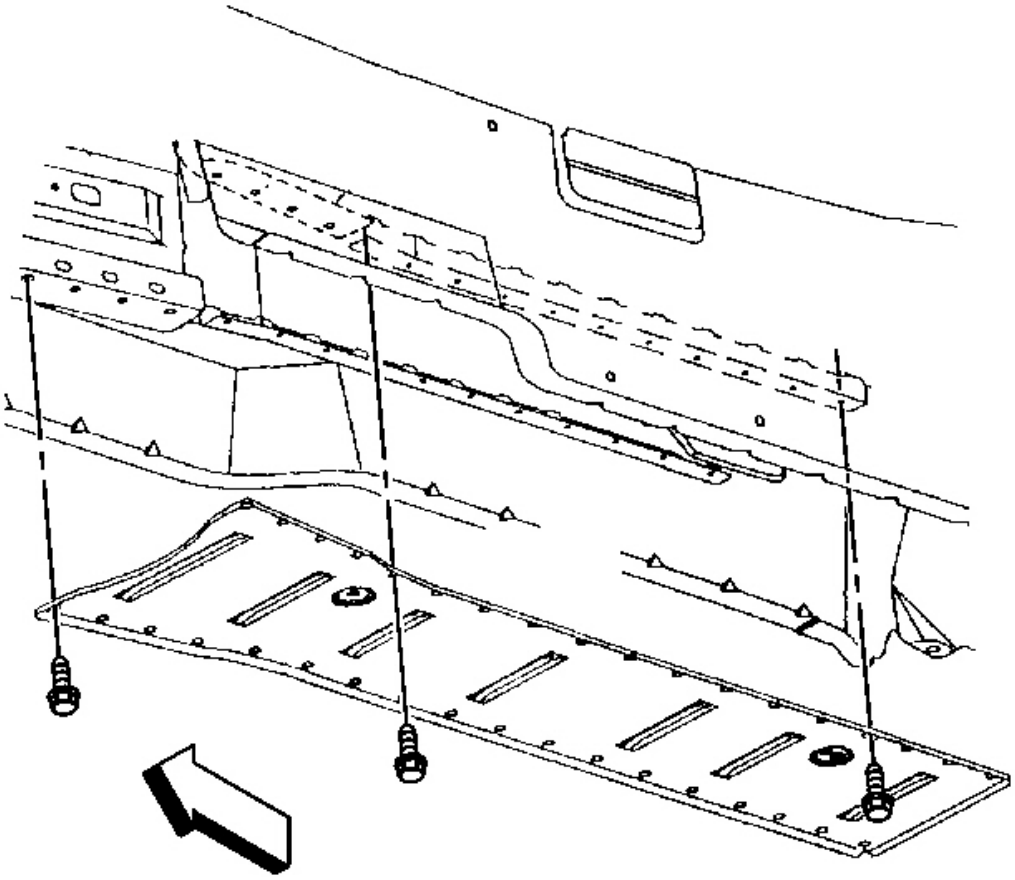


Fig. 58: View Of Driveline Tunnel Closeout Panel & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the driveline closeout panel. Refer to **Driveline Tunnel Closeout Panel Replacement** .
5. Install the exhaust intermediate pipe. Refer to **Intermediate Pipe Replacement**.
6. Lower the vehicle.

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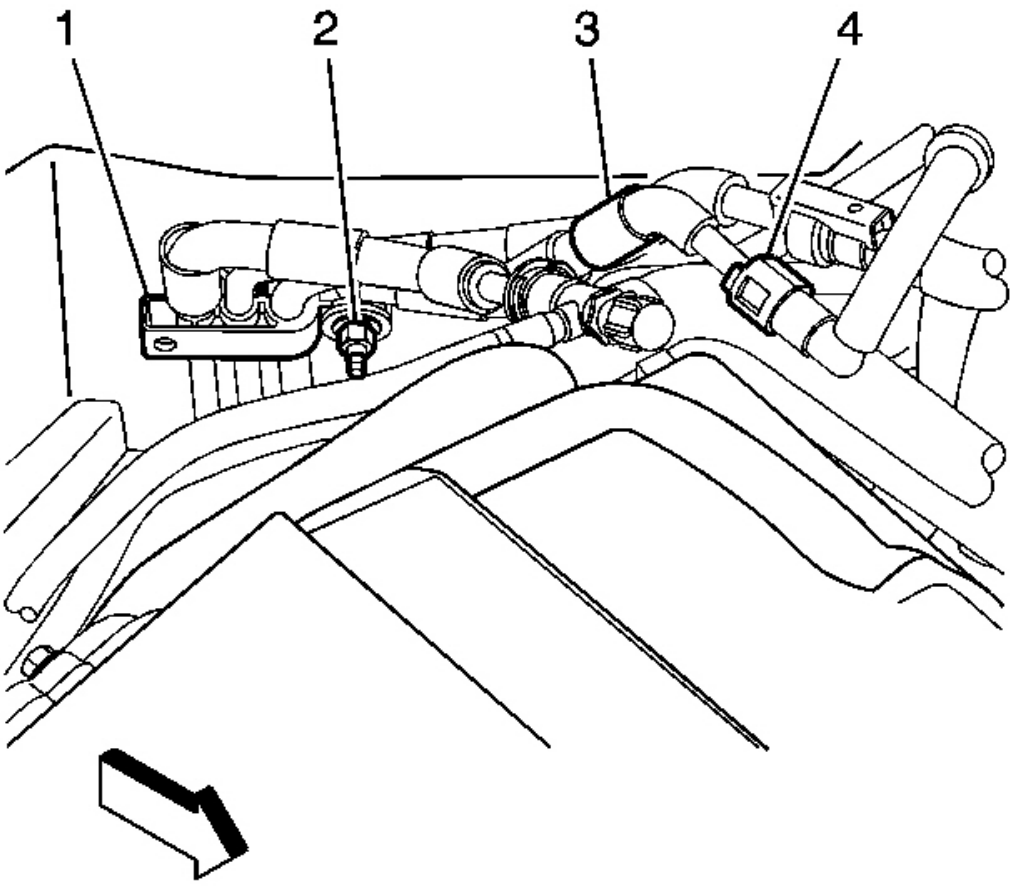


Fig. 59: Locating Quick Connect Fitting
Courtesy of GENERAL MOTORS CORP.

7. Connect the chassis fuel bundle retainer (1) to the upper front of dash mounting stud.
8. Connect the quick connect fitting (4) at the front of dash. Refer to **Plastic Collar Quick Connect Fitting Service** .
9. Install the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement** .

EXHAUST TAIL PIPE FLOW VALVE VACUUM PIPE REPLACEMENT - CHASSIS REAR

Removal Procedure

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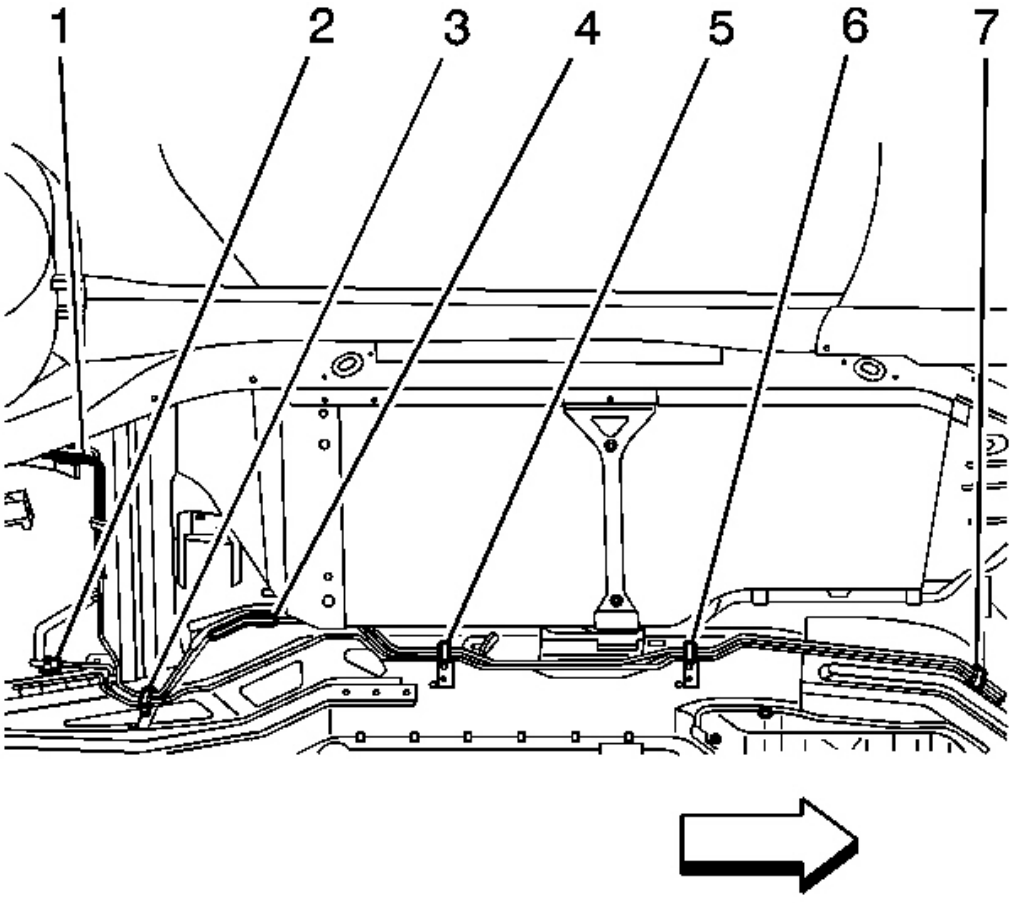


Fig. 60: Identifying Underbody Retainers
Courtesy of GENERAL MOTORS CORP.

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the right side muffler assembly. Refer to **Muffler Replacement - Right Side**.
3. Remove the intermediate exhaust pipe assembly. Refer to **Intermediate Pipe Replacement**.
4. Disconnect the vacuum line quick connect fitting (2) located on the left side of the vehicle forward of the rear drive module. Refer to **Plastic Collar Quick Connect Fitting Service** .

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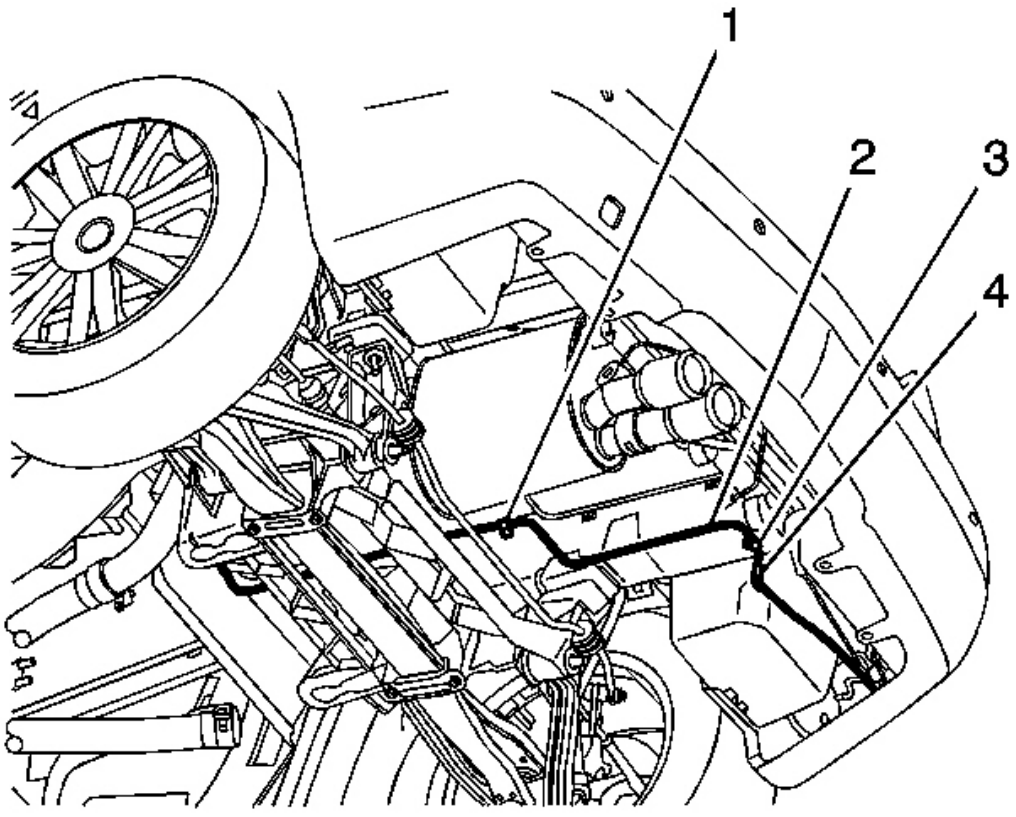


Fig. 61: View Of Retainer Straps & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the bolts from the retainer straps (1, 3) along the length of the rear chassis vacuum line.
6. Disconnect the rear chassis vacuum line quick connect fitting (4). Refer to **Plastic Collar Quick Connect Fitting Service** .
7. Remove the rear chassis vacuum line (2) from the vehicle.

Installation Procedure

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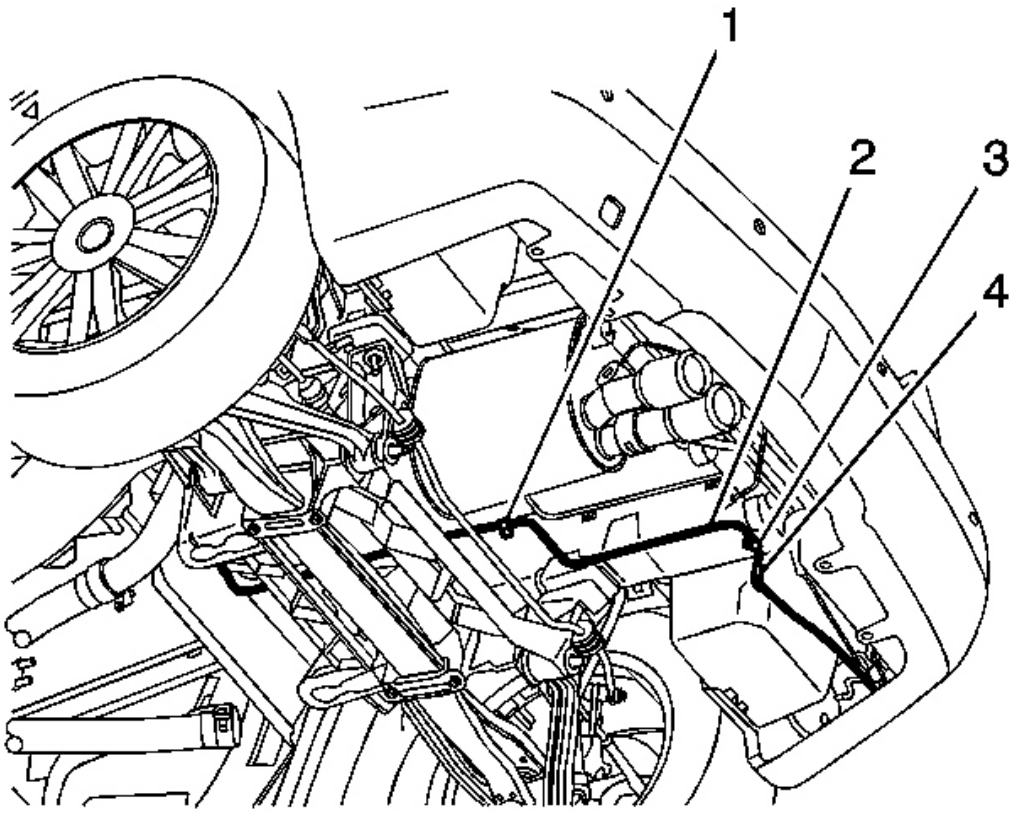


Fig. 62: View Of Retainer Straps & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the vacuum line (2) to the vehicle.
2. Connect the rear chassis vacuum line quick connect fitting (4). Refer to **Plastic Collar Quick Connect Fitting Service** .

NOTE: **Refer to Fastener Notice .**

3. Install the bolts to the retainer straps (1,3) along the length of the rear chassis vacuum line.

Tighten: Tighten the vacuum line strap bolts to 10 N.m (89 lb in).

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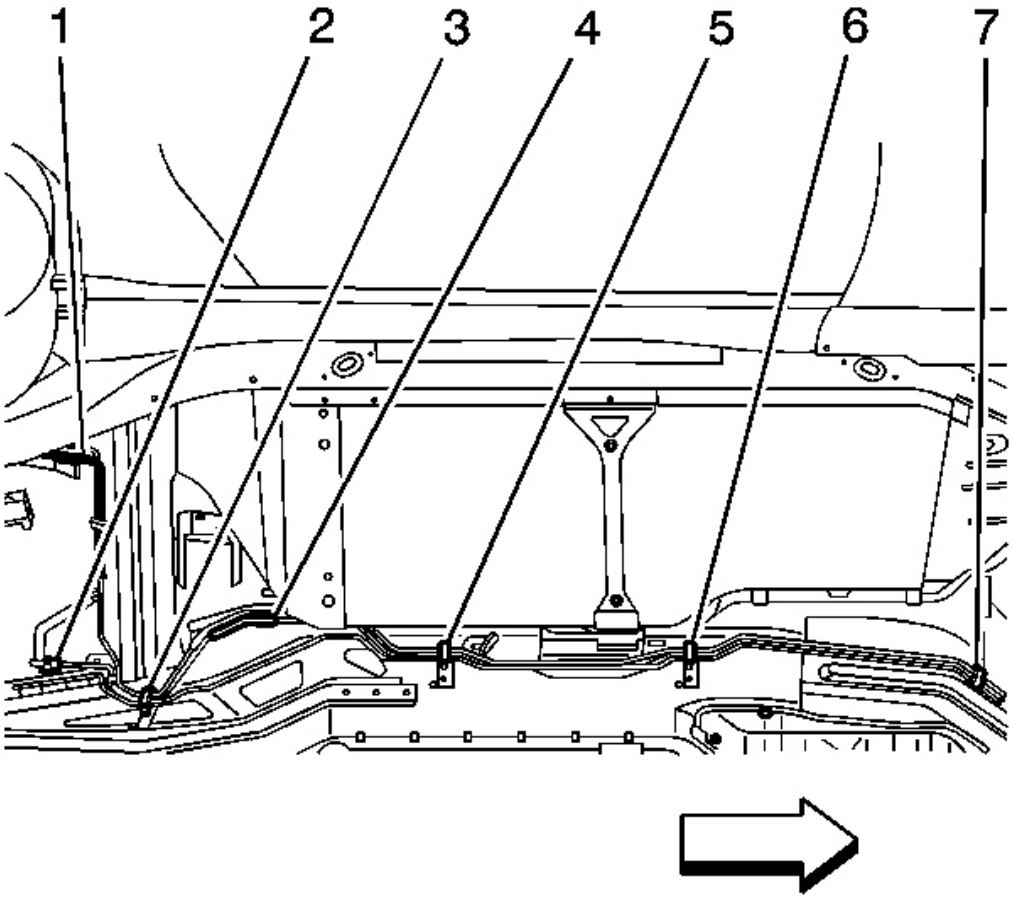


Fig. 63: Identifying Underbody Retainers
Courtesy of GENERAL MOTORS CORP.

4. Connect the vacuum line quick connect fitting (2) located on the left side of the vehicle forward of the rear drive module. Refer to **Plastic Collar Quick Connect Fitting Service** .
5. Install the intermediate exhaust pipe assembly. Refer to **Intermediate Pipe Replacement**.
6. Install the right side muffler assembly. Refer to **Muffler Replacement - Right Side**.
7. Lower the vehicle.

EXHAUST TAIL PIPE FLOW VALVE VACUUM PIPE REPLACEMENT - RESERVOIR TANK TO VALVE SOLENOID

Removal Procedure

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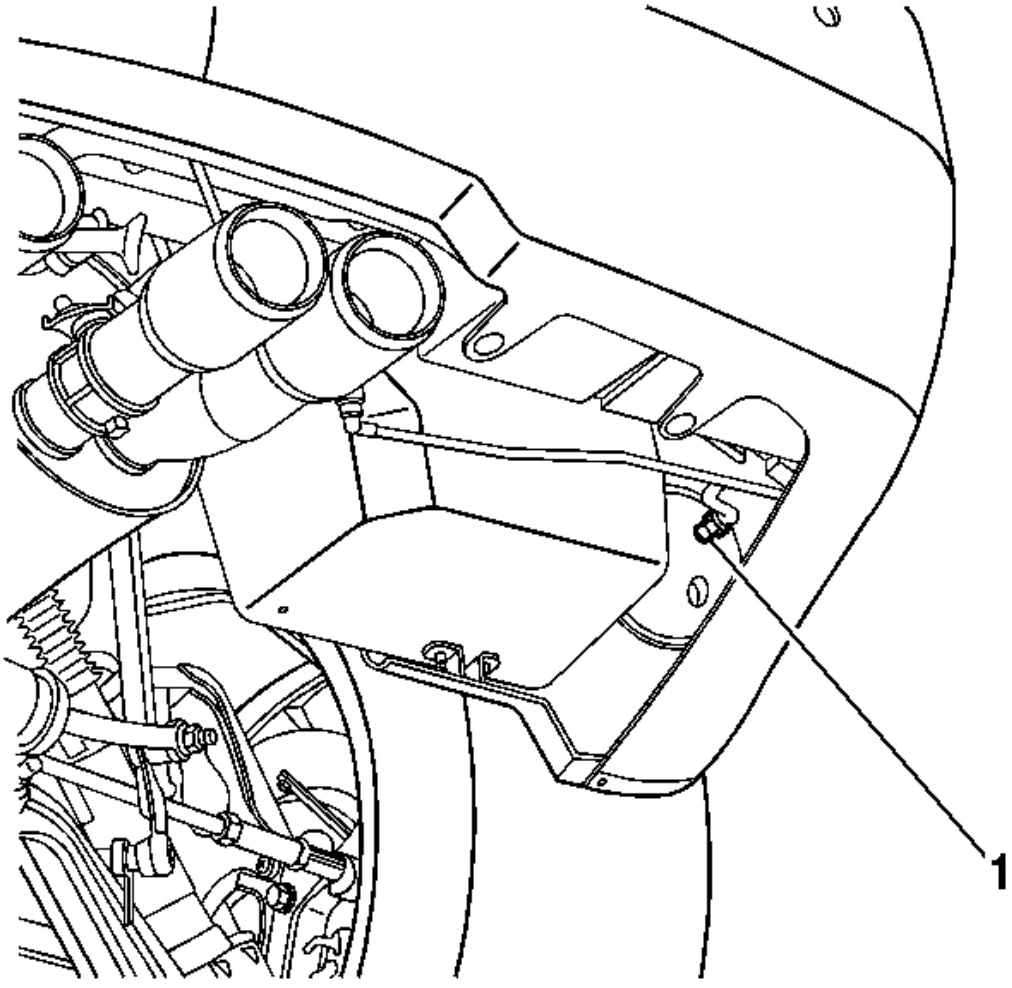


Fig. 64: Identifying Vacuum Pipe & Reservoir Tank
Courtesy of GENERAL MOTORS CORP.

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Disconnect the vacuum line fitting (1) from the flow control valve vacuum tank.

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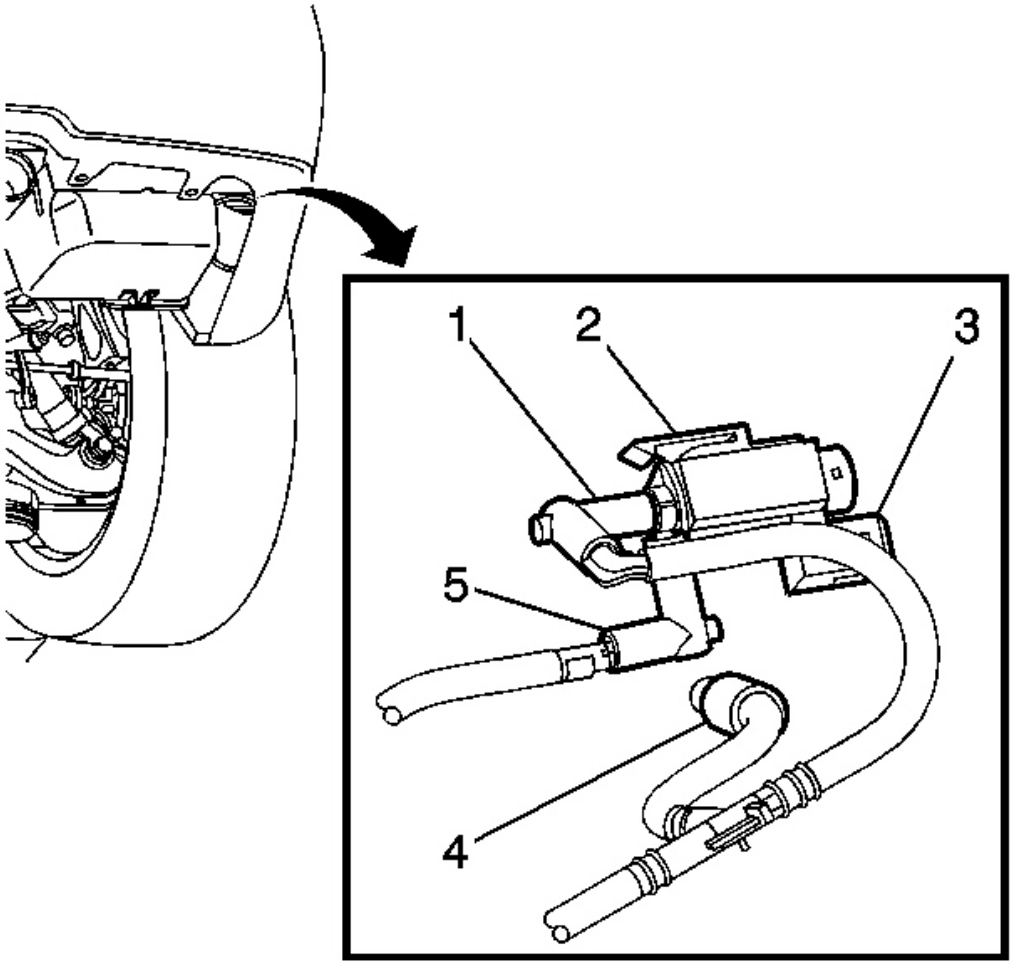


Fig. 65: Identifying Flow Control Valve Solenoid
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the vacuum line fitting (1) from the flow control valve solenoid.

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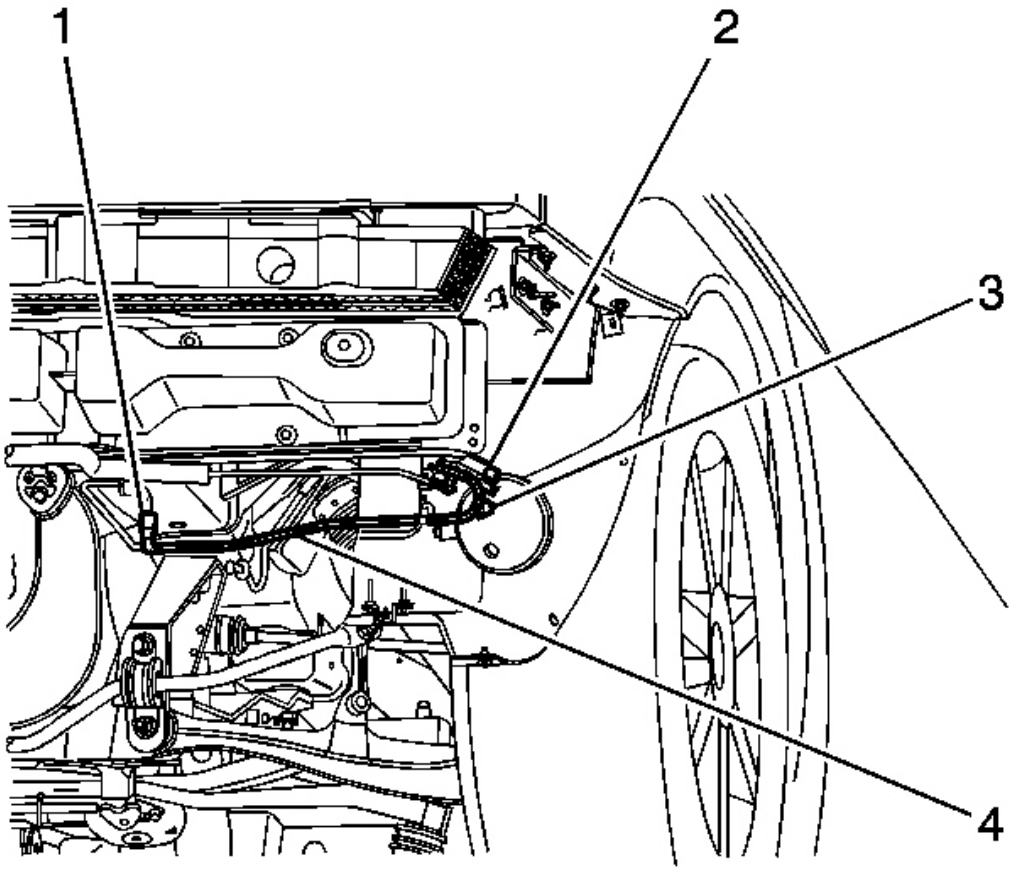


Fig. 66: Identifying Vacuum Line Fitting
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the vacuum line fitting (1) from the rear chassis vacuum line. Refer to **Plastic Collar Quick Connect Fitting Service** .
5. Remove the vacuum line from the vehicle.

Installation Procedure

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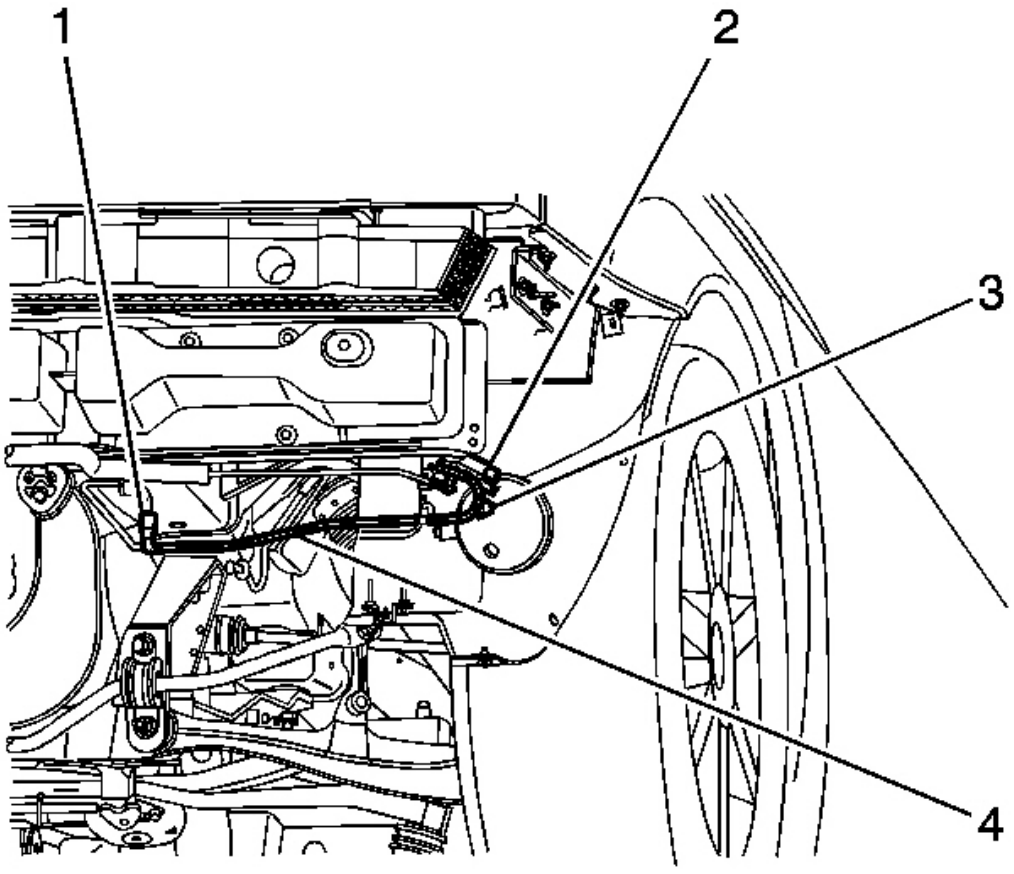


Fig. 67: Identifying Vacuum Line Fitting
Courtesy of GENERAL MOTORS CORP.

1. Install the vacuum line to the vehicle.
2. Connect the vacuum line quick connect fitting (1). Refer to **Plastic Collar Quick Connect Fitting Service** .

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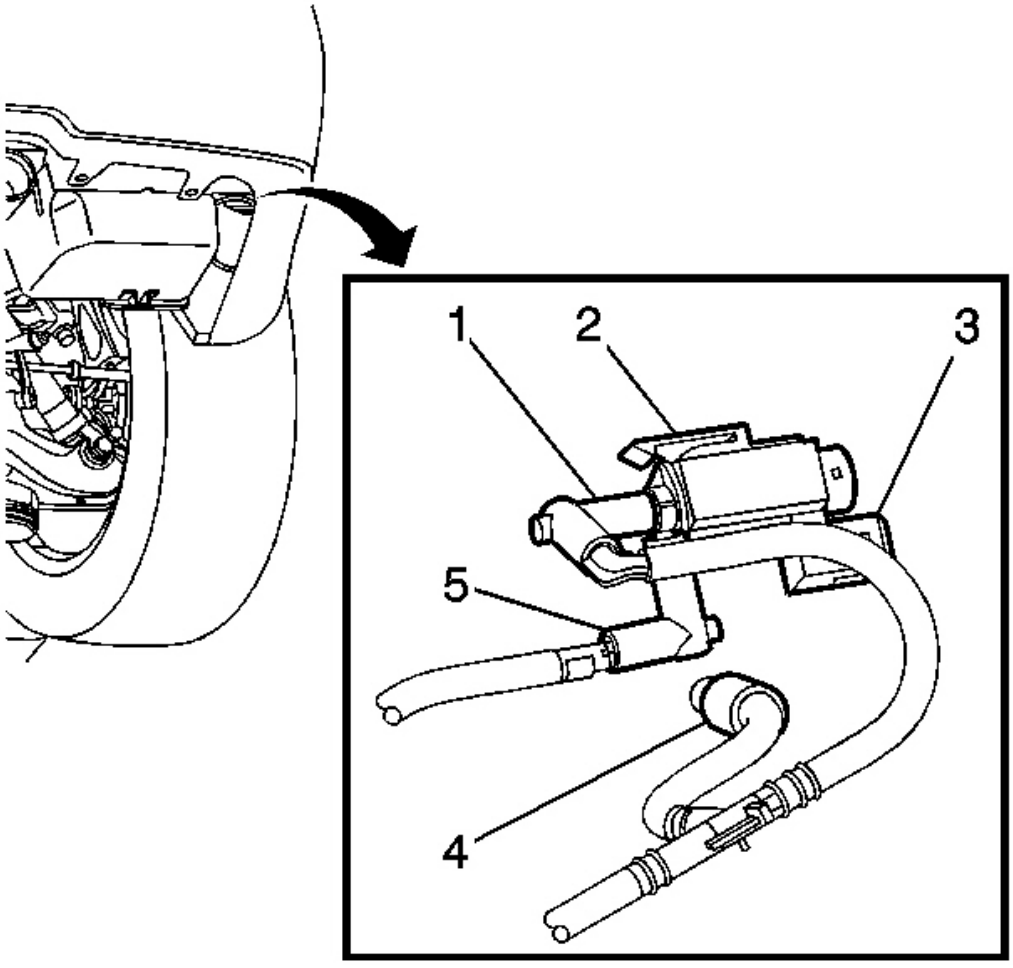


Fig. 68: Identifying Flow Control Valve Solenoid
Courtesy of GENERAL MOTORS CORP.

3. Connect the vacuum line fitting (1) to the flow control valve solenoid.

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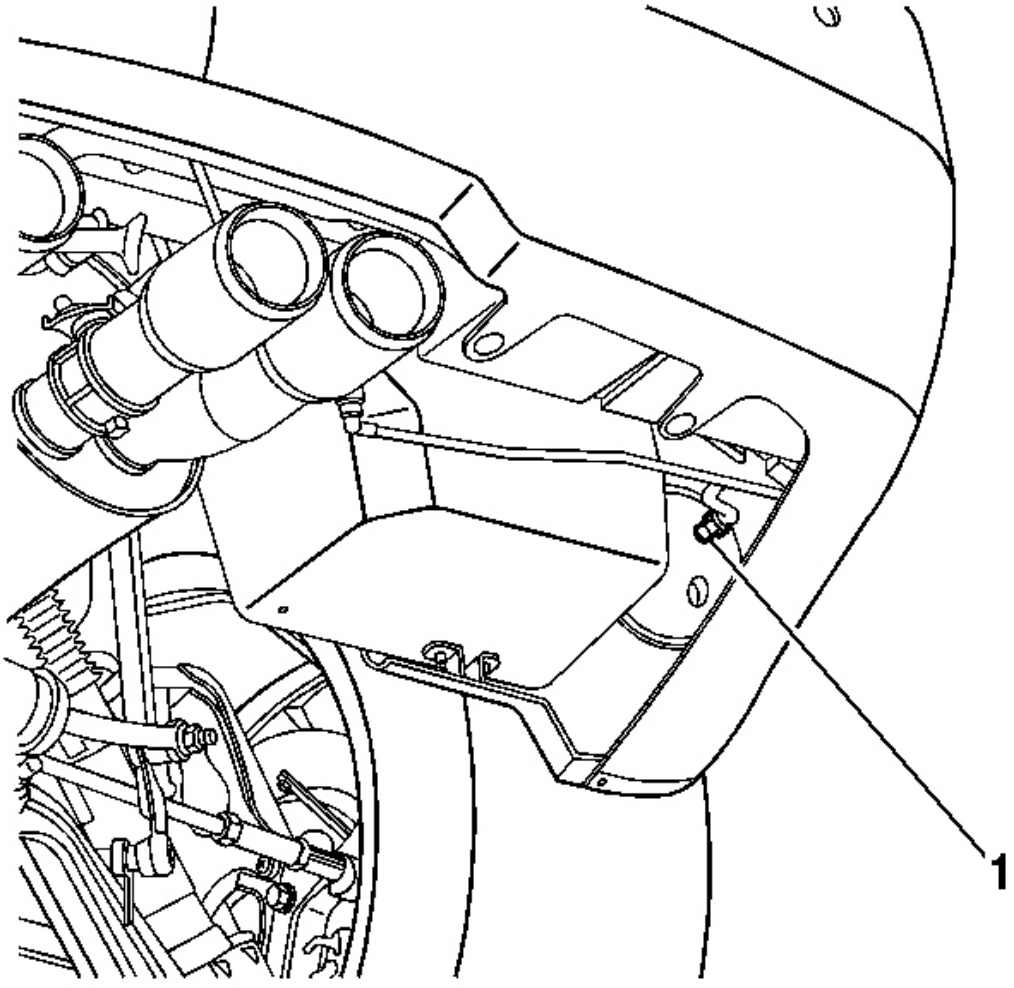


Fig. 69: Identifying Vacuum Pipe & Reservoir Tank
Courtesy of GENERAL MOTORS CORP.

4. Connect the vacuum line fitting (1) to the flow control valve vacuum tank.
5. Lower the vehicle.

EXHAUST TAIL PIPE FLOW VALVE VACUUM PIPE REPLACEMENT - VALVE SOLENOID TO CONTROL VALVES

Removal Procedure

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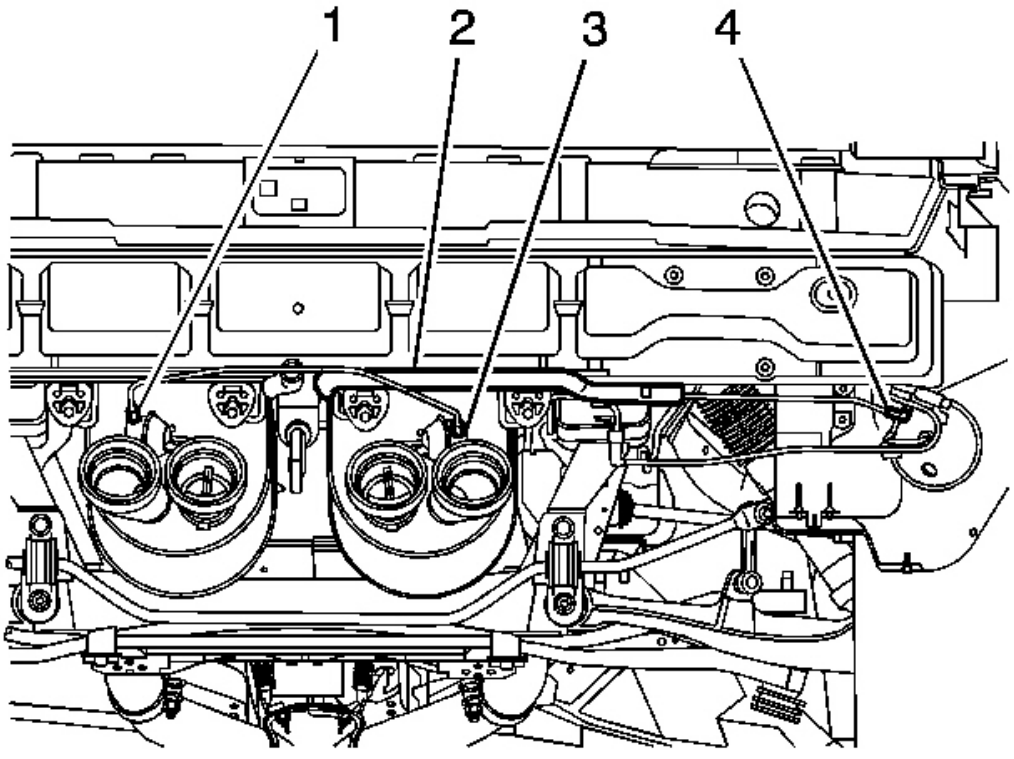


Fig. 70: Locating Flow Control Valve Vacuum Line Fittings
Courtesy of GENERAL MOTORS CORP.

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Disconnect the vacuum line fitting (4) from the flow control valve solenoid. The graphic shows the rear fascia removed for clarity.
3. Disconnect the vacuum line fittings (1 and 3) from the flow control valves.
4. Disengage the retainer clips along the length of the vacuum line (2).
5. Remove the vacuum line from the vehicle.

Installation Procedure

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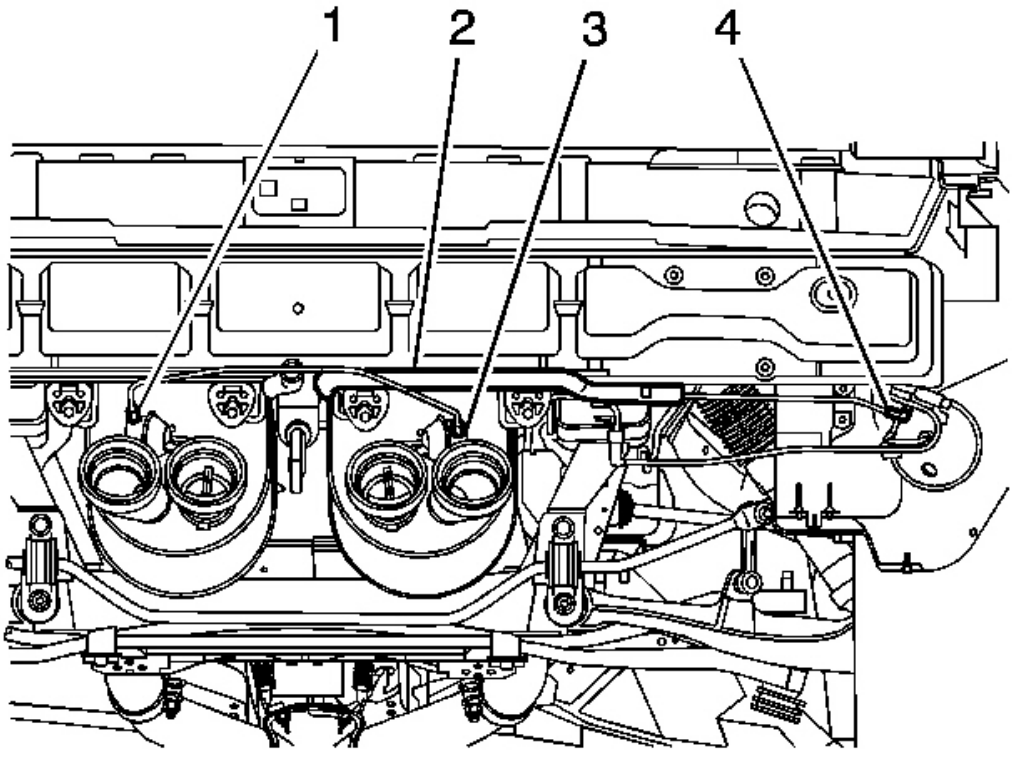


Fig. 71: Locating Flow Control Valve Vacuum Line Fittings
Courtesy of GENERAL MOTORS CORP.

1. Install the vacuum line to the vehicle.
2. Install the retainer clips along the length of the vacuum line (2).
3. Connect the vacuum line fittings (1 and 3) to the flow control valves.
4. Connect the vacuum line fitting (4) to the flow control valve solenoid.
5. Lower the vehicle.

EXHAUST TAIL PIPE FLOW CONTROL VALVE SOLENOID REPLACEMENT

Removal Procedure

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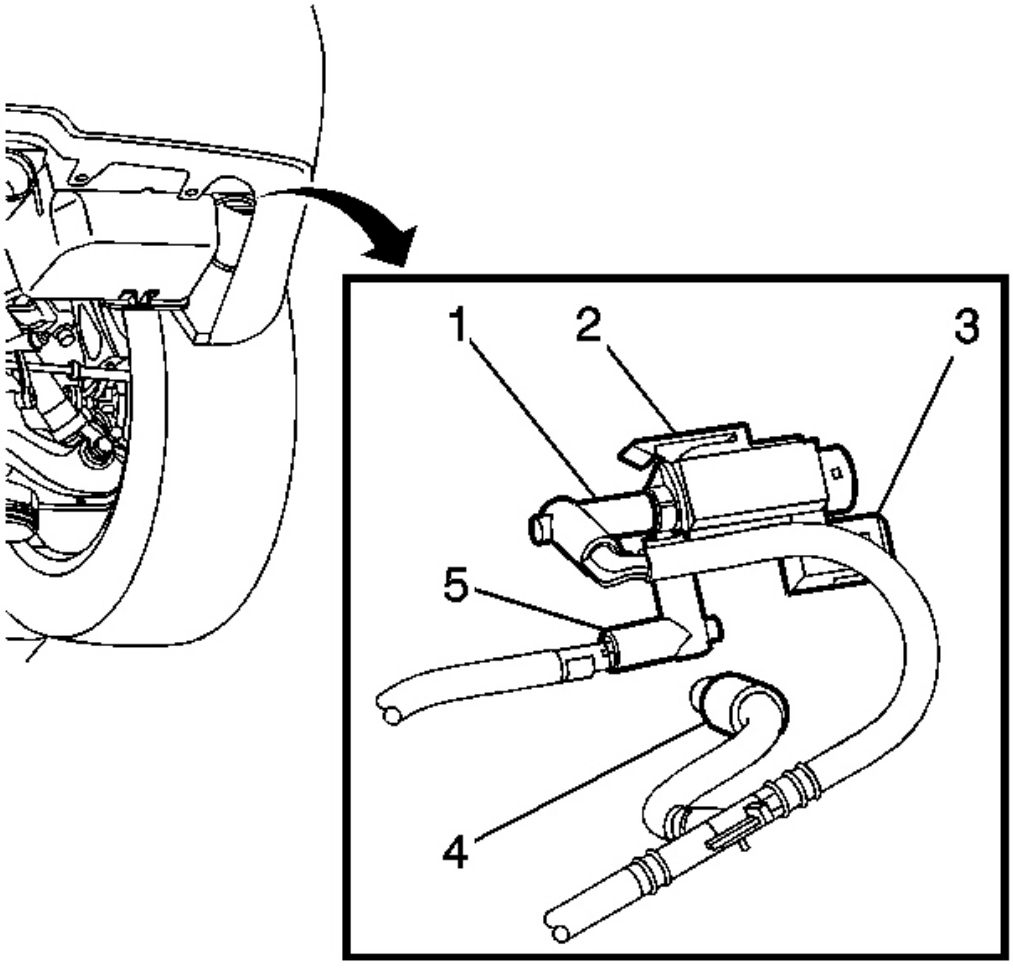


Fig. 72: Identifying Flow Control Valve Solenoid
Courtesy of GENERAL MOTORS CORP.

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Disconnect the solenoid electrical connector (3).
3. Disconnect the vacuum line fittings (1 and 5) from the solenoid.
4. Remove the solenoid (2) from the solenoid bracket.

Installation Procedure

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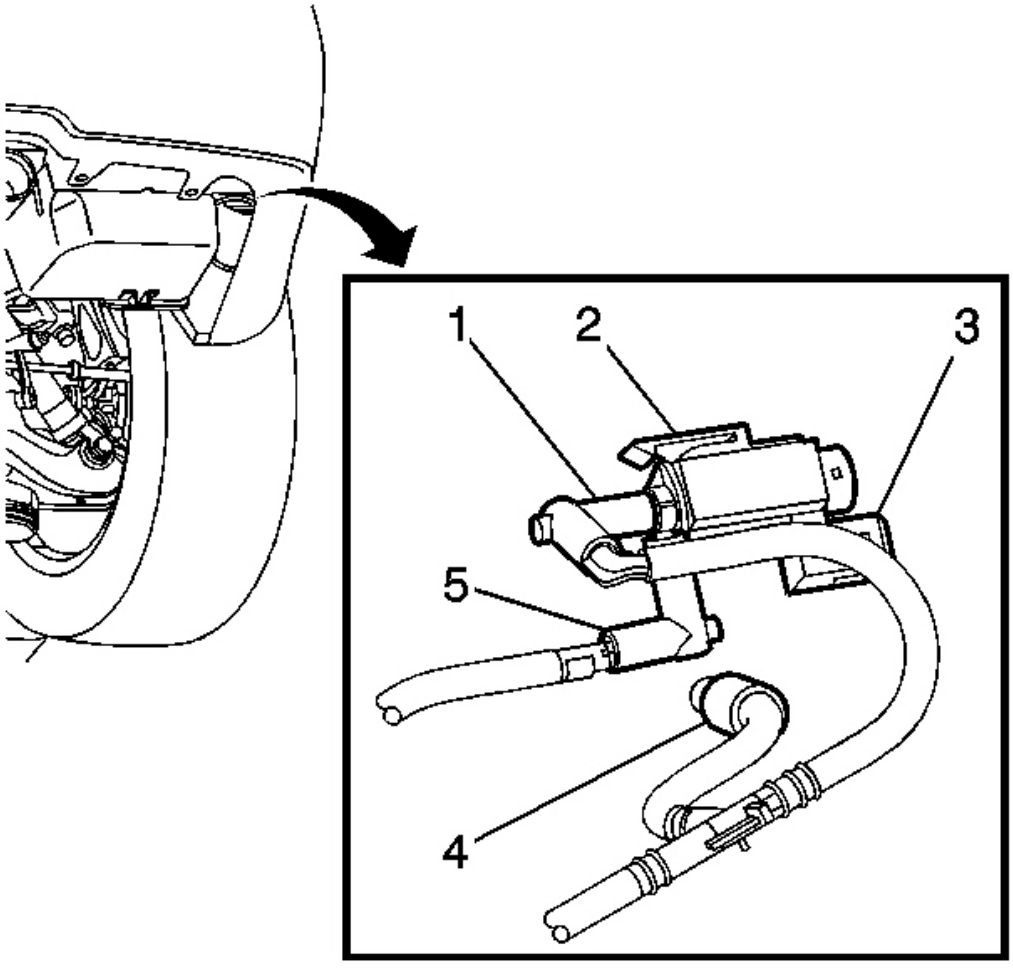


Fig. 73: Identifying Flow Control Valve Solenoid
Courtesy of GENERAL MOTORS CORP.

1. Install the solenoid (2) to the solenoid bracket.
2. Connect the vacuum line fittings (1 and 5) to the solenoid.
3. Connect the solenoid electrical connector (3).
4. Lower the vehicle.

EXHAUST TAIL PIPE FLOW VALVE CONTROL MODULE REPLACEMENT

Removal Procedure

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1. Remove the battery.

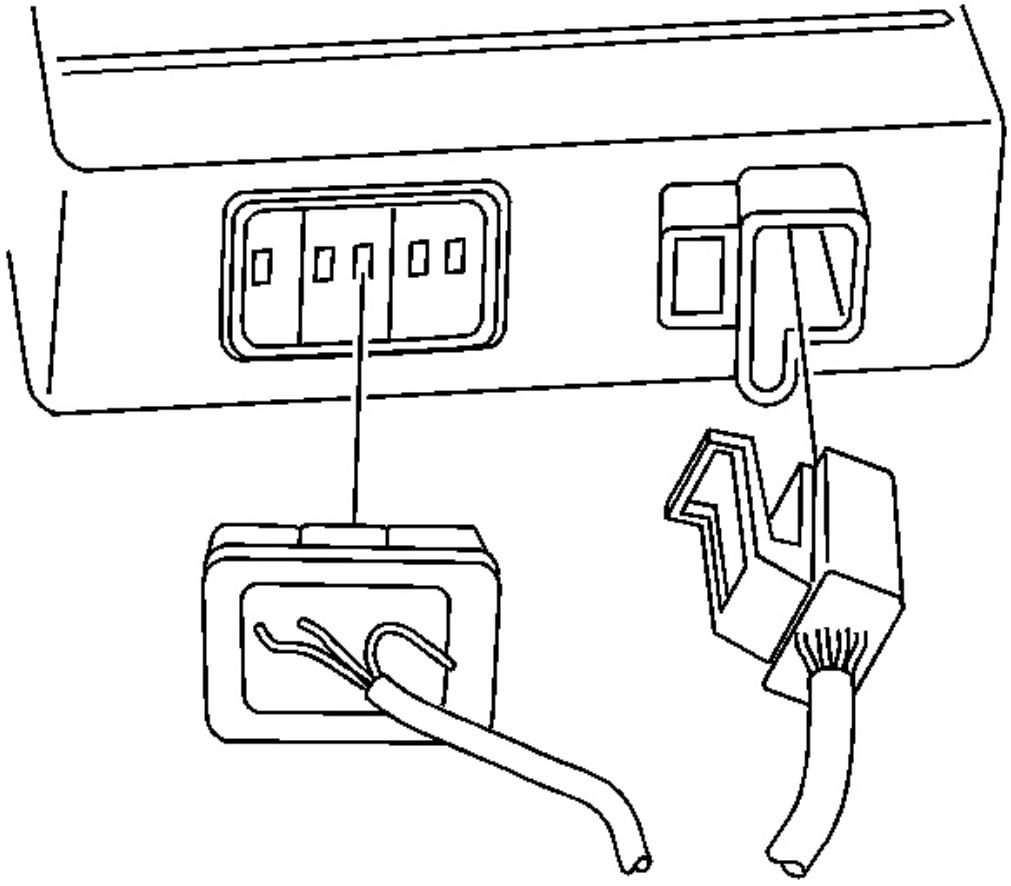


Fig. 74: Identifying Exhaust Tail Pipe Flow Valve Control Module Connector
Courtesy of GENERAL MOTORS CORP.

2. Disconnect both electrical connectors.
3. Detach the exhaust tail pipe flow valve control module by pulling off two-sided tape.

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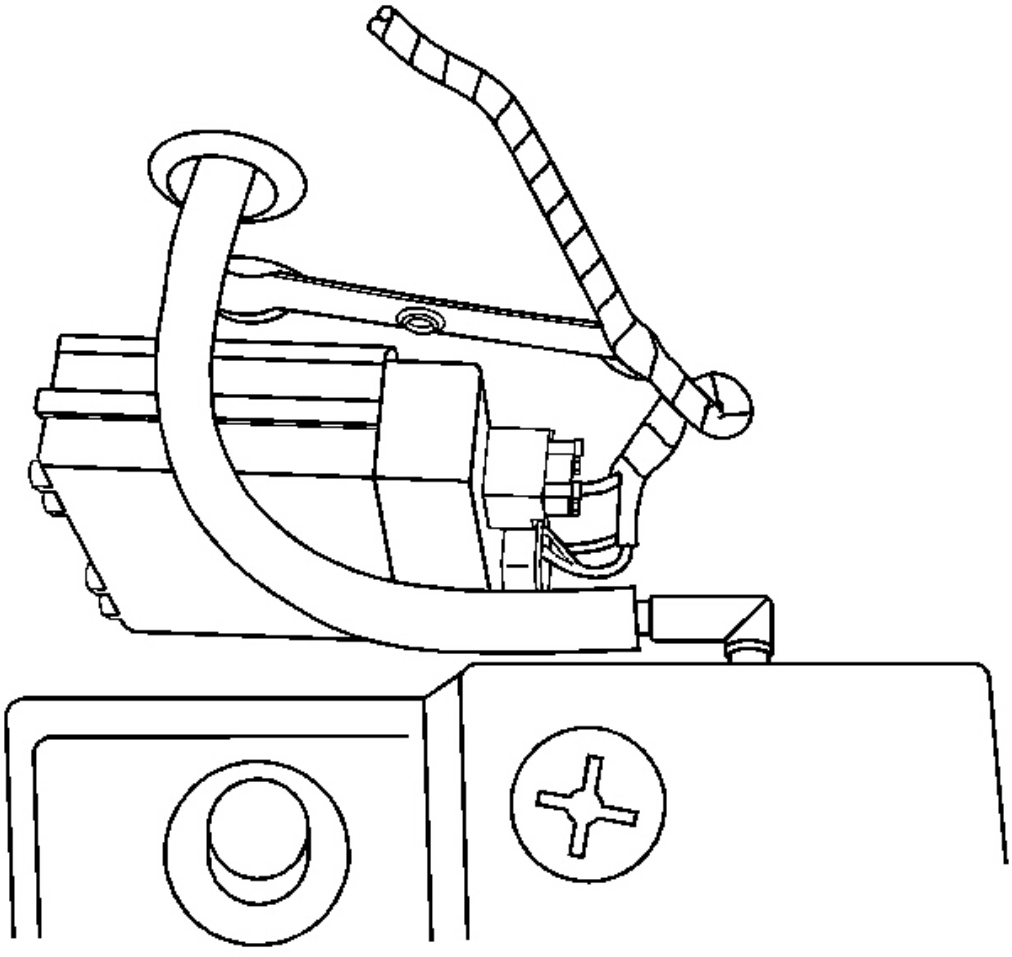


Fig. 75: Identifying Exhaust Tail Pipe Flow Valve Control Module
Courtesy of GENERAL MOTORS CORP.

4. Remove the exhaust tail pipe flow valve control module.

Installation Procedure

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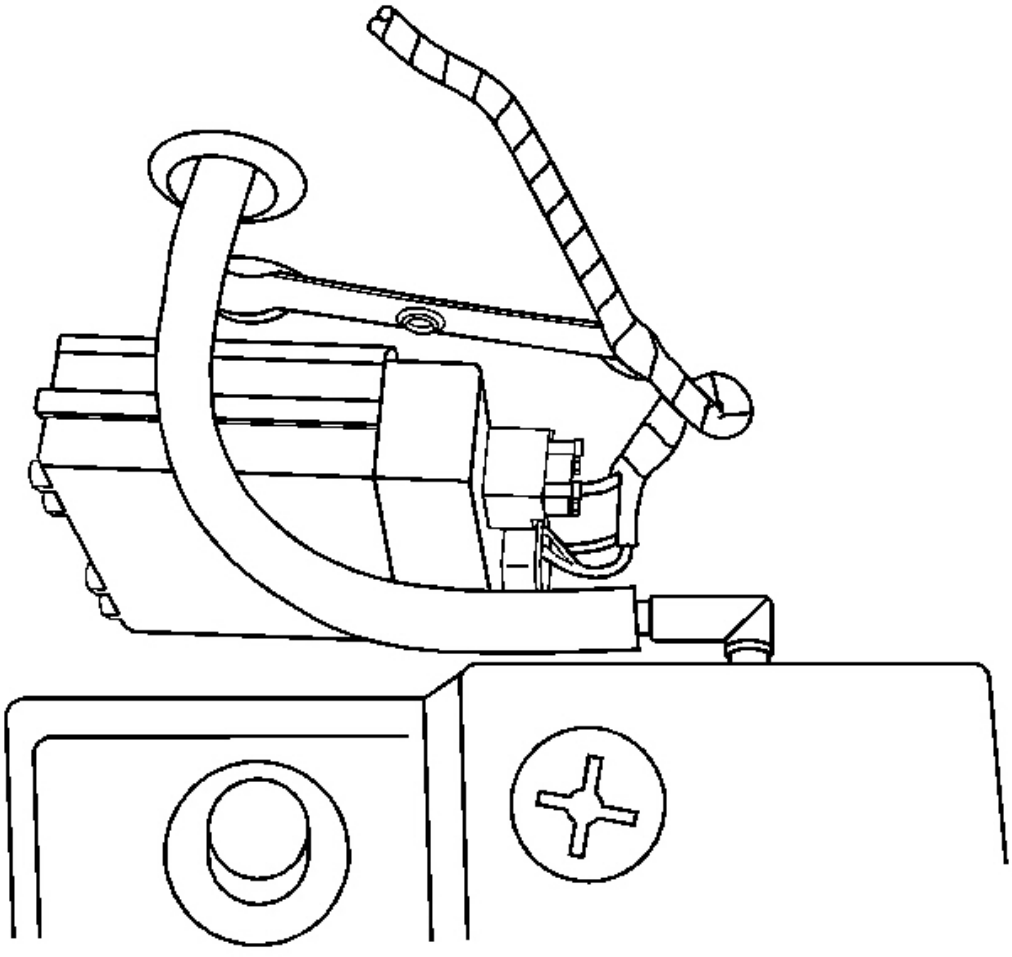


Fig. 76: Identifying Exhaust Tail Pipe Flow Valve Control Module
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust tail pipe flow valve control module.
2. Attach the exhaust tail pipe flow valve control module using a new piece of two-sided tape.

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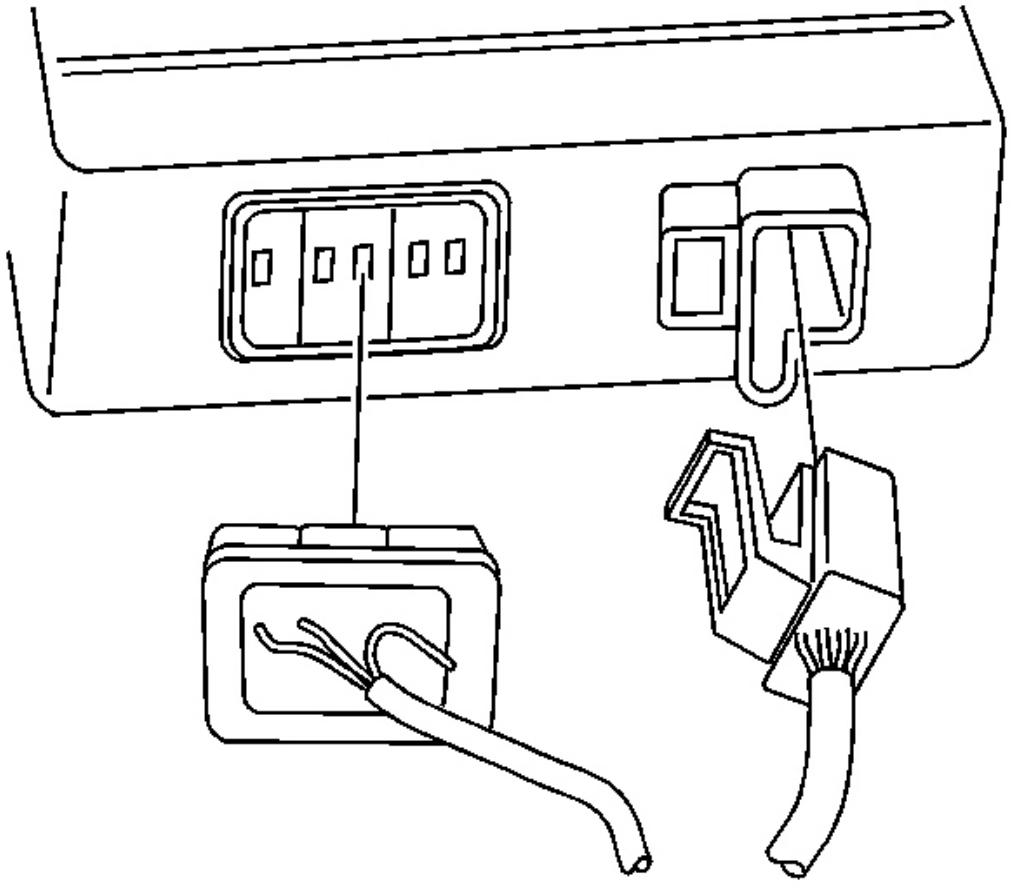


Fig. 77: Identifying Exhaust Tail Pipe Flow Valve Control Module Connector
Courtesy of GENERAL MOTORS CORP.

3. Connect both electrical connectors.
4. Install the battery.
5. Refer to **Control Module References** for programming and setup information.

EXHAUST MUFFLER INSULATOR, HANGER AND BRACKET REPLACEMENT

Removal Procedure

1. Remove the muffler. Refer to **Muffler Replacement - Left Side** or **Muffler Replacement - Right Side**.

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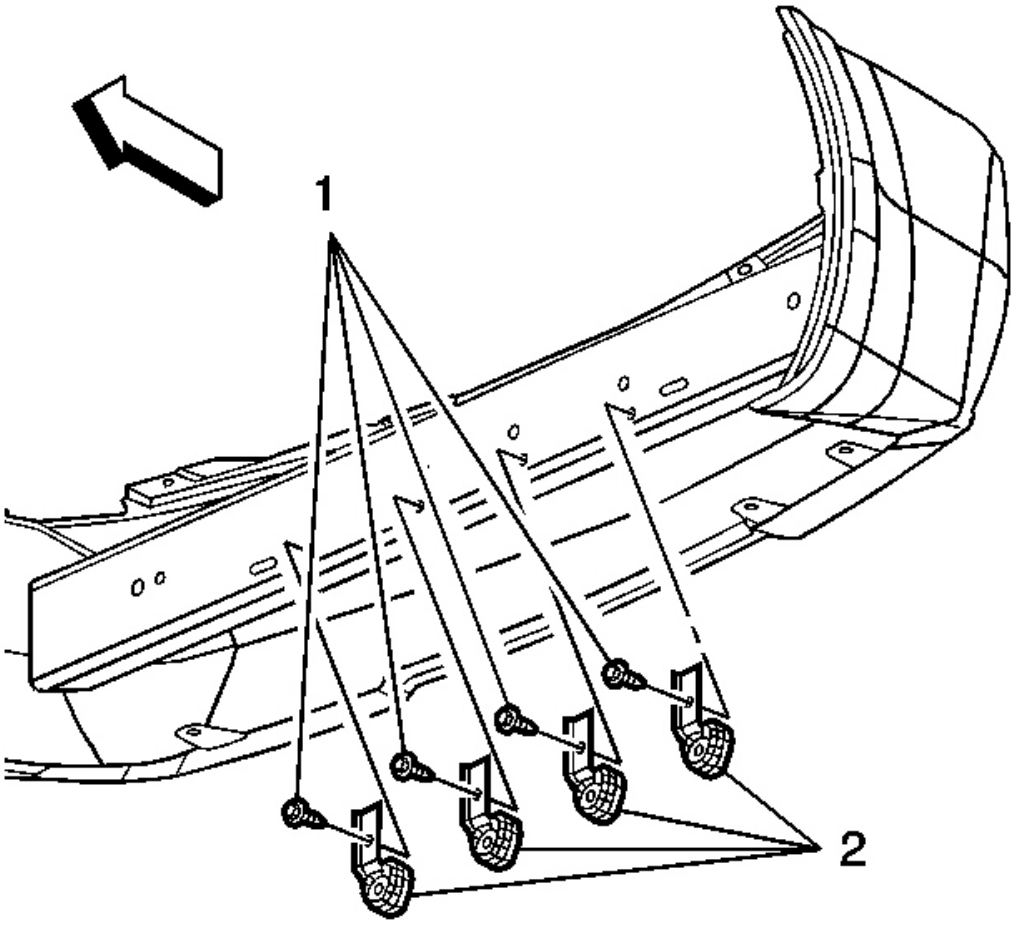


Fig. 78: View Of Muffler Hangers
Courtesy of GENERAL MOTORS CORP.

2. Remove the muffler hanger bolt and hanger.
3. Remove the hanger.

Installation Procedure

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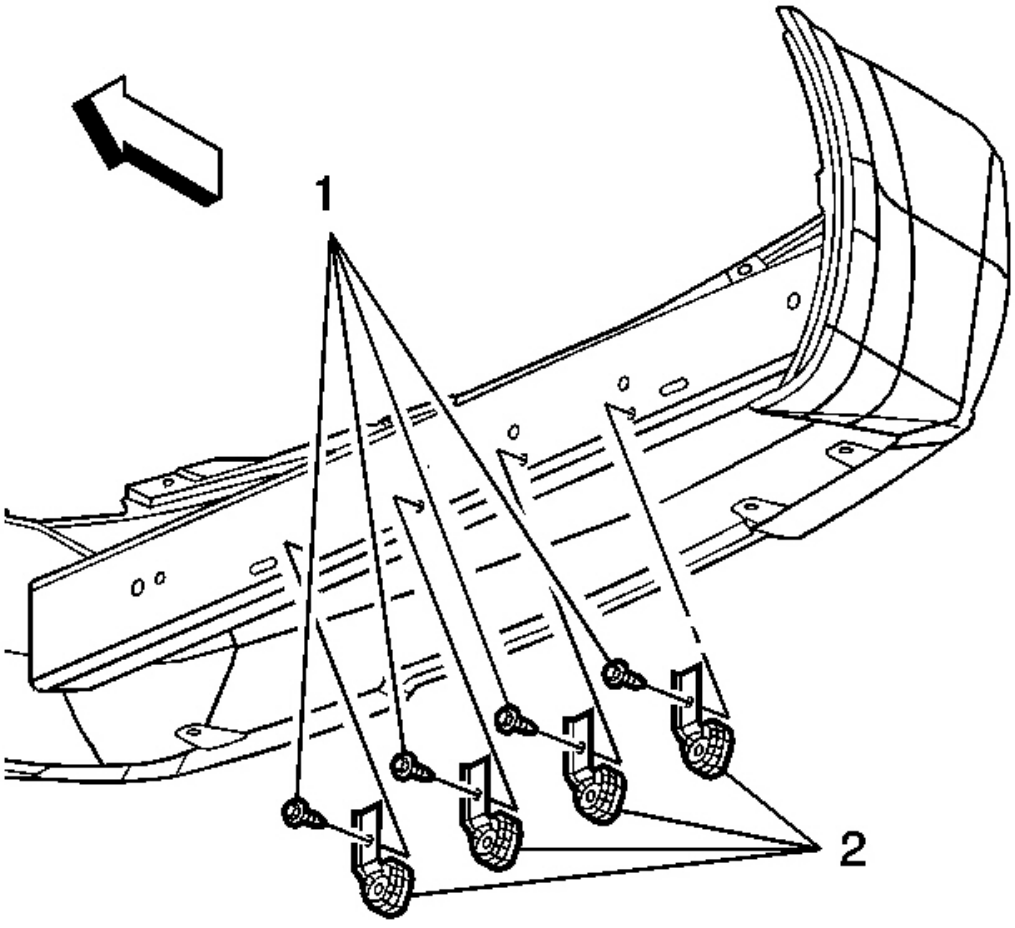


Fig. 79: View Of Muffler Hangers
Courtesy of GENERAL MOTORS CORP.

1. Install the hanger.

   NOTE: Refer to Fastener Notice.

2. Install the muffler hanger and bolt.

   Tighten: Tighten the muffler hanger nuts to 16 N.m (12 lb ft).

3. Install the muffler. Refer to **Muffler Replacement - Left Side** or **Muffler Replacement - Right Side**.

EXHAUST HEAT SHIELD REPLACEMENT

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Removal Procedure

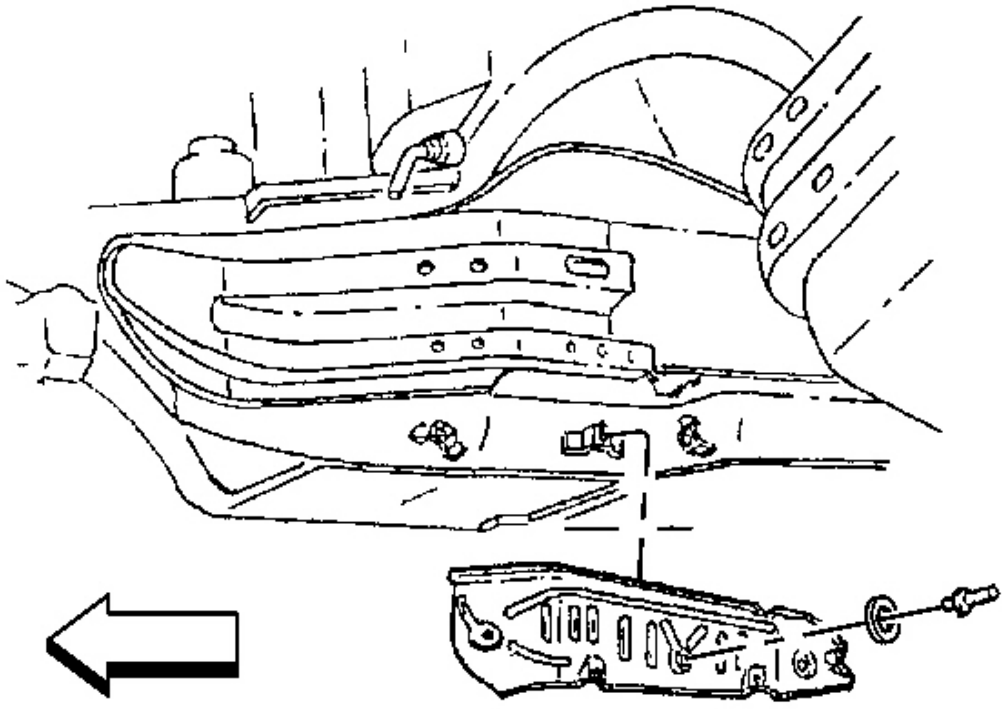


Fig. 80: View Of Exhaust Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the intermediate pipe. Refer to **Intermediate Pipe Replacement**.
2. Drill out the exhaust heat shield rivets.
3. Remove the exhaust heat shield.

Installation Procedure

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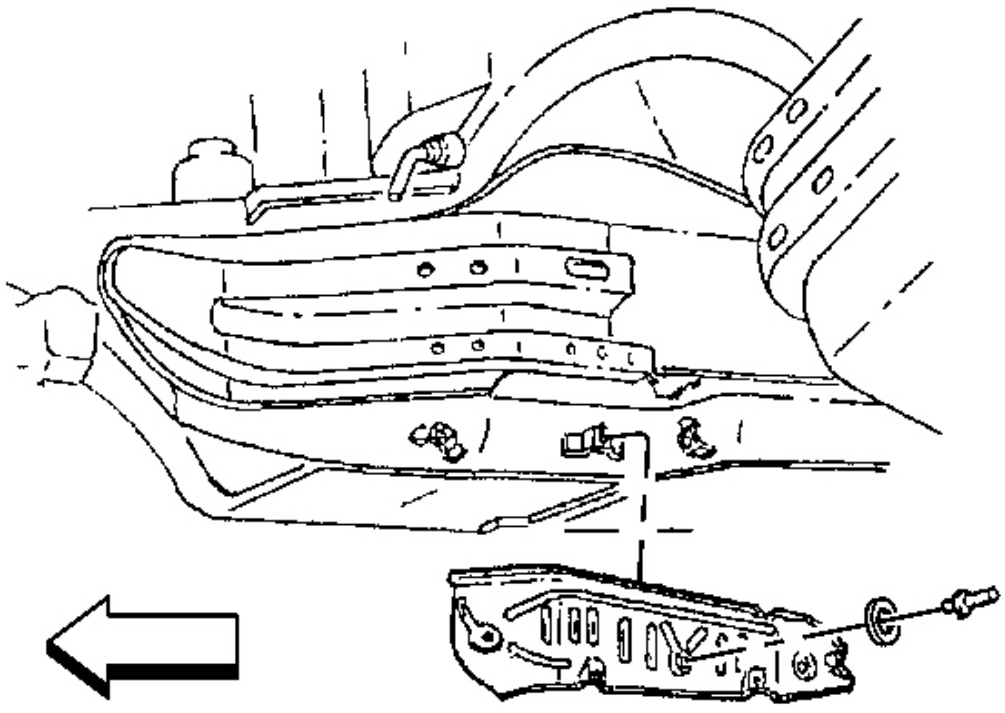


Fig. 81: View Of Exhaust Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust heat shield.
2. Install new exhaust heat shield rivets.
3. Install the intermediate pipe. Refer to **Intermediate Pipe Replacement**.

EXHAUST MUFFLER HEAT SHIELD REPLACEMENT

Removal Procedure

1. Remove the left and right muffler. Refer to **Muffler Replacement - Left Side** and **Muffler Replacement - Right Side**.
2. Drill out the muffler heat shield rivets.
3. Remove the heat shield washers and shield.

Installation Procedure

1. Install the heat shield and washers.

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2. Install new heat shield rivets.
3. Install the left and right muffler. Refer to **Muffler Replacement - Left Side** and**Muffler Replacement - Right Side**.

DESCRIPTION AND OPERATION

EXHAUST SYSTEM DESCRIPTION

IMPORTANT: Use of non-OEM parts may cause driveability concerns.

The exhaust system carries exhaust gases, treated by the catalytic converter, through a resonator, if applicable and into the exhaust muffler where exhaust noise is less.

In order to secure the exhaust pipe to the exhaust manifold, a flange and seal-joint coupling is utilized. The exhaust system may utilize a slip-joint coupling design with a clamp and a U-bolt or a flange connection with a gasket.

Exhaust hangers and rubber insulators help to support the weight of the exhaust pipe along with insulating any exhaust system vibration, rattle or noise.

Exhaust hangers also space the exhaust system away from the underbody of the vehicle and allows the exhaust system to expand as the exhaust system warms up.

Exhaust heat shields are used to protect the body and other components from damage due to the heat from the exhaust system.

The exhaust system may be comprised of the following components:

- Exhaust manifold
- Exhaust pipes
- Catalytic converters
- Exhaust muffler
- Exhaust resonator, if equipped
- Exhaust tail pipe, if equipped
- Exhaust hangers
- Exhaust heat shields

Resonator

Some exhaust systems are equipped with a resonator. The resonator, located either before or after the muffler, allows the use of mufflers with less back pressure. Resonators are used when vehicle characteristics require specific exhaust tuning.

Catalytic Converter

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The catalytic converter is an emission control device added to the engine exhaust system in order to reduce hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOx) pollutants from the exhaust gas.

The catalytic converter is comprised of a ceramic monolith substrate, supported in insulation and housed within a sheet metal shell. The substrate may be washcoated with 3 noble metals:

- Platinum (Pt)
- Palladium (Pd)
- Rhodium (Rh)

The catalyst in the converter is not serviceable.

Muffler

The exhaust muffler reduces the noise levels of the engine exhaust by the use of tuning tubes. The tuning tubes create channels inside the exhaust muffler that lower the sound levels created by the combustion of the engine.

EXHAUST TAIL PIPE FLOW CONTROL SYSTEM DESCRIPTION AND OPERATION

The Exhaust Flow Control (EFC) System enhances engine performance. The system has 2 modes of operation:

- Normal
- Competition

Normal Mode

When the vehicle is stationary with the engine running the exhaust flow control module (EFCM) commands the vacuum solenoid On, which supplies engine vacuum to both exhaust flow control valves. This causes the valves to close, diverting exhaust flow through a baffled path inside the mufflers. As vehicle speed increases, throttle position reaches 25 percent or greater and engine speed reaches 3500 RPM, the EFCM commands the vacuum solenoid off. This causes the valves to open, diverting exhaust flow through an un-baffled path inside the mufflers, thus enhancing engine performance.

Competition Mode

When traction control is driver disabled, vehicle speed increases, throttle position reaches 25 percent or greater and engine speed reaches 3000 RPM, the EFCM commands the vacuum solenoid off. This causes the valves to open; diverting exhaust flow through an un-baffled path inside the mufflers more frequently and at lower engine speeds.

The system also delays exhaust valve activity during wide-open throttle acceleration to inhibit exhaust valve actuation when the accelerator pedal is released and reapplied while shifting gears.

The EFCM has the ability to detect electrical malfunctions within the system. Any electrical malfunction detected will cause the system to be disabled and increased exhaust audibility.

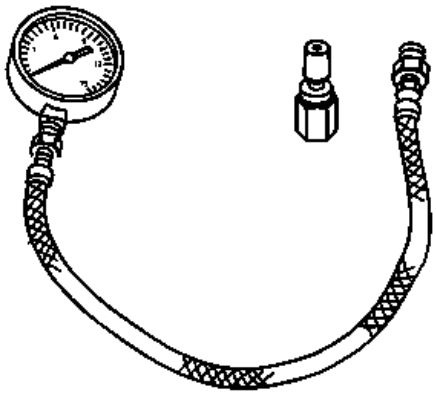
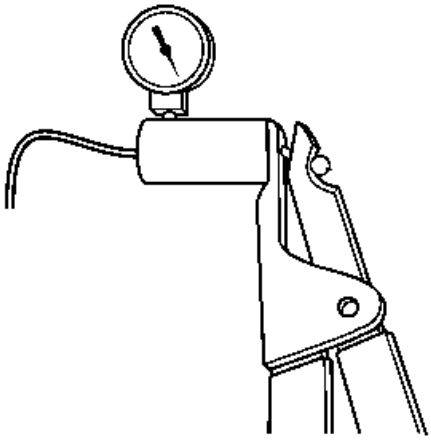
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The system uses the engine control module (ECM), body control module (BCM), electronic brake control module (EBCM), EFCM, exhaust flow control valve vacuum solenoid, vacuum reservoir, vacuum lines, 2 exhaust flow control valves and the serial data circuit to perform the system functions.

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Special Tools

Illustration	Tool Number/Description
	J 35314-A Exhaust Back Pressure Gage
	J 35555 Metal Mityvac

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2007 ENGINE

Engine Mechanical - 4.4L - XLR

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
A/C Compressor Bolt	25 N.m	18 lb ft
A/C Compressor and Power Steering Bracket Bolt	50 N.m	37 lb ft
A/C Drive Belt Tensioner Bolt	25 N.m	18 lb ft
Bell Housing Bolt	50 N.m	37 lb ft
Block Coolant Drain Hole Plug	20 N.m	15 lb ft
Camshaft Bearing Cap Bolt		
• First Pass	5 N.m	44 lb in
• Final Pass	30 degrees	
Camshaft Cover Bolt	10 N.m	89 lb in
Camshaft Cover Ground Strap		
• Camshaft Cover Bolt	10 N.m	89 lb in
• Cylinder Head Bolt	25 N.m	18 lb ft
Camshaft Intermediate Drive Shaft		
• Bolt	15 N.m	11 lb ft
• Sprocket Bolt	60 N.m	44 lb ft
Camshaft Position Actuator Bolt	120 N.m	89 lb ft
Camshaft Position Actuator Housing Bolt	10 N.m	89 lb in
Camshaft Position Actuator Magnet Bolt	8 N.m	71 lb in
Camshaft Position Sensor Bolt	10 N.m	89 lb in
Charge Air Bypass Regulator Solenoid Valve Bracket Bolt	10 N.m	89 lb in
Charge Air Cooler		
• Bolt - Long	10 N.m	89 lb in
• Bolt - Short	10 N.m	89 lb in
• Coolant Front Manifold Bolt	25 N.m	18 lb ft
• Cooling Fill Cap Bolt	10 N.m	89 lb in
• Front and Rear Manifold Bolt	10 N.m	89 lb in
Connecting Rod Bolt		
	30 N.m	22 lb ft

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• First Pass		
• Second Pass	Back off to zero	
• Third Pass	25 N.m	18 lb ft
• Final Pass	110 degrees	
Crankshaft Position Sensor and Knock Sensor Wiring Harness Bracket Bolt	10 N.m	89 lb in
Crankshaft Position Sensor Bolt	10 N.m	89 lb in
Crankshaft Balancer Bolt		
• First Pass	100 N.m	74 lb ft
• Final Pass	150 degrees	
Cylinder Head Bolt		
• M11		
• First Pass - In Sequence	30 N.m	22 lb ft
• Second Pass - In Sequence	60 degrees	
• Third Pass - In Sequence	60 degrees	
• Fourth Pass - In Sequence	60 degrees	
• Final Pass - In Sequence	40 degrees, 220 degrees total	
• M6	12 N.m	106 lb in
Cylinder Head Core Hole Threaded Plug	80 N.m	60 lb ft
Cylinder Head Oil Gallery Threaded Plug	60 N.m	44 lb ft
Drive Belt		
• A/C Compressor and Power Steering Pump Tensioner Bolt	25 N.m	18 lb ft
• Generator Tensioner Bolt	50 N.m	37 lb ft
• Idler Bolt	50 N.m	37 lb ft
• Idler Nut	50 N.m	37 lb ft
• Supercharger Tensioner Bolt	50 N.m	37 lb ft
Engine Block Coolant Drain Plug	20 N.m	15 lb ft
Engine Coolant Temperature (ECT) Sensor	20 N.m	15 lb ft
Engine Flywheel Bolt		
• First Pass	30 N.m	22 lb ft
• Final Pass	50 degrees	
Engine Front Cover Bolt	15 N.m	11 lb ft
Engine Mount Bracket Bolt	58 N.m	43 lb ft
Engine Mount Nut	58 N.m	43 lb ft
Engine Wiring Harness		

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• Front Clip Nut to Left Side Engine Mount Bracket Stud	35 N.m	26 lb ft
• Rear Clip Bolt to Left Side of Block	30 N.m	22 lb ft
• Bolt to Right Side of Block	35 N.m	26 lb ft
• Left Side Ground Bolt	12 N.m	106 lb in
• Right Side Ground to Intake Manifold Nut	8 N.m	71 lb in
EVAP Emission Canister Purge Valve Bolt	10 N.m	89 lb in
Exhaust Manifold		
• Bolt	25 N.m	18 lb ft
• Nut	25 N.m	18 lb ft
• Pipe Hanger Bolt	50 N.m	37 lb ft
Exhaust Manifold Heat Shield Bolt	10 N.m	89 lb in
Exhaust Manifold Stud	6 N.m	53 lb in
Fuel Injector Sight Shield Ballstud	10 N.m	89 lb in
Fuel Rail Bolt	10 N.m	89 lb in
Generator Bolt	50 N.m	37 lb ft
Generator Coolant Inlet Hose Fitting	25 N.m	18 lb ft
Generator Coolant Line Bolt	27 N.m	19 lb ft
Generator Rear Brace Bolt	50 N.m	37 lb ft
Generator Stud	12 N.m	106 lb in
Ignition Coil Assembly		
• Ballstud	10 N.m	89 lb in
• Bolt	10 N.m	89 lb in
Knock Sensor Bolt	25 N.m	18 lb ft
Lower Crankcase		
• Bearing Bolt		
• M10 x 1.5 First Pass - In Sequence	20 N.m	15 lb ft
• M10 x 1.5 Final Pass - In Sequence	65 degrees	
• Perimeter Bolt		
• M8 x 1.25 - In Sequence	30 N.m	22 lb ft
Oil Filter	32 N.m	24 lb ft
Oil Filter Adapter		
• Hole Plug	65 N.m	48 lb ft
• Oil Filter Fitting	29 N.m	21 lb ft
• Mounting Bolt	25 N.m	18 lb ft
• Pipe Fitting - Oil Cooler	25 N.m	18 lb ft

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Oil Level Indicator Tube Bolt	50 N.m	37 lb ft
Oil Level Sensor	20 N.m	15 lb ft
Oil Manifold Plate Bolt	10 N.m	89 lb in
Oil Outlet Tube Bolt	10 N.m	89 lb in
Oil Pan Bolt		
• First Pass	15 N.m	11 lb ft
• Final Pass	25 N.m	18 lb ft
Oil Pan Baffle Bolt	12 N.m	106 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pressure Switch	20 N.m	15 lb ft
Oil Pump		
• Cover Bolt	12 N.m	106 lb in
• Mounting Bolt		
• First Pass	10 N.m	89 lb in
• Final Pass	35 degrees	
• Relief Valve Plug	12 N.m	106 lb in
Oil Suction Tube		
• Bolt	10 N.m	89 lb in
• Nut	24 N.m	18 lb ft
Oxygen Sensor	42 N.m	31 lb ft
Plenum Duct Clamp	2.25 N.m	20 lb in
Piston Oil Nozzle Bolt	10 N.m	89 lb in
Power Steering Pulley Bolt	50 N.m	37 lb ft
Power Steering Pump Bolt	25 N.m	18 lb ft
Power Steering Pump Reservoir Bracket Nut	10 N.m	89 lb in
Primary Camshaft Drive Chain		
• Guide Bolt	25 N.m	18 lb ft
• Tensioner Bolt	25 N.m	18 lb ft
Secondary Camshaft Drive Chain		
• Guide Bolt	25 N.m	18 lb ft
• Shoe Bolt	25 N.m	18 lb ft
• Tensioner Bolt	25 N.m	18 lb ft
Sight Shield		
• Bracket Nut	10 N.m	89 lb in
• Retainer	7 N.m	62 lb in
Spark Plug	15 N.m	11 lb ft
Starter Motor Bolt	30 N.m	22 lb ft

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Starter Motor Wiring Harness		
• Generator Nut	20 N.m	15 lb ft
• Starter Nut - Large	10 N.m	89 lb in
• Starter Nut - Small	4 N.m	35 lb in
Supercharger		
• Bolt In Sequence	25 N.m	18 lb ft
• Bypass Valve Actuator Bolt	10 N.m	89 lb in
• Bypass Valve Cable Bolt	10 N.m	89 lb in
• Intake Air Temperature (IAT) Sensor 2	20 N.m	15 lb ft
Thermostat Housing Bolt	10 N.m	89 lb in
Throttle Body Bolt	10 N.m	89 lb in
Water Outlet Housing Bolt	25 N.m	18 lb ft
Water Pump Bolt	10 N.m	89 lb in
Water Pump Pulley Bolt	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General		
• Engine Type	V-8	
• Displacement	4.4 Liter	267 cu in
• RPO	LC3	
• VIN	D	
• Bore	91 mm	3.5827 in
• Stroke	84 mm	3.3071 in
• Compression Ratio	9.0:1	
• Engine Compression Test	900-1090 kPa	131-158 psi
• Firing Order	1-2-7-3-4-5-6-8	
• Spark Plug Gap	1.020 mm	0.0400 in
Block		
• Crankshaft Main Bearing Bore Diameter	72.430-72.442 mm	2.8516-2.8521 in
• Crankshaft Main Bearing Bore Out-of-Round	0.010 mm	0.0004 in
• Crankshaft Main Rear Oil Seal		
• Bore	115.962-116.038 mm	4.5654-4.5684 in

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• Runout	0.250 mm	0.0098 in
• Cylinder Bore Diameter @ 45 mm (1.7717 in) Below Deck Face	90.992-91.008 mm	3.5824-3.5830 in
• Cylinder Bore Out-of-Round		
• Production	0.010 mm	0.0004 in
• Service	0.100 mm	0.0039 in
• Cylinder Bore Taper		
• Production	0.010 mm	0.0004 in
• Service	0.100 mm	0.0039 in
• Cylinder Head Deck Height	224.55 mm	8.8406 in
• Cylinder Head Deck Surface Flatness	0.100 mm	0.0039 in
Camshaft		
• Camshaft End Play	0.120-0.220 mm	0.0050-0.0087 in
• Camshaft Journal Diameter	26.948-26.972 mm	1.0610-1.0619 in
• Camshaft Journal Out-of-Round	0.006 mm	0.0002 mm
• Camshaft Journal to Bore Clearance		
• Production	0.041-0.085 mm	0.0016-0.0034 in
• Service	0.040-0.090 mm	0.0016-0.0035 in
• Camshaft Lobe Duration @ 0.150 mm (0.006 in) Lift - Exhaust	260.5 degrees	
• Camshaft Lobe Duration @ 0.150 mm (0.006 in) Lift - Intake	246 degrees	
• Camshaft Lobe Lift - Exhaust	5.94 mm	0.2339 in
• Camshaft Lobe Lift - Intake	6.1659 mm	0.2428 in
• Camshaft Lobe Overlap @ 0.150 mm (0.006 in) Lift	0.0 degrees	
• Camshaft Runout	0.050 mm	0.0020 in
• Camshaft Thrust Surface		
• Runout	0.037 mm	0.0015 in
• Width	22.990-23.090 mm	0.9051-0.9091 in
• Camshaft Timing @ 0.150 mm (0.006 in) Lift		
• Intake Opens	11.5 degrees ATDC	
• Intake Centerline	133.0 degrees ATDC	
• Intake Closes	257.5 degrees ATDC	
• Exhaust Opens	246.1 degrees BTDC	

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• Exhaust Centerline	117.0 degrees BTDC	
• Exhaust Closes	14.4 degrees ATDC	
Camshaft Position Actuator		
• Exhaust Authority	50 crankshaft degrees/25 camshaft degrees	
• Intake Authority	40 crankshaft degrees/20 camshaft degrees	
Cooling System		
• Thermostat Full Open Temperature	85°C	185°F
Connecting Rod		
• Connecting Rod Bearing Clearance		
• Production and Service	0.0250-0.0760 mm	0.0010-0.0030 in
• Connecting Rod Bore Diameter - Bearing End	57.136-57.152 mm	2.2495-2.2501 in
• Connecting Rod Bore Diameter - Pin End	24.006-24.018 mm	0.9451-0.9456 in
• Connecting Rod Bore Out-of-Round - Bearing End	0.006 mm	0.0002 in
• Connecting Rod Bore Out-of-Round - Pin End	0.005 mm	0.0002 in
• Connecting Rod Length Center to Center	151.00 mm	5.9449 in
• Connecting Rod Side Clearance	0.200-0.500 mm	0.0079-0.0197 in
• Connecting Rod Straightness	0.050 mm	0.0020 in
Crankshaft		
• Connecting Rod Journal Diameter	53.947-53.963 mm	2.1239-2.1245 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Connecting Rod Journal Taper	0.005 mm	0.0002 in
• Connecting Rod Journal Width	43.840-43.960 mm	1.7260-1.7307 in
• Crankshaft Balancer		
• Surface Diameter	50.730-50.870 mm	1.9972-2.0028 in
• Hub Inside Diameter	34.847-34.864 mm	1.3719-1.3726 in
• Crankshaft End Play	0.050-0.500 mm	0.0020-0.0197 in
• Crankshaft Main Bearing Clearance		
• Production	0.0150-0.0550 mm	0.0006-0.0022 in
• Service	0.0150-0.0635 mm	0.0006-0.0025 in
• Crankshaft Main Journal Diameter	64.350-64.366 mm	2.5335-2.5341 in
• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft Main Journal Taper	0.005 mm	0.0002 in
• Crankshaft Main Journal Thrust Wall Runout	0.040 mm	0.0016 in

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• Crankshaft Main Journal Thrust Wall Square	0.010 mm	0.0004 in
• Crankshaft Main Journal Width, #1, #2, #4, #5	24.540-24.660 mm	0.9661-0.9709 in
• Crankshaft Main Journal Width, Thrust #3	25.150-25.250 mm	0.9902-0.9941 in
• Crankshaft Nose Diameter		
• From Front Face 0.00-21.00 mm (0.0000-0.8268 in)	34.500-34.750 mm	1.3583-1.3681 in
• From Front Face 21.00-53.00 mm (0.8268-2.0866 in)	34.892-34.912 mm	1.3737-1.3745 in
• From Front Face 53.00 to Rolled Fillet (2.0866-Rolled Fillet)	33.450-33.550 mm	1.3169-1.3209 in
• From Front Face 89.94-110.54 mm (3.5409-4.3520 in)	44.950-45.000 mm	1.7697-1.7717 in
• Crankshaft Nose Runout		
• From Front Face 0.00-21.00 mm (0.0000-0.8268 in)	0.100 mm	0.0039 in
• From Front Face 21.00-53.00 mm (0.8268-2.8066 in)	0.030 mm	0.0012 in
• From Front Face 53.00 to Rolled Fillet (2.0866-Rolled Fillet)	0.100 mm	0.0039 in
• From Front Face 89.94-110.54 mm (3.5409-4.3520 in)	0.025 mm	0.0010 in
• Crankshaft Rear Flange		
• Diameter	95.880-95.980 mm	3.7748-3.7787 in
• Runout	0.025 mm	0.0010 in
• Crankshaft Rear Flange Face to Engine Flywheel Runout	0.025 mm	0.0010 in
• Crankshaft Runout		
• Main Journals #1, #5	0.022 mm	0.0009 in
• Main Journals #2, #4, #6	0.025 mm	0.0010 in
Cylinder Head		
• Camshaft Bearing Bore Diameter	27.013-27.033 mm	1.0635-1.0642 in
• Camshaft Bearing Bore Out-of-Round	0.010 mm	0.0004 in
• Combustion Chamber Depth - at Measurement Point	10.470-10.710 mm	0.4122-0.4217 in
• Cylinder Head Height - Deck to Camshaft Centerline Bore	136.00 mm	5.3543 in
• Surface Flatness - Block Deck	0.050 mm	0.0020 in
• Surface Flatness - Exhaust Manifold Deck	0.220 mm	0.0087 in
• Surface Flatness - Intake Manifold Deck	0.220 mm	0.0087 in
• Valve Guide Bore - Exhaust	5.969-5.989 mm	0.2350-0.2359 in

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• Valve Guide Bore - Intake	5.969-5.989 mm	0.2350-0.2359 in
• Valve Guide Installed Height - Exhaust	14.300 mm	0.5630 in
• Valve Guide Installed Height - Intake	14.720 mm	0.5795 in
• Valve Lifter Bore Diameter	12.013-12.037 mm	0.4730-0.4739 in
Flywheel		
• Runout	0.300 mm	0.0118 in
Lubrication System		
• Oil Capacity - with New Dry Oil Filter	7.6 Liters	8.0 Quarts
• Oil Pressure - Minimum @ Idle	35 kPa	5 psi
• Oil Pressure - Minimum @ 2,000 RPM	250 kPa	35 psi
Piston Rings		
• Piston Ring End Gap		
• First Compression Ring	0.150-0.300 mm	0.0059-0.0118 in
• Second Compression Ring	0.300-0.450 mm	0.0118-0.0177 in
• Oil Control Ring	0.250-0.500 mm	0.0098-0.0197 in
• Piston Ring to Groove Clearance		
• First Compression Ring	0.040-0.095 mm	0.0016-0.0037 in
• Second Compression Ring	0.040-0.095 mm	0.0016-0.0037 in
• Oil Control Ring	None - Side Sealing	
• Piston Ring Thickness		
• First Compression Ring	1.199-1.203 mm	0.0472-0.0474 in
• Second Compression Ring	1.499-1.504 mm	0.0590-0.0592 in
• Oil Control Ring	1.876-1.974 mm	0.0739-0.0777 in
Pistons and Pins		
• Piston		
• Piston Diameter @ 42 mm (1.6353 in) Below Crown with Piston Skirt Coating	90.967-90.990 mm	3.5814-3.5823 in
• Piston Pin Bore Diameter	24.002-24.009 mm	0.9450-0.9452 in
• Piston Ring Groove Inside Diameter		
• First Compression Ring	82.520-82.770 mm	3.2488-3.2587 in
• Second Compression Ring	81.660-81.910 mm	3.2150-3.2248 in
• Oil Control Ring	84.210-84.460 mm	3.3153-3.3252 in
• Piston Ring Groove Width		
• First Compression Ring	1.230-1.255 mm	0.0484-0.0494 in

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• Second Compression Ring	1.530-1.555 mm	0.0602-0.0612 in
• Oil Control Ring	2.008-2.028 mm	0.0791-0.0798 in
• Piston to Bore Clearance with Piston Skirt Coating	-0.016-0.031 mm	-0.0006-0.0012 in
• Pin		
• Piston Pin Clearance to Connecting Rod Bore	0.006-0.021 mm	0.0002-0.0008 in
• Piston Pin Clearance to Piston Pin Bore	0.002-0.012 mm	0.0001-0.0005 in
• Piston Pin Diameter	23.997-24.000 mm	0.9448-0.9449 in
• Piston Pin Length	65.240-65.740 mm	2.5685-2.5882 in
Valve System		
• Valves		
• Valve Face Angle	45 degrees	
• Valve Face Runout	0.038 mm	0.0015 in
• Valve Face Width		
• Exhaust	1.500 mm	0.0591 in
• Intake	1.000 mm	0.0394 in
• Valve Head Diameter		
• Exhaust	28.880-29.140 mm	1.1370-1.1472 in
• Intake	36.090-36.350 mm	1.4209-1.4311 in
• Valve Length		
• Exhaust	91.730-91.990 mm	3.6114-3.6217 in
• Intake	110.600-110.860 mm	4.3543-4.3646 in
• Valve Seat Angle	45.75 degrees	
• Valve Seat Relief Angle	20 degrees	
• Valve Seat Relief Width		
• Exhaust	0.160-0.360 mm	0.0063-0.0142 in
• Intake	0.110-0.310 mm	0.0043-0.0118 in
• Valve Seat Runout	0.050 mm	0.0020 in
• Valve Seat Undercut Angle		
• Exhaust	65 degrees	
• Intake	60 degrees	
• Valve Seat Width		
• Exhaust	1.300-1.700 mm	0.0512-0.0669 in
• Intake	0.420-0.820 mm	0.0165-0.0323 in

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• Valve Stem Diameter	5.920-5.940 mm	0.2331-0.2339 in
• Valve Stem Out-of-Round	0.008 mm	0.0003 in
• Valve Stem Straightness	0.013 mm	0.0005 in
• Valve Stem-to-Guide Clearance		
• Exhaust		
• Production	0.050-0.100 mm	0.0020-0.0039 in
• Service	0.050-0.120 mm	0.0020-0.0047 in
• Intake		
• Production	0.028-0.068 mm	0.0011-0.0027 in
• Service	0.028-0.110 mm	0.0011-0.0043 in
• Valve Lifters		
• Valve Lifter Diameter	11.986-12.000 mm	0.4719-0.4724 in
• Valve Lifter-to-Bore Clearance	0.037-0.041 mm	0.0015-0.0016 in
• Rocker Arms		
• Valve Rocker Arm Ratio	1.68 to 1	
• Valve Rocker Arm Roller Diameter	17.740-17.800 mm	0.6984-0.7008 in
• Valve Springs		
• Valve Spring Coil Thickness	4.110 x 3.280 mm	0.1618 x 0.1291 in
• Valve Spring Diameter		
• Inside	17.750-18.250 mm	0.6988-0.7185 in
• Outside	26.23 mm	1.0327 in
• Valve Spring Free Length	40.790-43.690 mm	1.6059-1.7201 in
• Valve Spring Height		
• Closed	35.000 mm	1.3780 in
• Open	24.500 mm	0.9646 in
• Valve Spring Load		
• Closed	211.4-233.4 mm	47.5-52.4 lb
• Open	579.0-631.0 mm	130.2-141.9 lb
• Valve Spring Total Number of Coils	6.90-7.10	

SEALERS, ADHESIVES AND LUBRICANTS

Sealers, Adhesives and Lubricants

		GM Part Number	

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Application	Type of Material	United States	Canada
Camshaft Covers at Split Lines	Sealant	12378521	88901148
Camshaft Position Actuator Magnets	Sealant	12378521	88901148
Camshaft Prelube	Lubricant	12345501	992704
Crankshaft Prelube	Lubricant	1052367	992869
Crankshaft Rear Oil Seal at Split Lines	Sealant	12378521	88901148
Cylinder Head Core Hole Threaded Plug	Sealant	12345382	10953489
Cylinder Head Expansion Plug	Sealant	12345382	10953489
Cylinder Head Oil Gallery Threaded Plug	Sealant	12345382	10953489
Engine Flywheel Bolt	Sealant	12346004	10953480
Engine Front Cover at Split Lines	Sealant	12378521	88901148
Engine Front Cover Bolt	Threadlock	12345382	10953489
Fuel Injector Bores	Lubricant	12345610	993193
Ignition Coil Spark Plug Boot	Lubricant	12345579	1974984
Intake Air Temperature (IAT) Sensor 2	Sealant	12346004	10953480
Oil Filter Adapter Pipe Fitting	Threadlock	89021297	10953488
Oxygen Sensor	Lubricant	12377953	N/A
Power Steering Pump Shaft	Lubricant	1051344	993037
Upper-to-Lower Crankcase	Sealant - 6 ML	1052942	10953466
Upper-to-Lower Crankcase	Sealant - 50 ML	1052943	10953491
Valve Lifter	Lubricant	12345616	993182

THREAD REPAIR SPECIFICATIONS

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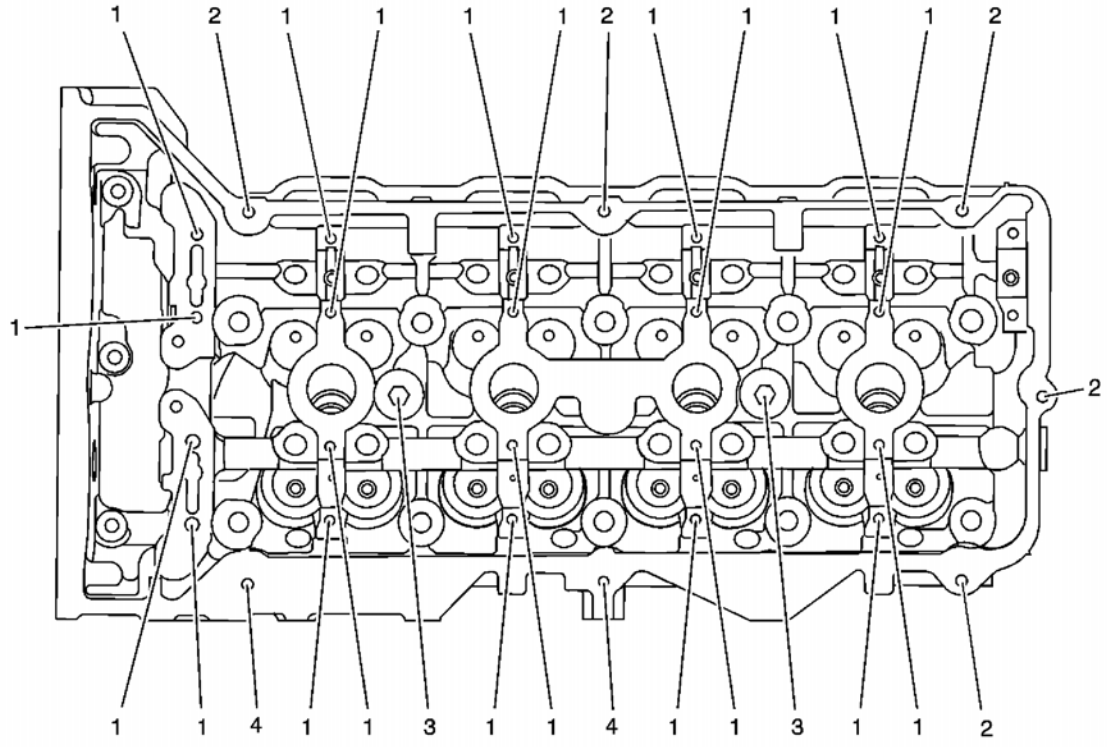


Fig. 1: Left Cylinder Head Camshaft Cover Face Thread Repair Locations
Courtesy of GENERAL MOTORS CORP.

Left Cylinder Head Camshaft Cover Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	608	N/A	N/A	203	204	205	26.0	1.0236	22.0	0.8661
2	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
3	M20 x 1.5	715	716	N/A	717	718	719	32.0	1.2598	21.0	0.8268
4	M6 x 1.0	201	202	N/A	203	204	205	22.0	0.8661	18.0	0.7087

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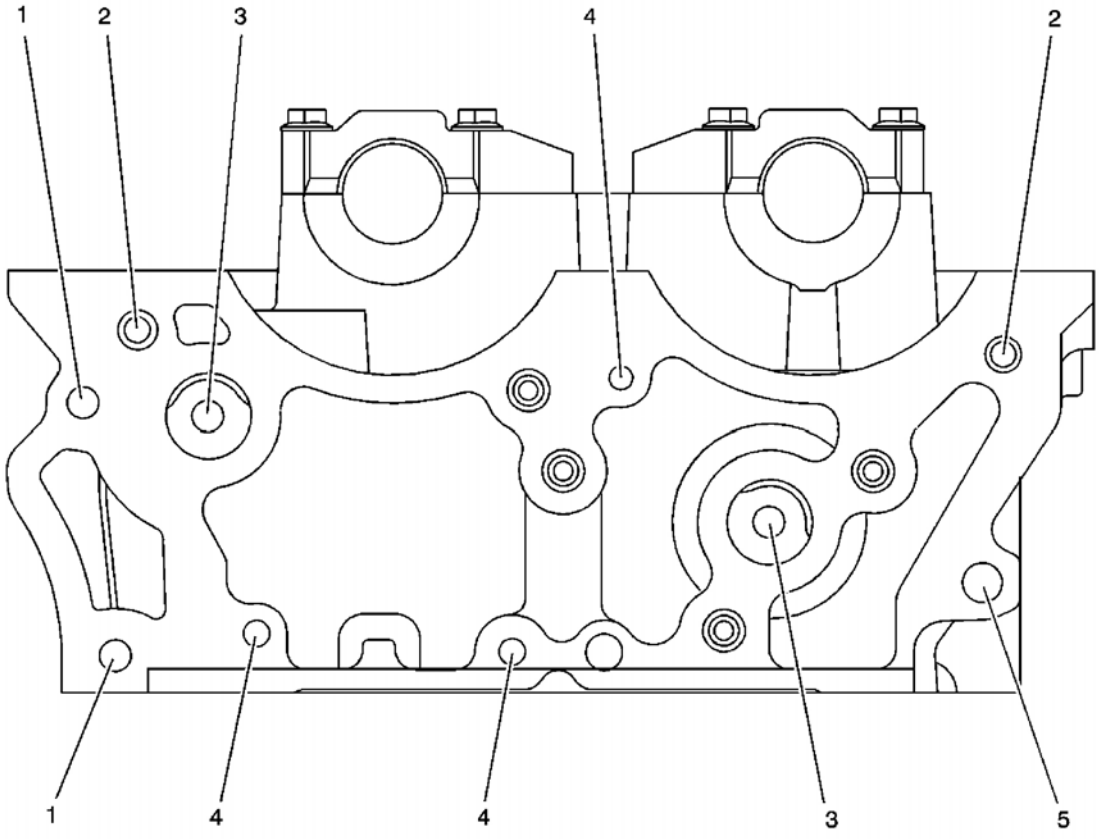


Fig. 2: Identifying Left Cylinder Head Front Face Thread Repair Locations
Courtesy of GENERAL MOTORS CORP.

Left Cylinder Head Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	27.0	1.0630	22.0	0.8661
2	M6 x 1.0	201	202	N/A	203	204	205	30.0	1.1811	26.0	1.0236
3	M8 x 1.25	610	N/A	619	208	209	620	27.0	1.0630	22.0	0.8661
4	M6 x 1.0	201	202	N/A	203	204	205	22.0	0.8661	18.0	0.7087
5	M10 x 1.5	211	212	N/A	213	214	215	32.0	1.2599	26.0	1.0236

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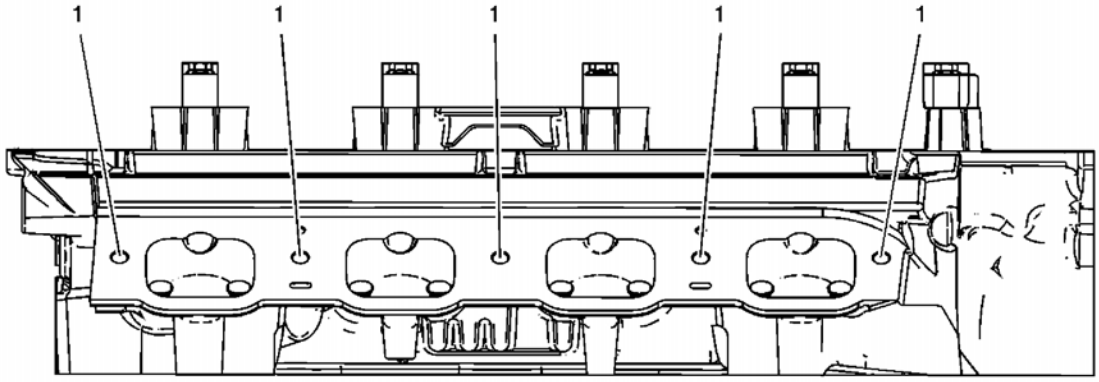


Fig. 3: View Of Left Cylinder Head Intake Face
Courtesy of GENERAL MOTORS CORP.

Left Cylinder Head Intake Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	25.00	0.9843	21.25	0.8366

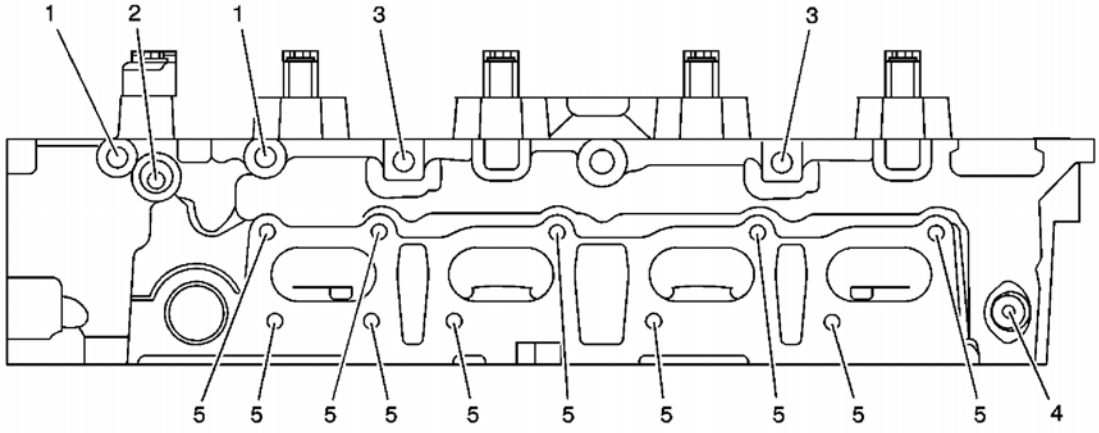


Fig. 4: Left Cylinder Head Exhaust Face Thread Repair Locations
Courtesy of GENERAL MOTORS CORP.

Left Cylinder Head Exhaust Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)

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1	M10 x 1.5	211	212	N/A	213	214	215	32.0	1.2599	27.5	1.0827
2	M16 x 1.5	861	862	N/A	863	864	860	20.0	0.7874	16.0	0.6299
3	M10 x 1.5	211	212	N/A	213	214	215	32.0	1.2599	26.0	1.0236
4	M6 x 1.0	201	202	N/A	203	204	205	22.0	0.8661	18.0	0.7087
5	M8 x 1.25	206	207	N/A	208	209	210	25.0	0.9843	20.0	0.7874

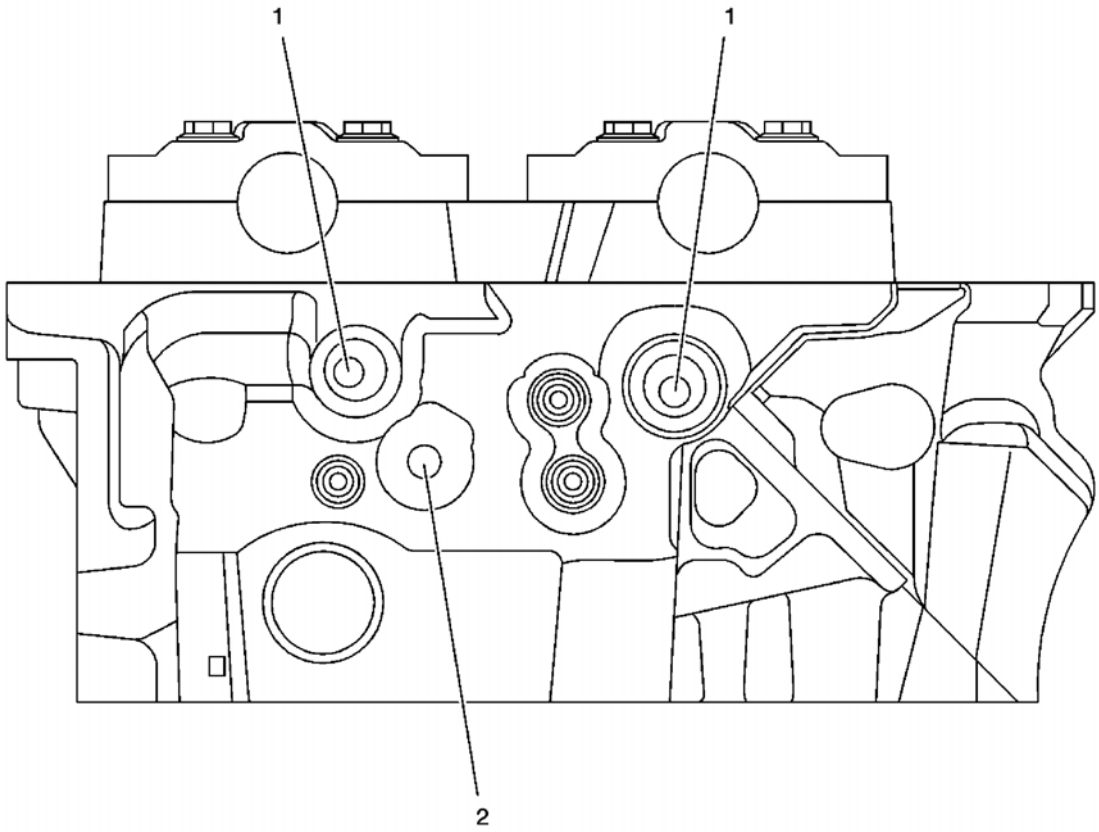


Fig. 5: Identifying Left Cylinder Head Rear Face Thread Repair Locations
Courtesy of GENERAL MOTORS CORP.

Left Cylinder Head Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M16 x	861	862	N/A	863	864	860	20.0	0.7874	16.0	0.6299

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	1.5										
2	M8 x 1.25	206	207	N/A	208	209	210	27.0	1.0630	22.0	0.8661

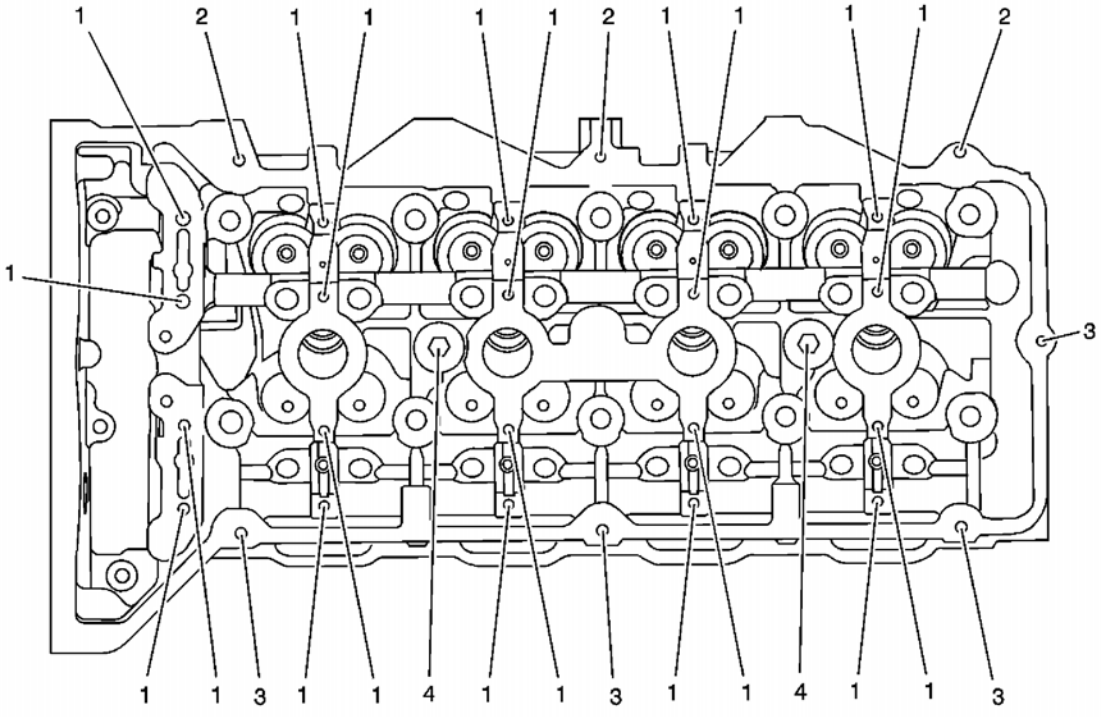


Fig. 6: Identifying Right Cylinder Head Camshaft Cover Face Thread Repair Locations
Courtesy of GENERAL MOTORS CORP.

Right Cylinder Head Camshaft Cover Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	608	N/A	N/A	203	204	205	26.0	1.0240	22.0	0.8660
2	M6 x 1.0	201	202	N/A	203	204	205	22.0	0.8660	18.0	0.7090
3	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
4	M20 x 1.5	715	716	N/A	717	718	719	32.0	1.2598	21.0	0.8268

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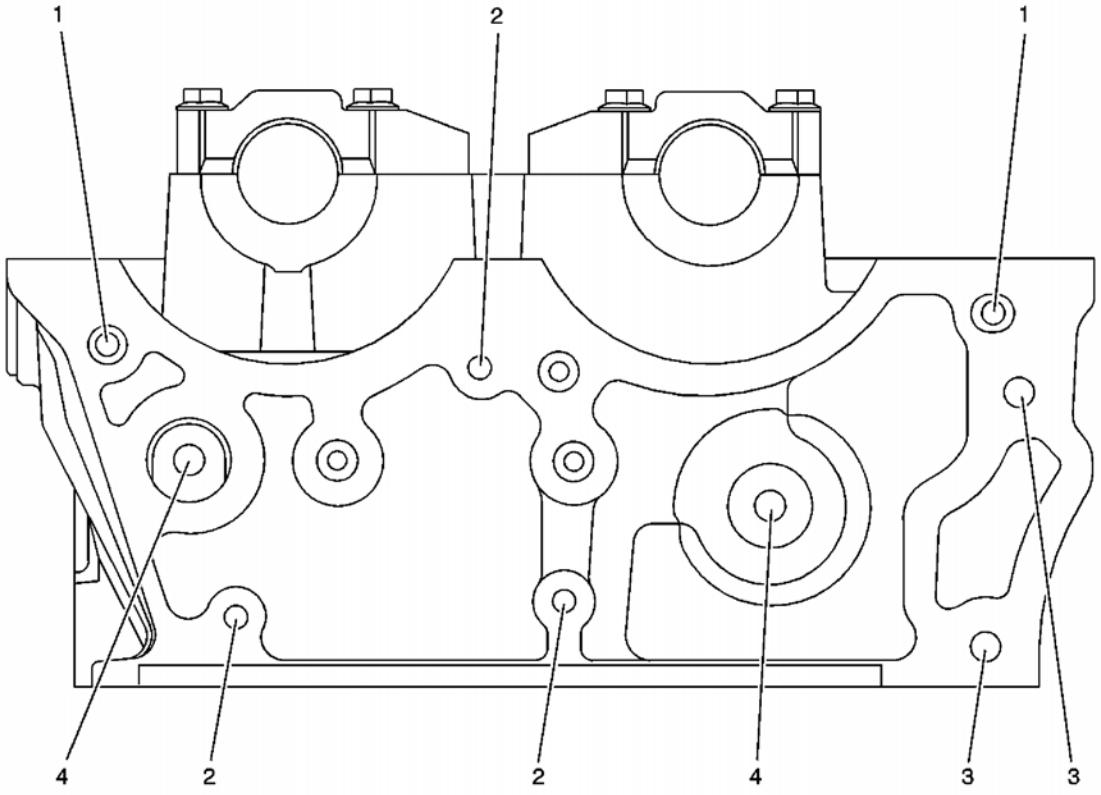


Fig. 7: Right Cylinder Head Front Face Thread Repair Locations
Courtesy of GENERAL MOTORS CORP.

Right Cylinder Head Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	30.0	1.1811	26.0	1.0236
2	M6 x 1.0	201	202	N/A	203	204	205	22.0	0.8661	18.0	0.7087
3	M8 x 1.25	206	207	N/A	208	209	210	27.0	1.0630	22.0	0.8661
4	M8 x 1.25	610	N/A	619	208	209	620	27.0	1.0630	22.0	0.8661

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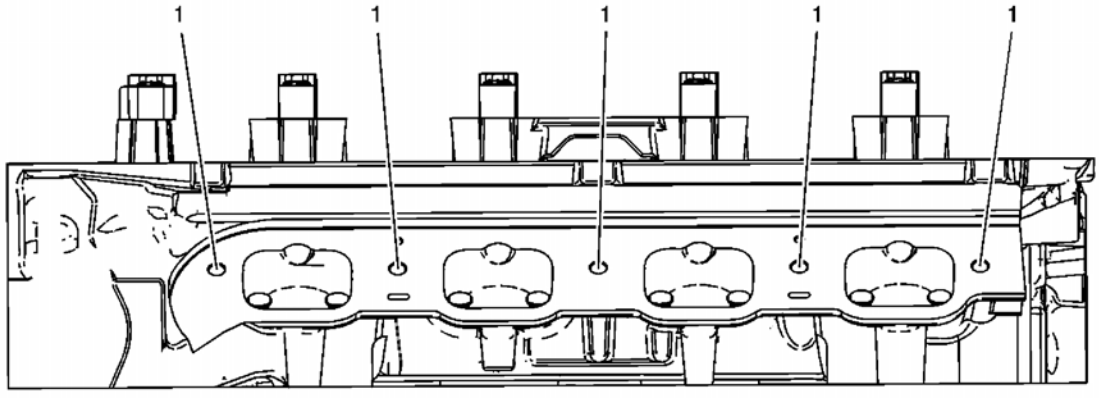


Fig. 8: Identifying Right Cylinder Head Intake Face
Courtesy of GENERAL MOTORS CORP.

Right Cylinder Head Intake Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	25.00	0.9843	21.25	0.8366

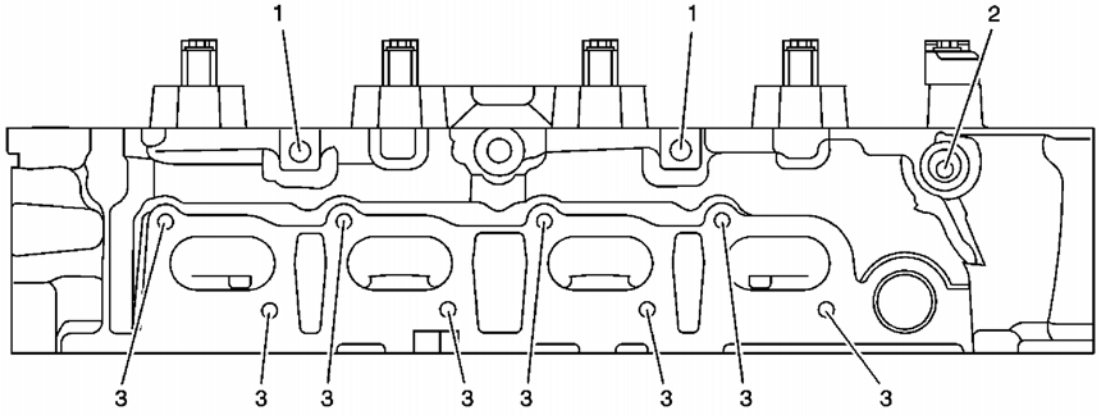


Fig. 9: Identifying Right Cylinder Head Exhaust Face Thread Repair Locations
Courtesy of GENERAL MOTORS CORP.

Right Cylinder Head Exhaust Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)

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1	M10 x 1.5	211	212	N/A	213	214	215	32.0	1.2599	27.5	1.0827
2	M16 x 1.5	861	862	N/A	863	864	860	20.0	0.7874	16.0	0.6299
3	M8 x 1.25	206	207	N/A	208	209	210	25.0	0.9843	20.0	0.7874

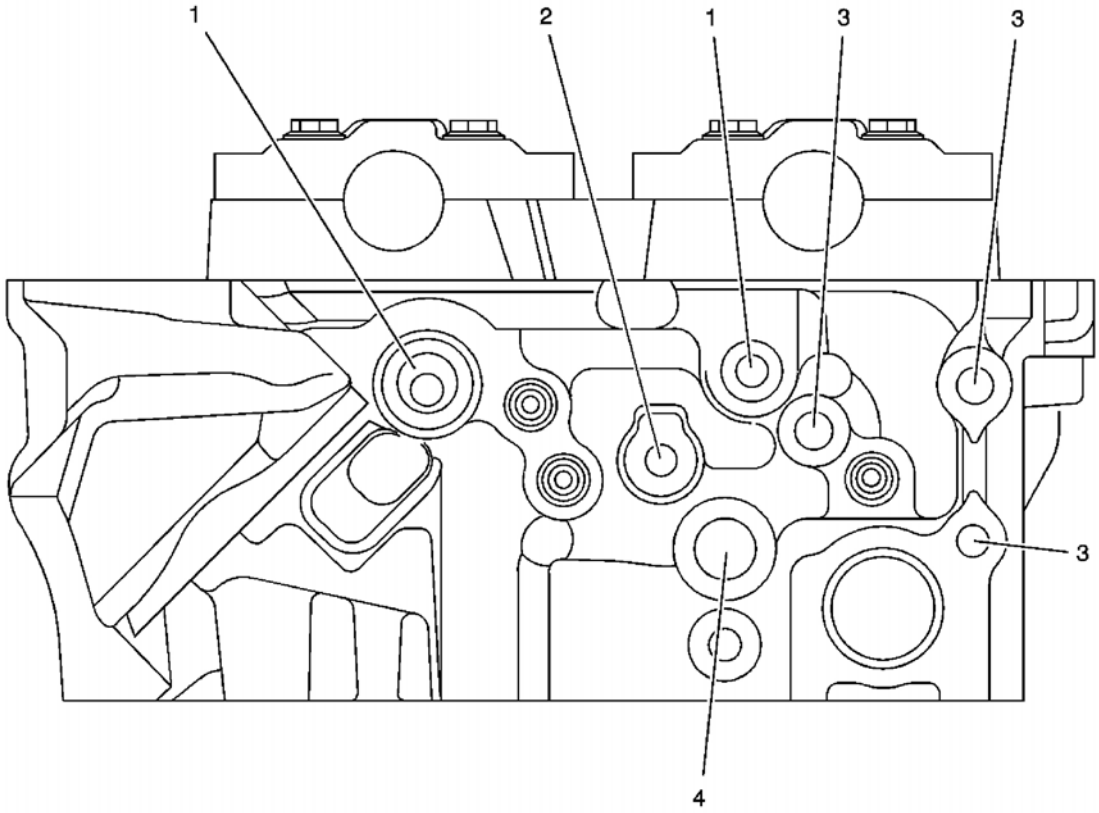


Fig. 10: Identifying Right Cylinder Head Rear Face Thread Repair Locations
Courtesy of GENERAL MOTORS CORP.

Right Cylinder Head Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M16 x 1.5	861	862	N/A	863	864	860	20.0	0.7874	16.0	0.6299
2	M8 x 1.25	206	207	N/A	208	209	210	27.0	1.0630	22.0	0.8661
3	M10 x 1.5	211	212	N/A	213	214	215	32.0	1.2598	26.0	1.0240

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4	3/8 - 18 NPSF	2013	N/A	N/A	2014	2015	2016	THRU	THRU

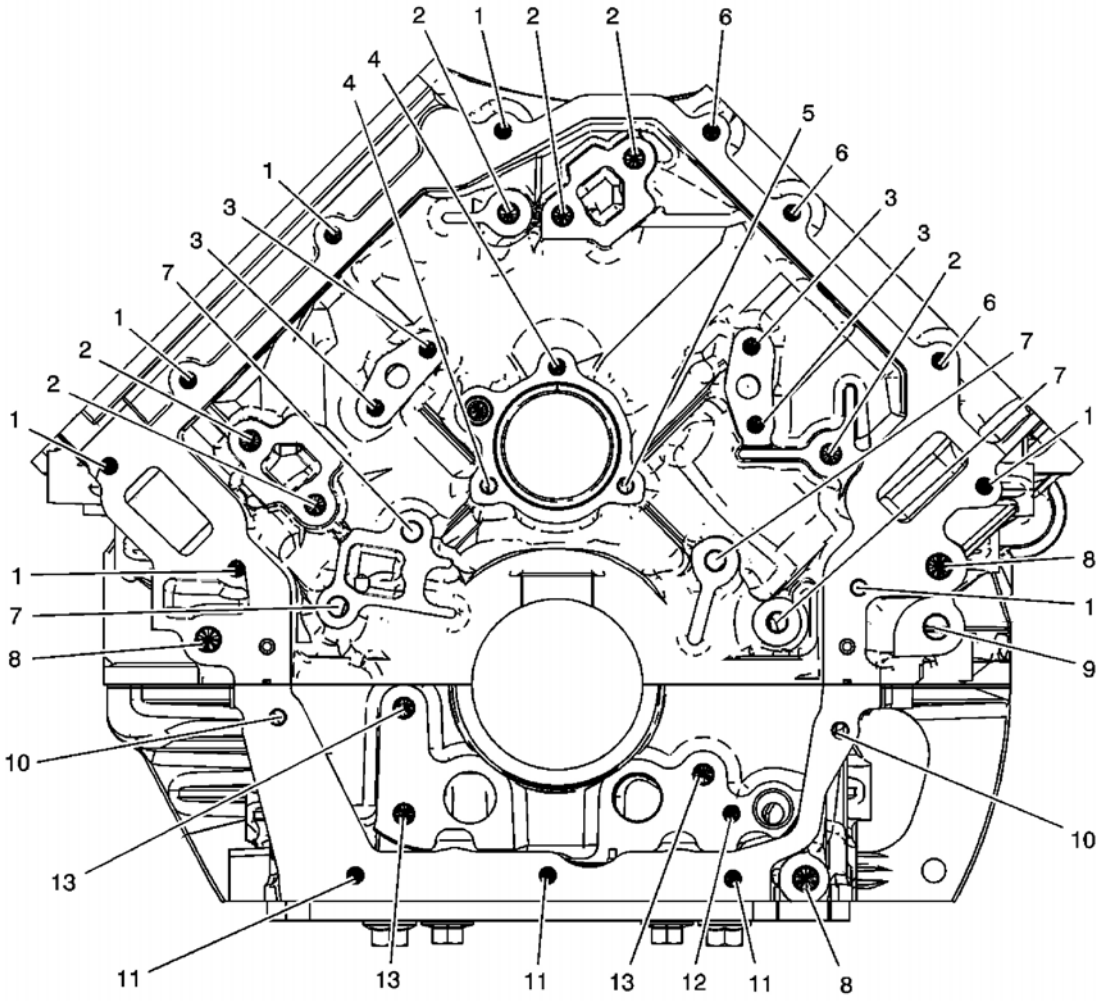


Fig. 11: View Of Engine Block Front
Courtesy of GENERAL MOTORS CORP.

Engine Block Front

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	19.5	0.7677	15.5	0.6102
2	M8 x 1.25	206	207	N/A	208	209	210	27.0	1.0630	22.0	0.8661
	M6 x										

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3	1.0	201	202	N/A	203	204	205	23.0	0.9055	19.0	0.7480
4	M6 x 1.0	201	202	N/A	203	204	205	THRU		17.0	0.6693
5	M6 x 1.0	201	202	N/A	203	204	205	24.0	0.9449	17.0	0.6693
6	M6 x 1.0	201	202	N/A	203	204	205	THRU		15.5	0.6102
7	M8 x 1.25	206	207	N/A	208	209	210	THRU		THRU	
8	M10 x 1.5	211	212	N/A	213	214	420	30.0	1.1811	24.0	0.9449
9	M10 x 1.5	211	212	N/A	213	214	420	THRU		THRU	
10	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
11	M6 x 1.0	201	202	N/A	203	204	205	20.25	0.7972	16.25	0.6398
12	M6 x 1.0	201	202	N/A	203	204	205	23.75	0.9350	19.75	0.7776
13	M8 x 1.75	2001	2002	N/A	2003	2004	2005	26.75	1.0532	21.75	0.8563

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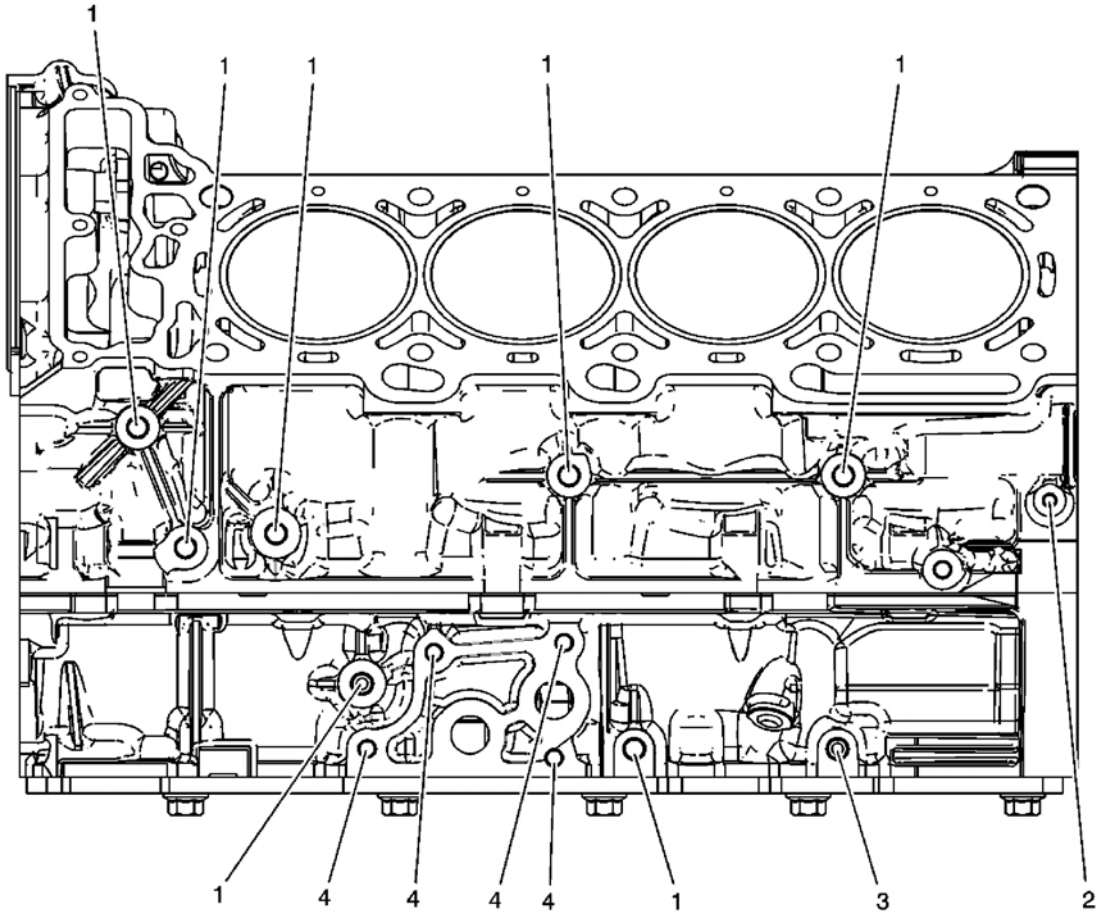


Fig. 12: View Of Engine Block Left Side
Courtesy of GENERAL MOTORS CORP.

Engine Block Left Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	420	30.0	1.1811	24.0	1.0827
2	M6 x 1.0	201	202	N/A	203	204	205	25.0	0.9843	21.0	0.8268
3	M8 x 1.25	610	N/A	N/A	208	209	620	30.0	1.1811	25.0	0.9843
4	M8 x 1.25	206	207	N/A	208	209	210	20.0	0.7874	16.0	0.6299

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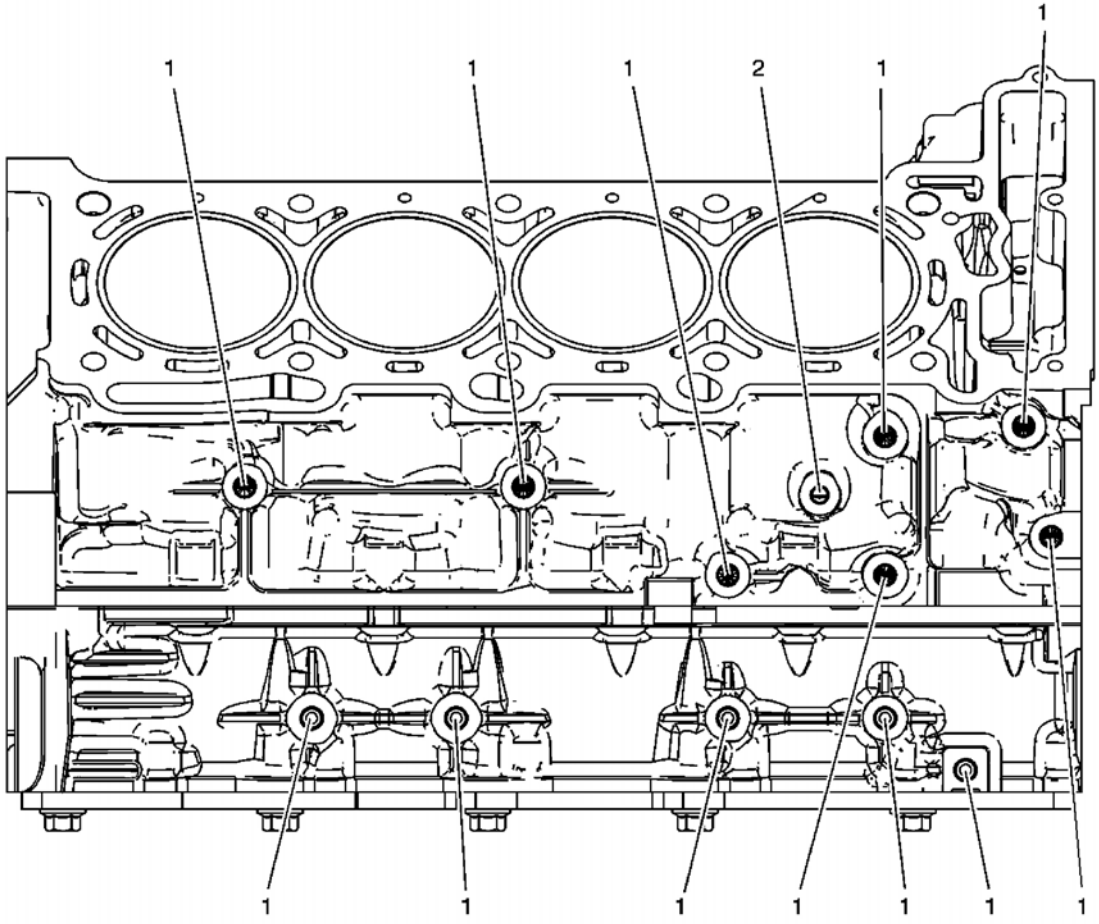


Fig. 13: View Of Engine Block Right Side
Courtesy of GENERAL MOTORS CORP.

Engine Block Right Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	420	30.0	1.1811	24.0	1.0827
2	M8 x 1.25	206	207	N/A	208	209	210	24.5	0.9646	15.0	0.5906

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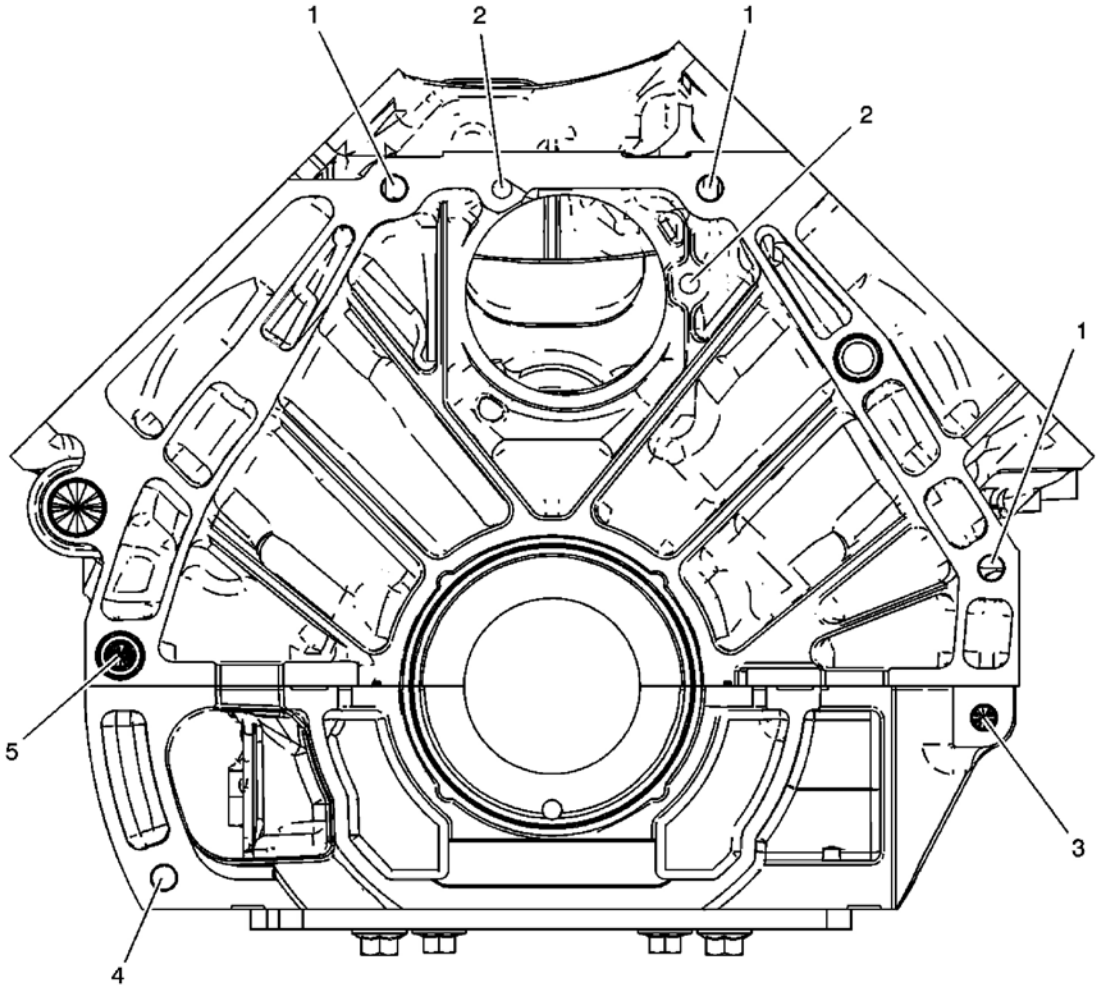


Fig. 14: View Of Engine Block Rear
Courtesy of GENERAL MOTORS CORP.

Engine Block Rear

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	420	THRU		THRU	
2	M8 x 1.25	206	207	N/A	208	209	210	THRU		THRU	
3	M10 x 1.5	211	212	N/A	213	214	420	39.75	1.5650	33.75	1.0827
4	M10 x 1.5	211	212	N/A	213	214	420	THRU		THRU	

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5	M10 x 1.5	211	212	N/A	213	214	420	39.0	1.5354	33.0	1.2992

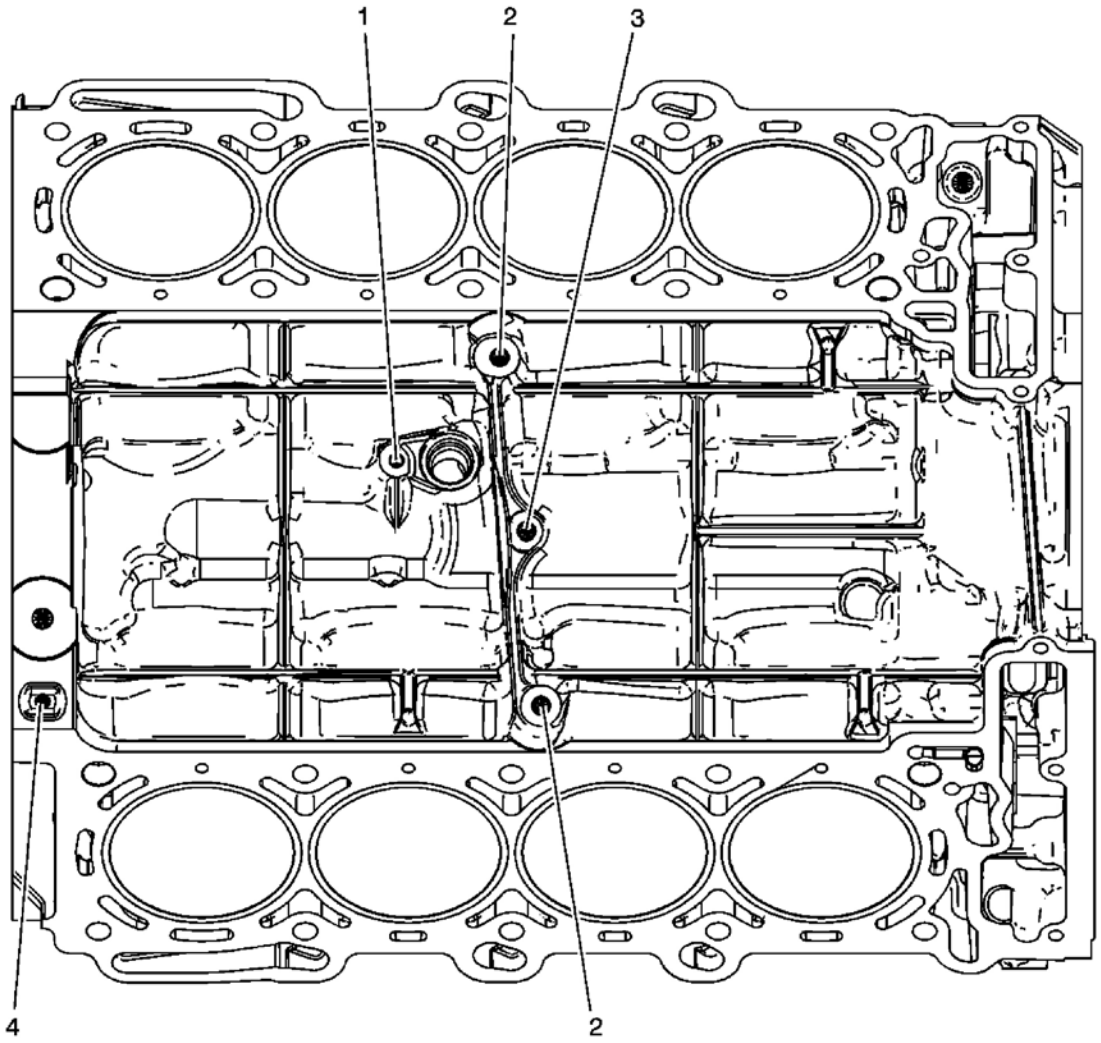


Fig. 15: View Of Engine Block Top
Courtesy of GENERAL MOTORS CORP.

Engine Block Top

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	20.0	0.7874	16.0	0.6299
2	M8 x 1.25	206	207	N/A	208	209	210	23.5	0.9252	18.5	0.7283

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3	M8 x 1.25	206	207	N/A	208	209	210	23.0	0.9055	19.0	0.7480
4	M6 x 1.0	201	202	N/A	203	204	205	23.0	0.9055	19.0	0.7480

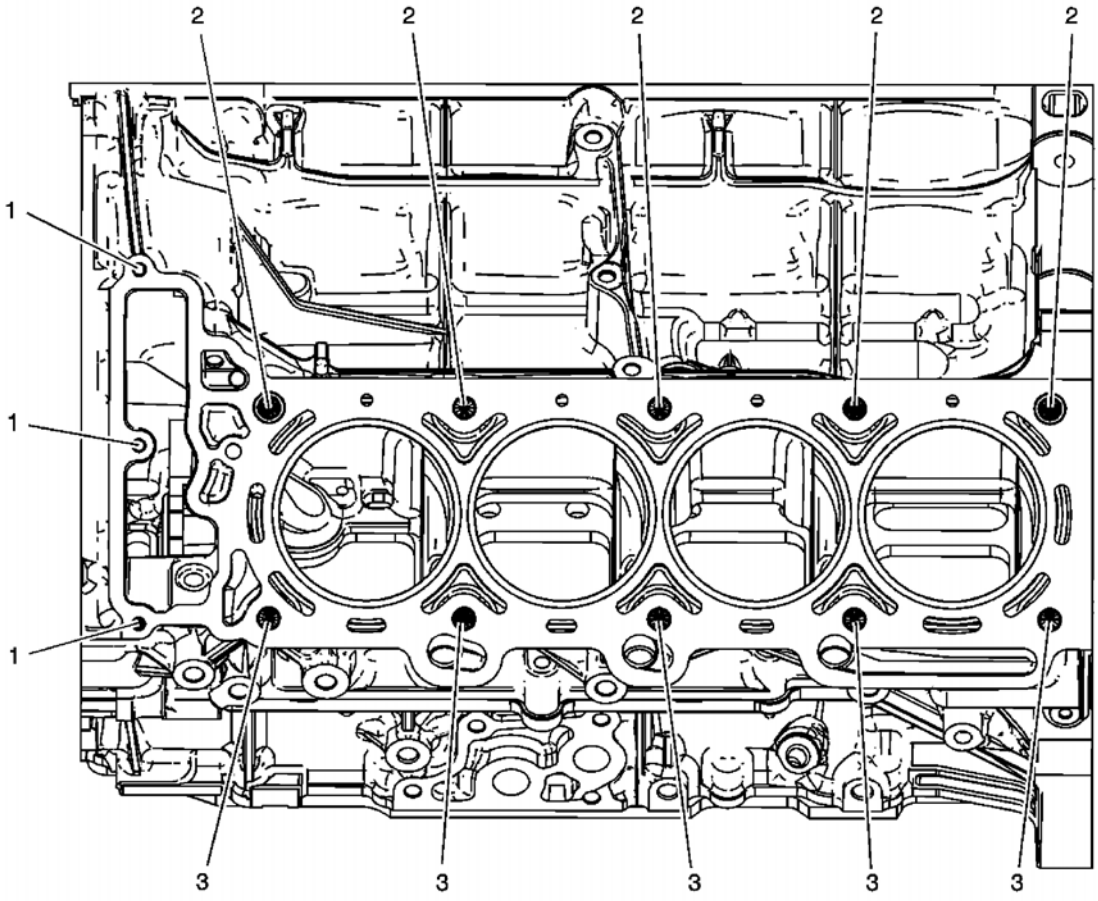


Fig. 16: View Of Engine Block Left Deck Face
Courtesy of GENERAL MOTORS CORP.

Engine Block Left Deck Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	608	N/A	N/A	203	204	205	30.0	1.1811	25.0	0.9843
2	M11 x 2.0	2031	N/A	2034	2032	2033	108	73.0	2.8740	67.0	2.6378
3	M11 x 2.0	2031	N/A	N/A	2032	2033	108	89.5	3.5236	83.5	3.2874

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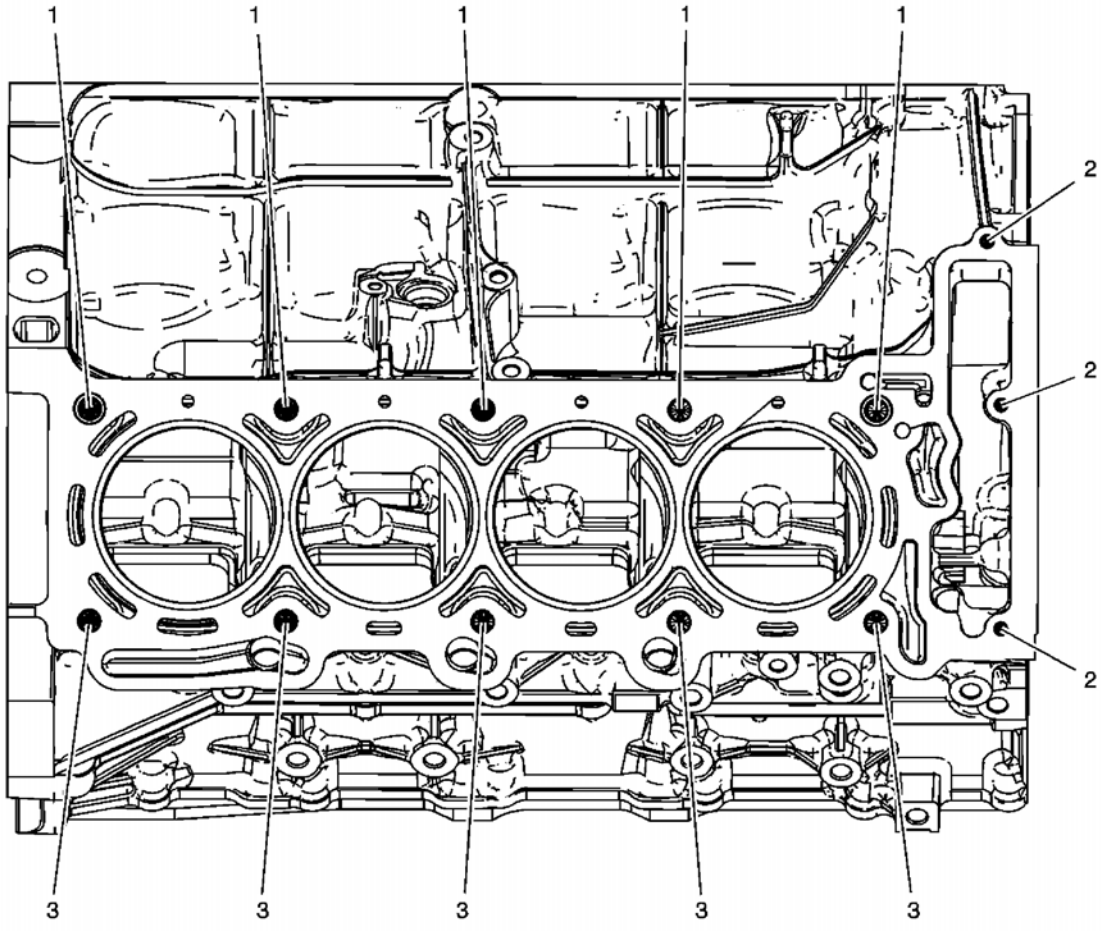


Fig. 17: View Of Engine Block Right Deck Face
Courtesy of GENERAL MOTORS CORP.

Engine Block Right Deck Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M11 x 2.0	2031	N/A	2034	2032	2033	108	73.0	2.8740	67.0	2.6378
2	M6 x 1.0	608	N/A	N/A	203	204	205	30.0	1.1811	25.0	0.9843
3	M11 x 2.0	2031	N/A	N/A	2032	2033	108	89.5	3.5236	83.5	3.2874

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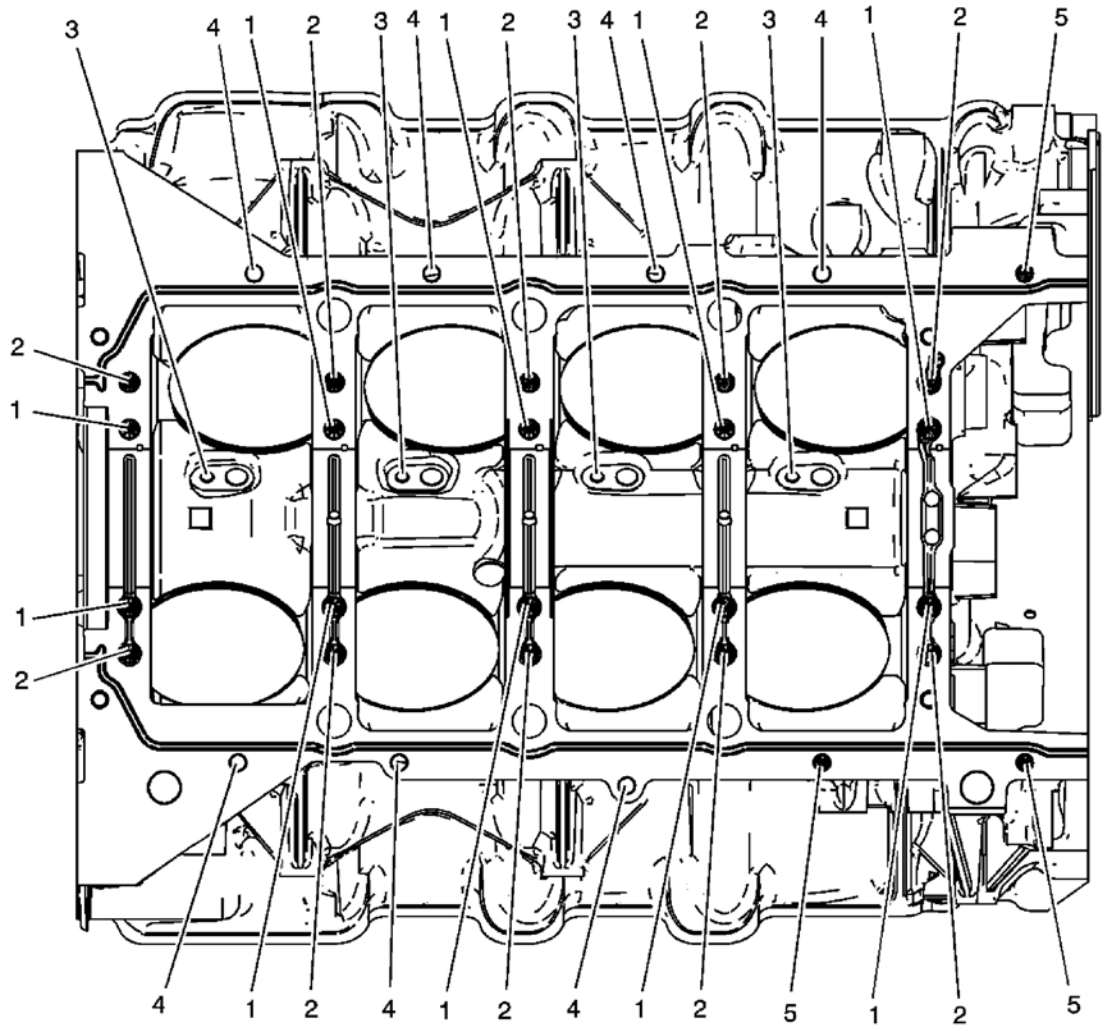


Fig. 18: View Of Engine Block Lower Face
Courtesy of GENERAL MOTORS CORP.

Engine Block Lower Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	No Service Tools Available						40.0	1.5748	34.5	1.3583
2	M10 x 1.5	511	N/A	N/A	512	513	514	32.0	1.2598	26.5	1.0433
3	M6 x 1.0	201	202	N/A	203	204	205	24.0	0.9449	17.0	0.6693
4	M8 x	610	N/A	N/A	208	209	620	THRU		THRU	

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	1.25										
5	M8 x 1.25	610	N/A	N/A	208	209	620	37.0	1.4567	32.0	1.2598

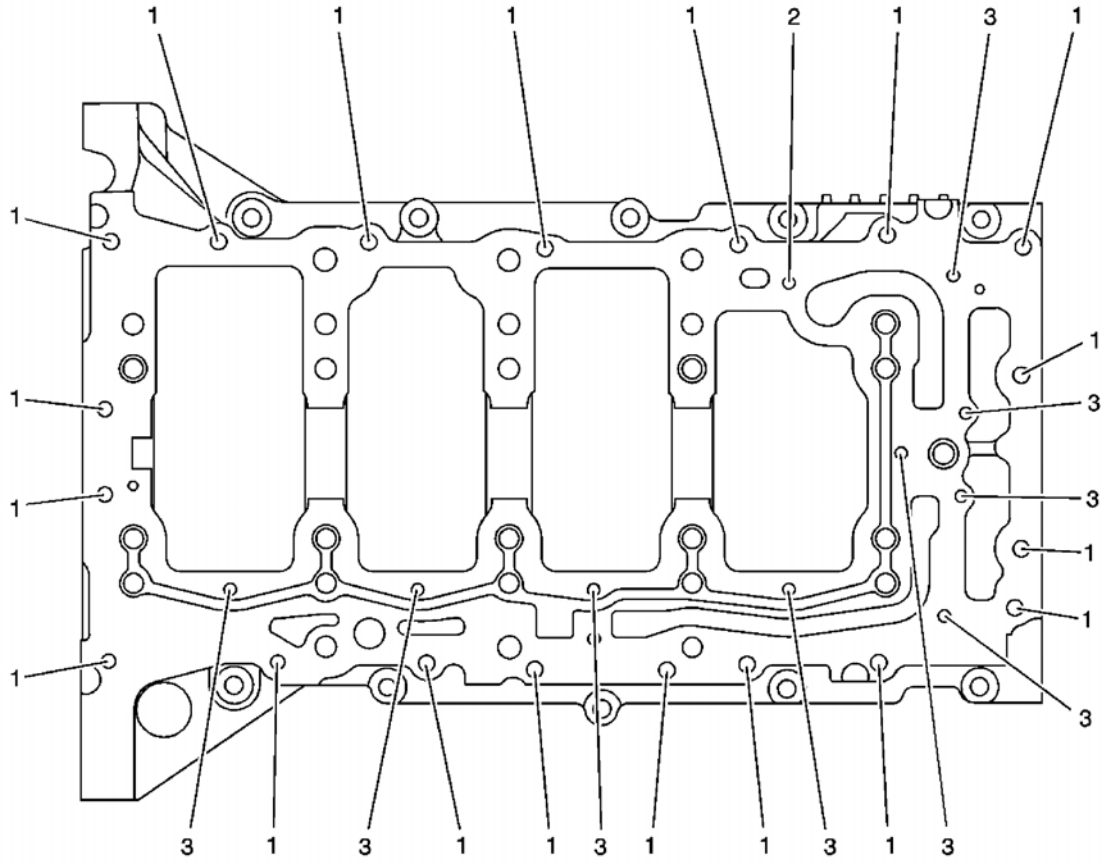


Fig. 19: View Of Lower Crankcase Pan Face Thread Repair Locations
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase Pan Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	25.0	0.9843	20.0	0.7874
2	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
3	M6 x 1.0	201	202	N/A	203	204	205	22.0	0.8661	18.0	0.7087

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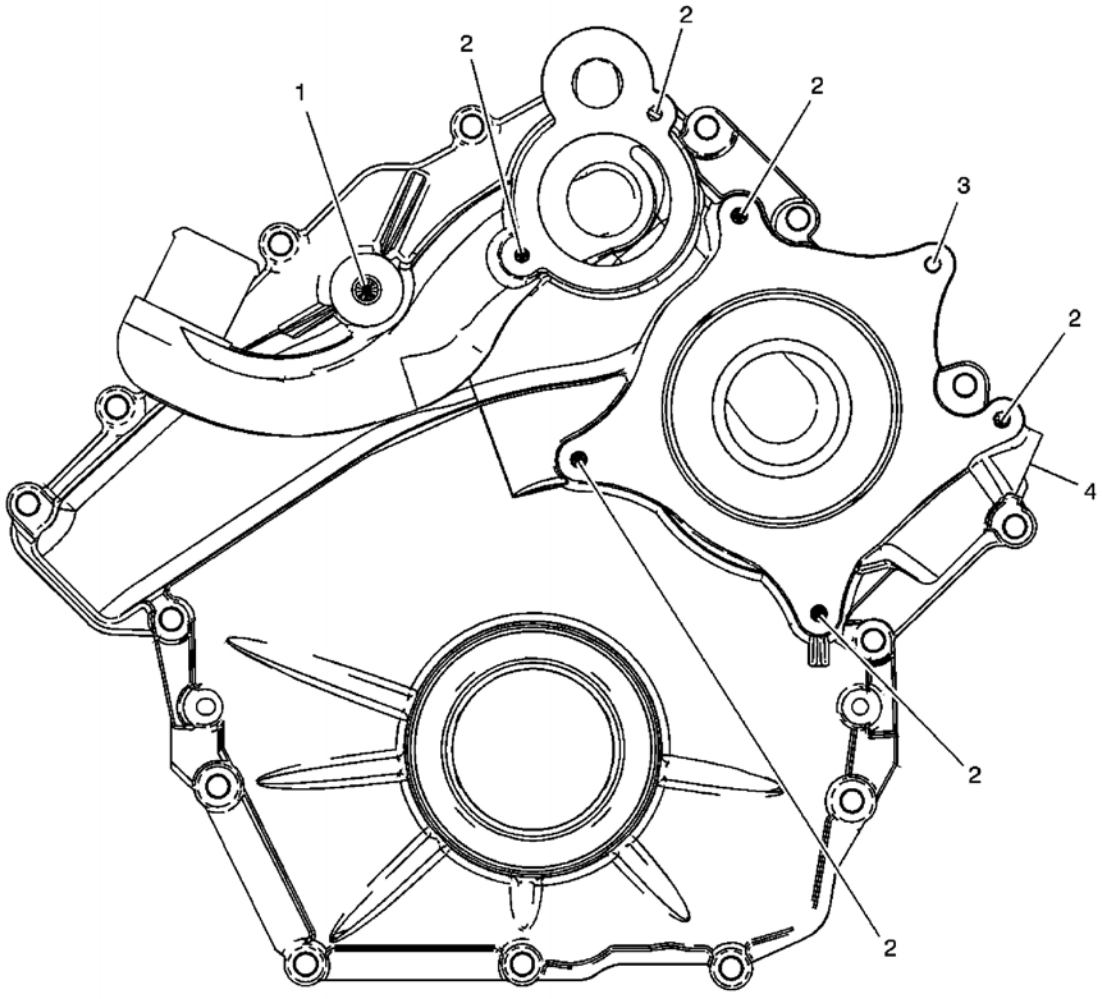


Fig. 20: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

Engine Front Cover

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	215	32.5	1.2795	27.0	1.0630
2	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.5	0.7283
3	M6 x 1.0	201	202	N/A	203	204	205	THRU		18.5	0.7823
4	M18 x 1.5	No Service Tools Available						11.7	0.4606	9.0	0.3543

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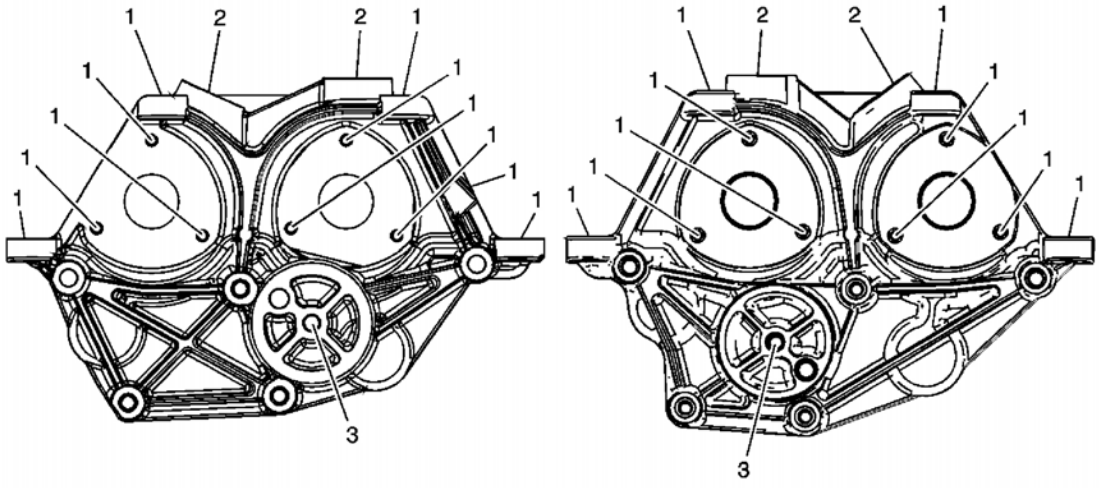


Fig. 21: View Of Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

Camshaft Position Actuator Housing

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
2	M6 x 1.0	201	202	N/A	203	204	205	18.0	0.7087	14.0	0.5512
3	M10 x 1.5	N/A	N/A	N/A	N/A	N/A	N/A	THRU		THRU	

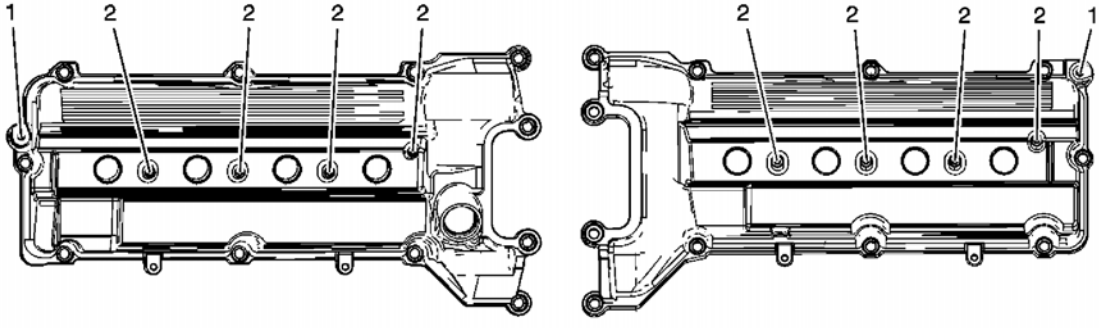


Fig. 22: Identifying Camshaft Cover Thread Repair Locations
Courtesy of GENERAL MOTORS CORP.

Camshaft Covers

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Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
2	M6 x 1.0	201	202	N/A	203	204	205	23.0	0.9055	19.0	0.7480

#1 Threads are created initially when coil ground strap bolt is installed.

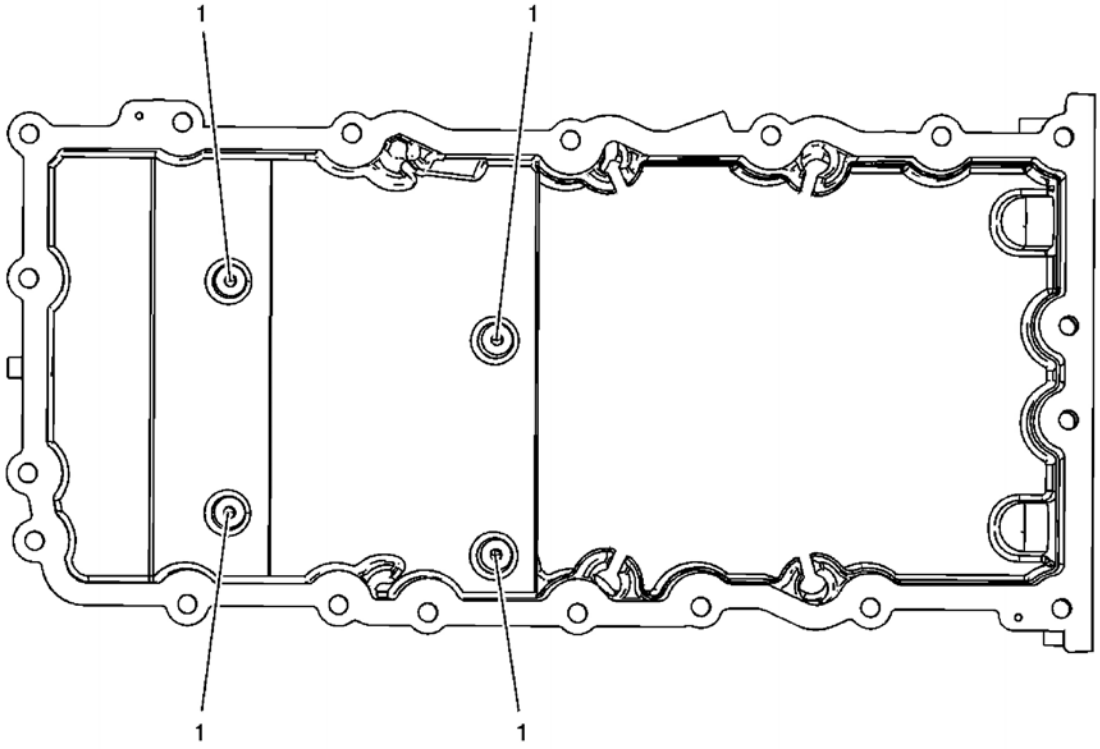


Fig. 23: View Of Oil Pan Thread Repair - Top
Courtesy of GENERAL MOTORS CORP.

Oil Pan - Top

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	-	-	-	-

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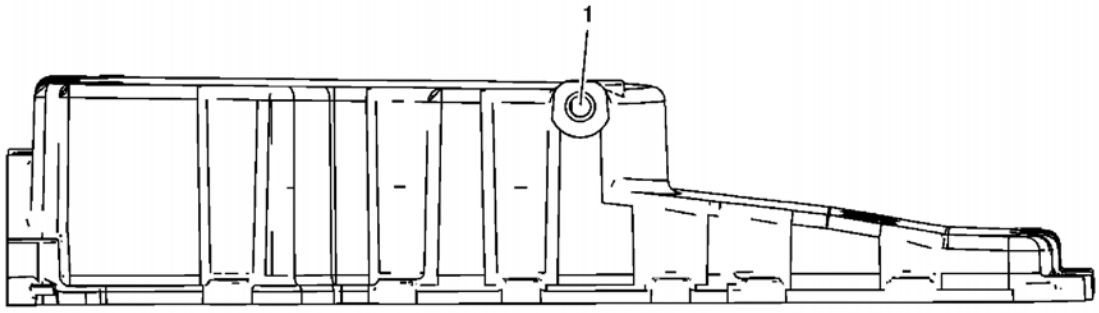


Fig. 24: View Of Oil Pan Thread Repair - Left
Courtesy of GENERAL MOTORS CORP.

Oil Pan - Left

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M12 x 1.75	856	857	N/A	858	859	865	THRU		THRU	

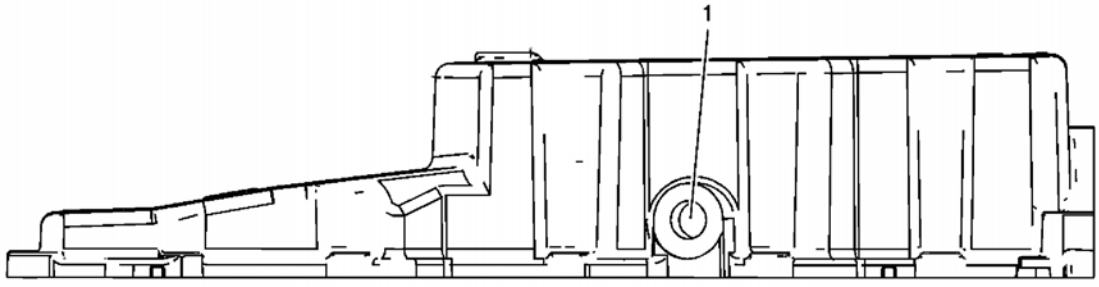


Fig. 25: View Of Oil Pan Thread Repair - Right
Courtesy of GENERAL MOTORS CORP.

Oil Pan - Right

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M20 x 1.5	715	716	N/A	717	718	719	THRU		THRU	

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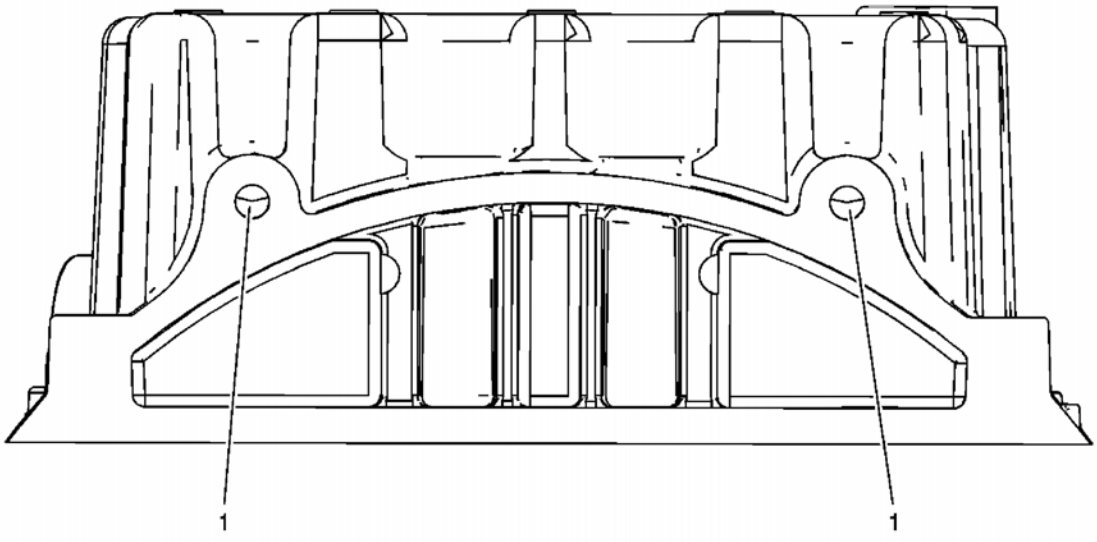


Fig. 26: View Of Oil Pan Thread Repair - Rear
Courtesy of GENERAL MOTORS CORP.

Oil Pan - Rear

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	215	37.0	1.4567	31.5	1.2401

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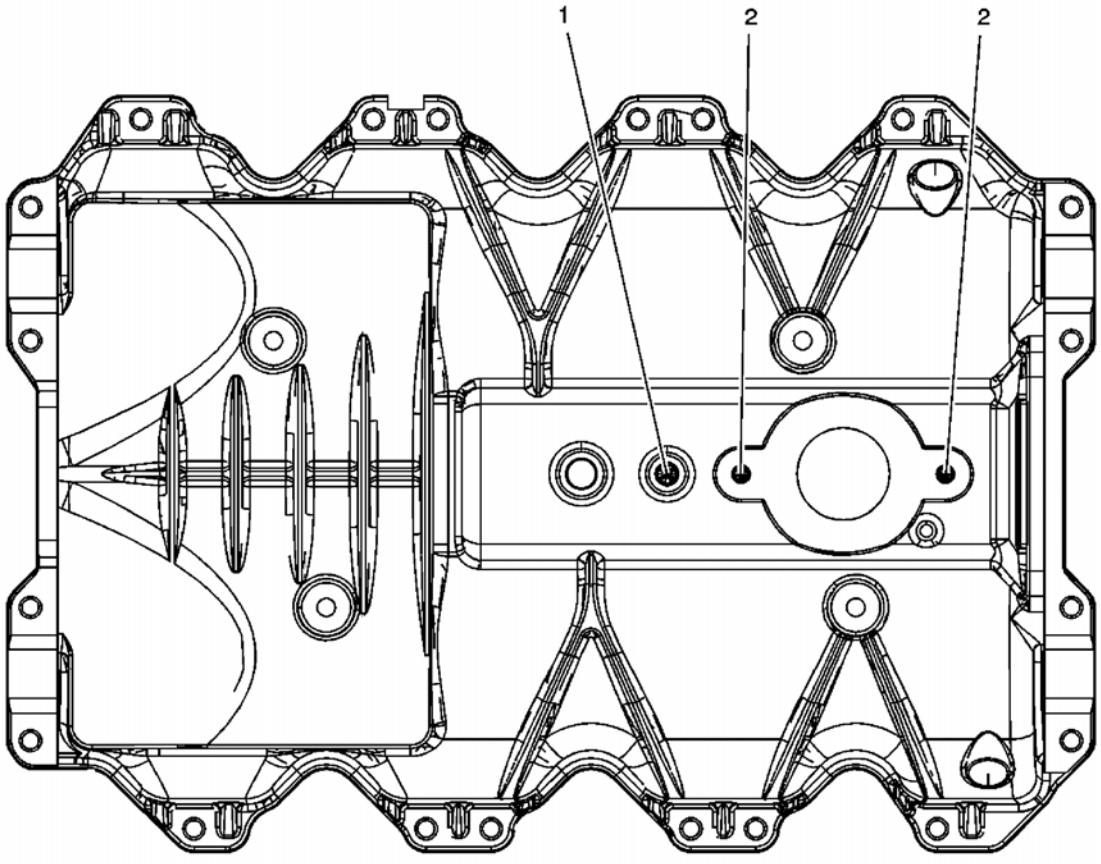


Fig. 27: View Of Charge Air Cooler Housing - Top
Courtesy of GENERAL MOTORS CORP.

Charge Air Cooler Housing - Top

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.50	1.1220	23.00	0.9055
2	M6 x 1.0	201	202	N/A	203	204	205	22.50	0.8858	18.00	0.7087

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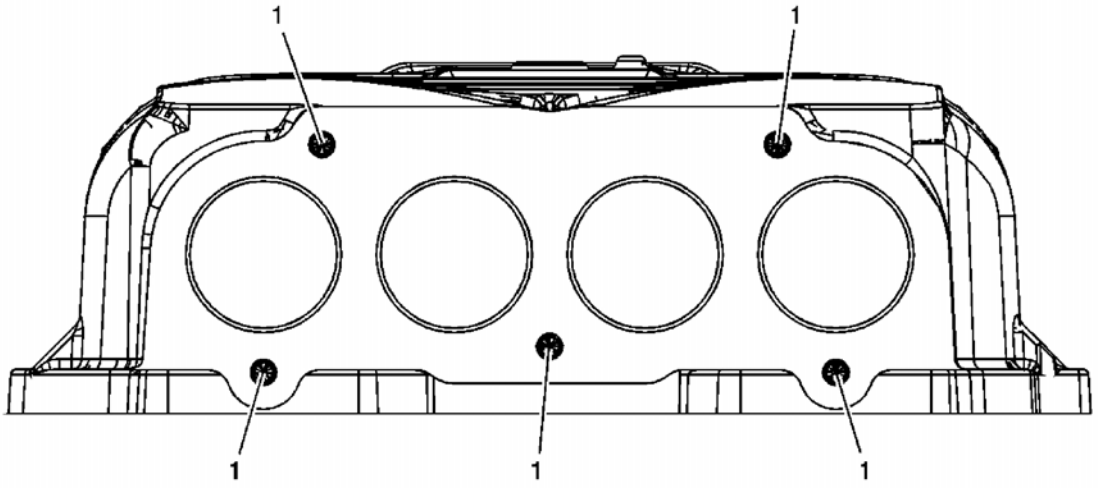


Fig. 28: View Of Charge Air Cooler Housing - Front
Courtesy of GENERAL MOTORS CORP.

Charge Air Cooler Housing - Front

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	22.50	0.8858	18.00	0.7087

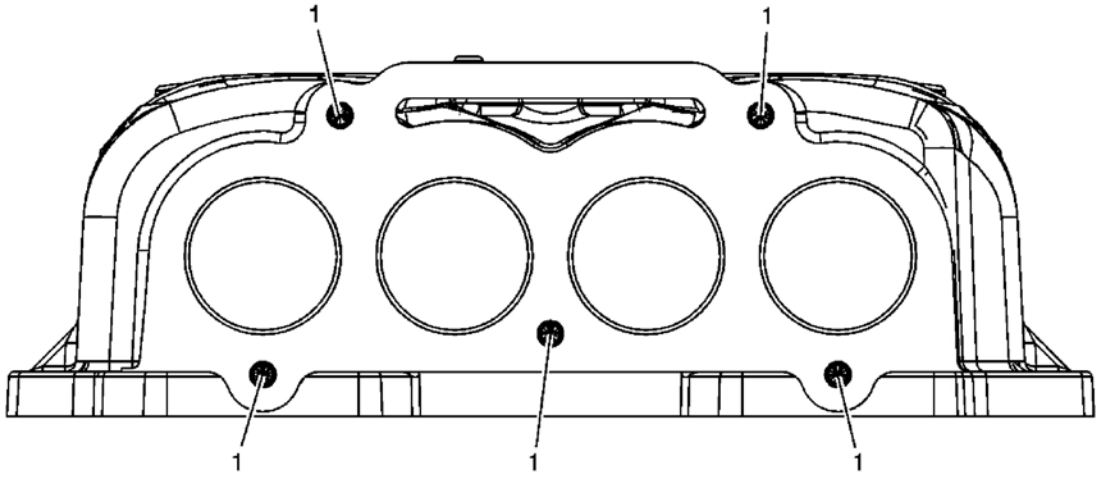


Fig. 29: View Of Charge Air Cooler Housing - Rear
Courtesy of GENERAL MOTORS CORP.

Charge Air Cooler Housing - Rear

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Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	22.50	0.8858	18.00	0.7087

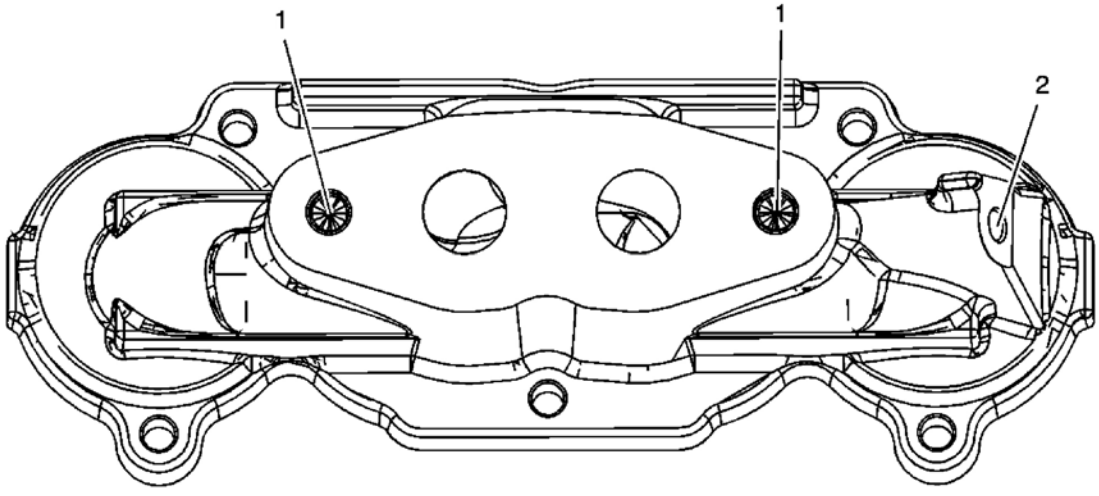


Fig. 30: View Of Charge Air Cooler Manifold - Front
Courtesy of GENERAL MOTORS CORP.

Charge Air Cooler Manifold - Front

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.50	1.1220	23.00	0.9055
2	M6 x 1.0	201	202	N/A	203	204	205	25.00	0.9843	20.00	0.7874

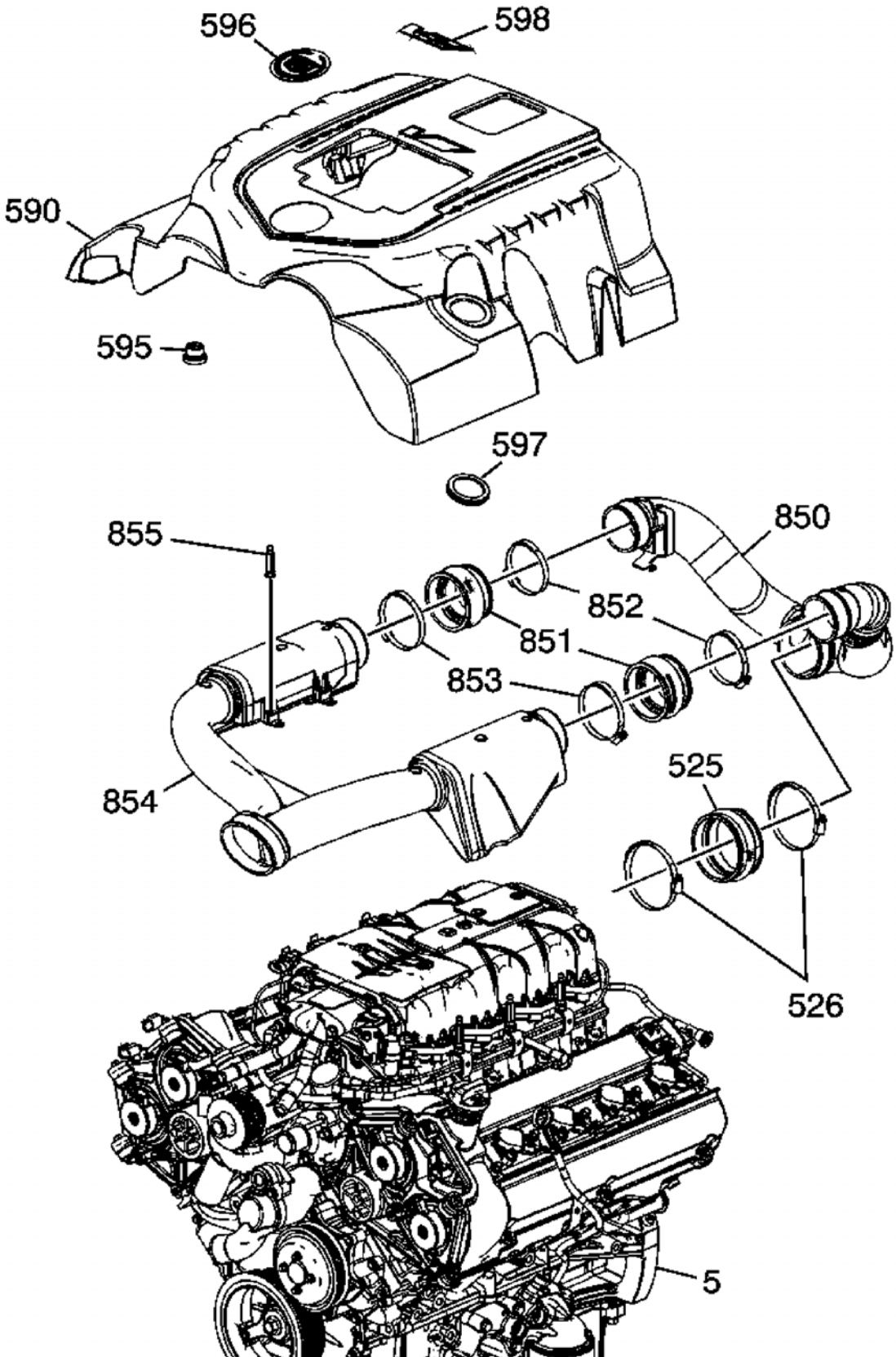
COMPONENT LOCATOR

DISASSEMBLED VIEWS

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2007 Cadillac XLR

2007 ENGINE Engine Mechanical - 4.4L - XLR



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Fig. 31: Identifying Engine Covers & Component Assemblies (1 Of 3)
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 31

Callout	Component Name
5	Engine Long Block Assembly
525	Rear Intake Air Duct Seal - Boot
526	Rear Intake Air Duct Seal - Clamp
590	Fuel Injector Sight Shield Cover
595	Fuel Injector Sight Shield Cover Ball Stud Socket Grommet
596	Fuel Injector Sight Shield Cover Emblem - Crest
597	Fuel Injector Sight Shield Cover Oil Fill Tube Grommet
598	Fuel Injector Sight Shield Cover Emblem - V Series
850	Rear Intake Air Duct
851	Front Intake Air Duct Seal - Boot
852	Front Intake Air Duct Seal - Small Clamp
853	Front Intake Air Duct Seal - Large Clamp
854	Front Intake Air Duct
855	Supercharger Inlet Air Duct Ballstud Nut

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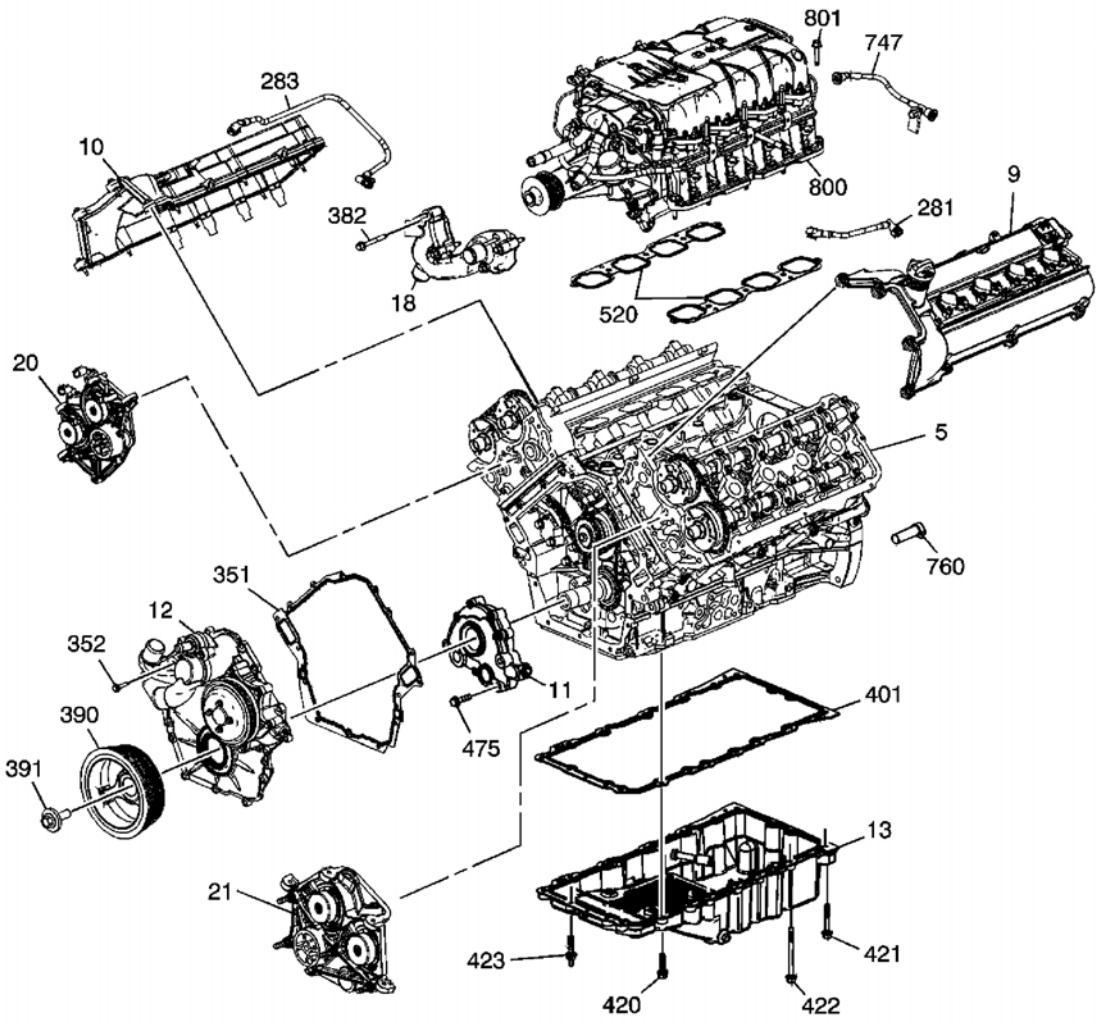


Fig. 32: Identifying Engine Covers & Component Assemblies (2 of 3)
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 32

Callout	Component Name
5	Engine Long Block Assembly
9	Left Camshaft Cover Assembly
10	Right Camshaft Cover Assembly
11	Oil Pump Assembly
12	Engine Front Cover Assembly
13	Oil Pan Assembly
18	Water Outlet Assembly
20	Right Camshaft Position Actuator Housing Assembly
21	Left Camshaft Position Actuator Housing Assembly
281	PCV Fresh Air Tube

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283	PCV Dirty Air Tube
351	Engine Front Cover Gasket
352	Engine Front Cover Bolt
382	Water Outlet Bolt
390	Crankshaft Balancer
391	Crankshaft Balancer Bolt
401	Oil Pan Gasket
420	Oil Pan Bolt - Short
421	Oil Pan Bolt - Medium
422	Oil Pan Bolt - Long
423	Oil Pan Stud
475	Oil Pump Bolt
520	Supercharger Gasket
747	EVAP Tube
760	Block Heater - 110 Volt
800	Supercharger Assembly
801	Supercharger Bolt

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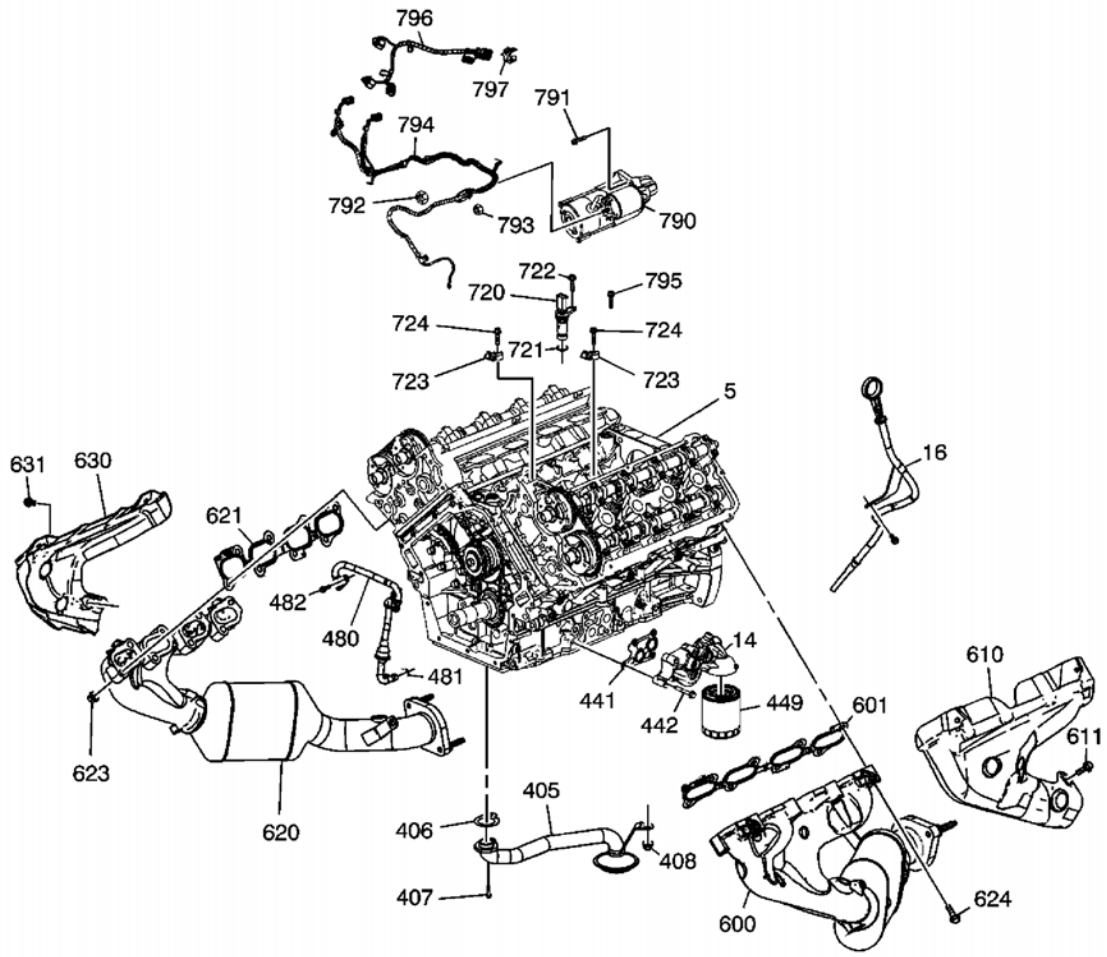


Fig. 33: Identifying Engine Covers & Component Assemblies (3 of 3)
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 33

Callout	Component Name
5	Engine Long Block Assembly
14	Oil Filter Adapter Assembly
16	Oil Level Indicator Assembly
405	Oil Pump Suction Pipe
406	Oil Pump Suction Pipe Gasket
407	Oil Pump Suction Pipe Bolt
408	Oil Pump Suction Pipe Nut
441	Oil Filter Adapter Gasket
442	Oil Filter Adapter Bolt
449	Oil Filter
480	Oil Pump Outlet Tube

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481	Oil Pump Outlet Tube O-ring
482	Oil Pump Outlet Tube Bolt
600	Left Exhaust Manifold and Converter
601	Left Exhaust Manifold Gasket
610	Left Exhaust Manifold Heat Shield
611	Left Exhaust Manifold Heat Shield Bolt
620	Right Exhaust Manifold and Converter
621	Right Exhaust Manifold Gasket
623	Cylinder Head Exhaust Manifold Nut
624	Cylinder Head Exhaust Manifold Bolt
630	Right Exhaust Manifold Heat Shield
631	Right Exhaust Manifold Heat Shield Bolt
720	Crankshaft Position Sensor
721	Crankshaft Position Sensor O-ring
722	Crankshaft Position Sensor Bolt
723	Knock Sensor
723	Knock Sensor
724	Knock Sensor Bolt
724	Knock Sensor Bolt
790	Starter Motor
791	Starter Motor Bolt
792	Starter Motor Solenoid Cable Nut - Larger
793	Starter Motor Solenoid Cable Nut - Small
794	Battery Positive and Negative Starter Cable
795	Bracket Bolt
796	Crankshaft Position Sensor and Knock Sensor Wiring Harness
797	Bracket

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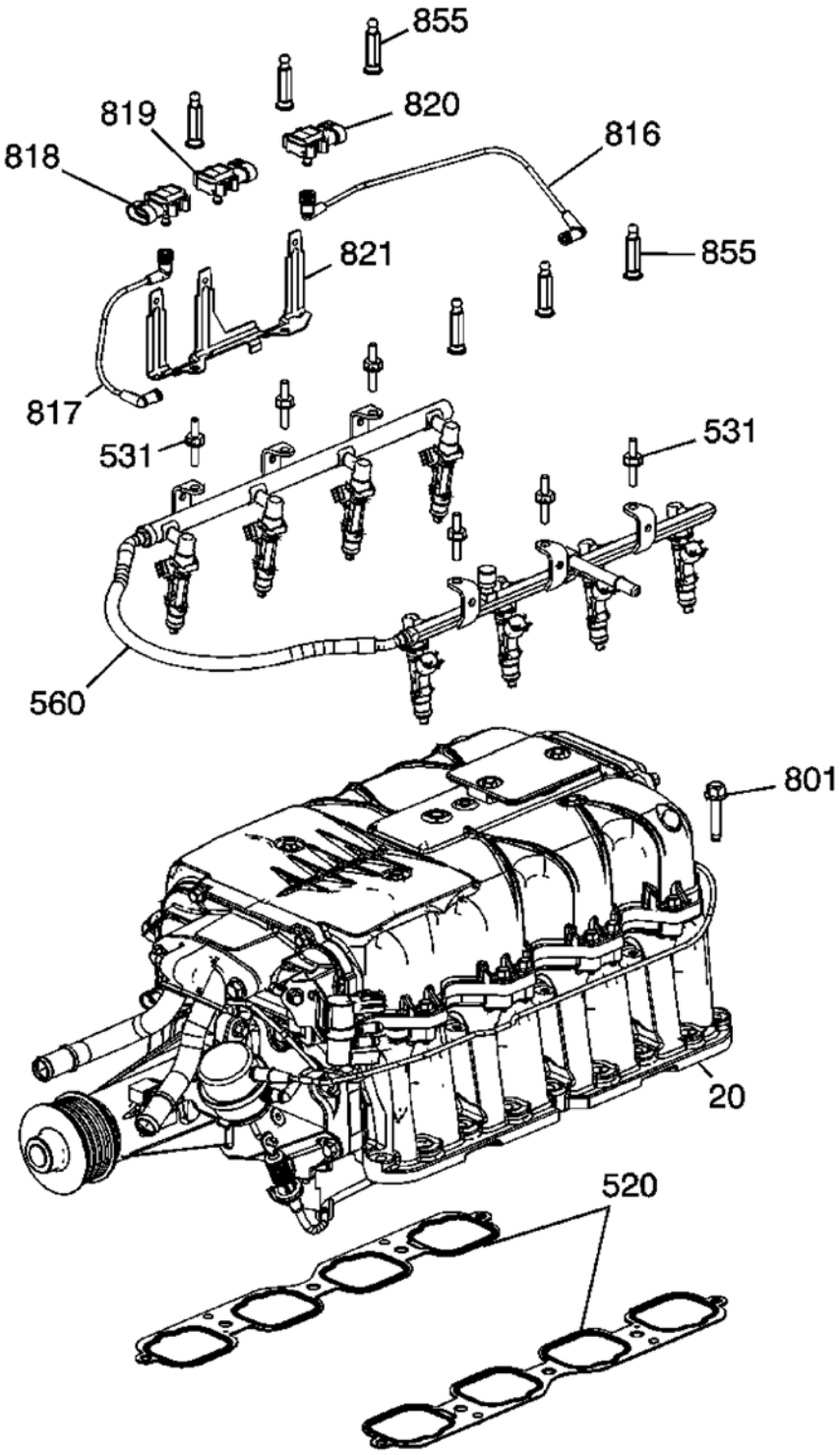


Fig. 34: Identifying Supercharger, Fuel Rail & Pressure Sensor Assemblies
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 34

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Callout	Component Name
20	Supercharger Assembly
520	Supercharger Gasket
531	Fuel Injection Rail Stud
531	Fuel Injection Rail Stud
560	Sequential Multiport Fuel Injection Rail Assembly
801	Supercharger Bolt
816	MAP Manifold Absolute Pressure Sensor Vacuum Tube - MAP Vacuum Side
817	MAP Manifold Absolute Pressure Sensor Vacuum Tube - BARO Pressure Side
818	Manifold Absolute Pressure (MAP) Sensor
819	Barometric Pressure (BARO) Sensor
820	Supercharger Inlet Absolute Pressure Sensor
821	Barometric Pressure and Manifold Absolute Pressure Sensor Bracket
855	Supercharger Inlet Air Duct Ballstud Nut
855	Supercharger Inlet Air Duct Ballstud Nut

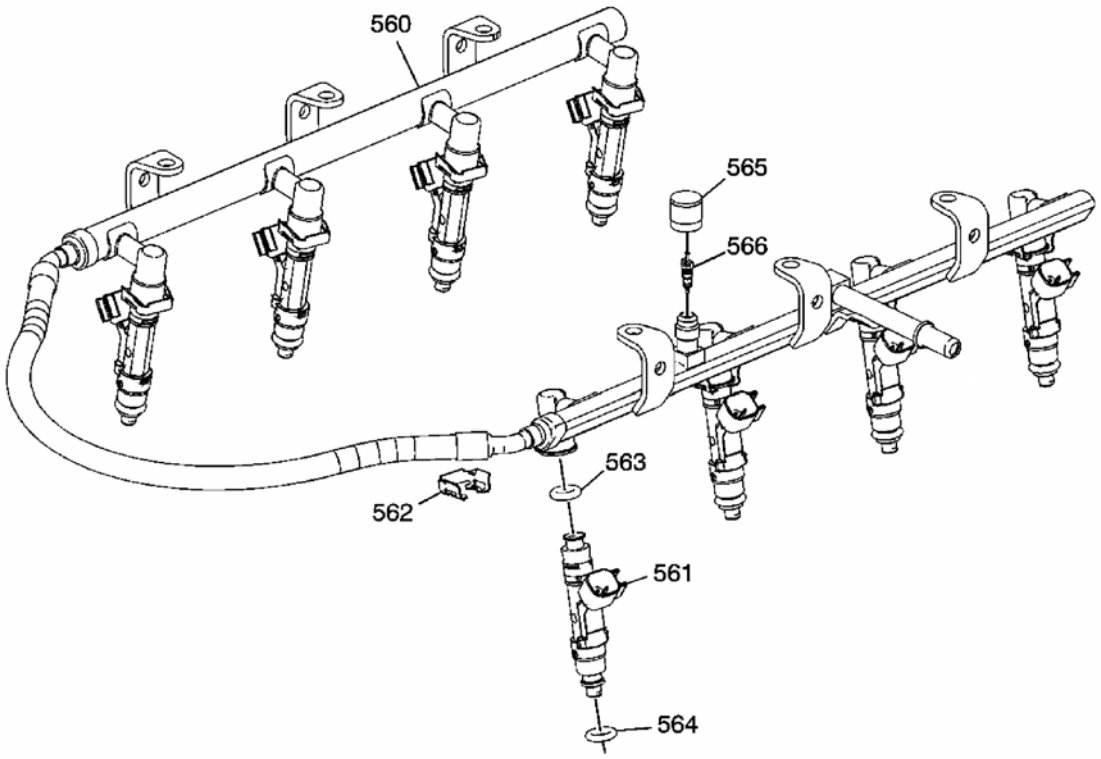


Fig. 35: Identifying Fuel Rail Assembly Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 35

Callout	Component Name

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560	Sequential Multiport Fuel Injection Rail
561	Multiport Fuel Injector
562	Multiport Fuel Injector Retaining Clip
563	Multiport Fuel Injector Upper O-ring
564	Multiport Fuel Injector Lower O-ring
565	Sequential Multiport Fuel Injection Rail Valve Service Port Valve Cap
566	Sequential Multiport Fuel Injection Rail Valve Service Port Valve Core

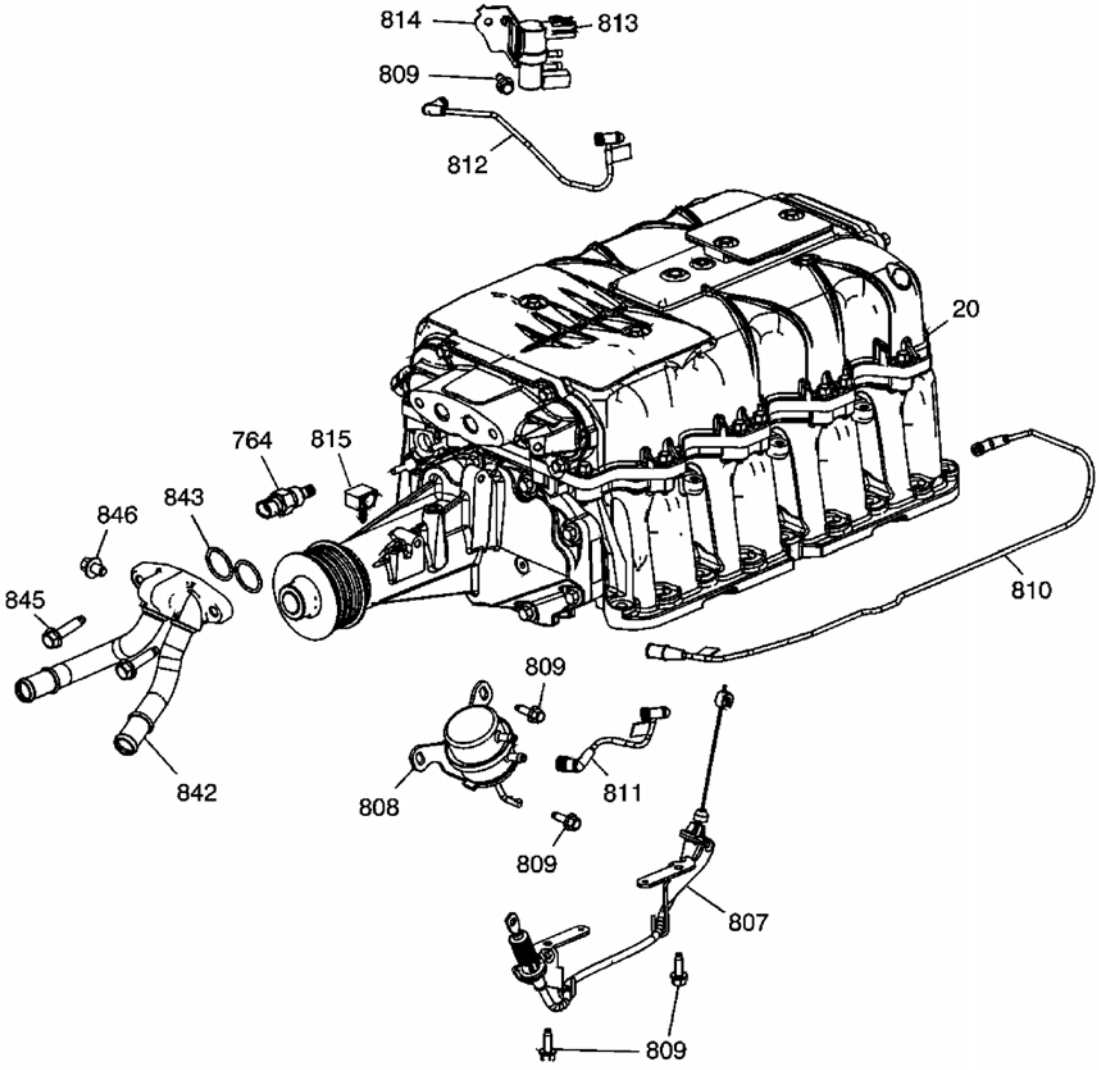


Fig. 36: View Of Supercharger Assembly and Charge Air Bypass Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 36

Callout	Component Name

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20	Supercharger Assembly
764	Manifold Air Temperature (MAT) Sensor
807	Supercharger Bypass Valve Cable
808	Supercharger Bypass Valve Actuator
809	Supercharger Component Bolt
809	Supercharger Component Bolt
809	Supercharger Component Bolt
809	Supercharger Component Bolt
810	Supercharger Bypass Valve Actuator Hose - Vacuum Source to Actuator
811	Supercharger Bypass Valve Actuator Hose - Actuator to Regulator
812	Supercharger Bypass Valve Actuator Hose - Pressure to Regulator
813	Charge Air Bypass Regulator Solenoid Valve Bracket
814	Charge Air Bypass Regulator Solenoid Valve
815	Fuel Injection Fuel Rail Crossover Tube Clip
842	Charge Air Cooler Front Manifold
843	Supercharger Water Manifold Gasket
845	Charge Air Cooler Front Manifold Bolt
846	Supercharger Coolant Hole Plug

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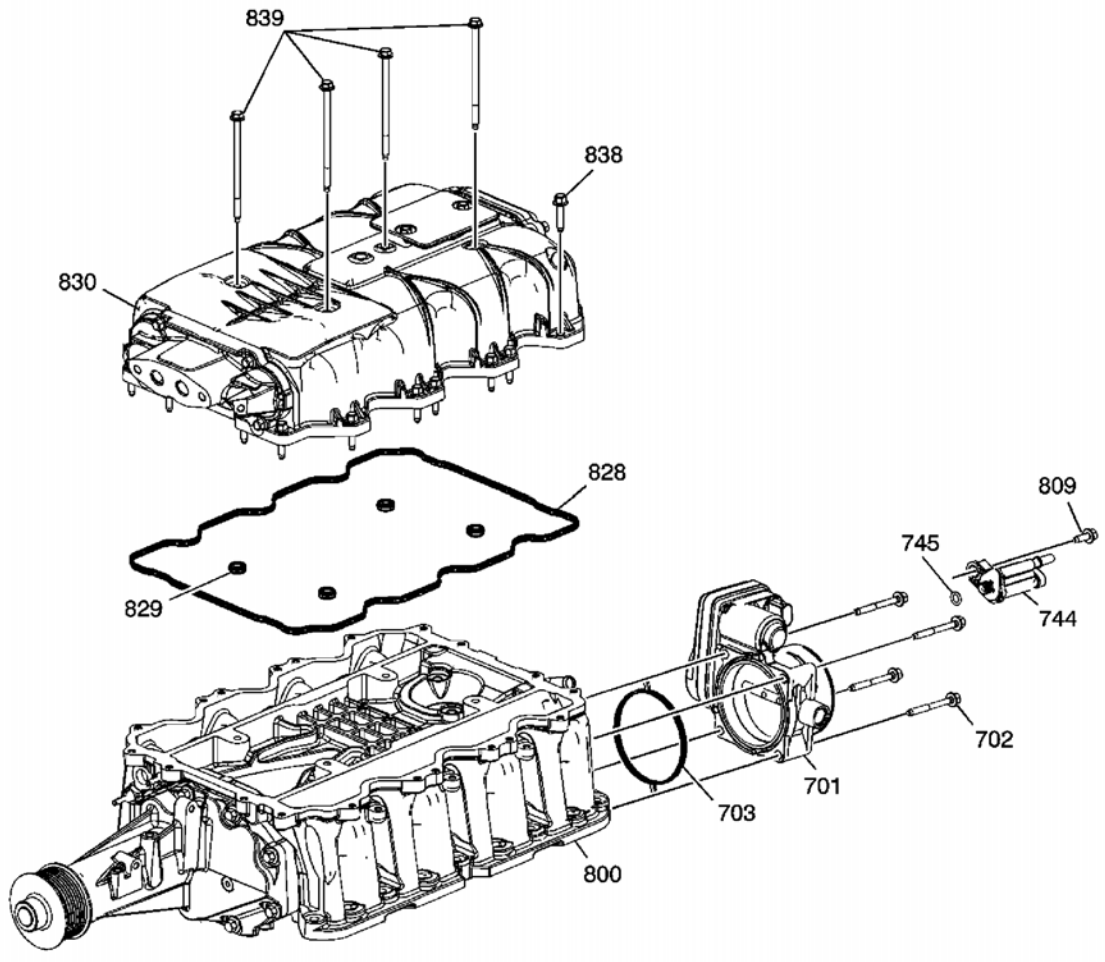


Fig. 37: View Of Supercharger, Charge Air Cooler Assembly, Throttle Body and EVAP Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 37

Callout	Component Name
701	Throttle Body
702	Throttle Body Bolt
703	Throttle Body Gasket
744	EVAP Emission Canister Purge Solenoid Valve
745	EVAP Emission Canister Purge Solenoid Valve O-ring
800	Supercharger
809	Supercharger Component Bolt
828	Charge Air Cooler Housing Gasket - Perimeter
829	Charge Air Cooler Housing Gasket - Mounting Bolt
830	Charge Air Cooler Housing
838	Charge Air Cooler Bolt - Short

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839	Charge Air Cooler Bolt - Long

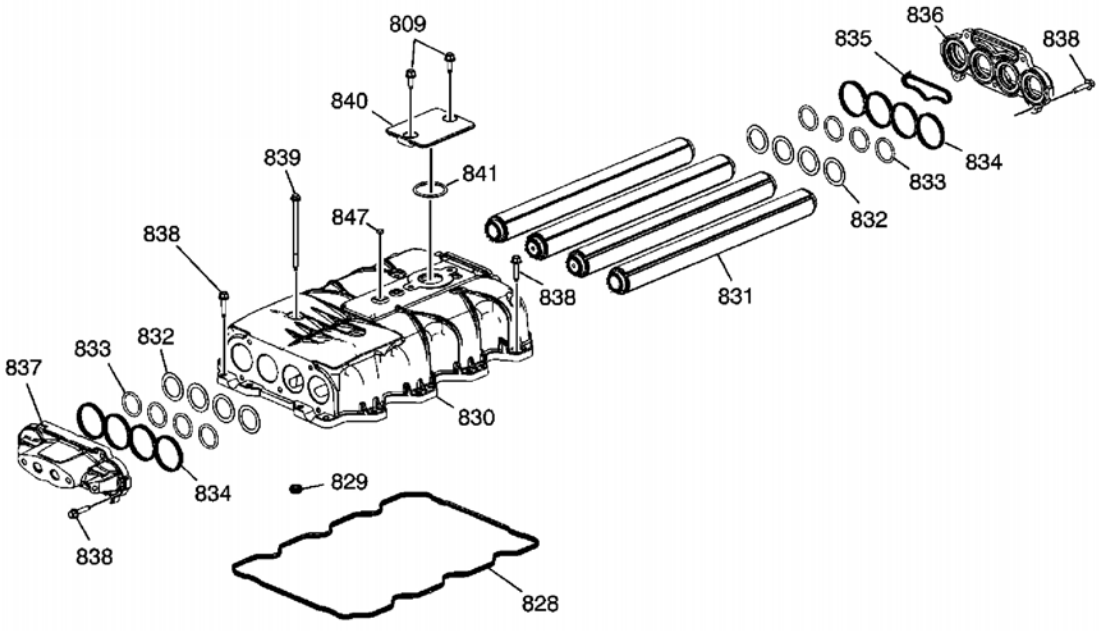


Fig. 38: View Of Charge Air Cooler Assembly Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 38

Callout	Component Name
809	Supercharger Component Bolt
828	Charge Air Cooler Housing Gasket - Perimeter
829	Charge Air Cooler Housing Gasket - Mounting Bolt
830	Charge Air Cooler Housing
831	Charge Air Cooler Cooling Tube
832	Charge Air Cooler Insulator Spacer
832	Charge Air Cooler Insulator Spacer
833	Charge Air Cooler Cooling Tube Seal
833	Charge Air Cooler Cooling Tube Seal
834	Supercharger Water Manifold Gasket
834	Supercharger Water Manifold Gasket
835	Charge Air Cooler Cooling Return Pipe Seal
836	Charge Air Cooler Cooling Rear Manifold
837	Charge Air Cooler Front Manifold
838	Charge Air Cooler Bolt - Short
838	Charge Air Cooler Bolt - Short
838	Charge Air Cooler Bolt - Short

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838	Charge Air Cooler Bolt - Short
839	Charge Air Cooler Bolt - Long
840	Charge Air Cooler Cooling Fill Cap
841	Charge Air Cooler Cooling Fill Cap Seal
847	Charge Air Cooler Housing Expansion Plug

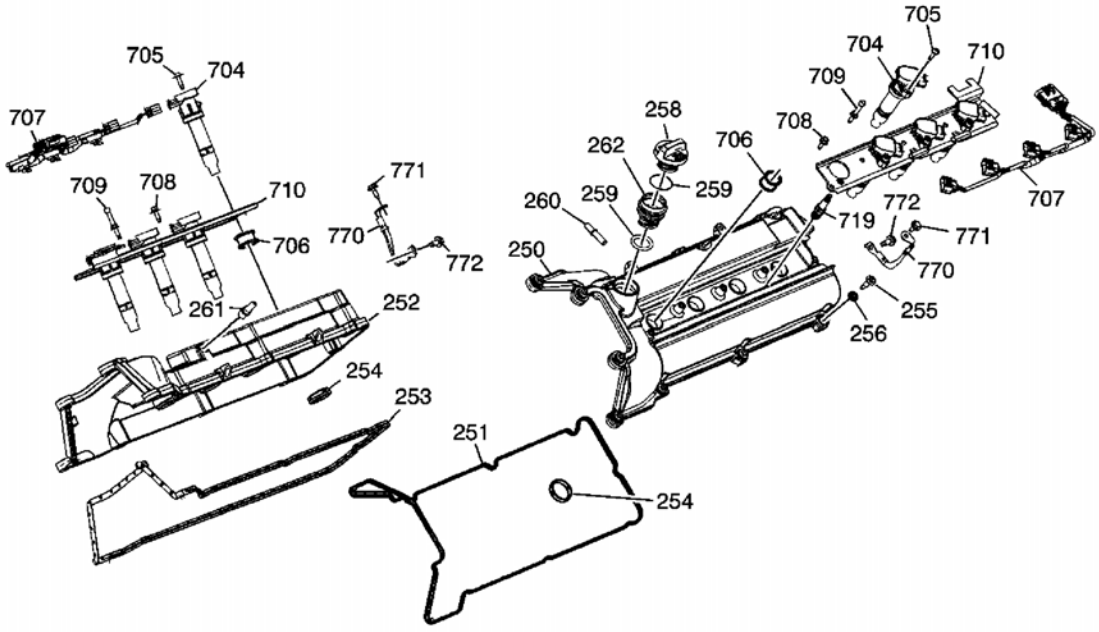


Fig. 39: View Of Camshaft Cover Assembly Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 39

Callout	Component Name
250	Left Camshaft Cover
251	Left Camshaft Cover Gasket
252	Right Camshaft Cover
253	Right Camshaft Cover Gasket
254	Camshaft Cover Spark Plug Port Seal
254	Camshaft Cover Spark Plug Port Seal
255	Camshaft Cover Bolt
256	Camshaft Cover Bolt Insulator
258	Oil Fill Cap
259	Oil Fill Cap O-ring
259	Oil Fill Cap O-ring
260	Left Camshaft Cover PCV Fitting
261	Right Camshaft Cover PCV Fitting Orifice

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262	Oil Fill Tube
704	Ignition Coil
704	Ignition Coil
705	Ignition Coil Bolt
705	Ignition Coil Bolt
706	Ignition Coil Seal
706	Ignition Coil Seal
707	Ignition Coil Assembly Wiring Harness
707	Ignition Coil Assembly Wiring Harness
708	Ignition Coil Assembly Bolt
708	Ignition Coil Assembly Bolt
709	Ignition Coil Assembly Ball Stud
709	Ignition Coil Assembly Ball Stud
710	Ignition Coil Assembly Bracket
710	Ignition Coil Assembly Bracket
719	Spark Plug
770	Camshaft Cover to Cylinder Head Ground Strap
770	Camshaft Cover to Cylinder Head Ground Strap
771	Ground Strap to Camshaft Cover Bolt
771	Ground Strap to Camshaft Cover Bolt
772	Ground Strap to Cylinder Head Bolt
772	Ground Strap to Cylinder Head Bolt

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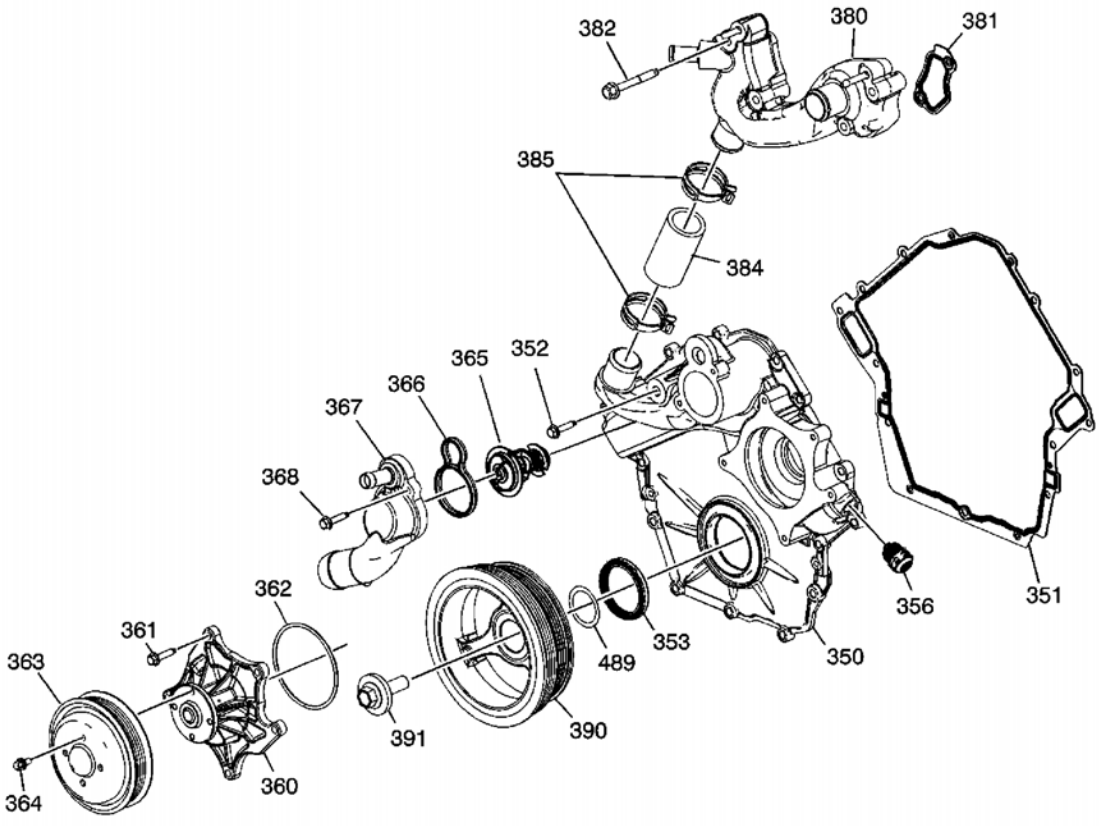


Fig. 40: View Of Engine Front Cover Assembly Components, Crankshaft Balancer & Water Crossover
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 40

Callout	Component Name
350	Engine Front Cover
351	Engine Front Cover Gasket
352	Engine Front Cover Bolt
353	Engine Front Cover Seal
356	Engine Front Cover Fitting
360	Water Pump Assembly
361	Water Pump Bolt
362	Water Pump Gasket
363	Water Pump Pulley
364	Water Pump Pulley Bolt
365	Engine Cooling Thermostat
366	Engine Cooling Thermostat Gasket
367	Engine Cooling Thermostat Housing
368	Engine Cooling Thermostat Housing Bolt

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380	Water Outlet
381	Water Outlet Gasket
382	Water Outlet Bolt
384	Water Bypass Hose
385	Water Bypass Hose Clamp
390	Crankshaft Balancer
391	Crankshaft Balancer Bolt
489	Crankshaft Balancer Washer - Oil Pump Drive to Crankshaft Balancer

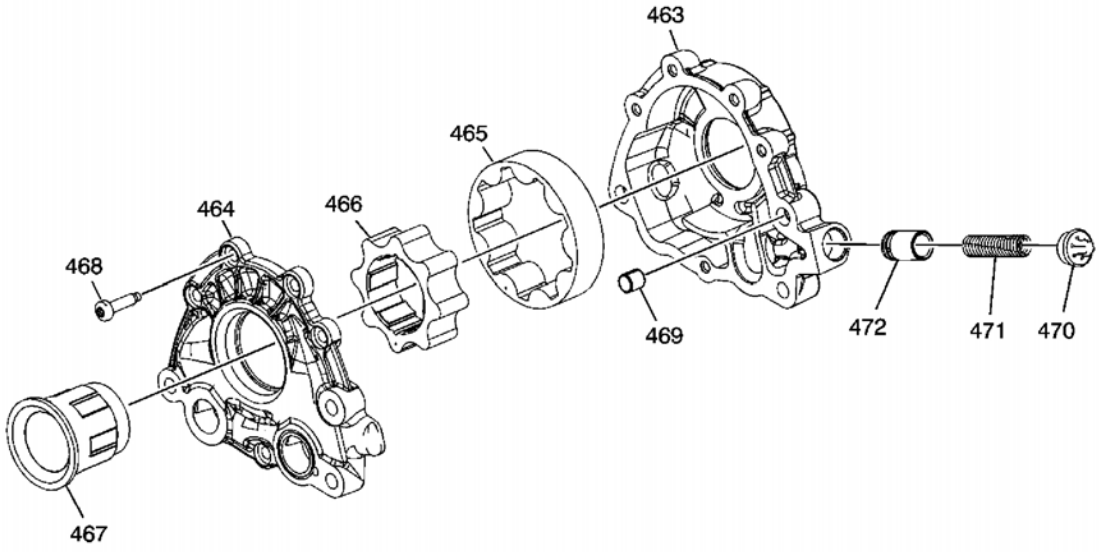


Fig. 41: View Of Oil Pump Assembly Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 41

Callout	Component Name
463	Oil Pump Housing
464	Oil Pump Cover
465	Oil Pump Driven Gear
466	Oil Pump Drive Gear
467	Oil Pump Driven Gear Spacer
468	Oil Pump Cover Bolt
469	Oil Pump Cover Locating Pin
470	Oil Pump Pressure Relief Valve Bore Plug
471	Oil Pump Pressure Relief Valve Spring
472	Oil Pressure Relief Valve

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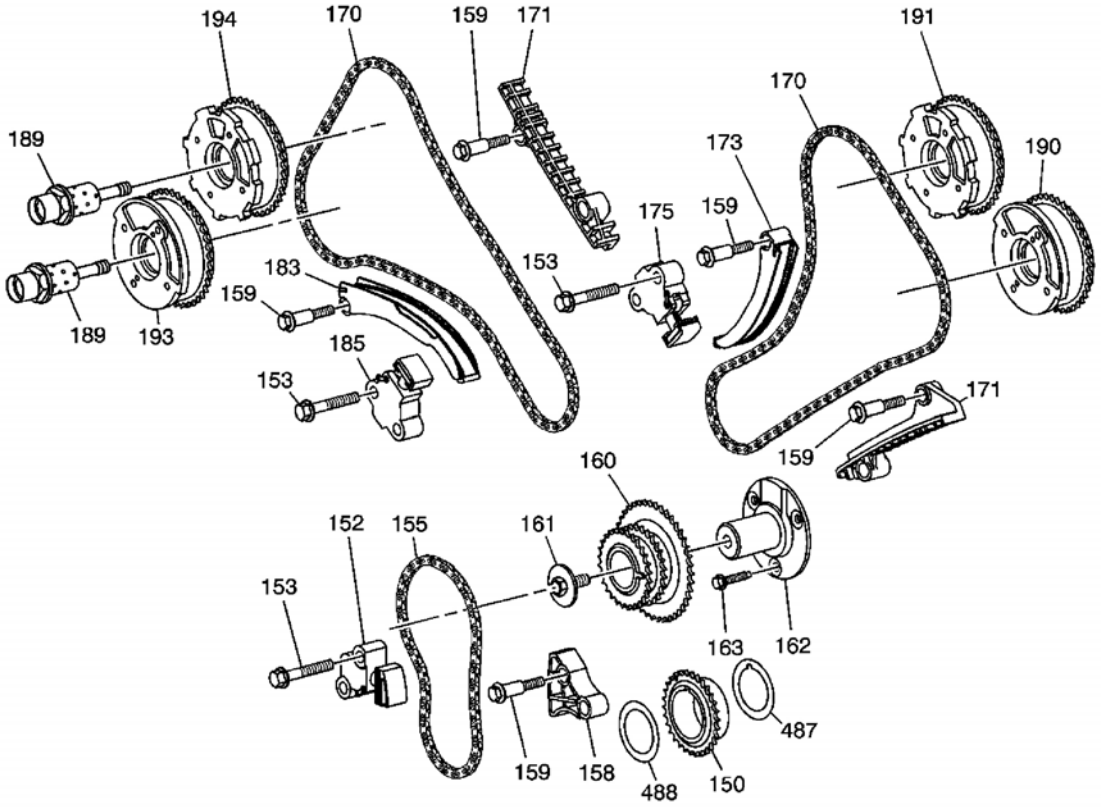


Fig. 42: View Of Camshaft Timing Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 42

Callout	Component Name
150	Crankshaft Sprocket
152	Primary Timing Chain Tensioner
153	Timing Chain Tensioner Bolt
153	Timing Chain Tensioner Bolt
153	Timing Chain Tensioner Bolt
155	Primary Timing Chain
158	Primary Timing Chain Guide
159	Timing Chain Guide and Shoe Bolt
159	Timing Chain Guide and Shoe Bolt
159	Timing Chain Guide and Shoe Bolt
159	Timing Chain Guide and Shoe Bolt
159	Timing Chain Guide and Shoe Bolt
160	Camshaft Intermediate Drive Shaft Sprocket
161	Camshaft Intermediate Drive Shaft Sprocket Bolt
162	Camshaft Intermediate Drive Shaft

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163	Camshaft Intermediate Drive Shaft Bolt
170	Secondary Timing Chain
170	Secondary Timing Chain
171	Secondary Timing Chain Guide
171	Secondary Timing Chain Guide
173	Left Secondary Timing Chain Shoe
175	Left Secondary Timing Chain Tensioner
183	Right Secondary Timing Chain Shoe
185	Right Secondary Timing Chain Tensioner
189	Camshaft Position Actuator Oil Control Valve
189	Camshaft Position Actuator Oil Control Valve
190	Left Exhaust Camshaft Position Actuator
191	Left Intake Camshaft Position Actuator
193	Right Exhaust Camshaft Position Actuator
194	Right Intake Camshaft Position Actuator
487	Crankshaft Balancer Washer - Crankshaft to Crankshaft Sprocket
488	Crankshaft Balancer Washer - Crankshaft Sprocket to Oil Pump Drive

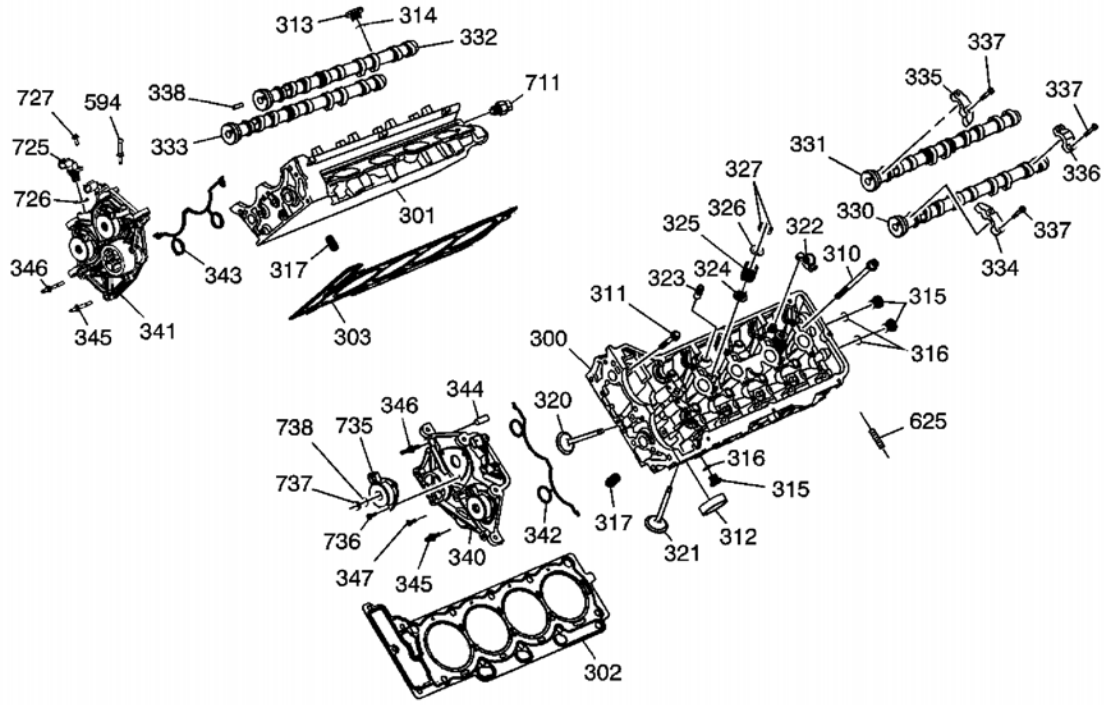


Fig. 43: View Of Cylinder Head Assembly Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 43

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Callout	Component Name
300	Left Cylinder Head
301	Right Cylinder Head
302	Left Cylinder Head Gasket
303	Right Cylinder Head Gasket
310	Cylinder Head Bolt - M11
311	Cylinder Head Front Bolt - M6
312	Cylinder Head Coolant Hole Expansion Plug
313	Cylinder Head Coolant Hole Plug
314	Cylinder Head Coolant Hole Plug Seal Ring
315	Cylinder Head Oil Gallery Plug
315	Cylinder Head Oil Gallery Plug
316	Cylinder Head Oil Gallery Plug Ring
316	Cylinder Head Oil Gallery Plug Ring
317	Engine Oil Gallery Restrictor
317	Engine Oil Gallery Restrictor
320	Exhaust Valve
321	Intake Valve
322	Valve Rocker Arm Assembly
323	Hydraulic Valve Lash Adjuster Assembly
324	Valve Stem Oil Seal
325	Valve Spring
326	Valve Spring Cap
327	Valve Stem Key
330	Left Exhaust Camshaft
331	Left Intake Camshaft
332	Right Intake Camshaft
333	Right Exhaust Camshaft
334	Cylinder Head Front Camshaft Cap
335	Cylinder Head Front Camshaft Cap
336	Cylinder Head Camshaft Cap
337	Cylinder Head Camshaft Cap Bolt
337	Cylinder Head Camshaft Cap Bolt
337	Cylinder Head Camshaft Cap Bolt
338	Camshaft Sprocket Locating Pin
340	Left Camshaft Position Actuator Housing
341	Right Camshaft Position Actuator Housing
342	Left Camshaft Position Actuator Housing Gasket
343	Right Camshaft Position Actuator Housing Gasket
344	Camshaft Position Actuator Housing Pin
345	Camshaft Position Actuator Housing Stud - Short

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345	Camshaft Position Actuator Housing Stud - Short
346	Camshaft Position Actuator Housing Stud - Long
346	Camshaft Position Actuator Housing Stud - Long
347	Camshaft Position Actuator Housing Bolt
594	Fuel Injector Sight Shield Cover Ball Stud
625	Cylinder Head Exhaust Manifold Stud
711	Engine Coolant Temperature Sensor
725	Camshaft Position Sensor
726	Camshaft Position Sensor O-ring
727	Camshaft Position Sensor Bolt
735	Camshaft Position Actuator Magnet
736	Camshaft Position Actuator Magnet Bolt
737	Camshaft Position Actuator Magnet Plug
738	Camshaft Position Actuator Magnet Plug O-ring

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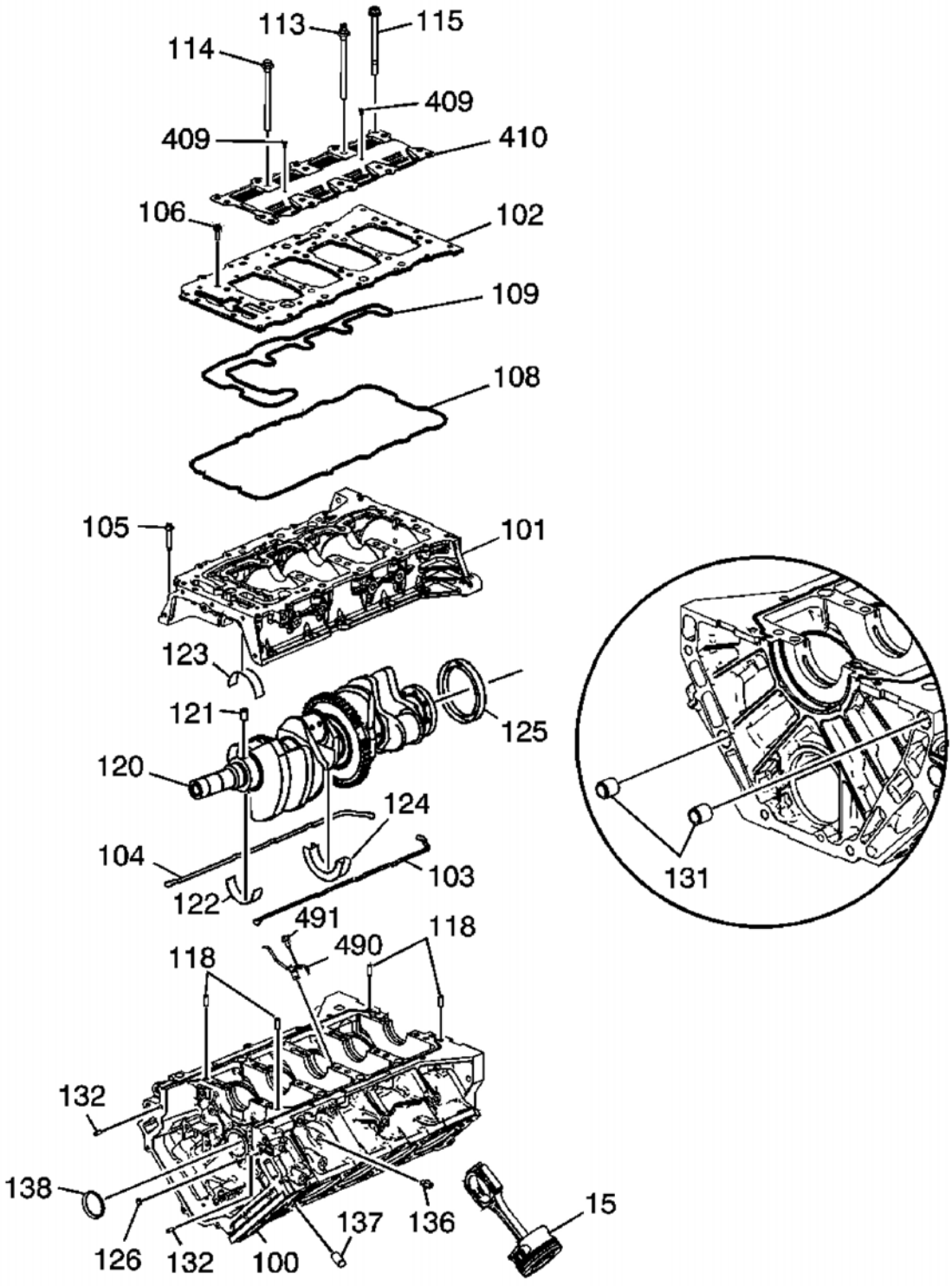


Fig. 44: View Of Engine Block Assembly Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 44

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Callout	Component Name
15	Piston and Connecting Rod Assembly
100	Engine Block
101	Lower Crankcase
102	Engine Oil Distribution Plate
103	Right Lower Crankcase Seal
104	Left Lower Crankcase Seal
105	Lower Crankcase Bolt
106	Engine Oil Distribution Plate Bolt
108	Engine Oil Distribution Plate Outer Seal
109	Engine Oil Distribution Plate Inner Seal
113	Lower Crankcase Main Stud
114	Lower Crankcase Inner Main Bolt
115	Lower Crankcase Outer Main Bolt
118	Lower Crankcase Locating Pin
118	Lower Crankcase Locating Pin
120	Crankshaft
121	Crankshaft Sprocket Locating Pin
122	Crankshaft Upper Bearing
123	Crankshaft Lower Bearing
124	Crankshaft Upper Thrust Bearing #3
125	Piston, Rings and Connecting Rod Assembly
126	Engine Block Oil Gallery Expansion Plug
131	Transaxle Locating Pin
132	Engine Front Cover Locating Pin
132	Engine Front Cover Locating Pin
136	Engine Block Coolant Drain Plug
137	Cylinder Head Locating Pin
138	Camshaft Intermediate Drive Shaft Plug
409	Oil Pan Baffle Stud
409	Oil Pan Baffle Stud
410	Oil Pan Baffle Scraper
490	Piston Oil Nozzle
491	Piston Oil Nozzle Bolt

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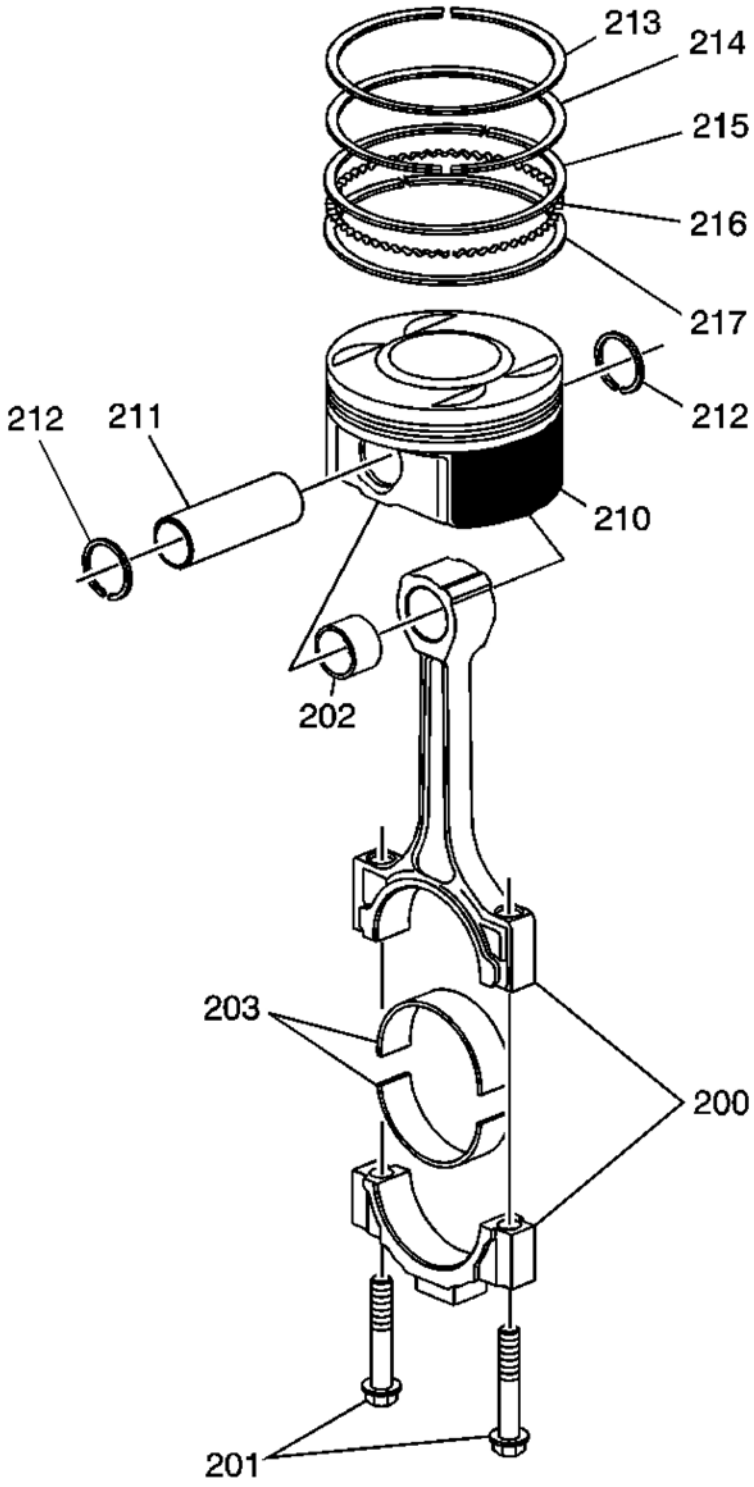


Fig. 45: Disassembled View Of Piston, Rings, Bearing & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 45

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Callout	Component Name
200	Connecting Rod
201	Connecting Rod Bolt
202	Connecting Rod Bushing
203	Connecting Rod Bearing
210	Piston
211	Piston Pin
212	Piston Pin Retainer
212	Piston Pin Retainer
213	Piston Upper Compression Ring
214	Piston Lower Compression Ring
215	Piston Oil Control Rail Ring
216	Piston Oil Control Ring Spacer
217	Lower Oil Control Ring

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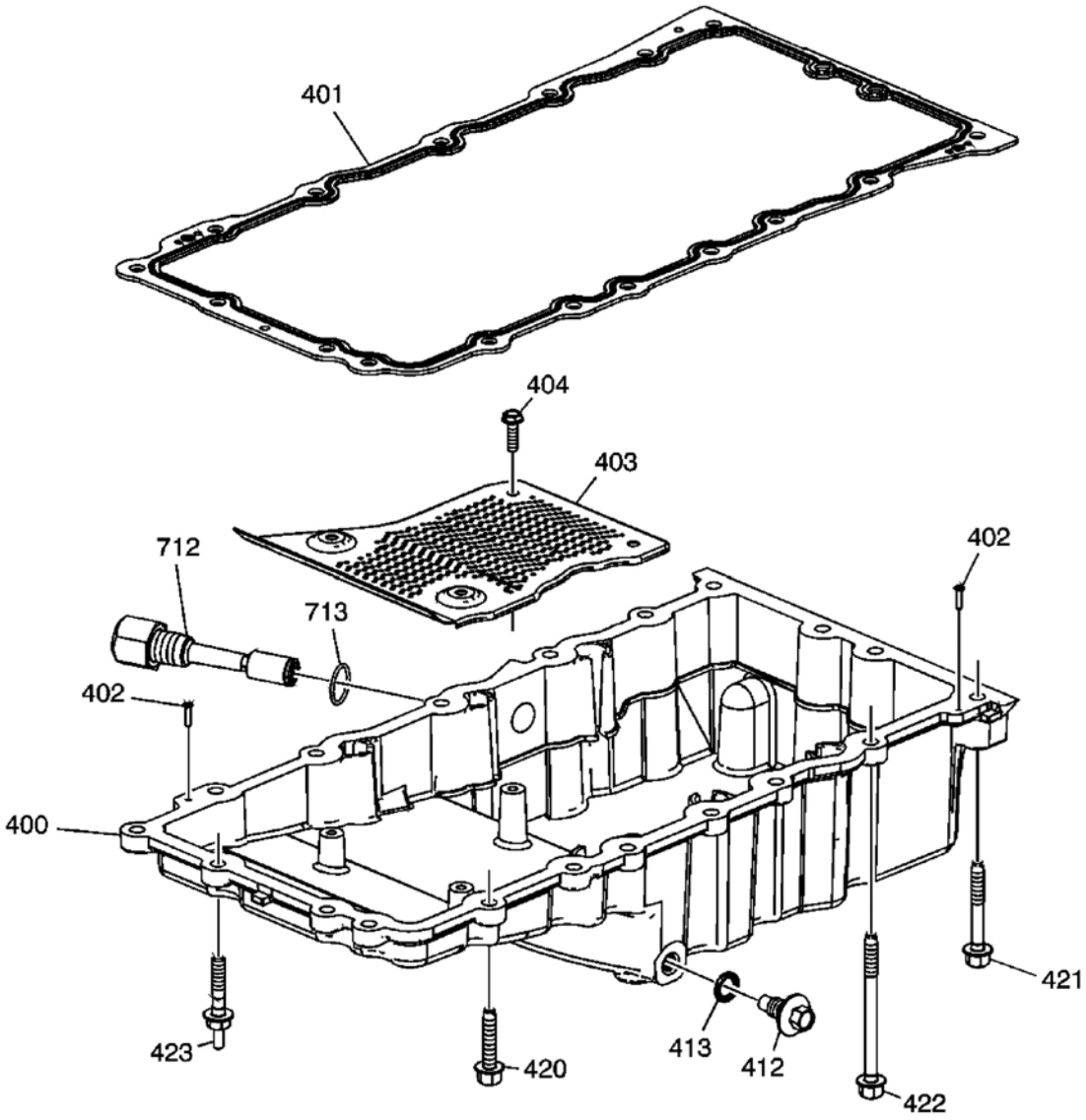


Fig. 46: Oil Pan Assembly Disassembled View
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 46

Callout	Component Name
400	Oil Pan
401	Oil Pan Gasket
402	Oil Pan Gasket Rivet
402	Oil Pan Gasket Rivet
403	Oil Pan Baffle
404	Oil Pan Baffle Bolt
412	Oil Pan Drain Plug

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413	Oil Pan Drain Plug O-ring
420	Oil Pan Bolt - Short
421	Oil Pan Bolt - Medium
422	Oil Pan Bolt - Long
423	Oil Pan Stud
712	Engine Oil Level Sensor
713	Engine Oil Level Sensor O-ring

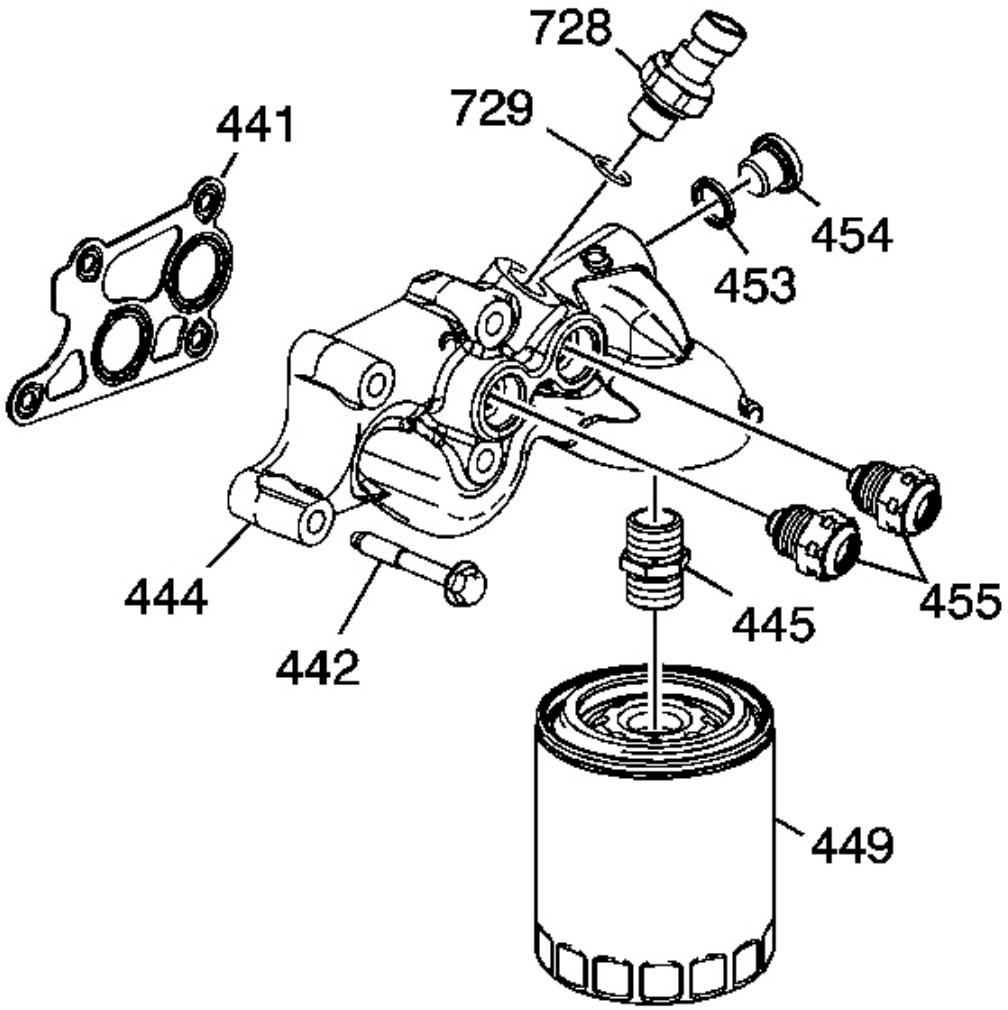


Fig. 47: Identifying Oil Filter Adapter Assembly Components
Courtesy of GENERAL MOTORS CORP.

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Callouts For Fig. 47

Callout	Component Name
441	Oil Filter Adapter Gasket
442	Oil Filter Adapter Bolt
444	Oil Filter Adapter with Oil Cooler
445	Oil Filter Fitting
449	Oil Filter
453	Oil Cooler Bypass Valve Hole Plug O-ring
454	Oil Cooler Bypass Valve Hole Plug
455	Oil Filter Adapter Oil Cooler Pipe Fitting
728	Engine Oil Pressure Sensor
729	Engine Oil Pressure Sensor O-ring

ENGINE IDENTIFICATION

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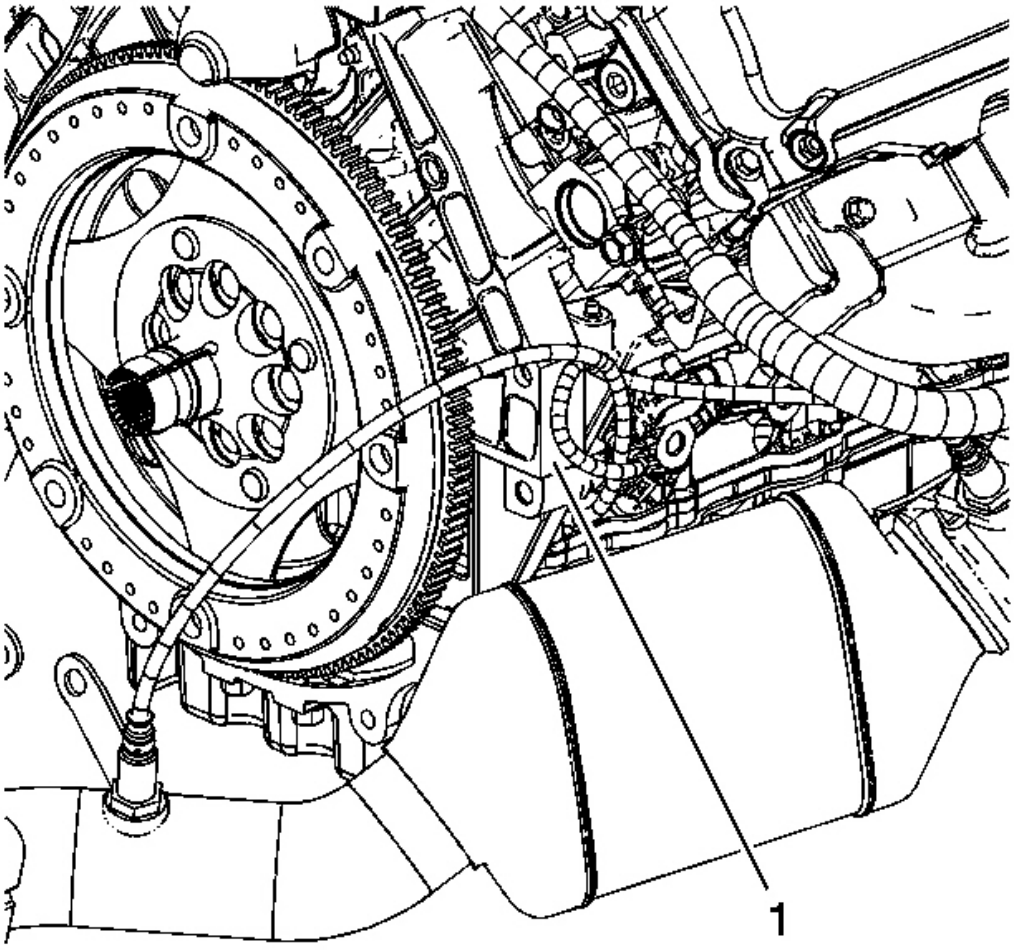


Fig. 48: Locating Engine Identification
Courtesy of GENERAL MOTORS CORP.

The Vehicle Identification Number (VIN) Derivative is located on the right rear side of the engine block (1) and is a nine digit number stamped or laser etched onto the engine at the vehicle assembly plant. If reading the identification number the following information can be obtained:

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

Engine Unit Number

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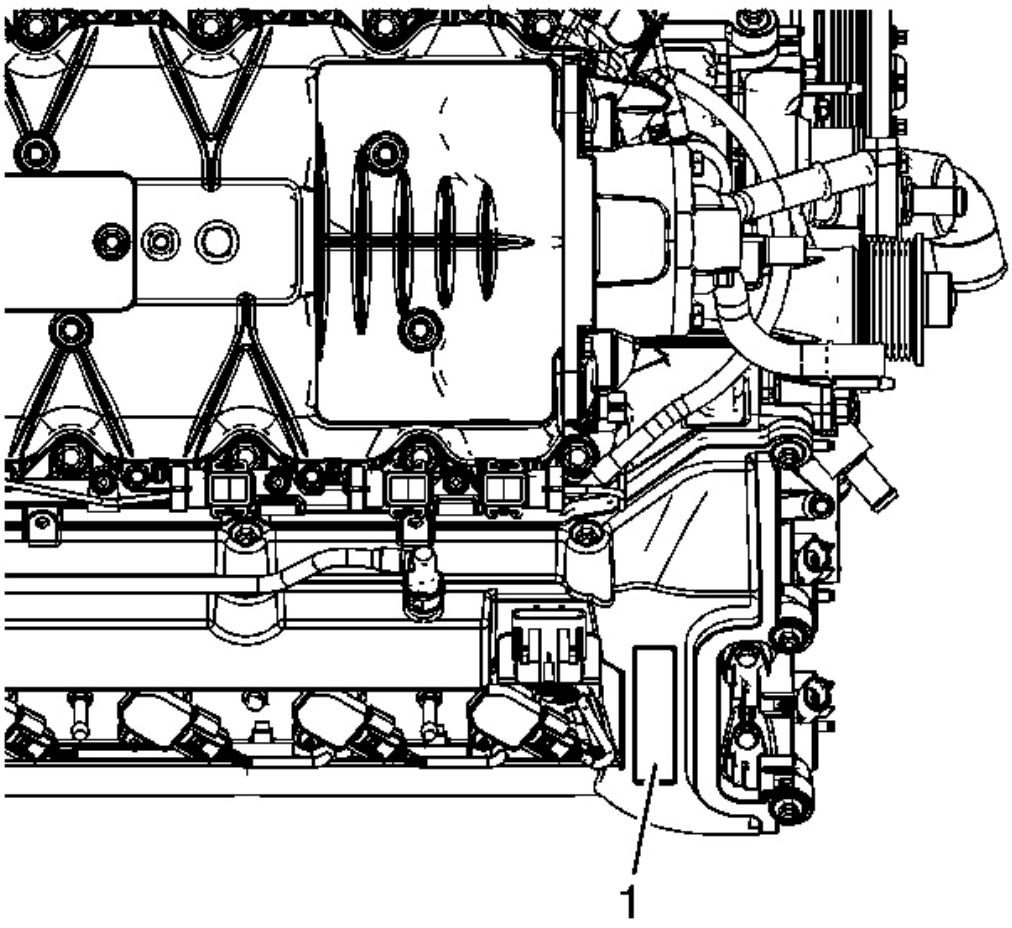


Fig. 49: Locating Engine Unit Number
Courtesy of GENERAL MOTORS CORP.

The engine unit number label (1) is placed on the right camshaft cover at the front of the engine.

Supercharger Identification

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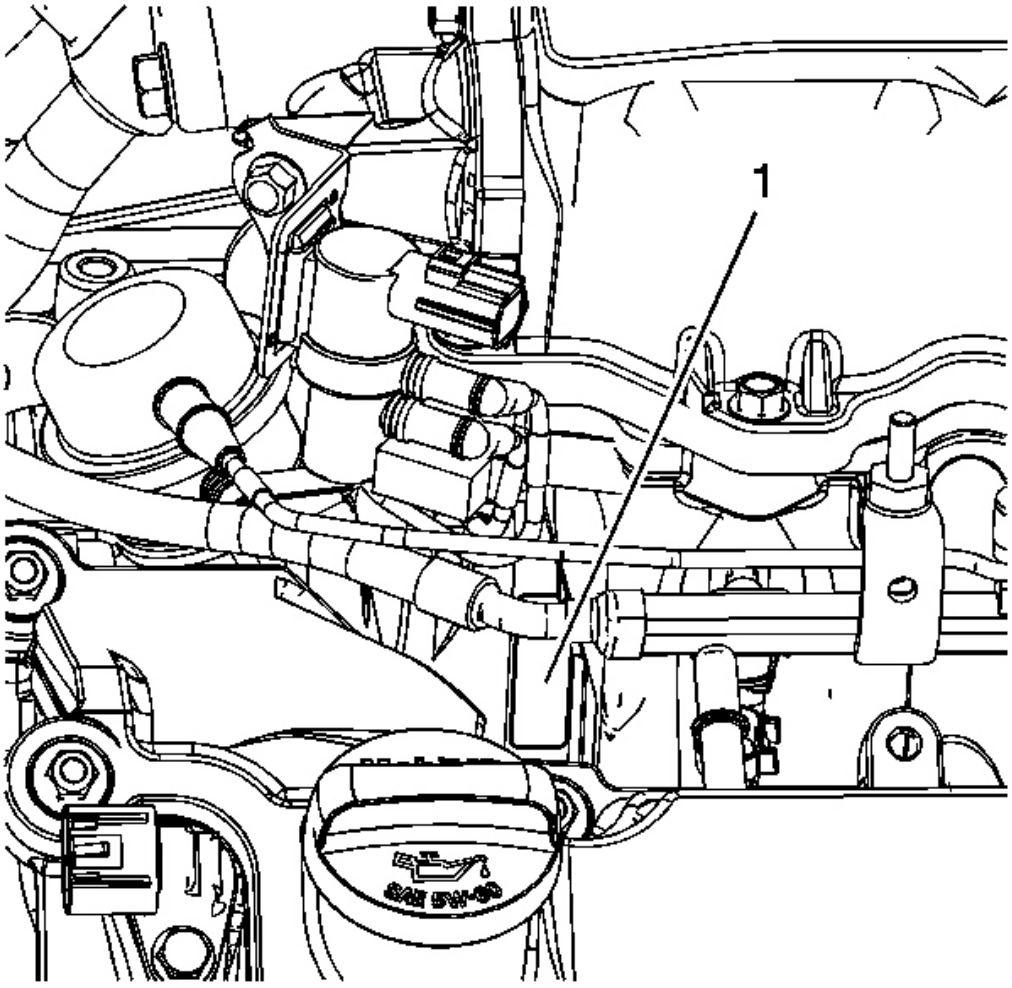


Fig. 50: Locating Supercharger Identification Label
Courtesy of GENERAL MOTORS CORP.

The supercharger identification label (1) is located on the left side of the supercharger unit. It is attached to the bearing plate that is between the front housing and the supercharger base. The following information is printed on the label:

- Barcode
- Part number
- Serial number

SCHEMATIC AND ROUTING DIAGRAMS

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CAMSHAFT TIMING DRIVE CHAIN ALIGNMENT DIAGRAM

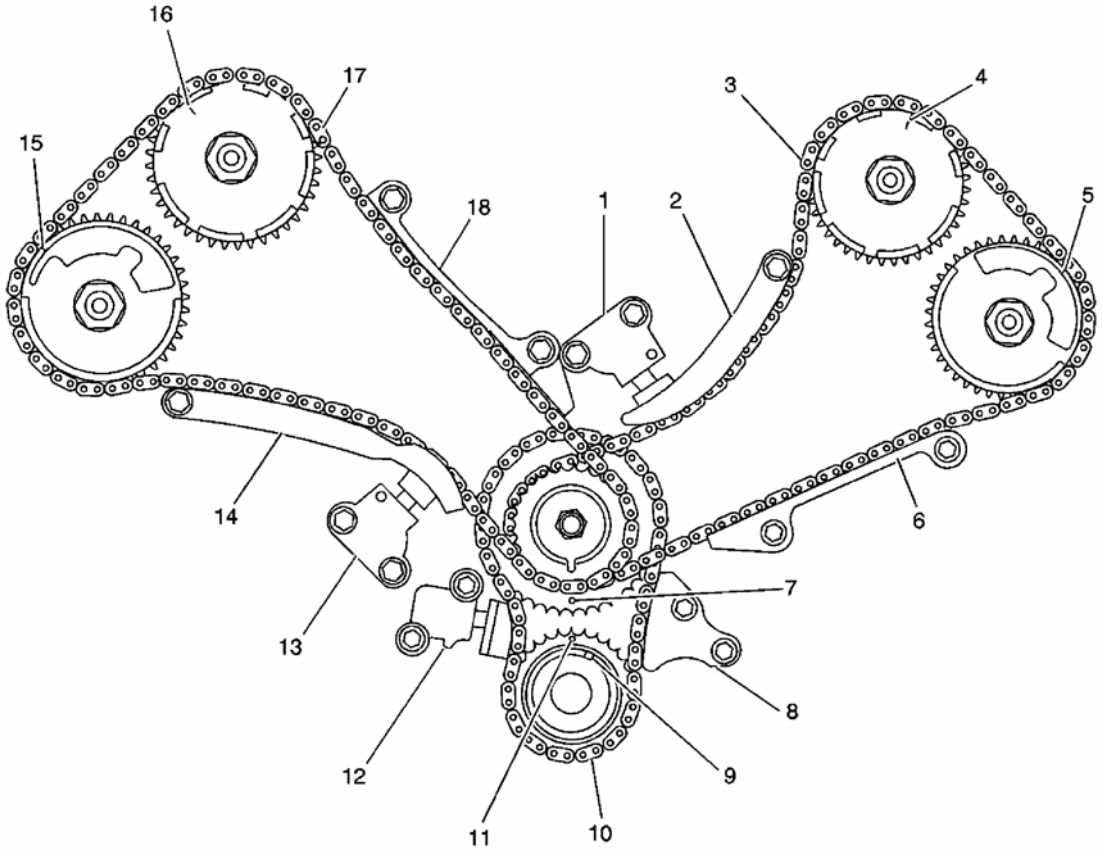


Fig. 51: Identifying Camshaft Drive System Set At Base Engine Timing
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 51

Callout	Component Name
1	Left Secondary Timing Chain Tensioner
2	Left Secondary Timing Chain Shoe
3	Left Secondary Timing Chain
4	Left Intake Camshaft Position Actuator Timing Mark
5	Left Exhaust Camshaft Position Actuator Timing Mark
6	Left Secondary Timing Chain Guide
7	Intermediate Position Actuator Timing Mark
8	Primary Timing Chain Guide
9	Crankshaft Position Actuator Pin Alignment Slot
10	Primary Timing Chain
11	Crankshaft Position Actuator Timing Mark
12	Primary Timing Chain Tensioner

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13	Right Secondary Timing Chain Tensioner
14	Right Secondary Timing Chain Shoe
15	Right Exhaust Camshaft Position Actuator Timing Mark
16	Right Intake Camshaft Position Actuator Timing Mark
17	Right Secondary Timing Chain
18	Right Secondary Timing Chain Guide

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing the **Disassembled Views** , **Engine Component Description** , **Drive Belt System Description** , **Lubrication Description** and **New Product Information** . 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 **Diagnostic System Check - Vehicle** in Vehicle DTC Information before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to **Disassembled Views** , **Engine Component Description** , **Drive Belt System Description** , **Lubrication Description** and **New Product Information** .

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

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the engine. Refer to **Checking Aftermarket Accessories** in Wiring Systems.
- 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.

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Intermittent

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

Symptom List

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

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

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Base Engine Misfire without Internal Engine Noises

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

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Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads, intake manifold and plenum duct, plenum duct and water outlet housing assembly, water outlet housing assembly and throttle body and/or pressure relief valve and intake manifold.	Replace the intake manifold, plenum duct, gaskets, cylinder heads, throttle body and/or water outlet housing assembly as required.
Improperly installed or damaged MAP sensor and/or seal The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
Improperly installed or damaged EVAP purge solenoid and/or O-ring seal	Repair or replace the EVAP purge solenoid as required.
Worn or loose followers, valve rocker arms The follower, valve rocker arm, roller bearing should be intact and in the proper position	Replace the followers, valve rocker arms, as required.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chains or components	Replace the primary timing chain, secondary timing chains, intermediate sprocket, camshaft position actuators and/or related timing components as required.
Worn camshaft lobes	Replace the camshaft or camshafts and SHLAs, valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing** . • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to **Diagnostic Starting Point - Engine Cooling** in Engine Cooling. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** in Engine Controls. • 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. Refer to **Spark Plug Inspection** in Engine Controls. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression**

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	Test. • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with SEVERE reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal and then re-sync the crankshaft position. • Systems with SLIGHT reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.	Replace the crankshaft as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Base Engine Misfire with Abnormal Internal Lower Engine Noises

Cause	Correction
Abnormalities, severe cracking, bumps or missing areas, in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Replacement** .
Worn, damaged or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the engine flywheel and/or crankshaft balancer as required. Refer to **Engine Flywheel Replacement** or **Crankshaft Balancer Replacement** .
Worn or Broken Piston Rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause.

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	• 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

Base Engine Misfire with Abnormal Valve Train Noise

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

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to **Diagnostic Starting Point - Engine Cooling** . Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** . • 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

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. Refer to **Spark Plug Inspection** .

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	• 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. Refer to **Spark Plug Inspection** . • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.

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

Engine Noise on Start-Up, but Only Lasting a Few Seconds

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	Drain the engine oil and replace with the correct viscosity oil.
High Stationary Hydraulic Lash Adjuster (SHLA), valve lifter, leak down rate	Replace the SHLAs, valve lifters, as required.
Worn crankshaft thrust bearing	• 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

Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing** . • Repair or replace as required.
Loose and/or worn follower, valve rocker arm	• Inspect the follower, valve rocker arm. • Repair or replace as required.
Improper lubrication to the followers, valve rocker arms	Inspect the following components and repair or replace as required: • The follower, valve rocker arm • The SHLA, valve lifter • The oil filter bypass valve

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	• The oil pump and pump screen • The cylinder head oil galleries • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or dirty stationary hydraulic lash adjusters (SHLAs), valve lifters	Replace the SHLAs, valve lifters.
Stretched or broken timing chain or chains and/or damaged camshaft position actuator sprocket teeth	Replace the primary timing chain, secondary timing chains, intermediate sprocket, camshaft position actuators and/or related timing components as required.
Worn timing chain tensioner or tensioners	Replace the timing chain tensioner or tensioners as required.
Worn timing chain shoe or shoes	Replace the timing chain shoe or shoes as required.
Worn timing chain guide or guides	Replace the timing chain guide or guides as required.
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft or camshafts and SHLAs, valve lifters, as required.
Worn valve guides or valve stems	Inspect the following components and repair as required: • The valves • The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay open	Inspect the following components and repair as required: • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Lower Engine Noise, Regardless of Engine Speed

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

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	• Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition system. Refer to **Electronic Ignition (EI) System Diagnosis** .
Loose torque converter bolts	• Inspect the torque converter bolts and engine flywheel. • Repair or replace as required.
Loose or damaged engine flywheel	Repair or replace the engine flywheel.
Damaged oil pan, contacting the oil pump screen An oil pan that has been damaged may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	• Inspect the oil pan. • Inspect the oil pump screen. • Repair or replace as required.
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

Engine Noise Under Load

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

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Engine Will Not Crank - Crankshaft Will Not Rotate

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

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Seized Automatic Transmission Torque Converter	1. Remove the torque converter bolts. 2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. 3. Repair or replace as required.
Material in Cylinder • Broken valve • Piston material • Foreign material	1. Inspect the cylinder for damaged components and/or foreign materials. 2. Repair or replace as required.
Seized Crankshaft or Connecting Rod Bearings	1. Inspect the crankshaft and the connecting rod bearings. 2. Repair as required.
Bent or Broken Connecting Rod	1. Inspect the connecting rods. 2. Repair as required.
Broken Crankshaft	1. Inspect the crankshaft. 2. Repair as required.
Seized or Broken Camshaft	1. Inspect the camshaft or camshafts. 2. Inspect the cylinder head camshaft journals for damage. 3. Repair as required.
Seized or Broken Intermediate Sprocket	1. Inspect the intermediate sprocket. 2. Inspect the intermediate shaft. 3. Inspect the oil feed to the intermediate shaft. 4. Repair as required.
Seized or Broken Camshaft Timing Components	1. Inspect the following sprockets: • The crankshaft sprocket • The intermediate sprocket • The exhaust camshaft position actuator sprockets • The intake camshaft position actuator sprockets 2. Inspect the following chains: • The primary camshaft drive chain • The secondary camshaft drive chains 3. Inspect the following guides: • The primary camshaft drive chain guide • The secondary camshaft drive chain

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	guides 4. Inspect the secondary camshaft drive chain shoes. 5. Inspect the following tensioners: • The primary camshaft drive chain tensioner • The secondary camshaft drive chain tensioners 6. Repair as required.
Seized or Broken Valve Train Components	1. Inspect the followers, rocker arms. 2. Inspect the lifters 3. Inspect the valves 4. Inspect the valve springs 5. Repair as required.

COOLANT IN COMBUSTION CHAMBER

Coolant in Combustion Chamber

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate**. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a **Cylinder Leakage Test**. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** and **Powertrain Removal and Installation** .
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection** .
Cracked cylinder head	Replace the cylinder head and gasket. Refer to **Powertrain Removal and Installation** .
Cracked cylinder liner or engine block	Replace the engine. Refer to **Engine Replacement** .

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Cylinder head or engine block porosity	Replace the cylinder head(s) or engine. Refer to **Powertrain Removal and Installation** or **Engine Replacement** .
Leaking supercharger cooling system	Inspect charge air cooler components. Refer to **Charge Air Cooler Cooling Tube Replacement** , **Charge Air Cooler Housing Replacement** or **Supercharger Replacement** and **Supercharger Cleaning and Inspection** . Replace components as required.

COOLANT IN ENGINE OIL

Coolant in Engine Oil

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

ENGINE COMPRESSION TEST

Tools Required

J 39313 Spark Plug Port Adapter. See **Special Tools**.

A compression pressure test of the engine cylinders determines the condition of the rings, the valves and the

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head gasket.

Test Procedure

1. Run the engine until it reaches normal operating temperature. The battery must be at or near full charge.
2. Turn the engine OFF.

IMPORTANT: Remove the Powertrain Control Module (PCM) and the ignition fuse from the IP fuse block.

3. Disable the ignition.
4. Disable the fuel systems.
5. Remove the spark plugs from all cylinders.
6. Remove the air duct from the throttle body.
7. Block the throttle plate in open position.
8. Measure the engine compression, using the following procedure:
    1. Thread the **J 39313** into the spark plug hole. See **Special Tools**.
    2. Thread the compression gage into the **J 39313** . See **Special Tools**.
    3. Have an assistant crank the engine through, at least four compression strokes, in the testing cylinder.
    4. Check and record the readings on the gage at each stroke.
    5. Remove the compression gage from the **J 39313** . See **Special Tools**.
    6. Remove the **J 39313** from the spark plug hole. See **Special Tools**.
    7. Repeat the compression test for each cylinder.
9. Record the compression readings from all of the cylinders.
    - The lowest reading should not be less than 70 percent of the highest reading.
    - No cylinder reading should be less than 965 kPa (140 psi).
10. The following are examples of measurement problems:
    - When the compression measurement is normal, the compression builds up quickly and evenly to specified compression on each cylinder
    - When low compression is caused by the piston rings, compression is low on the first stroke and tends to build up on the following strokes, but does not reach normal. Compression improves considerably with the addition of oil. Use approximately three squirts of oil from a plunger-type oiler.
    - When low compression is caused by the valves, the measurement is low on the first stroke and does not build up even with the addition of oil.
    - Leaking head gaskets will provide the same results as worn valves but engine coolant may be identified in the crankcase. In addition, a leaking head gasket will give low readings on paired cylinders.
11. Remove the block from the throttle plate.
12. Install the air duct to the throttle body.

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13. Install the spark plugs.
14. Install the Powertrain Control Module (PCM).
15. Install the ignition fuses to the IP fuse block.

CYLINDER LEAKAGE TEST

Tools Required

- **EN 46326** Flywheel Holding Tool. See **Special Tools**.
- **J 35667-A** Cylinder Head Leakdown Tester. See **Special Tools**.
- **J 39313** Spark Plug Port Adapter. See **Special Tools**.

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 CAUTION .

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls.
3. Rotate the crankshaft to place the piston in the cylinder being tested at Top Dead Center (TDC) of the compression stroke.
4. Install the **J 39313** . See **Special Tools**.
5. Install the **J 35667-A** or equivalent. See **Special Tools**.

IMPORTANT: In order to prevent the engine from turning, it may be necessary to install the EN 46326 . See Special Tools.

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

OIL CONSUMPTION DIAGNOSIS

Oil Consumption Diagnosis

Checks	Causes
DEFINITION: Excessive oil consumption (not due to leaks) is the use of 0.946 liter (1 quart) or more of engine oil within 3 200 km (2,000 mi). The causes of excessive oil consumption may include the following conditions:	
Preliminary	• External oil leaks Refer to **Oil Leak Diagnosis**. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time (2-3 minutes) and check for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components • Worn valve guides and/or valve stems • Worn, missing or improperly installed valve stem oil seals • Piston rings broken, worn, not seated properly

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	Allow adequate time for the rings to seat. Replace worn piston rings as necessary. • Piston and rings improperly installed or miss-fitted to the cylinder bore

OIL PRESSURE DIAGNOSIS AND TESTING

Tools Required

- **EN-47971** Oil Pressure Gage Adapter. See **Special Tools**.
- **J 21867** Pressure Gage. See **Special Tools**.

Test Procedure

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

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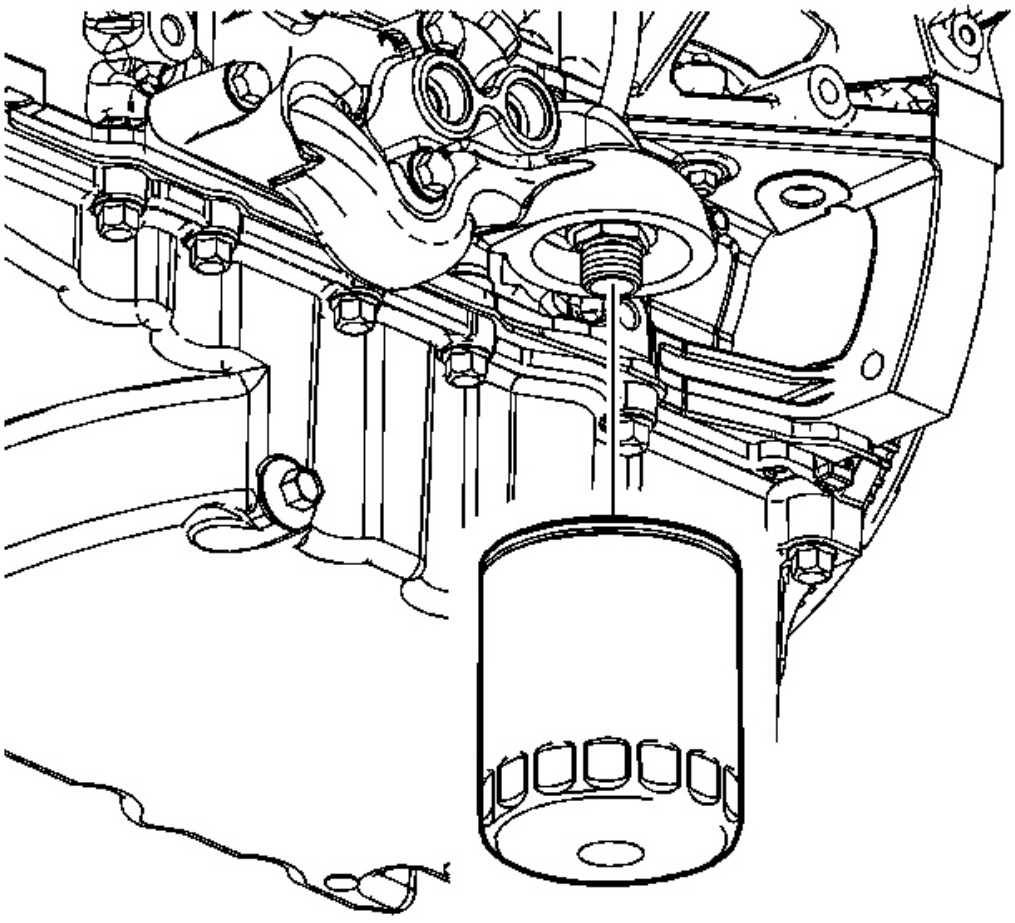


Fig. 52: Identifying Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil filter.

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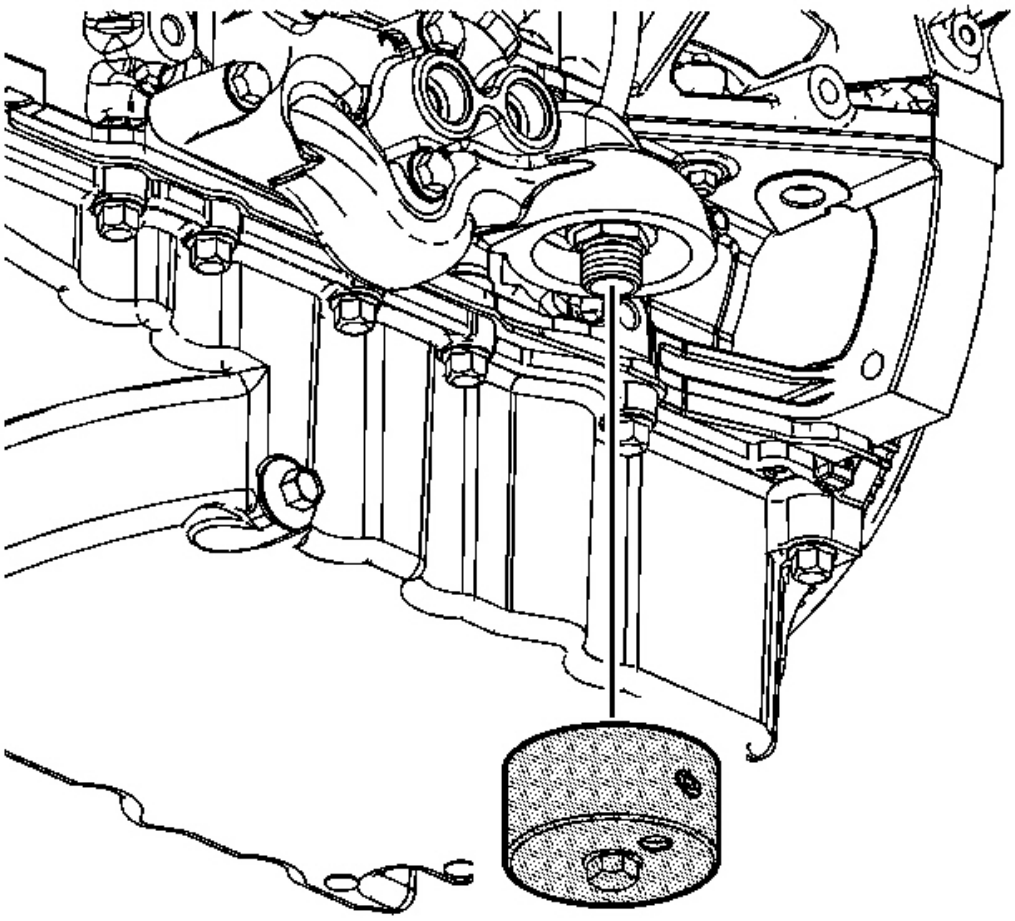


Fig. 53: View Of J 42907 Oil Pressure Tester
Courtesy of GENERAL MOTORS CORP.

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

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

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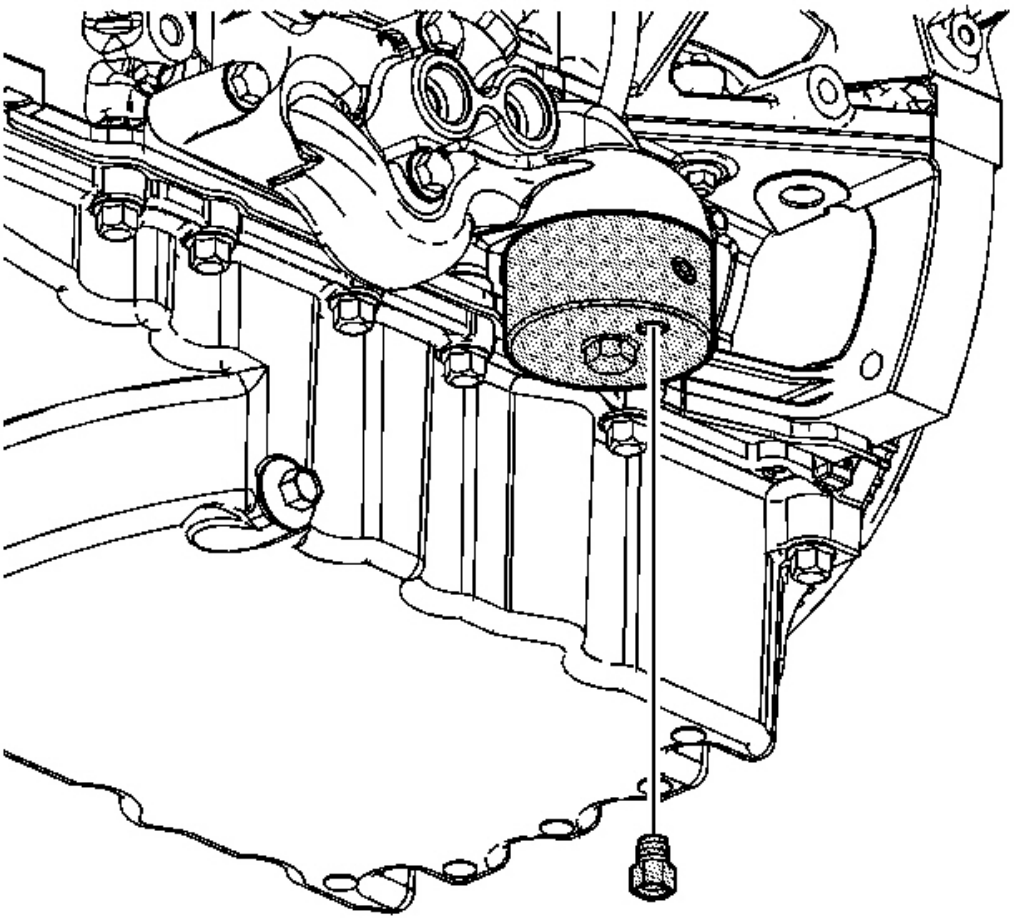


Fig. 54: View Of NPT Fitting
Courtesy of GENERAL MOTORS CORP.

8. Install the 1/8 NPT fitting from the **J 21867** into the port on the **EN-47971** . See **Special Tools**.

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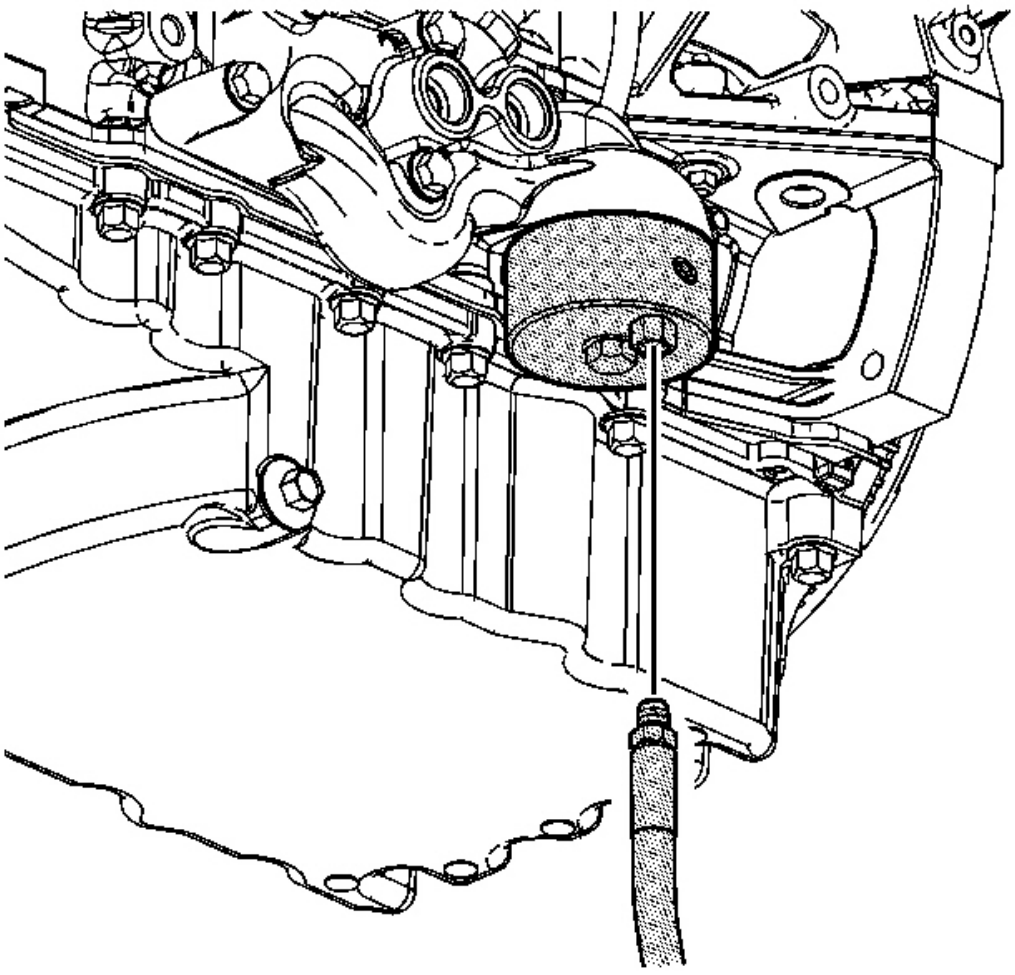


Fig. 55: View Of Flexible Hose
Courtesy of GENERAL MOTORS CORP.

9. Install the **J 21867** flexible hose to the **EN-47971** . See **Special Tools**.
10. Run the engine and measure the engine oil pressure.
11. Compare the readings to **Engine Mechanical Specifications**.
12. If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:
    - Oil pump worn or dirty. Refer to **Oil Pump Replacement** , **Oil Pump Disassemble** and **Oil Pump Cleaning and Inspection** .
    - Oil pump-to-engine block bolts loose. Refer to **Oil Pump Replacement** .
    - Oil pump screen loose, plugged or damaged. Refer to **Oil Pump Suction Pipe and Screen**

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Assembly Replacement and **Oil Pump Pipe and Screen Cleaning and Inspection** .

- Oil pump screen O-ring seal missing or damaged. Refer to **Oil Pump Suction Pipe and Screen Assembly Replacement** and **Oil Pump Pipe and Screen Cleaning and Inspection** .
- Oil pump pressure relief valve malfunction. Refer to **Oil Pump Replacement** .
- Oil outlet tube bolts loose or missing, O-rings damaged or missing, mounting flange damaged and/or tube broken or damaged. Refer to **Oil Pump Outlet Tube Removal** , **Oil Pump Outlet Tube Cleaning and Inspection** and **Oil Pump Outlet Tube Installation** .
- Engine bearing clearance excessive. Refer to **Crankshaft and Bearings Cleaning and Inspection** , **Crankshaft and Bearings Installation** and **Piston, Connecting Rod and Bearing Installation** .
- Cracked, porous or restricted oil galleries.
- Oil gallery plugs missing or incorrectly installed. Refer to **Engine Block Assemble - Upper** and **Cylinder Head Assemble** .
- Valve lifters broken. Repair, as necessary. Refer to **Valve Lifter Replacement - Left Side** and/or **Valve Lifter Replacement - Right Side** and **Valve Lifters Cleaning and Inspection** .
- Oil cooler lines or oil cooler heat exchanger leaking. Refer to Engine Oil Cooler Pipe/Hose Quick Connect Fitting, **Engine Oil Cooler Hose/Pipe Replacement** , **Auxiliary Engine Oil Cooler Replacement** and **Engine Oil Cooler Connector Replacement** .
- Crankshaft balancer bolt missing, loose or under-torqued.
- Friction washer missing between any of the following:
  - Crankshaft balancer and the oil pump
  - Oil pump and the crankshaft sprocket
  - Crankshaft sprocket and crankshaft

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

13. If the oil pressure reading on the **J 21867** or equivalent, is within specifications, inspect for the following conditions. See **Special Tools**.
    - Plugged or incorrect oil filter and/or malfunctioning oil bypass valve. Refer to **Engine Oil and Oil Filter Replacement** .
    - Malfunctioning oil pressure gage or sensor. Repair, as necessary. Refer to **Engine Oil Pressure Sensor and/or Switch Replacement** .

OIL LEAK DIAGNOSIS

Oil Leak Diagnosis

Checks	Action
NOTE: **It is important to correctly identify the source of an oil leak. A power steering fluid leak or spillage can travel across the valley area of the engine and run out the weep hole, which is located at the back of the block. Failure to correctly identify the source of an oil leak can lead to the incorrect or**	

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unnecessary replacement of components.

You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.

Locating and identifying the leak	To determine if the leaking fluid is engine oil, transmission fluid, power steering fluid, brake fluid or some other fluid, use the visual inspection method.
Visual Inspection Method	1. Bring the vehicle to normal operating temperature. 2. Park the vehicle over a large sheet of paper or other clean surface. 3. Wait several minutes, then check for drippings. 4. Identify the type of fluid and the approximate location of the leak. 5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 6. Check for leaks at sealing surfaces, fittings or from cracked or damaged components. 7. If you cannot locate the leak, do the following: 1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several miles at normal operation temperature and at varying speeds. 3. Park the vehicle over a large sheet of paper or other clean surface. 4. Wait several minutes, then check for drippings. 5. Identify the type of fluid and the approximate location of the leak. 6. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 7. See possible causes for leaks. 8. If you still cannot locate the leak, use the powder method or the black light and dye method.
Powder Method	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several miles at normal operation temperature and at varying speeds. 4. Identify the type of fluid and the approximate location of the leak, from the discolorations in the powder surface. 5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 6. See possible causes for leaks.

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

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Positive Crankcase Ventilation (PCV) System Inspection

- Test for vacuum while the engine is running at the foul air tube where it connects to the right side camshaft cover positive crankcase ventilation (PCV) orifice fitting. There should be manifold vacuum present at the tube connector. If there is no vacuum, inspect for a plugged tube or connector, leaking tube or connector or a plugged supercharger PCV fitting.
- Plug the end of the foul air PCV tube while the engine is running. Inspect the tube for any areas that collapse when the end of the tube is blocked. Replace the PCV tube if it collapses when blocked.
- If oil has accumulated in the intake air duct, inspect for the following conditions:
  - Plugged PCV orifice in the right side camshaft cover PCV fitting
  - Plugged or restricted PCV fitting on the supercharger
  - Excessive crankcase pressure or blow-by, refer to **Oil Consumption Diagnosis**.
- Additional items to inspect:
  - Plugged or leaking fresh air PCV tube
  - Plugged or restricted passages in the air duct
  - Missing or damaged PCV tube connectors
  - Inspect the cam covers, the oil pan gasket and other sealing areas for leaks

Results of Incorrect Operation

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- A plugged PCV orifice fitting or PCV foul air tube may contribute to the following conditions:
  - A rough idle
  - Stalling or a slow idle speed
  - Oil leaks
  - Oil accumulation in the intake air duct
  - Sludge in the engine
- A leaking PCV fresh air tube may contribute to the following conditions:
  - A rough idle
  - Stalling
  - Unstable idle speed

DRIVE BELT CHIRPING, SQUEAL AND WHINE DIAGNOSIS

Diagnostic Aids

- A chirping or squealing noise may be intermittent due to moisture on the drive belt(s) or the pulley(s). It may be necessary to spray a small amount of water on the drive belt(s) in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulley(s) 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 incorrect 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 diagnostic trouble codes (DTCs) may set when the engine is operating with the drive belt(s) 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.

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

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

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

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

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

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

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

Drive Belt Chirping, Squeal and Whine Diagnosis

Step	Action	Yes	No
	NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temperature. DEFINITION: The following items are indications of drive belt squealing: • 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 whining: • A high pitched continuous noise. • The noise may be caused by an accessory drive component failed bearing.		

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1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping, squealing or whining noise. Does the engine make the chirping, squealing or whining noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squealing or whining noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squealing or whining 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 accessory brackets. Did you find any bent or cracked brackets?	Go to **Step 9**	Go to **Step 10**
9	Replace any bent or cracked accessory brackets. Did you complete the repair?	Go to **Step 20**	Go to **Step 10**
10	Inspect for incorrect, loose or missing fasteners. Did you find the condition?	Go to **Step 11**	Go to **Step 12**
11	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**.		

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	2. Replace any incorrect 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 whining noise and the condition still exists, proceed to Diagnostic Aids.	Go to **Step 20**	Go to **Step 14**
14	Test the drive belt tensioner for correct operation. Refer to **Drive Belt Tensioner Diagnosis**. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 15**
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 16**
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 17**
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 20**	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to **Step 20**	Go to **Step 19**
19	Replace the drive belt(s). 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 being over charged, the power steering system being restricted or the incorrect fluid being used 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.

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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, diagnostic trouble codes (DTCs) may set when the engine is operating with the drive belt(s) removed.

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

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

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

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

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

Drive Belt Rumbling and Vibration Diagnosis

Step	Action	Yes	No

NOTE:
Refer to Belt Dressing Notice .
 	
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.			

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1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt(s). If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	For rumbling diagnosis, go to **Symptoms - Engine Mechanical**. For vibration diagnosis, go to **Vibration Analysis - Engine**	Go to **Step 4**
4	Inspect the drive belt(s) for wear, damage, separation, sections of missing ribs, and/or 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**
	NOTE: **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to		

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10	**Fastener Tightening Specifications**. 2. Replace any 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 accessory brackets. Did you find and correct the condition?	Go to **Step 13**	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

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

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

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

Test Description

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

2: This inspection is to verify the condition of the drive belt. Damage may have occurred to the drive belt when the drive belt fell off. The drive belt may be 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 being 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 repair procedure of that pulley.

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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 may allow the drive belt to fall off.

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

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

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

15: This inspection is to verify the drive belt is not contacting any component 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.

Drive Belt Falls Off and Excessive Wear Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice .** Definition • The drive belt falls off the pulleys or may not sit correctly on the pulleys. • Wear at the outside ribs of the drive belt may be due to an incorrectly installed drive belt.			
1	Did you review the symptoms-engine mechanical operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**.
2	If diagnosing excessive wear, proceed to step 13. If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to **Step 3**	Go to **Step 4**
3	Install a new drive belt. Does the drive belt continue to fall off?	Go to **Step 4**	System OK
4	Inspect for pulley misalignment. 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 accessory bracket. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 7**
	Inspect for improper, loose or missing		

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7	fasteners. Did you find loose or missing fasteners?	Go to **Step 8**	Go to **Step 9**
8	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace any improper or missing fasteners. Does the drive belt continue to fall off?	Go to **Step 9**	System OK
9	Inspect the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis**. Does the drive belt tensioner operate properly?	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/or 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 the drive belt for contact 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(s). Did you complete the replacement?	Go to **Step 17**	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Drive Belt Tensioner Diagnosis

Step	Action	Yes	No
1	Remove the drive belt and inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to **Step 4**	Go to **Step 2**
	Rotate the drive belt tensioner.		

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2	Does the tensioner rotate without any unusual resistance or binding?	Go to **Step 3**	Go to **Step 4**
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10% of the second torque reading?	System OK	Go to **Step 4**
4	Replace the drive belt tensioner. Is the repair complete?	System OK	-

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

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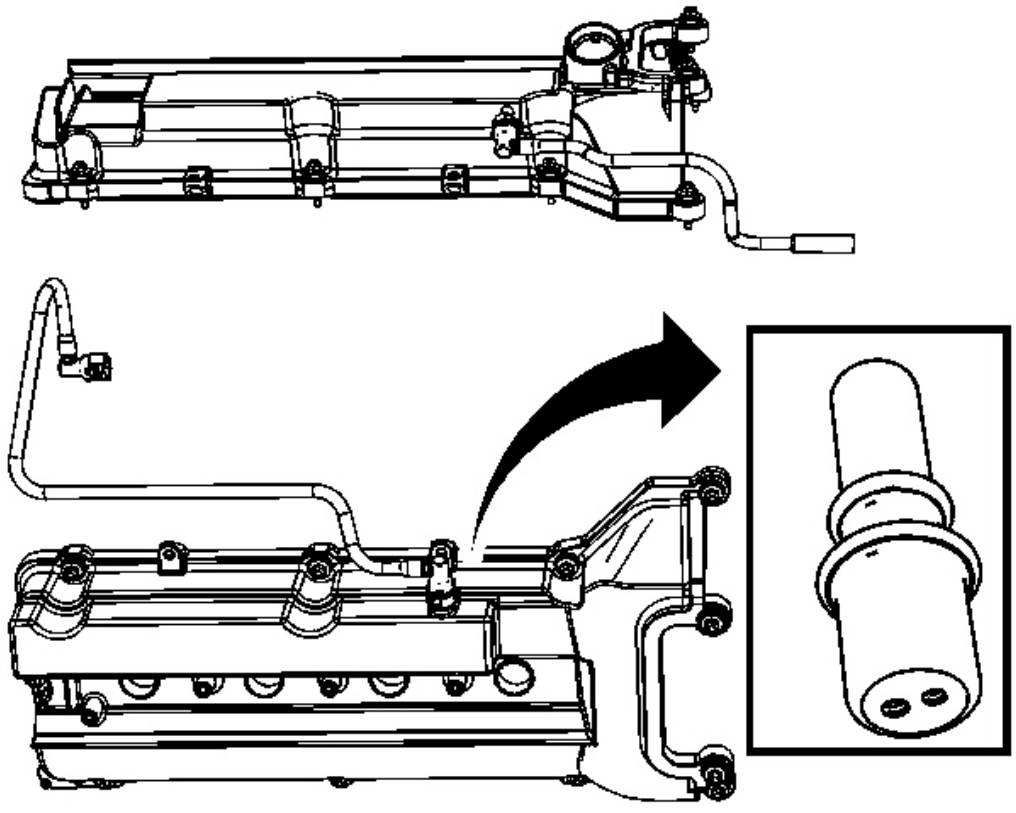


Fig. 56: View Of Crankcase Ventilation System
Courtesy of GENERAL MOTORS CORP.

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

Filtered fresh air is supplied to the crankcase through a PCV fresh air tube connecting from the air duct to the LH camshaft cover PCV fitting. In the crankcase, the fresh air mixes with blow-by gases and then is passed through a positive crankcase ventilation (PCV) orifice fitting located in the RH camshaft cover. The air/blow-by mixture is passed into the intake manifold through a foul air PCV tube.

The PCV orifice fitting restricts the flow rate of the blow-by gases using two small orifice holes located at the end of the PCV fitting. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back-flow through the PCV system fresh air tube back into the air duct in order to be consumed by normal combustion. The PCV orifice fitting is not serviceable. If the orifice fitting can not be unplugged, the camshaft cover must be replaced.

DRIVE BELT SYSTEM DESCRIPTION

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The drive belt system consists of the following components:

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

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

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

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

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

ENGINE COMPONENT DESCRIPTION

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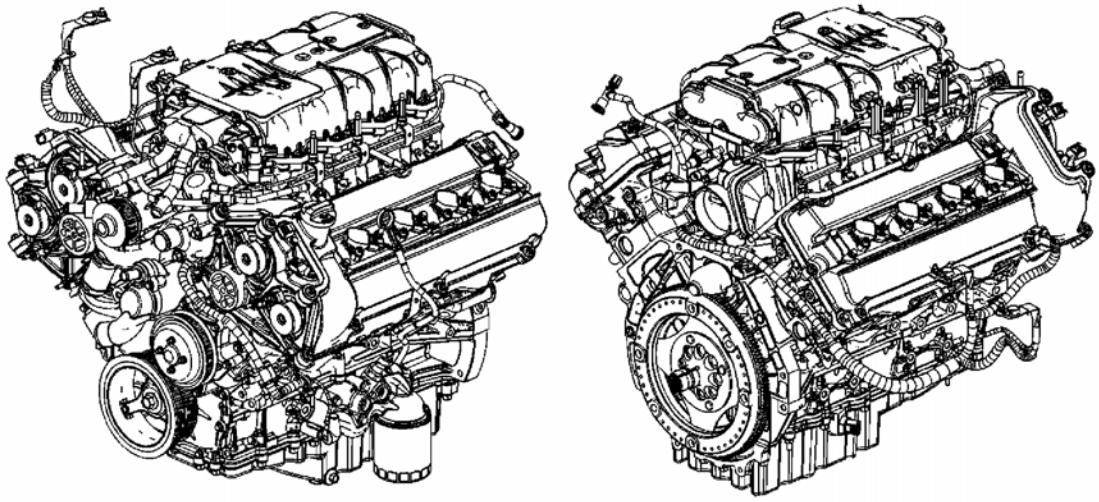


Fig. 57: Northstar V8 VIN D Engine
Courtesy of GENERAL MOTORS CORP.

The Northstar V8 VIN Code D is a 4.4L (267 cu in) supercharged engine incorporating two intake and two exhaust valves per cylinder with individual cylinder head mounted camshafts with camshaft position actuators for intake and exhaust functions (DOHC). The cylinder bore diameter is 91 mm (3.583 in) and the piston stroke is 84 mm (3.31 in). The cylinders are arranged in two banks of four with a 90 degree included angle. The left, front, bank of cylinders are number 2-4-6-8 and the right, rear, bank cylinders are 1-3-5-7. Engine firing order is 1-2-7-3-4-5-6-8.

Crankcase

The cylinder block is constructed of aluminum alloy by the precision sand casting method and is constructed of two sections, an upper and a lower crankcase, split at the crankshaft center line. The grey cast iron cylinder liners are cast with the upper crankcase. The upper and lower crankcase sections are held in alignment by four dowel pins. Once machined, the sections must be kept together as a set. Sealing between the crankcase halves consists of a silicone rubber seal and a bead of anaerobic sealant along each side. Since the lower crankcase contains the lower main bearings, this casting adds to the structural rigidity of the engine assembly. Both upper and lower crankcases incorporate oil drain back passages isolated from the crankcase. These passages provide a direct path from the cylinder heads to the oil pan in order to prevent the needless aeration of the oil through contact with the rotating components. An oil gallery through the block supplies four oil jet assemblies used to cool the cylinder pistons. The assembly is bolted between two cylinders and incorporates two jets. Each assembly contains a spring operated check valve to maintain proper oil pressure.

Crankshaft

The crankshaft is a forged steel design with five main bearings. Crankshaft thrust is taken by the number three main bearing. The position sensor, also known as the reluctor wheel, is integral with the crankshaft. The crankshaft is internally balanced and incorporates a one piece rear seal. A rolled fillet radius is incorporated on all bearing journals to improve fatigue strength.

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Connecting Rods and Pistons

The connecting rods are made from forged ferrous powder metal and have full floating piston pins. These pins are slip fit in the bronze bushed rods and are retained in the piston by round wire retainers. The cast hypereutectic aluminum alloy pistons use two low tension compression rings and one multi-piece oil ring. The top compression ring is nitrided steel. The second compression ring is coated cast iron. The oil ring is a three piece side seal type ring which incorporates a steel expander and two chrome plated steel rails. To provide a non-scuffing surface when the engine is new, the pistons are tin plated. The piston skirts are coated with a polymer coating to provide reduced friction.

Camshaft Drive System

The four overhead camshafts are driven by three separate fine pitch chains. The primary drive chain connects the crankshaft with the intermediate shaft and sprocket located directly above the crankshaft behind the engine front cover. Each camshaft drive chain connects the intermediate sprocket with the camshaft position actuators on each intake and exhaust camshafts on the cylinder heads. Two camshaft drive chains are used; one for each cylinder head. Each of the chains incorporates a hydraulic tensioner to minimize chain noise and provide accurate valve action by keeping slack out of the chain and continuously adjusting for chain wear. This is accomplished by providing engine oil pressure to each tensioner forcing a nylon pad into mesh with the slack side of the chain. As the chain stretches from wear, a ratchet mechanism inside the tensioner prevents the nylon pad from retracting when the engine is turned off and engine oil pressure ceases.

Camshaft Position Actuator System

The camshaft position actuator system is an electronically controlled and hydraulically actuated system. The camshaft position actuator system enables the engine control module (ECM) to change camshaft timing of all four camshafts hydraulically while the engine is operating.

Two camshaft position actuator magnets, one for each camshaft position actuator oil control valve, are mounted to a camshaft position actuator housing on the front of each cylinder head. The ECM energizes the camshaft position actuator magnet in order to create a magnetic field. The magnetic field created by the camshaft position actuator magnet pulls, from the home position, the spring loaded spool valve in the center of the camshaft position actuator oil control valve. The camshaft position actuator oil control valve is incorporated into the fastener that bolts the camshaft position actuator to the camshaft. Alignment between the camshaft position actuator magnet and the camshaft position actuator oil control valve is crucial. An air gap must be maintained between both components.

Oil under pressure is supplied to the front camshaft bearing cap and flows through passages into the camshaft front journal. The camshaft front journal passages supply oil to the camshaft position actuator oil control valve. The camshaft position actuator oil control valve supplies oil to the camshaft position actuator. The camshaft position actuator oil control valve incorporates a return spring in order to return the internal spool valve to the home position.

The camshaft position actuator contains an inner rotor with vanes bolted to the camshaft and an outer housing incorporating the timing drive chain sprocket and camshaft position sensor trigger wheel. Internally the camshaft position actuator contains a spring loaded locking pin that prevents movement between the inner rotor and outer housing and keeps the camshaft position actuator in the home position. The locking pin releases when

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proper oil pressure reaches the camshaft position actuator. The exhaust camshaft position actuators also incorporates return springs in order to return the exhaust camshaft position actuators to the home position when the engine is turned off. Due to rotation direction of the intake camshaft position actuators return springs are not necessary.

Oil directed by the camshaft position actuator oil control valve's position is used to vary the advance or return of the camshaft position actuator's vanes from the home position.

Cylinder Heads

The cylinder heads are semi permanent mold cast aluminum with powdered metal valve seat inserts and valve guides. Two 36.2 mm (1.425 in) intake valves and two 29 mm (1.142 in) exhaust valves are actuated by roller finger followers pivoting on a stationary hydraulic lash adjuster (SHLA). Separate intake and exhaust camshafts are supported by five bearings machined into the cylinder head with camshaft thrust taken by the first bearing. The combustion chamber is roughly in the shape of a clover leaf with a nominal volume of 58.08 cc (3.544 cubic inch) and a centrally located spark plug. The exhaust ports are specially polished using an abrasive flow machining method. The cylinder head gaskets are Multi-Layer Steel (Mls).

Engine Cooling System

The coolant pump assembly is located on the engine front cover. The water outlet housing distributes coolant to the cylinder block and collects it from the cylinder head for delivery to the radiator.

Lubrication System

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

The oil pump has increased output from other Northstar engines. The additional output is needed to supply the volume needed for the oil jets required to cool the pistons. An oil gallery, specific the LC3, is used to supply oil to the oil jets. A new oil filter is also required to meet the additional volume that needs to flow from the oil pump. The new oil filter incorporates a bypass valve and a specific filtering media for improved protection along with lower pressure drop through the oil filter. Supercharged Northstar engines oil filter adapters and oil filters utilize special thread size and pitch. The oil filter adapter does not contain the bypass valve.

Supercharger and Induction System

The induction system consists of induction tubes, throttle body and a Roots style supercharger with an integral intake manifold and intercooler. A forward section to the induction system consists of a central intake port that splits into twin thin wall cast aluminum induction tubes. Each tube incorporates a silencer in order to reduce induction noise without disrupting air flow. After each silencer a flexible port duct connects to the rear tube that combines the air flow into a single port at the rear of the engine. A flexible port duct connects the rear tube to the 80 mm (3.15 in) diameter throttle body mounted at the rear of the supercharger.

The throttle body is an electronic throttle controlled (ETC) design. The throttle body, EVAP purge valve solenoid and bypass actuator cable mount to the supercharger bypass valve.

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The supercharger pulley is driven by a serpentine drive belt. The pulley drives the supercharger from the front of the engine. The two tri-lobe helical Roots type rotors are counter-rotating as the drive and driven rotors are geared to each other. The rotors are mirror image, precision hobbed aluminum extrusions rotating on press-fit steel shafts. Ball bearings between the gears and the rotors support the rotors at their forward end. The forward bearings are lubricated and cooled by a volume of synthetic gear lubricant contained within the supercharger front cover. At the rear, sealed maintenance-free needle bearings support the rotors. The incoming air enters the rotor chambers at the lower rear just past the bypass valve. Air is pushed up around the outside of the rotors and is expelled from the rotors at the upper front of the supercharger body. Mounted on top of the supercharger body is the intercooler housing. The air flows up from the supercharger and travels through the intercooler tube fins and then down into the individual cylinder inlet runners. The supercharger displacement and pulley ration are proportioned to deliver almost two times the volume of air the engine would naturally aspirate, providing positive manifold pressure when the valve is closed. The bypass valve controls recirculation between the rotor outlet and inlet to reduce parasitic losses and noise during light load operation, at which time the valve is open.

The intercooler housing contains four longitudinal bores that house the four cylindrical intercoolers. The manifolds at the front and rear of the intercooler housing route the coolant through the interior of the four intercooler tubes. A coolant fill cap is located on the top of the intercooler housing. Slots in the intercooler housing direct the supercharged air flow past the fins of the intercooler tubes. Once cooled by the intercooler the supercharged air is directed through the top of the intercooler housing and down into the outboard sides of the intercooler housing and into individual runners that proceed through the supercharger housing and into the cylinder head intake runners. Inputs from multiple sensors for vacuum and pressure and a temperature sensor are used by the engine management system to control the supercharge operation. The bypass valve for the supercharger is operated through a cable by a supercharger bypass valve actuator. The supercharger bypass valve actuator is operated by supercharger pressure and vacuum operated by a charge air bypass regulator solenoid valve. The charge air bypass regulator solenoid valve is controlled by input from the engine management system. A cooling system separate from the engine cooling system is used for the intercooler. An electric remote-mounted coolant pump is used to circulate the coolant between the intercooler of the supercharger and the heat exchanger mounted at the front of the vehicle.

Right and Left Bank Designation

Right hand (RH) and Left hand (LH) designations through the engine mechanical On-Vehicle Service section are viewed from the rear of the engine.

SUPERCHARGER DESCRIPTION AND OPERATION

Description

The LC3 supercharger is a positive displacement pump that consists of 2 counter-rotating rotors, an inlet port and an outlet port and an air bypass valve that is built into a housing. The rotors are designed with 3 lobes and a helical twist. An air bypass valve is built into the housing. The rotors in the supercharger are designed to run at a minimal clearance, not in contact with each other or the housing and are timed to each other by a pair of precision spur gears which are pressed onto the rotor shafts. The front ends of the rotors are held in position by deep-groove ball bearings, while the rear ends of the rotors are supported by sealed roller bearings.

The gears and ball bearings are lubricated by a synthetic oil. The oil reservoir is self-contained in the supercharger, isolated from the engine oil, sealed for the life of the unit and is not serviceable.

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The cover on the supercharger contains the input shaft which is supported by 2 deep-groove ball bearings and is coupled to the rotor drive gears. The pulley is pressed onto the input shaft and is not serviceable. The bearings are lubricated by the synthetic oil contained in the same reservoir.

Operation

The supercharger is designed to increase the air pressure and density in the intake manifold. When this air is mixed with the correct amount of fuel the result is more power from the engine. This excess air creates a boost pressure in the intake manifold with a maximum engine boost of 83 kPa (12 psi). Because the supercharger is a positive displacement pump and is directly driven from the engine drive belt system, boost pressure is available at all driving conditions.

When boost is not required, such as during idle or light throttle cruising, the excess air is routed through the bypass passage between the intake manifold and the supercharger inlet. This bypass circuit is regulated by a bypass valve which is similar to a throttle plate. The bypass valve is controlled by a vacuum actuator which is connected to the vacuum signal between the throttle and the supercharger inlet. Spring force from the actuator holds the valve in a normally closed position to create boost and vacuum pulls the valve open when the throttle closes to decrease boost.

A solenoid valve is attached to the supercharger housing. This three-way valve, controlled by the engine control module (ECM), determines whether pressure from the manifold is routed to the bypass actuator or closed off. This valve allows pressure from the manifold to open the bypass valve and lower boost pressure during specific driving conditions. The open bypass valve reduces the pumping effort of the supercharger, thereby increasing the fuel efficiency in light load operations.

Intercooler

The supercharger has an integrated intercooler. Cooling the air enhances the effectiveness of the supercharger. The intercooler uses conventional coolant in a separate sealed system from the engine cooling system. The intercooler system has a radiator, a back fill port at the rear of the supercharger, attaching hoses and a pump capable of a flow rate of 22 liters (6 gallons) per minute. The pump is commanded ON, by the control module, whenever the engine is running, intake air temperature (IAT) sensor 2 is more than 0°C (32°F), intake air temperature (IAT) sensor is more than -25°C (-13°F) and engine run time is more than 10 seconds.

NEW PRODUCT INFORMATION

The purpose of New Product Information is to highlight or indicate important changes from the previous model year.

Changes may include one or more of the following items:

- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions

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- New special tools required
- A component comparison from the previous year

Torque Values and/or Fastener Tightening Strategies

There are no engine mechanical fastener tightening specification changes for 2007.

Changed Engine Specifications

There are no changes to the engine specifications for 2007.

New Sealants and/or Adhesives

There are no sealant and/or adhesive changes for 2007.

Disassembly and Assembly Procedure Revisions

There are no disassembly and assembly procedure changes for 2007.

Engine Mechanical Diagnostic Procedure Revisions

There are no revisions to the engine mechanical diagnostic procedures for 2007.

New Special Tools Required

There is a new special tool required for 2007.

A sealant applicator tool **EN-48072** is being used prior to installation of the crankshaft rear oil seal. See **Special Tools**.

A Component Comparison from the Previous Year

There are no component changes for 2007.

LUBRICATION DESCRIPTION

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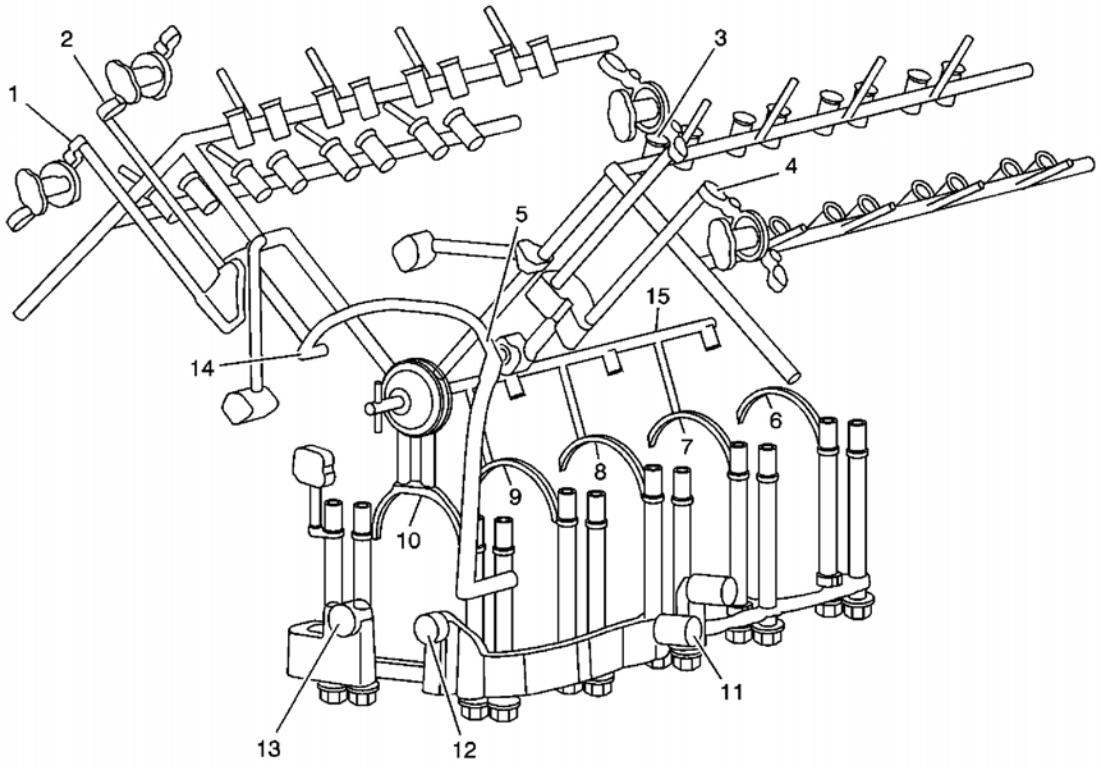


Fig. 58: Identifying Lubrication System Oil Flow
Courtesy of GENERAL MOTORS CORP.

The cast aluminum oil pan is used as a structural member of the powertrain by connecting the oil pan and the engine to the flywheel housing. The oil pan incorporates an oil baffle plate and seals to the lower crankcase with a gasket. The oil pan also provides mounting for an oil level sensor.

The oil sump pickup is fastened to the lower crankcase and oil manifold by a bolt and nut to one stud-headed main bearing bolt. A gasket seals this joint on the suction side of the oil system. The engine oil pump is a gerotor design mounted to the lower crankcase behind the engine front cover by 3 mounting bolts. Drive for the gerotor elements is provided by the clamp load of the harmonic dampener and bolt. As the pump rotates, oil is drawn from the sump through the sump pickup to a channel cast into the lower crankcase. The oil is then directed to the pump inlet cavity (13) on the lower crankcase front face. Oil compressed by the pump re-enters the lower crankcase distribution channel through the pump outlet cavity (12) opposite the inlet. A portion of the pump output is diverted via an internal passage to the oil pump inlet to provide a pressure seal at the crankcase interface.

The oil pump outlet channel in the lower crankcase routes the oil to the oil outlet tube for the camshaft position actuator system and the oil filter circuit connections on the, front/left, side of the lower crankcase.

The cast aluminum oil filter adapter is fastened to the crankcase with 3 bolts. The inlet and return (11) passages are sealed with a gasket. The adapter contains the oil pressure switch. The oil filter bypass valve is inside the oil filter.

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Filtered oil re-enters the crankcase distribution channels and is first directed to the main bearings (6-10). Cross drilled passages in the crankshaft in turn provide oil for the connecting rod bearings and provide splash oiling for the cylinder walls. The lower crankcase distribution channel also connects with passages in the upper crankcase to provide oil to the overhead camshafts and valve lifters. This passage (10), beside the number one bearing, also provides oil for the 3 hydraulic chain tensioners as well as lubrication for the camshaft drive intermediate shaft ultimately lubricating the camshaft chains via oil splash.

Designed into the upper crankcase behind the camshaft drive intermediate shaft is a chamber that feeds 2 passages in the upper crankcase. Each passage directs oil flow up to the cylinder block deck through the cylinder head gasket and into each cylinder head. The oil passage in each cylinder head that feeds the valve train system has a pressed-in restrictor. The orifice within the restrictor is 3 mm (0.1181 in). The restrictor ensures proper oil flow to the valve train and thereby ensures suitable oil flow from the oil pump to the camshaft position actuator system. After passing through the restrictor the oil enters a cross drilled passage that feeds the 2 valve train oil passages that rub the length of the cylinder head. Each valve train passages delivers oil to each set of exhaust and intake camshaft bearings along with the corresponding stationary hydraulic lifters (SHLAs).

Oil returns to the sump either through the camshaft chain area or by way of cast oil drain back passages on the outside walls of the cylinder heads, upper and lower crankcases and oil pan. The lubrication system also includes a baffle, attached by the main bearing bolts and channels oil thrown from the crankshaft back into the oil sump.

Oil to operate the camshaft position actuator system is supplied by the oil outlet tube located under the timing chain drive system. The oil outlet tube is sealed to the front of the engine block next to the oil pump with an O-ring. Oil travels up through the tube and is filtered by an integral screen. Oil is distributed by the oil outlet tube to both sides of the engine block just below the engine block deck (5, 14). A chamber within the block directs oil up 2 passages through the engine block deck and into 2 passages in each cylinder head. Oil supplied to the front camshaft bearing cap groove (1-4) supplies oil to passages drilled into the front camshaft journal. Oil passes through the center of the camshaft and into the camshaft position actuator oil control valve. The spool valve within the camshaft position actuator oil control valve directs the oil in and out of the camshaft position actuator. The spool valve is actuated by a magnetic field created by the camshaft position actuator magnet. The camshaft position actuator magnet is mounted to the camshaft position actuator housing bolted onto the front of each cylinder head. Oil pressure applied to either side of the internal vanes of the camshaft position actuator allows the ECM to vary the valve timing between the exhaust and intake camshafts.

Four piston cooling oil jet assemblies are mounted between each of the opposing cylinders. Each oil jet consists of a pressure valve and 2 tubes. Each tube sprays oil up the cylinder bore aimed at the bottom of the piston crown. The oil jets are supplied by an oil gallery (15) that is fed oil through branches off of the 3 center crankshaft main oil feeds (7-9).

CLEANLINESS AND CARE

An automobile engine is a combination of many of the following surfaces:

- Machined
- Honed
- Polished

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- Lapped

The tolerances of these surfaces are measured in the ten-thousandths of an inch. When you service any internal engine part, cleanliness and care are important. Apply a liberal coating of engine oil to the friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, practice proper cleaning and protection procedures to the machined surfaces and to the friction areas.

NOTE: Engine damage may result if an abrasive paper, pad or motorized wire brush is used to clean any engine gasket surfaces.

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

CAUTION: Refer to Battery Disconnect Caution.

Disconnect the negative battery cables before you perform any major work on the engine. For more information on the disconnection of the battery, refer to **ENGINE ELECTRICAL** .

SEPARATING PARTS

In addition to the room temperature vulcanizing (RTV) sealant's sealing capabilities, the RTV sealants may form an adhesive bond between the components. This may make the components difficult to remove or to separate. If possible, bump the components sideways rather than using prying tools in order to remove the components. This technique prevents damage when the bonding strength of the RTV sealant is stronger than the component itself. Perform bumping at the bends or at the reinforced areas in order to prevent part distortion.

REPLACING ENGINE GASKETS

Gasket Reuse and Applying Sealant

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.

Separating Components

- Use a rubber mallet in order to separate the components.
- Bump the part sideways in order to loosen the components.
- Bumping of the component should be done at bends or reinforced areas of the component to prevent distortion of the components.

Cleaning Gasket Surfaces

- Use care to avoid gouging or scraping the sealing surfaces.

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- Use a plastic or wood scraper in order to remove all the sealant from the components.

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

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

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

Assembling Components

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

IMPORTANT: Do not overtighten the fasteners.

- Tighten the fasteners to the proper specifications.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER

Sealant Types

IMPORTANT: The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant or equivalent, as specified in the service procedure.

The following 2 major types of sealant are commonly used in engines:

- Anaerobic sealant room temperature vulcanizing (RTV)
- Anaerobic sealant, which include the following:
  - Gasket eliminator
  - Pipe
  - Threadlock

Anaerobic Type Room Temperature Vulcanizing (RTV) Sealant

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Anaerobic type room temperature vulcanizing (RTV) sealant cures in the absence of air. This type of sealant is used where 2 components, such as the intake manifold and the engine block, are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Any other surfaces where a different type of sealant is specified in the service procedure
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

NOTE: Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.

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

- Assemble the components while the RTV sealant is still wet to the touch, within 3 minutes.

IMPORTANT: Do not overtighten the fasteners.

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

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where 2 rigid parts, such as castings, are assembled together. When 2 rigid parts are disassembled and no sealant or gasket is readily noticeable, then the 2 parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.

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- Apply a continuous bead of gasket eliminator sealant to one flange.

  The surfaces to be sealed must be clean and dry.

NOTE: **Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened or lead to component failure.**

IMPORTANT:

- **Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than 5 minutes, may result in incorrect shimming and sealing of the joint.**
- **Do not overtighten the fasteners.**
  - **Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.**
  - **Tighten the fasteners in sequence, if specified and to the proper torque specifications.**
  - **After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.**

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts and studs. This type of sealant cures only when confined between 2 close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

IMPORTANT:

- **Fasteners that are partially torqued and then the threadlock sealant allowed to cure more than 5 minutes, may result in incorrect clamp load of assembled components.**
- **Do not overtighten the fasteners.**

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

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where 2 parts are assembled together and require a leak proof joint.

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Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

NOTE: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened or lead to component failure.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to one sealing surface.

IMPORTANT: Do not overtighten the fasteners.

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

TOOLS AND EQUIPMENT

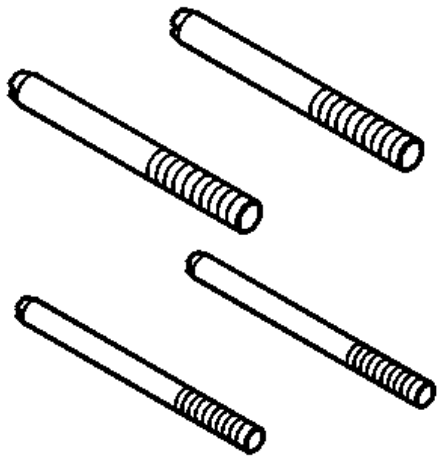
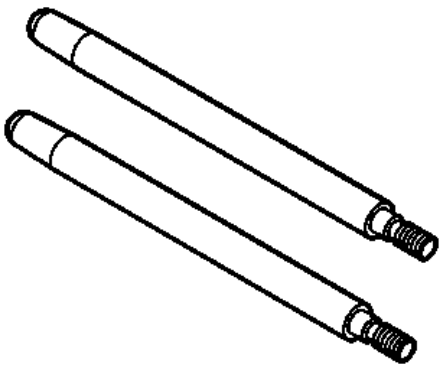
- Special tools are listed and illustrated throughout this section, with a complete listing at the end of the section. These tools or their equivalents, are designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.
- To properly service the engine assembly, the following items should be readily available:
  - Approved eye protection and safety gloves
  - A clean, well-lit, work area
  - A suitable component cleaning tank
  - A compressed air supply
  - Trays or storage containers to keep components and fasteners organized
  - An adequate set of hand tools
  - Approved engine repair stand
  - An approved engine lifting device that adequately supports the weight of the components

SPECIAL TOOLS AND EQUIPMENT

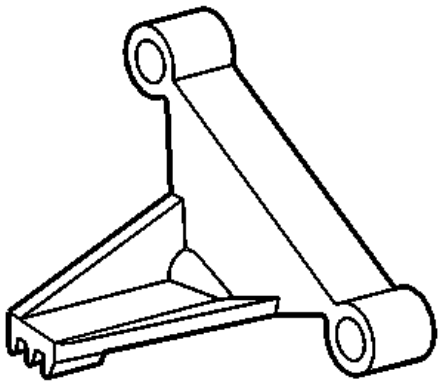
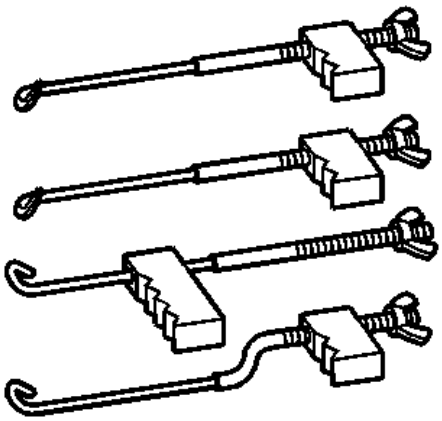
SPECIAL TOOLS

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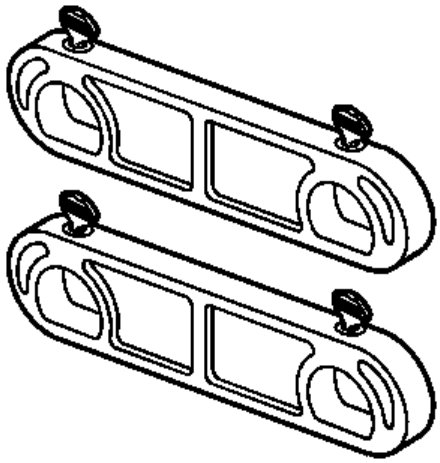
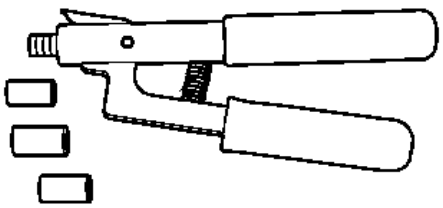
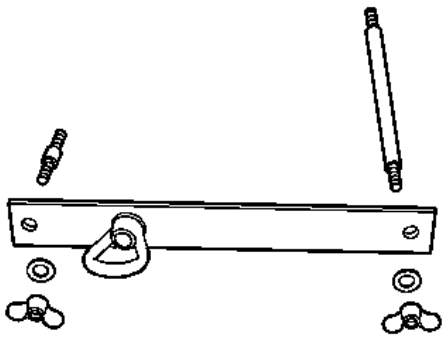
Special Tools

Illustration	Tool Number/Description
	EN 46109 Guide Pin Set
	EN 46121 Connecting Rod Guide Pin Set
	EN 46326 Flywheel Holding Tool

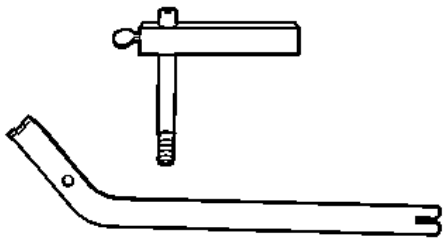
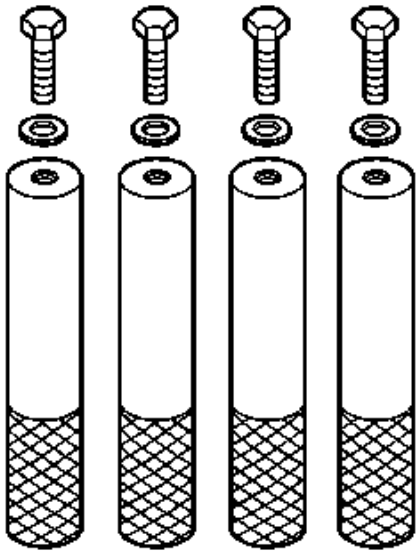
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	EN 46327 Timing Chain Retention Tool
	EN 46328 Camshaft Holding Tool

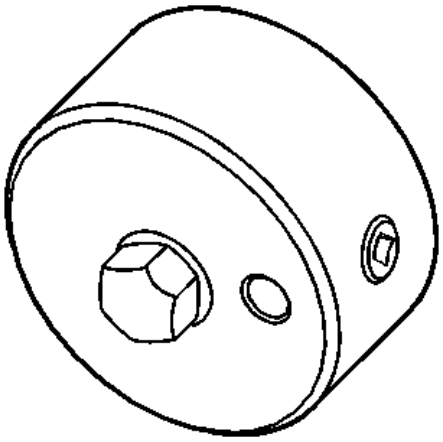
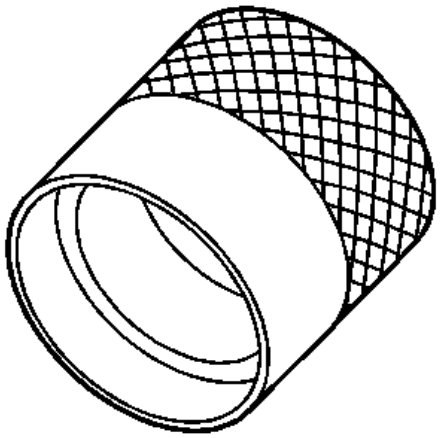
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	EN 46745 Piston Pin Clip Remover/Installer
	EN 47748 Supercharger Lifting Fixture

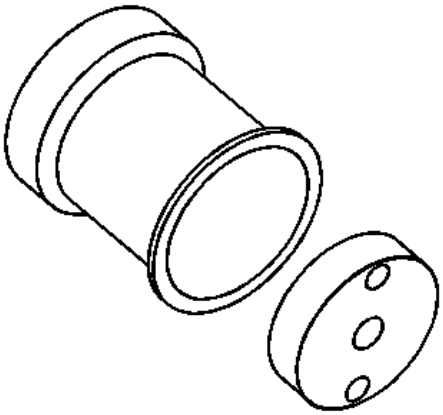
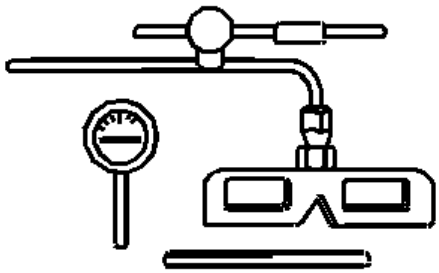
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	EN 47814 Supercharger Bypass Valve Actuator Setting Tool
	EN 47833 Supercharger Service Holding Fixture
	EN 47971 Oil Pressure Gage Adapter

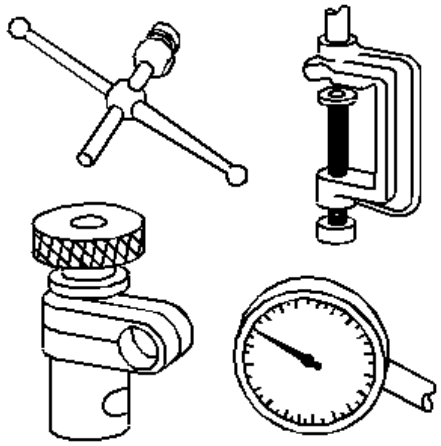
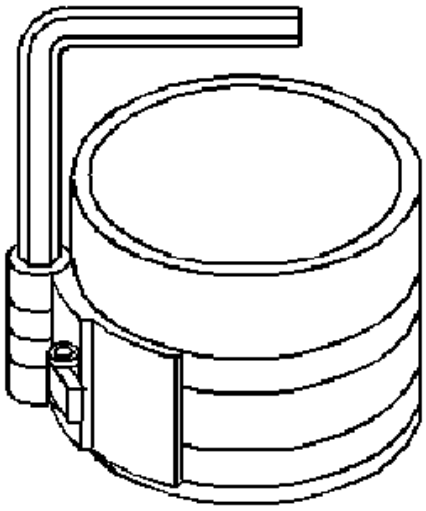
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	EN 48036 Oil Pump Alignment Tool
	EN 48072 Sealant Applicator

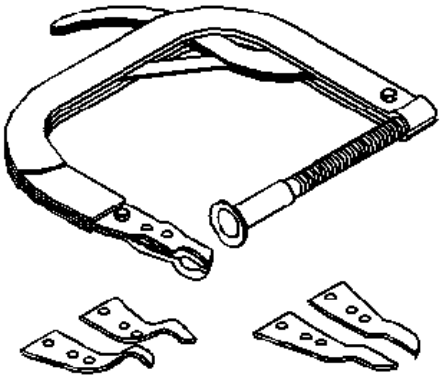
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	J 7872 Magnetic Base Dial Indicator
	J 8001 Dial Indicator Set

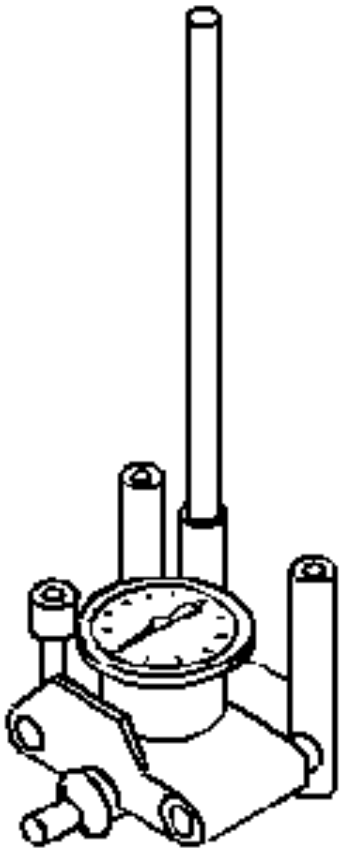
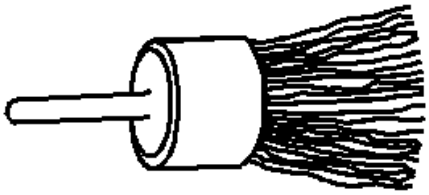
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	J 8037 Ring Compressor

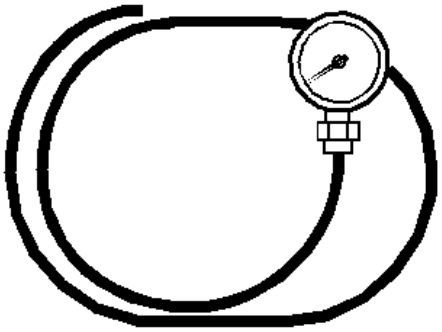
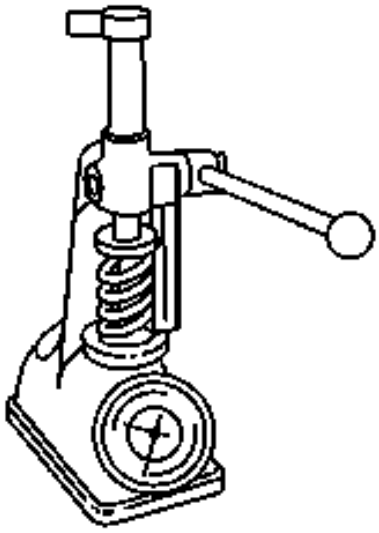
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	J 8062 Valve Spring Compressor - Head Off
	J 8087 Cylinder Bore Gage

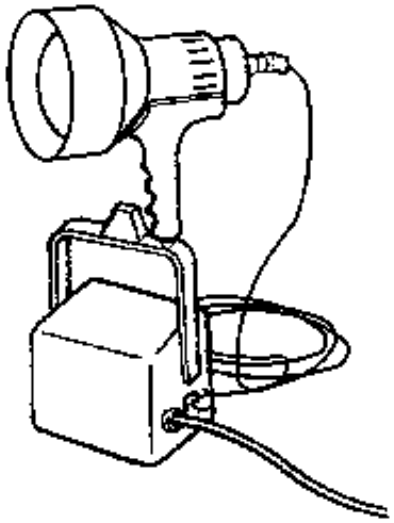
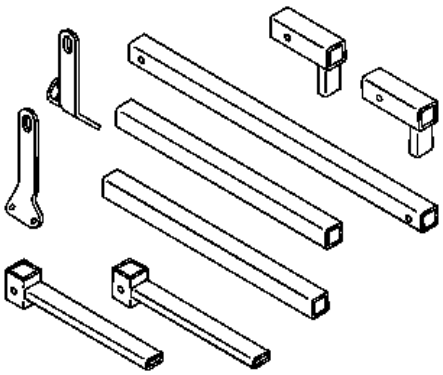
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	J 8358 Carbon Removal Brush

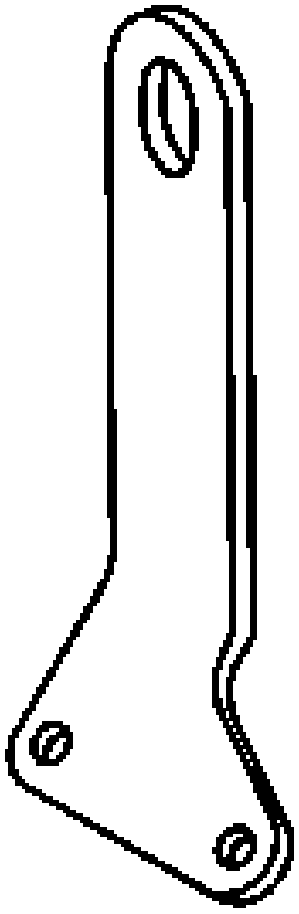
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	J 21867 Pressure Gage
	J 22738-B Valve Spring Tester
	J 28410 Gasket Remover

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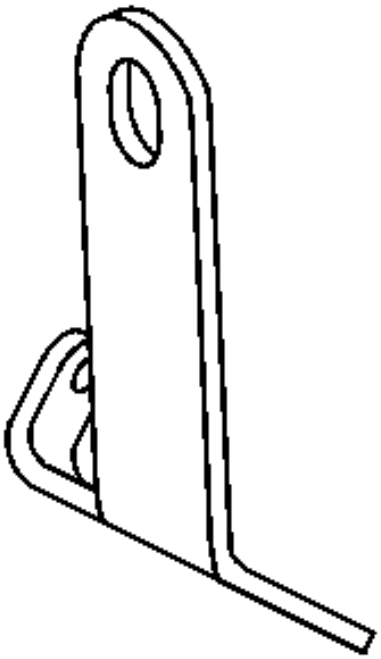
	J 28428-E High Intensity Black Light Kit
	J 28467-81 Engine Support Fixture Kit

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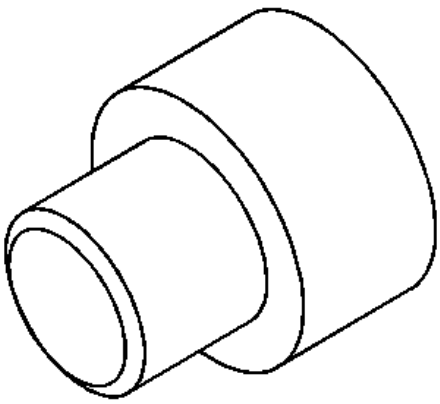


J 28467-86
Engine Lift Bracket

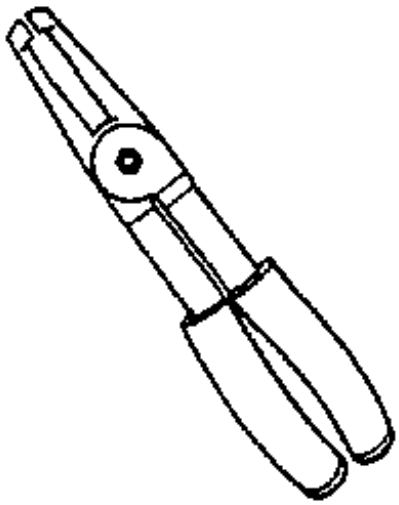
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	J 28467-87 Engine Lift Bracket
	J 35667-A Cylinder Head Leakdown Tester

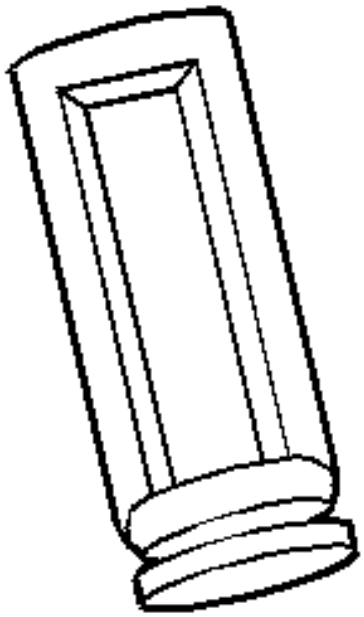
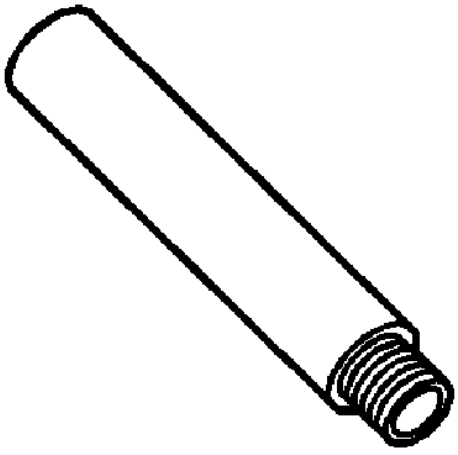
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	J 38416-2 Crankshaft Button

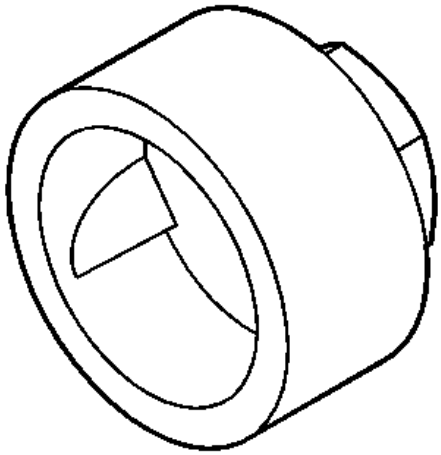
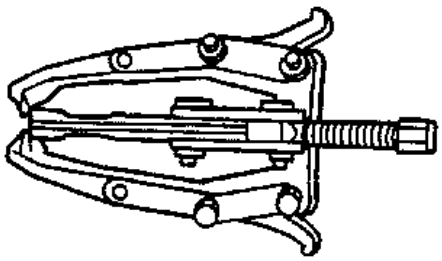
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	J 38820 Valve Stem Seal Installer
	J 38821 Valve Spring Compressor Adapter

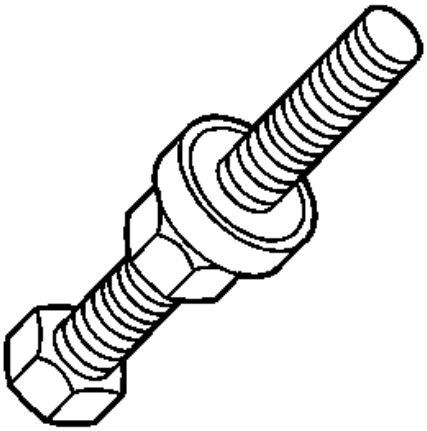
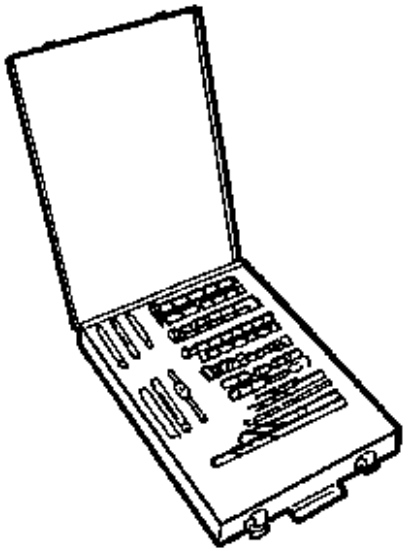
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	J 39313 Spark Plug Port Adapter

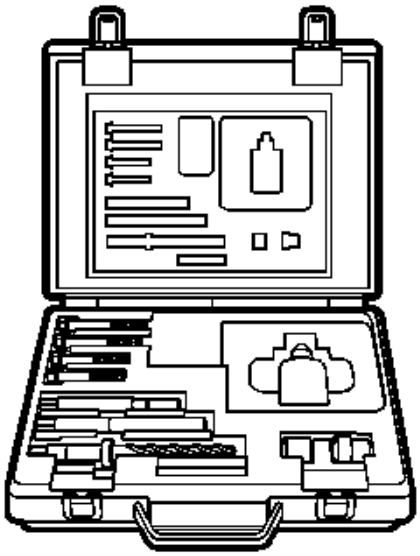
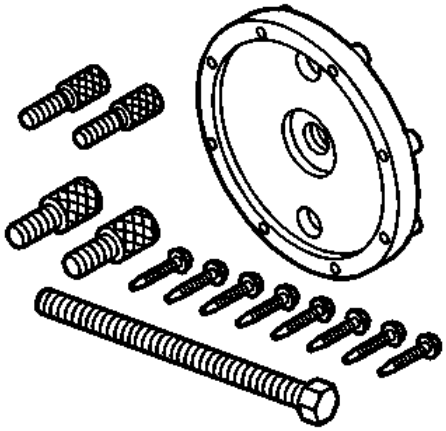
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	J 39946 Crankshaft Socket - 4.0L and 4.6L
	J 41816 Crankshaft Balancer Remover
	J 41998-B Crankshaft Balancer Installer

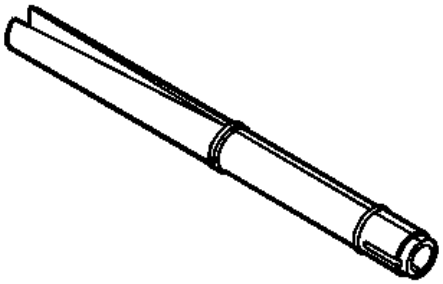
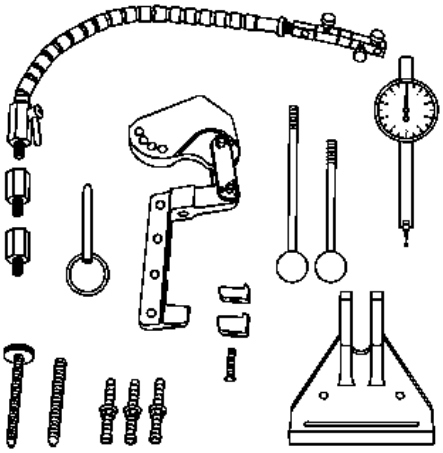
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	J 42385-2000 Thread Insert Kit

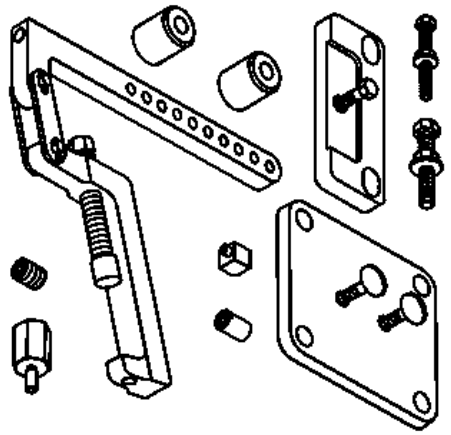
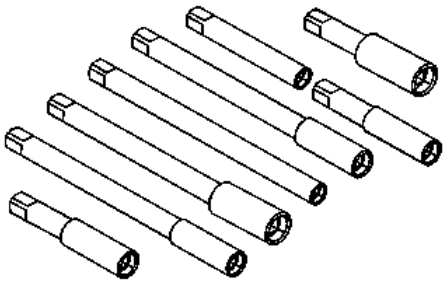
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	J 42385-2030 M11 x 2.0 Cylinder Head Bolt - Northstar/Premium V8 Thread Repair Kit
	J 42841-A Rear Oil Seal Remover

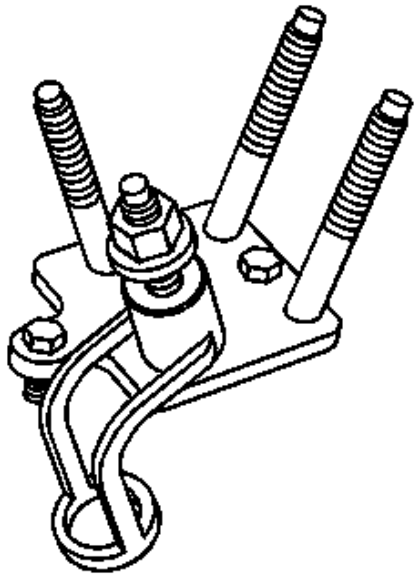
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	J 43059-A Valve Retainer Remover/Installer
	J 43690 Rod Bearing Clearance Checking Tool
	J 43690-100 Rod Bearing Clearance Checking Tool - Adapter Kit

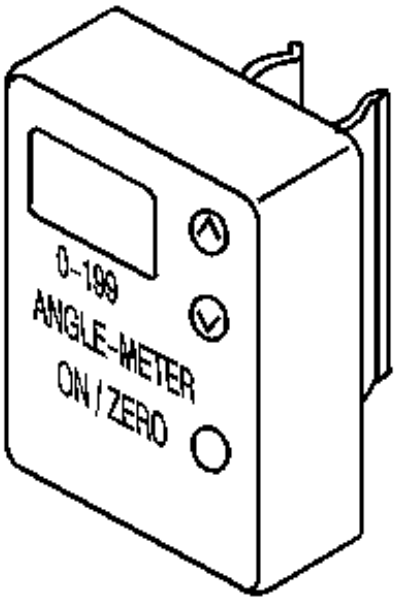
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	J 43965 Thread Repair Extension Kit
	J 44211 On-Vehicle Valve Spring Compressor

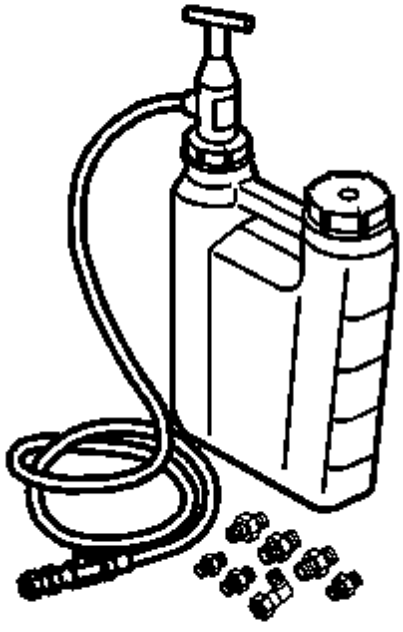
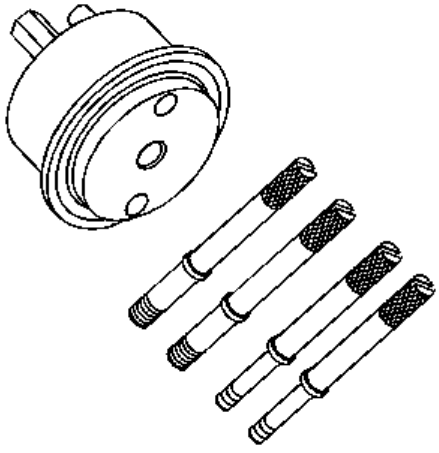
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	J 45059 Angle Meter

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	J 45299 Engine Preluber

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	J 45930-A Crankshaft Rear Oil Seal Installer

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2007 ENGINE

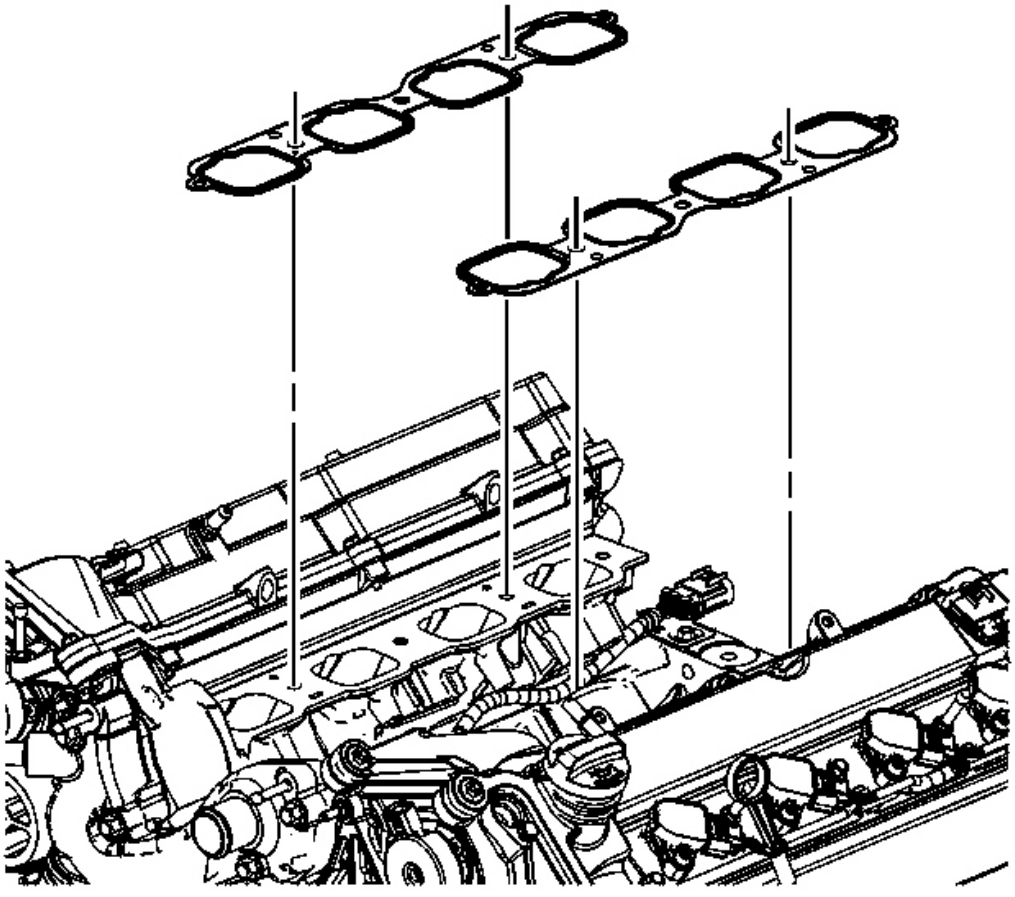
Engine Mechanical - 4.4L - XLR

SUPERCHARGER INSTALLATION

TOOLS REQUIRED

- **EN 46109** Guide Pins. See **Special Tools** .
- **EN-47748** Supercharger Lifting Fixture
- **EN-47833** Supercharger Service Holding Fixture

INSTALLATION PROCEDURE



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Fig. 1: Identifying Supercharger Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW supercharger gaskets.

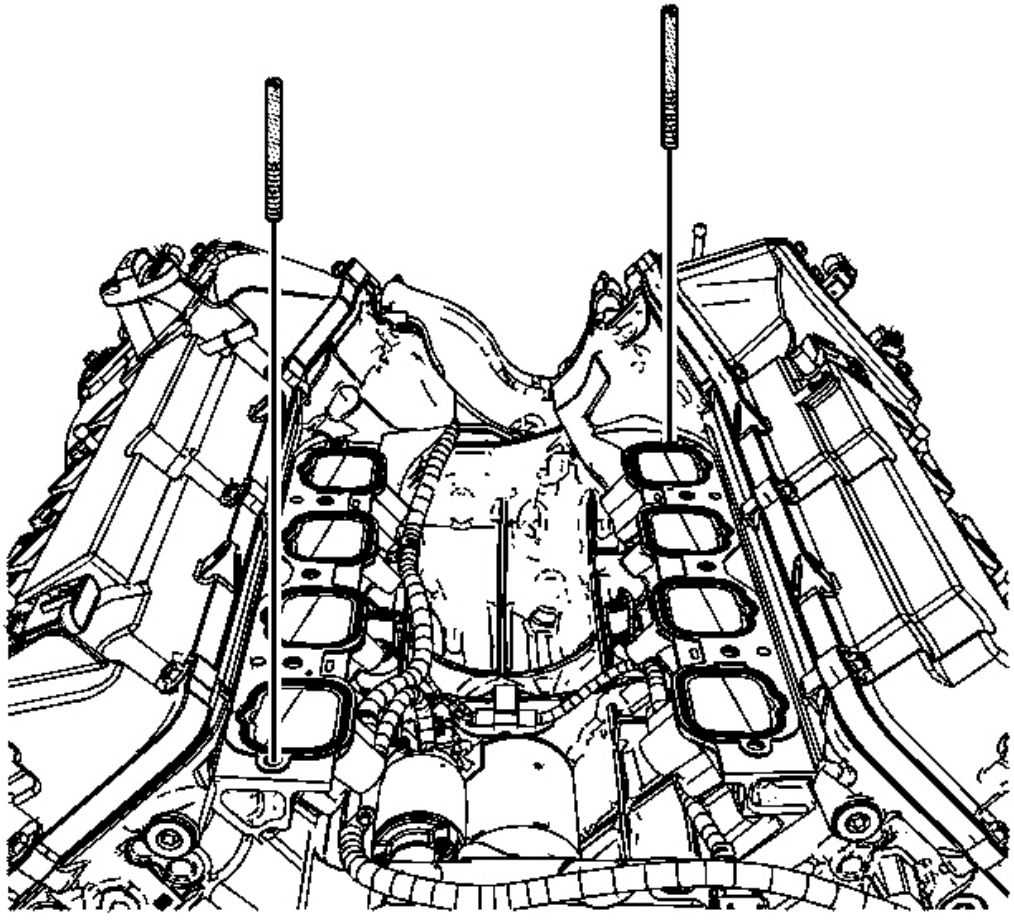


Fig. 2: View Of EN 46109 Guide Pins
Courtesy of GENERAL MOTORS CORP.

2. Install the 8 mm (0.31 in) **EN 46109** into cylinder head supercharger mounting bolt holes at opposing corners. See **Special Tools** .

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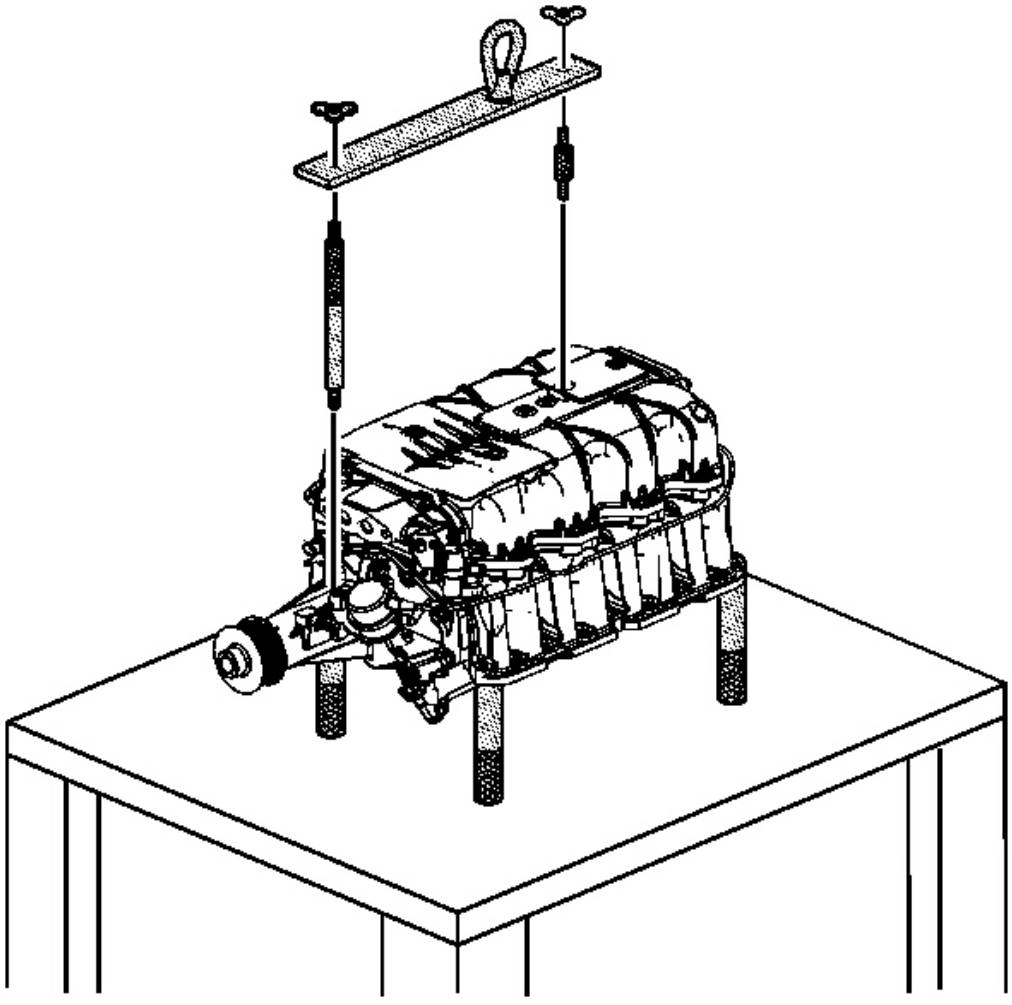


Fig. 3: View Of Supercharger Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: The supercharger must be lifted with the EN 47748. The weight of the supercharger assembly is approximately 34 kg (75 lb) and could cause injury if lifted by hand.

NOTE: The supercharger must be lifted with the EN 47748. Damage could occur to the finish and/or components of the supercharger and surrounding engine or vehicle components.

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3. Lift the supercharger assembly off of the table using appropriate lifting equipment.

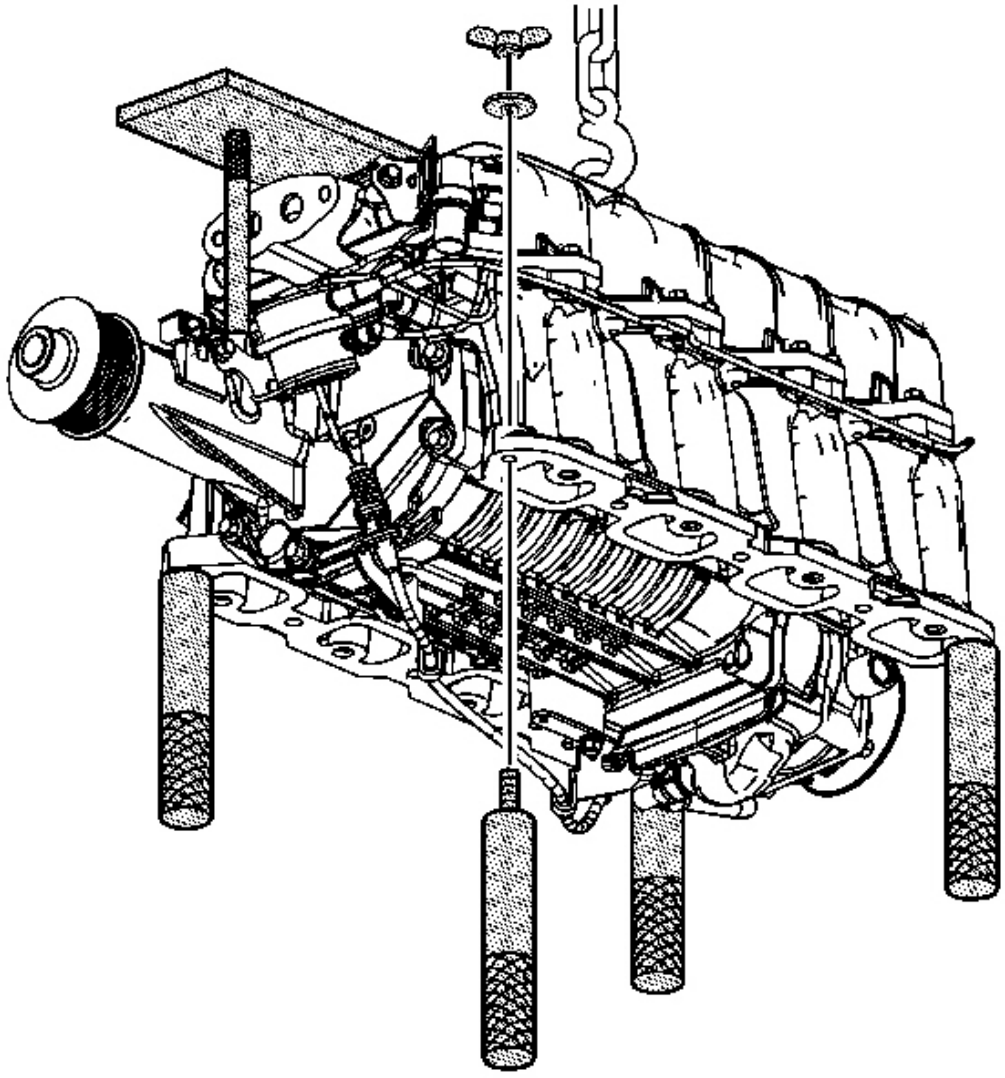


Fig. 4: Removing EN-47833 From Supercharger
Courtesy of GENERAL MOTORS CORP.

4. Remove the **EN-47833** from the supercharger.

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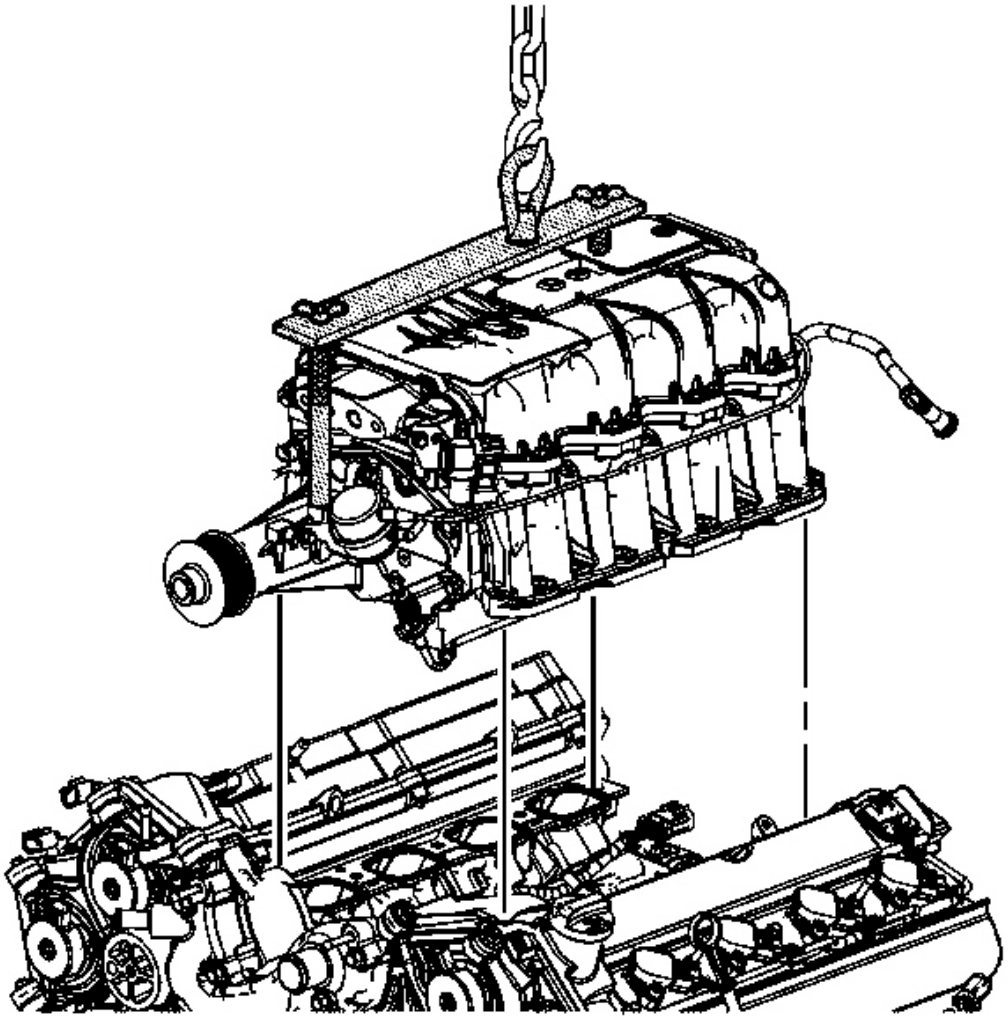


Fig. 5: View Of Supercharger Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the supercharger using the **EN-47748** with appropriate lifting equipment.

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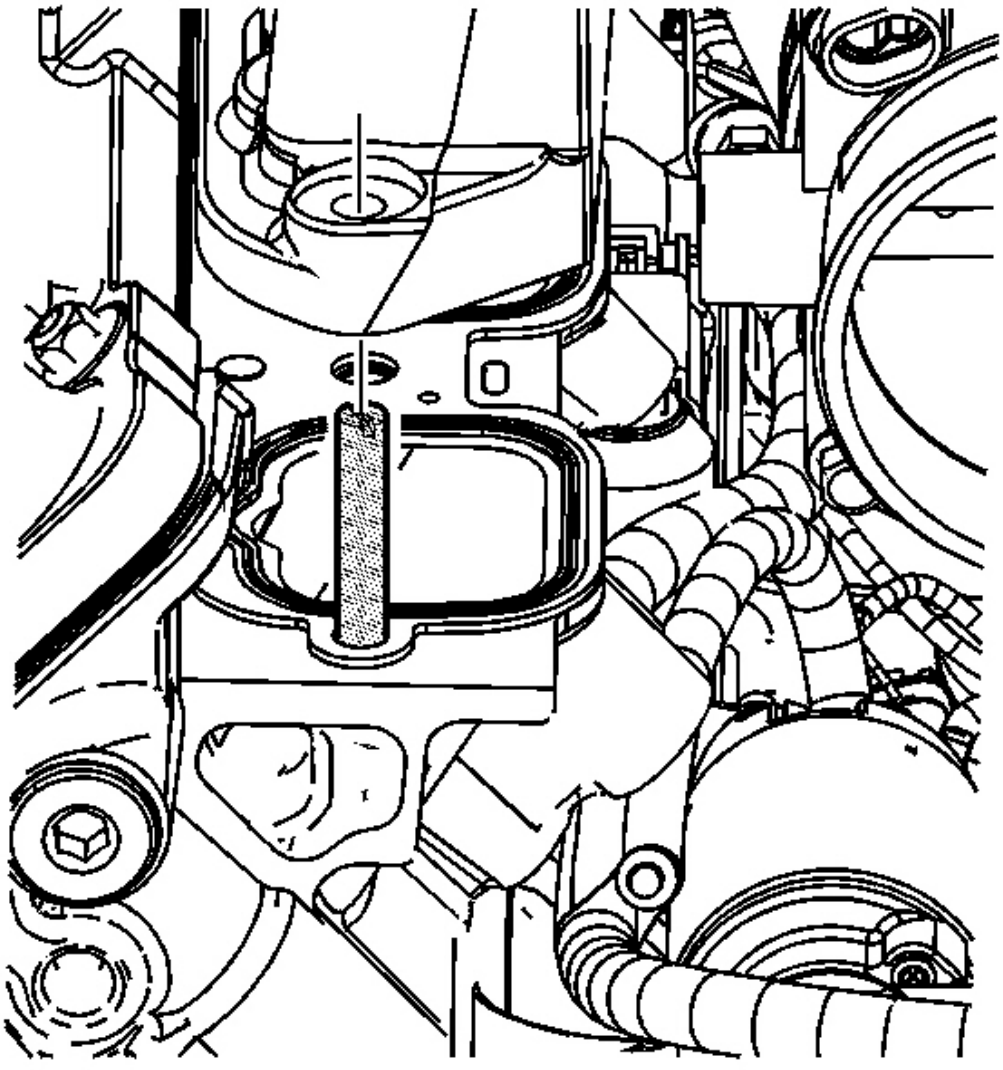


Fig. 6: Identifying Corner Mounting Hole
Courtesy of GENERAL MOTORS CORP.

6. As the supercharger is lowered into place carefully align the **EN 46109** with the corner mounting holes of the supercharger. See **Special Tools** .

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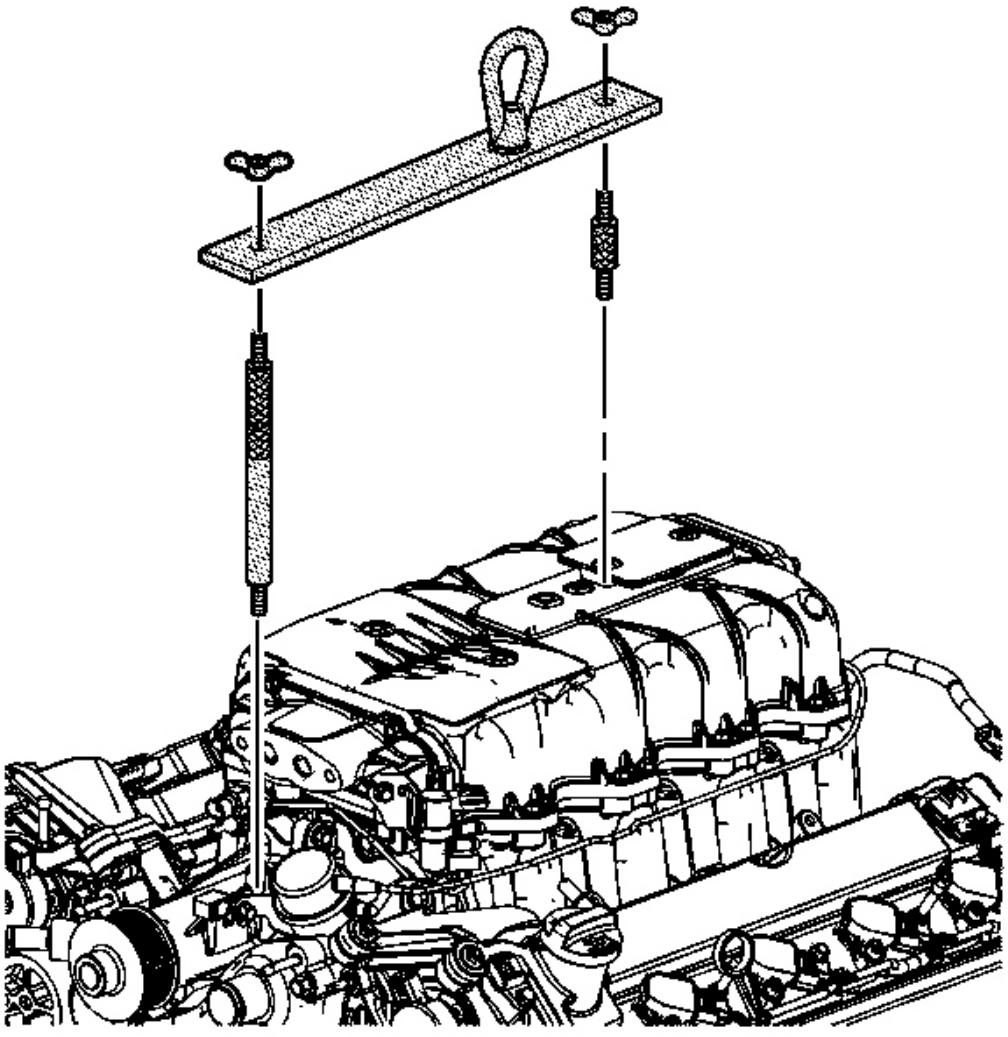


Fig. 7: Removing/Installing EN-47748 Supercharger Lifting Fixture
Courtesy of GENERAL MOTORS CORP.

7. Remove the **EN-47748** from the supercharger.

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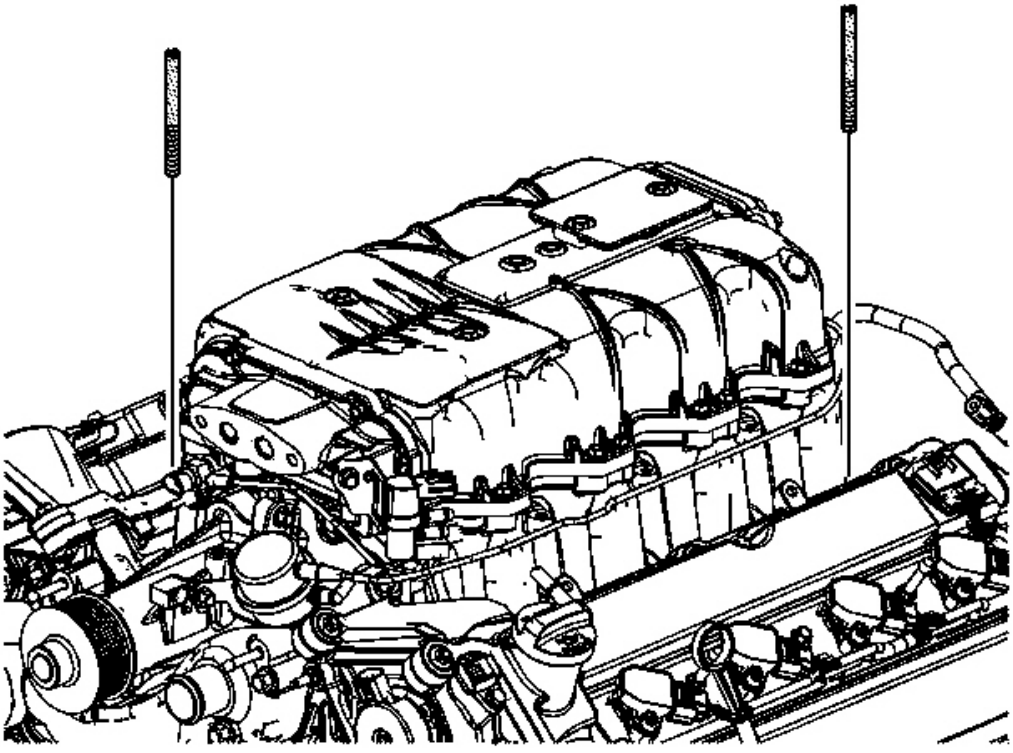


Fig. 8: View Of EN 46109 Guide Pins
Courtesy of GENERAL MOTORS CORP.

8. Remove the **EN 46109** . See **Special Tools** .

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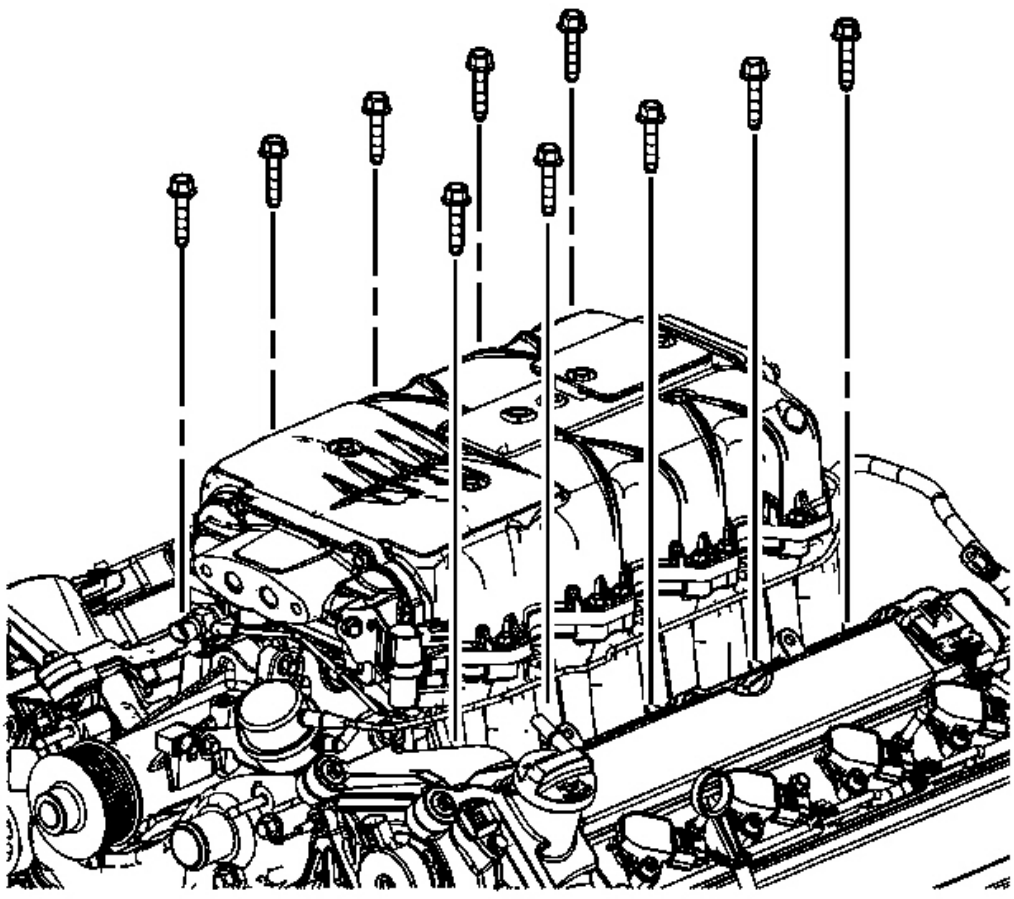


Fig. 9: Identifying Supercharger Bolts
Courtesy of GENERAL MOTORS CORP.

9. Loosely install the supercharger bolts.

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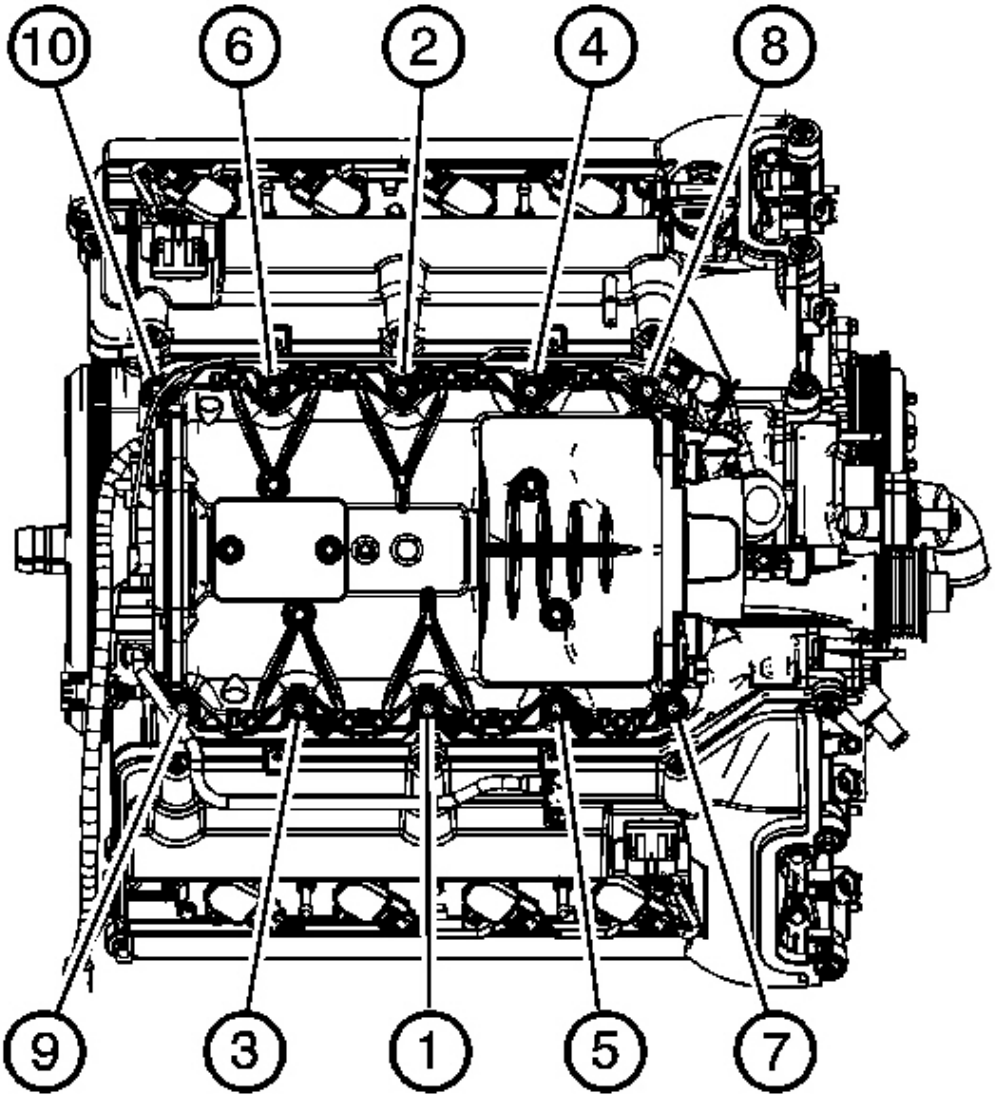


Fig. 10: Identifying Supercharger Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

10. Tighten the supercharger bolts in sequence as shown.

Tighten: Tighten the supercharger bolts in sequence to 25 N.m (18 lb ft).

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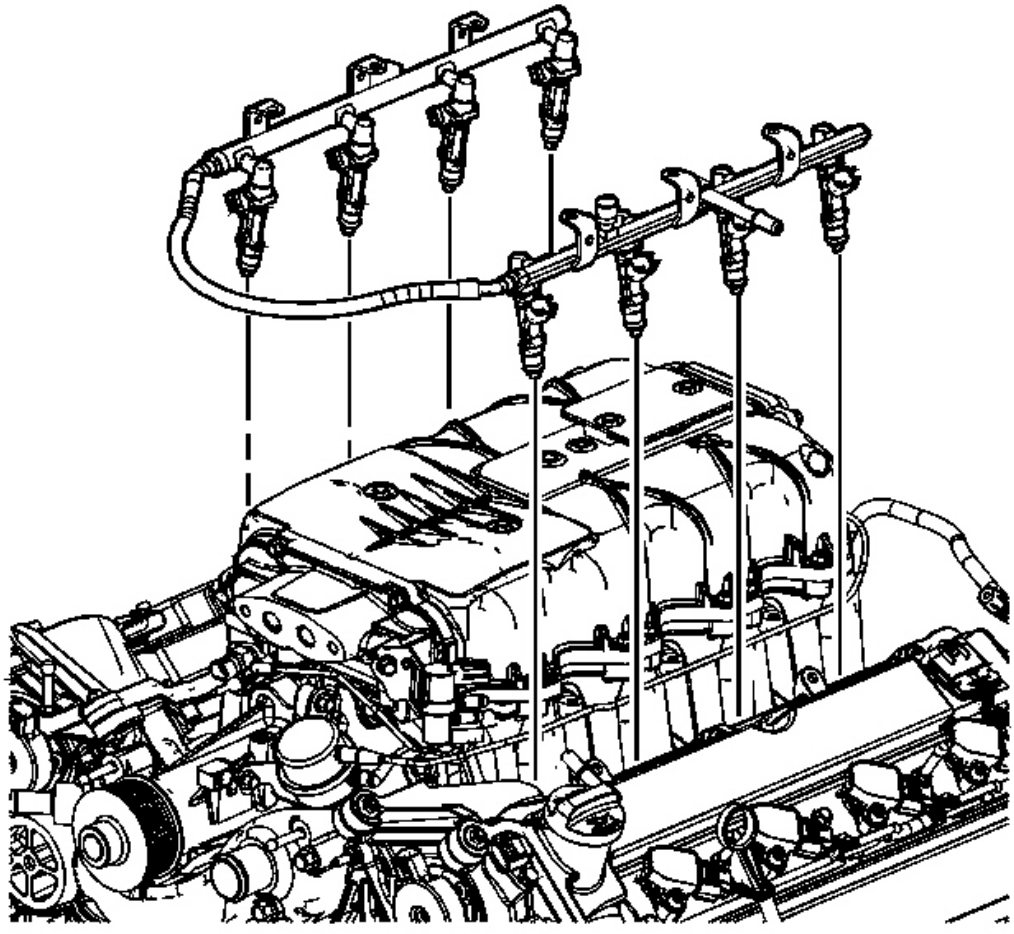


Fig. 11: View Of Fuel Injector Rail Assembly
Courtesy of GENERAL MOTORS CORP.

11. Place the fuel injector rail assembly into position and align each fuel injector with the fuel injector bores in the supercharger.

Automotive-Manual.net

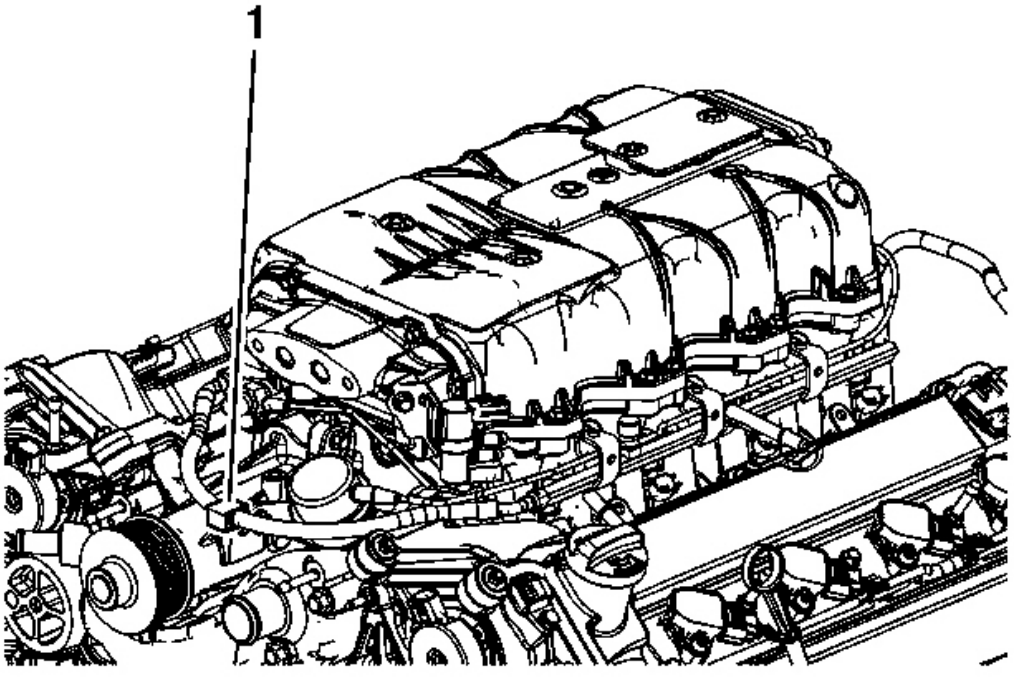


Fig. 12: View Of Fuel Injection Rail Crossover Tube Clip
Courtesy of GENERAL MOTORS CORP.

12. Place the fuel injection rail crossover tube into the clip (1) and fasten.

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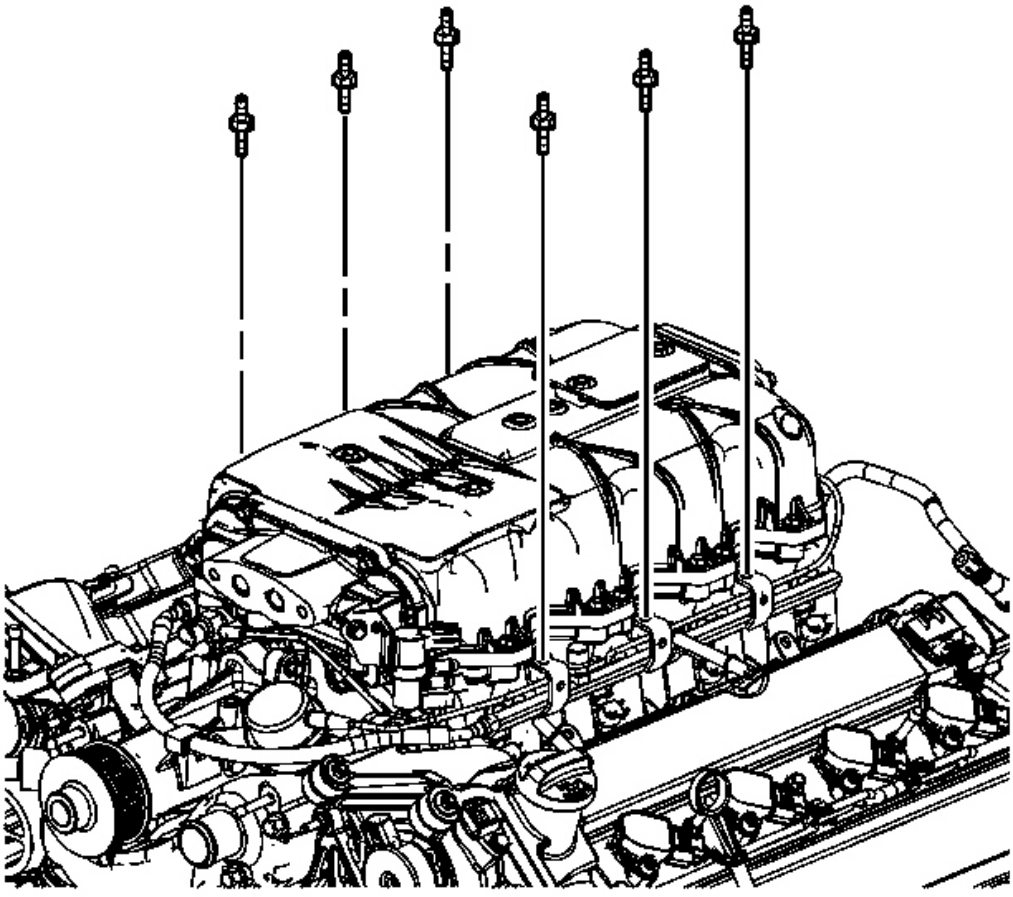


Fig. 13: Identifying Fuel Injection Rail Studs
Courtesy of GENERAL MOTORS CORP.

13. Install the fuel injection rail studs.

    Tighten: Tighten the fuel injection rail studs to 10 N.m (89 lb in).

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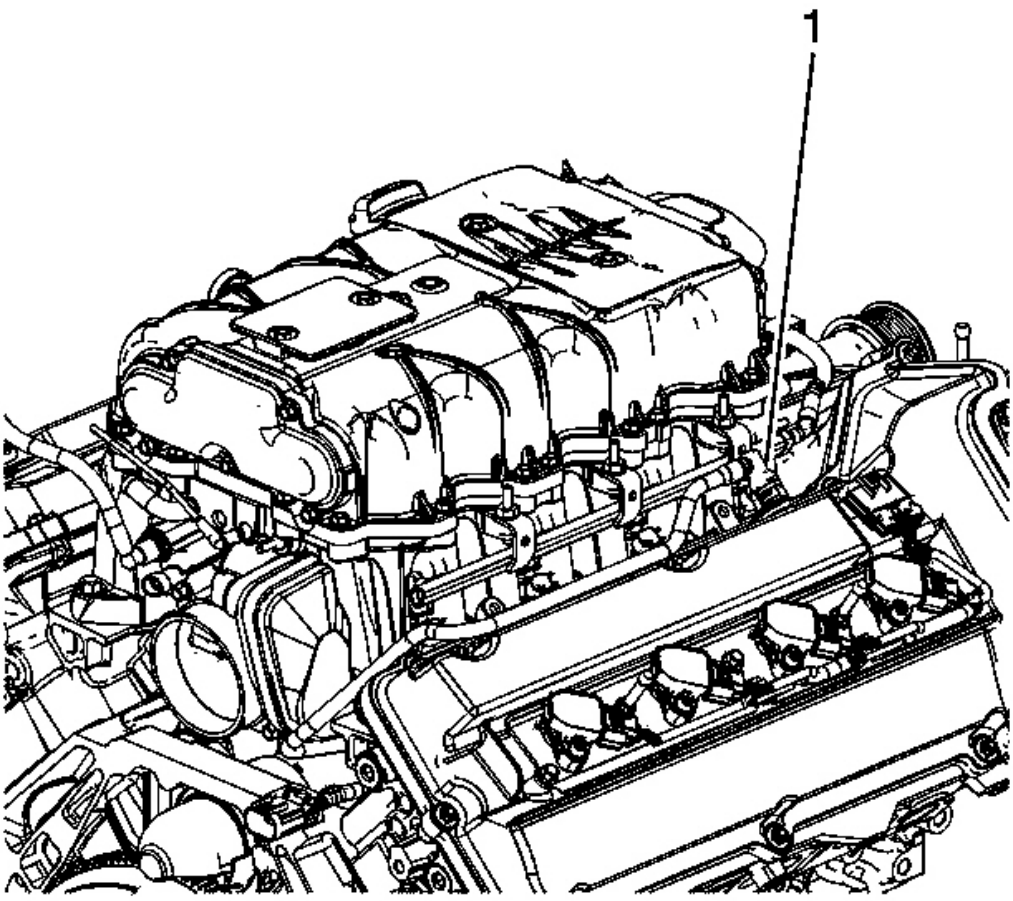


Fig. 14: Locating Dirty Air PCV Tube
Courtesy of GENERAL MOTORS CORP.

14. Connect the dirty air positive crankcase ventilation (PCV) tube (1) to the right camshaft cover.

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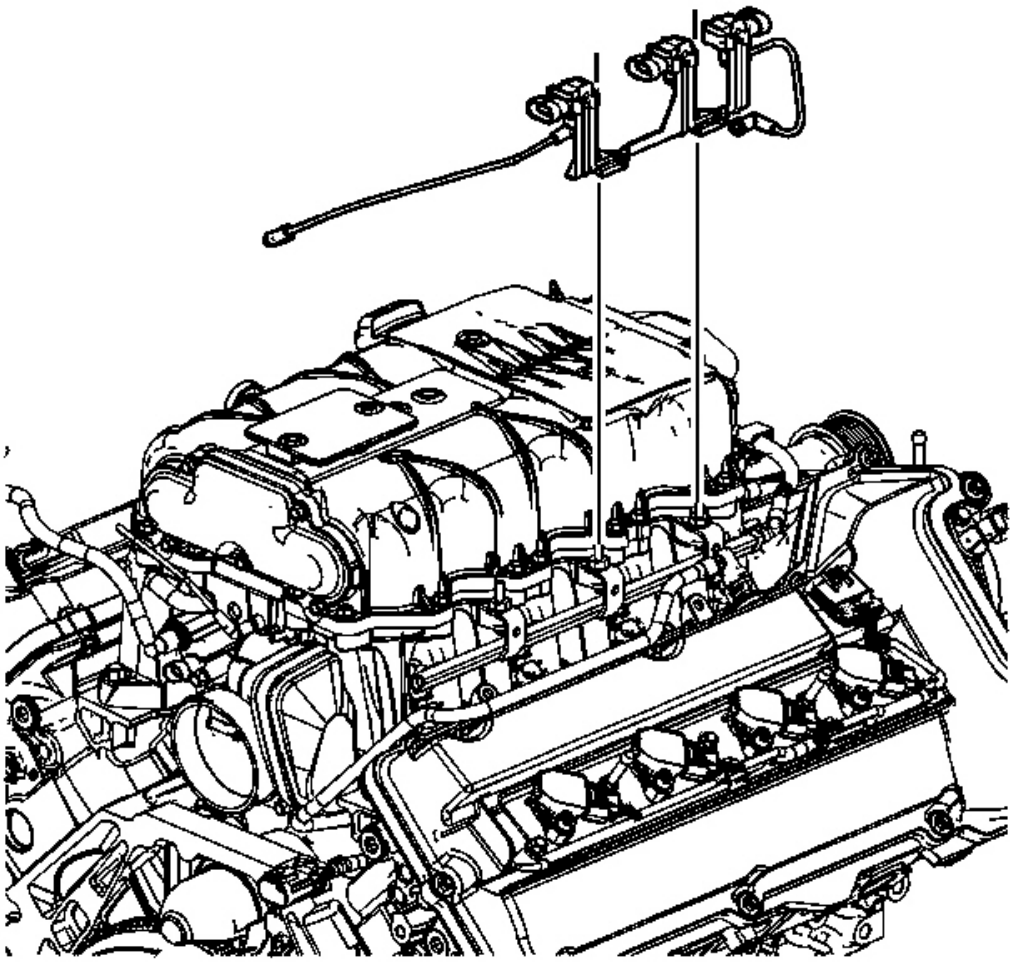


Fig. 15: Identifying Bracket With Sensors & Tubes
Courtesy of GENERAL MOTORS CORP.

15. Install the bracket with sensors and tubes.

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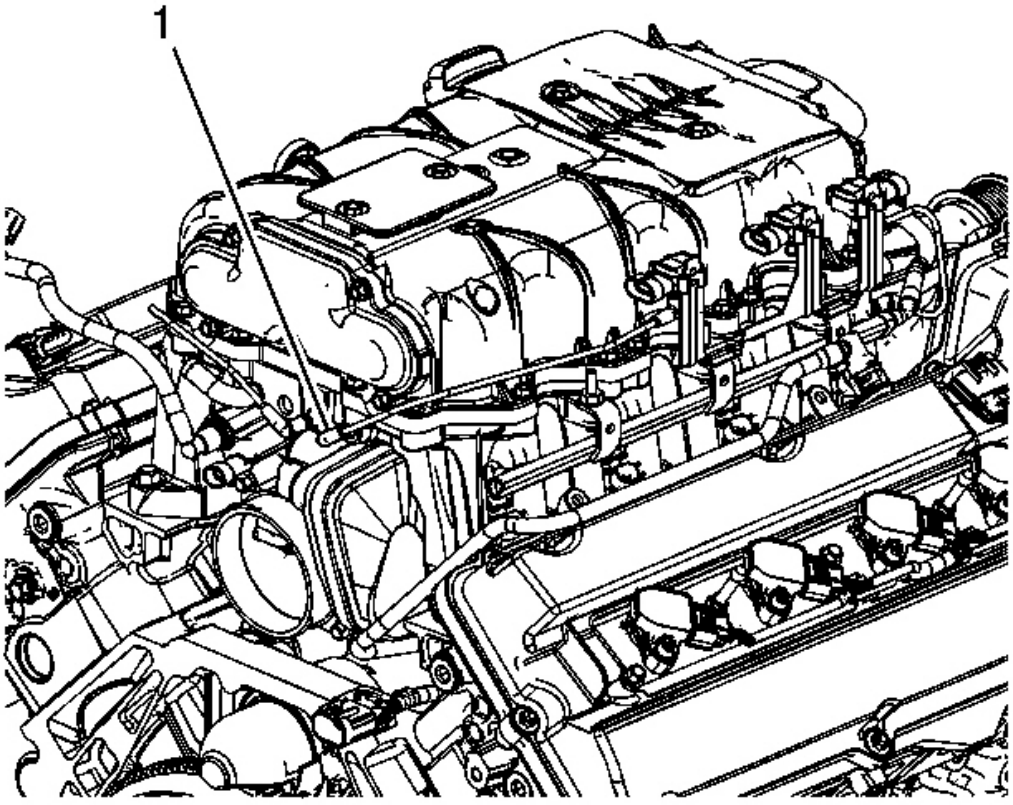


Fig. 16: Identifying Supercharger Inlet Absolute Pressure Sensor Vacuum Tube Connection
Courtesy of GENERAL MOTORS CORP.

16. Connect the supercharger inlet absolute pressure sensor vacuum tube connection (1) to the supercharger fitting.

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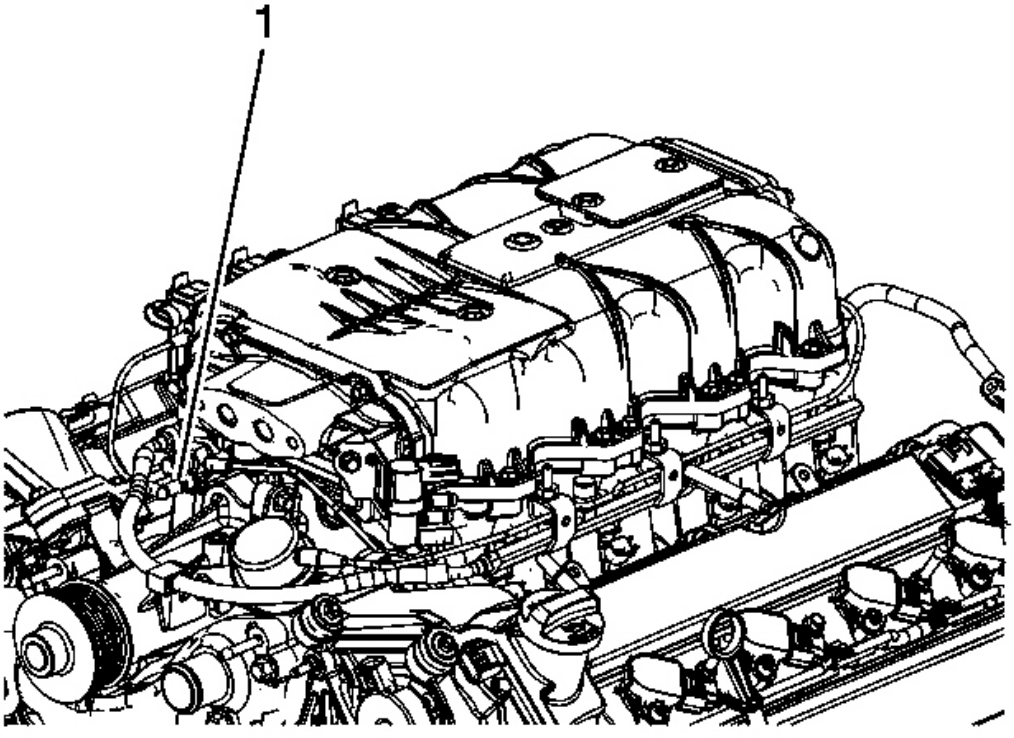


Fig. 17: Identifying MAP Sensor Vacuum Tube Connection
Courtesy of GENERAL MOTORS CORP.

17. Connect the manifold absolute pressure (MAP) sensor vacuum tube connection (1) to the supercharger fitting.

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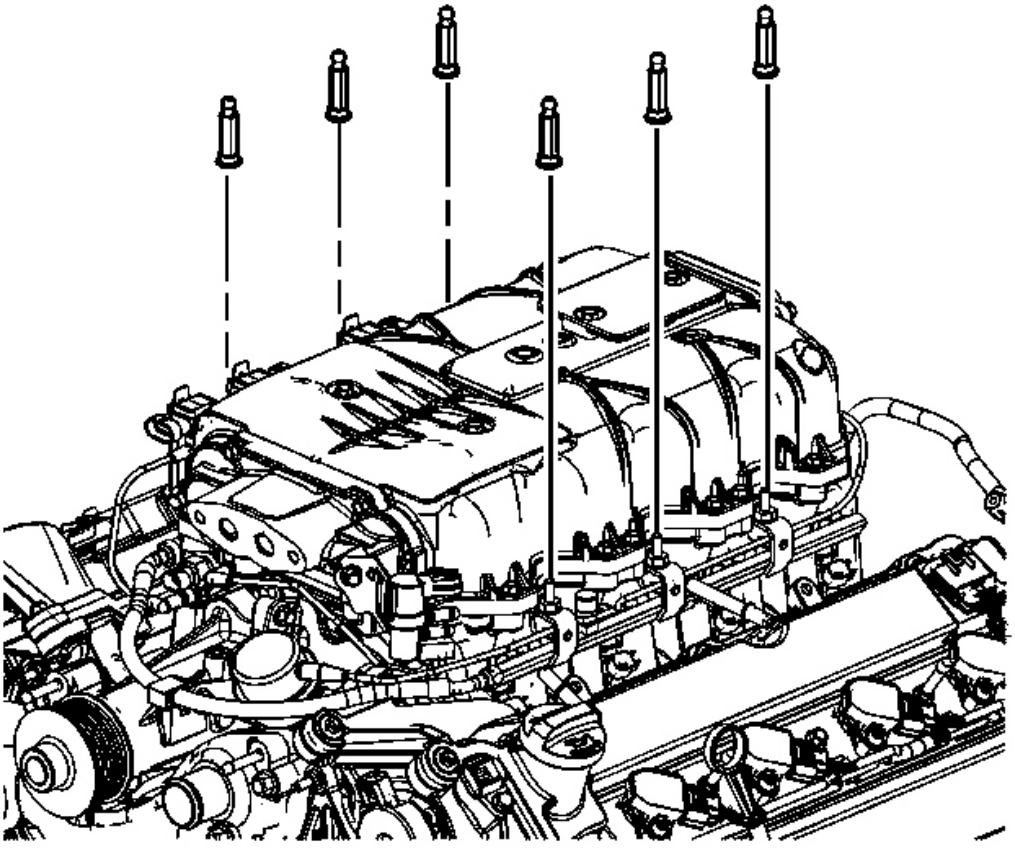


Fig. 18: Identifying Fuel Injector Sight Shield Cover Ball Studs
Courtesy of GENERAL MOTORS CORP.

18. Install the fuel injector sight shield cover ball studs.

    Tighten: Tighten the fuel injection sight shield cover ball studs to 10 N.m (89 lb in).

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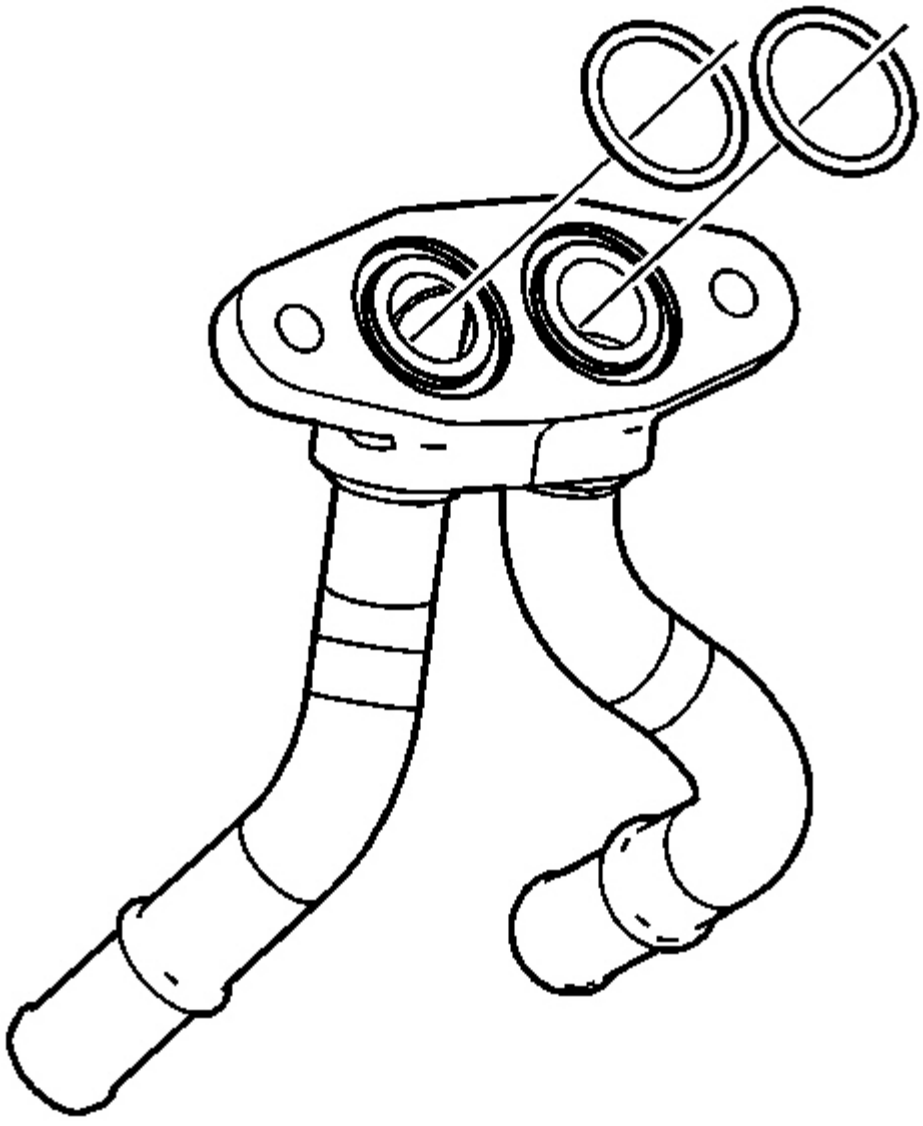


Fig. 19: Identifying Charge Air Cooler Coolant Front Manifold O-Rings
Courtesy of GENERAL MOTORS CORP.

19. Install the NEW charge air cooler coolant front manifold O-rings.

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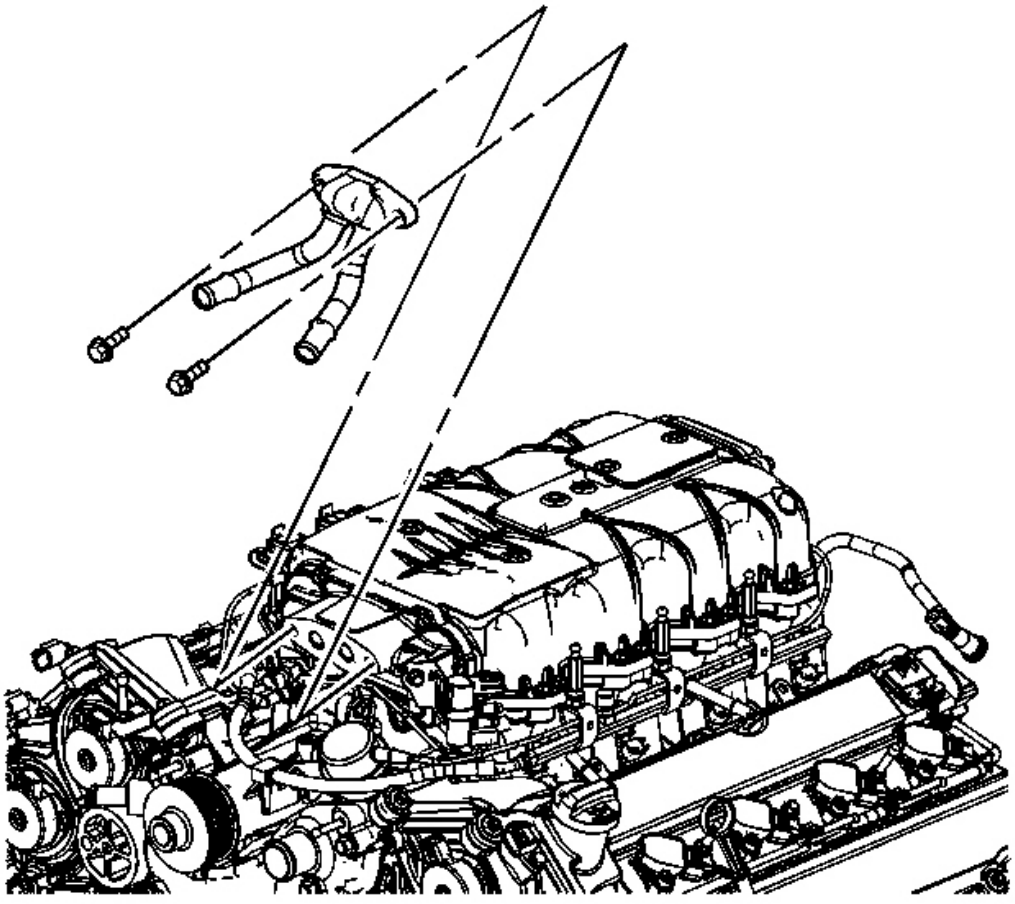


Fig. 20: Identifying Charge Air Cooler Coolant Front Manifold
Courtesy of GENERAL MOTORS CORP.

20. Install the charge air cooler coolant front manifold.
21. Install the charge air cooler coolant front manifold bolts.

Tighten: Tighten the charge air cooler coolant front manifold bolts to 25 N.m (18 lb ft).

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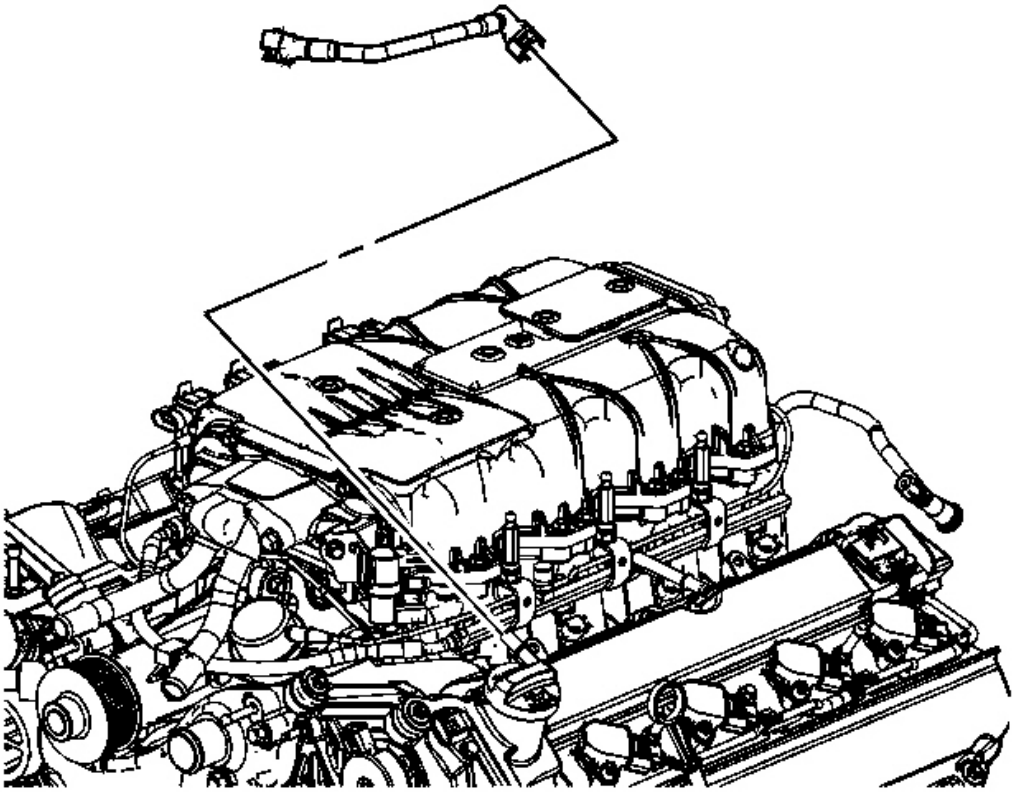


Fig. 21: Identifying PCV Clean Air Tube
Courtesy of GENERAL MOTORS CORP.

22. Install and connect the clean air positive crankcase ventilation (PCV) tube to the left camshaft cover.

AIR CONDITIONING (A/C) COMPRESSOR INSTALLATION

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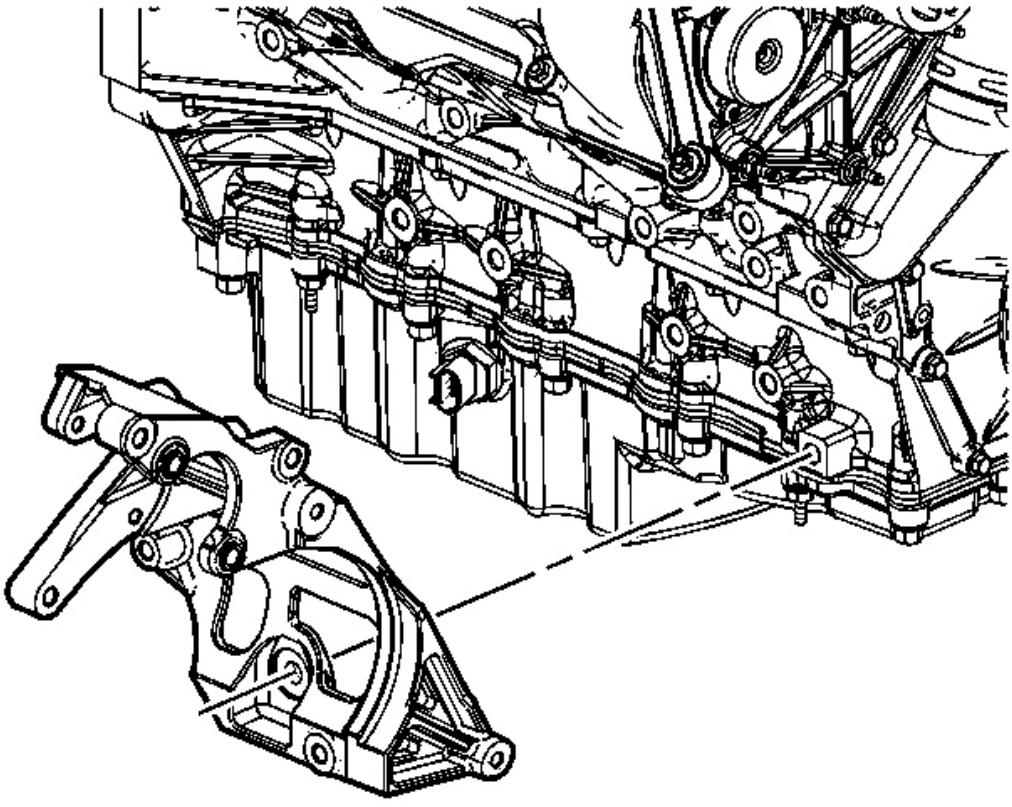


Fig. 22: Identifying A/C Compressor Bracket
Courtesy of GENERAL MOTORS CORP.

1. Place the air conditioner bracket in position to the engine.

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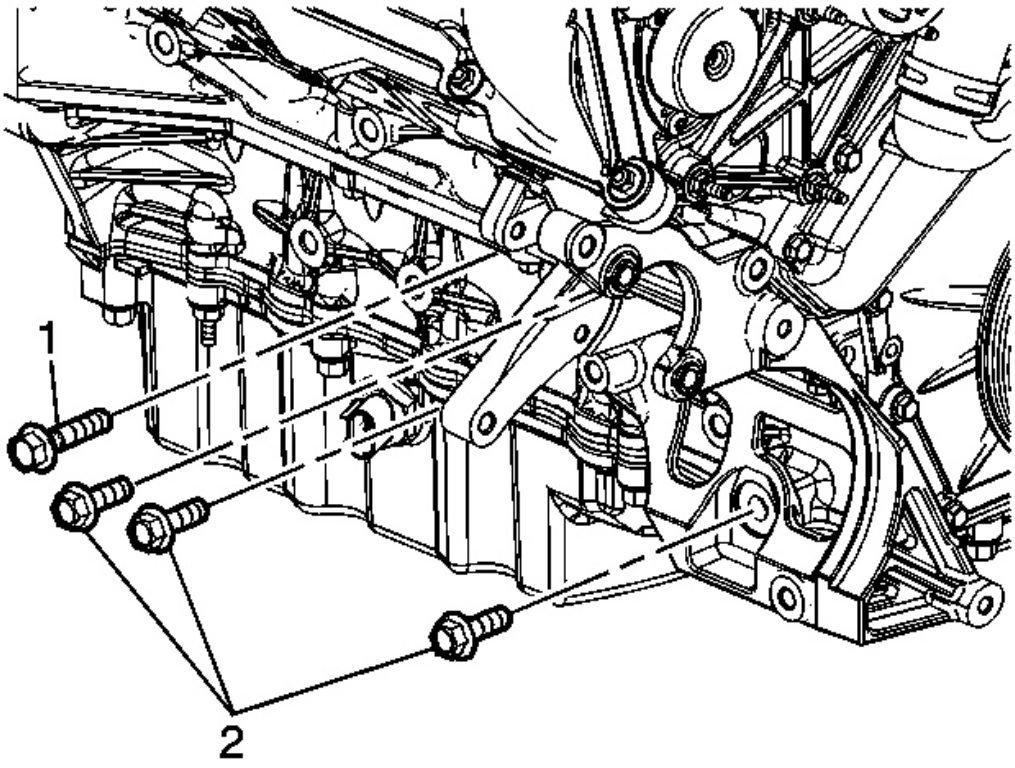


Fig. 23: Identifying A/C Compressor Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the air conditioner bracket bolts.

Automotive-Manual.net

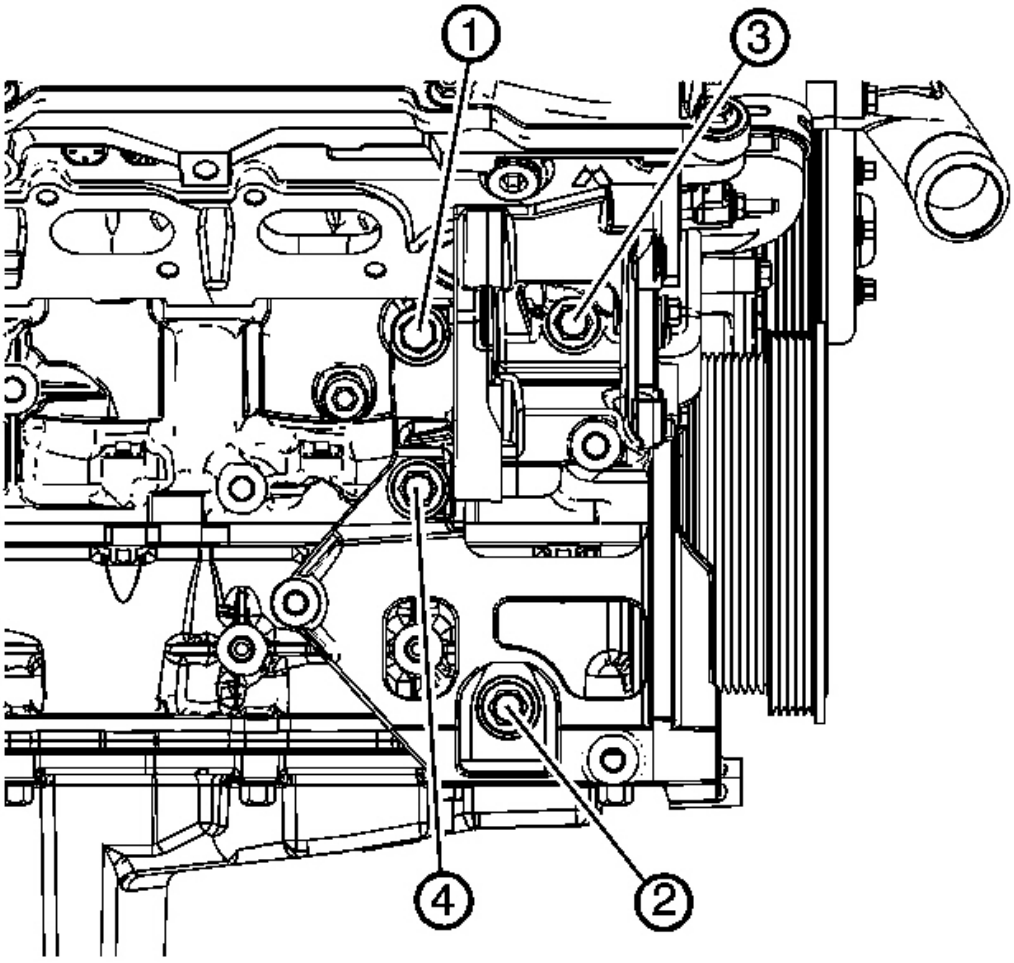


Fig. 24: Identifying A/C Compressor Bracket Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Tighten the air conditioner bracket bolts in the sequence shown.

Tighten:

1. Tighten the air conditioner bracket rear upper bolt (1) to 50 N.m (37 lb ft).
2. Tighten the air conditioner bracket lower bolt (2) to 50 N.m (37 lb ft).
3. Tighten the air conditioner bracket front upper bolt (3) to 50 N.m (37 lb ft).
4. Tighten the air conditioner bracket center bolt (4) to 50 N.m (37 lb ft).

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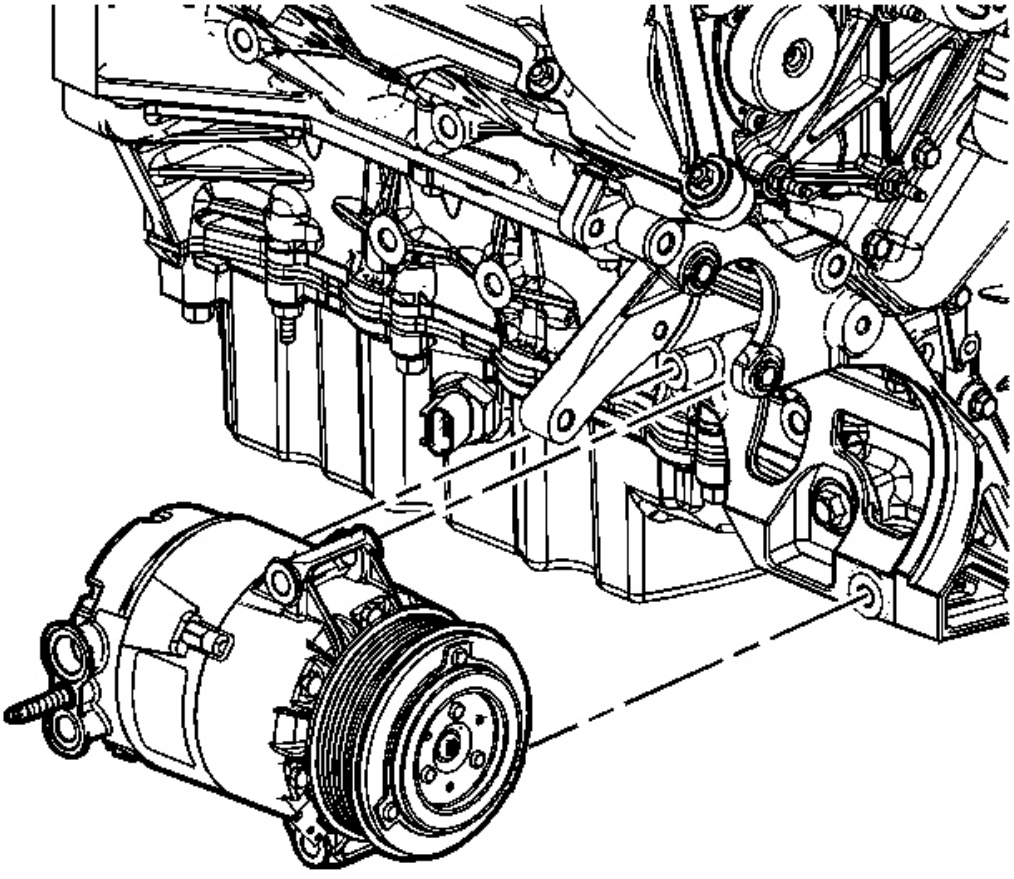


Fig. 25: View Of A/C Compressor
Courtesy of GENERAL MOTORS CORP.

4. Place the air conditioner compressor in position to the air conditioner bracket.

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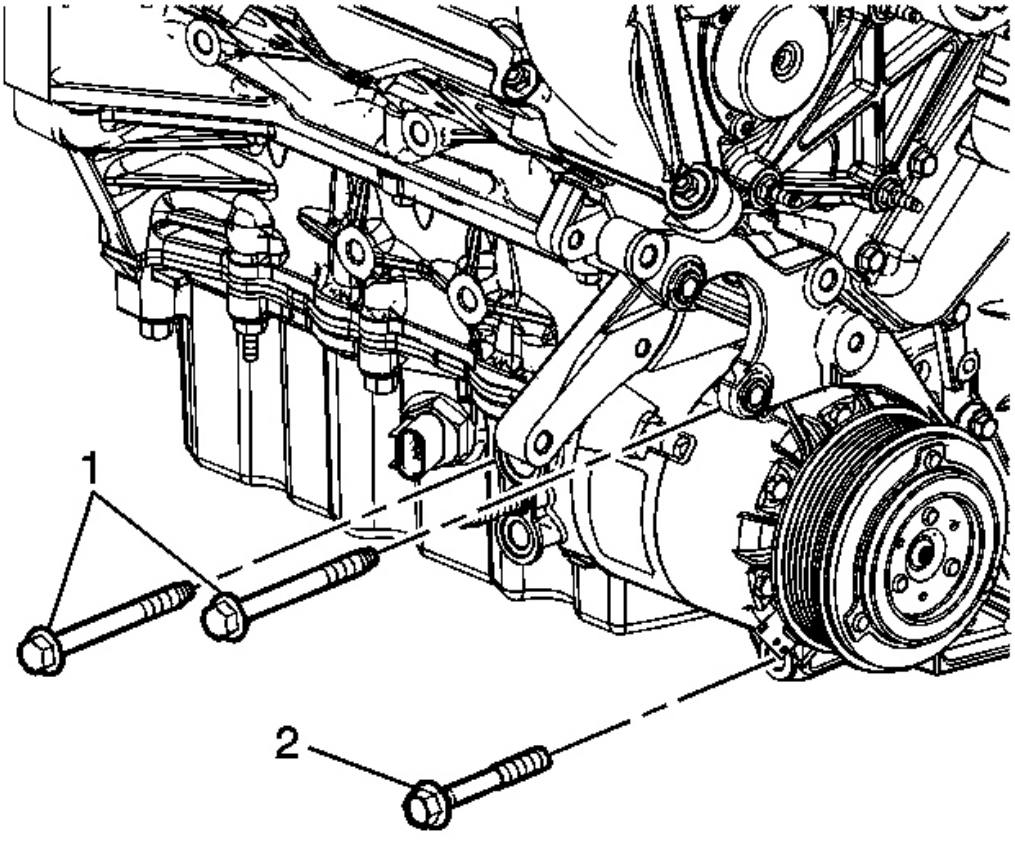


Fig. 26: Identifying A/C Compressor Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

5. Loosely install the air conditioner compressor bolts. Ensure the longer bolts (1) are installed in the upper front and rear positions and the shorter bolt (2) is installed in the lower front position.

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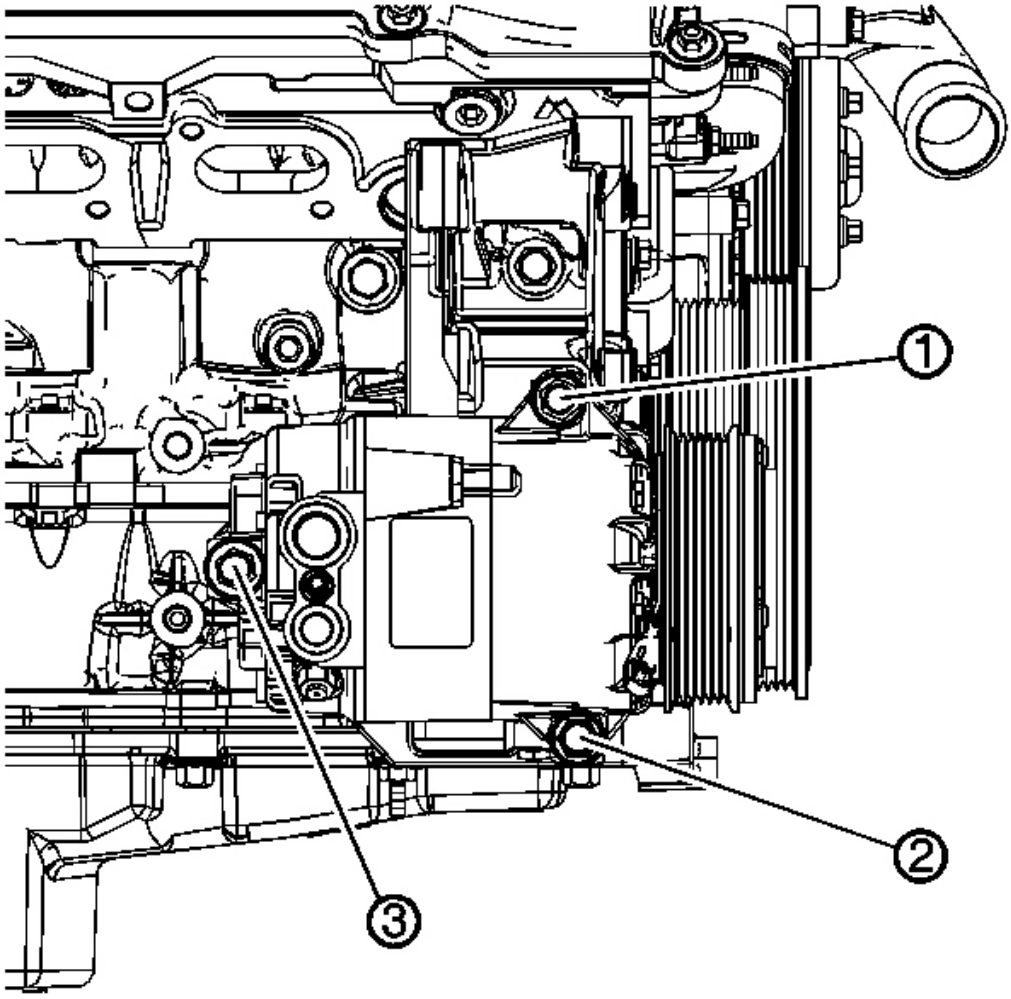


Fig. 27: Identifying A/C Compressor Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

6. Tighten the air conditioner compressor bolts in the sequence shown.

Tighten:

1. Tighten the air conditioner upper front bolt (1) to 25 N.m (18 lb ft).
2. Tighten the air conditioner compressor lower front bolt (2) to 25 N.m (18 lb ft).
3. Tighten the air conditioner compressor rear bolt (3) to 25 N.m (18 lb ft).

POWER STEERING PUMP INSTALLATION

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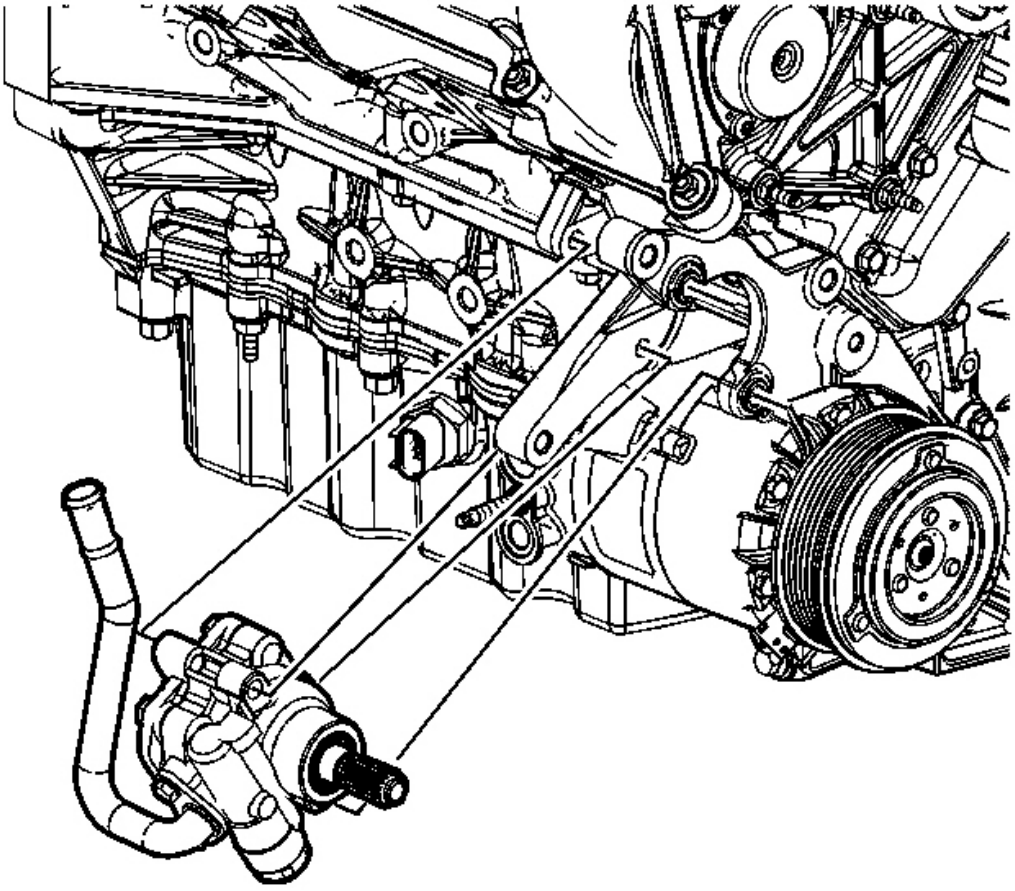


Fig. 28: View Of Power Steering Pump Placement
Courtesy of GENERAL MOTORS CORP.

1. Place the power steering pump in position to the engine.

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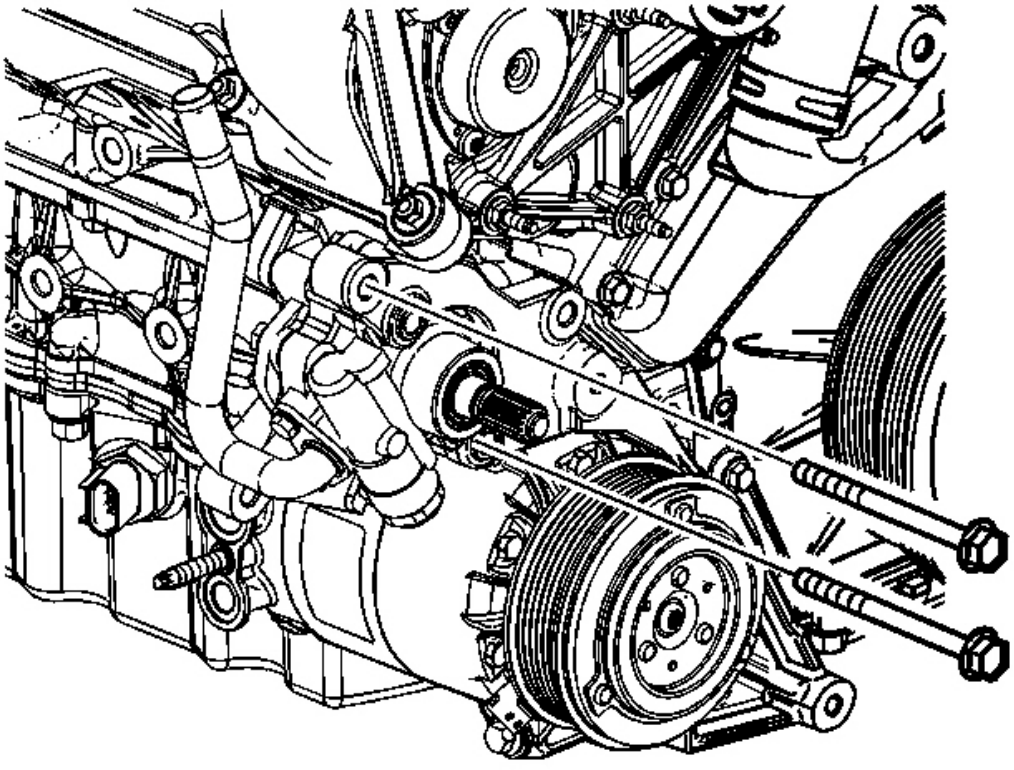


Fig. 29: Identifying Power Steering Pump Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the power steering pump bolts.

NOTE: **Refer to Fastener Notice .**

3. Tighten the power steering pump bolts.

Tighten: Tighten the power steering pump bolts to 25 N.m (18 lb ft).

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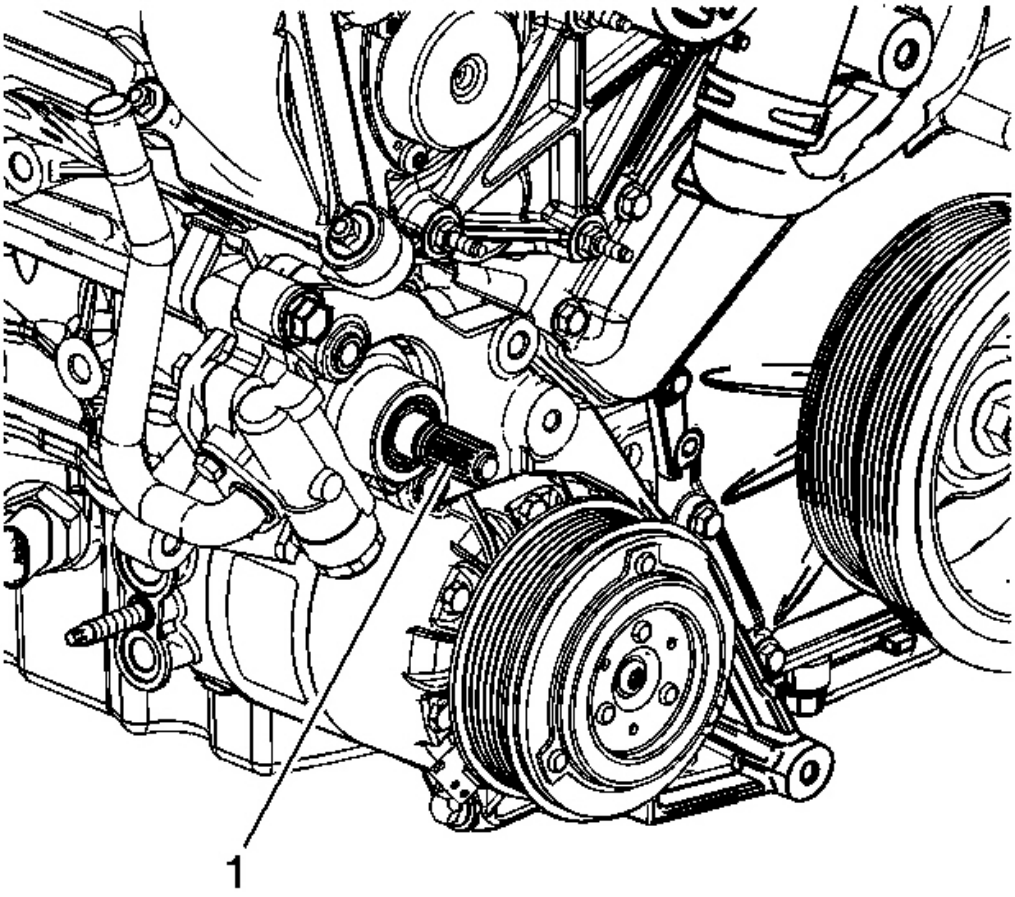


Fig. 30: Identifying Power Steering Pump Shaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the splined shaft has been cleaned. Remove all debris and old grease prior to applying the new grease.

4. Lubricate the splines (1) on the power steering pump shaft with G/M P/N 1051344 (Canadian P/N 993037).

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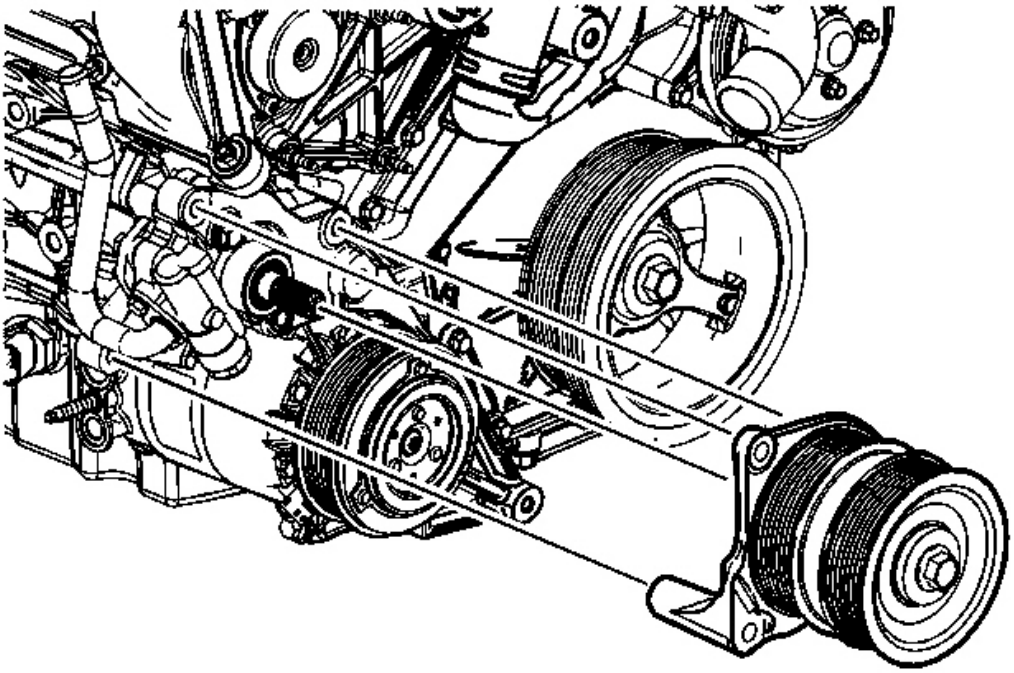


Fig. 31: Identifying Power Steering Pump Pulley
Courtesy of GENERAL MOTORS CORP.

5. Install the power steering pulley in position on the power steering pump.

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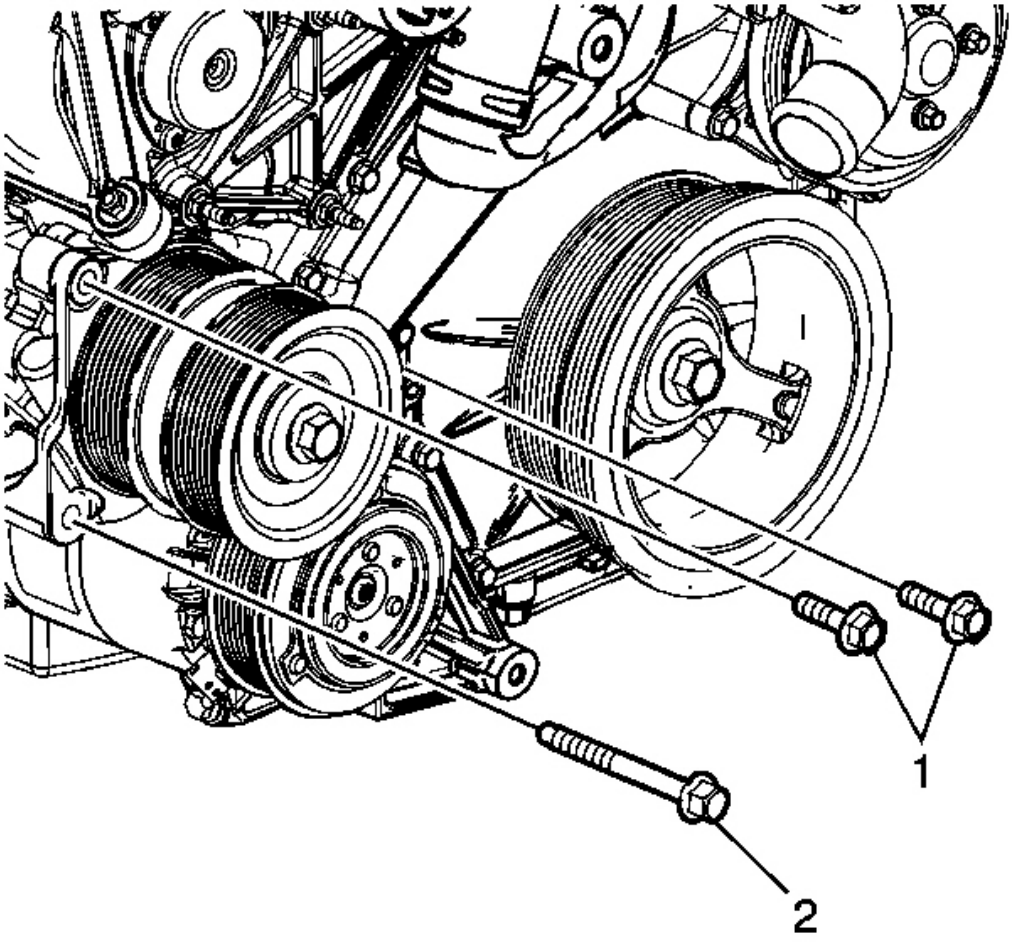


Fig. 32: Identifying Power Steering Pulley Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the power steering pulley bolts. Ensure the short bolts (1) are installed in the upper and inboard positions and the longer bolt (2) is installed in the lower outboard position.

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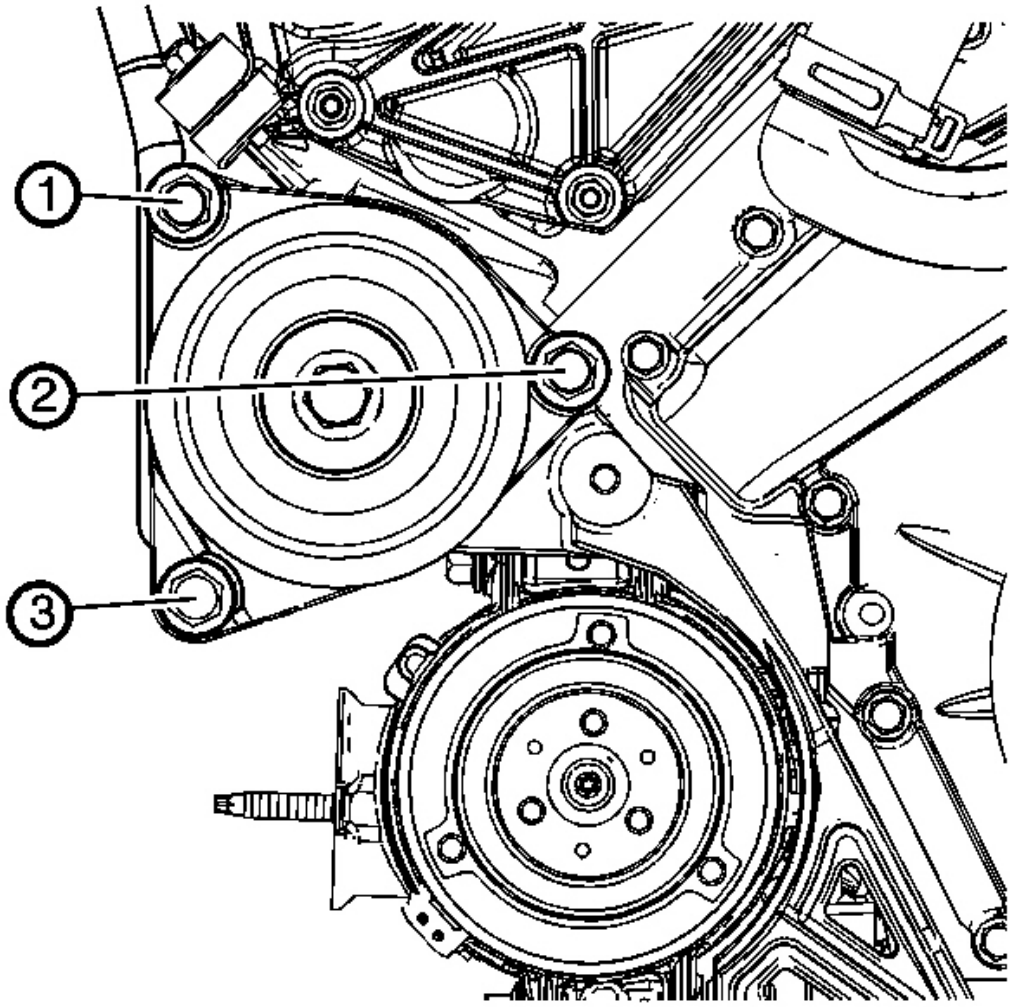


Fig. 33: Identifying Power Steering Pump Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

7. Tighten the bolts in the sequence shown (1-3).

   Tighten: Tighten the power steering pulley bolts in sequence (1-3) to 50 N.m (37 lb ft).

GENERATOR INSTALLATION

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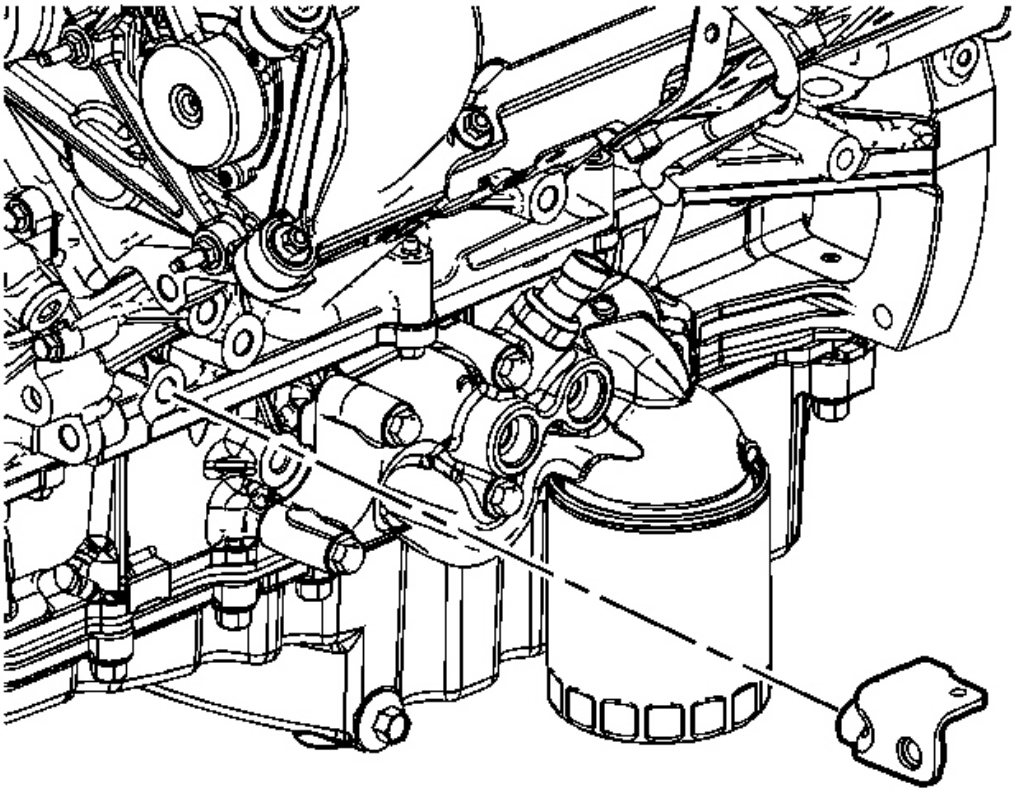


Fig. 34: Identifying Generator Rear Brace
Courtesy of GENERAL MOTORS CORP.

1. Position the generator rear brace to the engine.

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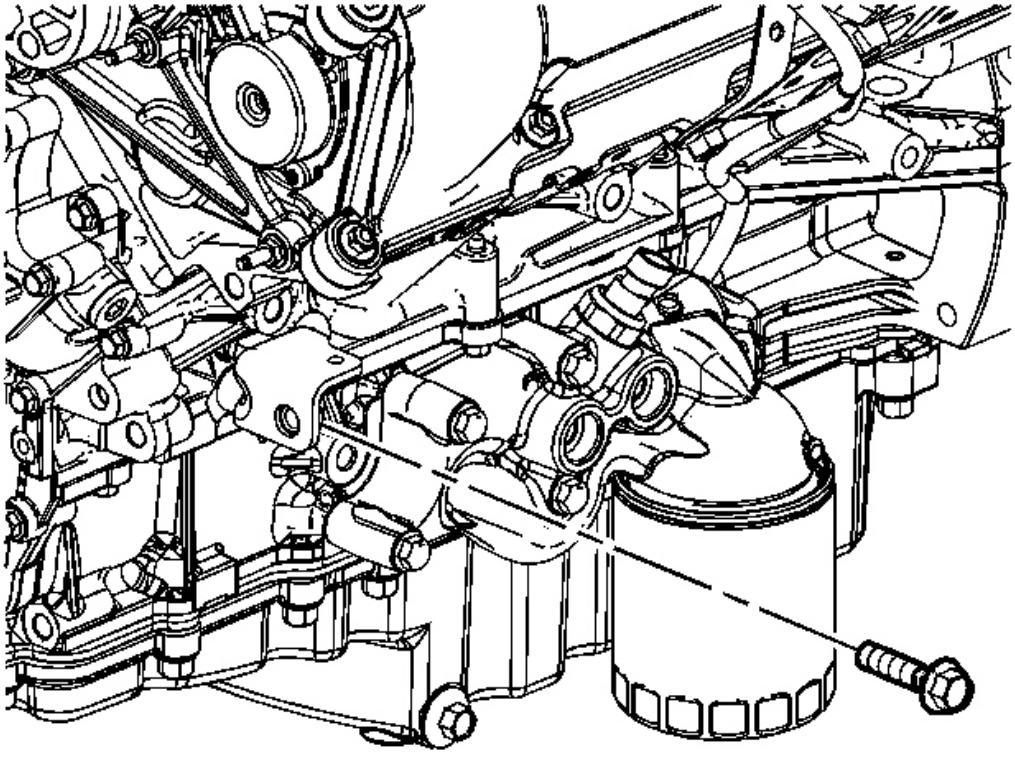


Fig. 35: Identifying Generator Rear Brace Bolt
Courtesy of GENERAL MOTORS CORP.

2. Install the generator rear brace bolt finger tight.

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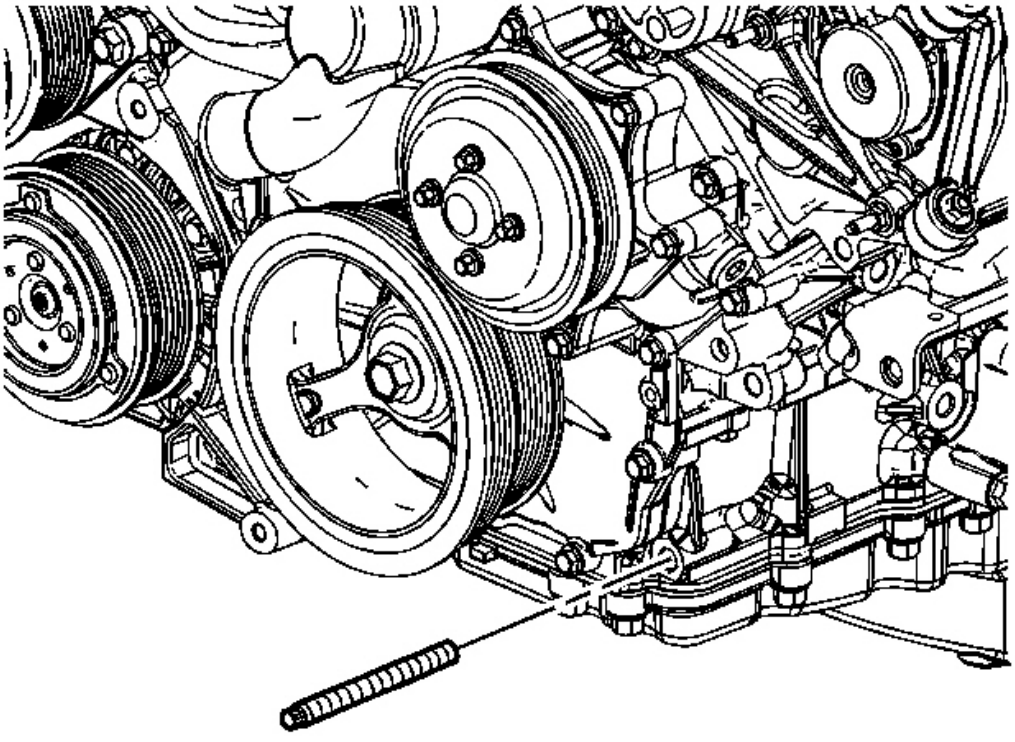


Fig. 36: Identifying Generator/Drive Belt Idler Pulley Mounting Stud
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

3. Install the generator/drive belt idler pulley mounting stud.

   Tighten: Tighten the generator/drive belt idler pulley mounting stud to 12 N.m (118 lb in).

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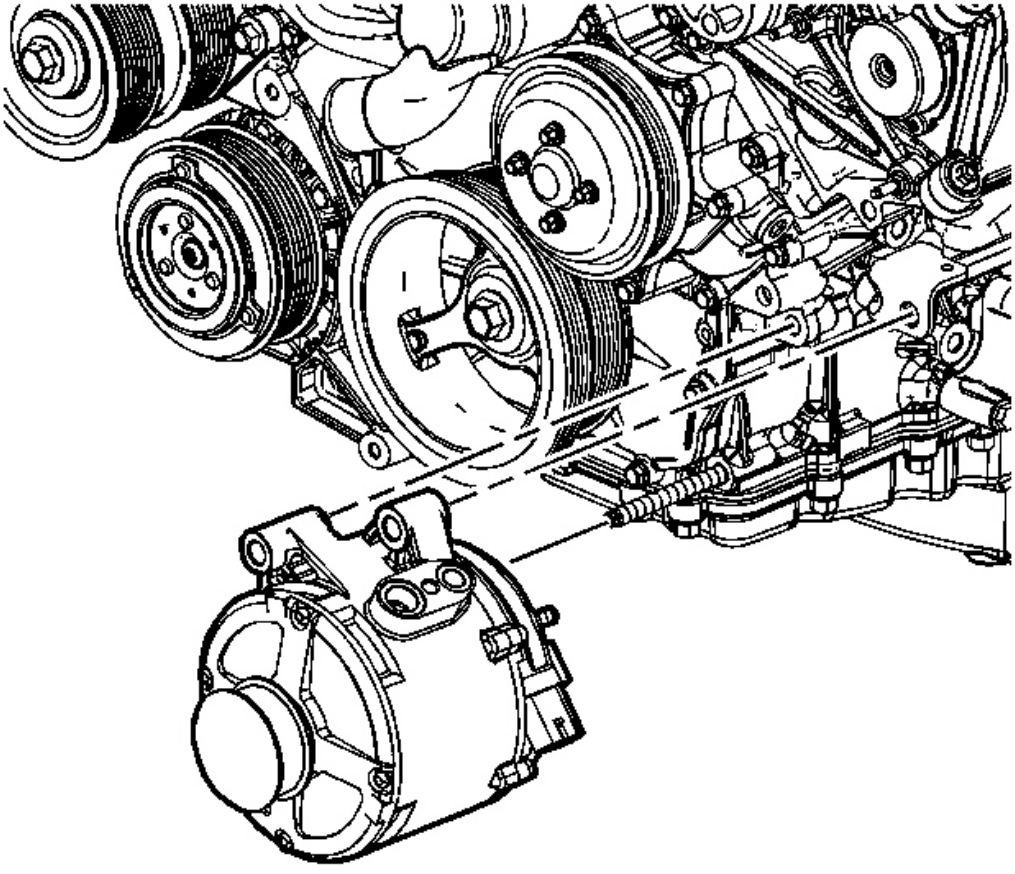


Fig. 37: View Of Generator
Courtesy of GENERAL MOTORS CORP.

4. Install the generator over the generator/drive belt idler pulley mounting stud.

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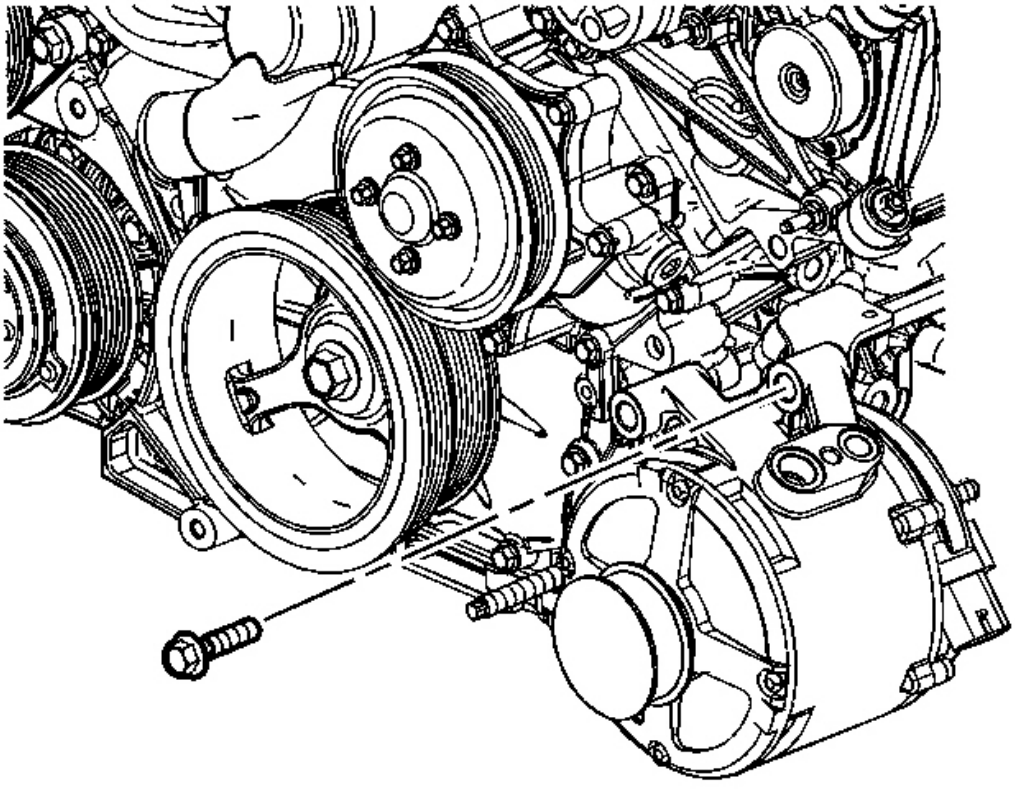


Fig. 38: Identifying Upper Front Generator Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the upper front generator bolt finger tight through the generator and into the rear generator brace.

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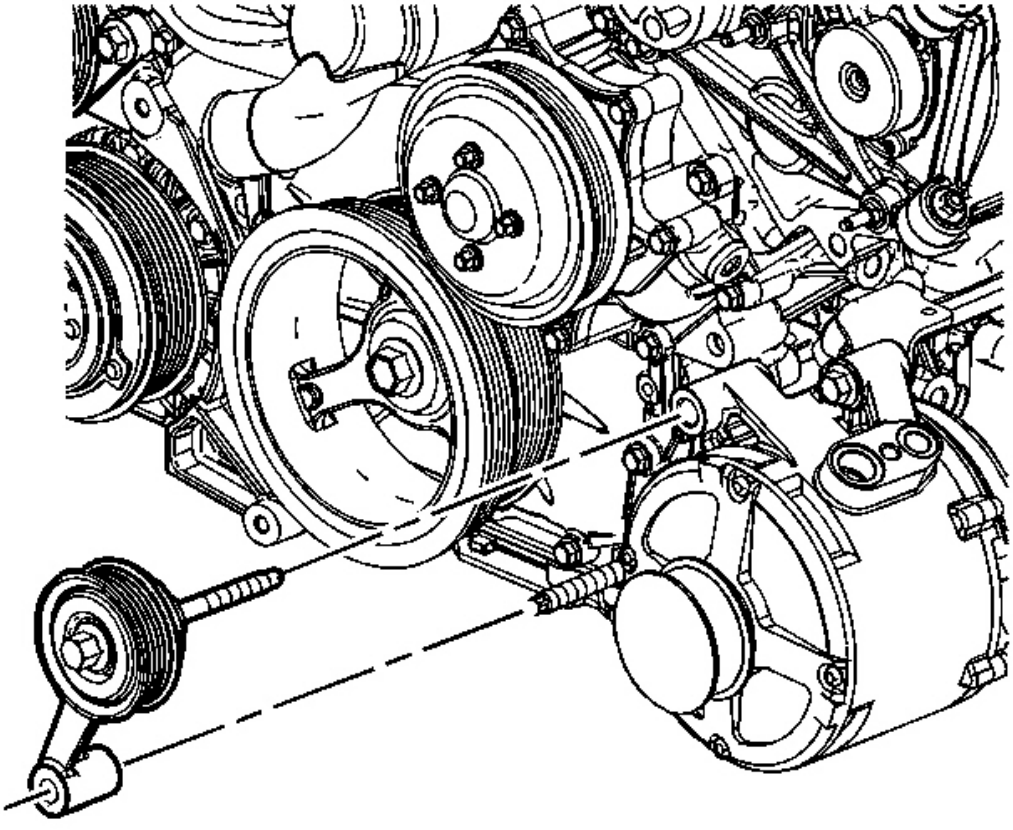


Fig. 39: Identifying Drive Belt Idler Pulley, Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

6. Install the drive belt idler pulley and bracket over the generator/drive belt idler pulley stud and the drive belt idler pulley bolt through the generator.

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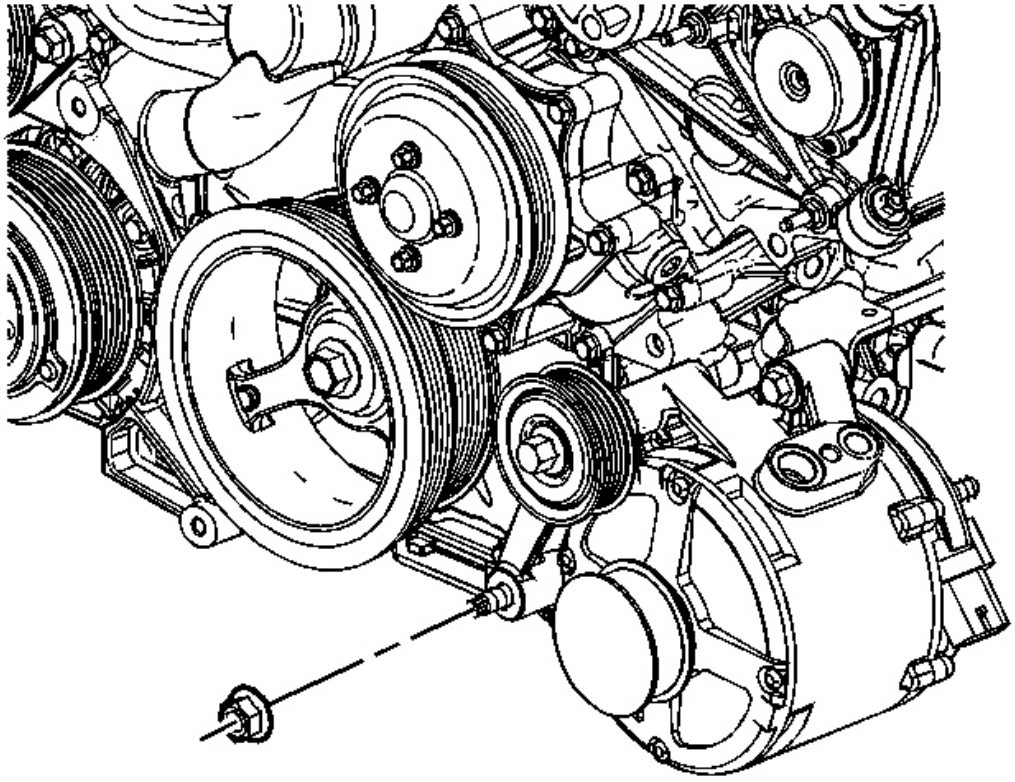


Fig. 40: Identifying Generator/Drive Belt Idler Pulley Mounting Stud Nut
Courtesy of GENERAL MOTORS CORP.

7. Install the nut on the generator/drive belt idler pulley mounting stud.

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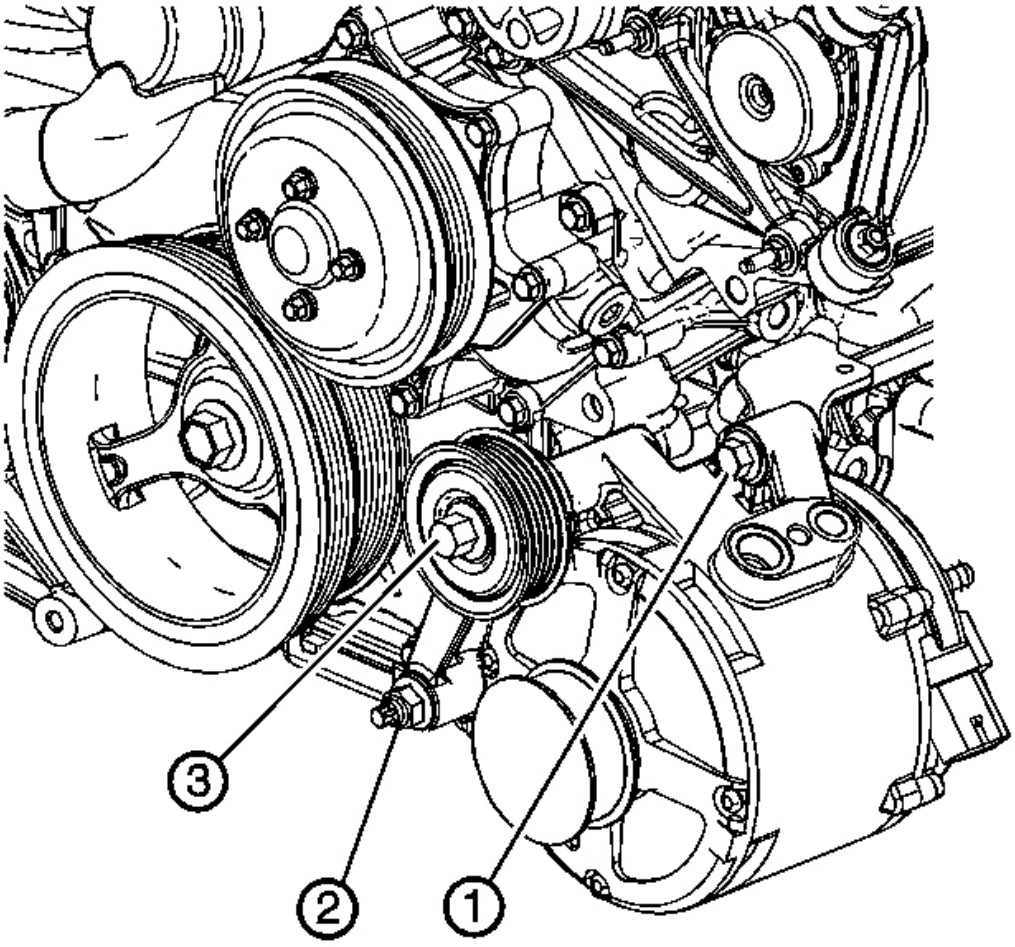


Fig. 41: Identifying Generator & Drive Belt Idler Pulley Bolt/Nut Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

8. Tighten the generator and drive belt idler pulley bolts and nut in the sequence shown.

Tighten:

1. Tighten the front upper generator bolt (1) to 50 N.m (37 lb ft).
2. Tighten the generator/drive belt idler pulley stud nut (2) to 50 N.m (37 lb ft).
3. Tighten the drive belt idler pulley bolt (3) to 50 N.m (37 lb ft).

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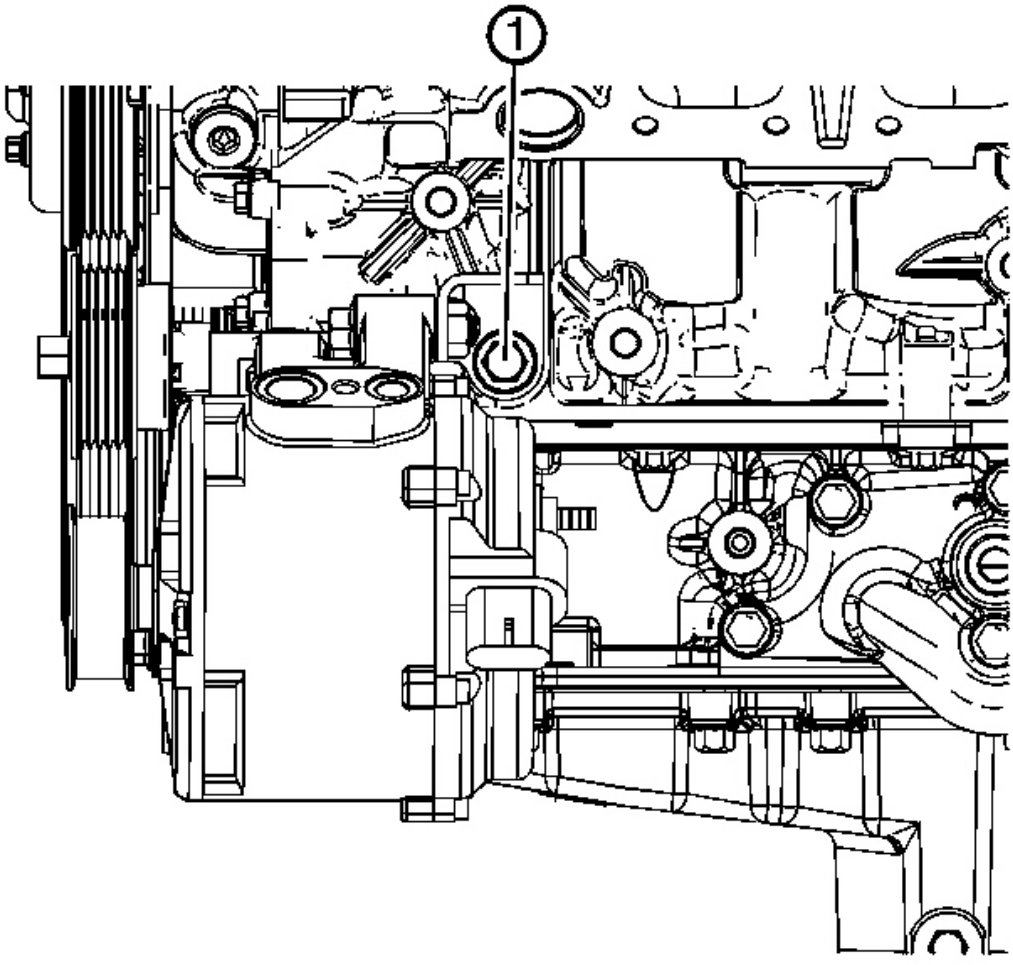


Fig. 42: Identifying Rear Generator Brace Bolt
Courtesy of GENERAL MOTORS CORP.

9. Tighten the rear generator brace bolt.

   Tighten: Tighten the rear generator brace bolt (1) to 50 N.m (37 lb ft).

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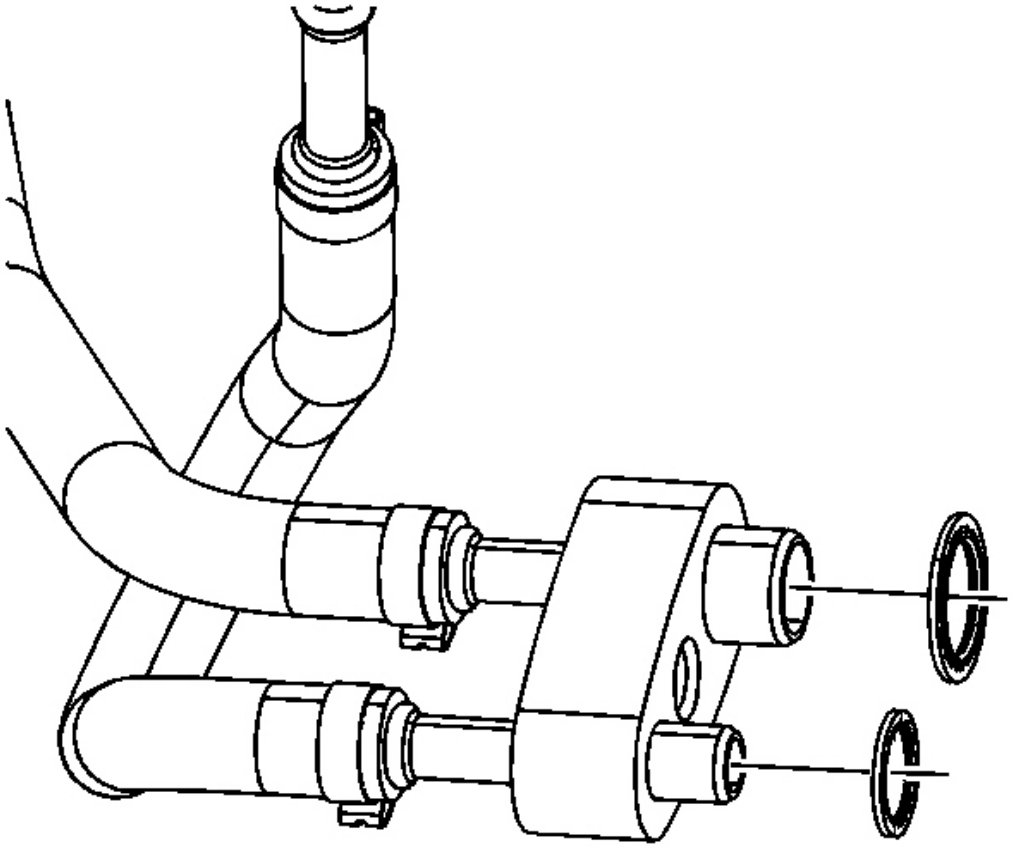


Fig. 43: View Of Generator Coolant Hose Sealing Rings
Courtesy of GENERAL MOTORS CORP.

10. Install the NEW generator coolant hose sealing rings.

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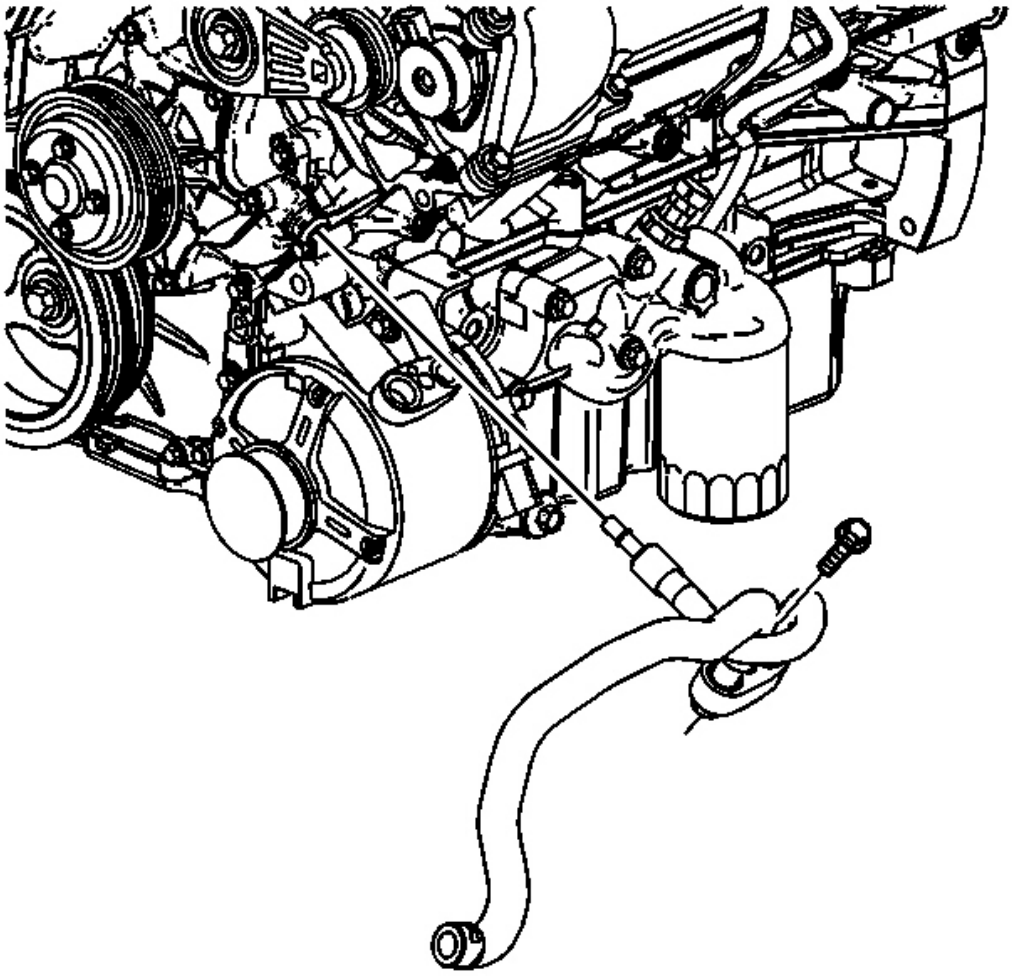


Fig. 44: View Of Generator Coolant Hose Assembly
Courtesy of GENERAL MOTORS CORP.

11. Install the hose into the fitting in the engine front cover.
12. Install the cooling hose assembly onto the generator port.
13. Install the bolt through the cooling hose assembly into the generator.

Tighten: Tighten the bolt to 27 N.m (19 lb ft).

DRIVE BELT IDLER PULLEY INSTALLATION

GENERATOR AND WATER PUMP

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Refer to **Generator Installation**.

SUPERCHARGER

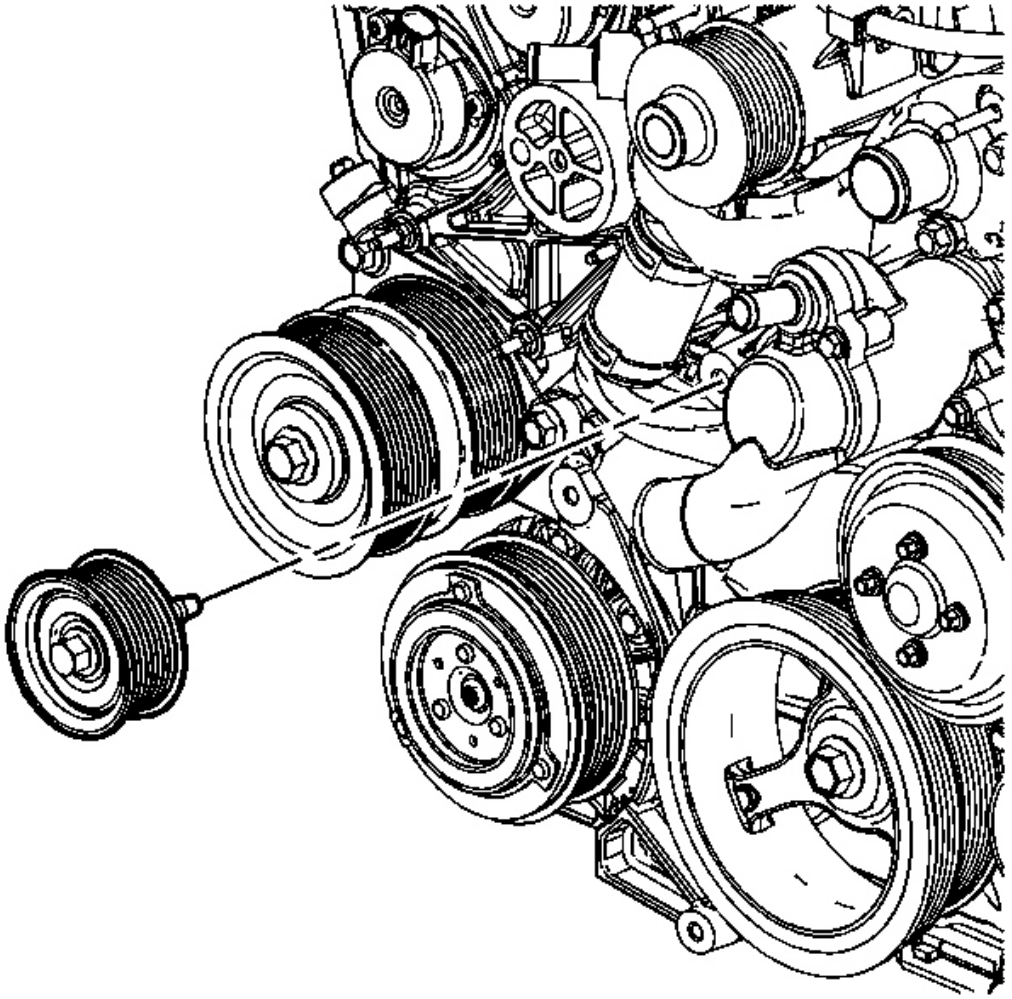


Fig. 45: Identifying Supercharger Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Install the supercharger drive belt idler pulley.

   NOTE: Refer to Fastener Notice .

2. Tighten the supercharger drive belt idler pulley bolt.

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Tighten: Tighten the supercharger drive belt idler pulley bolt to 50 N.m (37 lb ft).

DRIVE BELT TENSIONER INSTALLATION

GENERATOR AND WATER PUMP

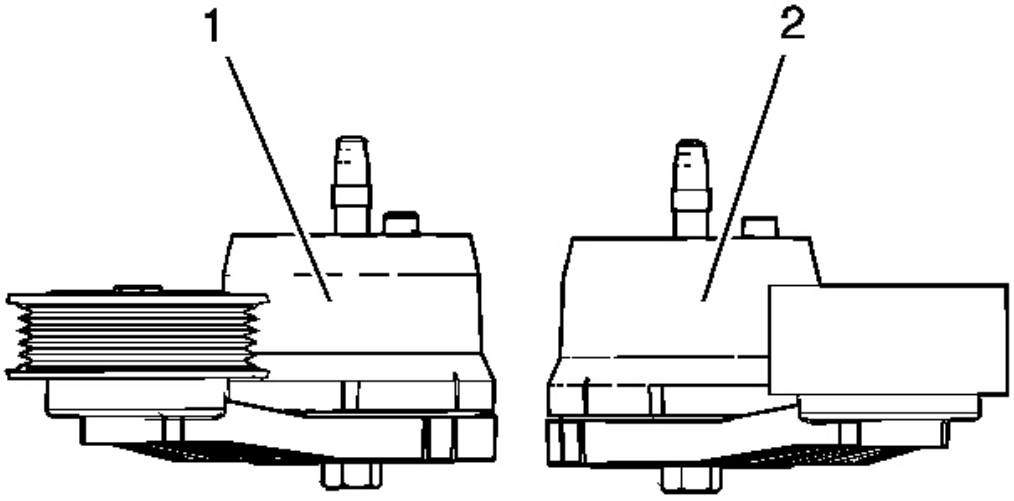


Fig. 46: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Select the generator drive belt tensioner (1).

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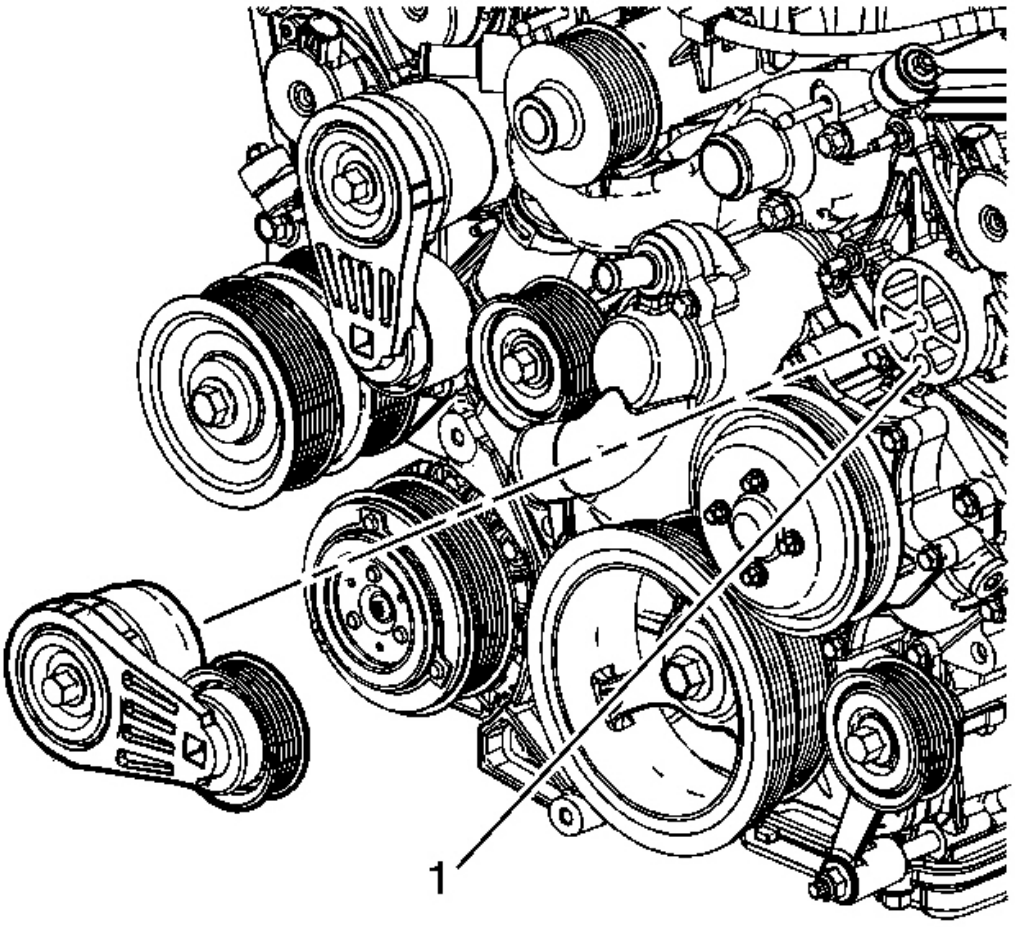


Fig. 47: Identifying Generator Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

2. Place the generator drive belt tensioner in position to the left camshaft position actuator housing. Ensure to properly locate the generator drive belt tensioner anchor pin in the recess (1) in the left camshaft position actuator housing.

NOTE: **Refer to Fastener Notice .**

3. Install the generator drive belt tensioner bolt.

Tighten: Tighten the generator drive belt tensioner bolt to 50 N.m (37 lb ft).

A/C COMPRESSOR AND POWER STEERING PUMP

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Refer to the A/C Compressor and Power Steering Pump Drive Belt Installation in **Drive Belt Installation**.

SUPERCHARGER

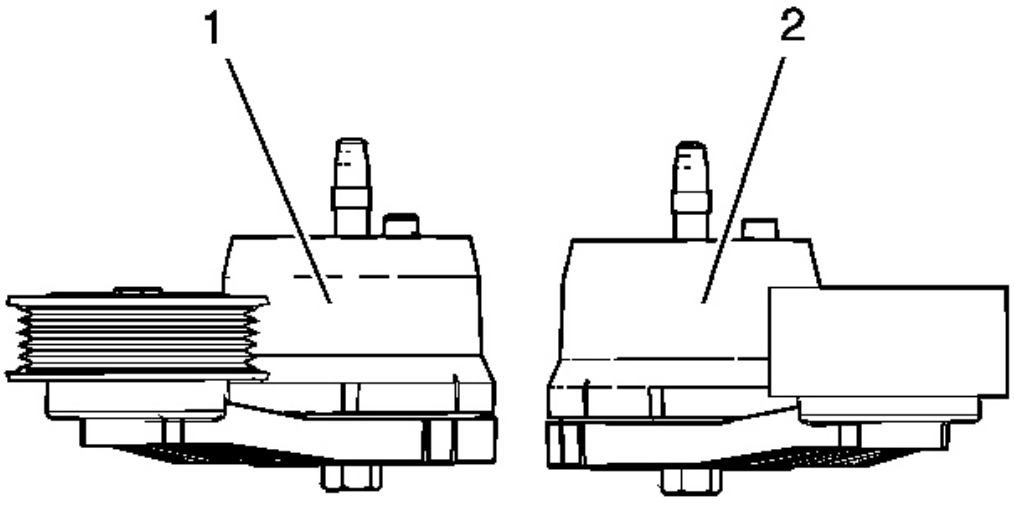


Fig. 48: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Select the supercharger drive belt tensioner (2).

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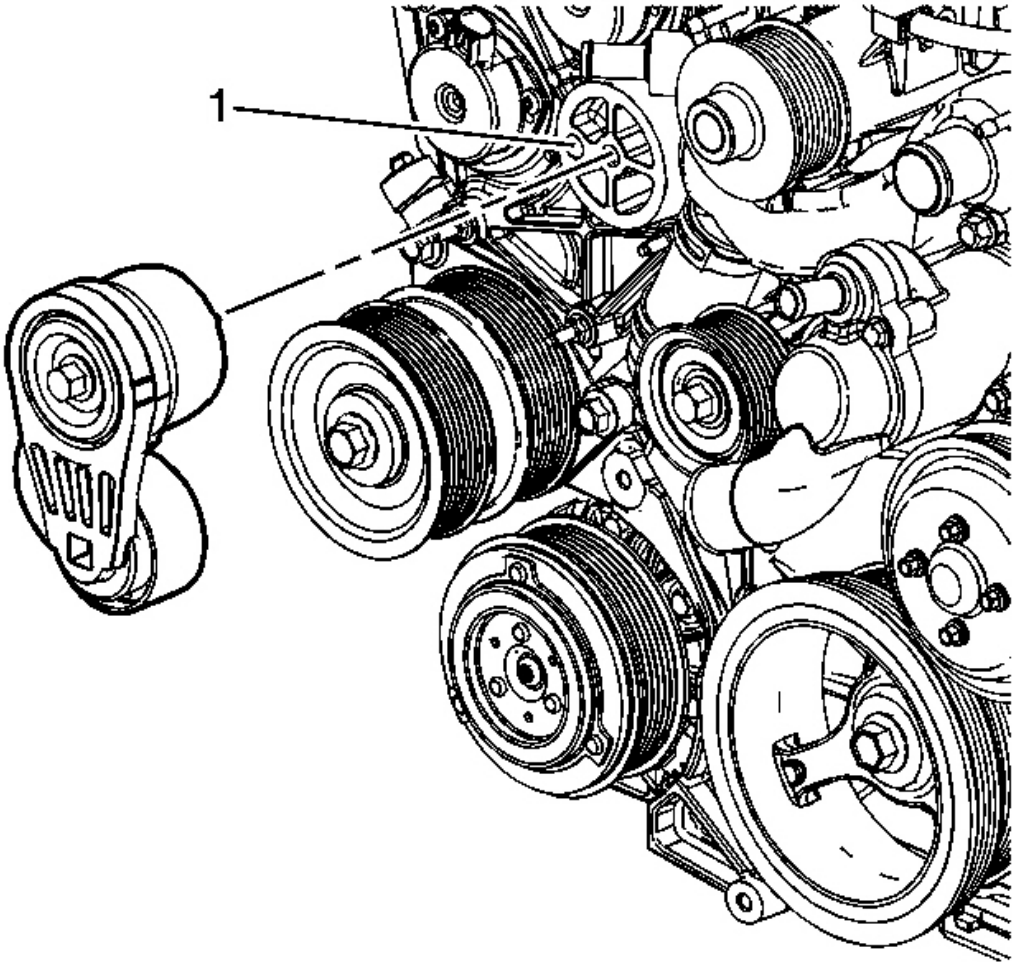


Fig. 49: Identifying Supercharger Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

2. Place the supercharger drive belt tensioner in position to the right camshaft position actuator housing. Ensure to properly locate the supercharger drive belt tensioner anchor pin in the recess (1) in the right camshaft position actuator housing.
3. Install the supercharger drive belt tensioner bolt.

Tighten: Tighten the supercharger drive belt tensioner bolt to 50 N.m (37 lb ft).

DRIVE BELT INSTALLATION

A/C COMPRESSOR AND POWER STEERING PUMP

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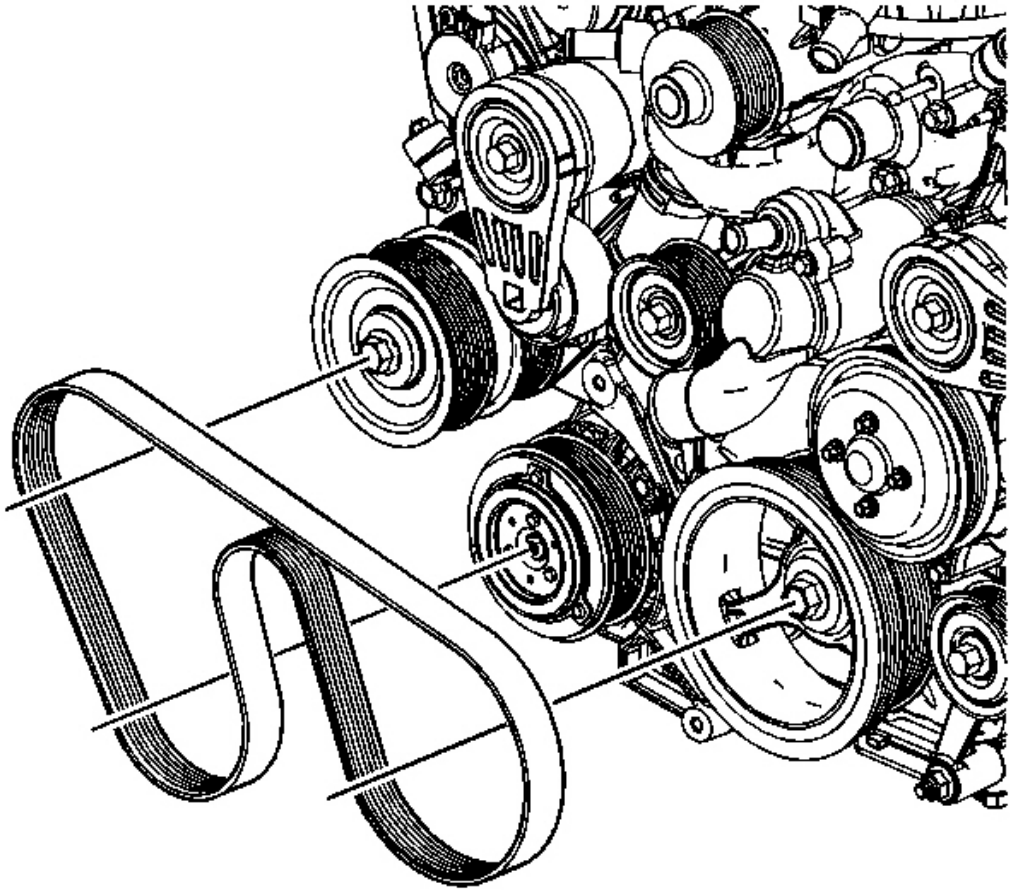


Fig. 50: View Of A/C Compressor & Power Steering Pump Drive Belt
Courtesy of GENERAL MOTORS CORP.

1. Install the A/C compressor and power steering pump drive belt around the crankshaft balancer inner pulley and the power steering pump inner pulley.

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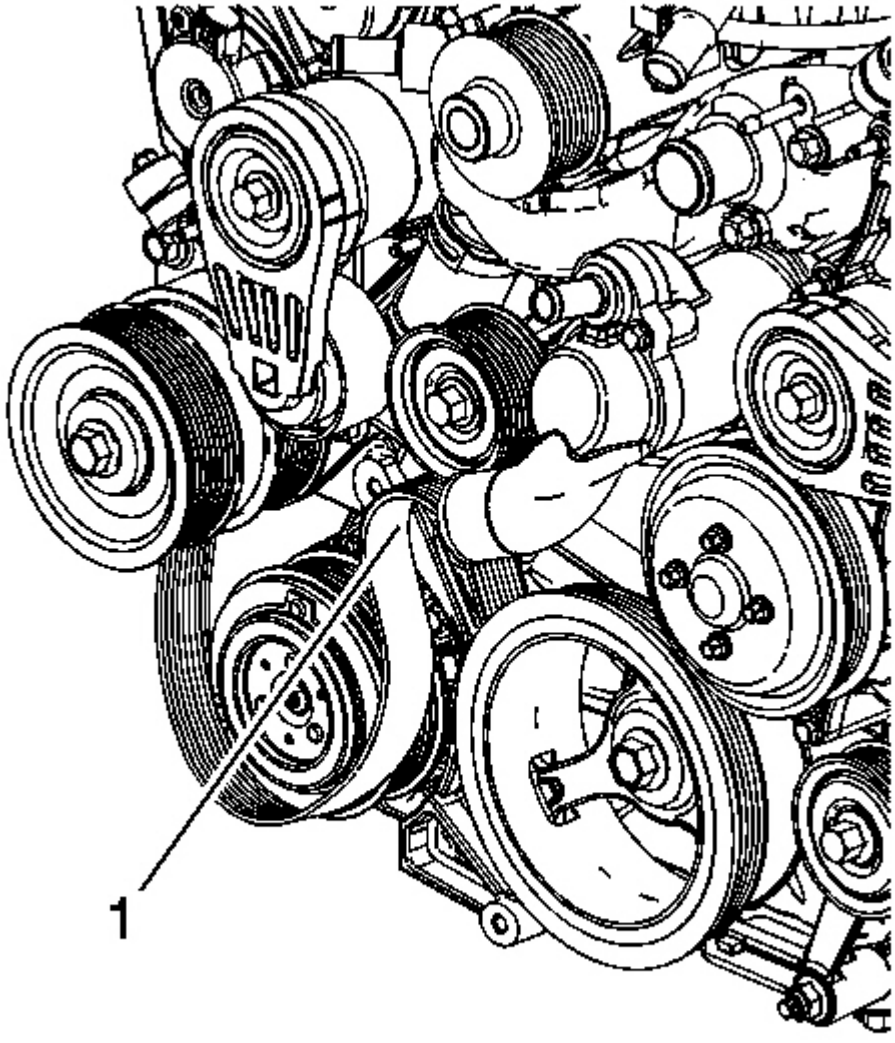


Fig. 51: Identifying A/C Compressor And Power Steering Pump Drive Belt
Courtesy of GENERAL MOTORS CORP.

2. Route the A/C compressor and power steering pump drive belt in front of the A/C compressor in order to create access (1) for the installation of the A/C compressor and power steering pump drive belt tensioner.

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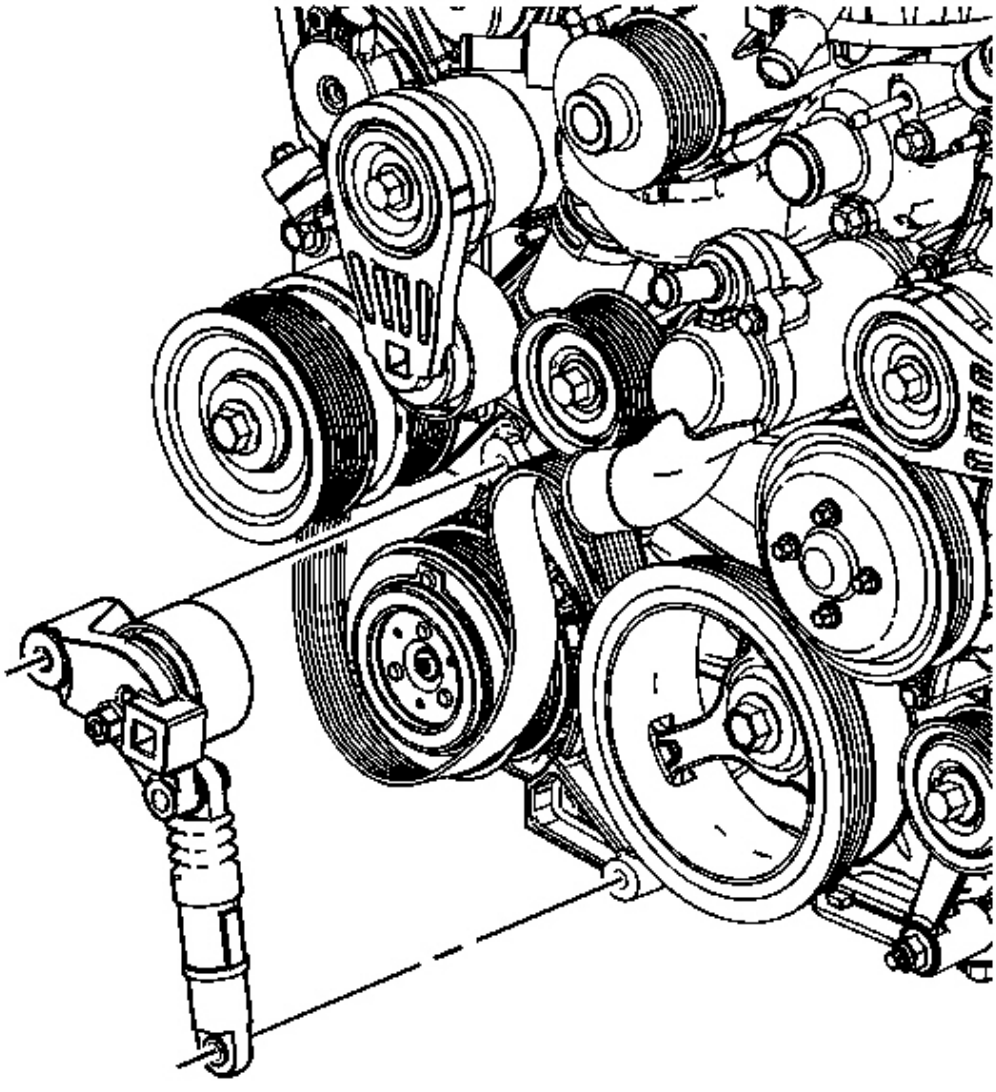


Fig. 52: Identifying A/C Compressor & Power Steering Pump Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Place the A/C compressor and power steering pump drive belt tensioner into position.

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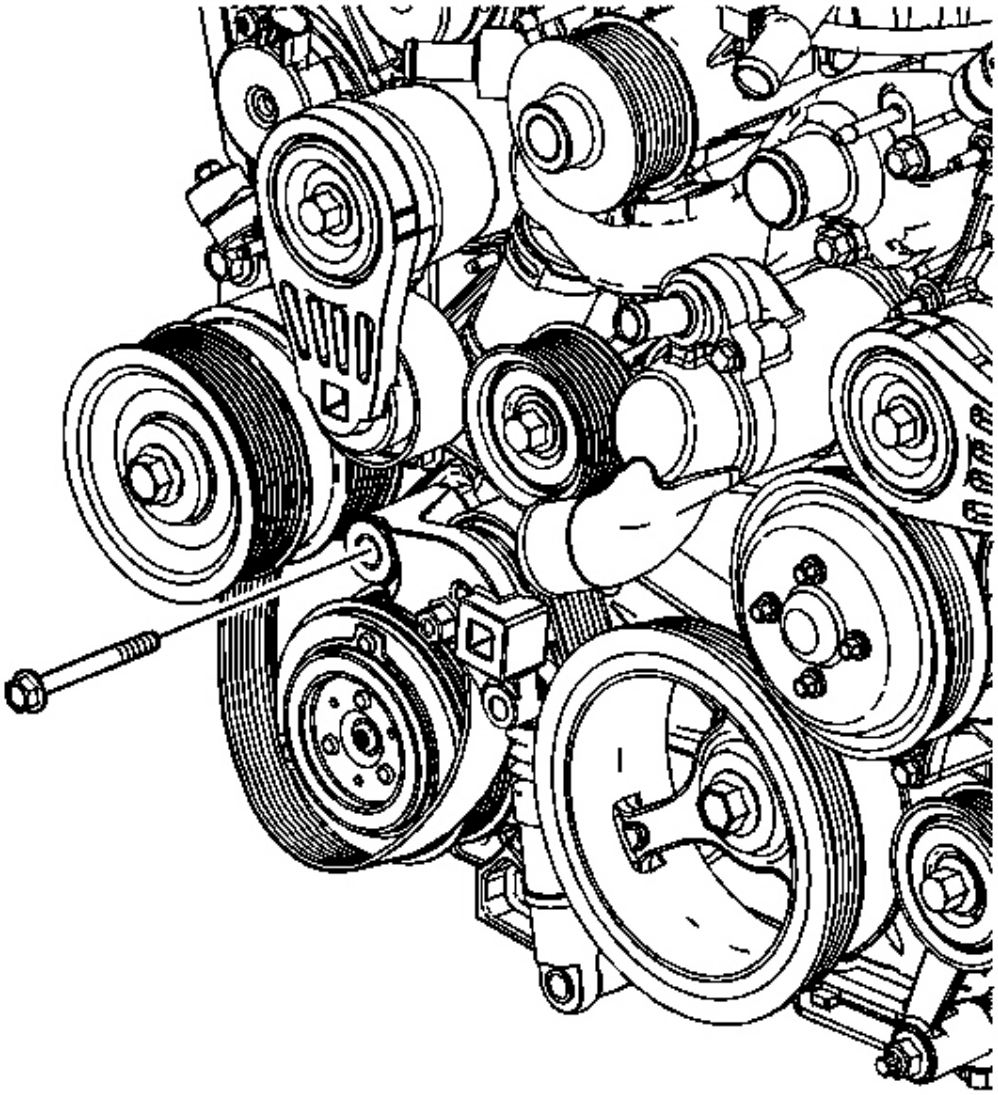


Fig. 53: Identifying A/C Compressor & Power Steering Pump Tensioner Upper Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

4. Loosely install the upper bolt into the A/C compressor and power steering pump drive belt tensioner.

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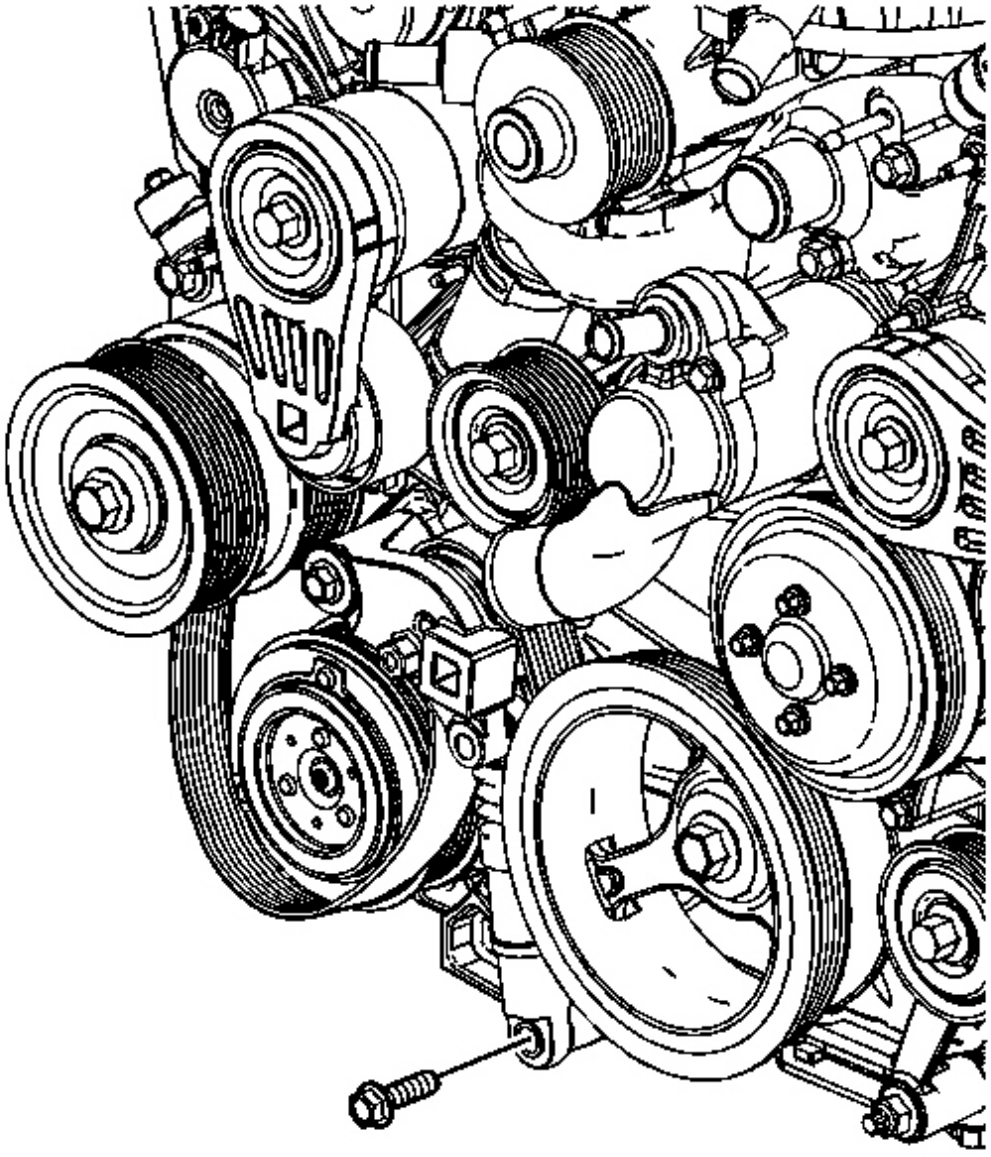


Fig. 54: Identifying A/C Compressor & Power Steering Pump Tensioner Lower Bolt
Courtesy of GENERAL MOTORS CORP.

5. Loosely install the lower bolt into the A/C compressor and power steering pump drive belt tensioner.

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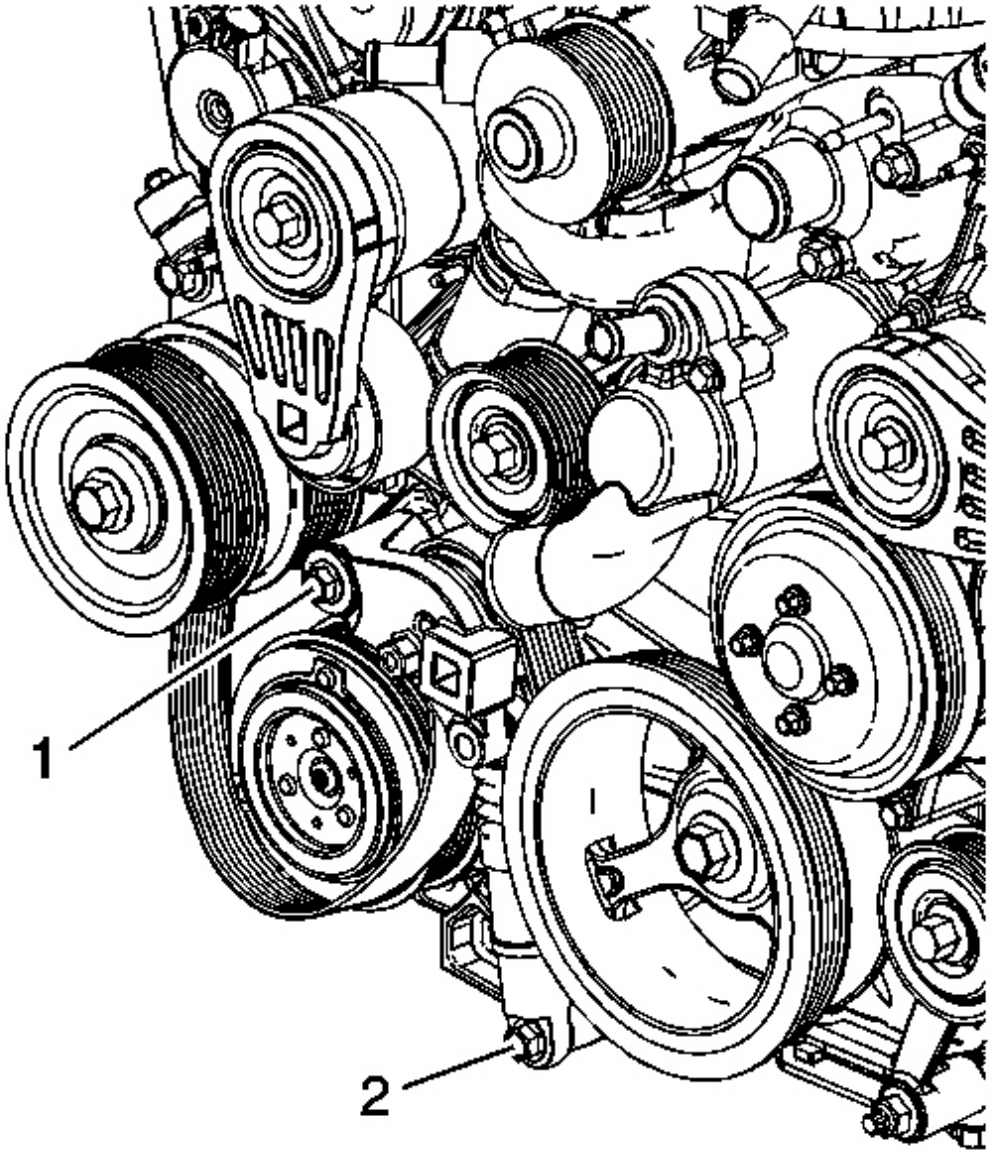


Fig. 55: Identifying A/C Compressor & Power Steering Pump Drive Belt Tensioner Bolt
Courtesy of GENERAL MOTORS CORP.

6. Tighten both A/C compressor and power steering pump drive belt tensioner bolts (1, 2).

   Tighten: Tighten the A/C compressor and power steering pump drive belt tensioner upper (1) and lower (2) bolts to 25 N.m (18 lb ft).

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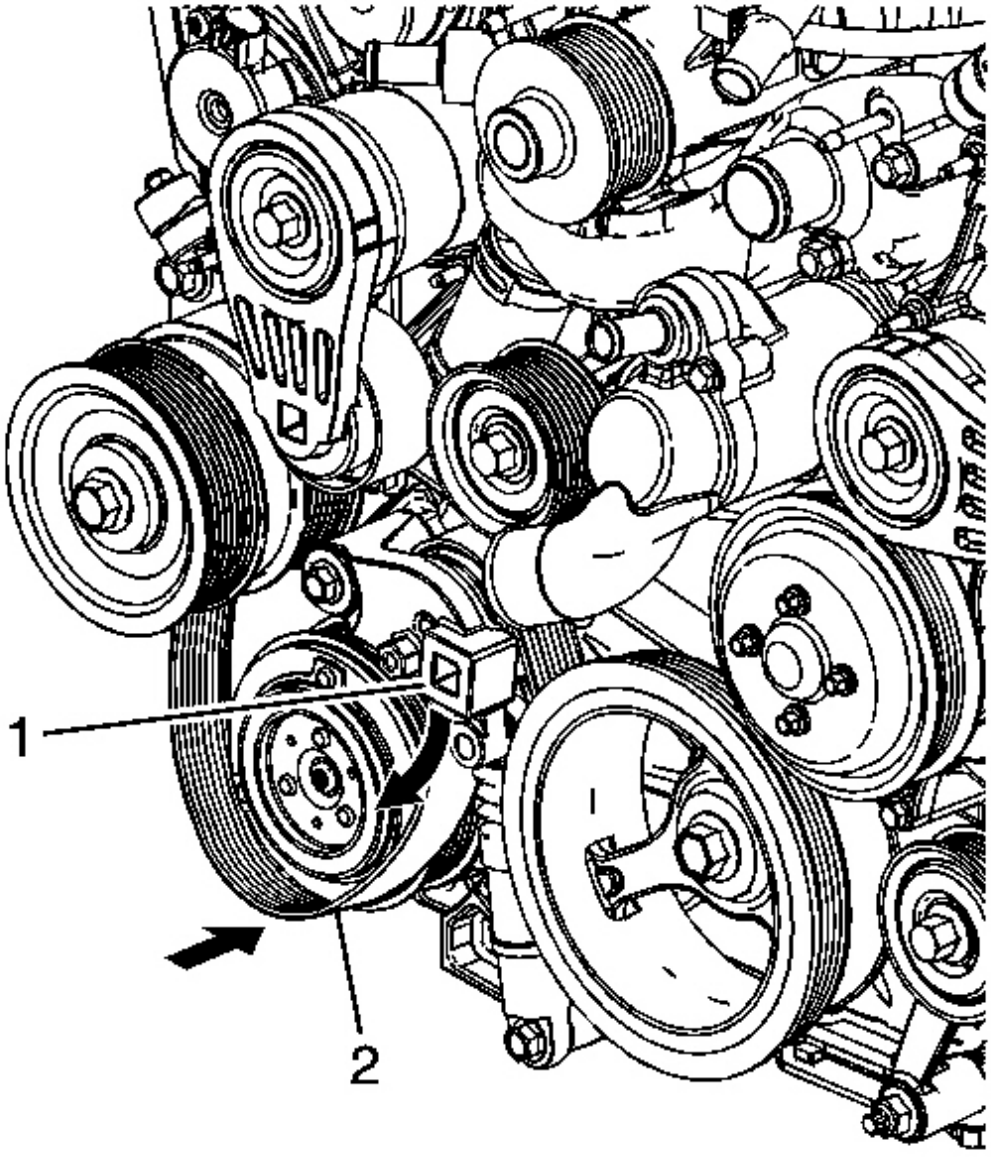


Fig. 56: Locating A/C Compressor And Power Steering Pump Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Insert a 1/2 inch drive breaker bar into the A/C compressor and power steering pump drive belt tensioner.
8. Rotate the breaker bar clockwise (1) in order to allow the installation of the A/C compressor and power steering pump drive belt around the A/C compressor (2).

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9. Ensure the A/C compressor and power steering pump drive belt is properly seated in all the pulleys.
10. Slowly release the A/C compressor and power steering pump drive belt tensioner back to its original position. This will apply tension to the A/C compressor and power steering pump drive belt.
11. Remove the breaker bar.
12. After installation, inspect the A/C compressor and power steering pump drive belt for proper routing and the correct alignment.

GENERATOR AND WATER PUMP

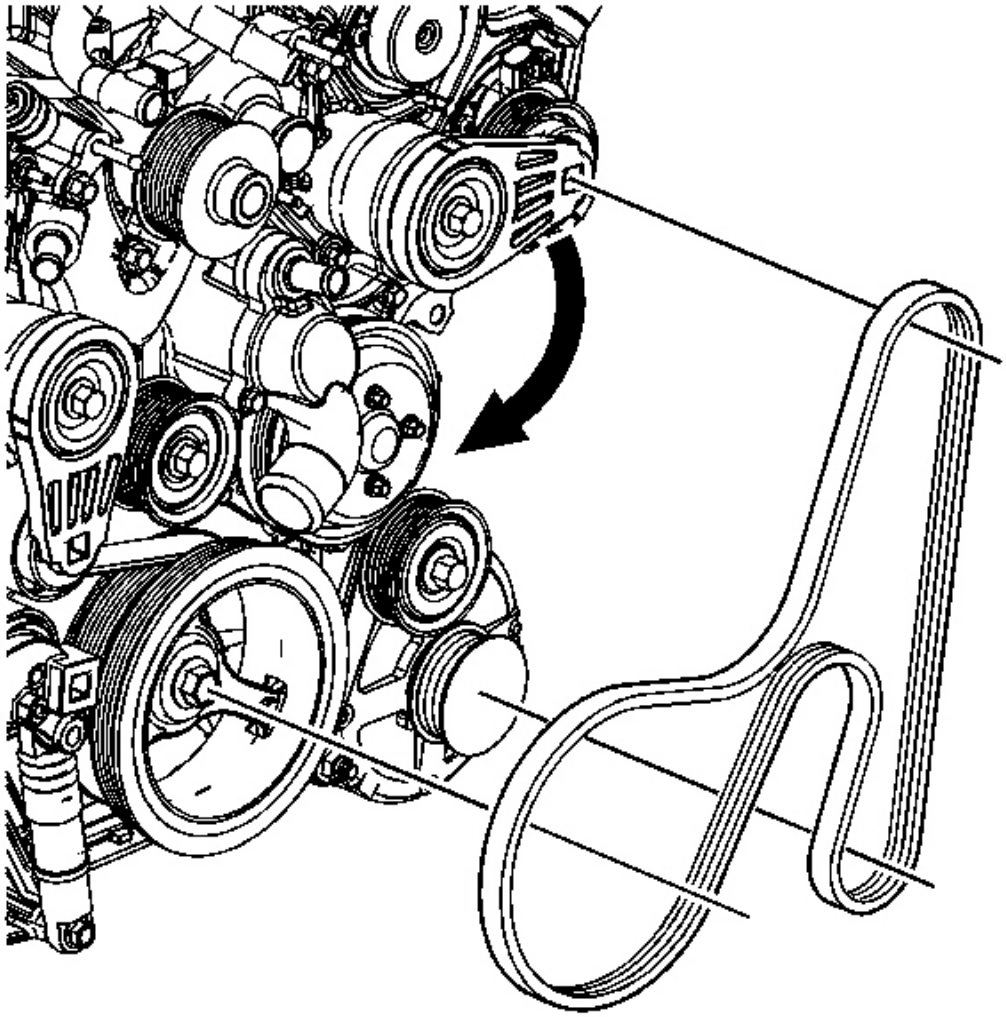


Fig. 57: View Of Generator and Water Pump Drive Belt

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Courtesy of GENERAL MOTORS CORP.

1. Insert a 1/2 inch drive breaker bar into the generator and water pump drive belt tensioner.
2. Rotate the breaker bar clockwise in order to allow the installation of the generator and water pump drive belt.
3. Route the generator and water pump drive belt around the crankshaft balancer outer pulley, the generator and water pump drive belt idler pulley, the generator pulley, the generator and water pump drive belt tensioner pulley and the water pump pulley.
4. Ensure the generator and water pump drive belt is properly seated in all the pulleys.
5. Slowly release the generator and water pump drive belt tensioner back to its original position. This will apply tension to the generator and water pump drive belt.
6. Remove the breaker bar.
7. After installation, inspect the generator and water pump drive belt for proper routing and the correct alignment.

SUPERCHARGER

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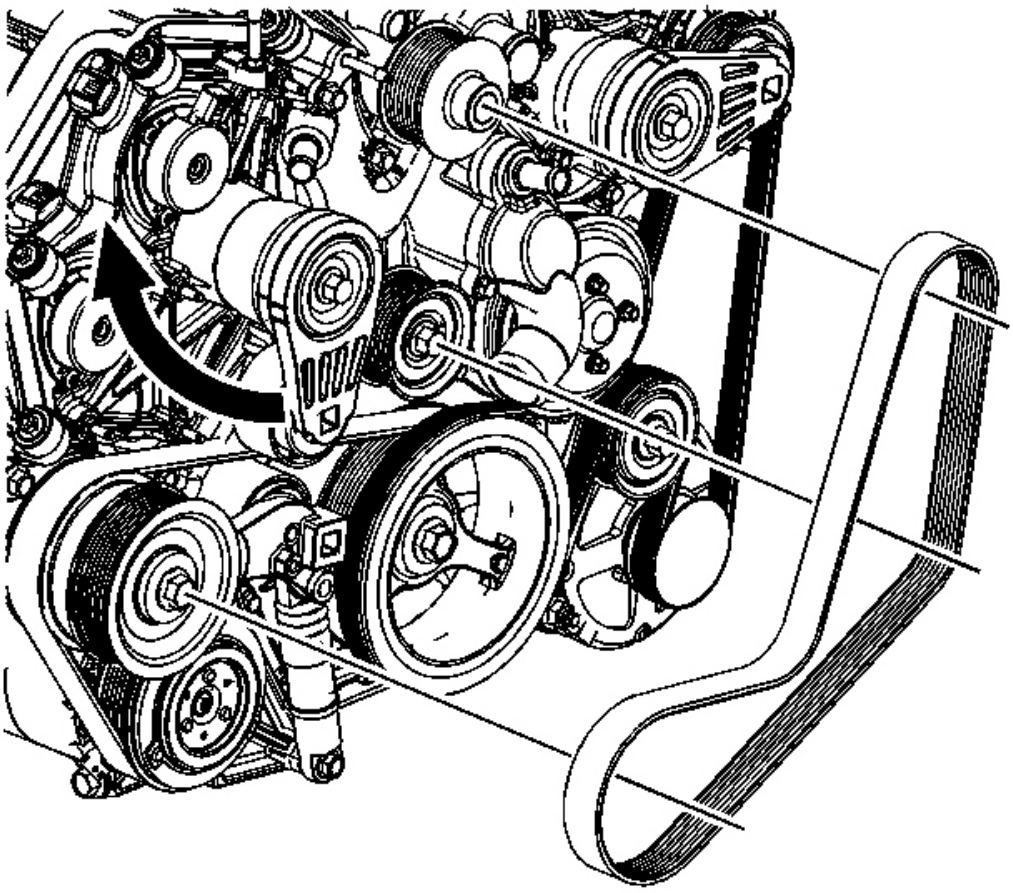


Fig. 58: View Of Supercharger Drive Belt
Courtesy of GENERAL MOTORS CORP.

1. Insert a 1/2 inch drive breaker bar into the supercharger drive belt tensioner.
2. Rotate the breaker bar clockwise in order to allow the installation of the supercharger drive belt.
3. Route the supercharger drive belt around the supercharger pulley, the supercharger drive belt idler pulley, the power steering outer pulley and the supercharger drive belt tensioner pulley.
4. Ensure the supercharger drive belt is properly seated in all the pulleys.
5. Slowly release the supercharger drive belt tensioner back to its original position. This will apply tension to the supercharger drive belt.
6. Remove the breaker bar.
7. After installation, inspect the supercharger drive belt for proper routing and the correct alignment.

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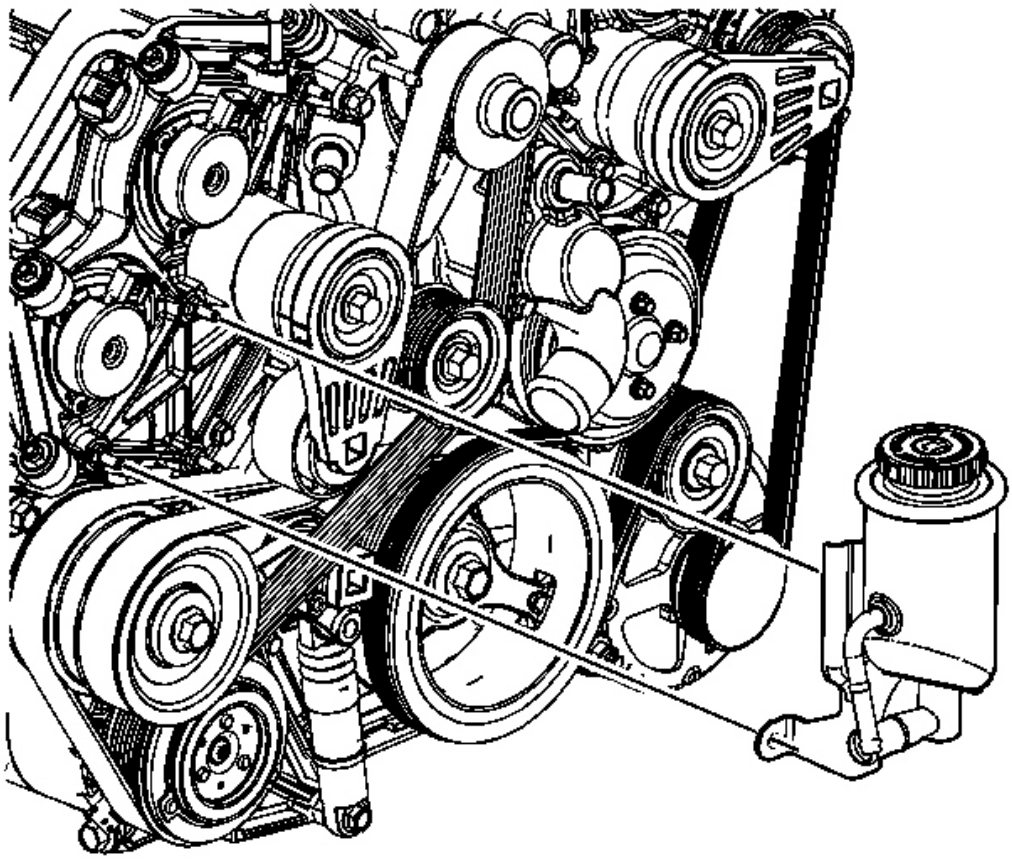


Fig. 59: View Of Power Steering Pump Reservoir
Courtesy of GENERAL MOTORS CORP.

8. Place the power steering pump reservoir into position.

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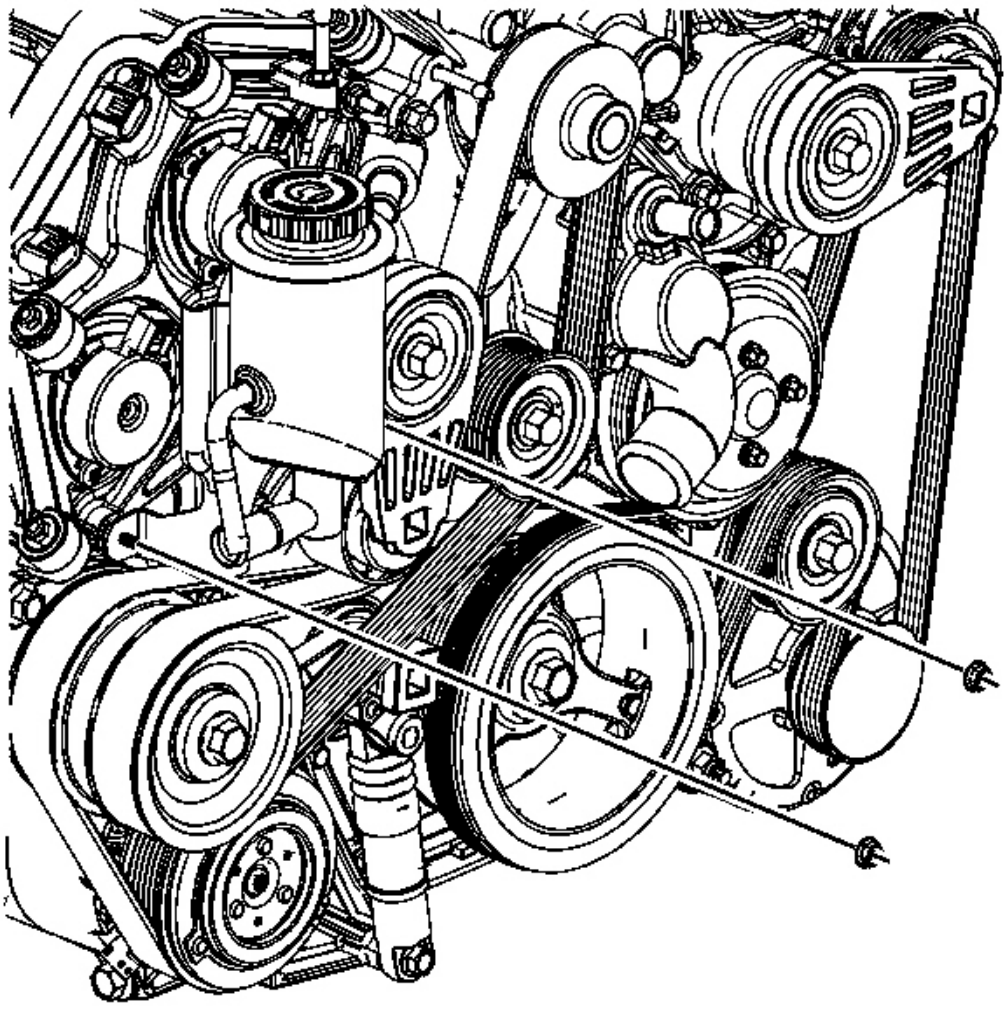


Fig. 60: Identifying Power Steering Pump Reservoir Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

9. Install the power steering pump reservoir bracket nuts.

   Tighten: Tighten the power steering pump reservoir bracket nut to 10 N.m (89 lb in).

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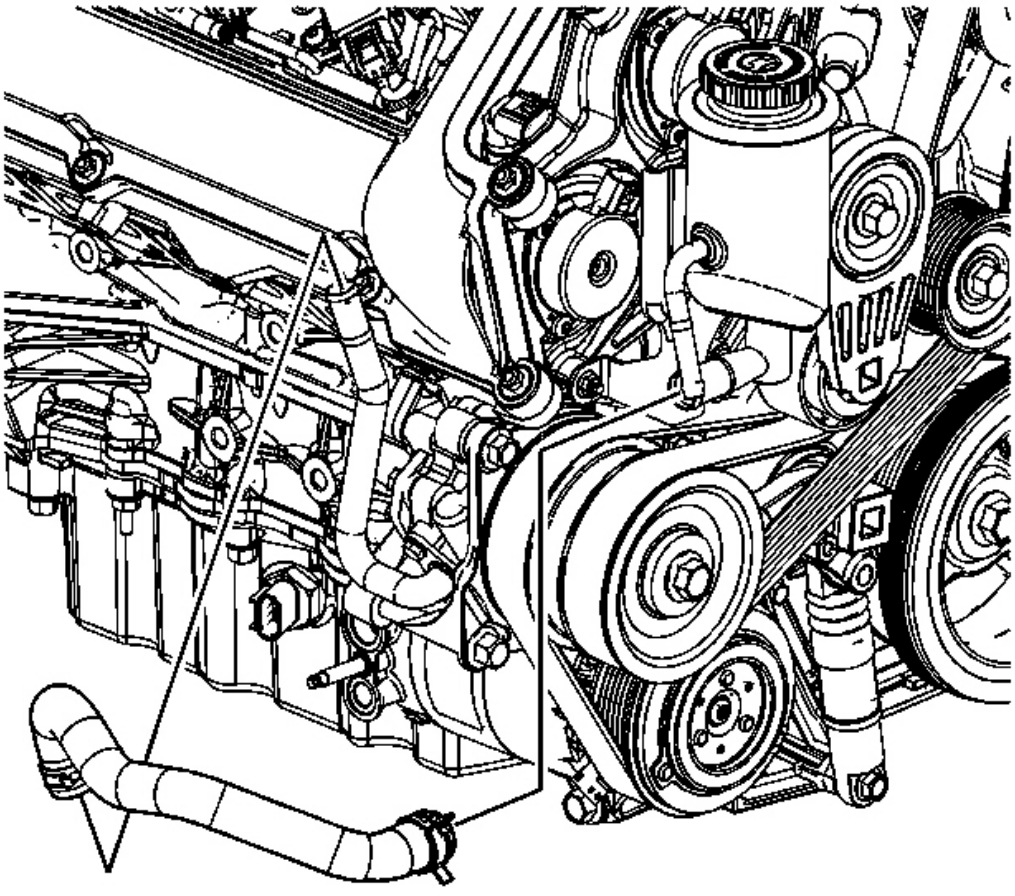


Fig. 61: Identifying Power Steering Pump Reservoir Hose
Courtesy of GENERAL MOTORS CORP.

10. Install the power steering pump reservoir hose.

EXHAUST MANIFOLD INSTALLATION - RIGHT SIDE

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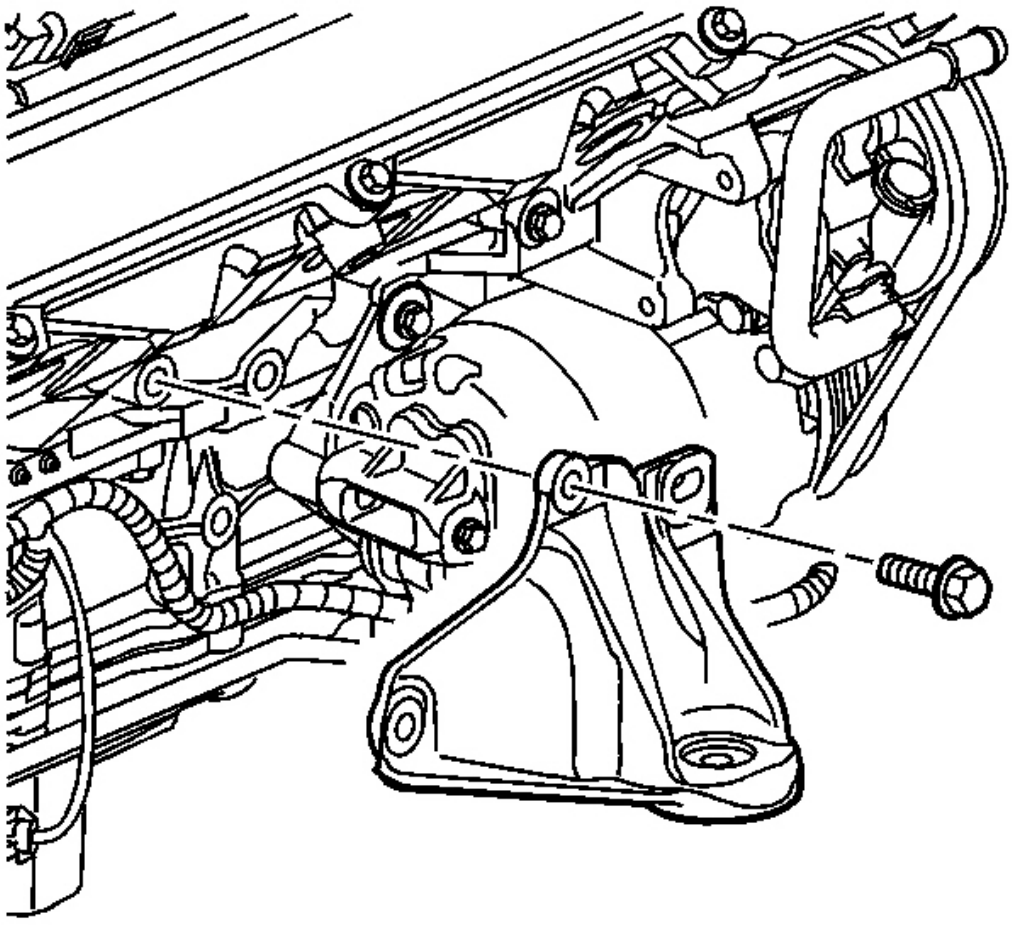


Fig. 62: View Of Right Engine Mount Bracket & Upper Nut
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the right engine mount bracket.
2. Install the right engine mount bracket bolts.

Tighten: Tighten the engine mount bracket bolts to 58 N.m (43 lb ft).

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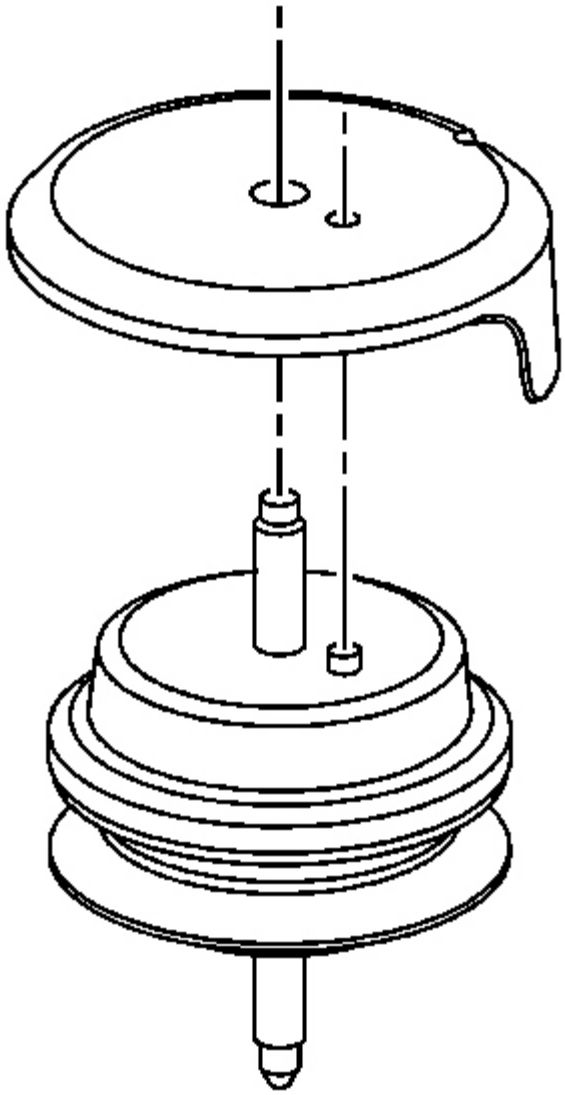


Fig. 63: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount heat shield to the engine mount.

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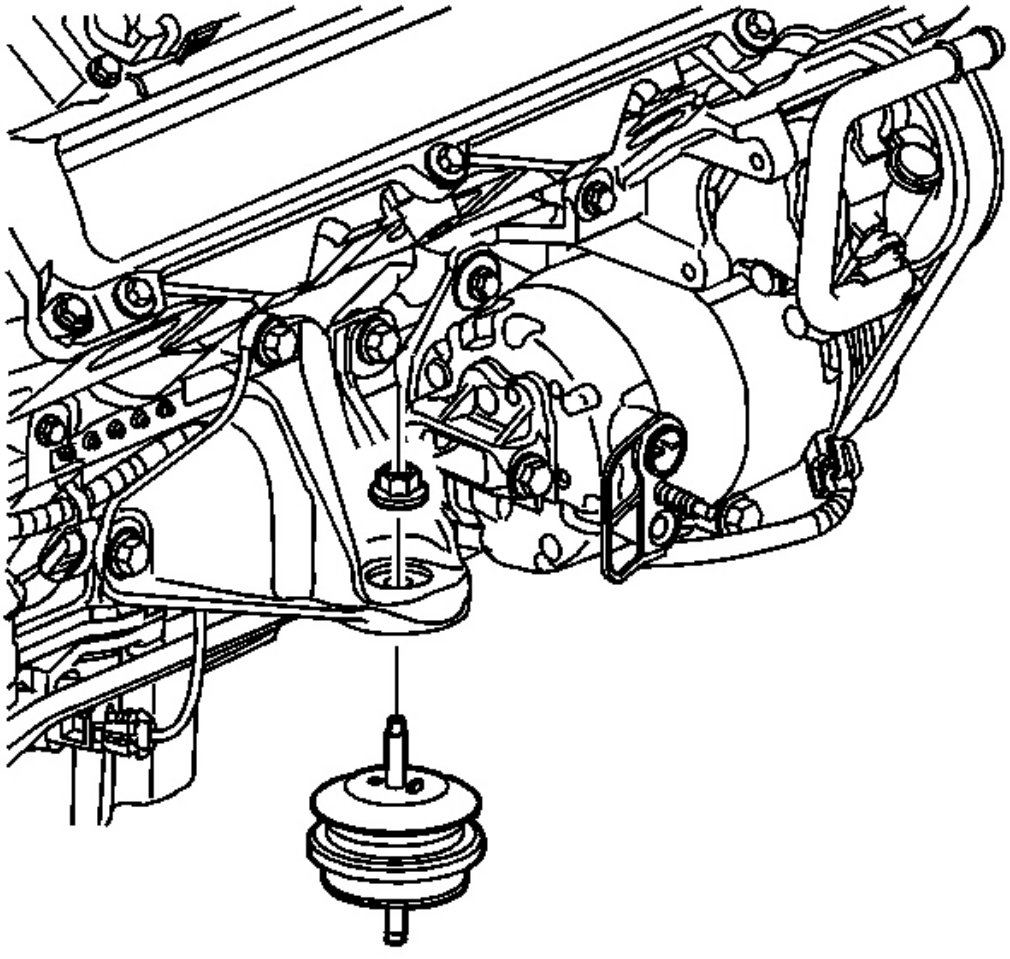


Fig. 64: View Of Right Engine Mount & Upper Nut
Courtesy of GENERAL MOTORS CORP.

4. Install the right engine mount.
5. Install the right engine mount upper nut.

Tighten: Tighten the engine mount upper nut to 58 N.m (43 lb ft).

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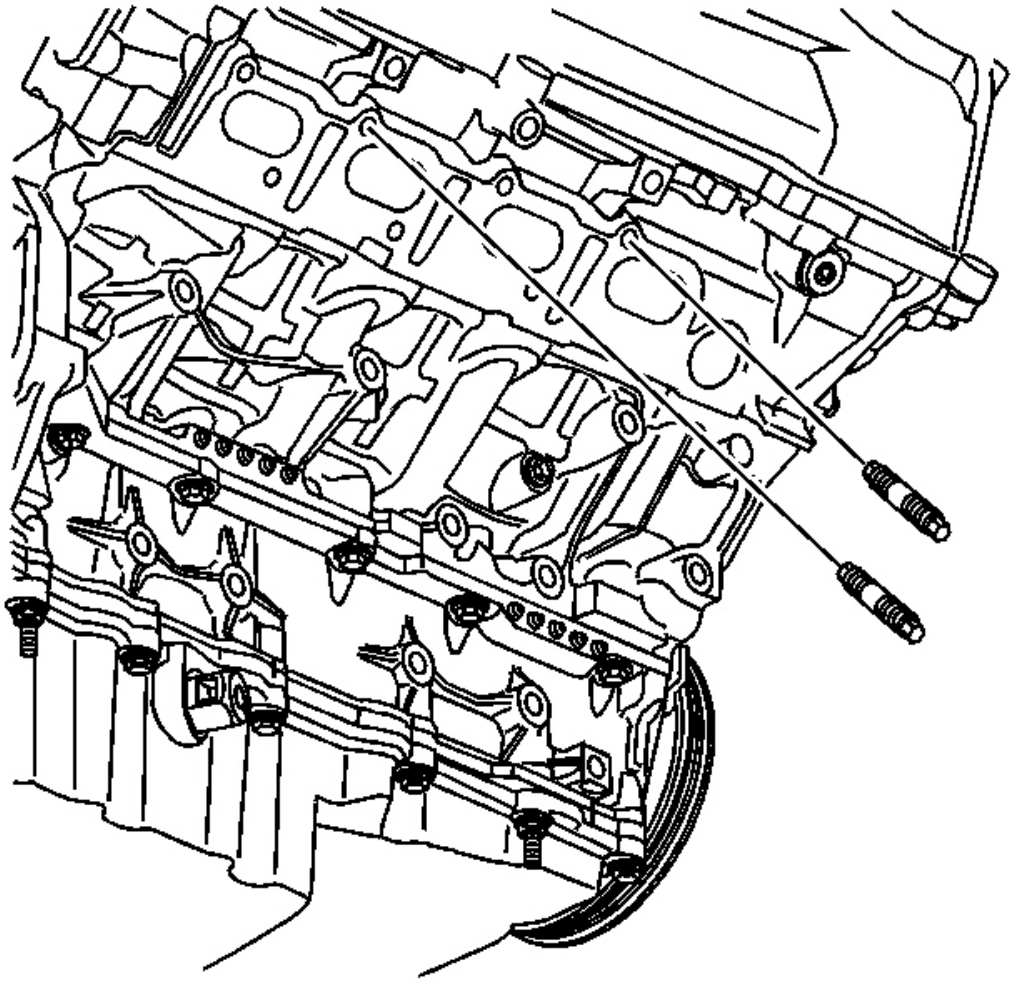


Fig. 65: View Of Right Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

6. Install the right exhaust manifold studs to the right cylinder head.

   Tighten: Tighten the exhaust manifold studs to 6 N.m (53 lb in).

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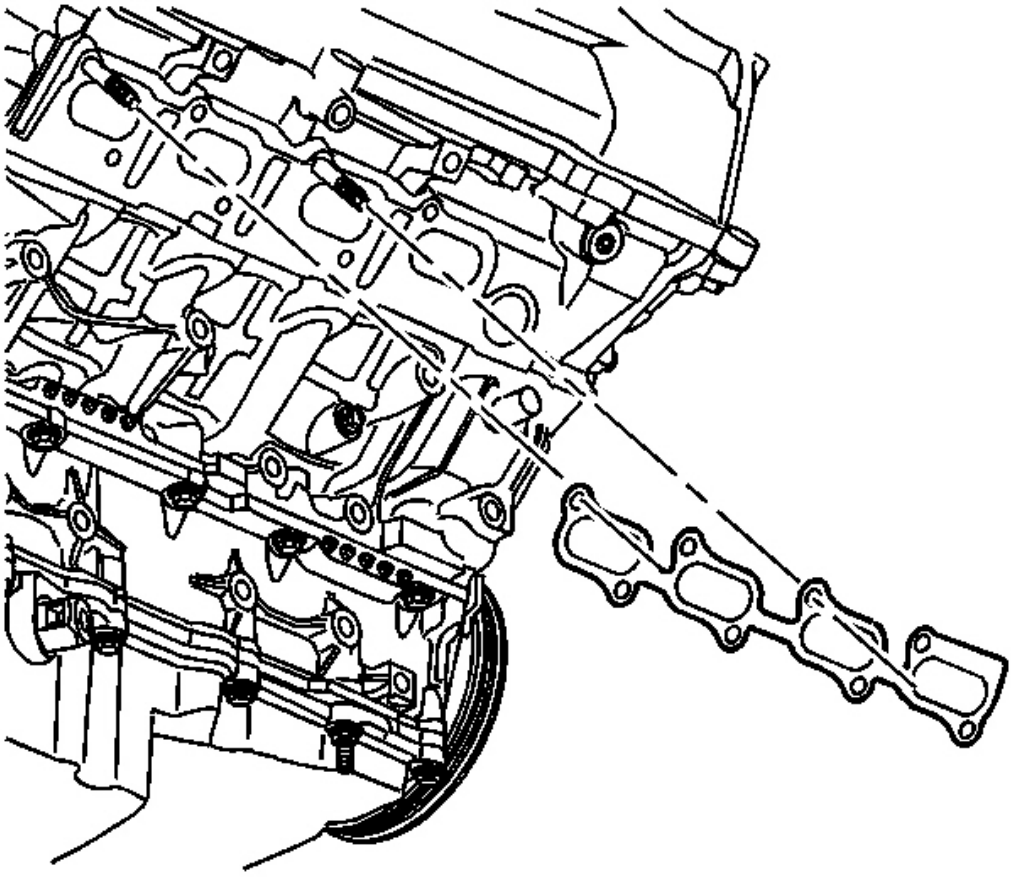


Fig. 66: View Of Right Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW right exhaust manifold gasket.

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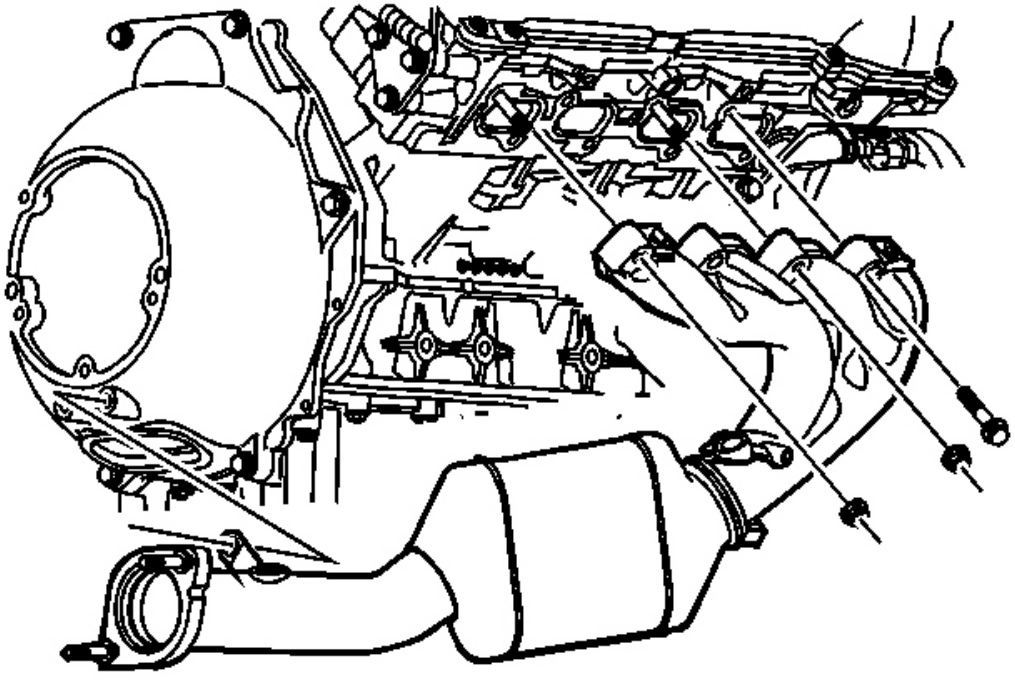


Fig. 67: View Of Right Exhaust Manifold, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

8. Install the right exhaust manifold.
9. Install the right exhaust manifold bolts to the right cylinder head and bell housing.

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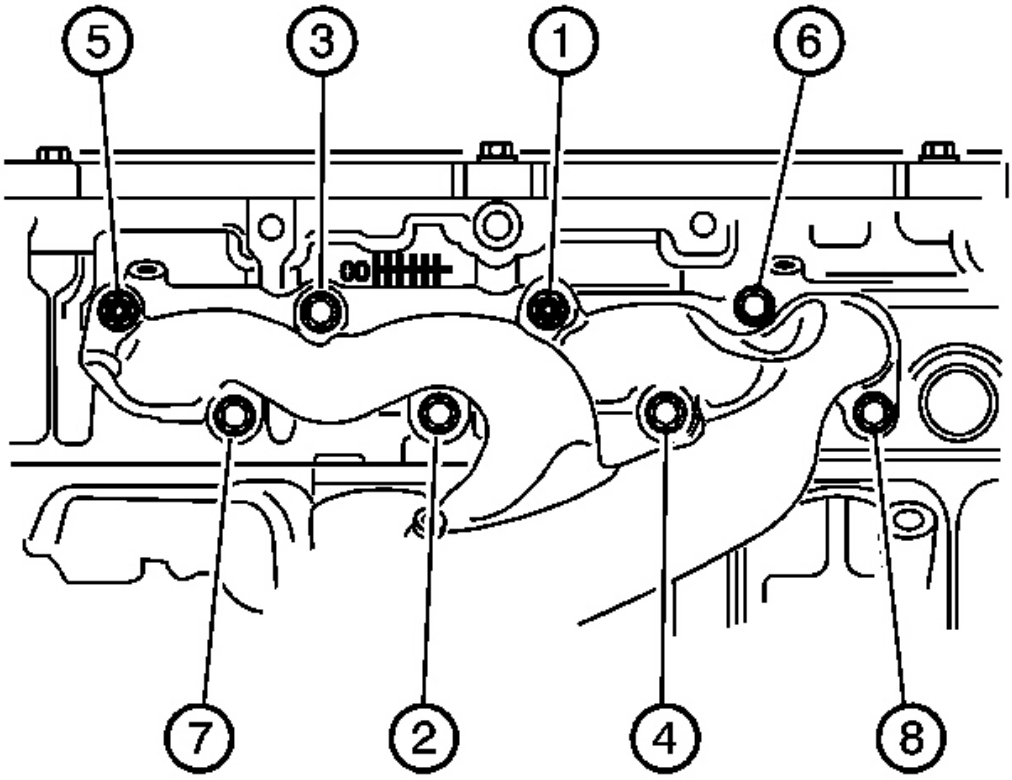


Fig. 68: Tightening Right Exhaust Manifold Bolts & Nuts In Sequence
Courtesy of GENERAL MOTORS CORP.

10. Tighten the exhaust manifold bolts and nuts in the sequence shown.

    Tighten: Tighten the exhaust manifold bolts and nuts to 25 N.m (18 lb ft).

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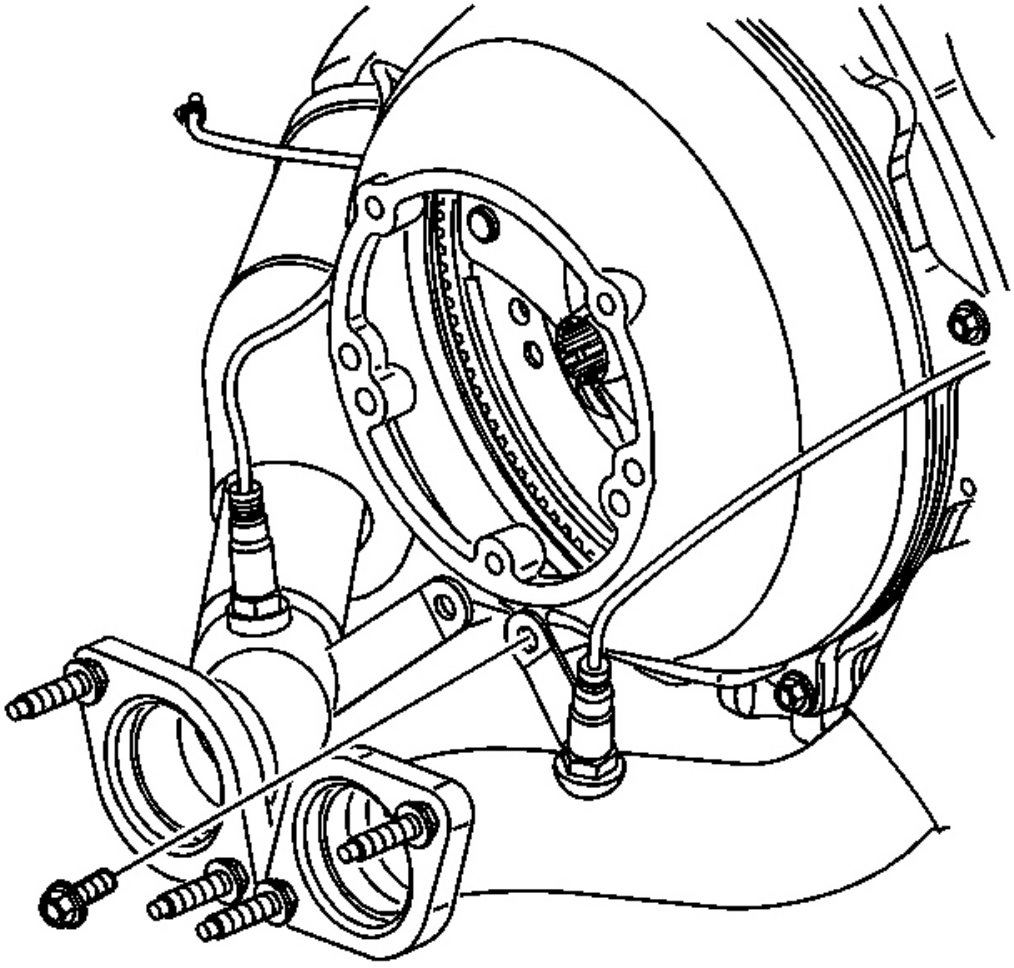


Fig. 69: View Of Right Exhaust Manifold Bolt & Bell Housing
Courtesy of GENERAL MOTORS CORP.

11. Install the right exhaust manifold bolt to the bell housing.

    Tighten: Tighten the right exhaust manifold bolt to 50 N.m (37 lb ft).

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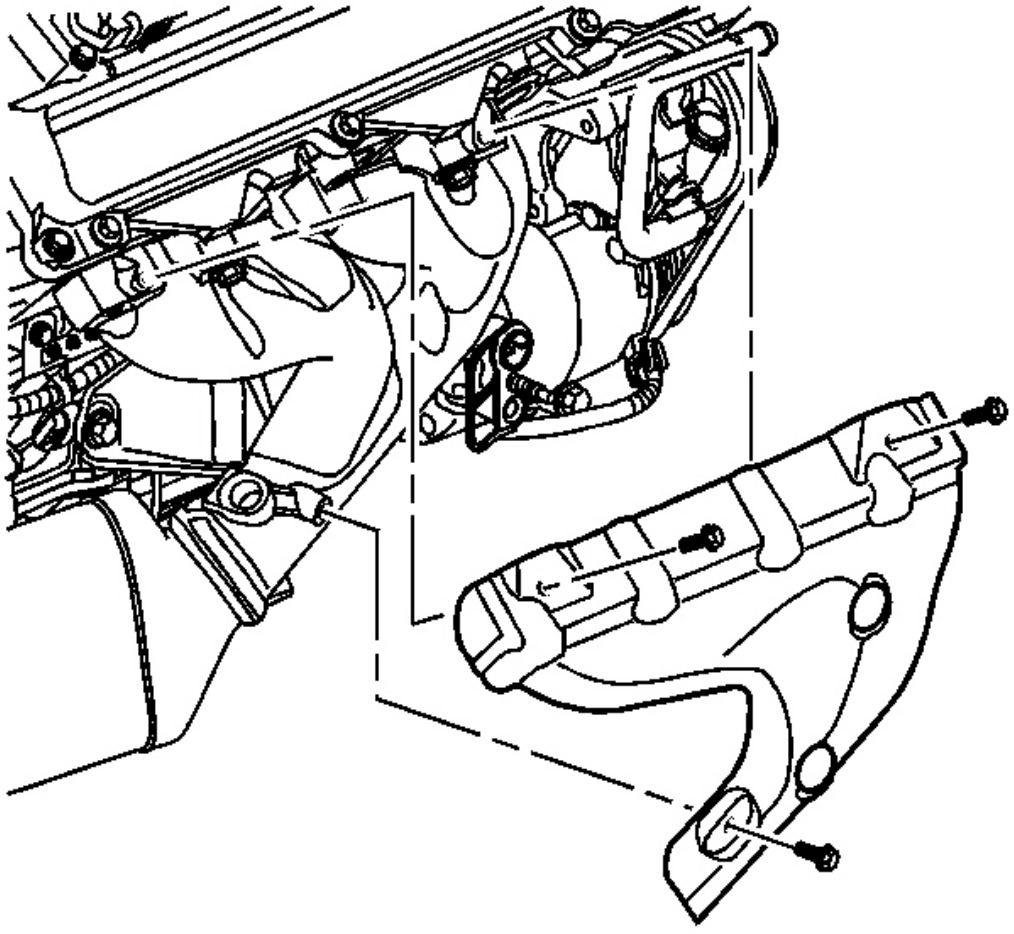


Fig. 70: View Of Right Exhaust Manifold Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the right exhaust manifold heat shield.
13. Install the right exhaust manifold heat shield bolts.

Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

EXHAUST MANIFOLD INSTALLATION - LEFT SIDE

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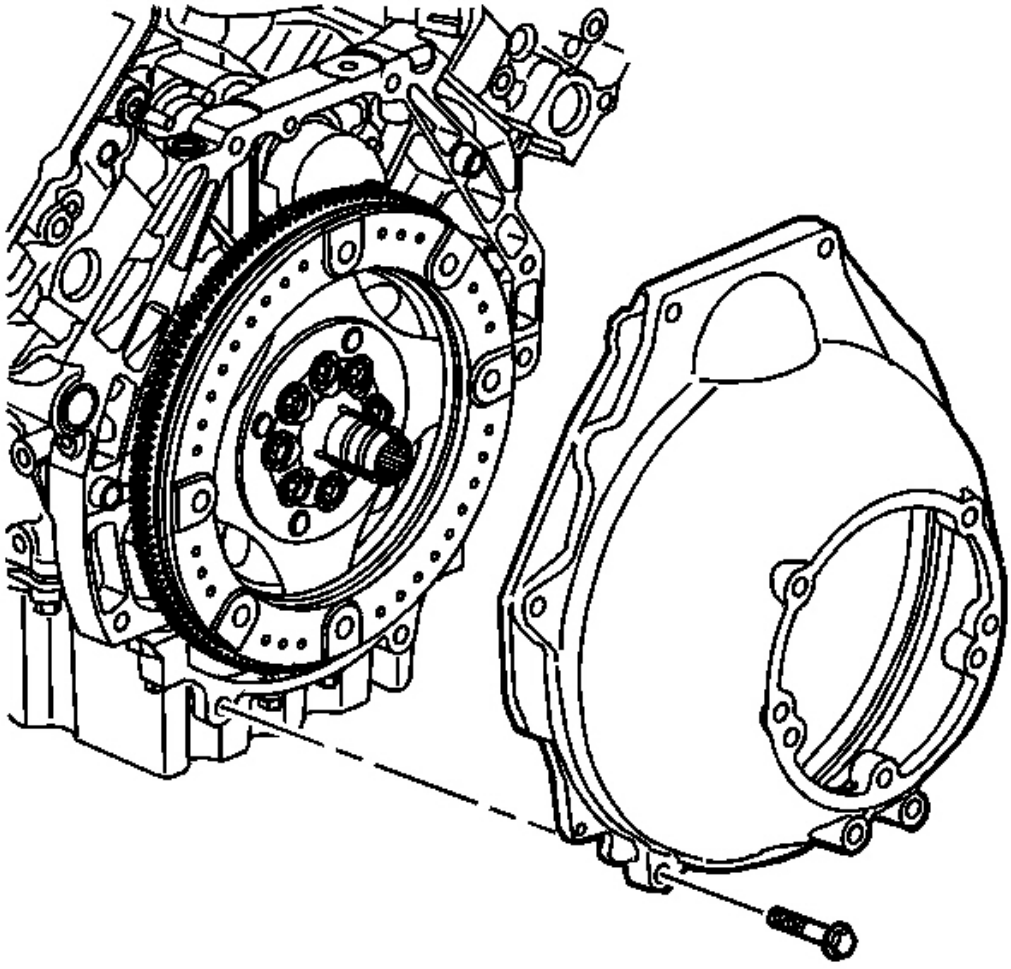


Fig. 71: View Of Bell Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the bell housing.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the bell housing bolts.

   Tighten: Tighten the bell housing bolts to 50 N.m (37 lb ft).

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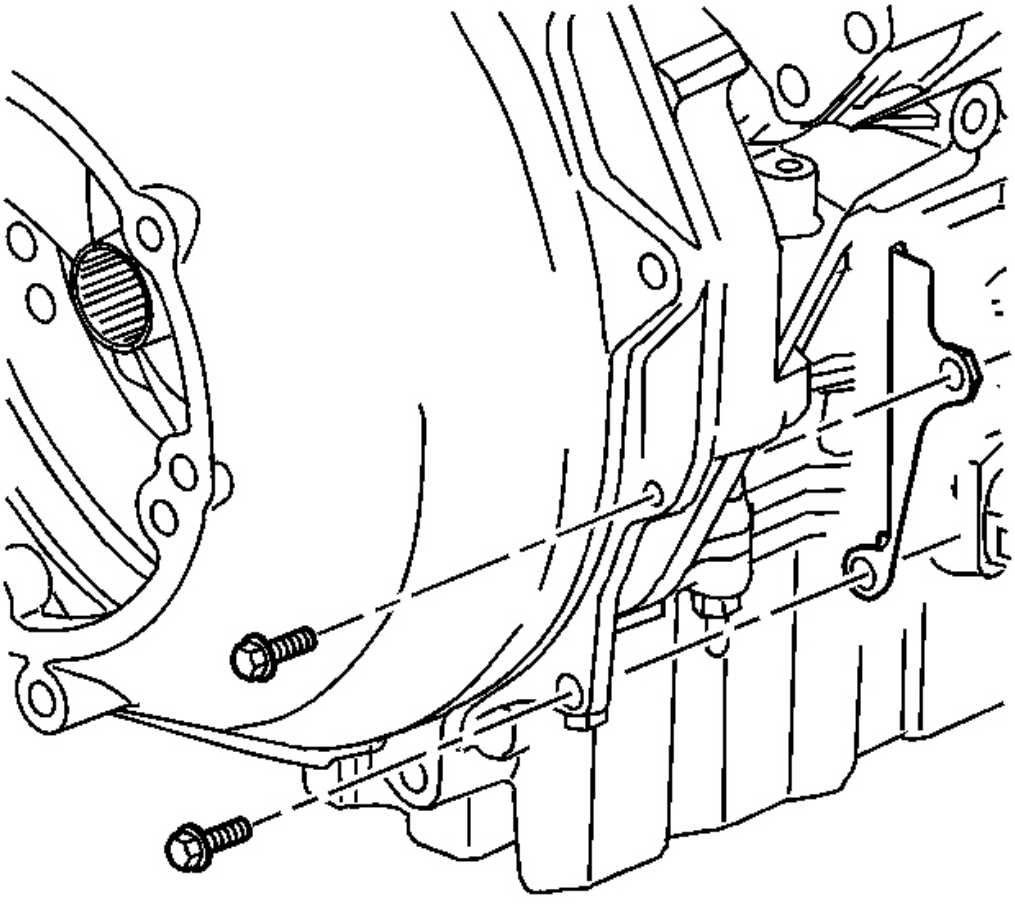


Fig. 72: View Of Right Engine Flywheel Housing Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the right engine flywheel housing cover.
4. Install the right engine flywheel housing cover bolts.

Tighten: Tighten the exhaust manifold studs to 10 N.m (89 lb in).

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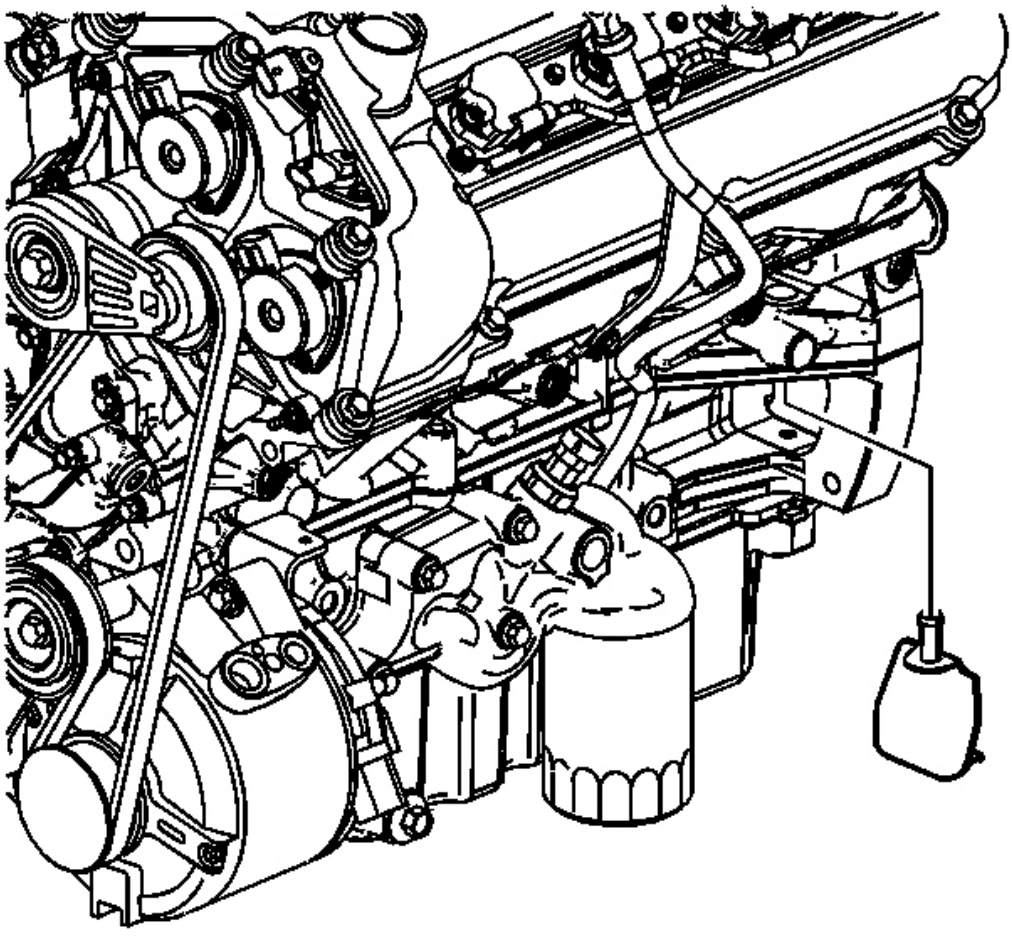


Fig. 73: View Of Left Engine Flywheel Housing Cover
Courtesy of GENERAL MOTORS CORP.

5. Install the left engine flywheel housing cover.

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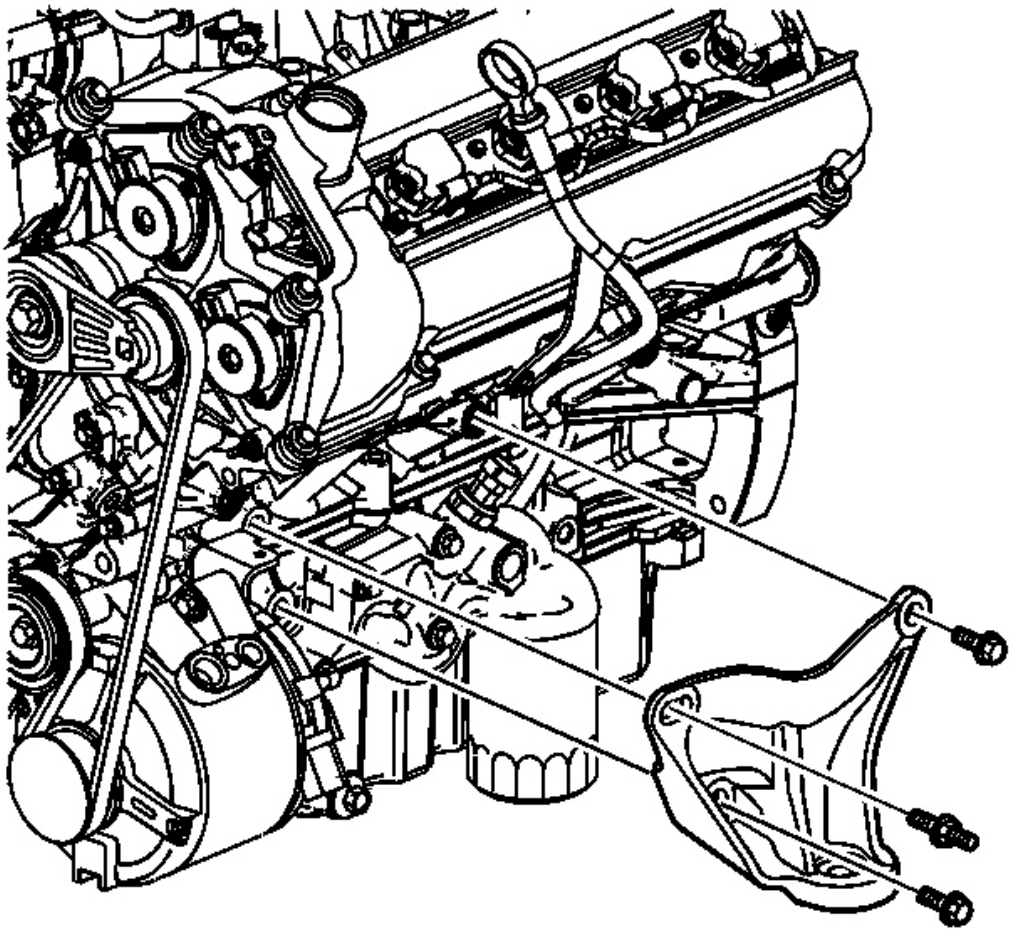


Fig. 74: View Of Left Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the left engine mount bracket.
7. Install the left engine mount bracket bolts.

Tighten: Tighten the engine mount bracket bolts to 58 N.m (43 lb ft).

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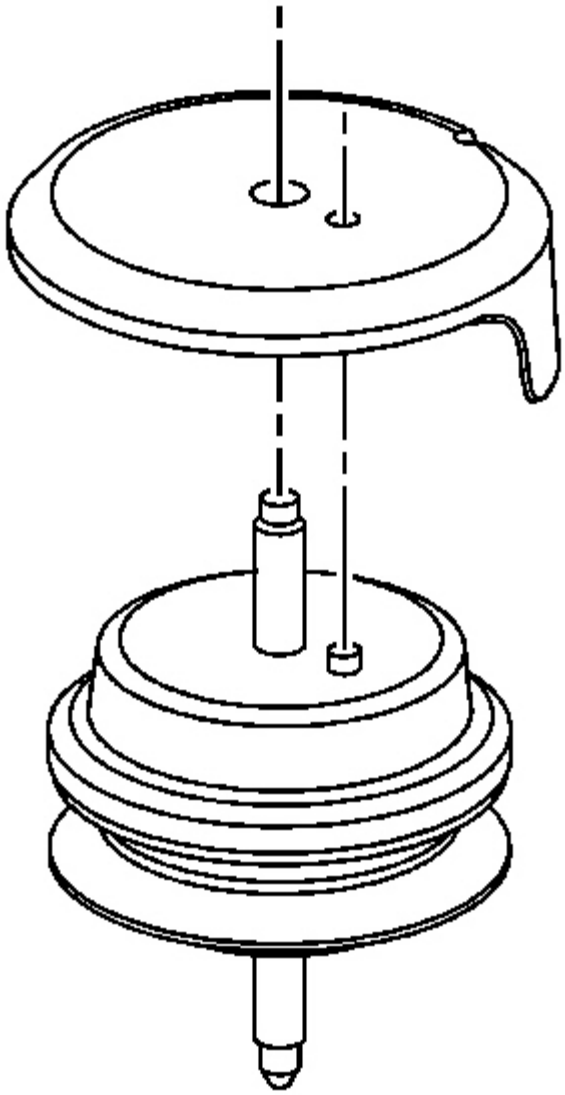


Fig. 75: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

8. Install the engine mount heat shield to the engine mount.

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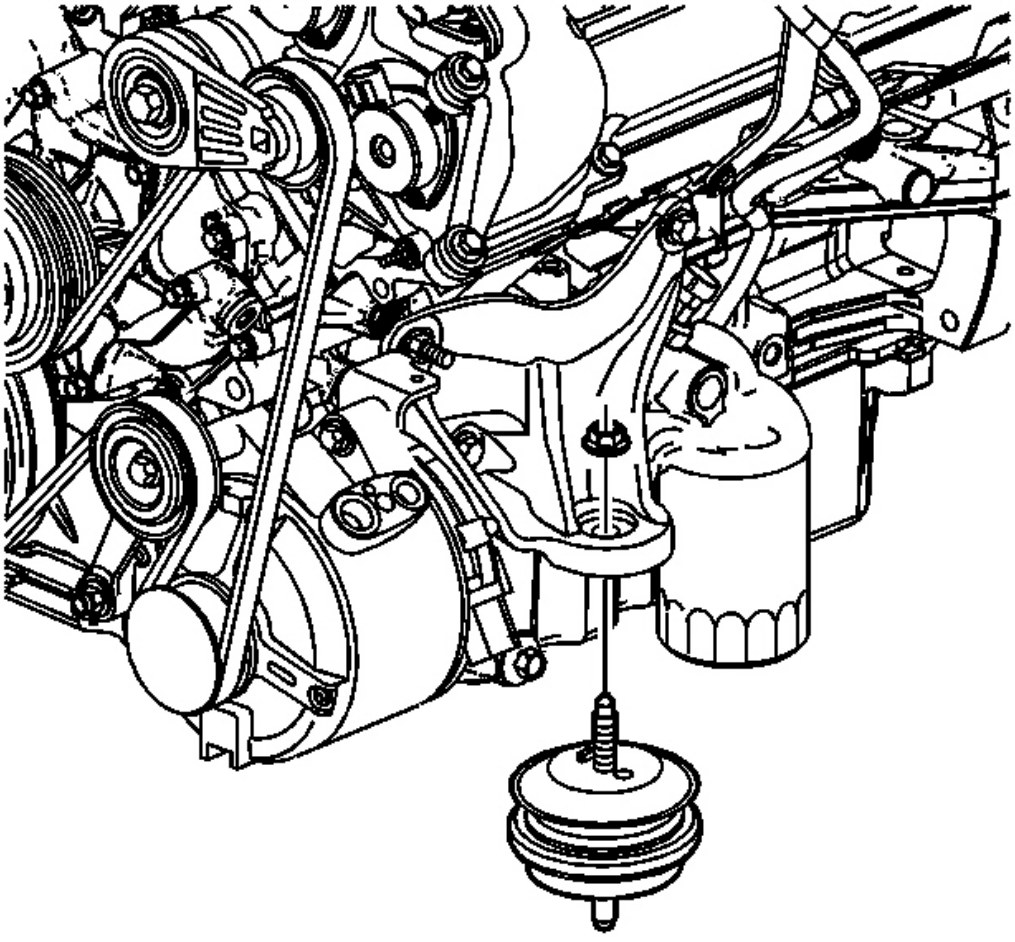


Fig. 76: View Of Left Engine Mount & Upper Nut
Courtesy of GENERAL MOTORS CORP.

9. Install the left engine mount.
10. Install the left engine mount upper nut.

Tighten: Tighten the engine mount upper nut to 58 N.m (43 lb ft).

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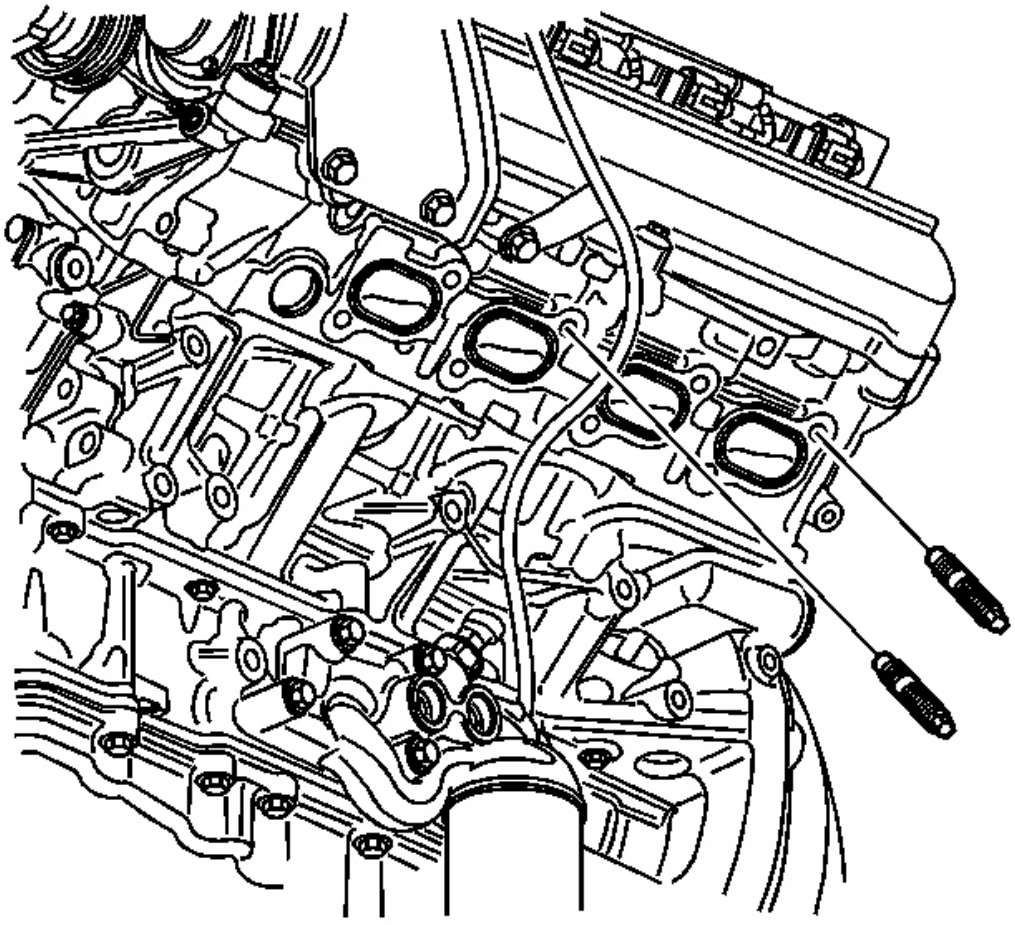


Fig. 77: View Of Left Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

11. Install the left exhaust manifold studs to the left cylinder head.

    Tighten: Tighten the exhaust manifold studs to 6 N.m (53 lb in).

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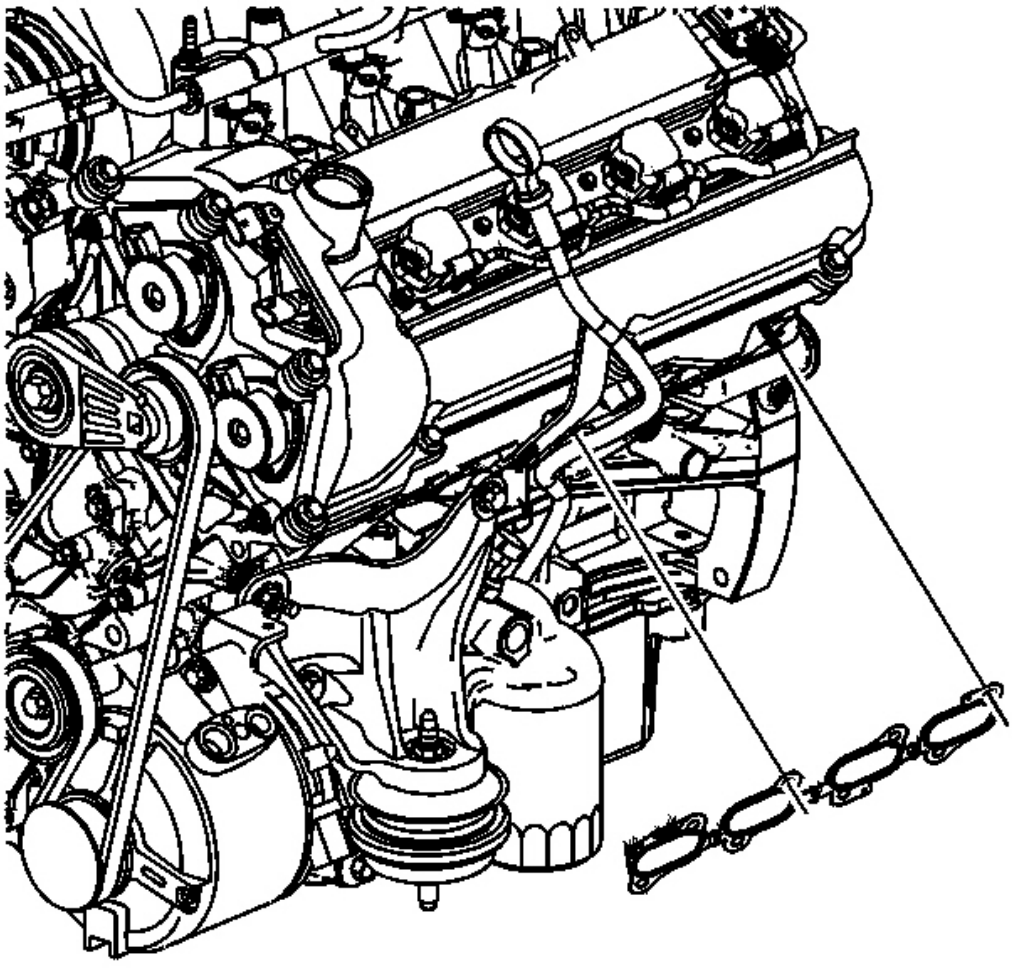


Fig. 78: View Of Left Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

12. Install the NEW left exhaust manifold gasket.

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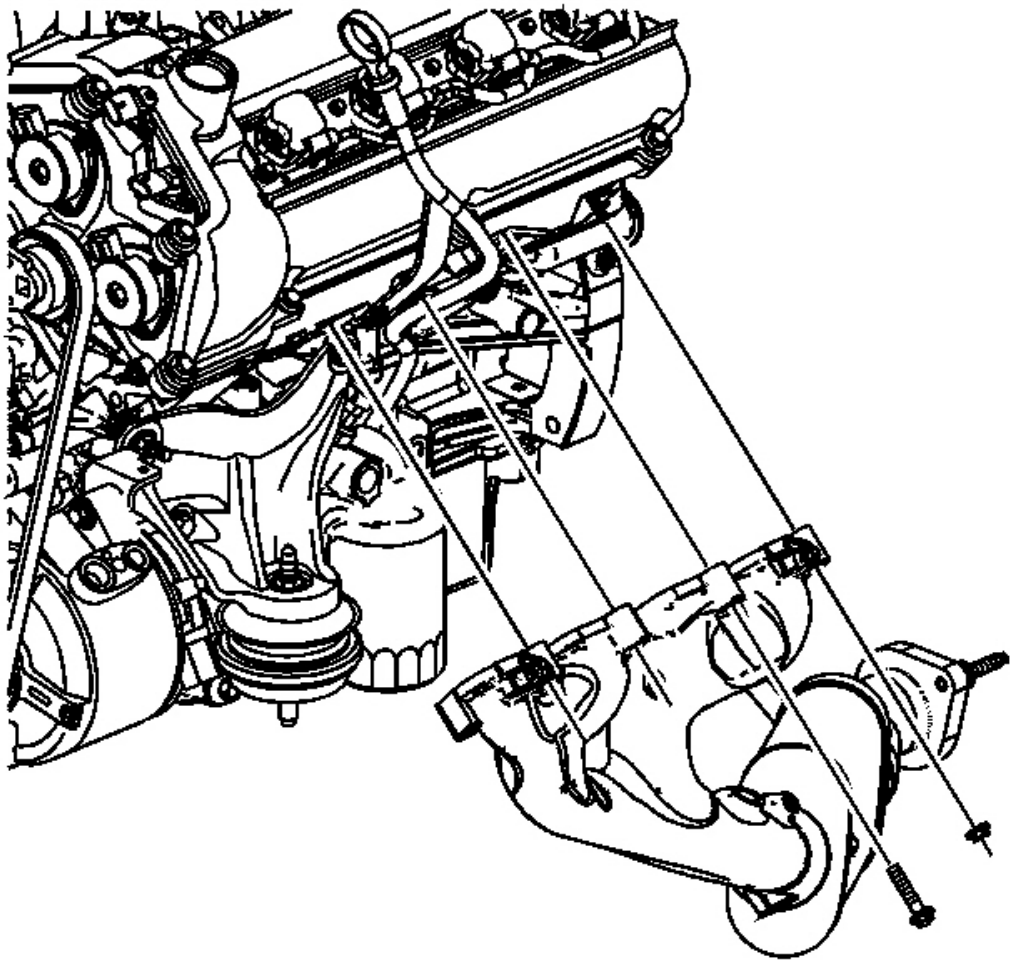


Fig. 79: View Of Left Exhaust Manifold, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

13. Install the left exhaust manifold.
14. Install the left exhaust manifold bolts to the left cylinder head and bell housing.

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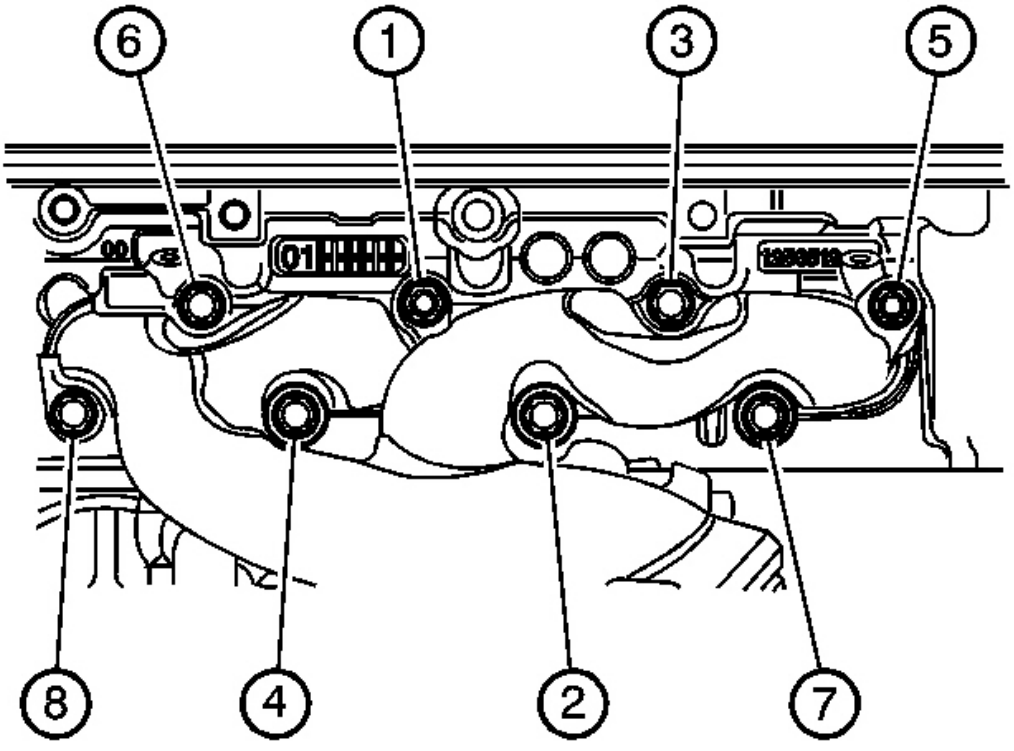


Fig. 80: Tightening Exhaust Manifold Bolts & Nuts In Sequence
Courtesy of GENERAL MOTORS CORP.

15. Tighten the exhaust manifold bolts and nuts in the sequence shown.

    Tighten: Tighten the exhaust manifold bolts and nuts to 25 N.m (18 lb ft).

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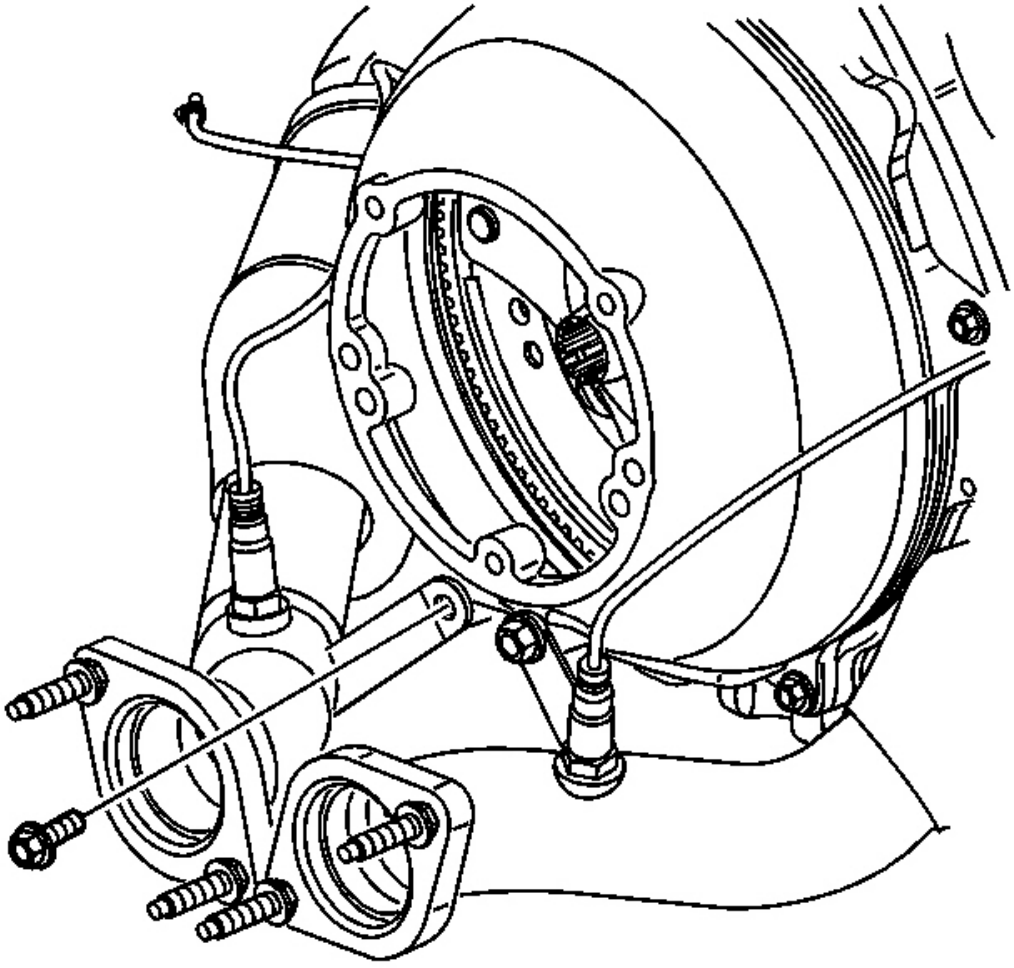


Fig. 81: View Of Left Exhaust Manifold Bolt & Bell Housing
Courtesy of GENERAL MOTORS CORP.

16. Tighten the left exhaust manifold bolt to the bell housing.

    Tighten: Tighten the left exhaust manifold bell housing bolt to 50 N.m (37 lb ft).

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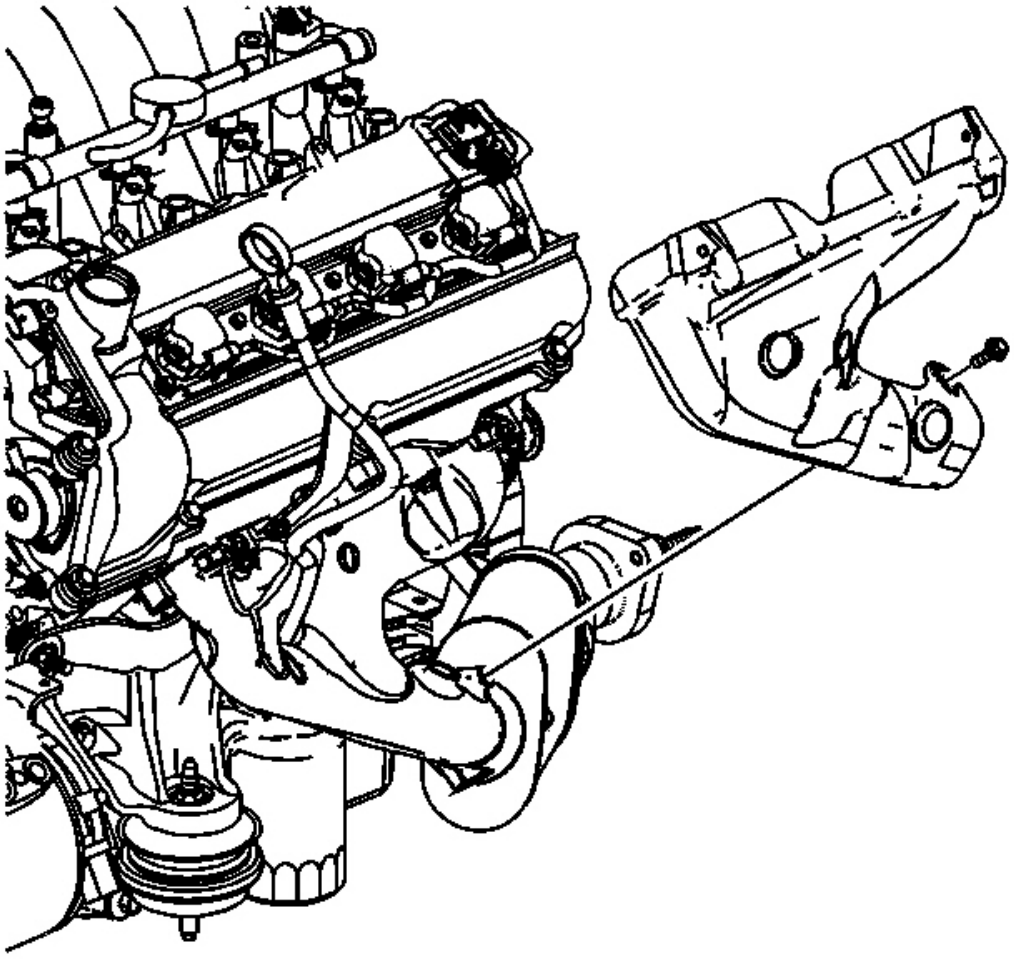


Fig. 82: View Of Left Exhaust Manifold Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

17. Install the left exhaust manifold heat shield.
18. Install the left exhaust manifold heat shield bolts.

Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

ENGINE WIRING HARNESS ASSEMBLY INSTALLATION

LEFT SIDE HARNESS CONNECTIONS

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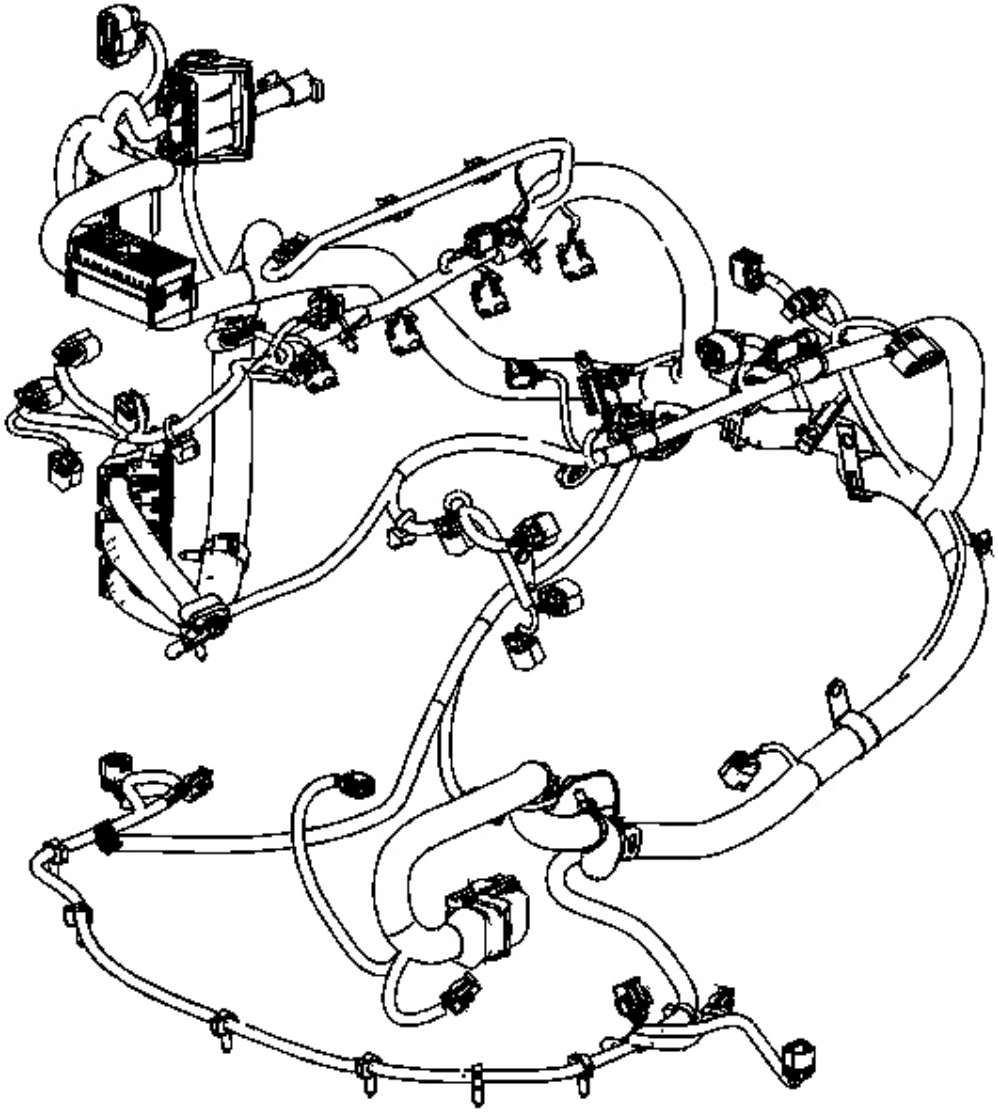


Fig. 83: View Of Engine Wiring Harness
Courtesy of GENERAL MOTORS CORP.

1. Install the engine wiring harness to the engine block.

Automotive-Manual.net

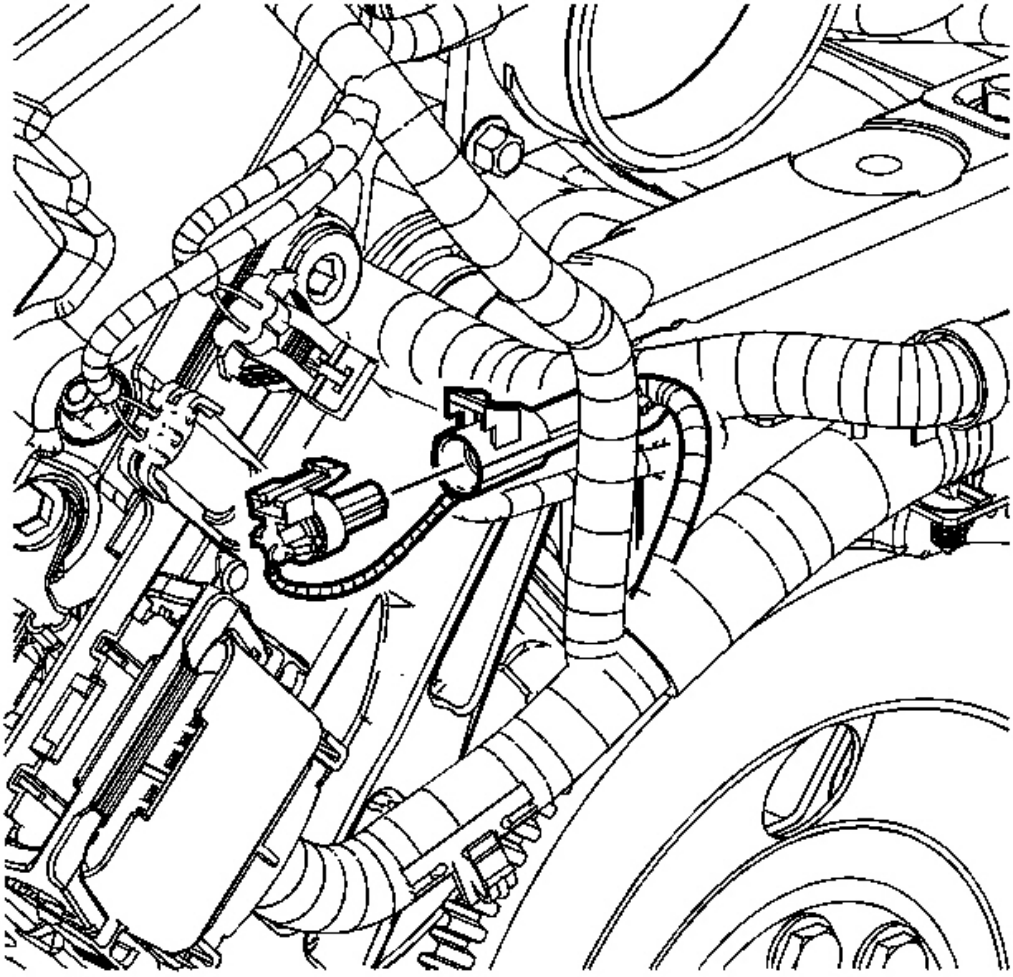


Fig. 84: Identifying Starter Wiring Harness
Courtesy of GENERAL MOTORS CORP.

2. Connect the engine wiring harness starter connector to the starter wiring harness.

Automotive-Manual.net

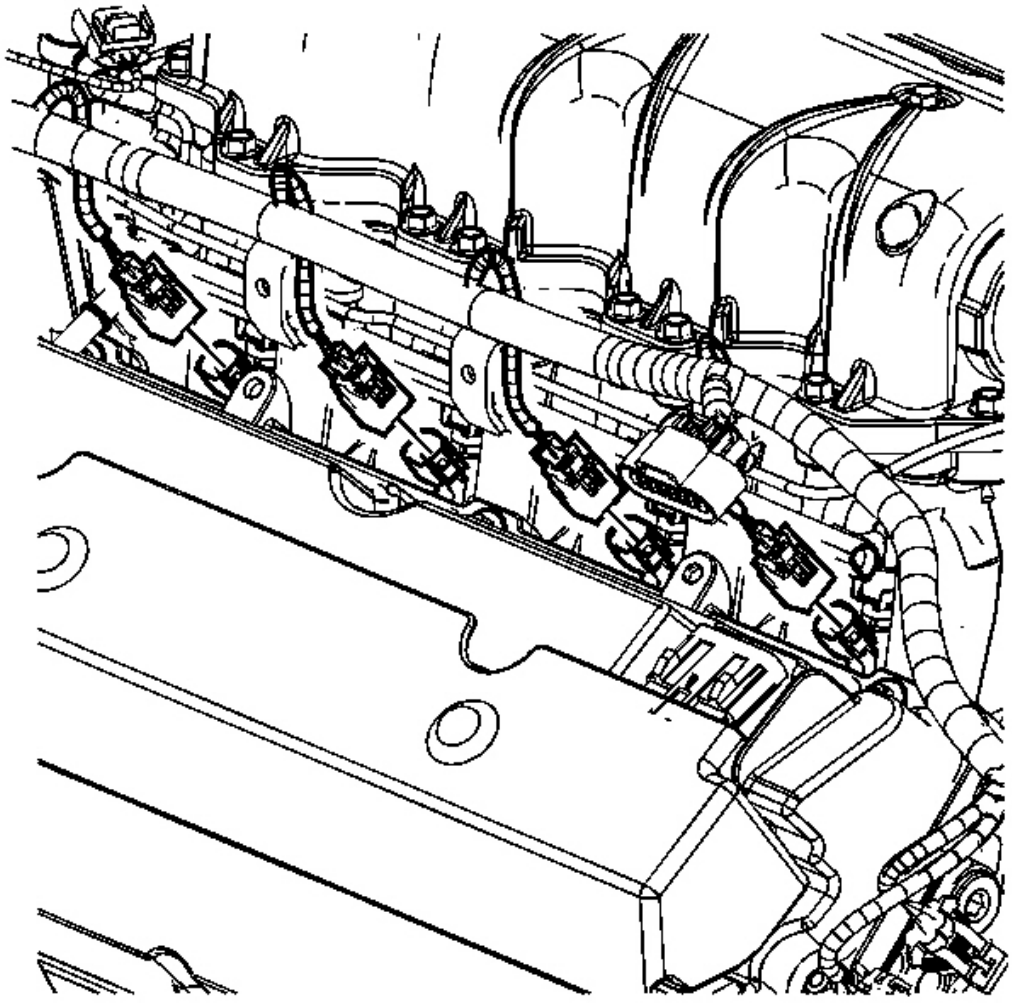


Fig. 85: View Of Engine Wiring Harness
Courtesy of GENERAL MOTORS CORP.

3. Connect the engine wiring harness to the left side fuel injectors.

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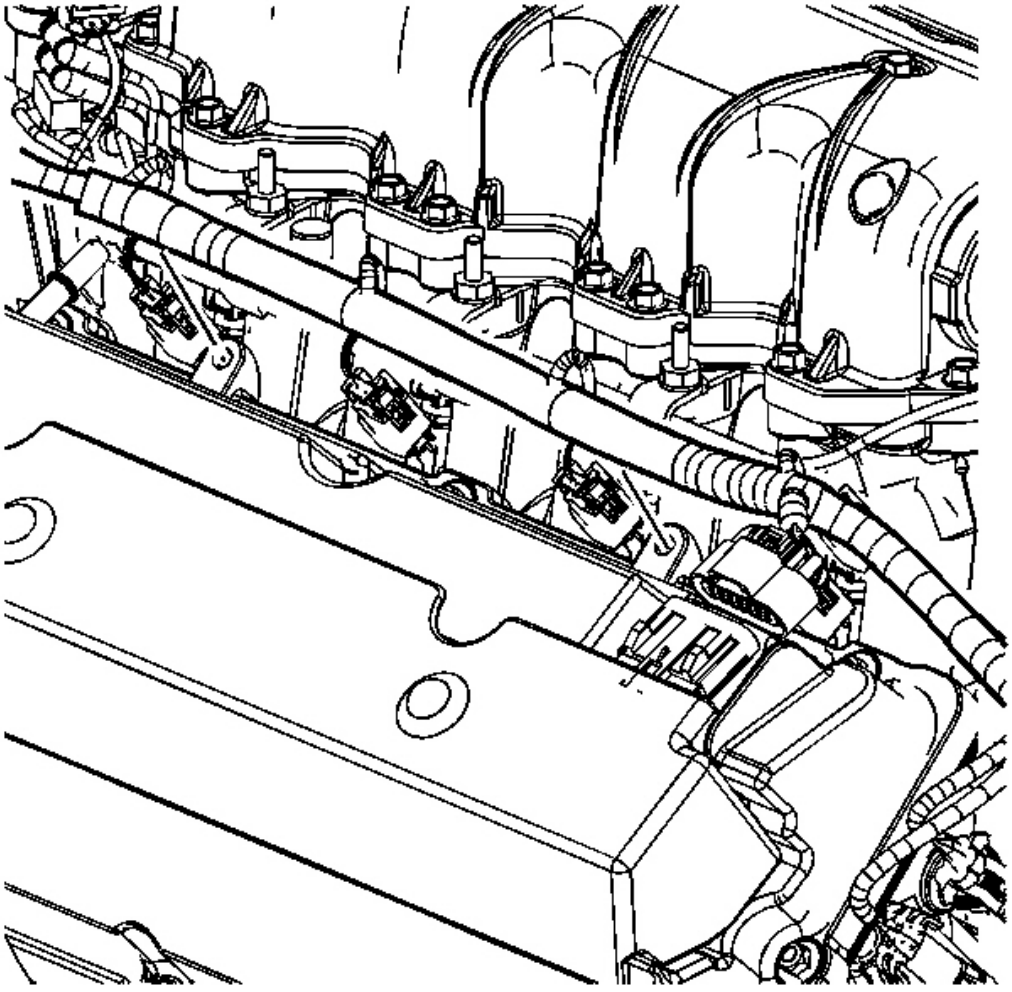


Fig. 86: Identifying Engine Wiring Harness & Left Side Fuel Injectors
Courtesy of GENERAL MOTORS CORP.

4. Connect the engine wiring harness to the left camshaft cover.

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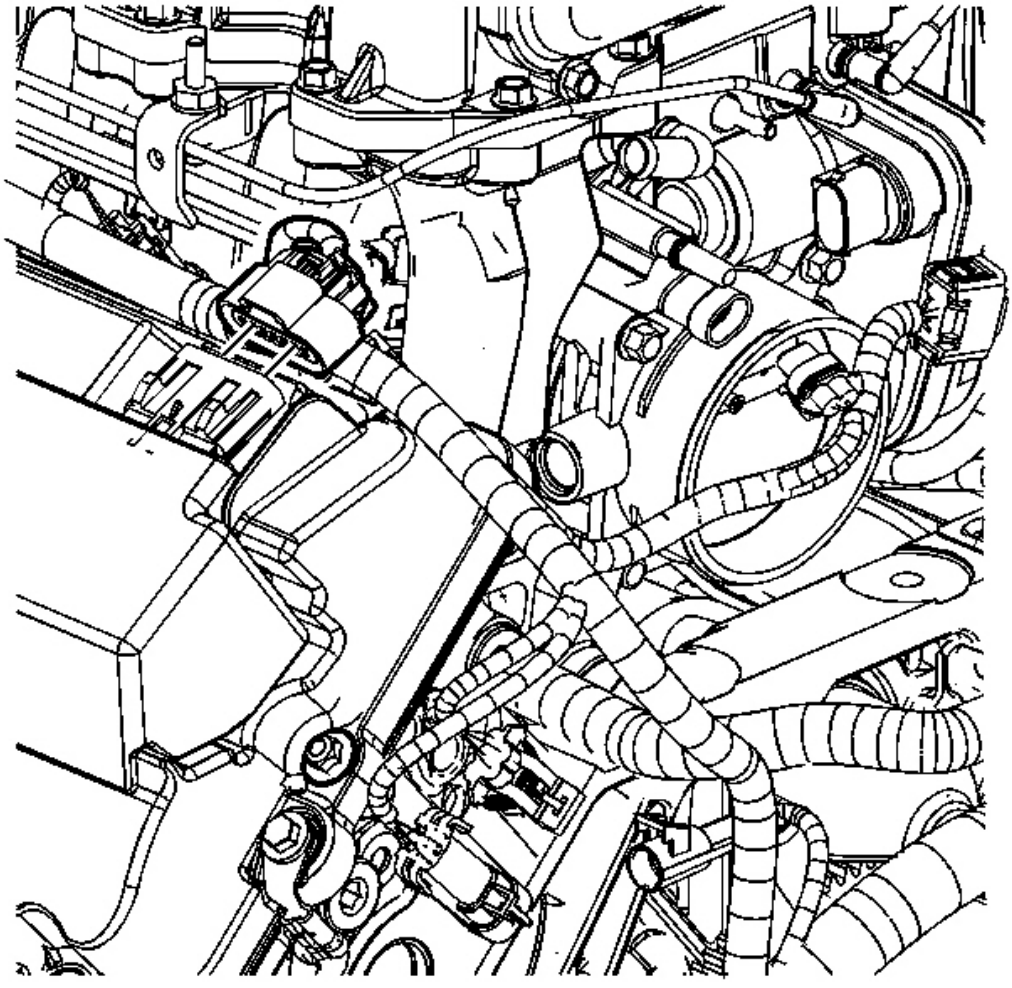


Fig. 87: Identifying Left Coil Assembly Harness
Courtesy of GENERAL MOTORS CORP.

5. Connect the engine wiring harness to the left coil assembly harness.

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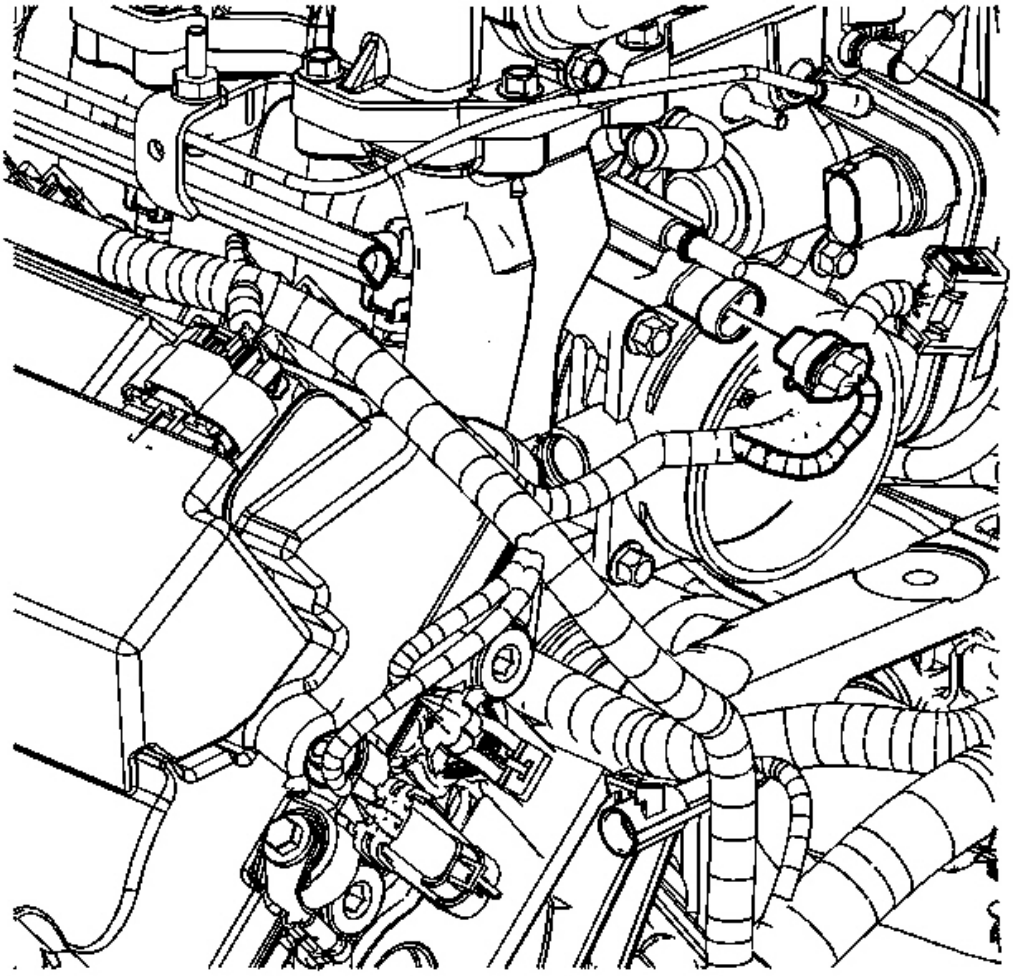


Fig. 88: Identifying EVAP Canister Purge Solenoid Harness
Courtesy of GENERAL MOTORS CORP.

6. Connect the engine wiring harness to the evaporative emissions (EVAP) canister purge solenoid.

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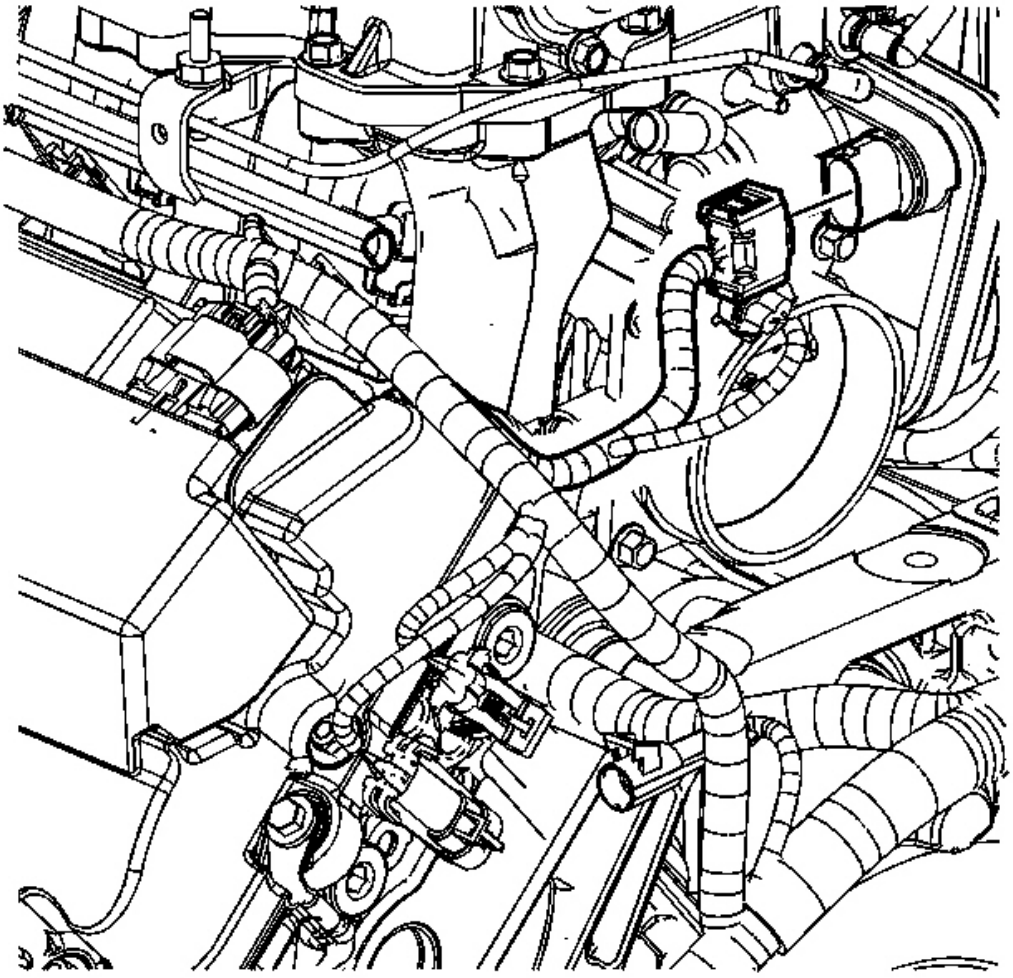


Fig. 89: Identifying Throttle Body Harness
Courtesy of GENERAL MOTORS CORP.

7. Connect the engine wiring harness to the throttle body.

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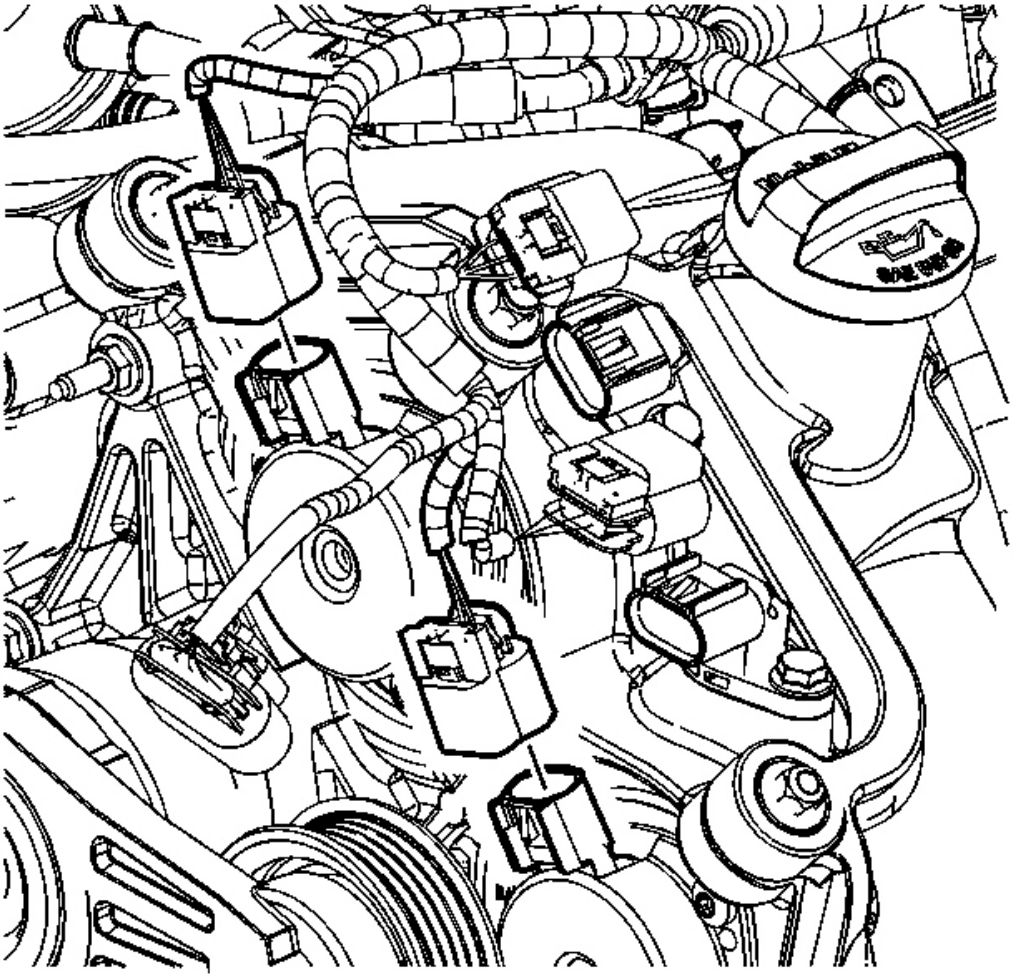


Fig. 90: Identifying Left Camshaft Position Actuator Harness
Courtesy of GENERAL MOTORS CORP.

8. Connect the engine wiring harness to the left camshaft position actuators.

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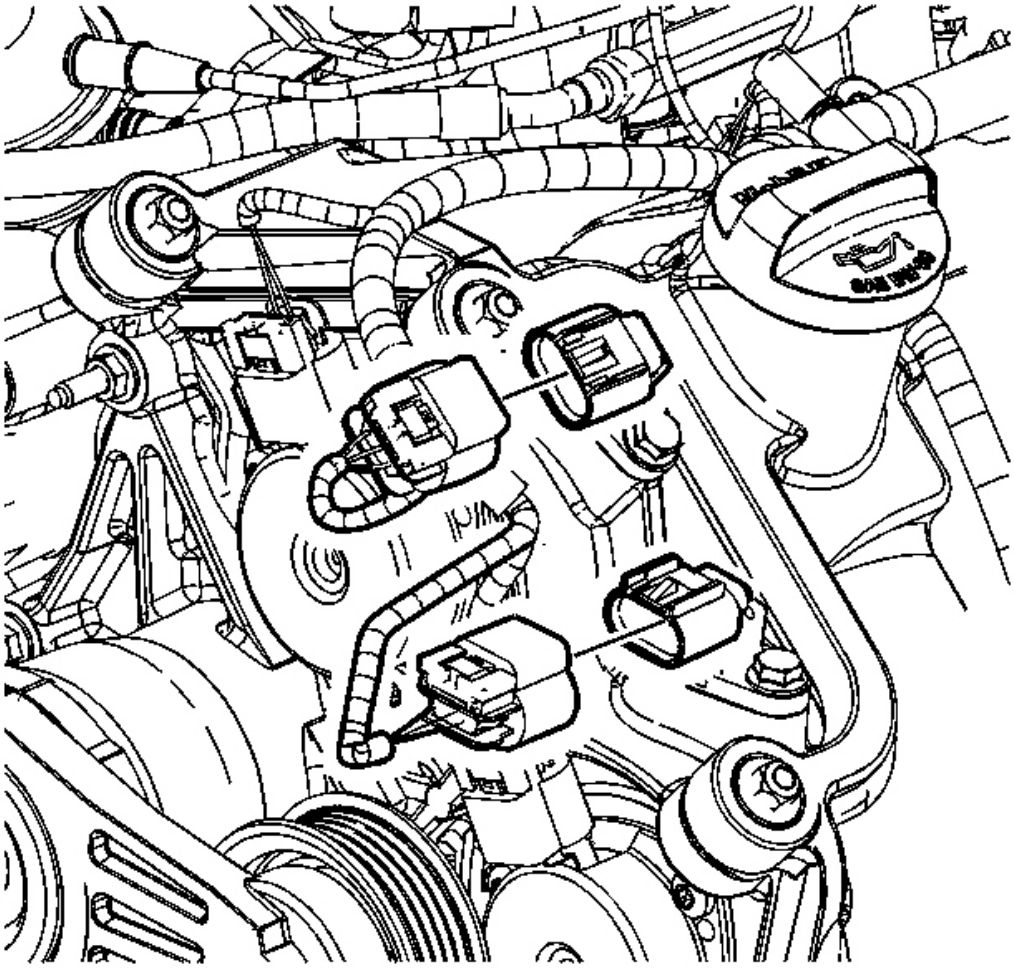


Fig. 91: Identifying Left Camshaft Position Sensor Harness
Courtesy of GENERAL MOTORS CORP.

9. Connect the engine wiring harness to the left camshaft position sensors.

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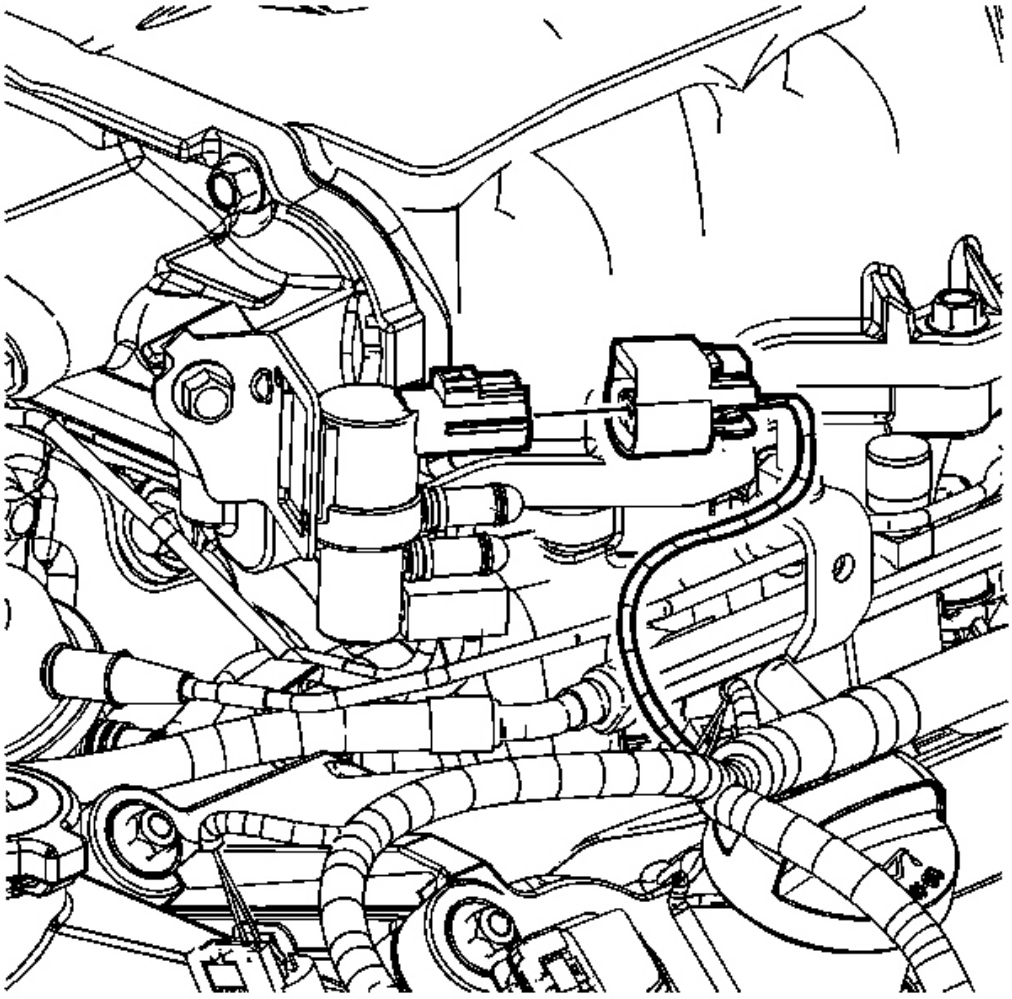


Fig. 92: Identifying Supercharger Charge Air Bypass Regulator Solenoid Valve Harness
Courtesy of GENERAL MOTORS CORP.

10. Connect the engine wiring harness to the supercharger charge air bypass regulator solenoid valve.

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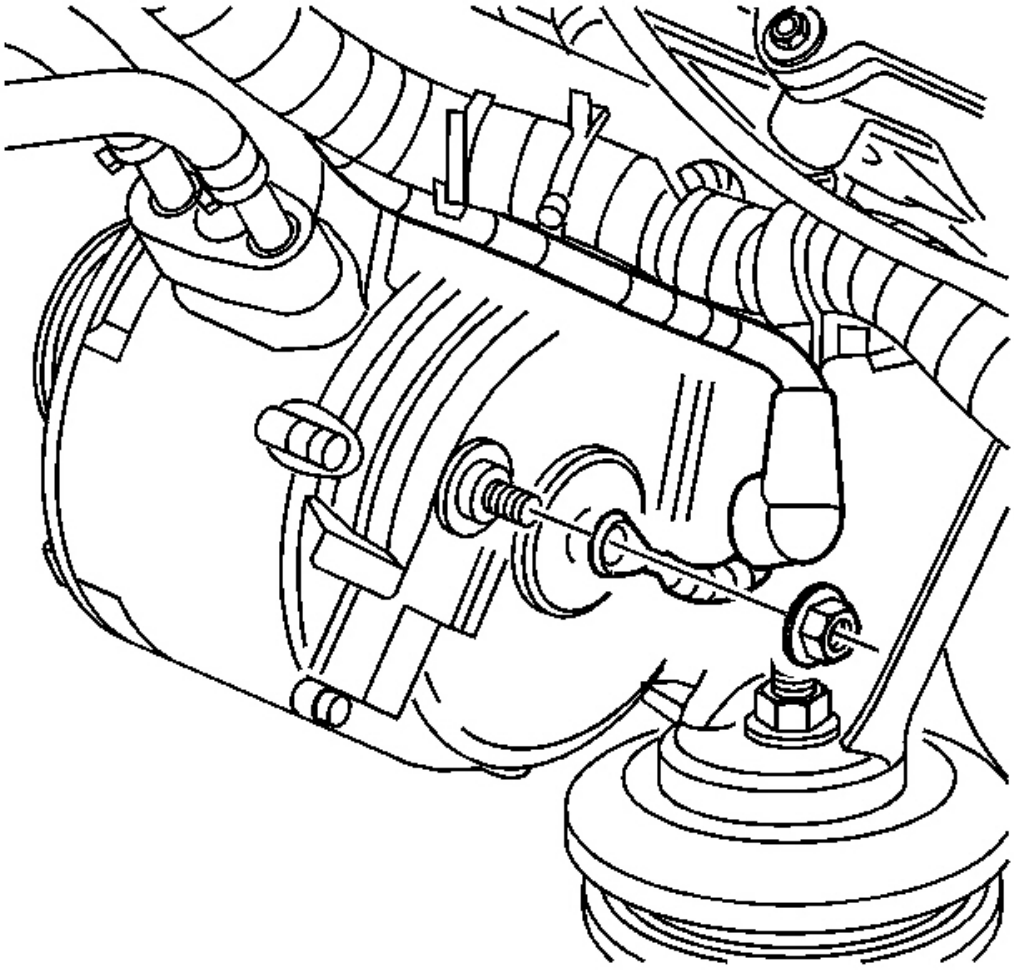


Fig. 93: View Of Starter Motor Wiring Harness, Generator Stud & Nut
Courtesy of GENERAL MOTORS CORP.

11. Connect the starter motor wiring harness to the generator stud.

NOTE: **Refer to Fastener Notice .**

12. Install the nut attaching the starter motor wiring harness to the generator stud.

Tighten: Tighten the generator stud nut to 20 N.m (15 lb ft).

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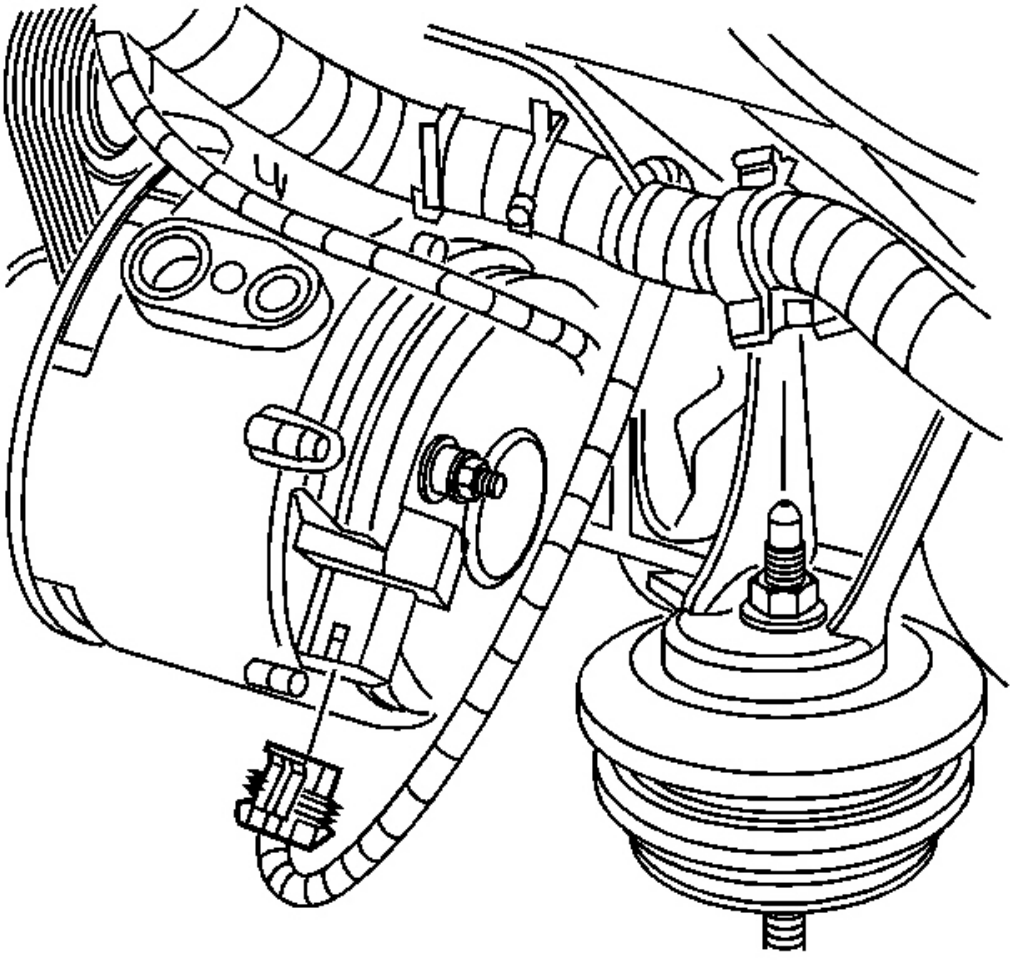


Fig. 94: View Of Engine Wiring Harness & Generator
Courtesy of GENERAL MOTORS CORP.

13. Connect the engine wiring harness to the generator.

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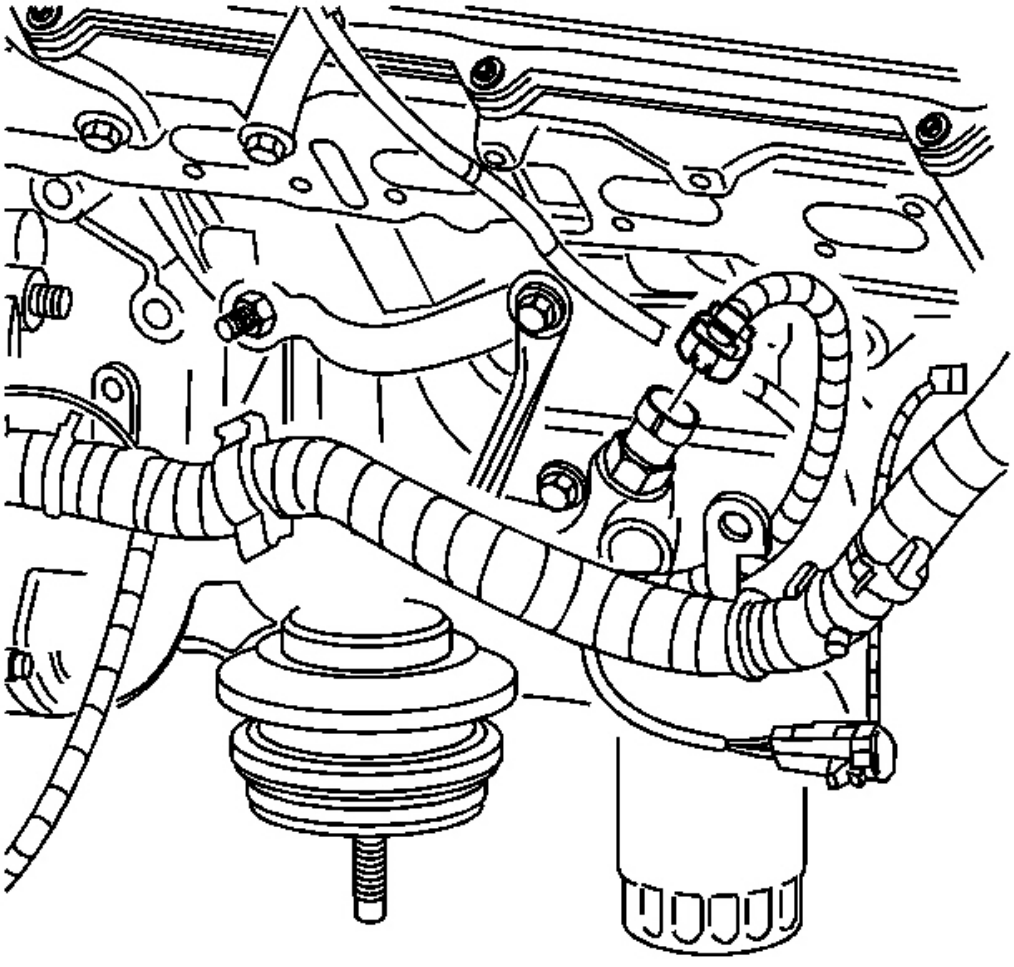


Fig. 95: View Of Engine Wiring Harness & Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

14. Connect the engine wiring harness to the oil pressure sensor.

RIGHT SIDE HARNESS CONNECTIONS

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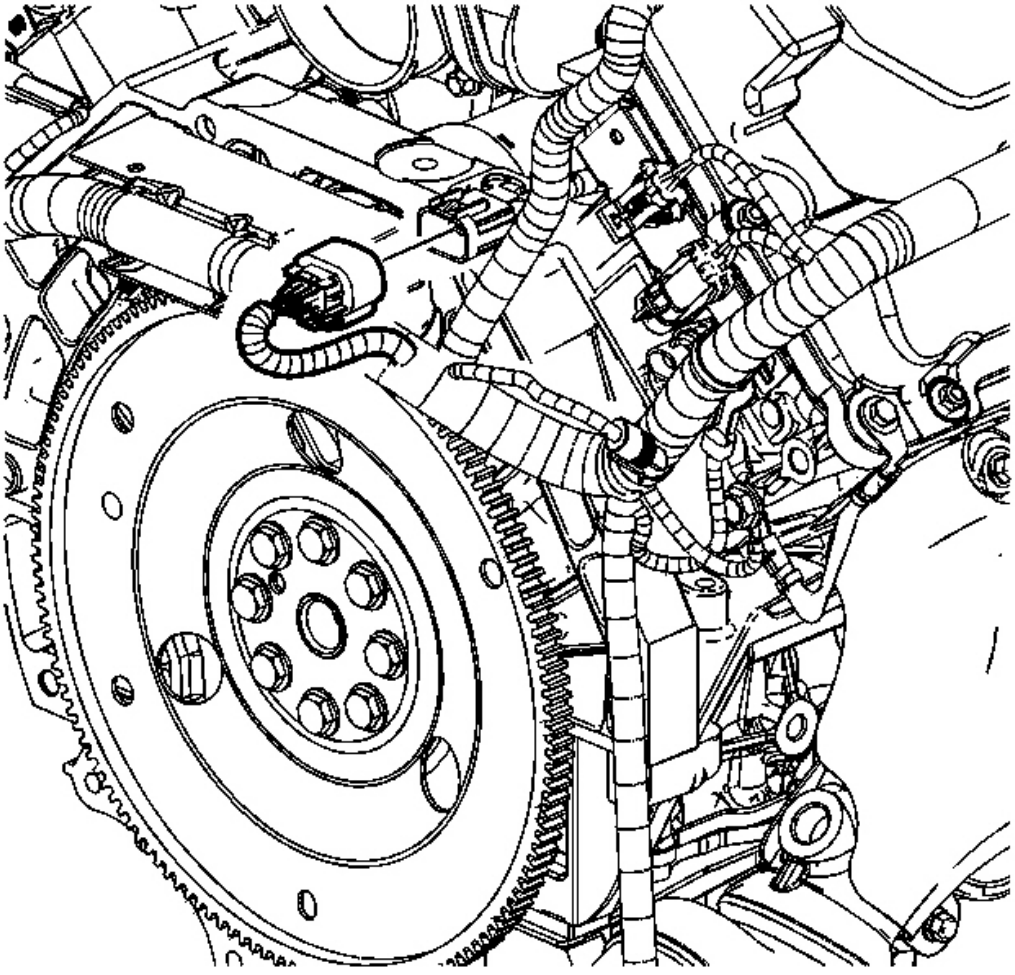


Fig. 96: Identifying Knock And Crankshaft Position Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

1. Connect the engine wiring harness to the knock and crankshaft position sensor wiring harness.

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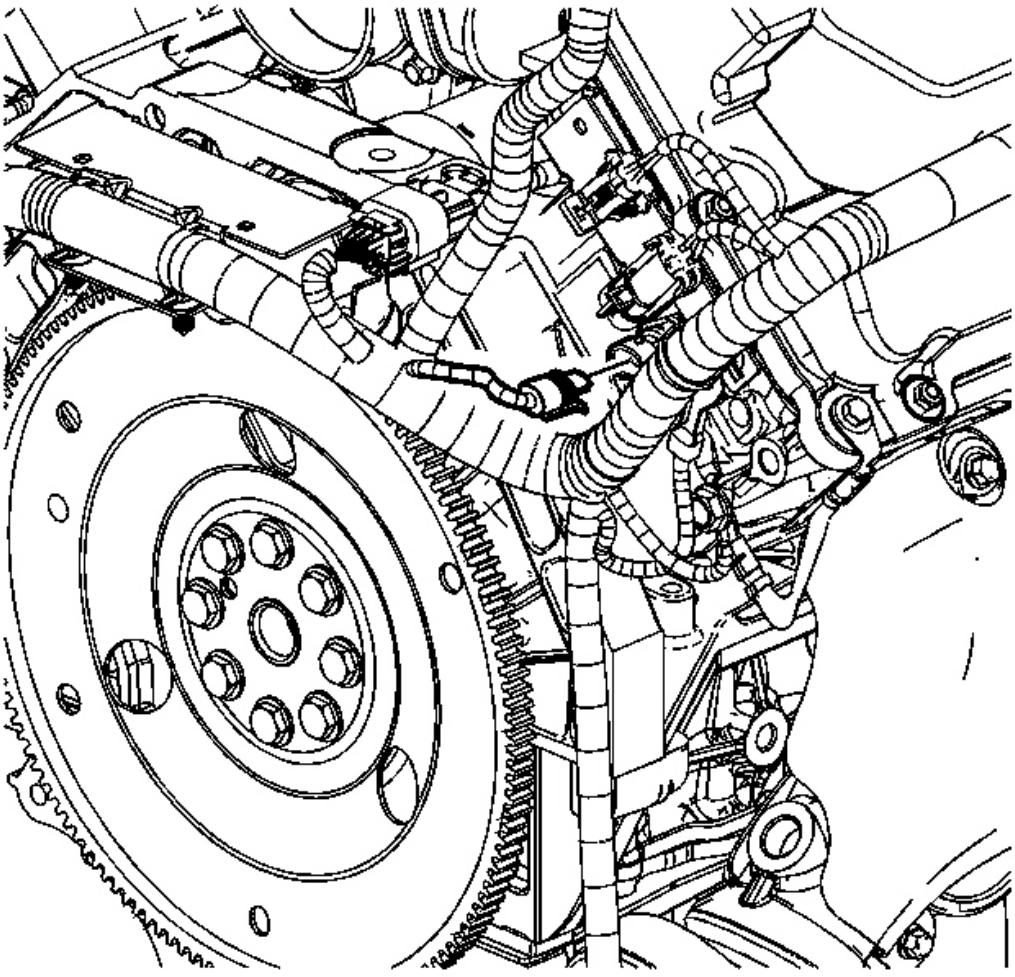


Fig. 97: Identifying ECT Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

2. Connect the engine wiring harness to the engine coolant temperature (ECT) sensor at the rear of the right cylinder head.

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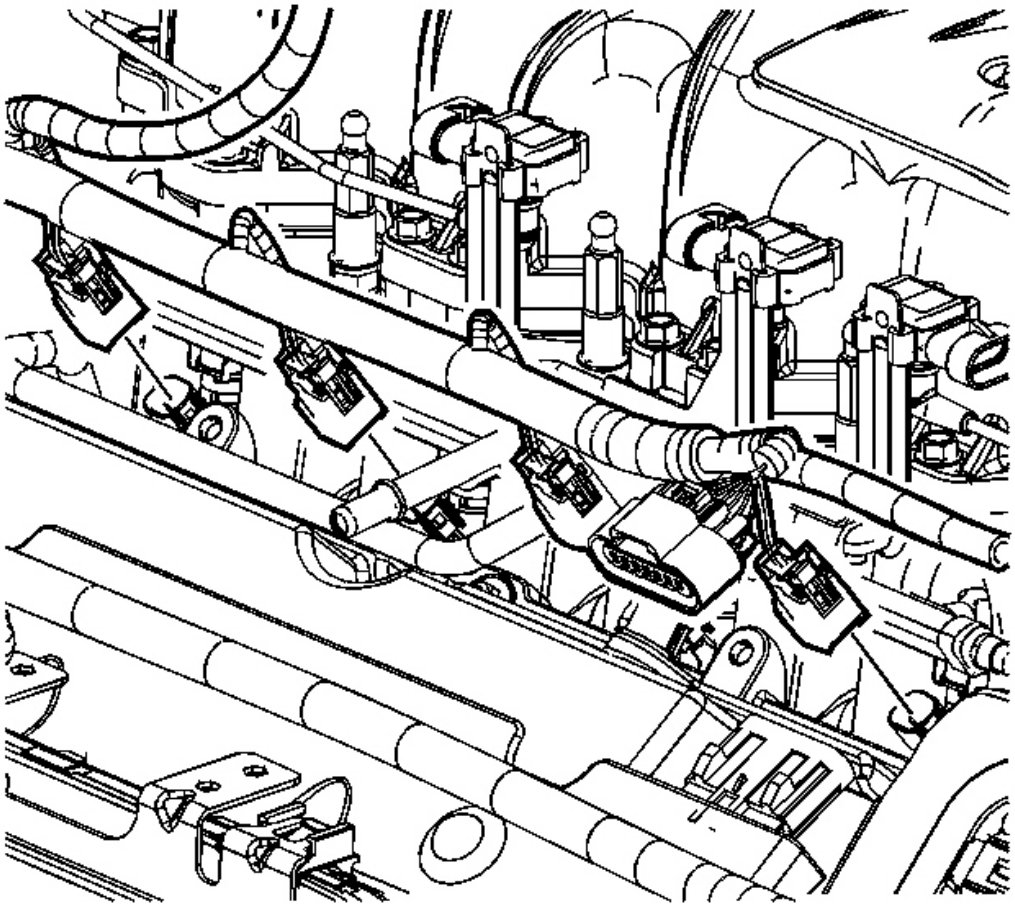


Fig. 98: Identifying Right Side Fuel Injectors Wiring Harness
Courtesy of GENERAL MOTORS CORP.

3. Connect the engine wiring harness to the right side fuel injectors.

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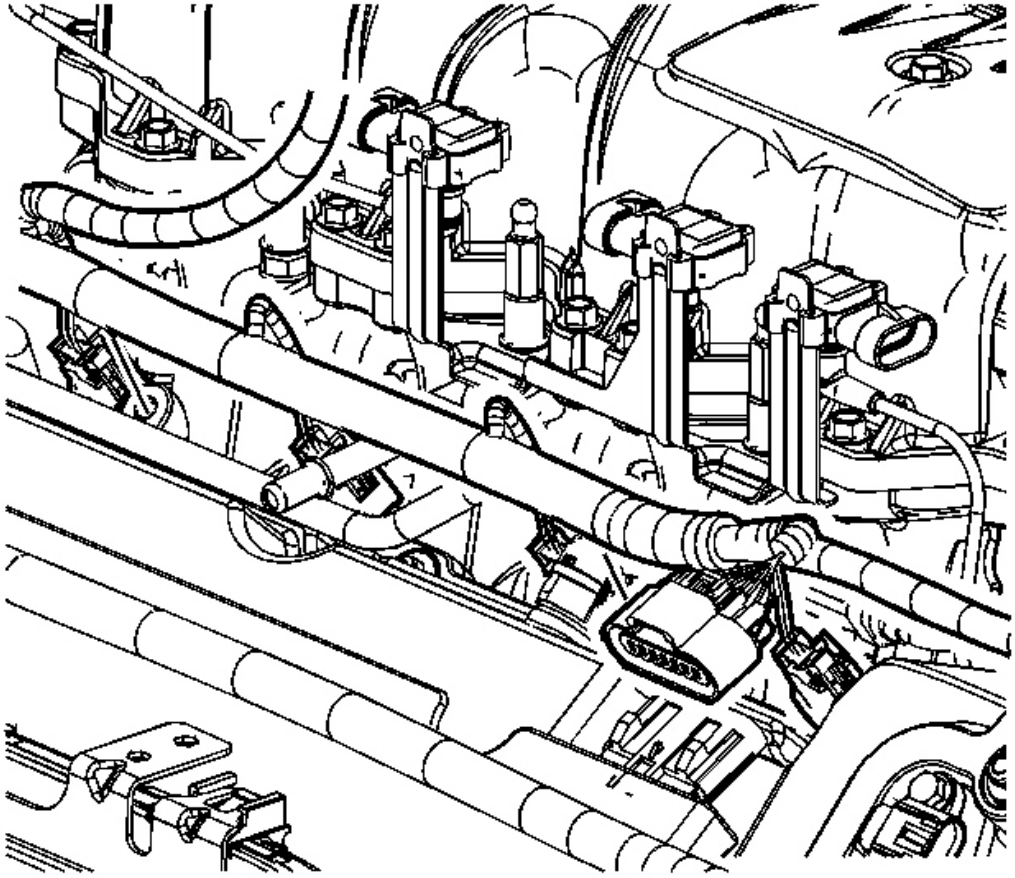


Fig. 99: Identifying Right Camshaft Cover Wiring Harness
Courtesy of GENERAL MOTORS CORP.

4. Connect the engine wiring harness to the right camshaft cover.

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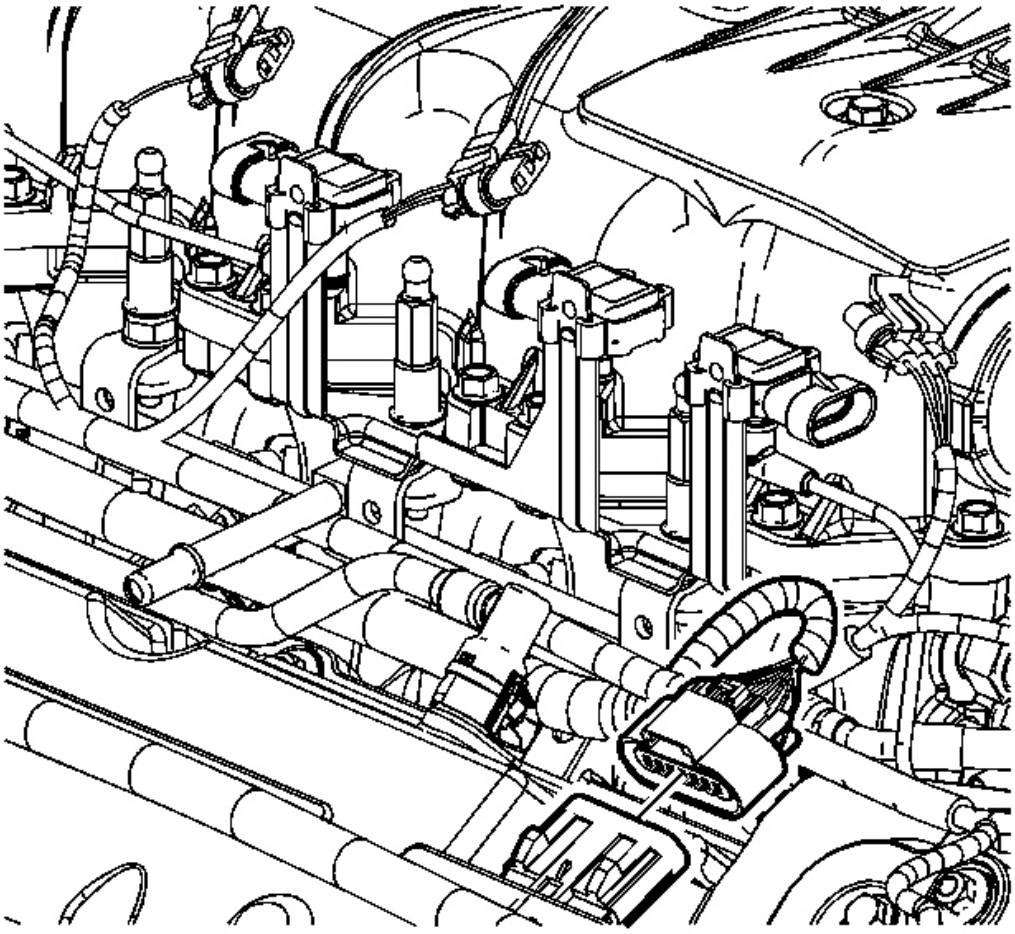


Fig. 100: Identifying Right Coil Assembly Harness
Courtesy of GENERAL MOTORS CORP.

5. Connect the engine wiring harness to right coil assembly harness.

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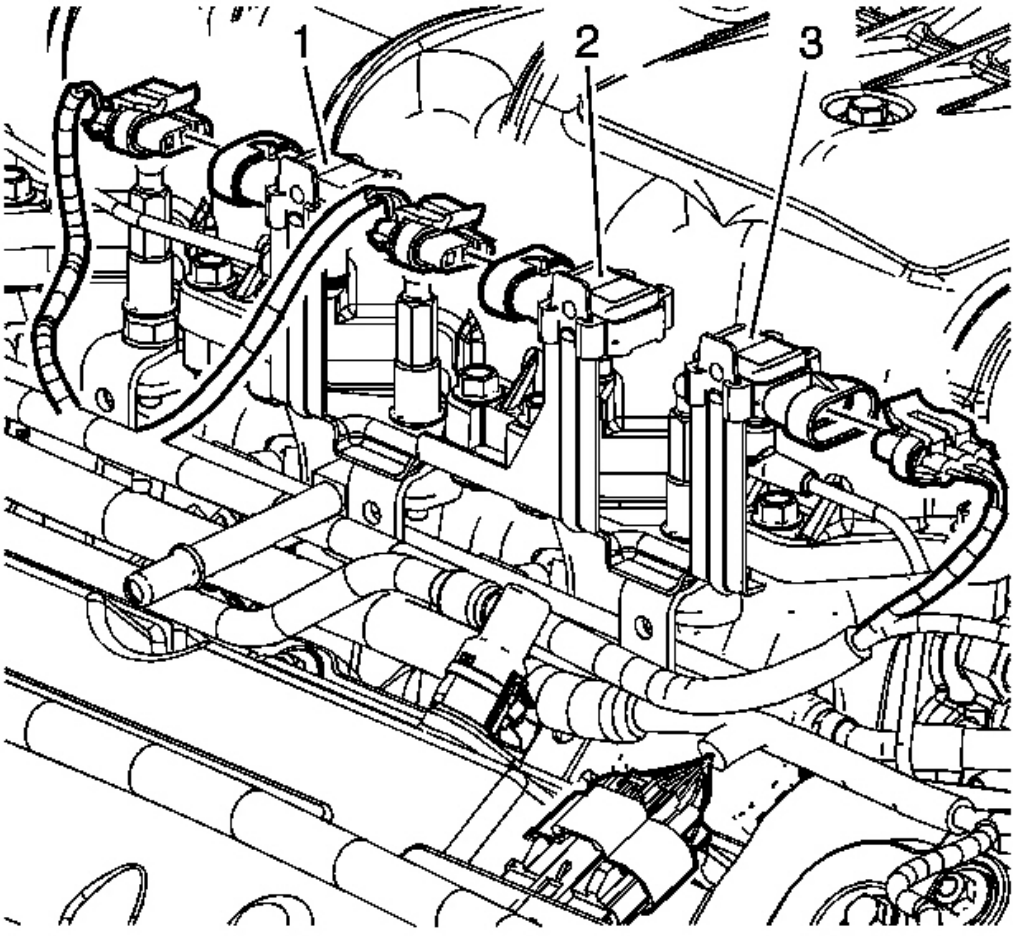


Fig. 101: Identifying MAP, BARO & Supercharger Inlet Absolute Pressure Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

6. Connect the engine wiring harness to the supercharger inlet absolute pressure sensor (1), barometric pressure (BARO) sensor (2) and manifold absolute pressure (MAP) sensor (3).

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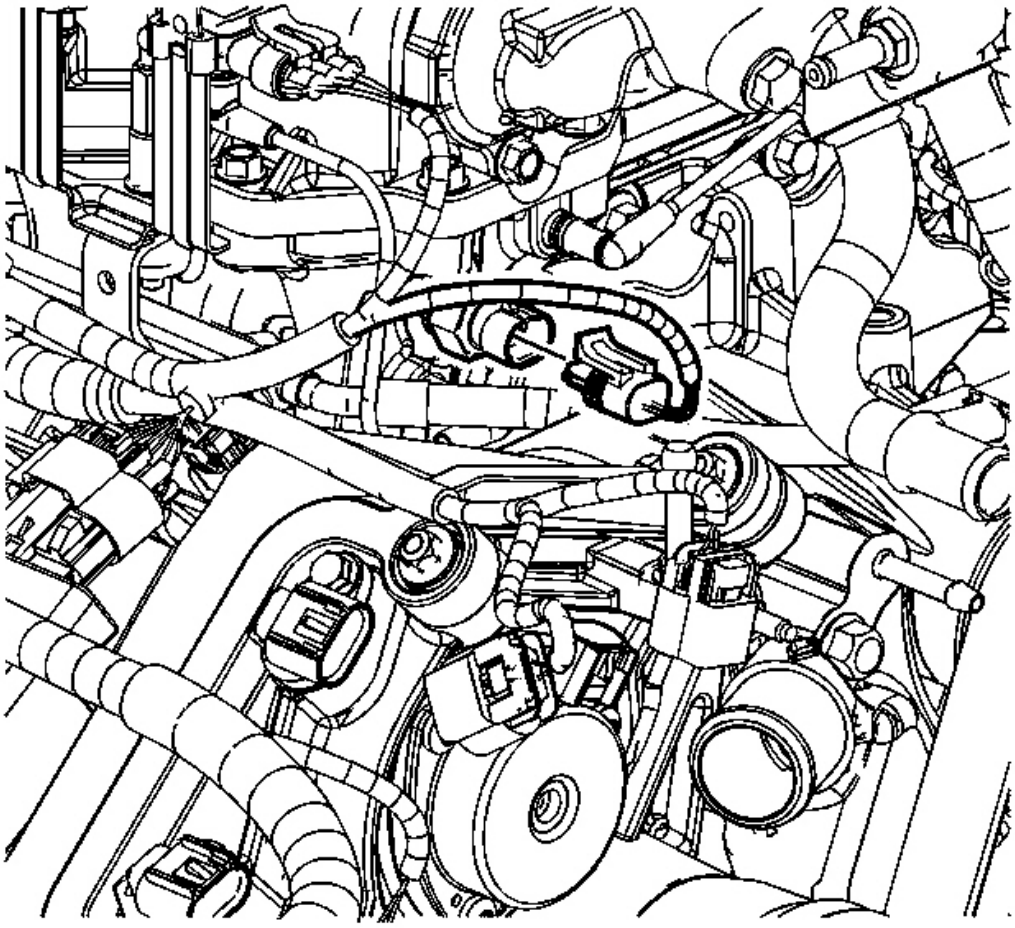


Fig. 102: Identifying IAT Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

7. Connect the engine wiring harness to the intake air temperature (IAT) sensor 2.

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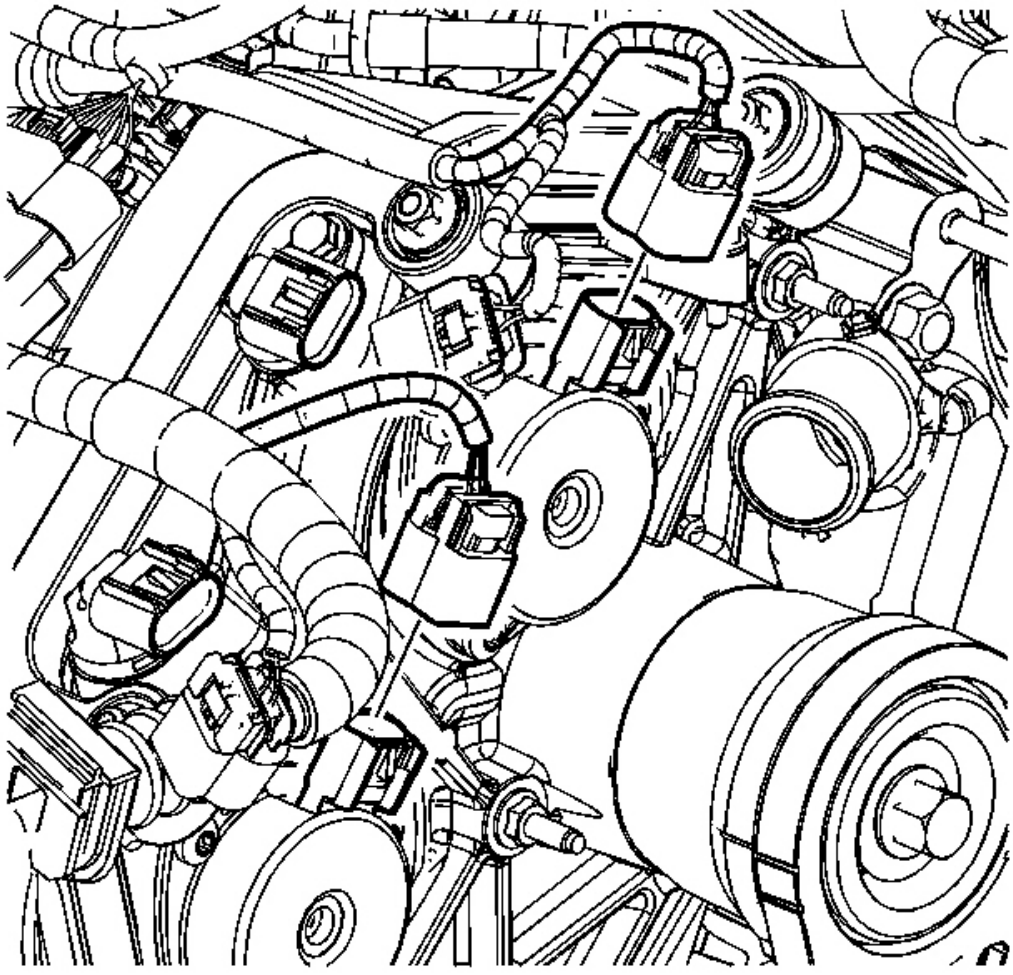


Fig. 103: Identifying Right Camshaft Position Actuator Wiring Harness
Courtesy of GENERAL MOTORS CORP.

8. Connect the engine wiring harness to the right camshaft position actuators.

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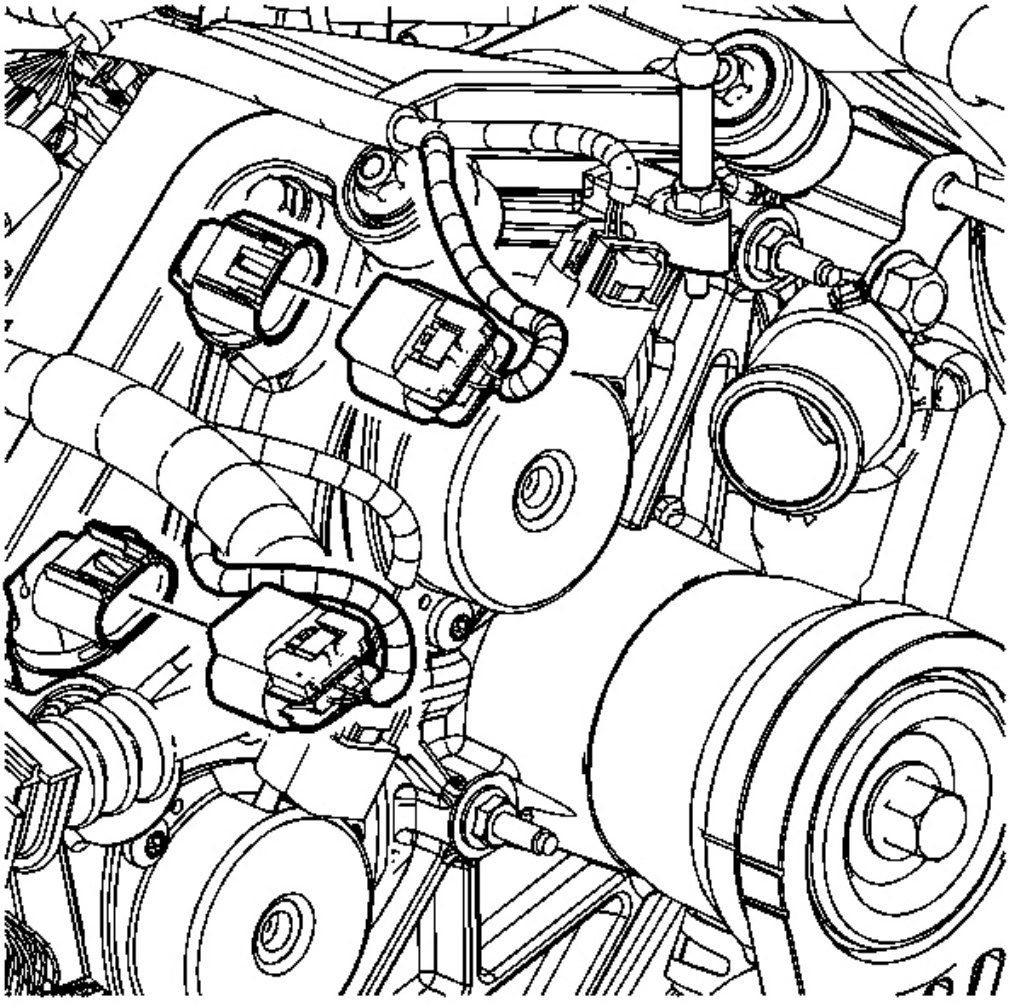


Fig. 104: Identifying Right Camshaft Position Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

9. Connect the engine wiring harness to right camshaft position sensors.

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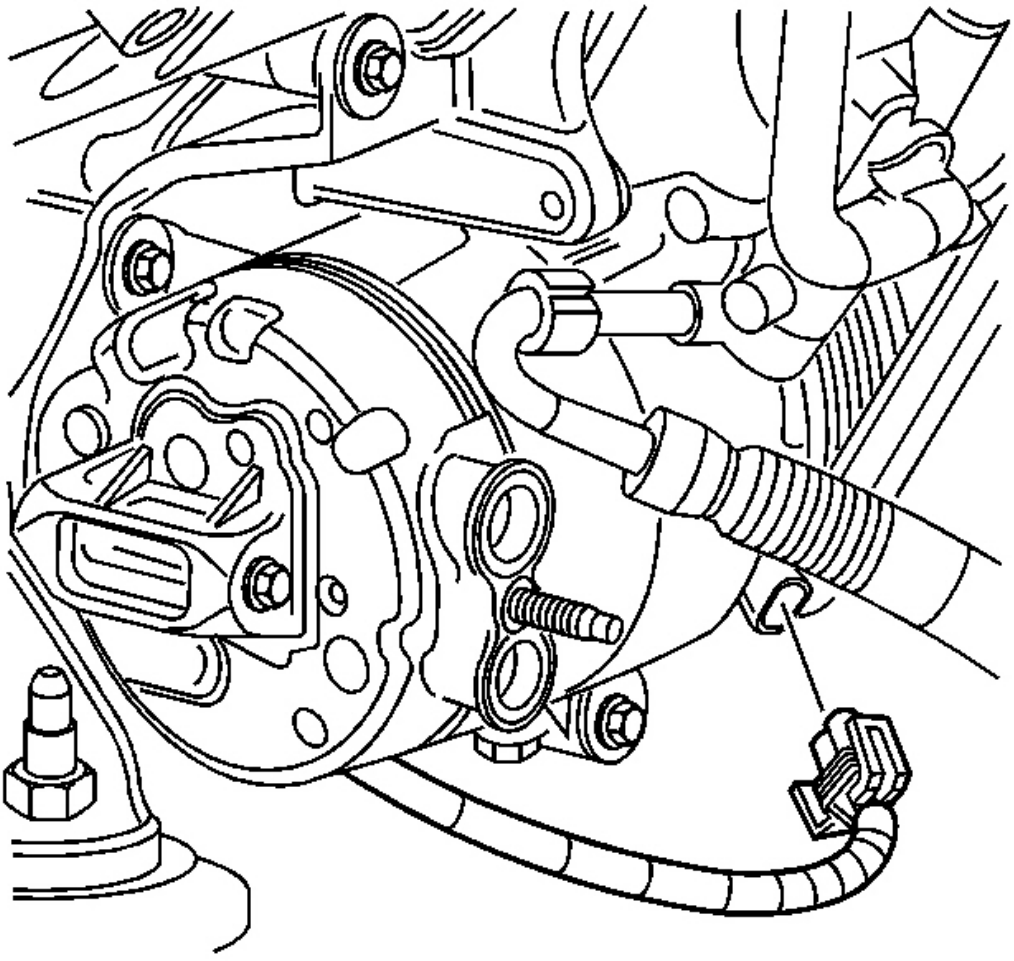


Fig. 105: View Of Engine Wiring Harness & Air Conditioning Compressor
Courtesy of GENERAL MOTORS CORP.

10. Connect the engine wiring harness to the air conditioning compressor.

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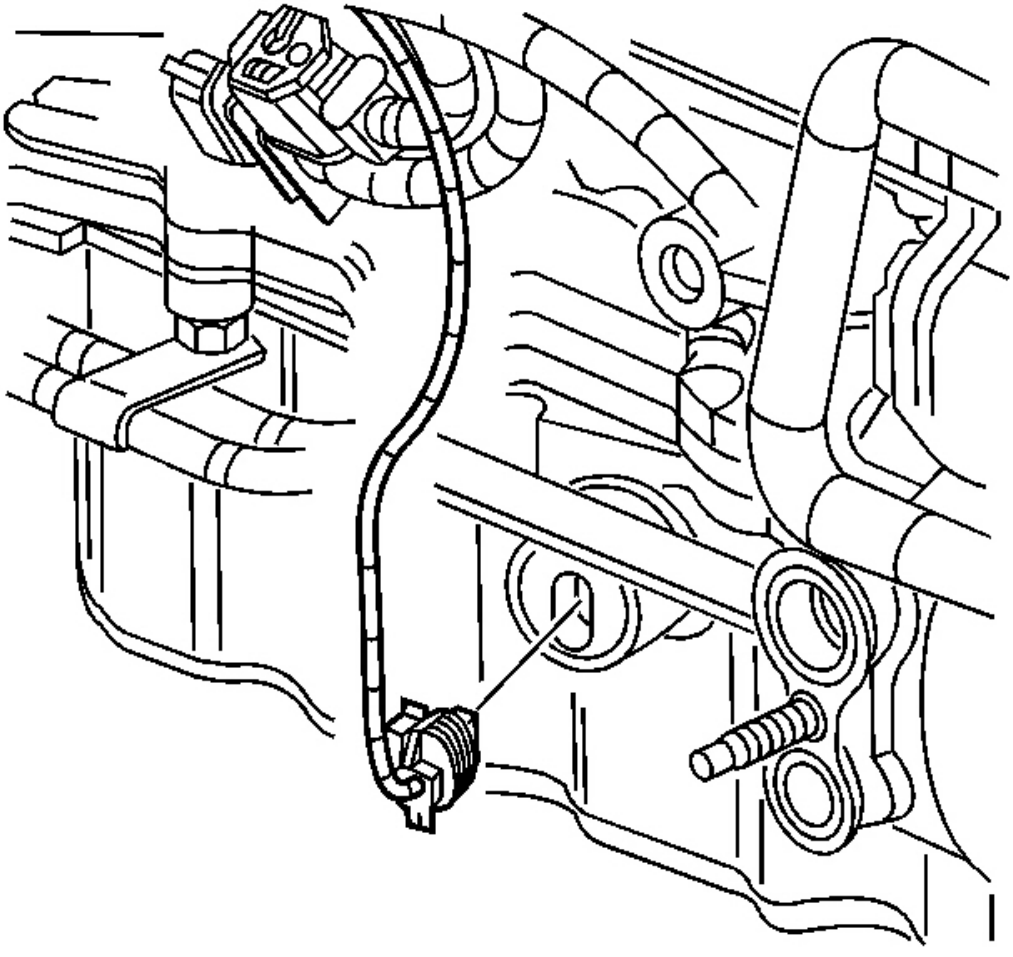


Fig. 106: View Of Engine Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

11. Connect the engine wiring harness to the engine oil level switch/temperature sensor.

SUPERCHARGER INLET DUCT INSTALLATION

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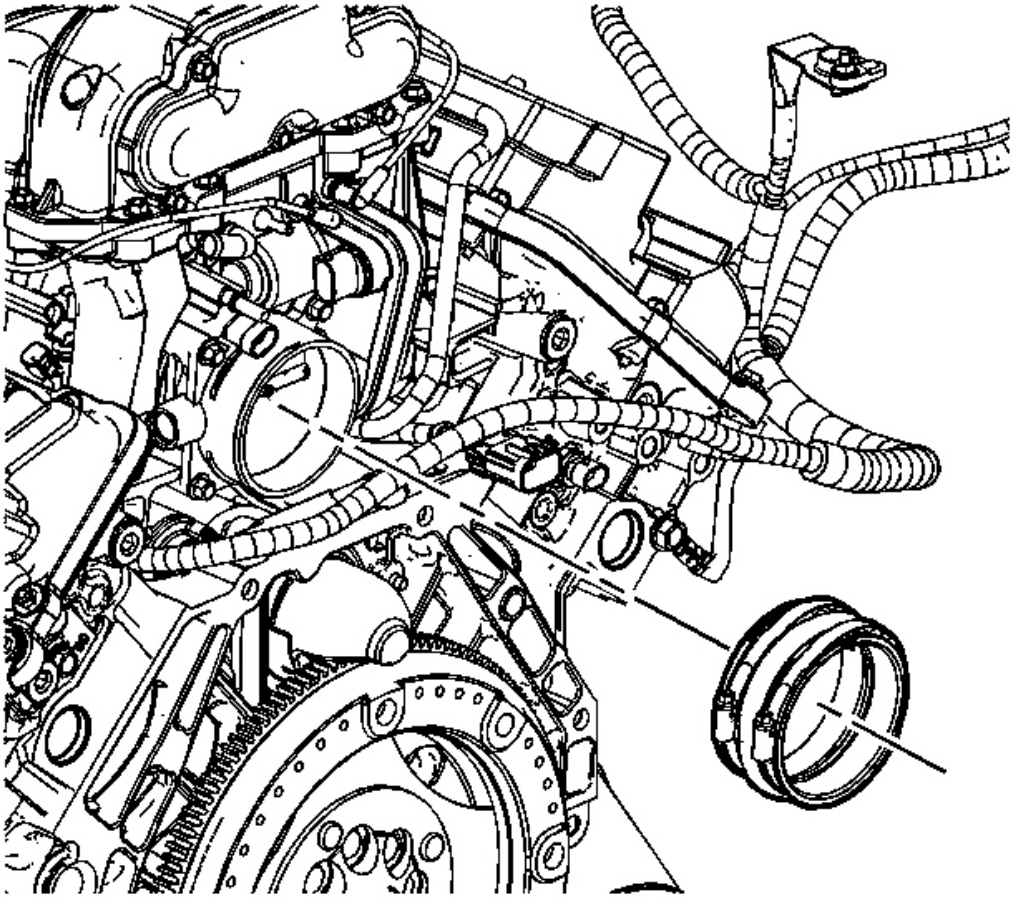


Fig. 107: View Of Throttle Body Duct Seal
Courtesy of GENERAL MOTORS CORP.

1. Install the throttle body duct seal.

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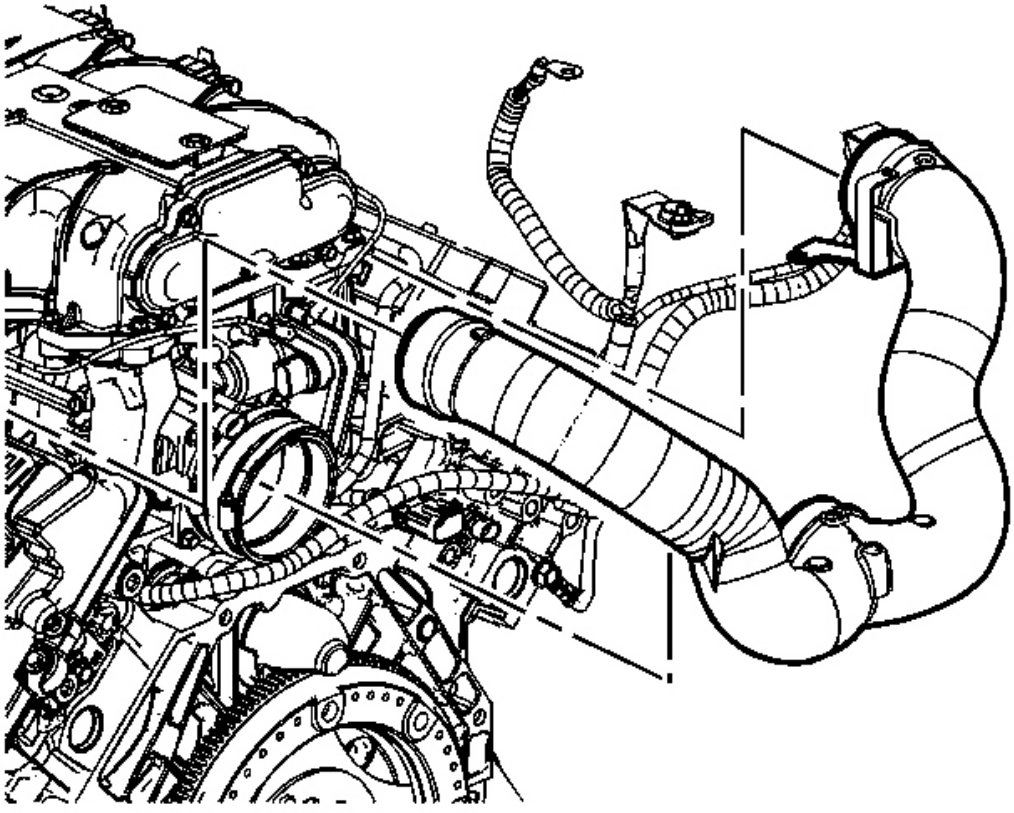


Fig. 108: View Of Rear Air Duct
Courtesy of GENERAL MOTORS CORP.

2. Install the rear air duct.

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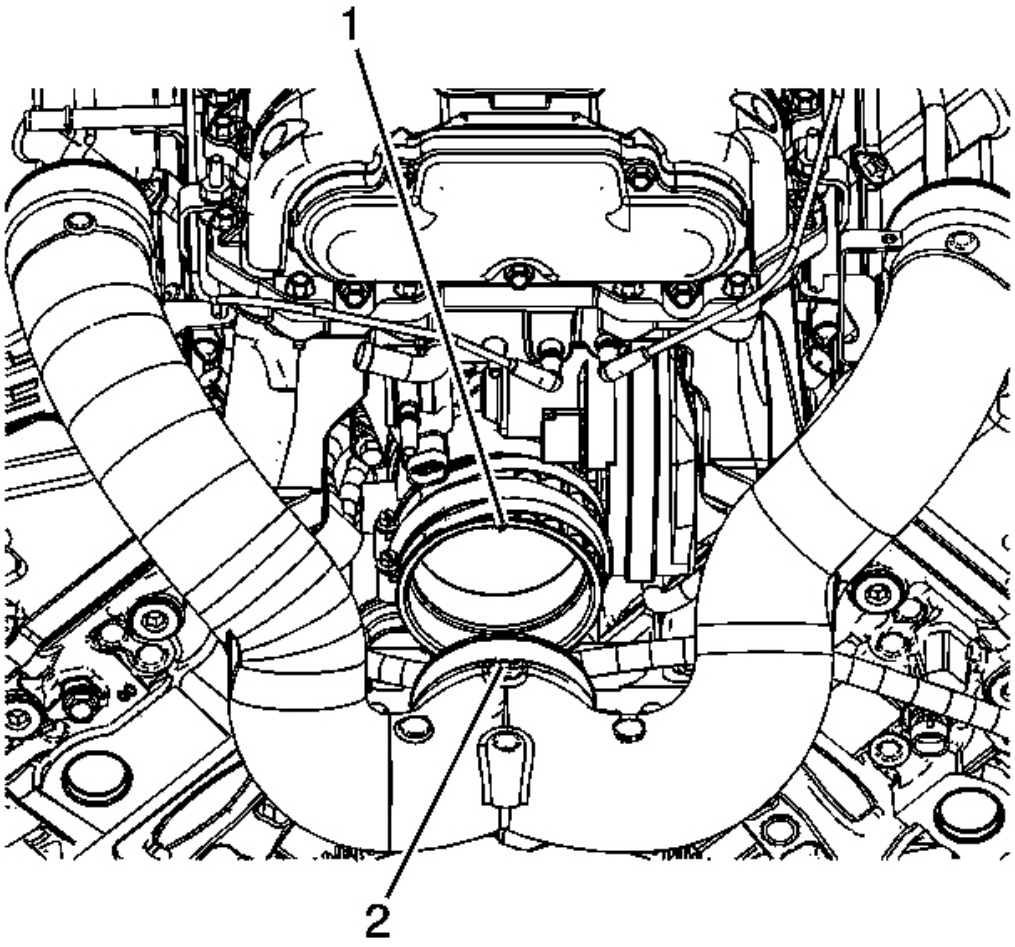


Fig. 109: Aligning Throttle Body Duct Seal To Notch
Courtesy of GENERAL MOTORS CORP.

3. Align the tab (1) on the throttle body duct seal with the notch (2) in the rear inlet duct.

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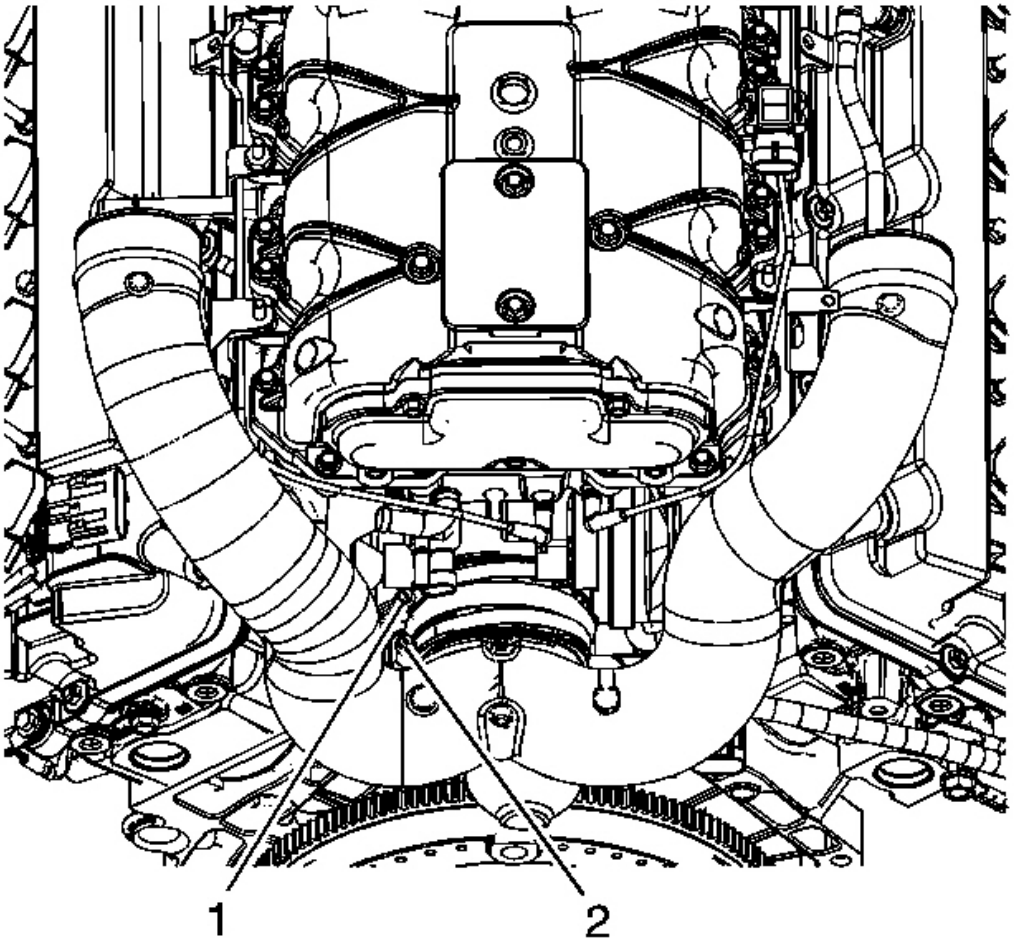


Fig. 110: View Of Throttle Body Duct Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Tighten the front screw clamp (1) on the throttle body duct seal.

   Tighten: Tighten the screw clamps to 3.25 N.m (29 lb in).

5. Tighten the rear screw clamp (2) on the throttle body duct seal.

   Tighten: Tighten the screw clamps to 3.25 N.m (29 lb in).

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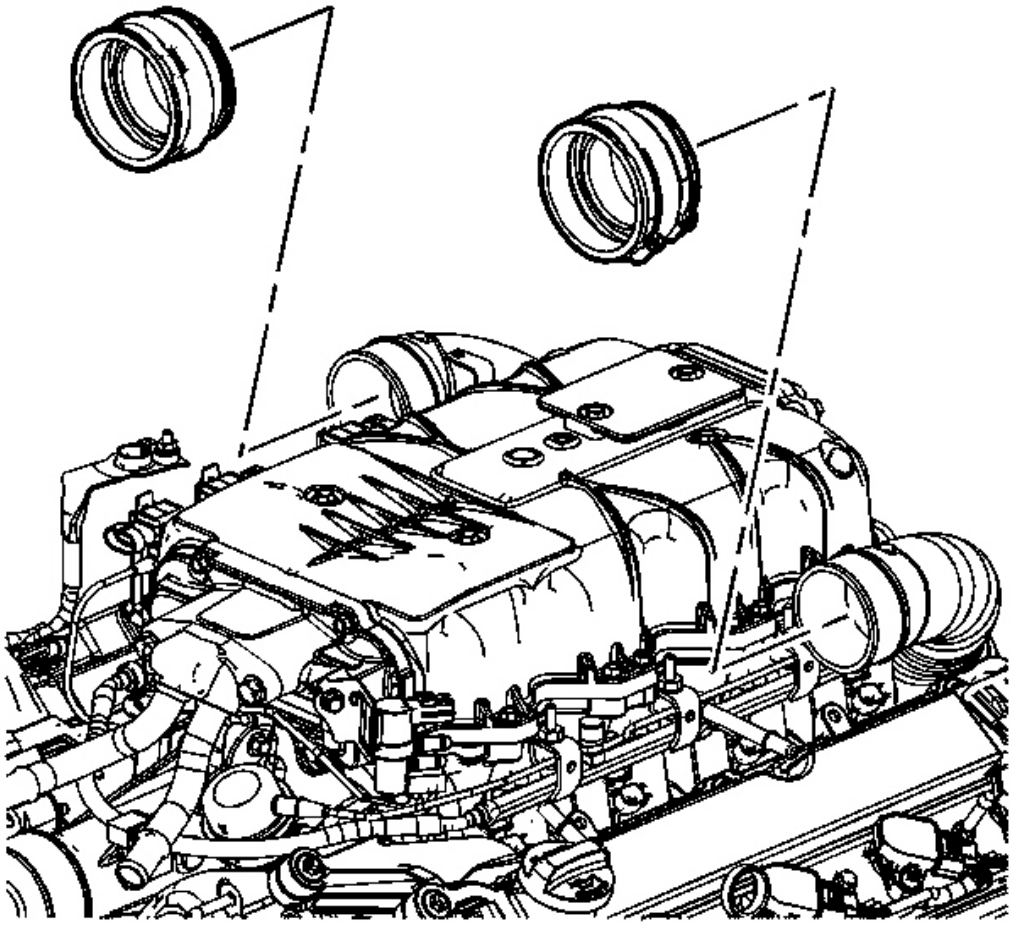


Fig. 111: Identifying Inlet Duct Seals
Courtesy of GENERAL MOTORS CORP.

6. Install the inlet duct seals.

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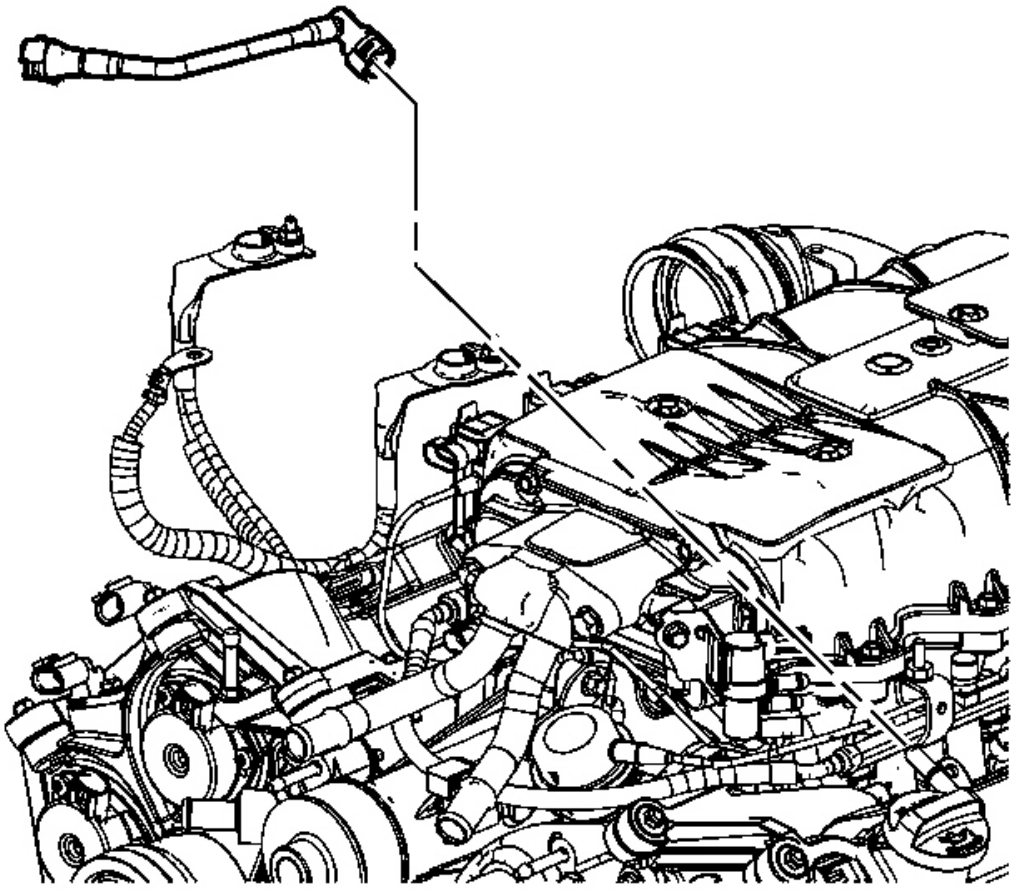


Fig. 112: Identifying Clean Air PCV Hose
Courtesy of GENERAL MOTORS CORP.

7. Install and connect the clean air positive crankcase ventilation (PCV) hose to the left camshaft cover fitting.

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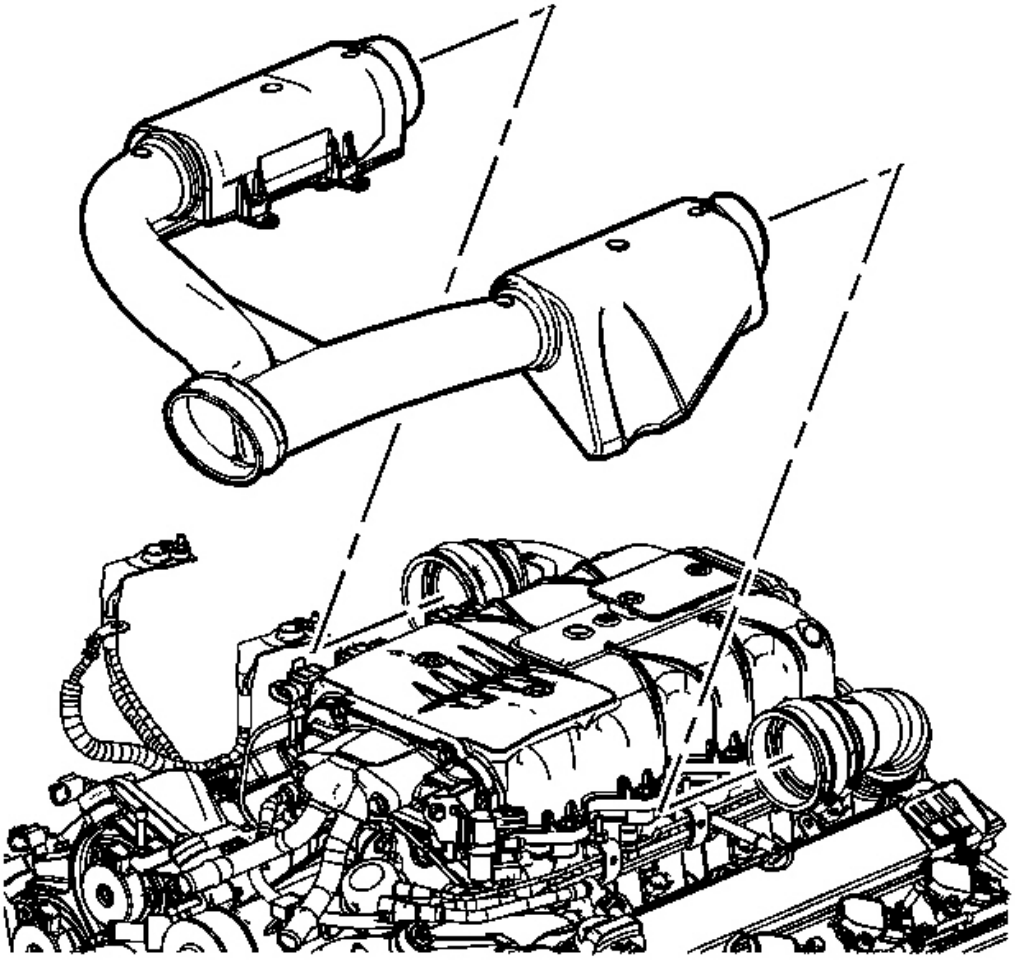


Fig. 113: View Of Front Air Duct
Courtesy of GENERAL MOTORS CORP.

8. Install the front air duct.

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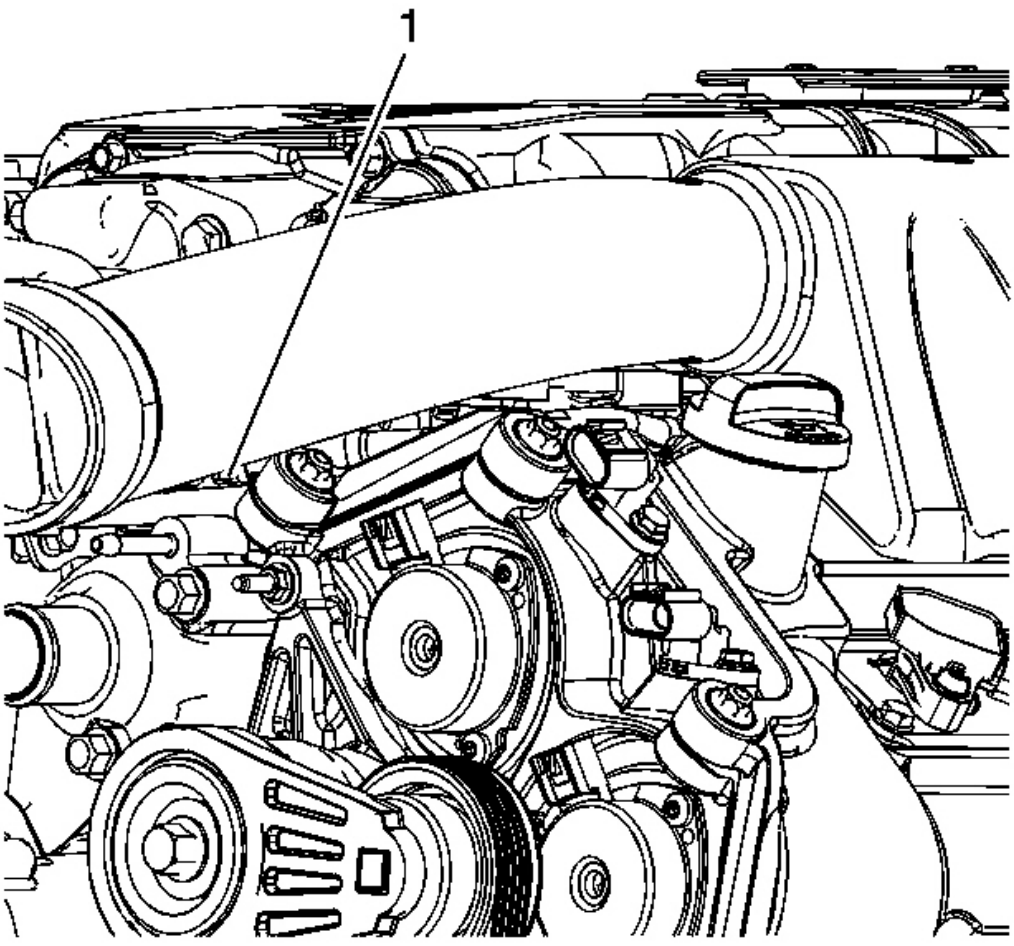


Fig. 114: Identifying PCV Hose
Courtesy of GENERAL MOTORS CORP.

9. Lift the front of the front air duct in order to access the clean air PCV hose connector at the bottom of the front air duct.
10. Connect the clean air PCV hose (1) to the front air duct.

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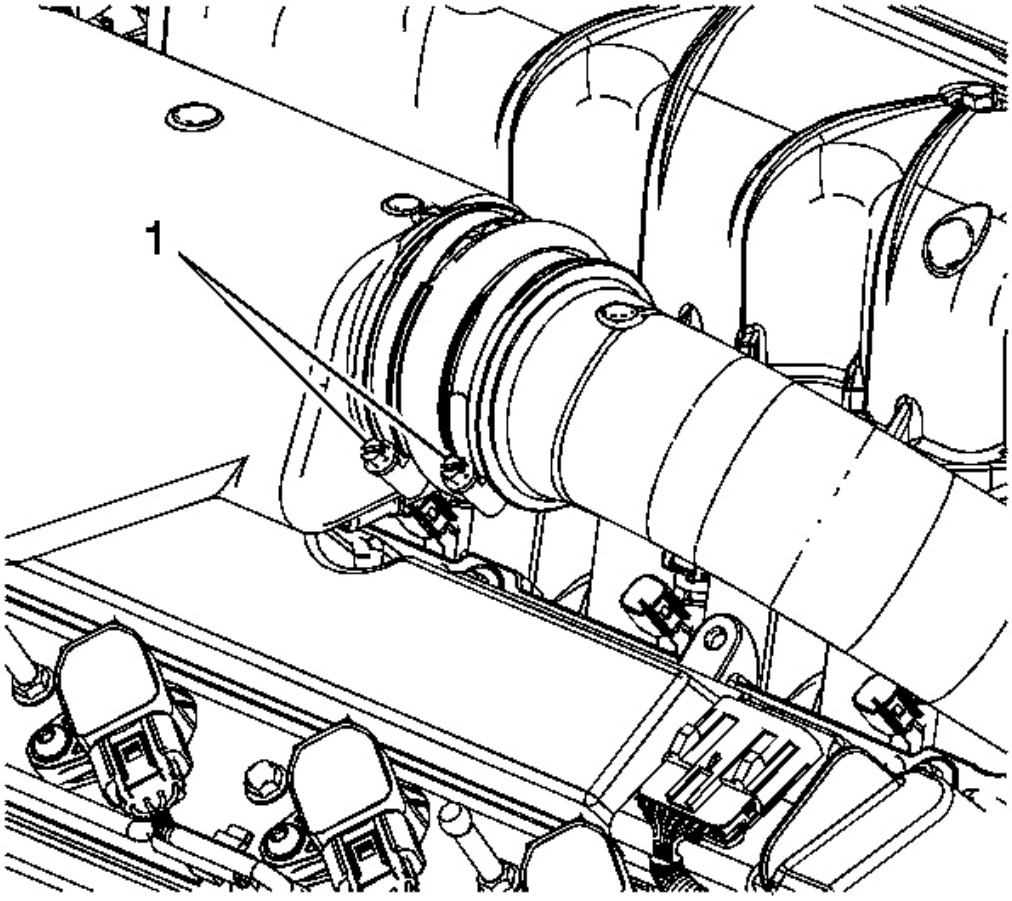


Fig. 115: Identifying Left Inlet Duct Seal And Clamp
Courtesy of GENERAL MOTORS CORP.

11. In order to leave clearance for the intake manifold sight shield align the left inlet duct seal and clamps (1) as shown.

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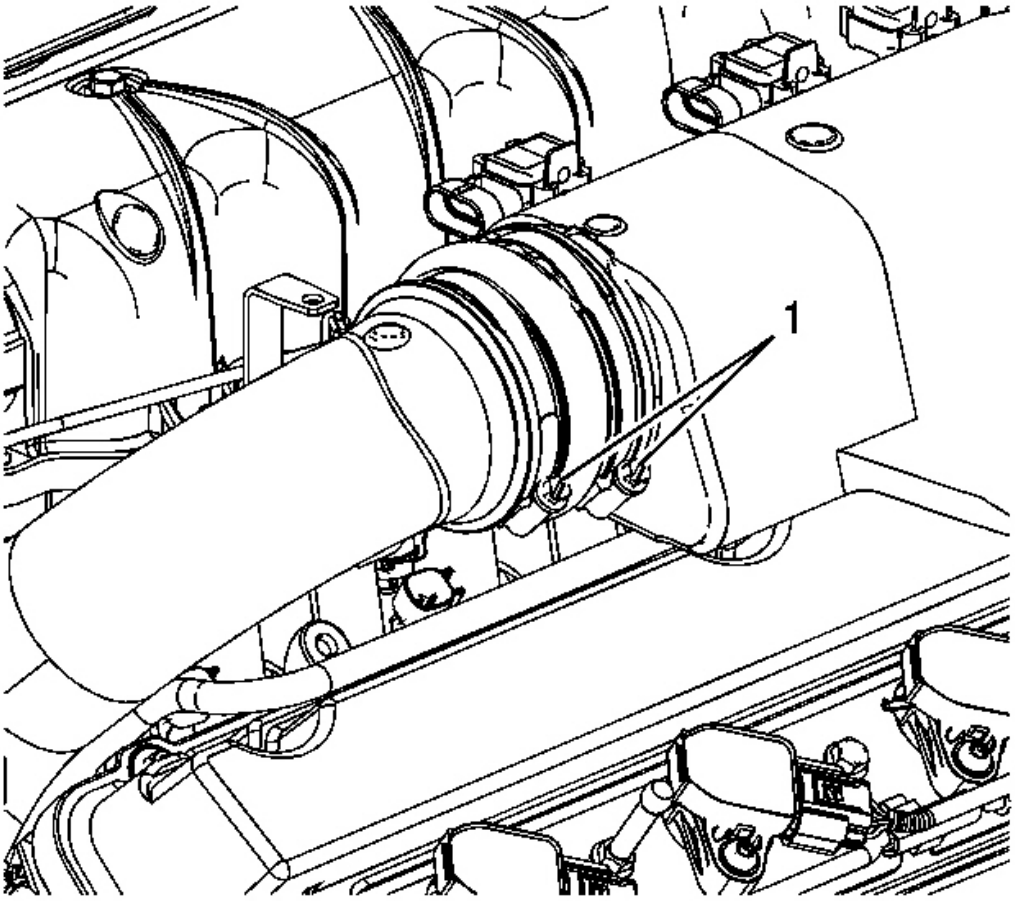


Fig. 116: Identifying Right Inlet Duct Seal And Clamp
Courtesy of GENERAL MOTORS CORP.

12. In order to leave clearance for the intake manifold sight shield align the right inlet duct seal and clamps (1) as shown.

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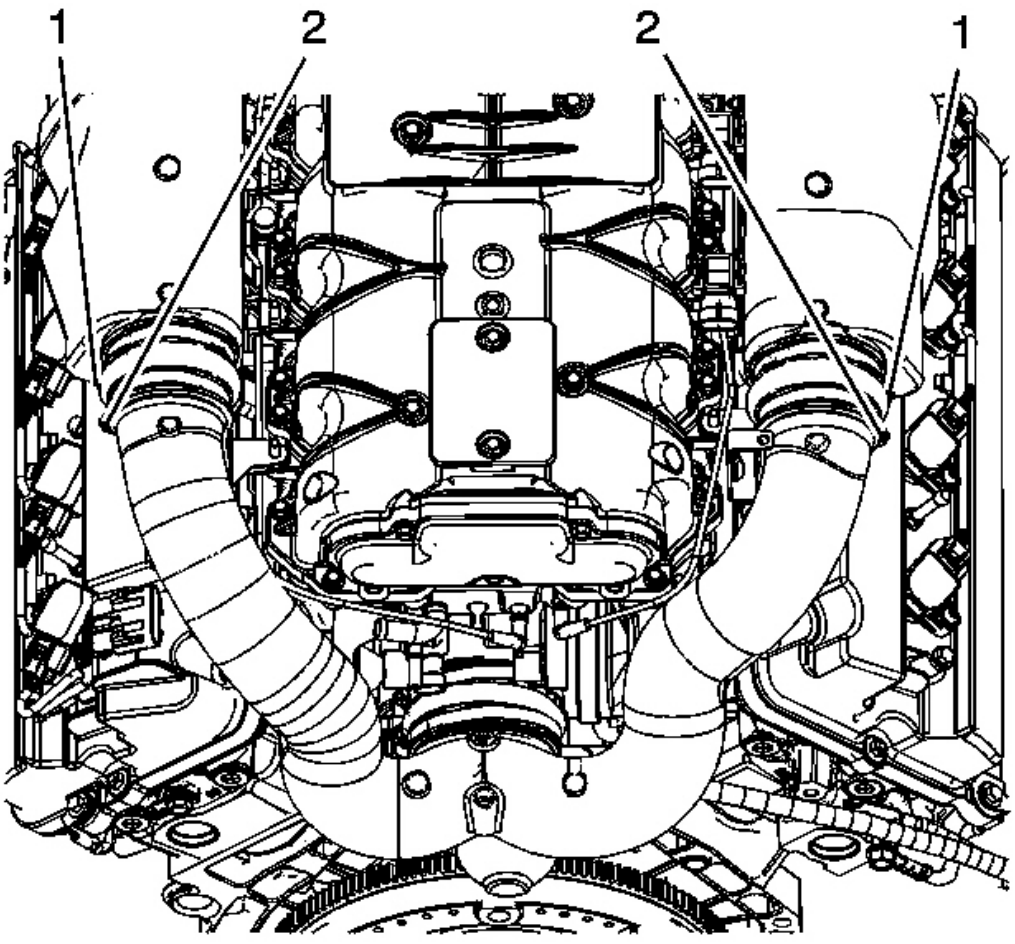


Fig. 117: Identifying Inlet Duct Seal Clamps
Courtesy of GENERAL MOTORS CORP.

13. Tighten the front screw clamps (1) on the inlet duct seals.

    Tighten: Tighten the screw clamps 3.25 N.m (29 lb in).

14. Tighten the rear screw clamps (2) on the inlet duct seals.

    Tighten: Tighten the screw clamps to 3.25 N.m (29 lb in).

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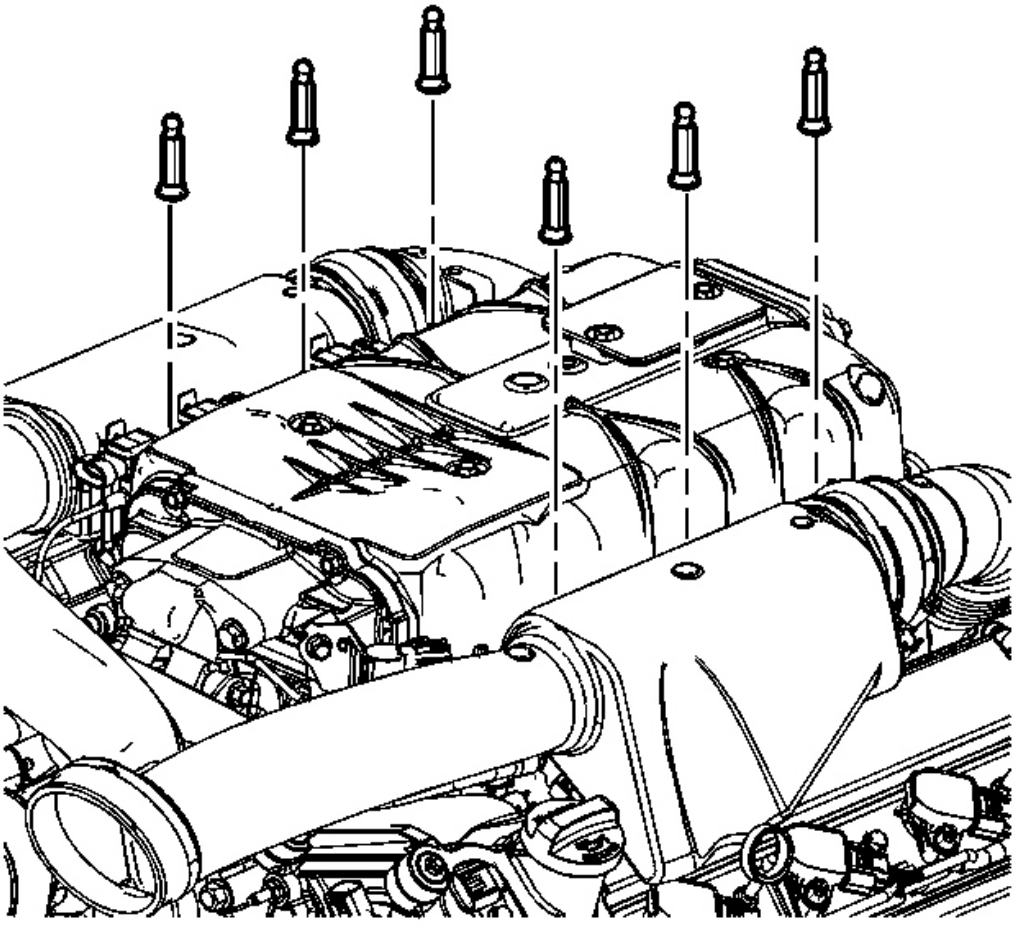


Fig. 118: Identifying Supercharger Inlet Duct Ball Stud
Courtesy of GENERAL MOTORS CORP.

15. Install the supercharger inlet duct ballstud nuts.

    Tighten: Tighten the supercharger inlet duct ballstud nuts to 10 N.m (89 lb in).

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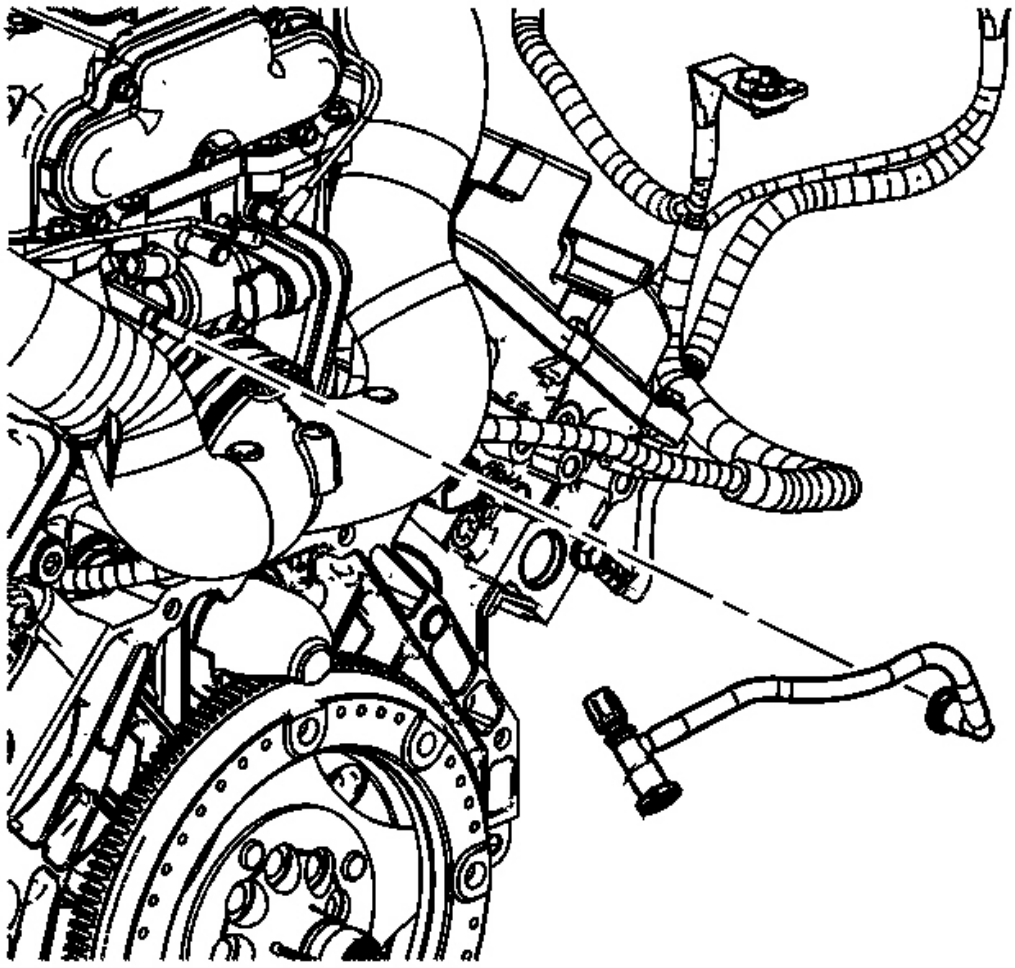


Fig. 119: Identifying EVAP Hose
Courtesy of GENERAL MOTORS CORP.

16. Install and connect the evaporative emissions (EVAP) hose.

ENGINE PRELUBING

TOOLS REQUIRED

- **EN-47971** Oil Pressure Gage Adapter. See **Special Tools** .
- **J 45299** Engine Preluber. See **Special Tools** .

PRELUBING PROCEDURE

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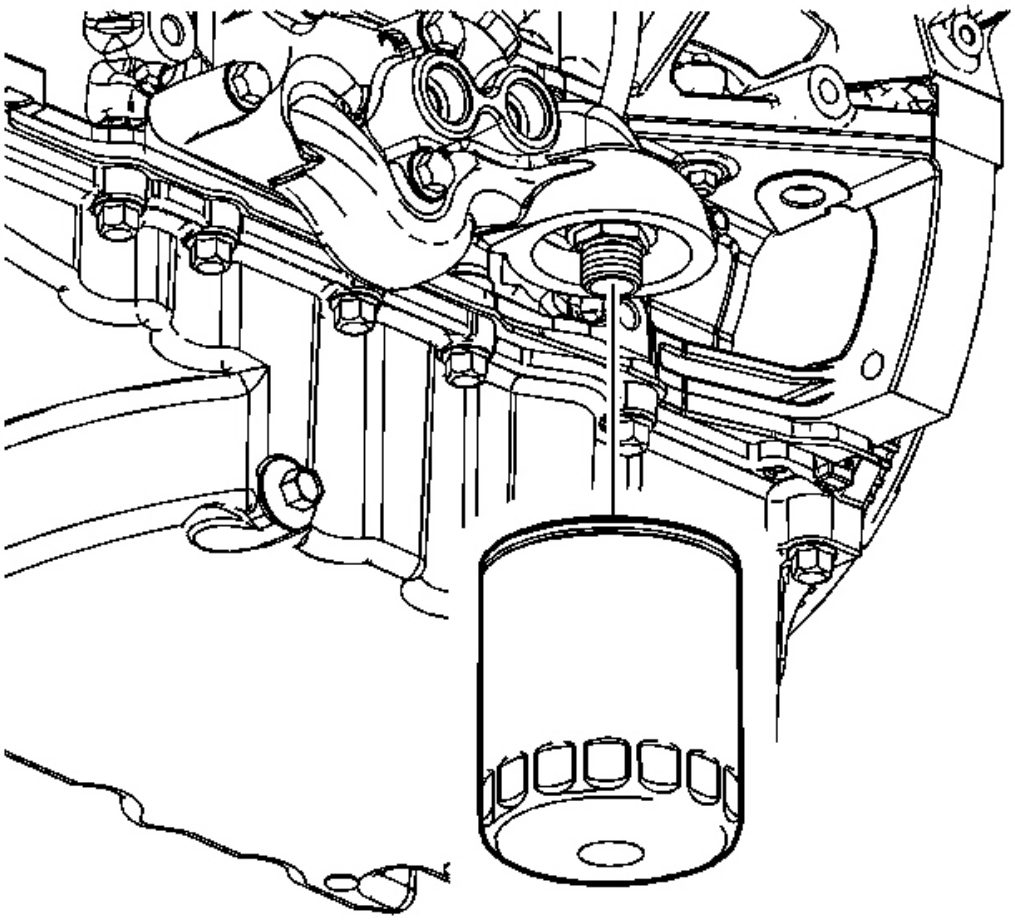


Fig. 120: Identifying Oil Filter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the oil cooler lines are disconnected and the oil filter adapter oil cooler line ports are blocked in order to direct the oil from the engine preluber into the engine.

1. Remove the engine oil filter.

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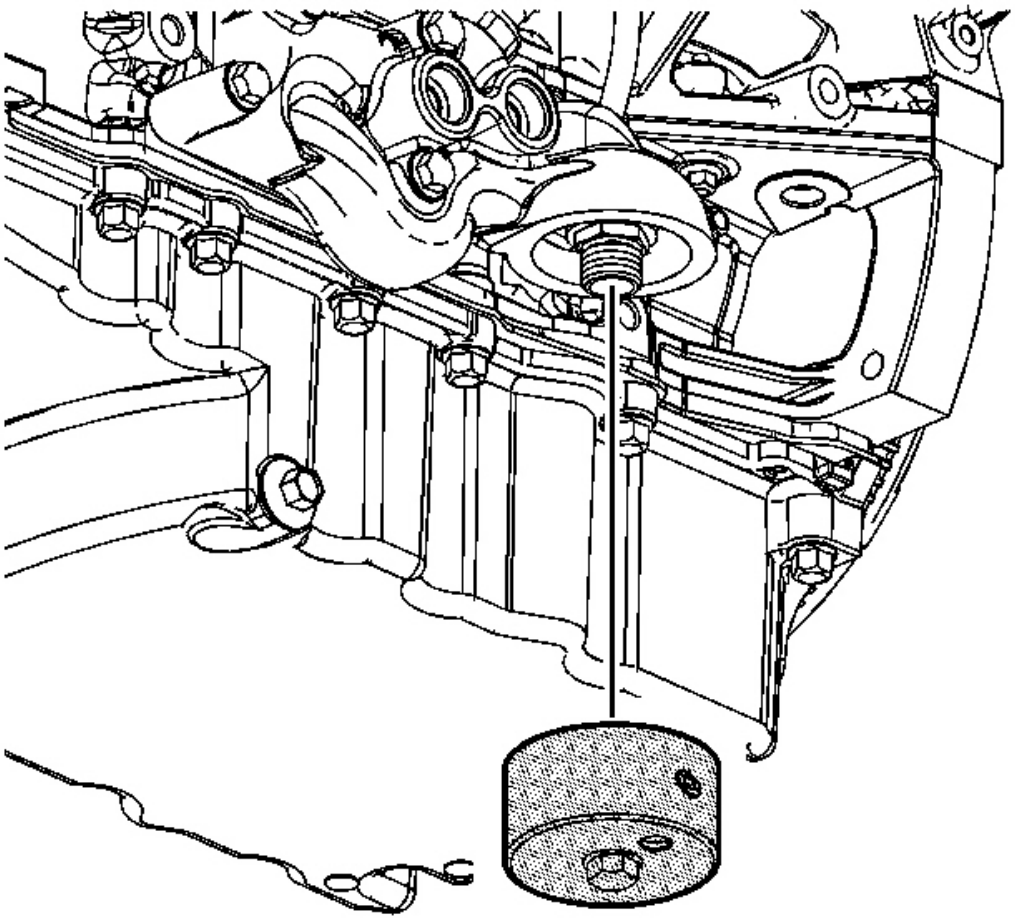


Fig. 121: View Of J 42907 Oil Pressure Tester
Courtesy of GENERAL MOTORS CORP.

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

2. Install the **EN-47971** onto the oil filter adapter. See **Special Tools** .

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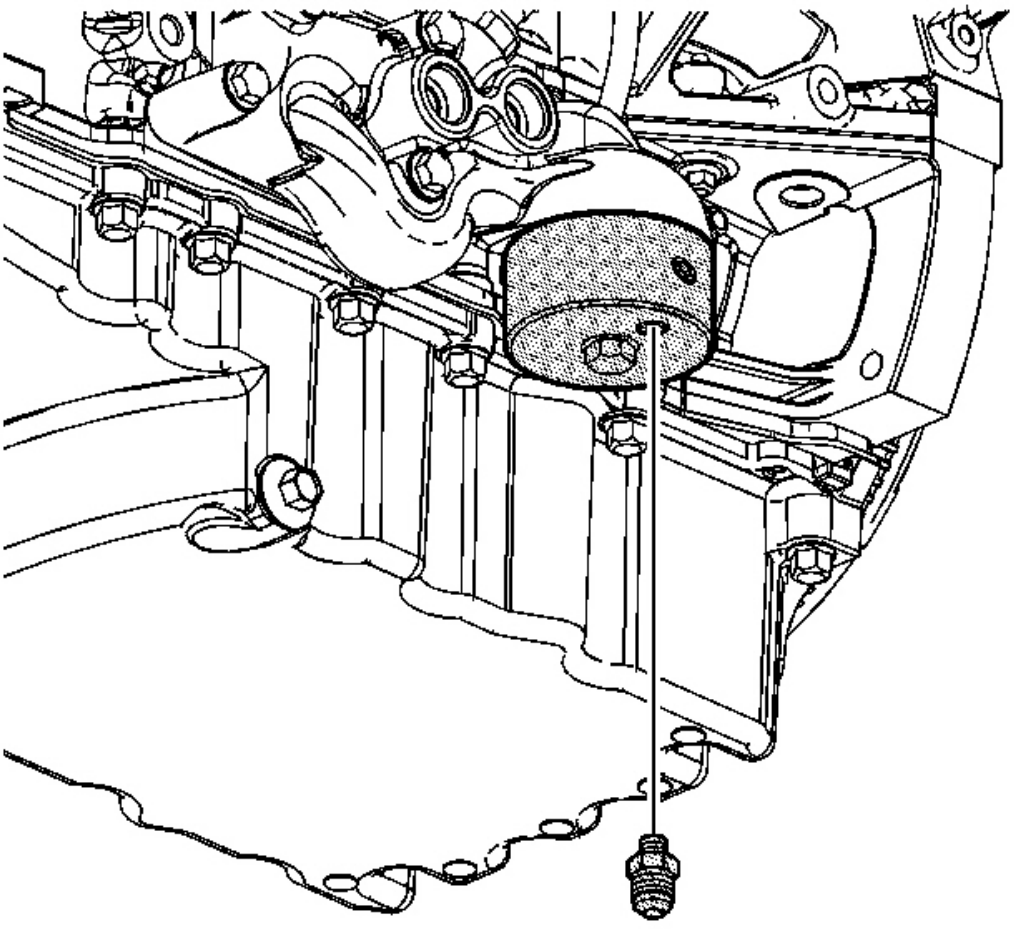


Fig. 122: Identifying NPT Fitting
Courtesy of GENERAL MOTORS CORP.

3. Install the 1/8 NPT fitting from the **J 45299** into the port on the **EN-47971** . See **Special Tools** .

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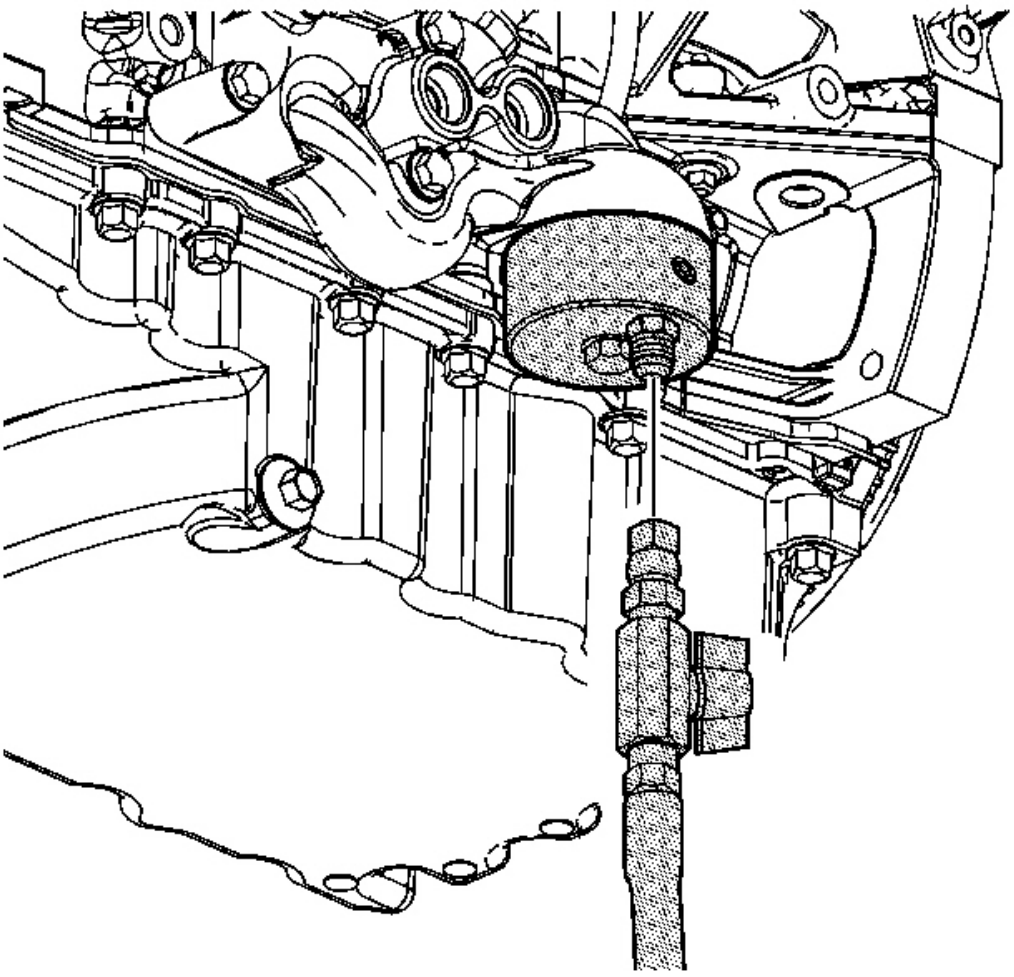


Fig. 123: Identifying J 45299 Flexible Hose
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 45299** flexible hose to the fitting. See **Special Tools** .

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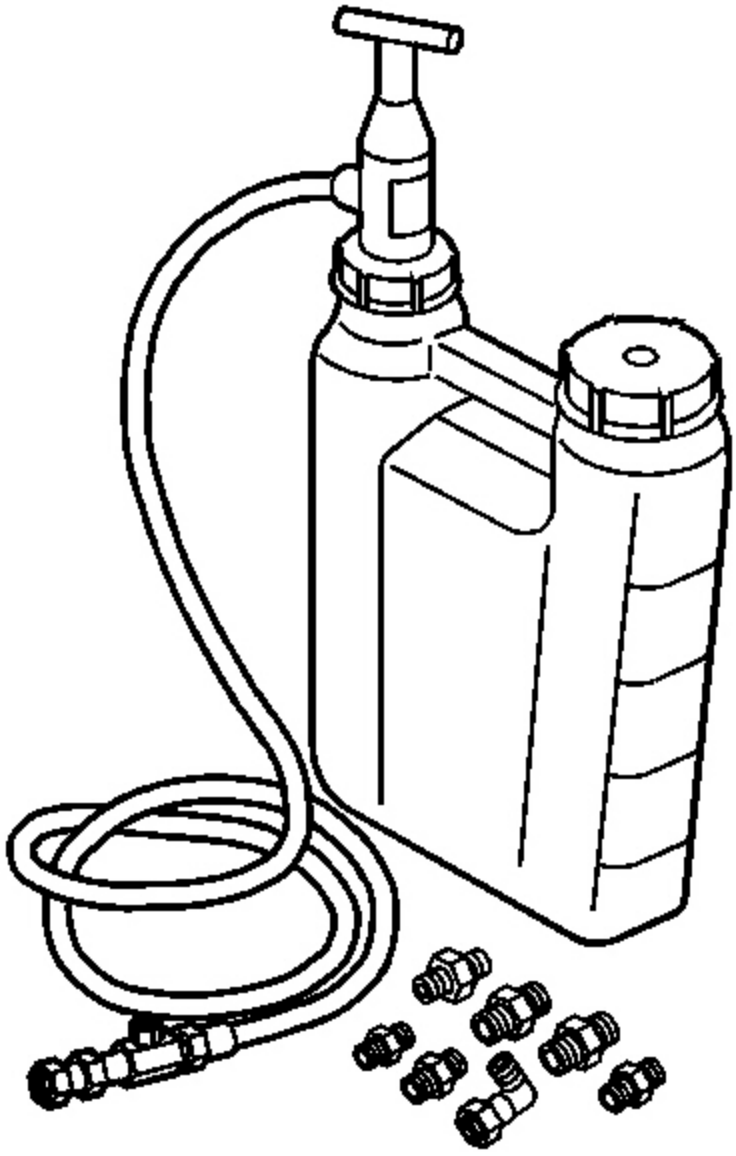


Fig. 124: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

5. Open the valve of the **J 45299** . See **Special Tools** .

IMPORTANT: A constant and continuous flow of clean engine oil is required in order to

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properly prime the engine. Use the approved engine oil as specified in the owner's manual.

6. Pump the handle of the**J 45299** in order to flow a minimum of 1-1. See **Special Tools** .9 liters (1-2 quarts) of fresh clean engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
7. Close the valve of the **J 45299** . See **Special Tools** .

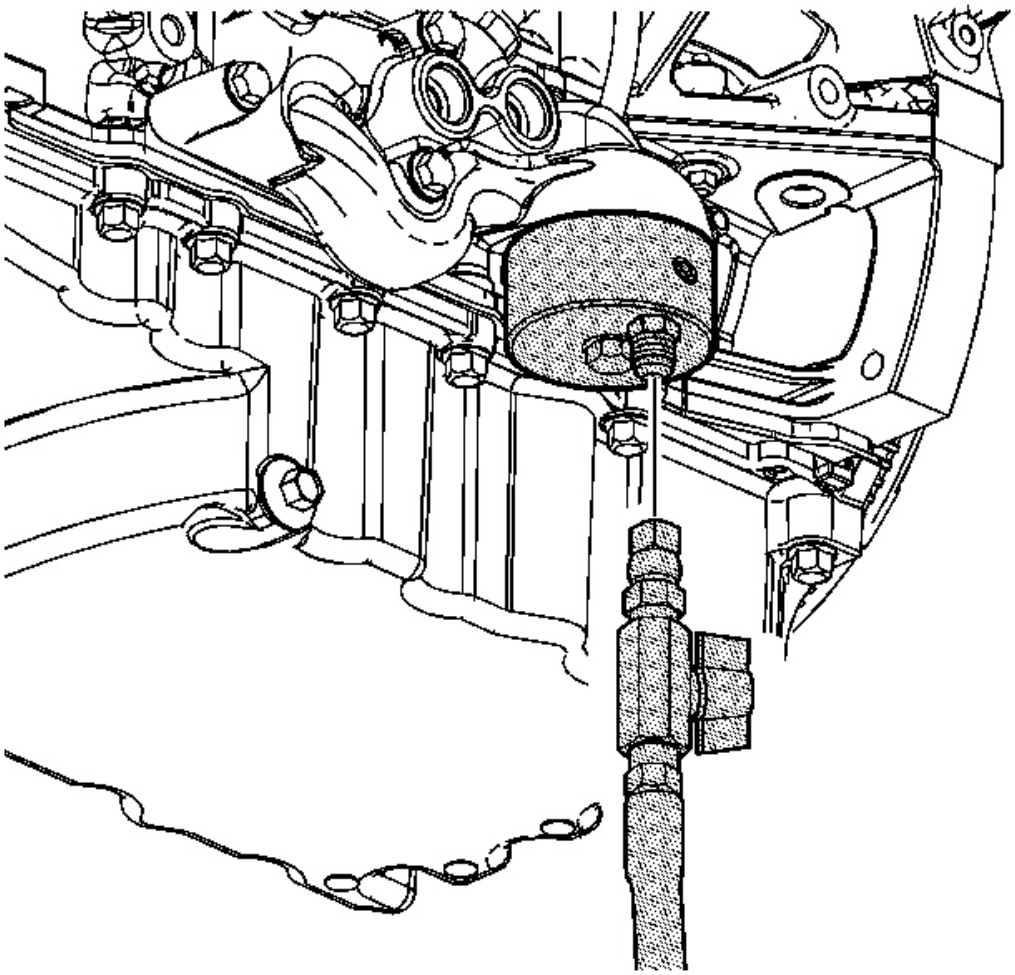


Fig. 125: Identifying J 45299 Flexible Hose
Courtesy of GENERAL MOTORS CORP.

8. Remove the **J 45299** flexible hose. See **Special Tools** .

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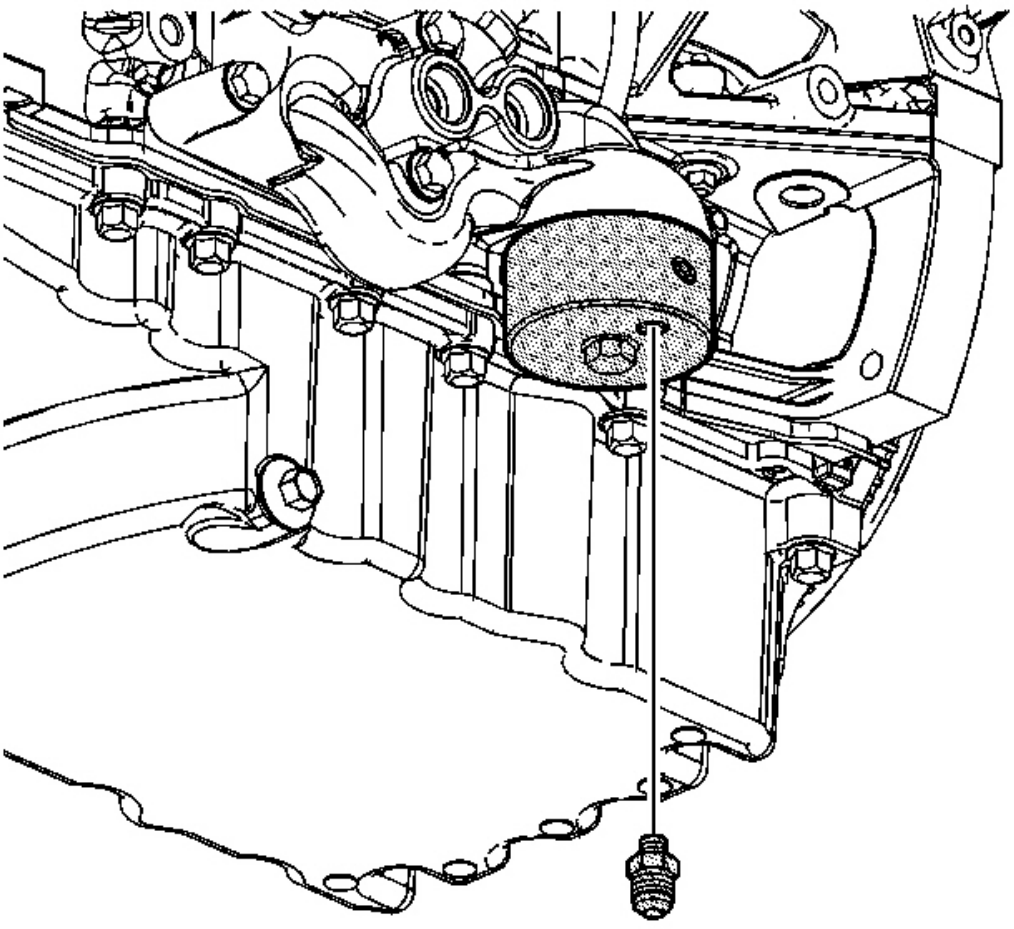


Fig. 126: Identifying NPT Fitting
Courtesy of GENERAL MOTORS CORP.

9. Remove the fitting from the **EN-47971** . See **Special Tools** .

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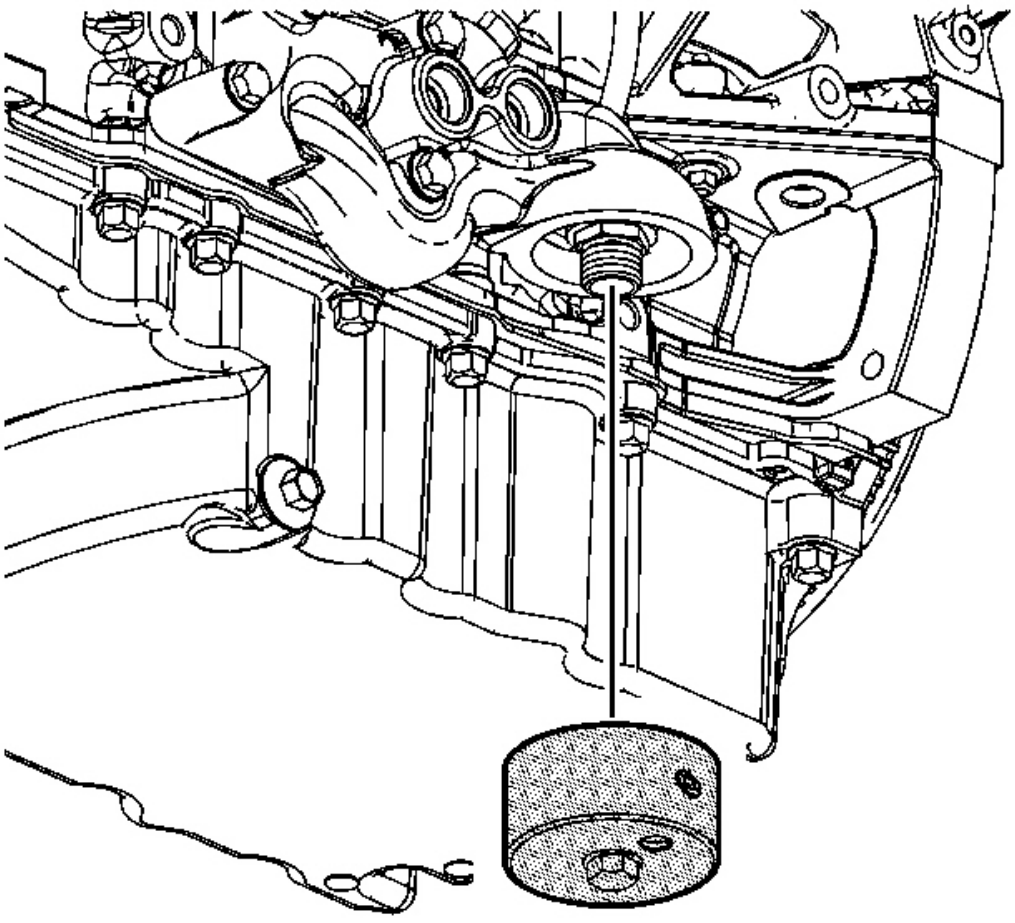


Fig. 127: View Of J 42907 Oil Pressure Tester
Courtesy of GENERAL MOTORS CORP.

10. Remove the **EN-47971** from the oil filter adapter. See **Special Tools** .

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

11. Ensure the NEW oil filter is filled with clean fresh engine oil.

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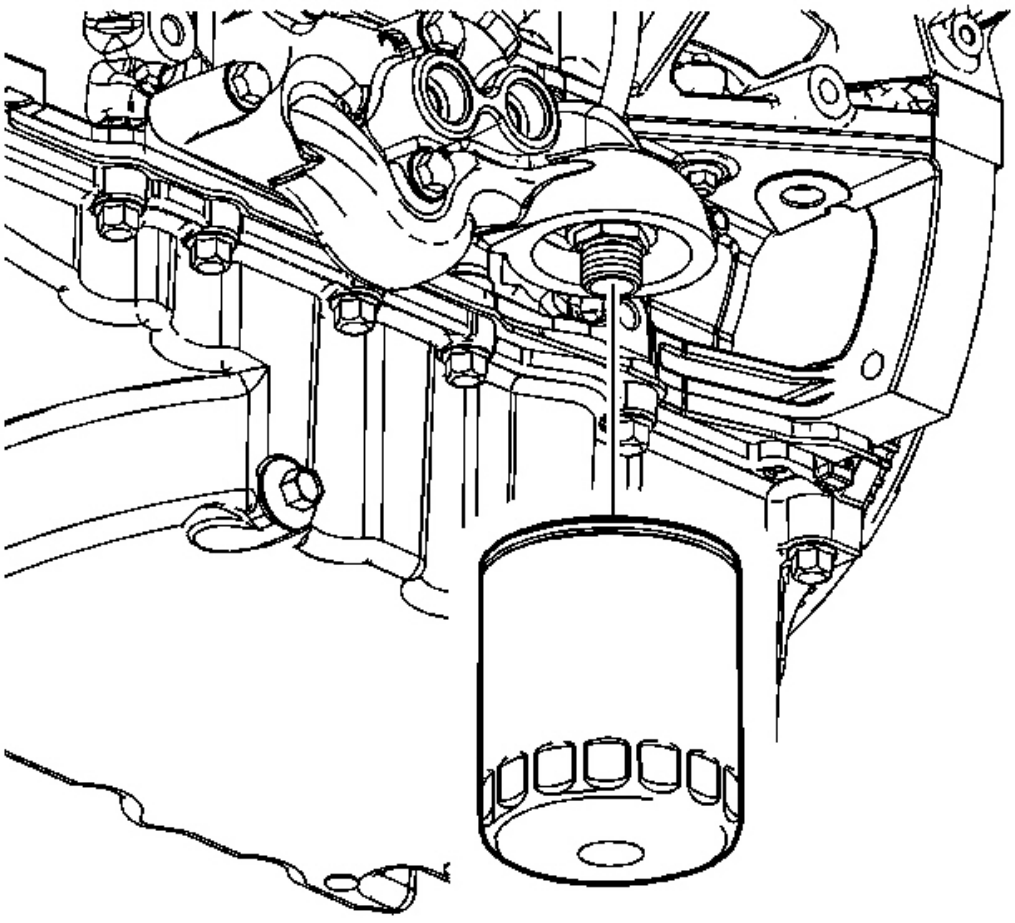


Fig. 128: Identifying Oil Filter
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

12. Install the NEW oil filter.

    Tighten: Tighten the oil filter to 32 N.m (24 lb ft).

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2007 ENGINE

Engine Mechanical - 4.4L - XLR

SUPERCHARGER BELT REPLACEMENT

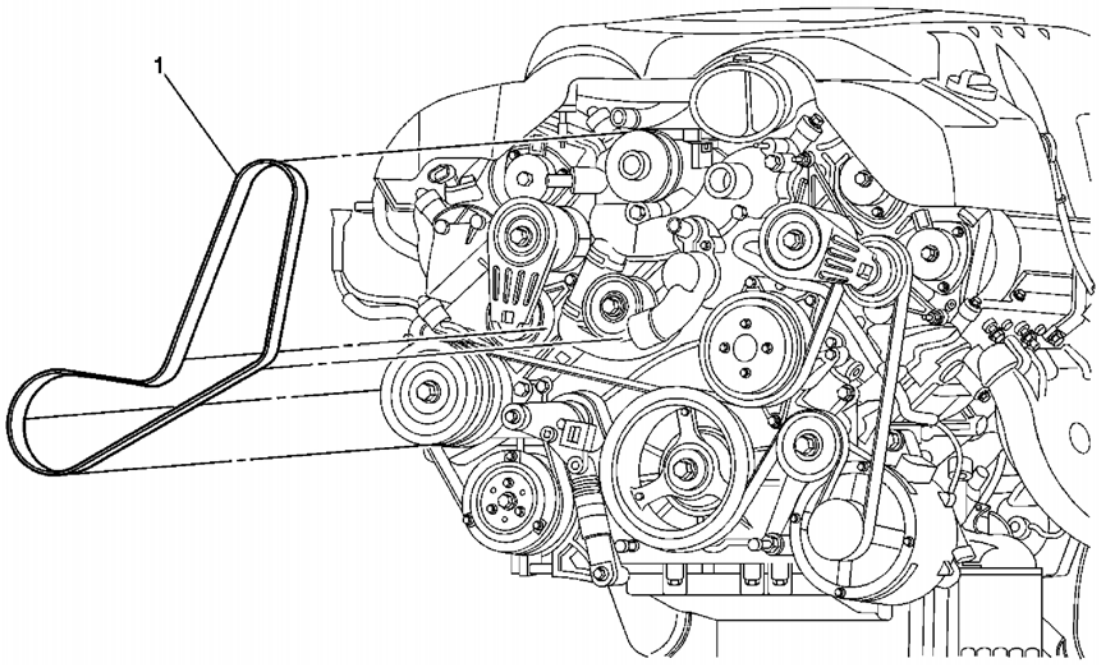


Fig. 1: View Of Supercharger Belt
Courtesy of GENERAL MOTORS CORP.

Supercharger Belt Replacement

Callout	Component Name
Fastener Tightening Specifications: Refer to **Fastener Tightening Specifications** . **Preliminary Procedures:** Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .	
1	Supercharger Drive Belt **Tip:** • Rotate the tensioner in a clockwise direction. • Ensure the drive belt is properly aligned and seated into the grooves of the accessory drive pulleys.

WATER PUMP AND GENERATOR BELT REPLACEMENT

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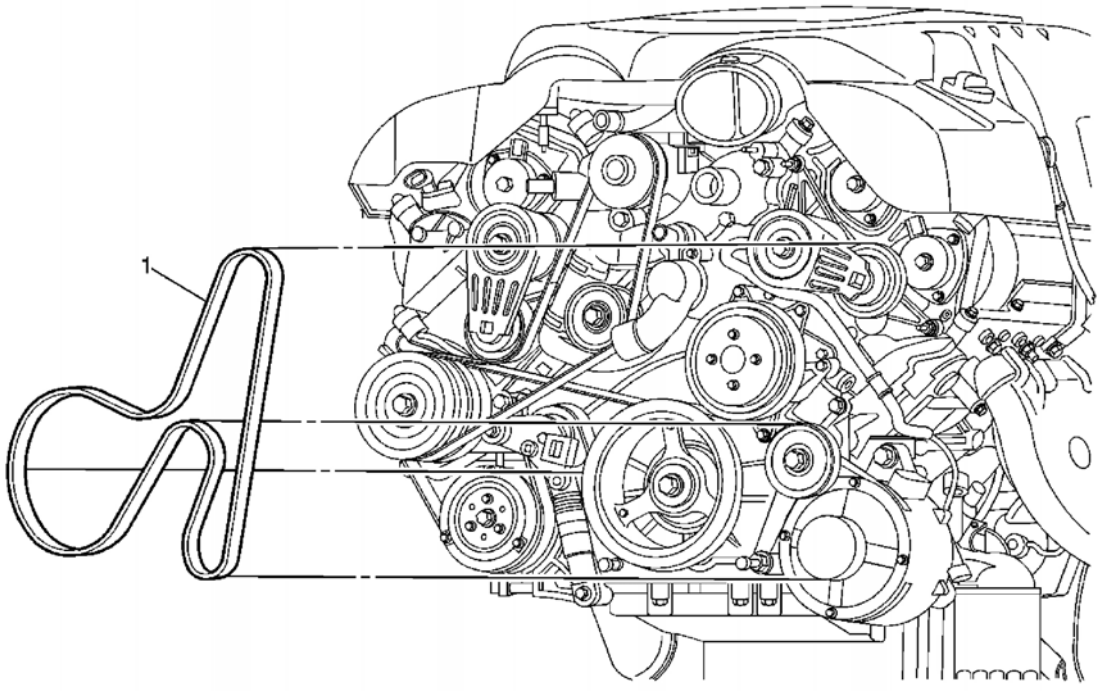


Fig. 2: View Of Water Pump & Generator Belt
Courtesy of GENERAL MOTORS CORP.

Water Pump and Generator Belt Replacement

Callout	Component Name
Fastener Tightening Specifications: Refer to **Fastener Tightening Specifications** . **Preliminary Procedures** 1. Remove the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**. 2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .	
1	Water Pump and Generator Drive Belt **Tip:** • Rotate the tensioner in a clockwise direction. • Ensure the drive belt is properly aligned and seated into the grooves of the accessory drive pulleys.

AIR CONDITIONING COMPRESSOR AND POWER STEERING PUMP BELT REPLACEMENT

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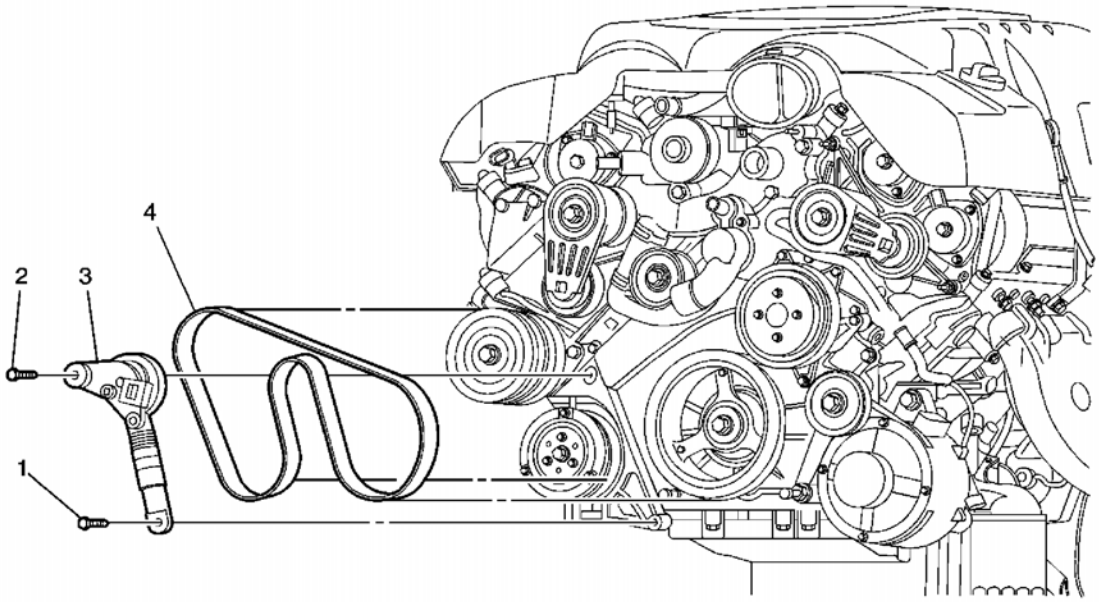


Fig. 3: View Of A/C Compressor & Power Steering Pump Belt
Courtesy of GENERAL MOTORS CORP.

Air Conditioning Compressor and Power Steering Pump Belt Replacement

Callout	Component Name
Preliminary Procedures 1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** . 2. Remove the water pump and generator drive belt. Refer to **Water Pump and Generator Belt Replacement**. 3. Remove the supercharger drive belt. Refer to **Supercharger Belt Replacement**. 4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .	
1	Air Conditioner Drive Belt Tensioner Bolt **NOTE:** **Refer to Fastener Notice .** **Tip:** Access this bolt from under the vehicle. **Tighten:** 25 N.m (18 lb ft)
2	Air Conditioner Drive Belt Tensioner Bolt **Tighten:** 25 N.m (18 lb ft)

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	Tip: Access the bolt from under the vehicle.
3	Air Conditioner Drive Belt Tensioner Assembly **Tip:** • Rotate the tensioner in a clockwise direction during belt removal and installation. • Relieve the tension, rotate the belt slack downward and remove the drive belt from the air conditioning compressor pulley. • Use care not to pinch the belt between the tensioner pulley and the air conditioning compressor pulley. • Remove the tensioner assembly in order to remove the drive belt from the vehicle.
4	Air Conditioning and Power Steering Drive Belt **Tip:** • Rotate the tensioner in a clockwise direction during belt removal and installation. • Relieve the tension, rotate the belt slack downward and remove the drive belt from the air conditioning compressor pulley. • Remove the tensioner assembly in order to remove the drive belt from the vehicle. • Ensure the drive belt is properly aligned and seated into the grooves of the accessory drive pulleys.

DRIVE BELT TENSIONER REPLACEMENT - SUPERCHARGER

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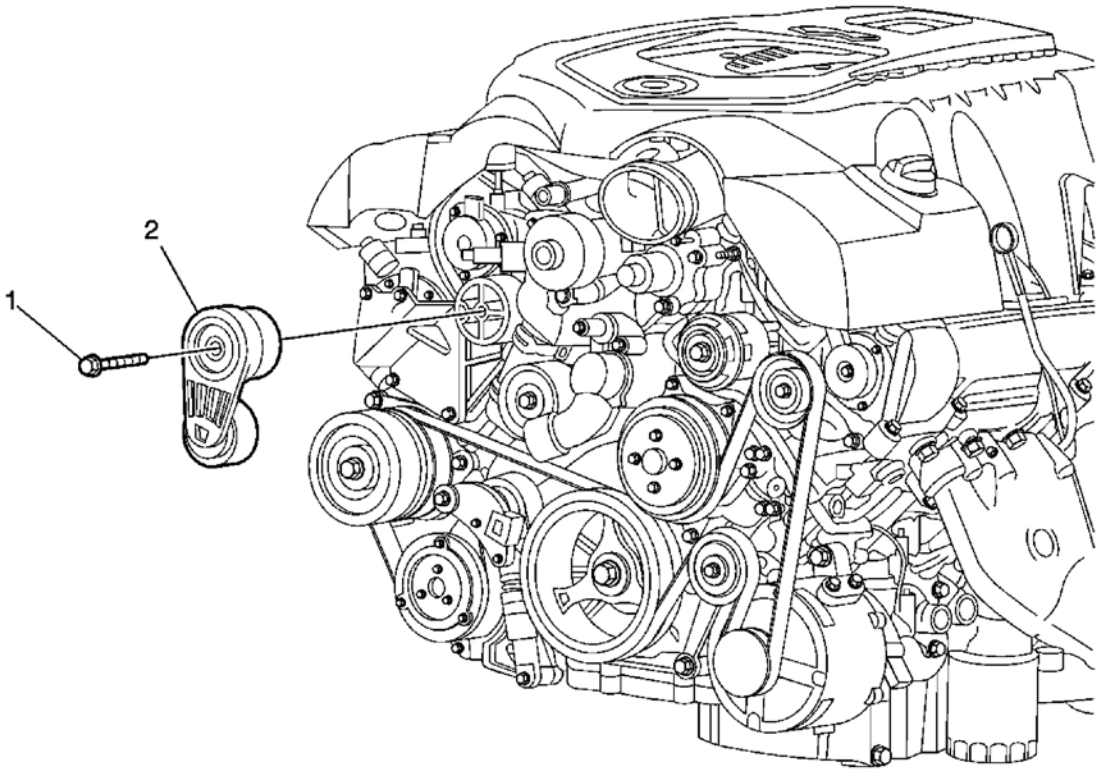


Fig. 4: View Of Supercharger Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

Drive Belt Tensioner Replacement - Supercharger

Callout	Component Name
Preliminary Procedures 1. Remove the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**. 2. Remove the supercharger drive belt. Refer to **Supercharger Belt Replacement**.	
1	Drive Belt Tensioner Assembly Bolt **NOTE:** **Refer to Fastener Notice .** **Tighten:** 50 N.m (37 lb ft)
2	Drive Belt Tensioner Assembly **Tip:** • Rotate the tensioner in a clockwise direction during belt removal and installation. • Ensure that the alignment pin on the rear of the tensioner assembly is aligned with the locating hole on the camshaft actuator housing during installation and torque procedure.

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WATER PUMP AND GENERATOR DRIVE BELT TENSIONER REPLACEMENT

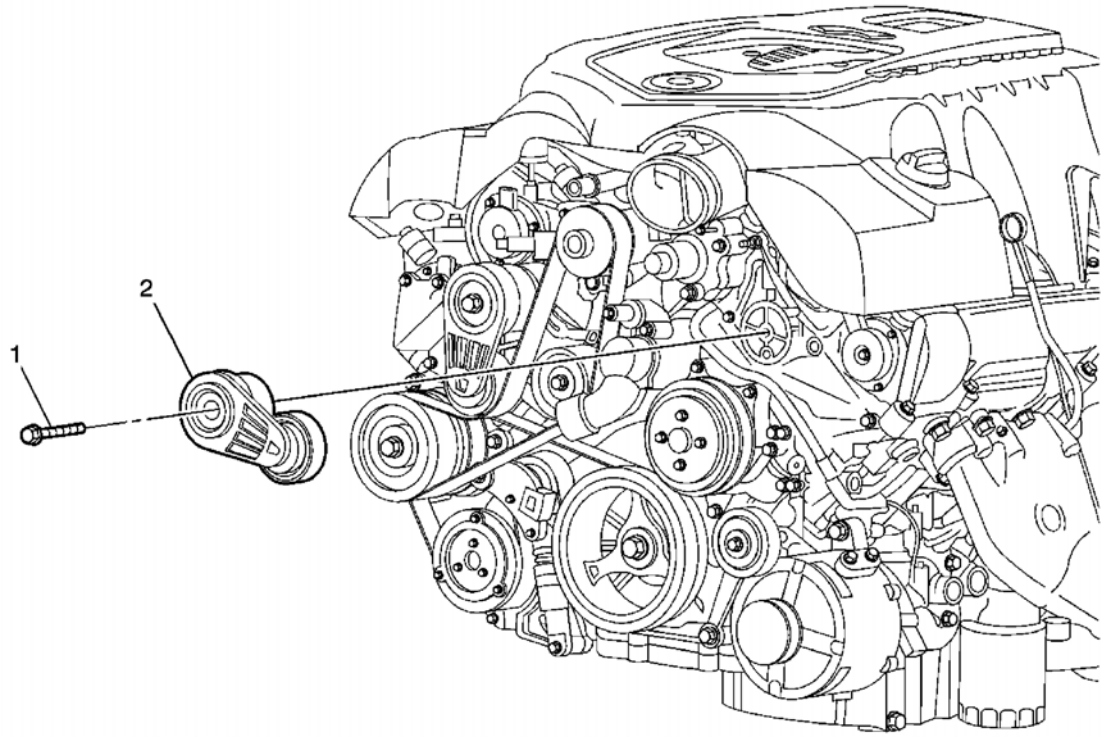


Fig. 5: View Of Water Pump & Generator Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

Water Pump and Generator Drive Belt Tensioner Replacement

Callout	Component Name
Preliminary Procedures 1. Remove the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**. 2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** . 3. Remove the water pump and generator drive belt. Refer to **Water Pump and Generator Belt Replacement**.	
1	Drive Belt Tensioner Assembly Bolt **NOTE:** **Refer to Fastener Notice .** **Tighten:** 50 N.m (37 lb ft)
	Drive Belt Tensioner Assembly **Tip:**

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2	• Rotate the tensioner in a clockwise direction during belt removal and installation. • Remove and install the tensioner and bolt as an assembly. • Ensure that the alignment pin on the rear of the tensioner assembly is aligned with the locating hole on the camshaft actuator housing during installation and torque procedure.

AIR CONDITIONING COMPRESSOR BELT TENSIONER REPLACEMENT

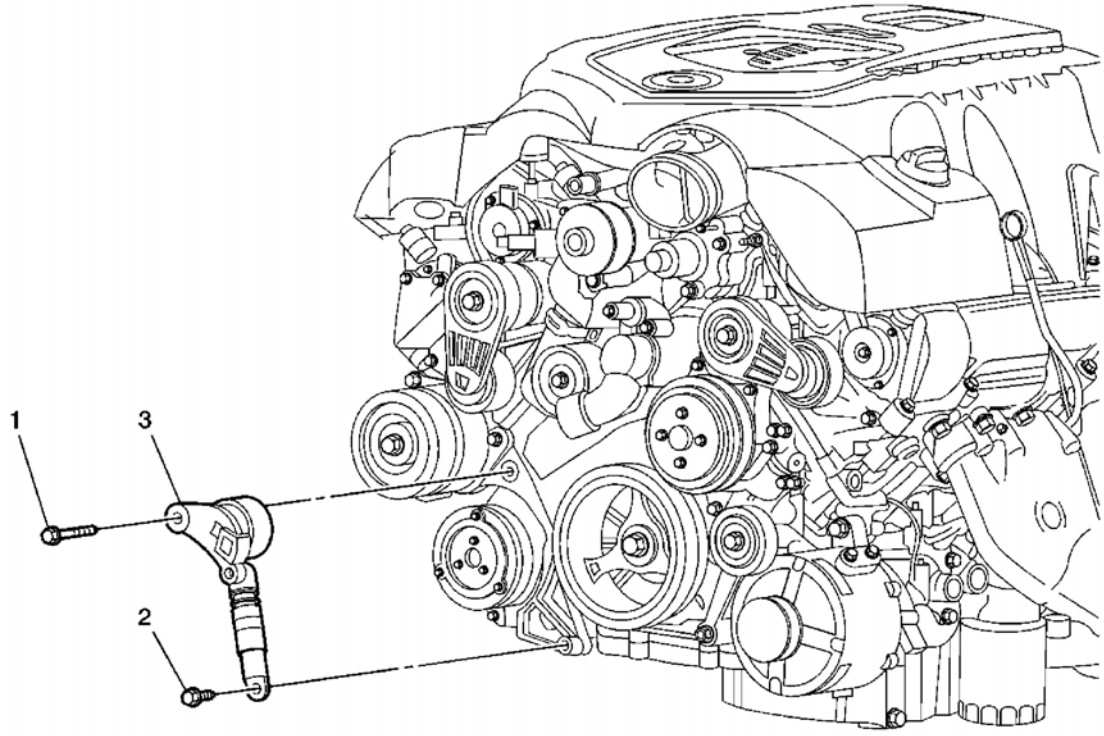


Fig. 6: View Of A/C Compressor Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

Air Conditioning Compressor Belt Tensioner Replacement

Callout	Component Name
NOTE: **Refer to Fastener Notice .** **Fastener Tightening Specifications:** Refer to **Fastener Tightening Specifications** . **Preliminary Procedures** 1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .	

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2. Remove the water pump and generator drive belt. Refer to **Water Pump and Generator Belt Replacement**.
3. Remove the supercharger drive belt. Refer to **Supercharger Belt Replacement**.
4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

1	Air Conditioner Drive Belt Tensioner Bolt **Tighten:** 25 N.m (18 lb ft) **Tip:** Access the bolt from under the vehicle.
2	Air Conditioner Drive Belt Tensioner Bolt **Tighten:** 25 N.m (18 lb ft) **Tip:** Access the bolt from under the vehicle.
3	Air Conditioner Drive Belt Tensioner Assembly **Tip:** • Rotate the tensioner in a clockwise direction during belt removal and installation. • Relieve the tension, rotate the belt slack downward and remove the drive belt from the air conditioning compressor pulley. • Use care not to pinch the belt between the tensioner pulley and the air conditioning compressor pulley.

SUPERCHARGER BELT IDLER PULLEY REPLACEMENT

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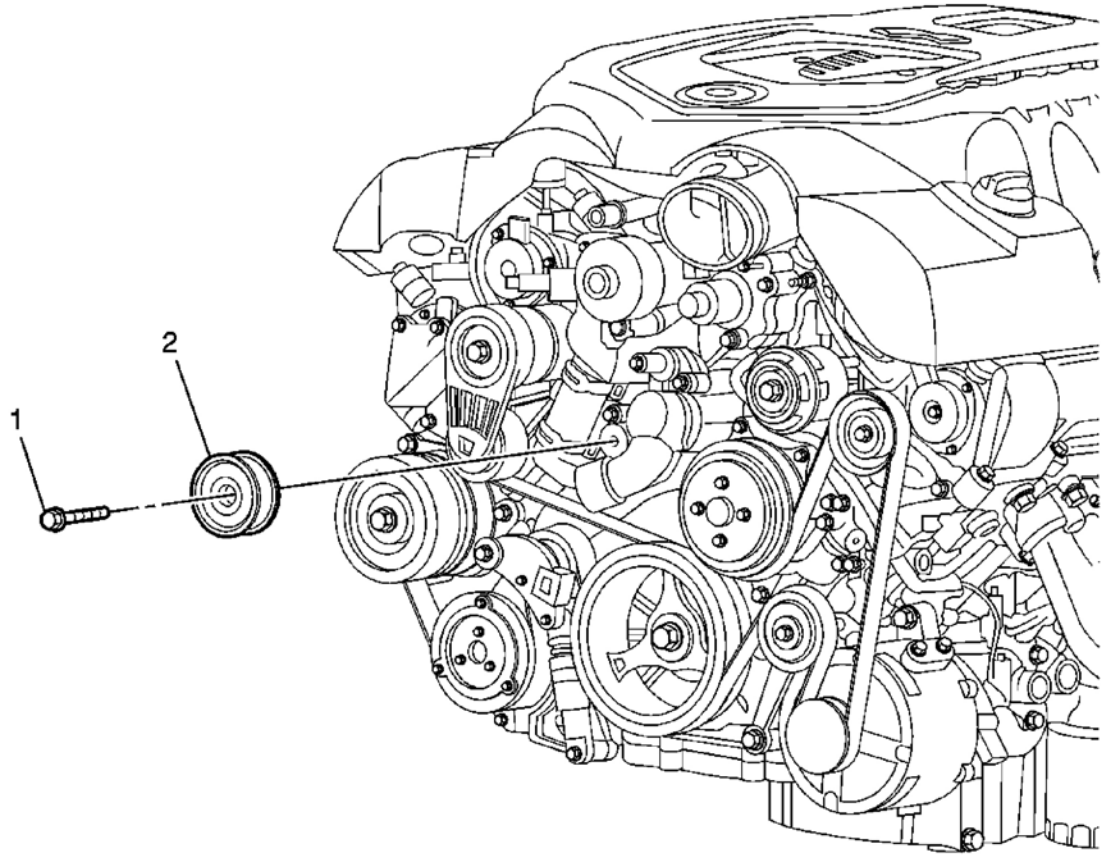


Fig. 7: View Of Supercharger Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

Supercharger Belt Idler Pulley Replacement

Callout	Component Name
Preliminary Procedures: Remove the supercharger drive belt. Refer to **Supercharger Belt Replacement**.	
1	Drive Belt Idler Pulley Bolt **NOTE:** **Refer to Fastener Notice .** **Tighten:** 50 N.m (37 lb ft)
2	Drive Belt Idler Pulley **Tip:** If the pulley and bolt bottom out on the bypass hose, reach behind the pulley and thread the spacer clockwise. Remove the pulley and bolt as an assembly.

WATER PUMP AND GENERATOR BELT IDLER PULLEY REPLACEMENT

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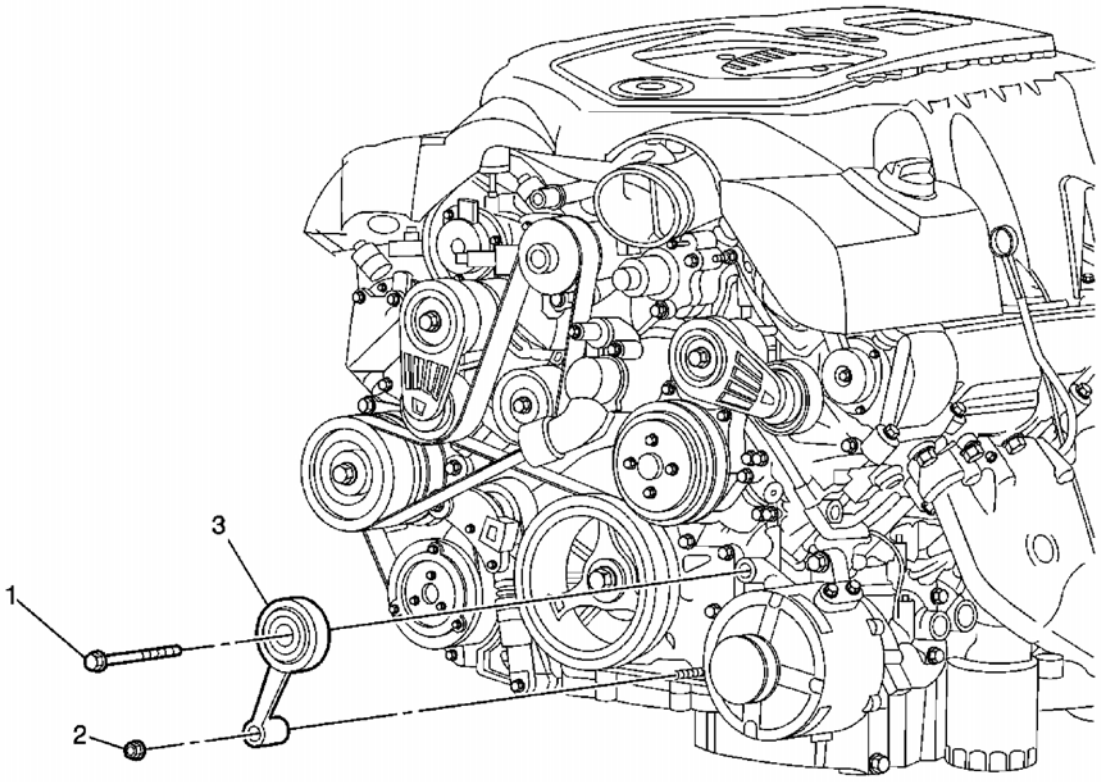


Fig. 8: View Of Water Pump & Generator Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

Water Pump and Generator Belt Idler Pulley Replacement

Callout	Component Name
Preliminary Procedures 1. Remove the water pump and generator drive belt. Refer to **Water Pump and Generator Belt Replacement**. 2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .	
1	Drive Belt Idler Pulley Bolt **NOTE:** **Refer to Fastener Notice .** **Tighten:** 50 N.m (37 lb ft)
2	Drive Belt Idler Pulley Nut **Tighten:** 50 N.m (37 lb ft)
3	Drive Belt Idler Pulley

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ENGINE SUPPORT FIXTURE

TOOLS REQUIRED

J 28467-81 Engine Support Fixture Kit. See **Special Tools** .

INSTALLATION PROCEDURE

1. Remove the hood. Refer to **Hood Replacement** .
2. Remove the engine cover. Refer to **Intake Manifold Sight Shield Replacement**.
3. Disconnect the negative battery cable from the battery. Refer to **Battery Negative Cable Disconnection and Connection** .

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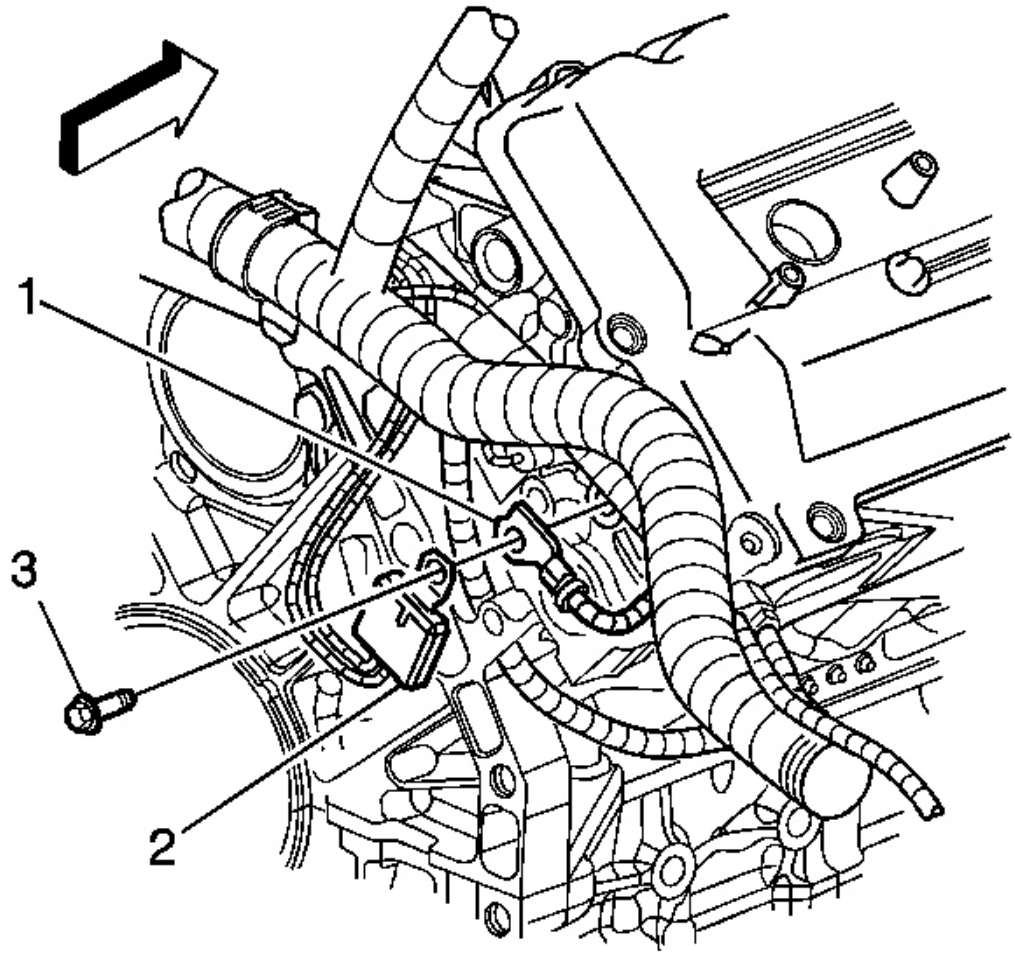


Fig. 9: View Of Battery Cable Bolt & Engine Harness Ground Pack
Courtesy of GENERAL MOTORS CORP.

4. Remove the battery negative cable bolt (3) from the RH rear of cylinder head. Position the battery negative cable (1) and ground junction (2) aside.
5. Remove the camshaft cover ground strap from the camshaft cover. Position the ground strap aside.
6. Remove the plastic wire harness protector from the frame rail pinch weld to provide clearance for the engine lift hook.

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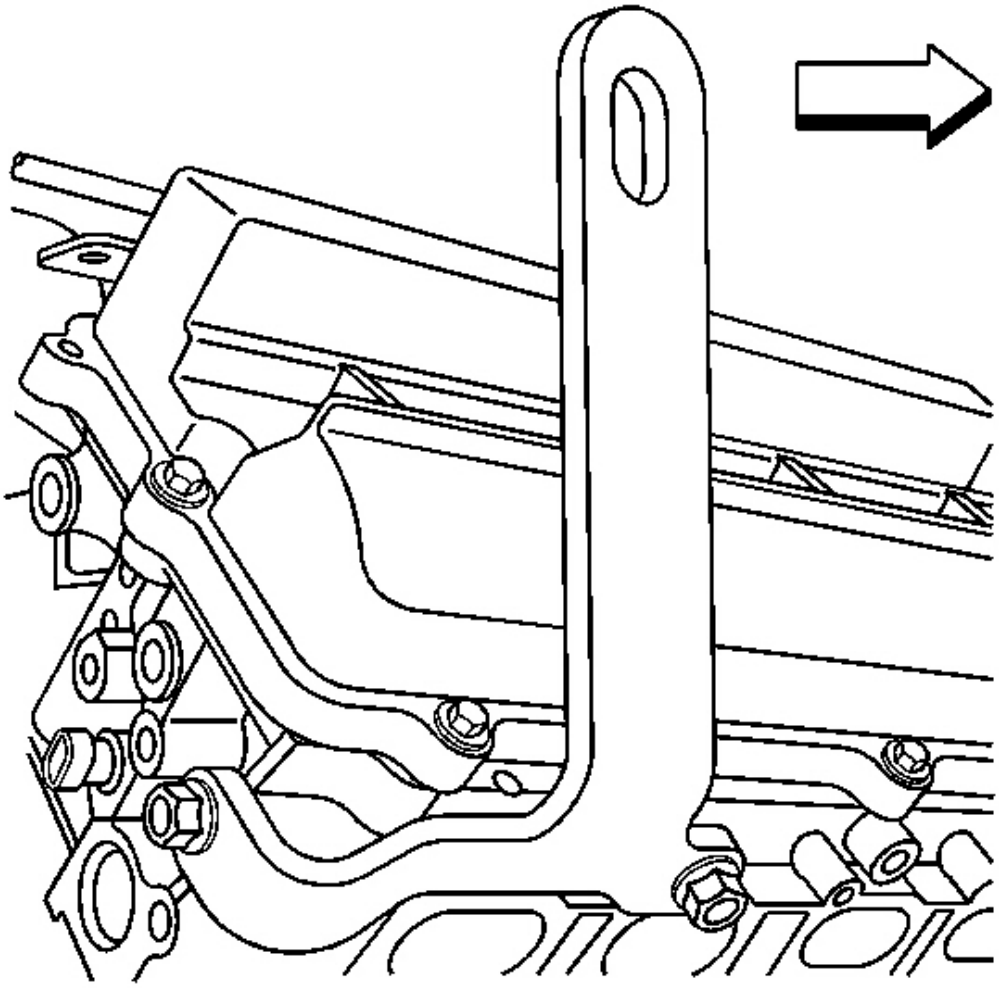


Fig. 10: View Of J 28467-87
Courtesy of GENERAL MOTORS CORP.

7. Install the J 28467-87 Right Engine Lift Bracket to the right cylinder head.

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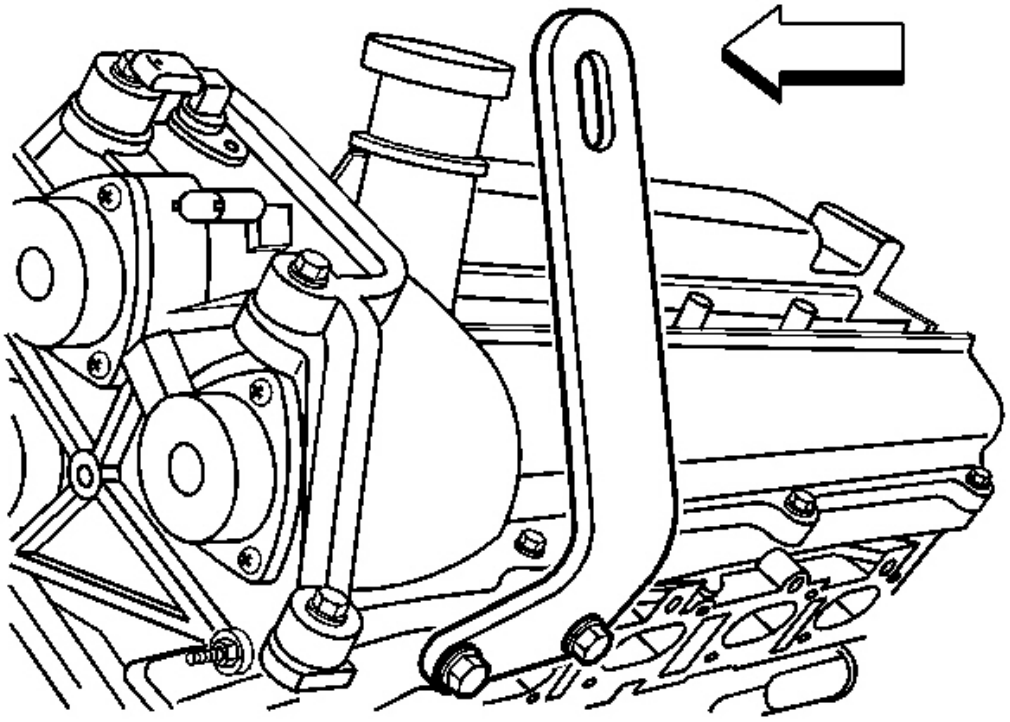


Fig. 11: View Of J 28467-86
Courtesy of GENERAL MOTORS CORP.

8. Remove the bolt securing the wiring harness to the left cylinder head.
9. Install the J 28467-86 Left Engine Lift Bracket to the left cylinder head.

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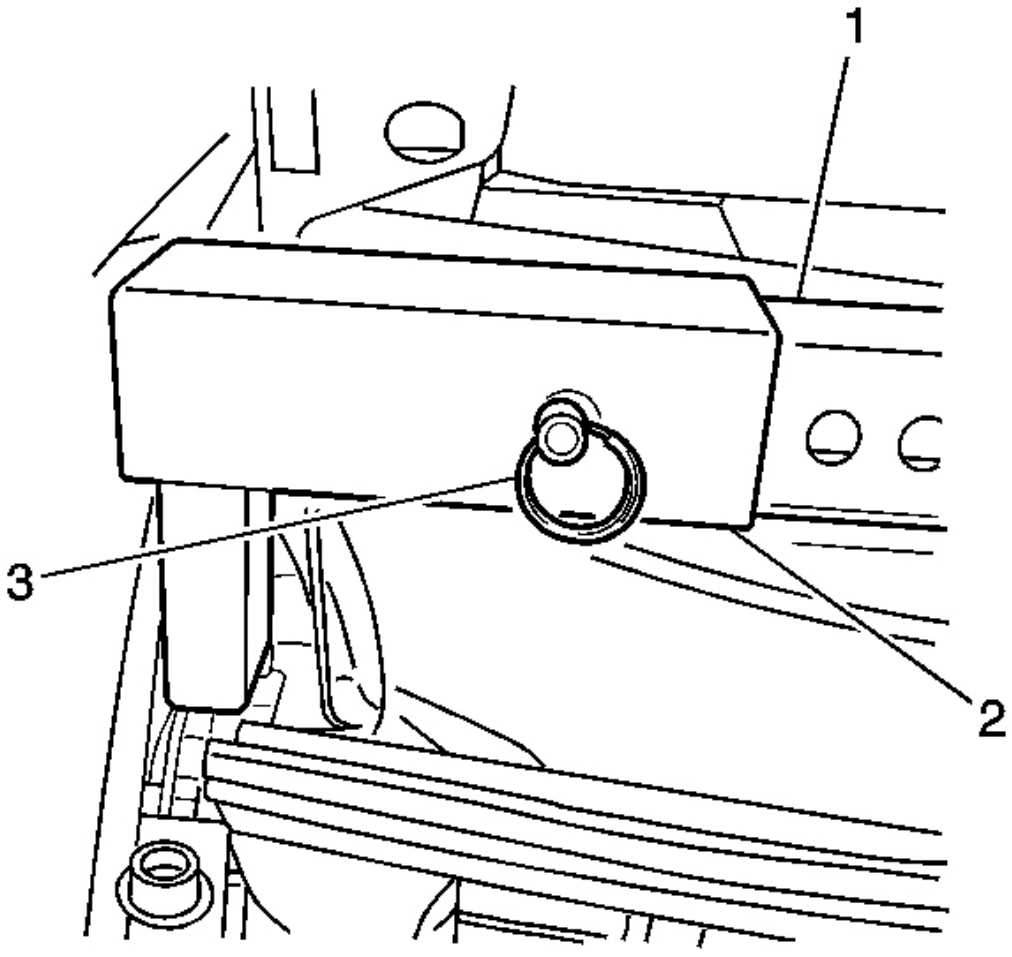


Fig. 12: View Of J 28467-83 & J 28467-3
Courtesy of GENERAL MOTORS CORP.

10. Assemble a J 28467-83 Rear Crossbar Support (2) to each end of the J 28467-3 Rear Crossbar (1). Secure the assembly with the lock pin (3).

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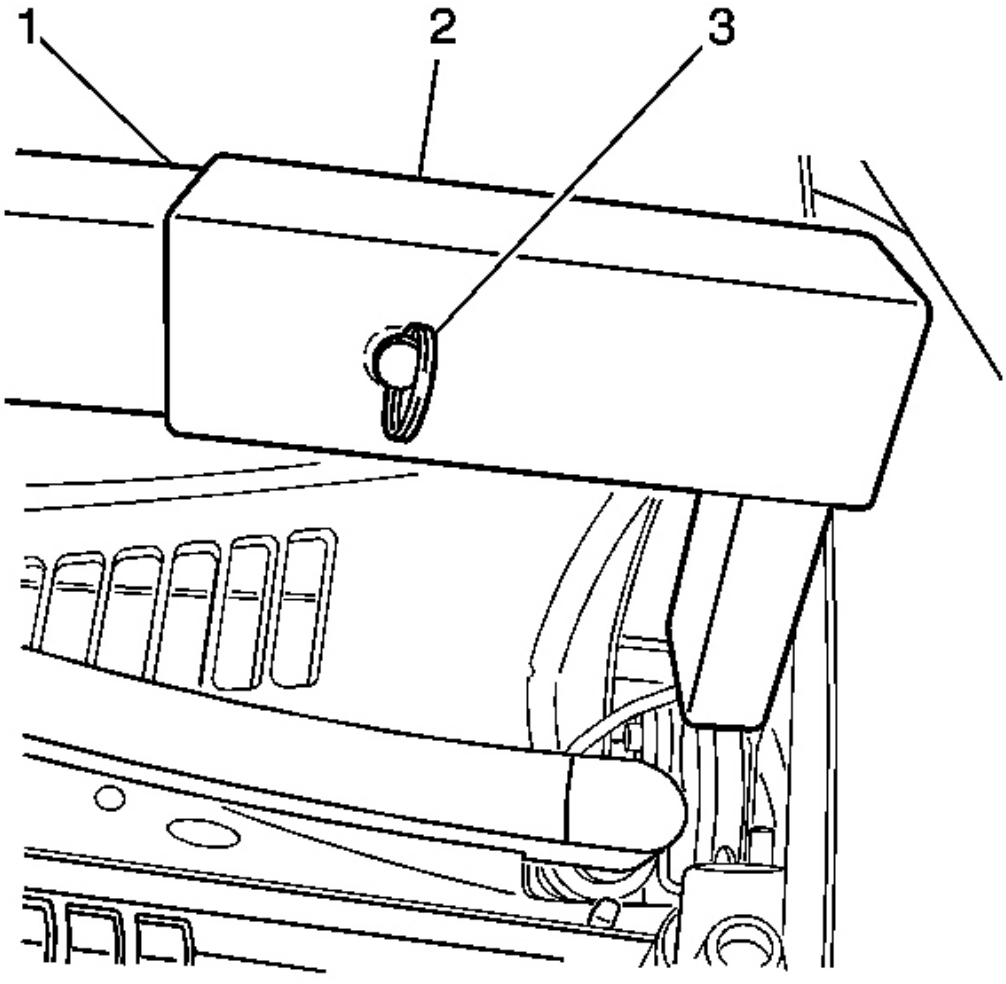


Fig. 13: View Of Rear Crossbar Assembly
Courtesy of GENERAL MOTORS CORP.

11. Position the rear crossbar assembly (1-3) over the hood hinge brackets with the support located over each hood safety catch bracket.

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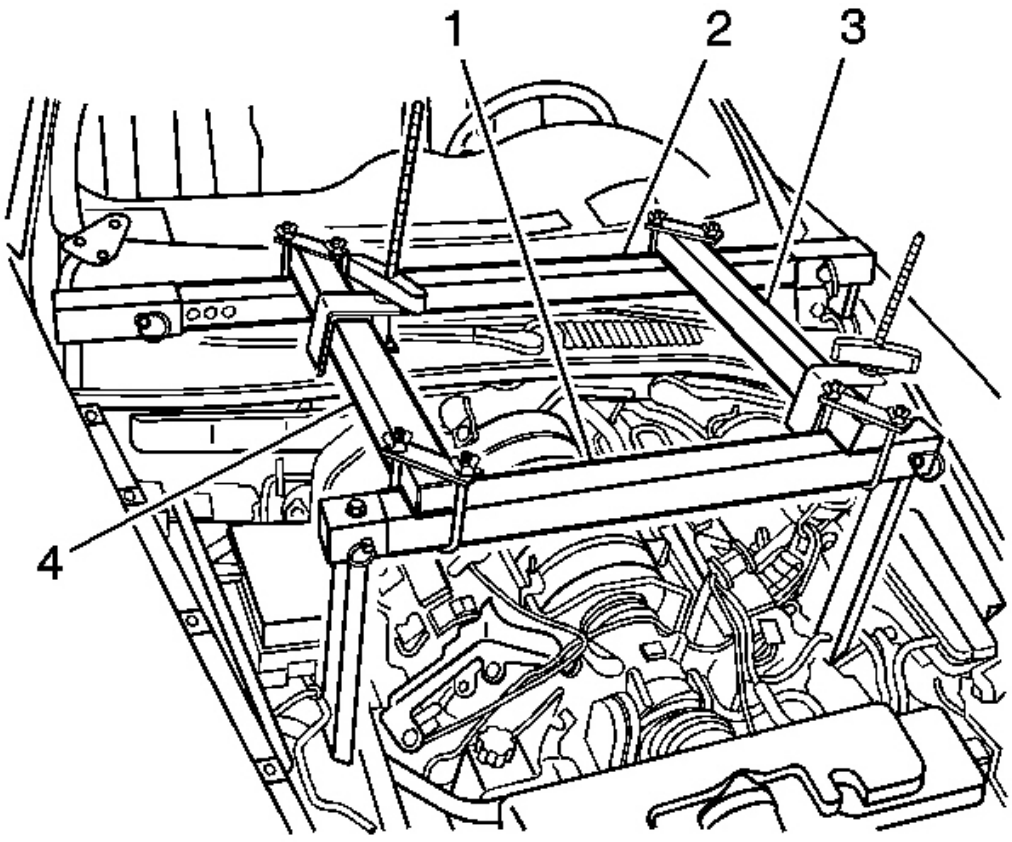


Fig. 14: View Of Front & Rear Crossbars & Left & Right Sidebars
Courtesy of GENERAL MOTORS CORP.

12. Assemble a J 28467-82 Front Crossbar Legs to each end of the J 28467-85 Front Crossbar (1).

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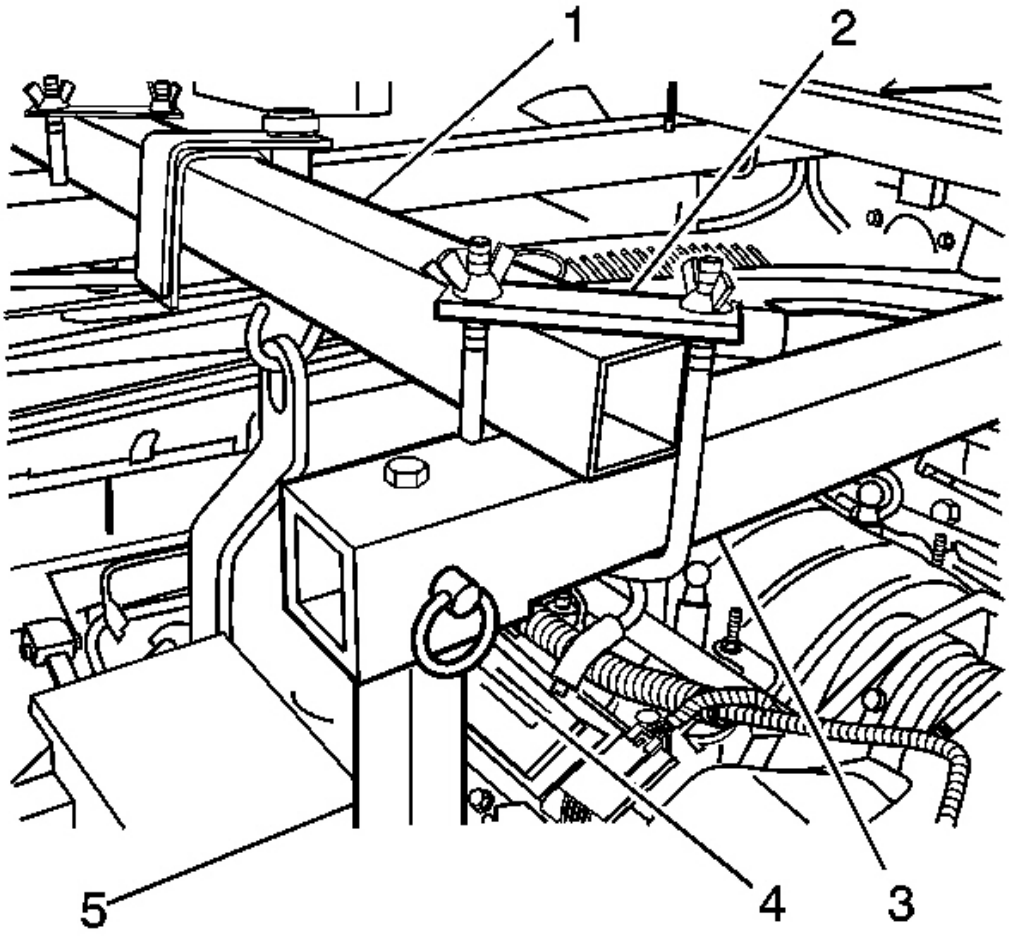


Fig. 15: View Of Quick Release Pins
Courtesy of GENERAL MOTORS CORP.

13. Install the 0.5 in X 2.5 in J 28467-10 Quick Release Pins (4).

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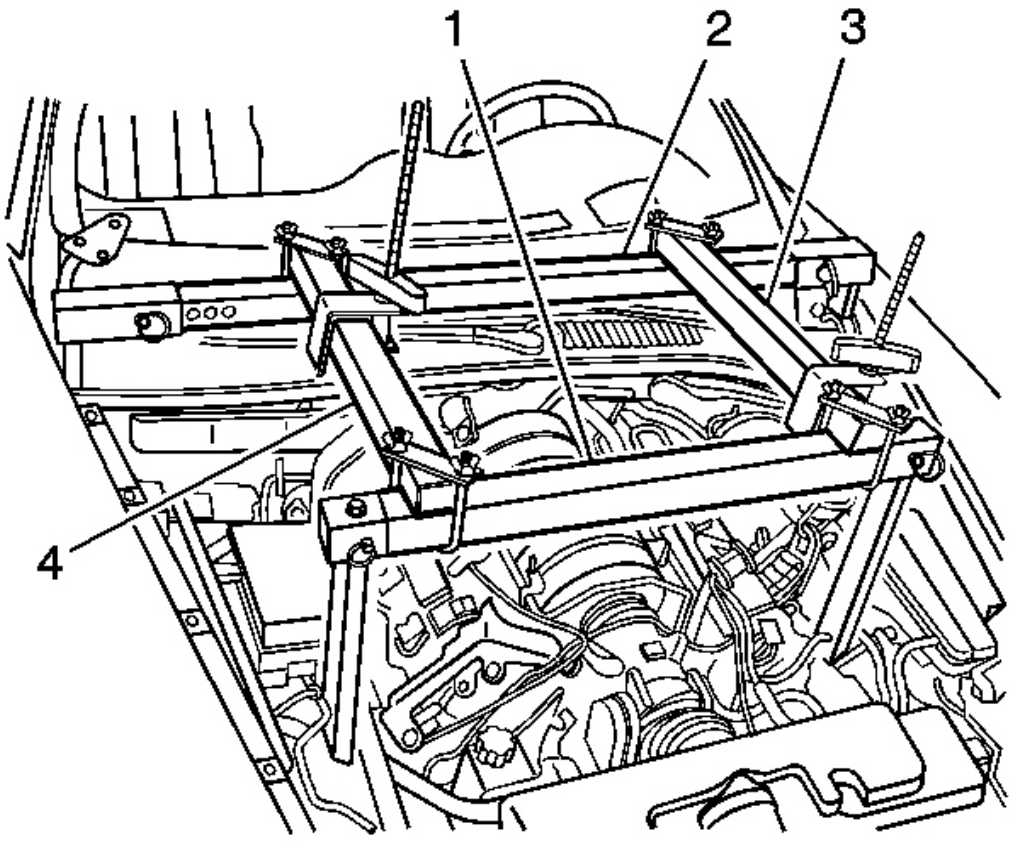


Fig. 16: View Of Front & Rear Crossbars & Left & Right Sidebars
Courtesy of GENERAL MOTORS CORP.

14. Place the front crossbar assembly with supporting legs on the right and left frame rails. Each leg should rest in the shock absorber upper mount on the frame rail.
15. Install the right and left sidebars (3-4) over the front and rear crossbars.

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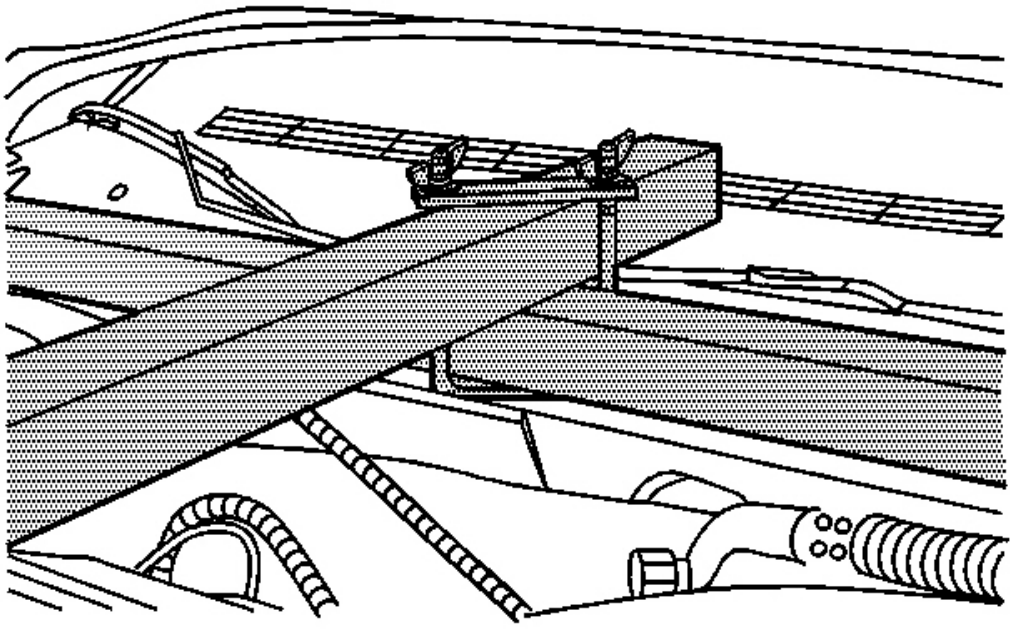


Fig. 17: View of Cross Bracket Assembly
Courtesy of GENERAL MOTORS CORP.

16. Install the J 28467-1A assembly and hand tighten.
17. Repeat steps 12 and 13 for the remaining three corners of the support fixture assembly.

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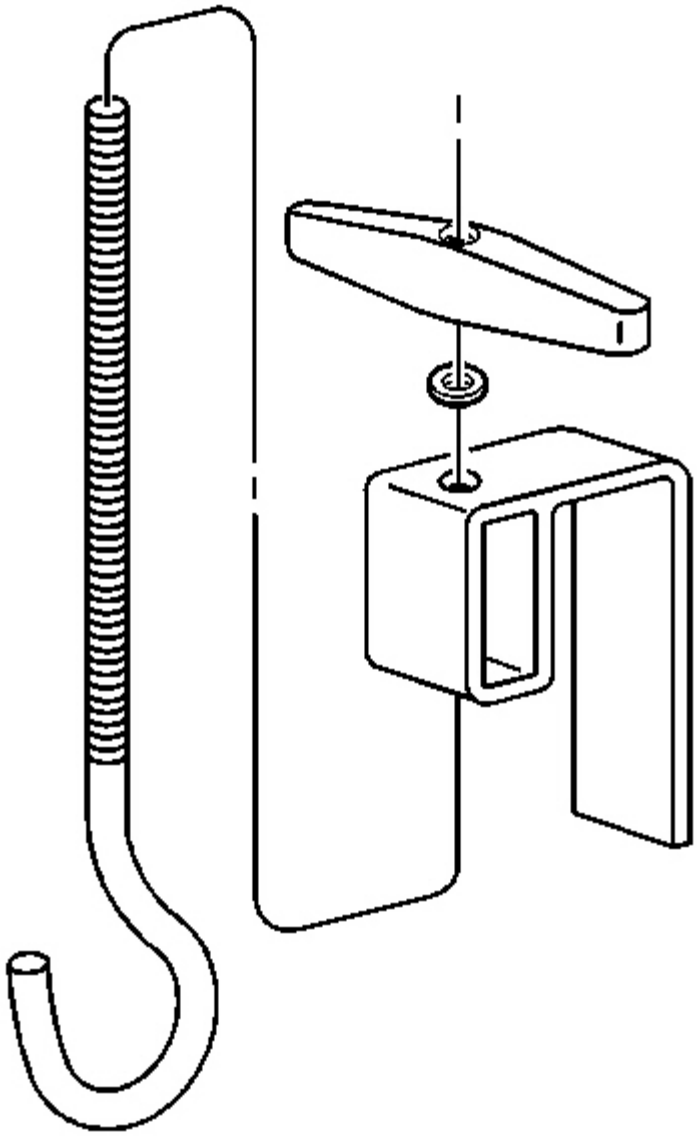


Fig. 18: View Of Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

18. Install the J 28467-7A lift hook through the **J 28467-6A** lift hook bracket.
19. Install the 1/2 inch lift hook washer and the J 28467-34 lift hook wing nut onto the J 28467-7A lift hook.

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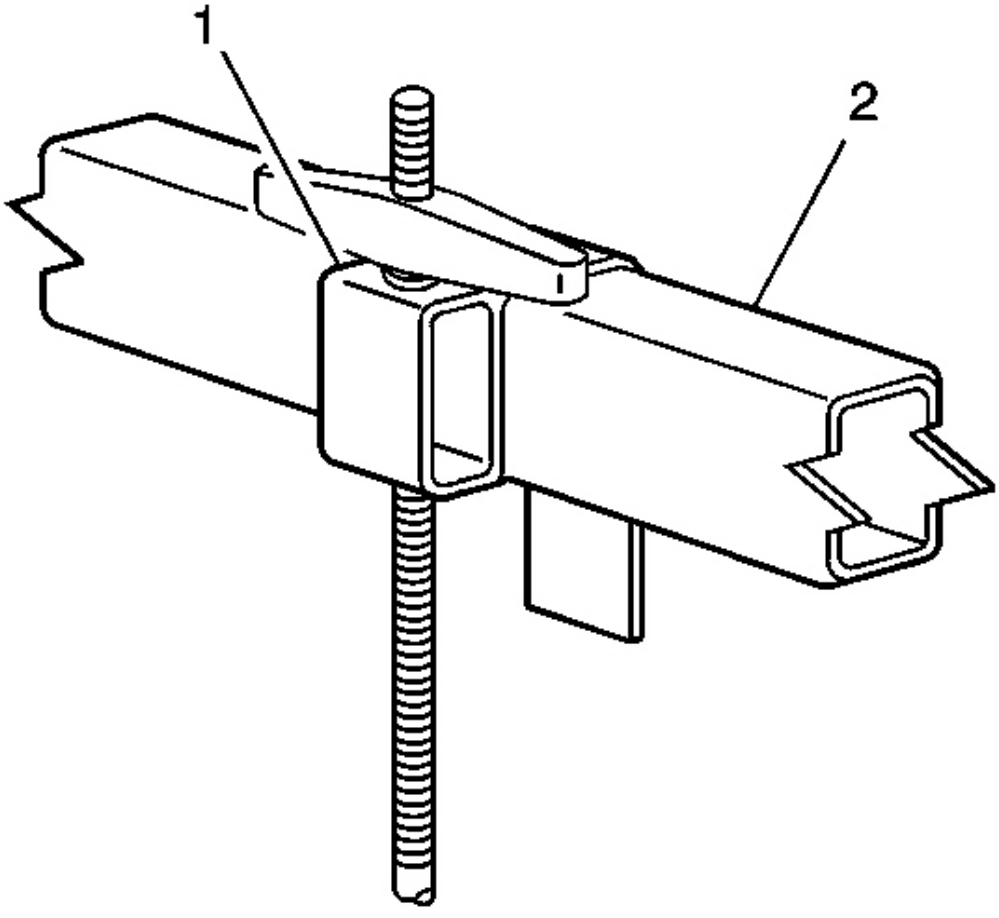


Fig. 19: View Of Lift Hook & Bracket Assembly At Longitudinal Mounted Cross Bar
Courtesy of GENERAL MOTORS CORP.

20. Install the J 28467-6A assembled lift hook (1) over the J 28467-84 left sidebar (2).
21. Adjust the J 28467-6A assembled lift hook bracket (1) in order to align the hook with the J 28467-86 left engine lift hook bracket.

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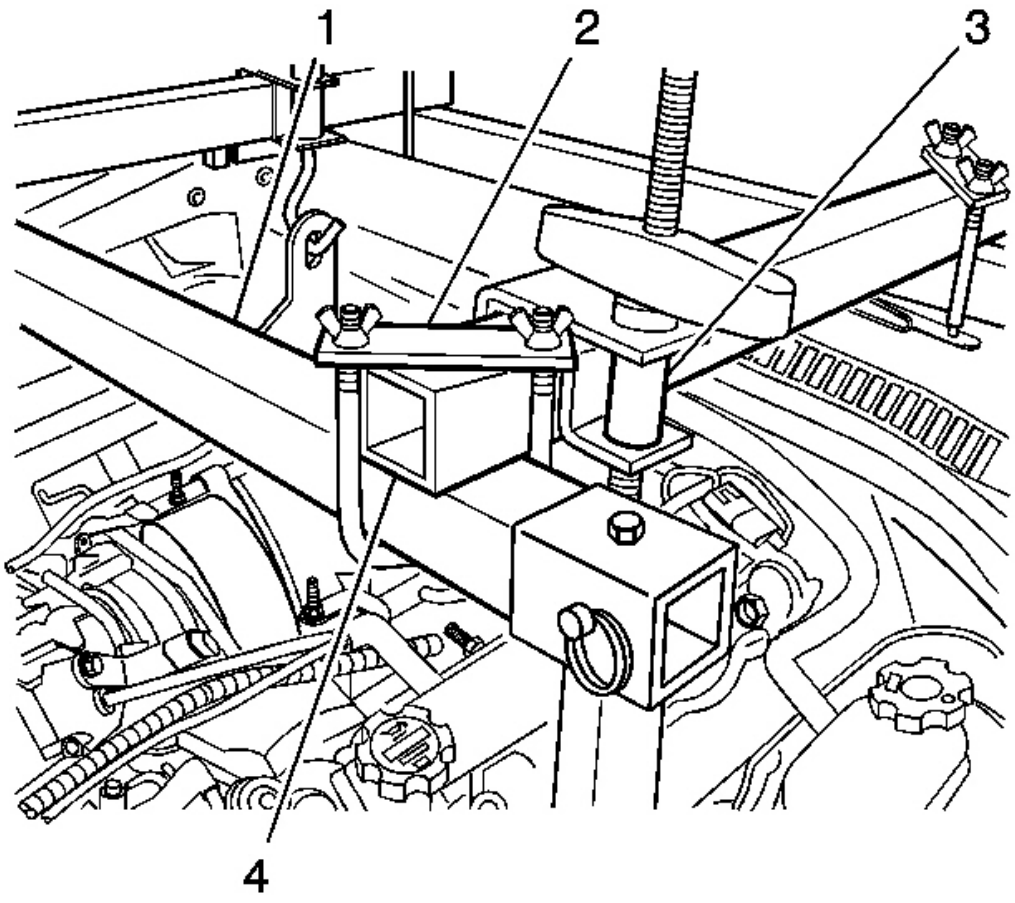


Fig. 20: Adjusting J 28467-6A
Courtesy of GENERAL MOTORS CORP.

22. Repeat step 18 for the right lift hook (3).

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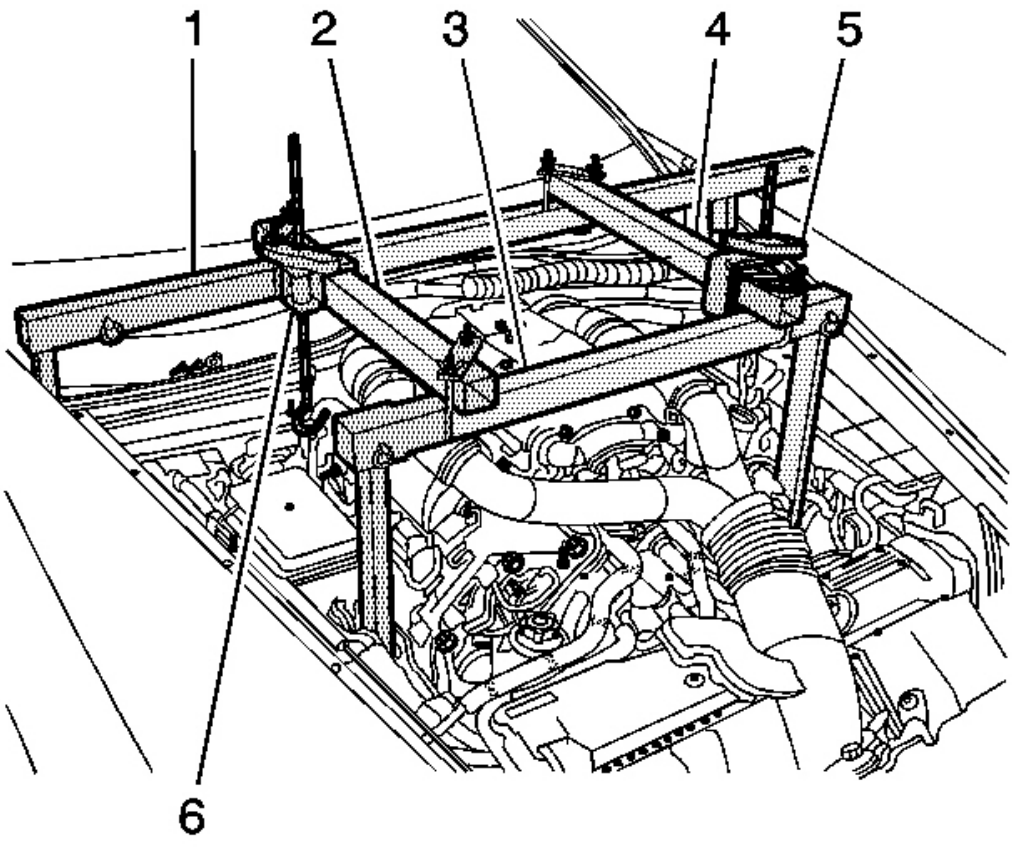


Fig. 21: View Of J 28467-7A Lift Hook
Courtesy of GENERAL MOTORS CORP.

23. Install each J 28467-7A lift hook (5,6) through each engine lift hook bracket. Ensure that the hooks do not damage the surrounding components.
24. Hand-tighten the lift hook wing nuts securely to remove all slack from the engine support fixture assembly.

REMOVAL PROCEDURE

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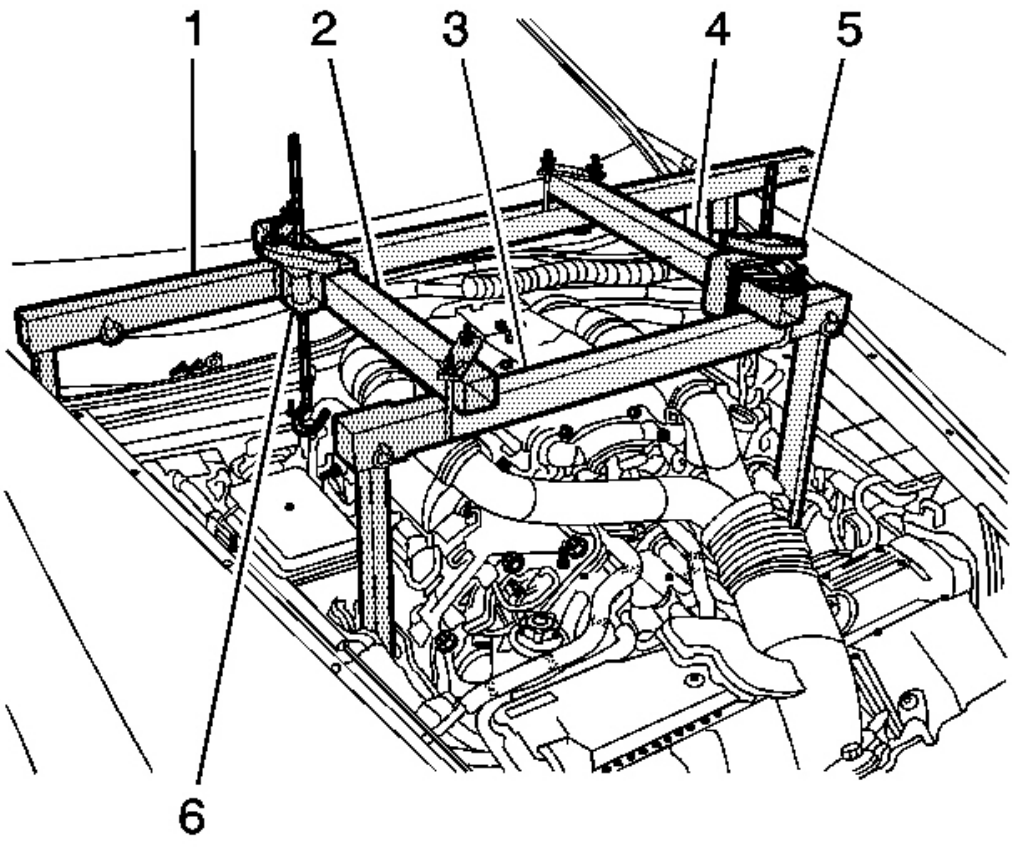


Fig. 22: View Of J 28467-7A Lift Hook
Courtesy of GENERAL MOTORS CORP.

1. Loosen and remove the J 28467-7A lift hooks (5,6)
2. Remove the **J 28467-81** Engine Support Fixture Kit (1-4). See **Special Tools** .

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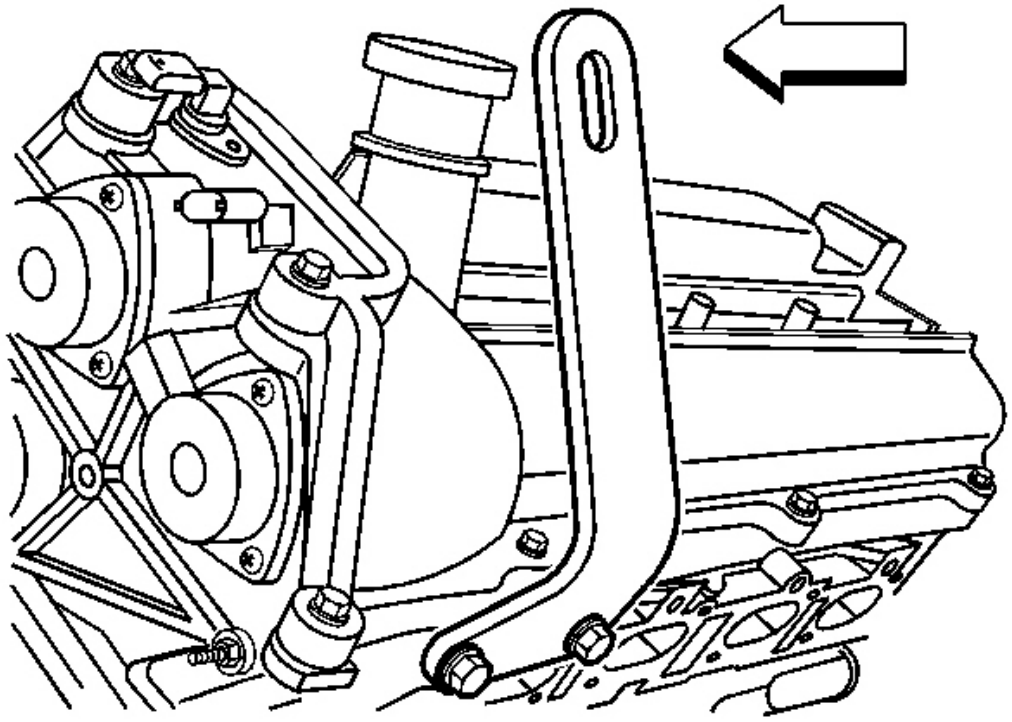


Fig. 23: View Of J 28467-86
Courtesy of GENERAL MOTORS CORP.

3. Remove the J 28467-86 Left Engine Lift Bracket from the left cylinder head.

   NOTE: Refer to Fastener Notice .

4. Install the bolt securing the wiring harness to the left cylinder head.

   Tighten: Tighten the wiring harness bolt to 35 N.m (26 lb ft).

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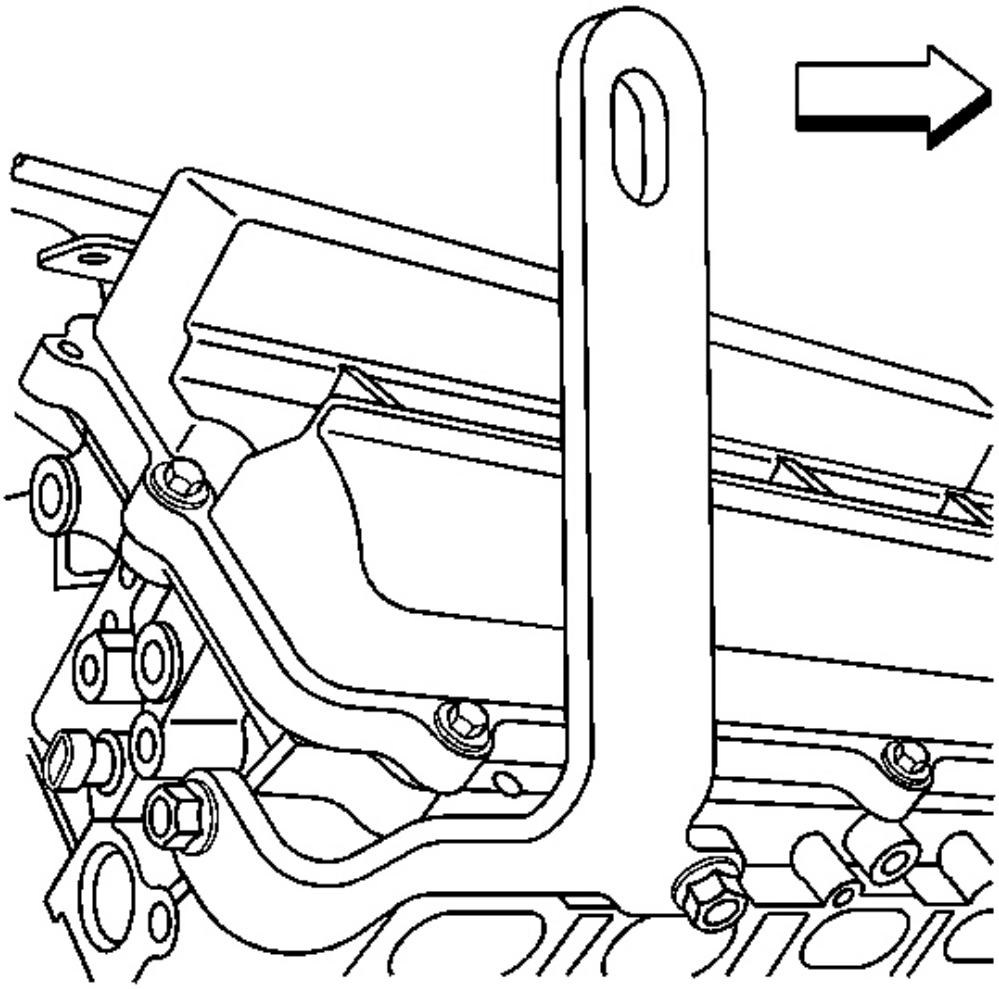


Fig. 24: View Of J 28467-87
Courtesy of GENERAL MOTORS CORP.

5. Remove the J 28467-87 Right Engine Lift Bracket from the right cylinder head.
6. Install the plastic wire harness protector to the frame rail pinch weld.
7. Install the camshaft cover ground strap to the camshaft cover.

   Tighten: Tighten the camshaft cover bolt to 10 N.m (89 lb in).

8. Install the battery negative cable and ground junction to the RH rear of cylinder head.

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Tighten: Tighten the negative battery cable bolt to 35 N.m (26 lb ft).

9. Connect the negative battery cable to the battery. Refer to **Battery Negative Cable Disconnection and Connection** .
10. Install the engine cover. Refer to **Intake Manifold Sight Shield Replacement**.
11. Install the hood. Refer to **Hood Replacement** .

ENGINE MOUNT INSPECTION

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

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

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

ENGINE MOUNT REPLACEMENT - LEFT SIDE

REMOVAL PROCEDURE

1. Remove the front suspension crossmember. Refer to **Front Suspension Crossmember Replacement** .

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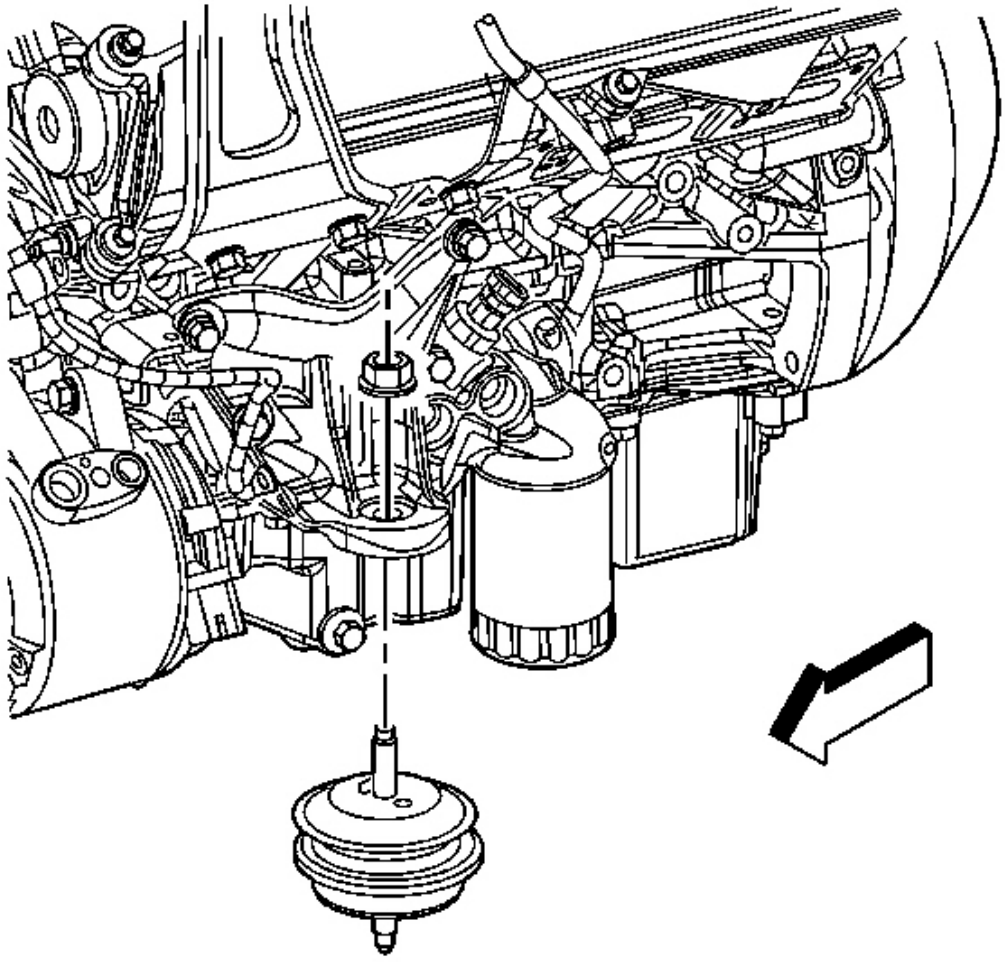


Fig. 25: View Of Left Engine Mount, Bracket & Nut
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount-to-engine mount bracket nut.
3. Remove the engine mount from the engine mount bracket.

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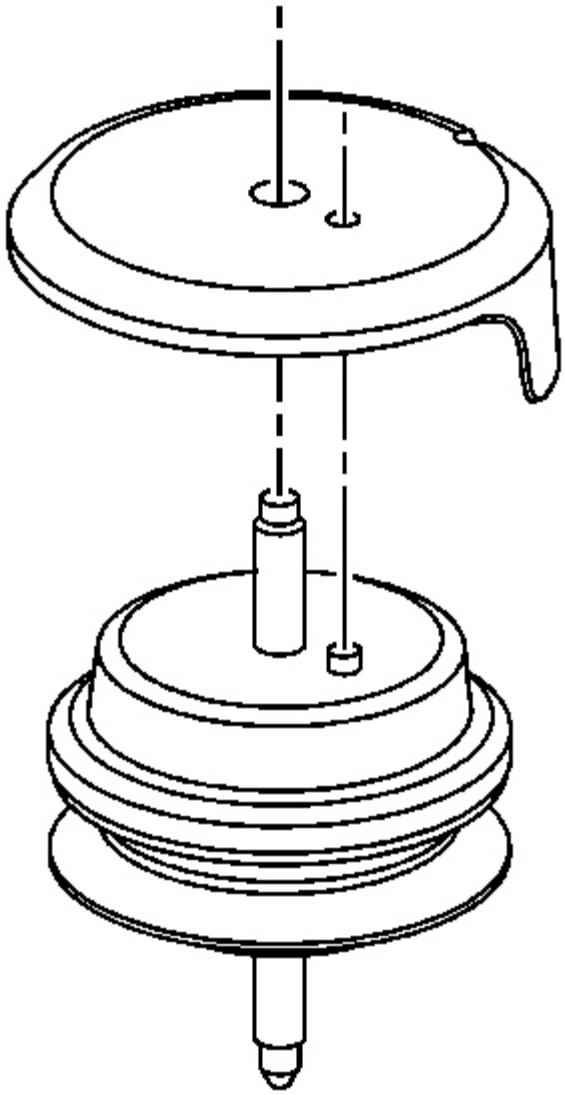


Fig. 26: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine mount heat shield from the engine mount.

INSTALLATION PROCEDURE

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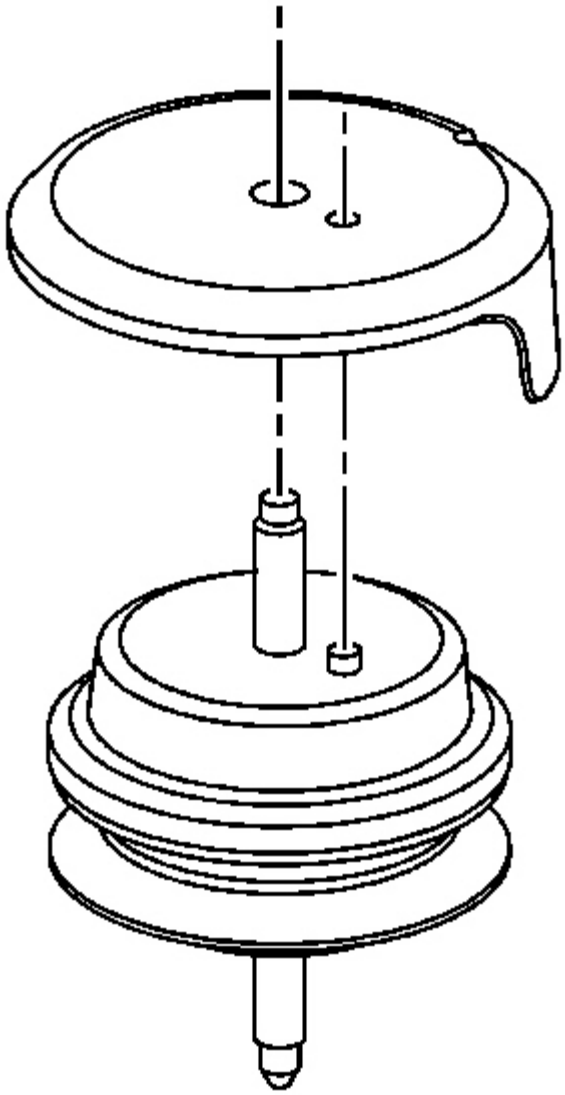


Fig. 27: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount heat shield to the engine mount.

IMPORTANT: When installing the engine mount be sure to have the locating dowel in the correct position.

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2. Position the engine mount to the engine mount bracket.

NOTE: **Refer to Fastener Notice .**

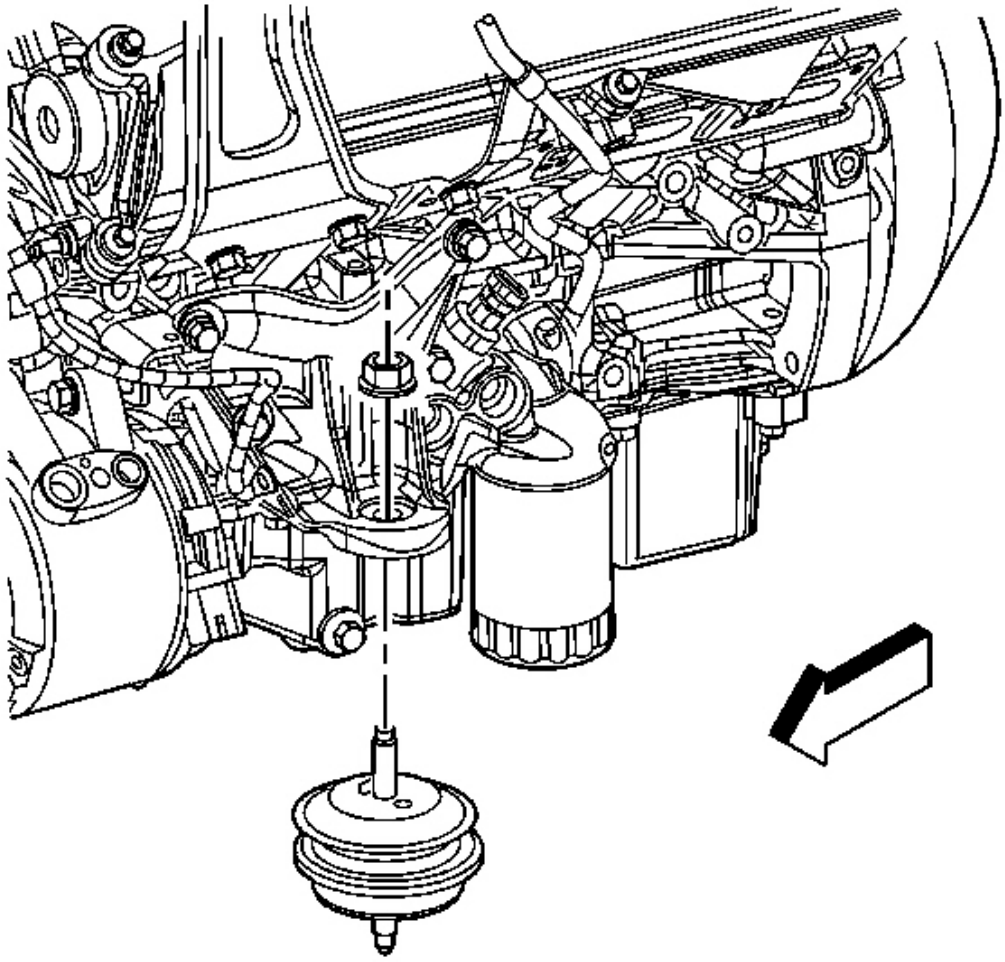


Fig. 28: View Of Left Engine Mount, Bracket & Nut
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount-to-engine mount bracket nut.

Tighten: Tighten the nut to 58 N.m (43 lb ft).

4. Install the front suspension crossmember. Refer to **Front Suspension Crossmember Replacement** .

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ENGINE MOUNT REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

1. Remove the front suspension crossmember. Refer to **Front Suspension Crossmember Replacement** .

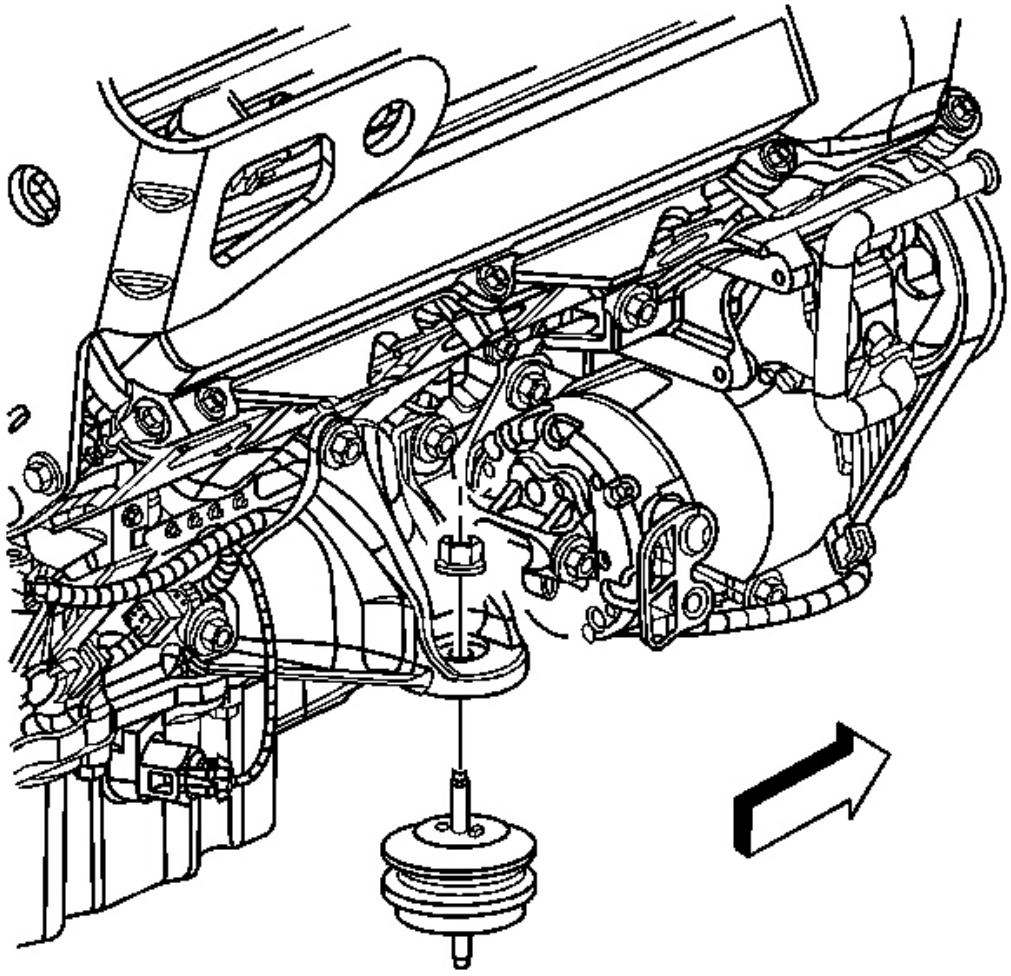


Fig. 29: View Of Right Engine Mount, Bracket & Nut
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount-to-engine mount bracket nut.
3. Remove the engine mount from the engine mount bracket.

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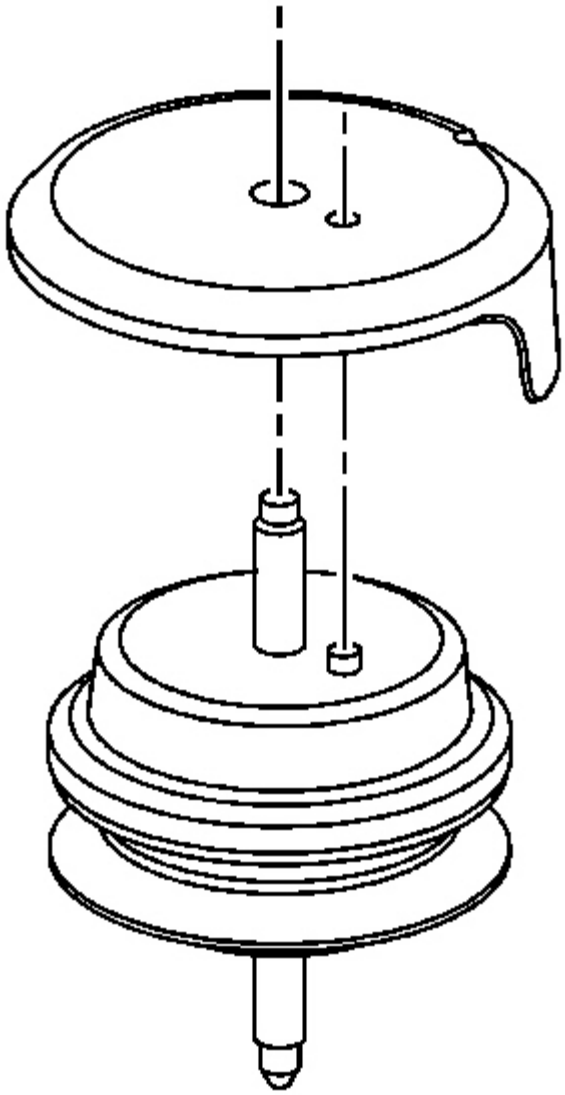


Fig. 30: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine mount heat shield from the engine mount.

INSTALLATION PROCEDURE

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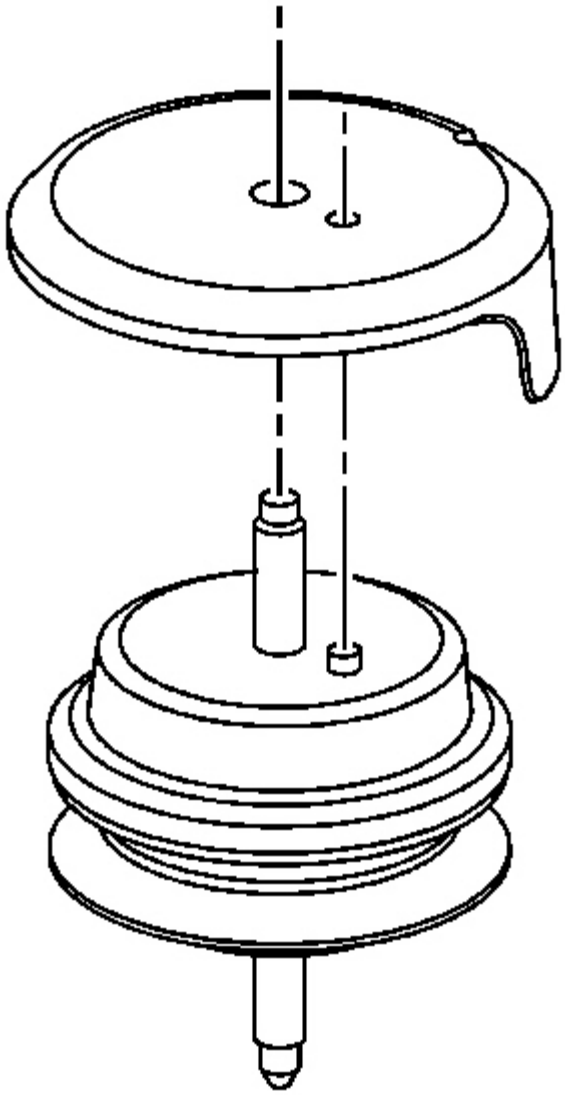


Fig. 31: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount heat shield to the engine mount.

IMPORTANT: When installing the engine mount be sure to have the locating dowel in the correct position.

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2. Position the engine mount to the engine mount bracket.

NOTE: **Refer to Fastener Notice .**

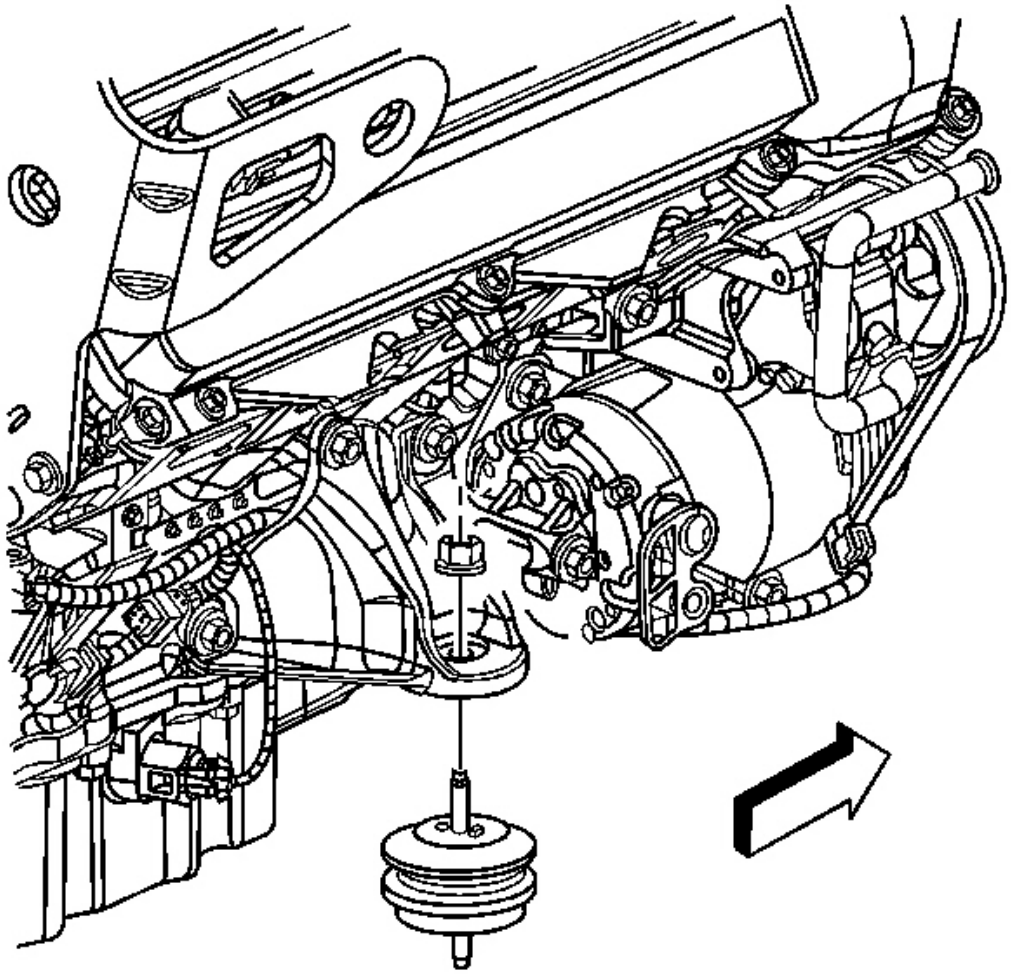


Fig. 32: View Of Right Engine Mount, Bracket & Nut
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount-to-engine mount bracket nut.

Tighten: Tighten the nut to 58 N.m (43 lb ft).

4. Install the front suspension crossmember. Refer to **Front Suspension Crossmember Replacement** .

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ENGINE MOUNT BRACKET REPLACEMENT - LEFT SIDE

REMOVAL PROCEDURE

1. Remove the left engine mount. Refer to **Engine Mount Replacement - Left Side**.

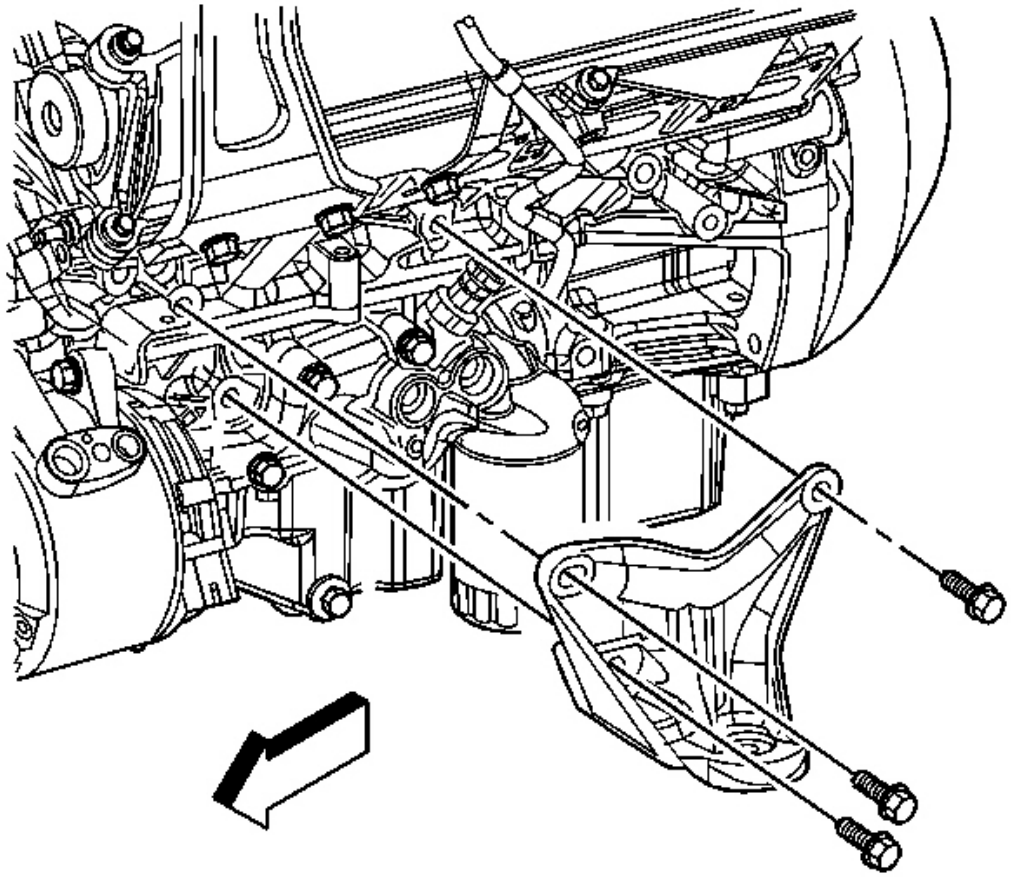


Fig. 33: View Of Left Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount bracket bolts.
3. Remove the engine mount bracket.

INSTALLATION PROCEDURE

1. Install the engine mount bracket.

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NOTE: **Refer to Fastener Notice .**

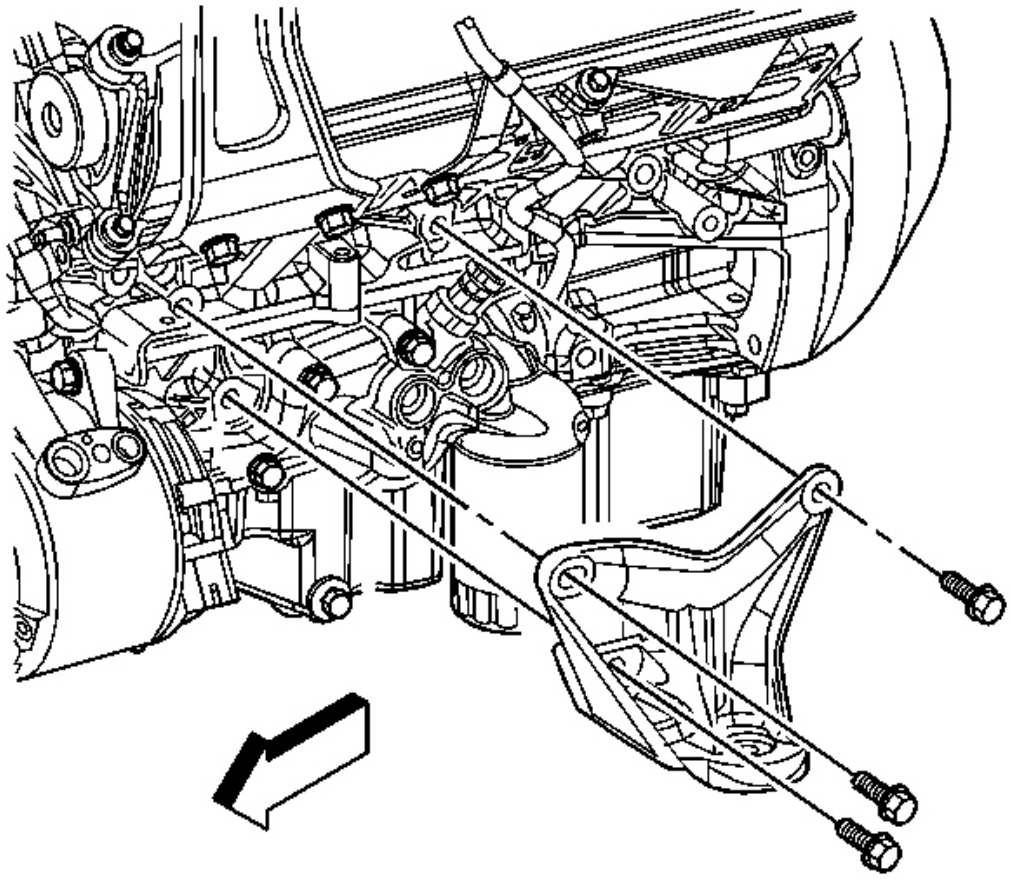


Fig. 34: View Of Left Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the engine mount bracket bolts.

   Tighten: Tighten the engine mount bracket bolts to 58 N.m (43 lb ft).

3. Install the left engine mount. Refer to **Engine Mount Replacement - Left Side**.

ENGINE MOUNT BRACKET REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

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1. Remove the right engine mount. Refer to **Engine Mount Replacement - Right Side**.

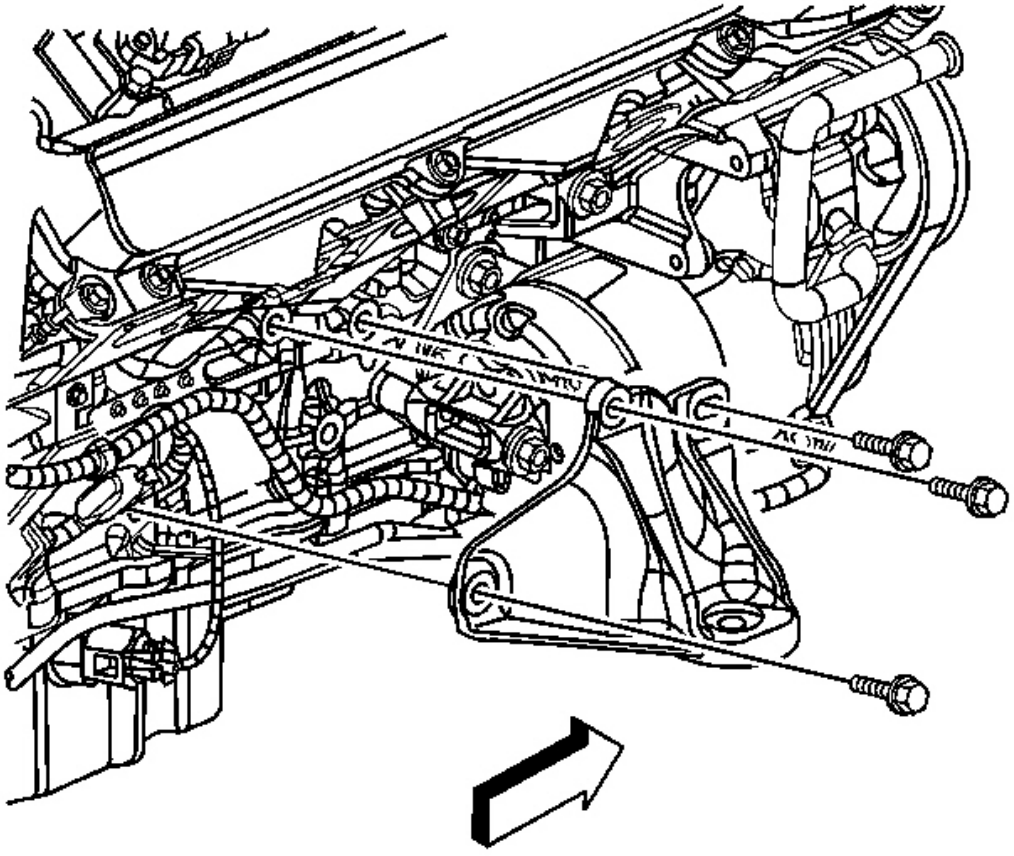


Fig. 35: View Of Right Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount bracket bolts.
3. Remove the engine mount bracket.

INSTALLATION PROCEDURE

1. Install the engine mount bracket.

NOTE: **Refer to Fastener Notice .**

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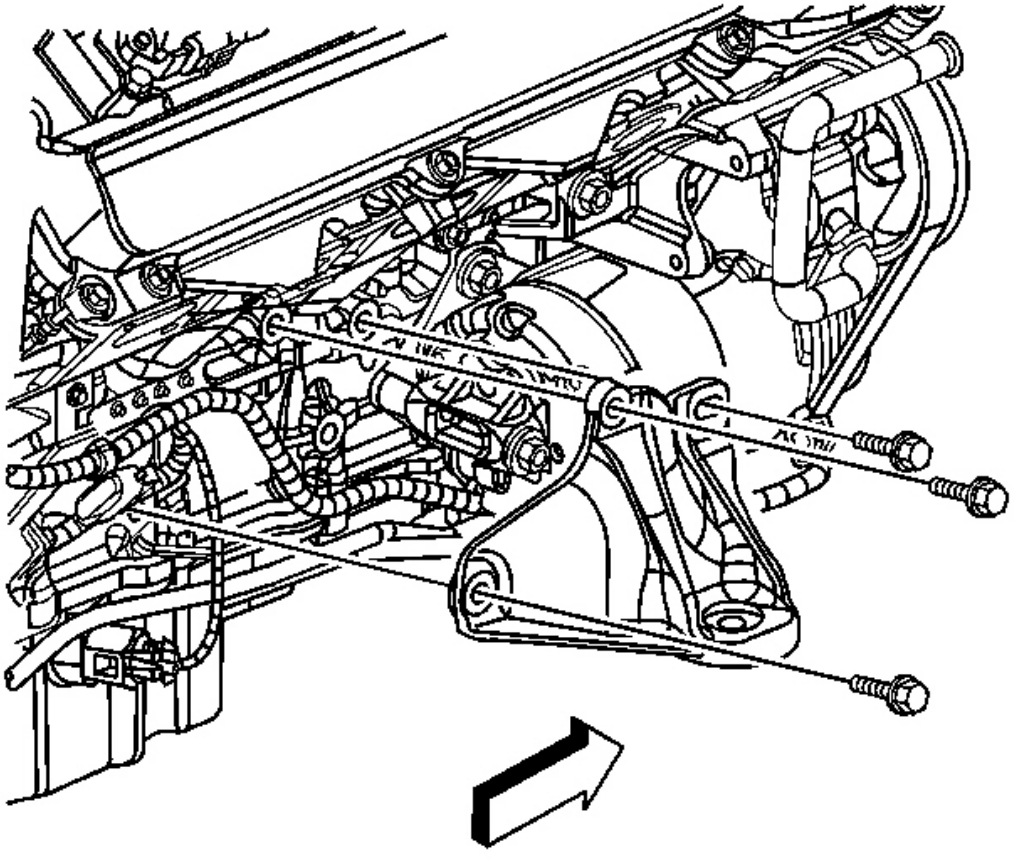


Fig. 36: View Of Right Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the engine mount bracket bolts.

   Tighten: Tighten the engine mount bracket bolts to 58 N.m (43 lb ft).

3. Install the right engine mount. Refer to **Engine Mount Replacement - Right Side**.

INTAKE MANIFOLD SIGHT SHIELD REPLACEMENT

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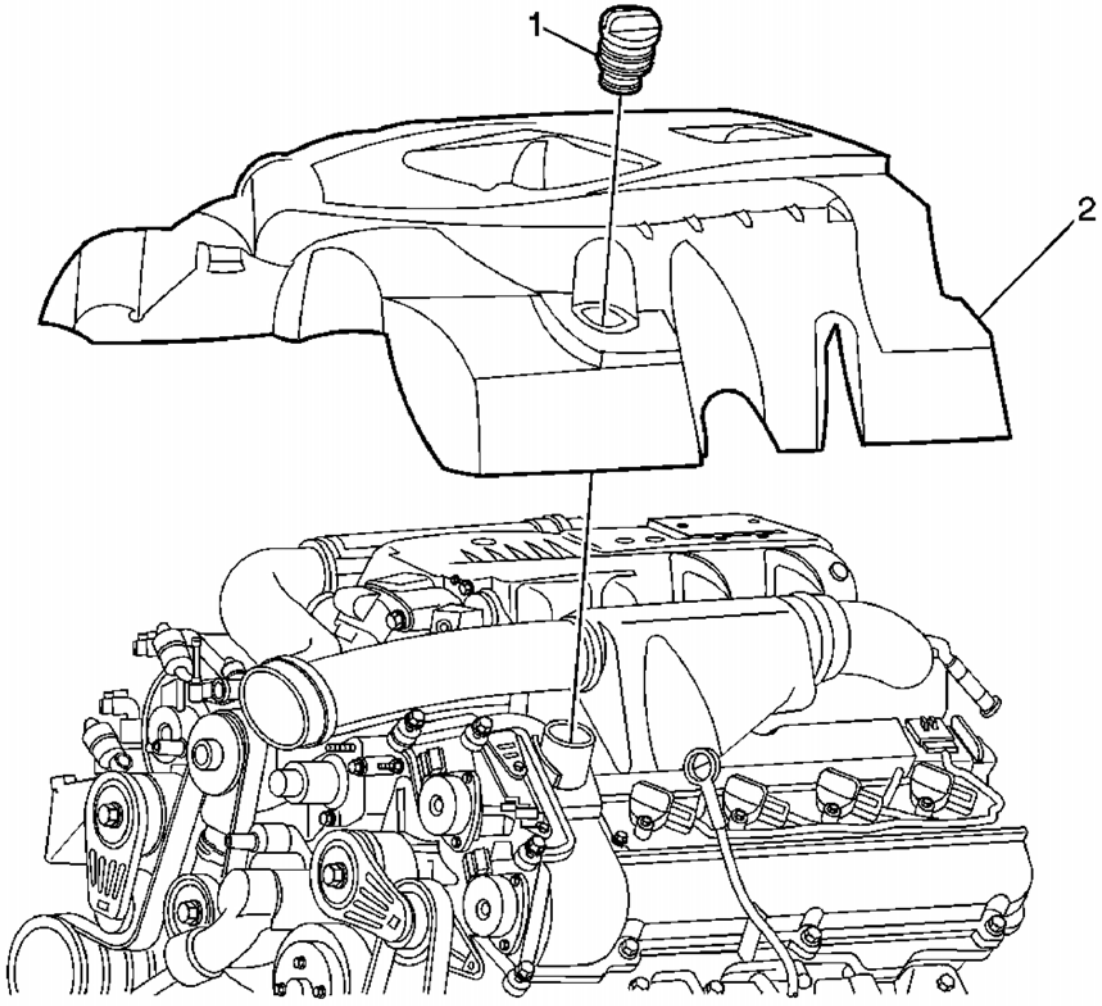


Fig. 37: View Of Intake Manifold Sight Shield
Courtesy of GENERAL MOTORS CORP.

Intake Manifold Sight Shield Replacement

Callout	Component Name
Fastener Tightening Specifications: Refer to **Fastener Tightening Specifications** .	
1	Engine Oil Fill Cap
2	Intake Manifold Sight Shield **Tip:** Pull the sight shield straight up to disengage the shield from the ball studs.

CRANKCASE VENTILATION HOSES/PIPES REPLACEMENT

REMOVAL PROCEDURE

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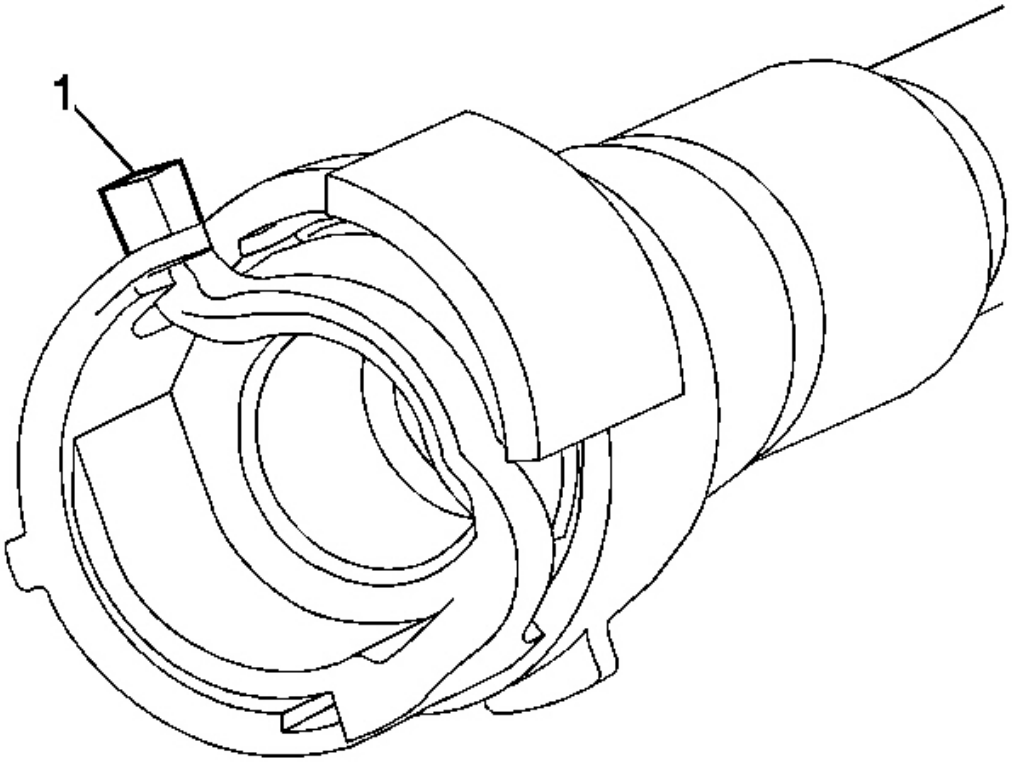


Fig. 38: Identifying PCV Tube Connection Lock Tab
Courtesy of GENERAL MOTORS CORP.

1. Release the lock tab (1) when disconnecting the positive crankcase ventilation (PCV) tube connections.

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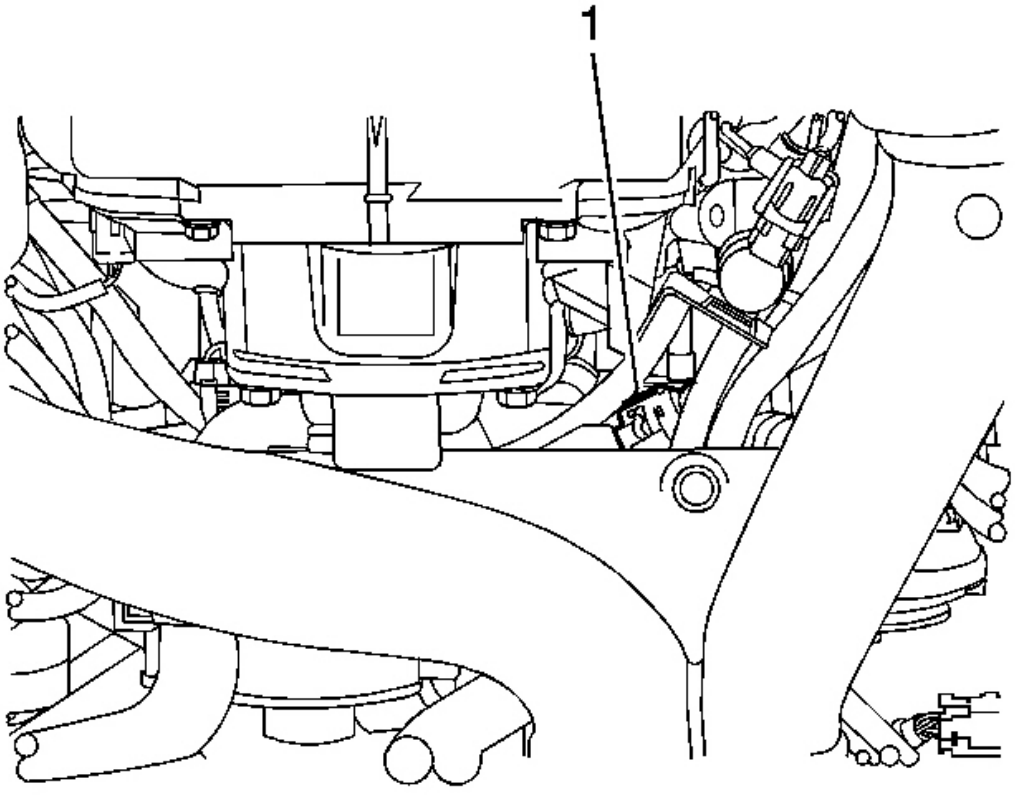


Fig. 39: Identifying PCV Hose Fitting
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the fresh air PCV tube (1) from the fitting on the underside of the supercharger inlet duct, during the removal procedure of the front section of the supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .

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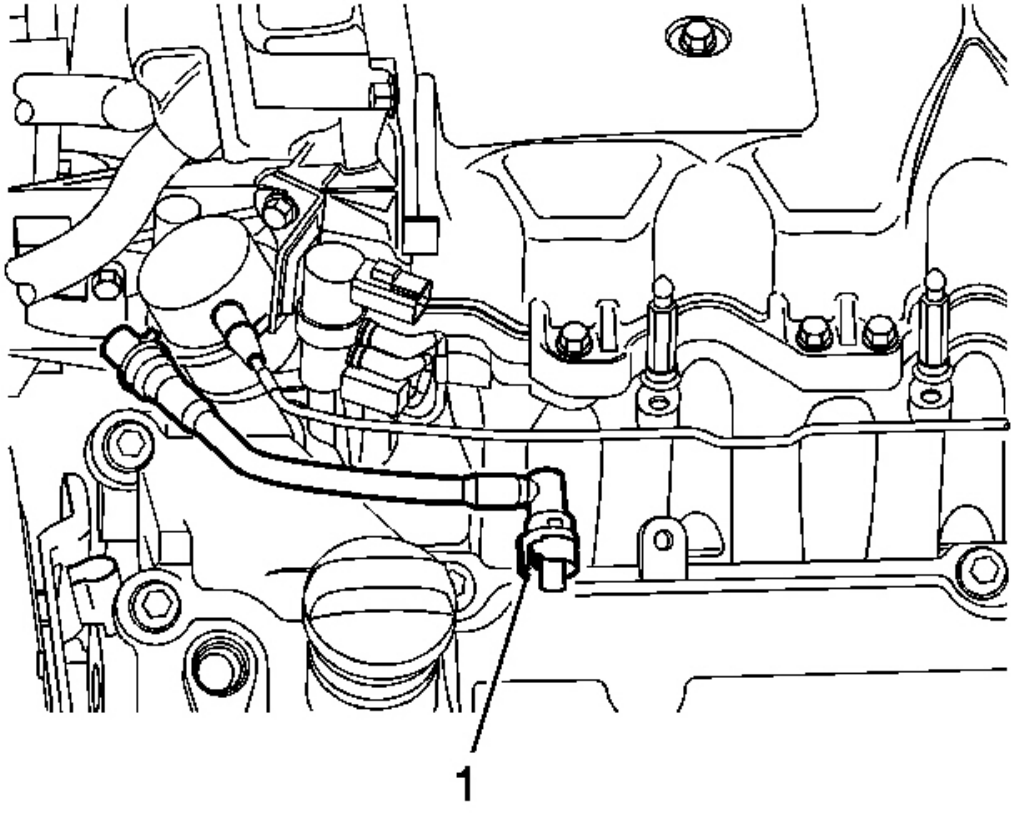


Fig. 40: View Of PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the PCV fresh air tube (1) from the left camshaft cover.

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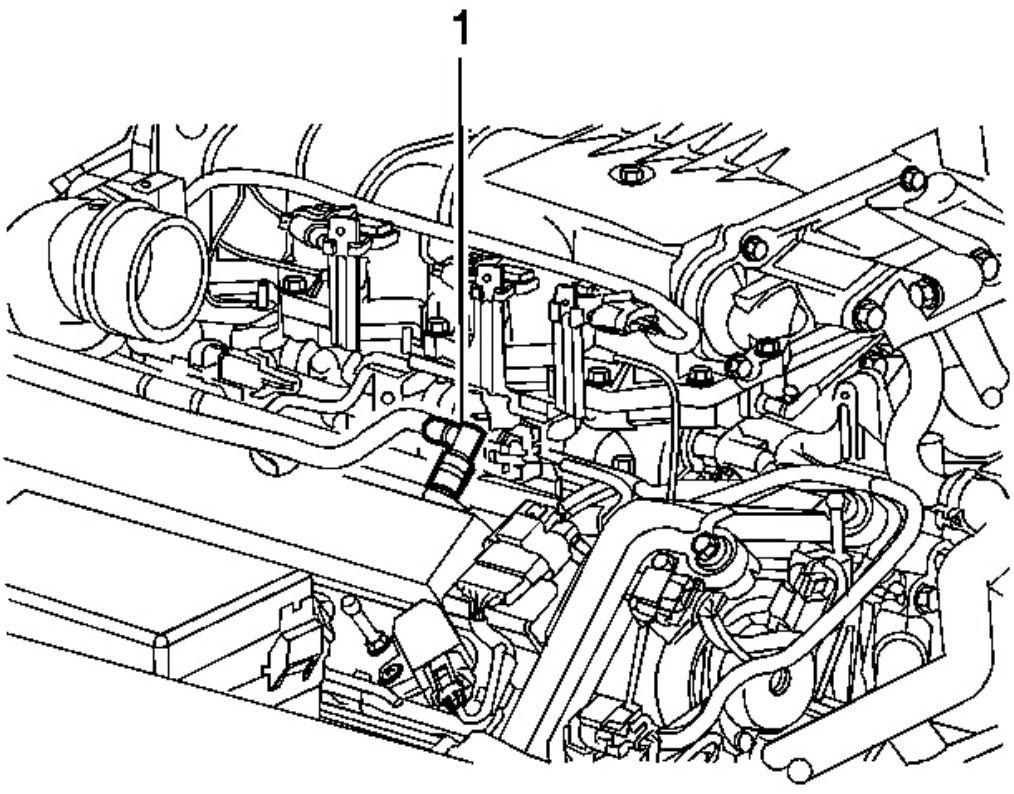


Fig. 41: Locating PCV Orifice Fitting
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the PCV foul air tube (1) from the PCV orifice fitting on the right camshaft cover.
5. Remove the supercharger assembly. Refer to **Supercharger Replacement**.

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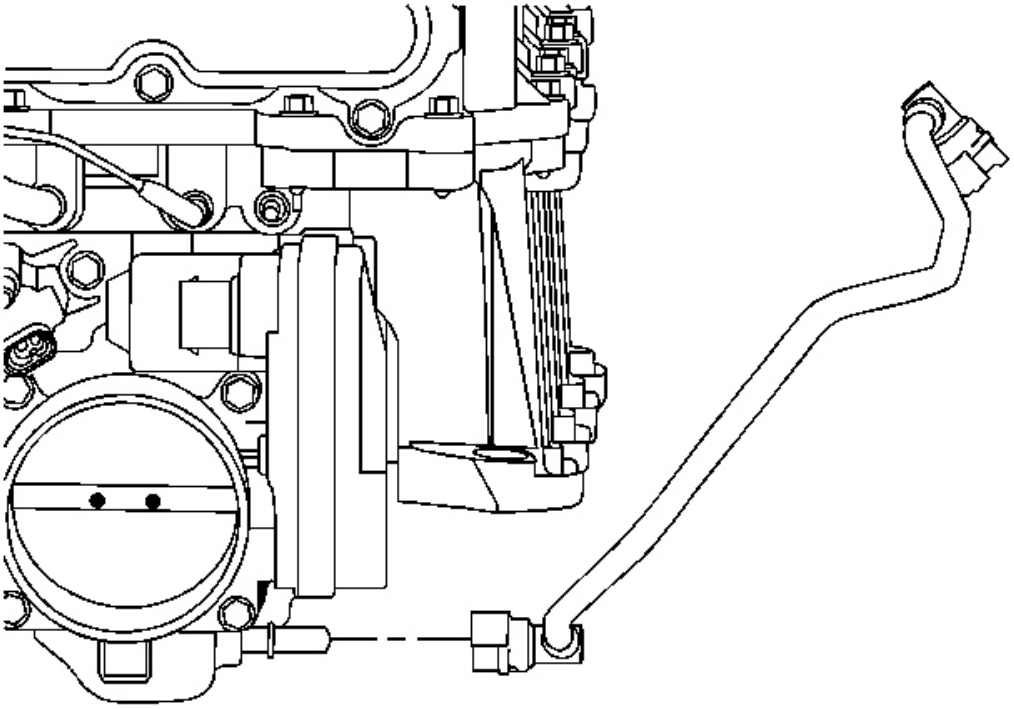


Fig. 42: Identifying PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

6. Remove the PCV foul air tube from the fitting on the underside of the supercharger assembly.

INSTALLATION PROCEDURE

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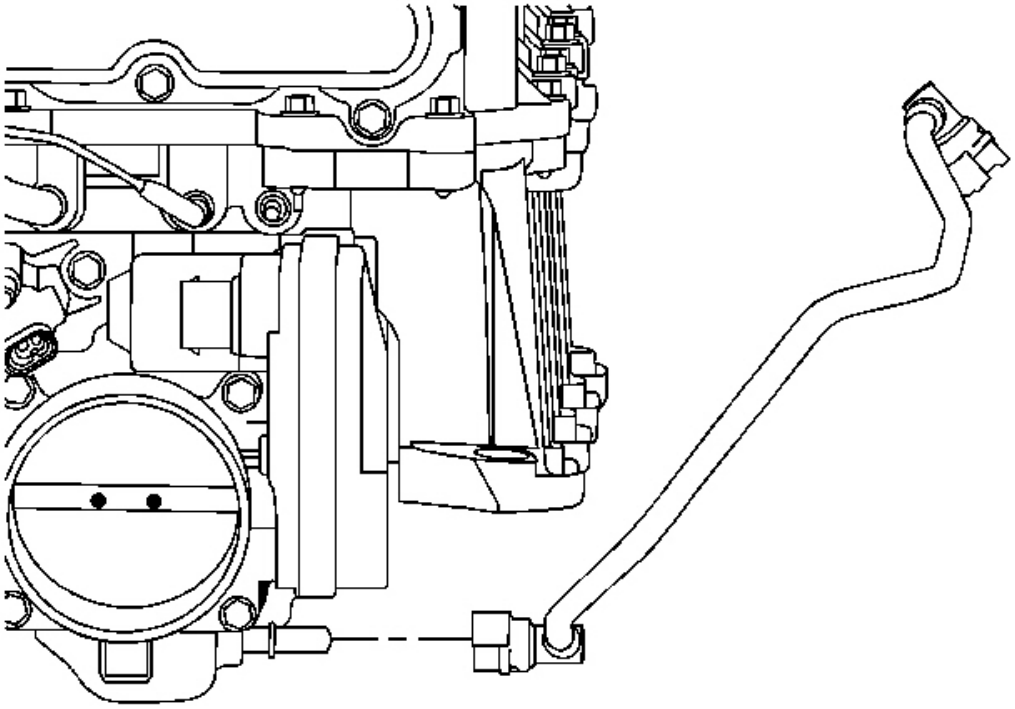


Fig. 43: Identifying PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Connect the PCV foul air tube to the fitting on the underside of the supercharger assembly.
2. Install the supercharger assembly. Refer to **Supercharger Replacement**.

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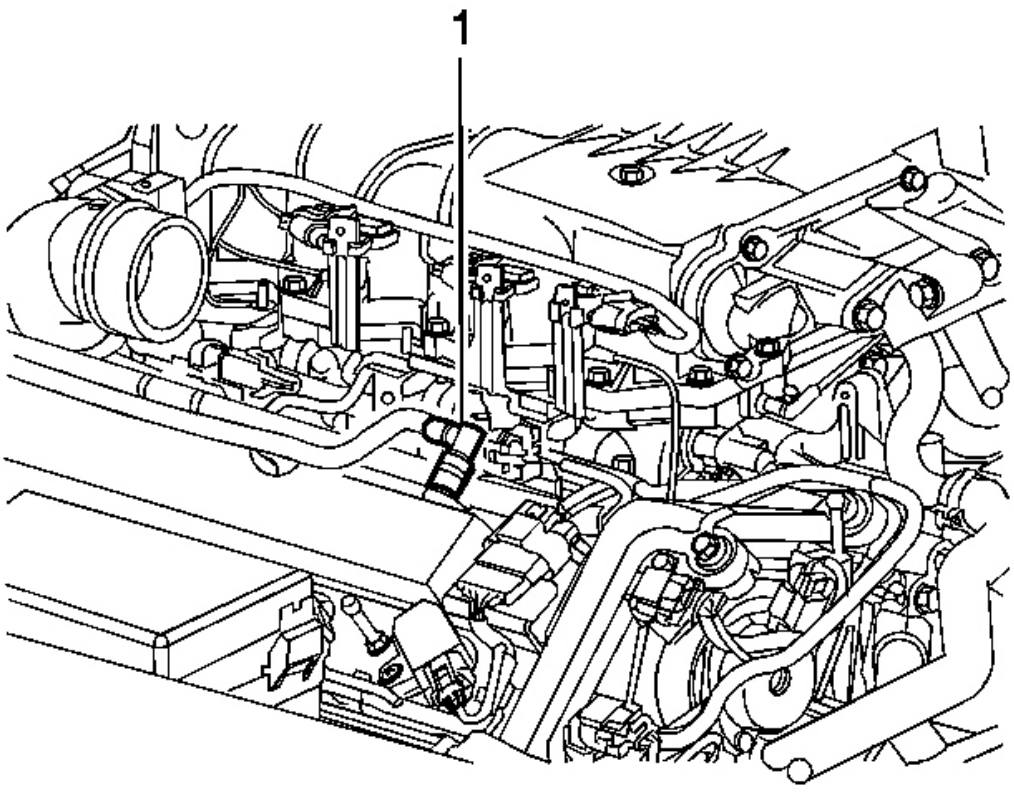


Fig. 44: Locating PCV Orifice Fitting
Courtesy of GENERAL MOTORS CORP.

3. Connect the PCV foul air tube (1) to the PCV orifice fitting on the right camshaft cover.

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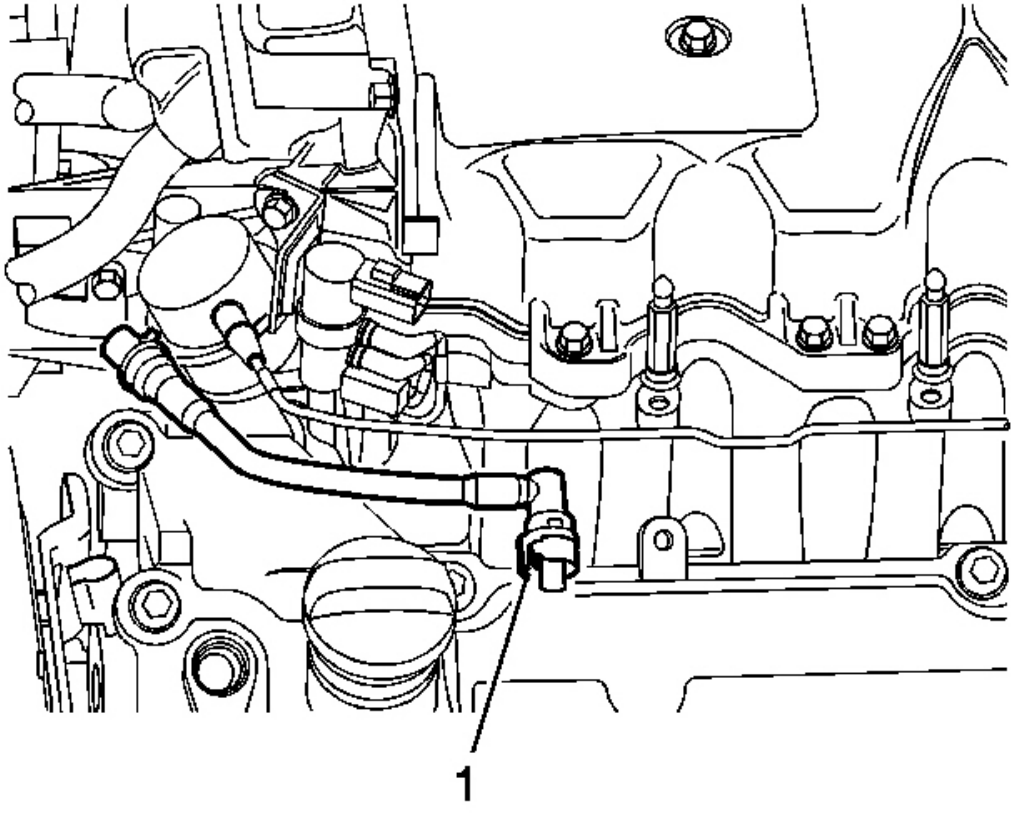


Fig. 45: View Of PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

4. Connect the PCV fresh air tube (1) to the left camshaft cover.

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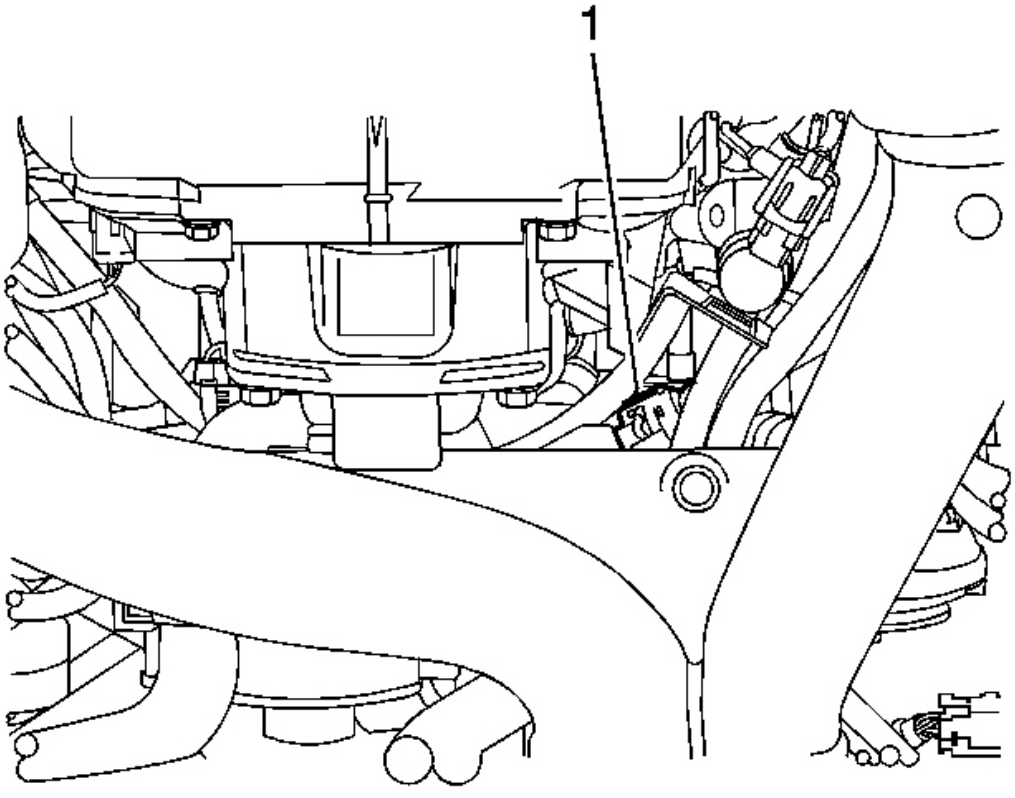


Fig. 46: Identifying PCV Hose Fitting
Courtesy of GENERAL MOTORS CORP.

5. Connect the fresh air PCV tube (1) to the fitting on the underside of the supercharger inlet duct, during the installation procedure of the front section of the supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .

CHARGE AIR COOLER COOLANT FILLER CAP REPLACEMENT

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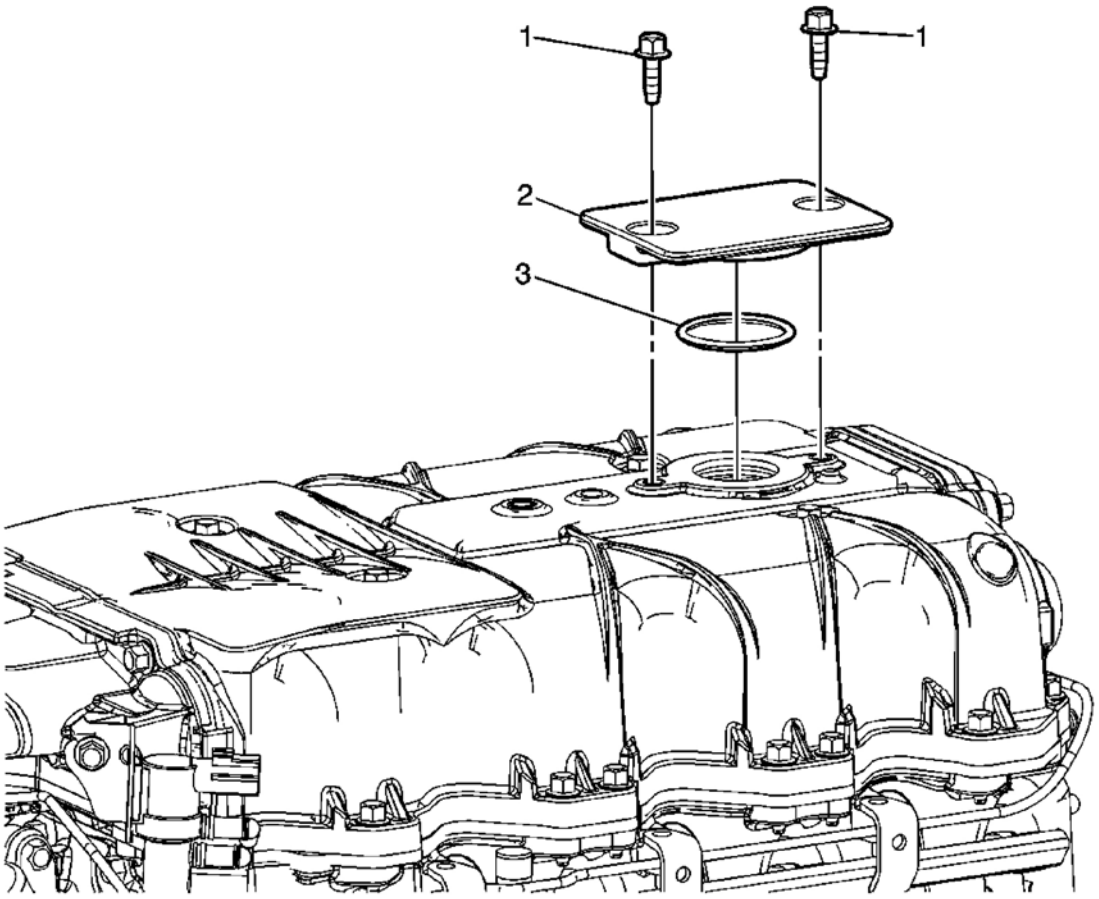


Fig. 47: View Of Charge Air Cooler Coolant Filler Cap
Courtesy of GENERAL MOTORS CORP.

Charge Air Cooler Coolant Filler Cap Replacement

Callout	Component Name
CAUTION: **To avoid being burned, do not remove the charge air coolant cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if the charge air coolant cap is removed while the engine and charge air cooling systems are still hot.** **NOTE:** **Refer to Fastener Notice .** **Fastener Tightening Specifications:** Refer to **Fastener Tightening Specifications** .	
1	Charge Air Cooler Coolant Filler Cap Bolt **Tighten:** 10 N.m (89 lb in)
	Charge Air Cooler Coolant Filler Cap **Tip:**

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2	• Ensure that the charge air cooler cooling fill cap is installed in the proper orientation. The dimple on the cap and the dimple on the supercharger DO NOT line up during assembly. • Check the charge air cooler coolant level. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .
3	Charge Air Cooler Coolant Filler Cap Seal

CHARGE AIR COOLER FRONT MANIFOLD REPLACEMENT

REMOVAL PROCEDURE

1. Remove the hood. Refer to **Hood Replacement** .
2. Remove the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**.
3. Remove the front supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
4. Drain the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .

IMPORTANT: Do not allow coolant to contact the supercharger drive belt. Place a shop rag under the front portion of the supercharger to catch any remaining coolant.

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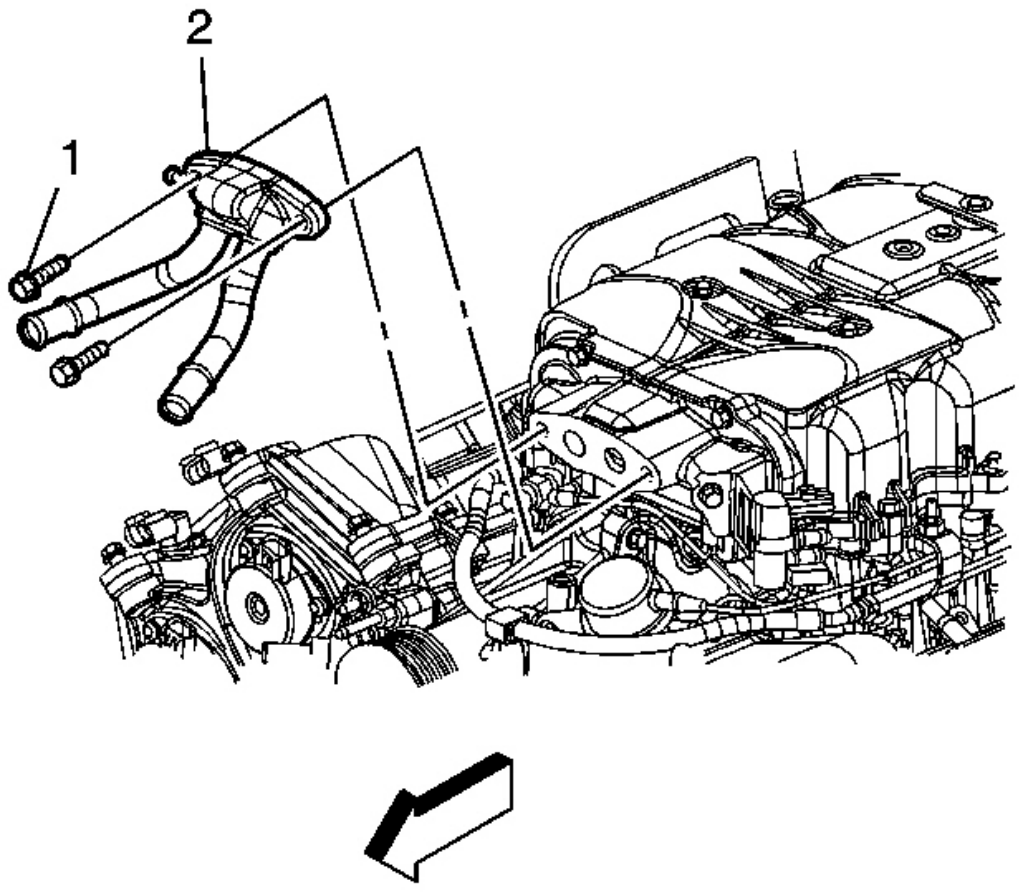


Fig. 48: View Of Charge Air Cooler & Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the charge air cooler hoses from the front section of the charge air cooler front manifold.
6. Remove the bolts (1) and remove the front portion of the supercharger front manifold (2). Discard the manifold O-ring seals.

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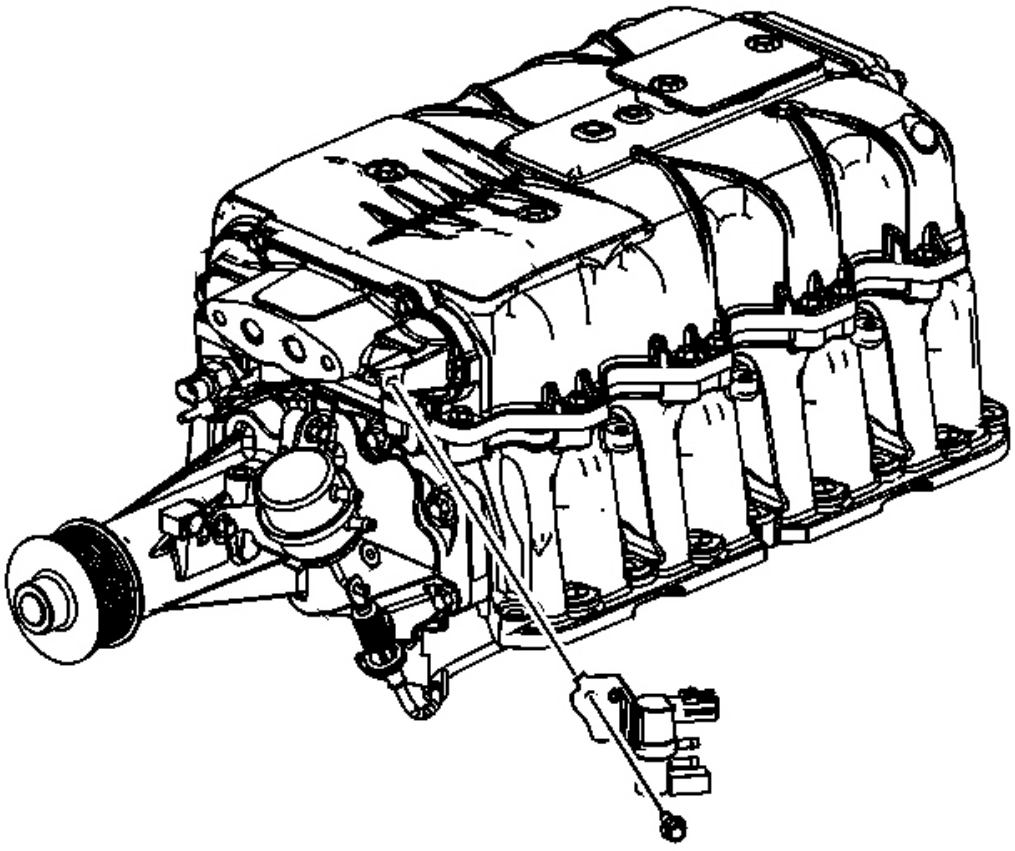


Fig. 49: View Of Supercharger Bypass Regulator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

7. Remove the supercharger bypass regulator solenoid valve and bracket. Refer to **Supercharger Bypass Regulator Solenoid Valve Replacement** .

IMPORTANT: The remaining section of the front manifold and the rear manifold must be serviced together. If only one manifold is serviced, there is a possibility of unseating the O-ring seals on the opposite manifold.

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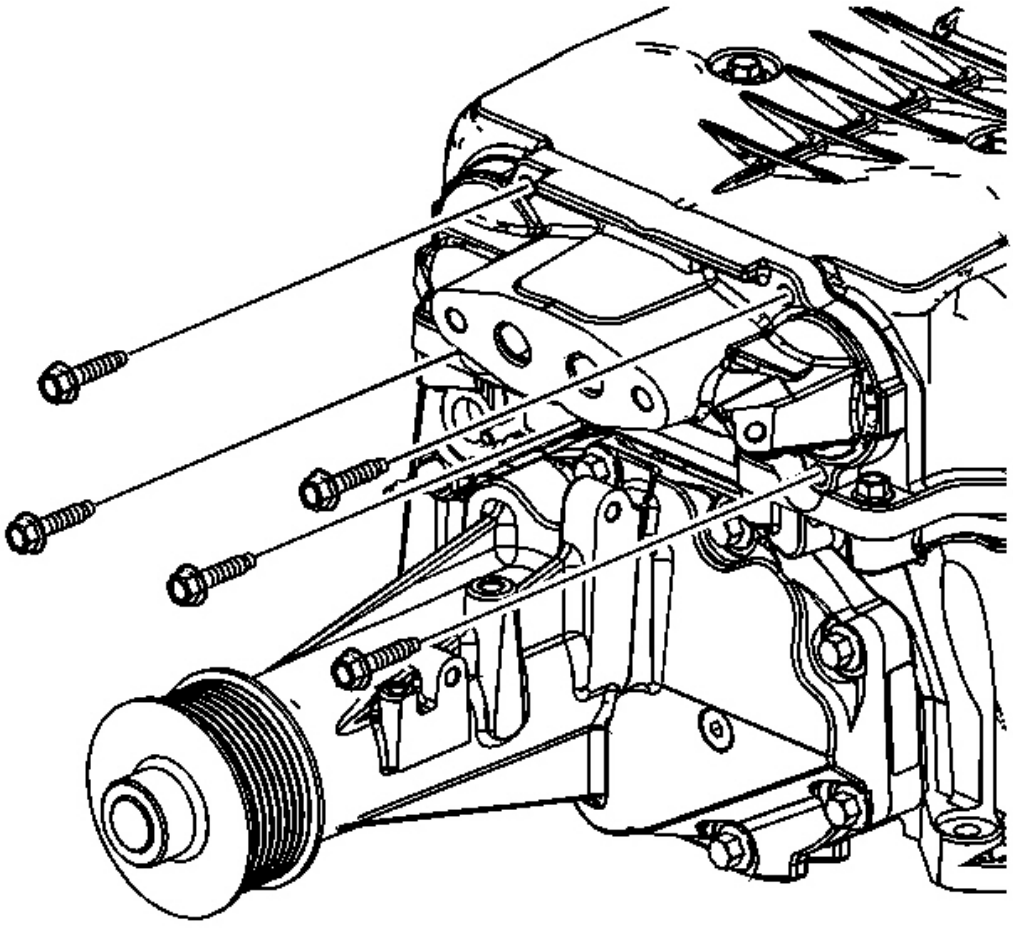


Fig. 50: Identifying Charge Air Cooler Front Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the charge air cooler front manifold bolts.

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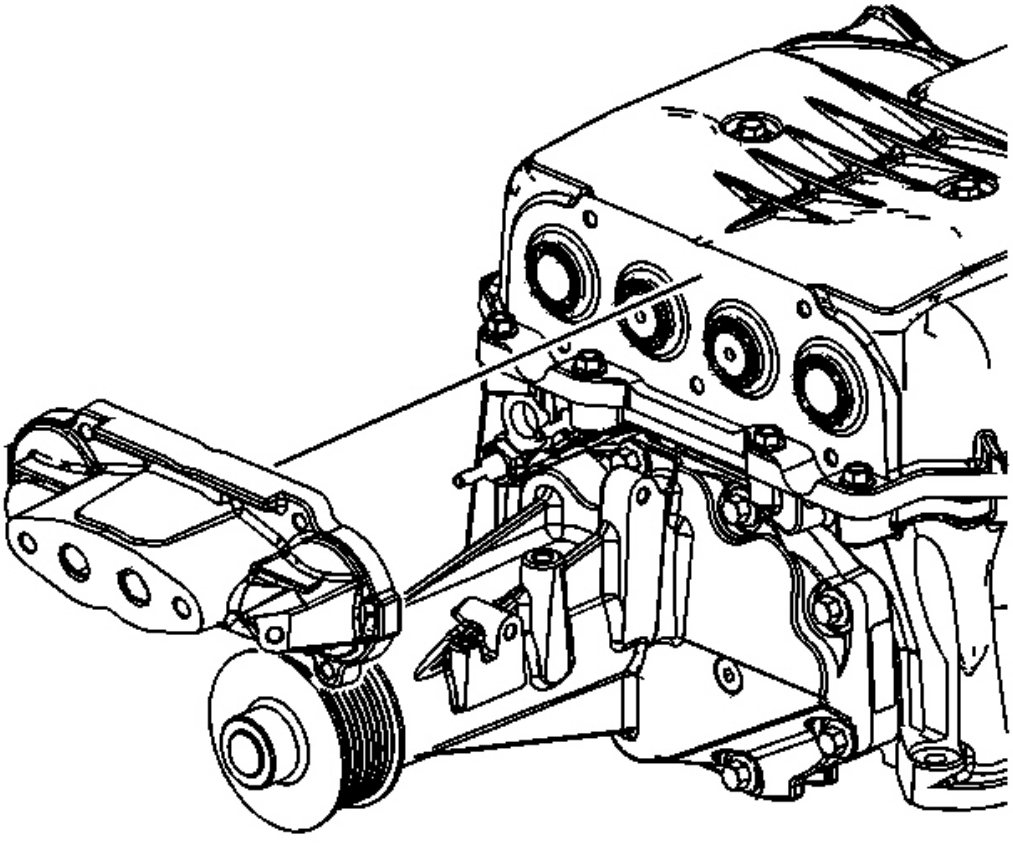


Fig. 51: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

9. Remove the charge air cooler front manifold.

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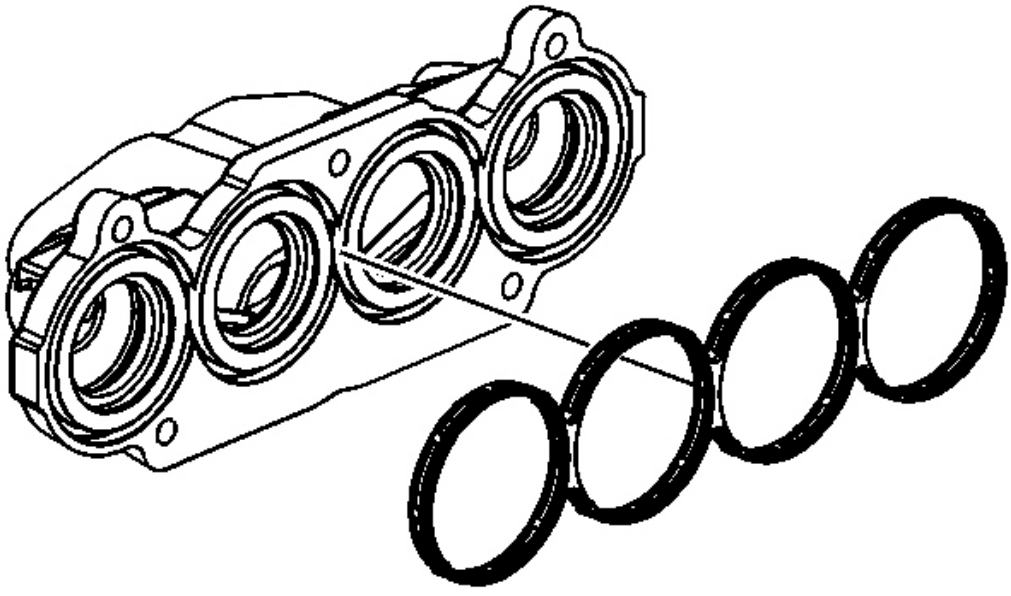


Fig. 52: View Of Charge Air Cooler Front Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the charge air cooler front manifold gasket.

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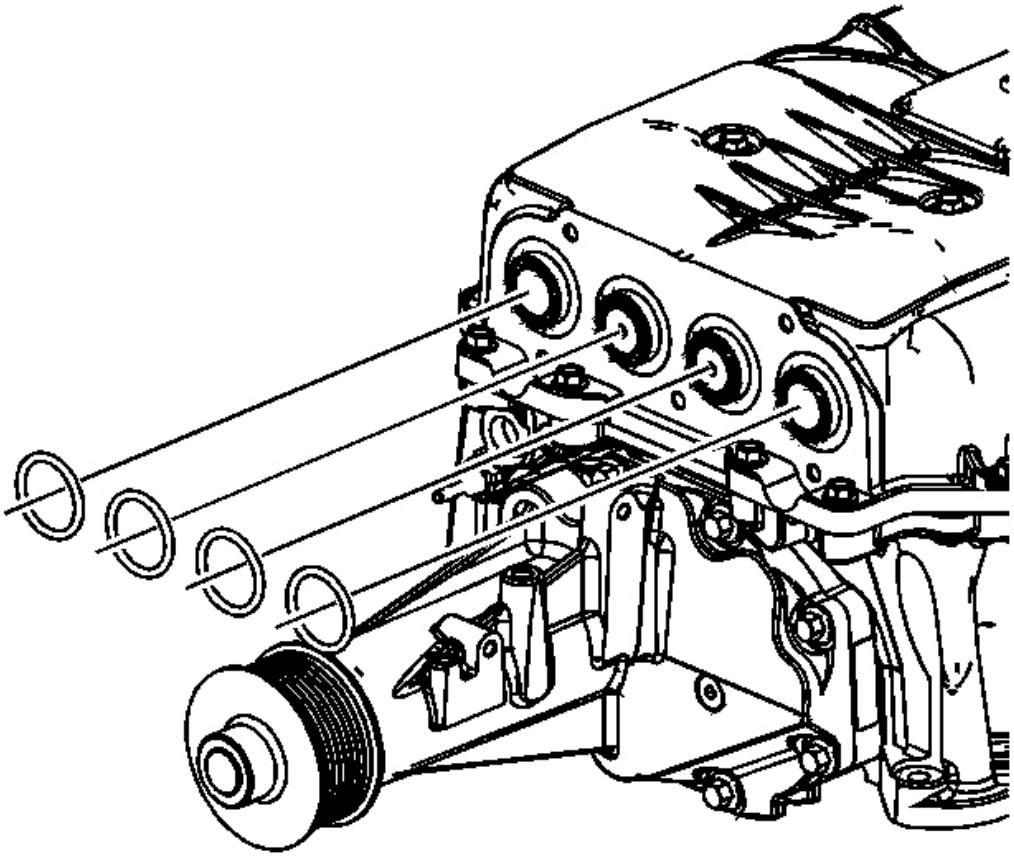


Fig. 53: View Of Charge Air Cooler Cooling Tube Front O-Rings
Courtesy of GENERAL MOTORS CORP.

11. Remove and discard the charge air cooler cooling tube front O-rings.

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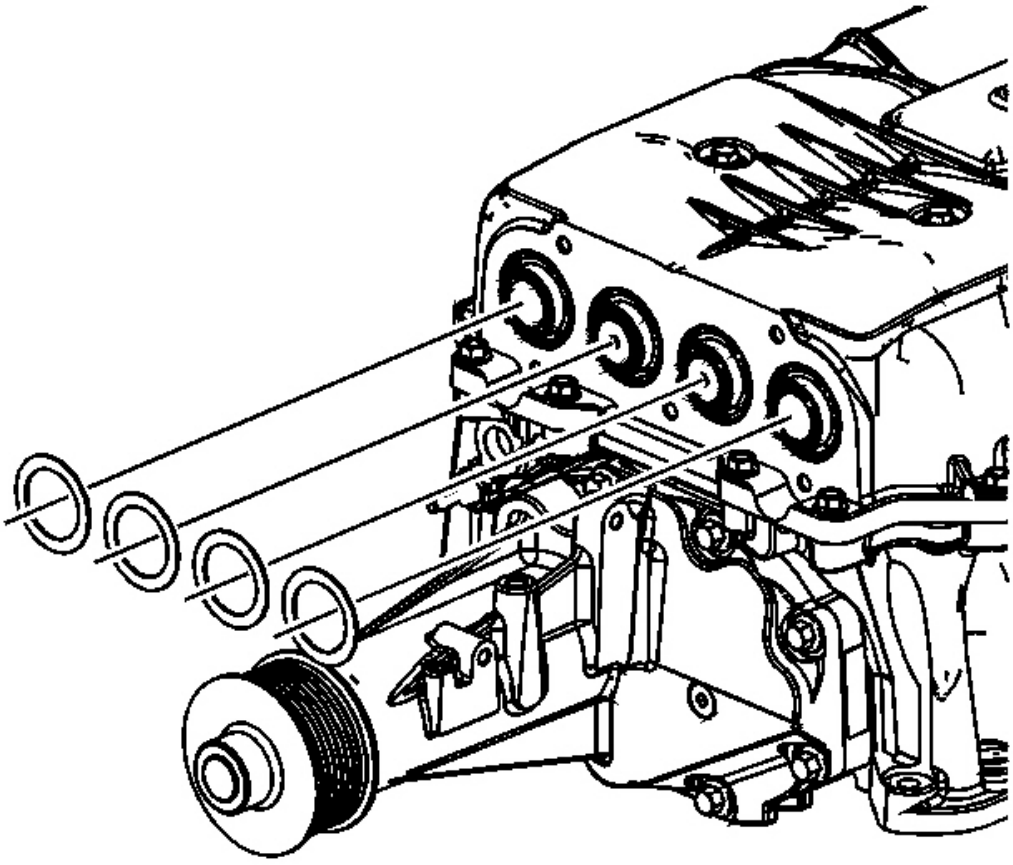


Fig. 54: View Of Charge Air Cooler Cooling Tube Front Spacers
Courtesy of GENERAL MOTORS CORP.

12. Remove the charge air cooler cooling tube front spacers if required.

Automotive-Manual.net

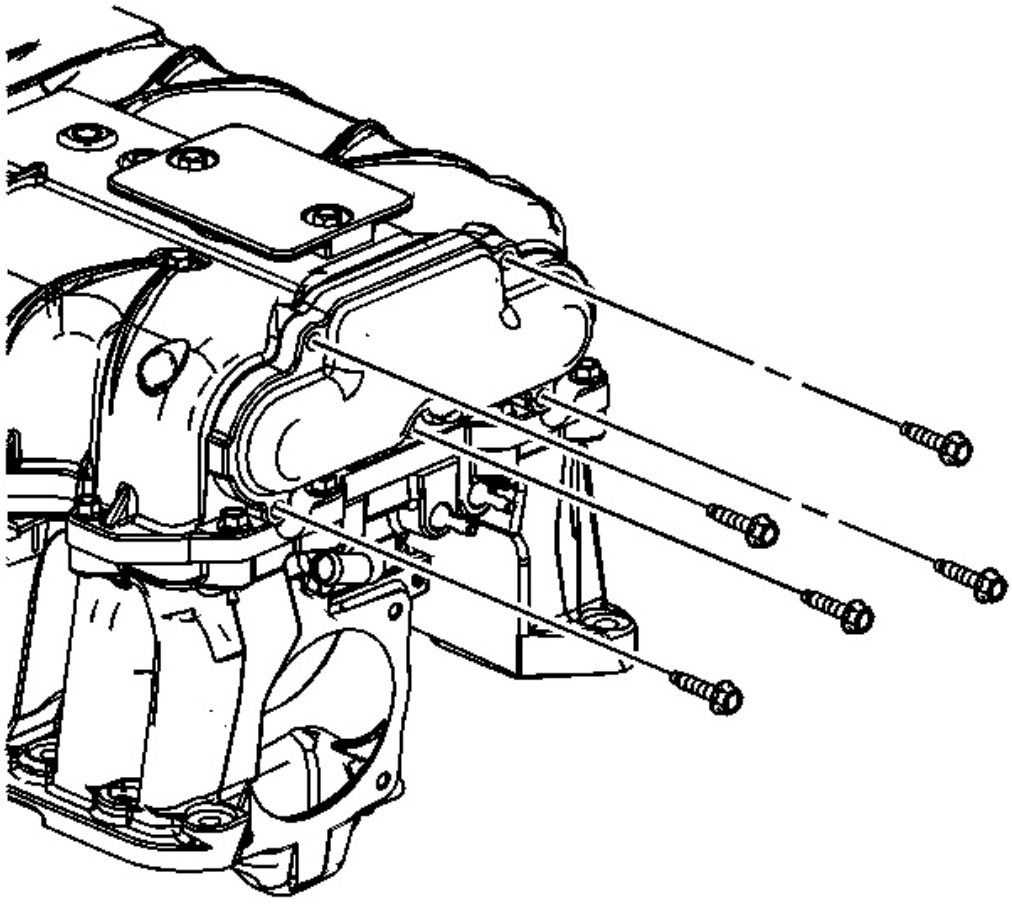


Fig. 55: Identifying Charge Air Cooler Rear Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the charge air cooler rear manifold bolts.

Automotive-Manual.net

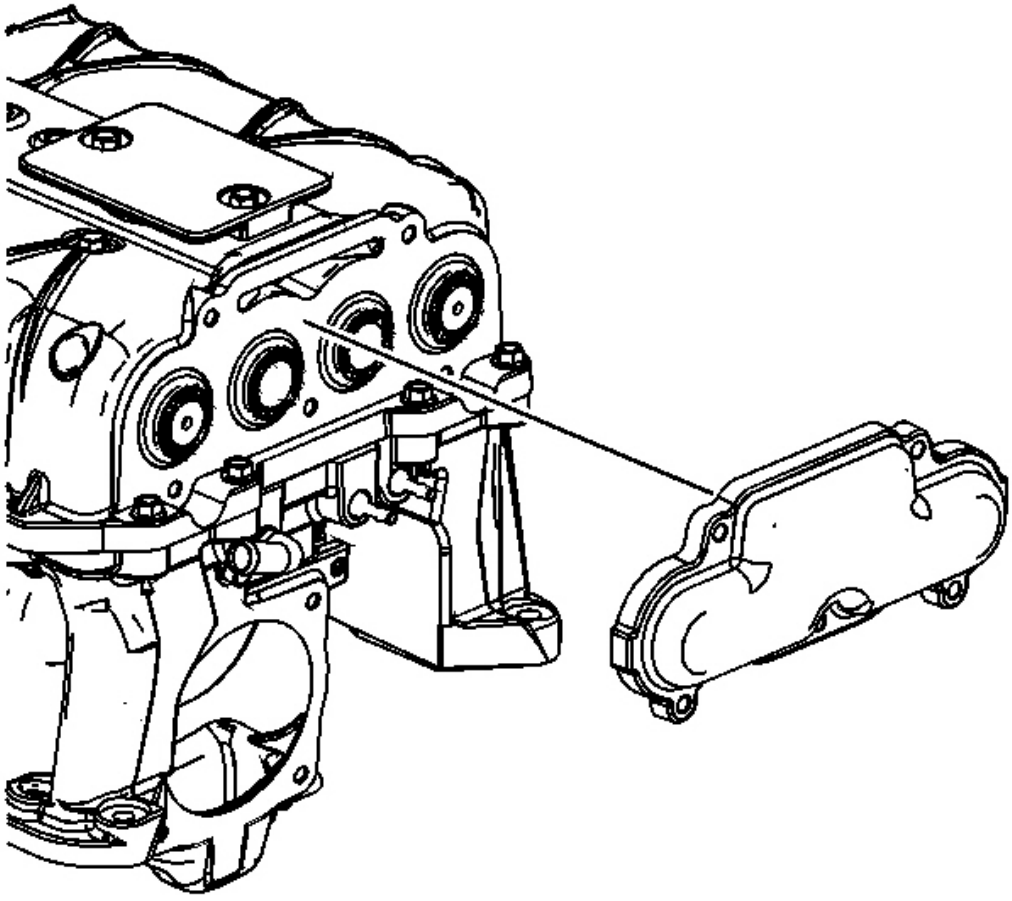


Fig. 56: Identifying Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

14. Remove the charge air cooler rear manifold.

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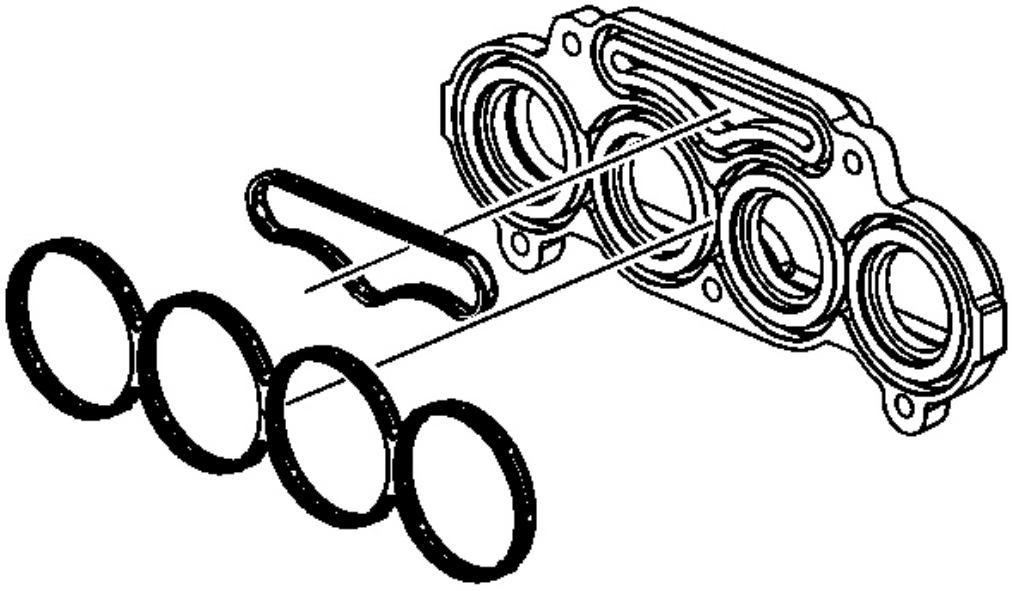


Fig. 57: View Of Charge Air Cooler Rear Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

15. Remove and discard the charge air cooler rear manifold gaskets.

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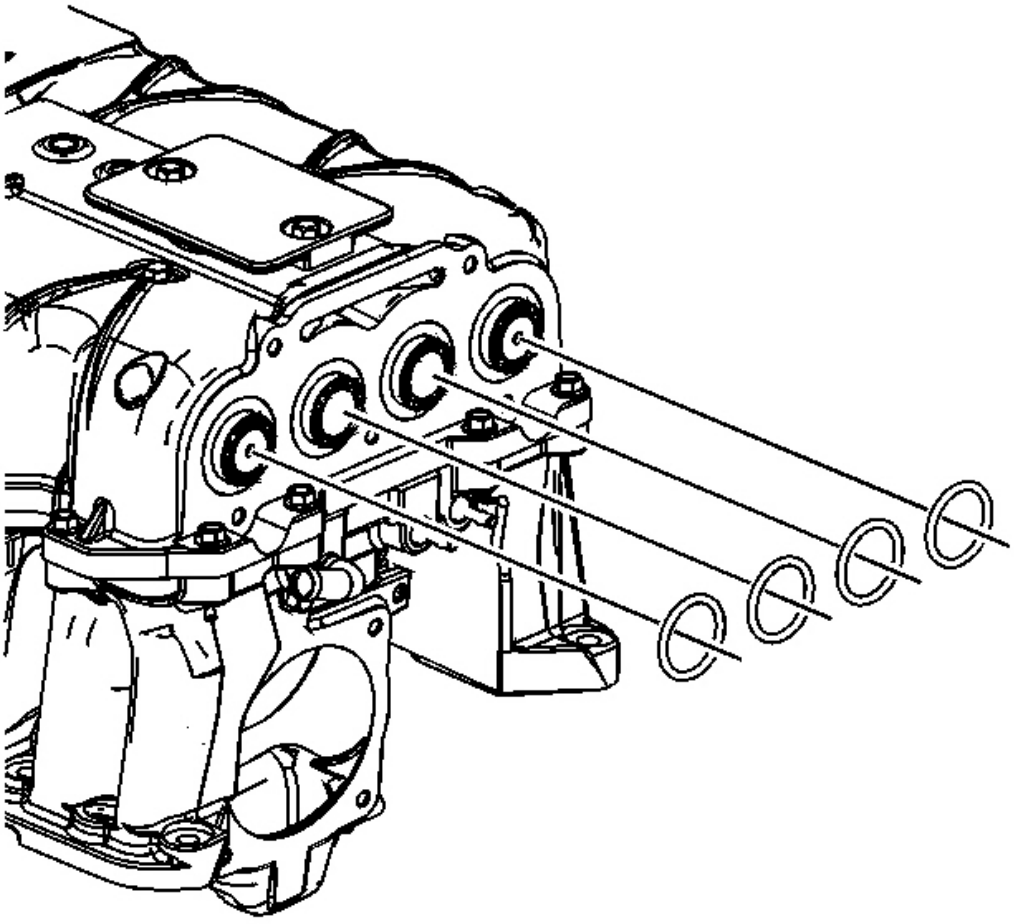


Fig. 58: View Of Charge Air Cooler Cooling Tube Rear O-Rings
Courtesy of GENERAL MOTORS CORP.

16. Remove and discard the charge air cooler cooling tube rear O-rings.

Automotive-Manual.net

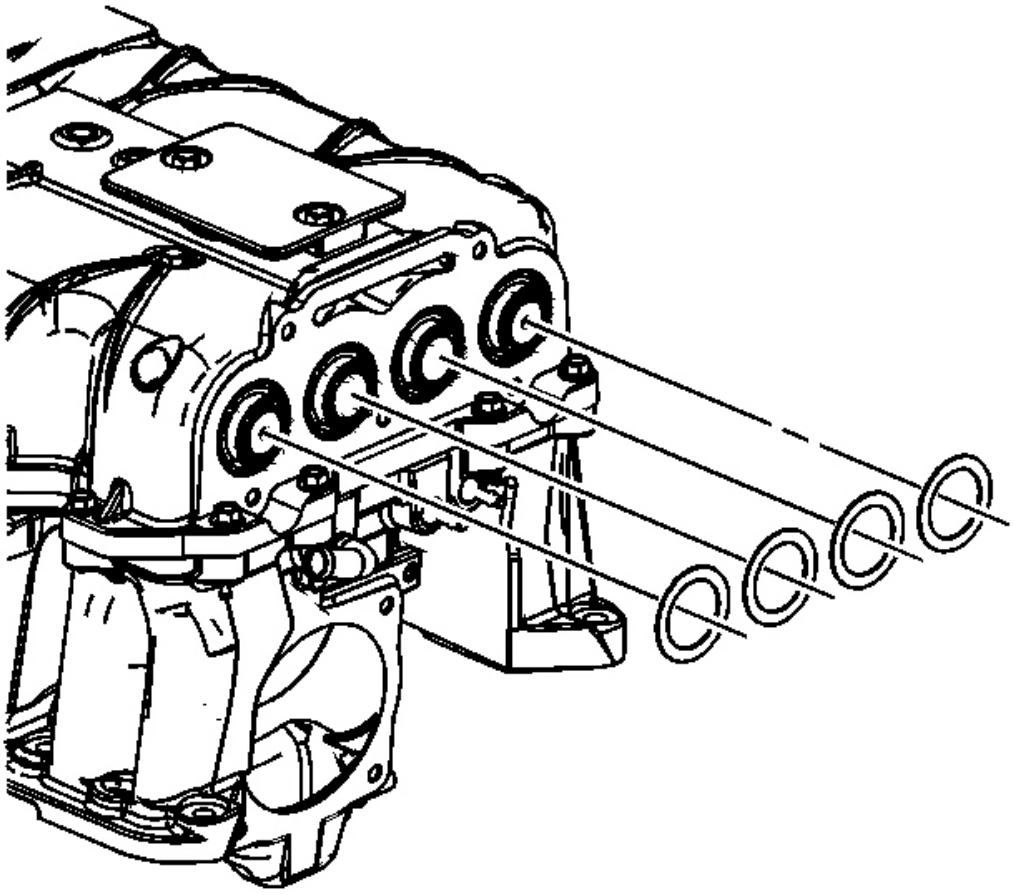


Fig. 59: View Of Charge Air Cooler Cooling Tube Rear Spacers
Courtesy of GENERAL MOTORS CORP.

17. Remove the charge air cooler cooling tube rear spacers, if required.
18. Remove the inboard and outboard charge air cooling tubes, if required. Refer to **Charge Air Cooler Cooling Tube Replacement**.
19. Clean and inspect the charge air cooler manifolds and cooling tubes. Refer to **Supercharger Cleaning and Inspection** .

INSTALLATION PROCEDURE

IMPORTANT: The charge air cooler cooling tubes must be installed with the restrictor plates and notch facing the proper directions.

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1. Install the charge air cooling tubes, if previously removed. Refer to **Charge Air Cooler Cooling Tube Replacement**.

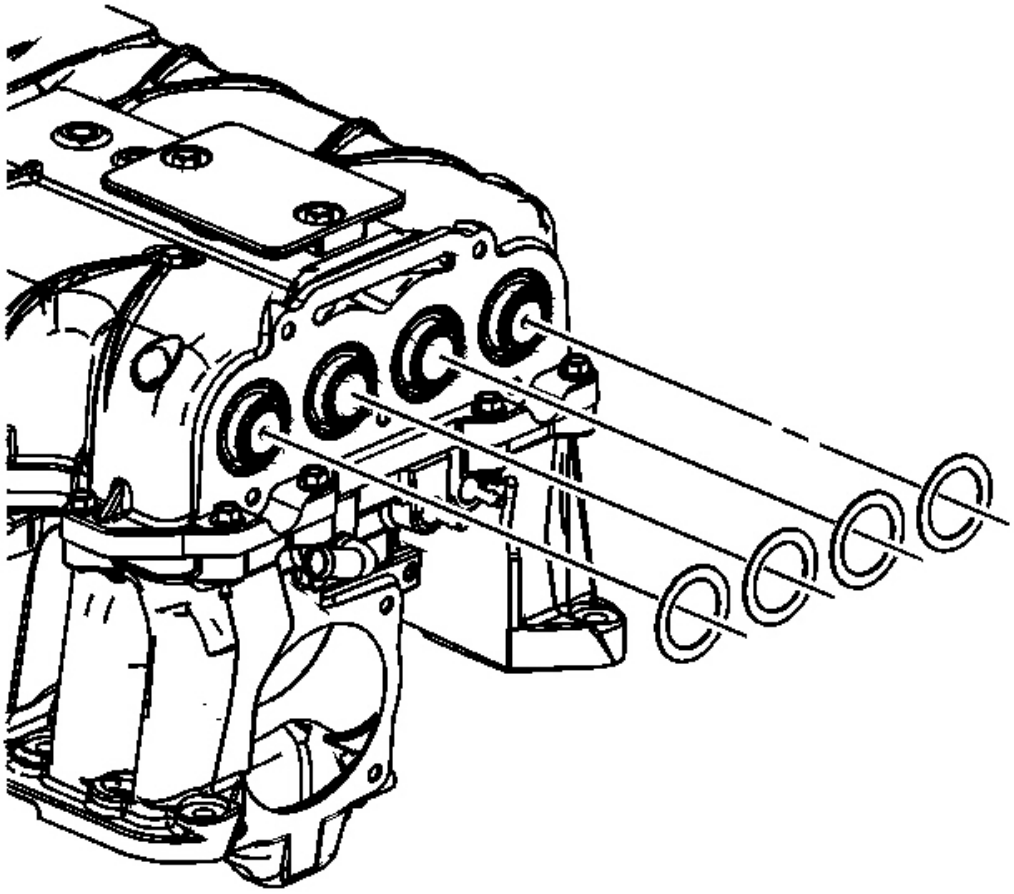


Fig. 60: View Of Charge Air Cooler Cooling Tube Rear Spacers
Courtesy of GENERAL MOTORS CORP.

2. Install the charge air cooler cooling tube rear spacers, if previously removed.

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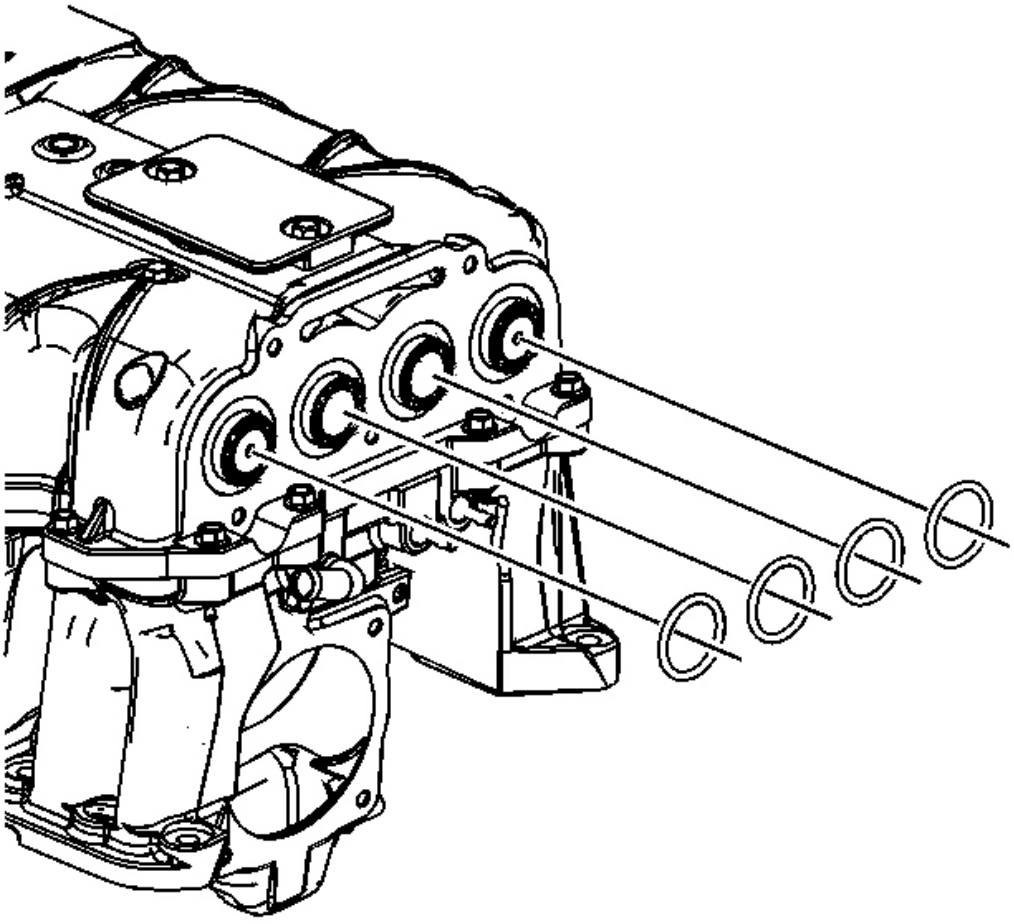


Fig. 61: View Of Charge Air Cooler Cooling Tube Rear O-Rings
Courtesy of GENERAL MOTORS CORP.

3. Install the NEW charge air cooler cooling tube rear O-rings.

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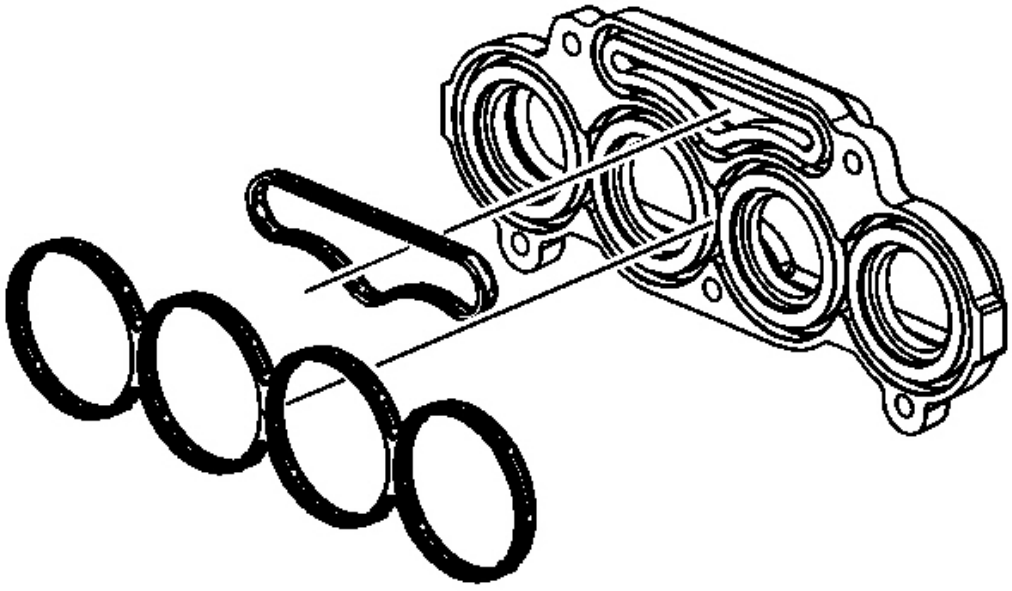


Fig. 62: View Of Charge Air Cooler Rear Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

4. Install the NEW charge air cooler rear manifold gaskets.

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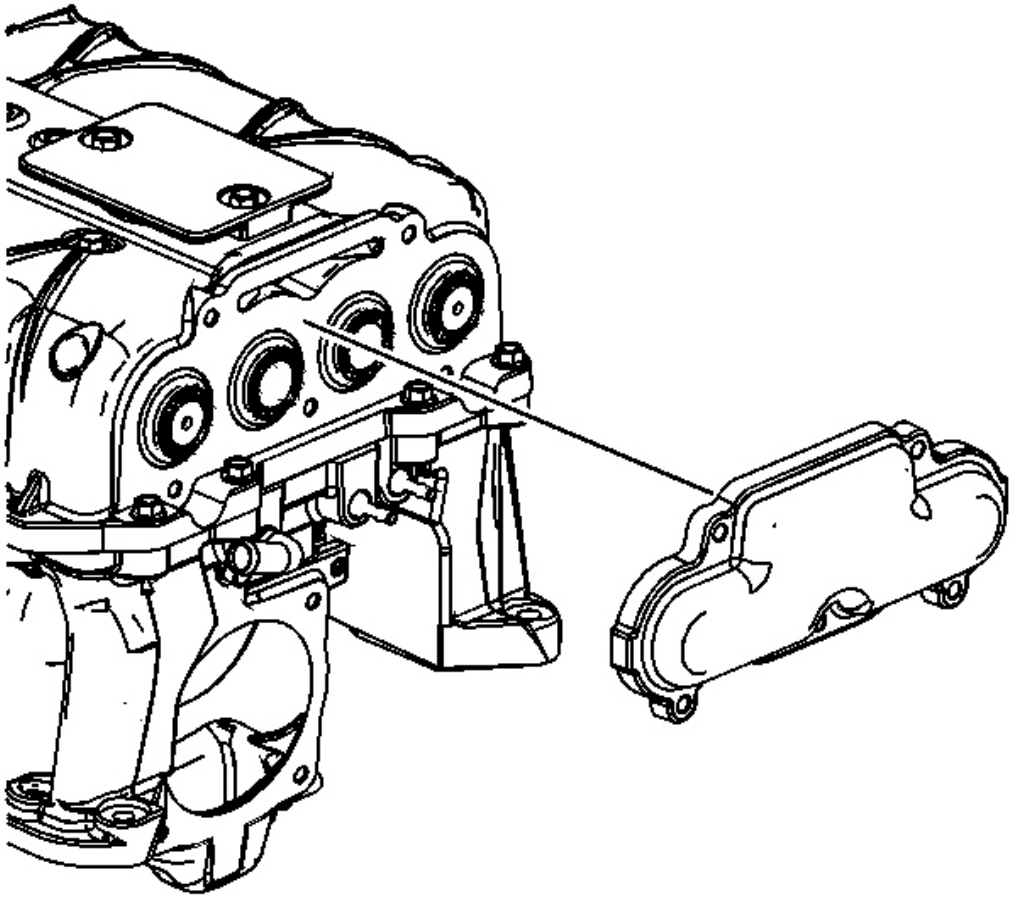


Fig. 63: Identifying Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

5. Install the charge air cooler rear manifold.

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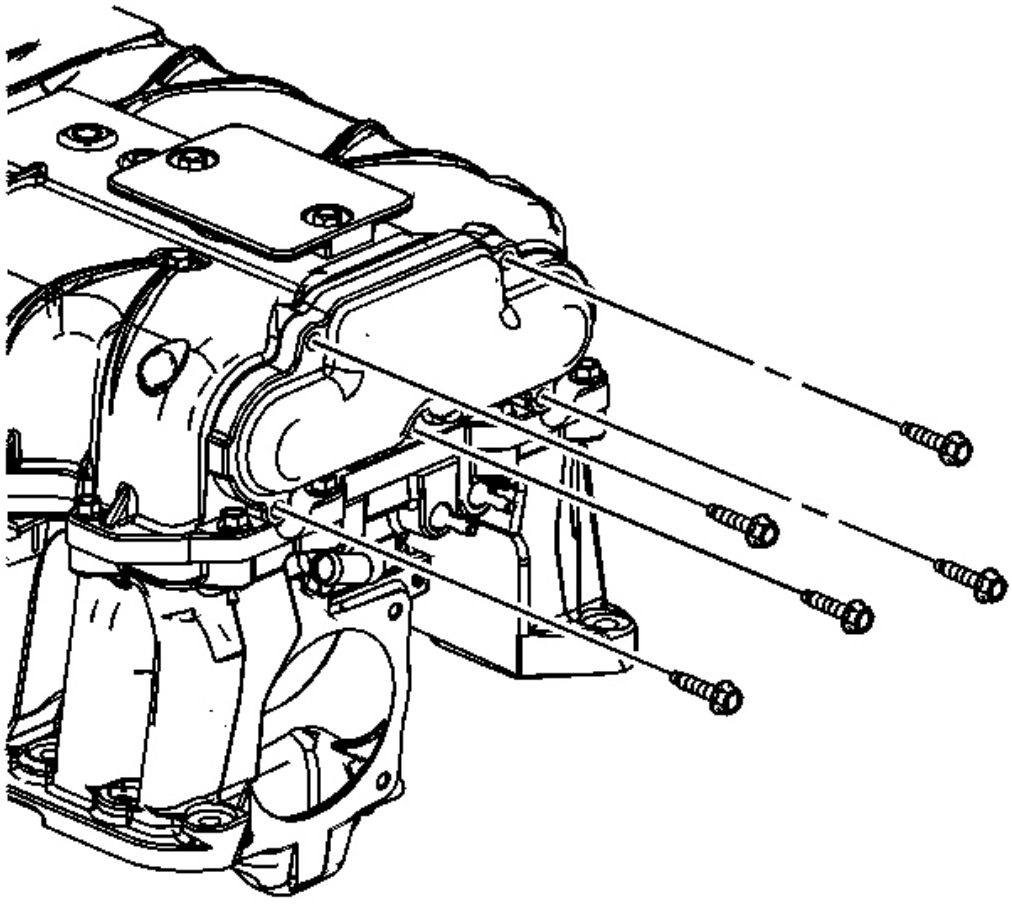


Fig. 64: Identifying Charge Air Cooler Rear Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the charge air cooler rear manifold bolts.

   Tighten: Tighten the charge air cooler rear manifold bolts to 10 N.m (89 lb in).

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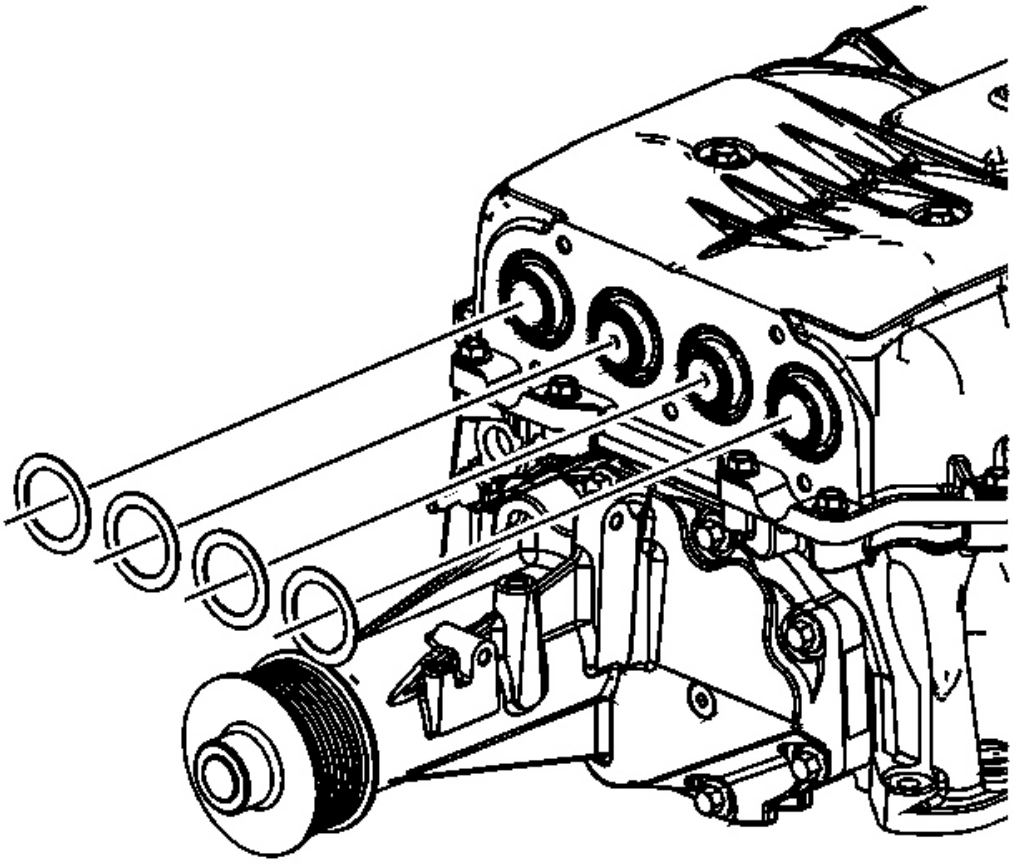


Fig. 65: View Of Charge Air Cooler Cooling Tube Front Spacers
Courtesy of GENERAL MOTORS CORP.

7. Install the charge air cooler cooling tube front spacers, if previously removed.

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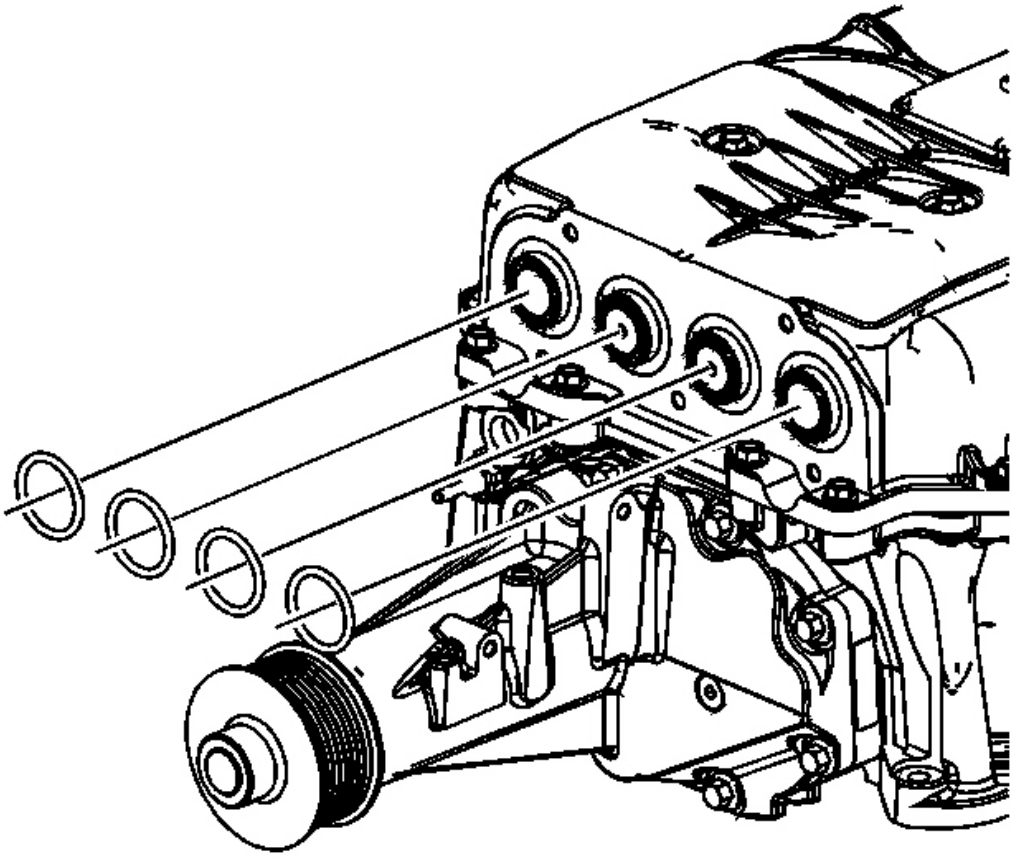


Fig. 66: View Of Charge Air Cooler Cooling Tube Front O-Rings
Courtesy of GENERAL MOTORS CORP.

8. Install the NEW charge air cooler cooling tube front O-rings.

Automotive-Manual.net

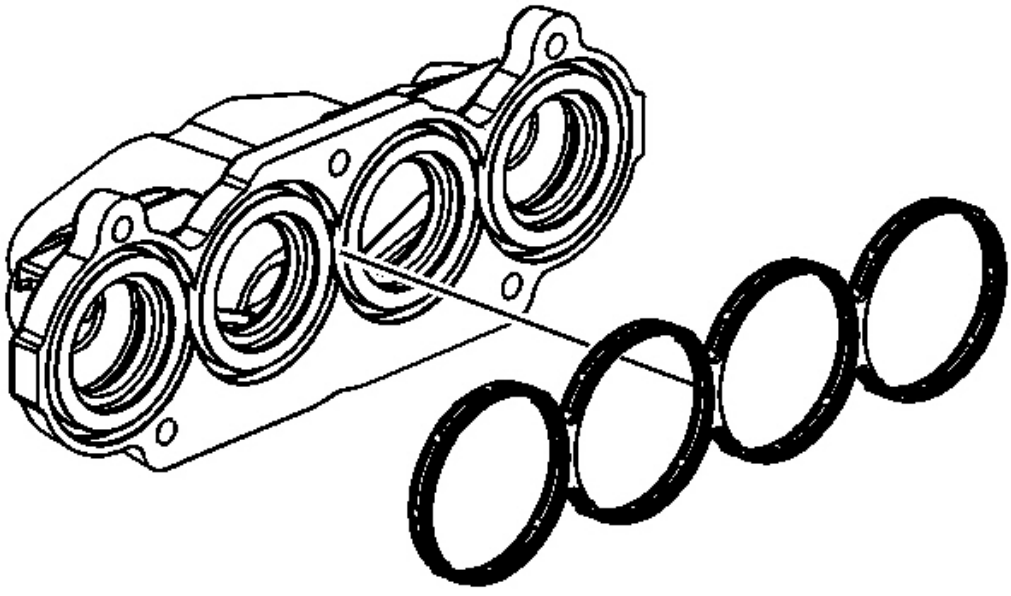


Fig. 67: View Of Charge Air Cooler Front Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

9. Install the NEW charge air cooler front manifold gasket.

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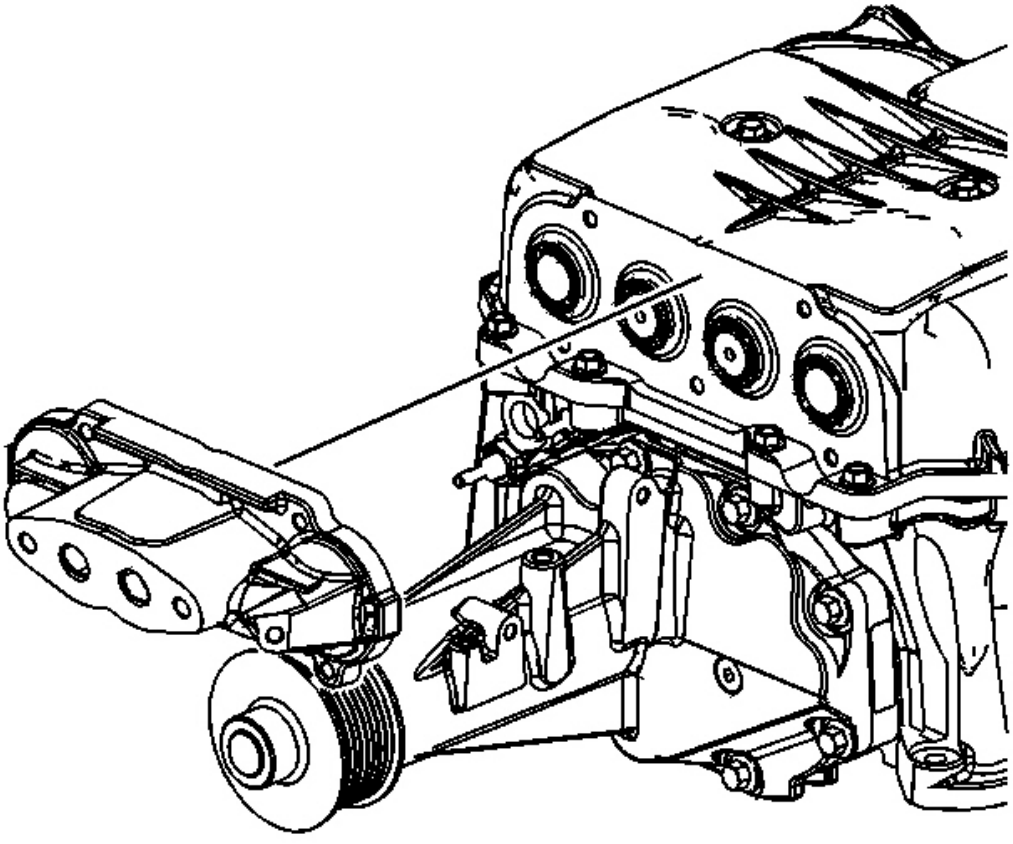


Fig. 68: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

10. Install the charge air cooler front manifold.

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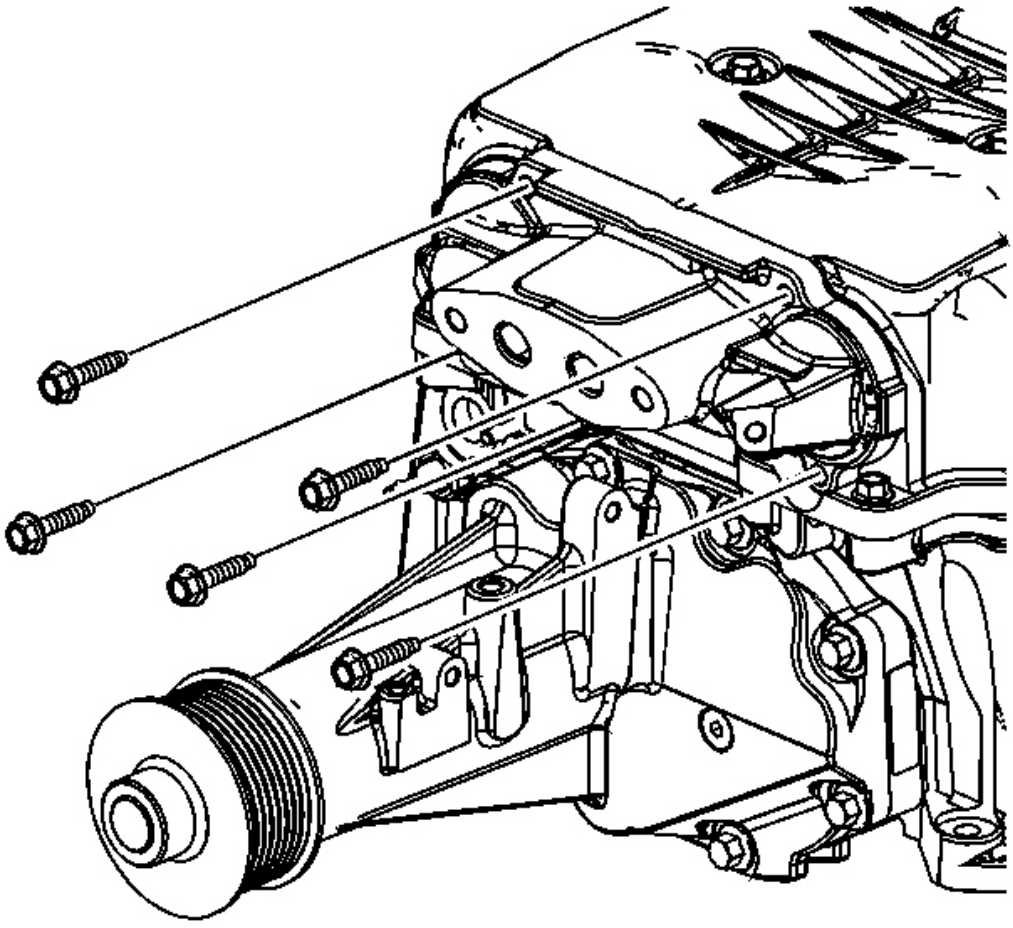


Fig. 69: Identifying Charge Air Cooler Front Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the charge air cooler front manifold bolts.

    Tighten: Tighten the charge air cooler front manifold bolts to 10 N.m (89 lb in).

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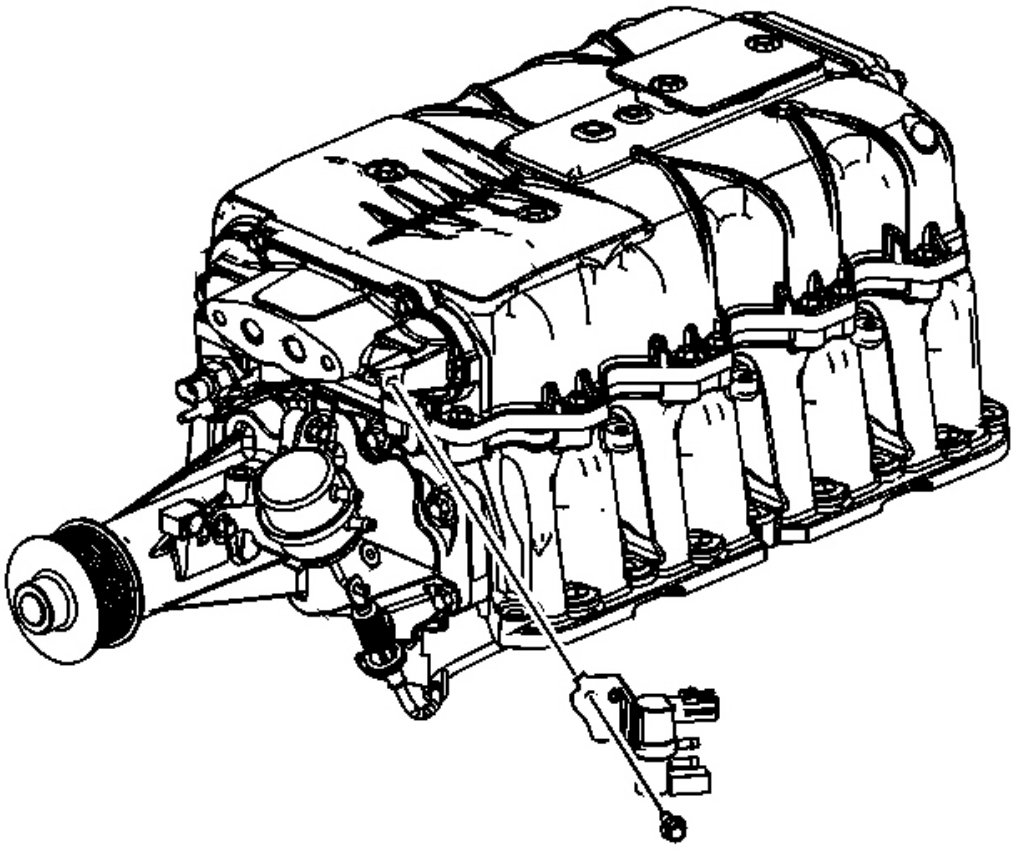


Fig. 70: View Of Supercharger Bypass Regulator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

12. Install the supercharger bypass regulator solenoid valve and bracket. Refer to **Supercharger Bypass Regulator Solenoid Valve Replacement** .

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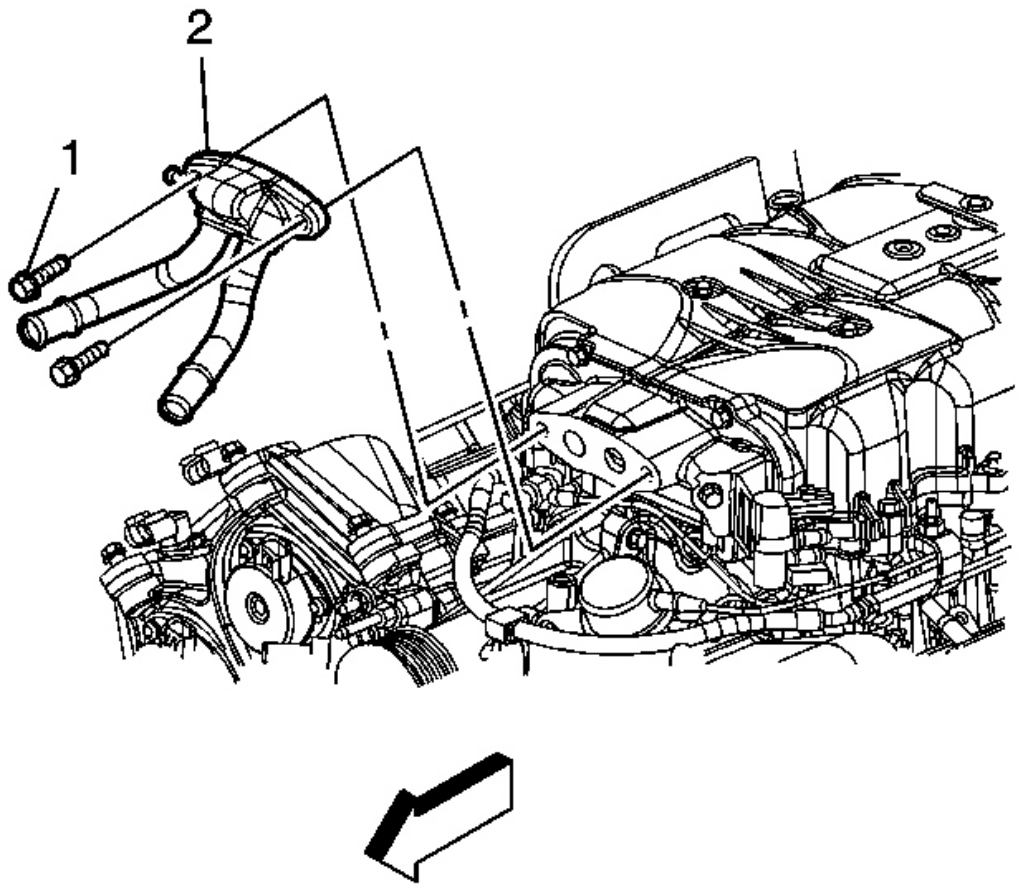


Fig. 71: View Of Charge Air Cooler & Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

13. Using NEW O-ring seals, install the front portion of the charge air cooler front manifold (2).
14. Install the manifold bolts (1).

    Tighten: Tighten the charge air cooler front manifold bolts to 10 N.m (89 lb in).

15. Install the charge air cooler hoses to the front section of the charge air cooler front manifold.
16. Fill the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .
17. Install the front supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
18. Install the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**.

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19. Install the hood. Refer to **Hood Replacement** .

CHARGE AIR COOLER COOLANT REAR MANIFOLD REPLACEMENT

REMOVAL PROCEDURE

1. Remove the hood. Refer to **Hood Replacement** .
2. Remove the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**.
3. Remove the front supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
4. Drain the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .

IMPORTANT: Do not allow coolant to contact the supercharger drive belt. Place a shop rag under the front portion of the supercharger to catch any remaining coolant.

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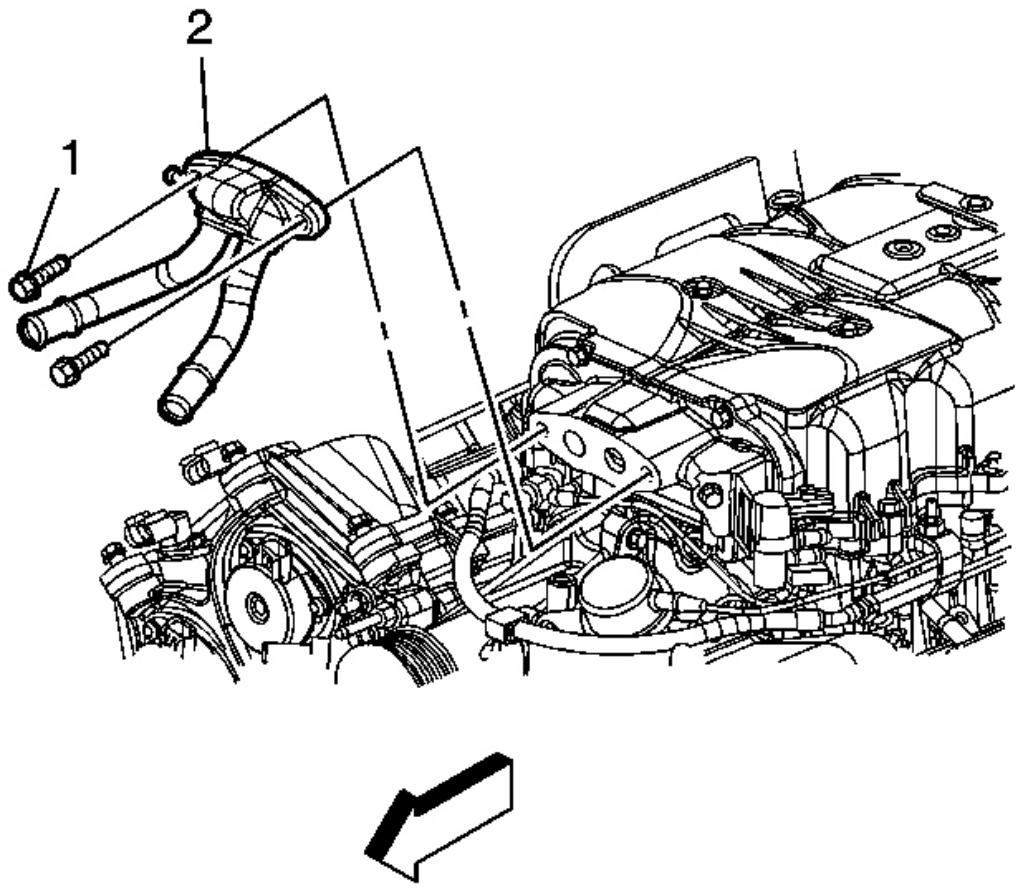


Fig. 72: View Of Charge Air Cooler & Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the charge air cooler hoses from the front section of the charge air cooler front manifold.
6. Remove the bolts (1) and remove the front portion of the supercharger front manifold (2). Discard the manifold O-ring seals.

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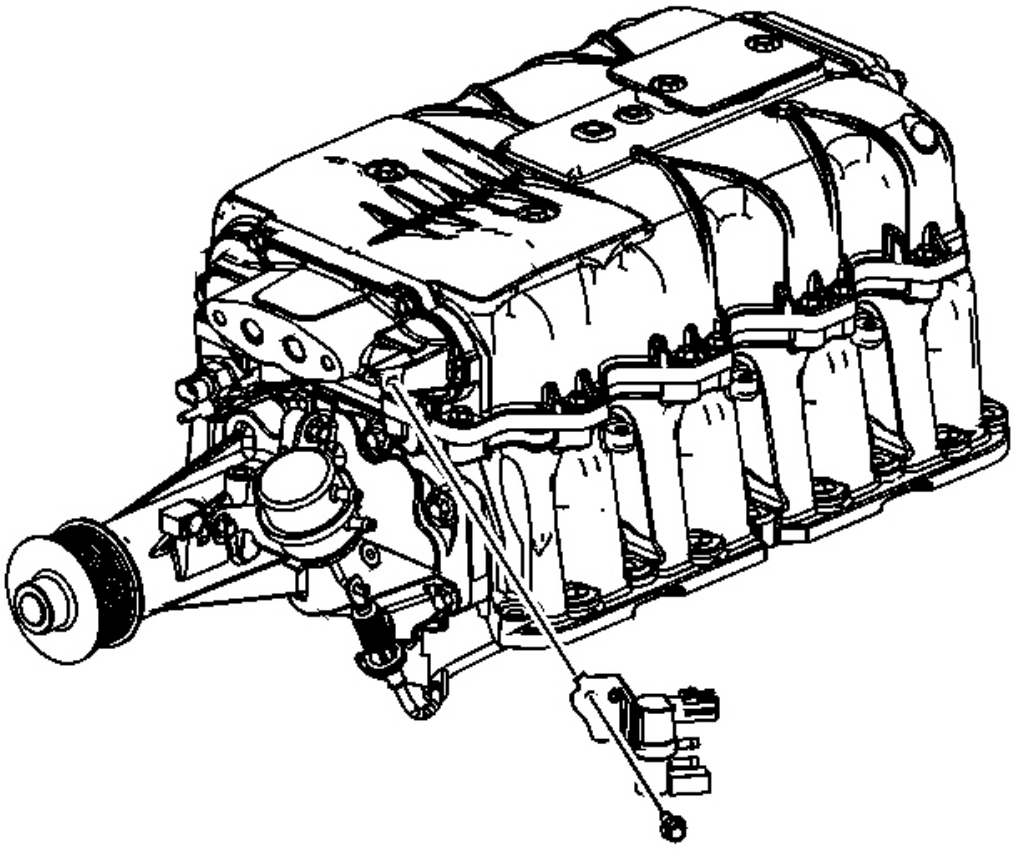


Fig. 73: View Of Supercharger Bypass Regulator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

7. Remove the supercharger bypass regulator solenoid valve and bracket. Refer to **Supercharger Bypass Regulator Solenoid Valve Replacement** .

IMPORTANT: The remaining section of the front manifold and the rear manifold must be serviced together. If only one manifold is serviced, there is a possibility of unseating the O-ring seals on the opposite manifold.

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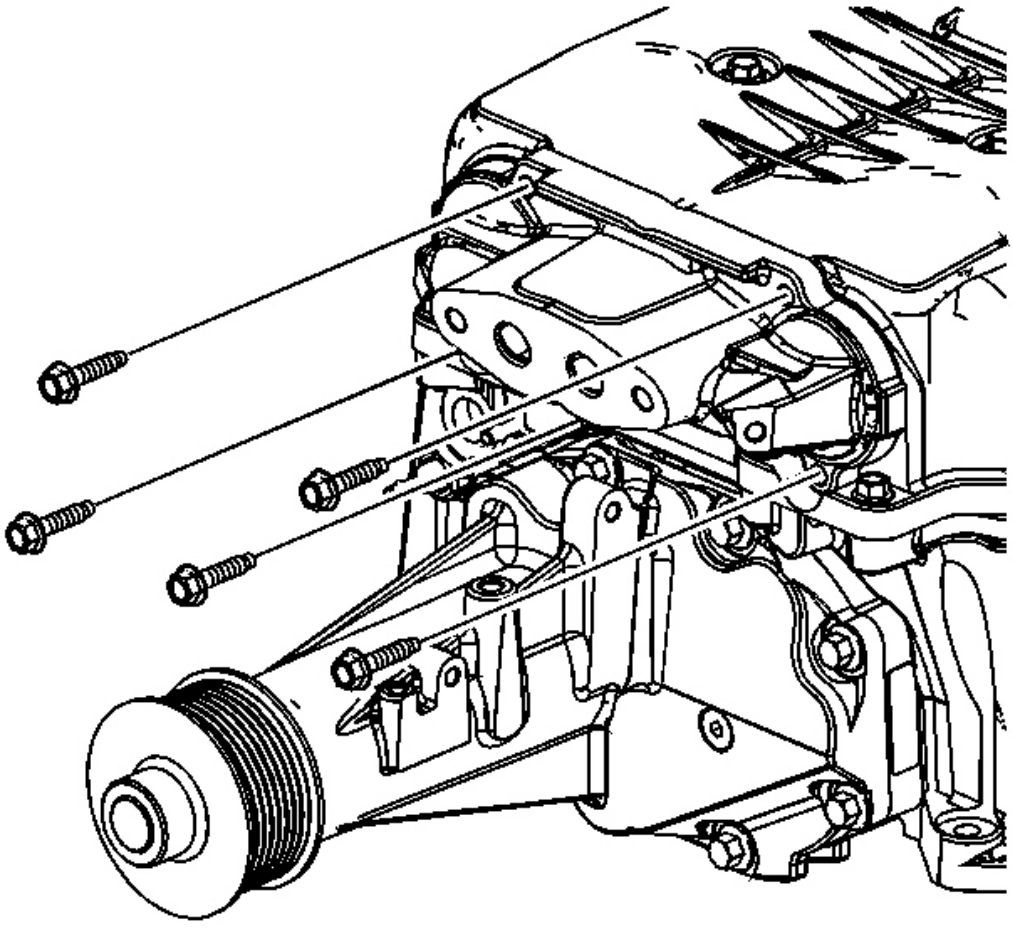


Fig. 74: Identifying Charge Air Cooler Front Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the charge air cooler front manifold bolts.

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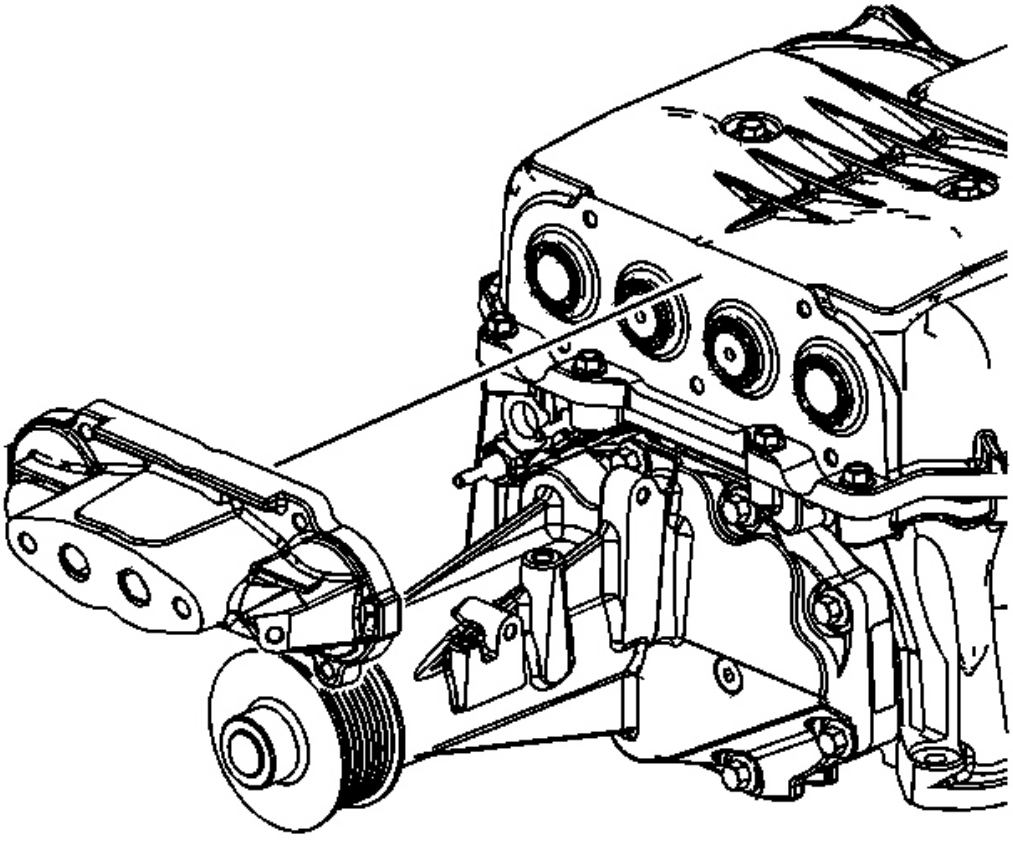


Fig. 75: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

9. Remove the charge air cooler front manifold.

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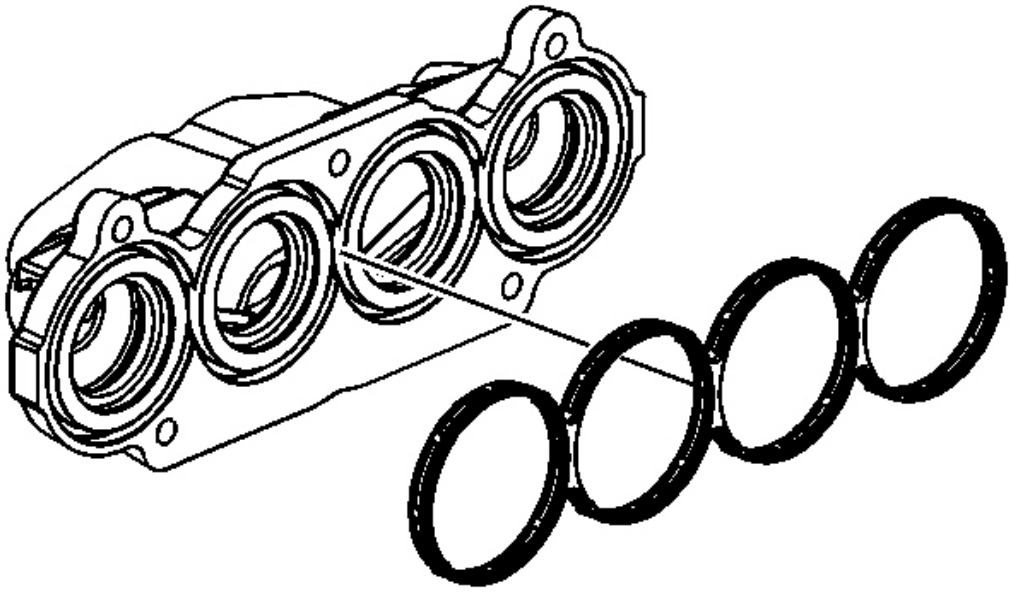


Fig. 76: View Of Charge Air Cooler Front Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the charge air cooler front manifold gasket.

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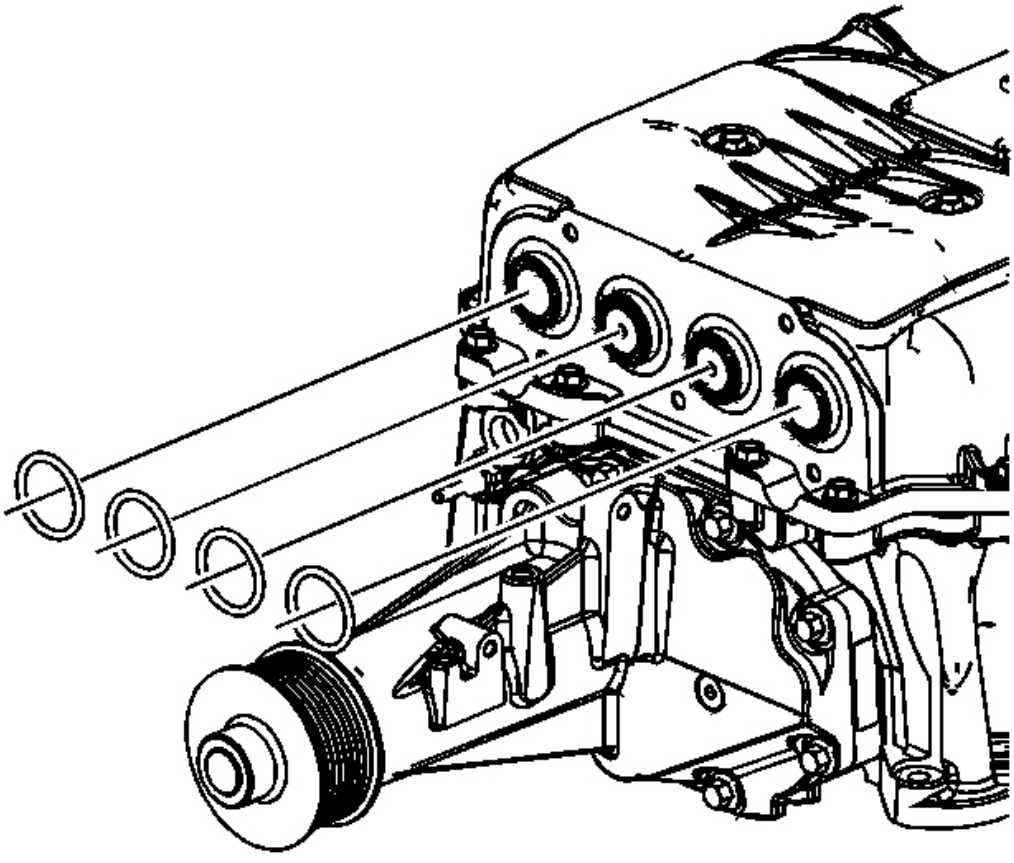


Fig. 77: View Of Charge Air Cooler Cooling Tube Front O-Rings
Courtesy of GENERAL MOTORS CORP.

11. Remove and discard the charge air cooler cooling tube front O-rings.

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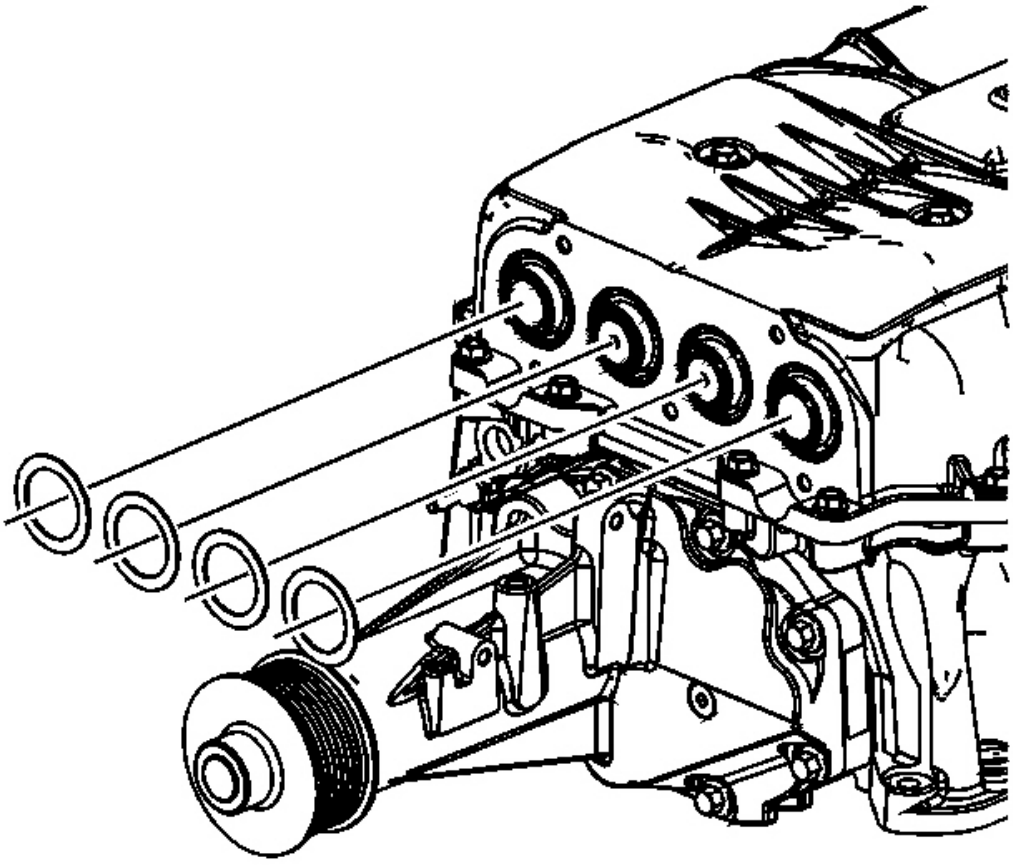


Fig. 78: View Of Charge Air Cooler Cooling Tube Front Spacers
Courtesy of GENERAL MOTORS CORP.

12. Remove the charge air cooler cooling tube front spacers if required.

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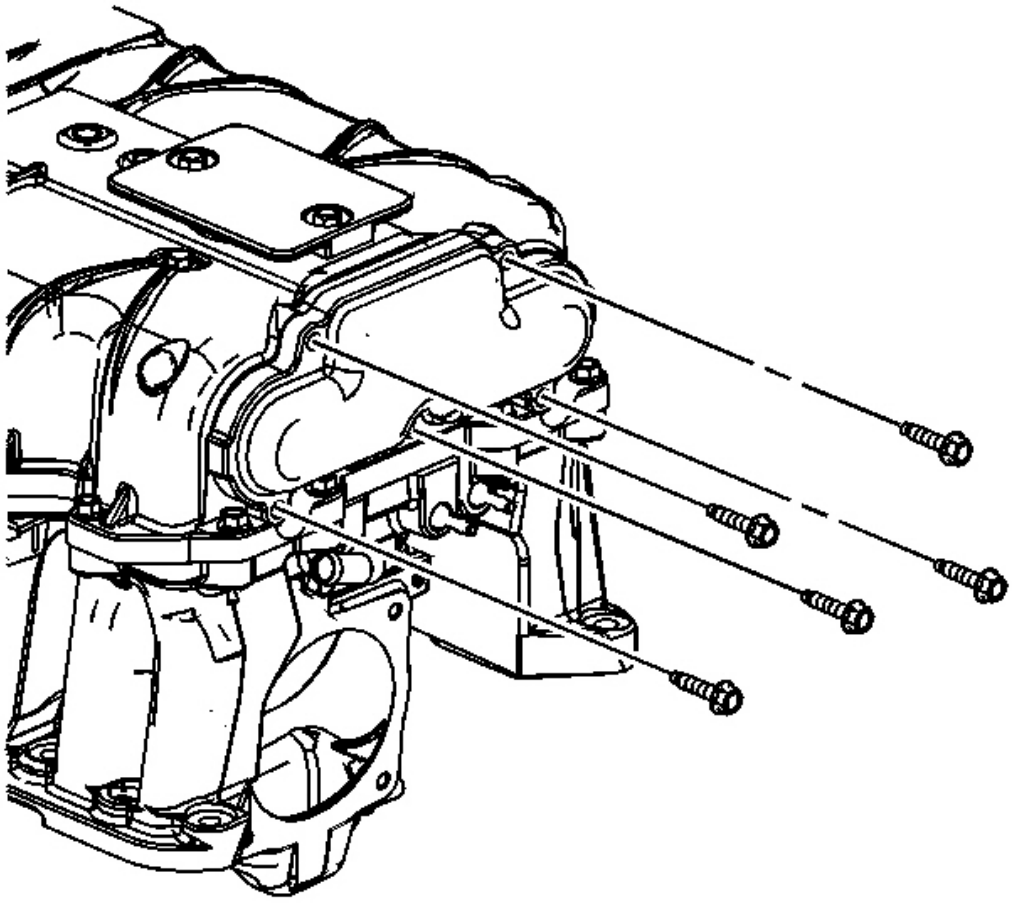


Fig. 79: Identifying Charge Air Cooler Rear Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the charge air cooler rear manifold bolts.

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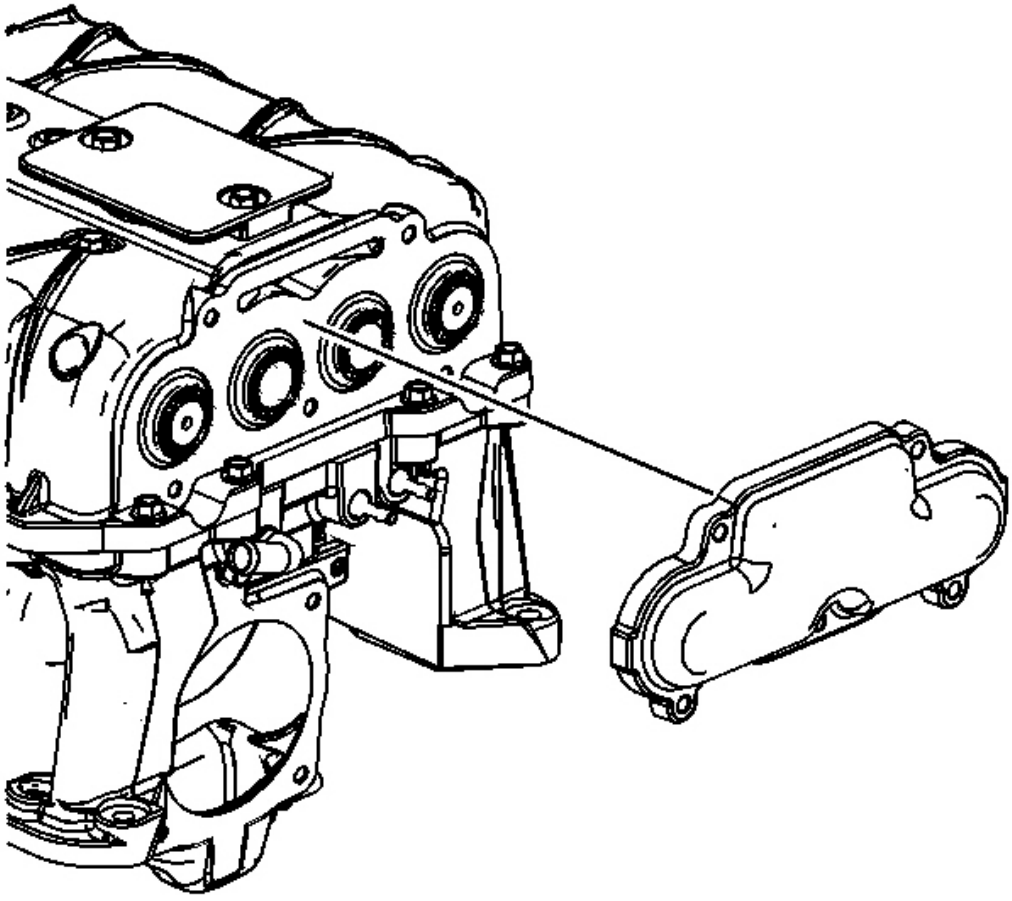


Fig. 80: Identifying Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

14. Remove the charge air cooler rear manifold.

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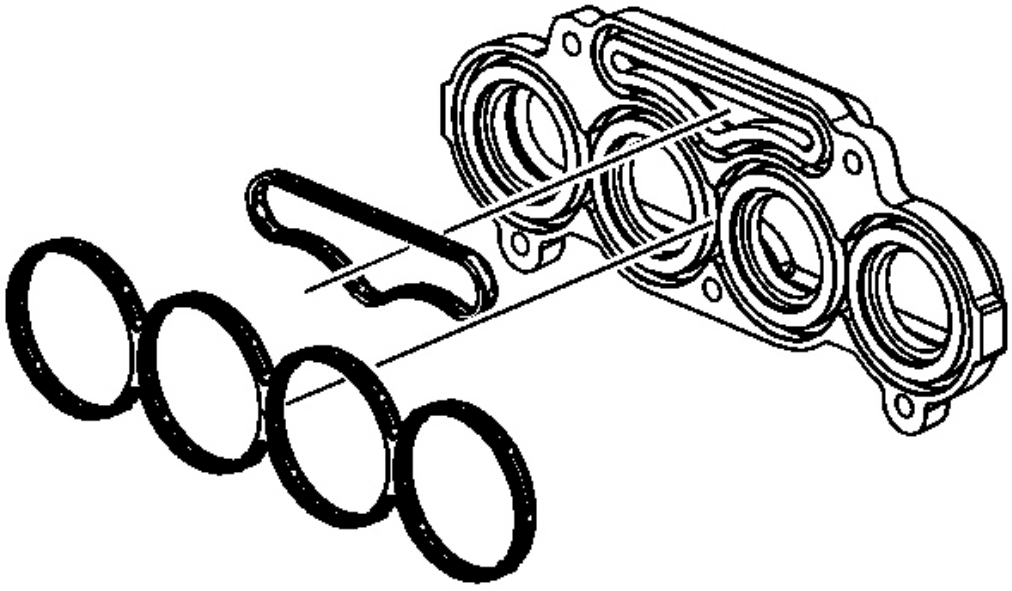


Fig. 81: View Of Charge Air Cooler Rear Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

15. Remove and discard the charge air cooler rear manifold gaskets.

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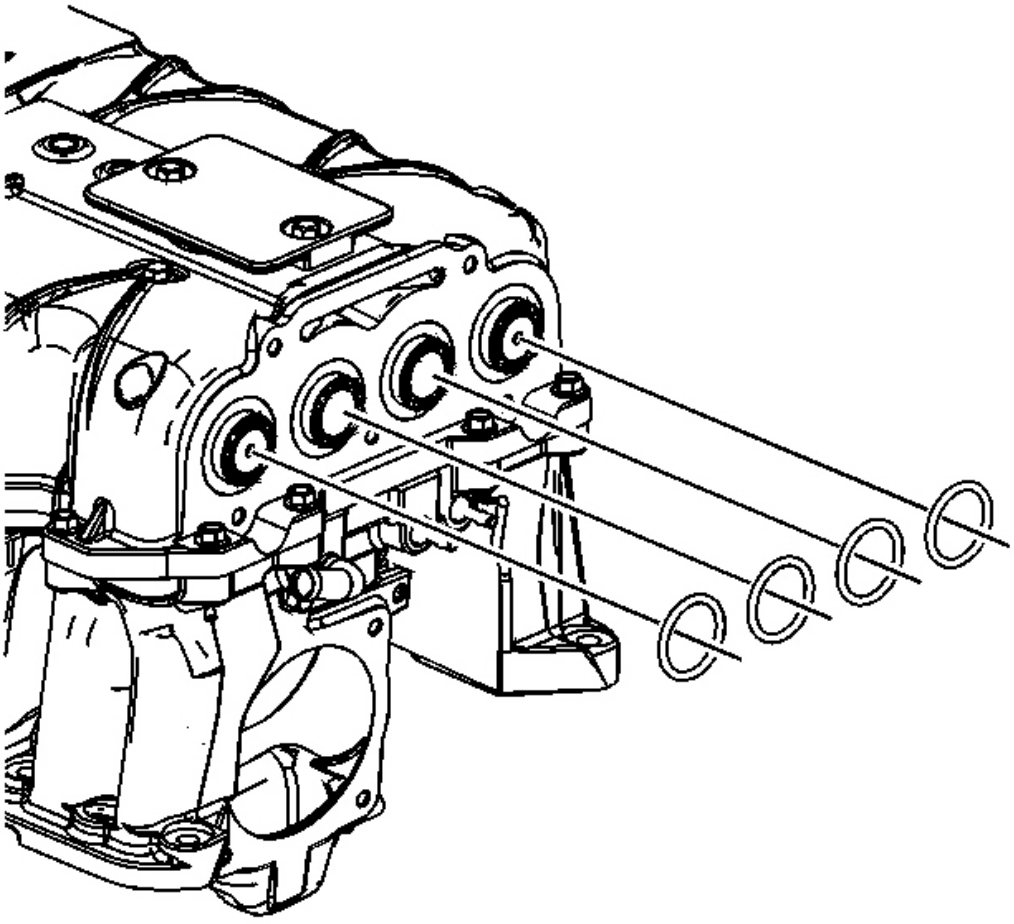


Fig. 82: View Of Charge Air Cooler Cooling Tube Rear O-Rings
Courtesy of GENERAL MOTORS CORP.

16. Remove and discard the charge air cooler cooling tube rear O-rings.

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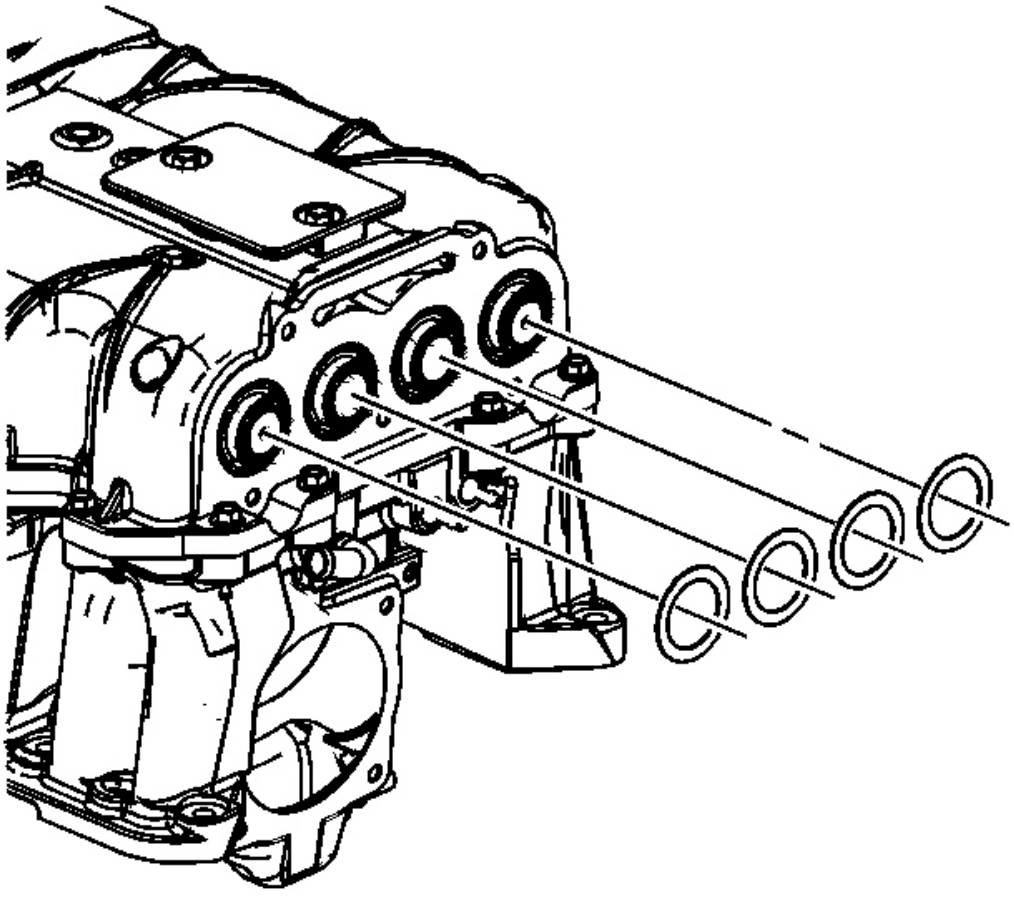


Fig. 83: View Of Charge Air Cooler Cooling Tube Rear Spacers
Courtesy of GENERAL MOTORS CORP.

17. Remove the charge air cooler cooling tube rear spacers, if required.
18. Remove the inboard and outboard charge air cooling tubes, if required. Refer to **Charge Air Cooler Cooling Tube Replacement**.
19. Clean and inspect the charge air cooler manifolds and cooling tubes. Refer to **Supercharger Cleaning and Inspection** .

INSTALLATION PROCEDURE

IMPORTANT: The charge air cooler cooling tubes must be installed with the restrictor plates and notch facing the proper directions.

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1. Install the charge air cooling tubes, if previously removed. Refer to **Charge Air Cooler Cooling Tube Replacement**.

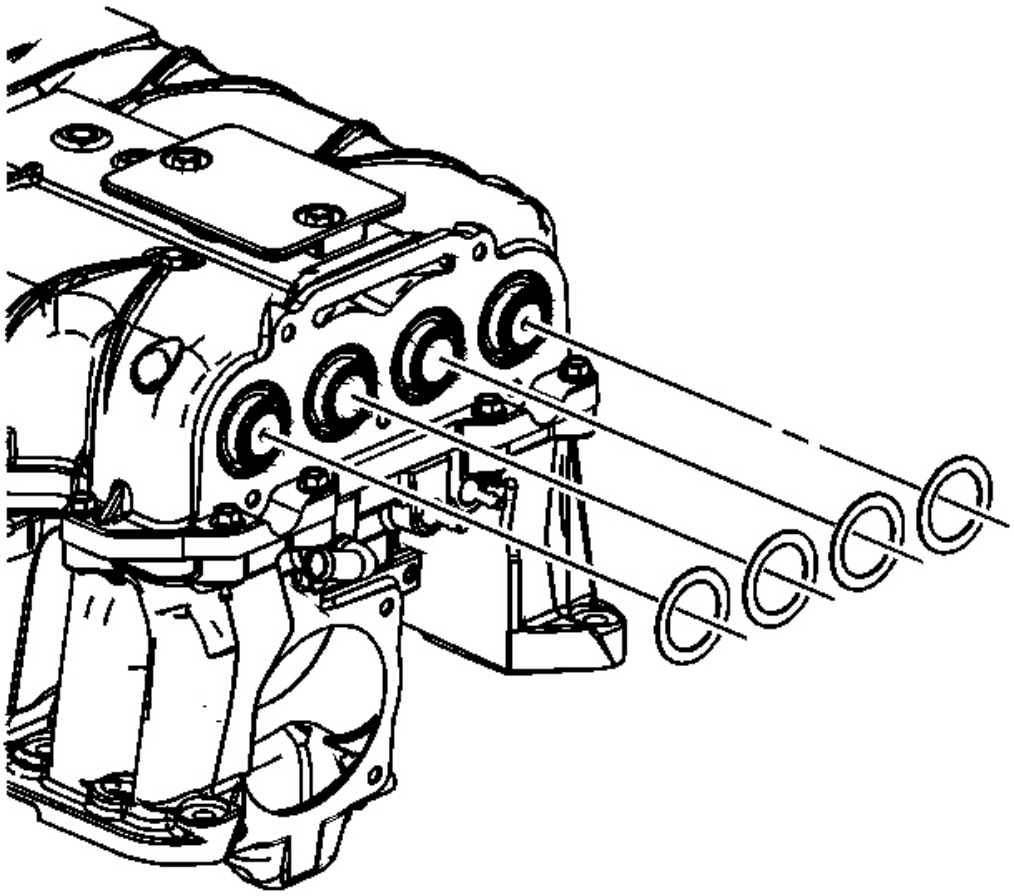


Fig. 84: View Of Charge Air Cooler Cooling Tube Rear Spacers
Courtesy of GENERAL MOTORS CORP.

2. Install the charge air cooler cooling tube rear spacers, if previously removed.

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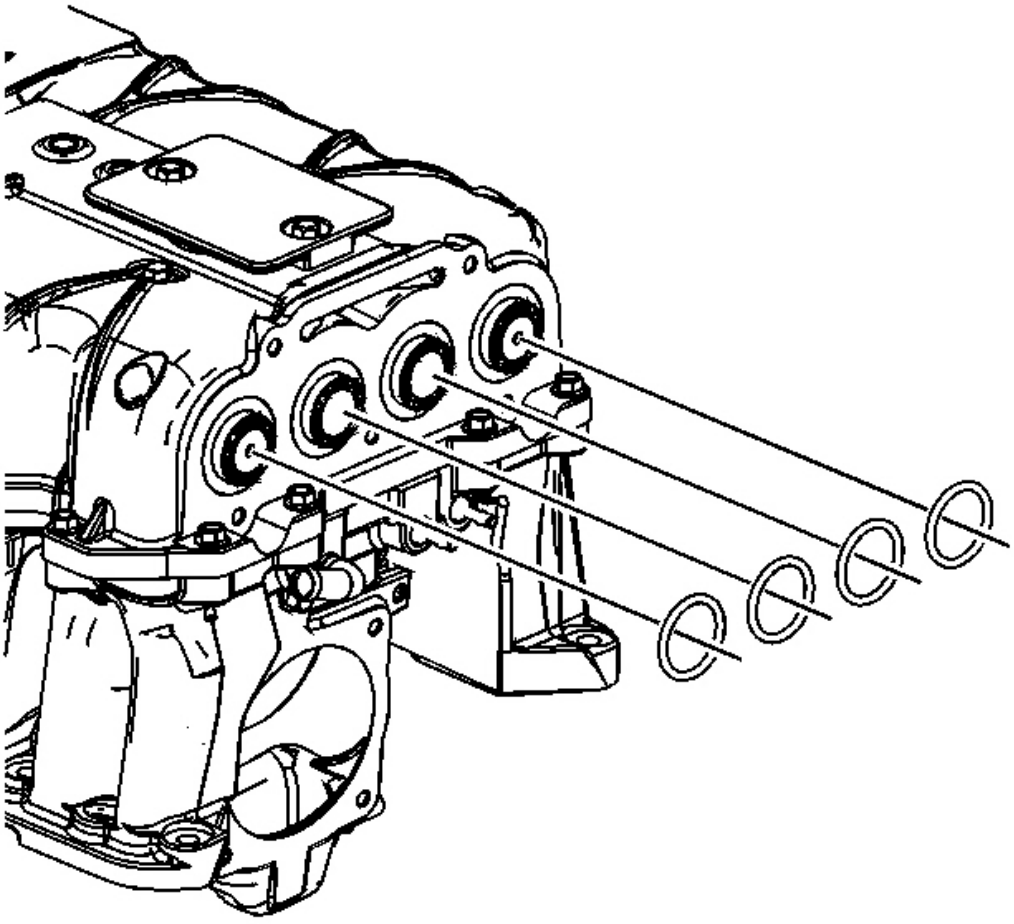


Fig. 85: View Of Charge Air Cooler Cooling Tube Rear O-Rings
Courtesy of GENERAL MOTORS CORP.

3. Install the NEW charge air cooler cooling tube rear O-rings.

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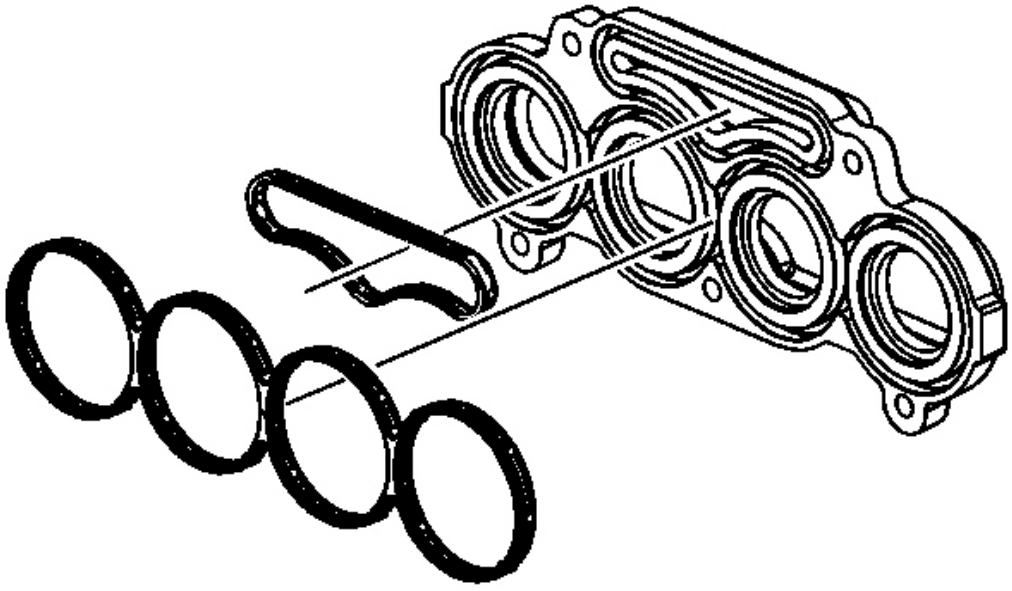


Fig. 86: View Of Charge Air Cooler Rear Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

4. Install the NEW charge air cooler rear manifold gaskets.

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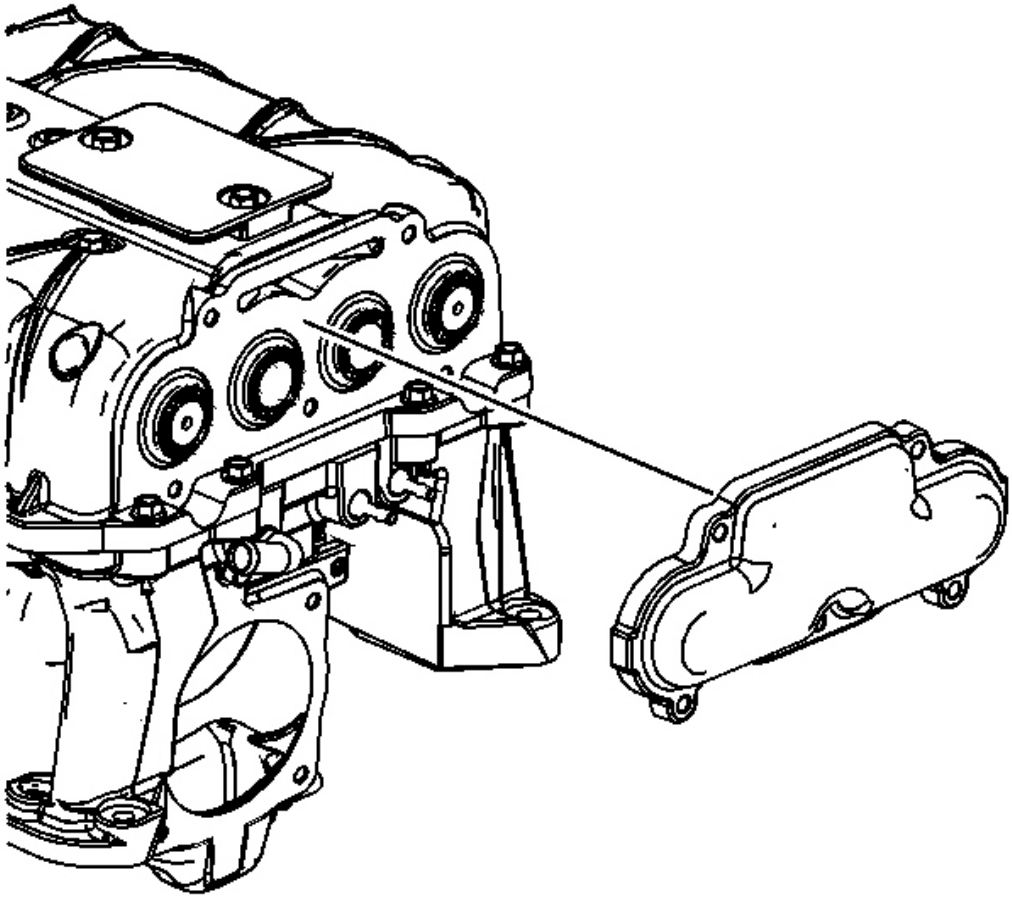


Fig. 87: Identifying Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

5. Install the charge air cooler rear manifold.

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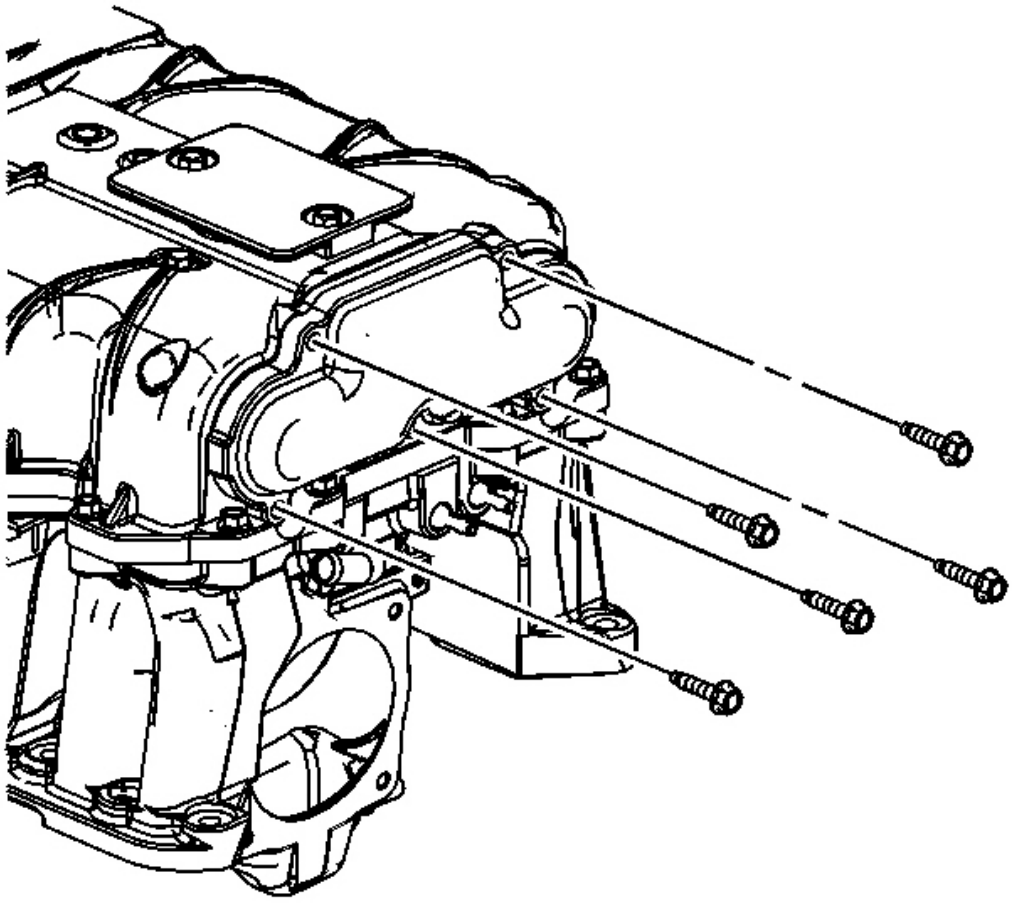


Fig. 88: Identifying Charge Air Cooler Rear Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the charge air cooler rear manifold bolts.

   Tighten: Tighten the charge air cooler rear manifold bolts to 10 N.m (89 lb in).

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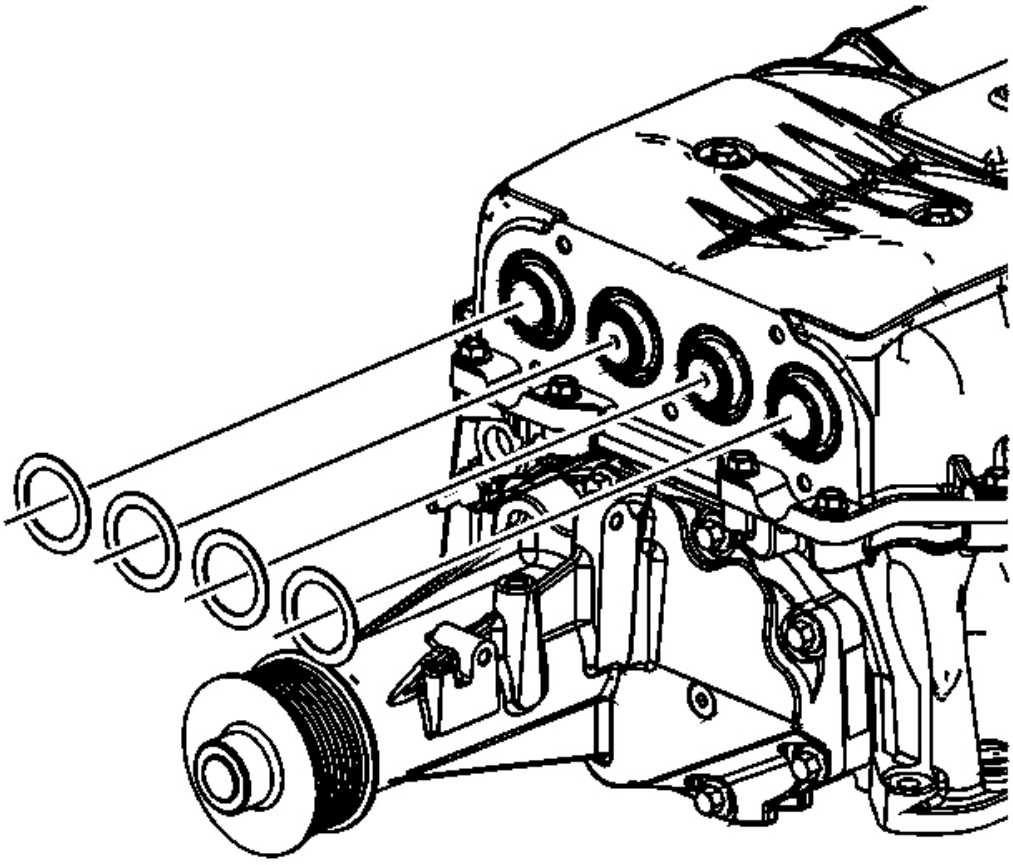


Fig. 89: View Of Charge Air Cooler Cooling Tube Front Spacers
Courtesy of GENERAL MOTORS CORP.

7. Install the charge air cooler cooling tube front spacers, if previously removed.

Automotive-Manual.net

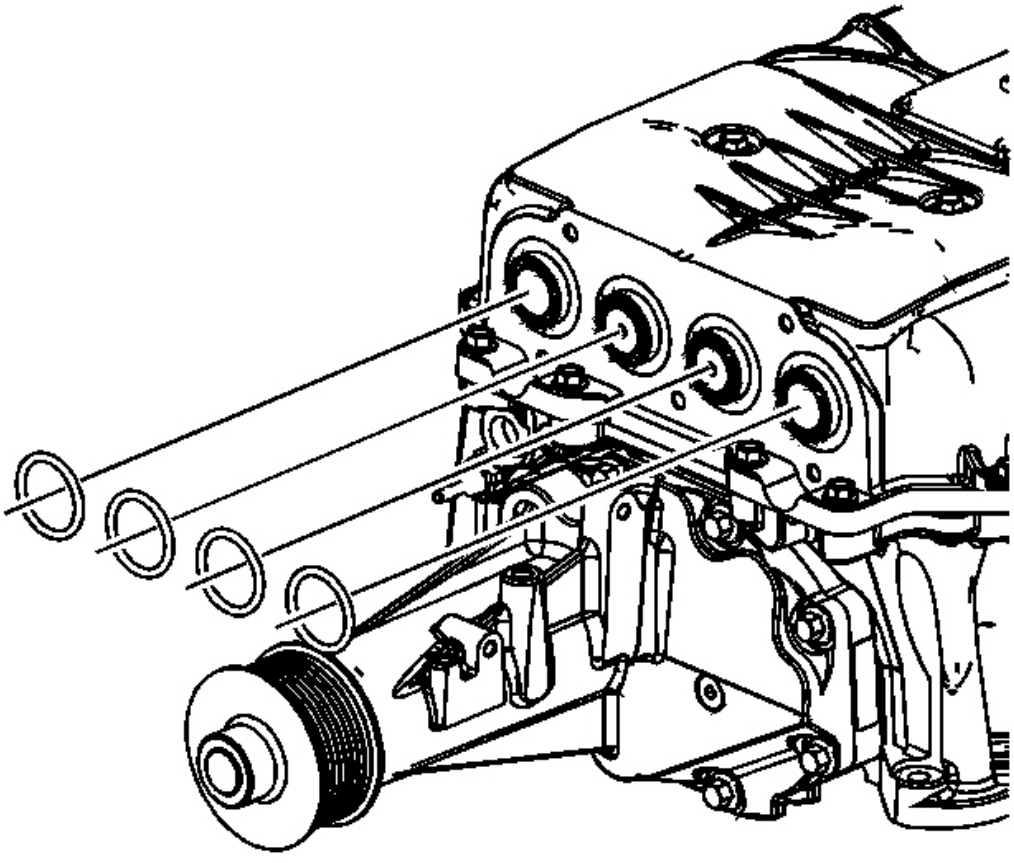


Fig. 90: View Of Charge Air Cooler Cooling Tube Front O-Rings
Courtesy of GENERAL MOTORS CORP.

8. Install the NEW charge air cooler cooling tube front O-rings.

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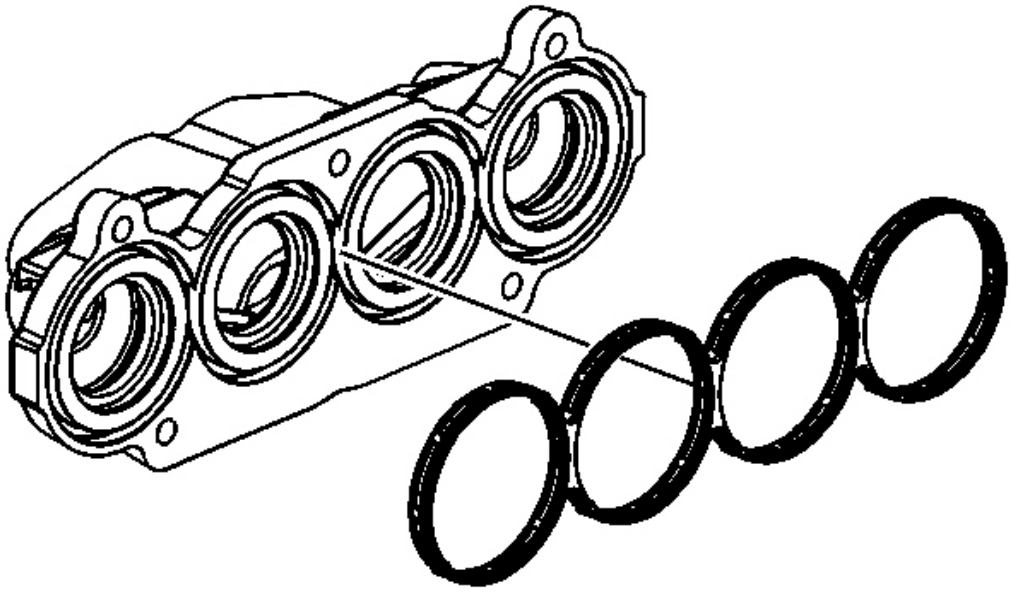


Fig. 91: View Of Charge Air Cooler Front Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

9. Install the NEW charge air cooler front manifold gasket.

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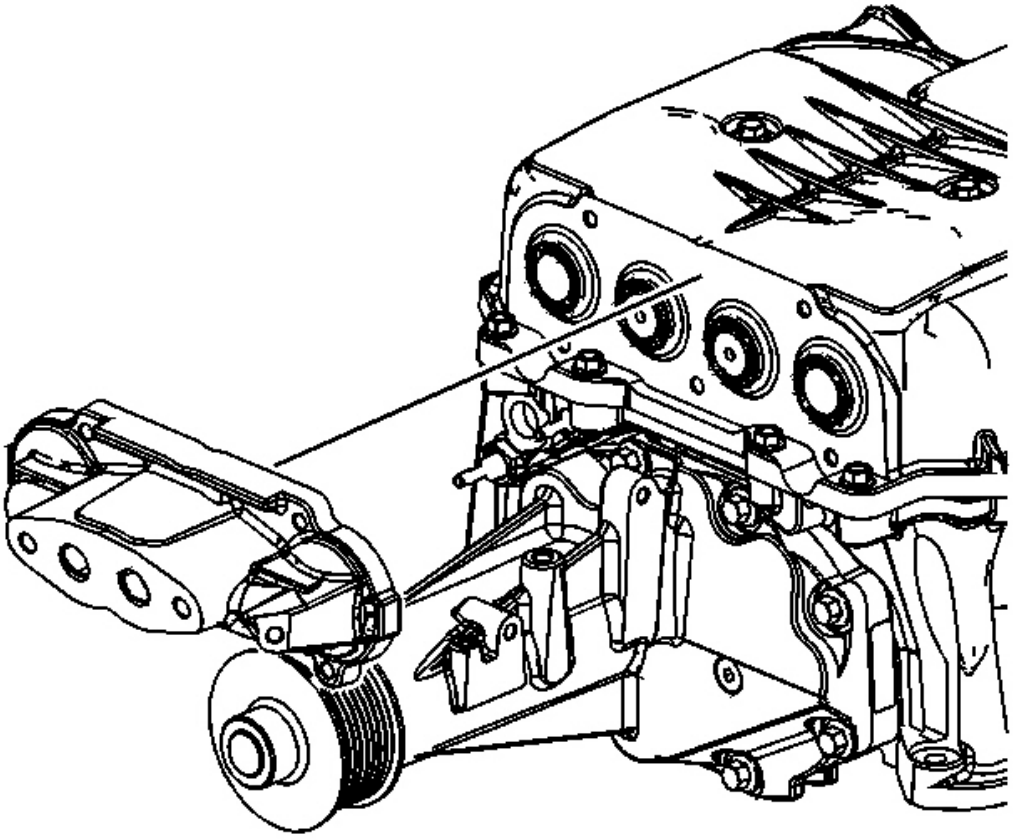


Fig. 92: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

10. Install the charge air cooler front manifold.

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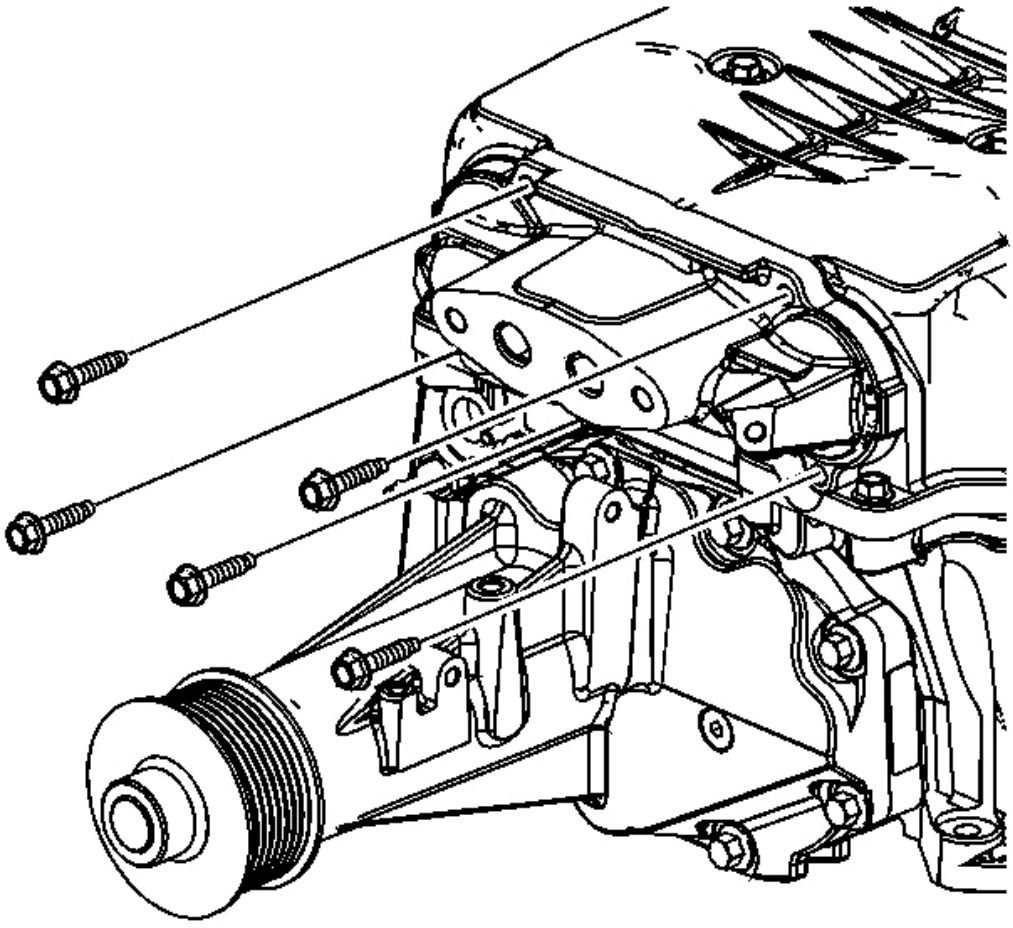


Fig. 93: Identifying Charge Air Cooler Front Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the charge air cooler front manifold bolts.

    Tighten: Tighten the charge air cooler front manifold bolts to 10 N.m (89 lb in).

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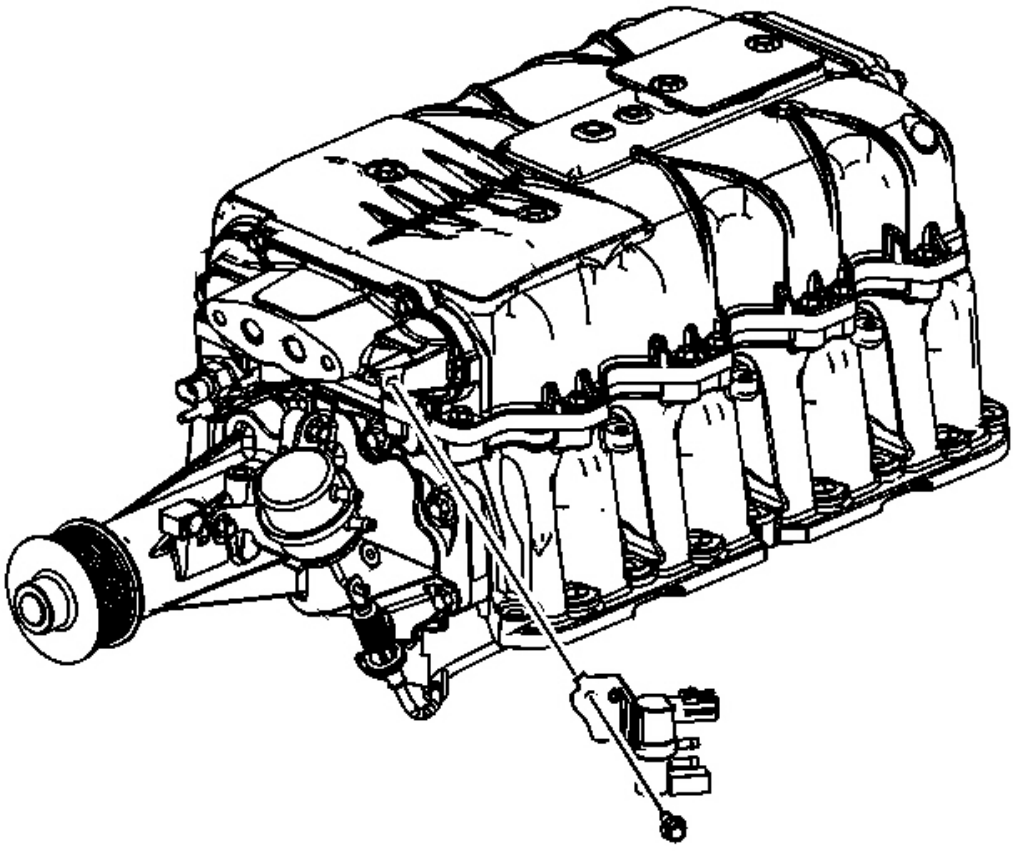


Fig. 94: View Of Supercharger Bypass Regulator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

12. Install the supercharger bypass regulator solenoid valve and bracket. Refer to **Supercharger Bypass Regulator Solenoid Valve Replacement** .

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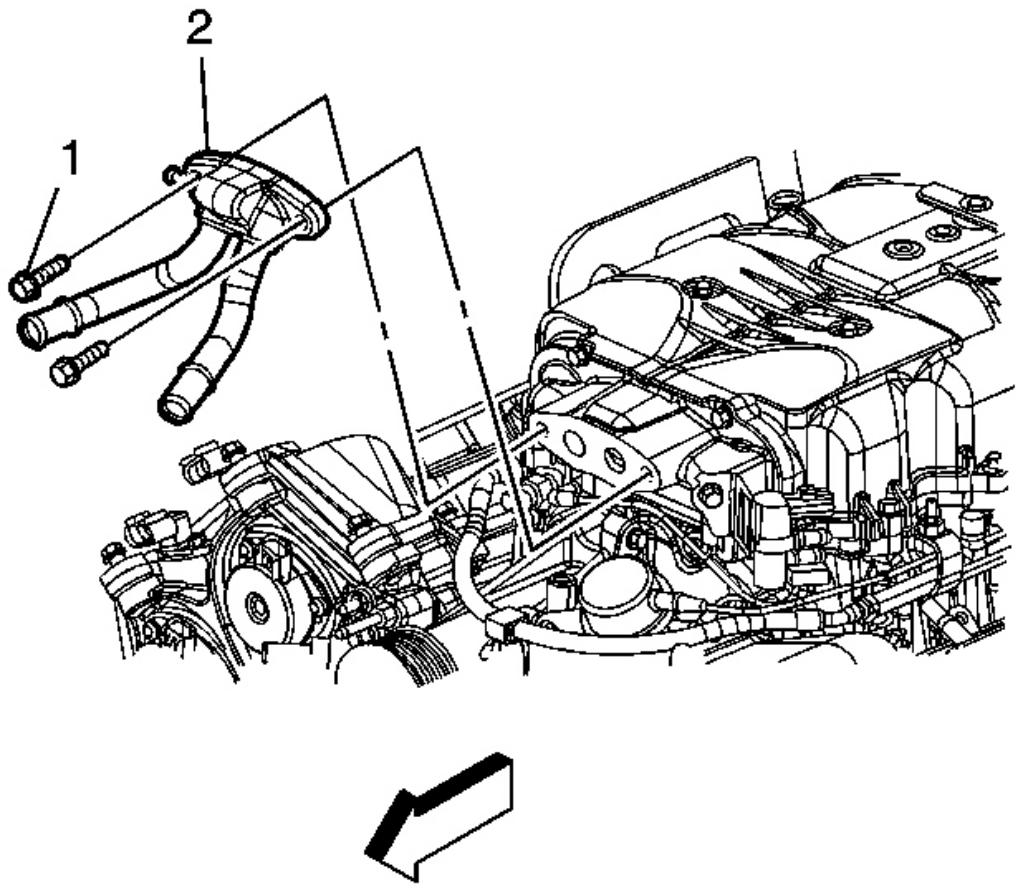


Fig. 95: View Of Charge Air Cooler & Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

13. Using NEW O-ring seals, install the front portion of the charge air cooler front manifold (2).
14. Install the manifold bolts (1).

    Tighten: Tighten the charge air cooler front manifold bolts to 10 N.m (89 lb in).

15. Install the charge air cooler hoses to the front section of the charge air cooler front manifold.
16. Fill the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .
17. Install the front supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
18. Install the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**.

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19. Install the hood. Refer to **Hood Replacement** .

CHARGE AIR COOLER COOLING TUBE REPLACEMENT

REMOVAL PROCEDURE

IMPORTANT: The charge air cooling tubes are replaced as a set. If any one of the charge air cooler cooling tubes needs to be replaced, all the charge air cooler cooling tubes must be replaced in order to maintain consistent cooling of the charge air.

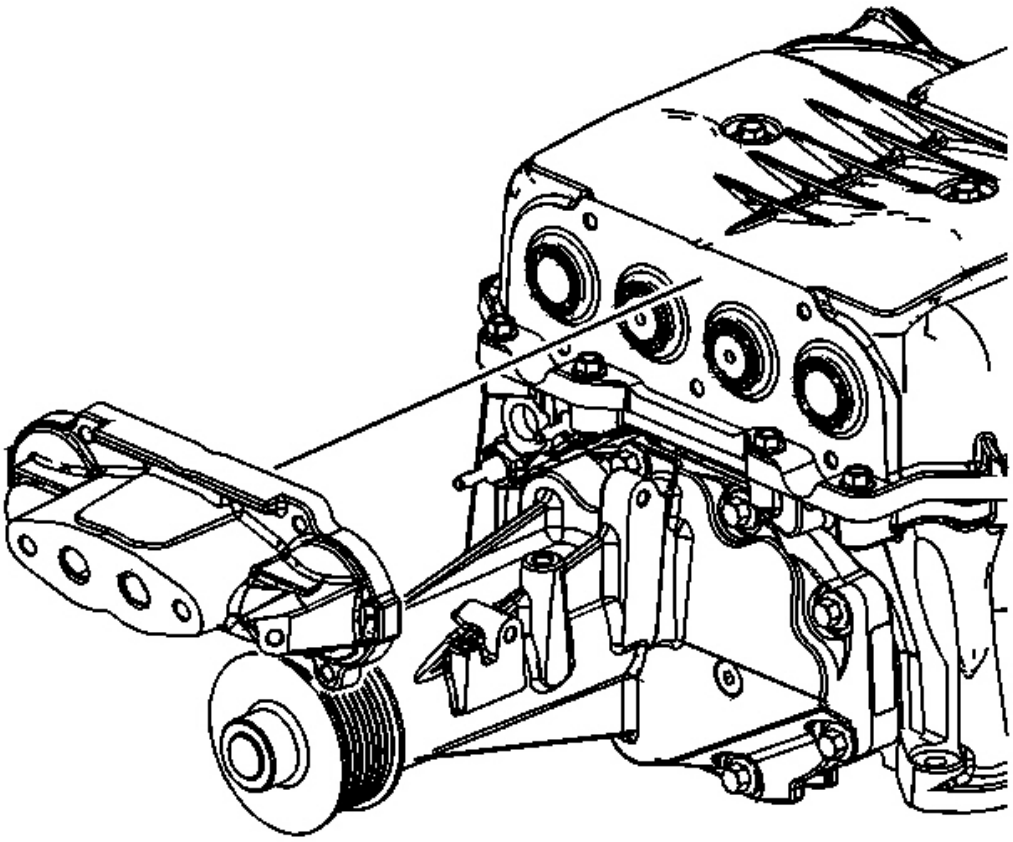


Fig. 96: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

1. Drain the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .

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2. Remove the front section of the supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .

IMPORTANT: Do not allow any draining coolant to contact the supercharger drive belt.

3. Place a shop rag under the front portion of the supercharger to collect any remaining coolant that may drain from the charge air cooling system.
4. Remove the charge air cooler front manifold, gasket, O-rings and spacers. Refer to **Charge Air Cooler Front Manifold Replacement**.

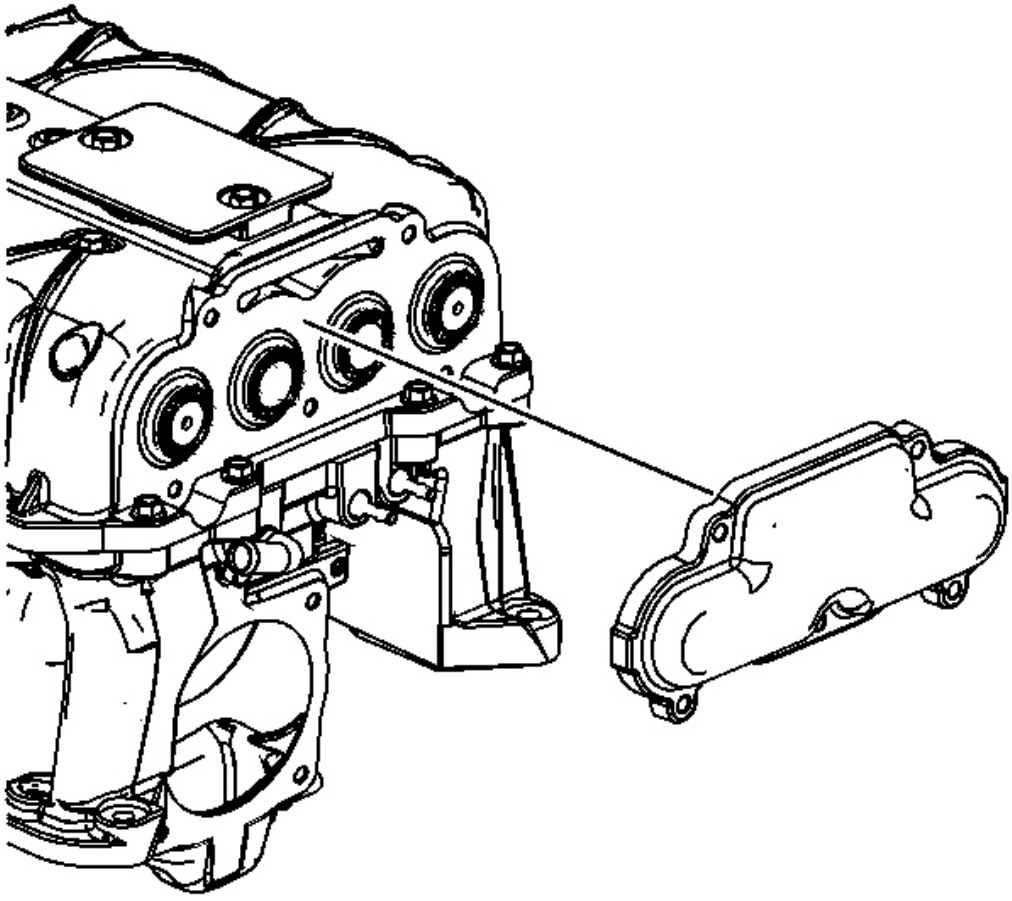


Fig. 97: Identifying Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

5. Remove the charge air cooler rear manifold, gaskets, O-rings and spacers. Refer to **Charge Air Cooler**

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Coolant Rear Manifold Replacement.

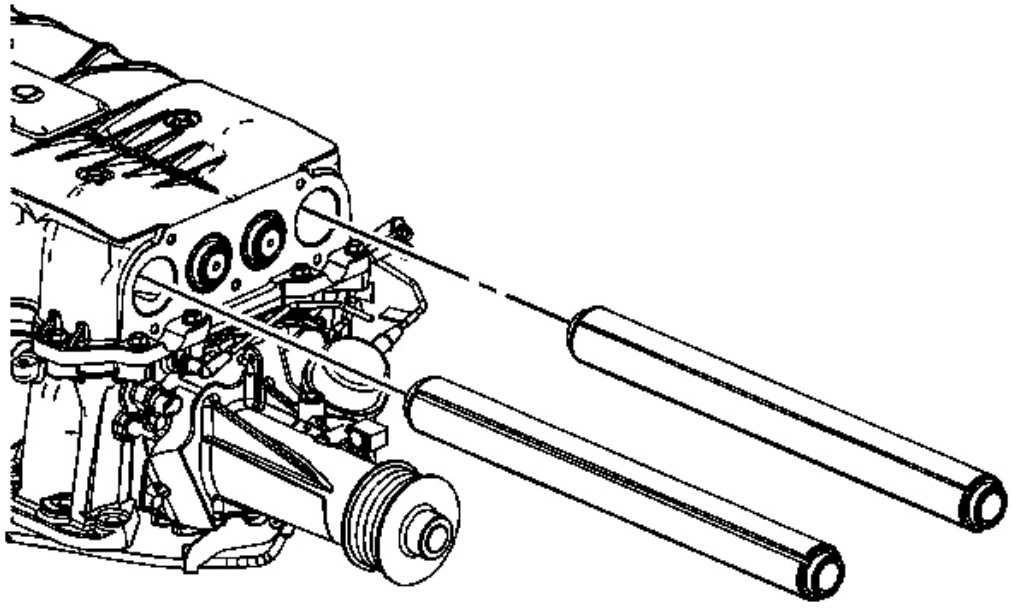


Fig. 98: Identifying Outboard Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

6. Carefully remove the outboard charge air cooler cooling tubes.
7. The charge air cooler cooling tubes are fragile and must be placed in a protected area.

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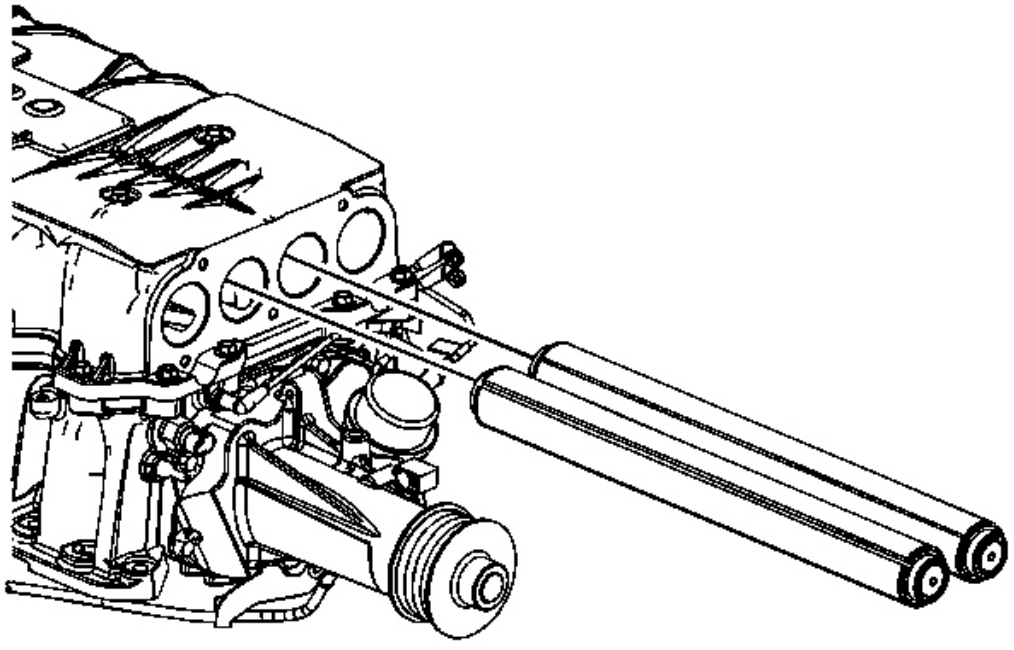


Fig. 99: View Of Inboard Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

8. Carefully remove the inboard charge air cooler cooling tubes.
9. The charge air cooler cooling tubes are fragile and must be placed in a protected area.



Fig. 100: View Of Charge Air Cooler Cooling Tubes

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Courtesy of GENERAL MOTORS CORP.

10. Inspect the charge air cooler cooling tubes for the following:
    - Damaged, clogged, bent or missing fins (1)
    - Damage, corrosion or restrictions to the cooling passages (2)
    - Damage, corrosion, restrictions or missing diversion end plate (3)

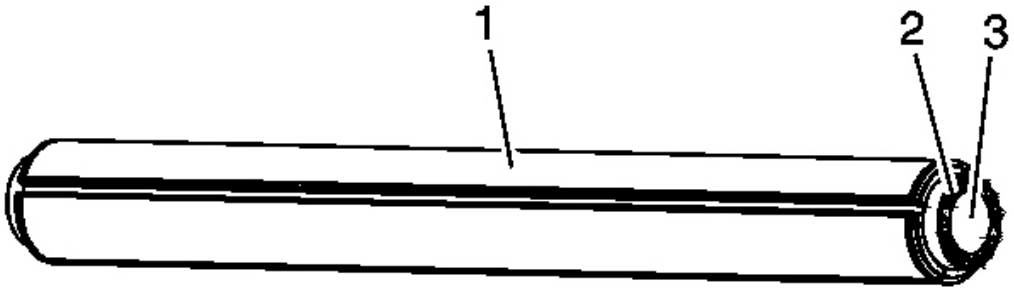


Fig. 101: Inspecting Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

11. Inspect the charge air cooler cooling tubes for the following:
    - Damaged, clogged, bent or missing fins (1)
    - Damage, corrosion or restrictions to the cooling passages (2)
    - Damage, corrosion or restrictions to the intake end (3)

IMPORTANT: The charge air cooling tubes are replaced as a set. If any one of the charge air cooler cooling tubes needs to be replaced, all the charge air cooler cooling tubes must be replaced in order to maintain consistent cooling of the charge air.

12. Replace any damaged, corroded or restricted charge air cooler cooling tubes as a set.

INSTALLATION PROCEDURE

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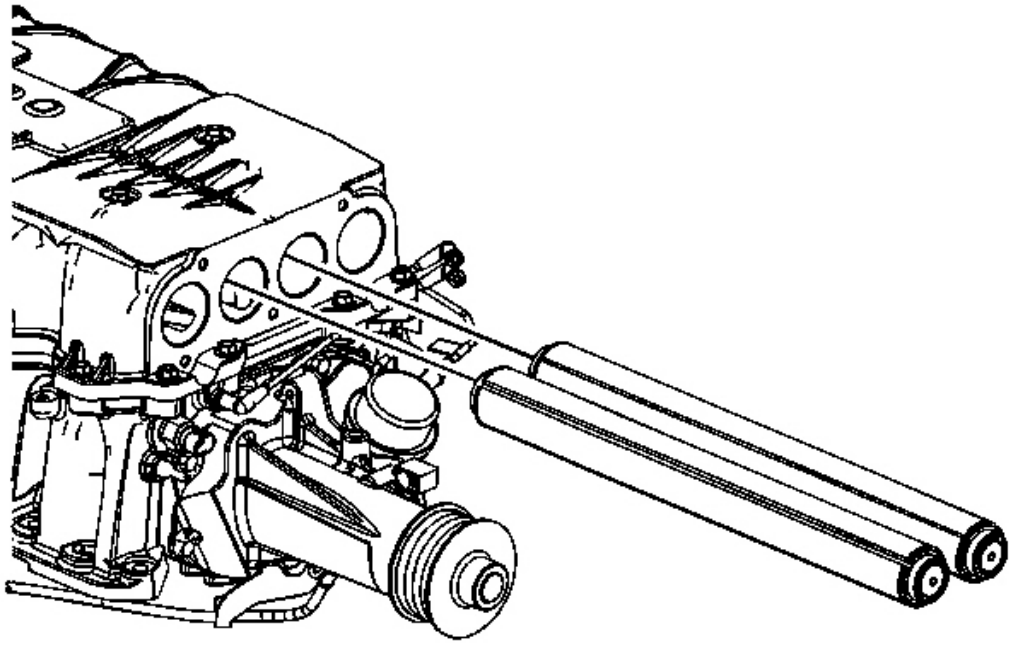


Fig. 102: View Of Inboard Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

1. Carefully install the inboard charge air cooler cooling tubes.

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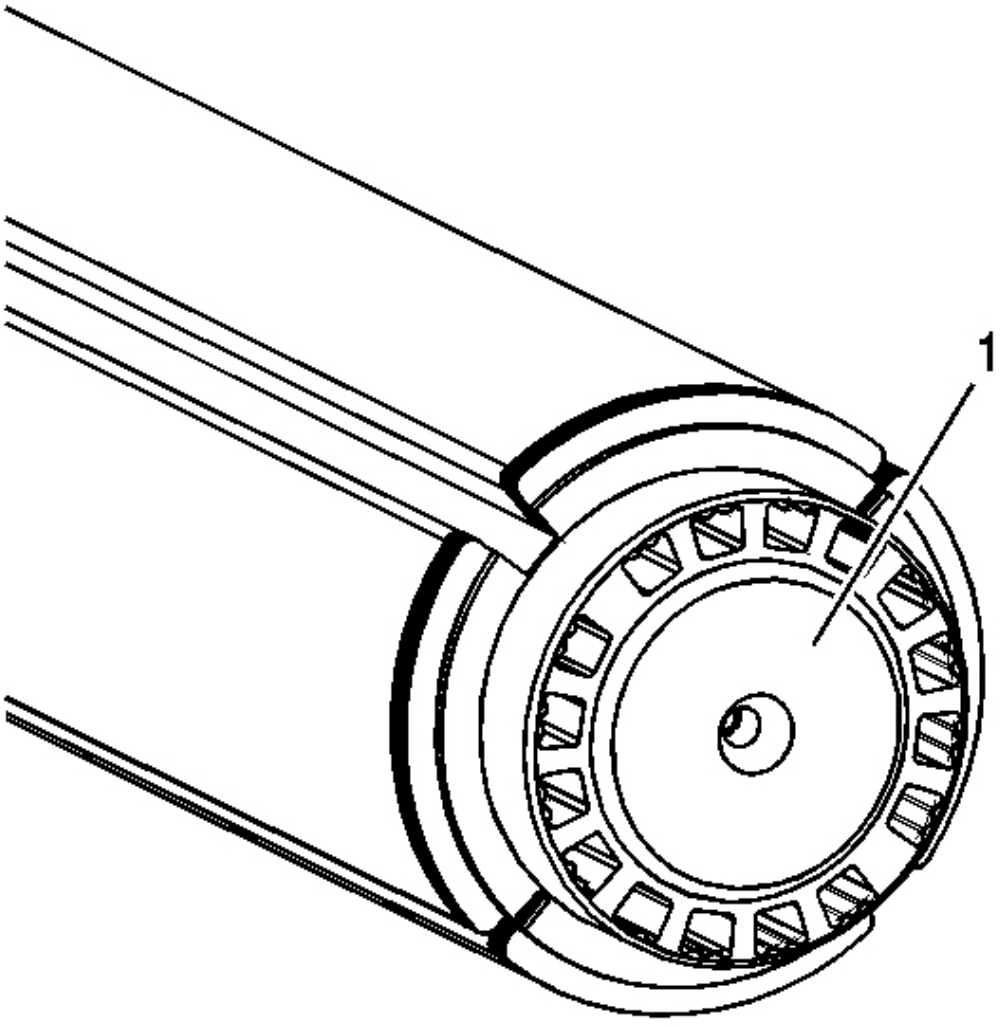


Fig. 103: Restrictor Plates
Courtesy of GENERAL MOTORS CORP.

2. The charge air cooler cooling inboard tubes are installed with the restrictor plates (1) to the front of the supercharger, towards the drive belt pulley.

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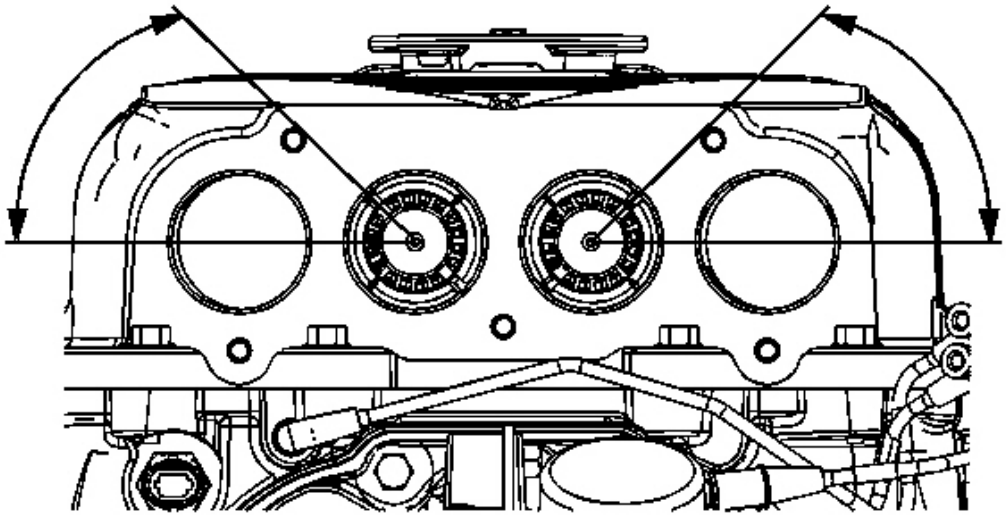


Fig. 104: Aligning Cooling Tube Notches
Courtesy of GENERAL MOTORS CORP.

3. Align the wide notch at a 45 degree angle up from horizontal and outboard as shown.

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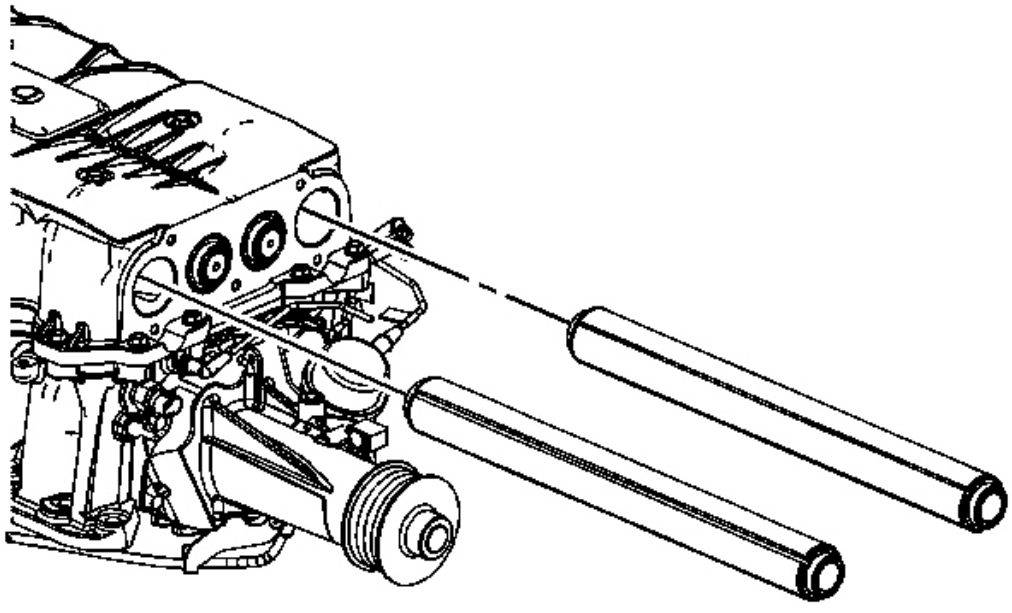


Fig. 105: Identifying Outboard Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

4. Carefully install the outboard charge air cooler cooling tubes.

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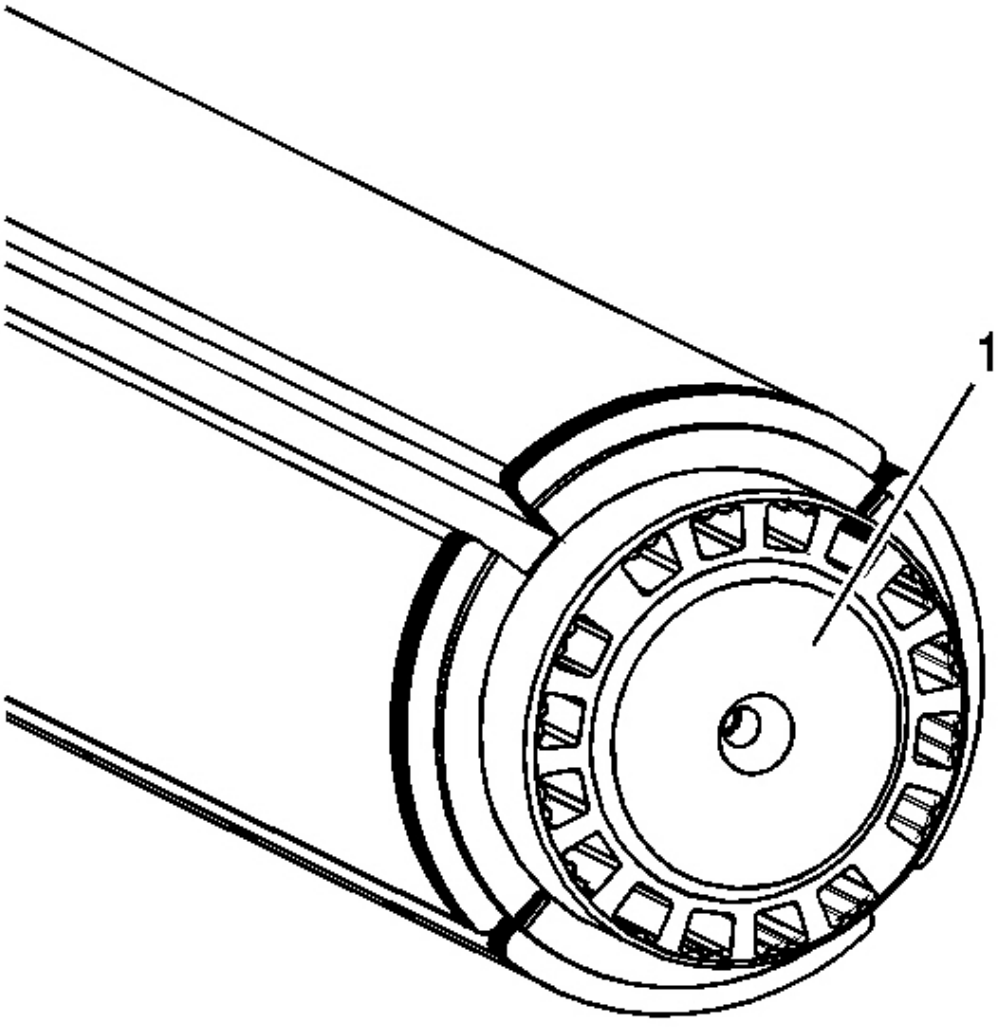


Fig. 106: Identifying Restrictor Plates
Courtesy of GENERAL MOTORS CORP.

5. The charge air cooler cooling outboard tubes are installed with the restrictor plates (1) to the rear of the supercharger. The open end of the cooling tube will be to the front of the supercharger, towards the drive belt pulley.

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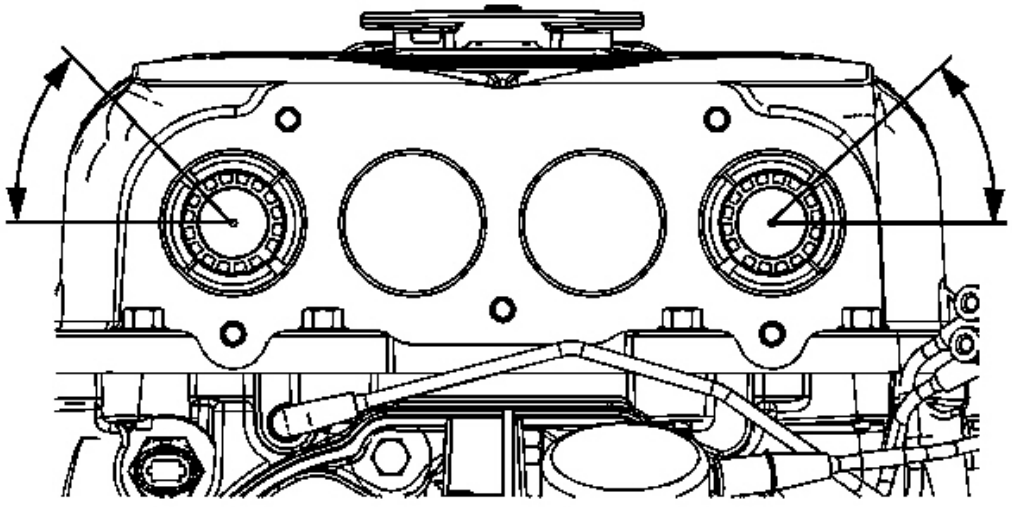


Fig. 107: Aligning Cooler Tube Notches
Courtesy of GENERAL MOTORS CORP.

6. Align the wide notch at a 45 degree angle up from horizontal and outboard as shown.

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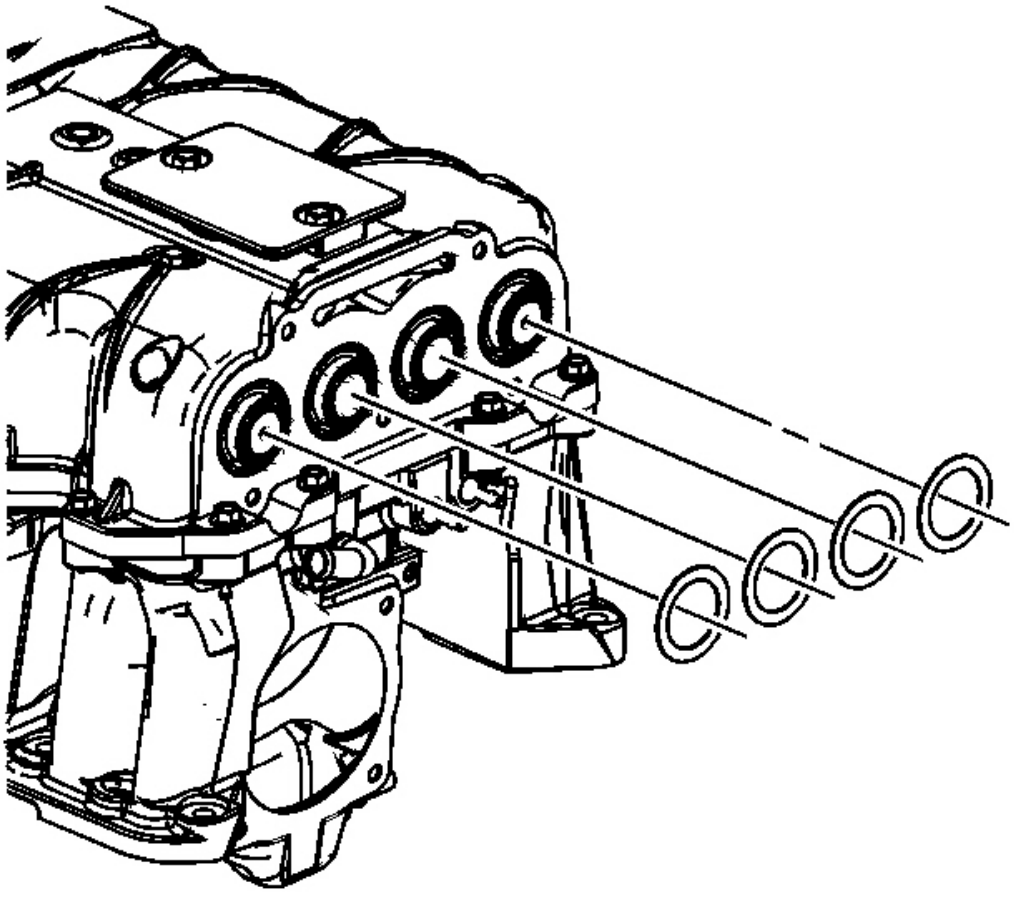


Fig. 108: View Of Charge Air Cooler Cooling Tube Rear Spacers
Courtesy of GENERAL MOTORS CORP.

7. Install the charge air cooler cooling tube rear spacers.

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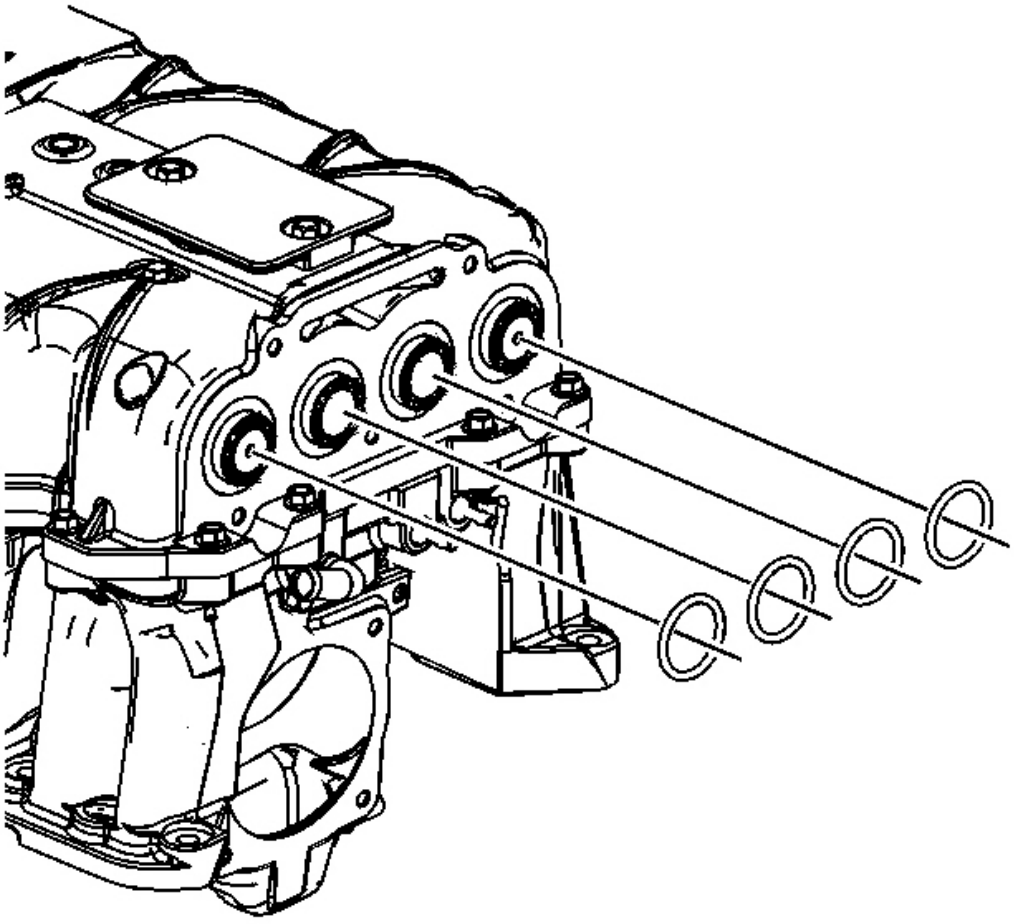


Fig. 109: View Of Charge Air Cooler Cooling Tube Rear O-Rings
Courtesy of GENERAL MOTORS CORP.

8. Install the NEW charge air cooler cooling tube rear O-rings.

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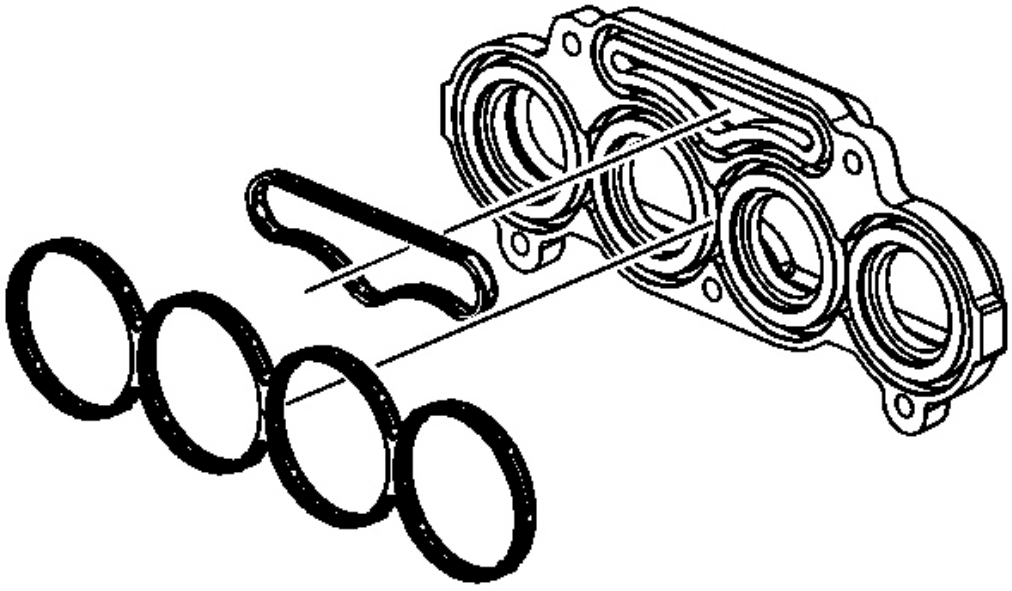


Fig. 110: View Of Charge Air Cooler Rear Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

9. Install the NEW charge air cooler rear manifold gaskets.

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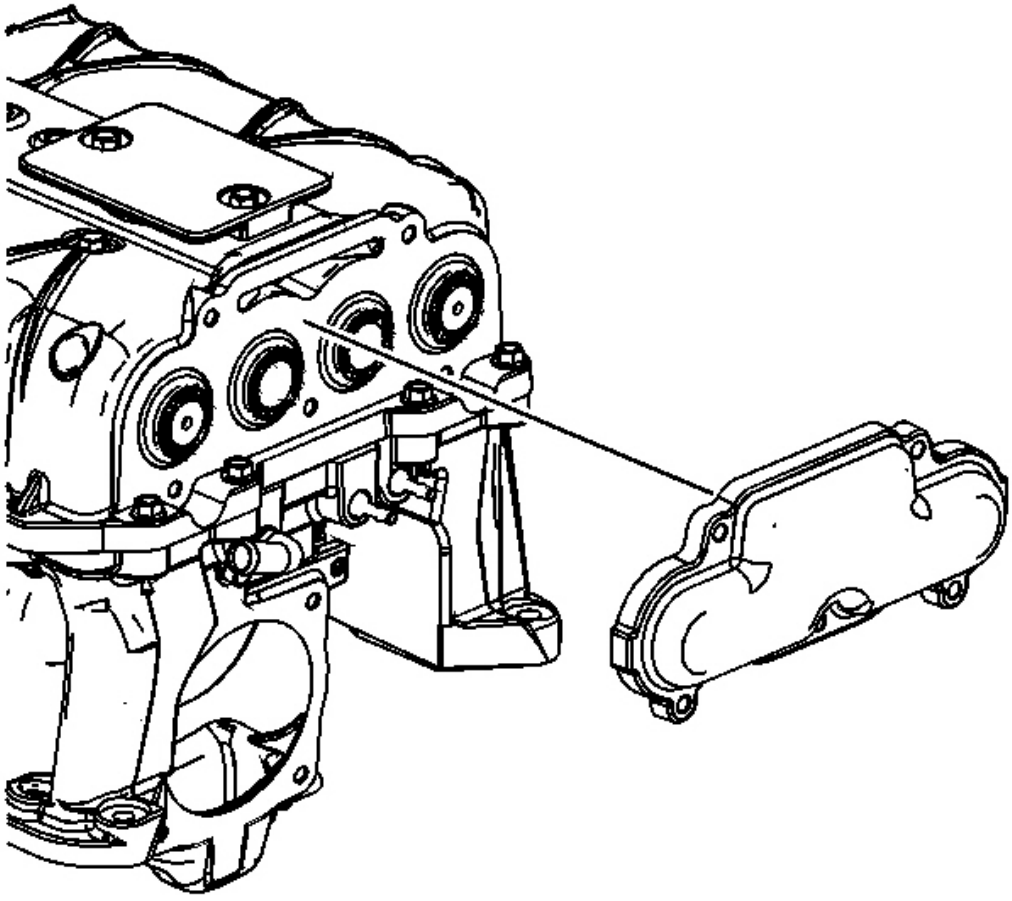


Fig. 111: Identifying Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

10. Install the charge air cooler rear manifold.

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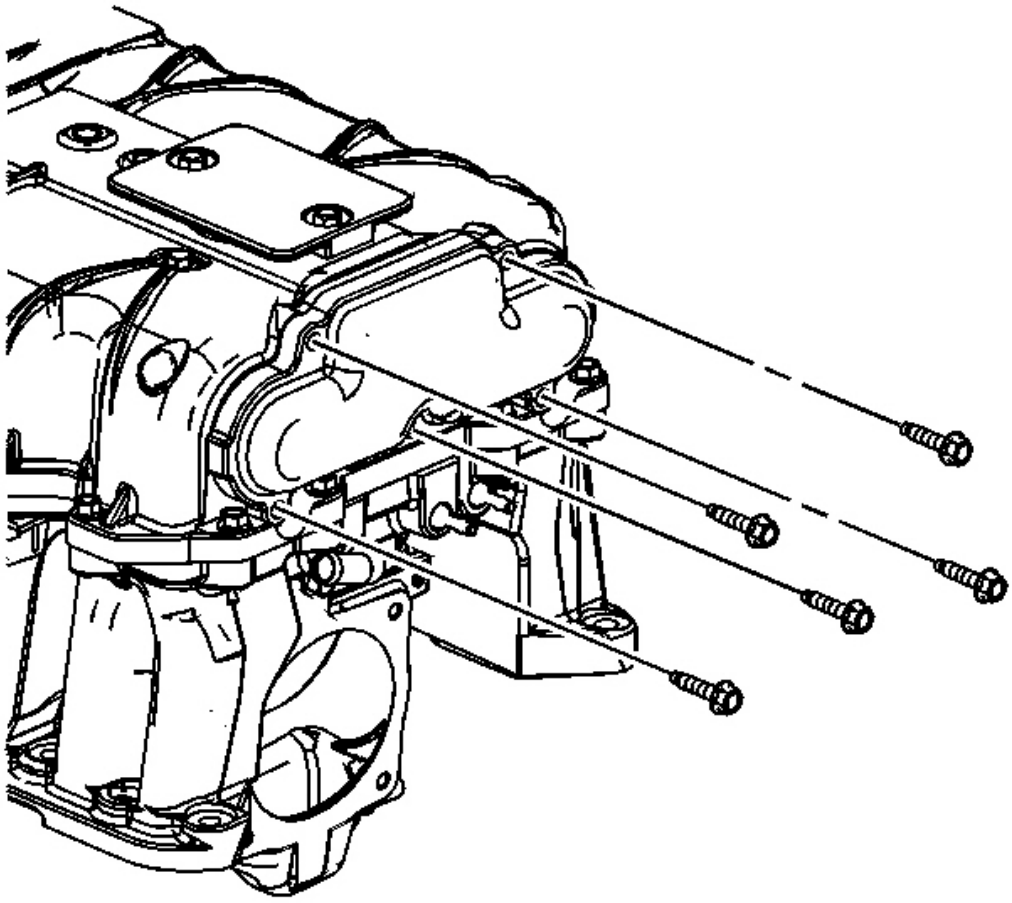


Fig. 112: Identifying Charge Air Cooler Rear Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

11. Install the charge air cooler rear manifold bolts.

    Tighten: Tighten the charge air cooler rear manifold bolt to 10 N.m (89 lb in).

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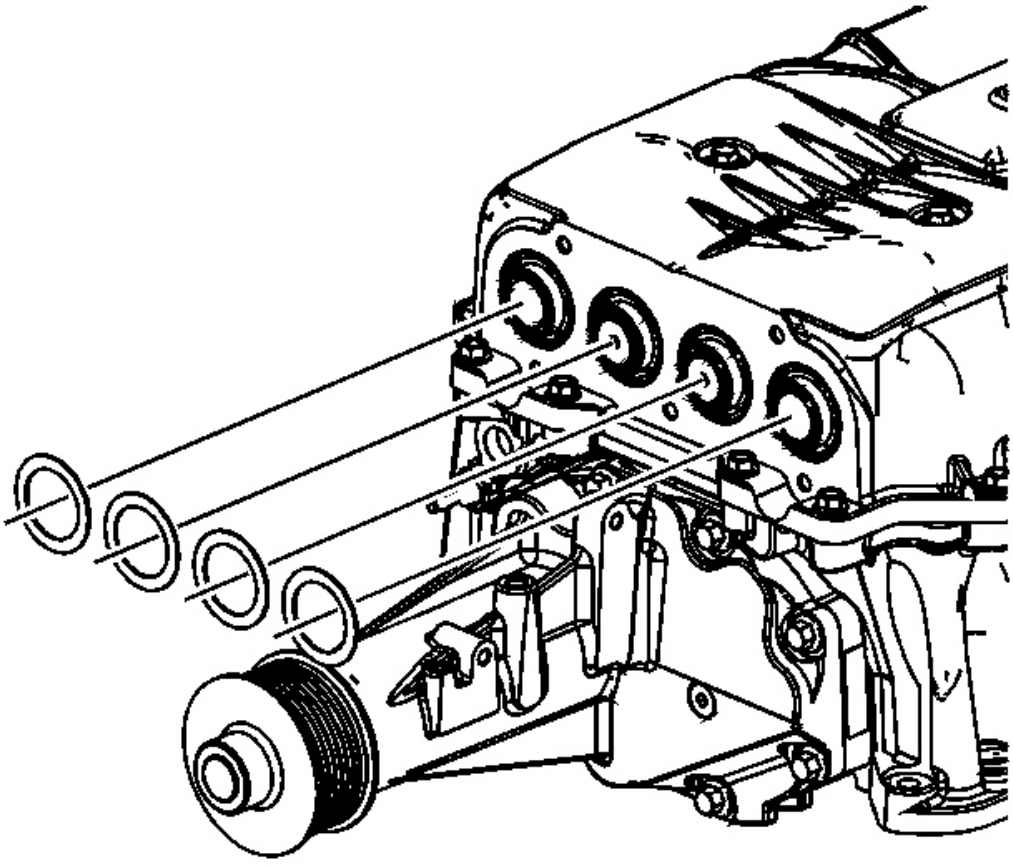


Fig. 113: View Of Charge Air Cooler Cooling Tube Front Spacers
Courtesy of GENERAL MOTORS CORP.

12. Install the charge air cooler cooling tube front spacers.

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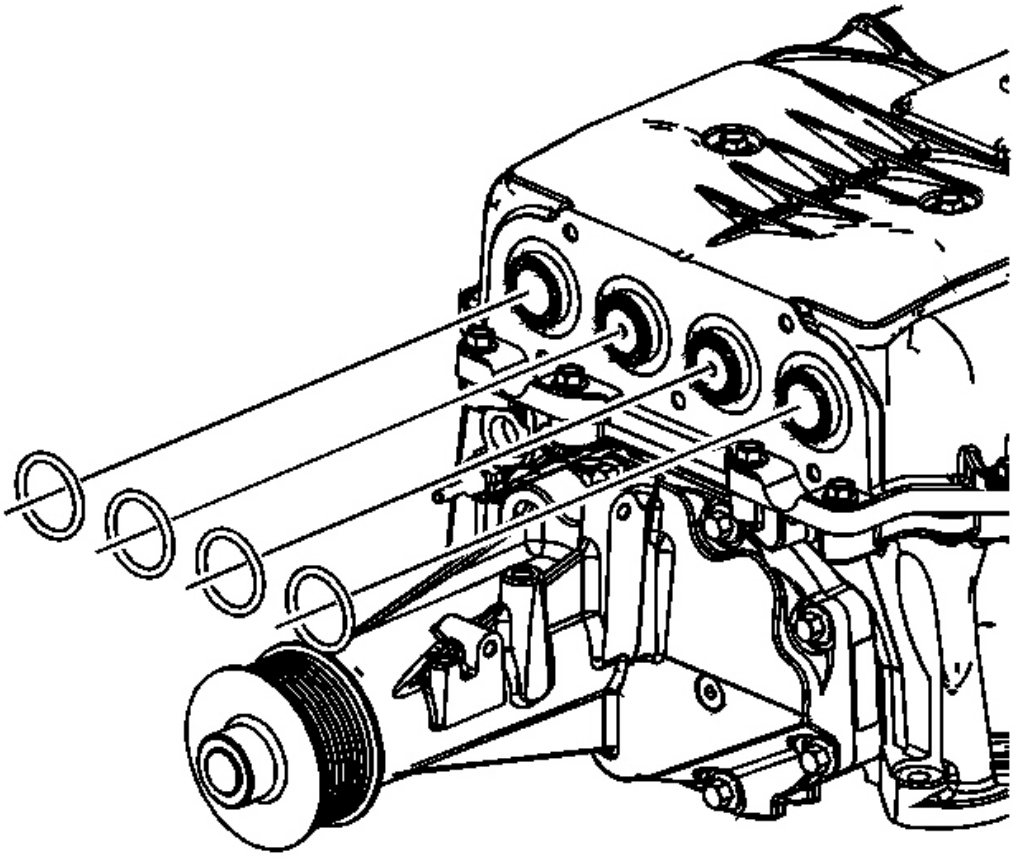


Fig. 114: View Of Charge Air Cooler Cooling Tube Front O-Rings
Courtesy of GENERAL MOTORS CORP.

13. Install the NEW charge air cooler cooling tube front O-rings.

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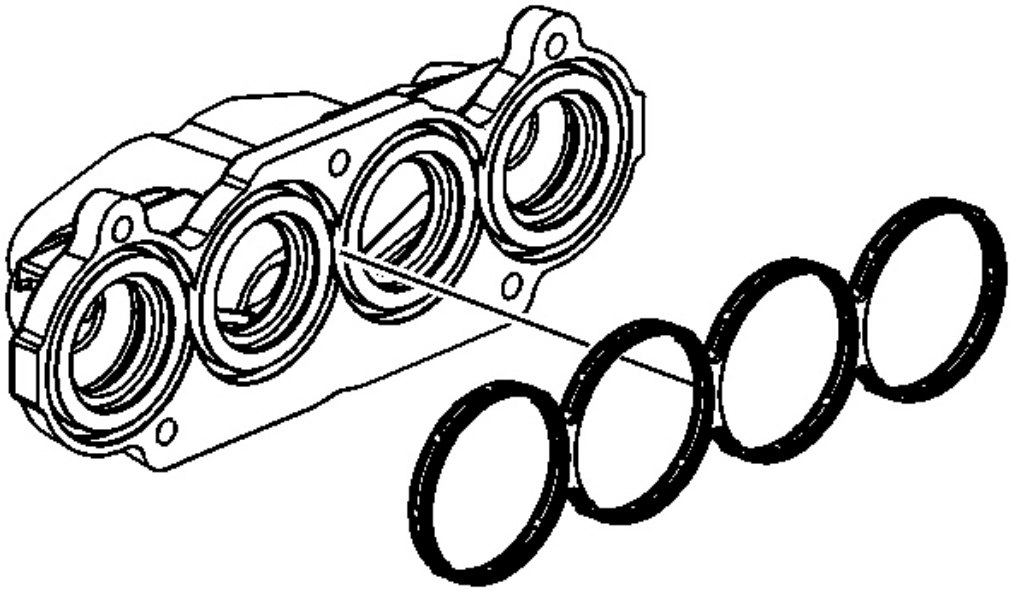


Fig. 115: View Of Charge Air Cooler Front Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

14. Install the NEW charge air cooler front manifold gasket.

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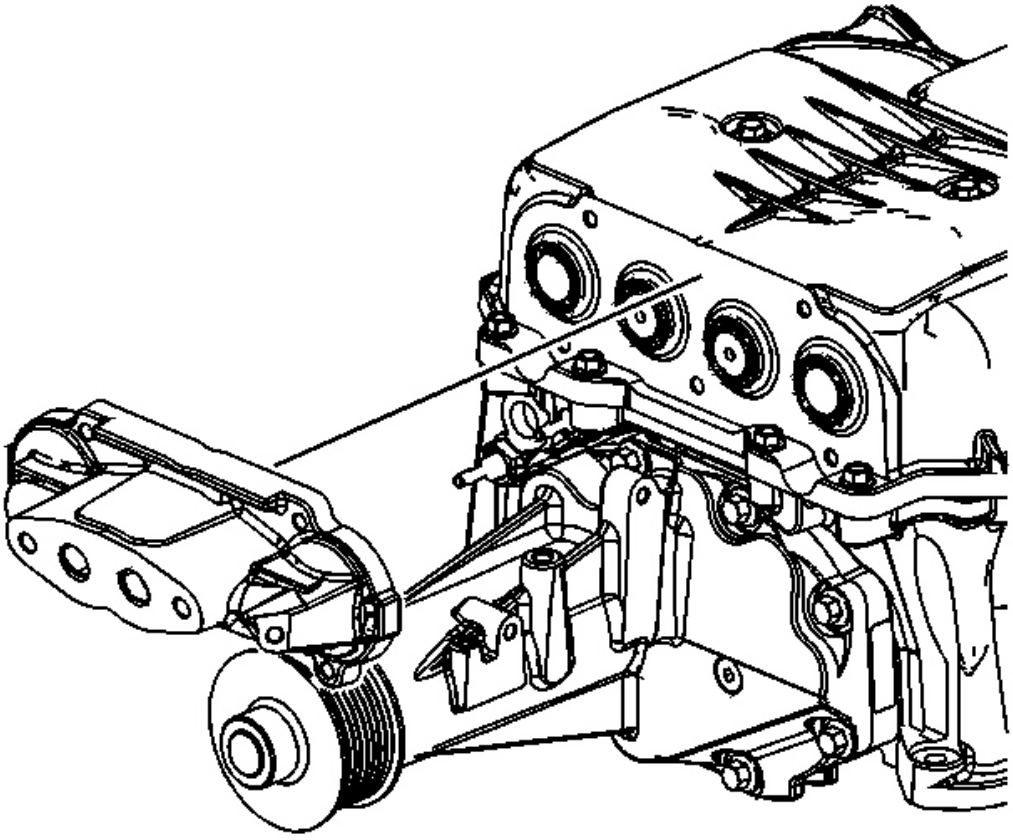


Fig. 116: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

15. Install the charge air cooler front manifold.

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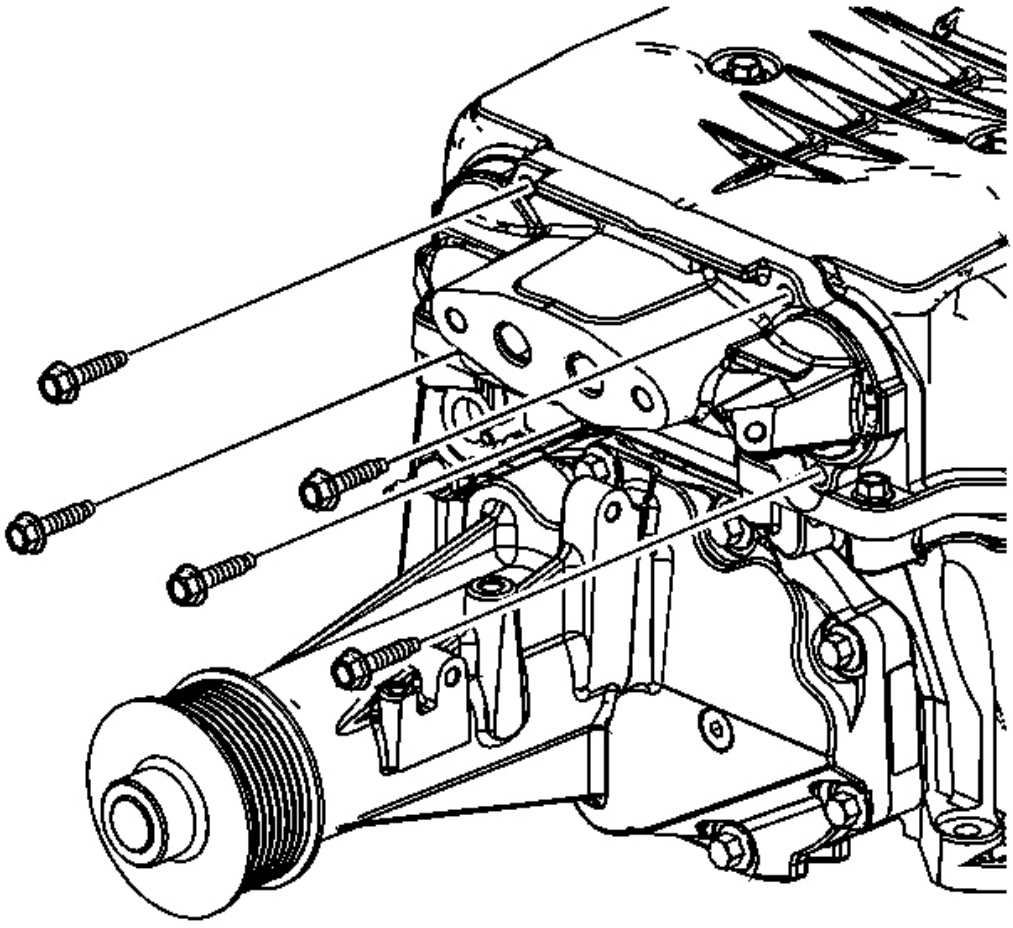


Fig. 117: Identifying Charge Air Cooler Front Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

16. Install the charge air cooler front manifold bolts.

    Tighten: Tighten the charge air cooler front manifold bolt to 10 N.m (89 lb in).

17. Install the remaining portion of the charge air cooler front manifold. Refer to **Charge Air Cooler Front Manifold Replacement**.
18. Install the front section of the supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
19. Fill the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .

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CHARGE AIR COOLER HOUSING REPLACEMENT

DISASSEMBLE PROCEDURE

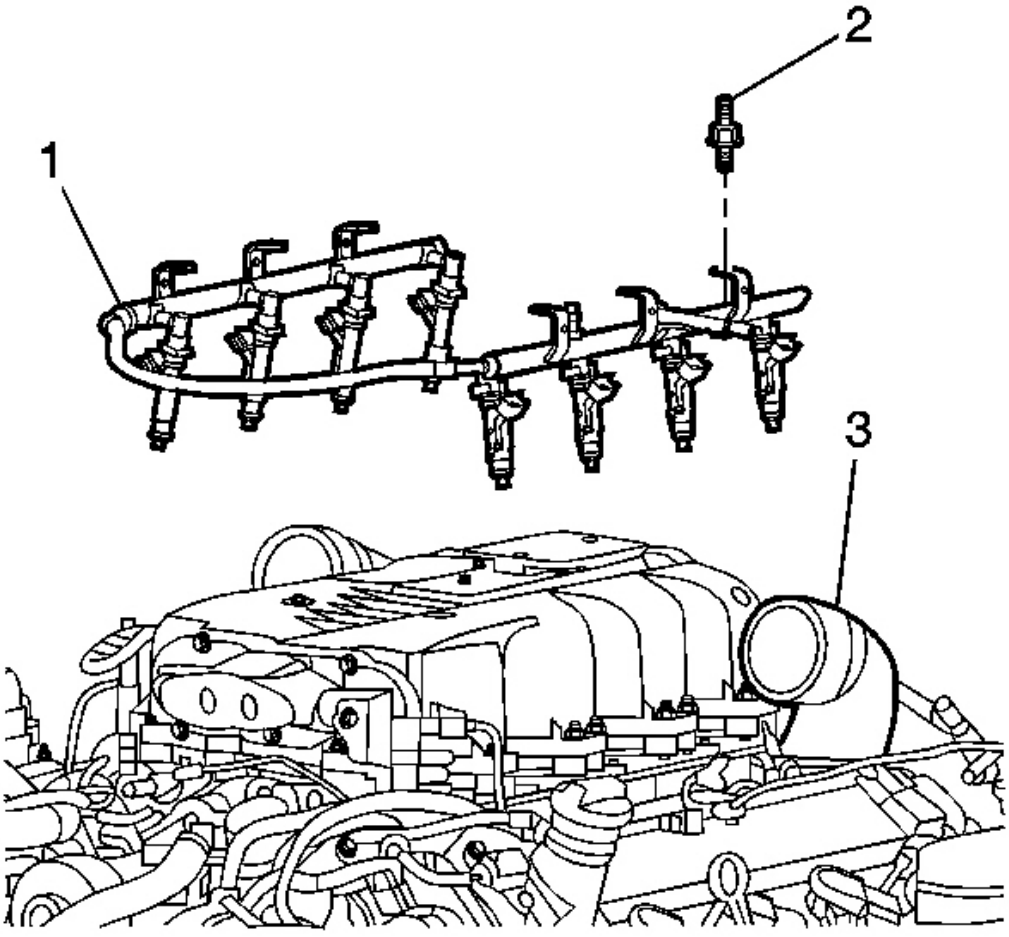


Fig. 118: View Of Fuel Rail
Courtesy of GENERAL MOTORS CORP.

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief** .
2. Remove the fuel rail. Refer to **Fuel Injector and Fuel Rail Replacement** .

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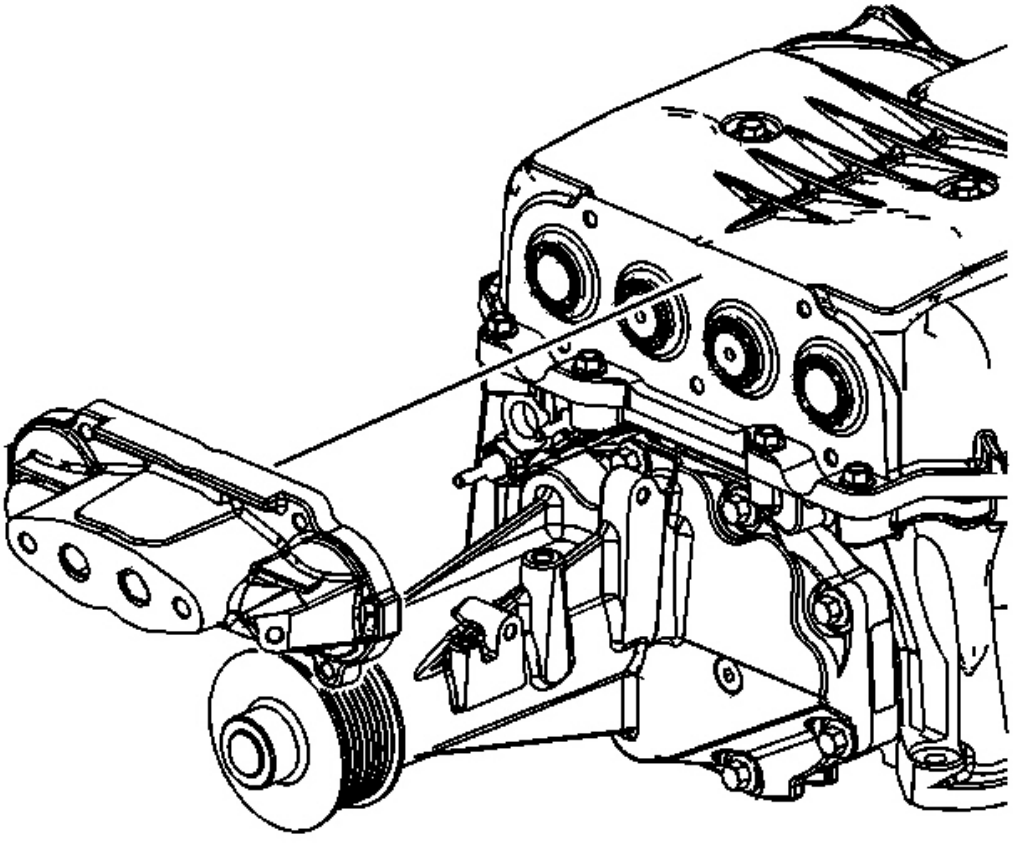


Fig. 119: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

3. Drain the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .

IMPORTANT: Do not allow draining coolant to contact the supercharger drive belt.

4. Place a shop rag under the front portion of the supercharger to catch any remaining coolant.
5. Remove the charge air cooler front manifold. Refer to **Charge Air Cooler Front Manifold Replacement**.

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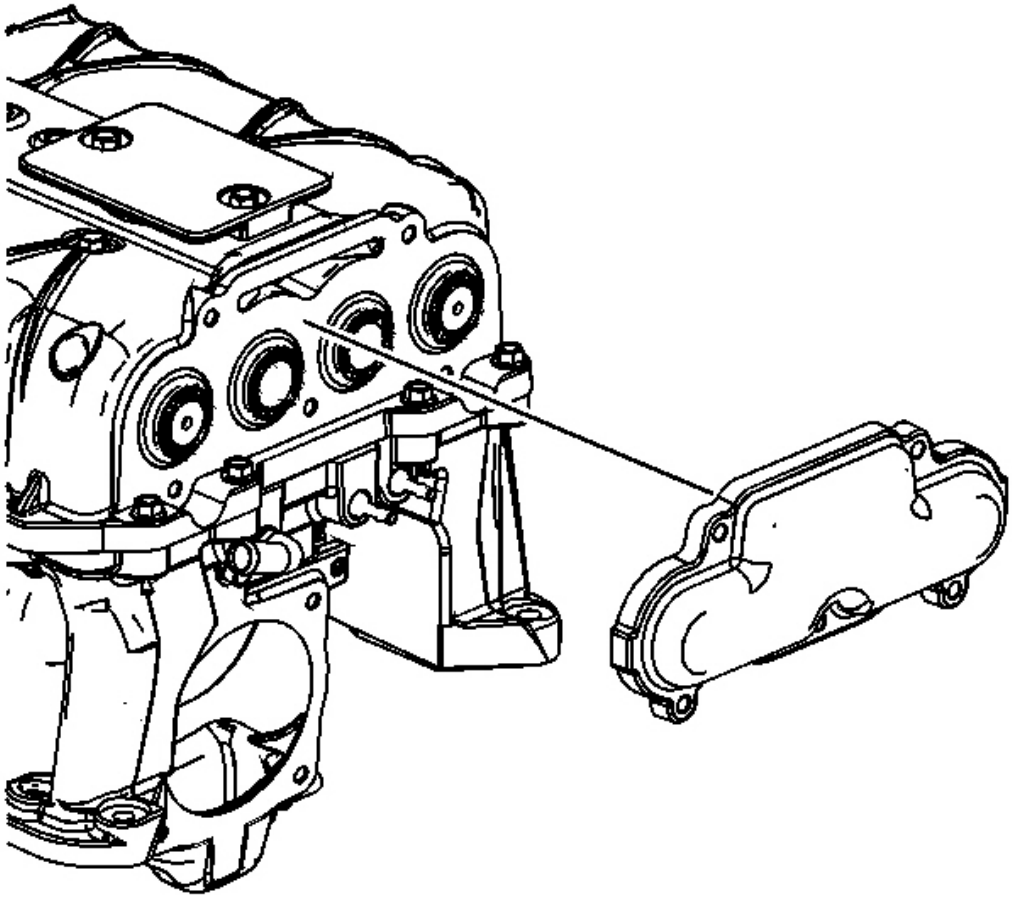


Fig. 120: Identifying Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

6. Remove the charge air cooler rear manifold. Refer to **Charge Air Cooler Coolant Rear Manifold Replacement**.
7. Remove the charge air cooler cooling tubes, if necessary. Refer to **Charge Air Cooler Cooling Tube Replacement**.

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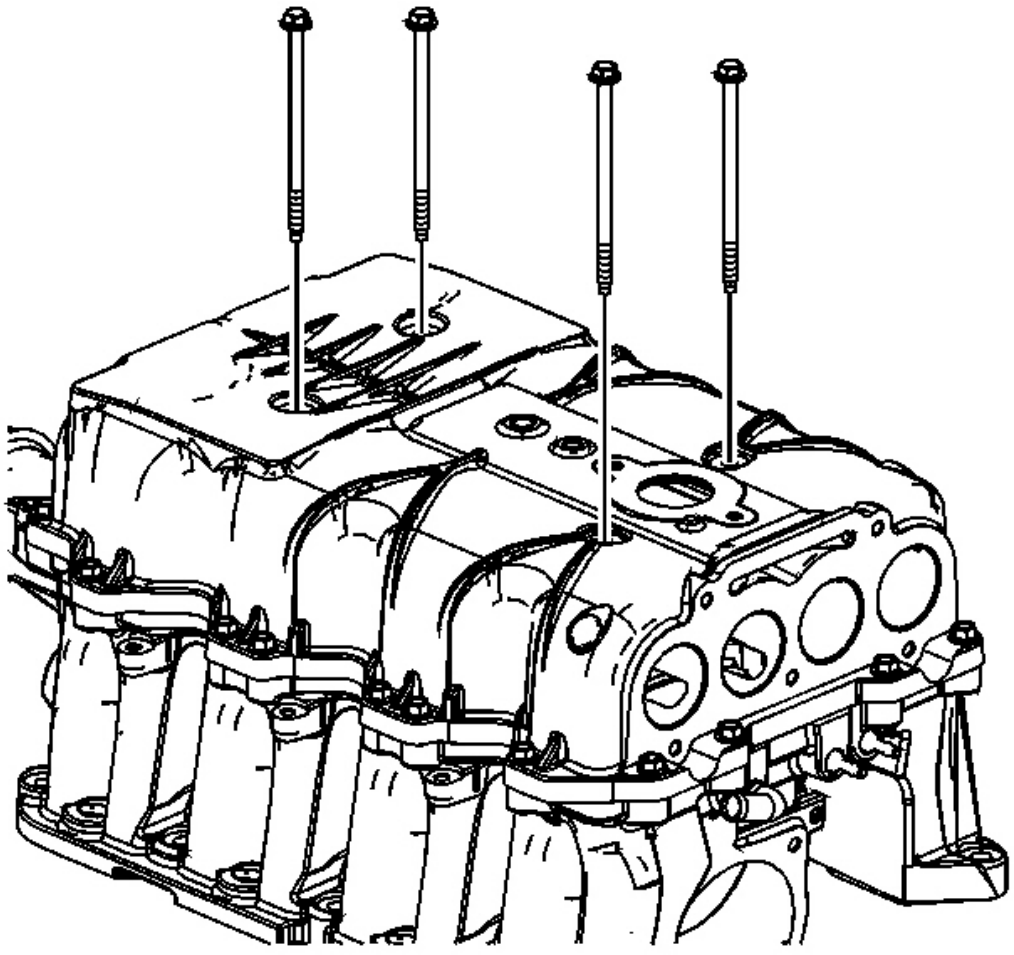


Fig. 121: Long Charge Air Cooler Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the long charge air cooler bolts.

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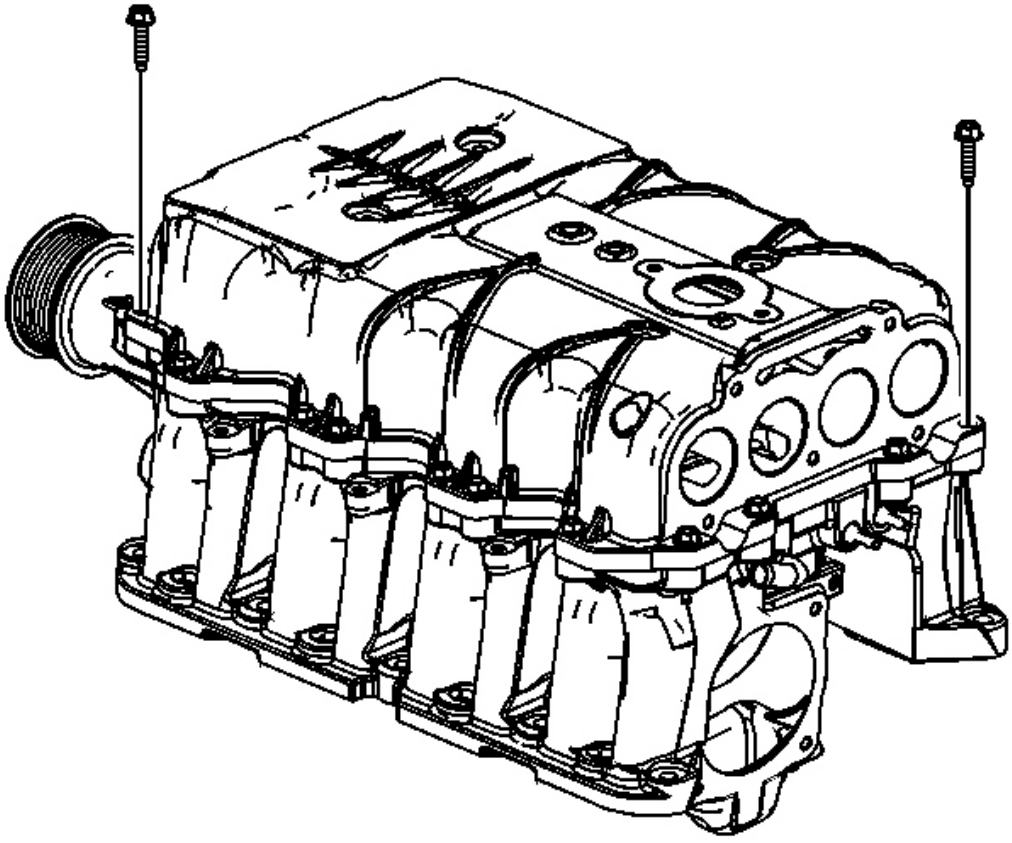


Fig. 122: View Of Short Charge Air Cooler Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the short charge air cooler perimeter bolts.

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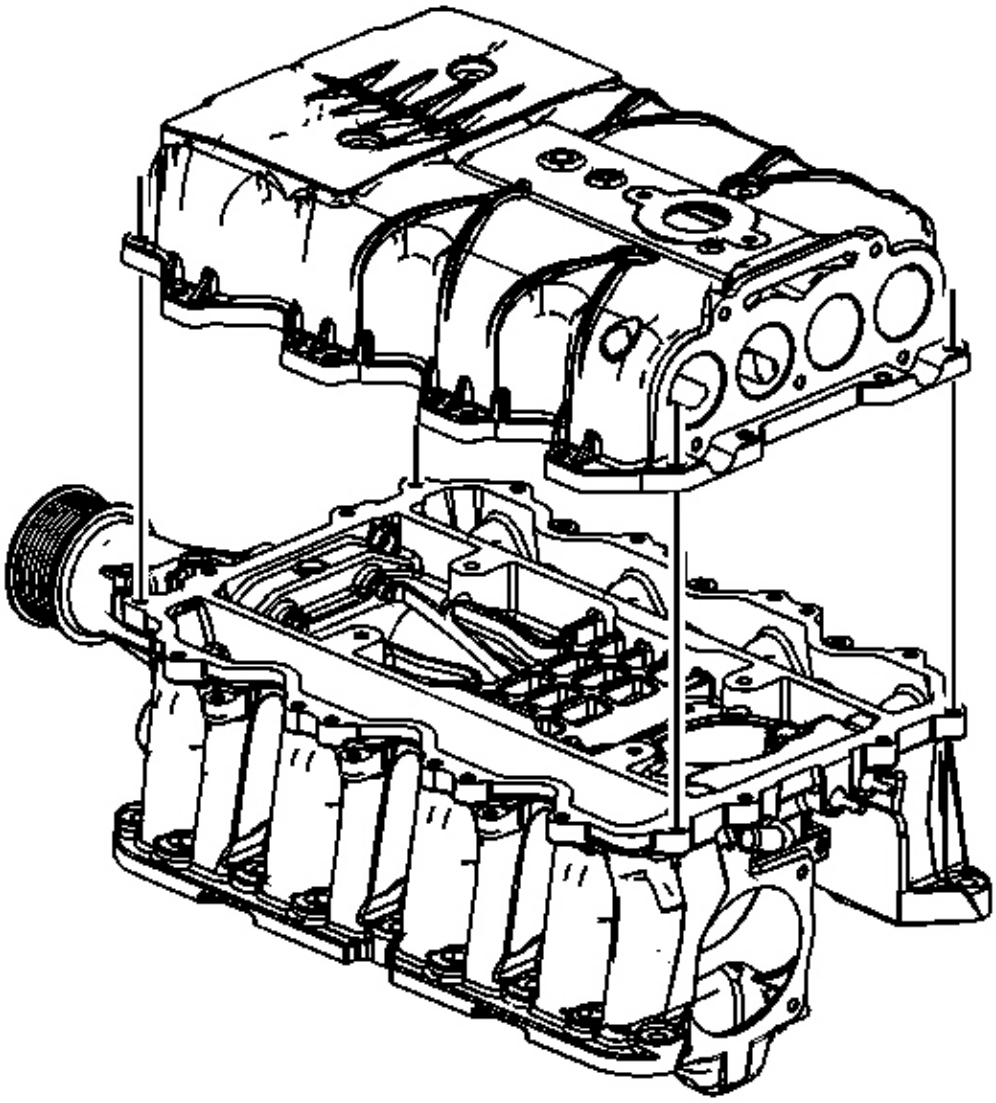


Fig. 123: View Of Charge Air Cooler Housing
Courtesy of GENERAL MOTORS CORP.

10. Remove the charge air cooler housing.

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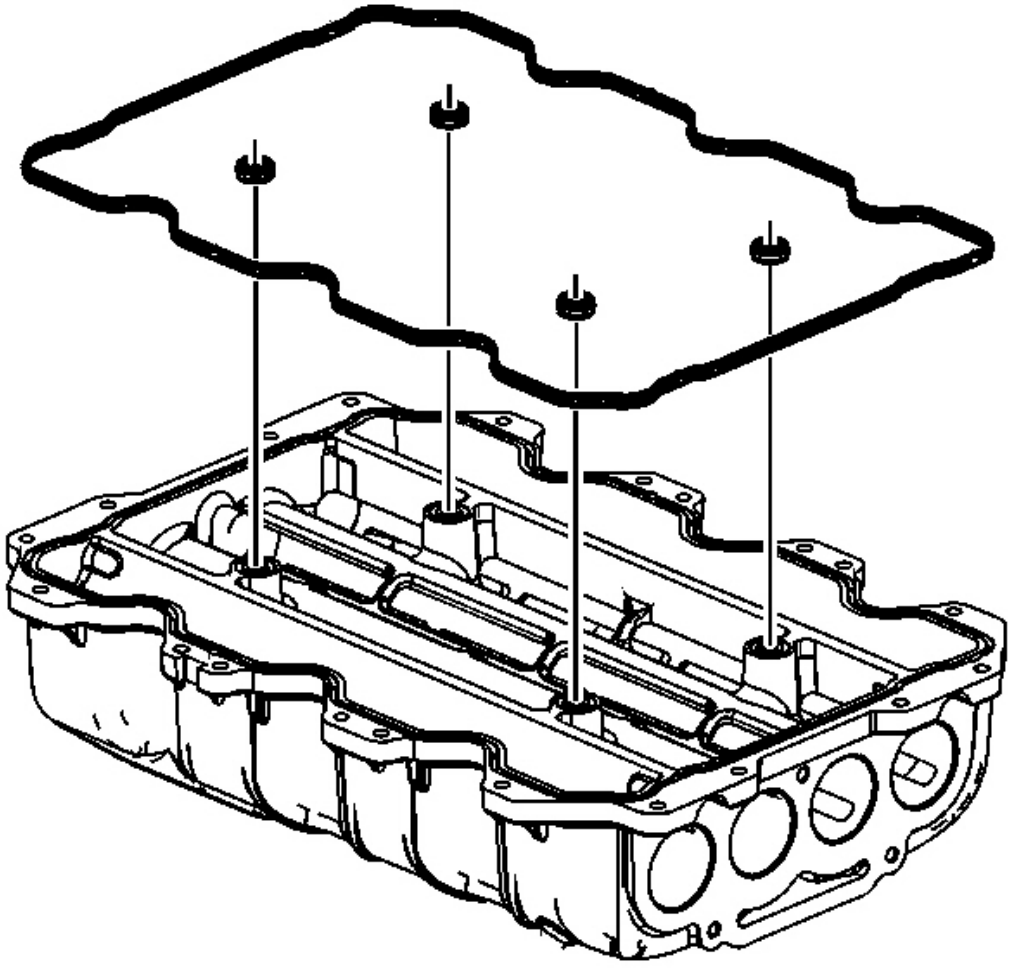


Fig. 124: View Of Charge Air Cooler Housing Perimeter Gasket
Courtesy of GENERAL MOTORS CORP.

11. Remove and discard the charge air cooler housing perimeter gasket.
12. Remove and discard the charge air cooler housing interior O-ring gaskets.

INSTALLATION PROCEDURE

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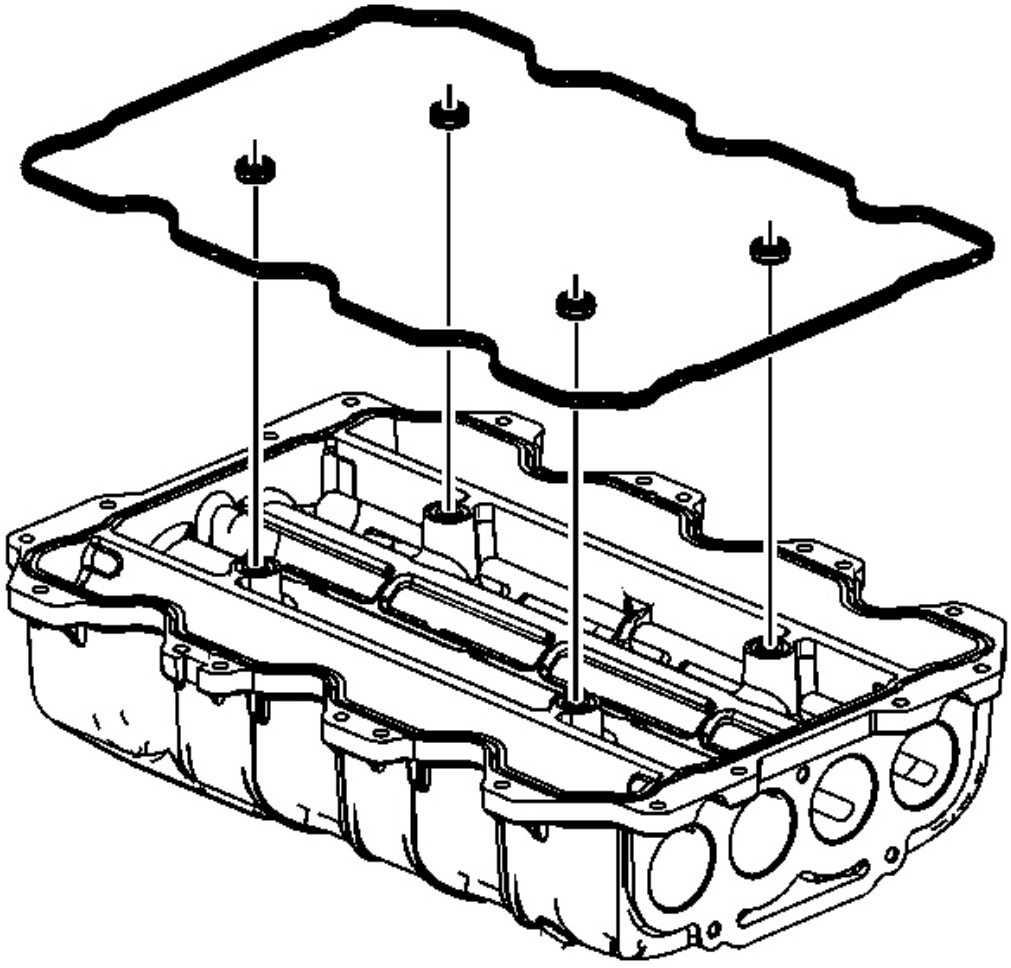


Fig. 125: View Of Charge Air Cooler Housing Perimeter Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW charge air cooler housing interior O-ring gaskets.
2. Install the NEW charge air cooler housing perimeter gasket.

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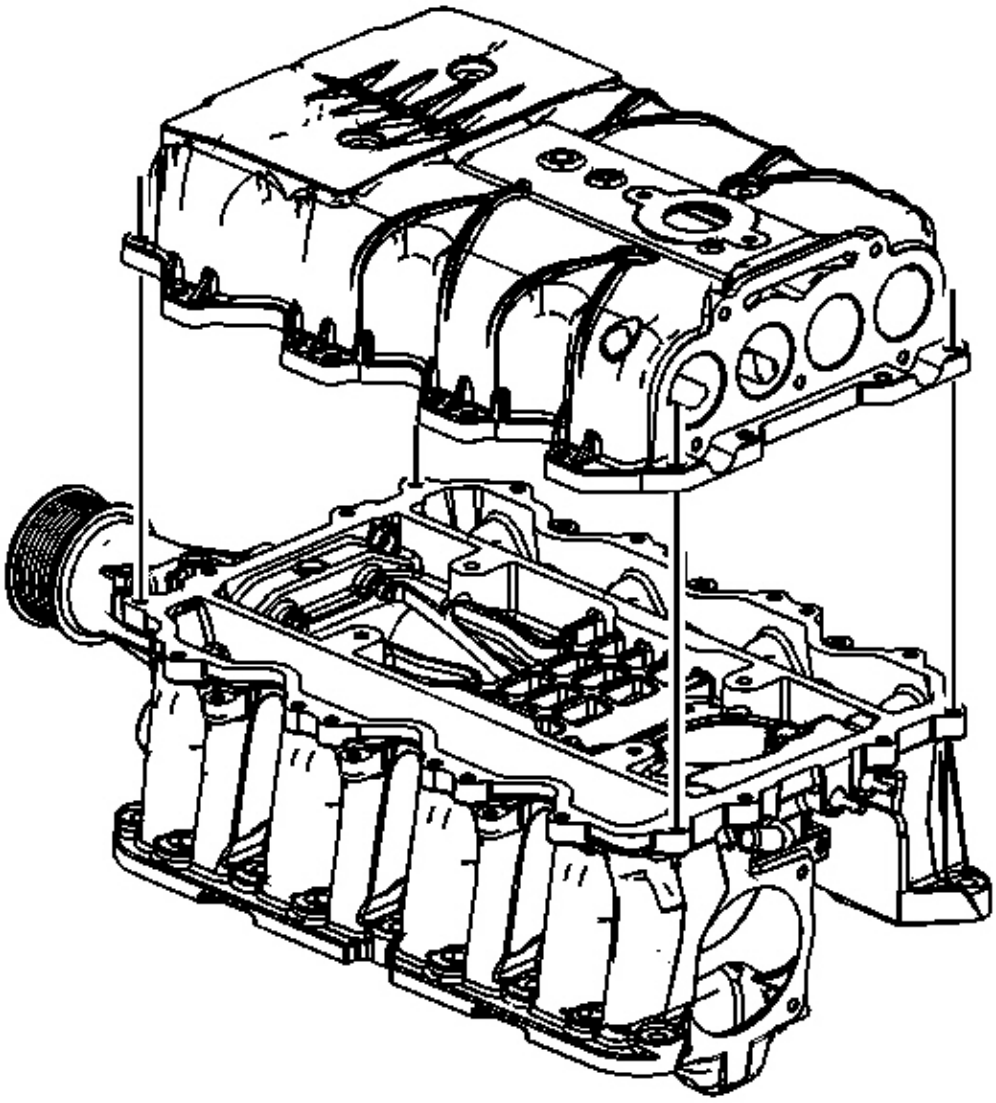


Fig. 126: View Of Charge Air Cooler Housing
Courtesy of GENERAL MOTORS CORP.

3. Install the charge air cooler housing.

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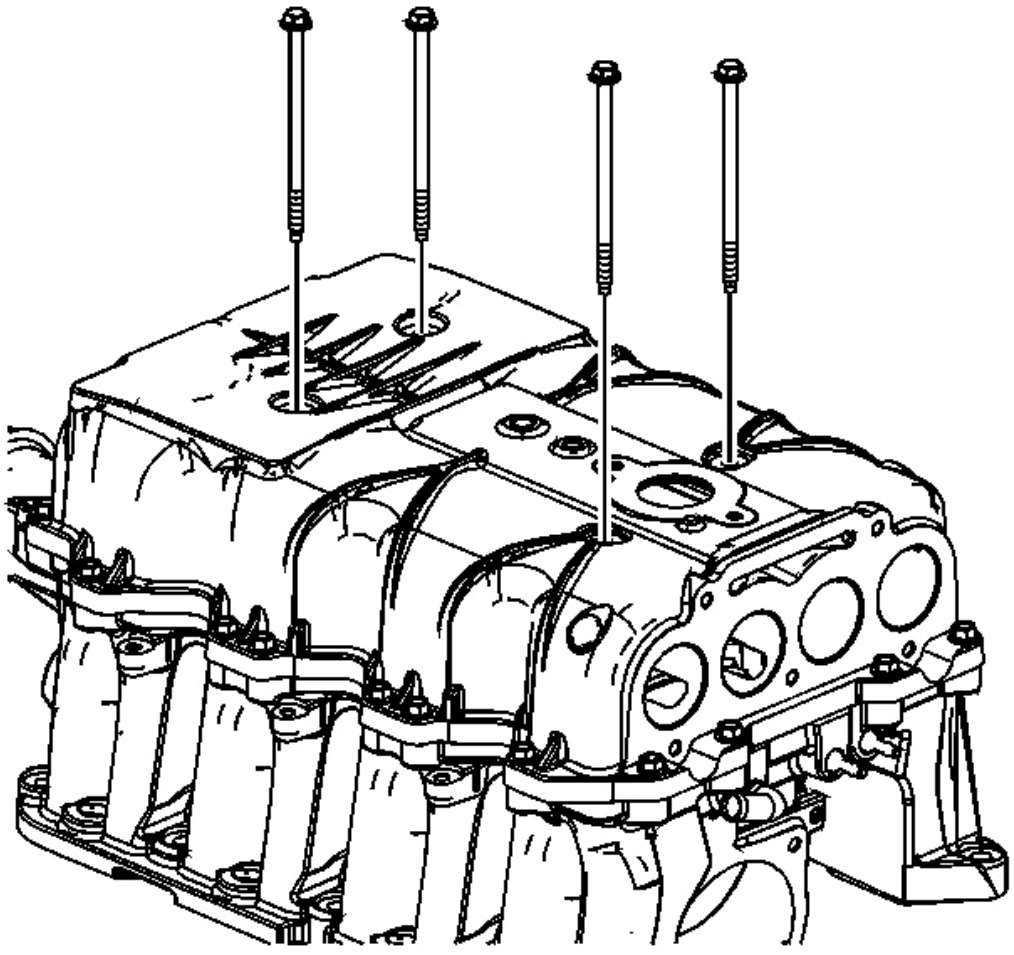


Fig. 127: Long Charge Air Cooler Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the long charge air cooler bolts.

   Tighten: Tighten the long charge air cooler bolt to 10 N.m (89 lb in).

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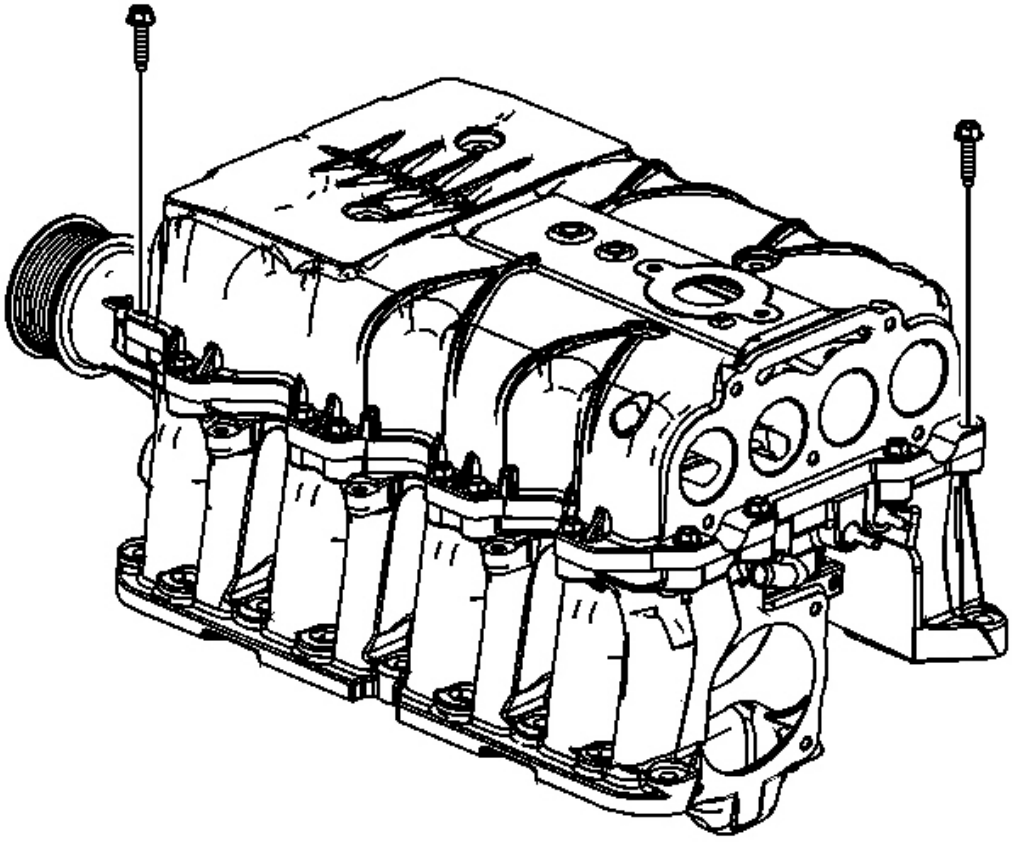


Fig. 128: View Of Short Charge Air Cooler Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the short charge air cooler perimeter bolts.

   Tighten: Tighten the short charge air cooler bolt to 10 N.m (89 lb in).

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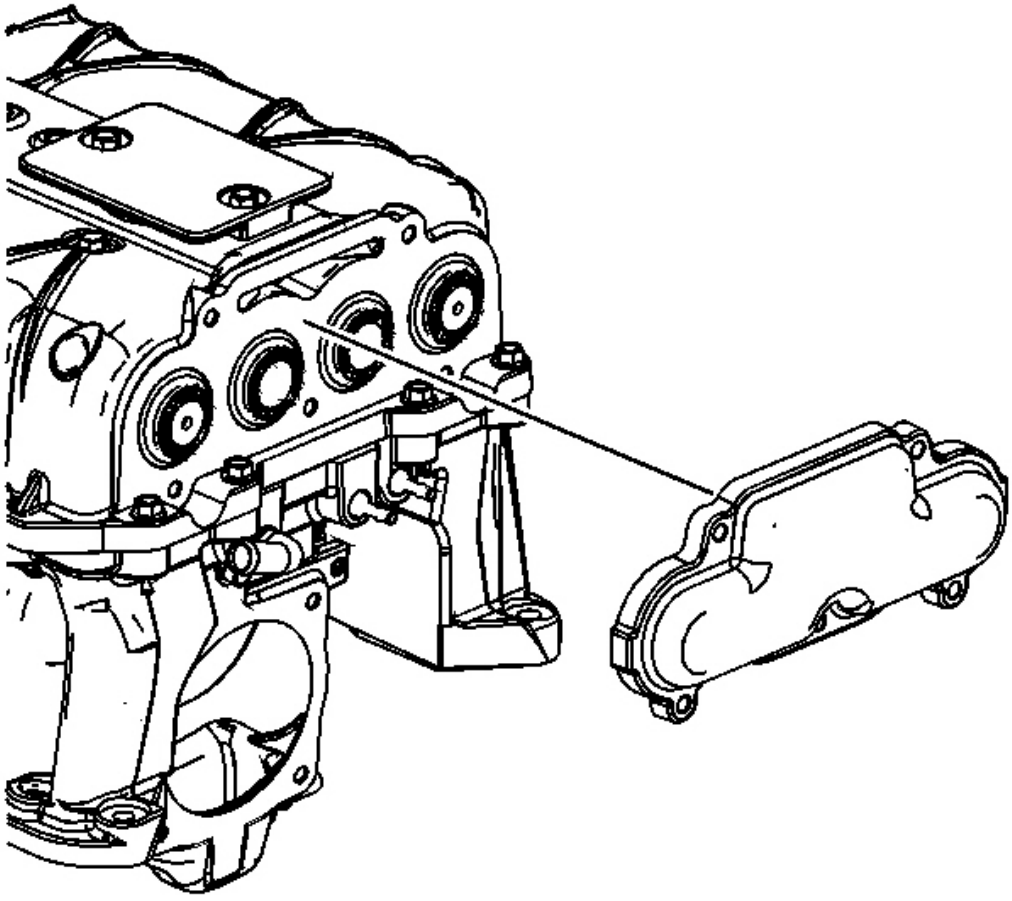


Fig. 129: Identifying Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

6. Install the charge air cooler cooling tubes, if necessary. Refer to **Charge Air Cooler Cooling Tube Replacement**.
7. Install the charge air cooler rear manifold. Refer to **Charge Air Cooler Coolant Rear Manifold Replacement**.

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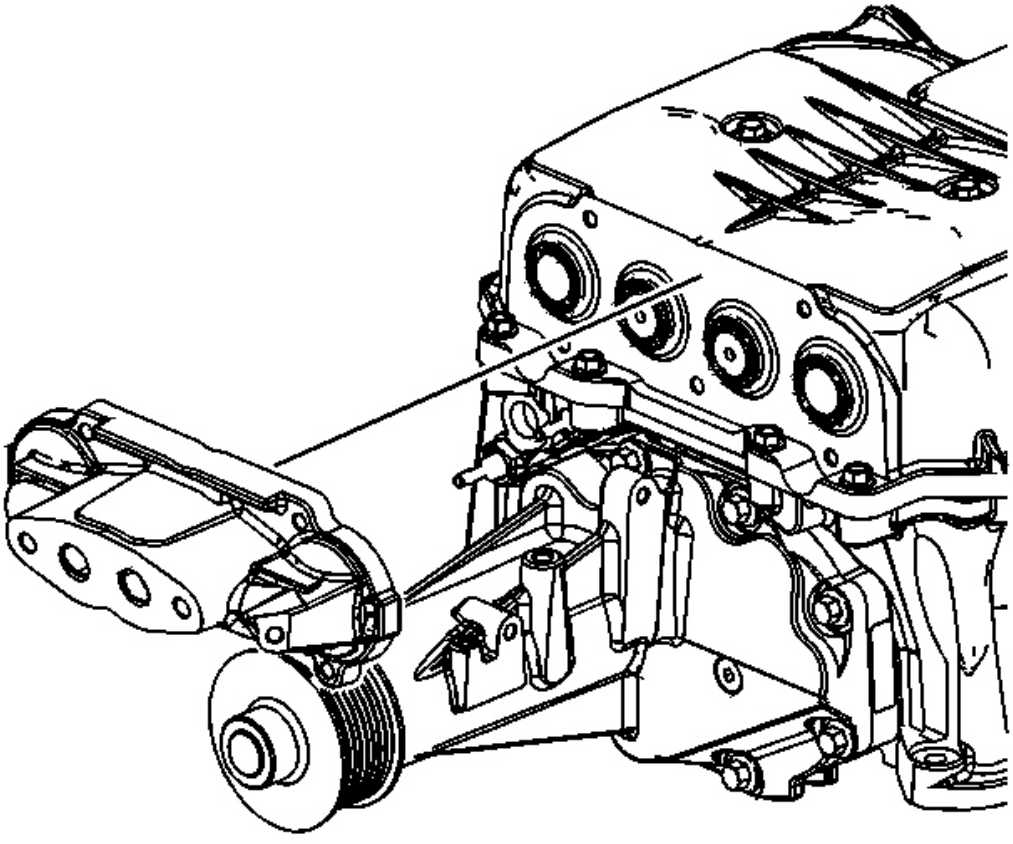


Fig. 130: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

8. Install the charge air cooler front manifold. Refer to **Charge Air Cooler Front Manifold Replacement**.
9. Fill the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .

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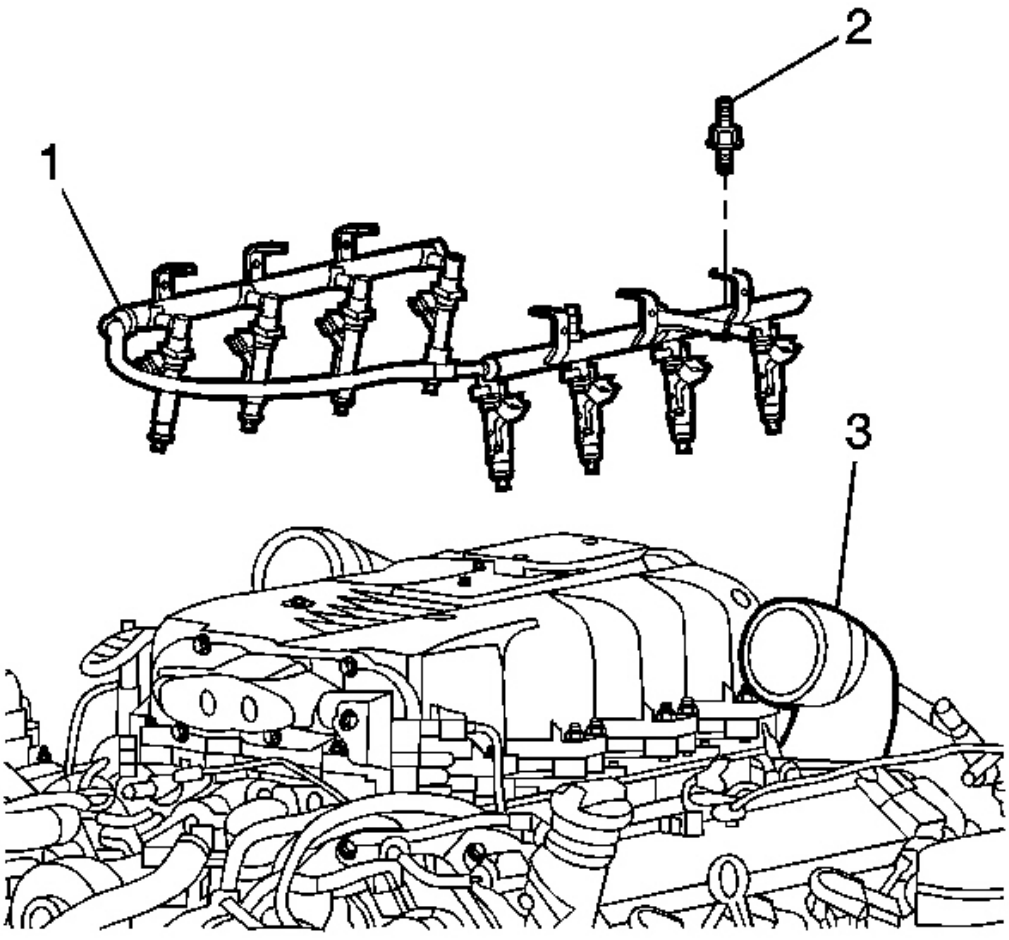


Fig. 131: View Of Fuel Rail
Courtesy of GENERAL MOTORS CORP.

10. Install the fuel rail. Refer to **Fuel Injector and Fuel Rail Replacement** .
11. Install the fuel fill cap.
12. Check the charge air cooling system for leaks.
13. Check the fuel system for leaks.

SUPERCHARGER REPLACEMENT

TOOLS REQUIRED

- **EN 46109** Guide Pins. See **Special Tools** .

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- **EN-47748** Supercharger Lift Bracket
- **EN-47833** Supercharger Service Holding Fixture

REMOVAL PROCEDURE

1. Remove the hood. Refer to **Hood Replacement** .
2. Remove the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**.
3. Remove the front supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
4. Drain the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .

IMPORTANT: Do not allow coolant to contact the supercharger drive belt. Place a shop rag under the front portion of the supercharger to catch any remaining coolant.

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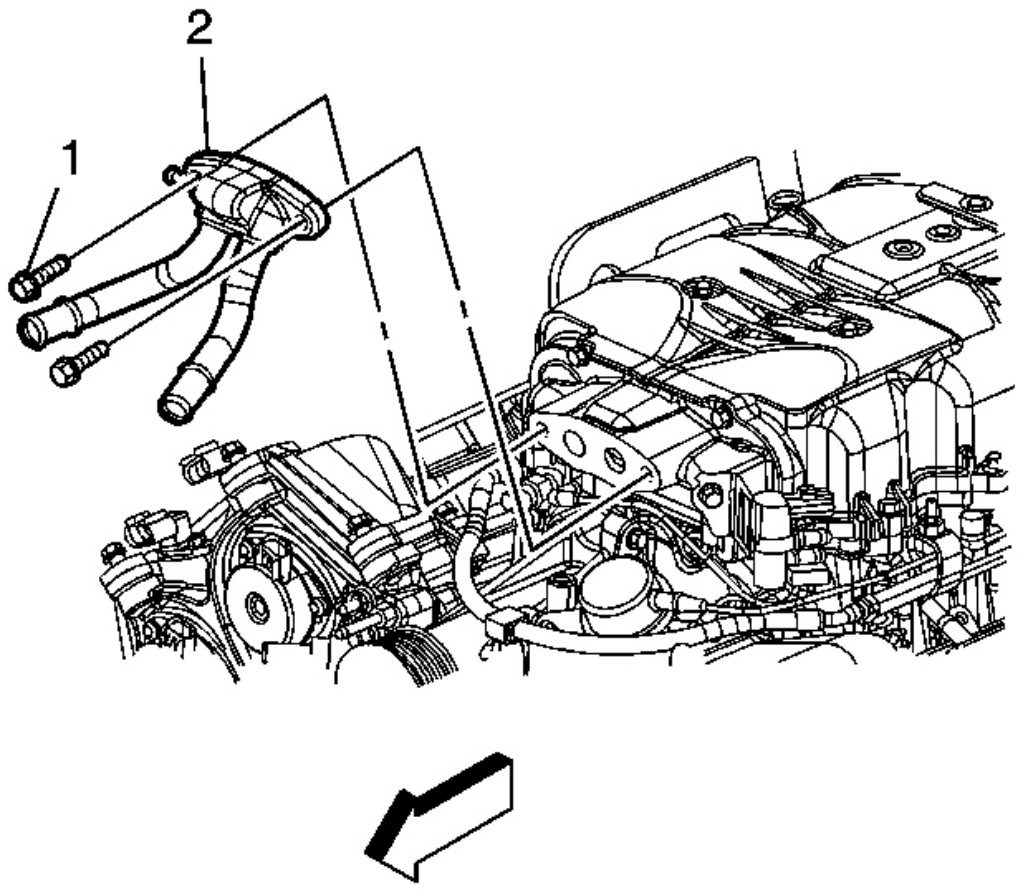


Fig. 132: View Of Charge Air Cooler & Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the front portion of the supercharger front manifold (2). It is not necessary to remove the hoses from the manifold. Discard the manifold O-ring seals. Position the hoses with manifold aside. Refer to **Charge Air Cooler Front Manifold Replacement**.

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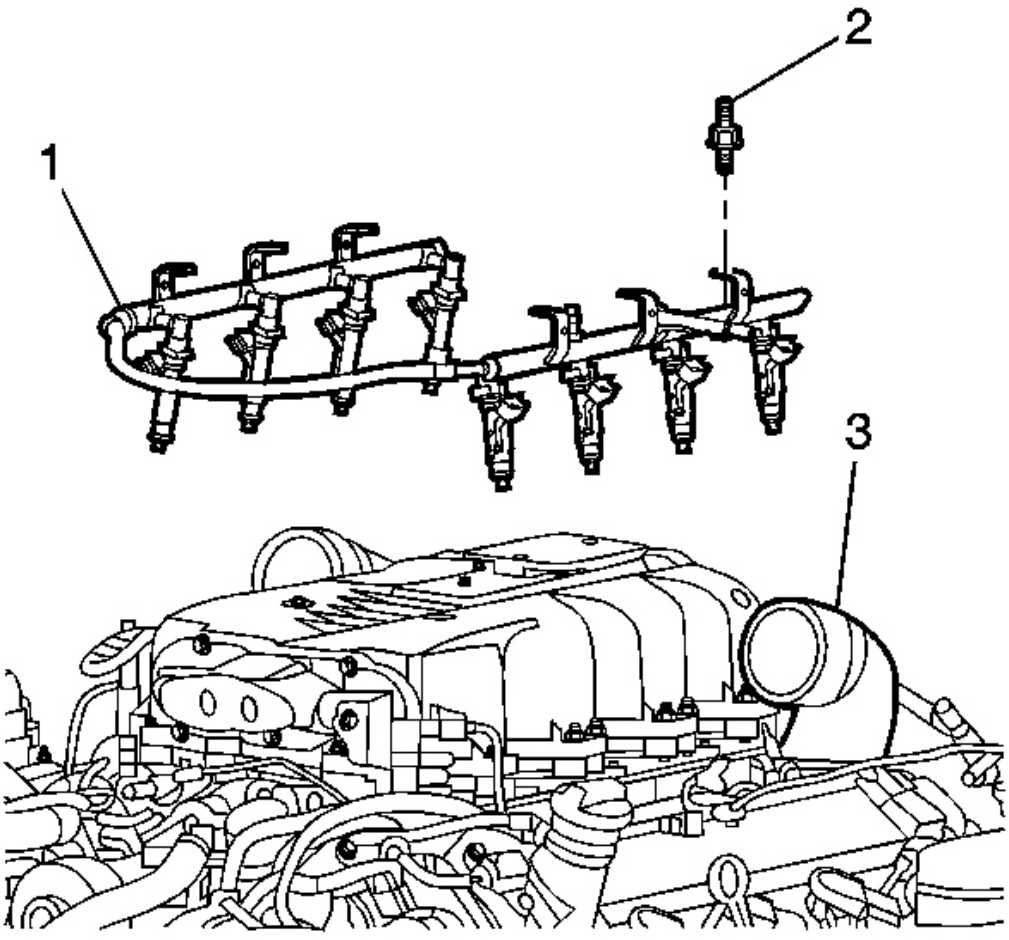


Fig. 133: View Of Fuel Rail
Courtesy of GENERAL MOTORS CORP.

6. Remove the fuel injector rail assembly (1). Refer to **Fuel Injector and Fuel Rail Replacement** .

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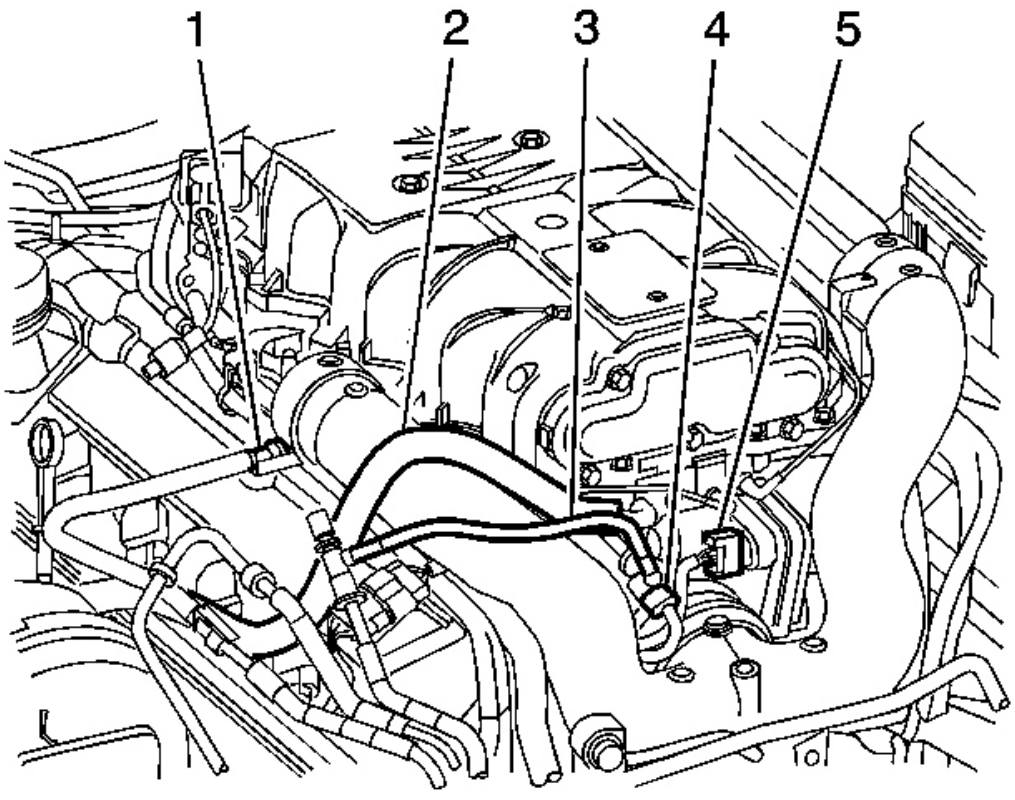


Fig. 134: Identifying EVAP Hose
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the throttle body electrical connector (5).
8. Disconnect the evaporative emission (EVAP) canister purge solenoid valve hose (3) from the EVAP valve. Refer to **Plastic Collar Quick Connect Fitting Service** . Position the hose aside.
9. Disconnect the EVAP canister purge solenoid valve electrical connector (4).
10. Disconnect the brake booster vacuum hose (2) from the fitting on the supercharger. Position the hose aside.

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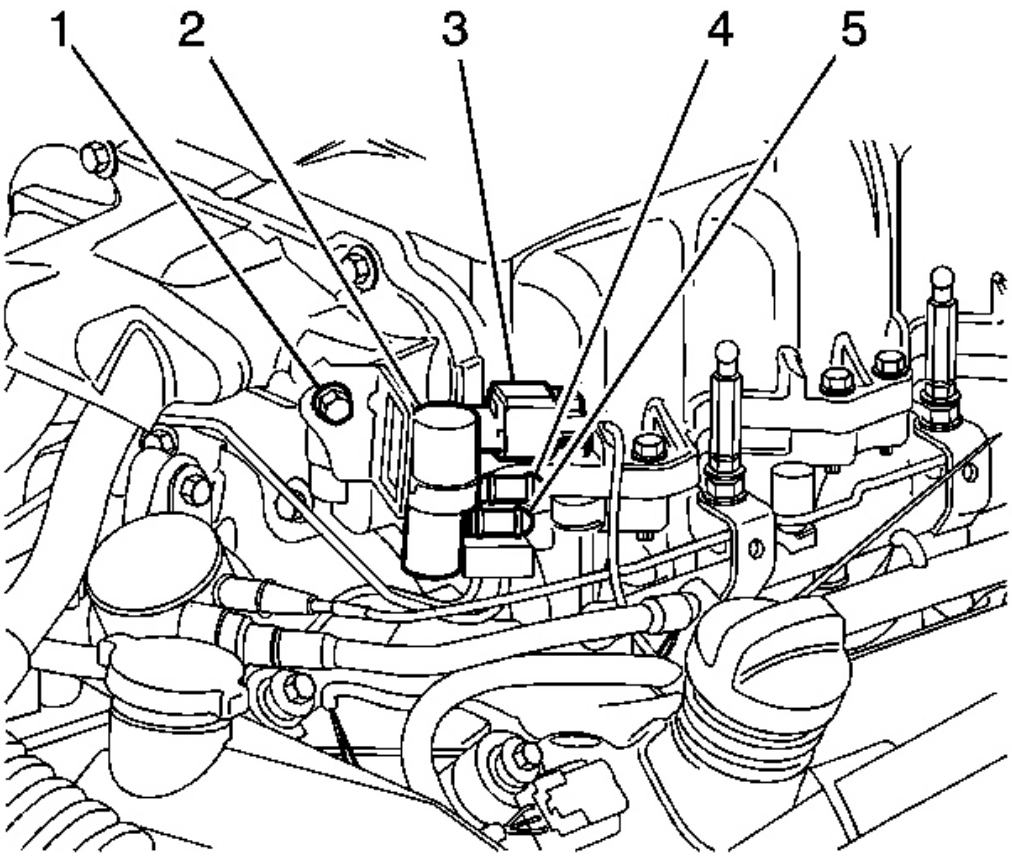


Fig. 135: Identifying Supercharger Bypass Solenoid Valve Electrical Connector
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the supercharger bypass regulator solenoid valve electrical connector (3).

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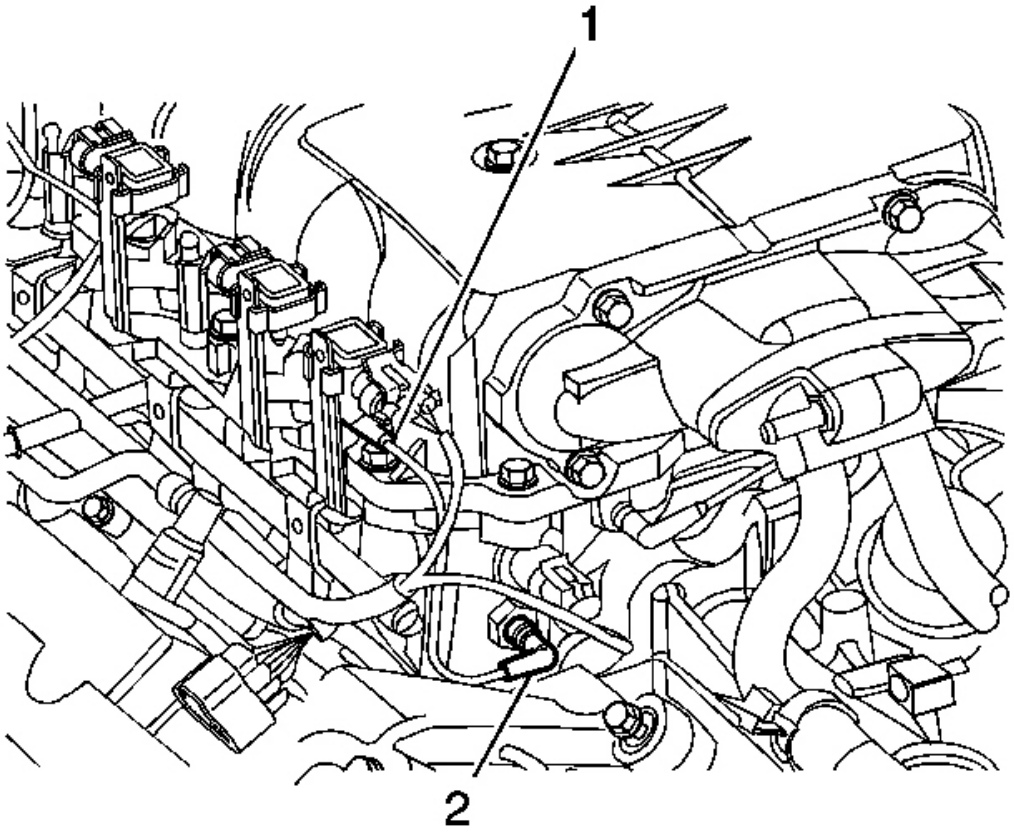


Fig. 136: View Of Vacuum Line Fitting
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the manifold absolute pressure (MAP) sensor vacuum line (2) from the supercharger.
13. Disconnect the supercharger intake air temperature (IAT) sensor electrical connector.

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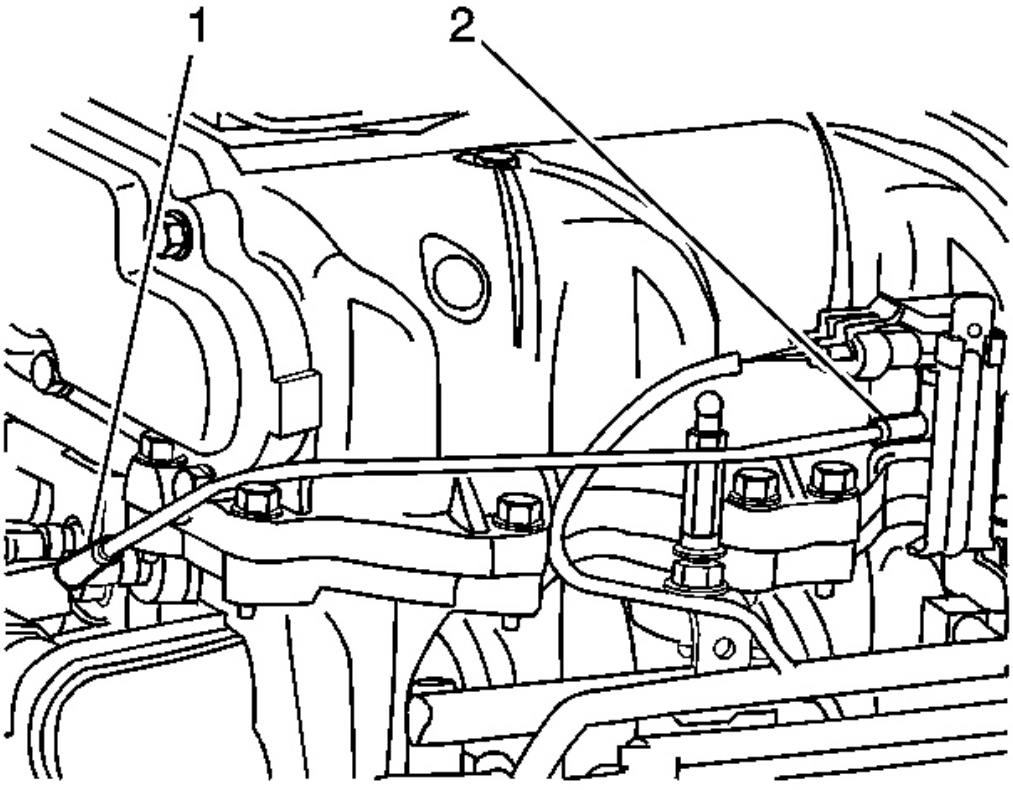


Fig. 137: Identifying Vacuum Line Fitting
Courtesy of GENERAL MOTORS CORP.

14. Disconnect the supercharger inlet absolute pressure (SIAP) sensor vacuum line fitting (1) from the rear of the supercharger. Position the sensors, vacuum lines and wire harness aside.

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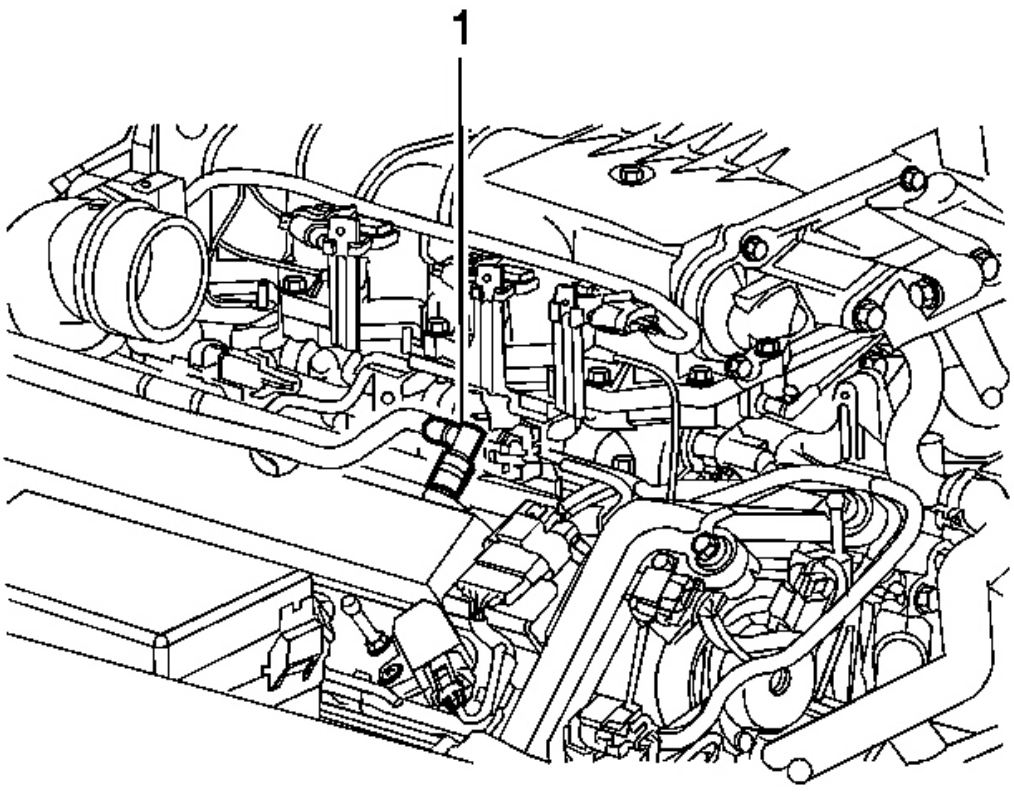


Fig. 138: Locating PCV Orifice Fitting
Courtesy of GENERAL MOTORS CORP.

15. Disconnect the positive crankcase ventilation (PCV) tube fitting (1) from the right camshaft cover.
16. Remove the supercharger drive belt. Refer to **Supercharger Belt Replacement**.

CAUTION: The supercharger must be lifted with the EN 47748. The weight of the supercharger assembly is approximately 34 kg (75 lb) and could cause injury if lifted by hand.

NOTE: The supercharger must be lifted with the EN 47748. Damage could occur to the finish and/or components of the supercharger and surrounding engine or vehicle components.

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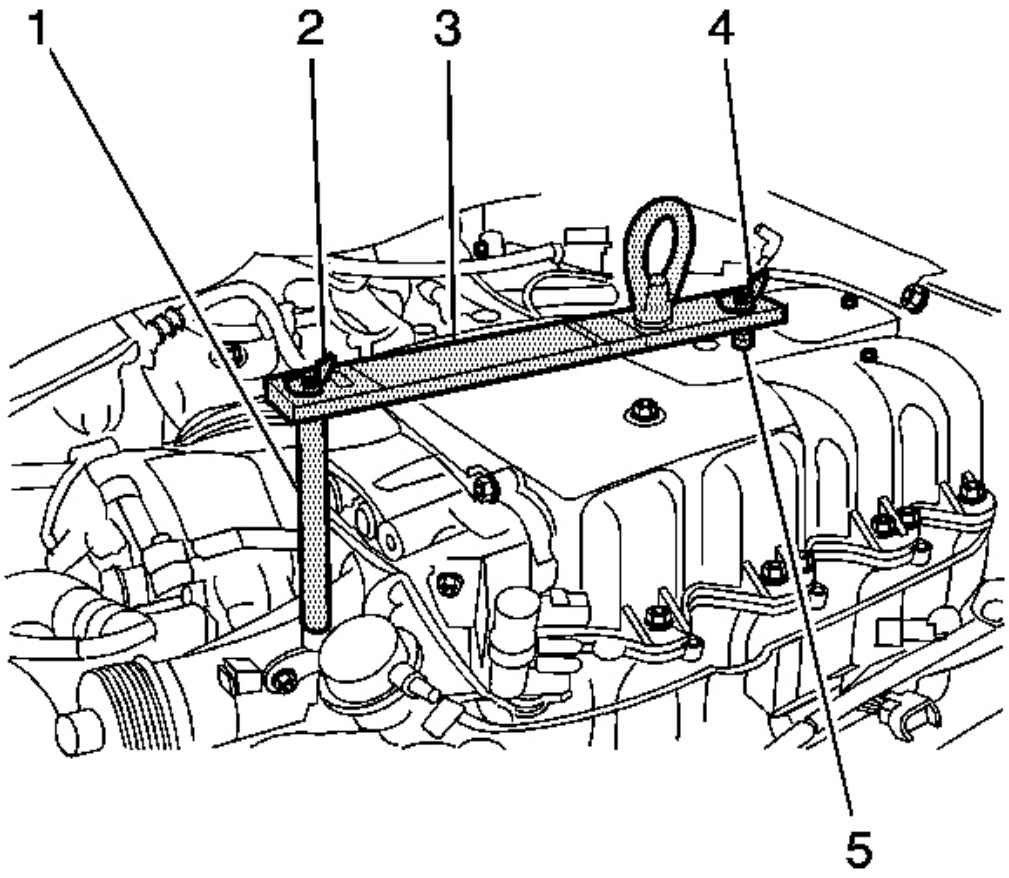


Fig. 139: View Of EN-47748 Supercharger Lift Bracket
Courtesy of GENERAL MOTORS CORP.

17. Install the **EN-47748** (1-5) to the supercharger.

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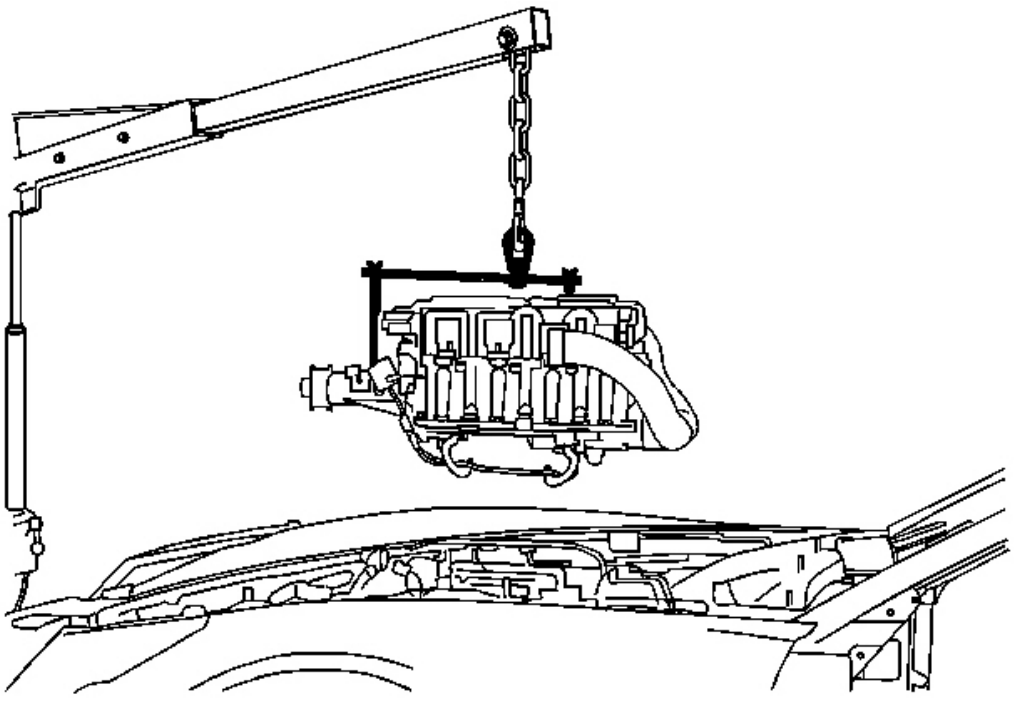


Fig. 140: View Of Supercharger Service Holding Tool Fixture
Courtesy of GENERAL MOTORS CORP.

18. Install an engine hoist to the **EN-47748** .
19. Remove and discard the supercharger bolts.
20. Remove the supercharger.

NOTE: **The EN 47833 must be installed to the supercharger in order to prevent damage to the supercharger bypass actuator cable and the finish of the supercharger. Failure to use the EN 47833 can lead to bending the brackets of the supercharger bypass actuator cable. Bent supercharger bypass actuator cable brackets will cause the supercharger bypass valve to function improperly.**

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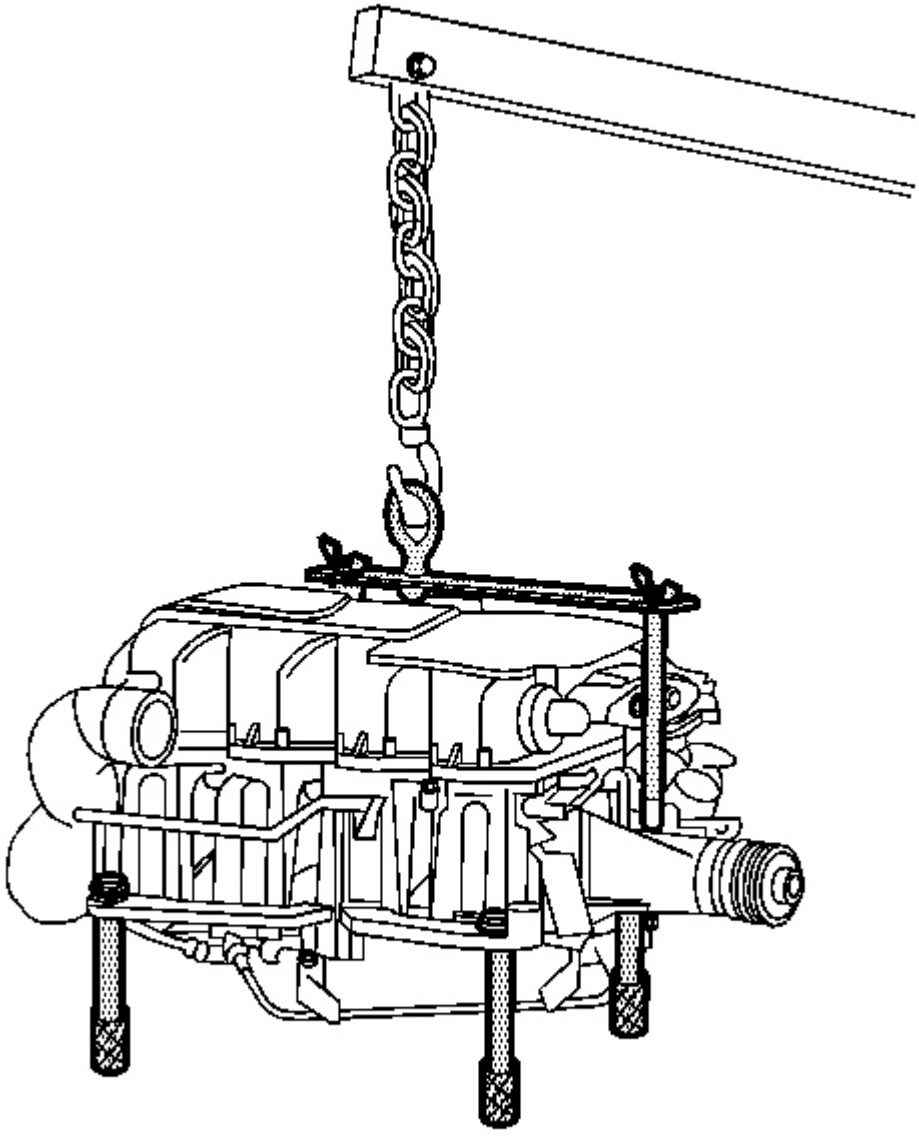


Fig. 141: Identifying Supercharger Service Holding Fixture
Courtesy of GENERAL MOTORS CORP.

21. Install the **EN-47833** to the supercharger while the supercharger is suspended by the engine hoist.
22. Place the supercharger on a workbench and remove the engine hoist.
23. If replacing the supercharger, transfer the necessary parts.

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24. Remove the supercharger gaskets from the engine.
25. Clean and inspect the supercharger. Refer to **Supercharger Cleaning and Inspection** .
26. Clean and inspect the supercharger mating surface on the engine.

INSTALLATION PROCEDURE

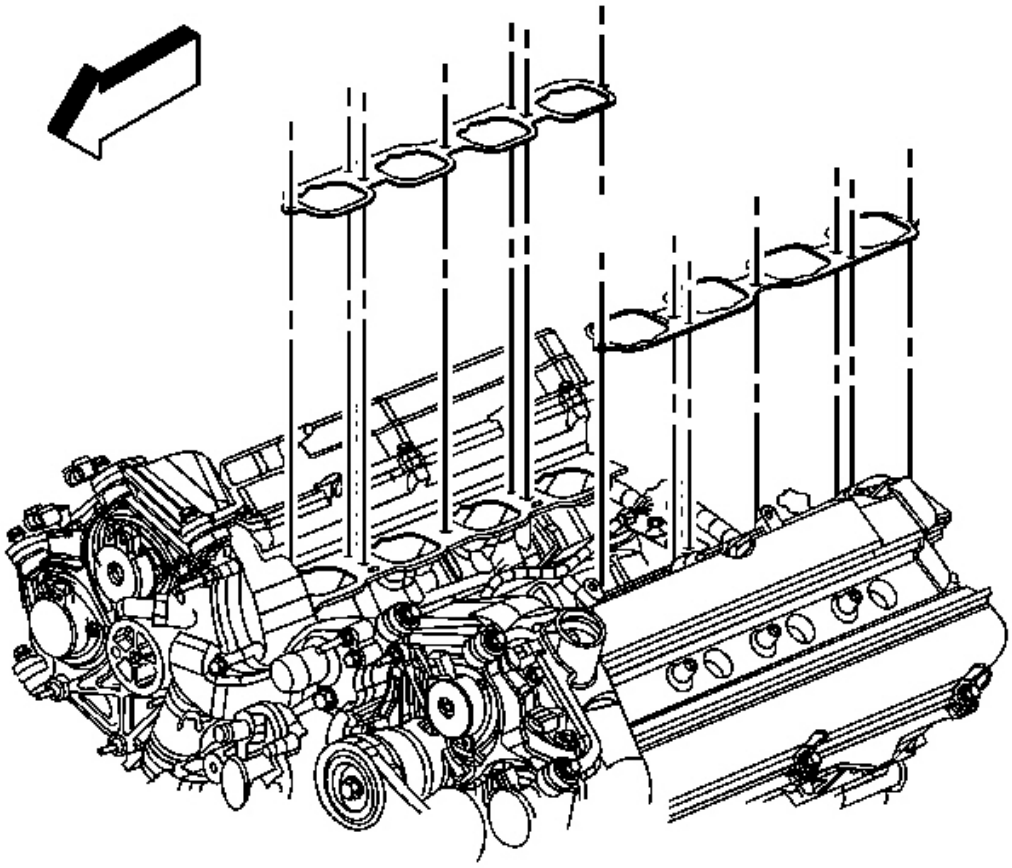


Fig. 142: View Of Supercharger Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Install the new supercharger gaskets to the engine.
2. Install two of the appropriate size guide pins from the **EN 46109** alignment pin set to the engine in the front two bolt hole locations. See **Special Tools** .

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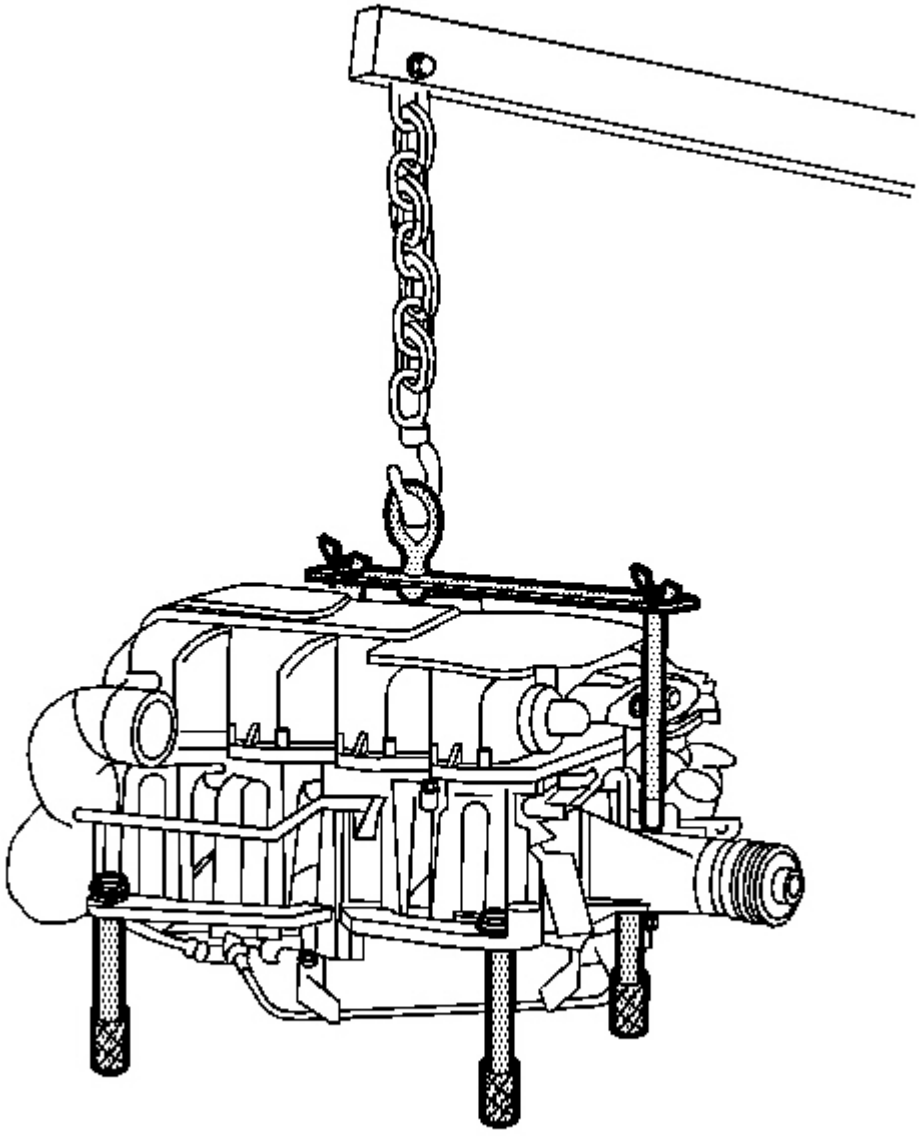


Fig. 143: Identifying Supercharger Service Holding Fixture
Courtesy of GENERAL MOTORS CORP.

3. If previously removed, install the **EN-47748** to the supercharger.
4. Install an engine hoist to the **EN-47748** and raise the supercharger off the workbench.
5. Remove the **EN-47833** from the supercharger.

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6. Inspect the gasket surface on the supercharger and clean as necessary.

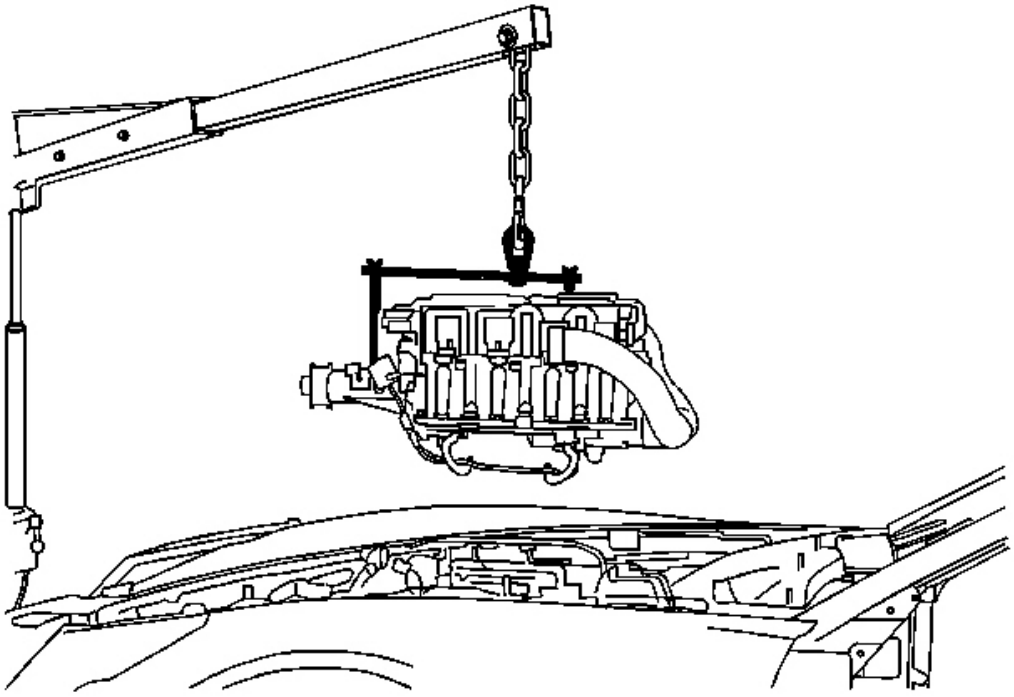


Fig. 144: View Of Supercharger Service Holding Tool Fixture
Courtesy of GENERAL MOTORS CORP.

7. Ensure that all wiring and vacuum lines are positioned aside and install the supercharger to the engine.
8. Remove the engine hoist and the **EN-47748** .
9. Remove the **EN 46109** alignment pins. See **Special Tools** .

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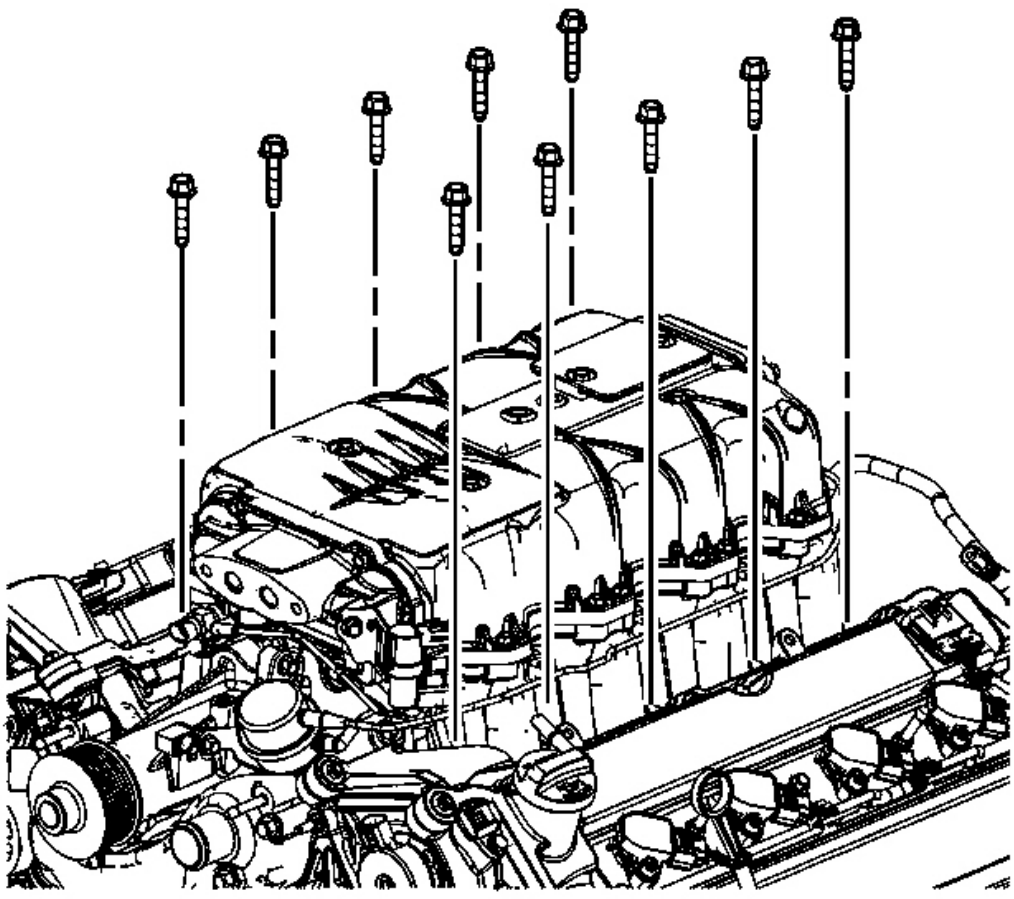


Fig. 145: Identifying Supercharger Bolts
Courtesy of GENERAL MOTORS CORP.

10. Loosely install the NEW supercharger bolts.

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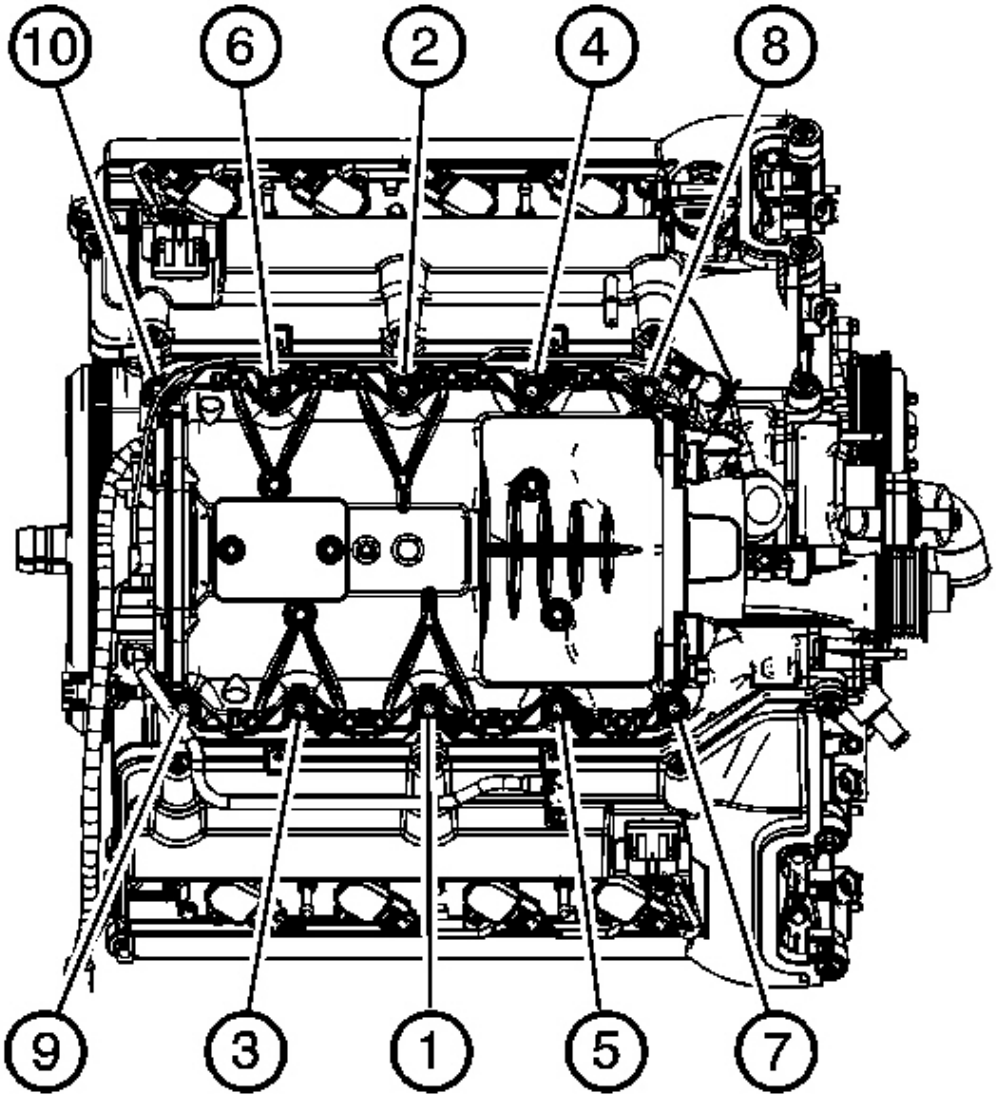


Fig. 146: Identifying Supercharger Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

11. Tighten the supercharger bolts in sequence as shown.

Tighten: Tighten the supercharger bolts to 40 N.m (30 lb ft).

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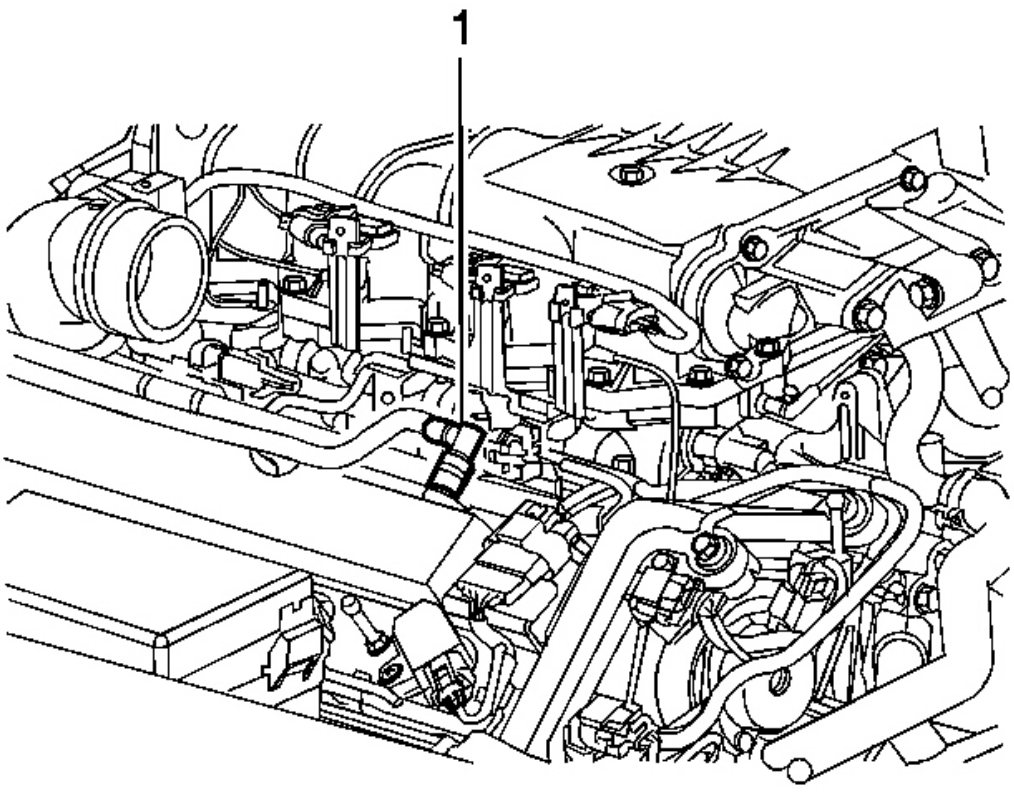


Fig. 147: Locating PCV Orifice Fitting
Courtesy of GENERAL MOTORS CORP.

12. Install the supercharger drive belt. Refer to **Supercharger Belt Replacement**.
13. Connect the PCV tube fitting (1) to the right side camshaft cover.

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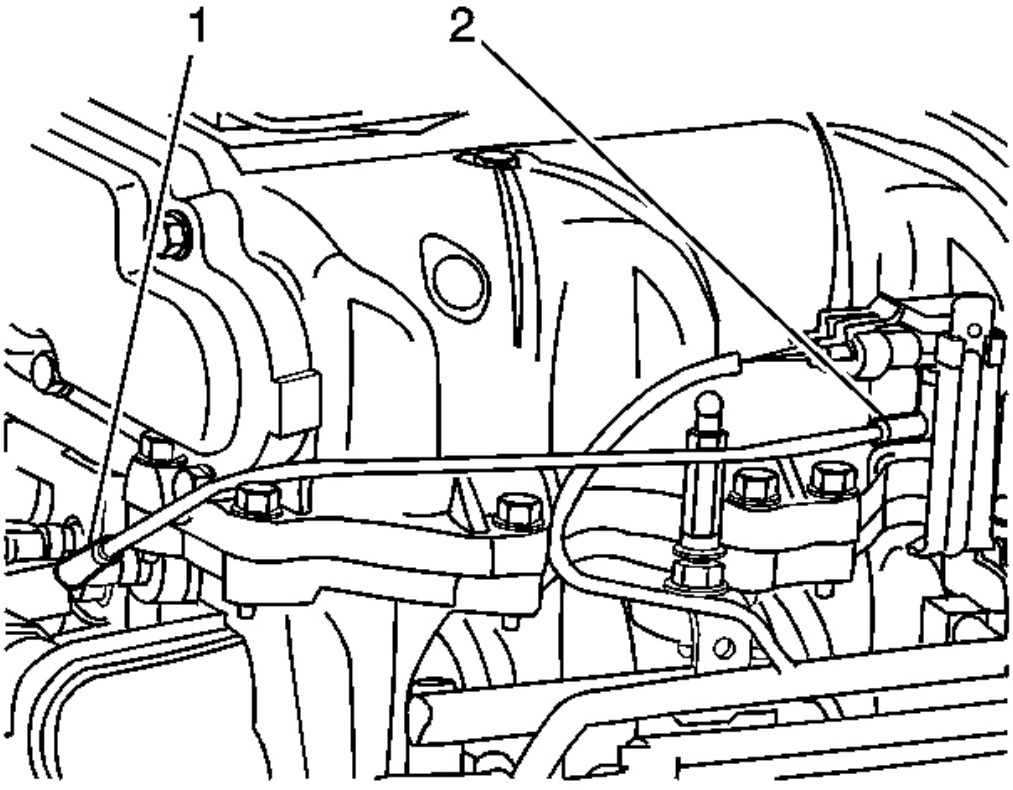


Fig. 148: Identifying Vacuum Line Fitting
Courtesy of GENERAL MOTORS CORP.

14. Connect the SIAP sensor vacuum line fitting (1) to the rear of the supercharger.

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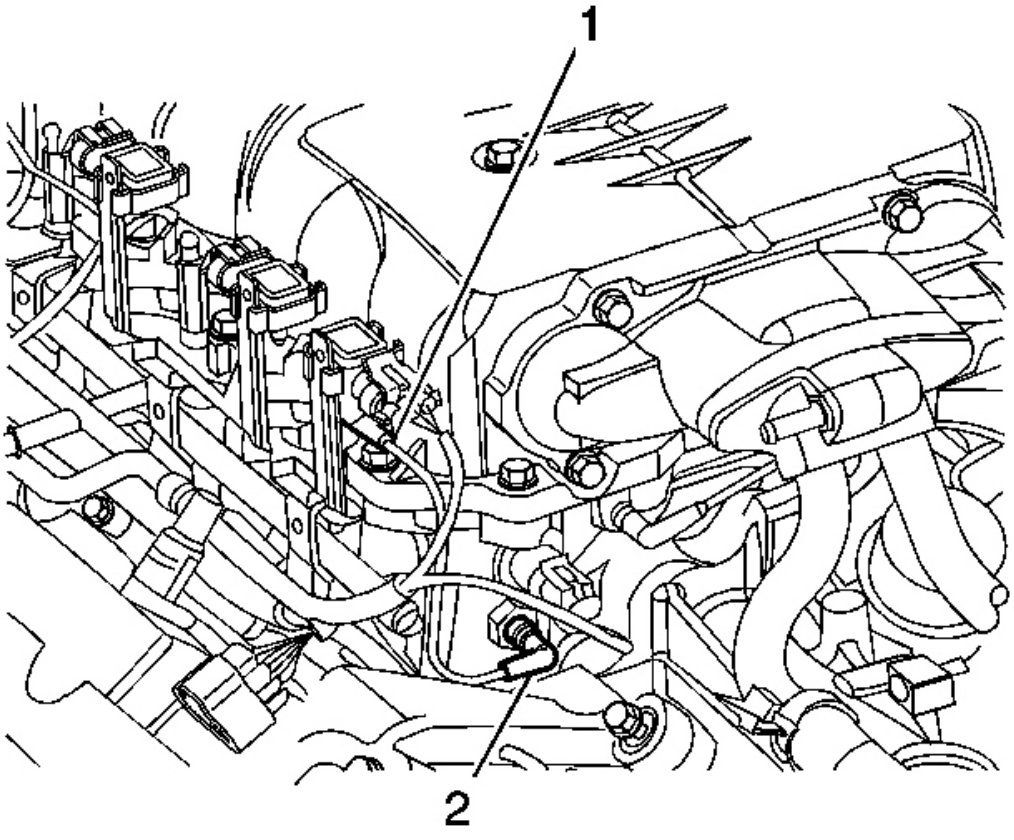


Fig. 149: View Of Vacuum Line Fitting
Courtesy of GENERAL MOTORS CORP.

15. Connect the supercharger IAT sensor electrical connector.
16. Connect the MAP sensor vacuum line fitting (2) to the supercharger.

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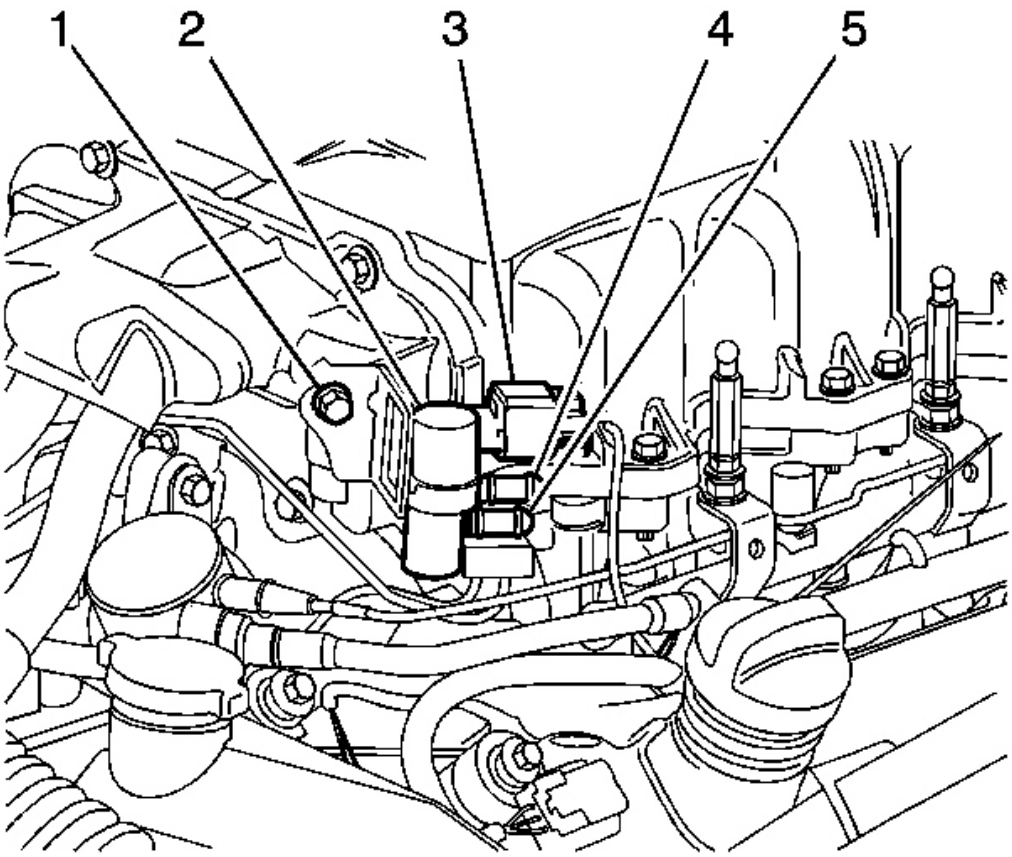


Fig. 150: Identifying Supercharger Bypass Solenoid Valve Electrical Connector
Courtesy of GENERAL MOTORS CORP.

17. Connect the supercharger bypass regulator solenoid valve electrical connector (3).

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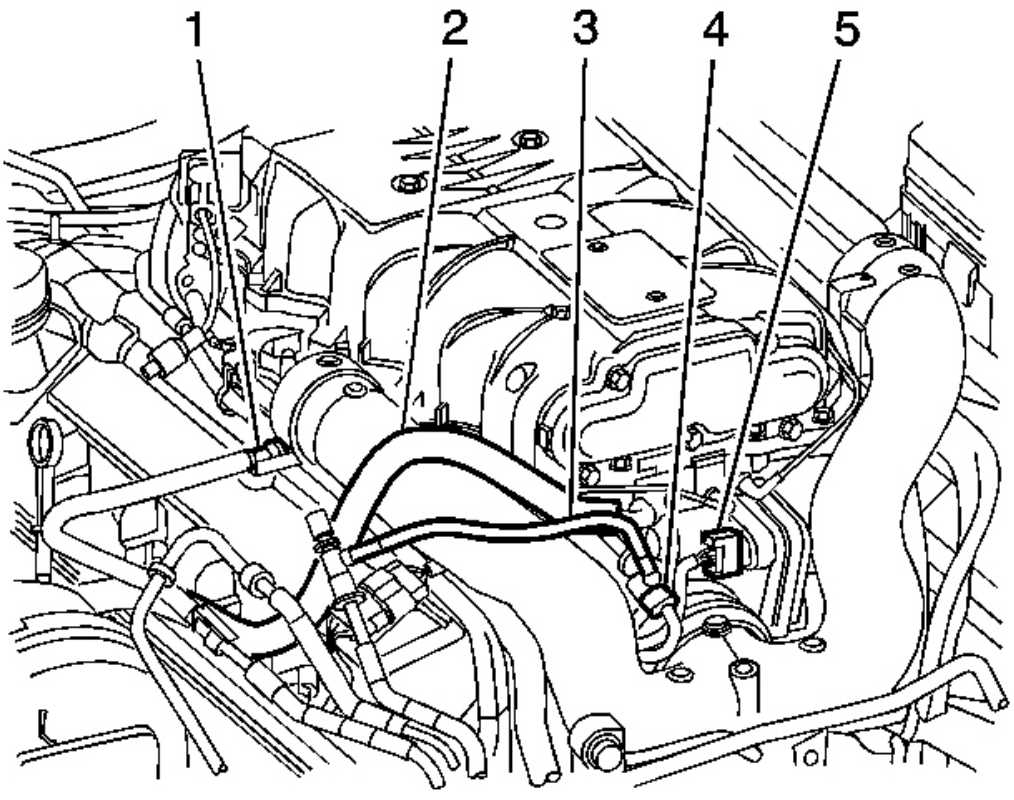


Fig. 151: Identifying EVAP Hose
Courtesy of GENERAL MOTORS CORP.

18. Connect the brake booster vacuum hose (2) to the fitting on the supercharger.
19. Connect the EVAP canister purge solenoid valve electrical connector (4).
20. Connect the EVAP canister purge solenoid valve hose (3) to the EVAP valve. Refer to **Plastic Collar Quick Connect Fitting Service** .
21. Connect the throttle body electrical connector (5).

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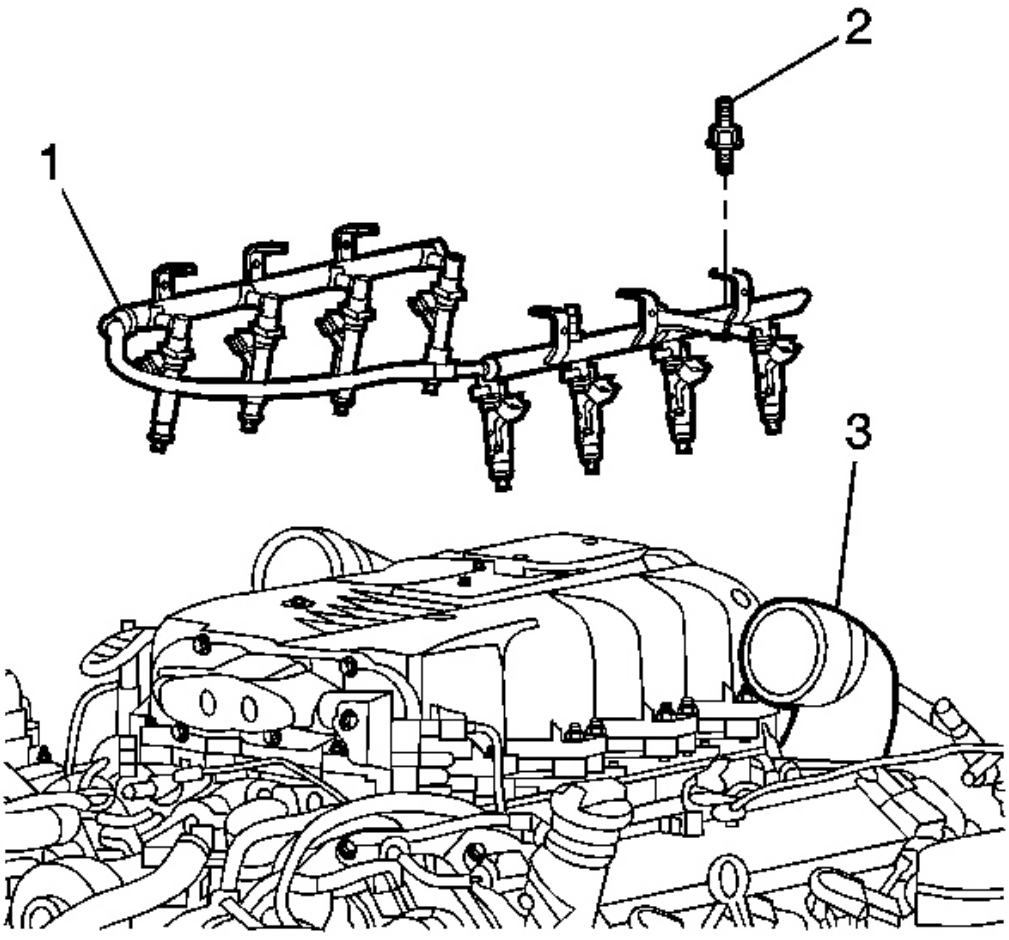


Fig. 152: View Of Fuel Rail
Courtesy of GENERAL MOTORS CORP.

22. Install the fuel injector rail assembly (1). Refer to **Fuel Injector and Fuel Rail Replacement** .

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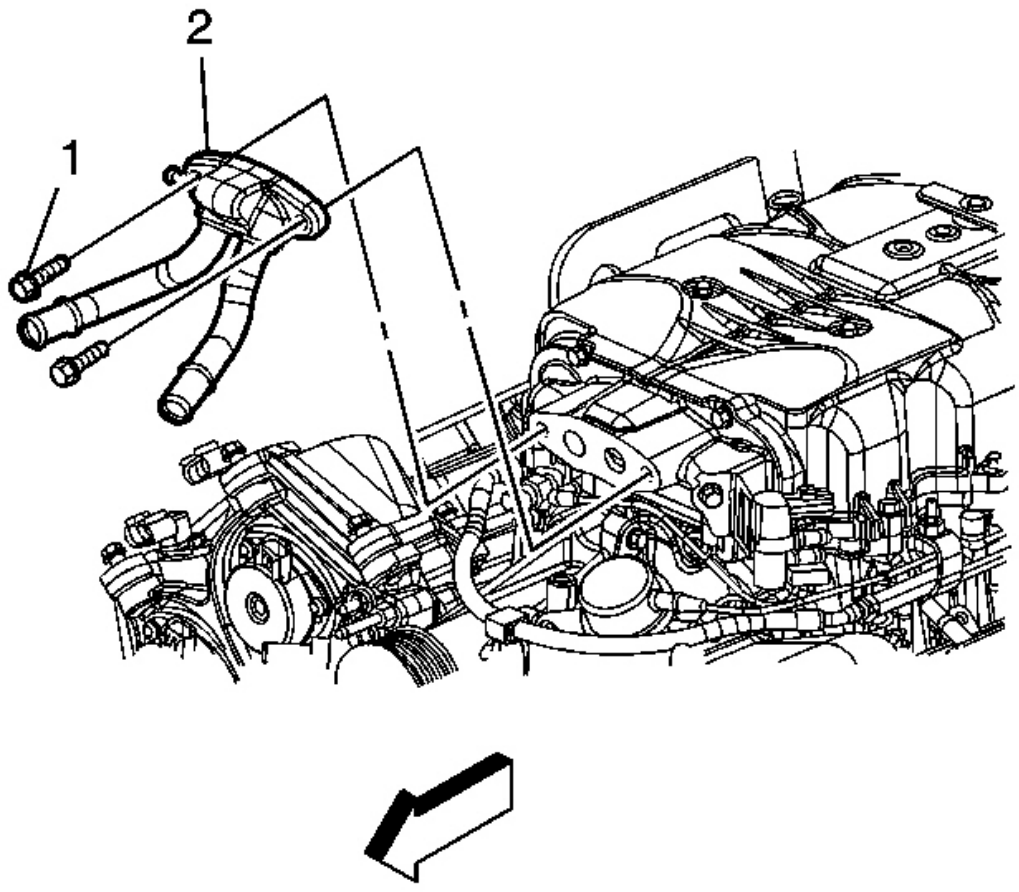


Fig. 153: View Of Charge Air Cooler & Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

23. Using NEW O-rings, install the front portion of the supercharger front manifold (2). Refer to **Charge Air Cooler Front Manifold Replacement**.
24. Install the front section of the supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
25. Install the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**.
26. Install the hood. Refer to **Hood Replacement** .
27. Fill the charge air cooling system with coolant and check for leaks. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .

OIL LEVEL INDICATOR AND TUBE REPLACEMENT

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REMOVAL PROCEDURE

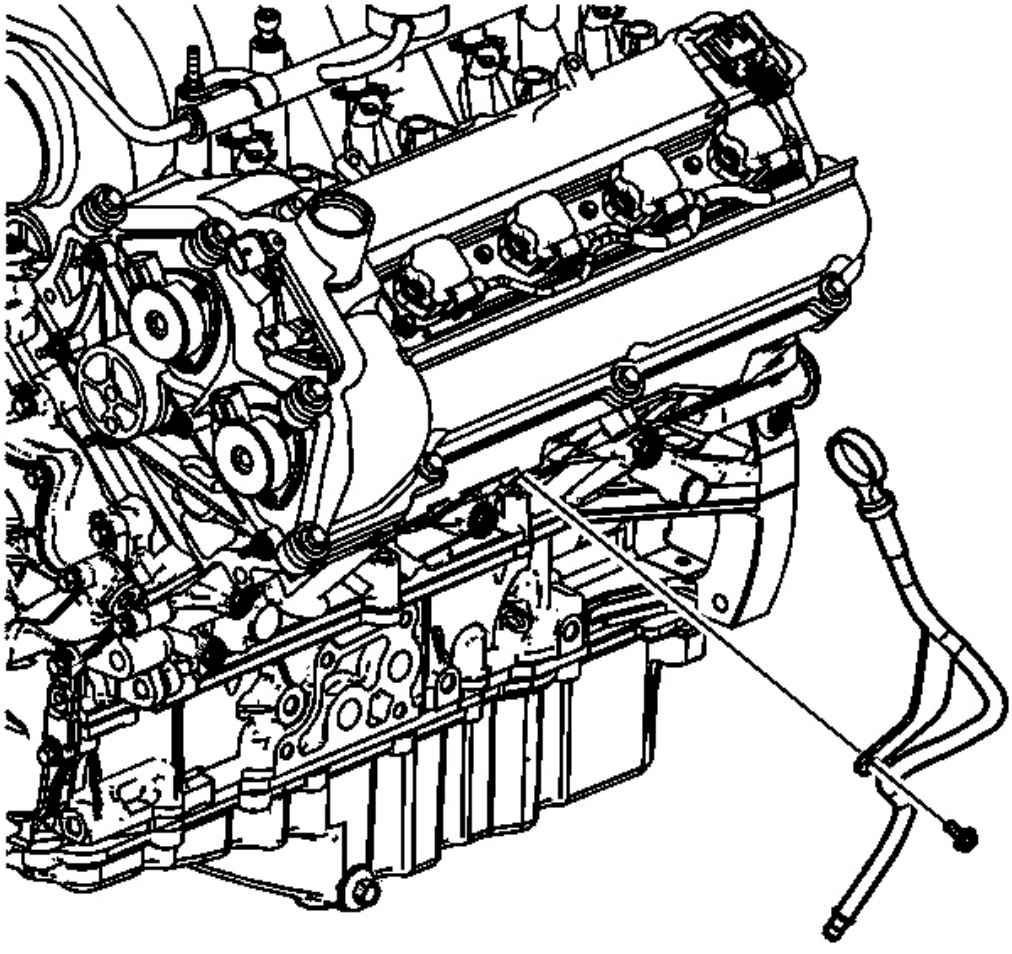


Fig. 154: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator.
2. Remove the oil level indicator tube bolt.
3. Disconnect the coolant surge tank fluid level indicator electrical connector.
4. Remove the surge tank nuts and reposition the surge tank away from the brake master cylinder.

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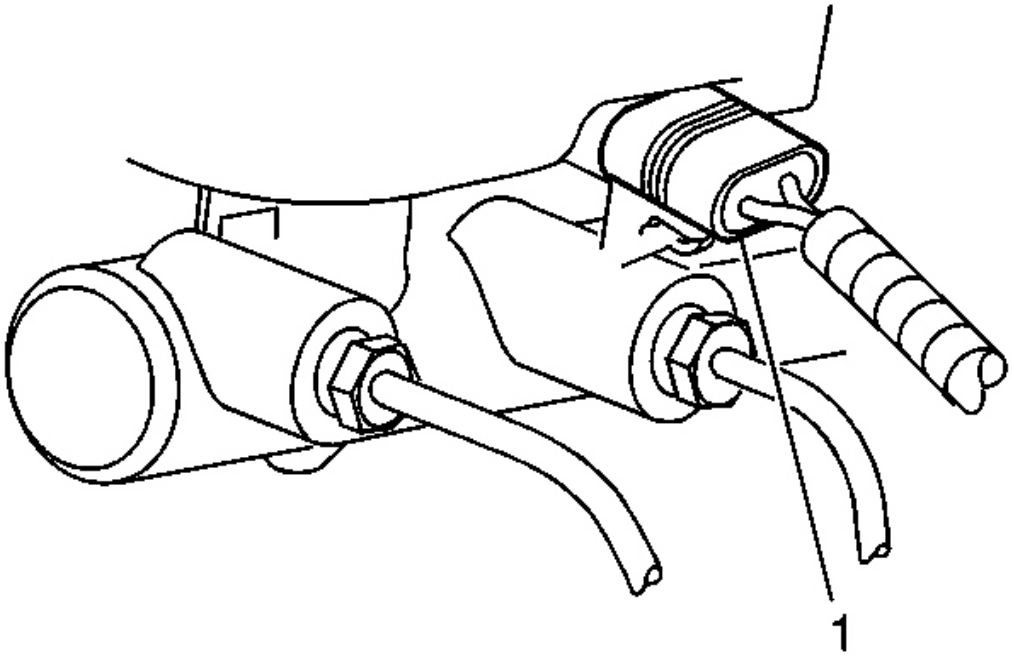


Fig. 155: View Of Brake Fluid Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the master cylinder fluid level sensor electrical connector (1).

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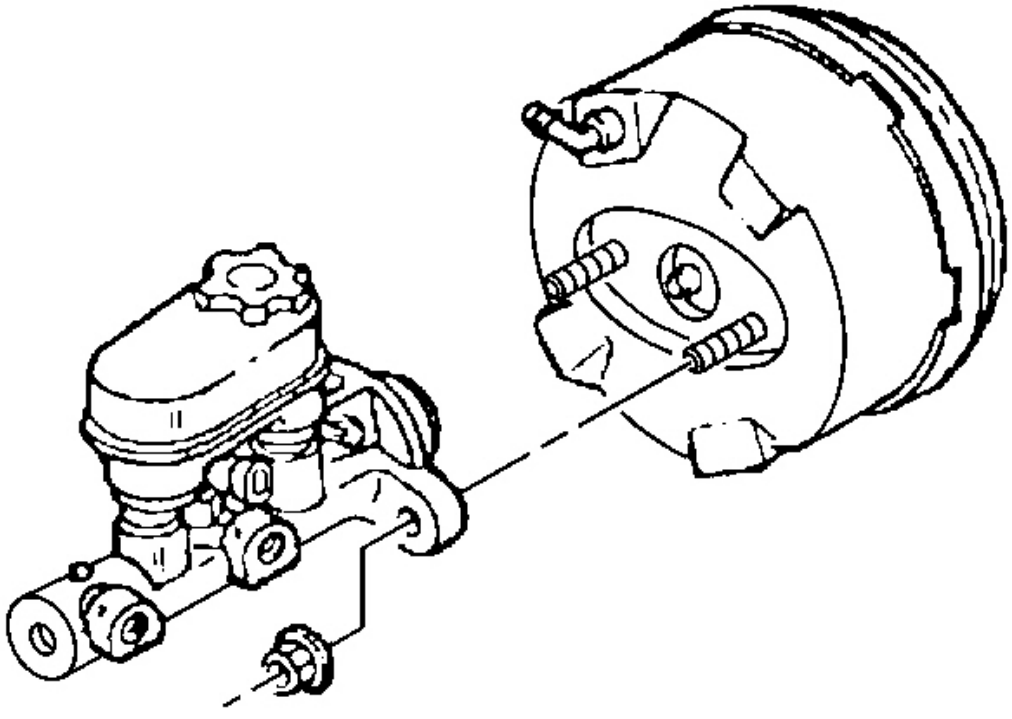


Fig. 156: View Of Master Cylinder & Mounting Nuts
Courtesy of GENERAL MOTORS CORP.

6. Remove the master cylinder mounting nuts and reposition the master cylinder away from the brake booster.
7. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
8. Pull the oil level indicator tube from the crankcase while rotating it counterclockwise.

INSTALLATION PROCEDURE

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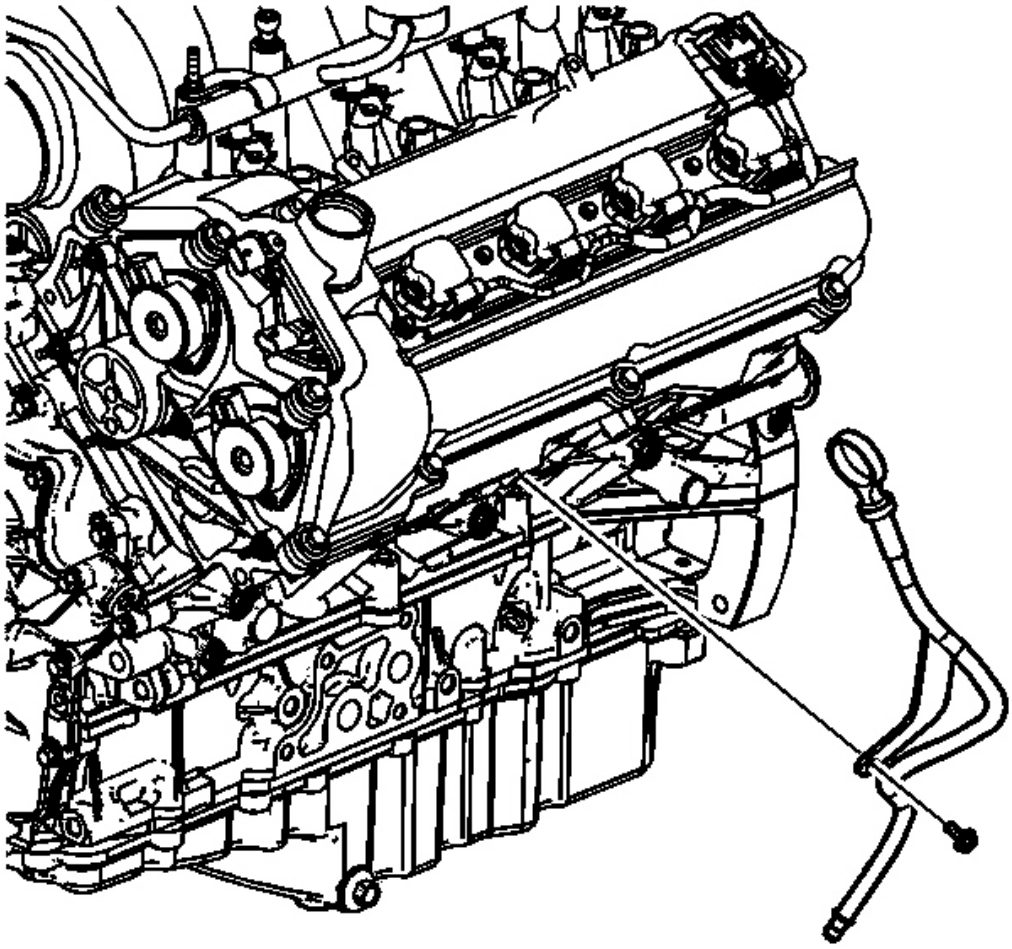


Fig. 157: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Replace the oil level indicator tube O-ring and lubricate with engine oil.
2. With the aid of an assistant, install the oil level indicator tube into the crankcase.
3. Lower the vehicle.

NOTE: **Refer to Fastener Notice .**

4. Install the oil level indictor tube bolt into the left cylinder head.

Tighten: Tighten the oil level indicator tube bolt to 50 N.m (37 lb in).

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5. Install the oil level indicator.
6. Reposition the brake master cylinder to the brake booster.

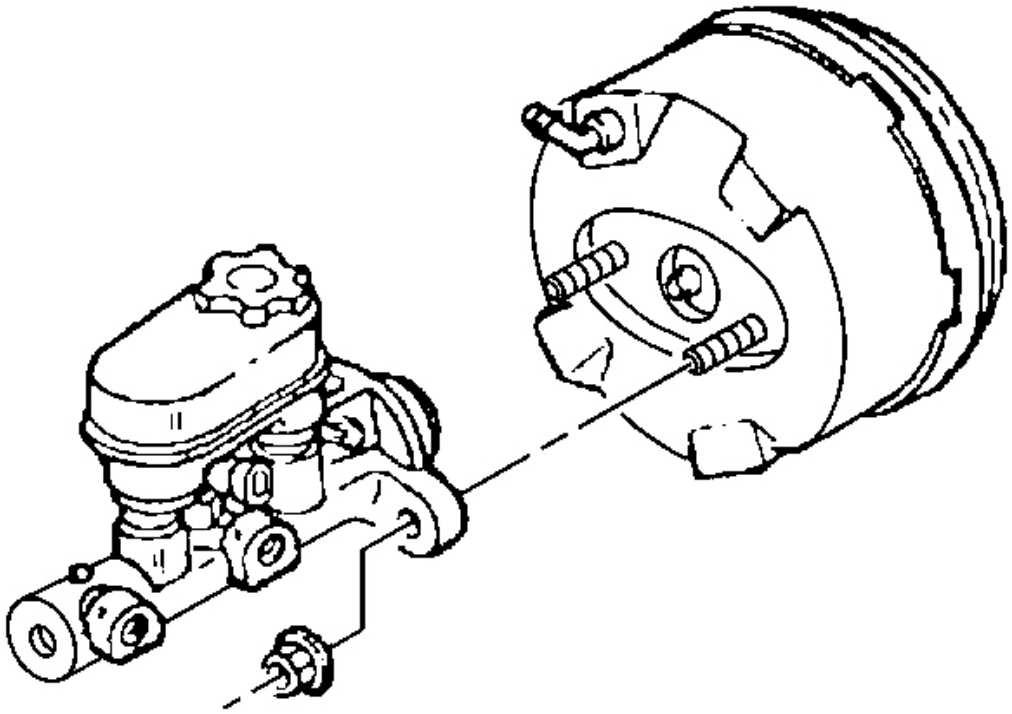


Fig. 158: View Of Master Cylinder & Mounting Nuts
Courtesy of GENERAL MOTORS CORP.

7. Install the master cylinder mounting nuts.

   Tighten: Tighten the master cylinder mounting nuts to 29 N.m (21 lb ft).

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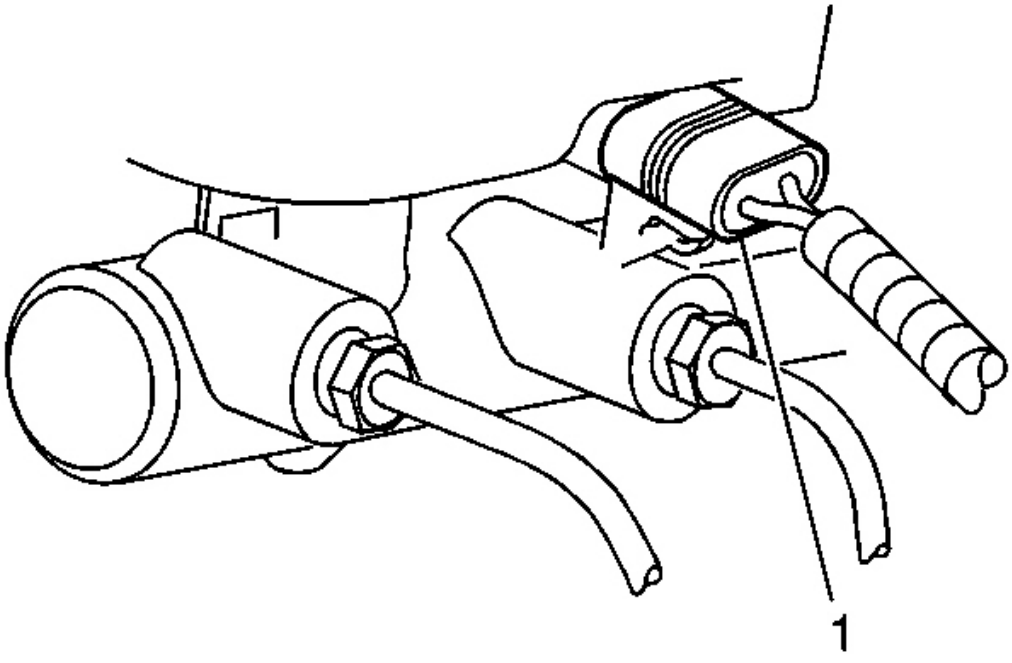


Fig. 159: View Of Brake Fluid Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

8. Connect the electrical connector (1) for the master cylinder fluid level sensor.
9. Install the coolant surge tank. Refer to **Surge Tank Replacement** .

OIL FILTER ADAPTER REPLACEMENT

REMOVAL PROCEDURE

1. Remove the left engine mount bracket. Refer to **Engine Mount Bracket Replacement - Left Side**.
2. Disconnect the engine oil cooler lines from the adapter.
3. Disconnect the electrical connector from the engine oil pressure switch.
4. Place a suitable drain pan under the vehicle.

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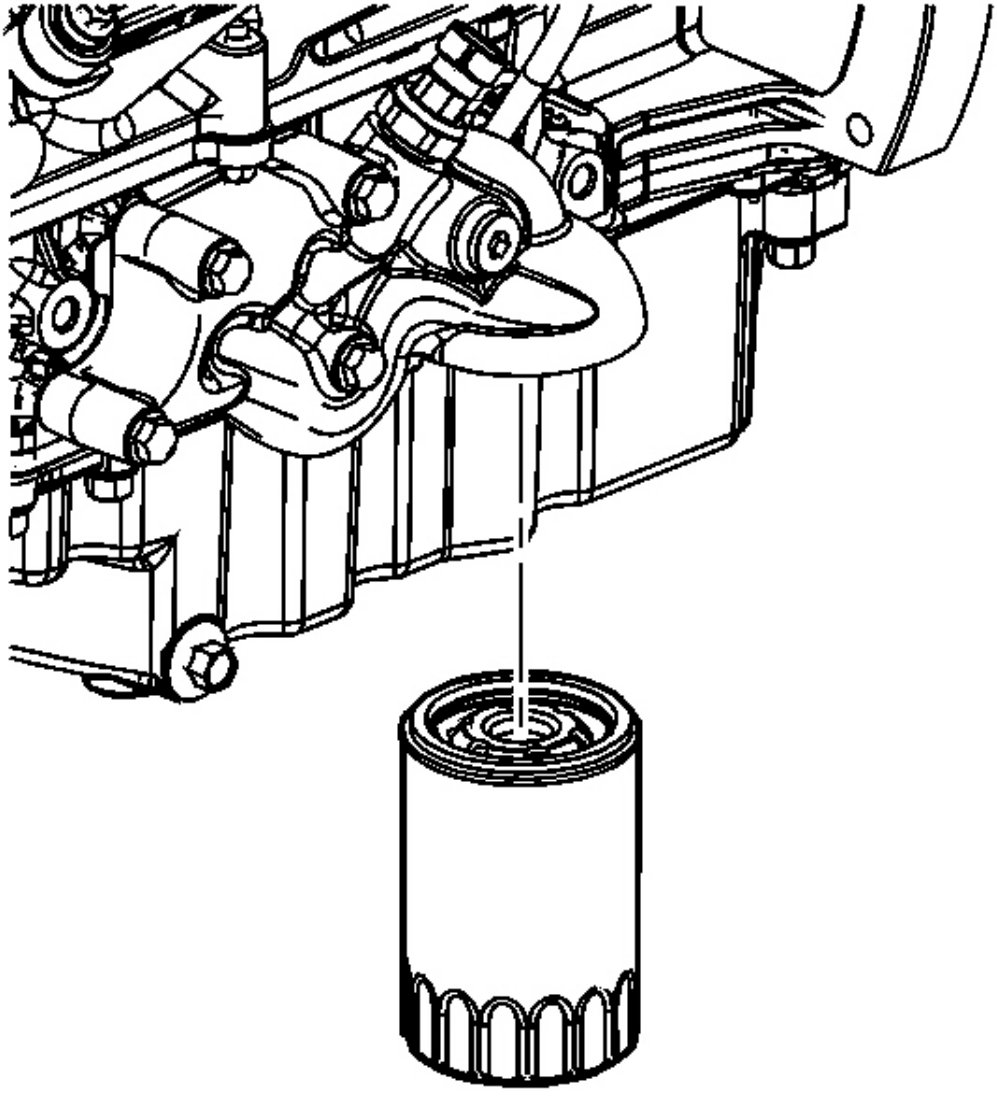


Fig. 160: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil filter.

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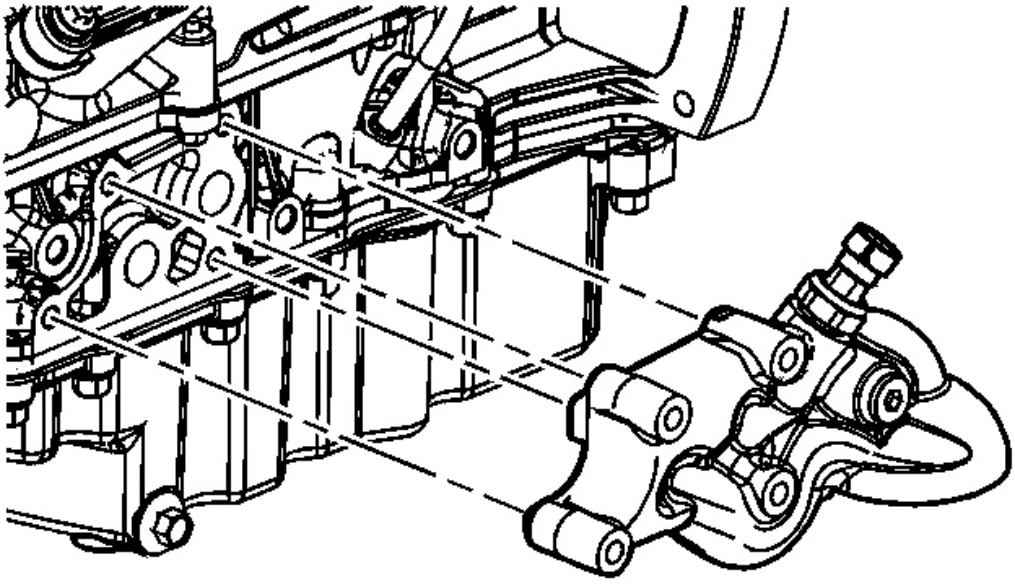


Fig. 161: View Of Oil Filter Adapter Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil filter adapter mounting bolts.
7. Remove the oil filter adapter and discard the gasket.
8. Disassemble the oil filter adapter as necessary. Refer to **Oil Filter Adapter Disassemble** .
9. Clean and inspect the oil filter adapter. Refer to **Oil Filter Adapter Cleaning and Inspection** .

INSTALLATION PROCEDURE

1. Assemble the oil filter adapter as necessary. Refer to **Oil Filter Adapter Assemble** .
2. Install a new gasket to the oil filter adapter.
3. Apply 10 drops of high-strength, high-temperature threadlocker to the engine oil filter adapter pipe fittings. Refer to **Sealers, Adhesives and Lubricants** .
4. Install the oil filter adapter to the engine block.

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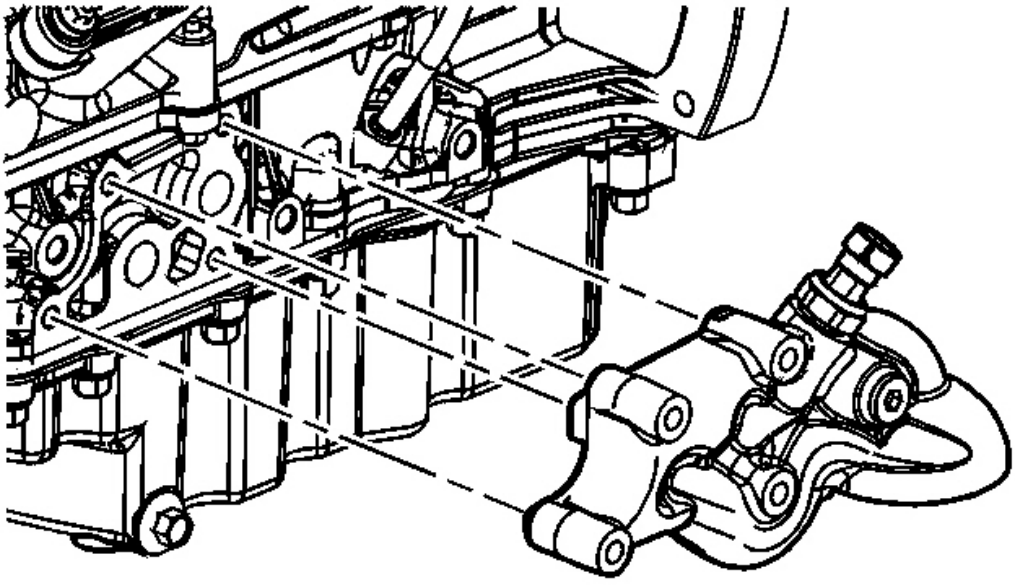


Fig. 162: View Of Oil Filter Adapter Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

5. Install the oil filter adapter bolts.

   Tighten: Tighten the oil filter adapter bolts to 25 N.m (18 lb ft).

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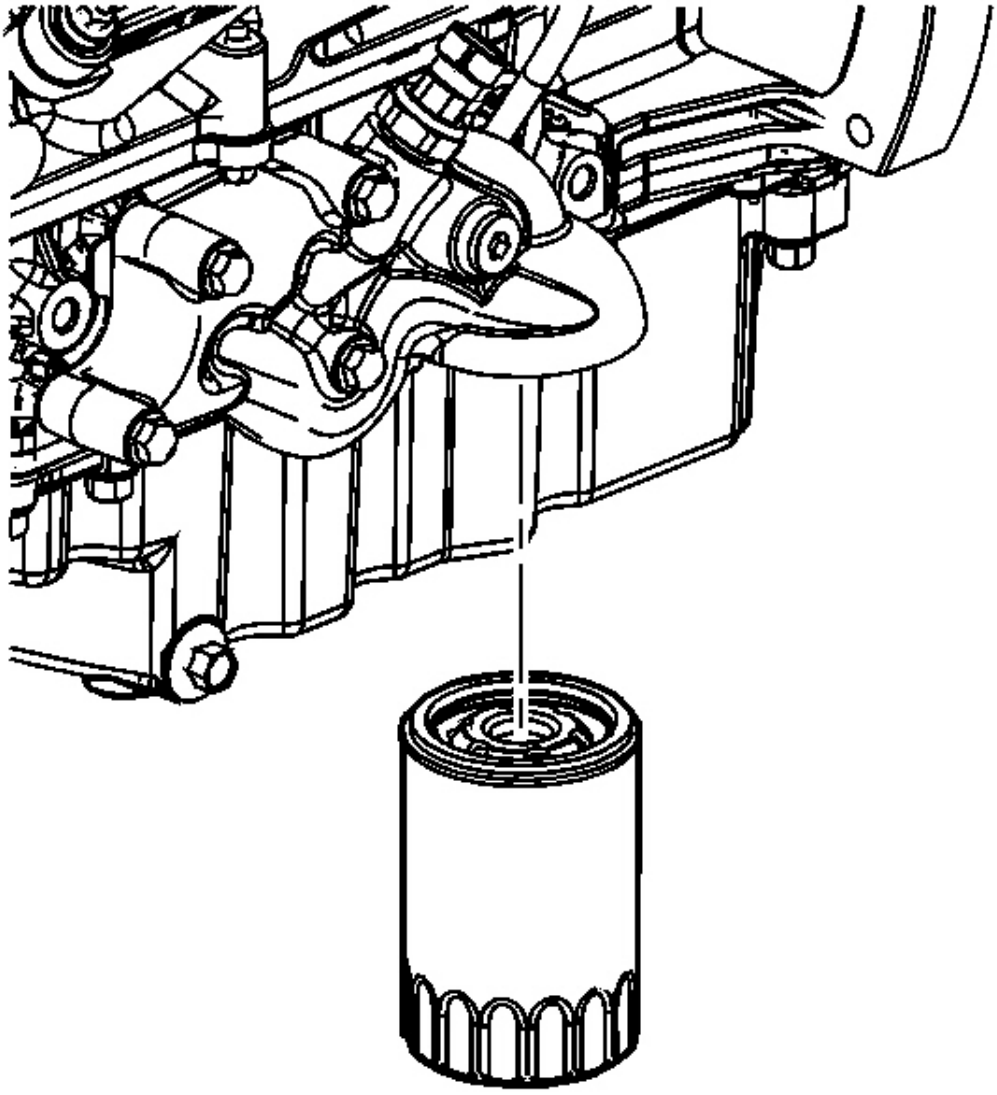


Fig. 163: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Lightly oil the oil filter gasket with clean oil.

IMPORTANT: Fill the oil filter with engine oil.

7. Install the oil filter. Refer to **Engine Oil and Oil Filter Replacement** .

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8. Connect the electrical connector to the engine oil pressure switch.
9. Connect the engine oil cooler lines to the adapter.
10. Install the left engine mount bracket. Refer to **Engine Mount Bracket Replacement - Left Side**.
11. Lower the vehicle.
12. Adjust the engine oil level to the full mark.
13. Inspect for oil leaks after engine start up.

CRANKSHAFT BALANCER REPLACEMENT

TOOLS REQUIRED

- **J 45059** Angle Meter. See **Special Tools** .
- **J 41816** Crankshaft Balancer Remover. See **Special Tools** .
- **J 41998-B** Crankshaft Balancer Installer. See **Special Tools** .
- **EN 46326** Flywheel Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the water pump and generator drive belt. Refer to **Water Pump and Generator Belt Replacement**.
2. Remove the supercharger drive belt. Refer to **Supercharger Belt Replacement**.
3. Remove the air conditioning and power steering drive belt. Refer to **Air Conditioning Compressor and Power Steering Pump Belt Replacement**.
4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
5. Remove the power steering gear. Refer to **Power Steering Gear Replacement** .

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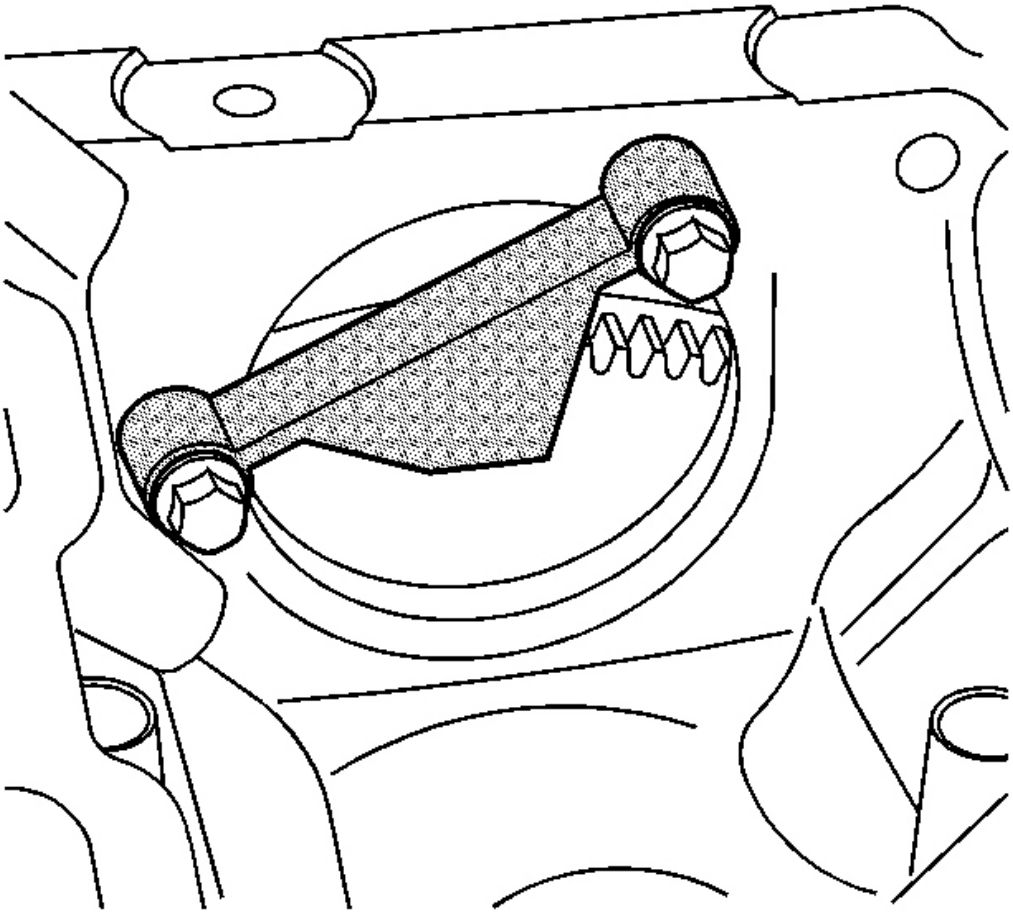


Fig. 164: View Of Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

6. Remove the starter motor. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)** .
7. Install the **EN 46326** . See **Special Tools** .

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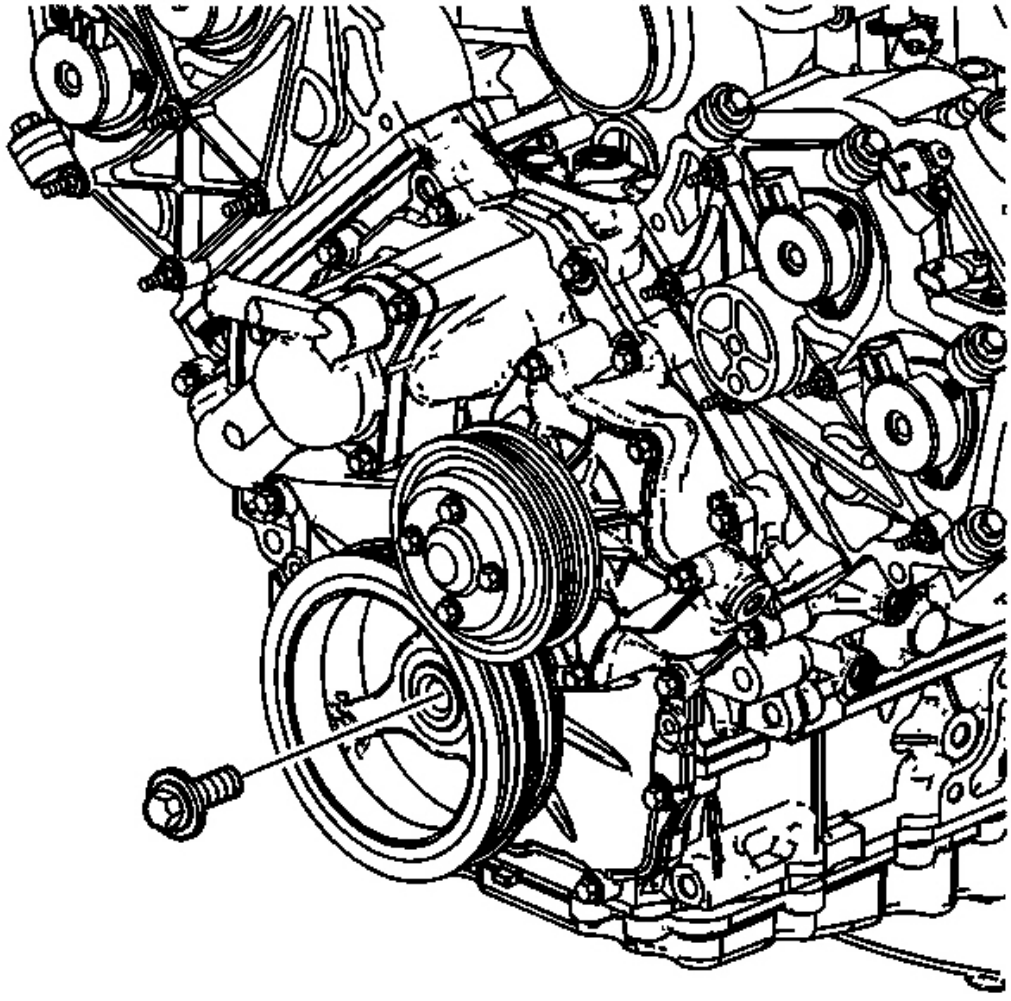


Fig. 165: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the crankshaft balancer bolt.

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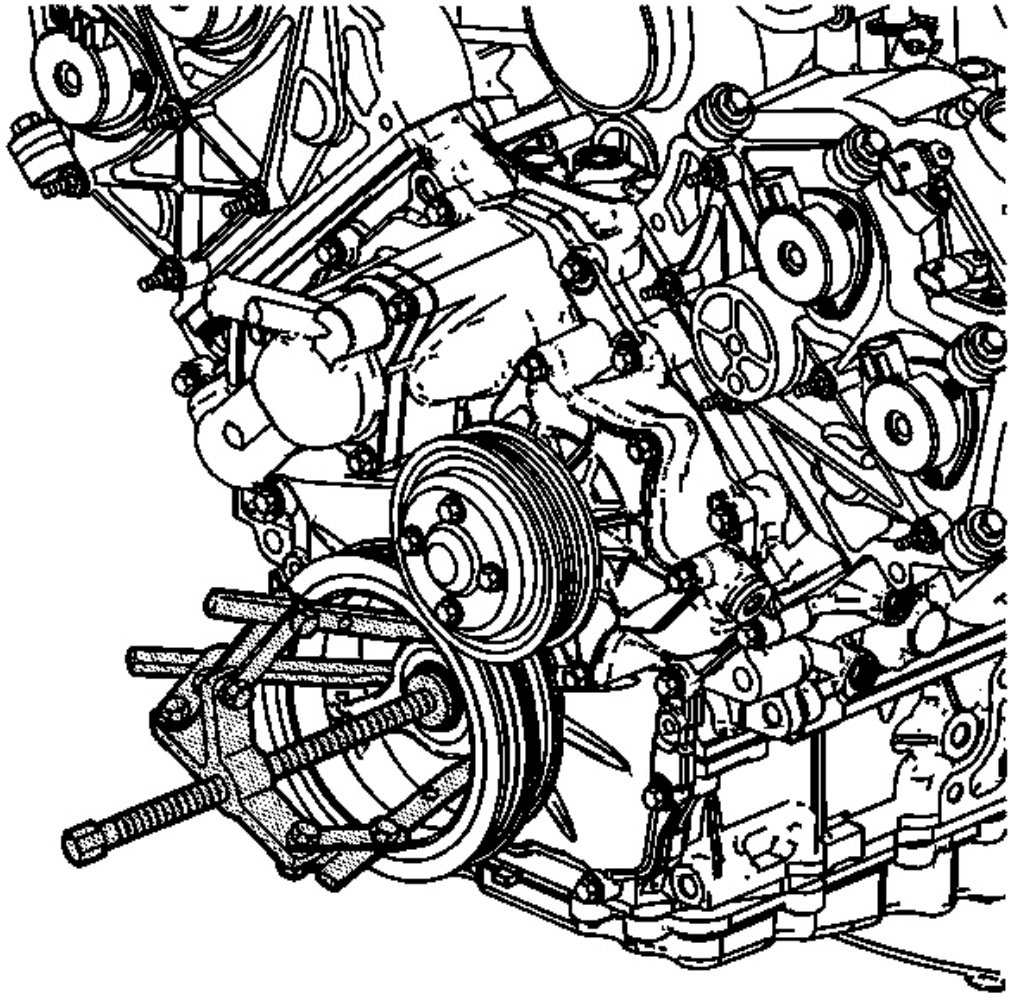


Fig. 166: View Of Remover Pilot & J 41816
Courtesy of GENERAL MOTORS CORP.

9. Place the remover pilot into the end of the crankshaft.
10. Install the **J 41816** on the crankshaft balancer. See **Special Tools** .

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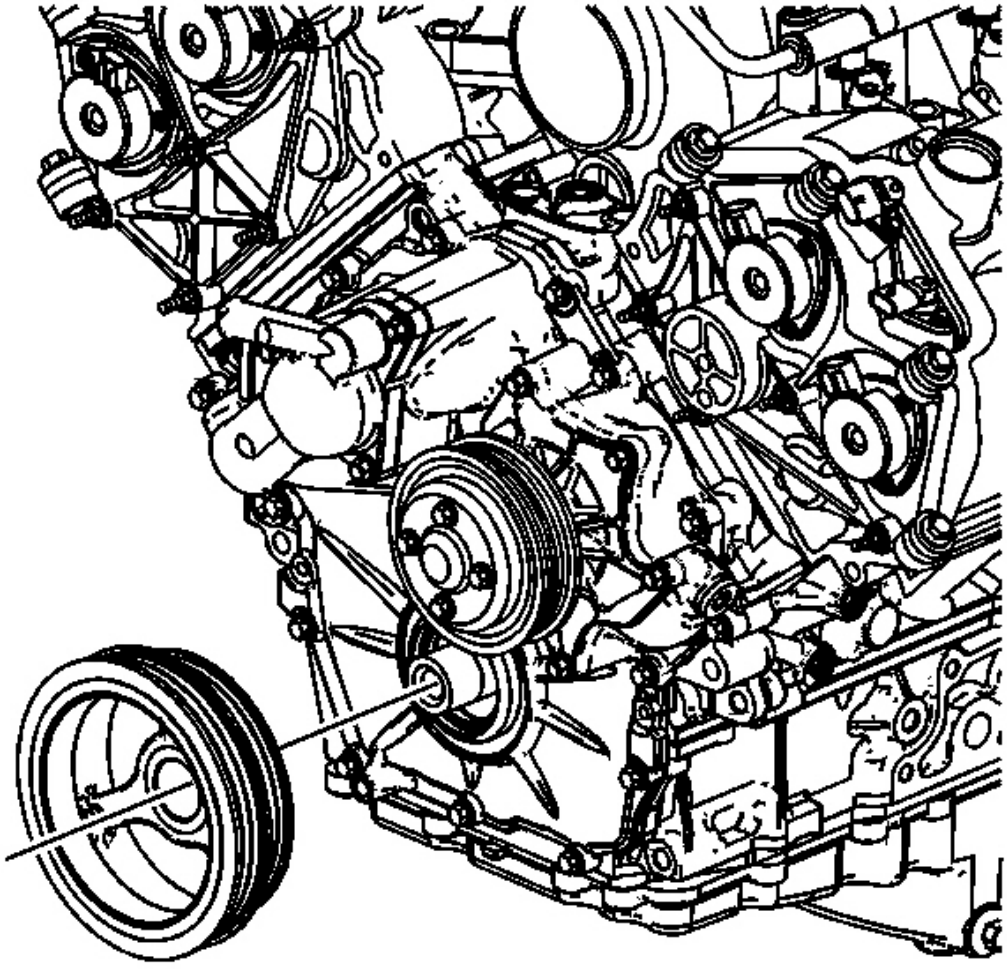


Fig. 167: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

11. Remove the crankshaft balancer using the **J 41816** . See **Special Tools** .
12. Ensure that you do not lose the oil pump drive to crankshaft balancer friction washer. The friction washer may come off with the balancer.
13. Clean and inspect the crankshaft balancer. Refer to **Crankshaft Balancer Cleaning and Inspection** .

INSTALLATION PROCEDURE

1. Ensure that the oil pump drive to crankshaft balancer friction washer is installed.

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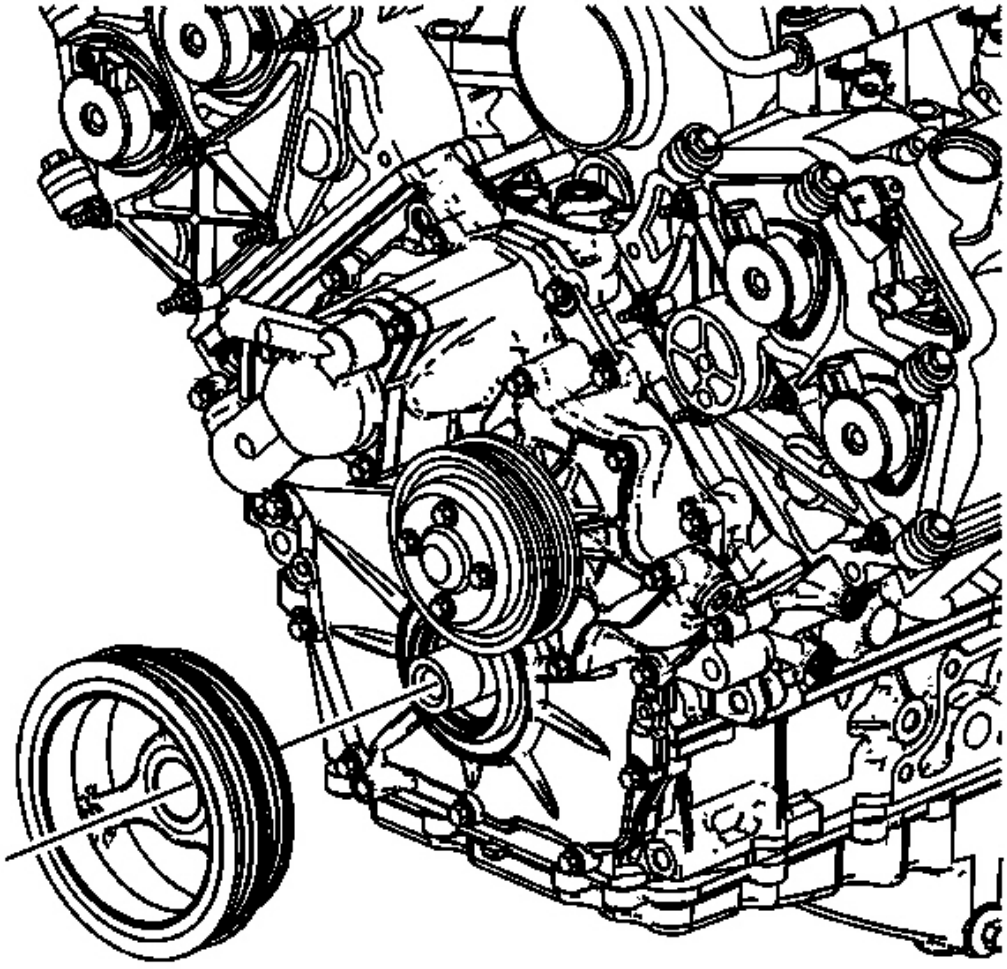


Fig. 168: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

2. Position the crankshaft balancer on the nose of the crankshaft.

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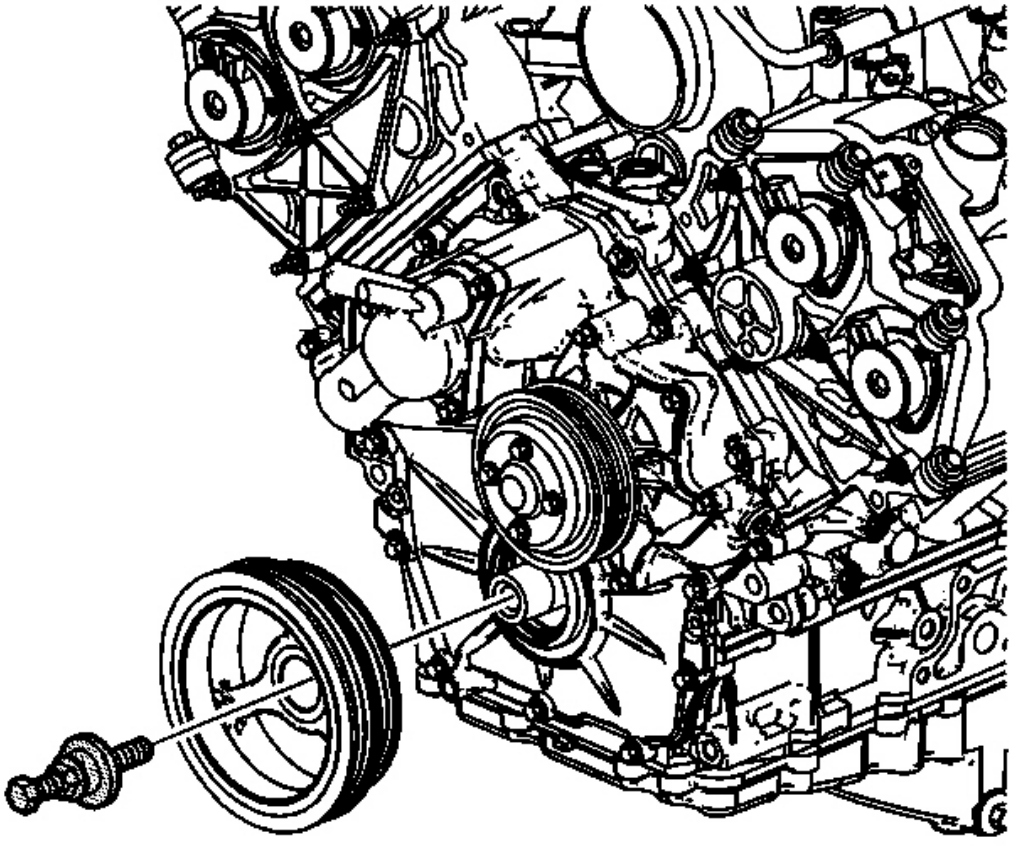


Fig. 169: Pressing Crankshaft Balancer In Place Using J 41998-B
Courtesy of GENERAL MOTORS CORP.

3. Press the crankshaft balancer in place using the **J 41998-B** . See **Special Tools** .

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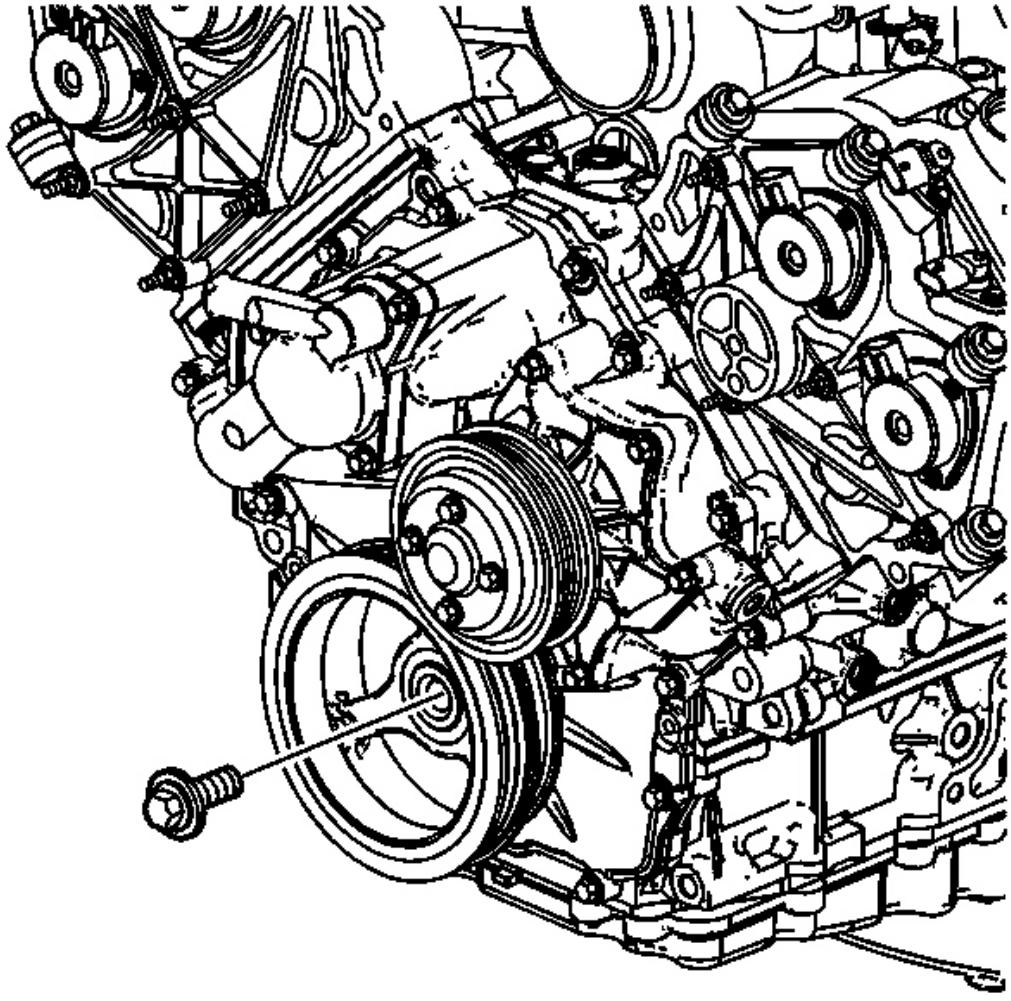


Fig. 170: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

4. Clean the crankshaft balancer bolt threads.
5. Apply engine oil to the crankshaft balancer bolt threads.

NOTE: Refer to Fastener Notice .

6. Install the crankshaft balancer bolt.
    1. First Pass

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Tighten: Tighten the crankshaft balancer bolt to 50 N.m (37 lb ft).

2. Final Pass

   Tighten: Tighten the crankshaft balancer bolt an additional 120 degrees using the **J 45059** . See **Special Tools** .

7. Install the steering gear. Refer to **Power Steering Gear Replacement** .

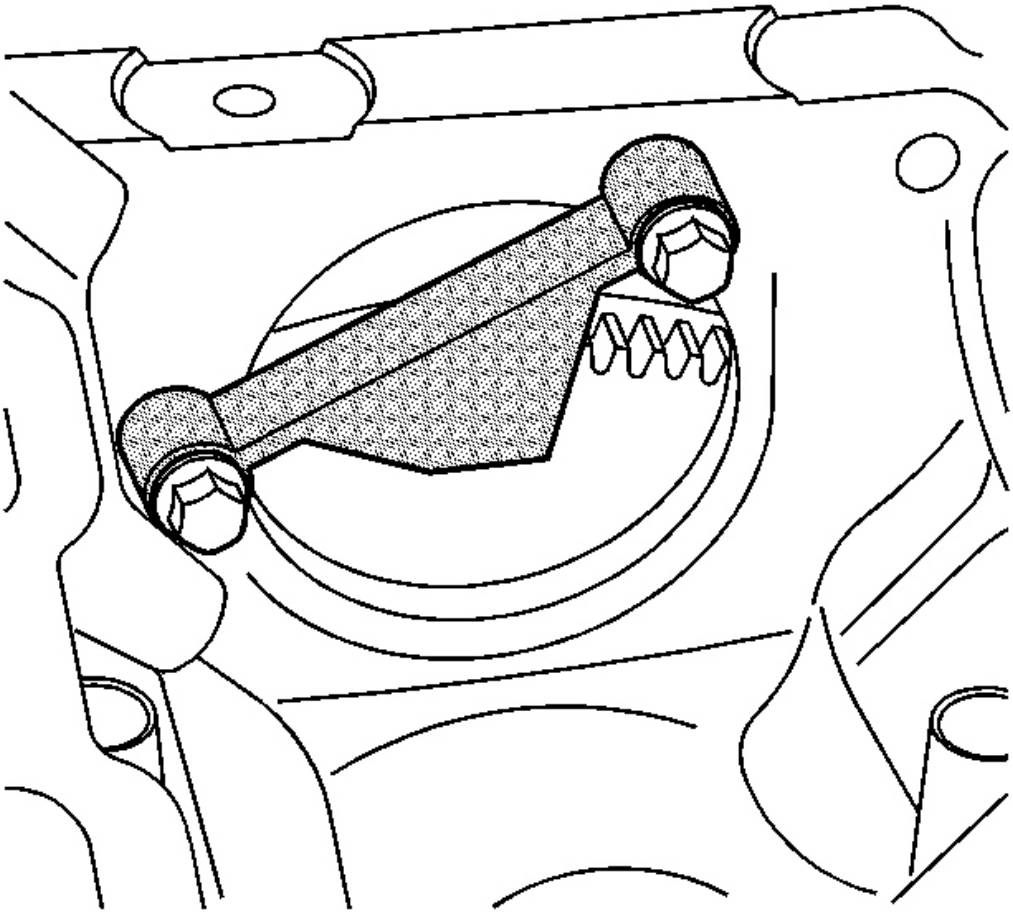


Fig. 171: View Of Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

8. Lower the vehicle.
9. Remove the **EN 46326** . See **Special Tools** .

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10. Install the starter motor. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)** .
11. Install the air conditioning and power steering drive belt. Refer to **Air Conditioning Compressor and Power Steering Pump Belt Replacement**.
12. Install the supercharger drive belt. Refer to **Supercharger Belt Replacement**.
13. Install the water pump and generator drive belt. Refer to **Water Pump and Generator Belt Replacement**.

ENGINE FRONT COVER REPLACEMENT

REMOVAL PROCEDURE

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)** .
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
3. Remove the accessory drive belts. Refer to **Supercharger Belt Replacement**, **Water Pump and Generator Belt Replacement** and **Air Conditioning Compressor and Power Steering Pump Belt Replacement**.
4. Remove the accessory drive belt tensioners. Refer to **Drive Belt Tensioner Replacement - Supercharger**, **Water Pump and Generator Drive Belt Tensioner Replacement** and **Air Conditioning Compressor Belt Tensioner Replacement**.
5. Remove the accessory drive belt idler pulleys. Refer to **Supercharger Belt Idler Pulley Replacement** and **Water Pump and Generator Belt Idler Pulley Replacement**.
6. Remove the water pump pulley. Refer to **Water Pump Replacement (LH2)** or **Water Pump Replacement (LC3)** .
7. Remove the water outlet housing. Refer to **Water Outlet Housing Replacement (LC3)** or **Water Outlet Housing Replacement (LH2)** .
8. Remove the radiator hose and the heater hose from the thermostat housing. position the hoses aside.
9. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

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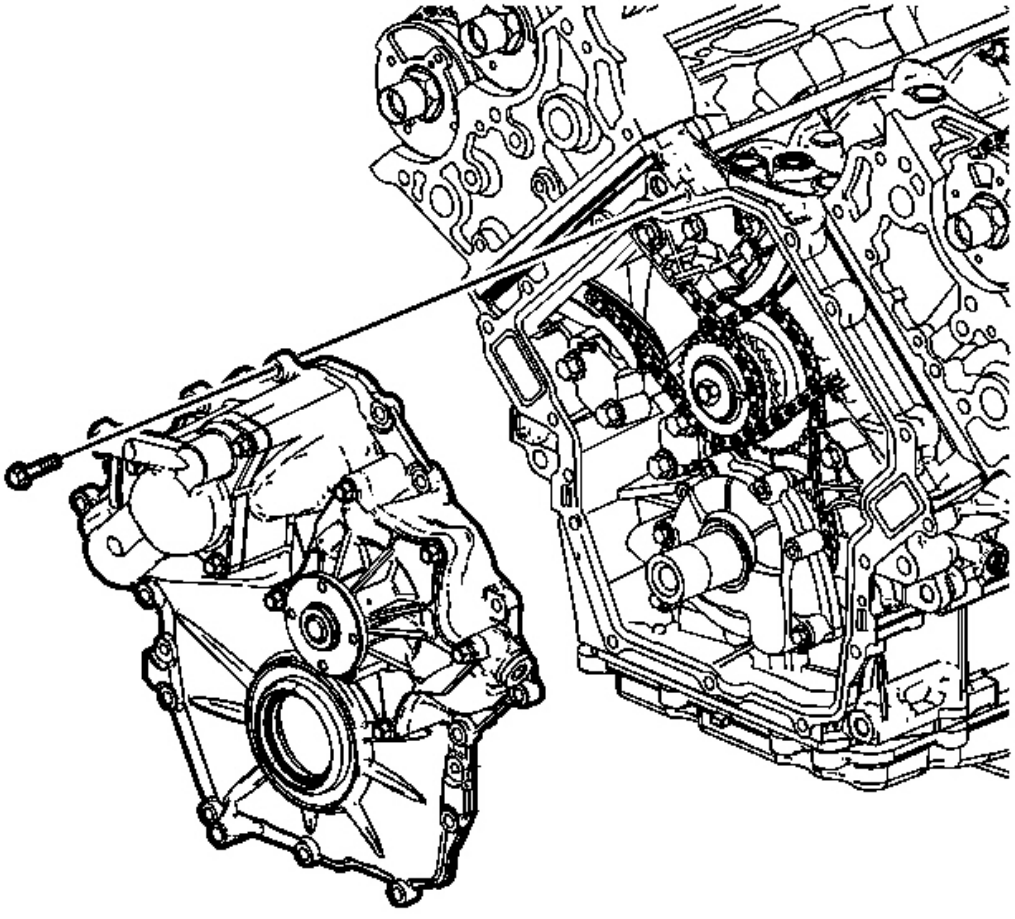


Fig. 172: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

10. Remove the engine front cover bolts.
11. Remove the engine front cover.

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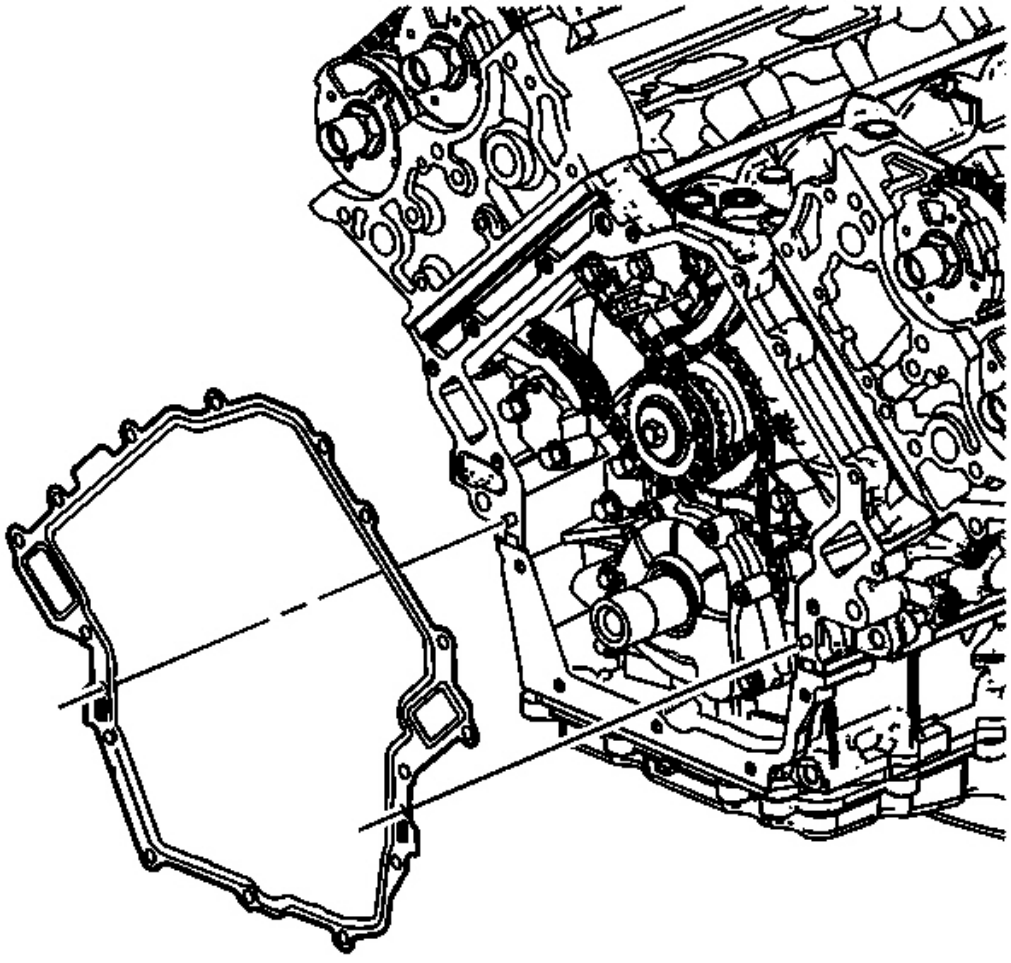


Fig. 173: View Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

12. Remove and discard the engine front cover gasket.

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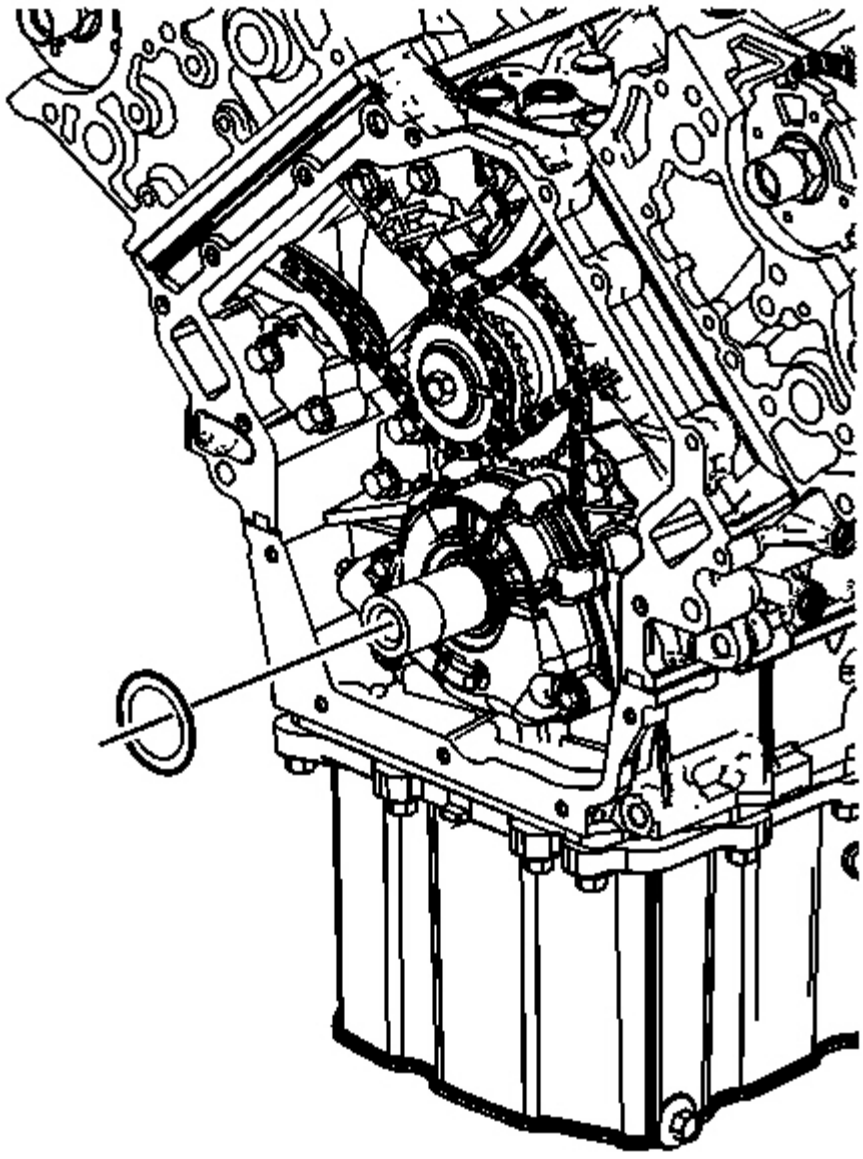


Fig. 174: Identifying Oil Pump Drive To Crankshaft Balancer Friction Washer
Courtesy of GENERAL MOTORS CORP.

13. Remove the oil pump drive to crankshaft balancer friction washer.
14. Clean and inspect the engine front cover. Refer to **Engine Front Cover Cleaning and Inspection** .

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INSTALLATION PROCEDURE

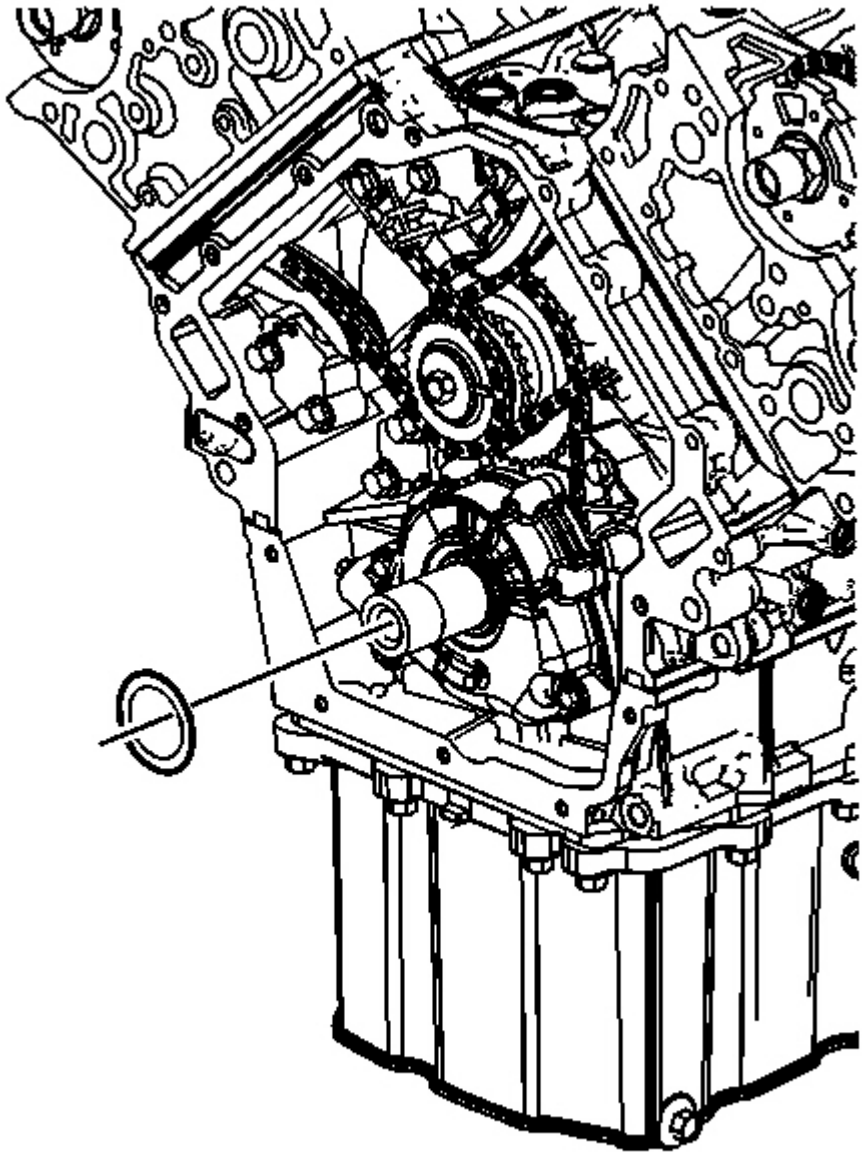


Fig. 175: Identifying Oil Pump Drive To Crankshaft Balancer Friction Washer
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pump drive to crankshaft balancer friction washer.

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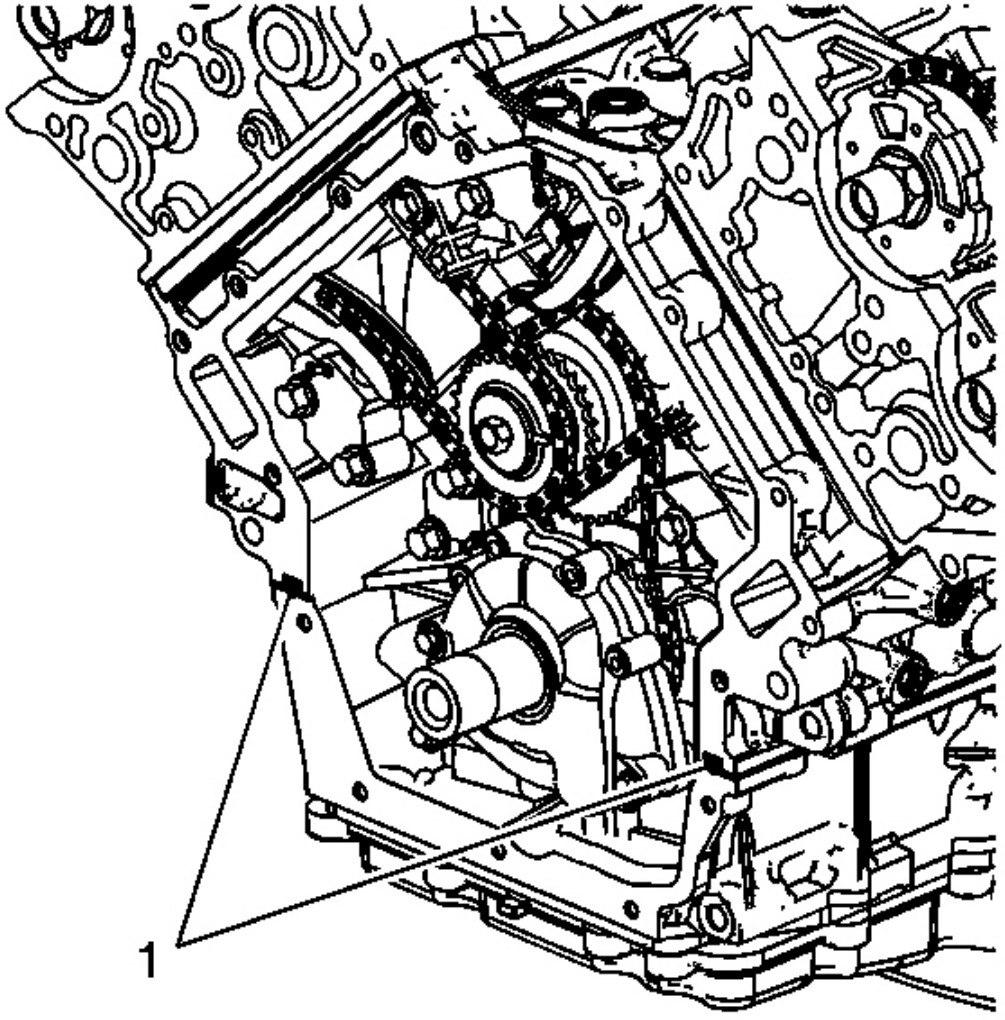


Fig. 176: Applying Sealant To Split Line Of Crankcases
Courtesy of GENERAL MOTORS CORP.

2. Place a small amount of sealant at the split line of the upper and lower crankcases (1). Refer to **Sealers, Adhesives and Lubricants** for the correct part number.

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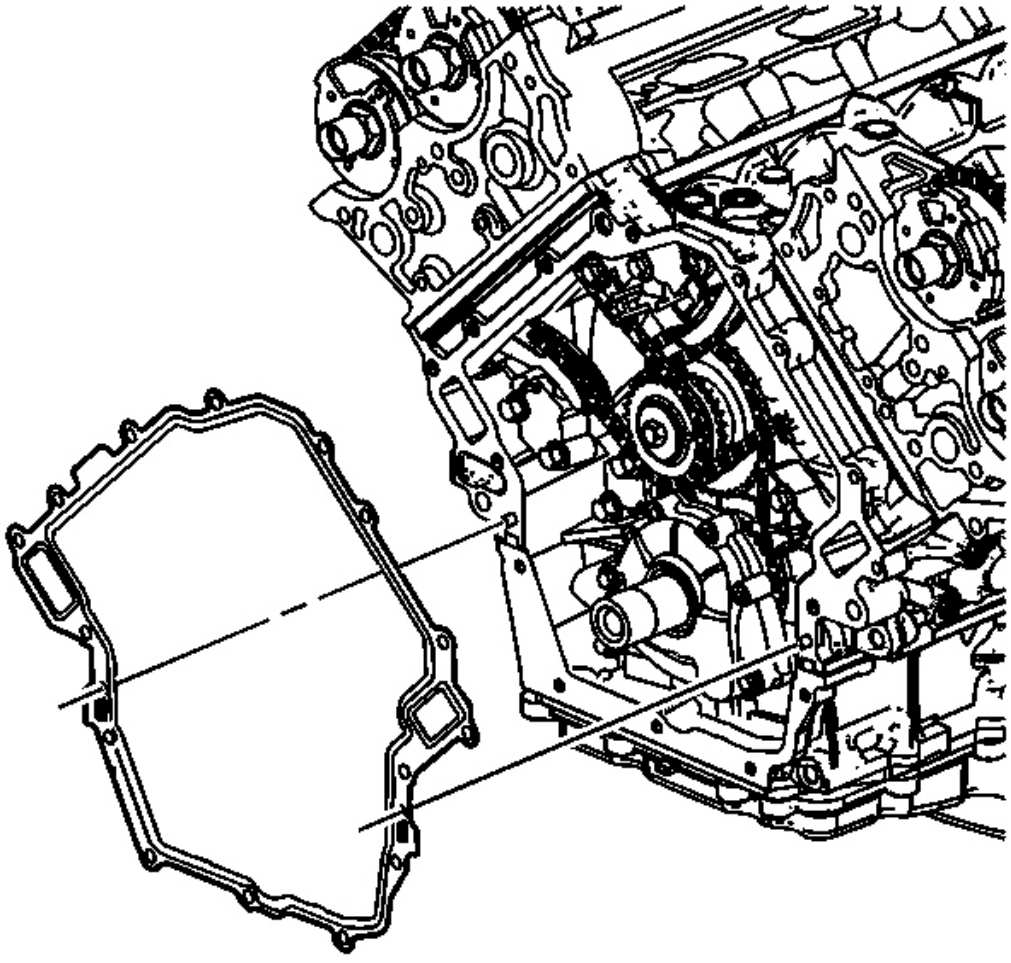


Fig. 177: View Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

3. Place the NEW engine front cover gasket over the crankcase dowel pins.

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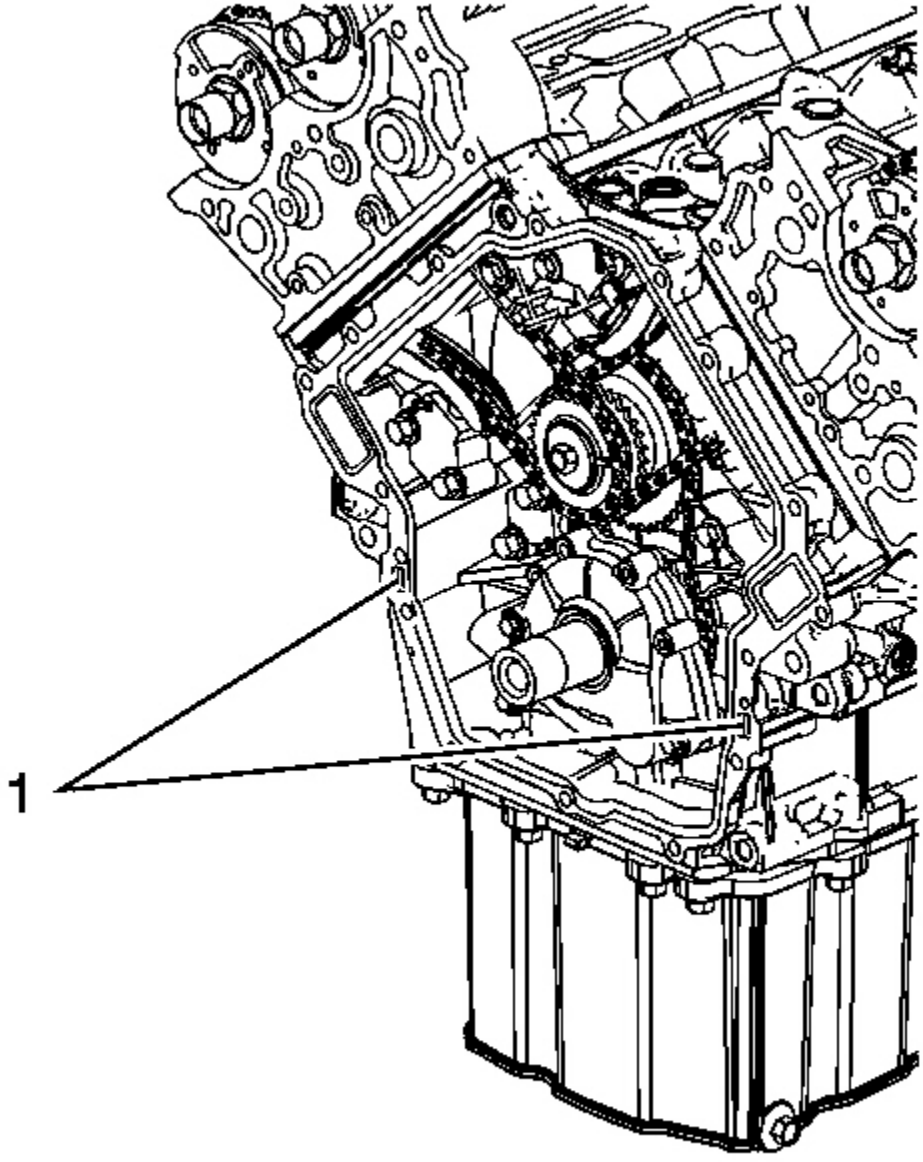


Fig. 178: Locating Split Line Of Upper & Lower Crankcases
Courtesy of GENERAL MOTORS CORP.

4. Place a small amount of sealant at the engine front cover gasket pad area located on top of the split line of the upper and lower crankcases (1). Refer to **Sealers, Adhesives and Lubricants** for the correct part number.

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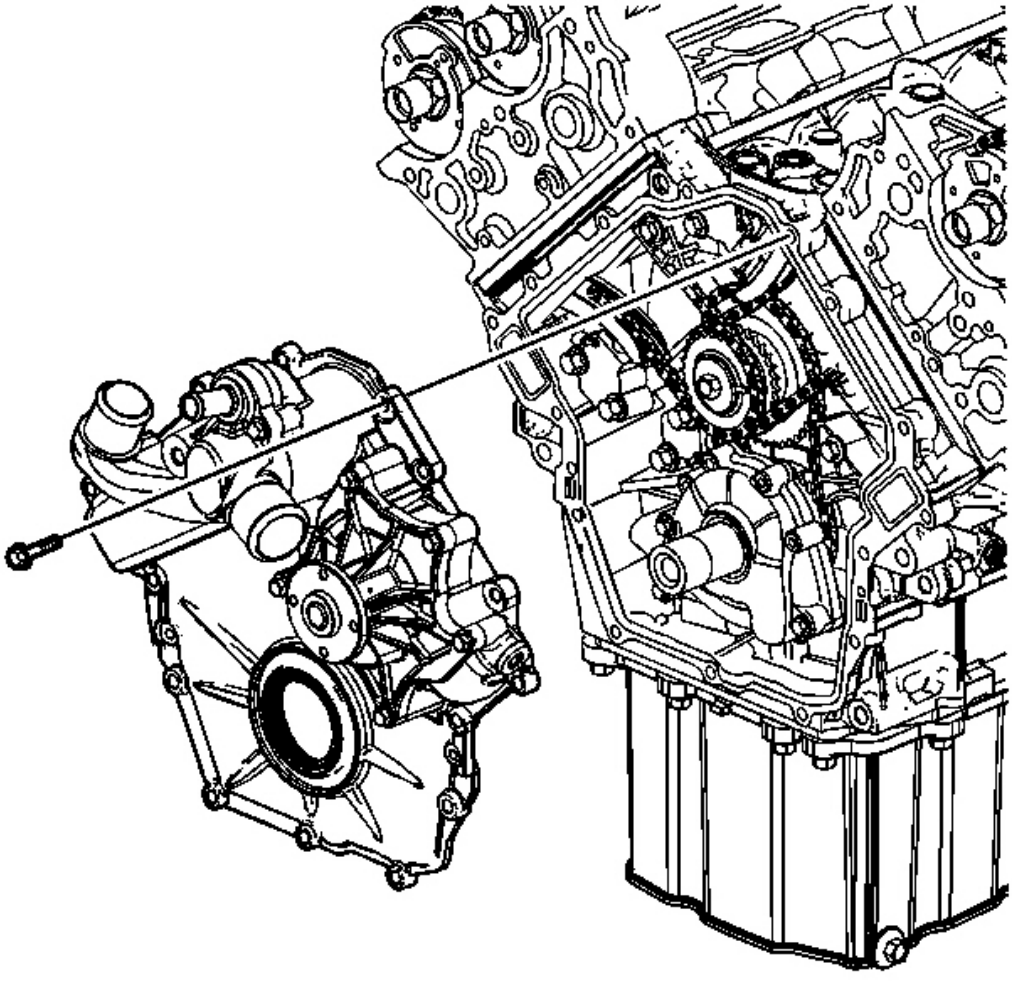


Fig. 179: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

5. Place the engine front cover in position on the crankcase.
6. Apply the thread locking compound to the threads of the engine front cover bolts. Refer to **Sealers, Adhesives and Lubricants** for the correct part number.
7. Install the engine front cover retaining bolts.

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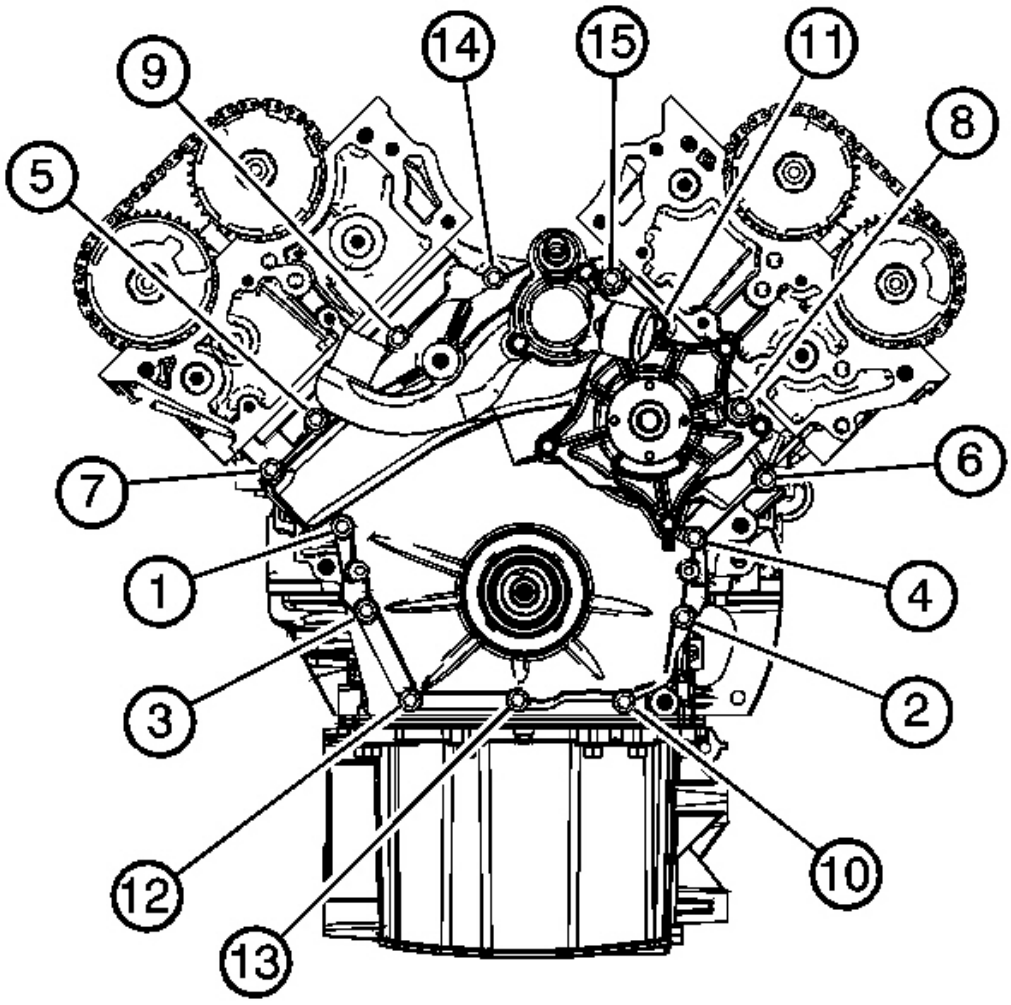


Fig. 180: Identifying Engine Front Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

8. Tighten the engine front cover bolts in the sequence shown.

   Tighten: Tighten the engine front cover bolts in proper sequence to 15 N.m (11 lb ft).

9. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
10. Install the radiator hose and the heater hose to the thermostat housing.

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11. Install the water outlet housing. Refer to **Water Outlet Housing Replacement (LC3)** or **Water Outlet Housing Replacement (LH2)** .
12. Install the water pump pulley. Refer to **Water Pump Replacement (LH2)** or **Water Pump Replacement (LC3)** .
13. Install the accessory drive belt idler pulleys. Refer to **Supercharger Belt Idler Pulley Replacement** and **Water Pump and Generator Belt Idler Pulley Replacement**.
14. Install the accessory drive belt tensioners. Refer to **Drive Belt Tensioner Replacement - Supercharger**, **Water Pump and Generator Drive Belt Tensioner Replacement** and**Air Conditioning Compressor Belt Tensioner Replacement**.
15. Install the accessory drive belts. Refer to **Supercharger Belt Replacement**, **Water Pump and Generator Belt Replacement** and **Air Conditioning Compressor and Power Steering Pump Belt Replacement**.
16. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
17. Fill the cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)** .

OIL PUMP REPLACEMENT

TOOLS REQUIRED

- **EN-48036** Oil Pump Alignment Tool. See **Special Tools** .
- **J 45059** Angle Meter. See **Special Tools** .

REMOVAL PROCEDURE

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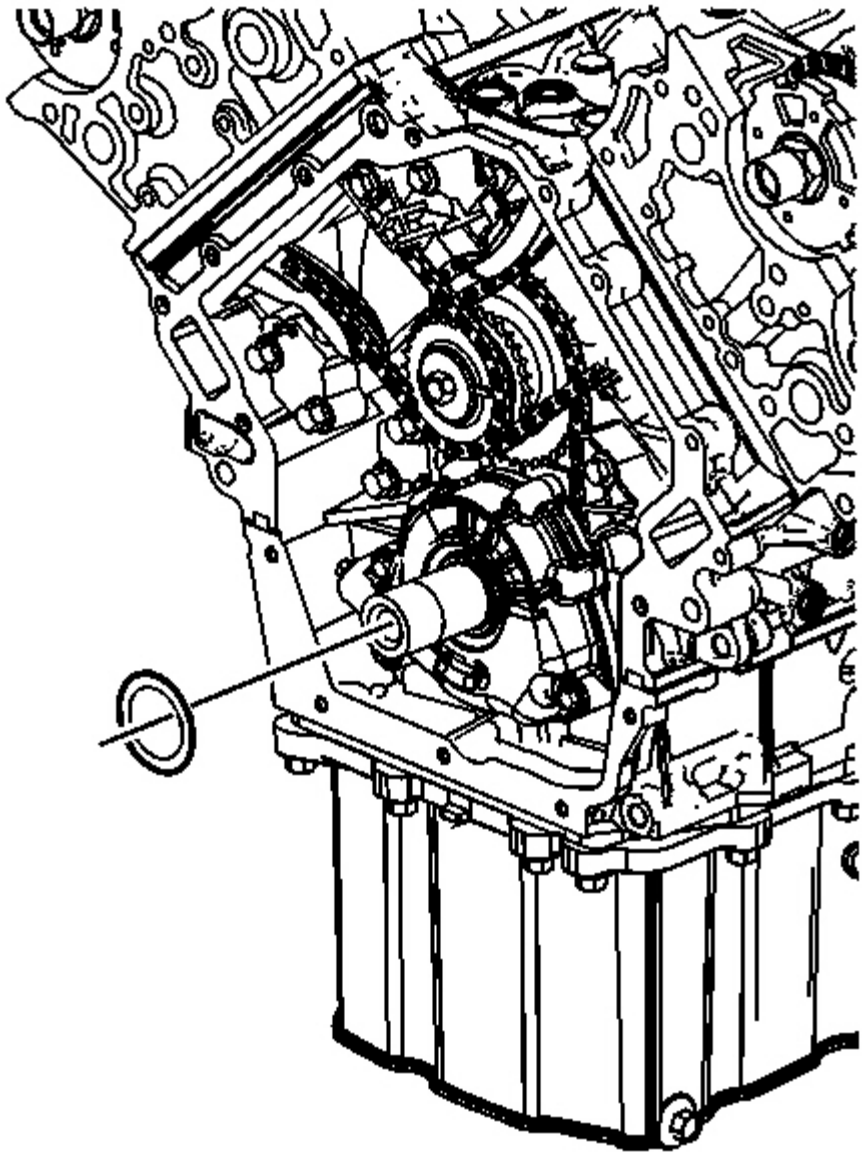


Fig. 181: Identifying Oil Pump Drive To Crankshaft Balancer Friction Washer
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
2. Remove the oil pump drive to crankshaft balancer friction washer.

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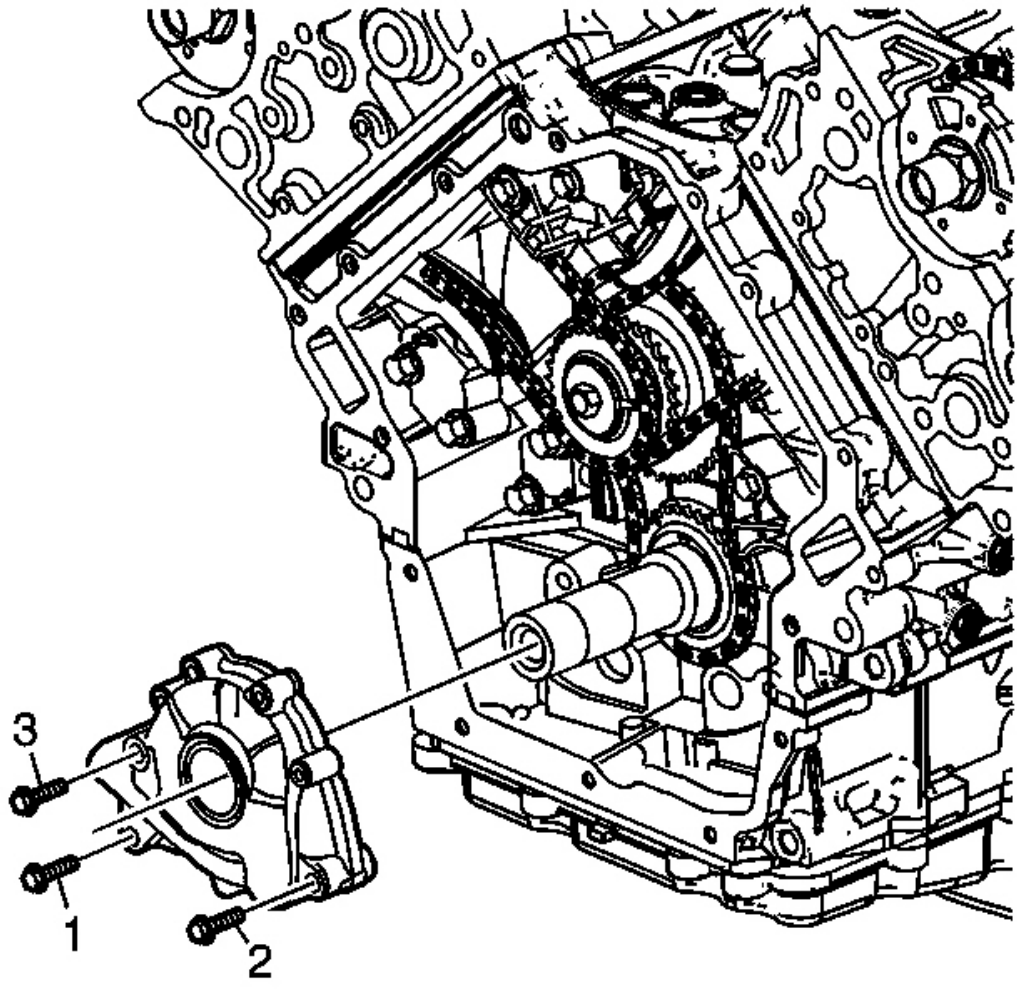


Fig. 182: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the 3 oil pump assembly retaining bolts (1, 2, 3) identified by the larger head size.
4. Slide the oil pump assembly off the nose of the crankshaft with the drive collar in place.

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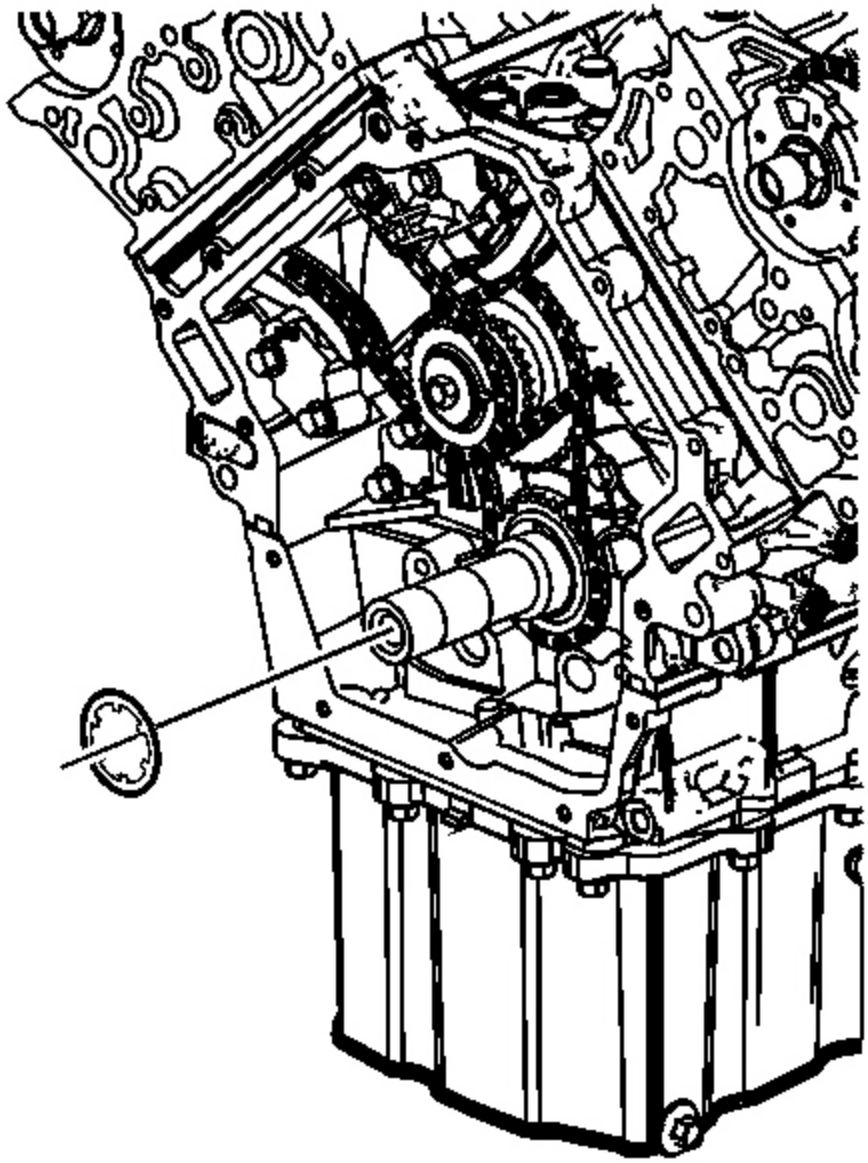


Fig. 183: Identifying Crankshaft Sprocket To Oil Pump Drive Friction Washer
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft sprocket to oil pump drive friction washer.
6. Disassemble the oil pump as necessary. Refer to **Oil Pump Disassemble** .
7. Clean and inspect the oil pump. Refer to **Oil Pump Cleaning and Inspection** .

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8. Assemble the oil pump if necessary. Refer to **Oil Pump Assemble** .

INSTALLATION PROCEDURE

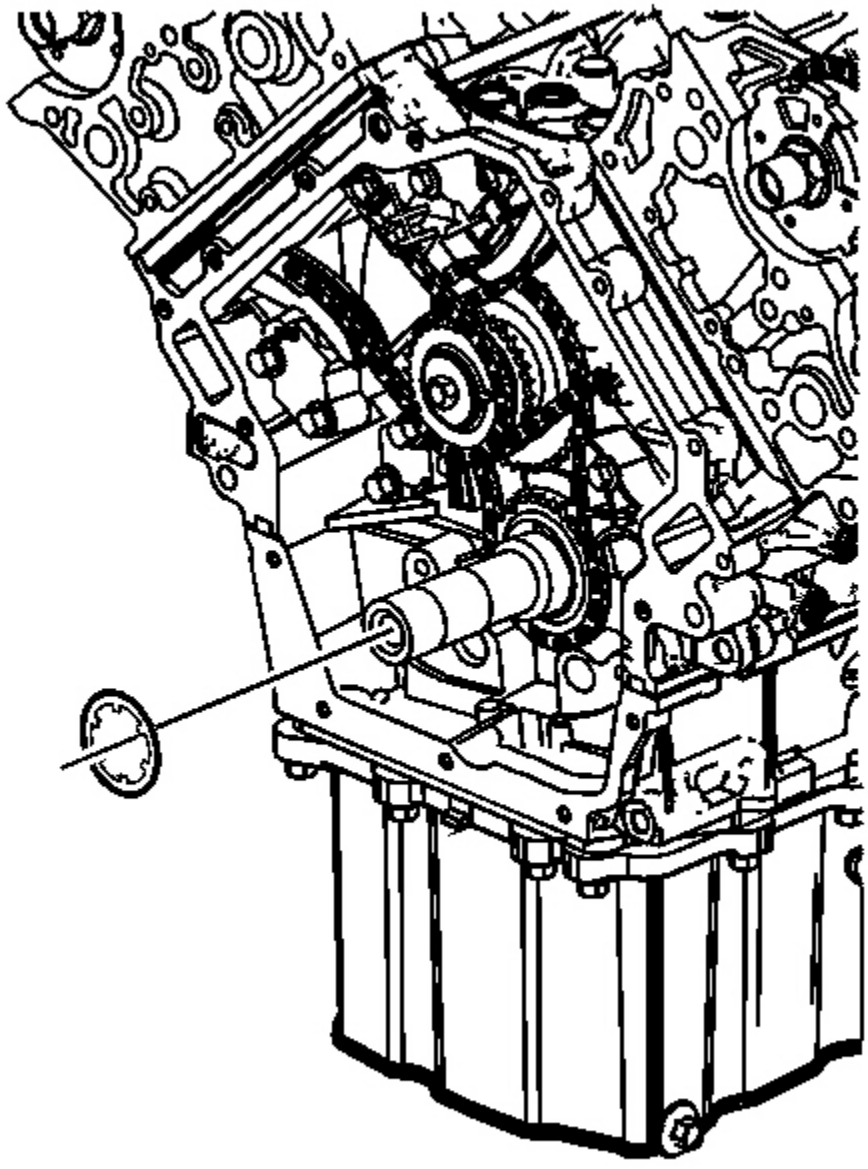


Fig. 184: Identifying Crankshaft Sprocket To Oil Pump Drive Friction Washer
Courtesy of GENERAL MOTORS CORP.

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1. Install the crankshaft sprocket to oil pump drive friction washer.

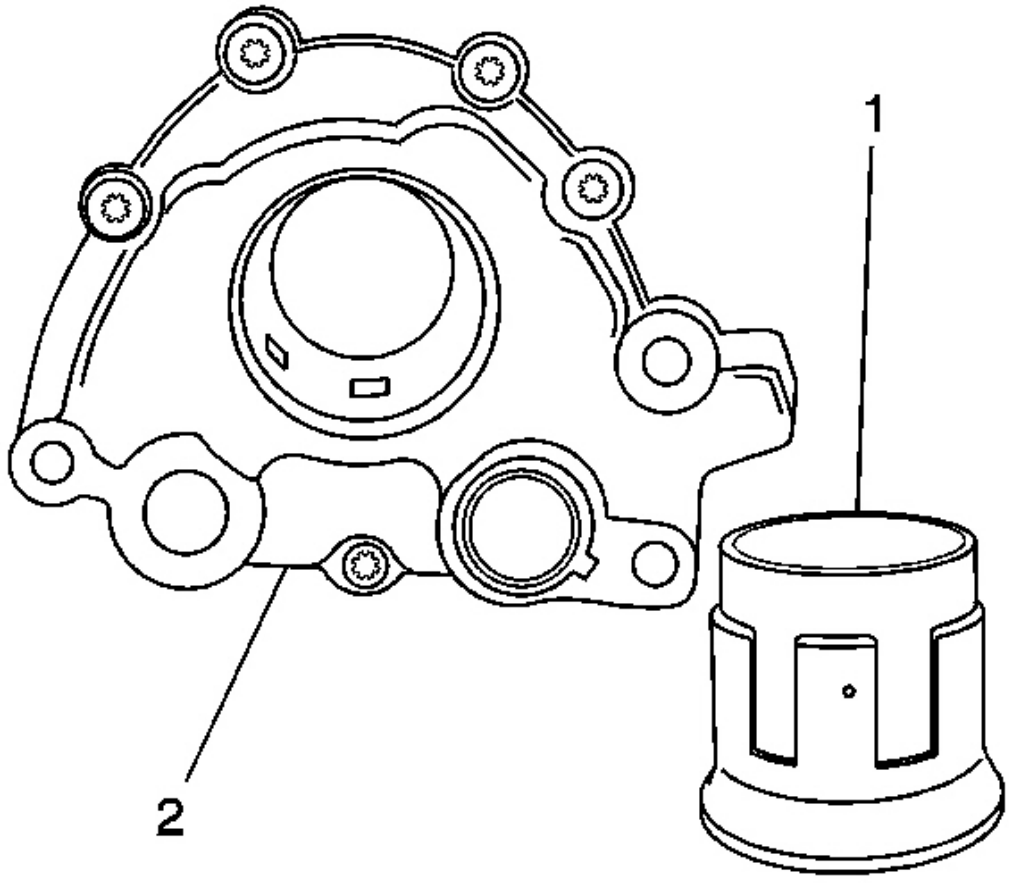


Fig. 185: Identifying Oil Pump & Drive Spacer
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pump drive spacer (1) into the oil pump (2) so that the drive flat engages the pump rotor.

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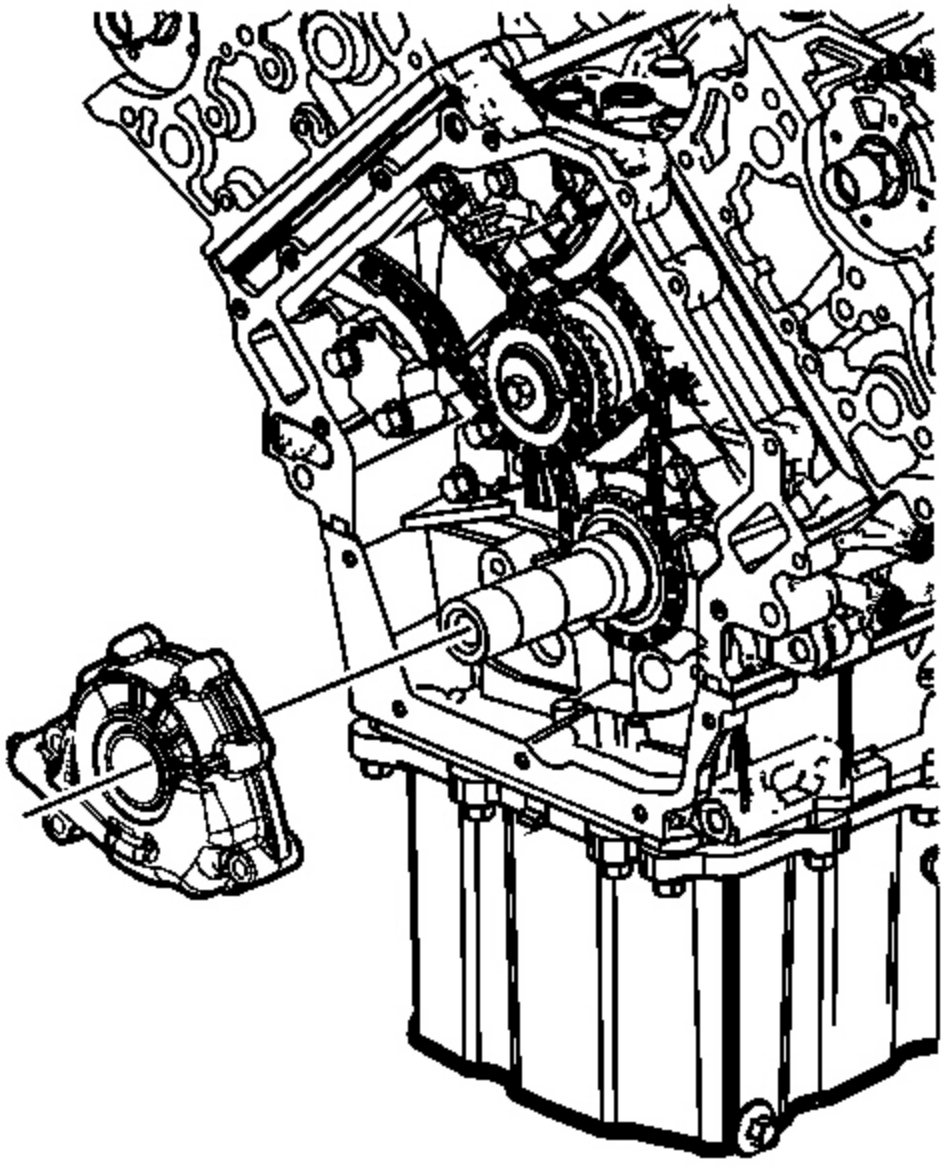


Fig. 186: View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pump.

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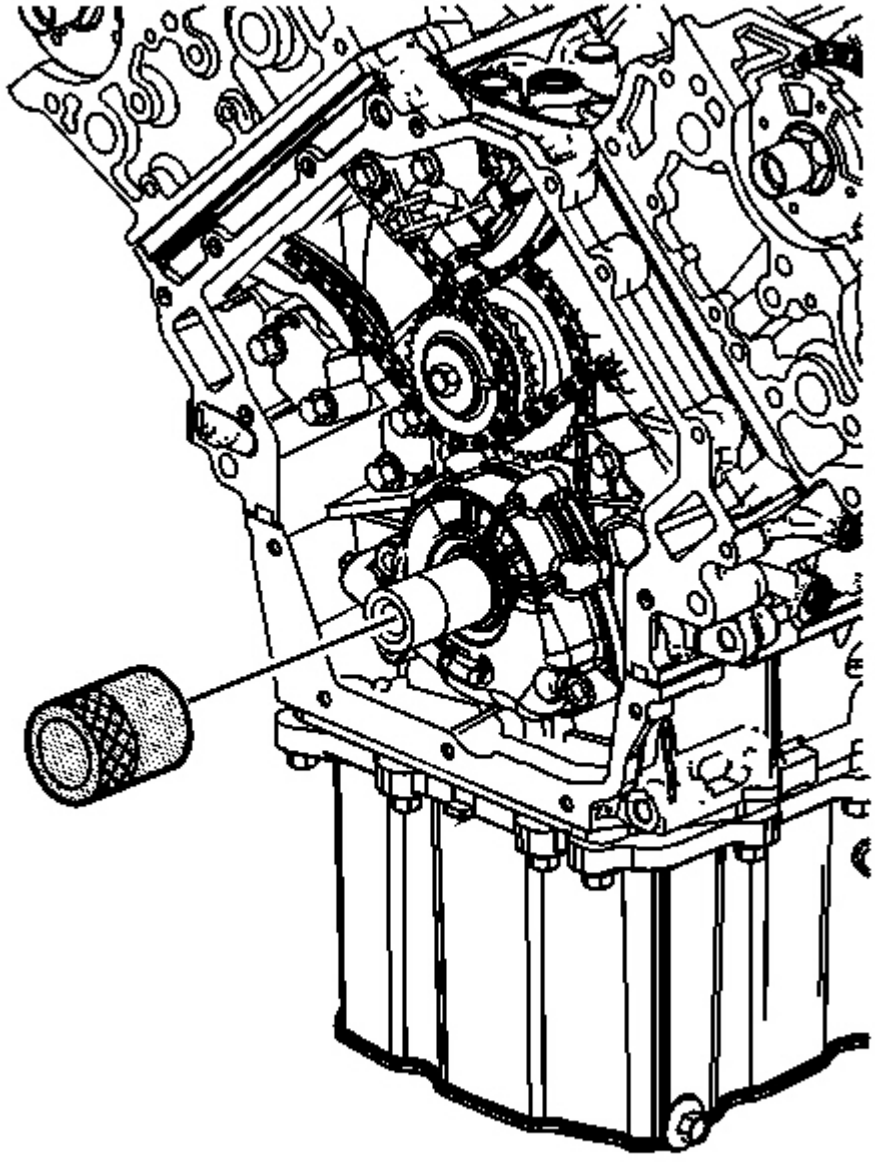


Fig. 187: View Of EN-48036 Oil Pump Alignment Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: **The EN 48036 must be used during the installation of the oil pump. Failure to use the EN 48036 to align the oil pump to the crankshaft can lead to oil pump damage and severe engine damage.**

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4. Install the **EN-48036** over the crankshaft nose and up to the oil pump. See **Special Tools** .

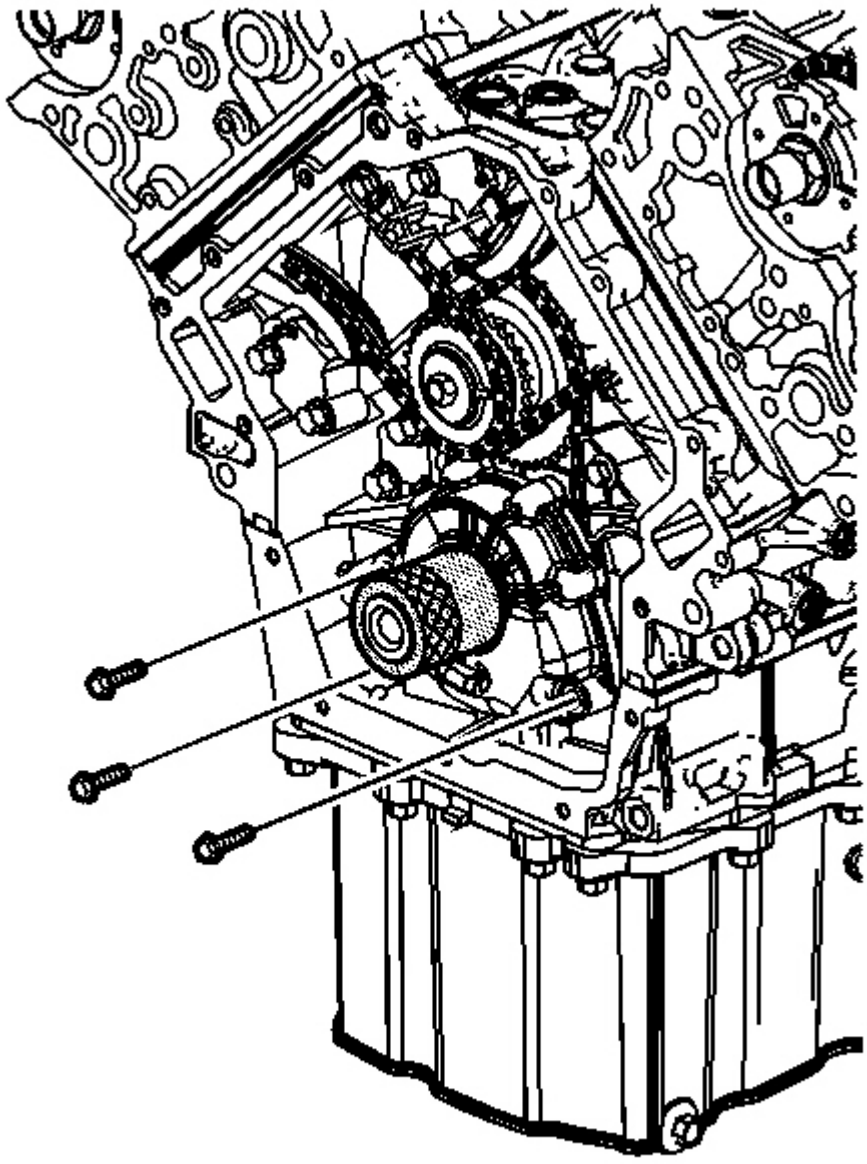


Fig. 188: Identifying Oil Pump Bolts
Courtesy of GENERAL MOTORS CORP.

5. Loosely install the oil pump bolts.

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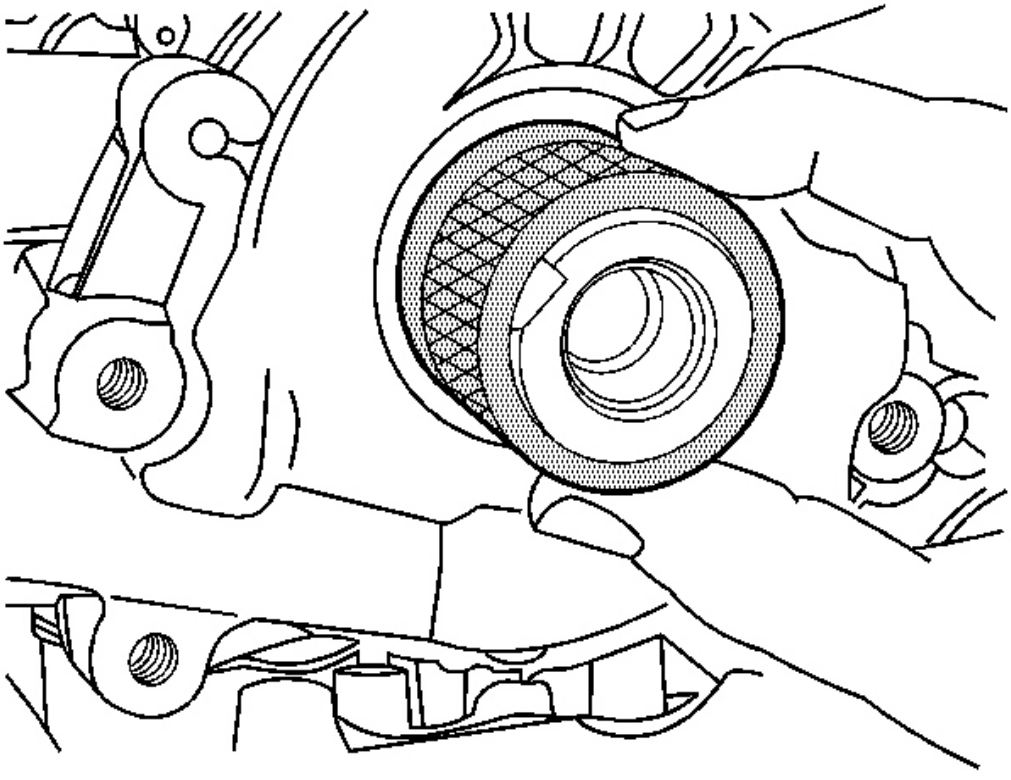


Fig. 189: Aligning Oil Pump To Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

6. Apply force by hand to the **EN-48036** against the oil pump in order to align the pump to the oil pump drive. See **Special Tools** .
7. Install the retaining bolts.

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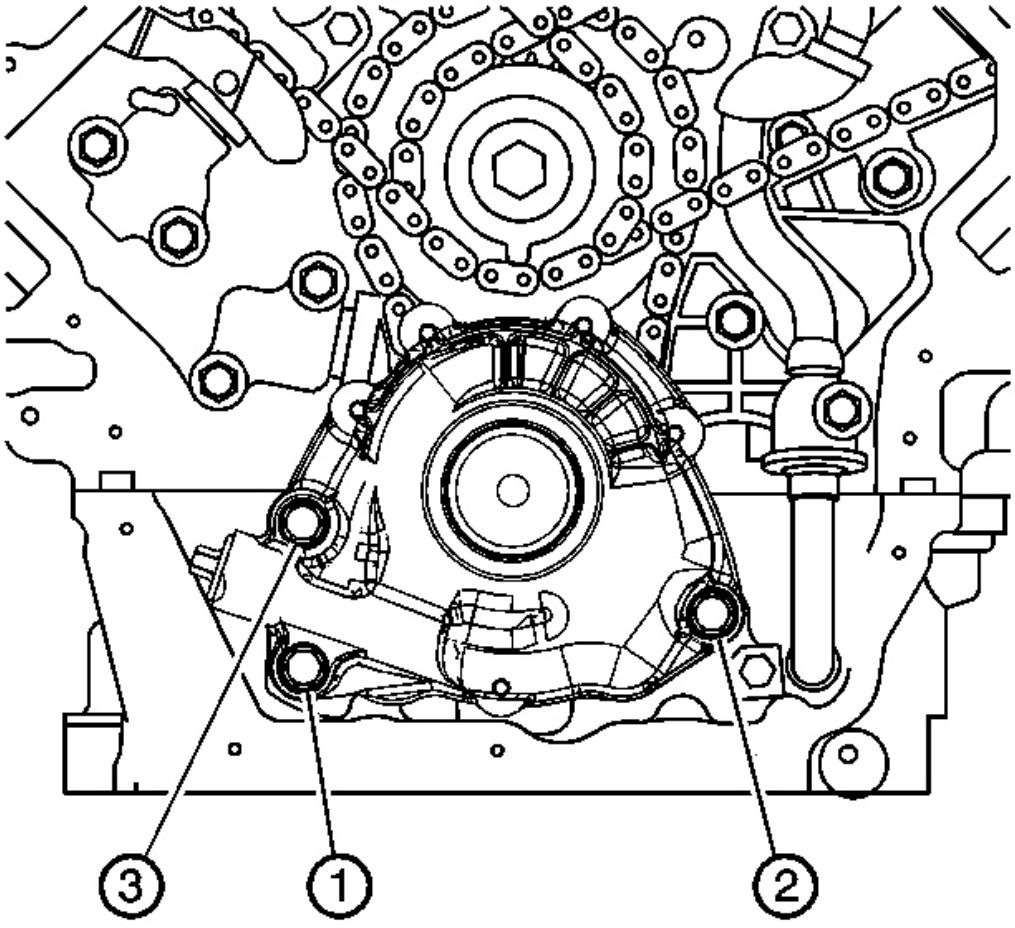


Fig. 190: Identifying Oil Pump Mounting Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

8. While keeping force on the **EN-48036** tighten the oil pump bolts in sequence (1, 2, 3) as shown. See **Special Tools** .

   Tighten:

   1. First Pass

      Tighten the oil pump mounting bolts in sequence to 10 N.m (89 lb in).

   2. Final Pass

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Tighten the oil pump mounting bolts in sequence an additional 35 degrees using the **J 45059** . See **Special Tools** .

9. Remove the **EN-48036** . See **Special Tools** .

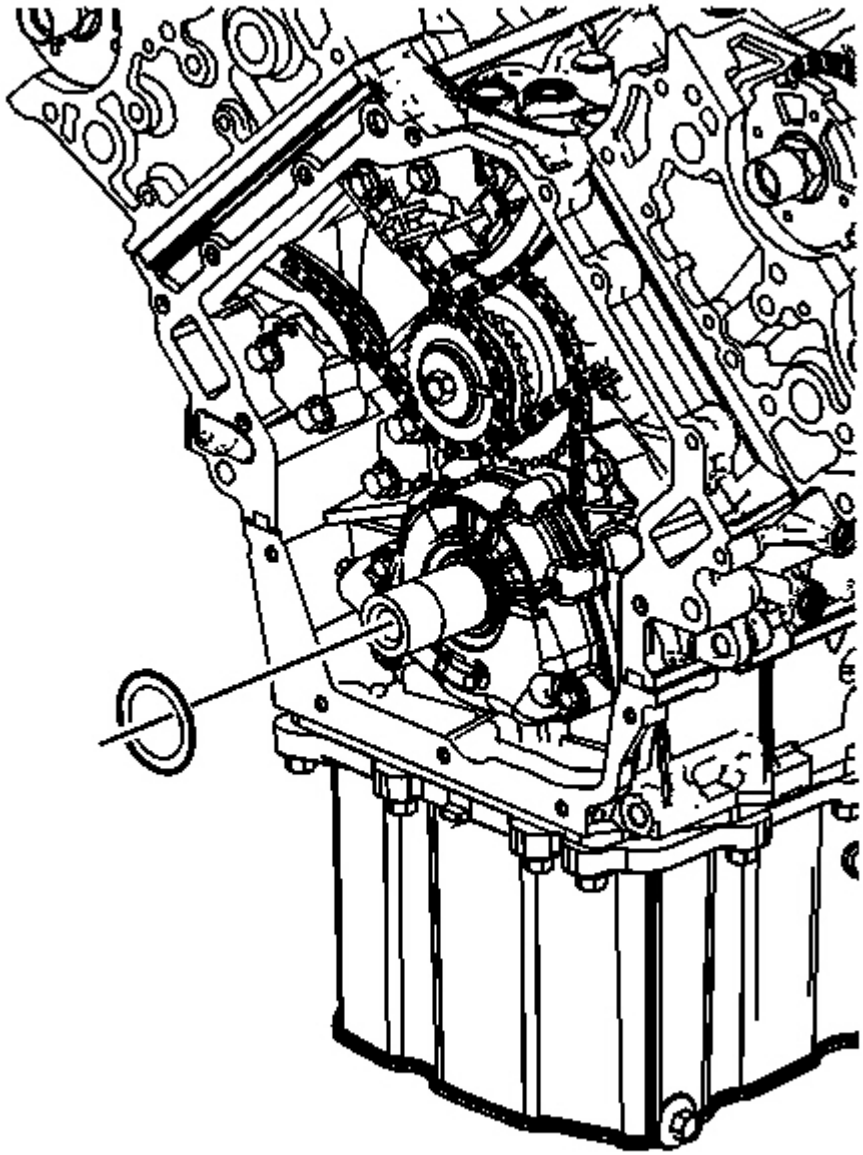


Fig. 191: Identifying Oil Pump Drive To Crankshaft Balancer Friction Washer
Courtesy of GENERAL MOTORS CORP.

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10. Install the oil pump drive to crankshaft balancer friction washer.
11. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

REMOVAL PROCEDURE

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

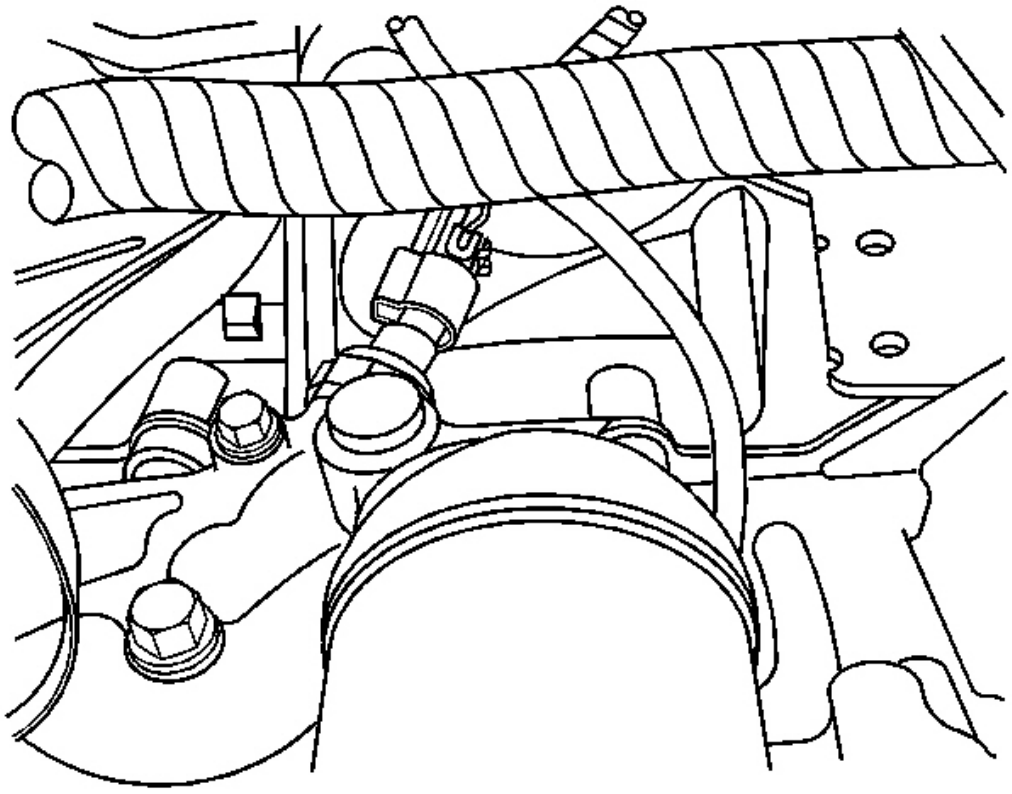


Fig. 192: View Of Engine Oil Pressure Switch Electrical Connector
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the electrical connector from the engine oil pressure switch.

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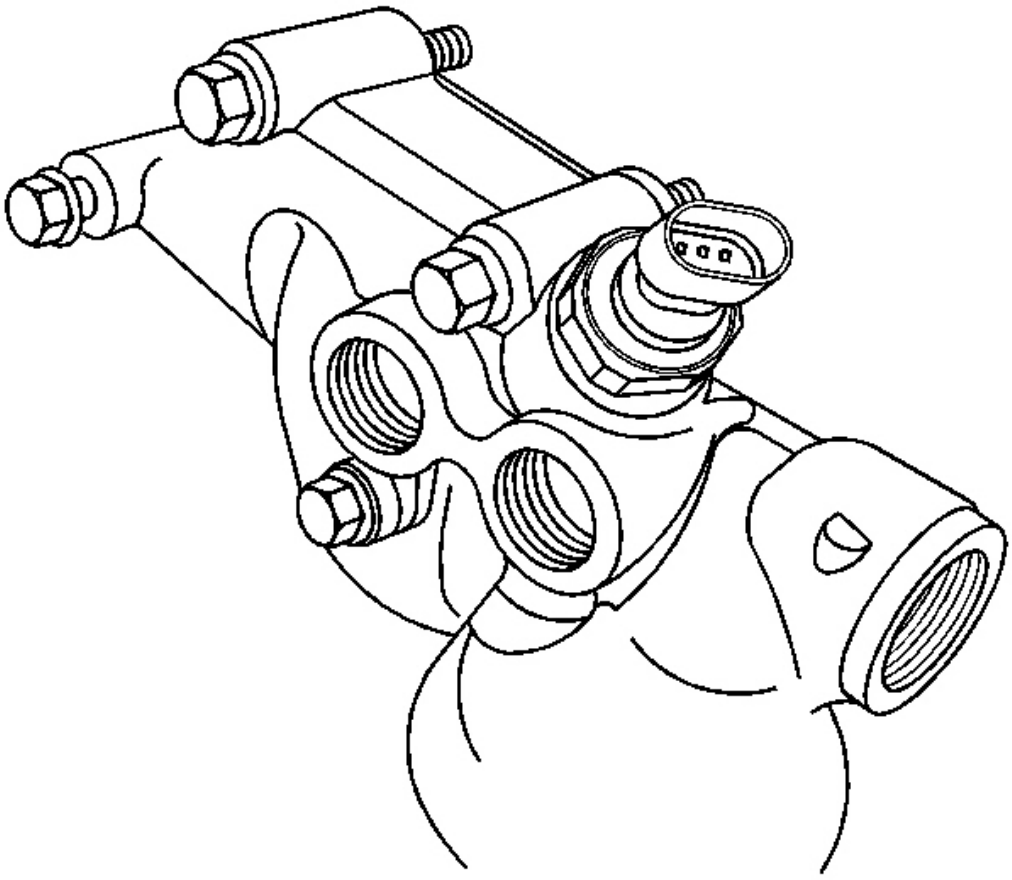


Fig. 193: View Of Engine Oil Pressure Switch & Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil pressure switch from the oil filter adapter using a snap-on S 6152 Oil Pressure Sender Switch Crowfoot Wrench™ (1 1/16") or equivalent.

INSTALLATION PROCEDURE

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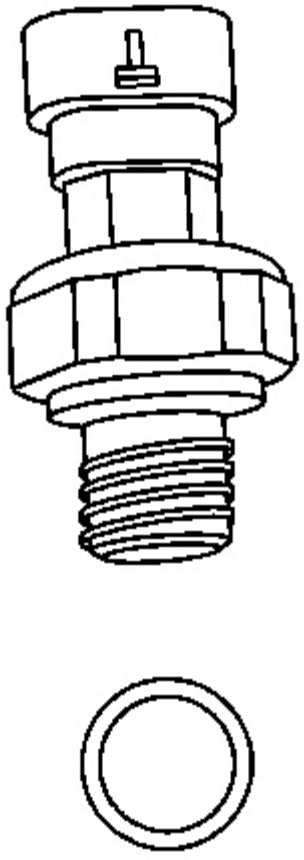


Fig. 194: View Of Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

1. Install a new O-ring on the oil pressure switch.

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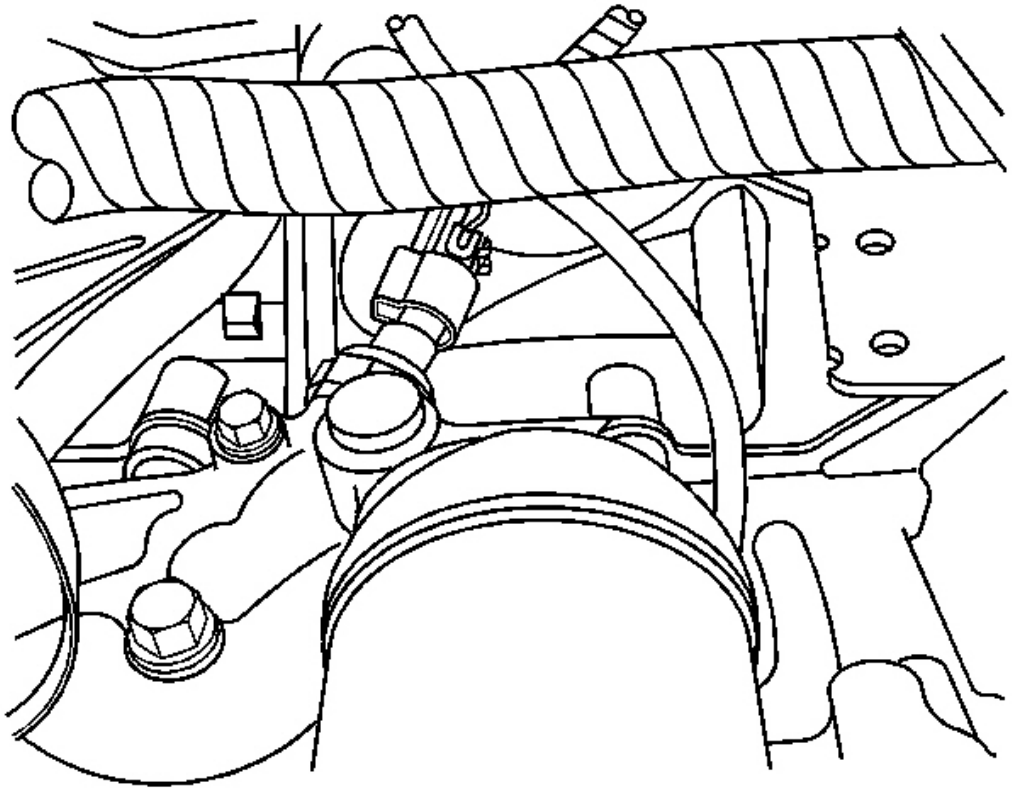


Fig. 195: View Of Engine Oil Pressure Switch Electrical Connector
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Component Fastener Tightening Notice .**

2. Install the engine oil pressure switch to the oil filter adapter using a Snap-On™ S 6152 Oil Pressure Sender Switch Crowfoot Wrench (1 1/16") or equivalent.

   Tighten: Tighten the engine oil pressure switch to 16 N.m (12 lb ft).

3. Connect the electrical connector to the engine oil pressure switch.
4. Lower the vehicle.
5. Adjust the engine oil level to the full mark.
6. Inspect for oil leaks after engine start up.

ENGINE OIL LEVEL SENSOR AND/OR SWITCH REPLACEMENT

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REMOVAL PROCEDURE

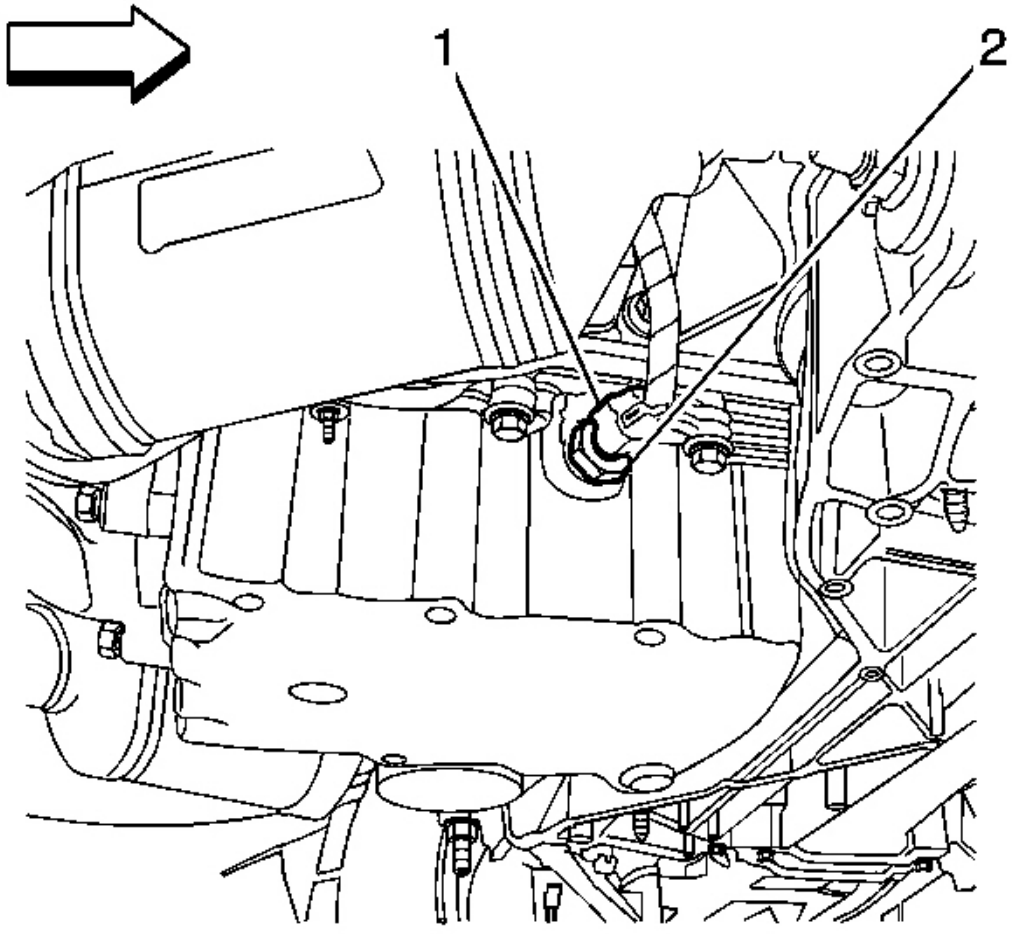


Fig. 196: Identifying Engine Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

1. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement** .
2. Disconnect the electrical connector (1) from the engine oil level sensor (2).
3. Remove the engine oil level sensor (2) from the oil pan.

INSTALLATION PROCEDURE

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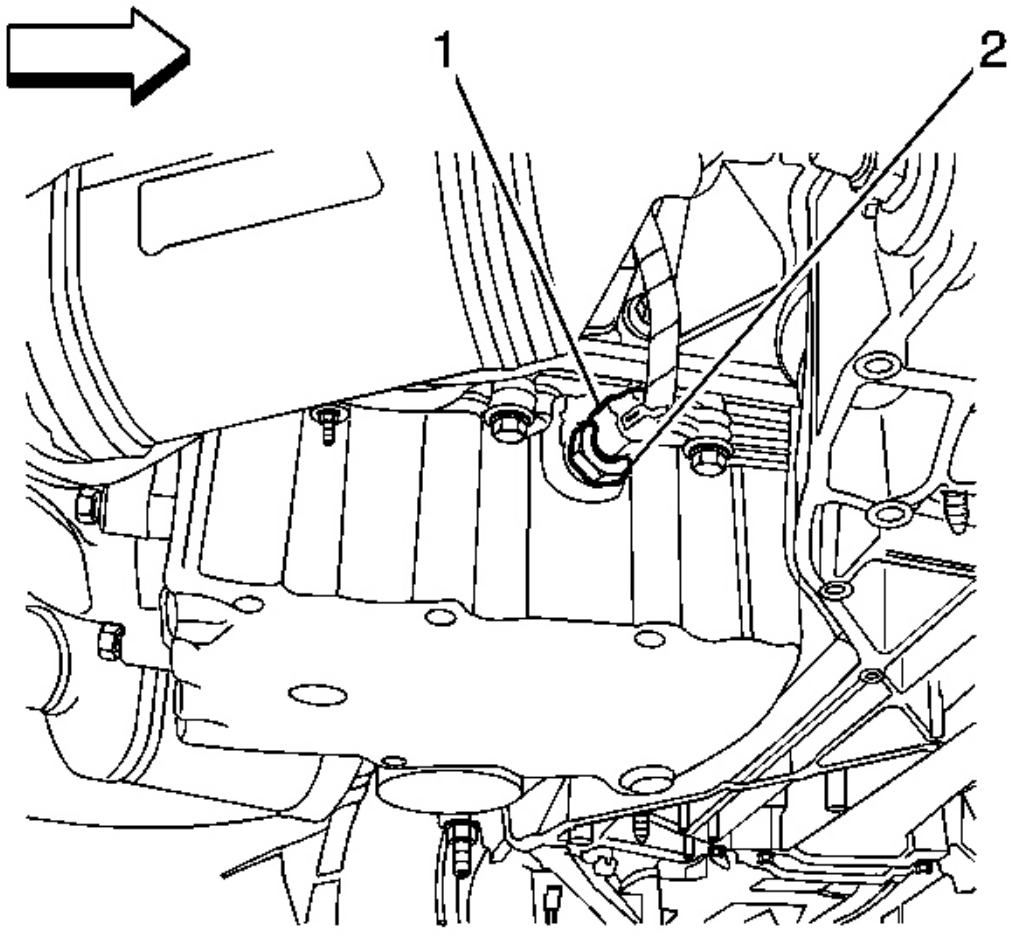


Fig. 197: Identifying Engine Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Component Fastener Tightening Notice .**

1. Install the engine oil level sensor (2) into the oil pan.

   Tighten: Tighten the engine oil level sensor to 20 N.m (15 lb ft).

2. Connect the electrical connector (1) to the engine oil level sensor (2).
3. Fill the engine oil. Refer to **Engine Oil and Oil Filter Replacement** .
4. Inspect for oil leaks after engine start up.

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OIL PUMP SUCTION PIPE AND SCREEN ASSEMBLY REPLACEMENT

REMOVAL PROCEDURE

1. Remove the engine oil pan. Refer to **Oil Pan Replacement** .

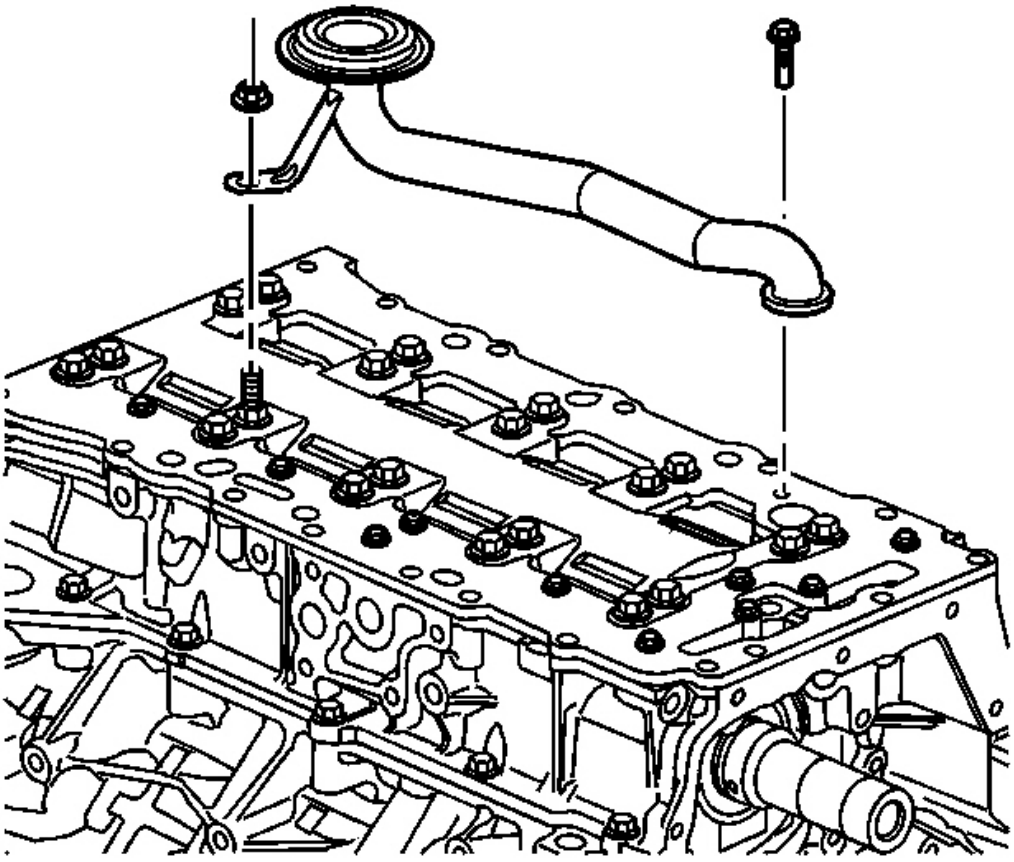


Fig. 198: View Of Oil Pump Pipe
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump pipe support bracket nut.
3. Remove the oil pump pipe bolt.
4. Remove the oil pump pipe and screen assembly.

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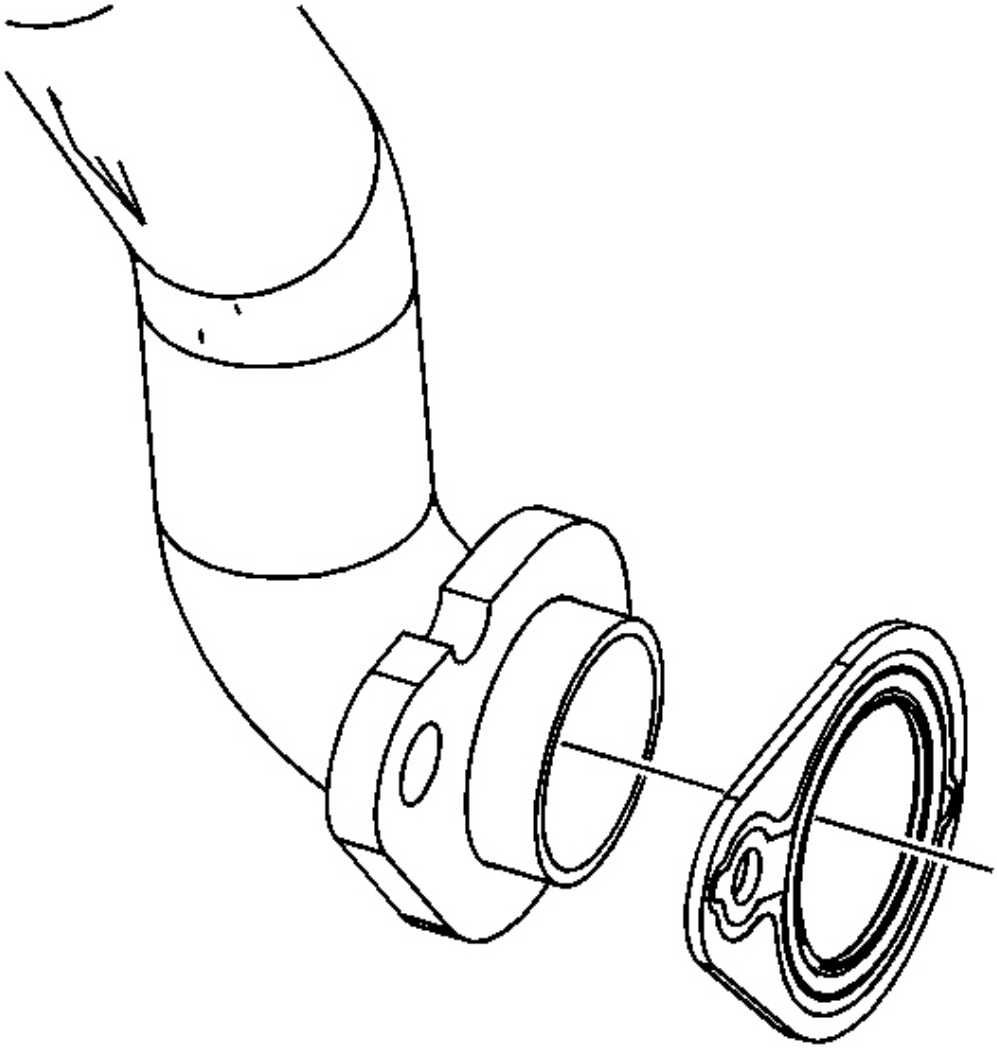


Fig. 199: View Of Oil Pump Pipe Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the oil pump pipe and screen assembly gasket.

INSTALLATION PROCEDURE

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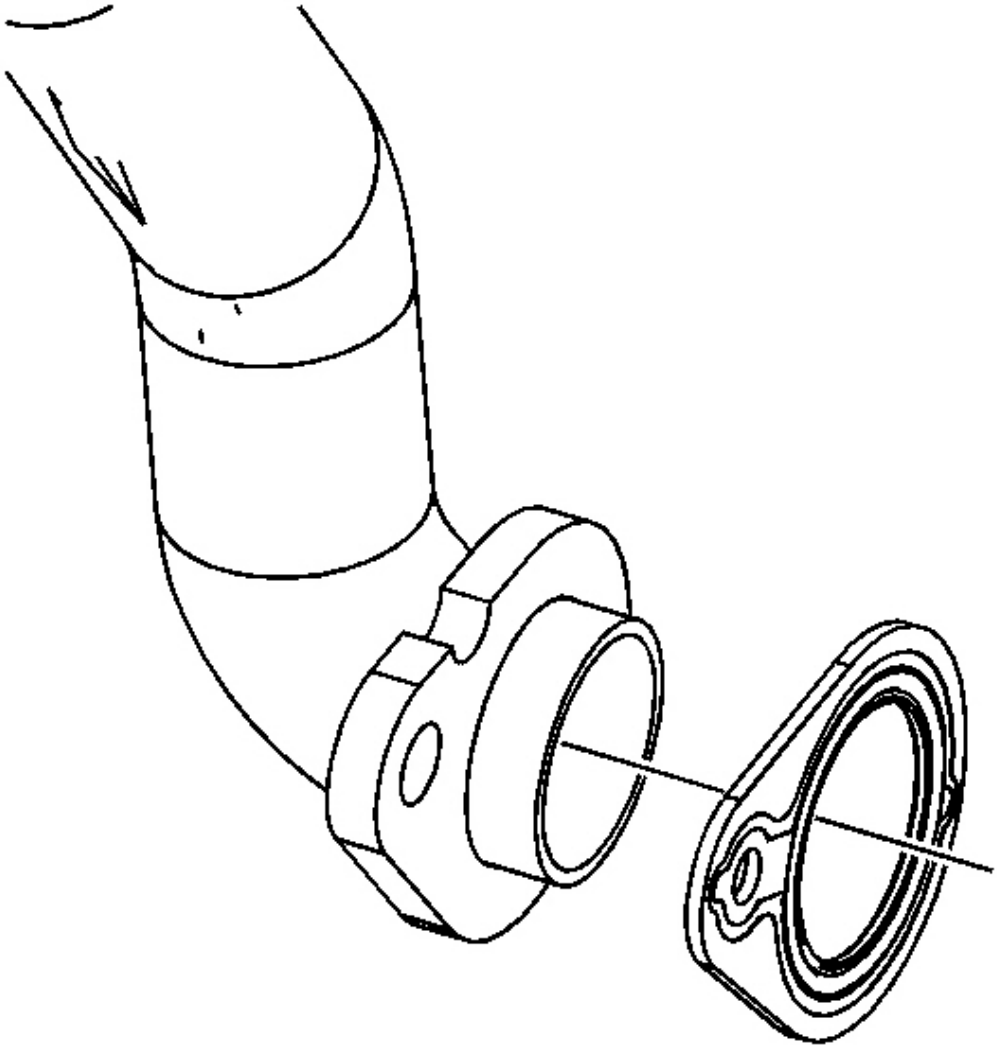


Fig. 200: View Of Oil Pump Pipe Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW gasket to the oil pump pipe and screen assembly.

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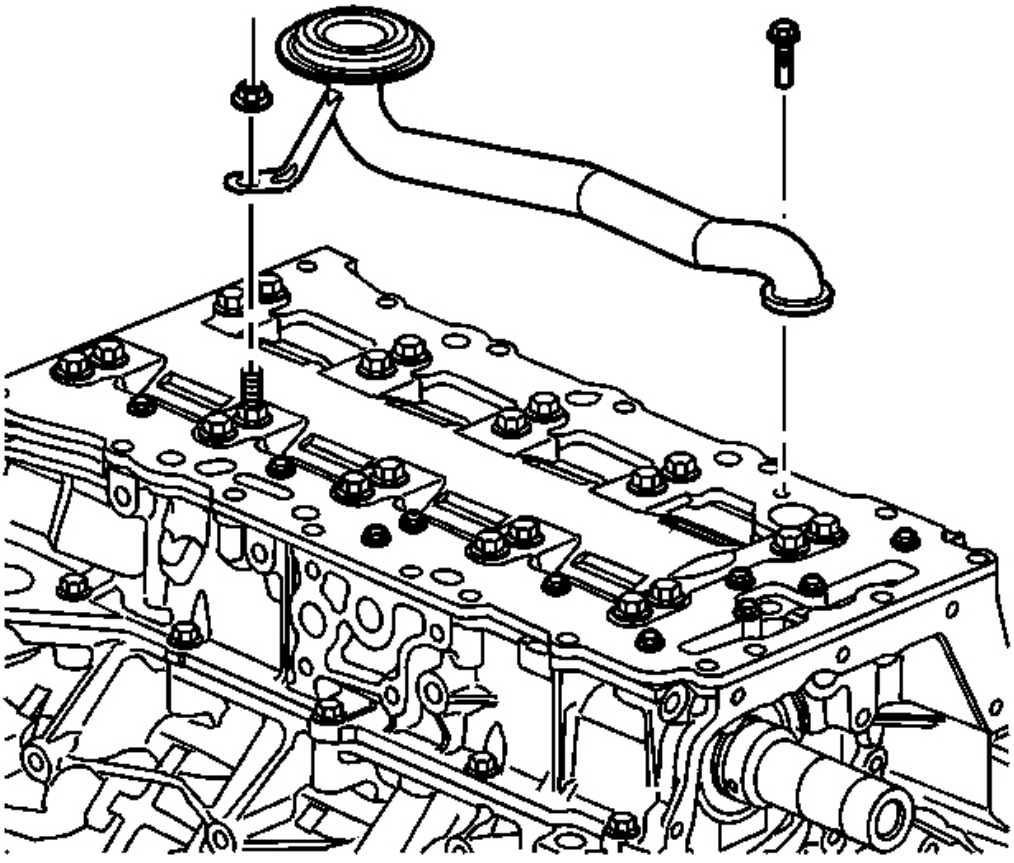


Fig. 201: View Of Oil Pump Pipe
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pump pipe and screen assembly.

NOTE: **Refer to Fastener Notice .**

3. Install the oil pump pipe and screen assembly retaining bolt and nut.

Tighten:

- Tighten the oil pump pick-up tube nut to 24 N.m (18 lb ft).
- Tighten the oil pump pick-up tube bolt to 10 N.m (89 lb in).

4. Install the oil pan. Refer to **Oil Pan Replacement** .

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OIL PUMP OUTLET TUBE REPLACEMENT

TOOLS REQUIRED

J 39946 Crankshaft Socket. See **Special Tools** .

REMOVAL PROCEDURE

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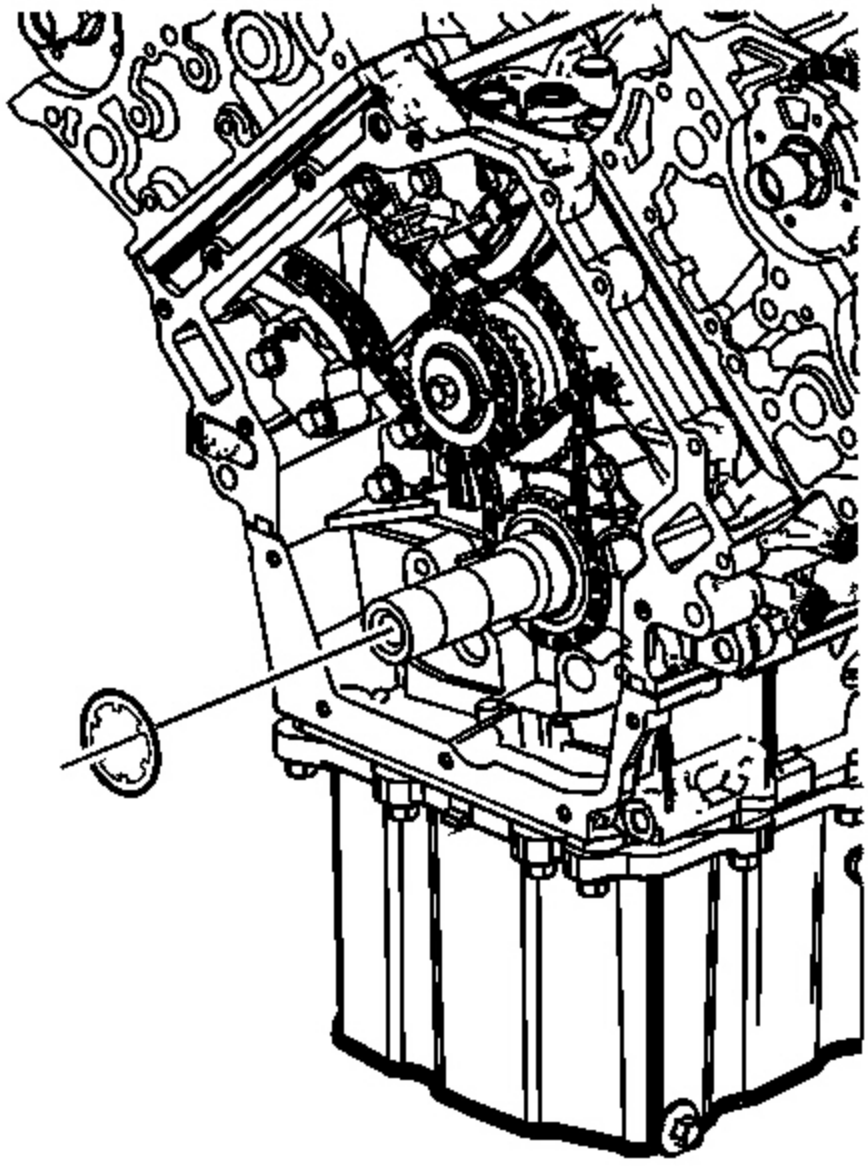


Fig. 202: Identifying Crankshaft To Crankshaft Sprocket Friction Washer
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump. Refer to **Oil Pump Replacement**.
2. Remove the crankshaft sprocket to oil pump drive friction washer.

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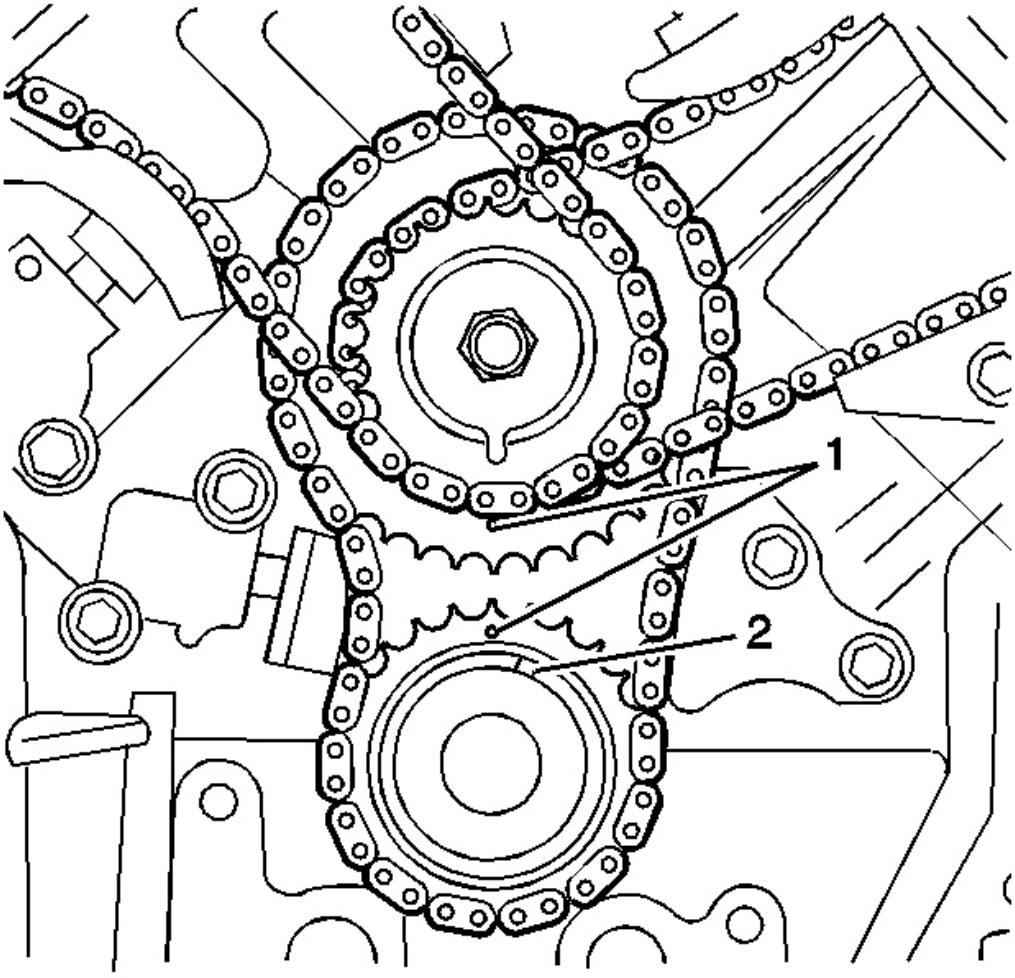


Fig. 203: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

3. Align the primary timing marks (1) using the **J 39946** . See **Special Tools** .
4. Remove the secondary camshaft drive chains. Refer to **Secondary Camshaft Drive Chain Replacement - Left Side** and **Secondary Camshaft Drive Chain Replacement - Right Side**.
5. Remove the primary drive chain tensioner. Refer to **Primary Camshaft Drive Chain Tensioner Replacement**.

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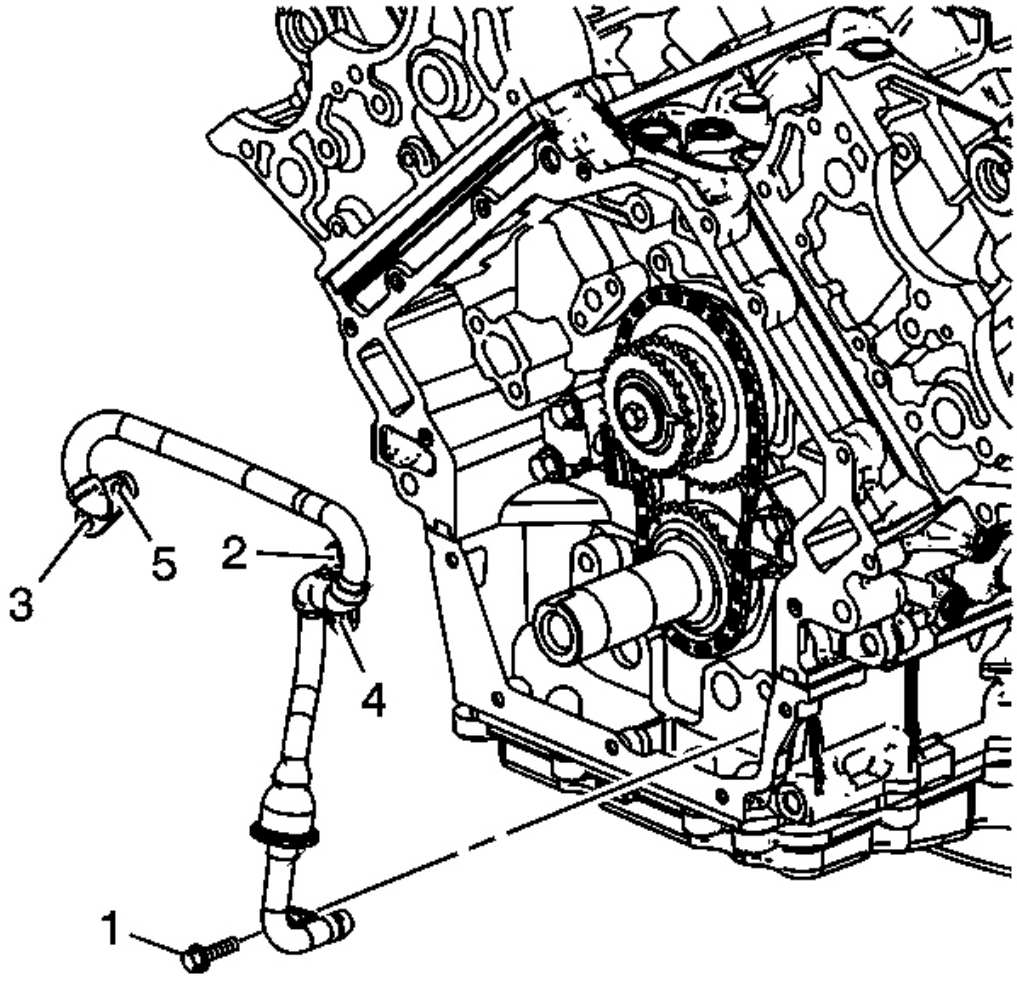


Fig. 204: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil outlet tube bolts (1-5).
7. Remove the oil outlet tube.

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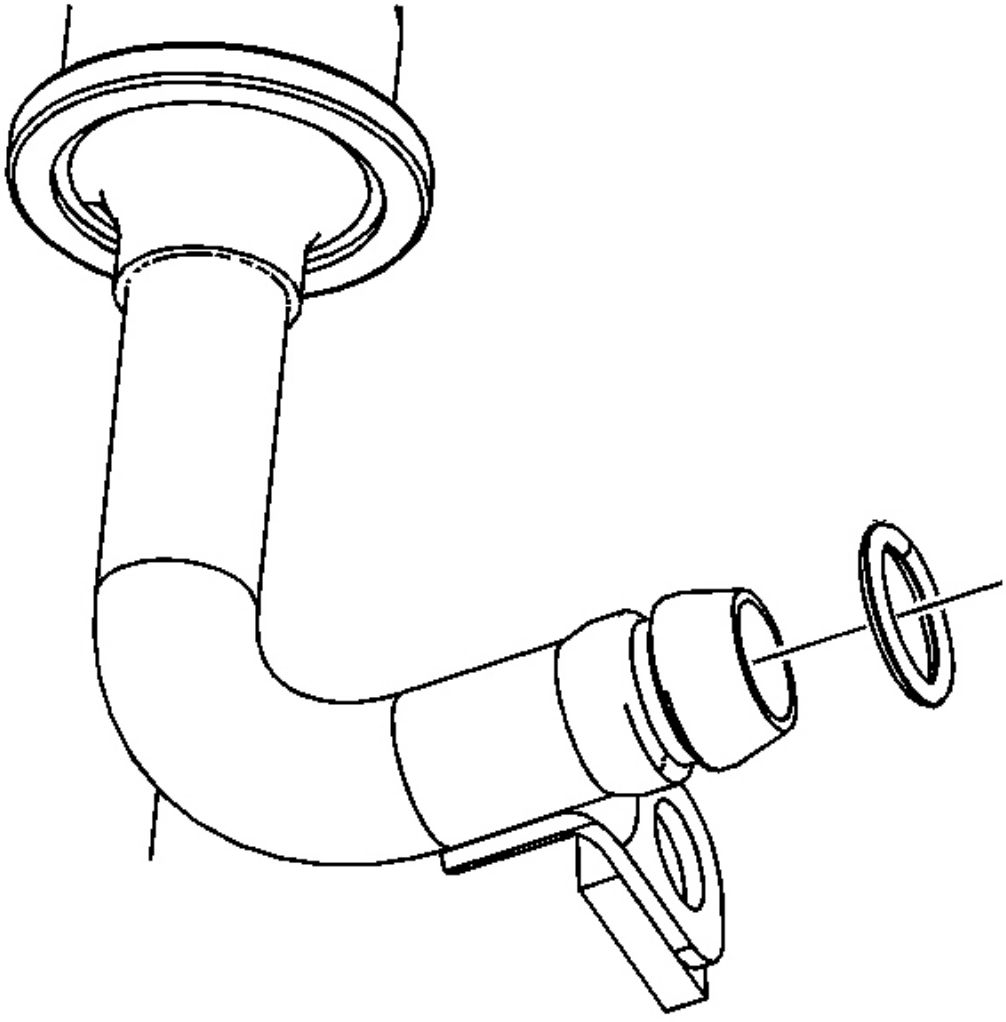


Fig. 205: View Of Oil Outlet Tube O-Ring
Courtesy of GENERAL MOTORS CORP.

8. Remove and discard the oil outlet tube O-ring.
9. Clean and inspect the oil outlet tube. Refer to **Oil Pump Outlet Tube Cleaning and Inspection** .

INSTALLATION PROCEDURE

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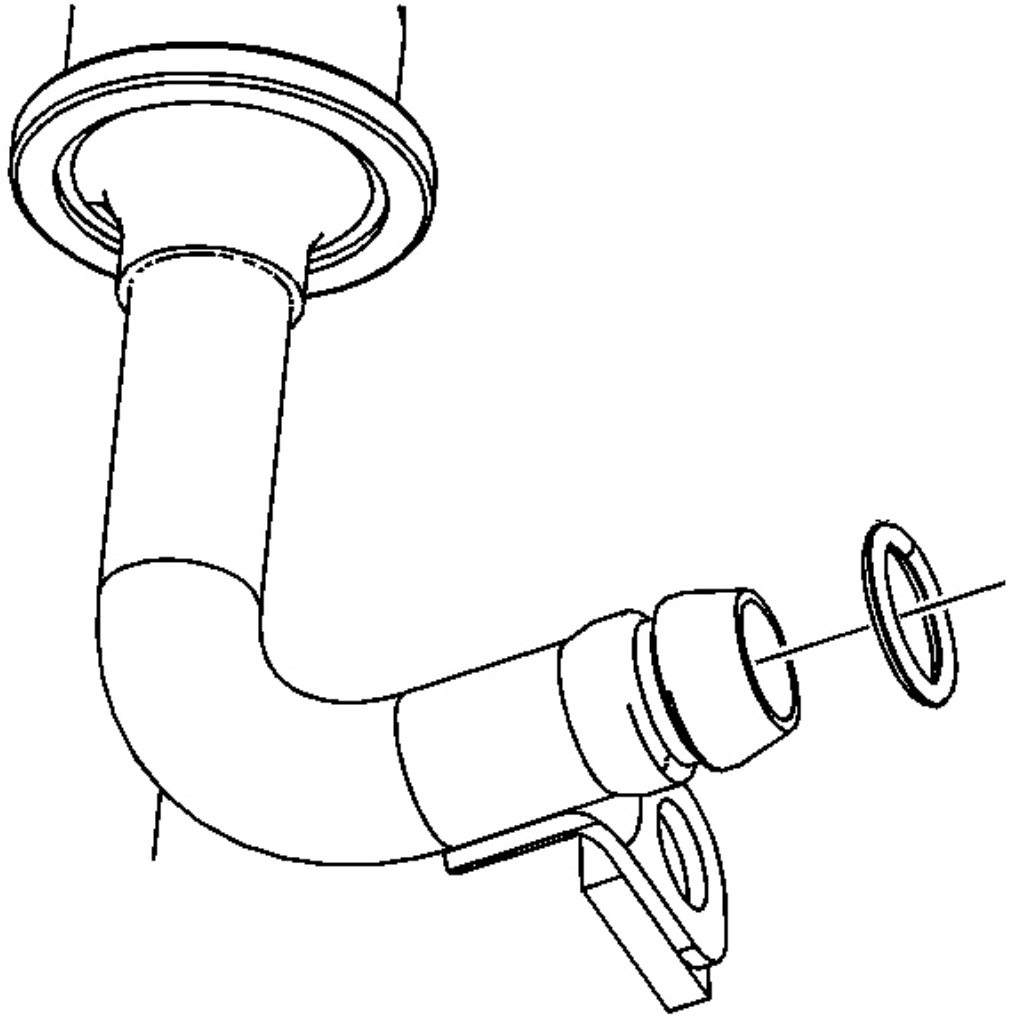


Fig. 206: View Of Oil Outlet Tube O-Ring
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW O-ring on the oil outlet tube.
2. Apply lubricant to the O-ring.

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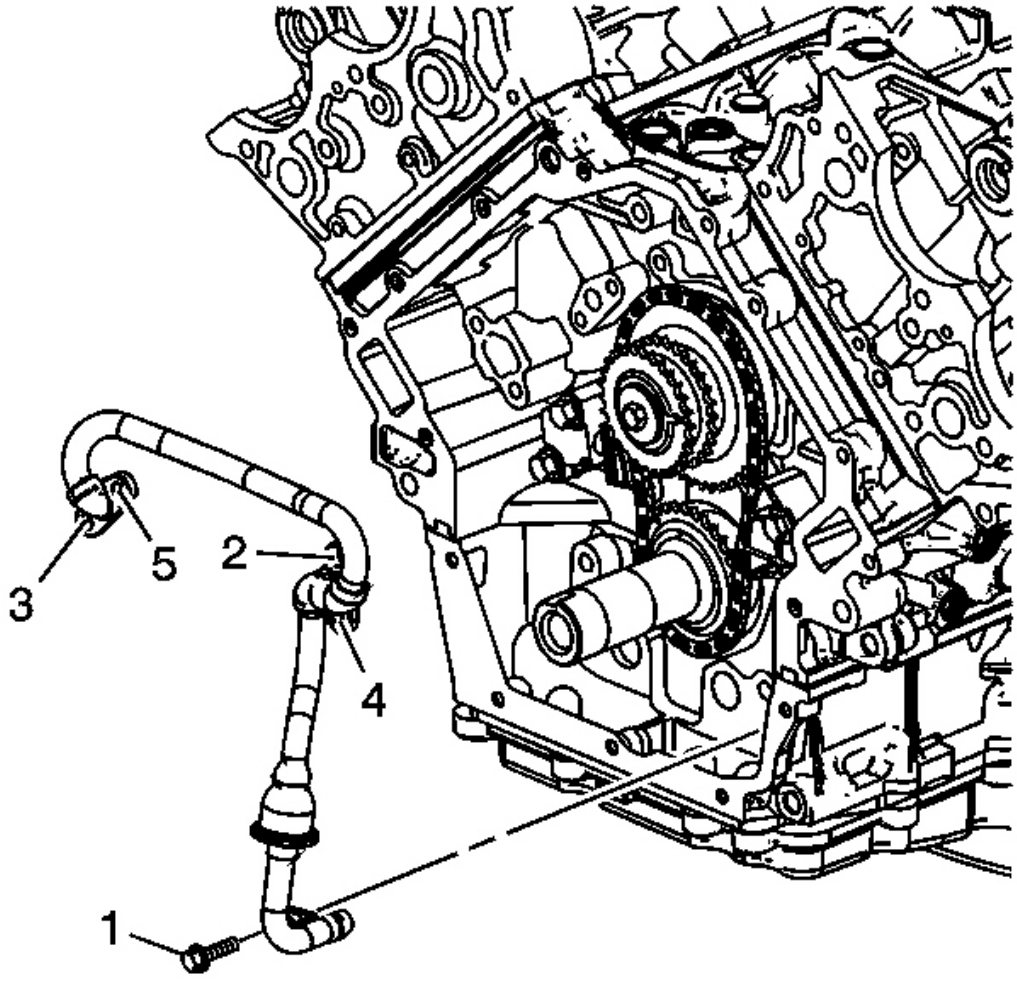


Fig. 207: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the oil outlet tube and bolts (1-5).

   Tighten: Tighten the oil outlet tube bolts to 10 N.m (89 lb in).

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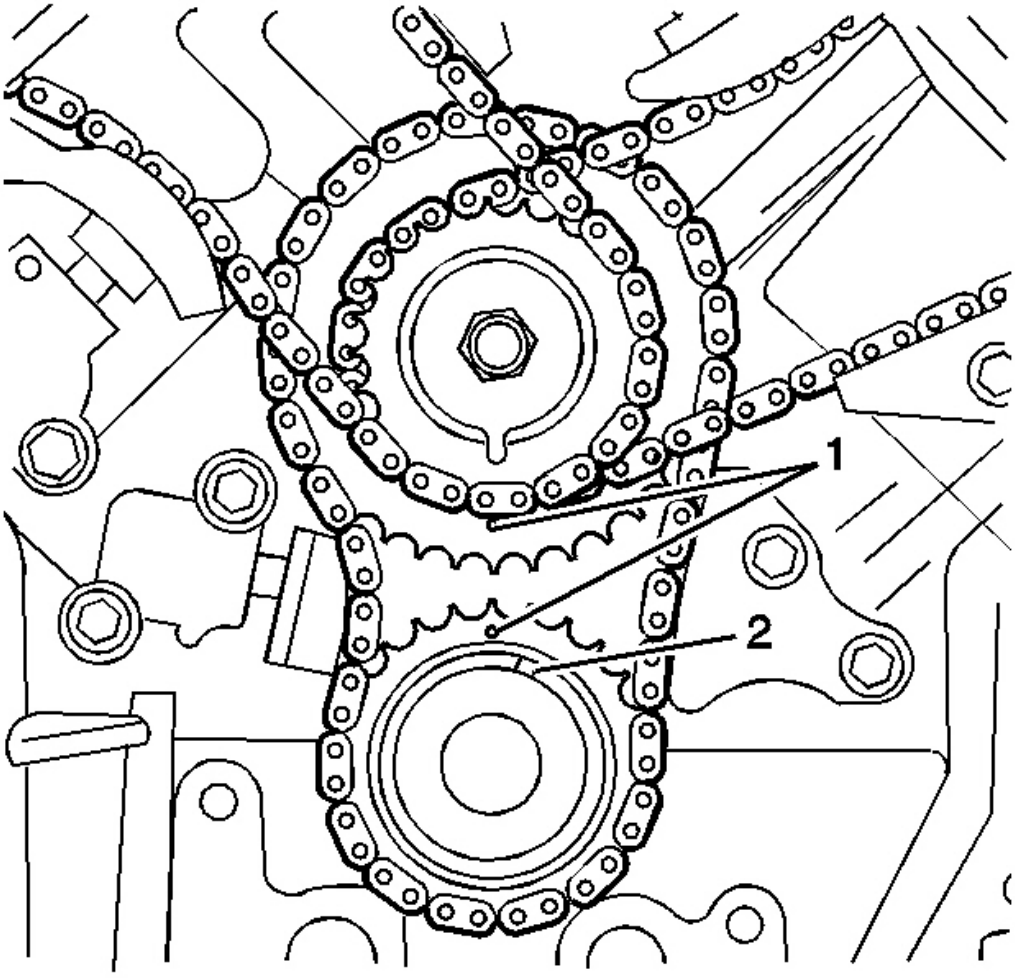


Fig. 208: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

4. Ensure the primary timing marks (1) are aligned vertically using the **J 39946** . See **Special Tools** .
5. Install the primary drive chain tensioner. Refer to **Primary Camshaft Drive Chain Tensioner Replacement**.
6. Install the secondary camshaft drive chains. Refer to **Secondary Camshaft Drive Chain Replacement - Left Side** and **Secondary Camshaft Drive Chain Replacement - Right Side**.

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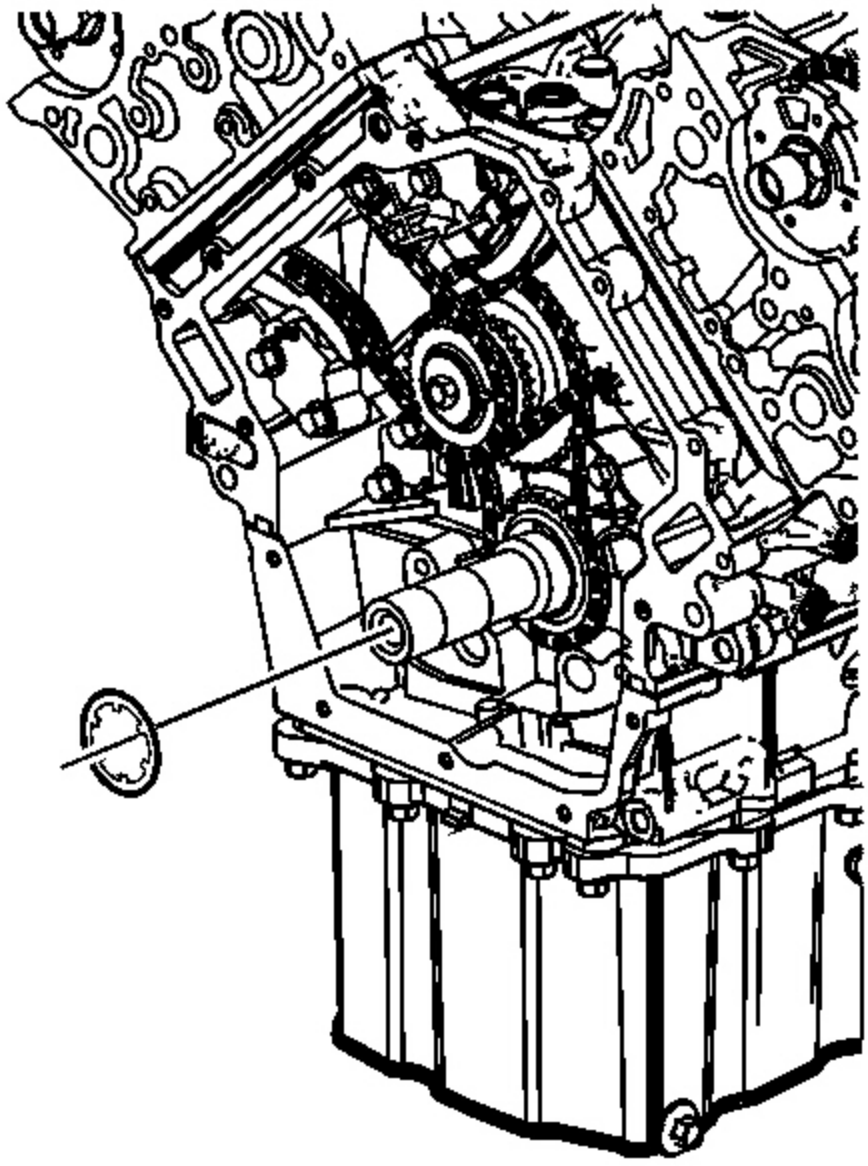


Fig. 209: Identifying Crankshaft To Crankshaft Sprocket Friction Washer
Courtesy of GENERAL MOTORS CORP.

7. Install the crankshaft sprocket to oil pump drive friction washer. The crankshaft sprocket to oil pump drive friction washer outer diameter is 62.0 mm (2.4410 in) and the inner diameter is 45.25 mm (1.7815 in).

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8. Install the oil pump. Refer to **Oil Pump Replacement**.

CAMSHAFT COVER REPLACEMENT - LEFT SIDE

REMOVAL PROCEDURE

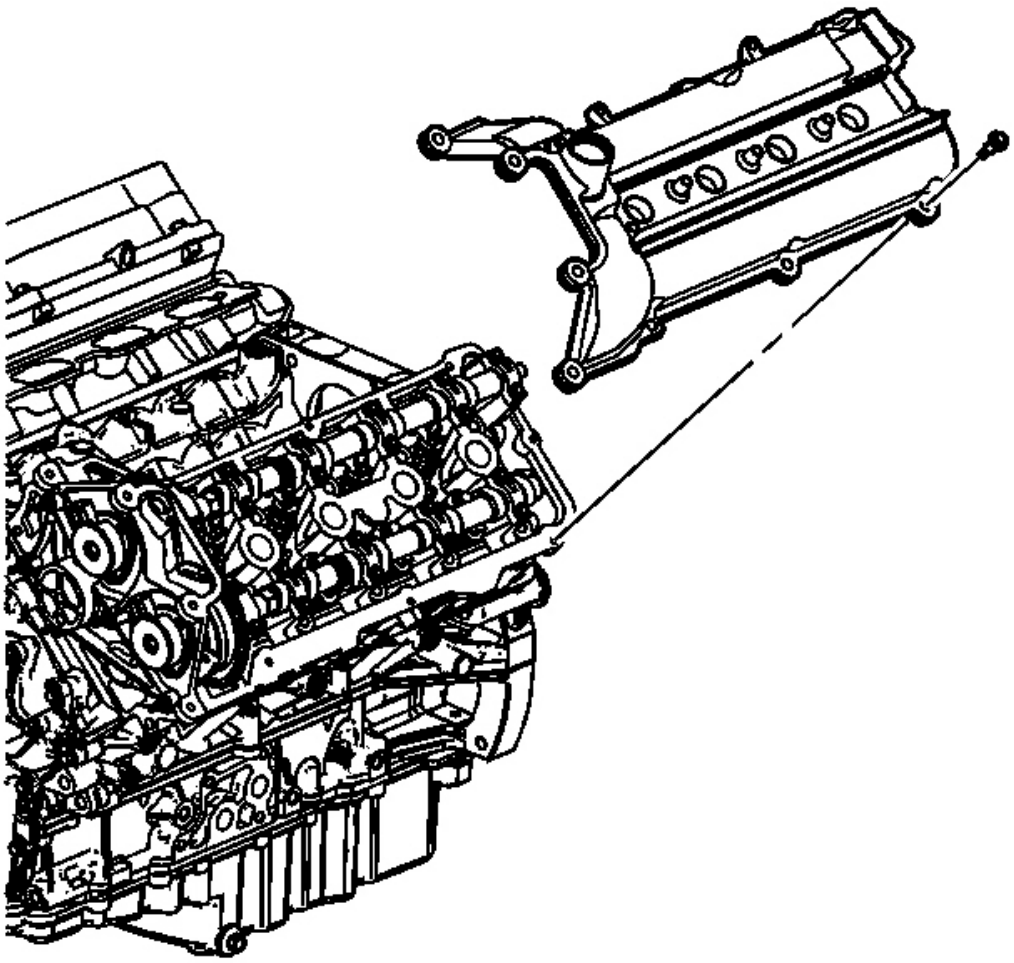


Fig. 210: View Of Left Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**.
2. Disconnect the vacuum hose from the brake booster. Position the hose aside.
3. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

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4. Remove the front section of the supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
5. Disconnect the positive crankcase ventilation (PCV) fresh air tube from the left camshaft cover.
6. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief** .
7. Disconnect the fuel line from the fuel rail. Position the fuel line aside. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** .
8. Disengage the wire harness retainers from the camshaft cover.
9. Remove the left bank ignition coils as an assembly. Refer to **Ignition Coil Replacement - Bank 2** .
10. Remove the bolt connecting the ground strap to the left rear corner of the camshaft cover.
11. Remove the bolt securing the oil level indicator tube to the left cylinder head and reposition the tube away from the camshaft cover.
12. Remove the camshaft cover bolts.
13. Lift the camshaft drive end of the camshaft cover up.
14. Remove the camshaft cover.
15. Discard the camshaft cover gasket and spark plug port seals if there is any evidence of damage or if the seal comes out of the groove in the cover during removal.
16. Clean and inspect the camshaft cover. Refer to **Camshaft Cover Cleaning and Inspection** .

INSTALLATION PROCEDURE

IMPORTANT: Be careful to prevent the exposed section of the camshaft cover gasket from being damaged by the edge of the cylinder head casting.

1. Work the camshaft cover into position by pivoting the cover down and aligning the bolt holes.

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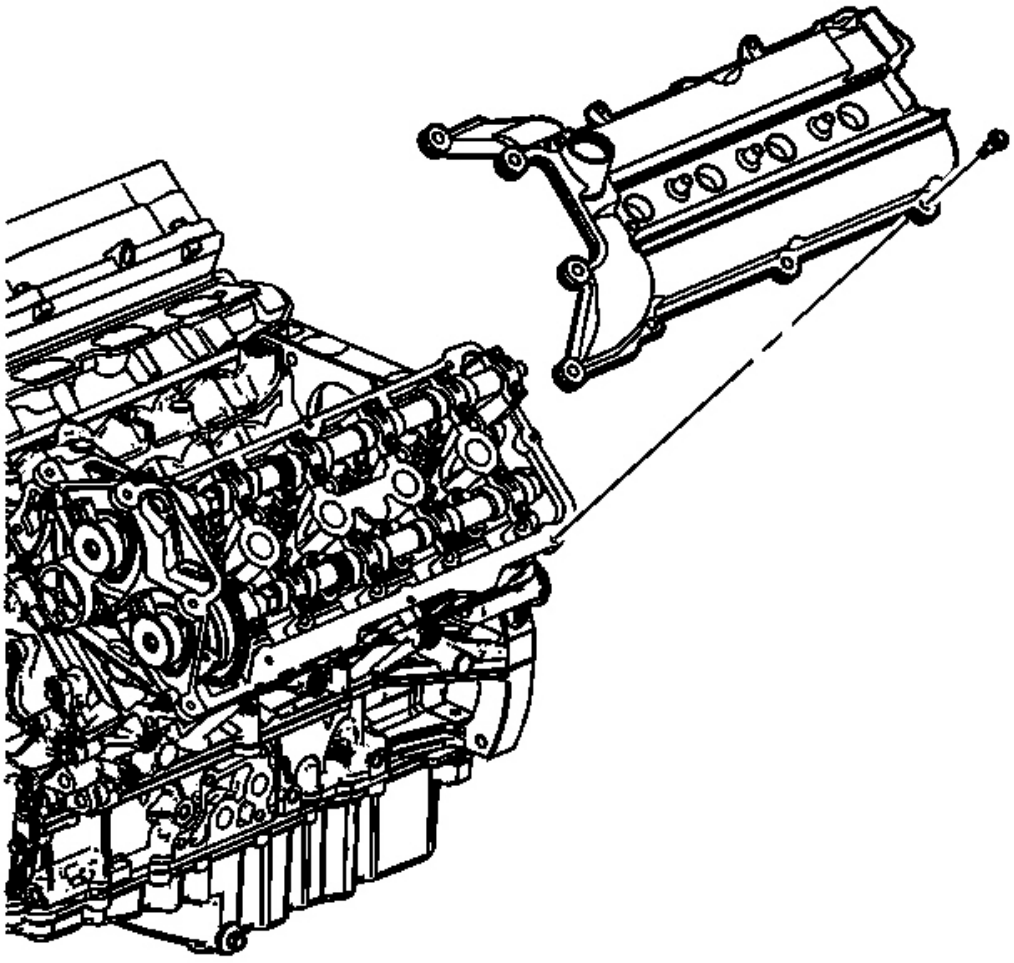


Fig. 211: View Of Left Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

2. Install the camshaft cover bolts installing the ground strap to the camshaft cover.

   Tighten: Tighten the camshaft cover bolts to 10 N.m (89 lb in).

3. Rotate the oil level indicator tube back into its original position and install the bolt securing the tube to the cylinder head.

   Tighten: Tighten the oil level indicator tube bolt to 10 N.m (89 lb in).

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4. Install the left bank ignition coil assembly. Refer to **Ignition Coil Replacement - Bank 2** .
5. Attach the wire harness retainers to the camshaft cover.
6. Connect the fuel line to the fuel rail. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** .
7. Install the PCV fresh air tube to the left camshaft cover.
8. Install the front section of the supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
9. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
10. Connect the vacuum hose to the brake booster.
11. Install the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**.

CAMSHAFT COVER REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

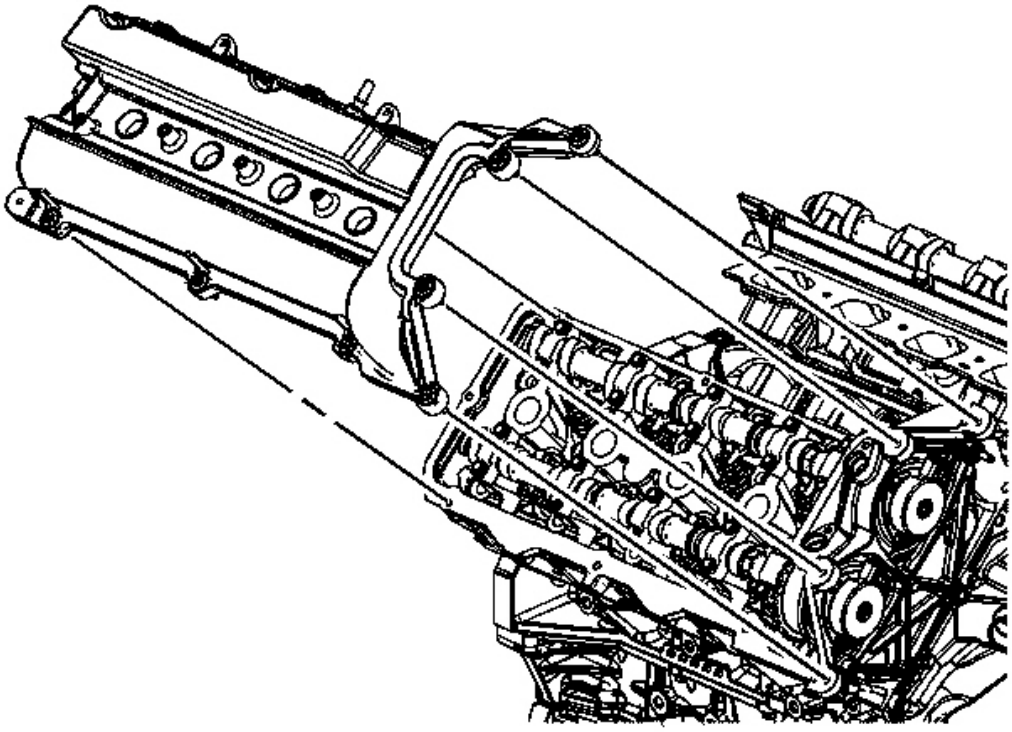


Fig. 212: View Of Right Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

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1. Remove the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**.
2. Remove the front section of the supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
3. Disconnect the PCV dirty air tube from the right side camshaft cover.
4. Remove the right bank ignition coils as an assembly. Refer to **Ignition Coil Replacement - Bank 1** .
5. Disconnect the wire harness clips from the camshaft cover and position the wire harness aside.
6. Remove the bolt connecting the ground strap to the right rear of the camshaft cover.
7. Remove the camshaft cover bolts.
8. Remove the camshaft cover.
9. Discard the camshaft cover gasket and spark plug port seals if there is any evidence of damage or if the seal comes out of the groove in the cover during removal.
10. Clean and inspect the camshaft cover. Refer to **Camshaft Cover Cleaning and Inspection** .

INSTALLATION PROCEDURE

1. Install the camshaft cover gasket as required.

IMPORTANT: Be careful to prevent the exposed section of the camshaft cover seal from being damaged by the edge of the cylinder head casting.

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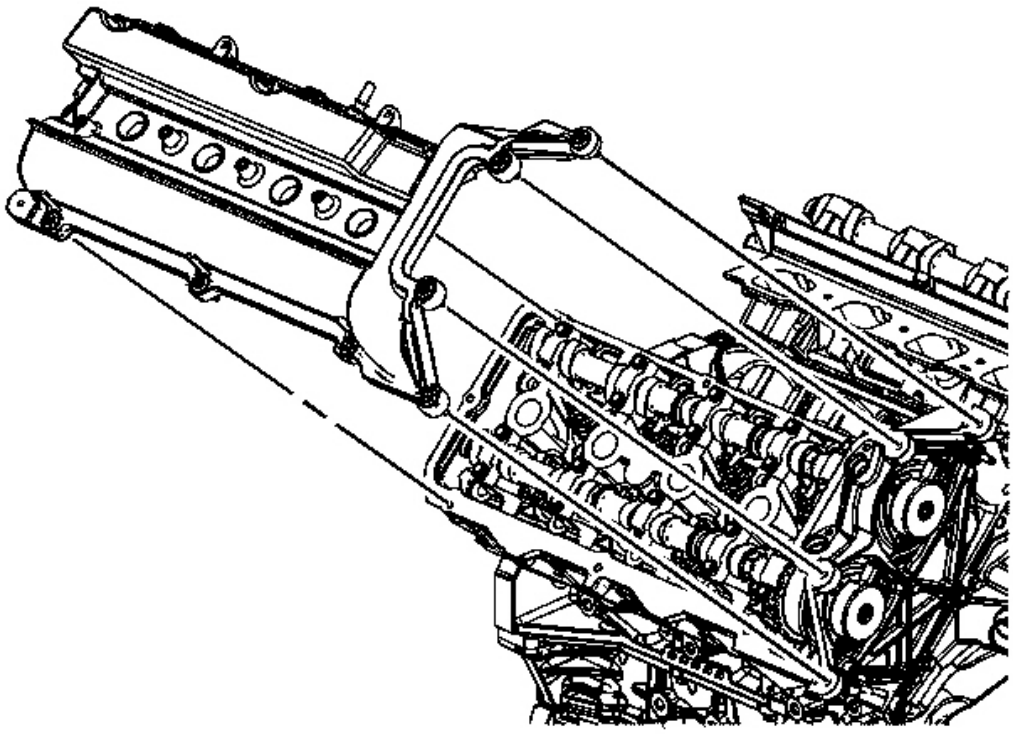


Fig. 213: View Of Right Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the camshaft cover.

NOTE: **Refer to Fastener Notice .**

3. Install the camshaft cover bolts installing the ground strap to the camshaft cover.

Tighten: Tighten the camshaft cover bolts to 10 N.m (89 lb in).

4. Connect the wire harness clips to the camshaft cover.
5. Install the right bank ignition coil assembly. Refer to **Ignition Coil Replacement - Bank 1** .
6. Connect the PCV dirty air tube to the right side camshaft cover.
7. Install the front section of the supercharger inlet duct assembly. Refer to **Supercharger Inlet Duct Assembly Replacement** .
8. Install the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement**.

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CAMSHAFT POSITION ACTUATOR HOUSING REPLACEMENT - LEFT SIDE

REMOVAL PROCEDURE

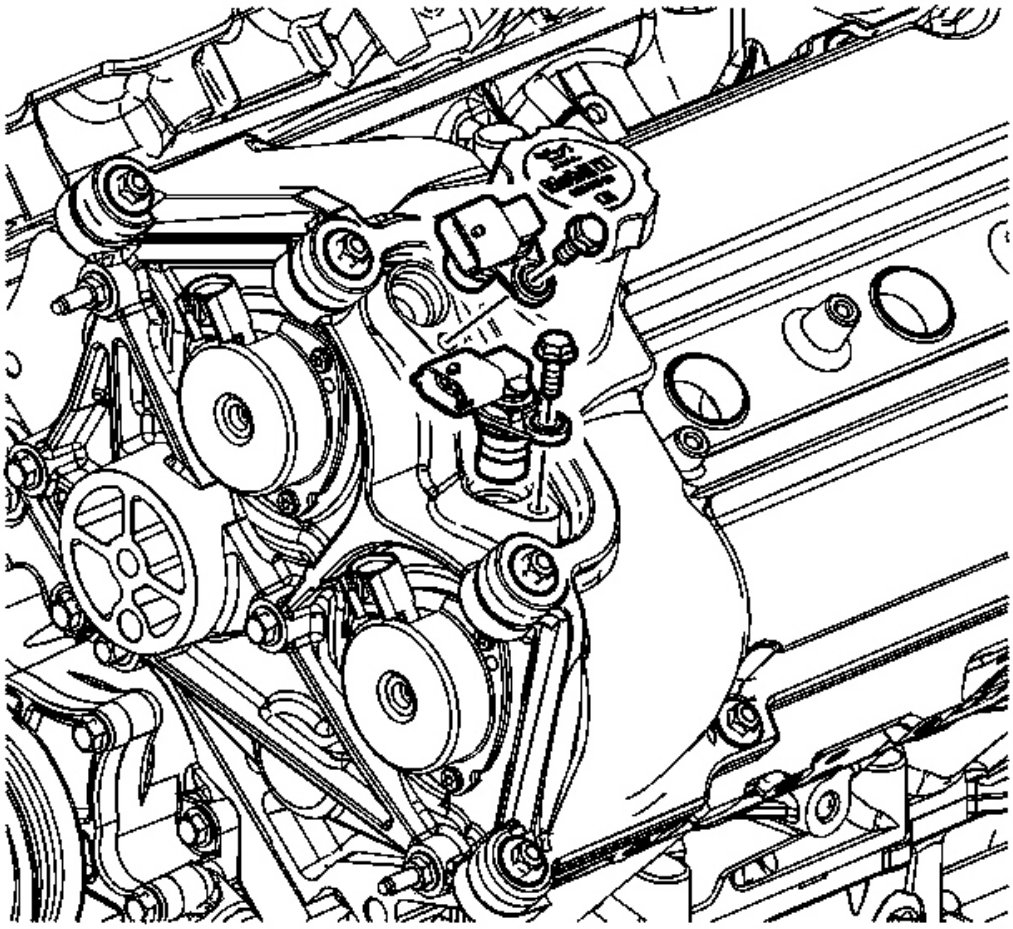


Fig. 214: View Of Left Intake Camshaft Sensor & Left Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the left exhaust camshaft sensor. Refer to **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust** .
2. Remove the left intake camshaft sensor. Refer to **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake** .
3. Remove the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
4. Remove the water pump and generator drive belt tensioner. Refer to **Water Pump and Generator Drive**

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Belt Tensioner Replacement.

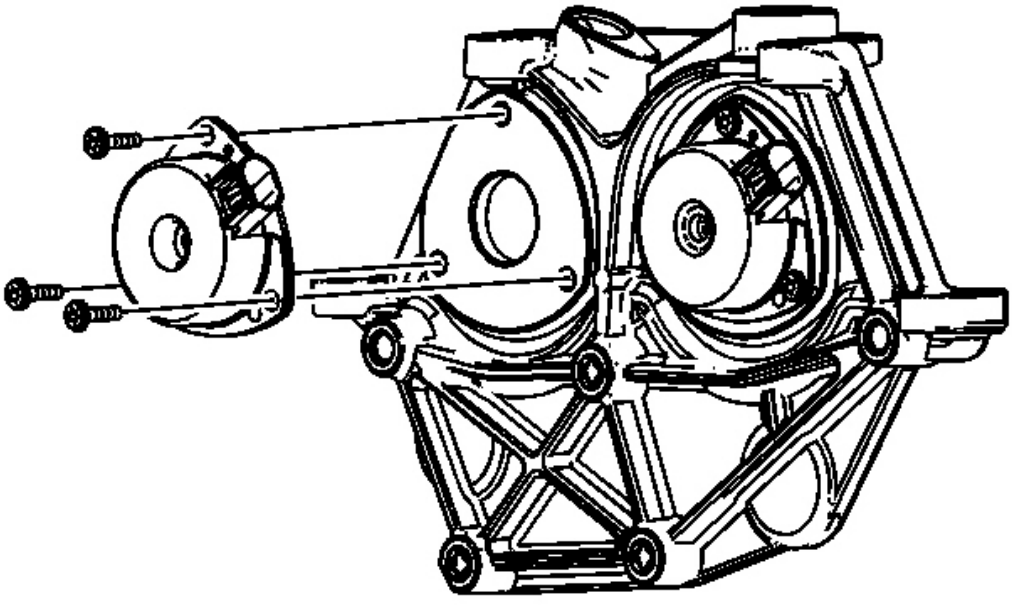


Fig. 215: View Of Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the left intake camshaft position actuator magnet bolts.
6. Remove the left intake camshaft position actuator magnet.
7. Remove the left intake camshaft position actuator magnet alignment plug and discard.
8. Remove the left exhaust camshaft position actuator magnet bolts.
9. Remove the left exhaust camshaft position actuator magnet.
10. Remove the left exhaust camshaft position actuator magnet alignment plug and discard.
11. Remove the wire harness retainers from the actuator housing studs.

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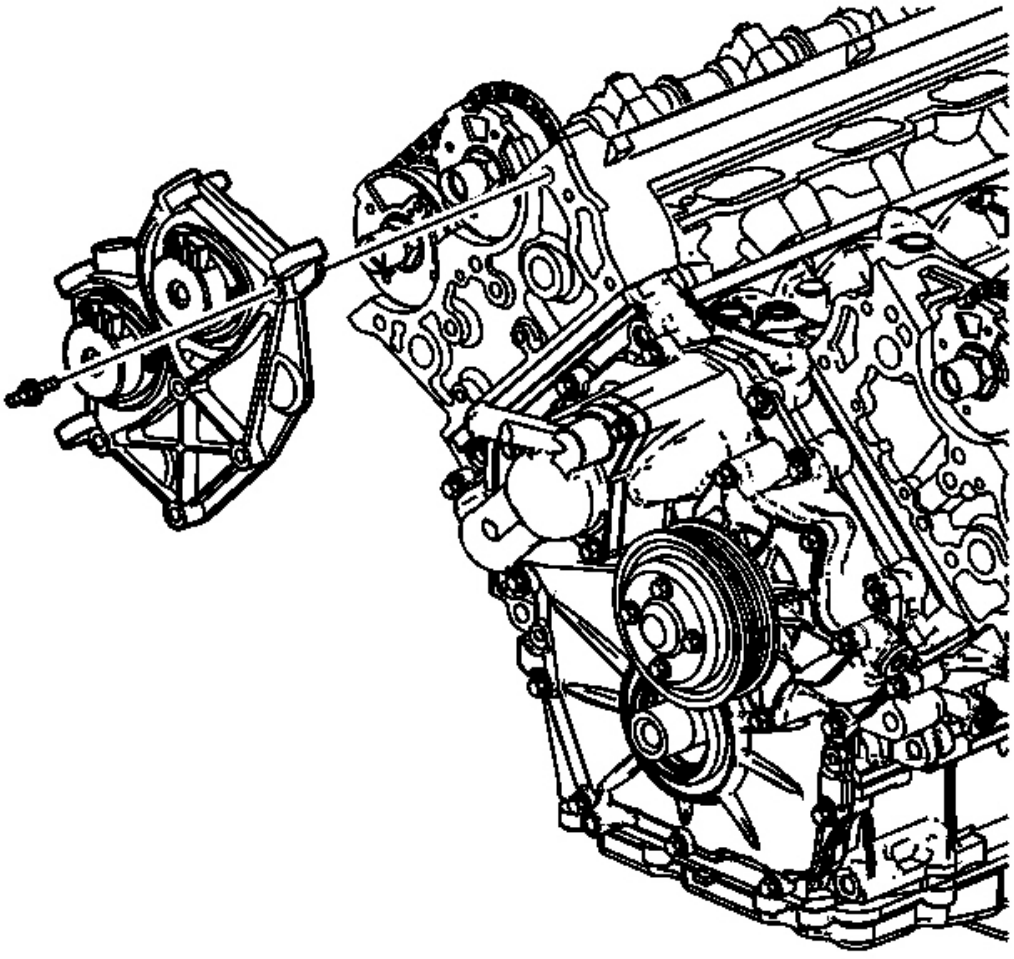


Fig. 216: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

12. Remove the left camshaft position actuator housing bolts.
13. Remove the left camshaft position actuator housing.

INSTALLATION PROCEDURE

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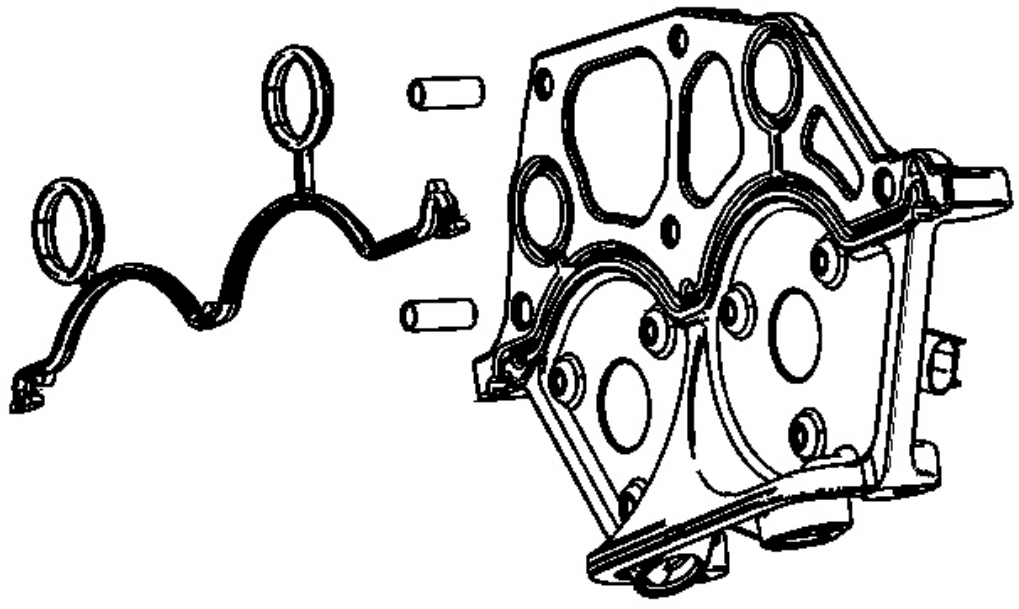


Fig. 217: View Of Camshaft Position Actuator Housing Gasket & Alignment Pins
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW gasket to the camshaft position actuator housing.

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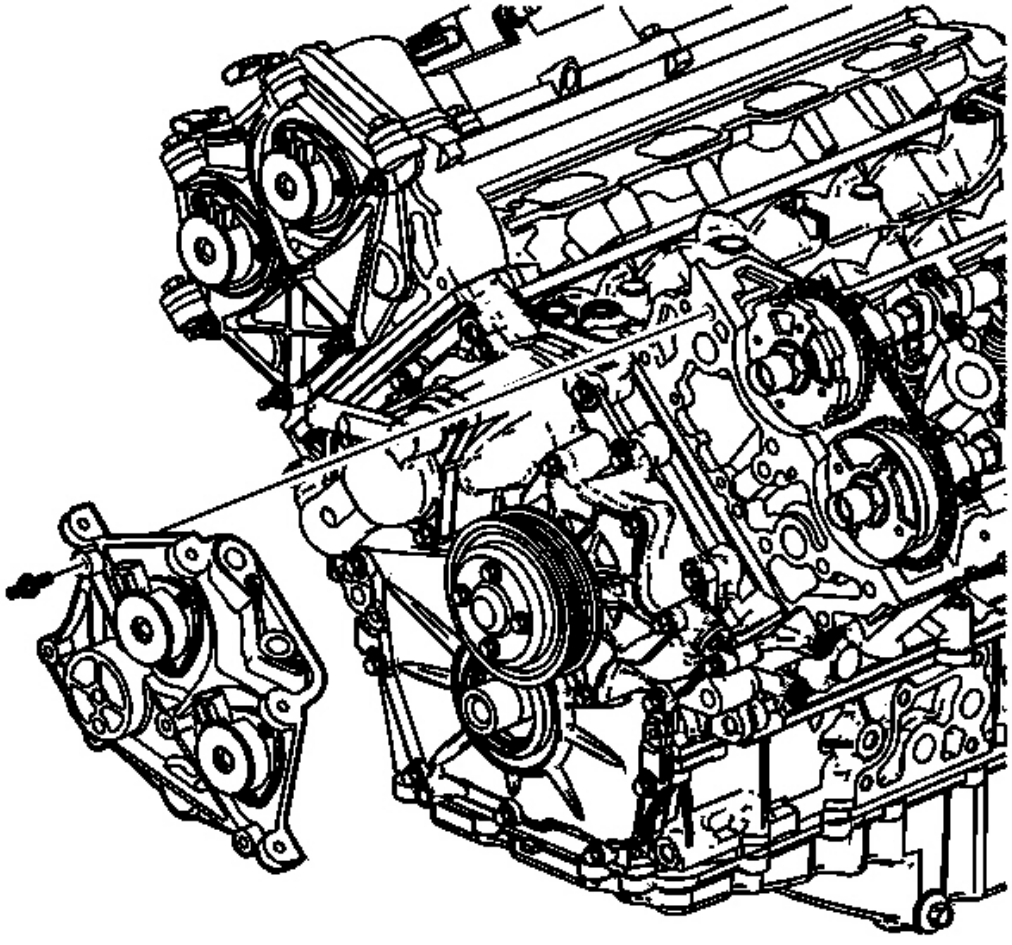


Fig. 218: View Of Left CMP Actuator Housing Removal
Courtesy of GENERAL MOTORS CORP.

2. Install the left camshaft position actuator housing to the left cylinder head.

NOTE: **Refer to Fastener Notice .**

3. Install the actuator housing bolts and studs.

Tighten: Tighten the actuator housing bolts and studs to 10 N.m (89 lb in).

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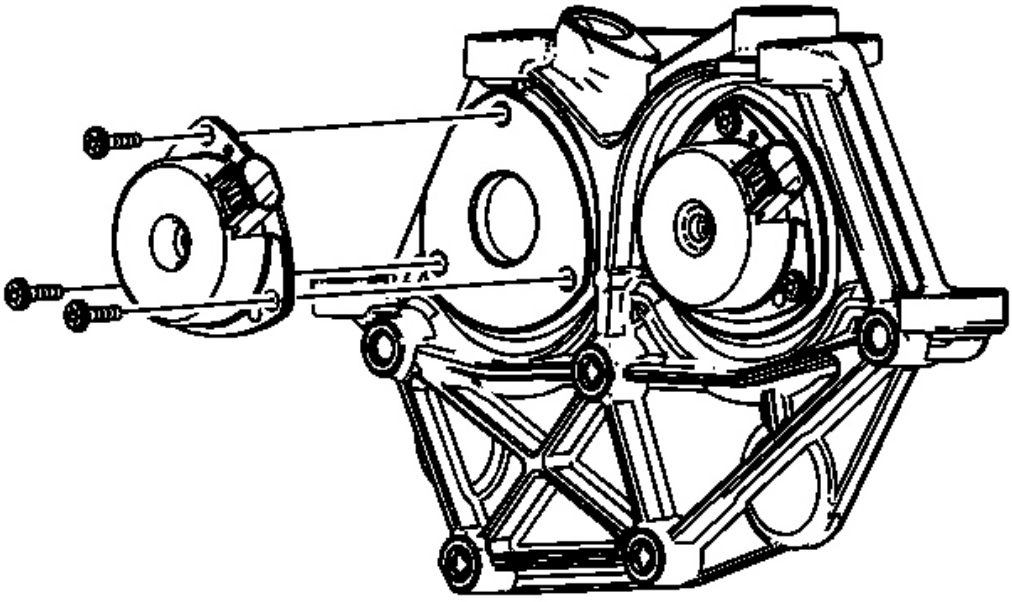


Fig. 219: View Of Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The camshaft position actuator solenoids must be precisely aligned to the camshaft position actuator oil control valves on the end of the camshafts. This is accomplished with an alignment pin. Failure to align the camshaft position actuator solenoids to the camshaft position actuator oil control valves can lead to poor engine performance and engine component concerns.

4. To allow for camshaft position actuator solenoid to camshaft position actuator oil control valve alignment, DO NOT install NEW camshaft position actuator solenoid alignment plugs at this time.
5. Use the following procedure for the camshaft position actuator solenoid alignment:
    1. Make an alignment pin from drill rod 15/64 inch diameter and at least 50 mm (1.97 in) long.
    2. Verify that the alignment pin will pass through the camshaft position actuator solenoid alignment hole.
    3. Verify that the alignment pin will fit into the alignment hole in the camshaft position actuator oil control valve.
    4. Apply a 2 mm (0.079 in) bead of RTV around the flange of the camshaft position actuator solenoid. Refer to **Sealers, Adhesives and Lubricants** for the correct part number.
    5. Install the camshaft position actuator solenoid over the oil control valve.

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6. Install the alignment pin through the solenoid alignment hole and into the oil control valve alignment hole.
7. With the alignment pin in place, install the camshaft position actuator solenoid bolts.

   Tighten: Tighten the camshaft position actuator solenoid bolts to 8 N.m (71 lb in).

8. Remove the alignment pin.
9. Install a NEW camshaft position actuator solenoid plug.
10. Repeat this alignment procedure for the exhaust camshaft position actuator solenoid.

6. Install the wire harness retainers to the actuator housing studs.
7. Install the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.

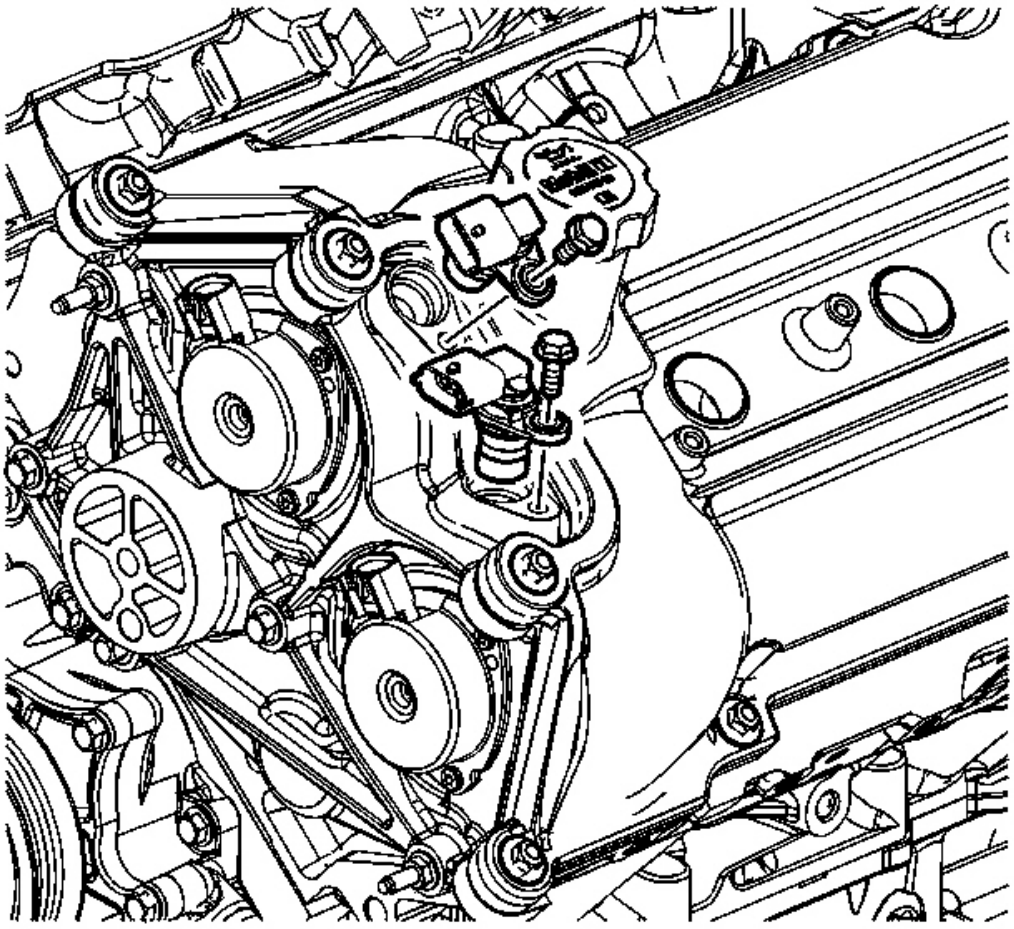


Fig. 220: View Of Left Intake Camshaft Sensor & Left Exhaust Camshaft Sensor

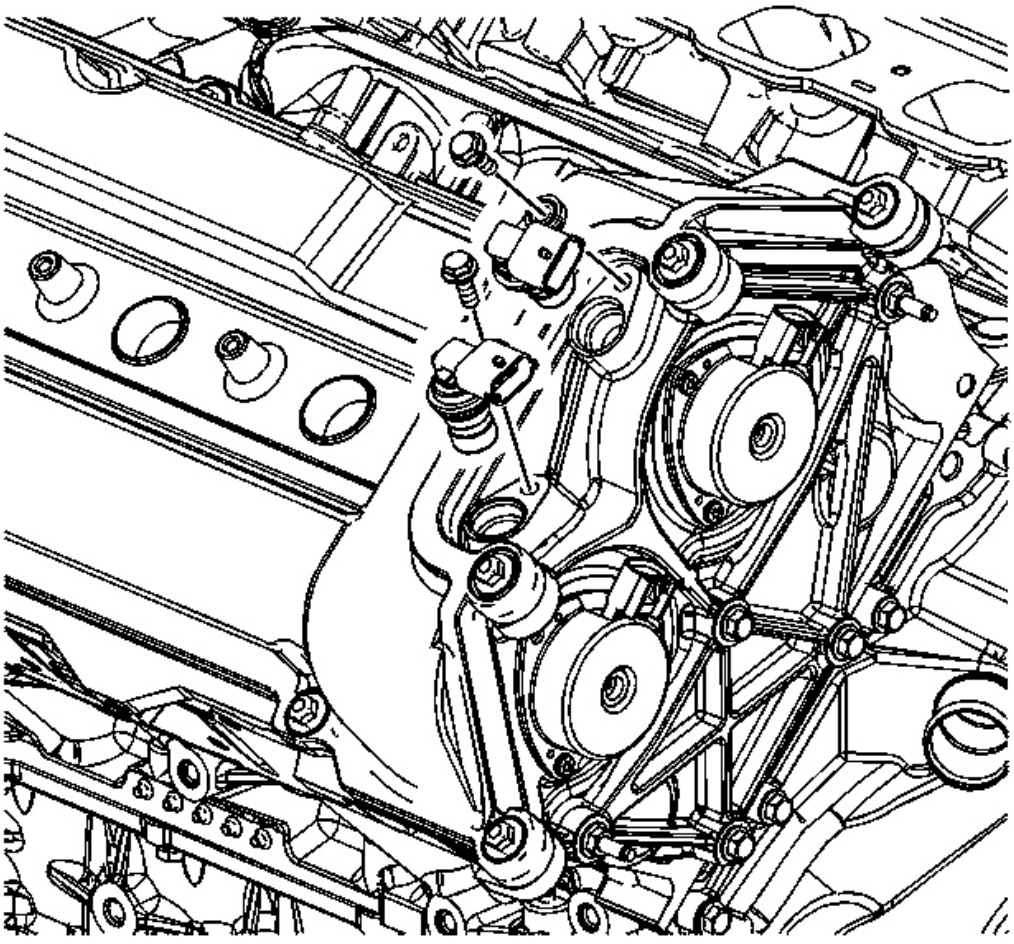
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Courtesy of GENERAL MOTORS CORP.

8. Install the left intake camshaft sensor. Refer to **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake** .
9. Install the left exhaust camshaft sensor. Refer to **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust** .
10. Install the water pump and generator drive belt tensioner. Refer to **Water Pump and Generator Drive Belt Tensioner Replacement**.

CAMSHAFT POSITION ACTUATOR HOUSING REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE



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Fig. 221: View Of Right Intake Camshaft Sensor & Right Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the right exhaust camshaft sensor. Refer to **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust** .
2. Remove the right intake camshaft sensor. Refer to **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake** .
3. Remove the wire harness retainers from the actuator housing studs. Position the wire harness aside.
4. Remove the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.
5. Remove the supercharger drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Supercharger**.
6. Remove the power steering reservoir. Refer to **Remote Power Steering Fluid Reservoir Replacement** .

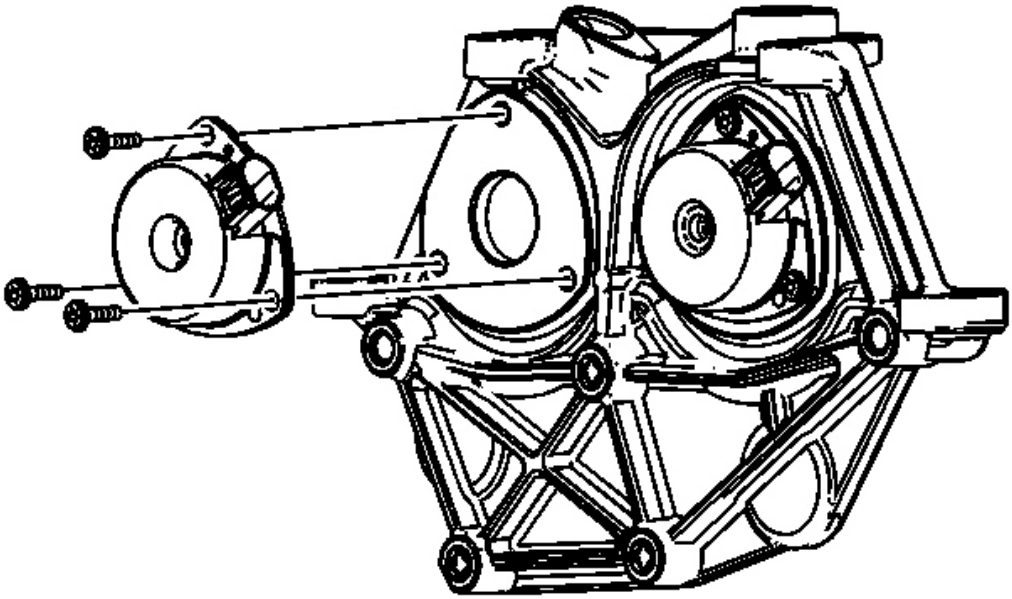


Fig. 222: View Of Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the right intake camshaft position actuator magnet bolts.
8. Remove the right intake camshaft position actuator magnet.
9. Remove the right intake camshaft position actuator magnet alignment plug and discard.
10. Remove the right exhaust camshaft position actuator magnet bolts.
11. Remove the right exhaust camshaft position actuator magnet.

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12. Remove the right exhaust camshaft position actuator magnet alignment plug and discard.

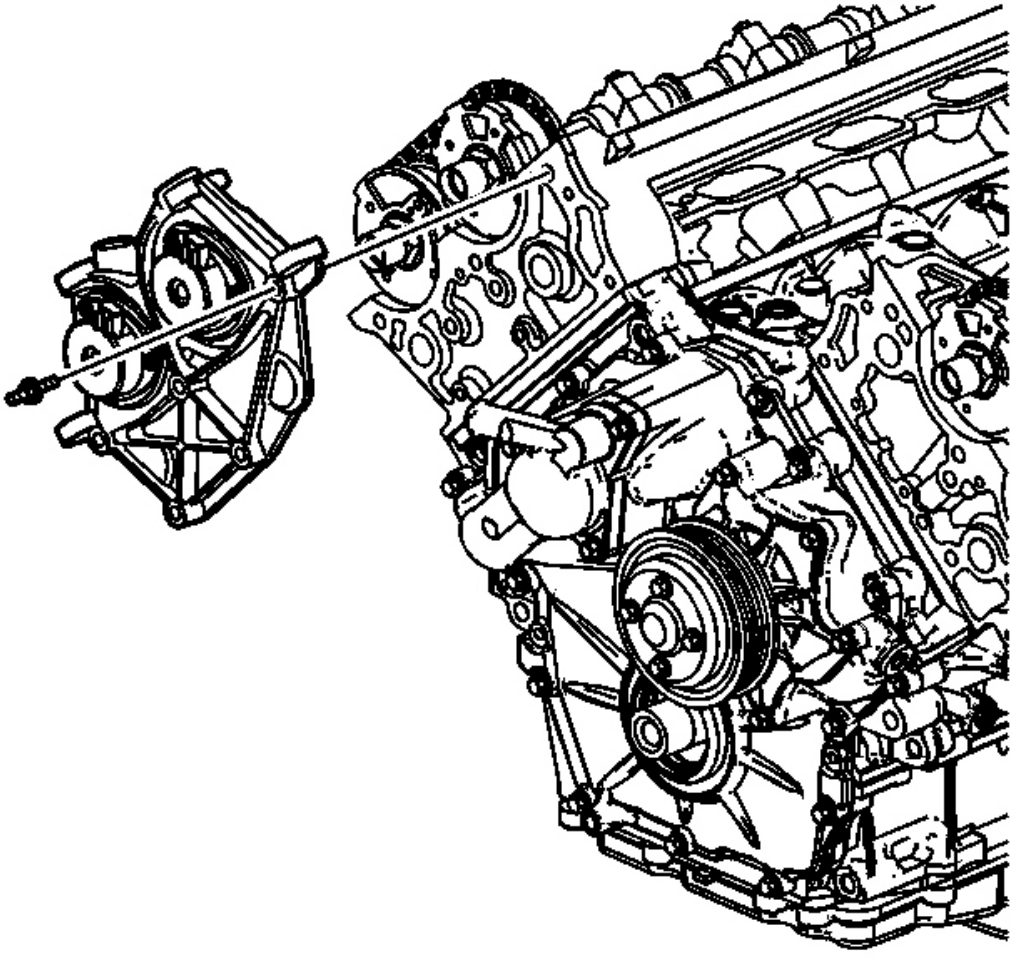


Fig. 223: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

13. Remove the right camshaft position actuator housing bolts.
14. Remove the right camshaft position actuator housing.

INSTALLATION PROCEDURE

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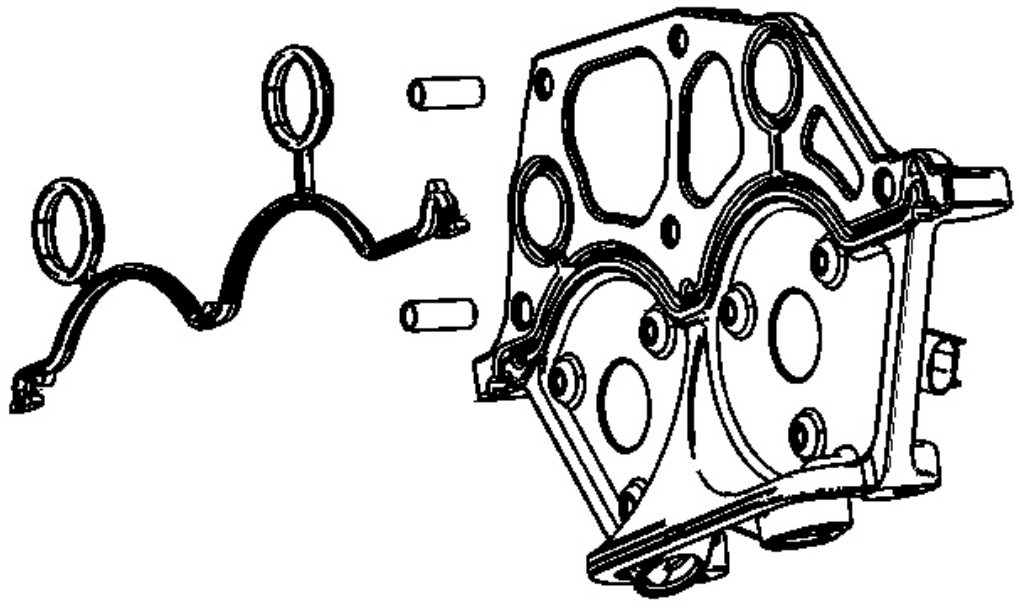


Fig. 224: View Of Camshaft Position Actuator Housing Gasket & Alignment Pins
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW gasket to the camshaft position actuator housing.

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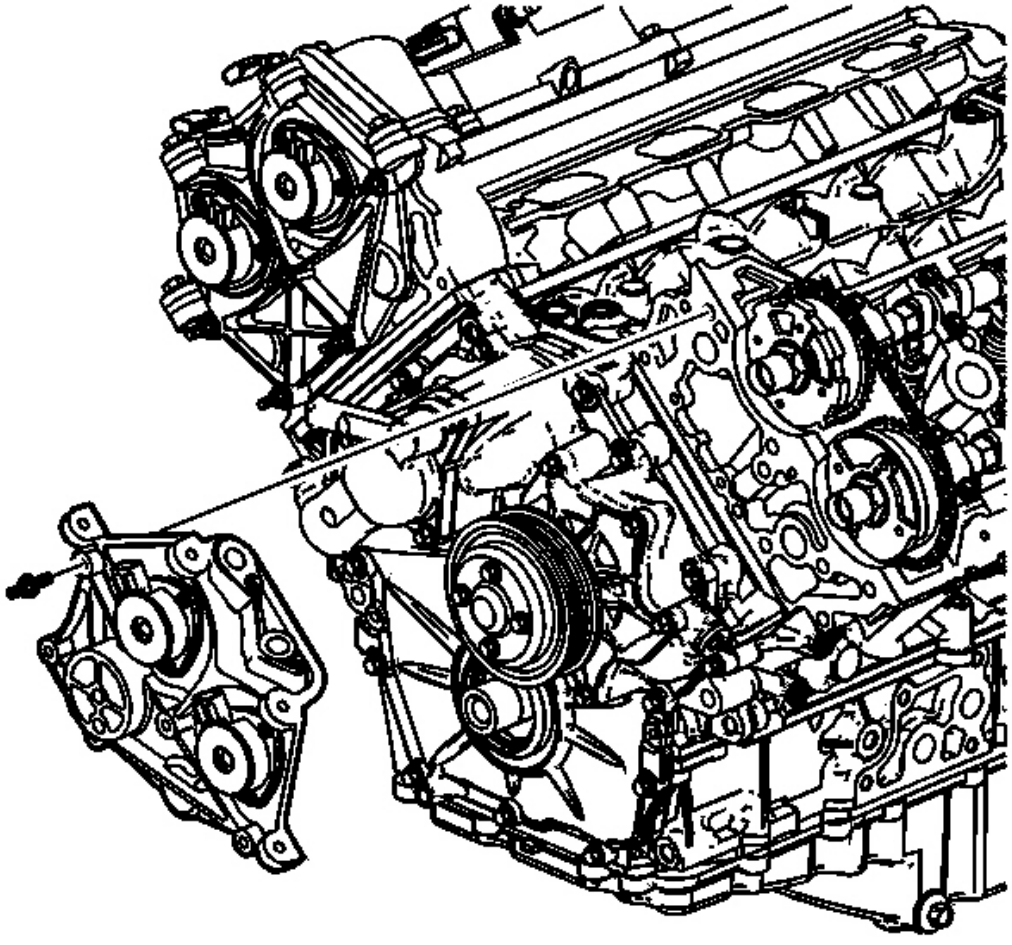


Fig. 225: View Of Left CMP Actuator Housing Removal
Courtesy of GENERAL MOTORS CORP.

2. Install the right camshaft position actuator housing to the right cylinder head.

NOTE: **Refer to Fastener Notice .**

3. Install the actuator housing bolts and studs.

Tighten: Tighten the actuator housing bolts and studs to 10 N.m (89 lb in).

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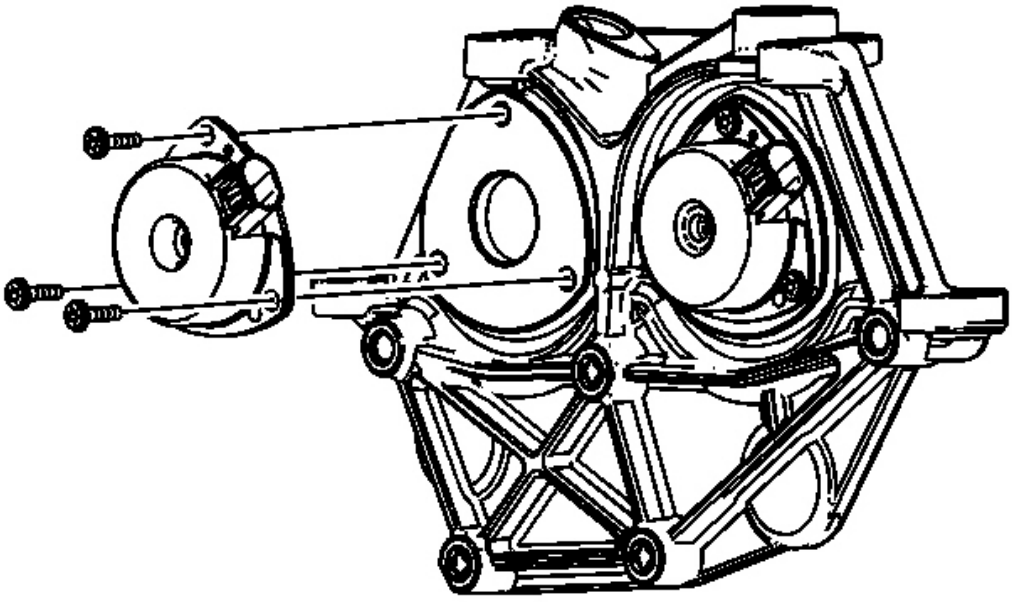


Fig. 226: View Of Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The camshaft position actuator solenoids must be precisely aligned to the camshaft position actuator oil control valves on the end of the camshafts. This is accomplished with an alignment pin. Failure to align the camshaft position actuator solenoids to the camshaft position actuator oil control valves can lead to poor engine performance and engine component concerns.

4. To allow for camshaft position actuator solenoid to camshaft position actuator oil control valve alignment, DO NOT install NEW camshaft position actuator solenoid alignment plugs at this time.
5. Use the following procedure for the camshaft position actuator solenoid alignment:
    1. Make an alignment pin from drill rod 15/64 inch diameter and at least 50 mm (1.97 in) long.
    2. Verify that the alignment pin will pass through the camshaft position actuator solenoid alignment hole.
    3. Verify that the alignment pin will fit into the alignment hole in the camshaft position actuator oil control valve.
    4. Apply a 2 mm (0.079 in) bead of RTV around the flange of the camshaft position actuator solenoid. Refer to **Sealers, Adhesives and Lubricants** for the correct part number.
    5. Install the camshaft position actuator solenoid over the oil control valve.

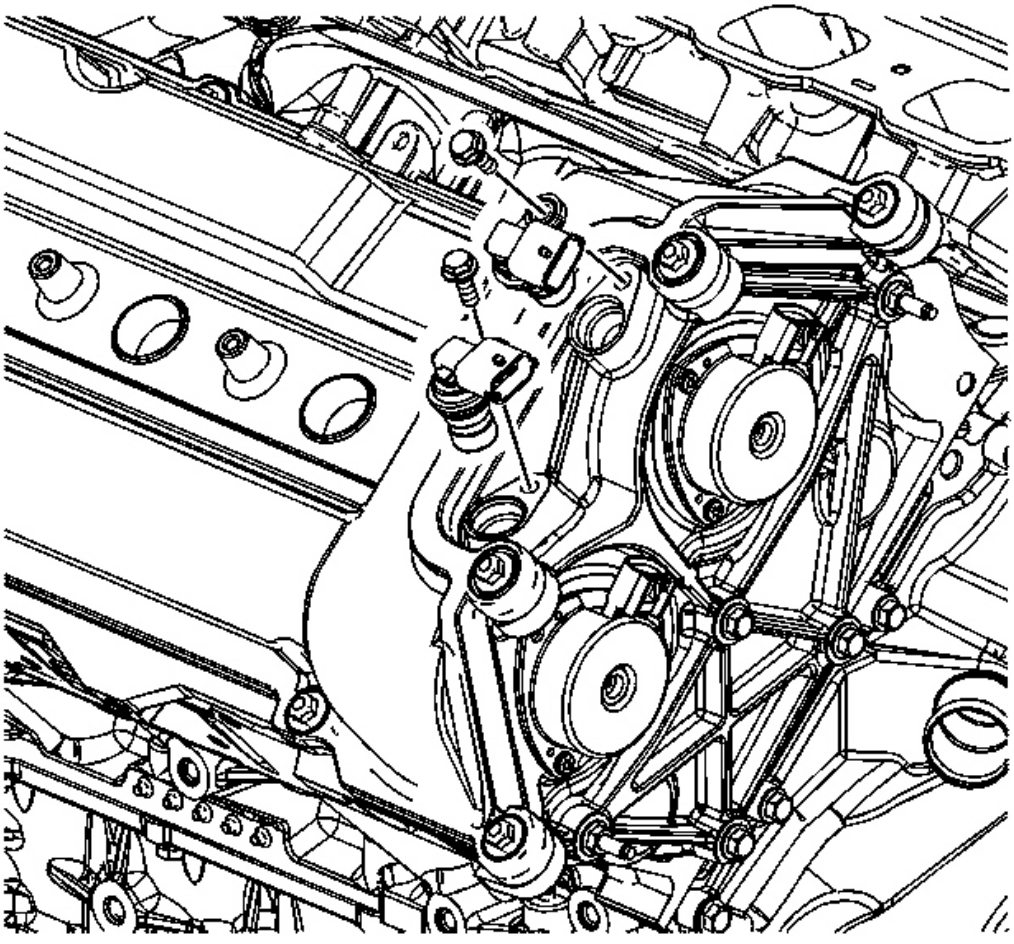
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6. Install the alignment pin through the solenoid alignment hole and into the oil control valve alignment hole.
7. With the alignment pin in place, install the camshaft position actuator solenoid bolts.

   Tighten: Tighten the camshaft position actuator solenoid bolts to 8 N.m (71 lb in).

8. Remove the alignment pin.
9. Install a NEW camshaft position actuator solenoid plug.
10. Repeat this alignment procedure for the exhaust camshaft position actuator solenoid.

6. Install the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.
7. Install the wire harness retainers to the actuator housing studs.



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Fig. 227: View Of Right Intake Camshaft Sensor & Right Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

8. Install the right intake camshaft sensor. Refer to **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake** .
9. Install the right exhaust camshaft sensor. Refer to **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust** .
10. Install the supercharger drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Supercharger**.
11. Install the power steering reservoir. Refer to **Remote Power Steering Fluid Reservoir Replacement** .

SECONDARY CAMSHAFT DRIVE CHAIN REPLACEMENT - LEFT SIDE

TOOLS REQUIRED

- **J 39946** Crankshaft Socket. See **Special Tools** .
- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the right secondary timing chain. Refer to **Secondary Camshaft Drive Chain Replacement - Right Side**.

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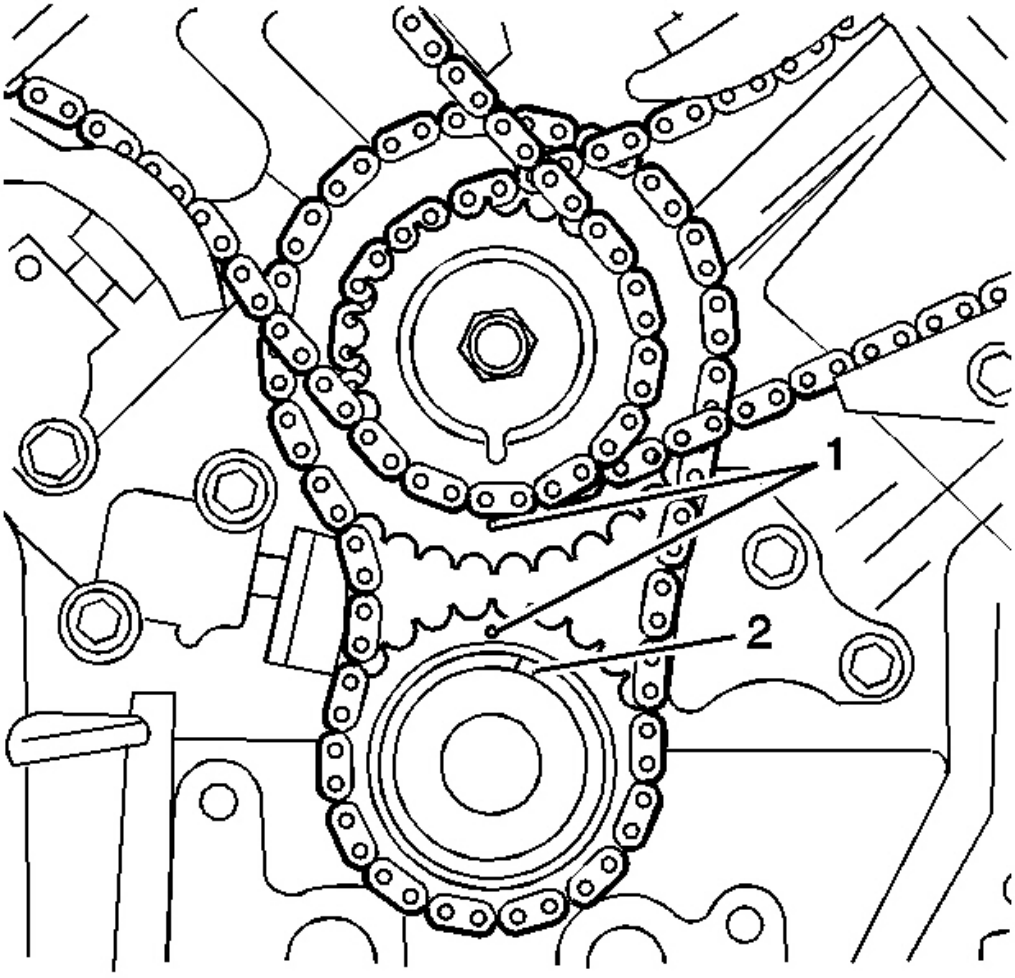


Fig. 228: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

2. Using the **J 39946** , rotate the crankshaft until the primary timing gear alignment marks (1) are adjacent to each other as shown. See **Special Tools** .
3. Remove the left camshaft position actuator housing. DO NOT remove the actuator solenoids from the housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side**.

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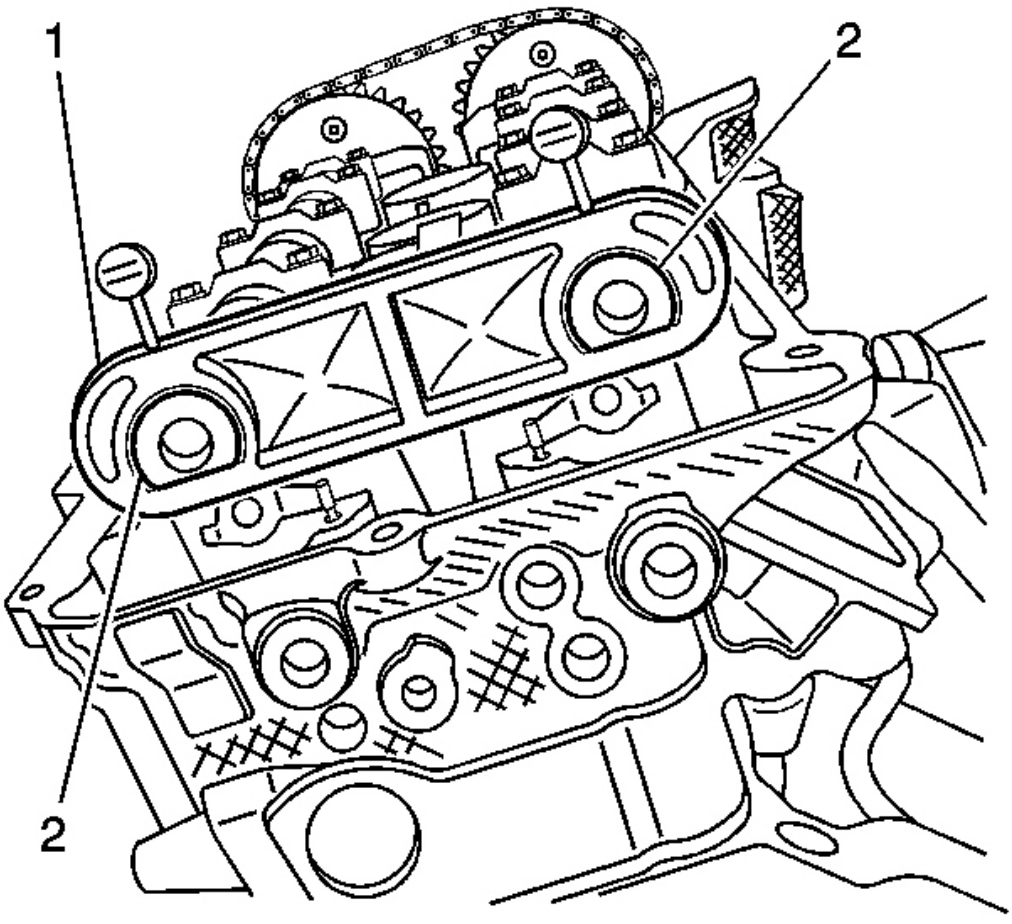


Fig. 229: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution .

4. Install the **EN 46328** (1) on the bank 2 (left) camshafts (2). See **Special Tools** .

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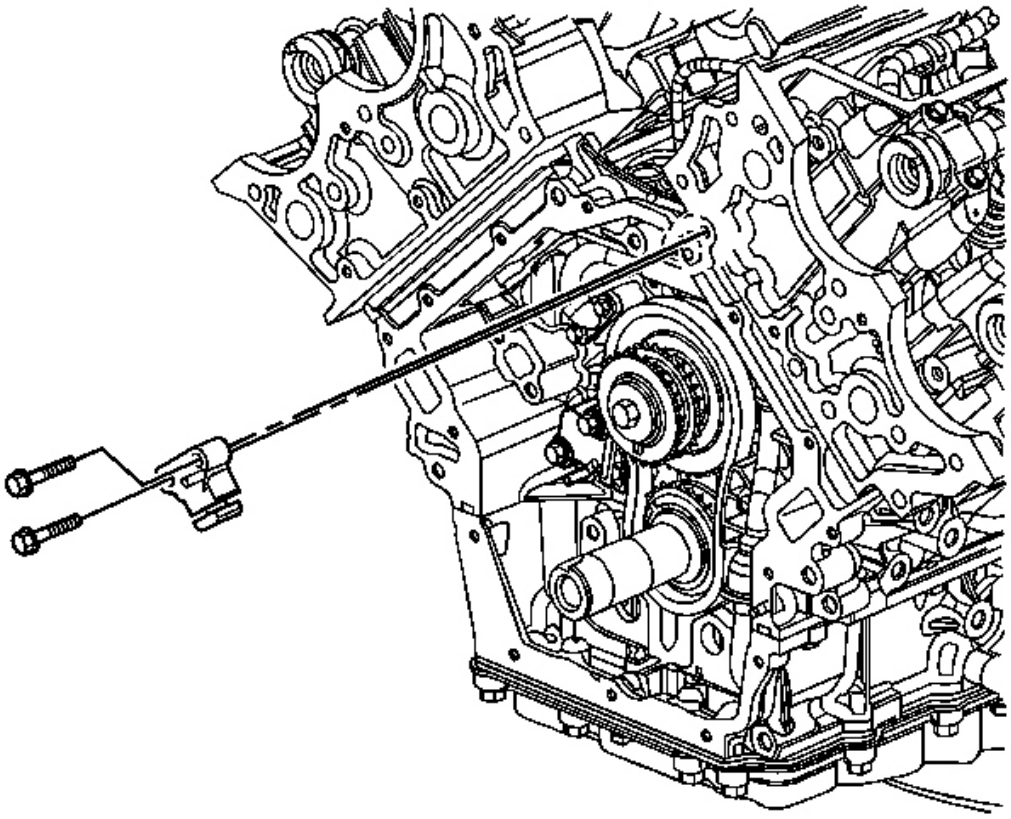


Fig. 230: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Loosen and remove the left secondary timing chain tensioner bolts and tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left Side**.

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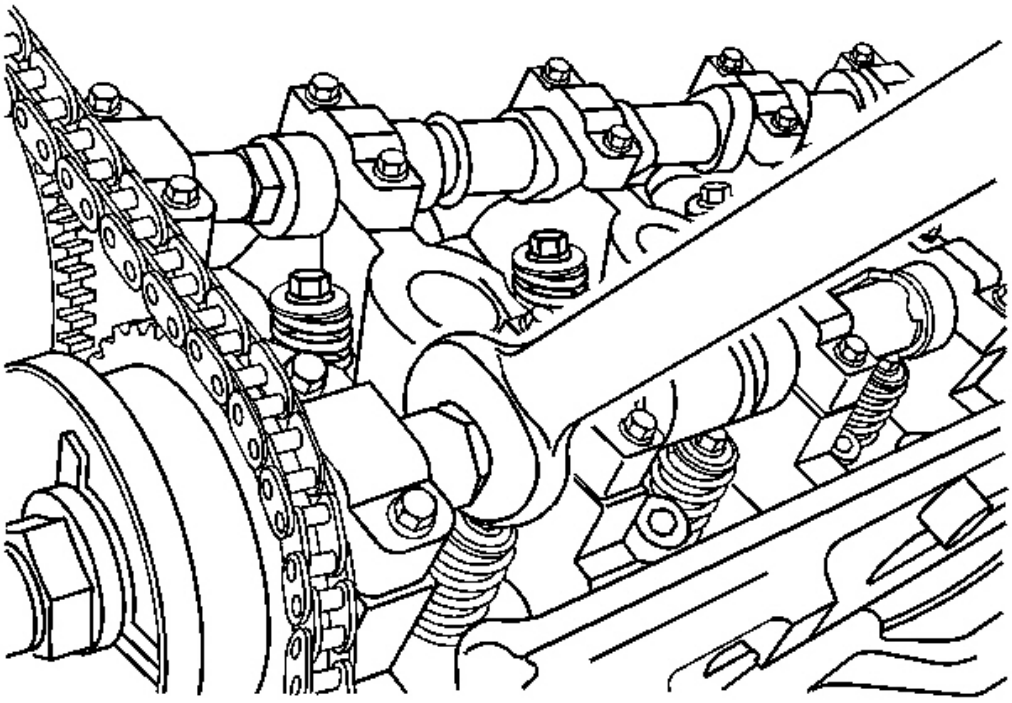


Fig. 231: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

6. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft oil control valve.
7. Loosen and remove the bank 2 (left) exhaust camshaft position oil control valve.
8. Slide the left exhaust camshaft position actuator off of the camshaft and remove the secondary timing chain from the camshaft actuator teeth.

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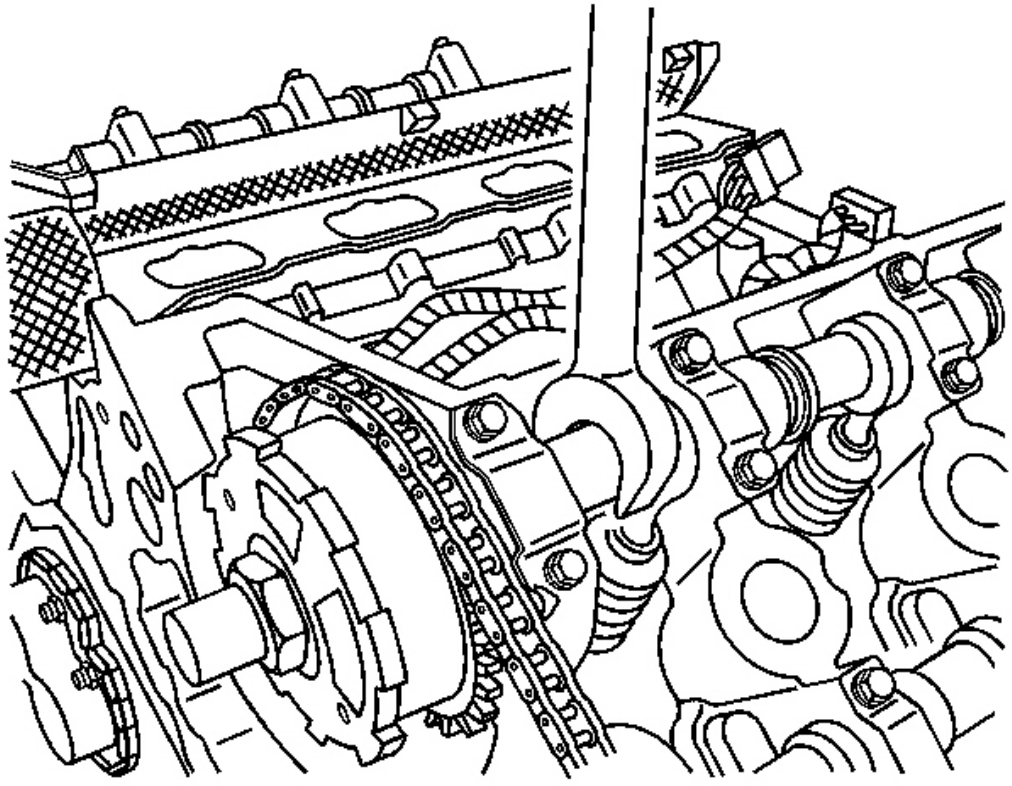


Fig. 232: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

9. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft oil control valve.
10. Loosen and remove the bank 2 (left) intake camshaft position oil control valve.
11. Slide the left intake camshaft position actuator off of the camshaft and remove the secondary timing chain from the camshaft actuator teeth.
12. Remove the left secondary timing chain from the engine.
13. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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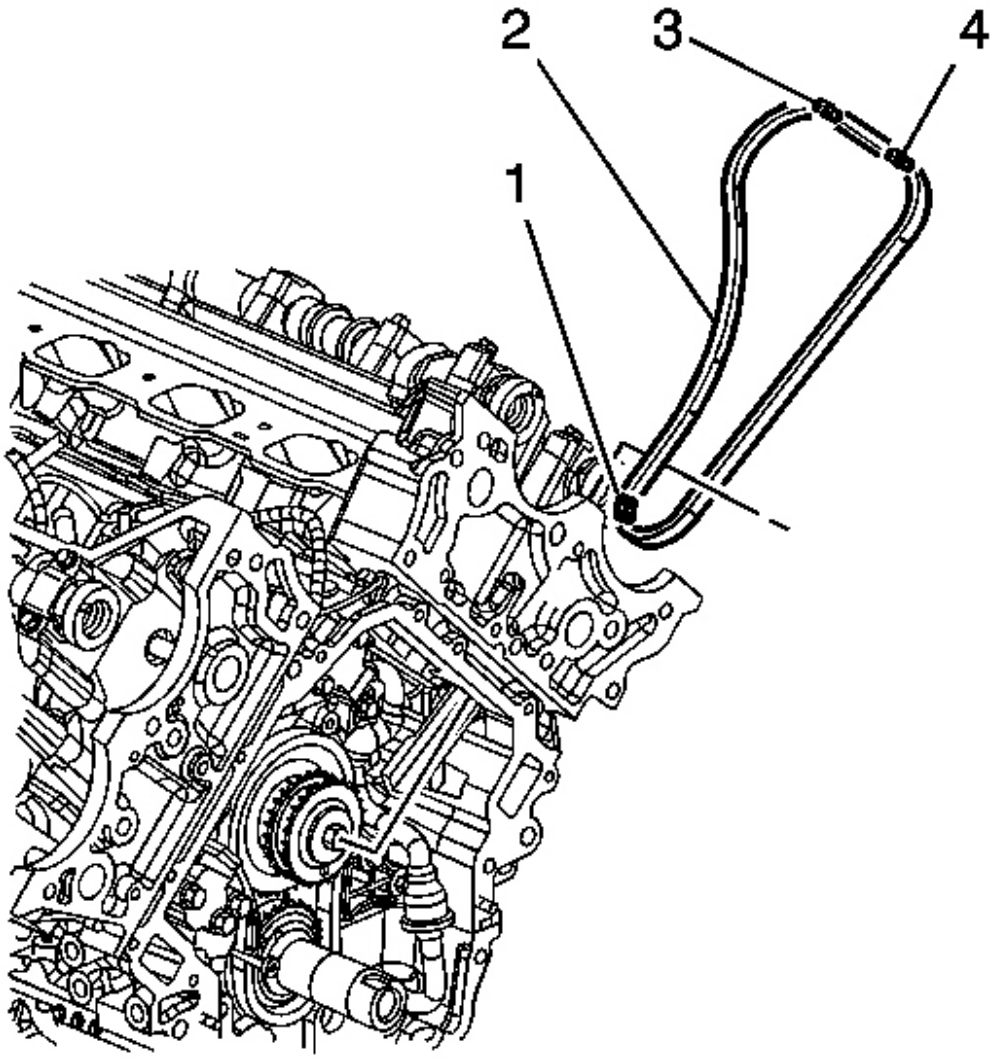


Fig. 233: Identifying Secondary Timing Chain Timing Marks
Courtesy of GENERAL MOTORS CORP.

1. The secondary timing chain (2) has 3 black links that aid in timing the camshaft position actuators to the intermediate sprocket.
2. The black link (4) is aligned with the bank 2 exhaust actuator timing mark. The black link (3) is aligned with the bank 2 intake actuator timing mark.
3. The black link (1) is aligned with the intermediate sprocket.

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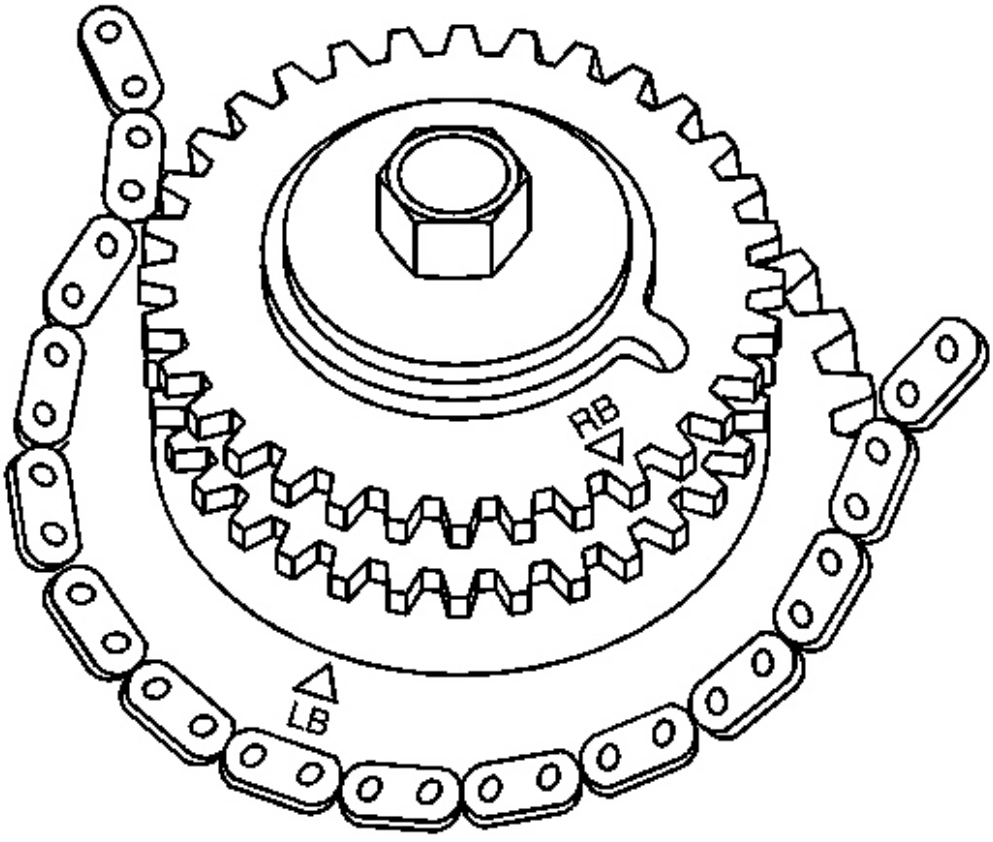


Fig. 234: Aligning Sprocket LB Timing Mark To Timing Chain Black Link
Courtesy of GENERAL MOTORS CORP.

4. The intermediate sprocket left bank timing mark is labeled left bank (LB) as shown.
5. Assemble the secondary timing chain to the intermediate sprocket aligning the sprocket LB timing mark to the timing chain black link.

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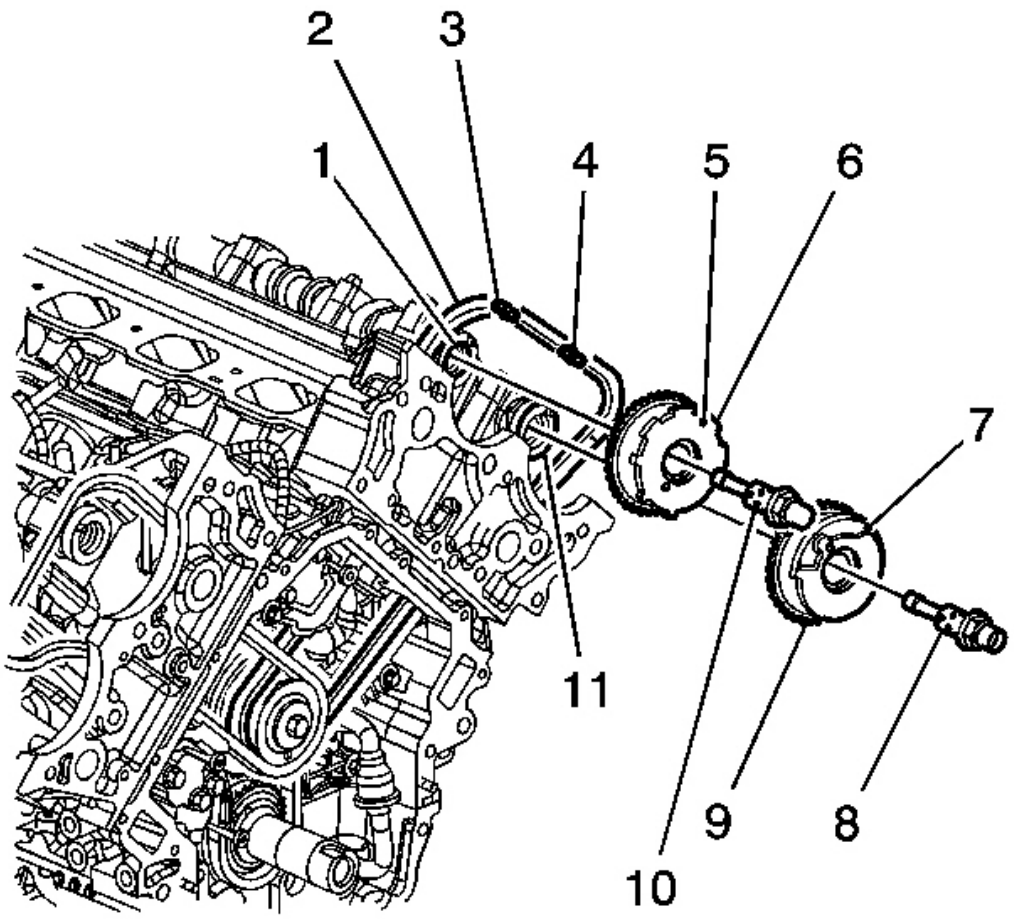


Fig. 235: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

6. Align the timing mark (5) of the LB intake camshaft position actuator with the timing chain black link (3) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface at the top of its rotation.
7. Loosely install the oil control valve (10) to secure the intake actuator.

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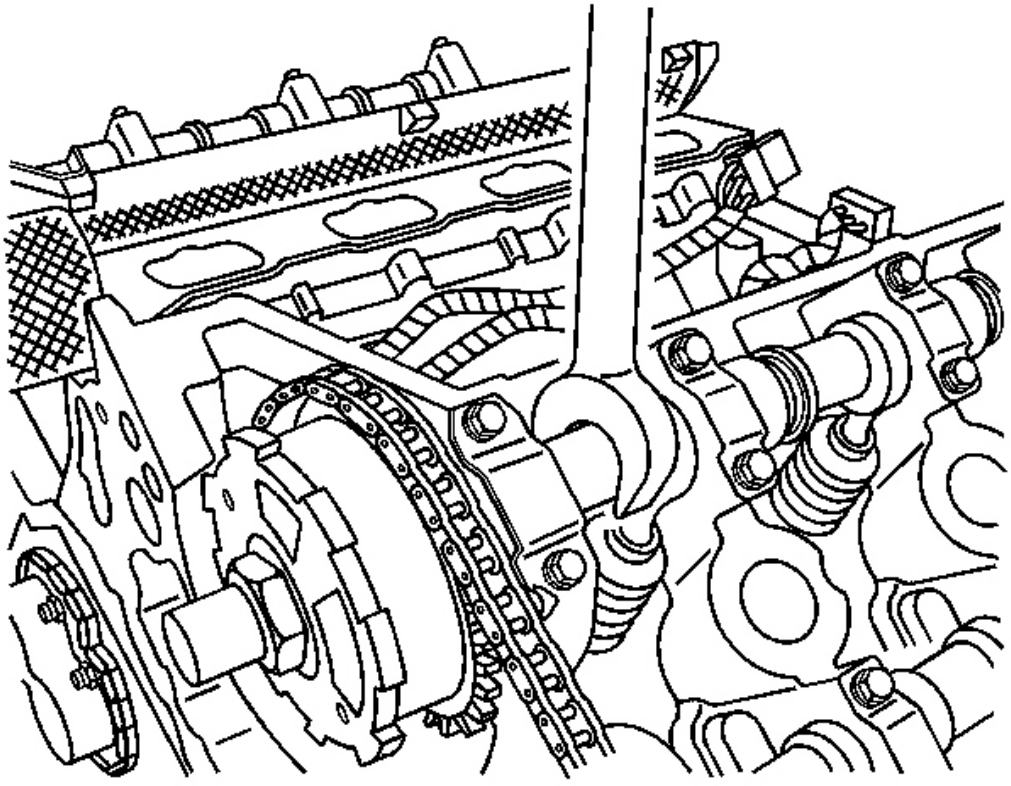


Fig. 236: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice .**

NOTE: **Refer to Fastener Notice .**

8. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

   Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

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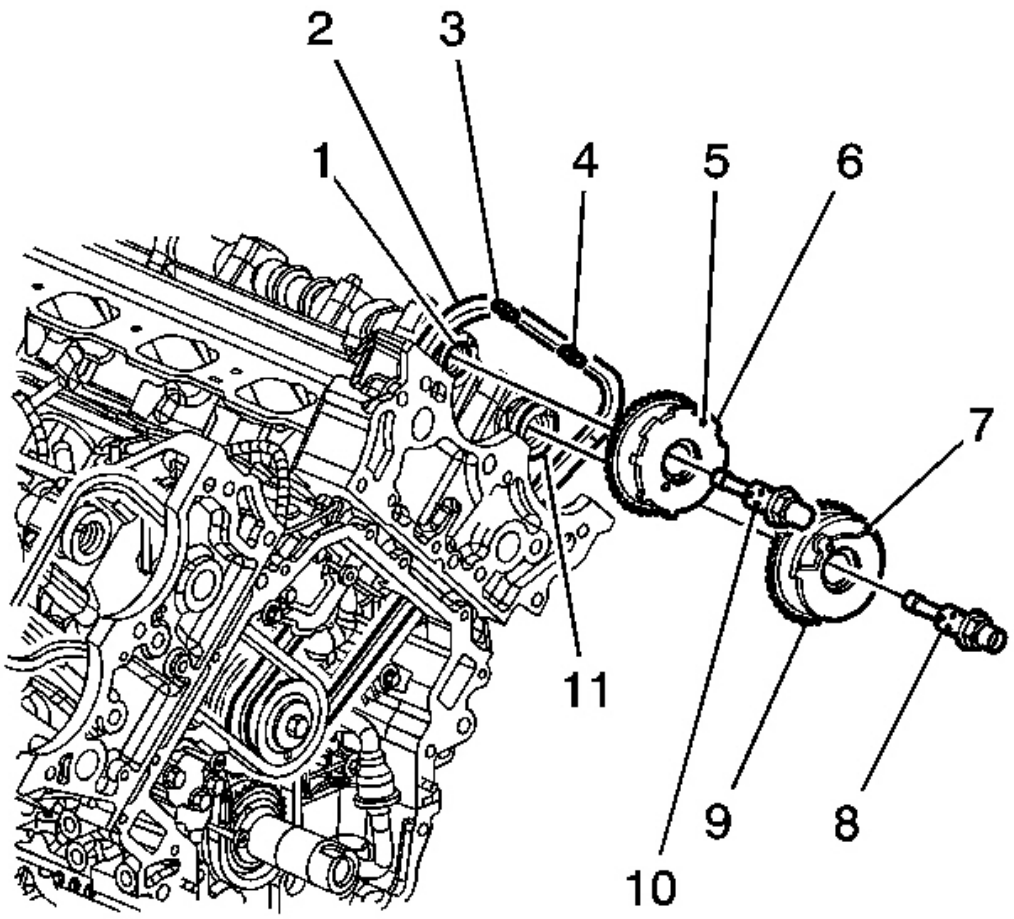


Fig. 237: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

9. Align the timing mark (7) of the LB exhaust camshaft position actuator with the timing chain black link (4) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface at the top of its rotation.
10. Loosely install the oil control valve (8) to secure the exhaust actuator.

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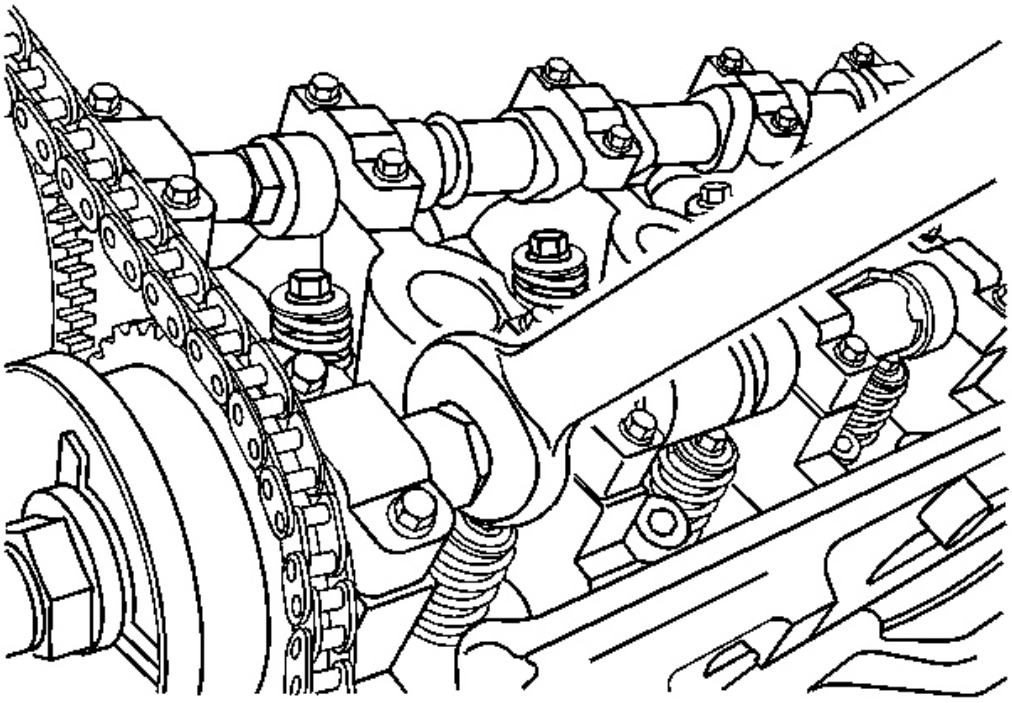


Fig. 238: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

11. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

    Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

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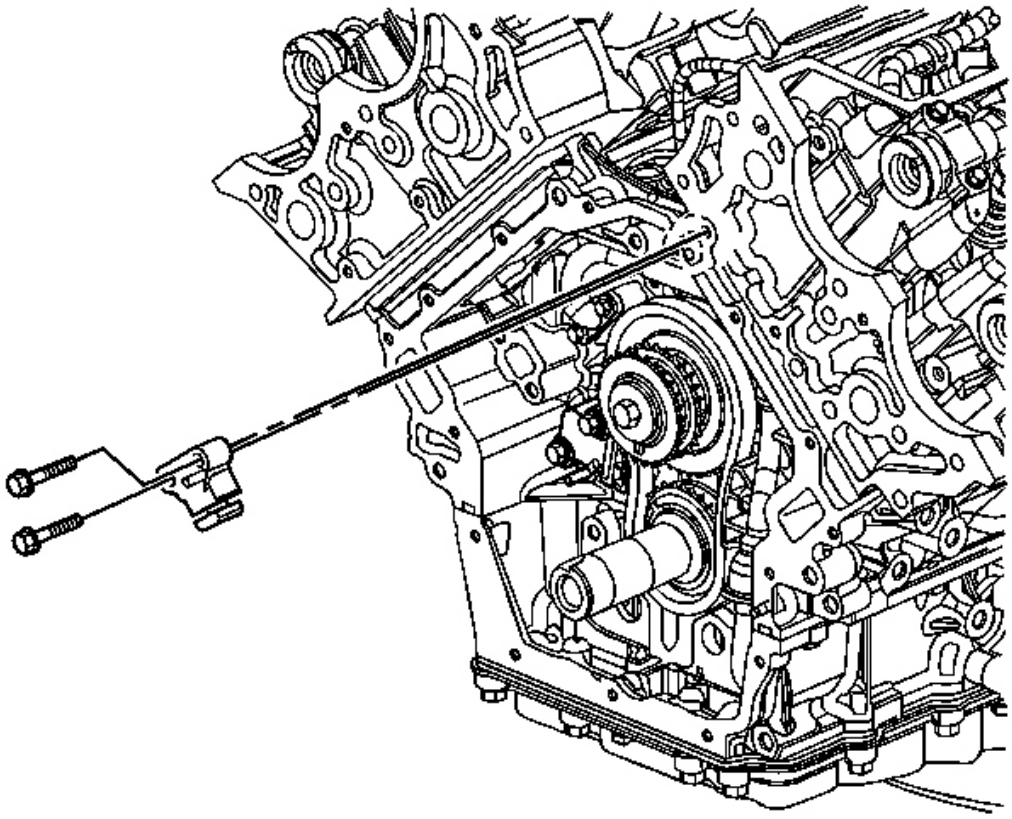


Fig. 239: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the left secondary timing chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left Side**.
13. Install the right secondary timing chain. Refer to **Secondary Camshaft Drive Chain Replacement - Right Side**.
14. Remove the **EN 46328** . See **Special Tools** .
15. Install the left camshaft position actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side**.

SECONDARY CAMSHAFT DRIVE CHAIN REPLACEMENT - RIGHT SIDE

TOOLS REQUIRED

- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

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- **J 39946** Crankshaft Socket. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the oil pump. Refer to **Oil Pump Replacement**.

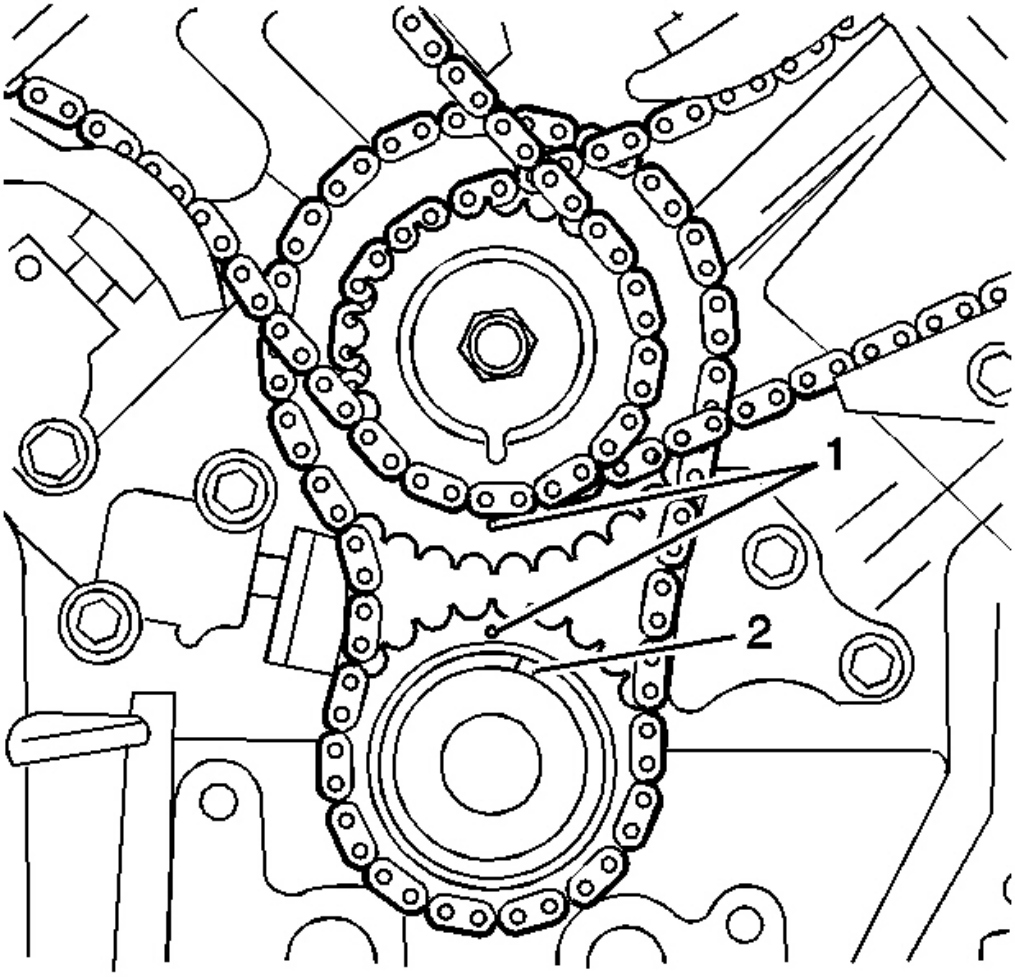


Fig. 240: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

2. Using the **J 39946** , rotate the crankshaft until the primary timing gear marks (1) are adjacent to each other as shown. See **Special Tools** .
3. Remove the right camshaft position actuator housing. DO NOT remove the actuator solenoids from the

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housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side**.

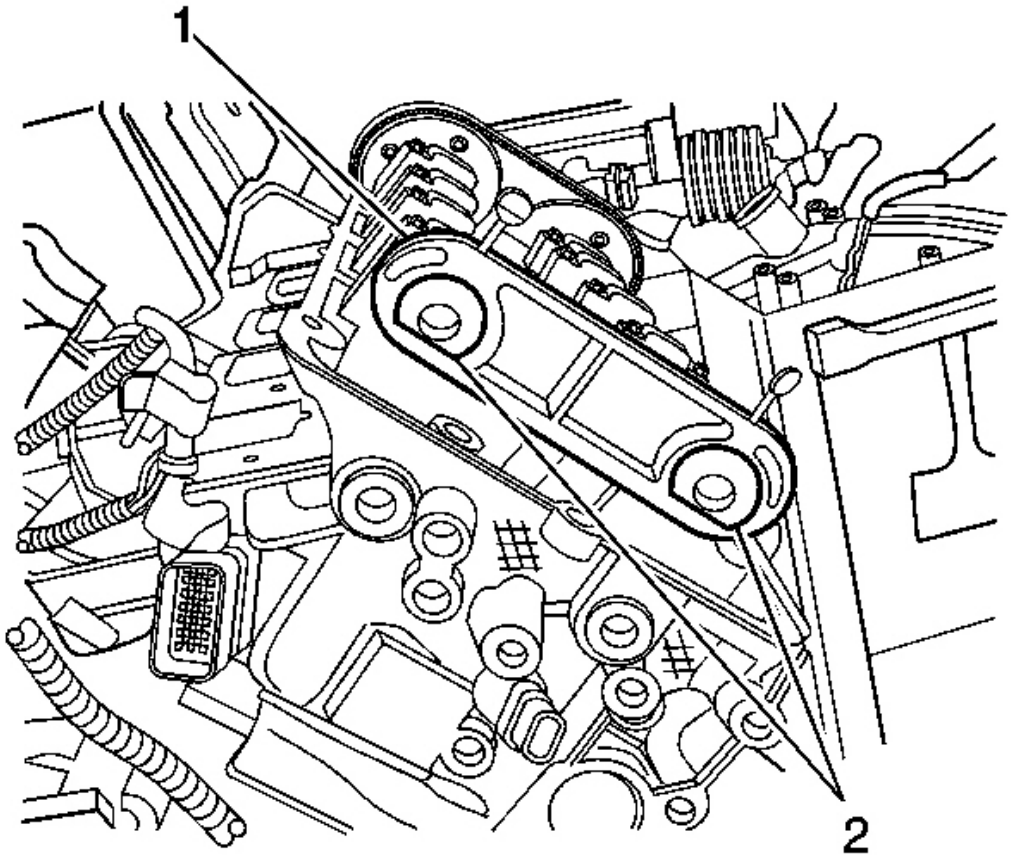


Fig. 241: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution .

4. Install the **EN 46328** (1) on the bank 1 (right) camshafts (2). See **Special Tools** .

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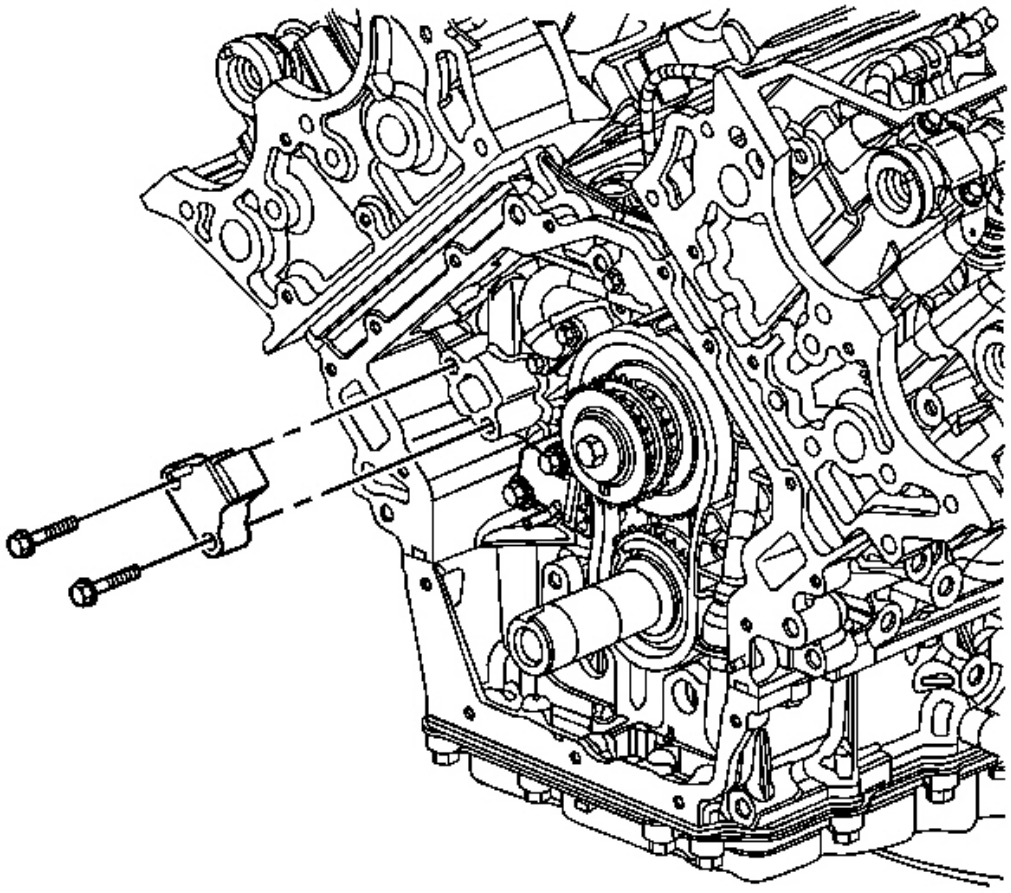


Fig. 242: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Loosen and remove the right secondary timing chain tensioner bolts and tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right Side**.

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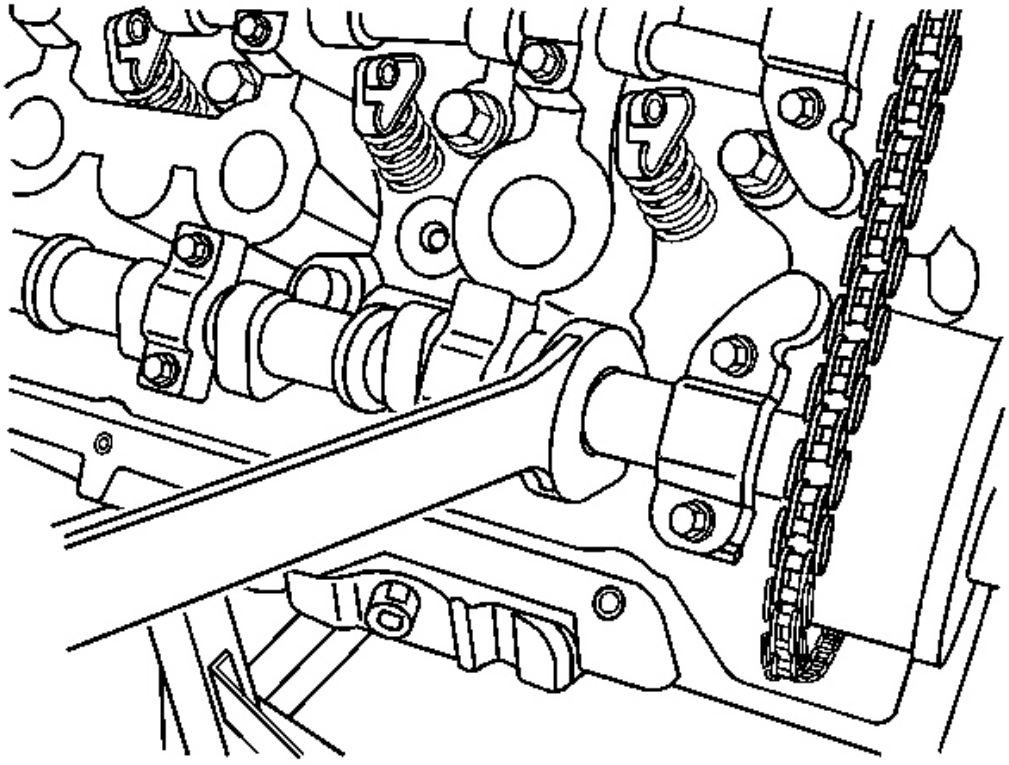


Fig. 243: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

6. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft oil control valve.
7. Loosen and remove the bank 1 (right) exhaust camshaft position oil control valve.
8. Slide the right exhaust camshaft position actuator off of the camshaft and remove the secondary timing chain from the camshaft actuator teeth.

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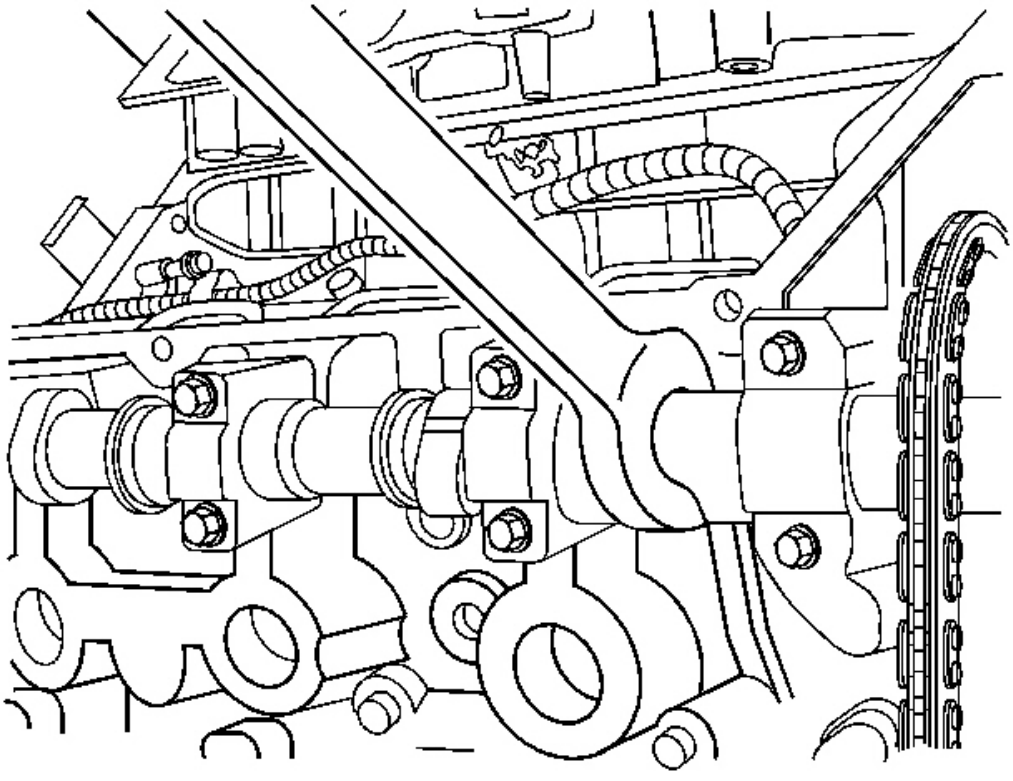


Fig. 244: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

9. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft oil control valve.
10. Loosen and remove the bank 1 (right) intake camshaft position oil control valve.
11. Slide the right intake camshaft position actuator off of the camshaft and remove the secondary timing chain from the camshaft actuator teeth.
12. Remove the right secondary timing chain from the engine.
13. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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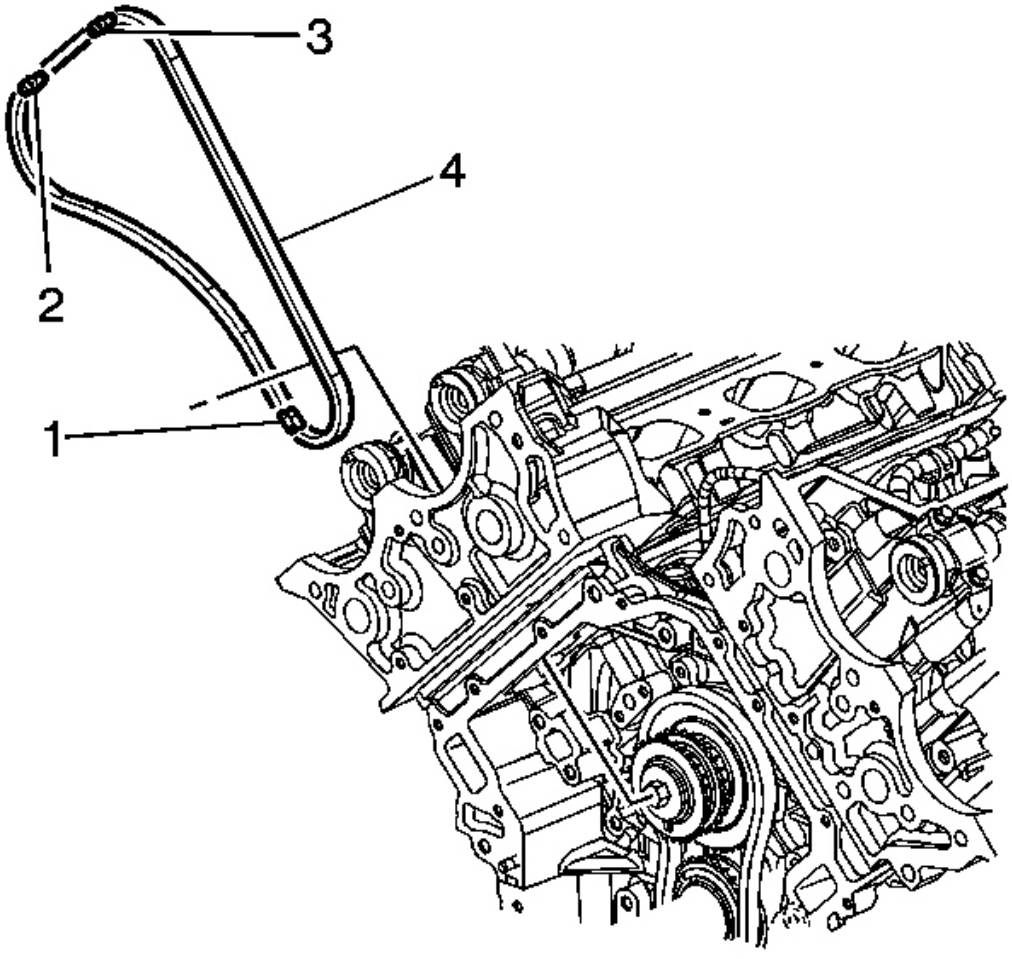


Fig. 245: Identifying Secondary Timing Chain Black Links
Courtesy of GENERAL MOTORS CORP.

1. The secondary timing chain has 3 black links that aid in timing the camshaft position actuators to the intermediate sprocket.
2. The black link (2) is aligned with the bank 1 exhaust actuator timing mark. The black link (3) is aligned with the bank 1 intake actuator timing mark.
3. The black link (1) is aligned with the intermediate sprocket.

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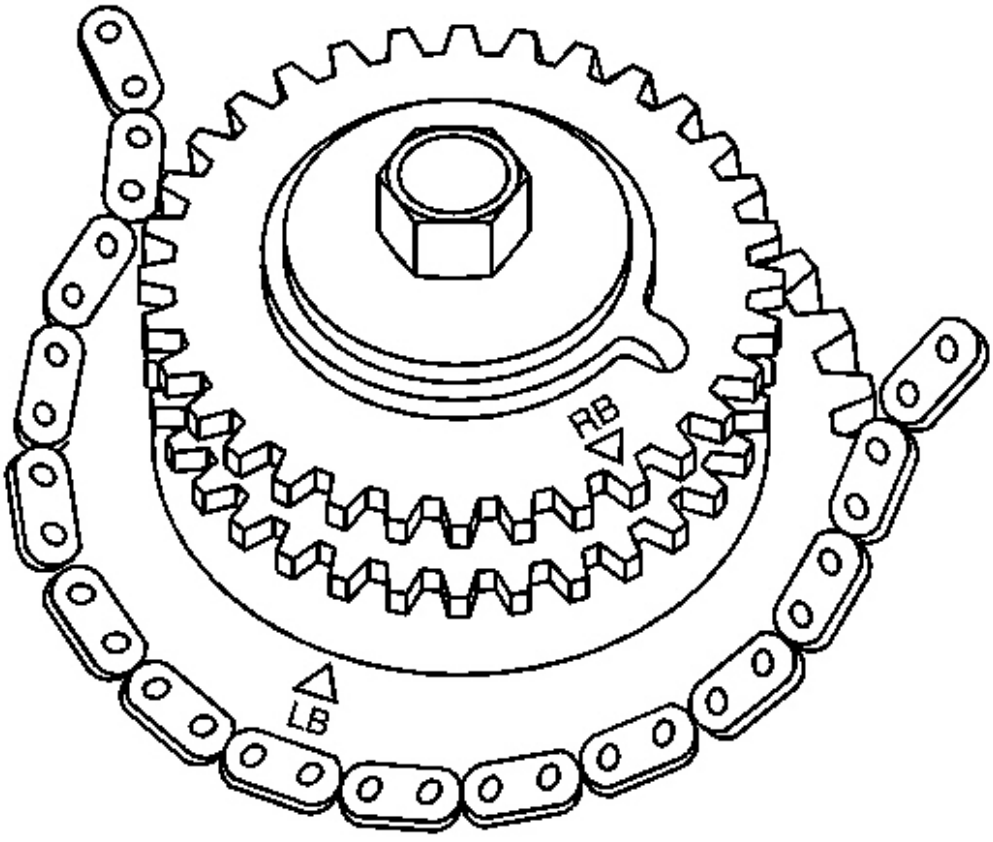


Fig. 246: Aligning Sprocket LB Timing Mark To Timing Chain Black Link
Courtesy of GENERAL MOTORS CORP.

4. The intermediate sprocket right bank timing mark is labeled right bank (RB) as shown.
5. Assemble the secondary timing chain to the intermediate sprocket aligning the sprocket RB timing mark to the timing chain black link.

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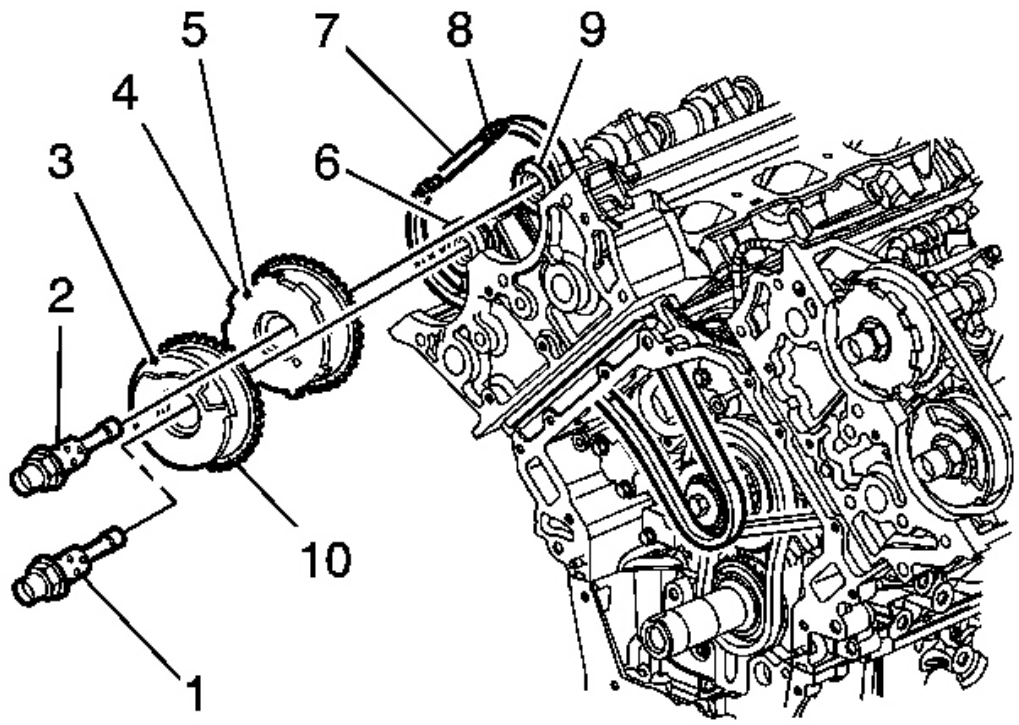


Fig. 247: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

6. Align the timing mark (5) of the RB intake camshaft position actuator with the timing chain black link (8) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface near the top of its rotation.
7. Loosely install the oil control valve (2) to secure the intake actuator.

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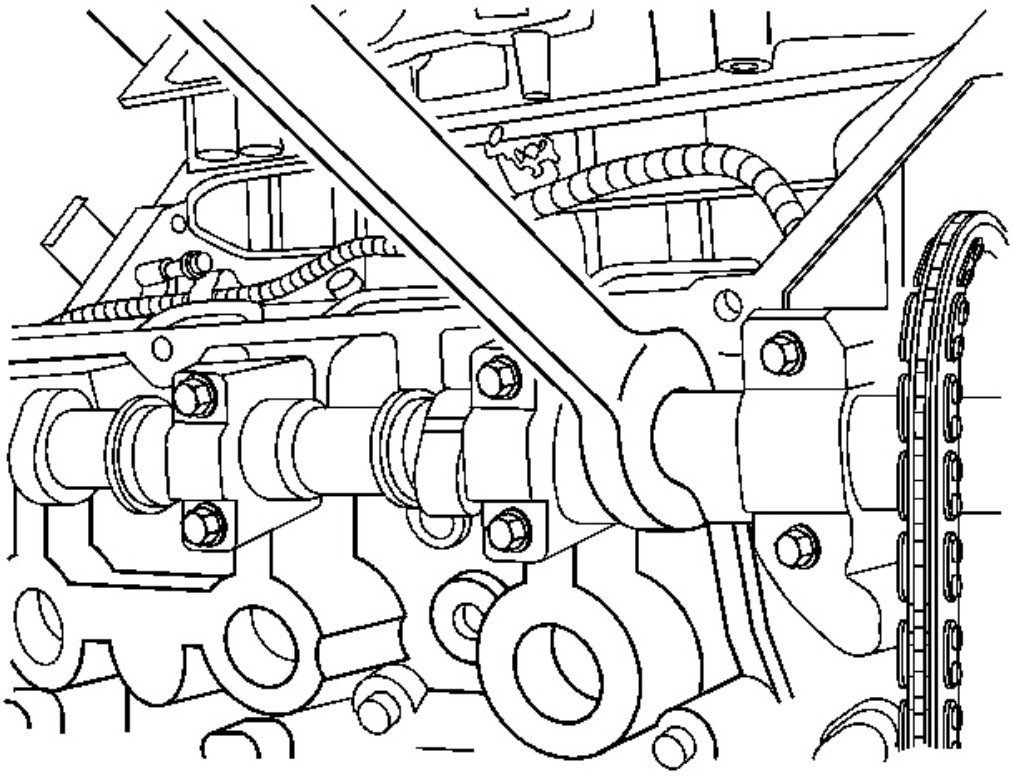


Fig. 248: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

8. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

   Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

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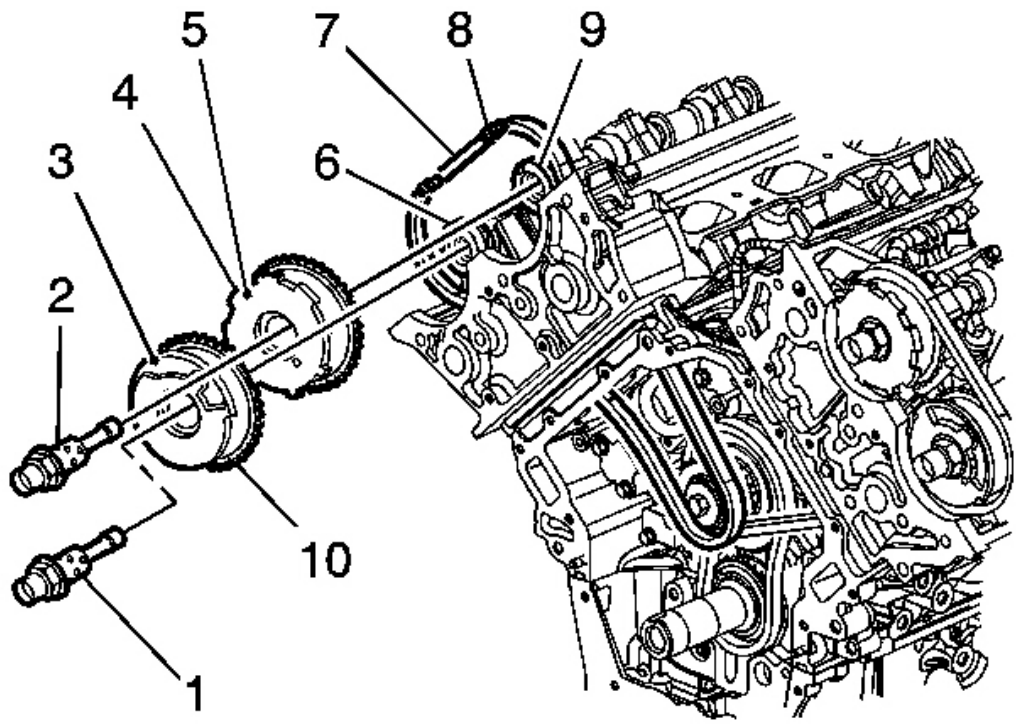


Fig. 249: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

9. Align the timing mark (3) of the RB exhaust camshaft position actuator with the timing chain black link and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface near the top of its rotation.
10. Loosely install the oil control valve (1) to secure the exhaust actuator.

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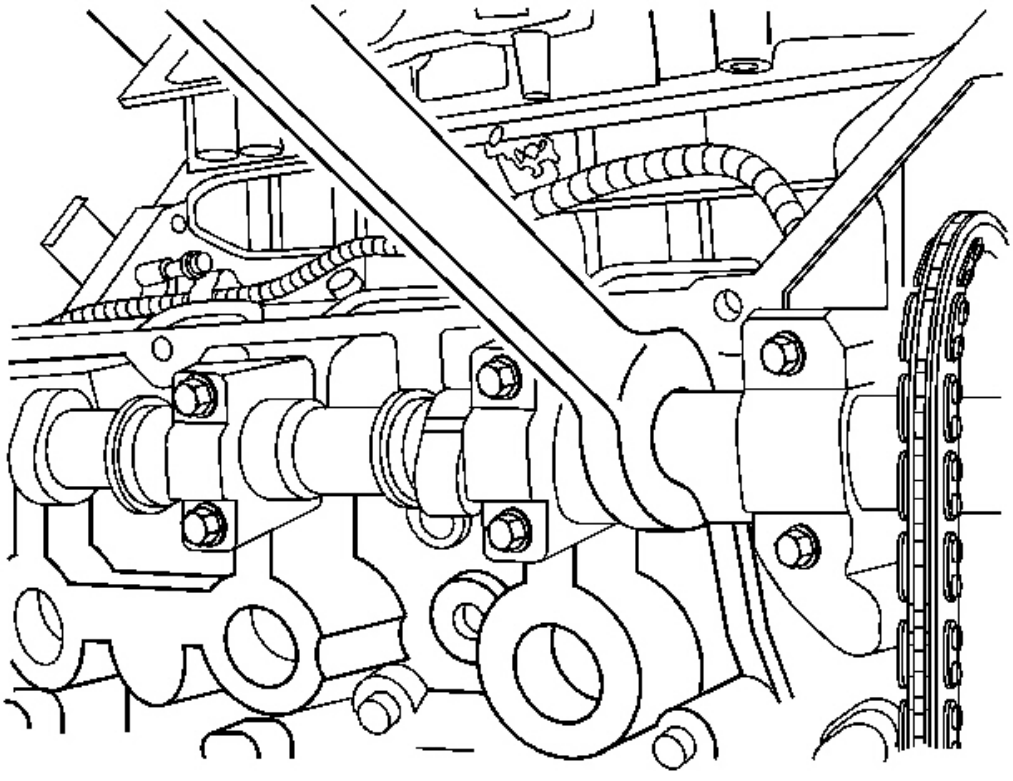


Fig. 250: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

11. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

    Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

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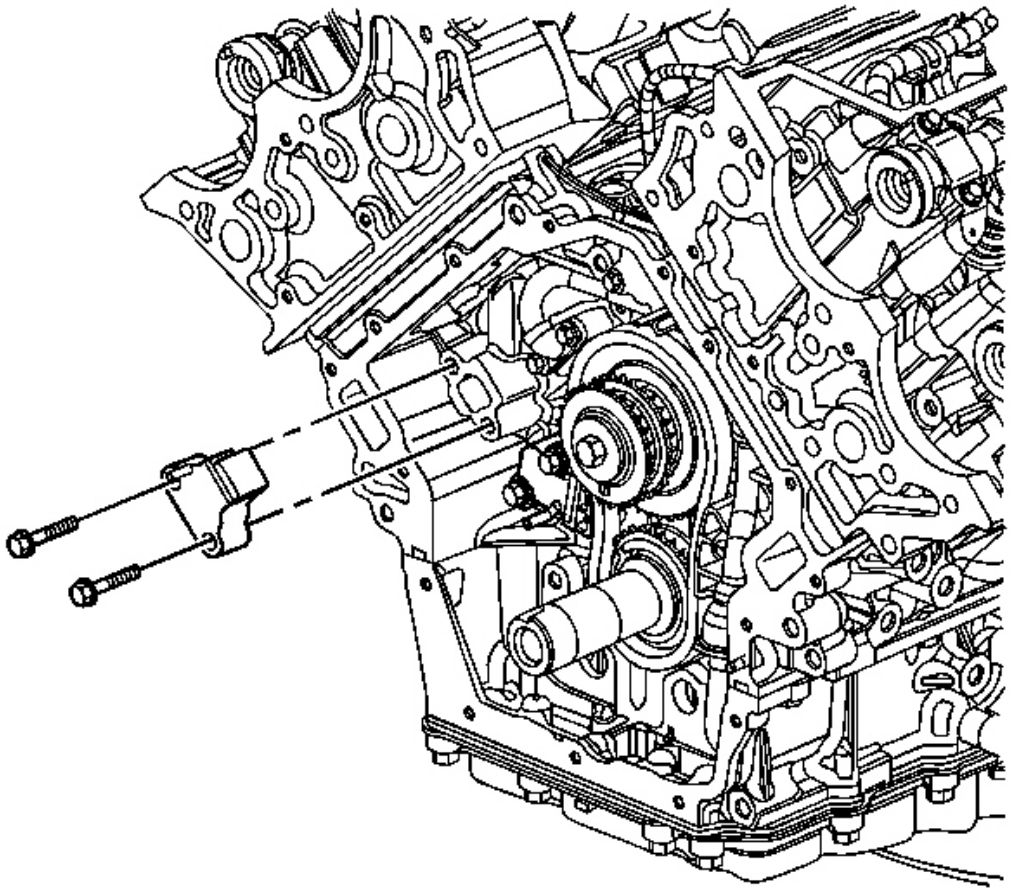


Fig. 251: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the right secondary timing chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right Side**.
13. Remove the **EN 46328** . See **Special Tools** .
14. Install the right camshaft position actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side**.
15. Install the oil pump. Refer to **Oil Pump Replacement**.

SECONDARY CAMSHAFT DRIVE CHAIN TENSIONER REPLACEMENT - LEFT SIDE

TOOLS REQUIRED

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- **J 39946** Crankshaft Rotation Socket. See **Special Tools** .
- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
2. Remove the engine oil pump. Refer to **Oil Pump Replacement**.

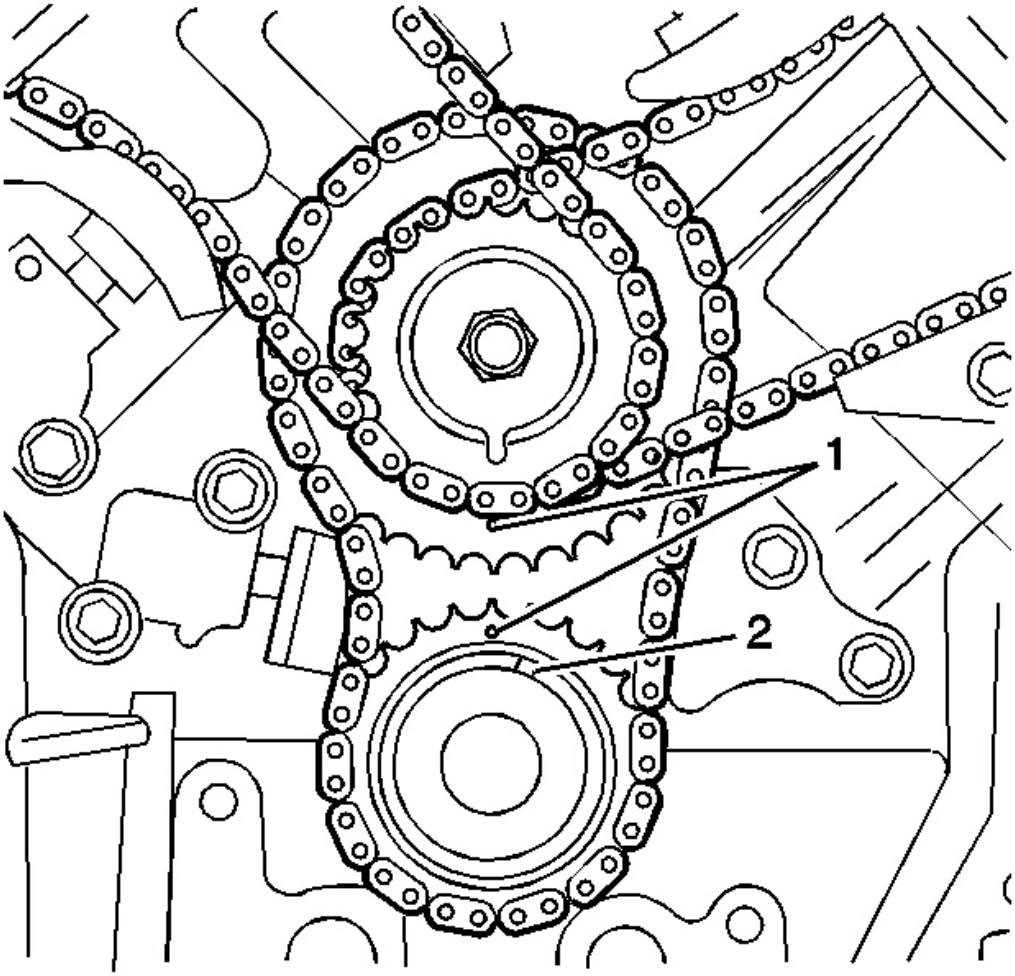


Fig. 252: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

3. Align the primary timing marks (1) using the **J 39946** . See **Special Tools** .

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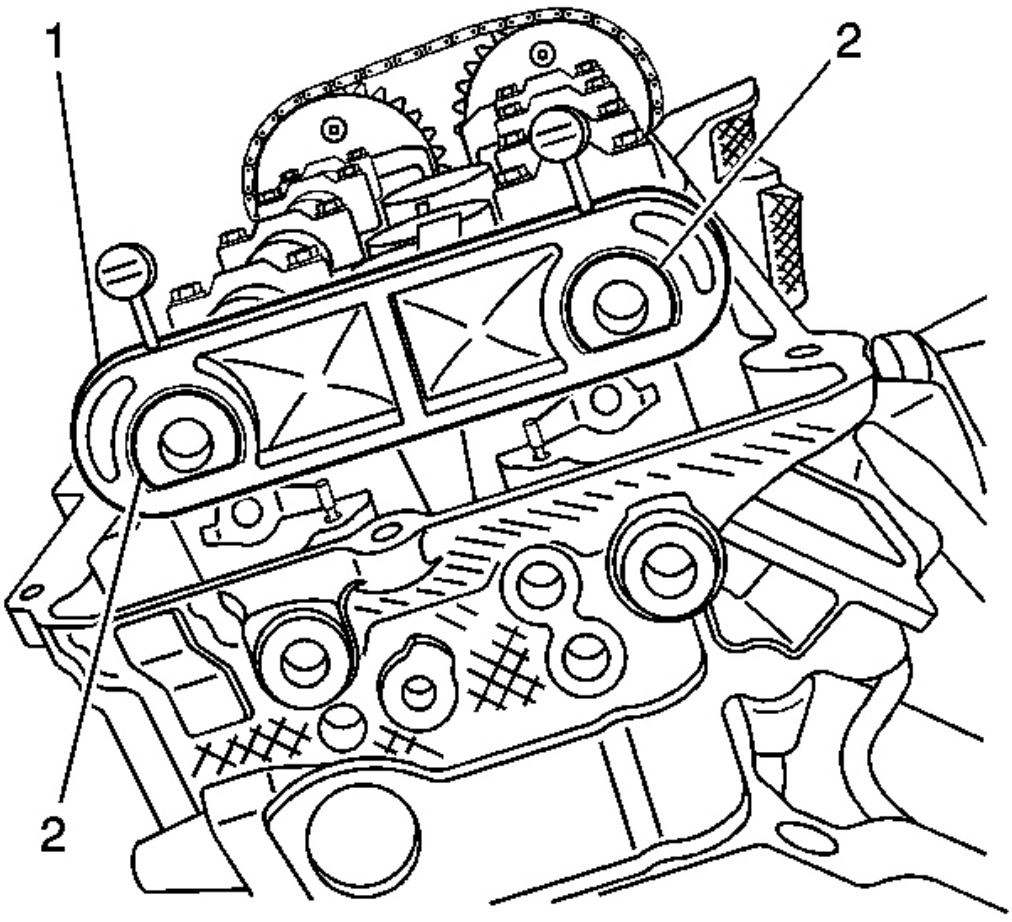


Fig. 253: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

4. Install the **EN 46328** (1) on the left bank camshafts (2). See **Special Tools** .

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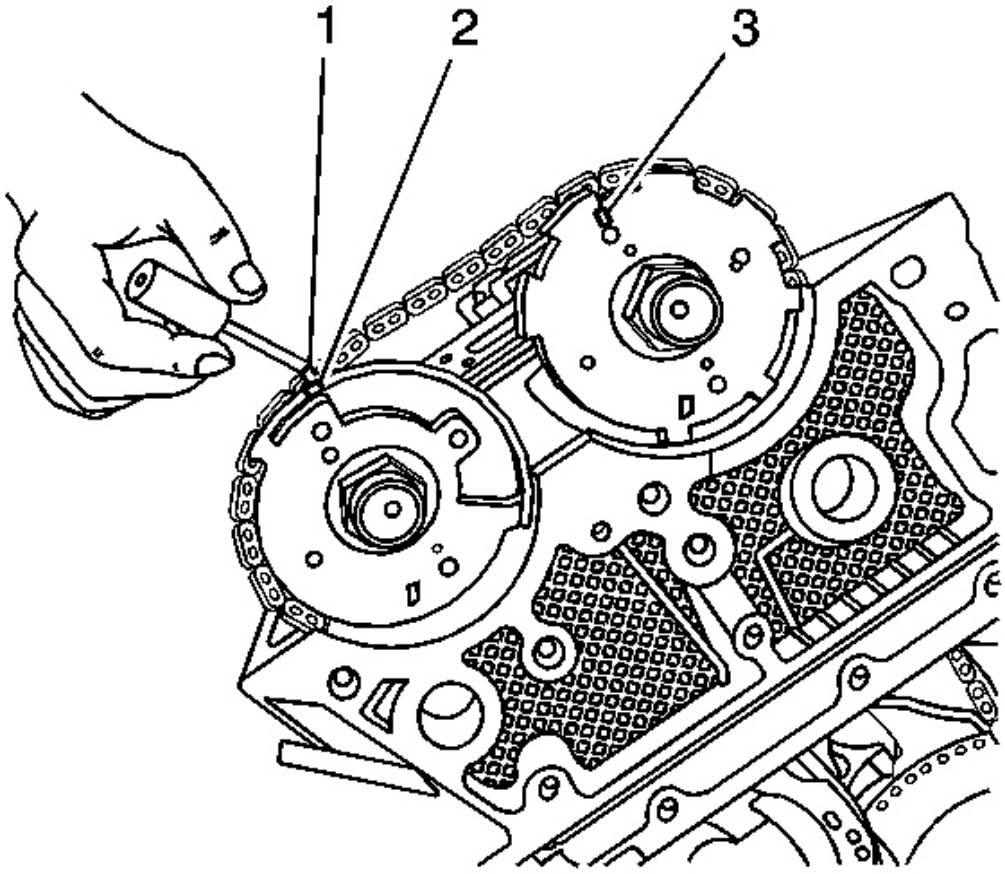


Fig. 254: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

5. Create 2 reference marks (1) using a paint stick to identify the chain link adjacent to each actuator timing mark (2, 3).

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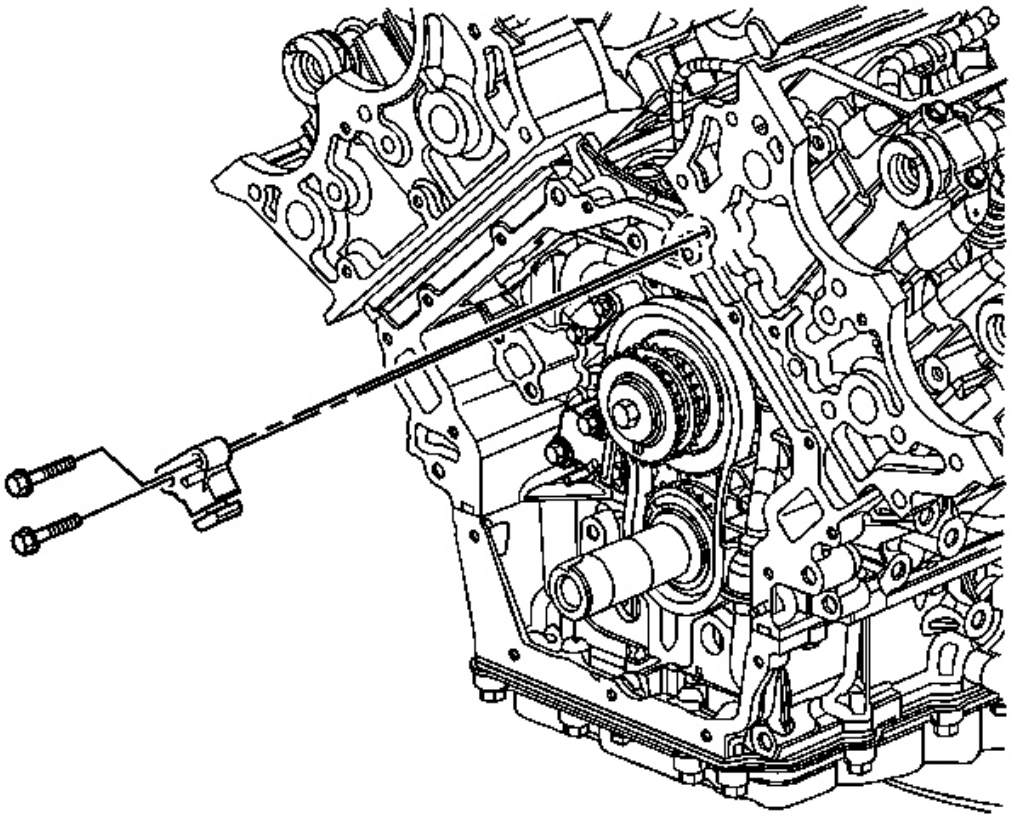


Fig. 255: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the 2 bolts attaching the left secondary camshaft drive chain tensioner to the engine block.
7. Remove the left secondary camshaft drive chain tensioner, allowing the tensioner to expand as you remove it.
8. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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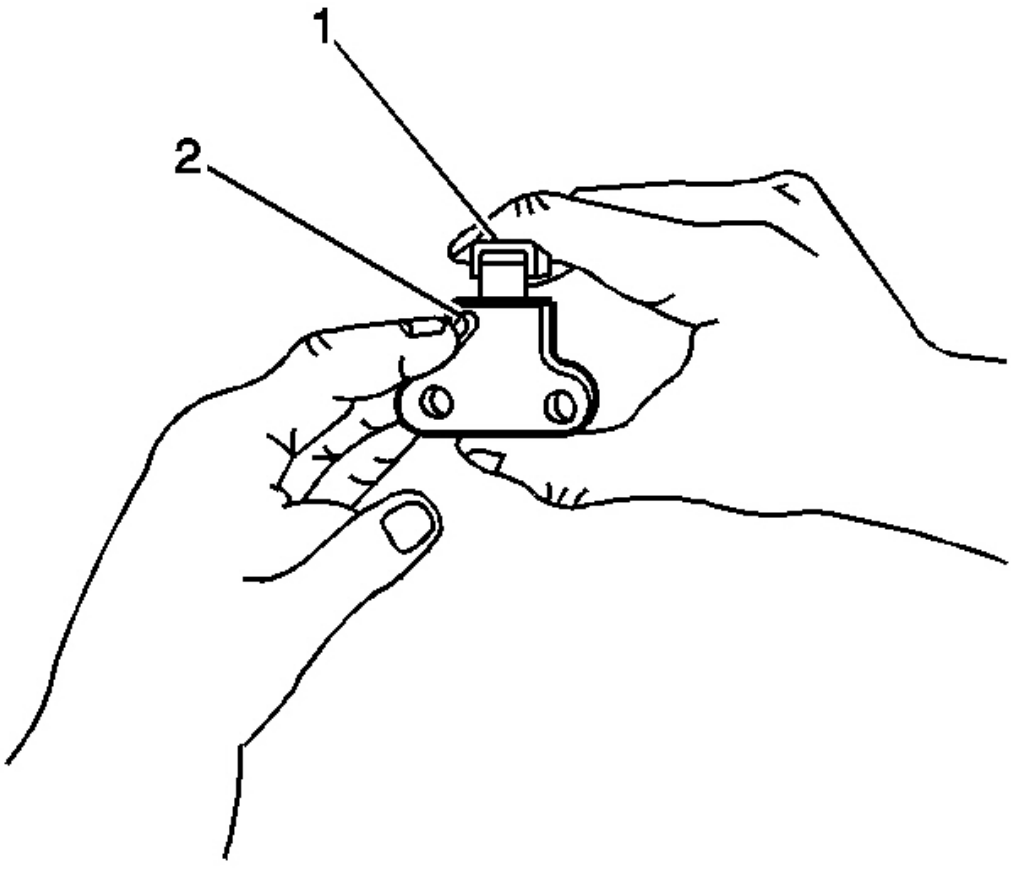


Fig. 256: View Of Tensioner Shoe & Ratchet Lever
Courtesy of GENERAL MOTORS CORP.

1. Collapse the left secondary camshaft chain tensioner using the following procedure:
    1. Rotate the ratchet release lever (2) counterclockwise and hold.
    2. Collapse the tensioner shoe (1) and hold.
    3. Release the ratchet lever (2).
2. Slowly release the pressure on the shoe (1), until the ratchet lever (2) moves to the first detent and a "click" is heard and felt.
3. Collapse the tensioner shoe (1) and hold.

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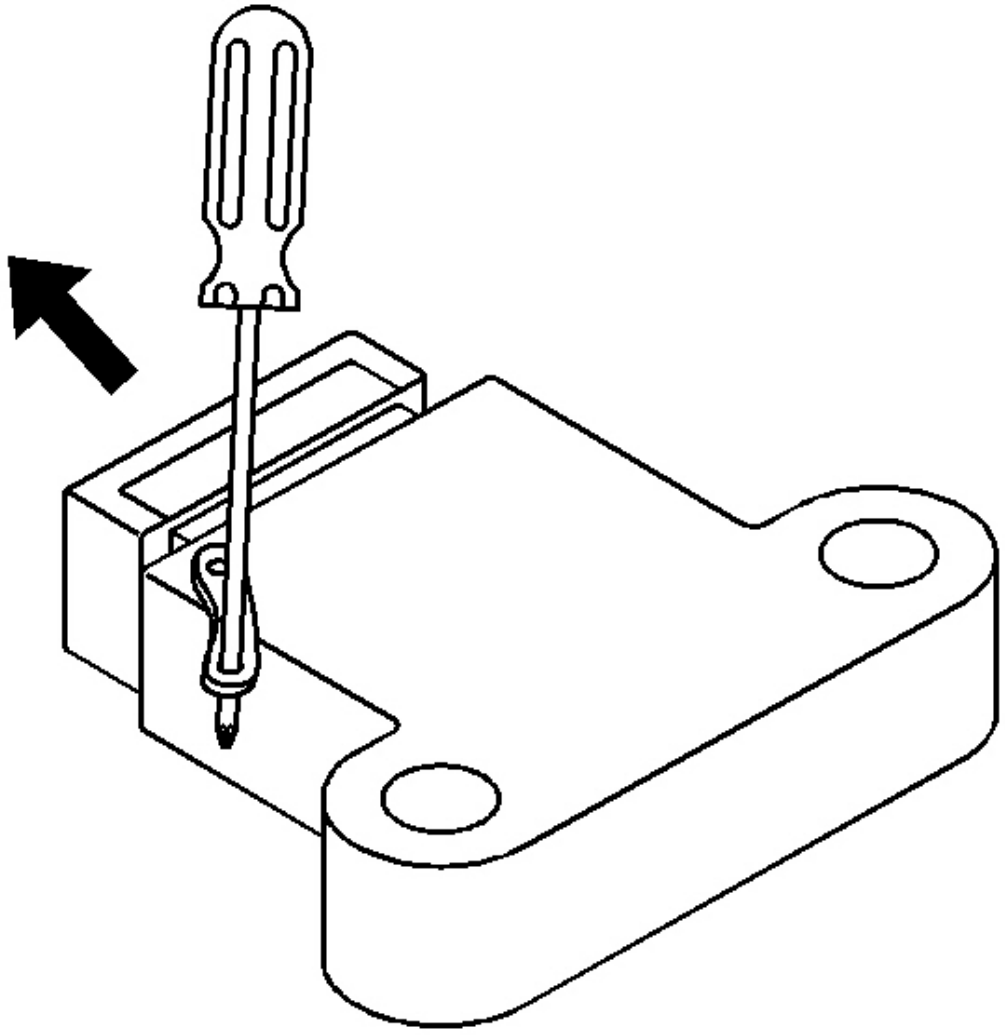


Fig. 257: Locking Tensioner Shoe In Collapsed Position
Courtesy of GENERAL MOTORS CORP.

4. Insert a pin through the hole in the release lever in order to lock the tensioner shoe in the collapsed position.

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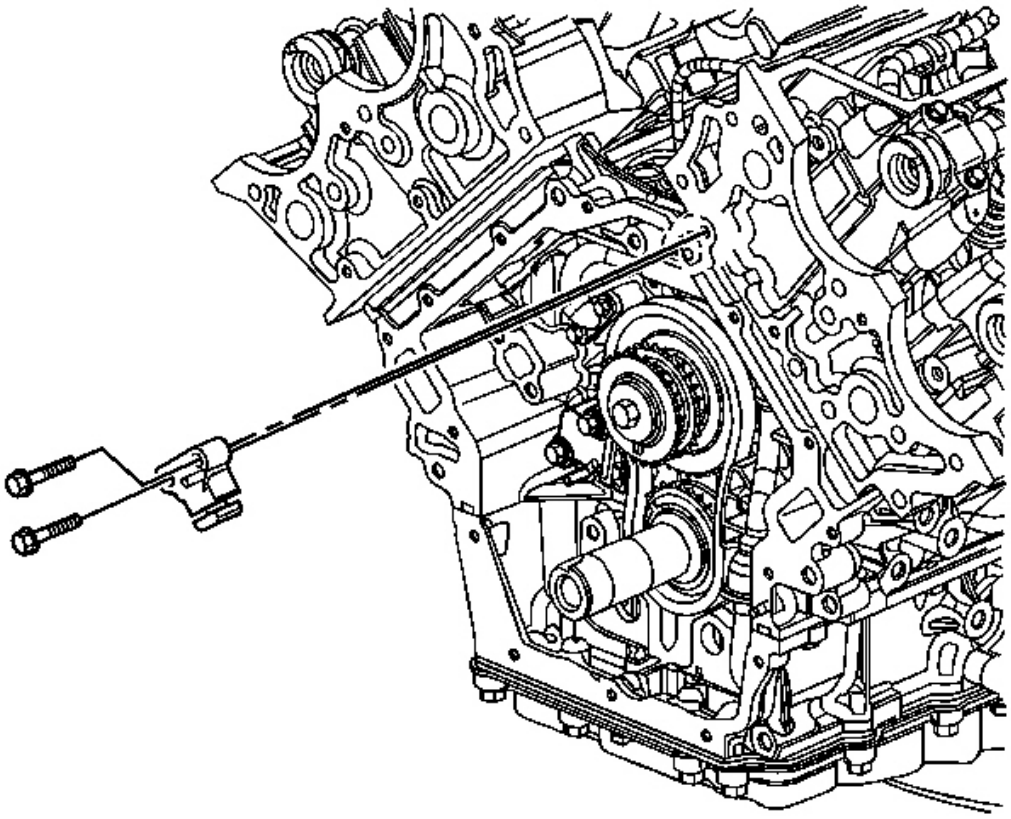


Fig. 258: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Ensure the tensioner release lever is facing outward.

5. Install the left secondary camshaft drive chain tensioner and retaining bolts.

   Tighten: Tighten the secondary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).

6. Remove the pin holding the tensioner to tighten any slack in the timing chain.

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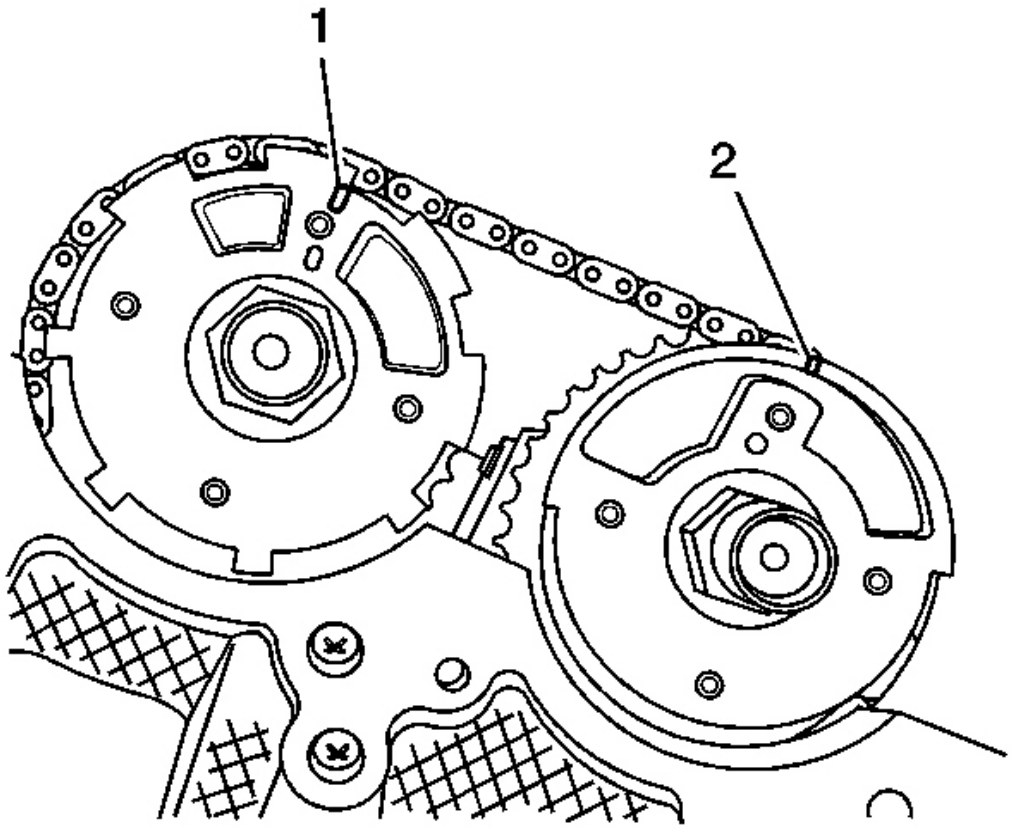


Fig. 259: Aligning Paint Marks With Actuator Timing Marks
Courtesy of GENERAL MOTORS CORP.

7. Inspect the 2 paint marks created previously to ensure they remain aligned with the timing marks (1, 2) on the actuator.
8. Install the engine oil pump. Refer to **Oil Pump Replacement**.

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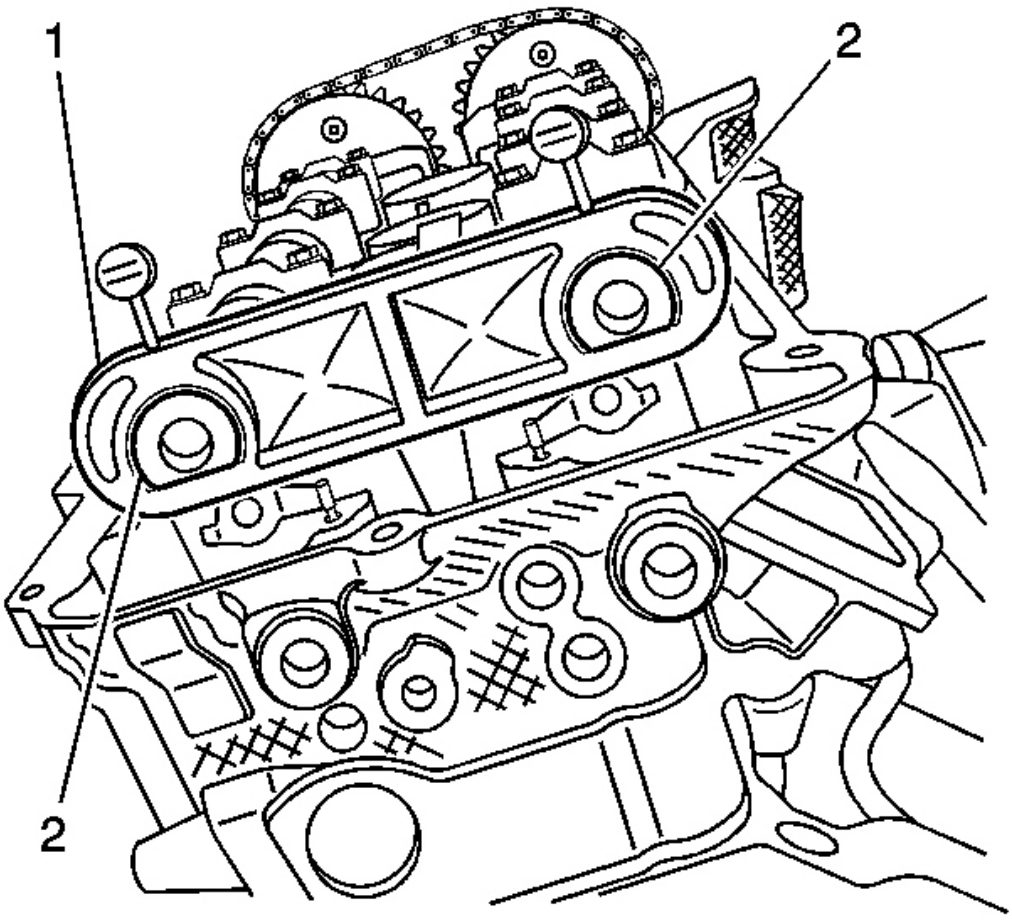


Fig. 260: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

9. Remove the **EN 46328** (1). See **Special Tools** .
10. Install the camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.

SECONDARY CAMSHAFT DRIVE CHAIN TENSIONER REPLACEMENT - RIGHT SIDE

TOOLS REQUIRED

- **EN 46328** Camshaft Holding Tool. See **Special Tools** .
- **J 39946** Crankshaft Socket. See **Special Tools** .

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REMOVAL PROCEDURE

1. Remove the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.
2. Remove the engine oil pump. Refer to **Oil Pump Replacement**.

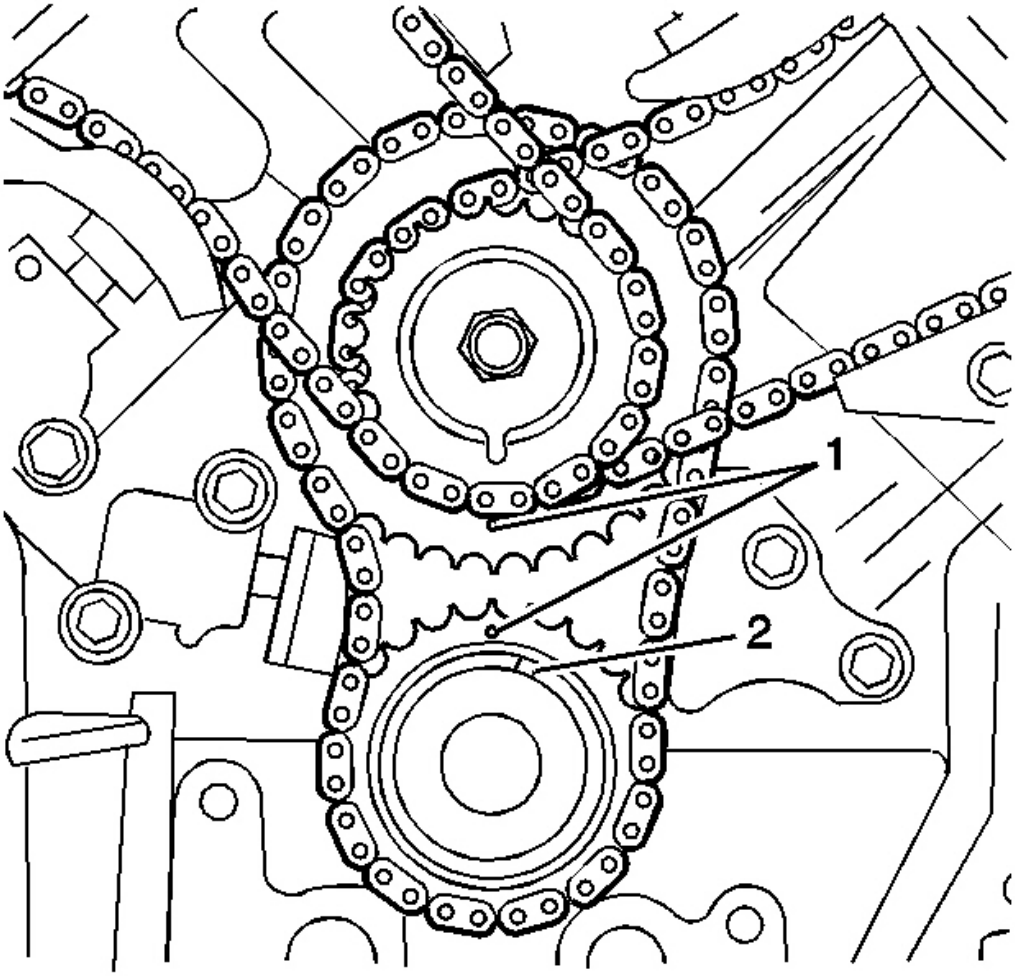


Fig. 261: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

3. Align the primary timing marks (1) using the **J 39946** . See **Special Tools** .

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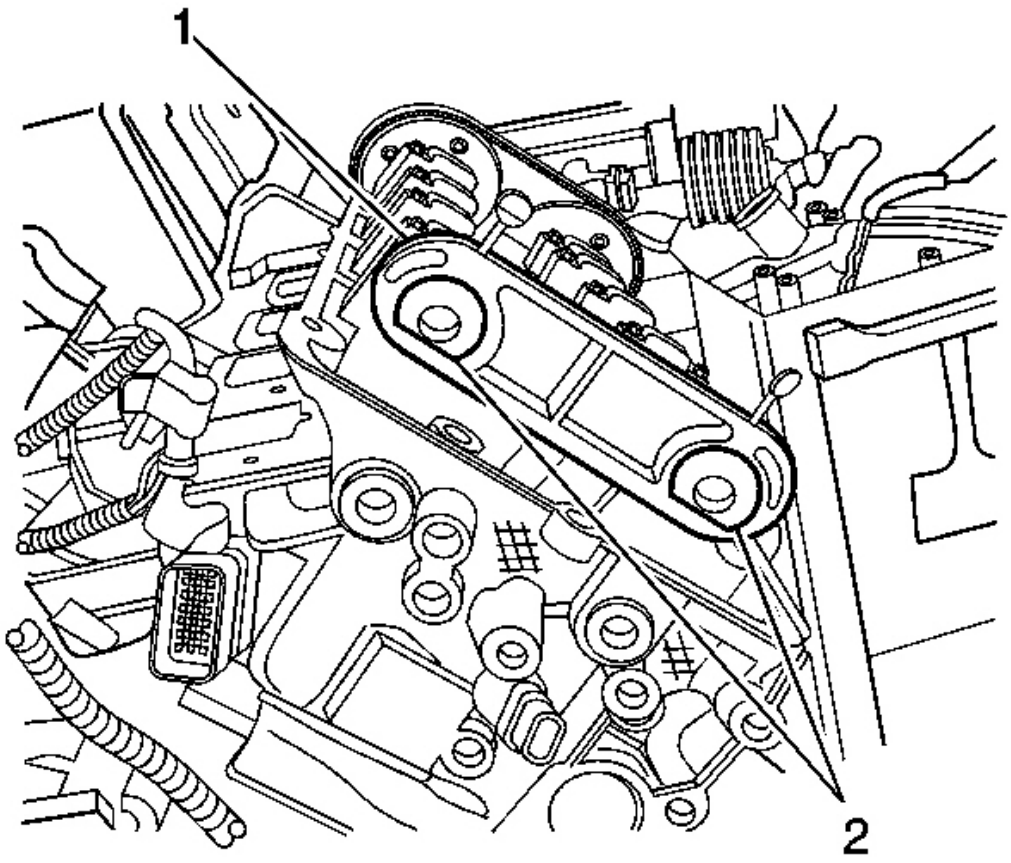


Fig. 262: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

4. Install the **EN 46328** (1) on the right bank camshafts (2). See **Special Tools** .

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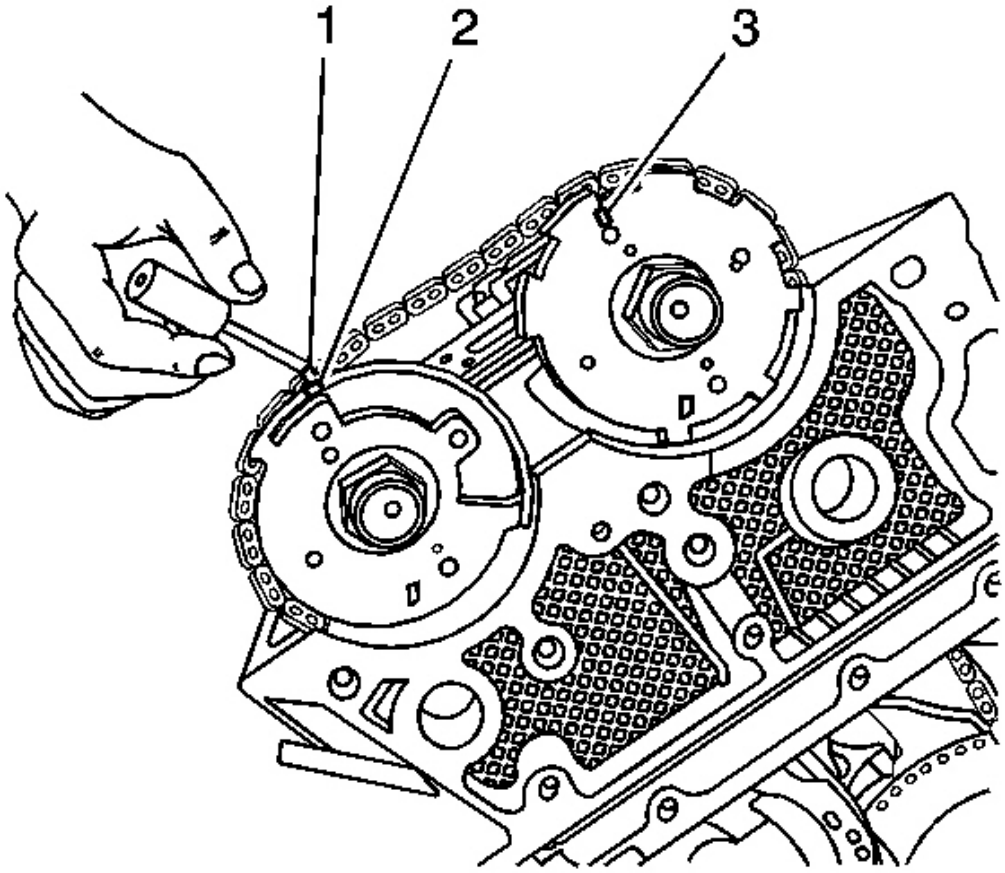


Fig. 263: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

5. Create 2 reference marks (1) using a paint stick to identify the chain link adjacent to each actuator timing mark (2, 3).

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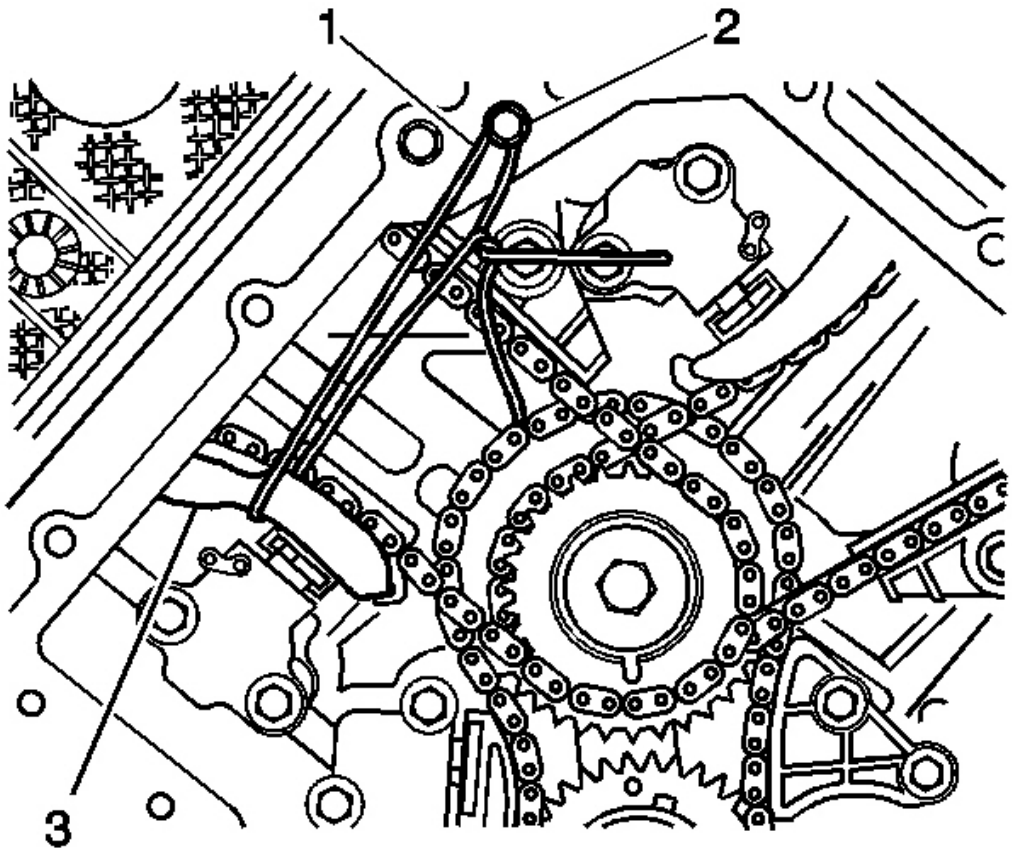


Fig. 264: View Of Mechanics Wire, Right Secondary Camshaft Drive Chain Shoe & Front Cover Bolt
Courtesy of GENERAL MOTORS CORP.

6. Install an engine front cover bolt (2) into the front of the engine.

IMPORTANT: Securing the right secondary camshaft drive chain shoe will prevent the right camshaft drive sprocket teeth from skipping on the right secondary timing chain.

7. Wrap mechanics wire (1) tightly around both the right secondary camshaft drive chain shoe (3) and the front cover bolt (2).

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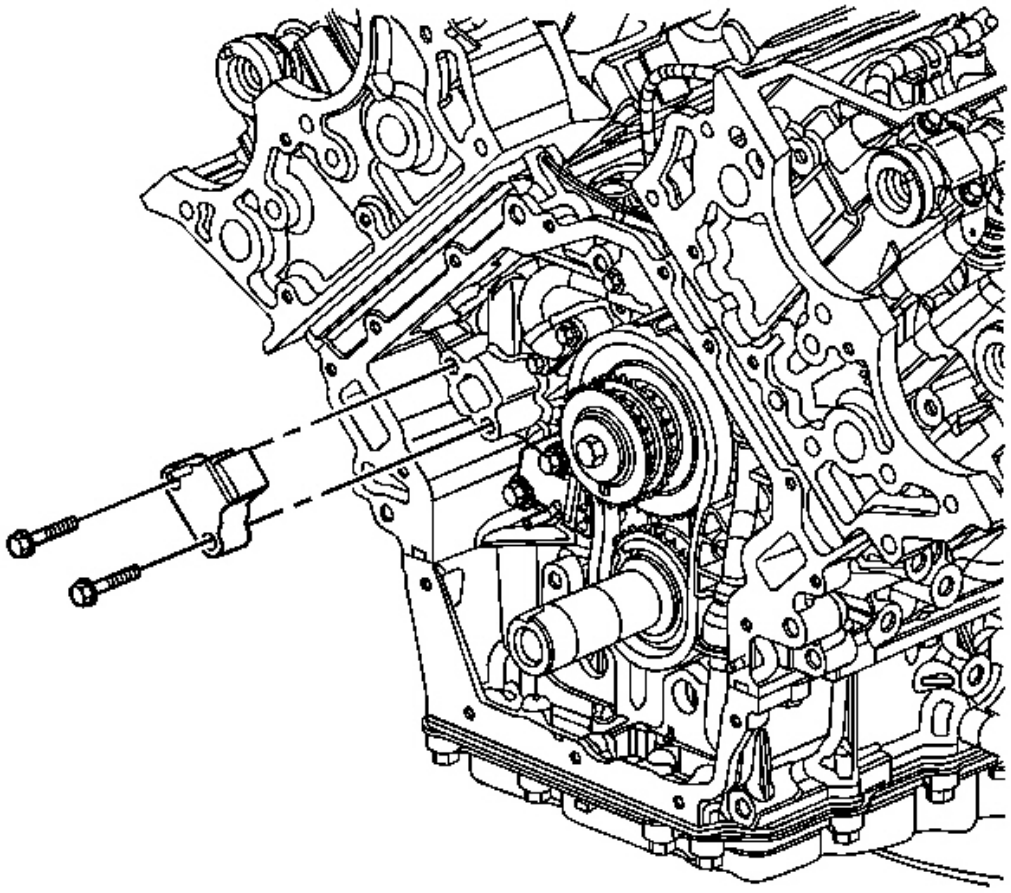


Fig. 265: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the 2 bolts attaching the right secondary camshaft drive chain tensioner to the engine block.
9. Remove the right secondary camshaft drive chain tensioner, allowing the tensioner to expand as you remove it.
10. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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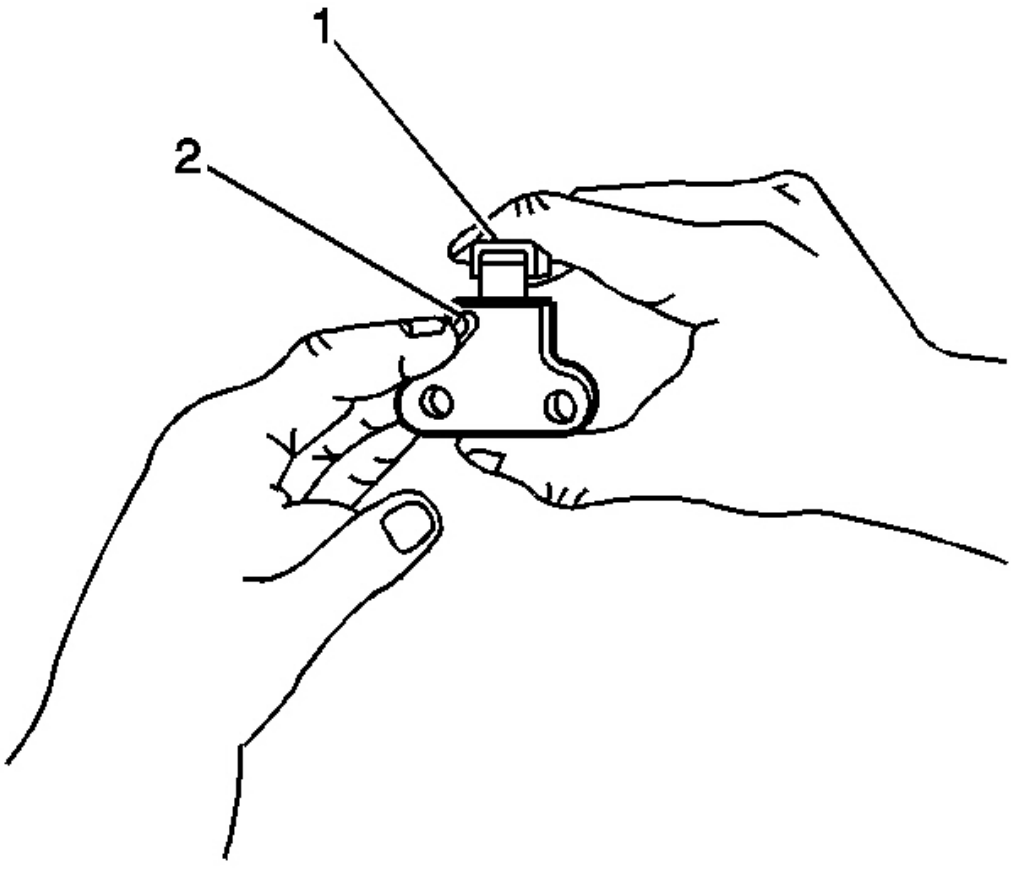


Fig. 266: View Of Tensioner Shoe & Ratchet Lever
Courtesy of GENERAL MOTORS CORP.

1. Collapse the right secondary camshaft chain tensioner using the following procedure:
    1. Rotate the ratchet release lever (2) counterclockwise and hold.
    2. Collapse the tensioner shoe (1) and hold.
    3. Release the ratchet lever (2).
2. Slowly release the pressure on the shoe (1), until the ratchet lever (2) moves to the first detent and a "click" is heard and felt.
3. Collapse the tensioner shoe (1) and hold.

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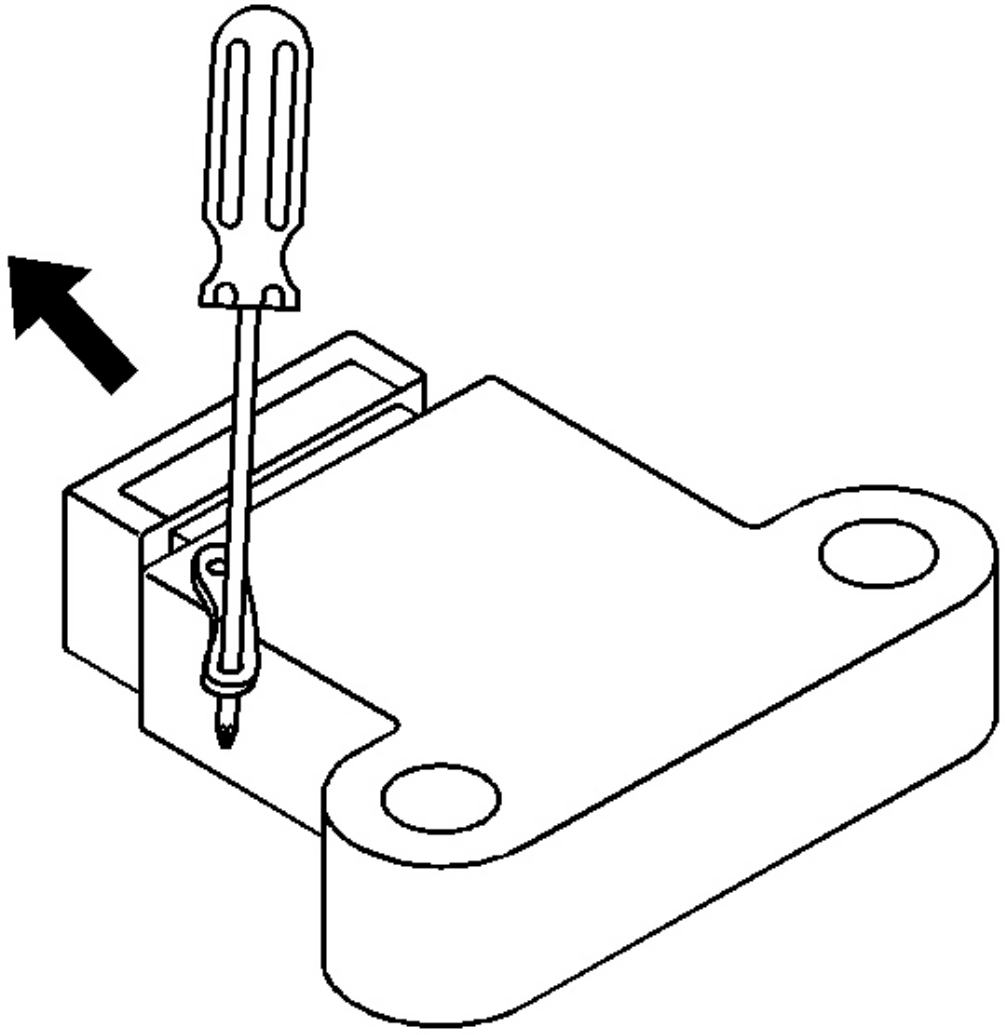


Fig. 267: Locking Tensioner Shoe In Collapsed Position
Courtesy of GENERAL MOTORS CORP.

4. Insert a pin through the hole in the release lever in order to lock the tensioner shoe in the collapsed position.

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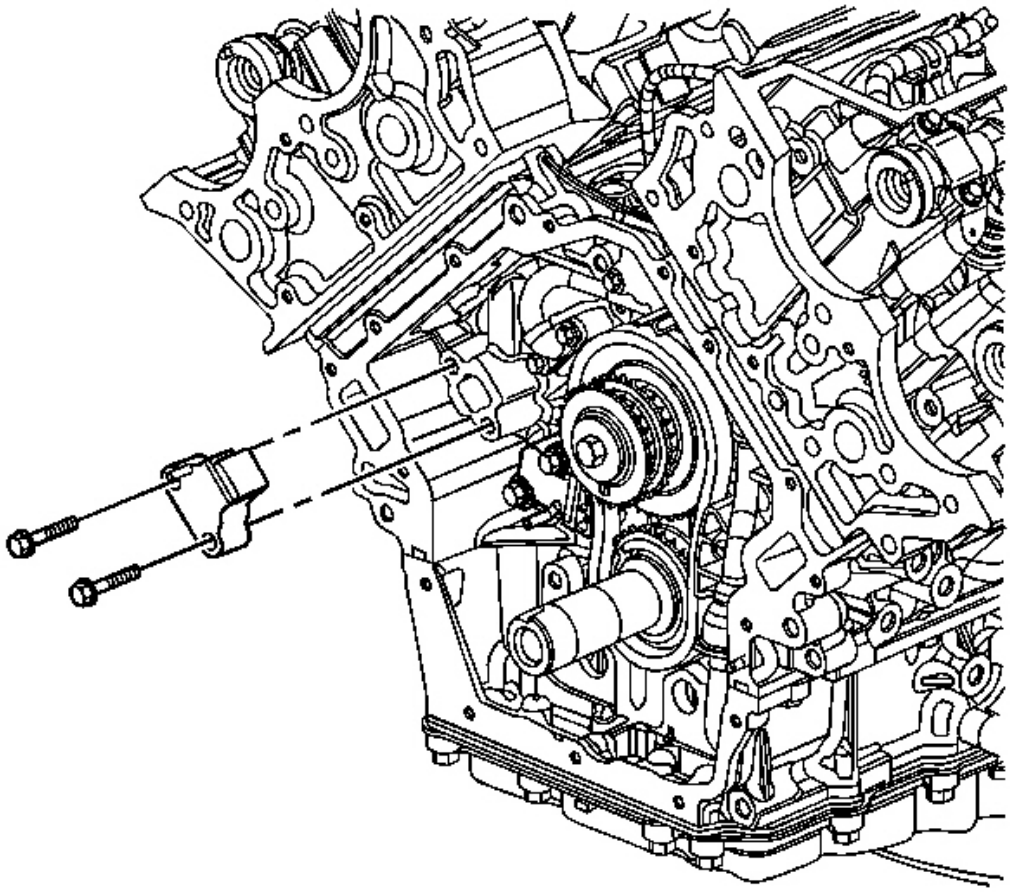


Fig. 268: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

IMPORTANT: Ensure the tensioner release lever is facing outward.

5. Install the right secondary camshaft drive chain tensioner and retaining bolts.

   Tighten: Tighten the secondary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).

6. Remove the pin holding the tensioner to tighten any slack in the timing chain.

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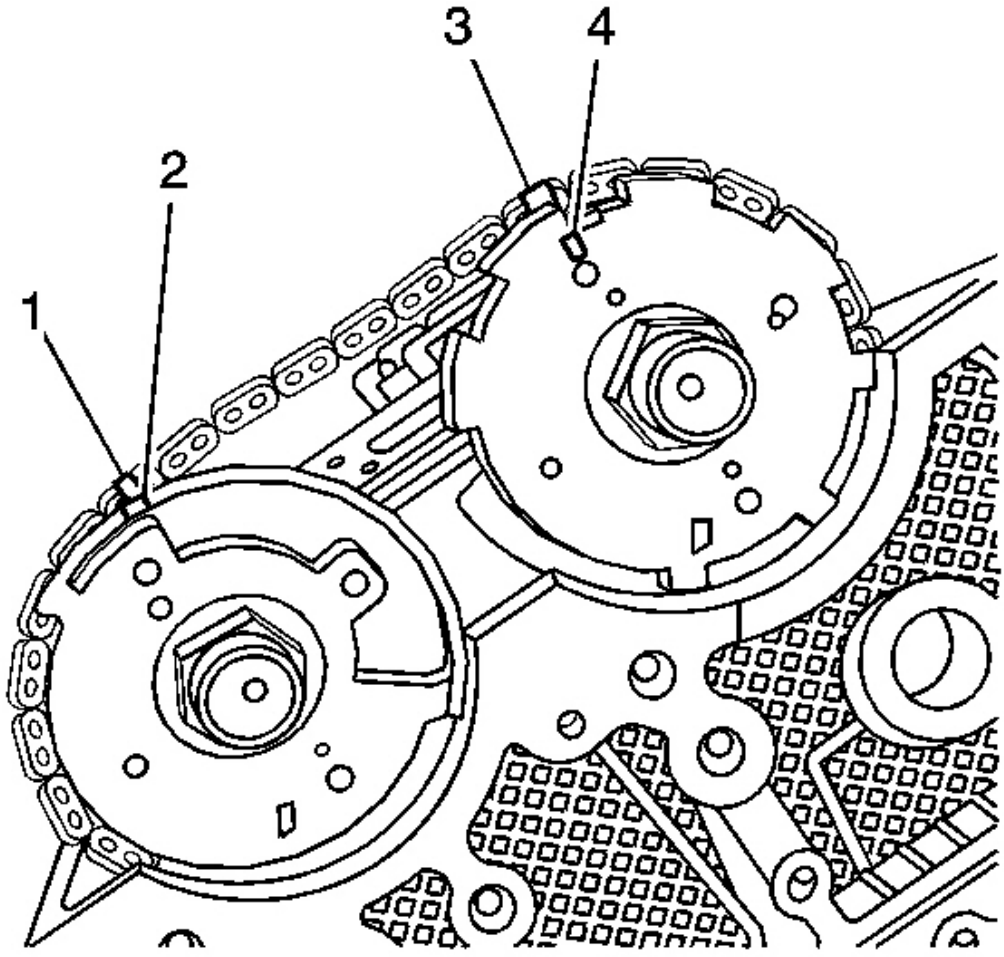


Fig. 269: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

7. Inspect the 2 paint marks (1, 3) created previously to ensure they remain aligned with the timing marks (2, 4) on the actuator.

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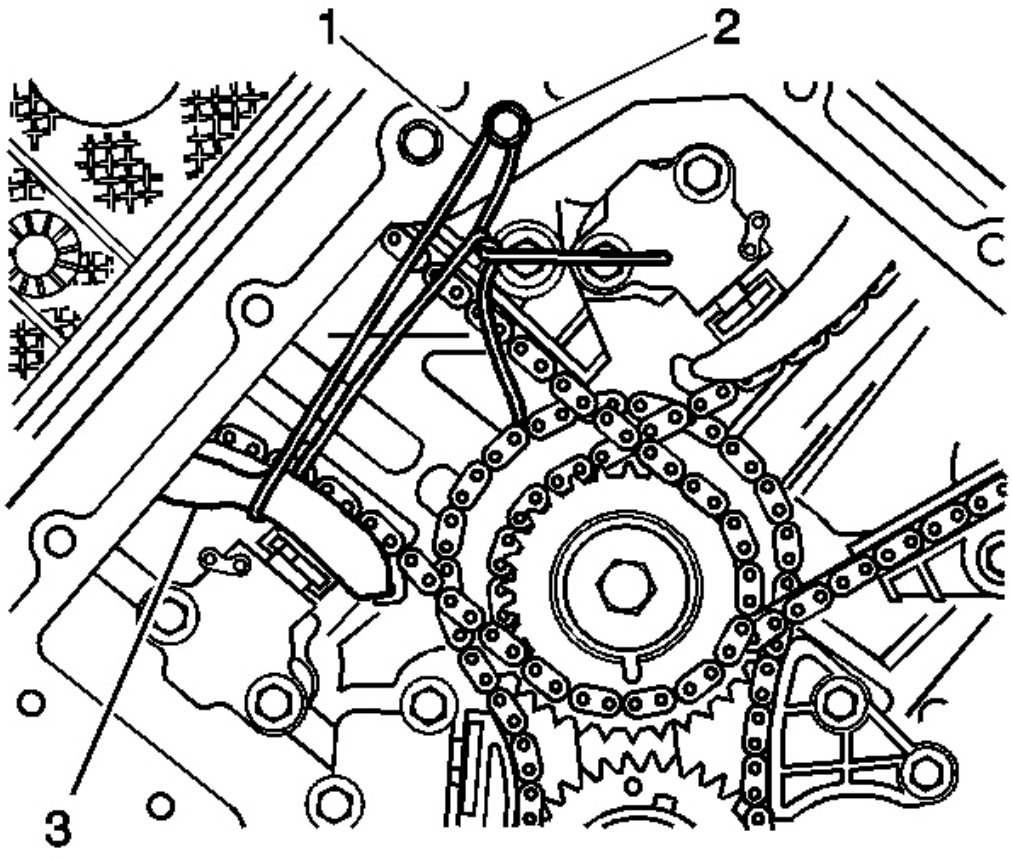


Fig. 270: View Of Mechanics Wire, Right Secondary Camshaft Drive Chain Shoe & Front Cover Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the mechanics wire (1) supporting the right secondary camshaft drive chain shoe (3).
9. Remove the engine front cover bolt (2) from the front of the engine.
10. Install the engine oil pump. Refer to **Oil Pump Replacement**.

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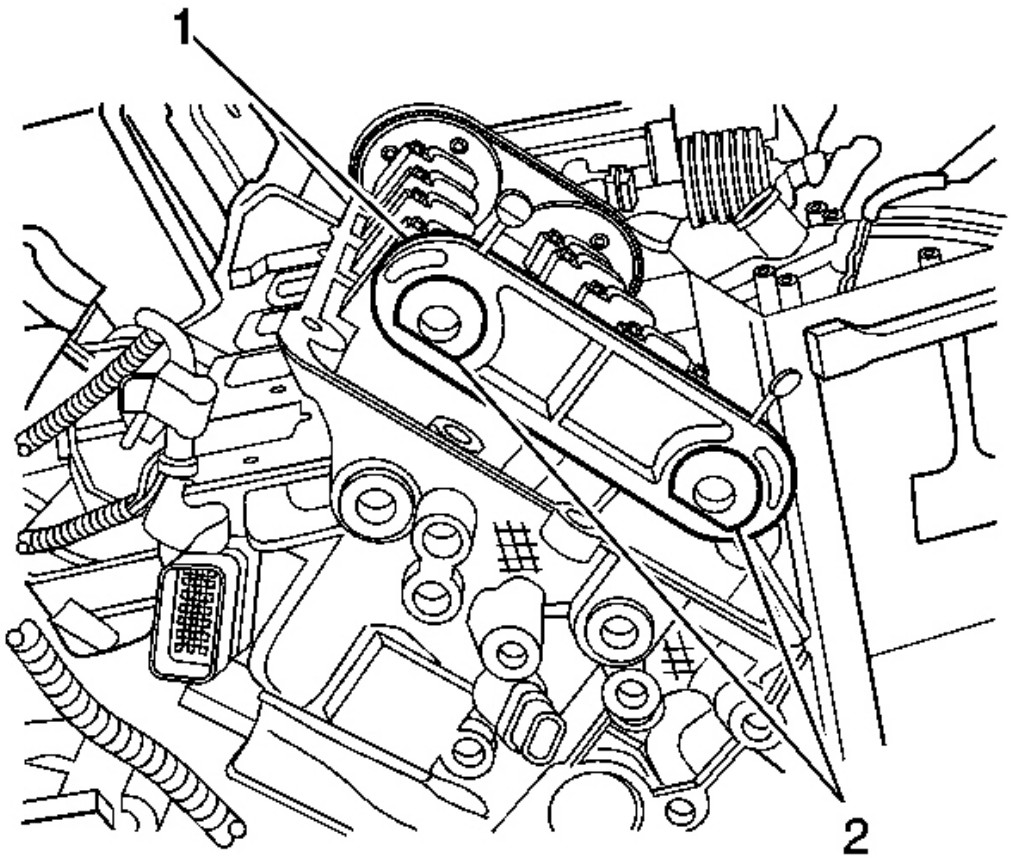


Fig. 271: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

11. Remove the **EN 46328** (1). See **Special Tools** .
12. Install the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.

SECONDARY CAMSHAFT DRIVE CHAIN SHOE REPLACEMENT - LEFT SIDE

TOOLS REQUIRED

- **J 39946** Crankshaft Socket. See **Special Tools** .
- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

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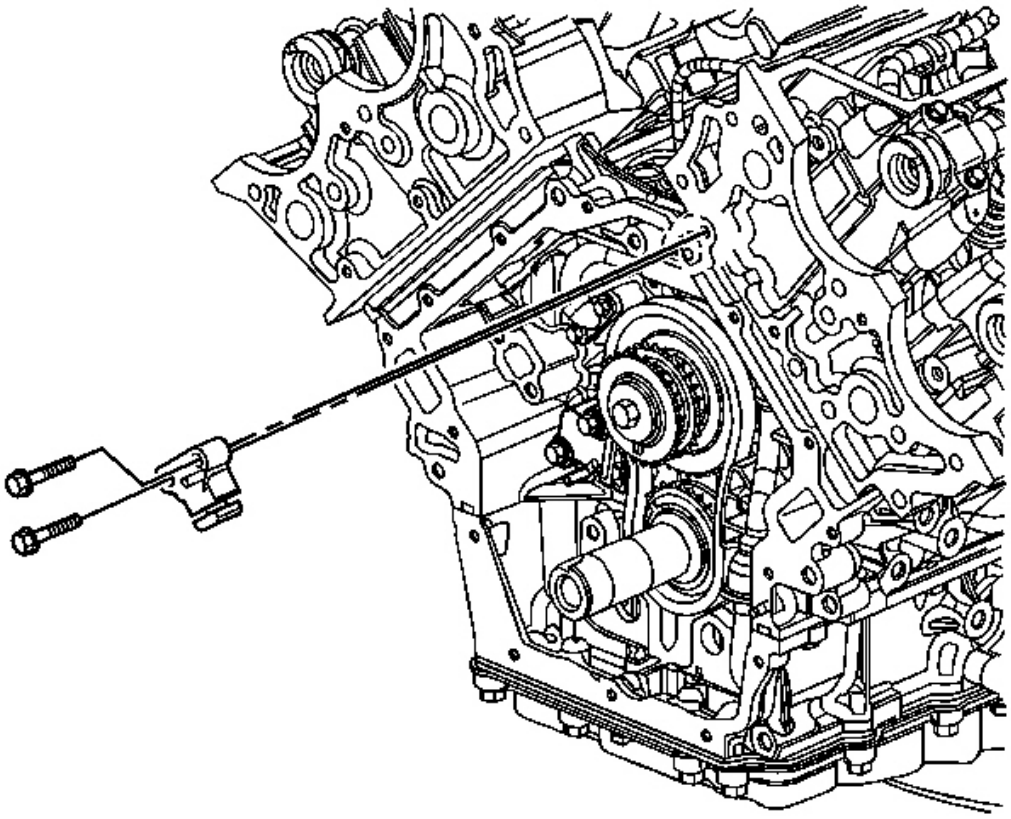


Fig. 272: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the left secondary camshaft tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left Side**.
2. Remove the left camshaft position actuator housing. DO NOT remove the camshaft actuator solenoids from the housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side**.

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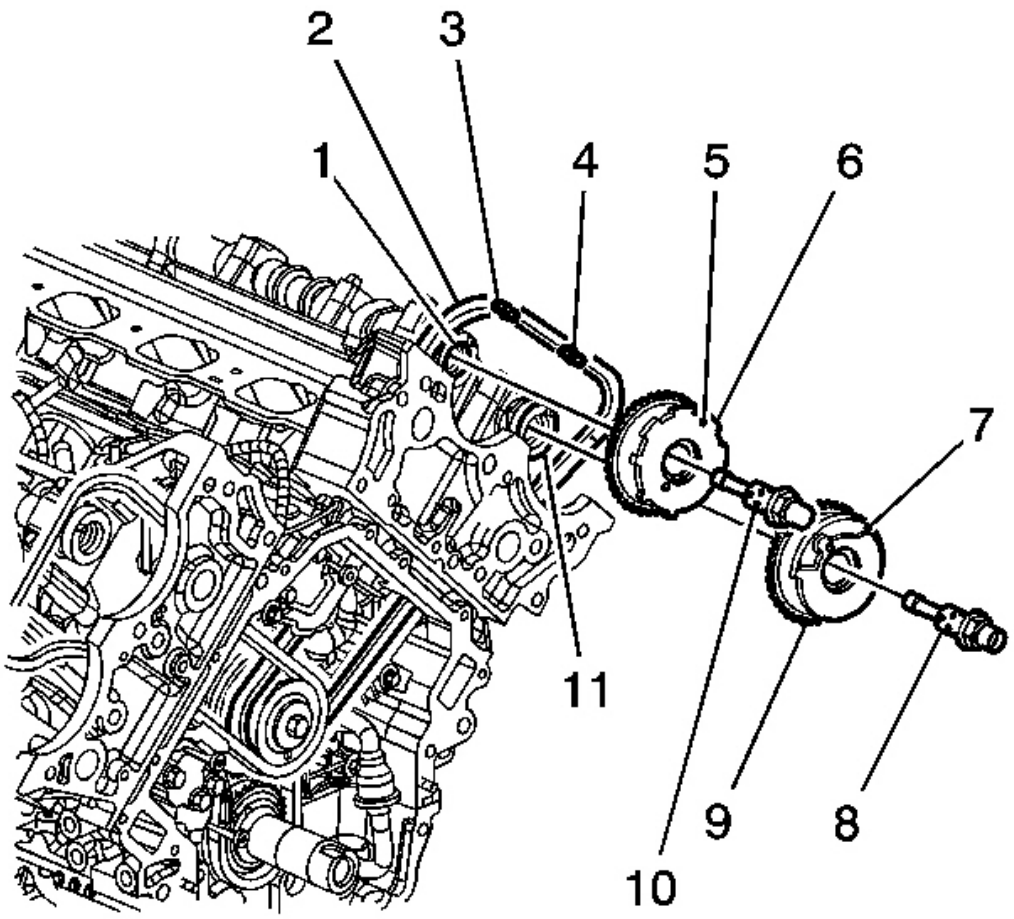


Fig. 273: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Using the **J 39946** , rotate the crankshaft until both camshaft position actuator timing marks (5, 7) are at the top of their rotation. See **Special Tools** .

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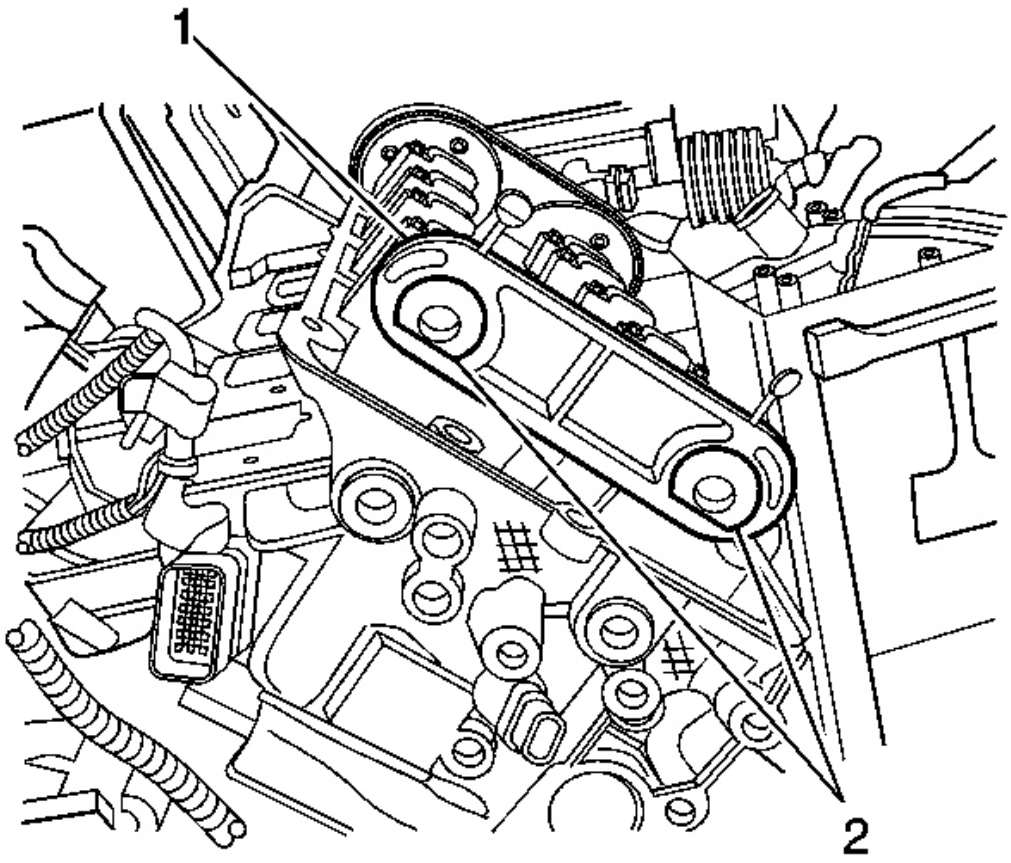


Fig. 274: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution .

4. Install the **EN 46328** (1) to the camshafts (2). See **Special Tools** .

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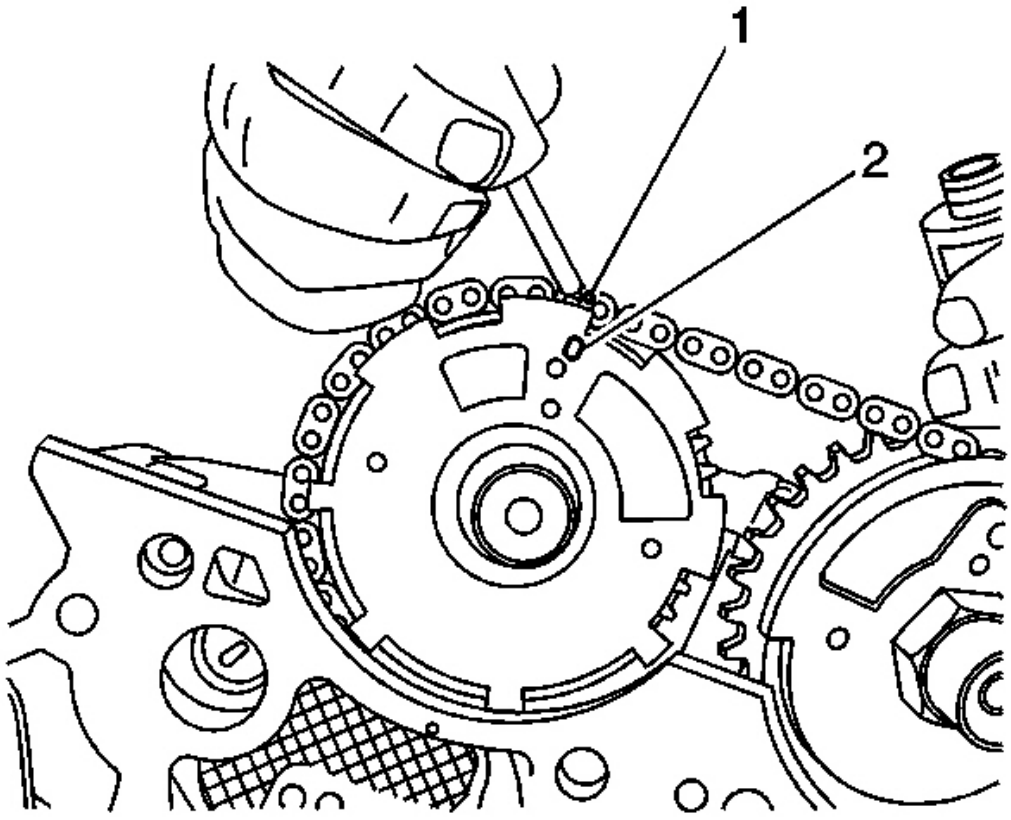


Fig. 275: Marking Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

5. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft position actuator timing mark (2).
6. Use a paint stick to create a mark on a primary chain link and intermediate primary chain sprocket tooth adjacent to the primary chain link.

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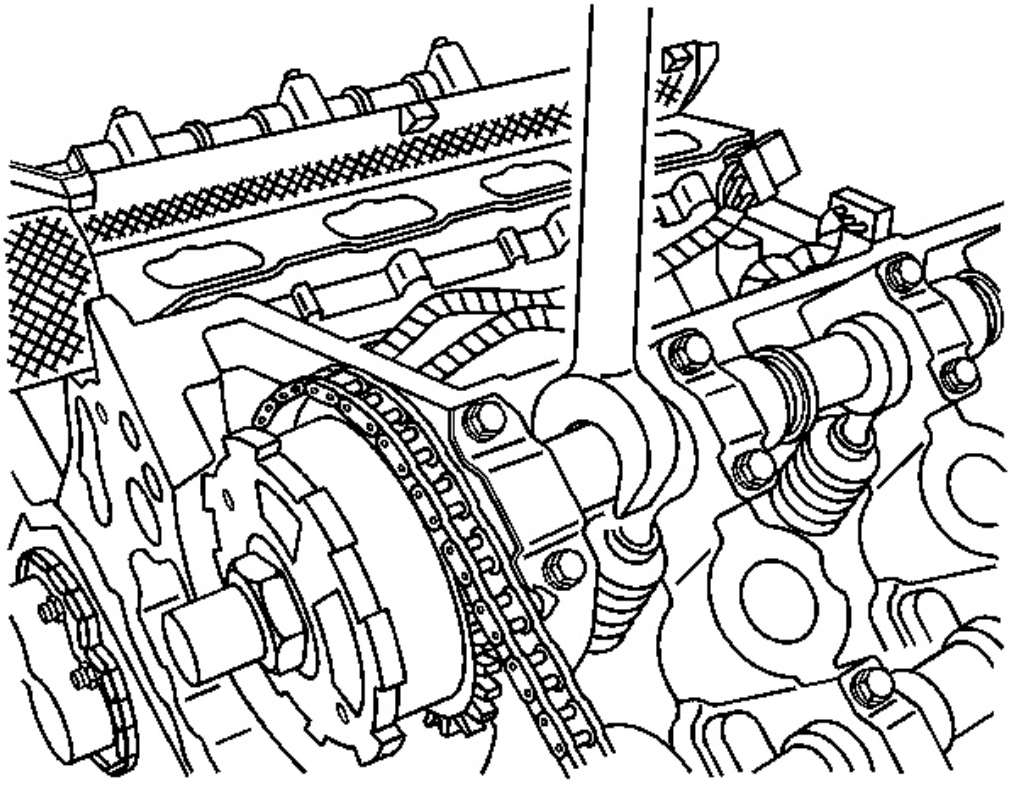


Fig. 276: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

7. Use an open end wrench on the hex cast into the left intake camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

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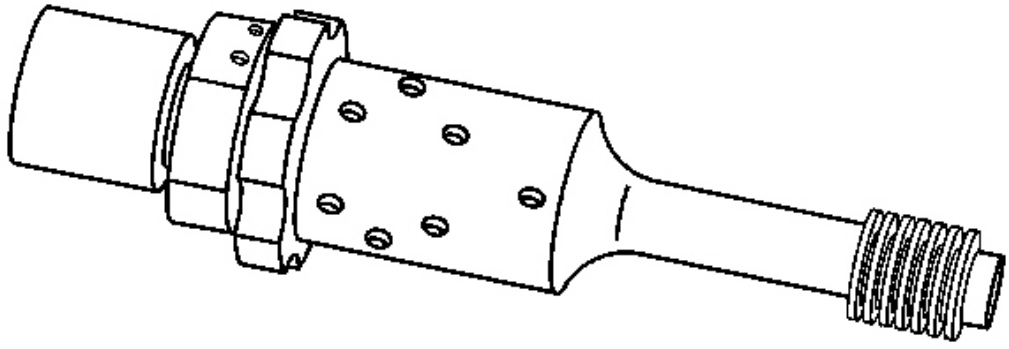


Fig. 277: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

8. Loosen and remove the left intake oil control valve.
9. Slide the left intake camshaft actuator off of the camshaft, disengage the sprocket teeth from the secondary timing chain and remove the actuator.

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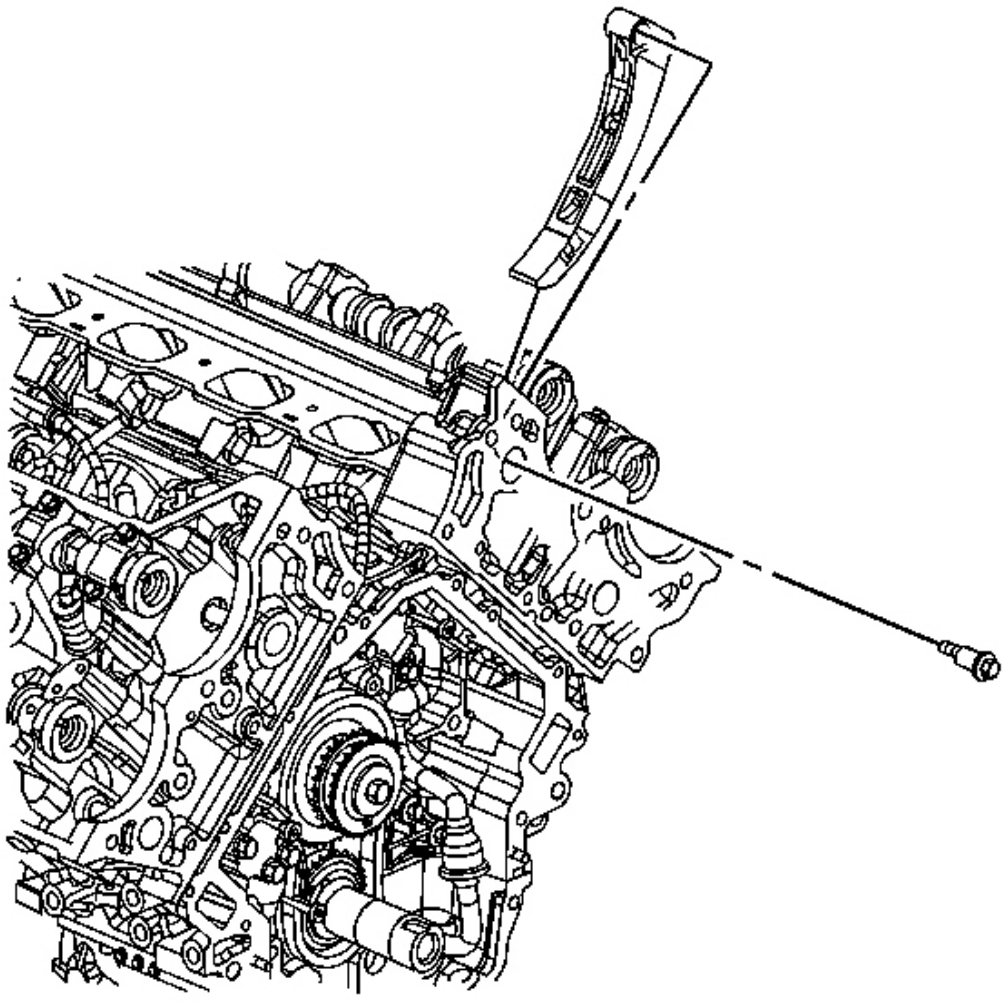


Fig. 278: View Of Left Secondary Camshaft Drive Timing Shoe
Courtesy of GENERAL MOTORS CORP.

10. Remove the left secondary camshaft drive timing chain shoe bolt.
11. Remove the left secondary camshaft drive timing shoe.
12. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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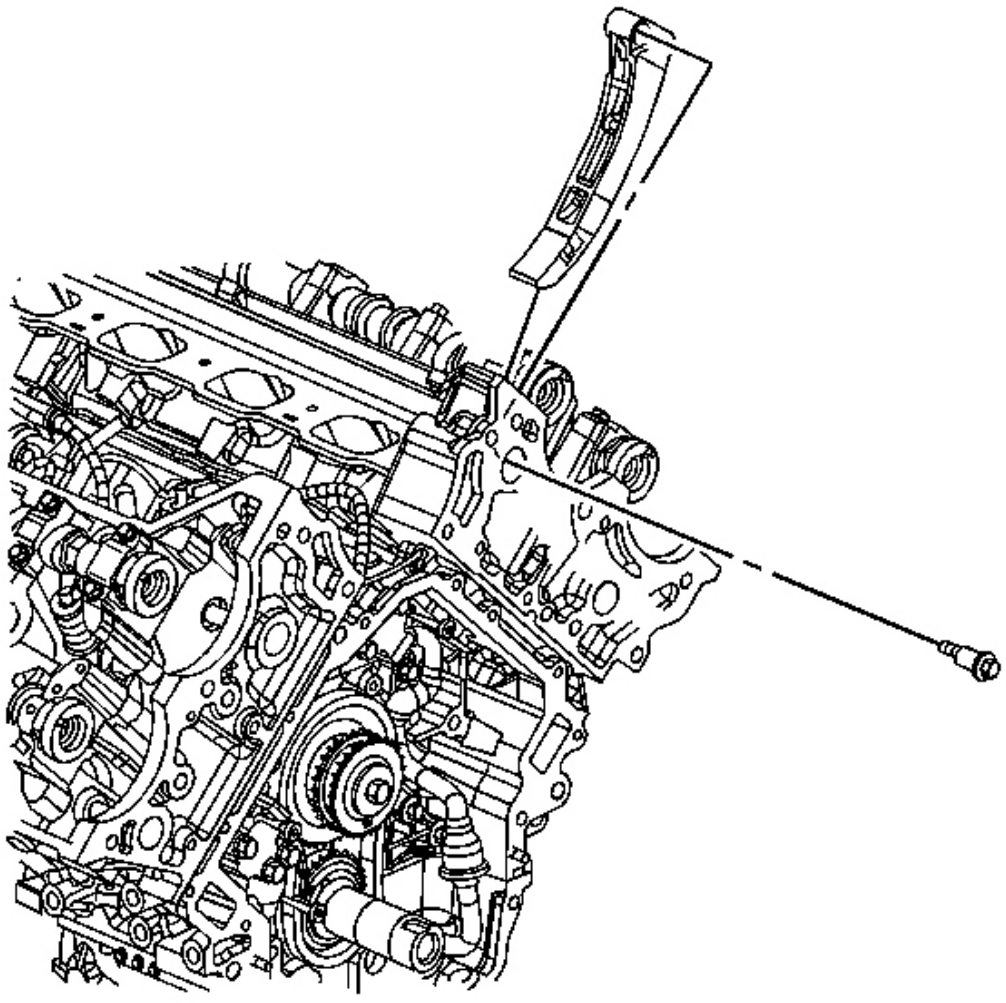


Fig. 279: View Of Left Secondary Camshaft Drive Timing Shoe
Courtesy of GENERAL MOTORS CORP.

1. Position the left secondary camshaft drive chain shoe in through the left front cylinder head as shown.

   NOTE: Refer to Fastener Notice .

2. Install the left secondary camshaft drive chain shoe bolt.

   Tighten: Tighten the secondary camshaft drive chain shoe bolt to 25 N.m (18 lb ft).

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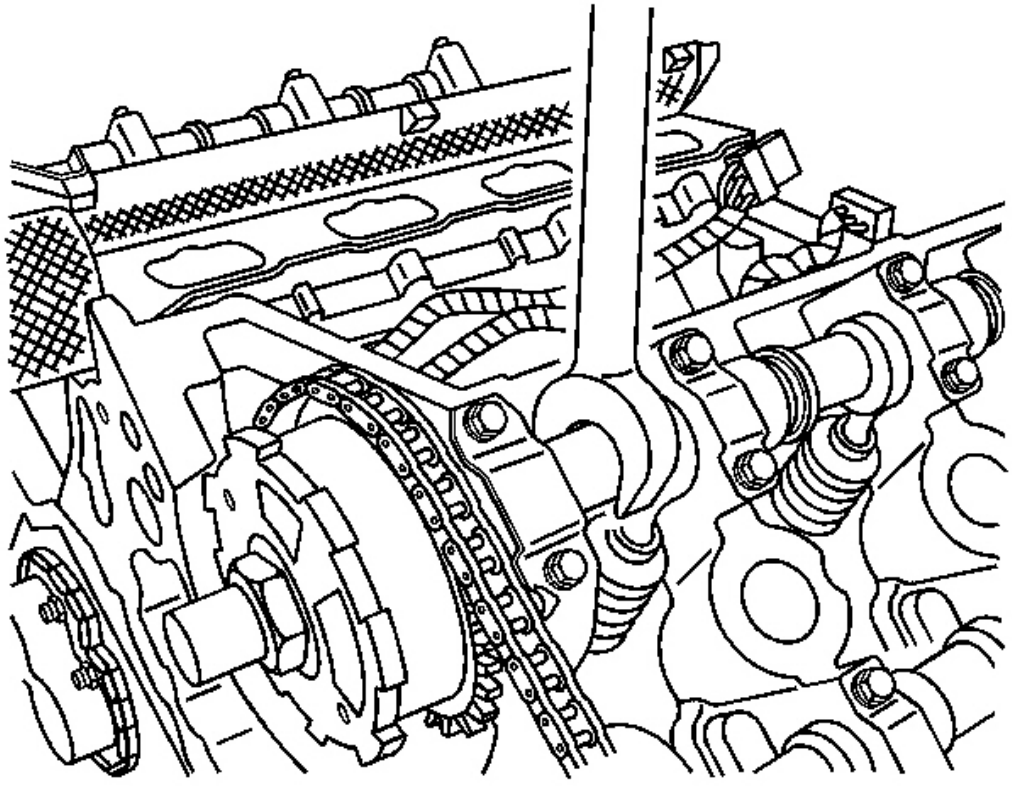


Fig. 280: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

3. Install the left intake actuator to the secondary chain, ensuring that the actuator timing mark is aligned with the chain link that was marked during disassembly.
4. Loosely install the oil control valve to secure the intake actuator to the camshaft.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice .**

5. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

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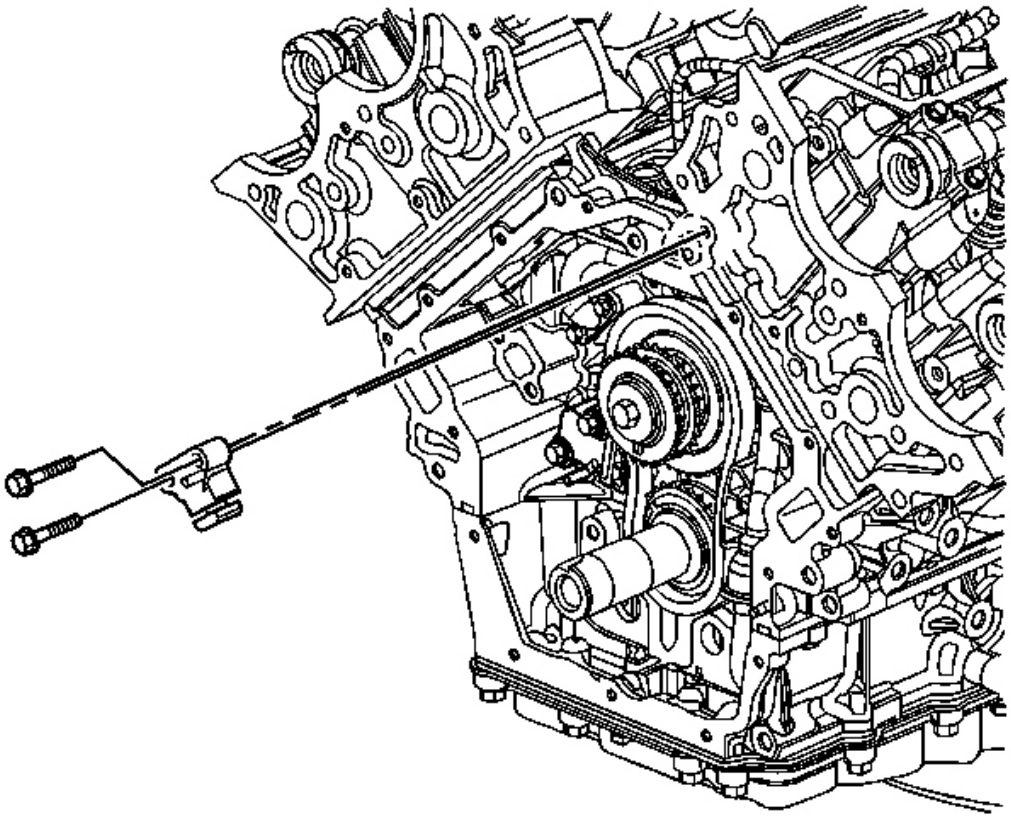


Fig. 281: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the left secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left Side**.

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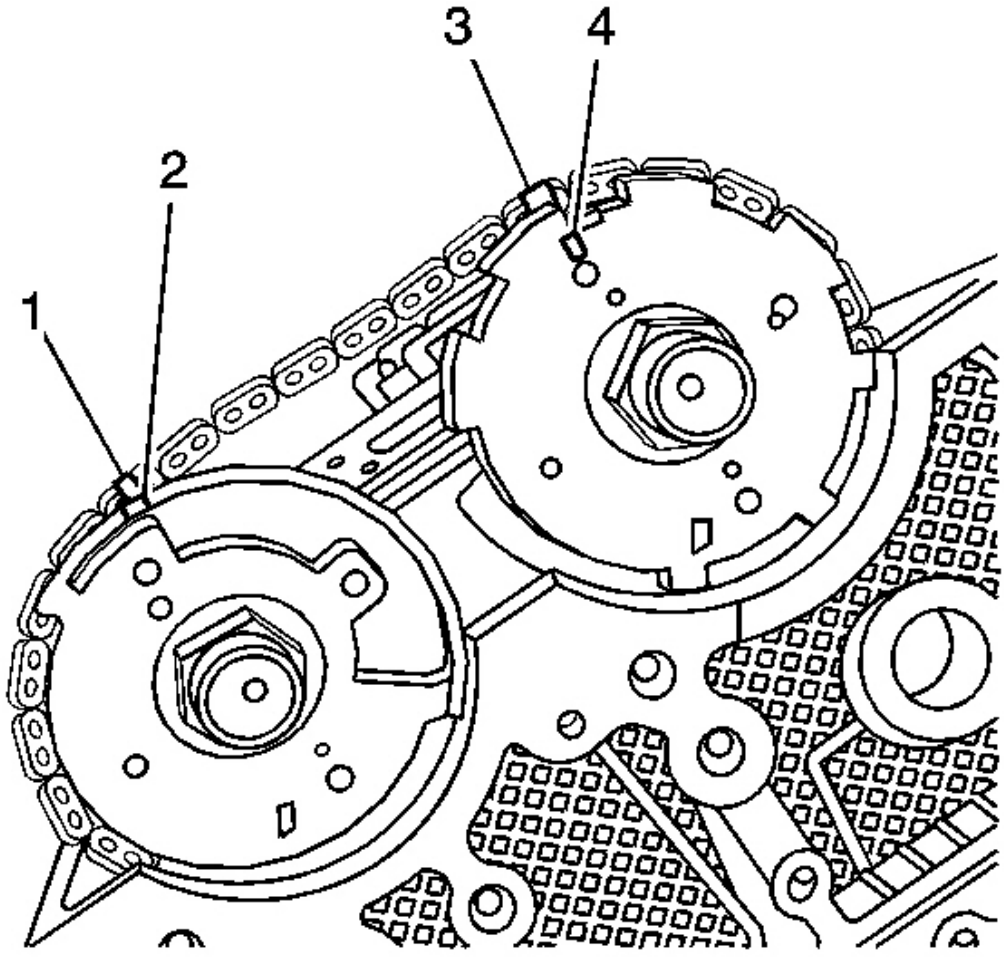


Fig. 282: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

7. Ensure that the previously created paint marks (1, 3) still line up with the sprocket timing marks (2, 4).
8. Install the left camshaft actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side**.

SECONDARY CAMSHAFT DRIVE CHAIN SHOE REPLACEMENT - RIGHT SIDE

TOOLS REQUIRED

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- **EN 46328** Camshaft Holding Tool. See **Special Tools** .
- **J 39946** Crankshaft Socket. See **Special Tools** .

REMOVAL PROCEDURE

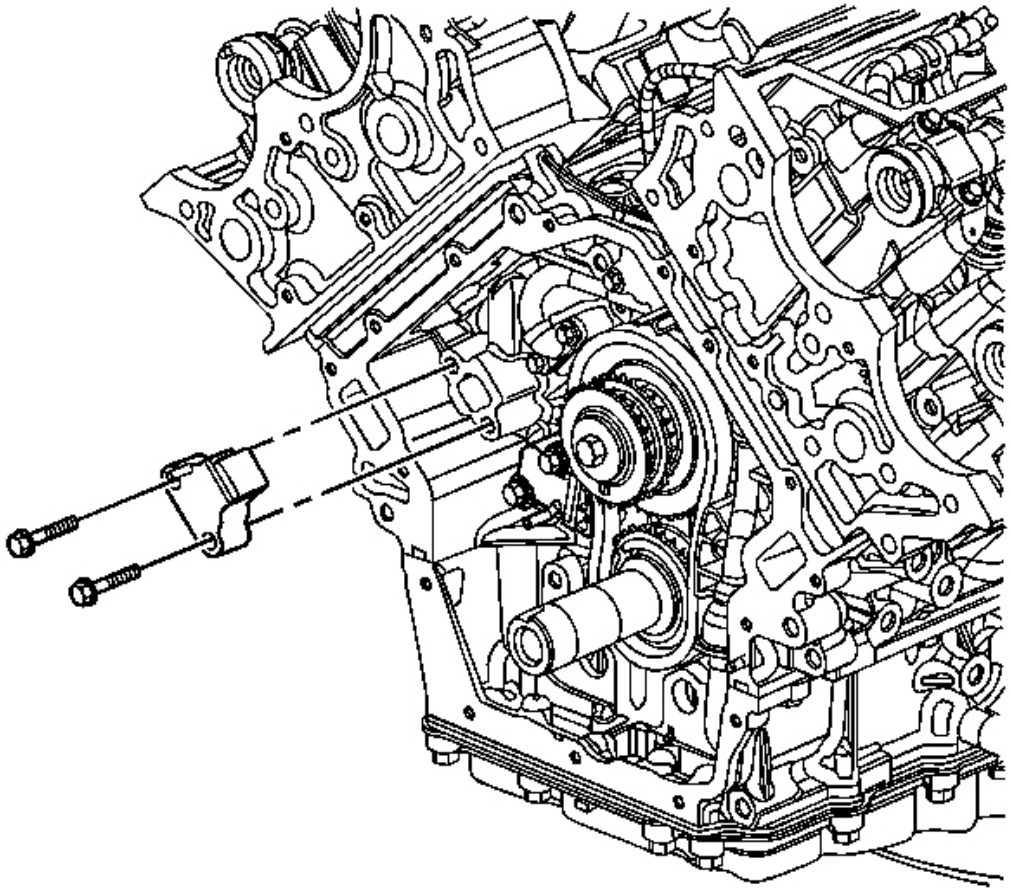


Fig. 283: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the right secondary camshaft tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right Side**.

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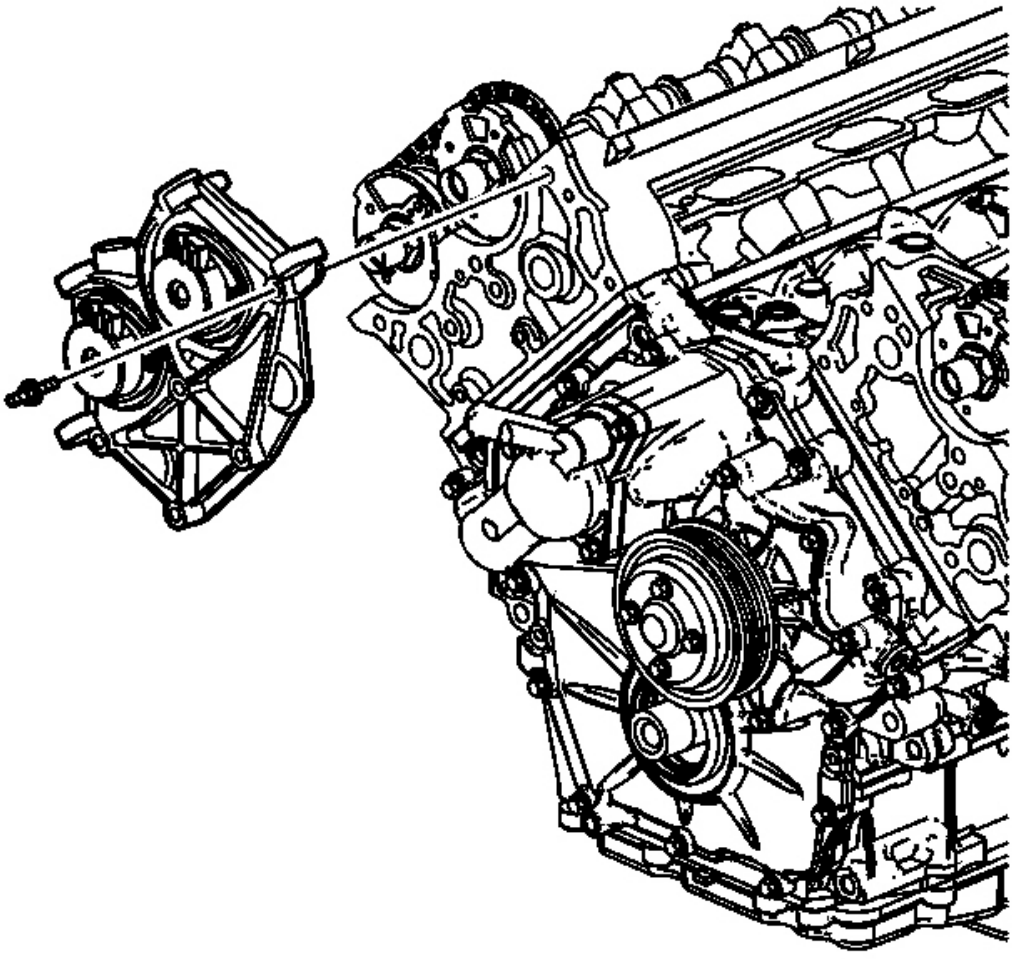


Fig. 284: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

2. Remove the right camshaft position actuator housing. DO NOT remove the camshaft actuator solenoids from the housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side**.

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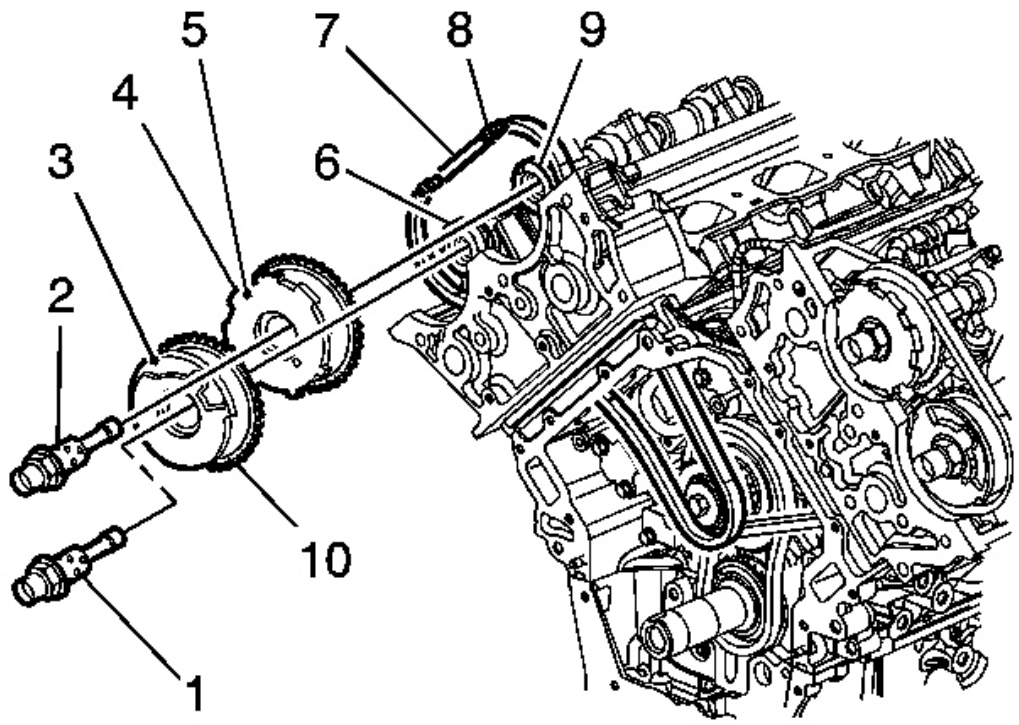


Fig. 285: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Using the **J 39946** , rotate the crankshaft until both camshaft position actuator timing marks (3, 5) are at the top of their rotation. See **Special Tools** .

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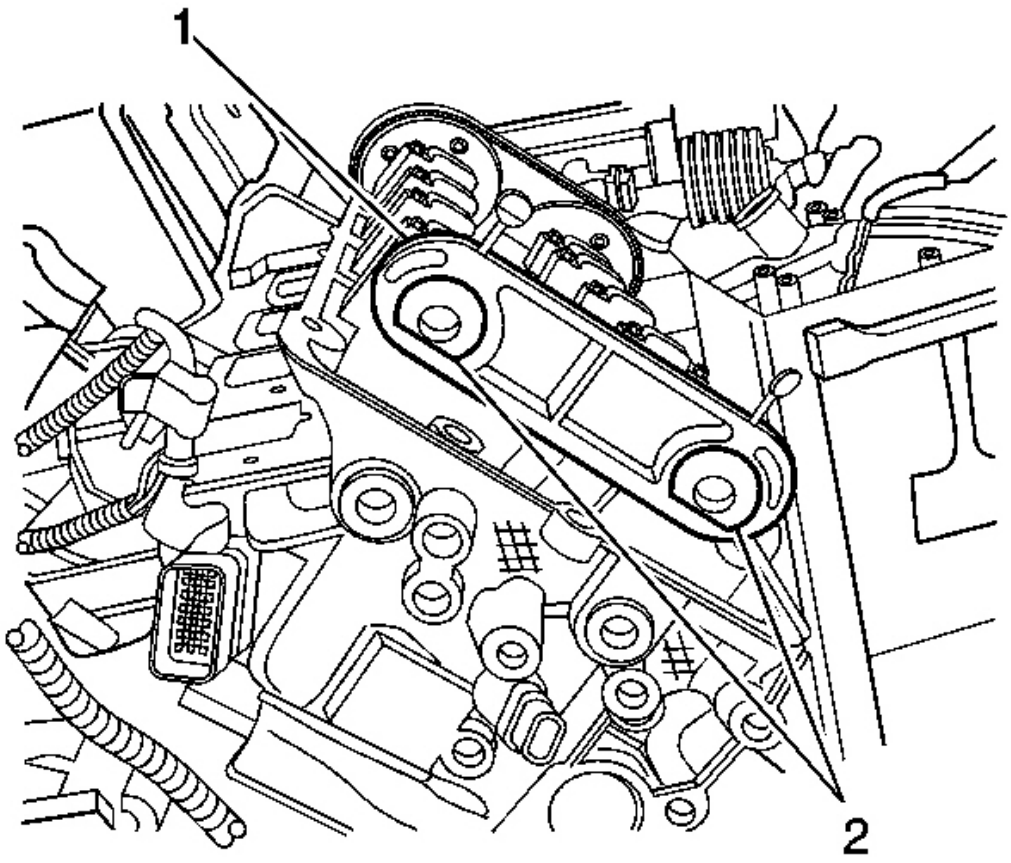


Fig. 286: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution .

4. Install the **EN 46328** (1) to the camshafts (2). See **Special Tools** .

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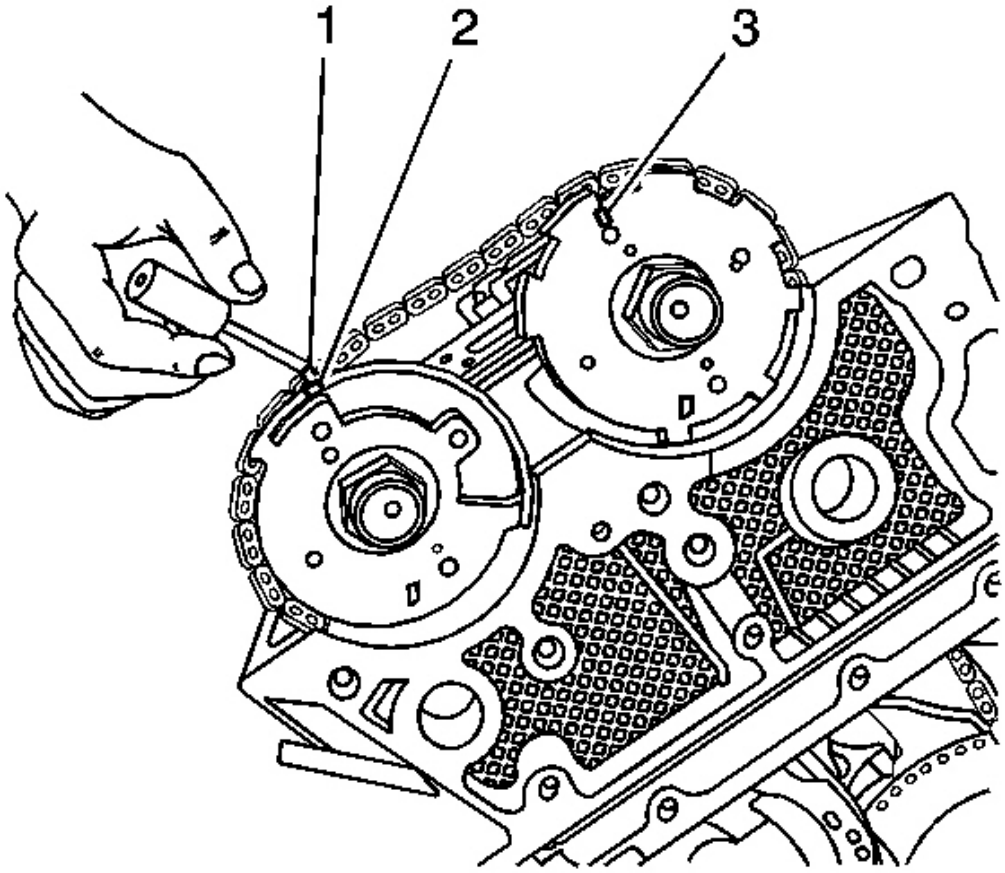


Fig. 287: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

5. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft position actuator timing mark (2, 3).
6. Use a paint stick to create a mark on a primary chain link and intermediate primary chain sprocket tooth adjacent to the primary chain link.

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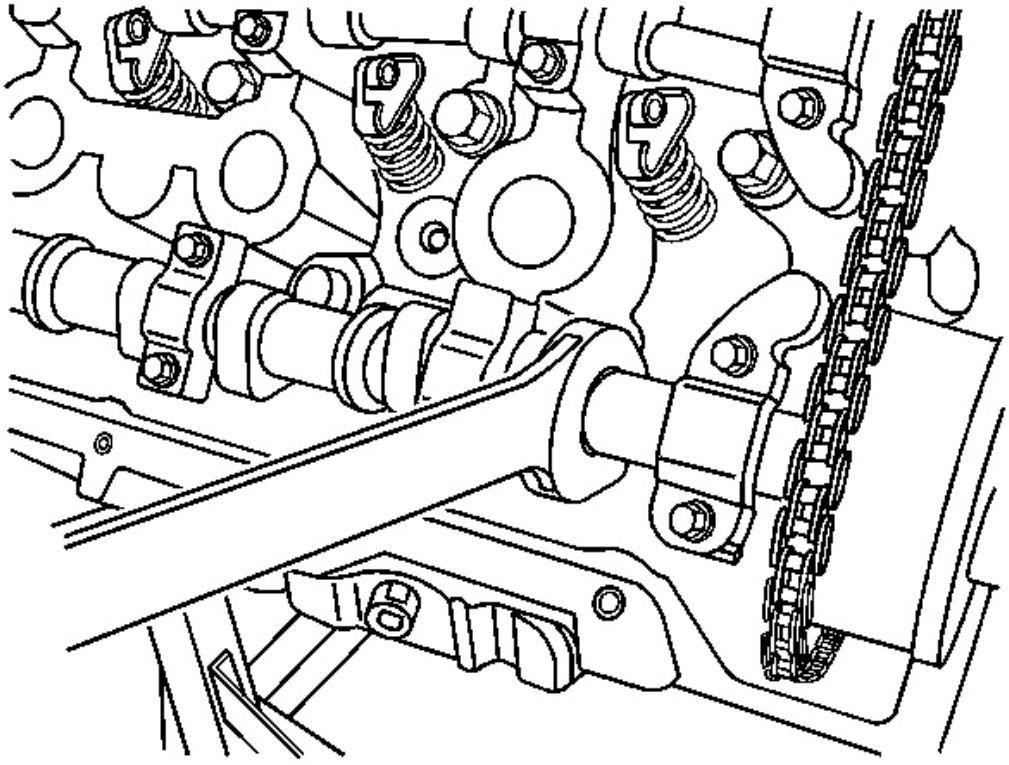


Fig. 288: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

7. Use an open end wrench on the hex cast into the right exhaust camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

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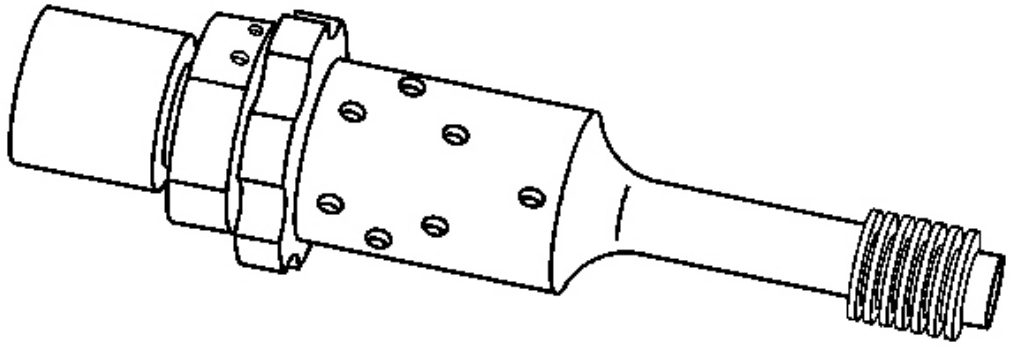


Fig. 289: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

8. Loosen and remove the right exhaust oil control valve.
9. Slide the right exhaust camshaft actuator off of the camshaft, disengage the sprocket teeth from the secondary timing chain and remove the actuator.

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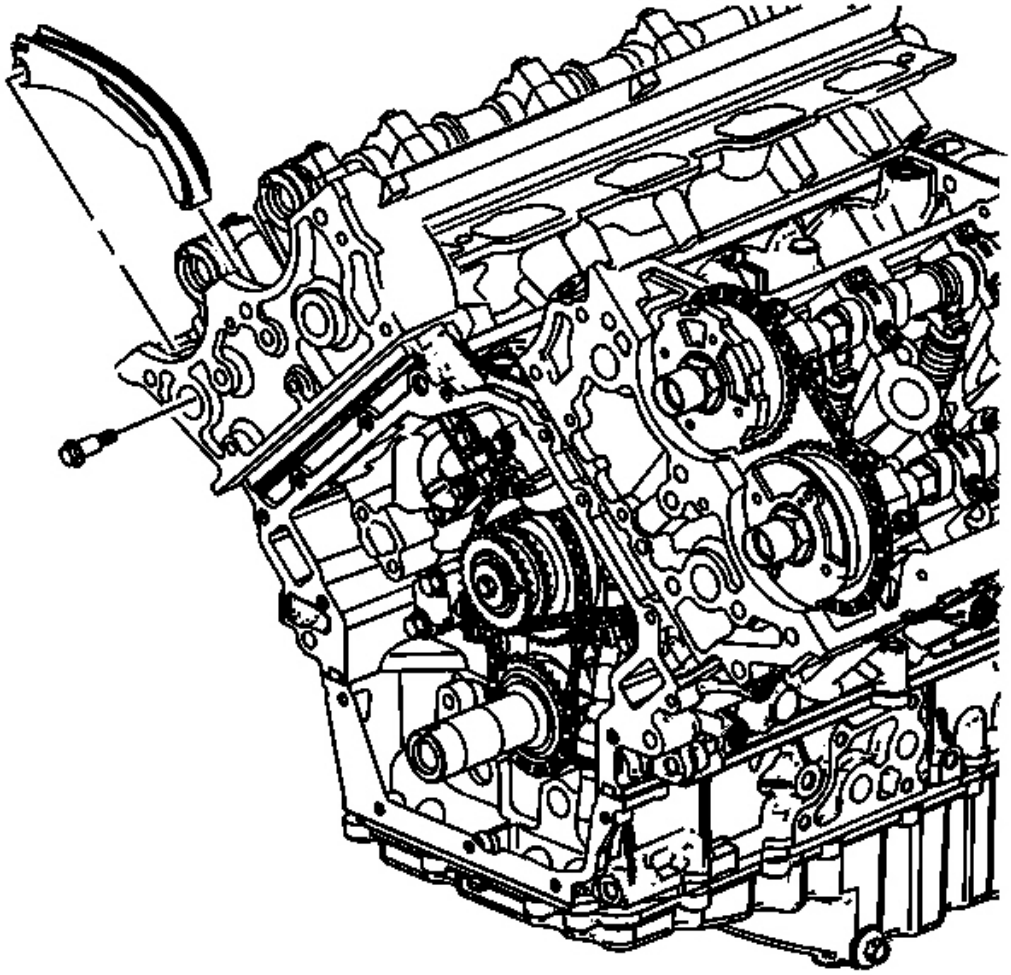


Fig. 290: View Of Right Secondary Camshaft Drive Timing Chain Shoe
Courtesy of GENERAL MOTORS CORP.

10. Remove the right secondary camshaft drive timing chain shoe bolt.
11. Remove the right secondary camshaft drive timing chain shoe.
12. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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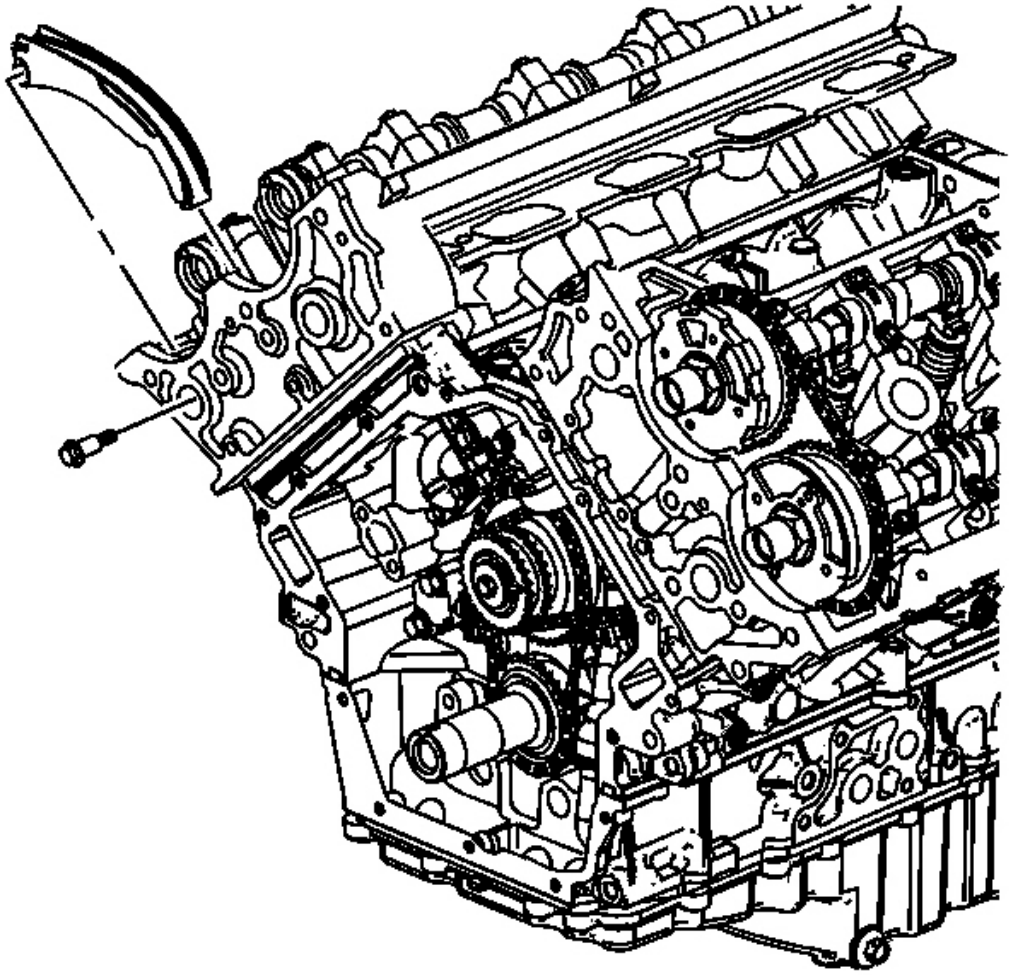


Fig. 291: View Of Right Secondary Camshaft Drive Timing Chain Shoe
Courtesy of GENERAL MOTORS CORP.

1. Position the right secondary camshaft drive timing chain shoe in through the right front cylinder head as shown.

NOTE: **Refer to Fastener Notice .**

2. Install the right secondary camshaft drive chain shoe bolt.

Tighten: Tighten the secondary camshaft drive chain shoe bolt to 25 N.m (18 lb ft).

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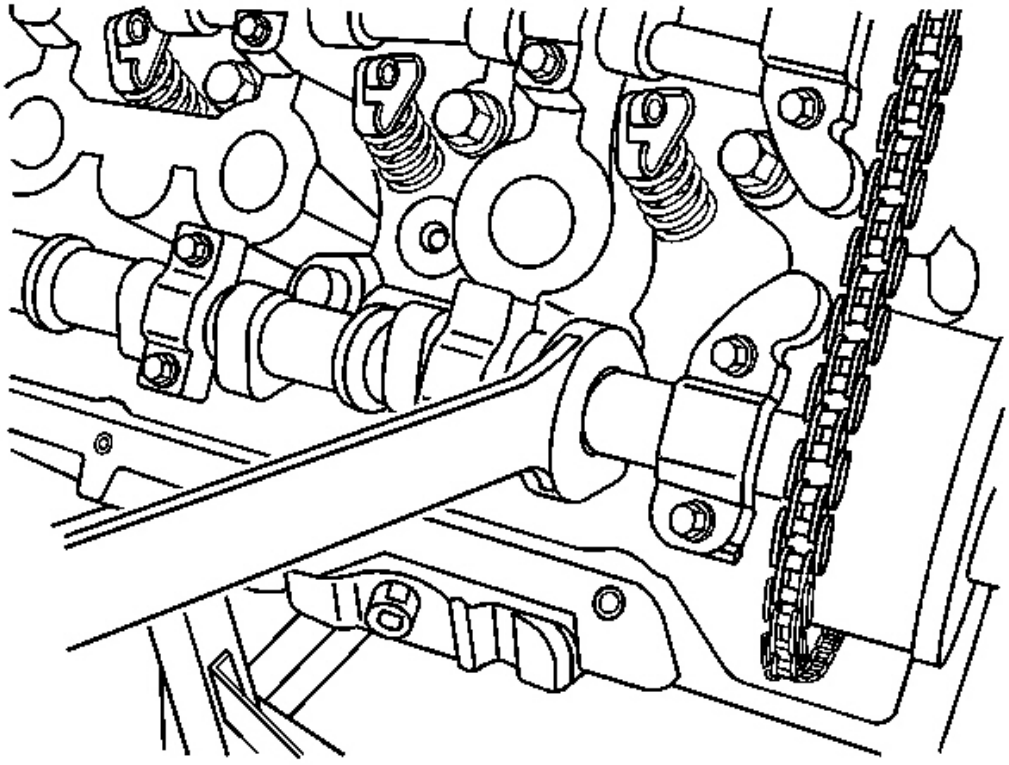


Fig. 292: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

3. Install the right exhaust actuator to the secondary chain, ensuring that the actuator timing mark is aligned with the chain link that was marked during disassembly.
4. Loosely install the oil control valve to secure the exhaust actuator to the camshaft.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice .**

5. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

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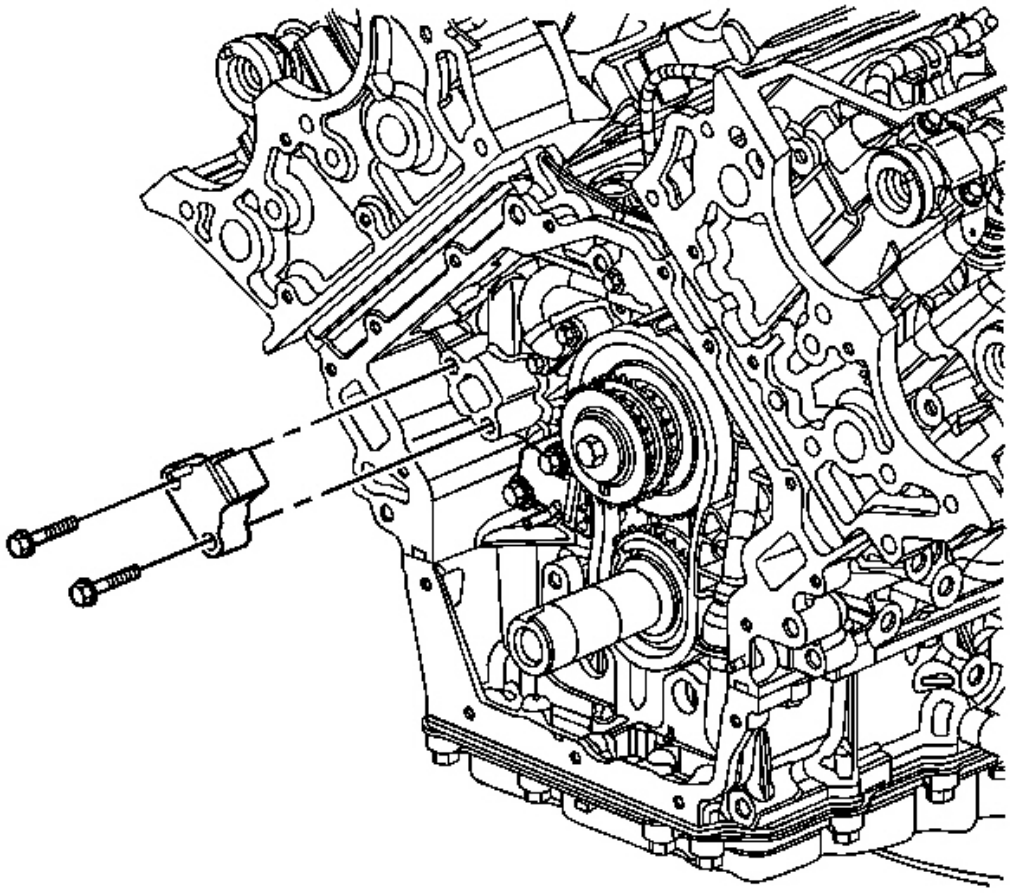


Fig. 293: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the right secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right Side**.

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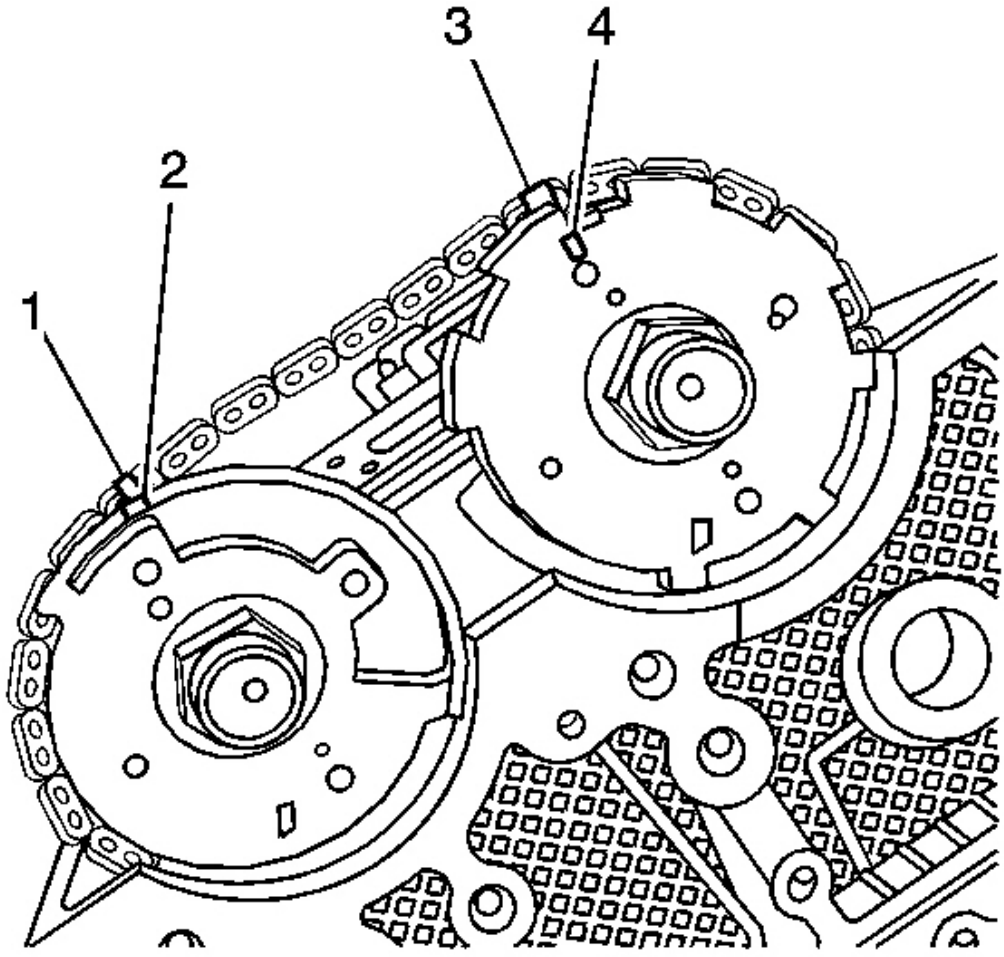


Fig. 294: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

7. Ensure that the previously created paint marks (1, 3) still line up with the sprocket timing marks (2, 4).

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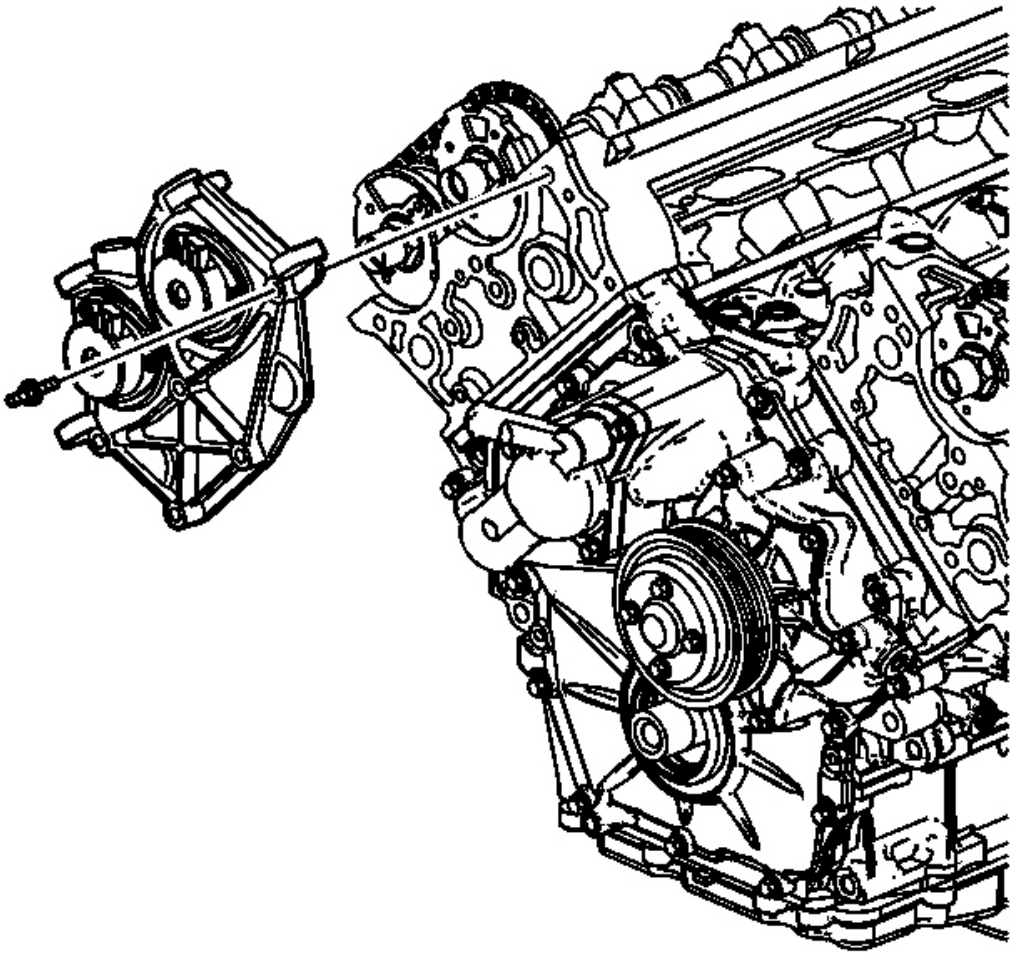


Fig. 295: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

8. Install the right camshaft actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side**.

SECONDARY CAMSHAFT DRIVE CHAIN GUIDE REPLACEMENT - LEFT SIDE

TOOLS REQUIRED

- **J 39946** Crankshaft Socket. See **Special Tools** .
- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

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REMOVAL PROCEDURE

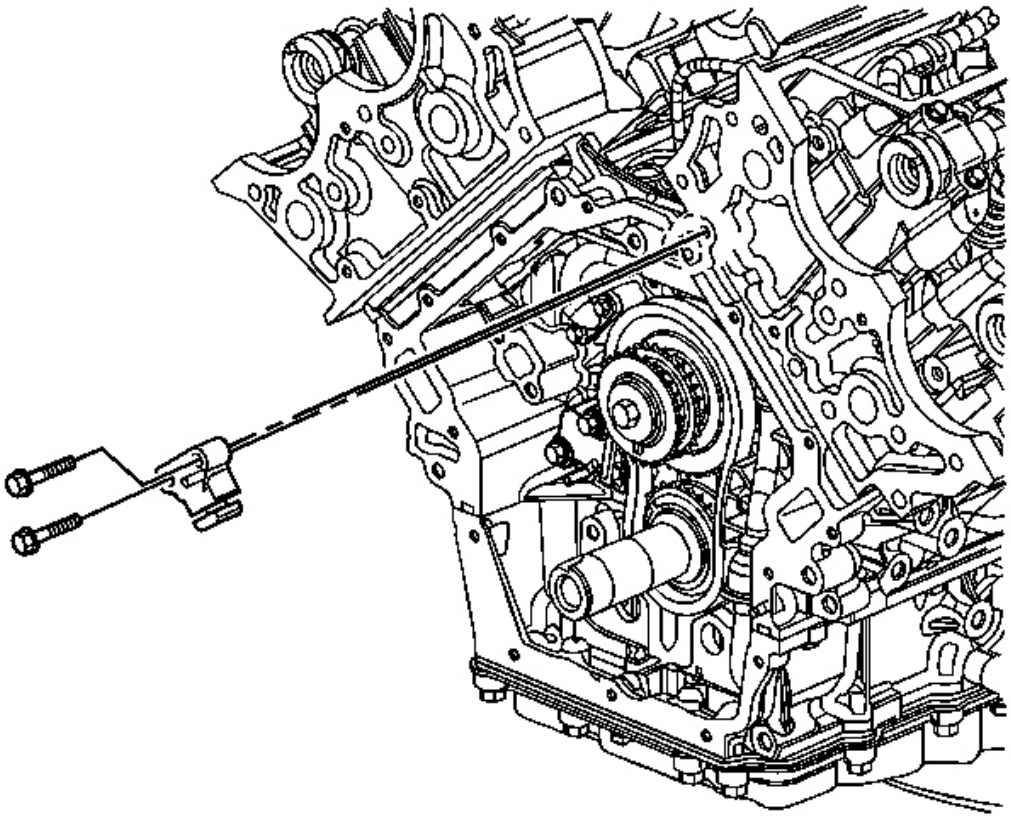


Fig. 296: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the left secondary camshaft tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left Side**.

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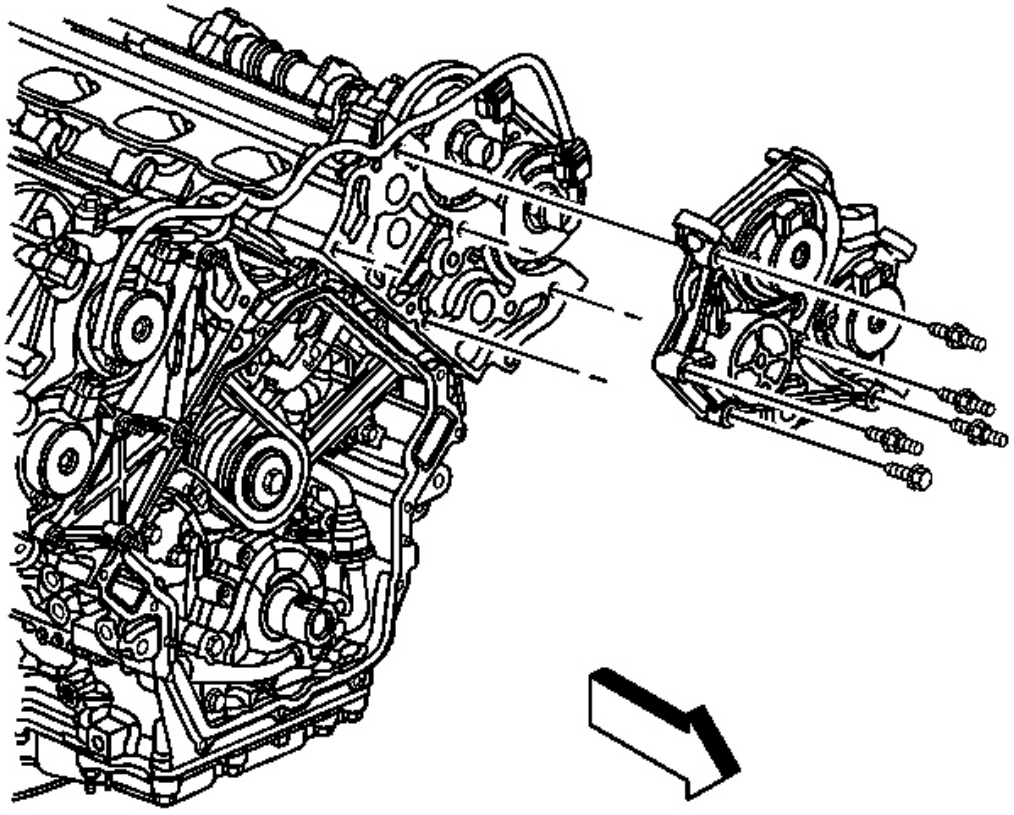


Fig. 297: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

2. Remove the left camshaft position actuator housing. DO NOT remove the camshaft actuator solenoids from the housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side**.

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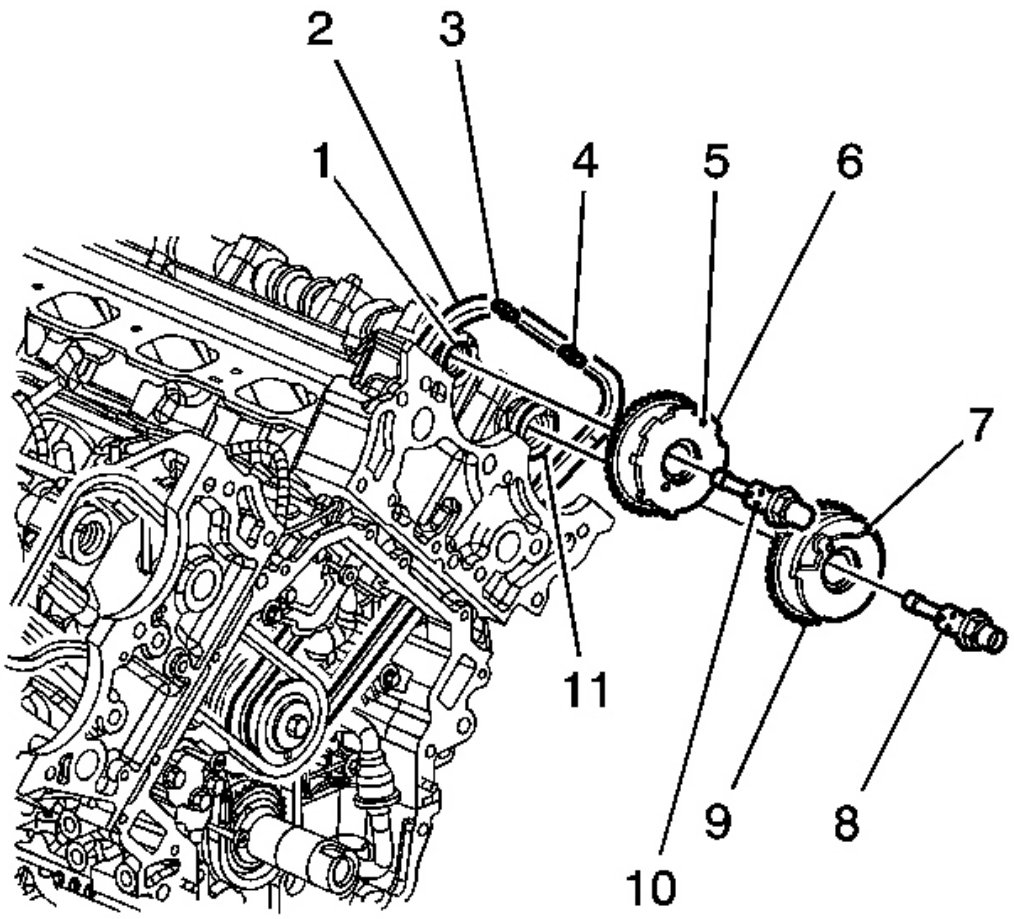


Fig. 298: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Using the **J 39946** , rotate the crankshaft until both camshaft position actuator timing marks (5, 7) are at the top of their rotation. See **Special Tools** .

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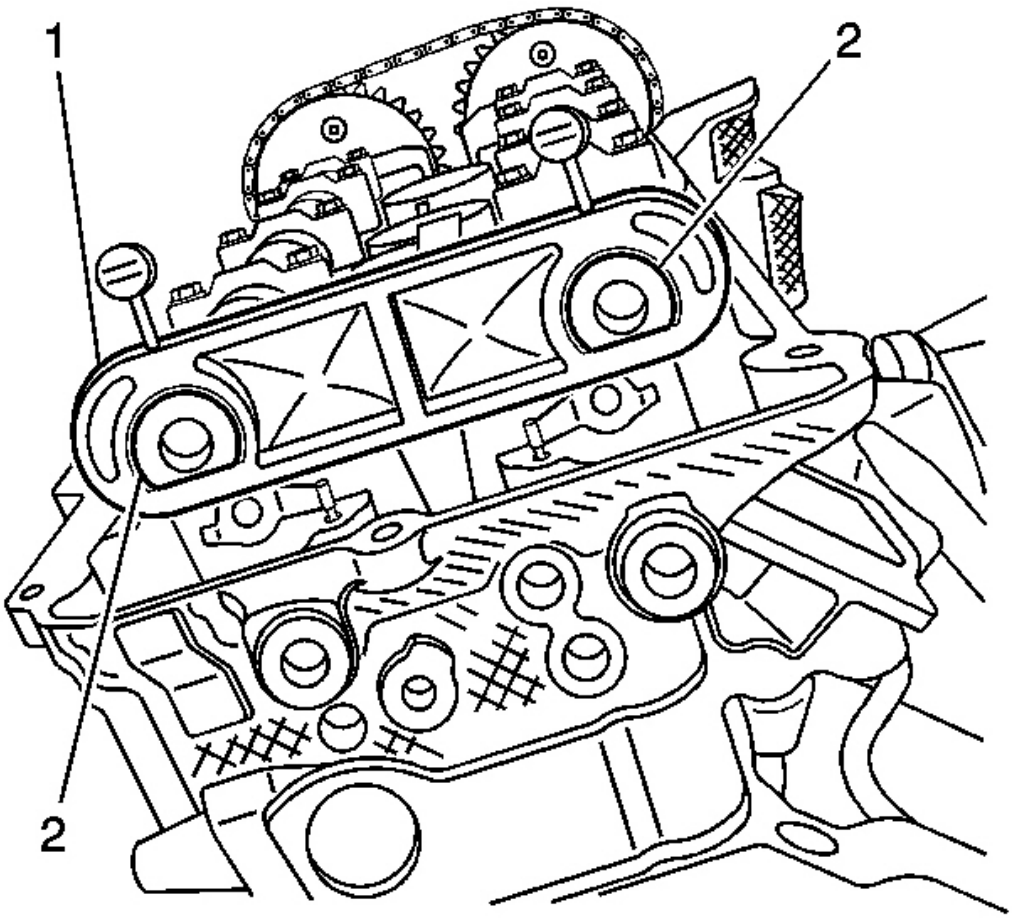


Fig. 299: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution .

4. Install the **EN 46328** (1) to the camshafts (2). See **Special Tools** .

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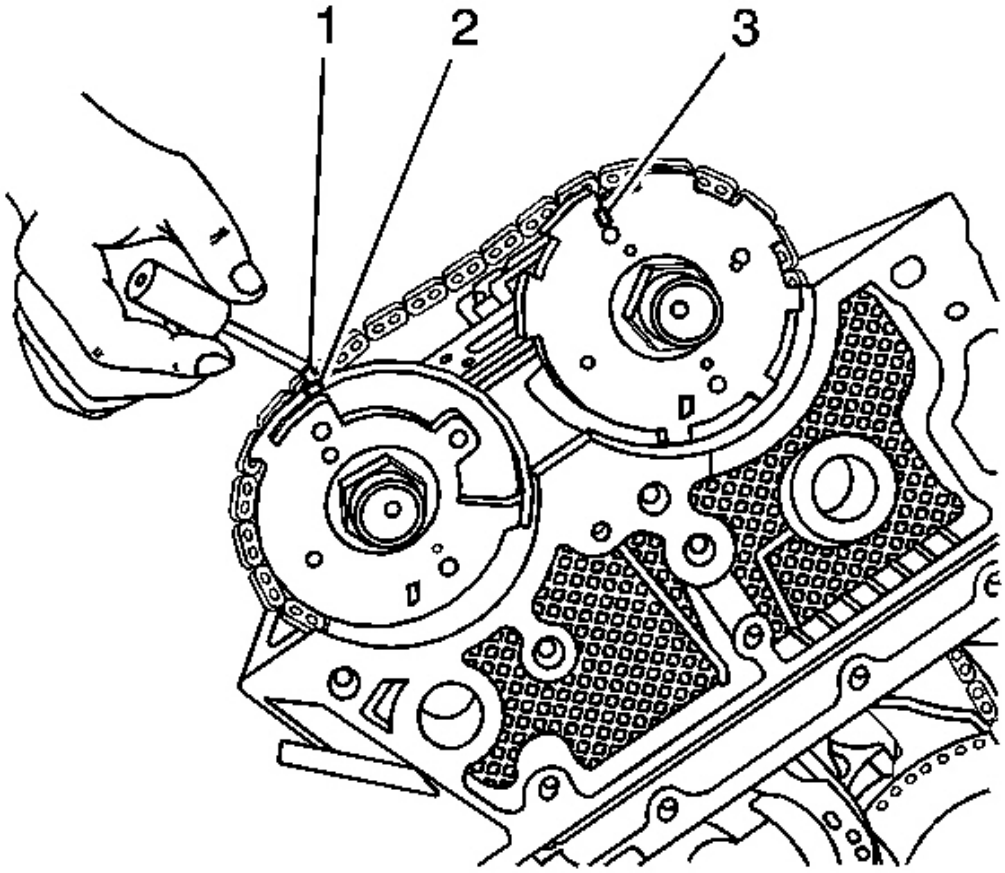


Fig. 300: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

5. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft position actuator timing mark (2, 3).
6. Use a paint stick to create a mark on a primary chain link and intermediate primary chain sprocket tooth adjacent to the primary chain link.

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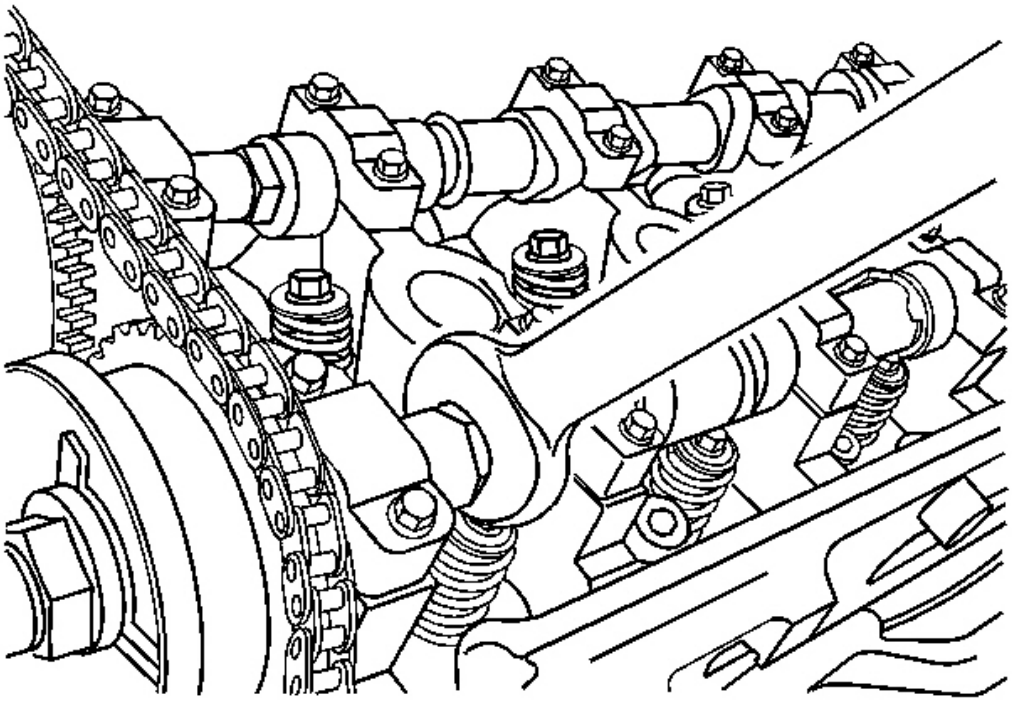


Fig. 301: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

7. Use an open end wrench on the hex cast into the left exhaust camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

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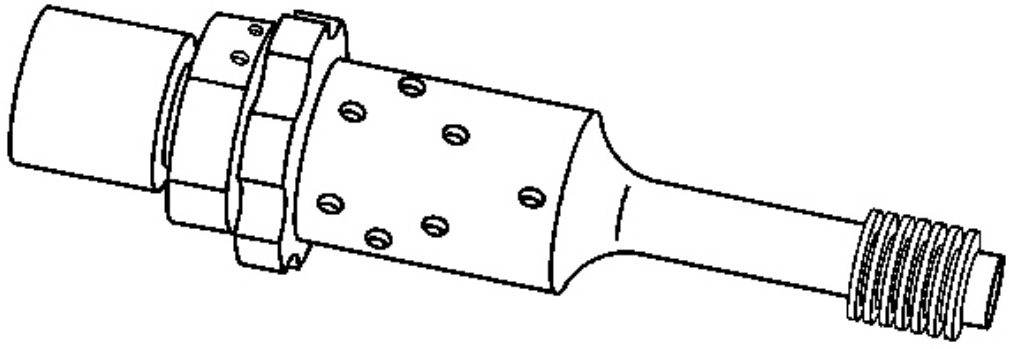


Fig. 302: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

8. Loosen and remove the left exhaust oil control valve.
9. Slide the left exhaust camshaft actuator off of the camshaft, disengage the sprocket teeth from the secondary timing chain and remove the actuator.

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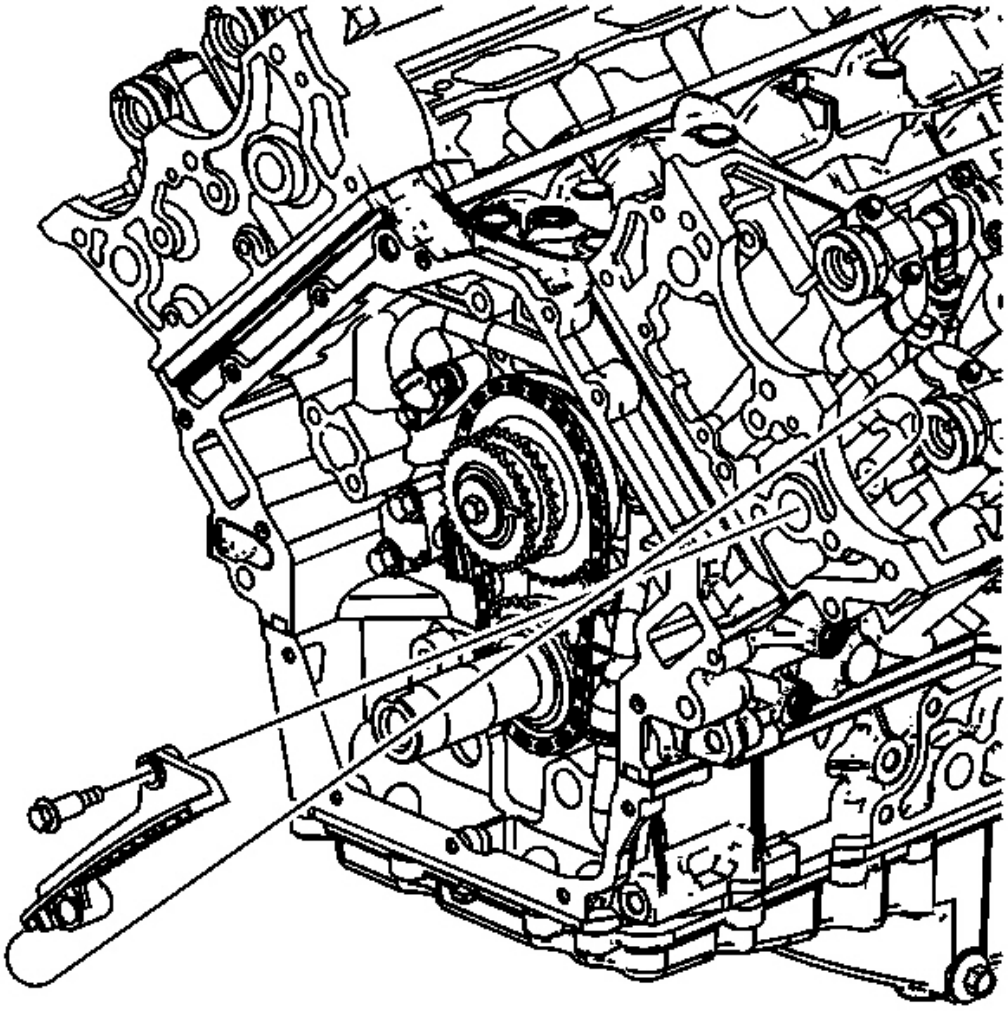


Fig. 303: View Of Left Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

10. Remove the secondary camshaft drive chain guide bolt.
11. Remove the left secondary camshaft drive chain guide.
12. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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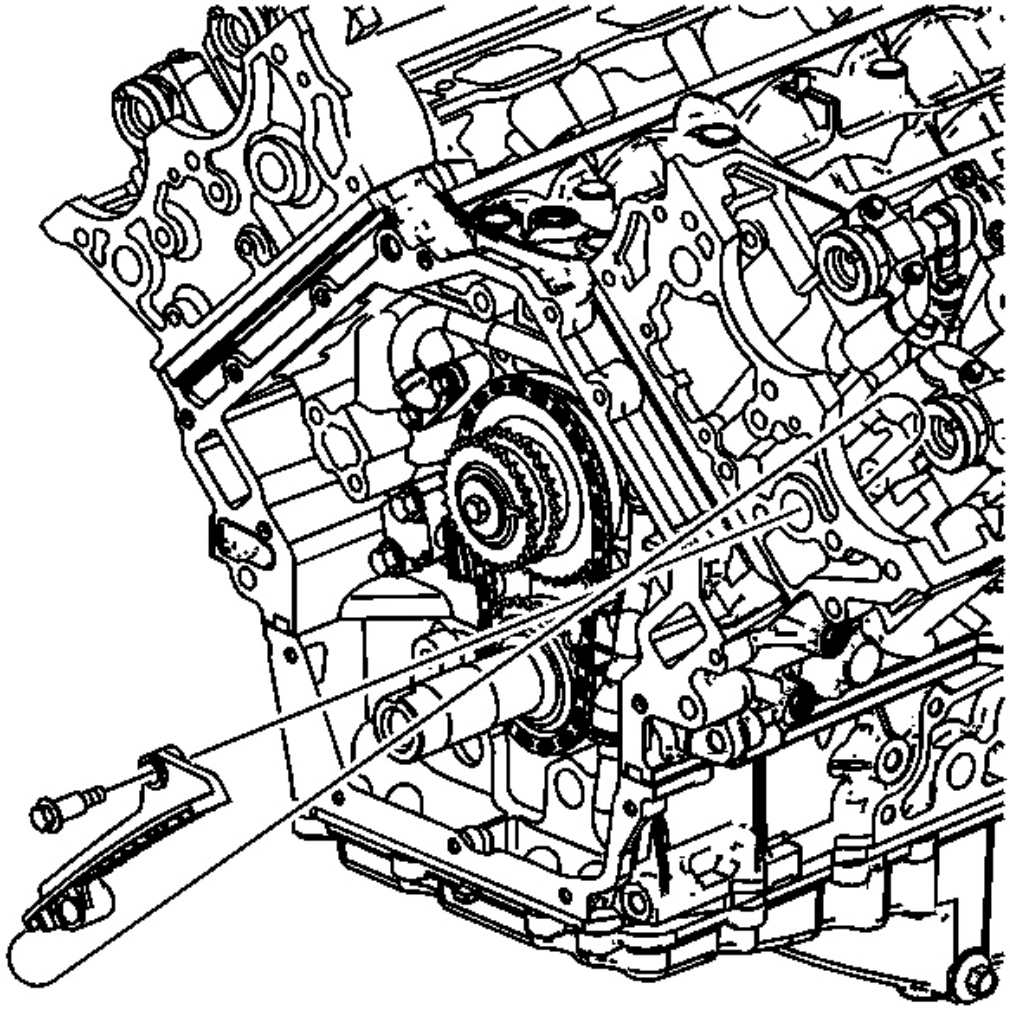


Fig. 304: View Of Left Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Position the left secondary camshaft drive chain guide in through the left front cylinder head as shown.

   NOTE: Refer to Fastener Notice .

2. Install the left secondary camshaft drive chain guide bolt.

   Tighten: Tighten the secondary camshaft drive chain guide bolt to 25 N.m (18 lb ft).

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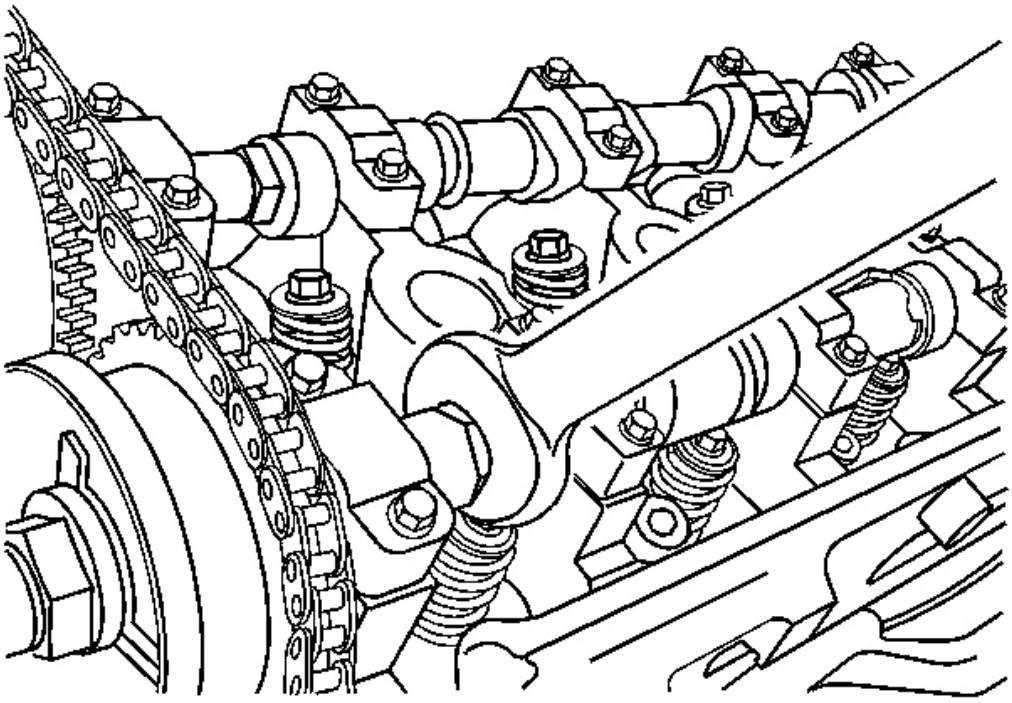


Fig. 305: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

3. Install the left exhaust actuator to the secondary chain, ensuring that the actuator timing mark is aligned with the chain link that was marked during disassembly.
4. Loosely install the oil control valve to secure the exhaust actuator to the camshaft.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice .**

5. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

   Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

6. Install the left secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left Side**.

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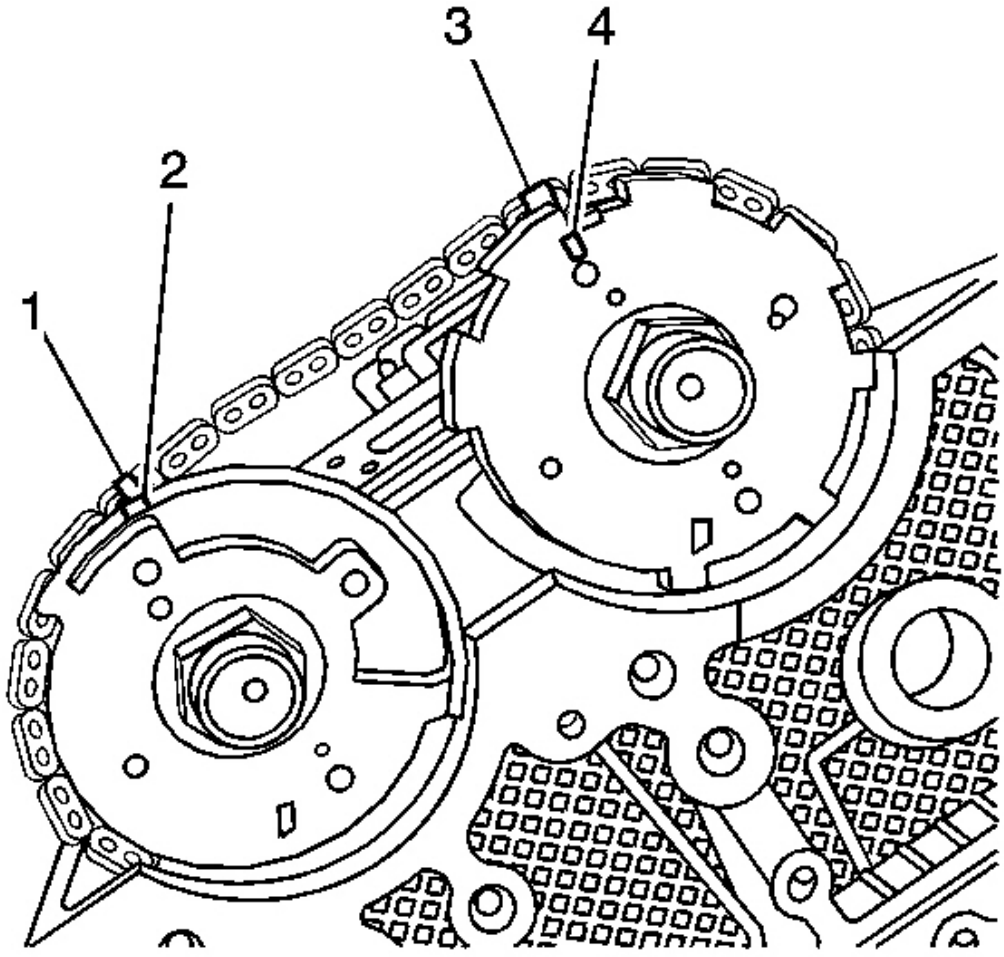


Fig. 306: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

7. Ensure that the previously created paint marks (1, 3) still line up with the sprocket timing marks (2, 4).
8. Install the left camshaft actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side**.

SECONDARY CAMSHAFT DRIVE CHAIN GUIDE REPLACEMENT - RIGHT SIDE

TOOLS REQUIRED

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- **J 39946** Crankshaft Socket. See **Special Tools** .
- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

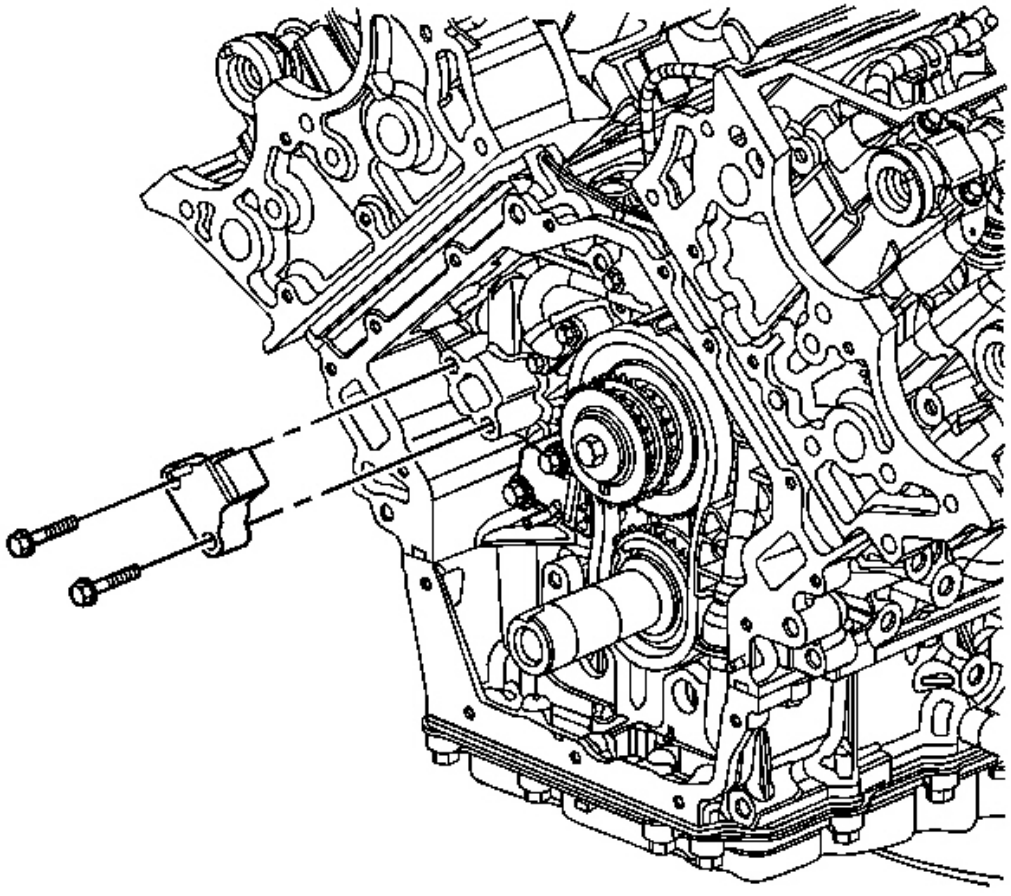


Fig. 307: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the right secondary camshaft tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right Side**.

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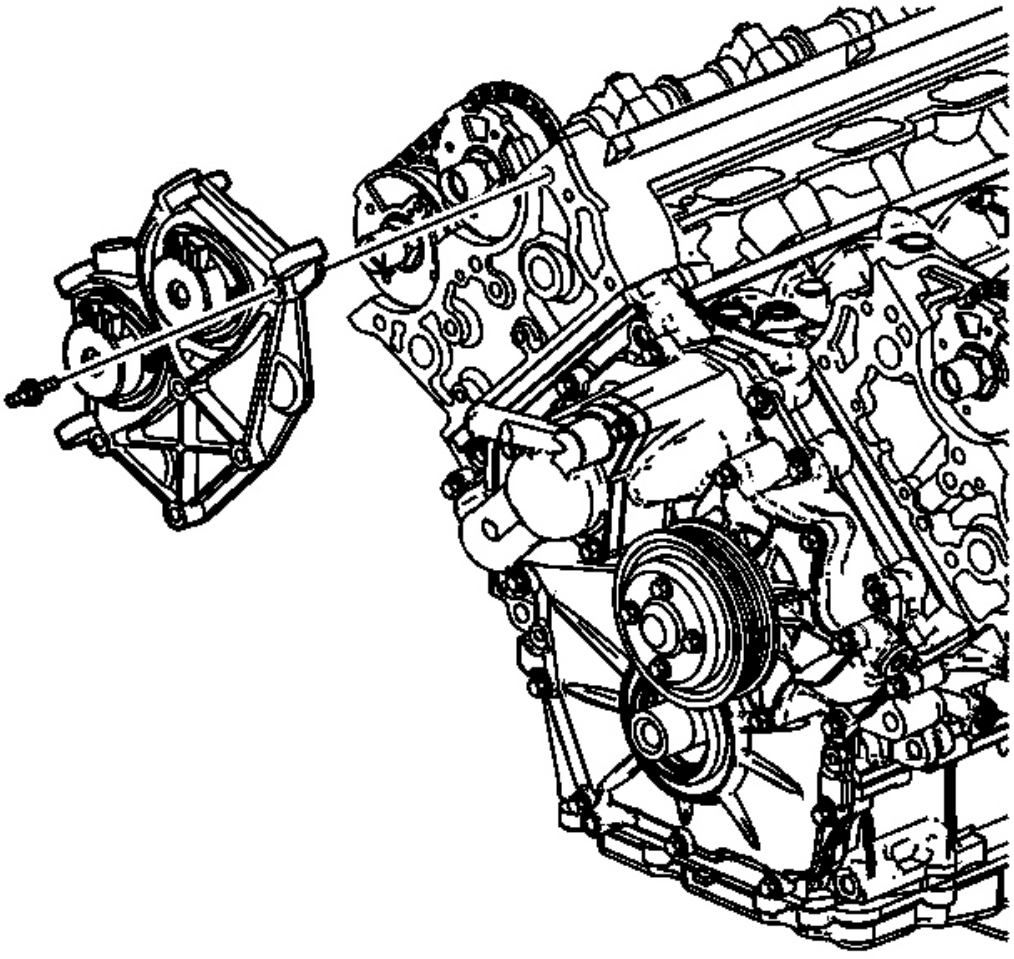


Fig. 308: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

2. Remove the right camshaft position actuator housing. DO NOT remove the camshaft actuator solenoids from the housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side**.

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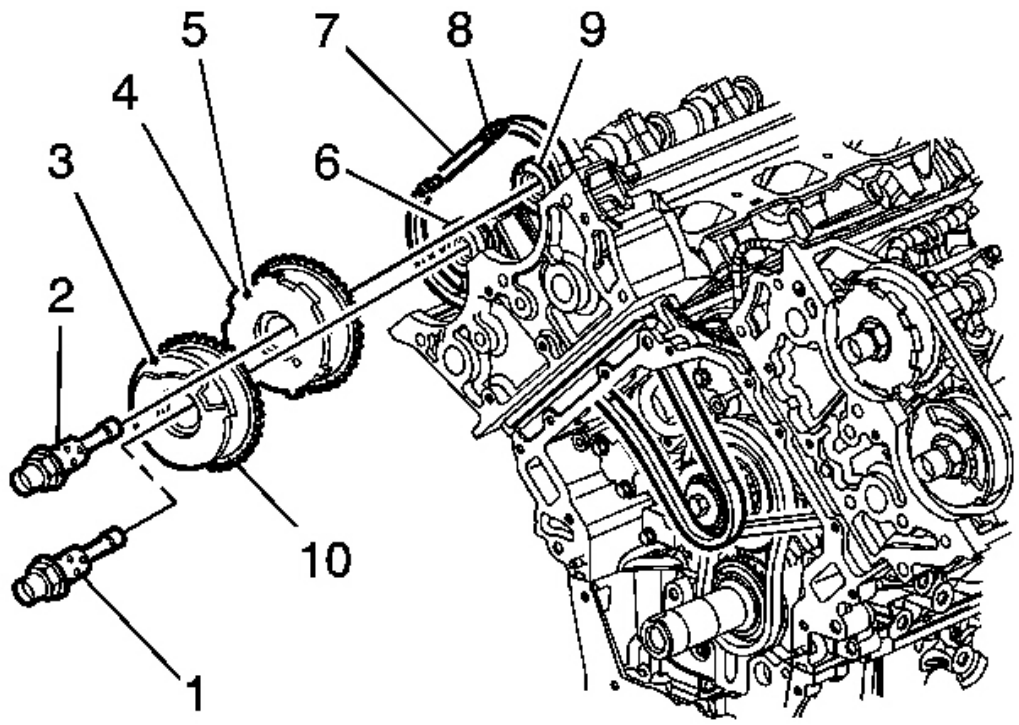


Fig. 309: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Using the **J 39946** , rotate the crankshaft until both camshaft position actuator timing marks (3, 5) are at the top of their rotation. See **Special Tools** .

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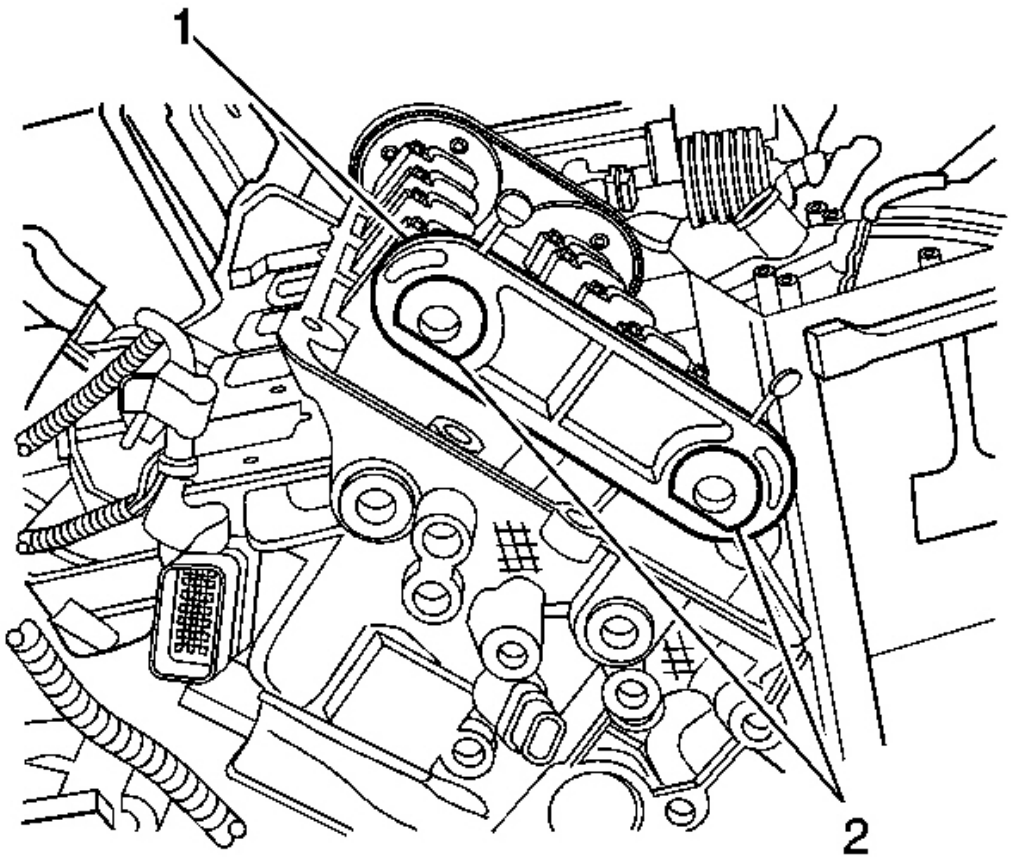


Fig. 310: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution .

4. Install the **EN 46328** (1) to the camshafts (2). See **Special Tools** .

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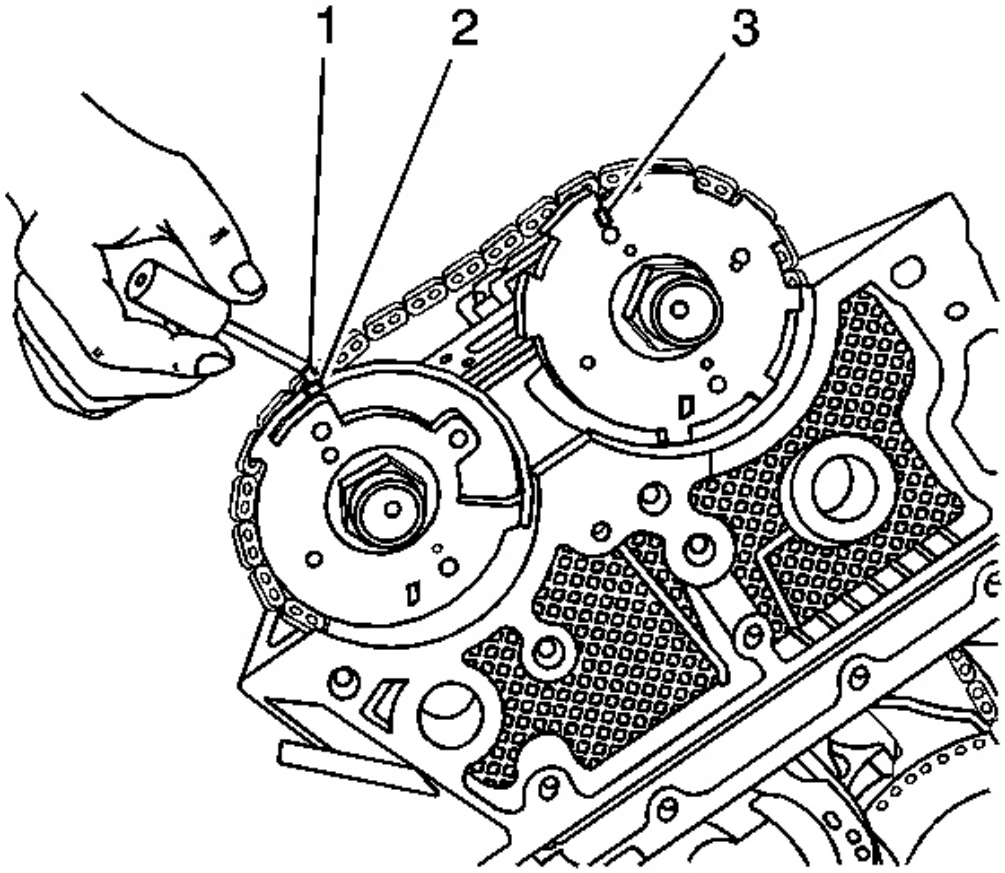


Fig. 311: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

5. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft position actuator timing mark (2, 3).
6. Use a paint stick to create a mark on a primary chain link and intermediate primary chain sprocket tooth adjacent to the primary chain link.

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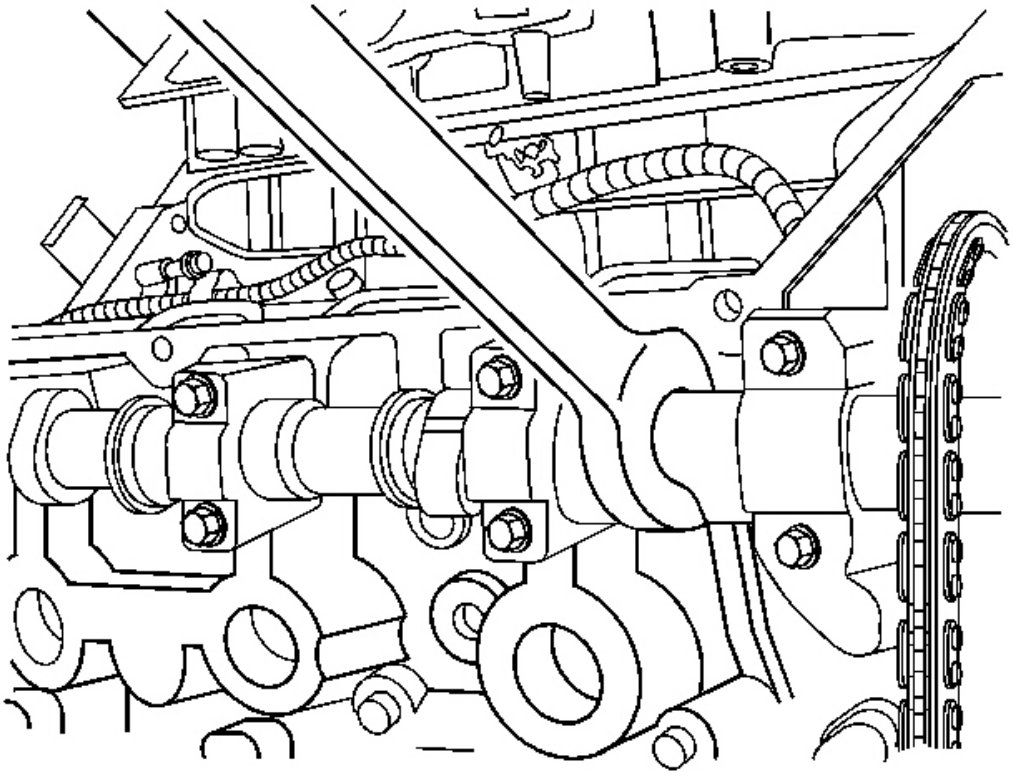


Fig. 312: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

7. Use an open end wrench on the hex cast into the right intake camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

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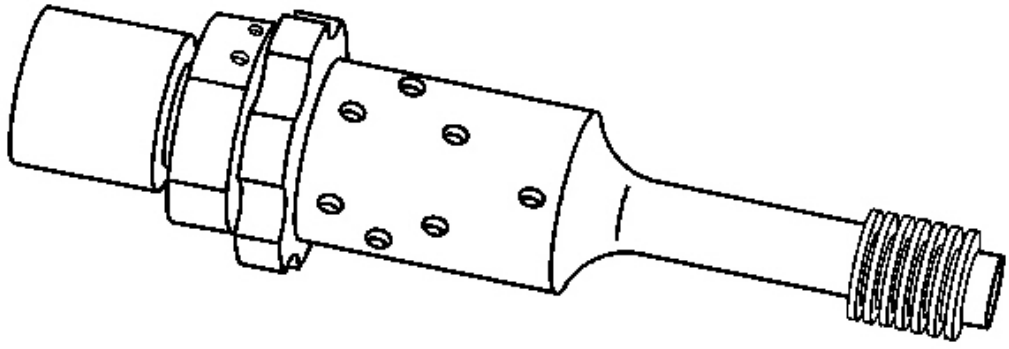


Fig. 313: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

8. Loosen and remove the right intake oil control valve.
9. Slide the right intake camshaft actuator off of the camshaft, disengage the sprocket teeth from the secondary timing chain and remove the actuator.

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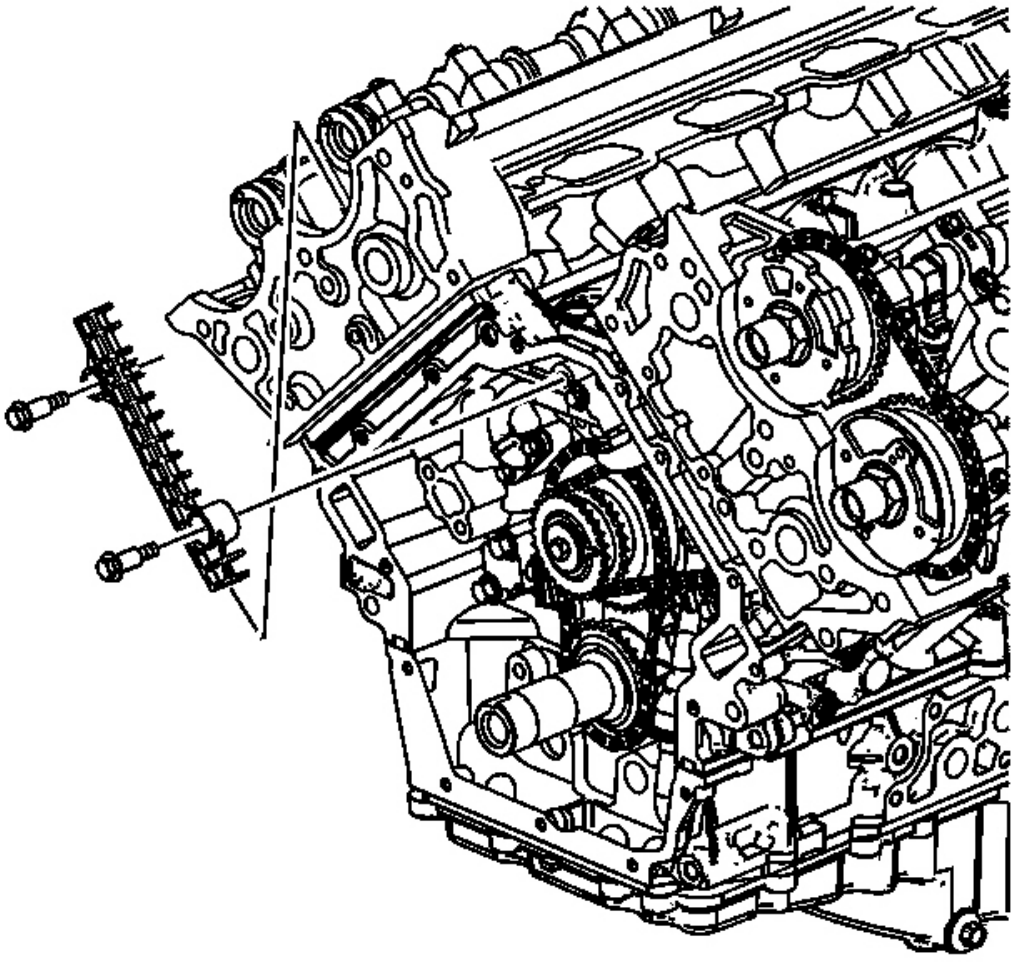


Fig. 314: View Of Right Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

10. Remove the secondary camshaft drive chain guide bolt.
11. Remove the right secondary camshaft drive chain guide.
12. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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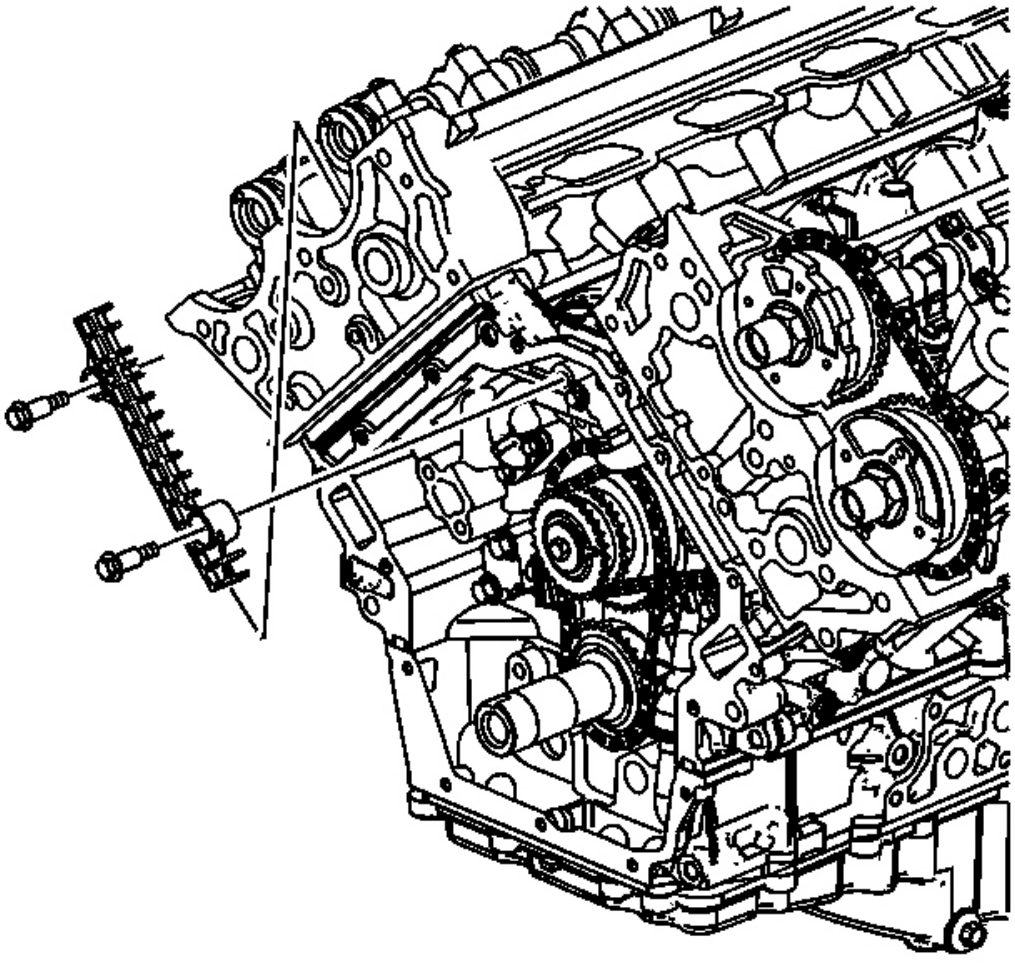


Fig. 315: View Of Right Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Position the right secondary camshaft drive chain guide in through the right front cylinder head as shown.

   NOTE: Refer to Fastener Notice .

2. Install the right secondary camshaft drive chain guide bolt.

   Tighten: Tighten the secondary camshaft drive chain guide bolt to 25 N.m (18 lb ft).

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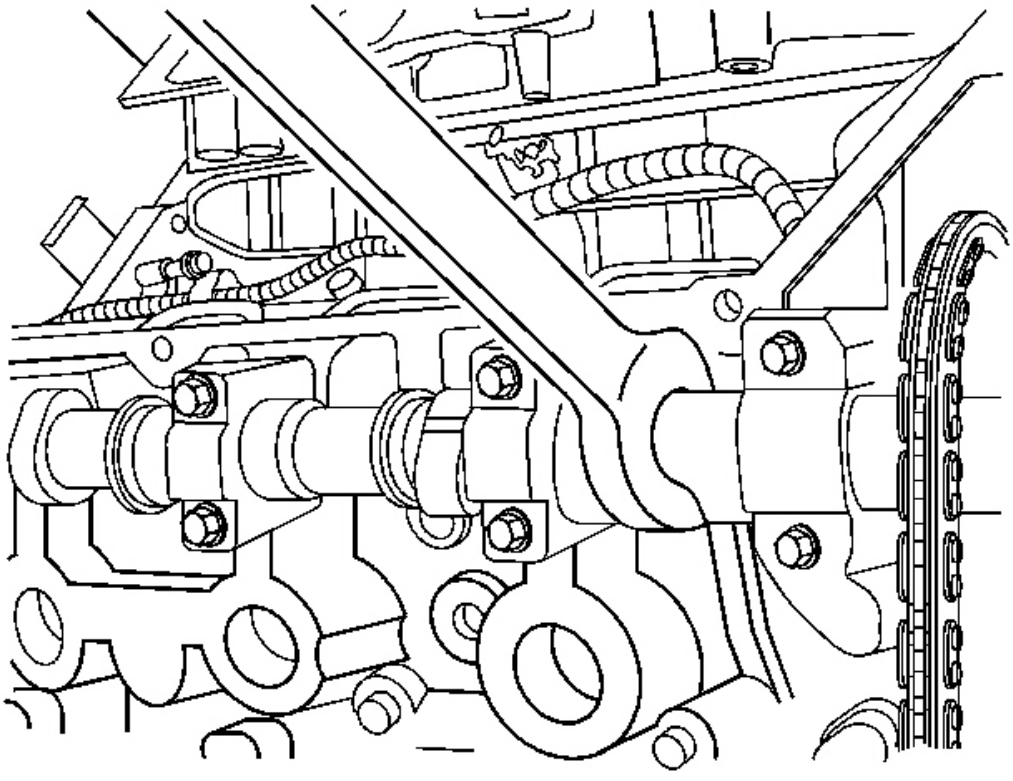


Fig. 316: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

3. Install the right intake actuator to the secondary chain, ensuring that the actuator timing mark is aligned with the chain link that was marked during disassembly.
4. Loosely install the oil control valve to secure the intake actuator to the camshaft.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice .**

5. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

   Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

6. Install the right secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right Side**.

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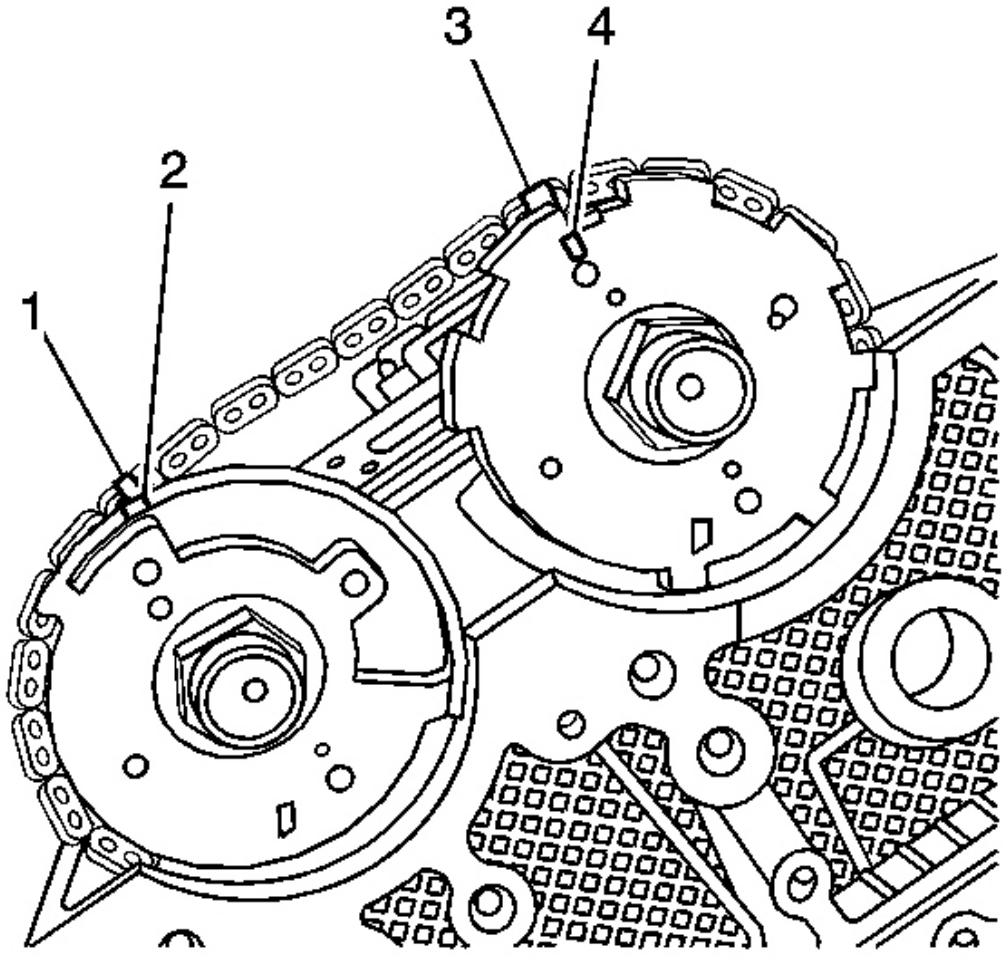


Fig. 317: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

7. Ensure that the previously created paint marks (1, 3) still line up with the sprocket timing marks (2, 4).
8. Install the right camshaft actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side**.

PRIMARY CAMSHAFT DRIVE CHAIN TENSIONER REPLACEMENT

TOOLS REQUIRED

J 39946 Crankshaft Socket. See **Special Tools** .

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REMOVAL PROCEDURE

1. Remove the engine oil pump. Refer to **Oil Pump Replacement**.

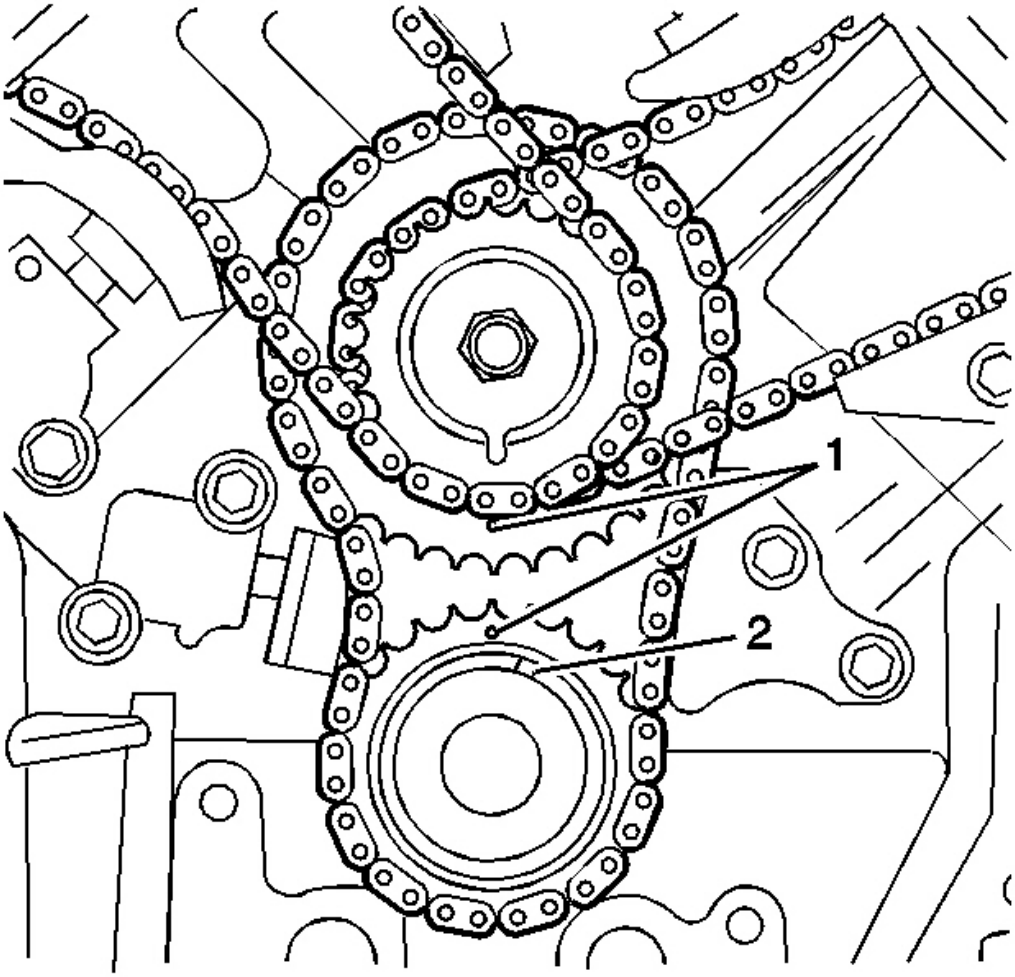


Fig. 318: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

2. Align the primary timing marks (1) using the **J 39946** . See **Special Tools** .

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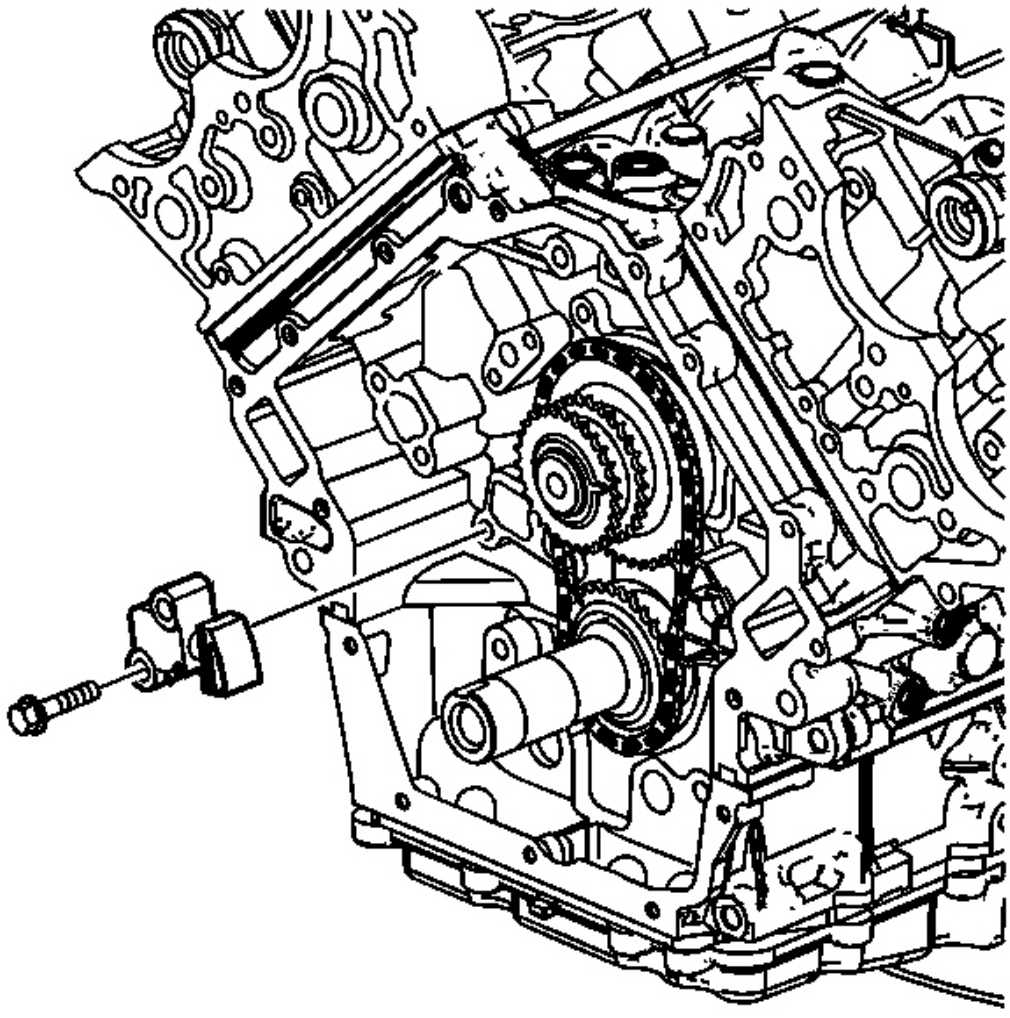


Fig. 319: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Remove the 2 bolts attaching the primary camshaft drive chain tensioner to the engine block.
4. Remove the primary camshaft drive chain tensioner, allowing the tensioner to expand as you remove it.
5. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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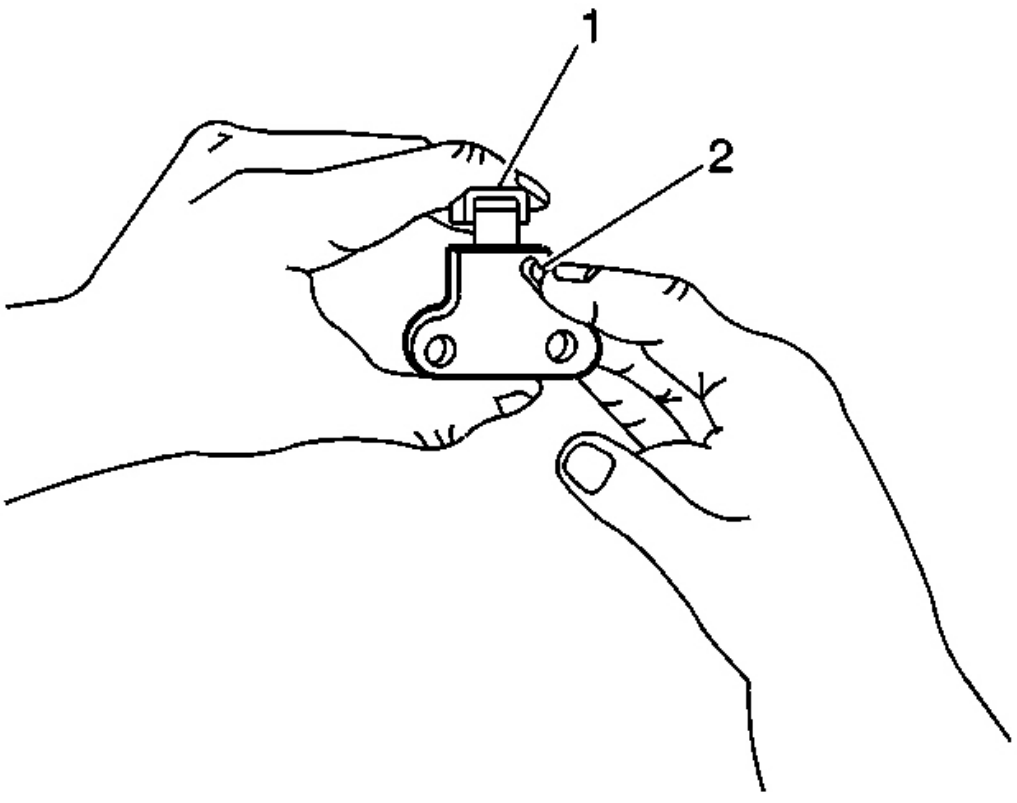


Fig. 320: View Of Primary Camshaft Drive Chain Tensioner Shoe & Ratchet Lever
Courtesy of GENERAL MOTORS CORP.

1. Collapse the primary camshaft drive chain tensioner using the following procedure:
    1. Rotate the ratchet release lever (2) clockwise and hold.
    2. Collapse the tensioner shoe (1) and hold.
    3. Release the ratchet lever (2).
2. Slowly release the pressure on the shoe (1), until the ratchet lever (2) moves to the first detent and a click is heard and felt.
3. Collapse the tensioner shoe (1) and hold.

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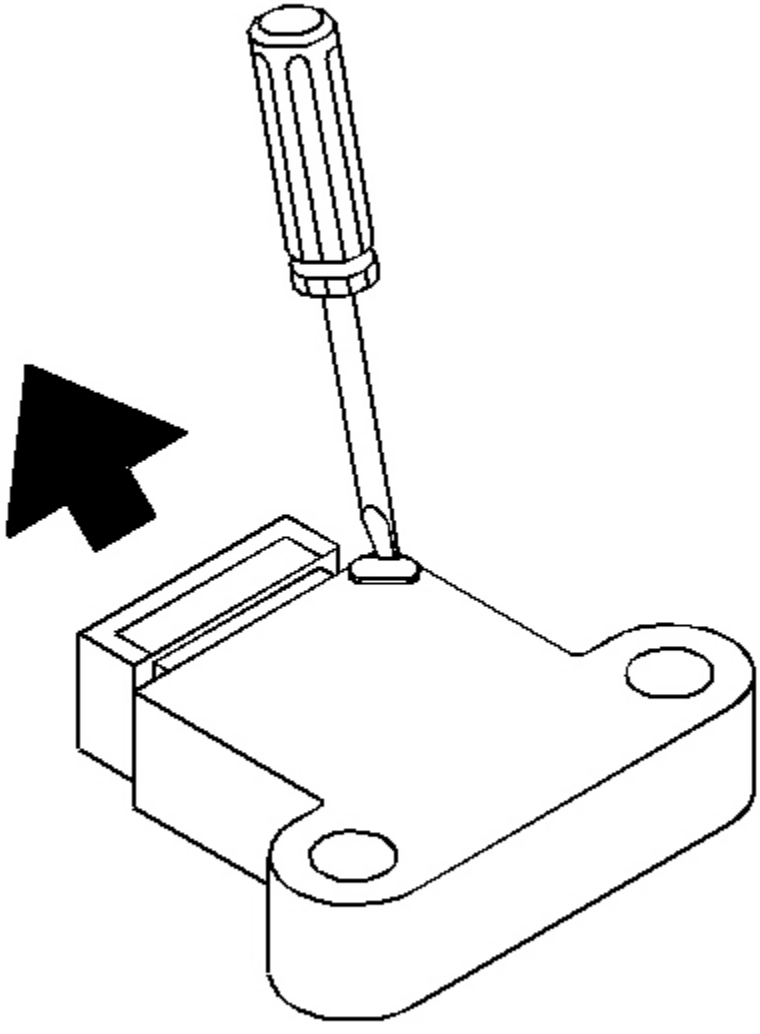


Fig. 321: Locking Primary Camshaft Drive Chain Tensioner Shoe Into Collapsed Position
Courtesy of GENERAL MOTORS CORP.

4. Insert a pin through the hole in the release lever in order to lock the tensioner shoe in the collapsed position.

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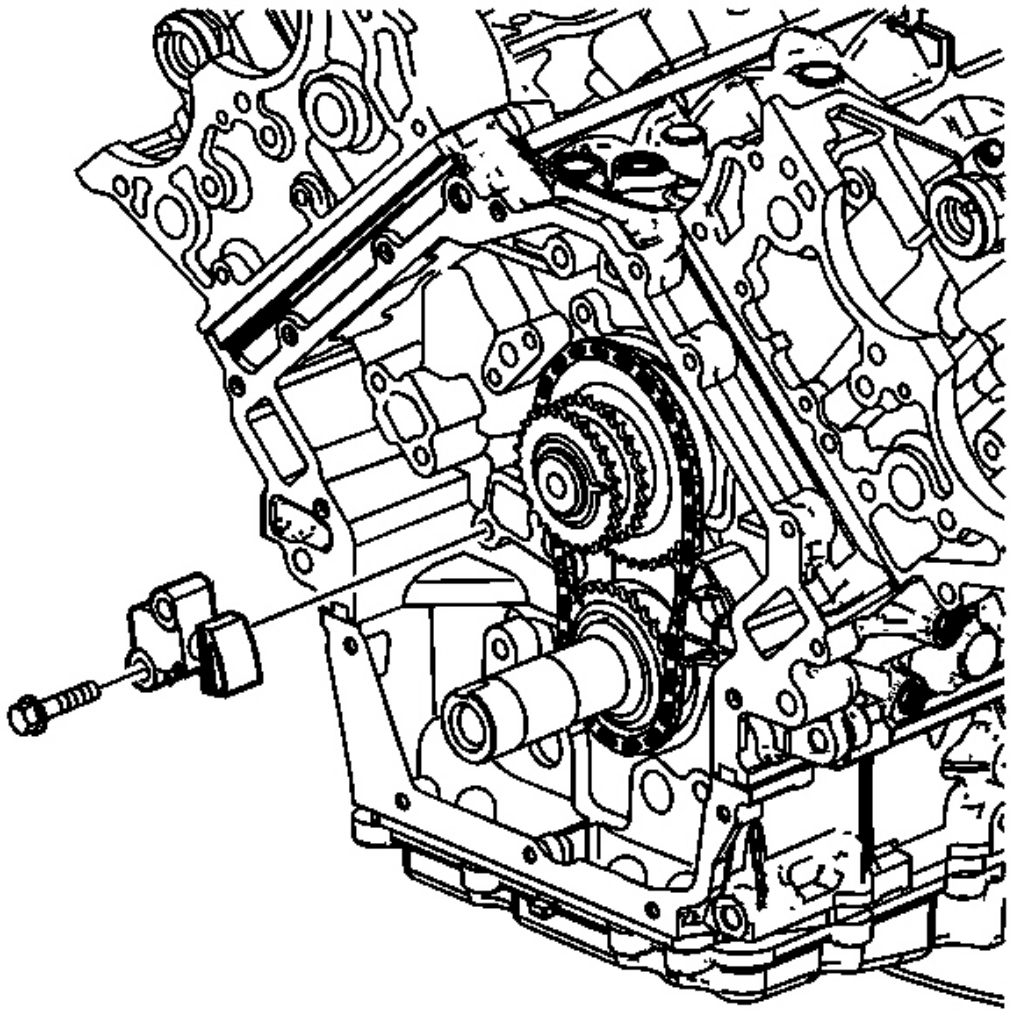


Fig. 322: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Ensure the tensioner release lever is facing outward.

5. Install the primary camshaft drive chain tensioner and retaining bolts.

   Tighten: Tighten the primary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).

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6. Remove the pin holding the tensioner to tighten any slack in the timing chain.

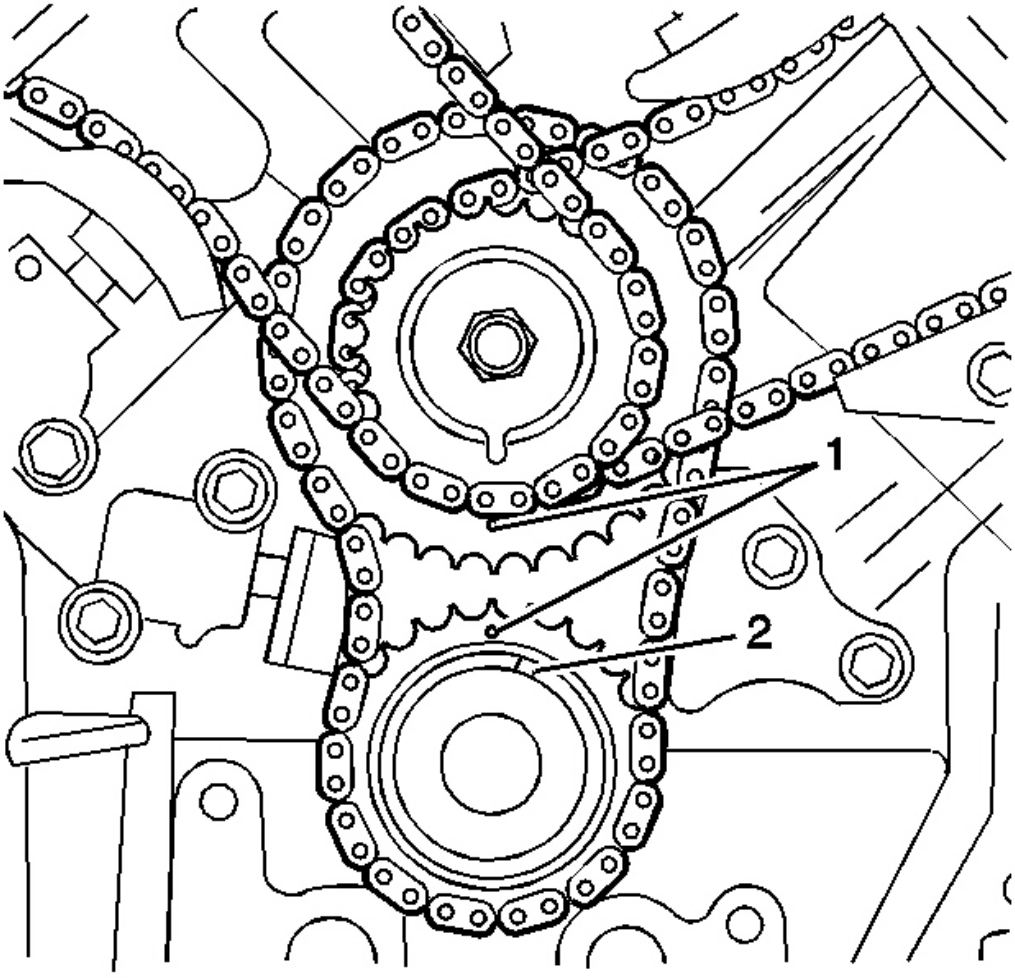


Fig. 323: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

7. Ensure the primary timing marks (1) are aligned vertically.
8. Install the engine oil pump. Refer to **Oil Pump Replacement**.

PRIMARY CAMSHAFT DRIVE CHAIN GUIDE REPLACEMENT

REMOVAL PROCEDURE

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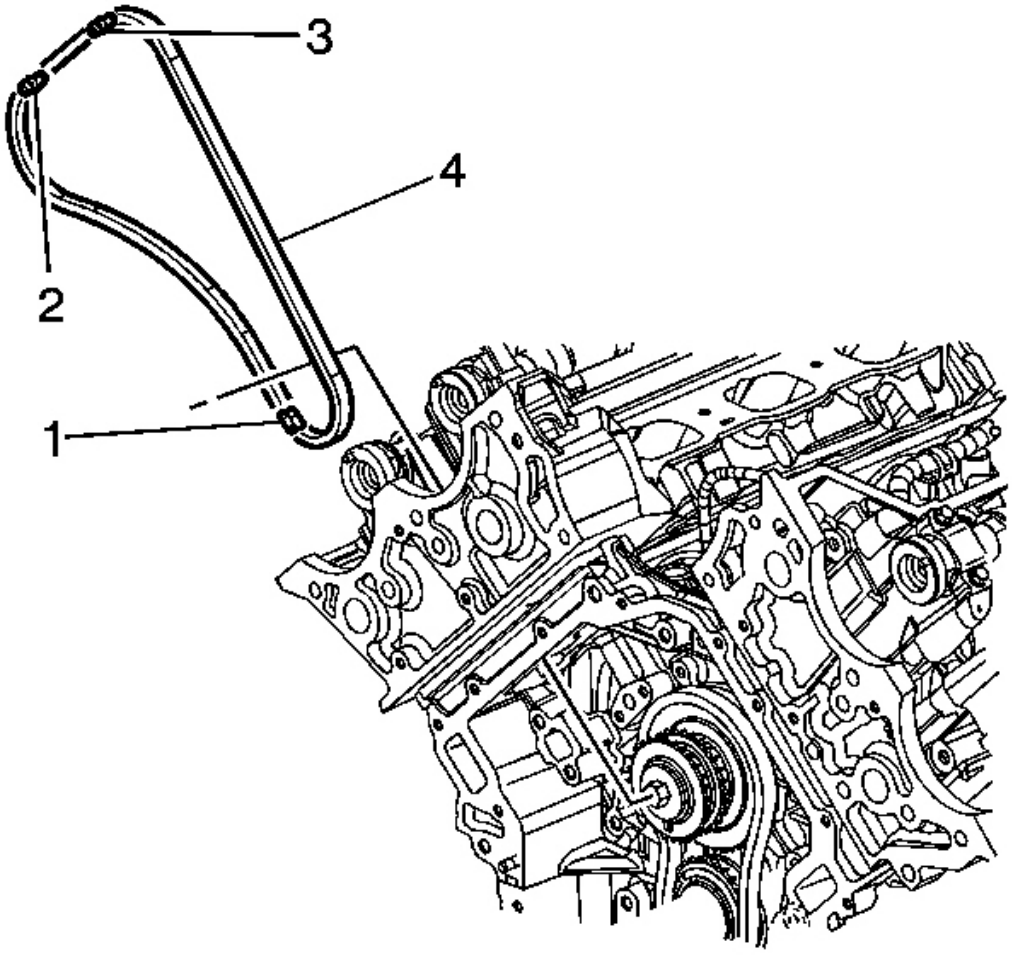


Fig. 324: Identifying Secondary Timing Chain Black Links
Courtesy of GENERAL MOTORS CORP.

1. Remove the right side secondary camshaft drive chain (4). Refer to **Secondary Camshaft Drive Chain Replacement - Right Side**.

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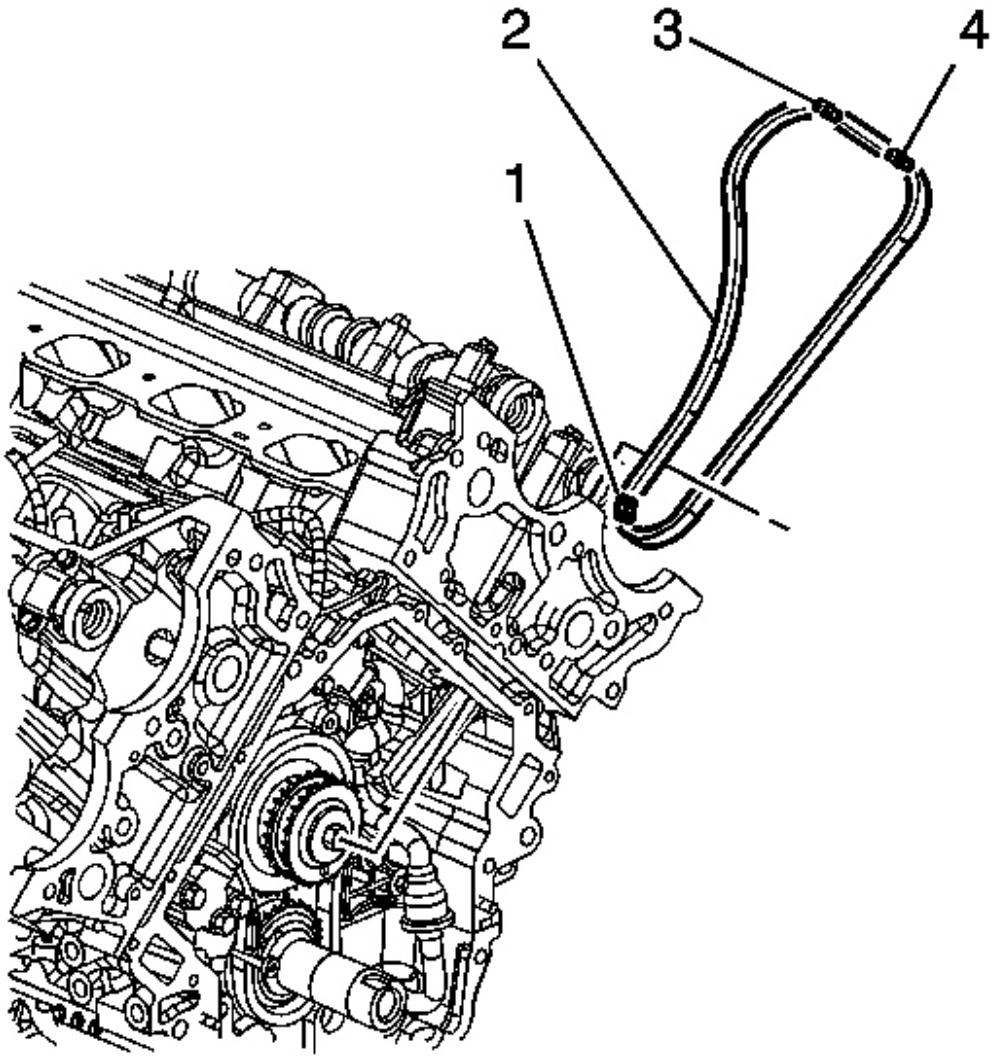


Fig. 325: Identifying Secondary Timing Chain Timing Marks
Courtesy of GENERAL MOTORS CORP.

2. Remove the left side secondary camshaft drive chain (2). Refer to **Secondary Camshaft Drive Chain Replacement - Left Side**.

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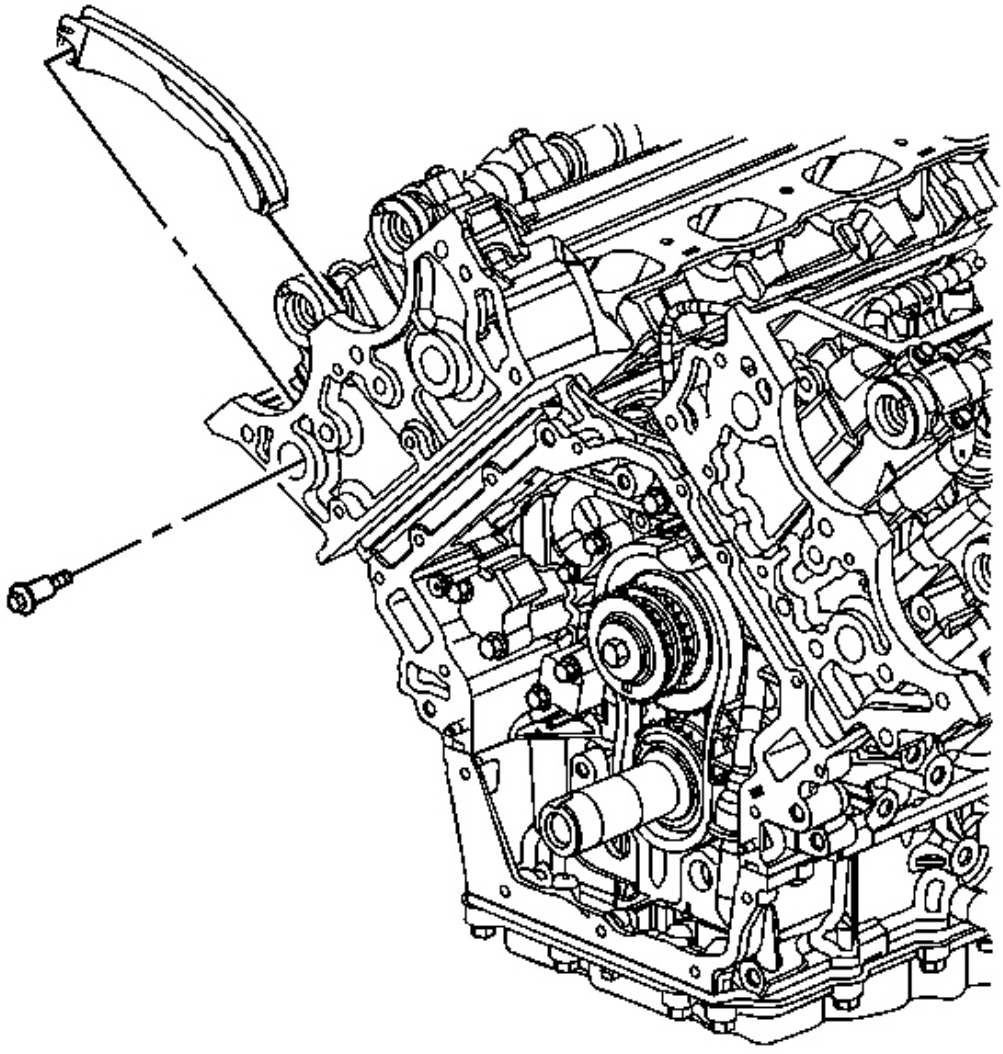


Fig. 326: View Of Right Side Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

3. Remove the right side secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Replacement - Right Side**.

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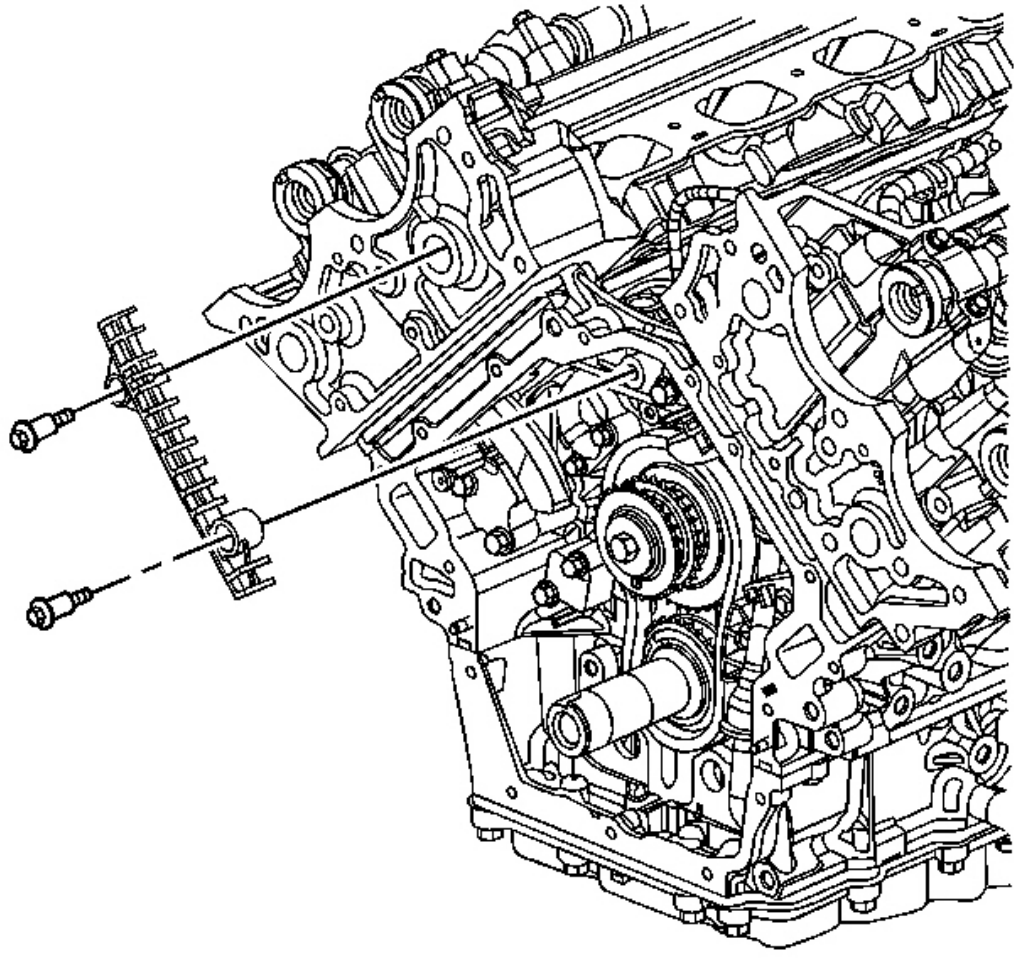


Fig. 327: View Of Right Side Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

4. Remove the right side secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Replacement - Right Side**.

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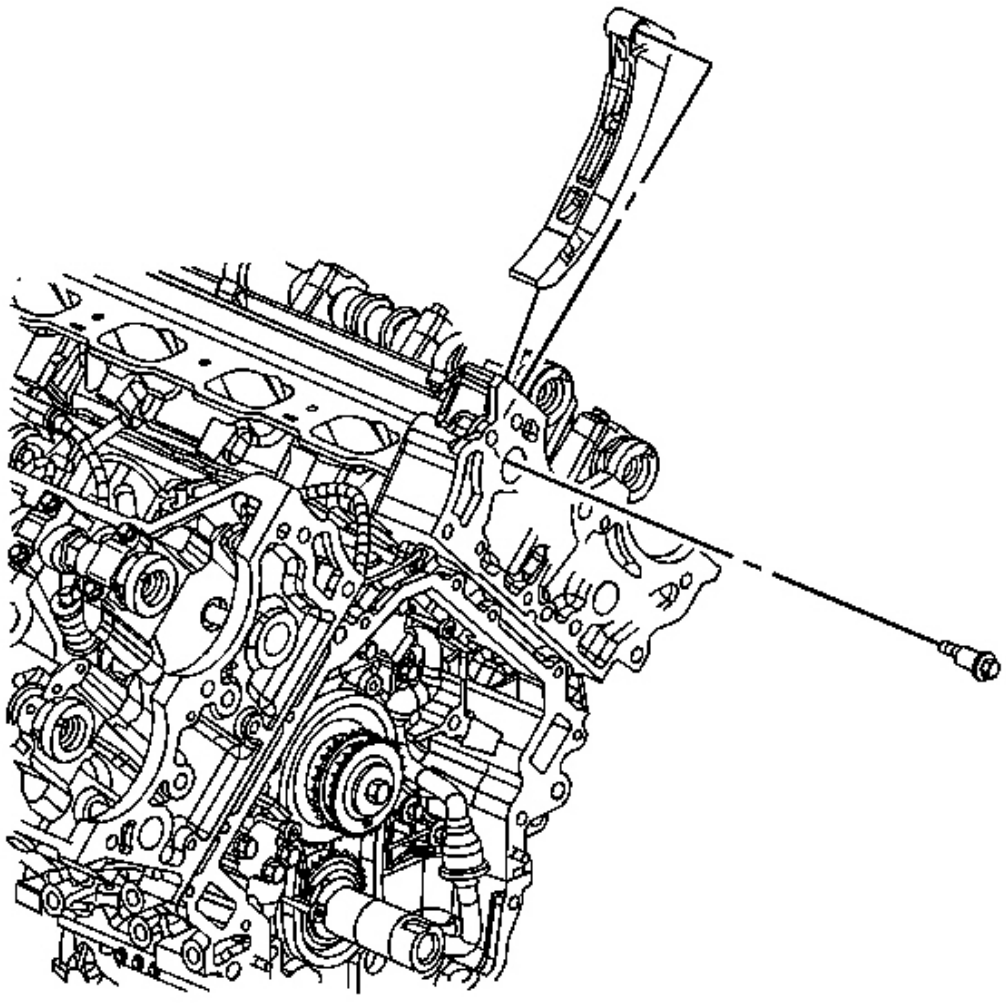


Fig. 328: View Of Left Secondary Camshaft Drive Timing Shoe
Courtesy of GENERAL MOTORS CORP.

5. Remove the left side secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Replacement - Left Side**.

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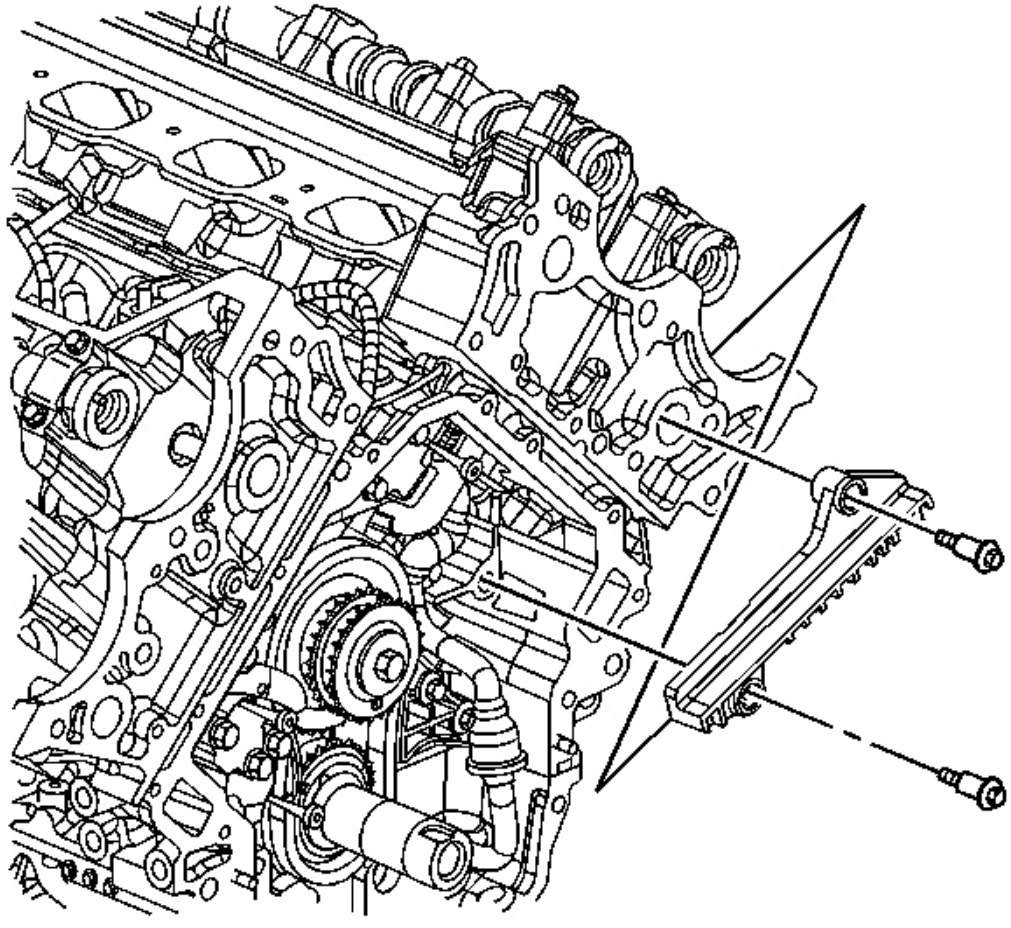


Fig. 329: View Of Left Side Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Remove the left side secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Replacement - Left Side**.

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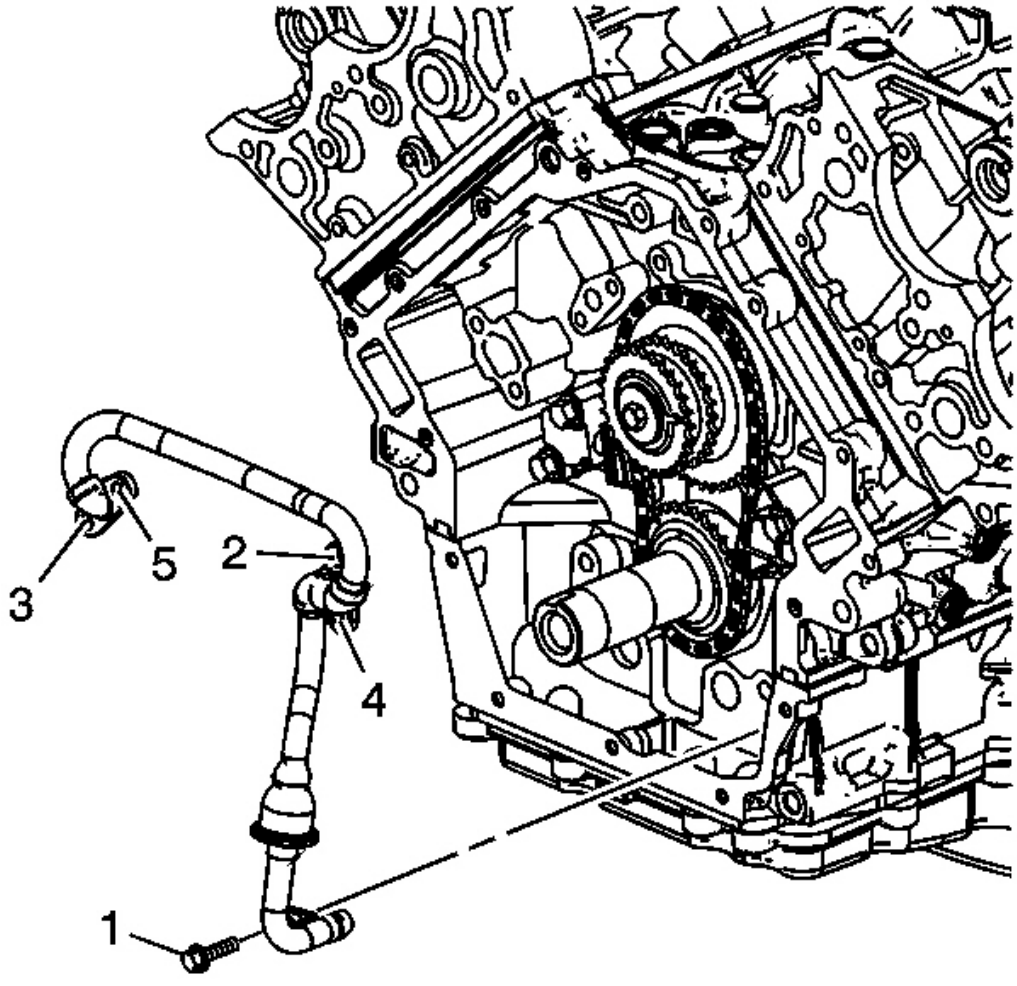


Fig. 330: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil outlet tube (4) from the engine. Refer to **Oil Pump Outlet Tube Removal** .

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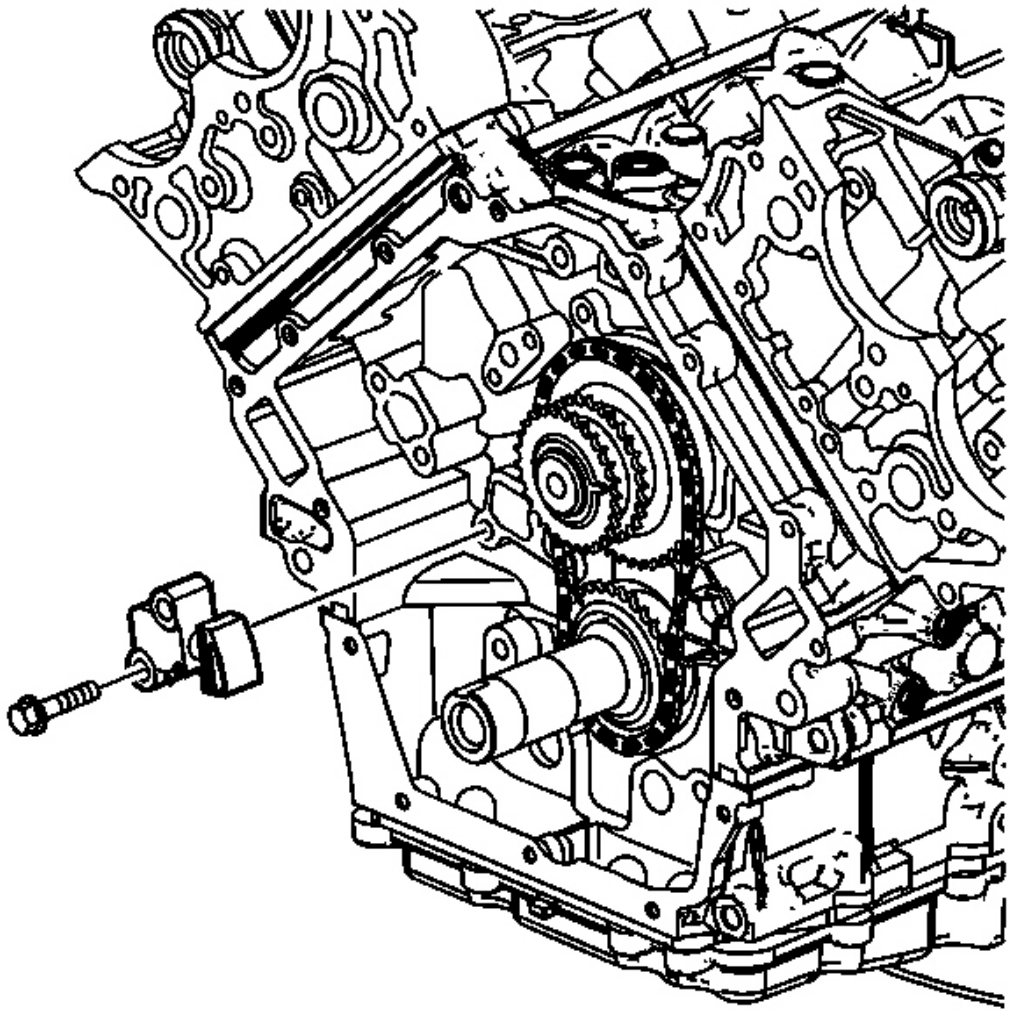


Fig. 331: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

8. Remove the primary camshaft drive chain tensioner. Refer to **Primary Camshaft Drive Chain Tensioner Replacement**.

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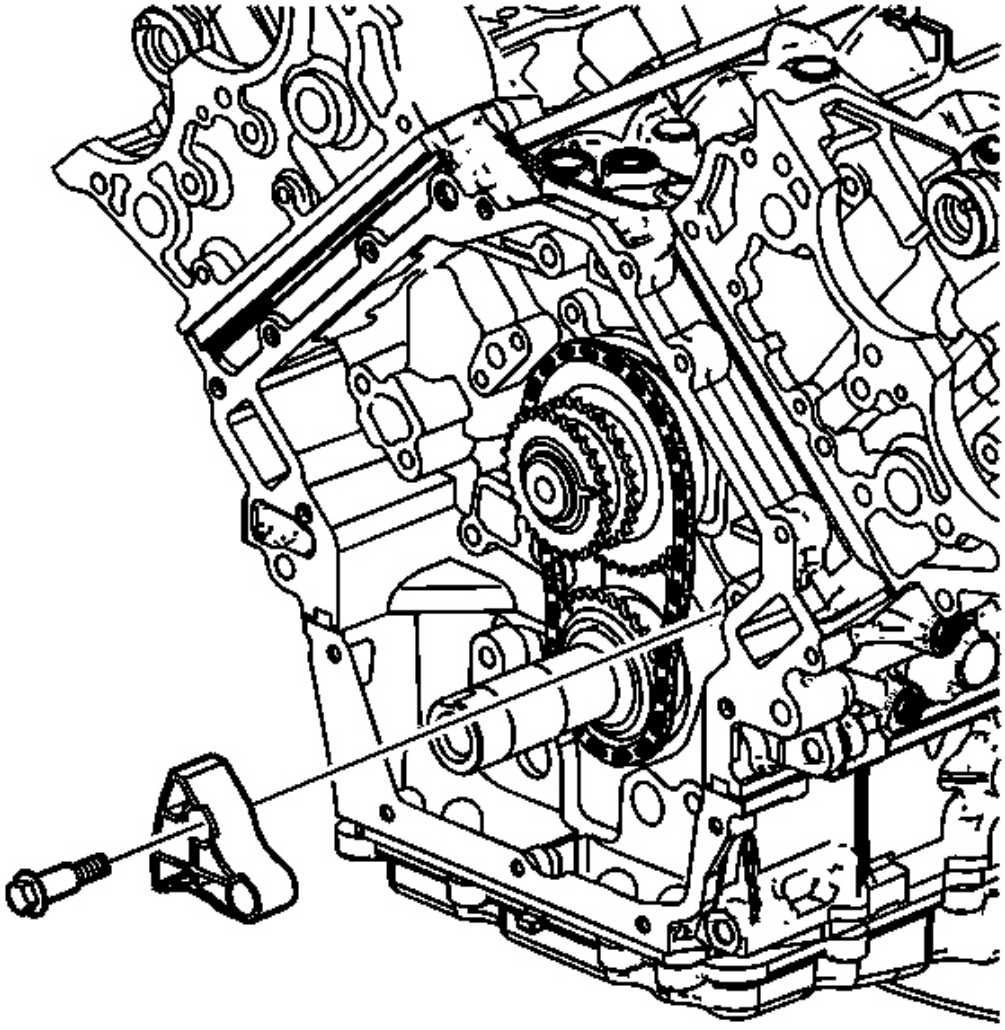


Fig. 332: View Of Primary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

9. Remove the bolts attaching the primary camshaft drive chain guide to the engine block.
10. Remove the primary camshaft drive chain guide.
11. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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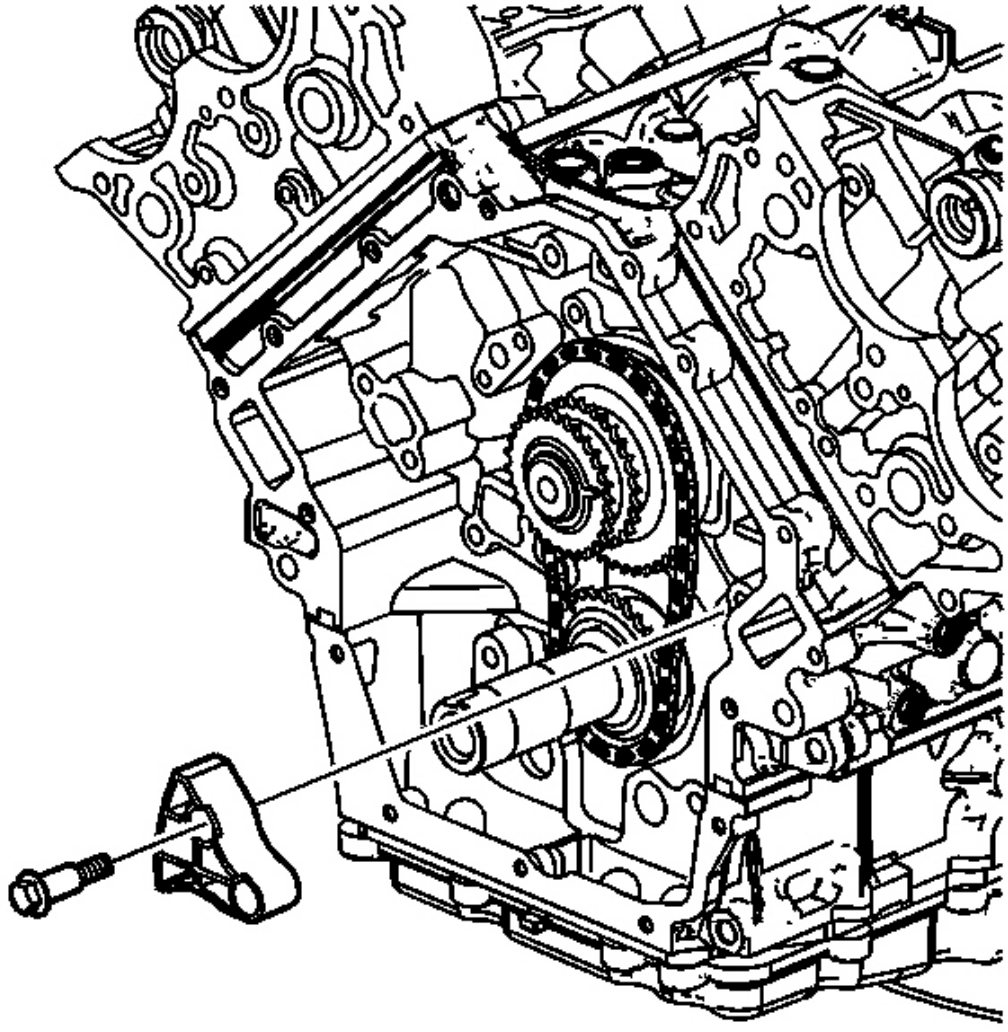


Fig. 333: View Of Primary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

1. Install the primary camshaft drive chain guide and retaining bolts.

   Tighten: Tighten the primary camshaft drive chain guide bolts to 25 N.m (18 lb ft).

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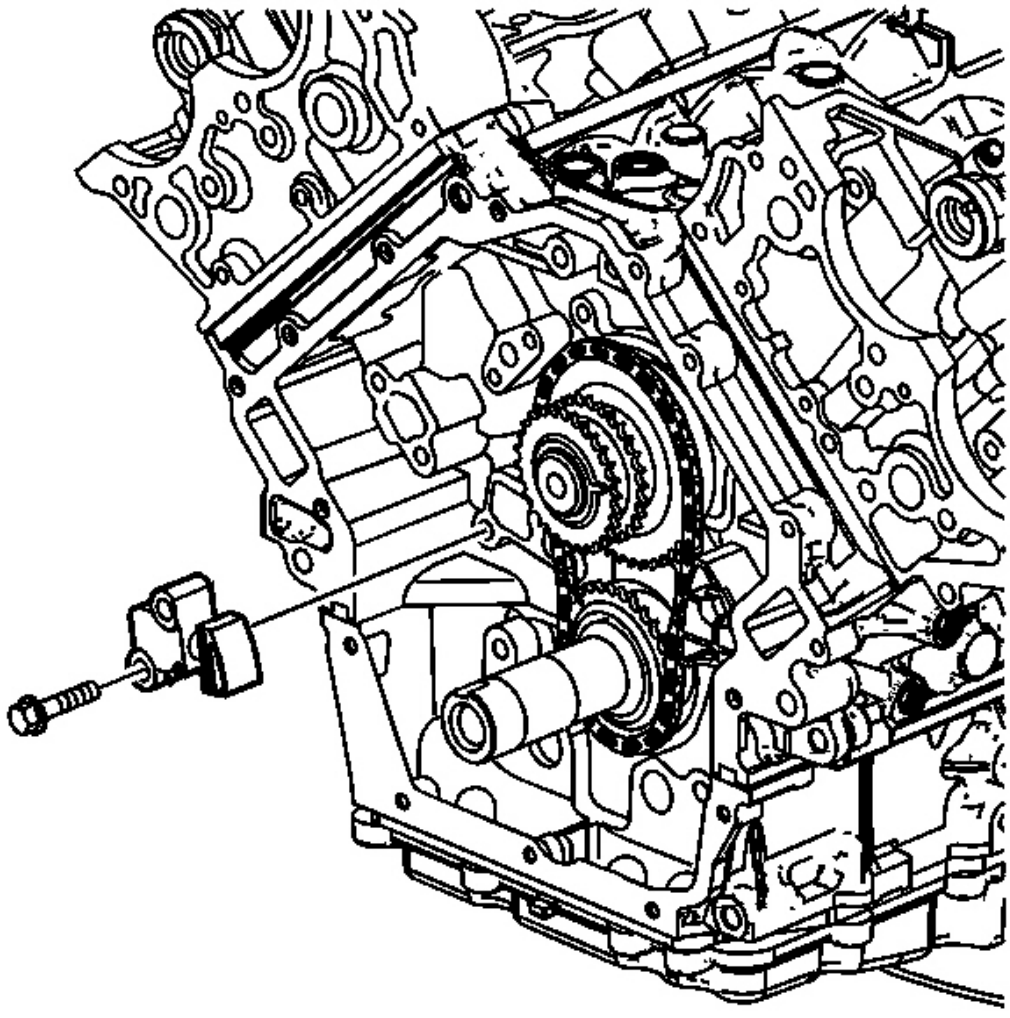


Fig. 334: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

2. Install the primary camshaft drive chain tensioner. Refer to **Primary Camshaft Drive Chain Tensioner Replacement**.

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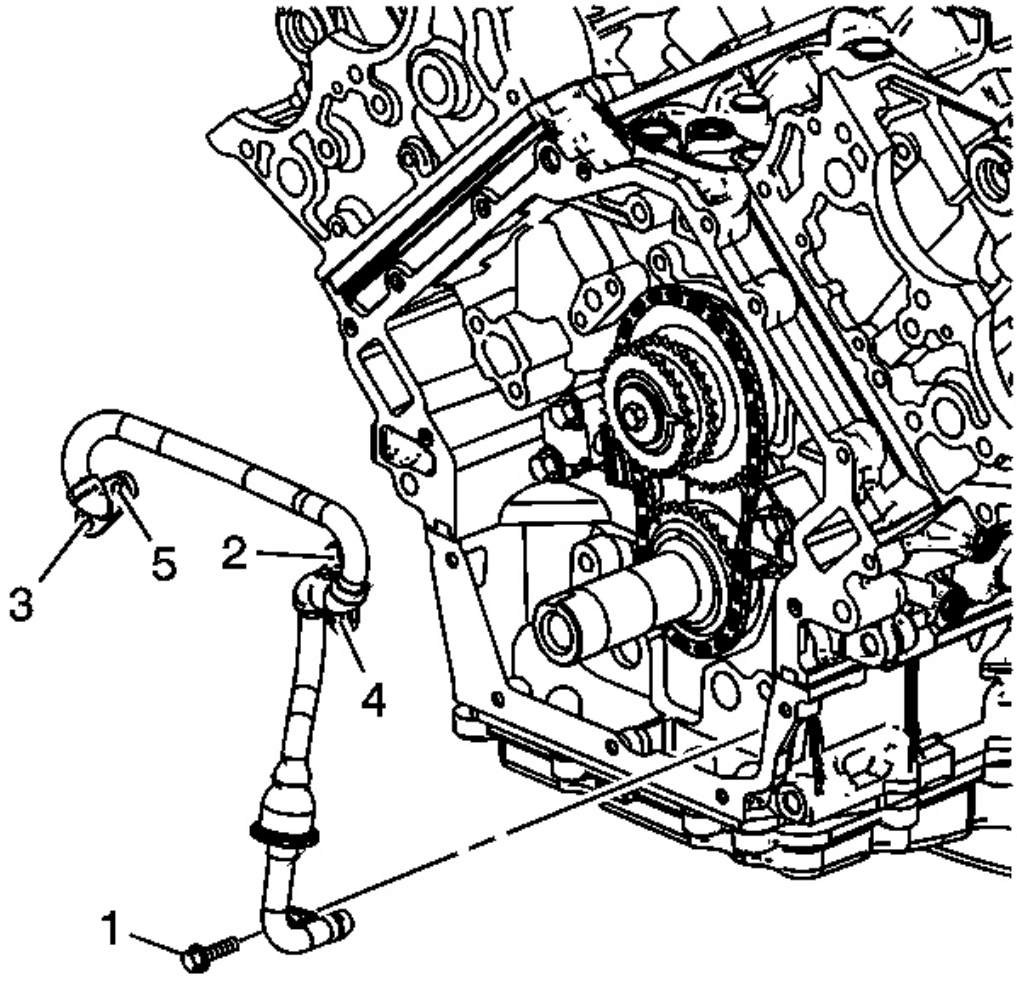


Fig. 335: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the oil outlet tube (4) to the engine. Refer to **Oil Pump Outlet Tube Installation** .

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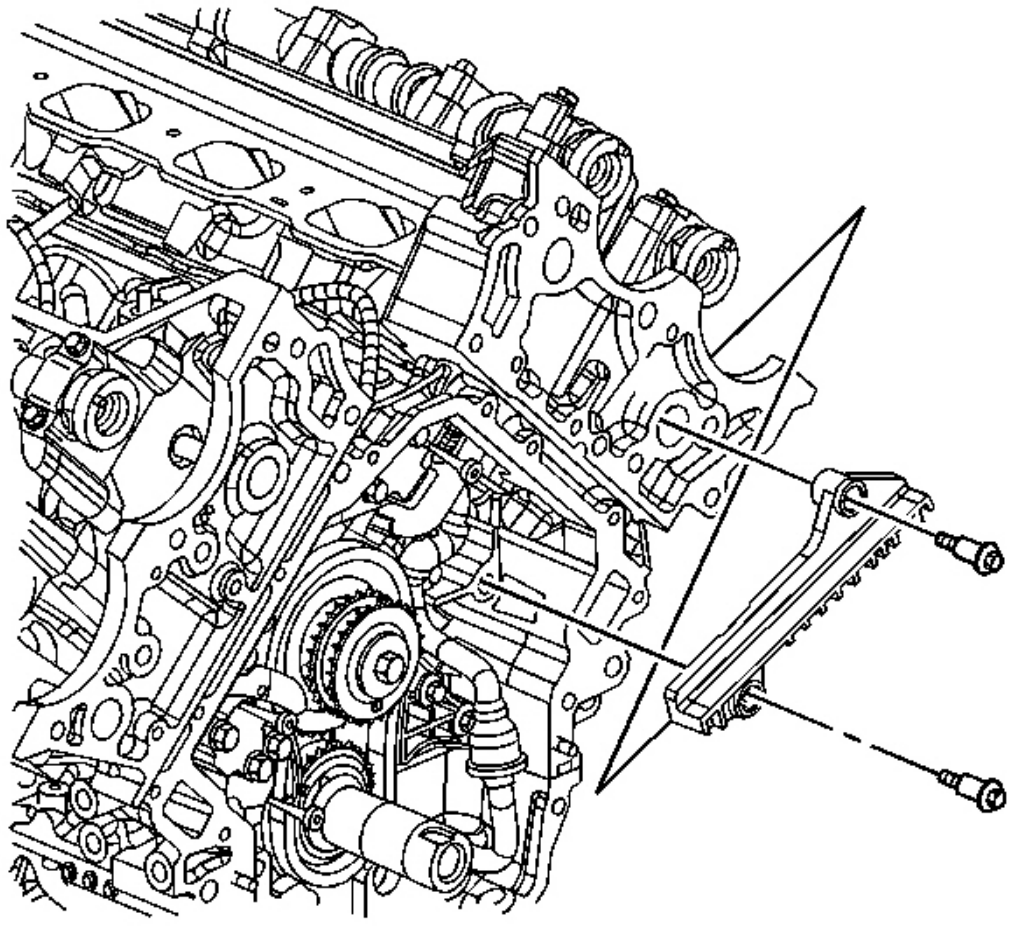


Fig. 336: View Of Left Side Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

4. Install the left side secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Replacement - Left Side**.

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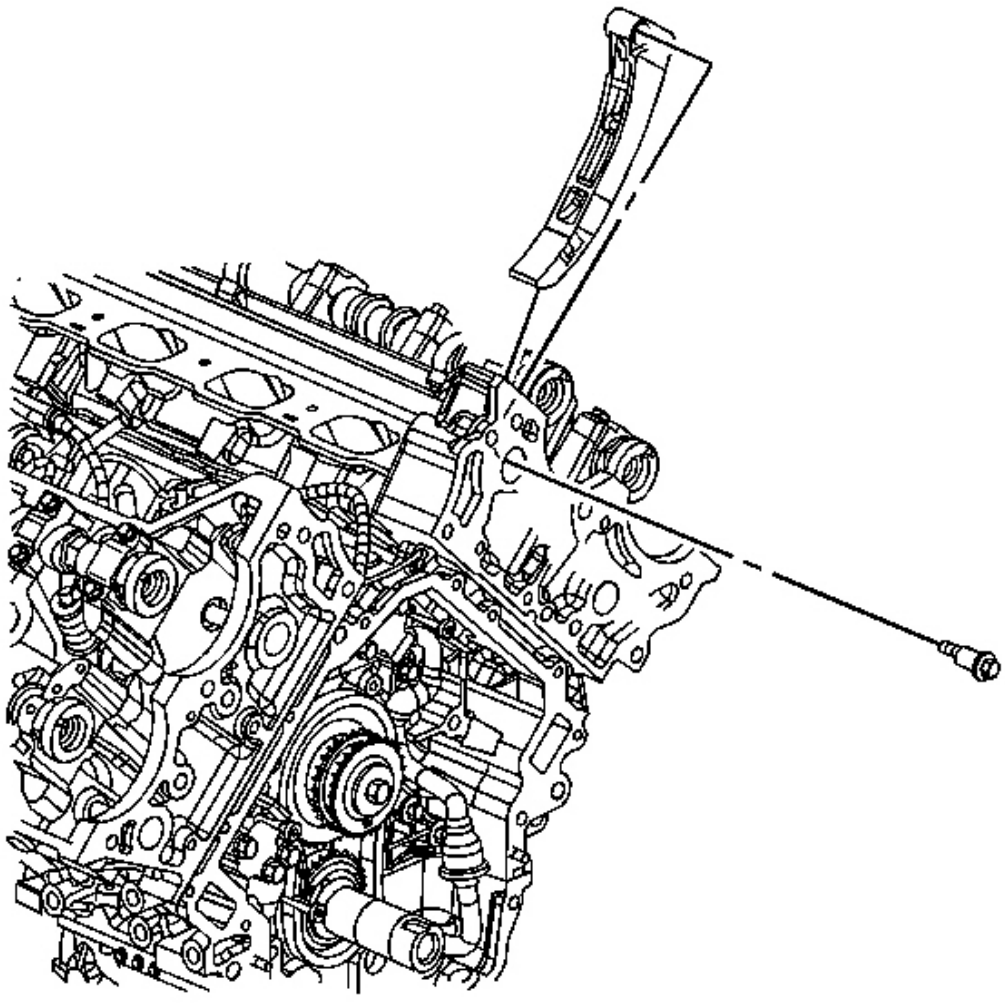


Fig. 337: View Of Left Secondary Camshaft Drive Timing Shoe
Courtesy of GENERAL MOTORS CORP.

5. Install the left side secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Replacement - Left Side**.

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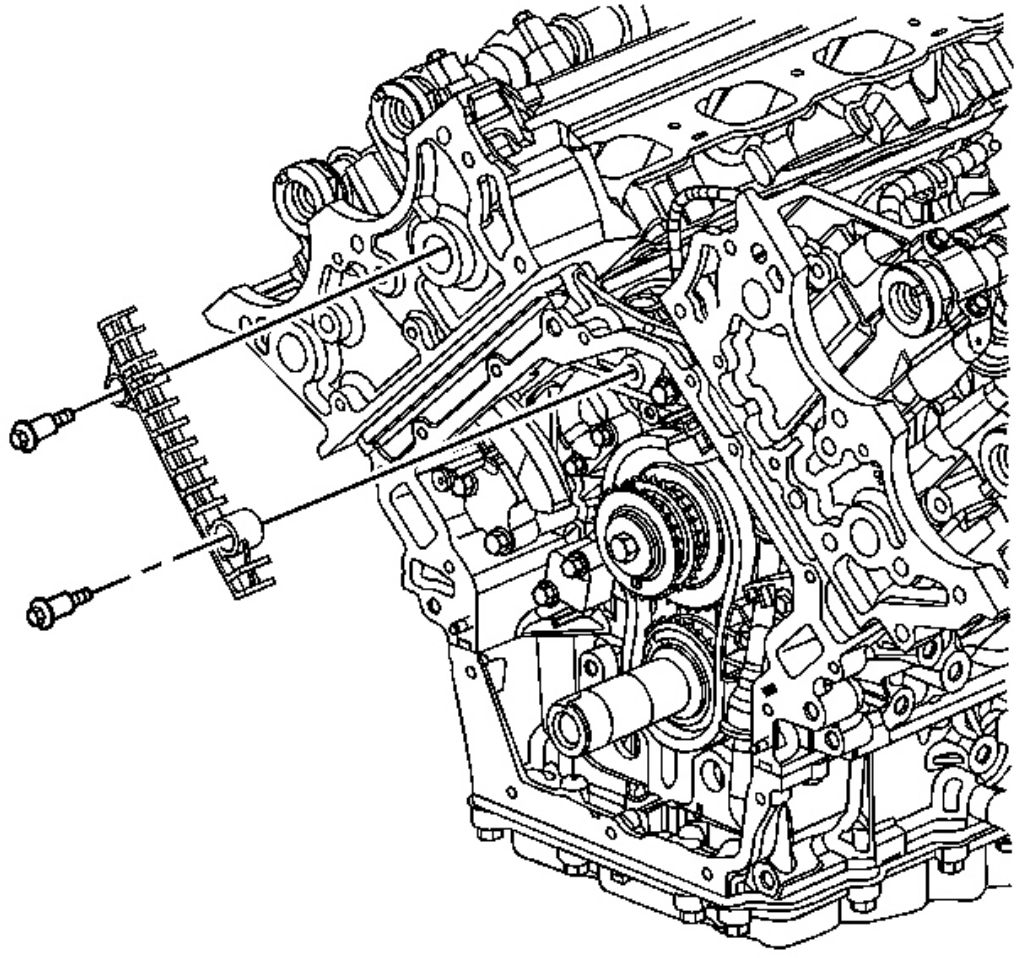


Fig. 338: View Of Right Side Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Install the right side secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Replacement - Right Side**.

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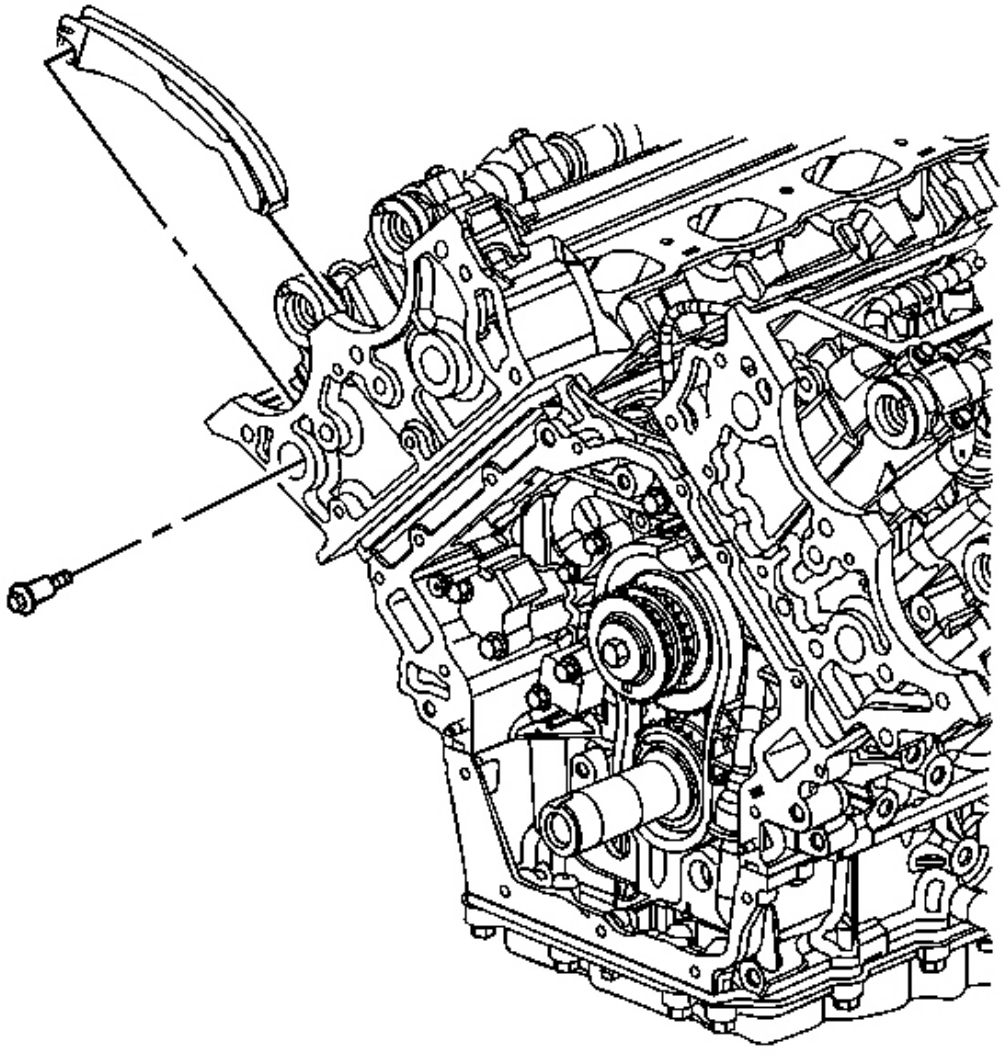


Fig. 339: View Of Right Side Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

7. Install the right side secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Replacement - Right Side**.

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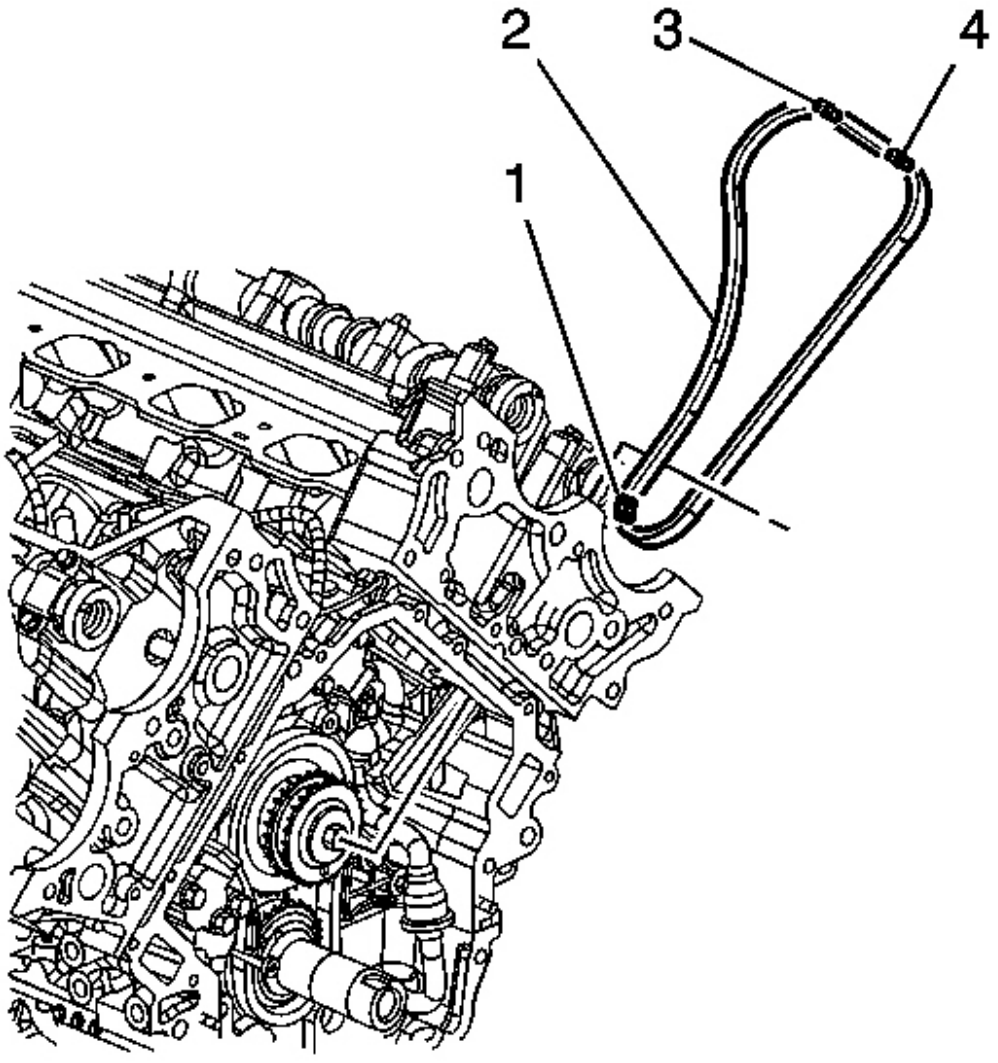


Fig. 340: Identifying Secondary Timing Chain Timing Marks
Courtesy of GENERAL MOTORS CORP.

8. Install the left side secondary camshaft drive chain (2). Refer to **Secondary Camshaft Drive Chain Replacement - Left Side**.

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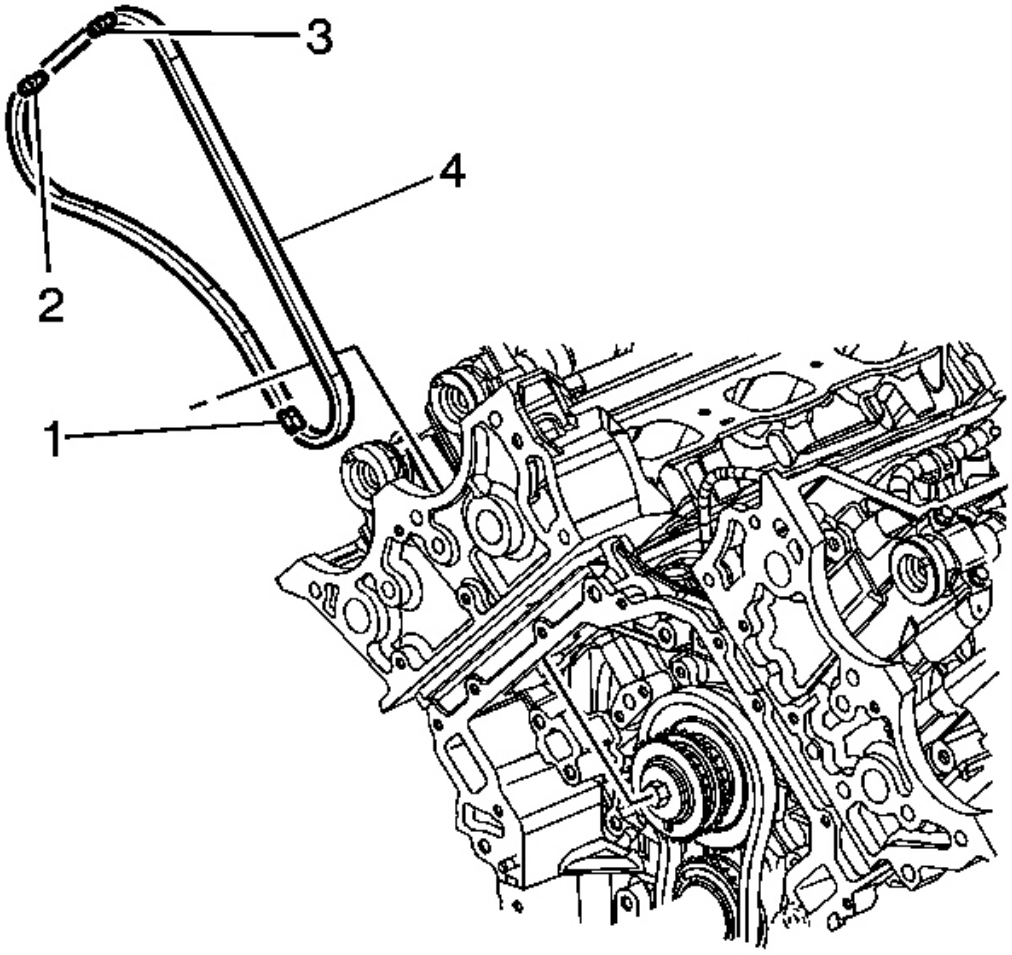


Fig. 341: Identifying Secondary Timing Chain Black Links
Courtesy of GENERAL MOTORS CORP.

9. Install the right side secondary camshaft drive chain (4). Refer to **Secondary Camshaft Drive Chain Replacement - Right Side**.

PRIMARY CAMSHAFT DRIVE CHAIN AND SPROCKETS REPLACEMENT

TOOLS REQUIRED

J 39946 Crankshaft Socket. See **Special Tools** .

REMOVAL PROCEDURE

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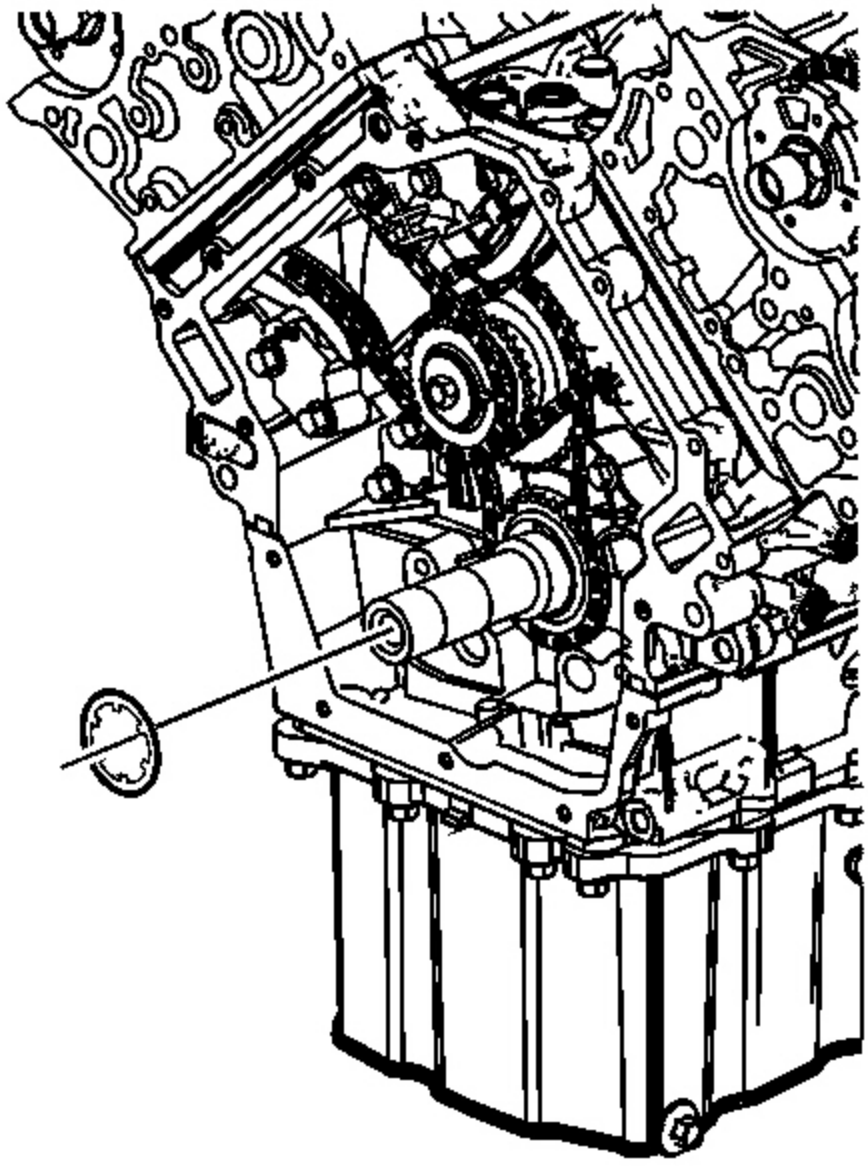


Fig. 342: Identifying Crankshaft To Crankshaft Sprocket Friction Washer
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump. Refer to **Oil Pump Replacement**.
2. Remove the crankshaft sprocket to oil pump drive friction washer.

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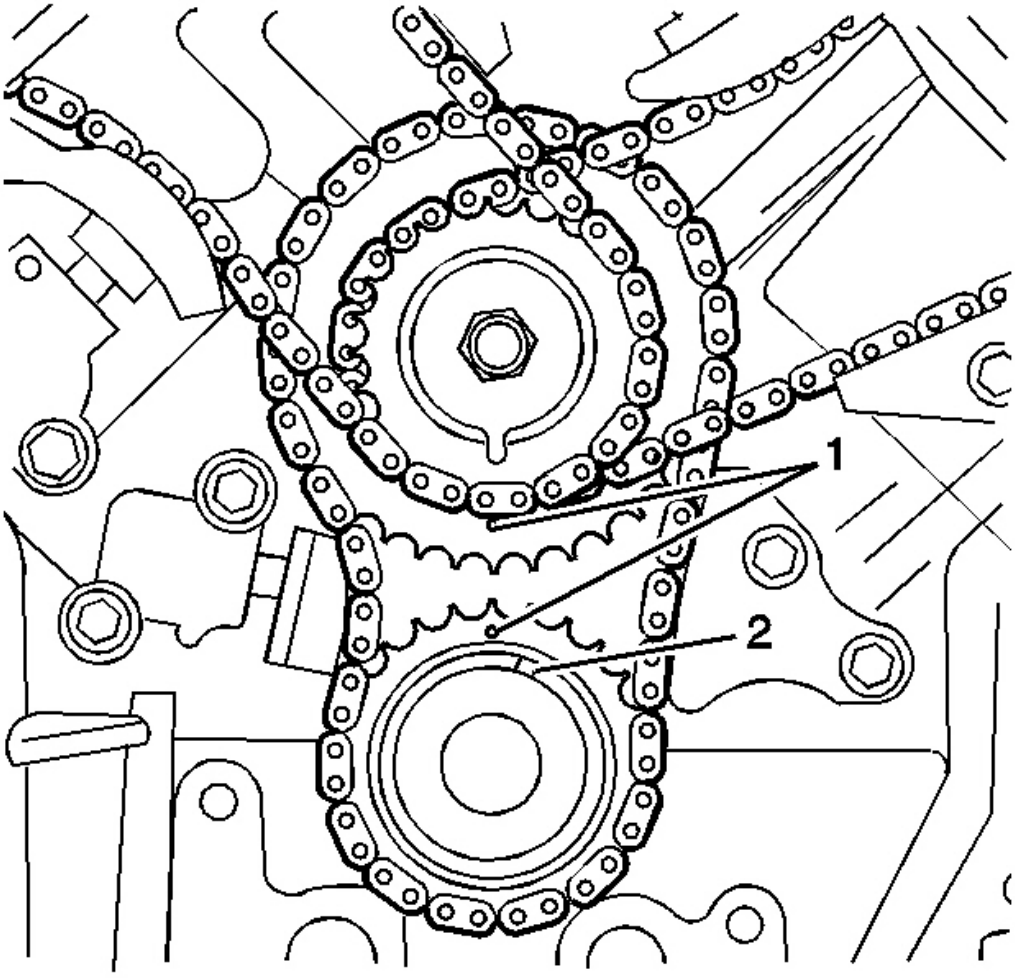


Fig. 343: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

3. Align the primary timing marks (1) using the **J 39946** . See **Special Tools** .
4. Remove the secondary camshaft drive chains. Refer to **Secondary Camshaft Drive Chain Replacement - Left Side** and **Secondary Camshaft Drive Chain Replacement - Right Side**.
5. Remove the primary drive chain tensioner. Refer to **Primary Camshaft Drive Chain Tensioner Replacement**.

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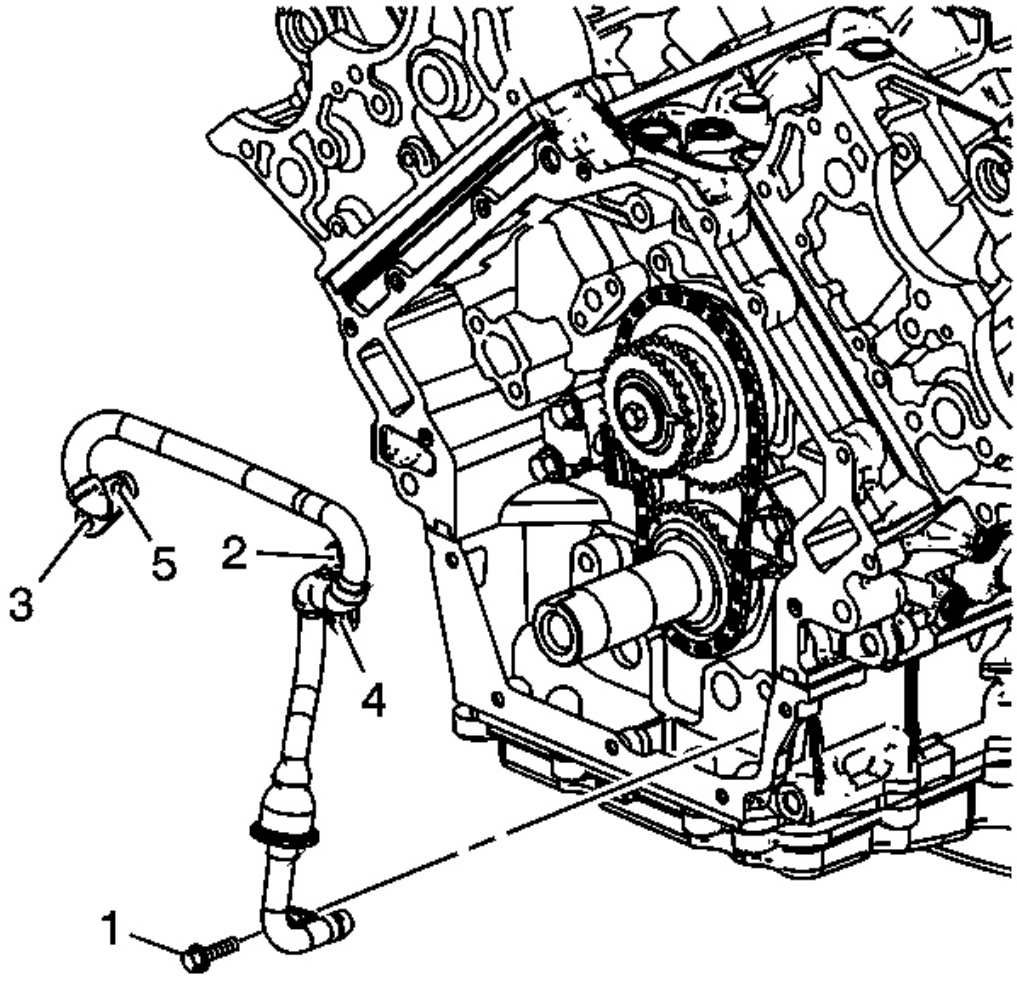


Fig. 344: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil outlet tube (4). Refer to **Oil Pump Outlet Tube Removal** .

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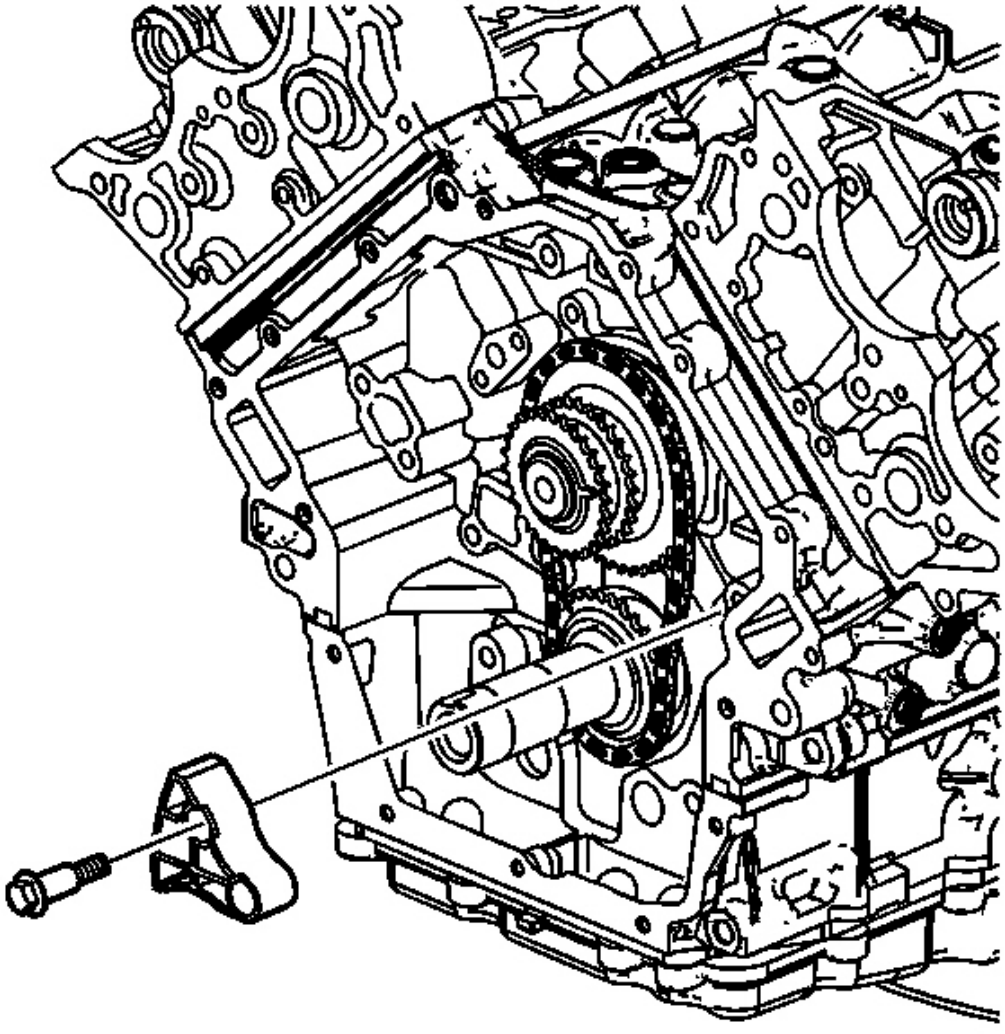


Fig. 345: View Of Primary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

7. Remove the primary camshaft drive chain guide bolts and guide.

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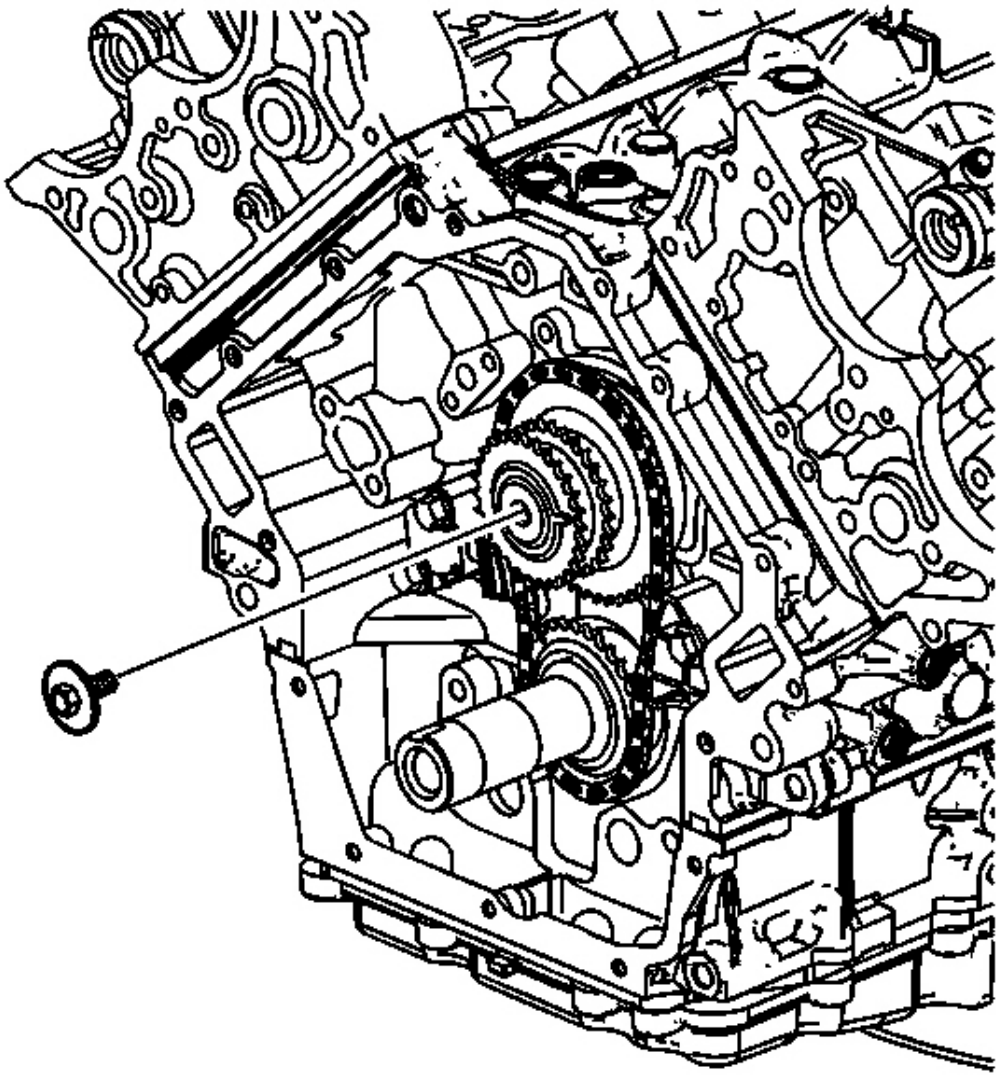


Fig. 346: View Of Camshaft Intermediate Sprocket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the camshaft intermediate sprocket retaining bolt.

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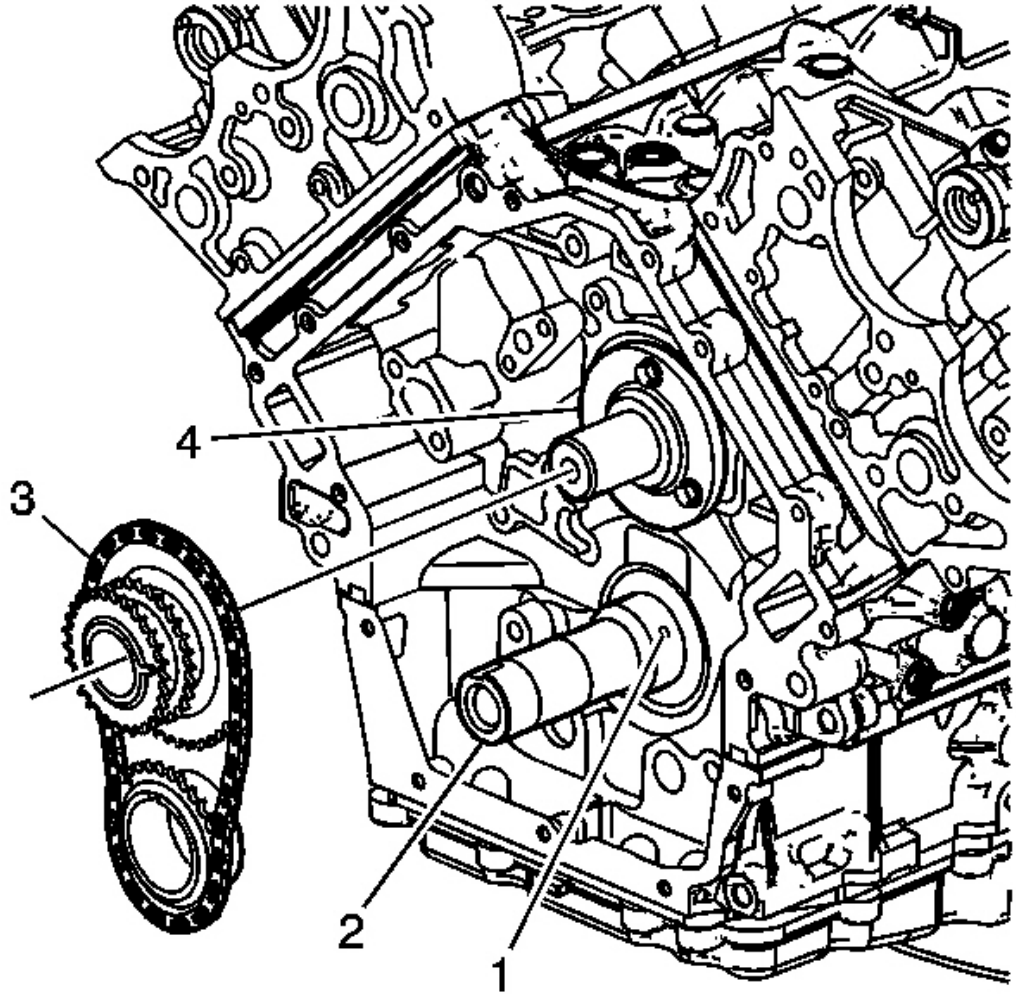


Fig. 347: View Of Primary Camshaft Drive Chain, Intermediate Drive Shaft Sprocket & Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

9. Remove the following as an assembly:
    - The primary camshaft drive chain (3)
    - The crankshaft sprocket
    - The camshaft intermediate sprocket

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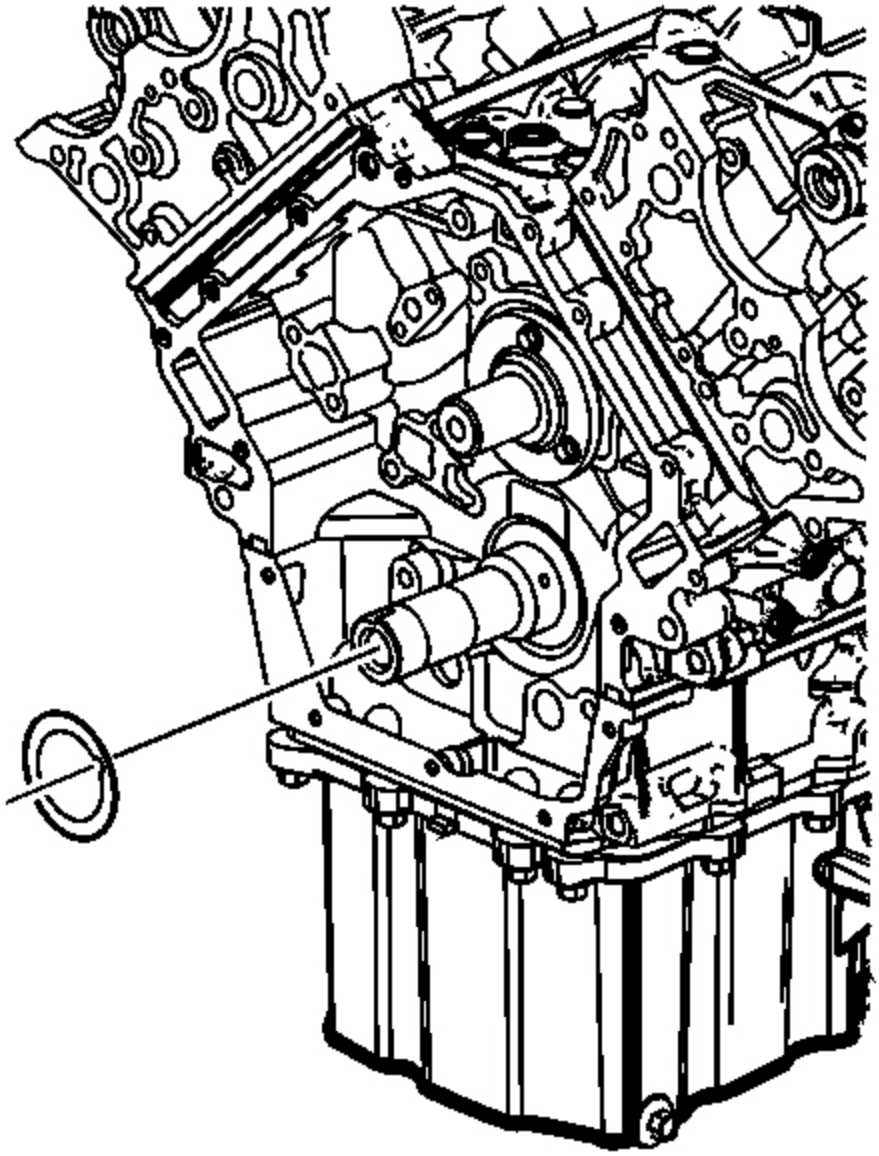


Fig. 348: Identifying Crankshaft To Crankshaft Sprocket Friction Washer
Courtesy of GENERAL MOTORS CORP.

10. Remove the crankshaft to crankshaft sprocket friction washer.
11. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

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INSTALLATION PROCEDURE

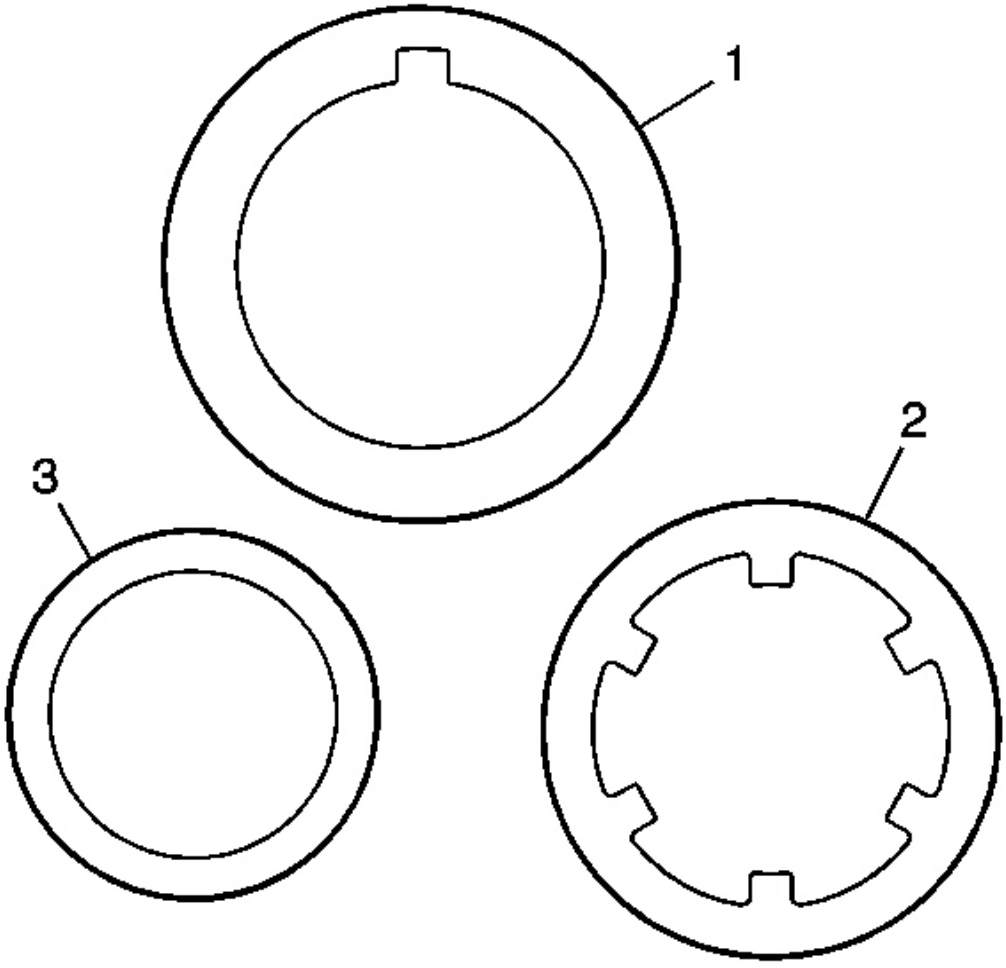


Fig. 349: View Of Friction Washers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the proper friction washer is installed in the correct position.

1. Select the crankshaft to crankshaft sprocket friction washer (1). The outer diameter is 63.5 mm (2.5000 in), an inner diameter of 45.25 mm (1.7815 in) and a notch to clear the crankshaft pin.

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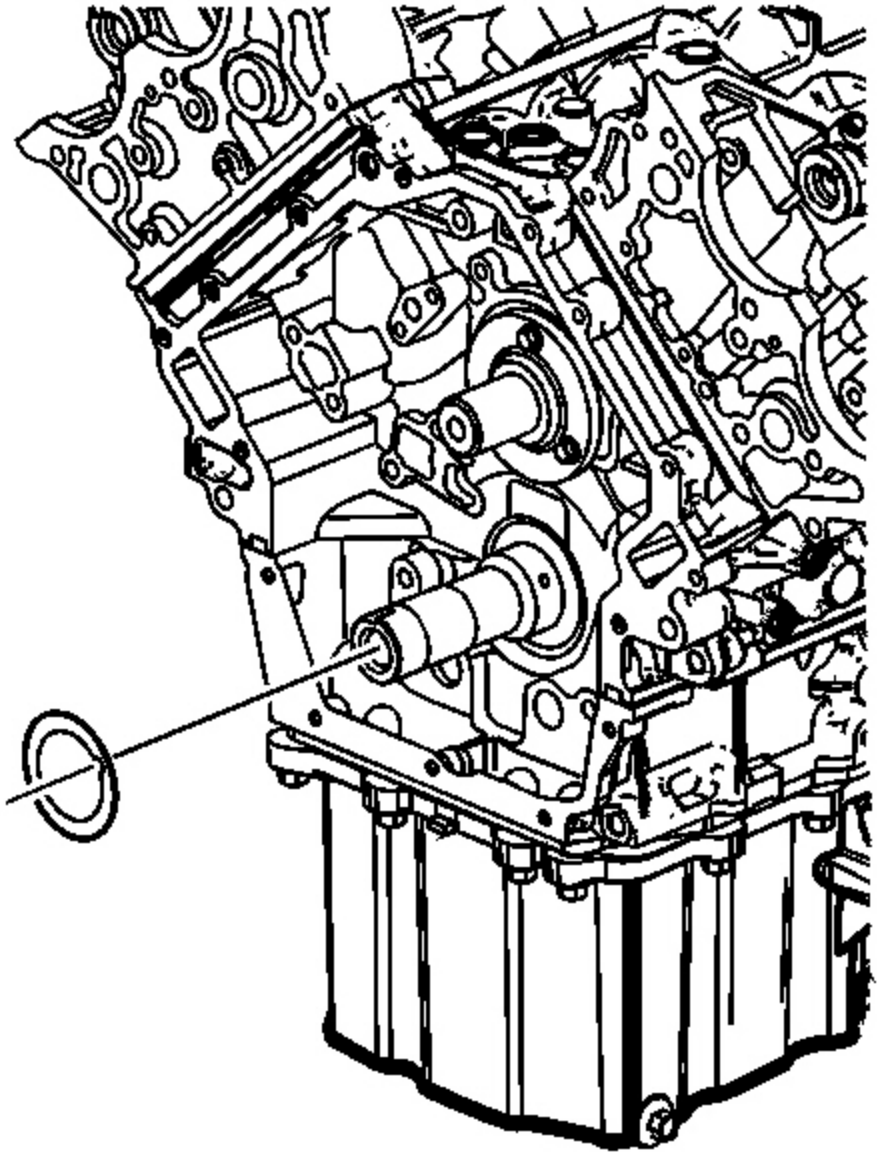


Fig. 350: Identifying Crankshaft To Crankshaft Sprocket Friction Washer
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft to crankshaft sprocket friction washer.

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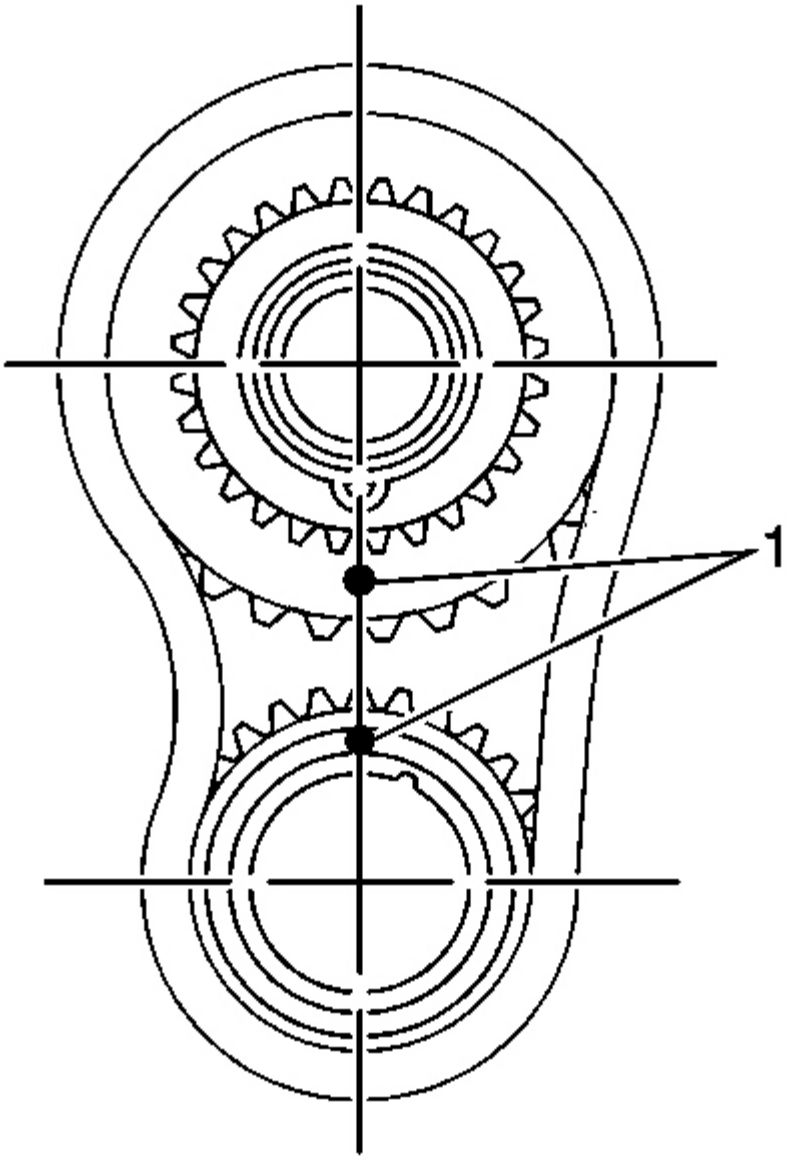


Fig. 351: Aligning Timing Marks Of Camshaft Intermediate & Crankshaft Sprockets
Courtesy of GENERAL MOTORS CORP.

3. Align the timing marks (1) of the camshaft intermediate and crankshaft sprockets. The marks should be aligned vertically in the installed position.
4. Install the primary camshaft drive chain on the drive sprockets.

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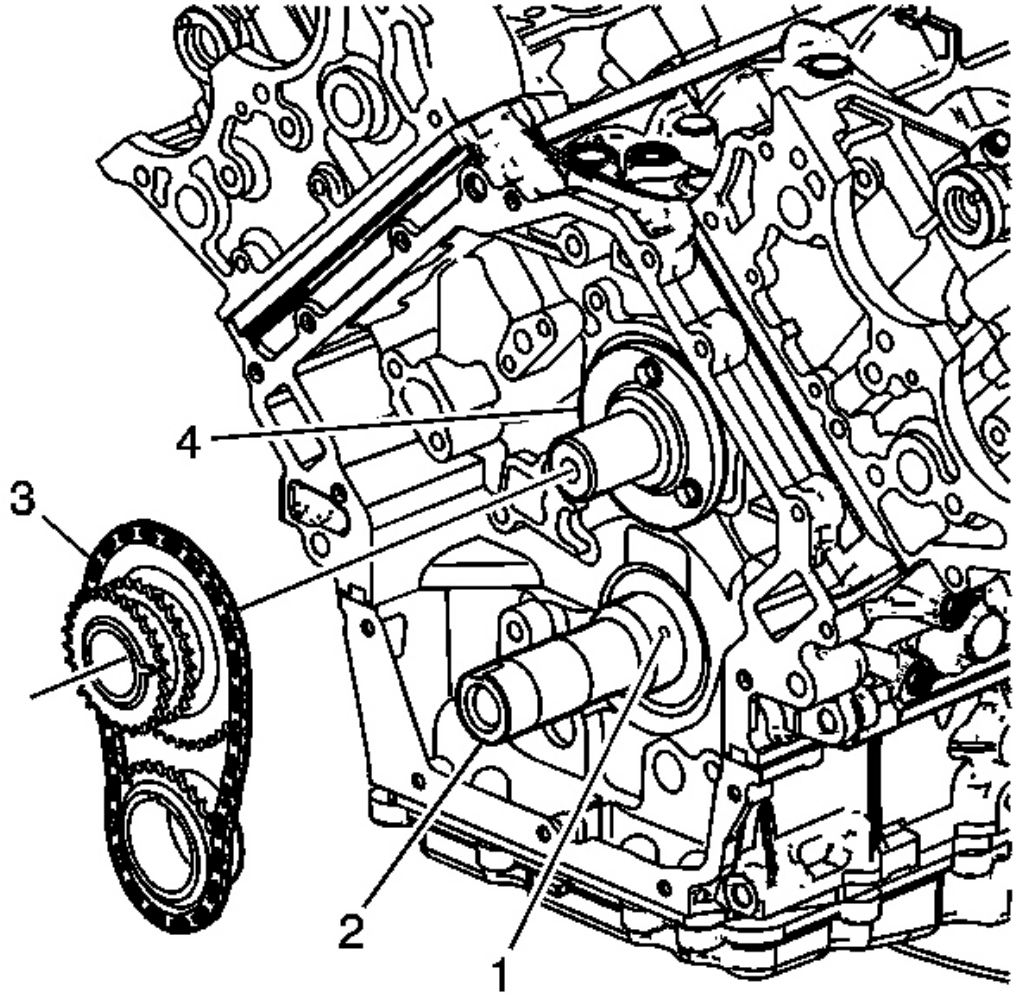


Fig. 352: View Of Primary Camshaft Drive Chain, Intermediate Drive Shaft Sprocket & Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

5. Ensure the number one piston is at Top Dead Center (TDC) and the crankshaft pin is approximately at the 1 o'clock position. Use the **J 39946** to rotate the crankshaft as necessary. See **Special Tools** .
6. Install the following as an assembly:
   - The primary camshaft drive chain (3)
   - The crankshaft sprocket
   - The camshaft intermediate sprocket

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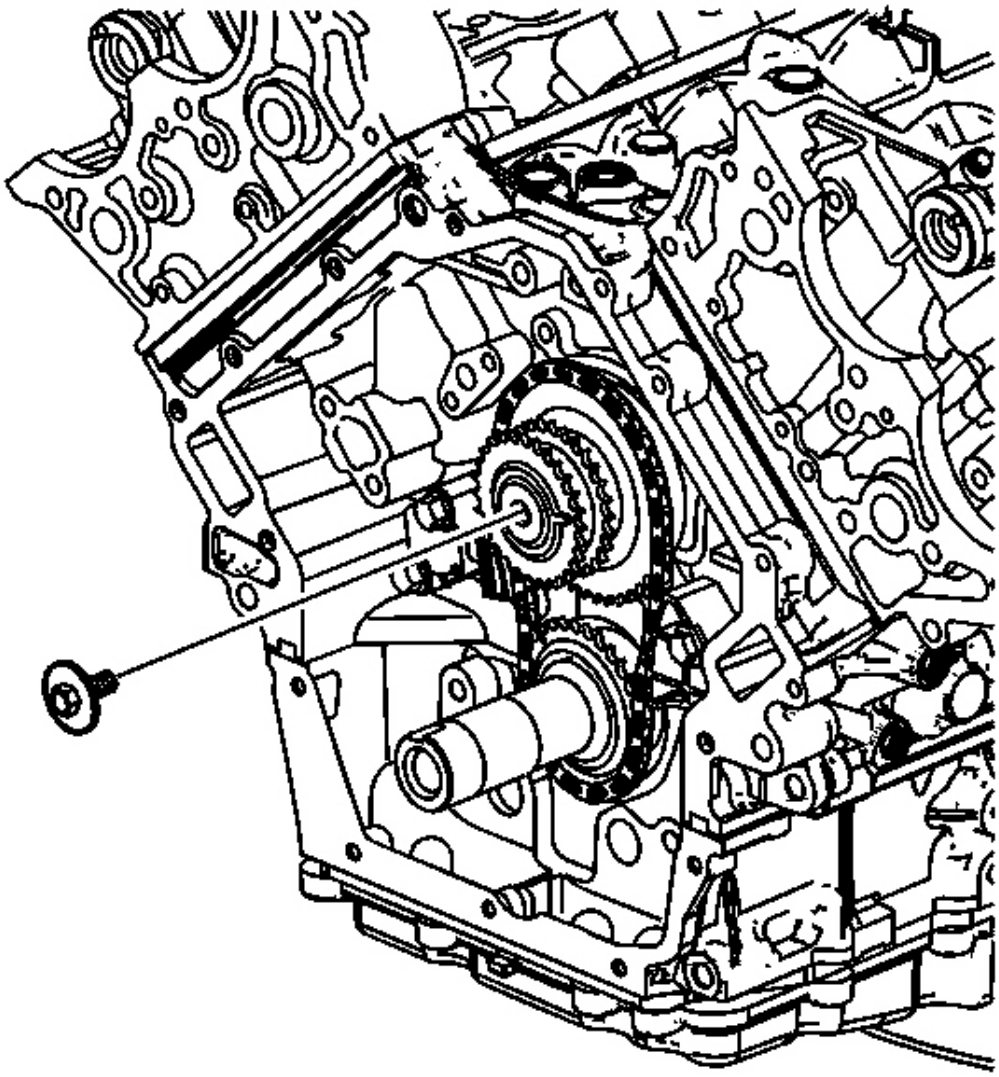


Fig. 353: View Of Camshaft Intermediate Sprocket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

7. Install the camshaft intermediate sprocket retaining bolt.

   Tighten: Tighten the camshaft intermediate sprocket retaining bolt to 60 N.m (44 lb ft).

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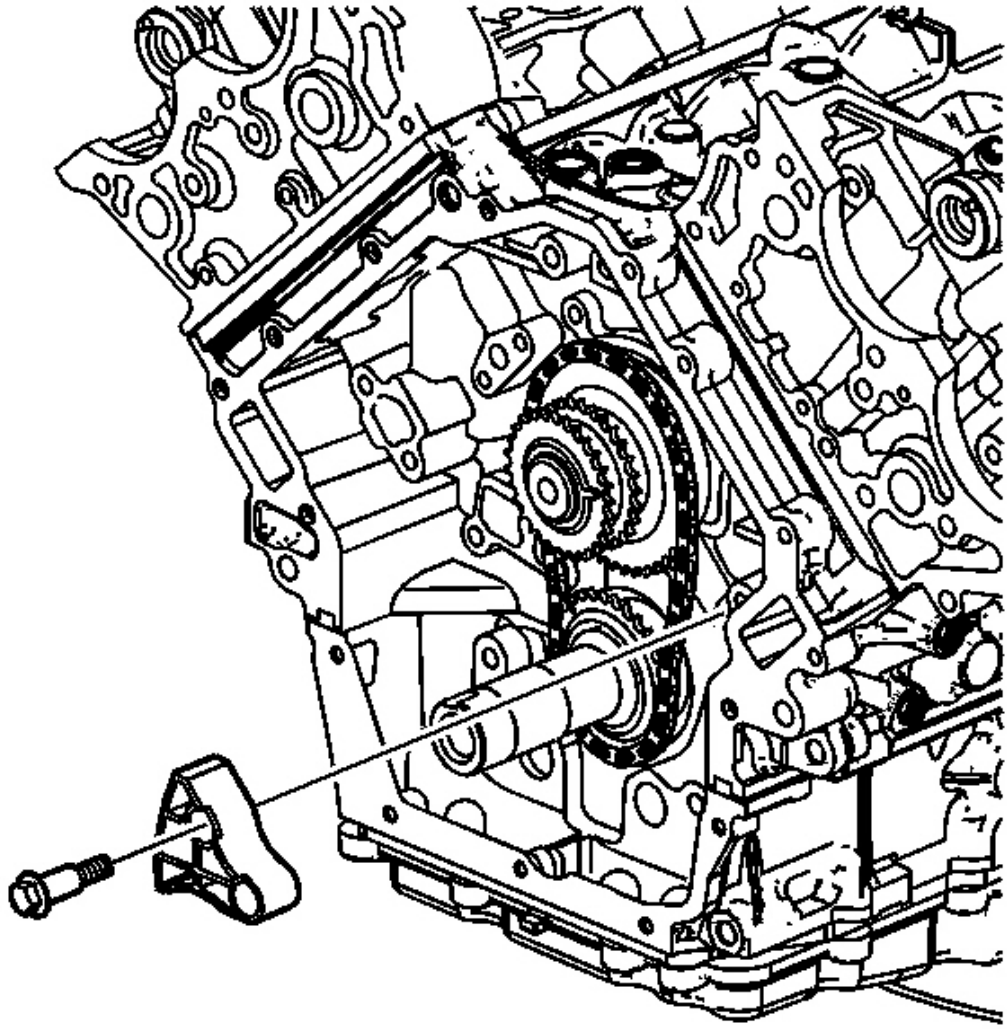


Fig. 354: View Of Primary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

8. Install the primary drive chain guide.
9. Install the primary drive chain guide bolts.

   Tighten: Tighten the primary drive chain guide bolts to 25 N.m (18 lb ft).

10. Install the primary drive chain tensioner. Refer to **Primary Camshaft Drive Chain Tensioner Replacement**.

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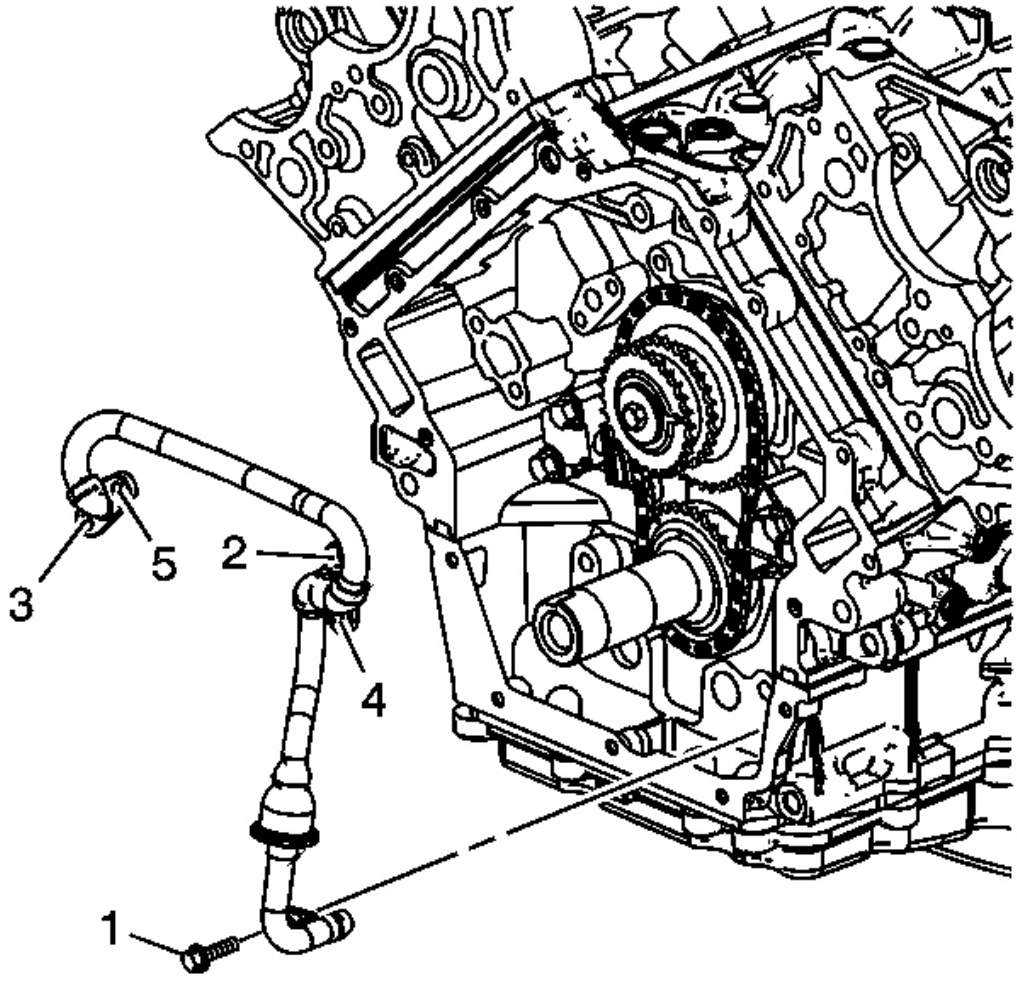


Fig. 355: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the oil outlet tube (4) and bolts. Refer to **Oil Pump Outlet Tube Installation** .

    Tighten: Tighten the oil outlet tube bolts to 10 N.m (89 lb in).

12. Install the secondary camshaft drive chains. Refer to **Secondary Camshaft Drive Chain Replacement - Left Side** and **Secondary Camshaft Drive Chain Replacement - Right Side**.
13. Remove the pin from the primary timing chain tensioner release lever.

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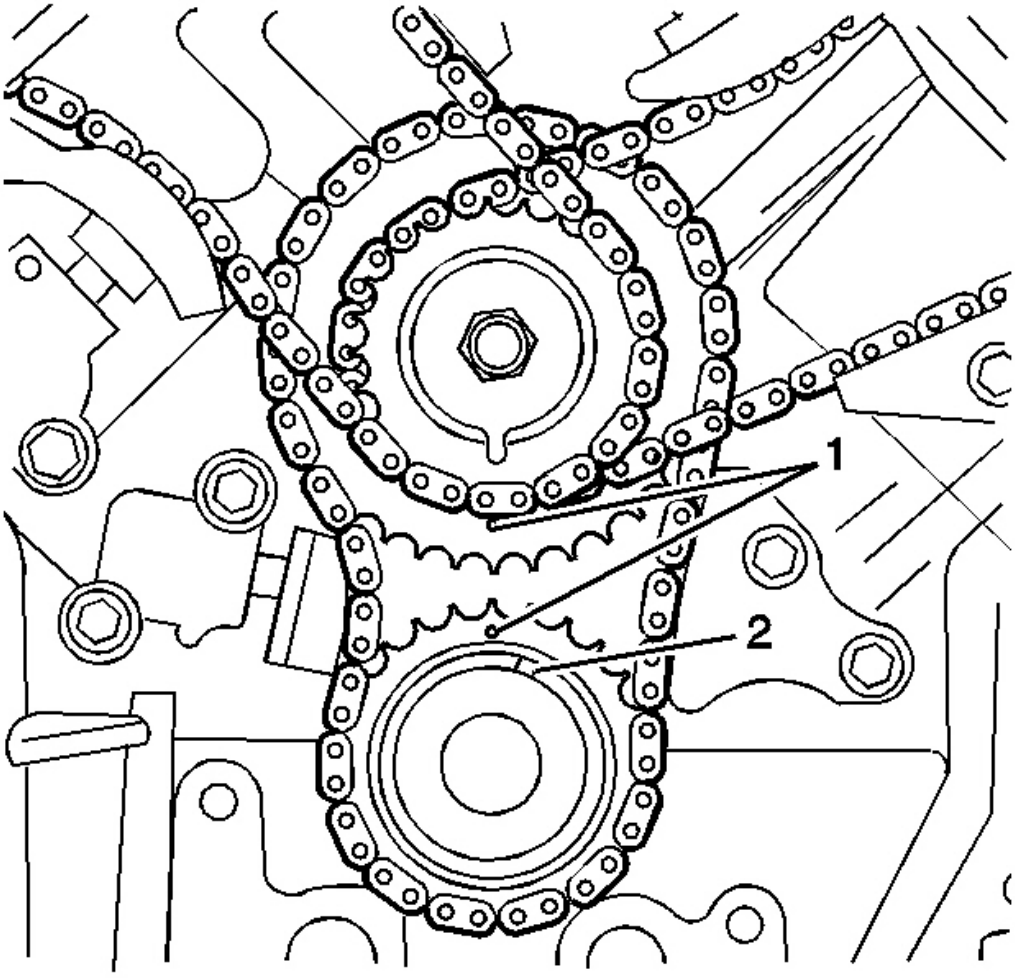


Fig. 356: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

14. Ensure the primary timing marks (1) are aligned vertically.

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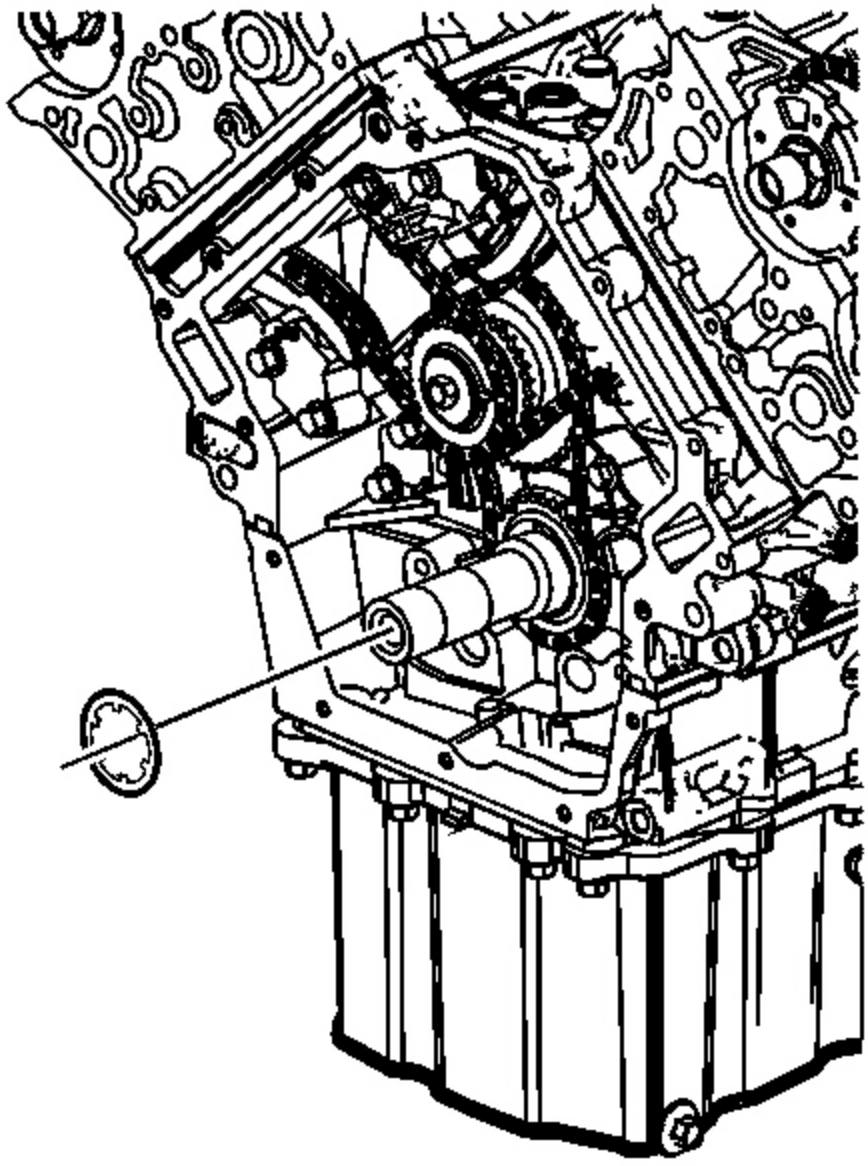


Fig. 357: Identifying Crankshaft To Crankshaft Sprocket Friction Washer
Courtesy of GENERAL MOTORS CORP.

15. Install the crankshaft sprocket to oil pump drive friction washer. The crankshaft sprocket to oil pump drive friction washer outer diameter is 62.0 mm (2.4410 mm) and the inner diameter is 45.25 mm (1.7815 in).

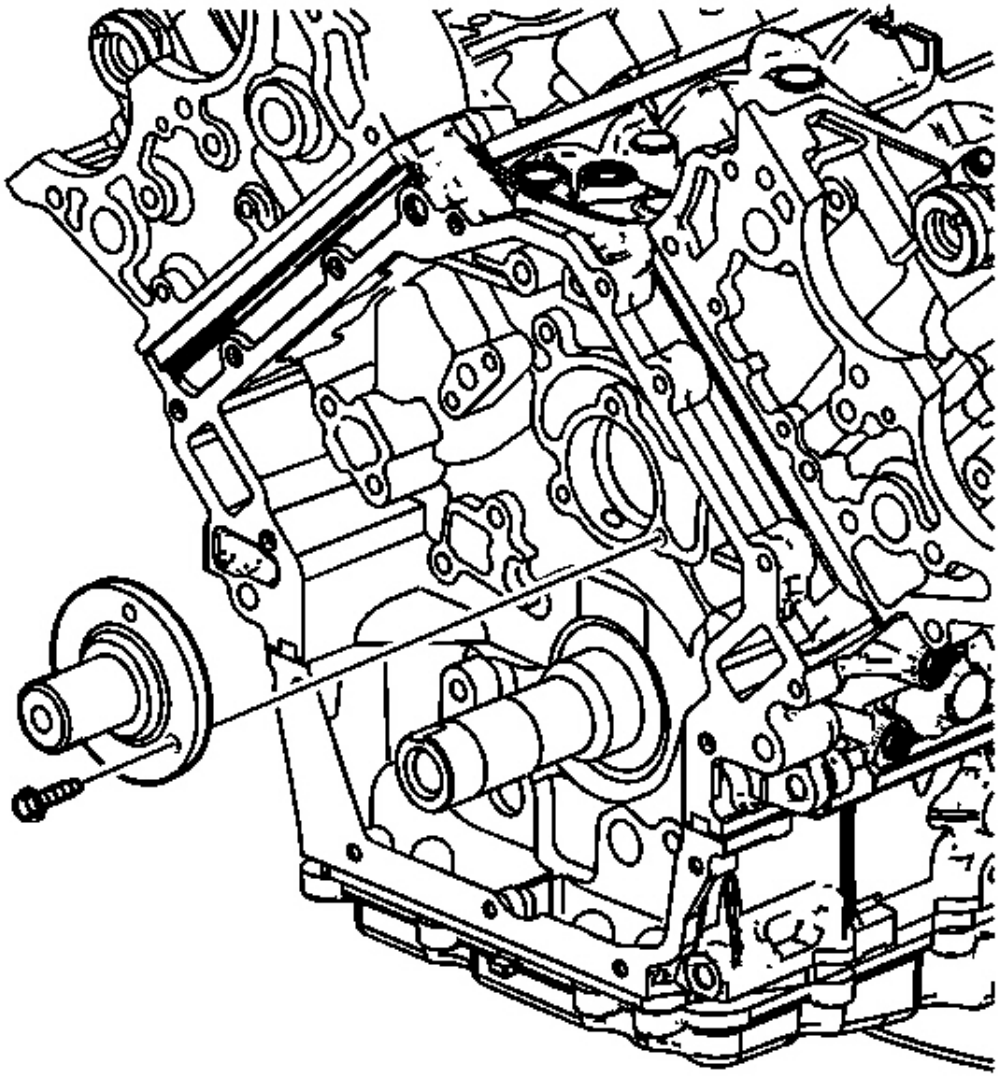
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16. Install the oil pump. Refer to **Oil Pump Replacement**.

CAMSHAFT INTERMEDIATE DRIVE SHAFT REPLACEMENT

REMOVAL PROCEDURE

1. Remove the camshaft intermediate drive shaft sprocket. Refer to **Primary Camshaft Drive Chain and Sprockets Replacement**.



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Fig. 358: View Of Intermediate Sprocket Shaft & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The camshaft intermediate drive shaft should not be removed unless wear is evident.

2. Remove the camshaft intermediate drive shaft retaining bolts.
3. Remove the camshaft intermediate drive shaft from the engine.
4. Clean and inspect the camshaft intermediate driveshaft. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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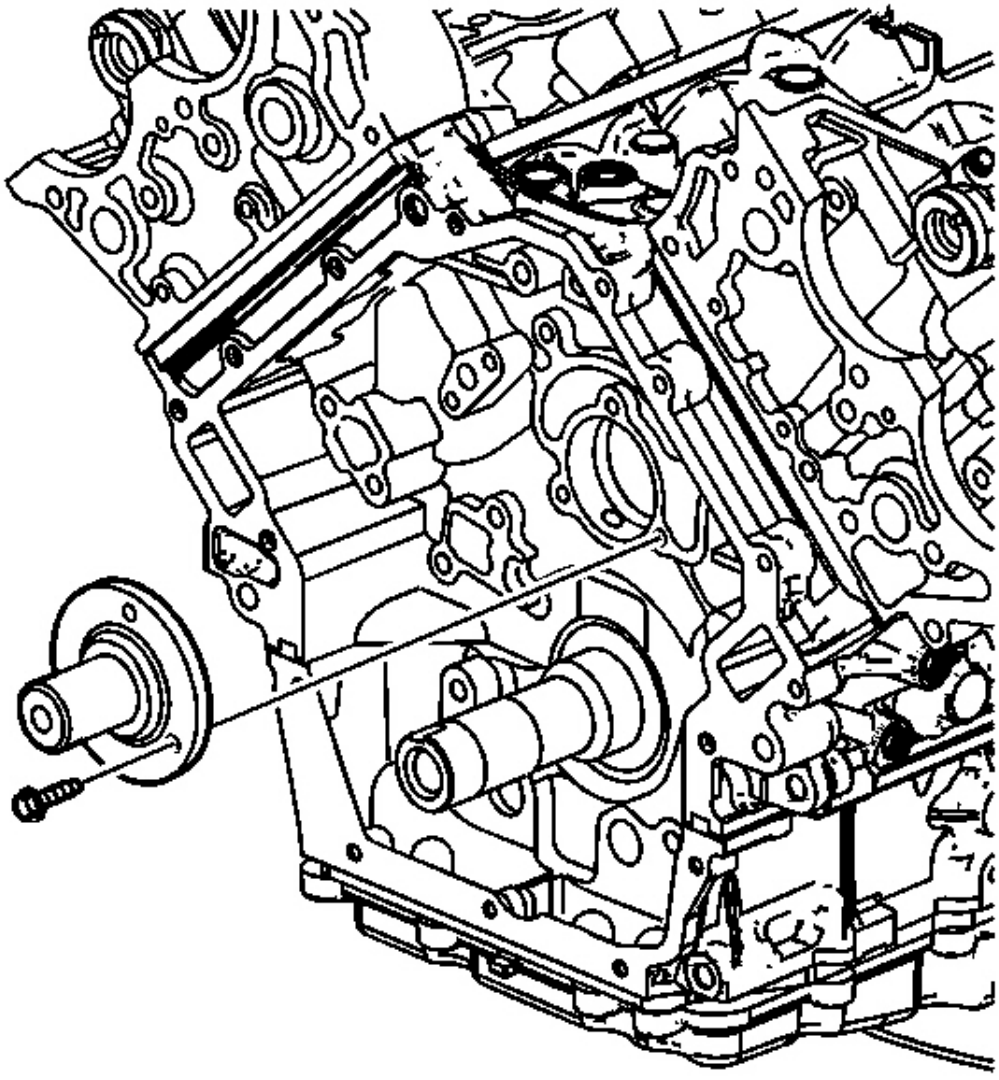


Fig. 359: View Of Intermediate Sprocket Shaft & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the camshaft intermediate drive shaft to the engine, aligning the bolt holes.

NOTE: **Refer to Fastener Notice .**

2. Install the camshaft intermediate drive shaft retaining bolts.

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Tighten: Tighten the camshaft intermediate drive shaft retaining bolts to 15 N.m (11 lb ft).

3. Install the camshaft intermediate drive shaft sprocket. Refer to **Primary Camshaft Drive Chain and Sprockets Replacement**.

CAMSHAFT POSITION ACTUATOR OIL CONTROL VALVE REPLACEMENT - BANK 1 (RIGHT SIDE) INTAKE

TOOLS REQUIRED

- **J 39946** Crankshaft Socket. See **Special Tools** .
- **EN 46327** Timing Chain Retention Tool. See **Special Tools** .
- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

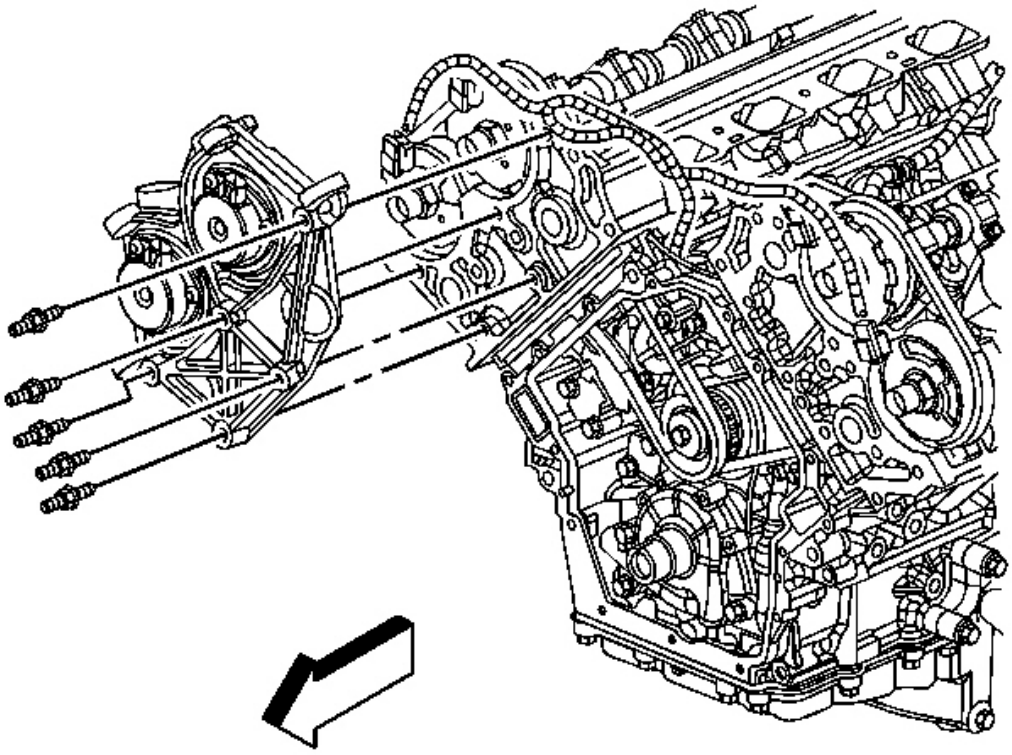


Fig. 360: View Of Right Camshaft Actuator Housing
Courtesy of GENERAL MOTORS CORP.

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1. Remove the right actuator housing. DO NOT remove the camshaft position (CMP) actuator solenoids from the housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

3. Using the **J 39946** , rotate the crankshaft until both bank 1 (right) CMP actuator timing marks are perpendicular (90 degrees) to the cylinder head deck surface and near the top of their rotation. See **Special Tools** .

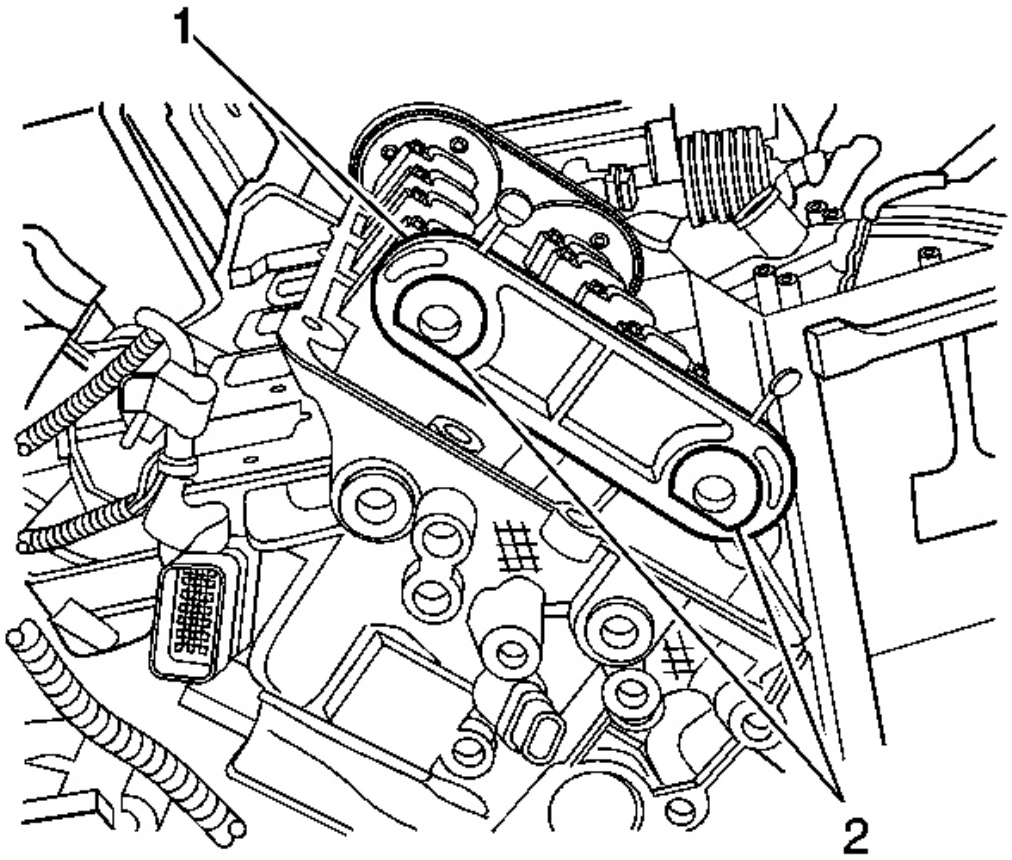


Fig. 361: Identifying EN 46328 Cam Tool

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Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution .

4. Install the **EN 46328** (1) to the camshafts (2). See **Special Tools** .

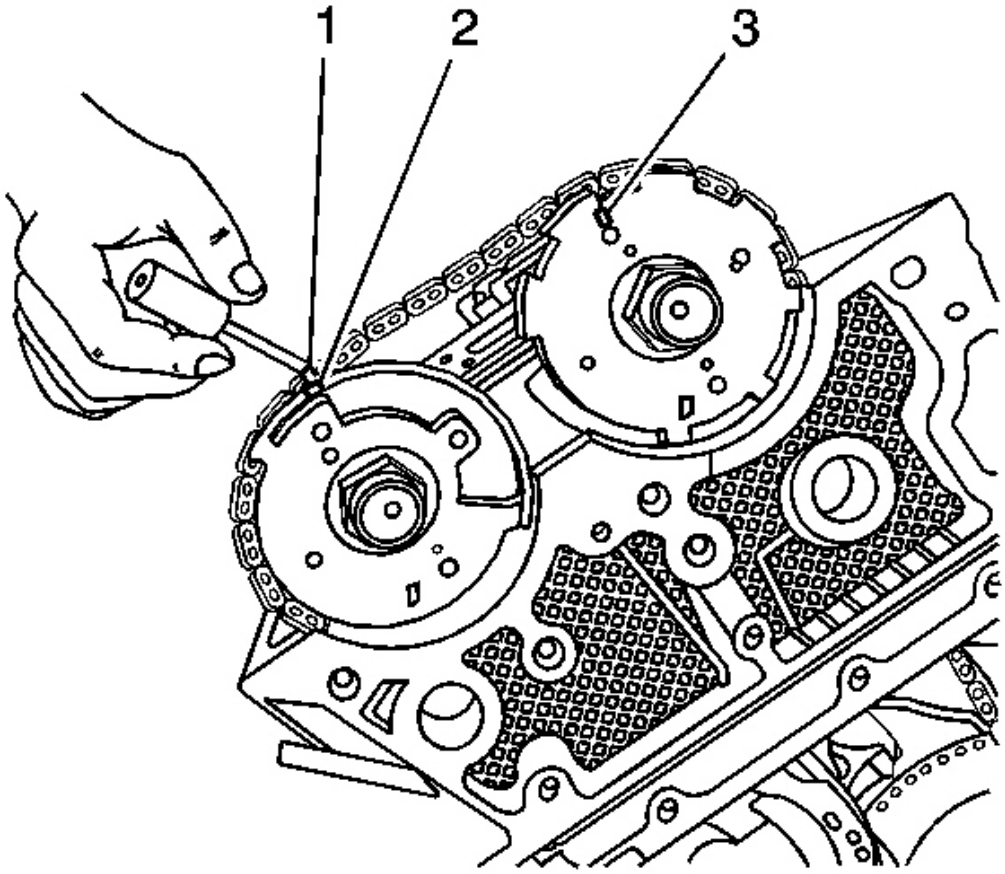


Fig. 362: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

5. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft position actuator timing mark (2, 3).

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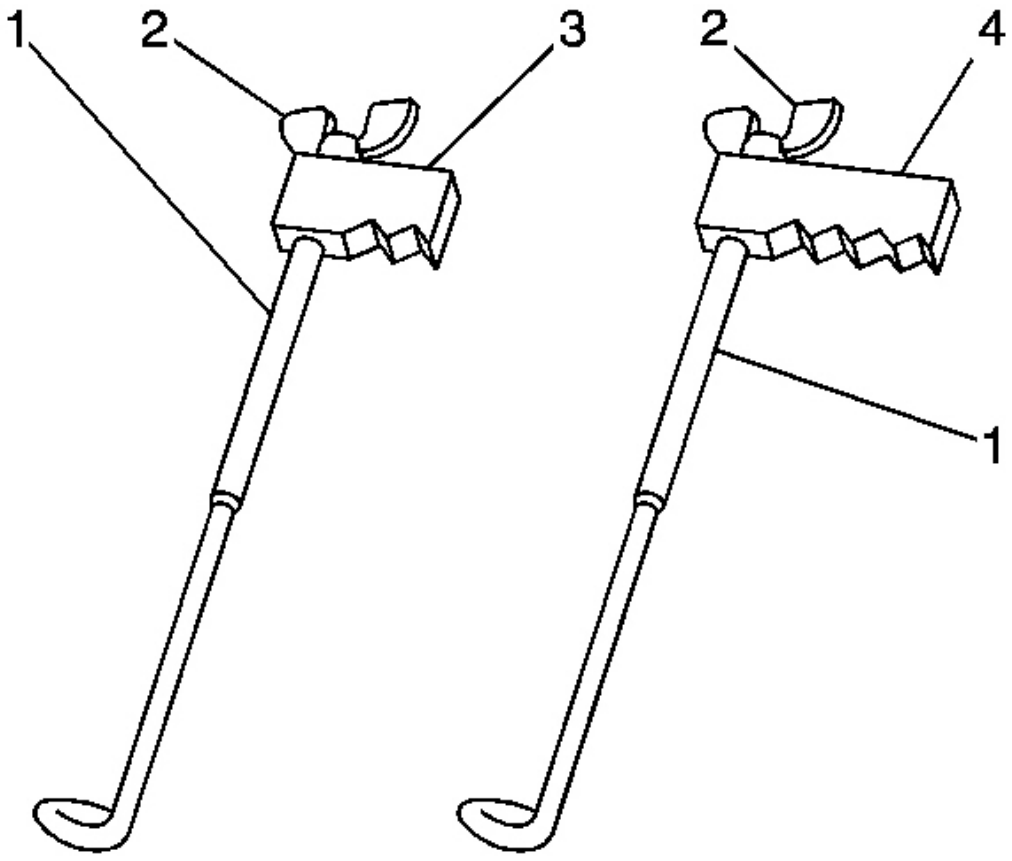


Fig. 363: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN 46327** (1) using the installation of the **EN 46327** timing chain retention tool procedure. See **Special Tools** .

INSTALLATION OF THE EN 46327 TIMING CHAIN RETENTION TOOL - RIGHT BANK

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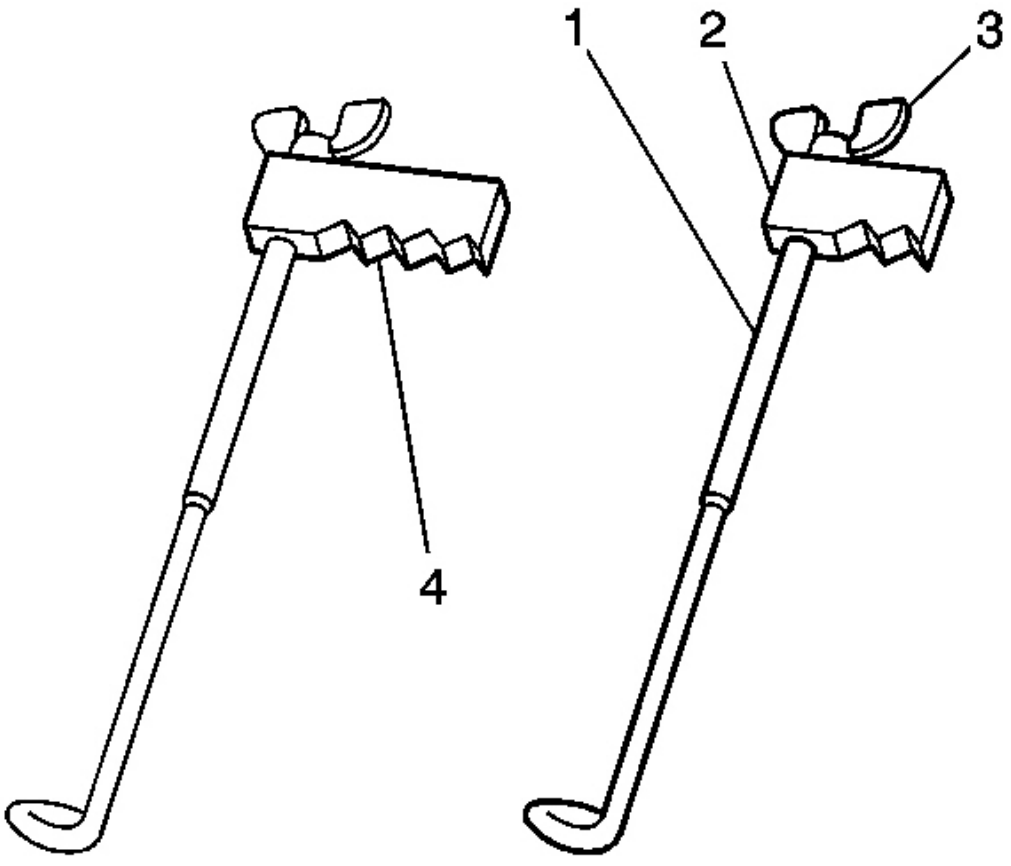


Fig. 364: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

1. Rotate the wing nut (3) of the **EN 46327** to the top of its travel. See **Special Tools** .

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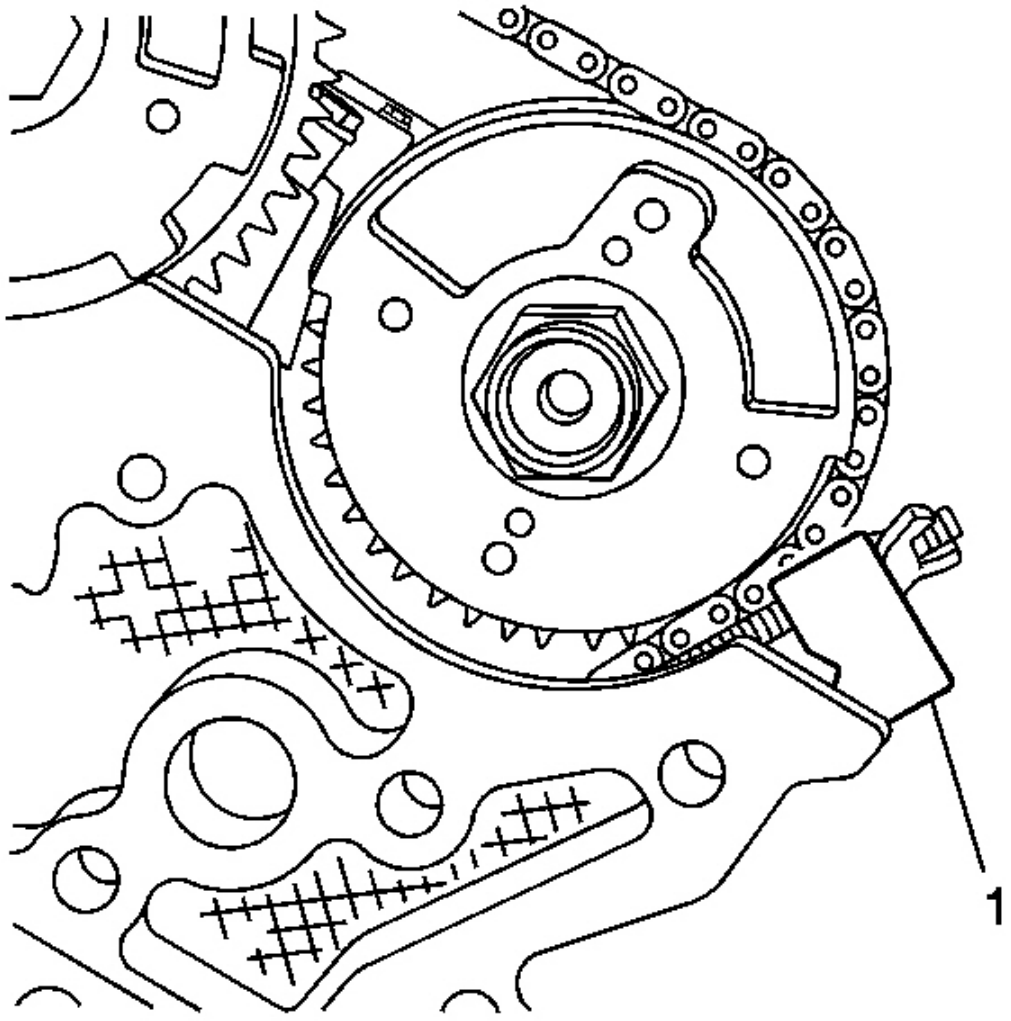


Fig. 365: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

2. Position the bottom retention tool on the cylinder head with the V-notch of the block (1) adjacent to the right exhaust camshaft actuator timing sprocket and chain as shown.

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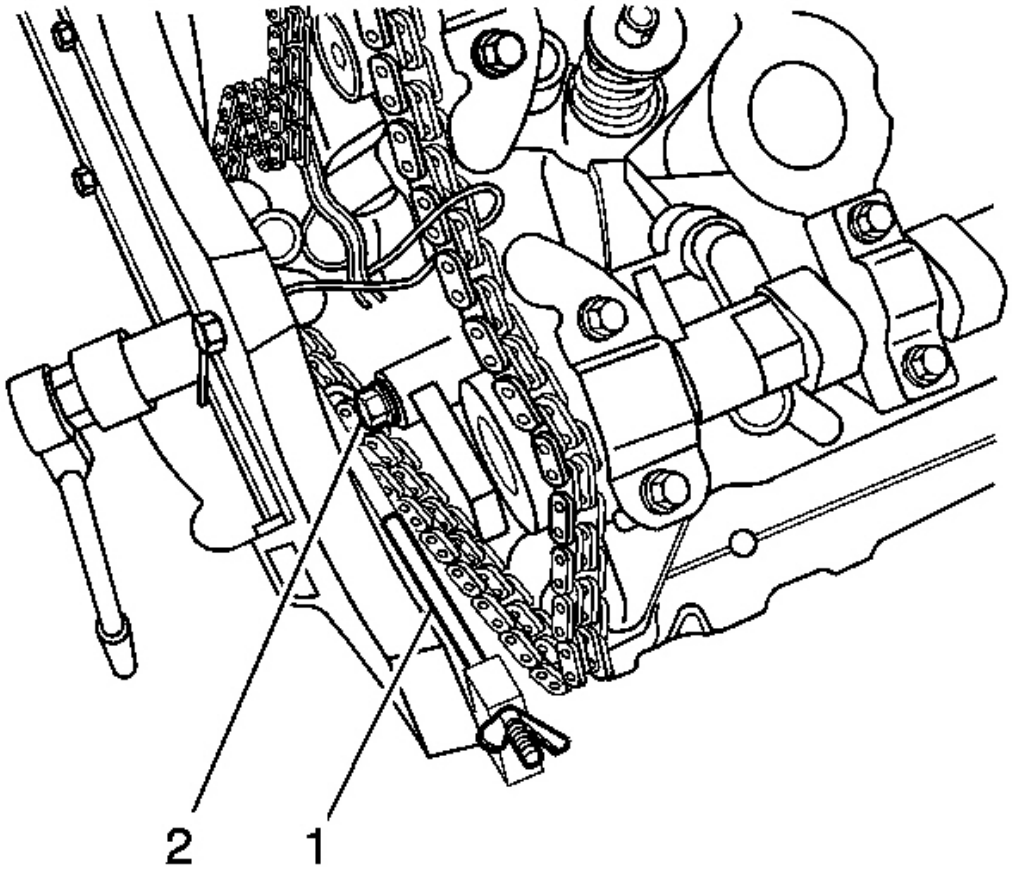


Fig. 366: Installing EN 46327 Hook End Into Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

3. Insert the hook end (2) into a secondary timing chain link as shown.

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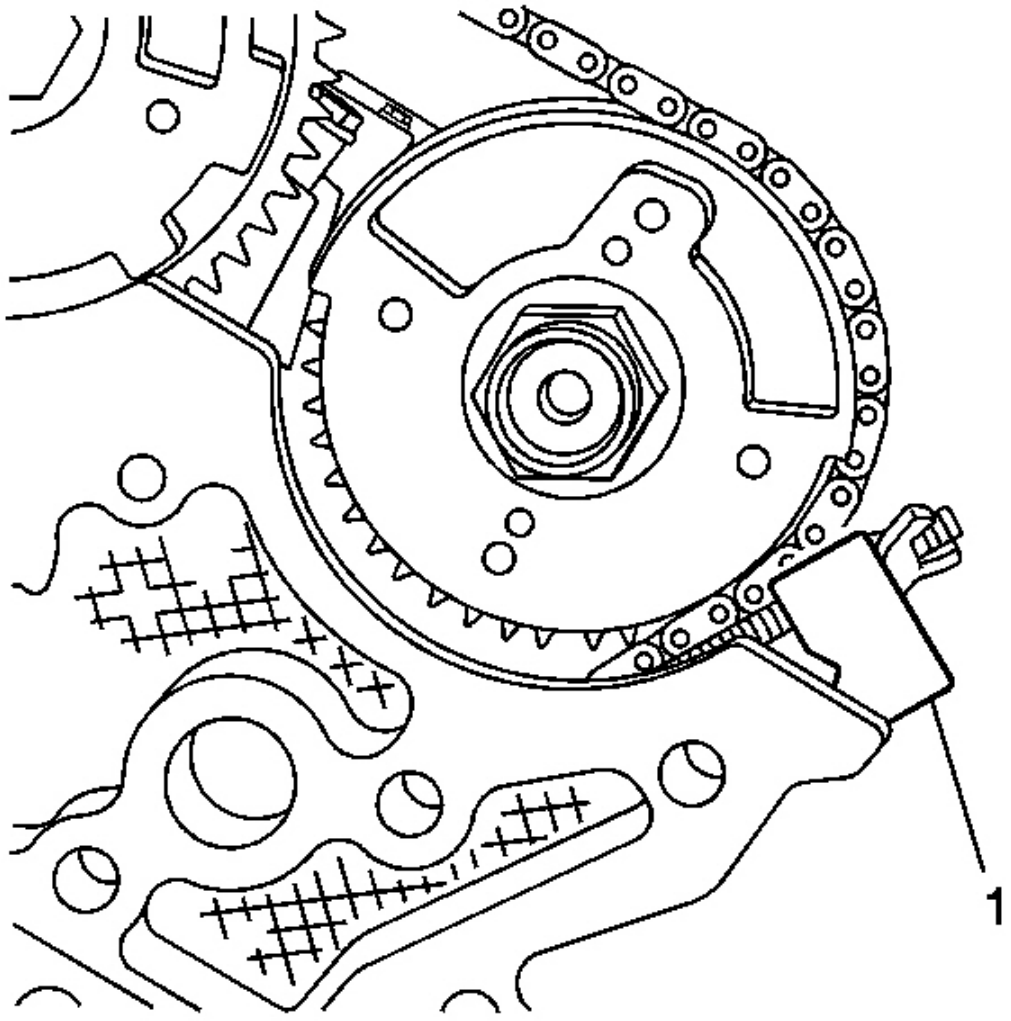


Fig. 367: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Rotate the wing nut until it contacts the retention tool block (1). DO NOT tighten the wing nut at this time.

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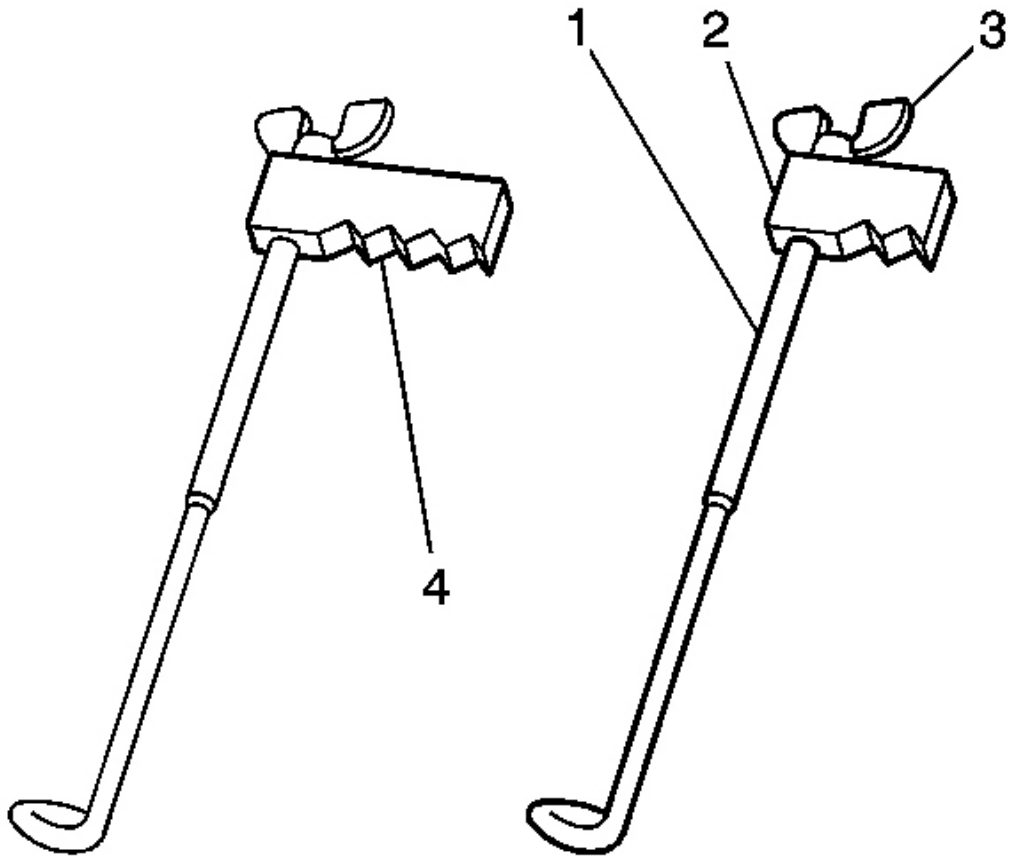


Fig. 368: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

5. Rotate the wing nut of the **EN 46327** (4) to the top of its travel. See **Special Tools** .

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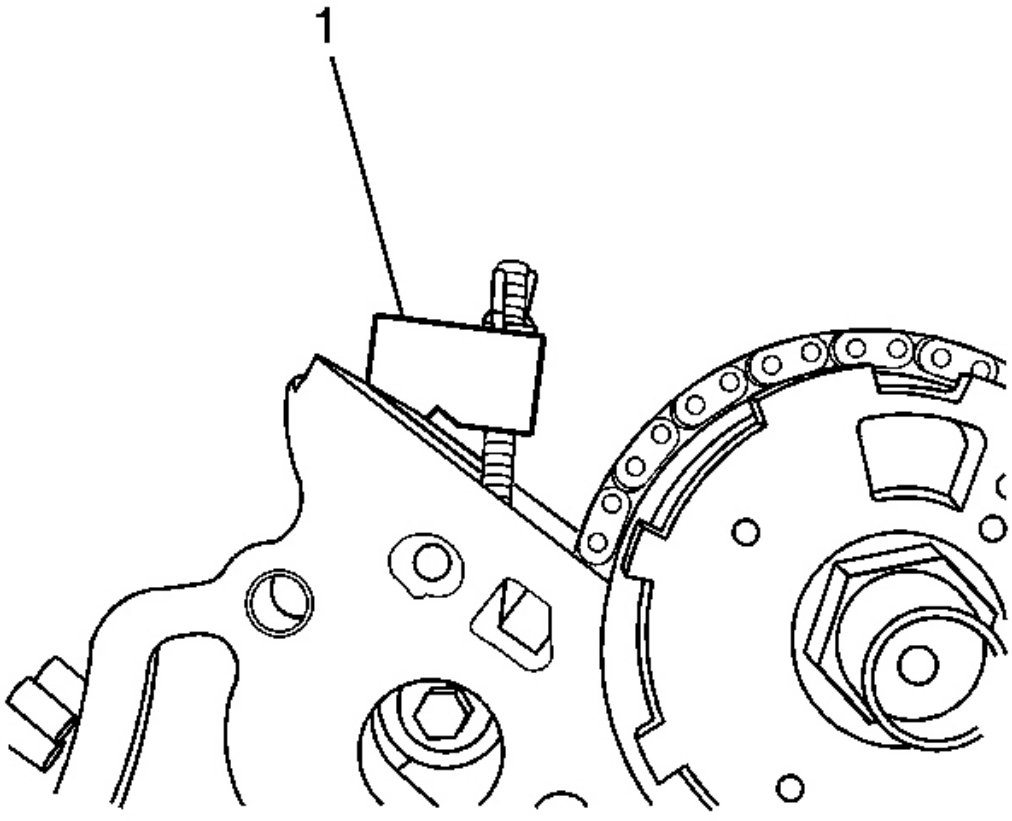


Fig. 369: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

6. Position the top retention tool on the cylinder head with the V-notch of the block (1) adjacent to the right intake camshaft actuator timing sprocket and chain as shown.

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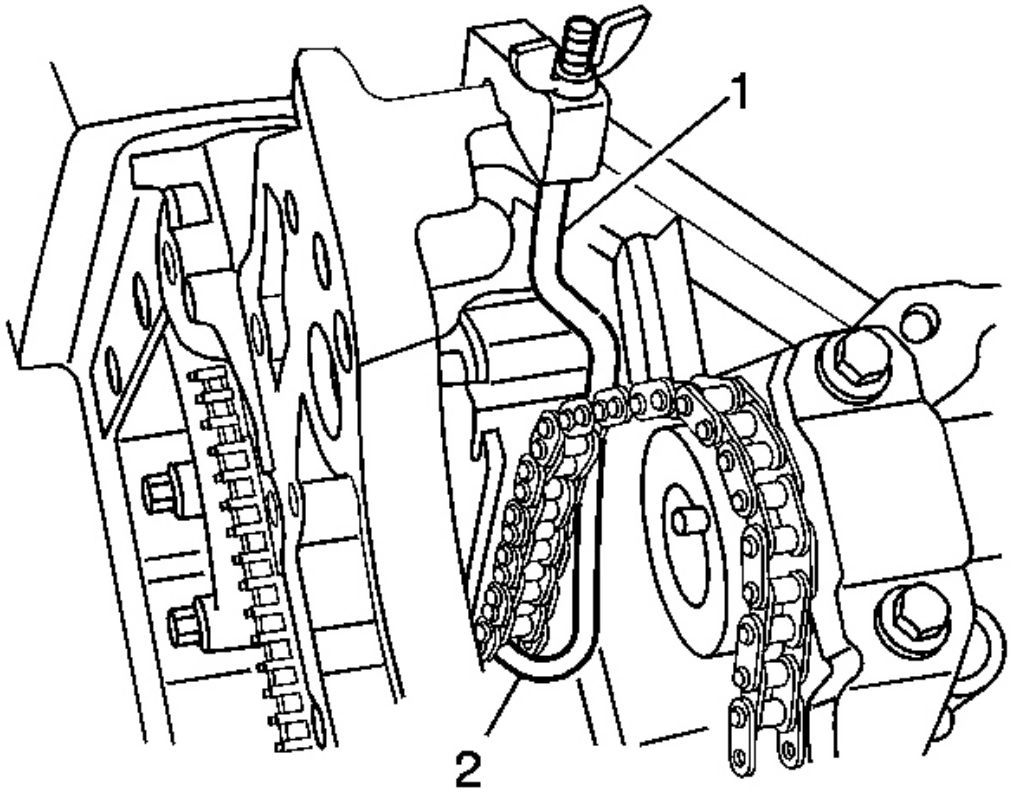


Fig. 370: View Of Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

7. Insert the hook end (2) into a secondary timing chain link as shown.

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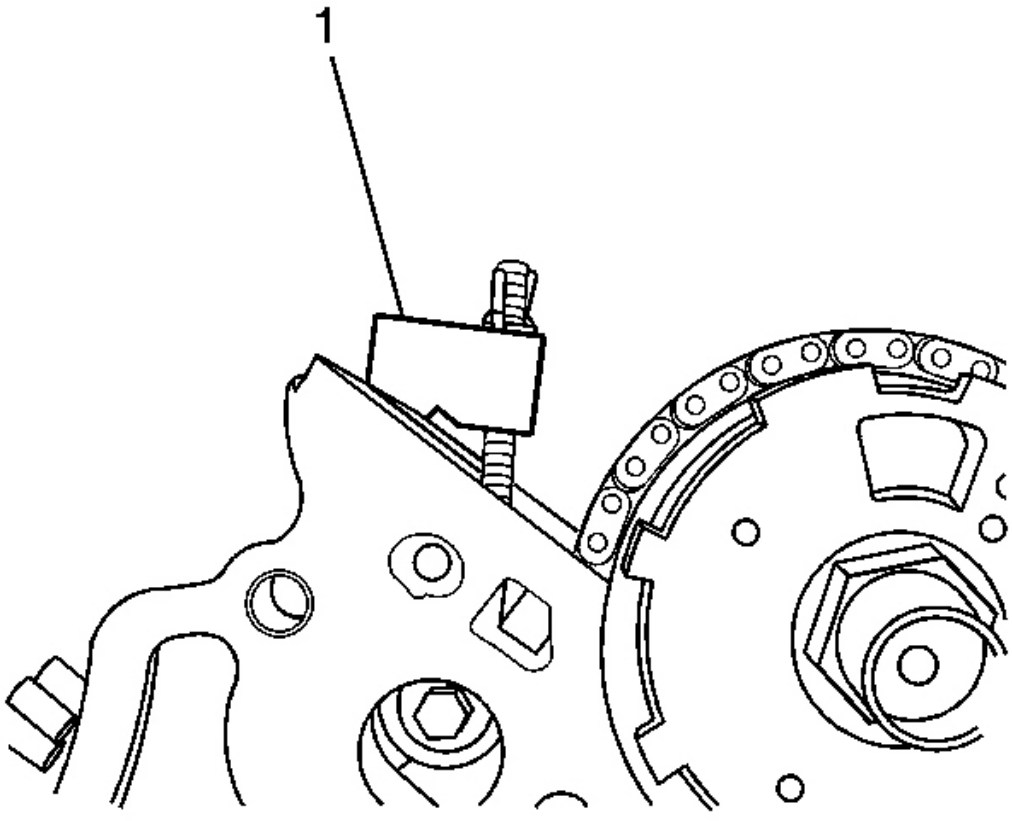


Fig. 371: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

8. Rotate the wing nut until it contacts the retention tool block (1). Alternately tighten both wing nuts to retain the chain.

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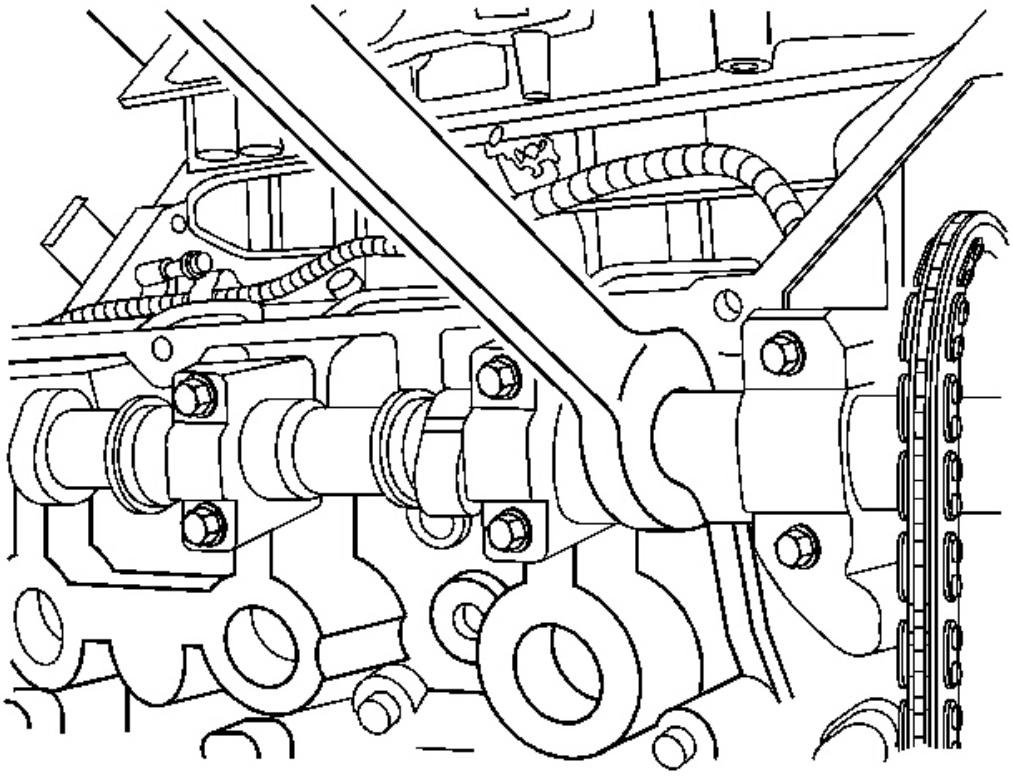


Fig. 372: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

9. Use an open end wrench on the hex cast into the right intake camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

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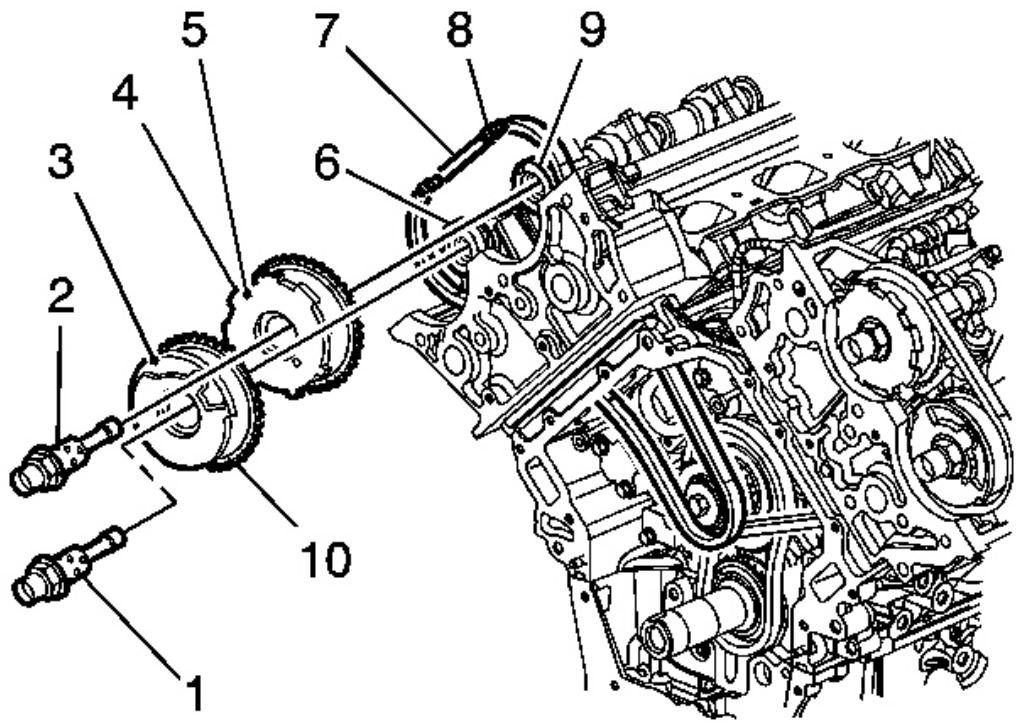


Fig. 373: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

10. Loosen and remove the right intake oil control valve (2).

INSTALLATION PROCEDURE

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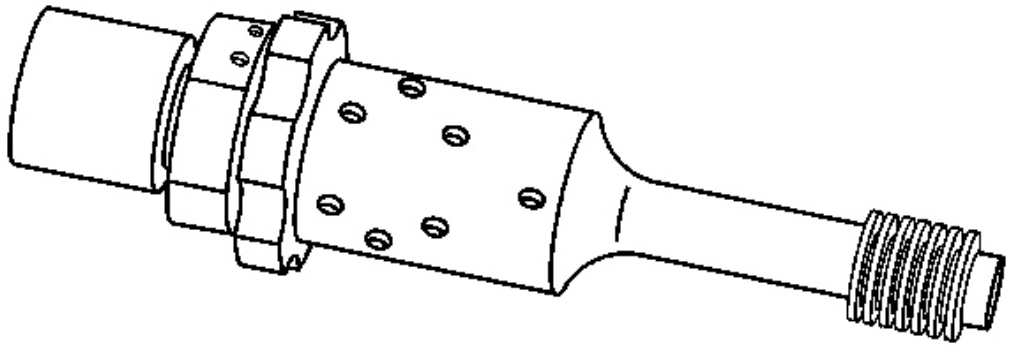


Fig. 374: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the oil control valve through the opening in the right intake camshaft position actuator and thread it into the right intake camshaft.

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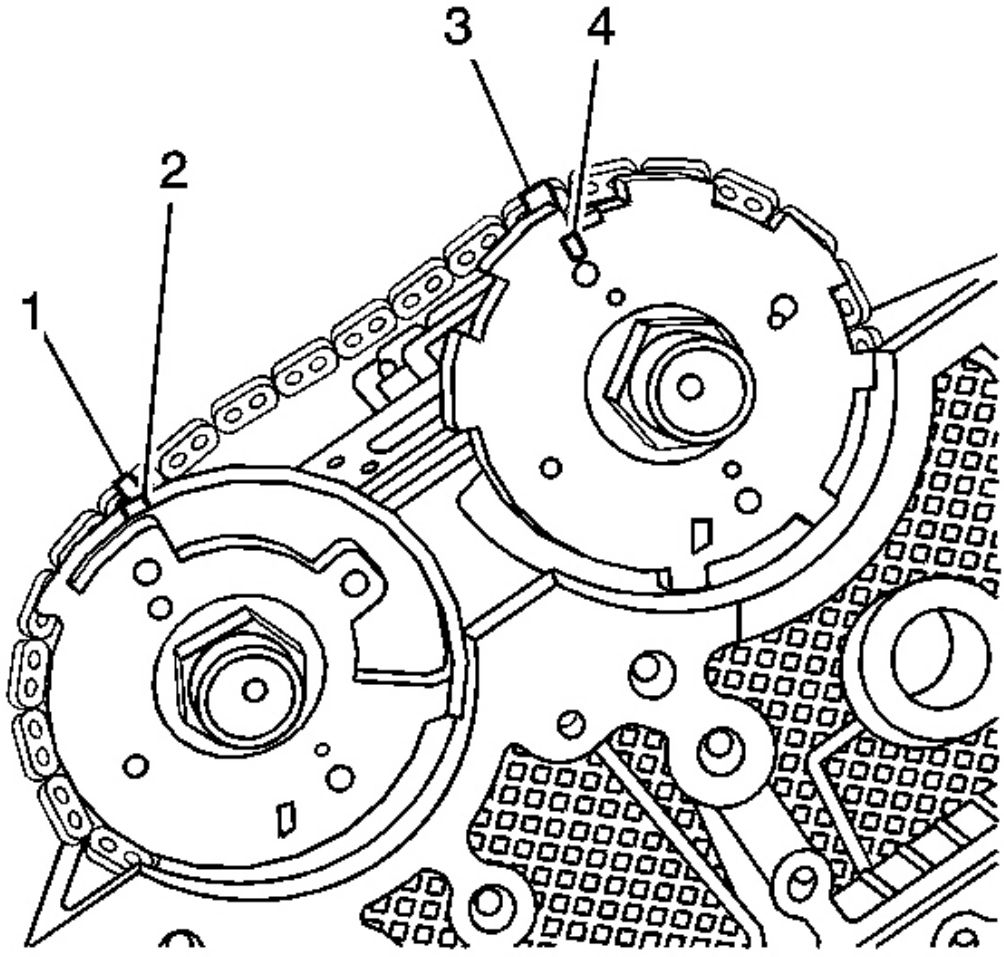


Fig. 375: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

2. Ensure both camshaft actuator timing marks (1, 3) are aligned with the paint marks on the secondary timing chain previously created.

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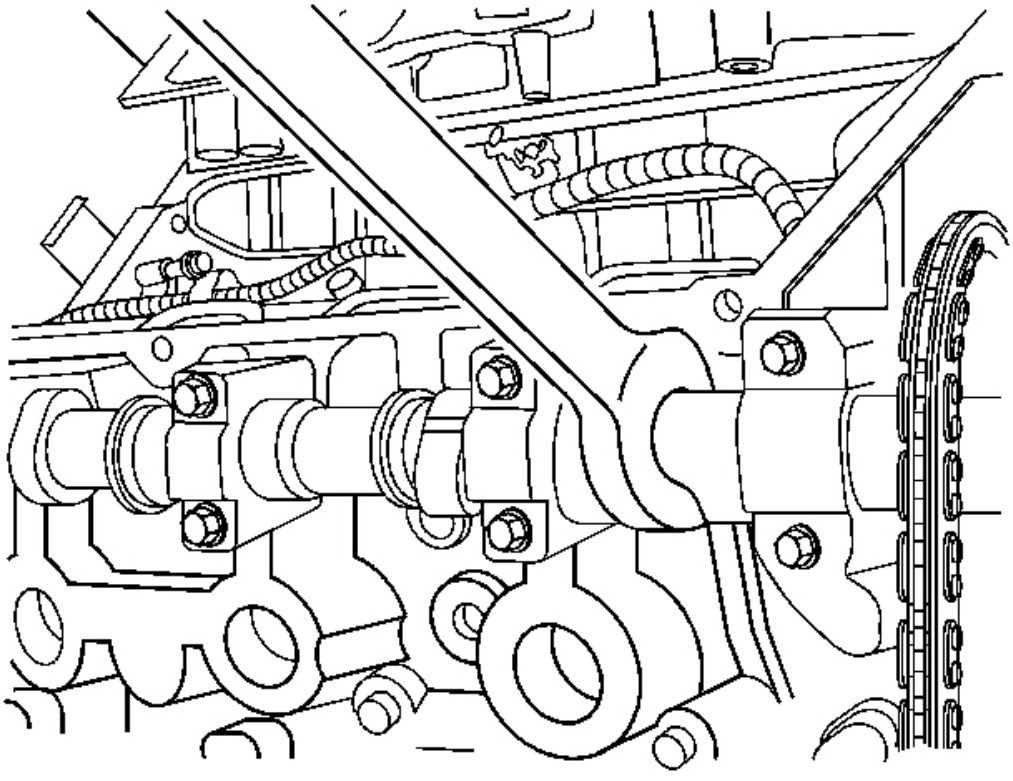


Fig. 376: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

3. Use an open end wrench on the hex cast into the right intake camshaft to prevent the camshaft from rotating when tightening the camshaft oil control valve.

   Tighten: Tighten the camshaft oil control valve to 120 N.m (89 lb ft).

4. Remove the **EN 46327** timing chain retention tools. See **Special Tools** .

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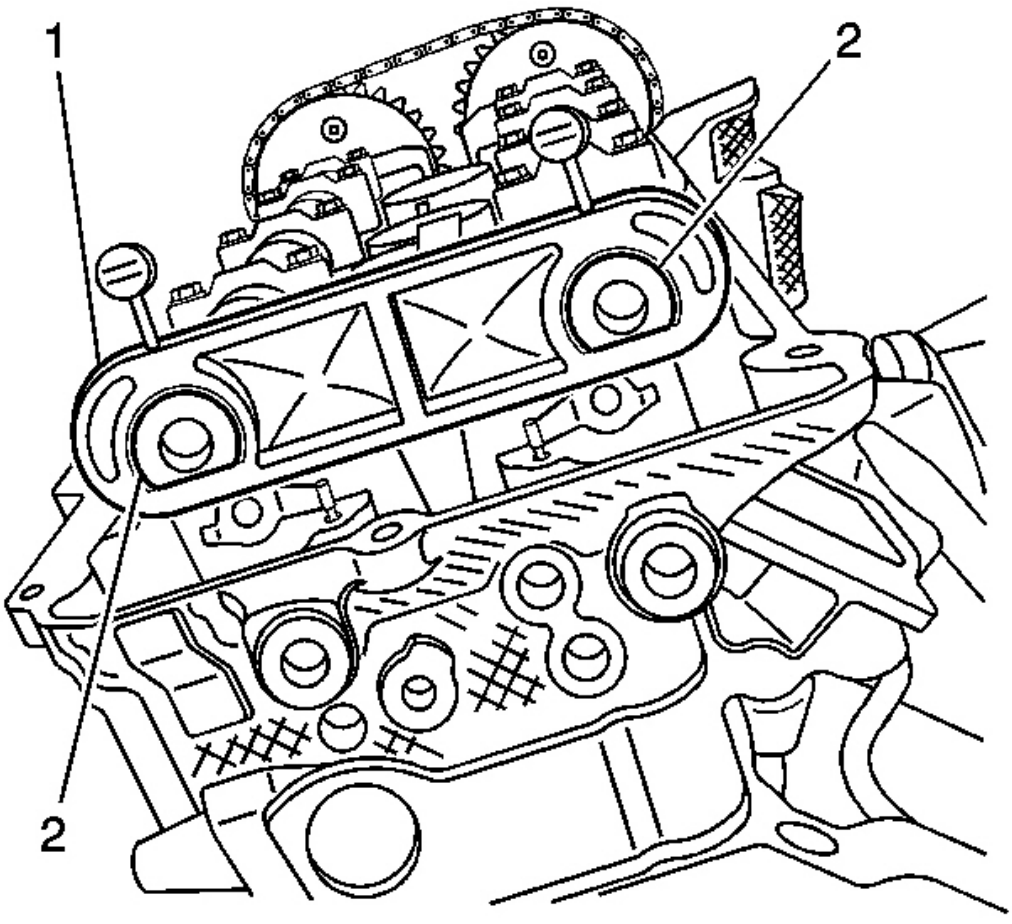


Fig. 377: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN 46328** (1) from the camshafts (2). See **Special Tools** .
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

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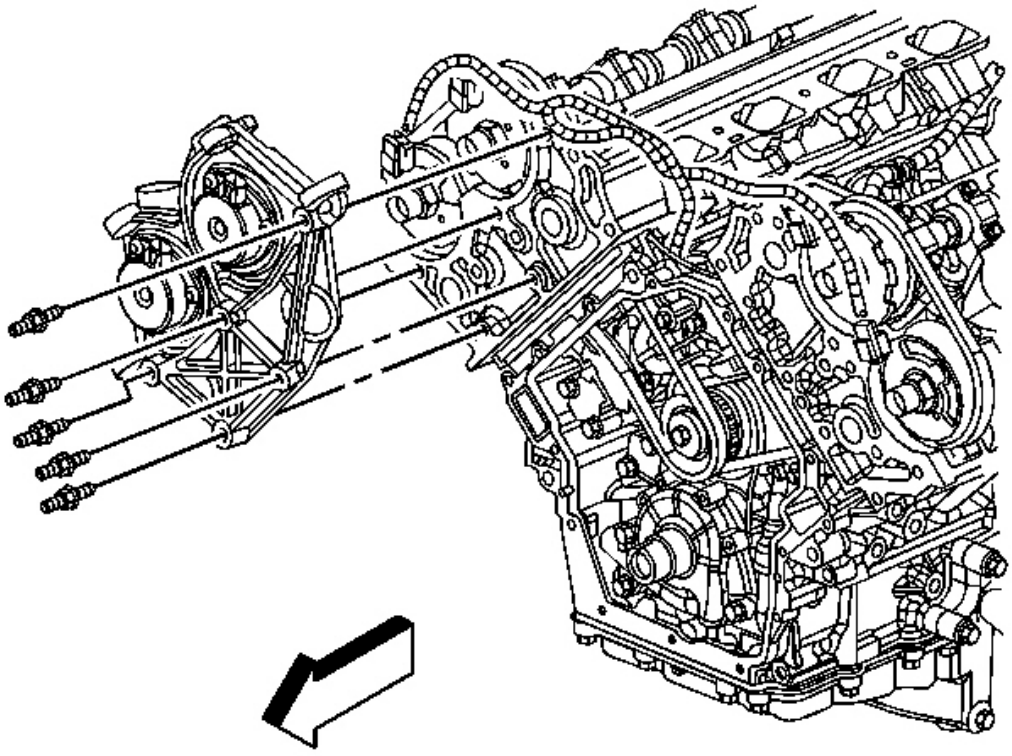


Fig. 378: View Of Right Camshaft Actuator Housing
Courtesy of GENERAL MOTORS CORP.

7. Install the right camshaft actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side**.

CAMSHAFT POSITION ACTUATOR OIL CONTROL VALVE REPLACEMENT - BANK 1 (RIGHT SIDE) EXHAUST

TOOLS REQUIRED

- **J 39946** Crankshaft Socket. See **Special Tools** .
- **EN 46327** Timing Chain Retention Tool. See **Special Tools** .
- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

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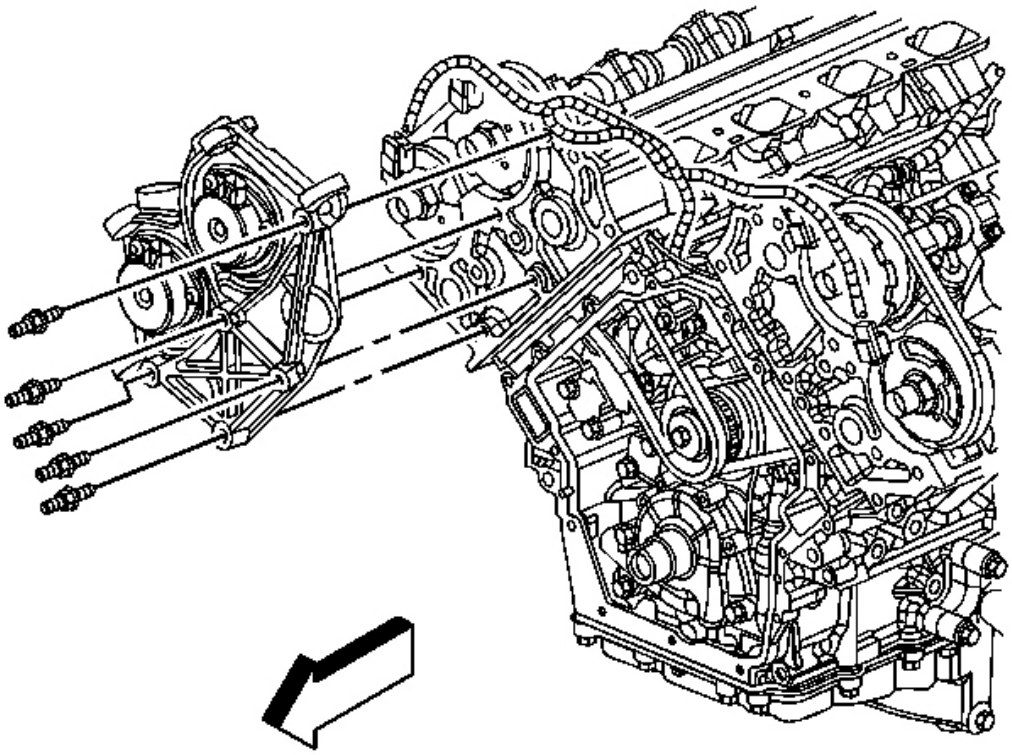


Fig. 379: View Of Right Camshaft Actuator Housing
Courtesy of GENERAL MOTORS CORP.

1. Remove the right actuator housing. DO NOT remove the camshaft position (CMP) actuator solenoids from the housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

3. Using the **J 39946** , rotate the crankshaft until both bank 1 (right) CMP actuator timing marks are perpendicular (90 degrees) to the cylinder head deck surface and near the top of their rotation. See **Special Tools** .

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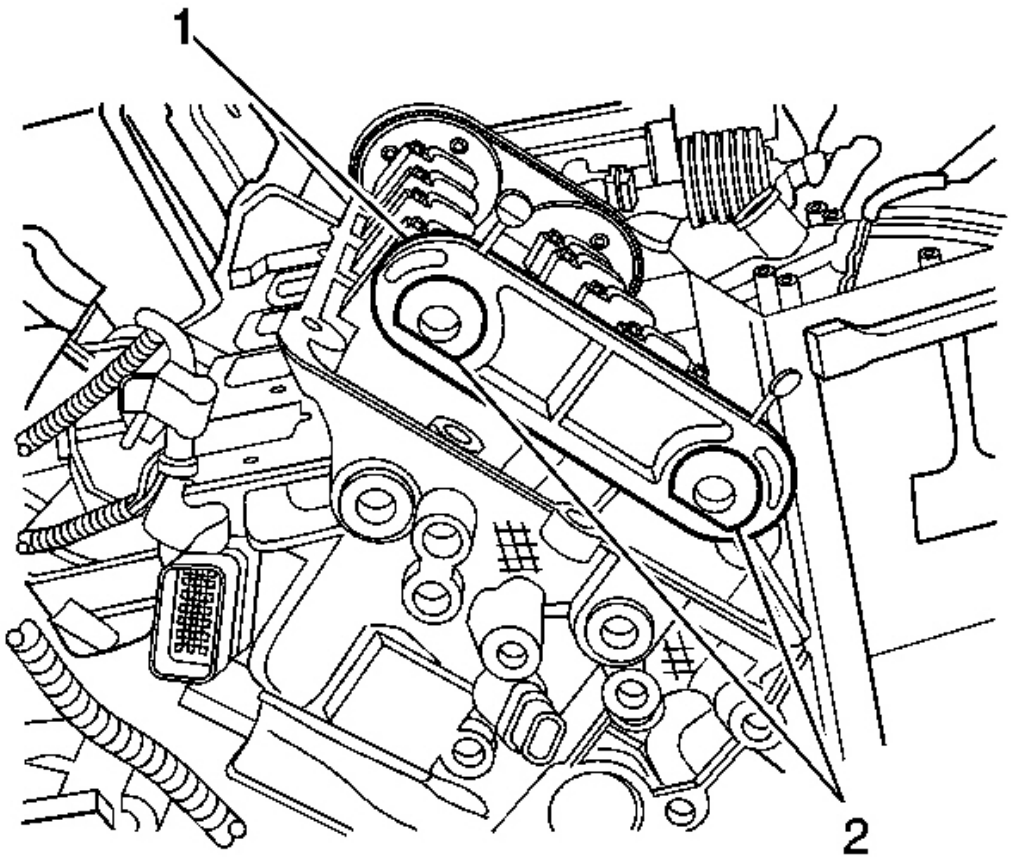


Fig. 380: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution .

4. Install the **EN 46328** (1) to the camshafts (2). See **Special Tools** .

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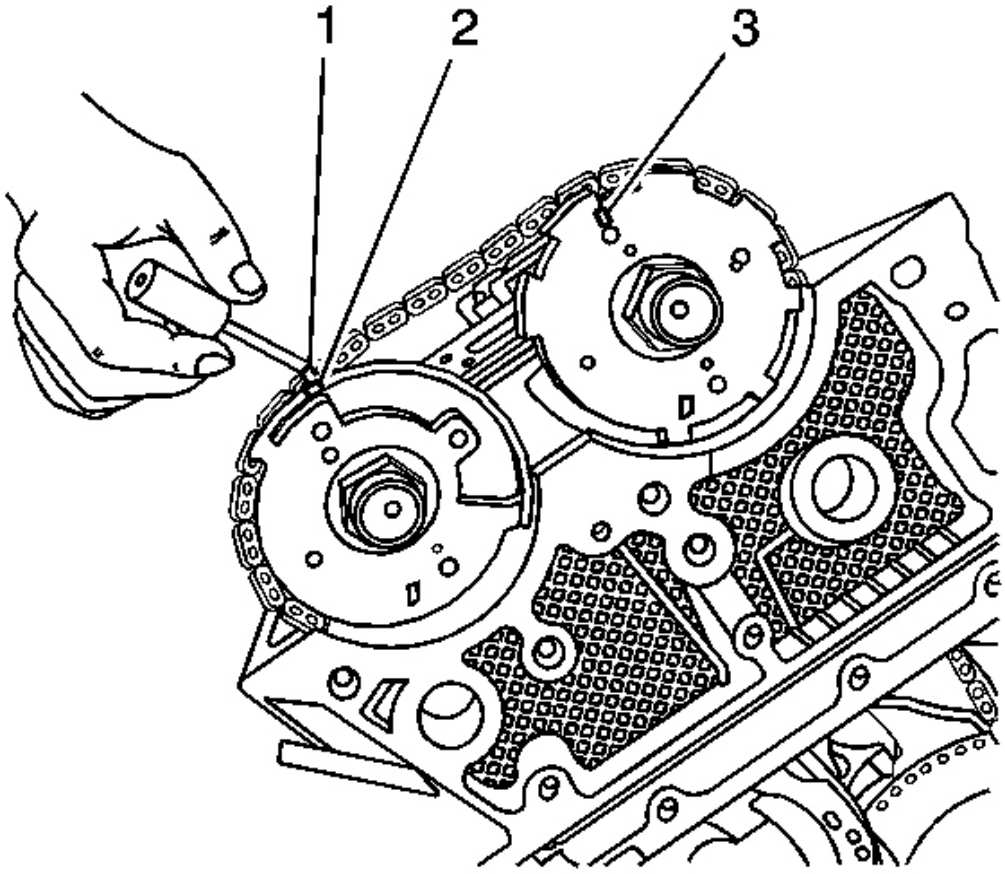


Fig. 381: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

5. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft position actuator timing mark (2, 3).

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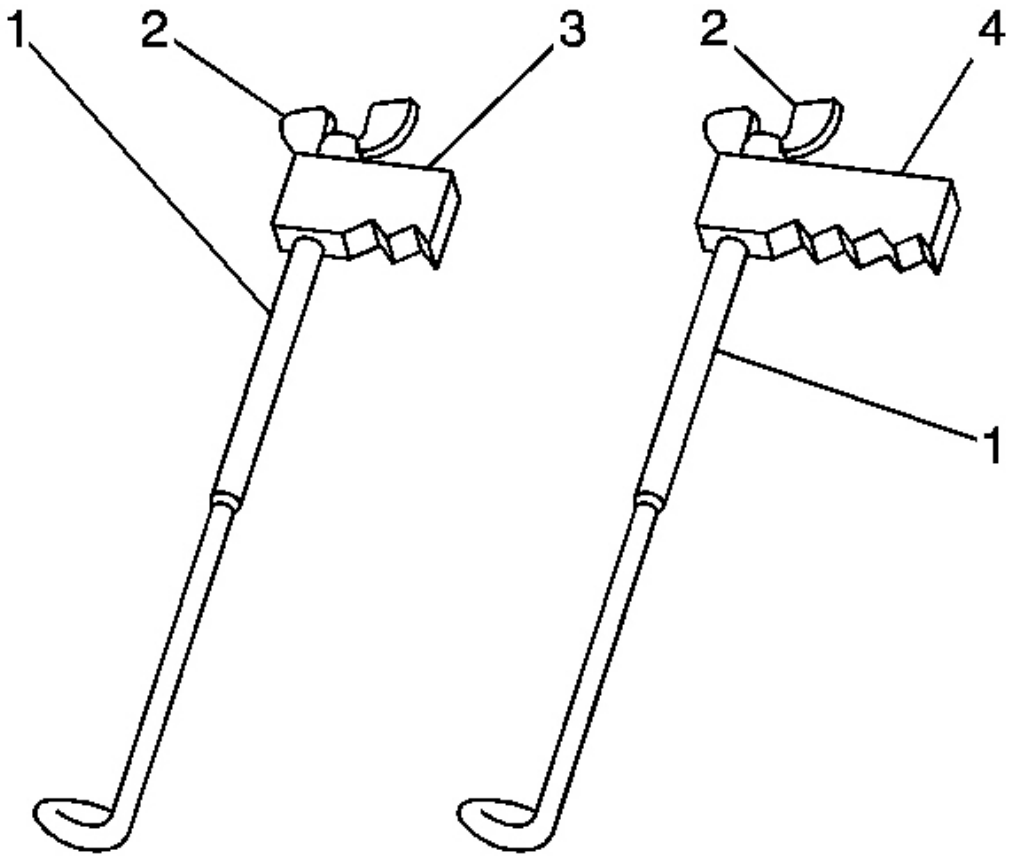


Fig. 382: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN 46327** (1) using the installation of the **EN 46327** timing chain retention tool procedure. See **Special Tools** .

INSTALLATION OF THE EN 46327 TIMING CHAIN RETENTION TOOL - RIGHT BANK

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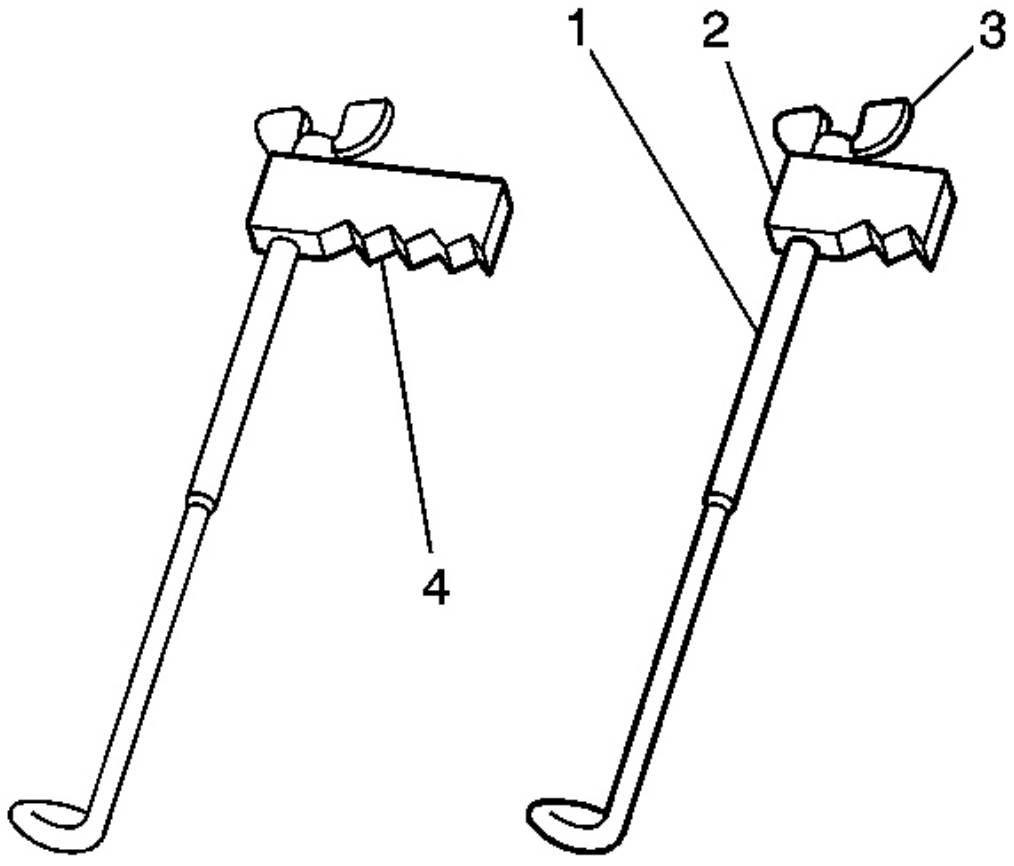


Fig. 383: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

1. Rotate the wing nut (3) of the **EN 46327** to the top of its travel. See **Special Tools** .

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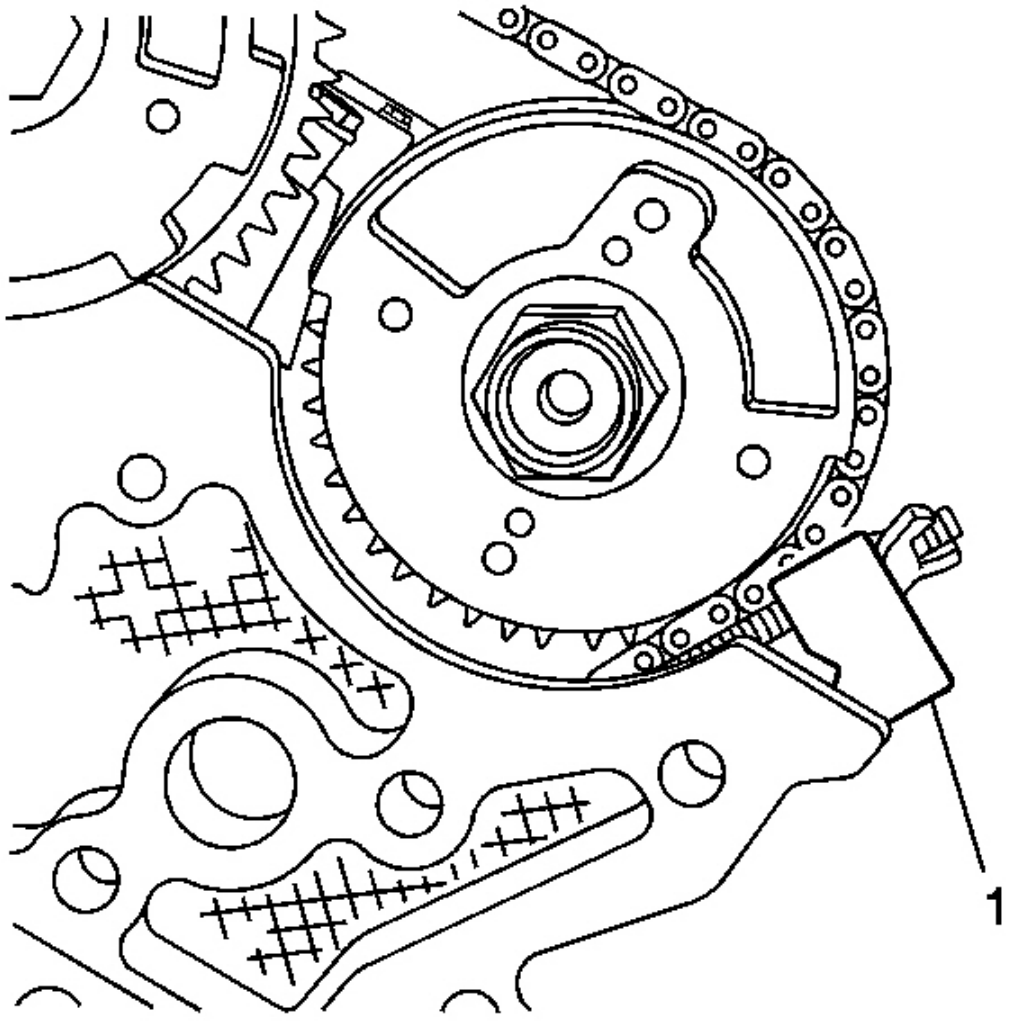


Fig. 384: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

2. Position the bottom retention tool on the cylinder head with the V-notch of the block (1) adjacent to the right exhaust camshaft actuator timing sprocket and chain as shown.

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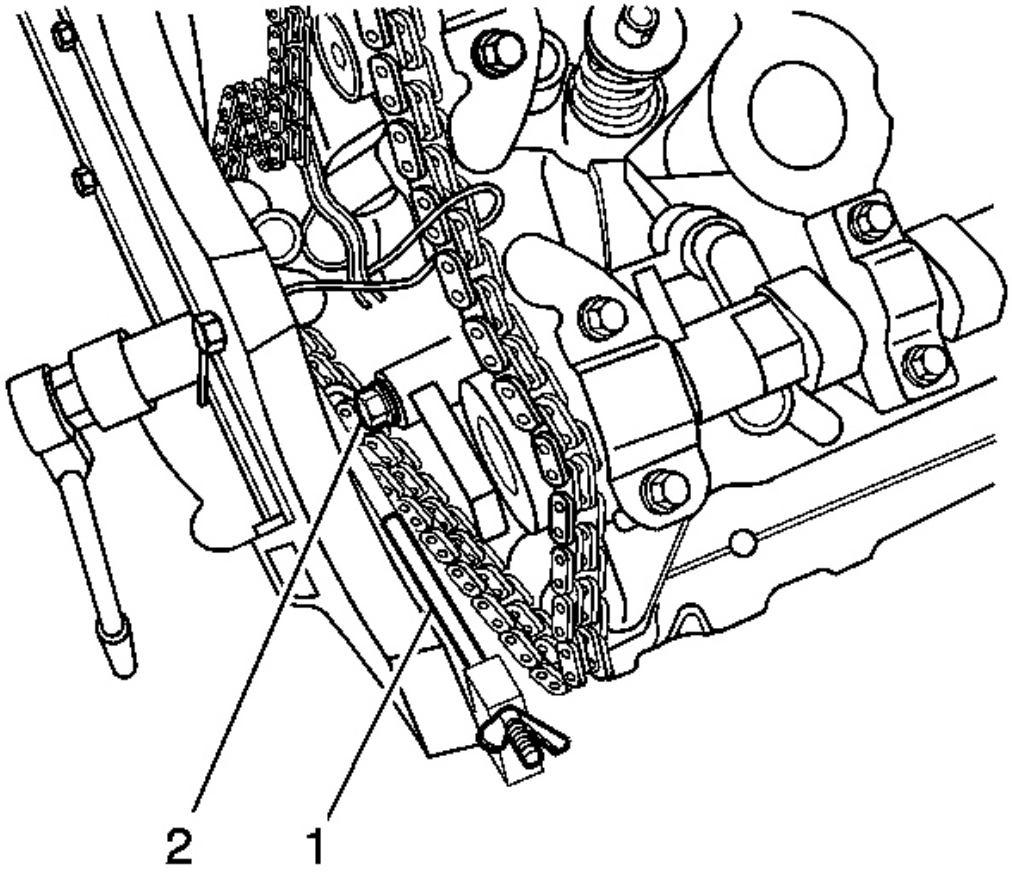


Fig. 385: Installing EN 46327 Hook End Into Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

3. Insert the hook end (2) into a secondary timing chain link as shown.

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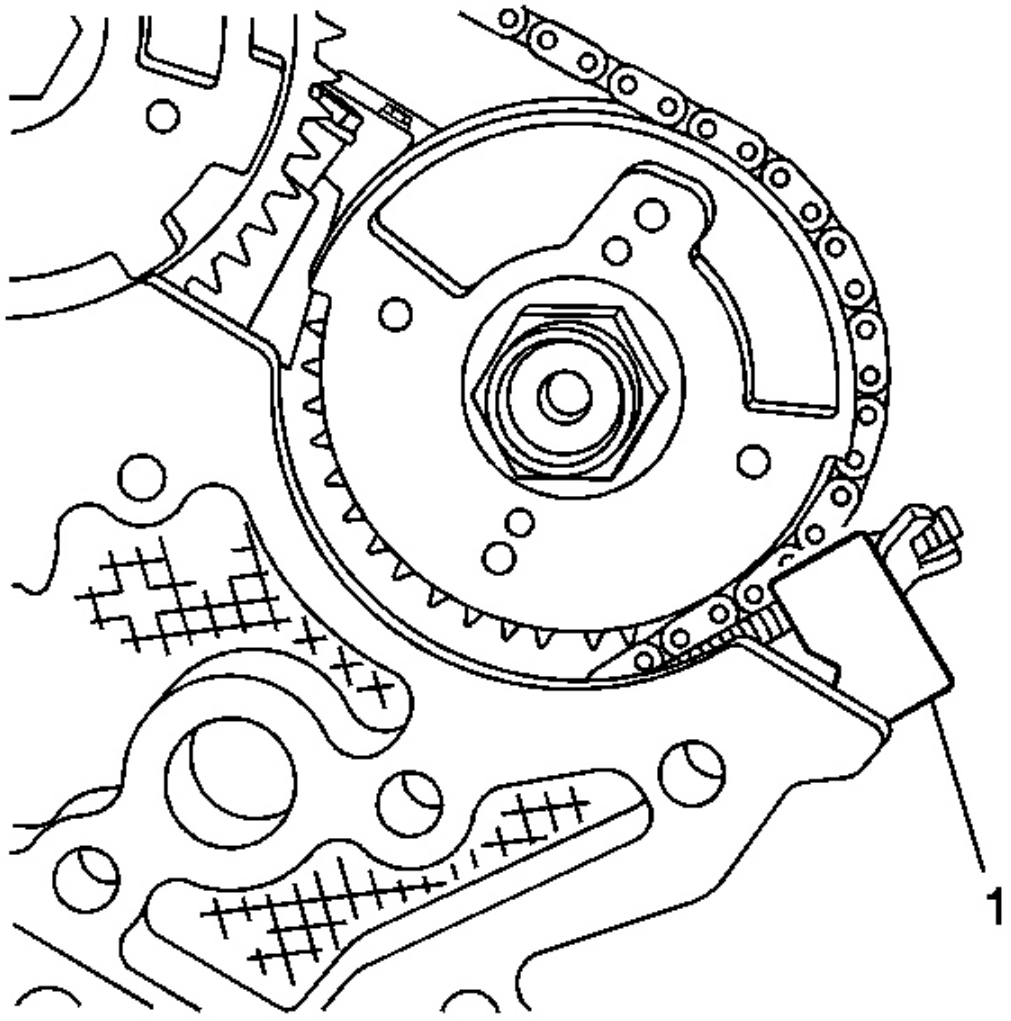


Fig. 386: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Rotate the wing nut until it contacts the retention tool block (1). DO NOT tighten the wing nut at this time.

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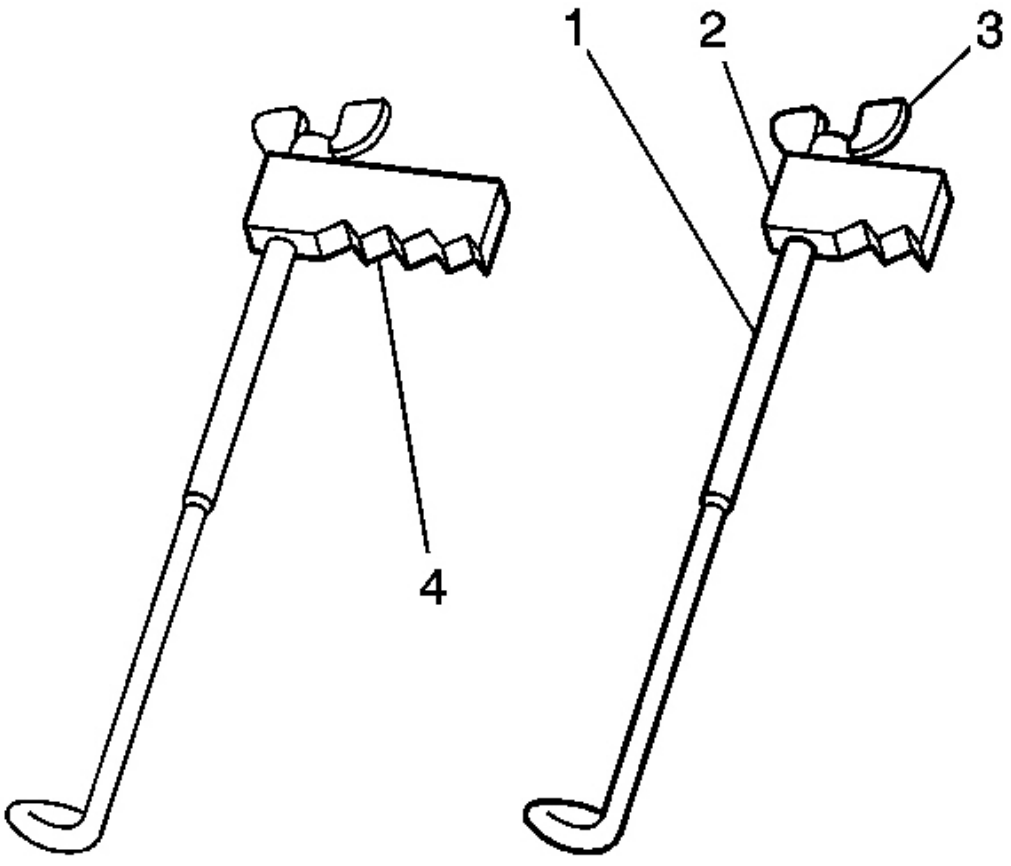


Fig. 387: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

5. Rotate the wing nut of the **EN 46327** (4) to the top of its travel. See **Special Tools** .

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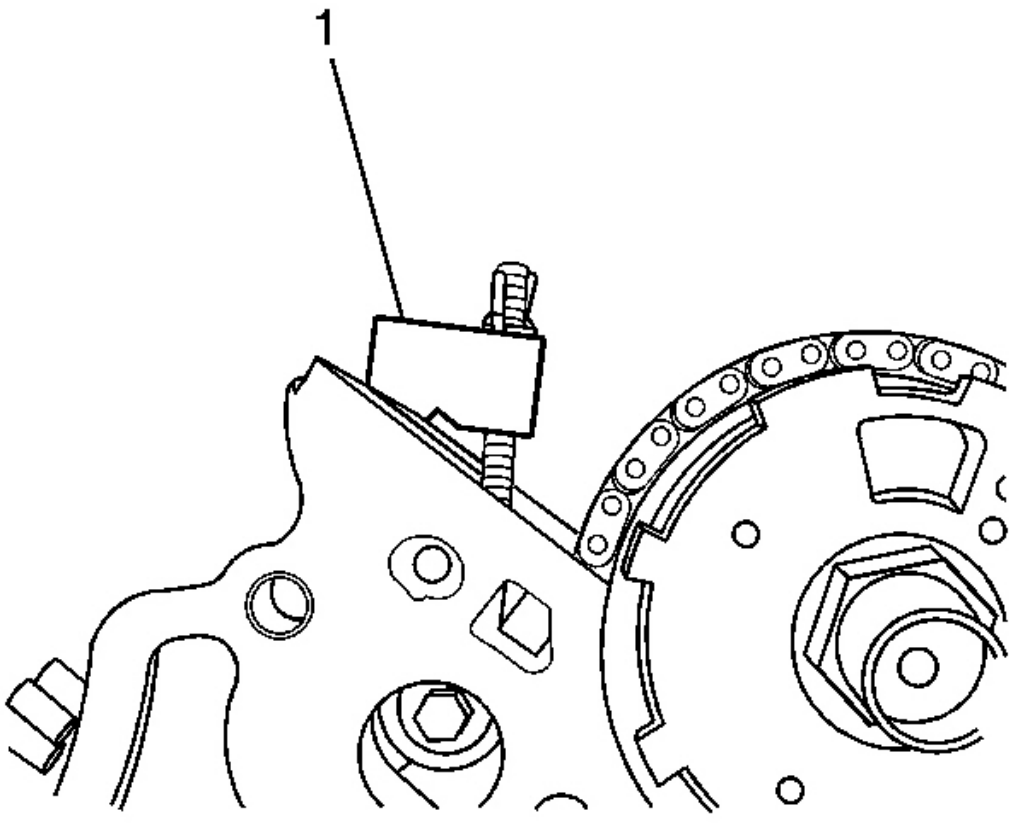


Fig. 388: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

6. Position the top retention tool on the cylinder head with the V-notch of the block (1) adjacent to the right intake camshaft actuator timing sprocket and chain as shown.

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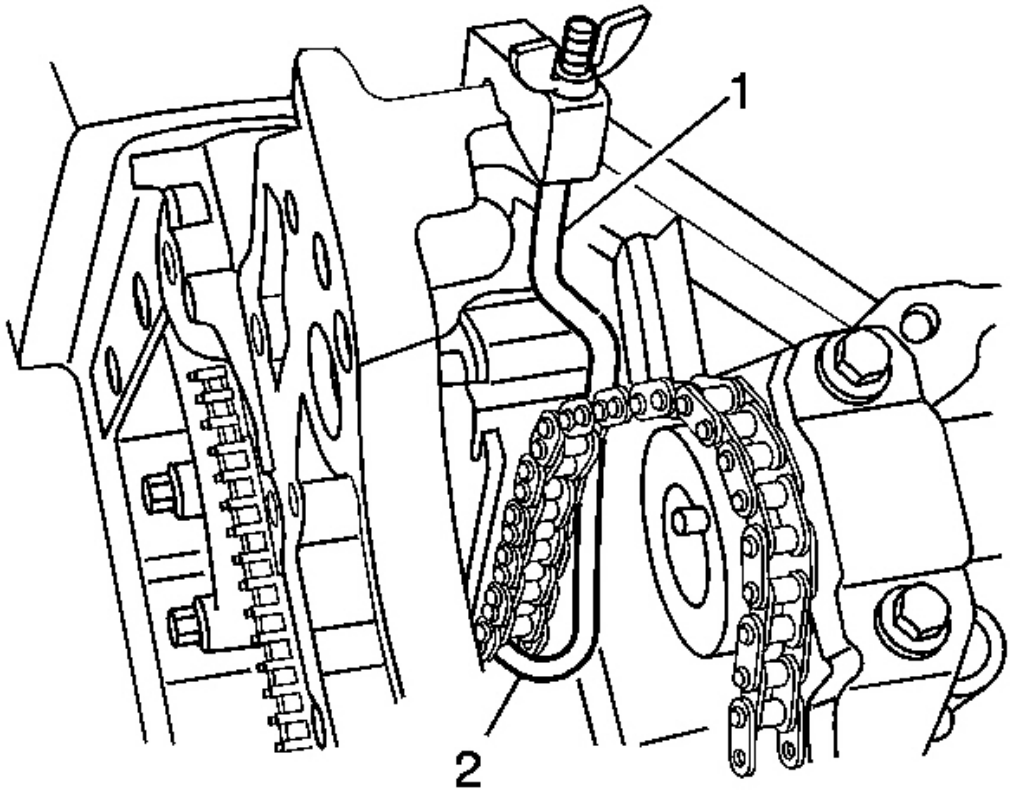


Fig. 389: View Of Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

7. Insert the hook end (2) into a secondary timing chain link as shown.

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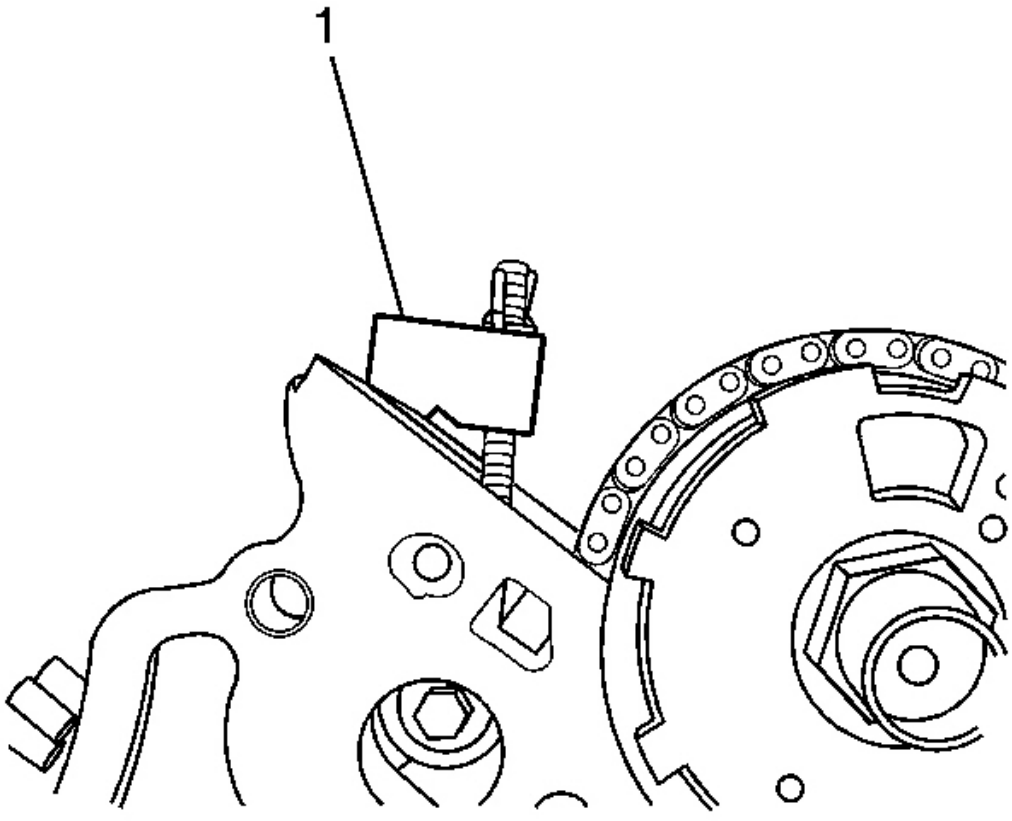


Fig. 390: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

8. Rotate the wing nut until it contacts the retention tool block (1). Alternately tighten both wing nuts to retain the chain.

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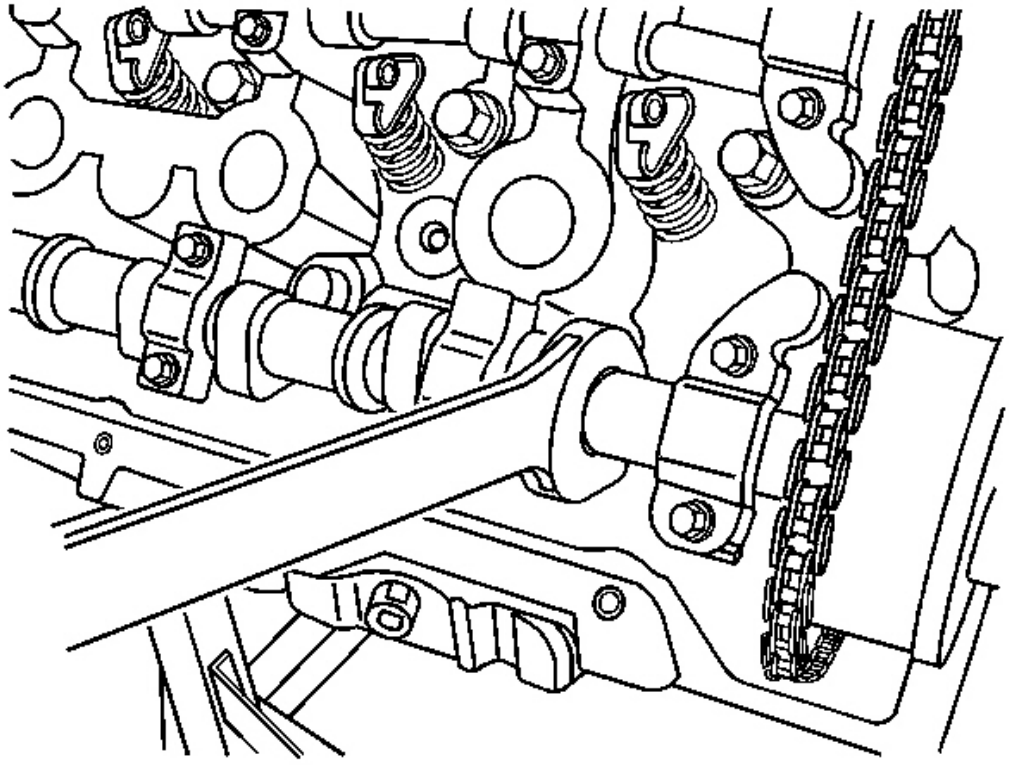


Fig. 391: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

9. Use an open end wrench on the hex cast into the right exhaust camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

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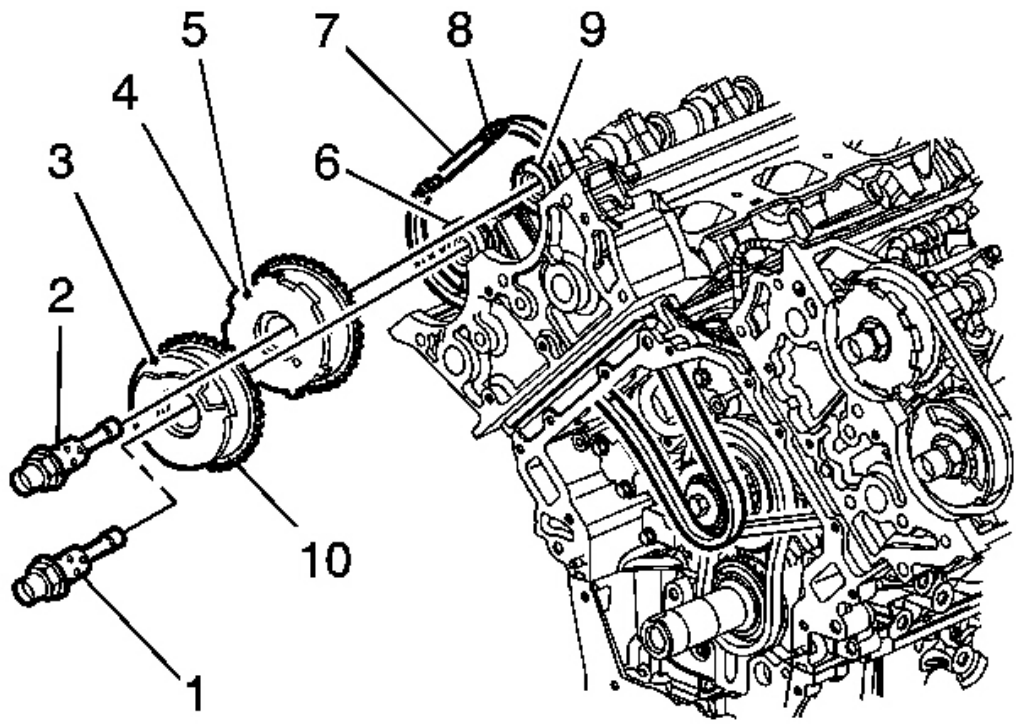


Fig. 392: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

10. Loosen and remove the right exhaust oil control valve (1).

INSTALLATION PROCEDURE

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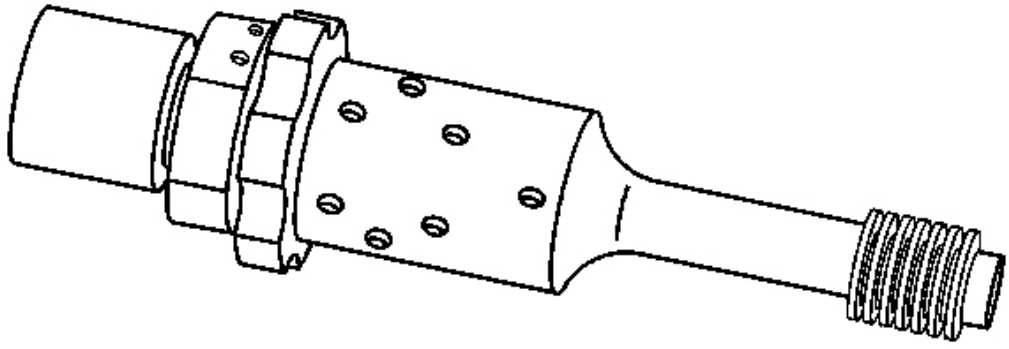


Fig. 393: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the oil control valve through the opening in the right exhaust camshaft position actuator and thread it into the right exhaust camshaft.

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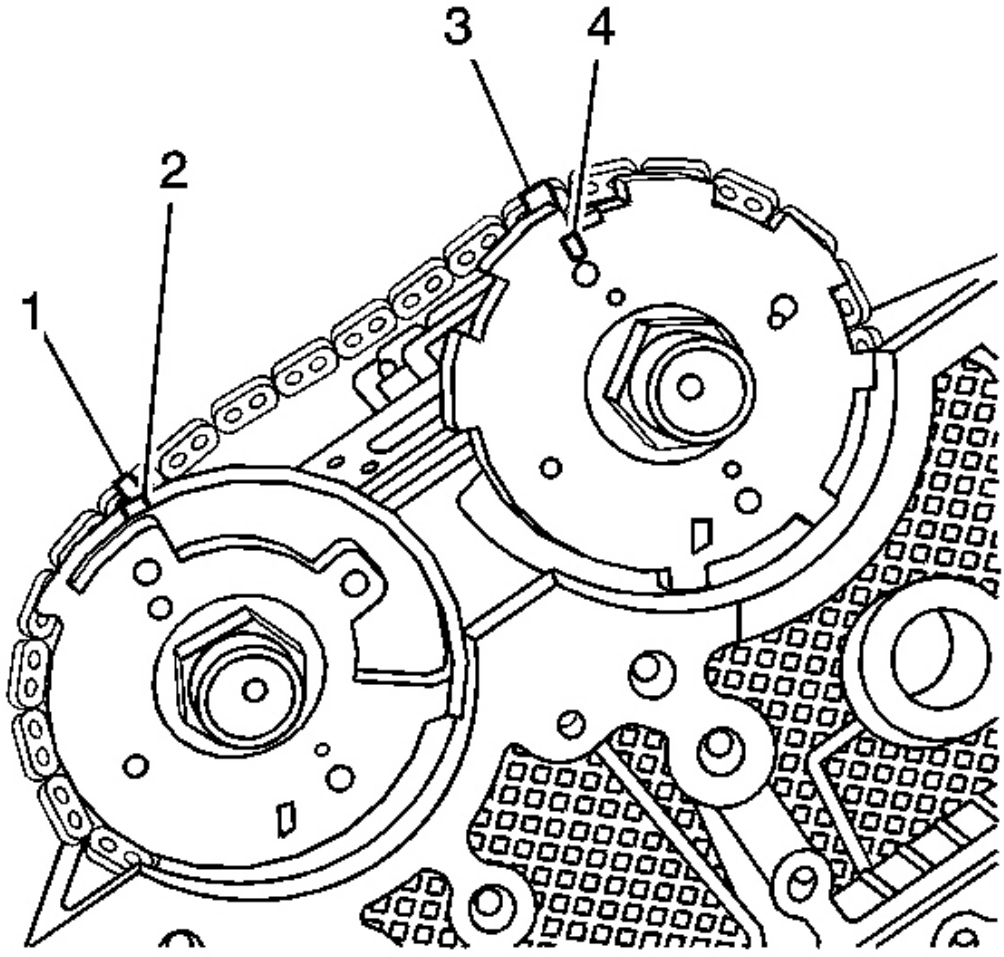


Fig. 394: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

2. Ensure both camshaft actuator timing marks (1, 3) are aligned with the paint marks on the secondary timing chain previously created.

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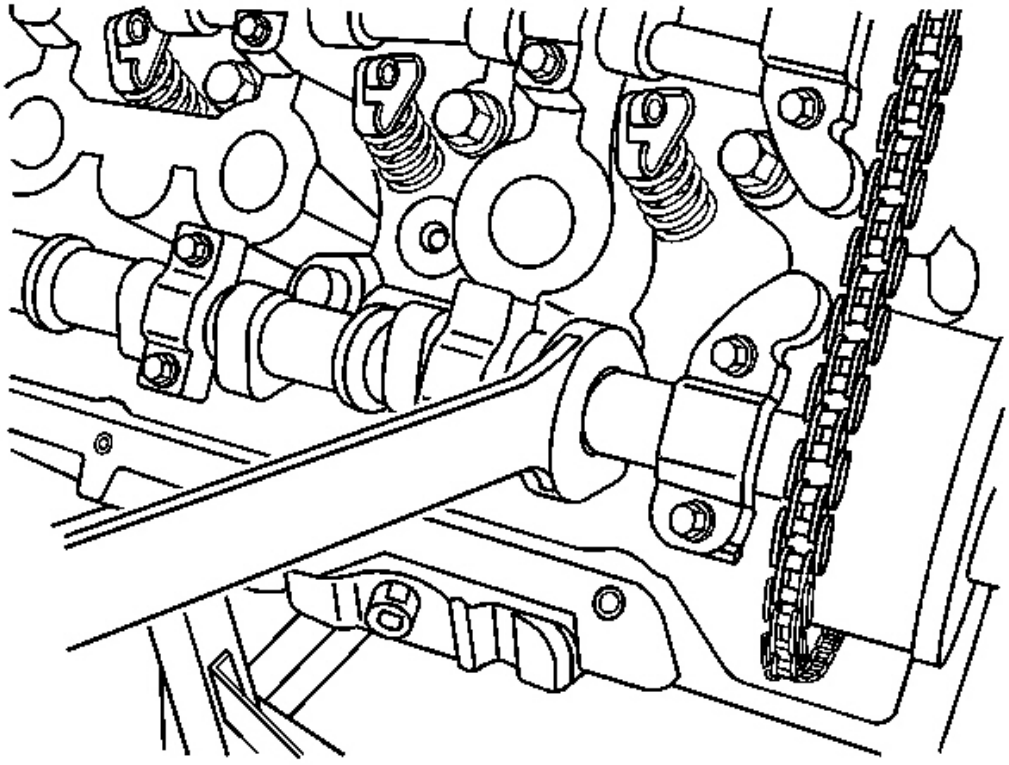


Fig. 395: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice .**

NOTE: **Refer to Fastener Notice .**

3. Use an open end wrench on the hex cast into the right exhaust camshaft to prevent the camshaft from rotating when tightening the camshaft oil control valve.

   Tighten: Tighten the camshaft oil control valve to 120 N.m (89 lb ft).

4. Remove the **EN 46327** timing chain retention tools. See **Special Tools** .

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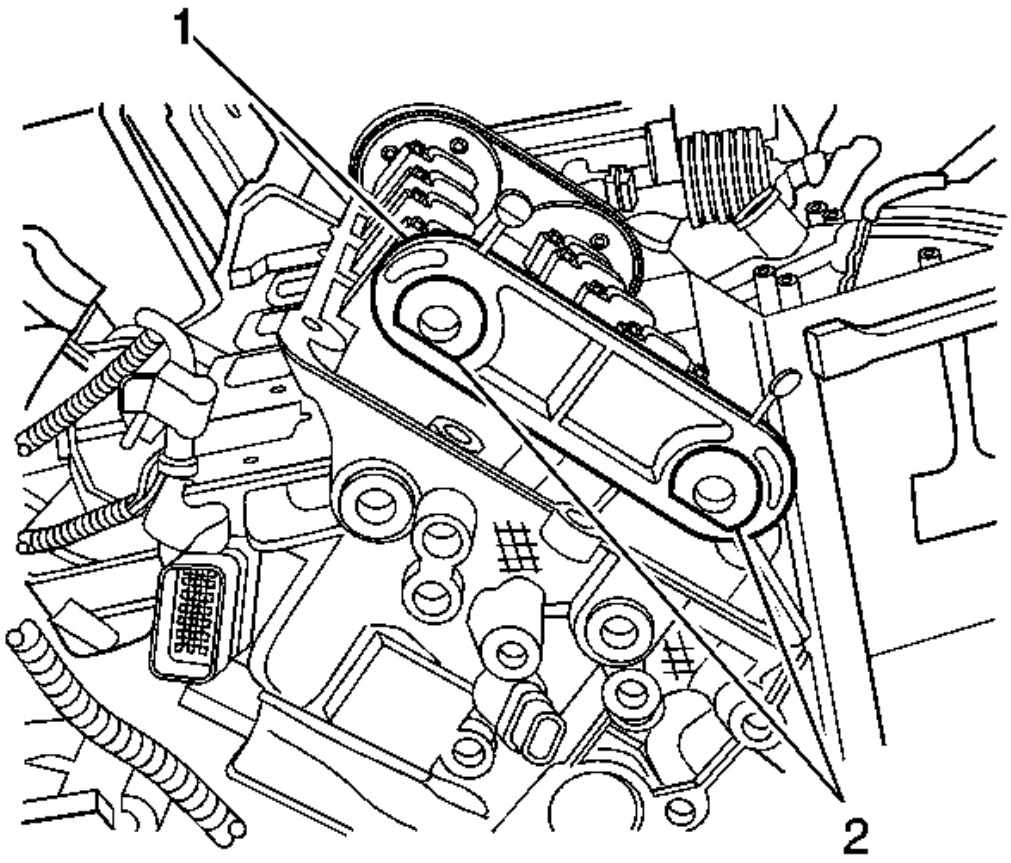


Fig. 396: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN 46328** (1) from the camshafts (2). See **Special Tools** .
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

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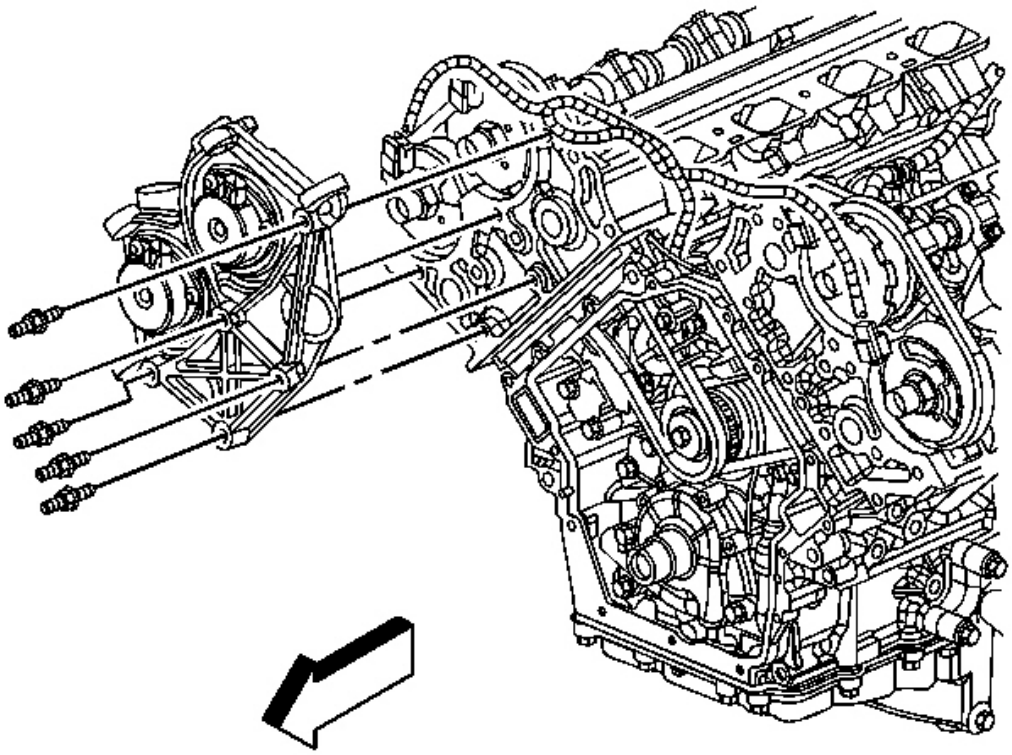


Fig. 397: View Of Right Camshaft Actuator Housing
Courtesy of GENERAL MOTORS CORP.

7. Install the right camshaft actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side**.

CAMSHAFT POSITION ACTUATOR OIL CONTROL VALVE REPLACEMENT - BANK 2 (LEFT SIDE) INTAKE

TOOLS REQUIRED

- **J 39946** Crankshaft Socket. See **Special Tools** .
- **EN 46327** Timing Chain Retention Tool. See **Special Tools** .
- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

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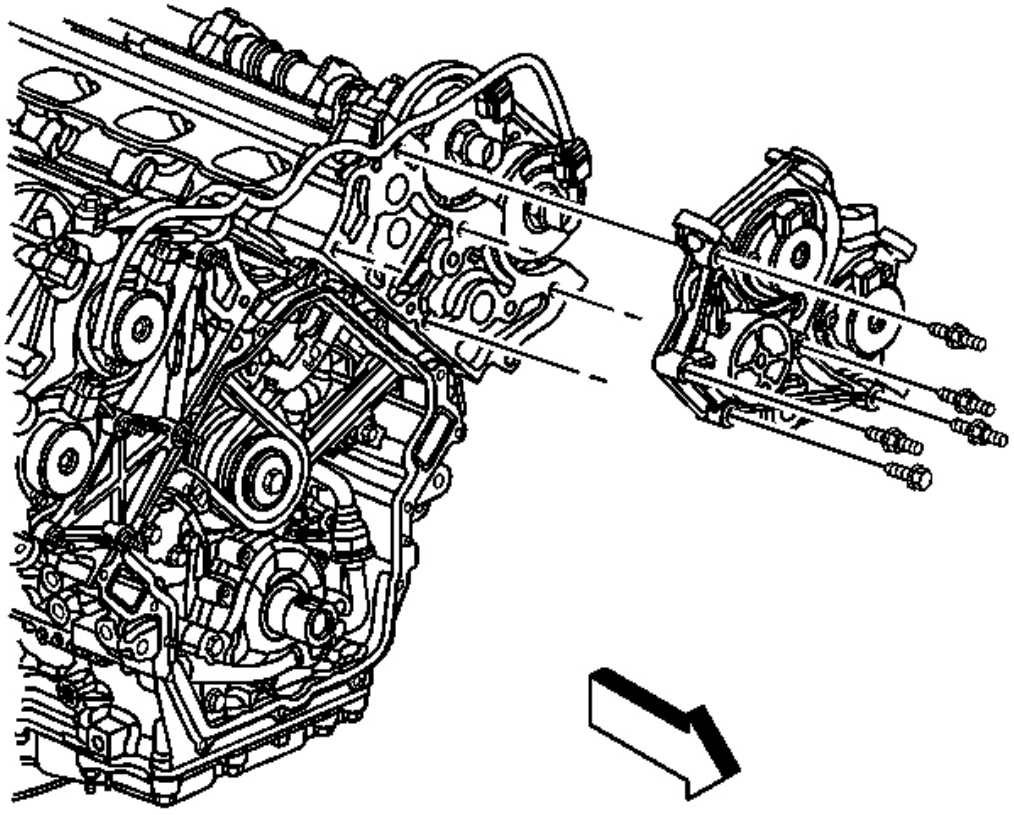


Fig. 398: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

1. Remove the left actuator housing. DO NOT remove the camshaft position (CMP) actuator solenoids from the housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

3. Using the **J 39946** , rotate the crankshaft until both bank 2 (left) CMP actuator timing marks are perpendicular (90 degrees) to the cylinder head deck surface and near the top of their rotation. See **Special Tools** .

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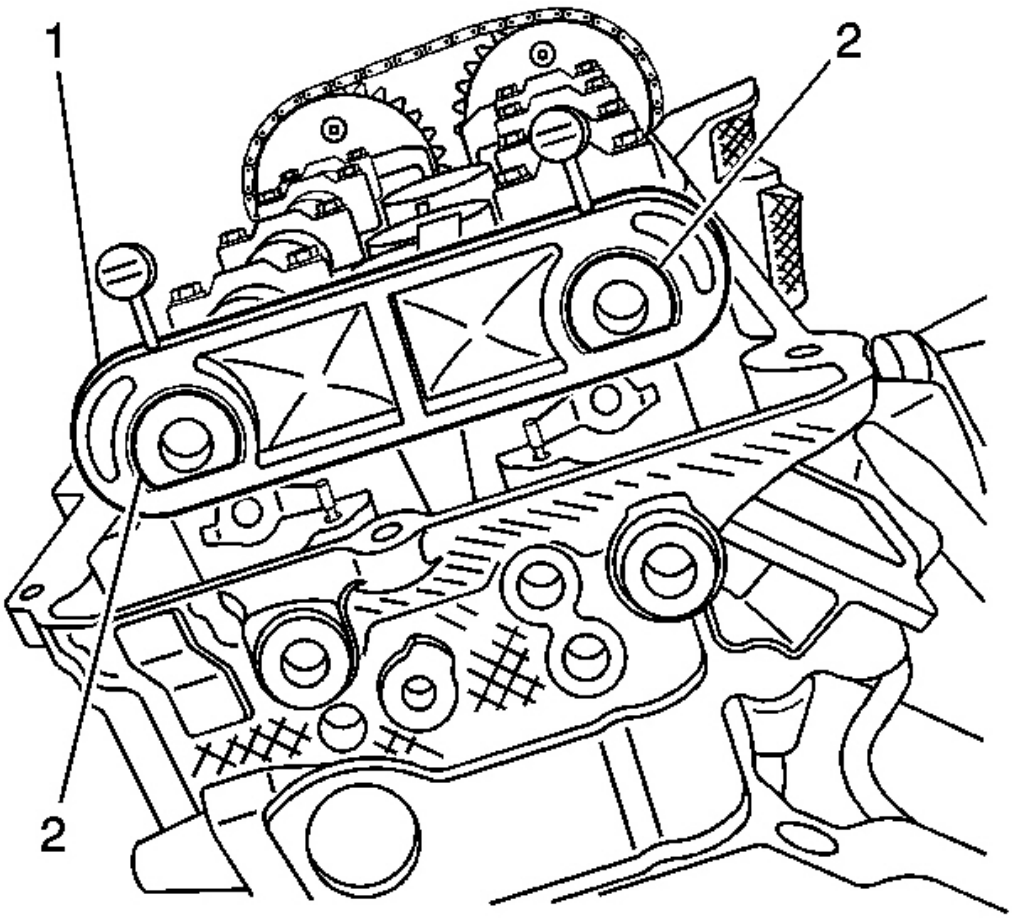


Fig. 399: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution .

4. Install the **EN 46328** (1) to the camshafts (2). See **Special Tools** .

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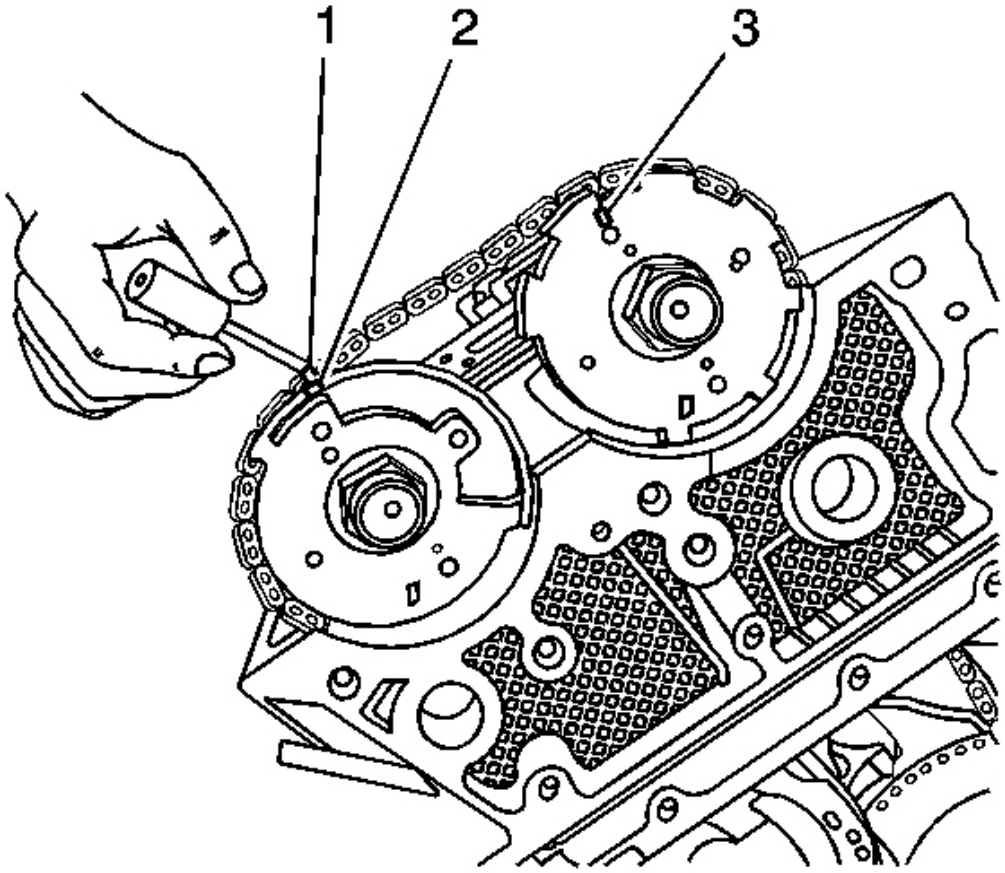


Fig. 400: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

5. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft position actuator timing mark (2, 3).

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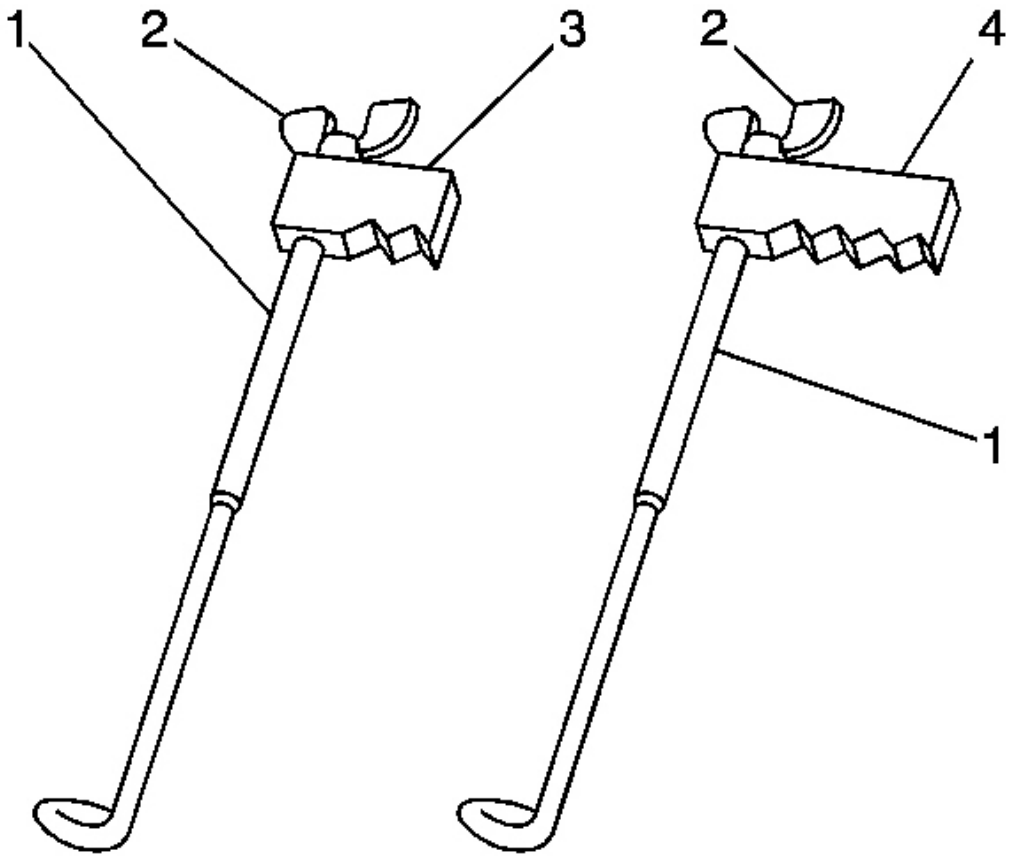


Fig. 401: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN 46327** (1) using the installation of the **EN 46327** timing chain retention tool procedure. See **Special Tools** .

INSTALLATION OF THE EN 46327 TIMING CHAIN RETENTION TOOL - LEFT BANK

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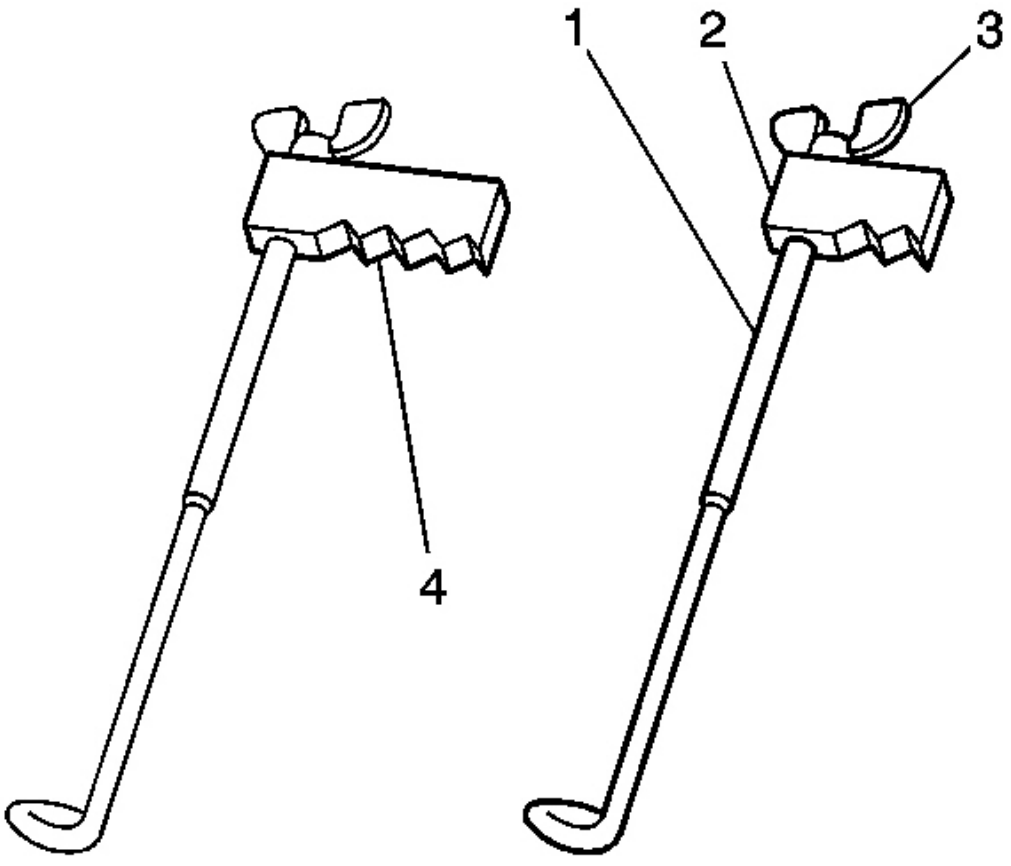


Fig. 402: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

1. Rotate the wing nut (3) of the **EN 46327** to the top of its travel. See **Special Tools** .

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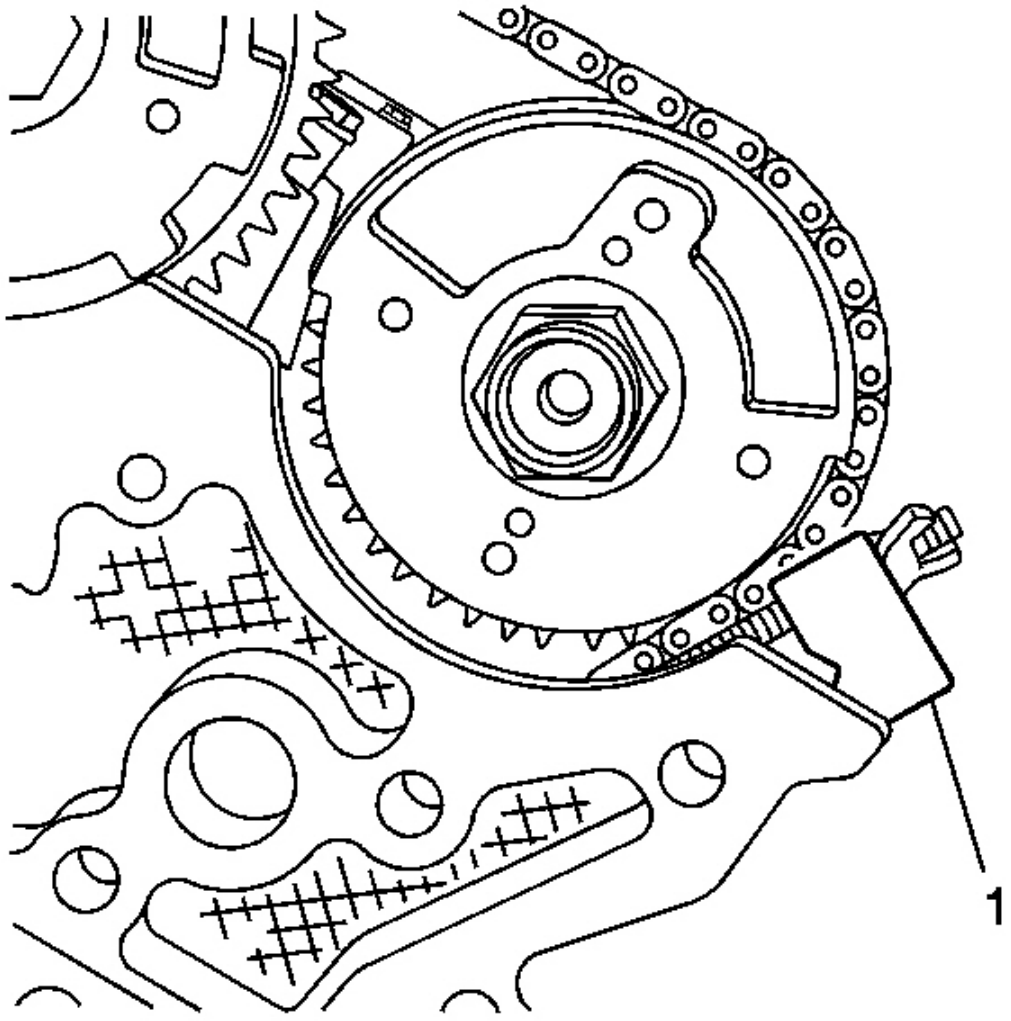


Fig. 403: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

2. Position the bottom retention tool on the cylinder head with the V-notch of the block (1) adjacent to the left exhaust camshaft actuator timing sprocket and chain as shown.

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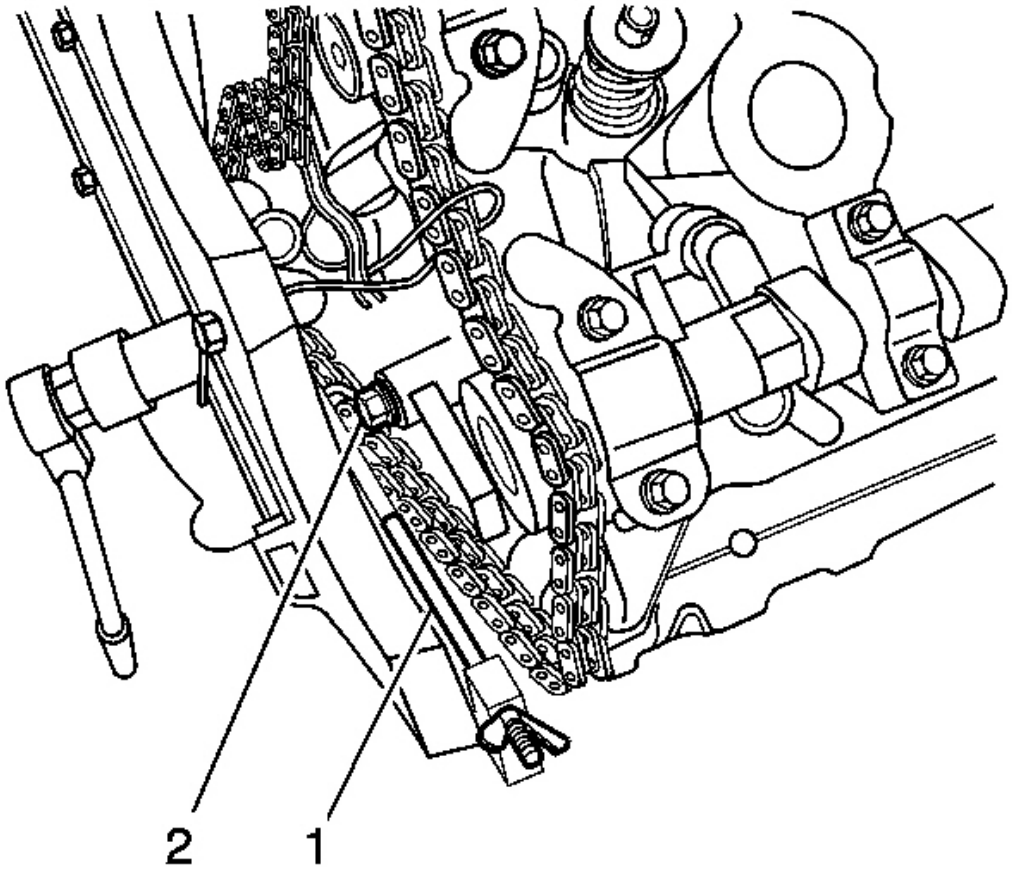


Fig. 404: Installing EN 46327 Hook End Into Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

3. Insert the hook end (2) into a secondary timing chain link as shown.

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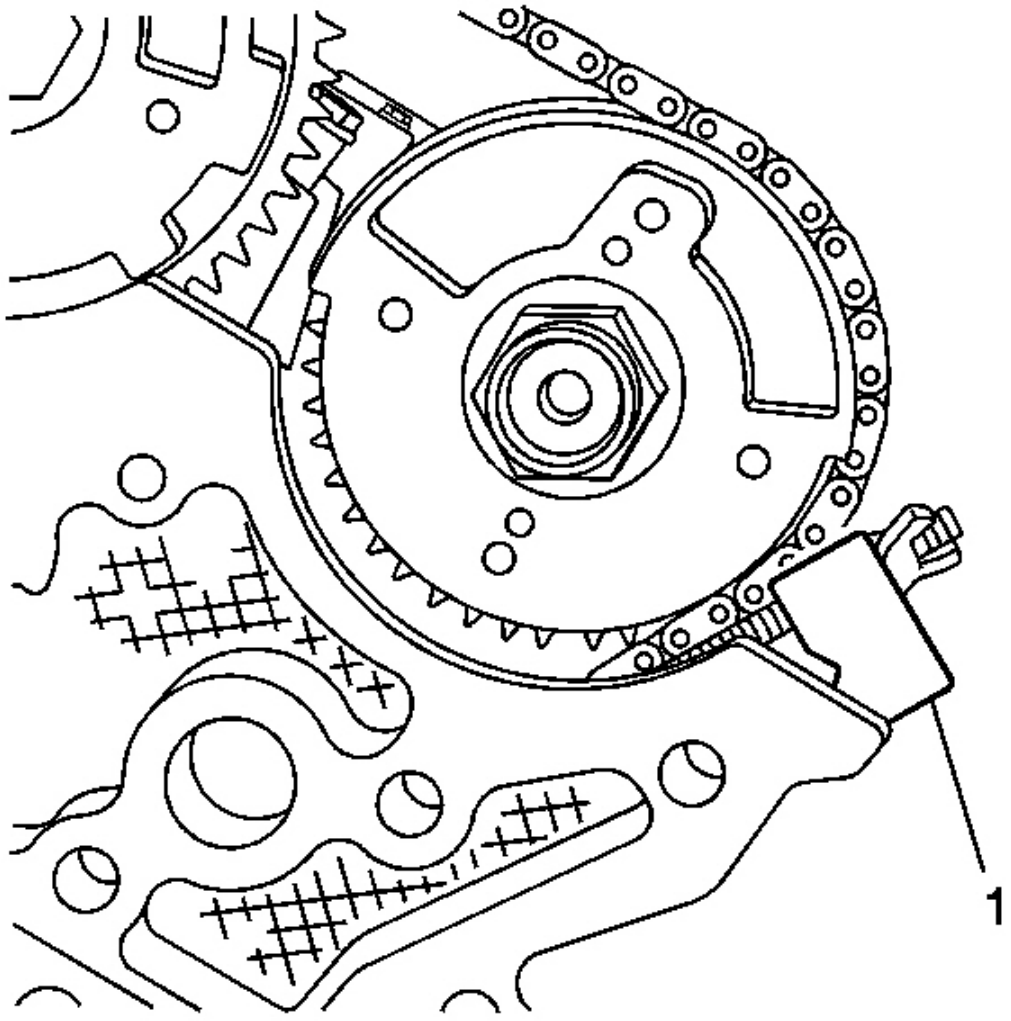


Fig. 405: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Rotate the wing nut until it contacts the retention tool block (1). DO NOT tighten the wing nut at this time.

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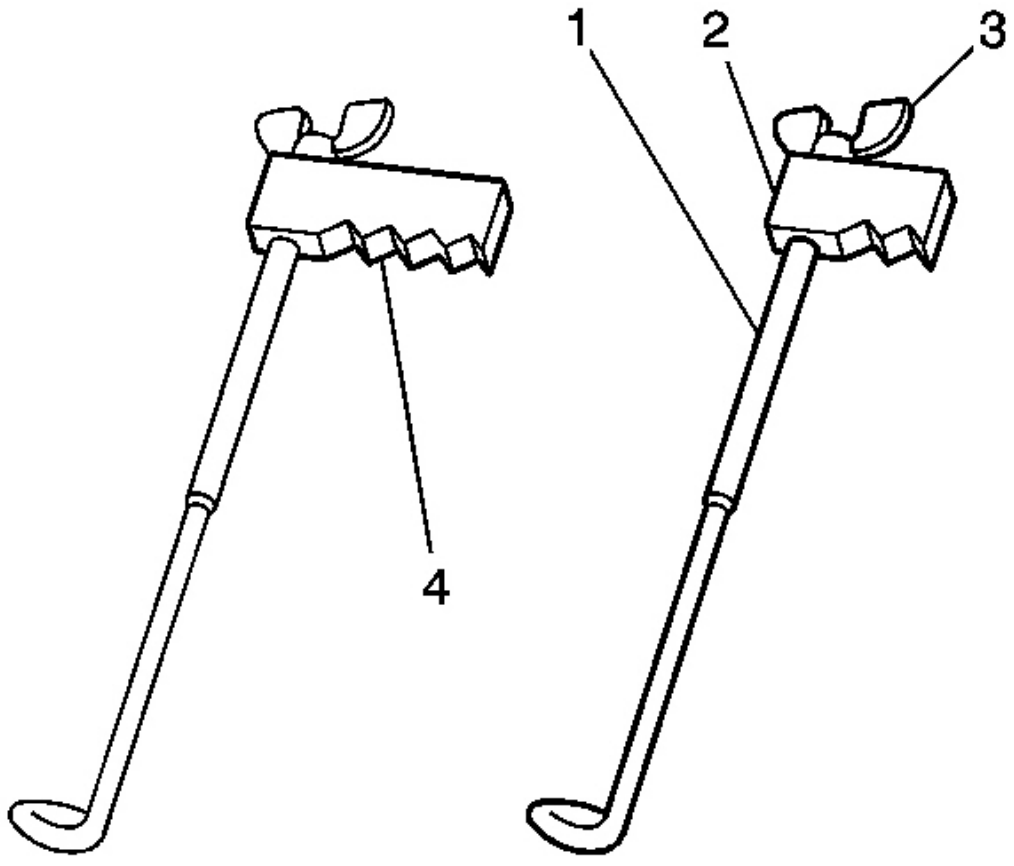


Fig. 406: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

5. Rotate the wing nut of the **EN 46327** (4) to the top of its travel. See **Special Tools** .

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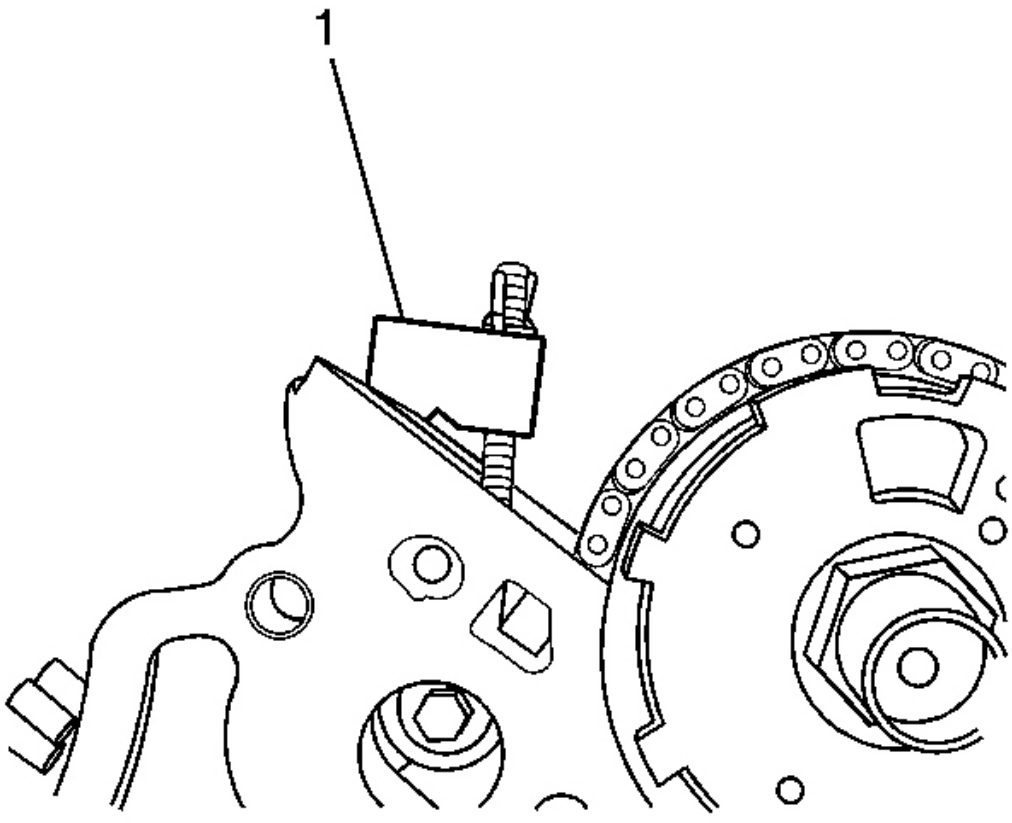


Fig. 407: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

6. Position the top retention tool on the cylinder head with the V-notch of the block (1) adjacent to the left intake camshaft actuator timing sprocket and chain as shown.

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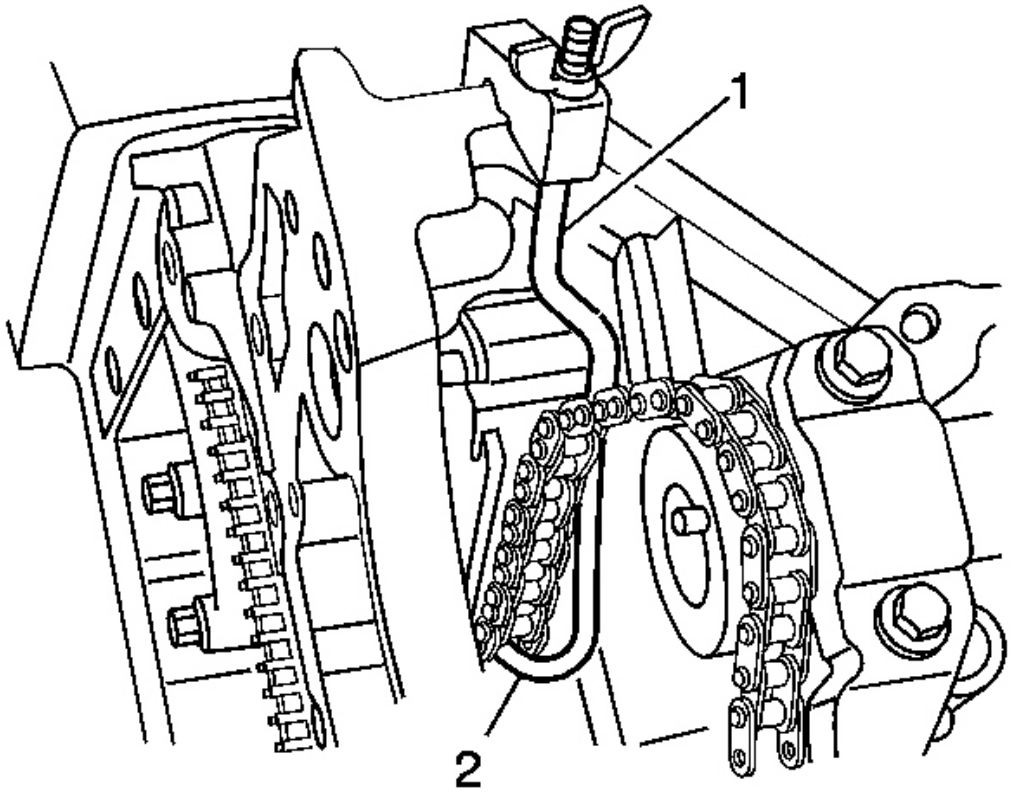


Fig. 408: View Of Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

7. Insert the hook end (2) into a secondary timing chain link as shown.

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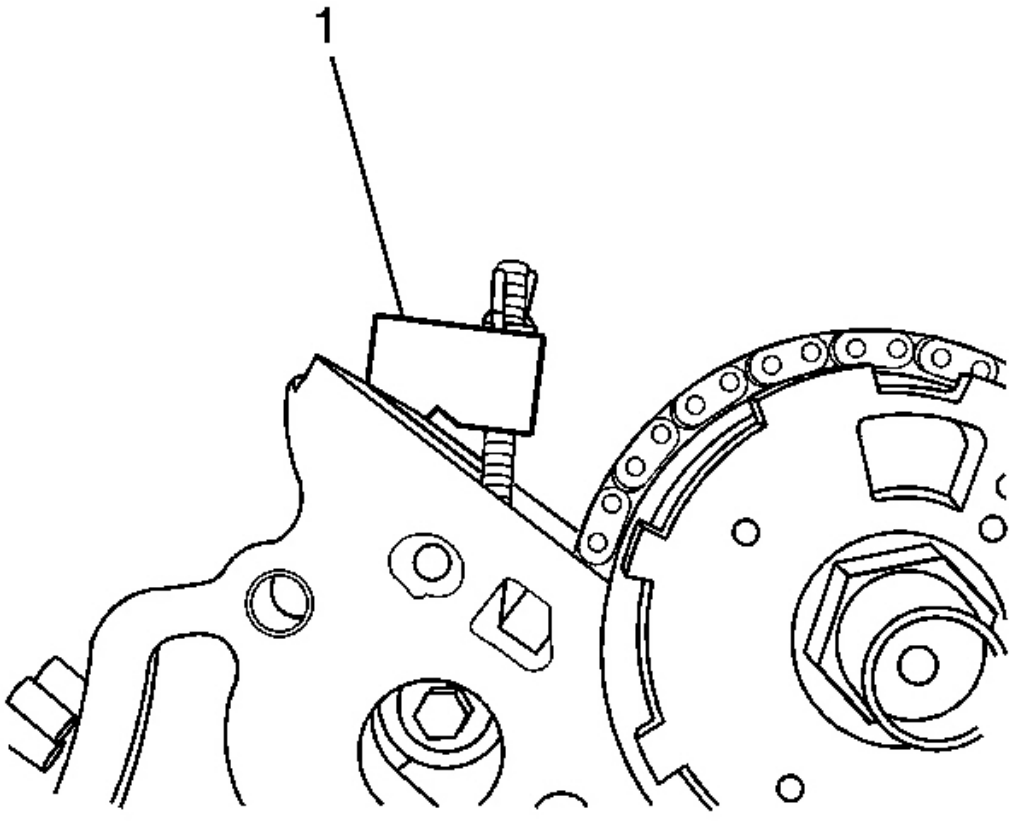


Fig. 409: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

8. Rotate the wing nut until it contacts the retention tool block (1). Alternately tighten both wing nuts to retain the chain.

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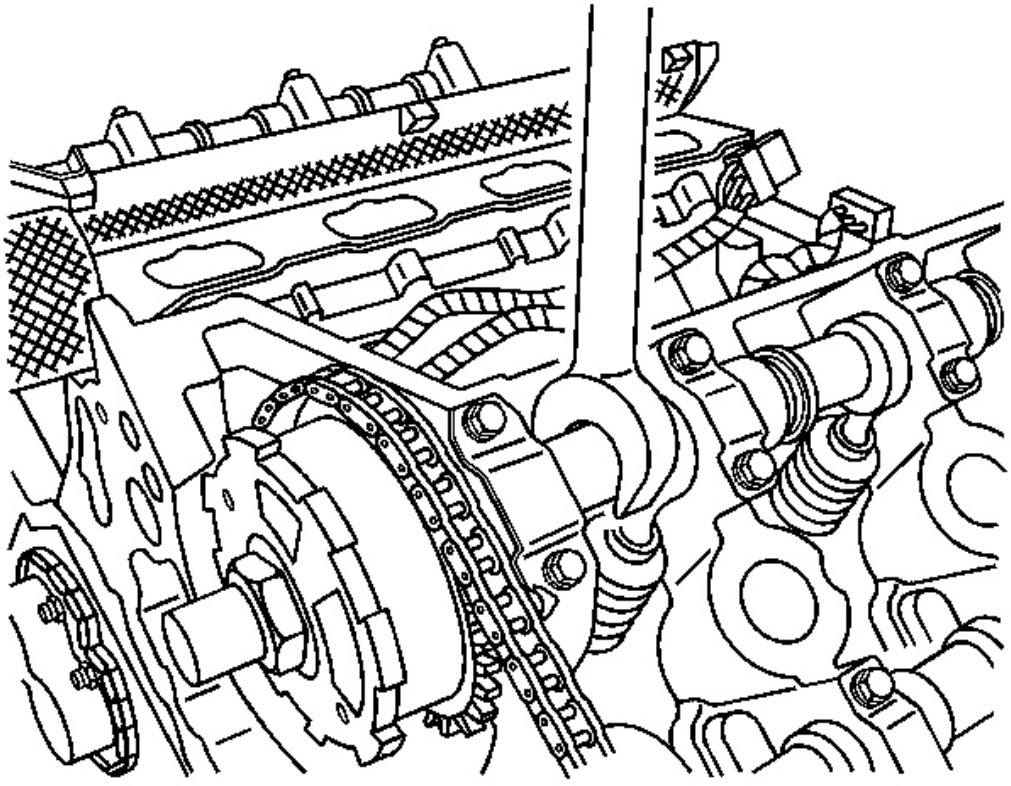


Fig. 410: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

9. Use an open end wrench on the hex cast into the left intake camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

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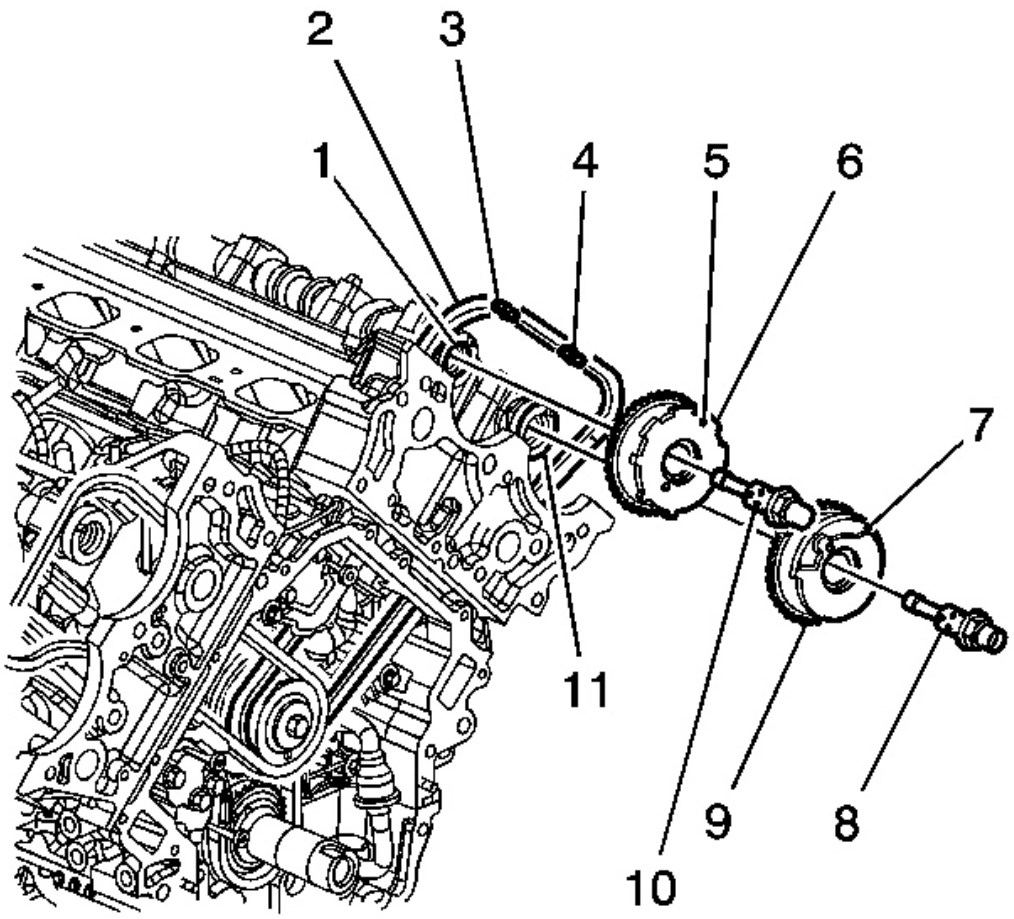


Fig. 411: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

10. Loosen and remove the left intake oil control valve (10).

INSTALLATION PROCEDURE

Automotive-Manual.net

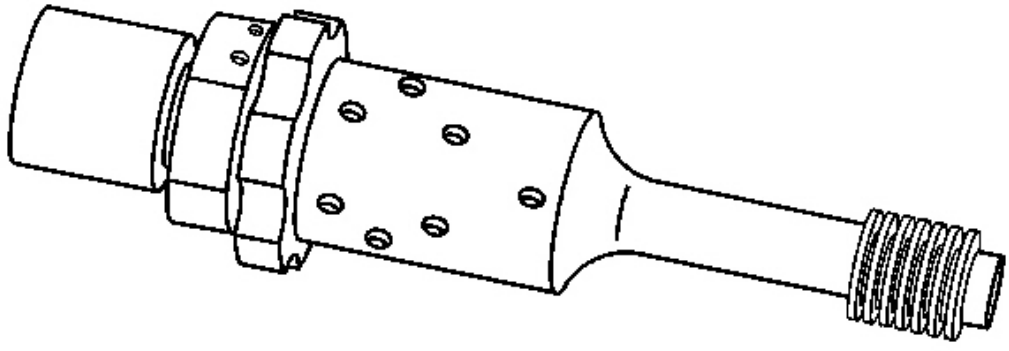


Fig. 412: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the oil control valve through the opening in the left intake camshaft position actuator and thread it into the left intake camshaft.

Automotive-Manual.net

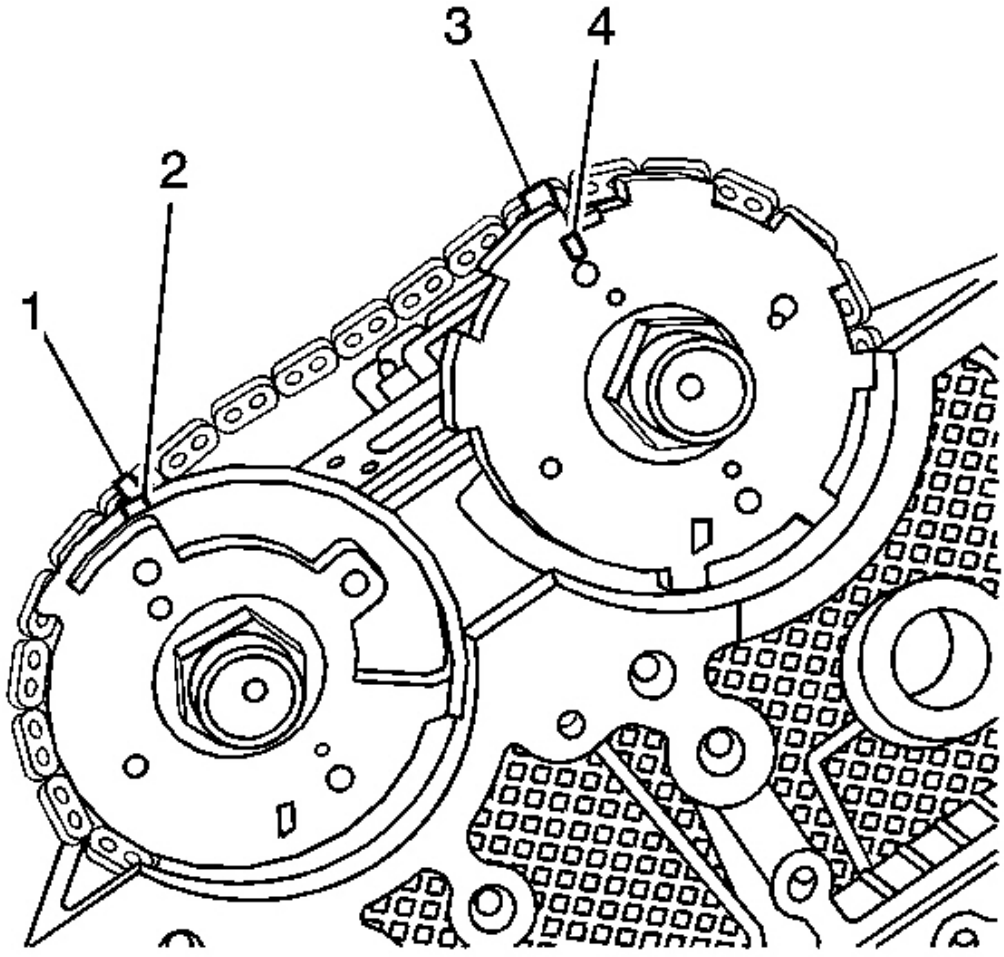


Fig. 413: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

2. Ensure both camshaft actuator timing marks (1, 3) are aligned with the paint marks on the secondary timing chain previously created.

Automotive-Manual.net

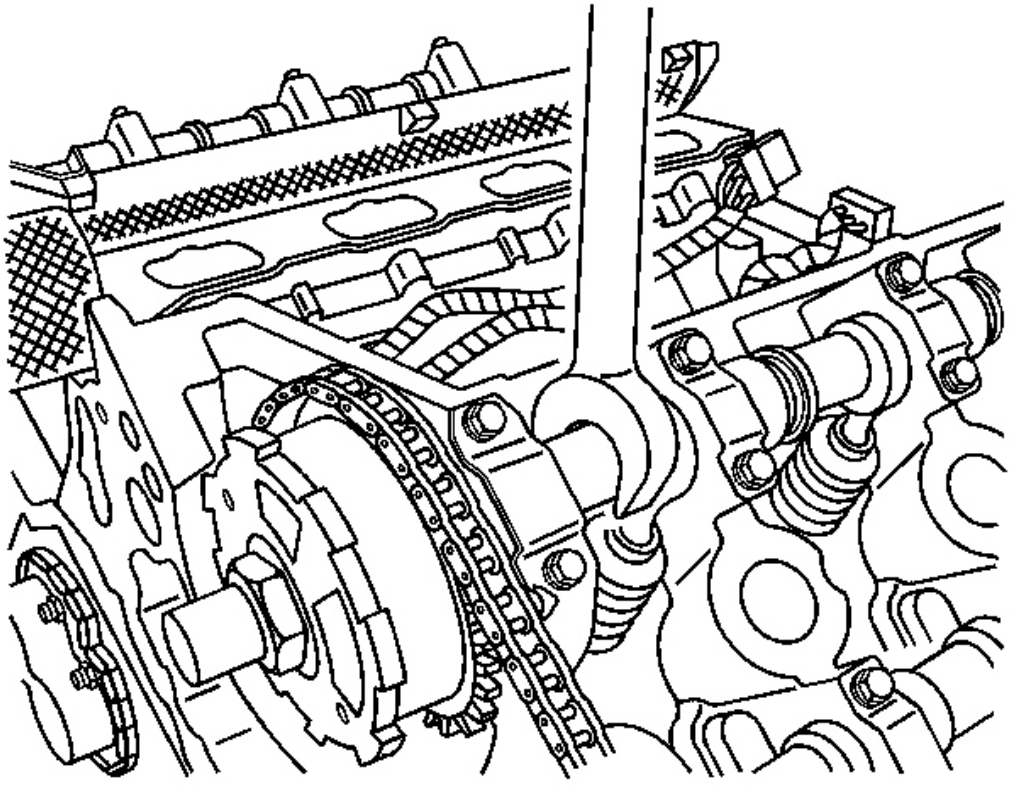


Fig. 414: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice .**

NOTE: **Refer to Fastener Notice .**

3. Use an open end wrench on the hex cast into the left intake camshaft to prevent the camshaft from rotating when tightening the camshaft oil control valve.

   Tighten: Tighten the camshaft oil control valve to 120 N.m (89 lb ft).

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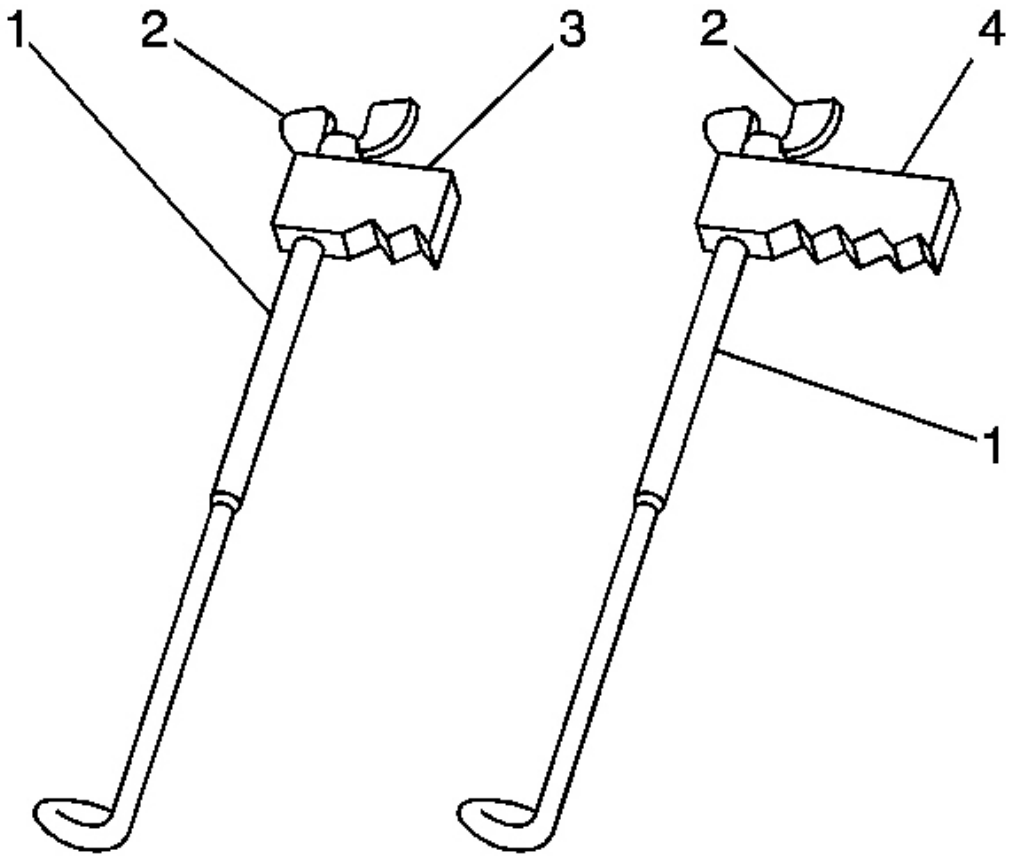


Fig. 415: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

4. Remove the **EN 46327** (1). See **Special Tools** .

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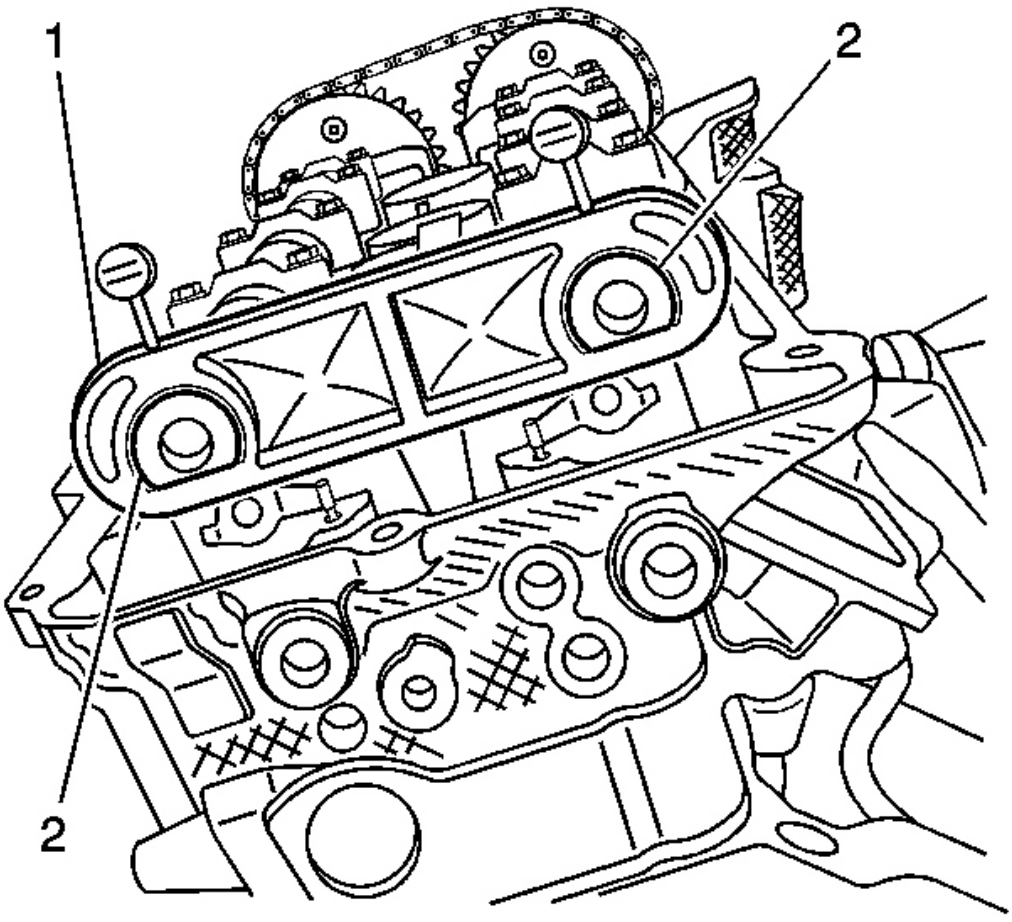


Fig. 416: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN 46328** (1) from the camshafts (2). See **Special Tools** .
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

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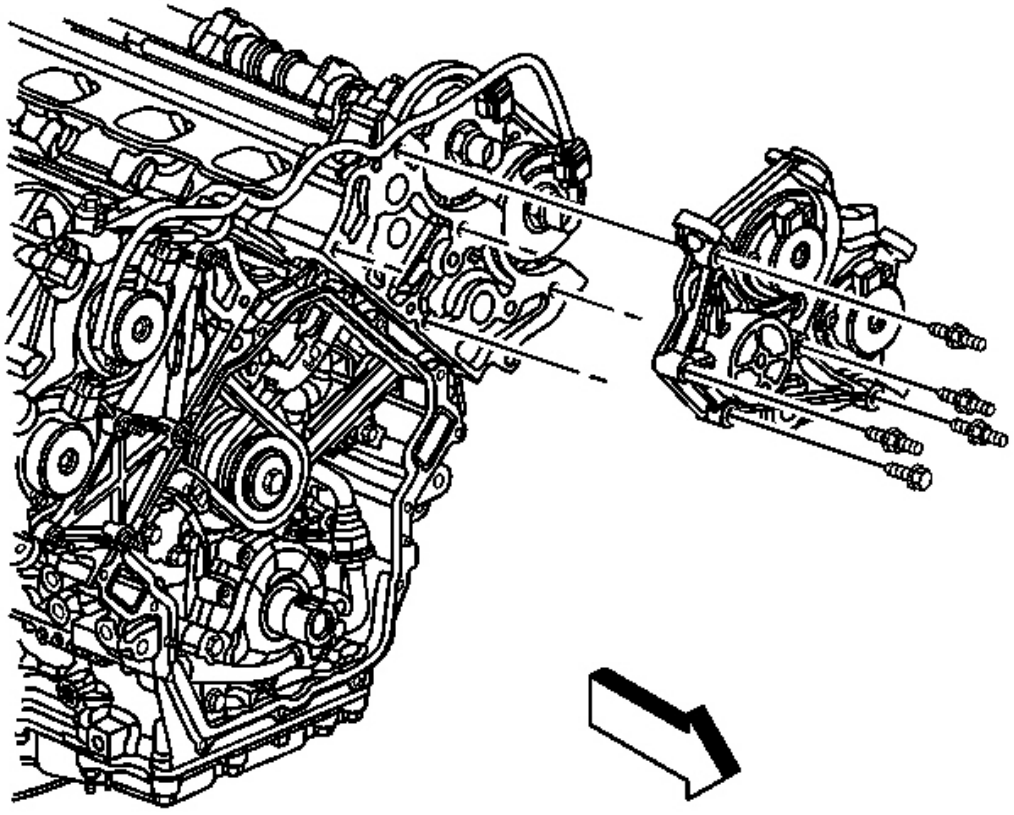


Fig. 417: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

7. Install the left camshaft actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side**.

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2007 ENGINE

Engine Mechanical - 4.4L - XLR

CAMSHAFT POSITION ACTUATOR OIL CONTROL VALVE REPLACEMENT - BANK 2 (LEFT SIDE) EXHAUST

TOOLS REQUIRED

- **J 39946** Crankshaft Socket. See **Special Tools** .
- **EN 46327** Timing Chain Retention Tool. See **Special Tools** .
- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

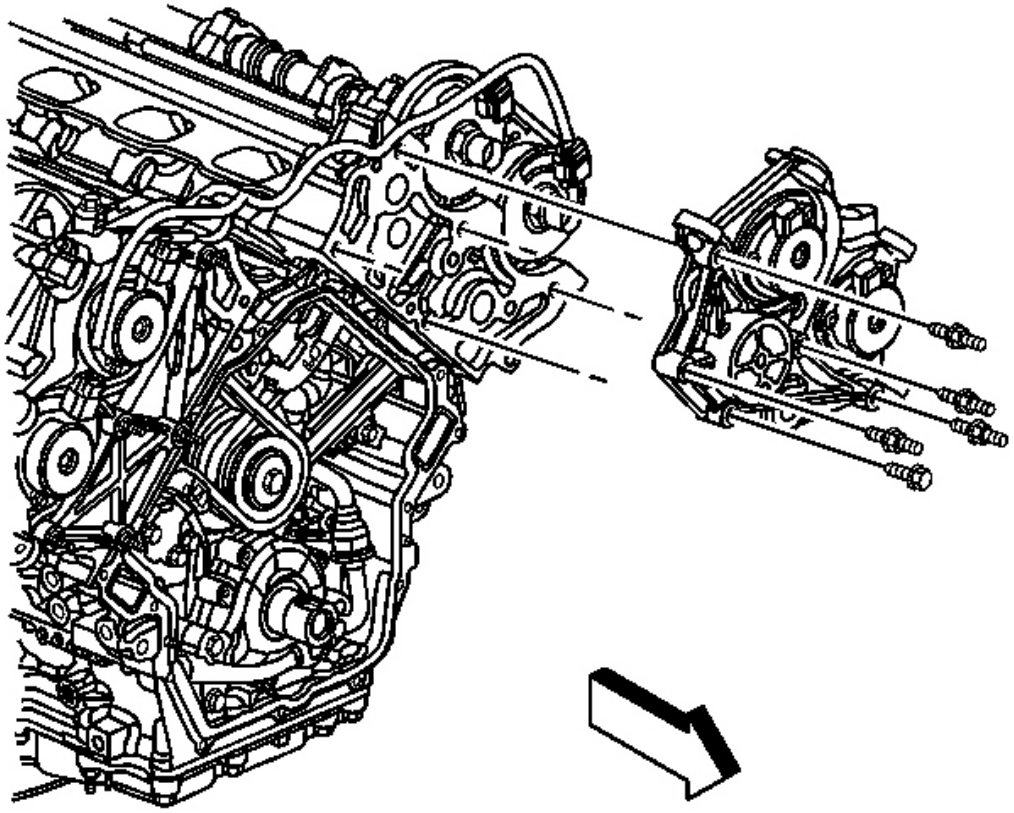


Fig. 1: View Of Left Camshaft Position Actuator Housing

Automotive-Manual.net

Courtesy of GENERAL MOTORS CORP.

1. Remove the left actuator housing. DO NOT remove the camshaft position (CMP) actuator solenoids from the housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side** .
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement** .

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

3. Using the **J 39946** , rotate the crankshaft until both bank 2 (left) CMP actuator timing marks are perpendicular (90 degrees) to the cylinder head deck surface and near the top of their rotation. See **Special Tools** .

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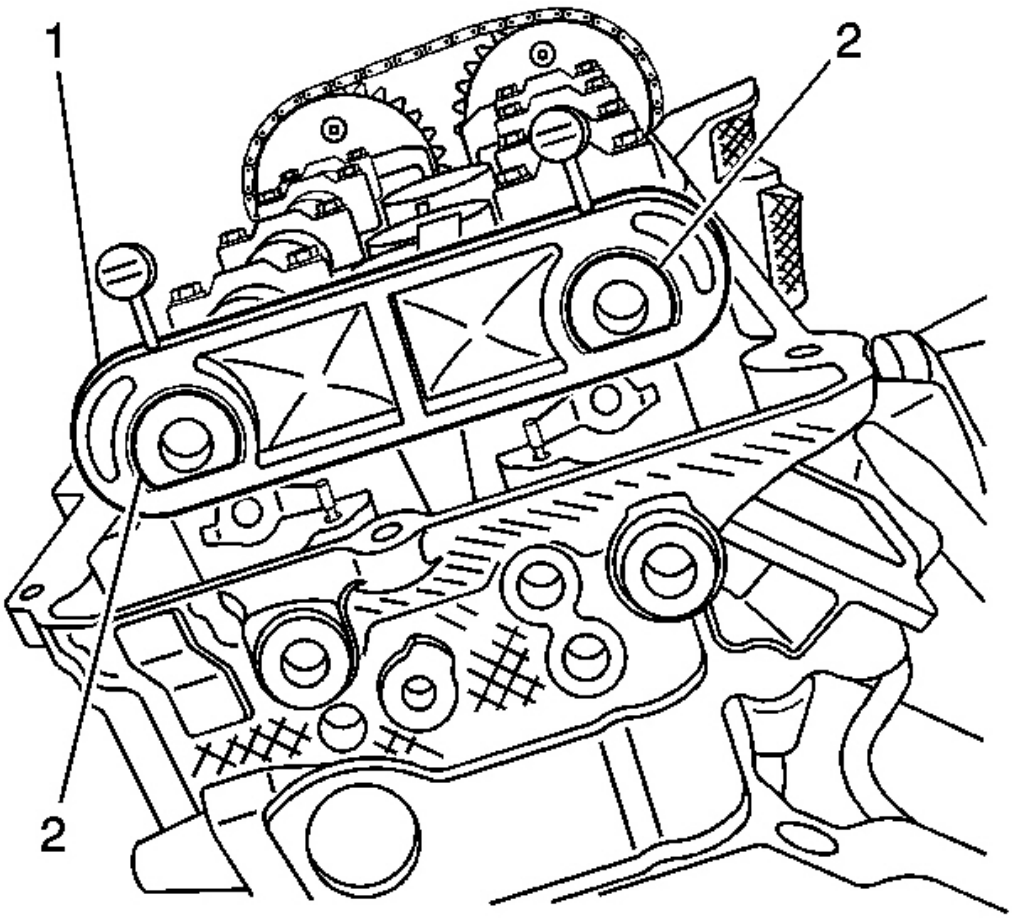


Fig. 2: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution .

4. Install the **EN 46328** (1) to the camshafts (2). See **Special Tools** .

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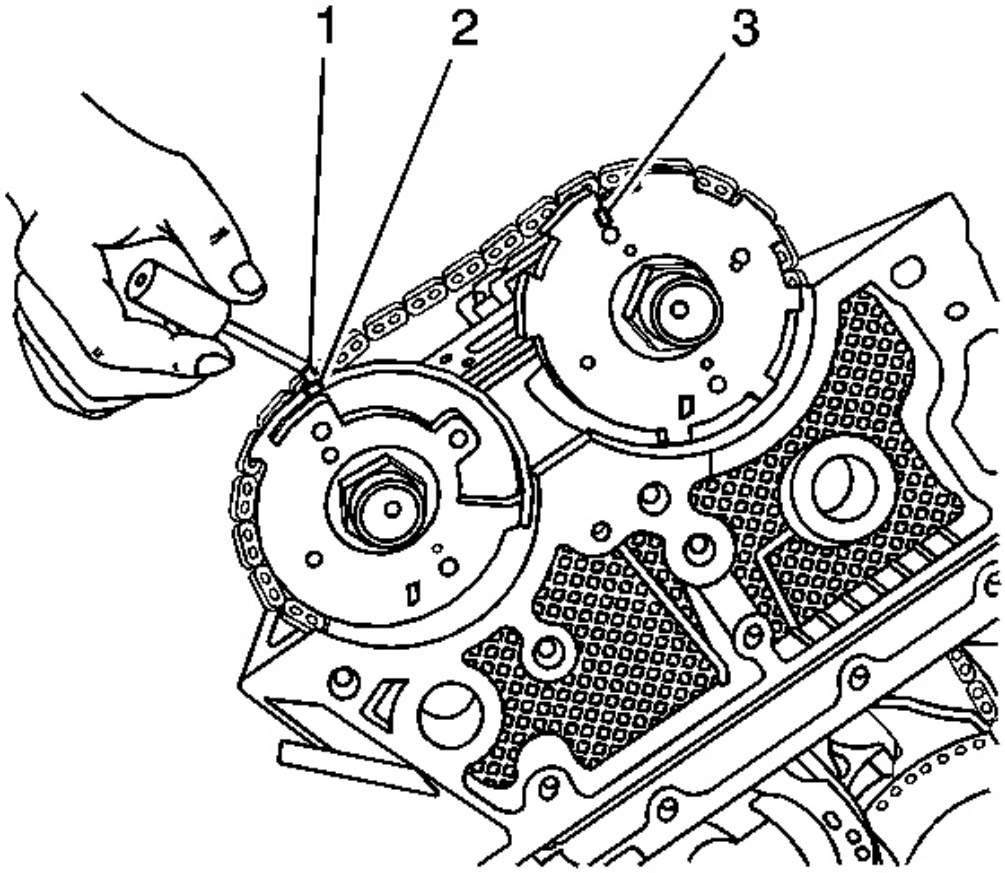


Fig. 3: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

5. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft position actuator timing mark (2, 3).

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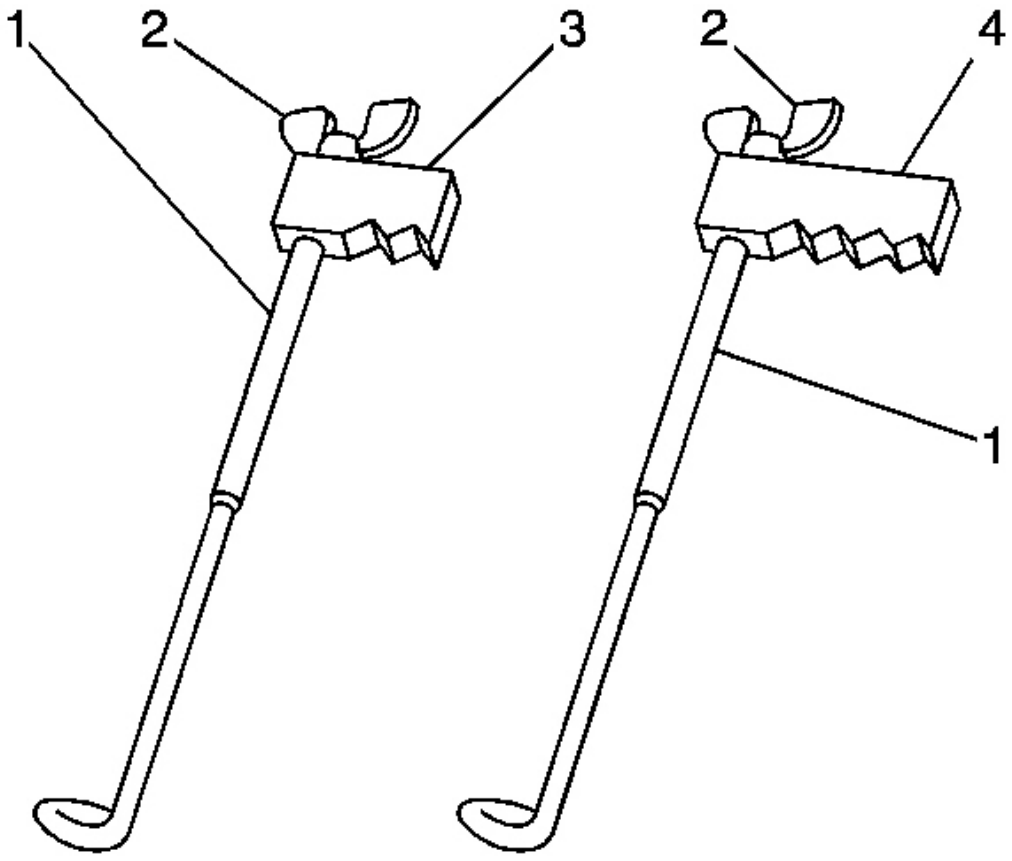


Fig. 4: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN 46327** (1) using the installation of the **EN 46327** timing chain retention tool procedure. See **Special Tools** .

INSTALLATION OF THE EN 46327 TIMING CHAIN RETENTION TOOL - LEFT BANK

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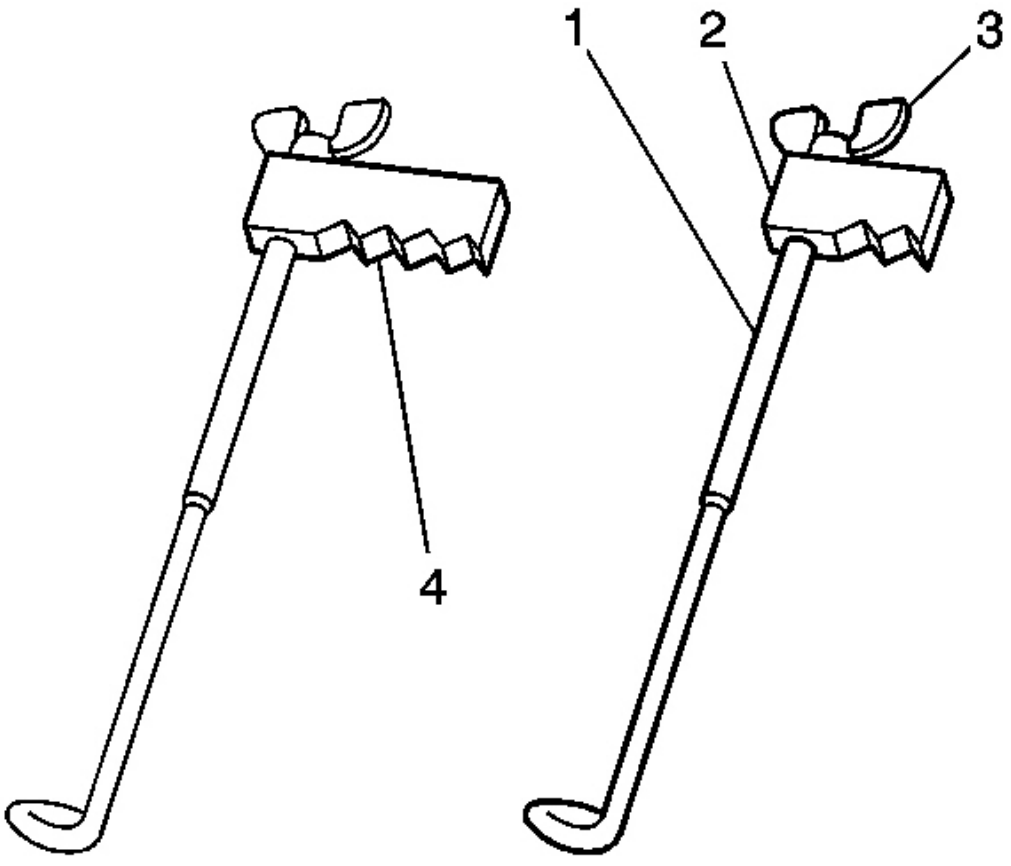


Fig. 5: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

1. Rotate the wing nut (3) of the **EN 46327** to the top of its travel. See **Special Tools** .

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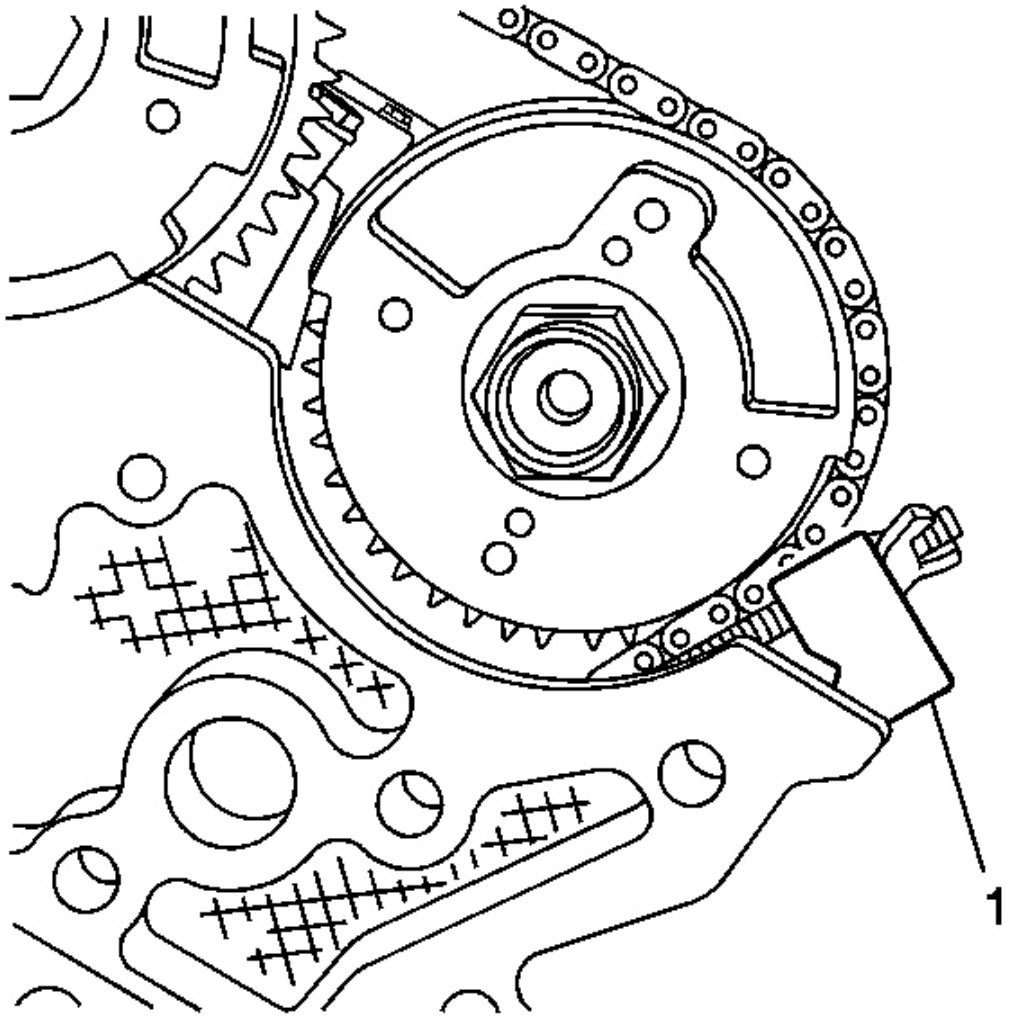


Fig. 6: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

2. Position the bottom retention tool on the cylinder head with the V-notch of the block (1) adjacent to the left exhaust camshaft actuator timing sprocket and chain as shown.

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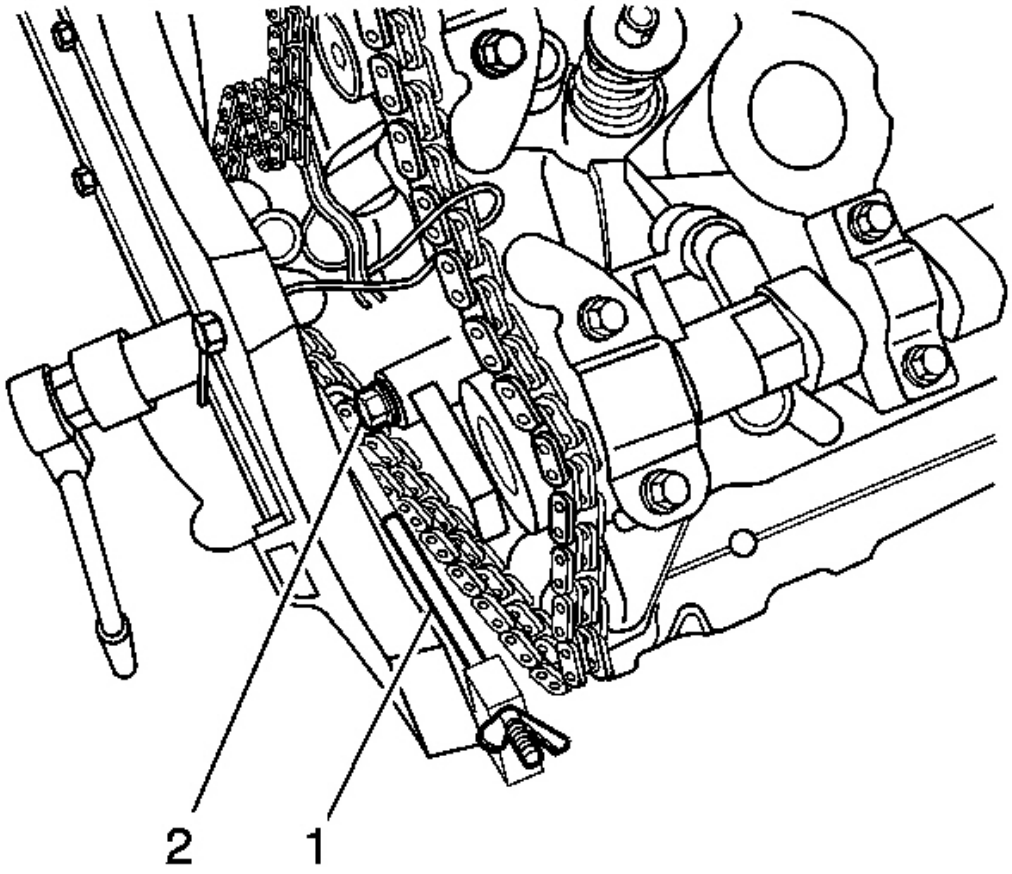


Fig. 7: Installing EN 46327 Hook End Into Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

3. Insert the hook end (2) into a secondary timing chain link as shown.

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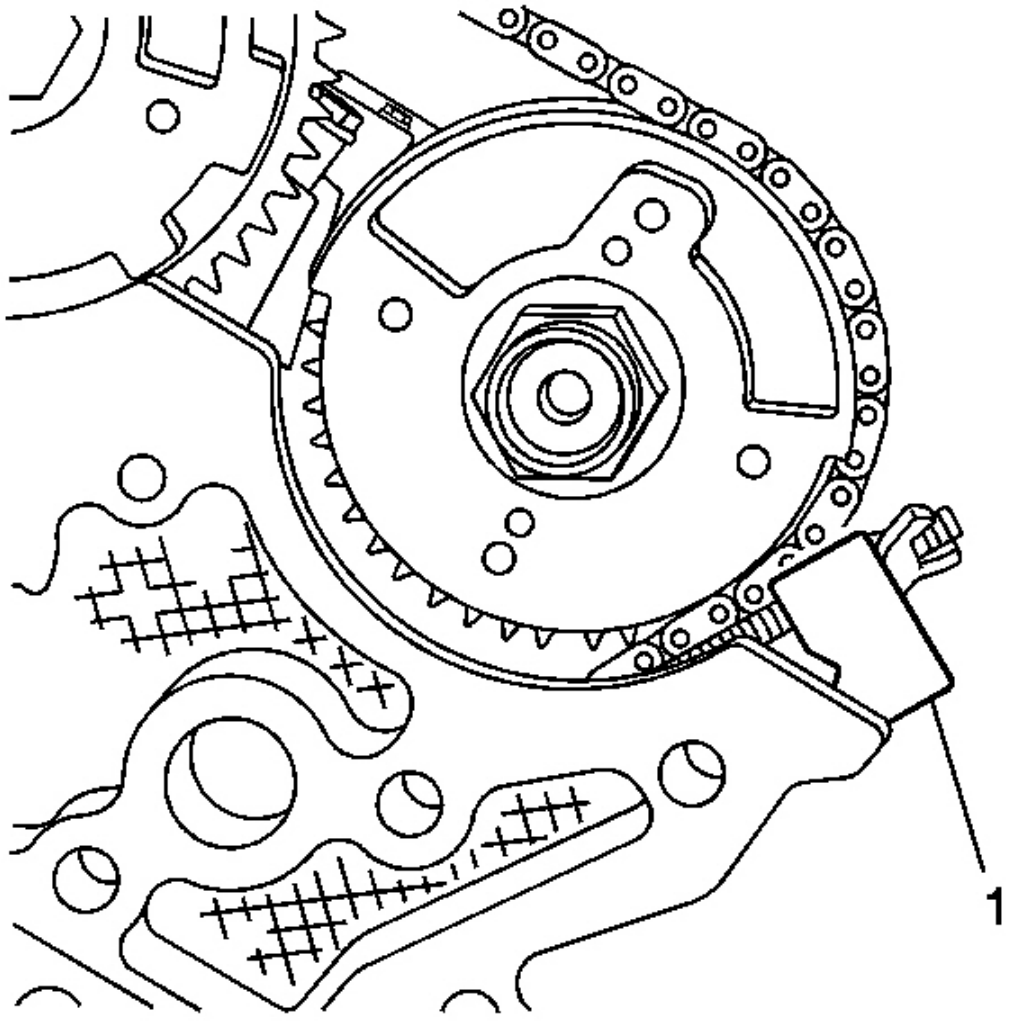


Fig. 8: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Rotate the wing nut until it contacts the retention tool block (1). DO NOT tighten the wing nut at this time.

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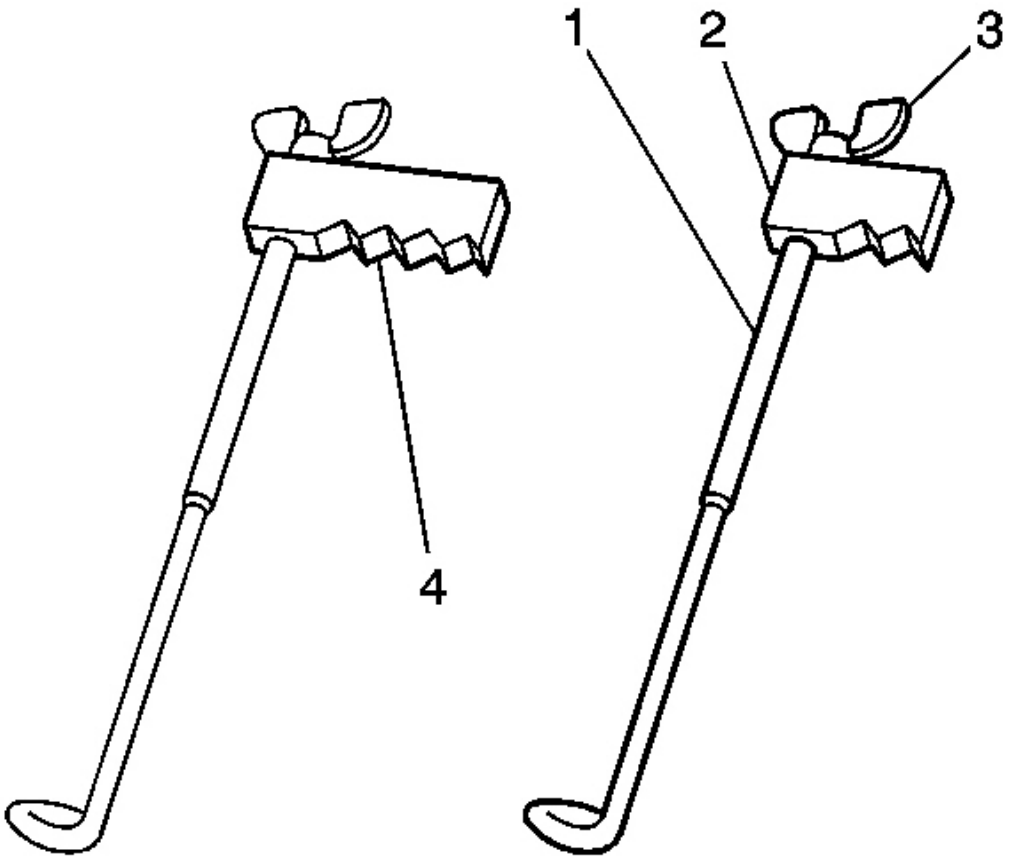


Fig. 9: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

5. Rotate the wing nut of the **EN 46327** (4) to the top of its travel. See **Special Tools** .

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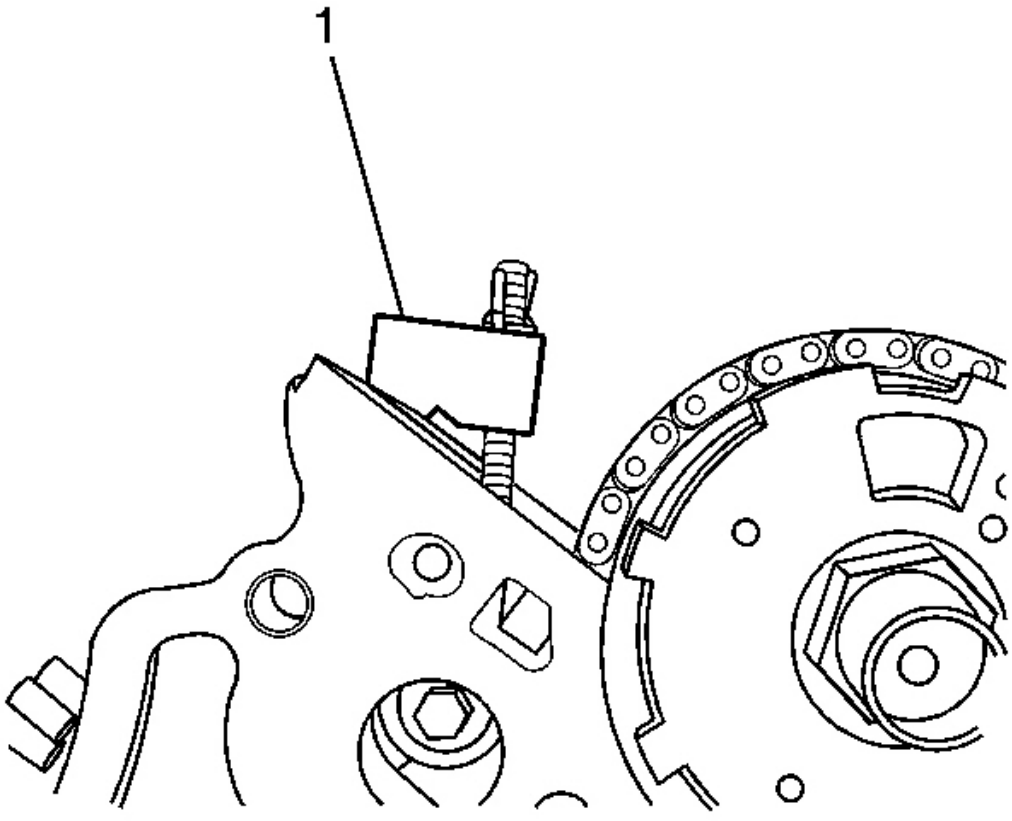


Fig. 10: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

6. Position the top retention tool on the cylinder head with the V-notch of the block (1) adjacent to the left intake camshaft actuator timing sprocket and chain as shown.

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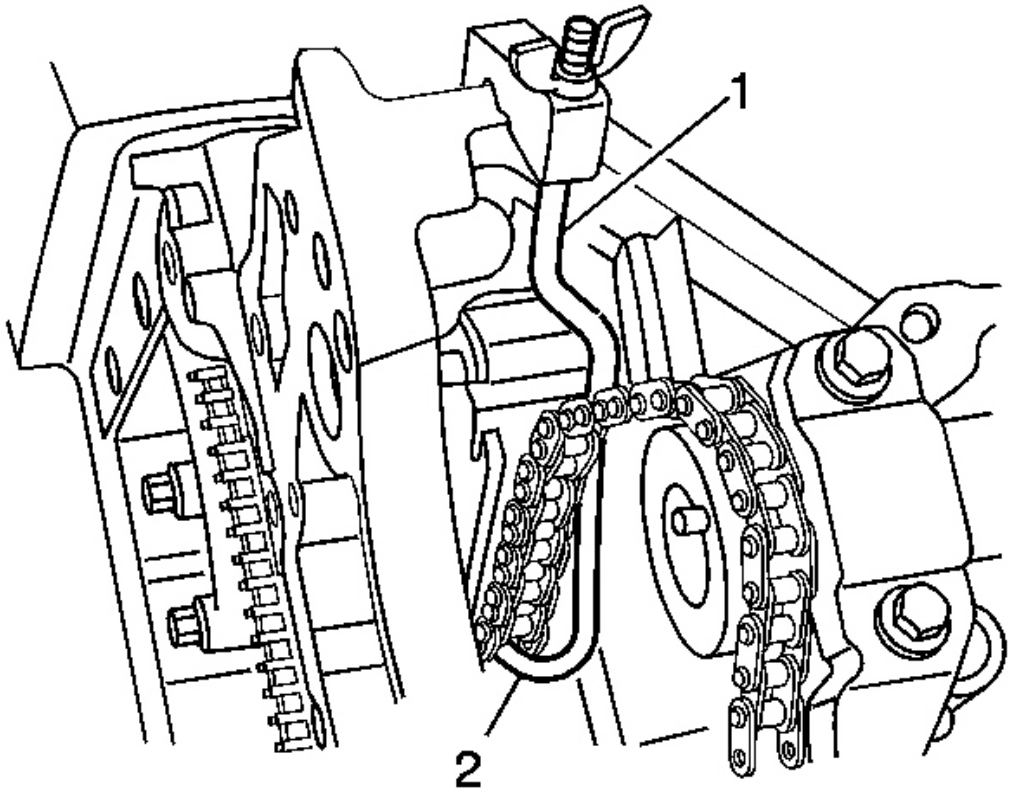


Fig. 11: View Of Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

7. Insert the hook end (2) into a secondary timing chain link as shown.

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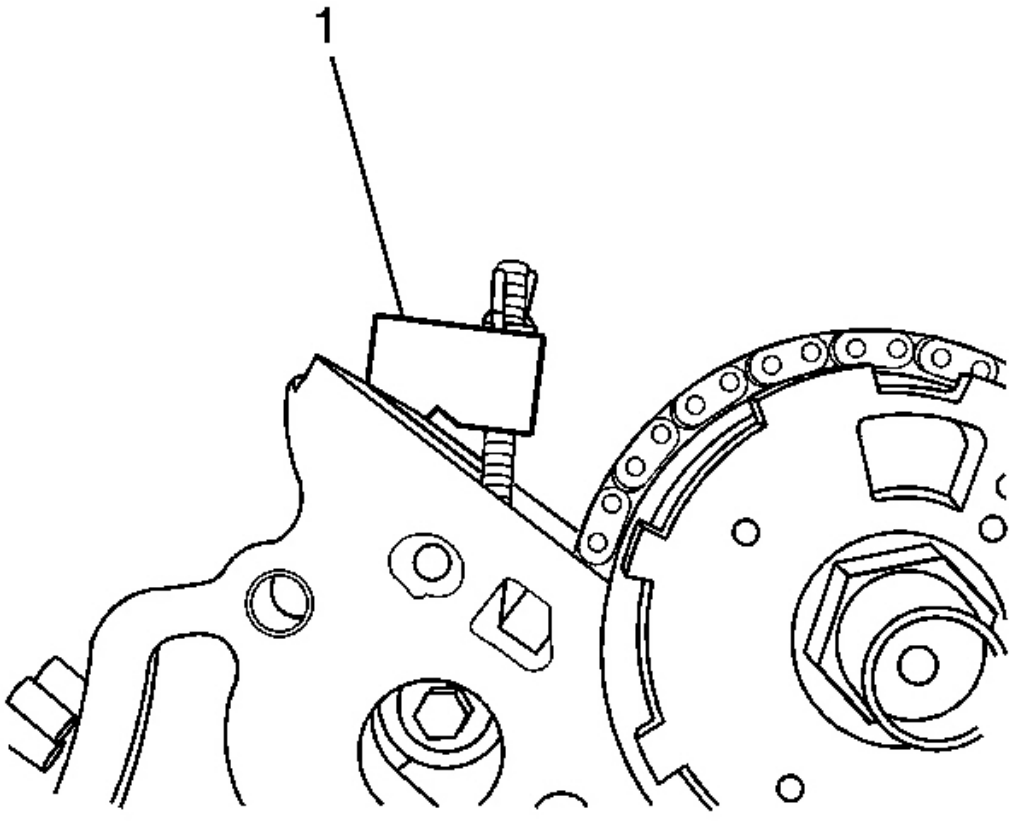


Fig. 12: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

8. Rotate the wing nut until it contacts the retention tool block (1). Alternately tighten both wing nuts to retain the chain.

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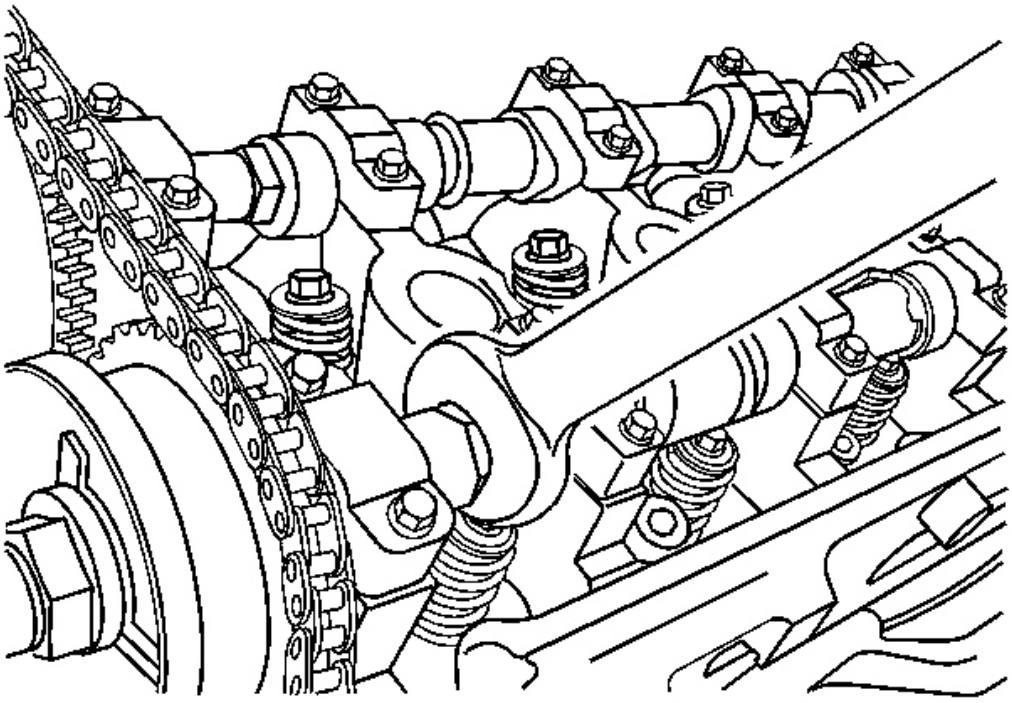


Fig. 13: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

9. Use an open end wrench on the hex cast into the left exhaust camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

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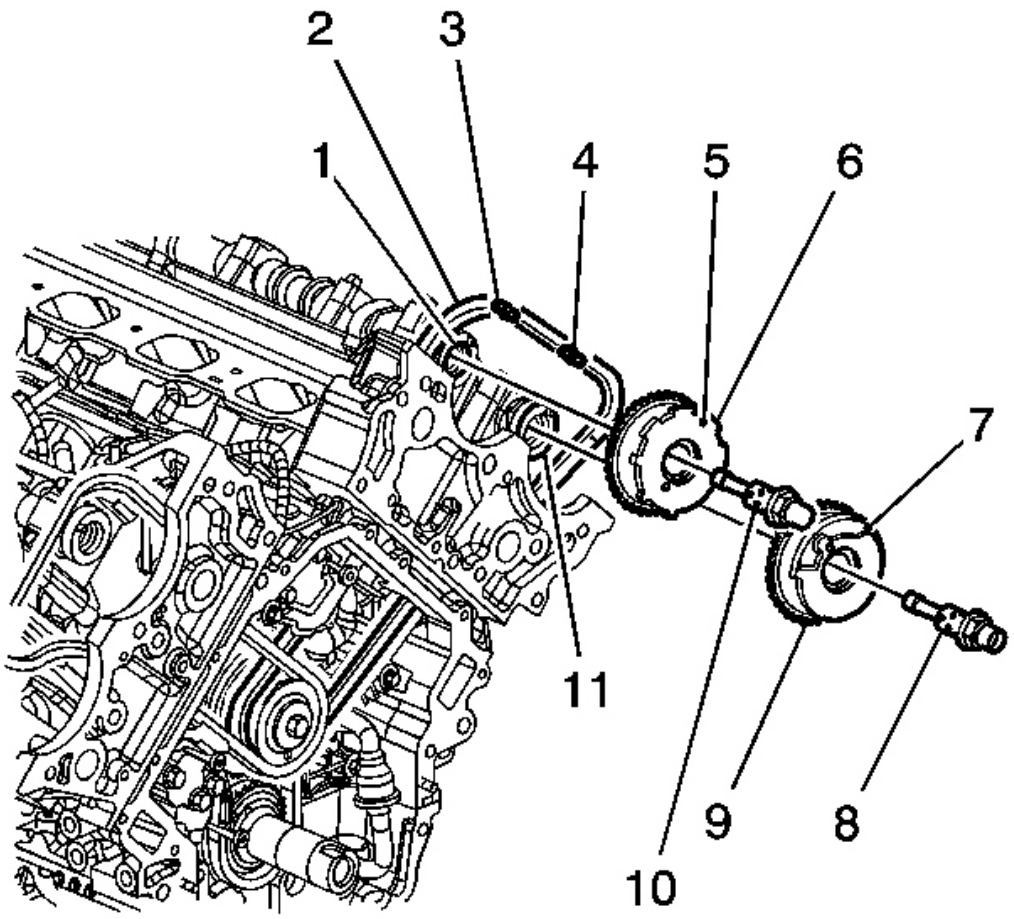


Fig. 14: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

10. Loosen and remove the left exhaust oil control valve (8).

INSTALLATION PROCEDURE

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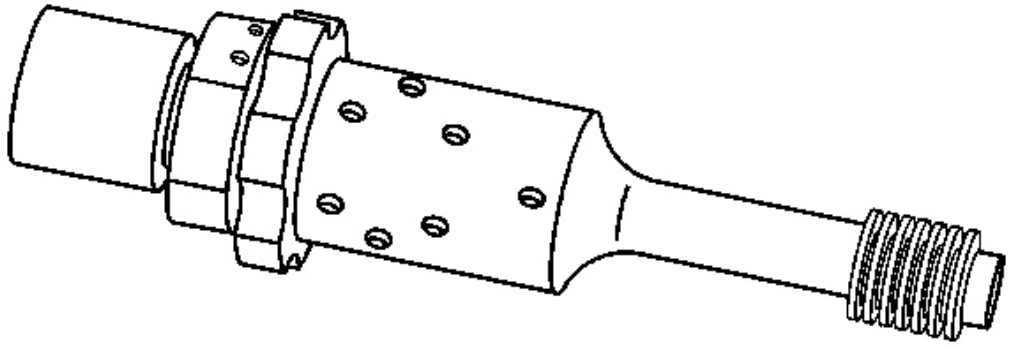


Fig. 15: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the oil control valve through the opening in the left exhaust camshaft position actuator and thread it into the left exhaust camshaft.

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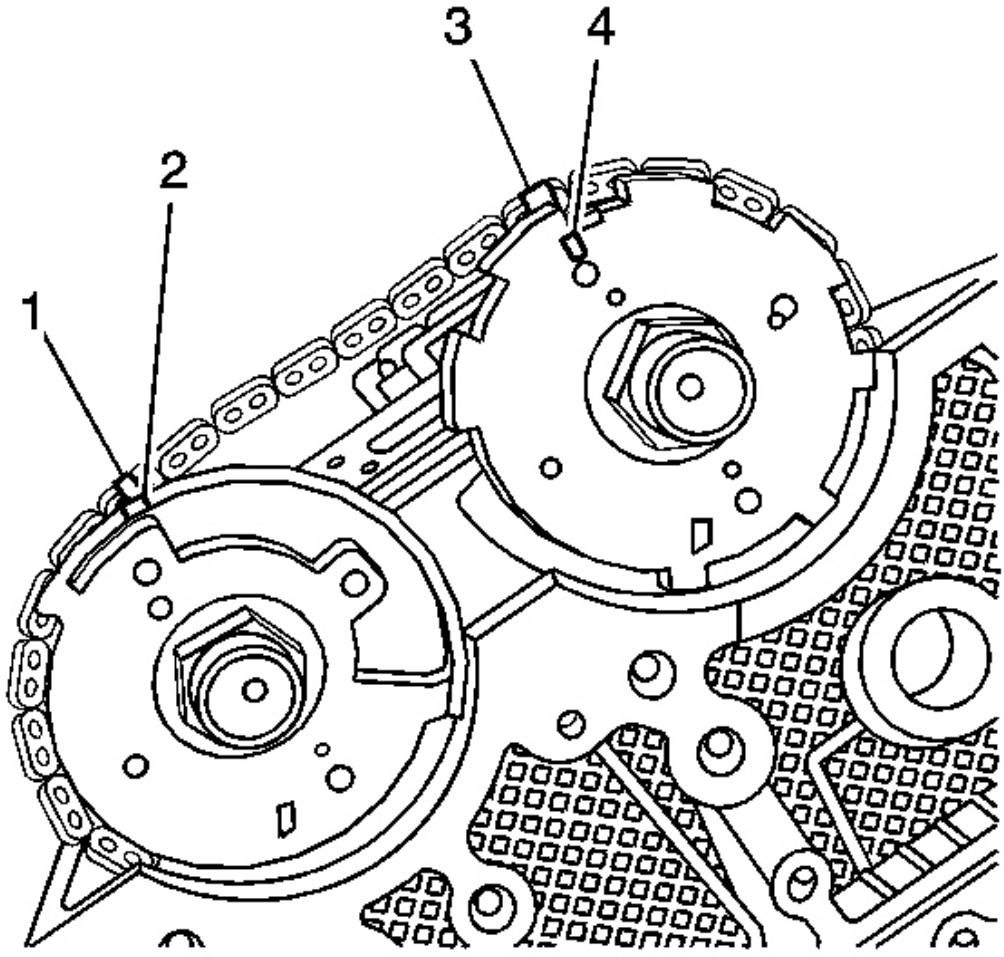


Fig. 16: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

2. Ensure both camshaft actuator timing marks (1, 3) are aligned with the paint marks on the secondary timing chain previously created.

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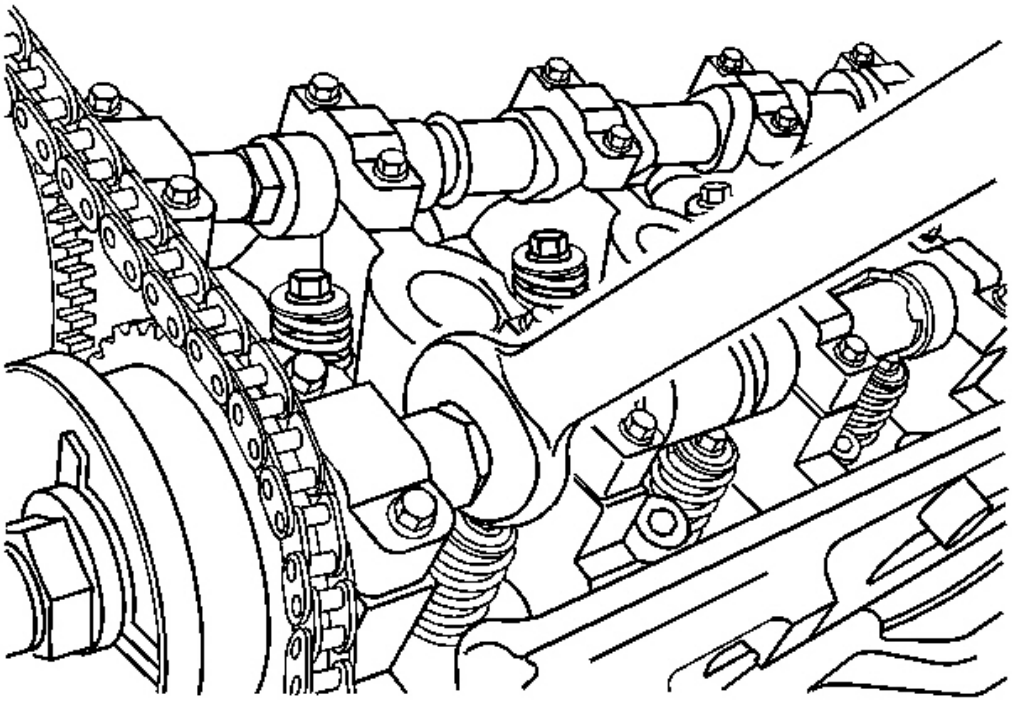


Fig. 17: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice .**

NOTE: **Refer to Fastener Notice .**

3. Use an open end wrench on the hex cast into the left exhaust camshaft to prevent the camshaft from rotating when tightening the camshaft oil control valve.

   Tighten: Tighten the camshaft oil control valve to 120 N.m (89 lb ft).

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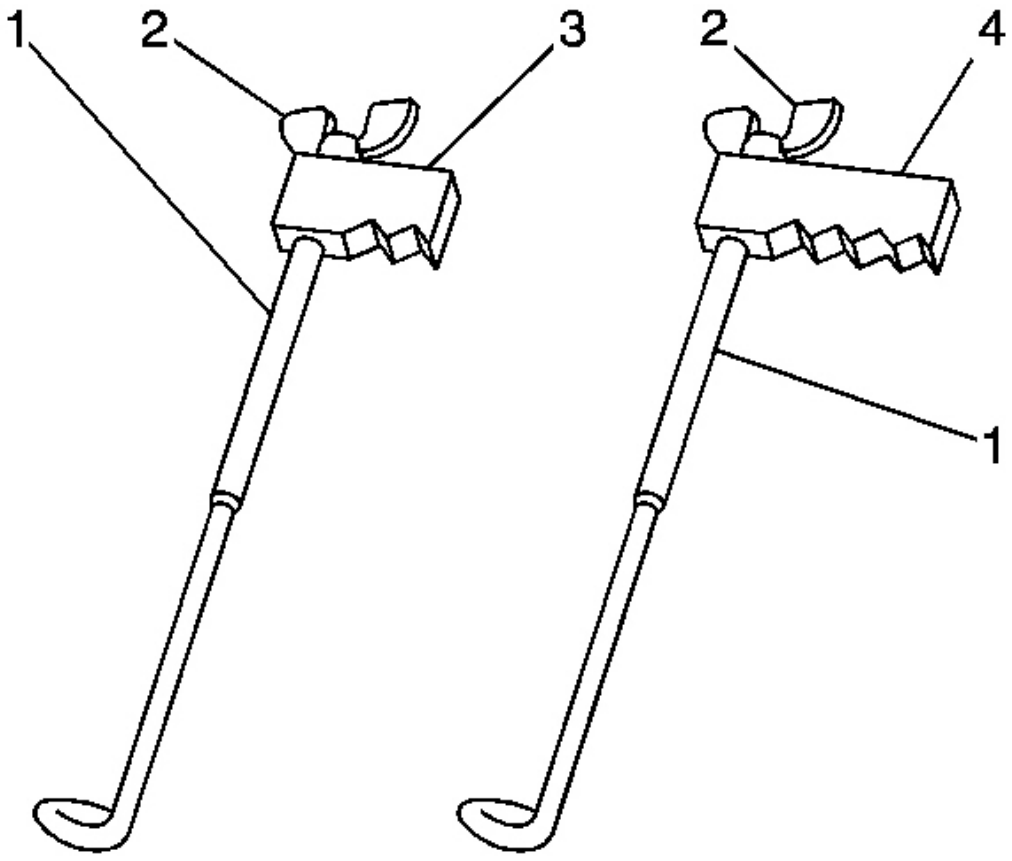


Fig. 18: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

4. Remove the **EN 46327** (1). See **Special Tools** .

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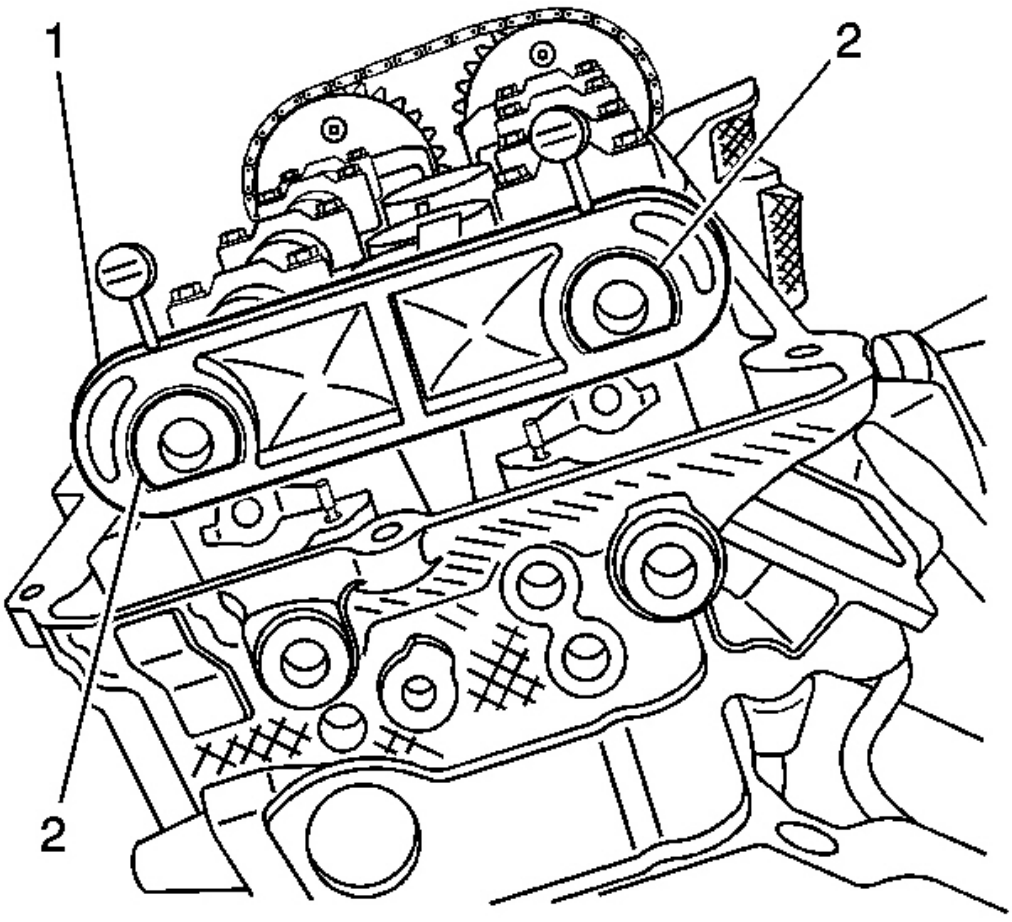


Fig. 19: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN 46328** (1) from the camshafts (2). See **Special Tools** .
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement** .

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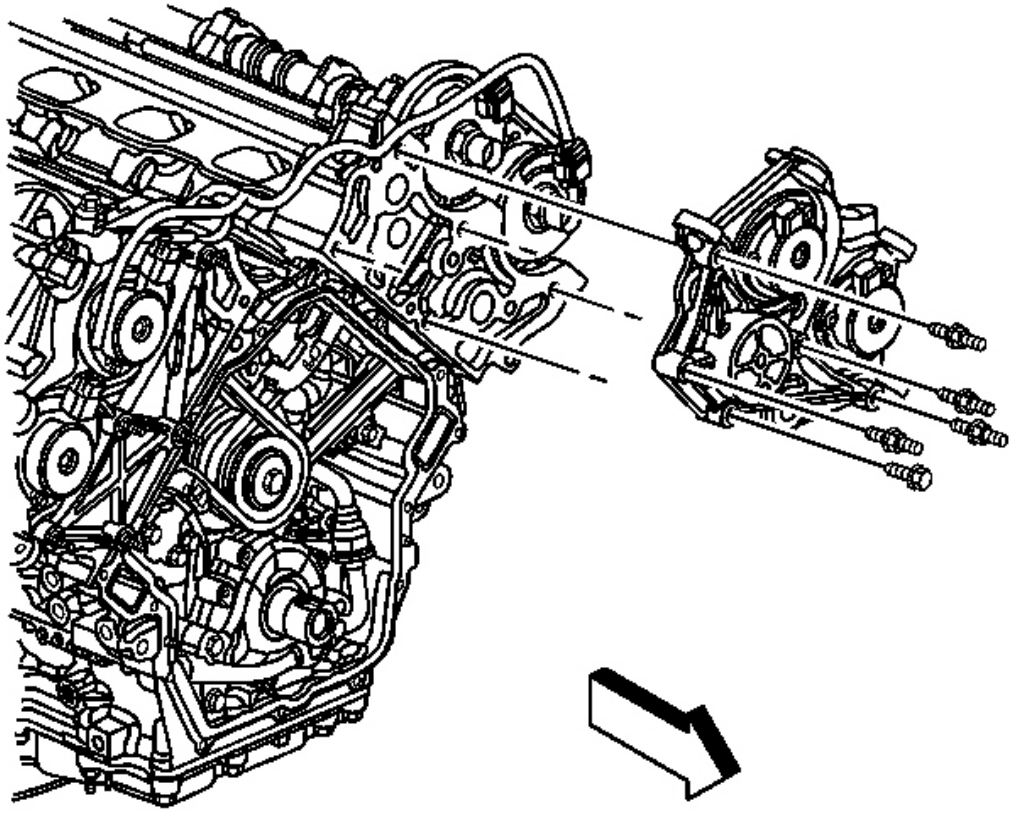


Fig. 20: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

7. Install the left camshaft actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side** .

CAMSHAFT POSITION ACTUATOR REPLACEMENT - BANK 1 (RIGHT SIDE) INTAKE

REMOVAL PROCEDURE

Automotive-Manual.net

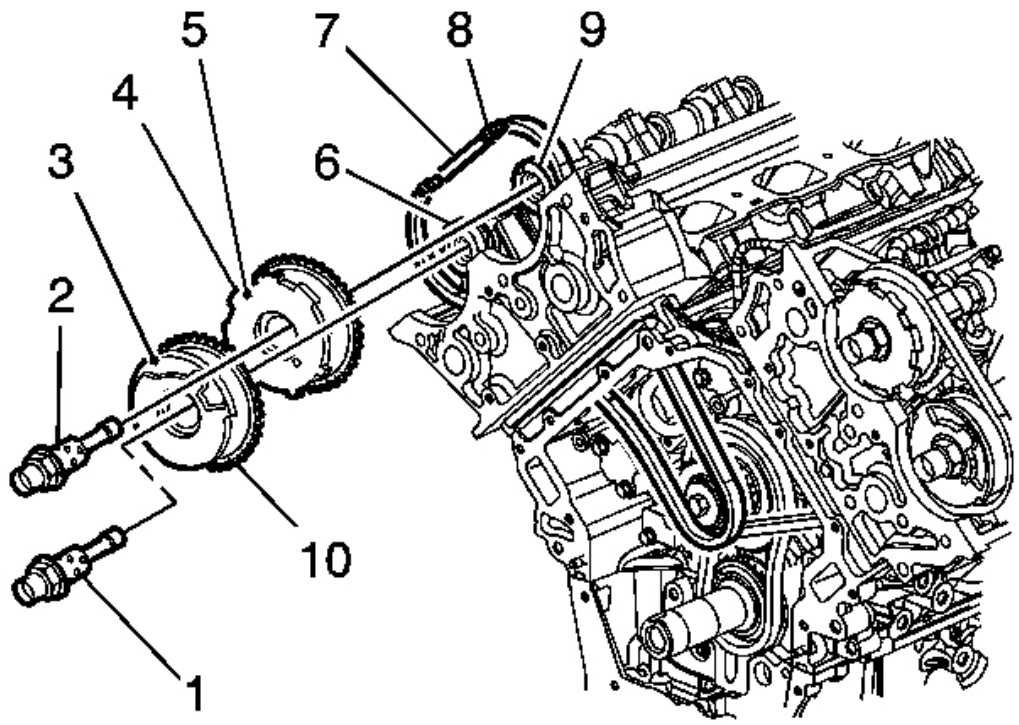


Fig. 21: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the right intake camshaft position actuator oil control valve (2). Refer to **Camshaft Position Actuator Oil Control Valve Replacement - Bank 1 (Right Side) Intake** .
2. Pull the actuator forward to disengage the actuator from the camshaft alignment pin.
3. Disengage the secondary timing chain from the actuator and remove the actuator.
4. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

Automotive-Manual.net

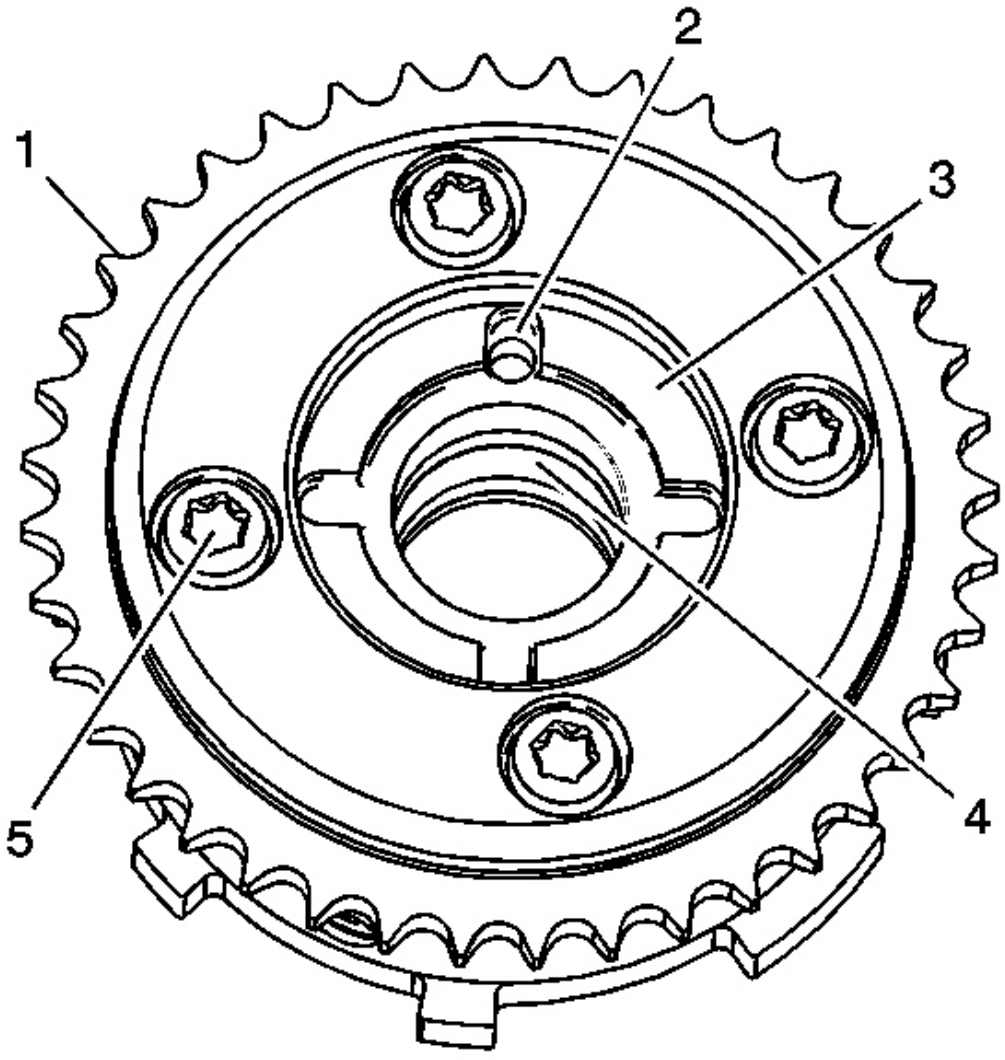


Fig. 22: Locating Camshaft Alignment Pin Hole
Courtesy of GENERAL MOTORS CORP.

1. Locate the camshaft alignment pin hole (2) on the back of the actuator. This hole will mate with the camshaft alignment pin.

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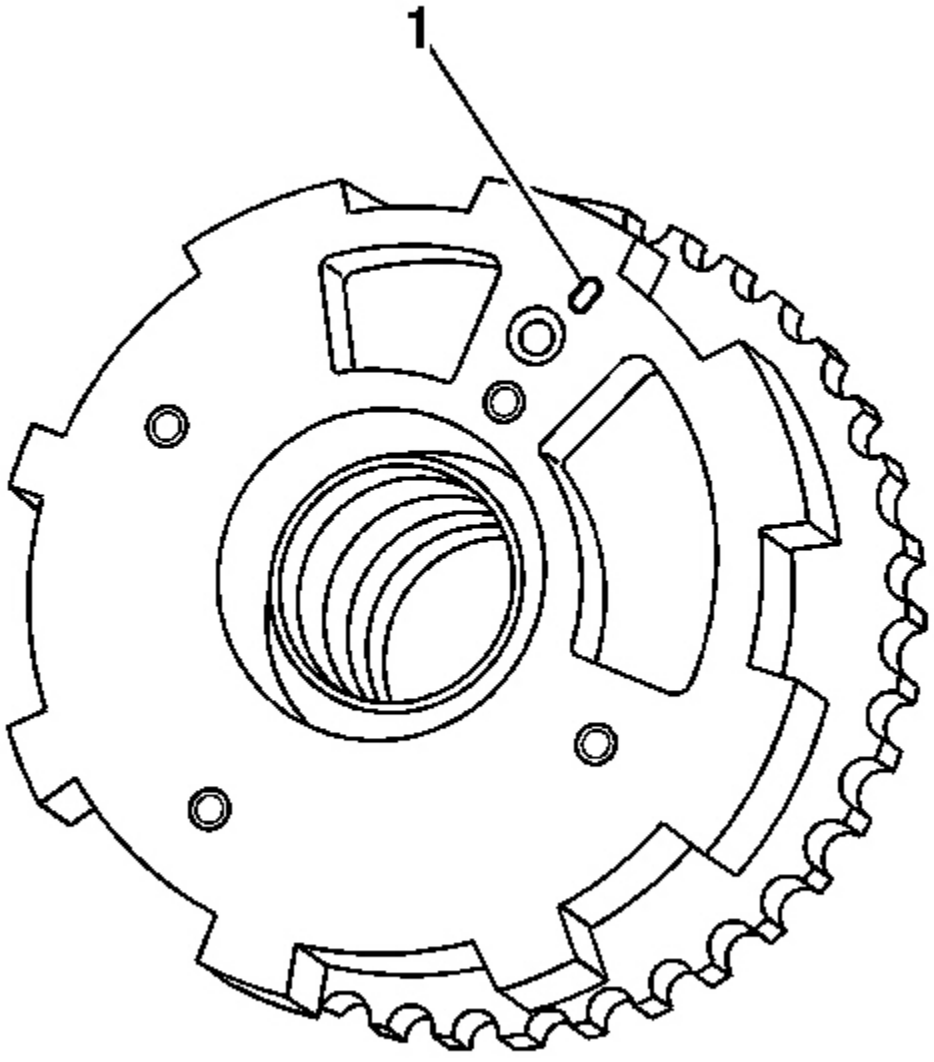


Fig. 23: Locating Timing Alignment Mark On Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

2. Locate the timing alignment mark (1) on the front of the actuator.

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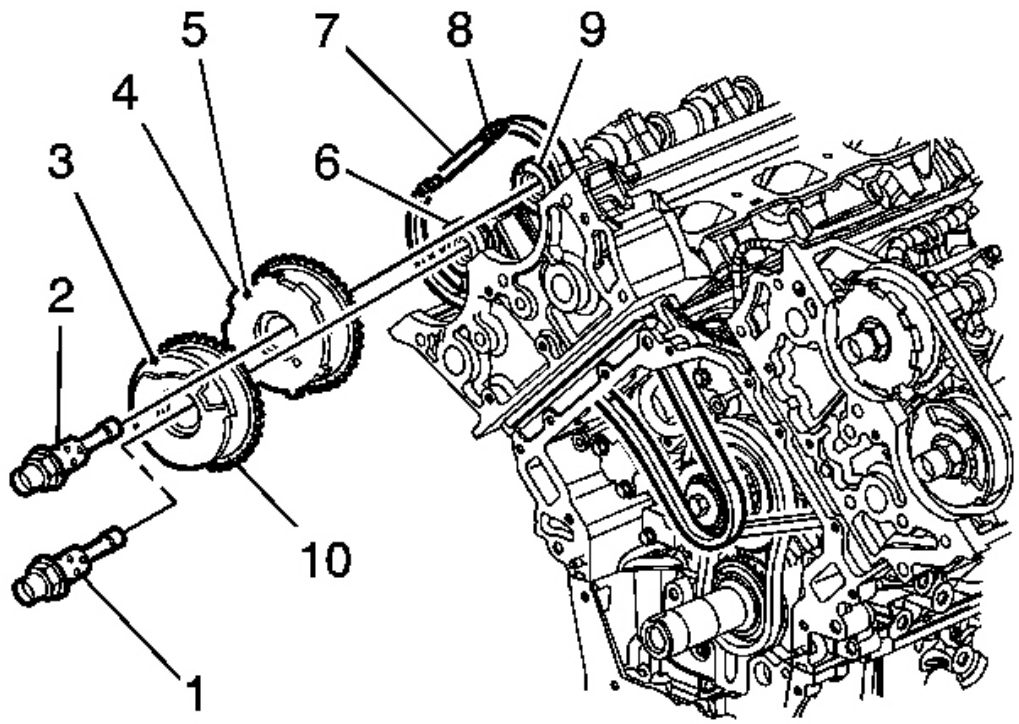


Fig. 24: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Engage the actuator timing gear teeth with the secondary timing chain ensuring that the actuator alignment mark (5) corresponds with the paint mark created on the chain link.
4. Slide the actuator over the camshaft alignment pin and install the actuator onto the camshaft.
5. Install the right intake camshaft position actuator oil control valve. Refer to **Camshaft Position Actuator Oil Control Valve Replacement - Bank 1 (Right Side) Intake** .

CAMSHAFT POSITION ACTUATOR REPLACEMENT - BANK 1 (RIGHT SIDE) EXHAUST

REMOVAL PROCEDURE

Automotive-Manual.net

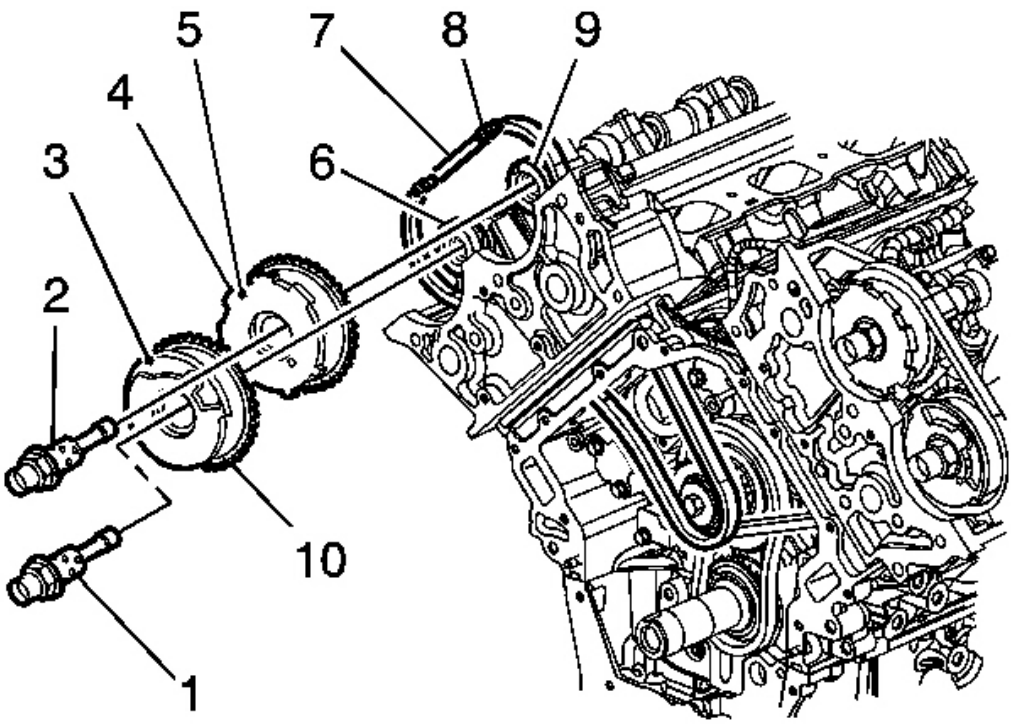


Fig. 25: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the right exhaust camshaft position actuator oil control valve (1). Refer to **Camshaft Position Actuator Oil Control Valve Replacement - Bank 1 (Right Side) Exhaust** .
2. Pull the actuator forward to disengage the actuator from the camshaft alignment pin.
3. Disengage the secondary timing chain from the actuator and remove the actuator.
4. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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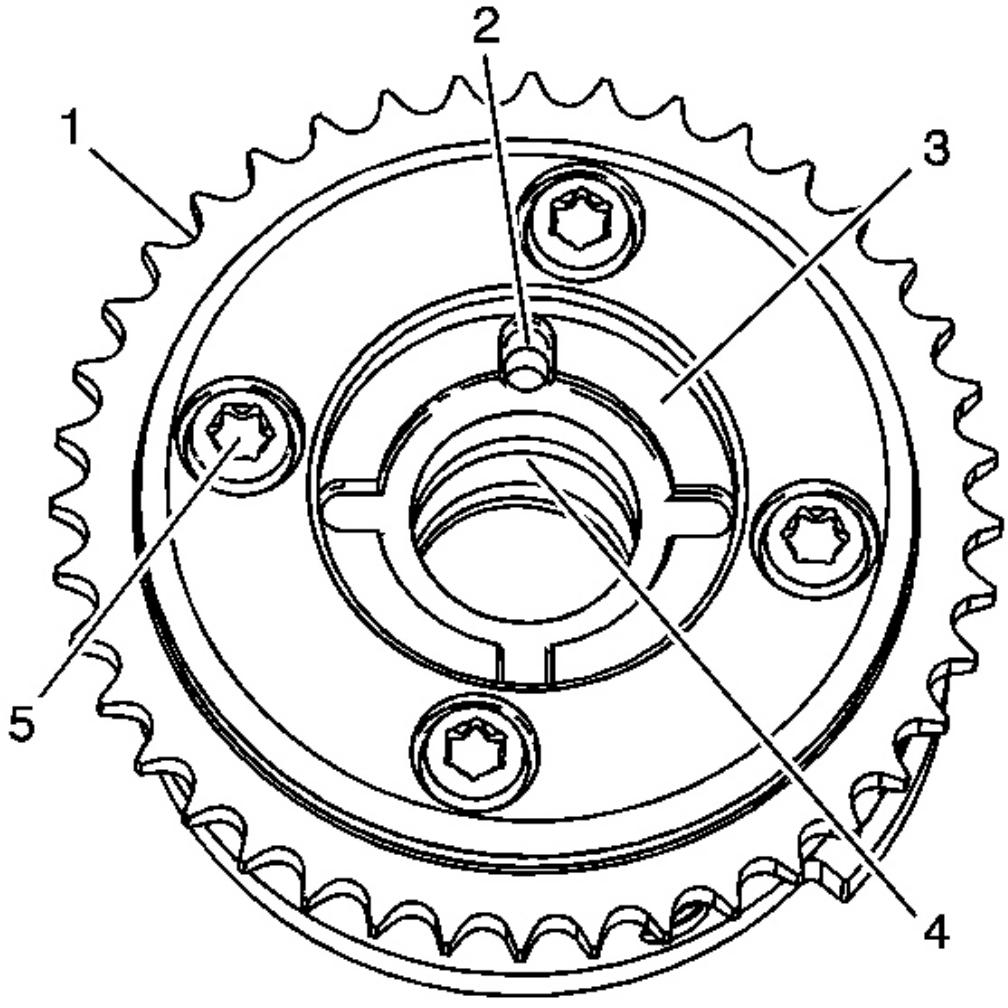


Fig. 26: Locating Camshaft Alignment Pin Hole On Back Of Actuator
Courtesy of GENERAL MOTORS CORP.

1. Locate the camshaft alignment pin hole (2) on the back of the actuator. This hole will mate with the camshaft alignment pin.

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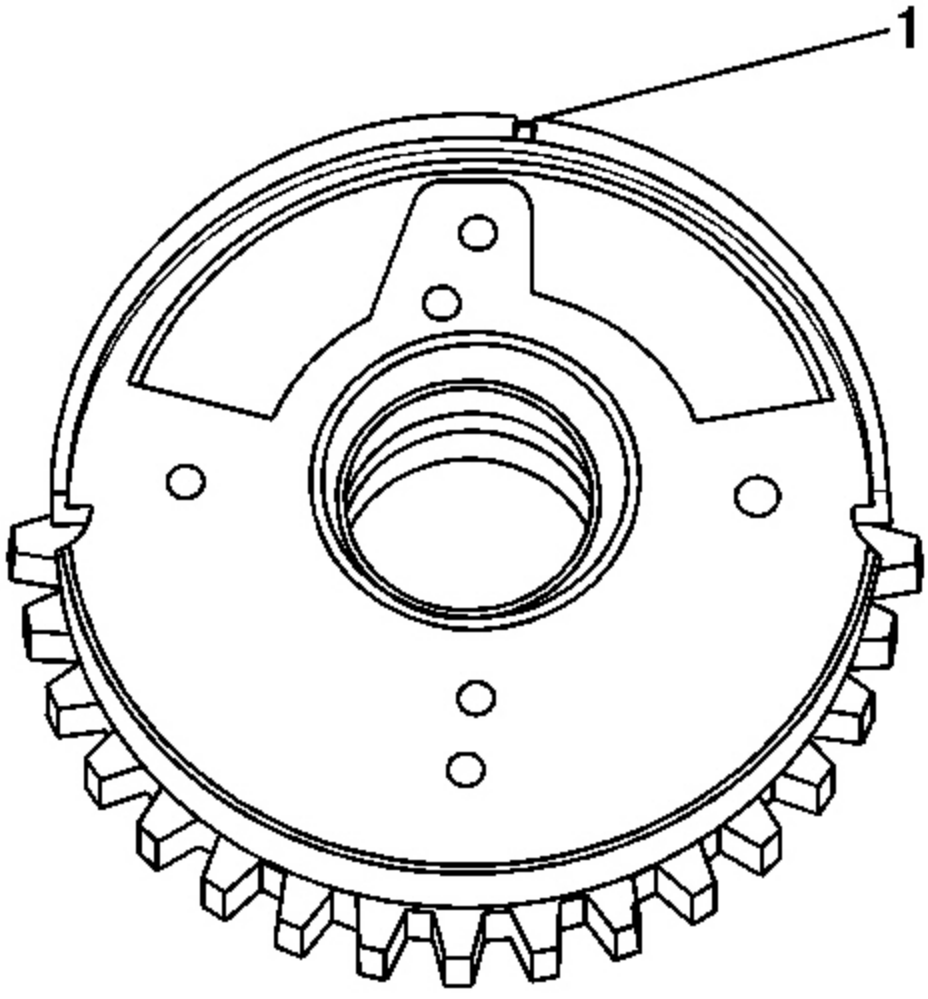


Fig. 27: Locating Timing Mark On Front Of Actuator
Courtesy of GENERAL MOTORS CORP.

2. Locate the timing alignment mark (1) on the front of the actuator.

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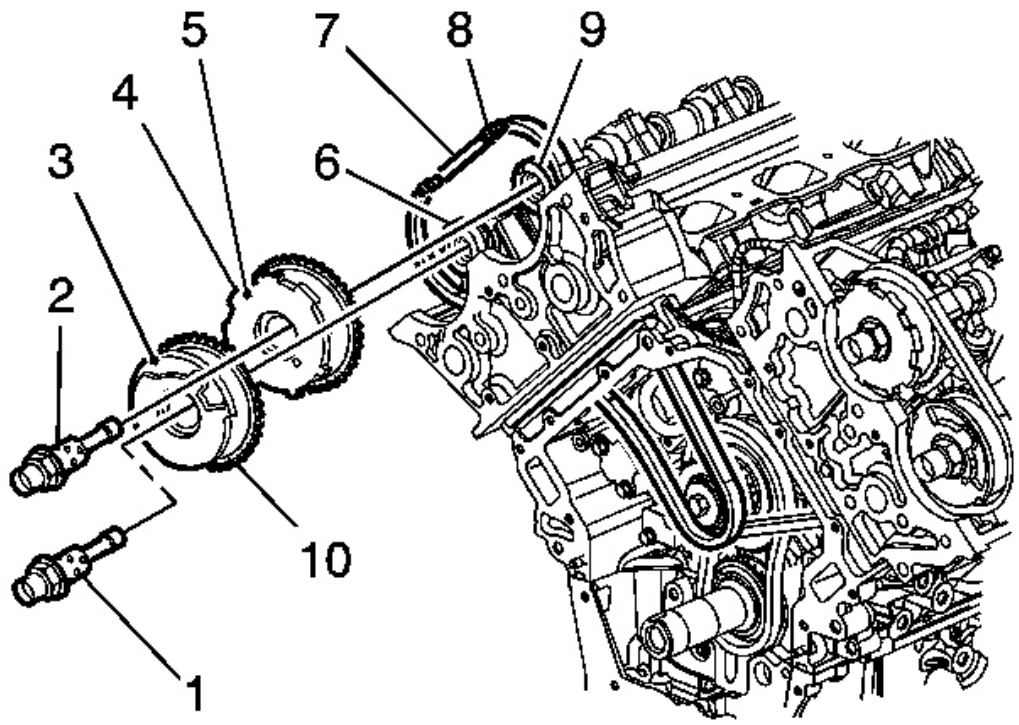


Fig. 28: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Engage the actuator timing gear teeth with the secondary timing chain ensuring that the actuator alignment mark (3) corresponds with the paint mark created on the chain link.
4. Slide the actuator over the camshaft alignment pin and install the actuator onto the camshaft.
5. Install the right exhaust camshaft position actuator oil control valve. Refer to **Camshaft Position Actuator Oil Control Valve Replacement - Bank 1 (Right Side) Exhaust** .

CAMSHAFT POSITION ACTUATOR REPLACEMENT - BANK 2 (LEFT SIDE) INTAKE

REMOVAL PROCEDURE

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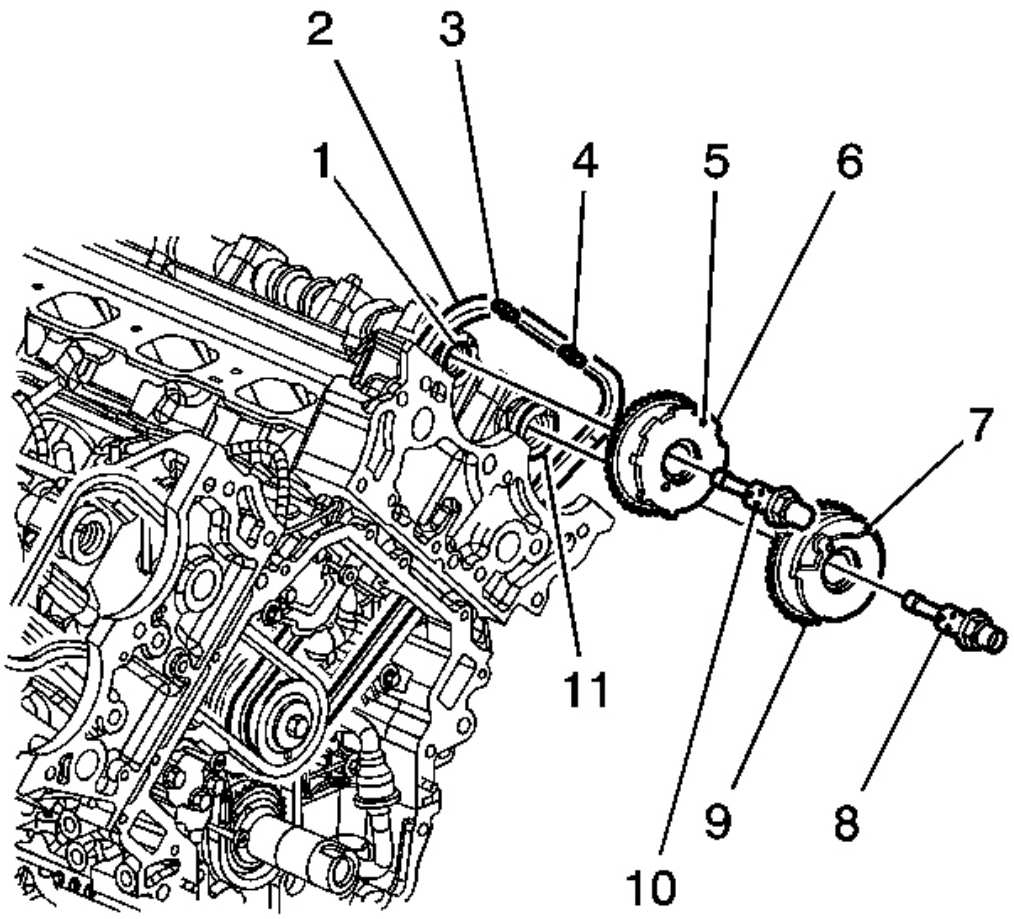


Fig. 29: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the left intake camshaft position actuator oil control valve (10). Refer to **Camshaft Position Actuator Oil Control Valve Replacement - Bank 2 (Left Side) Intake** .
2. Pull the actuator forward to disengage the camshaft alignment pin from the actuator.
3. Disengage the secondary timing chain from the actuator and remove the actuator.

INSTALLATION PROCEDURE

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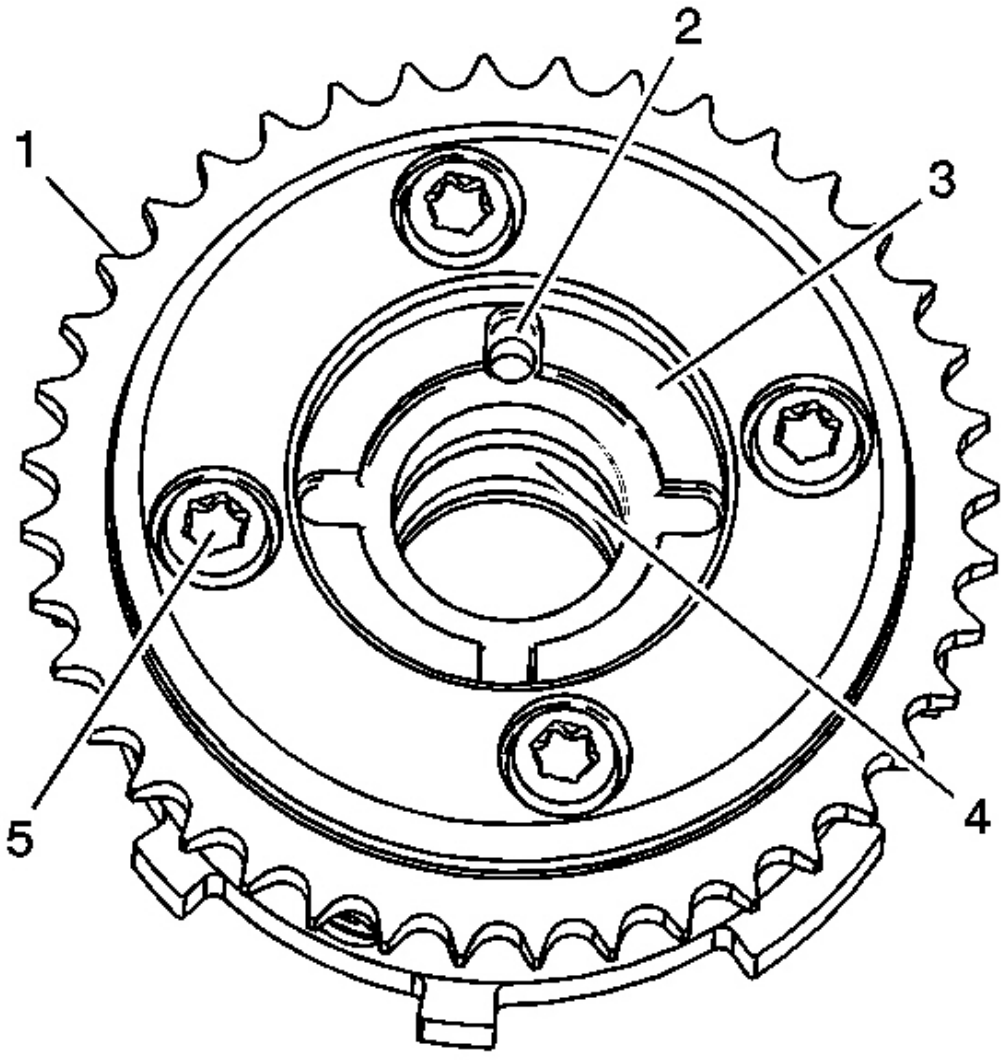


Fig. 30: Locating Camshaft Alignment Pin Hole
Courtesy of GENERAL MOTORS CORP.

1. Locate the camshaft alignment pin hole (2) on the back of the actuator.

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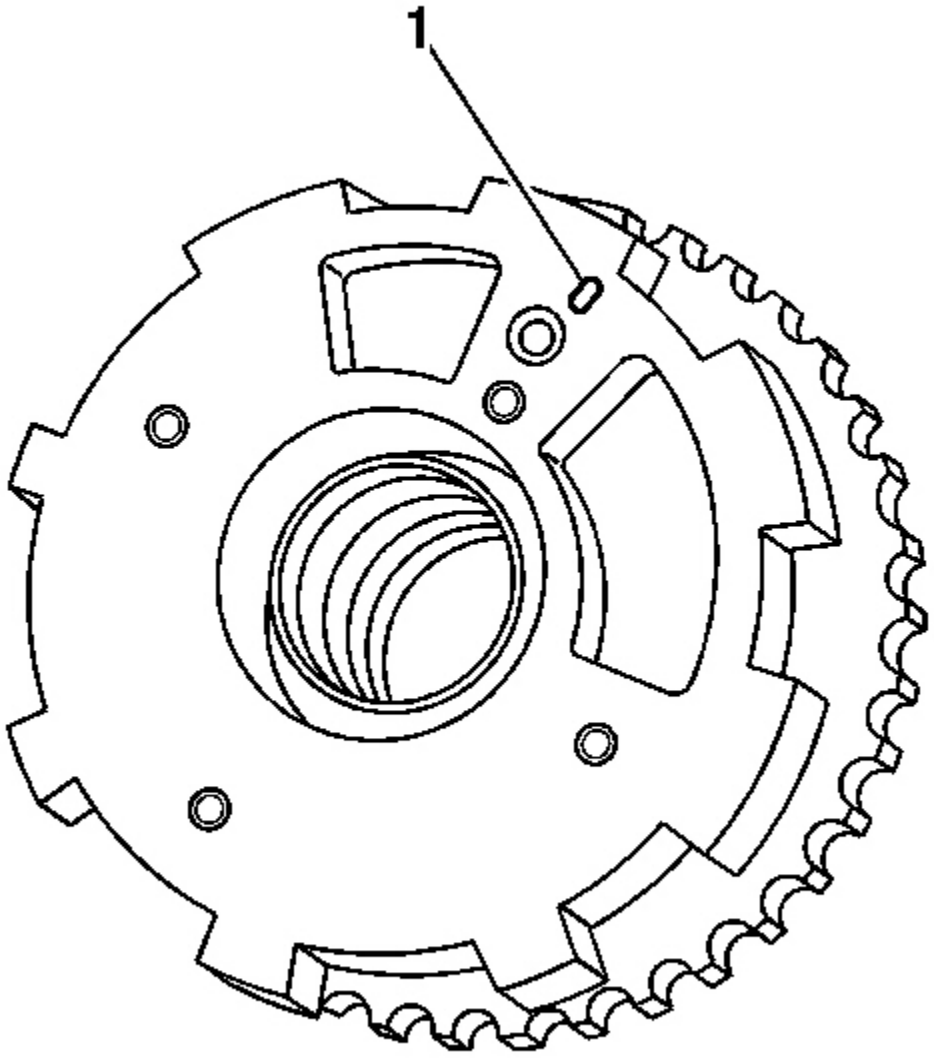


Fig. 31: Locating Timing Alignment Mark On Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

2. Locate the timing alignment mark (1) on the front of the actuator.

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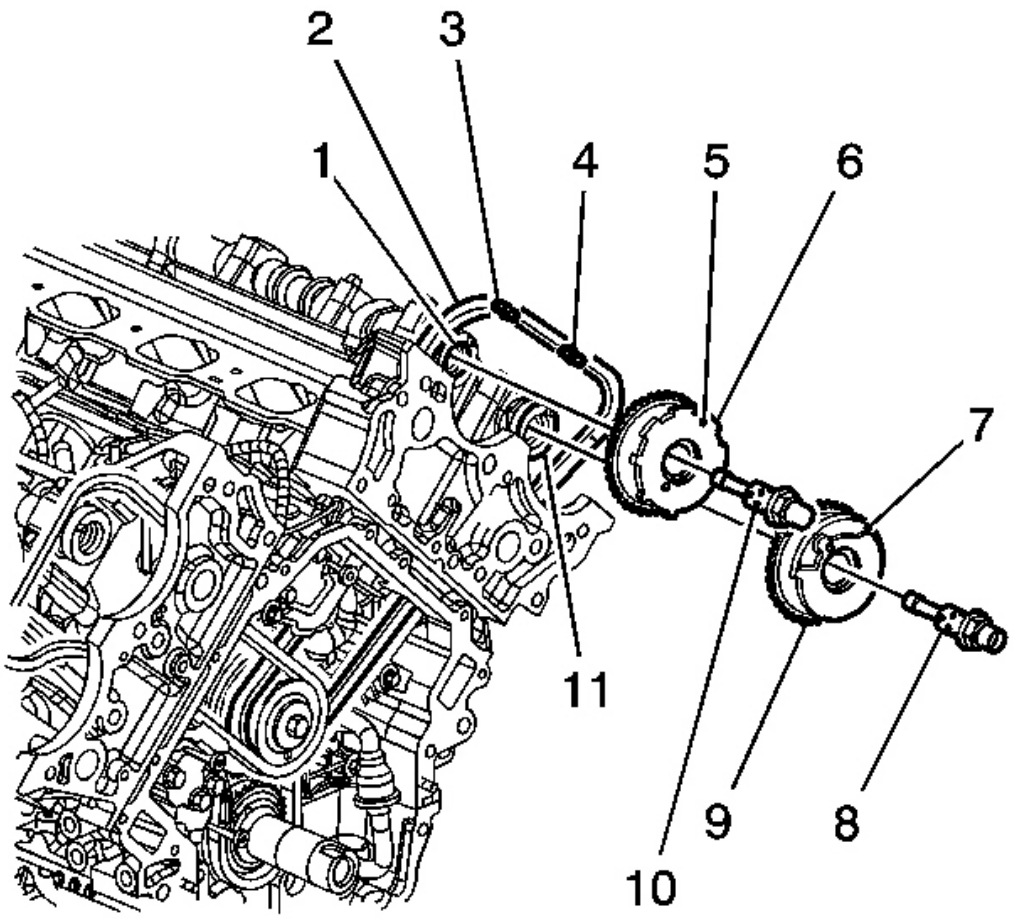


Fig. 32: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Engage the actuator timing gear teeth with the secondary timing chain ensuring that the actuator alignment mark (5) corresponds with the paint mark created on the chain link.
4. Slide the actuator over the camshaft alignment pin and install the actuator onto the camshaft.
5. Install the left intake camshaft position actuator oil control valve (10). Refer to **Camshaft Position Actuator Oil Control Valve Replacement - Bank 2 (Left Side) Intake** .

CAMSHAFT POSITION ACTUATOR REPLACEMENT - BANK 2 (LEFT SIDE) EXHAUST

REMOVAL PROCEDURE

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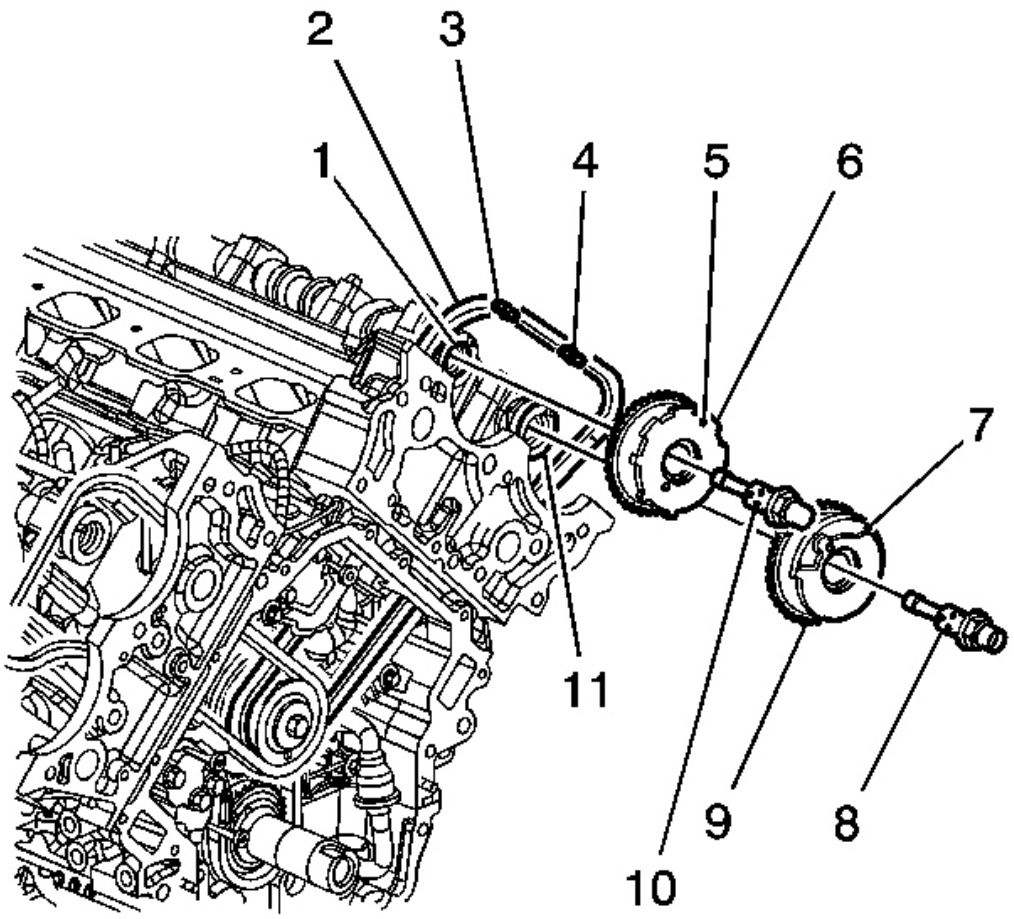


Fig. 33: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the left exhaust camshaft position actuator oil control valve (8). Refer to **Camshaft Position Actuator Oil Control Valve Replacement - Bank 2 (Left Side) Exhaust**.
2. Pull the actuator forward to disengage the camshaft alignment pin from the actuator.
3. Disengage the secondary timing chain from the actuator and remove the actuator.

INSTALLATION PROCEDURE

Automotive-Manual.net

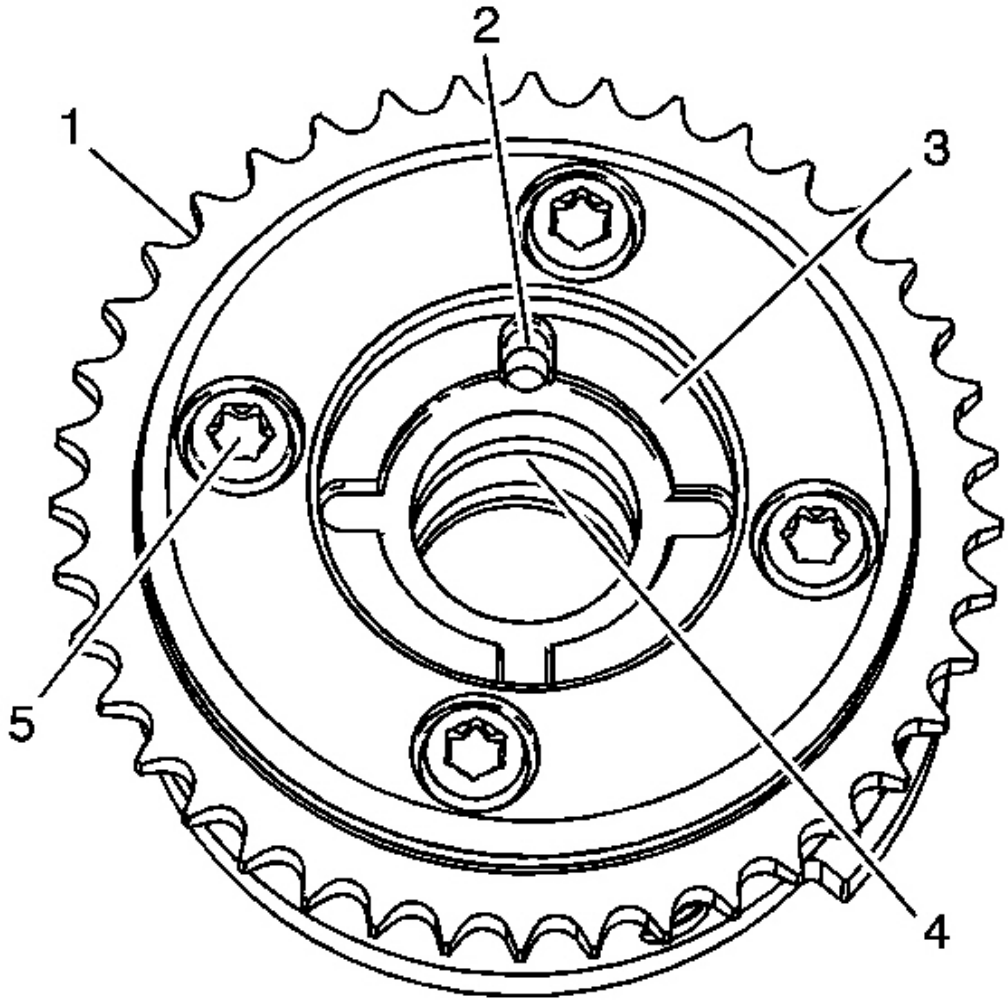


Fig. 34: Locating Camshaft Alignment Pin Hole On Back Of Actuator
Courtesy of GENERAL MOTORS CORP.

1. Locate the camshaft alignment pin hole (2) on the back of the actuator.

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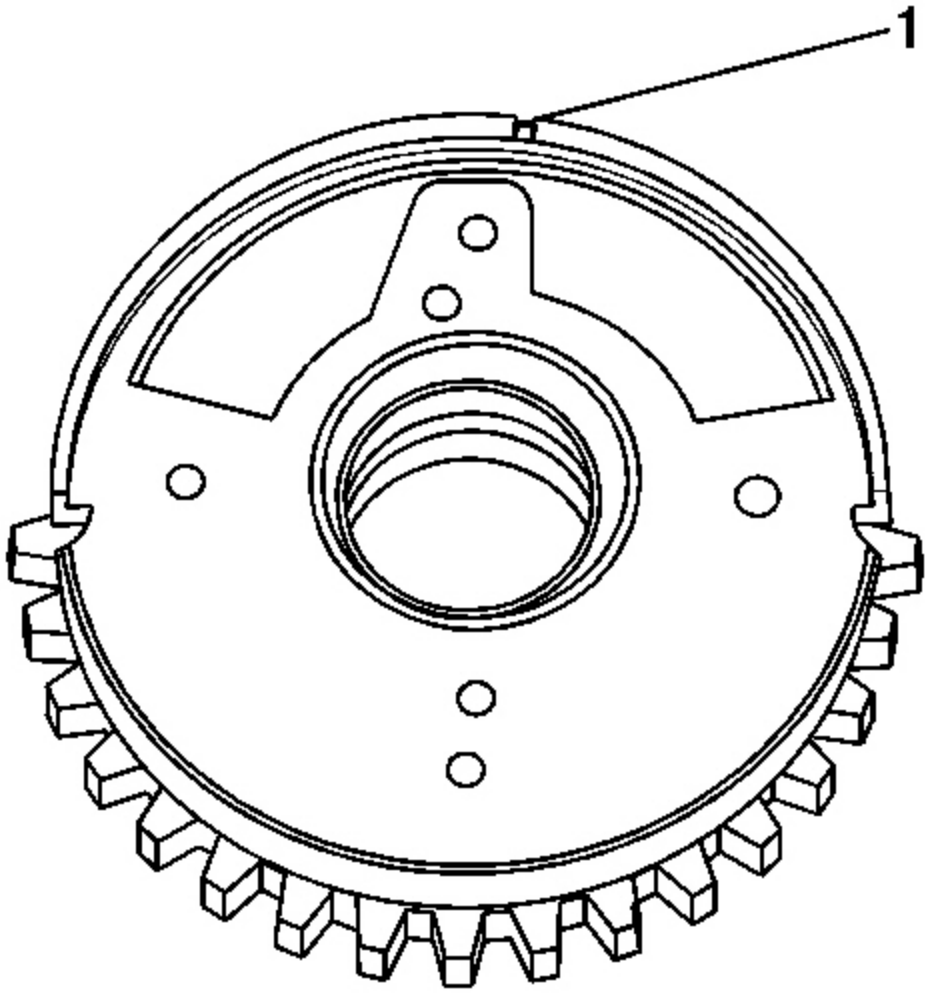


Fig. 35: Locating Timing Mark On Front Of Actuator
Courtesy of GENERAL MOTORS CORP.

2. Locate the timing alignment mark (1) on the front of the actuator.

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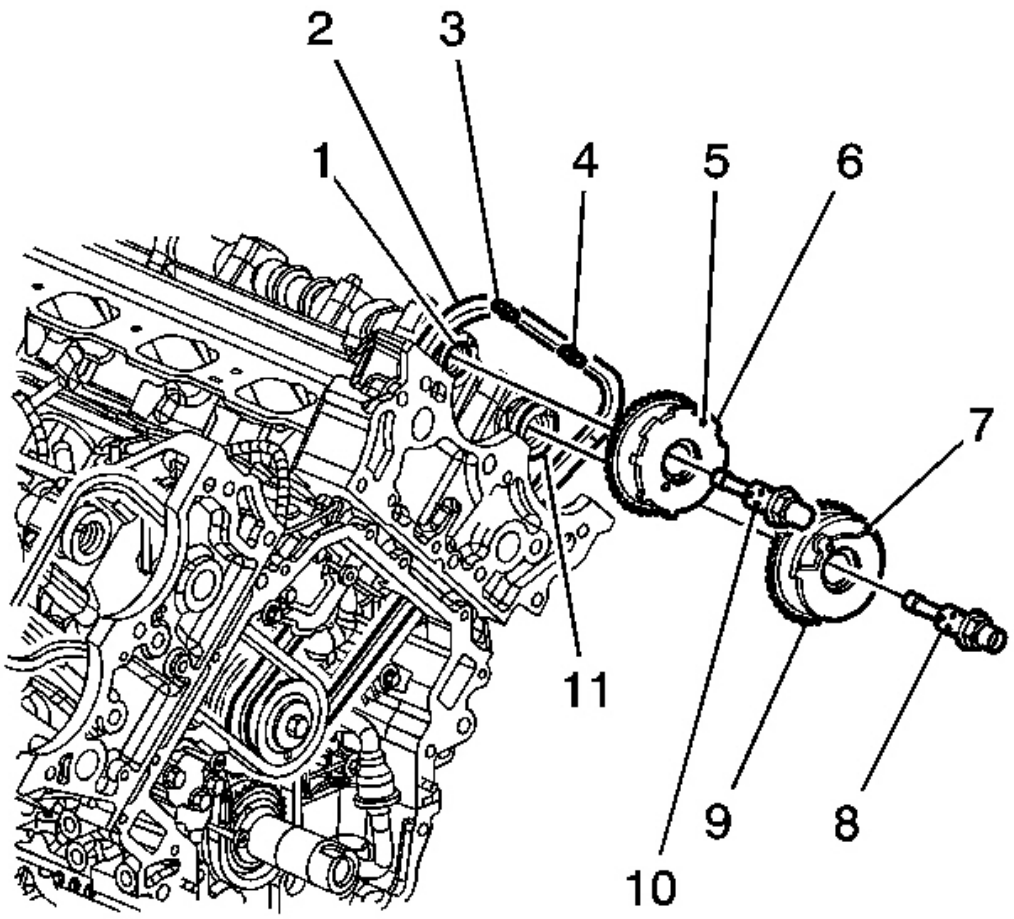


Fig. 36: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Engage the actuator timing gear teeth with the secondary timing chain ensuring that the actuator alignment mark (7) corresponds with the paint mark created on the chain link.
4. Slide the actuator over the camshaft alignment pin and install the actuator onto the camshaft.
5. Install the left exhaust camshaft position actuator oil control valve (8). Refer to **Camshaft Position Actuator Oil Control Valve Replacement - Bank 2 (Left Side) Exhaust**.

SETTING CAMSHAFT TIMING

TOOLS REQUIRED

J 39946 Crankshaft Socket. See **Special Tools** .

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Setting the camshaft timing is necessary whenever the camshaft drive system has been disturbed such that the alignment relationship between any chain and sprocket has been lost.

The crankshaft and camshafts are correctly timed when the crank sprocket and the intermediate shaft sprocket have their timing marks aligned and all 4 camshaft position actuator timing marks are perpendicular (90 degrees) to the cylinder head deck surface at the top of their rotation. The black timing chain links are used for assembly purposes. Do not reference these black links to determine if the engine timing components are properly aligned. The black links will only align with the actuator timing marks and the intermediate shaft sprocket, once every 126 revolutions. For this reason, it is not necessary to have the black secondary chain links aligned with the timing marks when servicing only one of the secondary timing components. Proper alignment is maintained by marking a chain link and sprocket gear tooth with a paint stick prior to disassembling individual components. When servicing individual components, refer to the appropriate procedure.

TIMING PROCEDURE

1. Remove the following components for access to the timing chains:
    - The left camshaft actuator housing-Refer to **Camshaft Position Actuator Housing Replacement - Left Side** .
    - The right camshaft actuator housing-Refer to **Camshaft Position Actuator Housing Replacement - Right Side** .
    - The engine front cover-Refer to **Engine Front Cover Replacement** .
    - The engine oil pump-Refer to **Oil Pump Replacement** .
    - The right secondary camshaft drive chain-Refer to **Secondary Camshaft Drive Chain Replacement - Right Side** .
    - The left secondary camshaft drive chain-Refer to **Secondary Camshaft Drive Chain Replacement - Left Side** .

IMPORTANT: The primary gears and chain must be properly timed prior to setting the left or right secondary camshaft timing.

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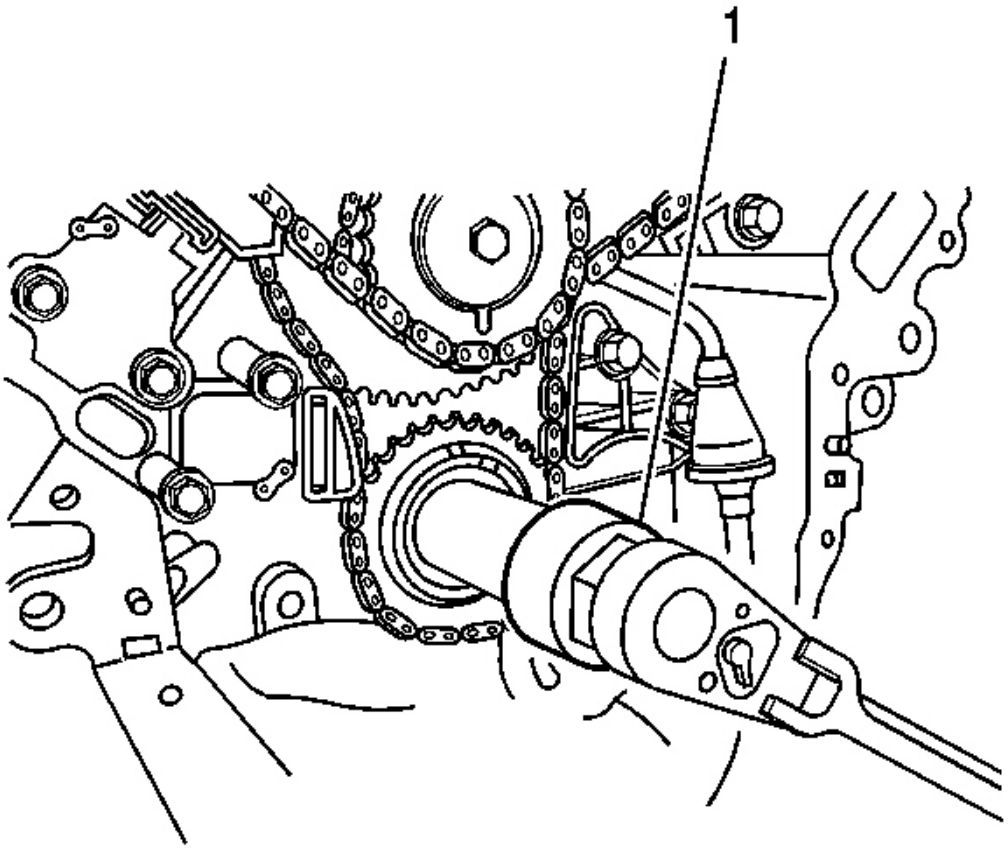


Fig. 37: Rotating Crankshaft Using J 39946
Courtesy of GENERAL MOTORS CORP.

2. Use the **J 39946** (1) in order to rotate the crankshaft. See **Special Tools** .

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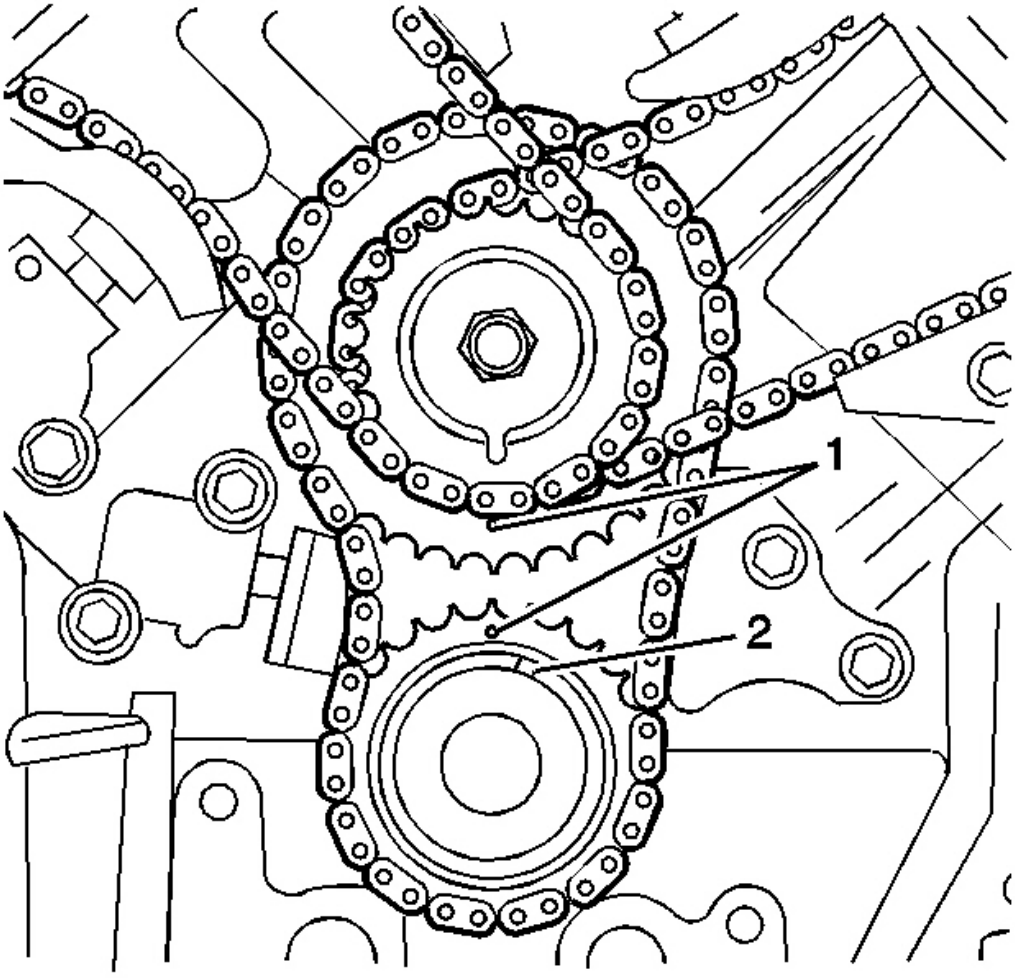


Fig. 38: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

3. Using the **J 39946** , rotate the crankshaft until:
    1. The primary timing gear alignment mark (1) is at the top of its position,
    2. The crankshaft keyway (2) is approximately at the 1 o'clock position,
    3. The intermediate sprocket timing mark (1) is at the bottom of its rotation, adjacent to the crank gear timing mark.

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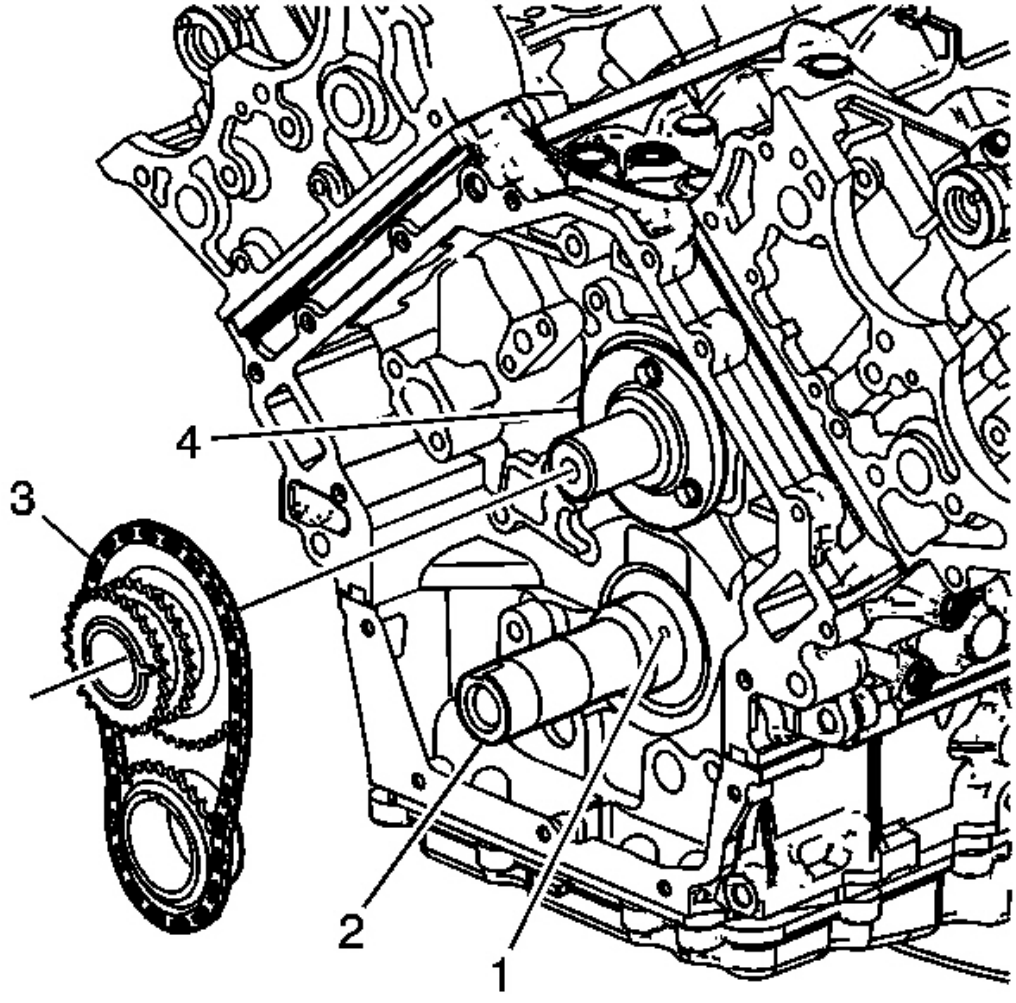


Fig. 39: View Of Primary Camshaft Drive Chain, Intermediate Drive Shaft Sprocket & Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Timing the primary timing gears ensures that the #1 cylinder piston, bank 1 right front cylinder, is at top dead center (TDC) beginning its power stroke event. If this condition can not be accomplished while rotating the crankshaft (2), remove the primary gears and chain (3) and realign the primary timing marks. Refer to **Primary Camshaft Drive Chain Removal** and **Primary Camshaft Drive Chain Installation** .

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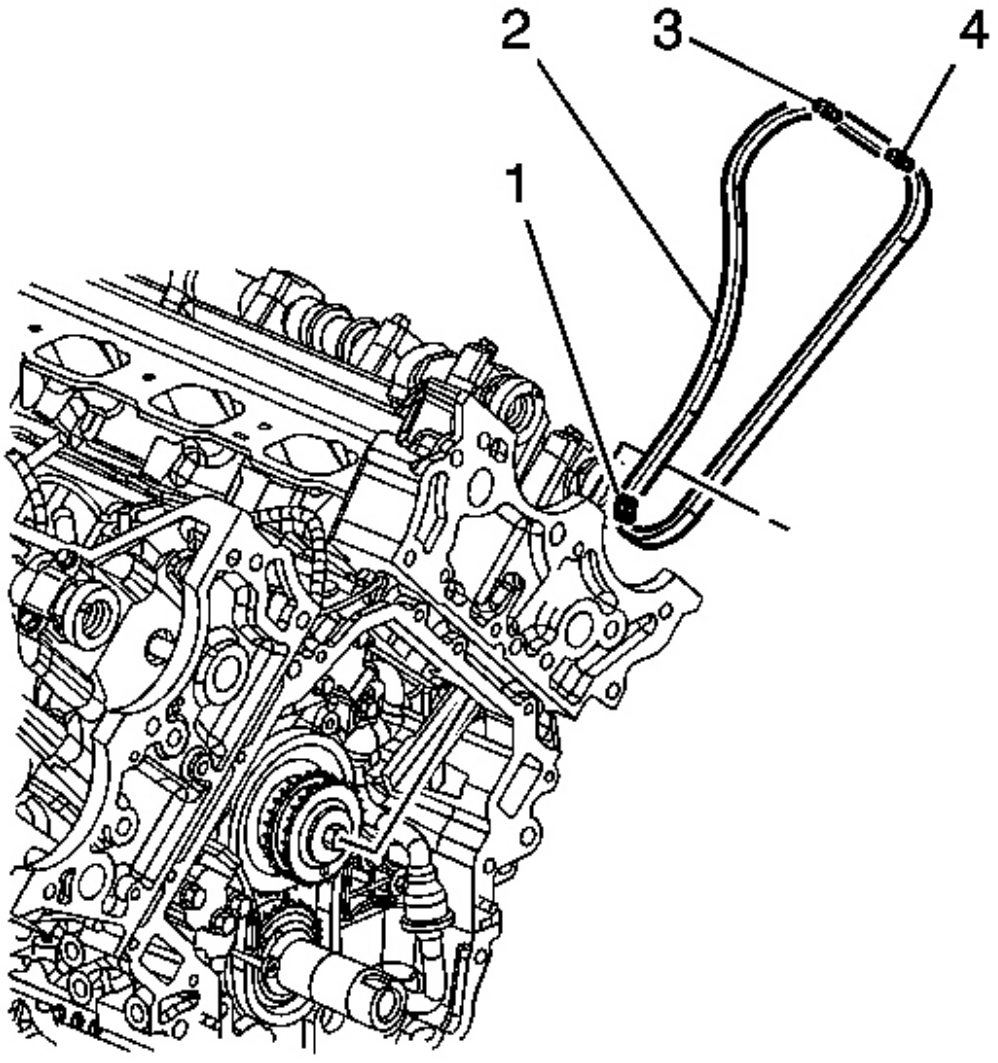


Fig. 40: Identifying Secondary Timing Chain Timing Marks
Courtesy of GENERAL MOTORS CORP.

5. The left bank 2 secondary timing chain (2) has 3 black links that aid in timing the camshaft position actuators to the intermediate sprocket.
6. The black link (4) is aligned with the bank 2 exhaust actuator timing mark. The black link (3) is aligned with the bank 2 intake actuator timing mark.
7. The black link (1) is aligned with the intermediate sprocket.

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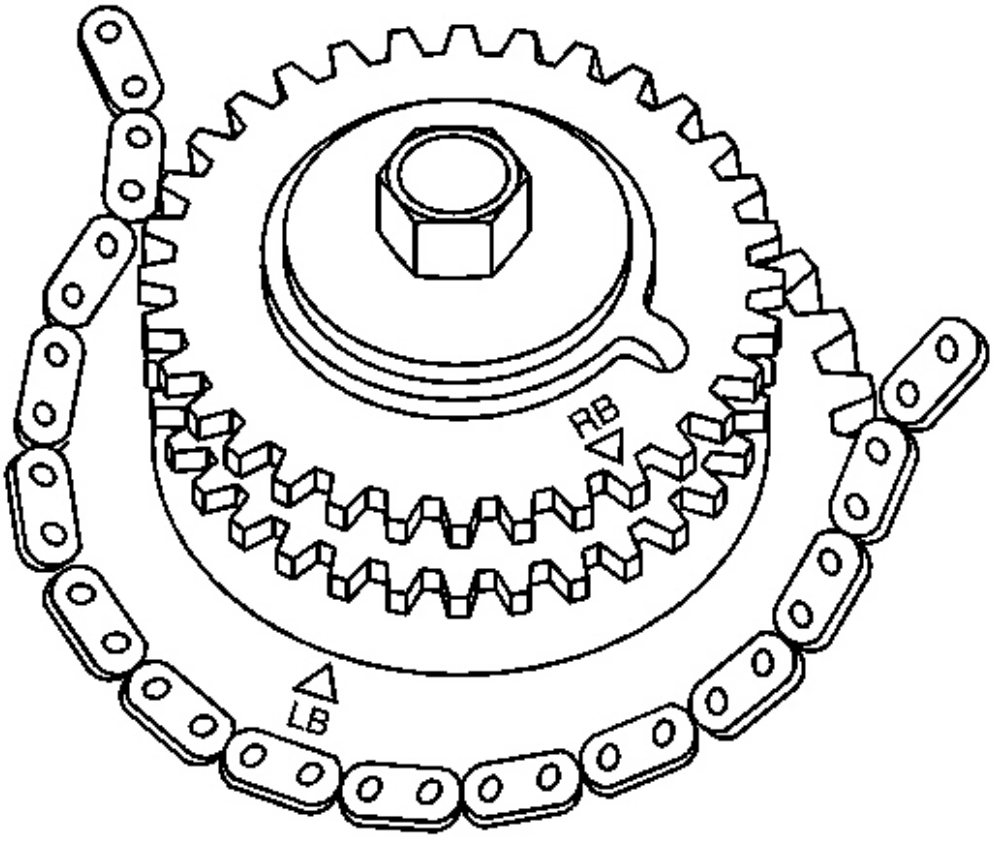


Fig. 41: Aligning Sprocket LB Timing Mark To Timing Chain Black Link
Courtesy of GENERAL MOTORS CORP.

8. The intermediate sprocket left bank 2 timing mark is labeled left bank (LB) as shown.
9. Assemble the secondary timing chain to the intermediate sprocket aligning the sprocket LB timing mark to the timing chain black link.

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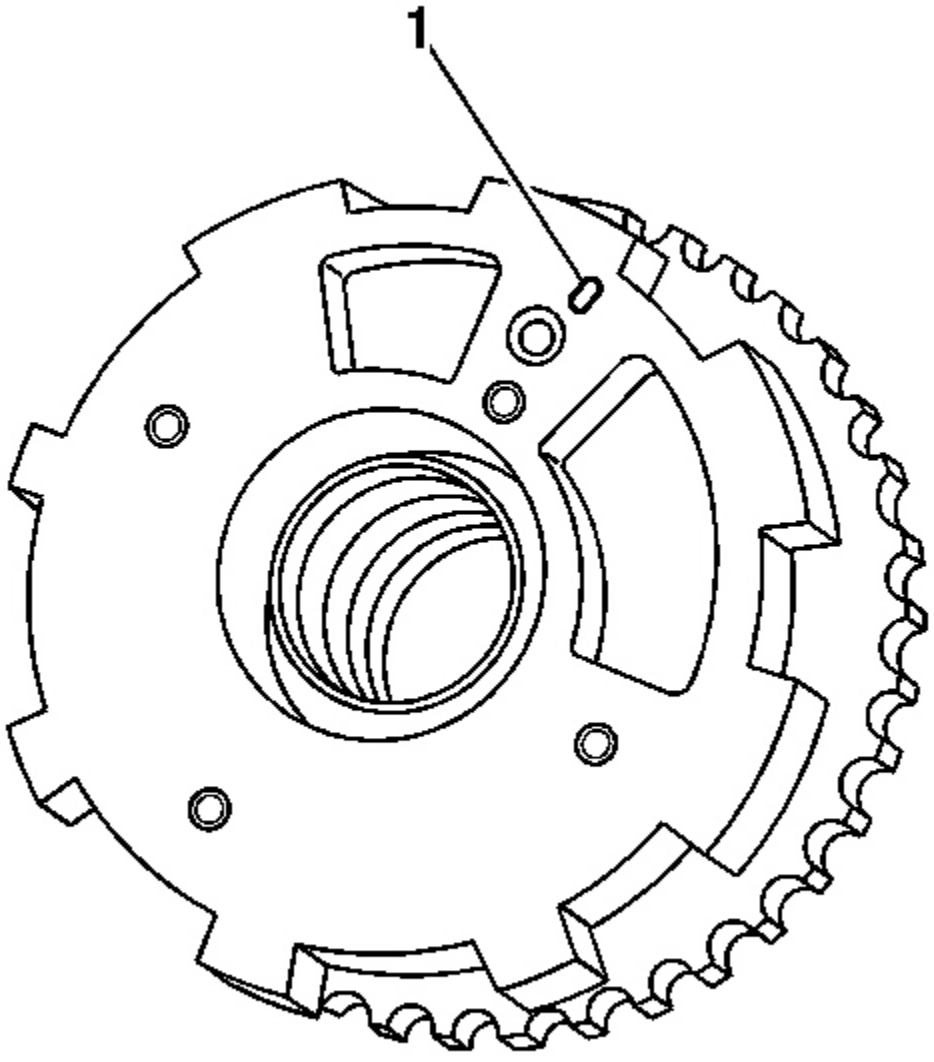


Fig. 42: Locating Timing Alignment Mark On Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

10. Locate the timing mark (1) on the front of the intake actuator marked LI which stands for left intake.

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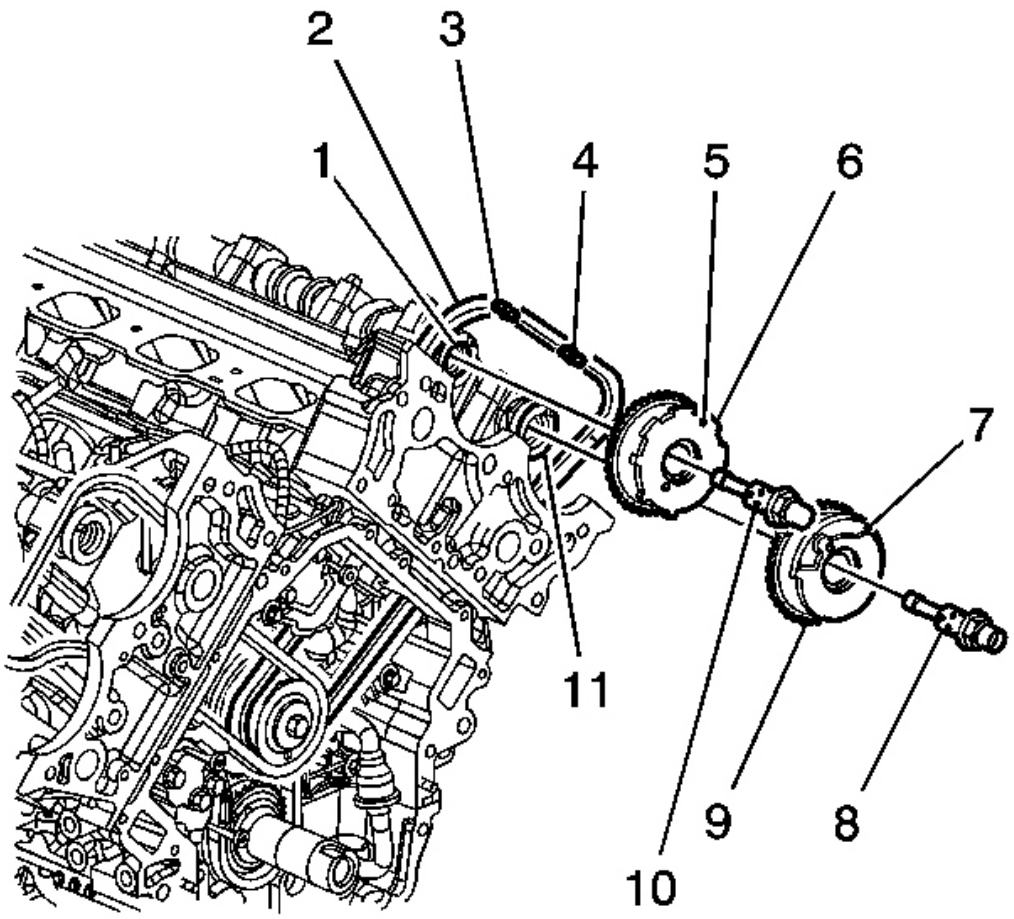


Fig. 43: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

11. Align the timing mark (5) of the left bank intake camshaft position actuator with the timing chain black link (3) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface at the top of its rotation. Ensure that the camshaft alignment pin hole on the rear of the actuator engages with the camshaft alignment pin. If necessary, use an open-end wrench on the hex cast into the camshaft to obtain proper camshaft pin to actuator engagement.
12. Loosely install the oil control valve (10) to secure the intake actuator.

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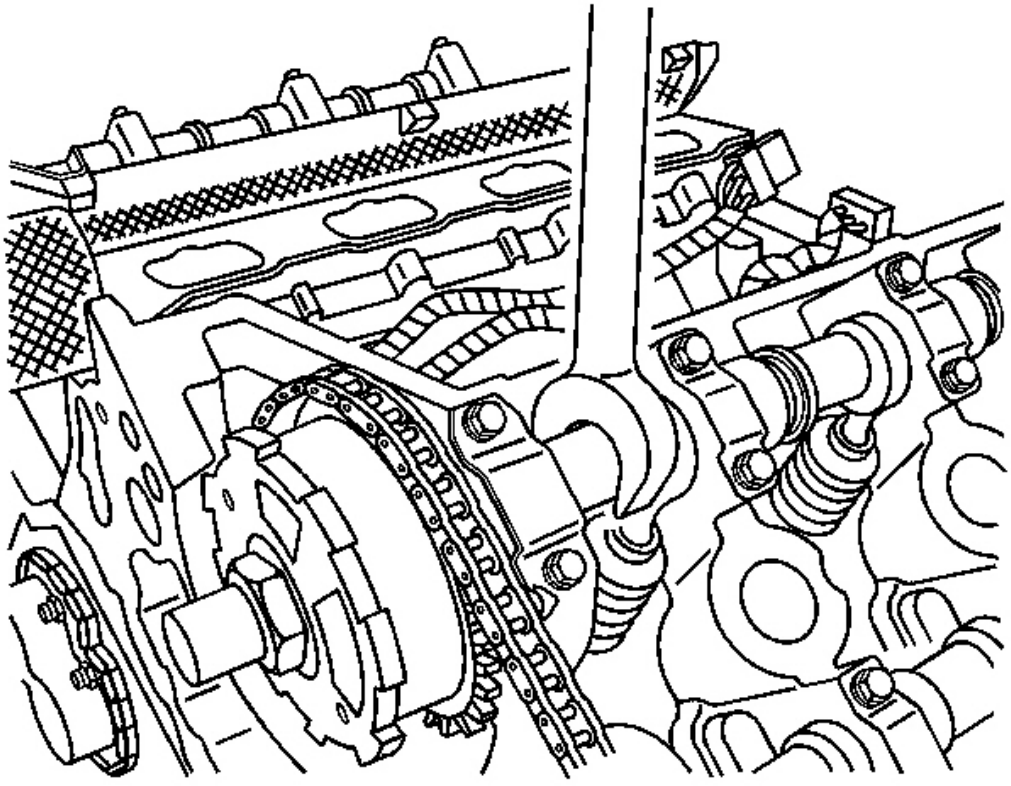


Fig. 44: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice .**

NOTE: **Refer to Fastener Notice .**

13. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

    Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

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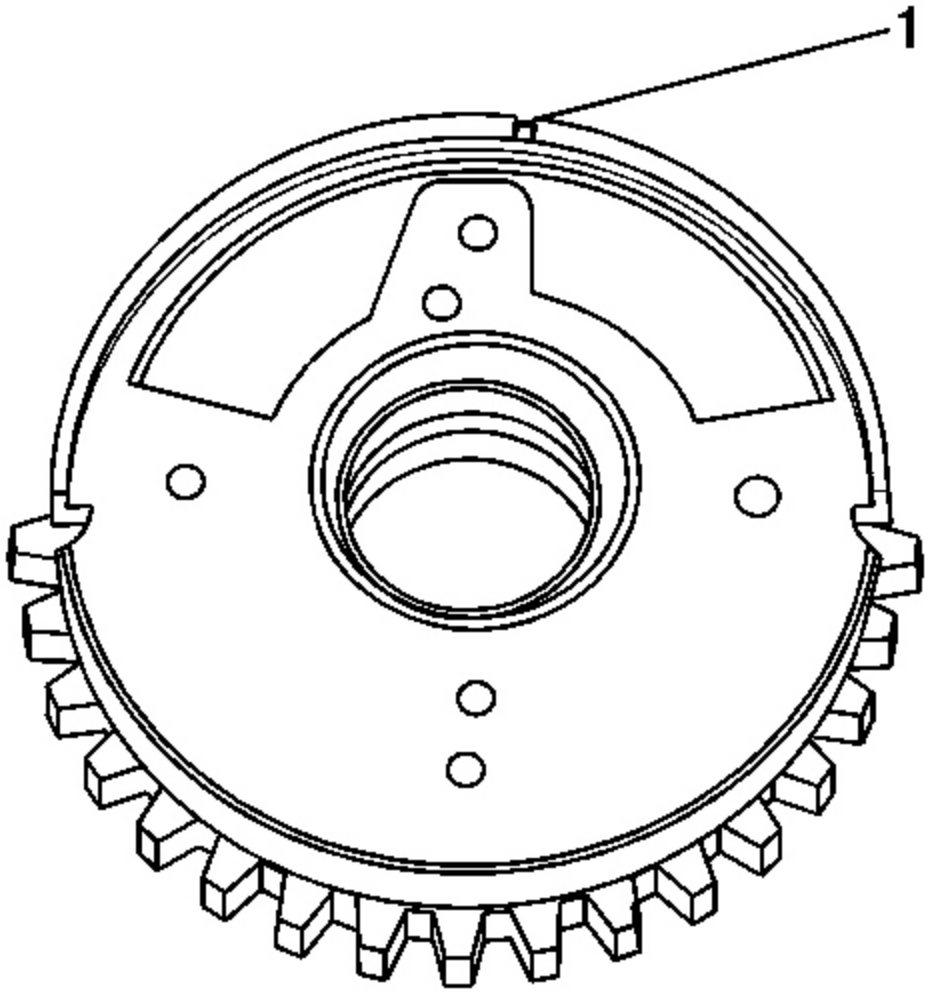


Fig. 45: Locating Timing Mark On Front Of Actuator
Courtesy of GENERAL MOTORS CORP.

14. Locate the timing mark (1) on the front of the exhaust actuator marked LE which stands for left exhaust.

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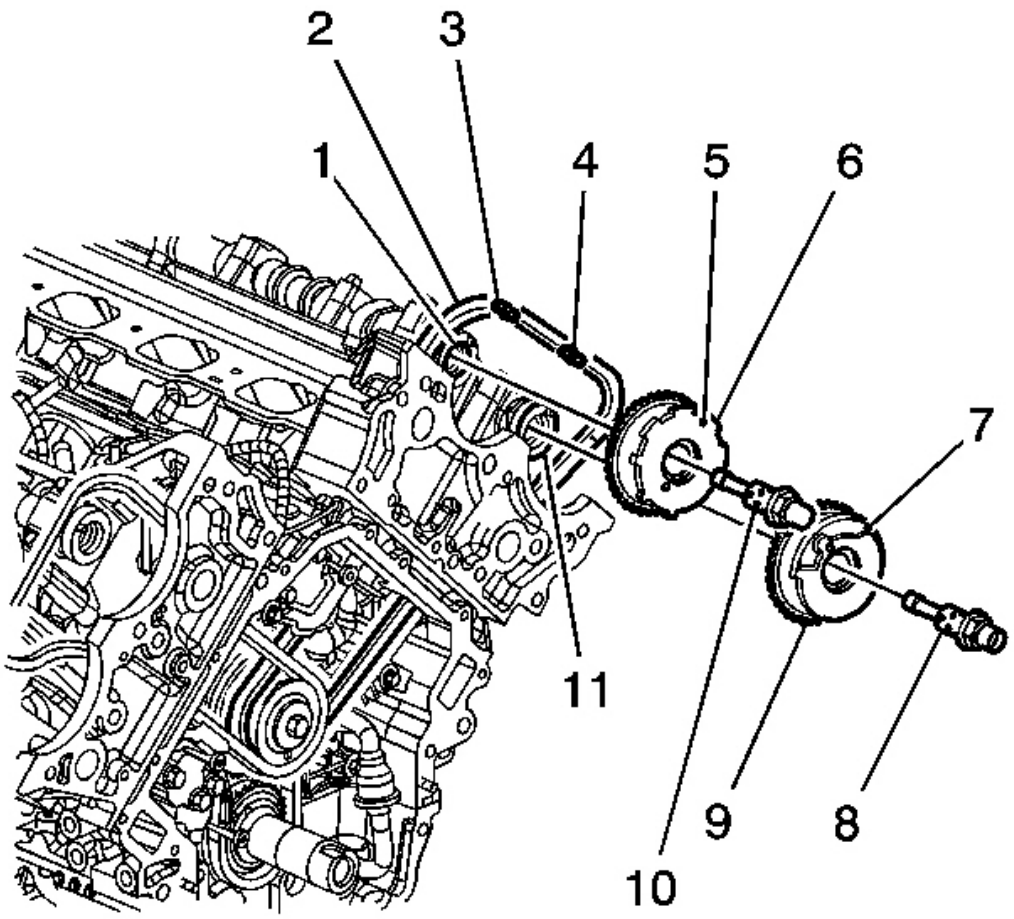


Fig. 46: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

15. Align the timing mark (7) of the left bank exhaust camshaft position actuator with the timing chain black link (4) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface at the top of its rotation. Ensure that the camshaft alignment pin hole on the rear of the actuator engages with the camshaft alignment pin. If necessary, use an open-end wrench on the hex cast into the camshaft to obtain proper camshaft pin to actuator engagement.
16. Loosely install the oil control valve (8) to secure the exhaust actuator.

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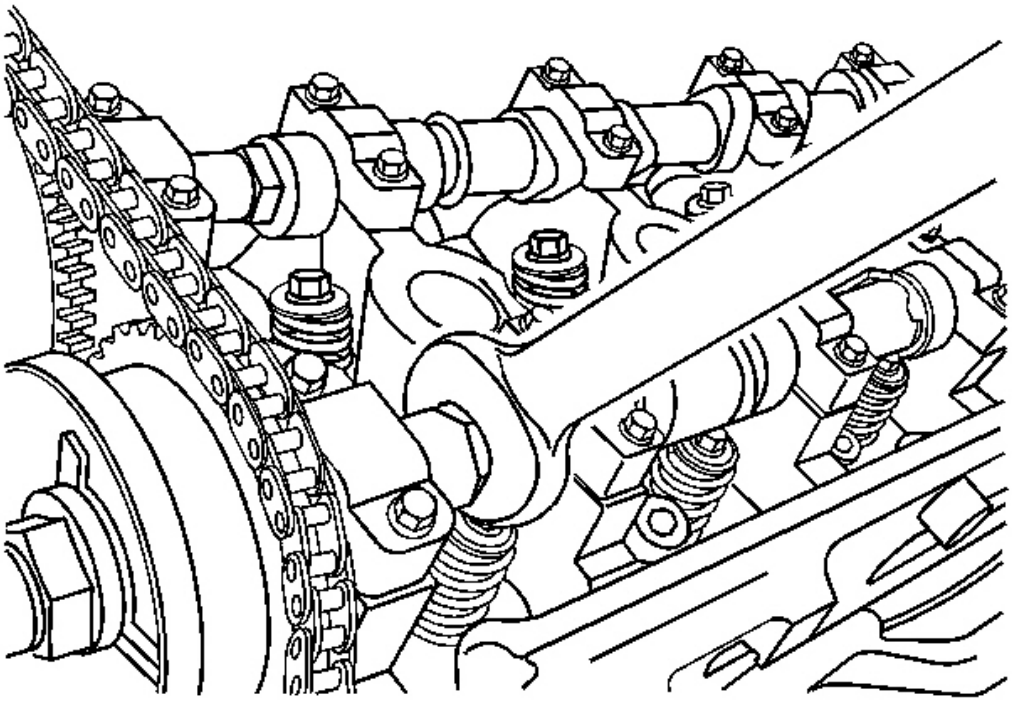


Fig. 47: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

17. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

    Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

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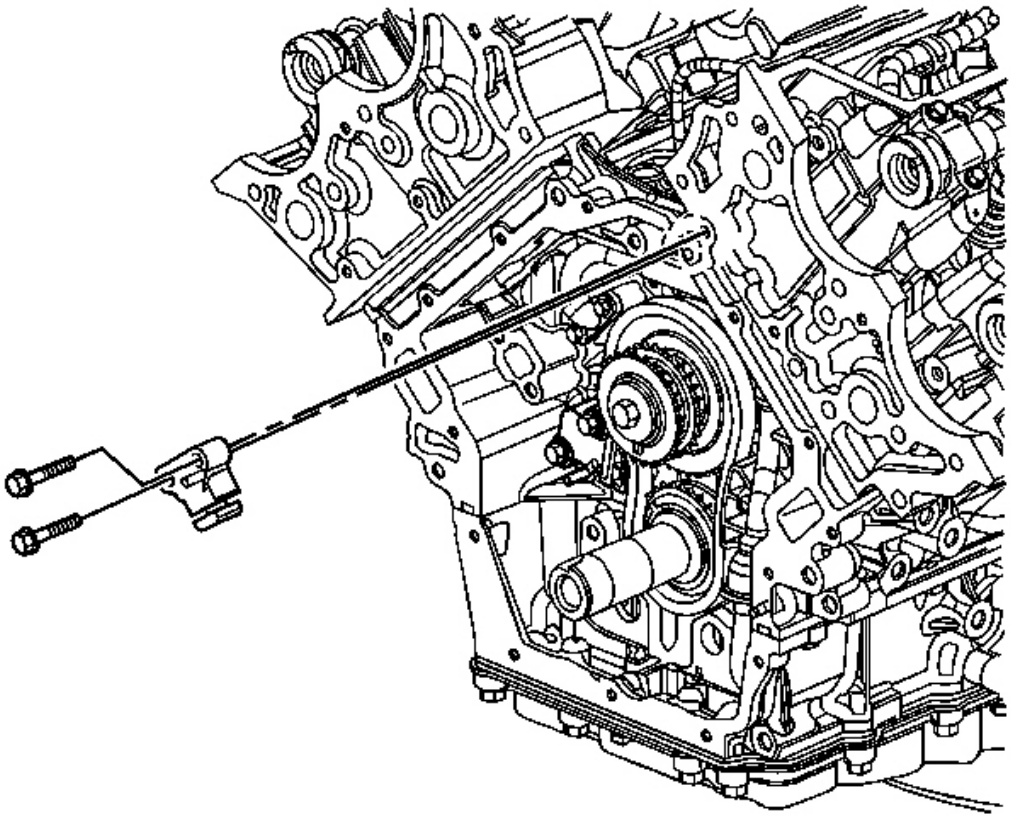


Fig. 48: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

18. Install the left secondary timing chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left Side** .

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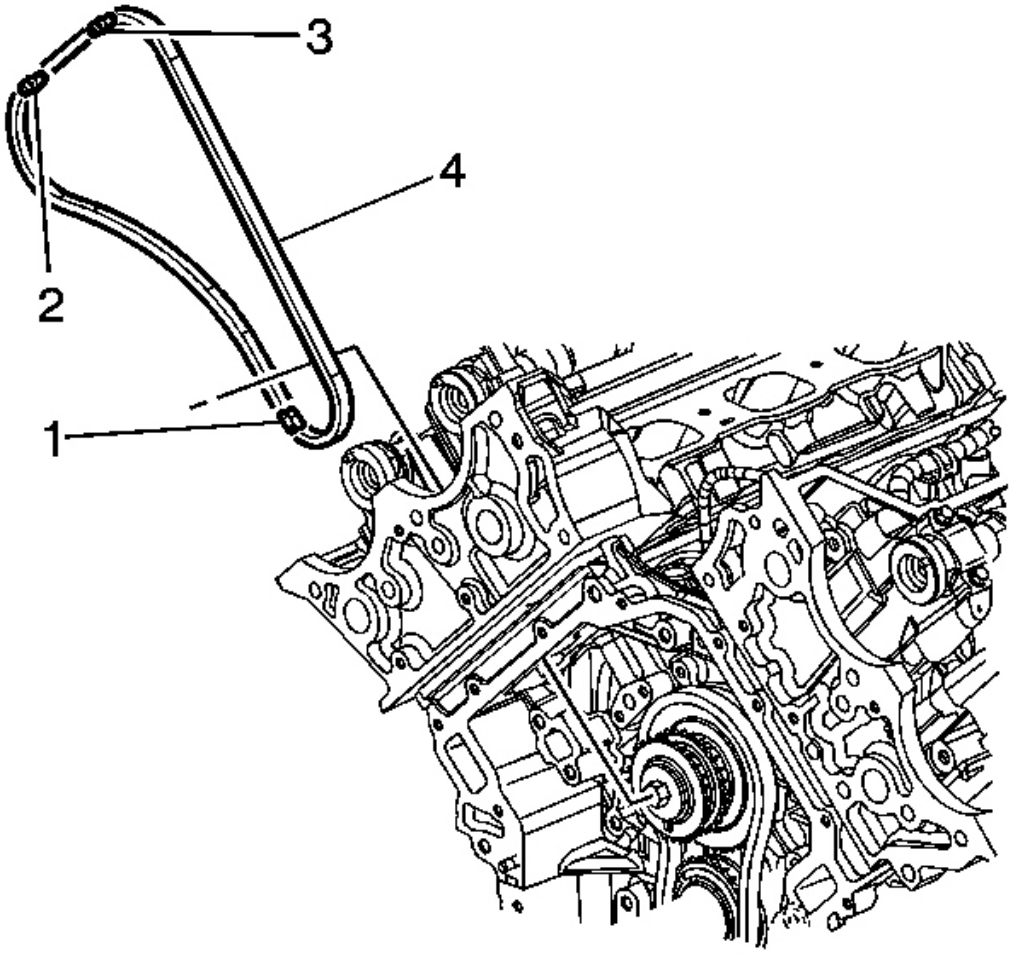


Fig. 49: Identifying Secondary Timing Chain Black Links
Courtesy of GENERAL MOTORS CORP.

19. The right bank 1 secondary timing chain has 3 black links that aid in timing the camshaft position actuators to the intermediate sprocket.
20. The black link (2) is aligned with the bank 1 exhaust actuator timing mark. The black link (3) is aligned with the bank 1 intake actuator timing mark.
21. The black link (1) is aligned with the intermediate sprocket.

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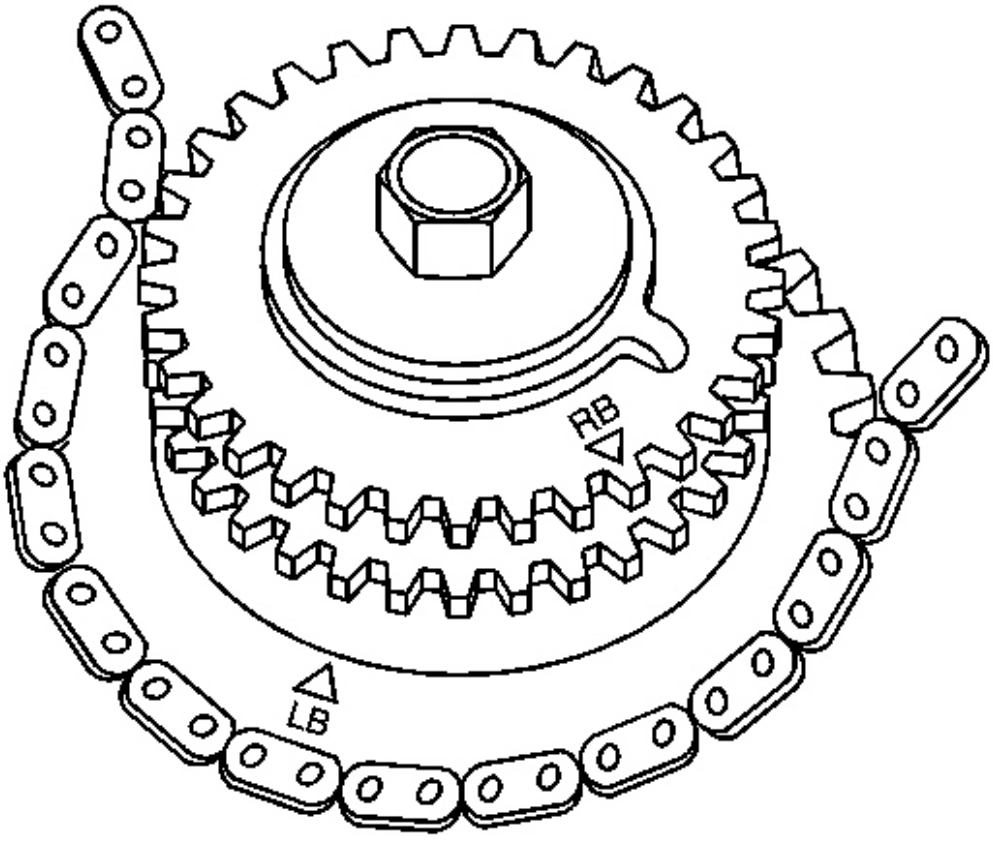


Fig. 50: Aligning Sprocket LB Timing Mark To Timing Chain Black Link
Courtesy of GENERAL MOTORS CORP.

22. The intermediate sprocket right bank timing mark is labeled right bank (RB) as shown.
23. Assemble the secondary timing chain to the intermediate sprocket aligning the sprocket RB timing mark to the timing chain black link.

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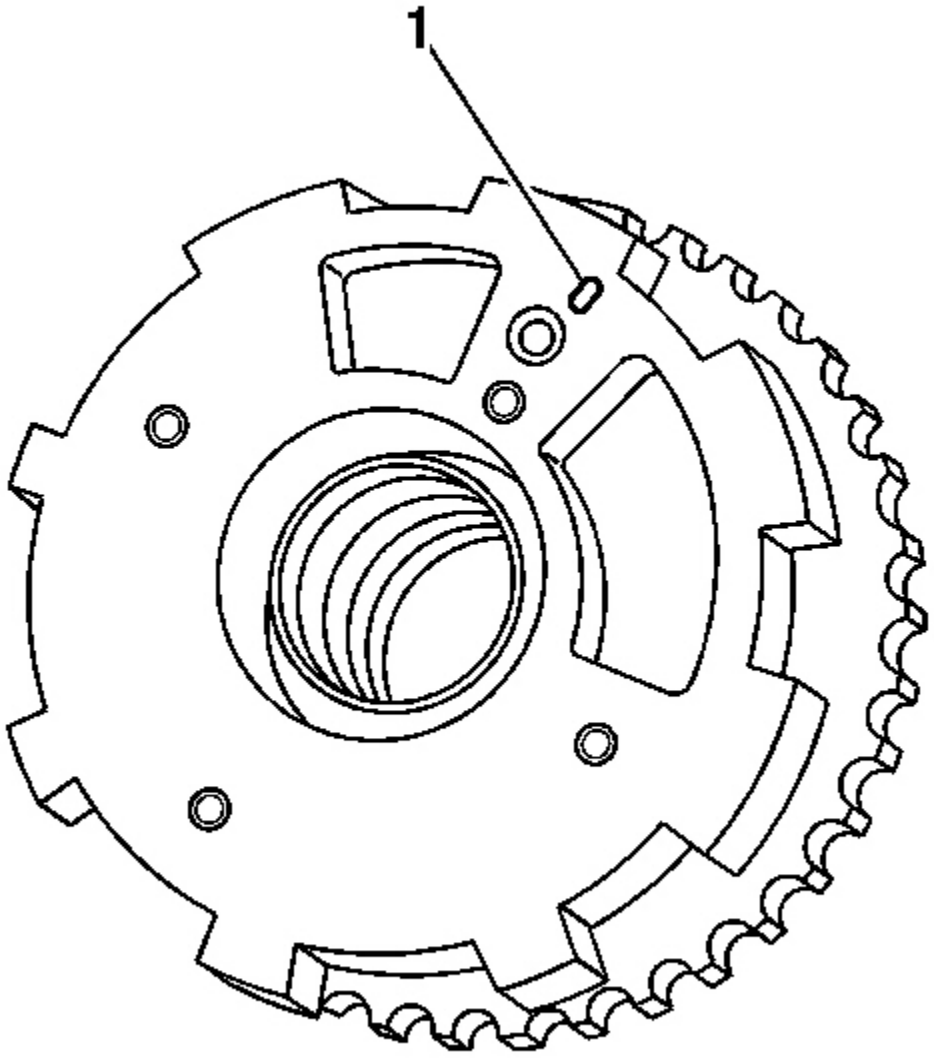


Fig. 51: Locating Timing Alignment Mark On Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

24. Locate the timing mark (1) on the intake actuator marked RI which stands for right intake.

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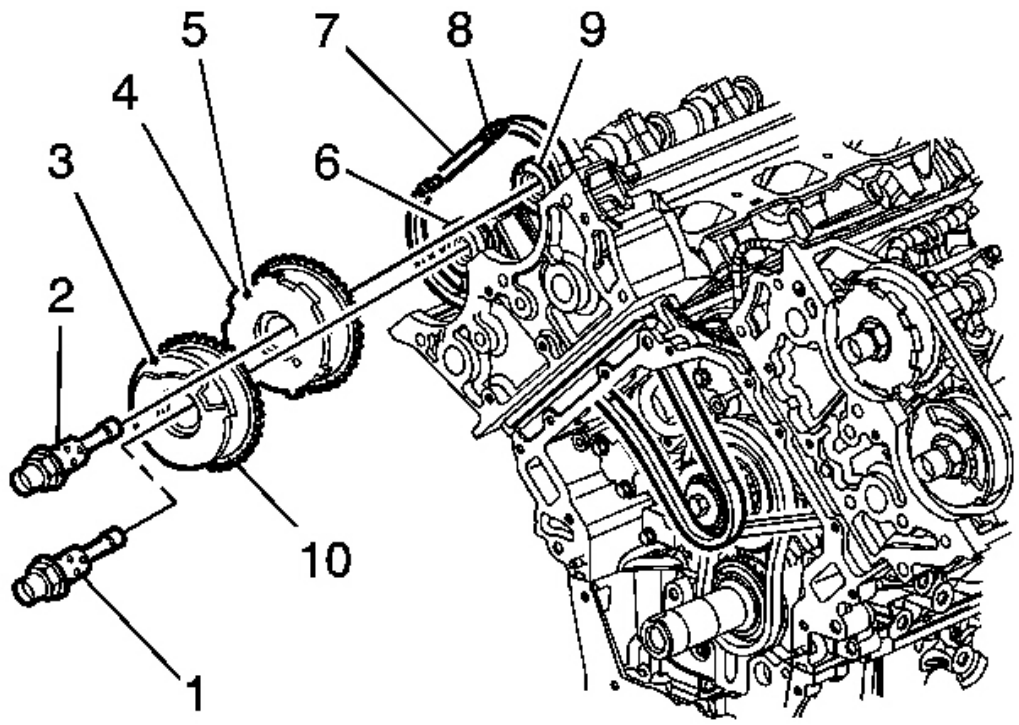


Fig. 52: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

25. Align the timing mark (5) of the right bank intake camshaft position actuator with the timing chain black link (8) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface near the top of its rotation. Ensure that the camshaft alignment pin hole on the rear of the actuator engages with the camshaft alignment pin. If necessary, use an open-end wrench on the hex cast into the camshaft to obtain proper camshaft pin to actuator engagement.
26. Loosely install the oil control valve (2) to secure the intake actuator.

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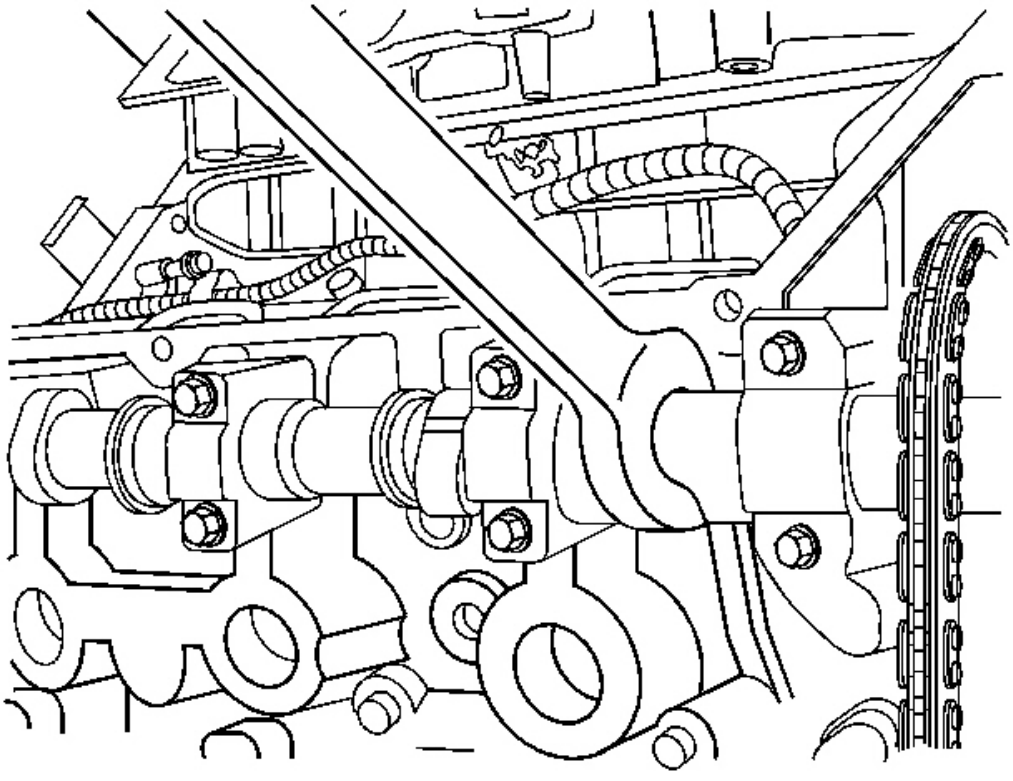


Fig. 53: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

27. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

    Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

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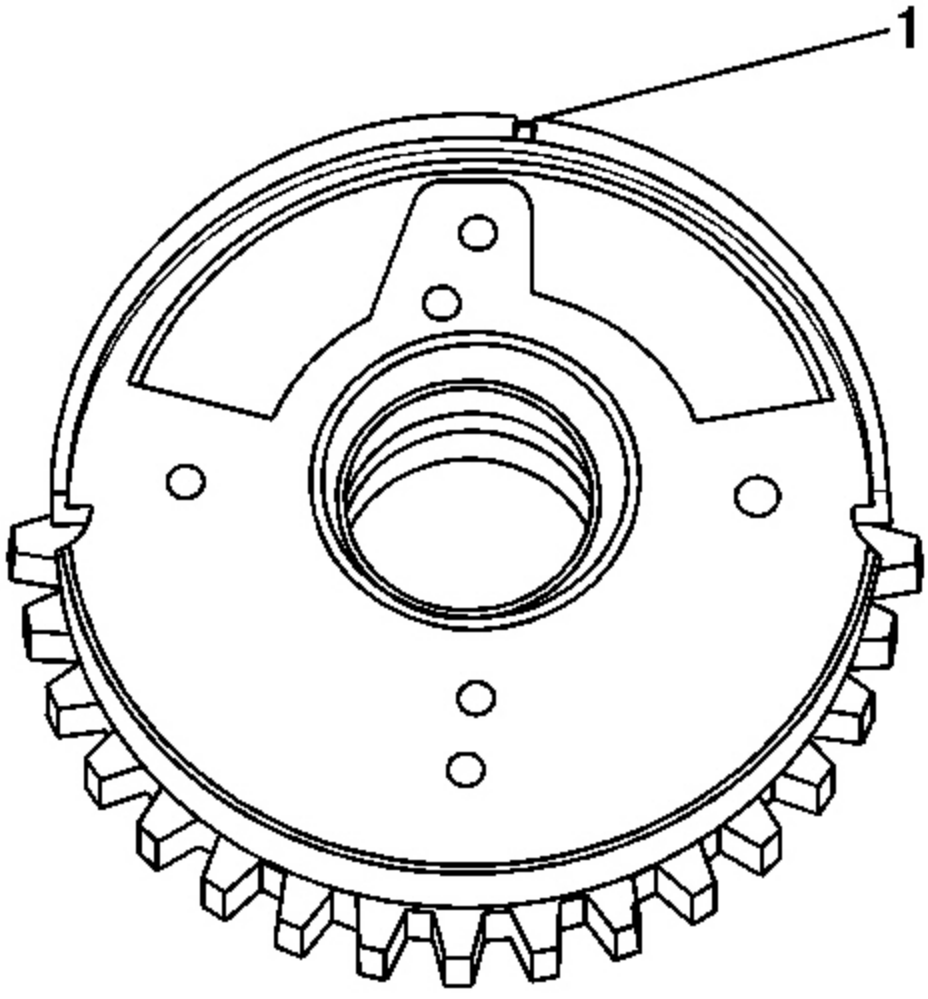


Fig. 54: Locating Timing Mark On Front Of Actuator
Courtesy of GENERAL MOTORS CORP.

28. Locate the timing mark (1) on the actuator marked RE which stands for right exhaust.

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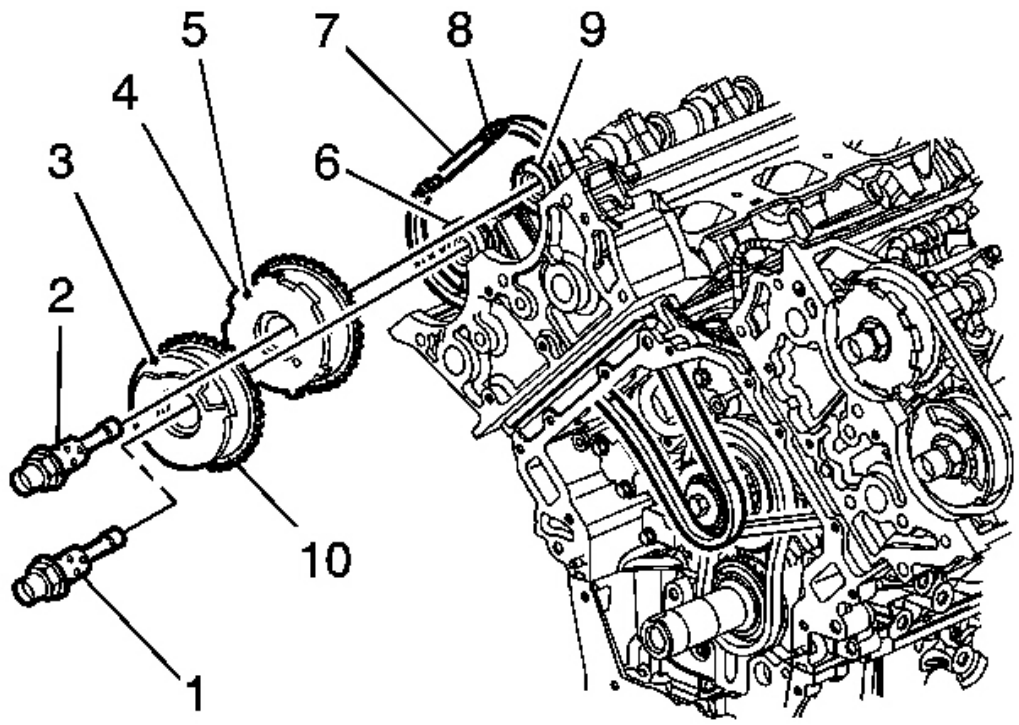


Fig. 55: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

29. Align the timing mark (3) of the right bank exhaust camshaft position actuator with the timing chain black link and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface near the top of its rotation. Ensure that the camshaft alignment pin hole on the rear of the actuator engages with the camshaft alignment pin. If necessary, use an open-end wrench on the hex cast into the camshaft to obtain proper camshaft pin to actuator engagement.
30. Loosely install the oil control valve (1) to secure the exhaust actuator.

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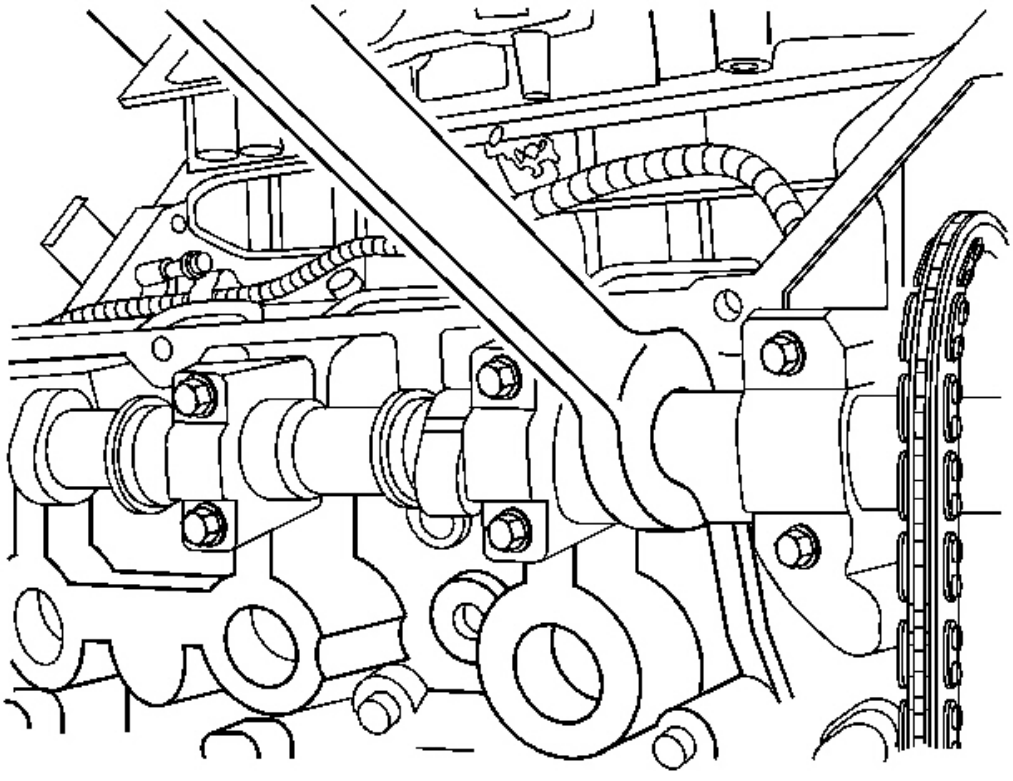


Fig. 56: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

31. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

    Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

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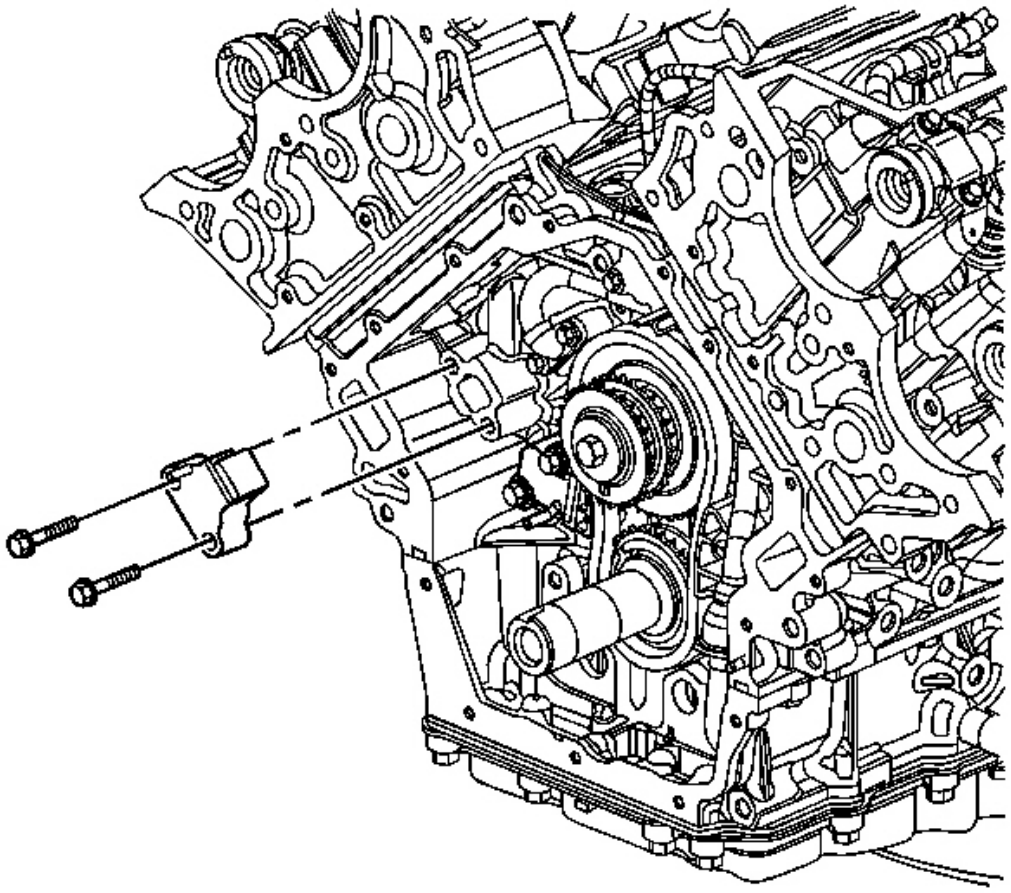


Fig. 57: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

32. Install the right secondary timing chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right Side** .
33. Remove the camshaft holding tools.

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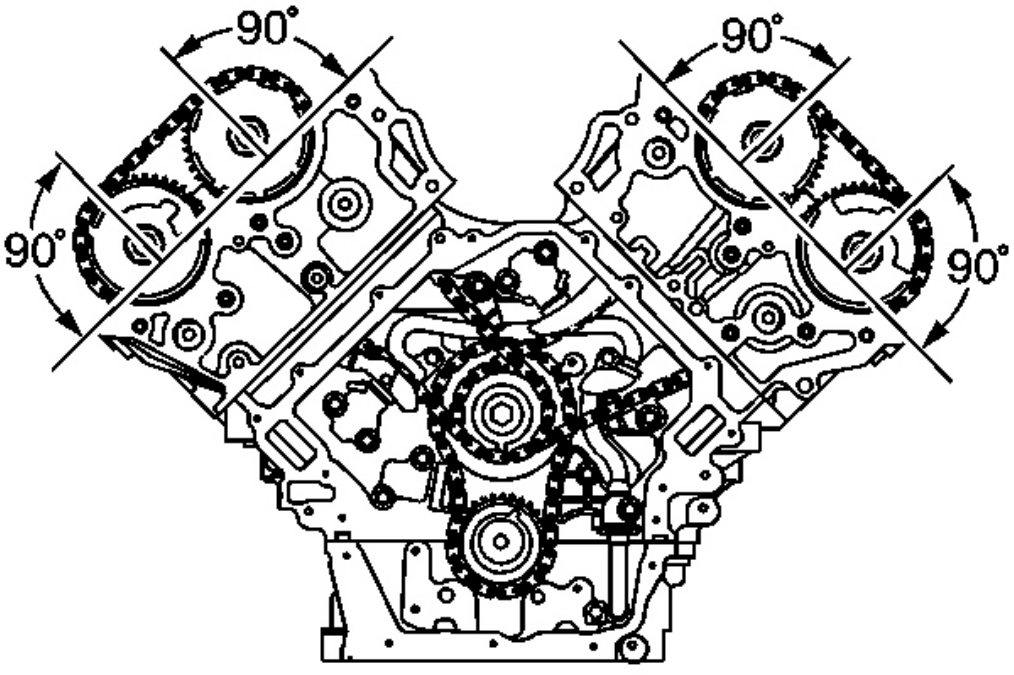


Fig. 58: Ensuring Correct Alignment Of All Secondary Timing Components
Courtesy of GENERAL MOTORS CORP.

34. Ensure the correct alignment of all secondary timing components.

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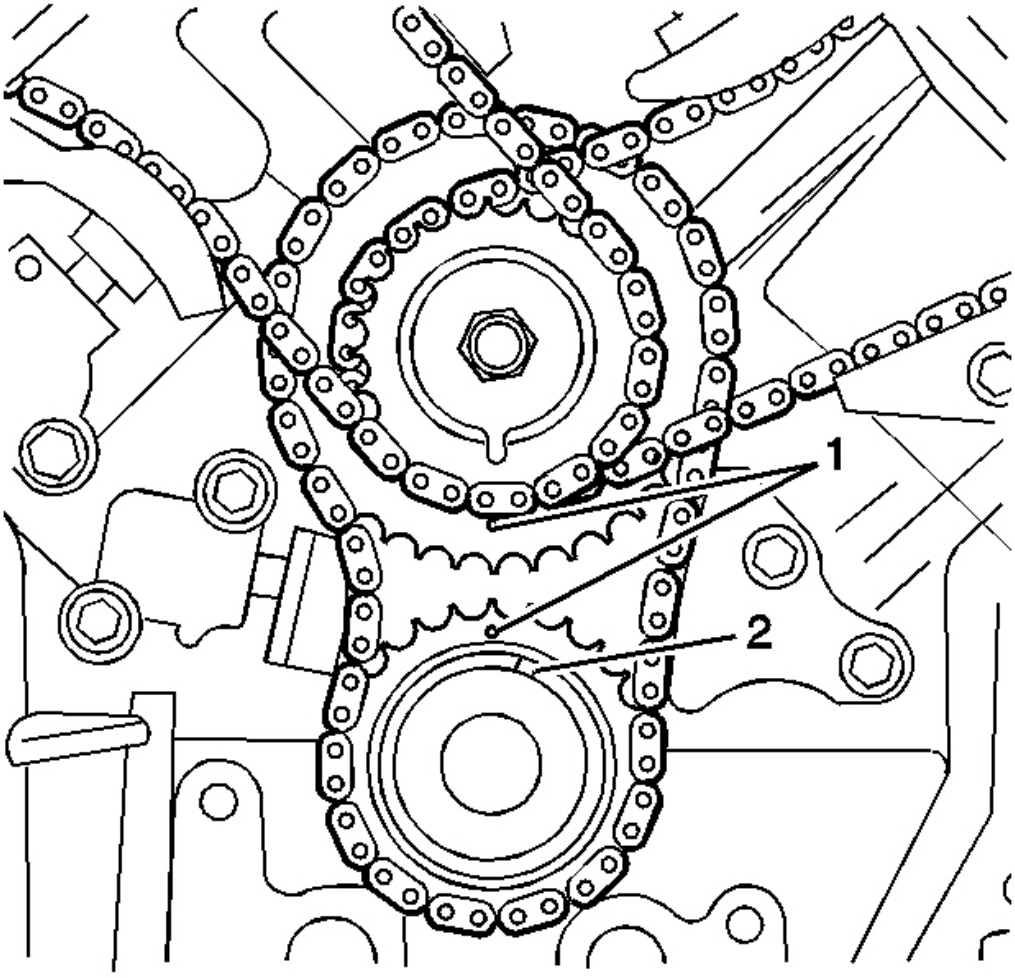


Fig. 59: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

35. Ensure the correct alignment of the primary timing drive components (1).
36. Install the engine oil pump. Refer to **Oil Pump Replacement** .
37. Install the engine front cover. Refer to **Engine Front Cover Replacement** .
38. Install the right camshaft actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Right Side** .
39. Install the left camshaft actuator housing. Refer to **Camshaft Position Actuator Housing Replacement - Left Side** .

CAMSHAFT REPLACEMENT - LEFT SIDE

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REMOVAL PROCEDURE

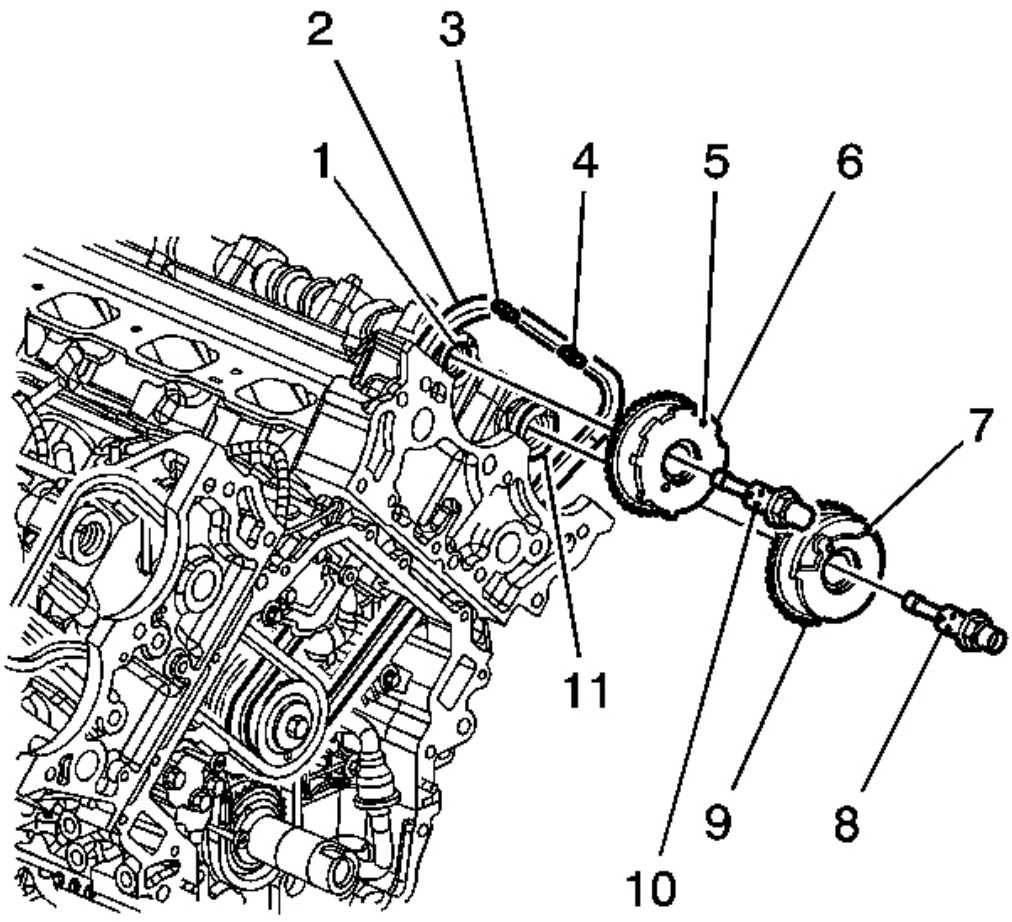


Fig. 60: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the left intake camshaft actuator (6). Refer to **Camshaft Position Actuator Replacement - Bank 2 (Left Side) Intake**.
2. Remove the left exhaust camshaft actuator (9). Refer to **Camshaft Position Actuator Replacement - Bank 2 (Left Side) Exhaust**.

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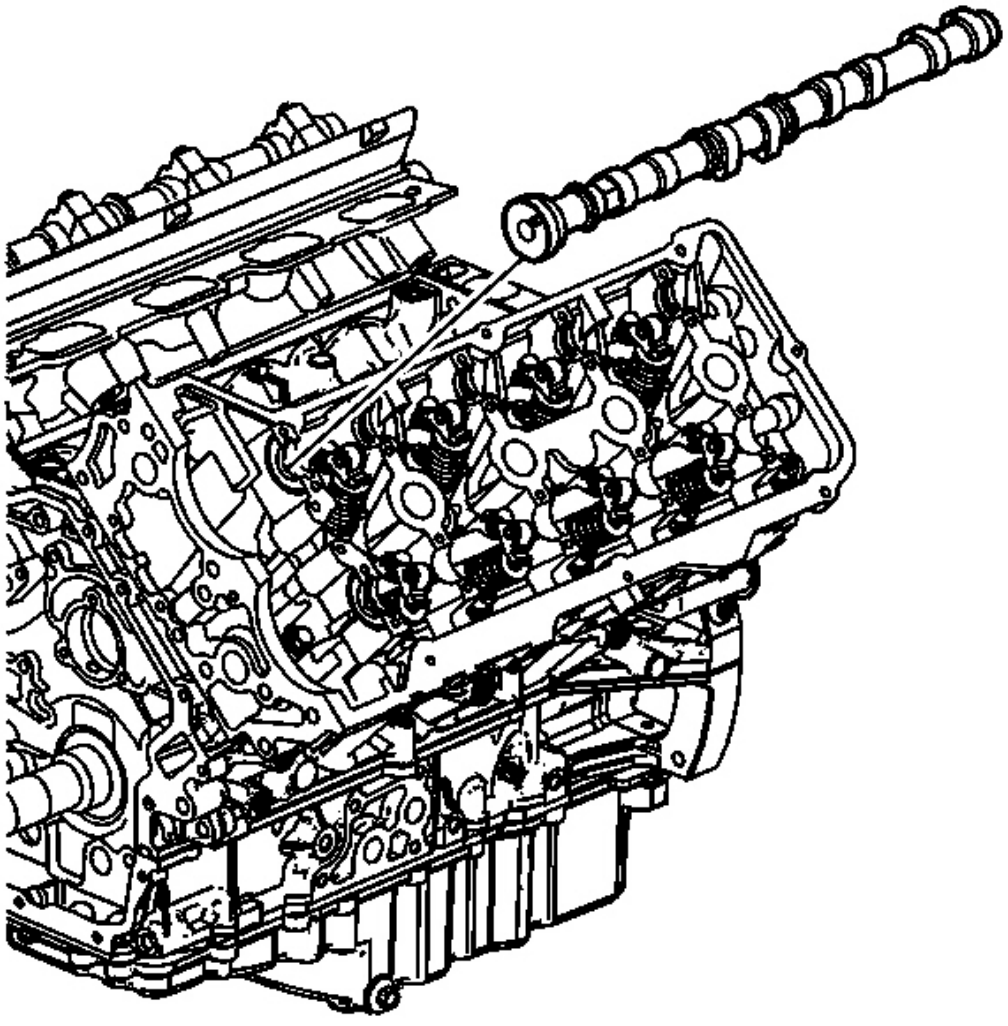


Fig. 61: View Of Left Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

3. Remove the left intake camshaft. Refer to **Intake Camshaft Removal - Left Side** .

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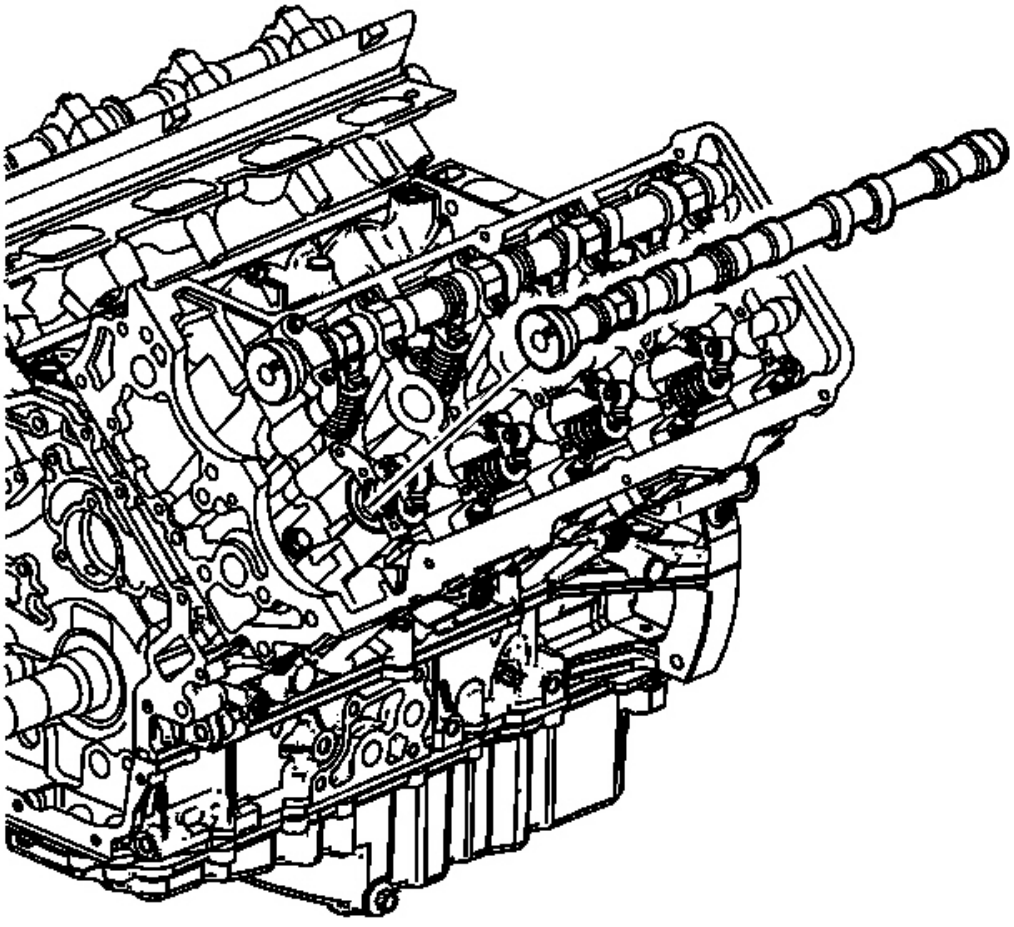


Fig. 62: View Of Left Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Remove the left exhaust camshaft. Refer to **Exhaust Camshaft Removal - Left Side** .
5. Clean and inspect the camshafts. Refer to **Camshaft Cleaning and Inspection** .

INSTALLATION PROCEDURE

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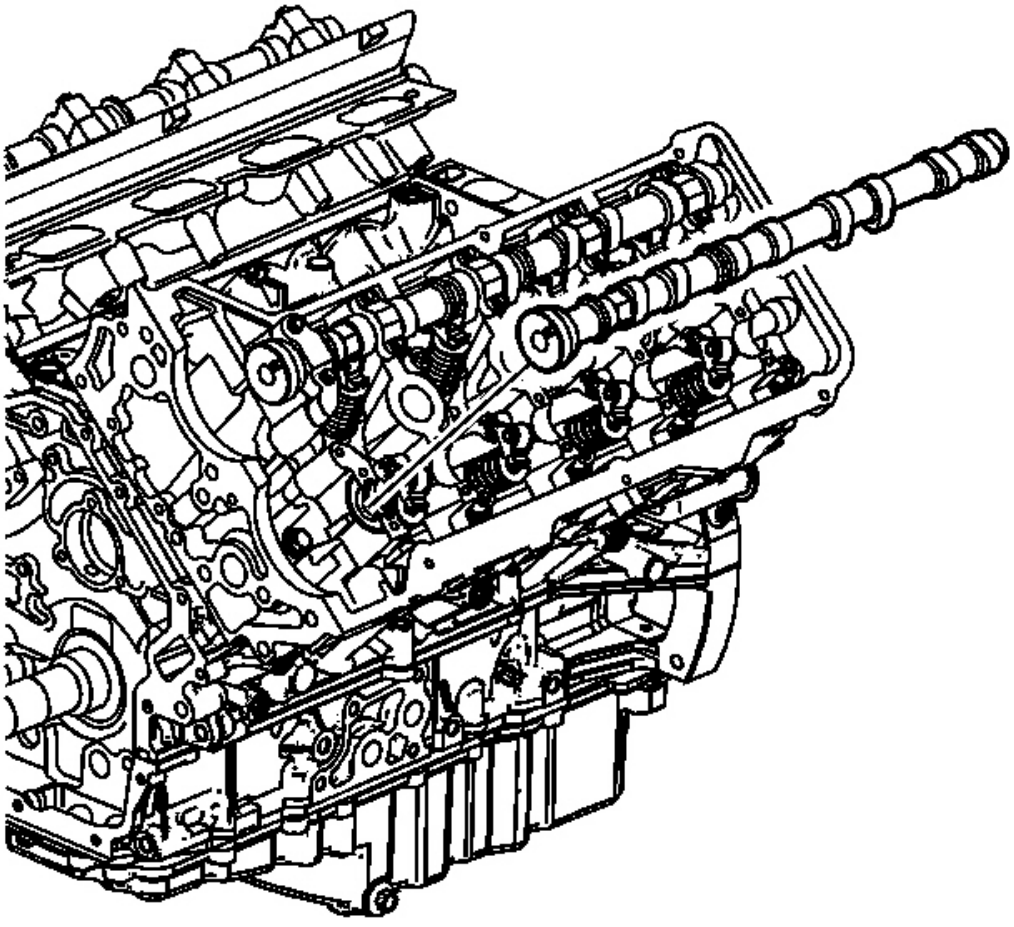


Fig. 63: View Of Left Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

1. Install the left exhaust camshaft. Refer to **Exhaust Camshaft Installation - Left Side** .

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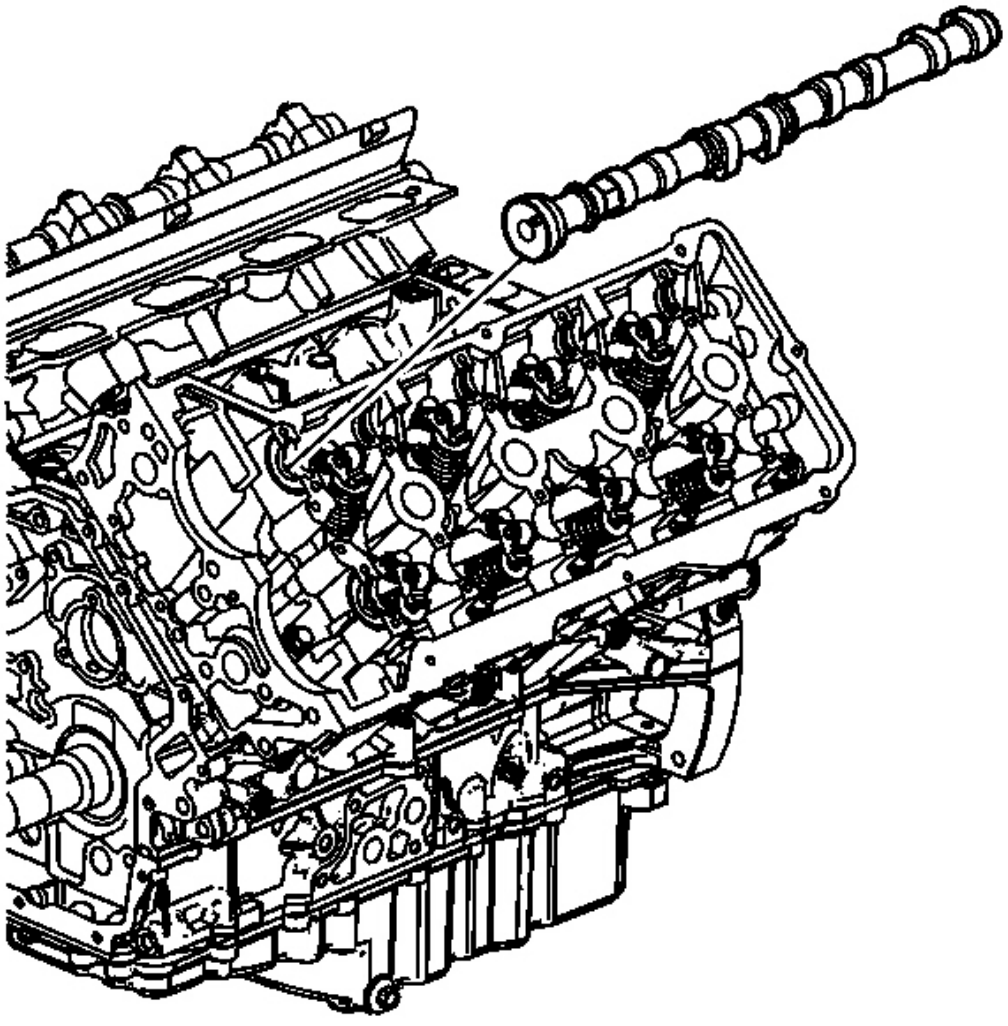


Fig. 64: View Of Left Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

2. Install the left intake camshaft. Refer to **Intake Camshaft Installation - Left Side** .

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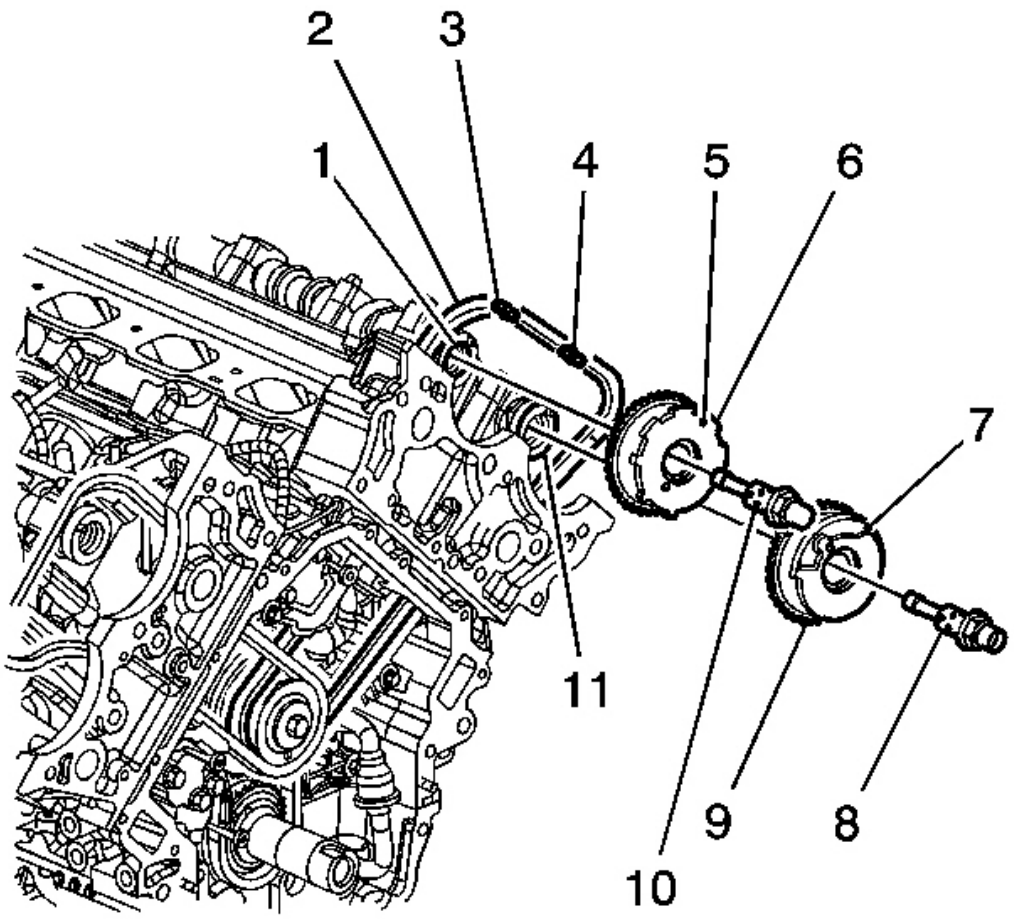


Fig. 65: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Install the left exhaust camshaft actuator (9). Refer to **Camshaft Position Actuator Replacement - Bank 2 (Left Side) Exhaust**.
4. Install the left intake camshaft actuator (6). Refer to **Camshaft Position Actuator Replacement - Bank 2 (Left Side) Intake**.

CAMSHAFT REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

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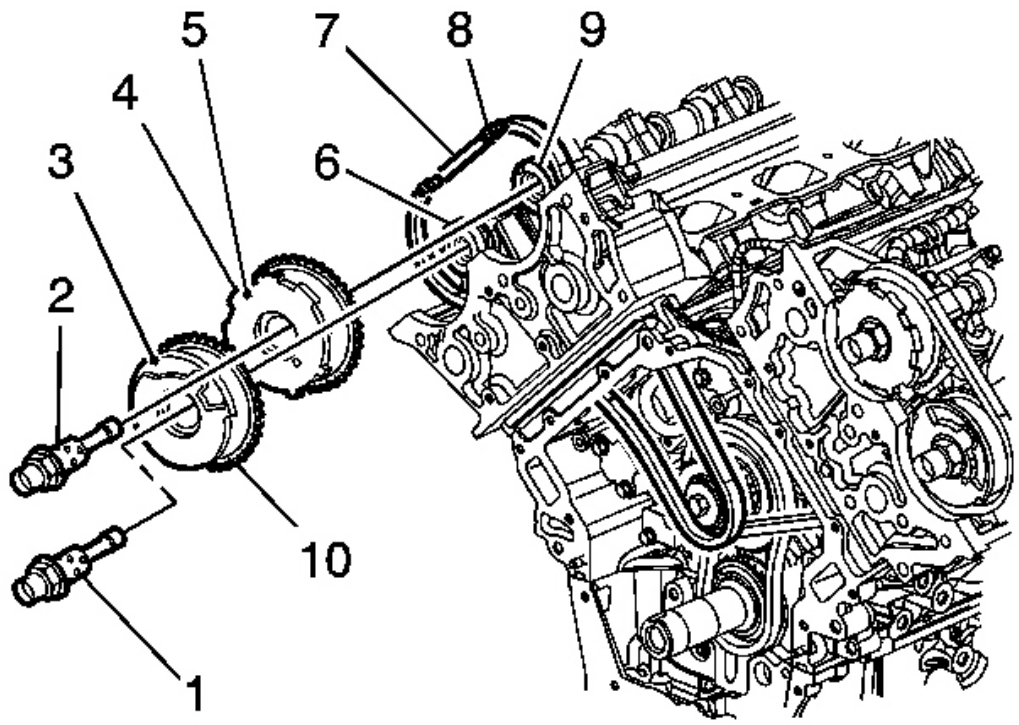


Fig. 66: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the right intake camshaft actuator (4). Refer to **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Intake**.
2. Remove the right exhaust camshaft actuator (10). Refer to **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Exhaust**.

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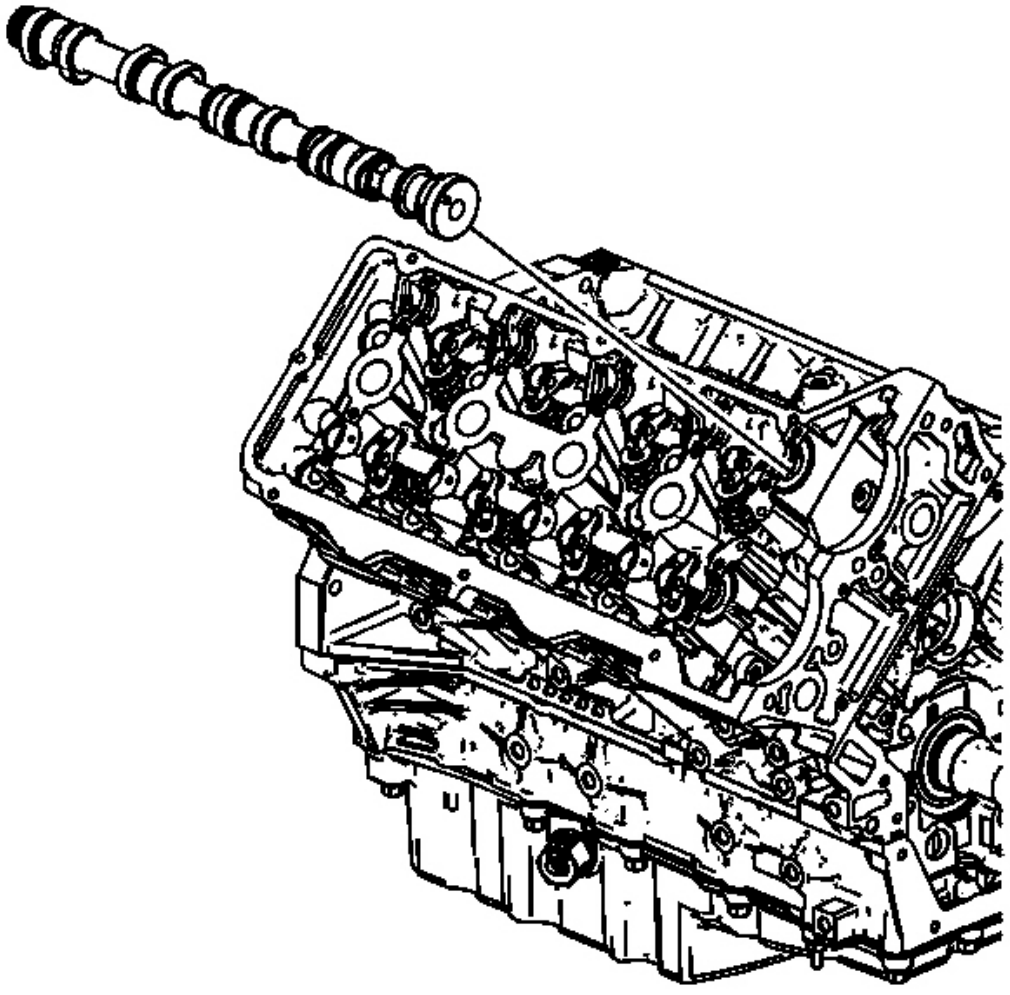


Fig. 67: View Of Right Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

3. Remove the right intake camshaft. Refer to **Intake Camshaft Removal - Right Side** .

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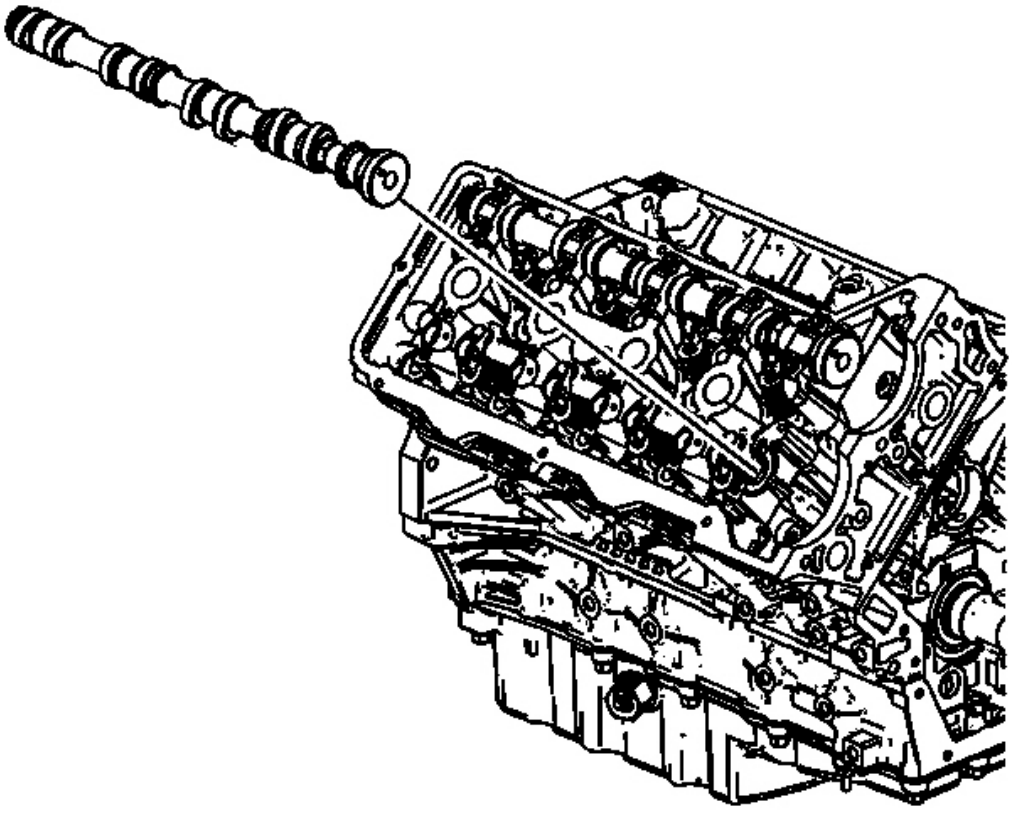


Fig. 68: View Of Right Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Remove the right exhaust camshaft. Refer to **Exhaust Camshaft Removal - Right Side** .
5. Clean and inspect the camshafts. Refer to **Camshaft Cleaning and Inspection** .

INSTALLATION PROCEDURE

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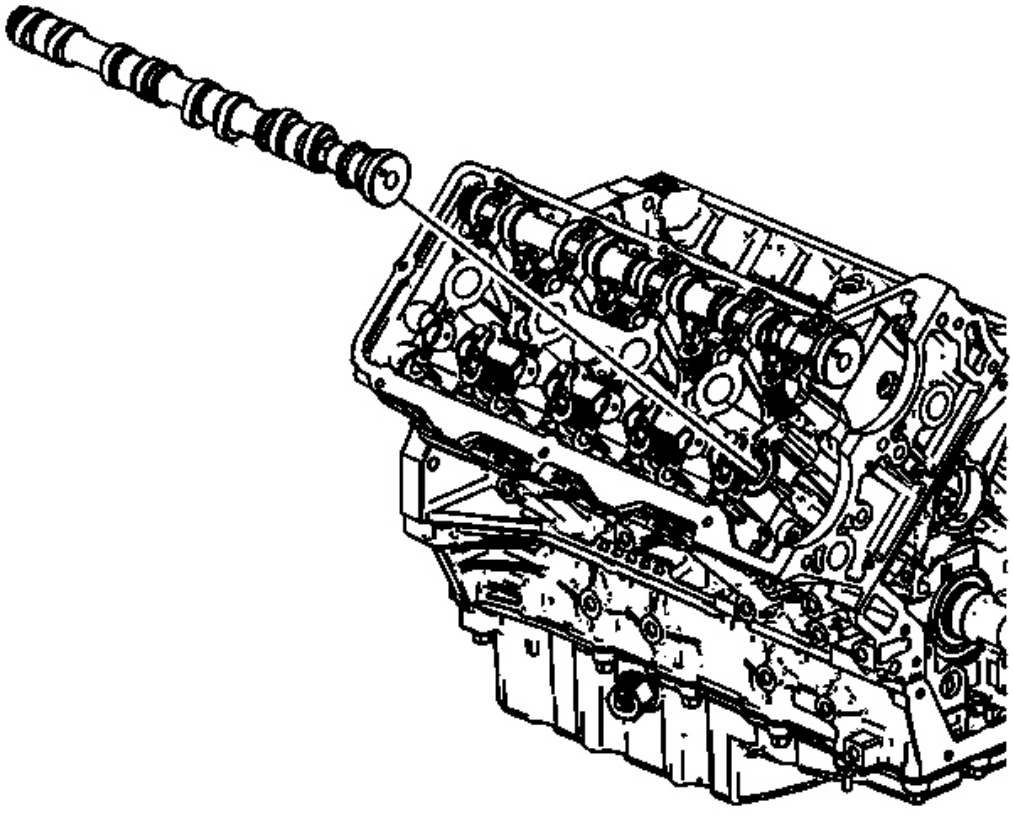


Fig. 69: View Of Right Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

1. Install the right exhaust camshaft. Refer to **Exhaust Camshaft Installation - Right Side** .

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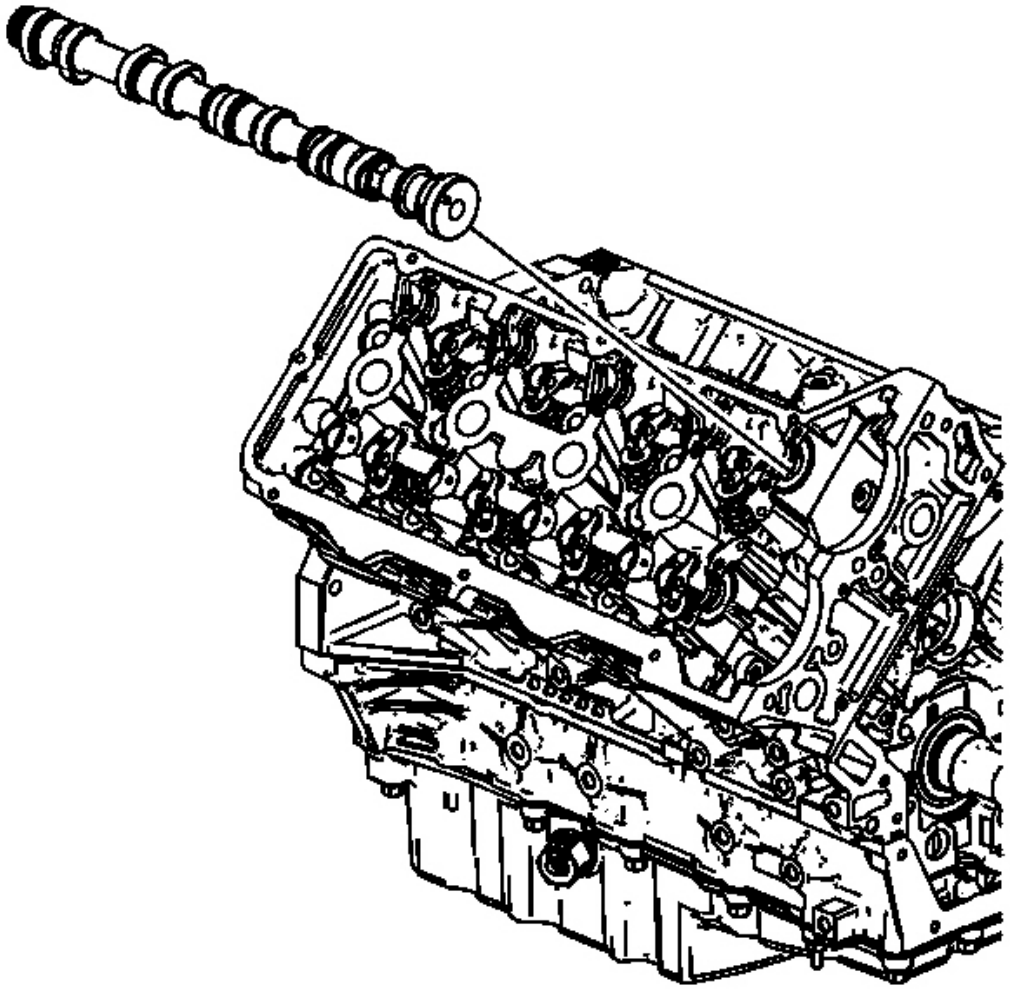


Fig. 70: View Of Right Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

2. Install the right intake camshaft. Refer to **Intake Camshaft Installation - Right Side** .

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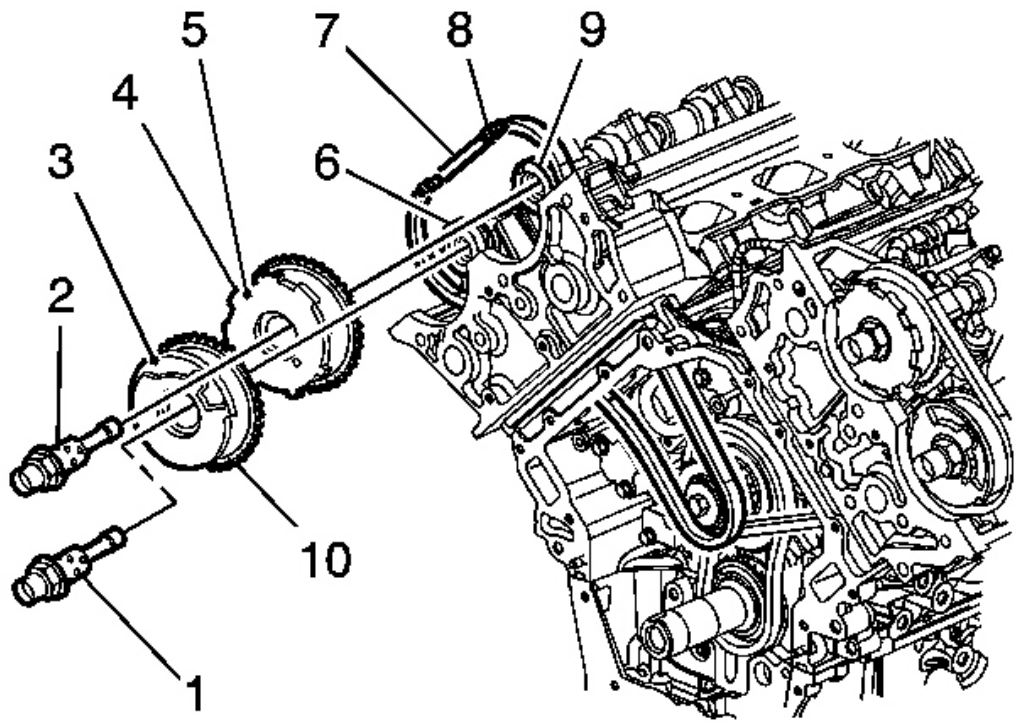


Fig. 71: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Install the right exhaust camshaft actuator (10). Refer to **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Exhaust**.
4. Install the right intake camshaft actuator (4). Refer to **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Intake**.

VALVE ROCKER ARM REPLACEMENT - LEFT SIDE

REMOVAL PROCEDURE

1. Remove the left camshafts. Refer to **Camshaft Replacement - Left Side**.

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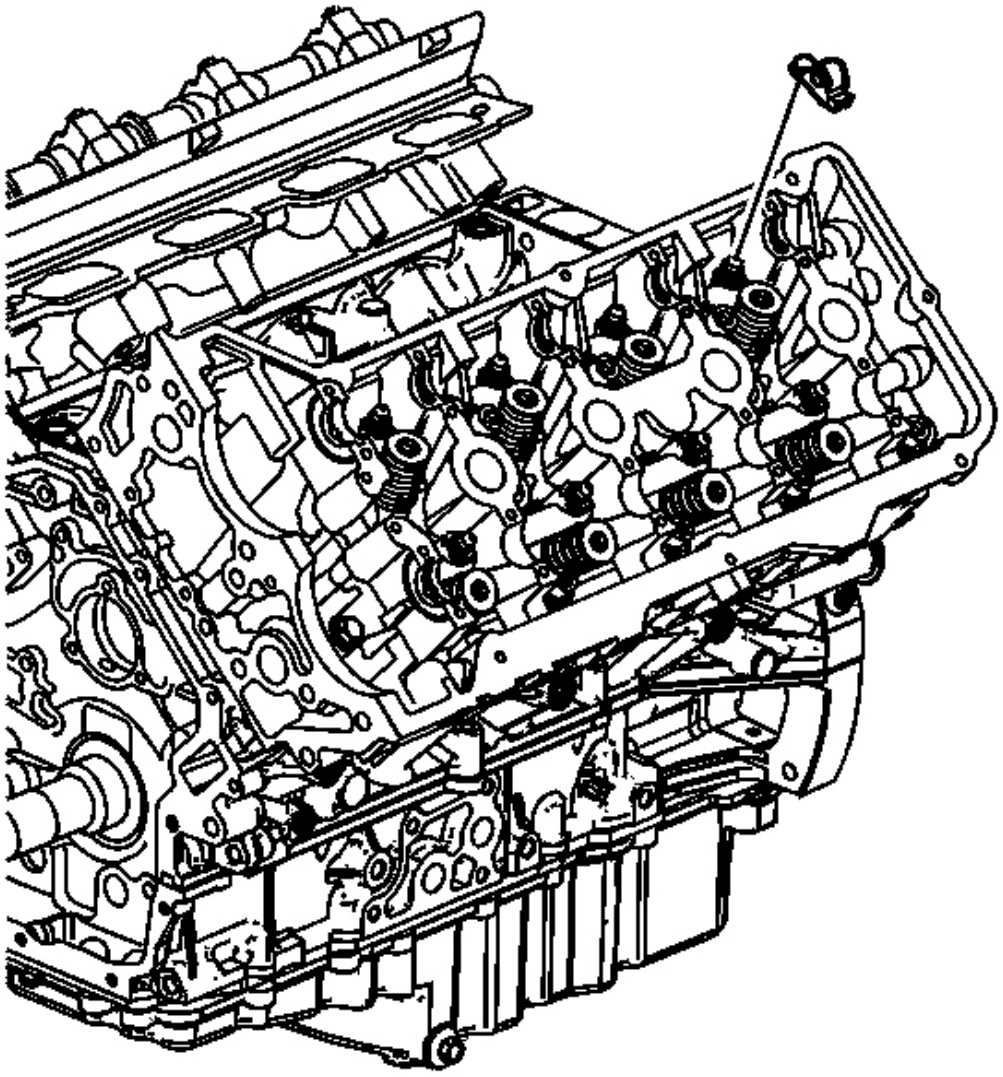


Fig. 72: View Of Left Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure each camshaft follower remains matched to the original Stationary Hydraulic Lash Adjuster (SHLAs) and original location the components were assembled in.

2. Remove the camshaft followers from the left cylinder head.
3. Clean and inspect the rocker arms. Refer to **Valve Rocker Arms Cleaning and Inspection** .

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INSTALLATION PROCEDURE

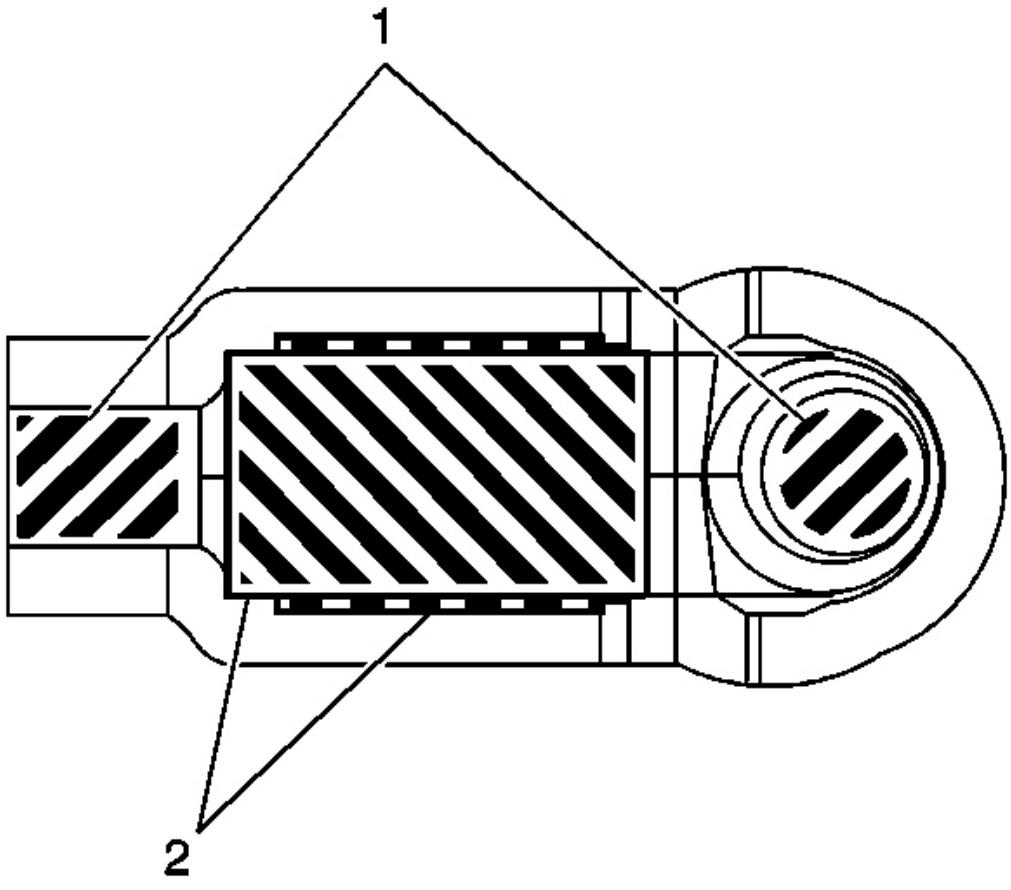


Fig. 73: Identifying Roller Pivot Pocket (2) & Valve Slot Areas (1) Of Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

1. Apply a liberal amount of lubricant to the roller pivot pocket (2) and valve slot areas (1) of the camshaft followers. Refer to **Sealers, Adhesives and Lubricants** for the correct part number.

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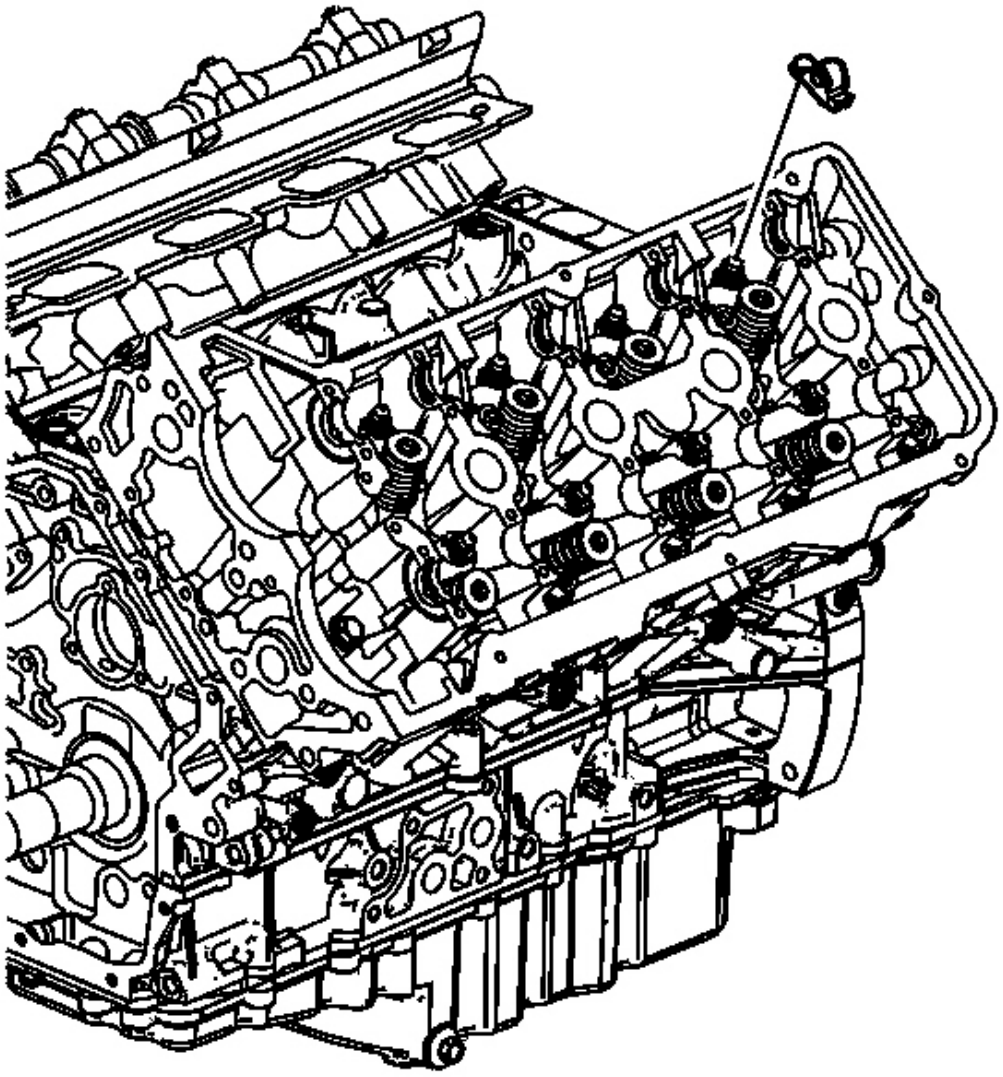


Fig. 74: View Of Left Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

2. Place the camshaft followers in position on the valve tip and the SHLA. The rounded head of the follower

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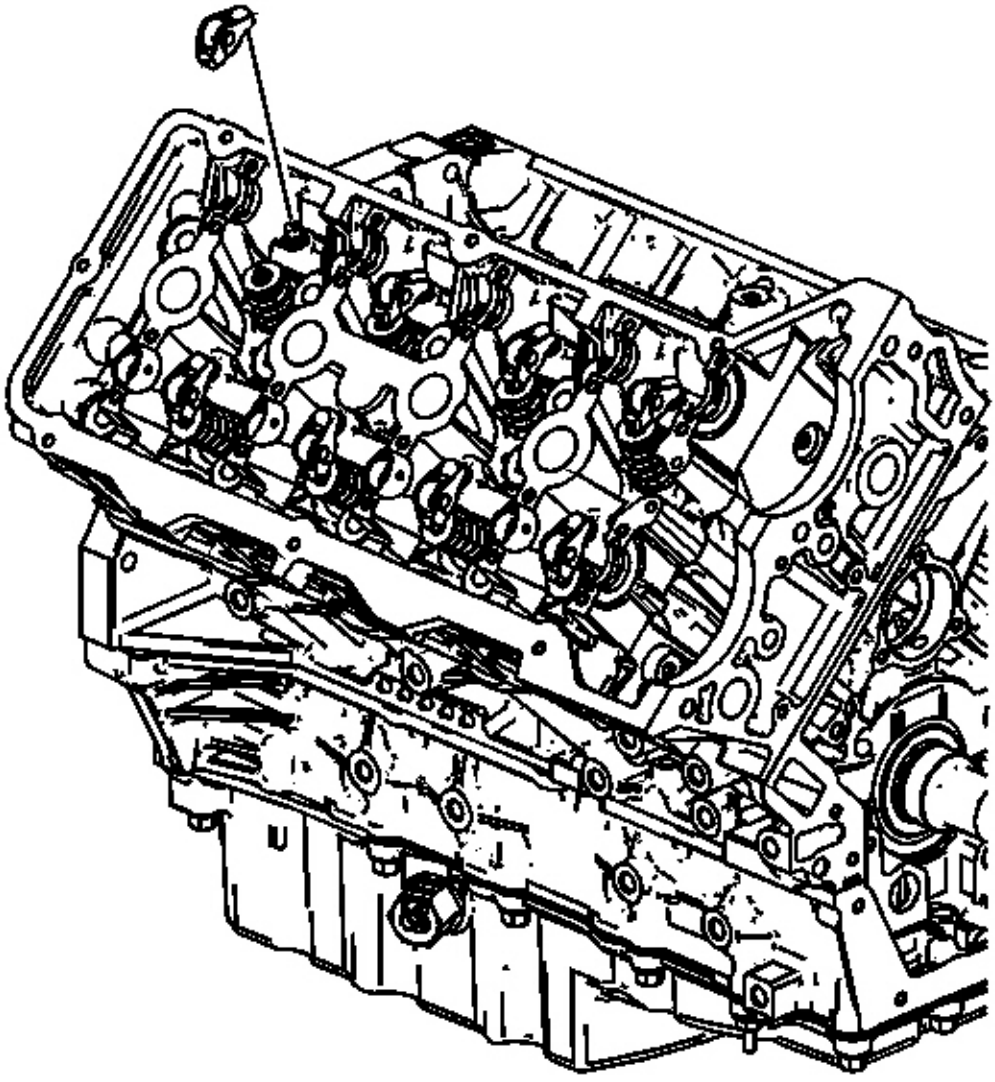
goes on the SHLA, while the flat end goes on the valve tip.

3. Install the left camshafts. Refer to **Camshaft Replacement - Left Side**.

VALVE ROCKER ARM REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

1. Remove the right camshafts. Refer to **Camshaft Replacement - Right Side**.



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Fig. 75: View Of Right Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure each camshaft follower remains matched to the original Stationary Hydraulic Lash Adjuster (SHLAs) and original location the components were assembled in.

2. Remove the camshaft followers from the right cylinder head.
3. Clean and inspect the rocker arms. Refer to **Valve Rocker Arms Cleaning and Inspection** .

INSTALLATION PROCEDURE

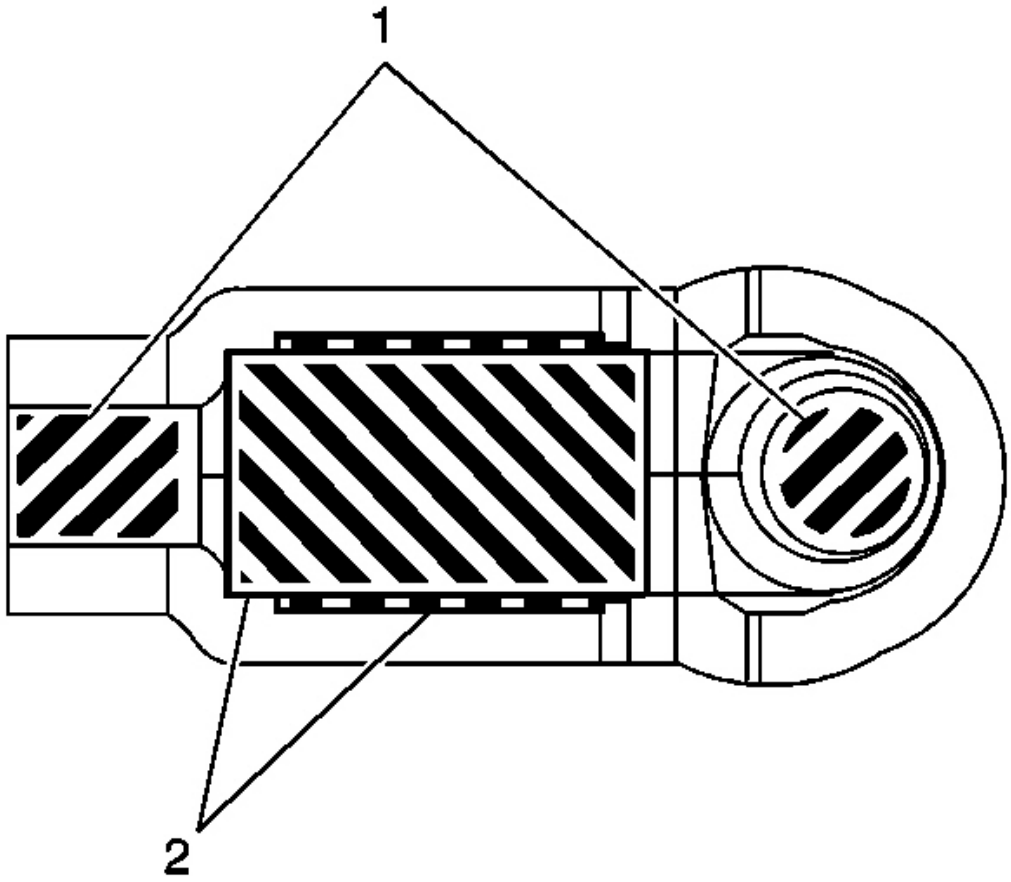


Fig. 76: Identifying Roller Pivot Pocket (2) & Valve Slot Areas (1) Of Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

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1. Apply a liberal amount of lubricant to the roller pivot pocket (2) and valve slot areas (1) of the camshaft followers. Refer to **Sealers, Adhesives and Lubricants** for the correct part number.

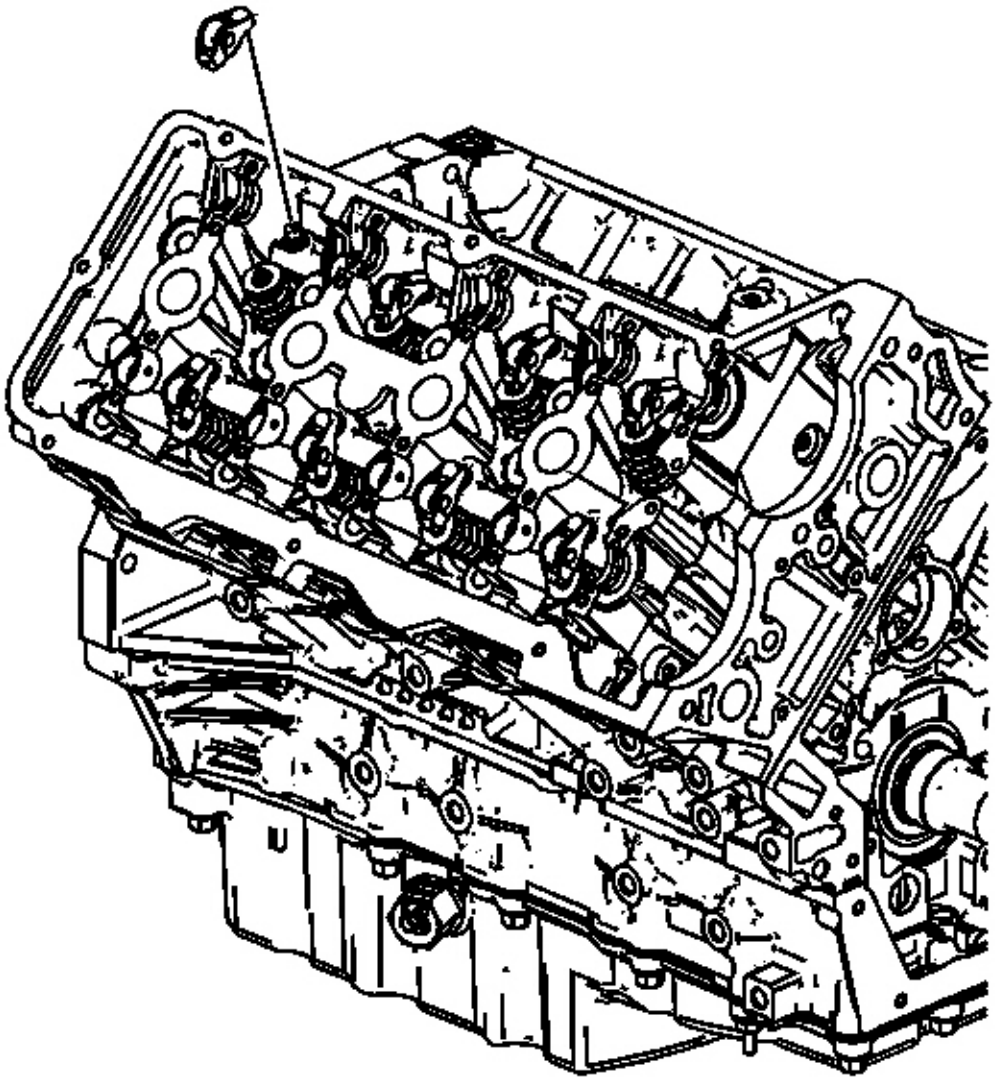


Fig. 77: View Of Right Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the

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followers are being reused you must put them back in their original location.

2. Place the camshaft followers in position on the valve tip and the SHLA. The rounded head of the follower goes on the SHLA, while the flat end goes on the valve tip.
3. Install the right camshafts. Refer to **Camshaft Replacement - Right Side**.

VALVE LIFTER REPLACEMENT - LEFT SIDE

REMOVAL PROCEDURE

1. Remove the left valve rocker arms. Refer to **Valve Rocker Arm Replacement - Left Side**.

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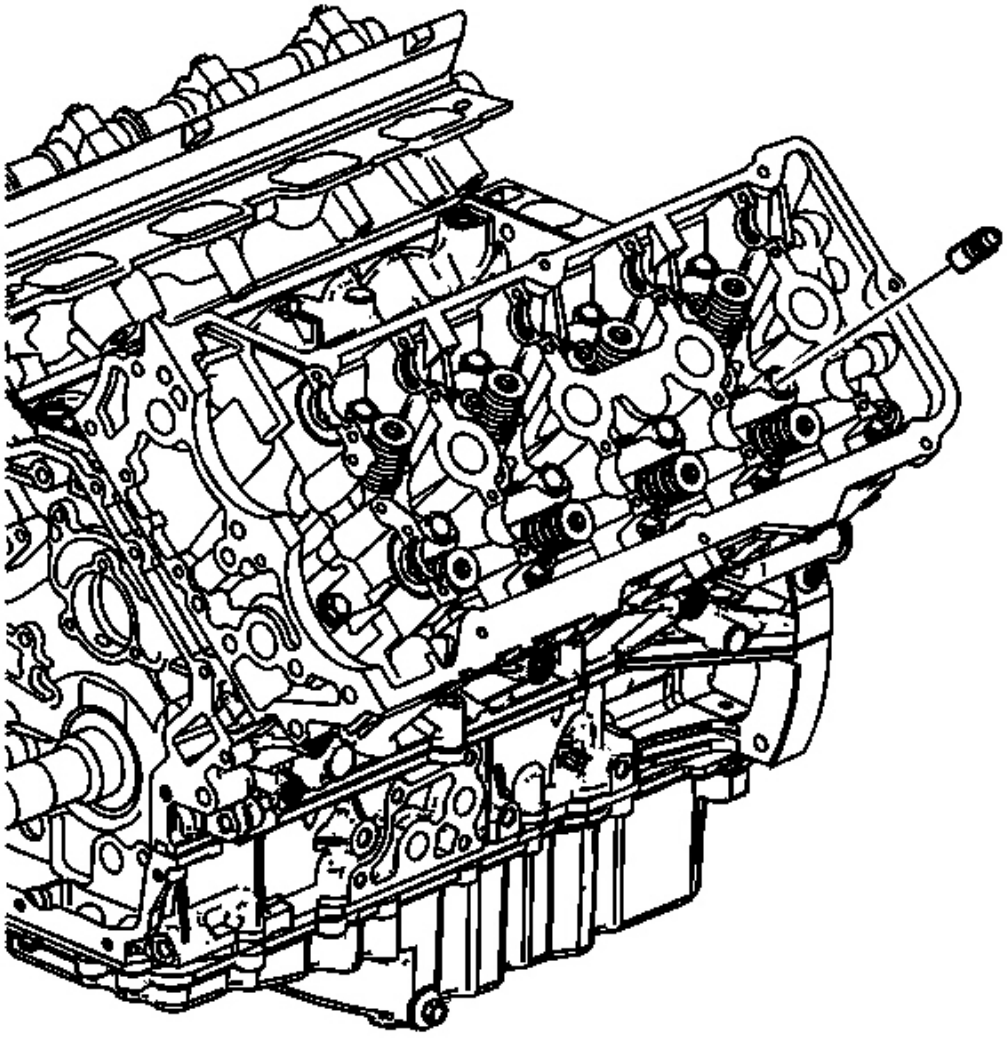


Fig. 78: View Of Left Valve Lifter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure each camshaft follower remains matched to the original stationary hydraulic lash adjuster (SHLA) and original location the components were assembled in.

2. Remove the SHLA from the left cylinder head bores.
3. Clean and inspect the valve lifters. Refer to **Valve Lifters Cleaning and Inspection** .

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INSTALLATION PROCEDURE

1. Ensure the crankshaft is in the top dead center (TDC) position for the number one cylinder.

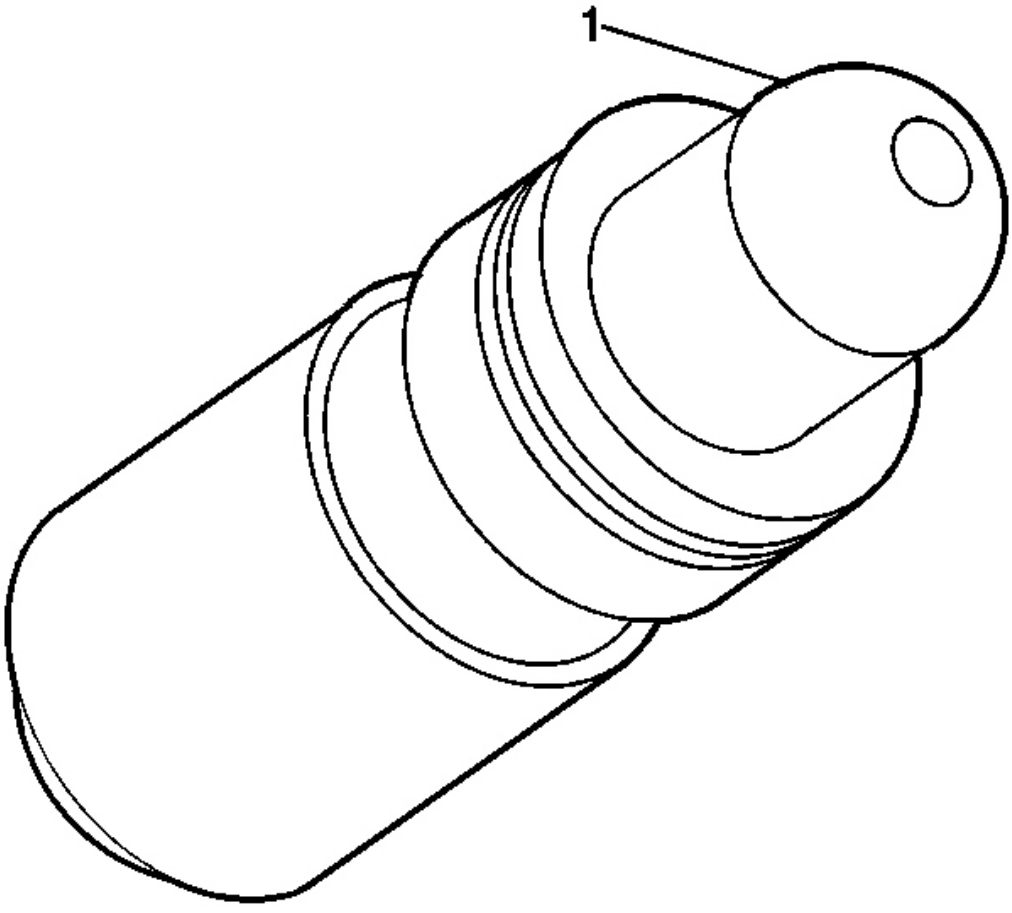


Fig. 79: View Of Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Valve Lifter Priming Notice .

2. Fill the SHLA with clean engine oil. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA. Refer to **Sealers, Adhesives and Lubricants** for the correct part number.

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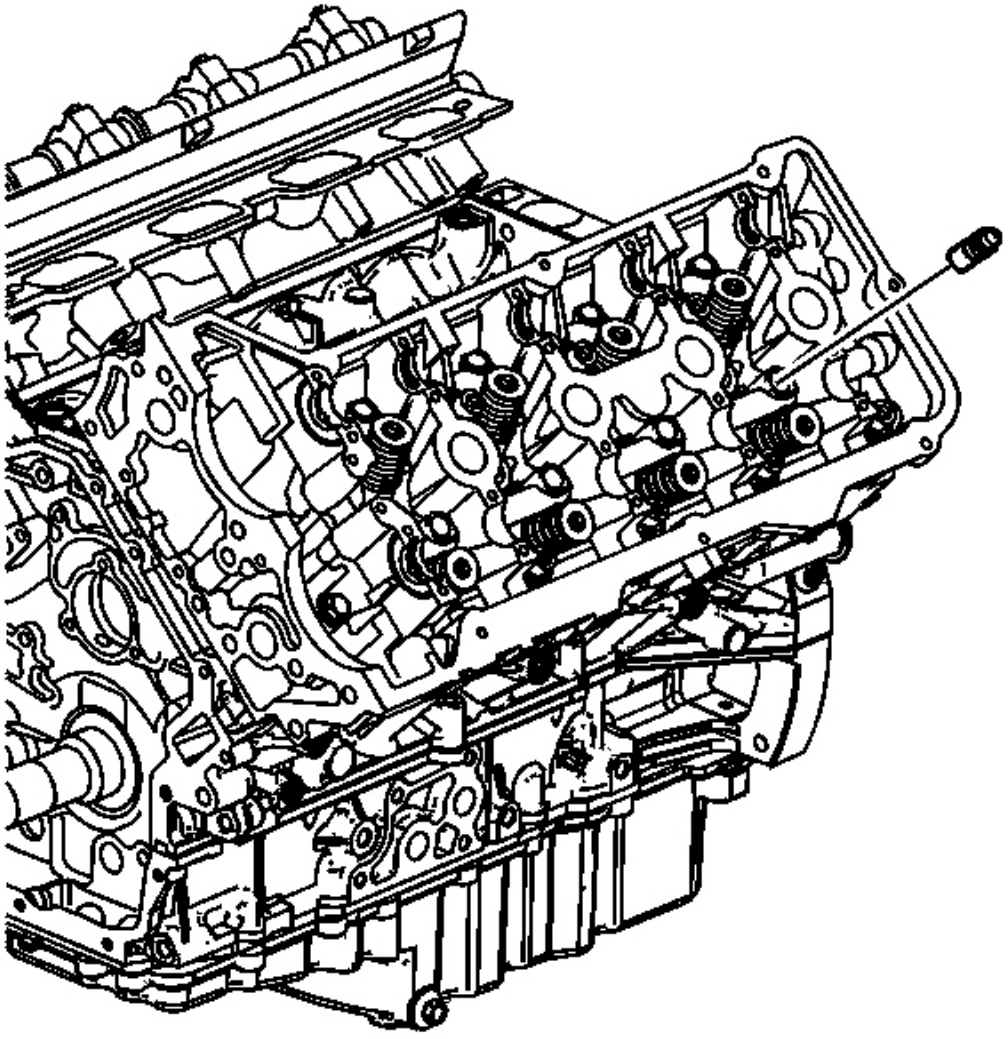


Fig. 80: View Of Left Valve Lifter
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the SHLA bores of the cylinder head with clean engine oil. Refer to **Sealers, Adhesives and Lubricants** for the correct part number.
4. Install the SHLA into the bores.
5. Install the left valve rocker arms. Refer to **Valve Rocker Arm Replacement - Left Side**.

VALVE LIFTER REPLACEMENT - RIGHT SIDE

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REMOVAL PROCEDURE

1. Remove the right valve rocker arms. Refer to **Valve Rocker Arm Replacement - Right Side**.

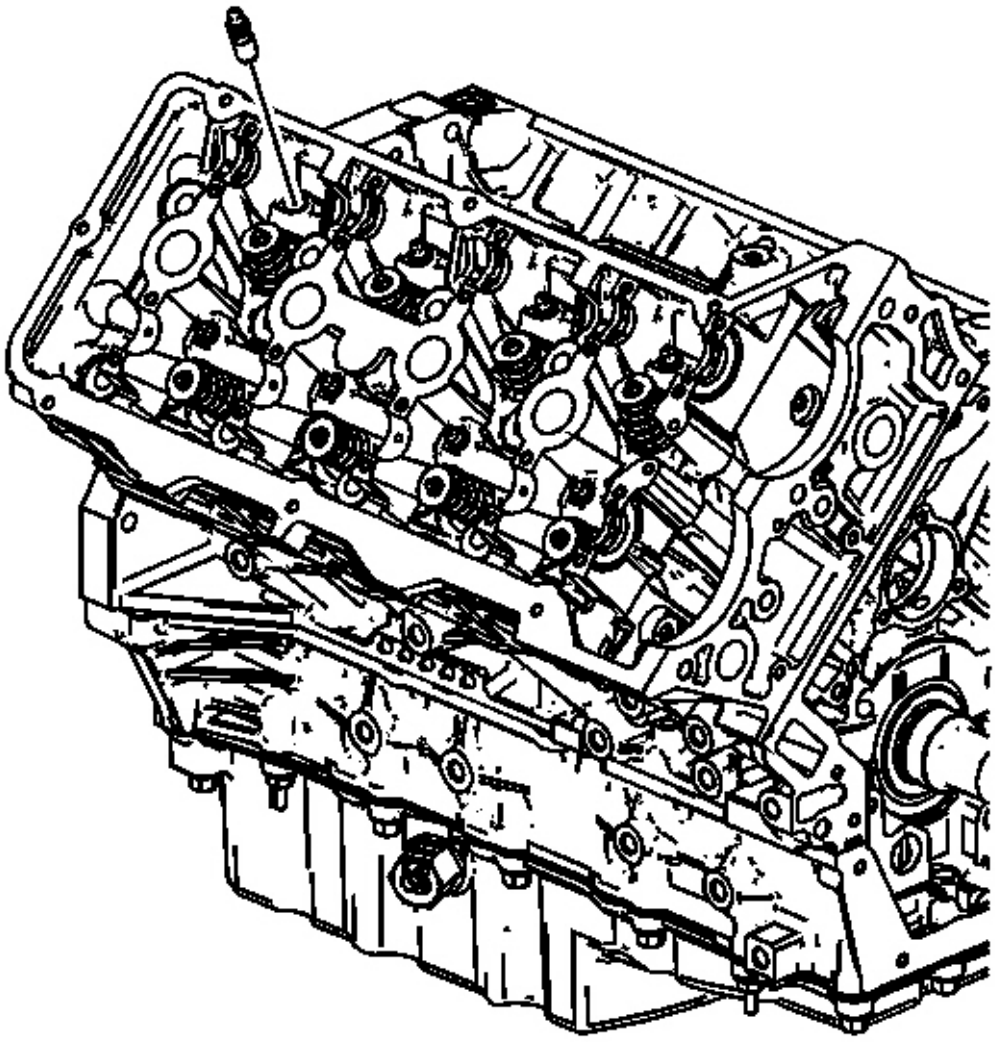


Fig. 81: View Of Right Valve Lifter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure each camshaft follower remains matched to the original stationary hydraulic lash adjuster (SHLA) and original location the components were assembled in.

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2. Remove the SHLA from the right cylinder head bores.
3. Clean and inspect the valve lifters. Refer to **Valve Lifters Cleaning and Inspection** .

INSTALLATION PROCEDURE

1. Ensure the crankshaft is in the top dead center (TDC) position for the number one cylinder.

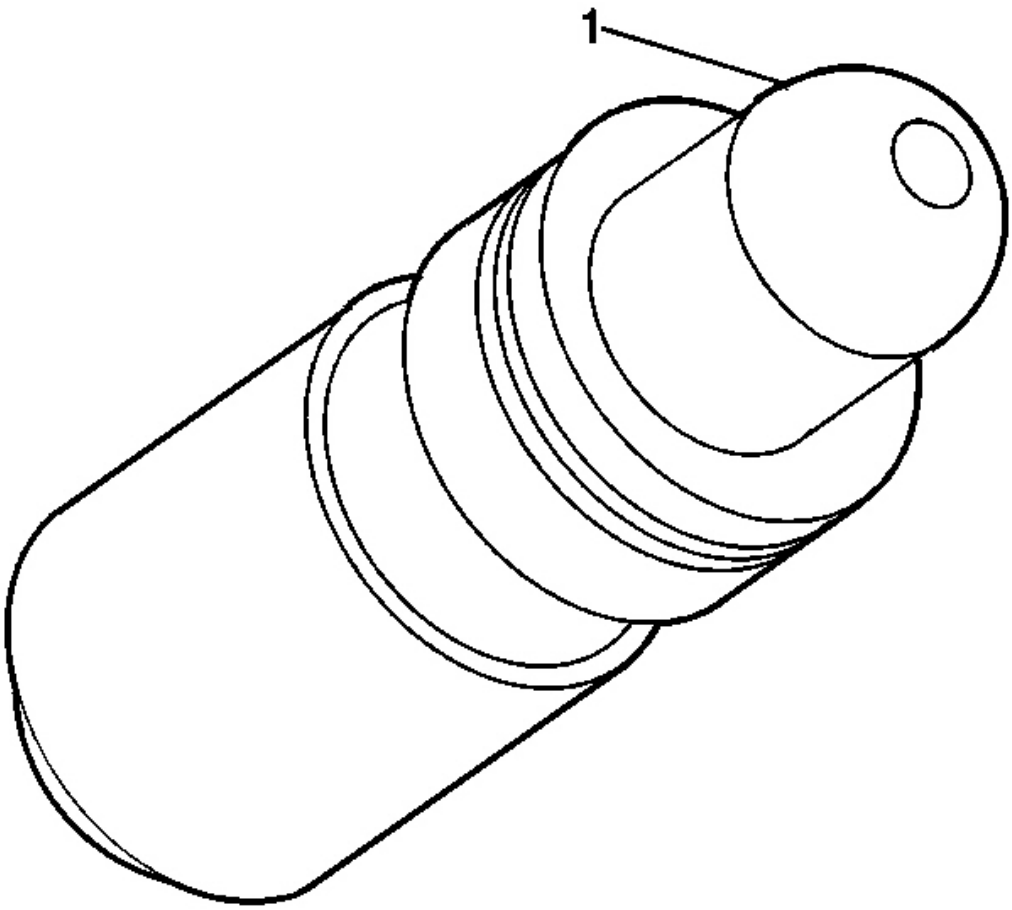


Fig. 82: View Of Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Valve Lifter Priming Notice .

2. Fill the SHLA with clean engine oil. Refer to **Sealers, Adhesives and Lubricants** for the correct part number. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.

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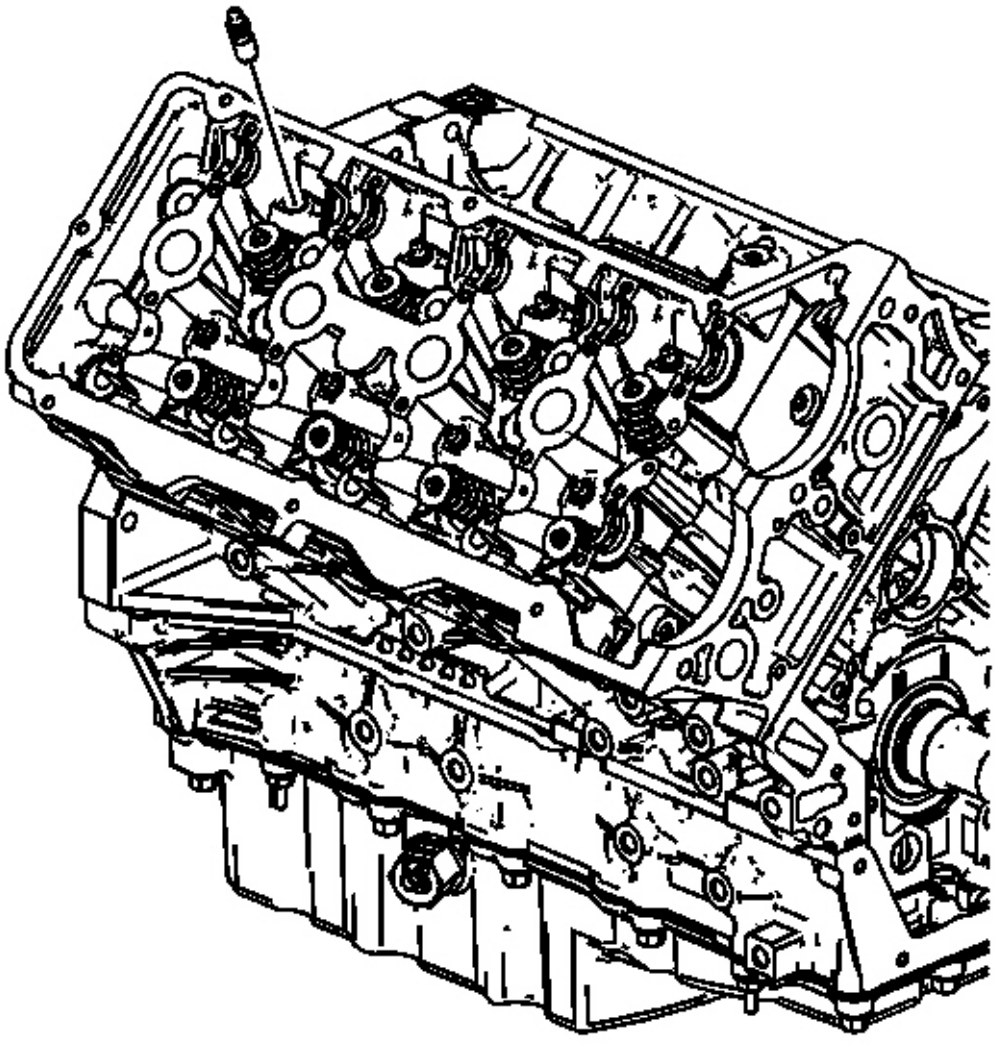


Fig. 83: View Of Right Valve Lifter
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the SHLA bores of the cylinder head with clean engine oil. Refer to **Sealers, Adhesives and Lubricants** for the correct part number.
4. Install the SHLA into the bores.
5. Install the right valve rocker arms. Refer to **Valve Rocker Arm Replacement - Right Side**.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT - LEFT SIDE

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TOOLS REQUIRED

- **J 38820** Valve Stem Seal Installer. See **Special Tools** .
- **J 39313** Spark Plug Port Adapter. See **Special Tools** .
- **J 44211** On-Vehicle Valve Spring Compressor. See **Special Tools** .
- **EN 46326** Flywheel Holder. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the left camshafts. Refer to **Camshaft Replacement - Left Side**.
2. Remove the starter motor. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)** .

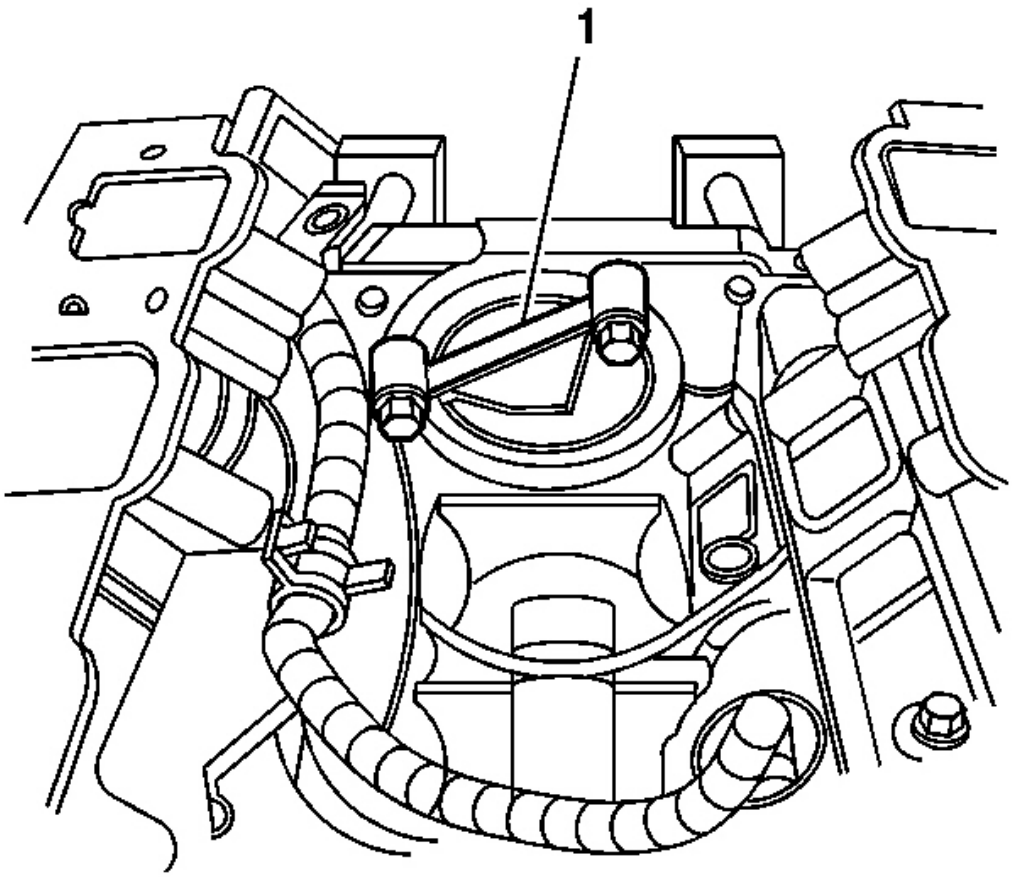


Fig. 84: View Of EN 46326 Installed To Engine Block
Courtesy of GENERAL MOTORS CORP.

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3. Install the **EN 46326** flywheel holder (1). See **Special Tools** .

NOTE: **Clean the spark plug recess area before removing the spark plug. Failure to do so could result in engine damage because of dirt or foreign material entering the cylinder head or by the contamination of the cylinder head threads. The contaminated threads may prevent the proper seating of the new plug. Use a thread chaser to clean the threads of any contamination.**

4. Remove the spark plug from the cylinder being worked on.

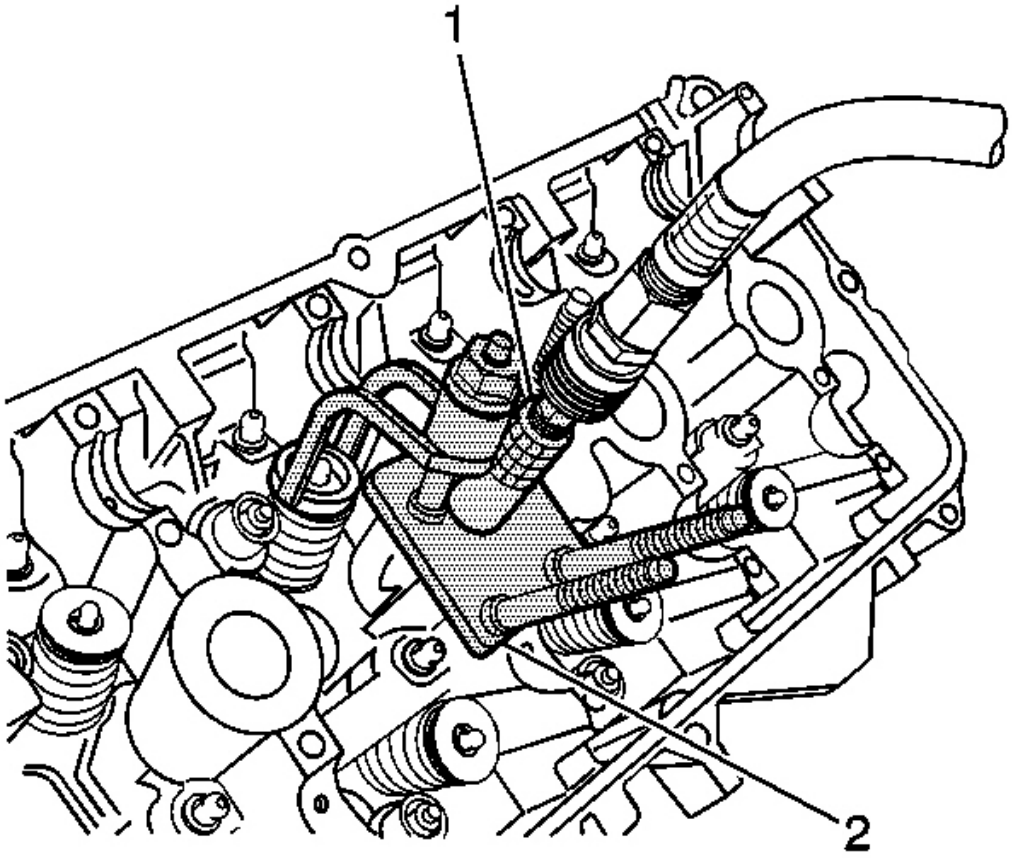


Fig. 85: View Of Base Plate Installed Over The Spark Plug Hole For Changing Valve Stem Seal
Courtesy of GENERAL MOTORS CORP.

5. Install the base plate of the **J 44211** (2) over the spark plug hole of the cylinder to be serviced. See **Special Tools** .

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6. Install the **J 39313** (1) in the spark plug hole. See **Special Tools** .
7. Apply constant air pressure to the **J 39313** (1) in order to keep the valve closed. See **Special Tools** .
8. Install the arm and swivel nut of the **J 44211** (2) over the stud corresponding to the valve to be serviced. See **Special Tools** .

CAUTION: Refer to Compressed Valve Spring Caution .

9. Tighten the swivel nut of the **J 44211** (2) down only enough to allow access for removal of the valve locks. See **Special Tools** .
10. Use a magnet to remove the valve locks.
11. Loosen the swivel nut of the **J 44211** (2) and swing the arm away from the valve spring retainer. See **Special Tools** .
12. Remove the valve spring retainer and valve spring.

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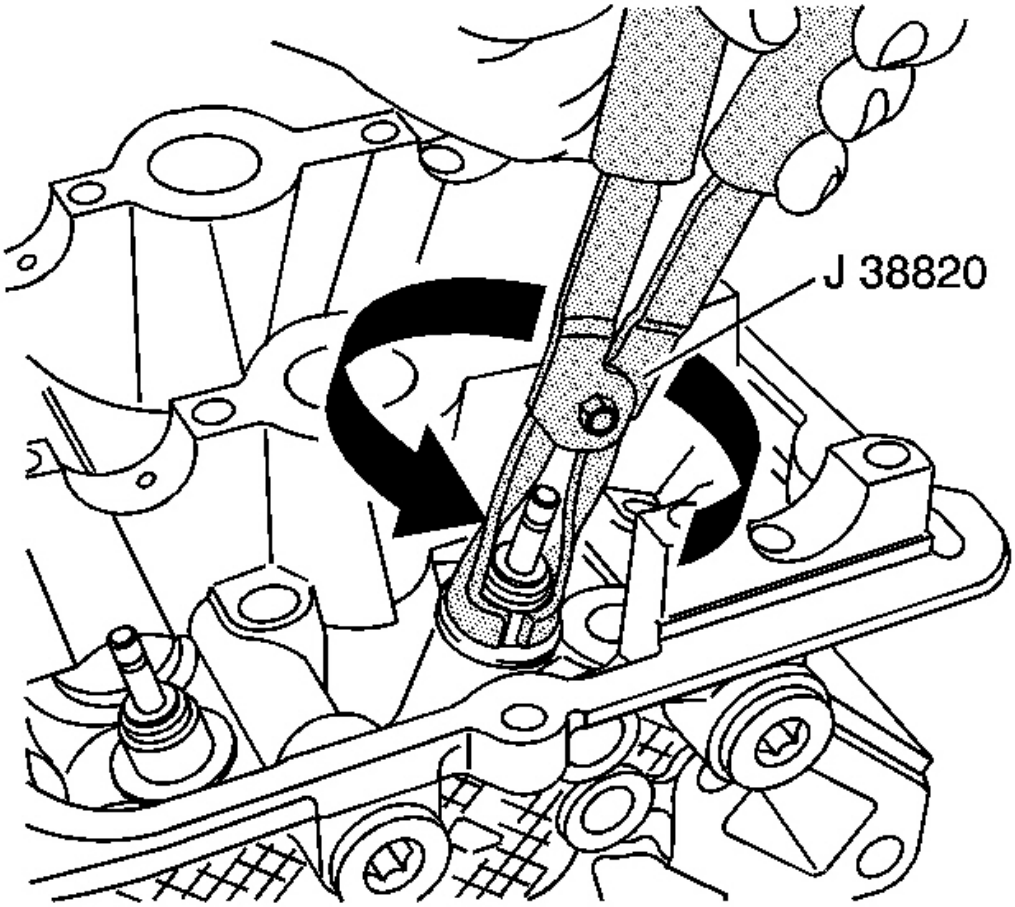


Fig. 86: Using J 38820 To Replace Valve Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The valve stem seal should not be removed unless replacement is required.

13. Use the **J 38820** in order to grip the seal. See **Special Tools** . Remove the seal by exerting a twisting, pulling motion. Discard the old valve stem seal.
14. Inspect and measure the valve spring. Refer to **Valve Spring Inspection and Measurement** .

INSTALLATION PROCEDURE

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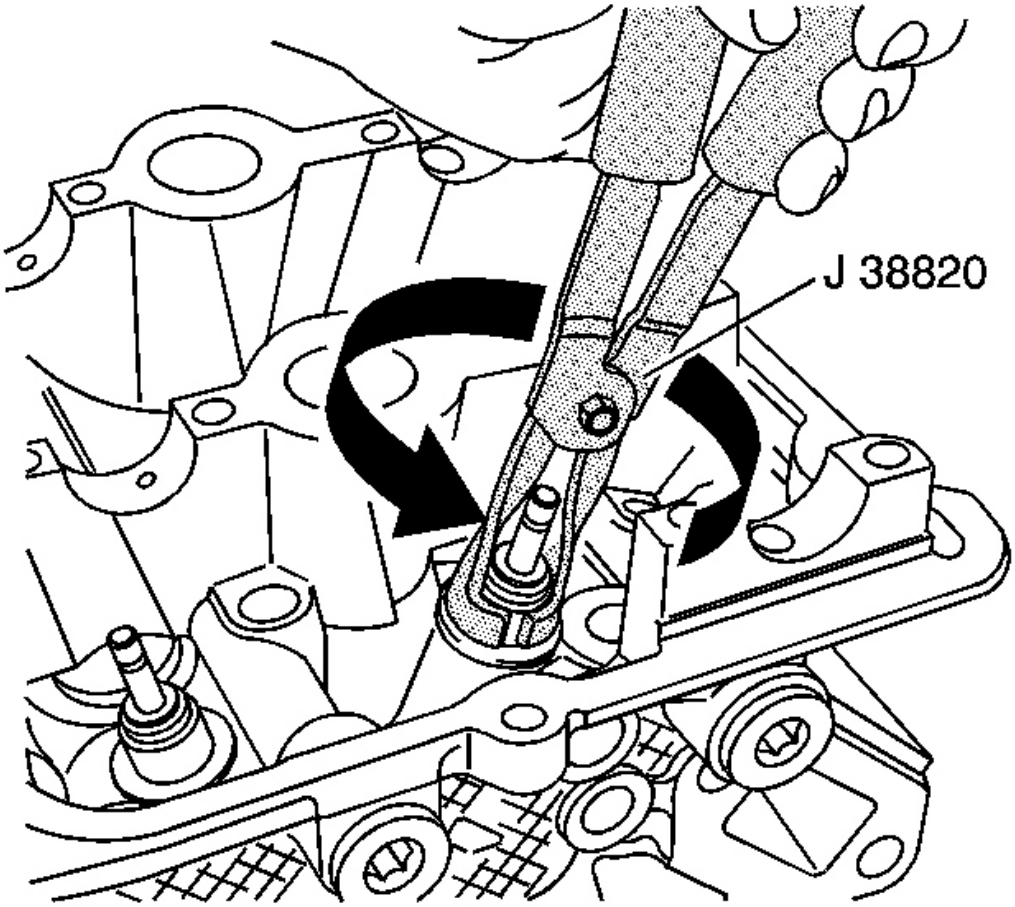


Fig. 87: Using J 38820 To Replace Valve Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve stem and the inner diameter of the new seal with clean engine oil.

IMPORTANT: Install a seal protector over the valve stem prior to installing the valve stem seal.

2. Using a twisting pushing motion install the NEW valve stem seal using the **J 38820** . See **Special Tools** .
3. Install the valve spring and valve spring retainer.

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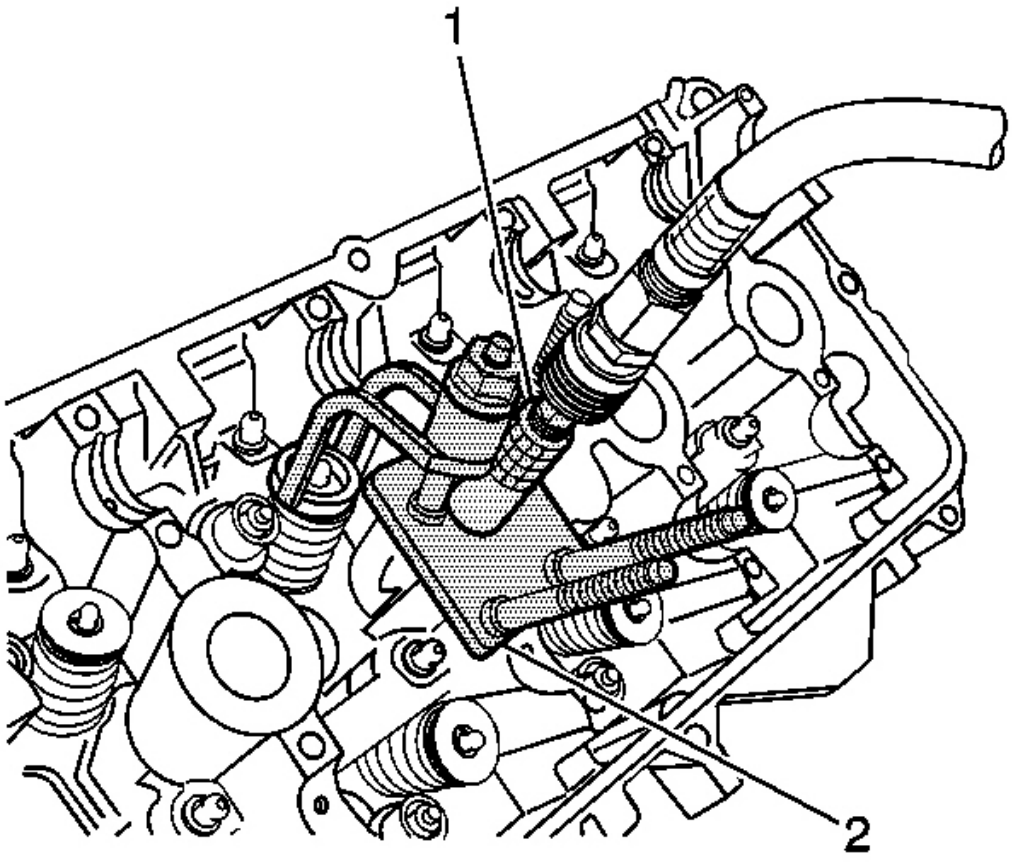


Fig. 88: View Of Base Plate Installed Over The Spark Plug Hole For Changing Valve Stem Seal
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Compressed Valve Spring Caution .

4. Swing the arm over the valve spring retainer and tighten the swivel nut of the **J 44211** (2) down only enough to allow access for installation of the valve locks. See **Special Tools** .
5. Using a magnet, position the valve locks to the valve stem retainer groove. Grease can be used to hold the locks in place.
6. Remove the swivel nut and arm of the **J 44211** (2). See **Special Tools** .
7. Install the arm and swivel nut of the **J 44211** (2) over the stud of any other valves being serviced and repeat these removal and installation steps. See **Special Tools** .
8. Relieve the air pressure to the cylinder being serviced.

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9. Remove the **J 39313** (1) from the spark plug hole. See **Special Tools** .
10. Remove the base plate of the **J 44211** (2). See **Special Tools** .
11. Install the spark plug. Refer to **Spark Plug Replacement** .
12. Install the left camshafts. Refer to **Camshaft Replacement - Left Side**.

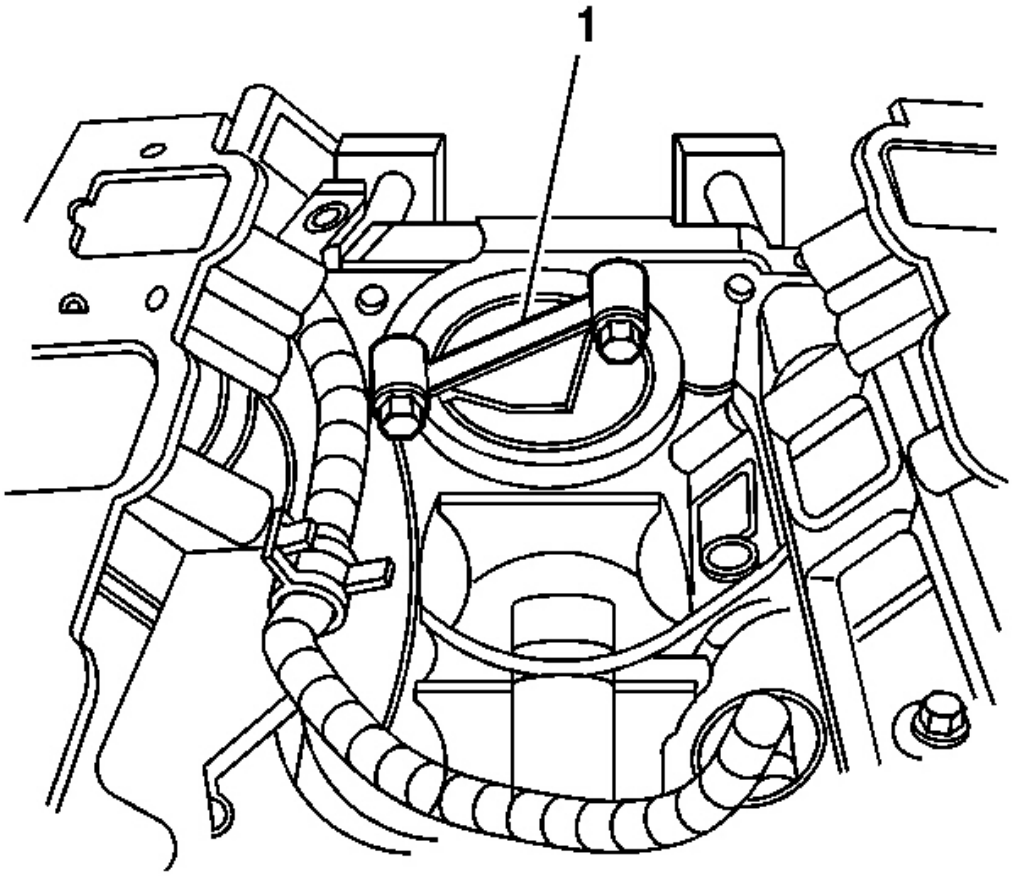


Fig. 89: View Of EN 46326 Installed To Engine Block
Courtesy of GENERAL MOTORS CORP.

13. Remove the **EN 46326** flywheel holder (1). See **Special Tools** .
14. Install the starter motor. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)** .

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT - RIGHT SIDE

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TOOLS REQUIRED

- **J 38820** Valve Stem Seal Installer. See **Special Tools** .
- **J 39313** Spark Plug Port Adapter. See **Special Tools** .
- **J 44211** On-Vehicle Valve Spring Compressor. See **Special Tools** .
- **EN 46326** Flywheel Holder. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the right camshafts. Refer to **Camshaft Replacement - Right Side**.
2. Remove the starter motor. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)** .

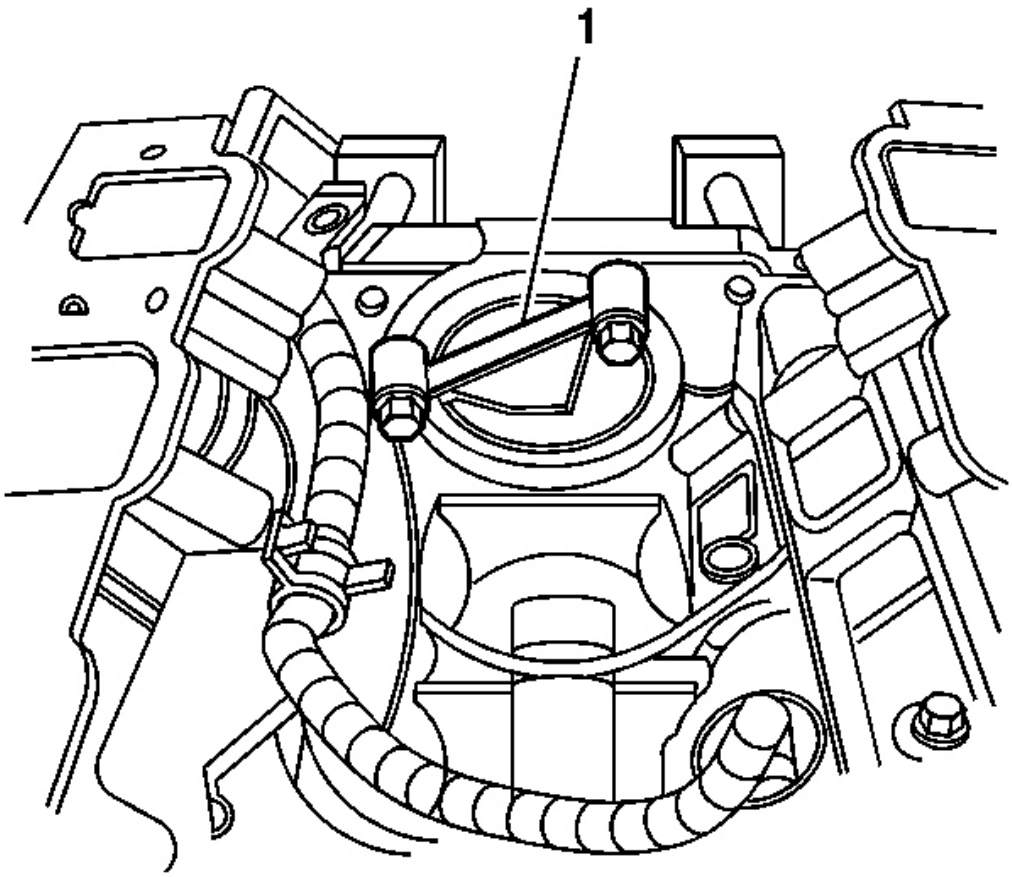


Fig. 90: View Of EN 46326 Installed To Engine Block
Courtesy of GENERAL MOTORS CORP.

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3. Install the **EN 46326** flywheel holder (1). See **Special Tools** .

NOTE: **Clean the spark plug recess area before removing the spark plug. Failure to do so could result in engine damage because of dirt or foreign material entering the cylinder head or by the contamination of the cylinder head threads. The contaminated threads may prevent the proper seating of the new plug. Use a thread chaser to clean the threads of any contamination.**

4. Remove the spark plug from the cylinder being worked on.

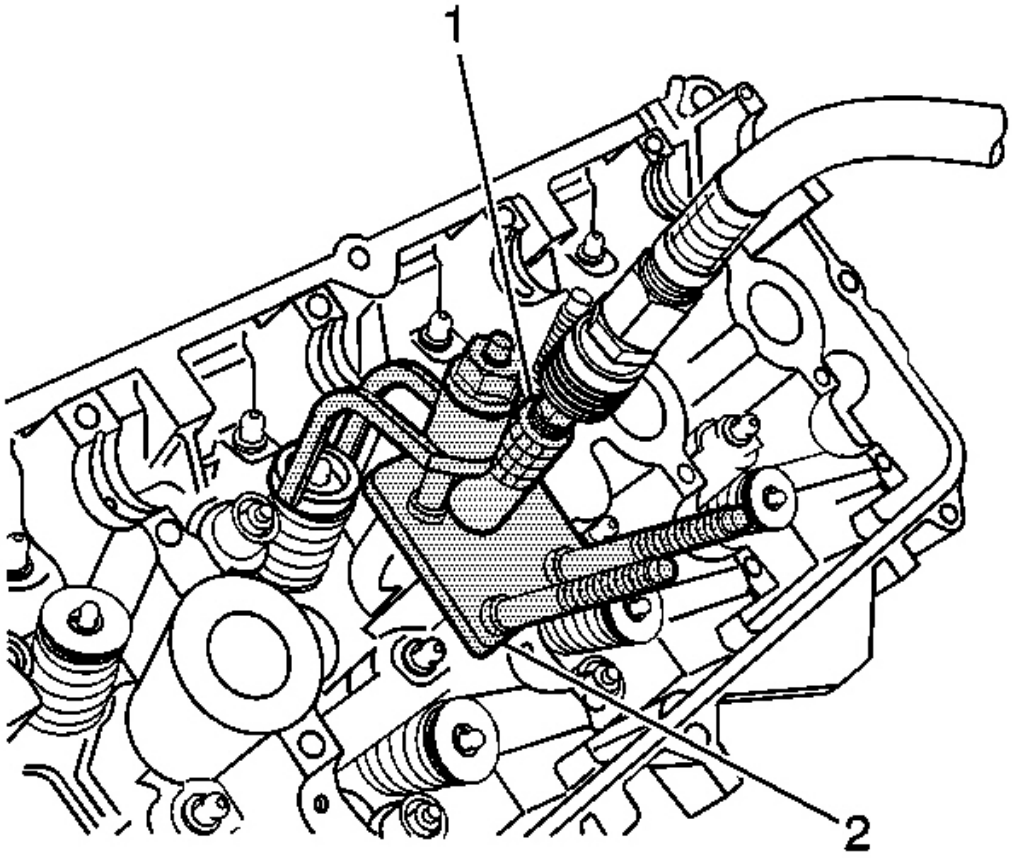


Fig. 91: View Of Base Plate Installed Over The Spark Plug Hole For Changing Valve Stem Seal
Courtesy of GENERAL MOTORS CORP.

5. Install the base plate of the **J 44211** (2) over the spark plug hole of the cylinder to be serviced. See **Special Tools** .

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6. Install the **J 39313** (1) in the spark plug hole. See **Special Tools** .
7. Apply constant air pressure to the **J 39313** (1) in order to keep the valve closed. See **Special Tools** .
8. Install the arm and swivel nut of the **J 44211** (2) over the stud corresponding to the valve to be serviced. See **Special Tools** .

CAUTION: Refer to Compressed Valve Spring Caution .

9. Tighten the swivel nut of the **J 44211** (2) down only enough to allow access for removal of the valve locks. See **Special Tools** .
10. Use a magnet to remove the valve stem locks.
11. Loosen the swivel nut of the **J 44211** (2) and swing the arm away from the valve spring retainer. See **Special Tools** .
12. Remove the valve spring retainer and valve spring.

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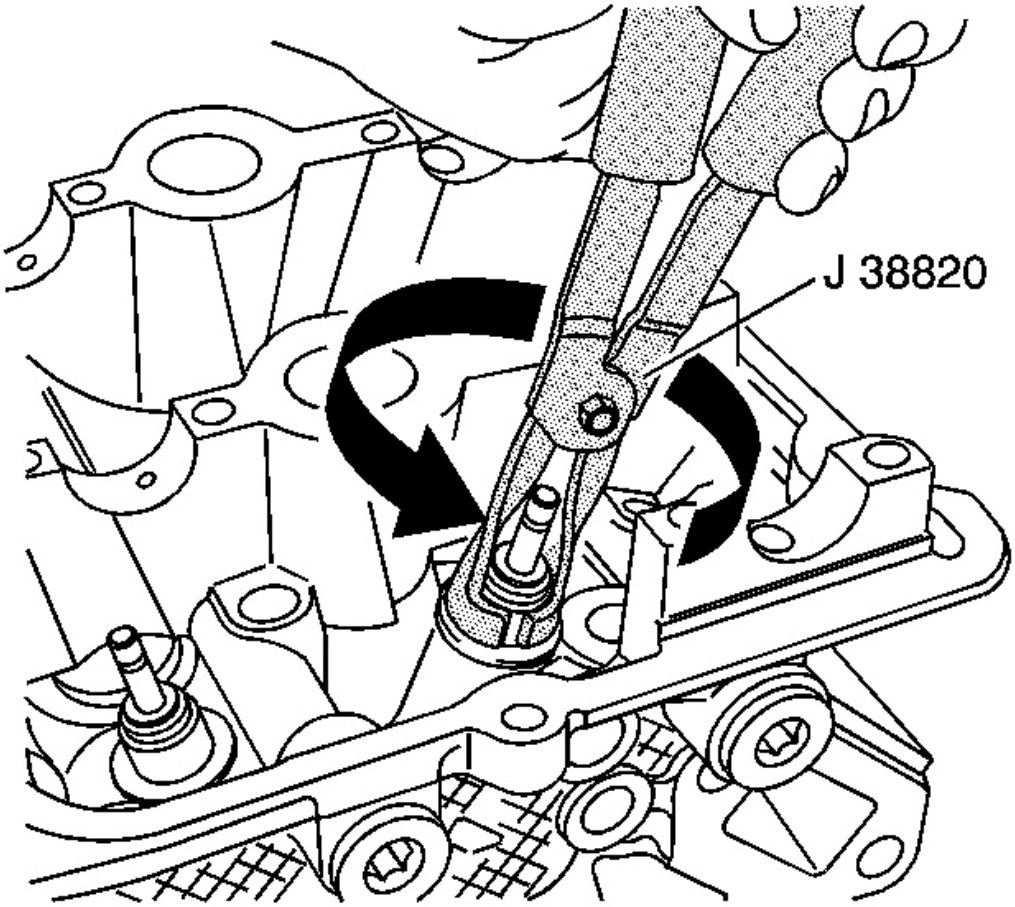


Fig. 92: Using J 38820 To Replace Valve Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The valve stem seal should not be removed unless replacement is required.

13. Use the **J 38820** in order to grip the seal. See **Special Tools** . Remove the seal by exerting a twisting, pulling motion. Discard the old valve stem seal.
14. Inspect and measure the valve spring. Refer to **Valve Spring Inspection and Measurement** .

INSTALLATION PROCEDURE

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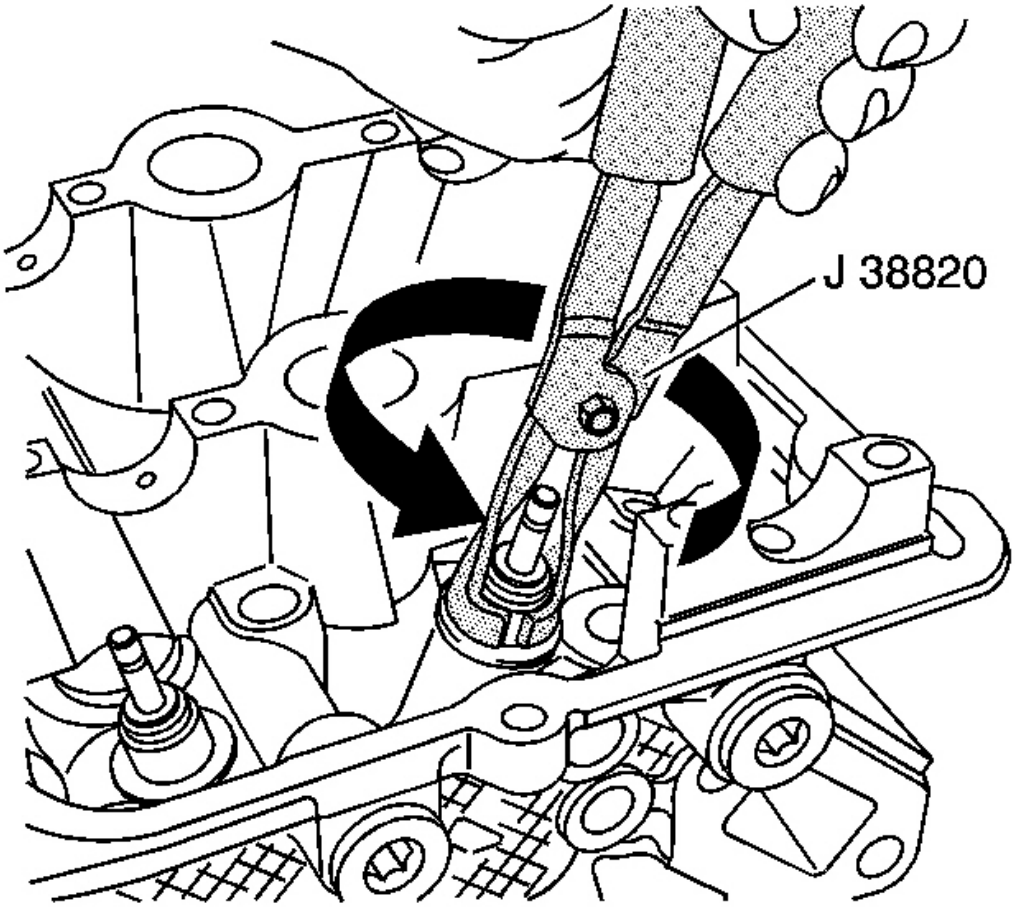


Fig. 93: Using J 38820 To Replace Valve Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve stem and the inner diameter of the new seal with clean engine oil.

IMPORTANT: Install a seal protector over the valve stem prior to installing the valve stem seal.

2. Using a twisting, pushing motion, install the NEW valve stem seal using the **J 38820** . See **Special Tools** .
3. Install the valve spring retainer and valve spring.

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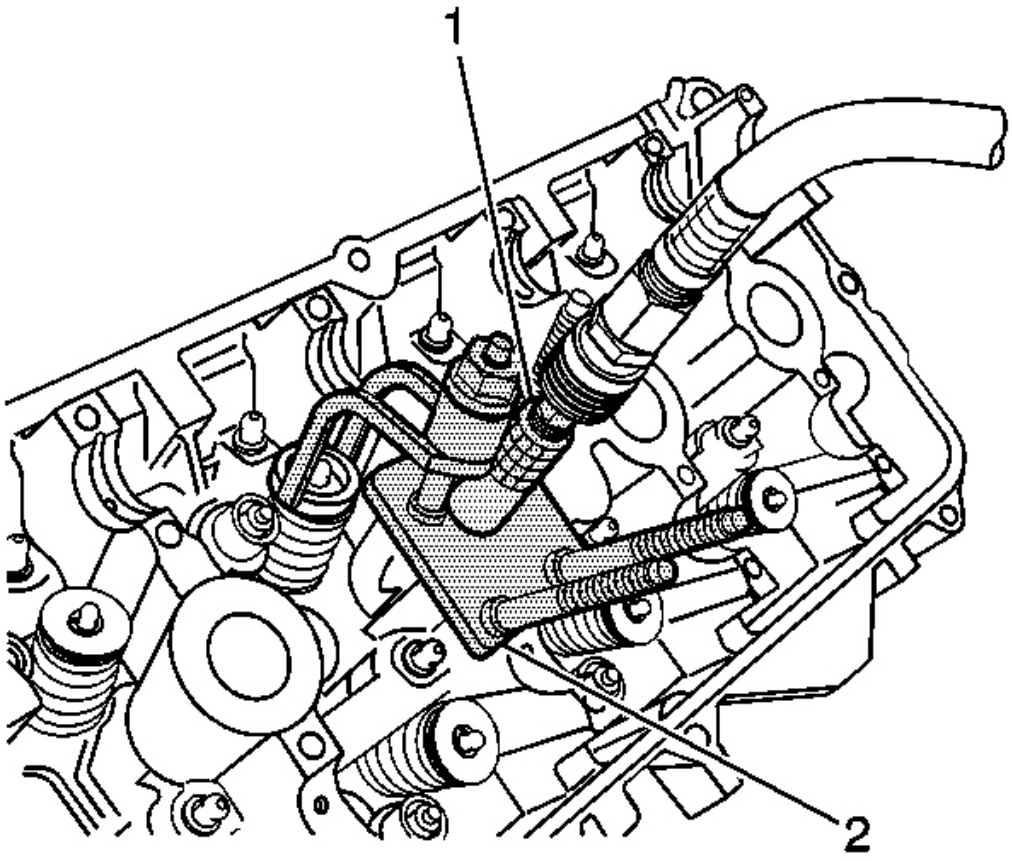


Fig. 94: View Of Base Plate Installed Over The Spark Plug Hole For Changing Valve Stem Seal
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Compressed Valve Spring Caution .

4. Swing the arm over the valve spring retainer and tighten the swivel nut of the **J 44211** (2) down only enough to allow access for installation of the valve locks. See **Special Tools** .
5. Using a magnet, position the valve locks to the valve stem retainer groove. Grease can be used to hold the locks in place.
6. Remove the swivel nut and arm of the **J 44211** (2). See **Special Tools** .
7. Relieve the air pressure to the cylinder being serviced.
8. Remove the **J 39313** (1) from the spark plug hole. See **Special Tools** .
9. Remove the base plate of the **J 44211** (2). See **Special Tools** .

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10. Install the spark plug. Refer to **Spark Plug Replacement** .
11. Repeat these removal and installation steps on any other cylinders being serviced.
12. Install the right camshafts. Refer to **Camshaft Replacement - Right Side**.

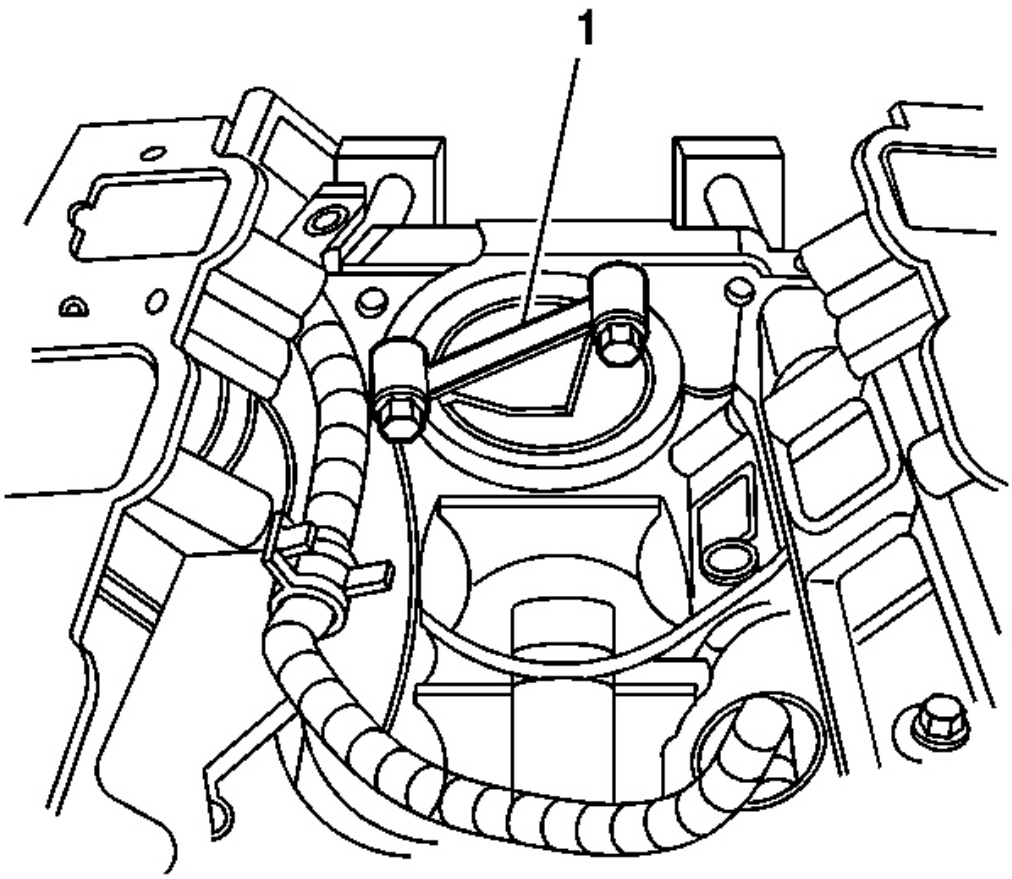


Fig. 95: View Of EN 46326 Installed To Engine Block
Courtesy of GENERAL MOTORS CORP.

13. Remove the **EN 46326** flywheel holder tool (1). See **Special Tools** .
14. Install the starter motor. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)** .

ENGINE FLYWHEEL REPLACEMENT

TOOLS REQUIRED

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J 45059 Angle Meter. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the powertrain. Refer to **Powertrain Removal and Installation**.

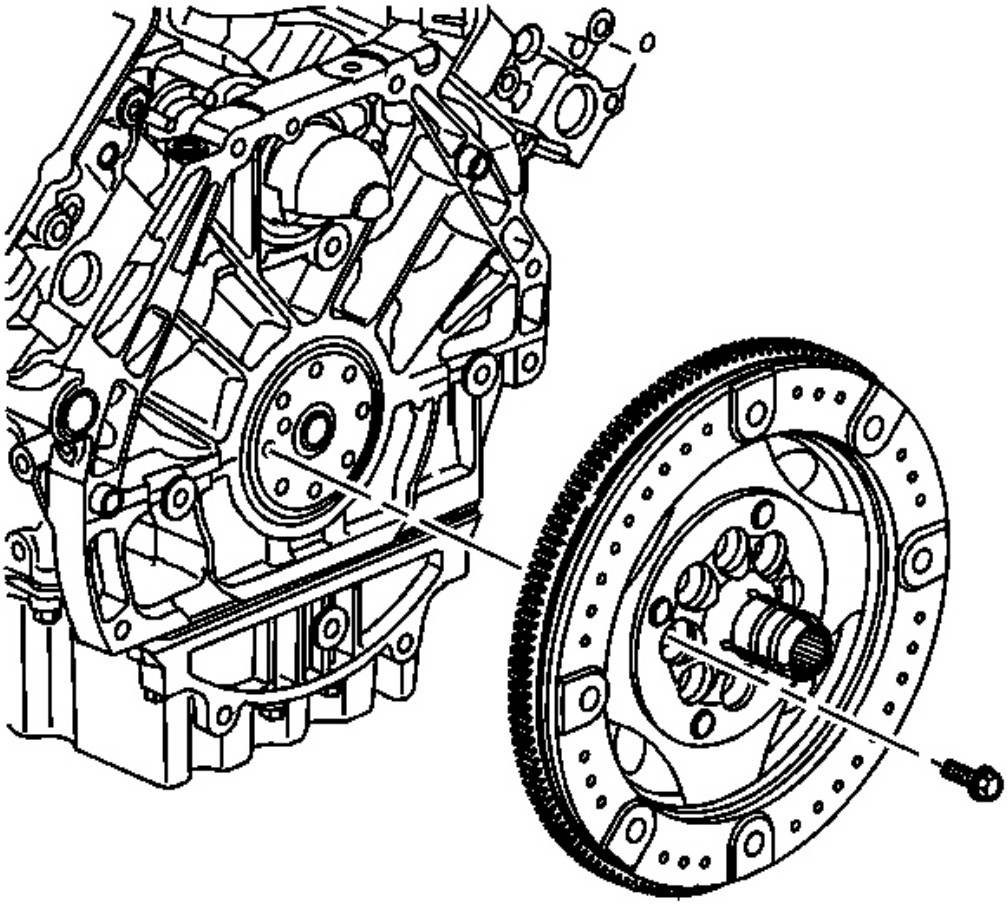


Fig. 96: View Of Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the driveline support assembly. Refer to **Driveline Support Assembly Replacement** .
3. Use a Snap-On™ A144A Flywheel Turner or equivalent to prevent the engine from turning.
4. Remove the engine flywheel bolts.
5. Remove the engine flywheel.

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6. Clean and inspect the engine flywheel. Refer to **Engine Flywheel Cleaning and Inspection** .

INSTALLATION PROCEDURE

1. Apply sealant to the flywheel mounting bolts. Refer to **Sealers, Adhesives and Lubricants** .

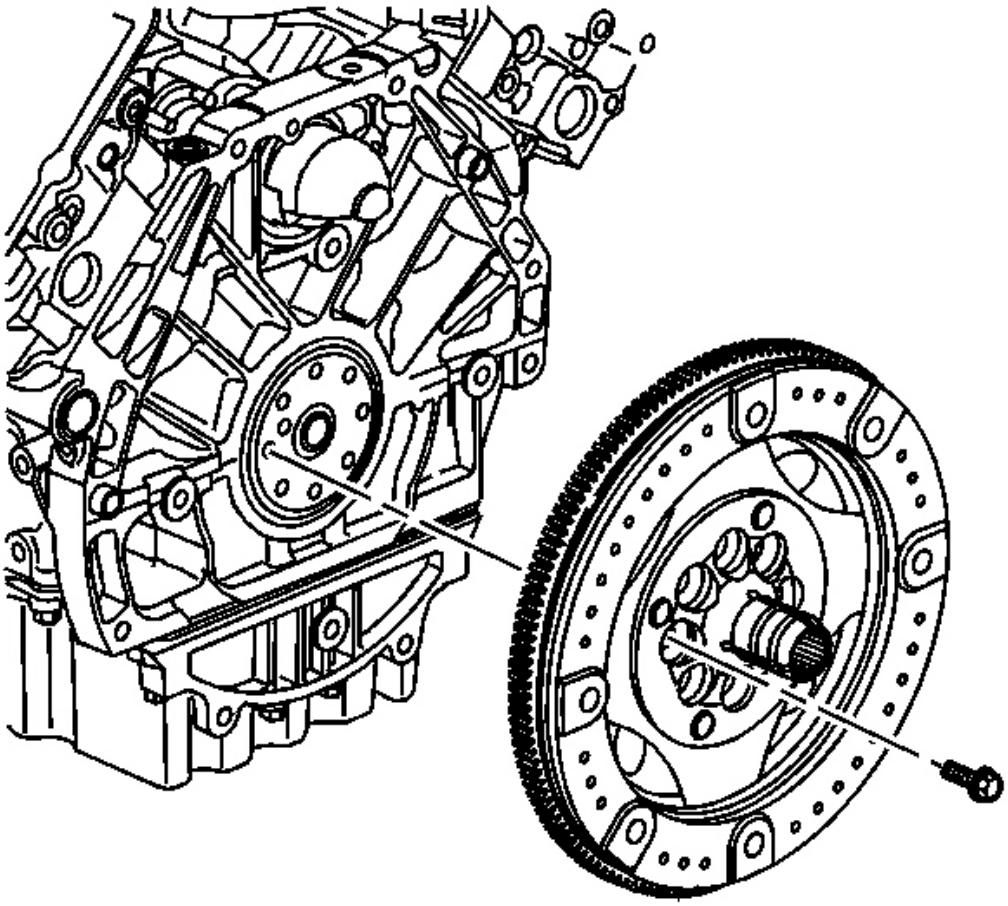


Fig. 97: View Of Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Position the flywheel to the crankshaft.

NOTE: Refer to Fastener Notice .

3. Install the flywheel mounting bolts.

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4. Use a Snap-On™ A144A Flywheel Turner or equivalent to prevent the engine from turning.

   Tighten:

   1. First Pass

      Tighten the flywheel mounting bolts to 30 N.m (22 lb ft).

   2. Final Pass

      Tighten the flywheel mounting bolts an additional 50 degrees using the **J 45059** . See **Special Tools** .

5. Install the driveline support assembly. Refer to **Driveline Support Assembly Replacement** .
6. Install the powertrain. Refer to **Powertrain Removal and Installation**.

OIL PAN REPLACEMENT

REMOVAL PROCEDURE

1. Remove the front suspension crossmember. Refer to **Front Suspension Crossmember Replacement** .
2. Drain the engine oil.
3. Remove the engine oil filter and allow to drain.
4. Remove the automatic transmission fluid cooler line mounting clips. Refer to **Transmission Fluid Cooler Lower Pipe Assembly Replacement - Transmission to Auxiliary Cooler** .

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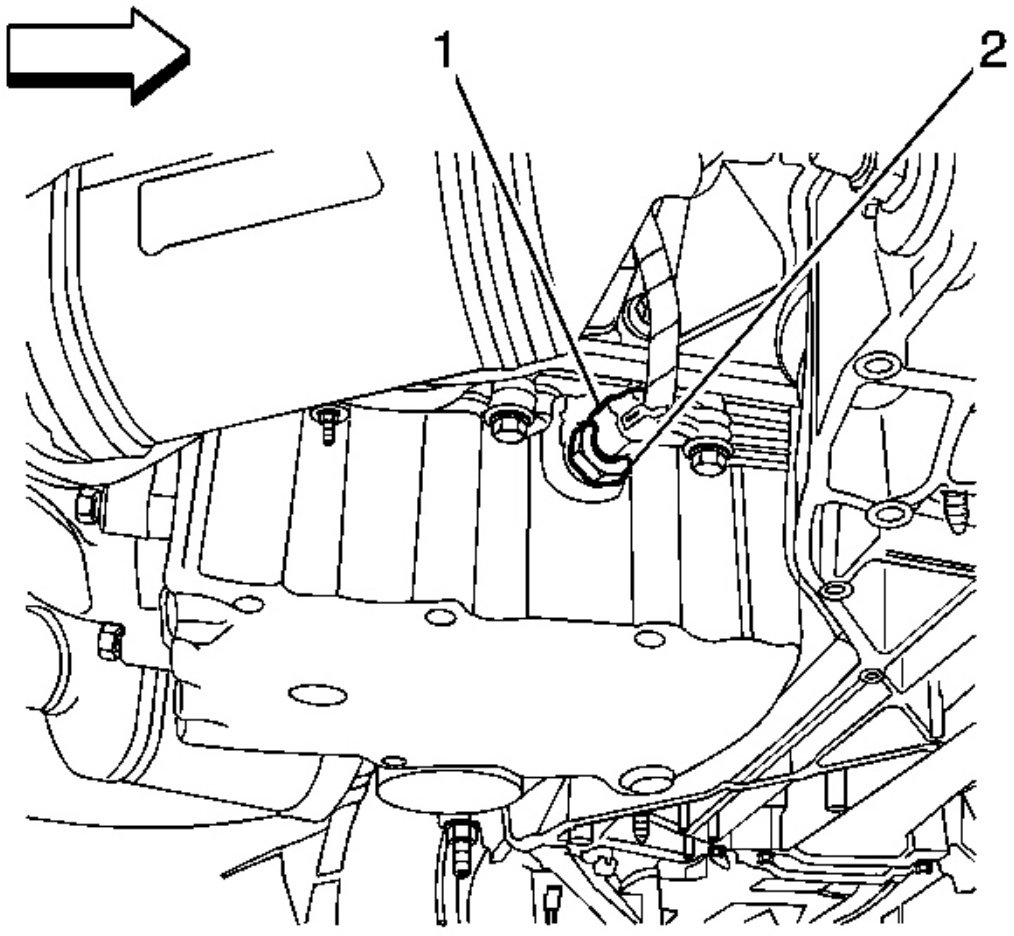


Fig. 98: Identifying Engine Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the engine oil level sensor electrical connector (1).
6. Remove the oil level sensor (2). Refer to **Engine Oil Level Sensor and/or Switch Replacement** .

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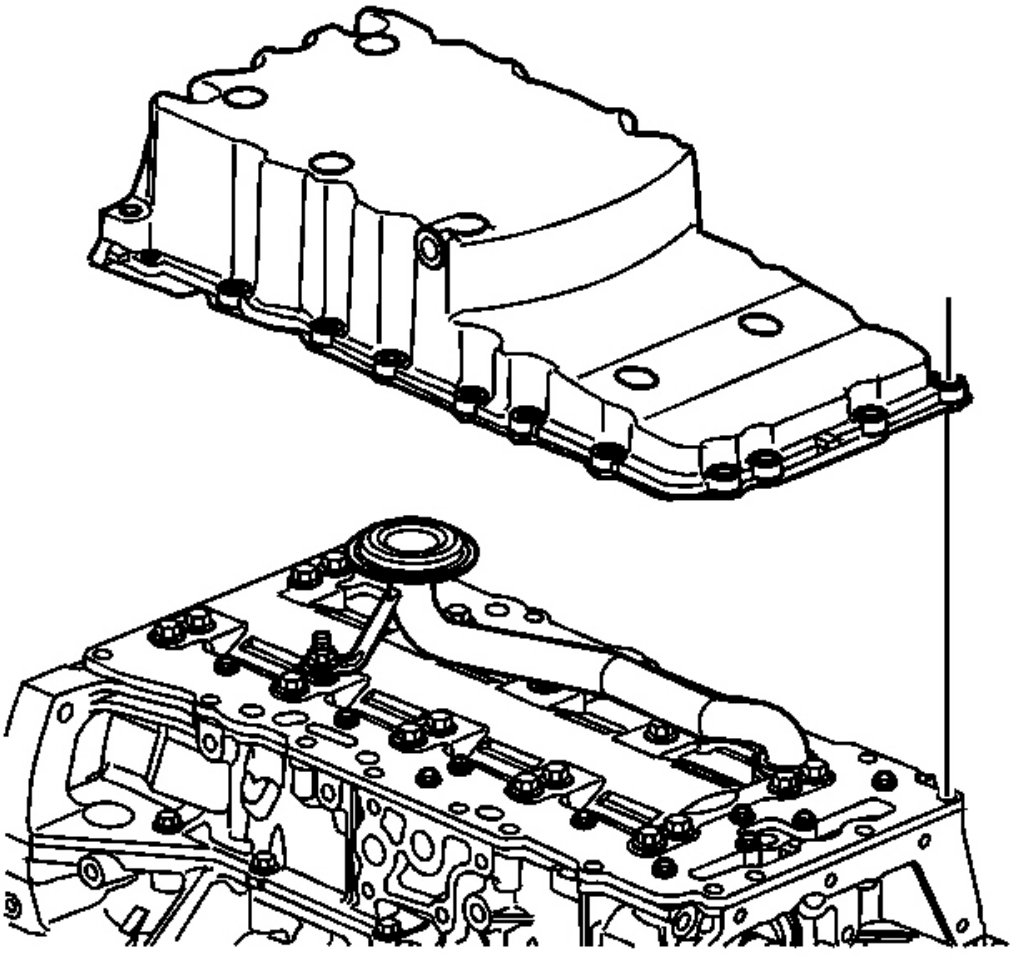


Fig. 99: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pan bolts.
8. Remove the oil pan.
9. Drill out the oil pan gasket rivets.

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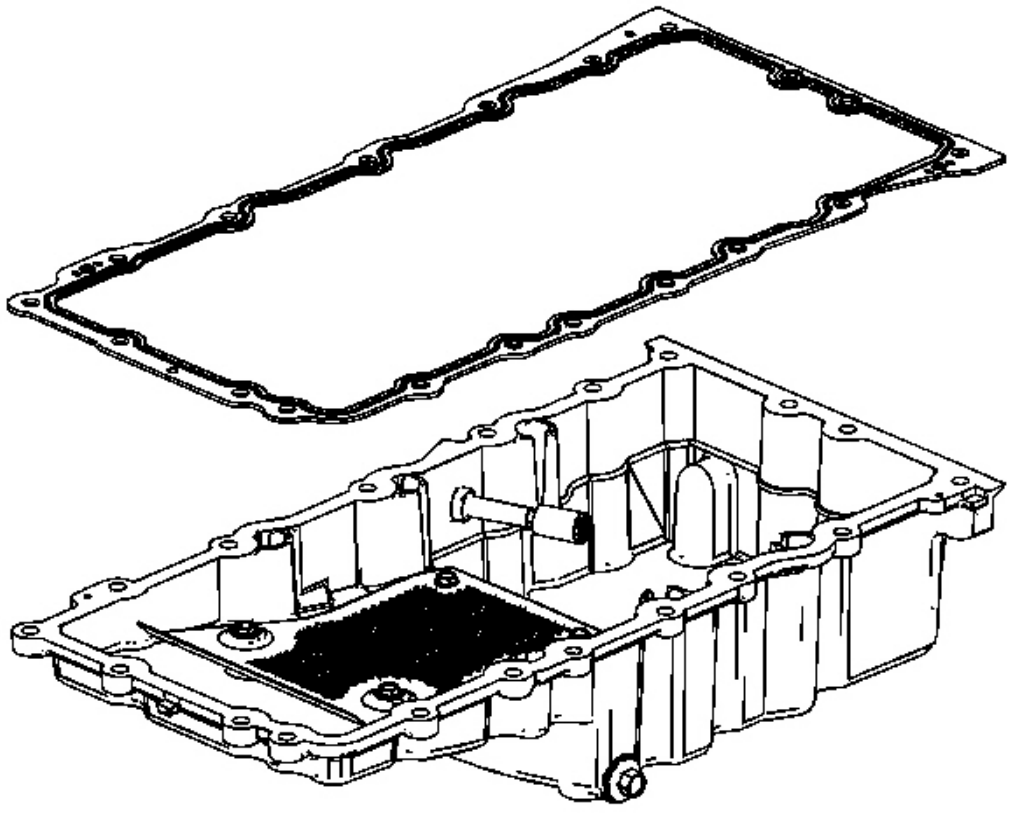


Fig. 100: Removing Oil Pan Gasket
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the oil pan gasket.
11. Clean and inspect the oil pan. Refer to **Oil Pan Cleaning and Inspection** .

INSTALLATION PROCEDURE

IMPORTANT: All gasket surfaces should be free of oil or other foreign material during assembly.
The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the flywheel housing cover. To ensure the rigidity of the powertrain it is important that the rear of the block and the rear of the oil pan are flush or even. The rear of the oil pan must NEVER protrude beyond the engine block.

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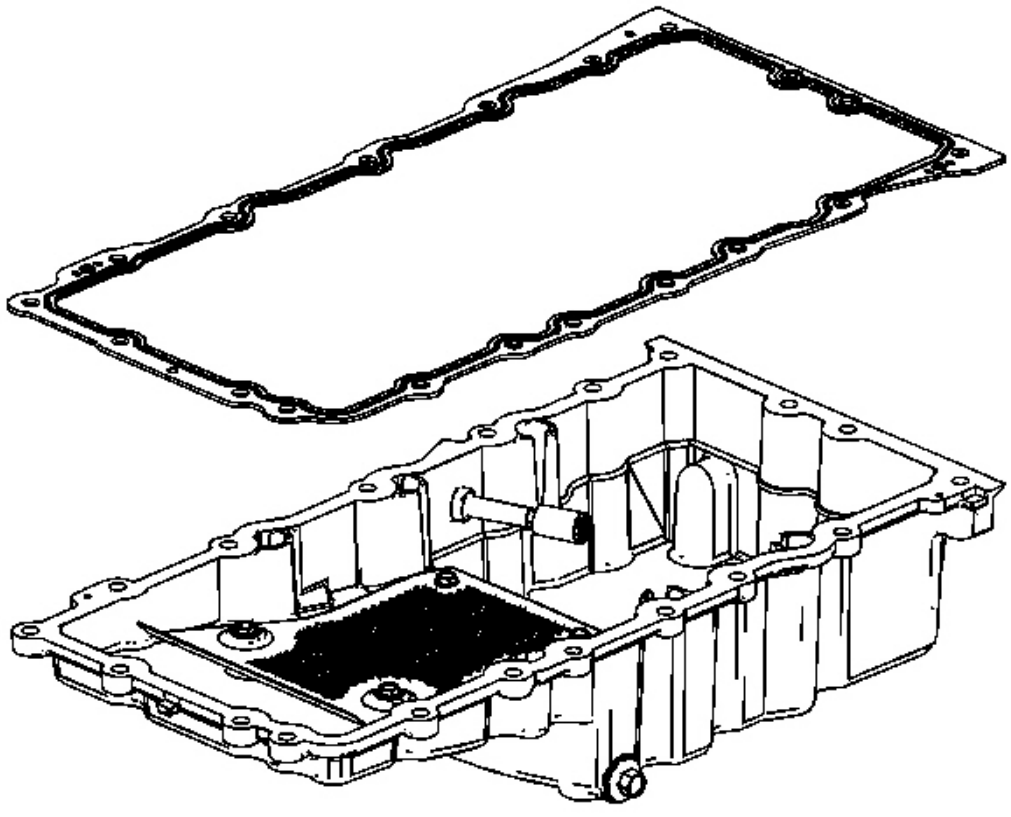


Fig. 101: Removing Oil Pan Gasket
Courtesy of GENERAL MOTORS CORP.

1. Use a new oil pan gasket. It is not necessary to rivet the new oil pan gasket to the oil pan.
2. Position the oil pan to the lower crankcase.

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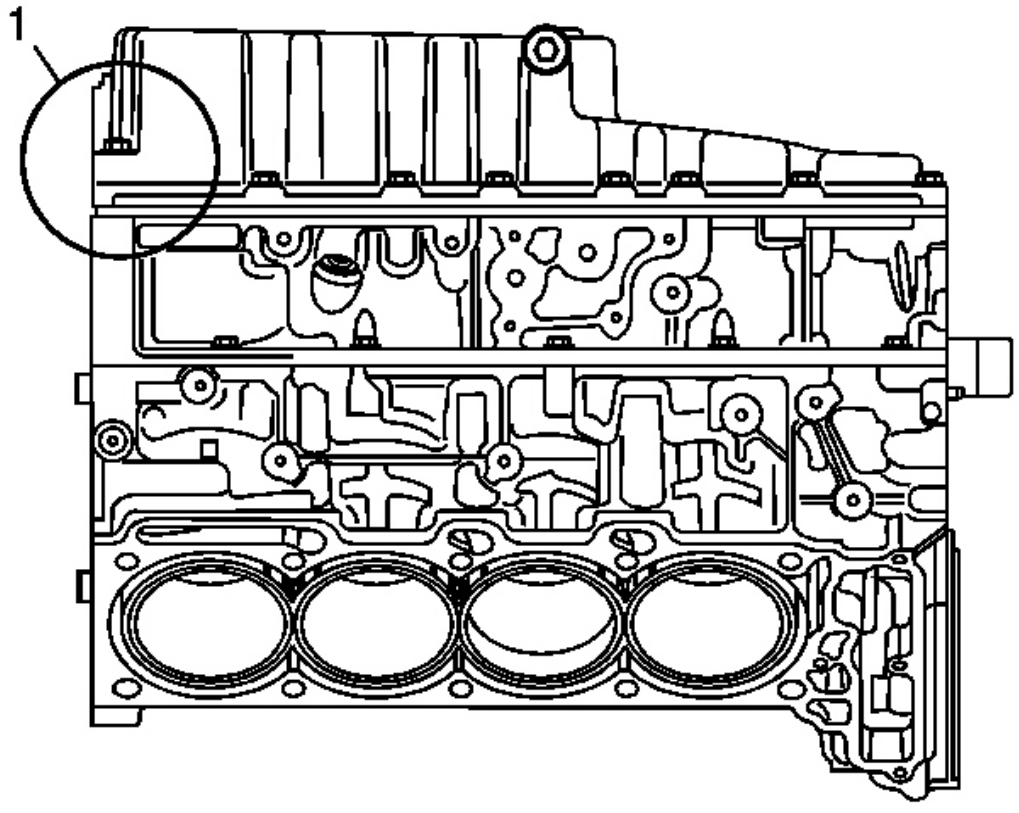


Fig. 102: View Of Rear Face Of Engine Block
Courtesy of GENERAL MOTORS CORP.

3. The oil pan must be held flush to 0.50 mm (0.020 in) forward of the rear face of the engine block (1).

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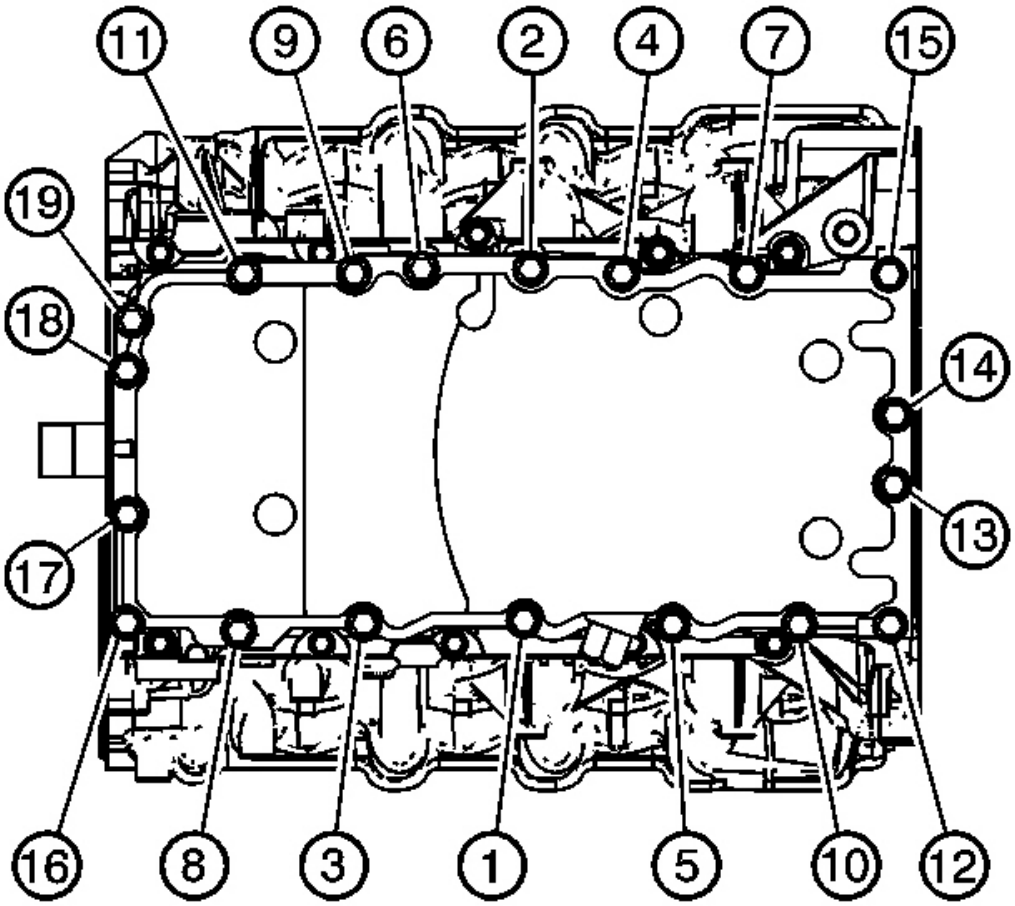


Fig. 103: View Of Oil Pan Retaining Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the oil pan bolts in the sequence shown.

   Tighten:
   - First Pass-Tighten the oil pan bolts to 15 N.m (11 lb ft).
   - Final Pass-Tighten the oil pan bolts to 25 N.m (18 lb ft).

5. Install the oil drain plug.

   Tighten: Tighten the oil drain plug to 25 N.m (18 lb ft).

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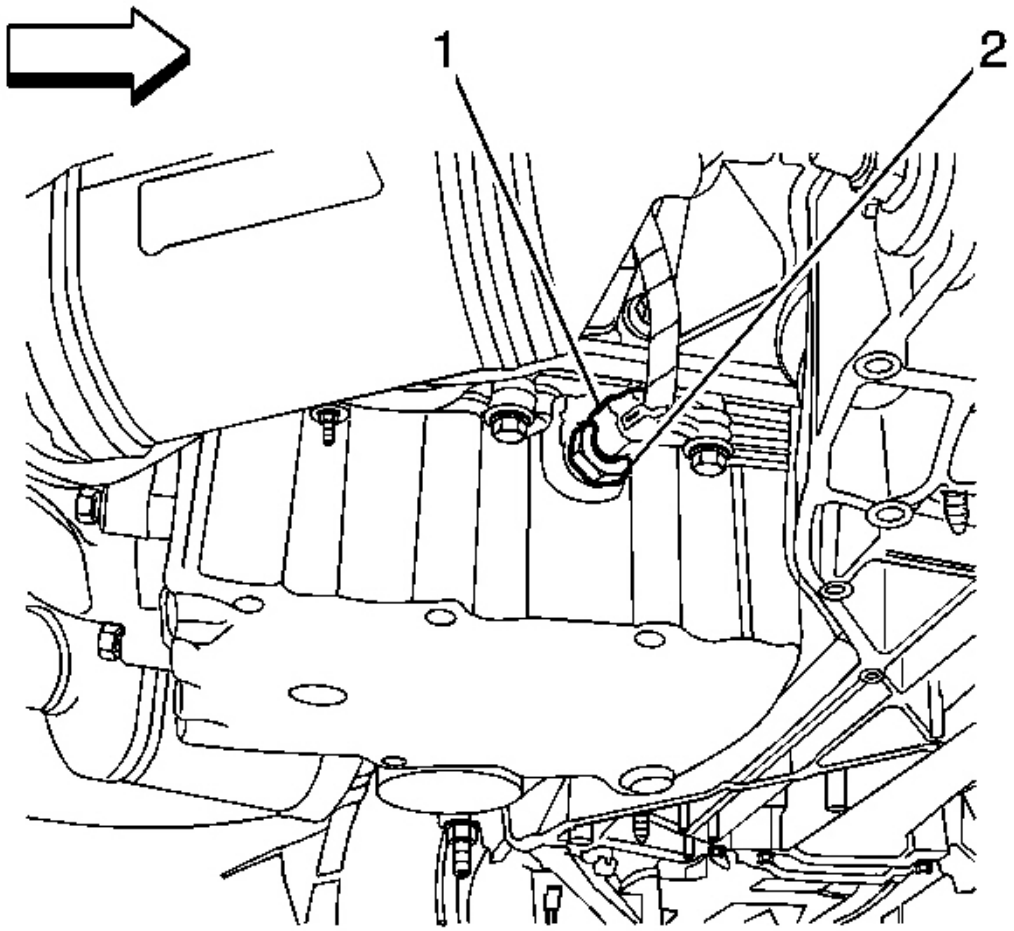


Fig. 104: Identifying Engine Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Component Fastener Tightening Notice .**

6. Install the engine oil level sensor into the oil pan.

   Tighten: Tighten the engine oil level sensor to 20 N.m (15 lb ft).

7. Connect the electrical connector to the engine oil level sensor.
8. Install the automatic transmission fluid cooler line mounting clips. Refer to **Transmission Fluid Cooler Lower Pipe Assembly Replacement - Transmission to Auxiliary Cooler** .
9. Install a NEW engine oil filter.

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Tighten: Tighten the engine oil filter to 30 N.m (22 lb ft).

10. Install the front suspension crossmember to the vehicle. Refer to **Front Suspension Crossmember Replacement** .
11. Fill the crankcase with the proper quantity and grade of engine oil. Refer to **Capacities - Approximate Fluid** and **Fluid and Lubricant Recommendations** .
12. Run the engine and check for leaks.

CRANKSHAFT REAR OIL SEAL REPLACEMENT

TOOLS REQUIRED

- **J 42841-A** Crankshaft Rear Oil Seal Remover. See **Special Tools** .
- **J 45930-A** Crankshaft Rear Oil Seal Installer. See **Special Tools** .
- **EN-48072** Seal Applicator. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the flywheel. Refer to **Engine Flywheel Replacement**.

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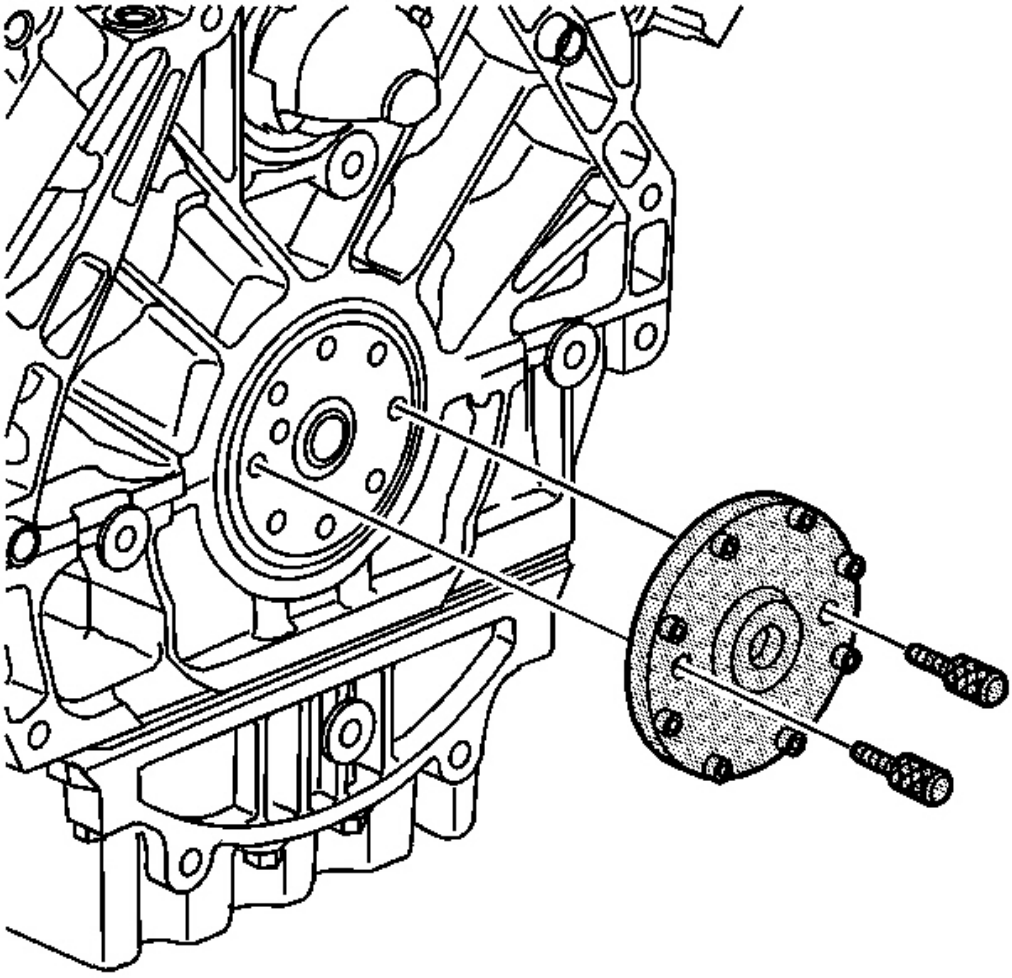


Fig. 105: View Of J 42841
Courtesy of GENERAL MOTORS CORP.

2. Place the **J 42841-A** on to the crankshaft. See **Special Tools** .
3. Install the **J 42841-A** retaining bolts. See **Special Tools** .

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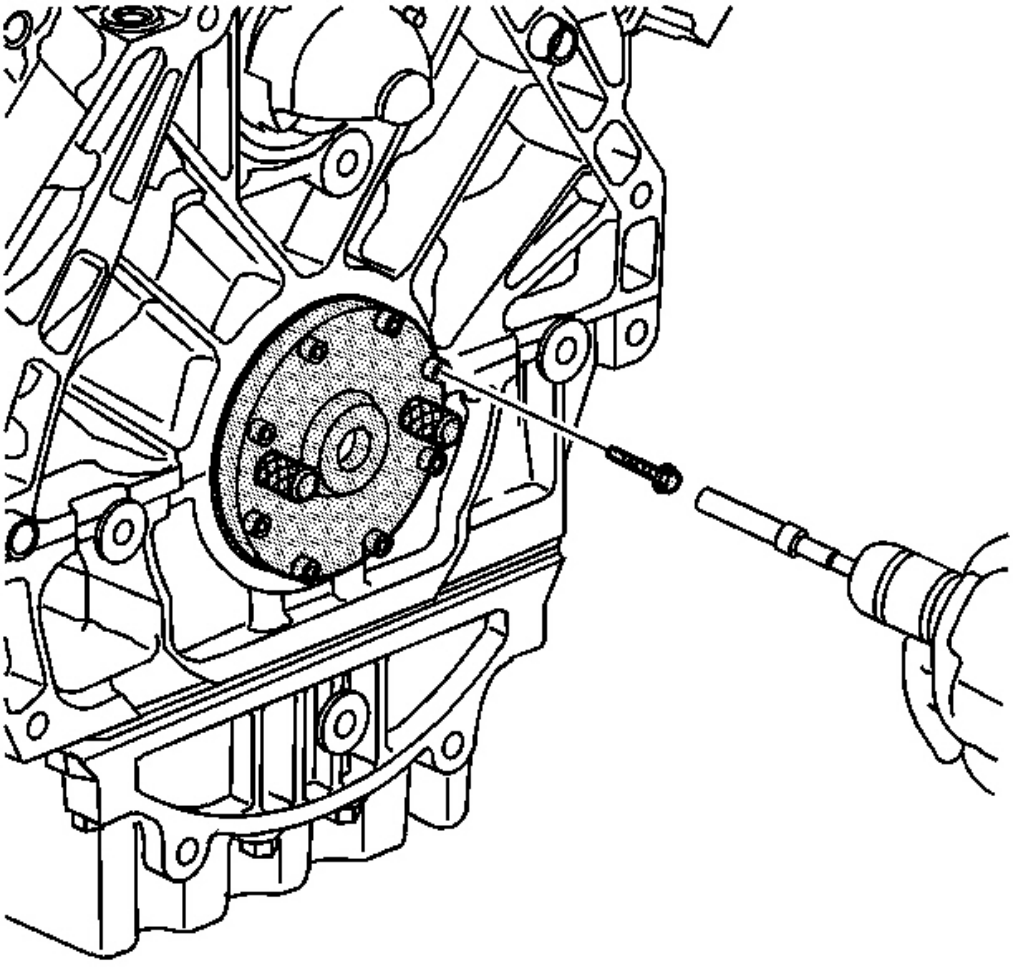


Fig. 106: Installing Self-Drilling Screws Into Seal
Courtesy of GENERAL MOTORS CORP.

4. Using a drill motor, variable speed preferred, with a socket adapter, install eight 25 mm (1.0 in) self-drilling screws into the seal using the guide holes in the removal tool. When drilling, make sure you reduce the drill speed when the screw begins threading into the seal.

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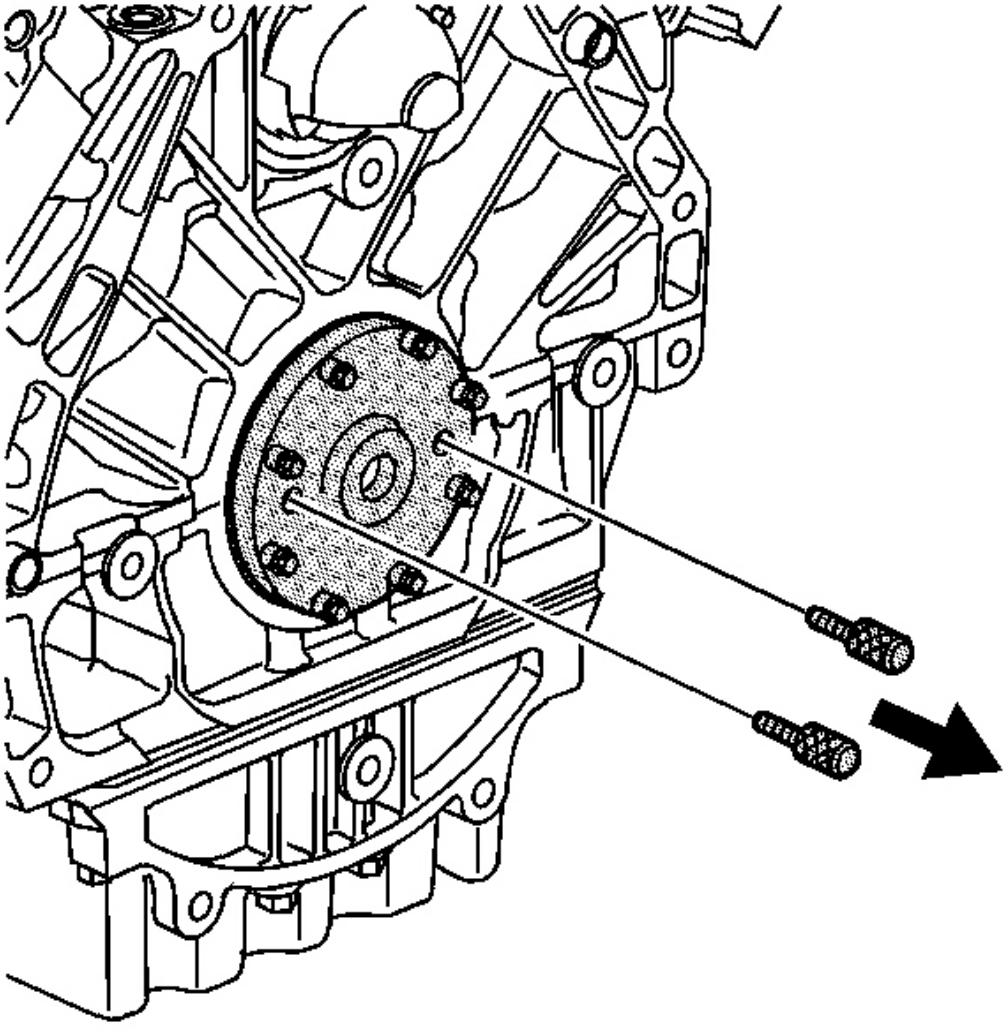


Fig. 107: Removing J 42841 Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

5. With all 8 removal screws installed, remove the **J 42841-A** retaining bolts. See **Special Tools** .

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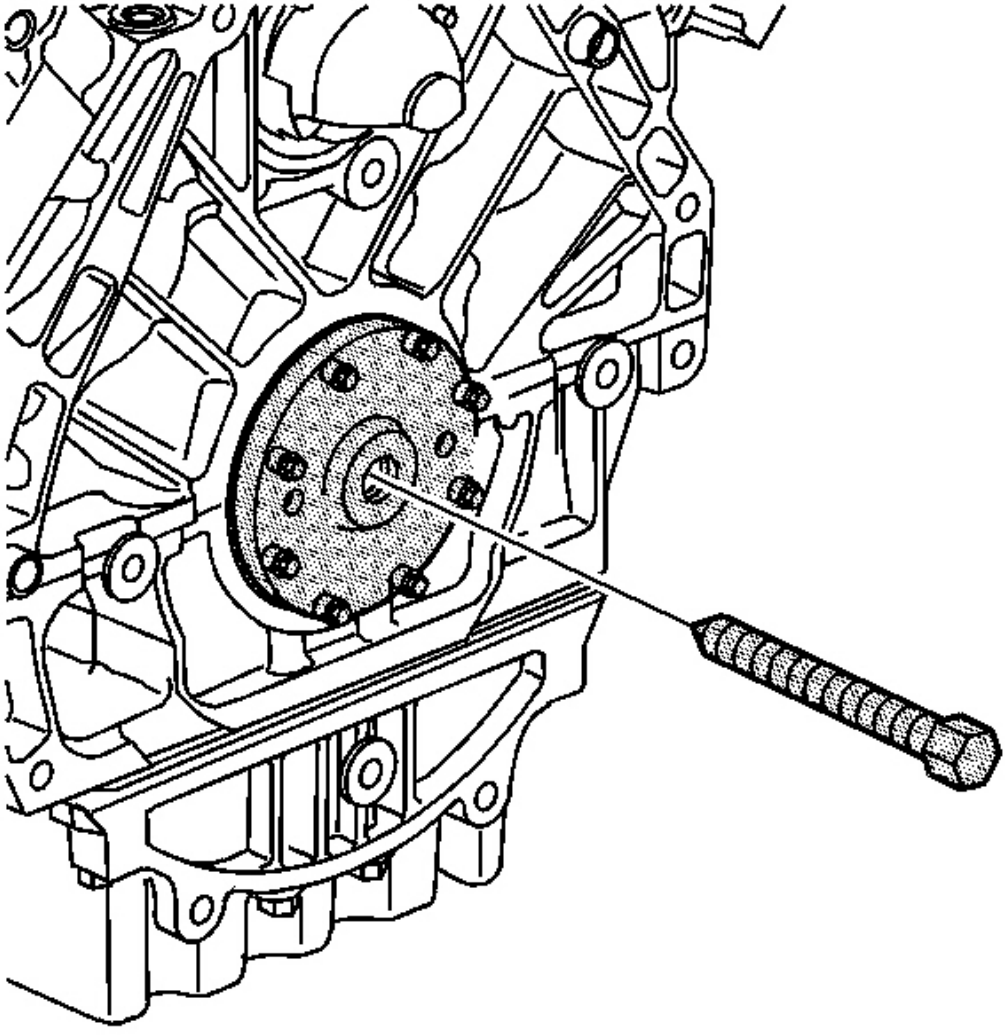


Fig. 108: View Of Center Forcing Screw
Courtesy of GENERAL MOTORS CORP.

6. Install the center forcing screw.

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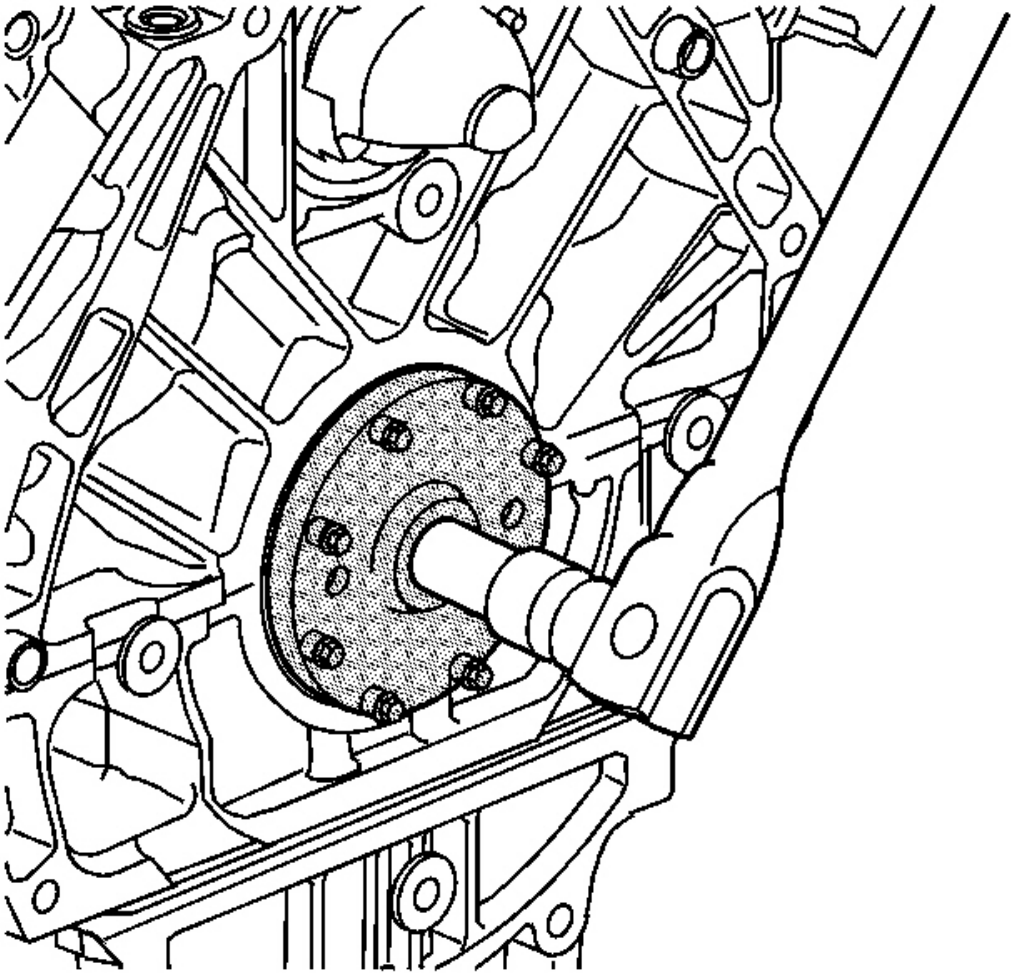


Fig. 109: Removing Crankshaft Rear Oil Seal Assembly
Courtesy of GENERAL MOTORS CORP.

7. Tighten the center screw on the removal tool to pull the seal assembly off the end of the crankshaft.

INSTALLATION PROCEDURE

IMPORTANT: The EN-48072 must be used to ensure even application of the sealant in the bore and to prevent blockage of the drain back hole. See Special Tools .

IMPORTANT: Ensure components that are being sealed with RTV sealant are assembled

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within 20 minutes. Components assembled after the RTV sealant has skinned-over, approximately 20 minutes, will not bond properly.

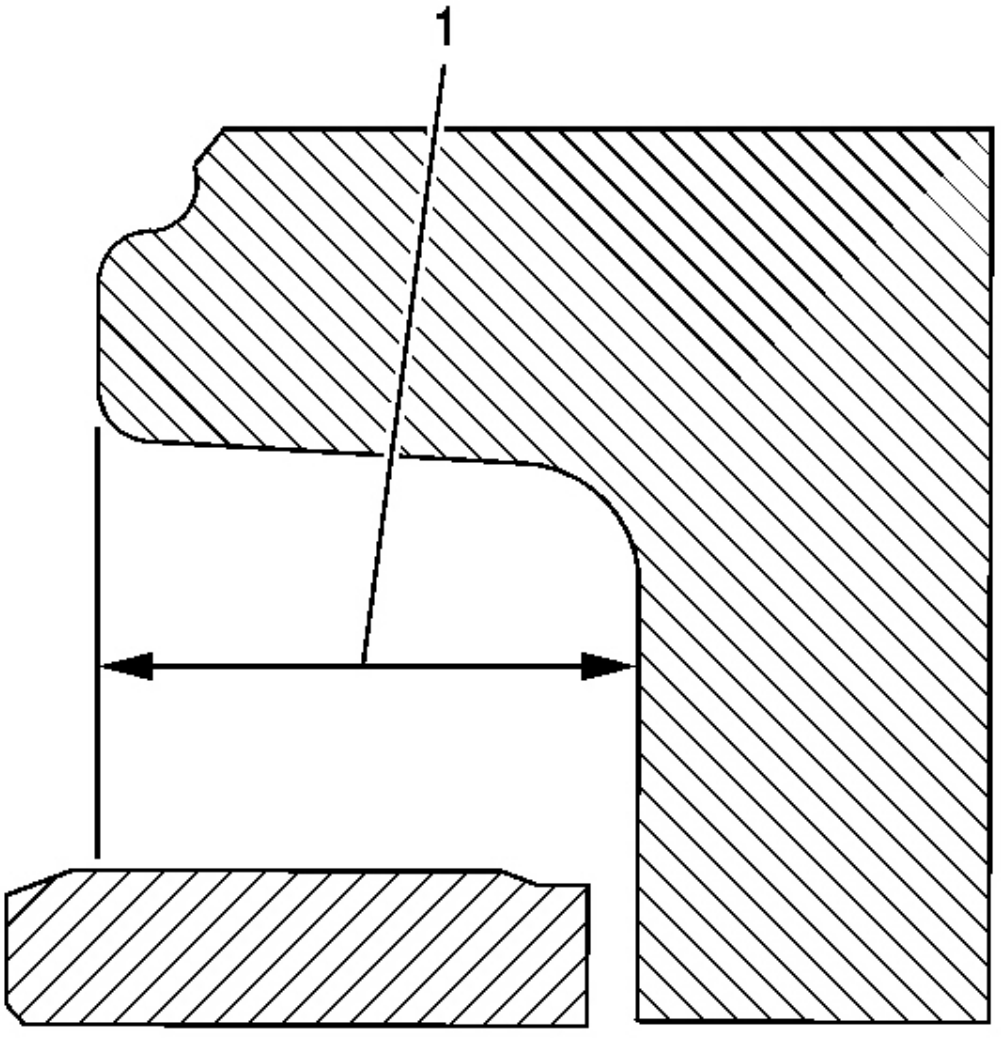


Fig. 110: Checking Oil Seal Bore Depth
Courtesy of GENERAL MOTORS CORP.

1. Ensure the engine block where the crankshaft rear oil seal is installed is a deep bore (1).
   - A deep bore of approximately 15 mm (0.5906 in) was used on engines from March 1, 1996 and later.
   - A shallow bore of approximately 8 mm (0.3150 in) was used on engines from 1993 thru February

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29, 1996. This block would use a lip-style crankshaft rear oil seal and the **J 38817-A** for installation.

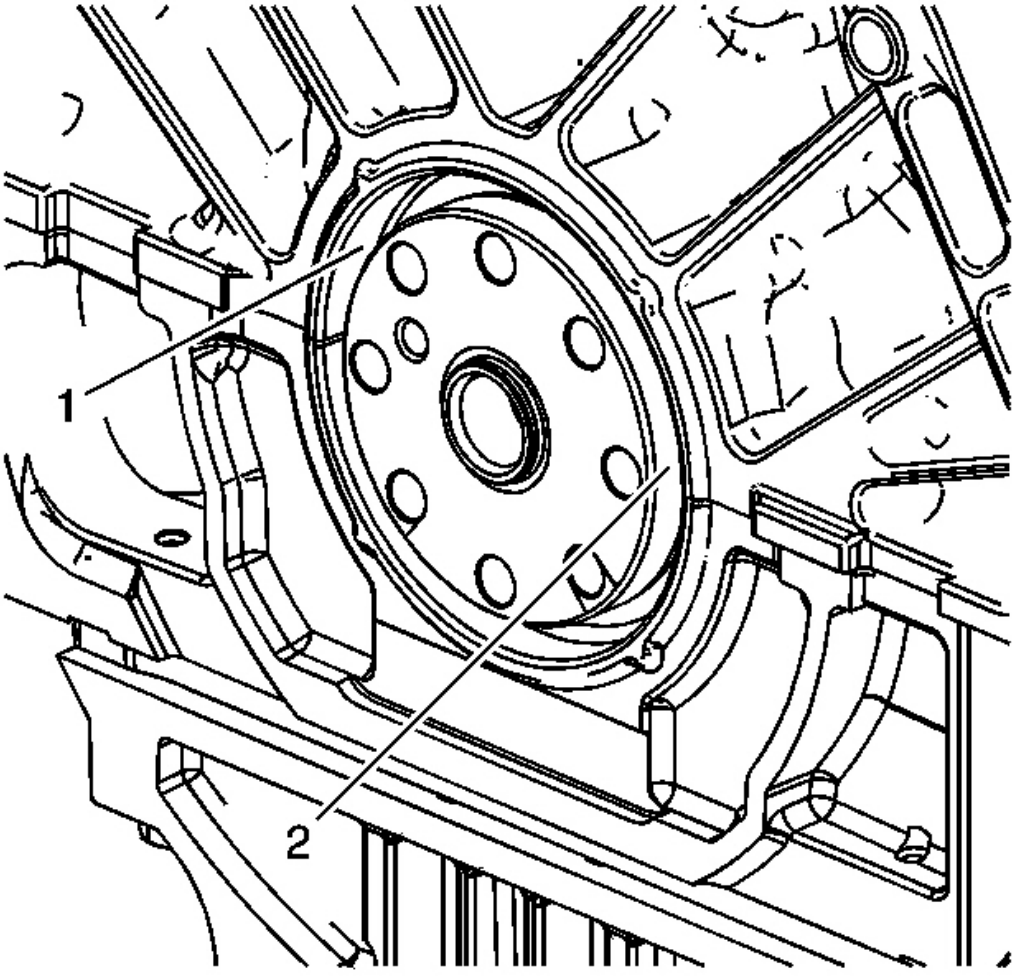


Fig. 111: Inspecting Engine Block Bore & Crankshaft Flange
Courtesy of GENERAL MOTORS CORP.

2. Inspect the engine block bore (1) and the crankshaft flange (2) for the damage. Repair or replace any damaged components.

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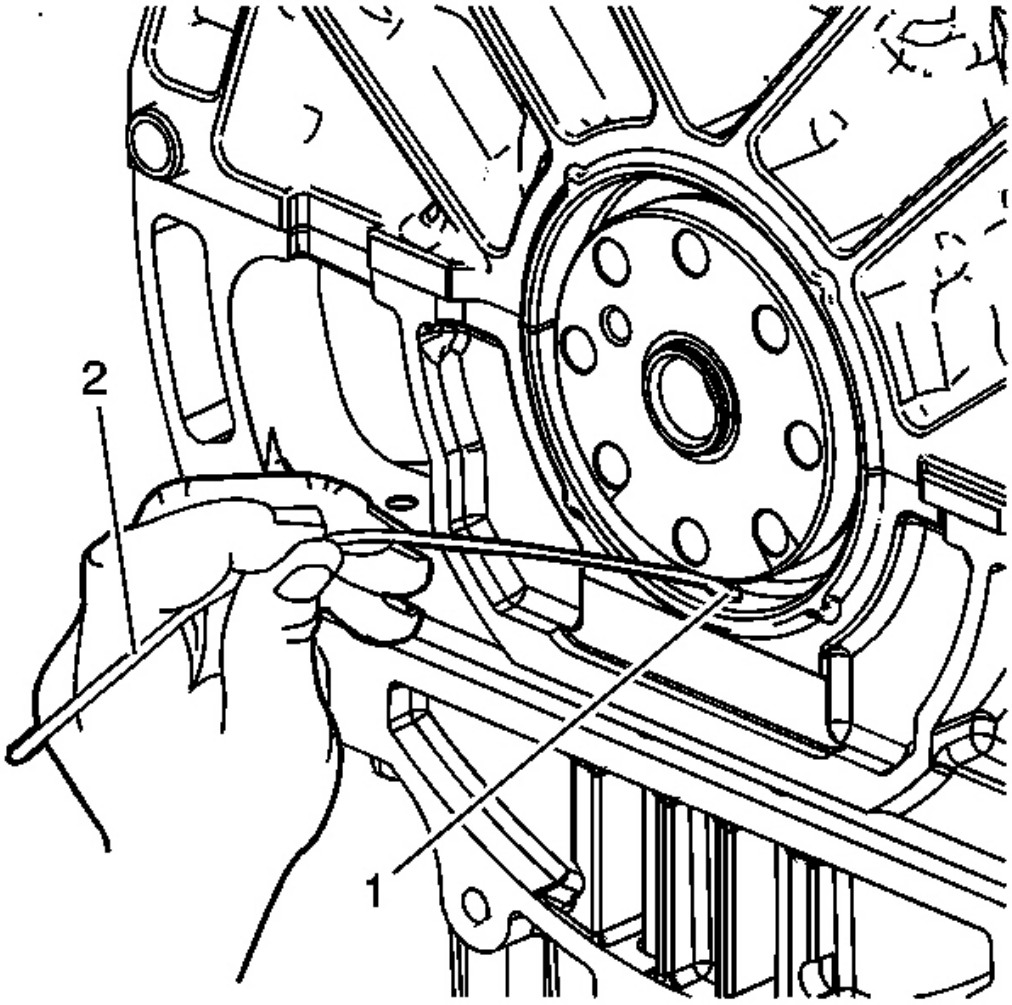


Fig. 112: View Of Crankshaft Rear Oil Seal Drain & Wire Or Unbound Plastic Tie-Wrap
Courtesy of GENERAL MOTORS CORP.

3. Ensure the oil drain-back hole is clear of debris using a wire or an unbound plastic tie wrap.

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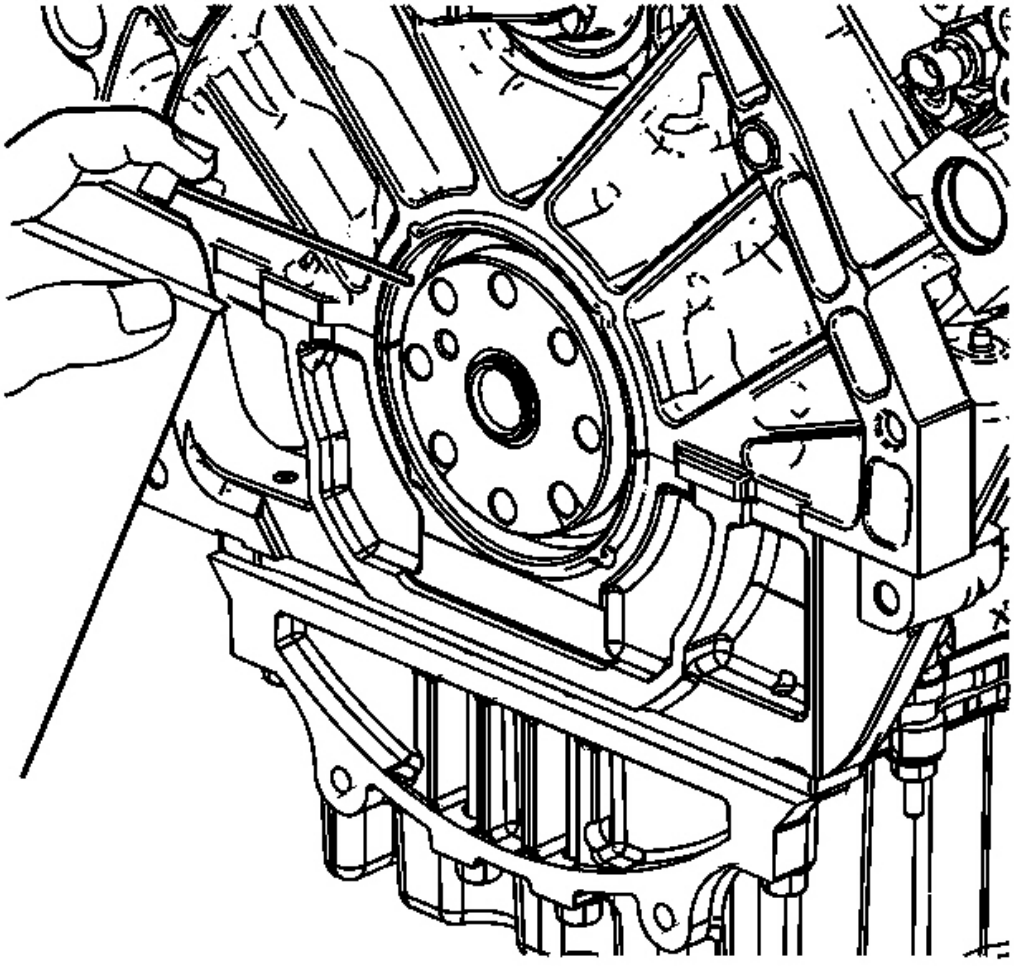


Fig. 113: Cleaning Bore In Block With Cleaner Solvent
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to ensure proper bonding of the sealant the bore must be clean and dry.

4. Clean the bore in the block with cleaner solvent GM P/N 12378392 or 12346139 (Canadian P/N 88901247).

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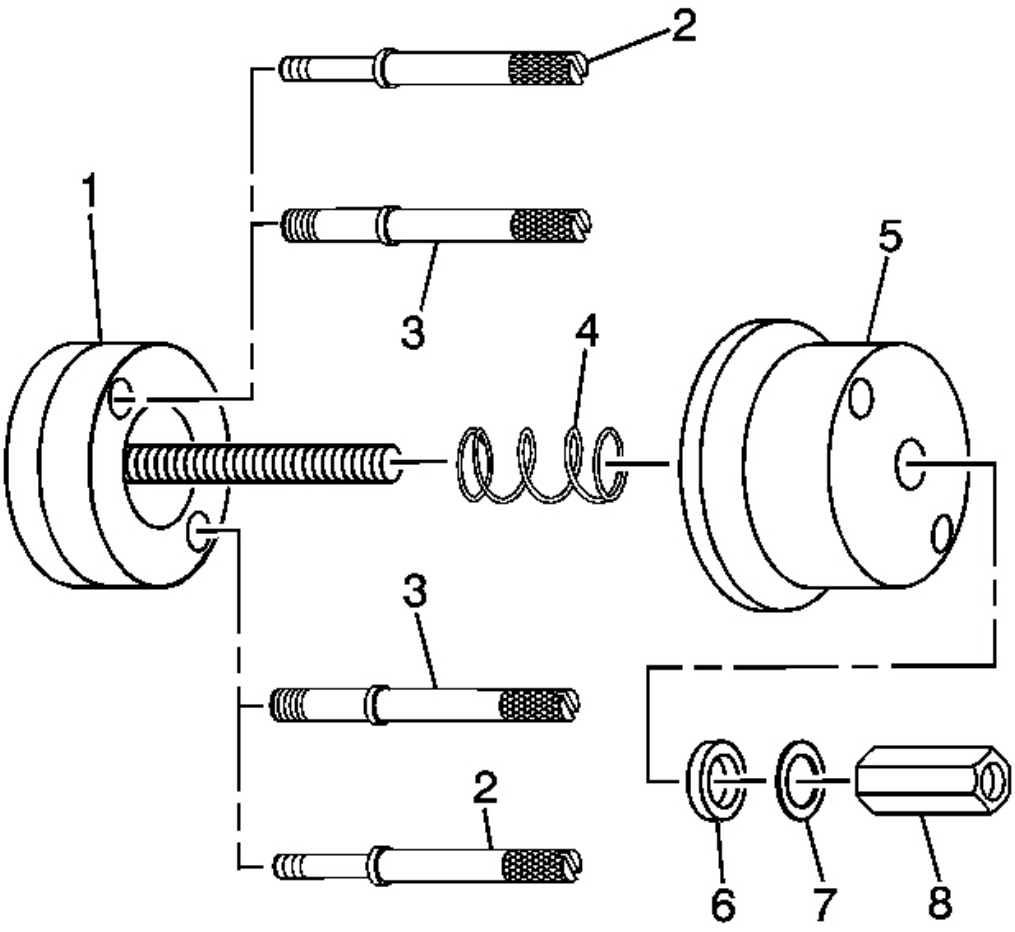


Fig. 114: View Of J 45930-A Tool Set
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Northstar engines 2005 and older have an 8 x 1.25 mm flywheel/flexplate crankshaft bolt hole thread. Northstar engines 2006 and later have an 11 x 1.5 mm flywheel/flexplate crankshaft bolt hole thread.

5. Remove the proper sized bolts from the **J 45930-A** . See **Special Tools** . Use the bolts (2) 8 mm or the bolts (3) 11 mm.

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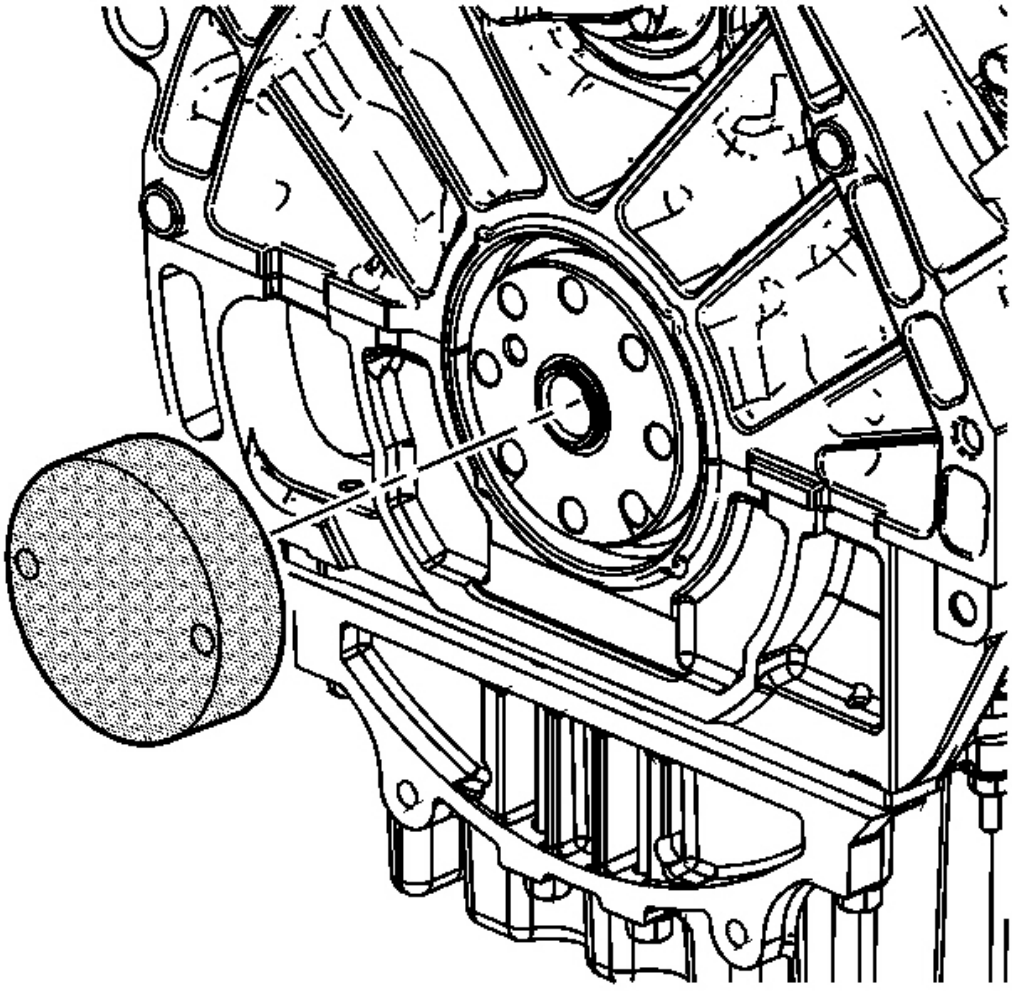


Fig. 115: View Of EN-48072 Pilot Base
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN-48072** pilot base onto the crankshaft. See **Special Tools** . The hub on the crankshaft will fit into the recess on the inboard side of the **EN-48072** pilot base. See **Special Tools** .

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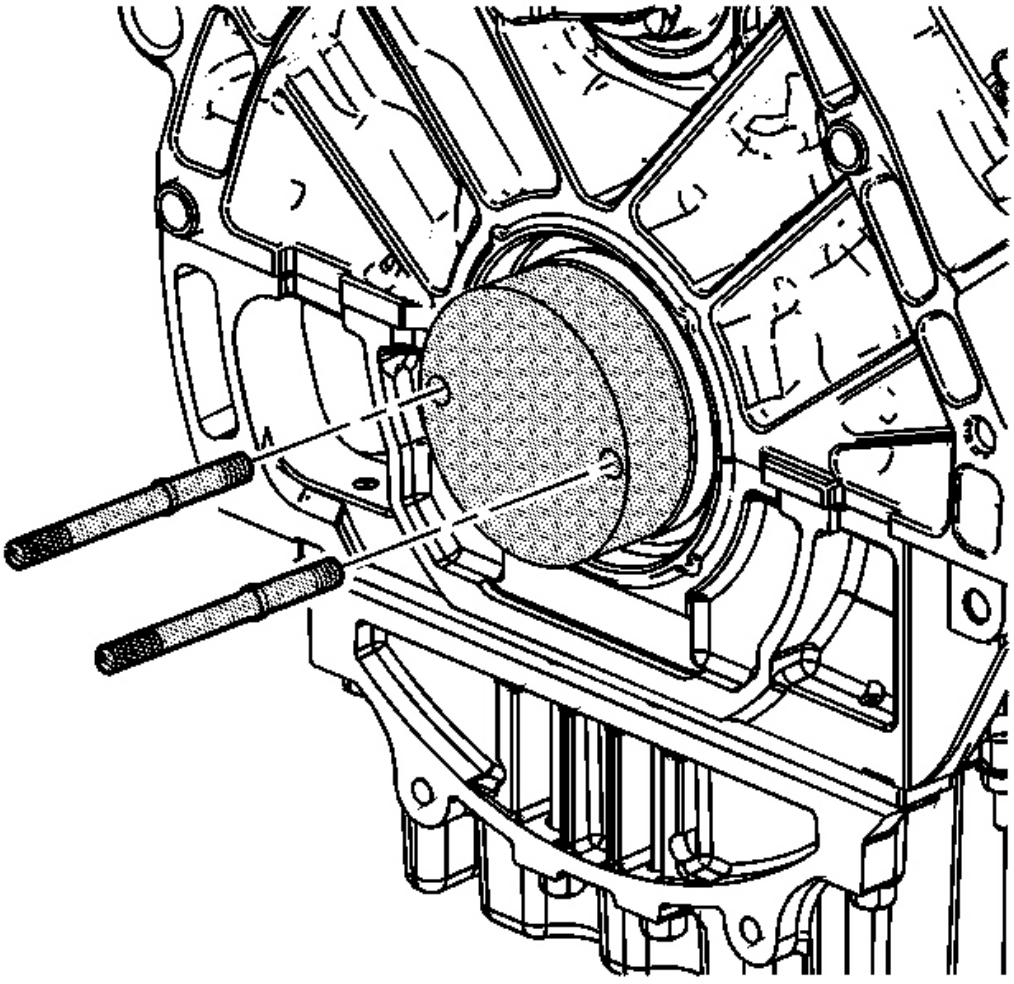


Fig. 116: View Of J 45930-A Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Northstar engines 2005 and older have an 8 x 1.25 mm flywheel/flexplate crankshaft bolt hole thread. Northstar engines 2006 and later have an 11 x 1.5 mm flywheel/flexplate crankshaft bolt hole thread.

7. Use the proper bolts from the **J 45930-A** to retain the **EN-48072** pilot base in place. See **Special Tools** .

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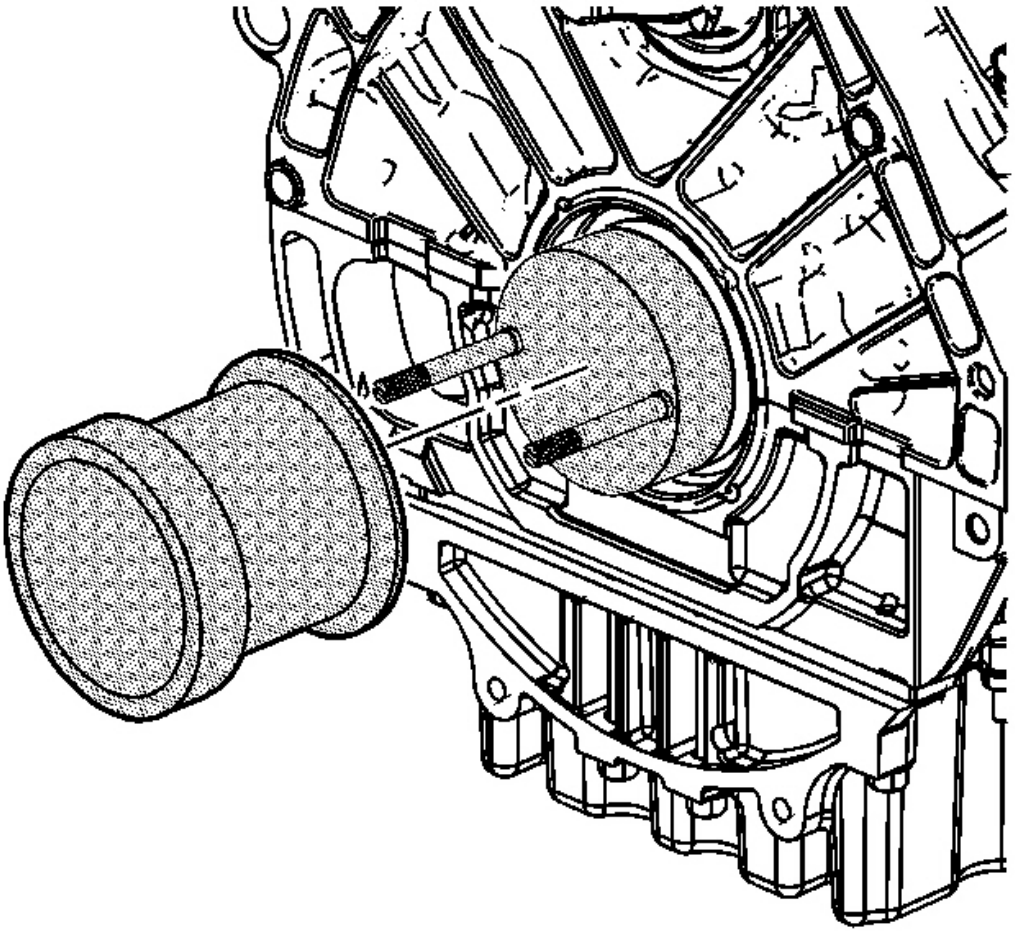


Fig. 117: View Of EN-48072 applicator housing
Courtesy of GENERAL MOTORS CORP.

8. Install the **EN-48072** applicator housing over the **EN-48072** pilot base. Ensure the **EN-48072** applicator housing bottoms in the bore of the block. See **Special Tools** .

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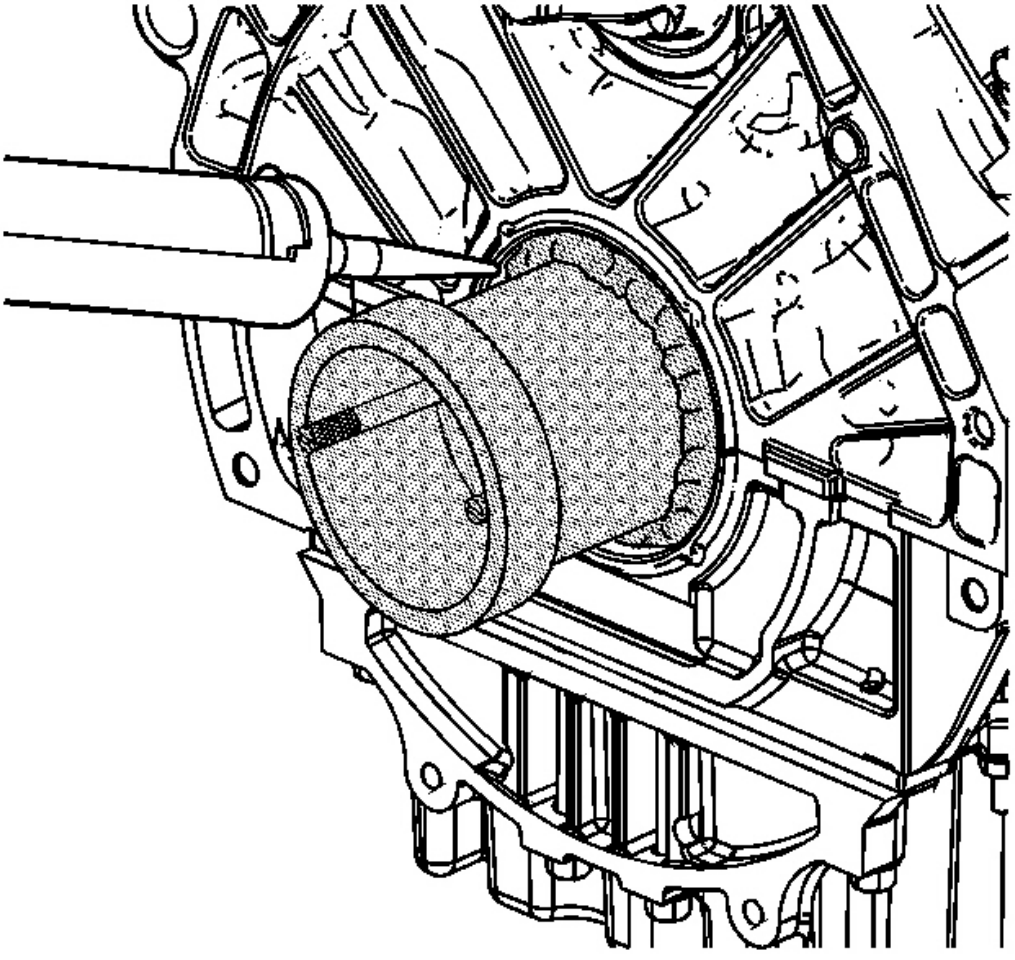


Fig. 118: Applying Sealant
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The sealant must not block the drain back hole. Blockage of the drain back hole can lead to oil leakage.

9. Apply the sealant GM P/N 12378521 (Canadian P/N 88901148) to the bore outer diameter in the block. Ensure the sealant does not block the drain hole.

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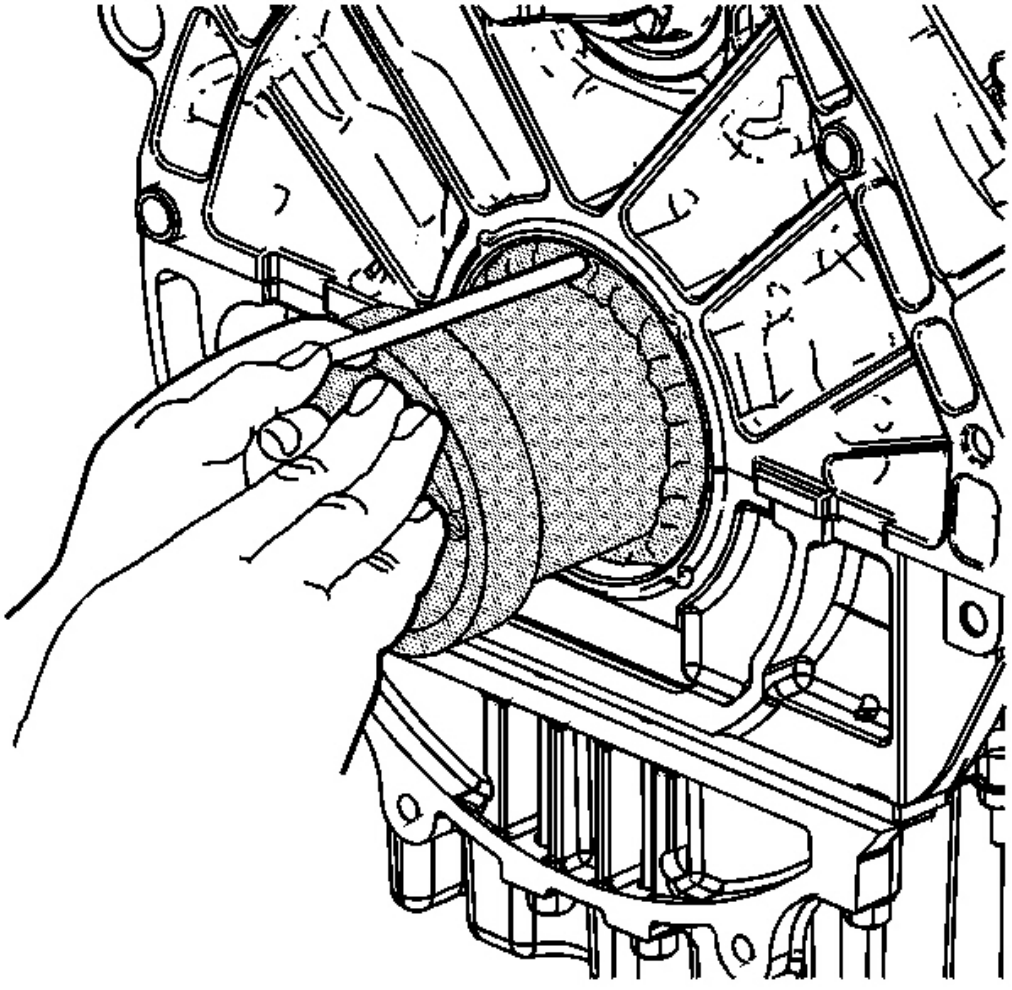


Fig. 119: Spreading Sealant
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Apply steady even pressure to the EN-48072 applicator housing. See Special Tools .

10. Using a suitable tool spread the sealant within the bore to ensure an even coating across the bore.

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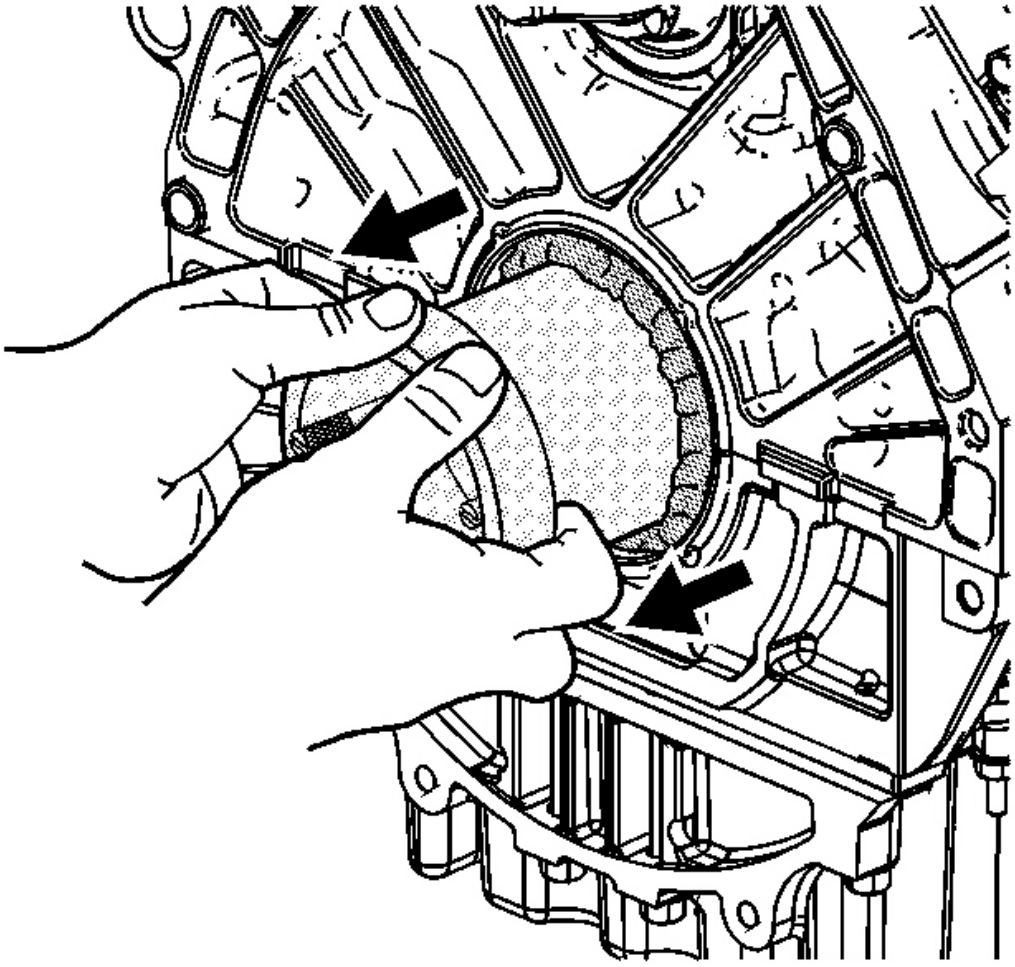


Fig. 120: Pulling EN-48072 Applicator Housing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to apply an even coat of the sealant do not twist or turn the EN-48072 applicator housing as it is pulled away from the bottom of the bore. See Special Tools .

11. Using both hands, slowly and evenly, pull the **EN-48072** applicator housing out of the bore and remove it from the **EN-48072** pilot base. See **Special Tools** .

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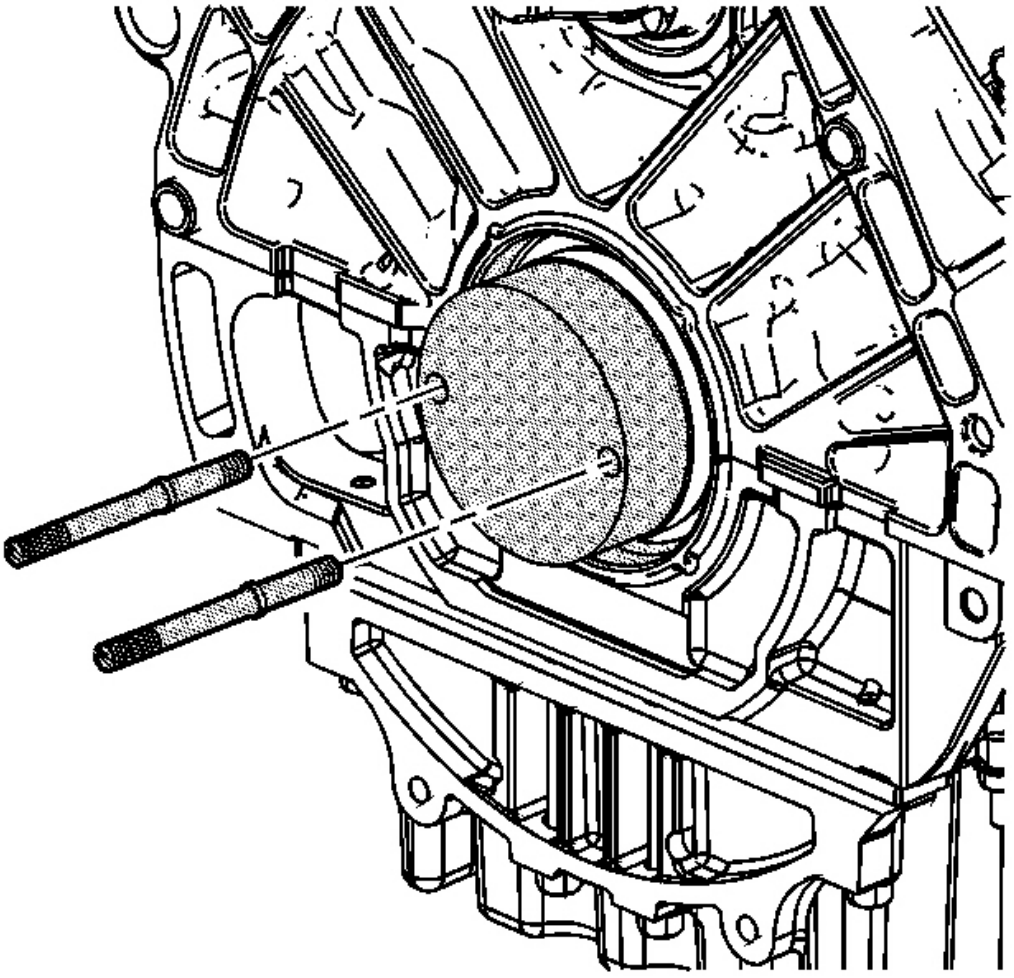


Fig. 121: View Of J 45930-A Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the **J 45930-A** bolts from the **EN-48072** pilot base. See **Special Tools** .

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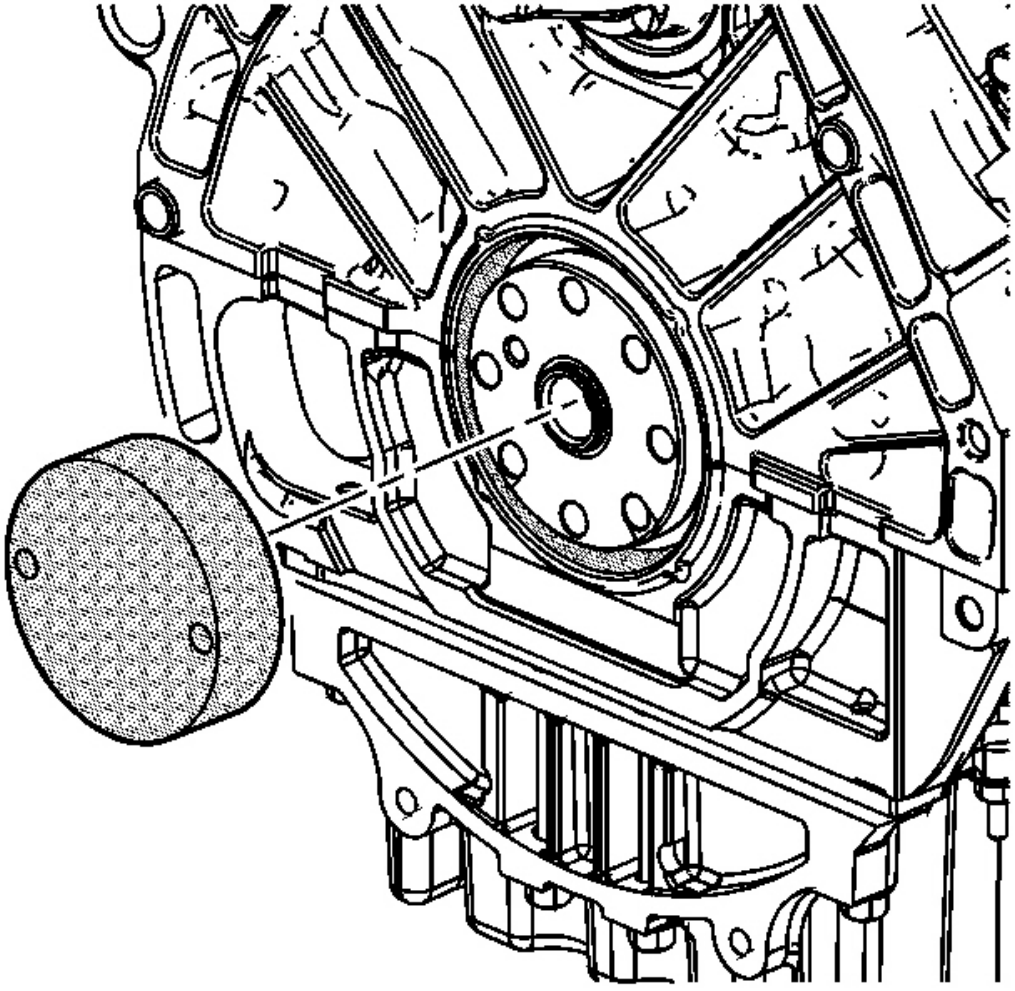


Fig. 122: View Of EN-48072 Pilot Base
Courtesy of GENERAL MOTORS CORP.

13. Remove the **EN-48072** pilot base. See **Special Tools** .

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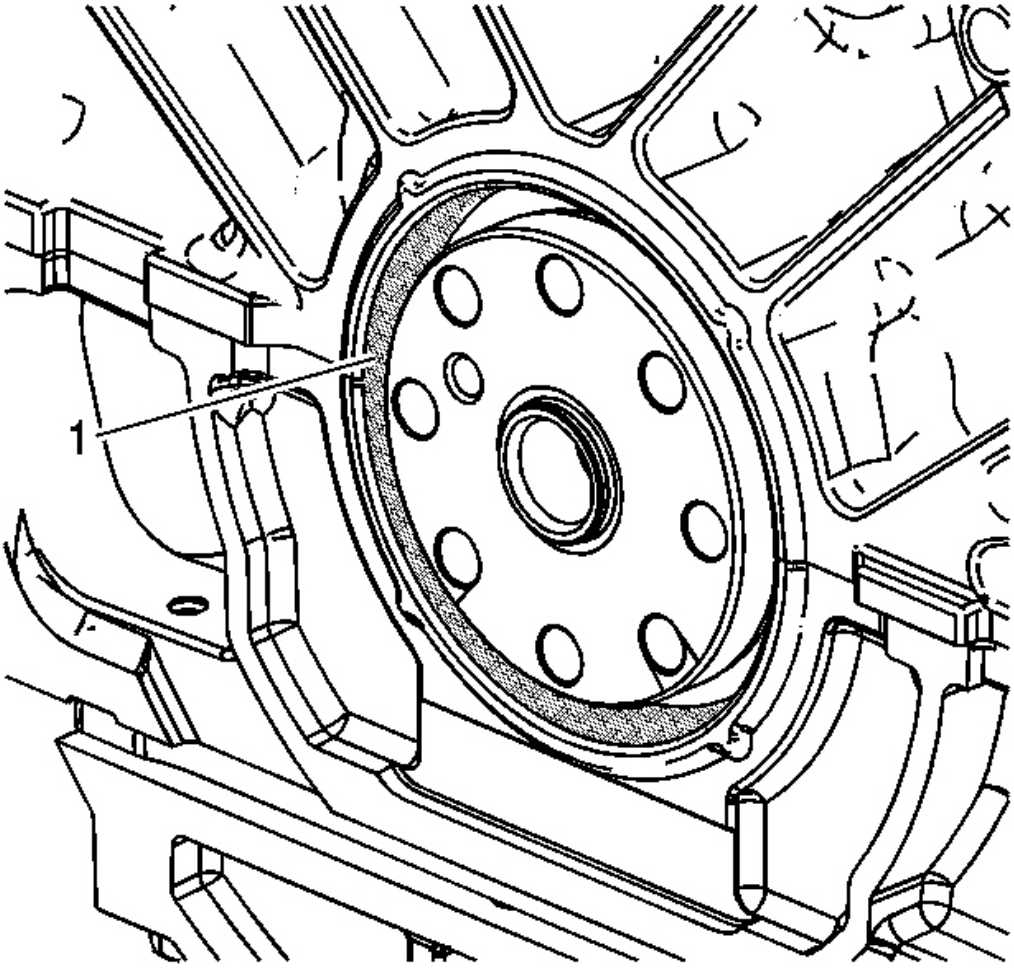


Fig. 123: Inspecting Sealant Distribution
Courtesy of GENERAL MOTORS CORP.

14. Ensure that the sealant (1) is evenly spread across the bore of the block.

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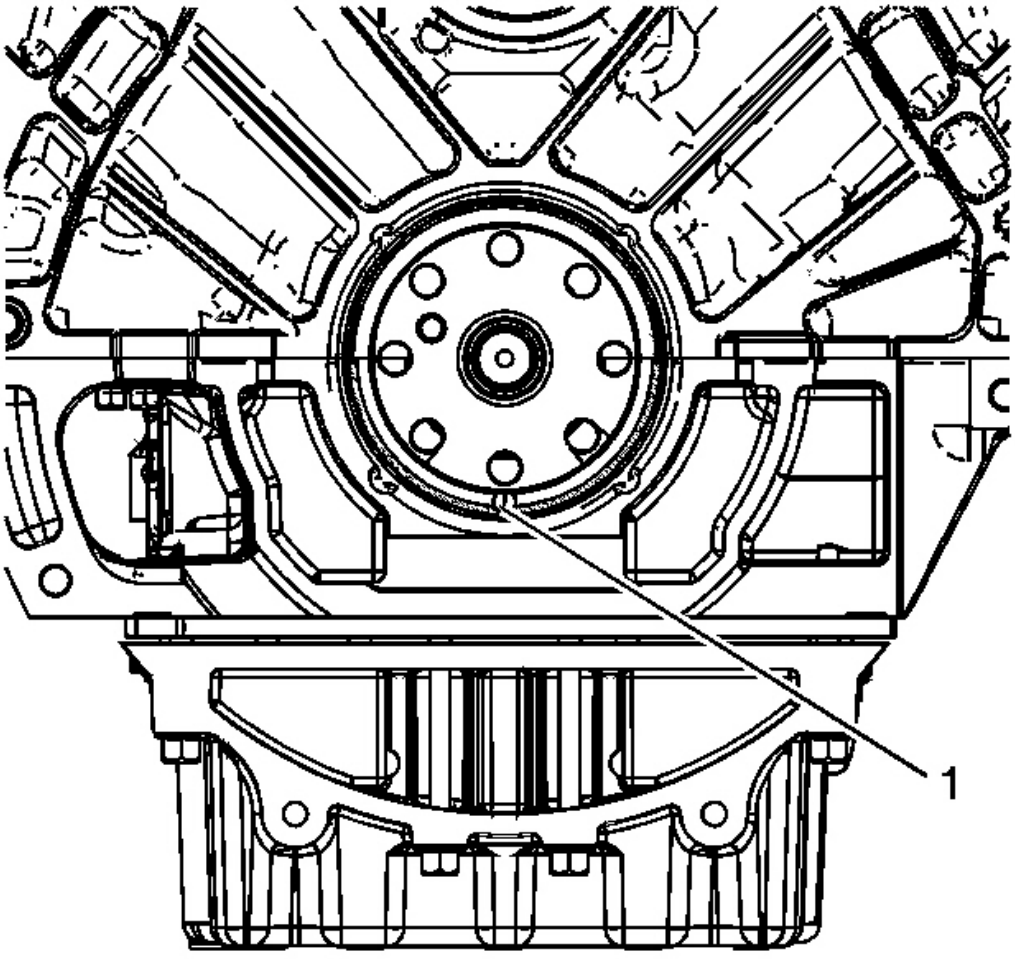


Fig. 124: Inspecting Drain Back Hole
Courtesy of GENERAL MOTORS CORP.

15. Ensure the drain back hole (1) is clear of the sealant.

IMPORTANT: Beginning with the model year 2006 the flywheel/flexplate crankshaft bolt hole thread was changed from 8 x 1.25 mm to 11 x 1.5 mm. The J 45930-A will service the cassette seals installed on engines from March 1, 1996 to 2006. See Special Tools . If a J 45930 is to be used on a 2006 or later engine the update kit, J 45930-10, must be used to convert the J 45930 to a J 45930-A .

IMPORTANT: Crankshaft rear oil seal and engine flywheel installation requires adequate

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space for installation. If the engine stand does not allow suitable space to use the J 45930-A install the crankshaft rear oil seal and engine flywheel with the engine properly supported on the floor or on a bench. See Special Tools .

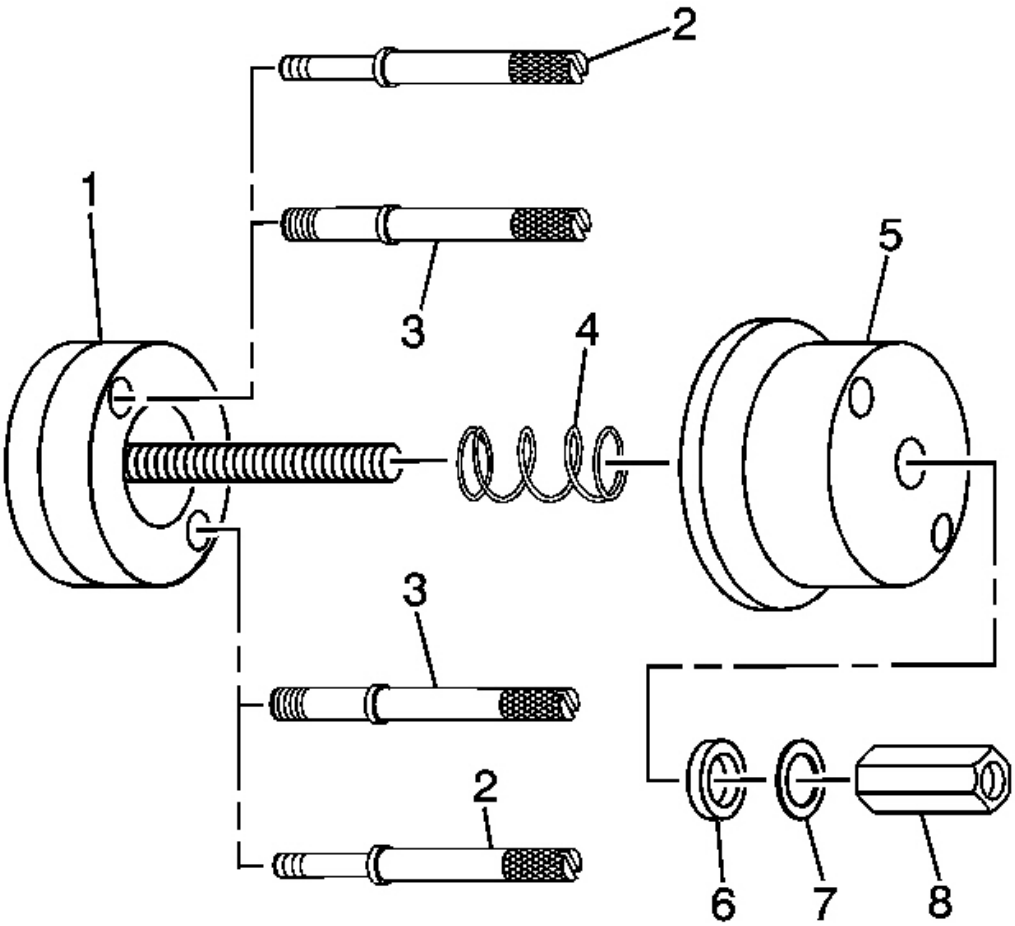


Fig. 125: View Of J 45930-A Tool Set
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Northstar engines 2005 and older have an 8 x 1.25 mm flywheel/flexplate crankshaft bolt hole thread. Northstar engines 2006 and later have an 11 x 1.5 mm flywheel/flexplate crankshaft bolt hole thread.

16. Ensure the proper size of bolt (2) 8 mm or (3) 11 mm is being installed in the **J 45930-A** . See **Special Tools** .

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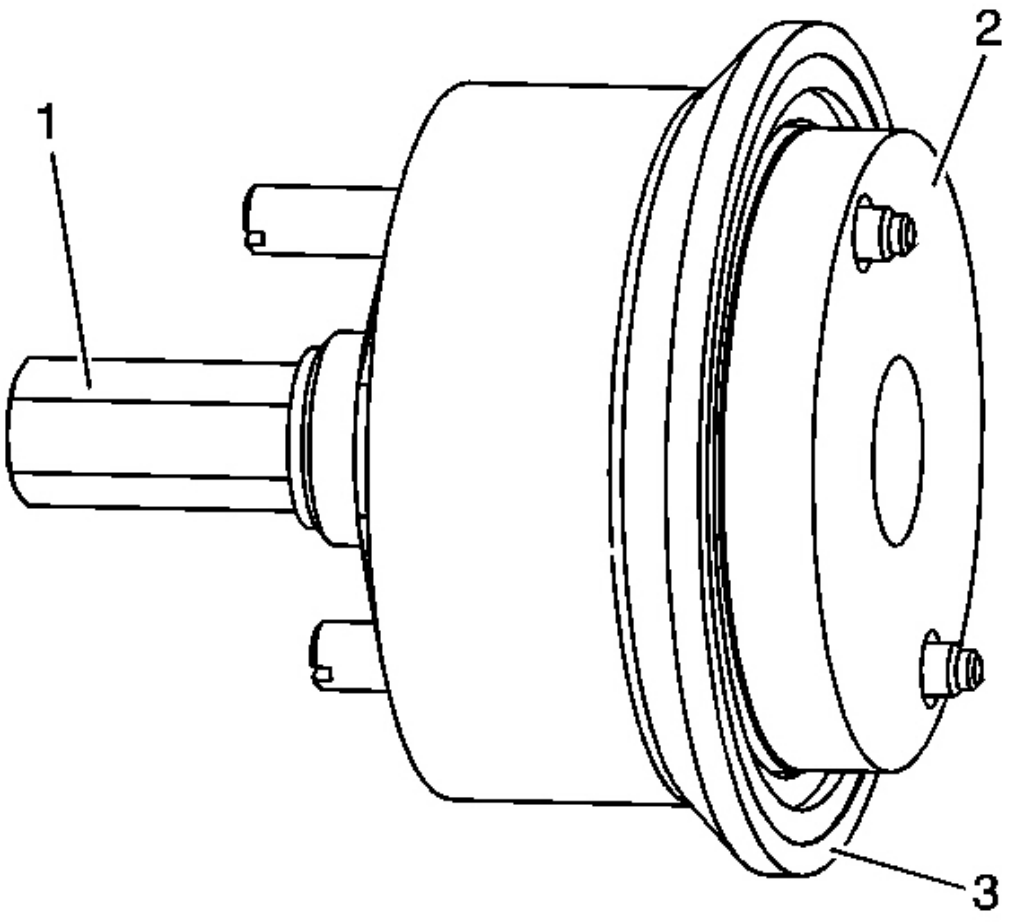


Fig. 126: View Of J 45930-A Crankshaft Rear Oil Seal Installer
Courtesy of GENERAL MOTORS CORP.

17. Turn the center nut (1) of the**J 45930-A** until the center hub (2) protrudes approximately 15 mm (0. See **Special Tools** .591 in) beyond the outer plate (3).

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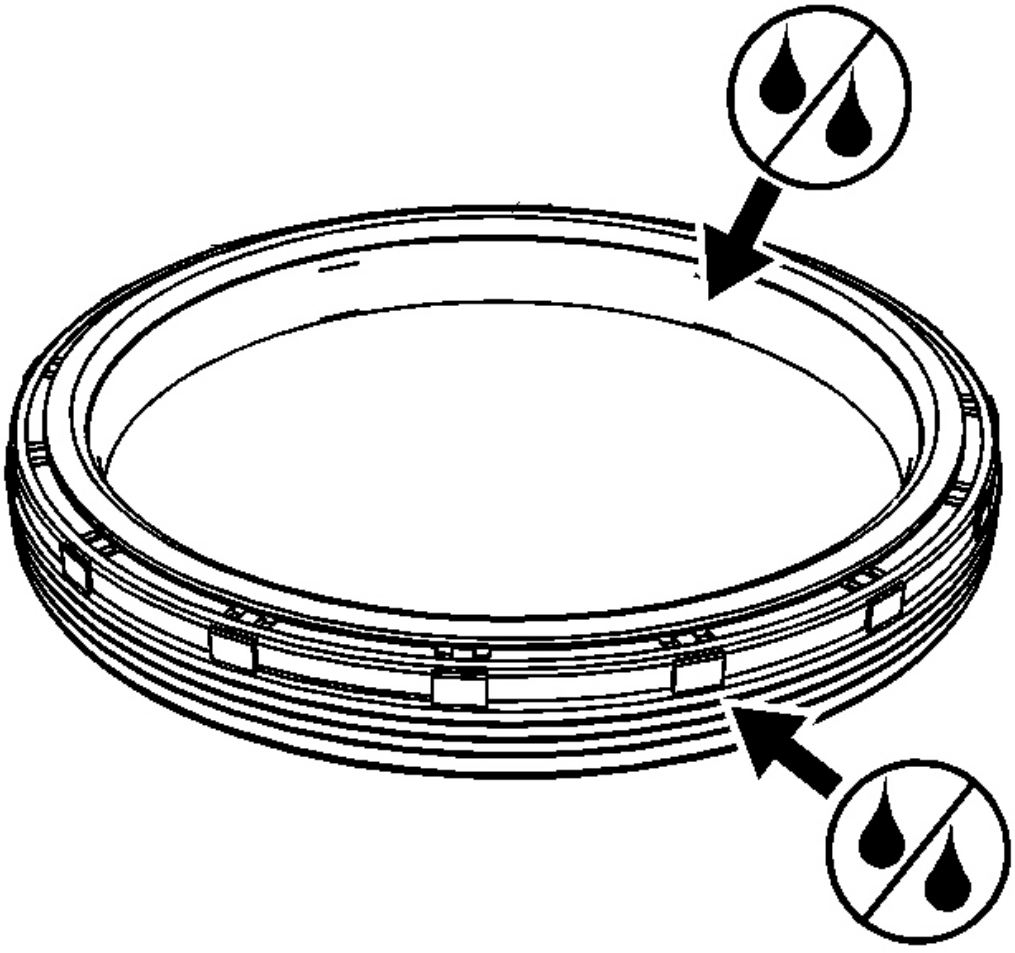


Fig. 127: Identifying Rear Seal Lubrication Points
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT use any lubricant in order to install the crankshaft rear oil seal. Do not use any lubricant on the coating pre-applied to the inner diameter of the crankshaft rear oil seal. The coating is a sealant that must not be contaminated. Do not use any lubricant on the outer diameter of the crankshaft rear oil seal. The sealant applied to the bore of the engine block will not properly bond to a lubricated crankshaft rear oil seal.

18. Do not lubricate any part of the new cassette style crankshaft rear oil seal.

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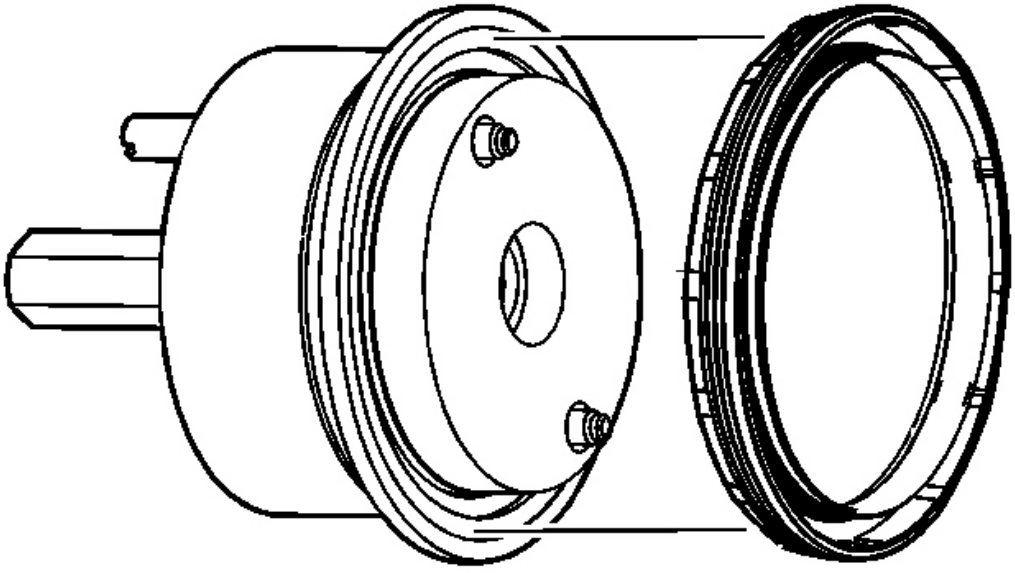


Fig. 128: Positioning Rear Seal Onto J 45930-A Crankshaft Rear Oil Seal Installer
Courtesy of GENERAL MOTORS CORP.

19. Install the new cassette style crankshaft rear oil seal onto the center hub of the **J 45930-A** . See **Special Tools** .

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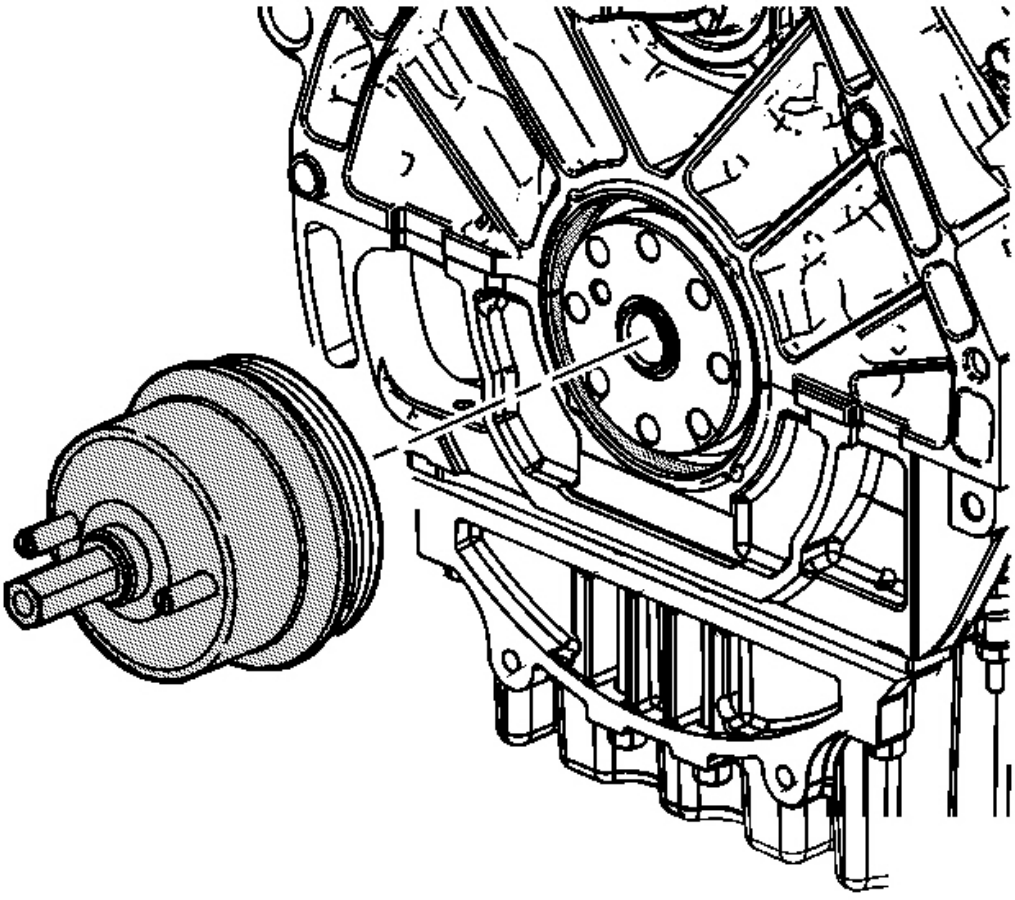


Fig. 129: Identifying J 45930-A Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

20. Thread the two **J 45930-A** mounting bolts into the crankshaft flywheel bolt holes. See **Special Tools** .

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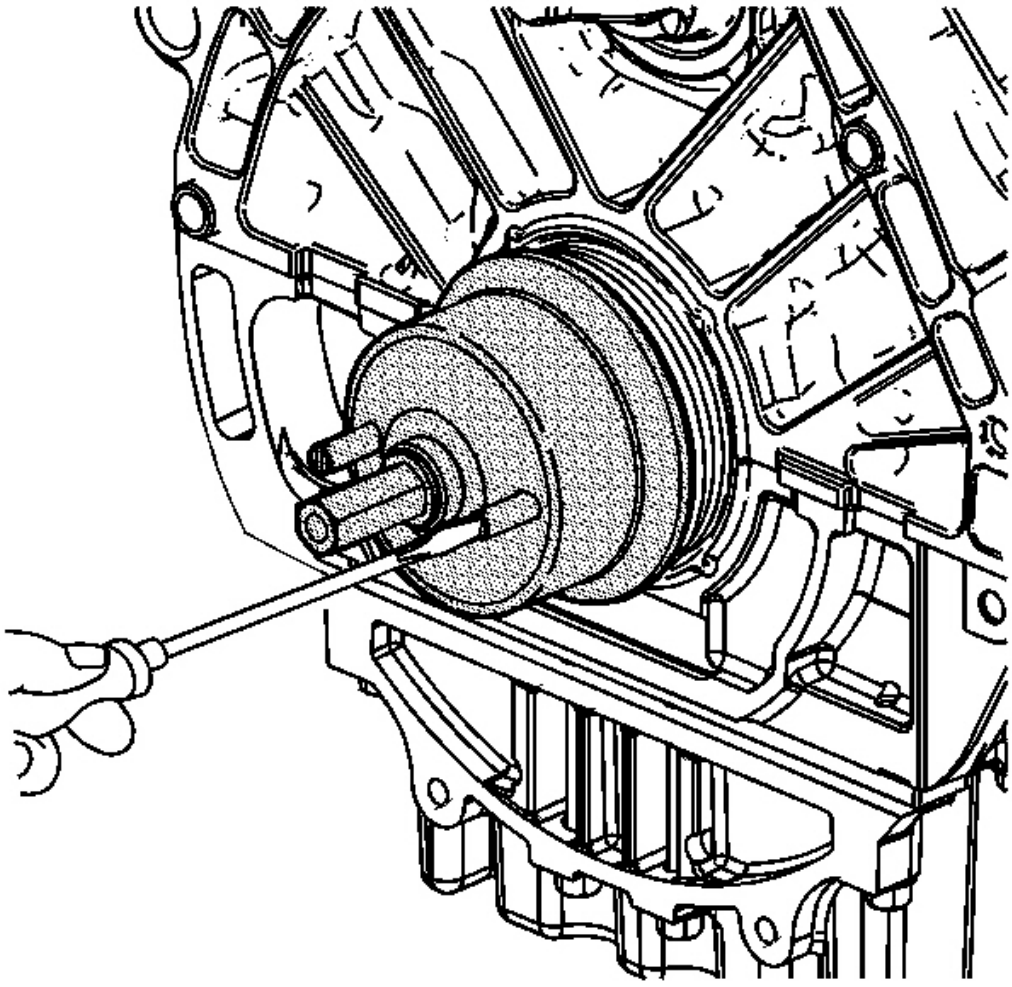


Fig. 130: Mounting J 45930-A To Crankshaft
Courtesy of GENERAL MOTORS CORP.

21. Tighten the two mounting bolts until the **J 45930-A** is firmly mounted on the crankshaft. See **Special Tools** .

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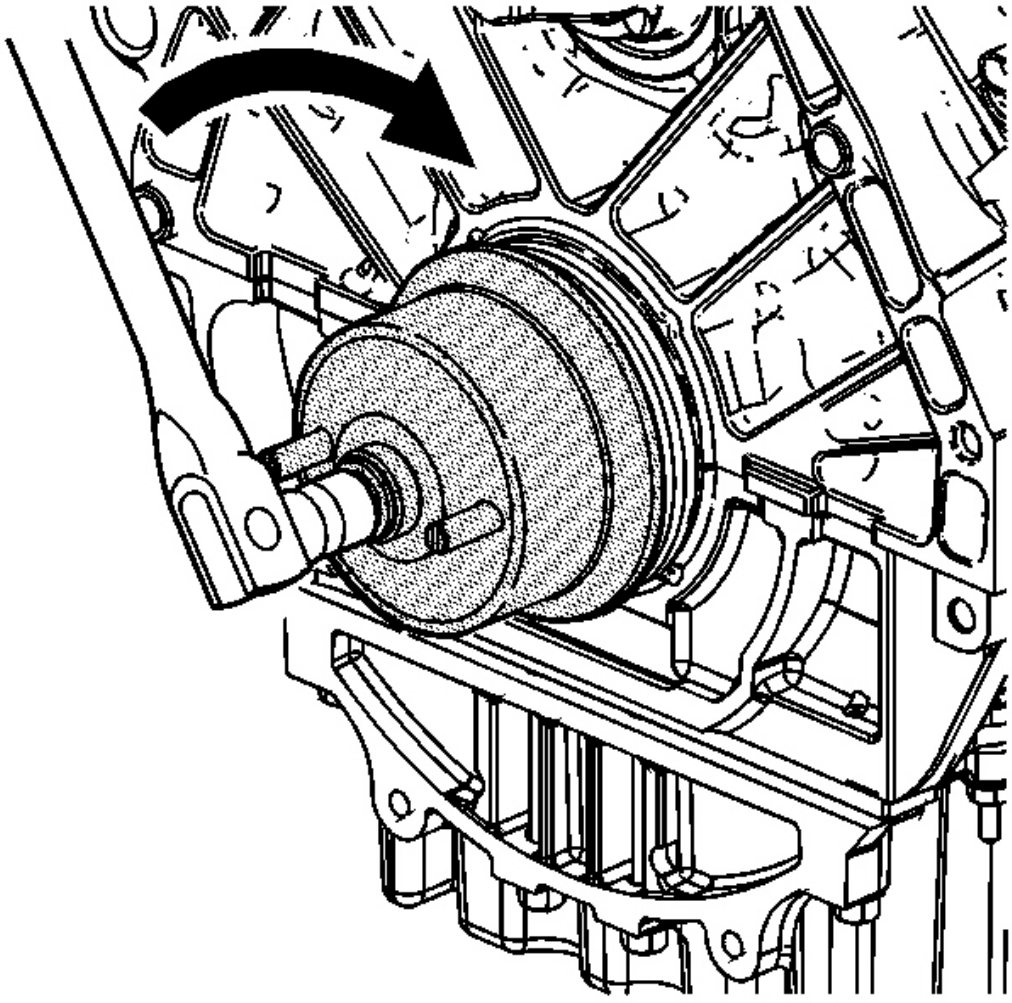


Fig. 131: Installing New Cassette Style Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

22. Install the new cassette style crankshaft rear oil seal by turning the nut of the **J 45930-A** until the drive portion of the **J 45930-A** bottoms against the crankcase. See **Special Tools** .

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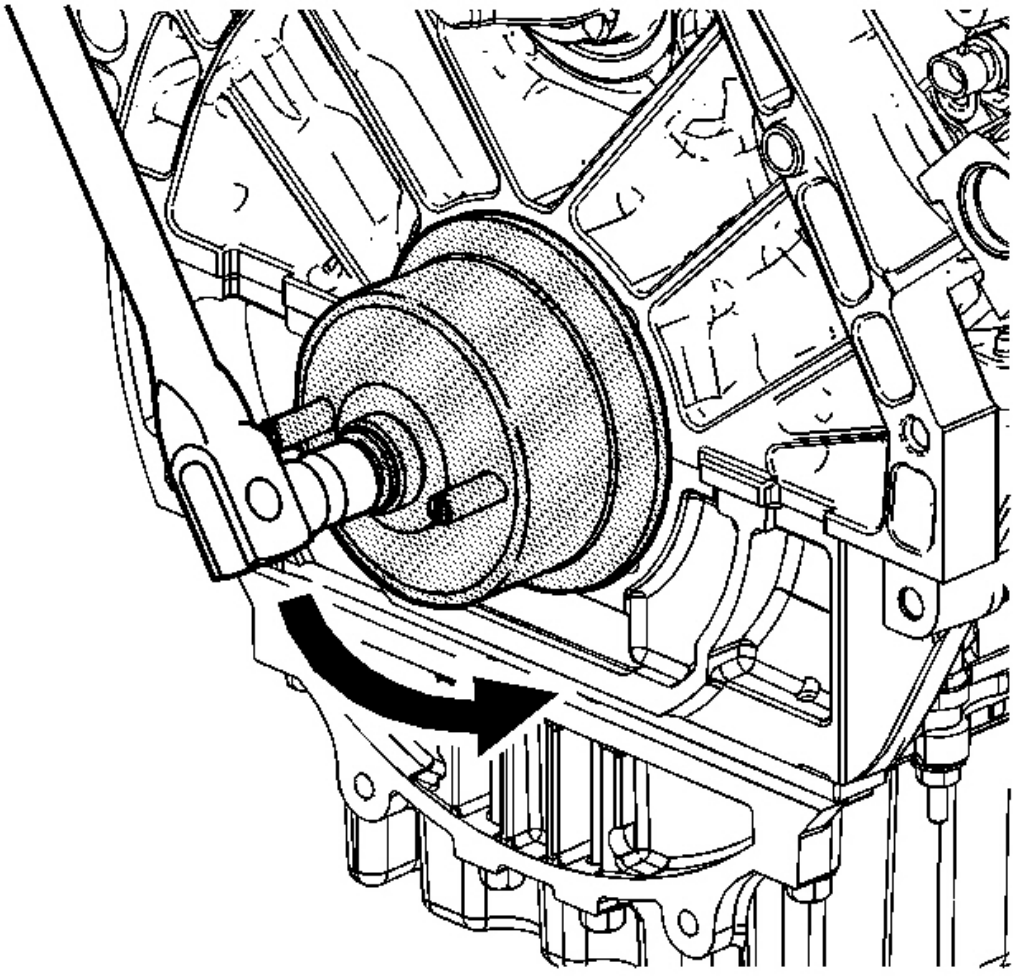


Fig. 132: Loosening Center Nut To Release Pressure On Crankcase
Courtesy of GENERAL MOTORS CORP.

23. Loosen the center nut to release pressure on the crankcase.

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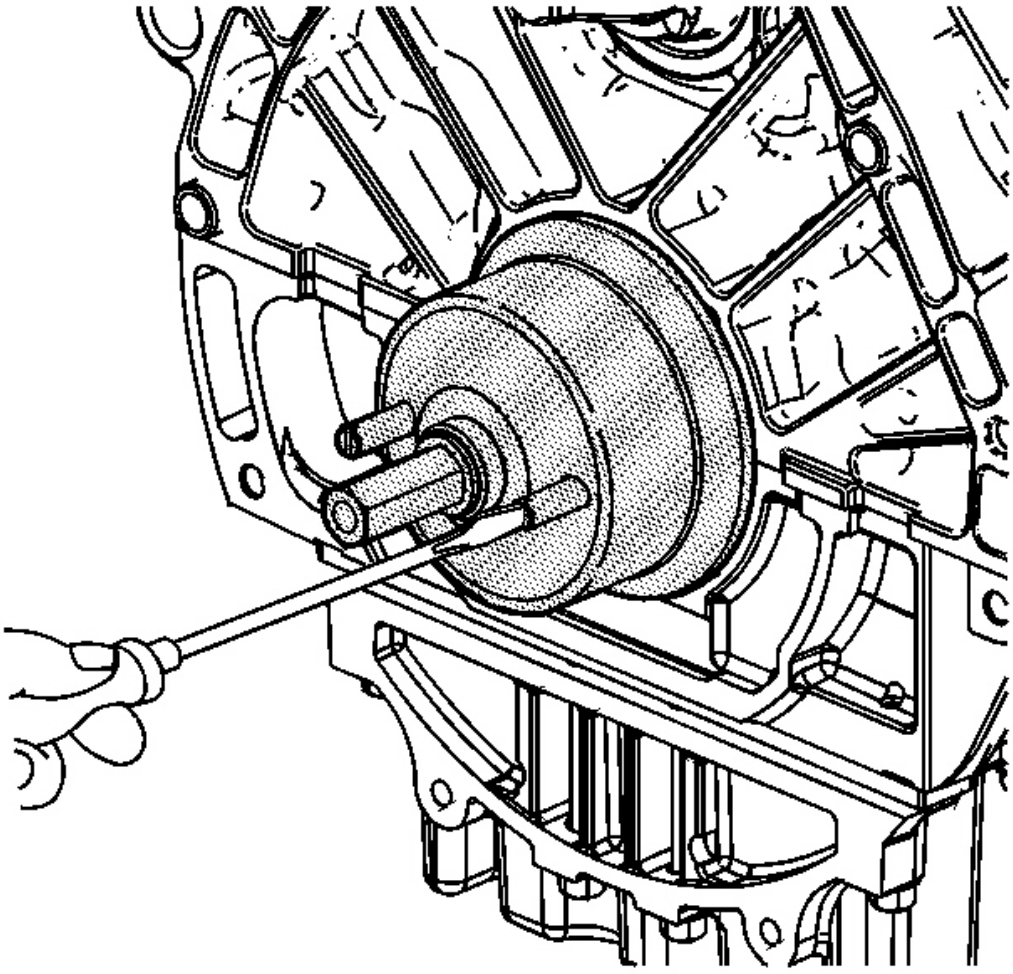


Fig. 133: Loosening Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

24. Loosen the two mounting bolts.

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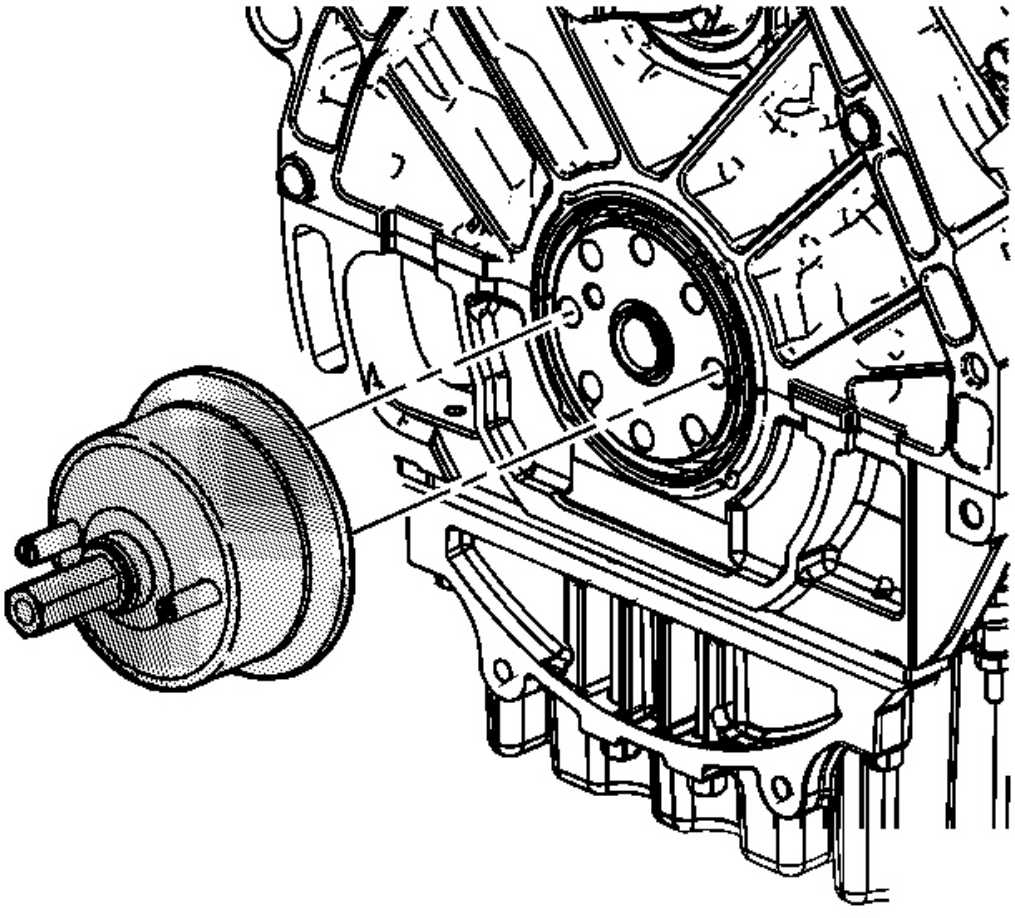


Fig. 134: View Of J 45930-A
Courtesy of GENERAL MOTORS CORP.

25. Remove the **J 45930-A** from the crankshaft. See **Special Tools** .
26. Wipe off any excessive sealant from the block.

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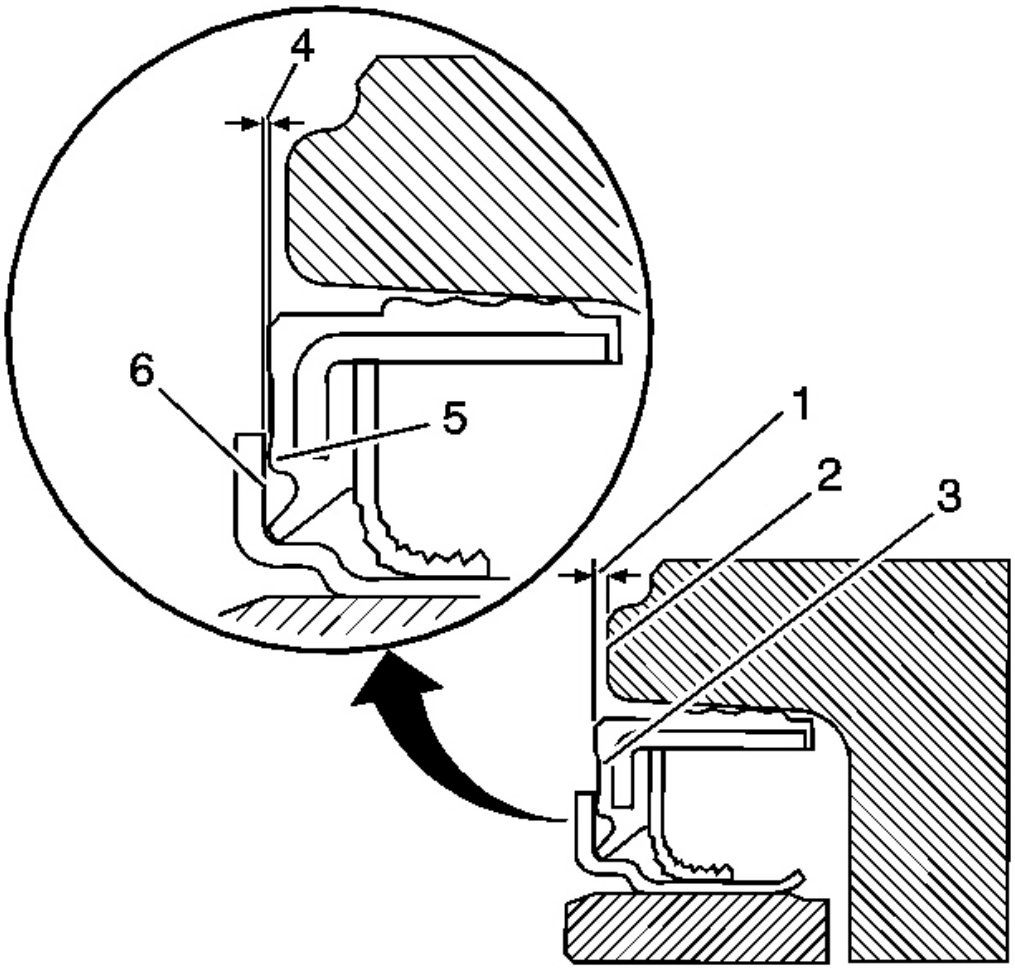


Fig. 135: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

27. Ensure the new cassette style crankshaft rear oil seal is installed properly.
    - The outer surface of the seal (3) should be 0.500-0.800 mm (0.0197-0.0315 in) (1) below the surface of the engine block (2).
    - The inner surface of the sleeve (6) should be 0.400-0.900 mm (0.0158-0.0354 in) (4) below the surface of the outer surface of the seal (5).
    - The installed seal and sleeve need to be parallel to the block by 0.000-0.500 mm (0.000-0.0197 in).
28. Clean all tools to remove any residual sealant.
29. Install the flywheel. Refer to **Engine Flywheel Replacement**.

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ENGINE REPLACEMENT

TOOLS REQUIRED

- **J 28467-86** Right Engine Lift Bracket. See **Special Tools** .
- **J 28467-87** Left Engine Lift Bracket. See **Special Tools** .

REMOVAL PROCEDURE

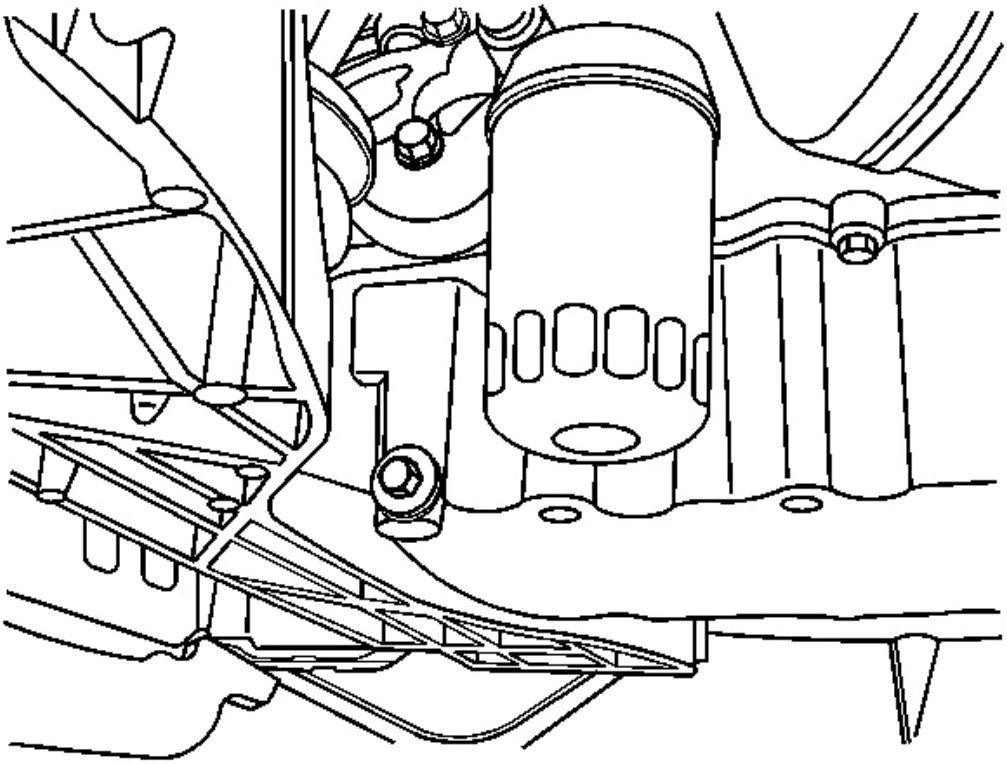


Fig. 136: Draining Engine Oil
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution .

1. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
2. Remove the powertrain. Refer to **Powertrain Removal and Installation**.

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3. Remove the left exhaust manifold assembly. Refer to **Exhaust Manifold Replacement - Left Side** .
4. Remove the left engine mount bracket. Refer to **Engine Mount Bracket Replacement - Left Side** .

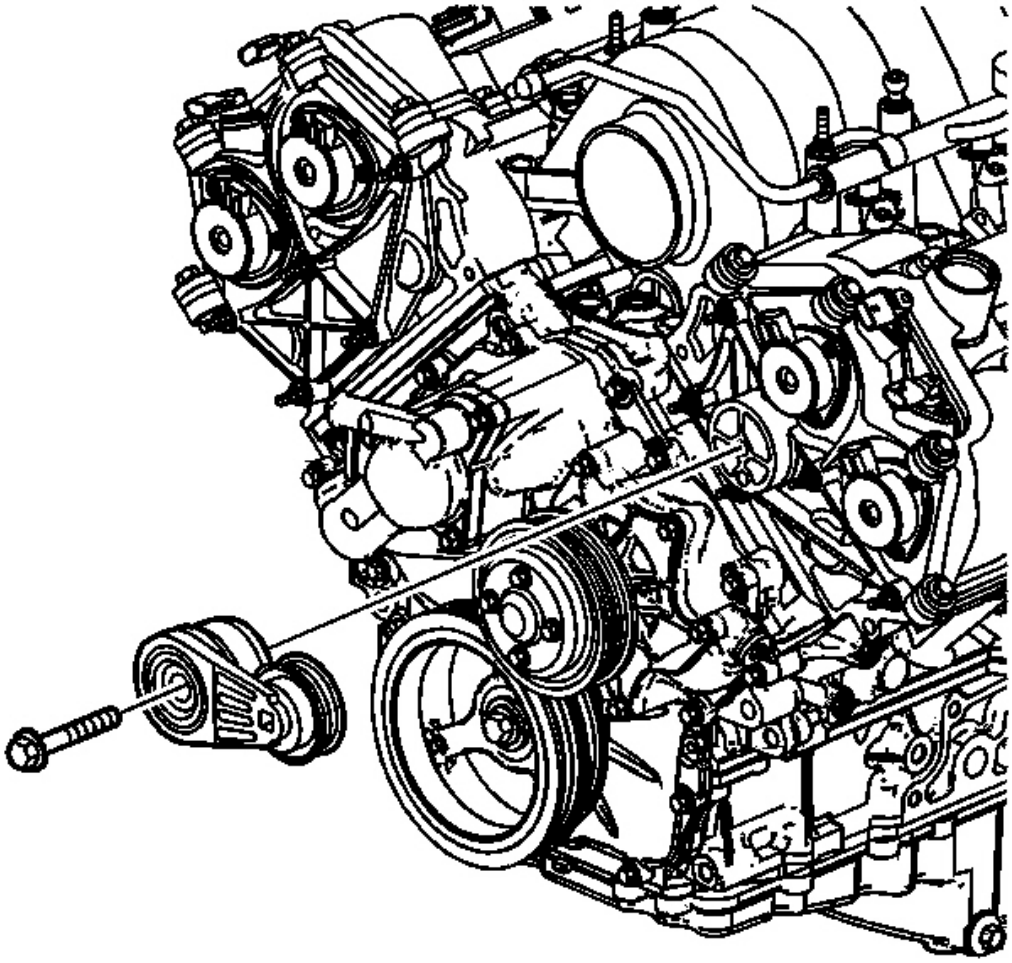


Fig. 137: View Of Drive Belt Tensioner & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the water pump and generator drive belt tensioner. Refer to **Water Pump and Generator Drive Belt Tensioner Replacement** .
6. Remove the supercharger drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Supercharger** .
7. Remove the generator. Refer to **Generator Replacement (LH2)** or **Generator Replacement (LC3)** .

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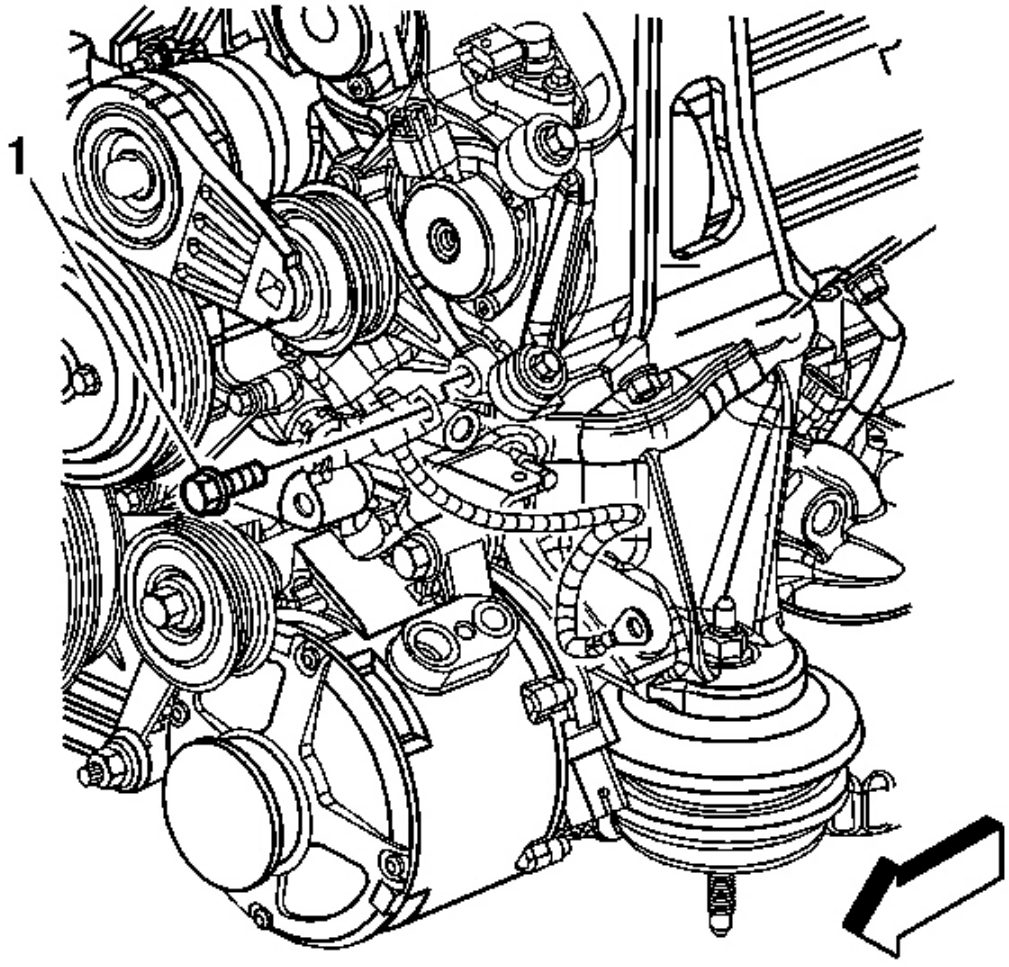


Fig. 138: Removing Starter/Generator Harness Clip Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the bolt (1) securing the starter/generator harness clip to the front of the engine.

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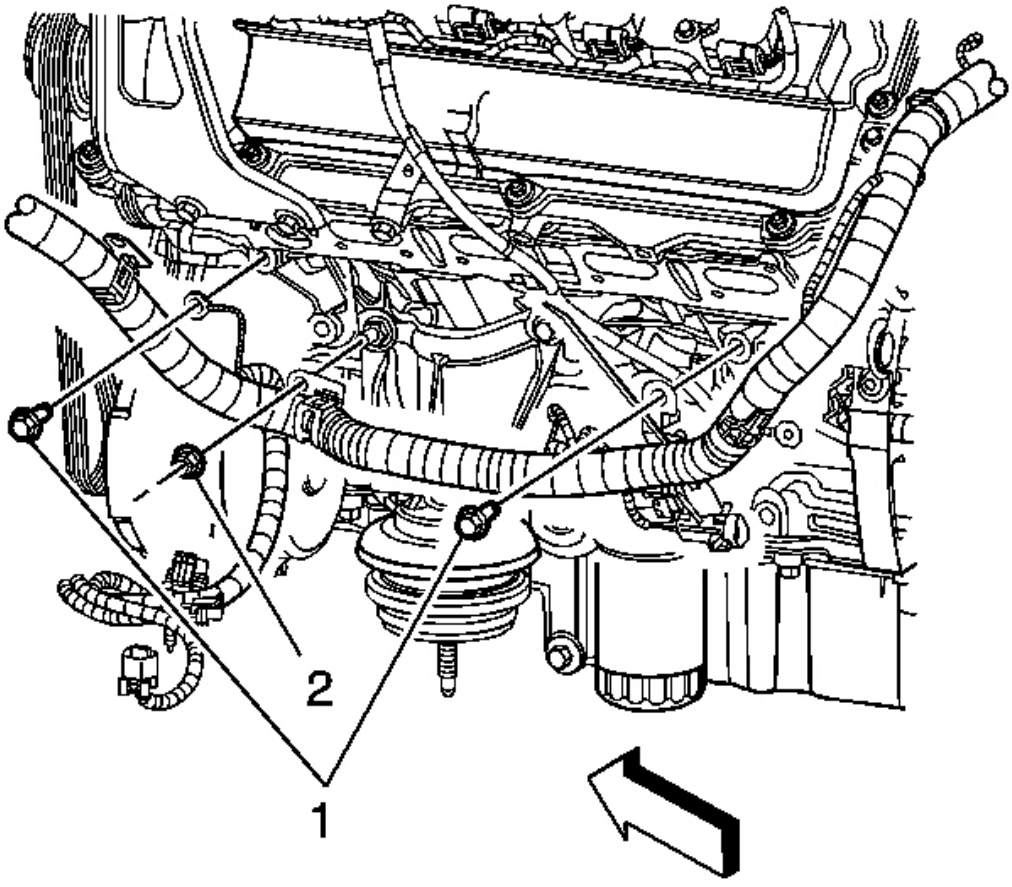


Fig. 139: View Of Engine Wiring Harness Bolts & Nut
Courtesy of GENERAL MOTORS CORP.

9. Remove the bolts and nut (1,2) securing the engine wiring harness to the left side of the engine.
10. Remove the right exhaust manifold assembly. Refer to **Exhaust Manifold Replacement - Right Side** .
11. Remove the right engine mount bracket. Refer to **Engine Mount Bracket Replacement - Right Side** .

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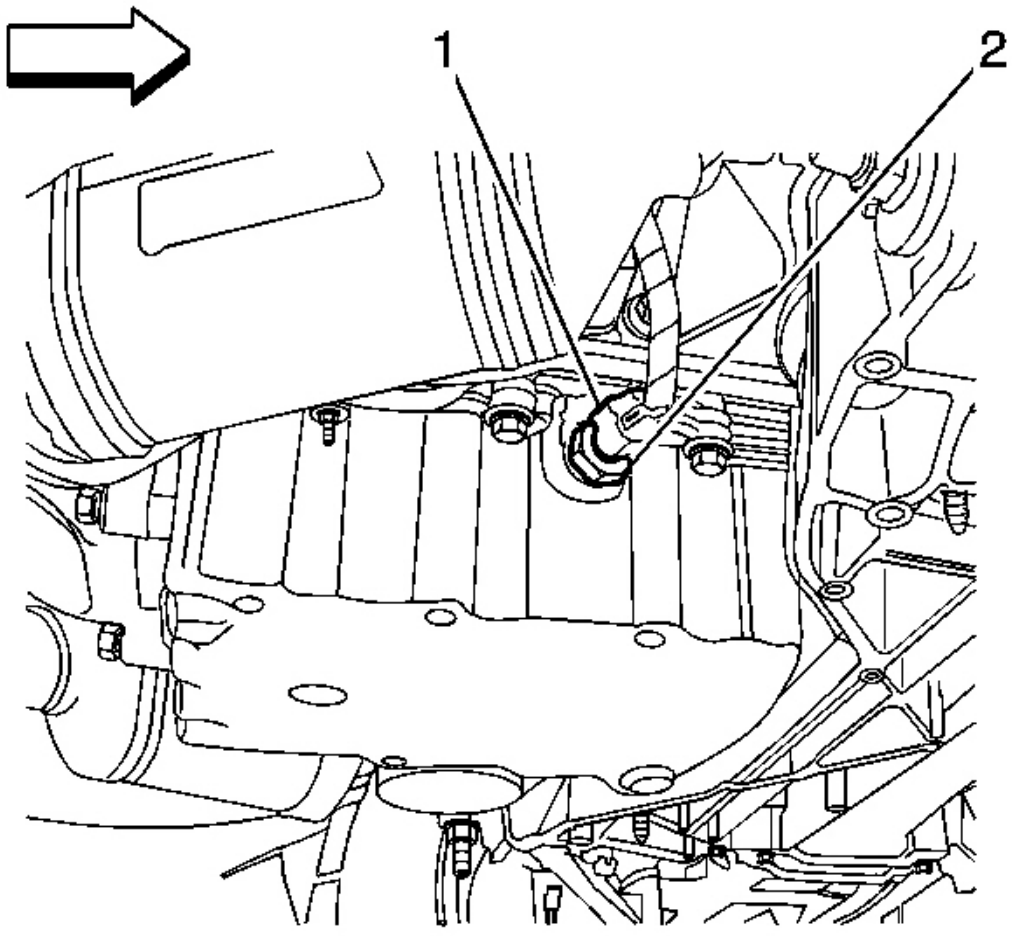


Fig. 140: Identifying Engine Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the electrical connector (1) from the engine oil level sensor (2).
13. Remove the power steering reservoir. Refer to **Remote Power Steering Fluid Reservoir Replacement** .
14. Remove the air conditioning compressor and bracket. Refer to **Compressor Replacement** .

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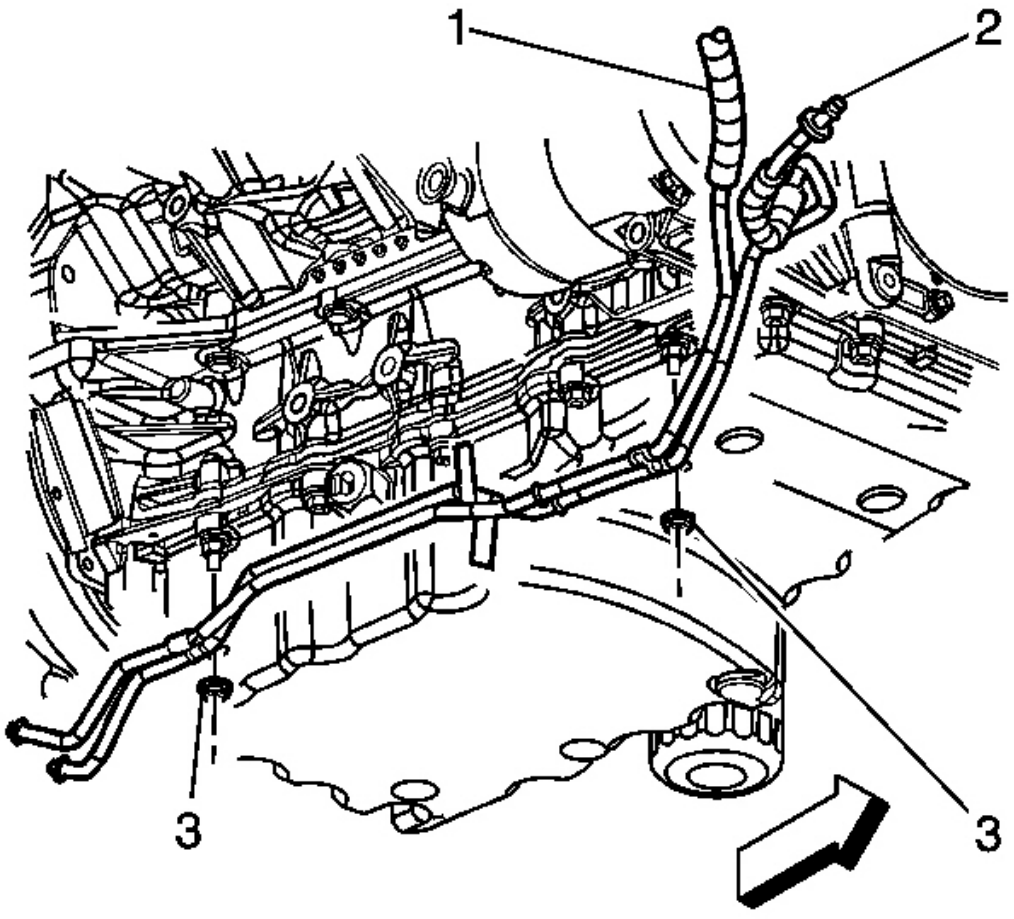


Fig. 141: View Of Transmission Cooler Lines
Courtesy of GENERAL MOTORS CORP.

15. Remove the transmission cooler lines (1,2). Refer to **Transmission Fluid Cooler Lower Pipe Assembly Replacement - Auxiliary Cooler to Radiator** and **Transmission Fluid Cooler Lower Pipe Assembly Replacement - Transmission to Auxiliary Cooler** .
16. Remove the coolant temperature sensor. Refer to **Engine Coolant Temperature Sensor Replacement** .

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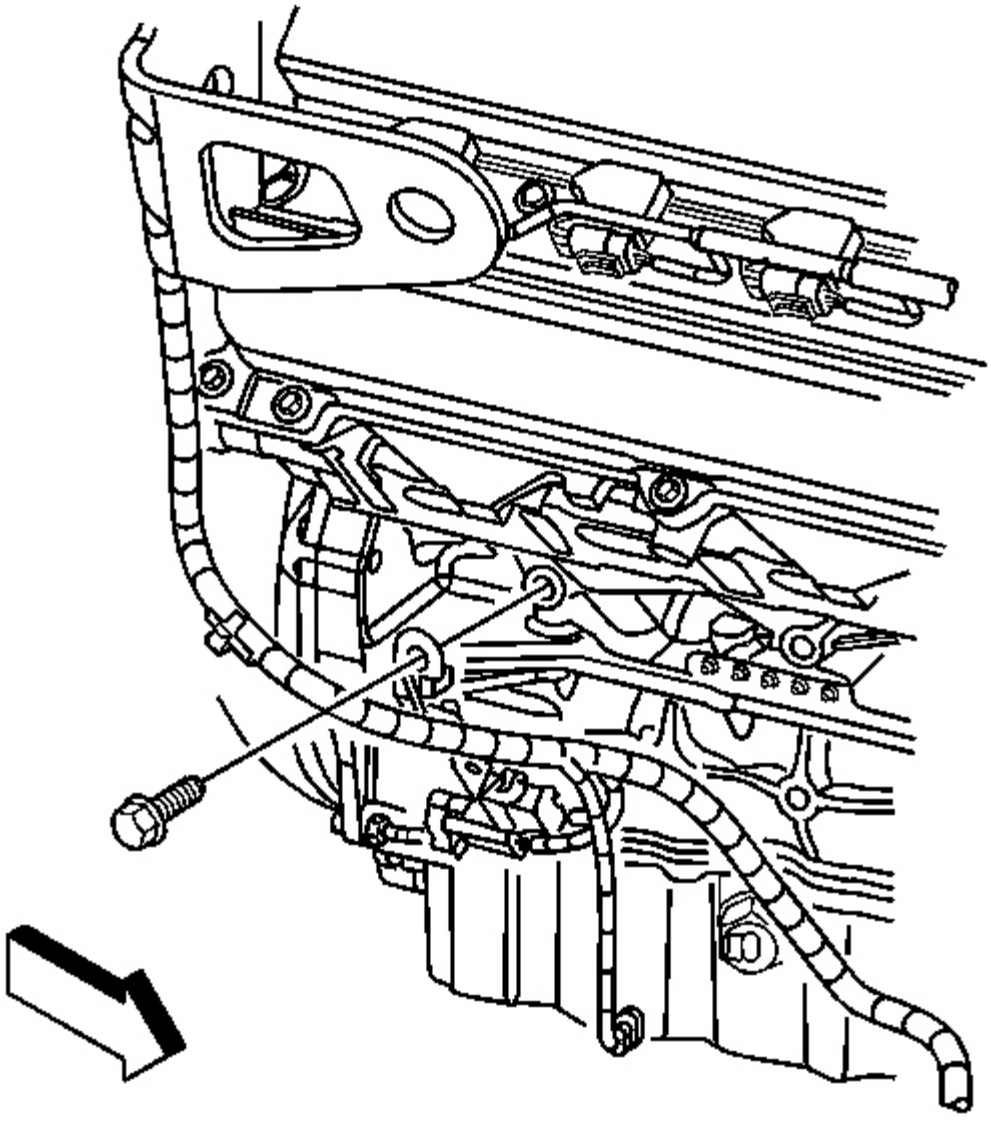


Fig. 142: View Of Height Adjuster Lock & Lower Square Notch
Courtesy of GENERAL MOTORS CORP.

17. Remove the bolt securing the wiring harness to the engine.

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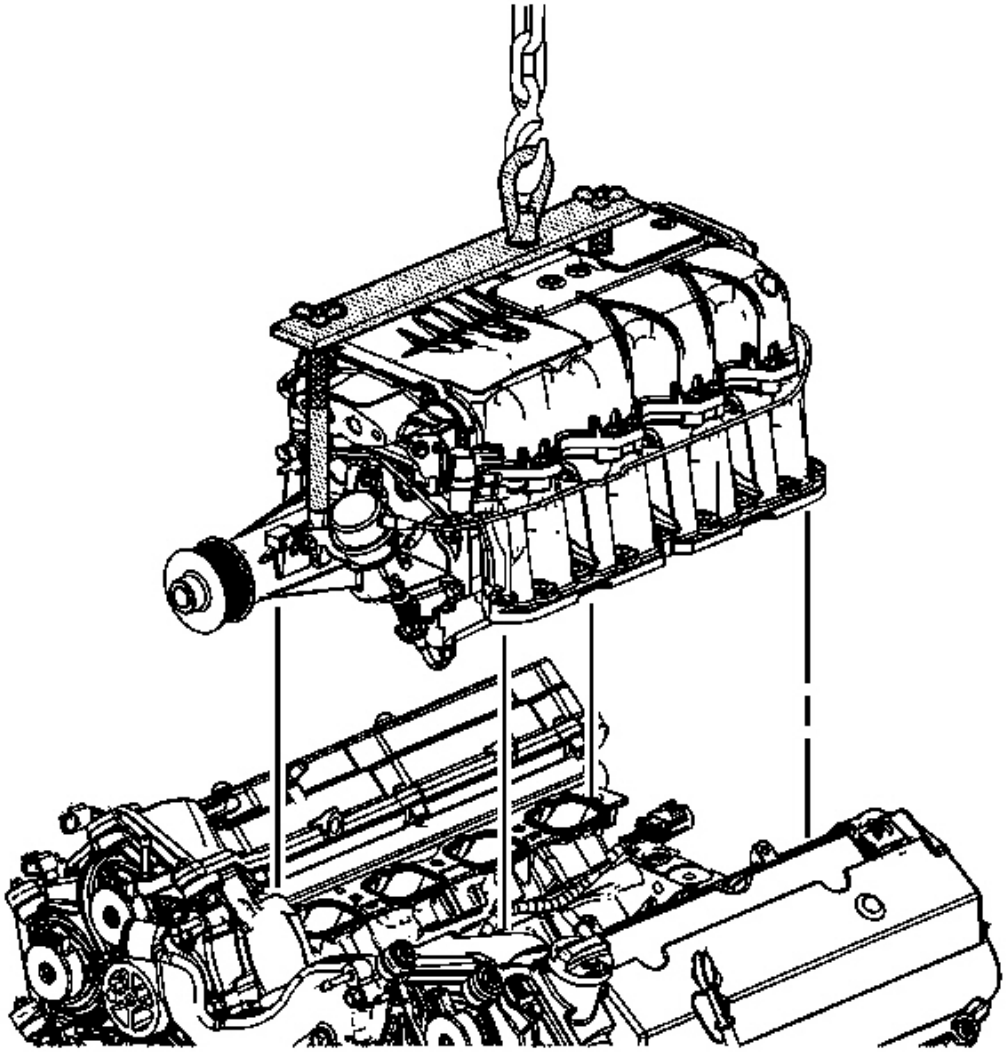


Fig. 143: Lifting Supercharger
Courtesy of GENERAL MOTORS CORP.

18. Remove the engine wiring harness.
19. Remove the supercharger assembly. Refer to **Supercharger Replacement** .
20. Remove the left bank ignition coils as an assembly. Refer to **Ignition Coil Replacement - Bank 2** .
21. Remove the right bank ignition coils as an assembly. Refer to **Ignition Coil Module Replacement - Right Side** .
22. Remove the starter motor from the engine. Refer to **Starter Motor Replacement (LC3)** or **Starter**

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Motor Replacement (LH2) .

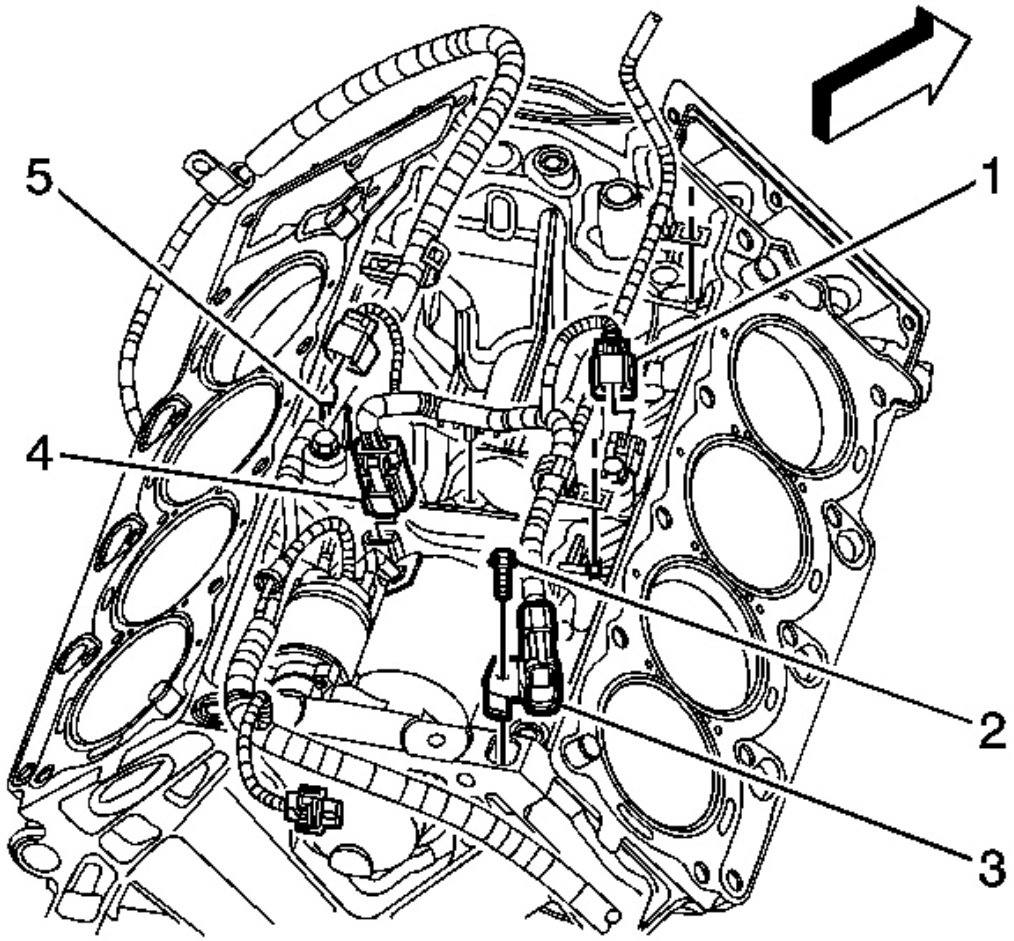


Fig. 144: View Of Crank Sensor, Electrical Connectors, Wiring Harness & Bolt
Courtesy of GENERAL MOTORS CORP.

23. Disconnect the electrical connector (5) from the left-hand knock sensor.
24. Disconnect the electrical connector (1) from the right-hand knock sensor.
25. Disconnect the electrical connector from the crank sensor (4).
26. Remove the bolt (2) securing the wiring harness (3) to the engine.
27. Remove the driveline support bolts.

IMPORTANT: Visually inspect the transmission wiring harness to ensure detachment

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from the engine.

28. Insert a flat-headed screwdriver or similar tool, between the driveline support and the flywheel housing, then separate the driveline assembly from the engine.
29. Slowly pull the driveline support assembly away from the engine.
30. Install the **J 28467-86** and **J 28467-87** to the engine. See **Special Tools** .
31. Install an engine hoist to the **J 28467-86** and **J 28467-87** . See **Special Tools** .
32. Remove the flywheel housing bolts.
33. Remove the flywheel housing from the engine.
34. Remove the engine from the lift table.
35. Remove the engine hoist.
36. Remove the engine lift brackets.

INSTALLATION PROCEDURE

1. Using an engine hoist, install the replacement engine on an engine stand.

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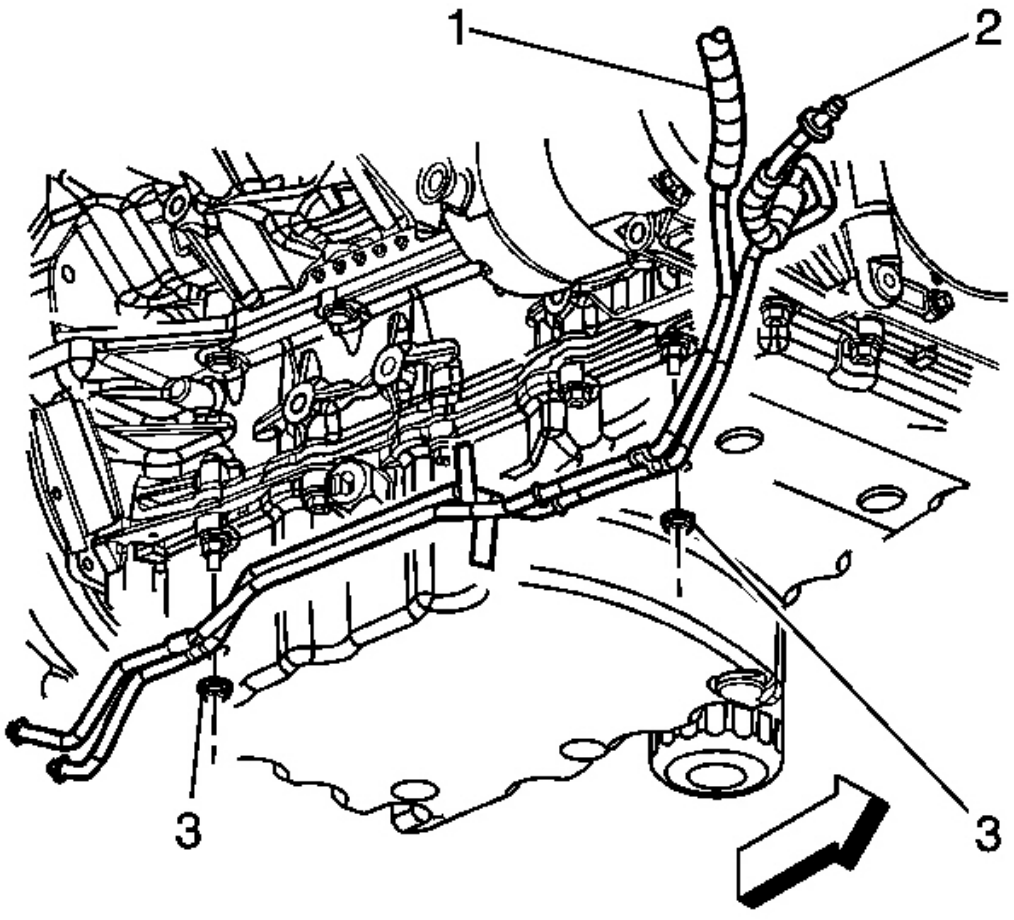


Fig. 145: View Of Transmission Cooler Lines
Courtesy of GENERAL MOTORS CORP.

2. Install the transmission cooler lines (1,2) to the engine. Refer to **Transmission Fluid Cooler Lower Pipe Assembly Replacement - Transmission to Auxiliary Cooler** .

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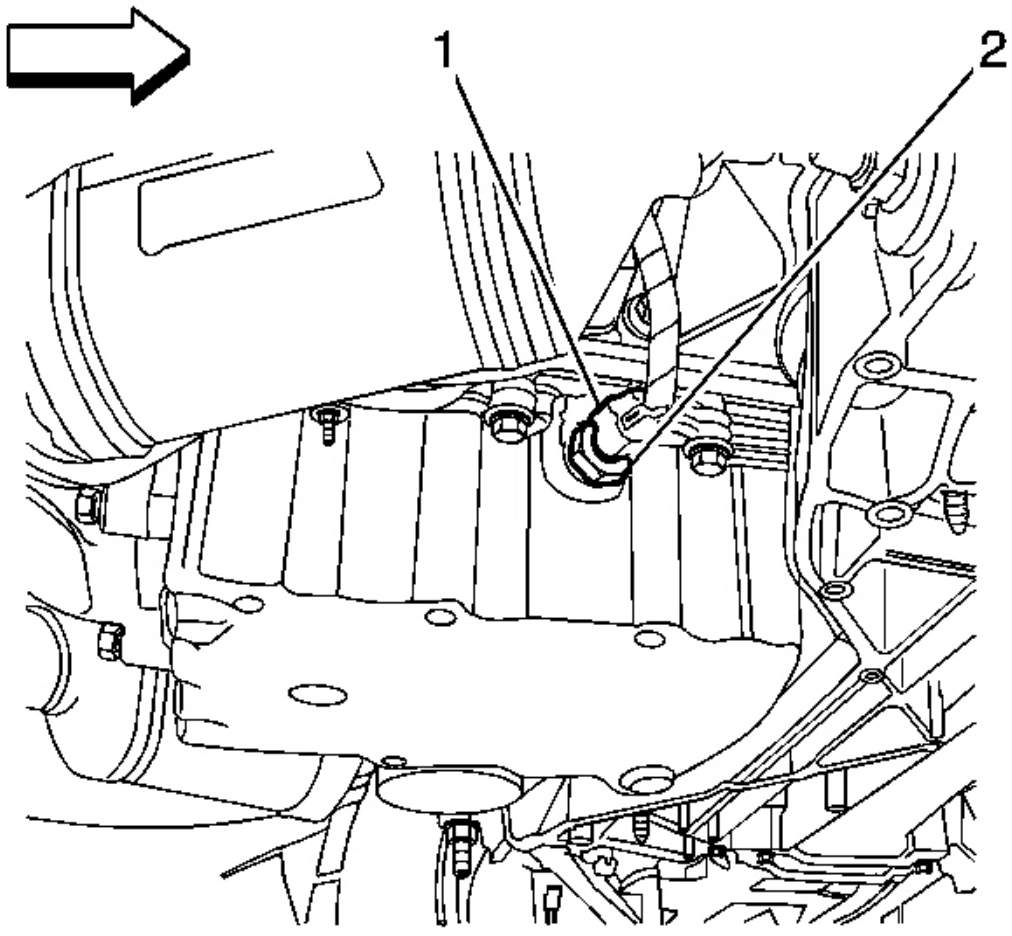


Fig. 146: Identifying Engine Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

3. Connect the electrical connector (1) to the engine oil level sensor (2).

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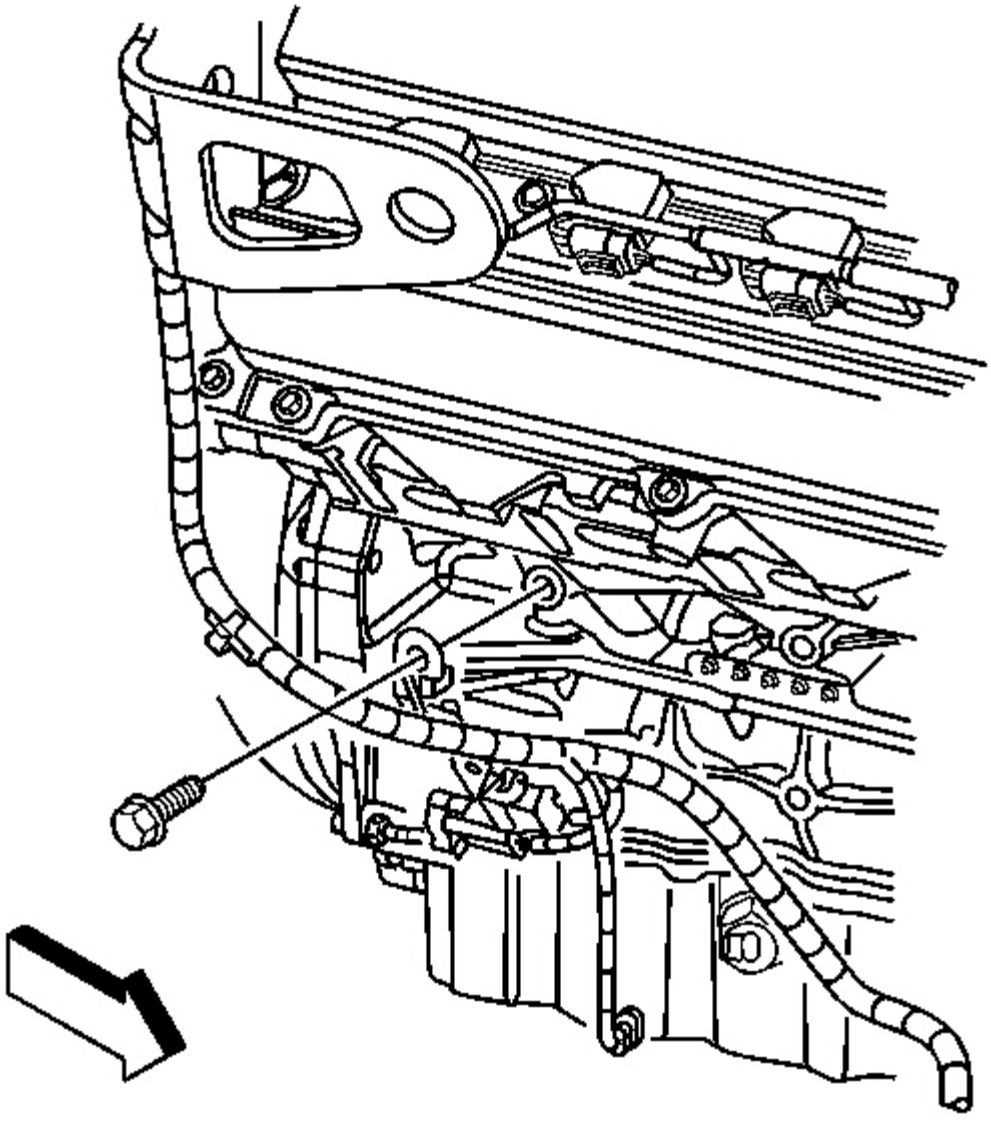


Fig. 147: View Of Height Adjuster Lock & Lower Square Notch
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

4. Install the bolt through the engine harness clip and secure to the right side of the engine.

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Tighten: Tighten the bolt to 35 N.m (26 lb ft).

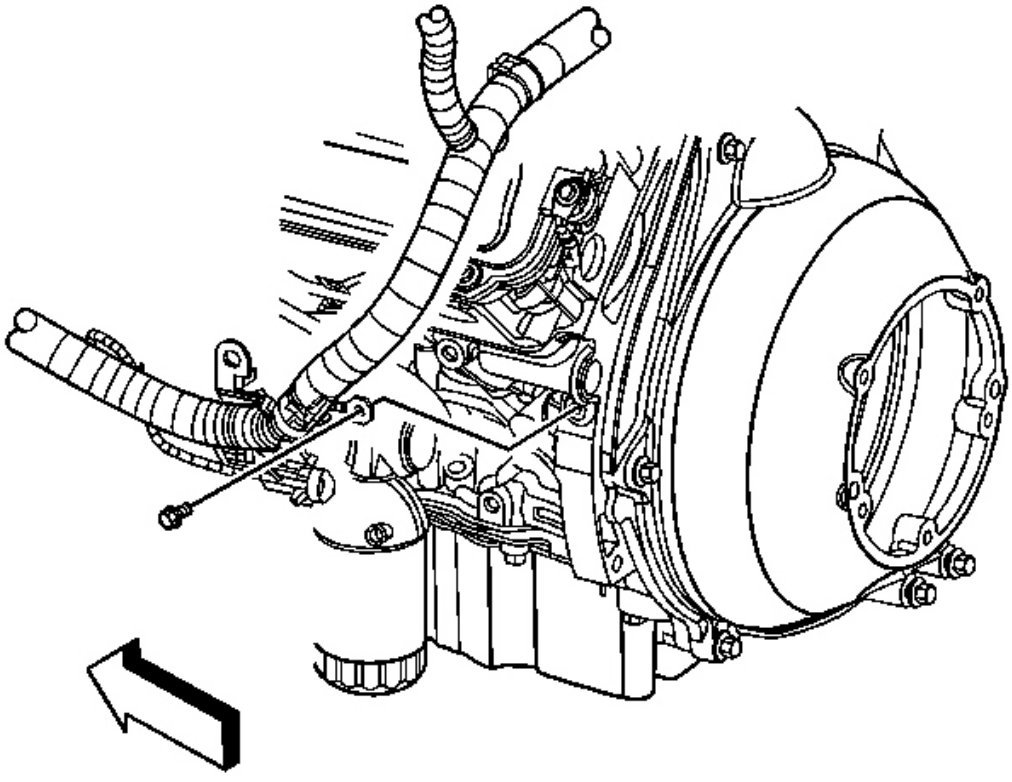


Fig. 148: View Of Left Rear Engine Harness Ground Terminal & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the bolt to the left rear engine harness ground terminal.

   Tighten: Tighten the bolt to 12 N.m (106 lb in).

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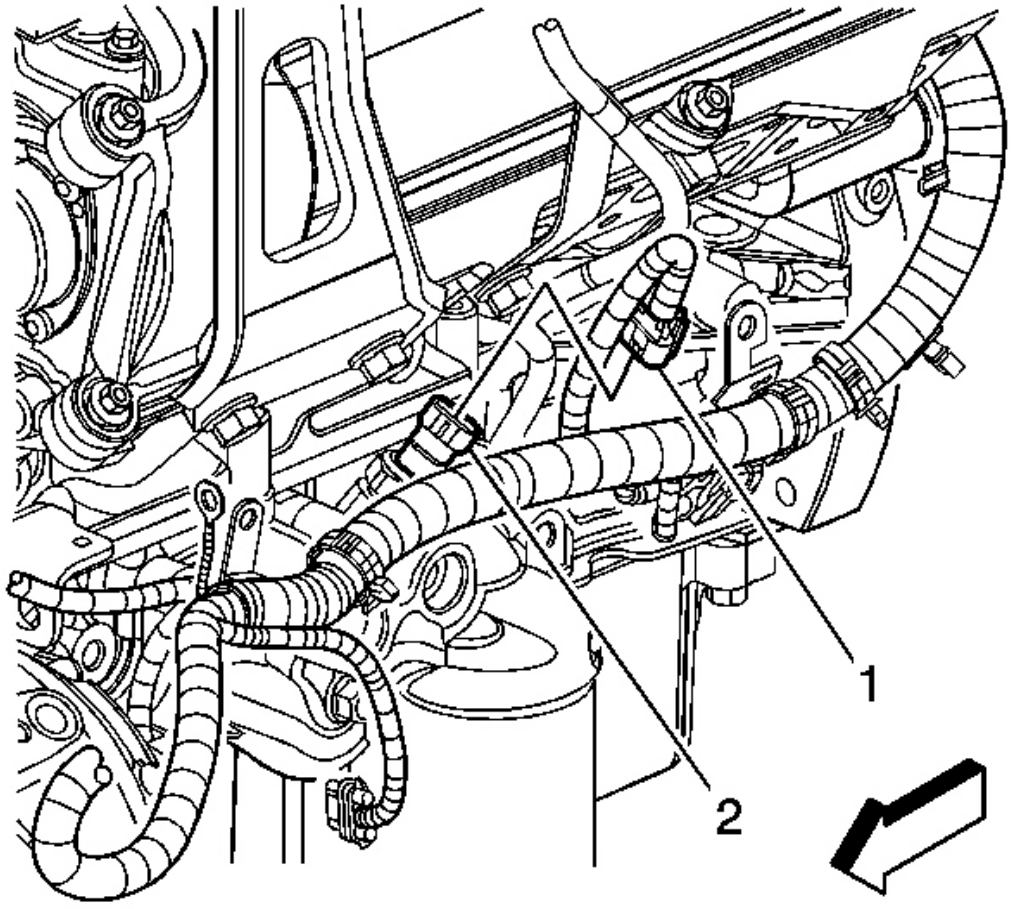


Fig. 149: View Of Oil Pressure Sensor & Harness
Courtesy of GENERAL MOTORS CORP.

6. Connect the harness (1) to the oil pressure sensor (2).

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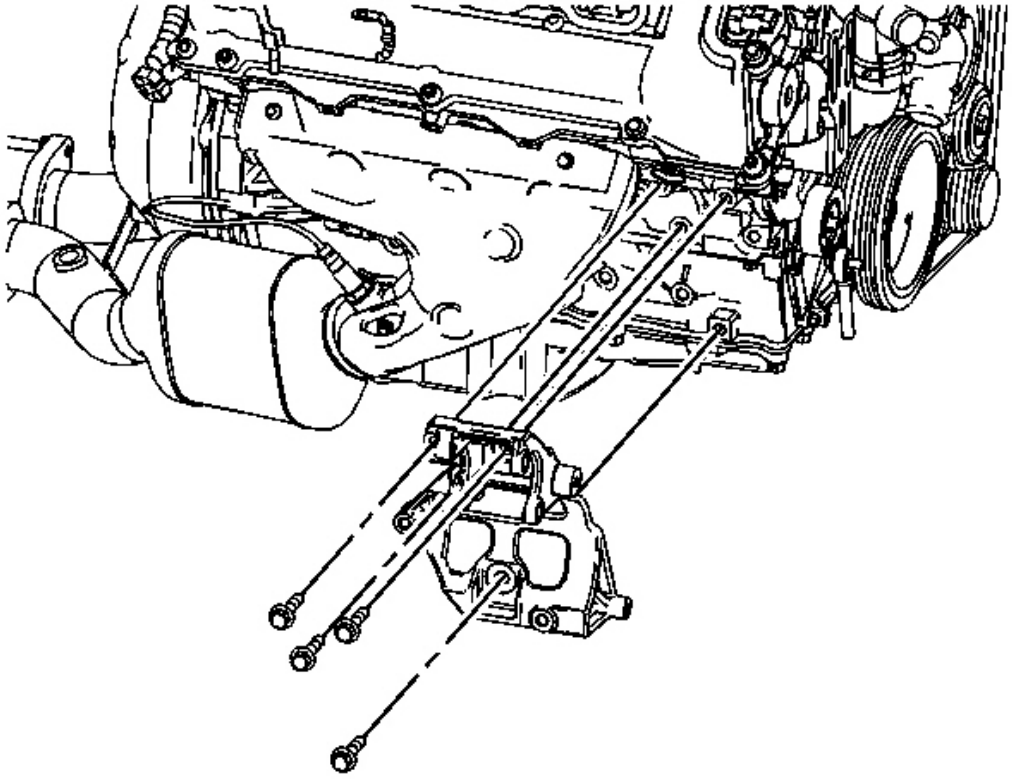


Fig. 150: Installing Air Conditioning/Power Steering Bracket
Courtesy of GENERAL MOTORS CORP.

7. Install the air conditioning/power steering bracket to the engine assembly. Refer to **Compressor Replacement** .
8. Install the power steering pump reservoir to the engine. Refer to **Remote Power Steering Fluid Reservoir Replacement** .
9. Install the supercharger drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Supercharger** .
10. Install the water pump and generator drive belt tensioner. Refer to **Water Pump and Generator Drive Belt Tensioner Replacement** .

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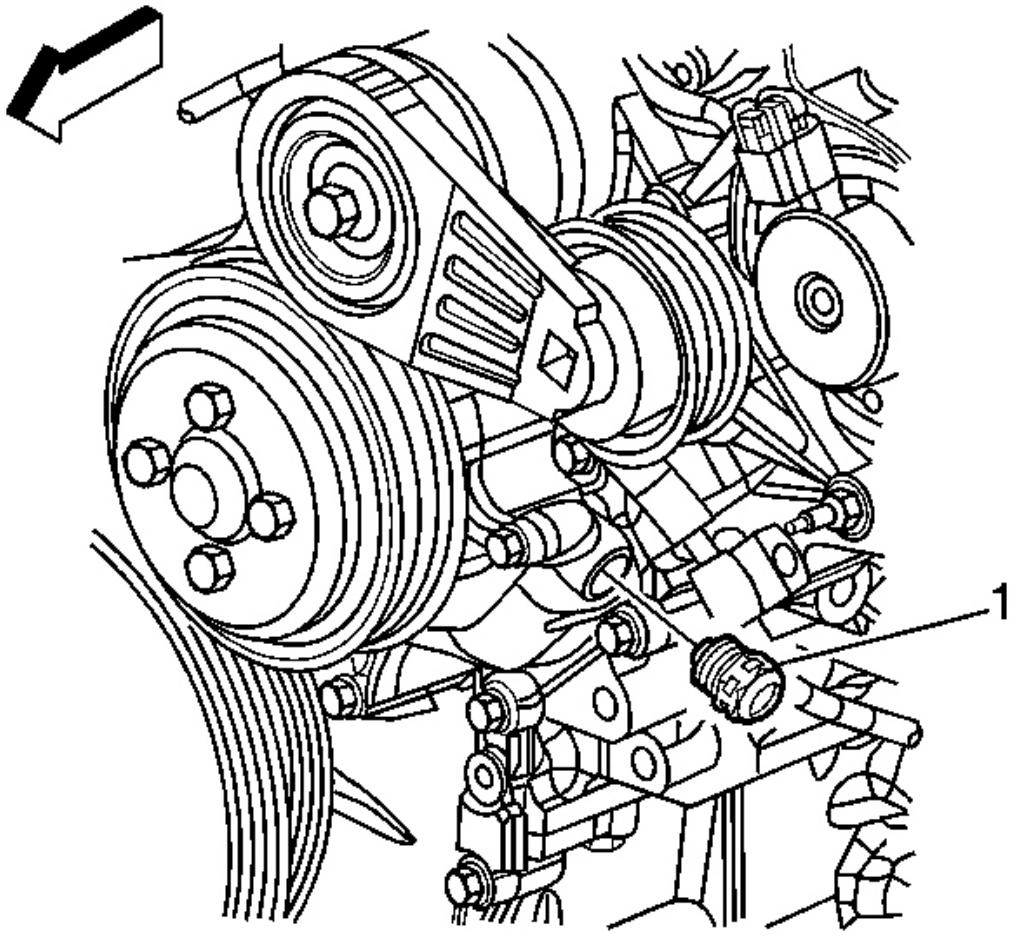


Fig. 151: Installing Generator Coolant Inlet Hose Fitting
Courtesy of GENERAL MOTORS CORP.

11. Install the generator coolant inlet hose fitting (1).

    Tighten: Tighten the fitting to 25 N.m (18 lb ft).

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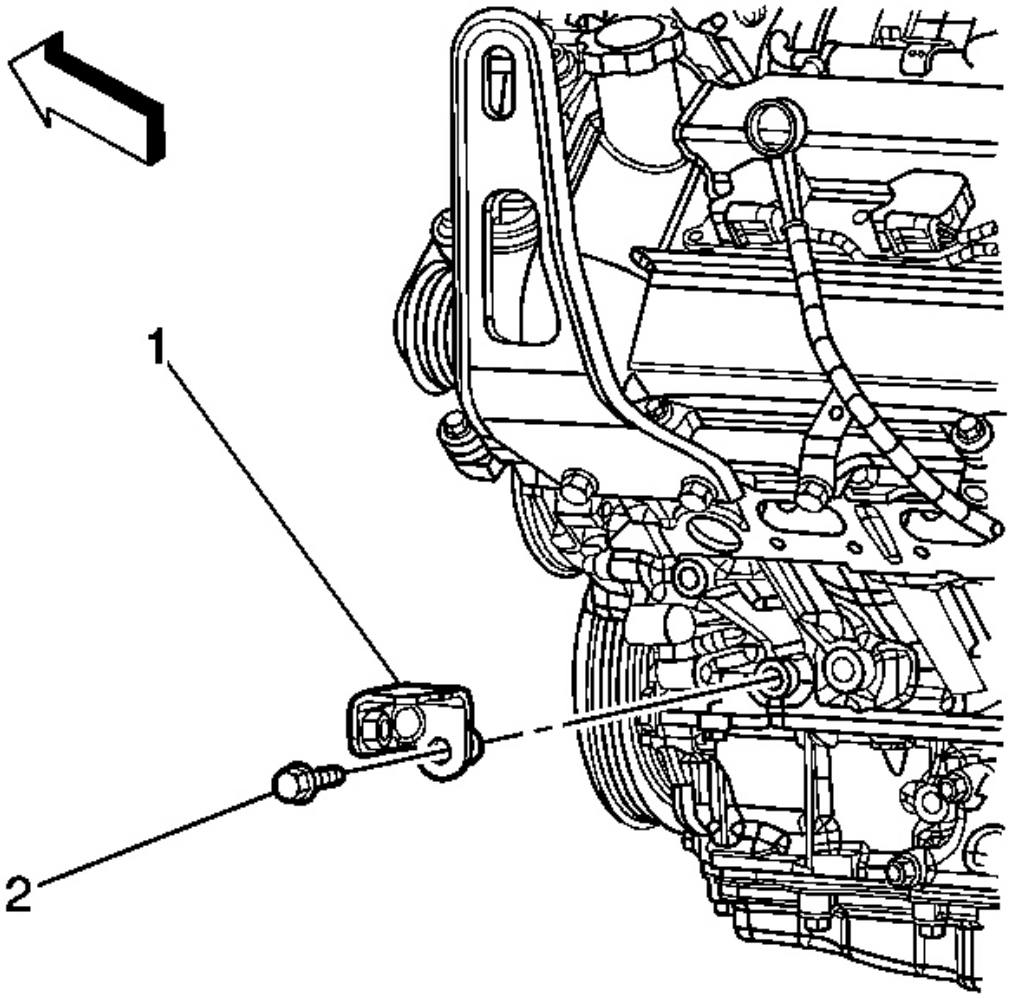


Fig. 152: Installing Generator Rear Brace & Stud
Courtesy of GENERAL MOTORS CORP.

12. Install the generator rear brace (1) to the engine.

    Tighten: Tighten the bolt to 50 N.m (37 lb ft).

13. Install the generator stud to the engine lower crankcase.

    Tighten: Tighten the stud to 12 N.m (106 lb in).

14. Install the generator. Refer to **Generator Replacement (LH2)** or **Generator Replacement (LC3)** .

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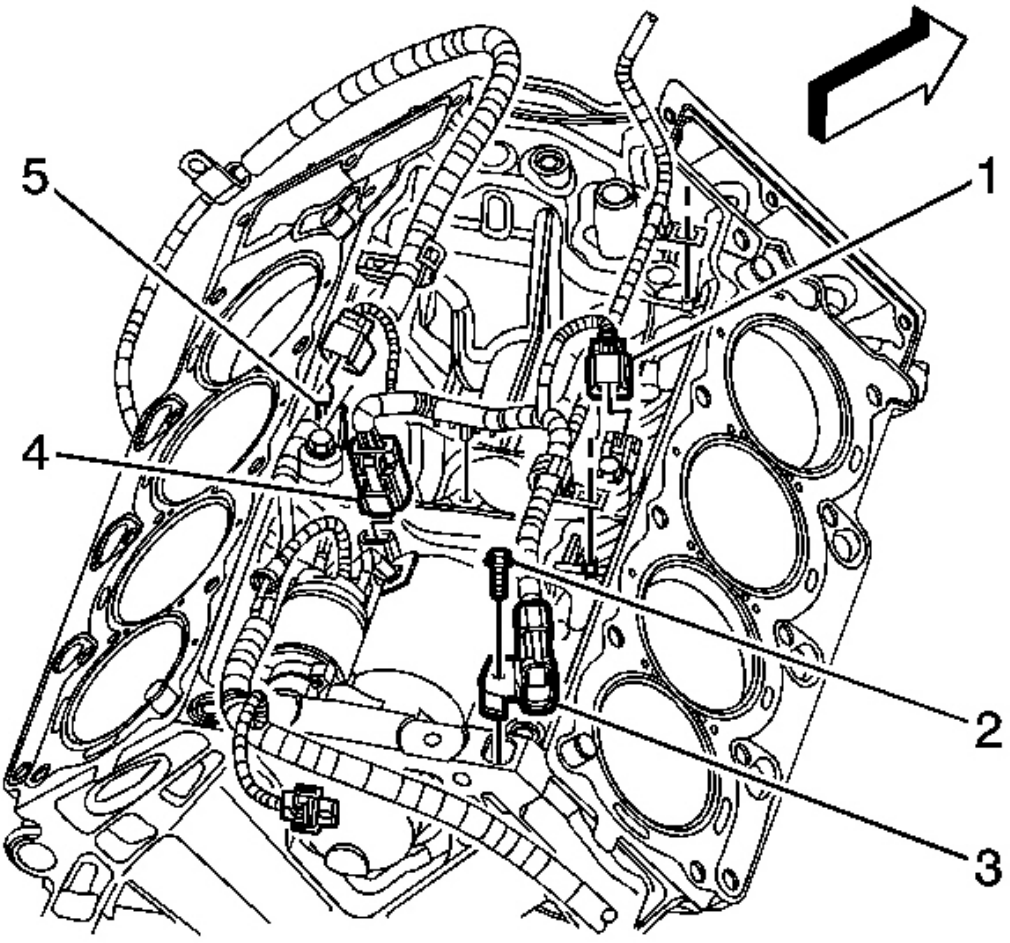


Fig. 153: View Of Crank Sensor, Electrical Connectors, Wiring Harness & Bolt
Courtesy of GENERAL MOTORS CORP.

15. Connect the harness connector (5) to the left knock sensor.
16. Connect the harness connector (1) to the right knock sensor.
17. Connect the harness connector (4) to the crank sensor.
18. Install the bolt (2) through the harness bracket.

    Tighten: Tighten the bolt to 10 N.m (89 lb in).

19. Install the starter. Refer to **Starter Motor Replacement (LC3)** or **Starter Motor Replacement (LH2)** .
20. Attach the right side upper wiring harness to the cam cover.

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21. Attach the left side upper wiring harness to the cam cover.
22. Connect the engine harness to the right camshaft position sensors.
23. Connect the engine wiring harness to the purge valve solenoid.
24. Connect the engine wiring harness to the left camshaft position sensors.

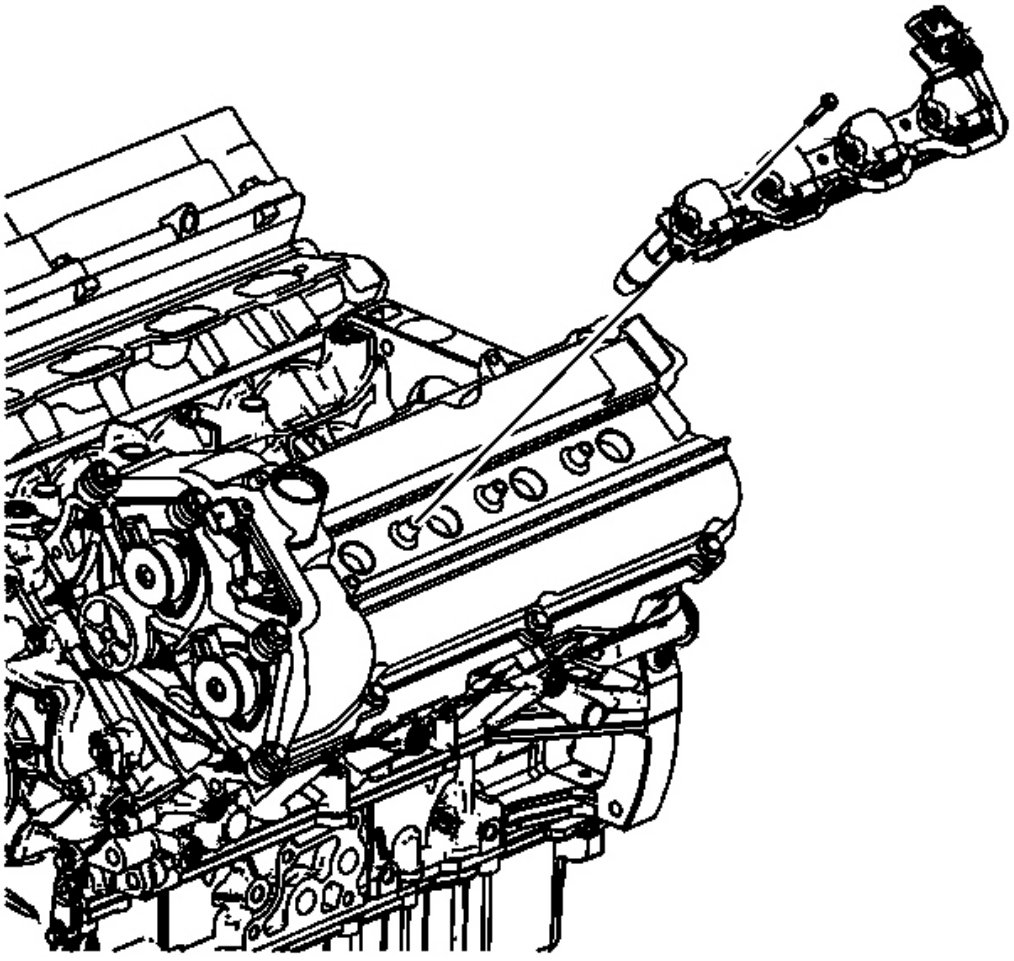


Fig. 154: View Of Left Ignition Coil Assembly, Bolts & Ball Studs
Courtesy of GENERAL MOTORS CORP.

25. Connect the starter motor jumper harness to the engine harness at the rear of the engine.
26. Install the left ignition coils as an assembly. Refer to **Ignition Coil Replacement - Bank 2** .

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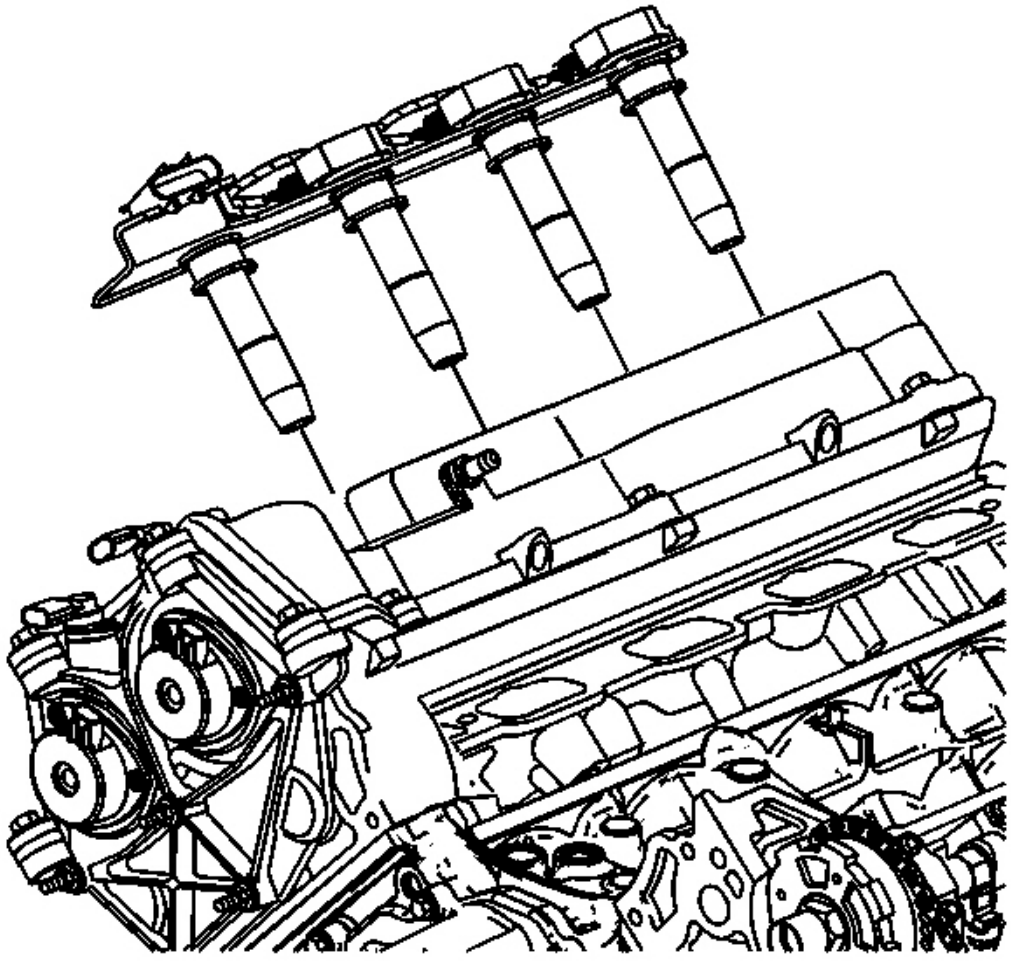


Fig. 155: View Of Ignition Coils
Courtesy of GENERAL MOTORS CORP.

27. Install the right ignition coils as an assembly. Refer to **Ignition Coil Replacement - Bank 1** .
28. Install the coolant temperature sensor. Refer to **Engine Coolant Temperature Sensor Replacement** .

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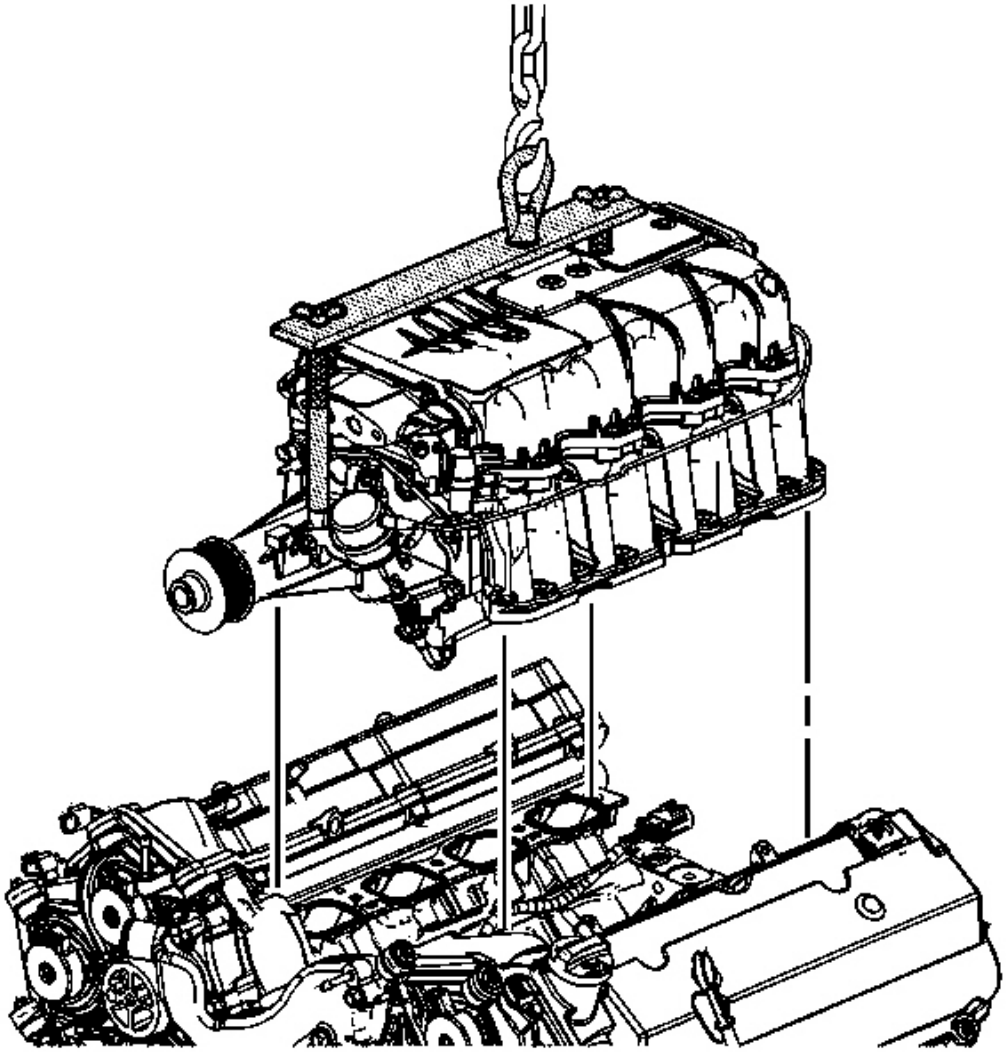


Fig. 156: Lifting Supercharger
Courtesy of GENERAL MOTORS CORP.

29. Install the supercharger assembly. Refer to **Supercharger Replacement** .
30. Install the left engine mount bracket to the engine. Refer to **Engine Mount Bracket Replacement - Left Side** .

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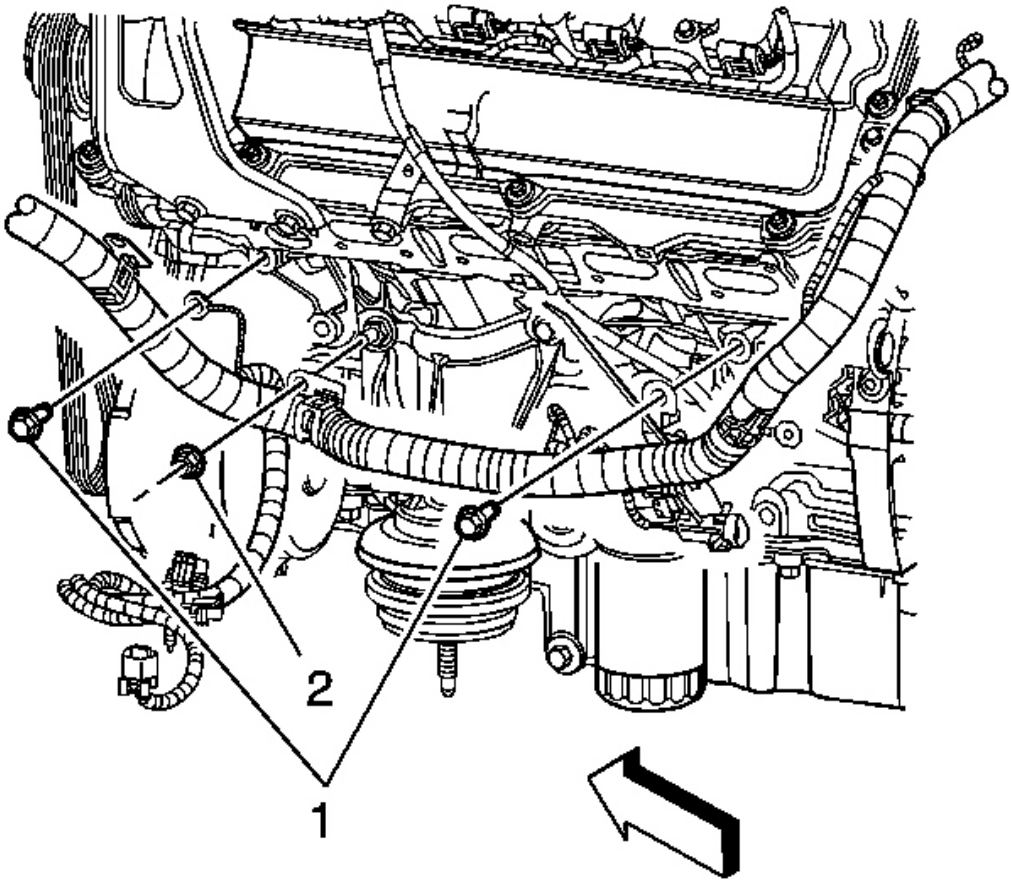


Fig. 157: View Of Engine Wiring Harness Bolts & Nut
Courtesy of GENERAL MOTORS CORP.

31. Secure the wiring harness to the engine.

    Tighten:

    - Tighten the bolts (1) to 35 N.m (26 lb ft).
    - Tighten the nut (2) to 35 N.m (26 lb ft).

32. Install the right engine mount bracket to the engine. Refer to **Engine Mount Bracket Replacement - Right Side** .
33. install the **J 28467-86** and **J 28467-87** engine lift brackets. See **Special Tools** .
34. Install an engine hoist to the engine.
35. Remove the engine from the engine stand.

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36. Install the flywheel housing and bolts. Refer to **Engine Flywheel Replacement**.

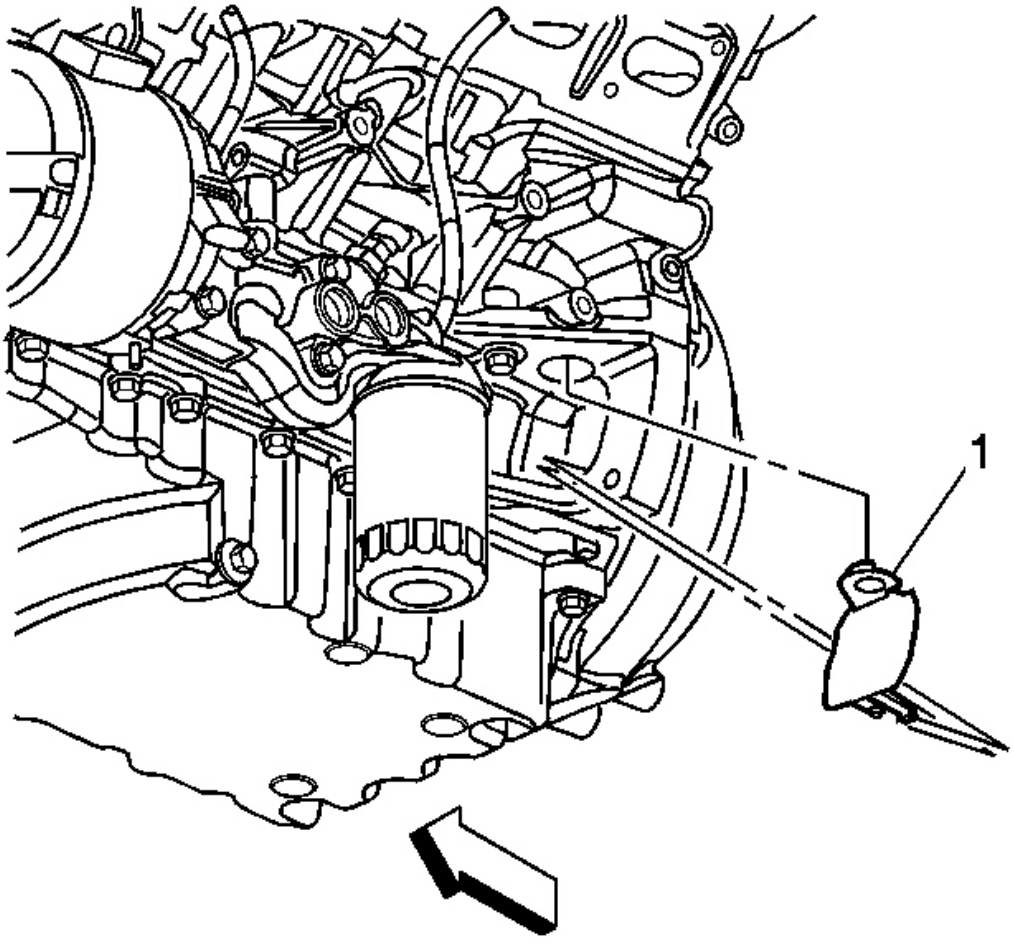


Fig. 158: View Of Flywheel Housing Left Side Cover
Courtesy of GENERAL MOTORS CORP.

37. Install the flywheel housing left side cover (1) to the engine.

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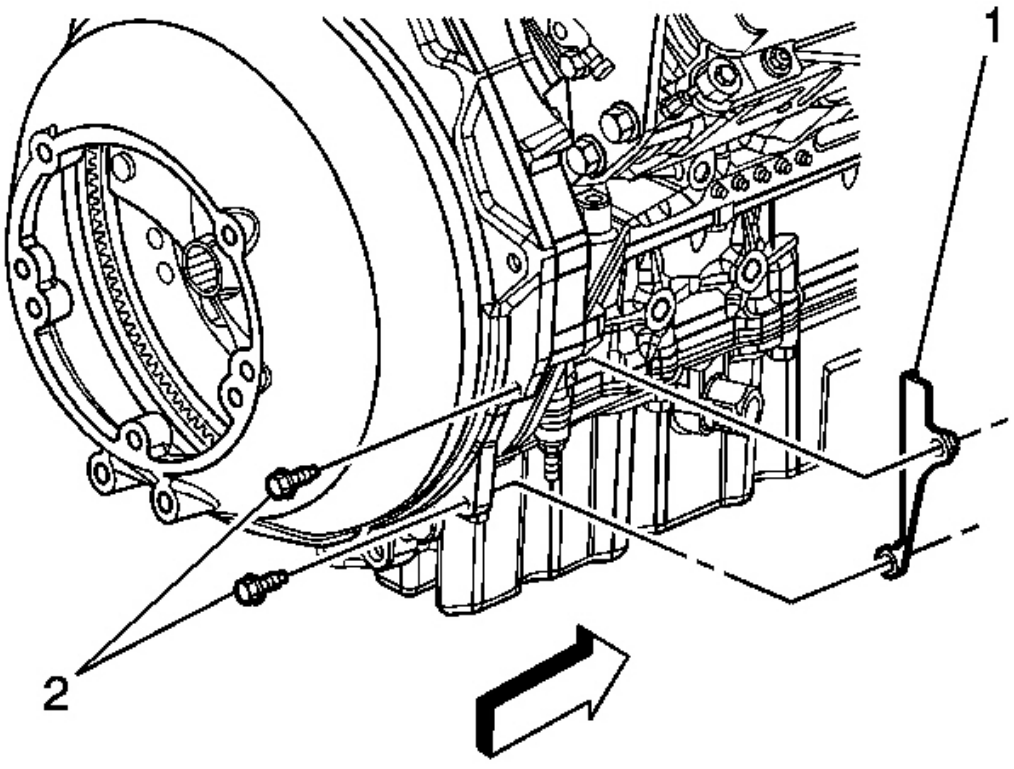


Fig. 159: View Of Engine Closeout Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

38. Install the engine closeout cover (1) to the right side of the bell housing.

    Tighten: Tighten the bolts to 10 N.m (89 lb in).

39. Install the engine wiring harness to the engine by inserting the bolts through the harness clips and into the bell housing.

    Tighten: Tighten the bolts to 50 N.m (37 lb ft).

40. Install the engine into the front cradle.
41. Remove the **J 28467-86** and **J 28467-87** engine lift brackets. See **Special Tools** .
42. Install the exhaust manifold studs to the right cylinder head.

    Tighten: Tighten the studs to 6 N.m (53 lb in).

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43. Install the exhaust manifold studs to the left cylinder head.

    Tighten: Tighten the studs to 6 N.m (53 lb in).

44. Install the right exhaust manifold assembly to the engine. Refer to **Exhaust Manifold Replacement - Right Side** .
45. Install the left exhaust manifold assembly to the engine. Refer to **Exhaust Manifold Replacement - Left Side** .
46. Install the evaporator emission canister purge tube assembly to the engine.
47. Install the powertrain. Refer to **Powertrain Removal and Installation**.
48. Fill the oil system to the proper level.

POWERTRAIN REMOVAL AND INSTALLATION

REMOVAL PROCEDURE

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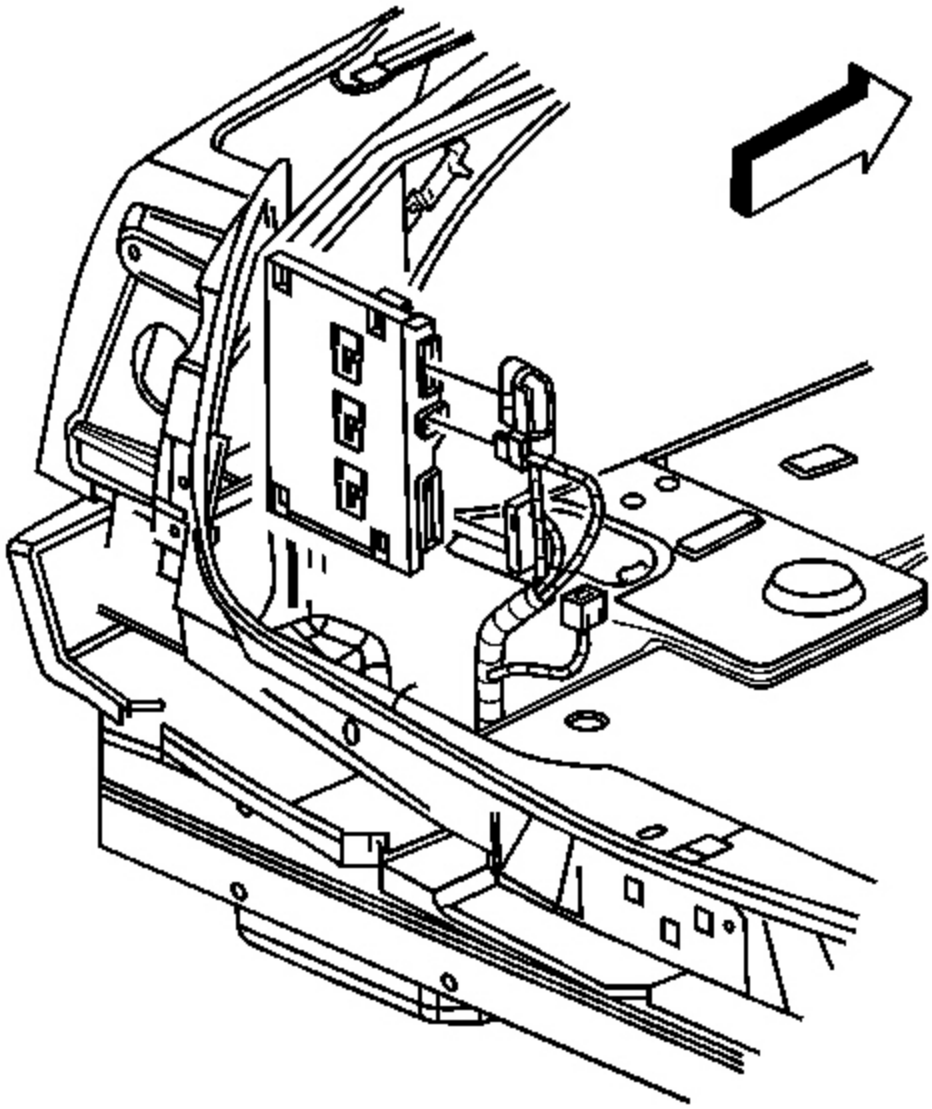


Fig. 160: ESC Module Harness Connector
Courtesy of GENERAL MOTORS CORP.

1. Open the trunk and disconnect the electronic suspension control module connectors from the module. Refer to **Electronic Suspension Control Module Replacement**
2. Close the trunk.
3. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and**

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Connection .

4. Recover the air conditioning (A/C) refrigerant. Refer to **Refrigerant Recovery and Recharging** .
5. Remove the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement** .
6. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief** .

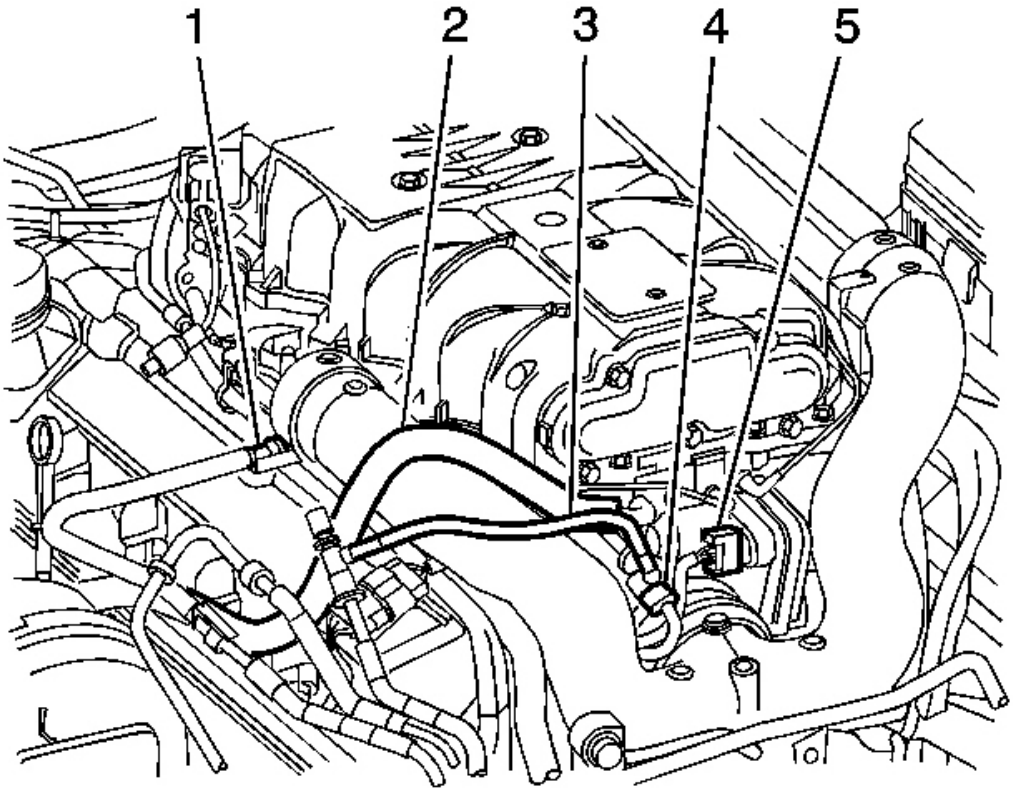


Fig. 161: Identifying EVAP Hose
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the engine compartment evaporative emission (EVAP) purge pipe (3) quick-connect fitting from the chassis pipe.
8. Cap the open pipes in order to prevent possible contamination.
9. Disconnect the fuel inlet quick-connect fitting (1) at the fuel rail and position the line aside. Refer to **Metal Collar Quick Connect Fitting Service** .

IMPORTANT: Cap the hoses and inlets when separating the cooling system components. This prevents dirt and other contaminants from entering the

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cooling system.

10. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

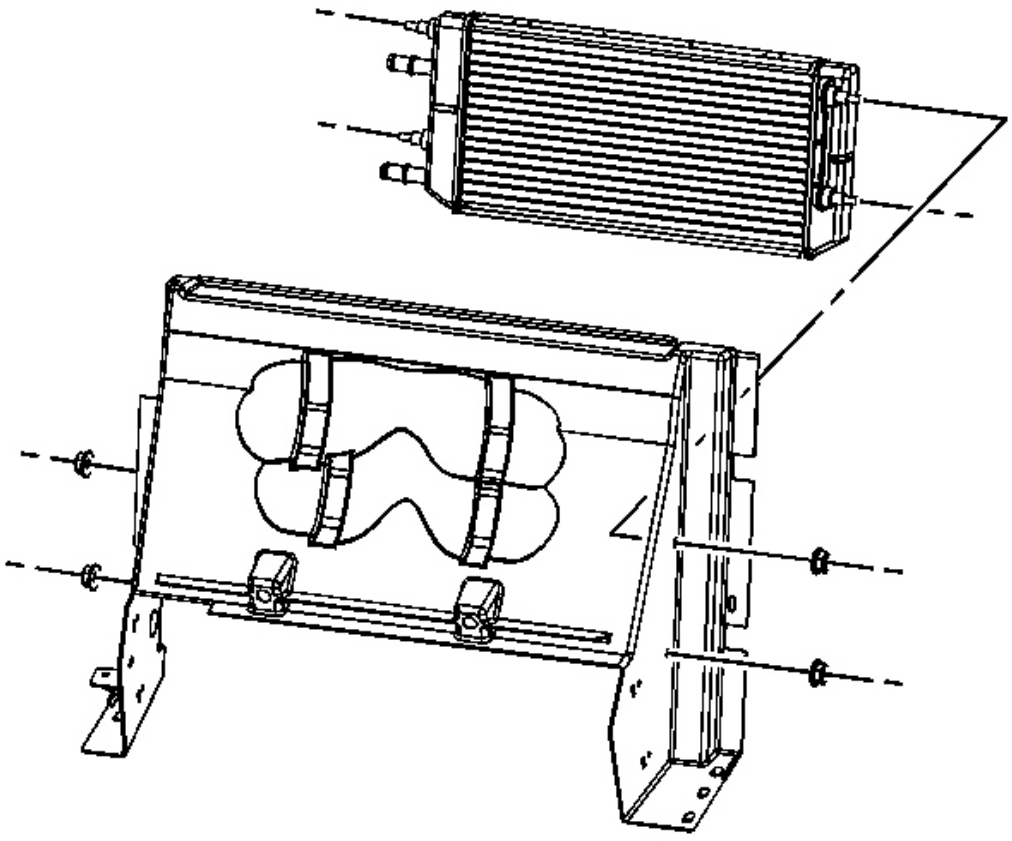


Fig. 162: View Of Charge Air Cooler Radiator
Courtesy of GENERAL MOTORS CORP.

11. Remove the charge air cooler radiator. Refer to **Radiator Replacement - Charge Air Cooler** .
12. Remove the radiator. Refer to **Radiator Replacement** .
13. Remove the surge tank. Refer to **Surge Tank Replacement** .
14. Remove the air conditioning condenser. Refer to **Condenser Replacement** .

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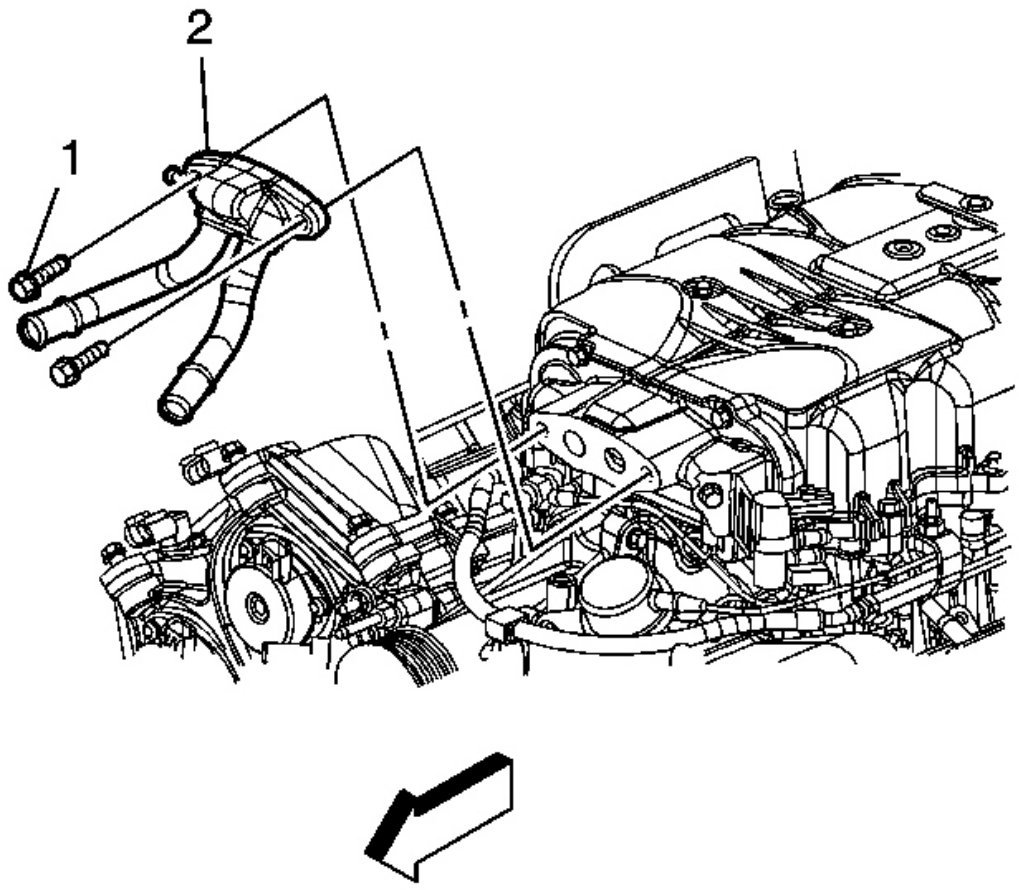


Fig. 163: View Of Charge Air Cooler & Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

15. Remove the front portion of the supercharger front manifold (2). It is not necessary to remove the hoses from the manifold. Position the hoses with manifold aside. Refer to **Charge Air Cooler Front Manifold Replacement** .

CAUTION: Refer to Brake Fluid Irritant Caution .

IMPORTANT: The brake hydraulic system does not need to be opened.

16. Disconnect the vacuum brake booster hose from the brake booster.

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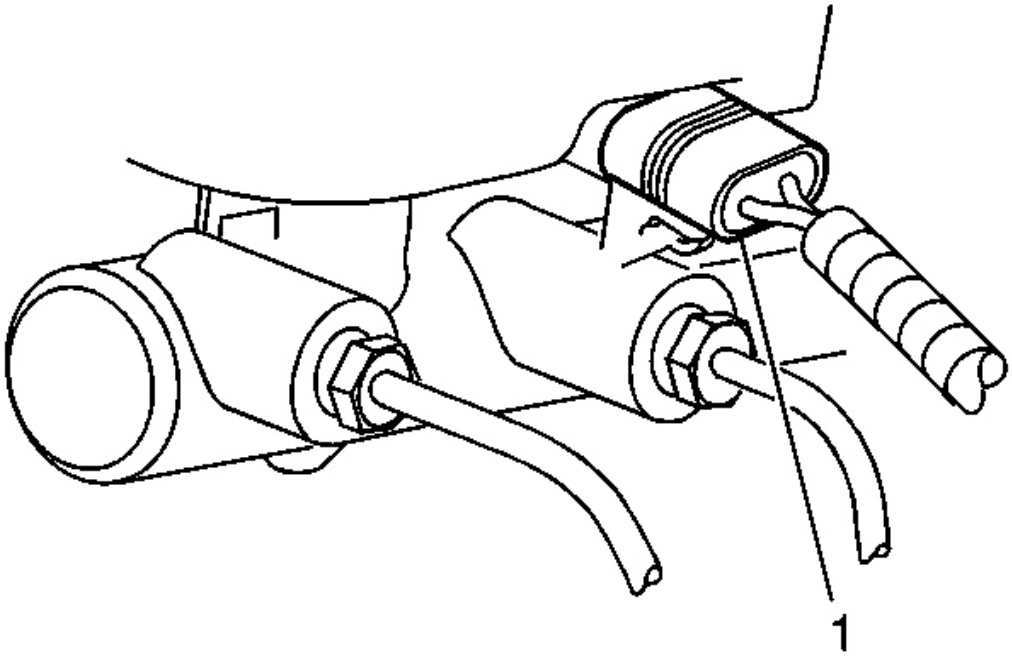


Fig. 164: View Of Brake Fluid Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

17. Disconnect the electrical connector (1) from the brake fluid level sensor.

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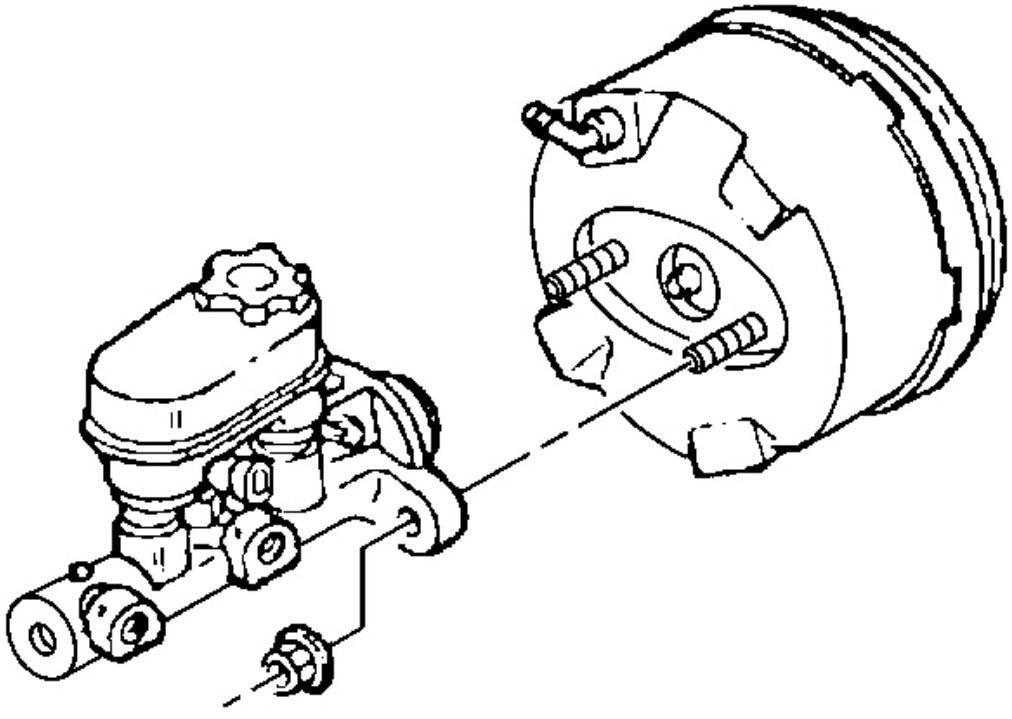


Fig. 165: View Of Master Cylinder & Mounting Nuts
Courtesy of GENERAL MOTORS CORP.

18. Remove the brake master cylinder nuts from the brake booster studs.
19. Pull the master cylinder forward out of contact with the brake booster studs.
20. Secure the master cylinder to the engine.

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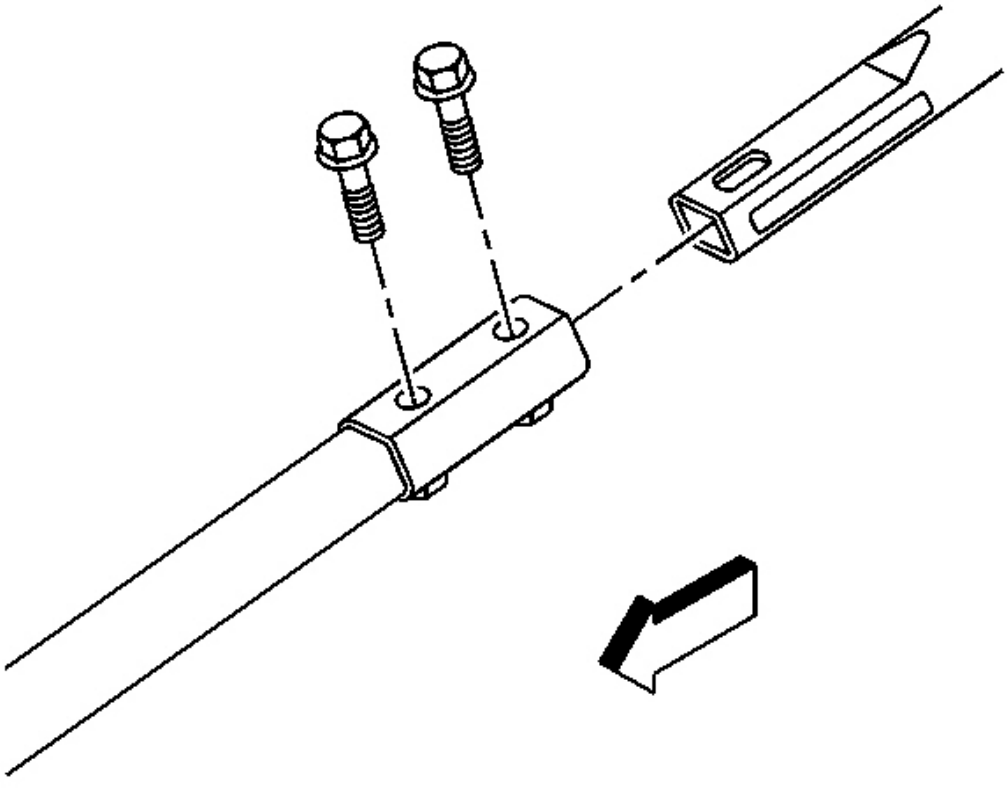


Fig. 166: View Of Steering Shaft & Bolts
Courtesy of GENERAL MOTORS CORP.

21. Remove the bolts from the intermediate steering shaft.
22. Disconnect the steering shaft from the steering gear.
23. Tie-wrap the steering shaft to the engine.
24. Remove the battery. Refer to **Battery Replacement** .
25. Remove the battery tray. Refer to **Battery Tray Replacement** .

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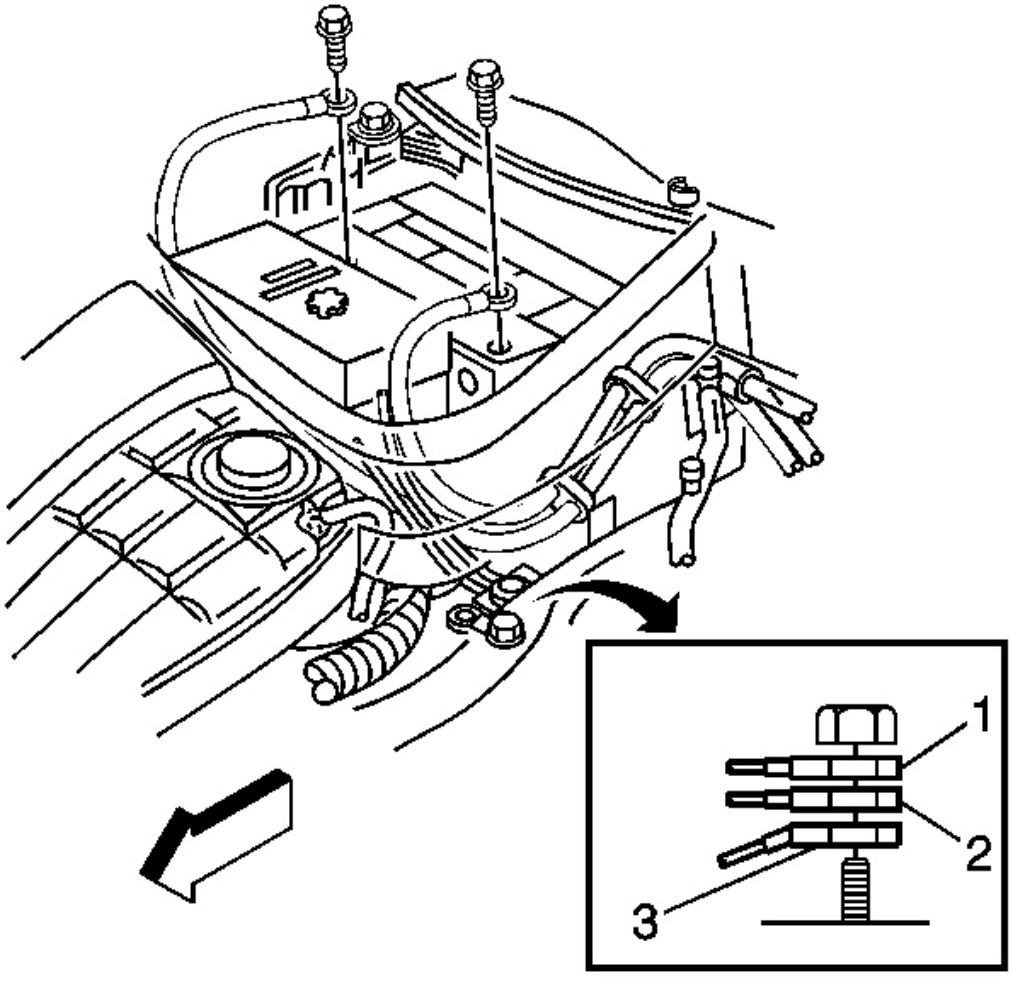


Fig. 167: View Of Ground Strap Nut, Terminal & Stud
Courtesy of GENERAL MOTORS CORP.

26. Remove the ground strap nut and terminals (1-3) from the stud on the frame.

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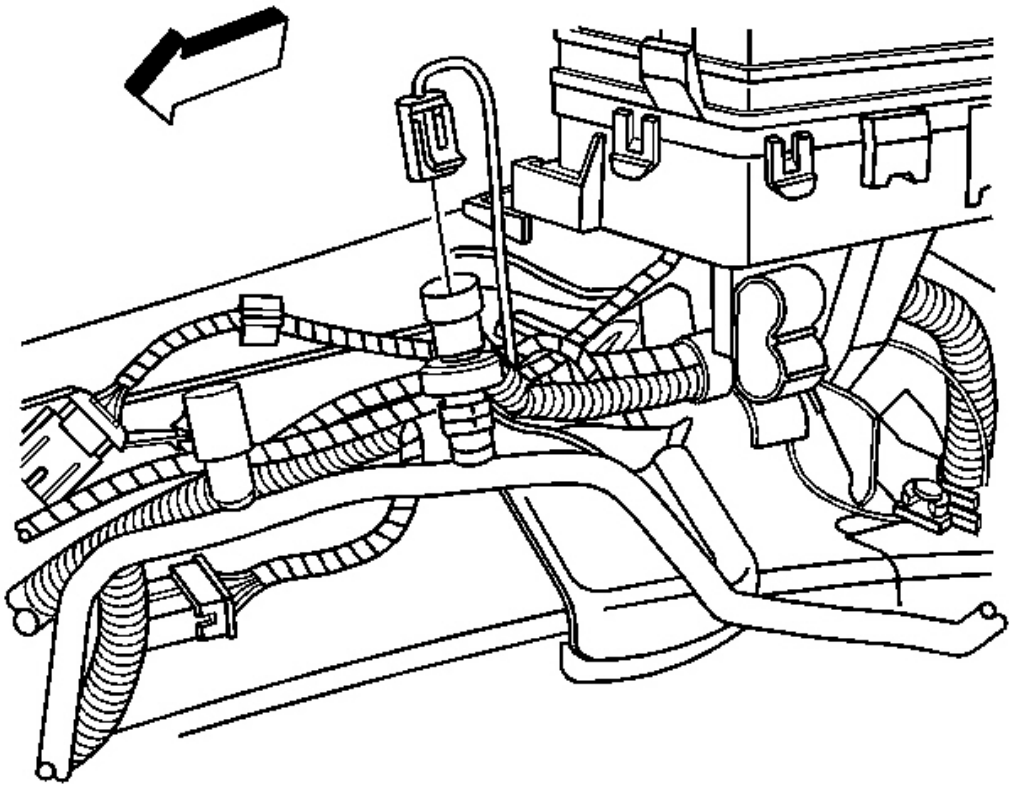


Fig. 168: View Of A/C Electrical Connector & Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

27. Disconnect the A/C electrical connector from the pressure sensor.
28. Remove the underhood junction block (UHJB) from the wheelhouse.
29. Disconnect the wiring harness connector from the UHJB.
30. Secure the wiring harness to the engine.
31. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
32. Remove the front wheels and tires. Refer to **Tire and Wheel Removal and Installation** .
33. Remove the right front wheelhouse panel in order to gain access to the engine control module (ECM) and transmission control module (TCM) electrical connectors. Refer to **Wheelhouse Liner Panel Replacement - Rear** .
34. Disconnect and secure the following wiring harness electrical connectors to the top of engine:
    - The ECM-Refer to **Engine Control Module Replacement** .
    - The engine electrical harness-Refer to **Underhood Electrical Center or Junction Block Replacement** .

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35. Disconnect A/C lines from front of dash connections. Refer to **Compressor Hose Assembly Replacement** .
36. Disconnect the heater hoses from the heater pipes. Refer to **Heater Pipes Replacement** .
37. Disconnect the front wheel speed sensor electrical connectors.

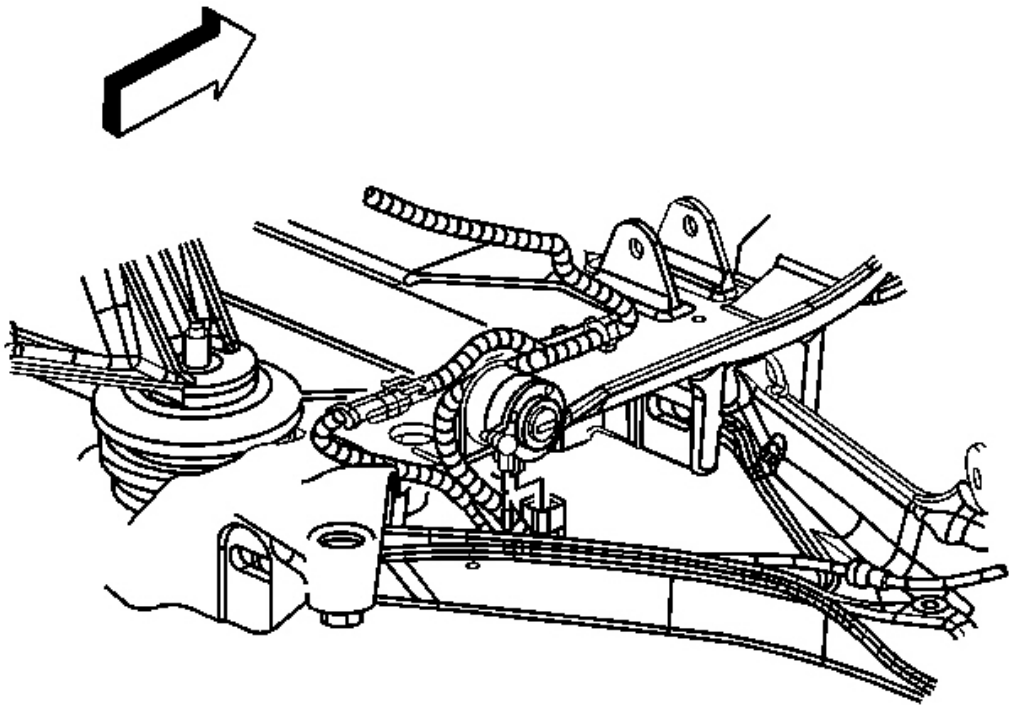


Fig. 169: View Of Road Sensing Suspension Position Sensor Links & Lower Control Arm
Courtesy of GENERAL MOTORS CORP.

38. Disconnect the road sensing suspension position sensor links from the front lower control arms.
39. Support the lower control arm with a suitable jack.

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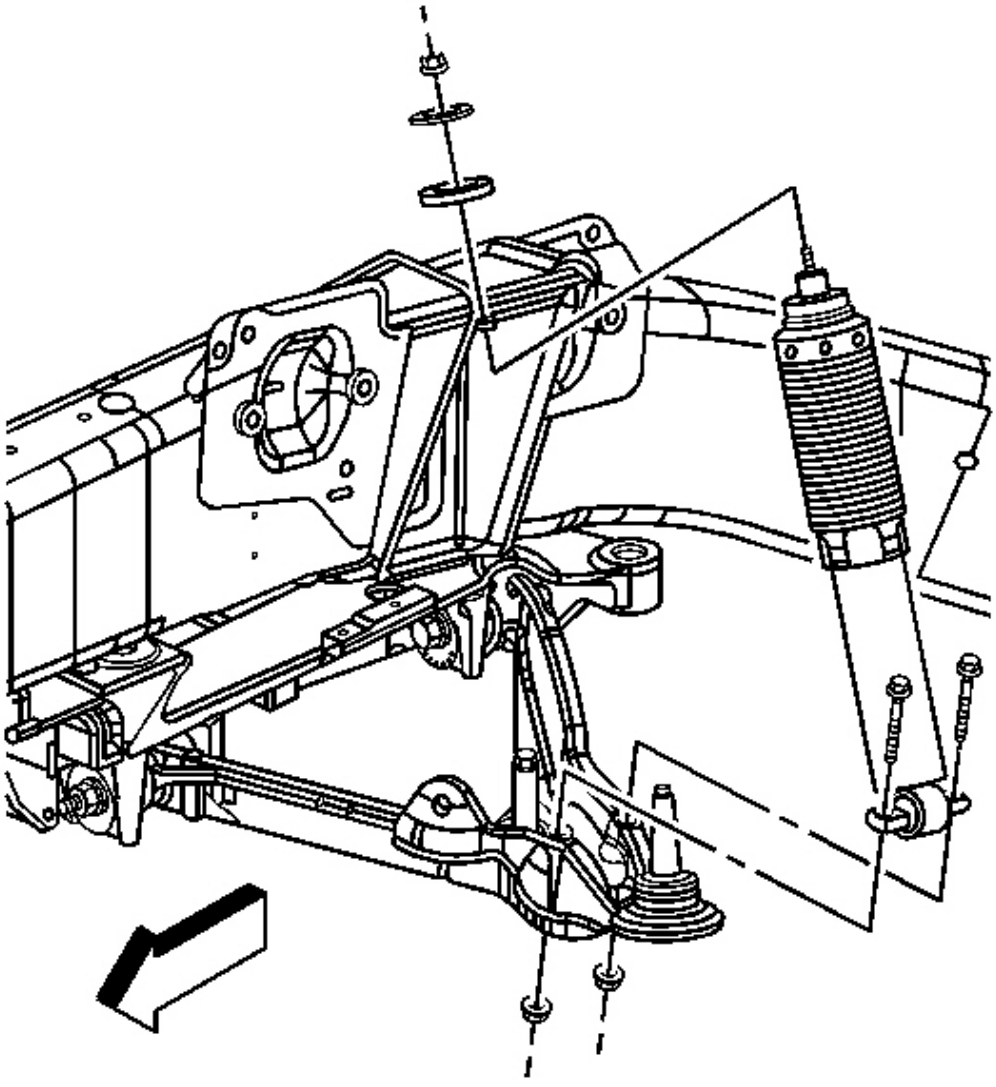


Fig. 170: Identifying Shock Absorber Lower Mounting Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

40. Remove the shock absorber lower mounting bolts.
41. Disconnect the upper ball joint from the suspension knuckle. Refer to **Steering Knuckle Replacement** .
42. Remove the jack from the control arm.
43. Repeat steps 40 through 43 for the other side of the vehicle.
44. Remove the rear tire and wheel assemblies. Refer to **Tire and Wheel Removal and Installation** .

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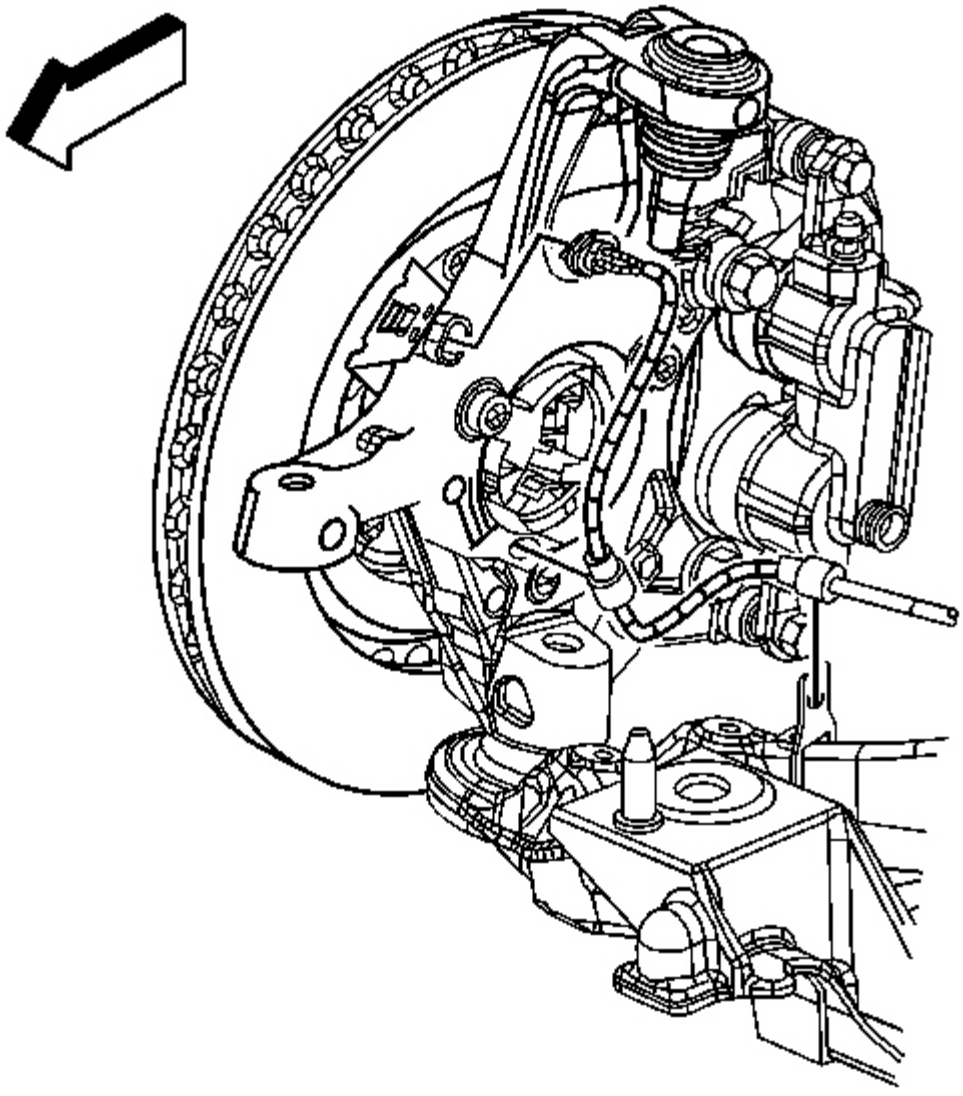


Fig. 171: View Of Wheel Speed Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

45. Disconnect the rear wheel speed sensor electrical connectors.

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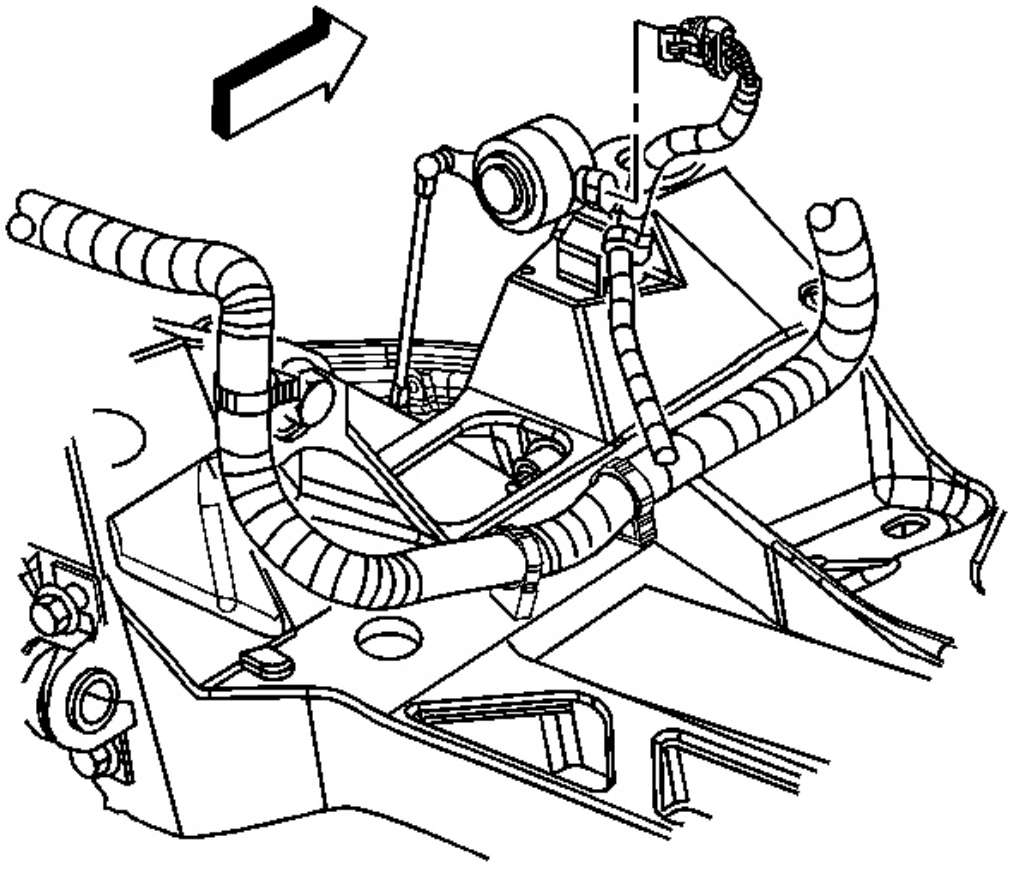


Fig. 172: View Of Road Sensing Suspension Position Sensor Links
Courtesy of GENERAL MOTORS CORP.

46. Disconnect the road sensing suspension position sensor links from the rear lower control arms.
47. Support the lower control arm with a suitable jack.

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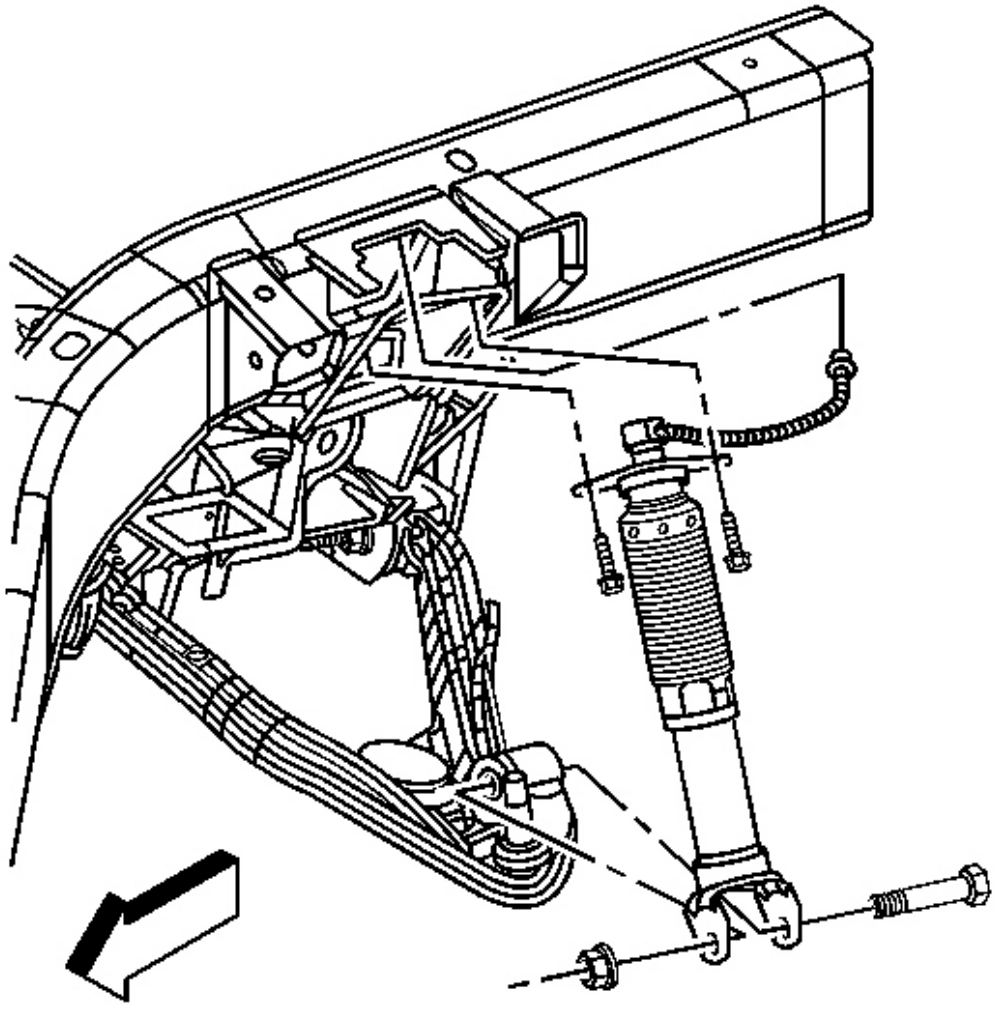


Fig. 173: View Of Shock Absorber, Ball Joint & Bolt
Courtesy of GENERAL MOTORS CORP.

48. Remove the rear shock absorber lower mounting bolt.
49. Disconnect the upper ball joint from the suspension knuckle. Refer to **Knuckle Replacement** .
50. Remove the jack from the control arm.
51. Repeat steps 48 through 51 for the other side of the vehicle.
52. Remove the RH muffler assembly. Refer to **Muffler Replacement - Right Side** .
53. Remove the LH muffler assembly. Refer to **Muffler Replacement - Left Side** .

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54. Remove the exhaust intermediate pipe. Refer to **Intermediate Pipe Replacement** .

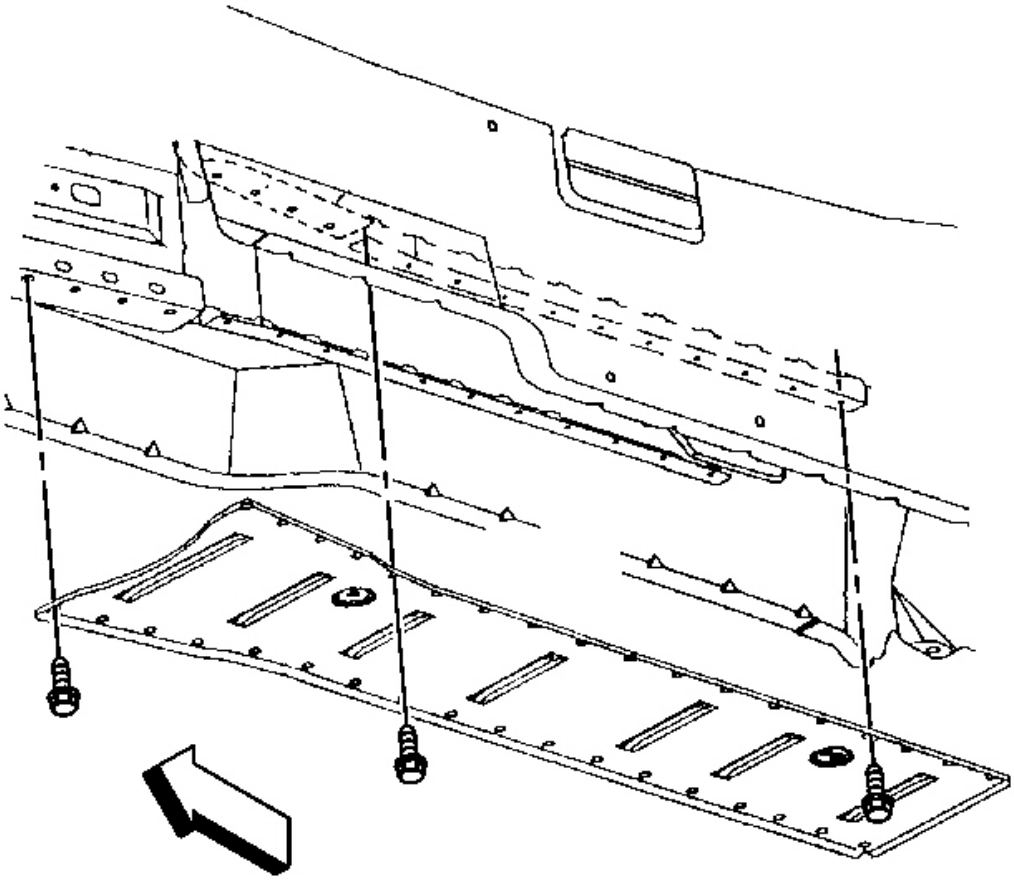


Fig. 174: View Of Driveline Tunnel Closeout Panel & Bolts
Courtesy of GENERAL MOTORS CORP.

55. Remove the bolts from the driveline tunnel closeout panel.
56. Remove the driveline tunnel closeout panel.

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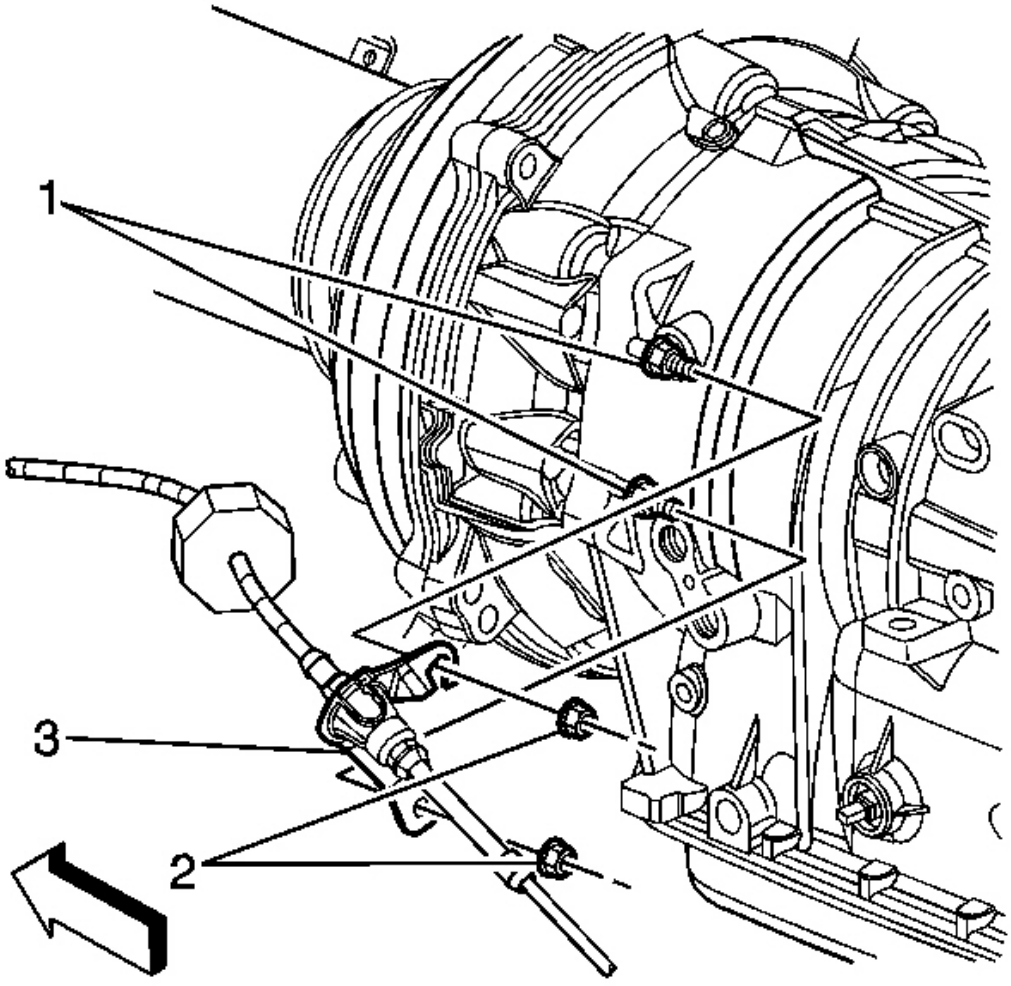


Fig. 175: View Of Transmission, Shift Cable Bracket & Nuts
Courtesy of GENERAL MOTORS CORP.

57. Remove the nuts (2) retaining the transmission shift cable bracket (3) to the transmission.

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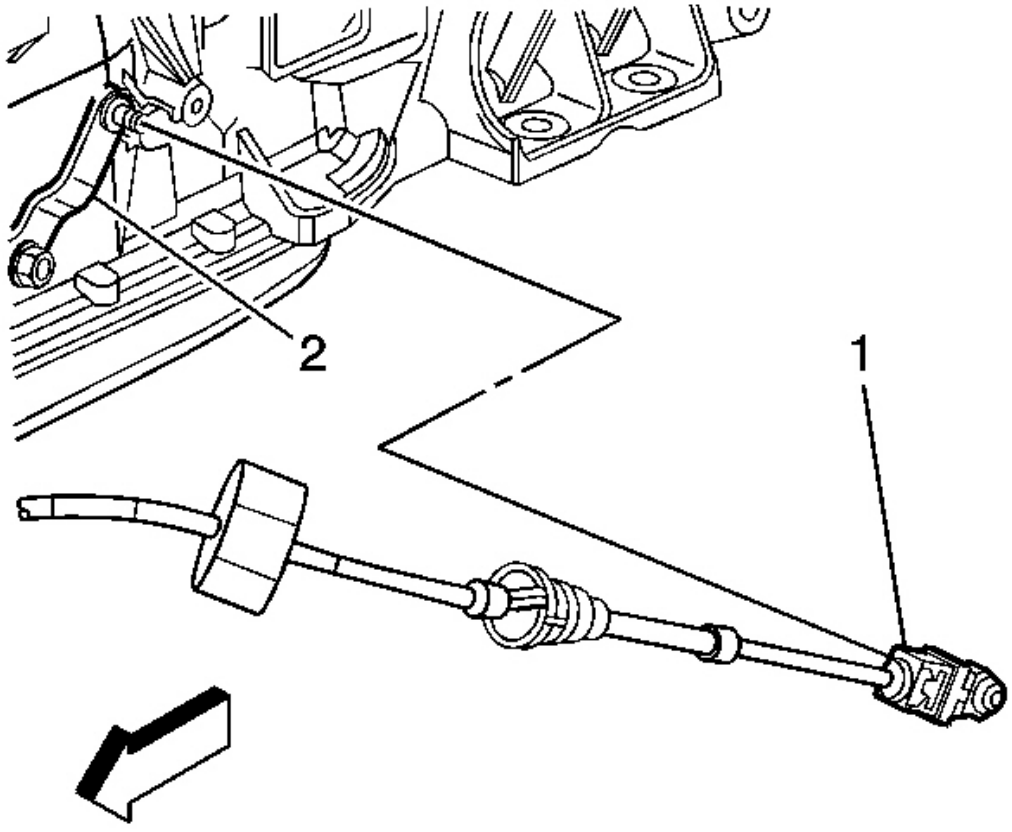


Fig. 176: View Of Transmission Shift Control Cable & Transmission Shift Lever
Courtesy of GENERAL MOTORS CORP.

58. Disconnect the transmission shift control cable (1) from the transmission shift lever (2). Unsnap to release the cable.
59. Reposition the transmission shift cable and bracket.
60. Position the powertrain table under the front cradle.
61. Position the powertrain table under the rear cradle.
62. With the aid of an assistant, slowly lower the vehicle onto the powertrain tables.

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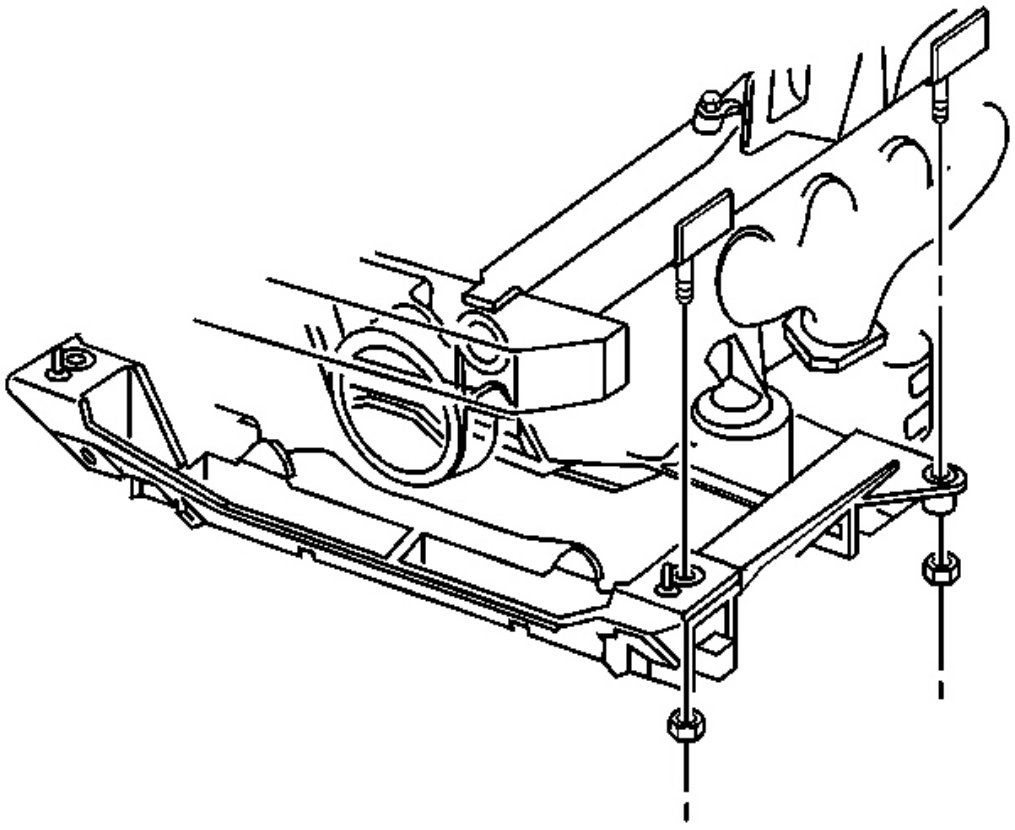


Fig. 177: View Of Front & Rear Crossmember Nuts
Courtesy of GENERAL MOTORS CORP.

63. Using HAND TOOLS ONLY, remove the front and rear crossmember nuts. Refer to **Front Suspension Crossmember Replacement** .
64. Carefully raise the vehicle to clear the supported powertrain assembly.

INSTALLATION PROCEDURE

1. Position the powertrain under the vehicle.
2. With the aid of an assistant, slowly lower the vehicle onto the powertrain.
3. Guide the front and rear cradle into the cradle bolts.

NOTE: Refer to Fastener Notice .

4. Using HAND TOOLS ONLY, install the front and rear cradle nuts.

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Tighten: Tighten the nuts to 110 N.m (81 lb ft).

5. Attach the transmission shift cable bracket to the transmission.

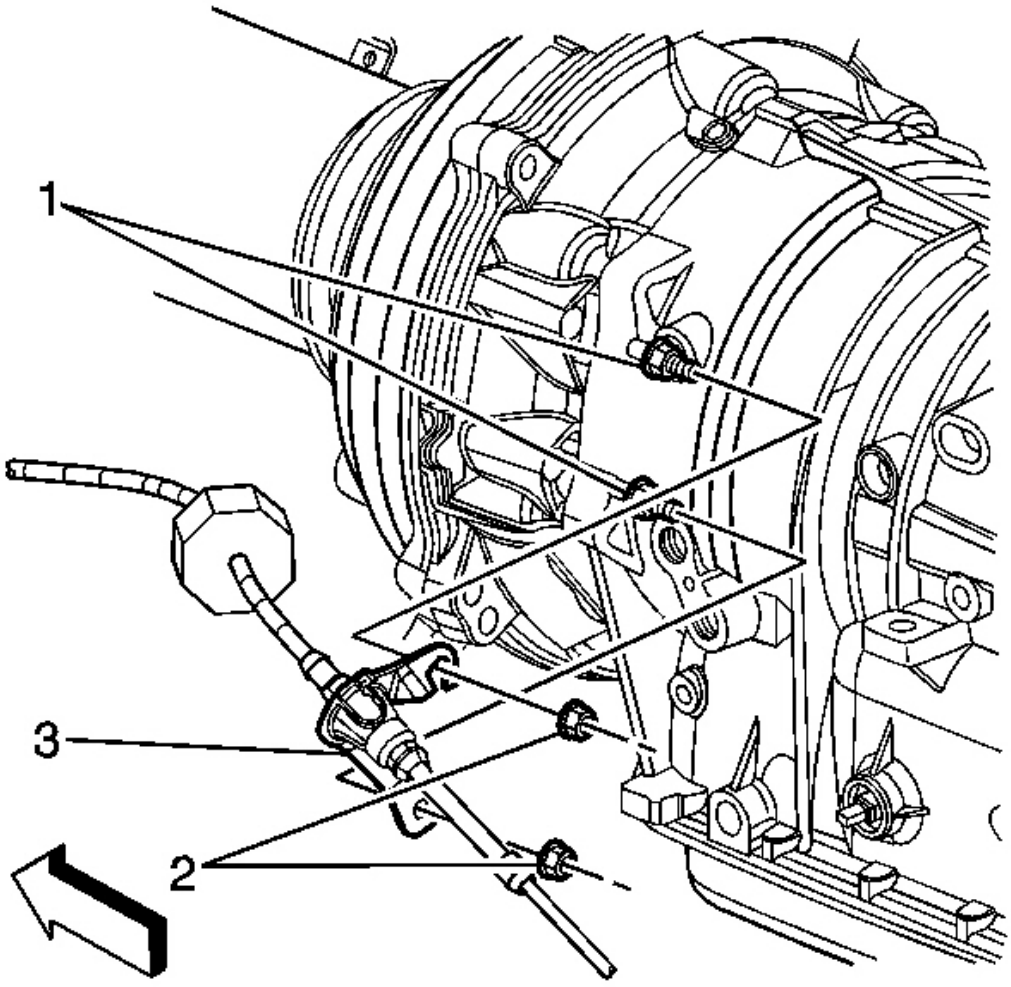


Fig. 178: View Of Transmission, Shift Cable Bracket & Nuts
Courtesy of GENERAL MOTORS CORP.

6. Install the nuts (2) retaining the transmission shift cable bracket (3) to the transmission.

Tighten: Tighten the nuts to 20 N.m (15 lb ft).

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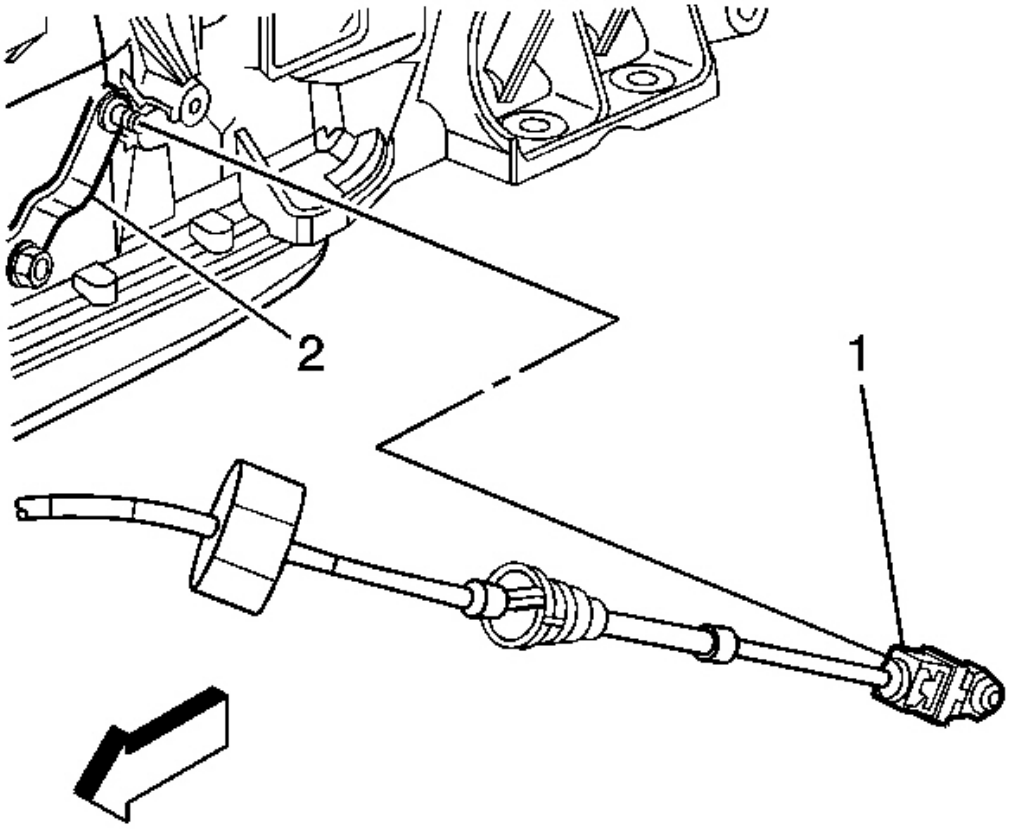


Fig. 179: View Of Transmission Shift Control Cable & Transmission Shift Lever
Courtesy of GENERAL MOTORS CORP.

7. Connect the transmission shift cable (1) to the transmission shift lever (2).

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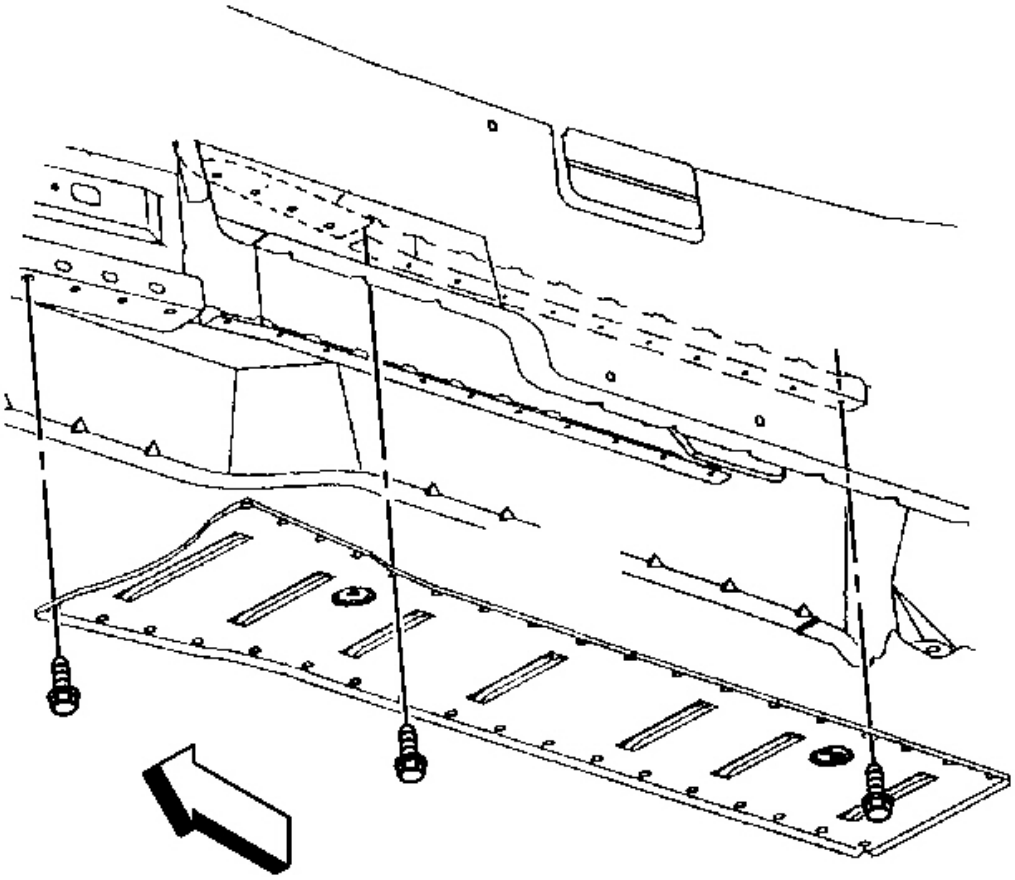


Fig. 180: View Of Driveline Tunnel Closeout Panel & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the driveline tunnel closeout panel.
9. Install the driveline closeout panel bolts.

   Tighten: Tighten the bolts to 10 N.m (89 lb in).

10. Install the RH muffler assembly. Refer to **Muffler Replacement - Right Side** .
11. Install the LH muffler assembly. Refer to **Muffler Replacement - Left Side** .
12. Install the exhaust intermediate pipe. Refer to **Intermediate Pipe Replacement** .
13. Connect the upper ball joint to the right knuckle. Refer to **Knuckle Replacement** .

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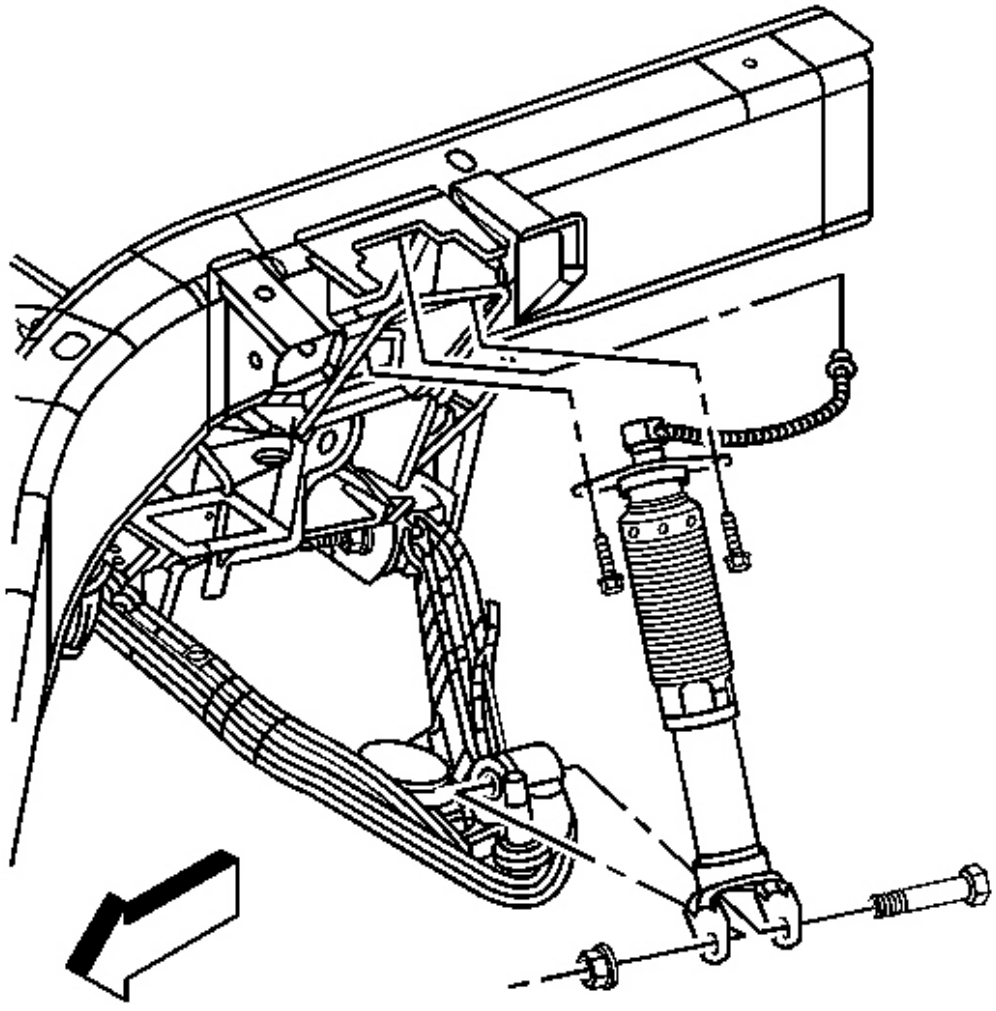


Fig. 181: View Of Shock Absorber, Ball Joint & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Install the rear shock absorber lower mounting bolts.

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

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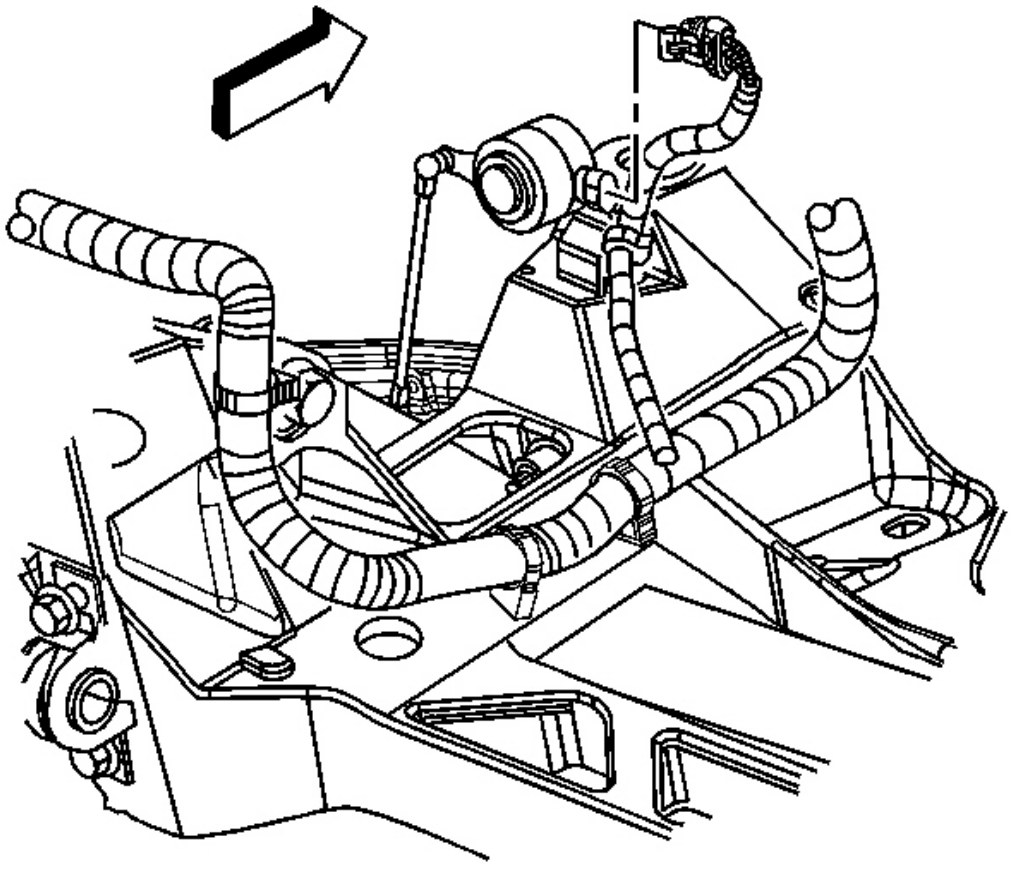


Fig. 182: View Of Road Sensing Suspension Position Sensor Links
Courtesy of GENERAL MOTORS CORP.

15. Connect the road sensing suspension position link to lower control arm.
16. Repeat for the other side of the vehicle.

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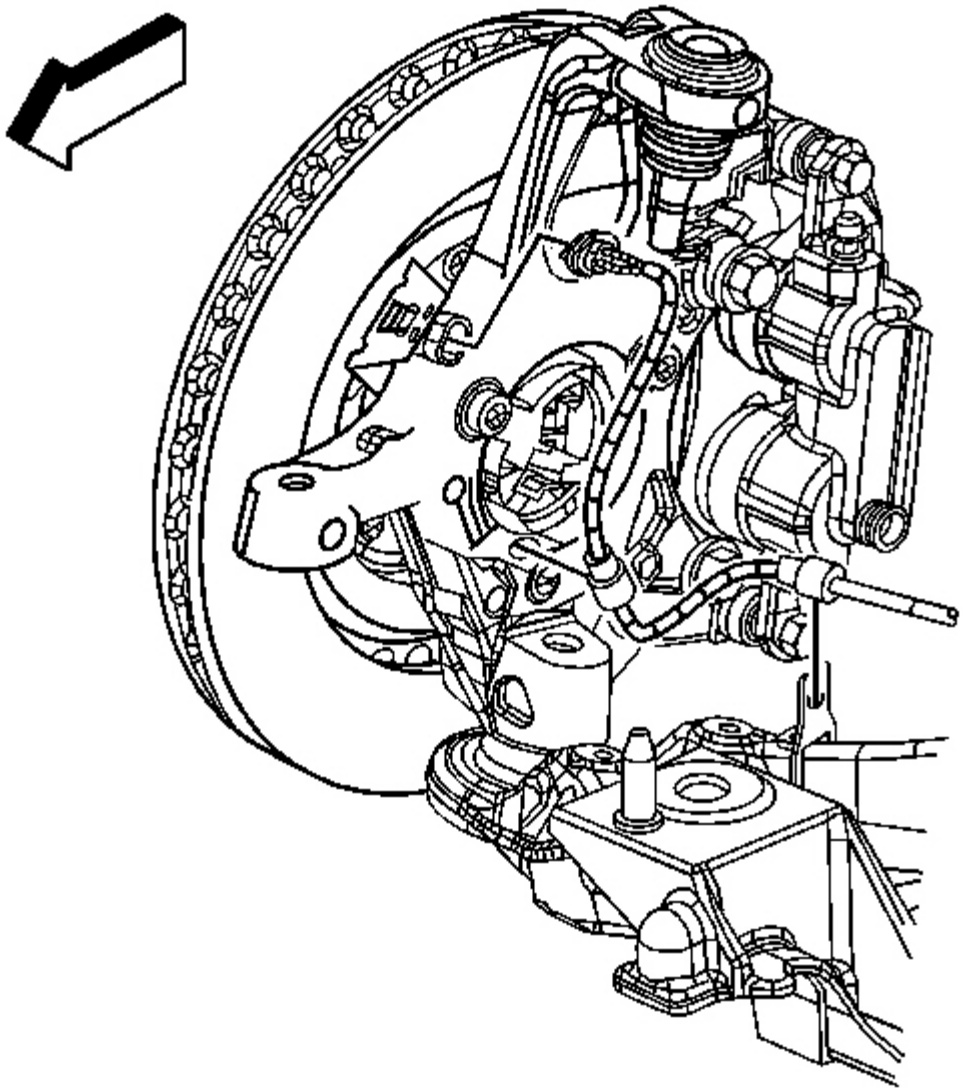


Fig. 183: View Of Wheel Speed Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

17. Connect the rear wheel speed sensor electrical connectors.
18. Install the rear tire and wheel assemblies. Refer to **Tire and Wheel Removal and Installation** .
19. Connect the upper ball joint to the right front suspension knuckle. Refer to **Steering Knuckle Replacement** .

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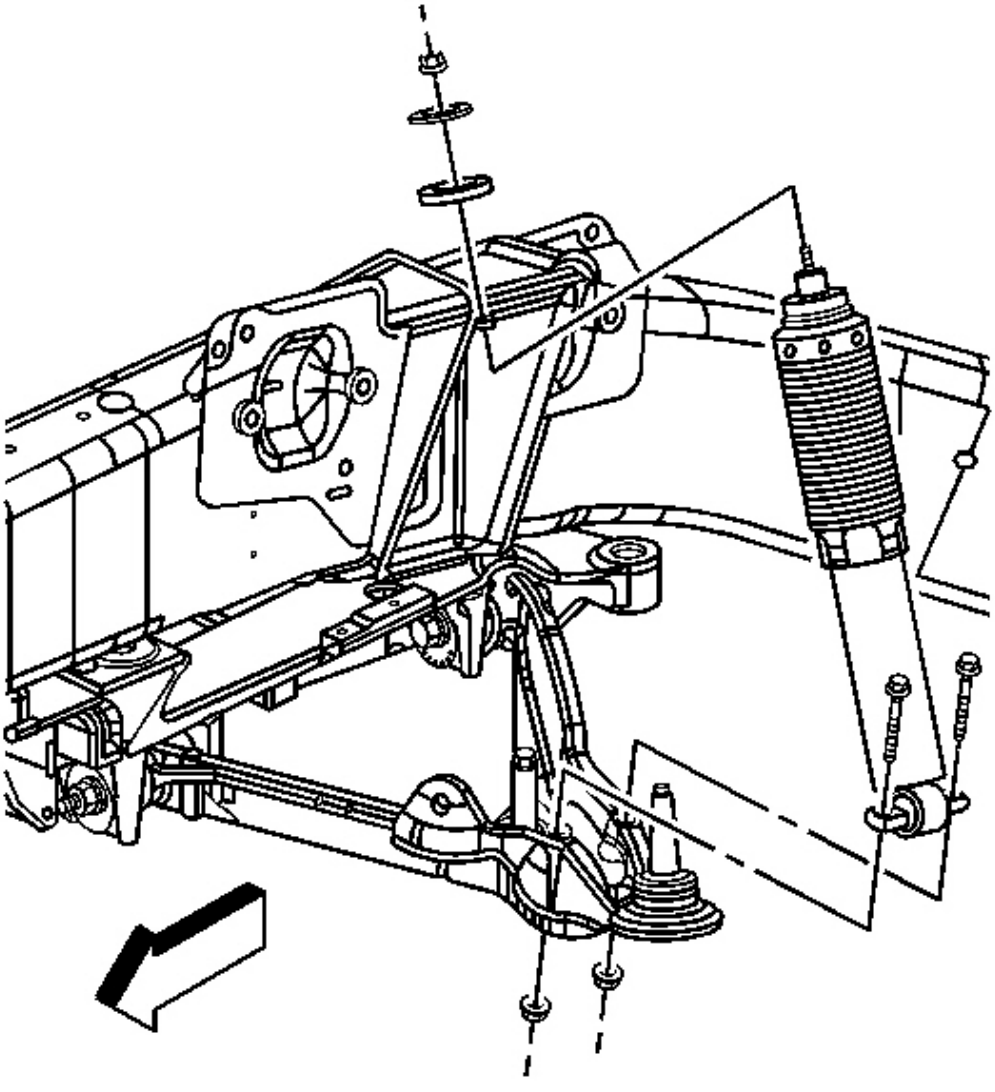


Fig. 184: Identifying Shock Absorber Lower Mounting Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

20. Install the shock absorber lower mounting bolts. Refer to **Shock Absorber Replacement (W/F55)** .

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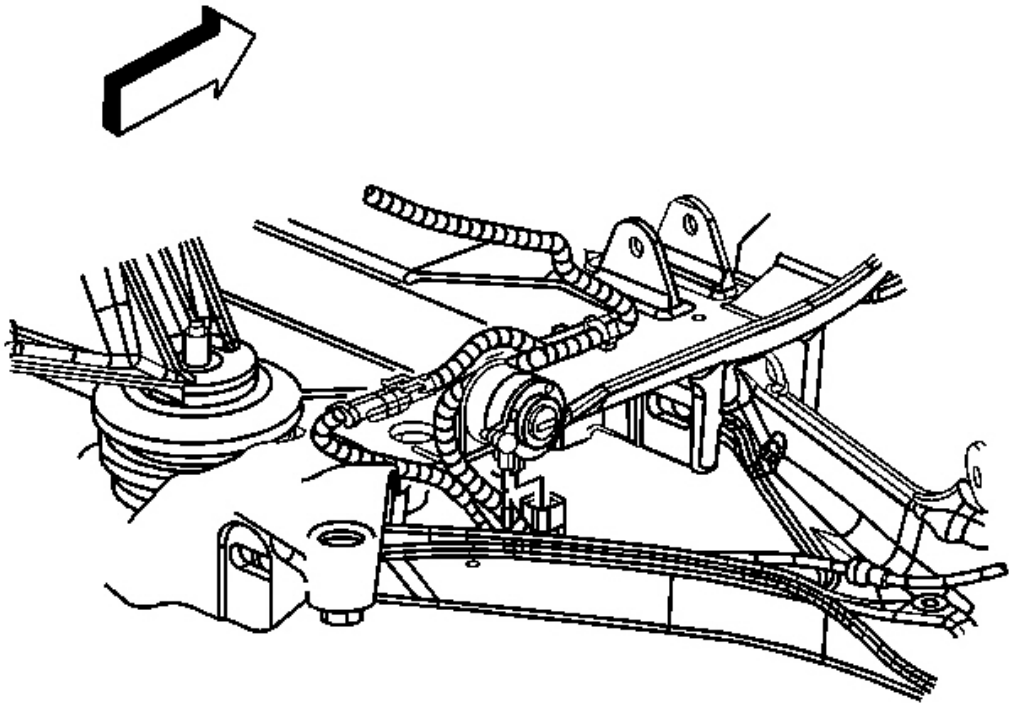


Fig. 185: View Of Road Sensing Suspension Position Sensor Links & Lower Control Arm
Courtesy of GENERAL MOTORS CORP.

21. Connect the road sensing suspension position sensor link to the front lower control arm.

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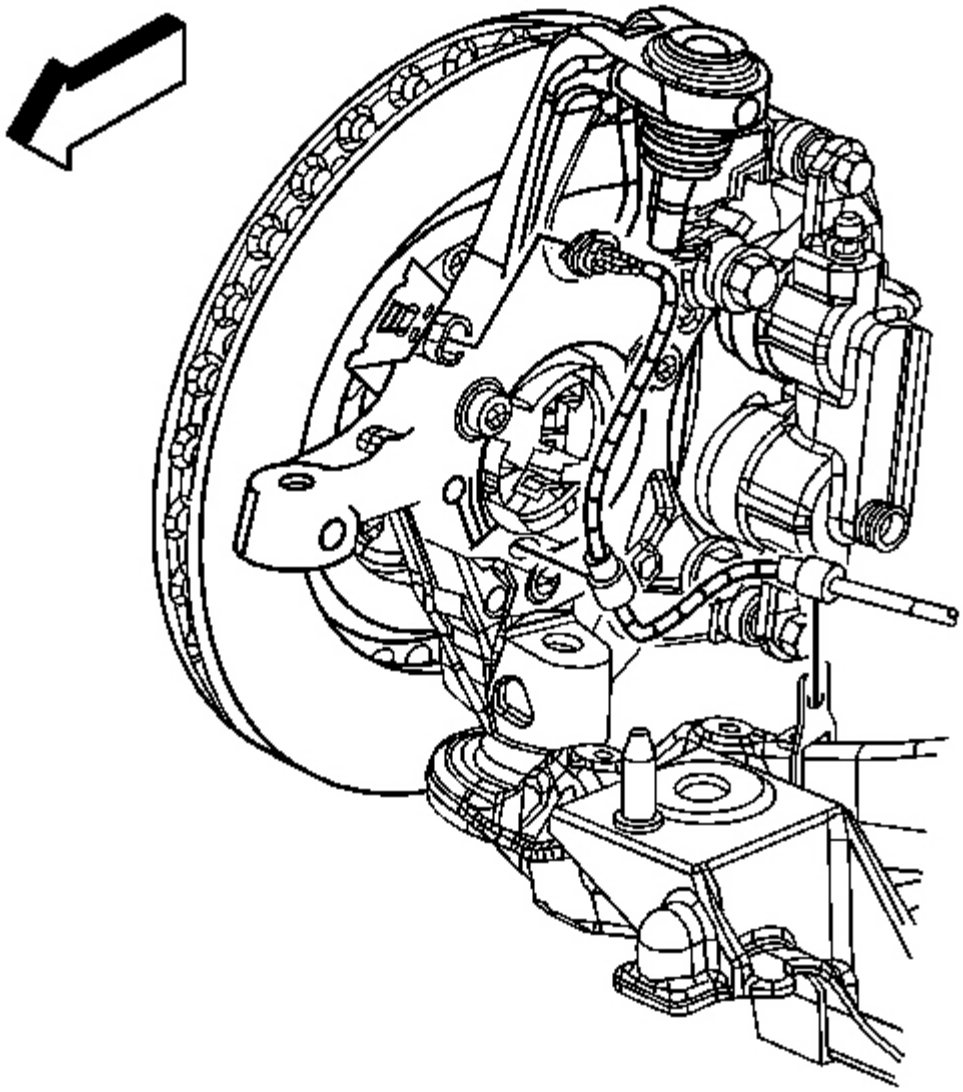


Fig. 186: View Of Wheel Speed Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

22. Connect the front wheel speed sensor electrical connector.
23. Repeat for the other side of the vehicle.
24. Install the master cylinder to the brake booster. Refer to **Master Cylinder Replacement** .
25. Install the intermediate steering shaft to the steering column. Refer to **Intermediate Steering Shaft Replacement** .

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26. Connect the vacuum brake booster hose to the brake booster.
27. Connect the heater hoses to the heater pipes. Refer to **Heater Pipes Replacement** .
28. Connect the A/C lines to the front of dash connections. Refer to **Compressor Hose Assembly Replacement** .

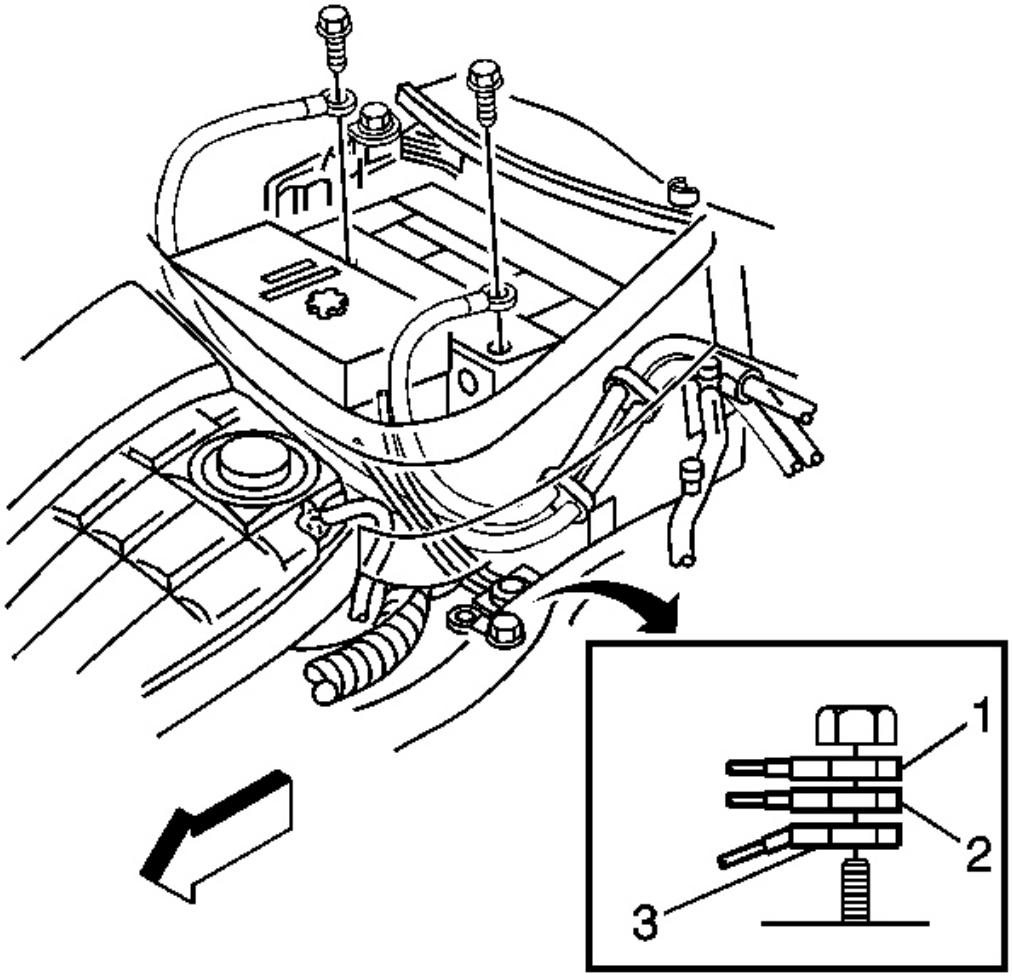


Fig. 187: View Of Ground Strap Nut, Terminal & Stud
Courtesy of GENERAL MOTORS CORP.

29. Attach the engine ground cables (1-3) to the right side body frame rail.

Tighten: Tighten to 8 N.m (71 lb in).

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30. Connect the following wiring harness electrical connectors:
    - The ECM-Refer to **Engine Control Module Replacement** .
    - C101 engine electrical harness-Refer to **Underhood Electrical Center or Junction Block Replacement** .
31. Install the right front wheelhouse panel. Refer to **Wheelhouse Liner Panel Replacement - Rear** .
32. Install the front wheels and tires. Refer to **Tire and Wheel Removal and Installation** .
33. Connect the UHJB to the wheelhouse.

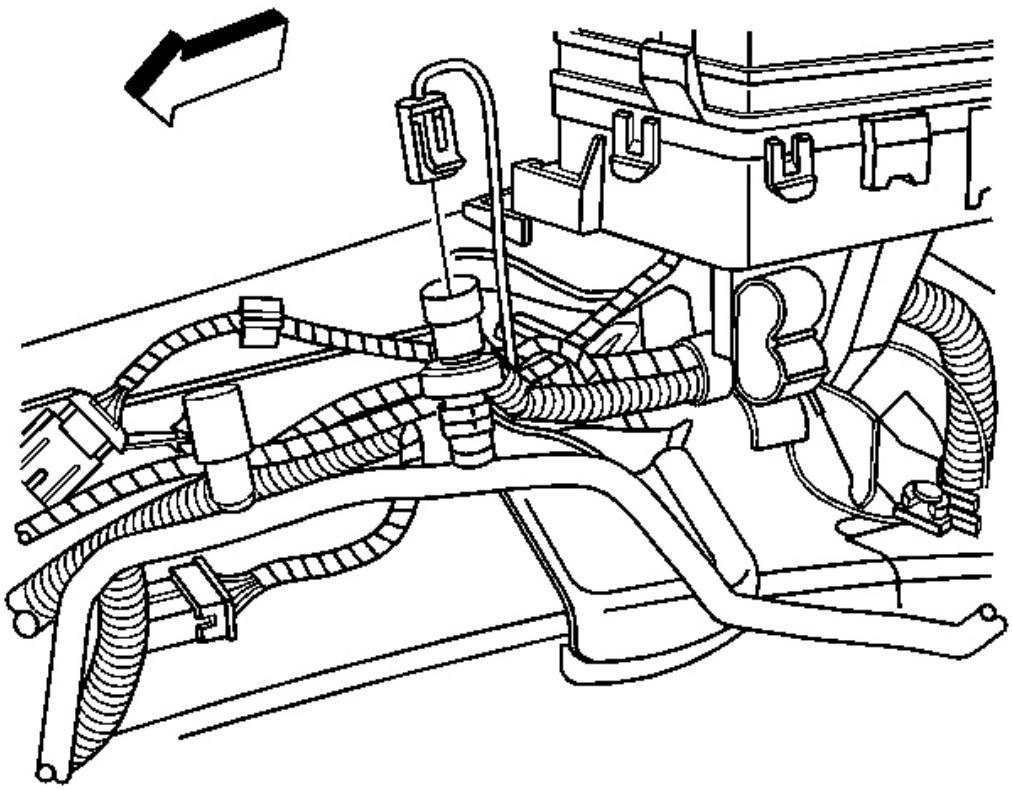


Fig. 188: View Of A/C Electrical Connector & Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

34. Connect the A/C electrical connector to the pressure sensor.
35. Install the battery tray. Refer to **Battery Tray Replacement** .
36. Install the battery. Refer to **Battery Replacement** .
37. Install the front portion of the supercharger front manifold. Refer to **Charge Air Cooler Front Manifold Replacement** .

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38. Install the air conditioning condenser. Refer to **Condenser Replacement** .
39. Install the radiator. Refer to **Radiator Replacement** .
40. Install the charge air cooler radiator. Refer to **Radiator Replacement - Charge Air Cooler** .
41. Install the surge tank. Refer to **Surge Tank Replacement** .
42. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
43. Connect the fuel inlet quick-connect fitting to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
44. Connect the EVAP emission canister purge pipe to the chassis purge pipe.
45. Install the engine sight shield. Refer to **Intake Manifold Sight Shield Replacement** .
46. Charge the air conditioning (A/C) refrigerant. Refer to **Refrigerant Recovery and Recharging** .
47. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection** .
48. Program the transmitters. Refer to **Transmitter Programming (Domestic and Japan)** or **Transmitter Programming (Export - Including Canada)** .
49. Fill the crankcase with the proper quantity and grade of engine oil. Refer to **Capacities - Approximate Fluid** and **Fluid and Lubricant Recommendations** .
50. Fill the engine cooling system. Refer to **Draining and Filling Cooling System (GE 47716)** or **Draining and Filling Cooling System (Static Fill)** .
51. Fill the charge air cooling system. Refer to **Draining and Filling Cooling System - Charge Air Cooling System (Static Fill)** .
52. Check the transmission fluid and add transmission fluid as necessary. Refer to **Transmission Fluid Checking** .
53. Reset the oil life monitoring system. Refer to **GM Oil Life System Resetting** .
54. Perform the engine pre-lubrication procedures. Refer to **Engine Prelubing** .
55. Start the engine.
56. Run the engine speed at about 1,000 RPM until the engine has reached normal operating temperature.
57. Inspect for fuel, oil, and/or coolant leaks while the engine is running.
58. Perform a final inspection for the proper engine oil and coolant levels.

ENGINE OIL AND OIL FILTER REPLACEMENT

REMOVAL PROCEDURE

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

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

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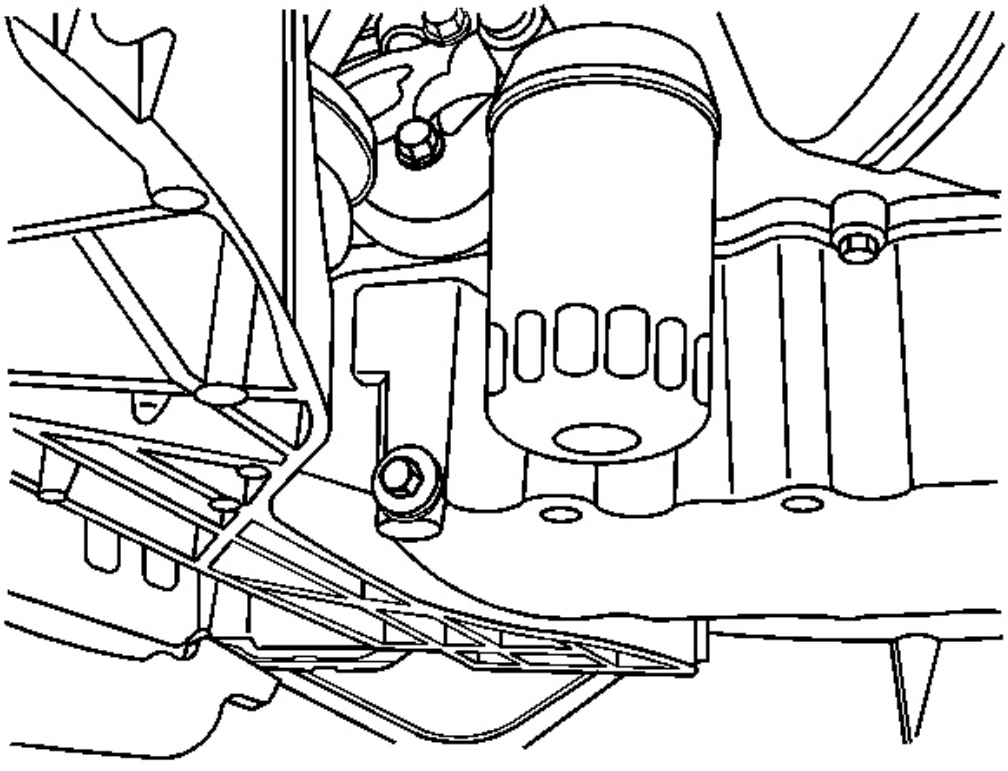


Fig. 189: Draining Engine Oil
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil drain plug.
4. Clean and inspect the engine oil drain plug, replace if necessary.
5. Clean and inspect the engine oil drain plug sealing surface on the oil pan, repair or replace oil pan if necessary.

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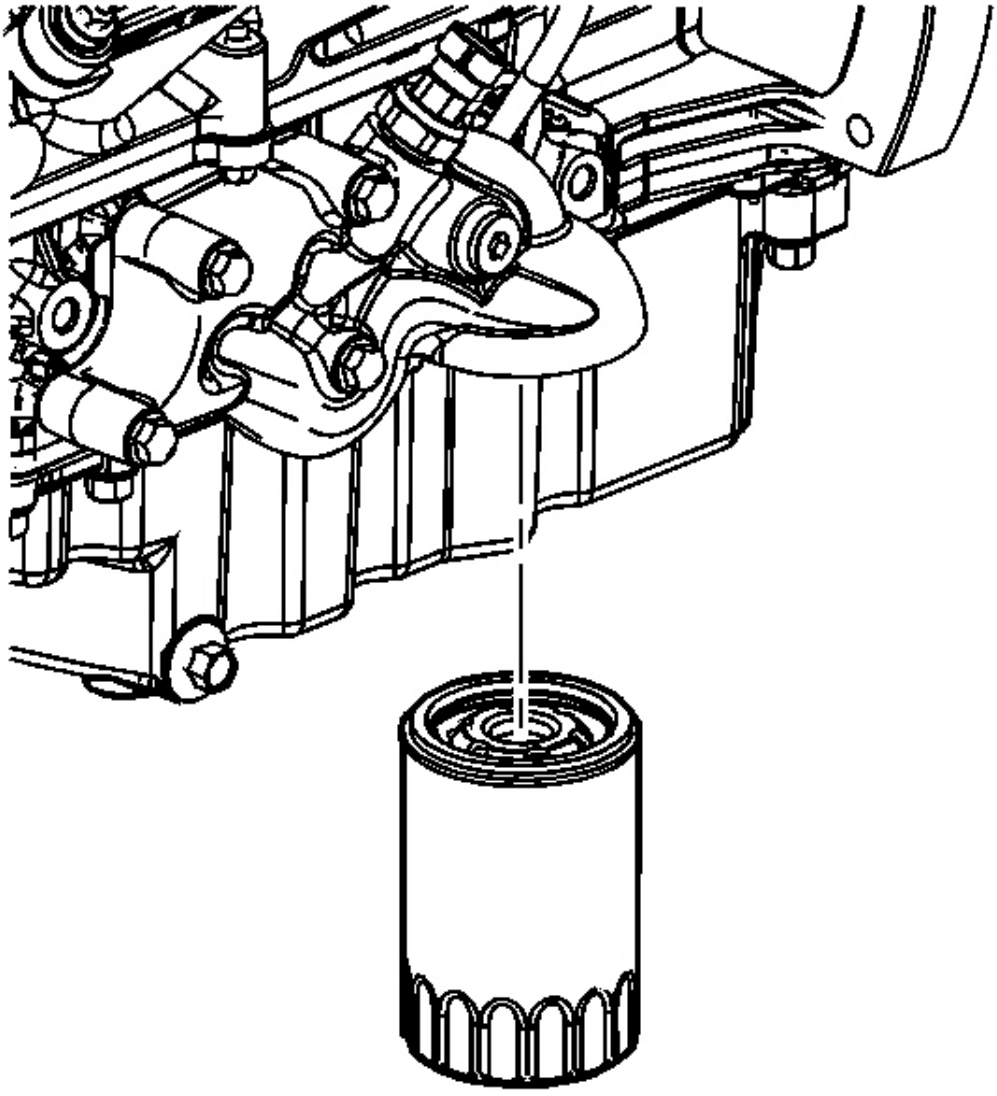


Fig. 190: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil filter.
7. Clean and inspect the oil filter sealing area on the oil filter adapter, repair or replace if necessary.

INSTALLATION PROCEDURE

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

1. Fill the oil filter with oil.
2. Lightly oil the replacement oil filter gasket with clean oil.

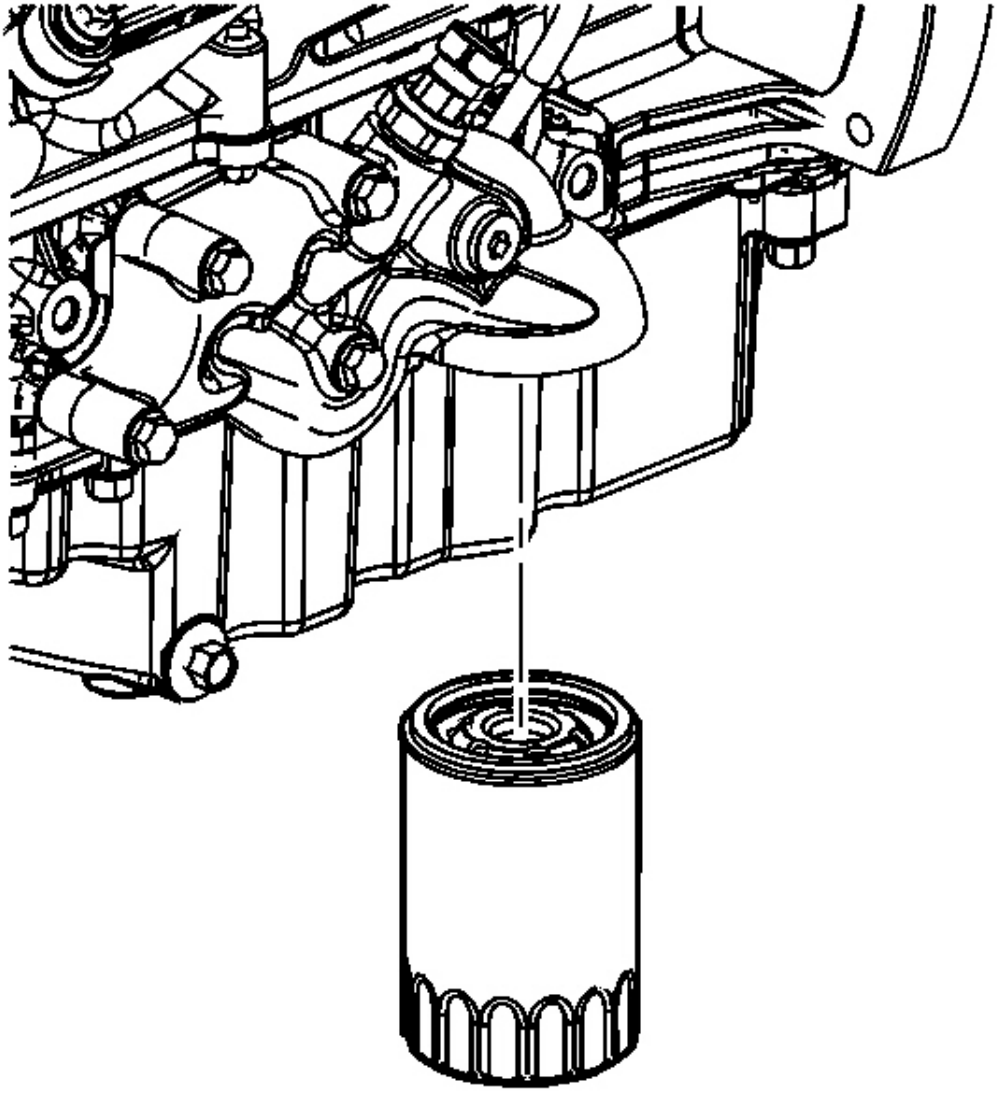


Fig. 191: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

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NOTE: **Refer to Fastener Notice .**

3. Install the new oil filter.

   Tighten: Tighten the engine oil filter to 32 N.m (24 lb ft).

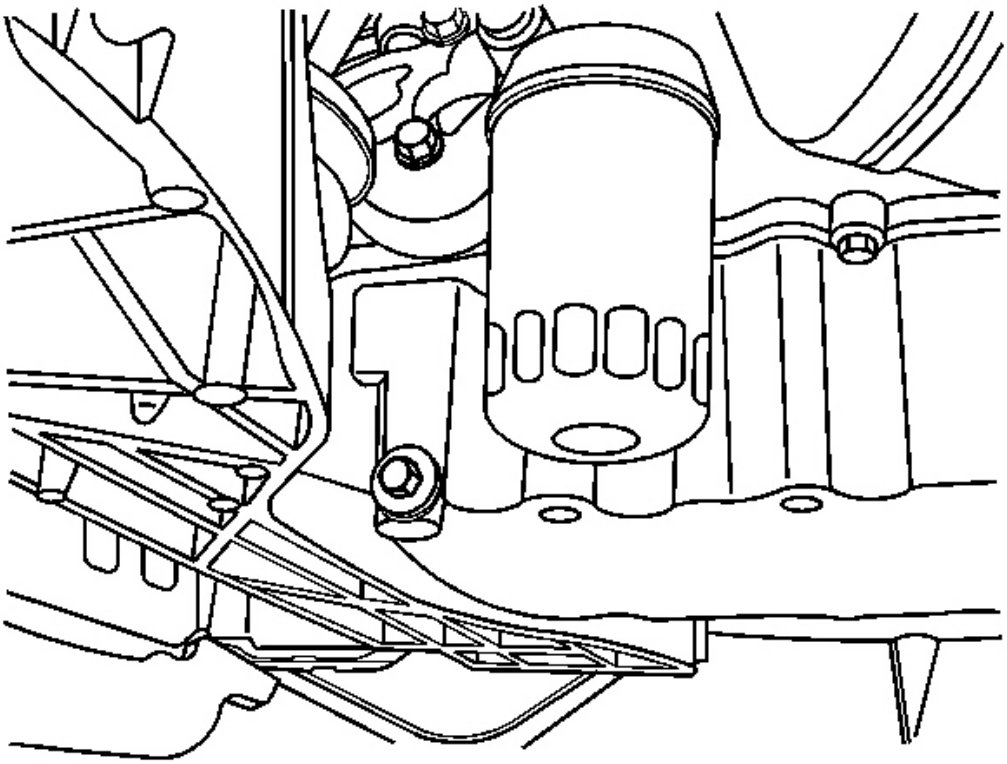


Fig. 192: Draining Engine Oil
Courtesy of GENERAL MOTORS CORP.

4. Install the engine oil drain plug.

   Tighten: Tighten the engine oil drain plug to 20 N.m (15 lb ft).

5. Lower the vehicle.
6. Fill the engine with new engine oil. Refer to **Capacities - Approximate Fluid** and **Fluid and Lubricant Recommendations** .
7. Inspect for oil leaks after engine start up.

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SUPERCHARGER INLET DUCT REMOVAL

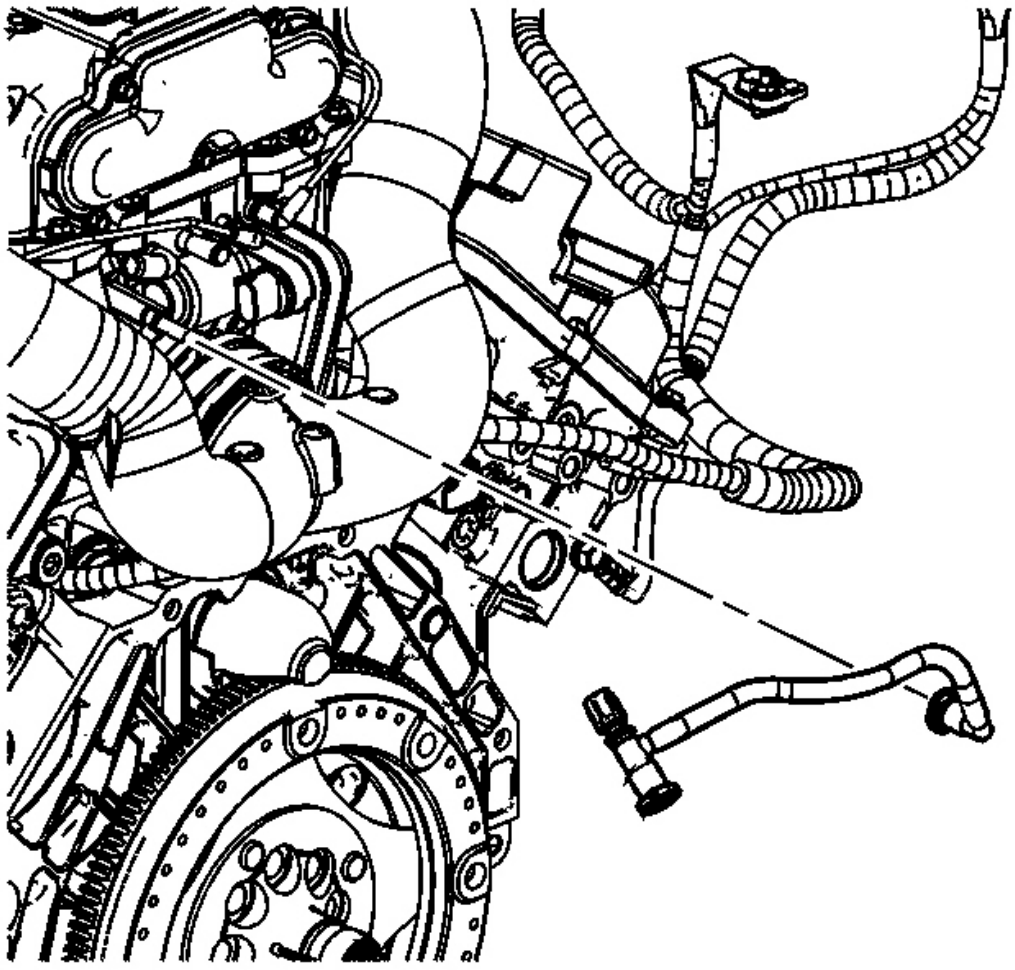


Fig. 193: Identifying EVAP Hose
Courtesy of GENERAL MOTORS CORP.

1. Disconnect and remove the evaporative emissions (EVAP) hose.

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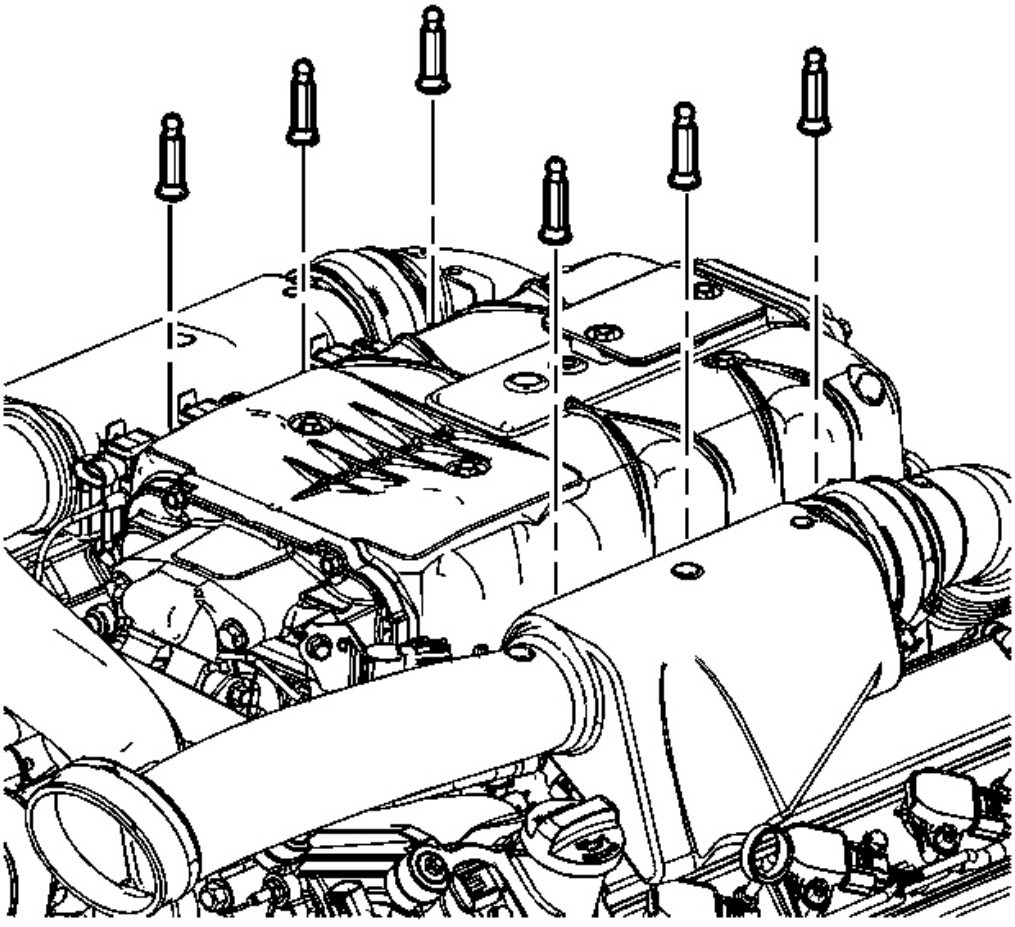


Fig. 194: Identifying Supercharger Inlet Duct Ball Stud
Courtesy of GENERAL MOTORS CORP.

2. Remove the supercharger inlet duct ballstud nuts.

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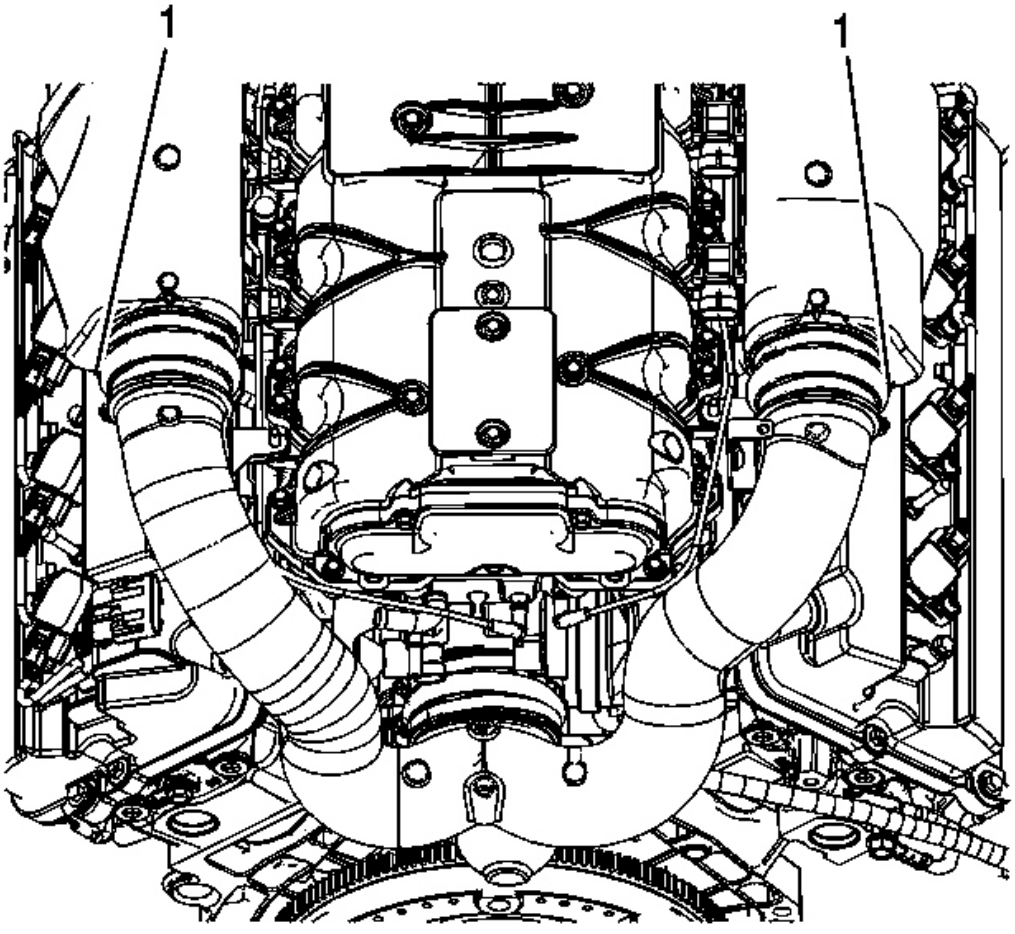


Fig. 195: Identifying Inlet Duct Seals
Courtesy of GENERAL MOTORS CORP.

3. Loosen the front screw clamps (1) on the inlet duct seals.

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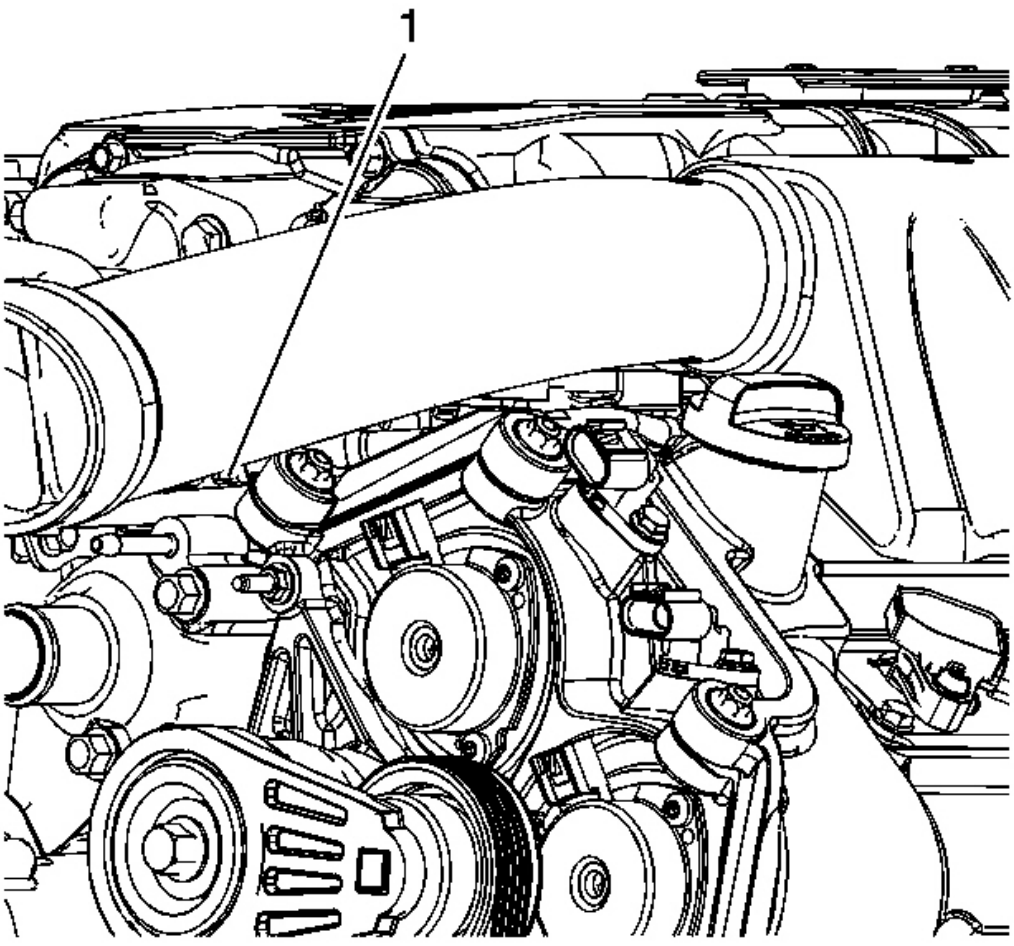


Fig. 196: Identifying PCV Hose
Courtesy of GENERAL MOTORS CORP.

4. Lift the front of the front air duct in order to access the clean air positive crankcase ventilation (PCV) hose connector at the bottom of the front air duct.
5. Disconnect the clean air PCV hose (1) from the front air duct.

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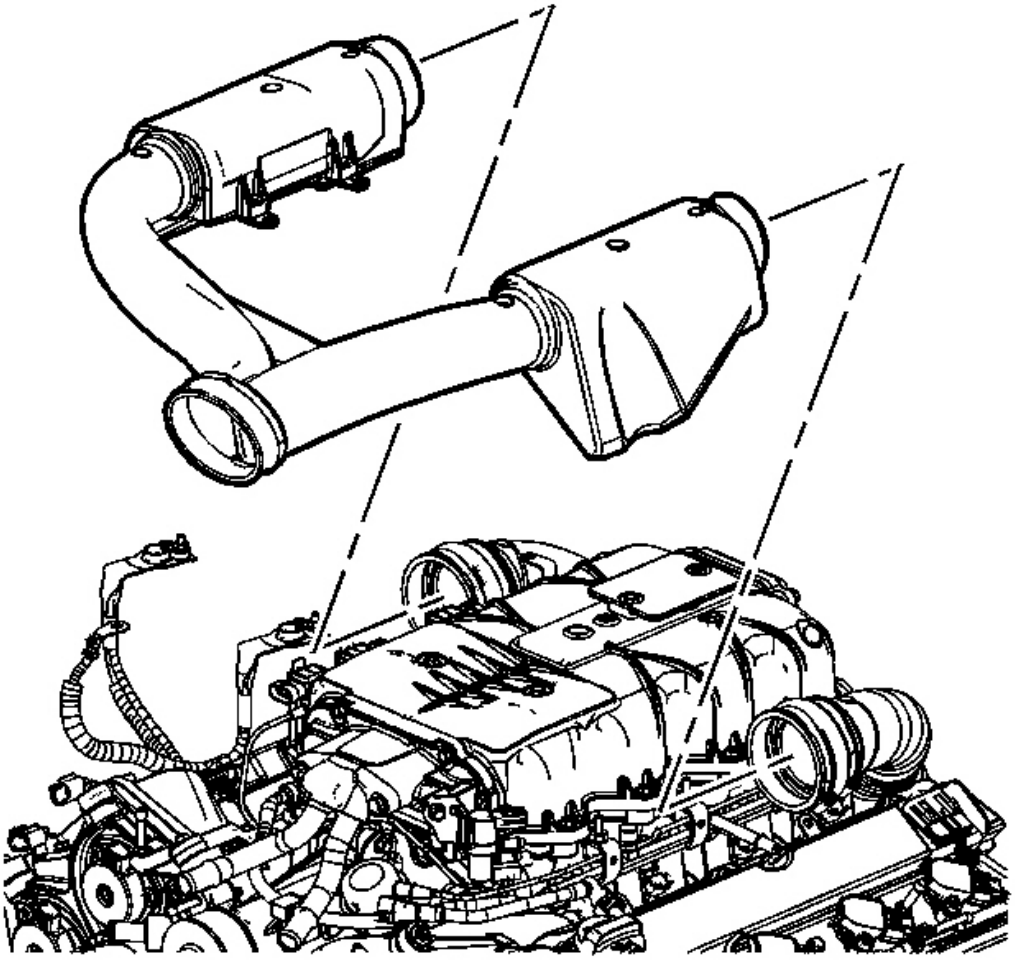


Fig. 197: View Of Front Air Duct
Courtesy of GENERAL MOTORS CORP.

6. Remove the front air duct.

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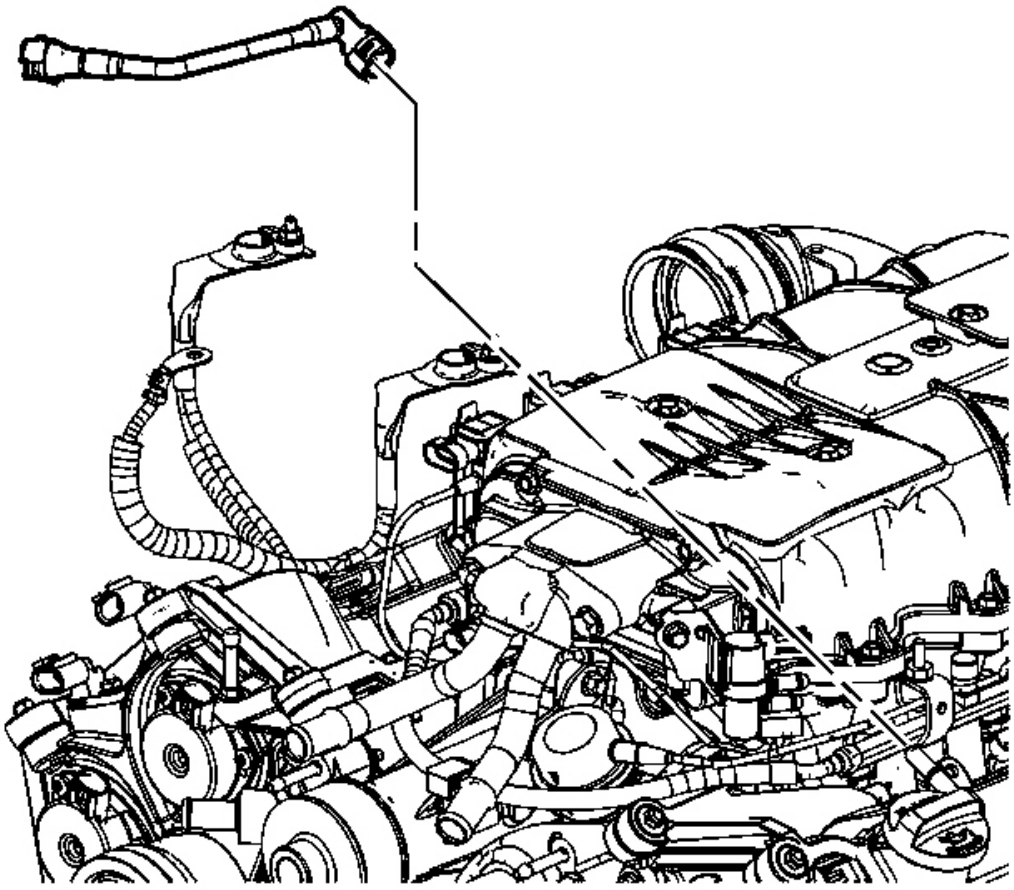


Fig. 198: Identifying Clean Air PCV Hose
Courtesy of GENERAL MOTORS CORP.

7. Disconnect and remove the clean air PCV hose from the left camshaft cover fitting.

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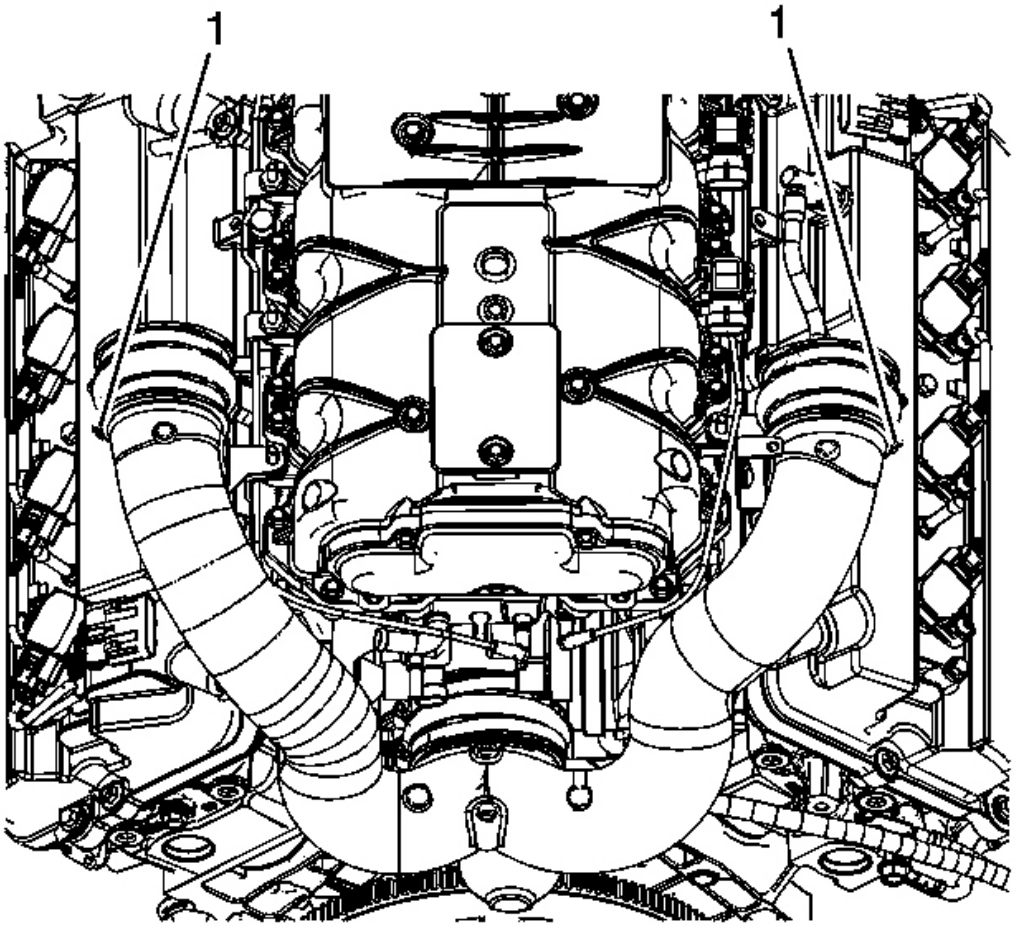


Fig. 199: Identifying Rear Screw Clamps
Courtesy of GENERAL MOTORS CORP.

8. Loosen the rear screw clamps (1) on the inlet duct seals.

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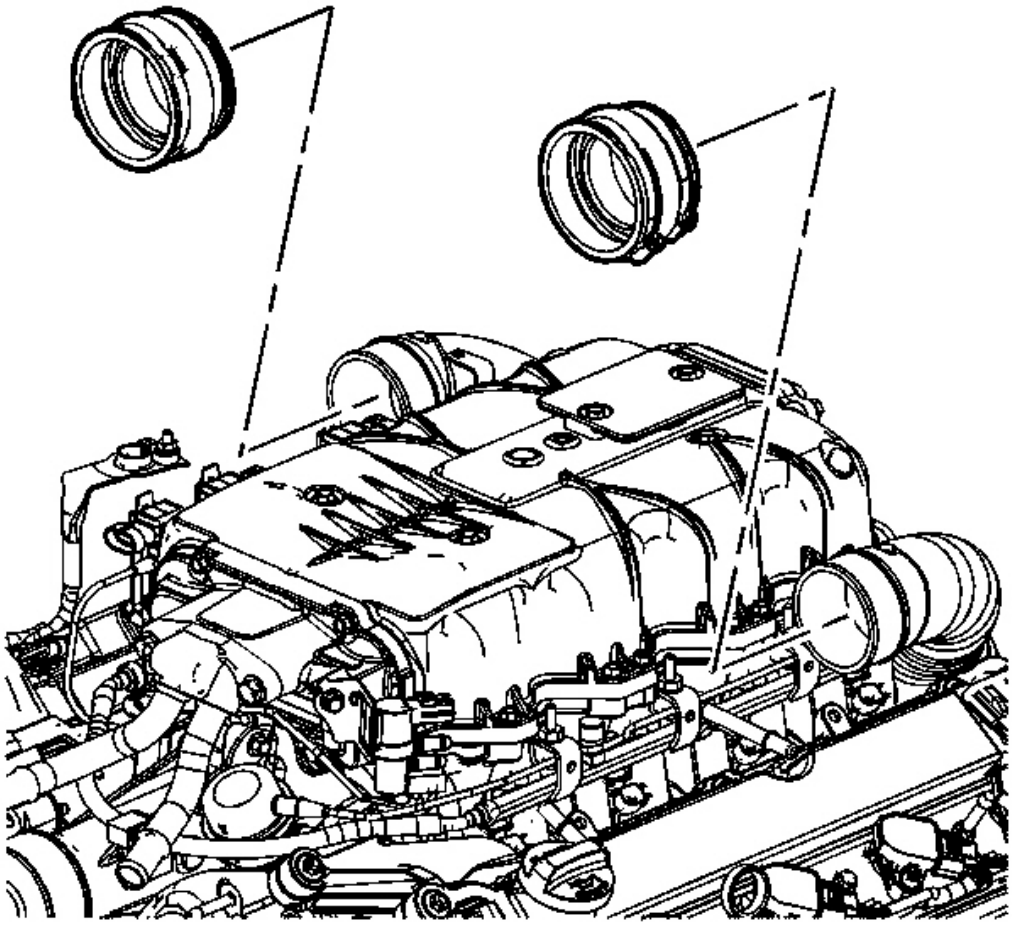


Fig. 200: Identifying Inlet Duct Seals
Courtesy of GENERAL MOTORS CORP.

9. Remove the inlet duct seals.

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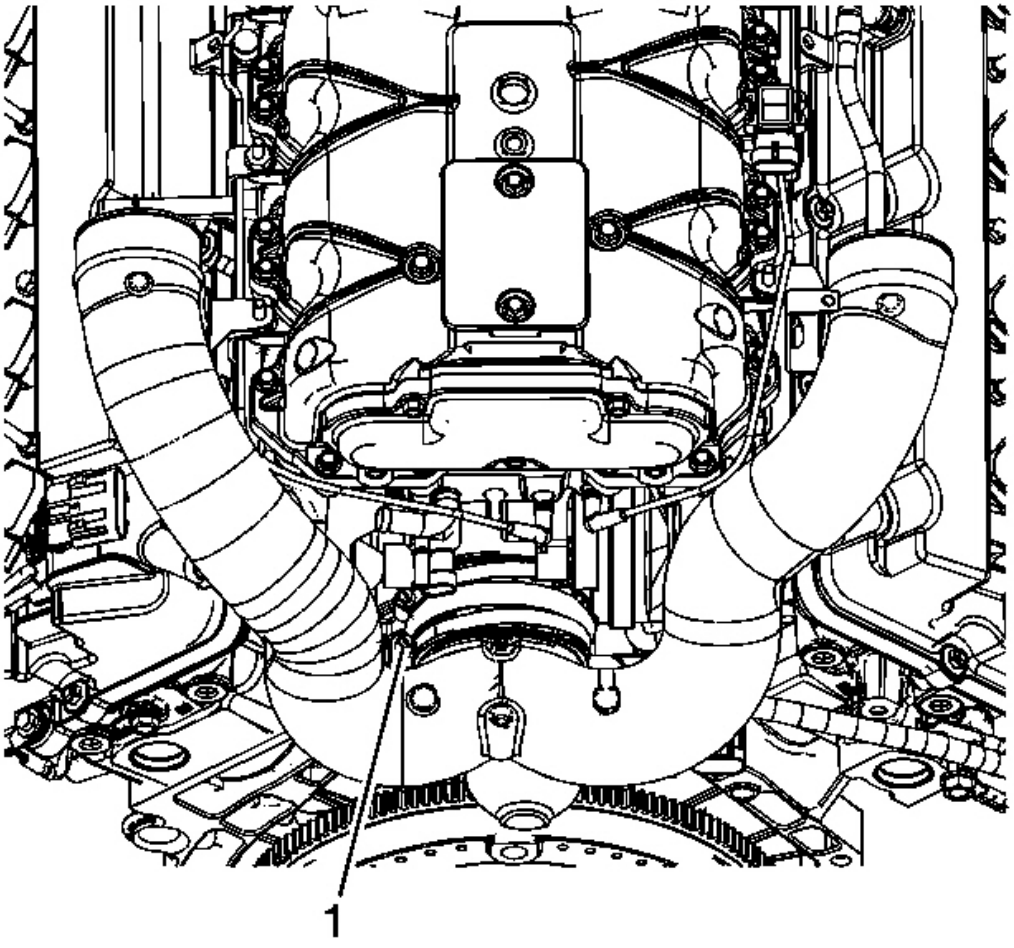


Fig. 201: Identifying Throttle Body Duct Seal
Courtesy of GENERAL MOTORS CORP.

10. Loosen the rear screw clamp (1) on the throttle body duct seal.

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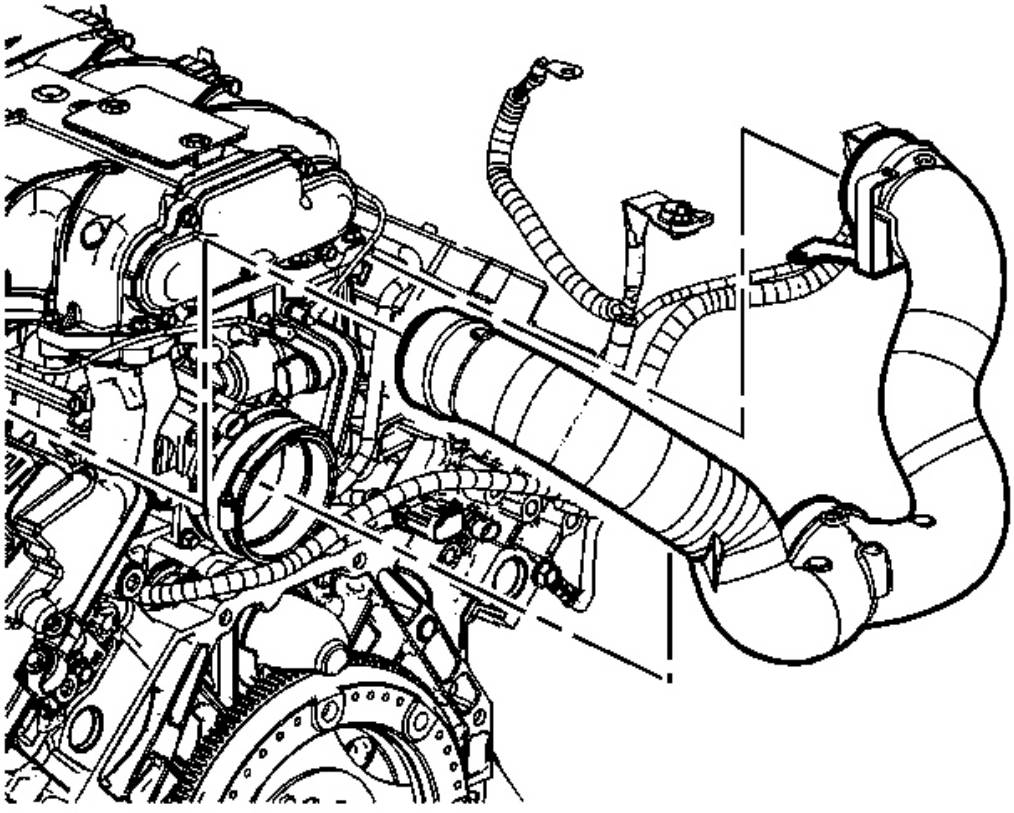


Fig. 202: View Of Rear Air Duct
Courtesy of GENERAL MOTORS CORP.

11. Remove the rear air duct.

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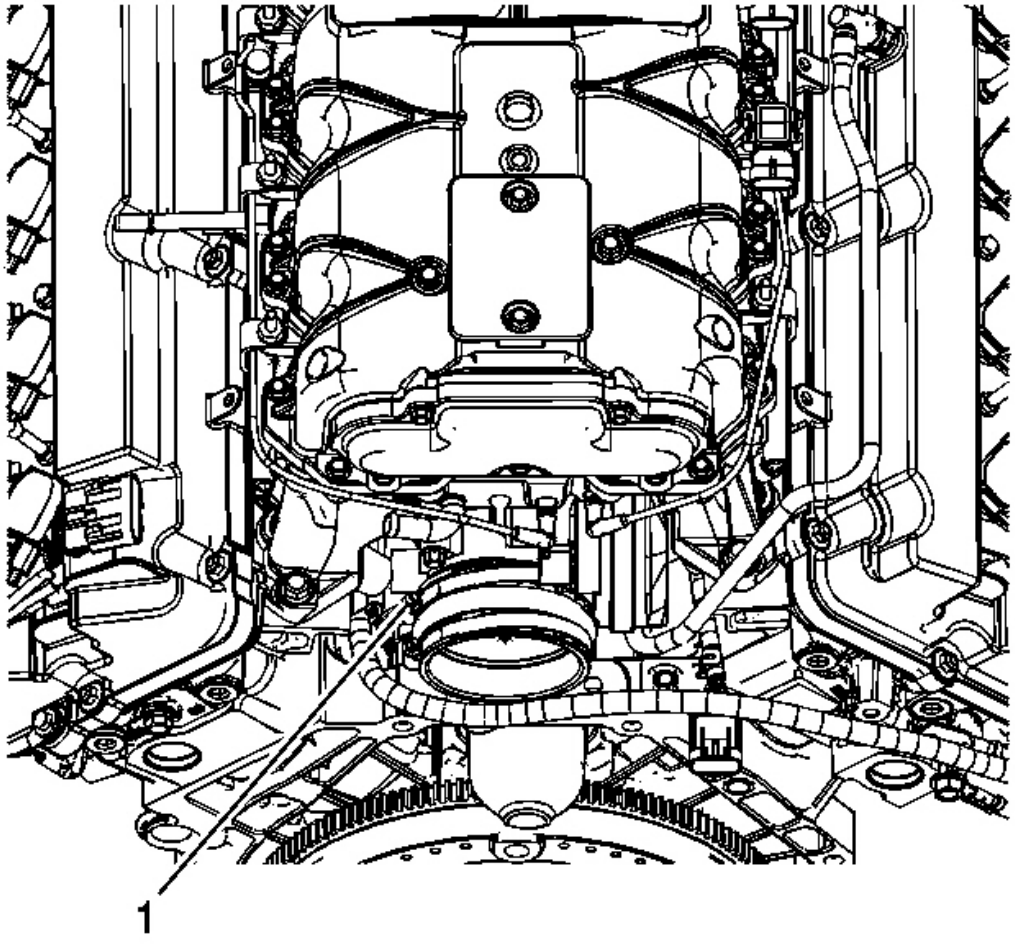


Fig. 203: Identifying Throttle Body Duct Seal
Courtesy of GENERAL MOTORS CORP.

12. Loosen the front screw clamp (1) on the throttle body duct seal.

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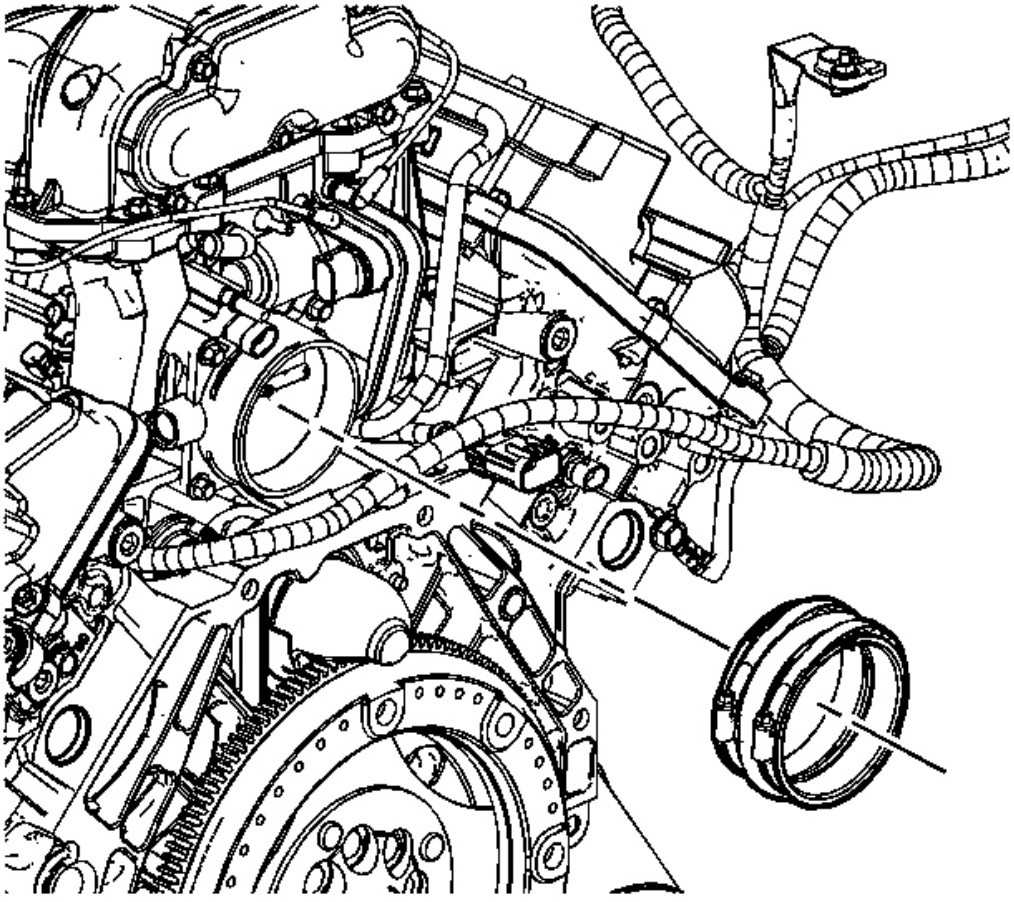


Fig. 204: View Of Throttle Body Duct Seal
Courtesy of GENERAL MOTORS CORP.

13. Remove the throttle body duct seal.

ENGINE WIRING HARNESS ASSEMBLY REMOVAL

LEFT SIDE HARNESS CONNECTIONS

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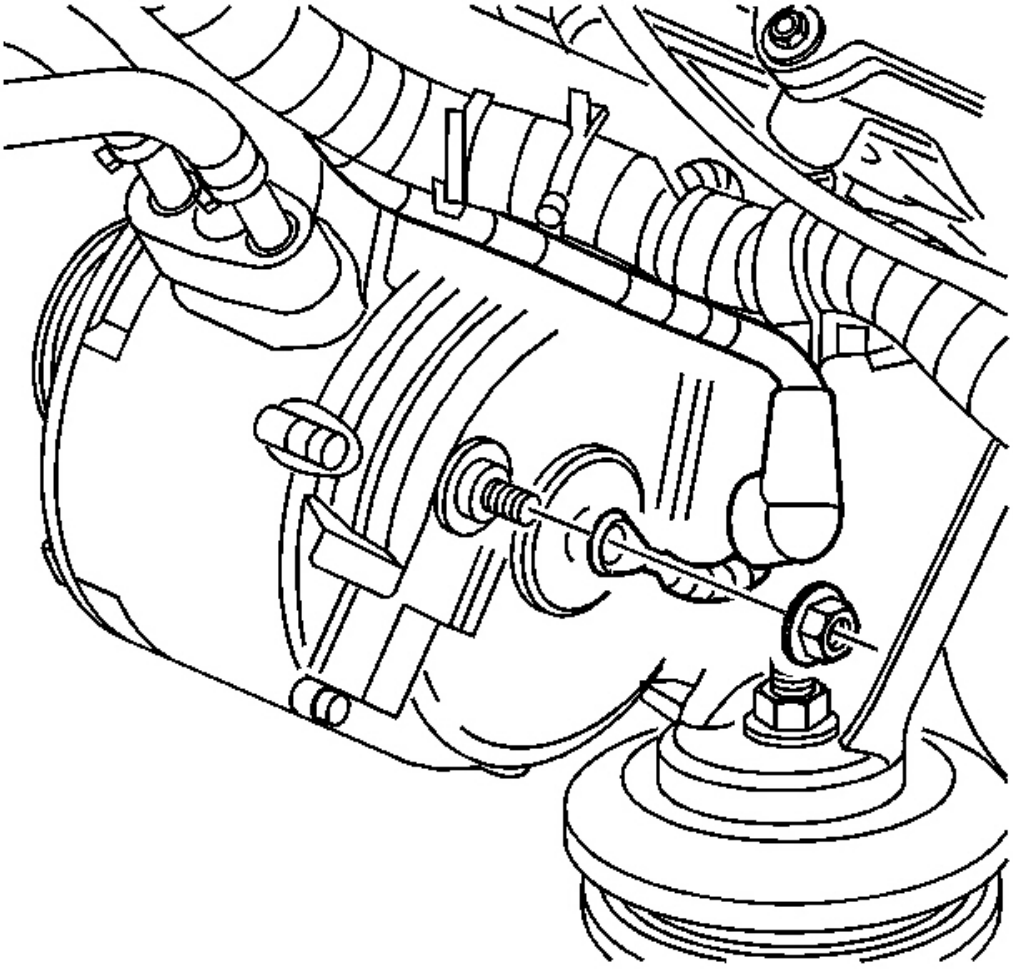


Fig. 205: View Of Starter Motor Wiring Harness, Generator Stud & Nut
Courtesy of GENERAL MOTORS CORP.

1. Remove the nut attaching the starter motor wiring harness to the generator stud.
2. Disconnect the starter motor wiring harness from the generator stud.

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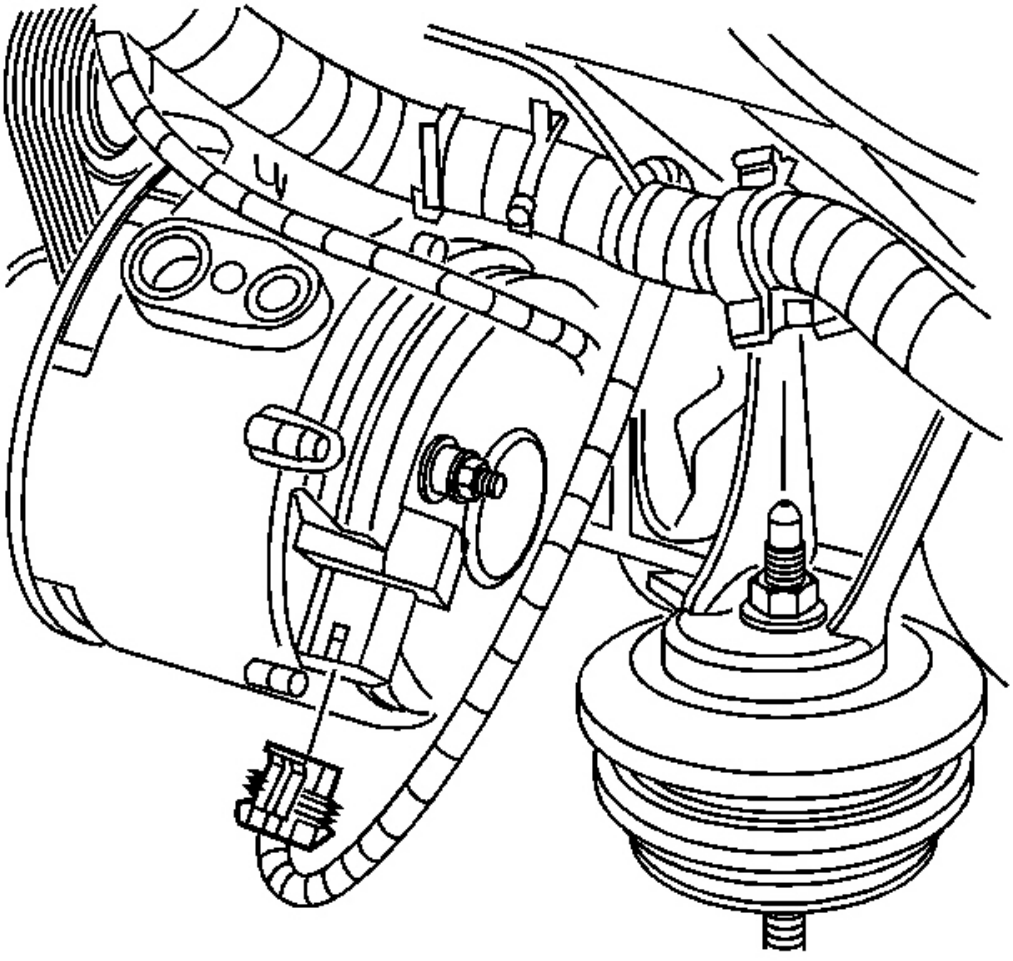


Fig. 206: View Of Engine Wiring Harness & Generator
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the engine wiring harness from the generator.

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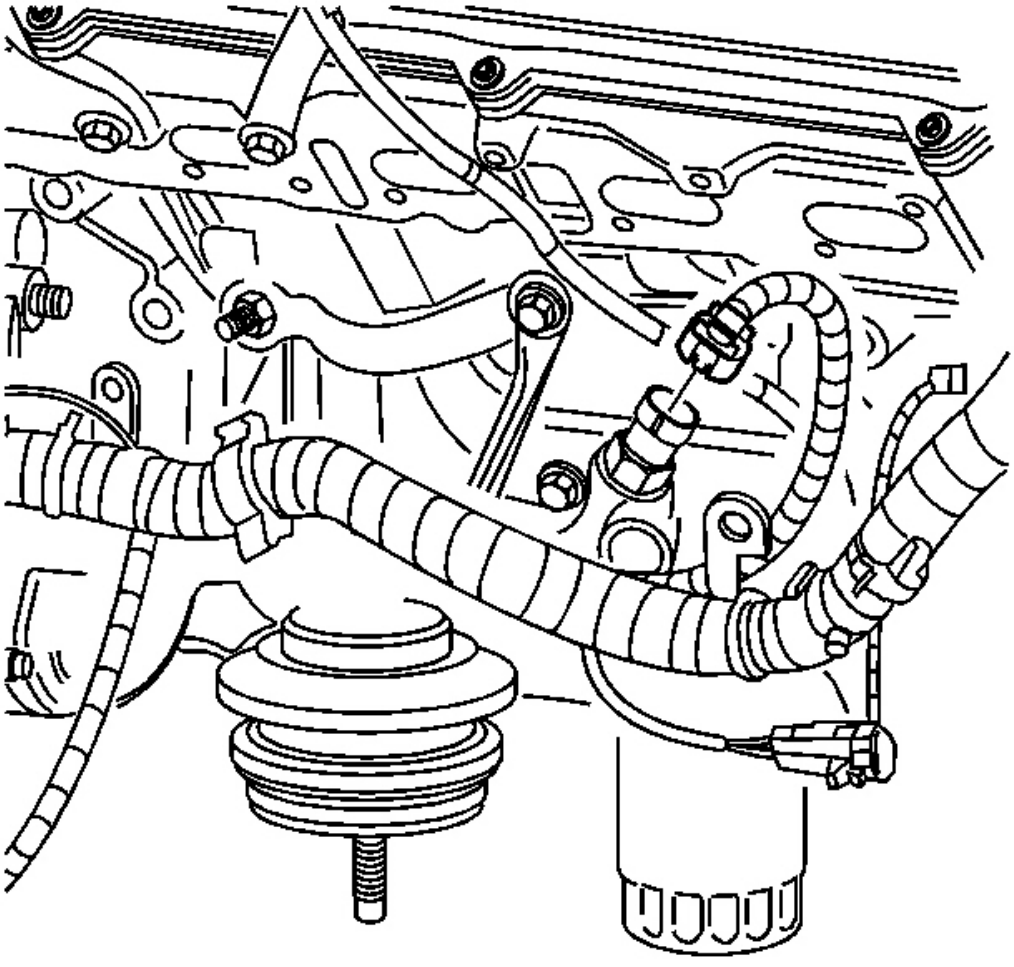


Fig. 207: View Of Engine Wiring Harness & Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the engine wiring harness from the oil pressure sensor.

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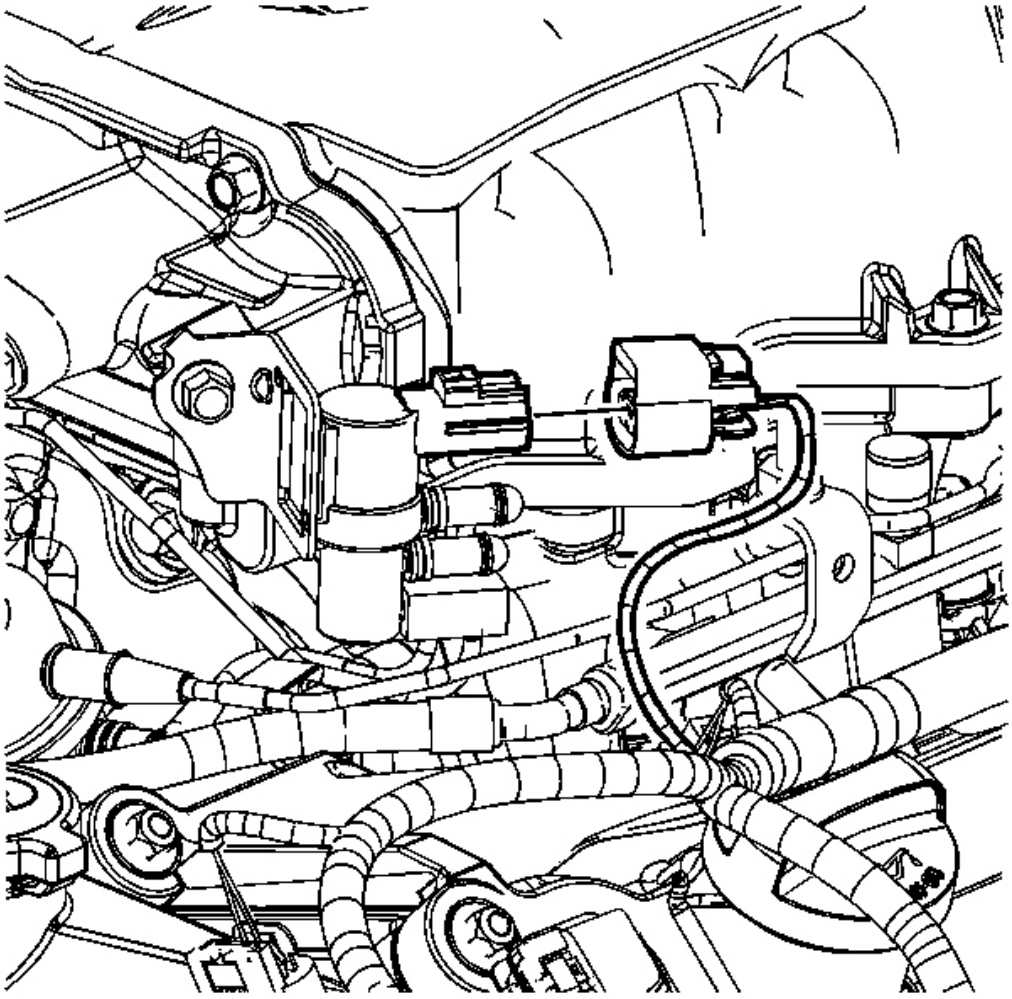


Fig. 208: Identifying Supercharger Charge Air Bypass Regulator Solenoid Valve Harness
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the engine wiring harness from the supercharger charge air bypass regulator solenoid valve.

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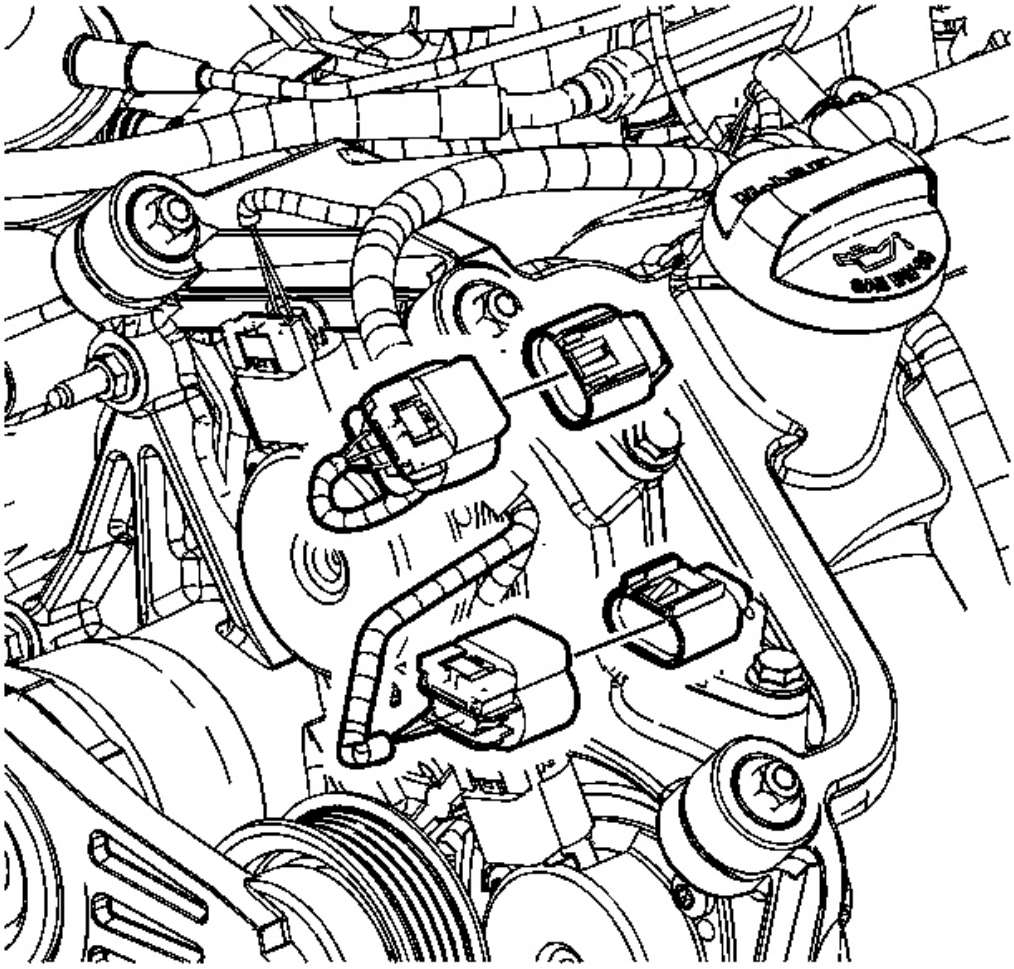


Fig. 209: Identifying Left Camshaft Position Sensor Harness
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the engine wiring harness from the left camshaft position sensors.

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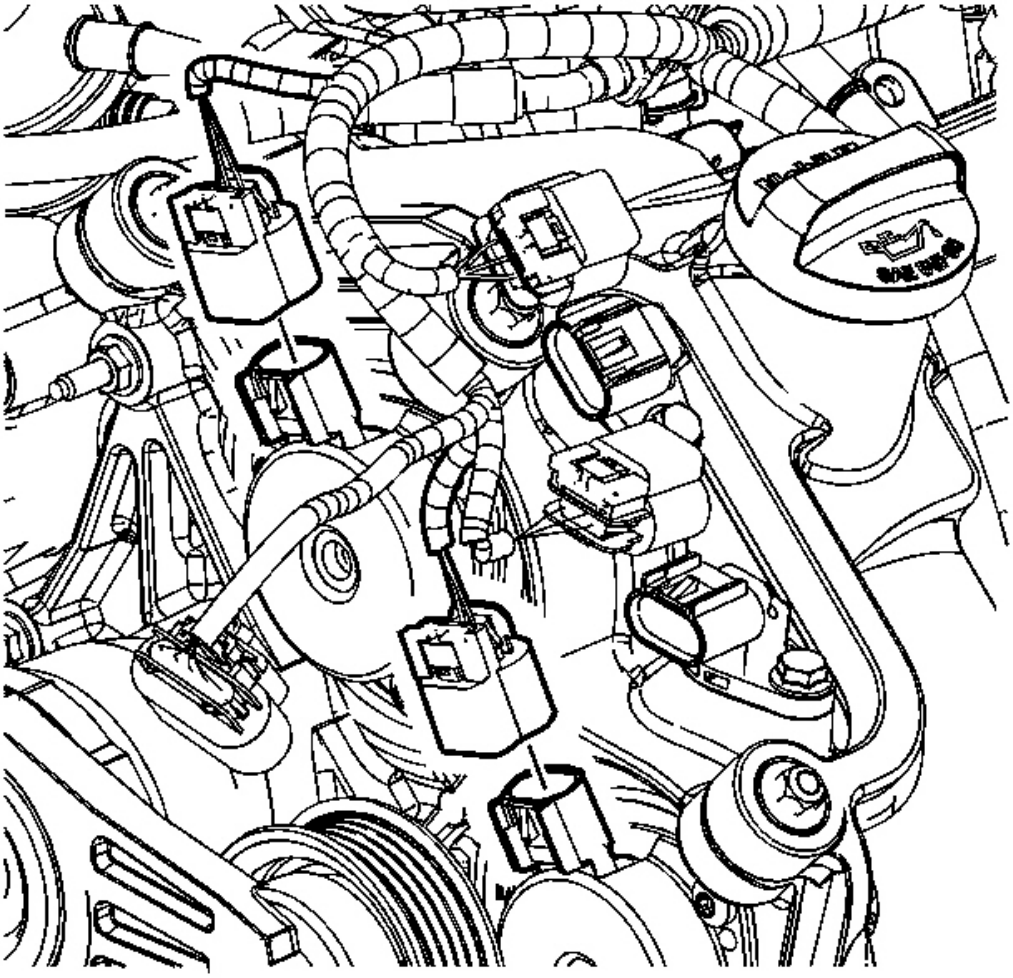


Fig. 210: Identifying Left Camshaft Position Actuator Harness
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the engine wiring harness from the left camshaft position actuators.

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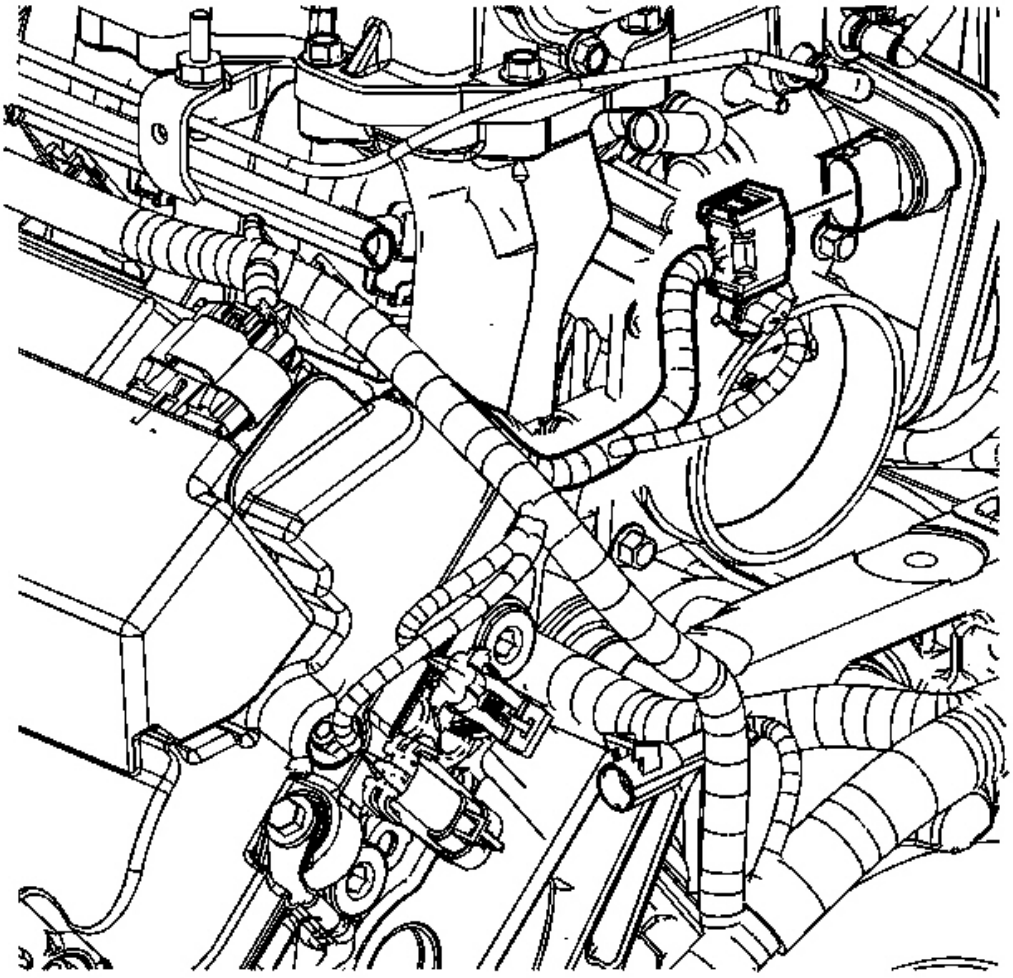


Fig. 211: Identifying Throttle Body Harness
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the engine wiring harness from the throttle body.

Automotive-Manual.net

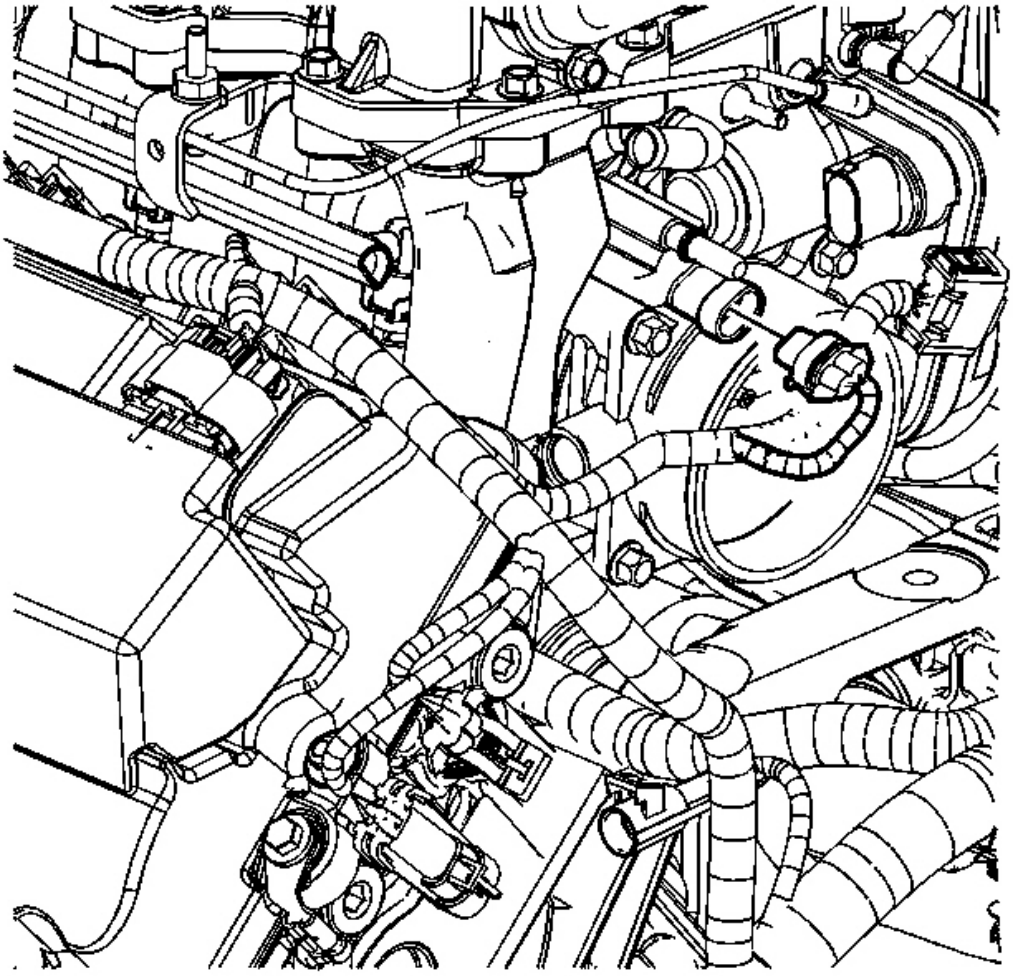


Fig. 212: Identifying EVAP Canister Purge Solenoid Harness
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the engine wiring harness from the evaporative emissions (EVAP) canister purge solenoid.

Automotive-Manual.net

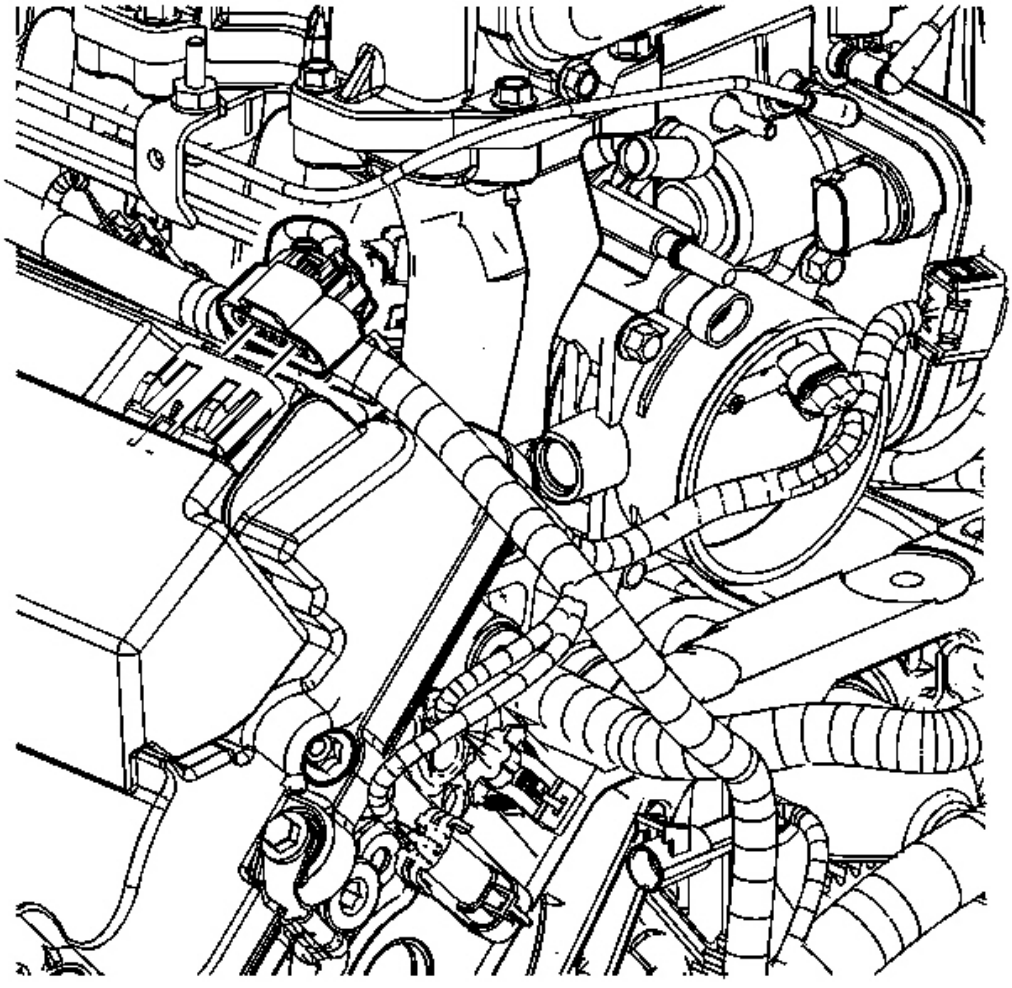


Fig. 213: Identifying Left Coil Assembly Harness
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the engine wiring harness from the left coil assembly harness.

Automotive-Manual.net

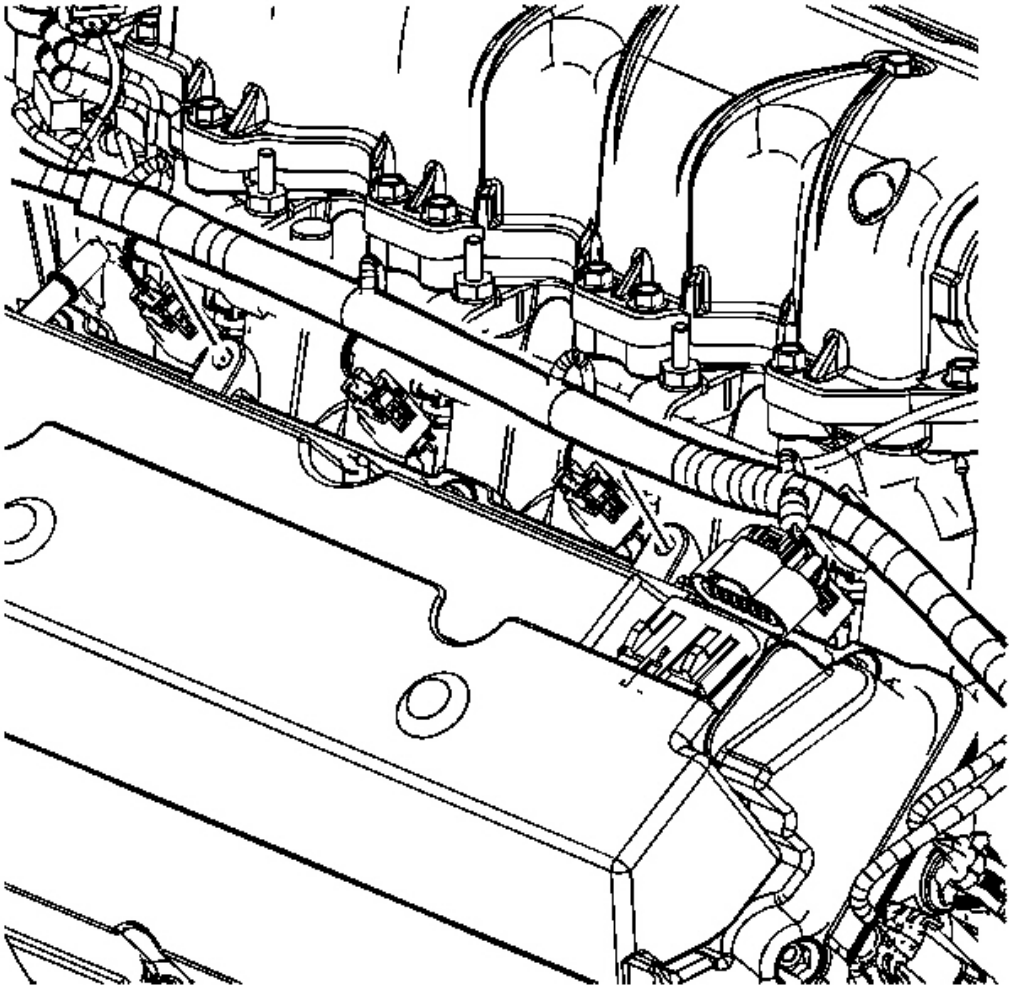


Fig. 214: Identifying Engine Wiring Harness & Left Side Fuel Injectors
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the engine wiring harness from the left camshaft cover.

Automotive-Manual.net

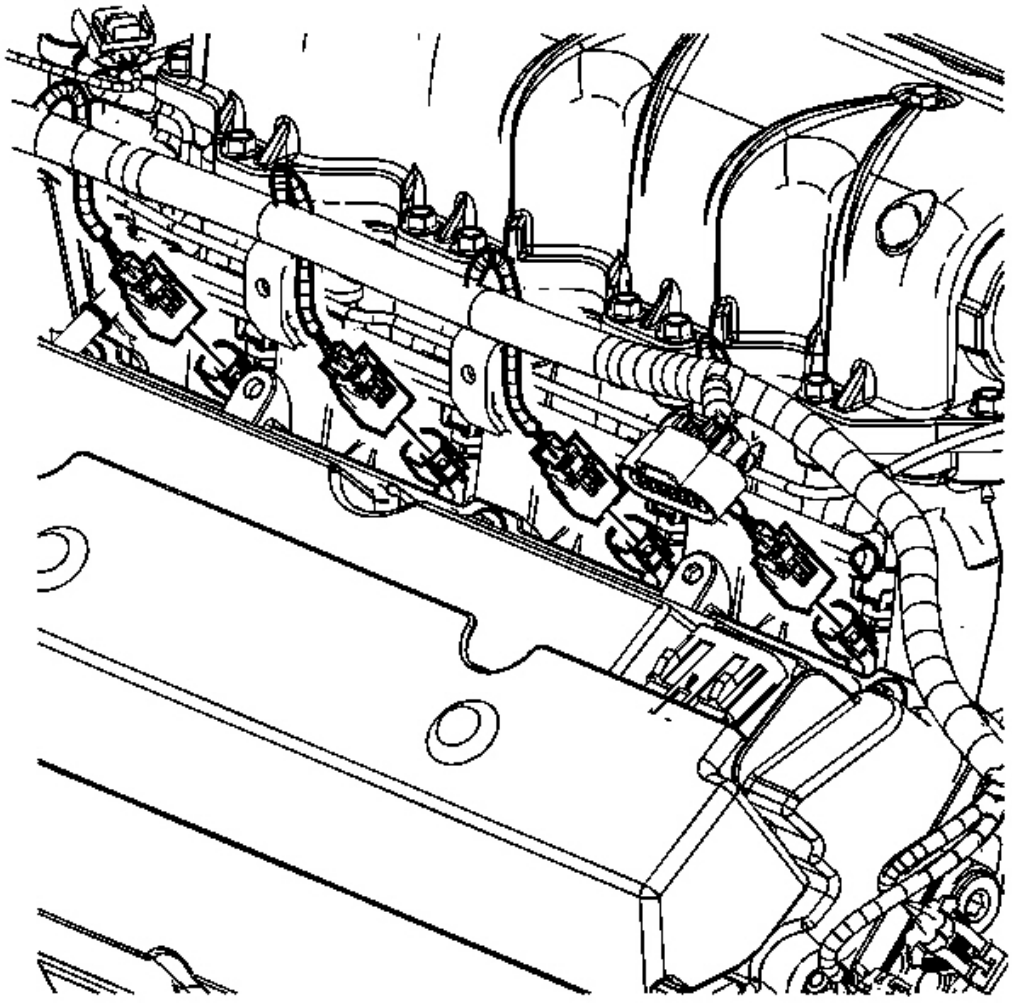


Fig. 215: View Of Engine Wiring Harness
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the engine wiring harness from the left side fuel injectors.

Automotive-Manual.net

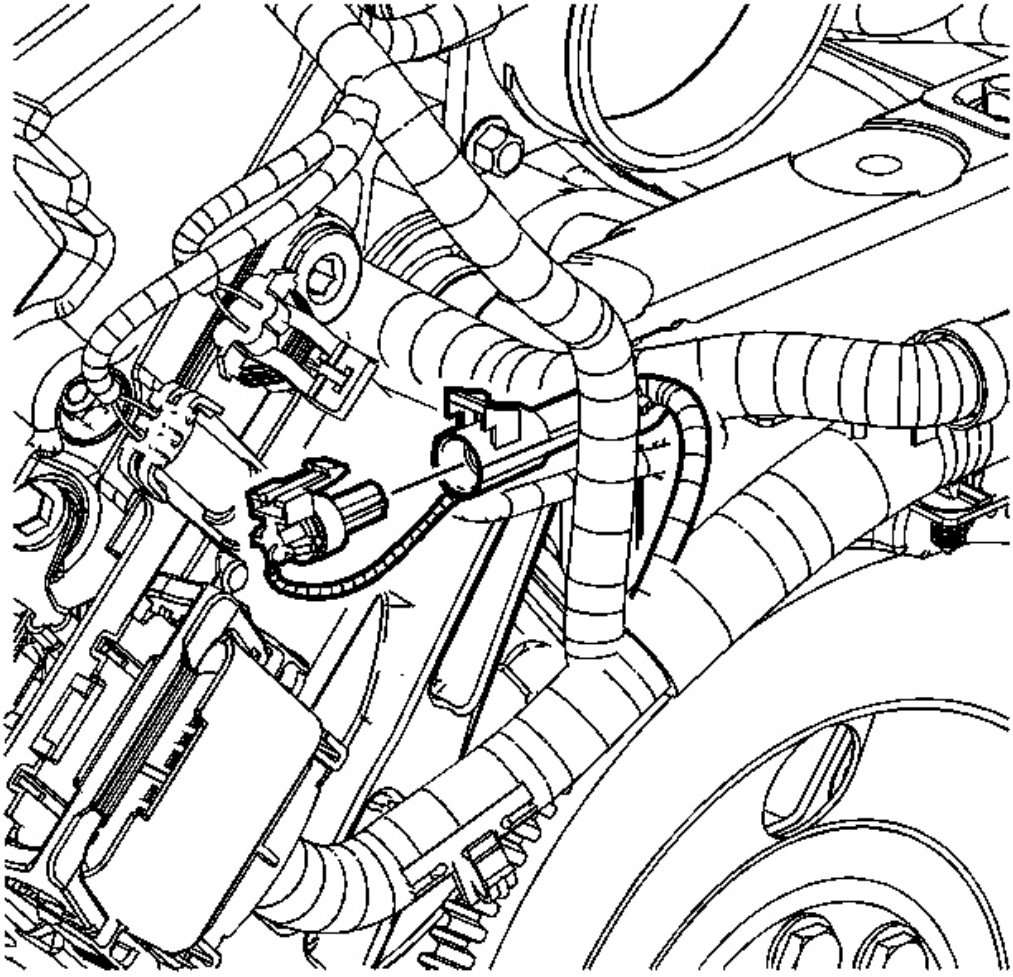


Fig. 216: Identifying Starter Wiring Harness
Courtesy of GENERAL MOTORS CORP.

13. Disconnect the engine wiring harness starter connector from the starter wiring harness.

RIGHT SIDE HARNESS CONNECTIONS

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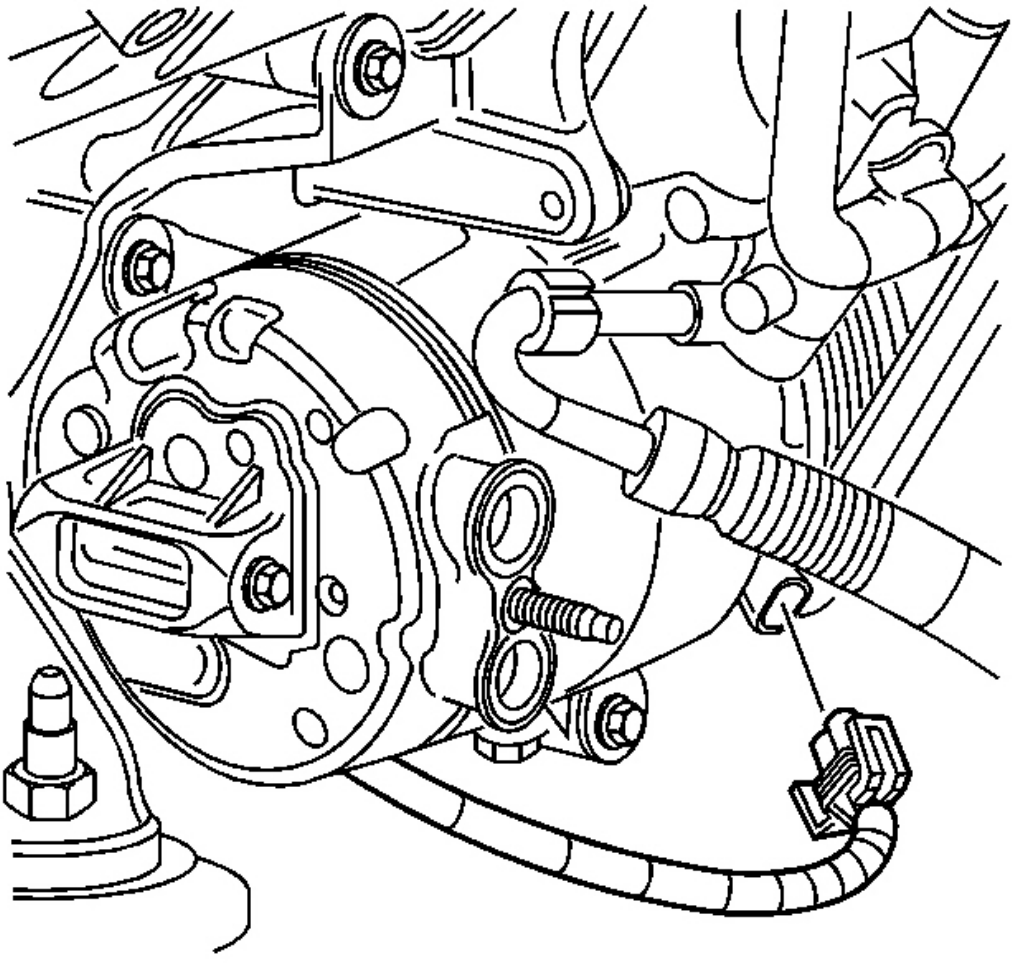


Fig. 217: View Of Engine Wiring Harness & Air Conditioning Compressor
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the engine wiring harness from the air conditioning compressor.

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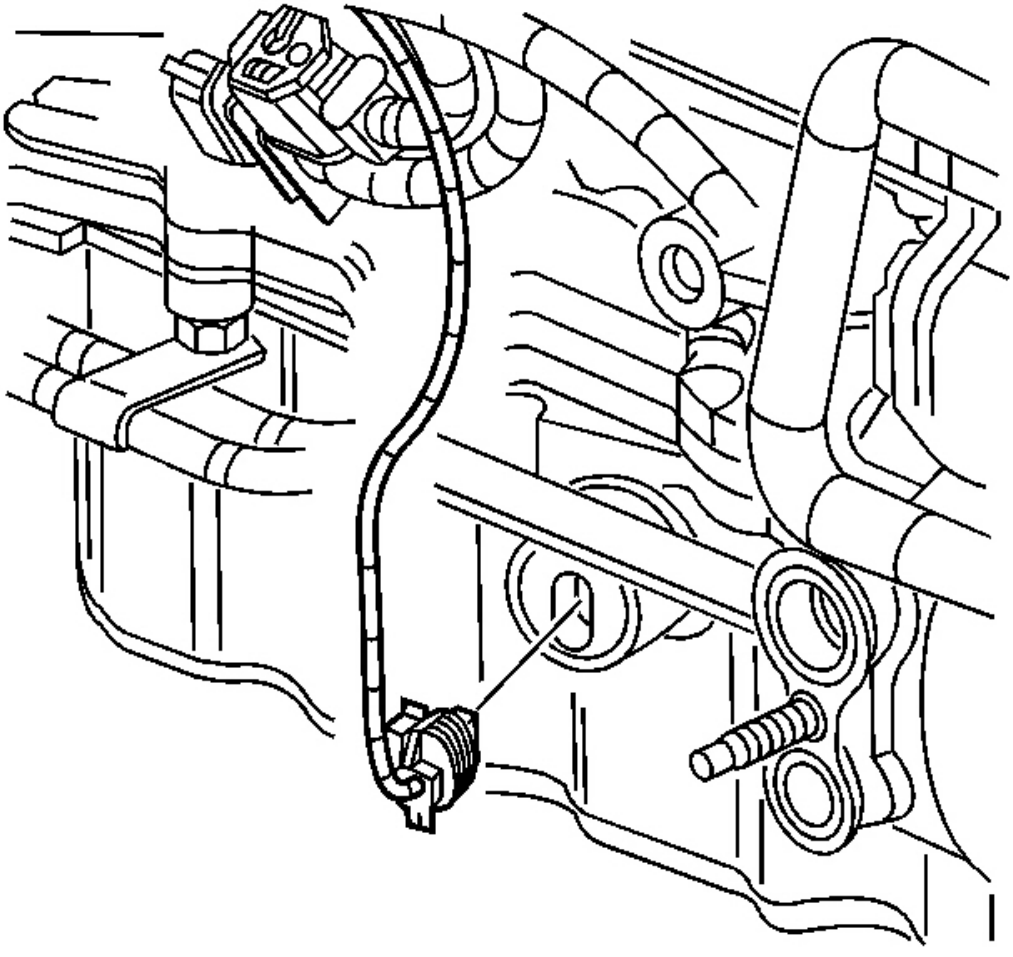


Fig. 218: View Of Engine Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the engine wiring harness from the oil level switch/temperature sensor.

Automotive-Manual.net

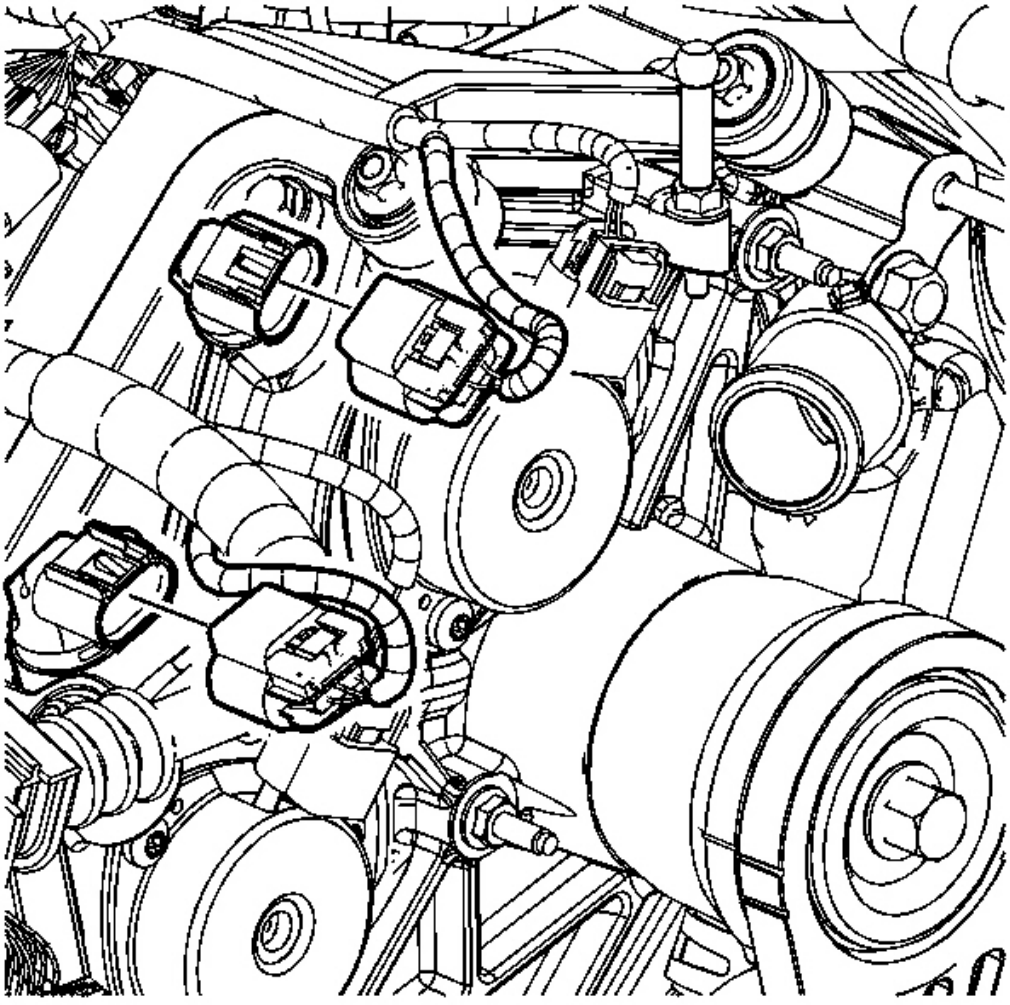


Fig. 219: Identifying Right Camshaft Position Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the engine wiring harness from the right camshaft position sensors.

Automotive-Manual.net

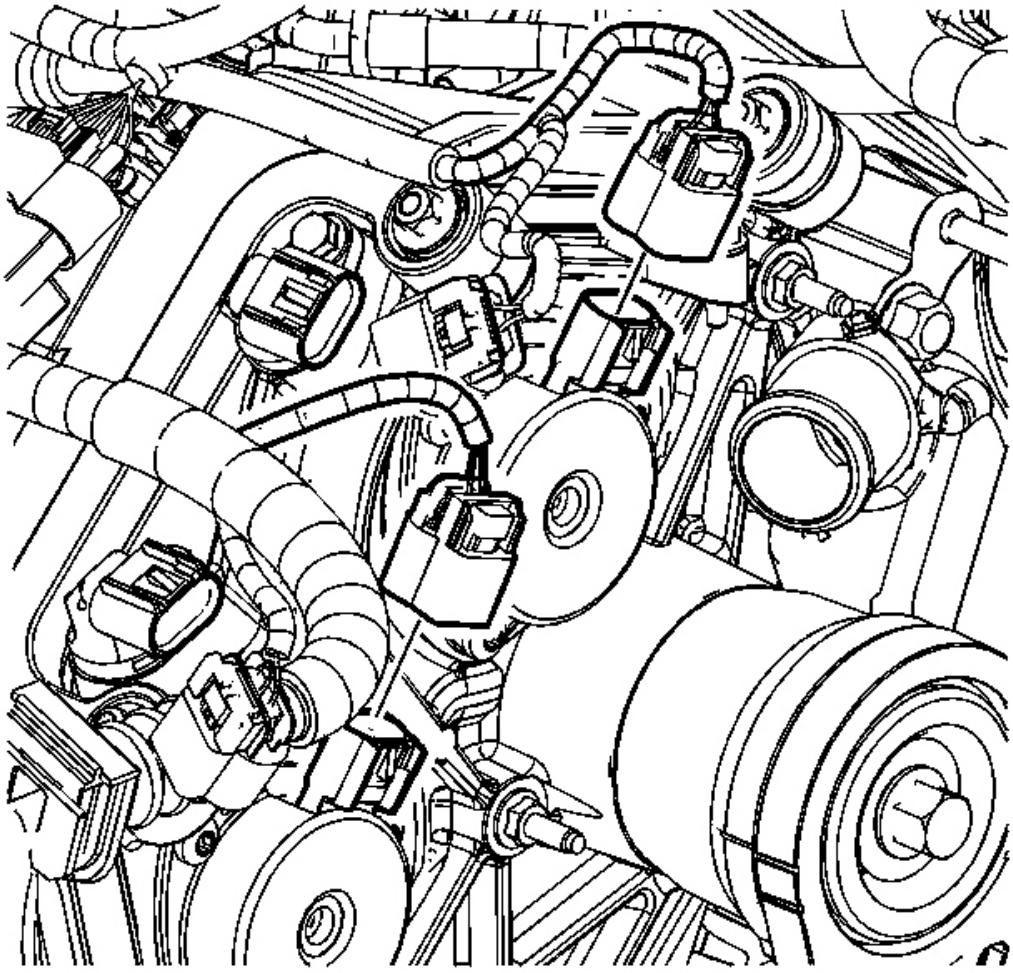


Fig. 220: Identifying Right Camshaft Position Actuator Wiring Harness
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the engine wiring harness from the right camshaft position actuators.

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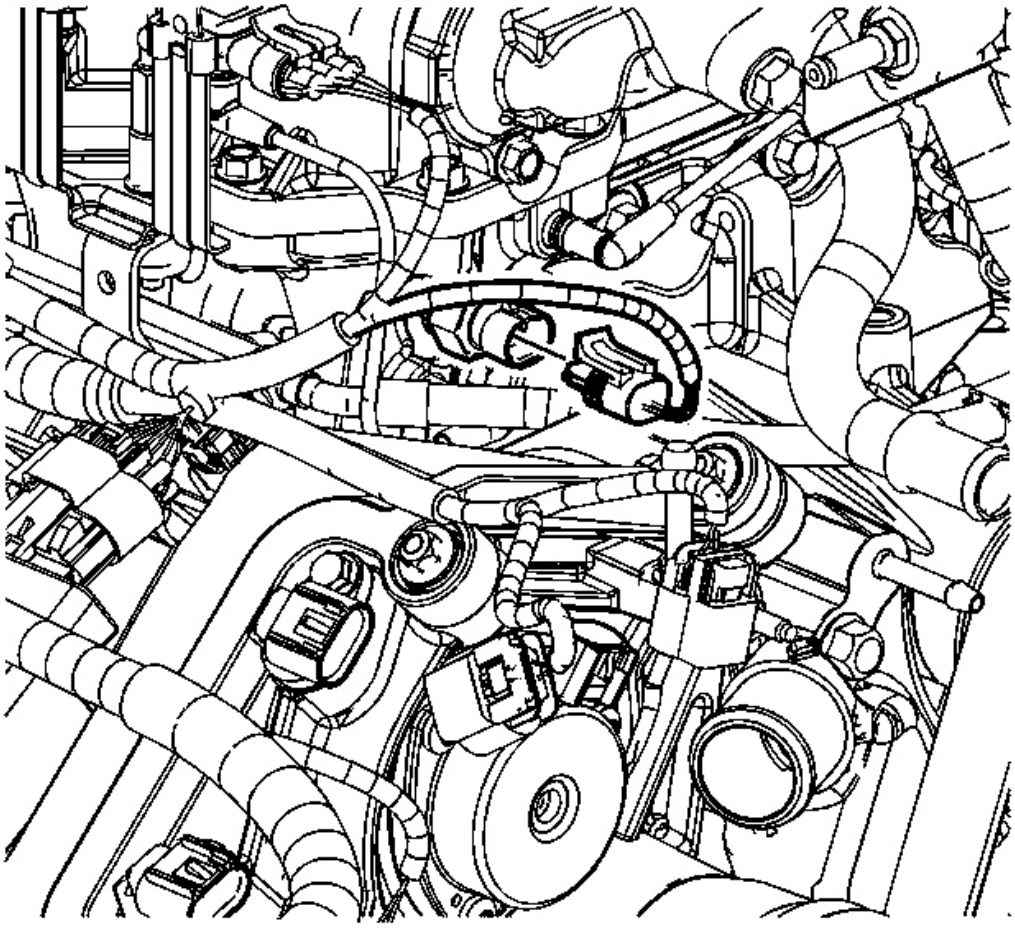


Fig. 221: Identifying IAT Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the engine wiring harness from the intake air temperature (IAT) sensor 2.

Automotive-Manual.net

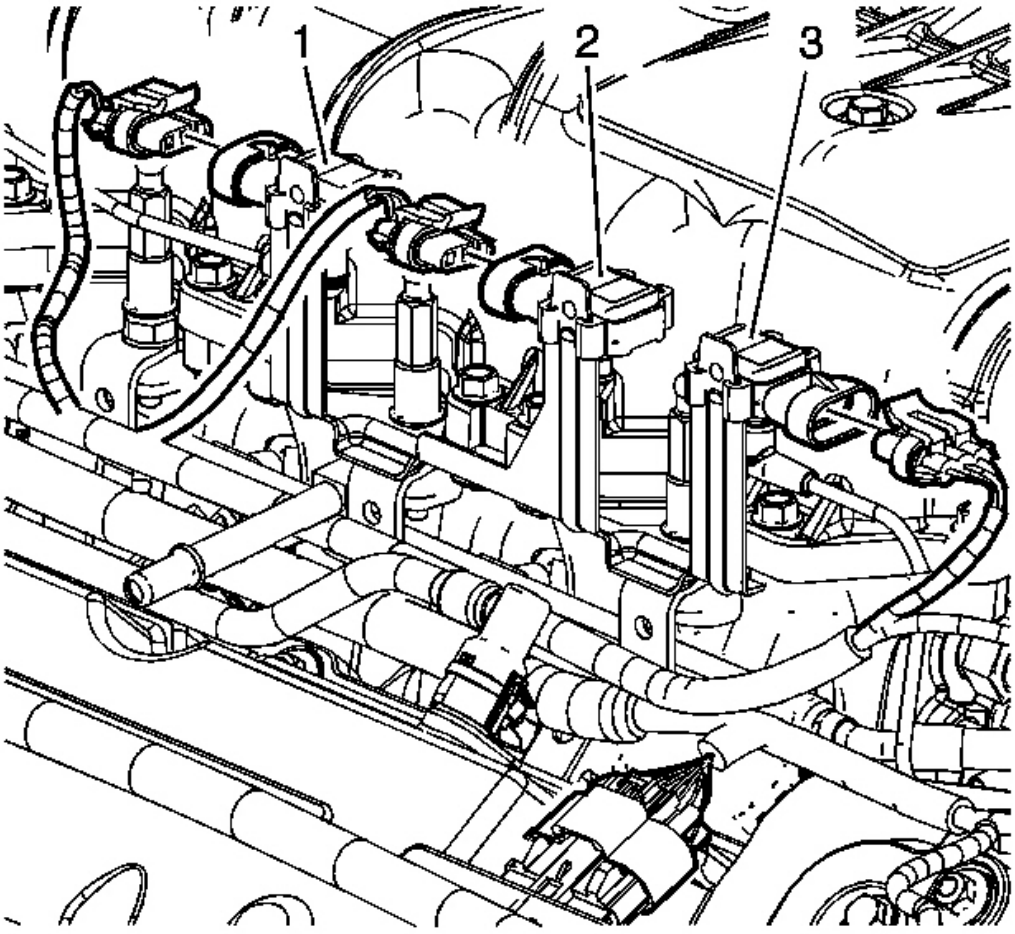


Fig. 222: Identifying MAP, BARO & Supercharger Inlet Absolute Pressure Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the engine wiring harness from the supercharger inlet absolute pressure sensor (1), barometric pressure (BARO) sensor (2), manifold absolute pressure (MAP) sensor (3).

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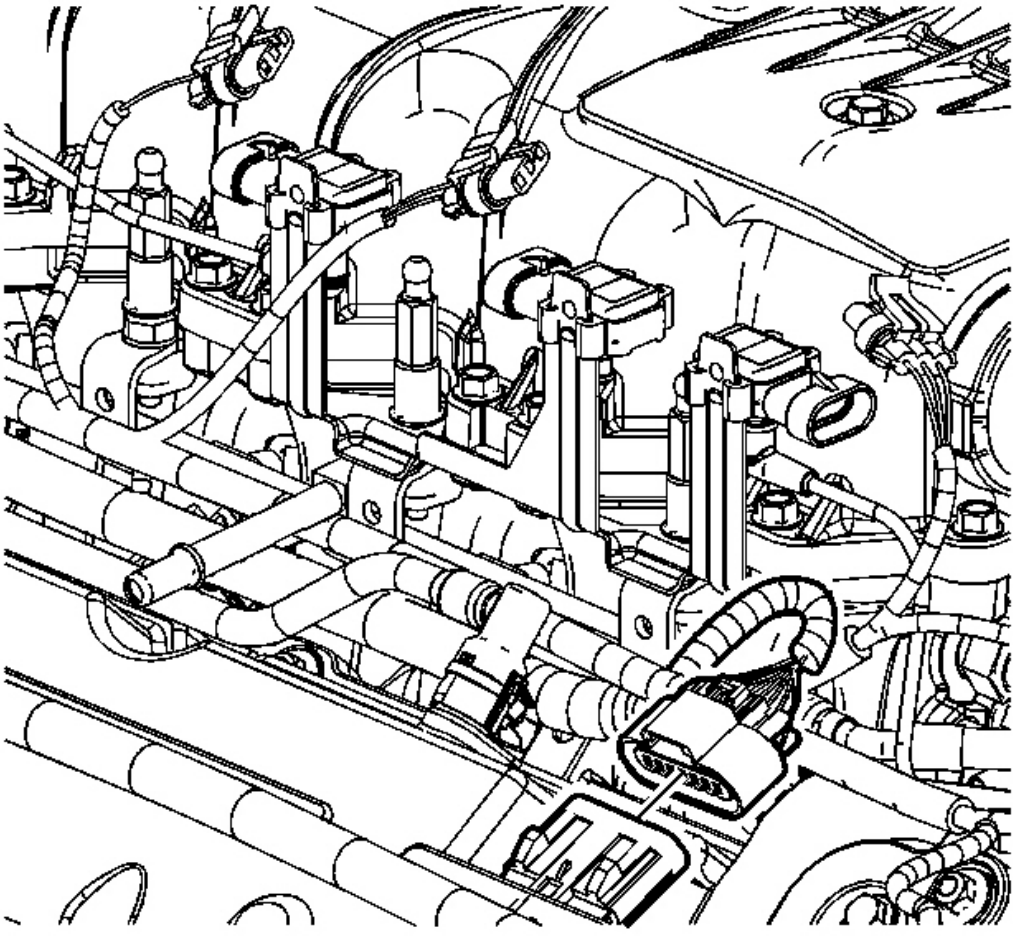


Fig. 223: Identifying Right Coil Assembly Harness
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the engine wiring harness from the right coil assembly harness.

Automotive-Manual.net

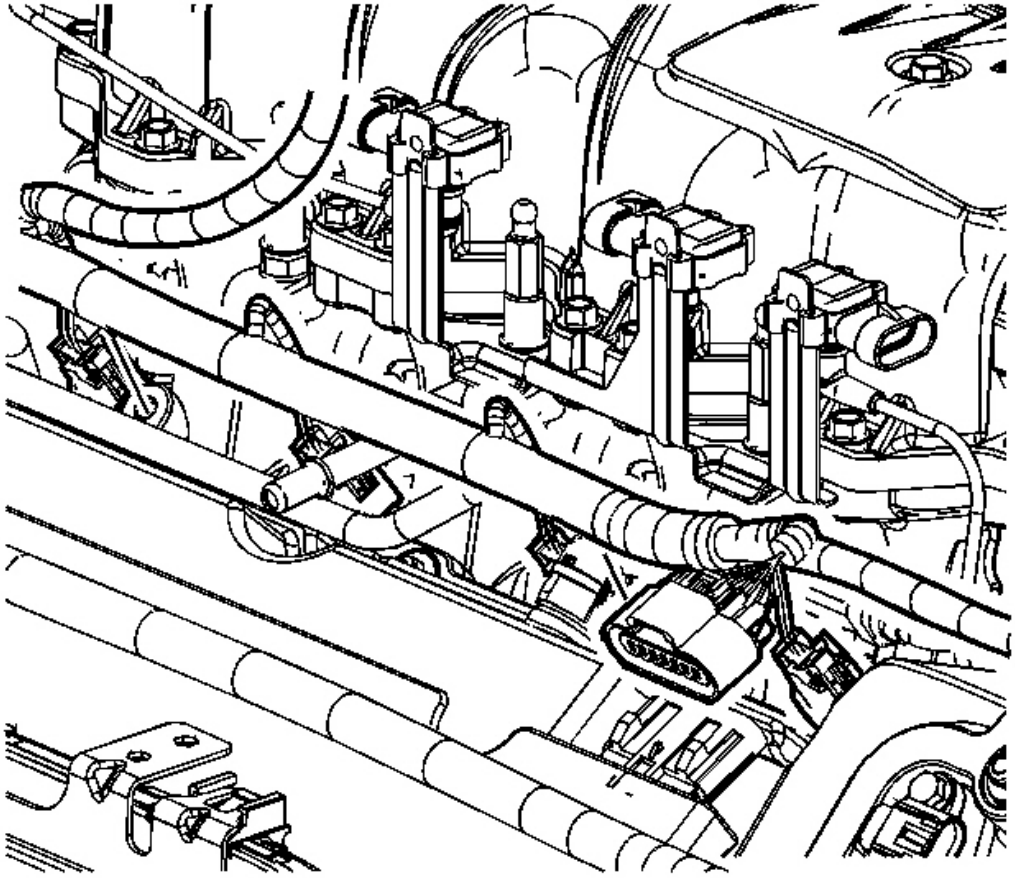


Fig. 224: Identifying Right Camshaft Cover Wiring Harness
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the engine wiring harness from the right camshaft cover.

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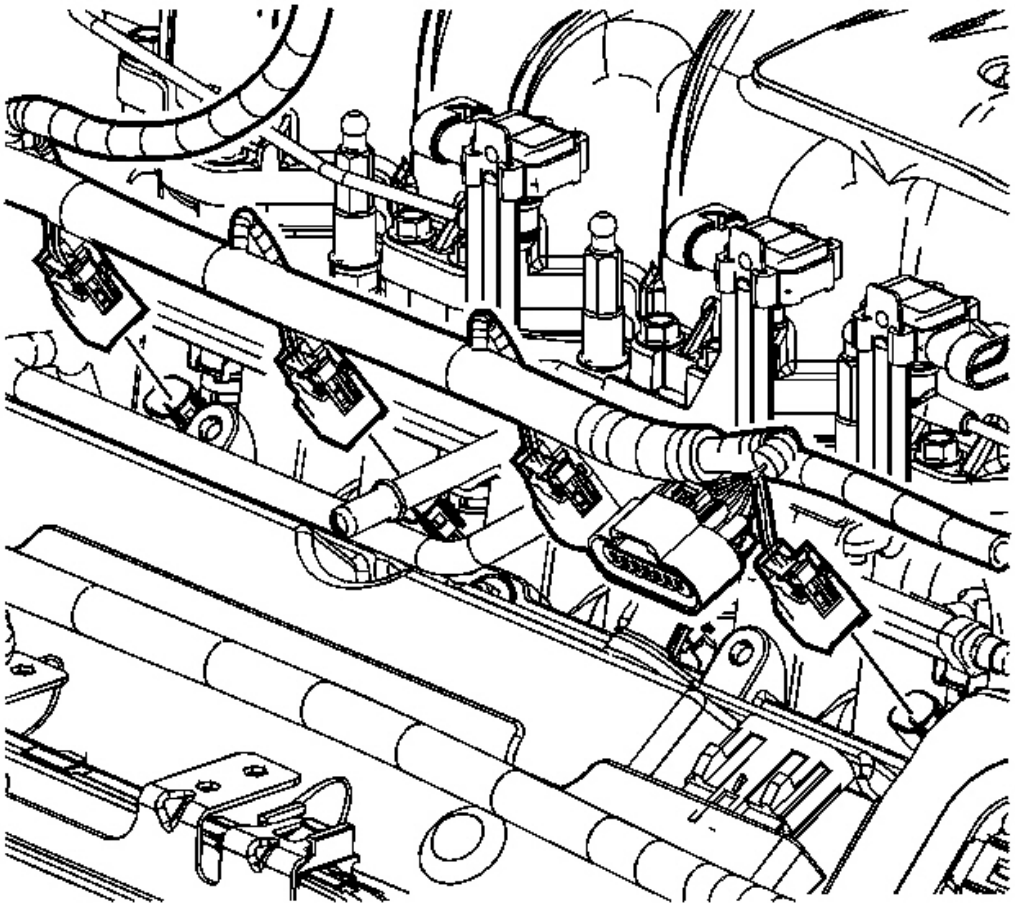


Fig. 225: Identifying Right Side Fuel Injectors Wiring Harness
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the engine wiring harness from the right side fuel injectors.

Automotive-Manual.net

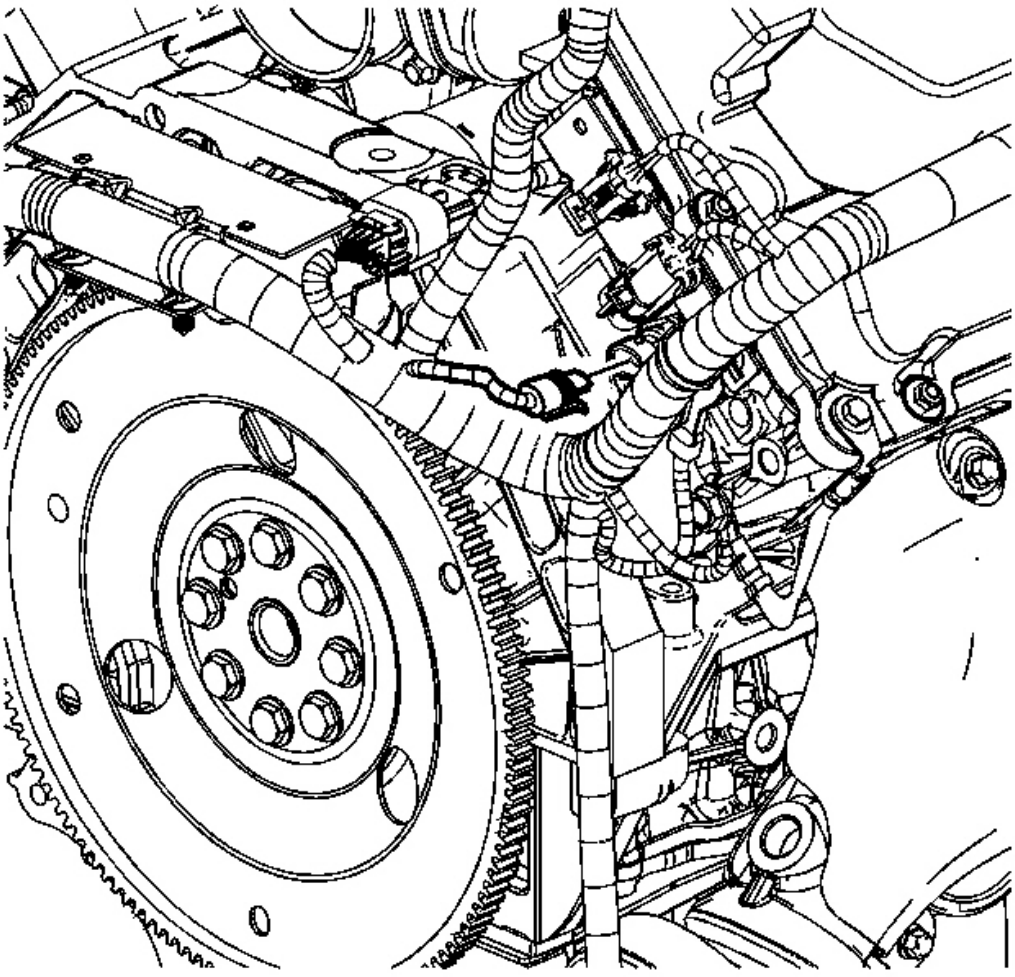


Fig. 226: Identifying ECT Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the engine wiring harness from the engine coolant temperature (ECT) sensor at the rear of the right cylinder head.

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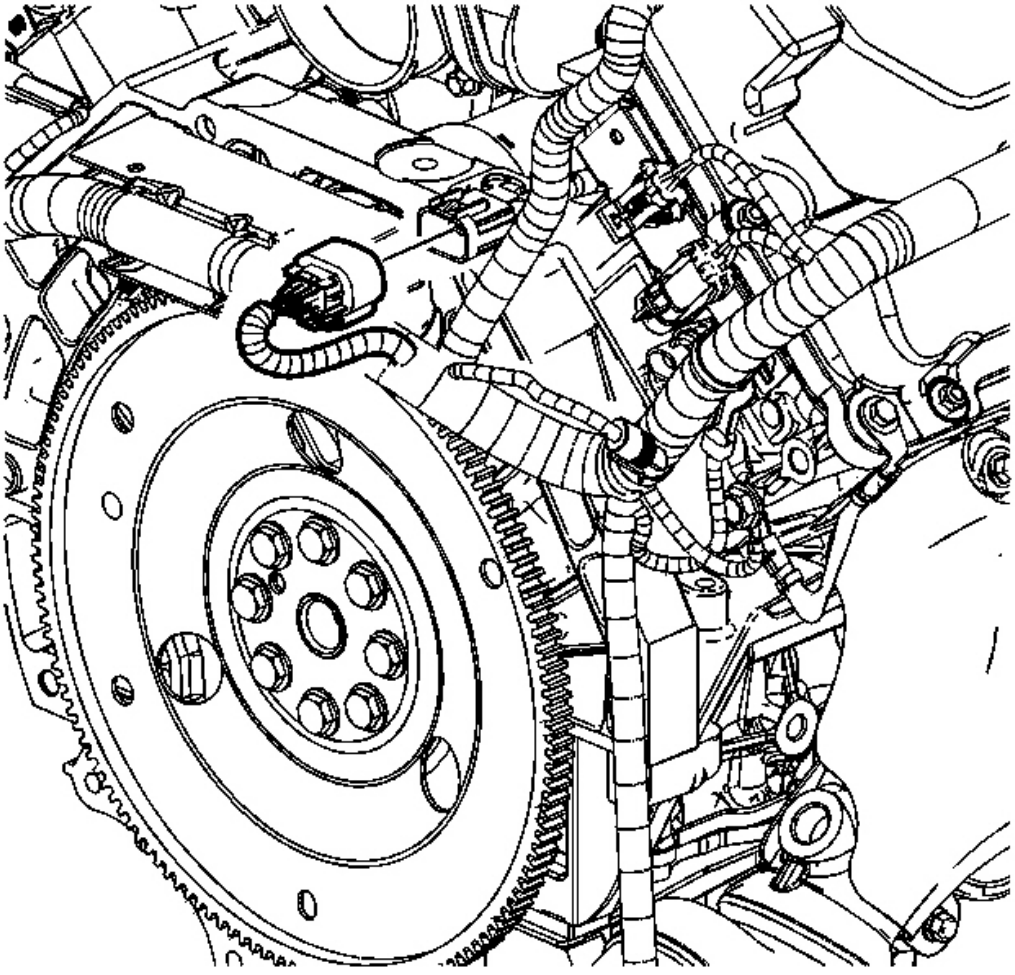


Fig. 227: Identifying Knock And Crankshaft Position Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the engine wiring harness from the knock and crankshaft position sensor wiring harness.

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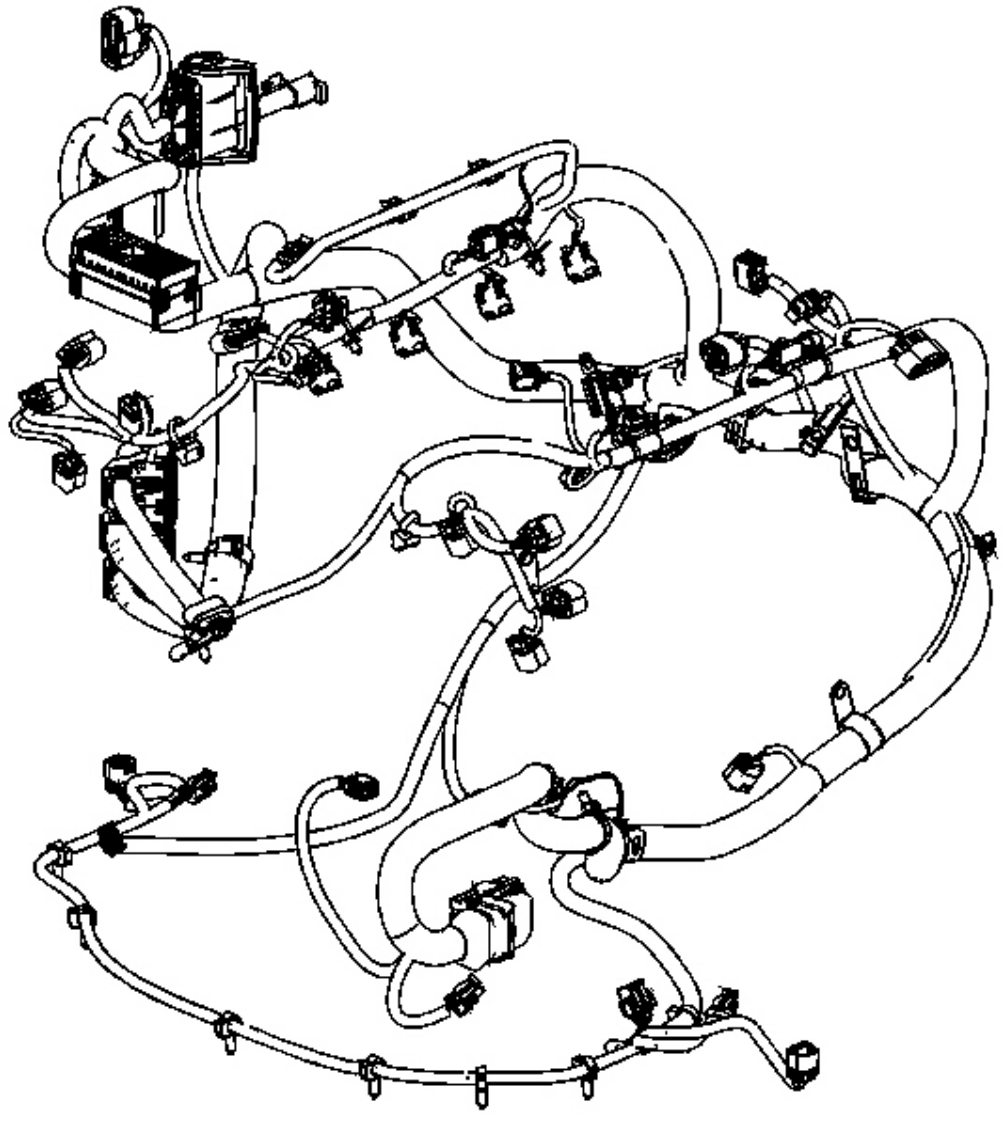


Fig. 228: View Of Engine Wiring Harness
Courtesy of GENERAL MOTORS CORP.

12. Remove the engine wiring harness from the engine block.

EXHAUST MANIFOLD REMOVAL - LEFT SIDE

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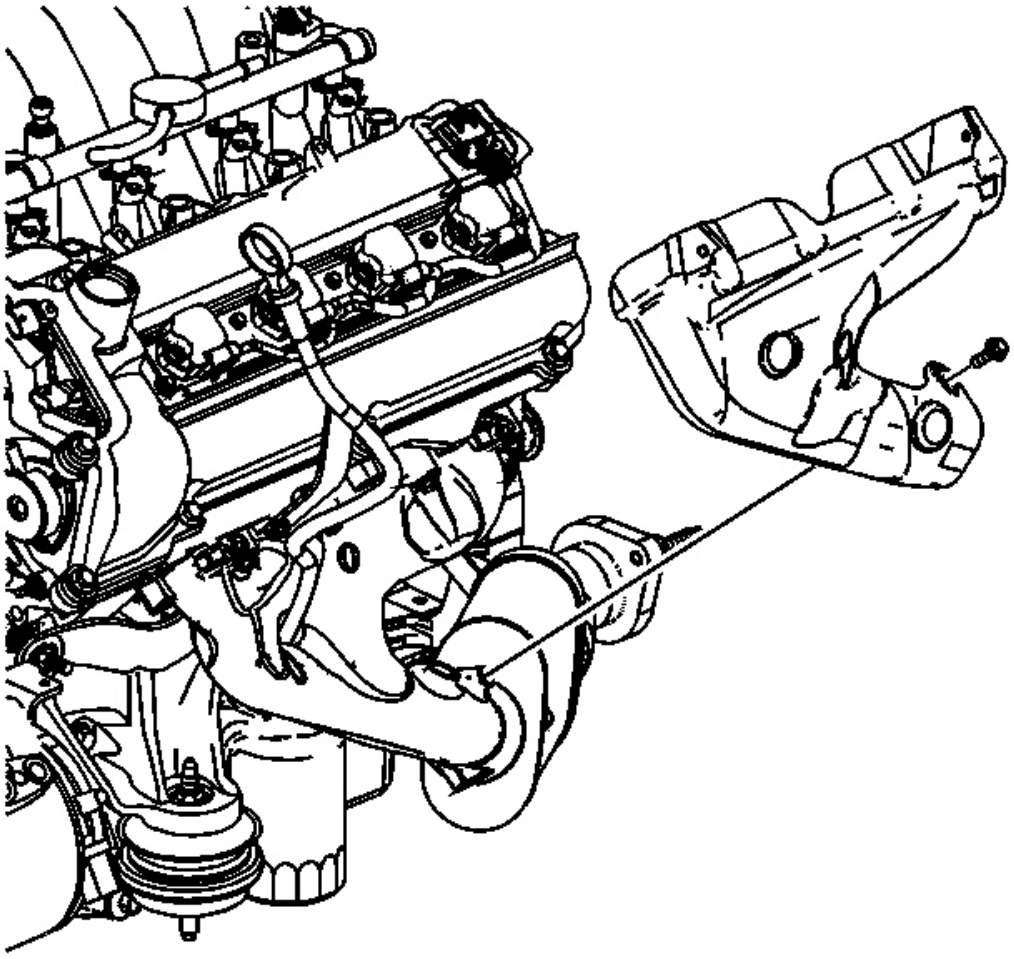


Fig. 229: View Of Left Exhaust Manifold Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the left exhaust manifold heat shield bolts.
2. Remove the left exhaust manifold heat shield.

Automotive-Manual.net

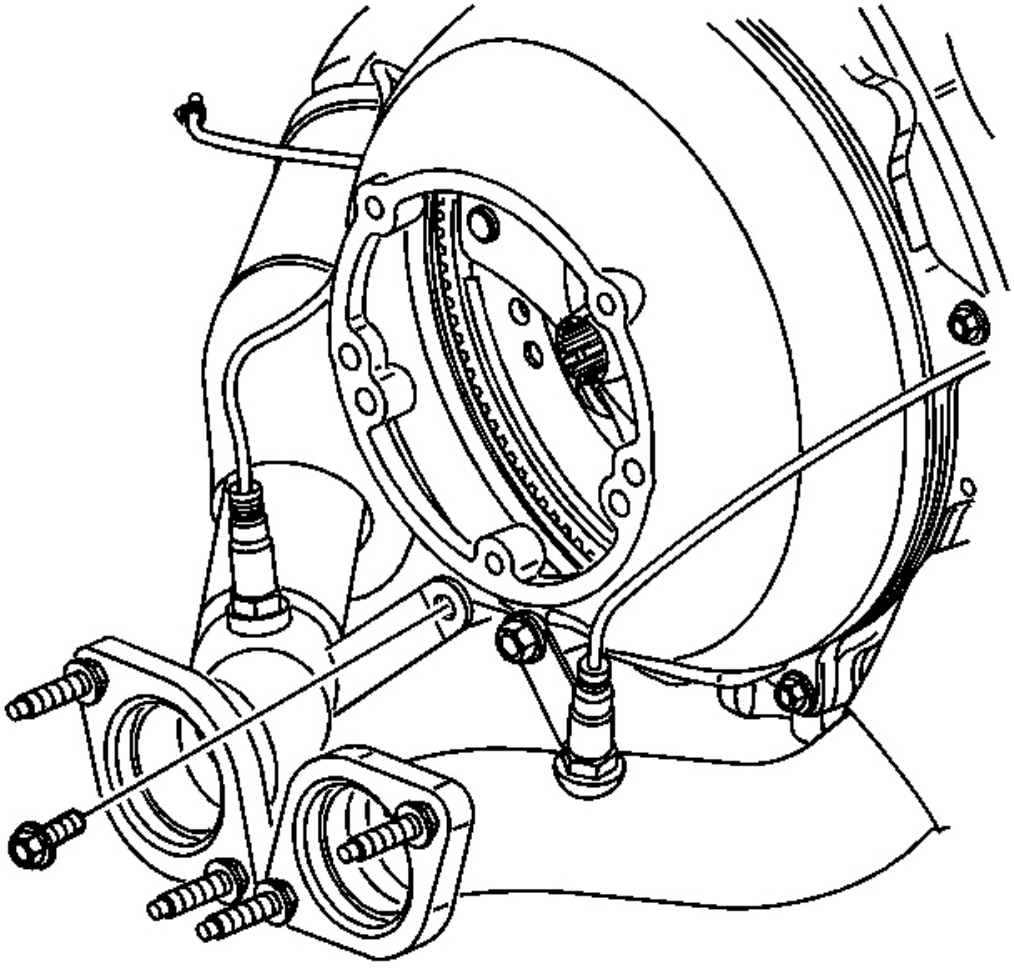


Fig. 230: View Of Left Exhaust Manifold Bolt & Bell Housing
Courtesy of GENERAL MOTORS CORP.

3. Remove the left exhaust manifold bolt from the bell housing.

Automotive-Manual.net

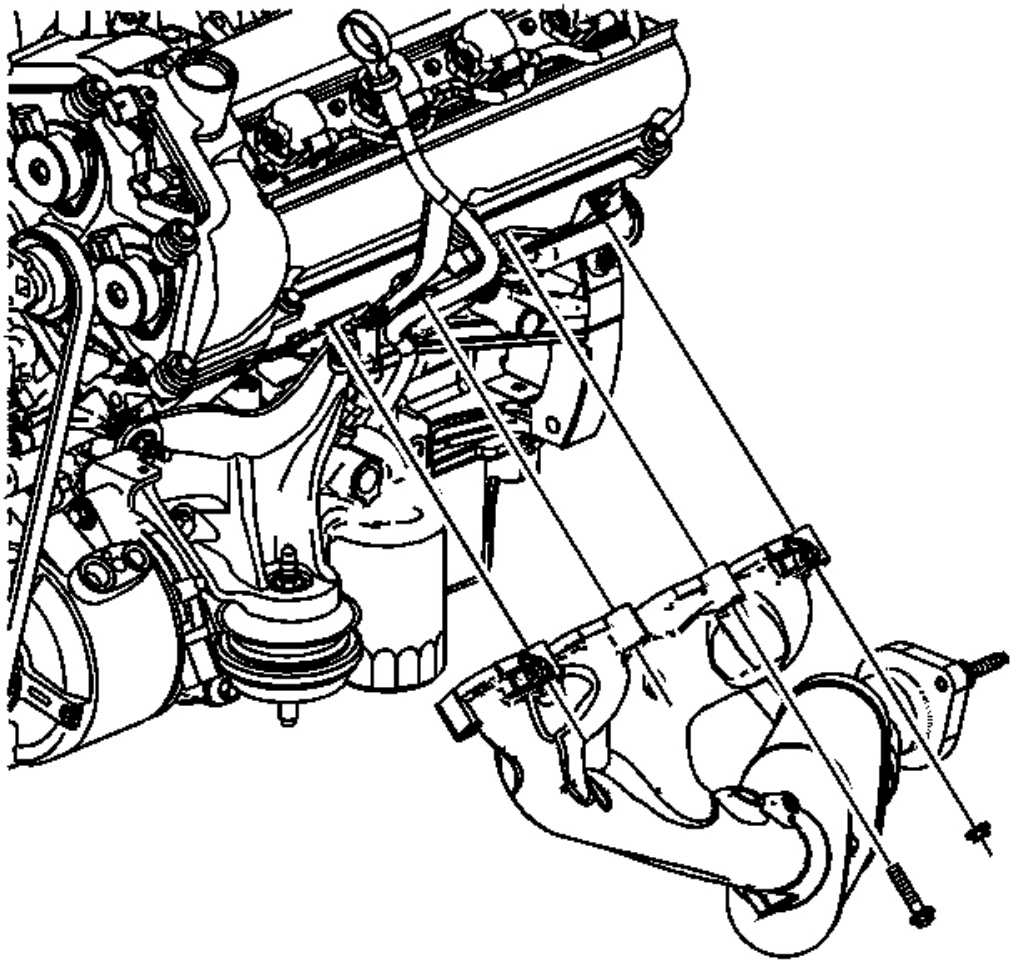


Fig. 231: View Of Left Exhaust Manifold, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

4. Remove the left exhaust manifold bolts and nuts from the left cylinder head.
5. Remove the left exhaust manifold.

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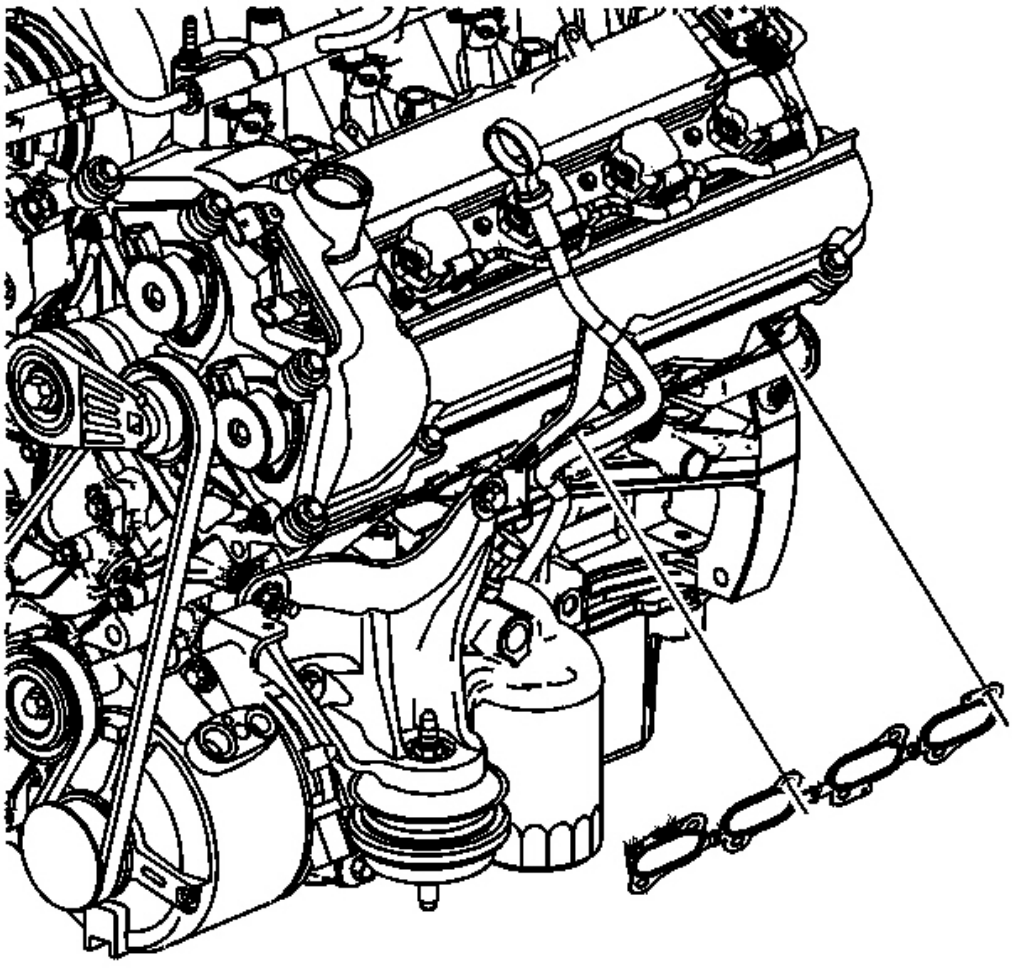


Fig. 232: View Of Left Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the left exhaust manifold gasket.

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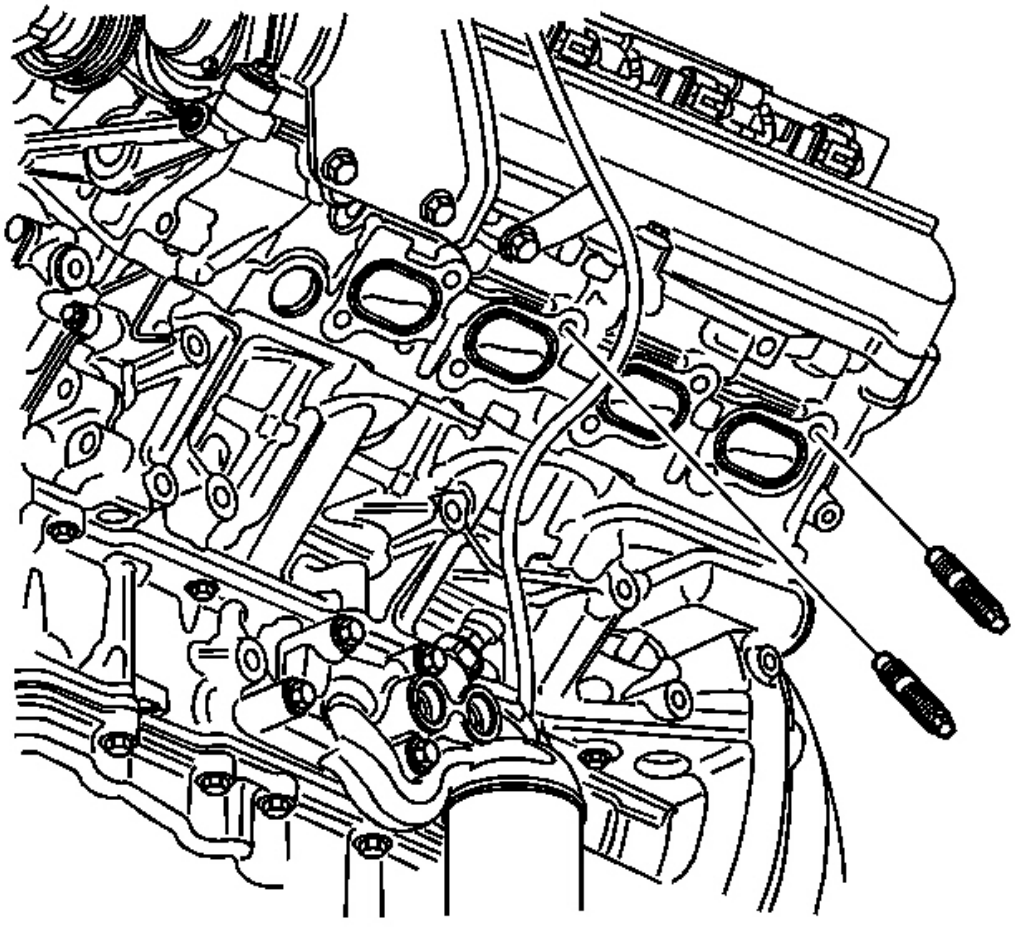


Fig. 233: View Of Left Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

7. Remove the left exhaust manifold studs from the left cylinder head.

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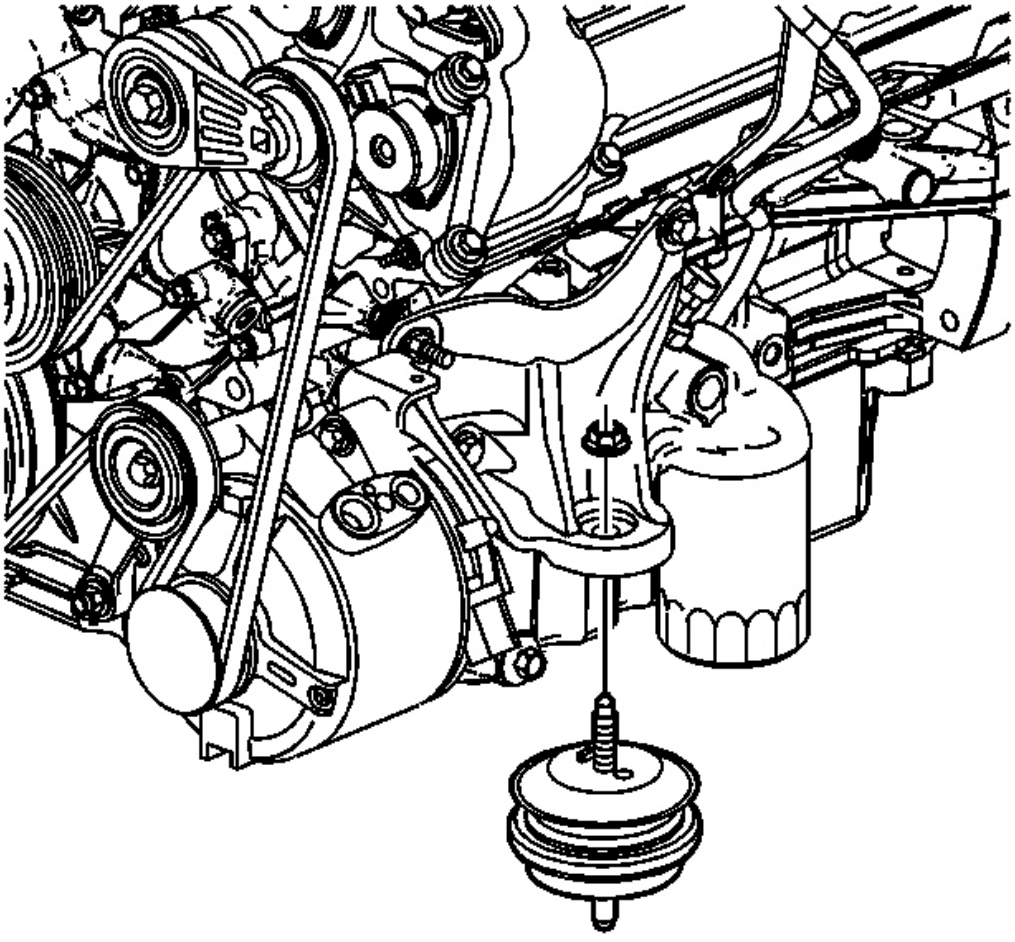


Fig. 234: View Of Left Engine Mount & Upper Nut
Courtesy of GENERAL MOTORS CORP.

8. Remove the left engine mount upper nut.
9. Remove the left engine mount.

Automotive-Manual.net

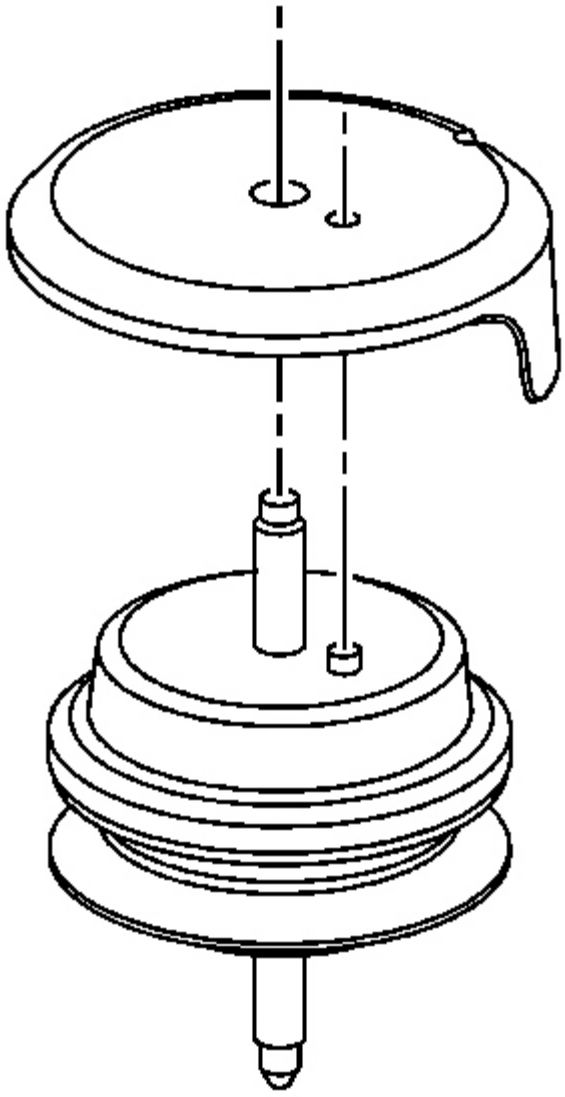


Fig. 235: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

10. Remove the engine mount heat shield from the engine mount.

Automotive-Manual.net

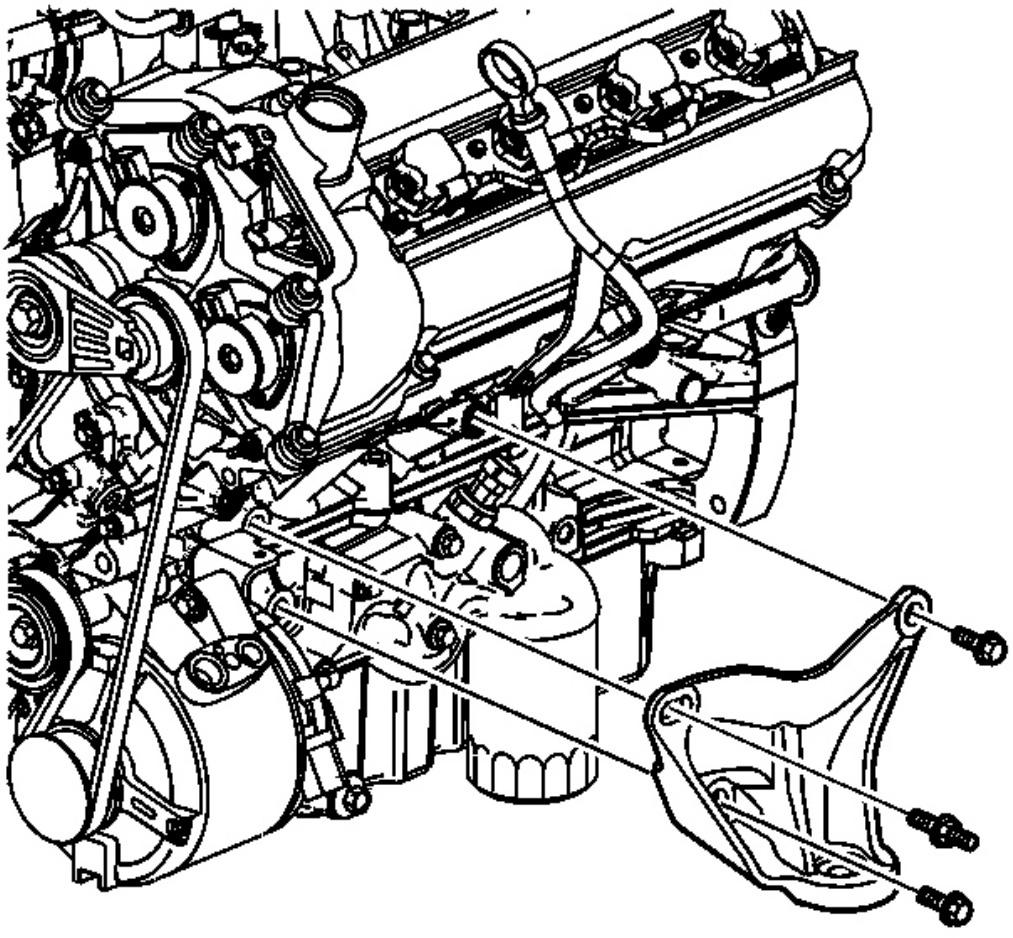


Fig. 236: View Of Left Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Remove the left engine mount bracket bolts.
12. Remove the left engine mount bracket.

EXHAUST MANIFOLD REMOVAL - RIGHT SIDE

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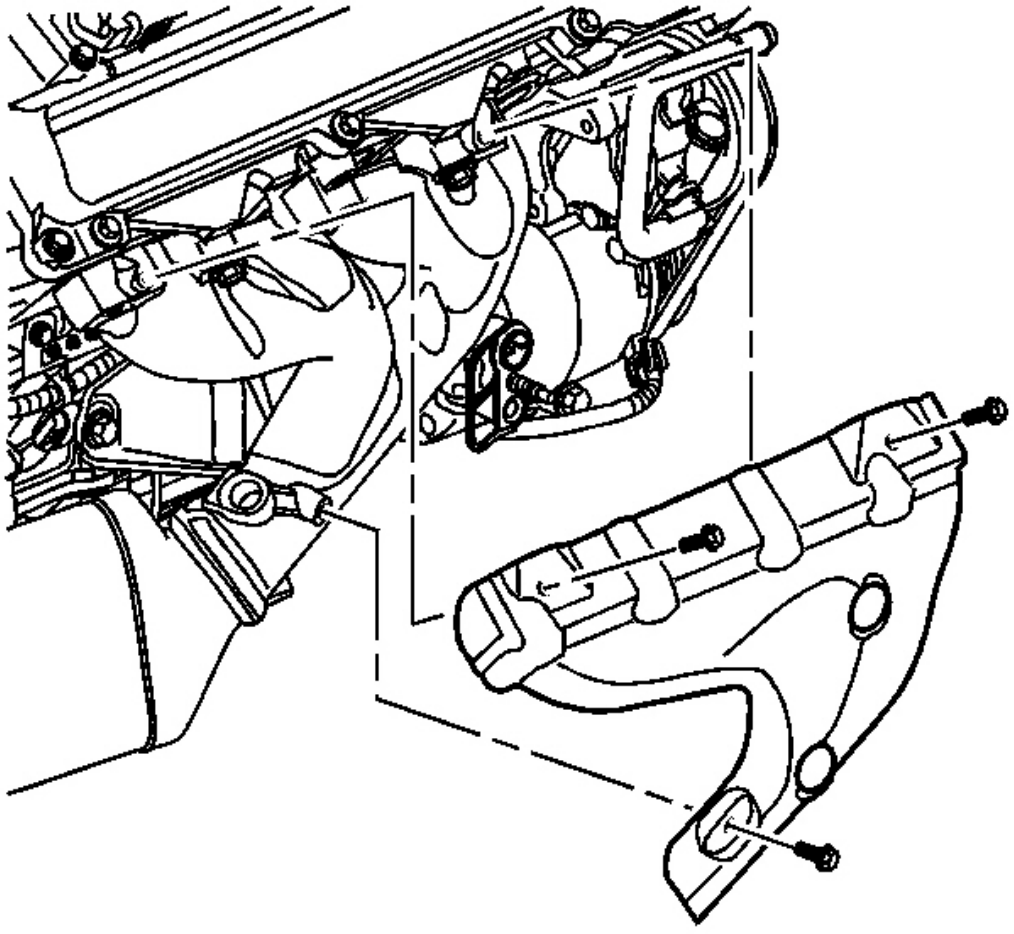


Fig. 237: View Of Right Exhaust Manifold Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the right exhaust manifold heat shield bolts.
2. Remove the right exhaust manifold heat shield.

Automotive-Manual.net

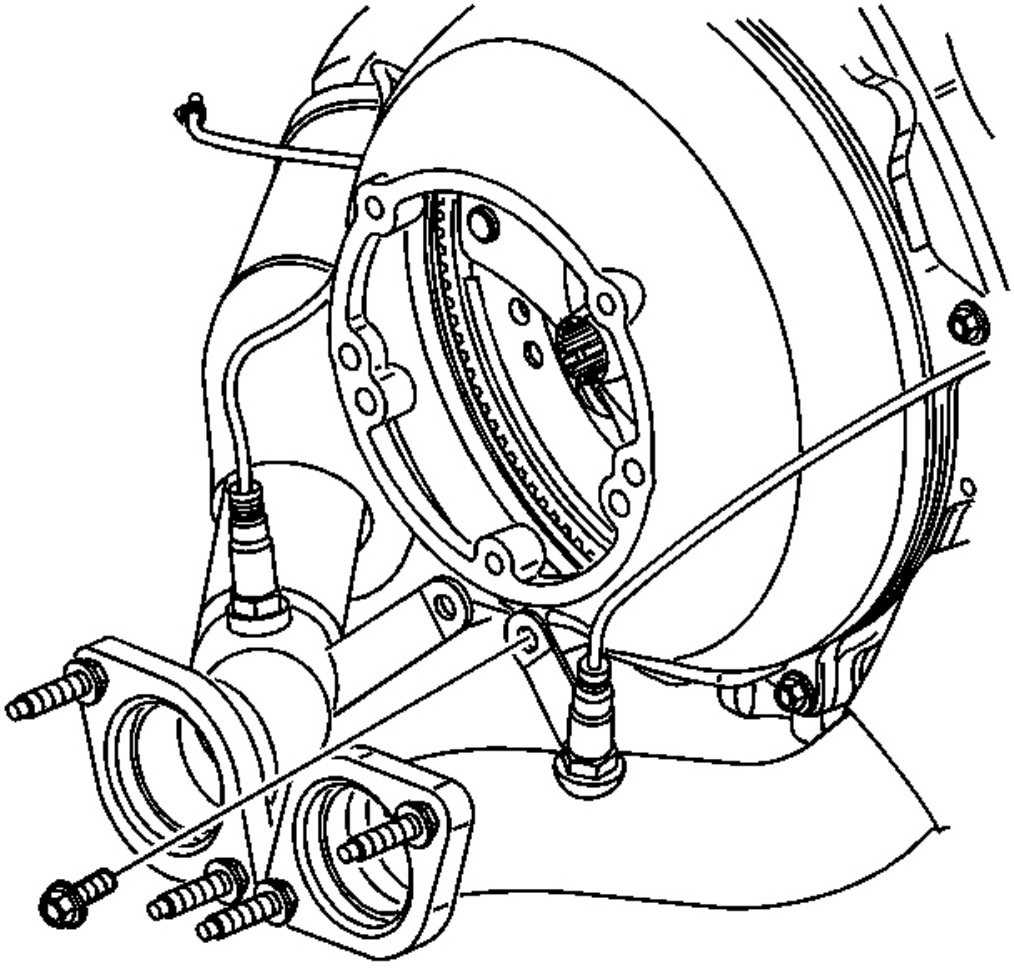


Fig. 238: View Of Right Exhaust Manifold Bolt & Bell Housing
Courtesy of GENERAL MOTORS CORP.

3. Remove the right exhaust manifold bolt from the bell housing.

Automotive-Manual.net

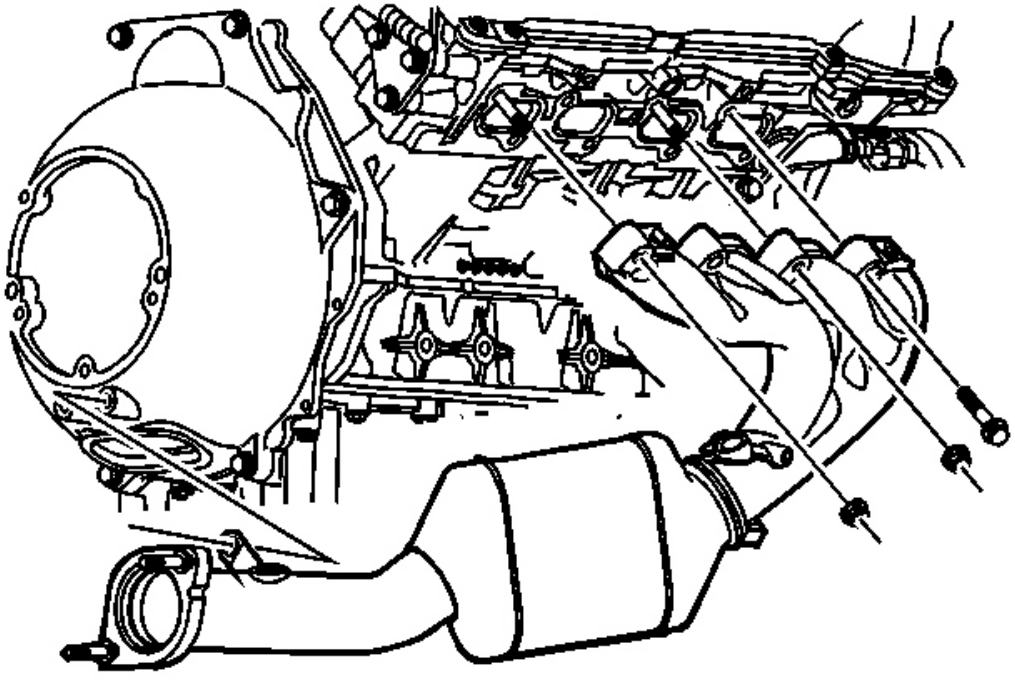


Fig. 239: View Of Right Exhaust Manifold, Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

4. Remove the right exhaust manifold bolts and nuts from the right cylinder head.
5. Remove the right exhaust manifold.

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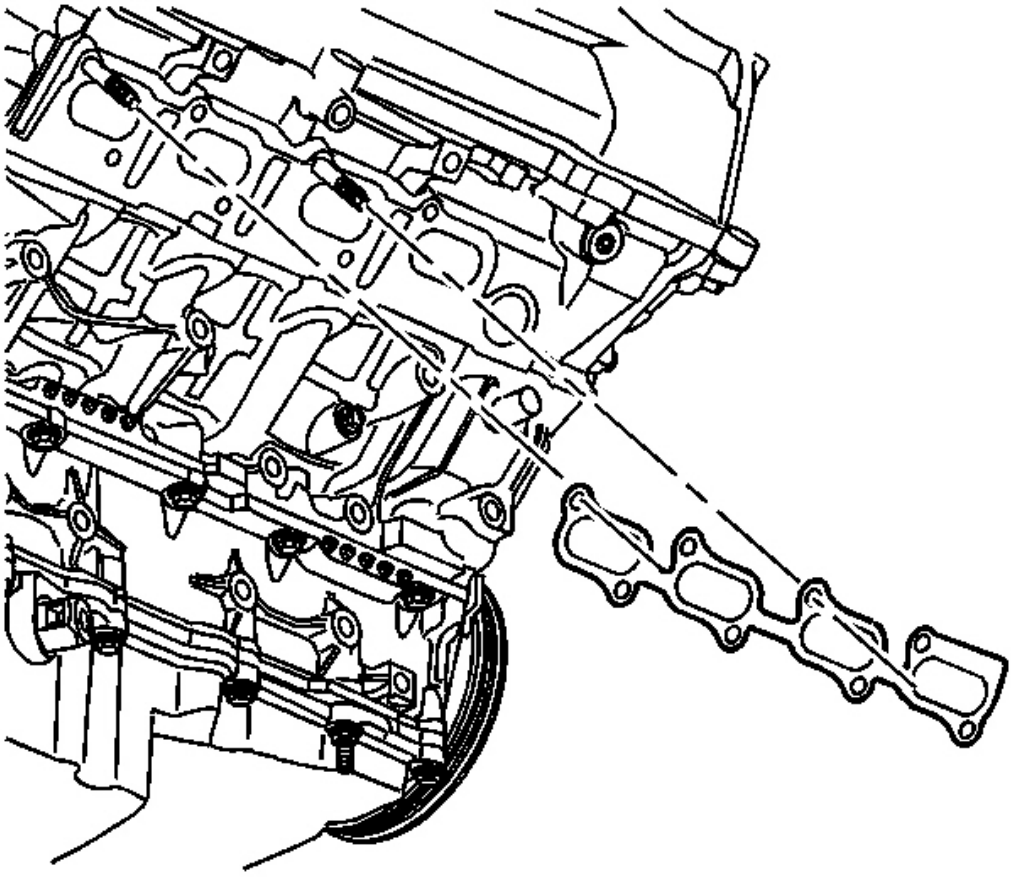


Fig. 240: View Of Right Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the right exhaust manifold gasket.

Automotive-Manual.net

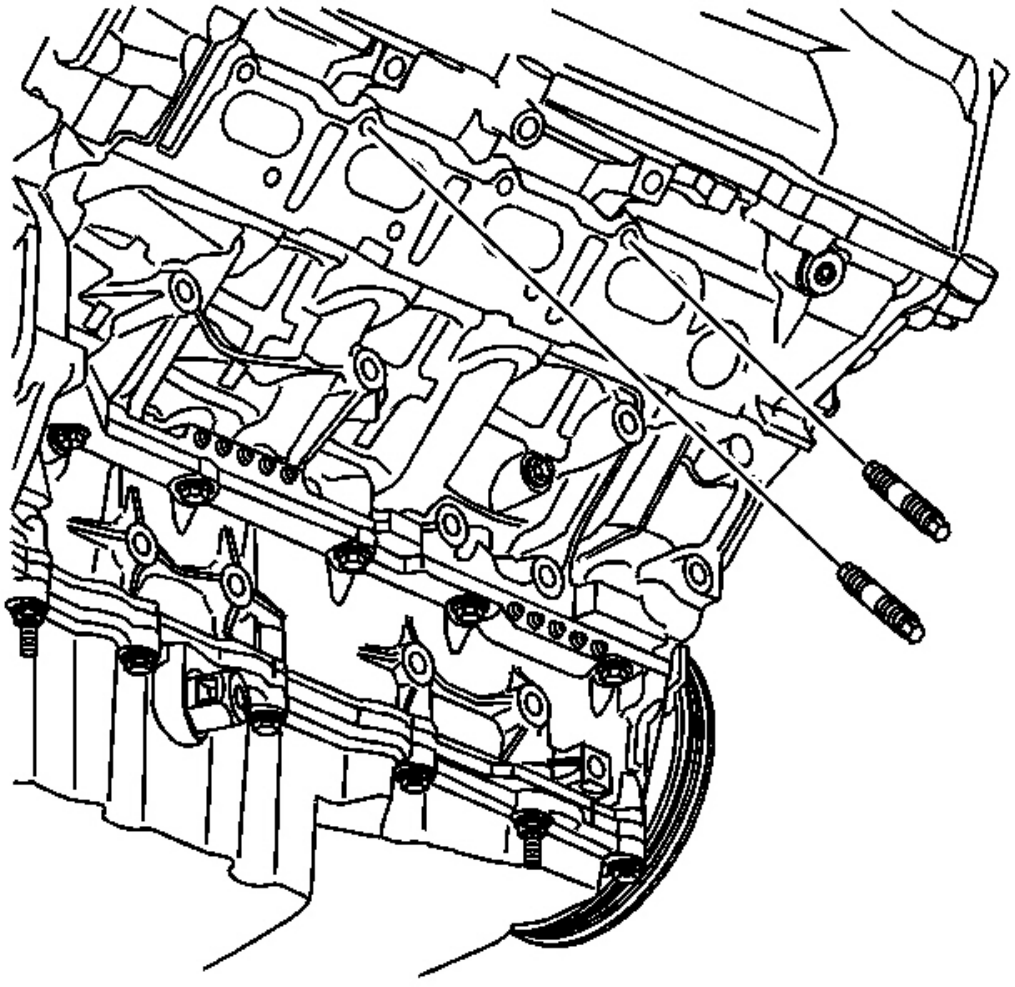


Fig. 241: View Of Right Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

7. Remove the right exhaust manifold studs from the right cylinder head.

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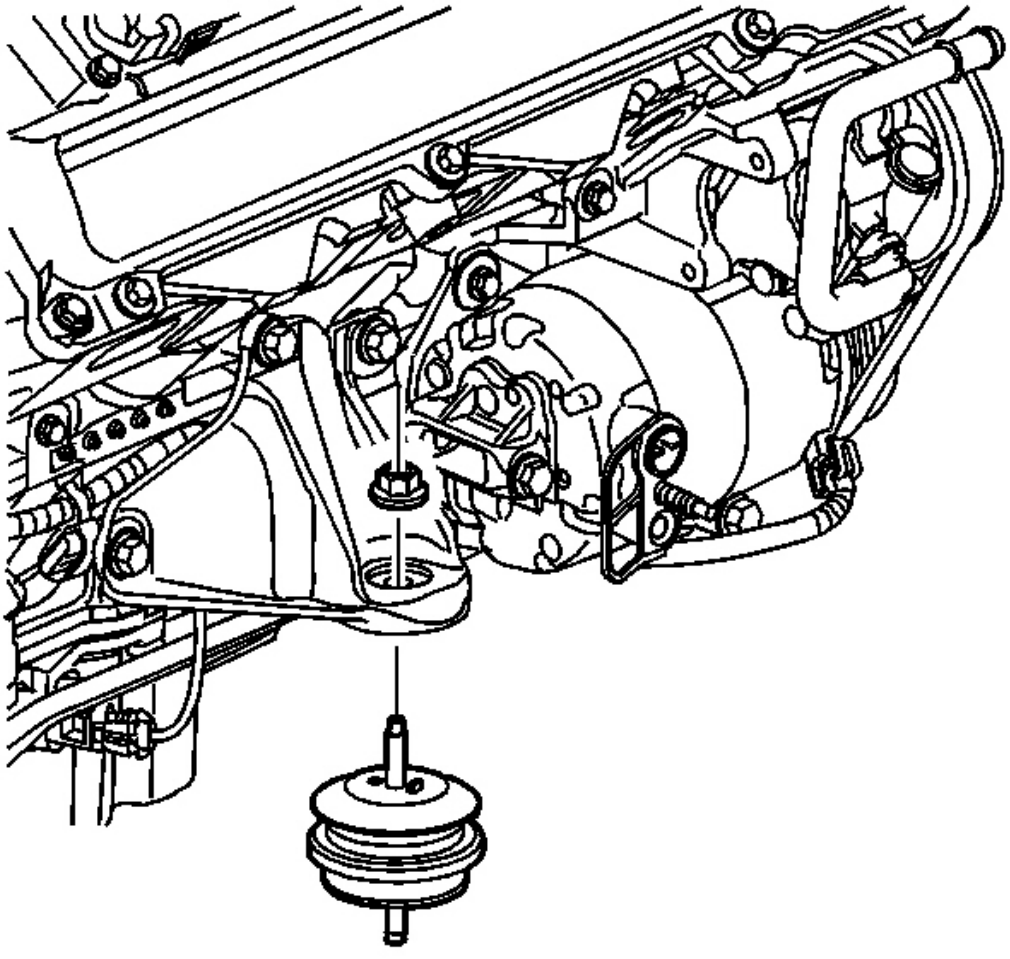


Fig. 242: View Of Right Engine Mount & Upper Nut
Courtesy of GENERAL MOTORS CORP.

8. Remove the right engine mount upper nut.
9. Remove the right engine mount.

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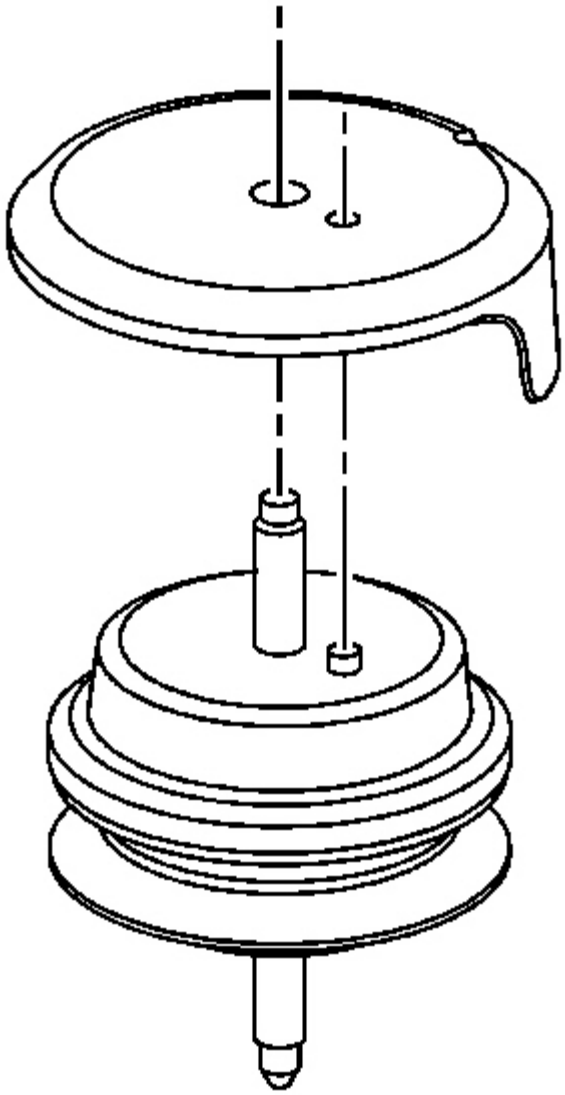


Fig. 243: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

10. Remove the engine mount heat shield from the engine mount.

Automotive-Manual.net

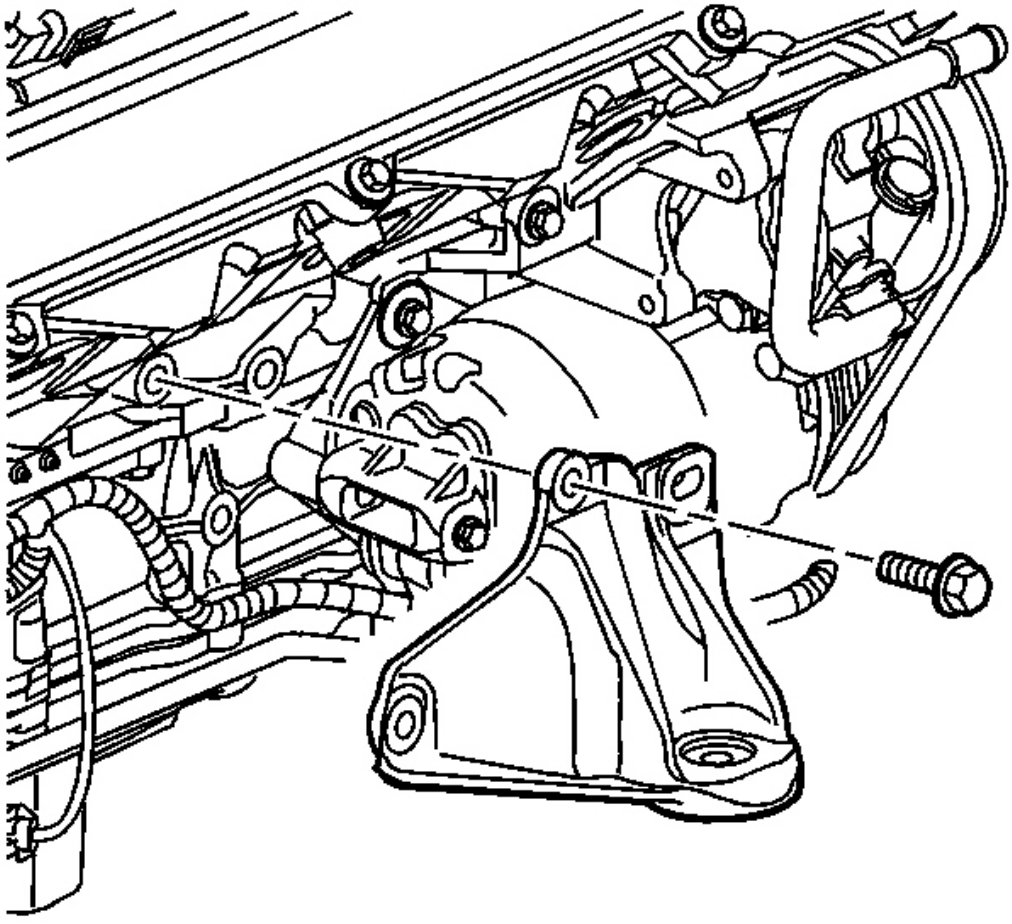


Fig. 244: View Of Right Engine Mount Bracket & Upper Nut
Courtesy of GENERAL MOTORS CORP.

11. Remove the right engine mount upper nut.
12. Remove the right engine mount.

Automotive-Manual.net

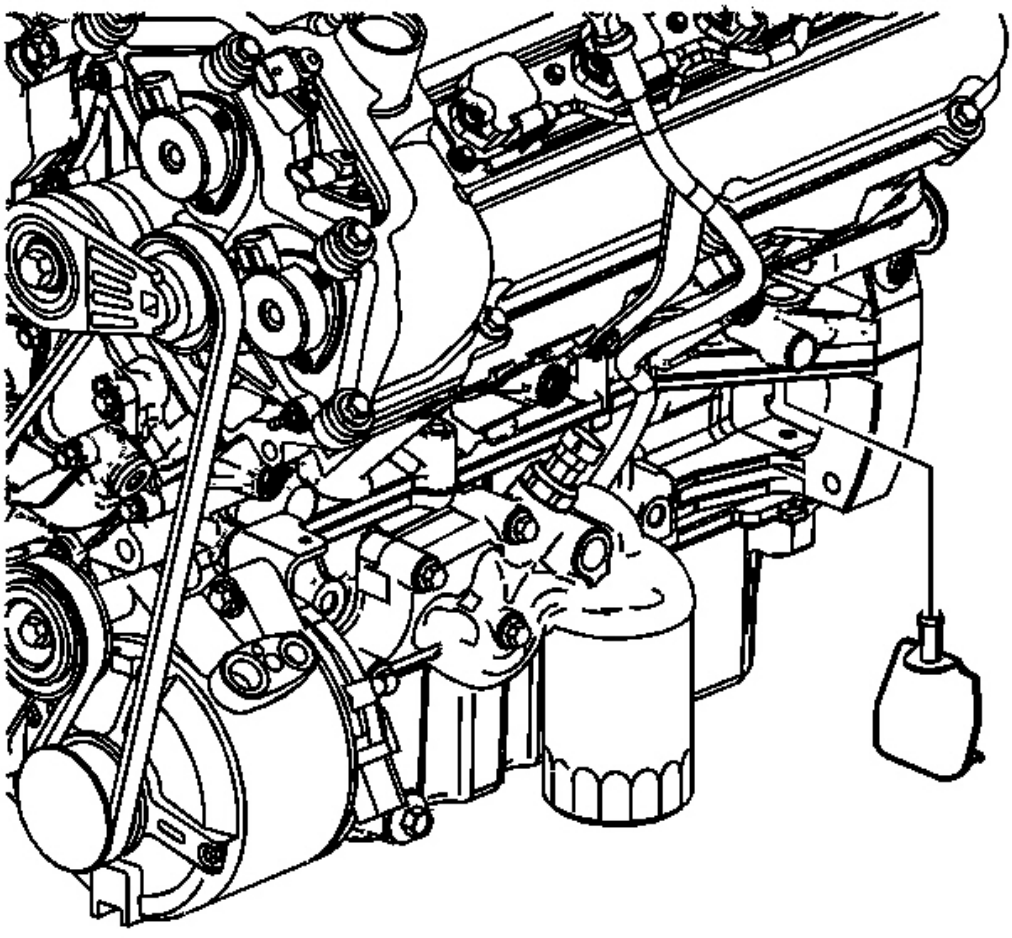


Fig. 245: View Of Left Engine Flywheel Housing Cover
Courtesy of GENERAL MOTORS CORP.

13. Remove the left engine flywheel housing cover.

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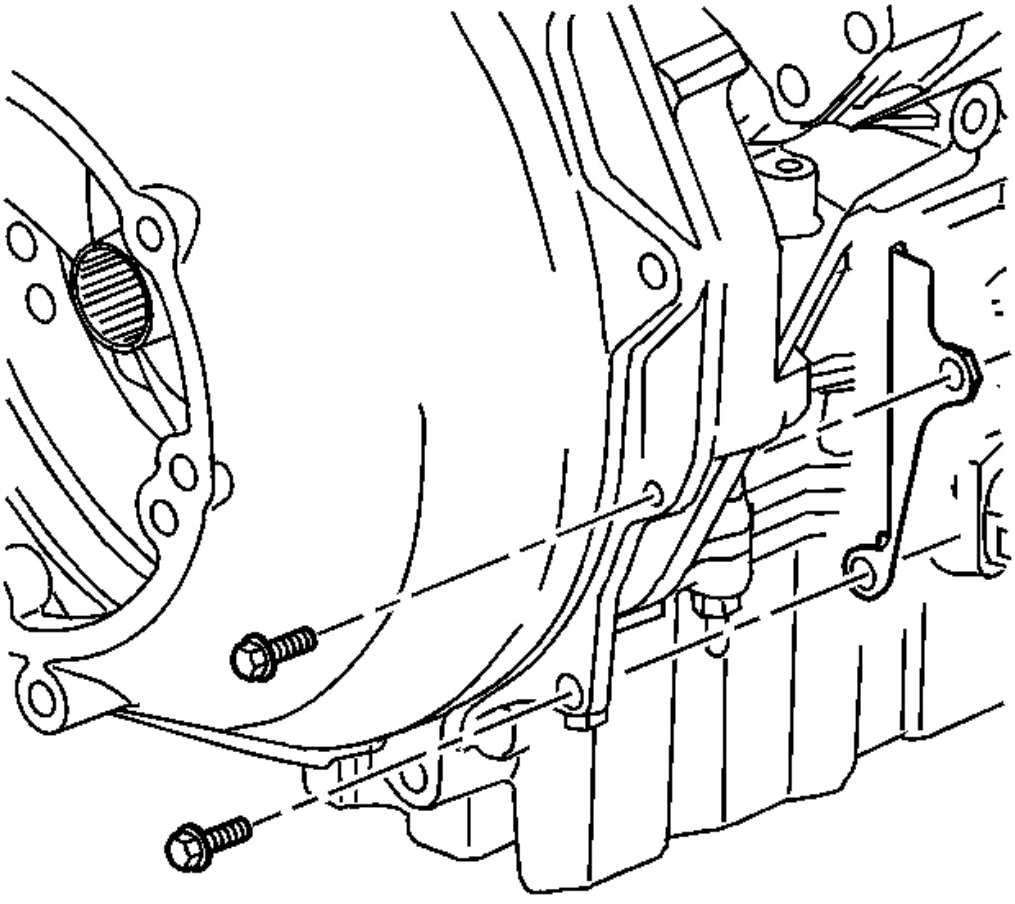


Fig. 246: View Of Right Engine Flywheel Housing Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the right engine flywheel housing cover bolts.
15. Remove the right engine flywheel housing cover.

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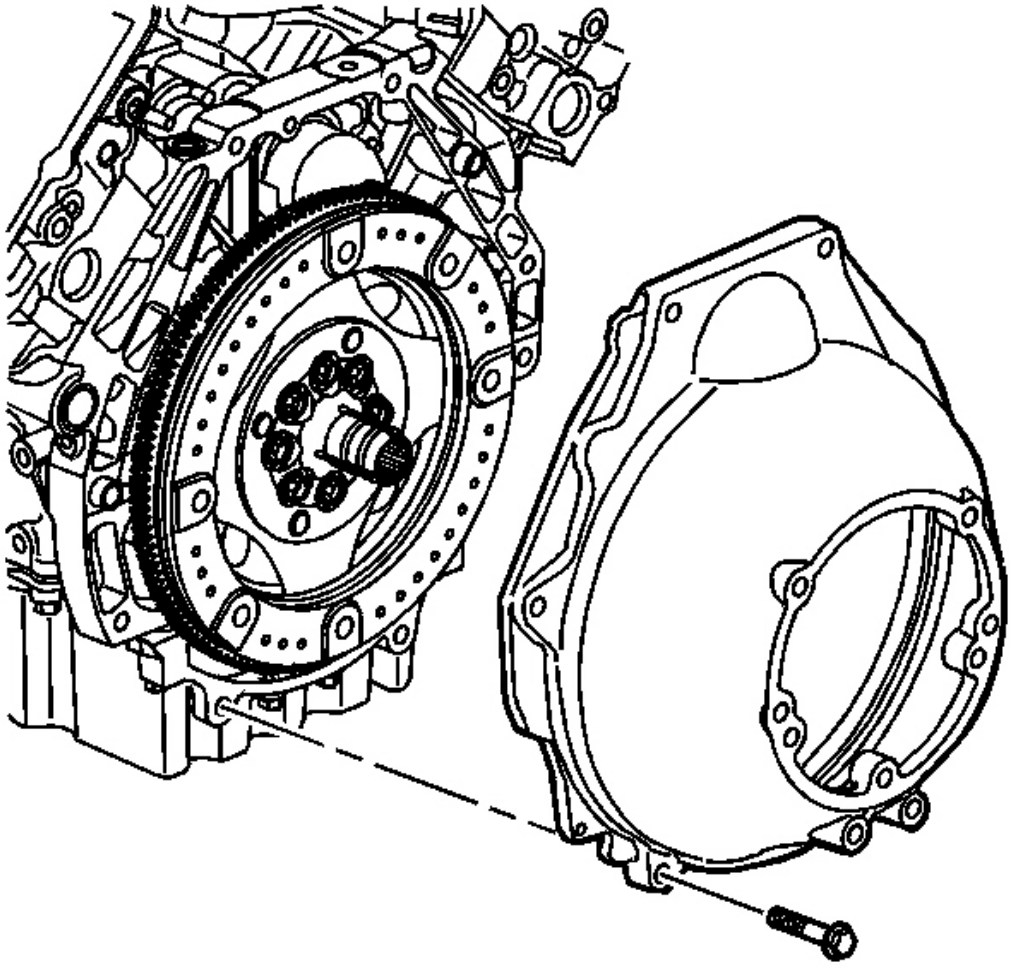


Fig. 247: View Of Bell Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

16. Remove the bell housing bolts.
17. Remove the bell housing.

DRIVE BELT REMOVAL

SUPERCHARGER

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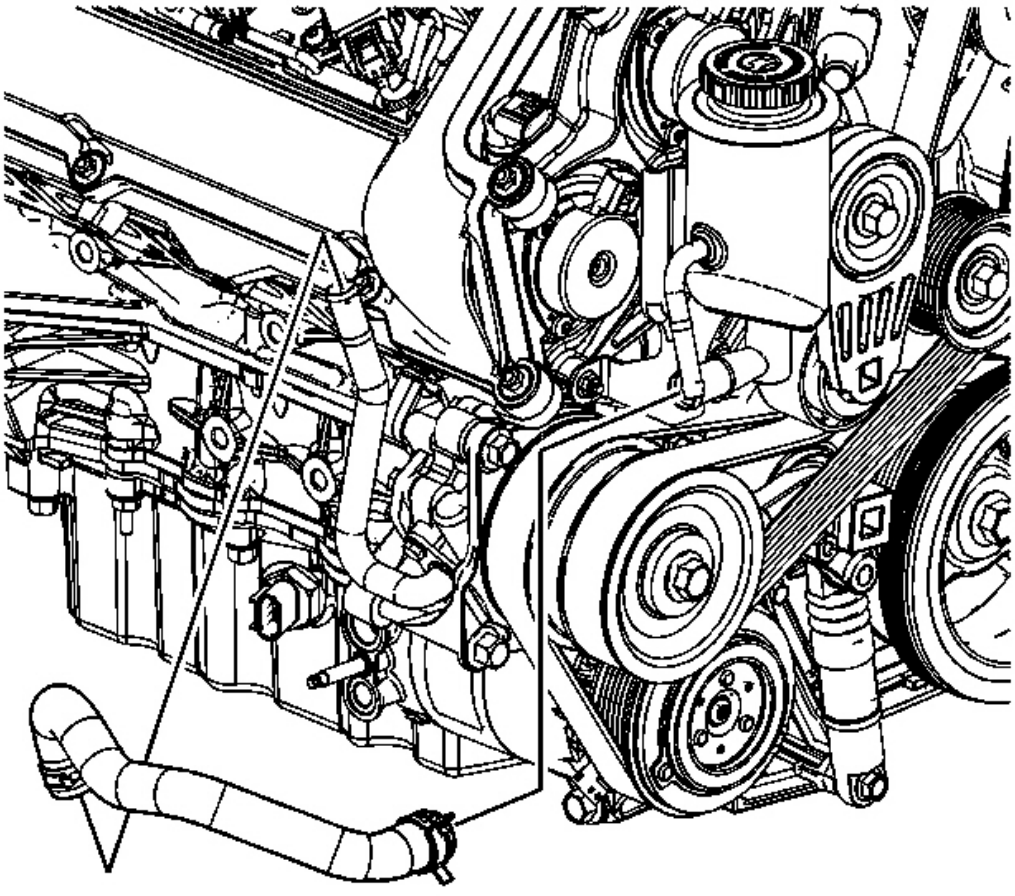


Fig. 248: Identifying Power Steering Pump Reservoir Hose
Courtesy of GENERAL MOTORS CORP.

1. Remove any fluid from the power steering reservoir into an appropriate container for disposal.
2. Remove the power steering reservoir hose.

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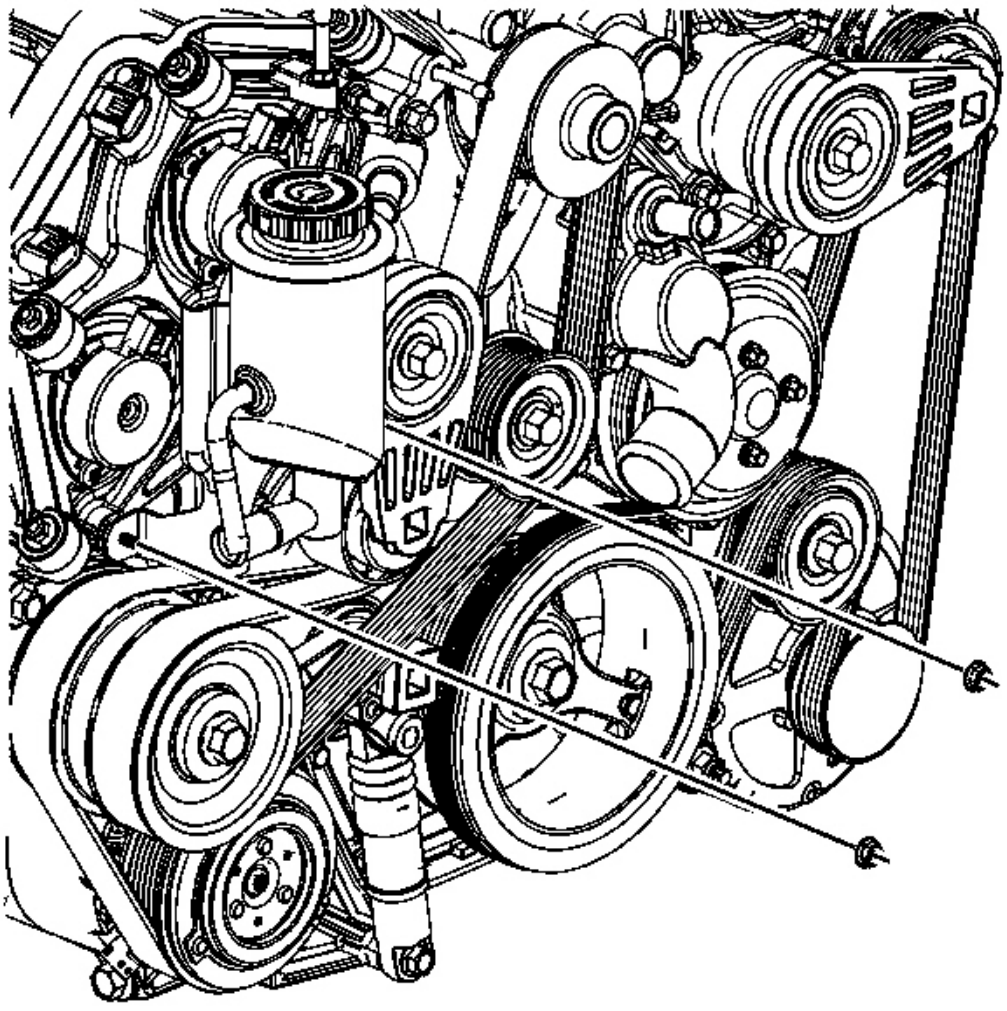


Fig. 249: Identifying Power Steering Pump Reservoir Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

3. Remove the power steering reservoir bracket nuts.

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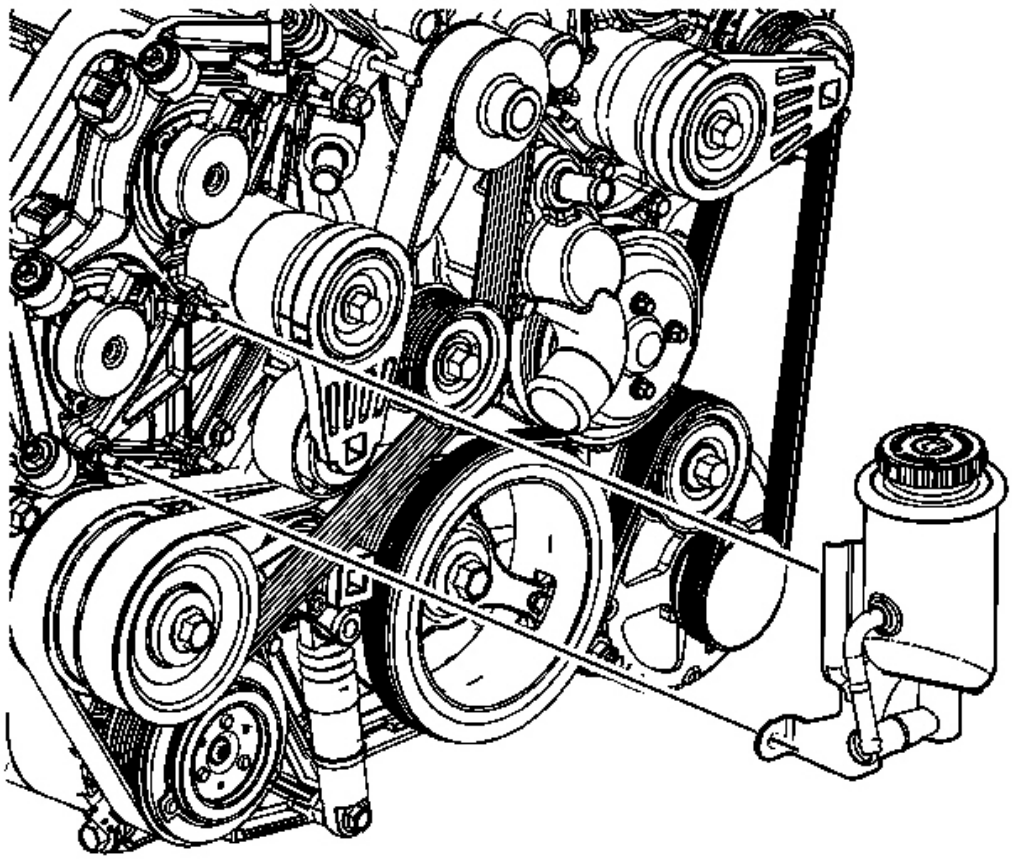


Fig. 250: View Of Power Steering Pump Reservoir
Courtesy of GENERAL MOTORS CORP.

4. Remove the power steering reservoir.

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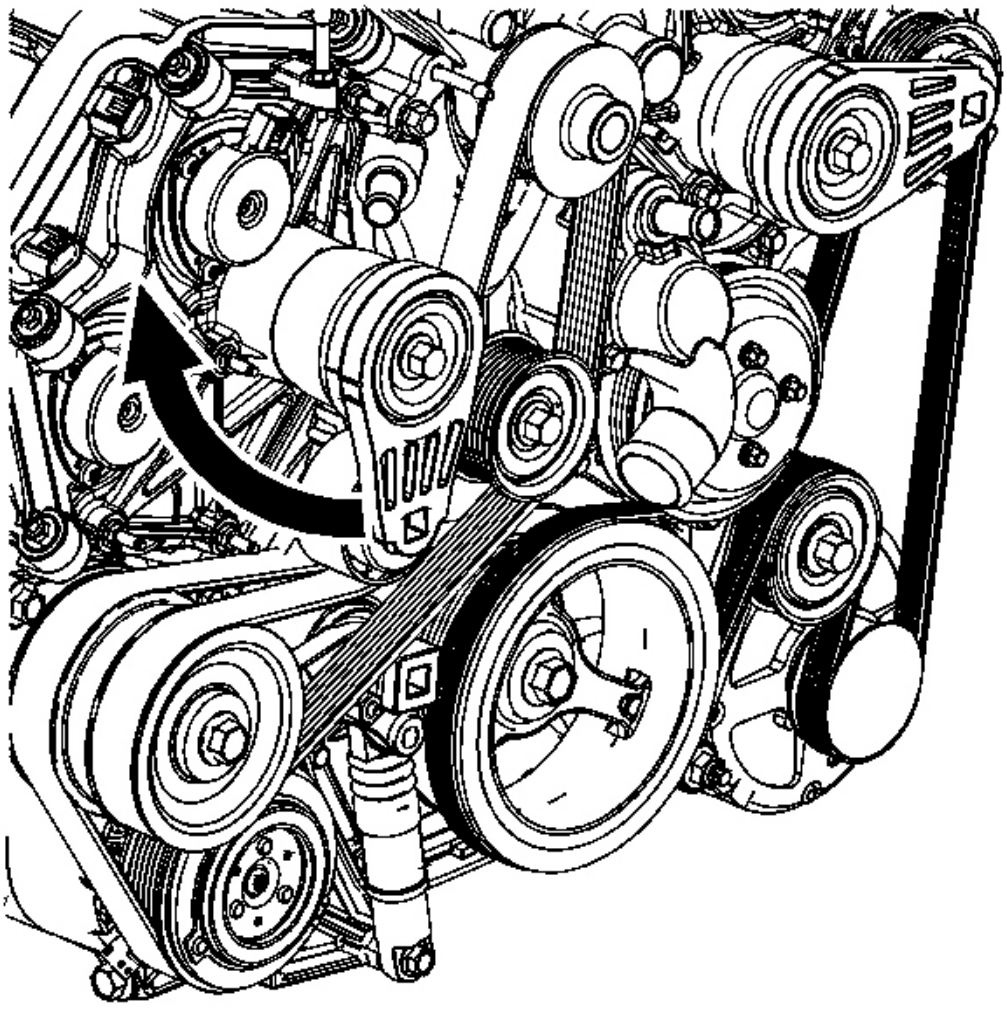


Fig. 251: View Of Supercharger Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

5. Insert a 1/2 inch drive breaker bar into the supercharger drive belt tensioner.
6. Rotate the breaker bar clockwise to release the tension.
7. Remove the supercharger drive belt from the supercharger pulley.
8. Slowly return the supercharger drive belt tensioner to the original position.

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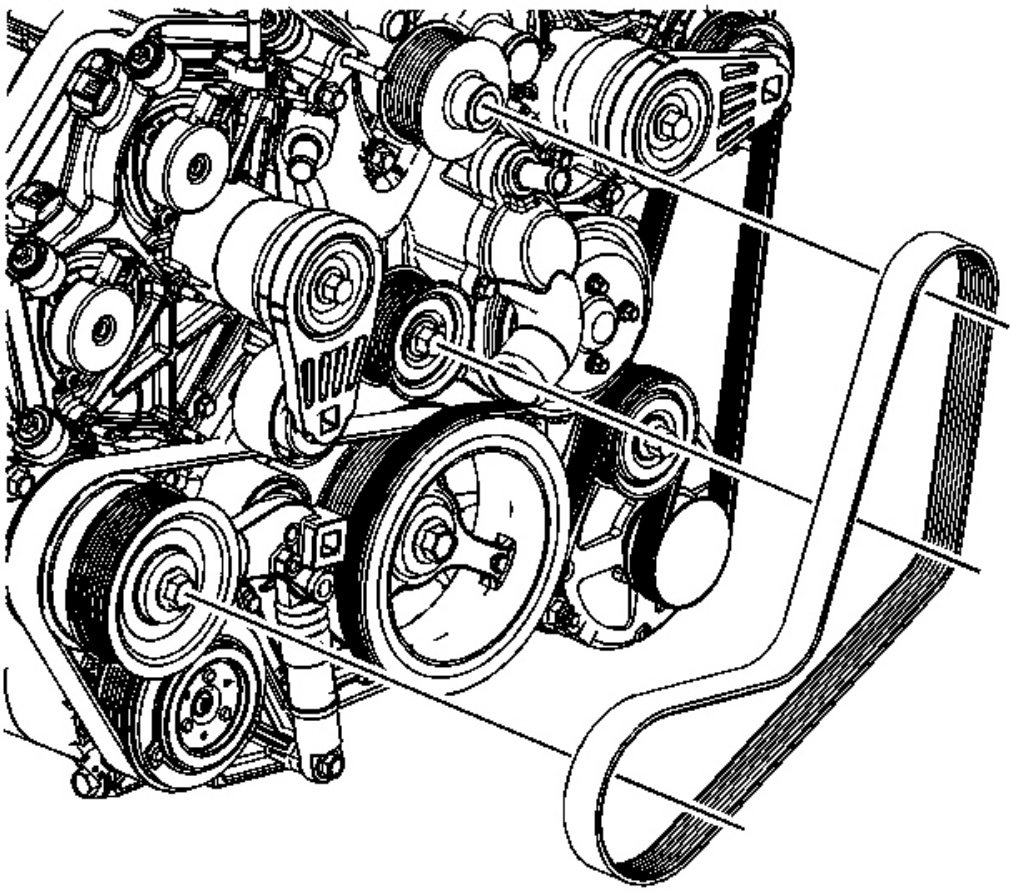


Fig. 252: View Of Supercharger Drive Belt
Courtesy of GENERAL MOTORS CORP.

9. Remove the supercharger drive belt.

GENERATOR AND WATER PUMP

Automotive-Manual.net

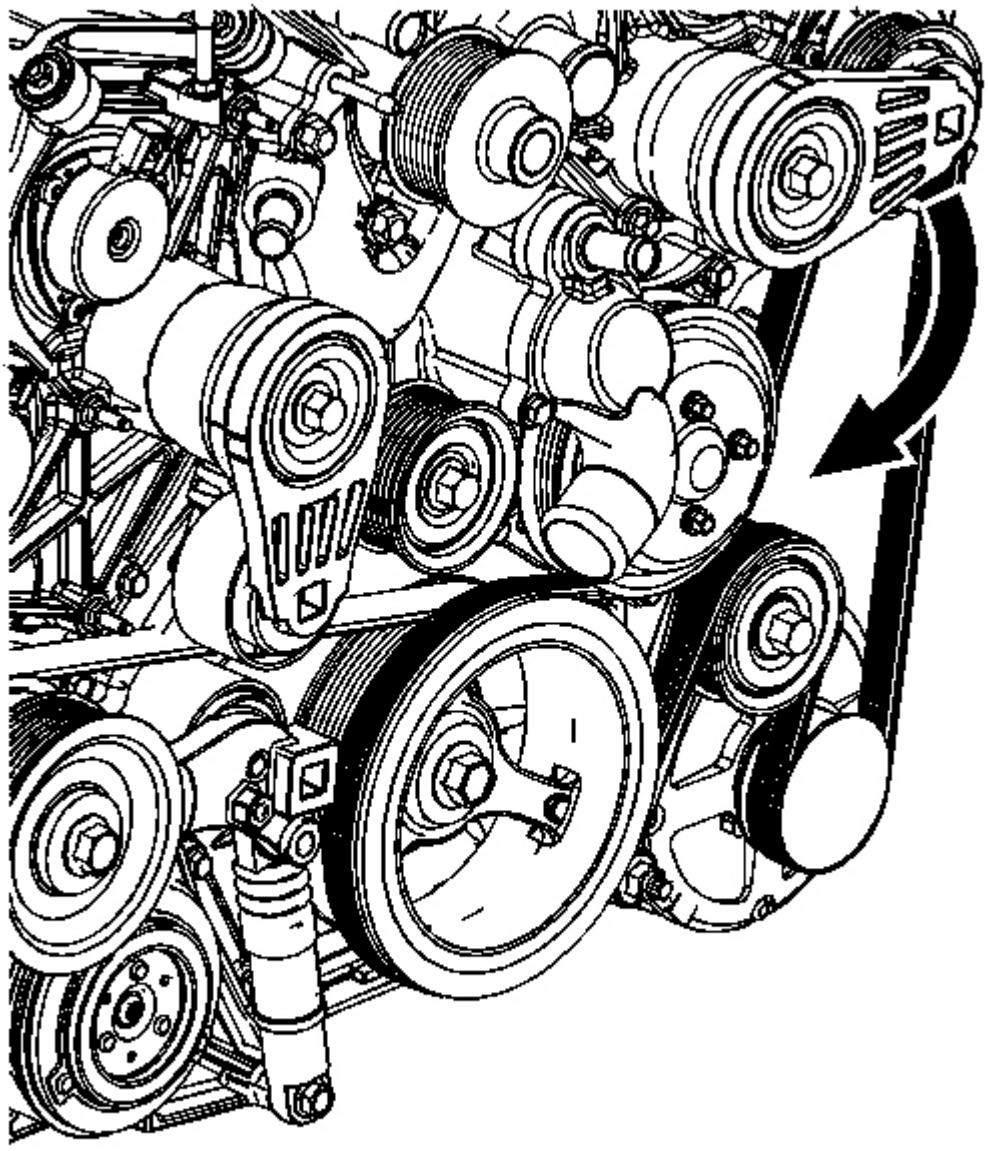


Fig. 253: View Of Generator And Water Pump Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Insert a 1/2 inch drive breaker bar into the generator and water pump drive belt tensioner.
2. Rotate the breaker bar clockwise to release the tension.

Automotive-Manual.net

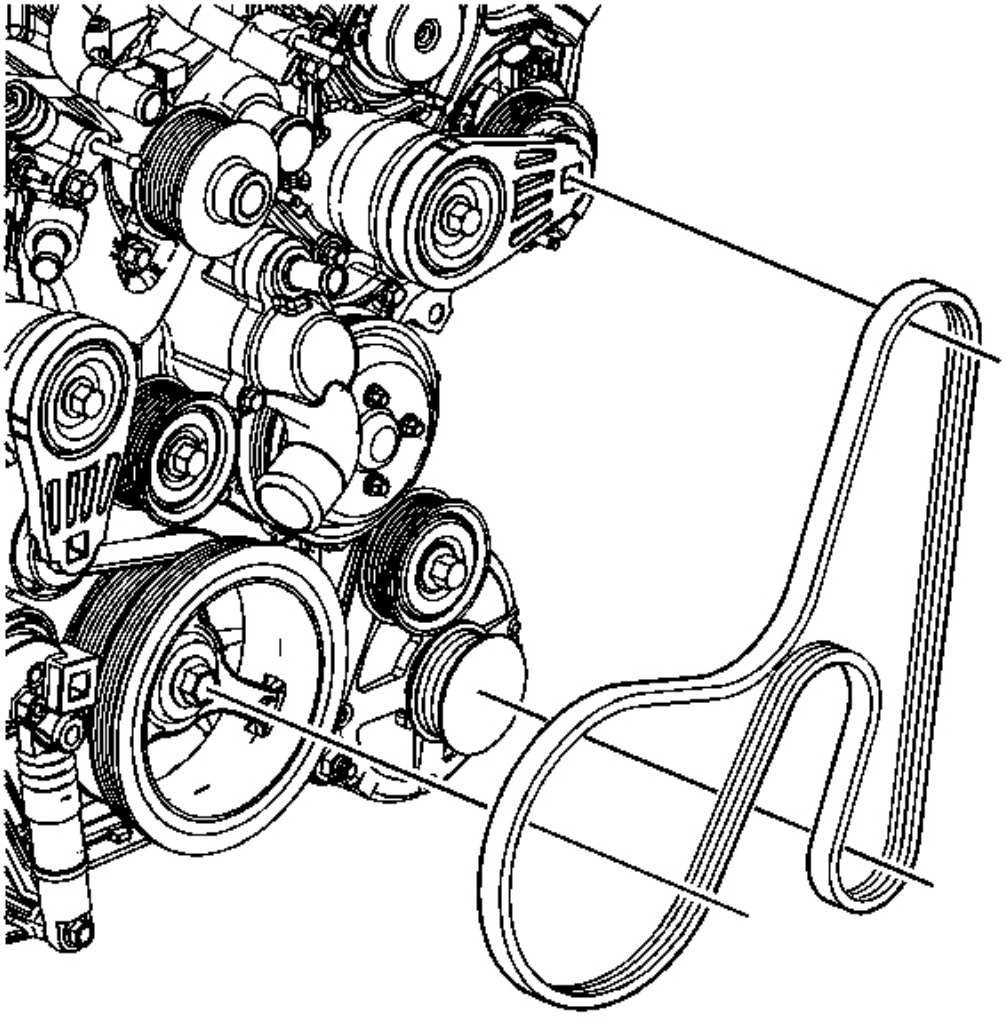


Fig. 254: View Of Generator And Water Pump Drive Belt
Courtesy of GENERAL MOTORS CORP.

3. Remove the generator and water pump drive belt from the generator pulley.
4. Slowly return the generator and water pump drive belt tensioner to the original position.
5. Remove the generator and water pump drive belt.

A/C COMPRESSOR AND POWER STEERING PUMP

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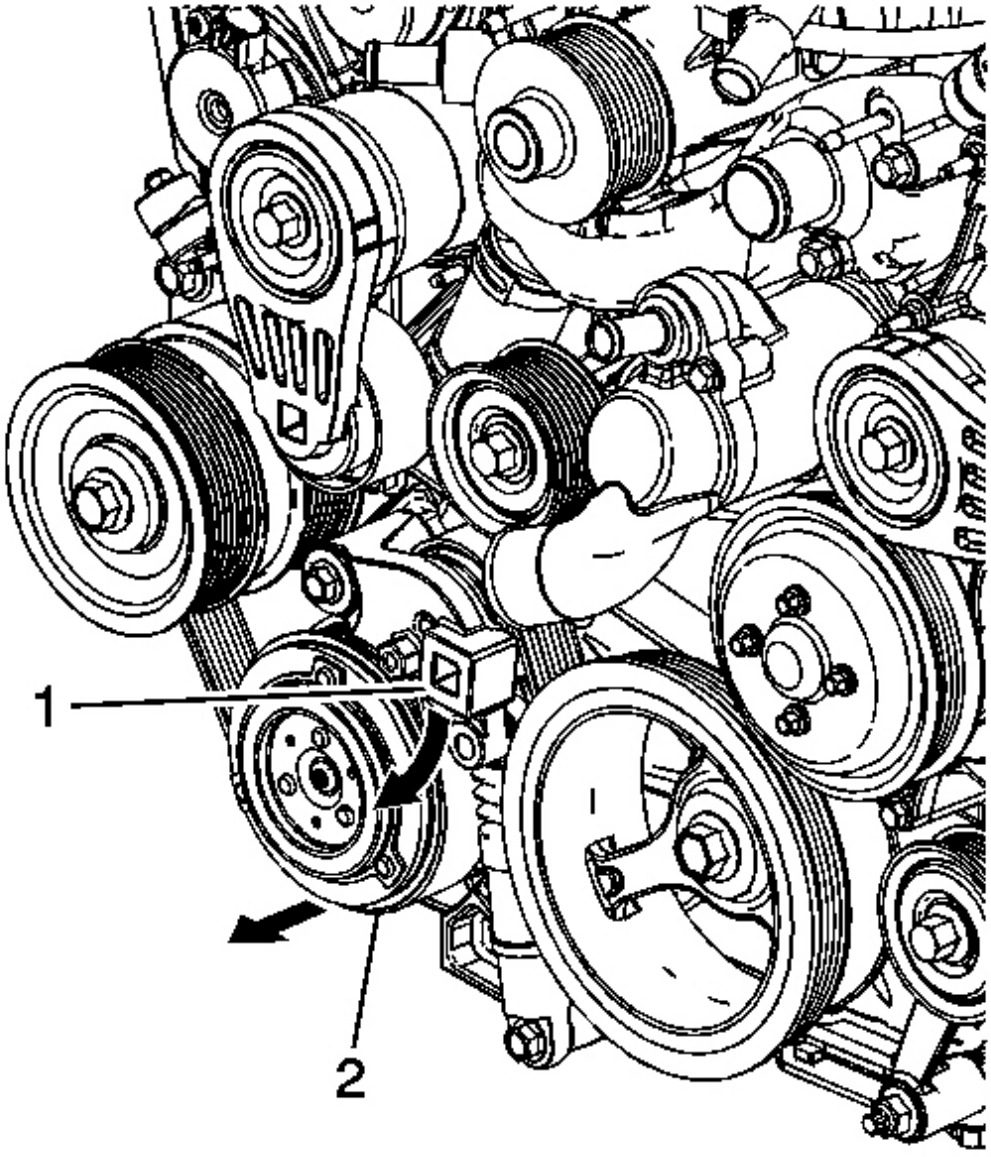


Fig. 255: View Of A/C Compressor And Power Steering Pump Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Insert a 1/2 inch drive breaker bar into the A/C compressor and power steering pump drive belt tensioner.
2. Rotate the breaker bar clockwise to release the tension (1).
3. Remove the A/C compressor and power steering pump drive belt from the A/C compressor pulley (2).

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4. Slowly return the A/C compressor and power steering pump drive belt tensioner to the original position.

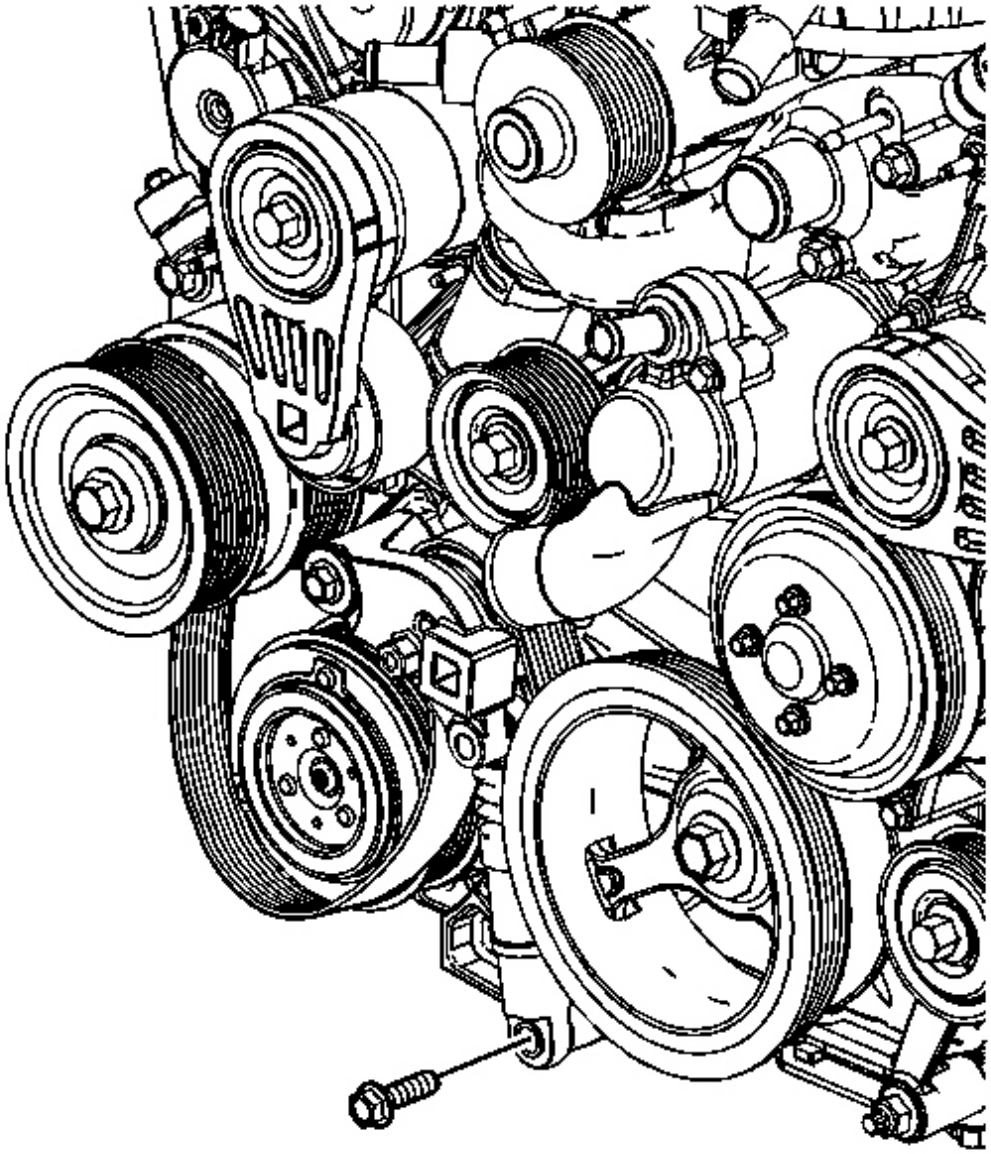


Fig. 256: Identifying A/C Compressor & Power Steering Pump Tensioner Lower Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the A/C compressor and power steering pump tensioner lower bolt.

Automotive-Manual.net

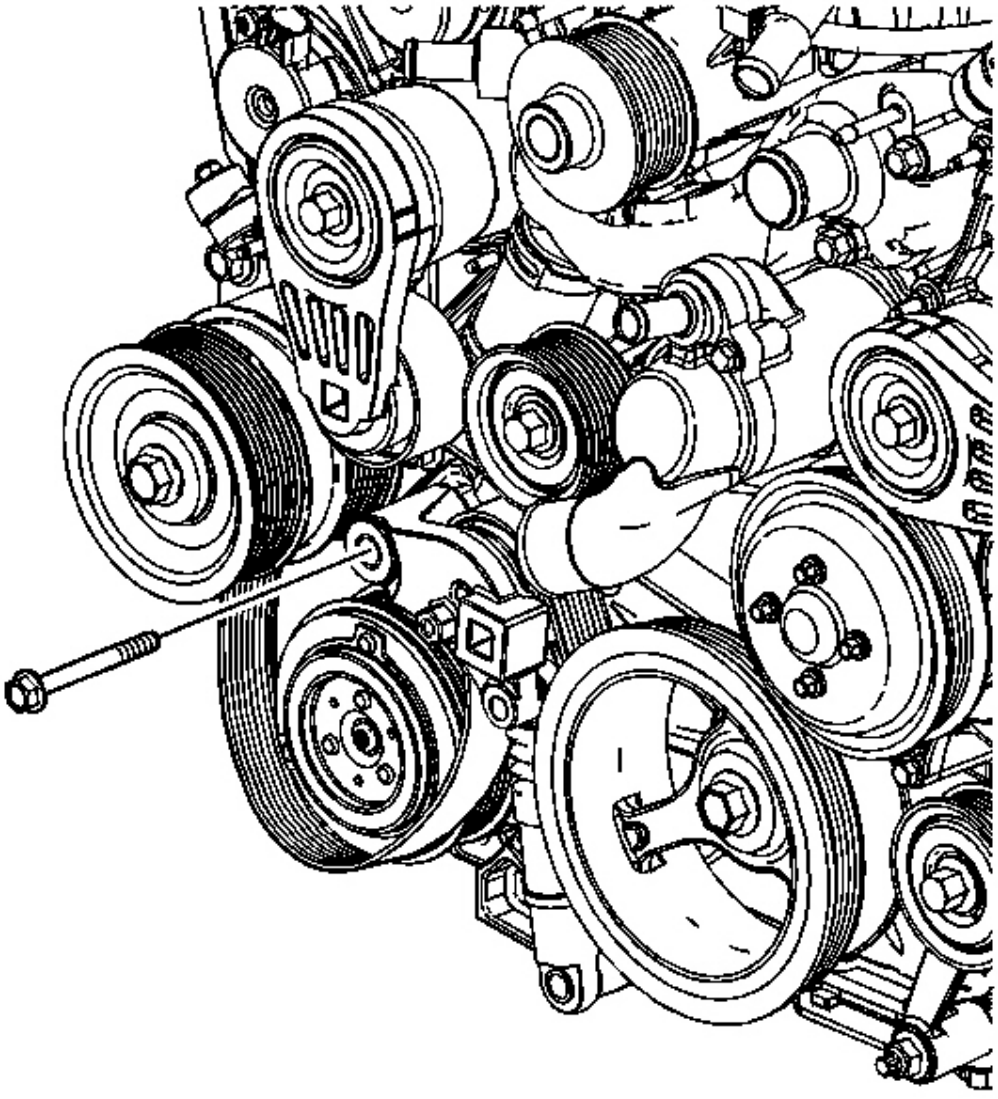


Fig. 257: Identifying A/C Compressor & Power Steering Pump Tensioner Upper Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the A/C compressor and power steering pump tensioner upper bolt.

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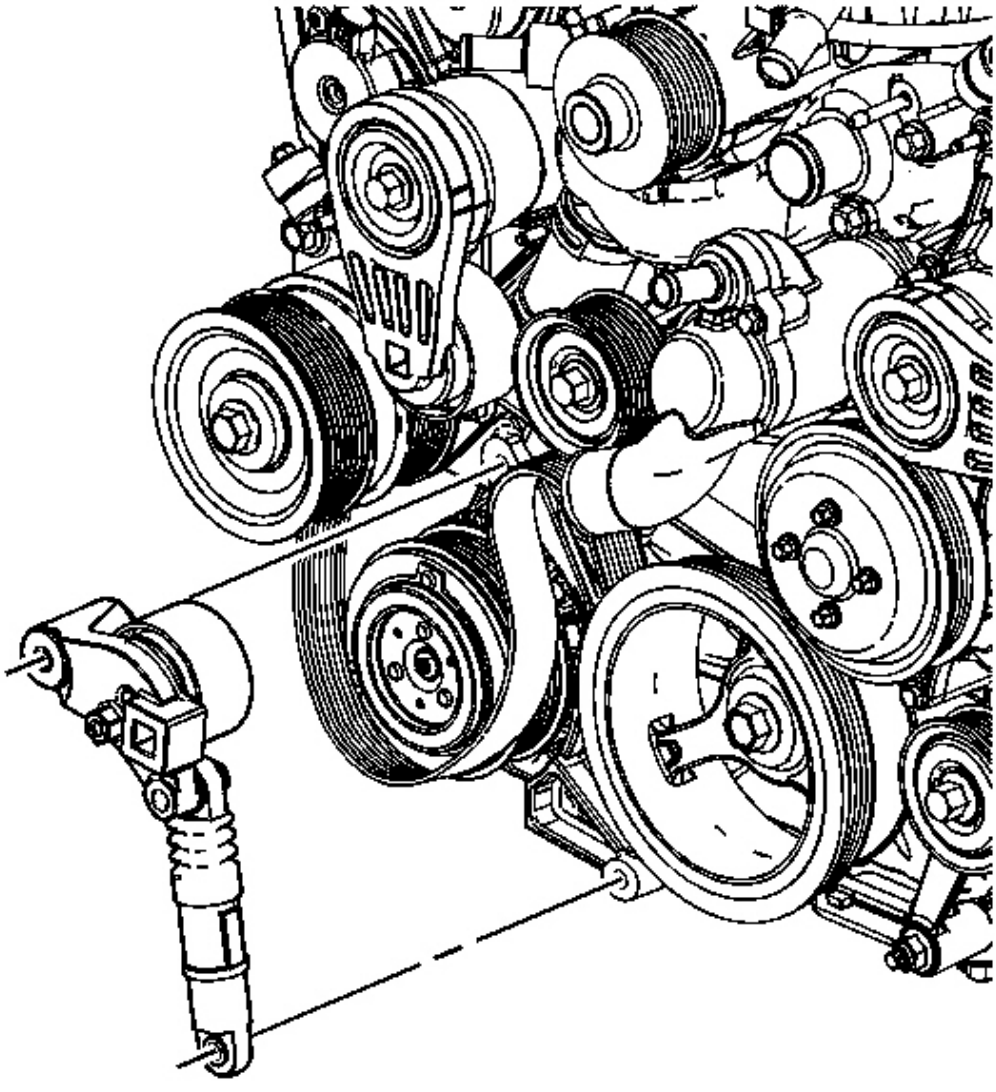


Fig. 258: Identifying A/C Compressor & Power Steering Pump Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Remove the A/C compressor and power steering pump tensioner.

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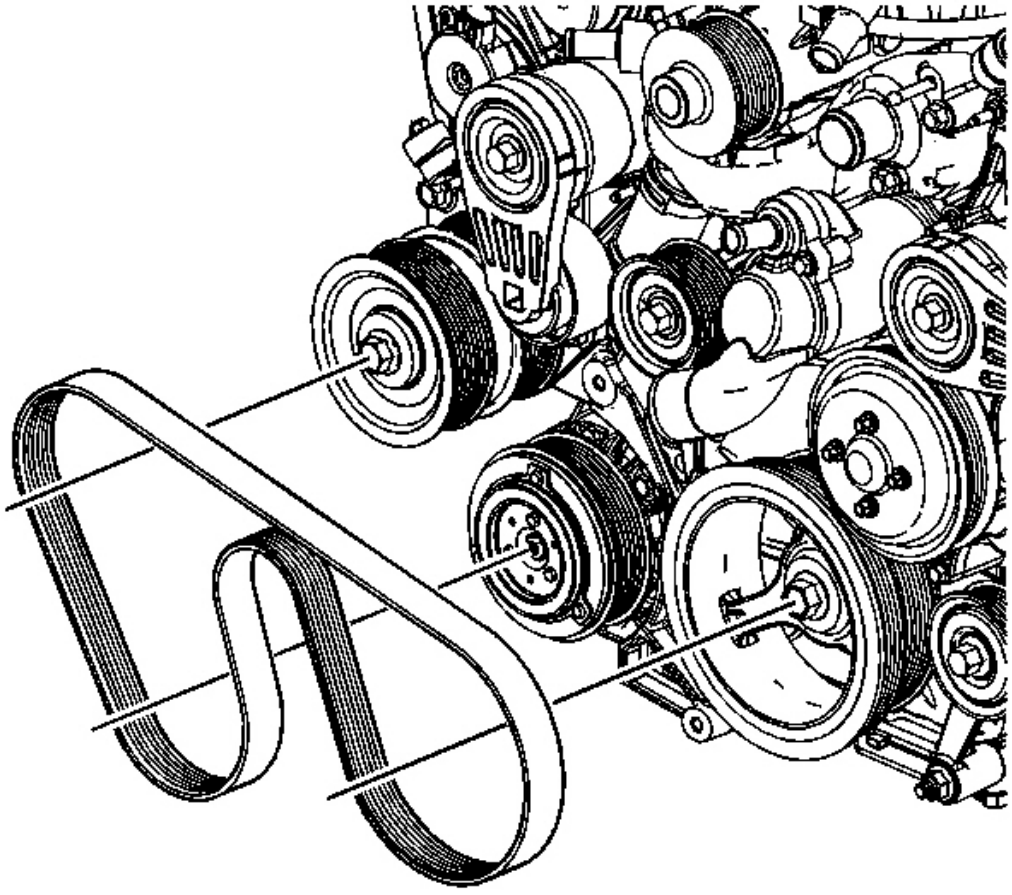


Fig. 259: View Of A/C Compressor & Power Steering Pump Drive Belt
Courtesy of GENERAL MOTORS CORP.

8. Remove the A/C compressor and power steering pump drive belt.

DRIVE BELT TENSIONER REMOVAL

SUPERCHARGER

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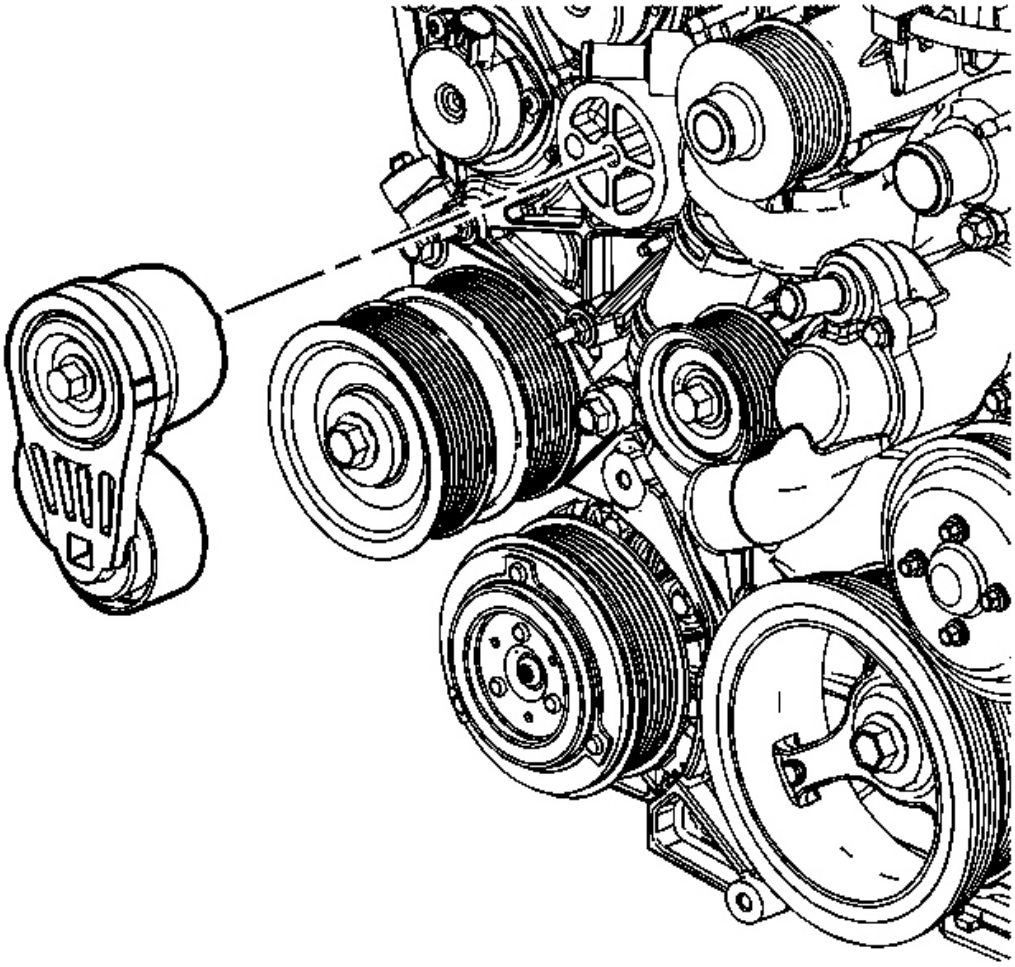


Fig. 260: View Of Outer Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the outer drive belt tensioner bolt.
2. Remove the outer drive belt tensioner.

GENERATOR AND WATER PUMP

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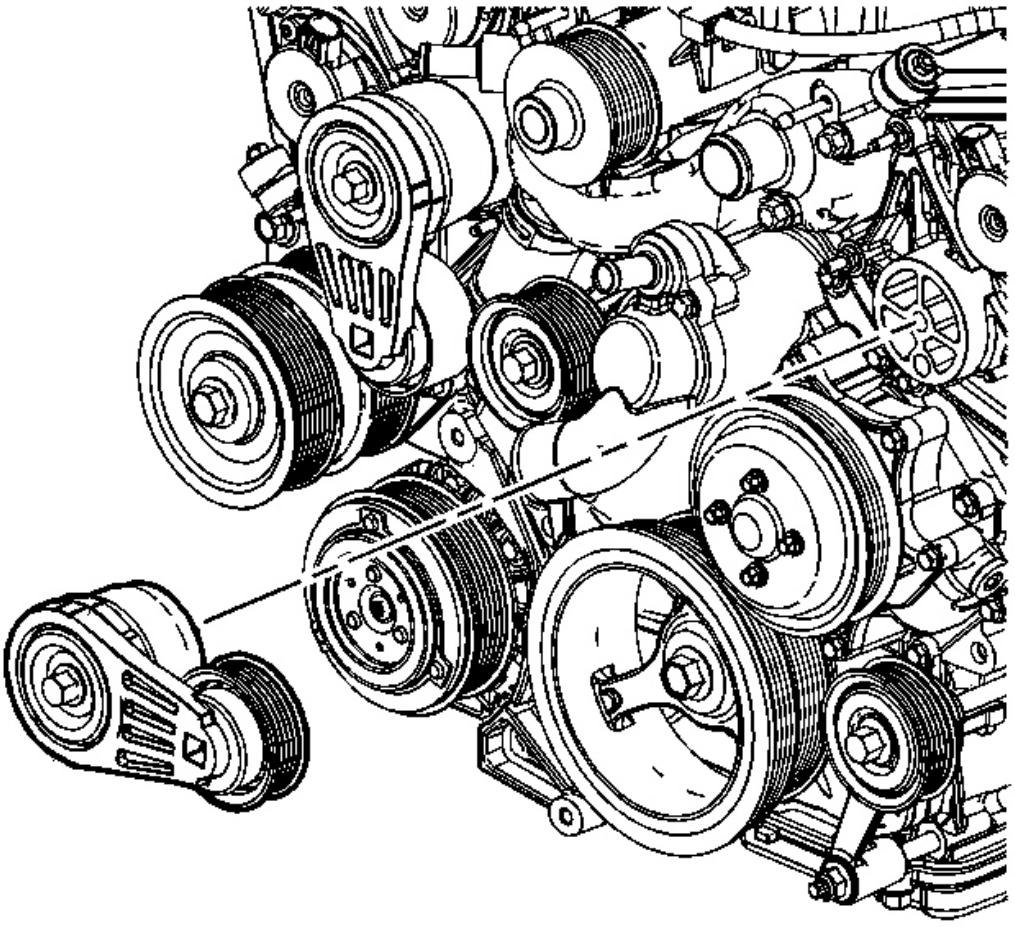


Fig. 261: View Of Inner Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the inner drive belt tensioner bolt.
2. Remove the inner drive belt tensioner.

A/C COMPRESSOR AND POWER STEERING PUMP

Refer to the A/C Compressor and Power Steering Pump Drive Belt Removal in the **Drive Belt Removal**.

DRIVE BELT IDLER PULLEY REMOVAL

SUPERCHARGER

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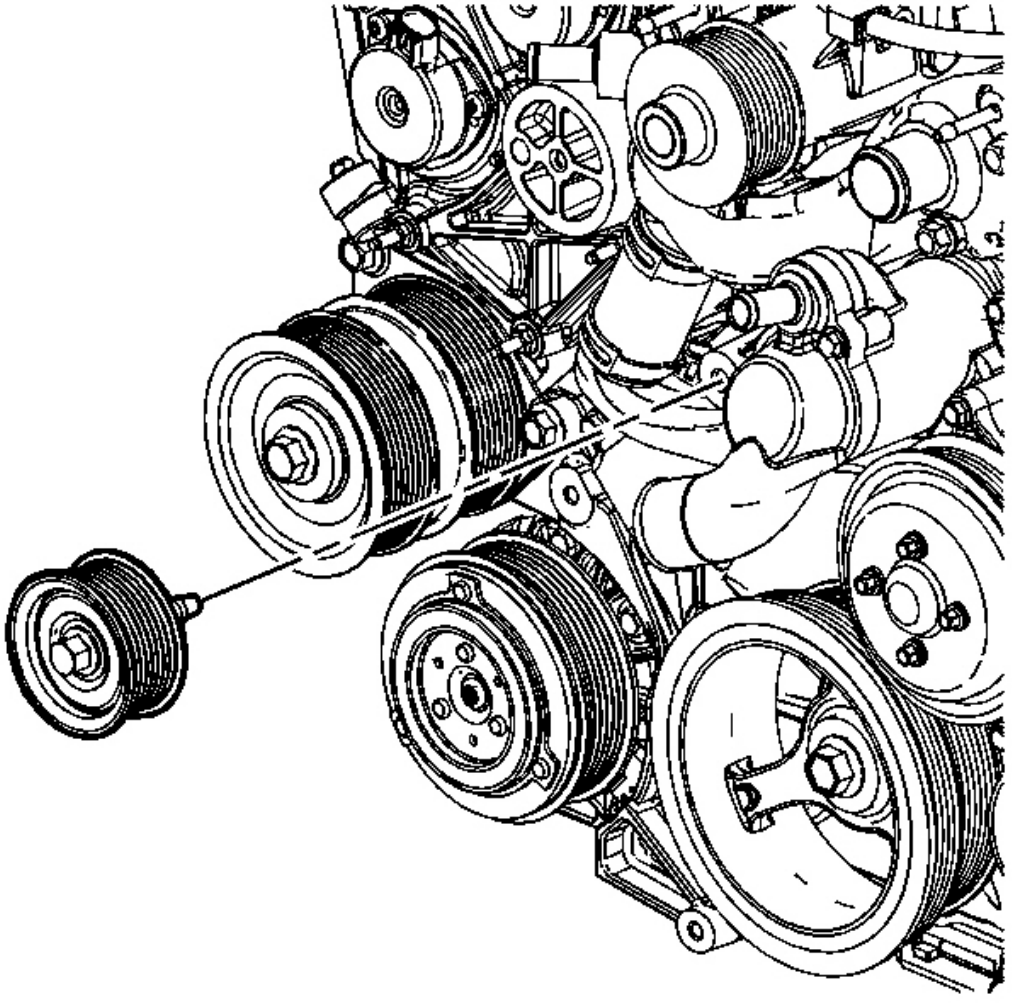


Fig. 262: Identifying Supercharger Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Loosen the supercharger drive belt idler pulley bolt.
2. Remove the supercharger drive belt idler pulley.

GENERATOR AND WATER PUMP

Refer to **Generator Removal**.

GENERATOR REMOVAL

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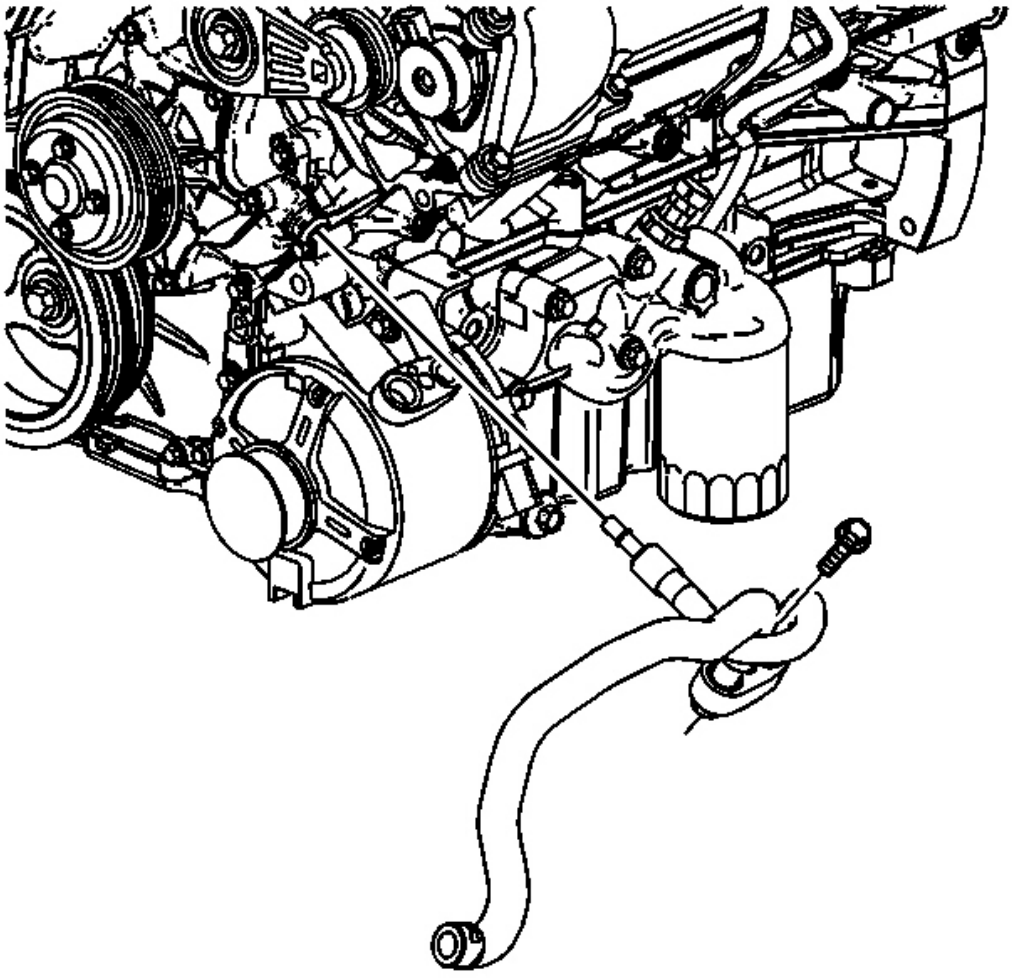


Fig. 263: View Of Generator Coolant Hose Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolt from the generator coolant hose assembly on the generator.
2. Remove the generator coolant hose assembly from the generator port.
3. Disconnect the generator coolant hose from the fitting in the engine front cover.
4. Remove the generator coolant hose assembly.

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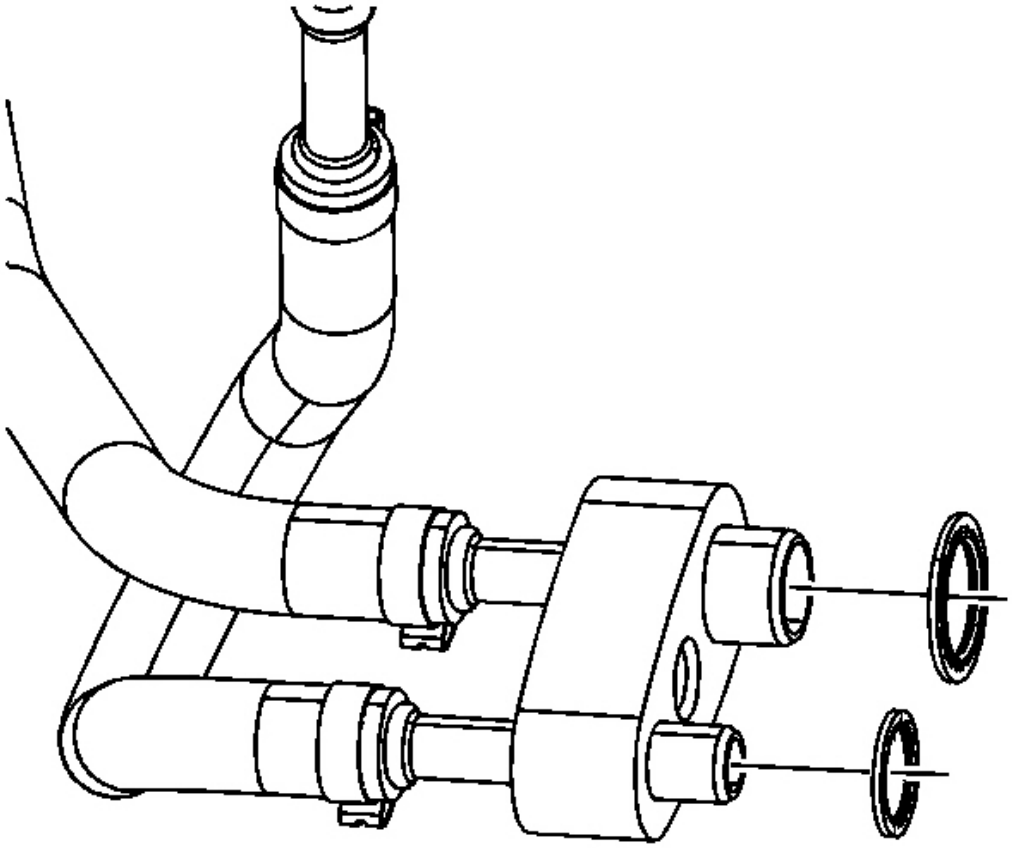


Fig. 264: View Of Generator Coolant Hose Sealing Rings
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the generator coolant hose sealing rings.

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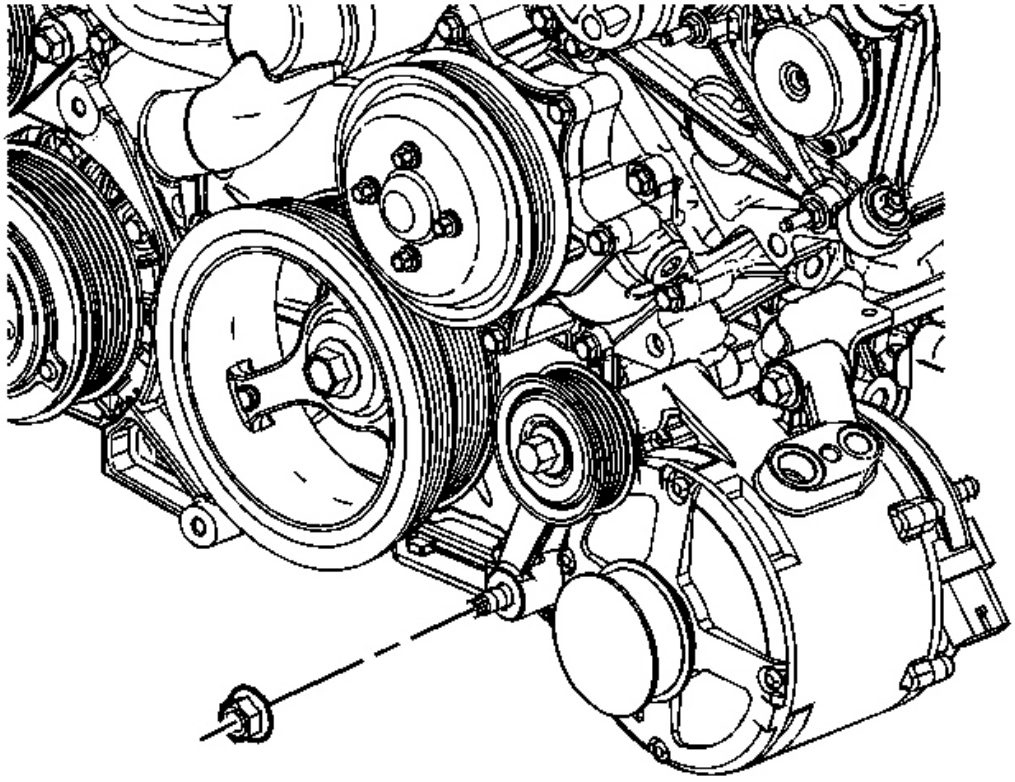


Fig. 265: Identifying Generator/Drive Belt Idler Pulley Mounting Stud Nut
Courtesy of GENERAL MOTORS CORP.

6. Remove the generator drive belt idler pulley bracket nut.

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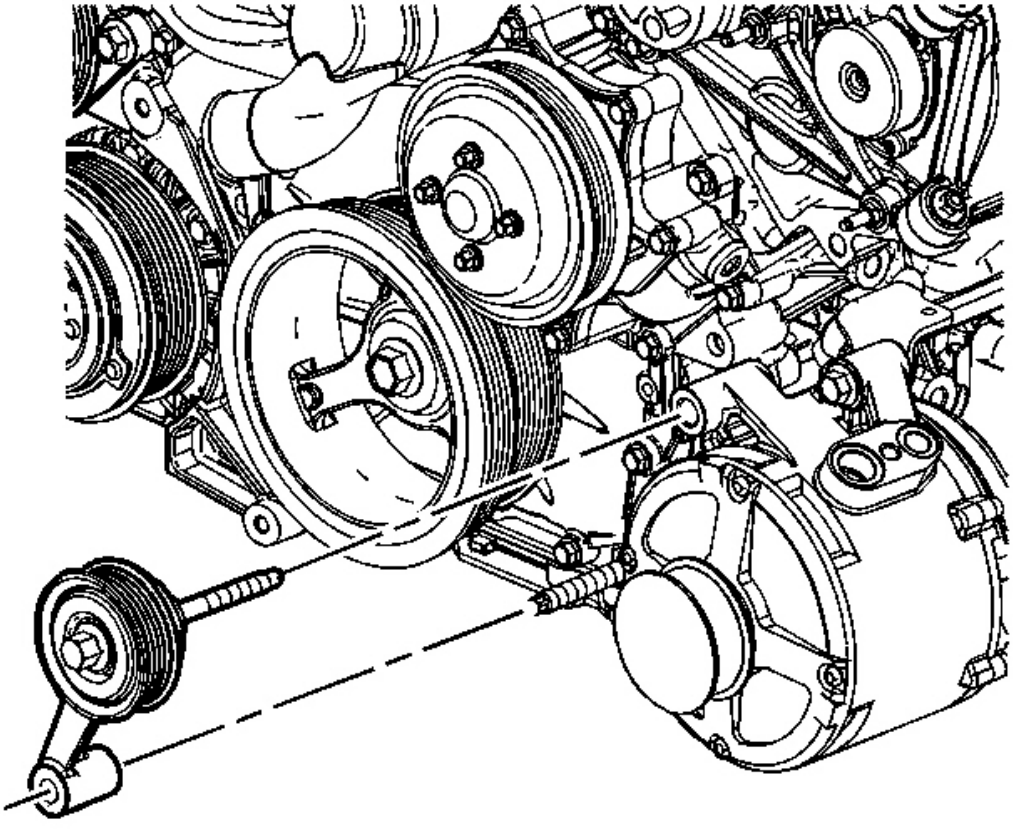


Fig. 266: Identifying Drive Belt Idler Pulley, Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

7. Loosen the generator/drive belt idler pulley bolt.
8. Remove the generator/drive belt idler pulley and bracket.

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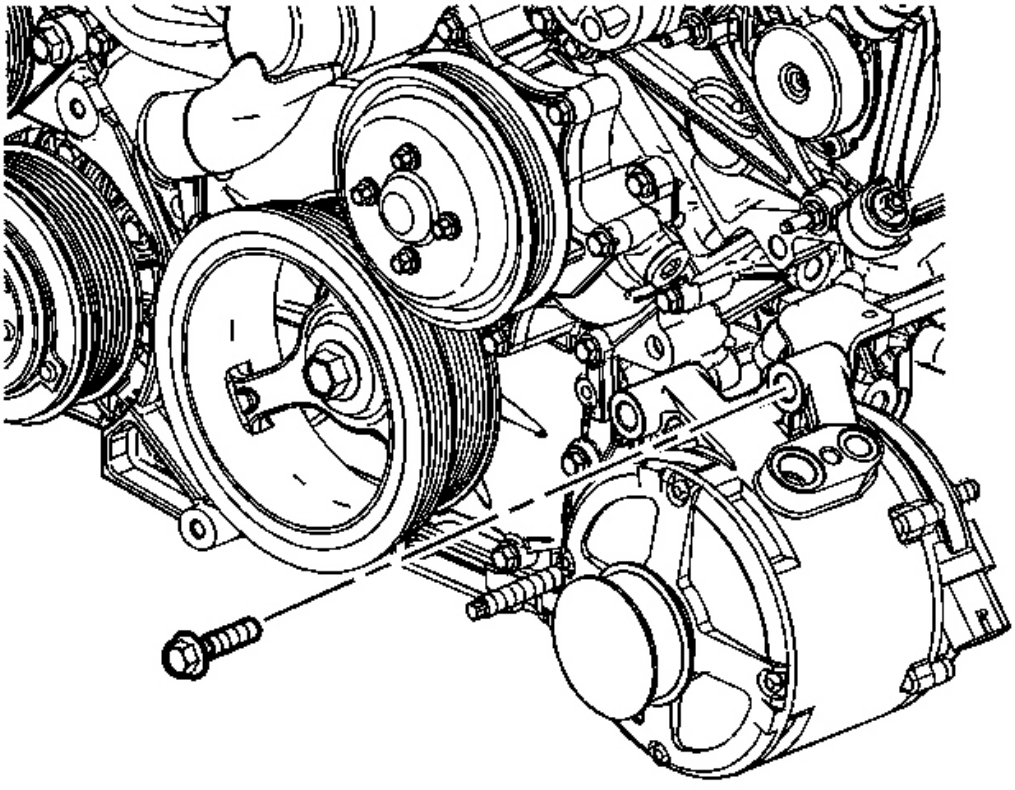


Fig. 267: Identifying Upper Front Generator Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper front generator bolt.

Automotive-Manual.net

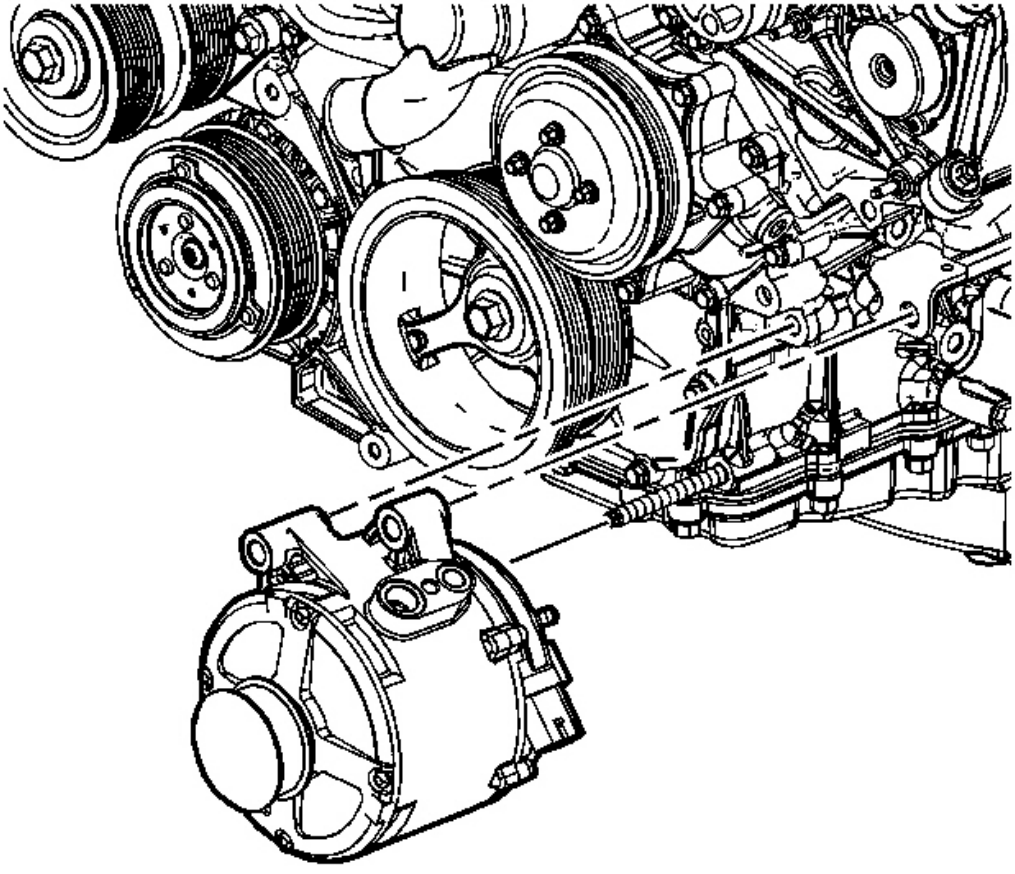


Fig. 268: View Of Generator
Courtesy of GENERAL MOTORS CORP.

10. Remove the generator.

Automotive-Manual.net

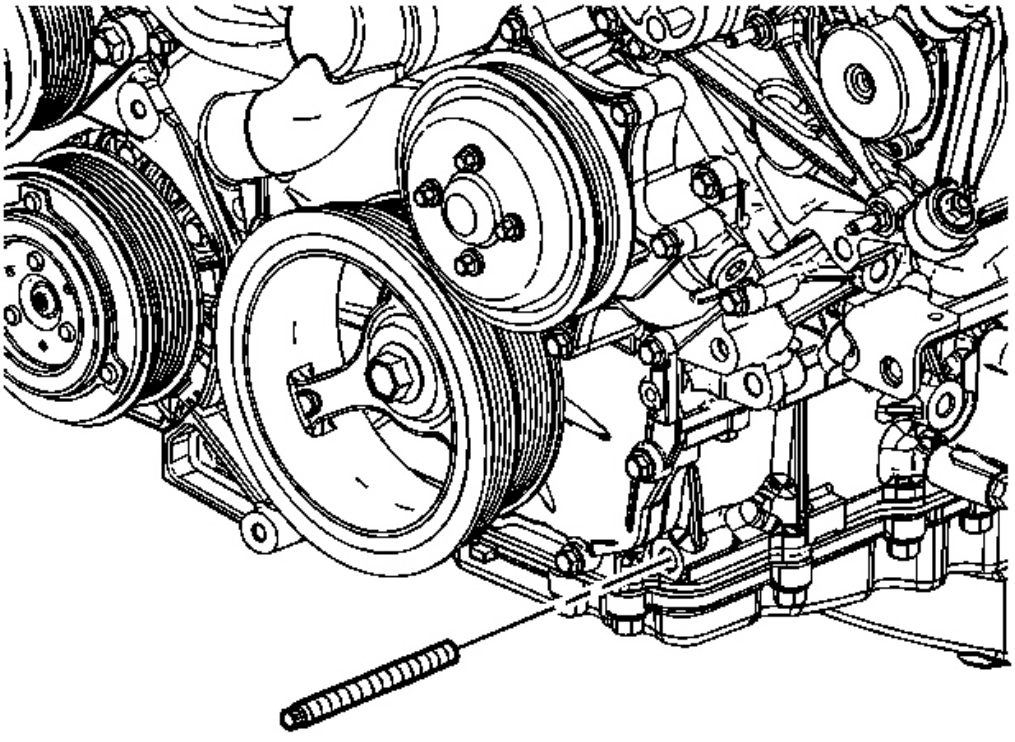


Fig. 269: Identifying Generator/Drive Belt Idler Pulley Mounting Stud
Courtesy of GENERAL MOTORS CORP.

11. Remove the generator/drive belt idler pulley mounting stud from the engine block.

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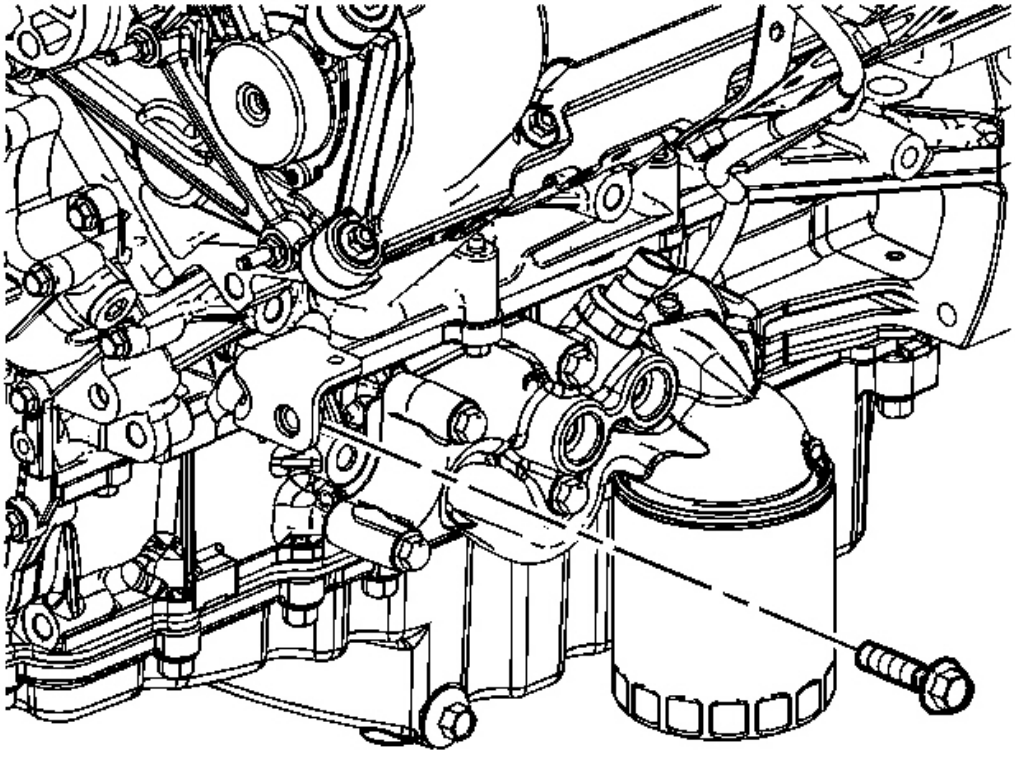


Fig. 270: Identifying Generator Rear Brace Bolt
Courtesy of GENERAL MOTORS CORP.

12. Remove the generator rear brace bolt.

Automotive-Manual.net

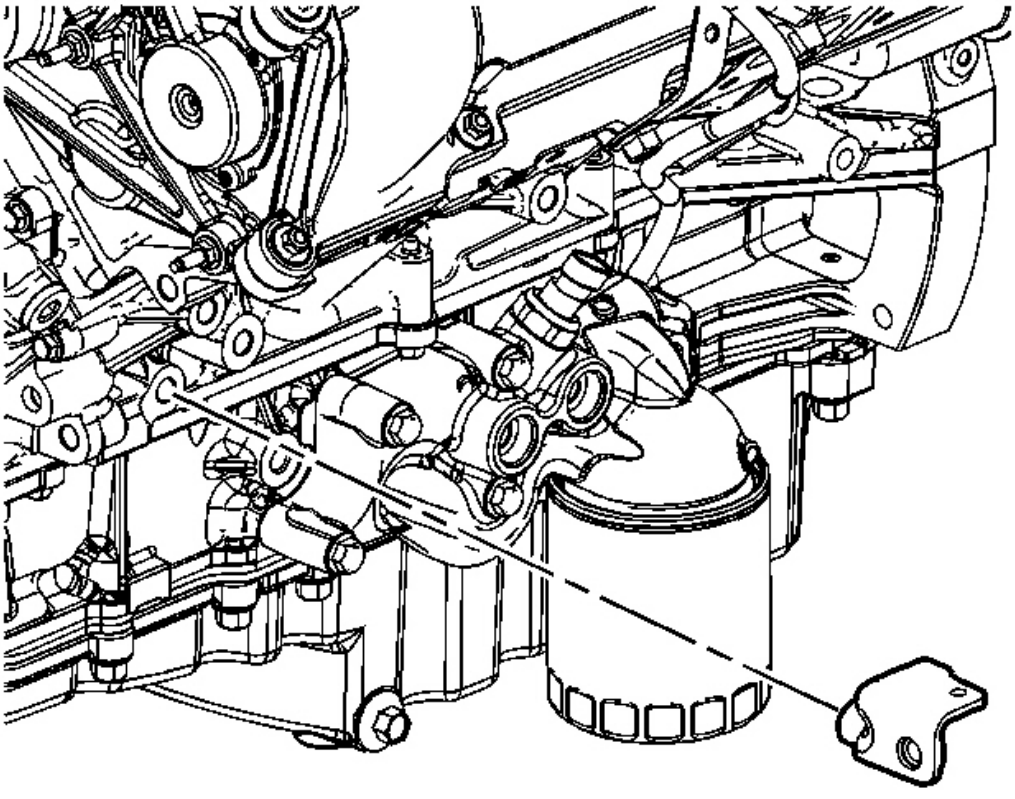


Fig. 271: Identifying Generator Rear Brace
Courtesy of GENERAL MOTORS CORP.

13. Remove the generator rear brace.

POWER STEERING PUMP REMOVAL

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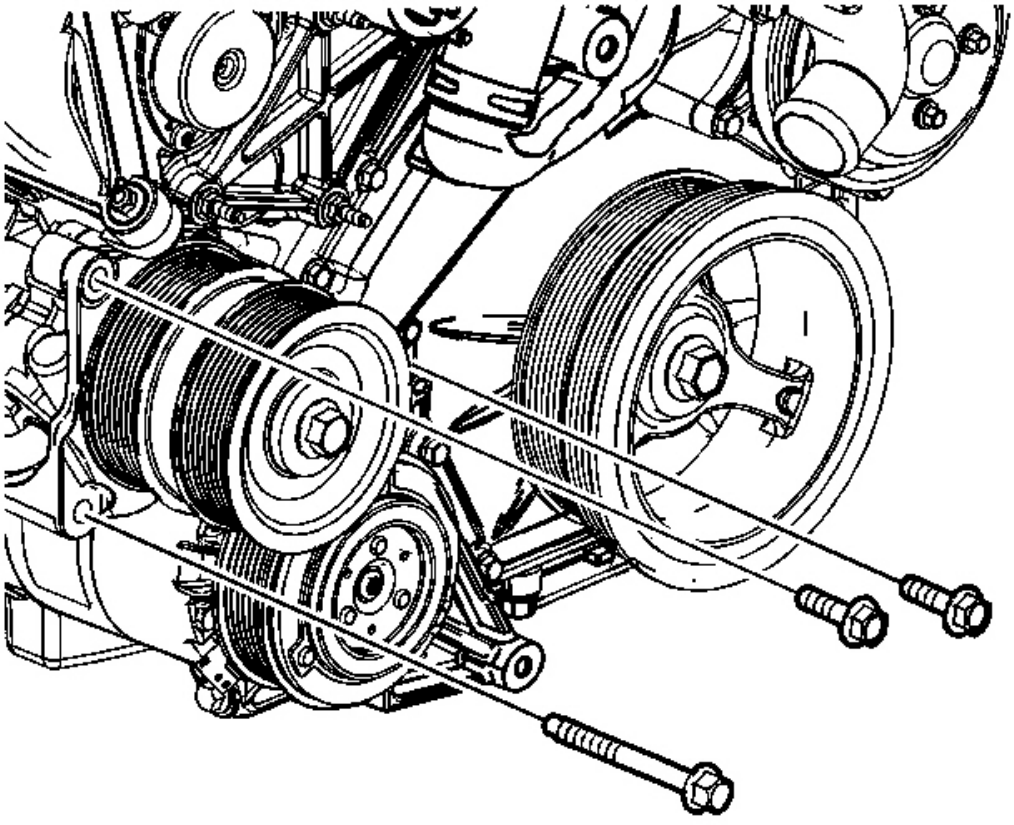


Fig. 272: Power Steering Pump Pulley Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the power steering pump pulley bolts.

Automotive-Manual.net

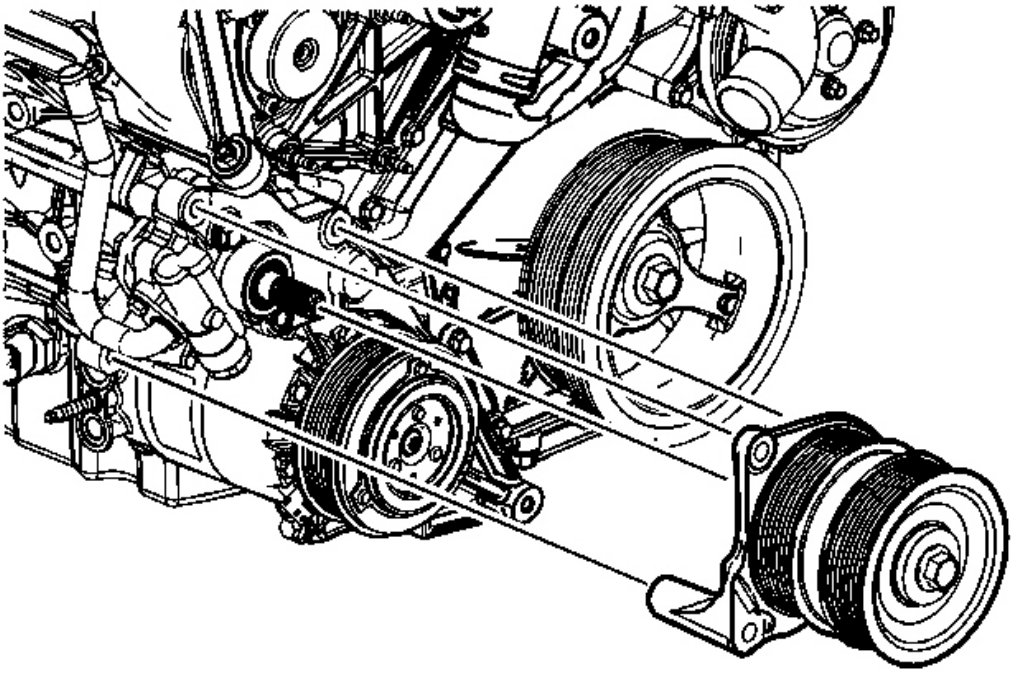


Fig. 273: Identifying Power Steering Pump Pulley
Courtesy of GENERAL MOTORS CORP.

2. Remove the power steering pump pulley.

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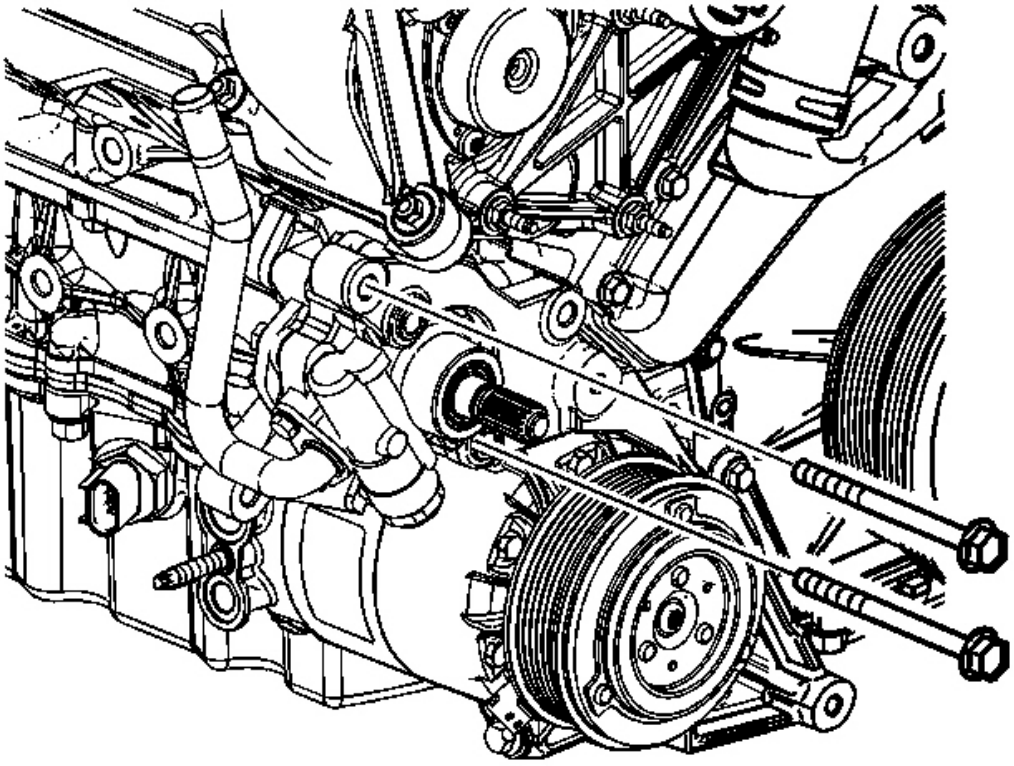


Fig. 274: Identifying Power Steering Pump Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the power steering pump bolts.

Automotive-Manual.net

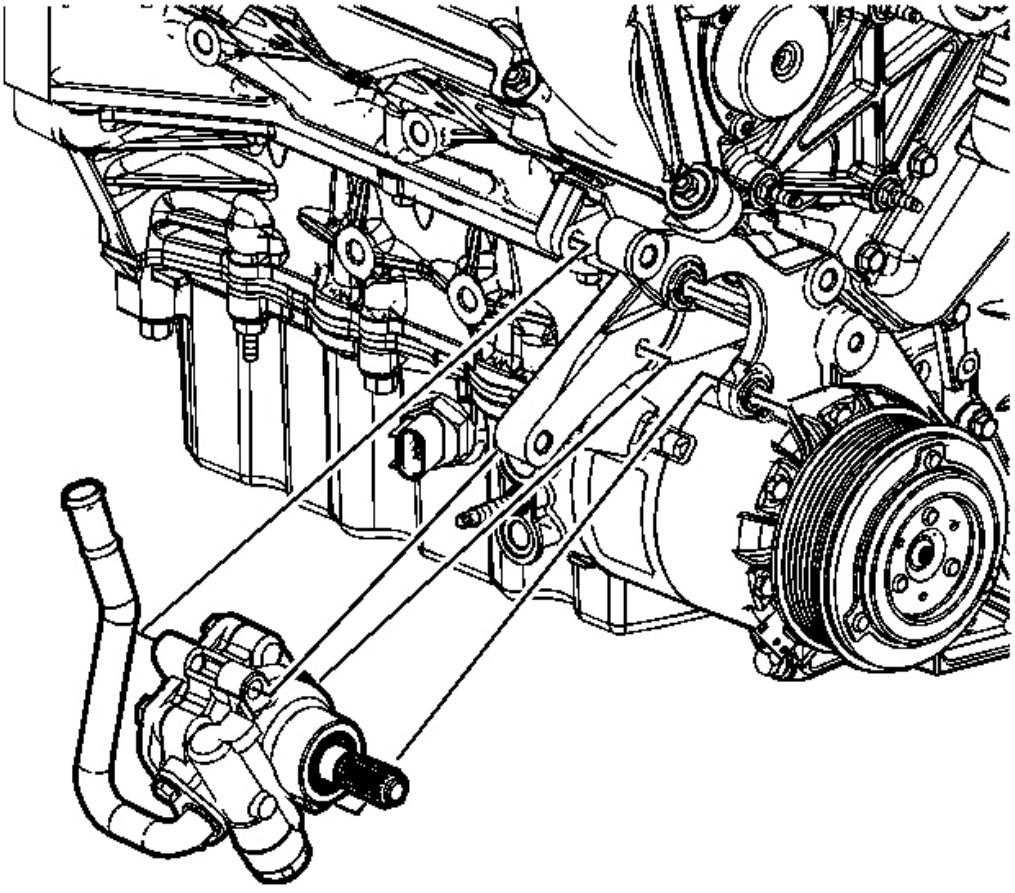


Fig. 275: View Of Power Steering Pump Placement
Courtesy of GENERAL MOTORS CORP.

4. Remove the power steering pump.

AIR CONDITIONING (A/C) COMPRESSOR REMOVAL

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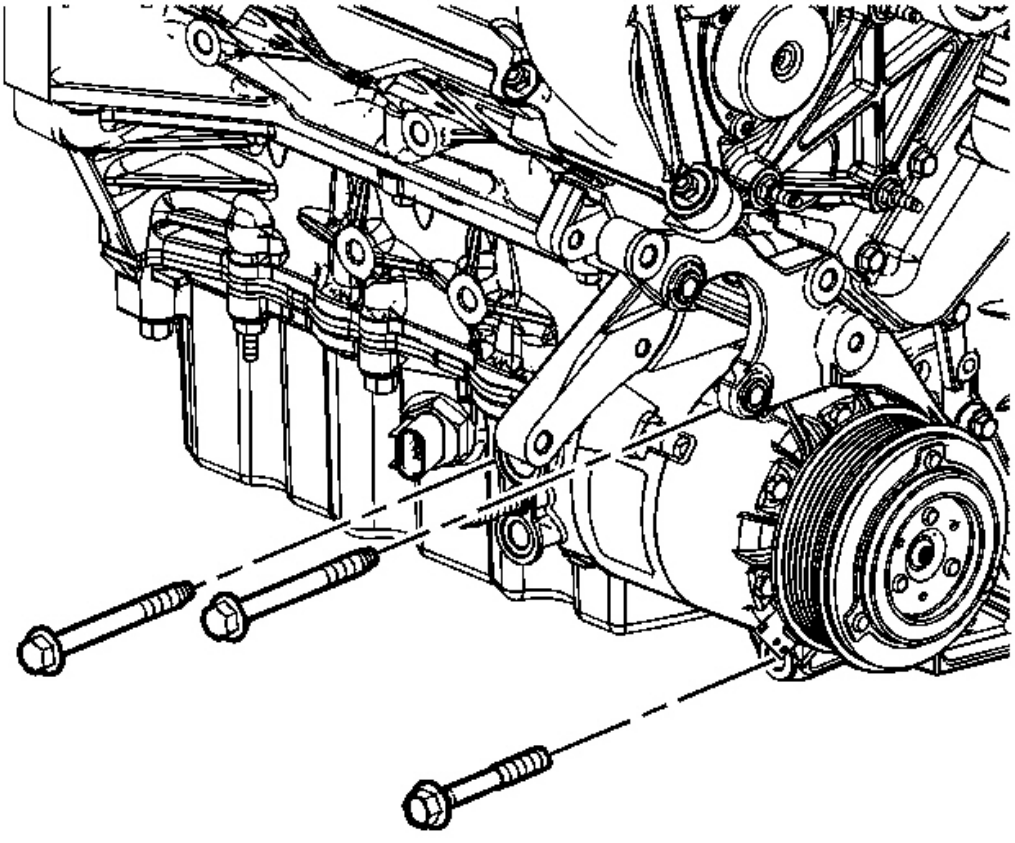


Fig. 276: View Of A/C Compressor Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the A/C compressor bolts.

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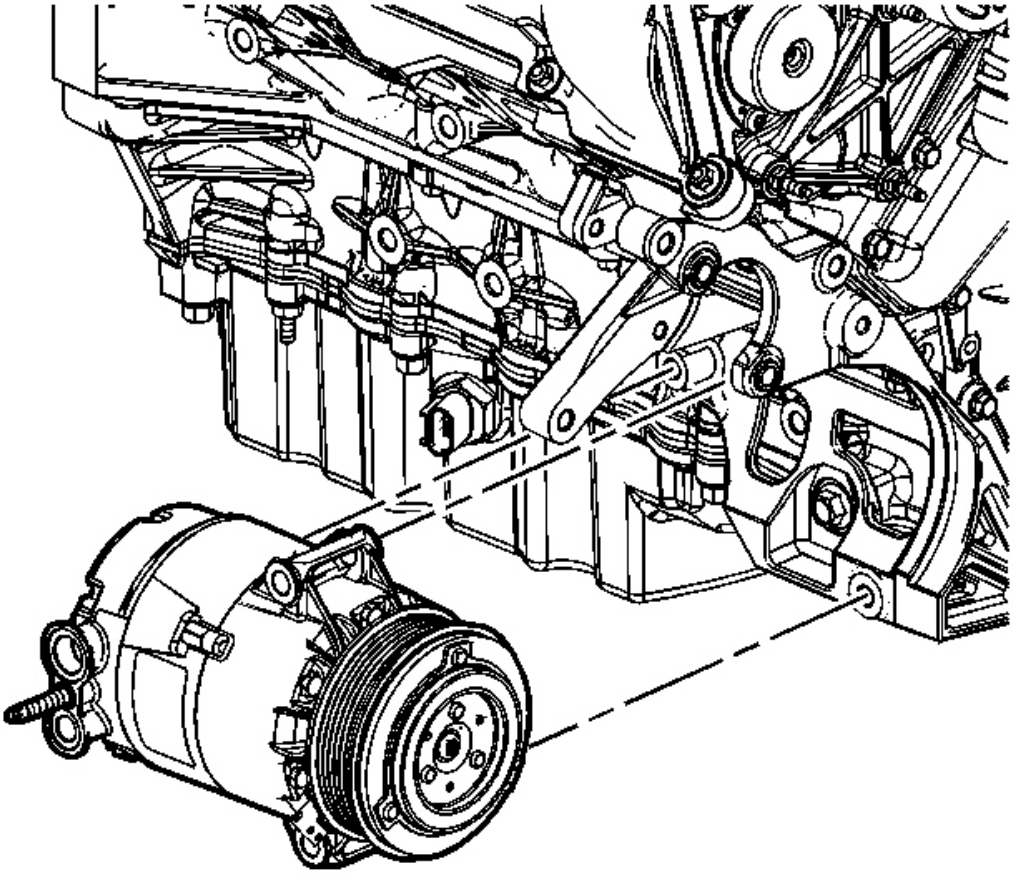


Fig. 277: View Of A/C Compressor
Courtesy of GENERAL MOTORS CORP.

2. Remove the A/C compressor.

Automotive-Manual.net

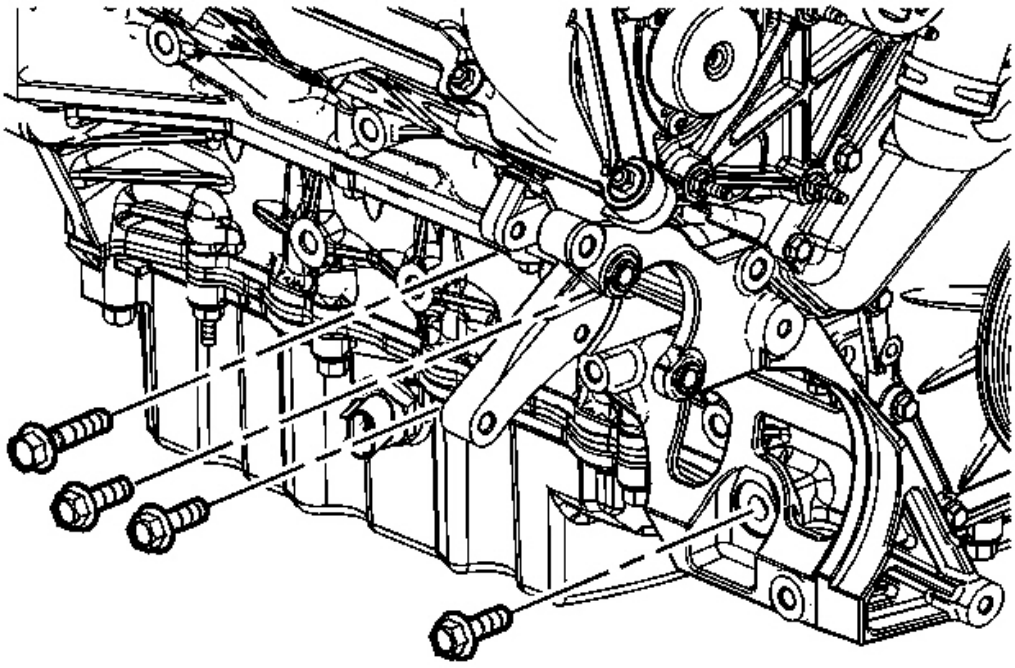


Fig. 278: View Of A/C Compressor Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the A/C compressor bracket bolts.

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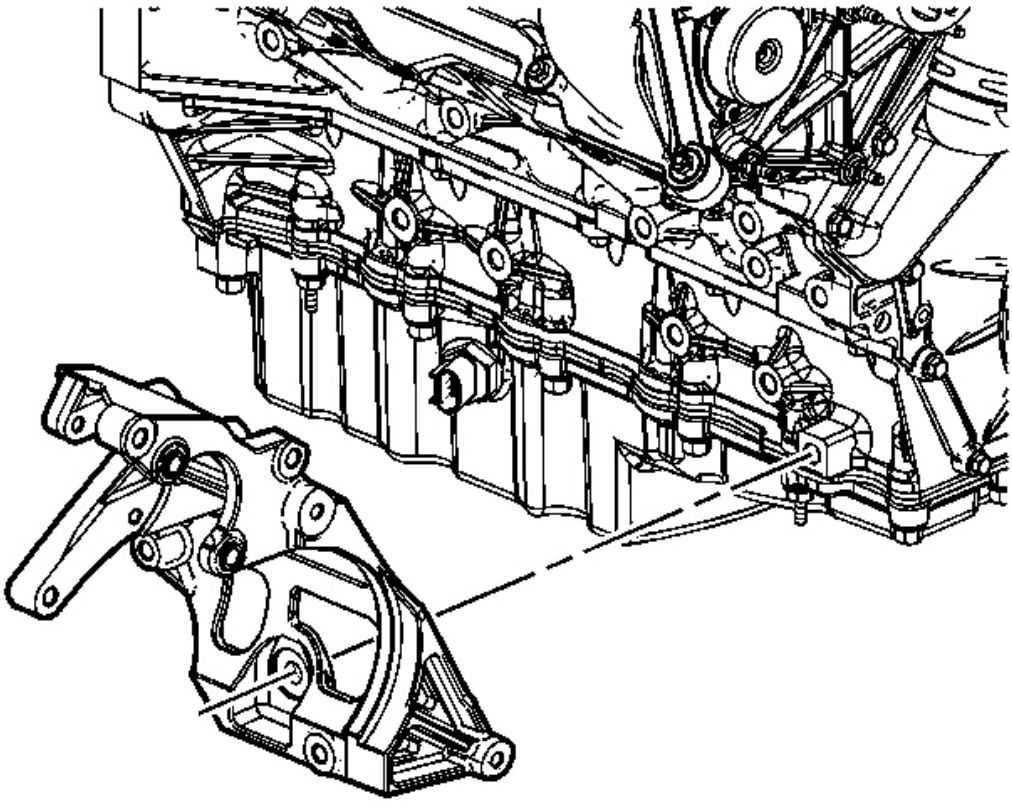


Fig. 279: Identifying A/C Compressor Bracket
Courtesy of GENERAL MOTORS CORP.

4. Remove the A/C compressor bracket.

SUPERCHARGER REMOVAL

TOOLS REQUIRED

- **EN-47748** Supercharger Lifting Fixture
- **EN-47833** Supercharger Service Holding Fixture

REMOVAL PROCEDURE

Automotive-Manual.net

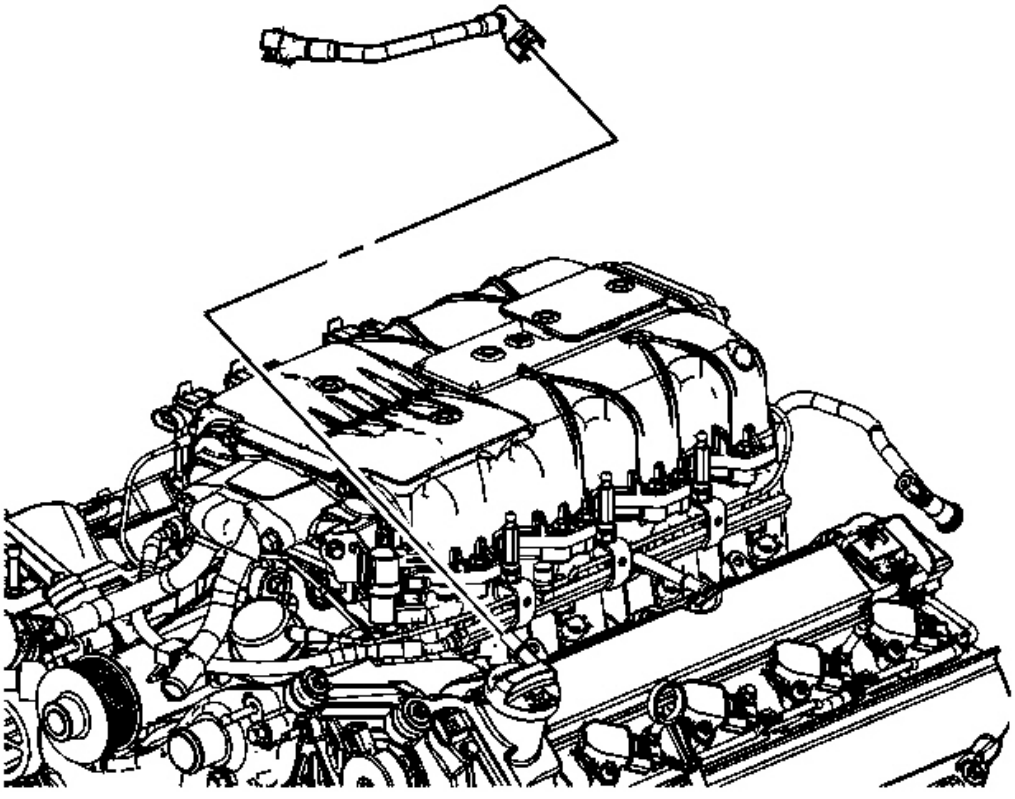


Fig. 280: Identifying PCV Clean Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Disconnect and remove the clean air positive crankcase ventilation (PCV) tube from the left camshaft cover.

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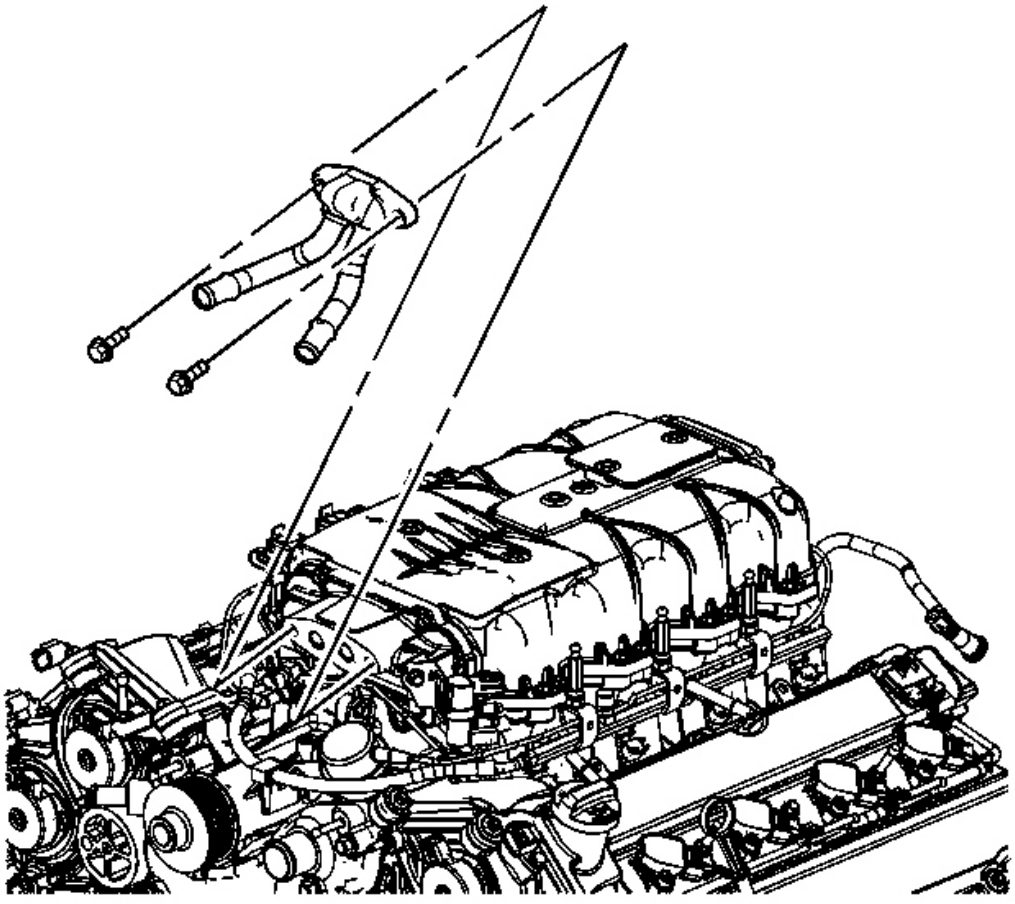


Fig. 281: Identifying Charge Air Cooler Coolant Front Manifold
Courtesy of GENERAL MOTORS CORP.

2. Remove the charge air cooler coolant front manifold bolts.
3. Remove the charge air cooler coolant front manifold.

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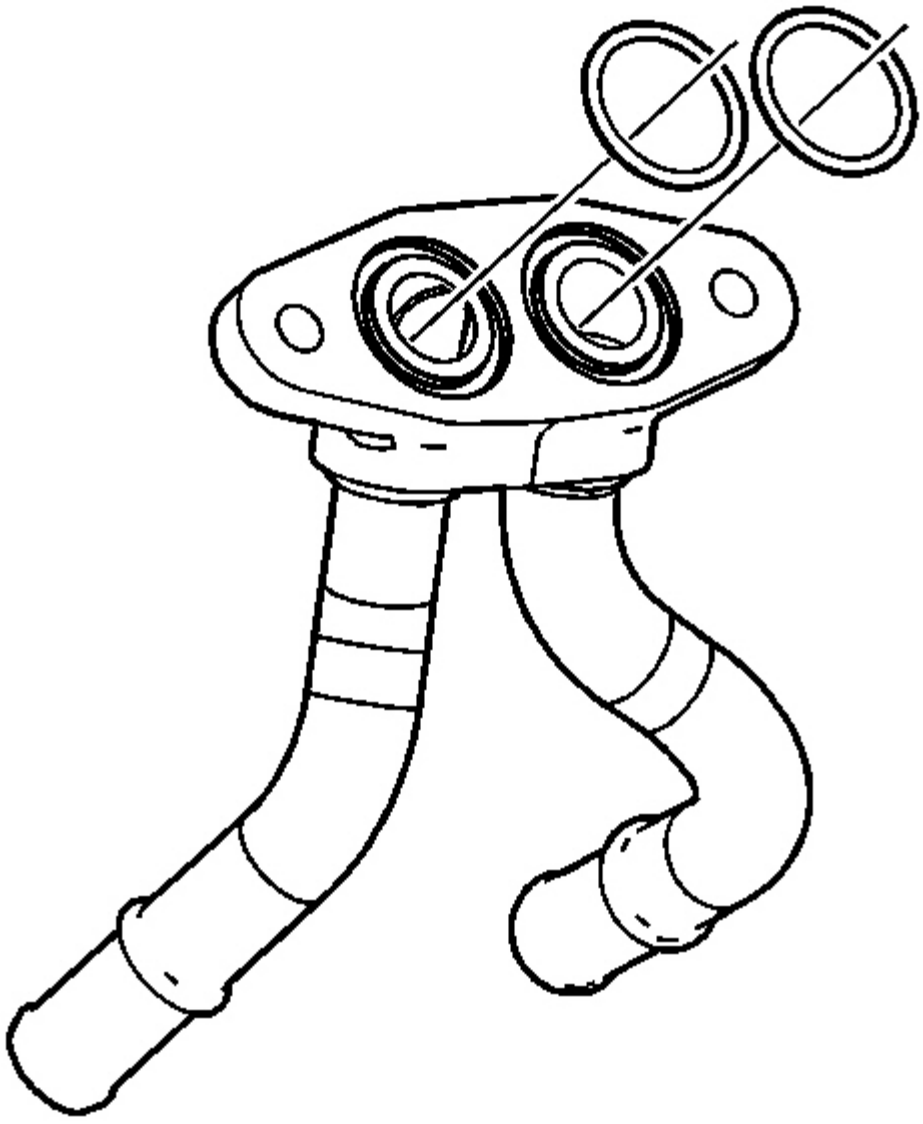


Fig. 282: Identifying Charge Air Cooler Coolant Front Manifold O-Rings
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the charge air cooler coolant front manifold O-rings.

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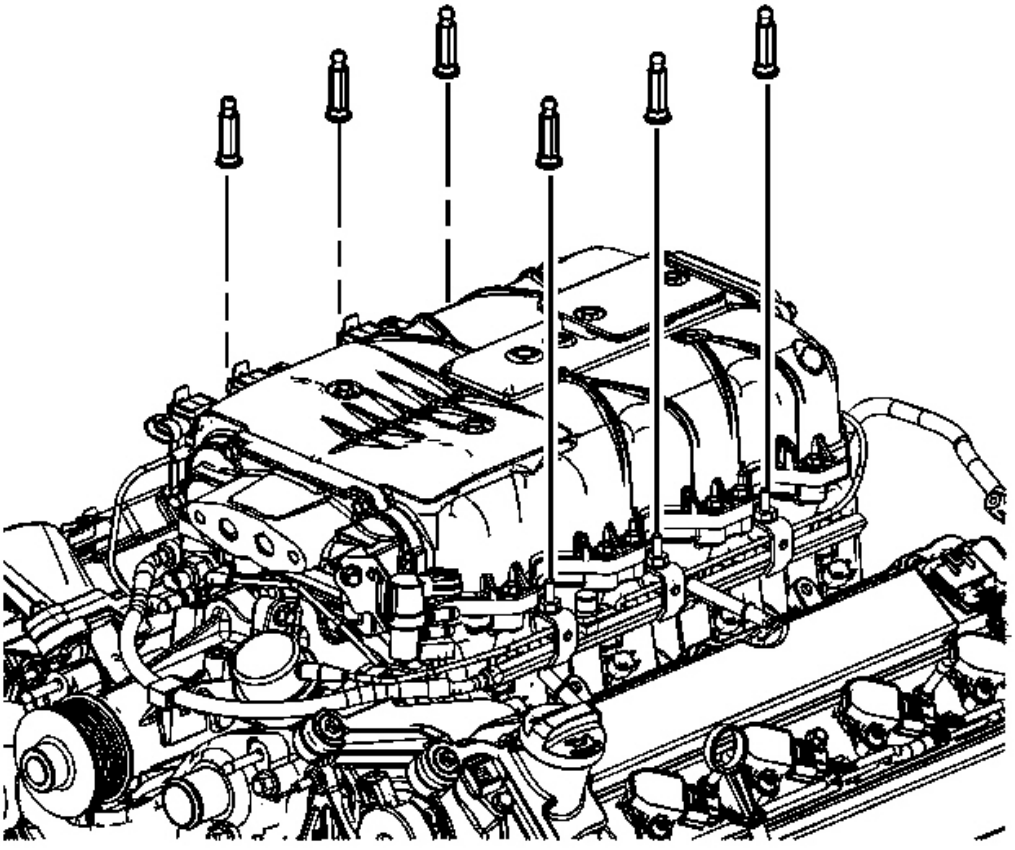


Fig. 283: Identifying Fuel Injector Sight Shield Cover Ball Studs
Courtesy of GENERAL MOTORS CORP.

5. Remove the fuel injector sight shield cover ball studs.

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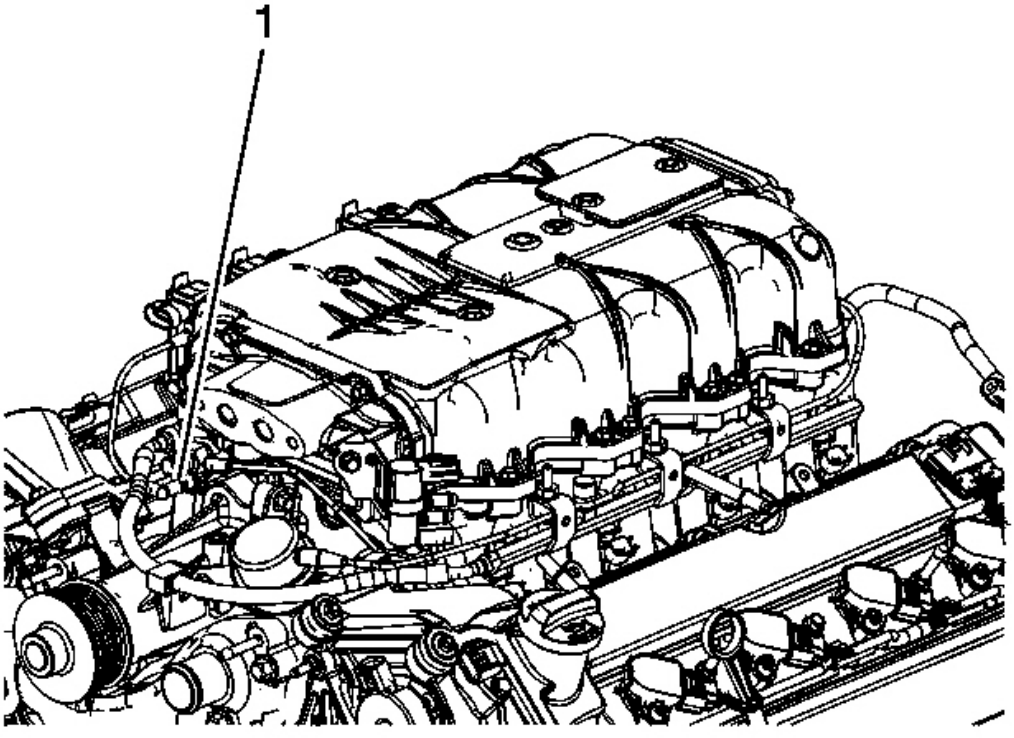


Fig. 284: Identifying MAP Sensor Vacuum Tube Connection
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the manifold absolute pressure (MAP) sensor vacuum tube connection (1) from the supercharger fitting.

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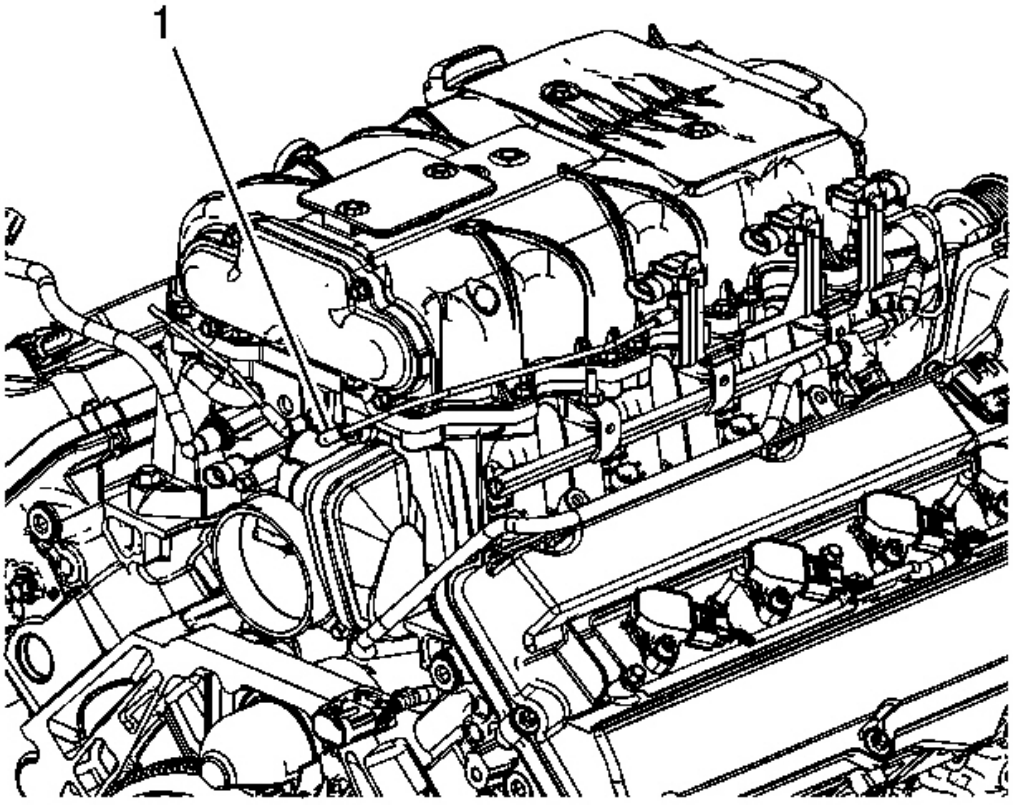


Fig. 285: Identifying Supercharger Inlet Absolute Pressure Sensor Vacuum Tube Connection
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the supercharger inlet absolute pressure sensor vacuum tube connection (1) from the supercharger fitting.

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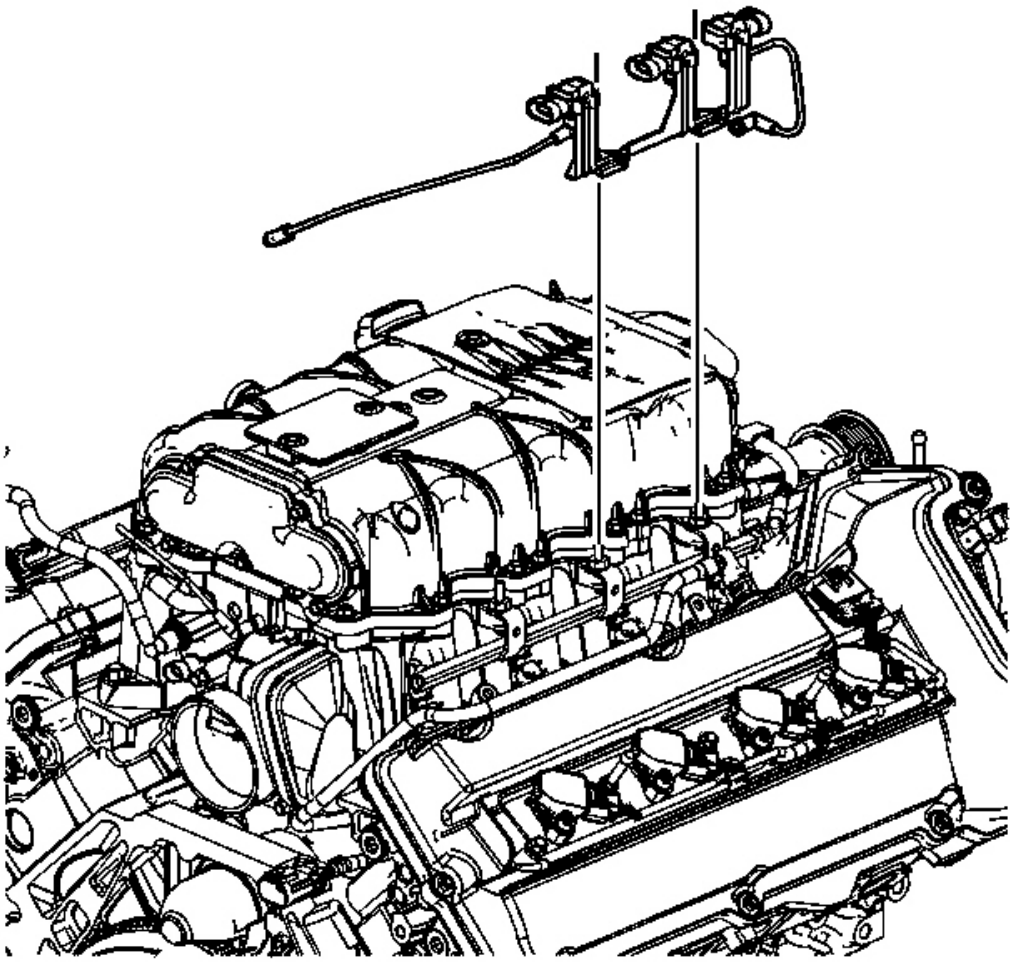


Fig. 286: Identifying Bracket With Sensors & Tubes
Courtesy of GENERAL MOTORS CORP.

8. Remove the bracket with sensors and tubes.

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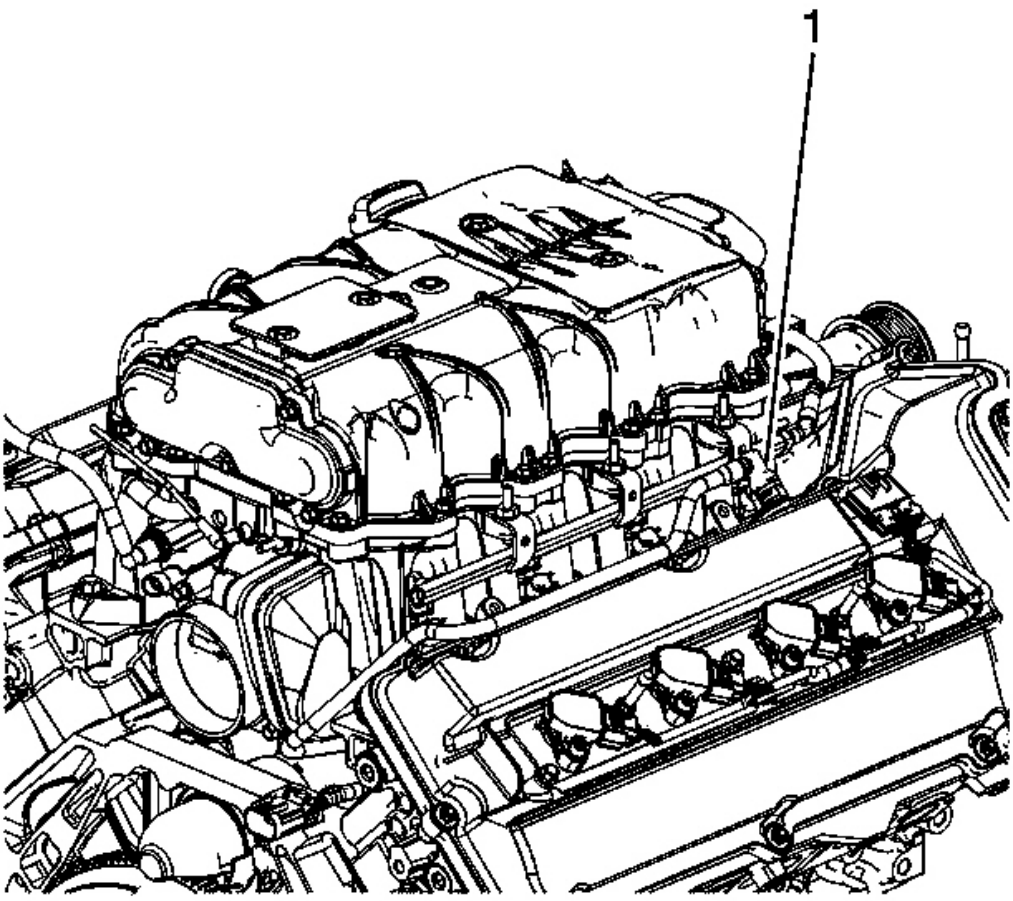


Fig. 287: Locating Dirty Air PCV Tube
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the dirty air positive crankcase ventilation (PCV) tube (1) from the right camshaft cover.

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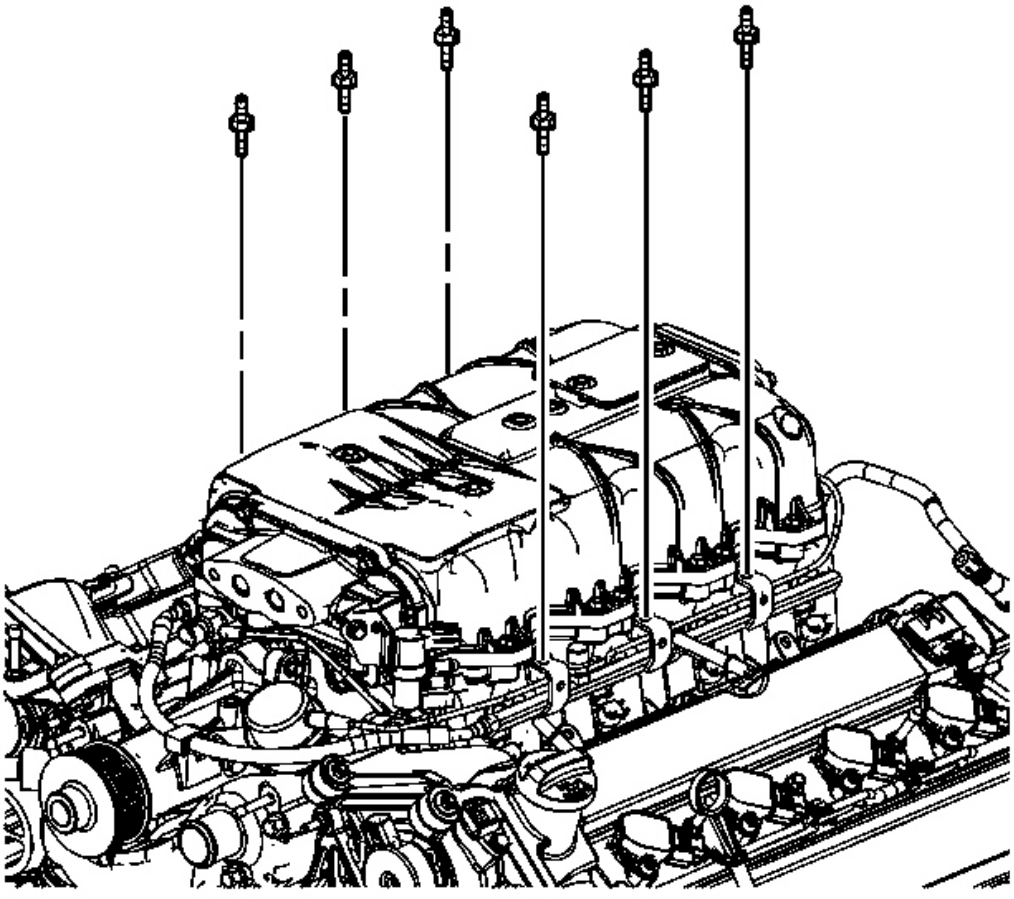


Fig. 288: Identifying Fuel Injection Rail Studs
Courtesy of GENERAL MOTORS CORP.

10. Remove the fuel injection rail studs.

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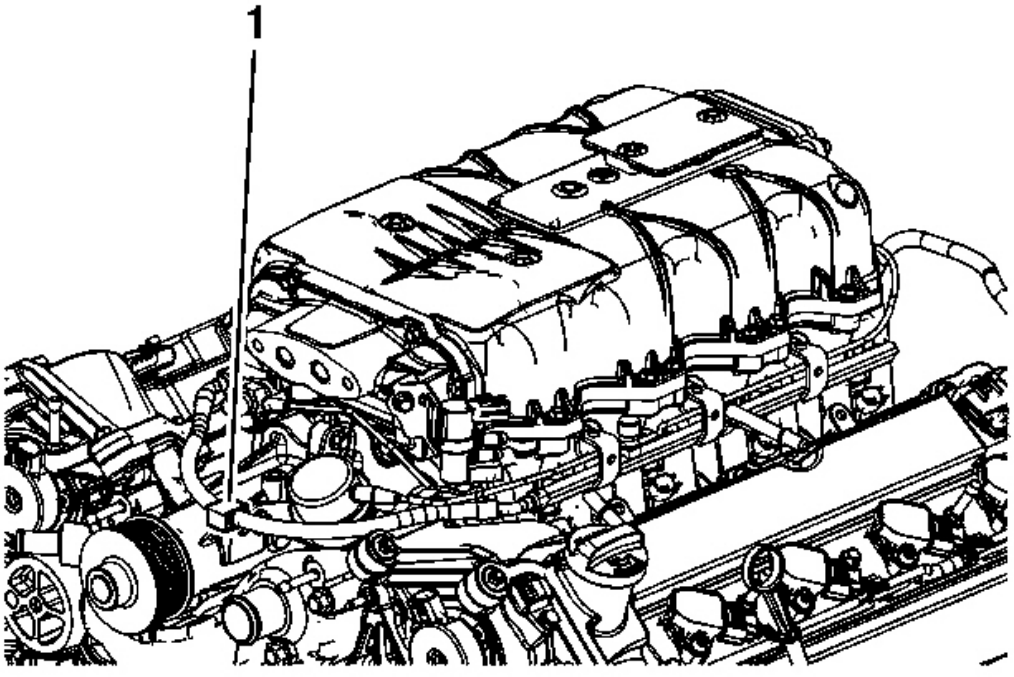


Fig. 289: View Of Fuel Injection Rail Crossover Tube Clip
Courtesy of GENERAL MOTORS CORP.

11. Release the fuel injection rail crossover tube clip (1).

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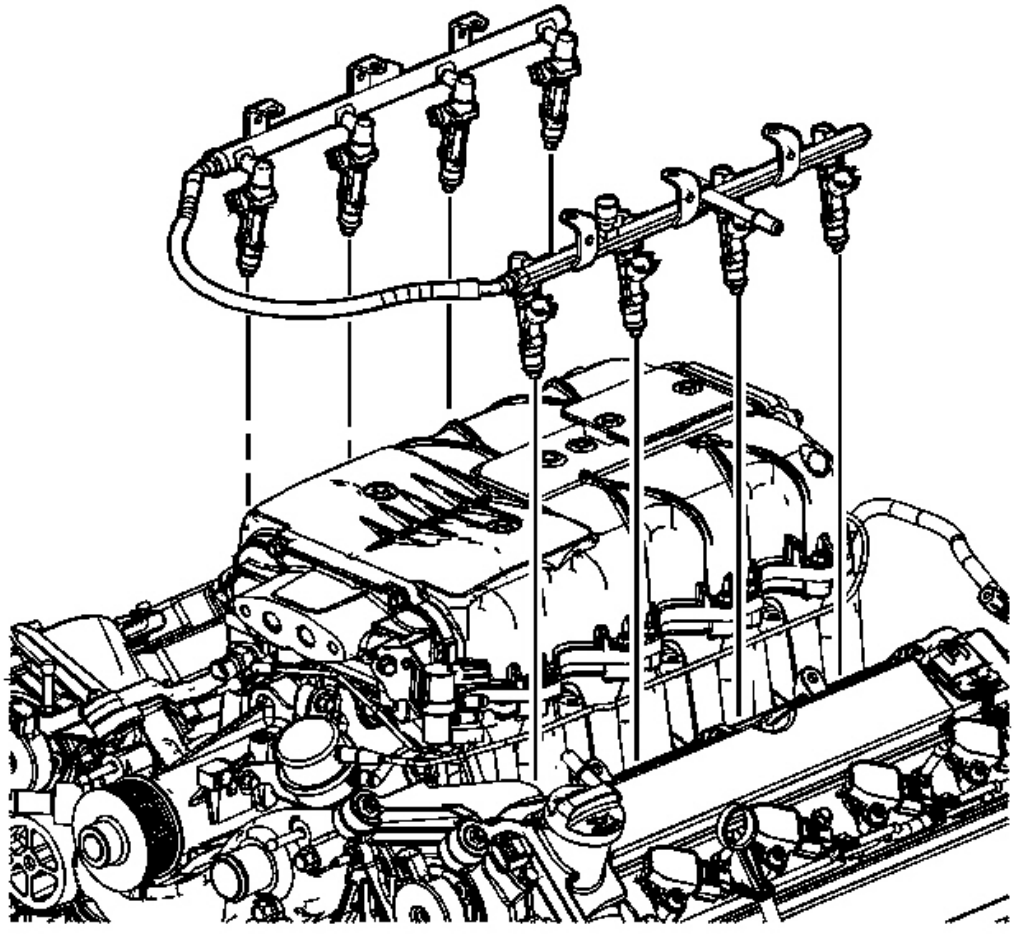


Fig. 290: View Of Fuel Injector Rail Assembly
Courtesy of GENERAL MOTORS CORP.

12. Lift each fuel injector out of the bores in the supercharger and lift off the fuel injector rail assembly.

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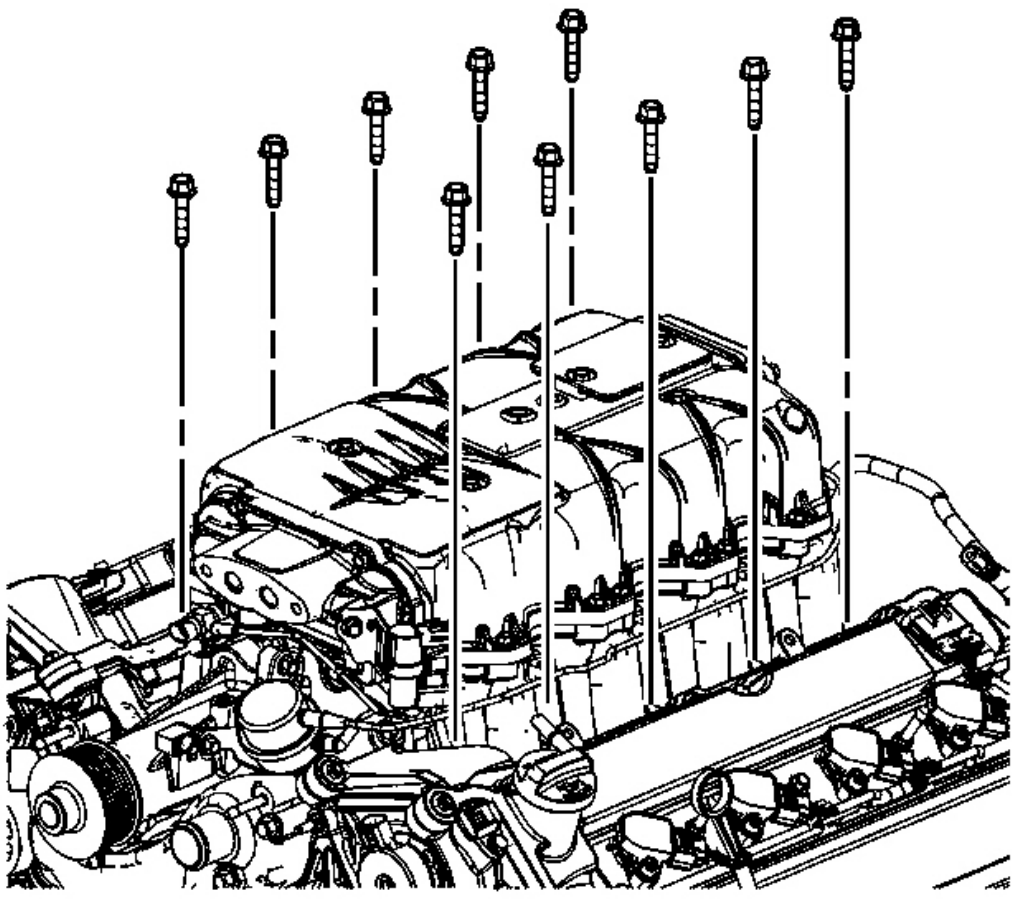


Fig. 291: Identifying Supercharger Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the supercharger bolts.

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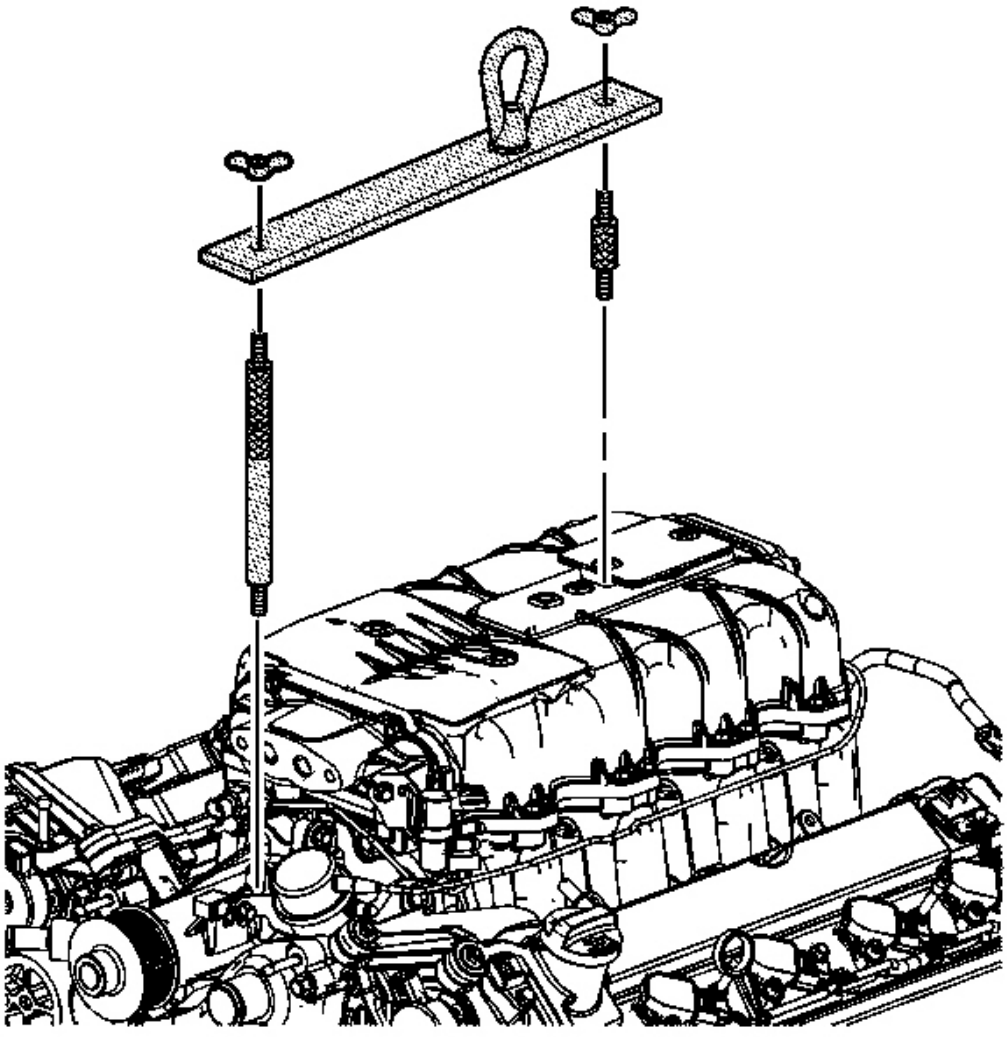


Fig. 292: Removing/Installing EN-47748 Supercharger Lifting Fixture
Courtesy of GENERAL MOTORS CORP.

14. Install the **EN-47748** onto the supercharger.

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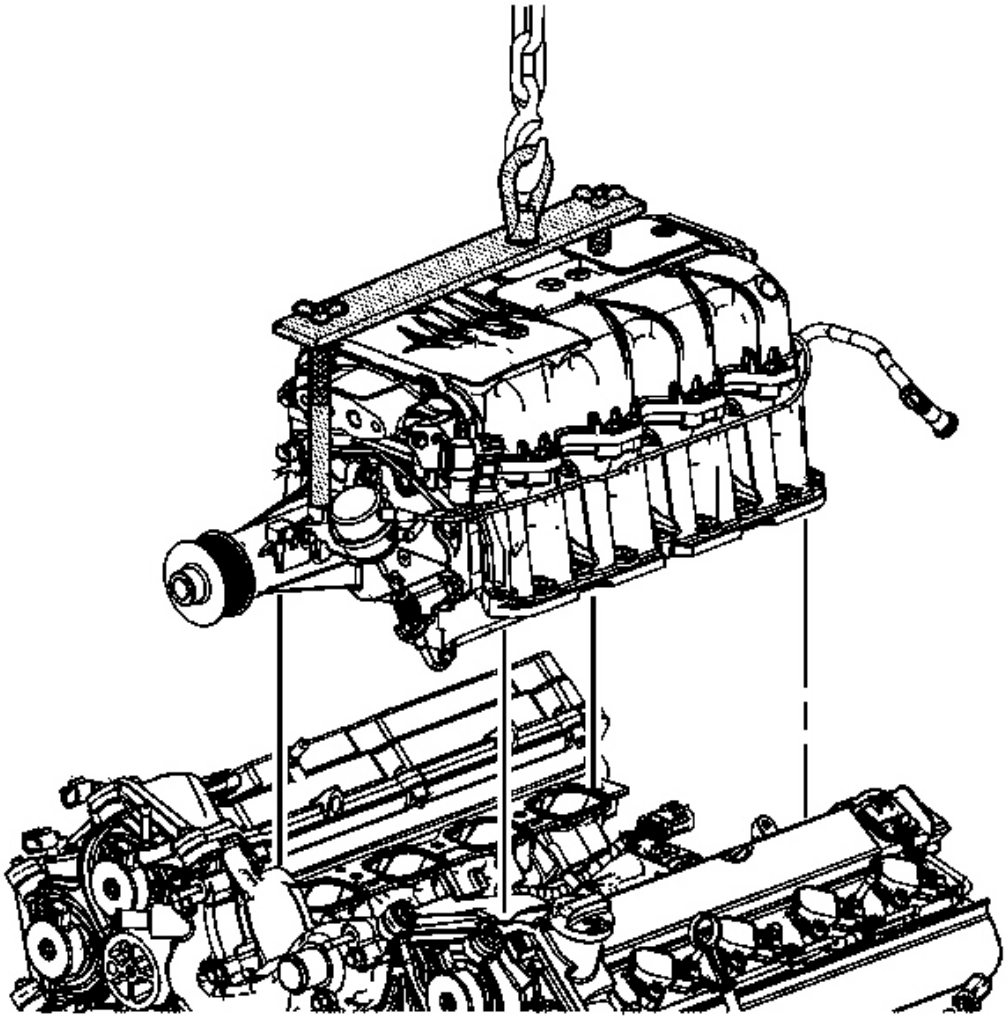


Fig. 293: View Of Supercharger Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: The supercharger must be lifted with the EN 47748. The weight of the supercharger assembly is approximately 34 kg (75 lb) and could cause injury if lifted by hand.

NOTE: The supercharger must be lifted with the EN 47748. Damage could occur to the finish and/or components of the supercharger and surrounding engine or vehicle components.

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15. Remove the supercharger using the **EN-47748** with appropriate lifting equipment.

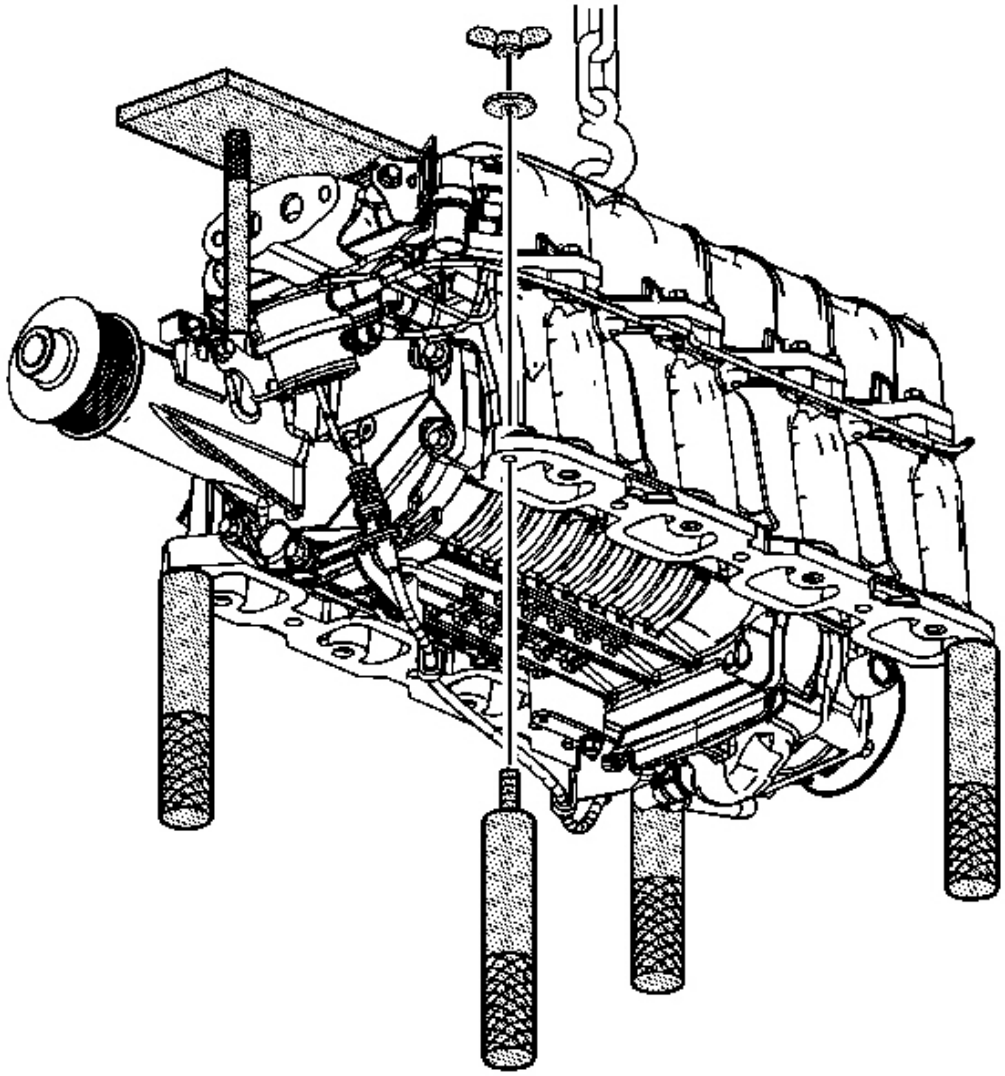


Fig. 294: Removing EN-47833 From Supercharger
Courtesy of GENERAL MOTORS CORP.

NOTE: The EN 47833 must be installed to the supercharger in order to prevent damage to the supercharger bypass actuator cable and the finish of the supercharger. Failure to use the EN 47833 can lead to bending the brackets of the supercharger bypass actuator cable. Bent supercharger

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bypass actuator cable brackets will cause the supercharger bypass valve to function improperly.

16. Install the **EN-47833** through the end mounting bolts holes of the supercharger.

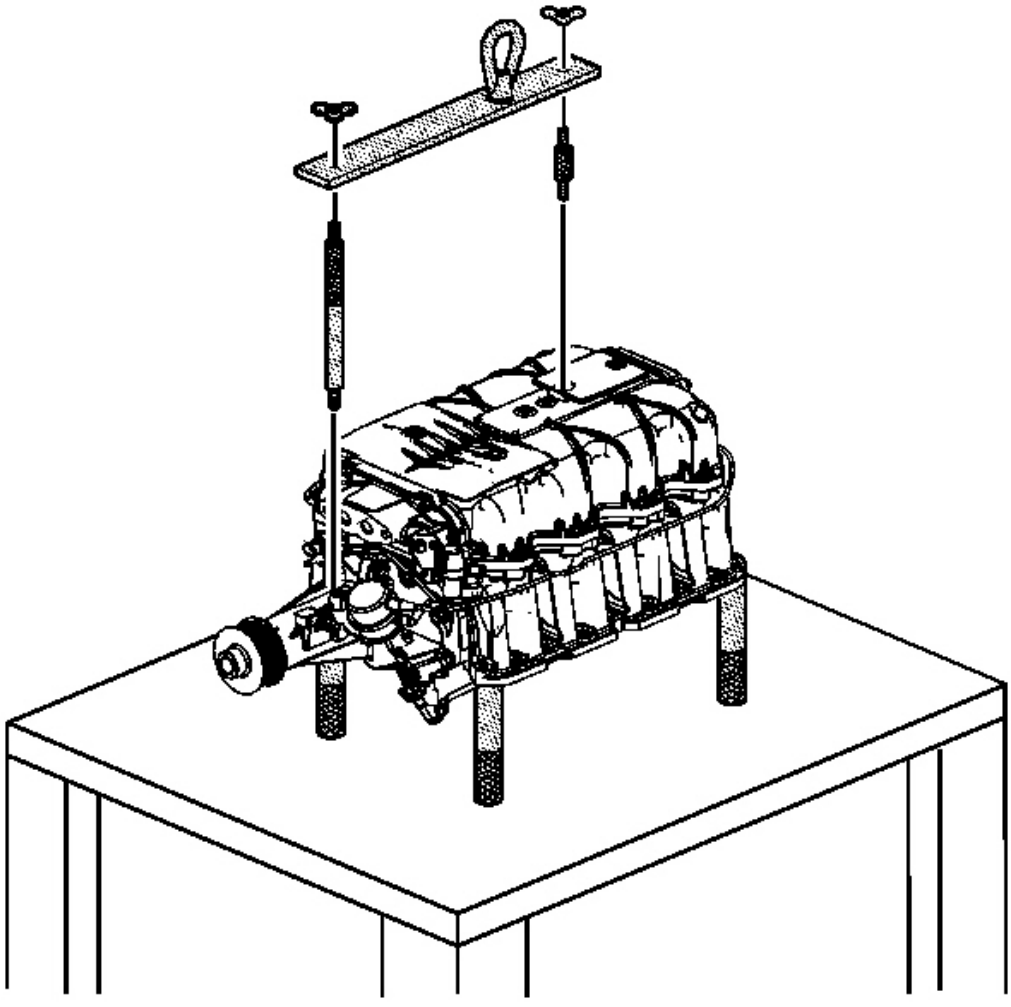


Fig. 295: View Of Supercharger Assembly
Courtesy of GENERAL MOTORS CORP.

17. Place the supercharger assembly on an appropriate clean, stable and flat surface.

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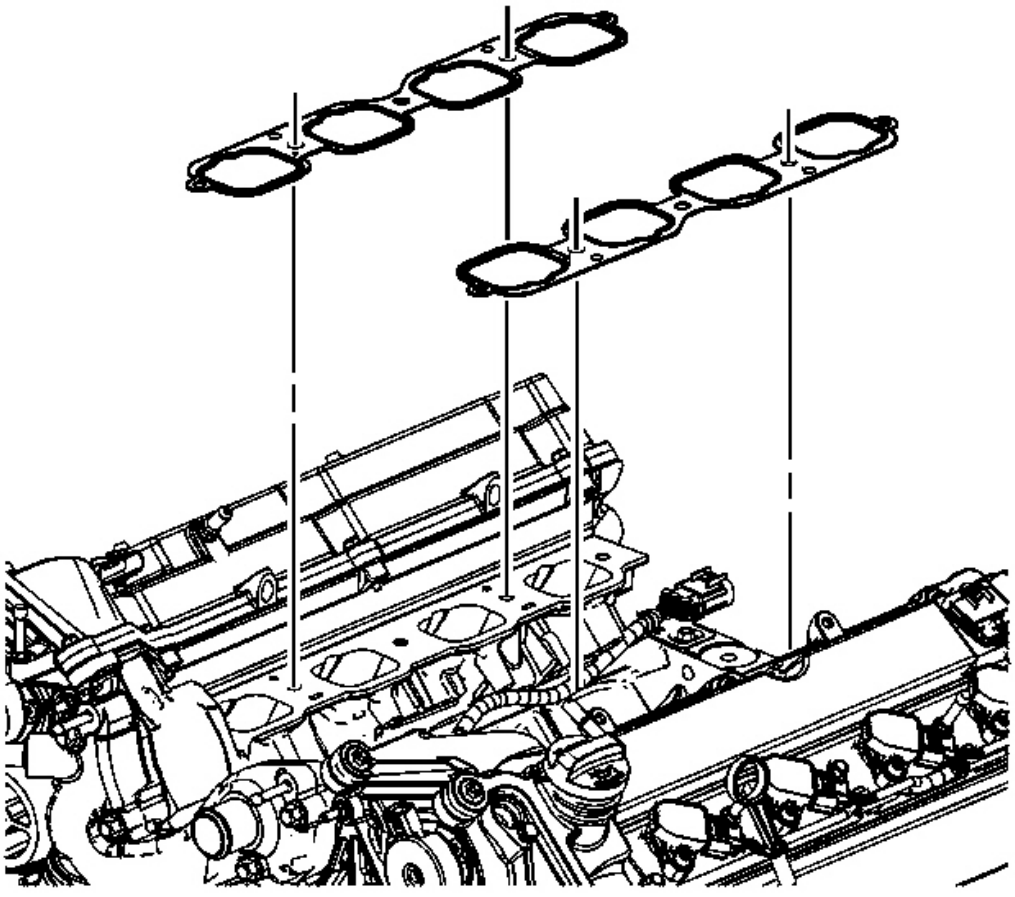


Fig. 296: Identifying Supercharger Gaskets
Courtesy of GENERAL MOTORS CORP.

18. Remove and discard the supercharger gaskets.

WATER OUTLET HOUSING REMOVAL

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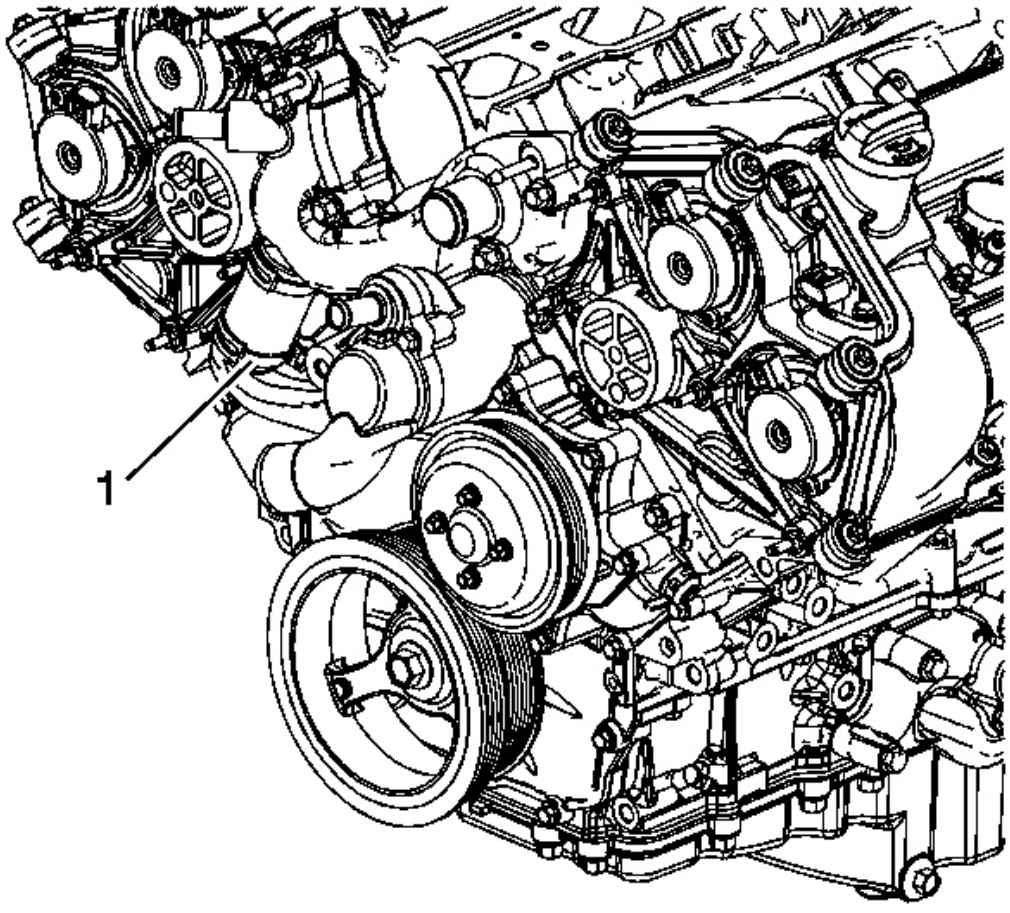


Fig. 297: Identifying Bypass Hose Clamp
Courtesy of GENERAL MOTORS CORP.

1. Reposition the clamp (1) on the bypass hose.

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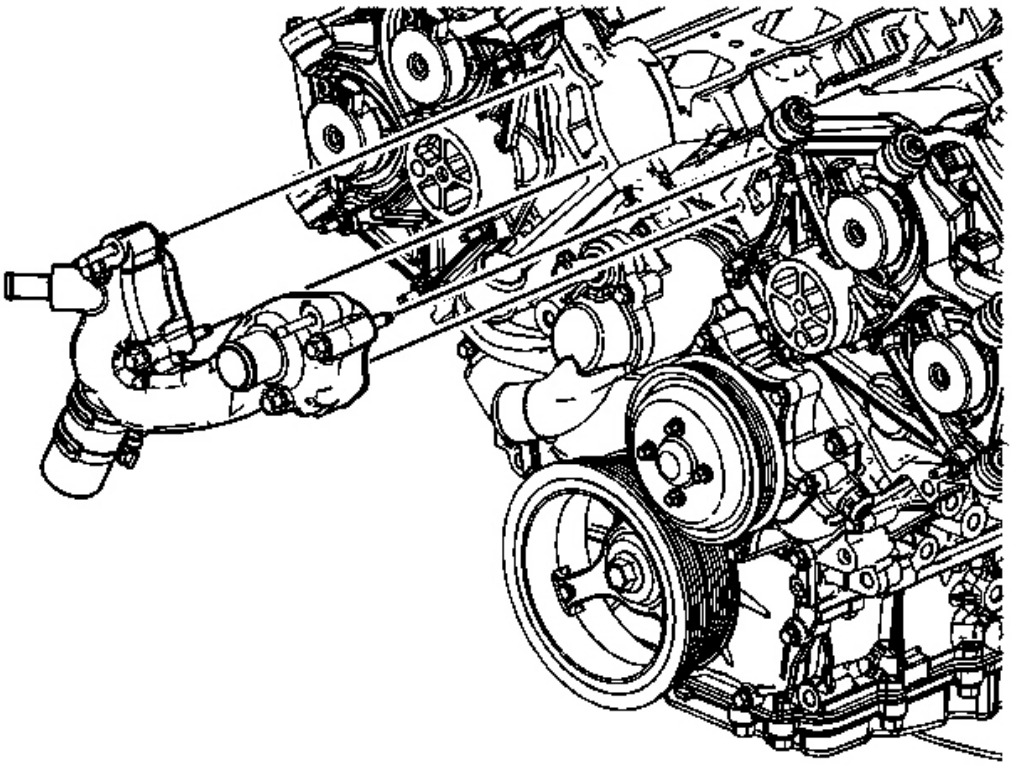


Fig. 298: View Of Water Outlet Housing
Courtesy of GENERAL MOTORS CORP.

2. Loosen the water outlet housing bolts.
3. Remove the water outlet housing while removing the bypass hose from the engine front cover.

STARTER REMOVAL

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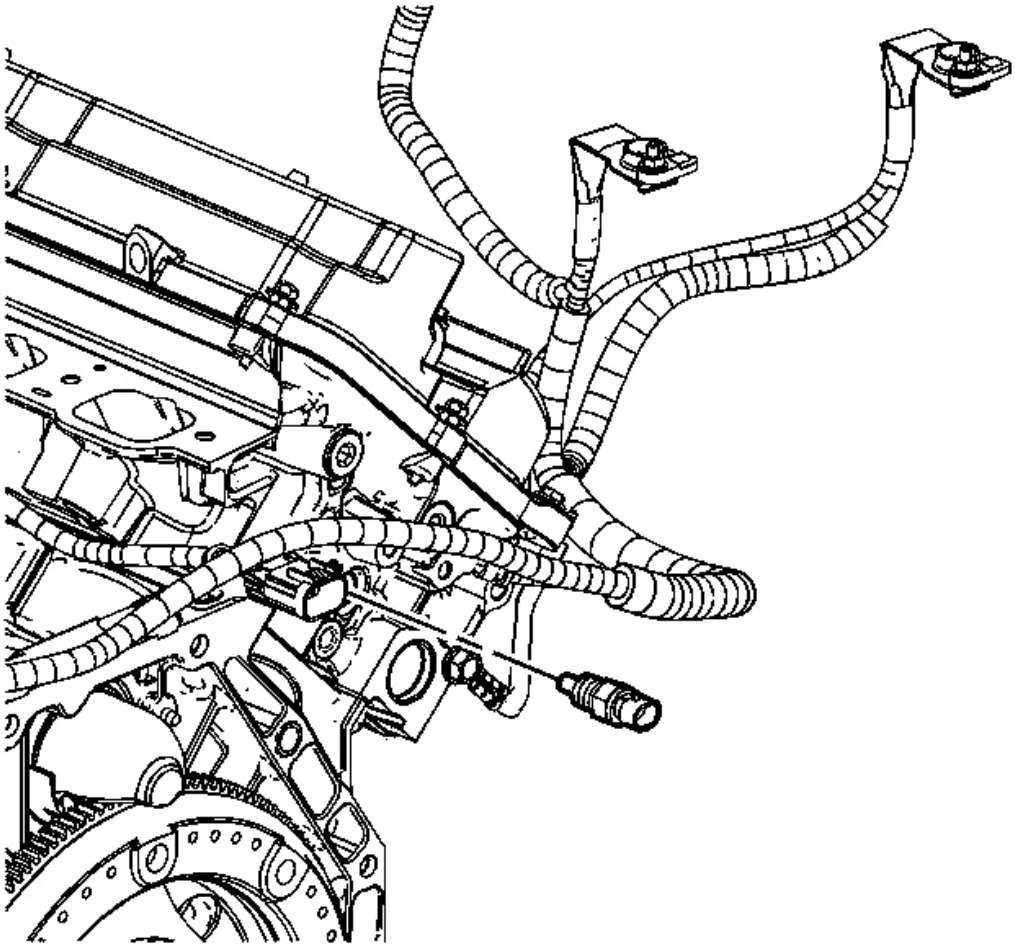


Fig. 299: Locating ECT Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the ECT sensor from the rear of the right cylinder head.

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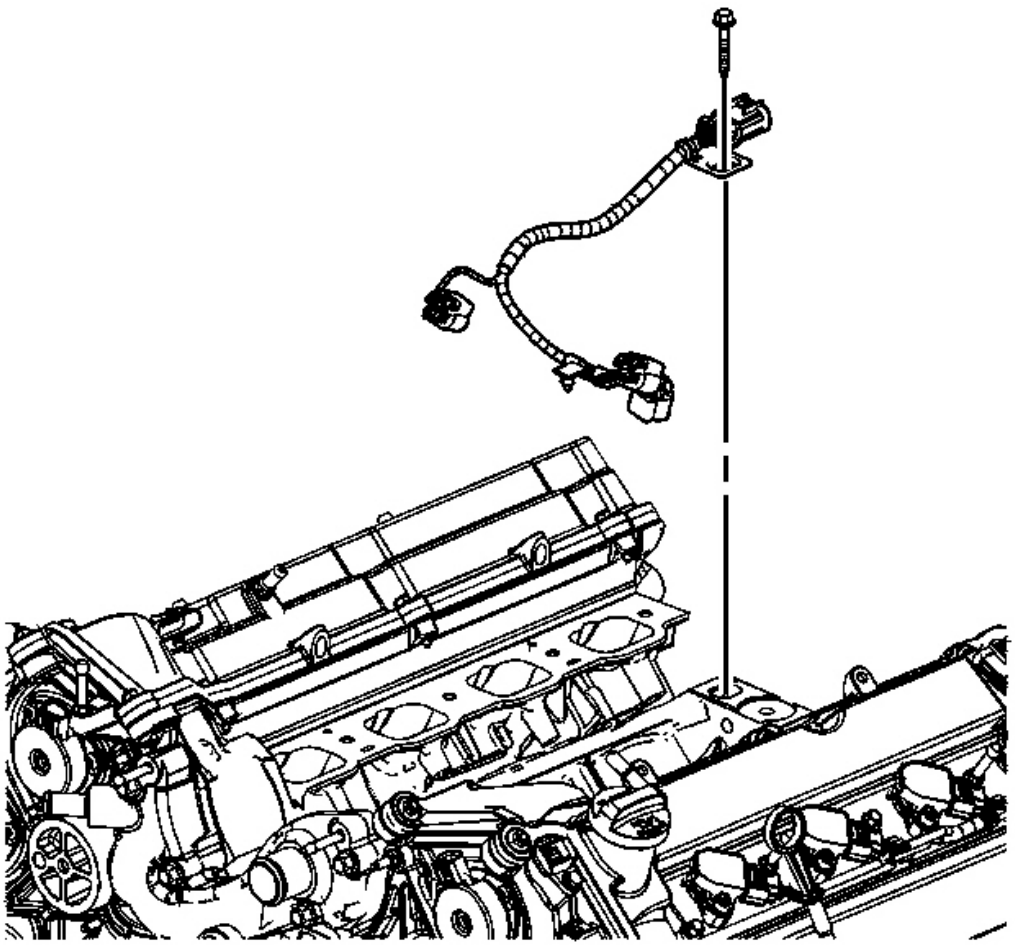


Fig. 300: Identifying Knock And Crankshaft Position Sensor Wiring Harness Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the knock and crankshaft position sensor wiring harness bolt.
3. Disconnect the knock and crankshaft position sensor wiring harness connectors from the knock sensors and the crankshaft position sensor.
4. Disconnect the knock and crankshaft position sensor wiring harness from the attaching points in the center, back and front of block valley.
5. Remove the knock and crankshaft position sensor wiring harness.

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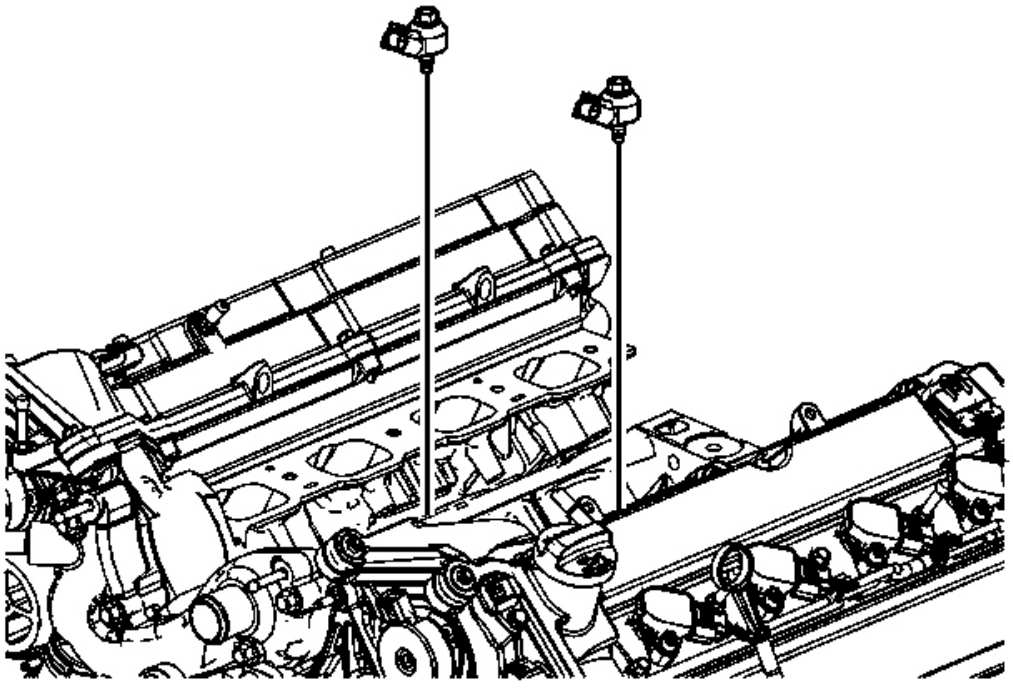


Fig. 301: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

6. Loosen the knock sensor bolts.
7. Remove the knock sensors.

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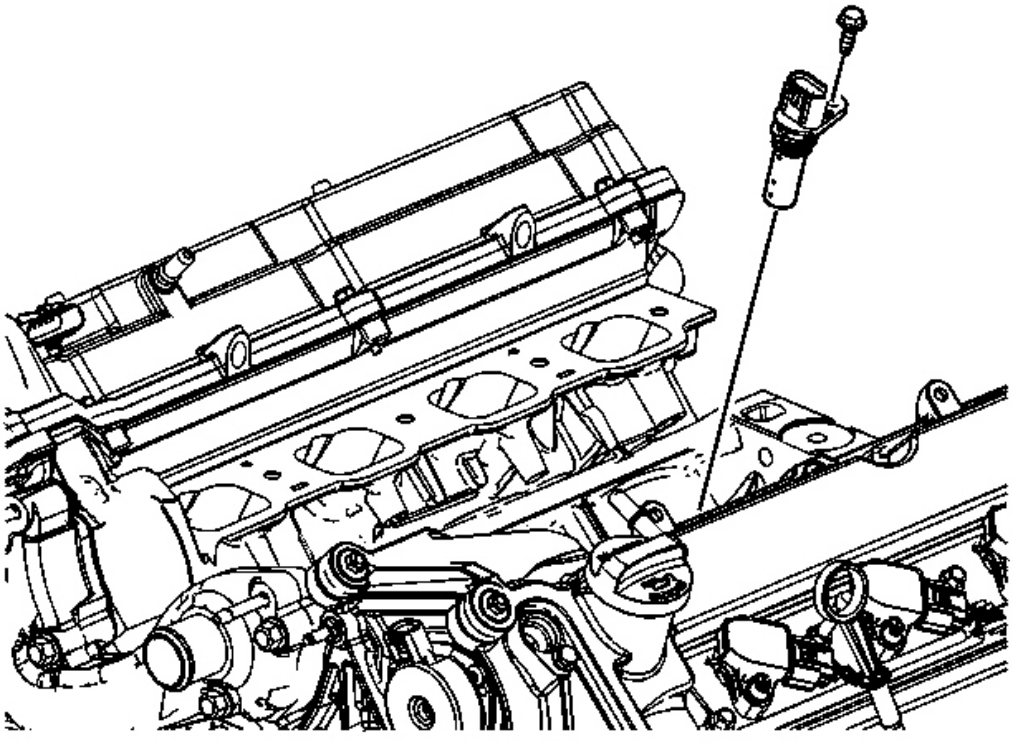


Fig. 302: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

8. Remove the crankshaft position sensor bolt.
9. Remove the crankshaft position sensor.

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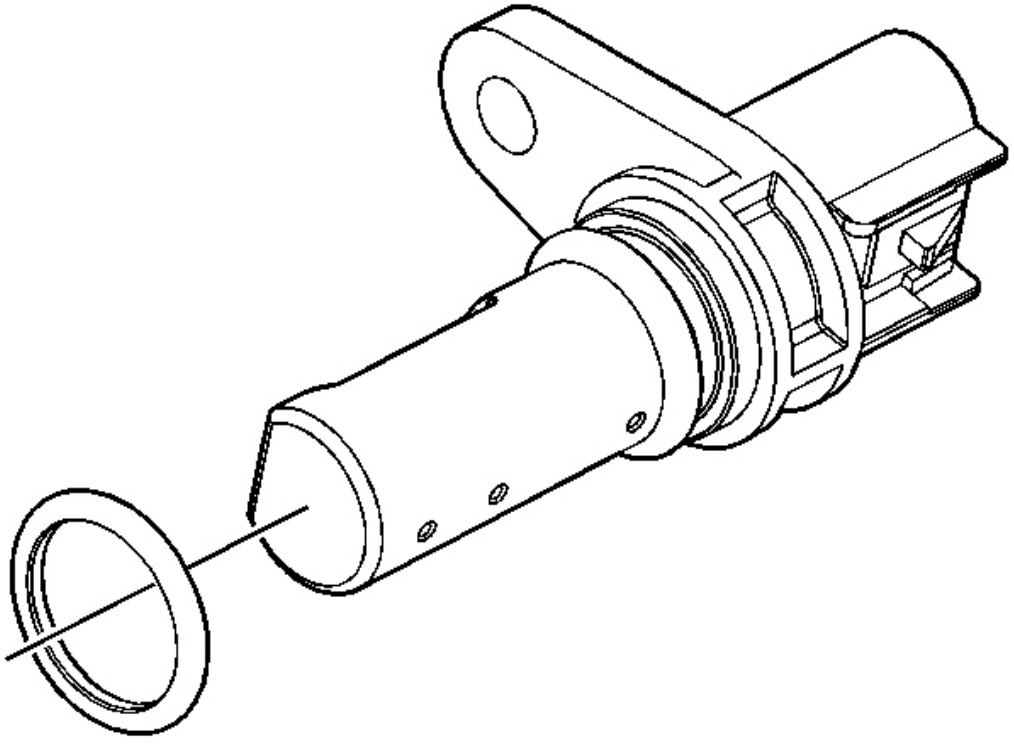


Fig. 303: View Of Crankshaft Position Sensor O-Ring
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the crankshaft position sensor O-ring.

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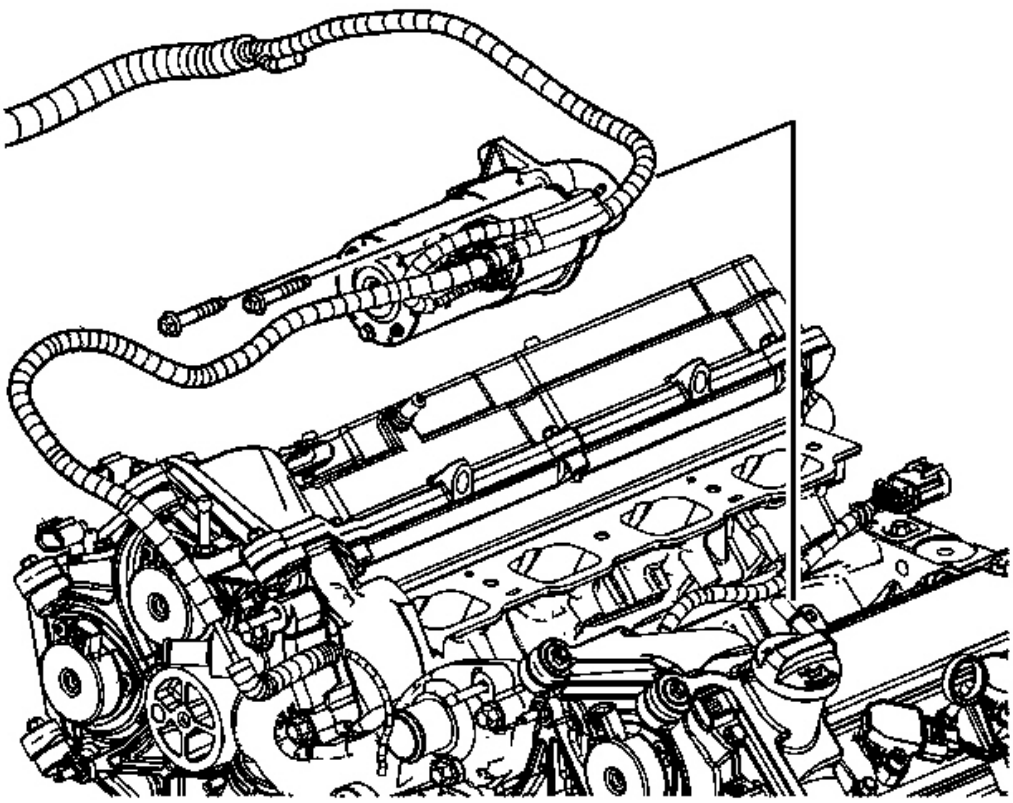


Fig. 304: View Of Starter Motor Bolts
Courtesy of GENERAL MOTORS CORP.

11. Remove the starter motor bolts.
12. Remove the starter motor and starter motor wiring harness.

CRANKSHAFT BALANCER REMOVAL

TOOLS REQUIRED

- **EN 46326** Flywheel Holding Tool. See **Special Tools** .
- **J 38416-2** Crankshaft Button. See **Special Tools** .
- **J 41816** Crankshaft Balancer Remover. See **Special Tools** .

REMOVAL PROCEDURE

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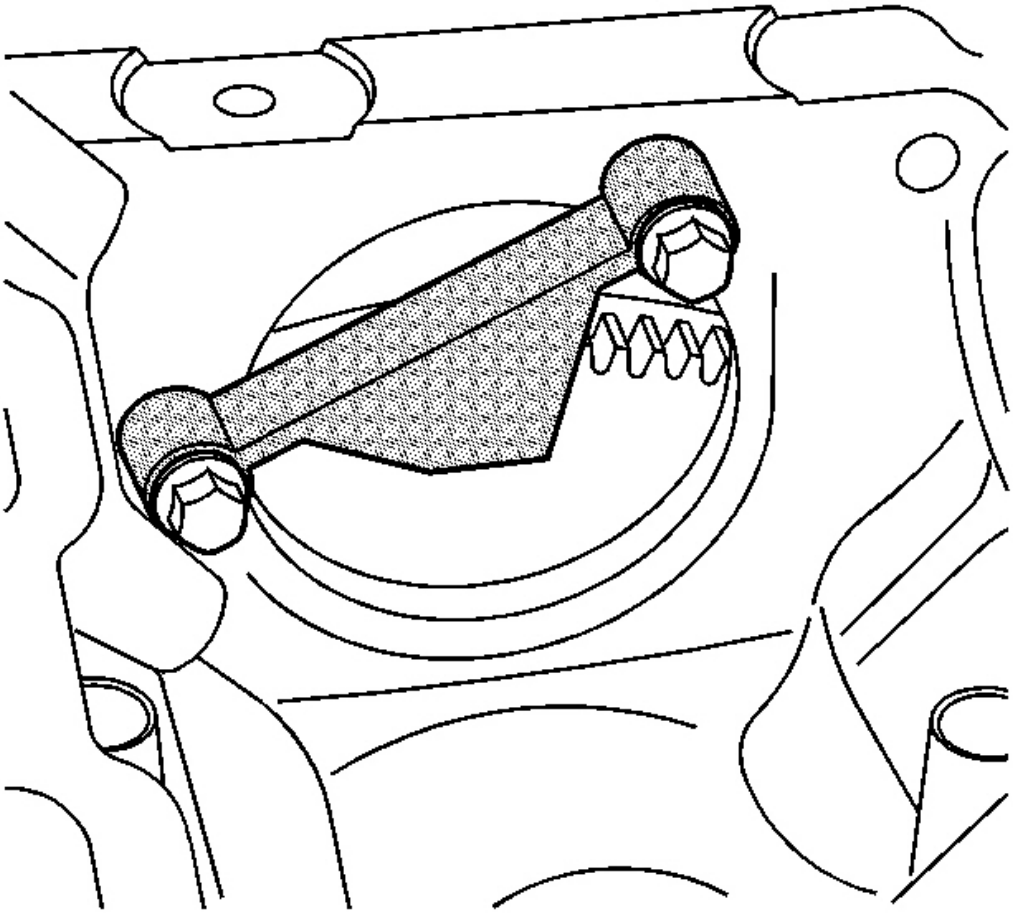


Fig. 305: View Of Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

1. Install the **EN 46326** . See **Special Tools** .

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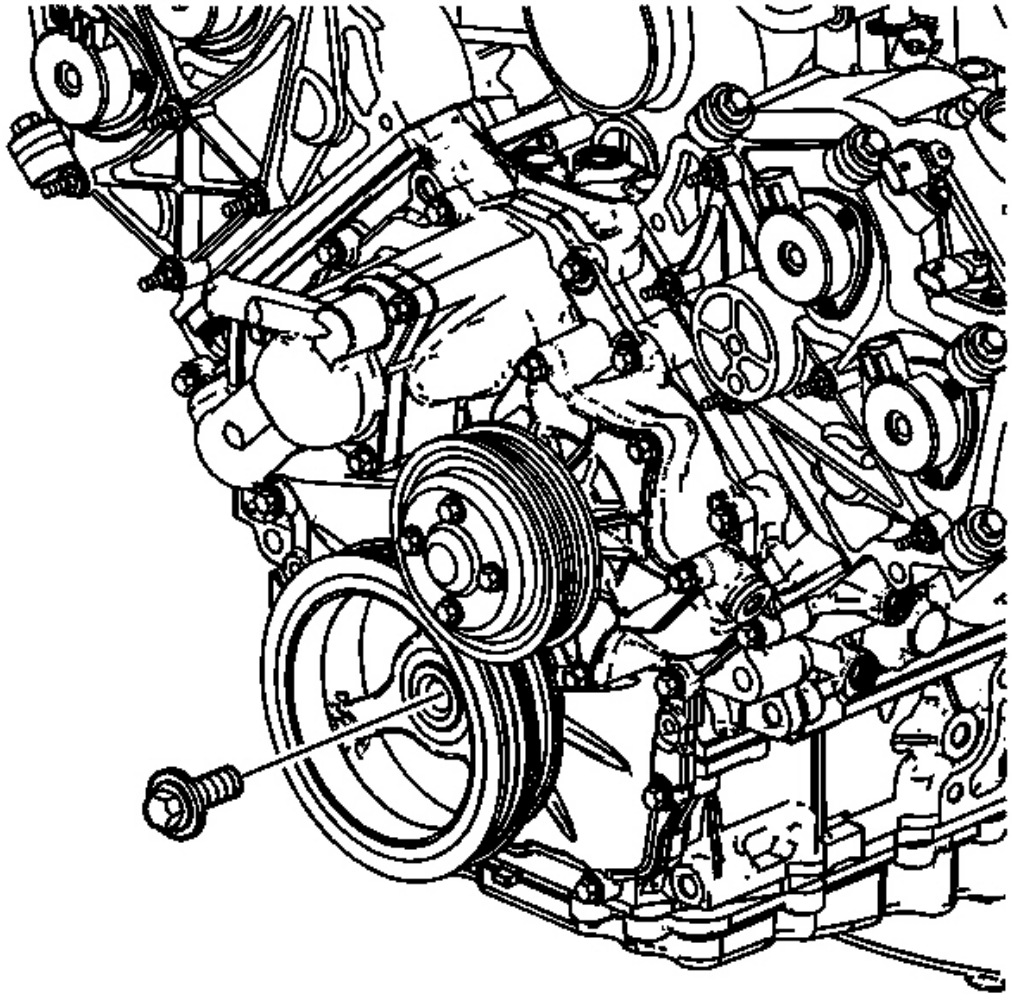


Fig. 306: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft balancer bolt.

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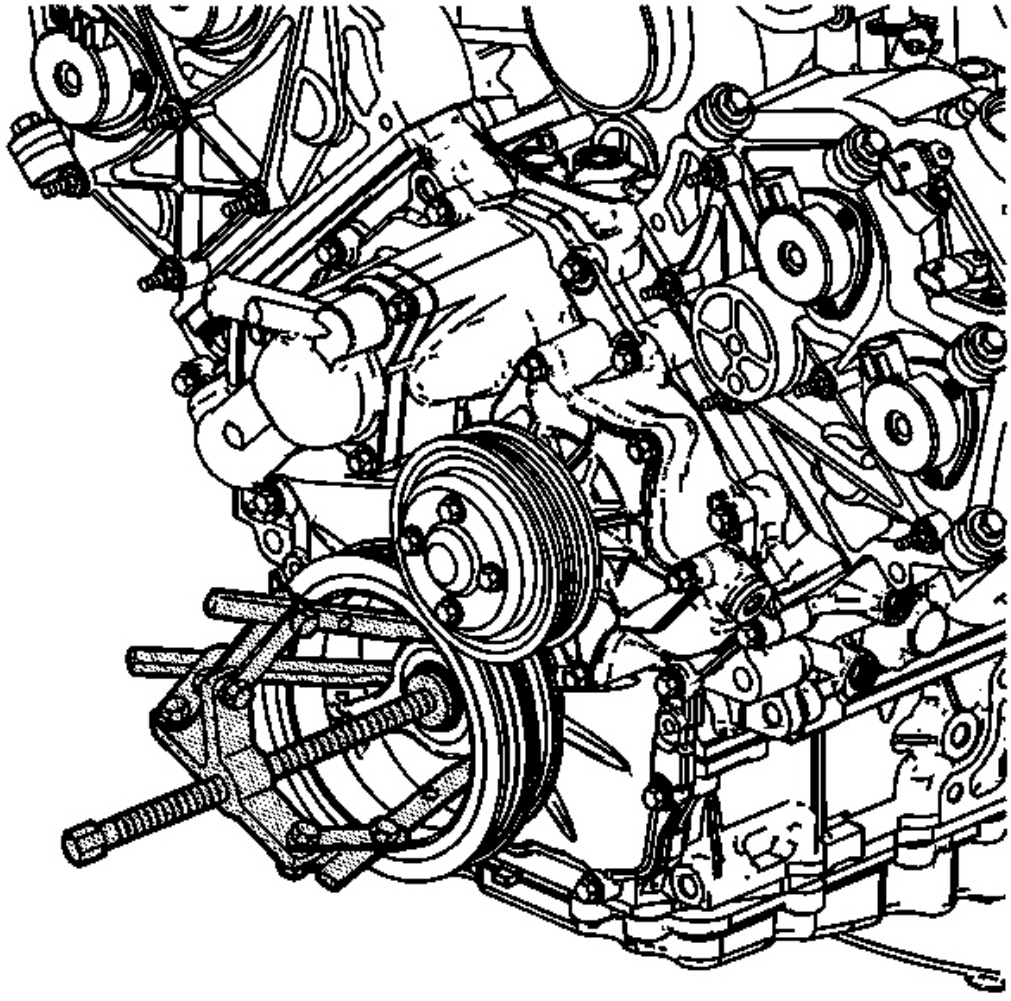


Fig. 307: View Of Remover Pilot & J 41816
Courtesy of GENERAL MOTORS CORP.

3. Place the **J 38416-2** into the end of the crankshaft. See **Special Tools** .
4. Install the **J 41816** on the crankshaft balancer. See **Special Tools** .

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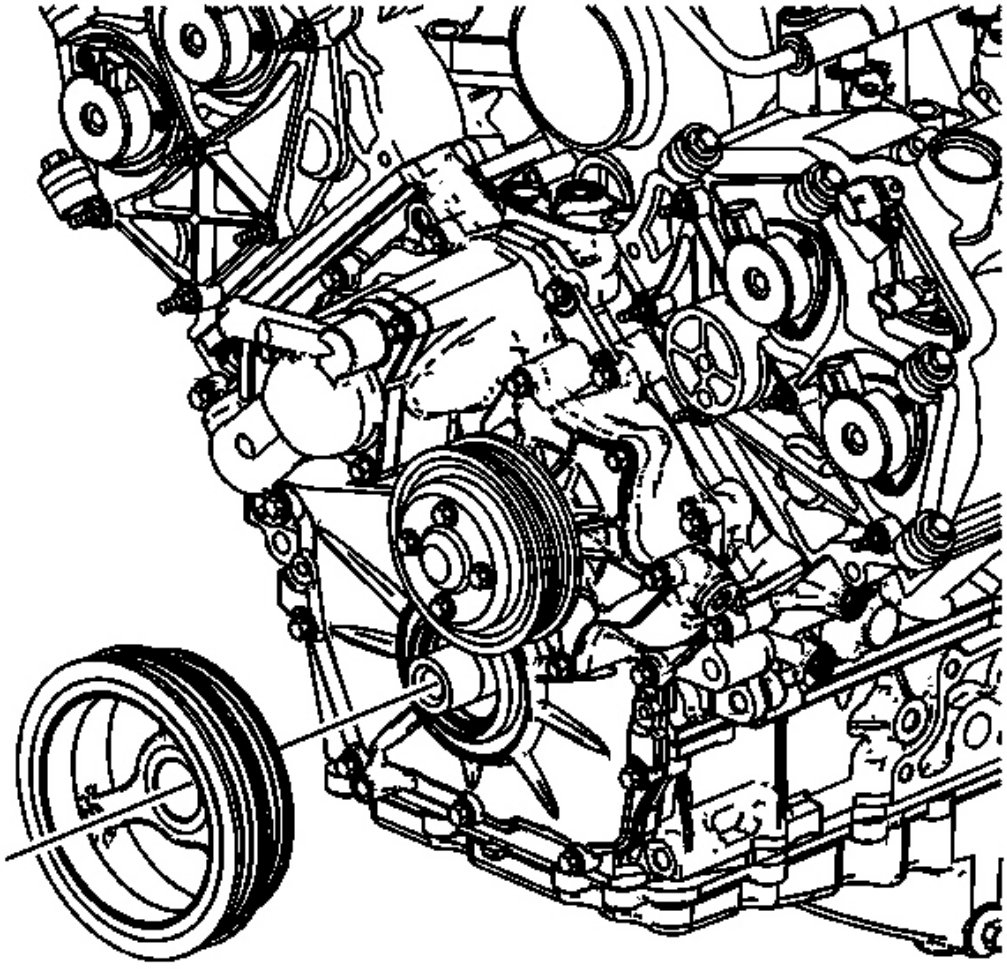


Fig. 308: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft balancer using the **J 41816** . See **Special Tools** .

ENGINE FLYWHEEL REMOVAL

TOOLS REQUIRED

EN 46326 Flywheel Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

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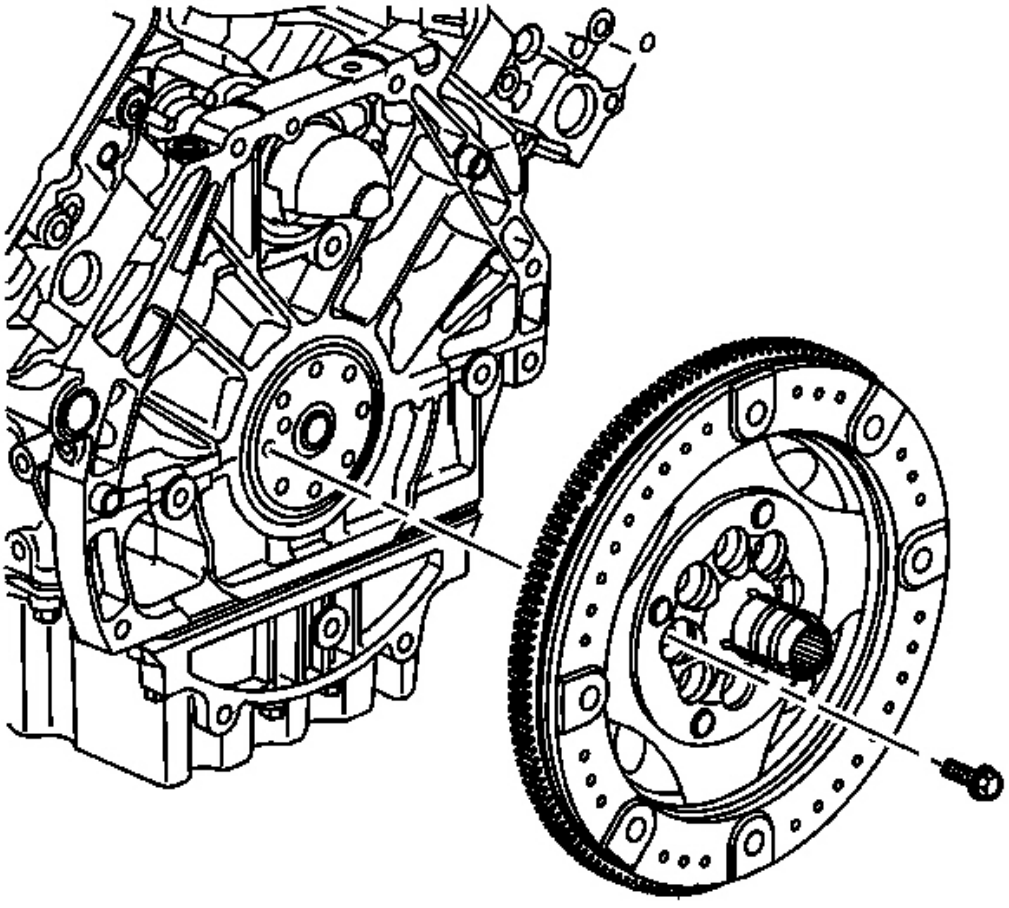


Fig. 309: View Of Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel bolts.
2. Remove the engine flywheel.

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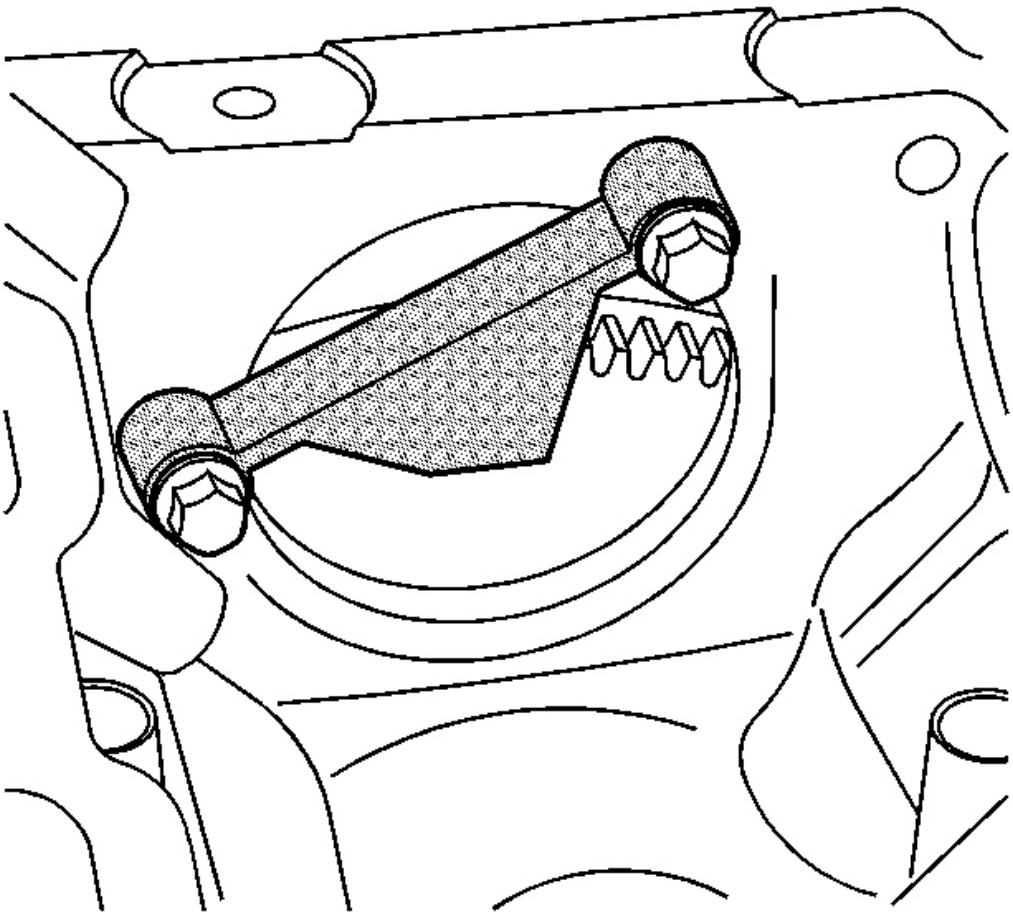


Fig. 310: View Of Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

3. Remove the **EN 46326** . See **Special Tools** .

CRANKSHAFT REAR OIL SEAL REMOVAL

TOOLS REQUIRED

J 42841-A Rear Oil Seal Remover. See **Special Tools** .

REMOVAL PROCEDURE

IMPORTANT: If the engine is in the vehicle, the crankshaft rear oil seal can be

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removed/installed after the transmission/transaxle and engine flywheel are removed.

IMPORTANT: Crankshaft rear oil seal removal requires adequate space for removal. Mount the engine on a suitable engine stand which will properly space the engine in order to use the J 42841-A in order to remove the crankshaft rear oil seal. See Special Tools . If necessary remove the crankshaft rear oil seal with the engine properly supported on the floor or on a bench.

IMPORTANT: Beginning with the model year 2006 the flywheel/flexplate crankshaft bolt hole thread was changed from 8 x 1.25 mm to 11 x 1.5 mm. The J 42841-A will service the cassette seals installed on engines from March 1, 1996 and later. If the older J 42841 is to be used on a 2006 or later engine the update kit, J 42841-10, must be used to convert the J 42841 to a J 42841-A . See Special Tools .

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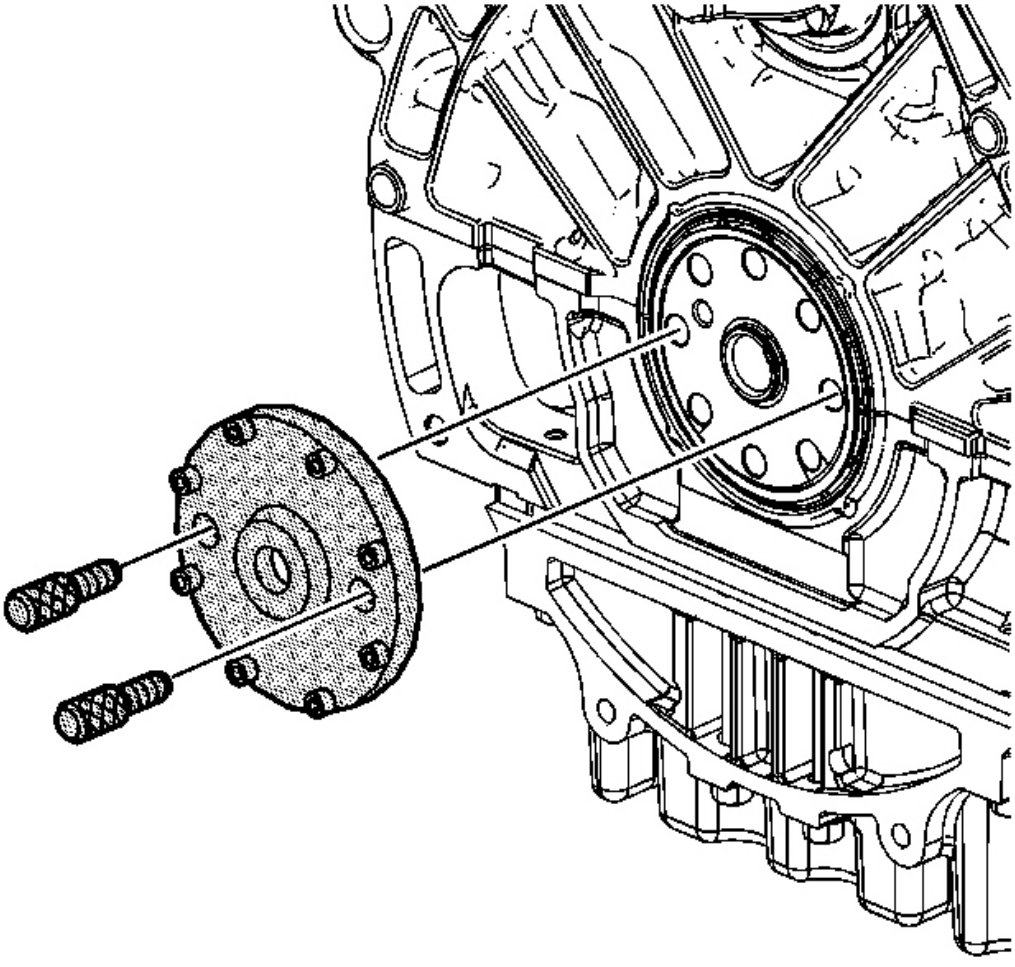


Fig. 311: View Of J 42841-A Plate
Courtesy of GENERAL MOTORS CORP.

1. Install the **J 42841-A** plate onto the crankshaft. See **Special Tools** . The hub on the crankshaft will fit into the recess on the inboard side of the **J 42841-A** plate. See **Special Tools** .

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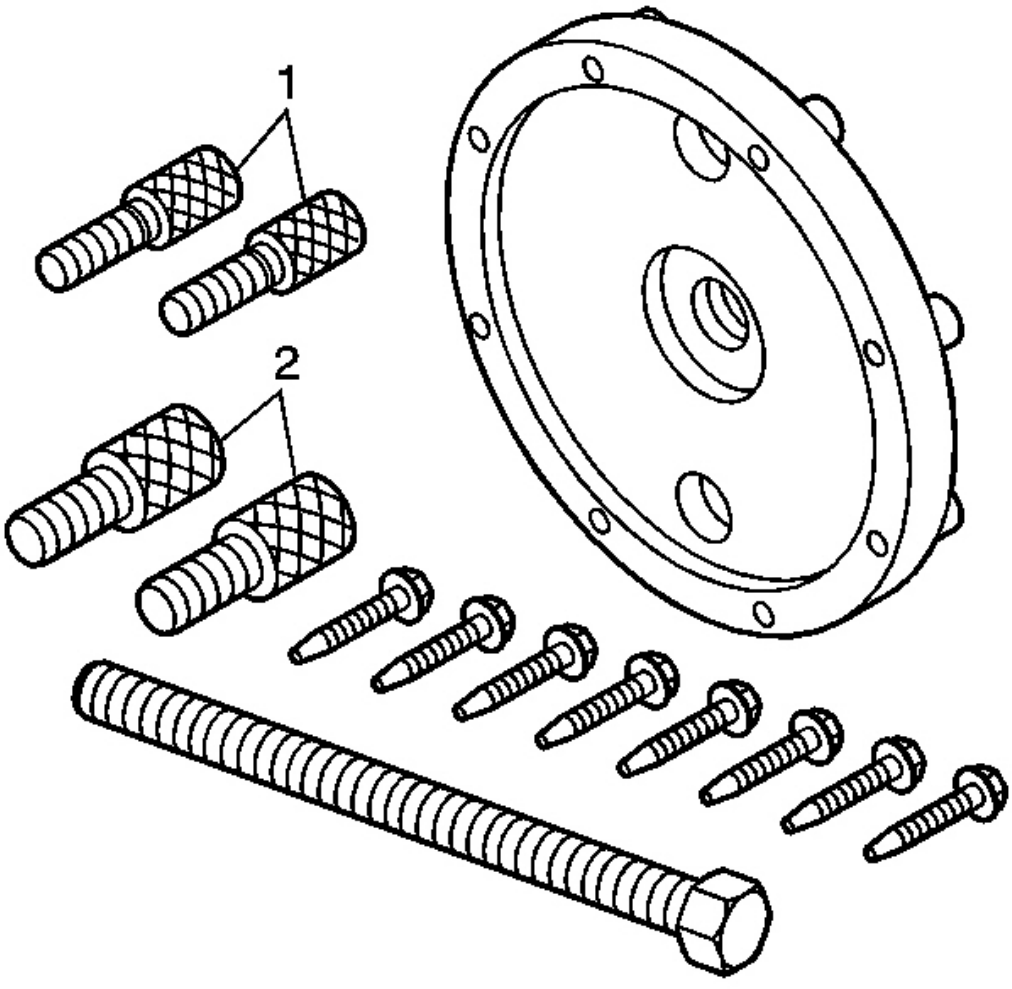


Fig. 312: Identifying J 42841 Crankshaft Rear Oil Seal Remover
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Northstar engines 2005 and older have an 8 x 1.25 mm flywheel/flexplate crankshaft bolt hole thread. Northstar engines 2006 and later have an 11 x 1.5 mm flywheel/flexplate crankshaft bolt hole thread.

2. Use the proper bolts from the **J 42841-A** to retain the plate in place. See **Special Tools** . Use the bolts (1) 8 mm or the bolts (2) 11 mm.

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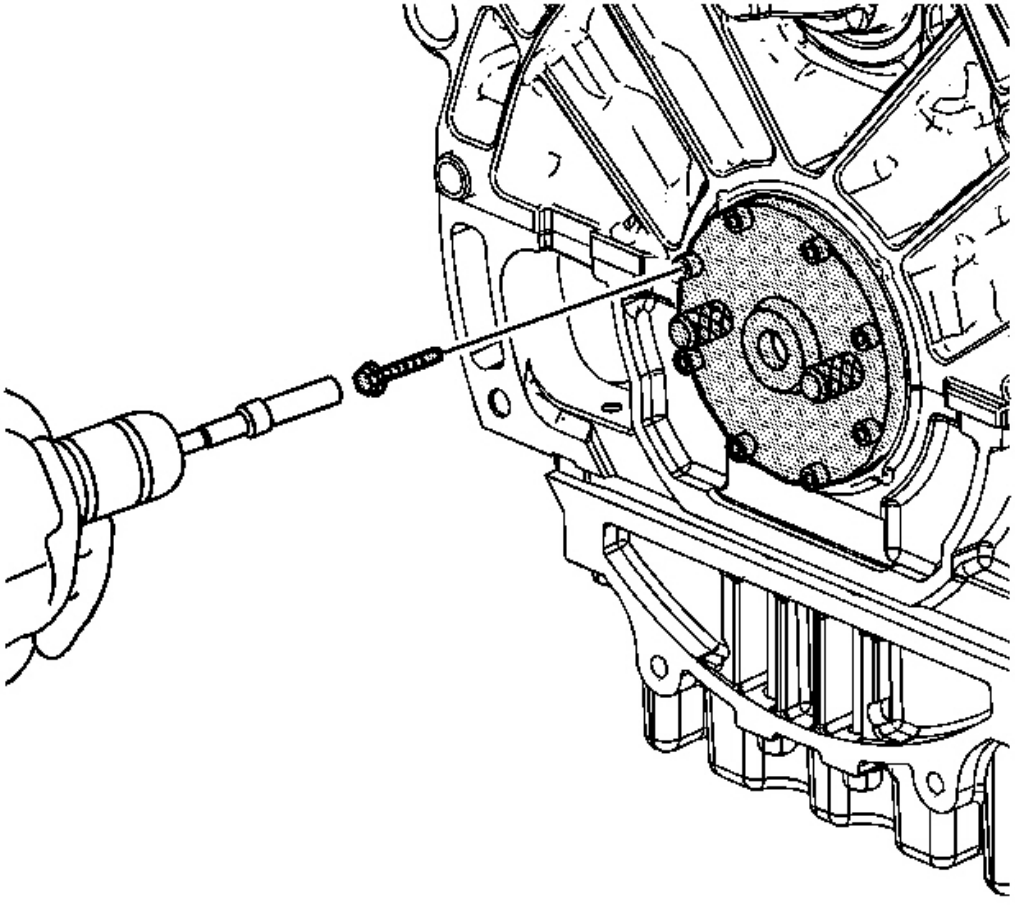


Fig. 313: Identifying Self-Drilling Screws
Courtesy of GENERAL MOTORS CORP.

3. Using a drill motor, variable speed preferred, with a socket adapter, install eight 25 mm (1.0 in) self-drilling screws into the seal using the guide holes in the removal tool. When drilling, ensure the drill motor speed is reduced when the screw begins threading into the seal.

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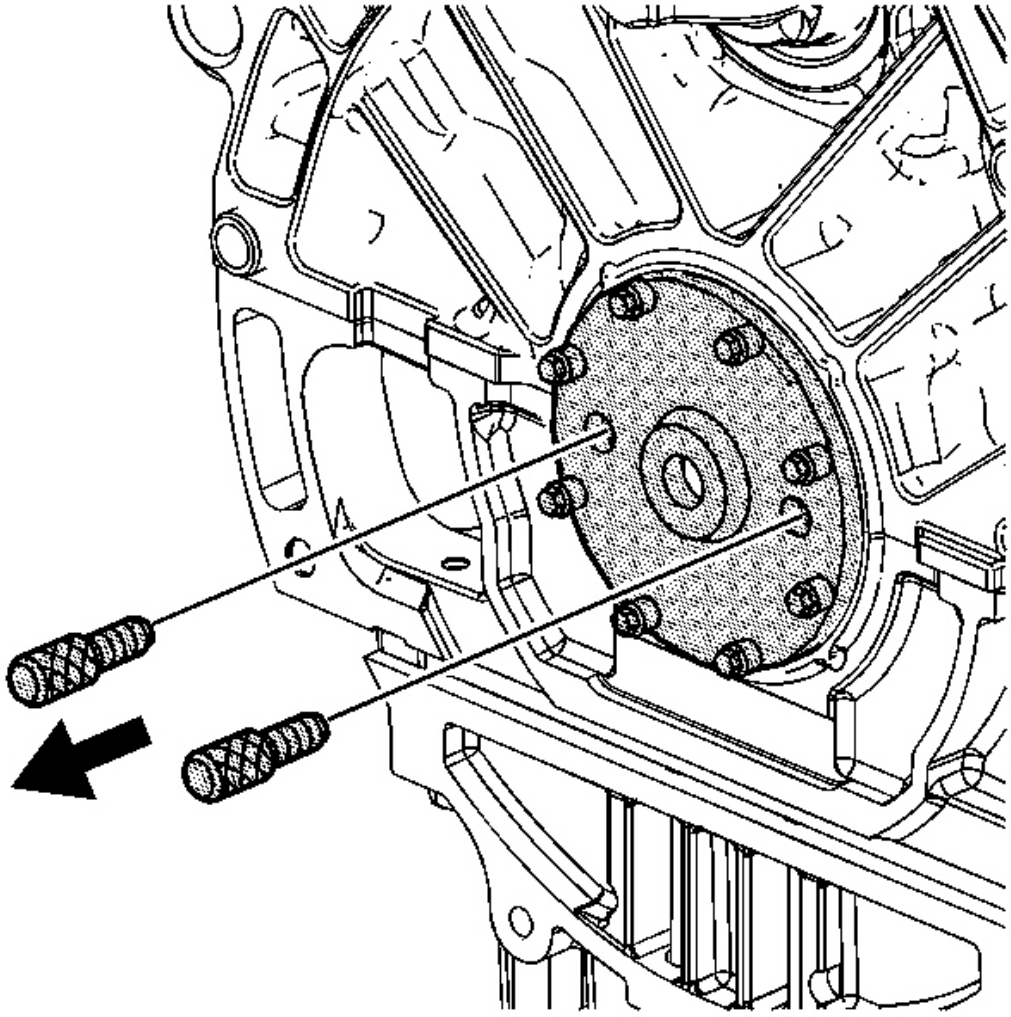


Fig. 314: View Of J 42841-A Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

4. With all eight removal screws installed, remove the **J 42841-A** retaining bolts. See **Special Tools** .

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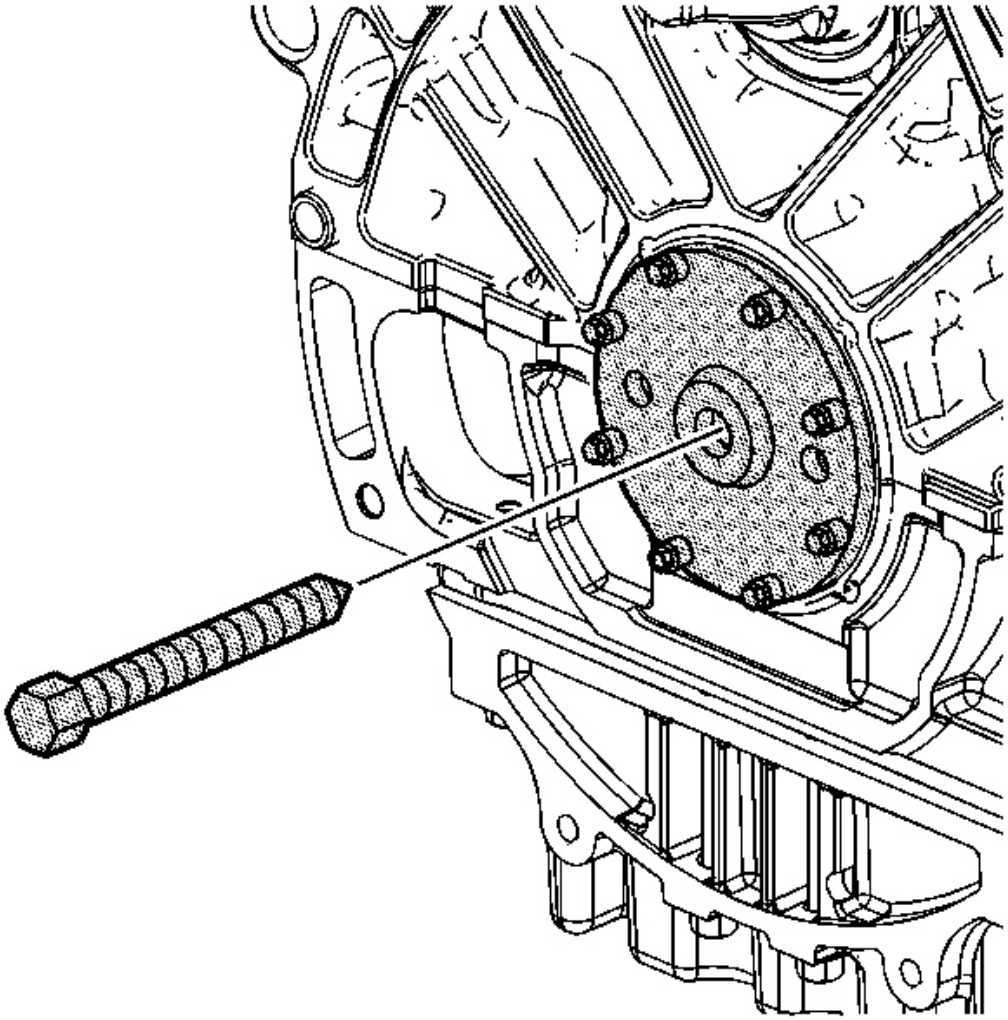


Fig. 315: Identifying Center Forcing Screw
Courtesy of GENERAL MOTORS CORP.

5. Install the center forcing screw.

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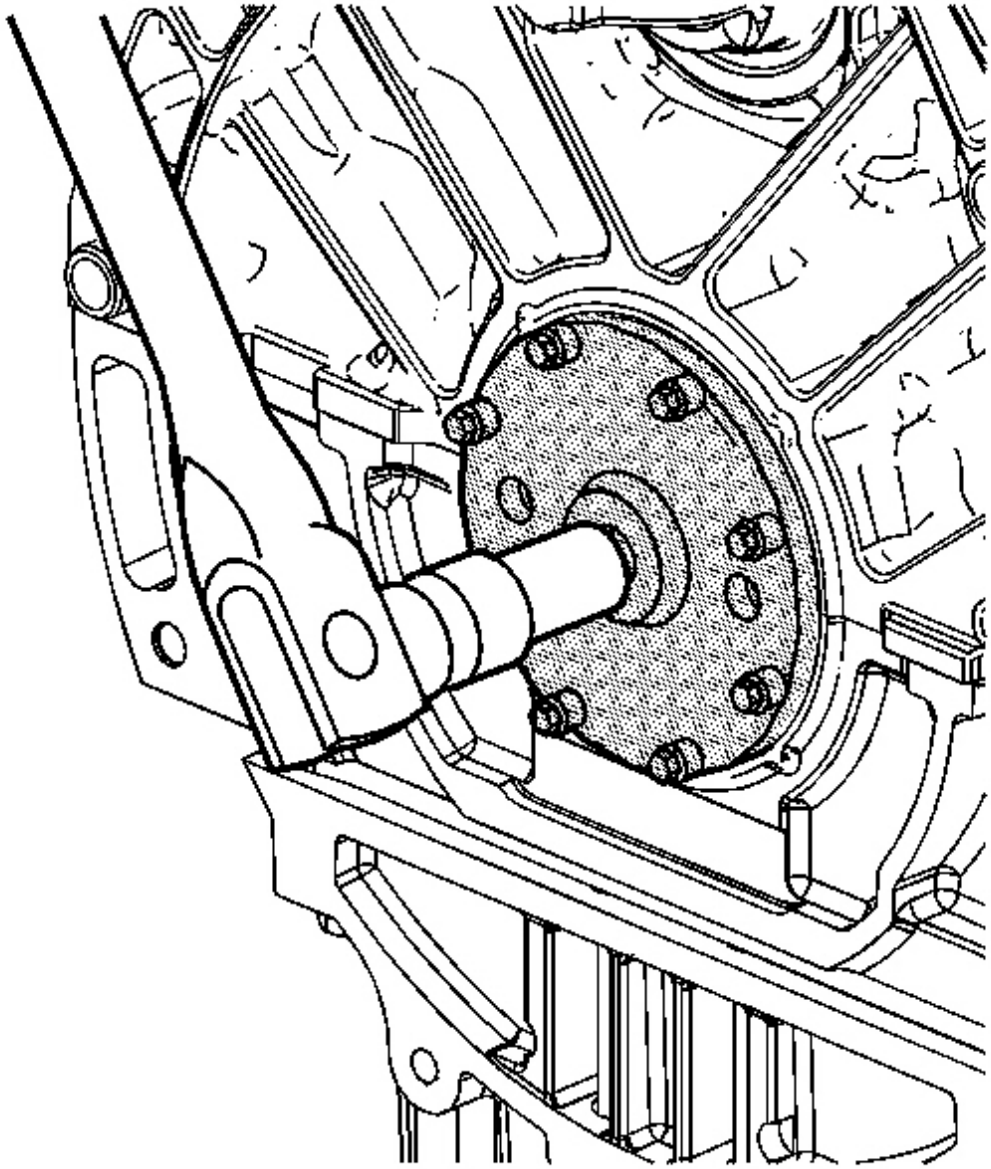


Fig. 316: Pulling Seal Assembly Off Crankshaft
Courtesy of GENERAL MOTORS CORP.

6. Tighten the center screw on the **J 42841-A** to pull the seal assembly off the end of the crankshaft. See **Special Tools** .

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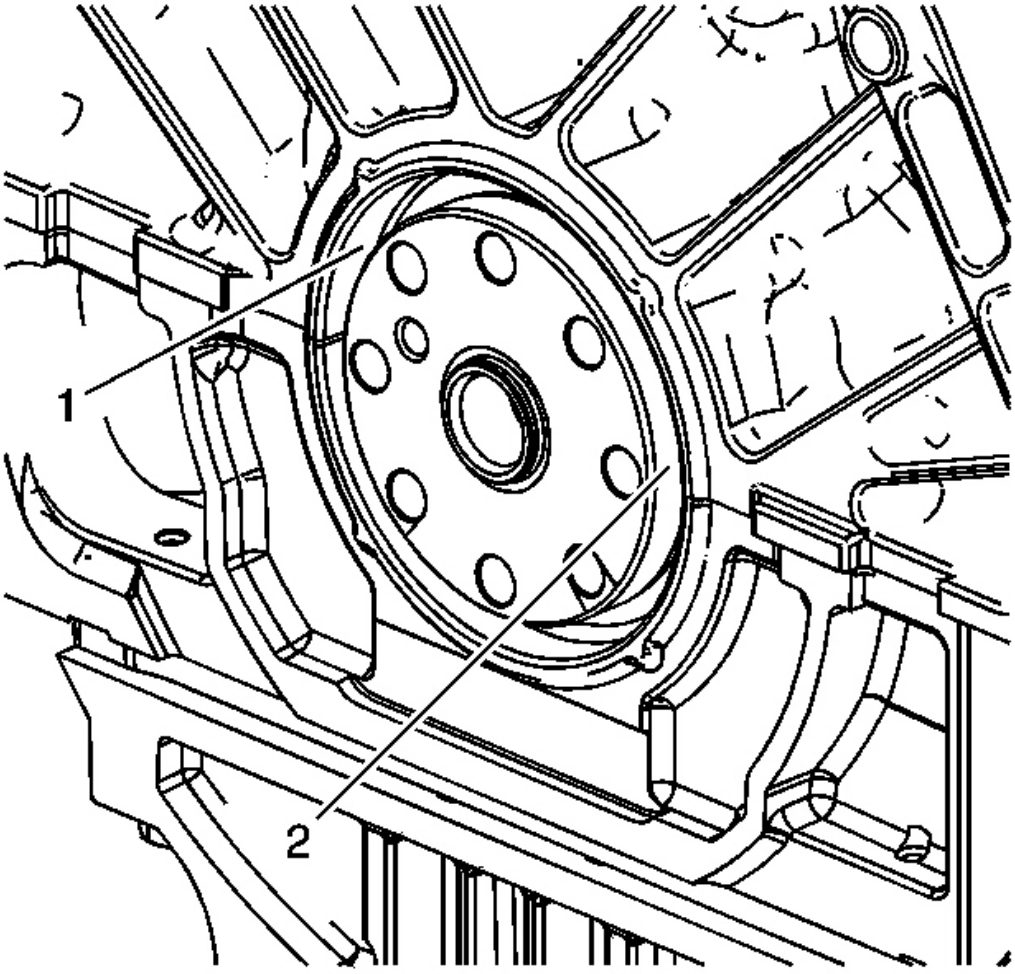


Fig. 317: Inspecting Engine Block Bore & Crankshaft Flange
Courtesy of GENERAL MOTORS CORP.

7. After removing the crankshaft rear oil seal inspect the engine block bore (1) and the crankshaft flange (2) for the damage. Repair or replace any damaged components.

OIL LEVEL INDICATOR AND TUBE REMOVAL

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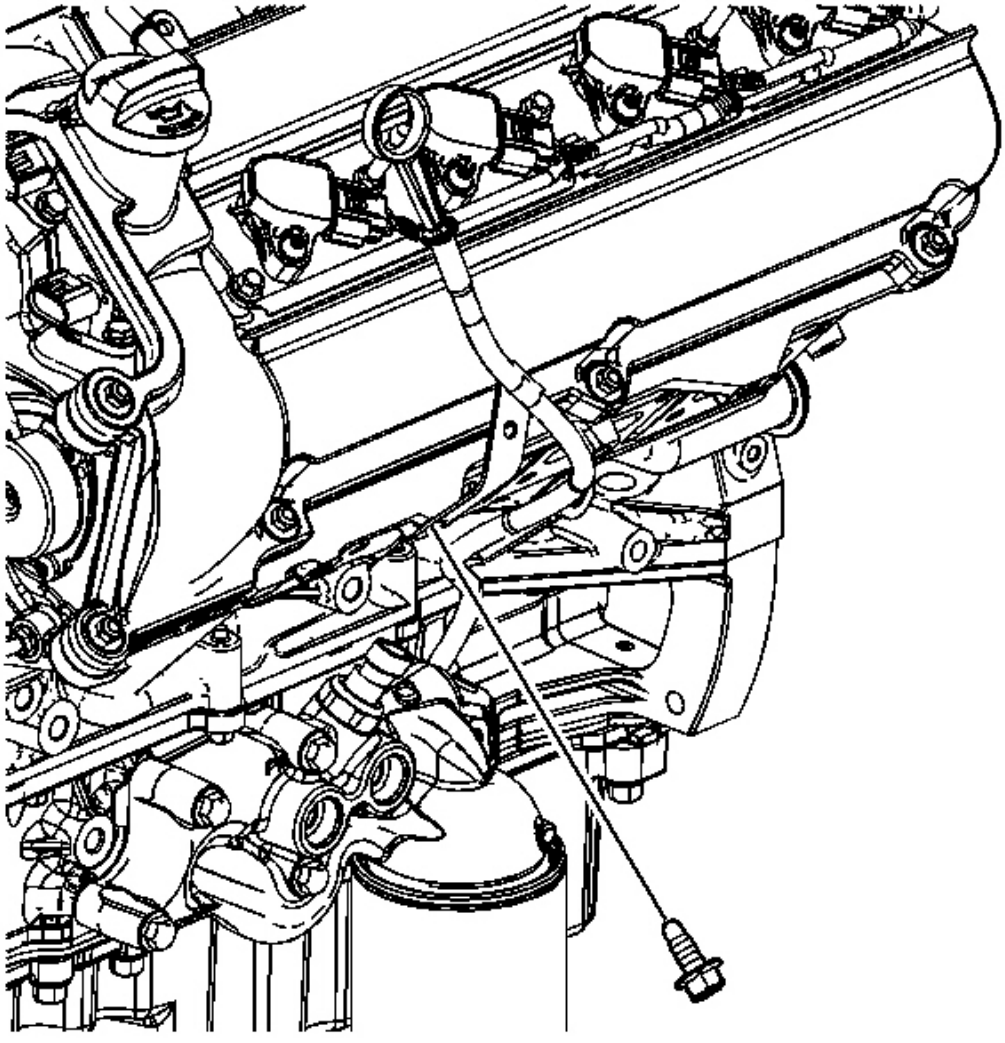


Fig. 318: Identifying Oil Level Indicator Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator bolt.

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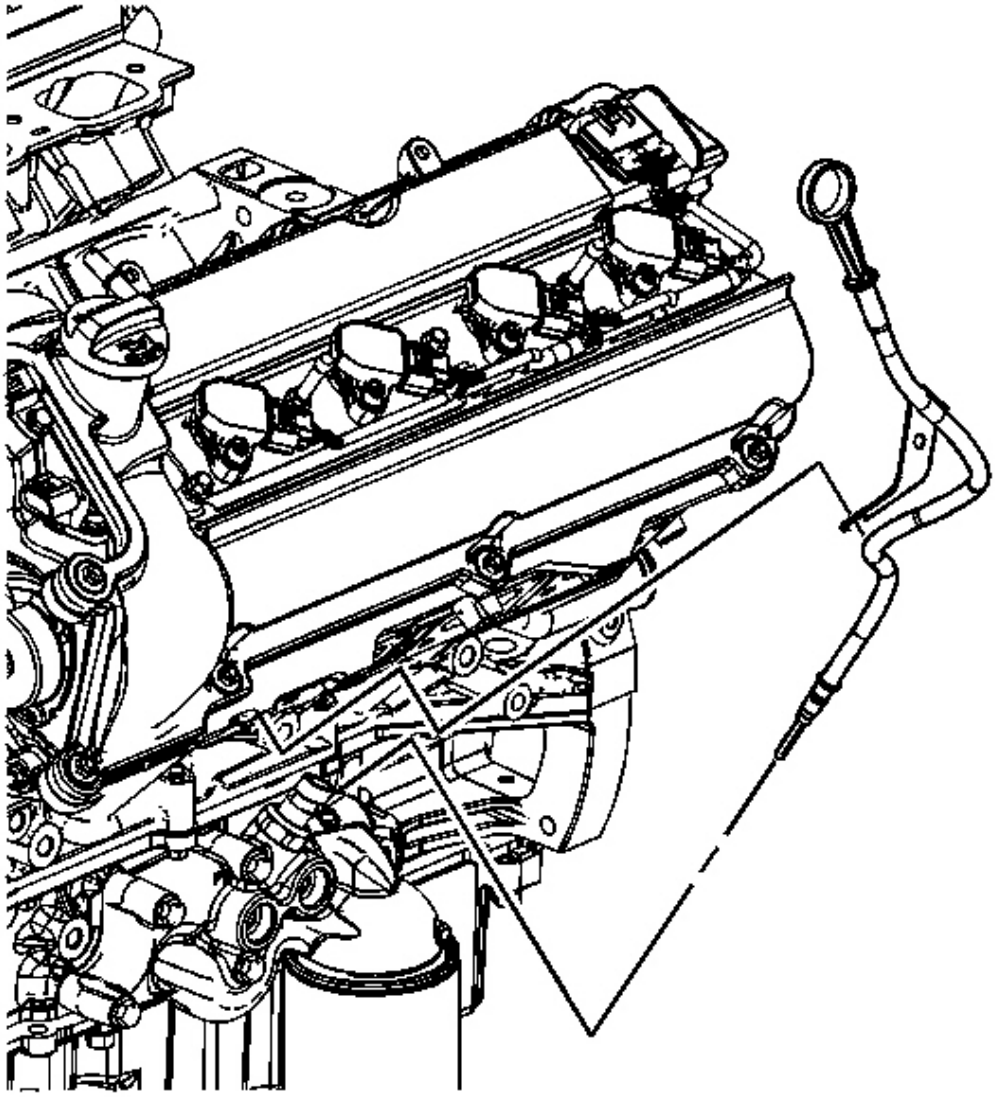


Fig. 319: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil level indicator tube.

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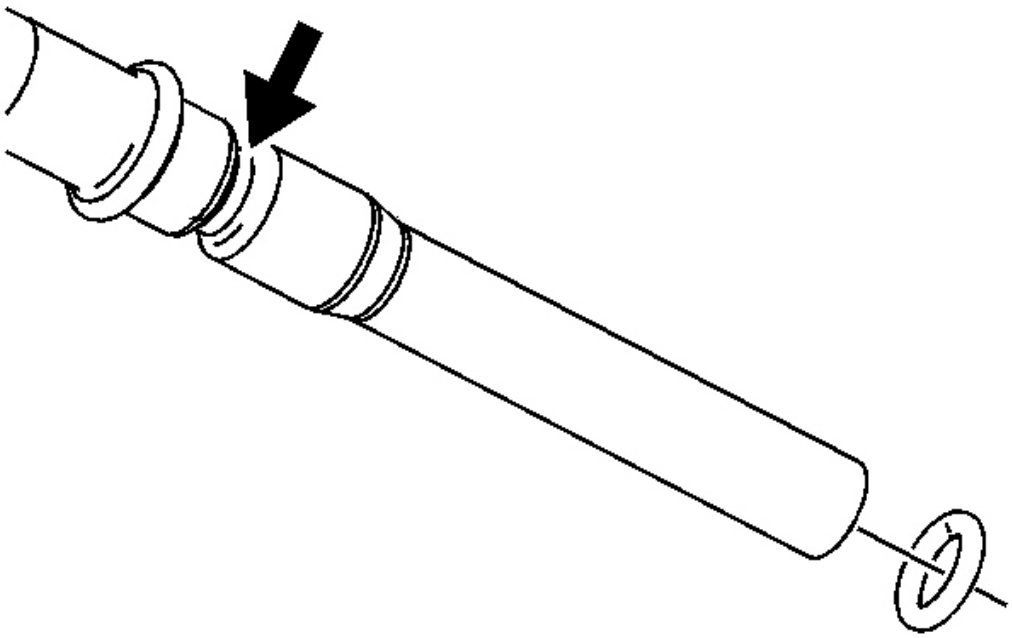


Fig. 320: View Of Oil Level Indicator Tube O-Ring
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the oil level indicator tube O-ring.

OIL FILTER ADAPTER REMOVAL

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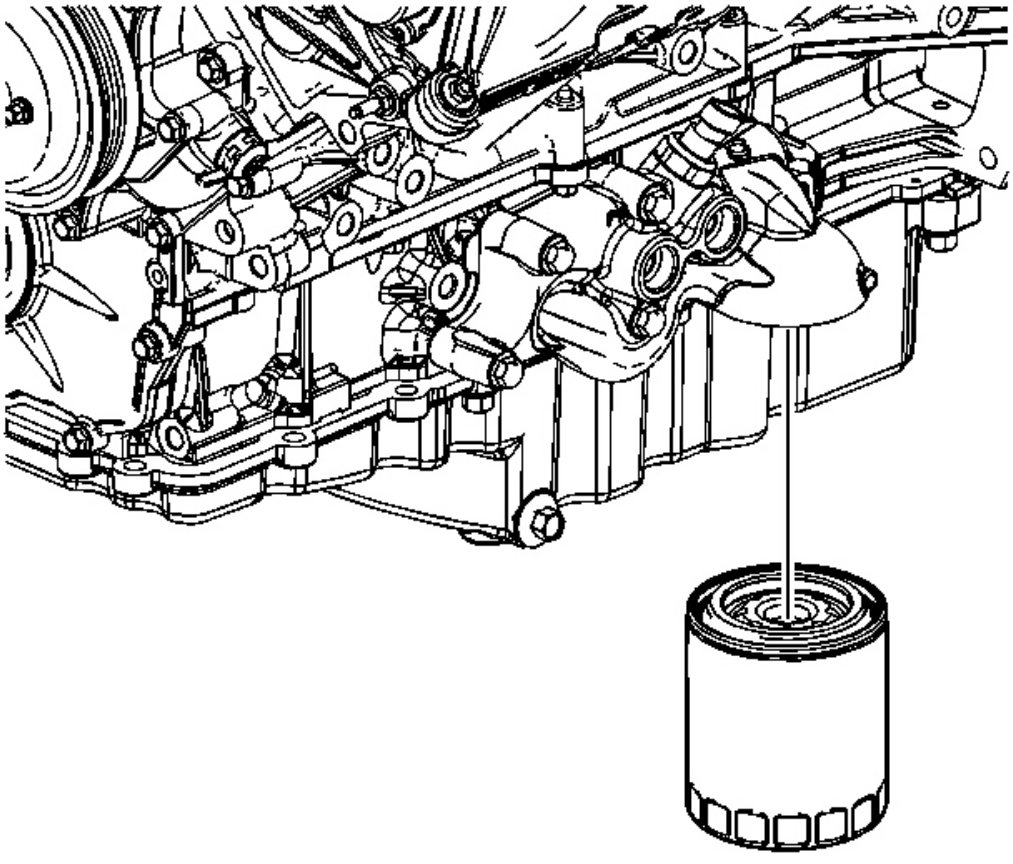


Fig. 321: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter.

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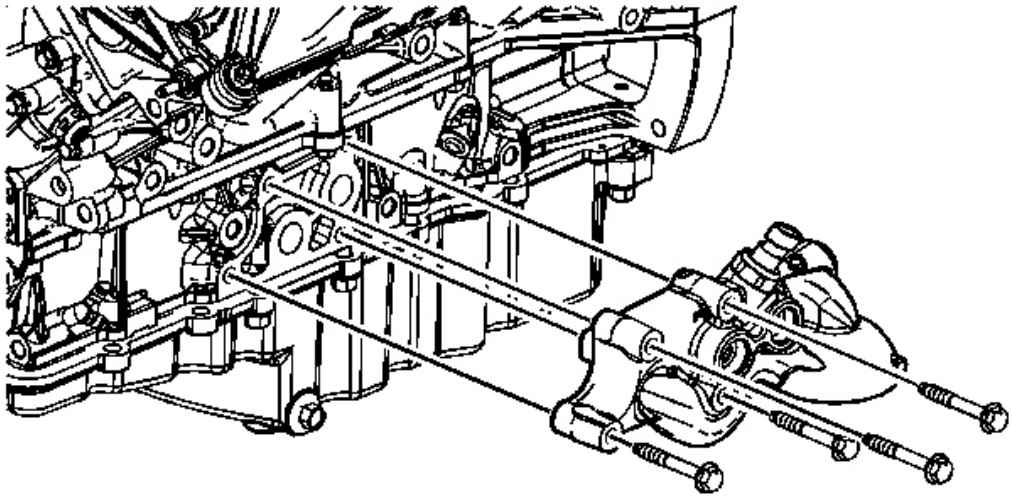


Fig. 322: View Of Oil Filter Adapter Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter adapter bolts.
3. Remove the oil filter adapter.
4. Remove and discard the oil filter adapter gasket.

IGNITION COIL MODULE REMOVAL - LEFT SIDE

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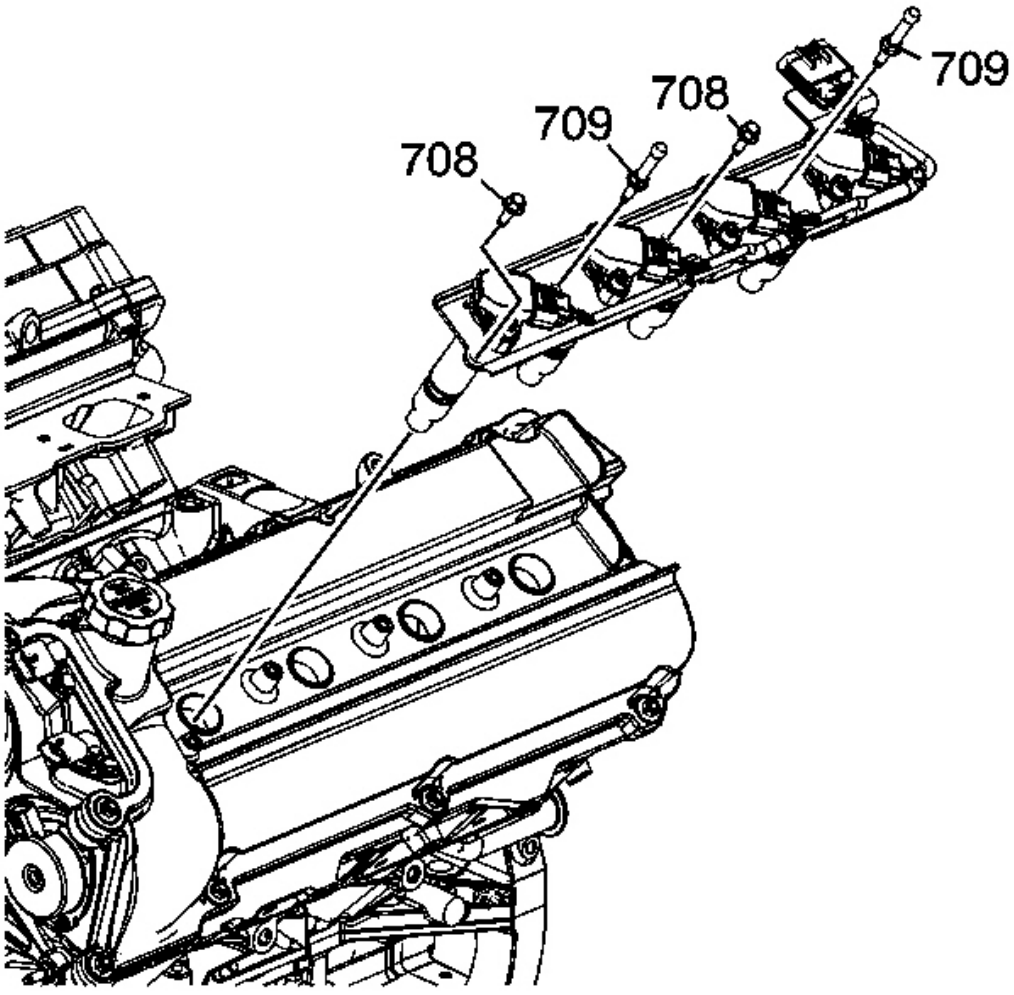


Fig. 323: View Of Ignition Coil Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition coil assembly bolts (708) and ball studs (709).
2. Carefully, remove the ignition coil assembly.

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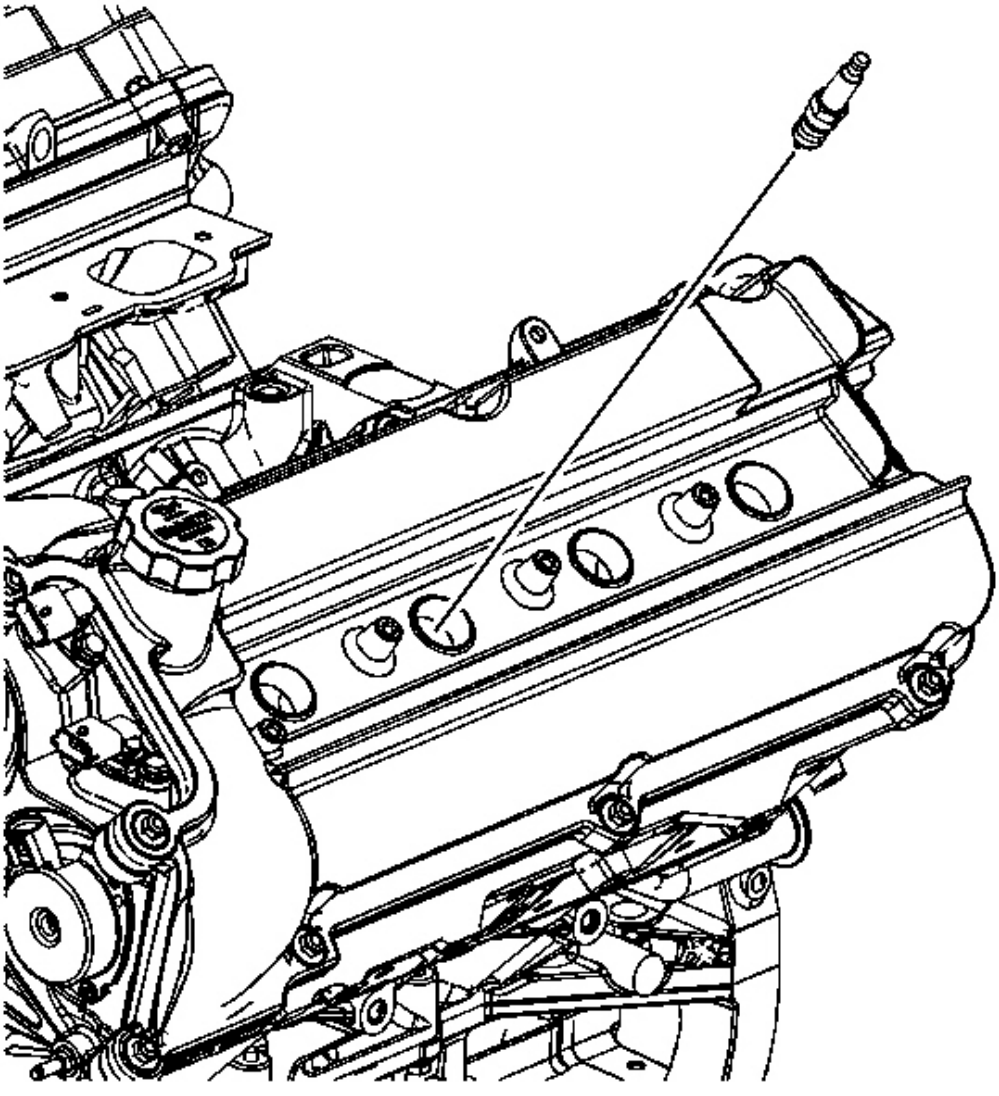


Fig. 324: Locating Spark Plugs
Courtesy of GENERAL MOTORS CORP.

3. Remove the spark plugs.

CAMSHAFT COVER REMOVAL - LEFT SIDE

TOOLS REQUIRED

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- **J 39946** Crankshaft Socket - 4.0L and 4.6L. See **Special Tools** .
- **EN 46328** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

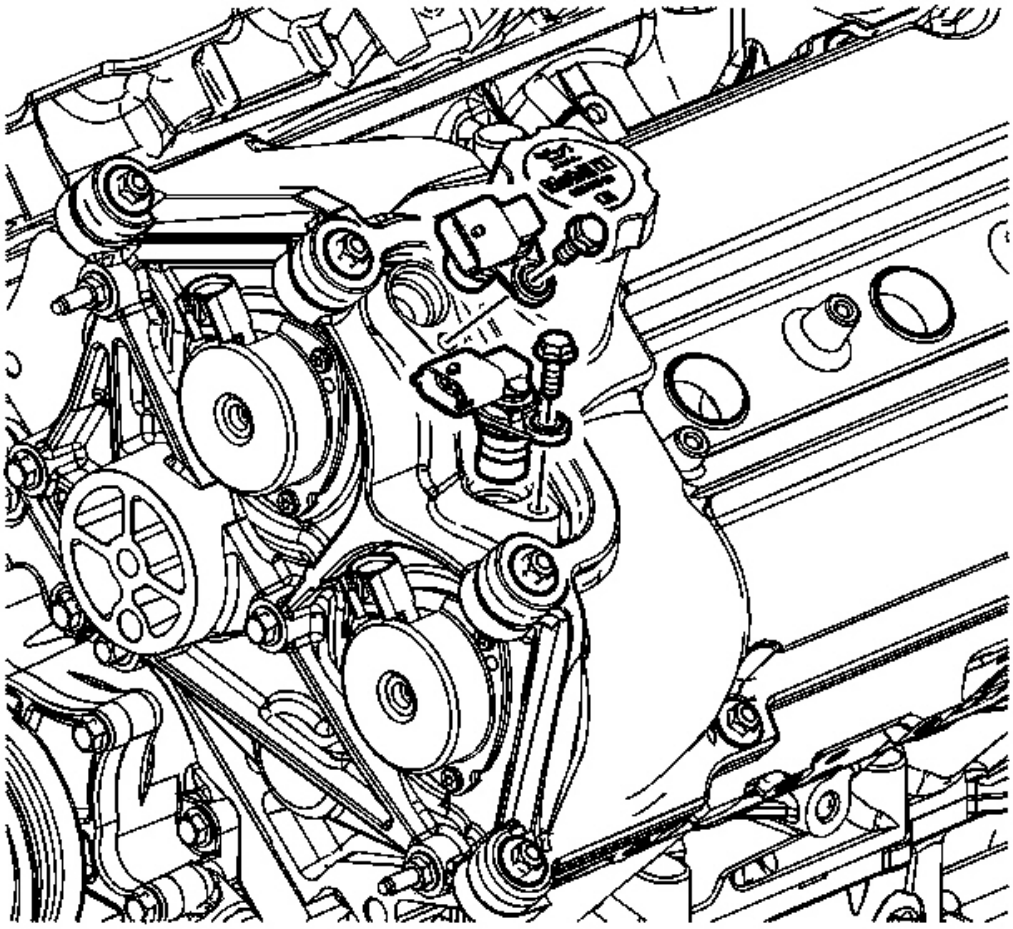


Fig. 325: View Of Left Intake Camshaft Sensor & Left Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

1. Loosen the left camshaft position sensor bolts.
2. Remove the left camshaft position sensors.

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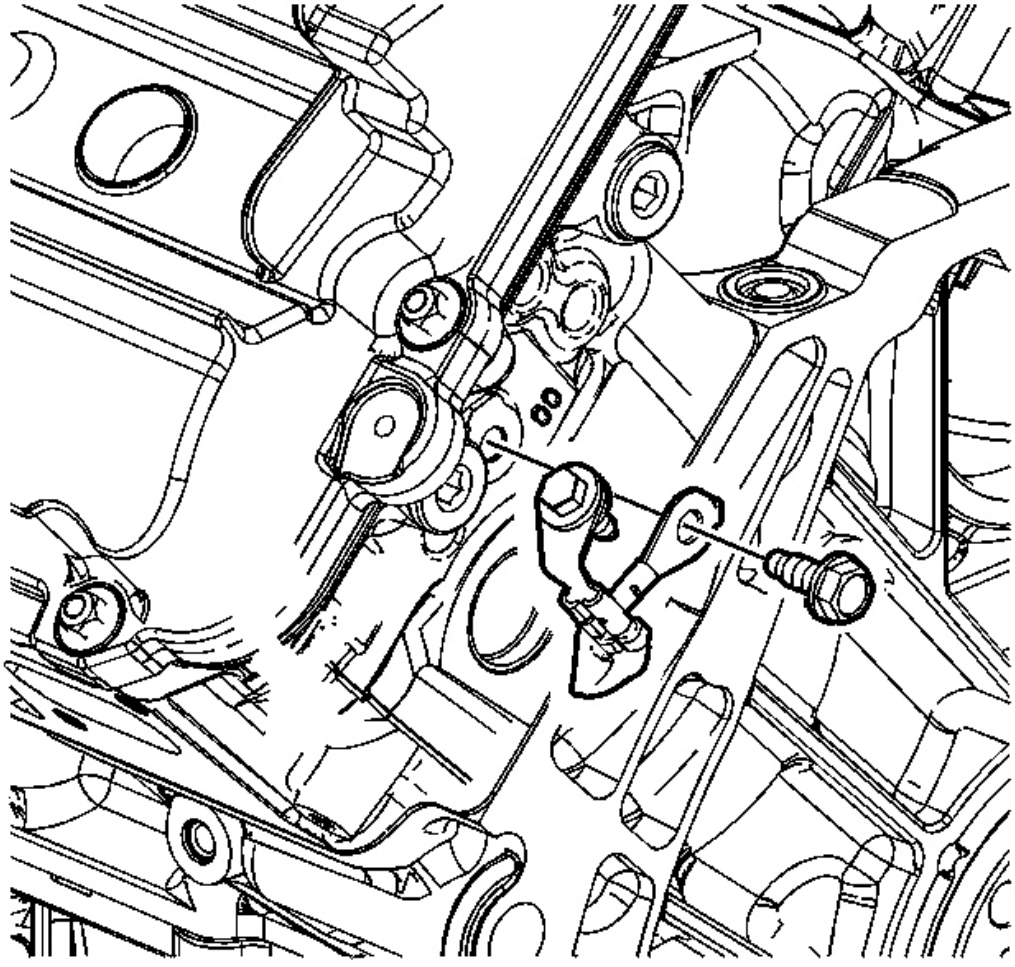


Fig. 326: View Of Left Camshaft Cover Ground Strap & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the bolts connecting the left camshaft cover ground strap to the left cylinder head and to the left camshaft cover.
4. Remove the left camshaft cover ground strap.

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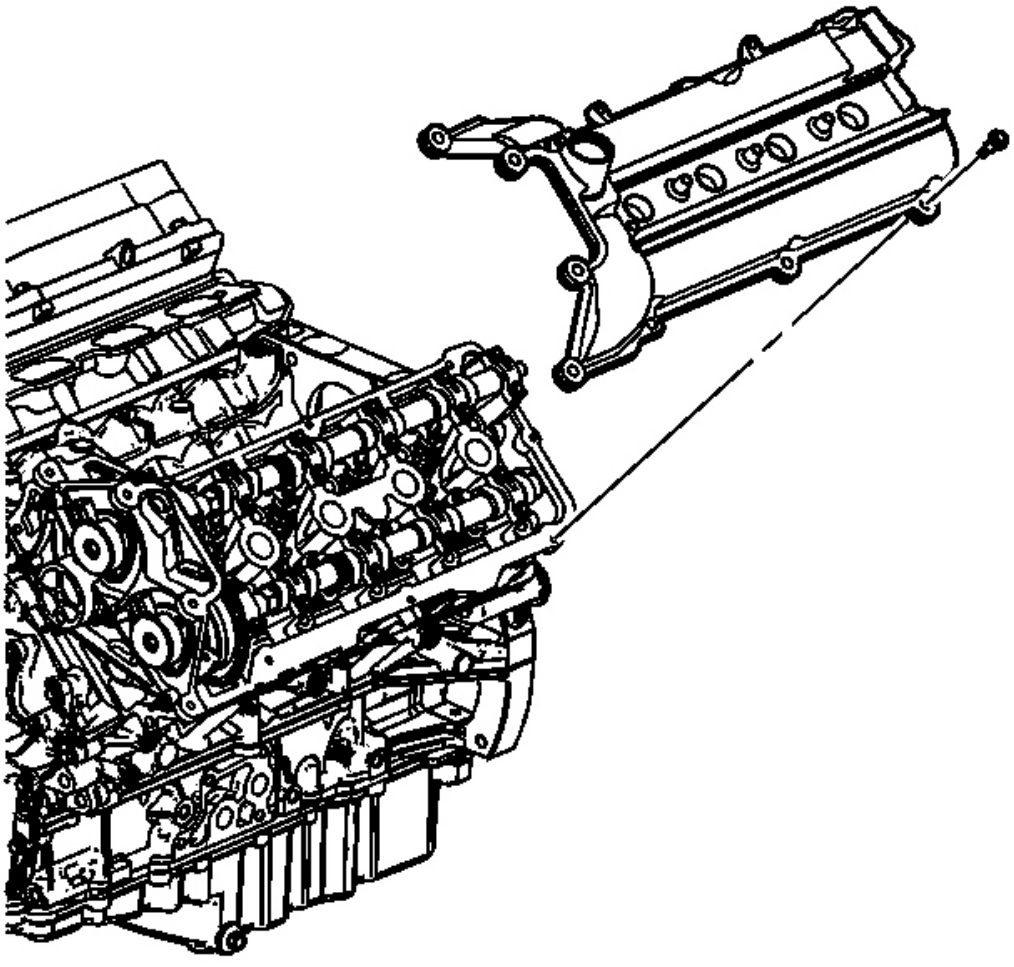


Fig. 327: View Of Left Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Loosen the left camshaft cover bolts.
6. Remove the left camshaft cover.
7. Use the **J 39946** on the nose of the crankshaft in order to align and install the **EN 46328** on the rear of the left cylinder head camshafts. See **Special Tools** .

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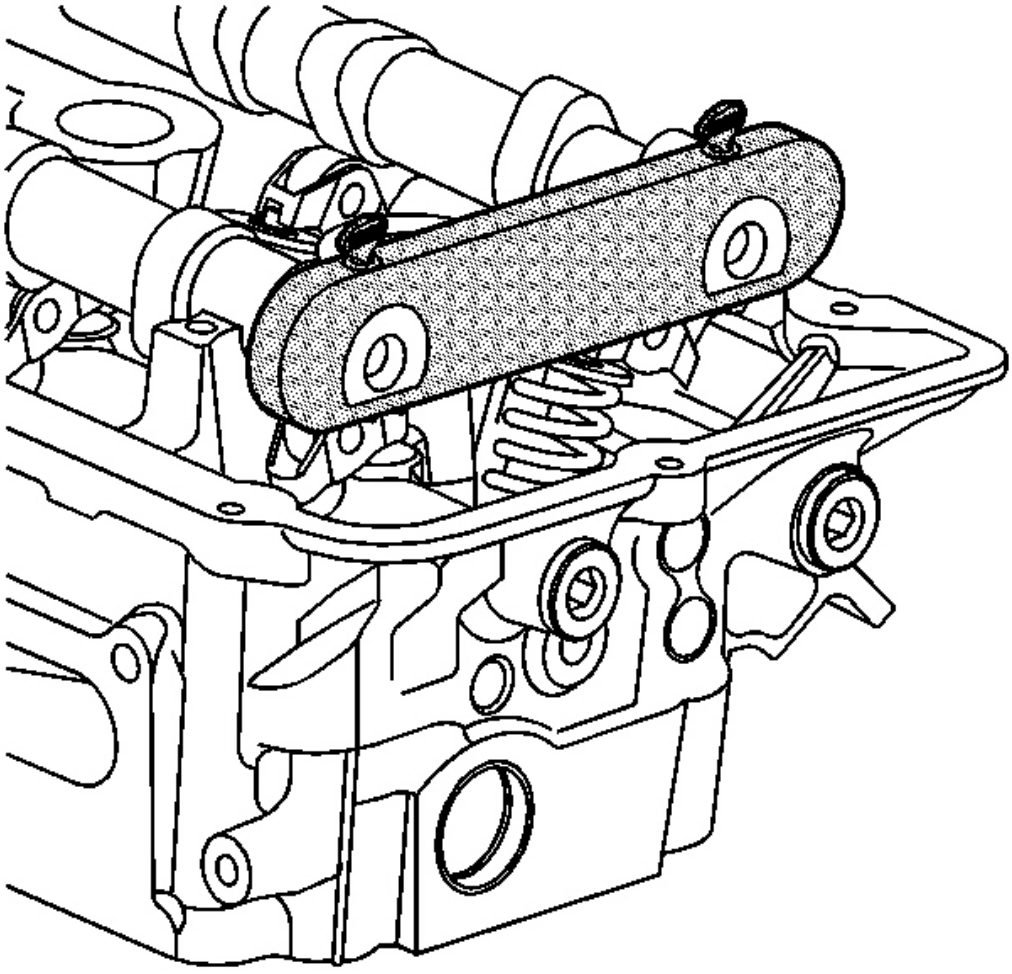


Fig. 328: Installing EN 46328 On Left Cylinder Head Camshafts
Courtesy of GENERAL MOTORS CORP.

CAUTION: The camshaft holding tools must be installed on the camshafts to prevent camshaft rotation. When performing service to the valve train and/or timing components, valve spring pressure can cause the camshafts to rotate unexpectedly and can cause personal injury.

8. Install the **EN 46328** on the left cylinder head camshafts. See **Special Tools** .

CAMSHAFT POSITION ACTUATOR HOUSING REMOVAL - LEFT SIDE

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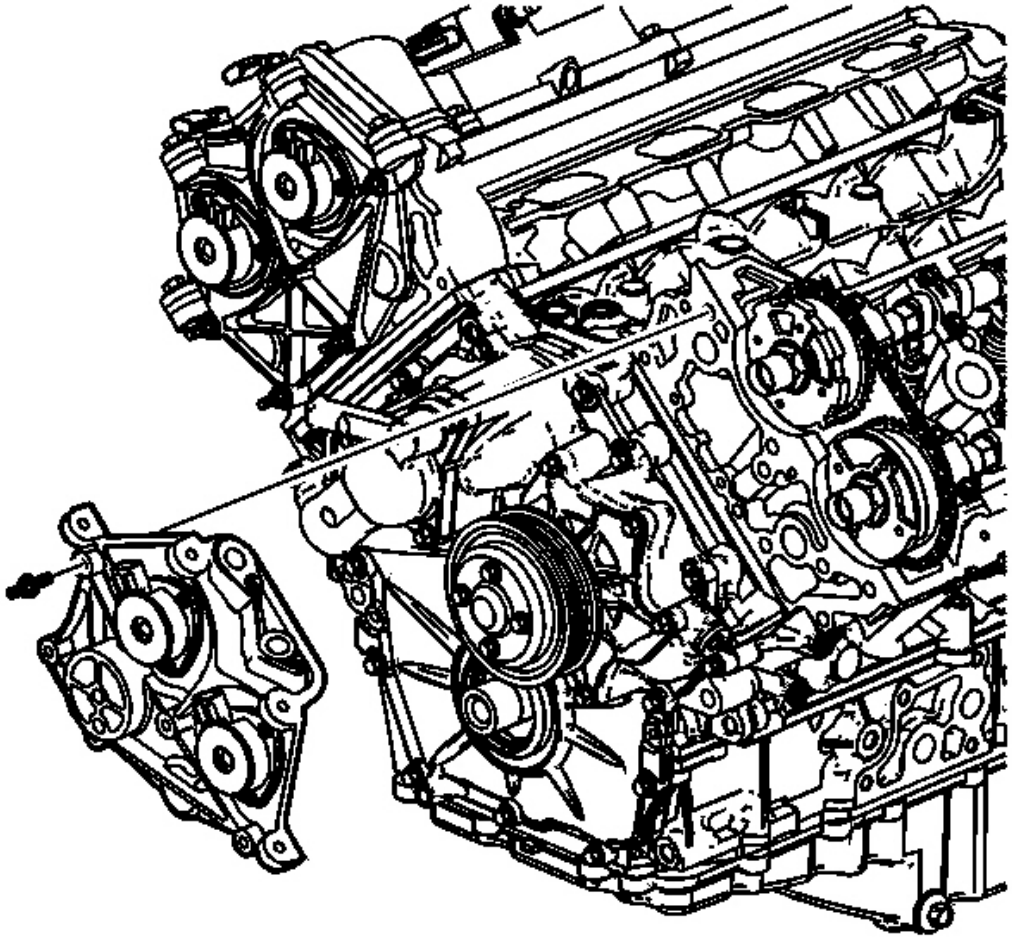


Fig. 329: View Of Left CMP Actuator Housing Removal
Courtesy of GENERAL MOTORS CORP.

NOTE: **DO NOT remove the camshaft position actuator magnet unless it needs to be replaced. The camshaft position actuator magnet is precisely aligned to the camshaft position actuator oil control valve on the end of the camshaft during engine assembly. If the camshaft position actuator magnet is removed and/or needs to be replaced, it will be necessary to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve after the camshaft position actuator housing is installed to the cylinder head. Failure to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve can lead to poor engine performance and engine component damage.**

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1. Remove the left camshaft position actuator housing bolts.
2. Remove the left camshaft position actuator housing.

IGNITION COIL MODULE REMOVAL - RIGHT SIDE

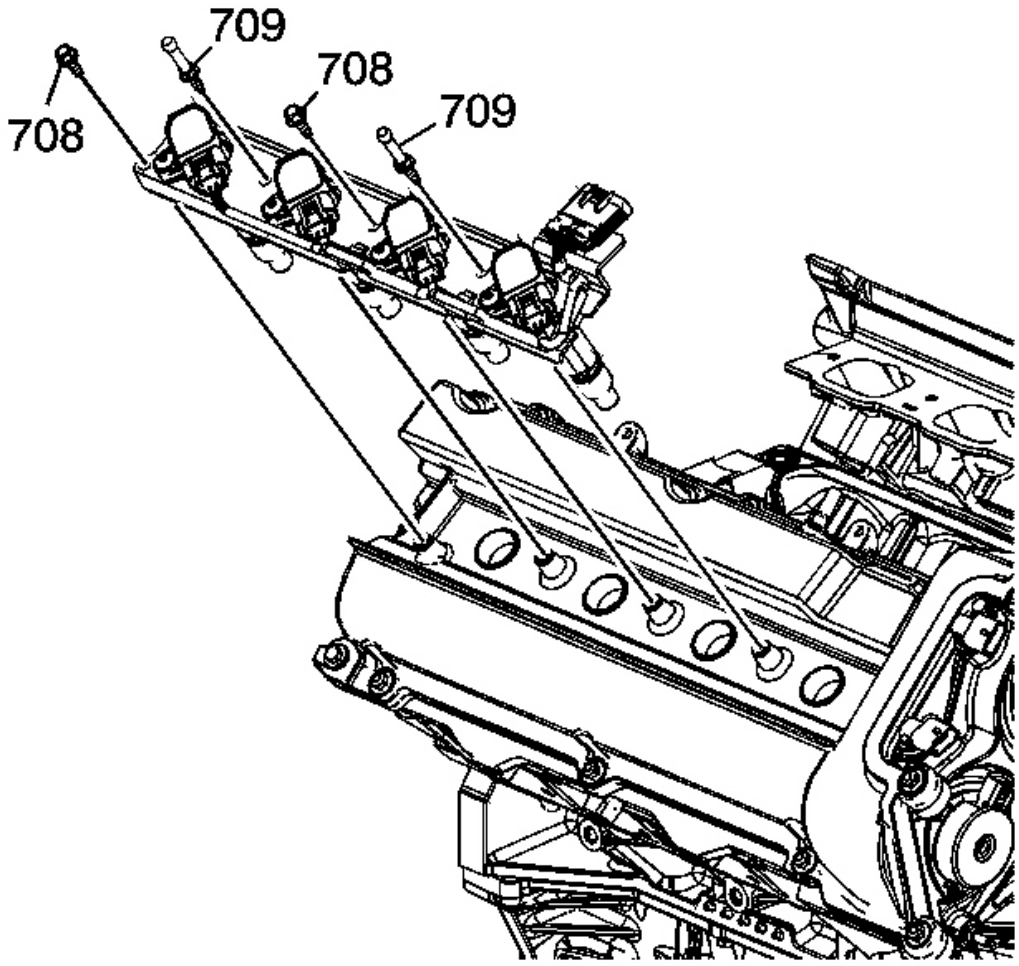


Fig. 330: View Of Ignition Coil Assembly Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition coil assembly bolts (708) and ball studs (709).
2. Carefully, remove the ignition coil assembly.

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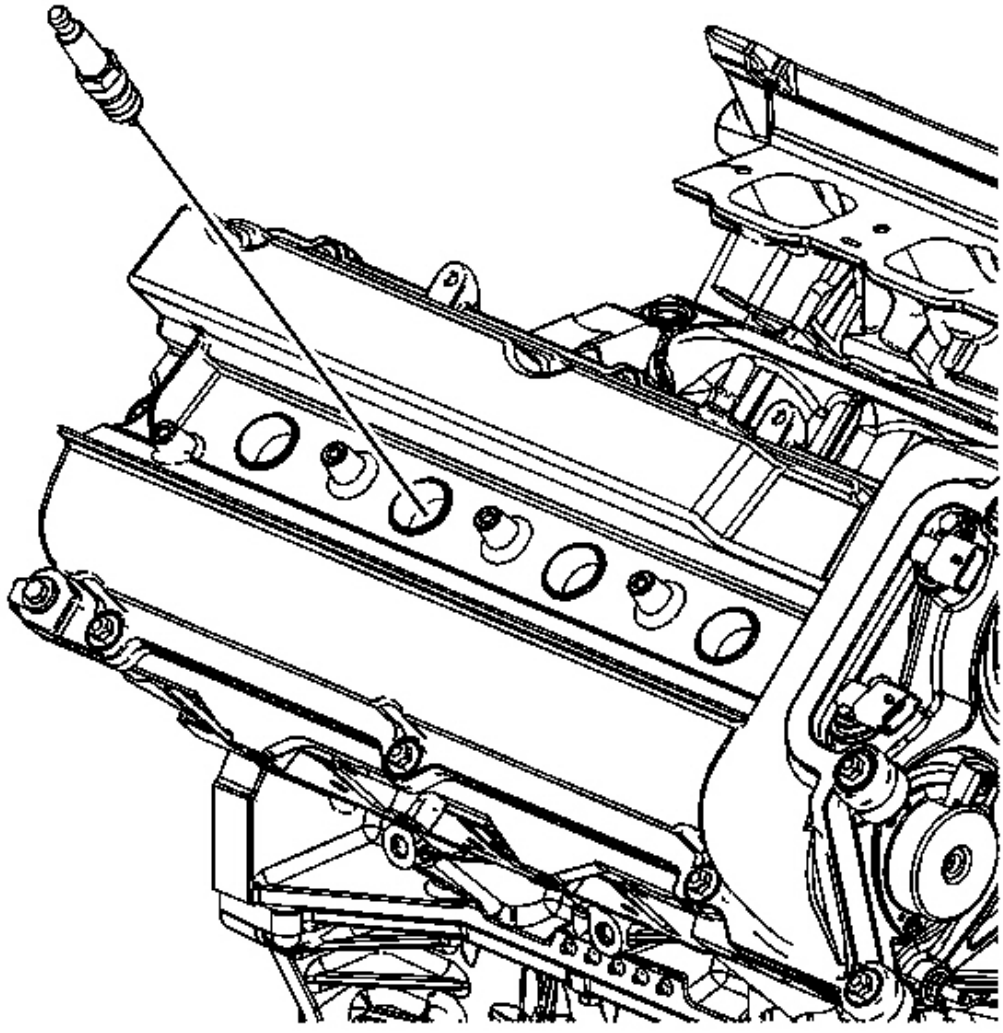


Fig. 331: Identifying Spark Plug Location
Courtesy of GENERAL MOTORS CORP.

3. Remove the spark plugs.

CAMSHAFT COVER REMOVAL - RIGHT SIDE

TOOLS REQUIRED

EN 46328 Camshaft Holding Tool. See **Special Tools** .

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REMOVAL PROCEDURE

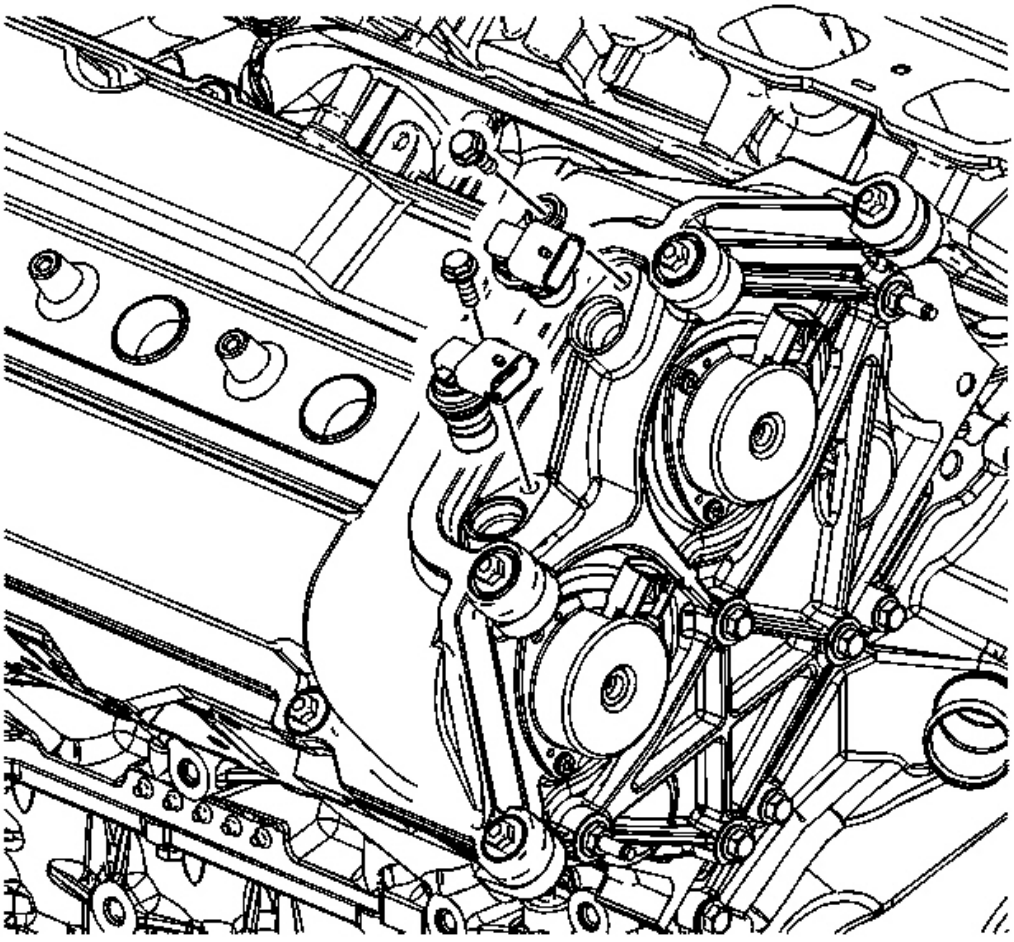


Fig. 332: View Of Right Intake Camshaft Sensor & Right Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

1. Loosen the right camshaft position sensor bolts.
2. Remove the right camshaft position sensors.

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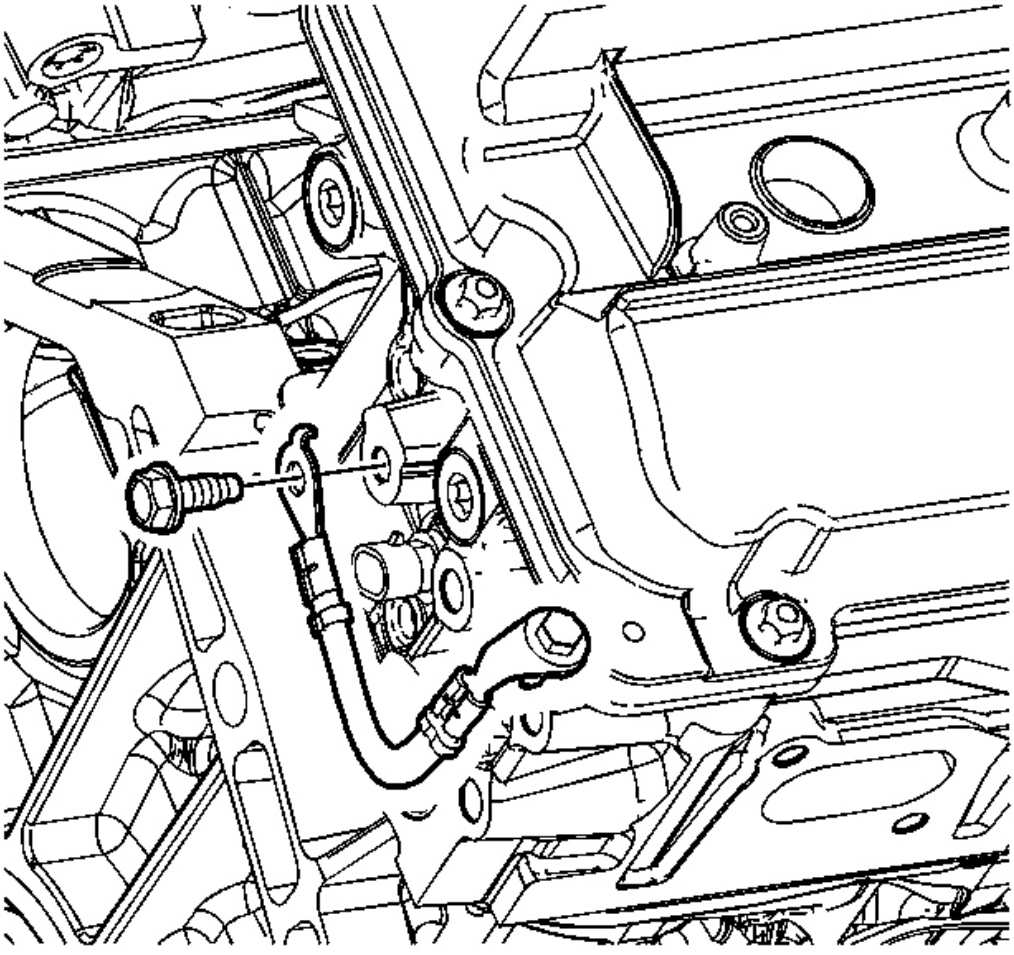


Fig. 333: View Of Ground Strap, Right Camshaft Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the bolts connecting the right camshaft cover ground strap to the right cylinder head and to the right camshaft cover.
4. Remove the right camshaft cover ground strap.

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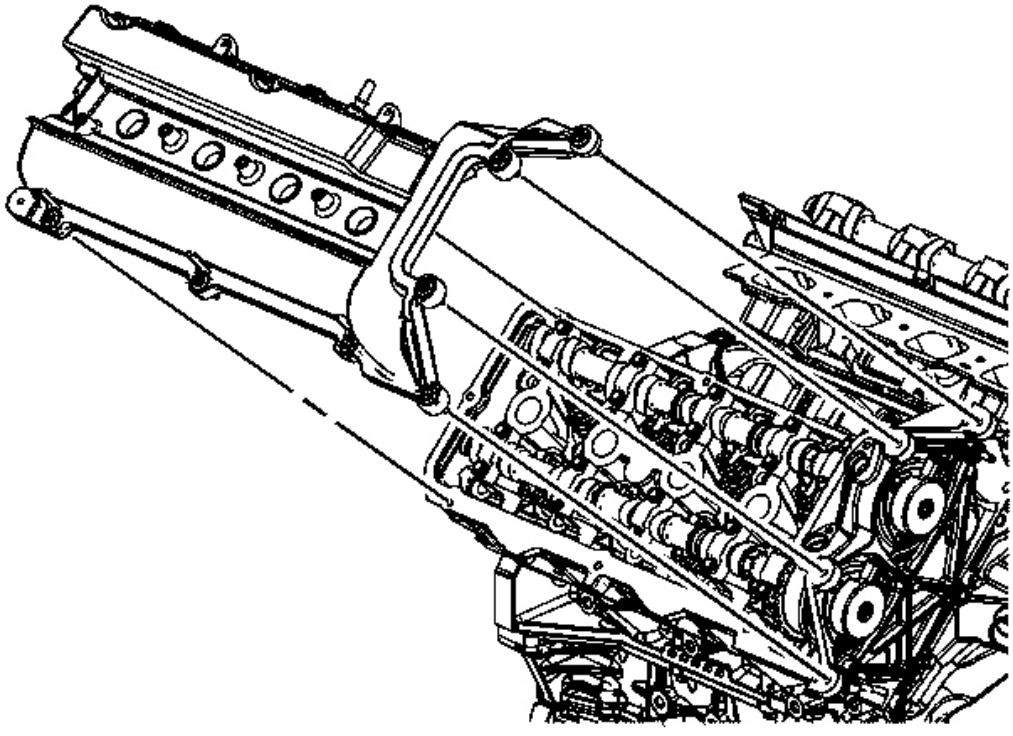


Fig. 334: View Of Right Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Loosen the right camshaft cover bolts.
6. Remove the right camshaft cover.

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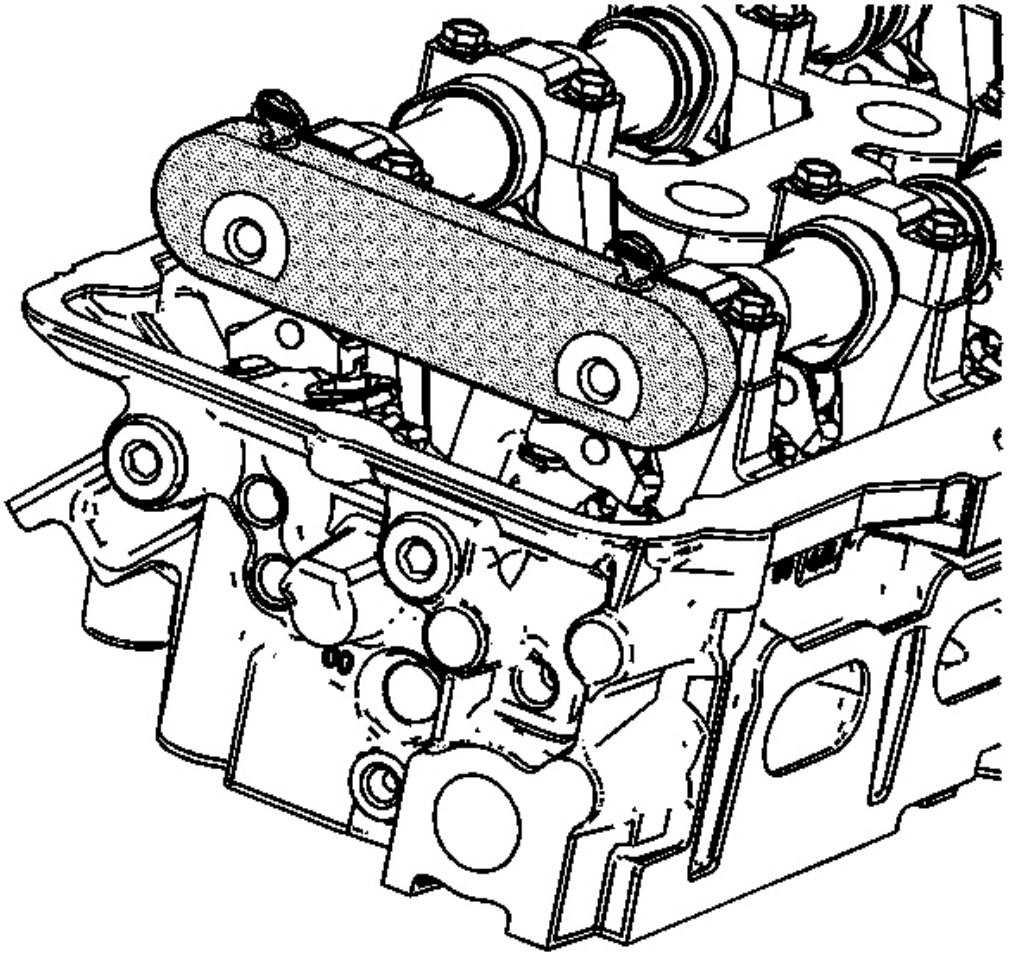


Fig. 335: Installing EN 46328 On Right Cylinder Head Camshafts
Courtesy of GENERAL MOTORS CORP.

CAUTION: The camshaft holding tools must be installed on the camshafts to prevent camshaft rotation. When performing service to the valve train and/or timing components, valve spring pressure can cause the camshafts to rotate unexpectedly and can cause personal injury.

7. Install the **EN 46328** on the right cylinder head camshafts. See **Special Tools** .

CAMSHAFT POSITION ACTUATOR HOUSING REMOVAL - RIGHT SIDE

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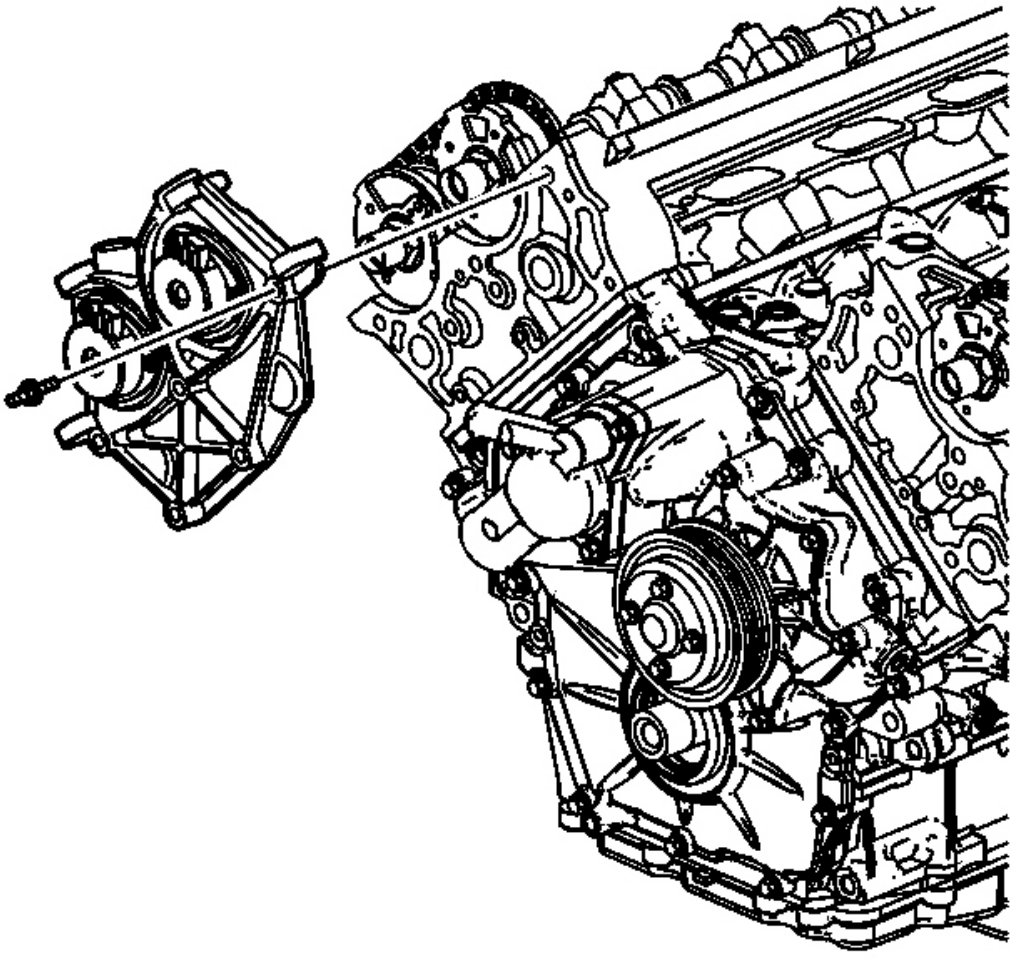


Fig. 336: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

NOTE: **DO NOT remove the camshaft position actuator magnet unless it needs to be replaced. The camshaft position actuator magnet is precisely aligned to the camshaft position actuator oil control valve on the end of the camshaft during engine assembly. If the camshaft position actuator magnet is removed and/or needs to be replaced, it will be necessary to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve after the camshaft position actuator housing is installed to the cylinder head. Failure to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve can lead to poor engine performance and engine component damage.**

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1. Remove the right camshaft position actuator housing bolts.
2. Remove the right camshaft position actuator housing.

ENGINE FRONT COVER REMOVAL

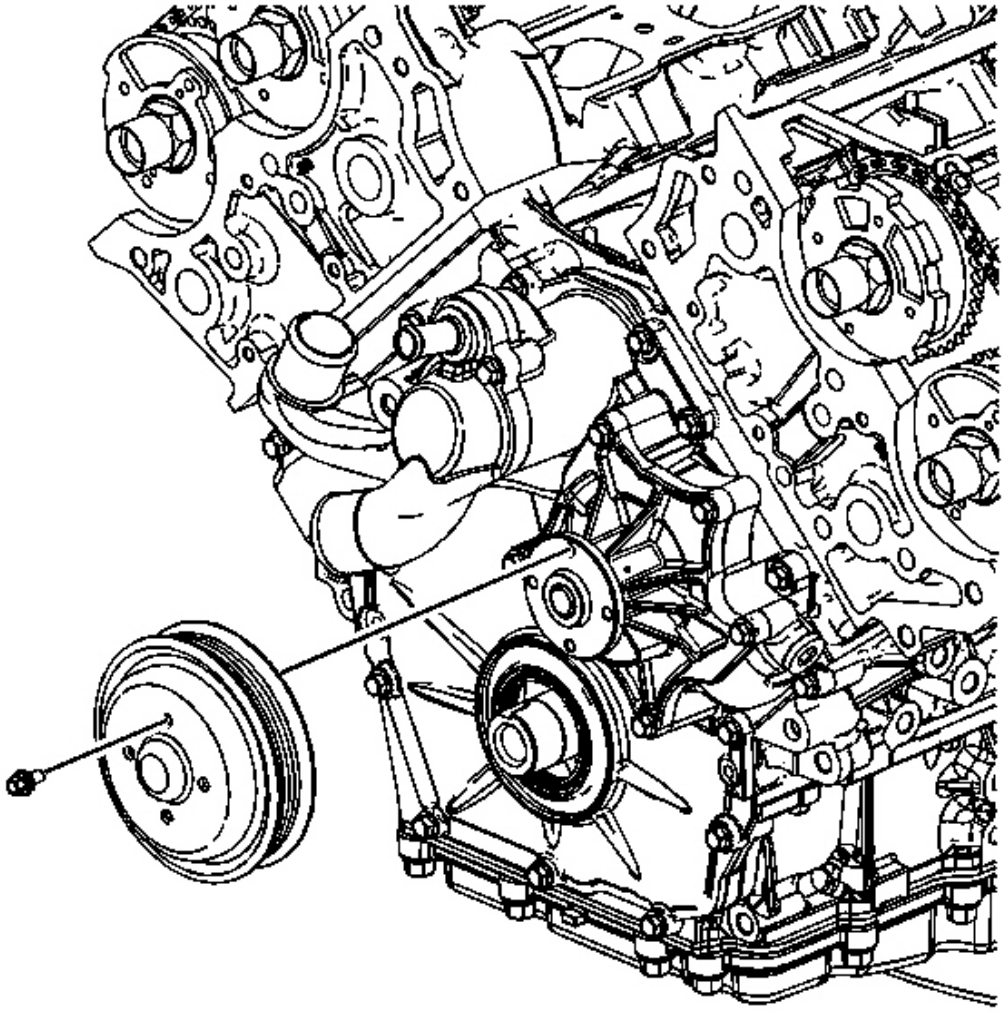


Fig. 337: View Of Water Pump Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump pulley bolts.
2. Remove the water pump pulley.

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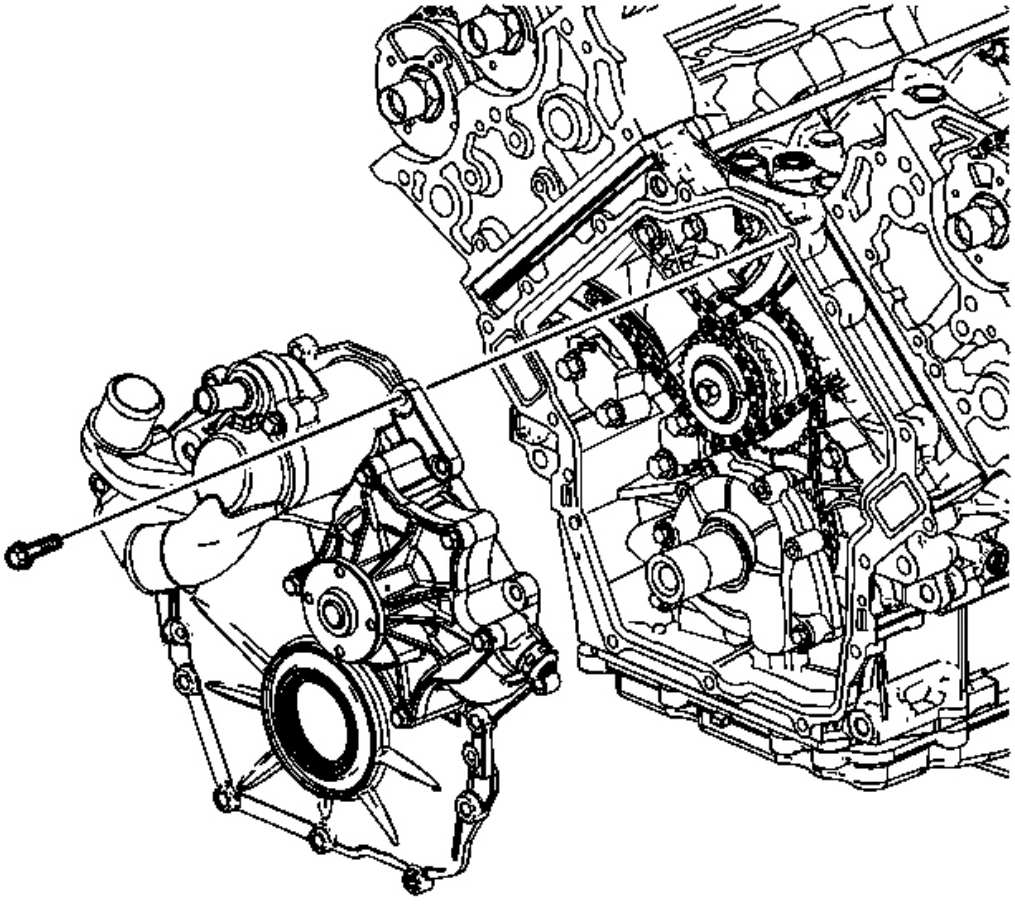


Fig. 338: View Of Engine Front Cover Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine front cover bolts.
4. Remove the engine front cover.

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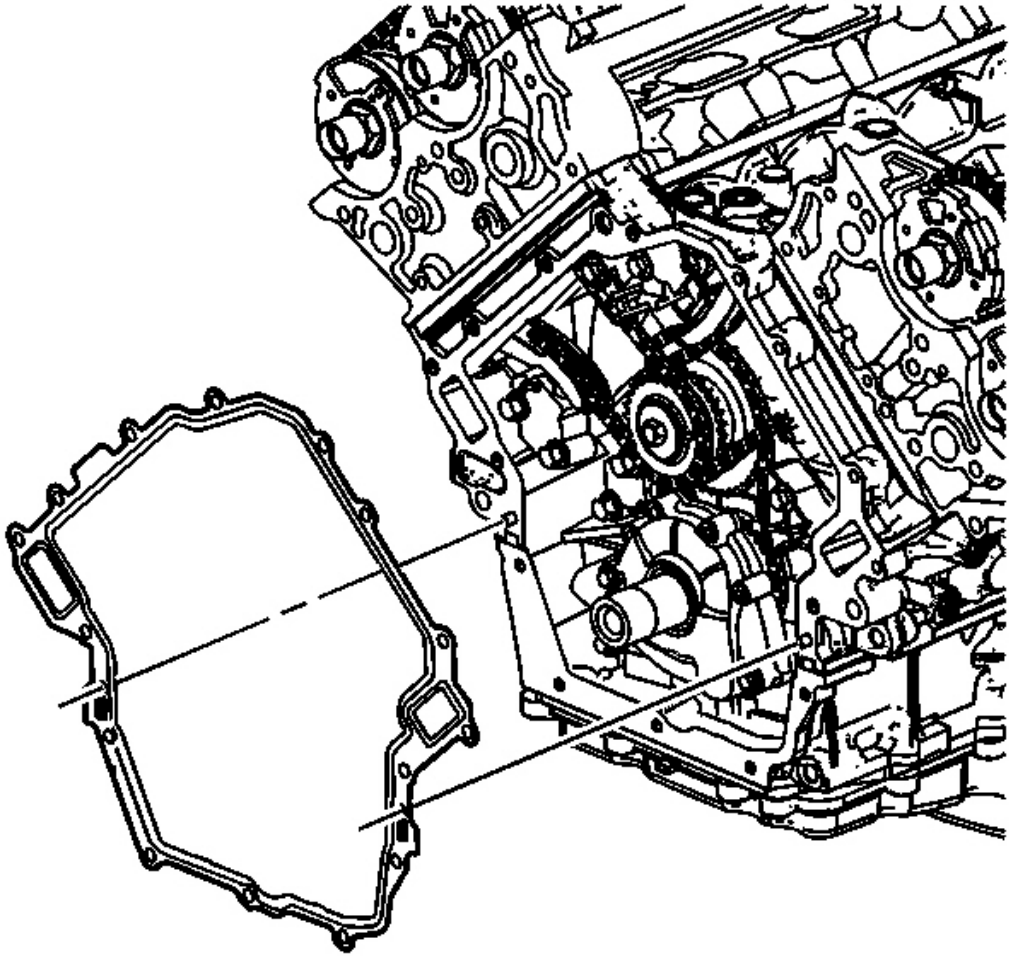


Fig. 339: View Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the engine front cover gasket.

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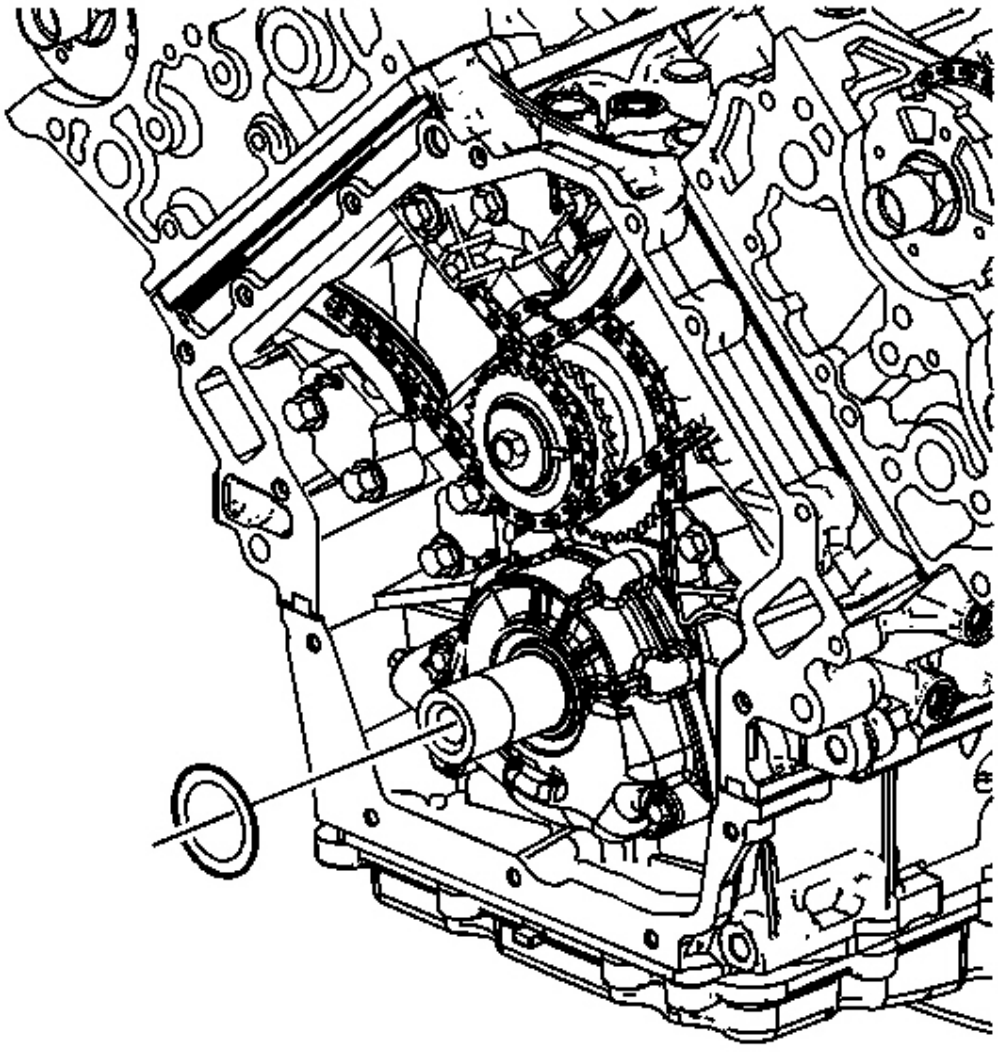


Fig. 340: View Of Oil Pump Drive To Crankshaft Balancer Friction Washer
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pump drive to crankshaft balancer friction washer.

OIL PUMP REMOVAL

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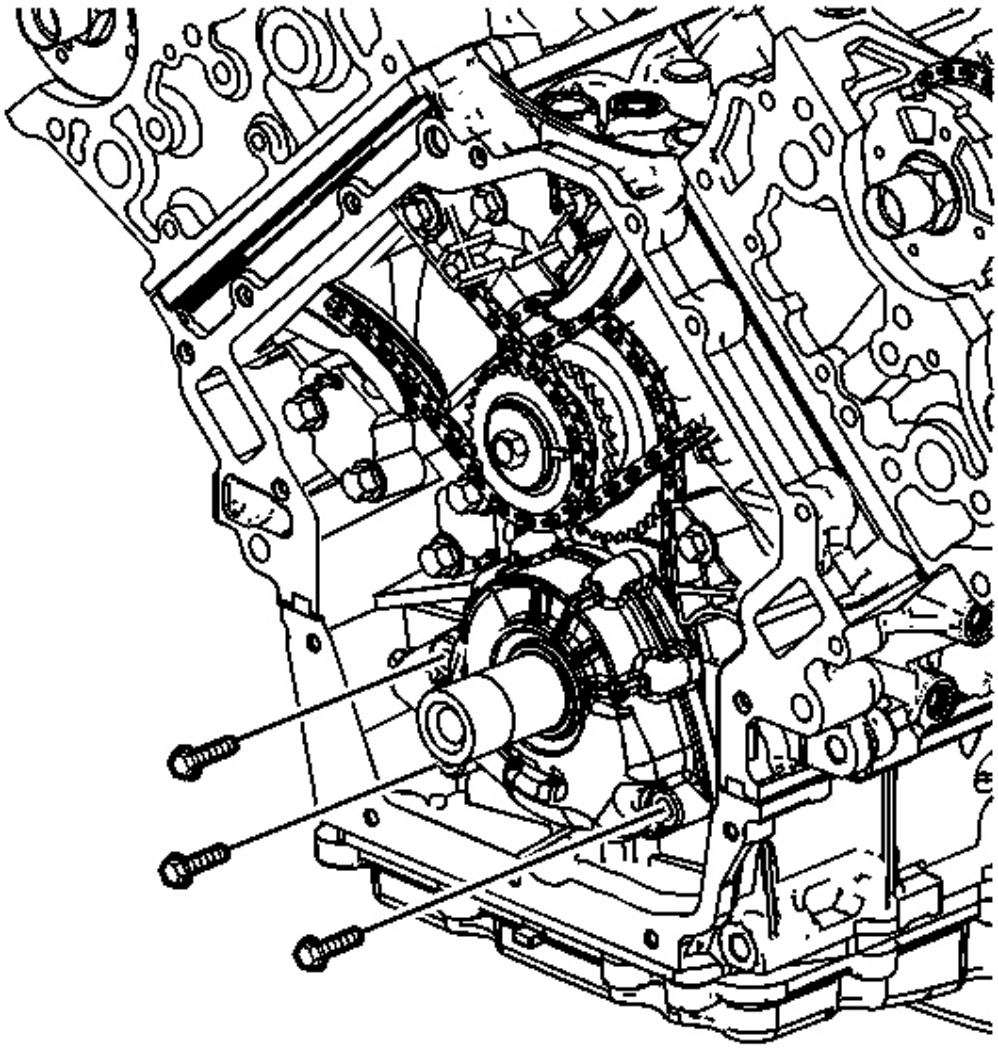


Fig. 341: View Of Oil Pump Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump bolts.

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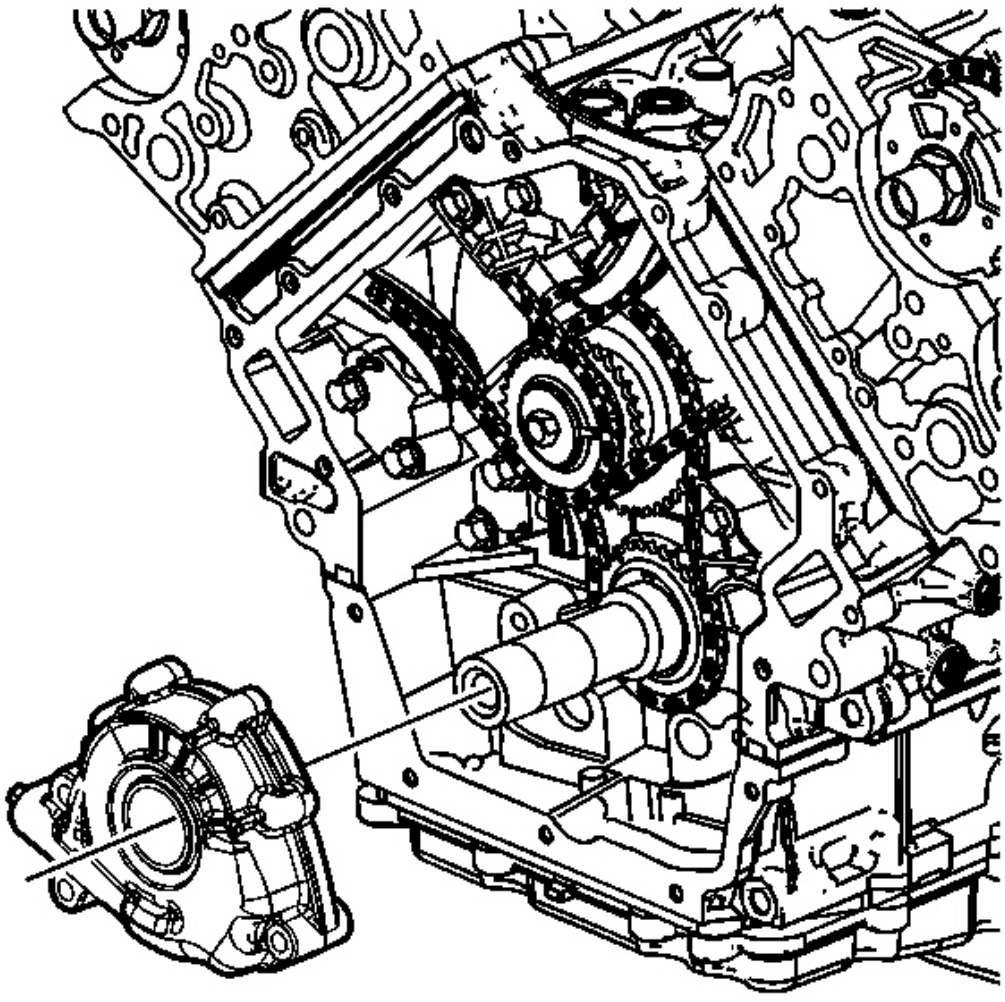


Fig. 342: View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump.

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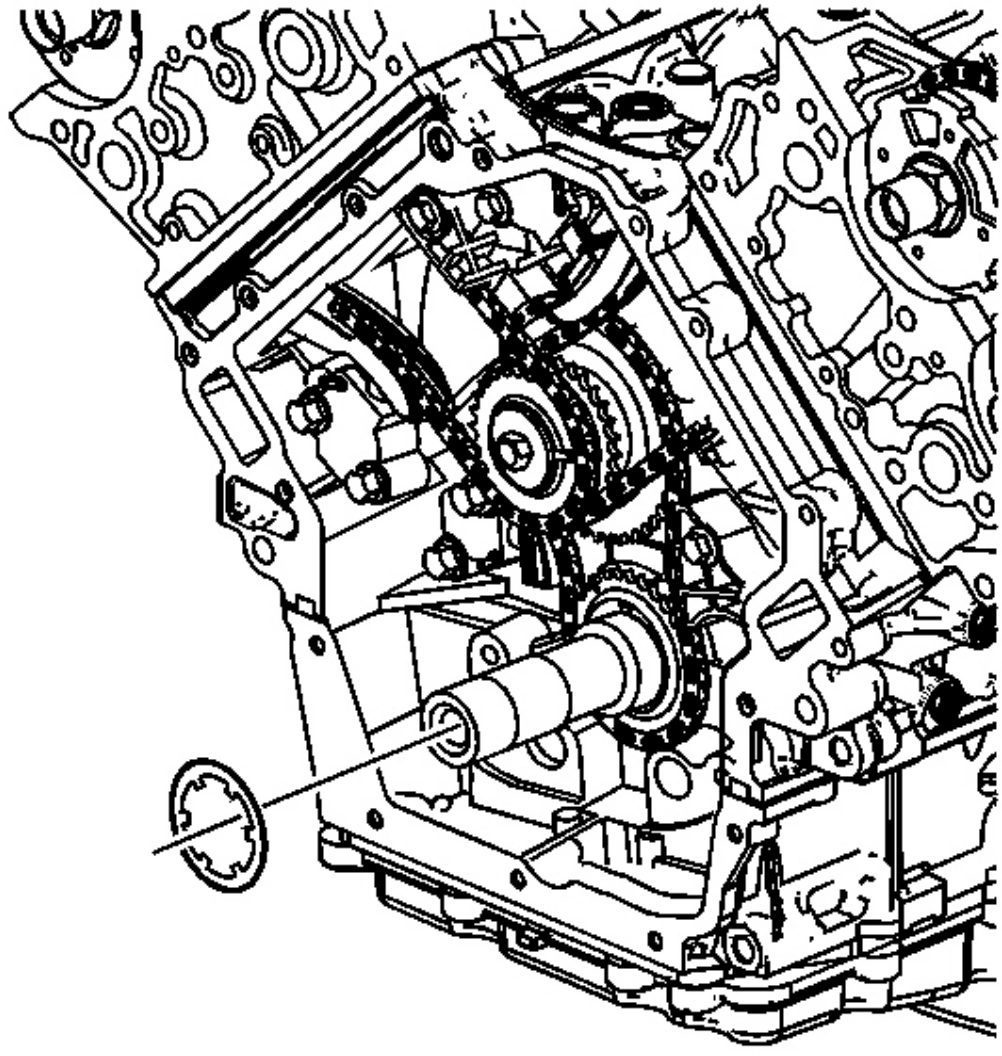


Fig. 343: View Of Crankshaft Sprocket To Oil Pump Drive Friction Washer
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft sprocket to oil pump drive friction washer.

SECONDARY CAMSHAFT DRIVE CHAIN REMOVAL - RIGHT SIDE

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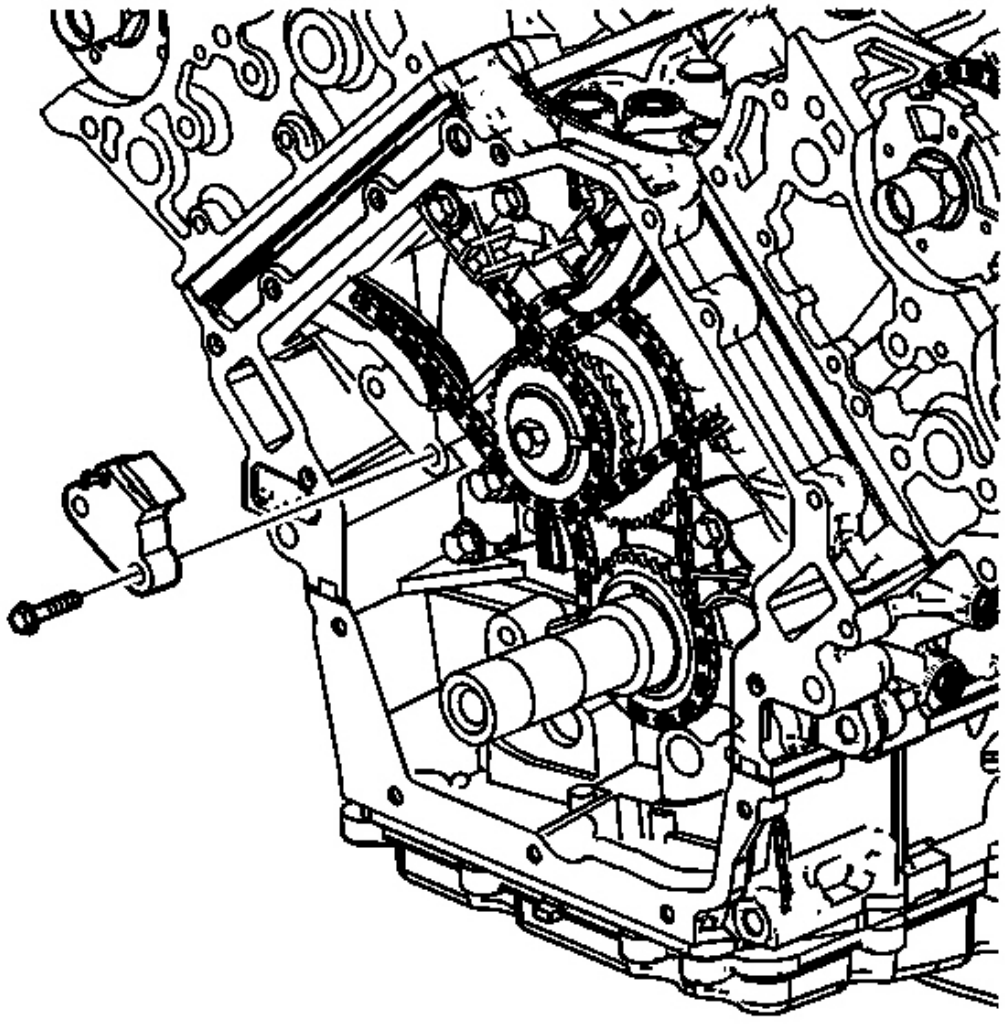


Fig. 344: View Of Right Secondary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the right secondary camshaft drive chain tensioner.

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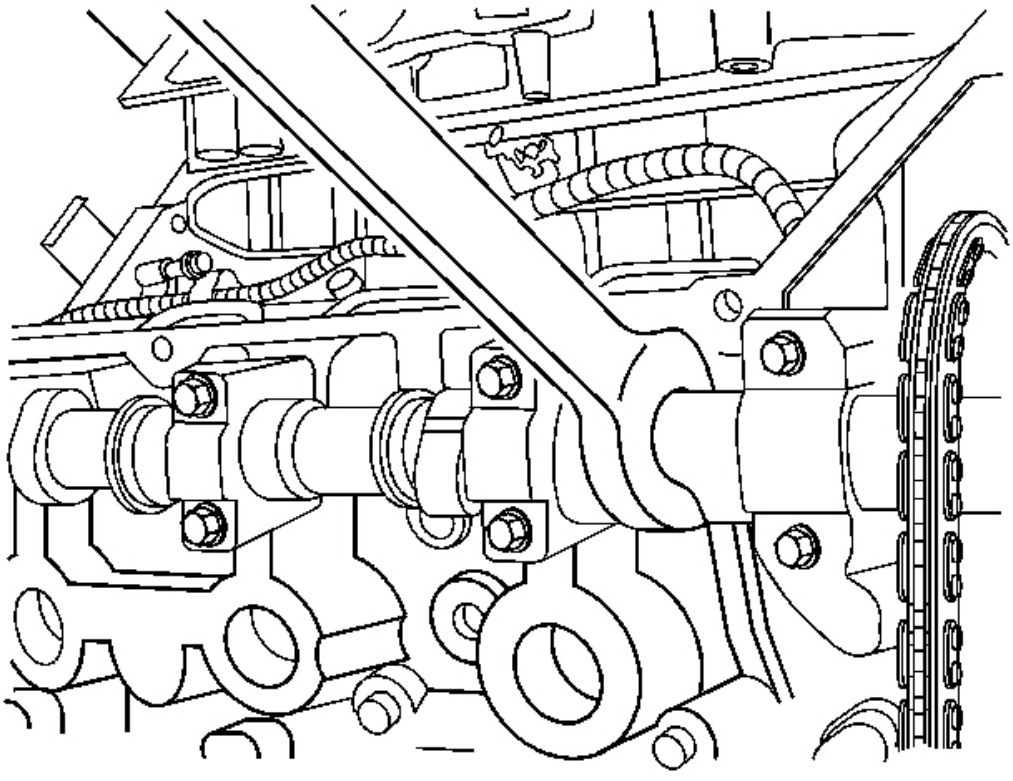


Fig. 345: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

2. Use an open end wrench on the hex cast into the right intake camshaft, in order to prevent the camshaft from rotating, when loosening the camshaft position actuator oil control valve on the right intake camshaft.

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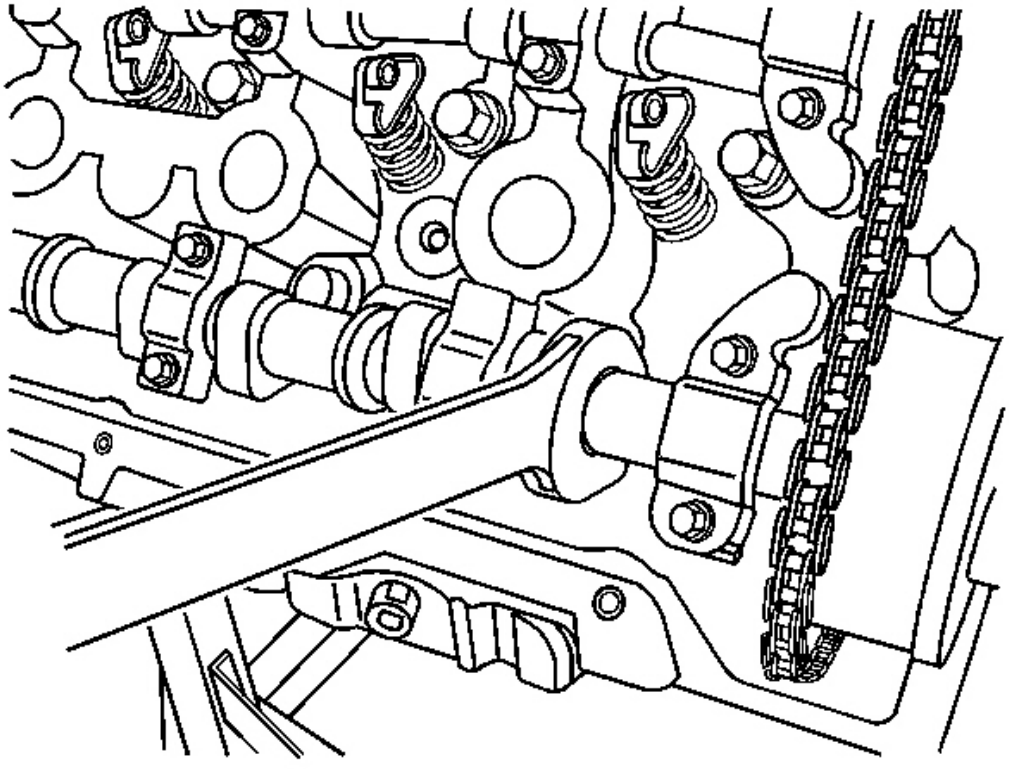


Fig. 346: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

3. Use an open end wrench on the hex cast into the right exhaust camshaft, in order to prevent the camshaft from rotating, when loosening the camshaft position actuator oil control valve on the right exhaust camshaft.

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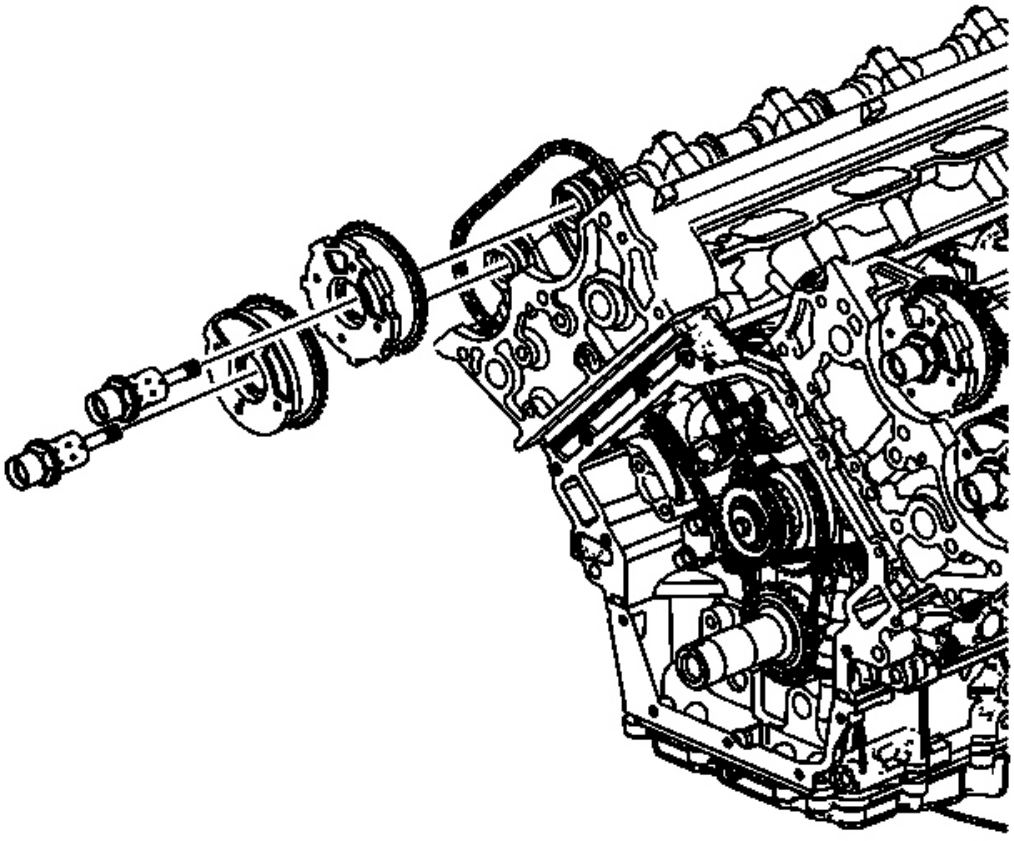


Fig. 347: View Of Right Camshaft Position Actuators
Courtesy of GENERAL MOTORS CORP.

4. Remove the right camshaft position actuator oil control valves from the right side camshafts.
5. Slide the right camshaft position actuators off the right side camshafts.

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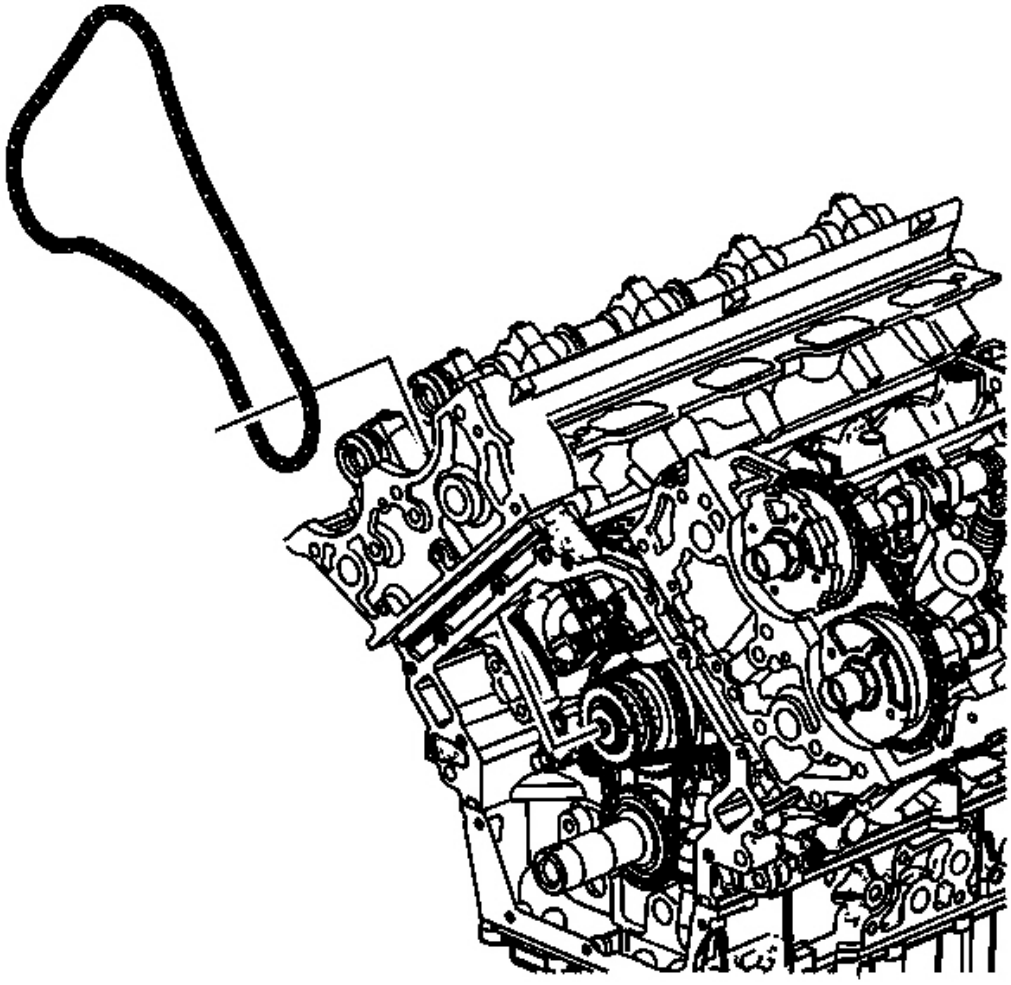


Fig. 348: View Of Right Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

6. Remove the right secondary camshaft drive chain from the outer camshaft intermediate drive shaft sprocket teeth.
7. Remove the right secondary camshaft drive chain from the engine.

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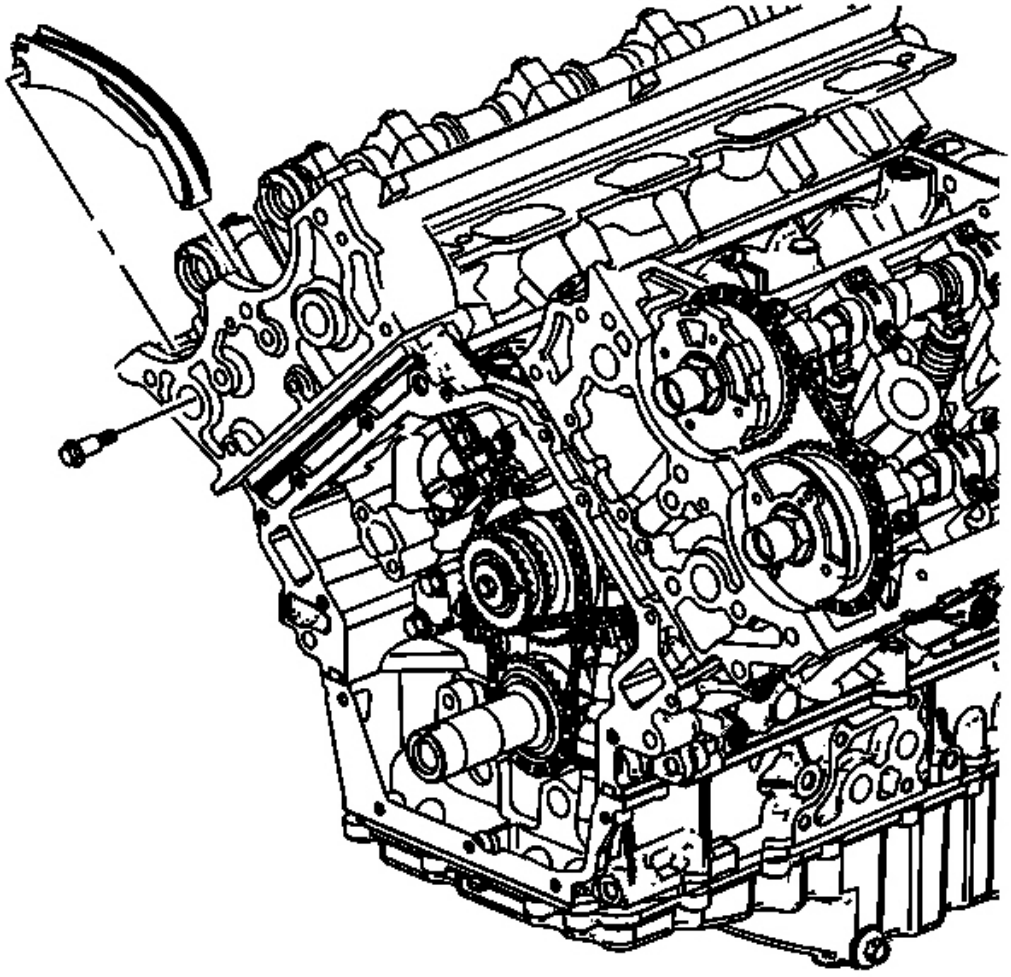


Fig. 349: View Of Right Secondary Camshaft Drive Timing Chain Shoe
Courtesy of GENERAL MOTORS CORP.

8. Remove the right secondary camshaft drive chain shoe bolt.
9. Remove the right secondary camshaft drive chain shoe.

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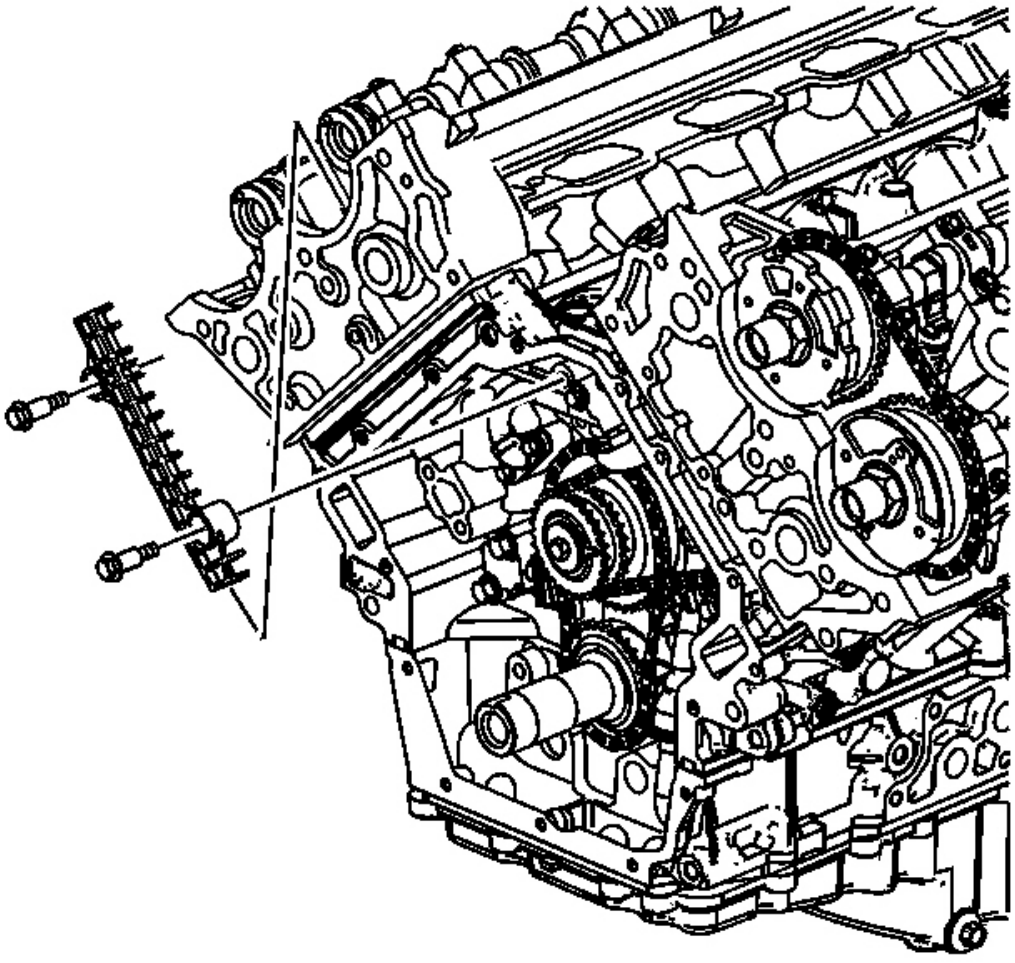


Fig. 350: View Of Right Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

10. Remove the right secondary camshaft drive chain guide bolt.
11. Remove the right secondary camshaft drive chain guide.

SECONDARY CAMSHAFT DRIVE CHAIN REMOVAL - LEFT SIDE

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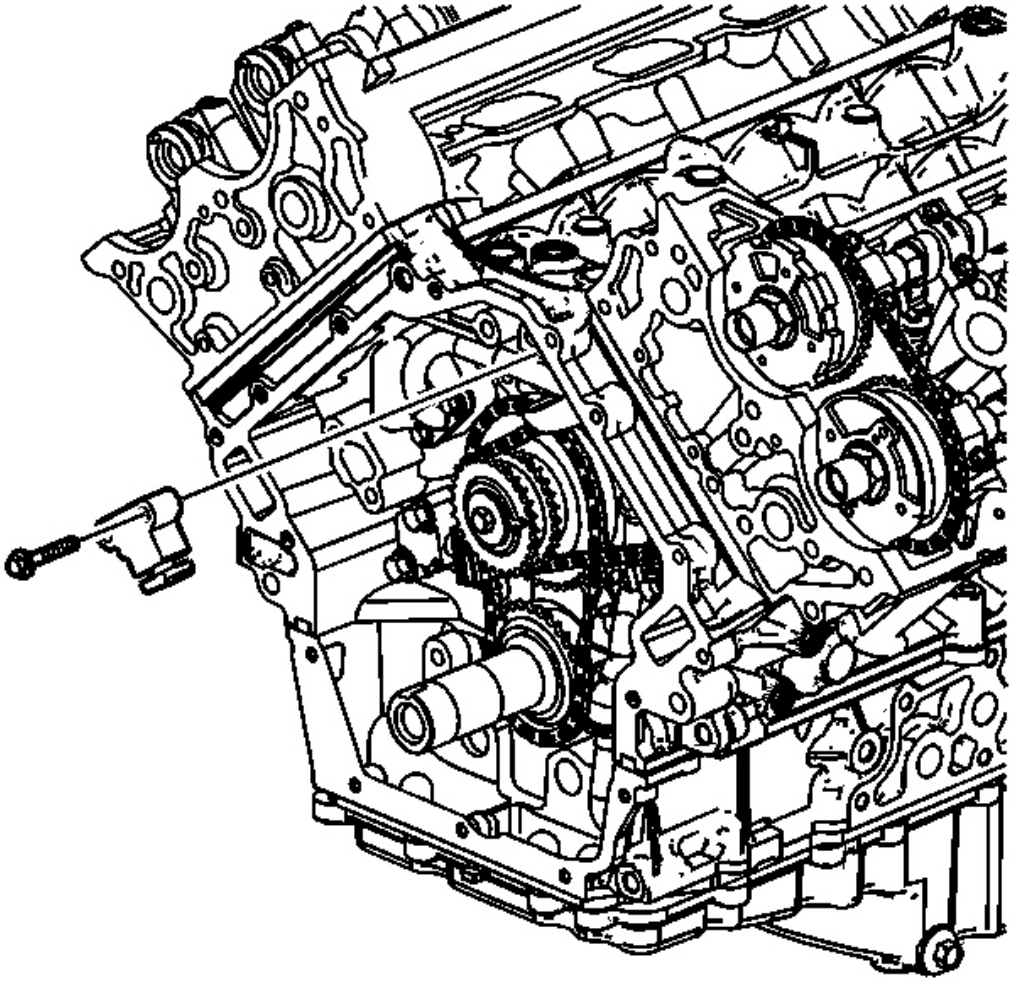


Fig. 351: View Of Left Secondary Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the left secondary camshaft drive chain tensioner.

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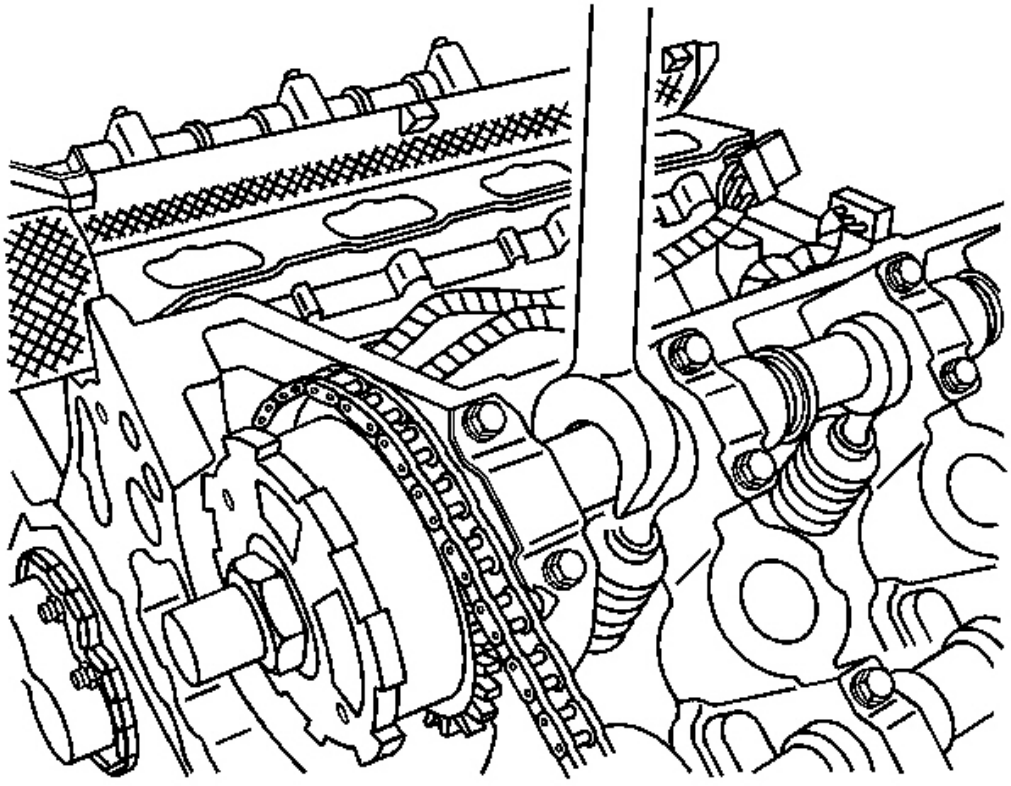


Fig. 352: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice .

2. Use an open end wrench on the hex cast into the left intake camshaft, in order to prevent the camshaft from rotating, when loosening the camshaft position actuator oil control valve on the left intake camshaft.

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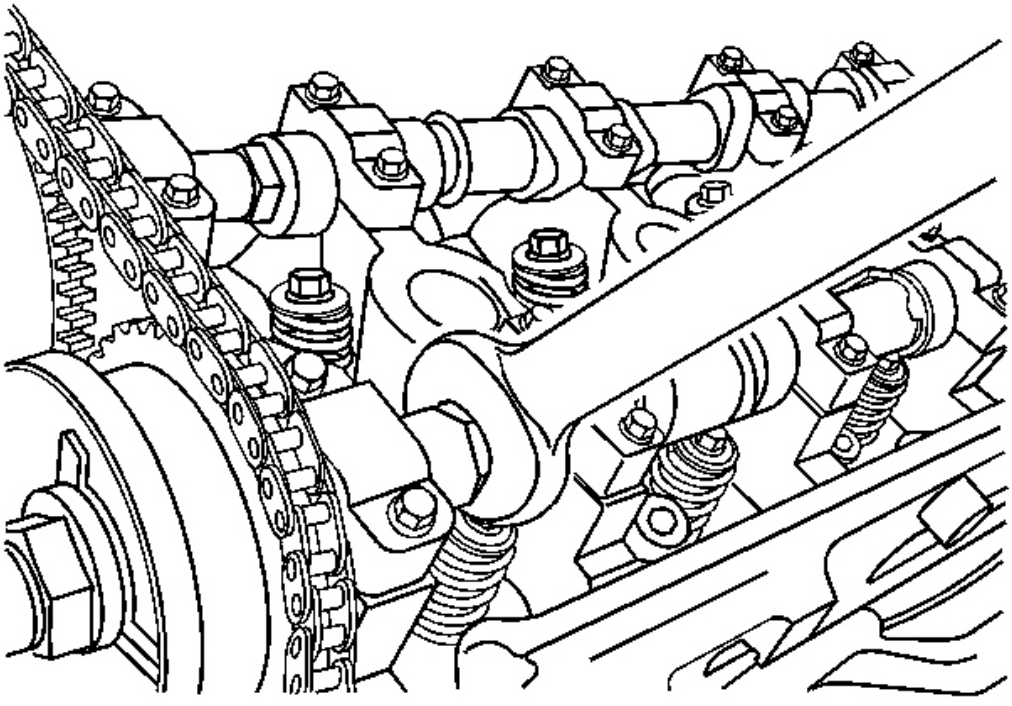


Fig. 353: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

3. Use an open end wrench on the hex cast into the left exhaust camshaft, in order to prevent the camshaft from rotating, when loosening the camshaft position oil actuator control valve on the left exhaust camshaft.

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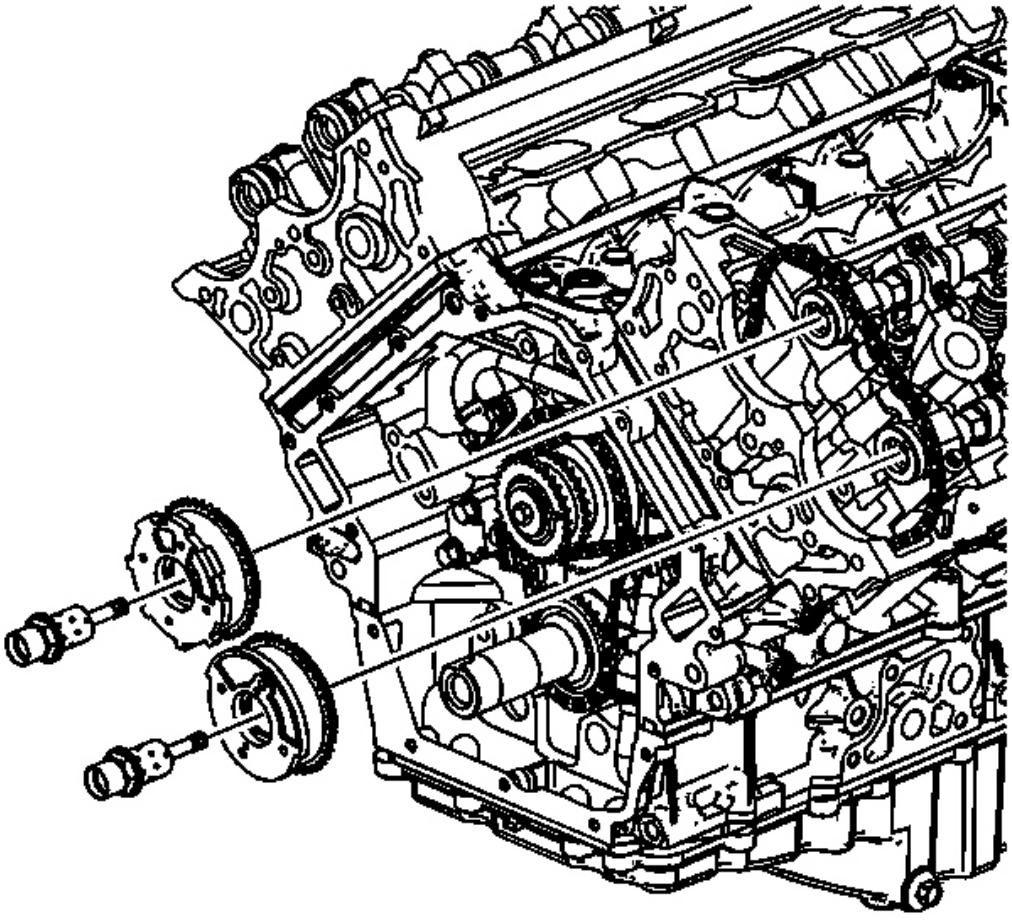


Fig. 354: View Of Left Camshaft Position Actuators
Courtesy of GENERAL MOTORS CORP.

4. Remove the left camshaft position actuator oil control valves from the left side camshafts.
5. Slide the left camshaft position actuators off the left side camshafts.

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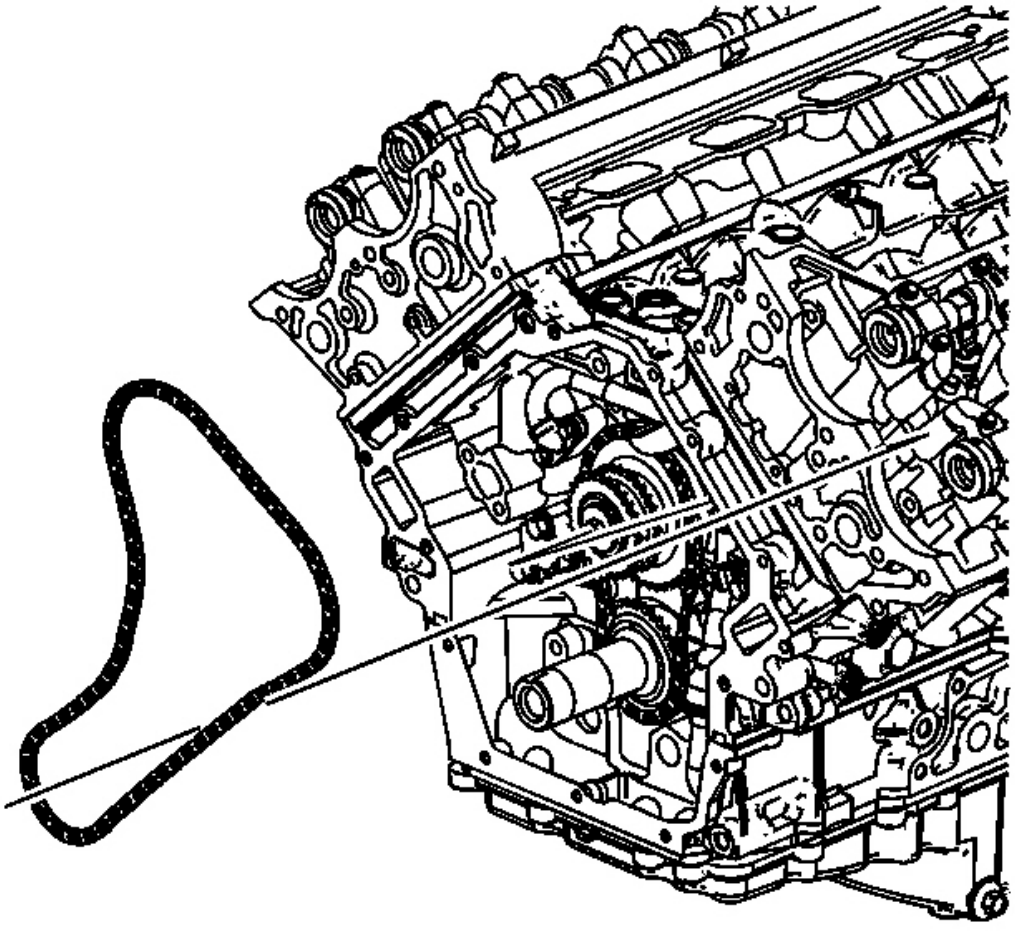


Fig. 355: View Of Left Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

6. Remove the left secondary camshaft drive chain from the inner camshaft intermediate drive shaft sprocket teeth.
7. Remove the left secondary camshaft drive chain from the engine.

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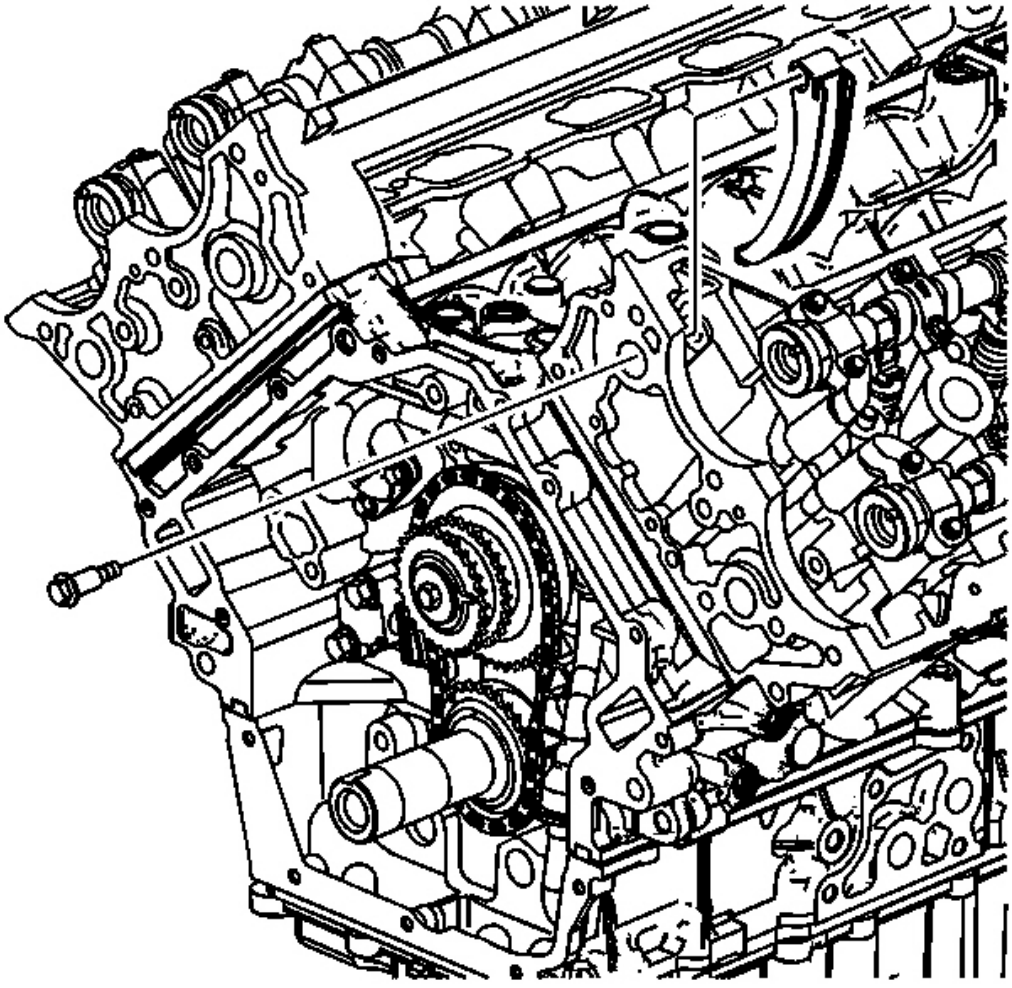


Fig. 356: View Of Left Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

8. Remove the left secondary camshaft drive chain shoe bolt.
9. Remove the left secondary camshaft drive chain shoe.

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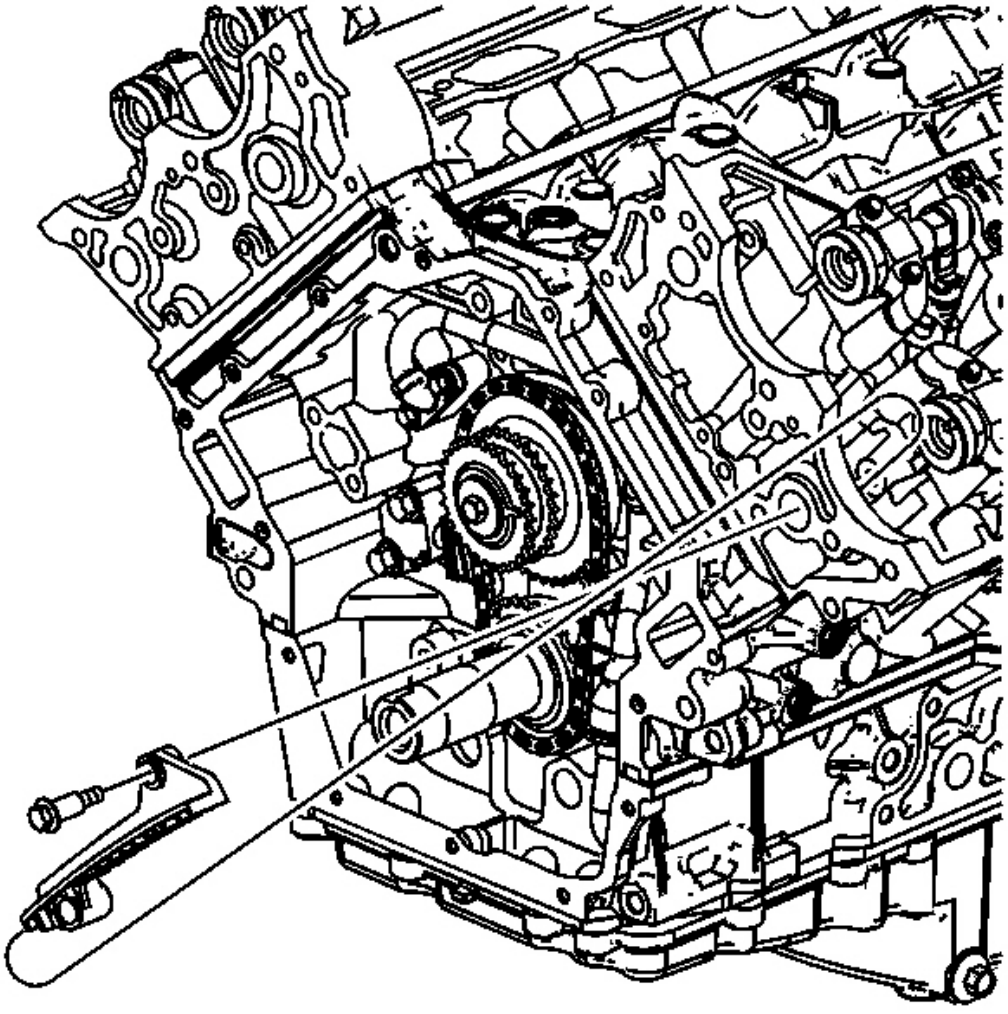


Fig. 357: View Of Left Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

10. Remove the left secondary camshaft drive chain guide bolt.
11. Remove the left secondary camshaft drive chain guide.

OIL PUMP OUTLET TUBE REMOVAL

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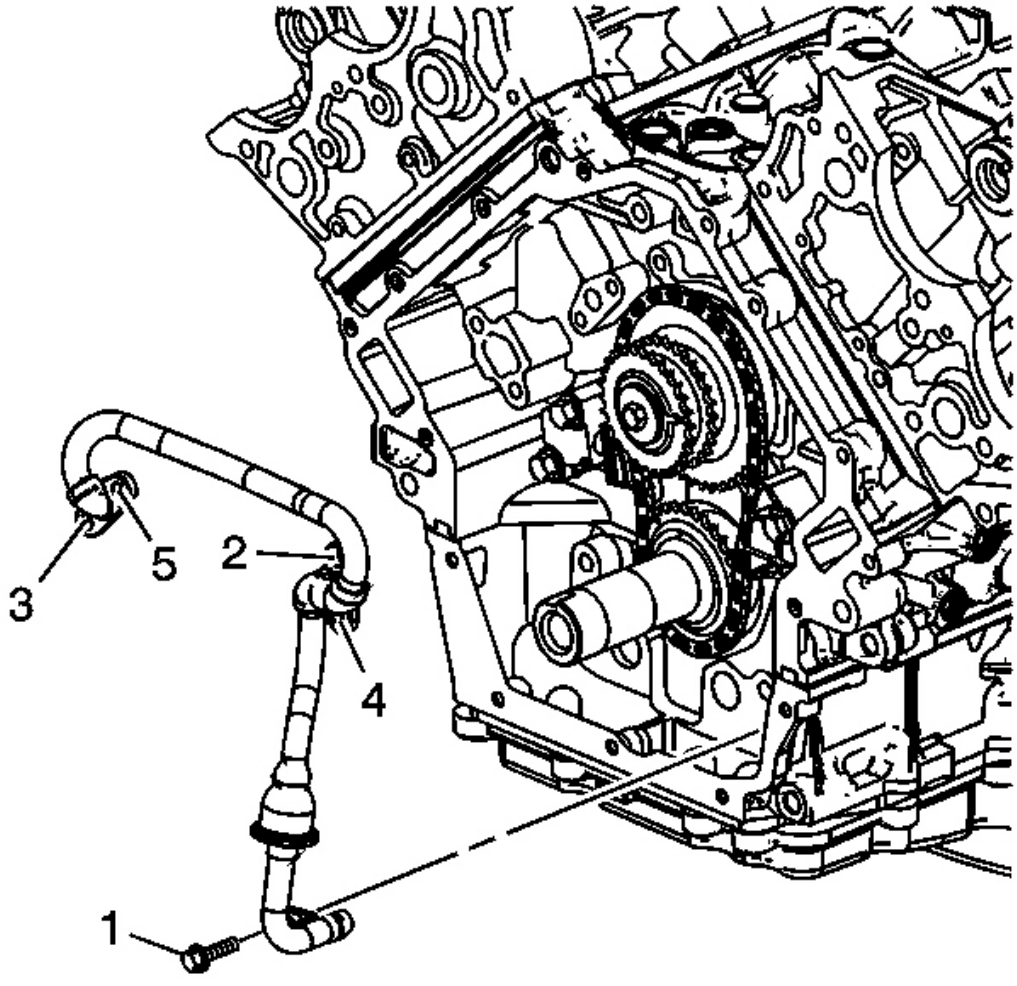


Fig. 358: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil outlet tube bolts (1-5).
2. Remove the oil outlet tube.

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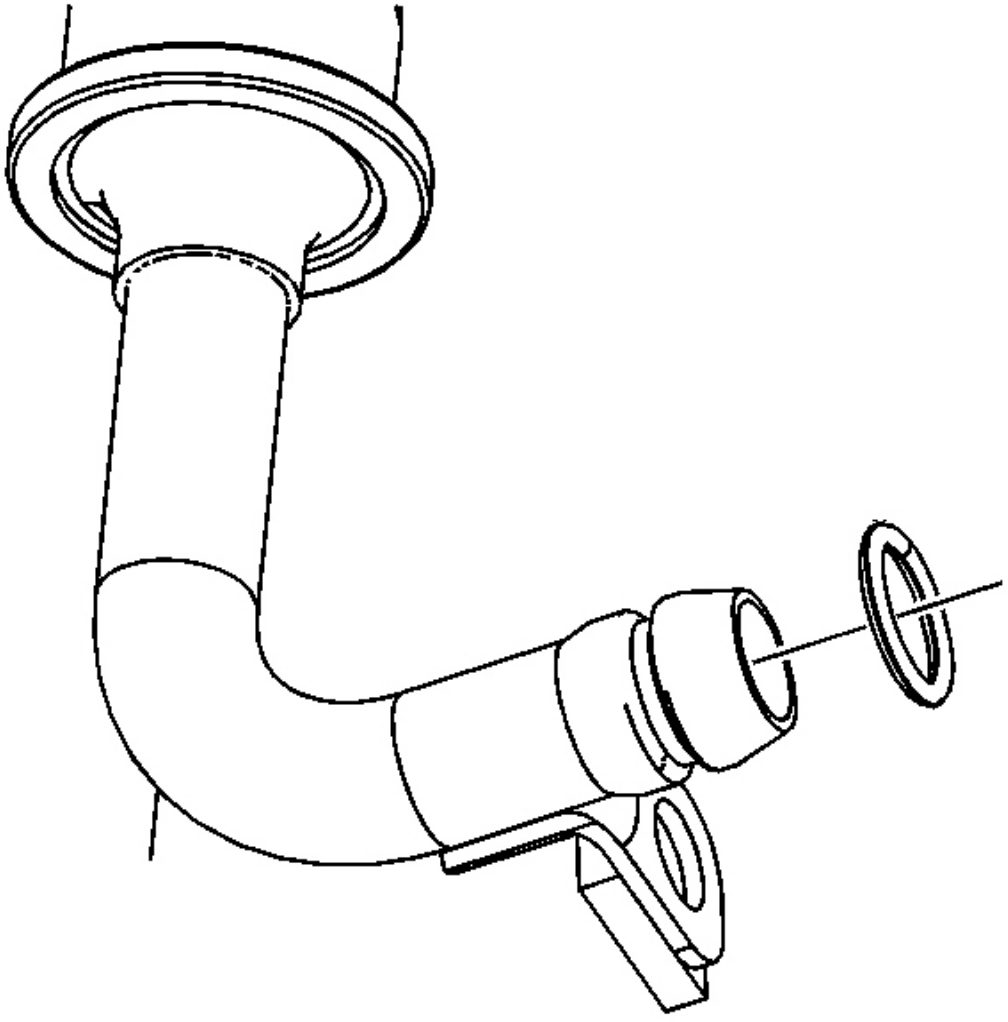


Fig. 359: View Of Oil Outlet Tube O-Ring
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the oil outlet tube O-ring.

PRIMARY CAMSHAFT DRIVE CHAIN REMOVAL

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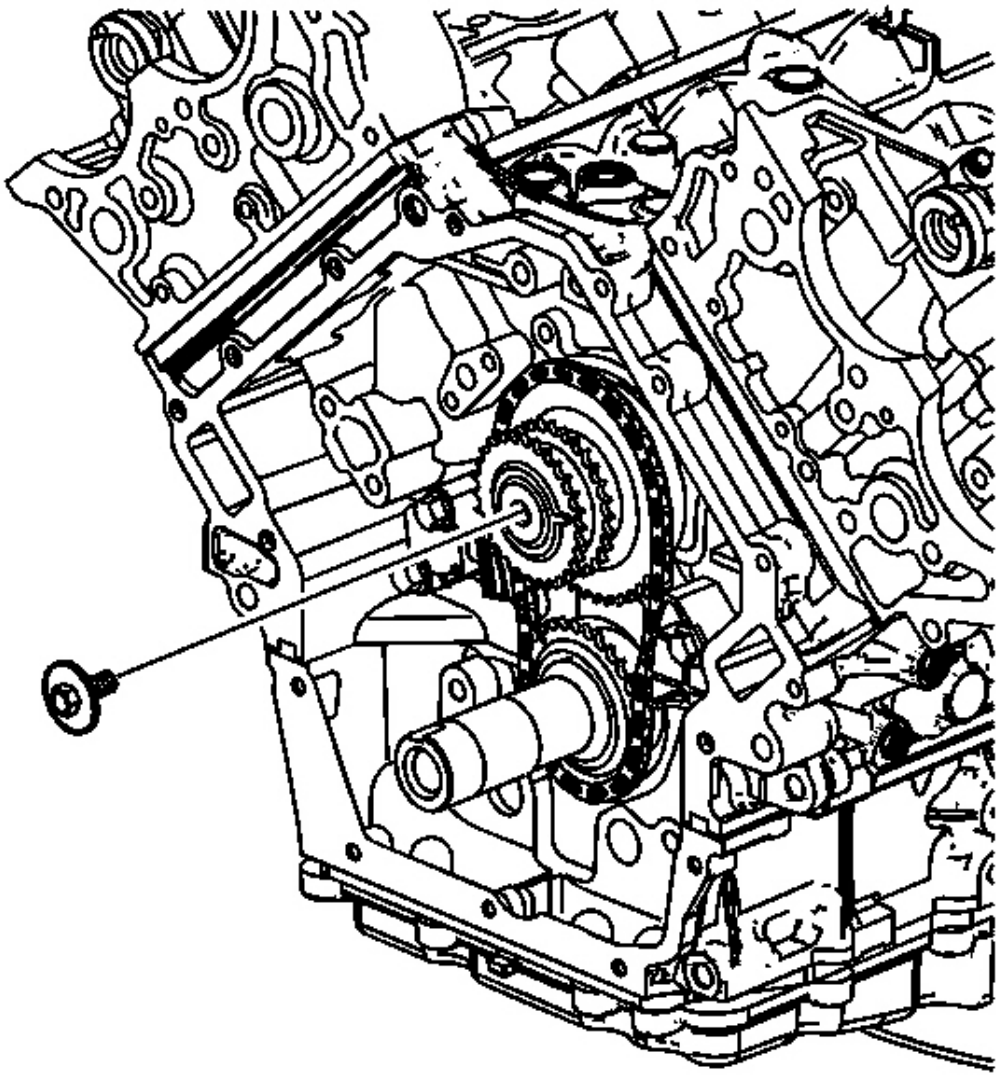


Fig. 360: View Of Camshaft Intermediate Sprocket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft intermediate drive shaft sprocket bolt.

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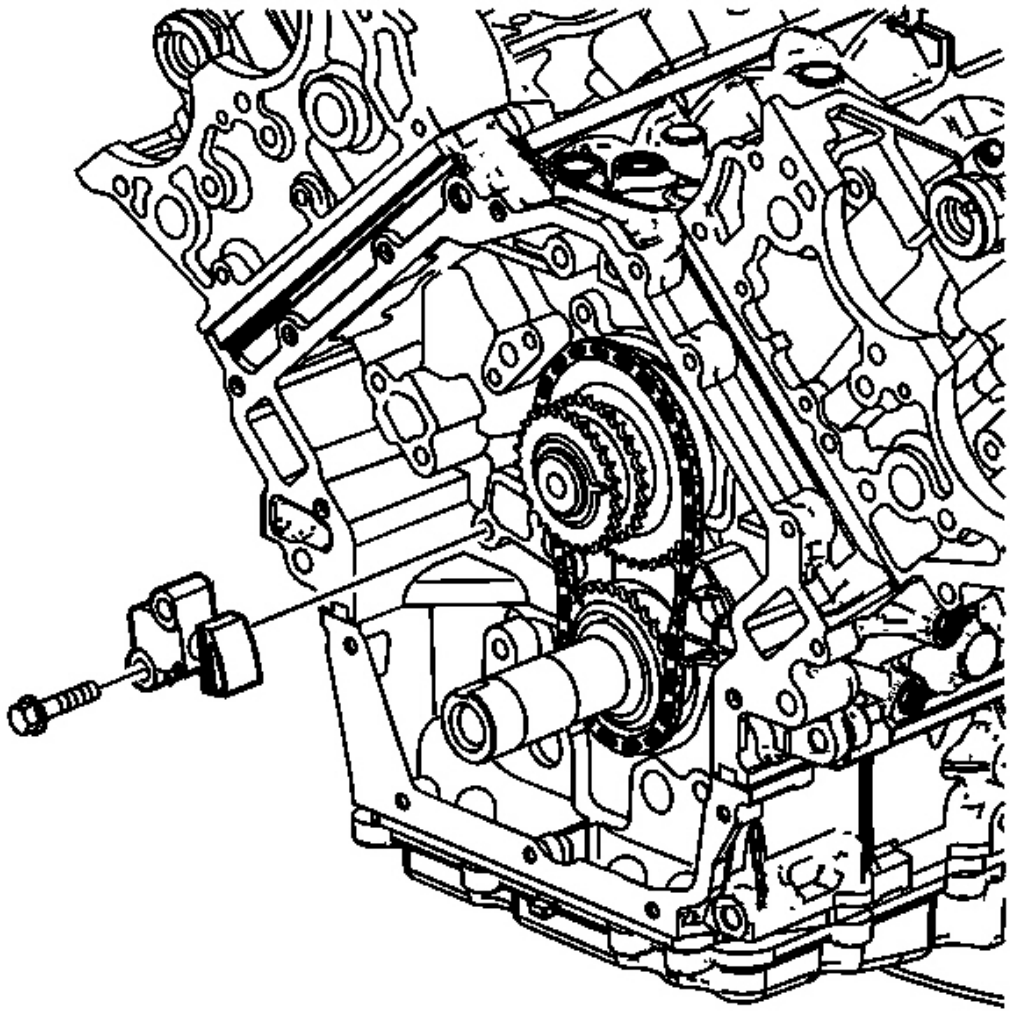


Fig. 361: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

2. Remove the primary camshaft drive chain tensioner bolts.
3. Remove the primary camshaft drive chain tensioner.

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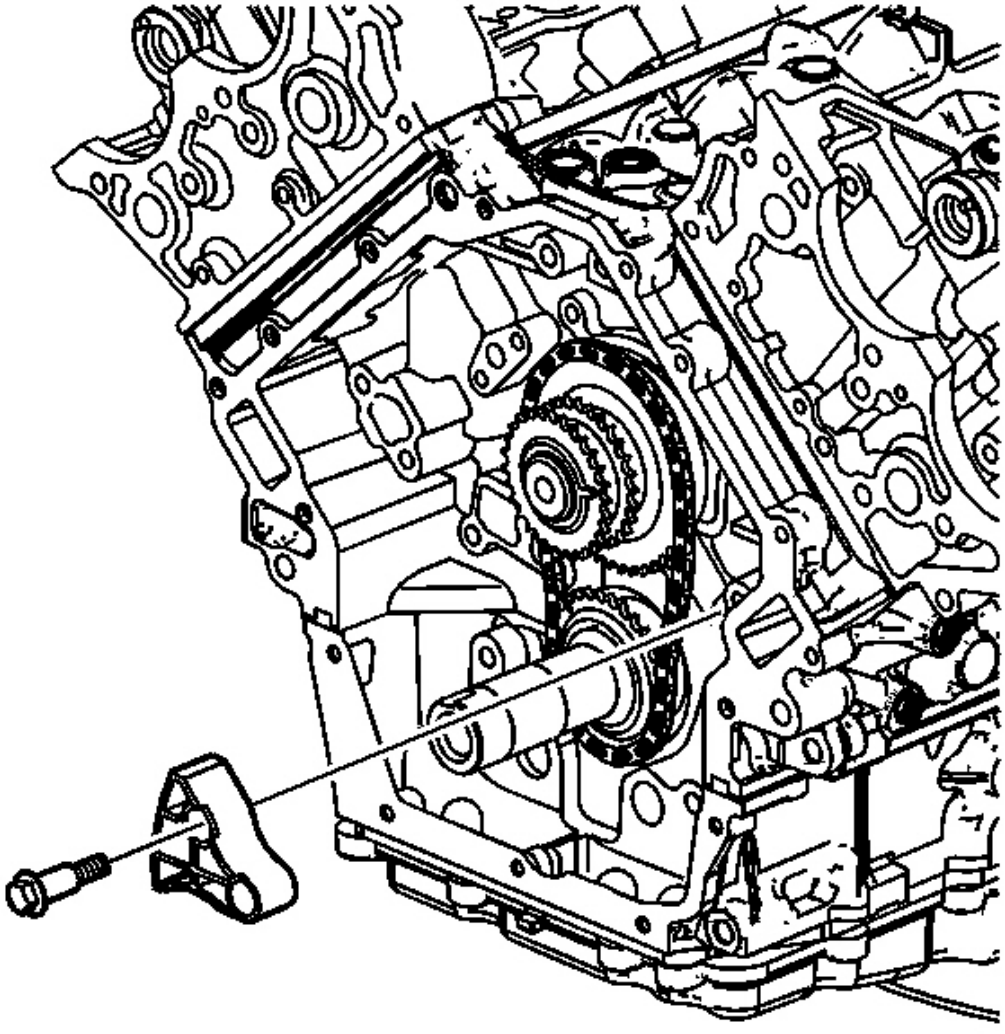


Fig. 362: View Of Primary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

4. Remove the primary camshaft drive chain guide bolts.
5. Remove the primary camshaft drive chain guide.

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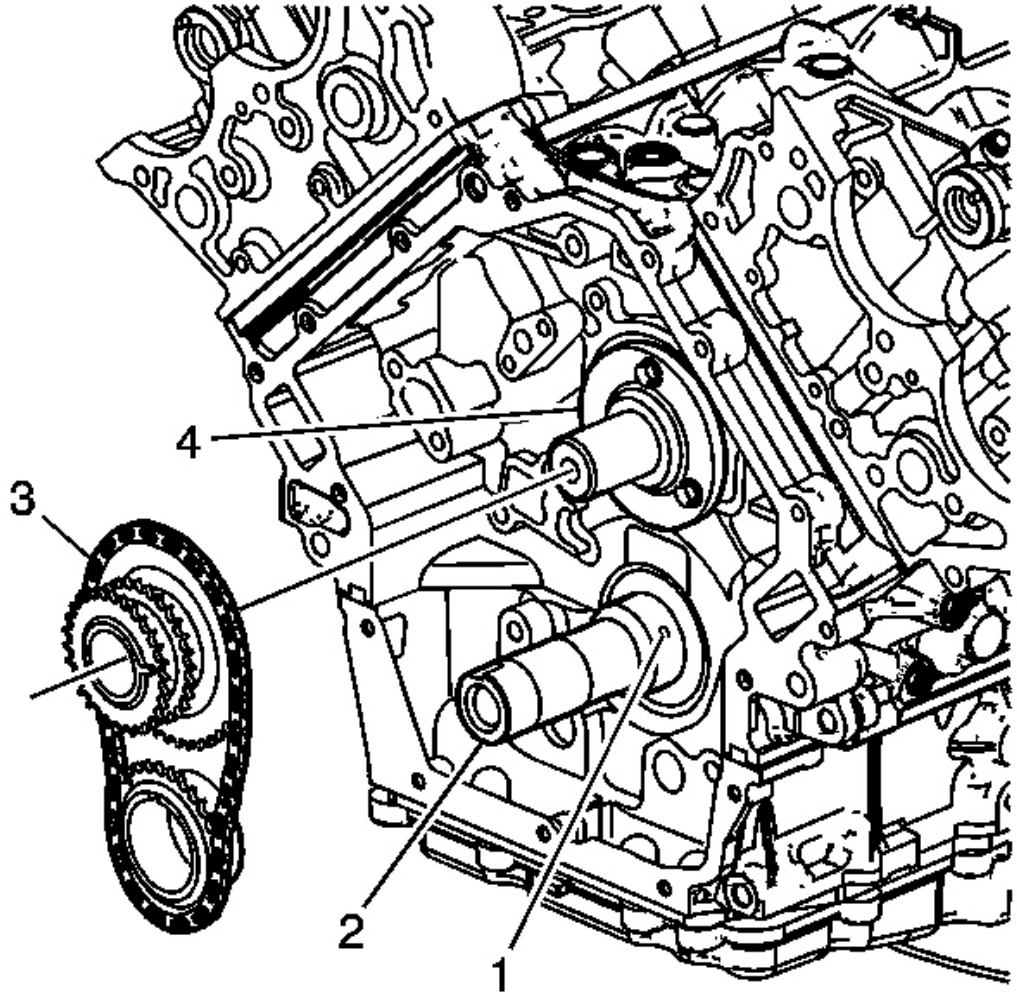


Fig. 363: View Of Primary Camshaft Drive Chain, Intermediate Drive Shaft Sprocket & Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft intermediate drive shaft sprocket, primary camshaft drive chain and crankshaft sprocket (3) as an assembly.

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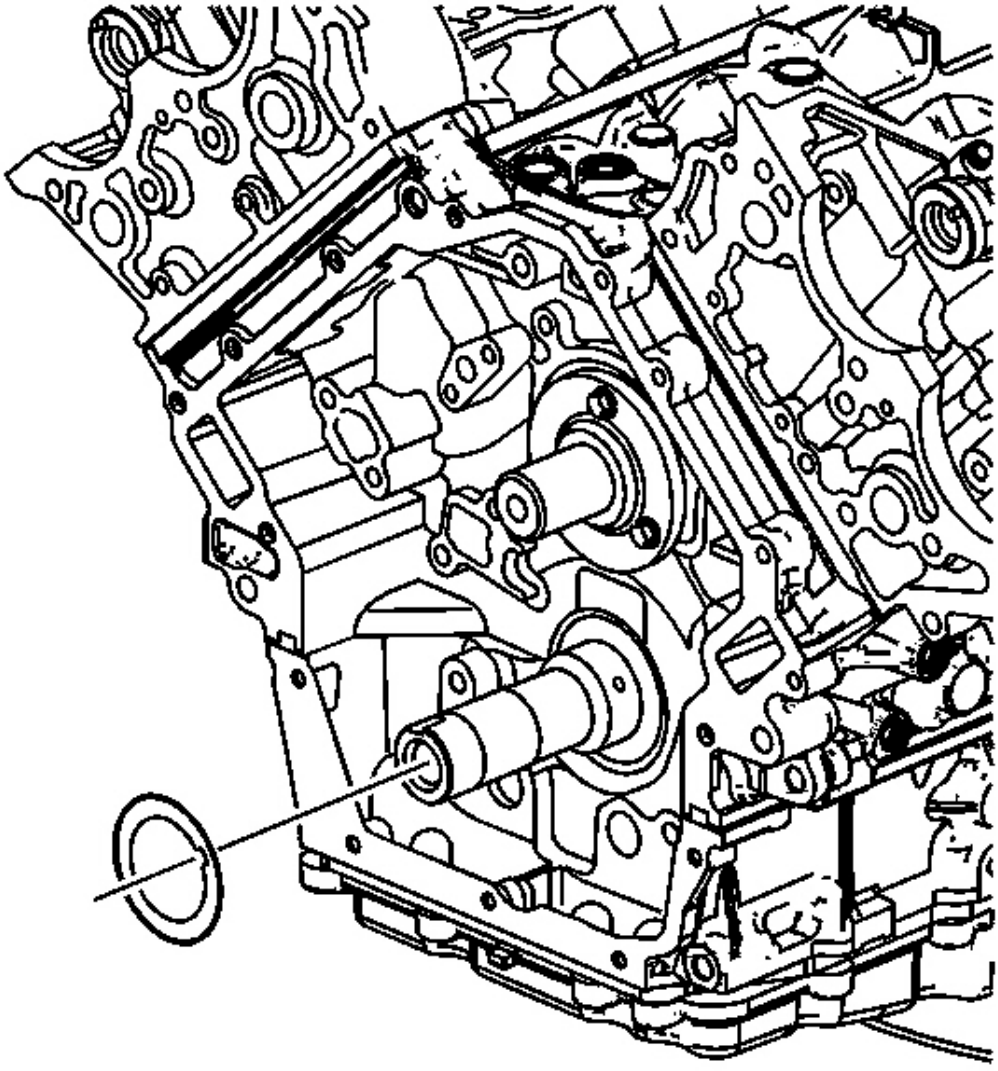


Fig. 364: View Of Crankshaft To Crankshaft Sprocket Friction Washer
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft to crankshaft sprocket friction washer.

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2007 ENGINE

Engine Mechanical - 4.4L - XLR

CAMSHAFT INTERMEDIATE DRIVE SHAFT REMOVAL

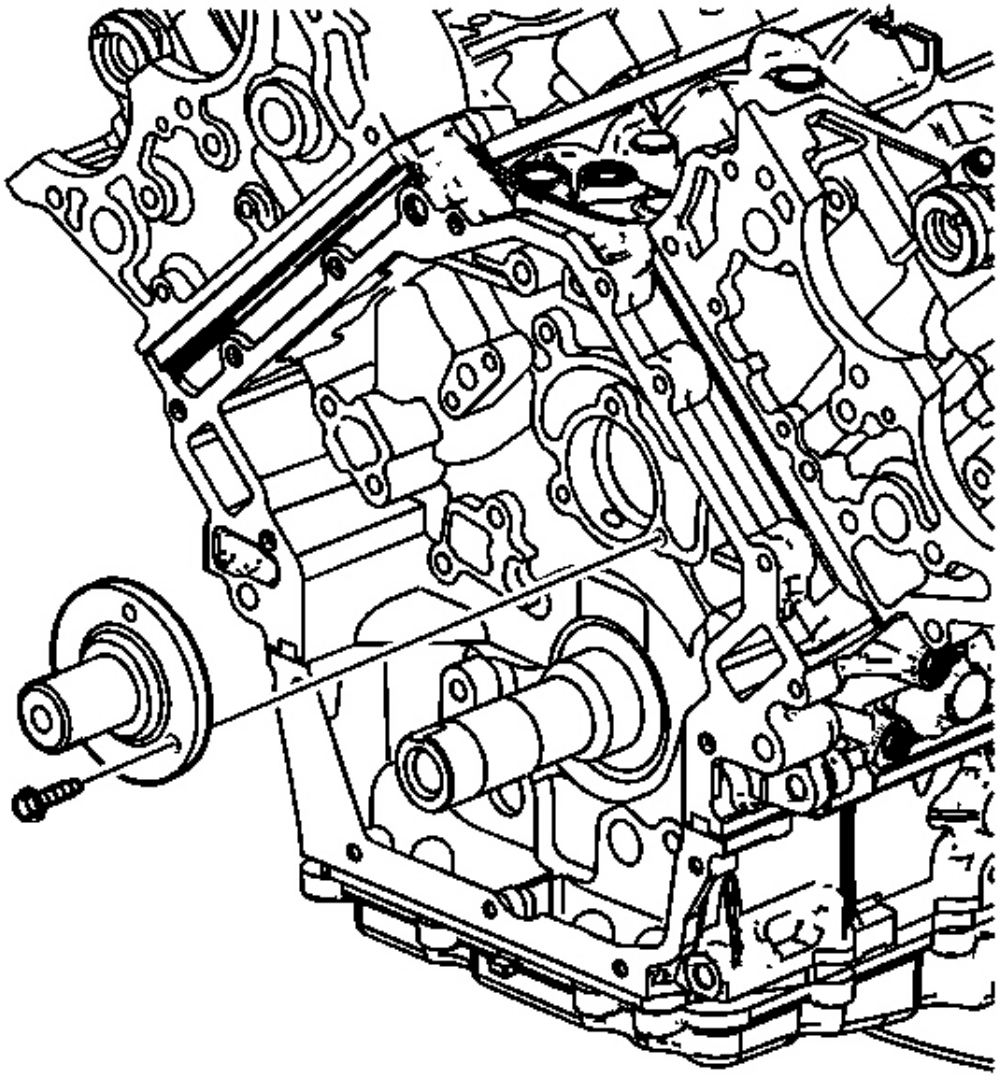


Fig. 1: View Of Intermediate Sprocket Shaft & Bolts
Courtesy of GENERAL MOTORS CORP.

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1. Remove the intermediate sprocket shaft retaining bolts.
2. Remove the intermediate sprocket shaft.

EXHAUST CAMSHAFT REMOVAL - LEFT SIDE

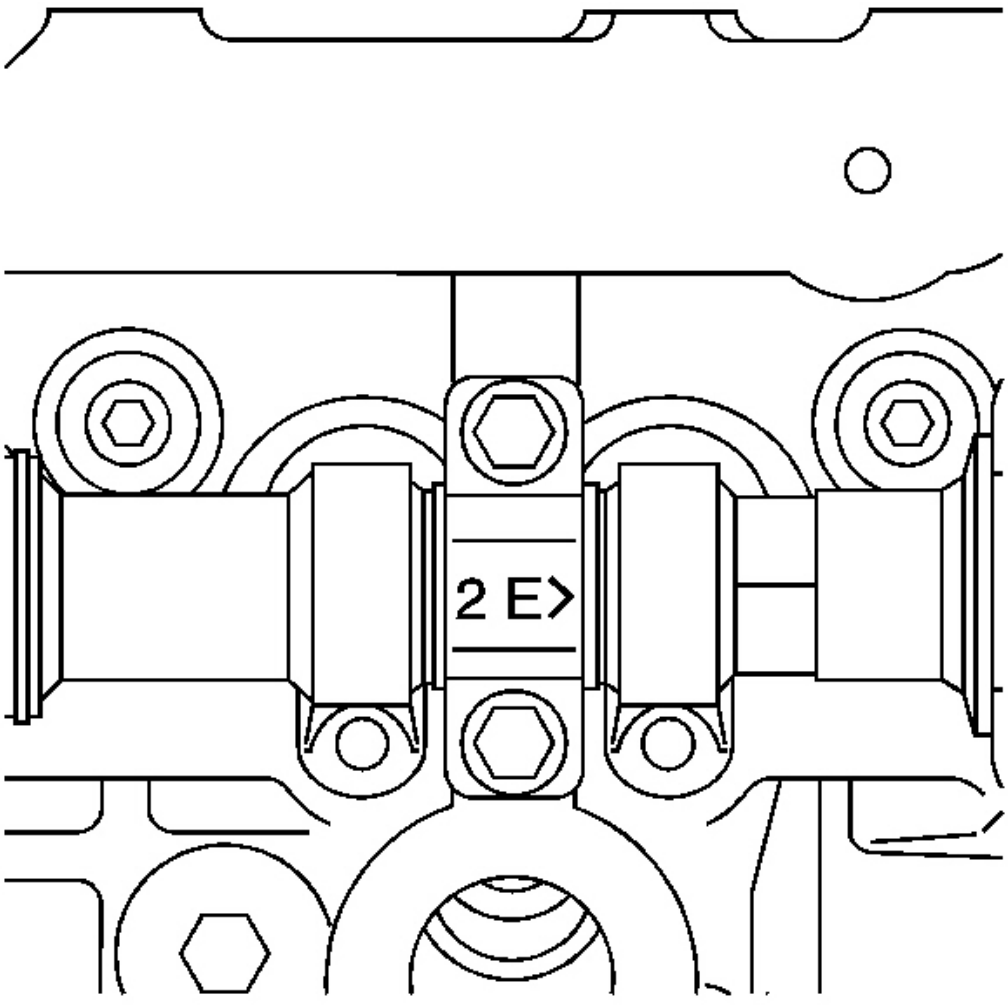


Fig. 2: View Of Exhaust Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Bearing caps must remain with their original cylinder head and in their original location. Do not mix bearing caps.

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1. Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The arrow points toward the front of the engine.
   - The "E" indicates the exhaust camshaft.
   - The number indicates the journal position from the front of the engine.

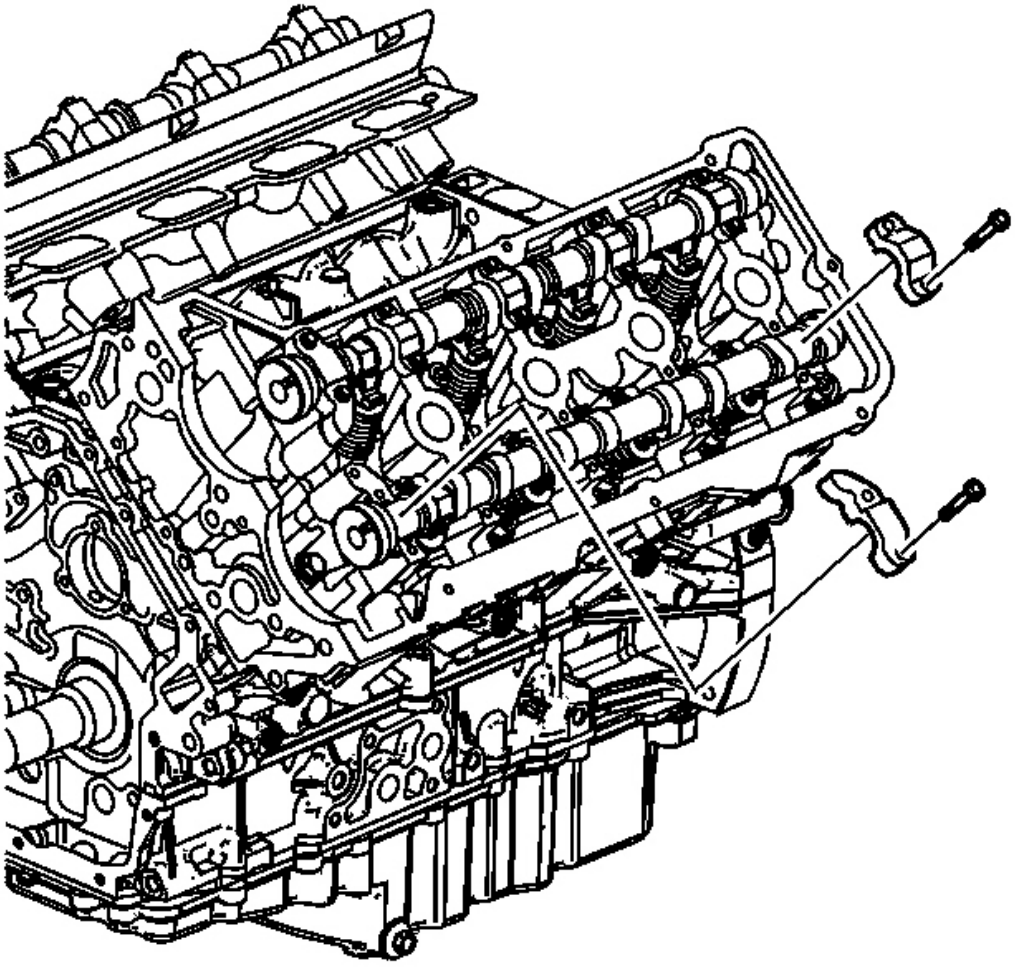


Fig. 3: View Of Left Exhaust Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the left exhaust camshaft bearing cap bolts.
3. Remove the left exhaust camshaft bearing caps. Store the bearing caps in a clean shop towel.

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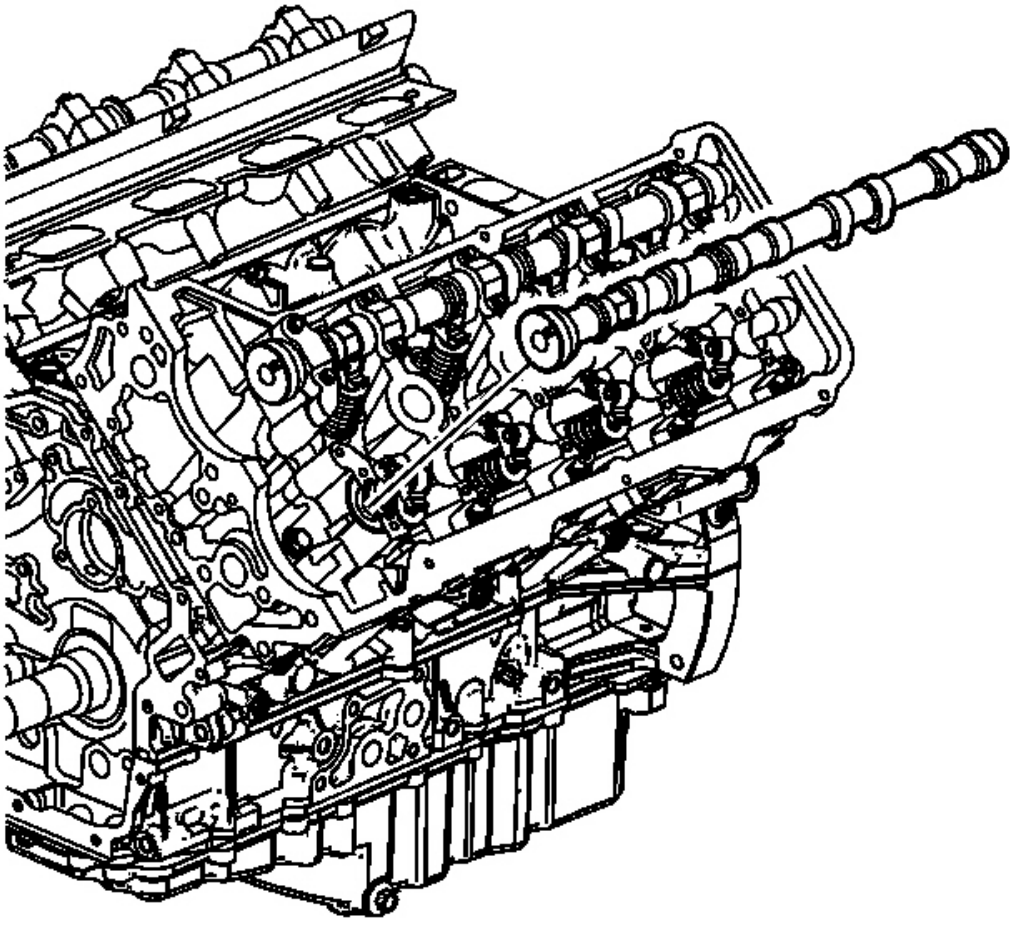


Fig. 4: View Of Left Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Remove the left exhaust camshaft. Place the camshaft in a secure location.
5. Cover the camshaft with an oil soaked towel in order to prevent corrosion.

INTAKE CAMSHAFT REMOVAL - LEFT SIDE

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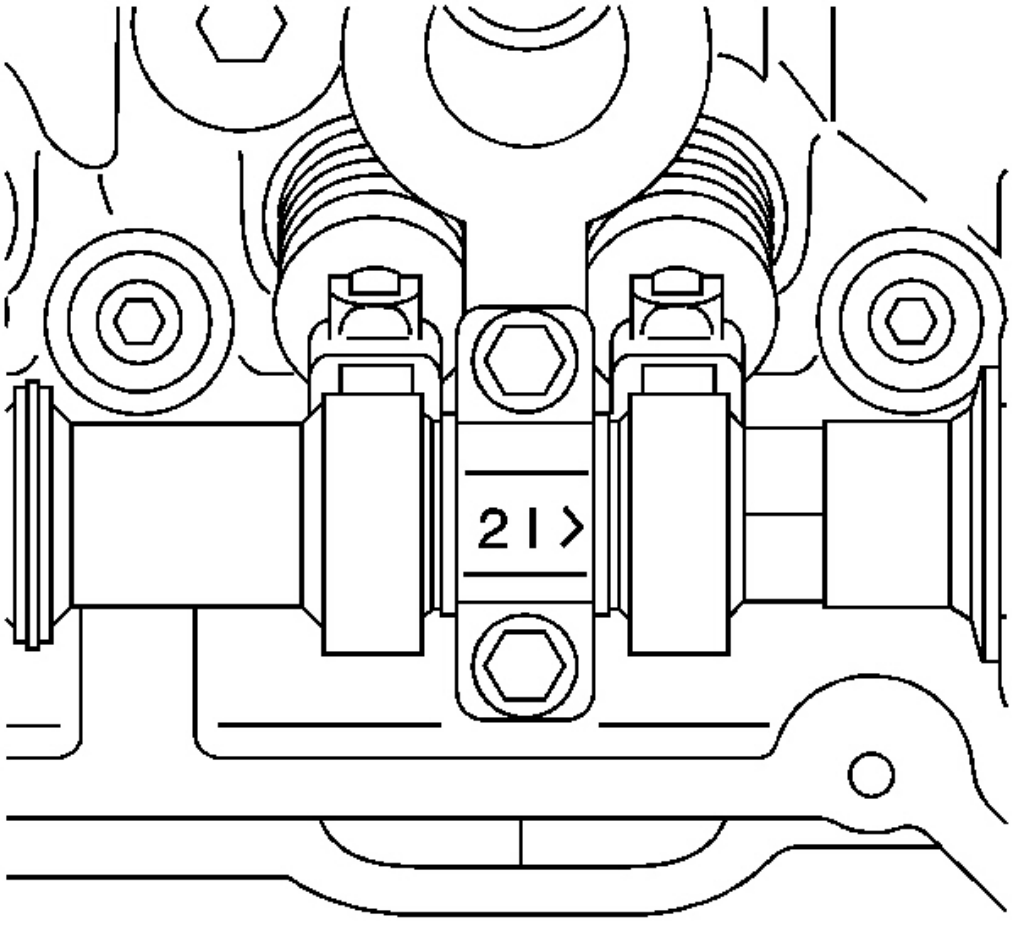


Fig. 5: View Of Intake Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Bearing caps must remain with their original cylinder head and in their original location. Do not mix bearing caps.

1. Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The arrow points toward the front of the engine.
   - The "I" indicates the intake camshaft.
   - The number indicates the journal position from the front of the engine.

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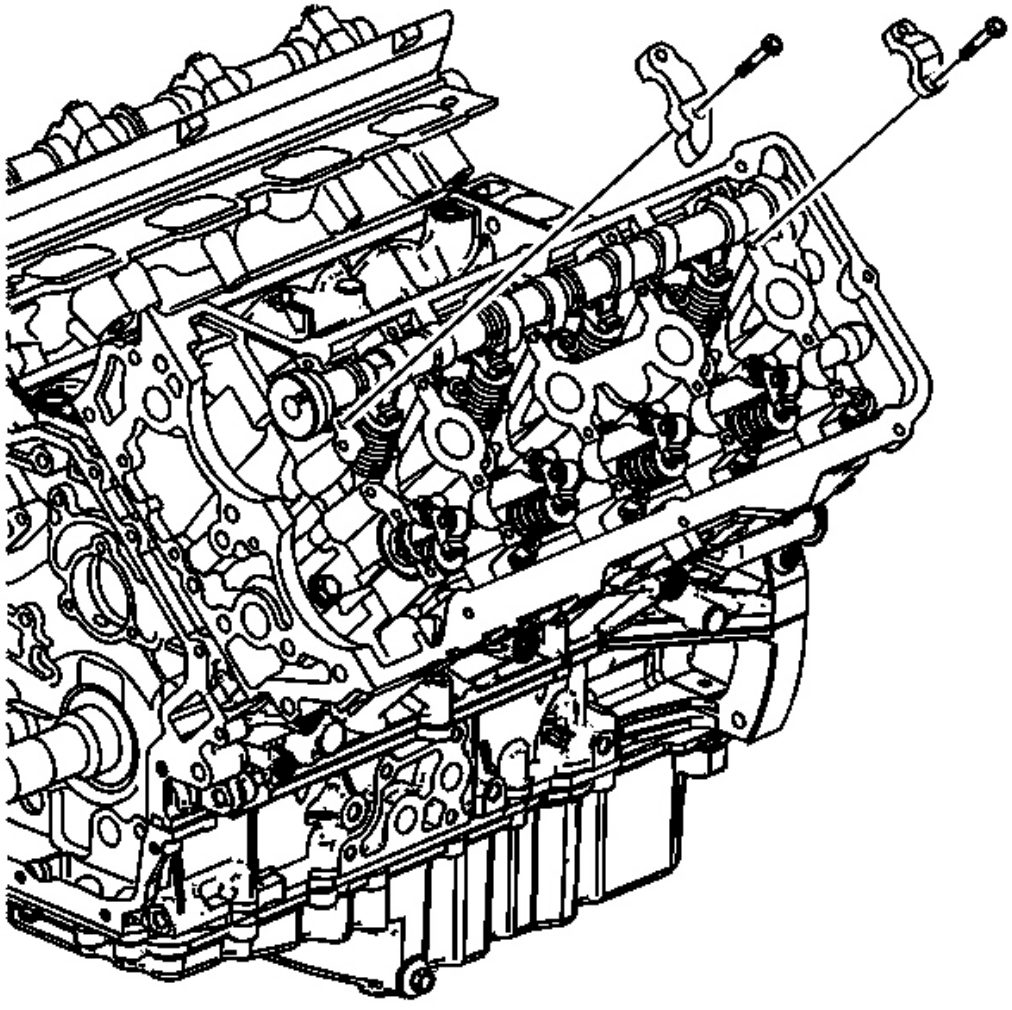


Fig. 6: View Of Left Intake Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

2. Remove the left intake camshaft bearing cap bolts.
3. Remove the left intake camshaft bearing caps. Store the bearing caps in a clean shop towel.

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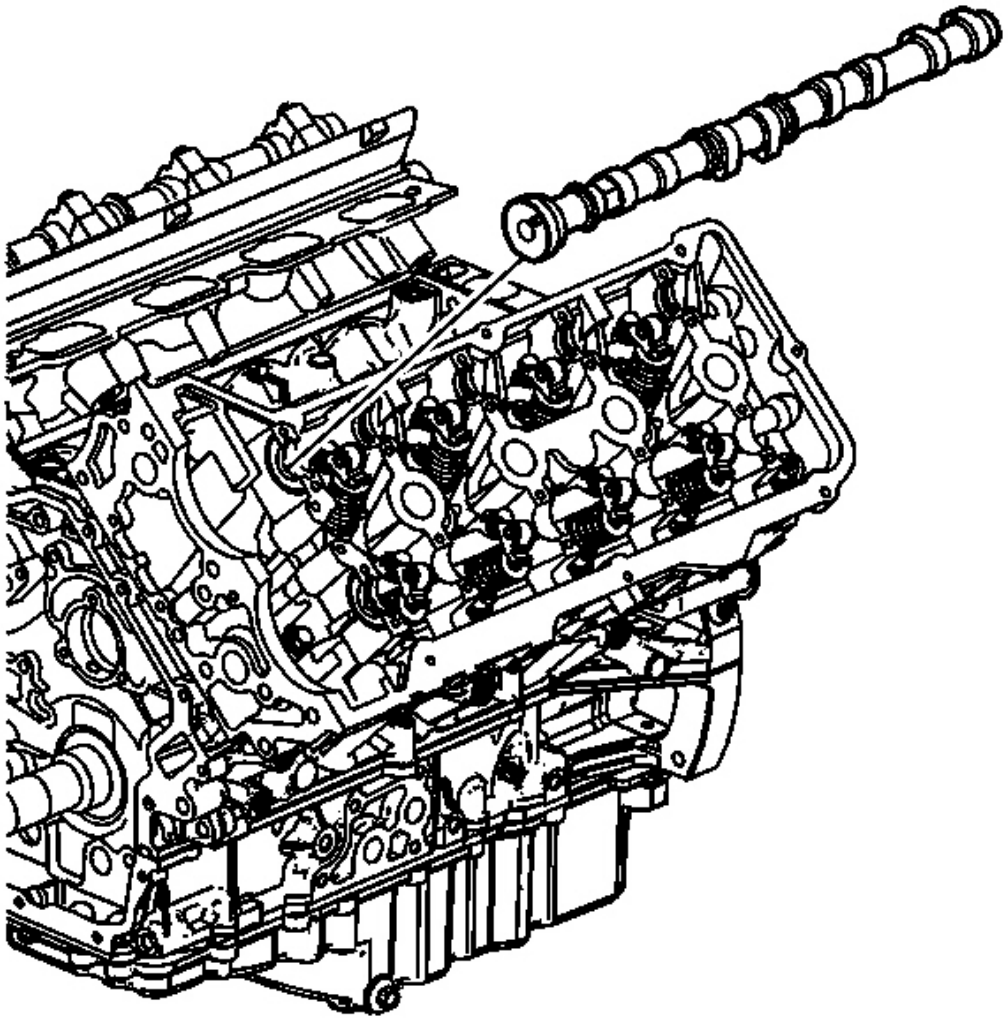


Fig. 7: View Of Left Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Remove the left intake camshaft. Place the camshaft in a secure location.
5. Cover the camshaft with an oil soaked towel in order to prevent corrosion.

VALVE ROCKER ARM REMOVAL - LEFT SIDE

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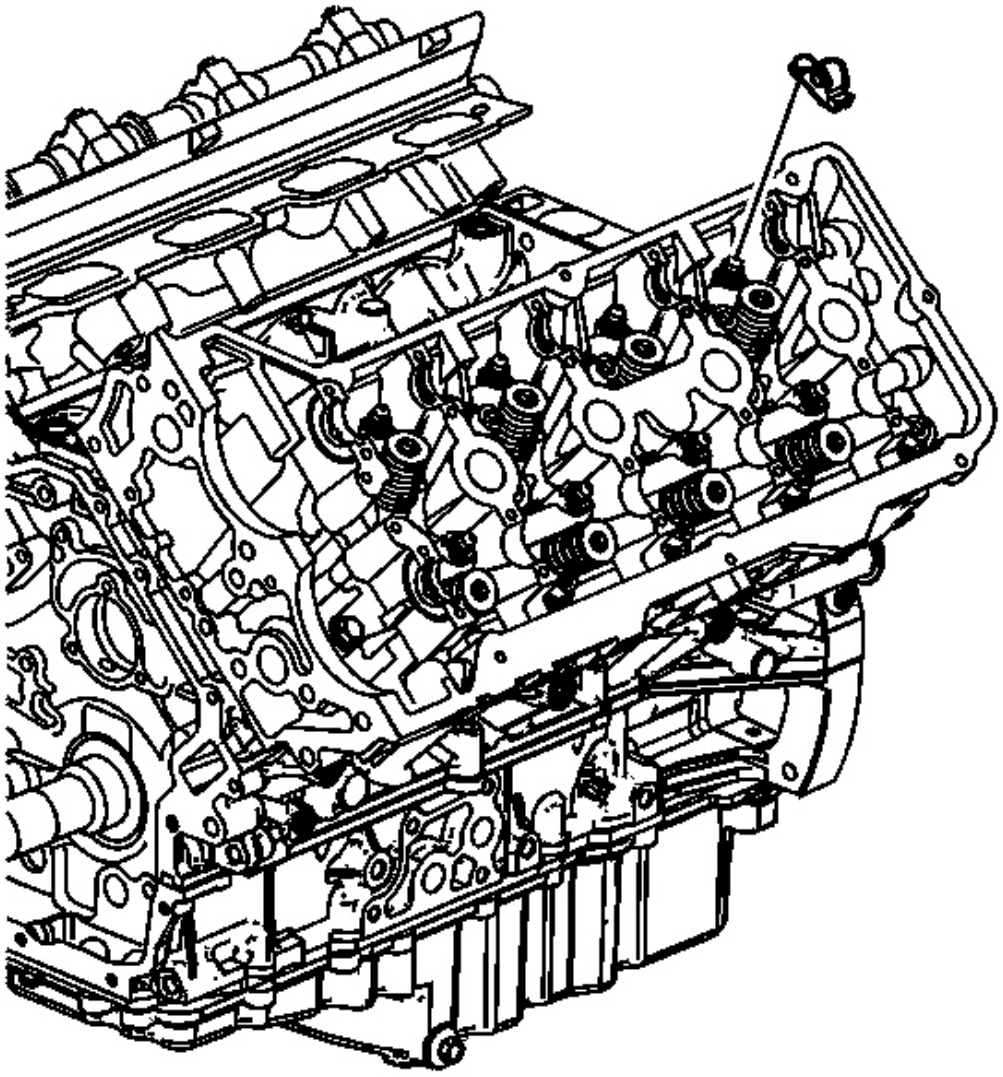


Fig. 8: View Of Left Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure each camshaft follower remains matched to the original Stationary Hydraulic Lash Adjuster (SHLAs) and original location the components were assembled in.

1. Remove the camshaft followers from the left cylinder head.
2. Store the camshafts, followers and SHLAs in a clean, secure location.

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VALVE LIFTER REMOVAL - LEFT SIDE

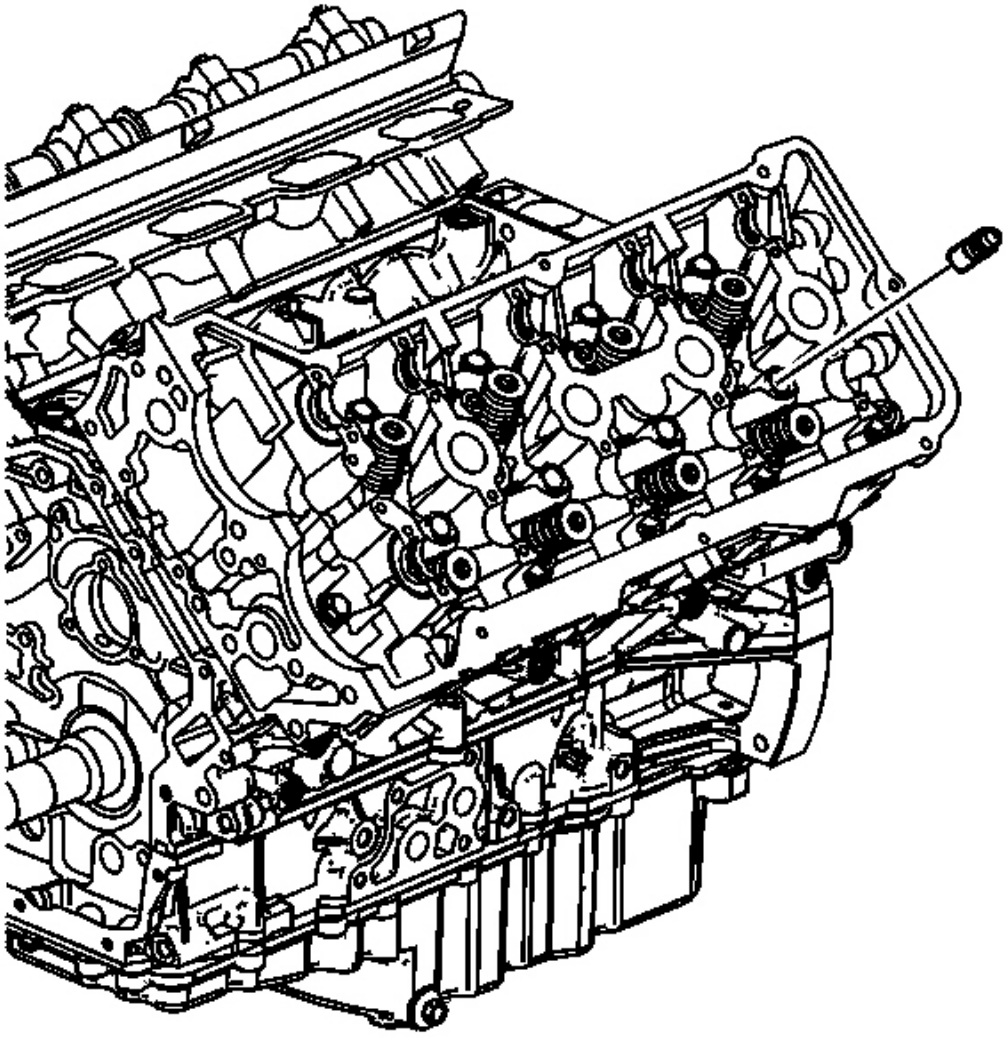


Fig. 9: View Of Left Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Valve Lifter Priming Notice .**

IMPORTANT: **Ensure each camshaft follower remains matched to the original Stationary Hydraulic Lash Adjuster (SHLAs) and original location the components were assembled in.**

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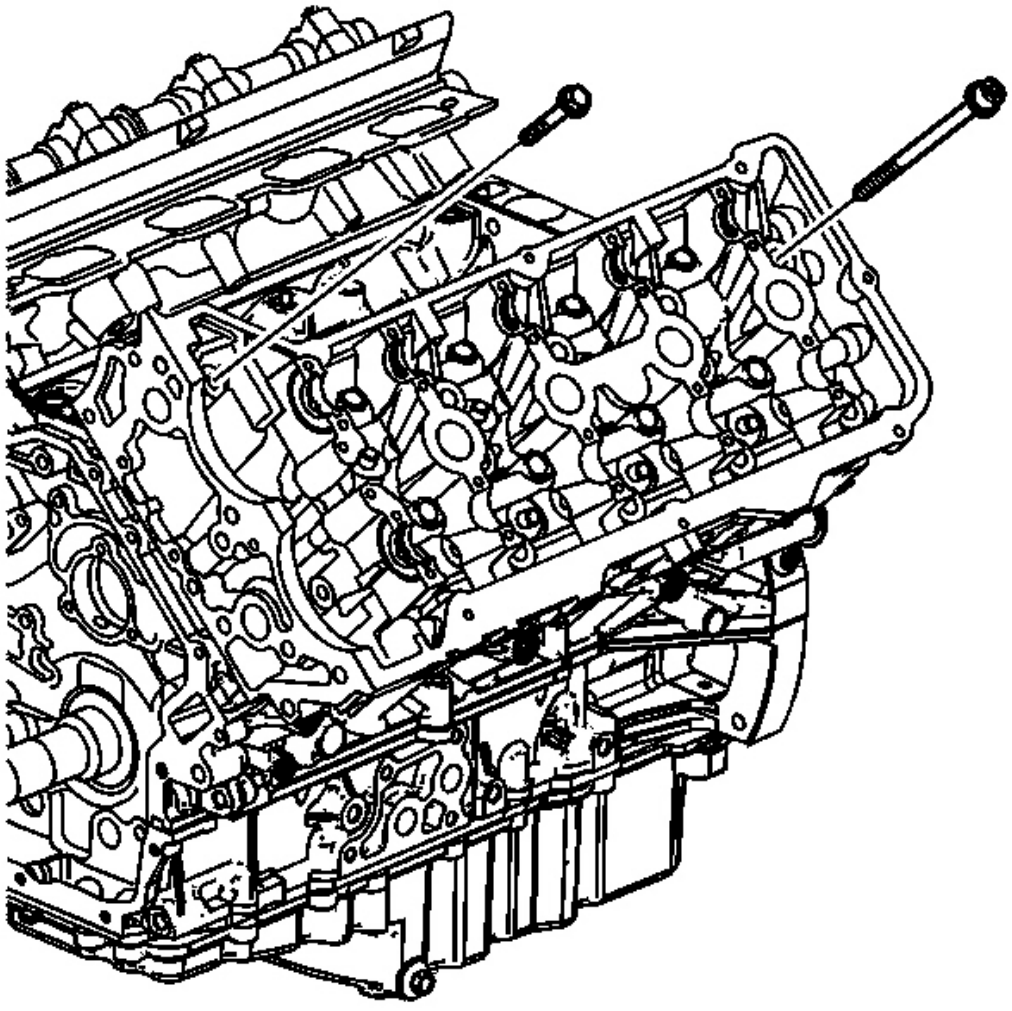
1. Remove the stationary hydraulic lash adjuster (SHLAs) from the left cylinder head lifter bores.
2. Store the camshafts, followers and SHLAs in a clean, secure location.

CYLINDER HEAD REMOVAL - LEFT SIDE

TOOLS REQUIRED

J 28410 Gasket Remover. See **Special Tools** .

REMOVAL PROCEDURE



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Fig. 10: View Of Left Cylinder Head M6 External Drive Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the 3 M6 external drive bolts from the front portion of the cylinder head.

IMPORTANT: DO NOT reuse the M11 cylinder head bolts.

2. Remove and discard the 10 M11 internal drive cylinder head bolts.

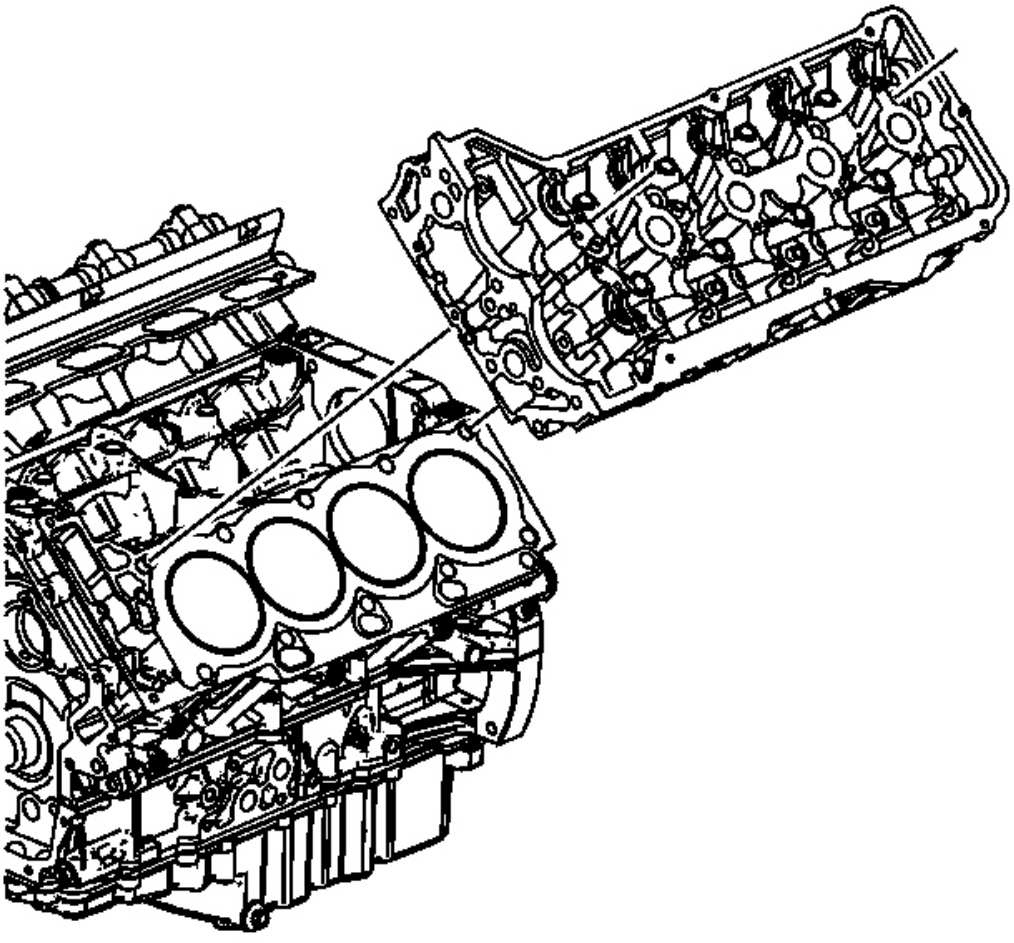


Fig. 11: View Of Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

3. Remove the left cylinder head. Ensure that no dowel guide pins are stuck in the cylinder head.

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IMPORTANT: You must clean the thread sealant material from the cylinder head bolt holes in the cylinder block. Failure to do so could cause false torque readings during reassembly.

4. After removing the cylinder head, remove any remaining bolt thread sealant material from the threaded cylinder block holes.

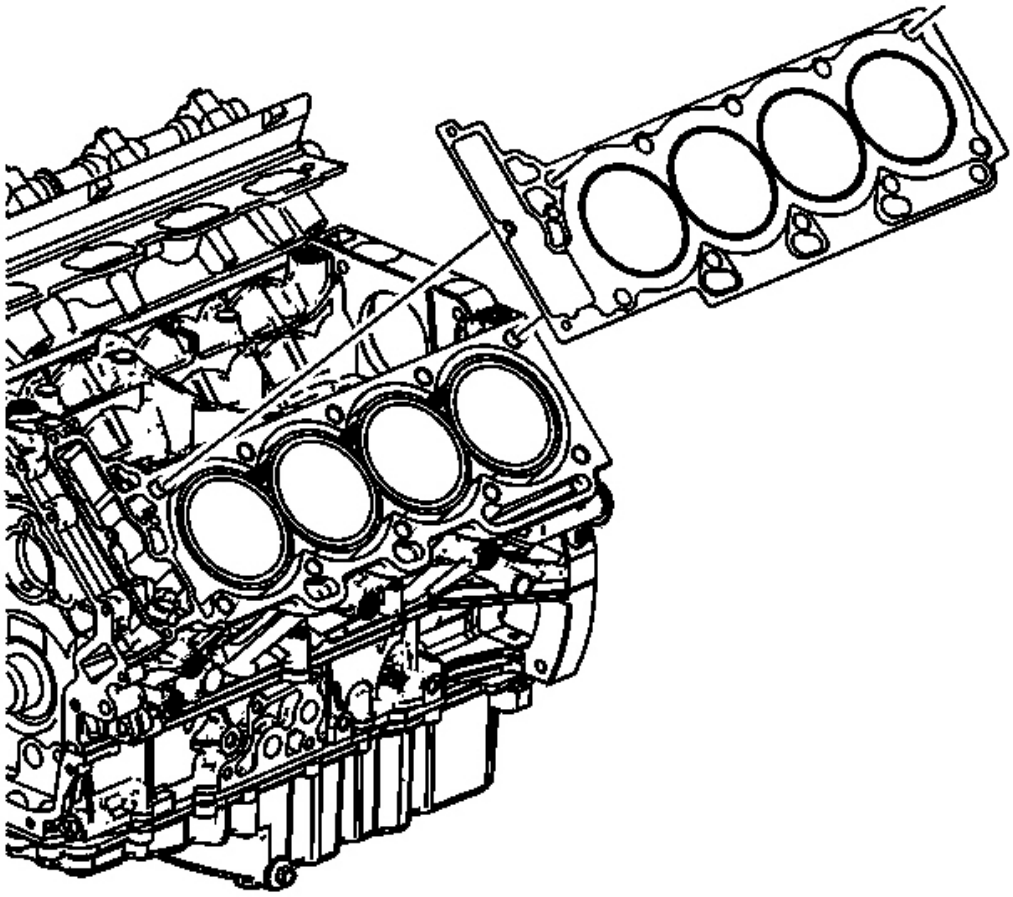


Fig. 12: View Of Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the cylinder head gasket.

5. Remove the left cylinder head gasket.
6. Remove all remaining gasket material from the cylinder head and cylinder block using the **J 28410** . See

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Special Tools .

EXHAUST CAMSHAFT REMOVAL - RIGHT SIDE

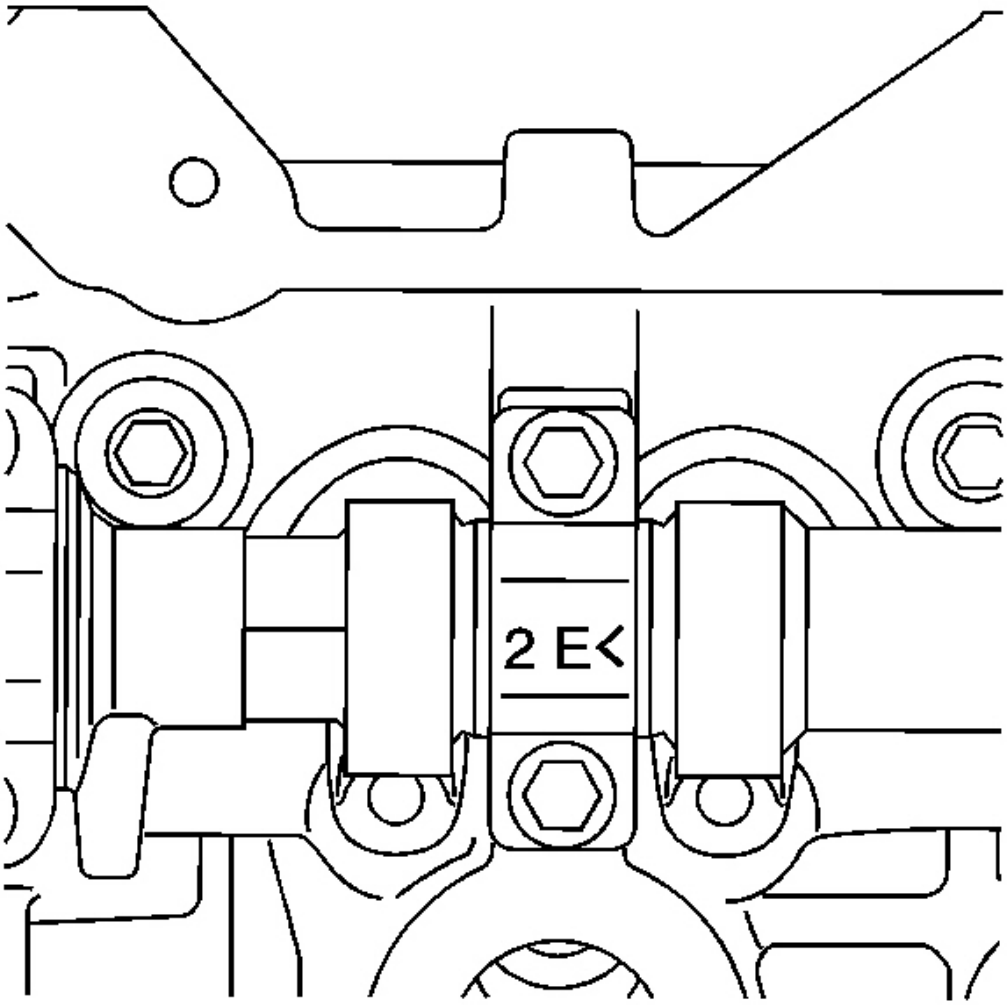


Fig. 13: View Of Exhaust Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Bearing caps must remain with their original cylinder head and in their original location. Do not mix bearing caps.

1. Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location.

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The markings have the following meanings:

- The arrow points toward the front of the engine.
- The "E" indicates the exhaust camshaft.
- The number indicates the journal position from the front of the engine.

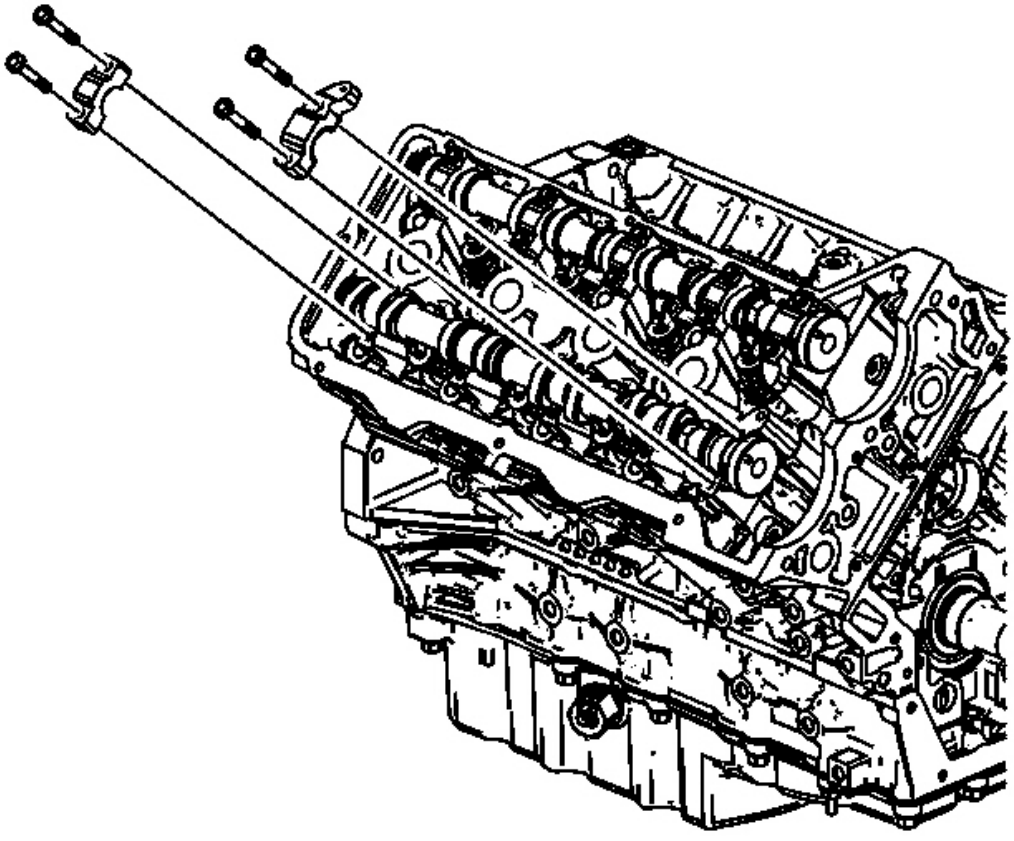


Fig. 14: View Of Right Exhaust Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

2. Remove the right exhaust camshaft bearing cap bolts.
3. Remove the right exhaust camshaft bearing caps. Store the bearing caps in a clean shop towel.

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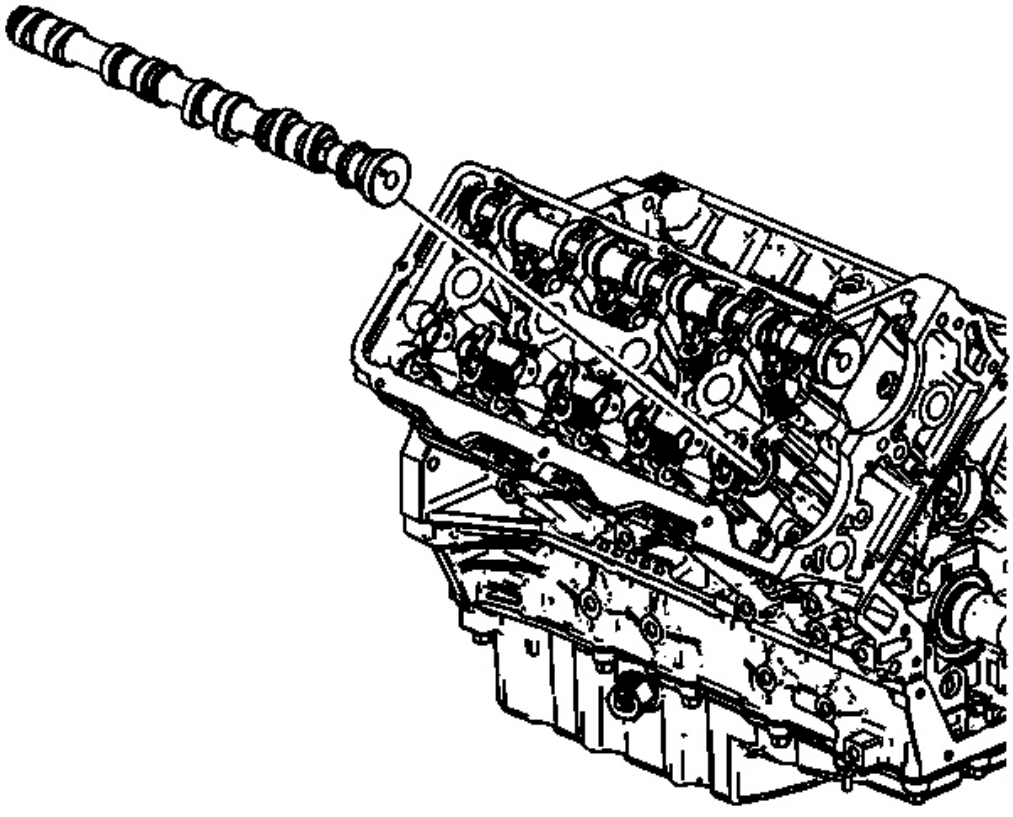


Fig. 15: View Of Right Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Remove the right exhaust camshaft. Place the camshaft in a secure location.
5. Cover the camshaft with an oil soaked towel in order to prevent corrosion.

INTAKE CAMSHAFT REMOVAL - RIGHT SIDE

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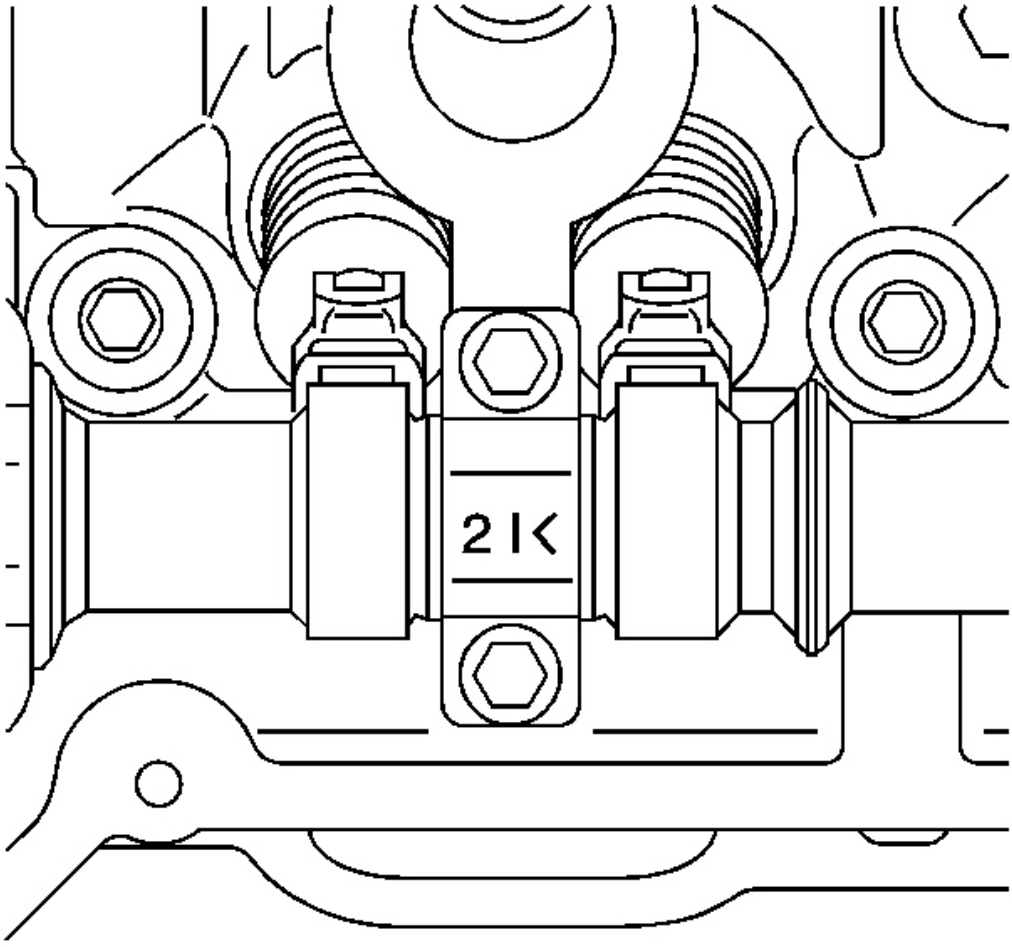


Fig. 16: View Of Intake Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Bearing caps must remain with their original cylinder head and in their original location. Do not mix bearing caps.

1. Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The arrow points toward the front of the engine.
   - The "I" indicates the intake camshaft.
   - The number indicates the journal position from the front of the engine.

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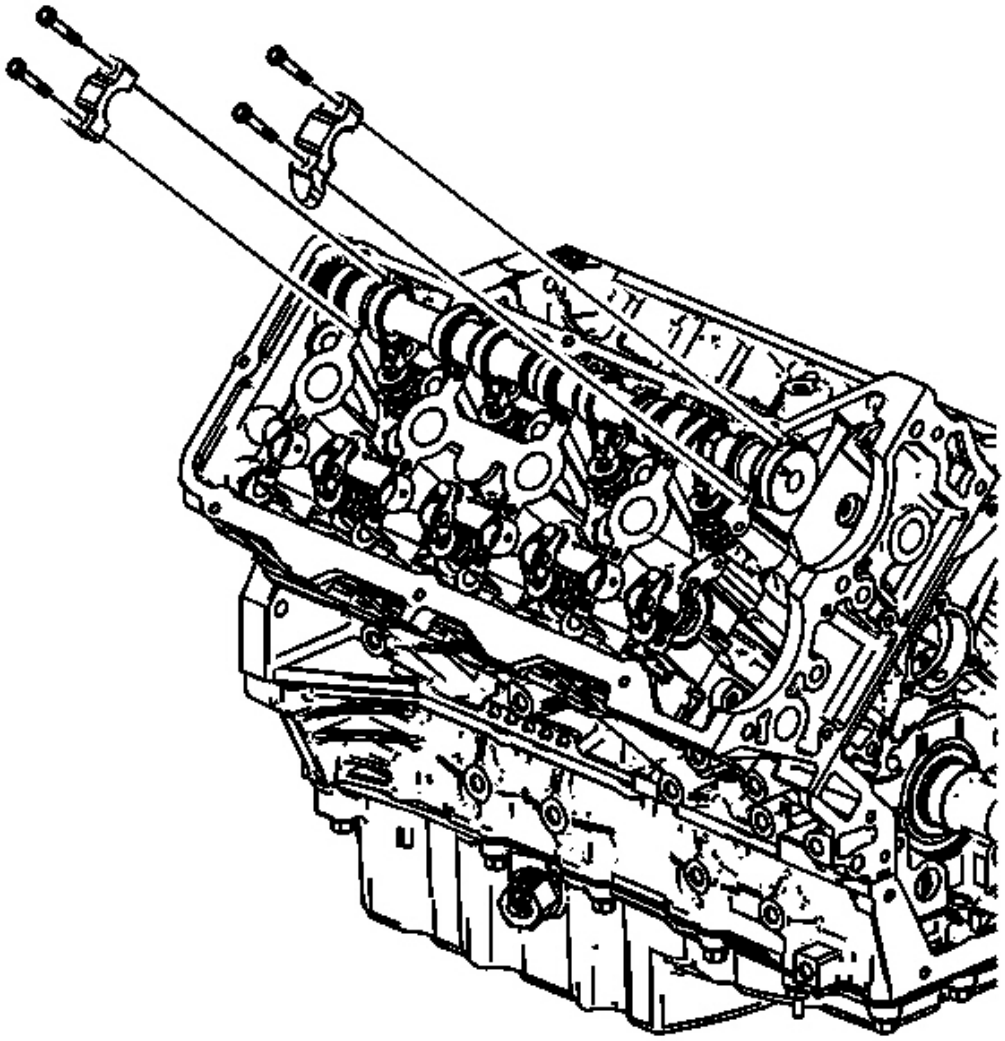


Fig. 17: View Of Right Intake Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

2. Remove the right intake camshaft bearing cap bolts.
3. Remove the right intake camshaft bearing caps. Store the bearing caps in a clean shop towel.

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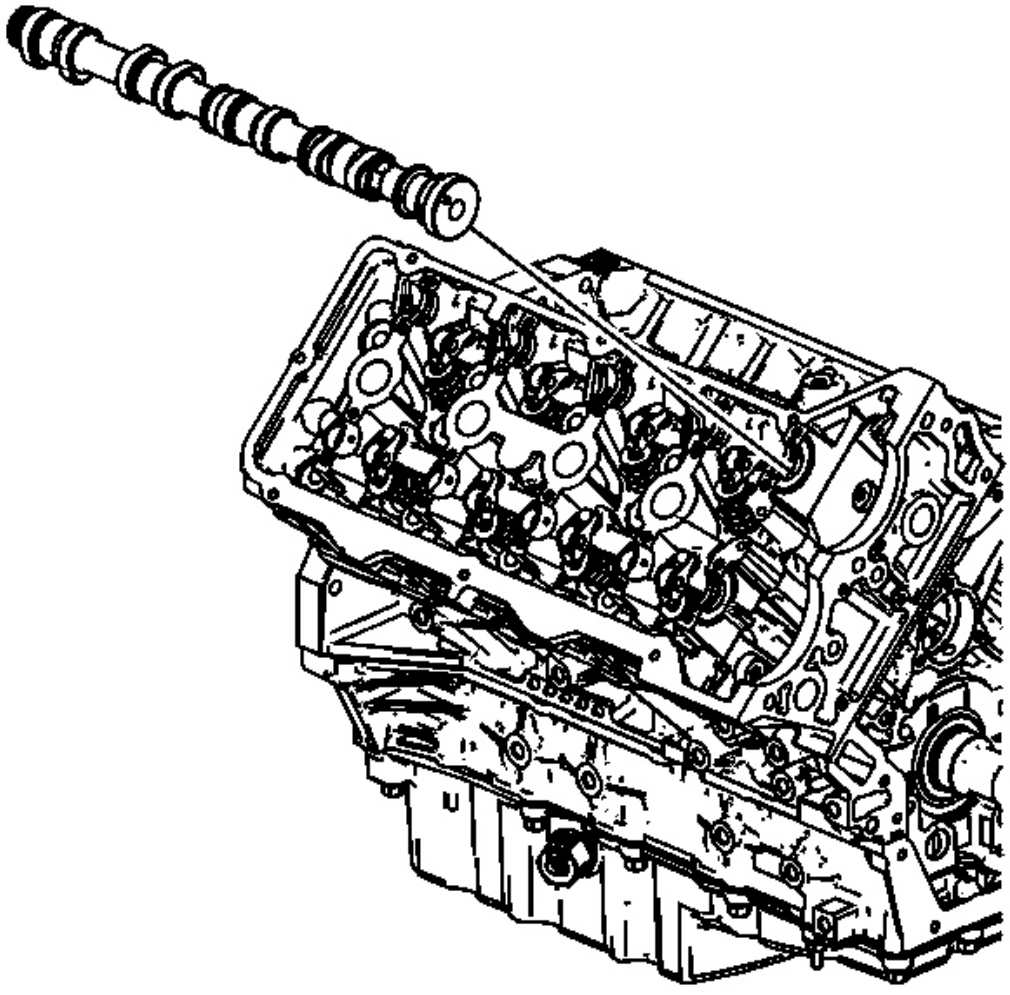


Fig. 18: View Of Right Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Remove the right intake camshaft. Place the camshaft in a secure location.
5. Cover the camshaft with an oil soaked towel in order to prevent corrosion.

VALVE ROCKER ARM REMOVAL - RIGHT SIDE

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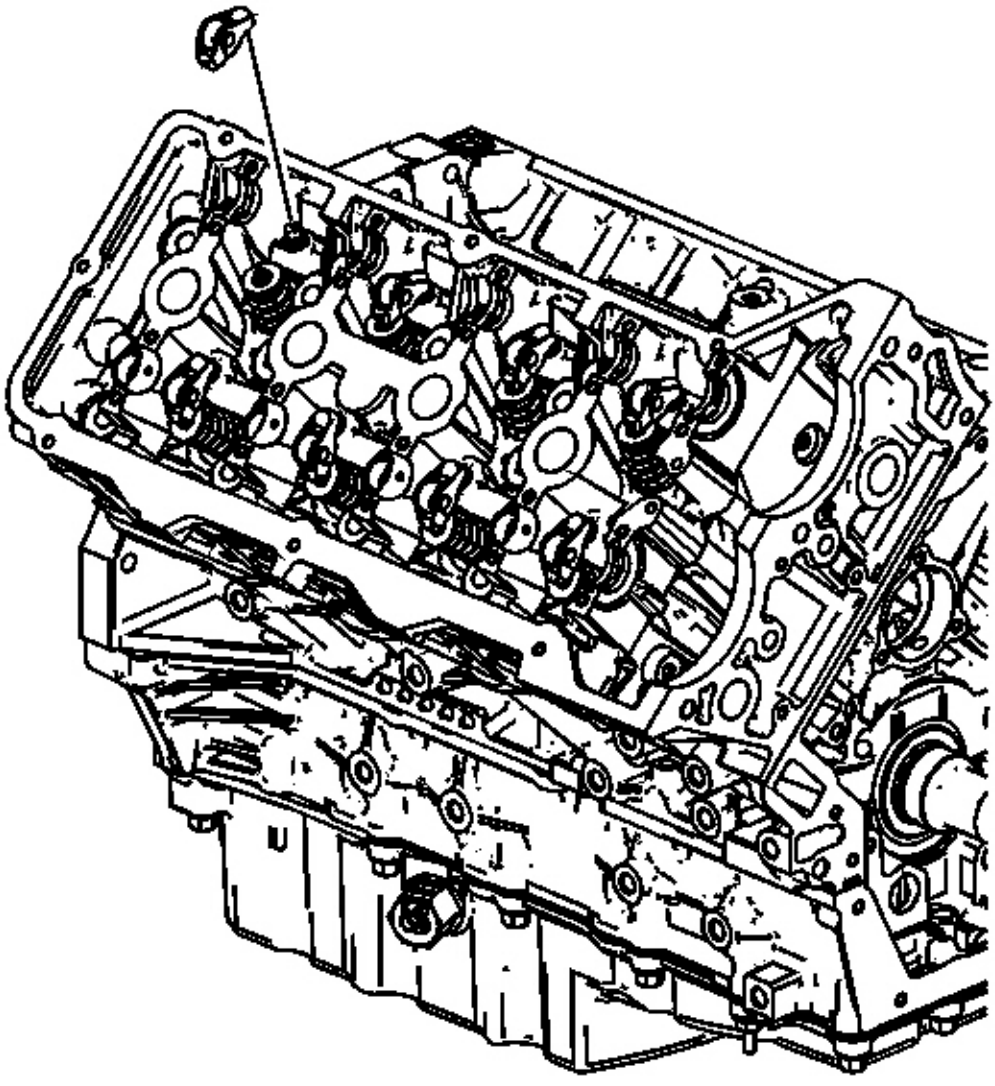


Fig. 19: View Of Right Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure each camshaft follower remains matched to the original Stationary Hydraulic Lash Adjuster (SHLAs) and original location the components were assembled in.

1. Remove the camshaft followers from the right cylinder head.

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2. Store the camshafts, followers and SHLAs in a clean, secure location.

VALVE LIFTER REMOVAL - RIGHT SIDE

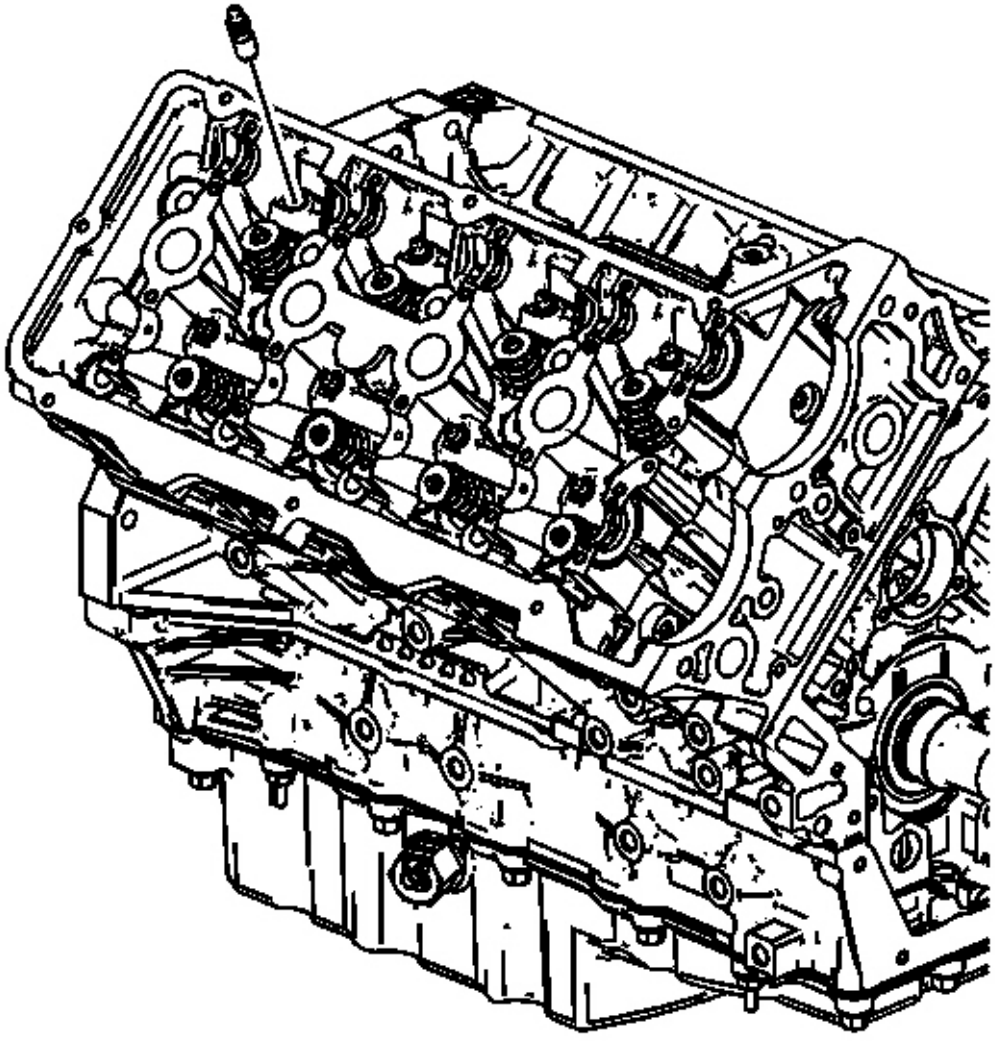


Fig. 20: View Of Right Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Valve Lifter Priming Notice .**

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IMPORTANT: Ensure each camshaft follower remains matched to the original Stationary Hydraulic Lash Adjuster (SHLAs) and original location the components were assembled in.

1. Remove the stationary hydraulic lash adjuster (SHLAs) from the right cylinder head lifter bores.
2. Store the camshafts, followers and SHLAs in a clean, secure location.

CYLINDER HEAD REMOVAL - RIGHT SIDE

TOOLS REQUIRED

J 28410 Gasket Remover. See **Special Tools** .

REMOVAL PROCEDURE

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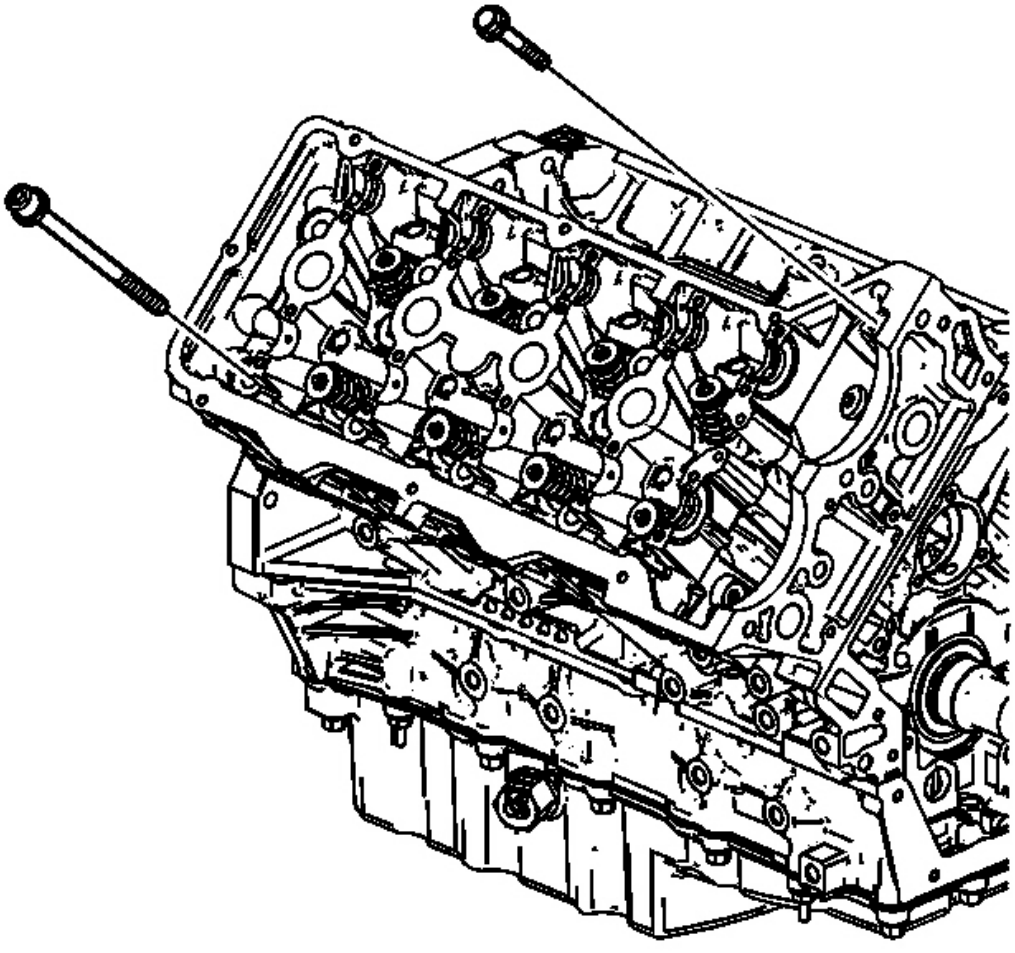


Fig. 21: View Of Right Cylinder Head M6 External Drive Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the 3 M6 external drive bolts from the front portion of the cylinder head.

IMPORTANT: DO NOT reuse the M11 cylinder head bolts.

2. Remove and discard the 10 M11 internal drive cylinder head bolts.

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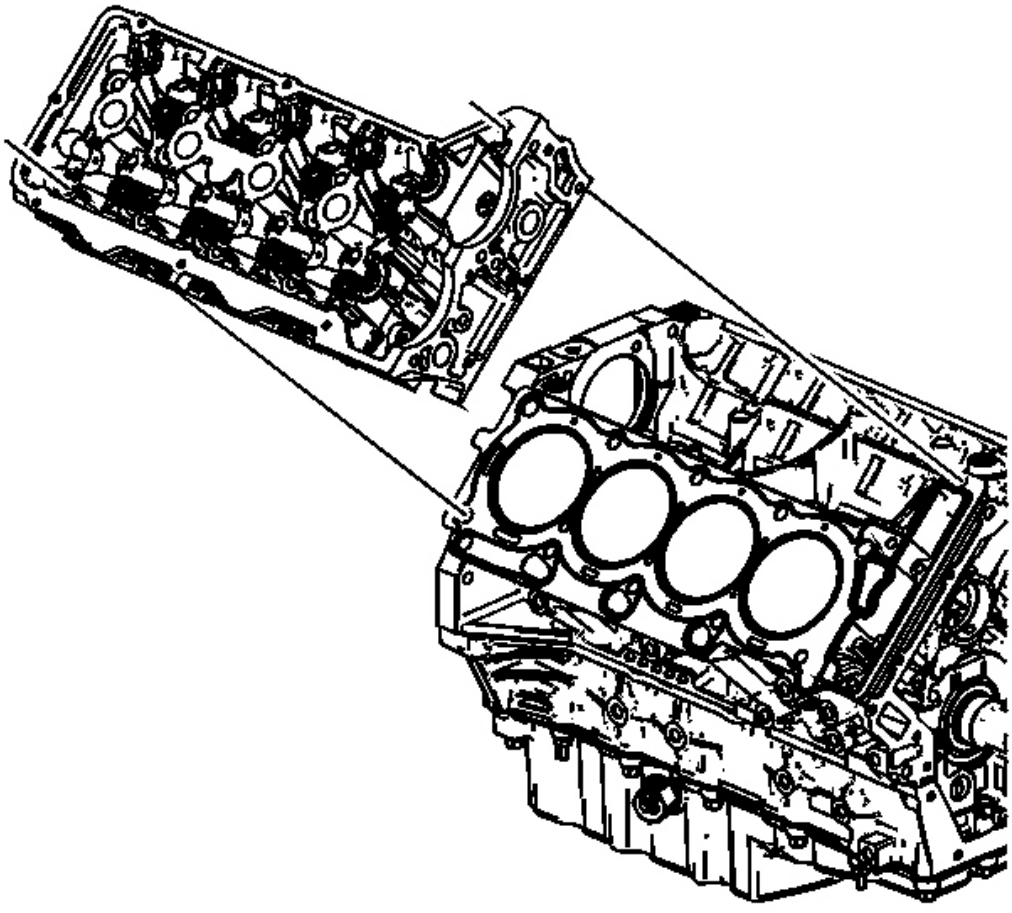


Fig. 22: View Of Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

3. Remove the right cylinder head. Ensure that no dowel guide pins are stuck in the cylinder head.

IMPORTANT: You must clean the thread sealant material from the cylinder head bolt holes in the cylinder block. Failure to do so could cause false torque readings during reassembly.

4. After removing the cylinder head, remove any remaining bolt thread sealant material from the threaded cylinder block holes.

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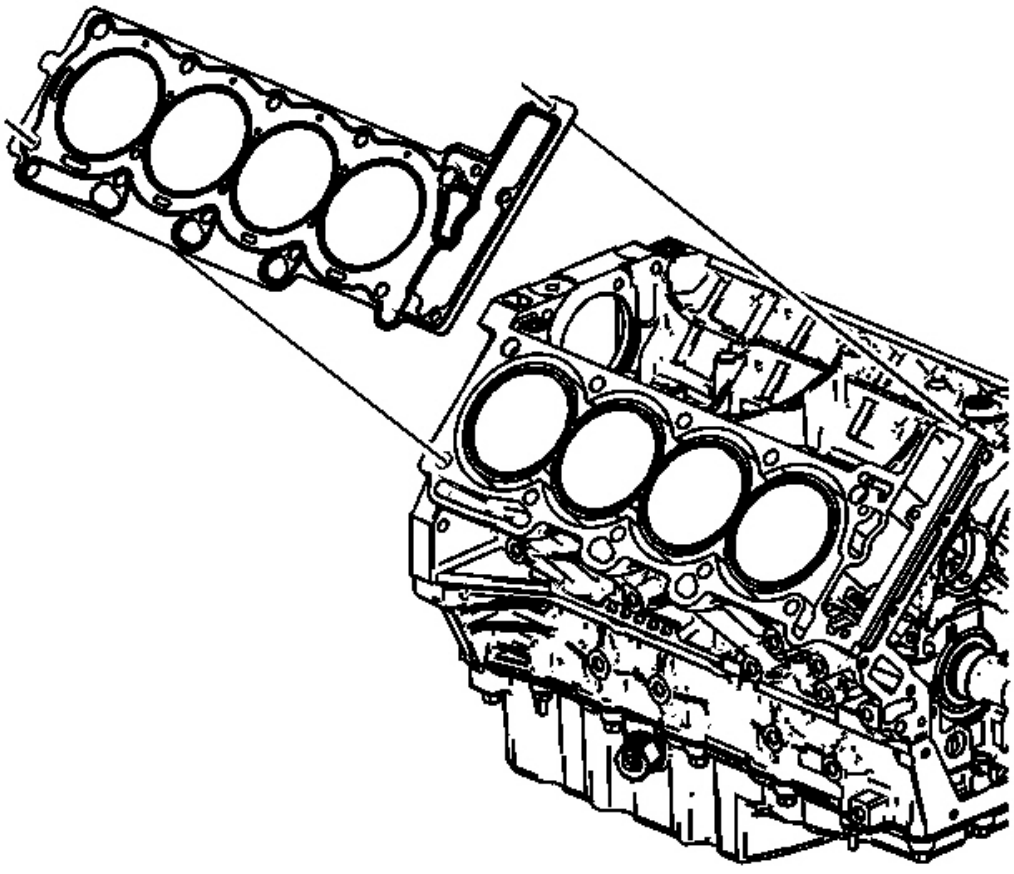


Fig. 23: View Of Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the cylinder head gasket.

5. Remove the right cylinder head gasket.
6. Remove all remaining gasket material from the cylinder head and cylinder block using the **J 28410** . See **Special Tools** .

OIL PAN REMOVAL

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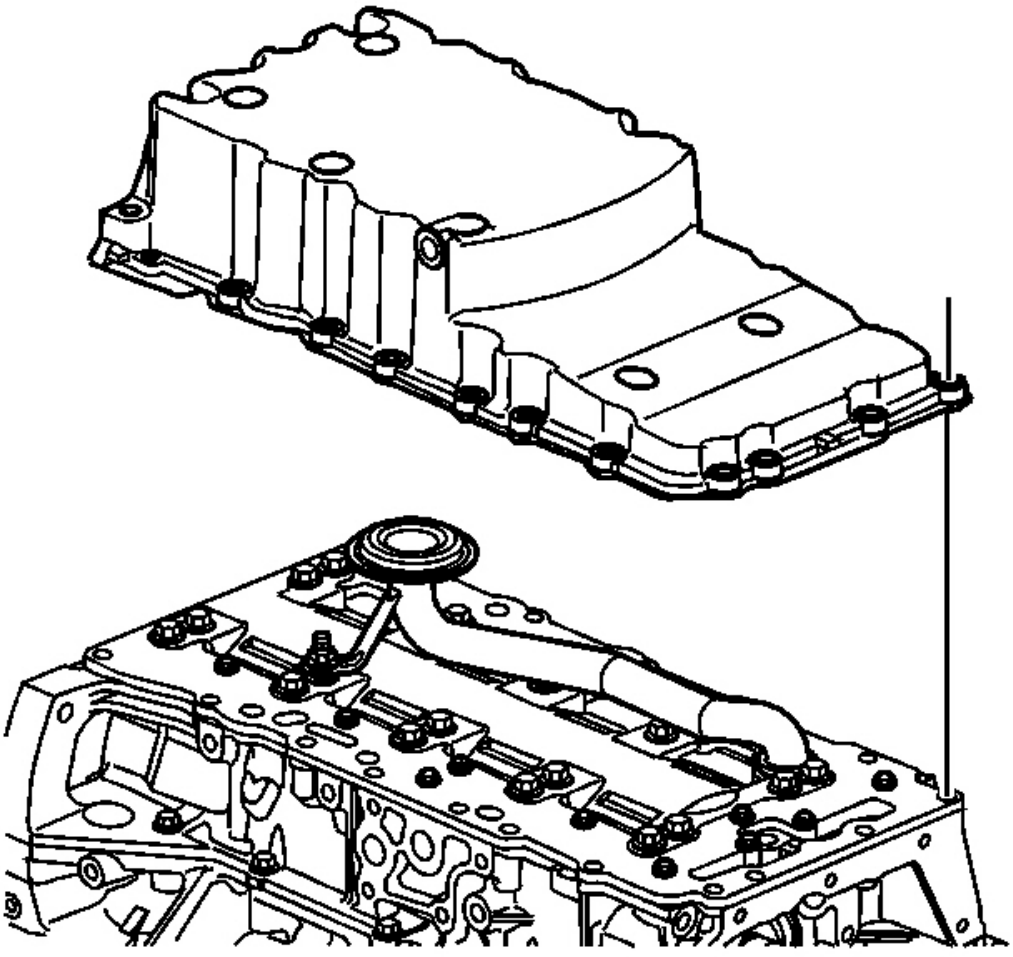


Fig. 24: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Loosen the oil pan bolts.
2. Remove the oil pan.

OIL PUMP PIPE AND SCREEN ASSEMBLY REMOVAL

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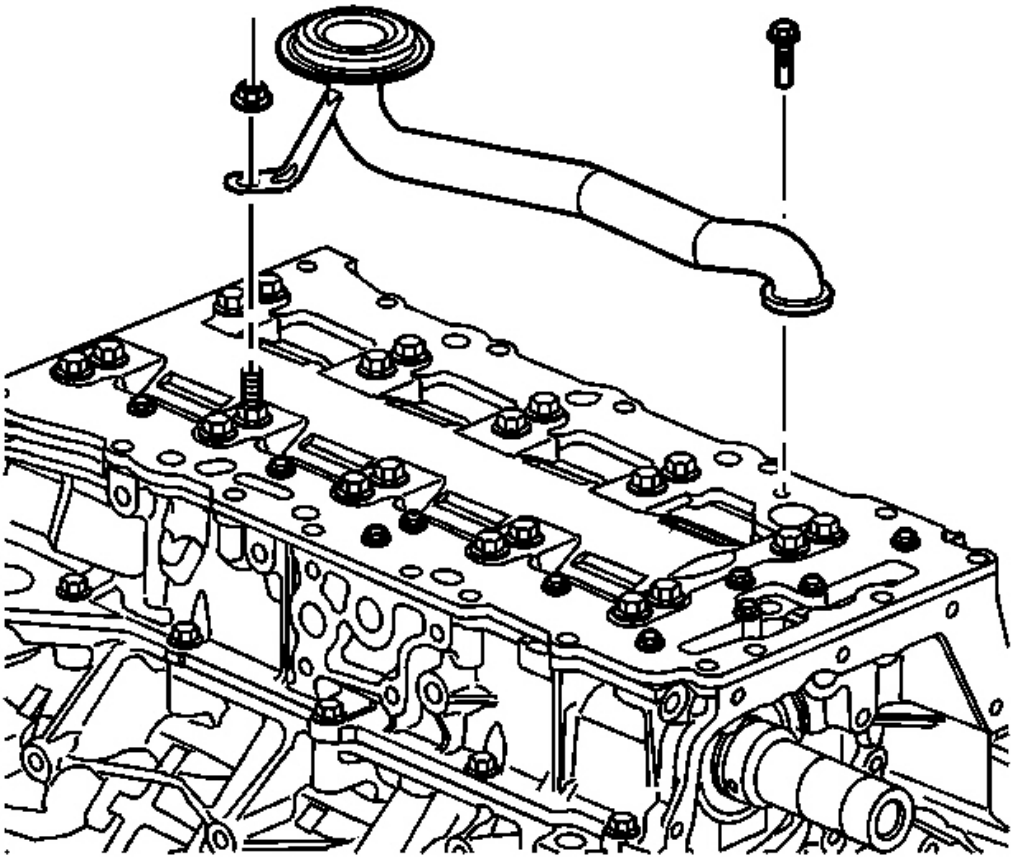


Fig. 25: View Of Oil Pump Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump pipe support bracket nut.
2. Remove the oil pump pipe bolt.
3. Remove the oil pump pipe and screen assembly.

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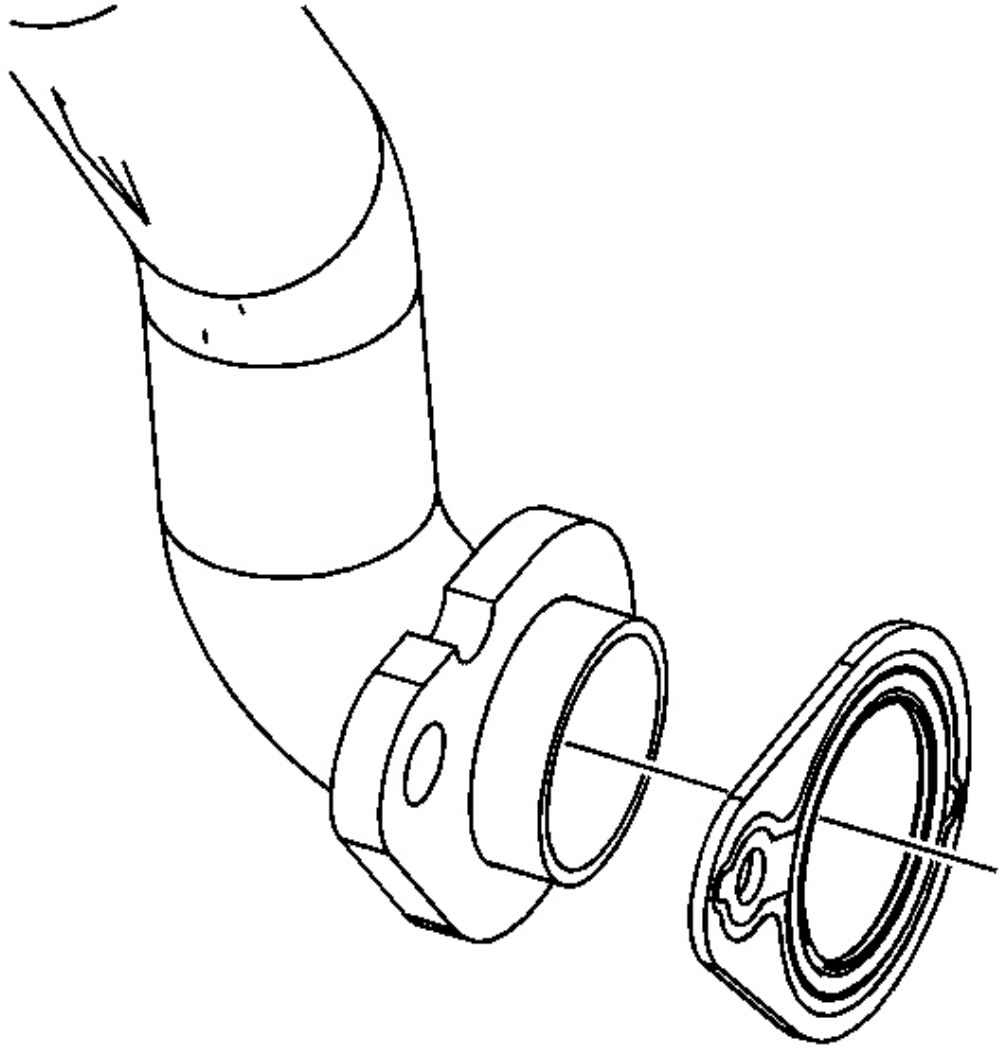


Fig. 26: View Of Oil Pump Pipe Gasket
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the oil pump pipe gasket.

LOWER CRANKCASE REMOVAL

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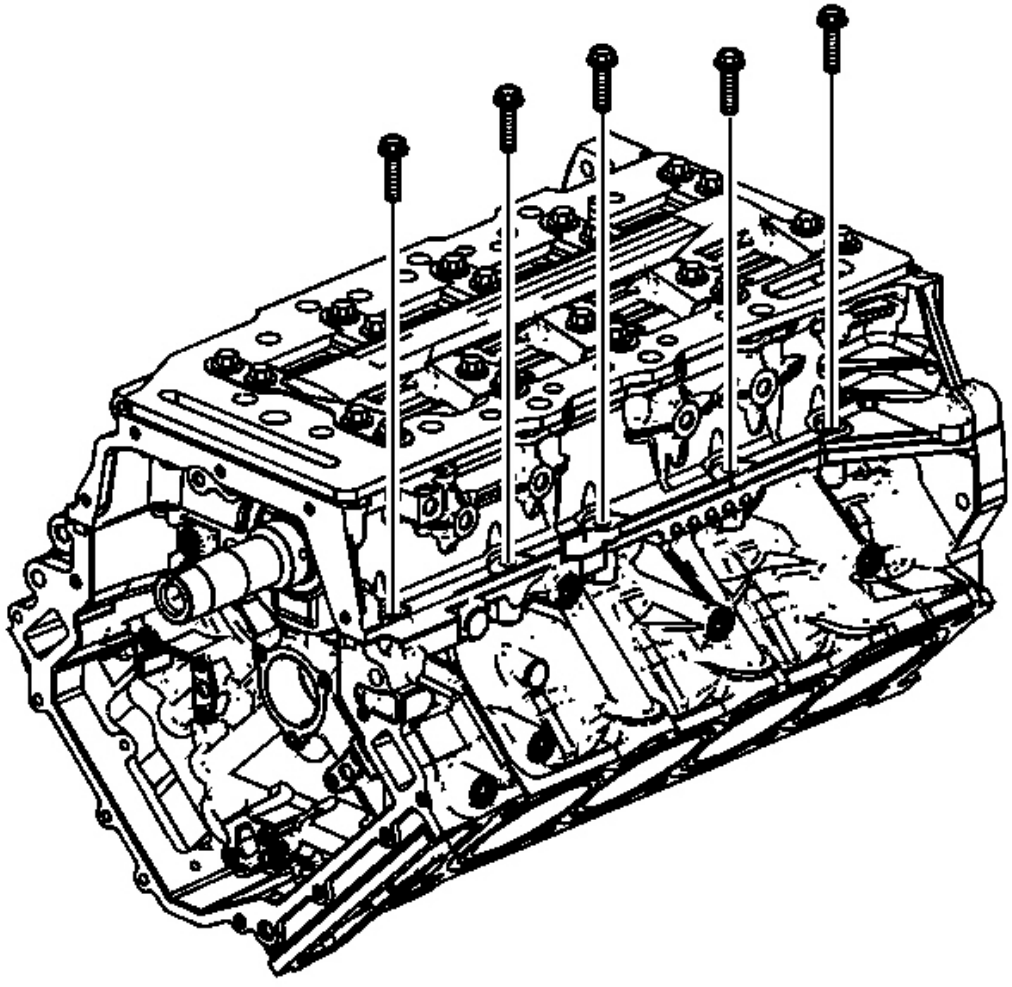


Fig. 27: View Of Right Upper-To-Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the 4 lower crankcase perimeter retaining bolts along the right side of the engine.

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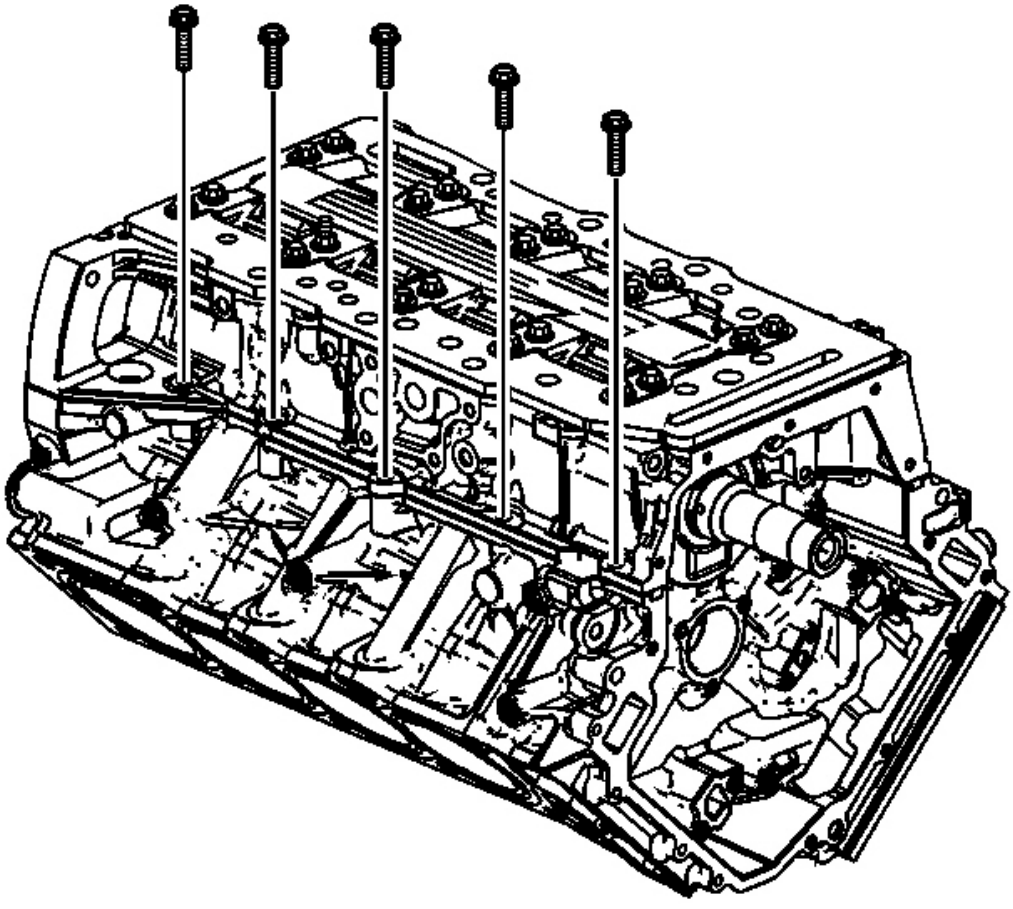


Fig. 28: View Of Lower Left Crankcase Perimeter Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the 4 lower crankcase perimeter retaining bolts along the left side of the engine.

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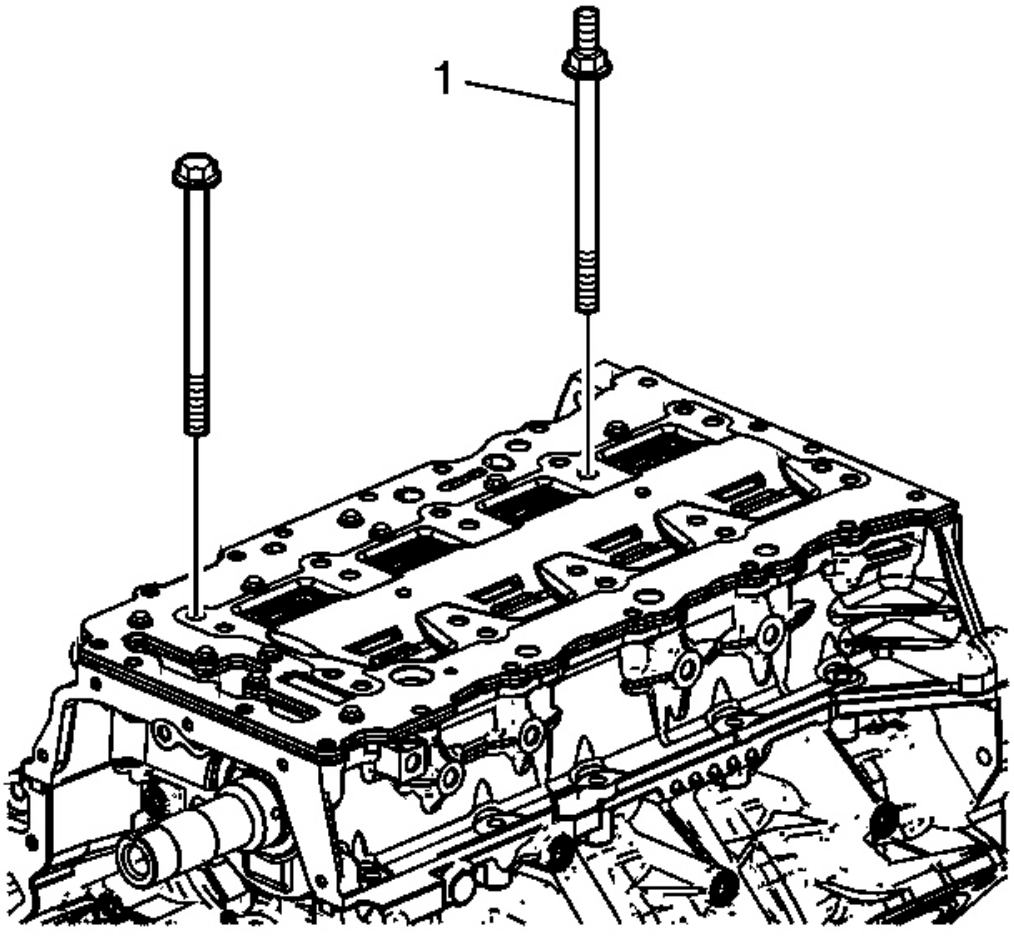


Fig. 29: View Of Single Stud-End Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the main bearing bolts. Note the location of the single stud-end bolt (1) used to attach the oil pump pickup tube.

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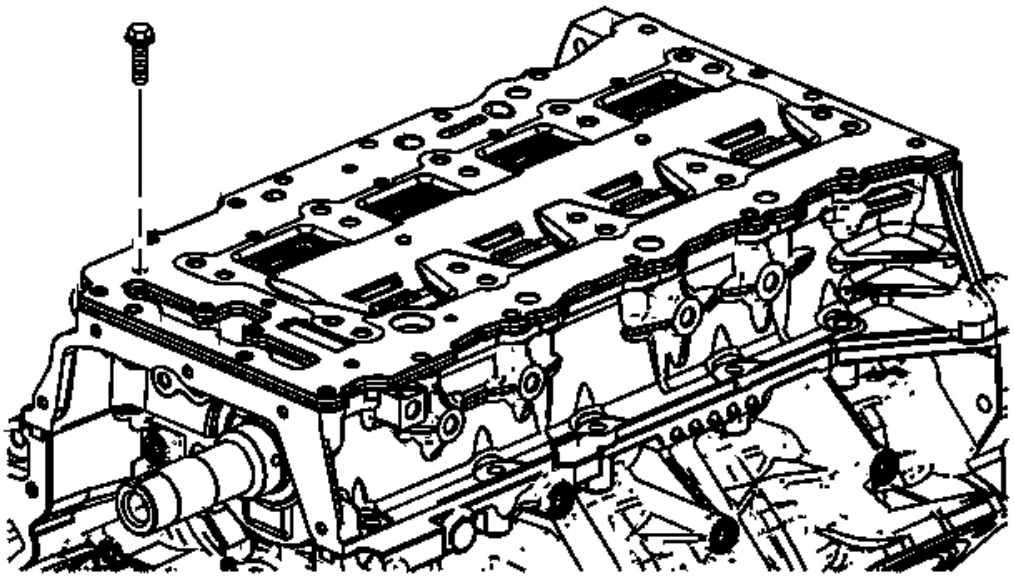


Fig. 30: View Of Oil Manifold Plate Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil manifold plate bolts.

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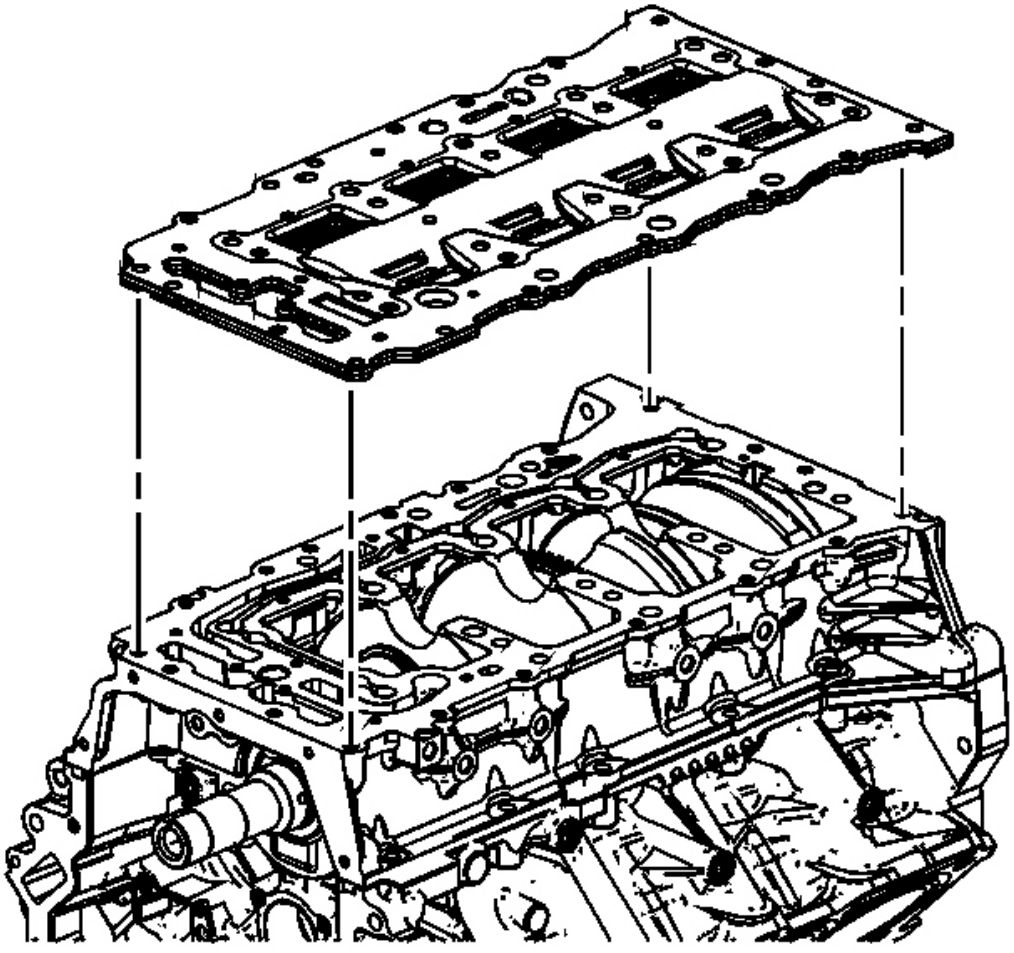


Fig. 31: View Of Oil Manifold & Oil Scraper Plate Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil manifold and oil scraper plate assembly.

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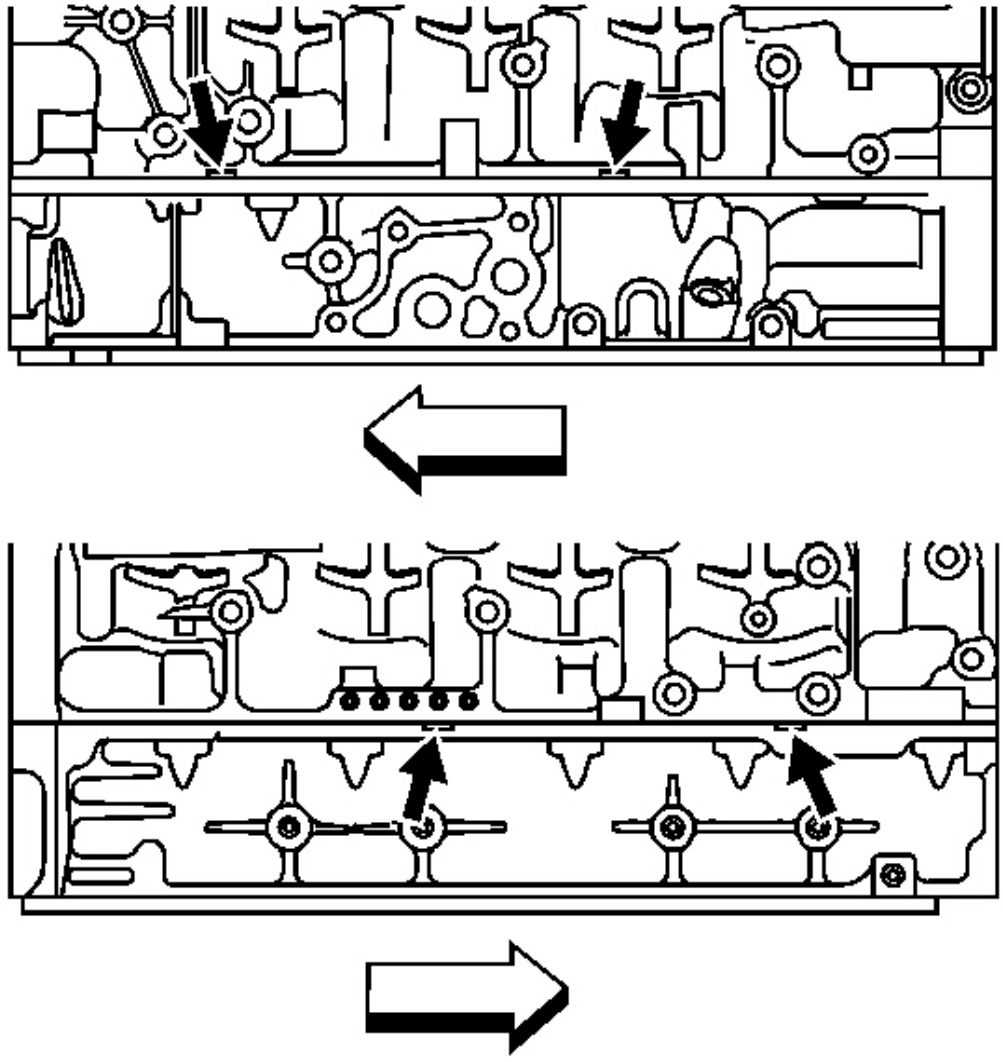


Fig. 32: Separating Crankcase Halves
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a plastic pry tool when prying case halves apart to prevent damage to the Upper and Lower Crankcase surface. Do not continue to push the pry tool in the crankcase as the Upper and Lower Crankcase halves separate. This may damage the sealing surface.

6. Working on either side of the lower crankcase, separate the crankcase halves by alternately prying in the

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grooves provided until the lower crankcase is free of the dowel pins.

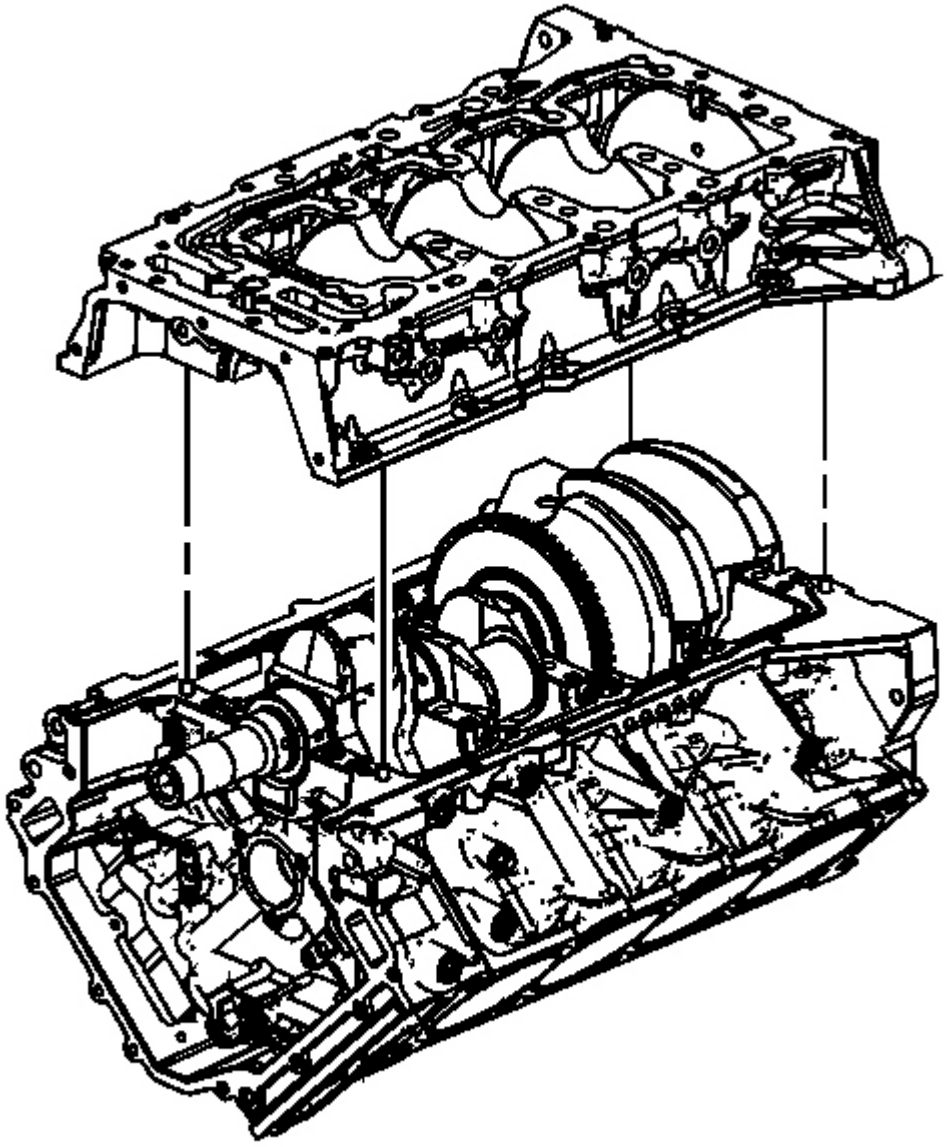


Fig. 33: View Of Lower Crankcase
Courtesy of GENERAL MOTORS CORP.

7. Remove the lower crankcase.

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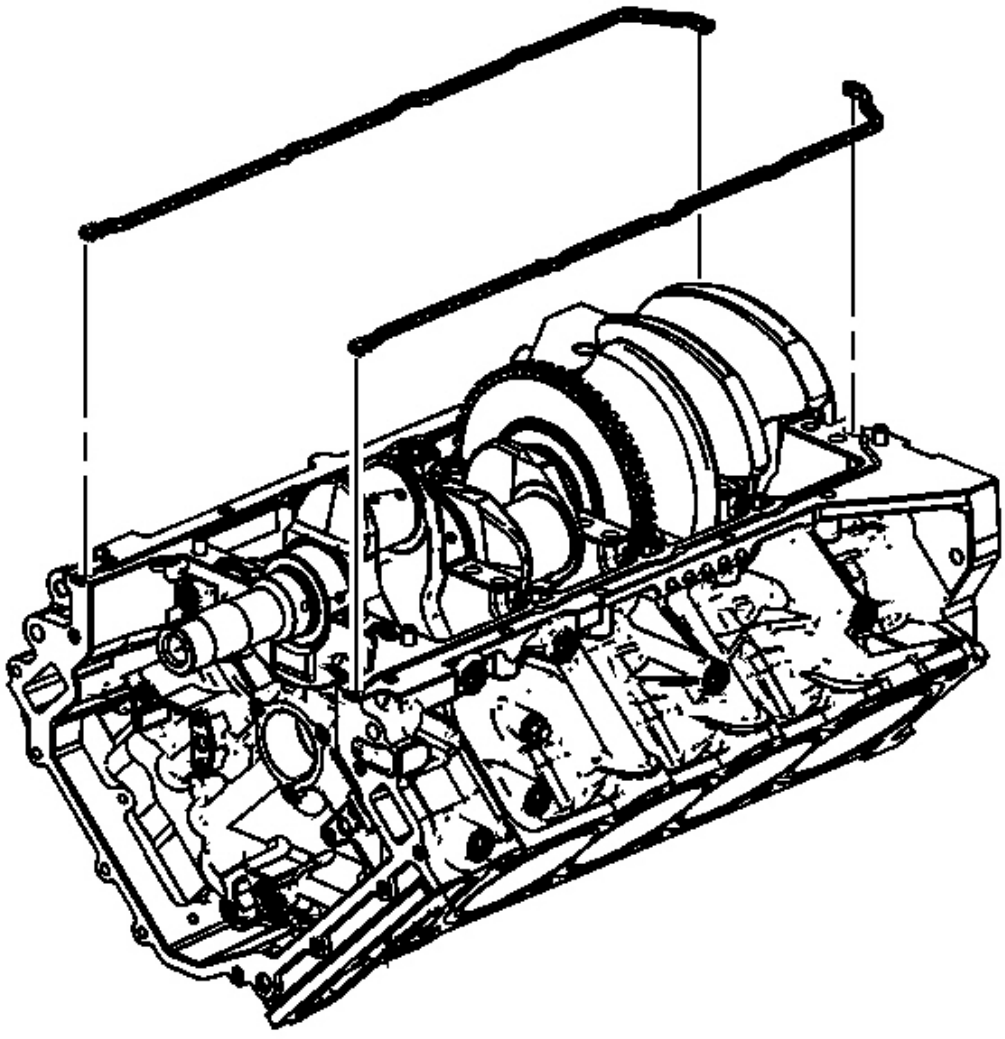


Fig. 34: View Of Upper-To-Lower Crankcase Seals
Courtesy of GENERAL MOTORS CORP.

8. If equipped, remove the upper-to-lower crankcase seal.

PISTON, CONNECTING ROD AND BEARING REMOVAL

TOOLS REQUIRED

EN 46121 Connecting Rod Guide Pin Set. See **Special Tools** .

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REMOVAL PROCEDURE

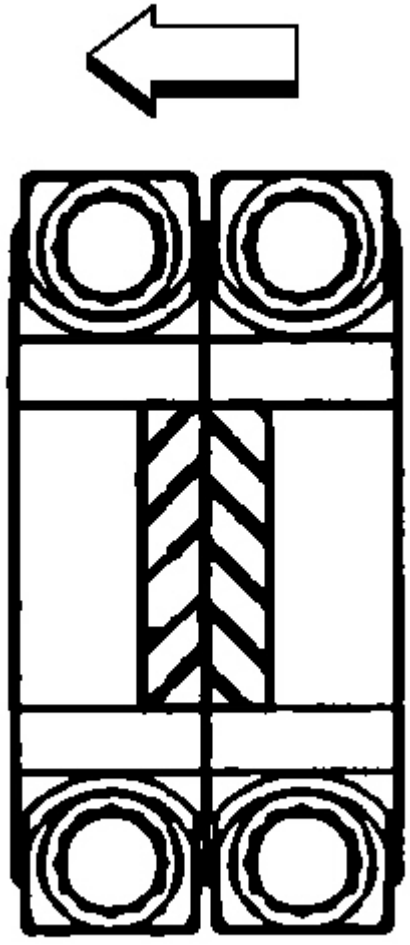


Fig. 35: View Of Paired Connecting Rod Bearing Cap Notches
Courtesy of GENERAL MOTORS CORP.

1. Note the orientation of paired connecting rods on each crankpin. The notches in the connecting rod cap must be facing each other.
2. Before removing the connecting rods, check the connecting rod end play using the following procedure:
    1. Tap the connecting rod to one end of the crankshaft journal with a dead-blow or wooden hammer.
    2. Using feeler gages, measure the clearance between the crankshaft counterweight and the connecting rod.

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3. The connecting rod end play should not exceed 0.500 mm (0.020 in).
4. If the end play exceeds the specified limits, measure the width of the crankpin end of the connecting rod.
5. The width of the crankpin end of the connecting rod should be 21.745 - 21.805 mm (0.856 - 0.858 in).
6. If the connecting rod width is significantly smaller than specified and severe wear is present on the side of the connecting rod, replace the connecting rod.
7. If the connecting rod width is within specification and excessive scoring is present on the crankshaft journals, replace the crankshaft.

3. Using a paint stick or permanent marker, number each piston face. Draw an arrow along the centerline of the piston pointing toward the front of the engine.

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

IMPORTANT: Do NOT stamp or use a punch to mark a powdered metal connecting rod for identification.

4. Mark the cylinder number on the connecting rod and the connecting rod cap with paint stick, scribe or permanent marker. The connecting rod caps must remain with the original connecting rod.

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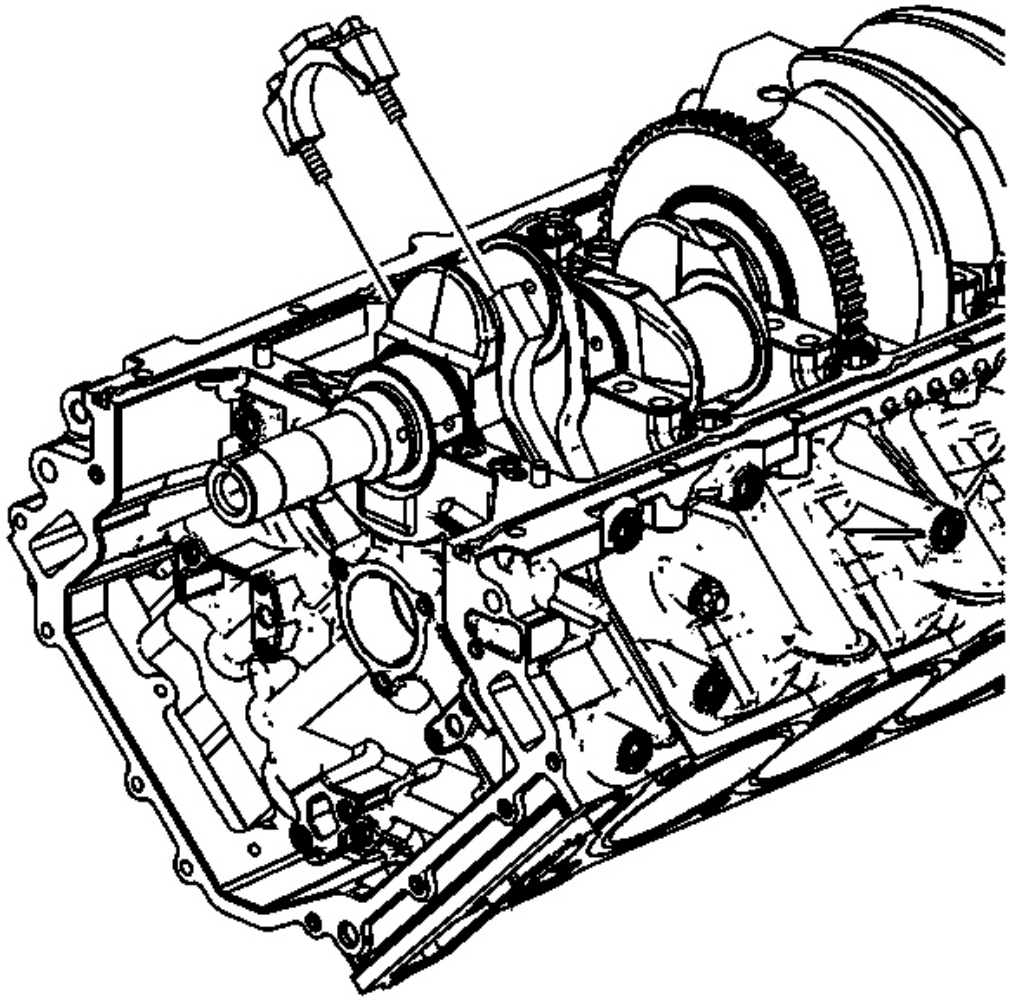


Fig. 36: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

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

5. Remove the connecting rod bolts.
6. Remove the connecting rod cap.

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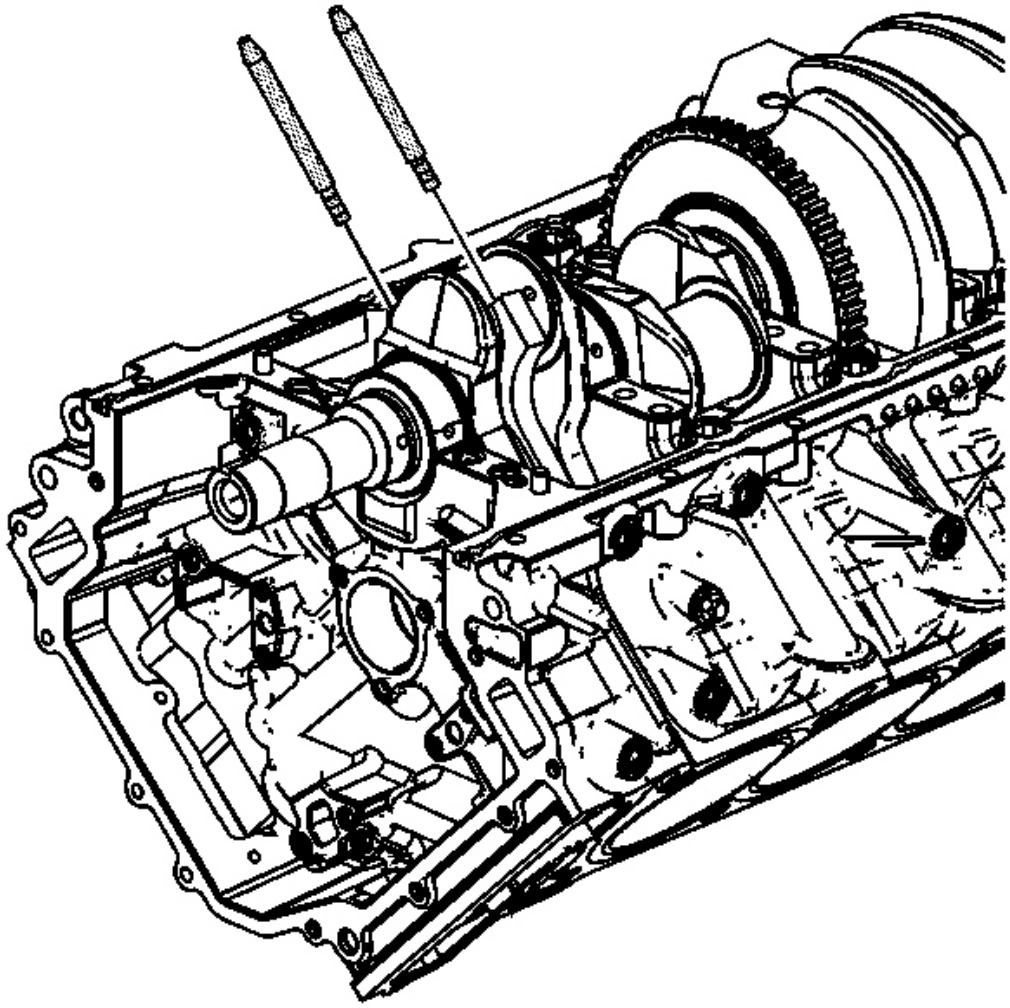


Fig. 37: Installing EN 46121
Courtesy of GENERAL MOTORS CORP.

7. Install the **EN 46121** into the connecting rod bolt holes. See **Special Tools** .

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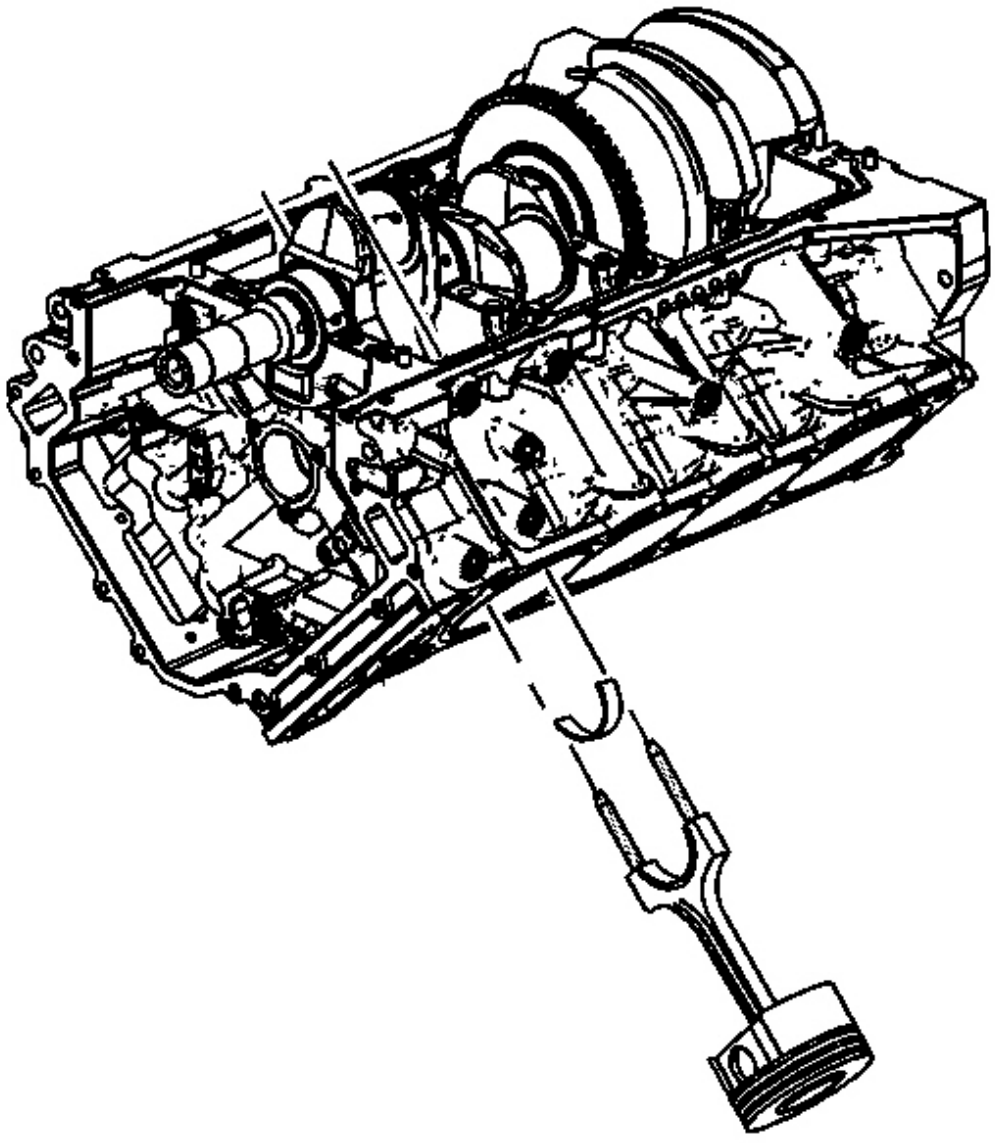


Fig. 38: Removing Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS CORP.

8. Using the **EN 46121** push the connecting rod and piston assembly down through the top of the cylinder. See **Special Tools** . Do not scratch the crankshaft journal or the cylinder wall when removing the connecting rod and piston assembly.

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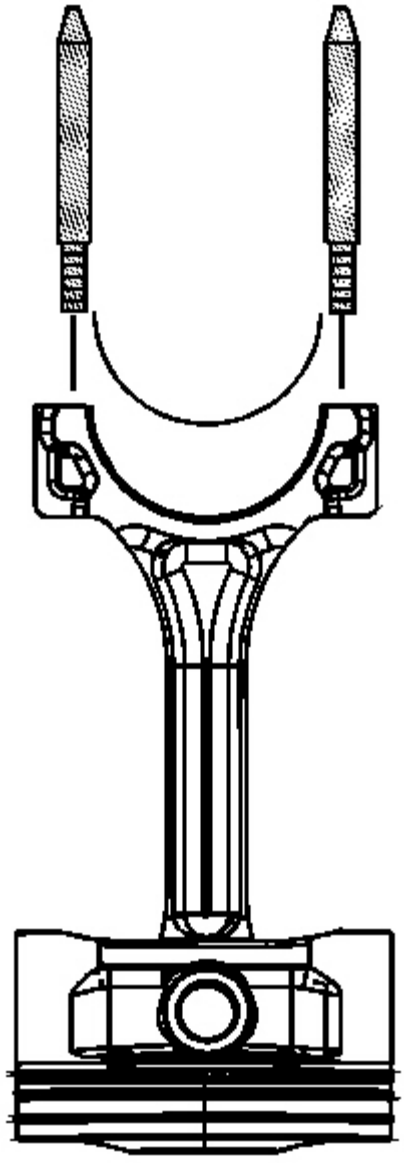


Fig. 39: Removing EN 46121
Courtesy of GENERAL MOTORS CORP.

9. Remove the **EN 46121** from the connecting rod bolt holes. See **Special Tools** .

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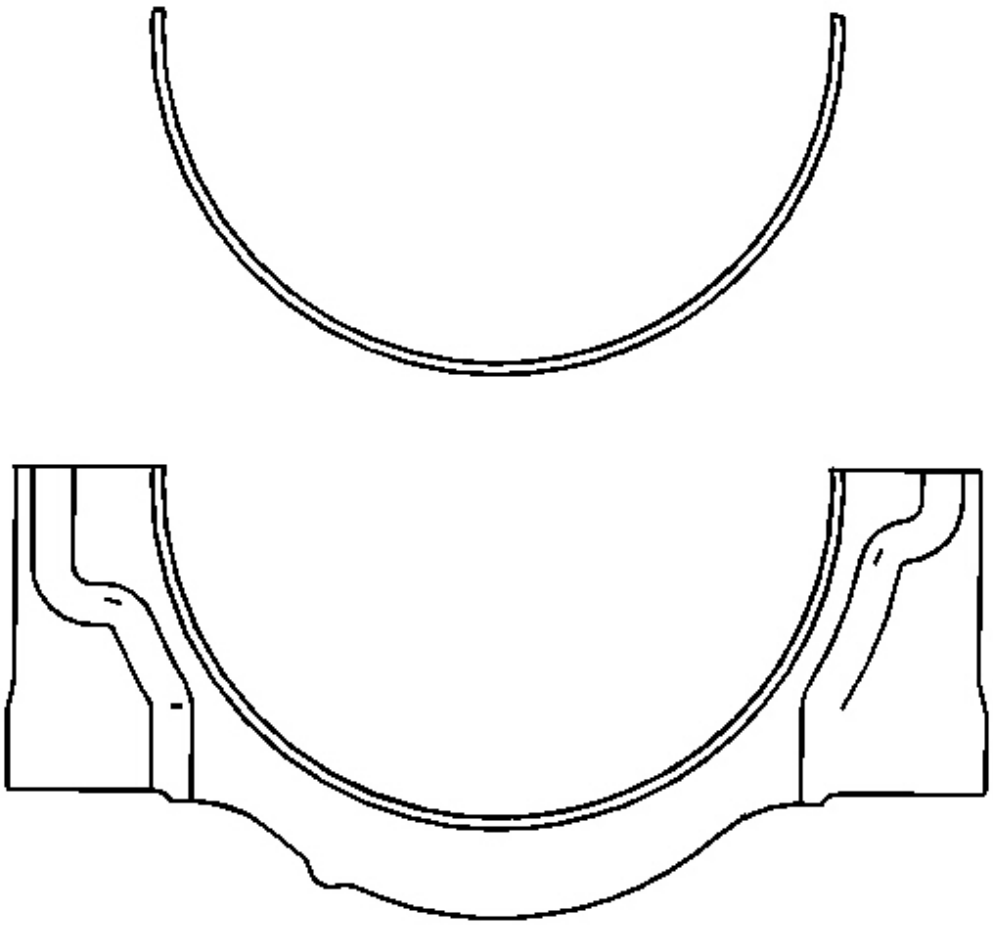


Fig. 40: View Of Lower Connecting Rod Cap And Bearing
Courtesy of GENERAL MOTORS CORP.

10. Remove the connecting rod bearings. NEVER re-use the connecting rod bearings. Refer to **Crankshaft and Bearings Cleaning and Inspection** for inspection.
11. Reattach the connecting rod cap to the connecting to prevent damage to their mating surfaces. The cap and rod are a matched set and must be kept together.

CRANKSHAFT AND BEARINGS REMOVAL

CRANKSHAFT REMOVAL PROCEDURE

1. Before removing the crankshaft, measure the crankshaft end play using the following procedure:

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1. Reinstall the lower crankcase.
2. Place a dial indicator at the crankshaft nose.
3. Gently force the crankshaft to the extreme front and rear positions with a pry tool while monitoring the movement of the dial indicator.
4. The crankshaft end play should not exceed 0.05-0.5 mm (0.002-0.020 in).
5. If the specifications are exceeded, replace the thrust bearing.
6. If a new thrust bearing does not bring the tolerances within specification, replace the crankshaft.
7. Remove the lower crankcase.

2. Locate or fabricate two V-blocks to support the crankshaft.

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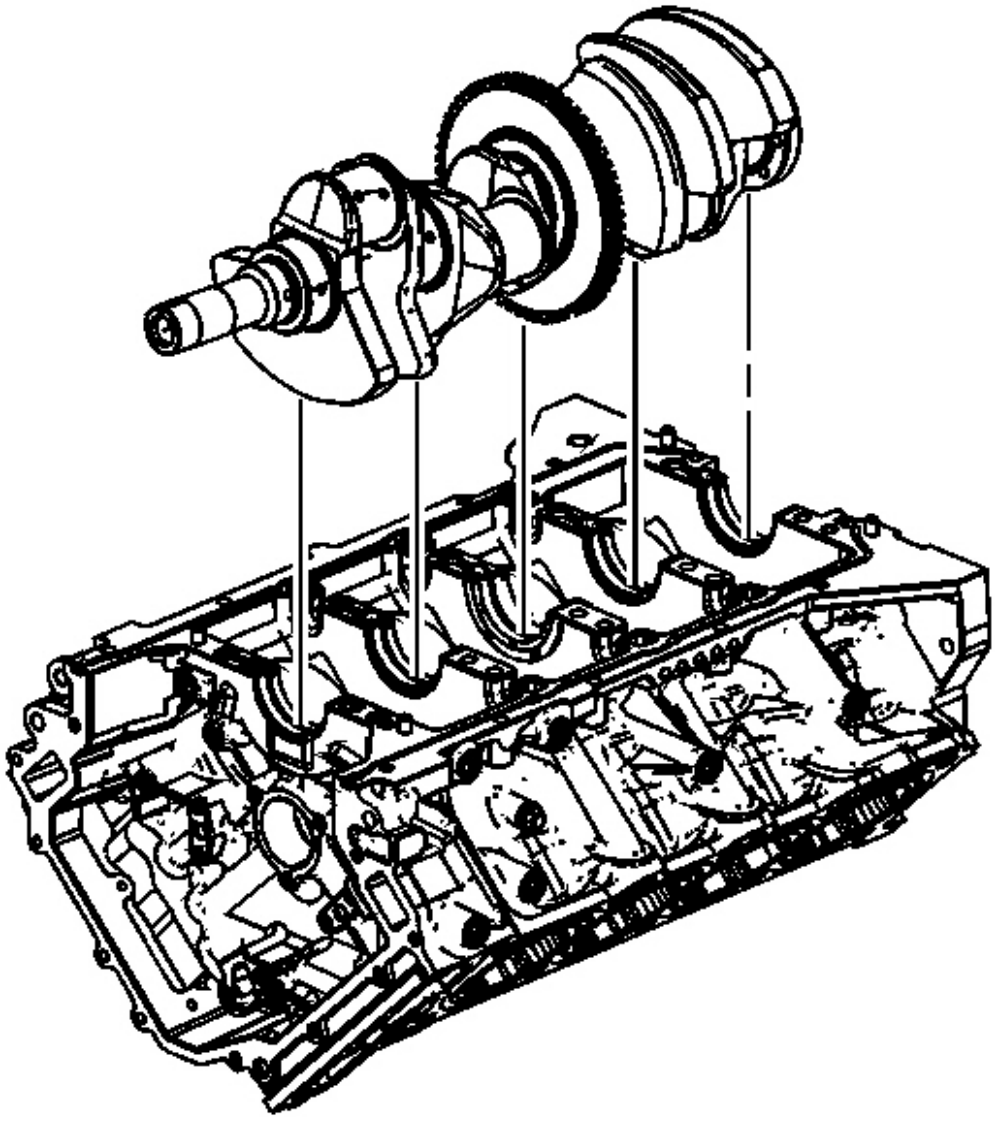


Fig. 41: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

3. Using two hands, lift the crankshaft straight up from the engine block.
4. Place the crankshaft on the V-blocks in a secure place.

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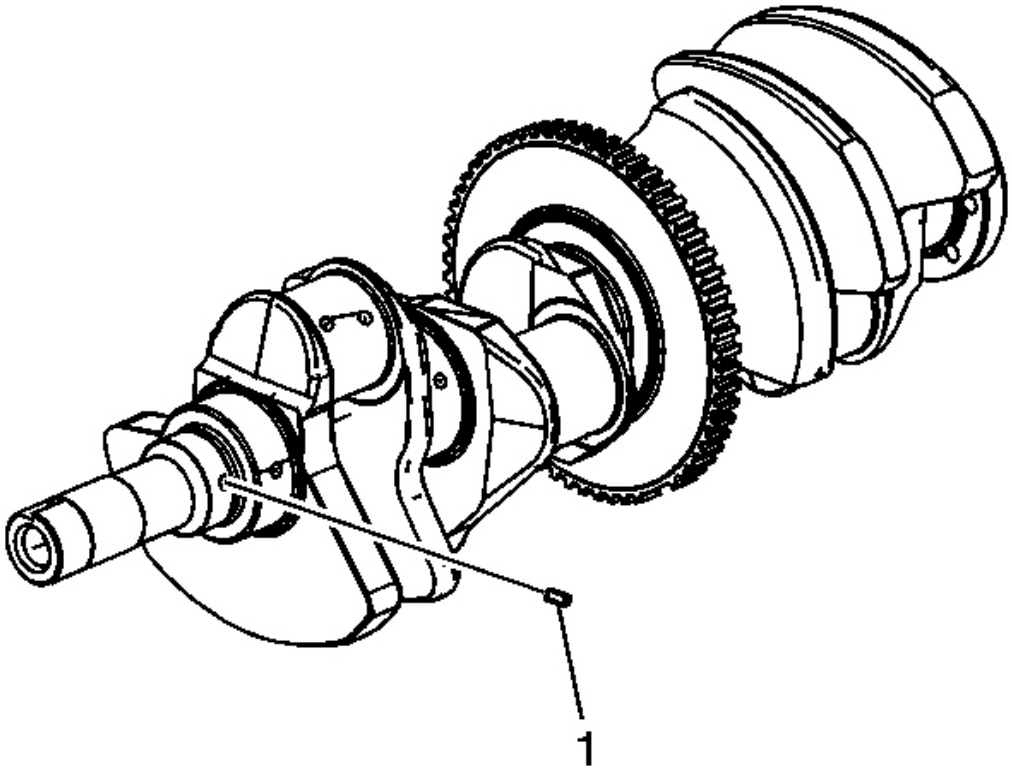


Fig. 42: View Of Crankshaft Sprocket Drive Pin
Courtesy of GENERAL MOTORS CORP.

5. If damaged, remove the crankshaft sprocket drive pin (1) from the nose of the crankshaft.

CRANKSHAFT BEARING REMOVAL PROCEDURE

1. Prepare a piece of cardboard or equivalent, numbered one to five for bearing identification. Main bearing journals are numbered from the front of the engine.

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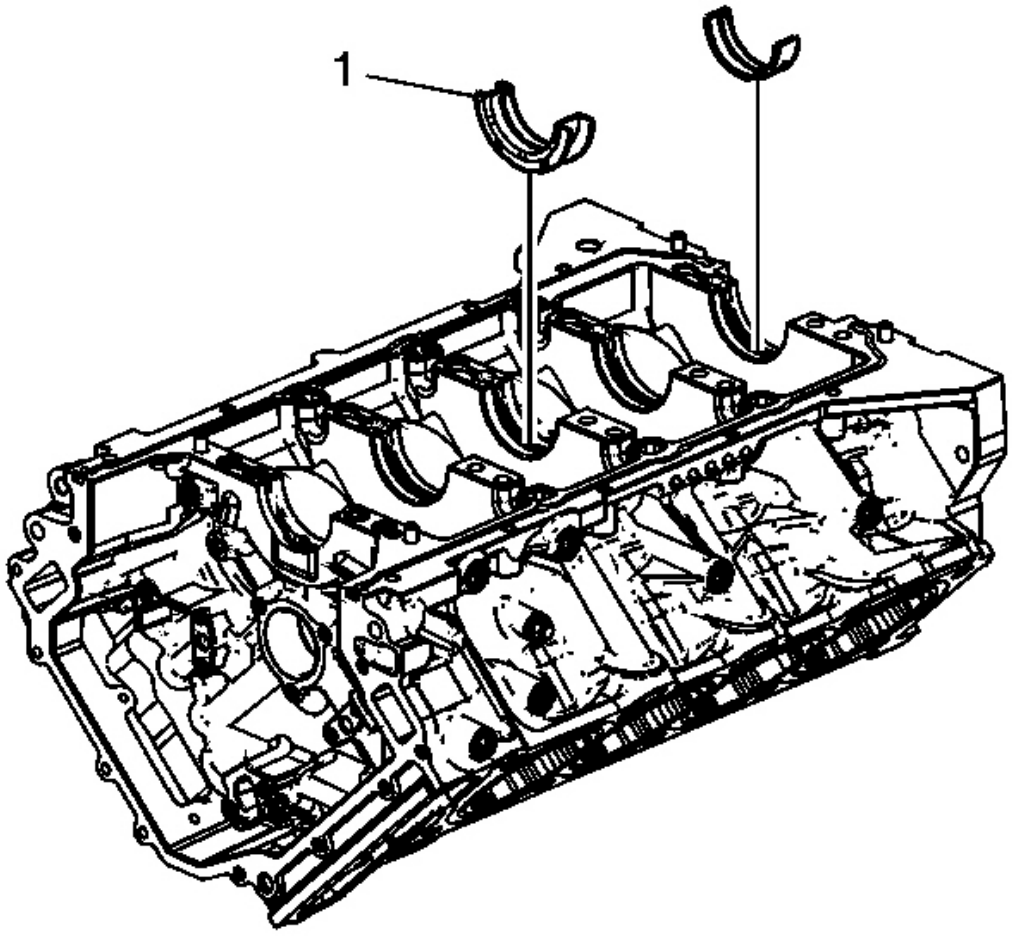


Fig. 43: View Of Thrust Bearing
Courtesy of GENERAL MOTORS CORP.

2. Remove the upper crankshaft bearing halves from the cylinder block. Note the position of the thrust bearing (1) at the number three journal.
3. Place the upper main bearing halves on the cardboard in the correct positions. Note that the number three bearing is the thrust bearing.

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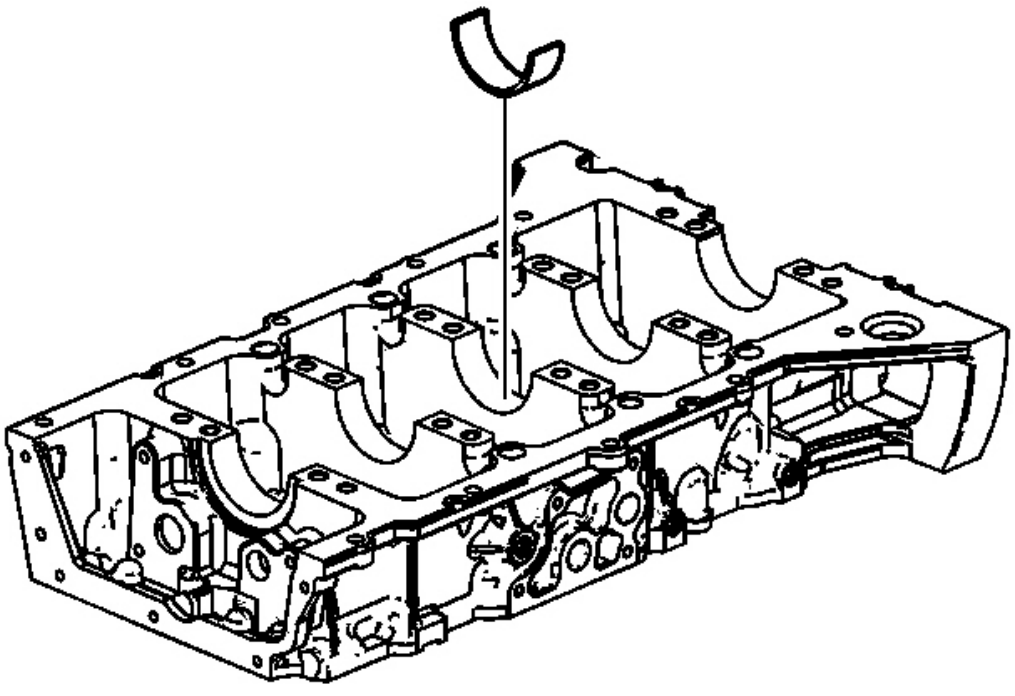


Fig. 44: View Of Lower Main Bearing Half
Courtesy of GENERAL MOTORS CORP.

4. Remove the lower main bearing halves from the lower crankcase.
5. Place the lower main bearing halves in the correct positions on the cardboard.

ENGINE BLOCK DISASSEMBLE - UPPER

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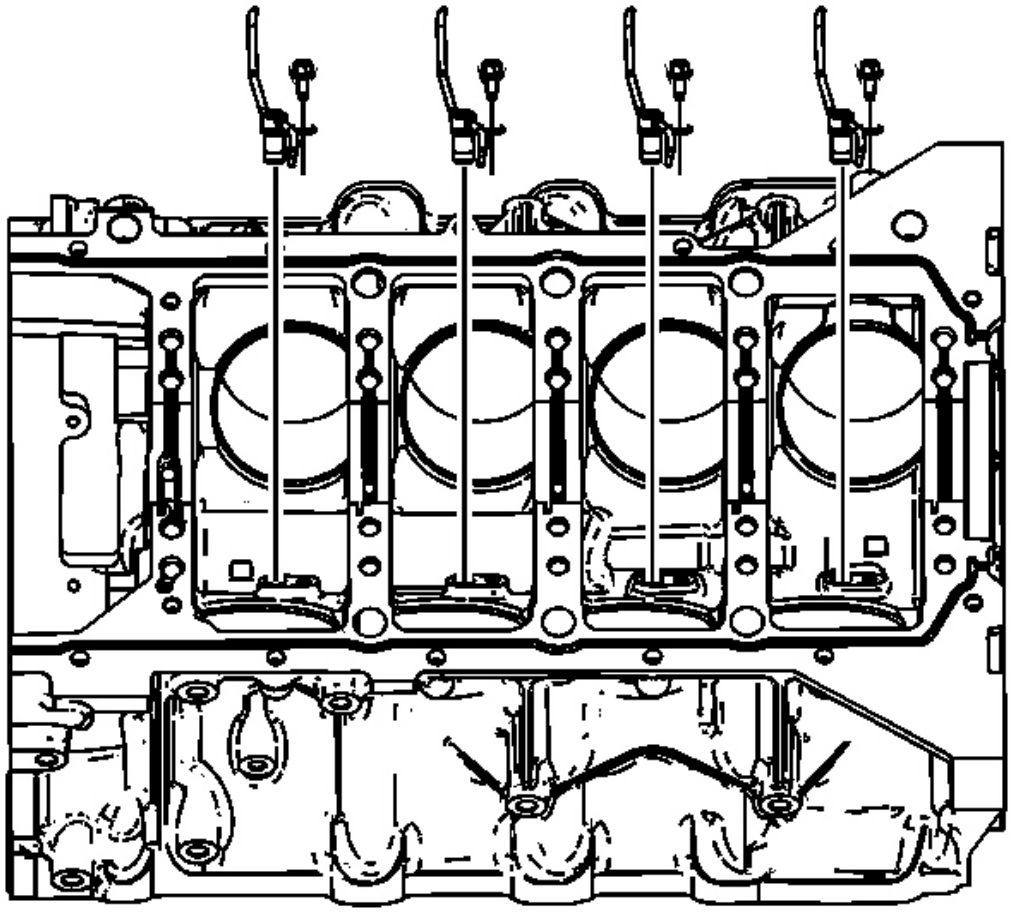


Fig. 45: Identifying Piston Oil Nozzle & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the piston oil nozzle bolts.
2. Remove the piston oil nozzles.

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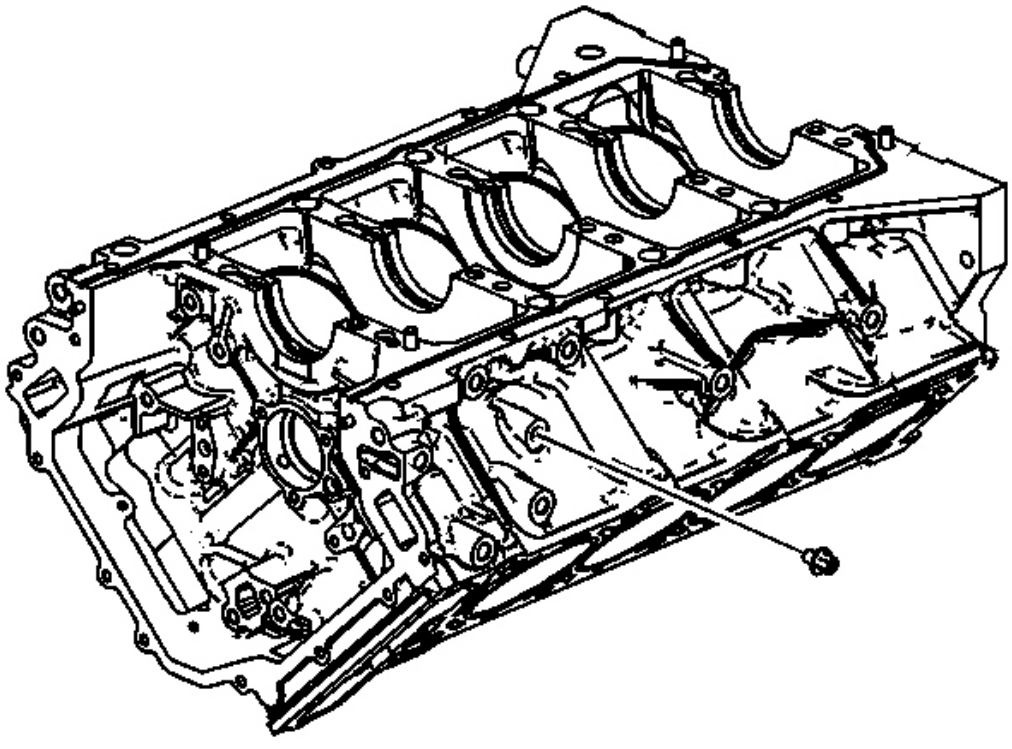


Fig. 46: Identifying Engine Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine coolant drain plug.

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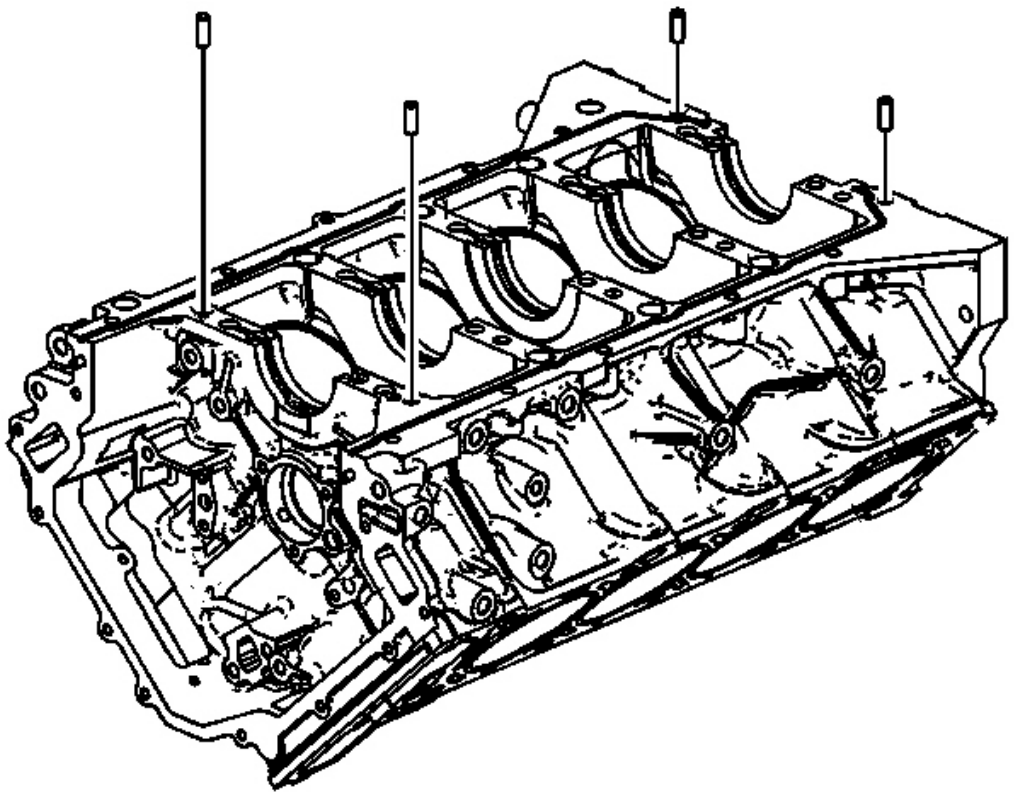


Fig. 47: Identifying Engine Block To Crankcase Pins
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine block to crankcase pins.

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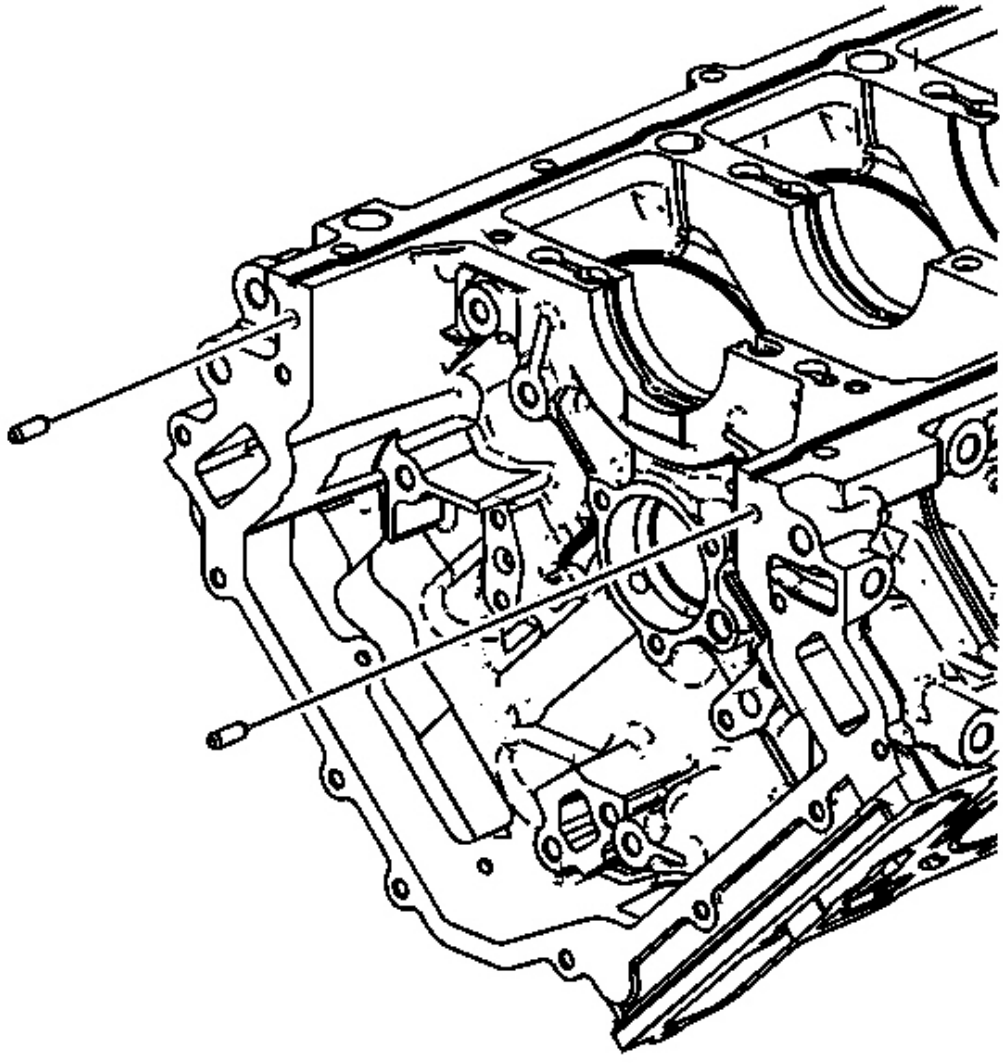


Fig. 48: Identifying Engine Block To Engine Front Cover Pins
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine block to engine front cover pins.

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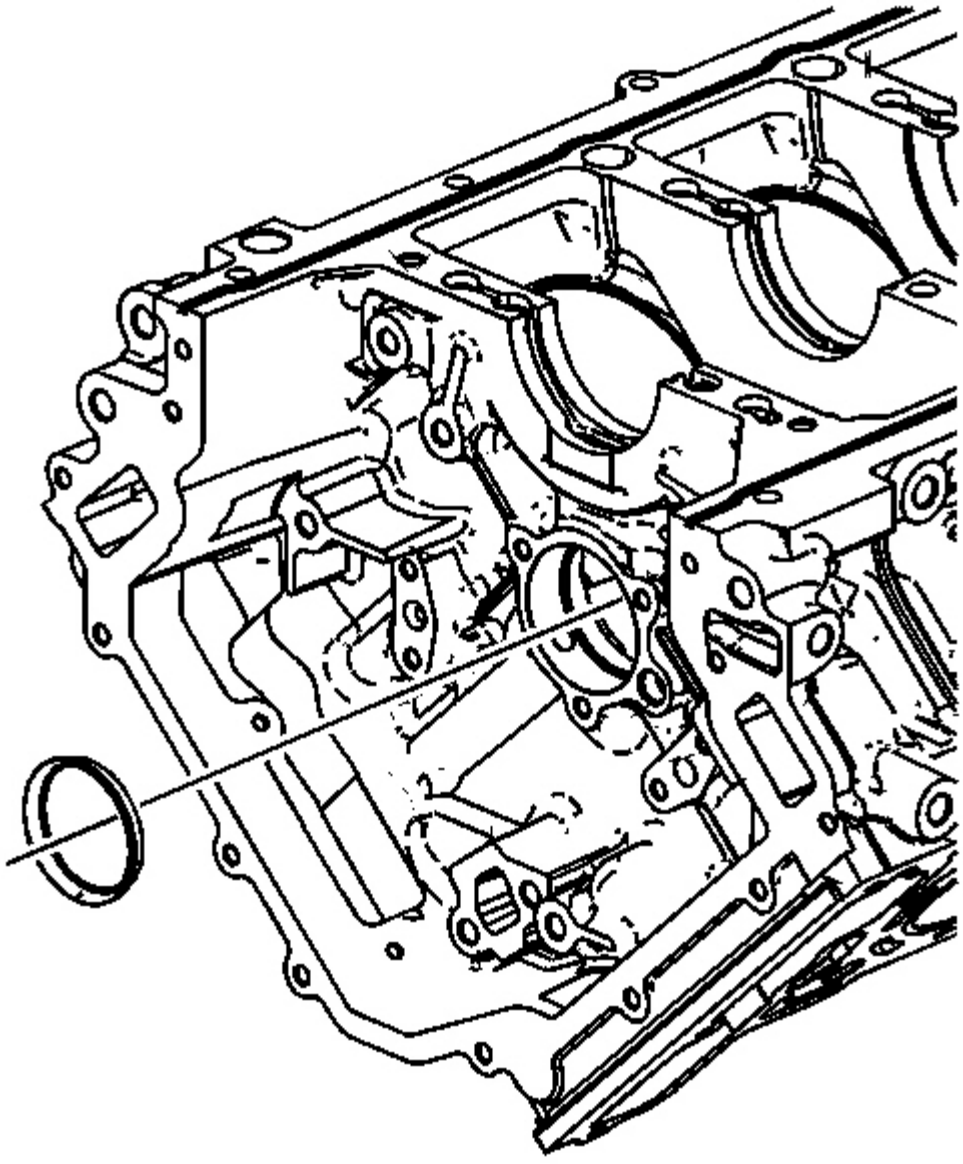


Fig. 49: Identifying Camshaft Intermediate Drive Shaft Block Plug
Courtesy of GENERAL MOTORS CORP.

6. Remove and discard the camshaft intermediate drive shaft block plug.

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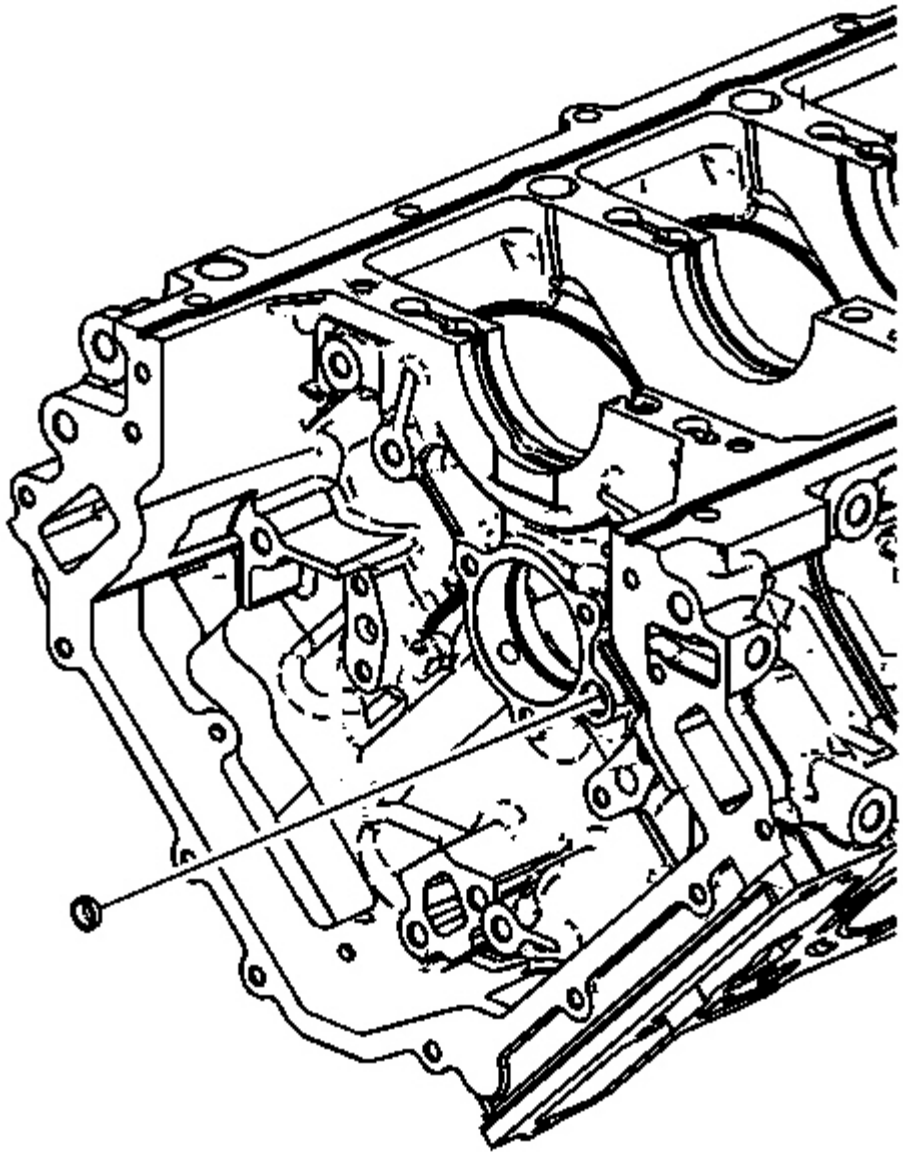


Fig. 50: Identifying Piston Oil Nozzle Oil Gallery Expansion Plug
Courtesy of GENERAL MOTORS CORP.

7. Remove and discard the piston oil nozzle oil gallery expansion plug.

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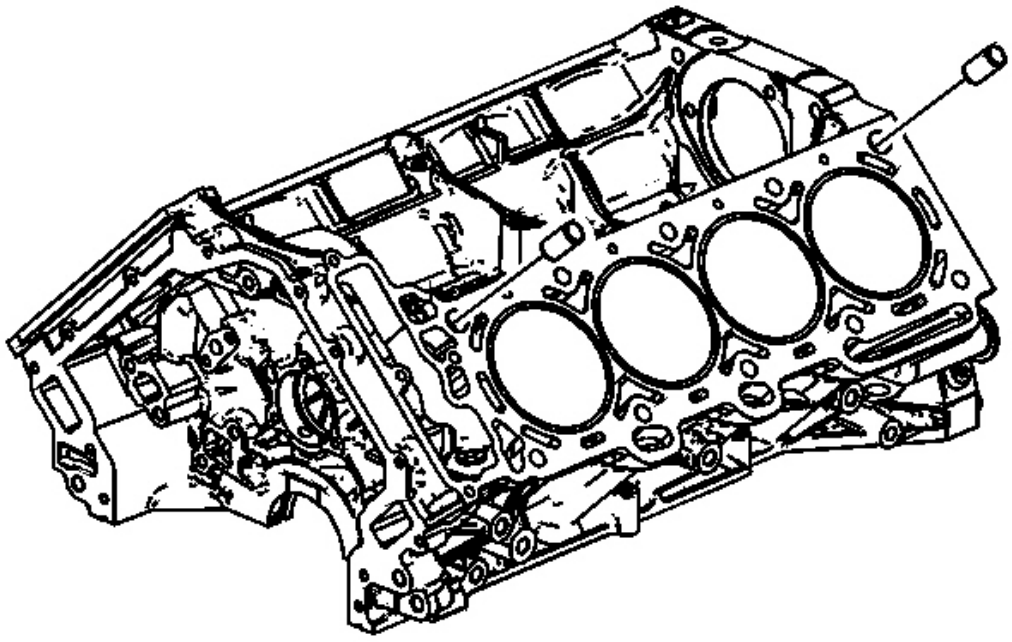


Fig. 51: Identifying Cylinder Head Dowel
Courtesy of GENERAL MOTORS CORP.

8. Remove the left side block deck face to left cylinder head dowels.

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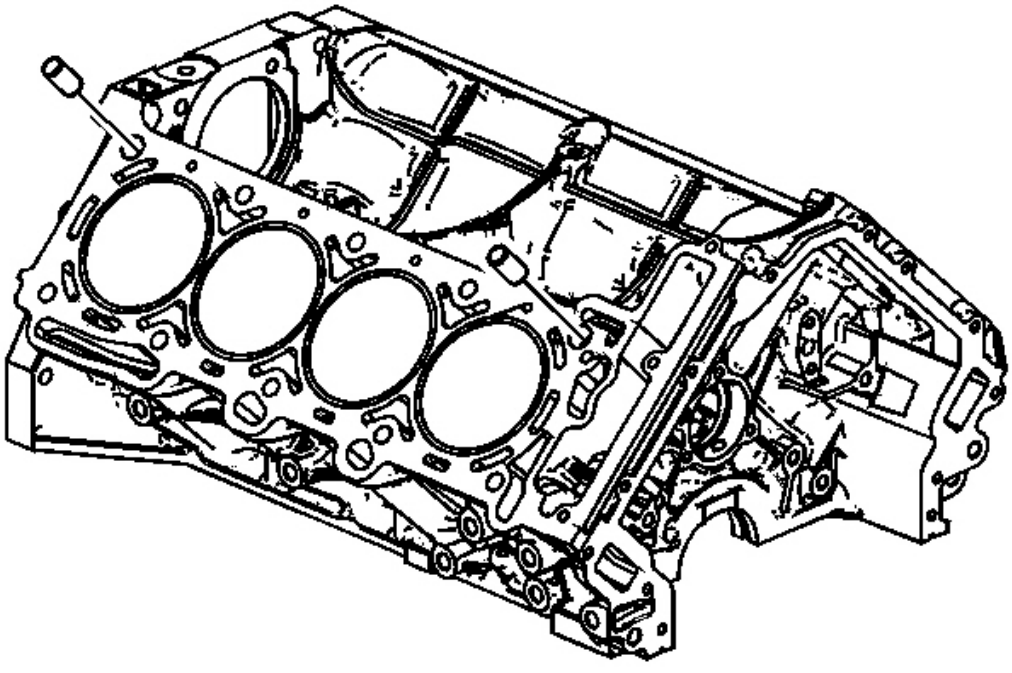


Fig. 52: Identifying Cylinder Head Dowel
Courtesy of GENERAL MOTORS CORP.

9. Remove the right side block deck face to right cylinder head dowels.

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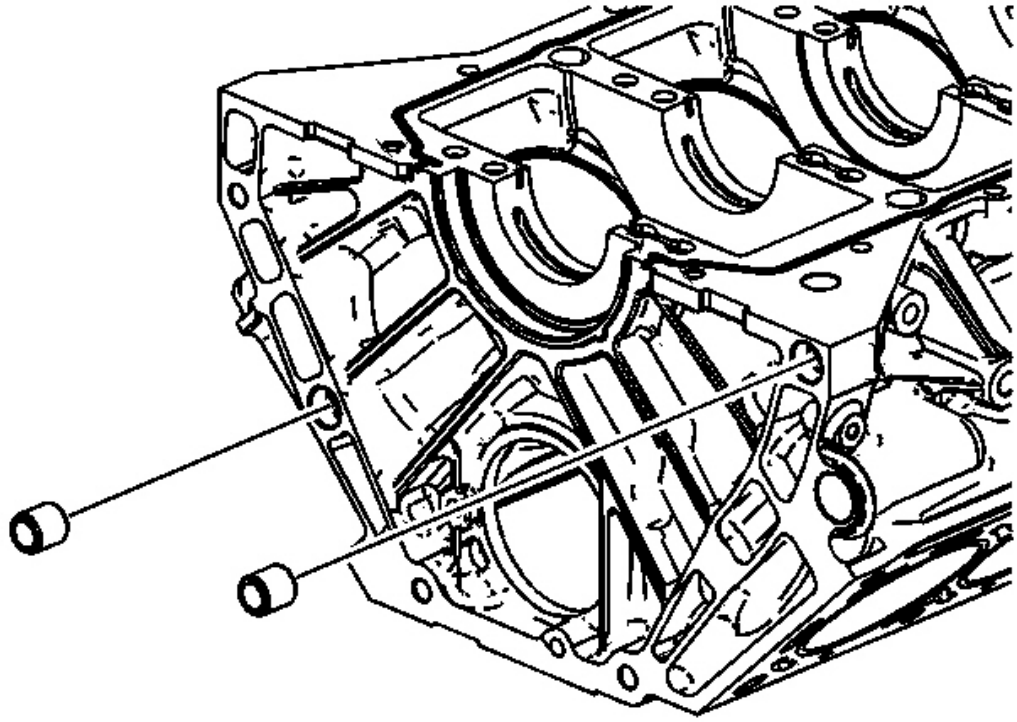


Fig. 53: Identifying Engine Block To Transmission Dowels
Courtesy of GENERAL MOTORS CORP.

10. Remove the engine block to transmission dowels.

ENGINE BLOCK CLEANING AND INSPECTION - UPPER

TOOLS REQUIRED

J 8087 Cylinder Bore Gage. See **Special Tools** .

CLEANING PROCEDURE

1. Remove any old thread sealant and gasket material or sealant.
2. Clean all the following areas with solvent:
   - Sealing surfaces
   - Cooling passages
   - Oil passages

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- Bearing journals

3. Clean all threaded and through holes with solvent.
4. Prior to the application of RTV sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the engine block seal groove clean the groove and mating surfaces of the upper engine block and the mating surface of the lower crankcase with cleaner solvent GM P/N 12378392 or 12346139 (Canadian P/N 88901247).

CAUTION: Refer to Safety Glasses Caution .

5. Dry the upper engine block with compressed air.

VISUAL INSPECTION

1. Inspect the crankshaft bearing journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the cylinder block assembly must be replaced.
2. Inspect the crankshaft rear oil seal bore for damage. The crankshaft rear oil seal bore is not repairable, if the crankshaft rear oil seal bore is damaged the cylinder block assembly must be replaced.
3. Inspect all sealing and mating surfaces for damage, repair or replace the cylinder block assembly if necessary.
4. Inspect all threaded and through holes for damage or excessive debris.
5. Inspect all bolts for damage, if damaged replace with new bolts only.
6. Inspect the cylinder walls for cracks or damage. The cylinders sleeves are not serviced separately, if the cylinders are damaged the cylinder block assembly must be replaced.
7. Inspect the upper engine block for cracks. Do not repair any cracks. If cracks are found, the cylinder block assembly must be replaced.
8. Repair any damaged threaded holes. Refer to **Thread Repair Specifications** and **Thread Repair** .

CYLINDER BORE DIAMETER MEASUREMENT PROCEDURE

1. Measure the cylinder bore diameter at 41 mm (1.61 in) below the cylinder block deck surface using the **J 8087** . See **Special Tools** .
2. Compare your results with the engine mechanical specifications. If the cylinder diameter exceeds the specifications, the cylinder block must be replaced. There are no oversized pistons available for service.

DECK FACE FLATNESS MEASUREMENT PROCEDURE

1. Place a straight edge across the deck face of the cylinder block at an angle starting at the front of the block and sloping downward to the rear of the block.
2. Measure the gap between the straight edge and cylinder block by sliding the feeler gages under the straight edge at the front, center and rear of the block. Insert the greatest thickness gage that will fit.
3. Find the difference between the largest and smallest measurement.

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4. Change the position of the straight edge so that the angle travels up from the front of the block to the rear.
5. Measure the gap between the straight edge and the deck face again at the front, center and rear. Insert the greatest thickness gage that will fit.
6. Find the difference between the largest and smallest measurement.
7. Position the straight edge so it travels through the center of the cylinder bores.
8. Measure the gap between the straight edge and the deck face a final time at the front, center and rear. Insert the greatest thickness gage that will fit.
9. Find the difference between the largest and smallest measurement.

IMPORTANT: If the flatness measurement exceeds the specifications, replace the cylinder block. Machining of the deck face surface is NOT allowed.

10. Compare your measurement to the engine mechanical specifications.

CYLINDER BORE TAPER MEASUREMENT PROCEDURE

1. Measure the cylinder bore along the thrust surfaces at 5 mm (0.200 in) below the deck surface with the bore gage perpendicular to the crankshaft centerline and record the measurements.
2. Measure the cylinder bore along the thrust surfaces at 102 mm (4.000 in) below the deck surface with the bore gage perpendicular to the crankshaft centerline and record the measurements.
3. Calculate the difference between the two measurements. The result will be the cylinder taper.
4. Compare your results with the engine mechanical specifications. If the cylinders exceed these specifications, replace the cylinder block.

CYLINDER BORE OUT-OF-ROUND MEASUREMENT PROCEDURE

1. Measure both the thrust and non-thrust cylinder diameter 5 mm (0.20 in) below the deck surface using the **J 8087** . See **Special Tools** . Record your measurements.
2. Calculate the difference between the two measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter 102 mm (4.00 in) below the deck surface using the **J 8087** . See **Special Tools** . Record your measurements.
4. Calculate the difference between the two measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the engine mechanical specifications. If the cylinders exceed these specifications, replace the cylinder block.

ENGINE BLOCK ASSEMBLE - UPPER

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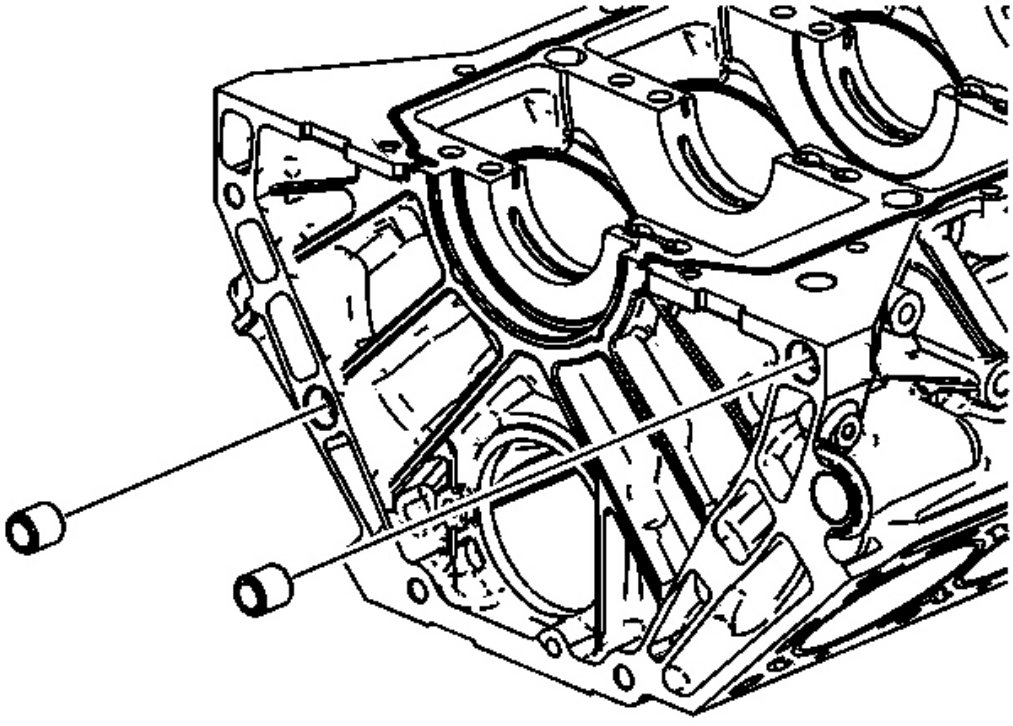


Fig. 54: Identifying Engine Block To Transmission Dowels
Courtesy of GENERAL MOTORS CORP.

1. Install the engine block to transmission dowels.

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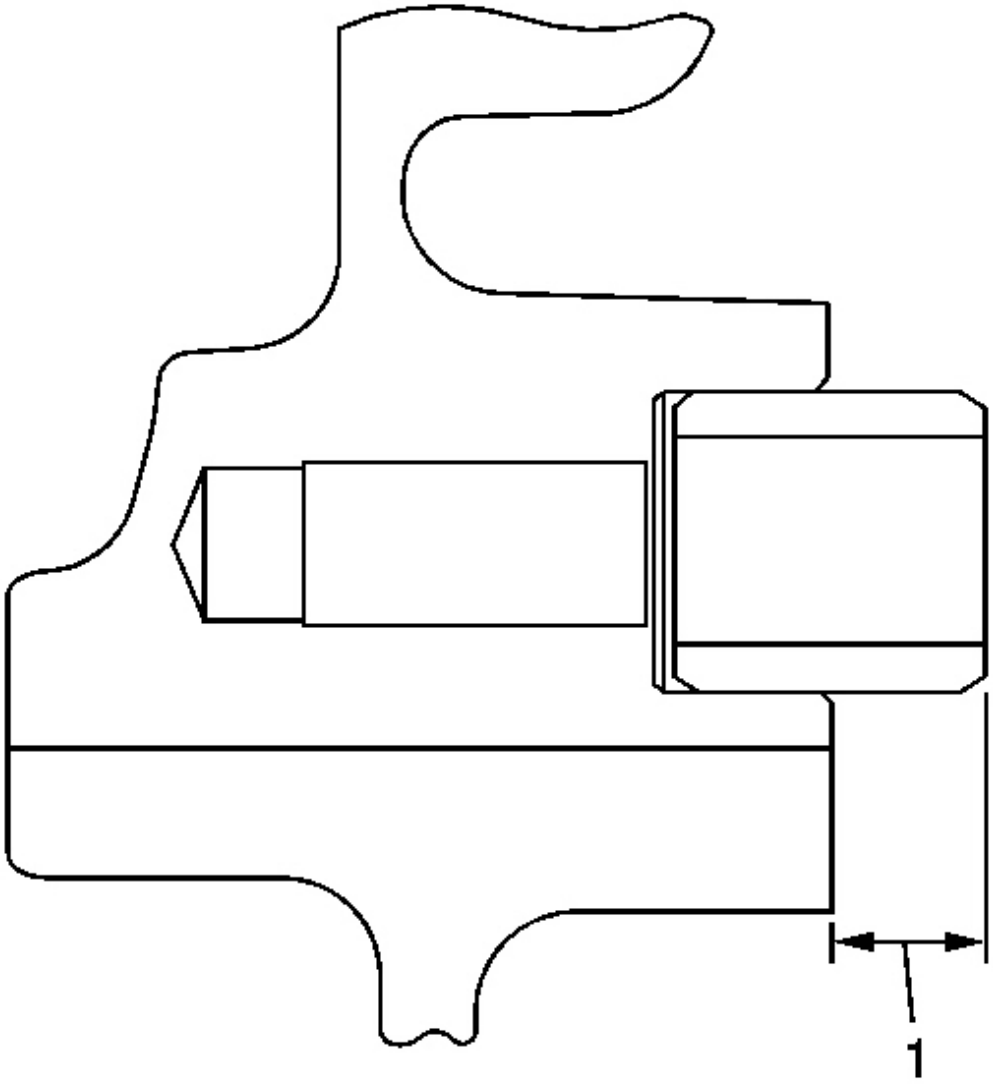


Fig. 55: View Of Dowel Protrusion
Courtesy of GENERAL MOTORS CORP.

2. Ensure the dowels are installed to the proper depth. The dowel should protrude (1) 9.0-10.0 mm (0.3543-0.3937 in).

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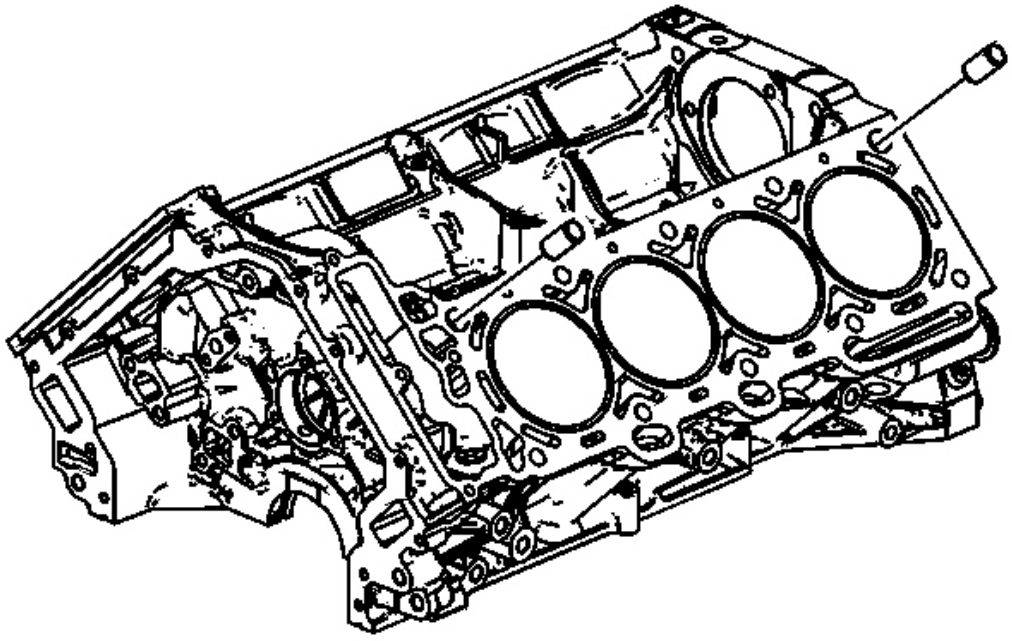


Fig. 56: Identifying Cylinder Head Dowel
Courtesy of GENERAL MOTORS CORP.

3. Remove the left side block deck face to left cylinder head dowels.

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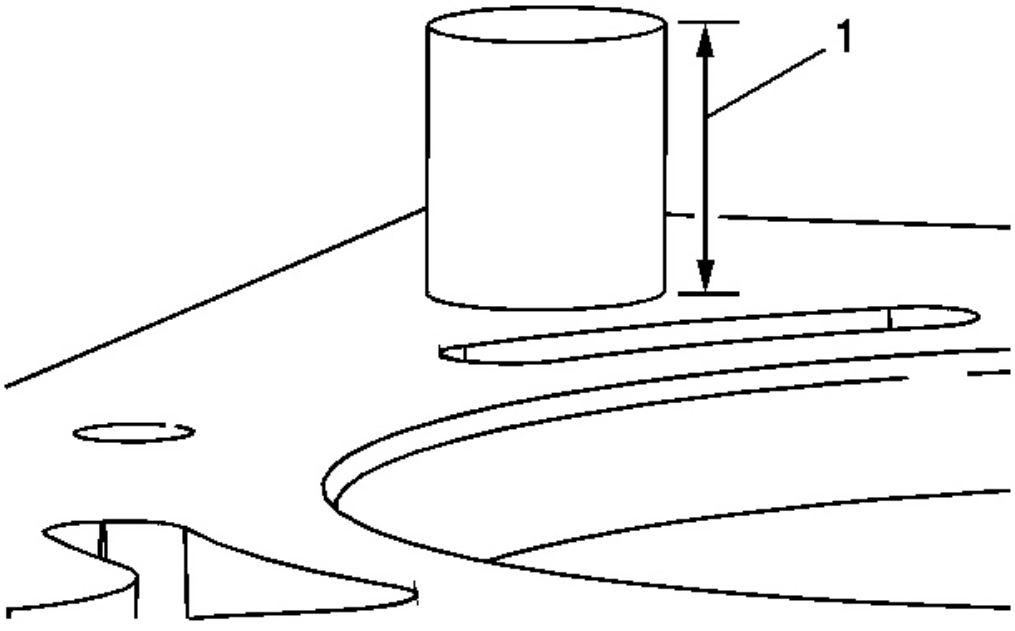


Fig. 57: View Of Dowel Protrusion
Courtesy of GENERAL MOTORS CORP.

4. Ensure the dowels are installed to the proper depth. The dowel should protrude (1) 13.5-14.5 mm (0.5315-0.5709 in).

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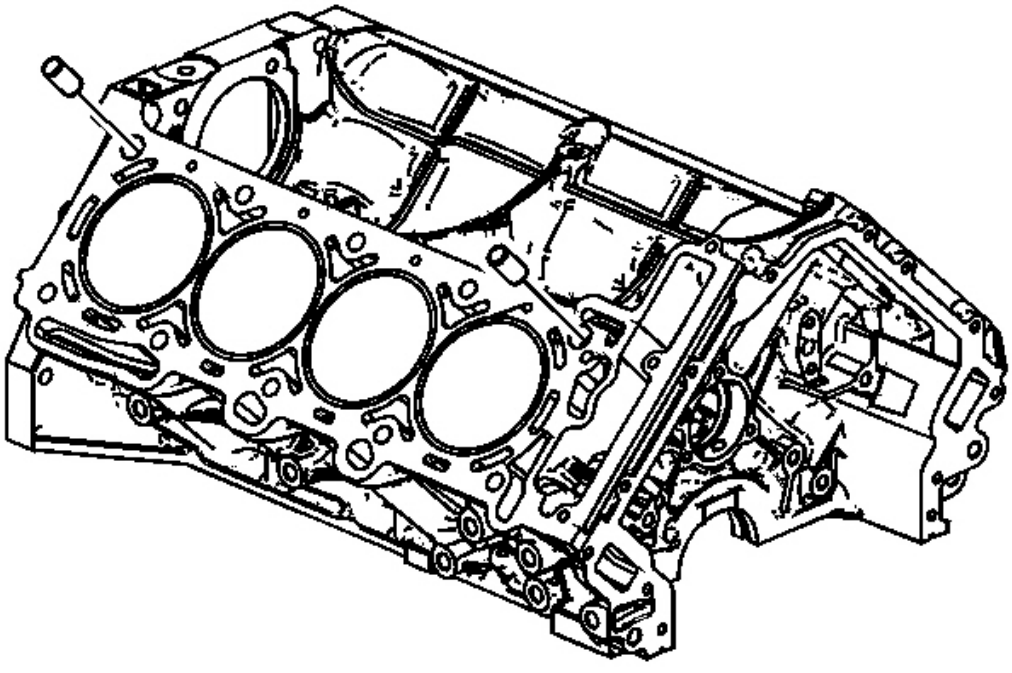


Fig. 58: Identifying Cylinder Head Dowel
Courtesy of GENERAL MOTORS CORP.

5. Install the right side block deck face to right cylinder head dowels.

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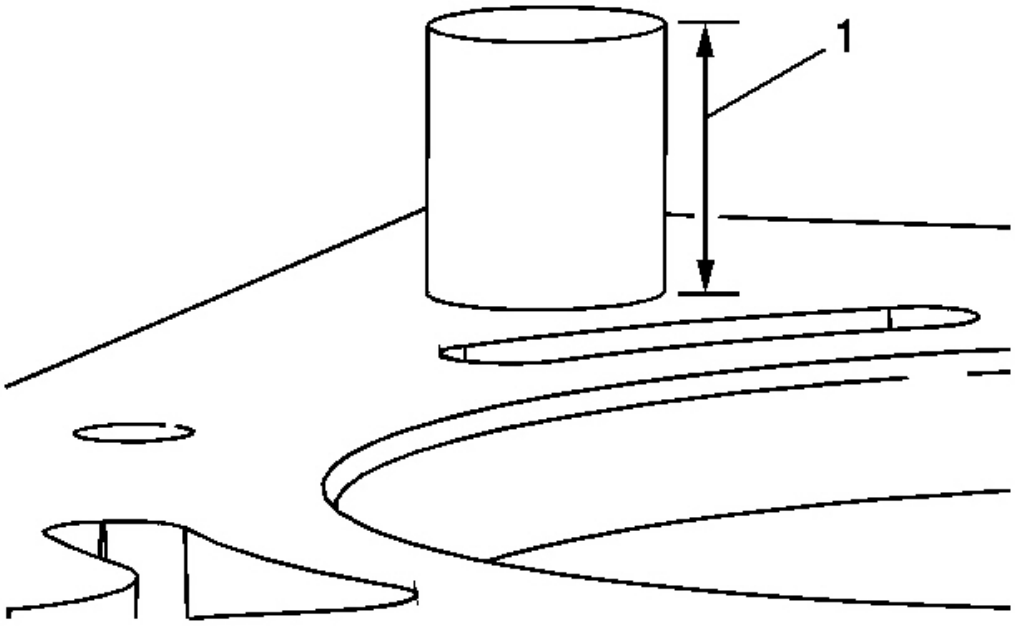


Fig. 59: Checking Dowel Protrusion
Courtesy of GENERAL MOTORS CORP.

6. Ensure the dowels are installed to the proper depth. The dowel should protrude (1) 13.5-14.5 mm (0.5315-0.5709 in).

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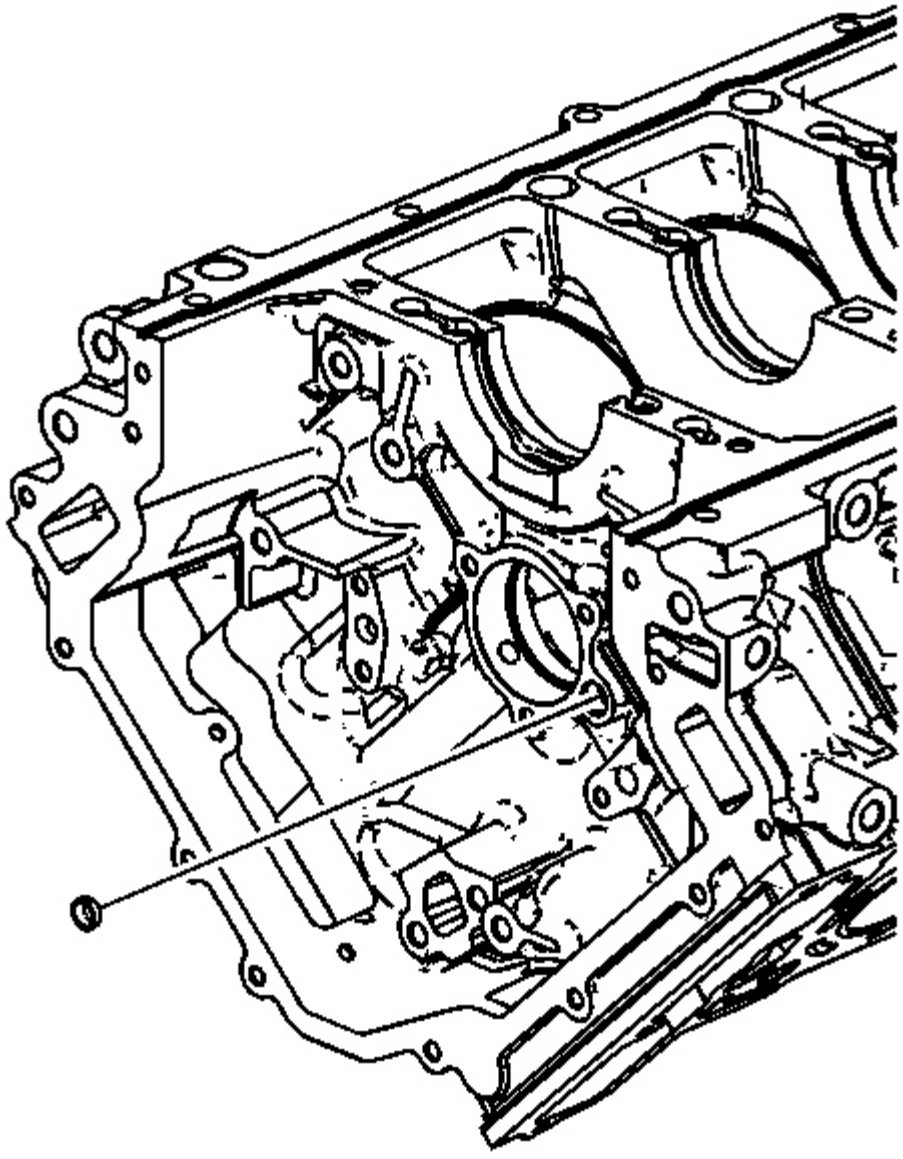


Fig. 60: Identifying Piston Oil Nozzle Oil Gallery Expansion Plug
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW piston oil nozzle oil gallery expansion plug.

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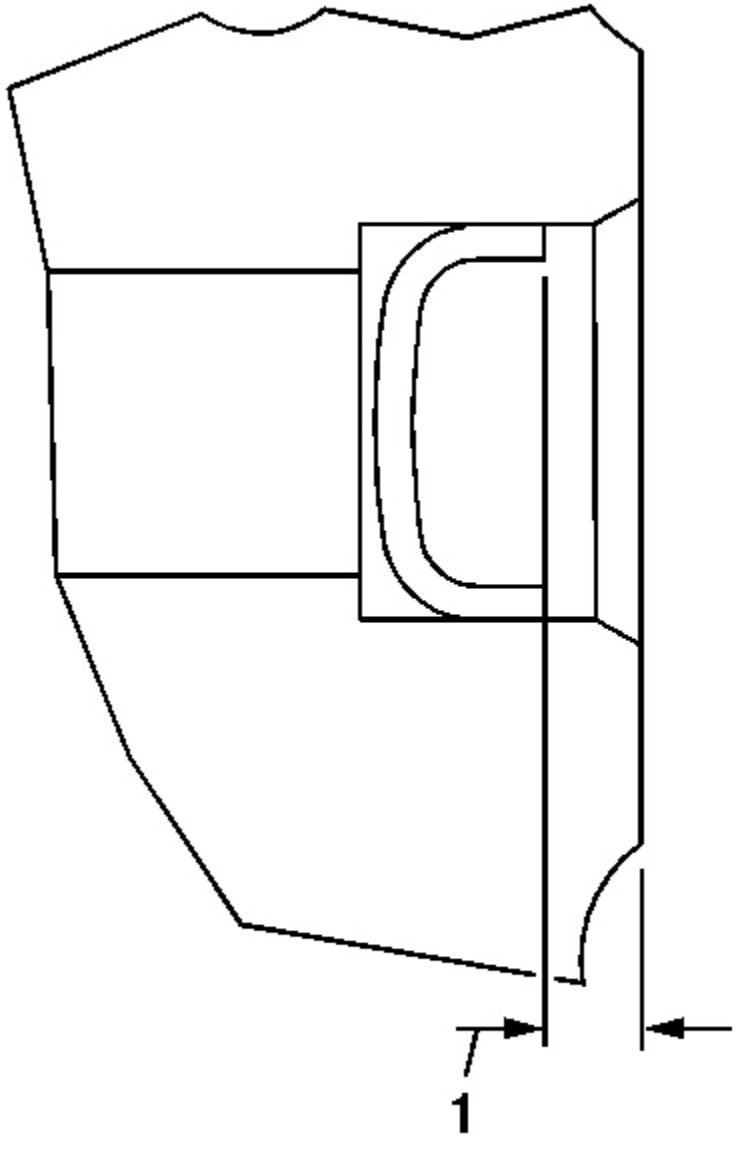


Fig. 61: Checking Plug Installed Depth
Courtesy of GENERAL MOTORS CORP.

8. Ensure the plug is installed to the proper depth (1) of 2.0-3.5 mm (0.0787-0.1378 in).

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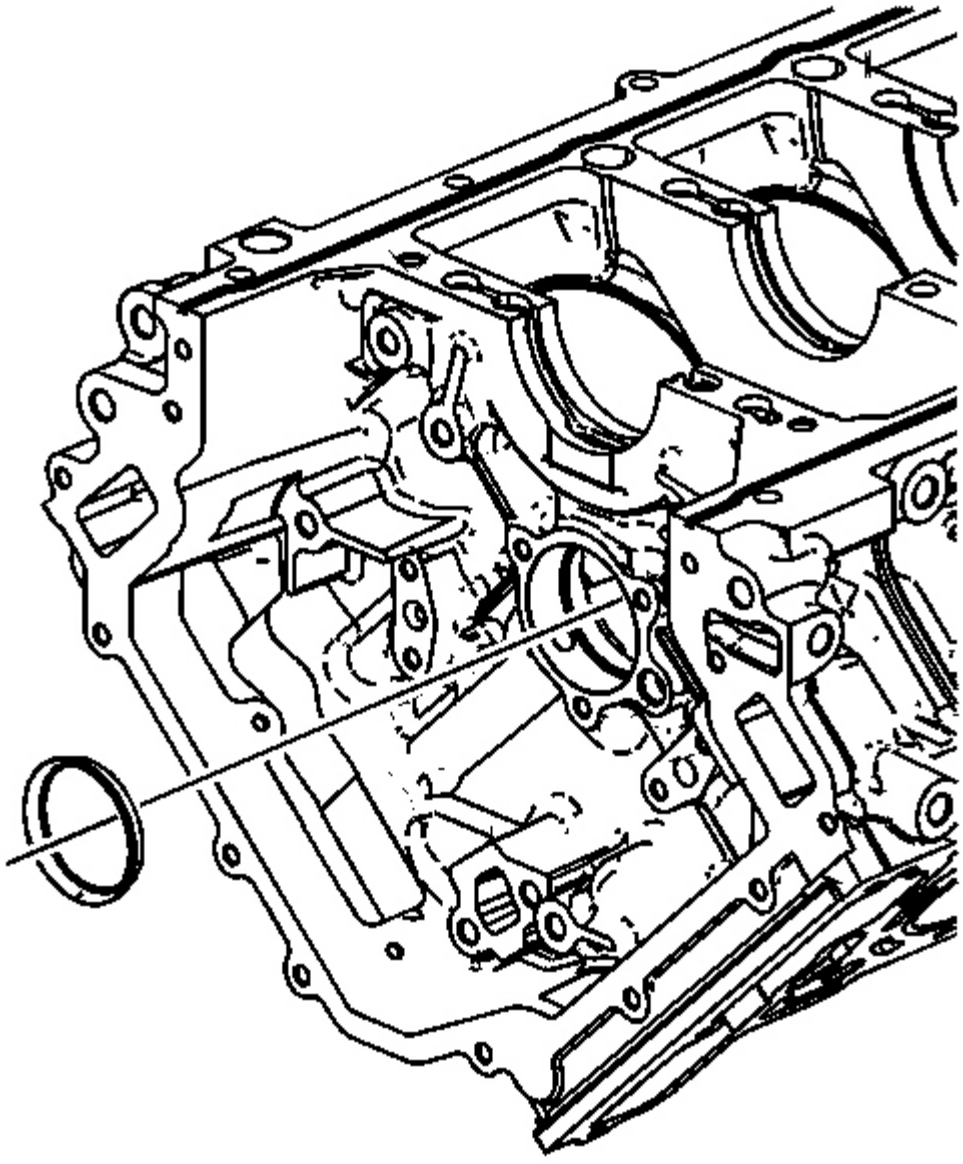


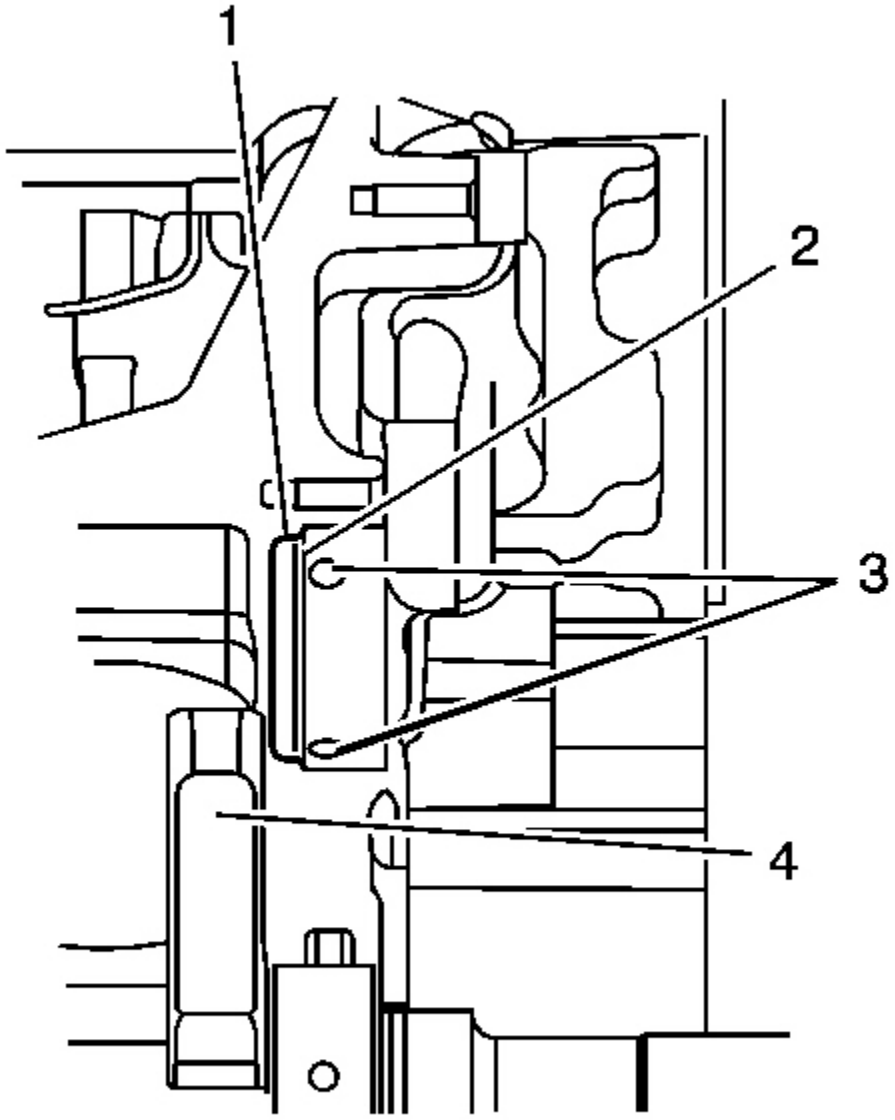
Fig. 62: Identifying Camshaft Intermediate Drive Shaft Block Plug
Courtesy of GENERAL MOTORS CORP.

NOTE: **Proper installation of the camshaft intermediate shaft plug must be ensured. An improperly installed camshaft intermediate shaft plug can interfere and restrict oil flow to the cylinder heads if installed too shallow**

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and may interfere with the crankshaft if installed too deep. Failure to properly install the camshaft intermediate shaft plug can lead to engine damage.

9. Install the NEW camshaft intermediate drive shaft block plug. The installation tool must not deform the rear face of the plug and cause interference with the crankshaft.



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Fig. 63: Identifying Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

10. Ensure the plug (1) is properly seated to the flange (2) in the bore and will not interfere with the engine block oil passages (3) or the crankshaft counter-weight (4).

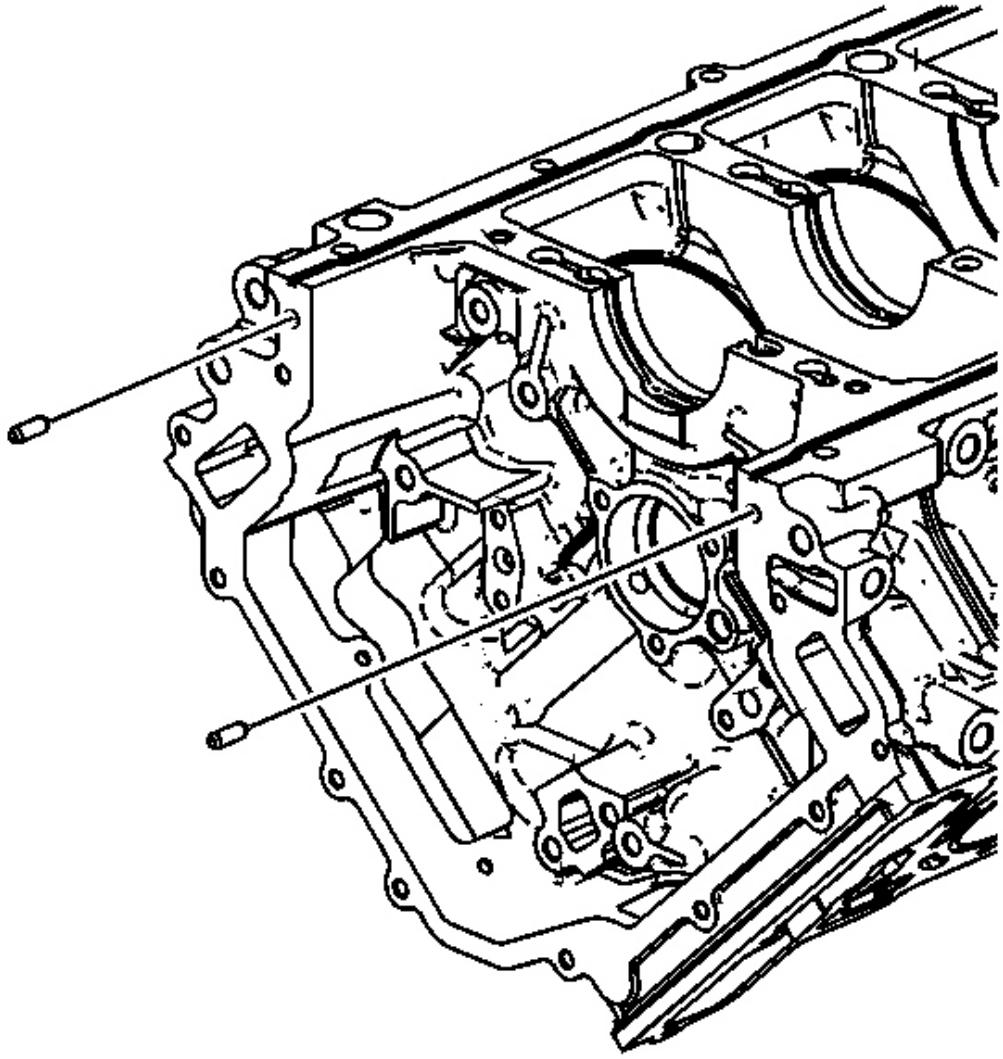


Fig. 64: Identifying Engine Block To Engine Front Cover Pins
Courtesy of GENERAL MOTORS CORP.

11. Install the engine block to engine front cover pins.

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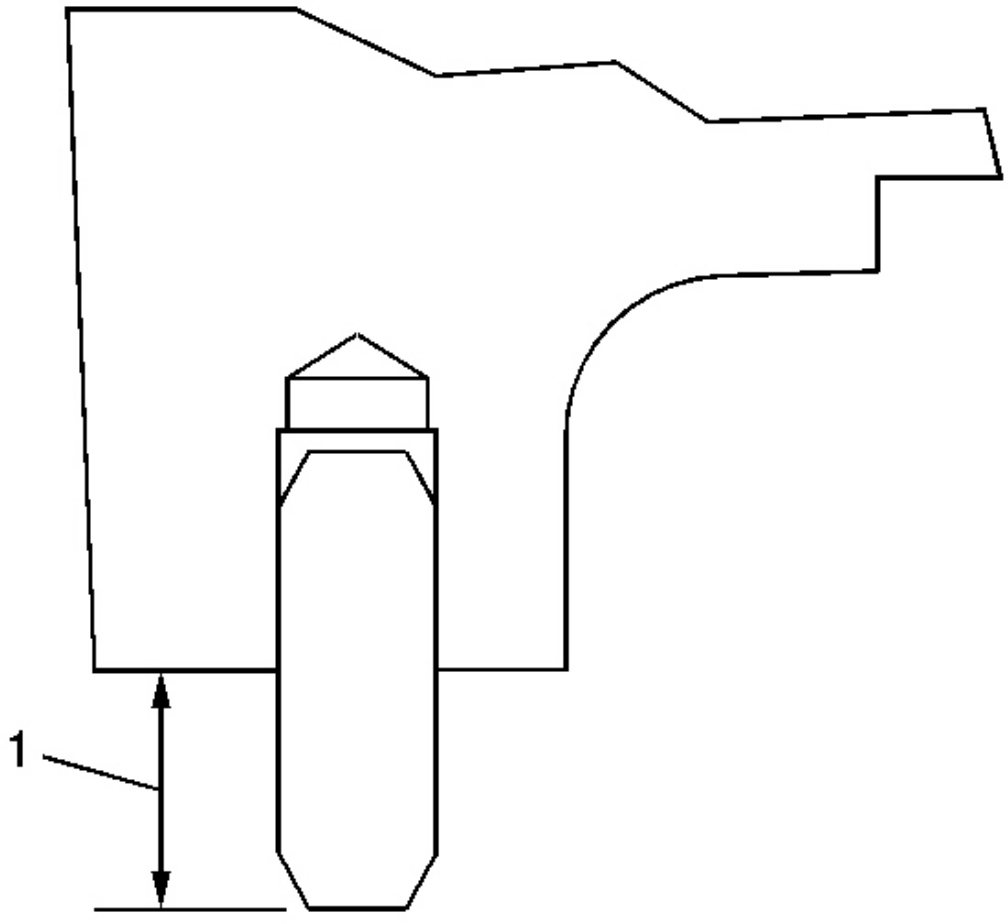


Fig. 65: Checking Pin Installed Depth
Courtesy of GENERAL MOTORS CORP.

12. Ensure the pins are installed to the proper depth. The pin should protrude (1) 8.5-9.5 mm (0.3347-0.3740 in).

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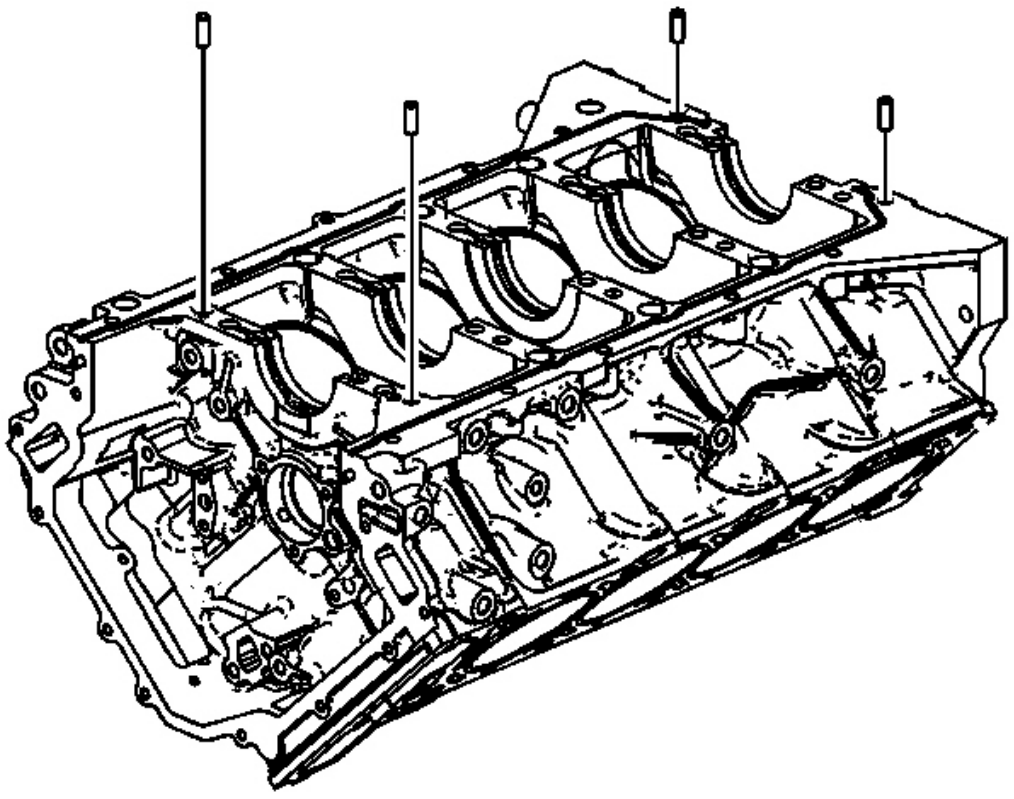


Fig. 66: Identifying Engine Block To Crankcase Pins
Courtesy of GENERAL MOTORS CORP.

13. Install the engine block to crankcase pins.

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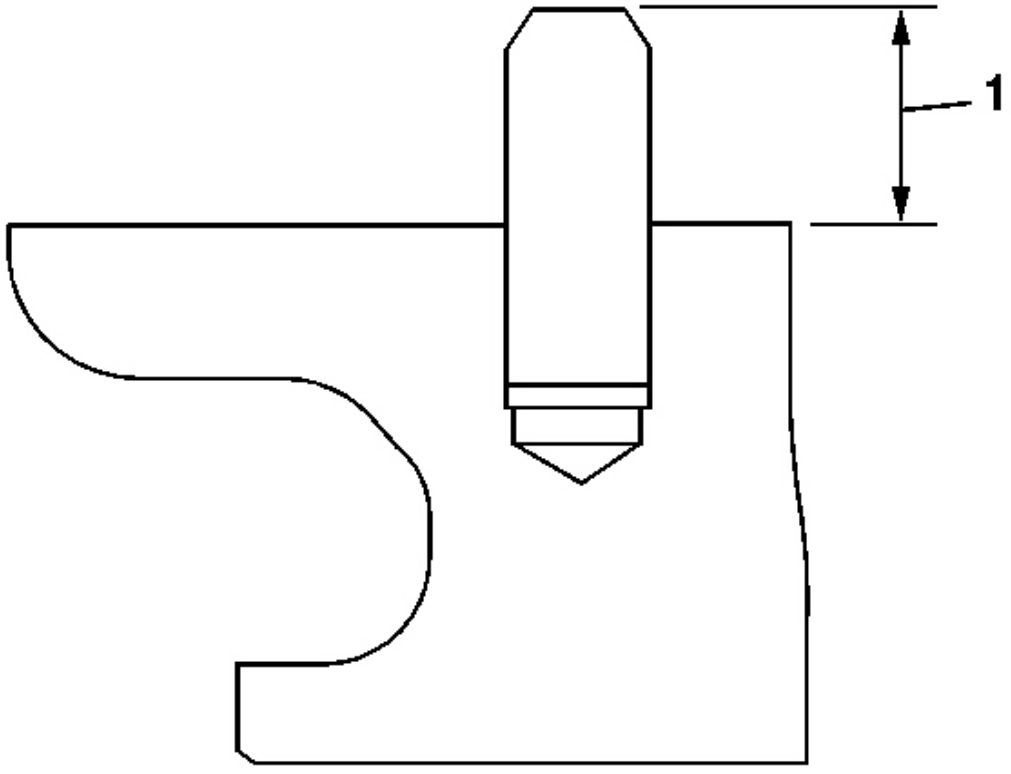


Fig. 67: View Of Pin Installed Depth
Courtesy of GENERAL MOTORS CORP.

14. Ensure the pins are installed to the proper depth. The pin should protrude (1) 12 mm (0.4724 in).

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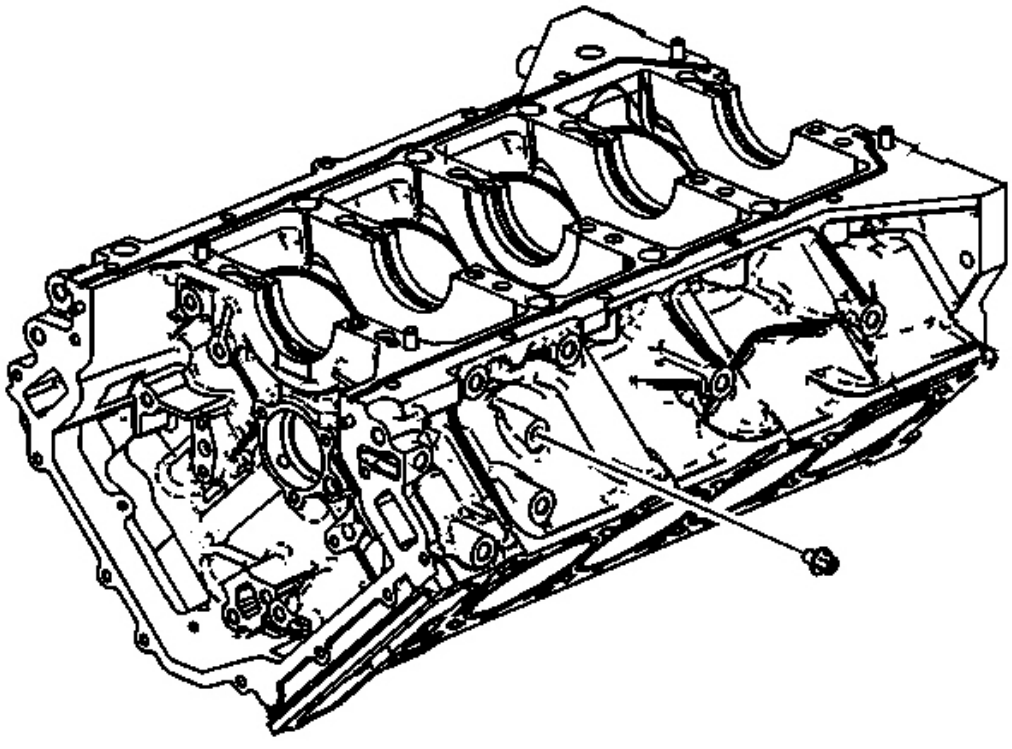


Fig. 68: Identifying Engine Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

15. Install the engine coolant drain plug.

    Tighten: Tighten the engine coolant drain plug to 20 N.m (15 lb ft).

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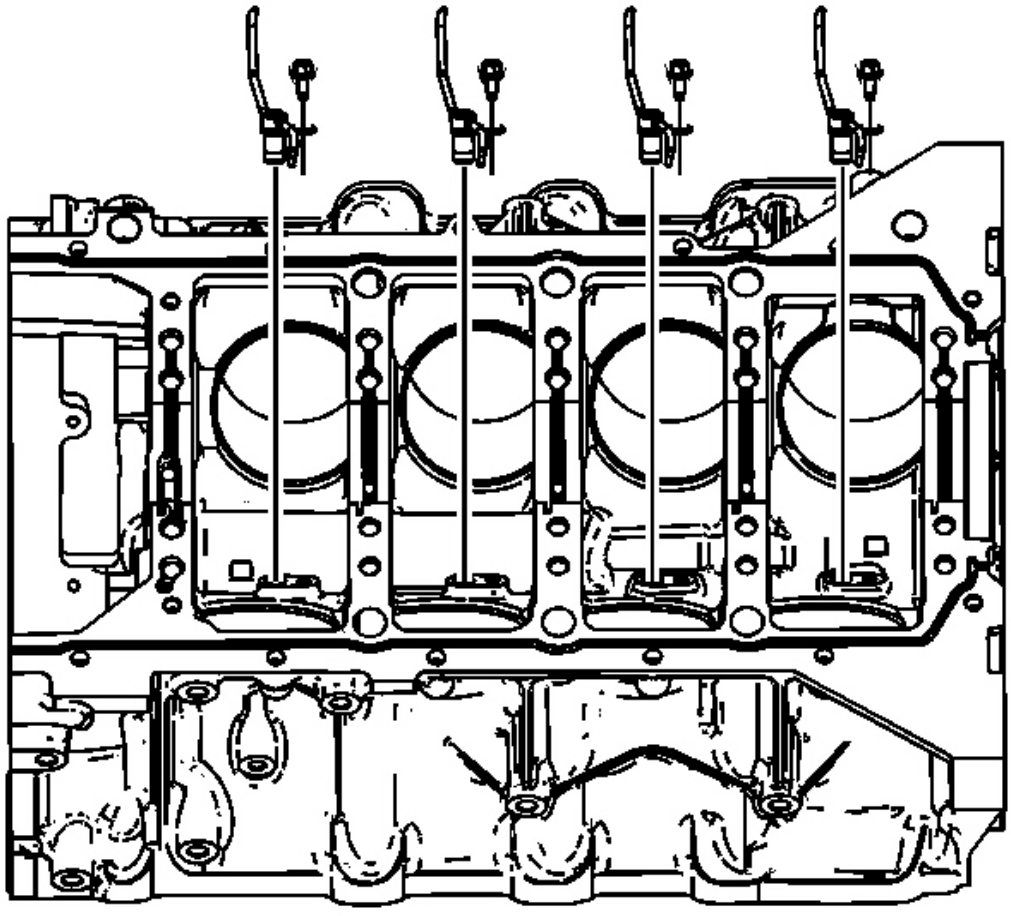


Fig. 69: Identifying Piston Oil Nozzle & Bolts
Courtesy of GENERAL MOTORS CORP.

16. Install the piston oil nozzles.
17. Install the piston oil nozzle bolts.

Tighten: Tighten the piston oil nozzle bolt to 10 N.m (89 lb in).

ENGINE BLOCK CLEANING AND INSPECTION - LOWER

CLEANING PROCEDURE

1. Remove any old thread sealant and gasket material or sealant.
2. Clean all the following areas with solvent:

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- Sealing surfaces
- Oil passages
- Bearing journals

3. Clean all threaded and through holes with solvent.
4. Prior to the application of RTV sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the engine block seal groove clean the groove and mating surfaces of the upper engine block and the mating surface of the lower crankcase with cleaner solvent GM P/N 12378392 or 12346139 (Canadian P/N 88901247).

CAUTION: Refer to SAFETY GLASSES CAUTION in Cautions and Notices.

5. Dry the lower engine block with compressed air.

VISUAL INSPECTION

1. Inspect the crankshaft bearing journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the cylinder block assembly must be replaced.
2. Inspect the crankshaft rear oil seal bore for damage. The crankshaft rear oil seal bore is not repairable, if the crankshaft rear oil seal bore is damaged the cylinder block assembly must be replaced.
3. Inspect all sealing and mating surfaces for damage, repair or replace the cylinder block assembly if necessary.
4. Inspect all threaded and through holes for damage or excessive debris.
5. Inspect all bolts for damage, if damaged replace with new bolts only.
6. Inspect the crankshaft oil scraper for cracks or damage, replace if cracked or damaged.
7. Inspect the lower engine block for cracks. Do not repair any cracks. If cracks are found, the cylinder block assembly must be replaced.
8. Repair any damaged threaded holes. Refer to **Thread Repair Specifications** and **Thread Repair** .

CRANKSHAFT AND BEARINGS CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the following components in solvent:
   - Crankshaft bearings
   - Connecting rod bearings
   - Crankshaft journals
   - Crankpin journals
   - Crankshaft oil passages
   - Crankshaft threaded holes

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CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the following components with compressed air:
   - Crankshaft bearings
   - Connecting rod bearings
   - Crankshaft journals
   - Crankpin journals
   - Crankshaft oil passages
   - Crankshaft threaded holes

VISUAL INSPECTION

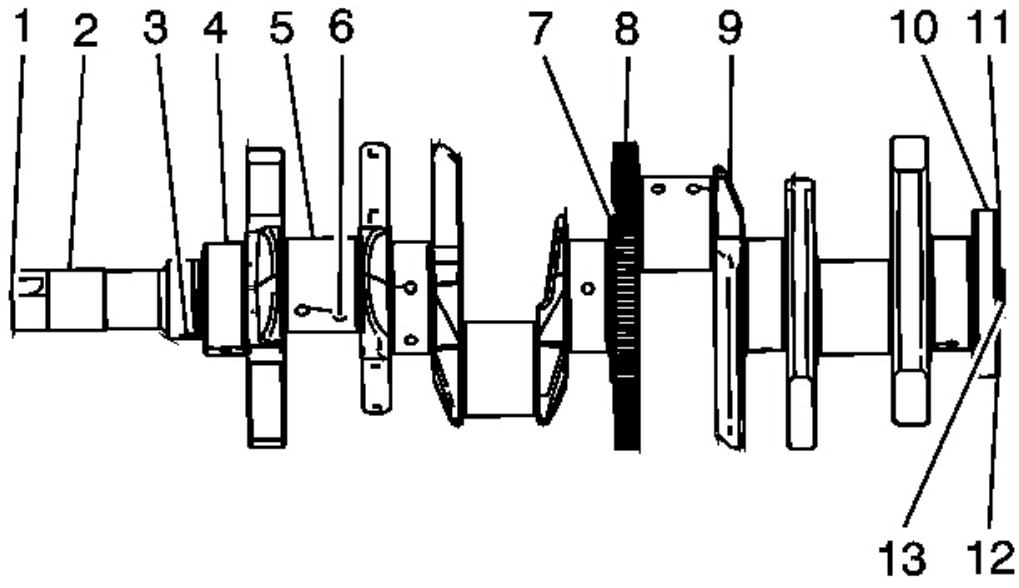


Fig. 70: Inspecting Crankshaft
Courtesy of GENERAL MOTORS CORP.

1. Perform the following visual inspections:
   - Inspect the crankshaft balancer bolt hole (1) for thread damage
   - Inspect the crankshaft balancer mounting area (2) for damage
   - Inspect the crankshaft sprocket pin hole (3) for damage
   - Inspect the crankshaft main journals (4) for damage

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- Inspect the crankshaft connecting rod journals (5) for damage
- Inspect the crankshaft oil passages (6) for obstructions
- Inspect the crankshaft main bearing thrust wall surfaces (7) for damage
- Inspect the crankshaft reluctor ring teeth (8) for damage
- Inspect the crankshaft counterweights (9) for damage
- Inspect the crankshaft rear main oil seal surface (10) for damage
- Inspect the crankshaft engine flywheel mounting surface (11) for damage
- Inspect the crankshaft engine flywheel bolt holes (12) for thread damage
- Inspect the crankshaft pilot hole (13) for damage

2. Repair or replace the crankshaft as necessary.

CRANKSHAFT BEARING INSPECTION

IMPORTANT: All connecting rod and main journal bearings that have been used in a running engine must be replaced. Never re-use the crankshaft or connecting rod bearings.

The following bearing wear conditions should be used to diagnose engine operating conditions or root cause of a condition.

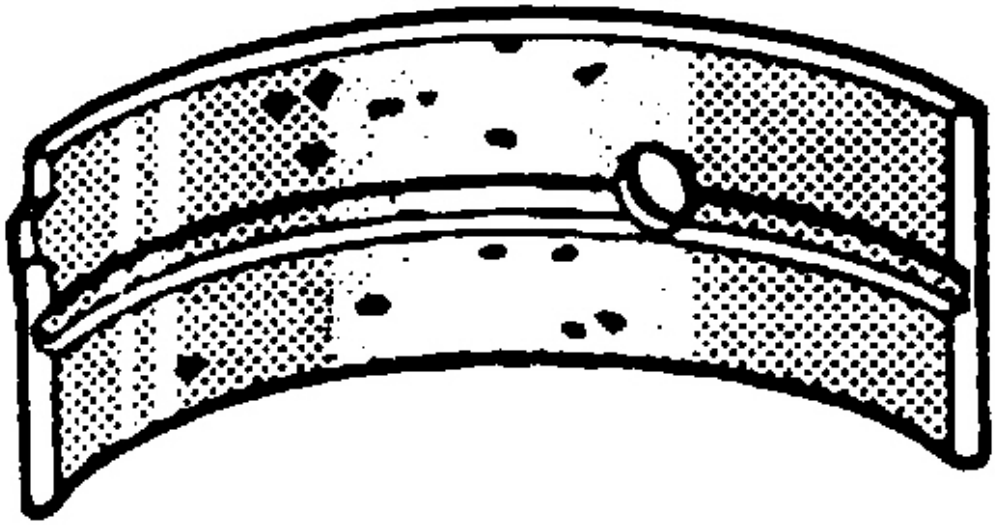


Fig. 71: Identifying Crankshaft Bearing Craters Or Pockets

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Courtesy of GENERAL MOTORS CORP.

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

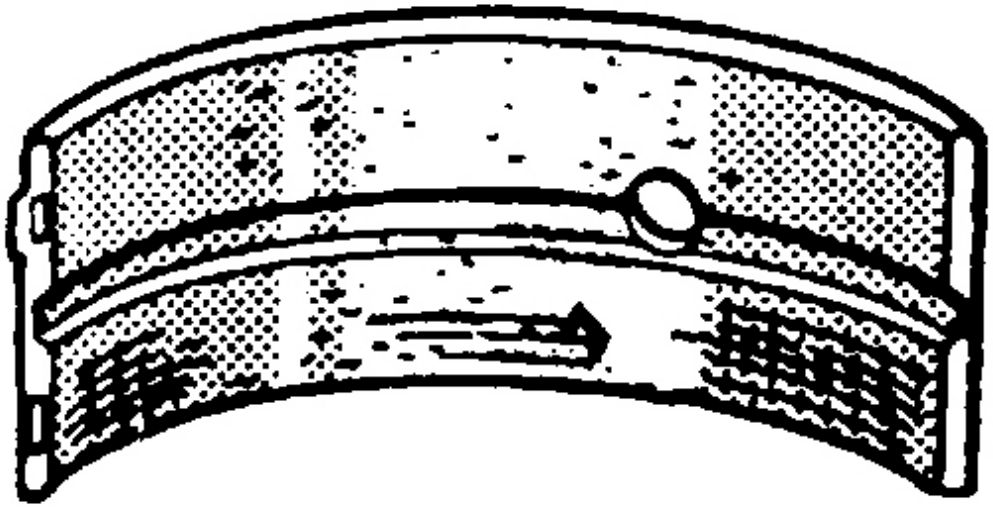


Fig. 72: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

2. Inspect for excessive scoring or discoloration on both front and back of the bearing halves.
3. Inspect the main bearings for dirt imbedded into the bearing material.

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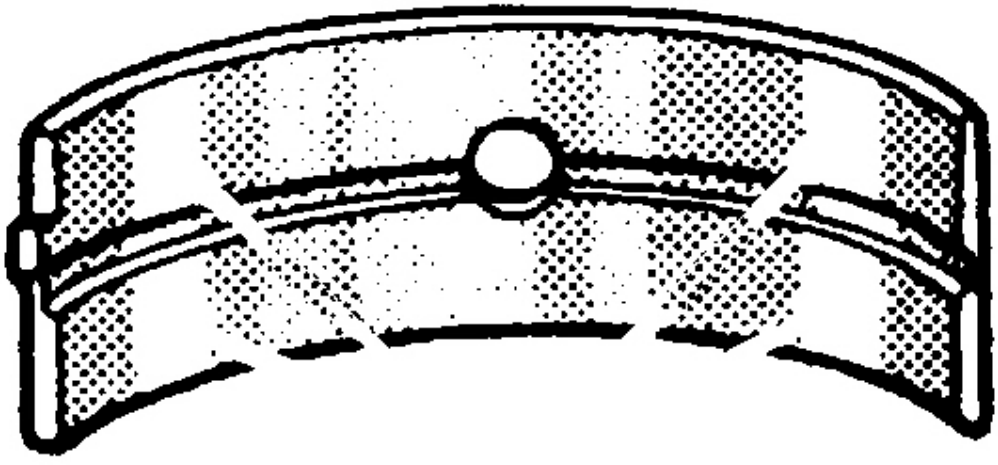


Fig. 73: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

4. Inspect for improper seating indicated by bright, polished sections.

CRANKSHAFT MEASUREMENT

Tools Required

J 7872 Magnetic Base Dial Indicator

Measuring Procedure

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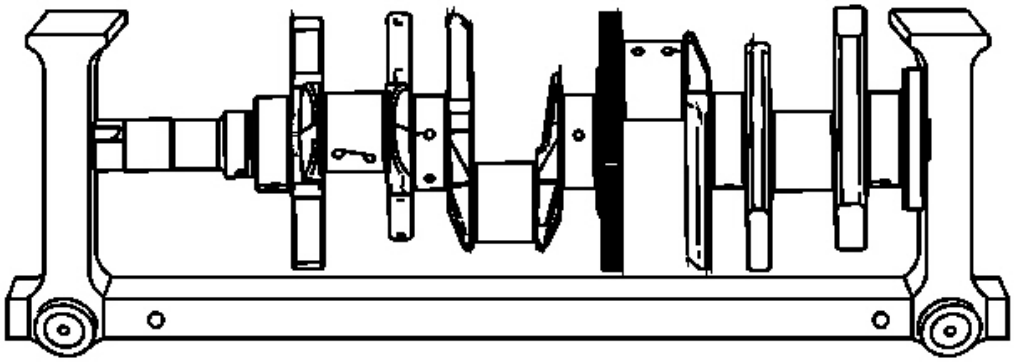


Fig. 74: Supporting Crankshaft
Courtesy of GENERAL MOTORS CORP.

1. Using a suitable fixture, support the crankshaft.

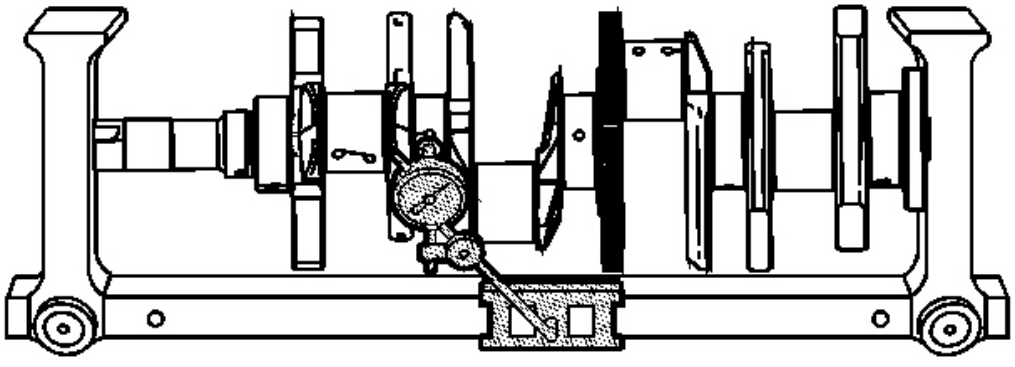


Fig. 75: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 7872** .
3. Measure the crankshaft runout using **J 7872** . Refer to **Engine Mechanical Specifications** .

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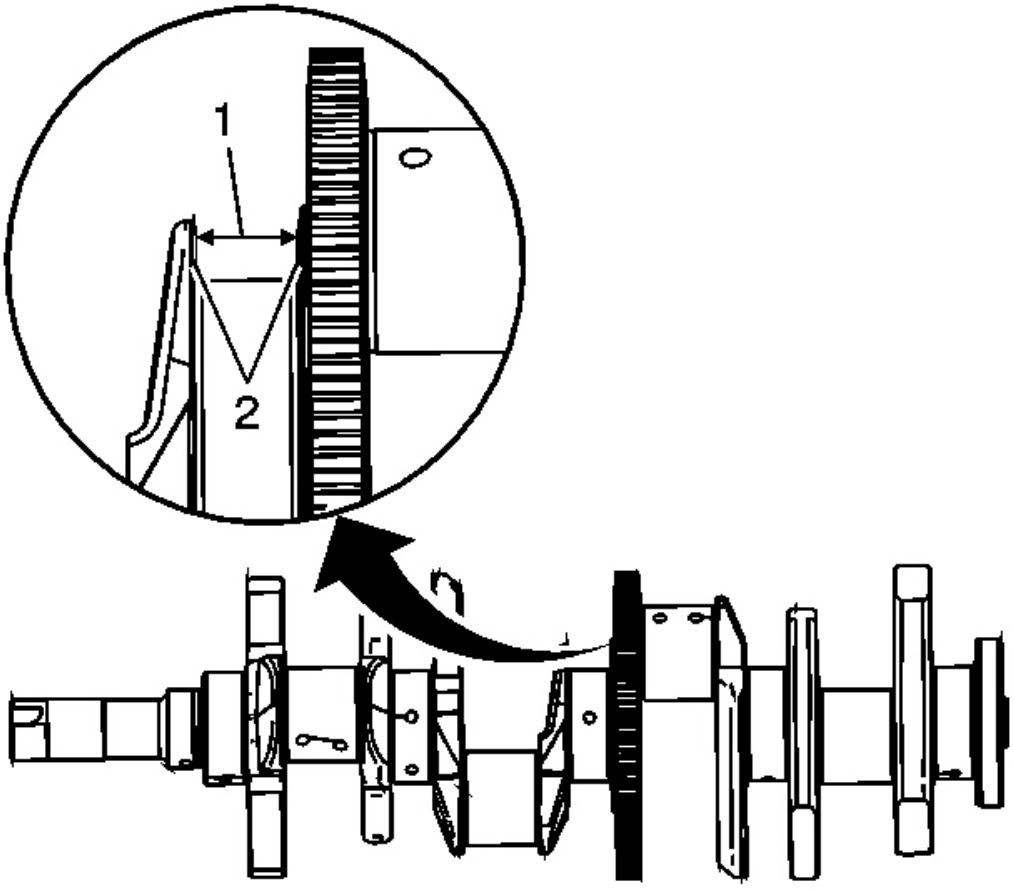


Fig. 76: Measuring Crankshaft Thrust Wall Width & Surface
Courtesy of GENERAL MOTORS CORP.

4. Measure the crankshaft thrust wall width (1) for wear using an inside micrometer. Refer to **Engine Mechanical Specifications** .
5. Measure the crankshaft thrust wall surface (2) for runout using**J 7872** . Refer to **Engine Mechanical Specifications** .
6. If the crankshaft thrust walls are damaged or worn beyond specifications, replace the crankshaft. No machining of the crankshaft thrust wall is allowed.

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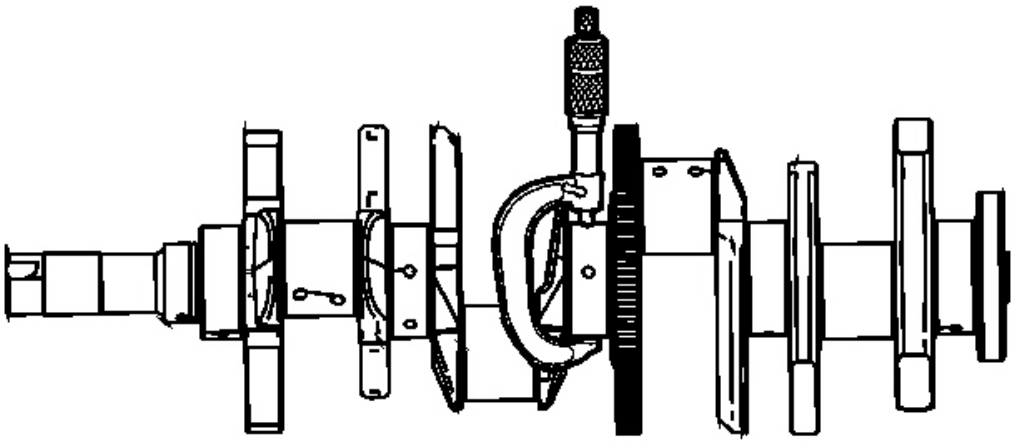


Fig. 77: Checking Crankshaft Main Journals For Undersize
Courtesy of GENERAL MOTORS CORP.

7. Check the crankshaft main journals for undersize using an outside micrometer.

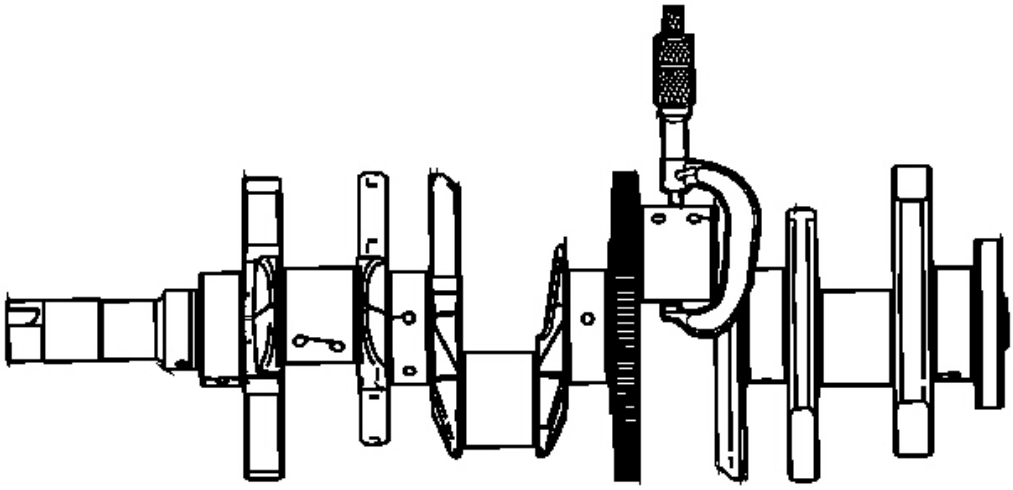


Fig. 78: Checking Crankpins For Undersize
Courtesy of GENERAL MOTORS CORP.

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8. Check the crankpins for undersize using an outside micrometer.
9. Compare your measurements with those listed in the **Engine Mechanical Specifications** . If the crankshaft journals are worn beyond the specified limits, the crankshaft must be replaced. Crankshaft machining is not allowed and there are no undersized bearings available for service.

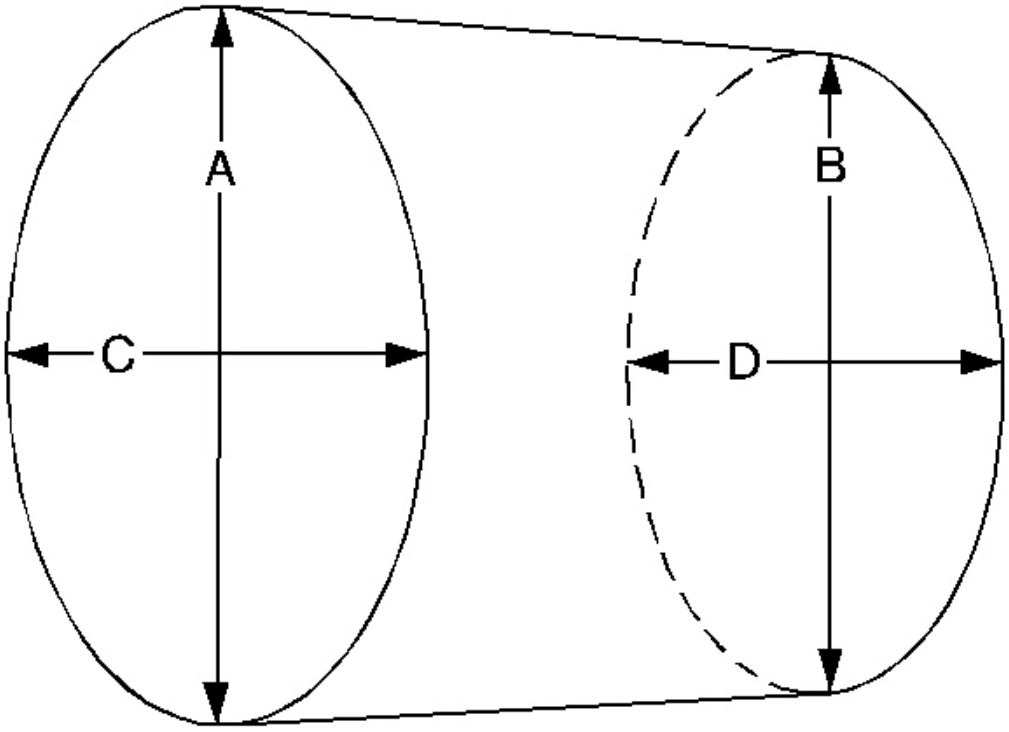


Fig. 79: Identifying Out-Of-Round Measurements
Courtesy of GENERAL MOTORS CORP.

10. Measure the main bearing and crankpin journals for out-of-round using the following procedure:
    1. Using an outside micrometer, measure the journal at the extreme front and rear locations on the journal. Call these points A and B.
    2. Measure the journal in two new locations exactly 90 degrees from the first points. Call these points C and D.
    3. Subtract A from C and B from D. The differences will indicate journal out-of-round.
    4. The out-of-round should not exceed 0.004 mm (0.00016 in) maximum.
    5. If the specifications are exceeded, replace the crankshaft.
11. Measure the main bearing and crankpin journals for taper using the following procedure:

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1. Using an outside micrometer, measure the journal at the extreme front (A) and rear (B) of the journal parallel to the crankshaft centerline.
2. Subtract the smallest from the largest measurement. The result will be the journal taper.
3. If the main bearing journal taper exceeds 0.004 mm (0.00016 in), replace the crankshaft.
4. If the crankpin journal taper exceeds 0.004 mm (0.00016 in), replace the crankshaft.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

CLEANING PROCEDURE

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

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the crankshaft balancer with compressed air.

INSPECTION PROCEDURE

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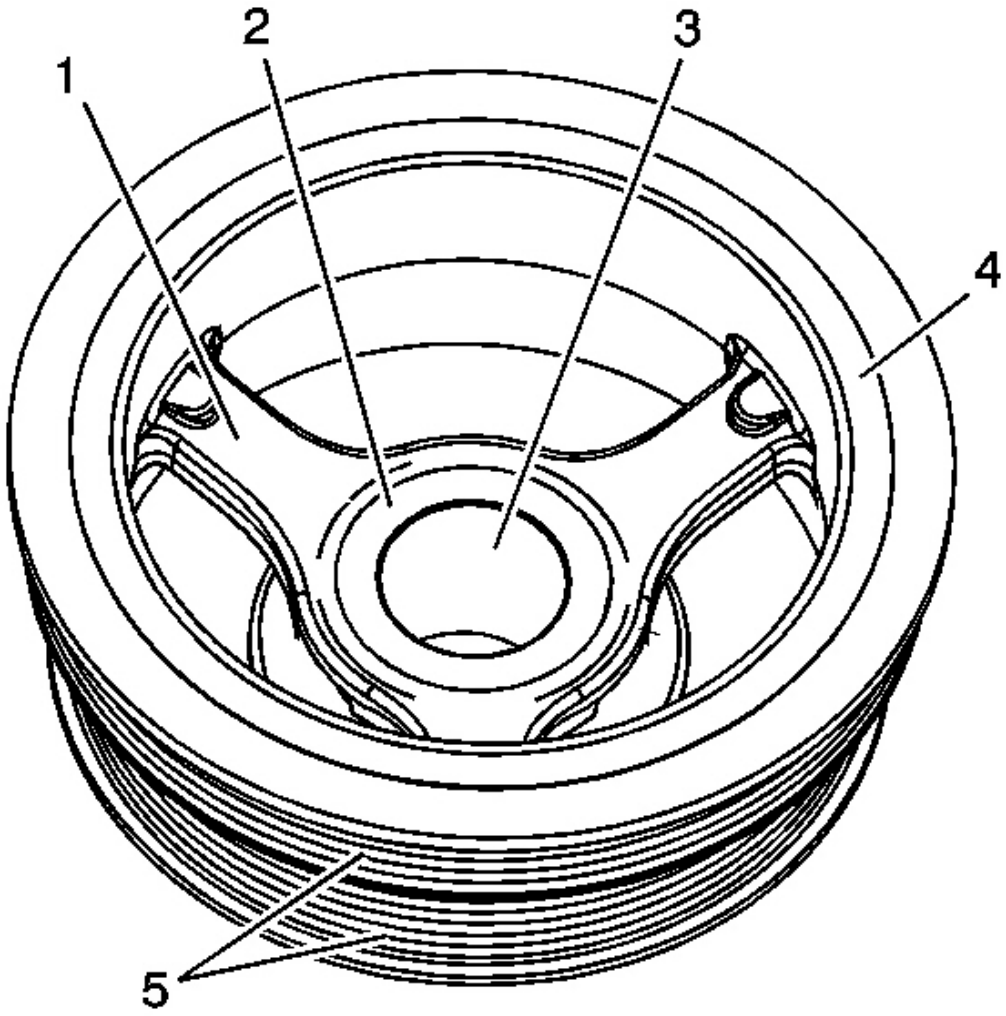


Fig. 80: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exterior of the crankshaft balancer for the following:
   - Damage to the webs (1) between the hub and the drive belt inner pulley
   - Damage to the seating surface (2) for the crankshaft balancer bolt's washer
   - Wear or damage to the hub-to-crankshaft surface (3)
   - Wear, chunking or deteriorated rubber (4) between the drive belt inner and outer pulleys
   - Damage to the drive belt inner and/or outer pulley ribs (5)

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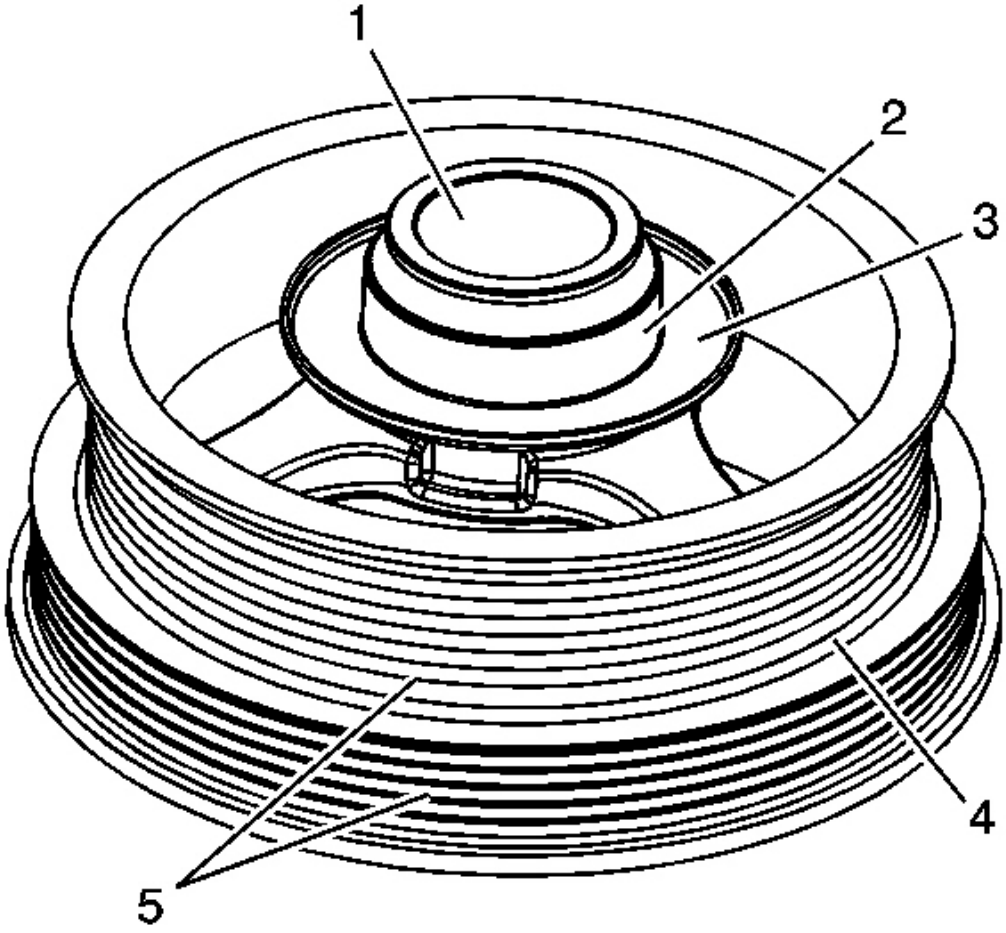


Fig. 81: Identifying Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the crankshaft balancer for the following:
   - Wear or damage to the hub-to-crankshaft surface (1)
   - Wear, grooves or damage to the hub sealing surface (2). A crankshaft balancer hub sealing surface with excessive scoring, grooves, rust or other damage must be replaced.
   - Bent, damage or missing crankshaft front oil seal shield (3)
   - Wear, chunking or deteriorated rubber (4) between the drive belt inner and outer pulleys
   - Damage to the drive belt inner and/or outer pulley ribs (5)
3. Repair or replace the crankshaft balancer as necessary.

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ENGINE FLYWHEEL CLEANING AND INSPECTION

CLEANING PROCEDURE

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

1. Clean the engine flywheel in solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the engine flywheel with compressed air.

INSPECTION PROCEDURE

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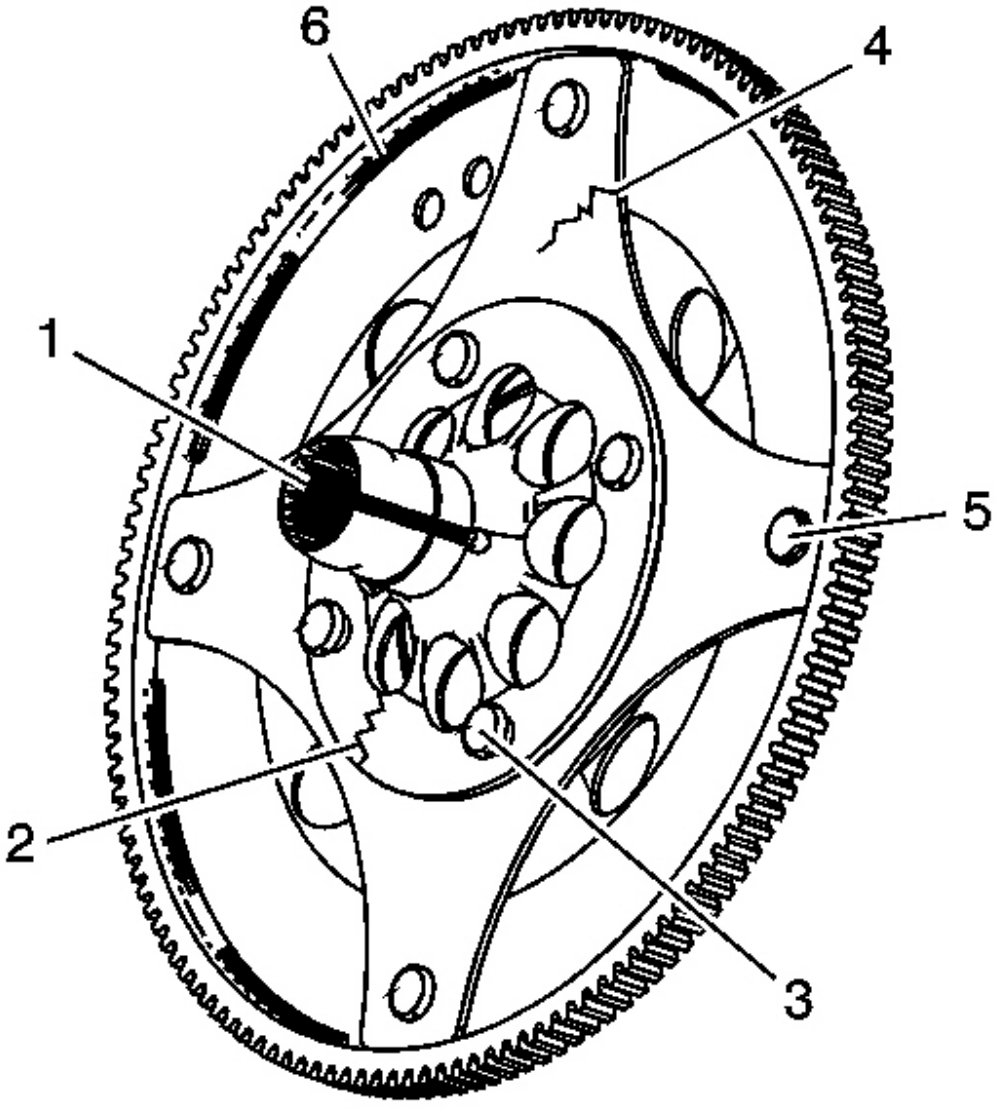


Fig. 82: Inspecting Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Inspect the engine flywheel hub spline for damage (1).
2. Inspect the engine flywheel hub for cracks (2).
3. Inspect the engine flywheel hub to plate rivets for damage or looseness (3).
4. Inspect the engine flywheel plate for cracks (4).

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5. Inspect the engine flywheel plate rivets for damage or looseness (5).
6. Inspect the engine flywheel ring gear welds that retain the ring gear to the engine flywheel for cracks (6).

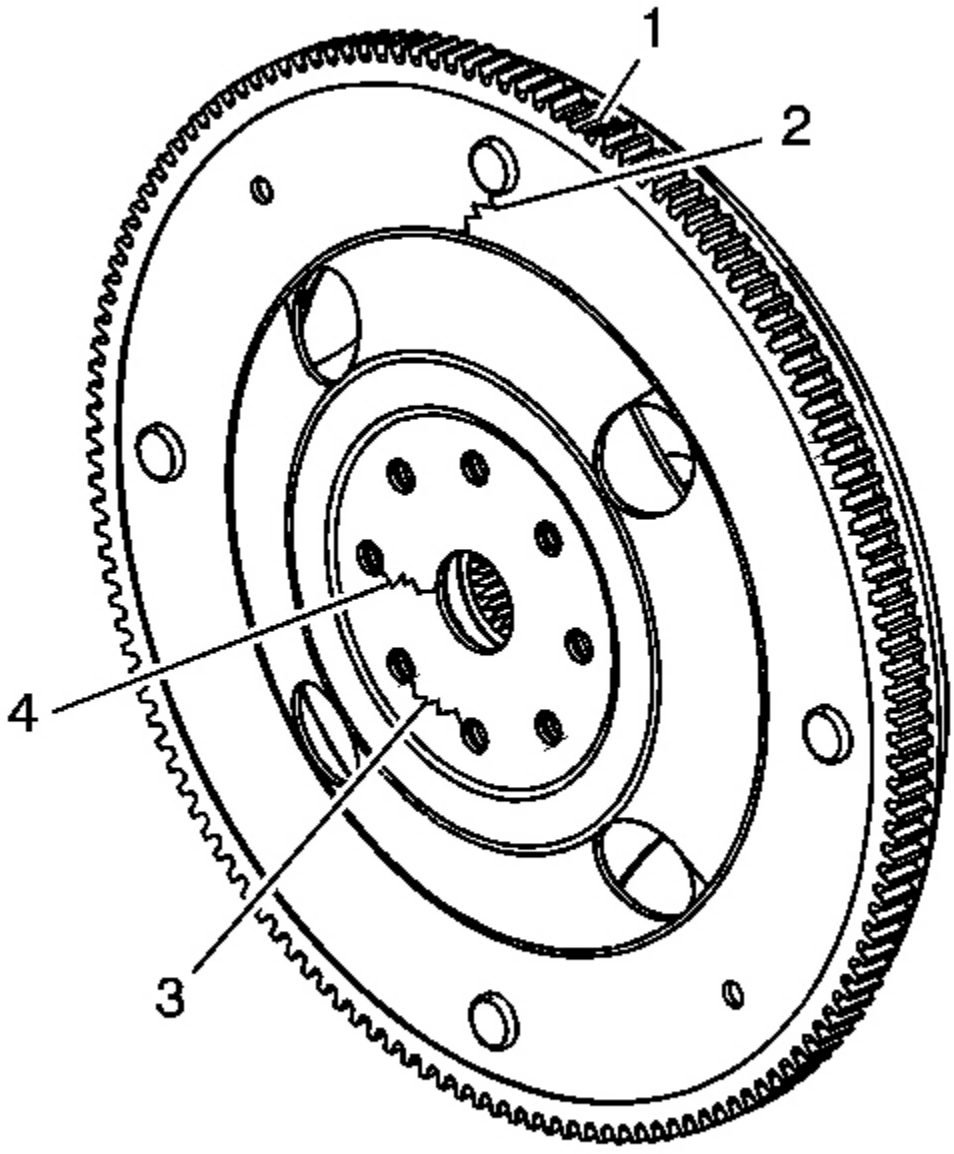


Fig. 83: Additional Inspection Areas Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

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7. Inspect the engine flywheel ring gear teeth for damage (1).
8. Inspect the engine flywheel for stress cracks at rivets (2).
9. Inspect the engine flywheel for stress cracks at the engine flywheel to crankshaft mounting holes (3, 4).

PISTON AND CONNECTING ROD DISASSEMBLE

TOOLS REQUIRED

EN-46745 Piston Pin Clip Remover/Installer. See **Special Tools** .

DISASSEMBLY PROCEDURE

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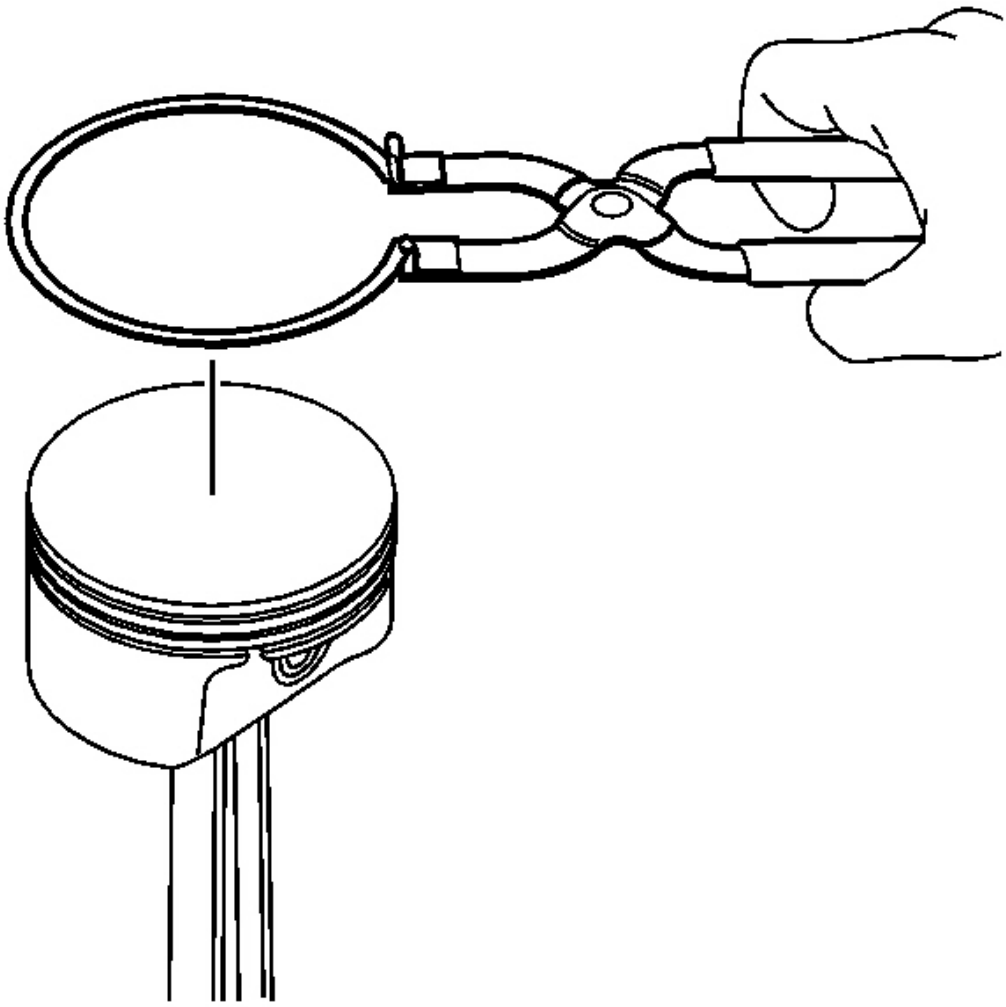


Fig. 84: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

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

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

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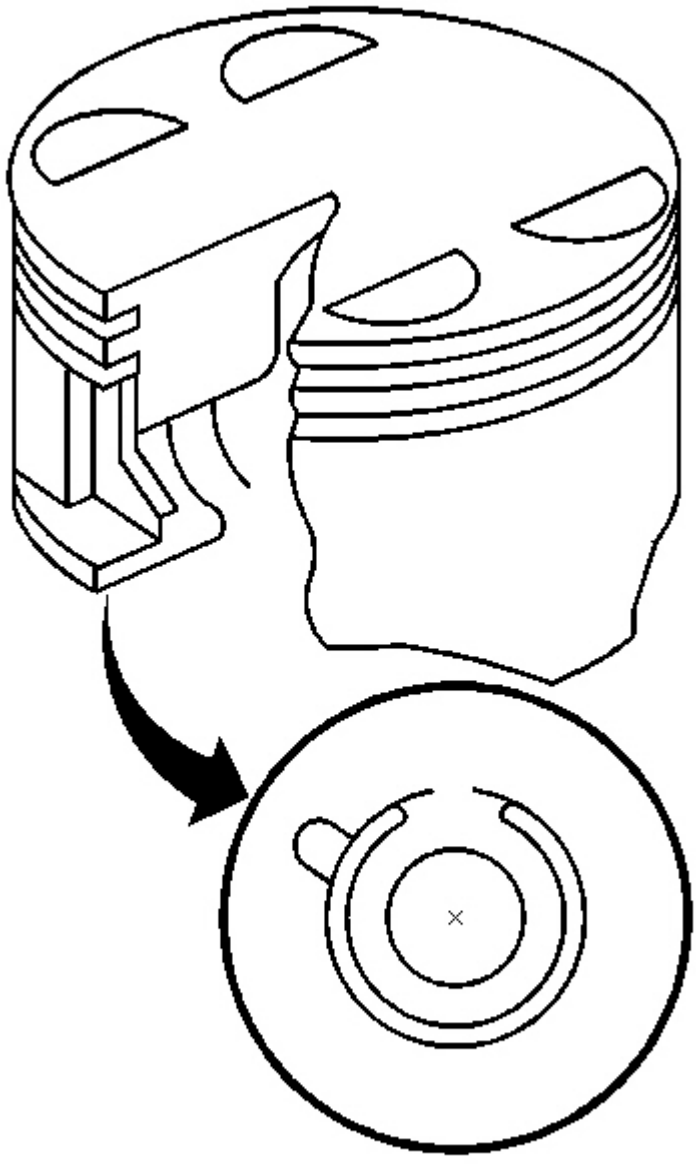


Fig. 85: Locating Piston Ring Retainers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be careful not to nick or gouge the piston or the retaining ring groove with the screwdriver if the piston is to be reused.

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2. Using the **EN-46745** , pry out the piston pin retainers by using the removal access notch in the side of the piston. See **Special Tools** .
3. Discard the old piston pin retainers.

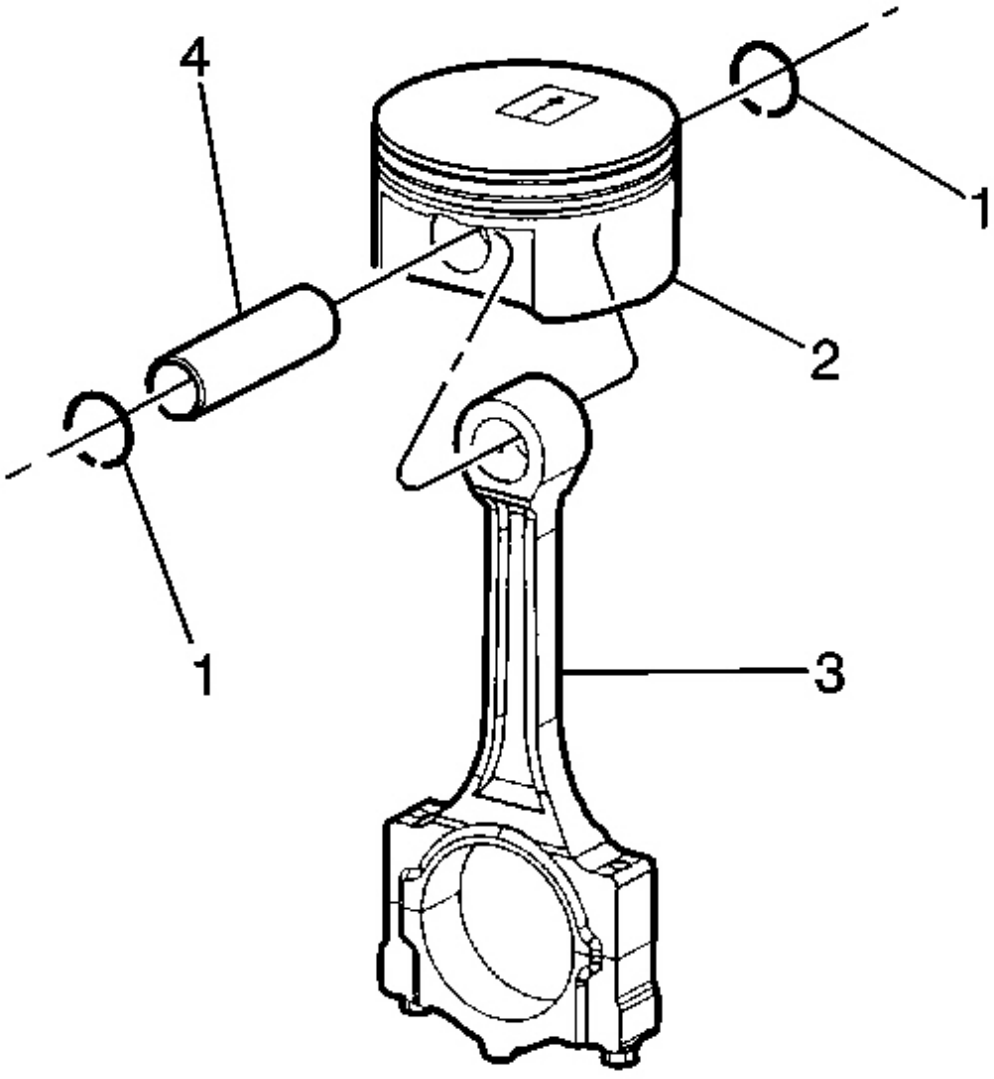


Fig. 86: Exploded View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

4. Slide the piston pin (4) out of the piston. The piston will disconnect from the connecting rod (2).

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PISTON, CONNECTING ROD AND BEARINGS CLEANING AND INSPECTION

CONNECTING ROD CLEANING PROCEDURE

1. Clean the connecting rods in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the connecting rods with compressed air.

CONNECTING ROD VISUAL INSPECTION PROCEDURE

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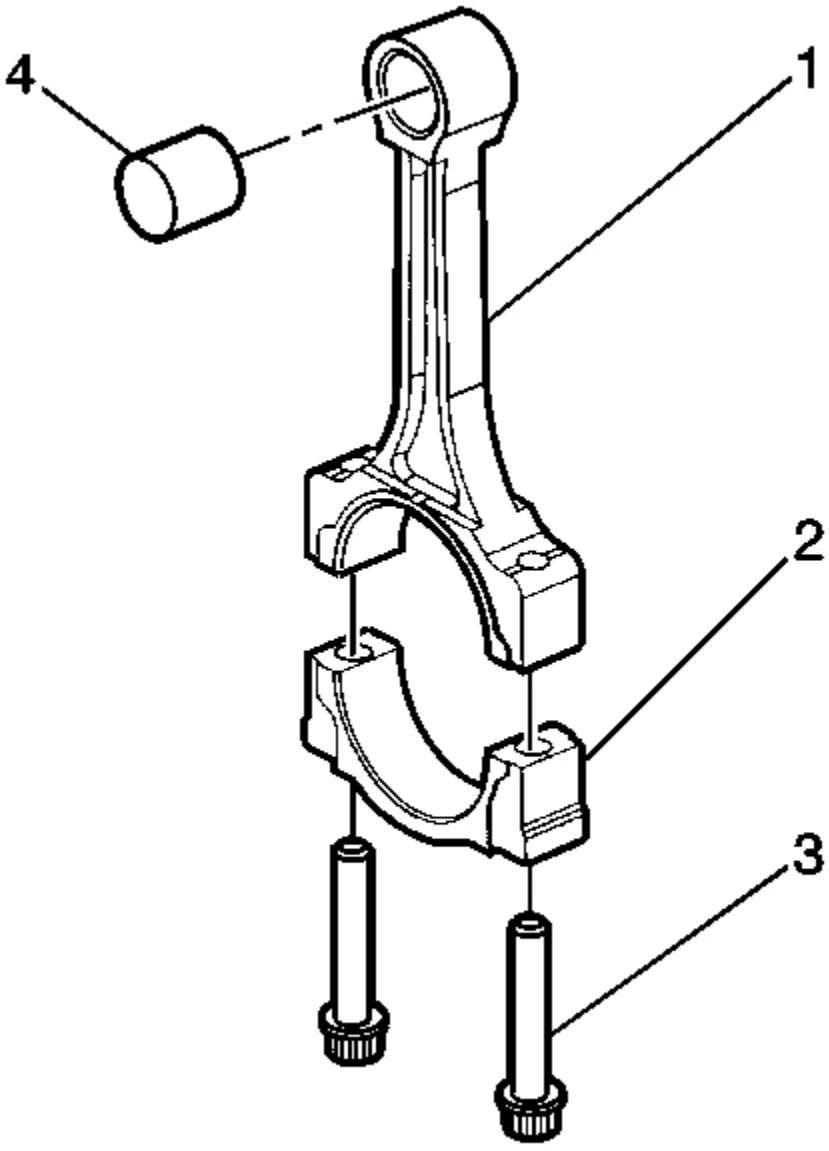


Fig. 87: Inspecting Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

1. Inspect the piston pin bushing (4) for scoring or damage.
2. Inspect the connecting rod beam (1) for twisting or bending.
3. Inspect the rod cap (2) for any nicks or damage caused by possible interference.

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4. Inspect for scratches or abrasion on the rod bearing seating surface.

IMPORTANT: DO NOT scrape the rod or rod cap.

5. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper.

CONNECTING ROD MEASUREMENT PROCEDURE

Piston Pin End

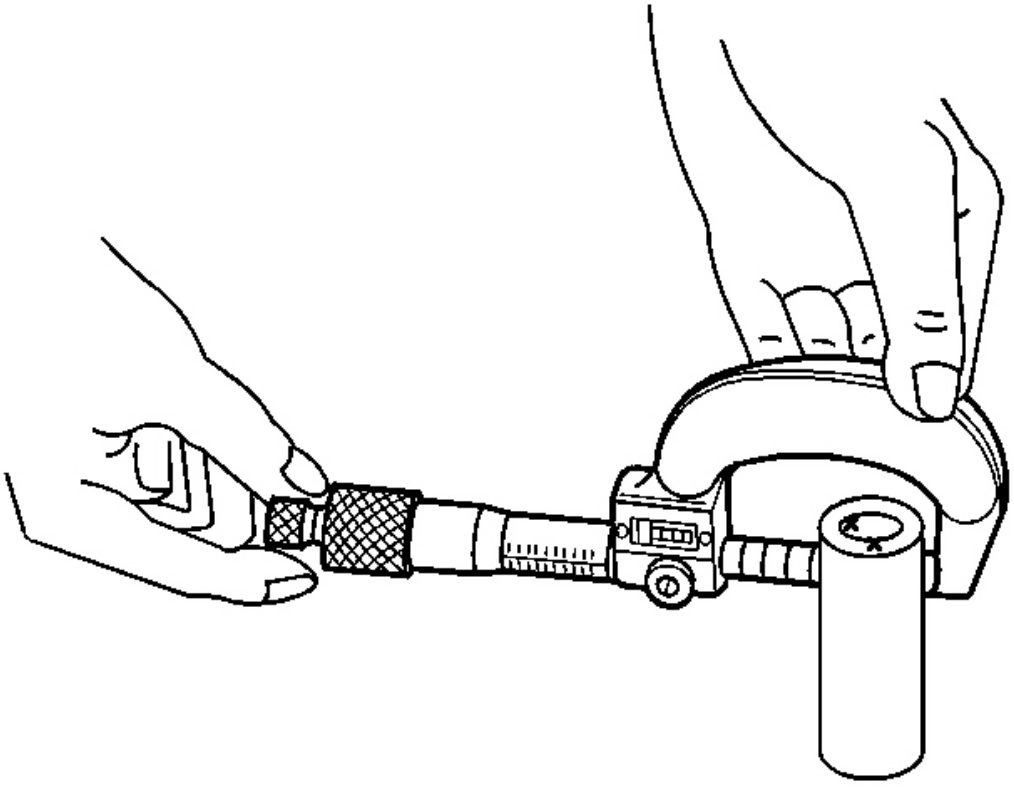


Fig. 88: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

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

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

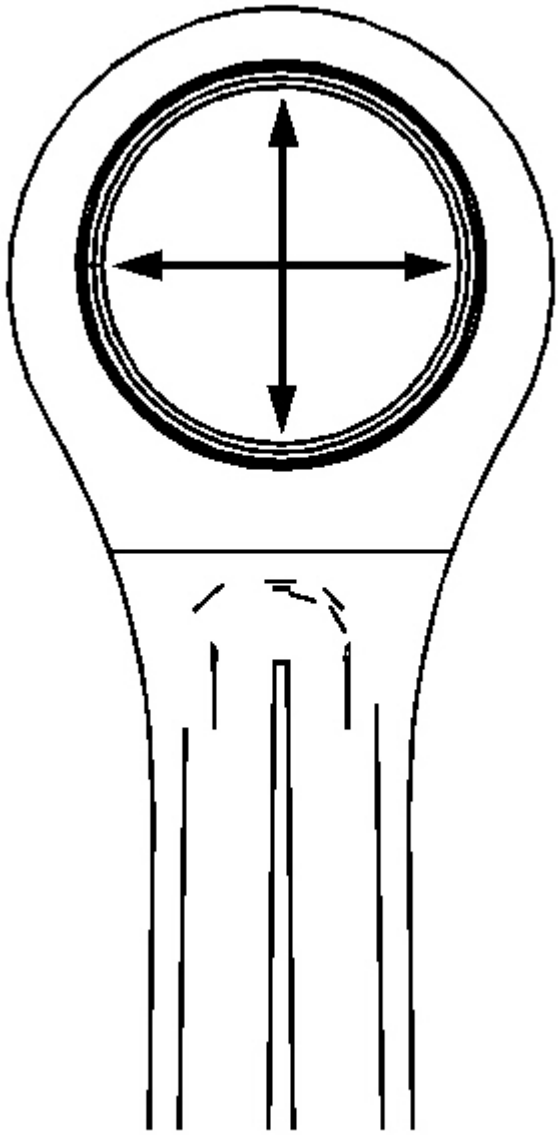


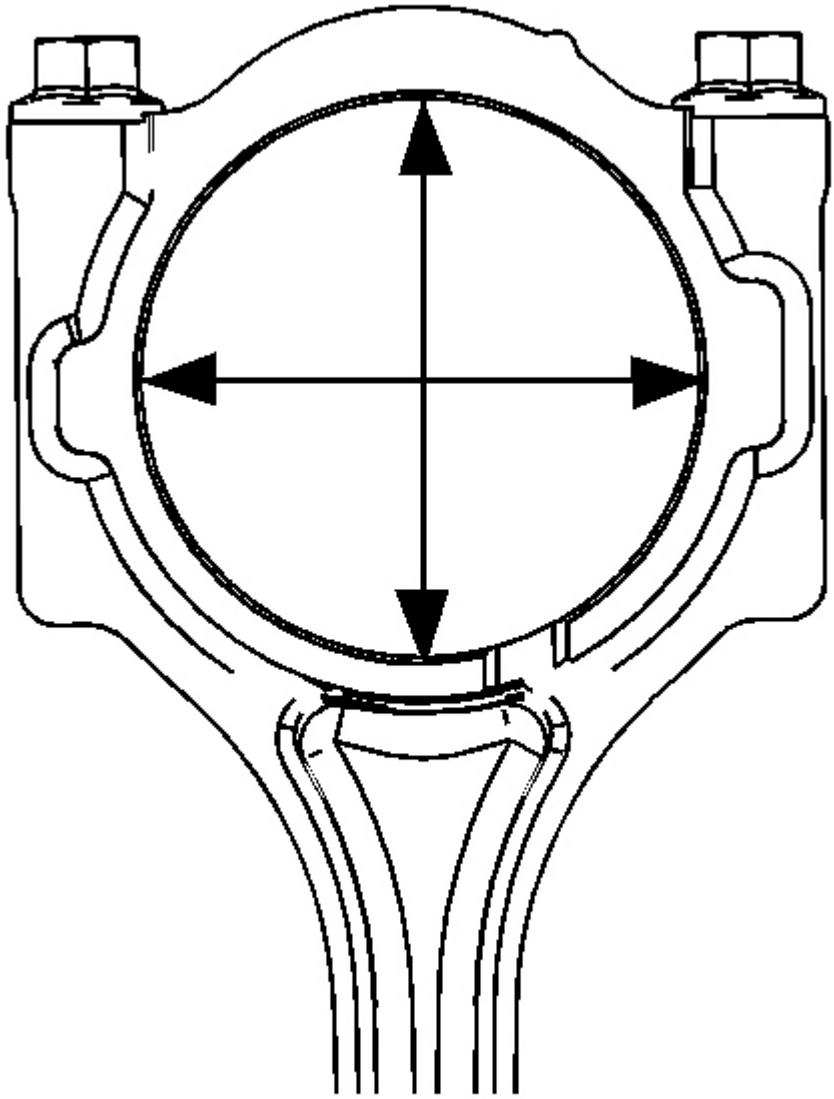
Fig. 89: Checking Connecting Rod Piston Pin Bore Dimensions
Courtesy of GENERAL MOTORS CORP.

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

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3. Subtract the piston pin diameter from the piston pin bore.
4. Compare the clearance measurements with the **Engine Mechanical Specifications** .
5. If the clearance is excessive, replace the piston pin. If a new pin does not resolve the clearance problem, replace the connecting rod.

Connecting Rod Crankshaft Bearing End



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Fig. 90: Measuring Connecting Rod Crankshaft Bearing Bore
Courtesy of GENERAL MOTORS CORP.

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

1. Using an inside micrometer, measure the connecting rod crankshaft bearing bore.
2. Compare the bore measurements with the **Engine Mechanical Specifications** .
3. Replace the connecting rod if the bore is out of specifications. DO NOT recondition the connecting rod.

PISTON CLEANING PROCEDURE

IMPORTANT: DO NOT wire brush any part of the piston.

1. Clean the piston and piston pin with solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

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

PISTON INSPECTION PROCEDURE

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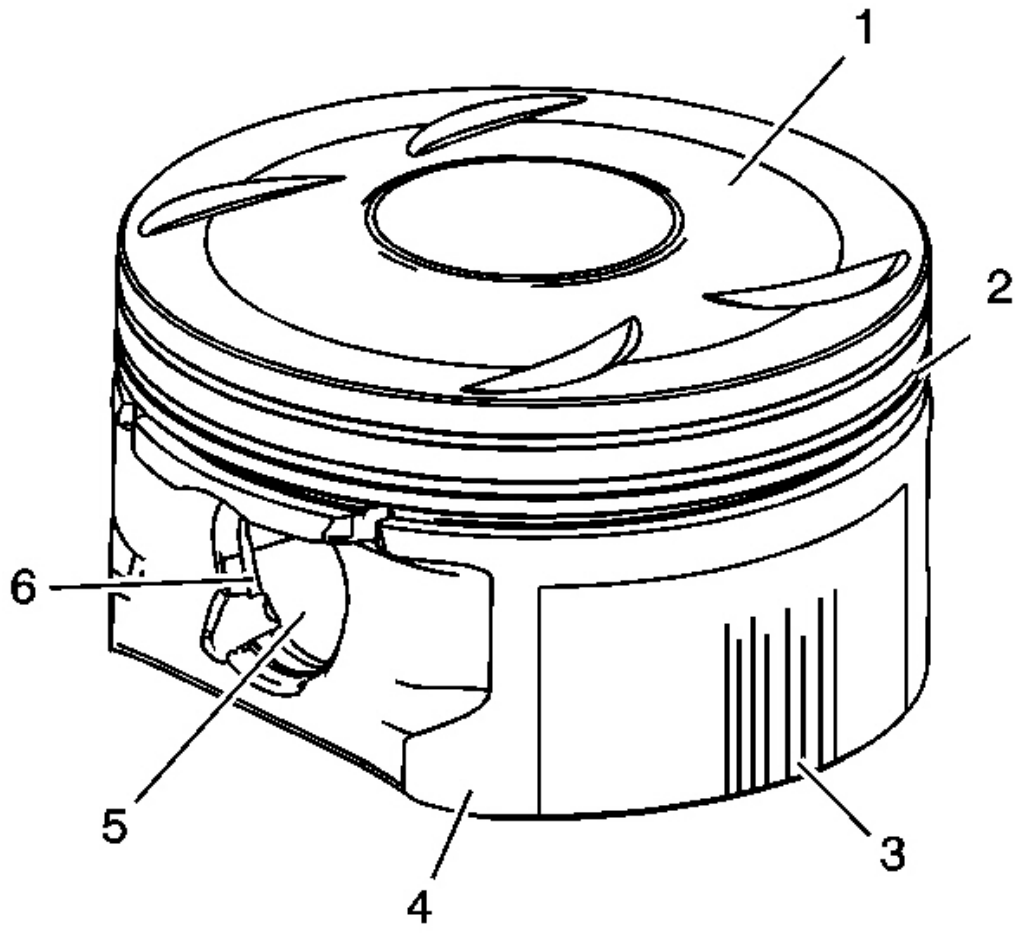


Fig. 91: Inspecting Piston
Courtesy of GENERAL MOTORS CORP.

1. Inspect the top of the piston (1) for erosion.
2. Inspect the ring lands and ring grooves (2) for cracks, warpage, wear and nicks/burrs that cause binding.
3. Inspect the piston skirt coating (3) for excessive wear.
4. Inspect the piston skirt (4) for cracks.
5. Inspect the piston pin bore (5) for wear, cracks and pin retainer grooves (6) for burrs.

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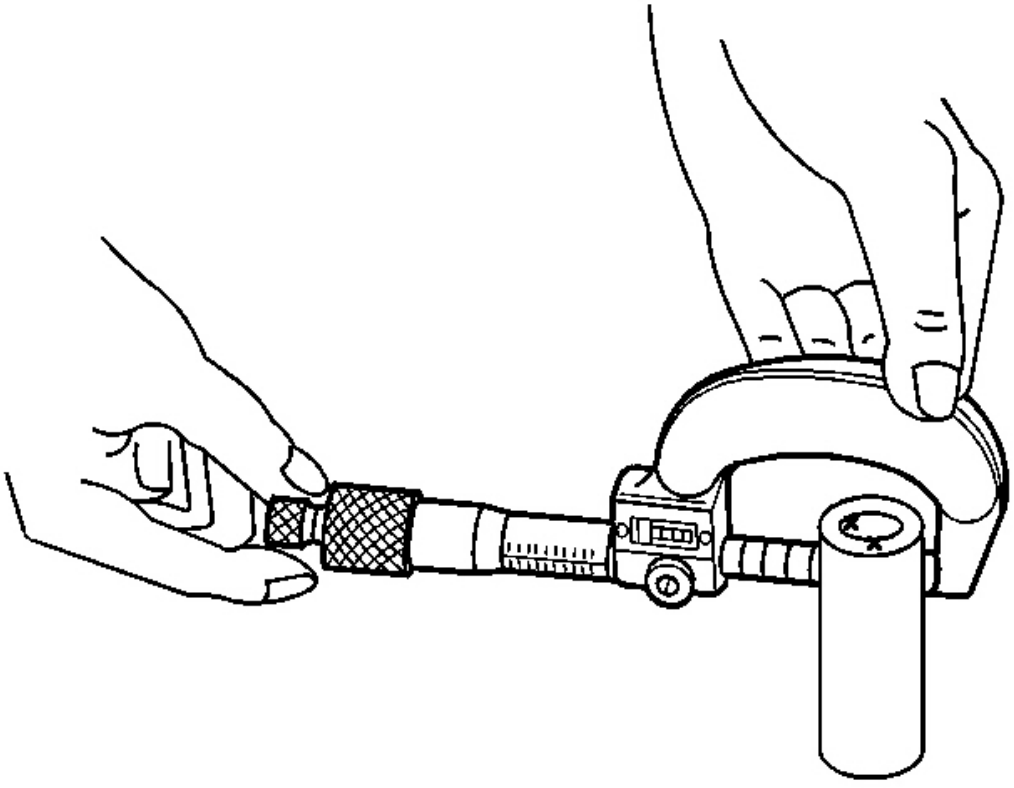


Fig. 92: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

6. Replace any piston and/or piston pin that have damage or excessive wear.

PISTON DIAMETER MEASUREMENT PROCEDURE

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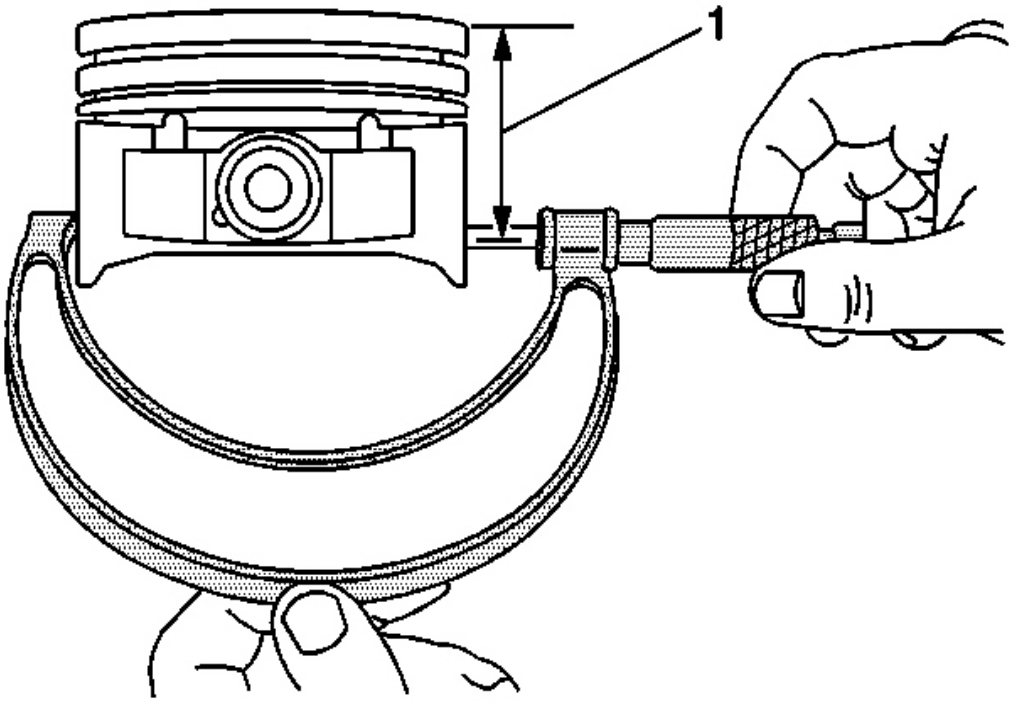


Fig. 93: Measuring Width Of Piston
Courtesy of GENERAL MOTORS CORP.

1. Using an outside micrometer, measure the width of the piston 40 mm (1.575 in) below the crown (top) of the piston at the thrust surface which is perpendicular to the centerline of the piston pin (1).
2. Compare the measurement to the diameter listed in the engine mechanical specifications.
3. You must replace the piston if any of its dimensions are out of specification. There are no oversized pistons available.

PISTON PIN BORE MEASUREMENT PROCEDURE

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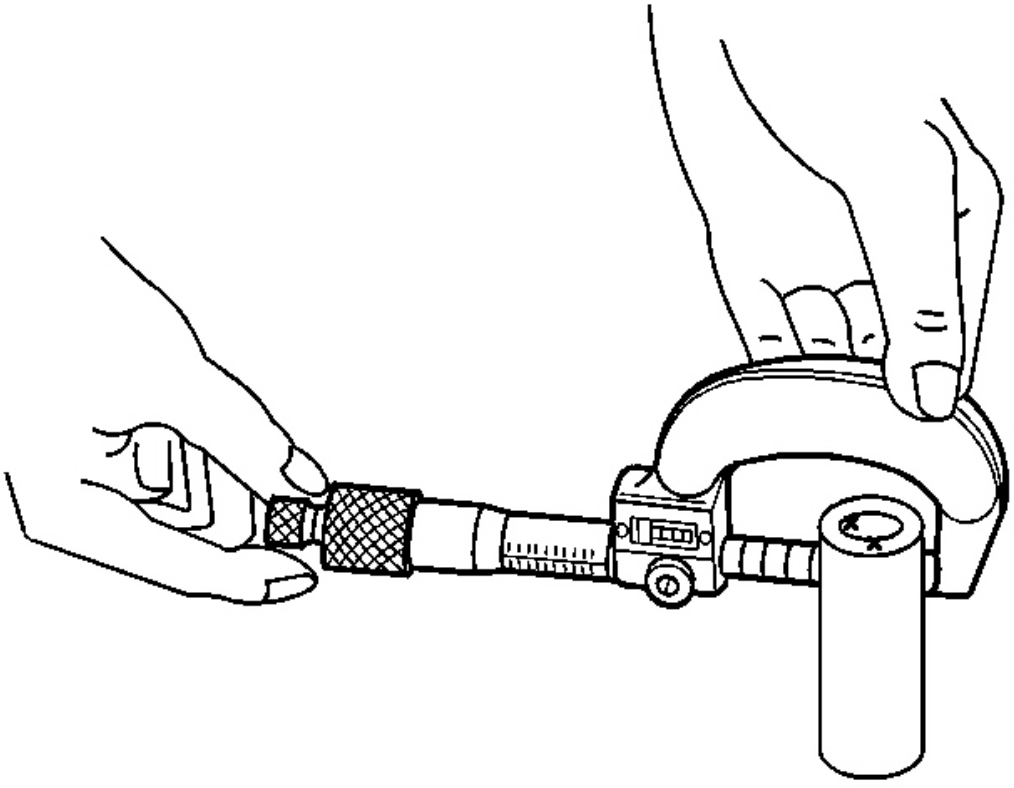


Fig. 94: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

1. Piston pin bores and pins must be free of varnish or scuffing.
2. Use an outside micrometer to measure the piston pin in the piston contact areas.

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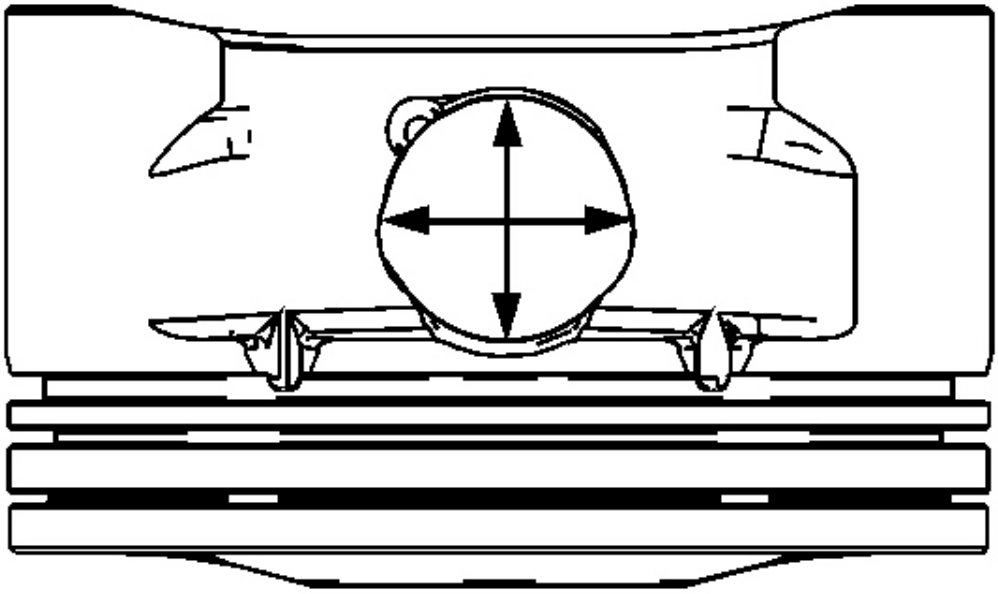


Fig. 95: Measuring Piston Pin Bore
Courtesy of GENERAL MOTORS CORP.

3. Using an inside micrometer, measure the piston pin bore.
4. Subtract the measurement of the piston pin bore from the piston pin.
5. Compare the result with the engine mechanical specifications.
6. If the clearance is excessive, determine which piece is out of specification and replace as necessary.

PISTON RING END GAP MEASUREMENT PROCEDURE

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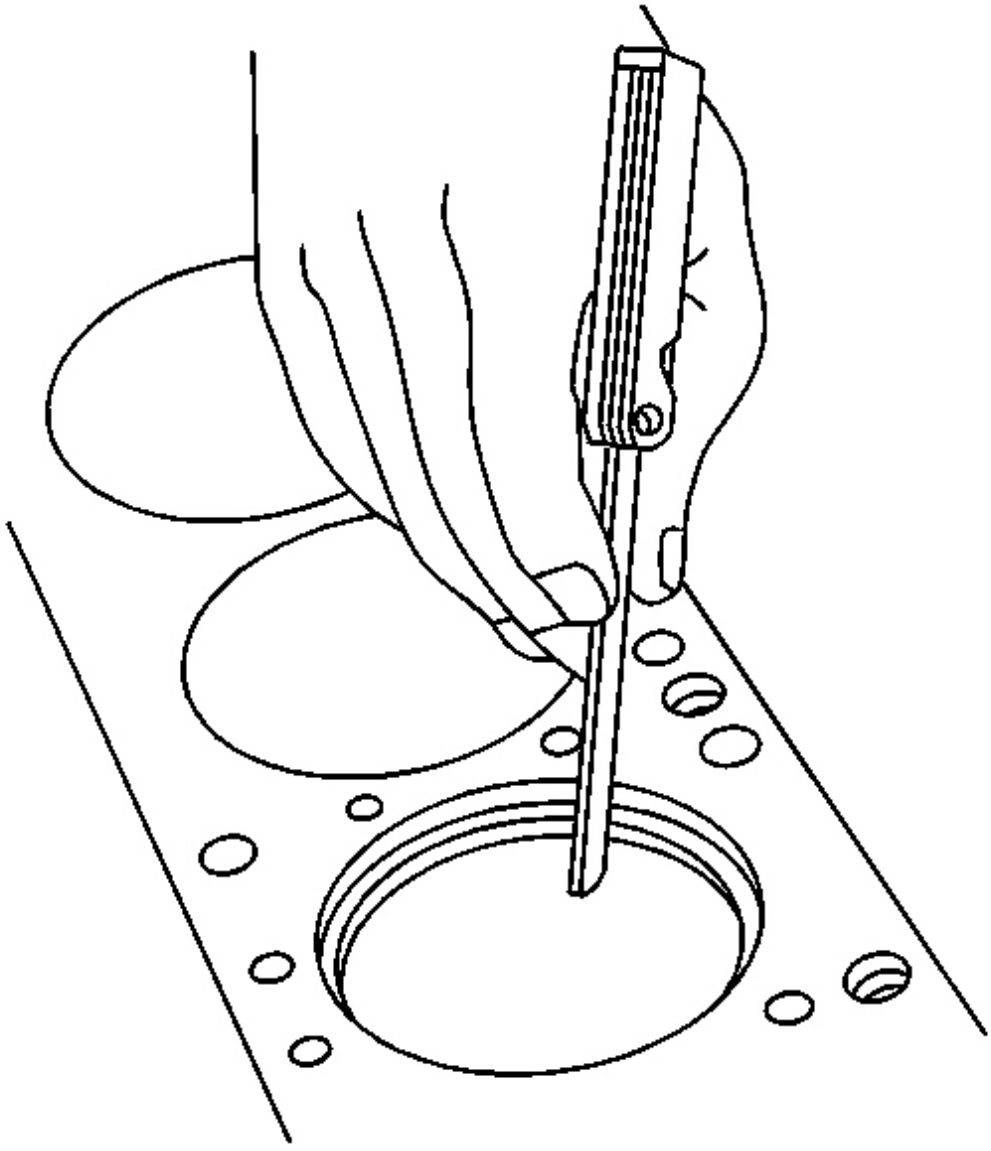


Fig. 96: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

1. Place the piston ring in the area of the bore where the piston ring will travel, approximately 25 mm (1 in) down from the deck surface. Be sure the ring is square with the cylinder bore by positioning the ring with the piston head.
2. Measure the end gap of the piston ring with feeler gages. Compare the measurements with those provided

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in the engine mechanical specifications.

3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat this procedure for all the piston rings.

PISTON RING SIDE CLEARANCE MEASUREMENT PROCEDURE

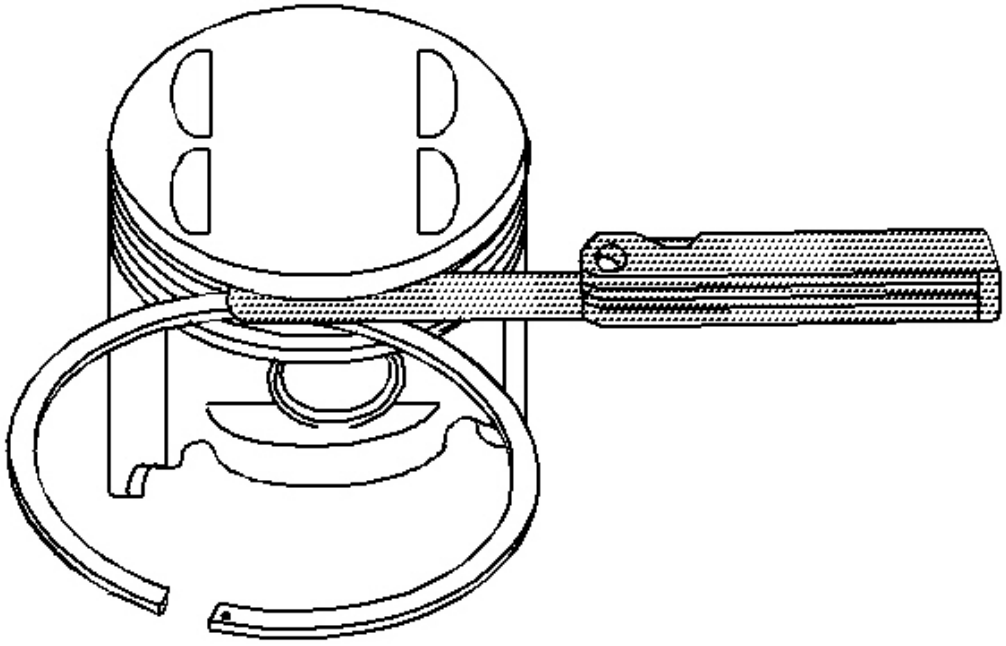


Fig. 97: Checking Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston ring, replace the ring.
2. With the piston ring on the piston, use feeler gages to check side clearance at multiple locations.
3. Compare your measurements with those found in the engine mechanical specifications.
4. If the clearance is greater than specifications, replace the piston rings.
5. If new piston rings do not bring the clearance within specification, the piston must be replaced.
6. When replacing the piston rings, only install re-ring sets that have a 1.2 mm (0.047 in) thick nitrided steel upper compression ring and multi-piece oil rings. The top compression ring may be installed with either side up. There is a locating dimple on the 2nd compression ring near the end for identification of the top side. Install the 2nd compression ring with the dimple facing up.

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PISTON AND CONNECTING ROD ASSEMBLE

TOOLS REQUIRED

EN-46745 Piston Pin Clip Remover/Installer. See **Special Tools** .

PISTON AND PISTON PIN INSTALLATION PROCEDURE

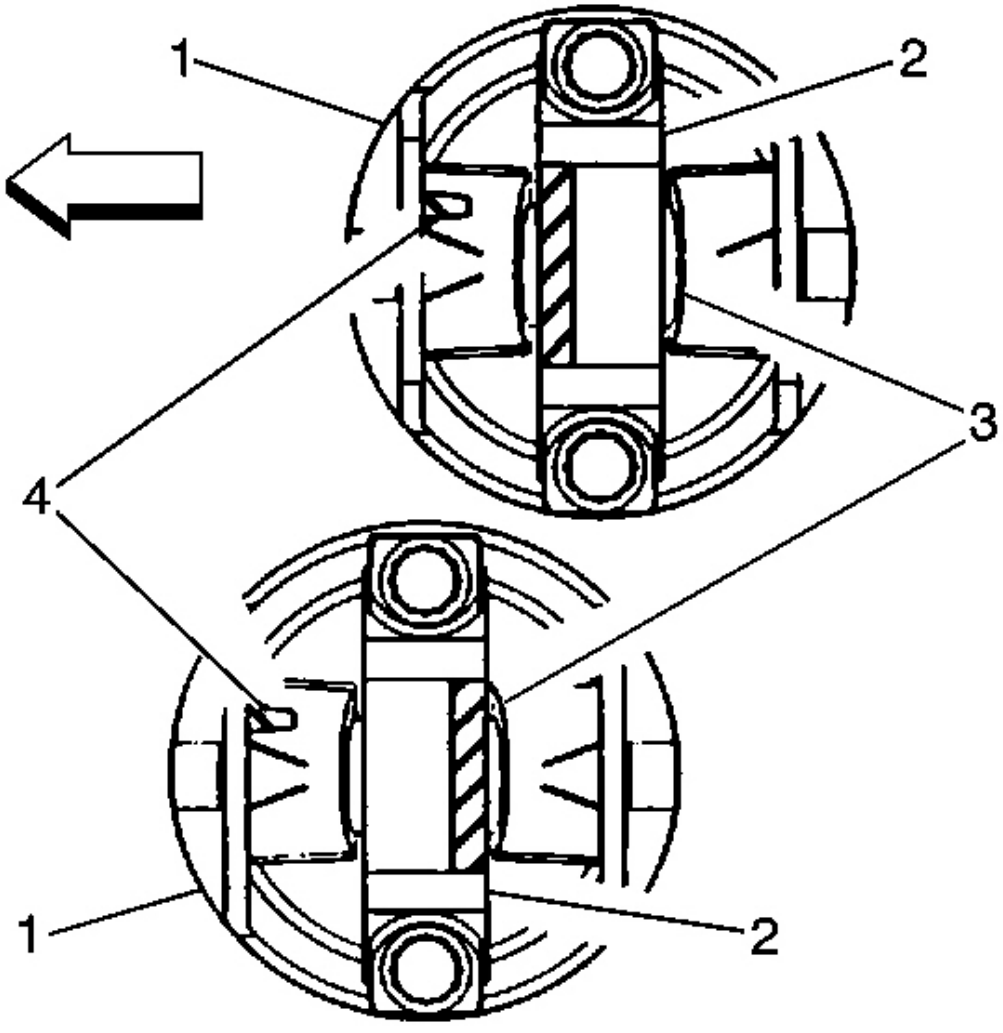
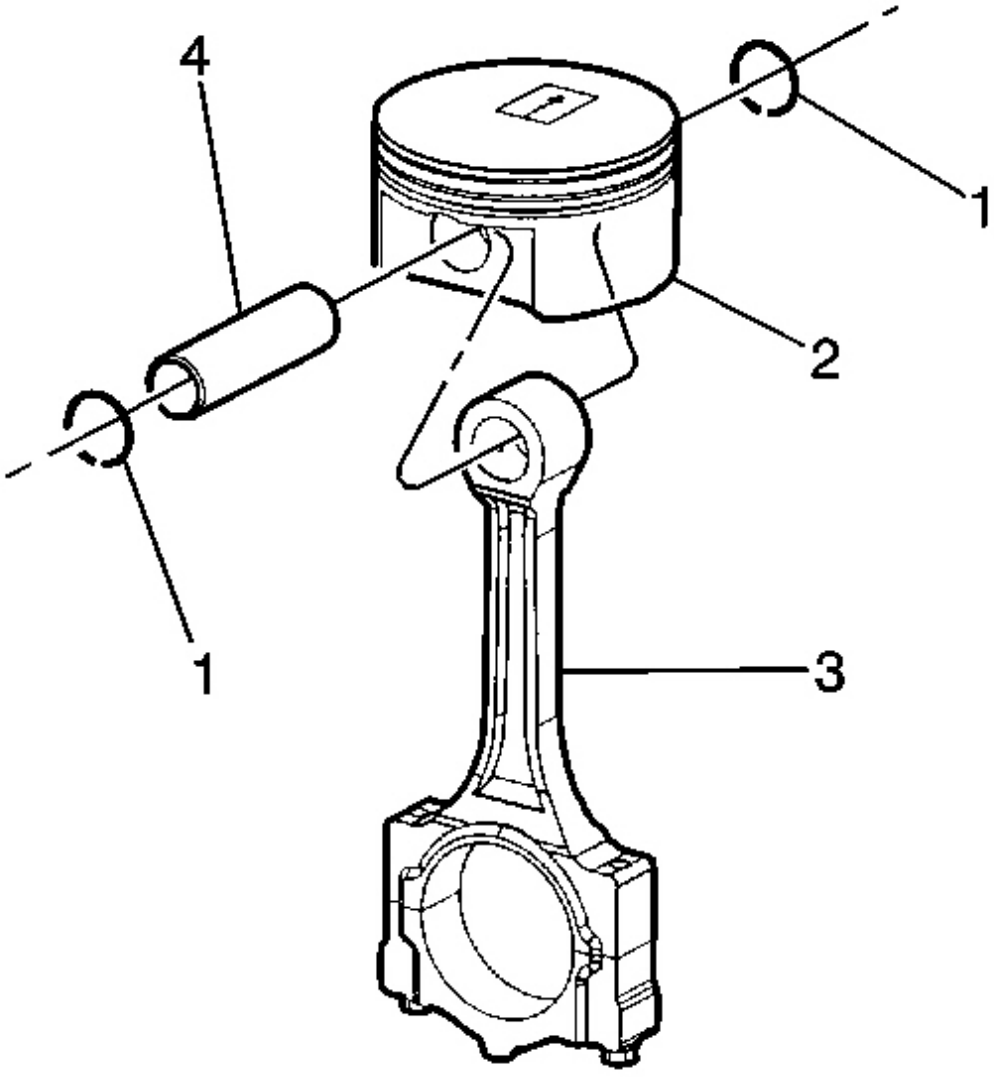


Fig. 98: Identifying Piston & Connecting Rod Locating Marks
Courtesy of GENERAL MOTORS CORP.

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1. Properly orient the piston (1) on the connecting rod (2) as follows:
   - The locating mark (4) cast into the underside of the piston should point towards the front of the engine.
   - The locating notch (3) on the connecting rod cap should be pointing towards the rear of the engine on odd-numbered cylinders and towards the front of the engine on even-numbered cylinders.
2. Lubricate the piston pin bores in the piston and connecting rod with GM prelube lubricant GM P/N 1052367 (Canadian P/N 992869) or equivalent.



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Fig. 99: Exploded View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

3. Align the piston pin bore with the connecting rod pin bore.
4. Slide the piston pin (4) into the piston and the connecting rod (3).

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

5. Install NEW piston pin retainers (1) using the **EN-46745** . See **Special Tools** .
6. Ensure that the piston pin retainers are fully seated in their grooves.
7. Repeat these procedures for the remaining pistons.

PISTON RING INSTALLATION PROCEDURE

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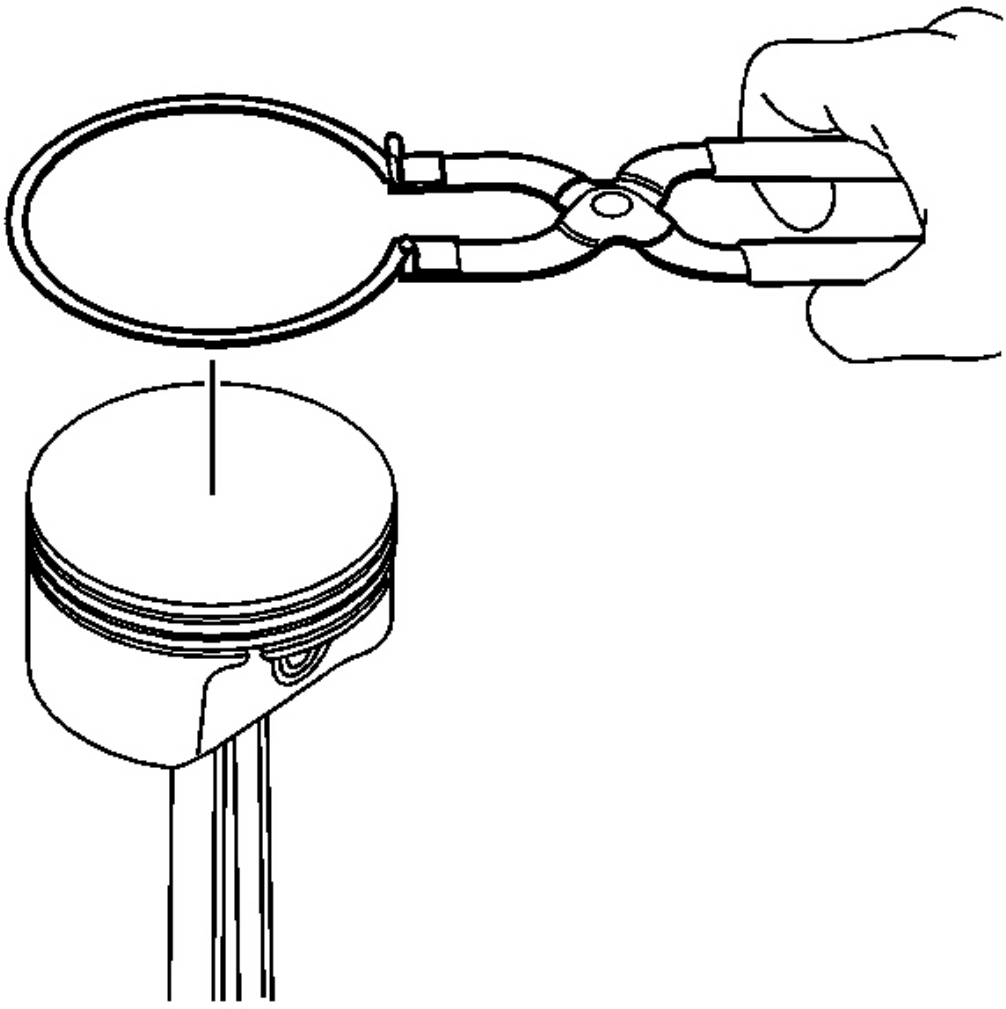


Fig. 100: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

1. Install the piston rings using a piston ring installer.

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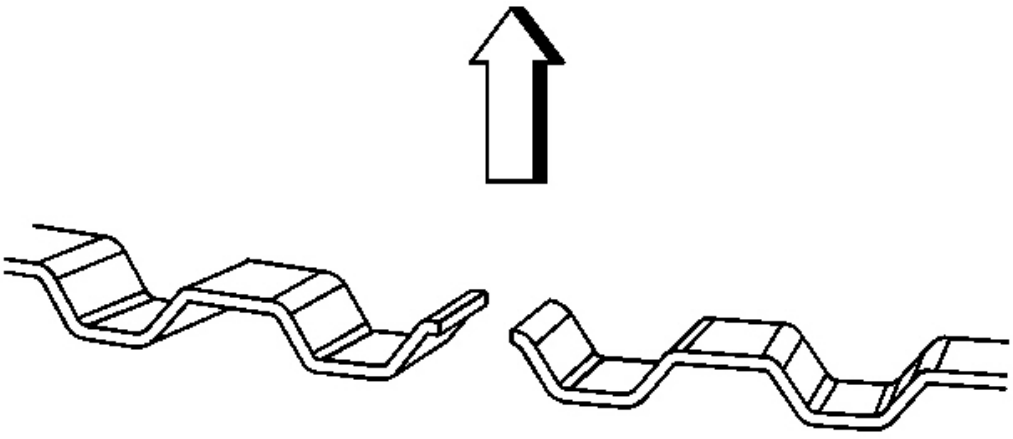


Fig. 101: Aligning Oil Control Ring Expander
Courtesy of GENERAL MOTORS CORP.

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

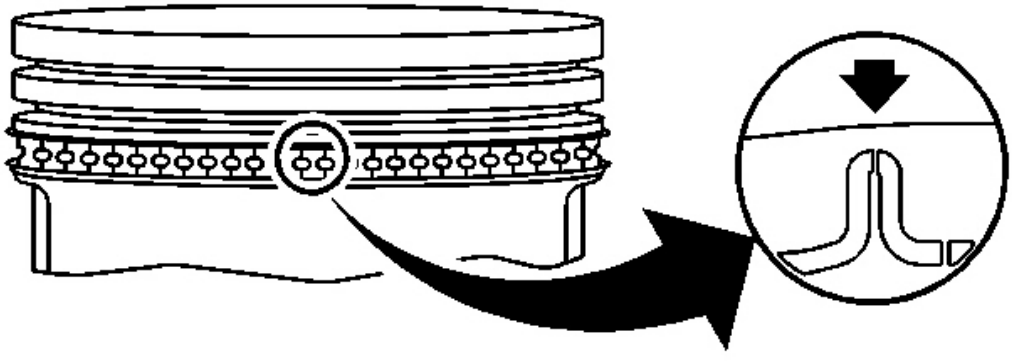


Fig. 102: View Of Lower Oil Control Piston Ring Spacer
Courtesy of GENERAL MOTORS CORP.

3. Install the oil control piston ring spacer onto the piston.

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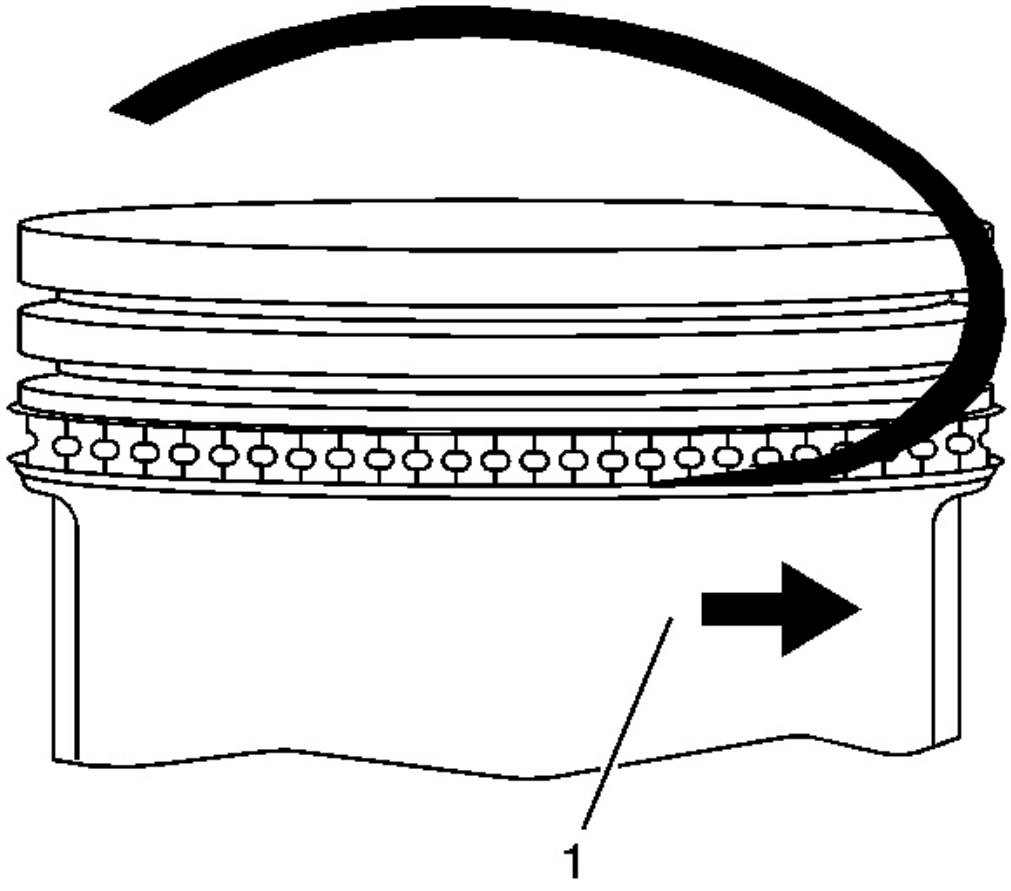


Fig. 103: View Of Lower Oil Control Piston Ring
Courtesy of GENERAL MOTORS CORP.

4. Install the lower oil control piston ring onto the piston (1).

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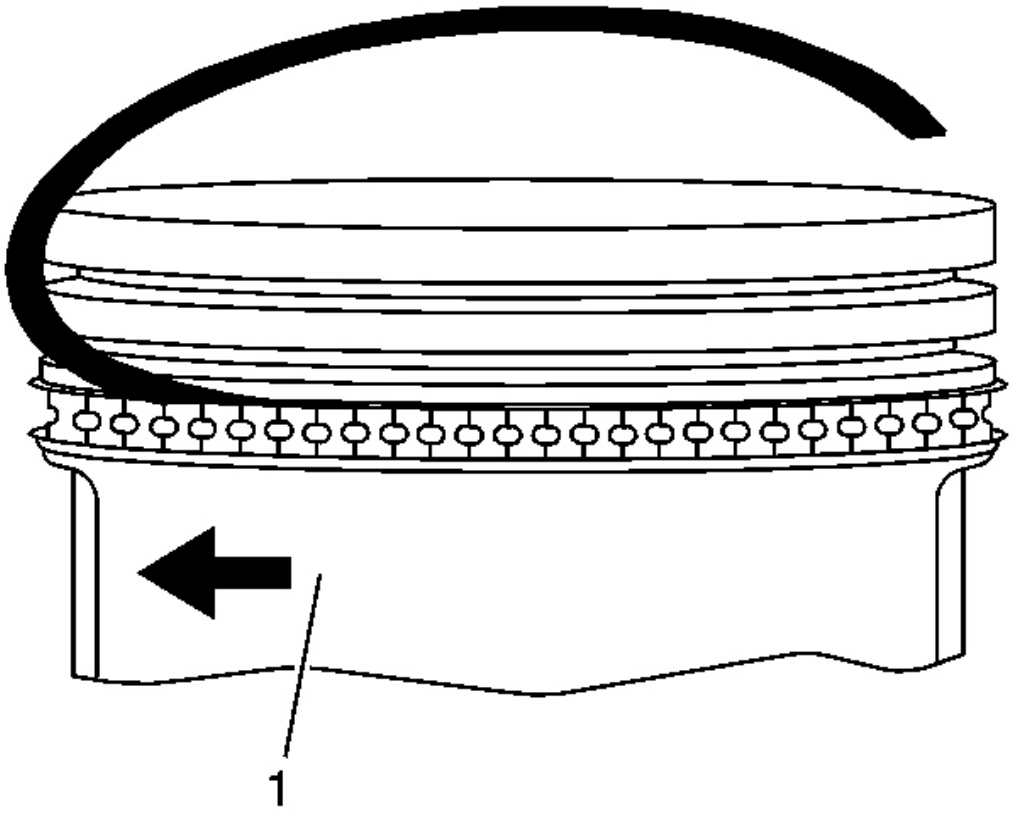


Fig. 104: View Of Upper Oil Control Piston Ring
Courtesy of GENERAL MOTORS CORP.

5. Install the upper oil control piston ring onto the piston (1).

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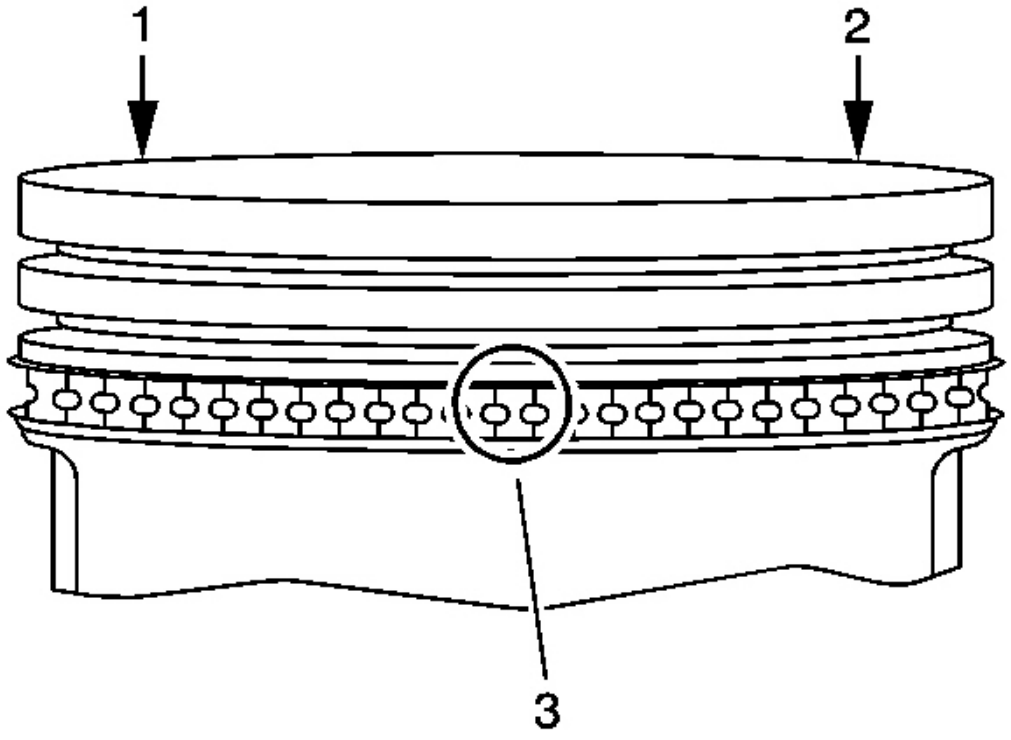


Fig. 105: View Of Oil Control Piston Rings
Courtesy of GENERAL MOTORS CORP.

6. Space the oil control piston ring end gaps (1, 2) a minimum of 90 degrees apart.

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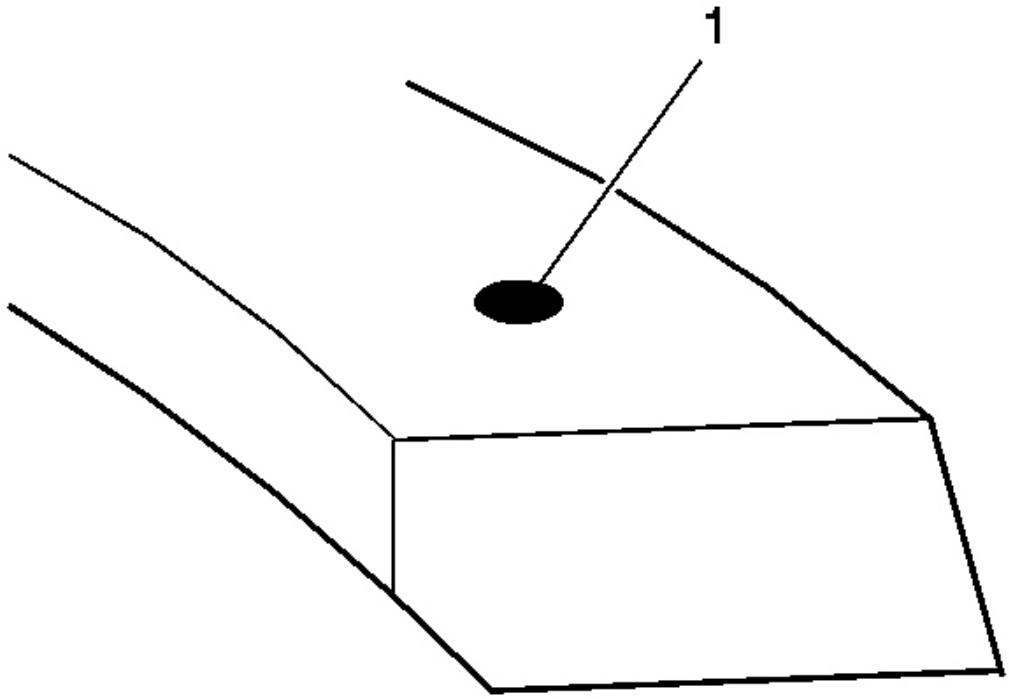


Fig. 106: View Of Lower Compression Piston Ring Mark
Courtesy of GENERAL MOTORS CORP.

7. Install the lower compression piston ring onto the piston (1).

   The mark on the side of the piston ring should face the top of the piston.

8. Install the upper compression piston ring onto the piston.

   The top compression ring may be installed with either side up.

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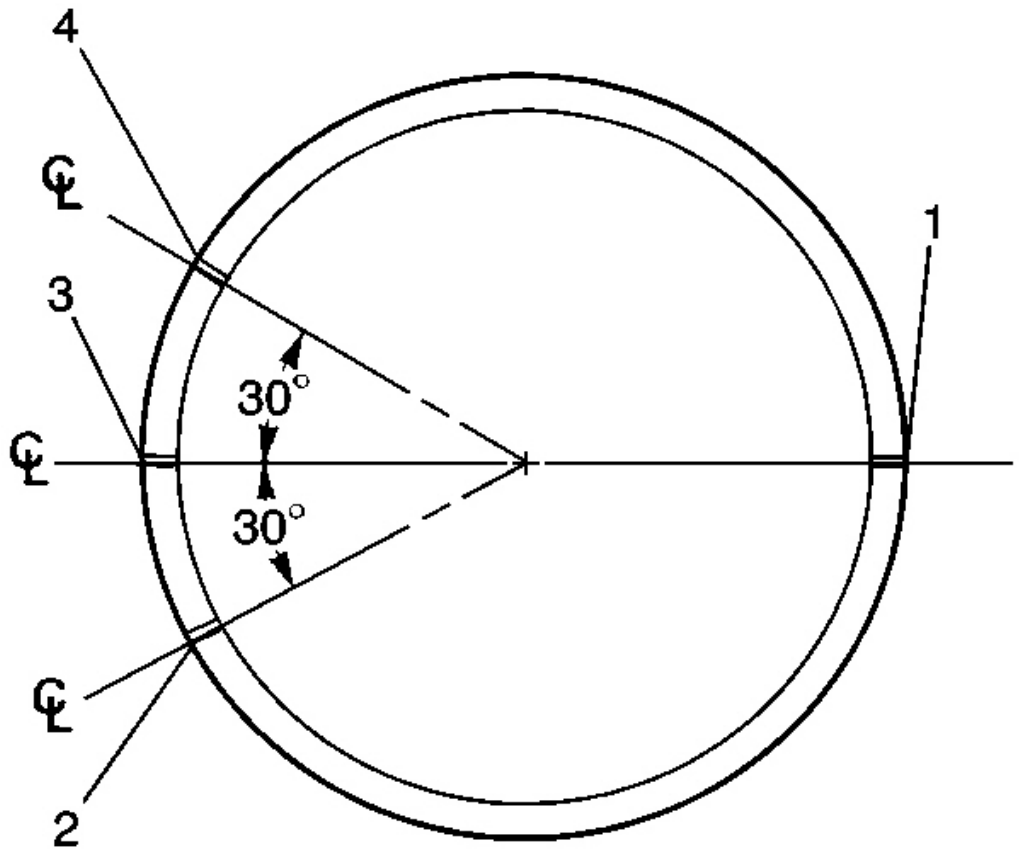


Fig. 107: Identifying Proper Oil Control Ring Gap Positioning
Courtesy of GENERAL MOTORS CORP.

9. Once the rings are installed, set the ring gaps for the oil control, second and top rings in the positions shown:
    1. Oil control ring expander and second compression ring gaps position 1.
    2. Upper oil control ring gap position 2.
    3. Top compression ring gap position 3.
    4. Lower oil control ring gap position 4.

CONNECTING ROD BEARING INSTALLATION PROCEDURE

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

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

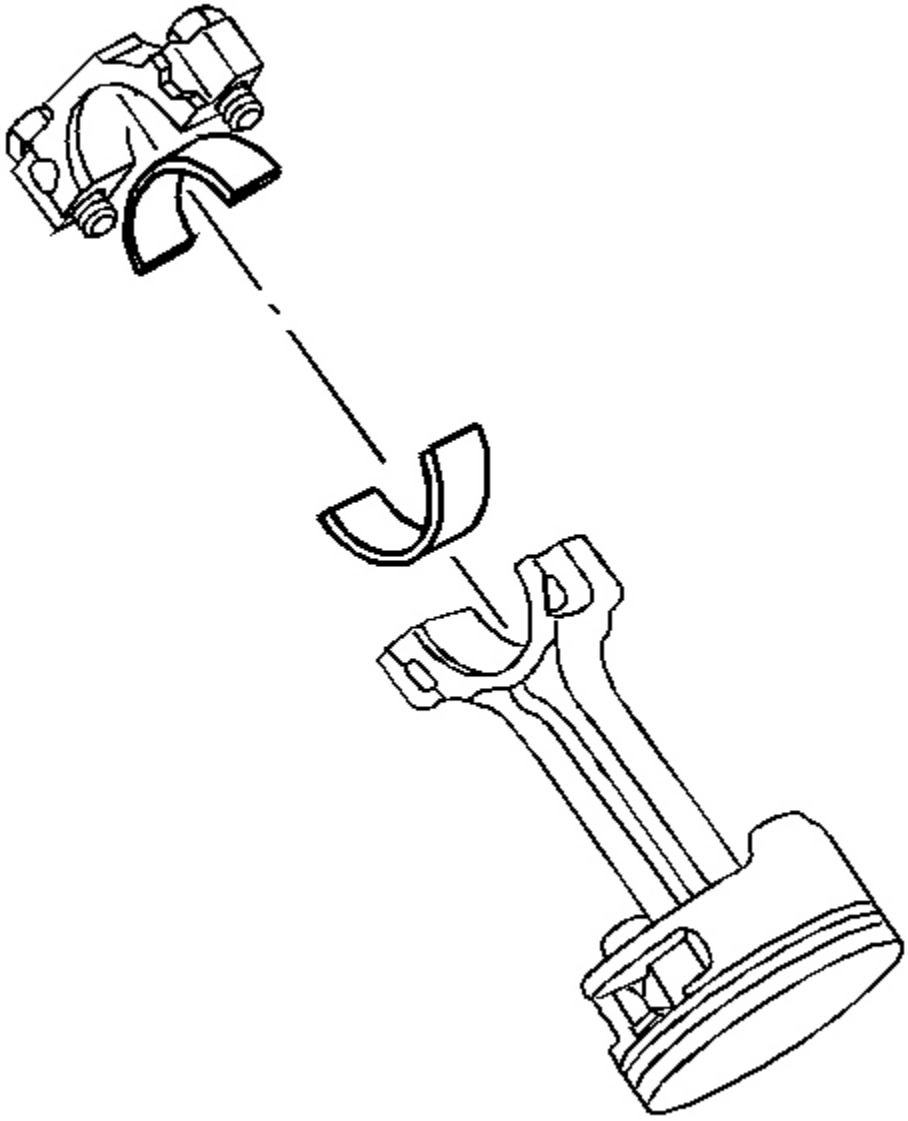


Fig. 108: View Of Piston, Connecting Rod, Bearing Cap, Bearing Halves & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Clean all the oil from behind the connecting rod bearing halves.
3. Install new upper connecting rod bearings into position. Roll the bearing into position so that the lock

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tang engages the alignment slot. The bearing must fit flush in the connecting rod.

4. Install new lower connecting rod bearings into position in the connecting rod cap. Roll the bearing into position so that the lock tang engages the alignment slot. The bearings must fit flush with the connecting rod cap.

CYLINDER HEAD DISASSEMBLE

TOOLS REQUIRED

- **J 8062** Valve Spring Compressor. See **Special Tools** .
- **J 38820** Valve Stem Seal Installer. See **Special Tools** .
- **J 38821** Valve Spring Compressor Adapter. See **Special Tools** .
- **J-43059-A** Valve Retainer Remover/Installer. See **Special Tools** .

DISASSEMBLY PROCEDURE

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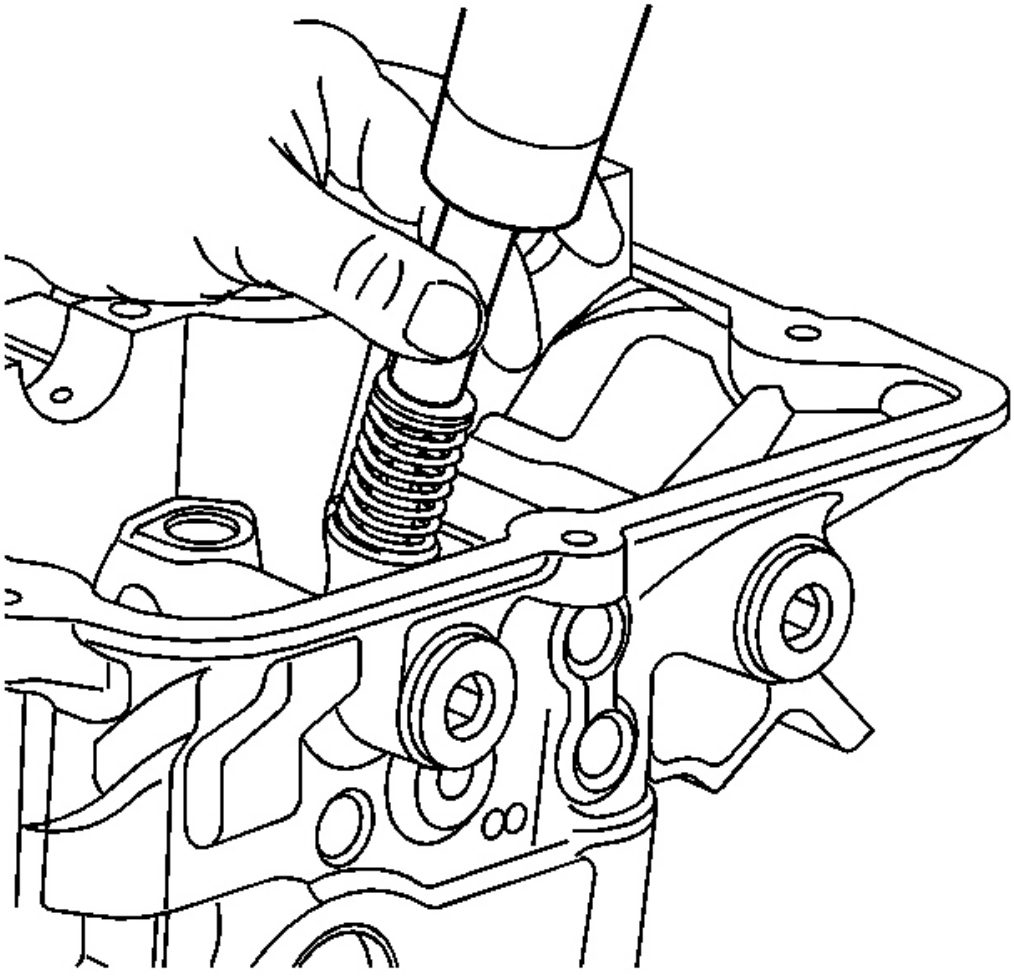


Fig. 109: Loosening Valve Keepers
Courtesy of GENERAL MOTORS CORP.

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

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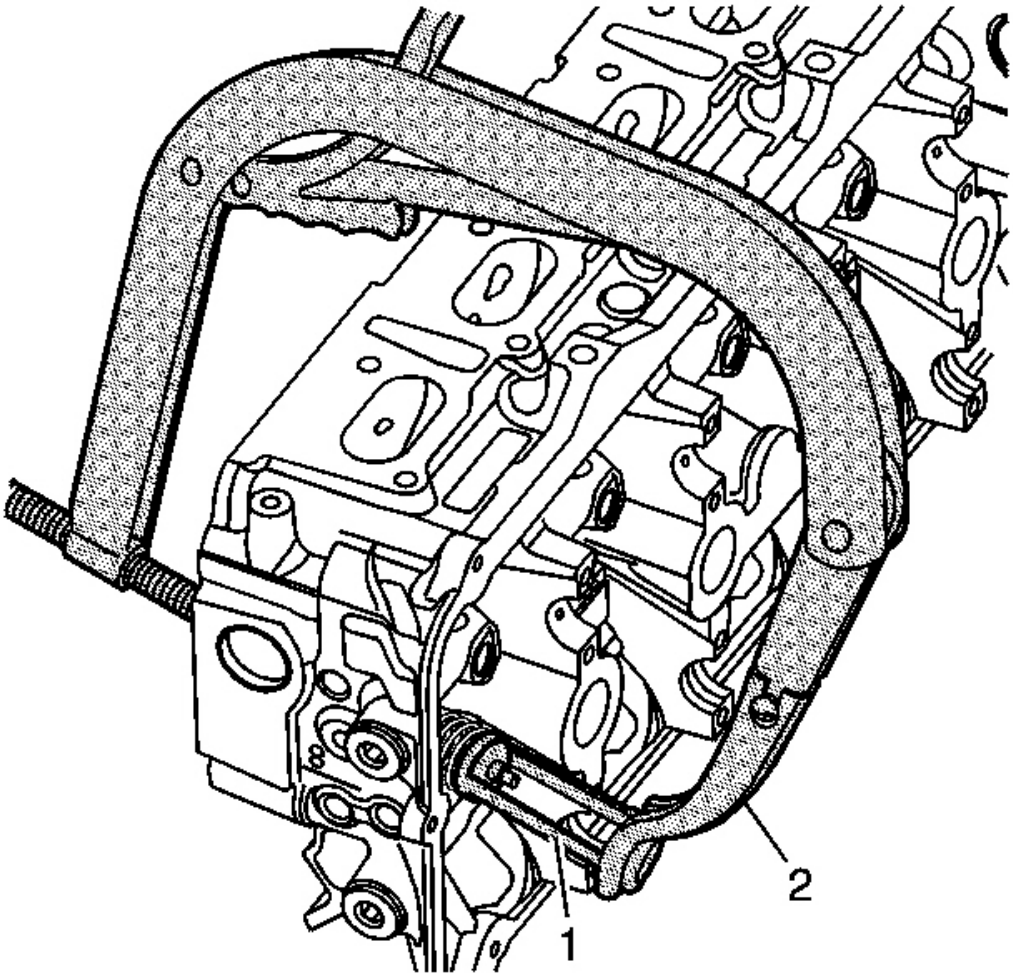


Fig. 110: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Do not compress the valve springs less than 24.0 mm (0.943 in). Contact

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between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

2. Compress the valve spring with the **J 8062** (2) and the **J 38821** (1). See **Special Tools** .

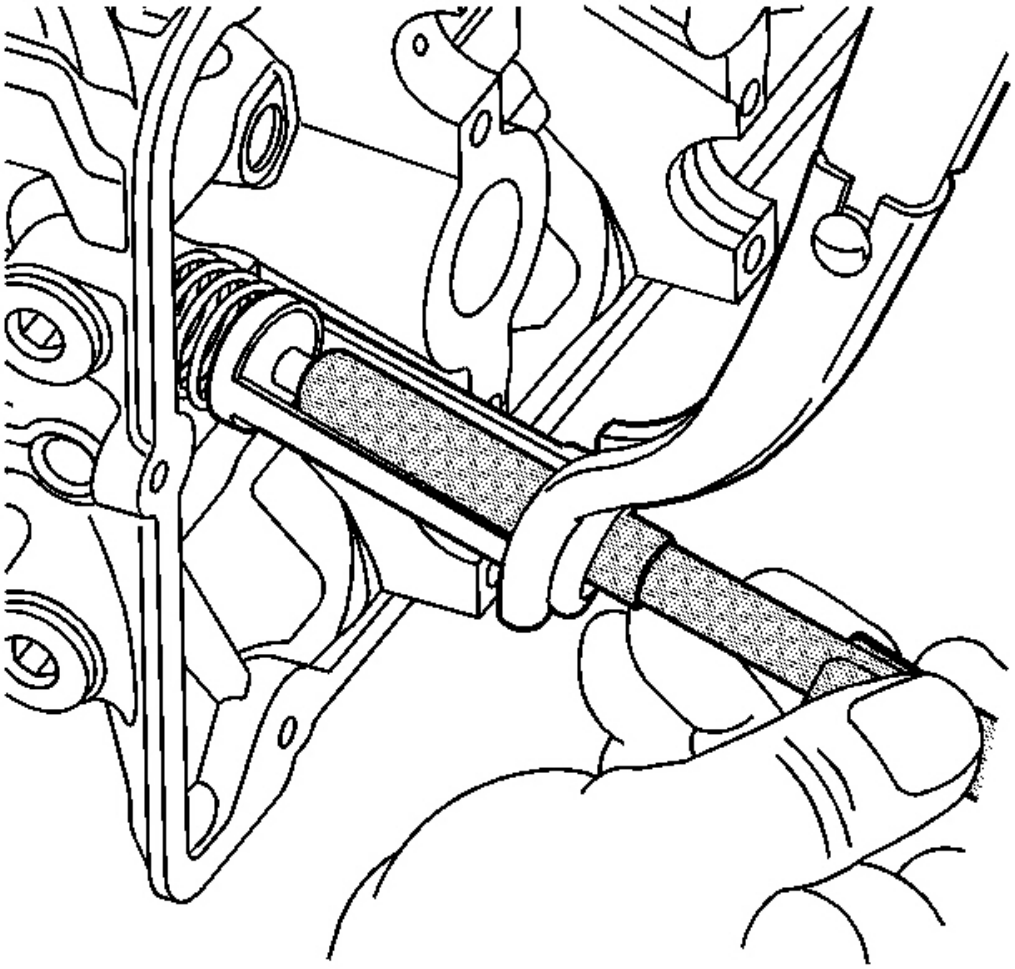


Fig. 111: Removing Valve Keepers
Courtesy of GENERAL MOTORS CORP.

3. Use the magnet of the **J-43059-A** in order to remove the valve keepers. See **Special Tools** .
4. Remove the **J 8062** and the **J 38821** . See **Special Tools** .

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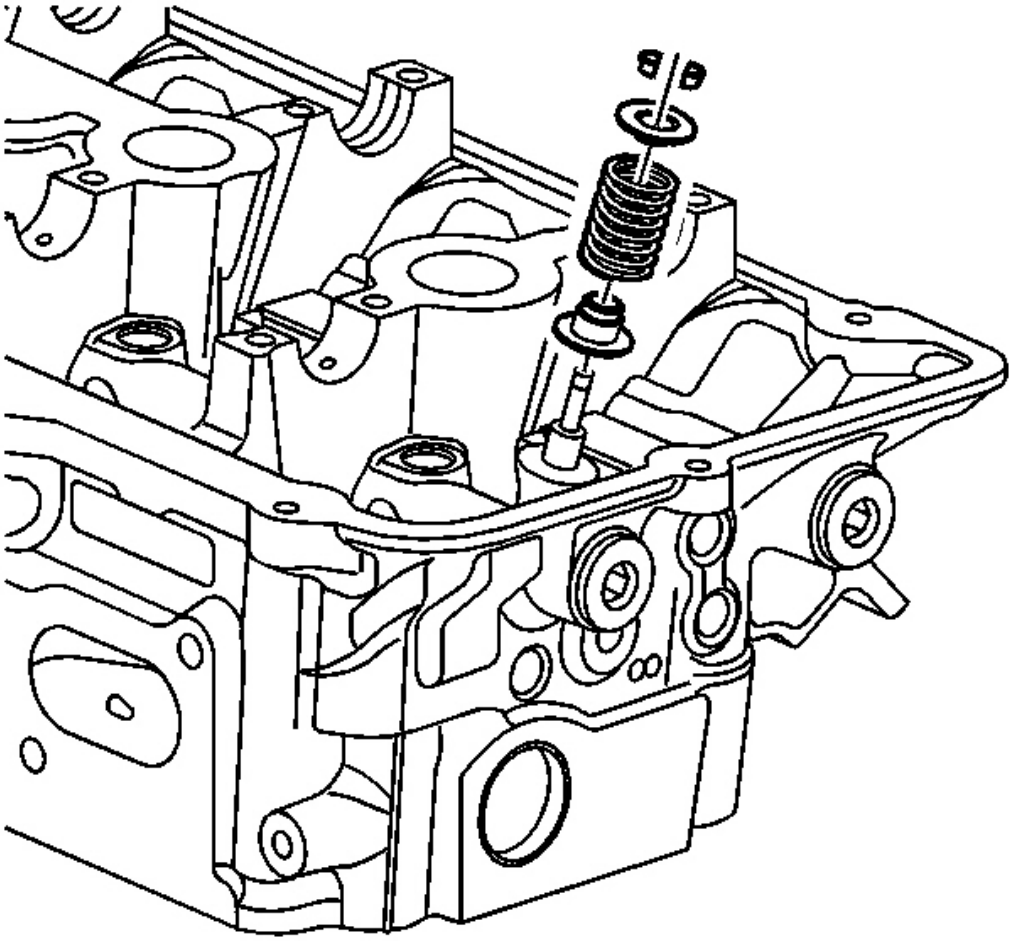


Fig. 112: View Of Valve Spring
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve spring.

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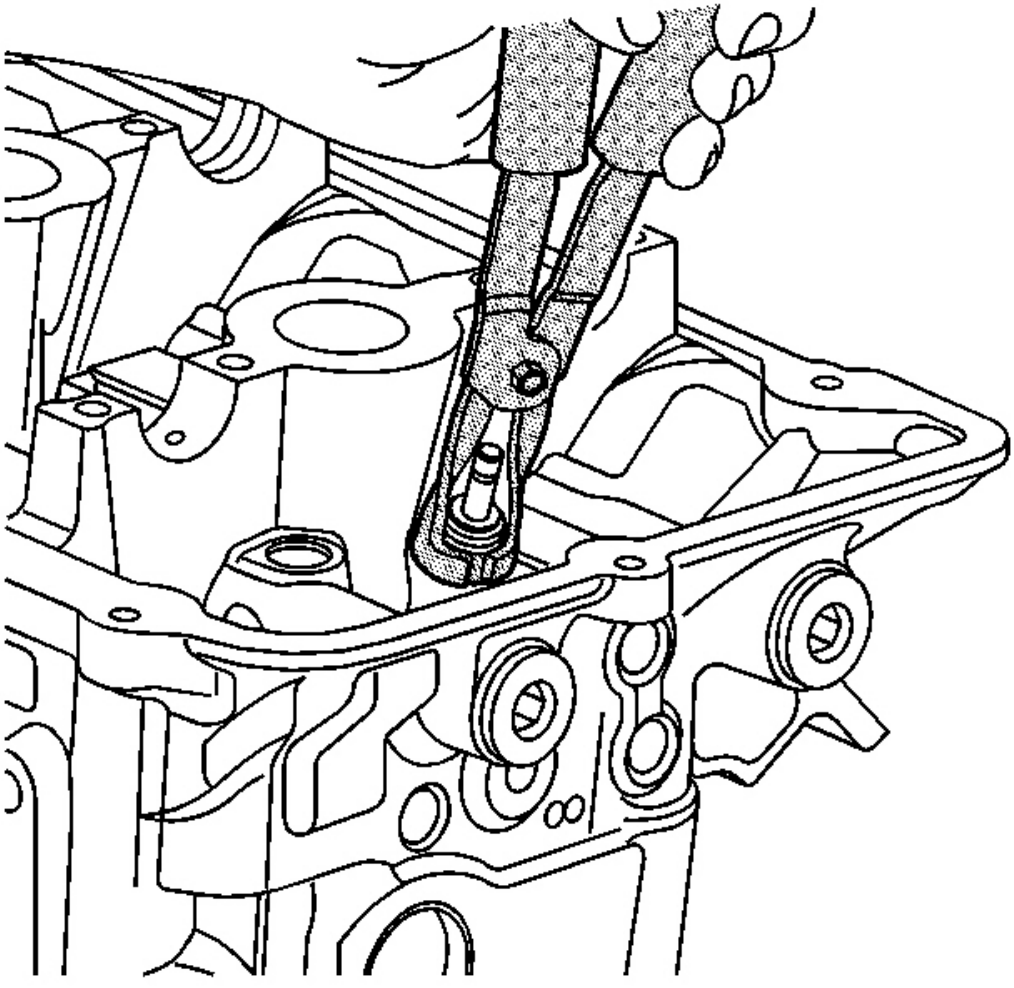


Fig. 113: Removing/Installing Valve Seal
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve seal with the **J 38820** . See **Special Tools** . Discard the valve seal, NEVER re-use the valve seal.
7. Remove the valve.
8. Repeat the procedure for the remaining valves.

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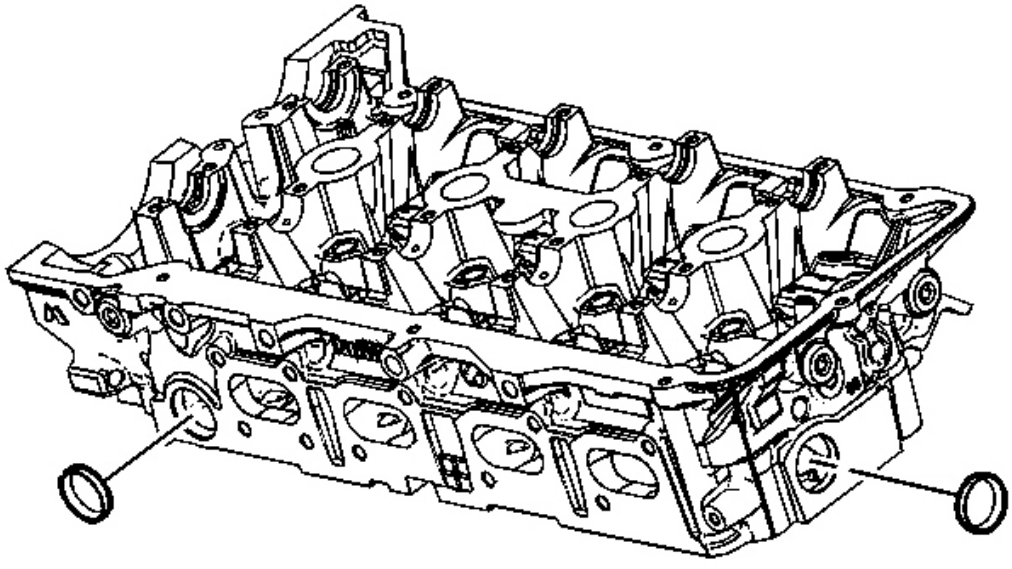


Fig. 114: Identifying Engine Coolant Expansion Plug
Courtesy of GENERAL MOTORS CORP.

9. Remove and discard the engine coolant expansion plugs.

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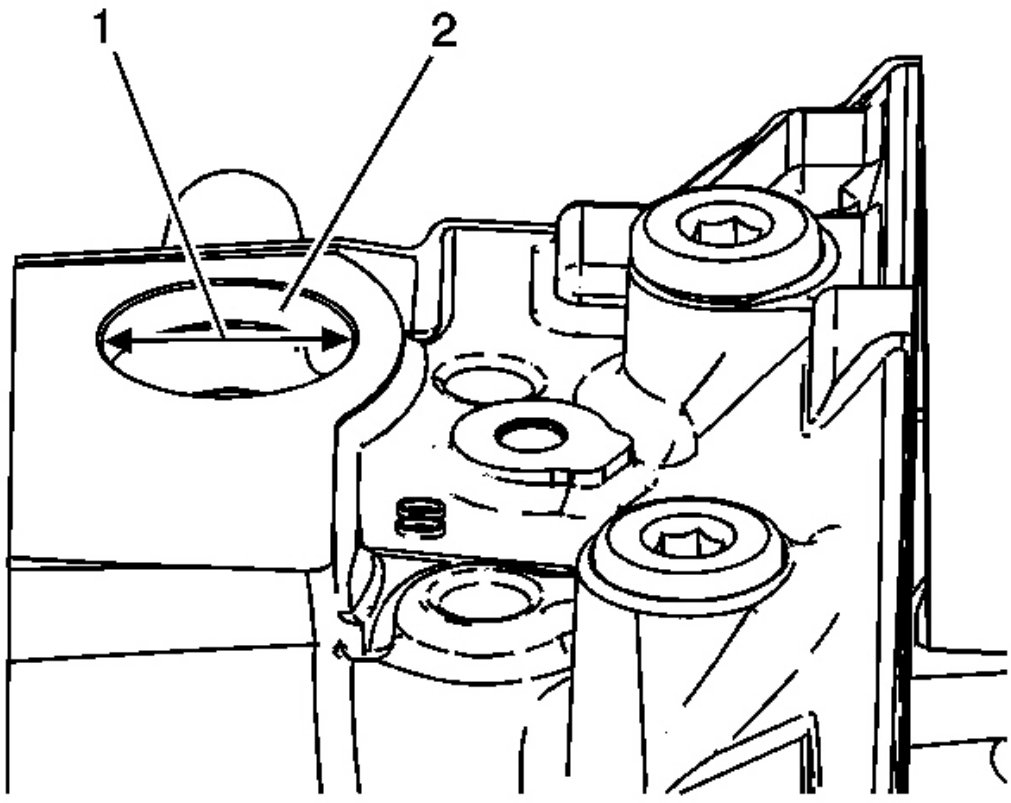


Fig. 115: Inspecting Engine Coolant Expansion Plug Bore
Courtesy of GENERAL MOTORS CORP.

10. Inspect the engine coolant expansion plug bore of the cylinder head. Ensure the hole is concentric, within specifications (1) and not damaged/corroded (2). Replace the cylinder head if necessary.

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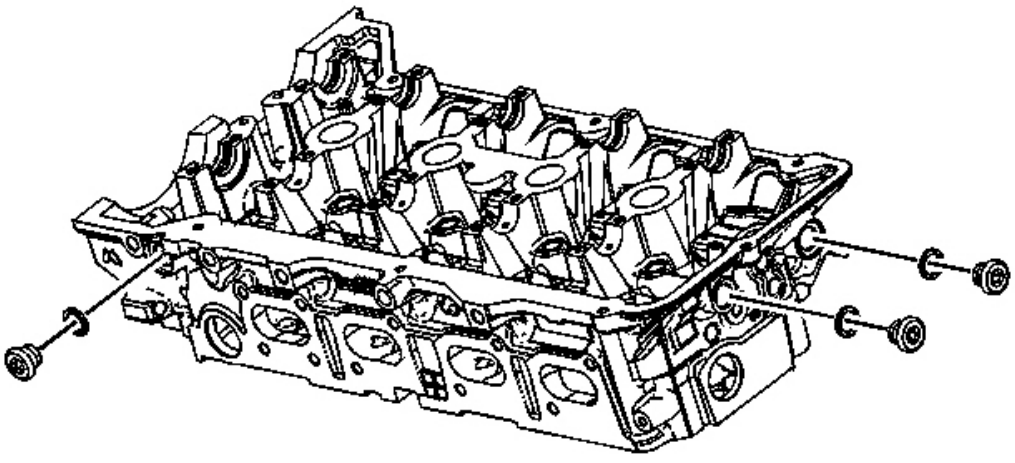


Fig. 116: Identifying Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

11. Remove the oil gallery threaded plugs.

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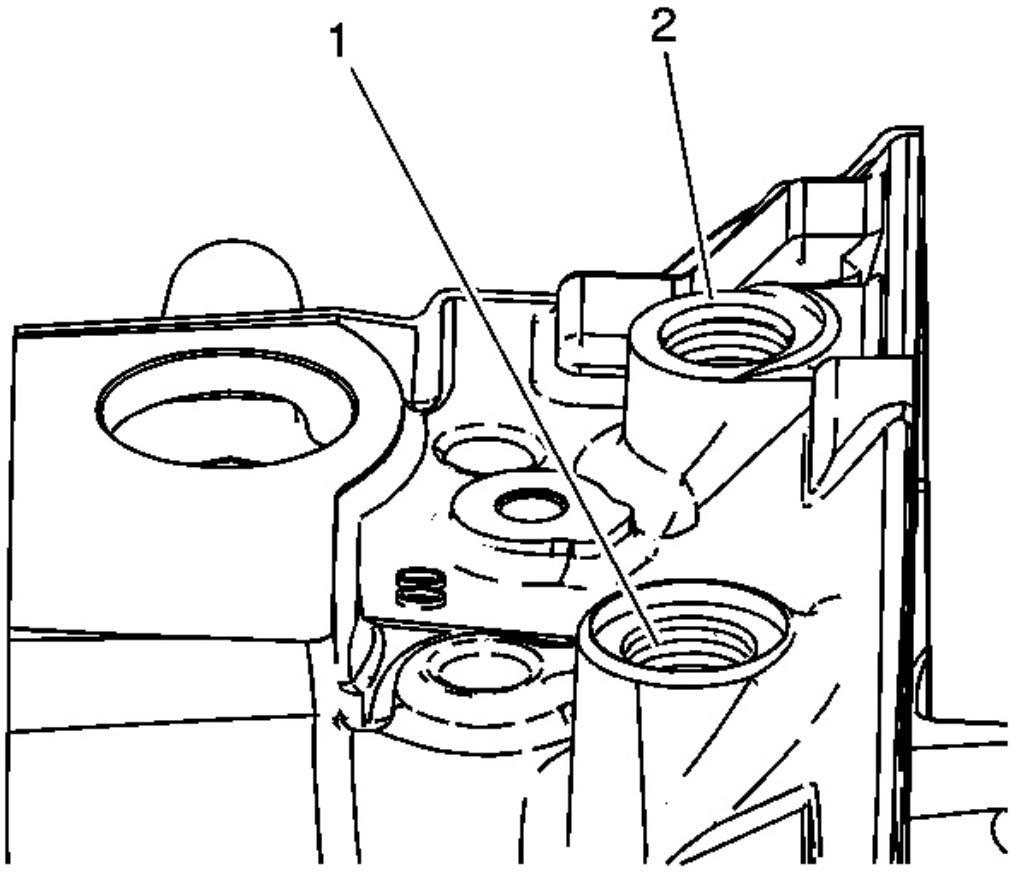


Fig. 117: View Of Oil Gallery Threaded Plug Holes
Courtesy of GENERAL MOTORS CORP.

12. Inspect the oil gallery threaded plug hole threads of the cylinder head. Ensure the threads (1) are serviceable and the washer sealing surface (2) is flat and free of defects. Repair the threads in the cylinder head if necessary.

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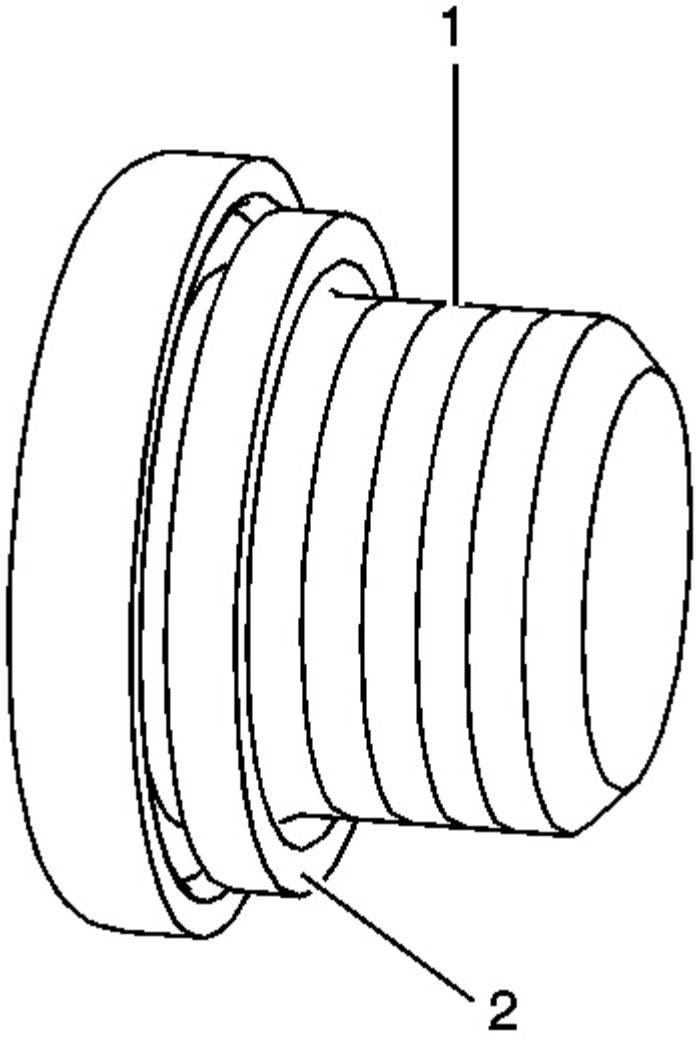


Fig. 118: View Of Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

13. Inspect the oil gallery threaded plugs. Ensure the threads (1) are serviceable and the washer sealing ring surface (2) is flat and free of defects. Replace the oil gallery threaded plugs if necessary.

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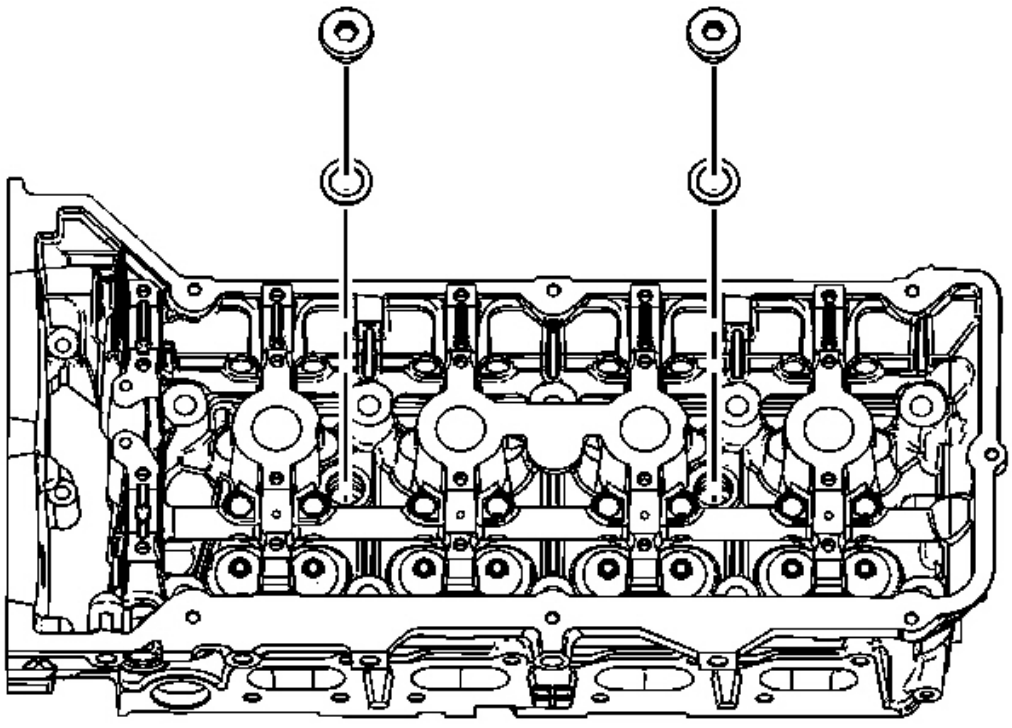


Fig. 119: Identifying Core Hole Threaded Plugs
Courtesy of GENERAL MOTORS CORP.

14. Remove the core hole threaded plugs.

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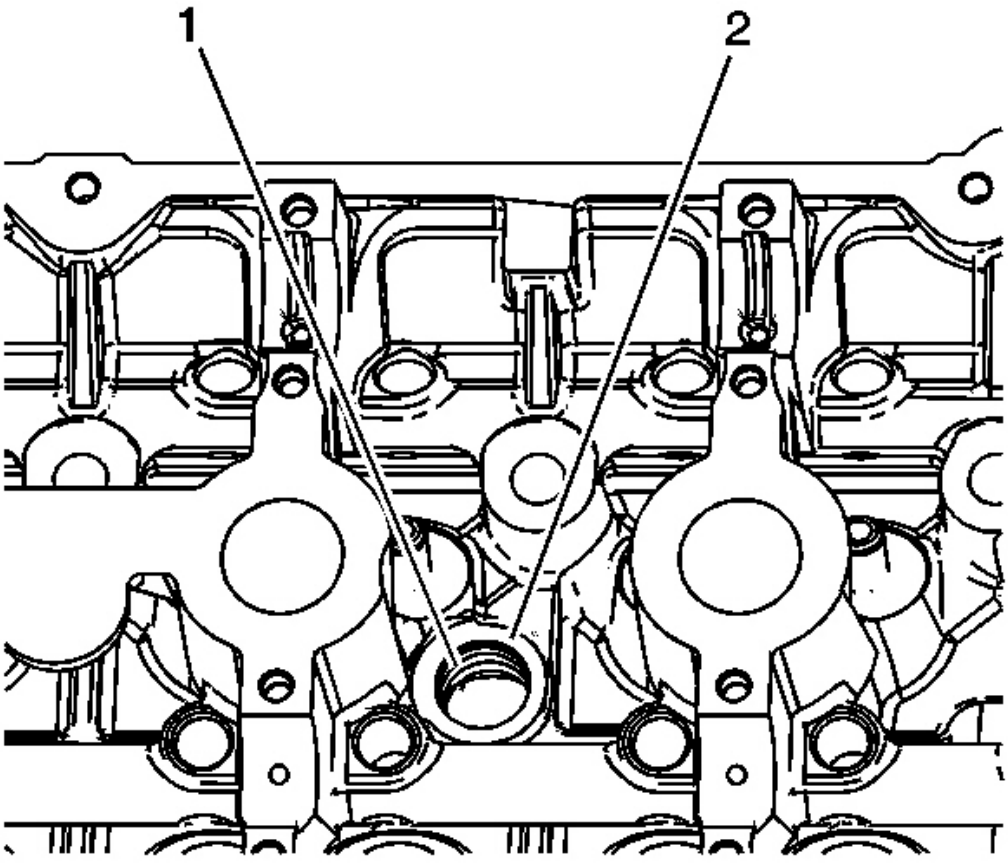


Fig. 120: Identifying Washer Sealing Surface
Courtesy of GENERAL MOTORS CORP.

15. Inspect the core hole threads of the cylinder head. Ensure the threads (1) are serviceable and the washer sealing surface (2) is flat and free of defects. Repair the threads in the cylinder head if necessary.

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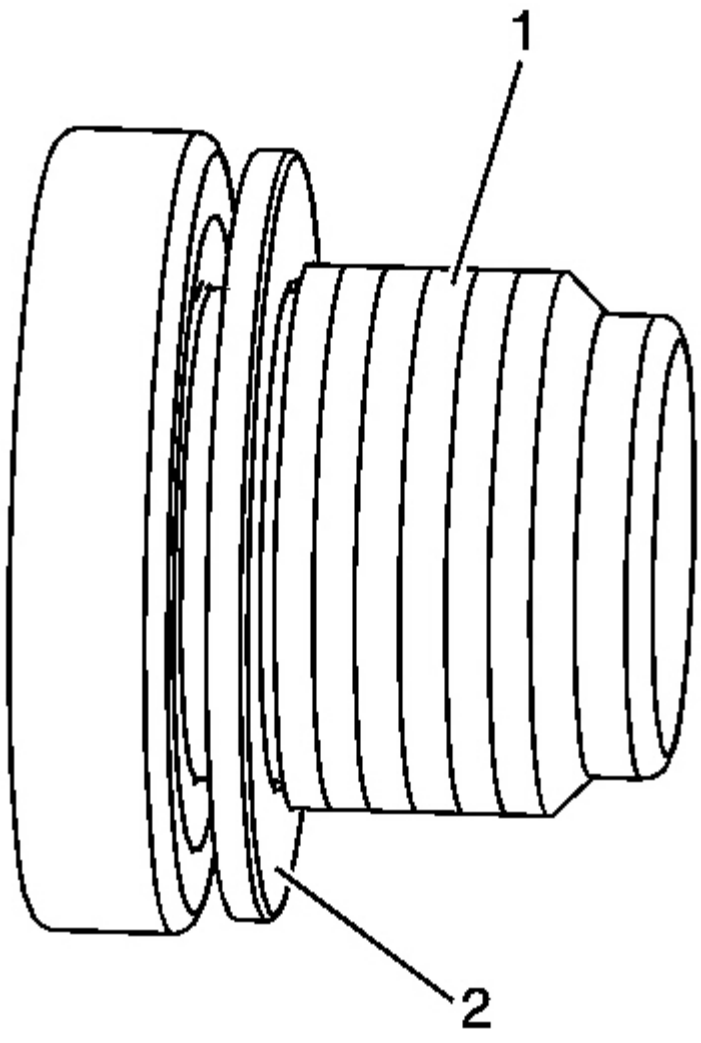


Fig. 121: View Of Core Hole Threaded Plug
Courtesy of GENERAL MOTORS CORP.

16. Inspect the core hole threaded plugs. Ensure the threads (1) are serviceable and the washer sealing ring surface (2) is flat and free of defects. Replace the core hole threaded plugs if necessary.

CYLINDER HEAD CLEANING AND INSPECTION

TOOLS REQUIRED

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- **J 8001** Dial Indicator Set
- **J 8358** Carbon Removal Brush. See **Special Tools** .
- **J 28410** Gasket Remover. See **Special Tools** .

VISUAL INSPECTION PROCEDURE

1. Inspect the cylinder head for the following:
    - Cracks, damage or pitting in the combustion chambers.

      IMPORTANT: DO NOT machine the camshaft bearing journals.

    - Scoring of the camshaft bearings and/or the journals. If the camshaft bearing journals appear to be scored or damaged, you must replace the cylinder head.
    - Debris in the oil galleries. Continue to clean the galleries until all debris is removed.
    - Coolant leaks or damage to the deck face sealing surface. If coolant leaks are present, measure the surface warpage as described under Cylinder Head Measurement.
    - Damage to any gasket surfaces
    - Damage to any threaded bolt holes
    - Burnt or eroded areas in the combustion chamber
    - Cracks in the exhaust ports and combustion chambers
    - External cracks in the water chamber
    - Restrictions in the intake or exhaust passages
    - Restrictions in the cooling system passages
    - Rusted, damaged or leaking core plugs
2. If the cylinder head is cracked or damaged, it must be replaced. No welding or patching of the cylinder head is recommended.

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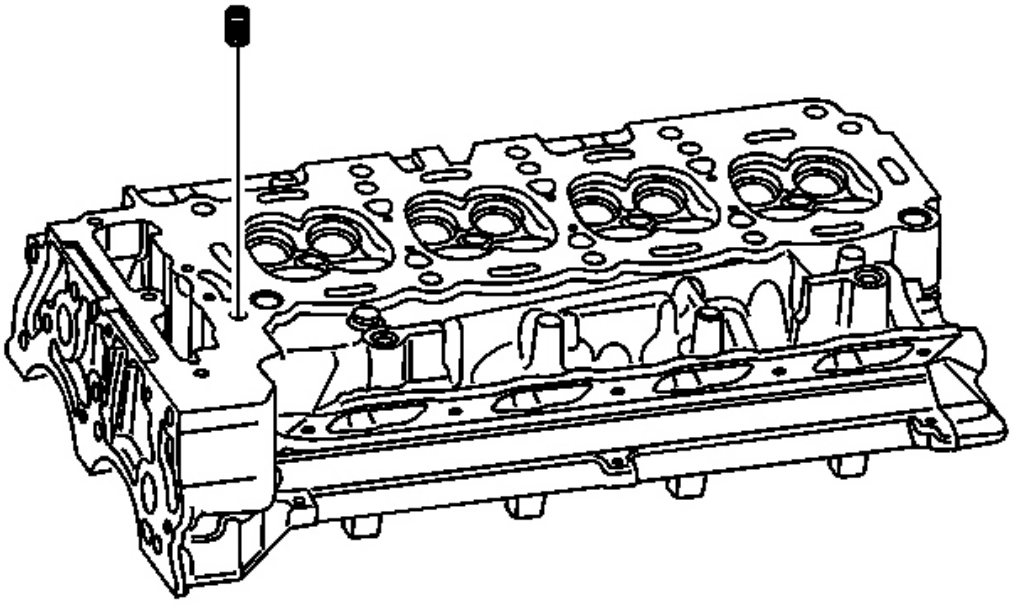


Fig. 122: Locating Left Pressed-In Restrictor
Courtesy of GENERAL MOTORS CORP.

3. The oil passage from the left cylinder head deck face that feeds the stationary hydraulic lifters (SHLAs) and the camshafts has a pressed-in restrictor. The orifice within the restrictor is 3 mm (0.1181 in). DO NOT remove the restrictor. Ensure the restrictor and oil passage are clean and free of any debris.

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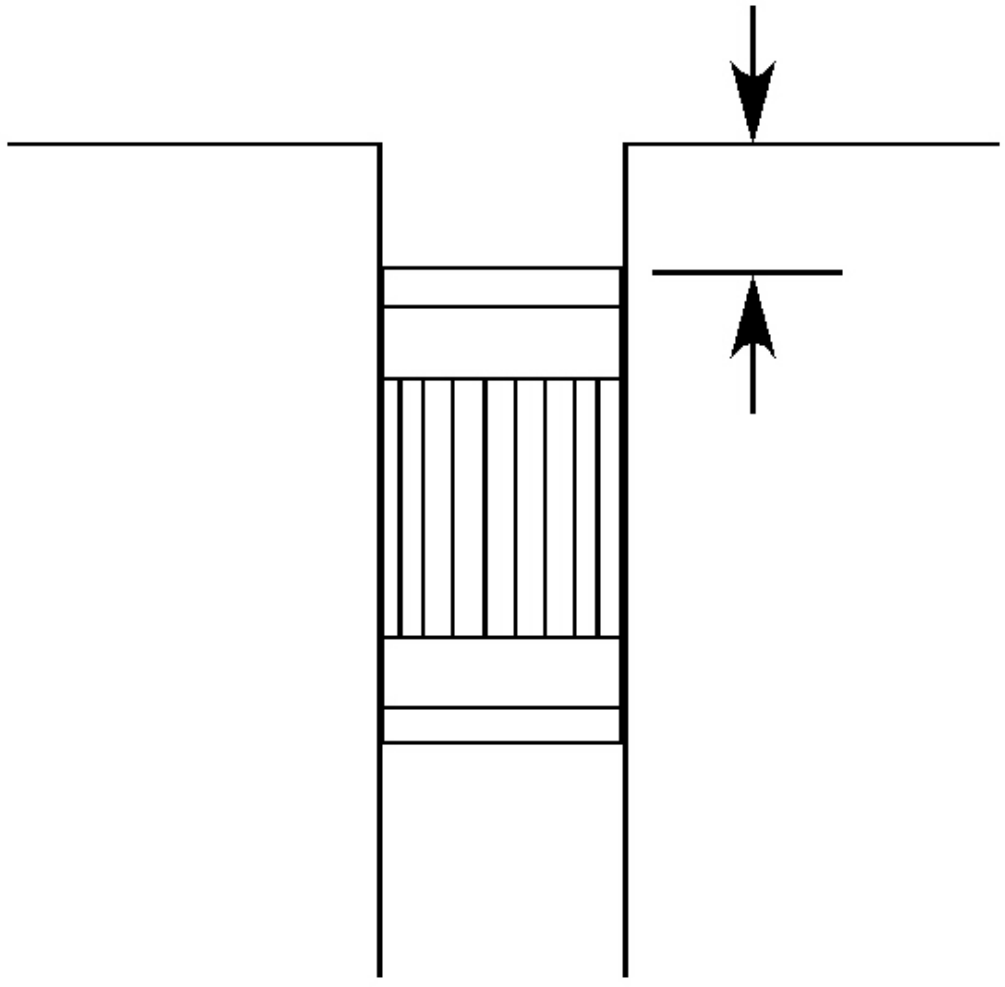


Fig. 123: Insuring Proper Cylinder Head Oil Gallery Restrictor Installation Depth
Courtesy of GENERAL MOTORS CORP.

4. Ensure the left cylinder head oil gallery resticter is installed to the proper depth of 1.5-5.5 mm (0.059-0.216 in).

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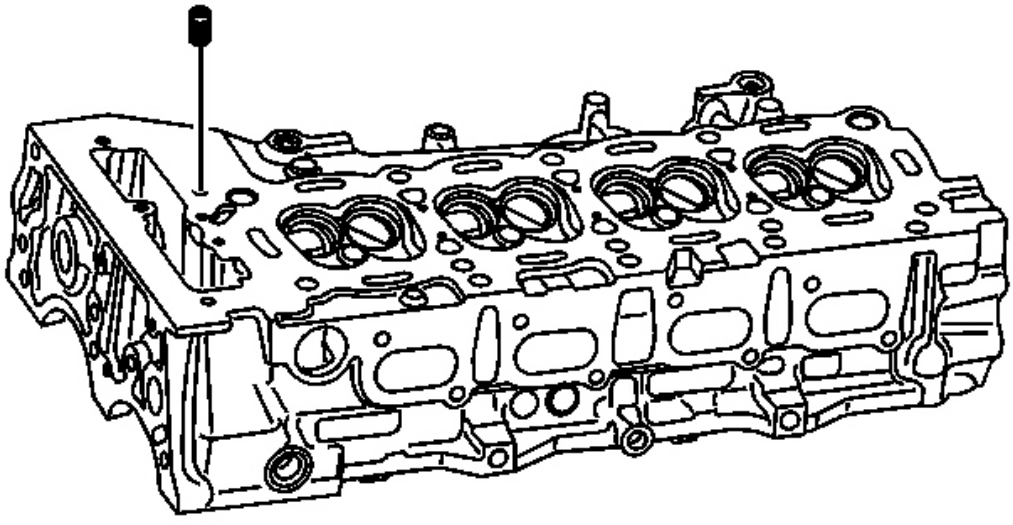


Fig. 124: Locating Right Pressed-In Restrictor
Courtesy of GENERAL MOTORS CORP.

5. The oil passage from the right cylinder head deck face that feeds the stationary hydraulic lifters (SHLAs) and the camshafts has a pressed-in restrictor. The orifice within the restrictor is 3 mm (0.1181 in). DO NOT remove the restrictor. Ensure the restrictor and oil passage are clean and free of any debris.

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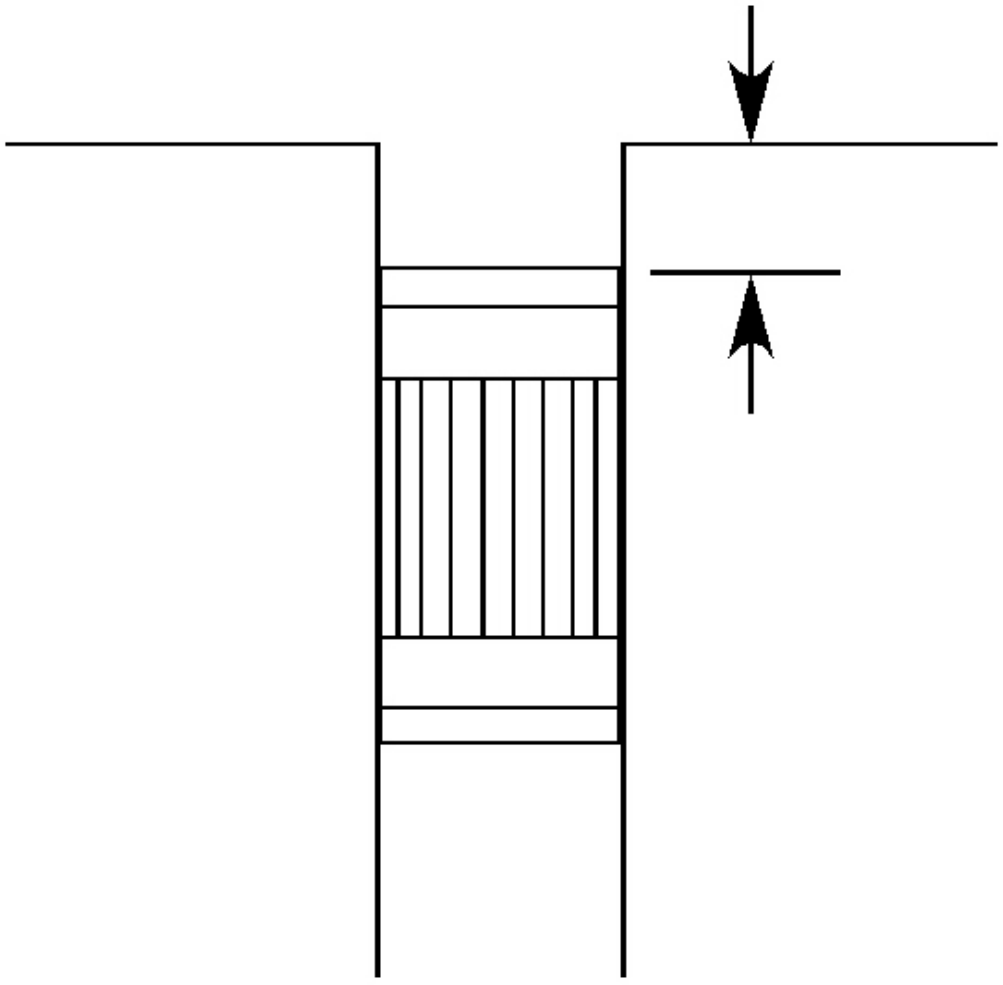


Fig. 125: Insuring Proper Cylinder Head Oil Gallery Restrictor Installation Depth
Courtesy of GENERAL MOTORS CORP.

6. Ensure the right cylinder head oil gallery resticter is installed to the proper depth of 1.5-5.5 mm (0.059-0.216 in).

CLEANING PROCEDURE

1. Clean all cylinder head surfaces with non-corrosive solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

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2. Blow out all the oil galleries using compressed air.
3. Remove any carbon deposits from the combustion chambers using the **J 8358** . See **Special Tools** .
4. Remove any gasket material with the **J 28410** . See **Special Tools** .
5. Clean any debris or build-up from the lifter pockets.
6. Inspect the cylinder head again for the items noted under Visual Inspection.

CYLINDER HEAD MEASUREMENT

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Measure the camshaft clearance specification using the following procedure:
    1. Install the camshaft caps.
    2. Install the camshaft caps bolts.

       Tighten: Tighten the camshaft bearing caps bolts to 5 N.m (44 lb in).

    3. Measure the camshaft bearings using an inside micrometer.
    4. Inspect and measure the camshaft journal diameters. Refer to **Camshaft Cleaning and Inspection**.
    5. Subtract the camshaft journal diameter from the camshaft bearing diameter in order to obtain the running clearance.
    6. If the running clearance exceeds the specifications and the camshaft journals are within specification, replace the cylinder head. Refer to **Engine Mechanical Specifications** .
2. Measure the camshaft thrust specification using the following procedure:
    1. Inspect each camshaft cap thrust surface for excessive scoring/wear.
    2. Inspect each camshaft. Refer to **Camshaft Cleaning and Inspection**.
    3. Install the intake and exhaust camshafts in the cylinder head.
    4. Install the camshaft caps.
    5. Install the camshaft caps bolts.

       Tighten: Tighten the camshaft bearing caps bolts to 5 N.m (44 lb in).

    6. Measure the camshaft thrust bearing clearance at the front camshaft bearing cap. Refer to **Engine Mechanical Specifications** .
    7. If the camshaft thrust bearing clearance is not to specification repair or replace the cylinder head.

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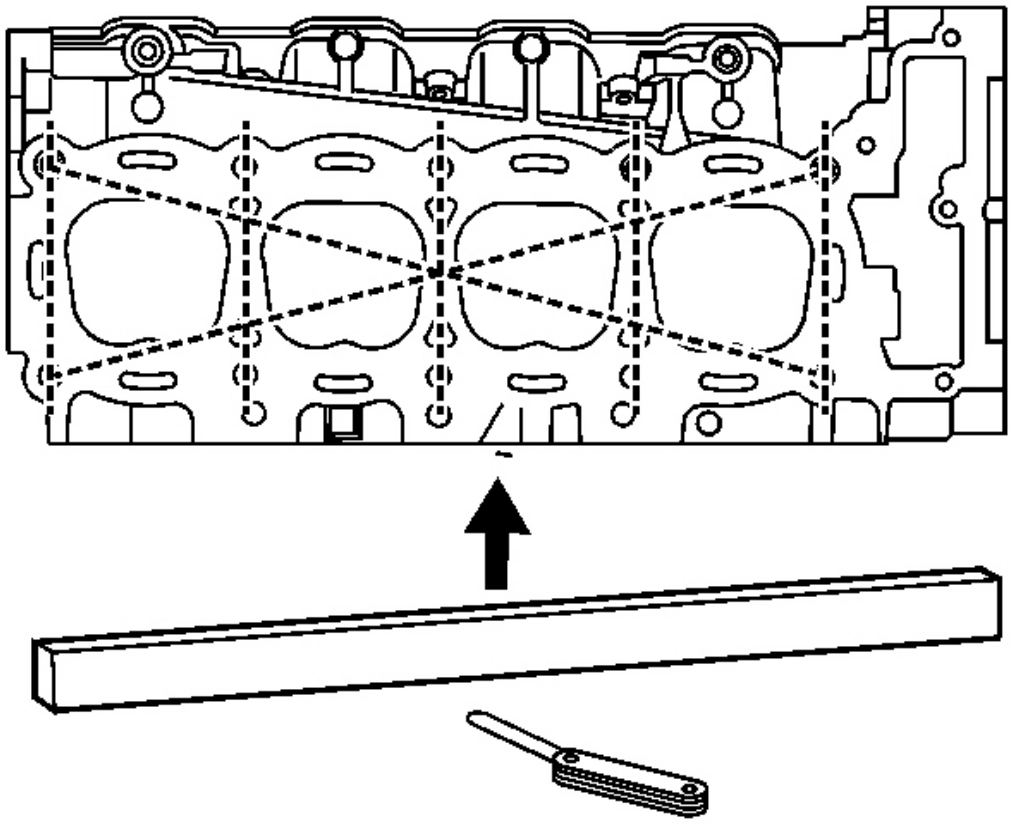


Fig. 126: Measuring Cylinder Head Flatness
Courtesy of GENERAL MOTORS CORP.

3. Measure the cylinder head flatness using the following procedure:
    1. Clean any remaining head gasket material from the cylinder head face.
    2. Place a straight-edge diagonally across the cylinder head face surface.
    3. Measure the clearance between the straight-edge and the cylinder head using a feeler gage at four points along the straight-edge.
        - If warpage is less than 0.05 mm (0.002 in), the cylinder head surface does not require resurfacing.
        - If warpage is between 0.05-0.20 mm (0.002-0.008 in), the cylinder head must be resurfaced.

VALVE GUIDE MEASUREMENT PROCEDURE

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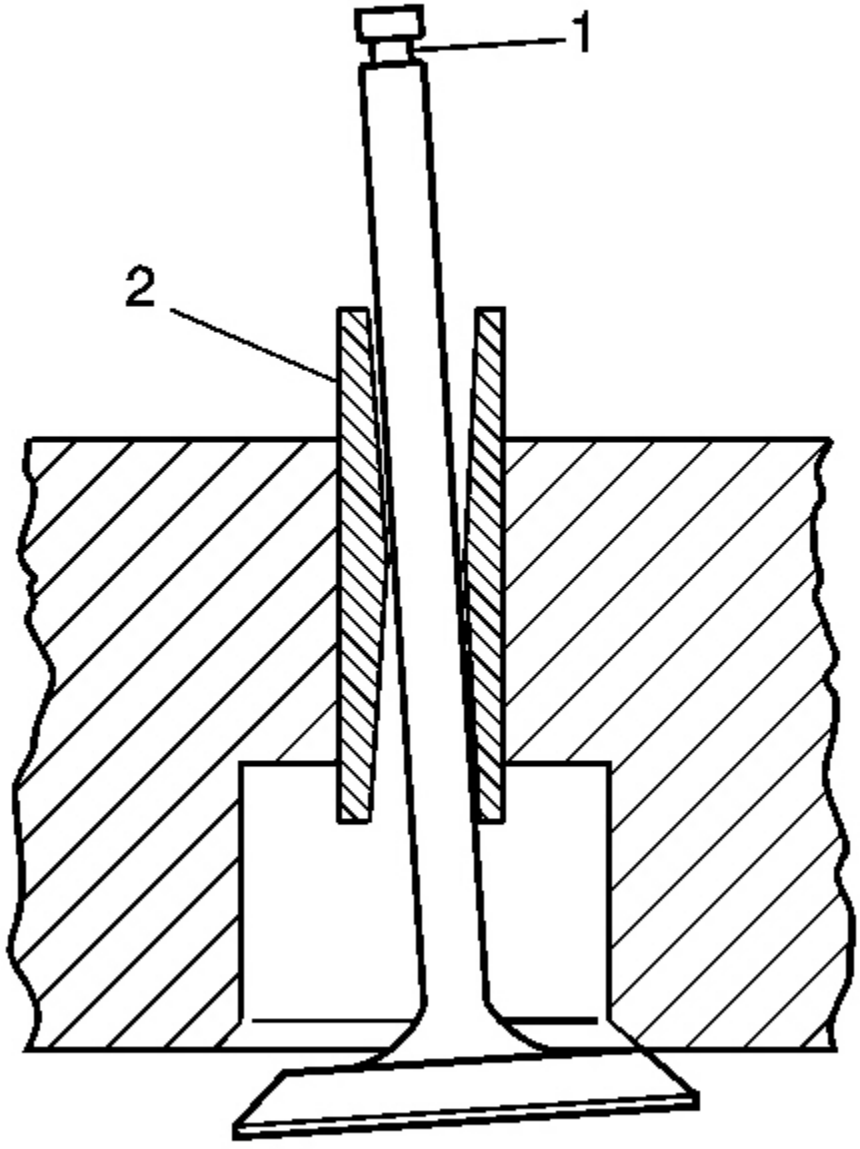


Fig. 127: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve stem (1)-to-guide (2) clearance as follows:
    - Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also case a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.

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- Clamp the **J 8001** to the cylinder head at the camshaft cover rail.
- Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem.

  The dial indicator stem must contact the side of the valve stem just above the valve guide.

- Drop the valve head about 1.6 mm (0.0064 in) off the valve seat.
- Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading.

2. If the clearance for the intake valve is greater than 0.11 mm (0.0045 in) and a new standard diameter valve stem will not bring the clearance within specifications, the cylinder head must be replaced.
3. If the clearance for the exhaust valve is greater than 0.12 mm (0.005 in) and a new standard diameter valve stem will not bring the clearance within specifications, the cylinder head must be replaced.
4. Valve guide wear at the bottom 10 mm (0.39 in) of the valve guide is not significant to normal operation.

VALVE SPRING INSPECTION AND MEASUREMENT

TOOLS REQUIRED

J 22738-B Valve Spring Tester. See **Special Tools** .

INSPECTION AND MEASUREMENT PROCEDURE

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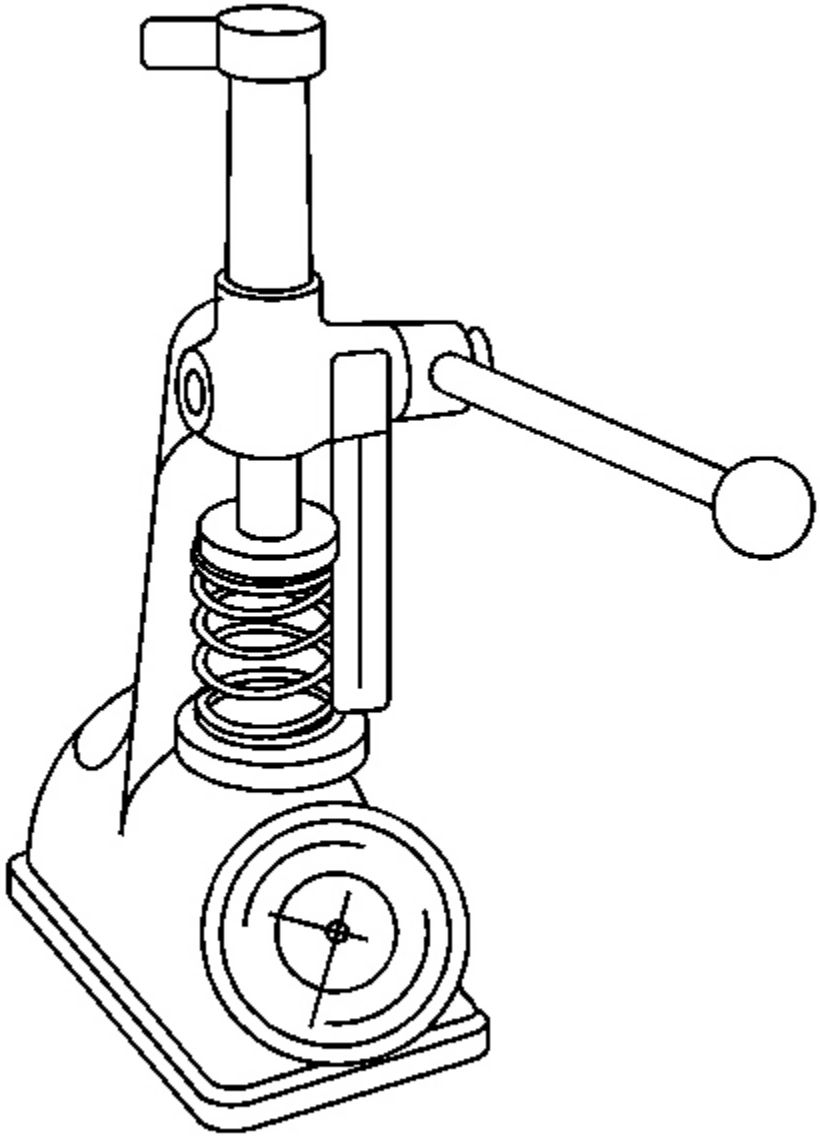


Fig. 128: Inspecting Valve Spring
Courtesy of GENERAL MOTORS CORP.

1. Place the valve spring in the **J 22738-B** . See **Special Tools** .
2. Compress the **J 22738-B** to the valve open, valve spring compressed, dimension listed in the **Engine Mechanical Specifications** . See **Special Tools** .

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

3. If low valve spring load is found to be too low, replace the valve spring, DO NOT shim.

VALVE AND SEAT GRINDING

VALVE CLEANING PROCEDURE

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

VALVE VISUAL INSPECTION PROCEDURE

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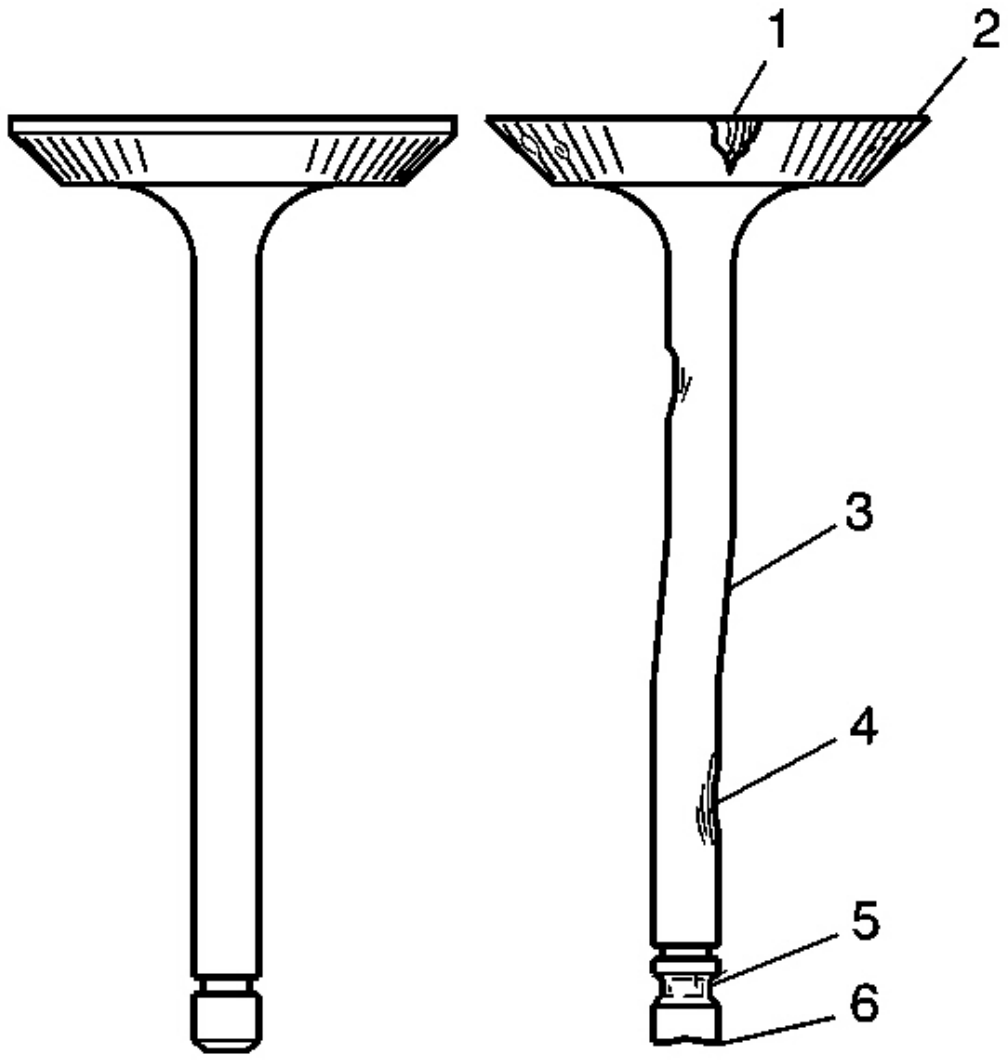


Fig. 129: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

1. Inspect the valve for damage from the head to tip for the following conditions:
    - Pitting in the valve seat area (1)
    - Lack of valve margin (2)
    - Bending in the valve stem (3)
    - Pitting or excessive wear in the stem (4)
    - Worn valve key grooves (5)

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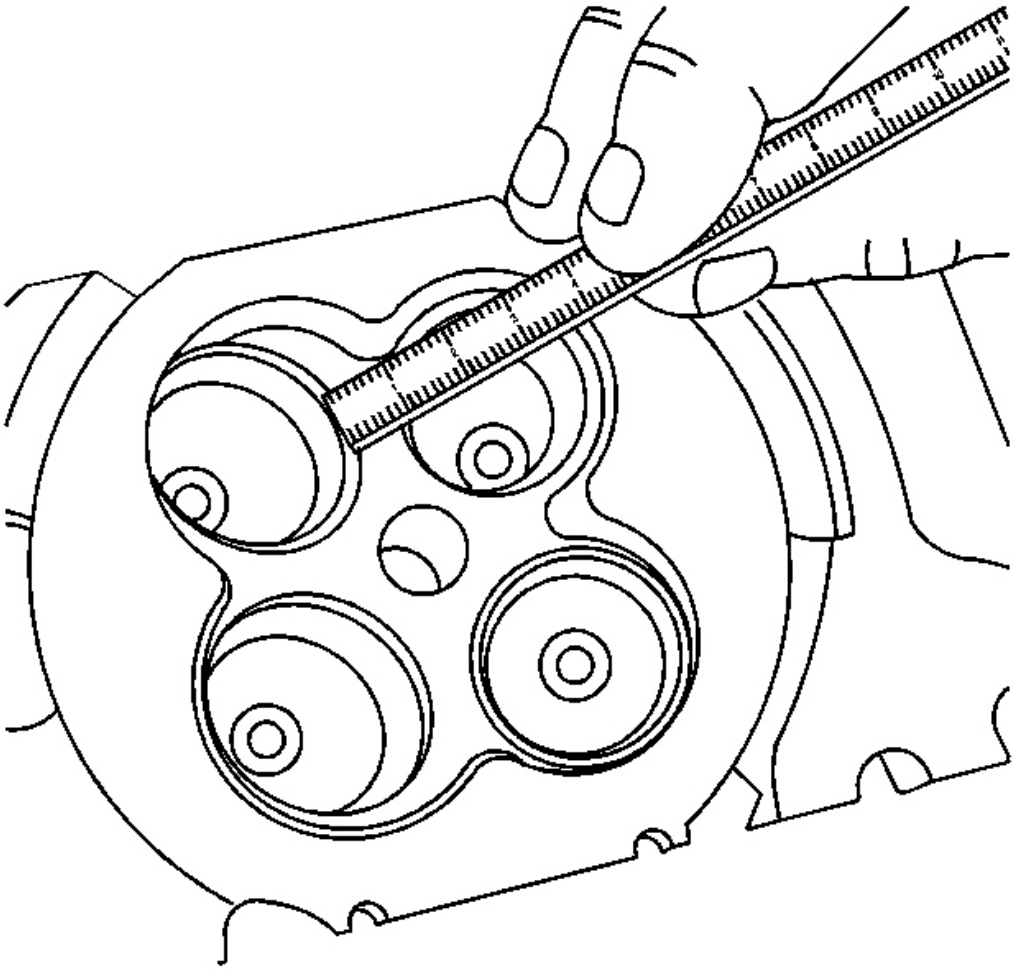
- Worn valve tip (6)

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

VALVE MEASUREMENT AND RECONDITIONING OVERVIEW

- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning.

VALVE SEAT WIDTH MEASUREMENT PROCEDURE



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Fig. 130: Checking Valve Seat Width
Courtesy of GENERAL MOTORS CORP.

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

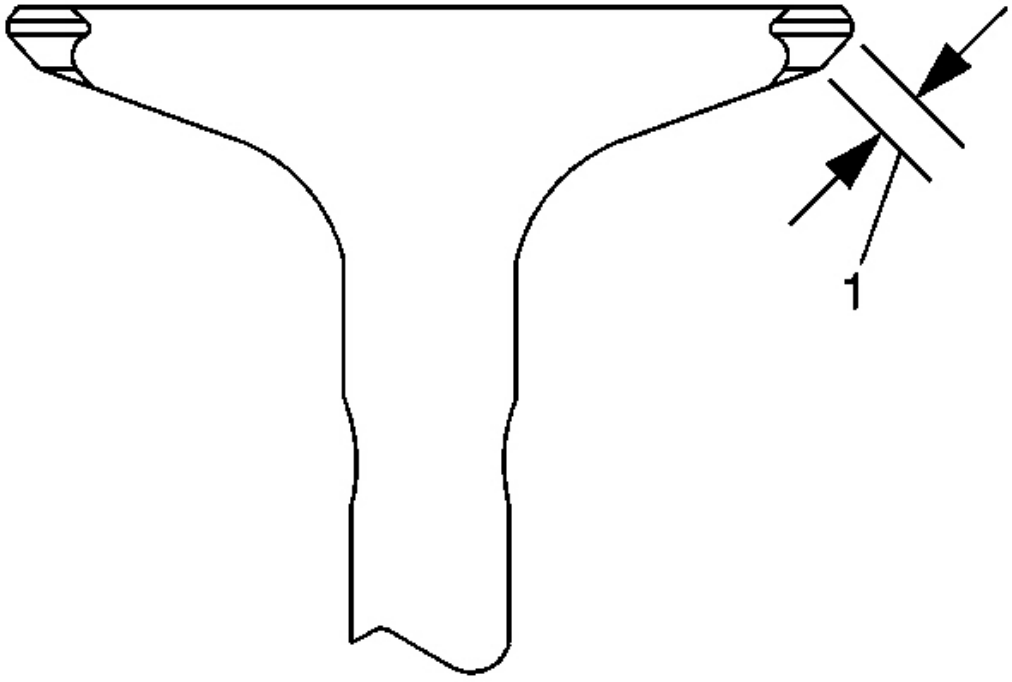


Fig. 131: Measuring Seat Width On Valve Face
Courtesy of GENERAL MOTORS CORP.

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

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

3. Compare your measurements with the specifications listed in **Engine Mechanical Specifications** .
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. Proper valve seat width is critical to providing the

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correct amount of valve heat dissipation.

VALVE SEAT ROUNDNESS MEASUREMENT PROCEDURE

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

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

2. Compare your measurements with the specifications listed in **Engine Mechanical Specifications** .
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

VALVE MARGIN MEASUREMENT PROCEDURE

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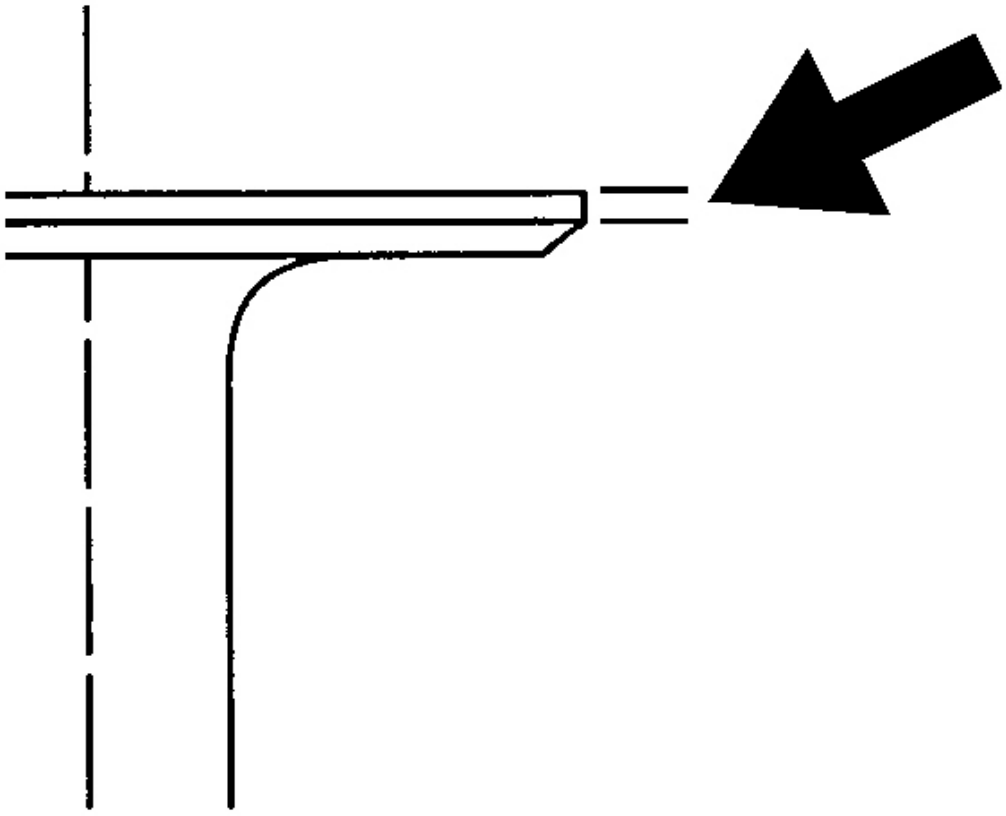


Fig. 132: View Of Valve Margin Measurement
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve margin using an appropriate scale.
2. Reference the specifications in this section for minimum valve margin and compare them to your measurements.
3. If the valve margins are beyond specification, replace the valves.
4. If the valve margins are within specification and do not require refacing, test the valve for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

VALVE-TO-SEAT CONCENTRICITY MEASUREMENT PROCEDURE

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

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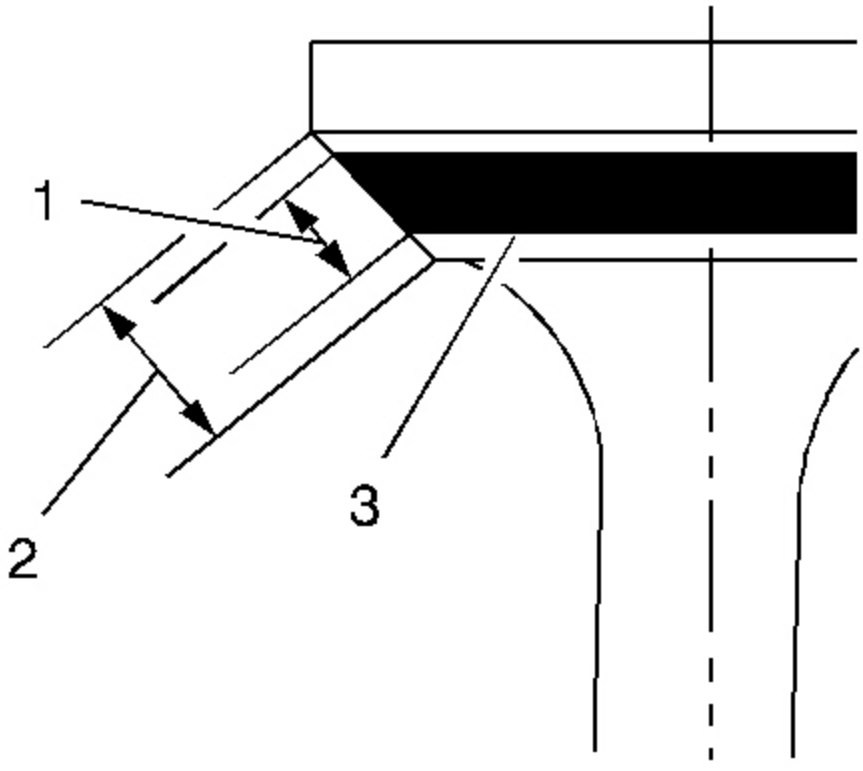


Fig. 133: View Of Valve Contact Face Measurements
Courtesy of GENERAL MOTORS CORP.

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

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

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

VALVE AND SEAT RECONDITIONING PROCEDURE

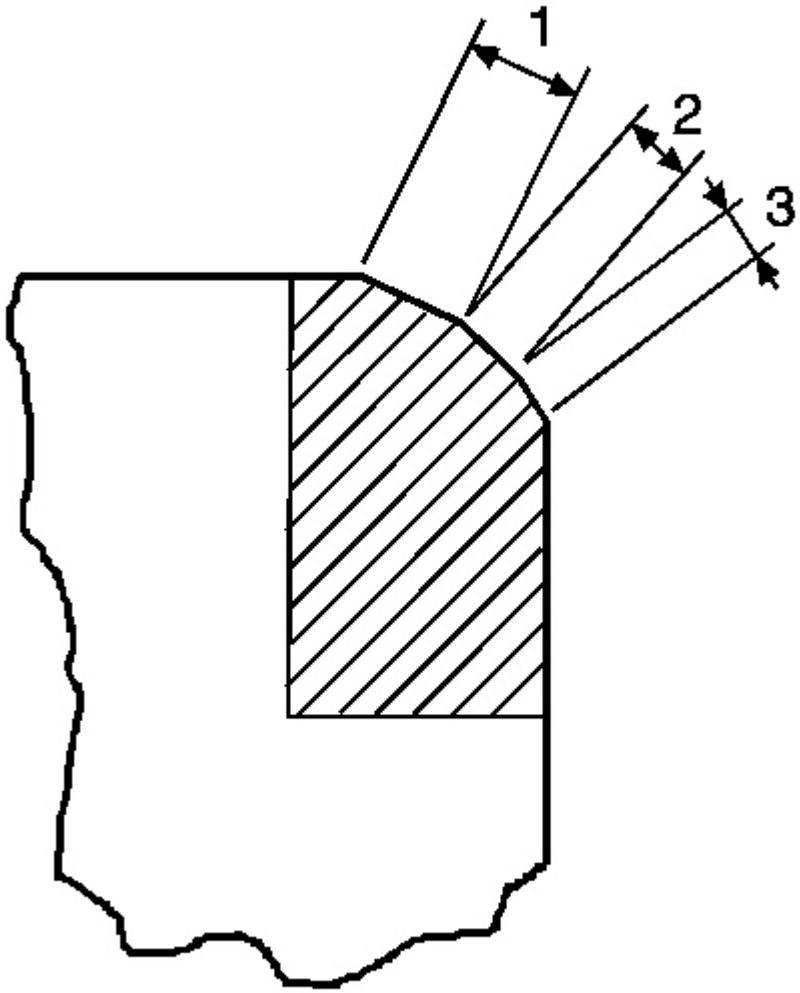


Fig. 134: Illustrating Valve Seat Proper Angles
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **If the valve seat width, roundness or concentricity is beyond**

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specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.

- **It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.**

1. Grind the valve seats (2) to the proper angle specification listed in **Engine Mechanical Specifications** .
2. Using the proper angle specification listed in **Engine Mechanical Specifications** , grind, relieve, the valve seats (1) to correctly position the valve seating surface (2) to the valve.
3. Using the proper angle specification listed in **Engine Mechanical Specifications** , grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in **Engine Mechanical Specifications** .
4. If the original valve is being used, grind the valve to the specifications listed in **Engine Mechanical Specifications** . Measure the valve margin again after grinding using the Valve Margin Measurement Procedure. Replace the valve if the margin is out of specification. New valves do not require grinding.
5. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
6. Install the valve in the cylinder head.
   - If you are using refaced valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.

     IMPORTANT: Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.

   - If you are using new valves, do not lap the valves under any condition.
7. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
8. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

VALVE STEM HEIGHT MEASUREMENT PROCEDURE

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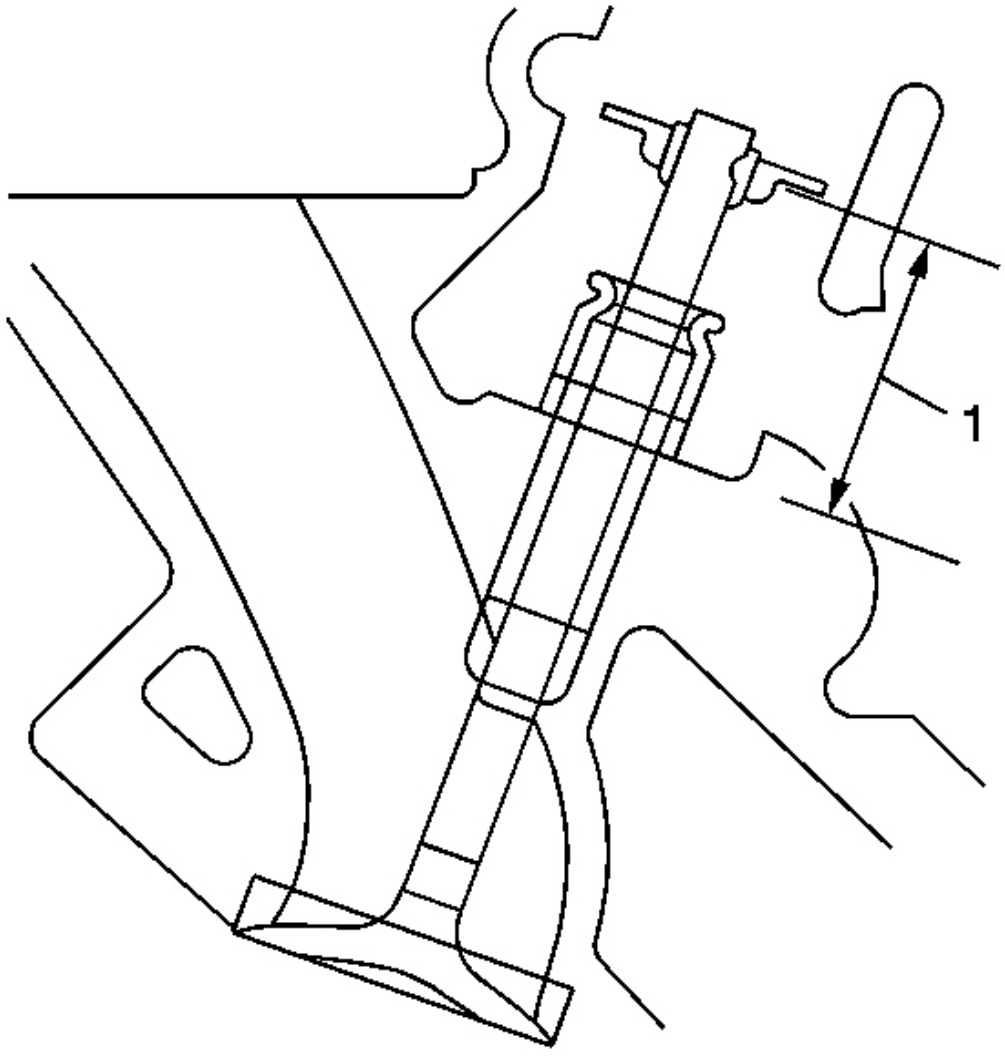


Fig. 135: Measuring Valve Stem Height
Courtesy of GENERAL MOTORS CORP.

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

1. Install the valve into the valve guide.
2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.

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4. Install the valve spring retainer and valve stem locks.
5. Measure the distance (1) between the valve stem oil seal spring seat to the bottom of the valve spring retainer.
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

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

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

7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

CYLINDER HEAD ASSEMBLE

TOOLS REQUIRED

- **J 8062** Valve Spring Compressor. See **Special Tools** .
- **J 38820** Valve Stem Seal Installer. See **Special Tools** .
- **J 38821** Valve Spring Compressor Adapter. See **Special Tools** .
- **J-43059-A** Valve Retainer Remover/Installer. See **Special Tools** .

ASSEMBLY PROCEDURE

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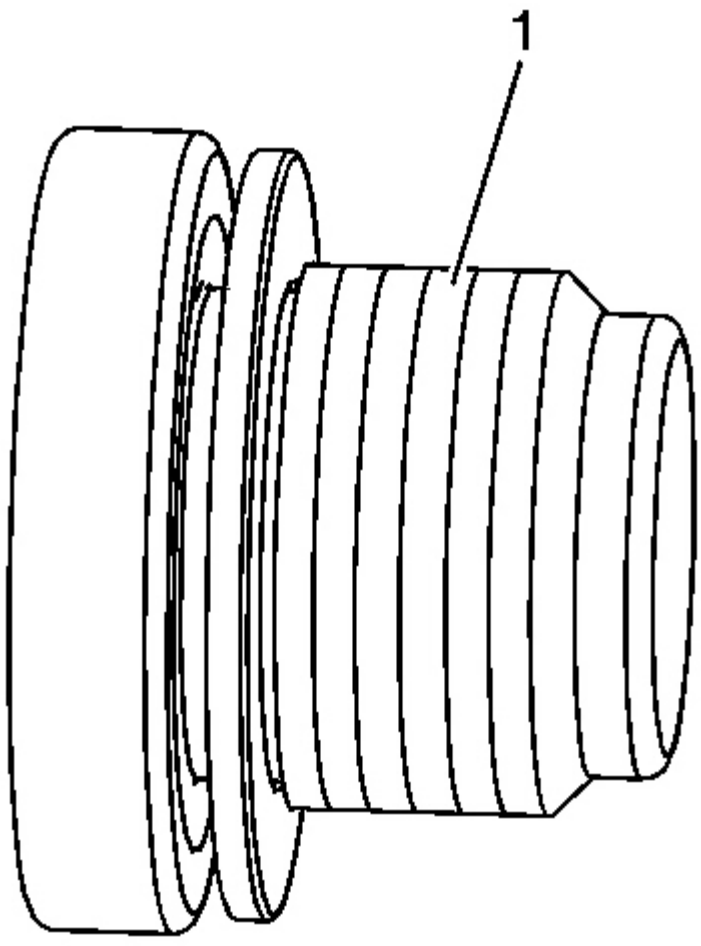


Fig. 136: View Of Core Hole Threaded Plug
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant GM P/N 12345382 (Canadian P/N 10953489) to the threads (1) of the core hole threaded plugs.

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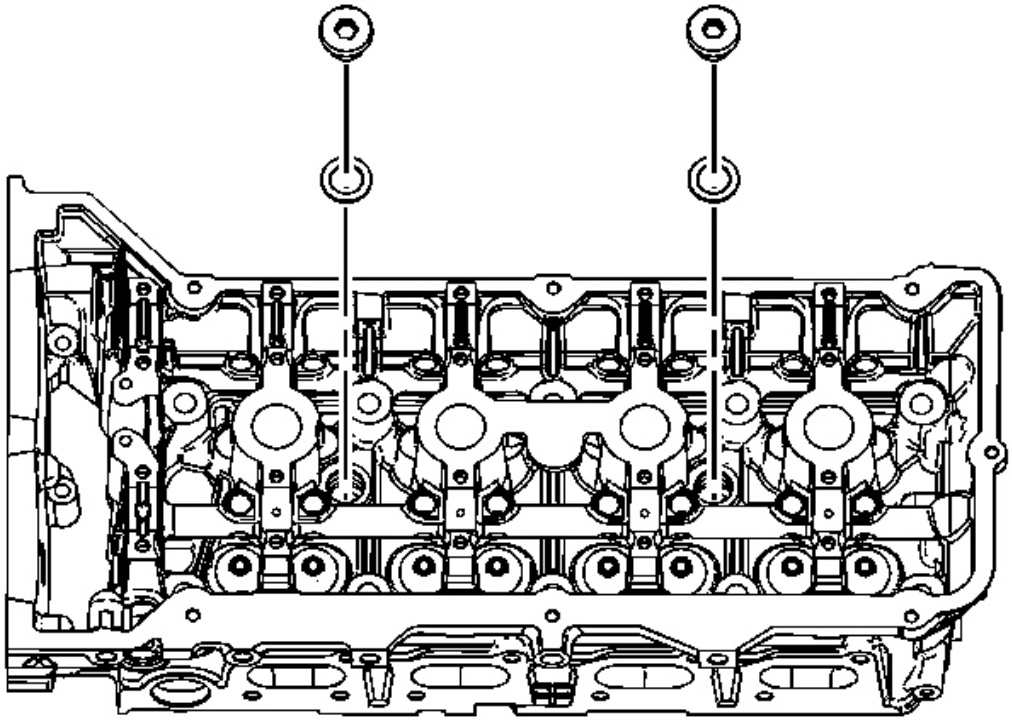


Fig. 137: Identifying Core Hole Threaded Plugs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install the core hole threaded plugs.

   Tighten: Tighten the core hole threaded plugs to 80 N.m (60 lb ft).

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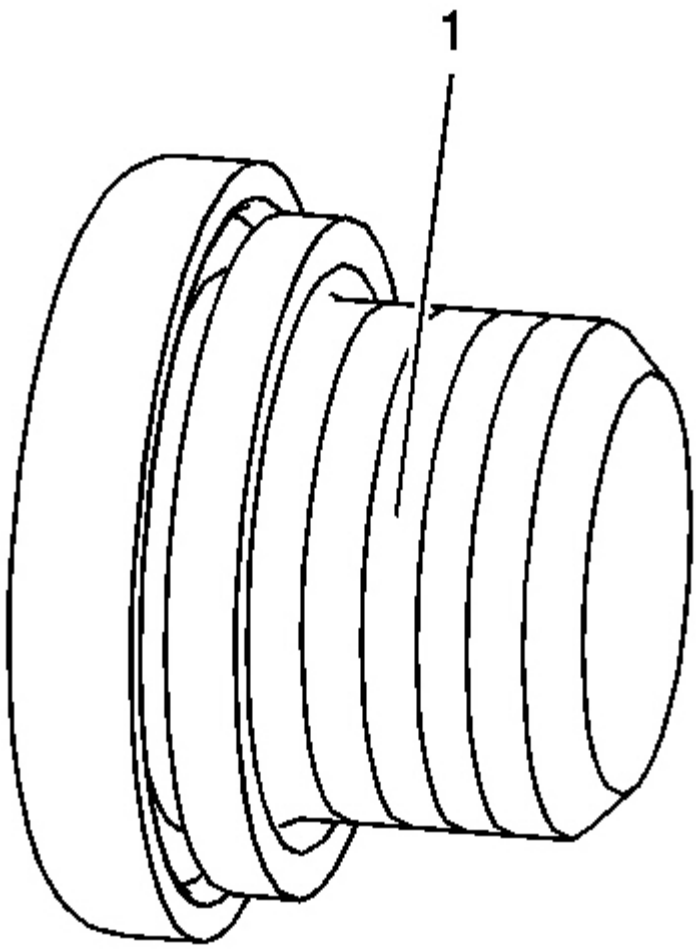


Fig. 138: View Of Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

3. Apply sealant GM P/N 12345382 (Canadian P/N 10953489) to the threads (1) of the oil gallery threaded plugs.

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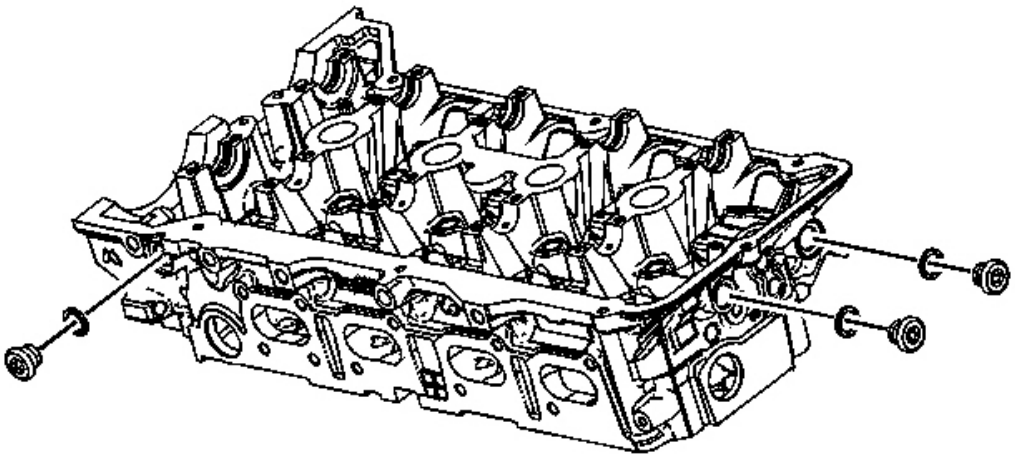


Fig. 139: Identifying Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

4. Install the oil gallery threaded plugs.

   Tighten: Tighten the oil gallery threaded plugs to 60 N.m (44 lb ft).

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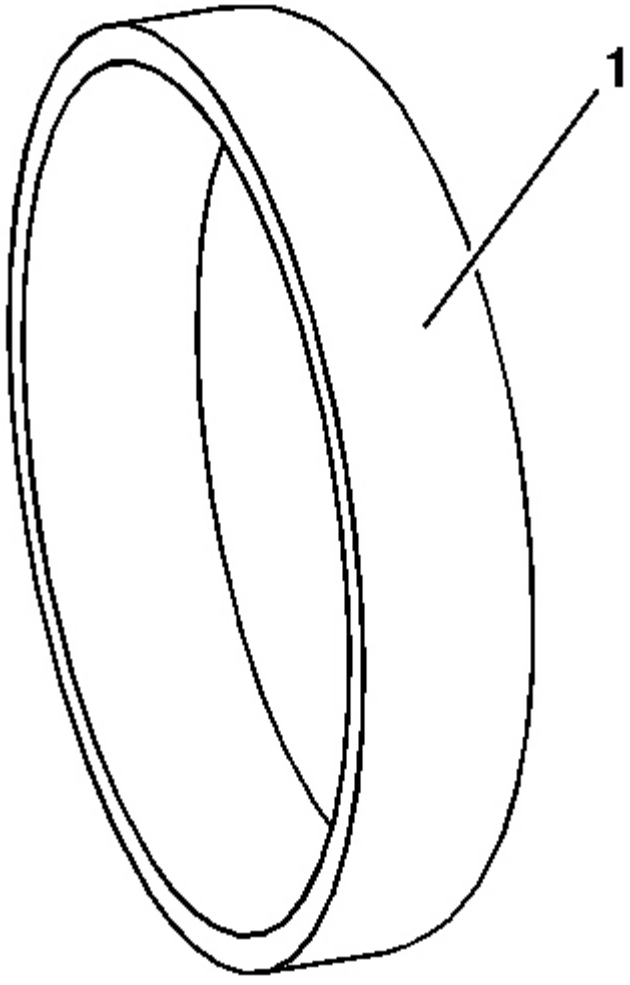


Fig. 140: View Of Engine Coolant Expansion Plug
Courtesy of GENERAL MOTORS CORP.

5. Apply sealant GM P/N 12345382 (Canadian P/N 10953489) to the outside diameter (1) of the NEW engine coolant expansion plugs.

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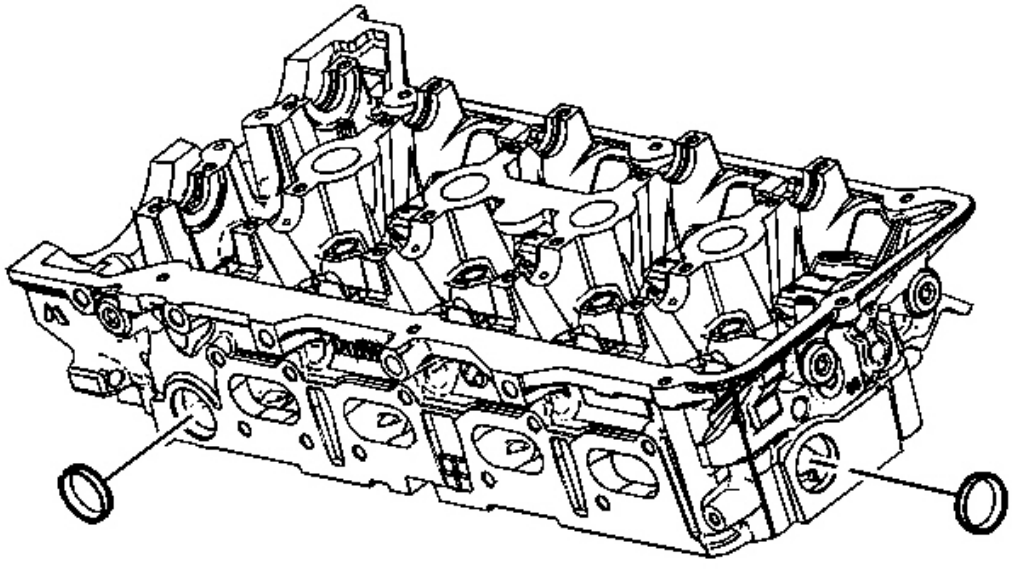


Fig. 141: Identifying Engine Coolant Expansion Plug
Courtesy of GENERAL MOTORS CORP.

6. Install the NEW engine coolant expansion plugs.

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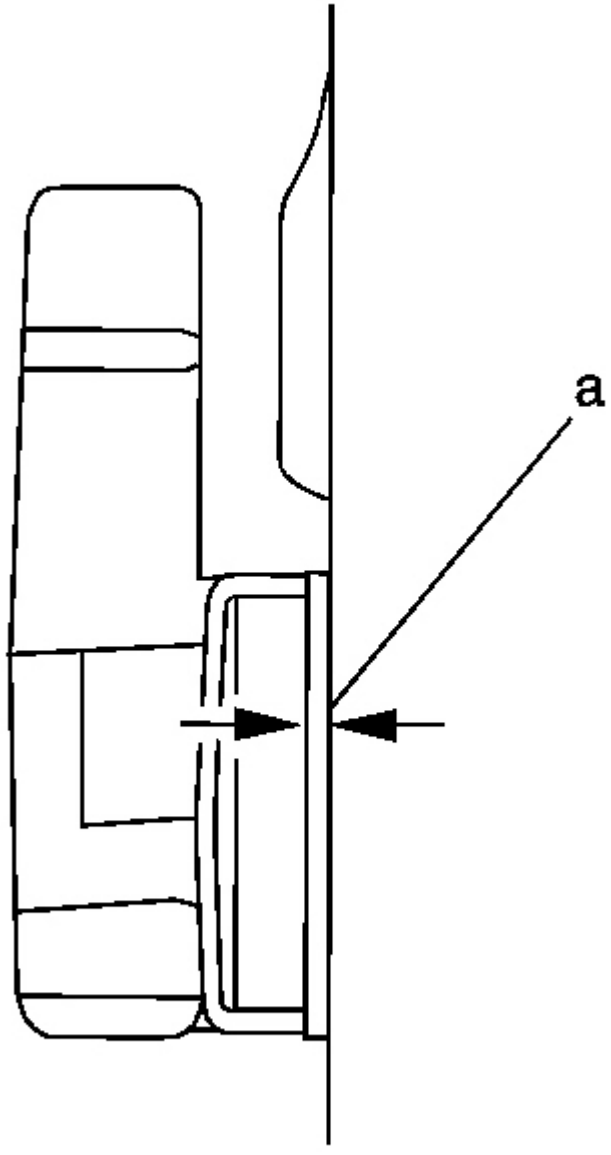


Fig. 142: Ensuring Engine Coolant Expansion Plug Installed Depth
Courtesy of GENERAL MOTORS CORP.

7. Ensure the engine coolant expansion plugs are installed to the proper depth (a) of 0.00-0.50 mm (0.00-0.020 in) deep.

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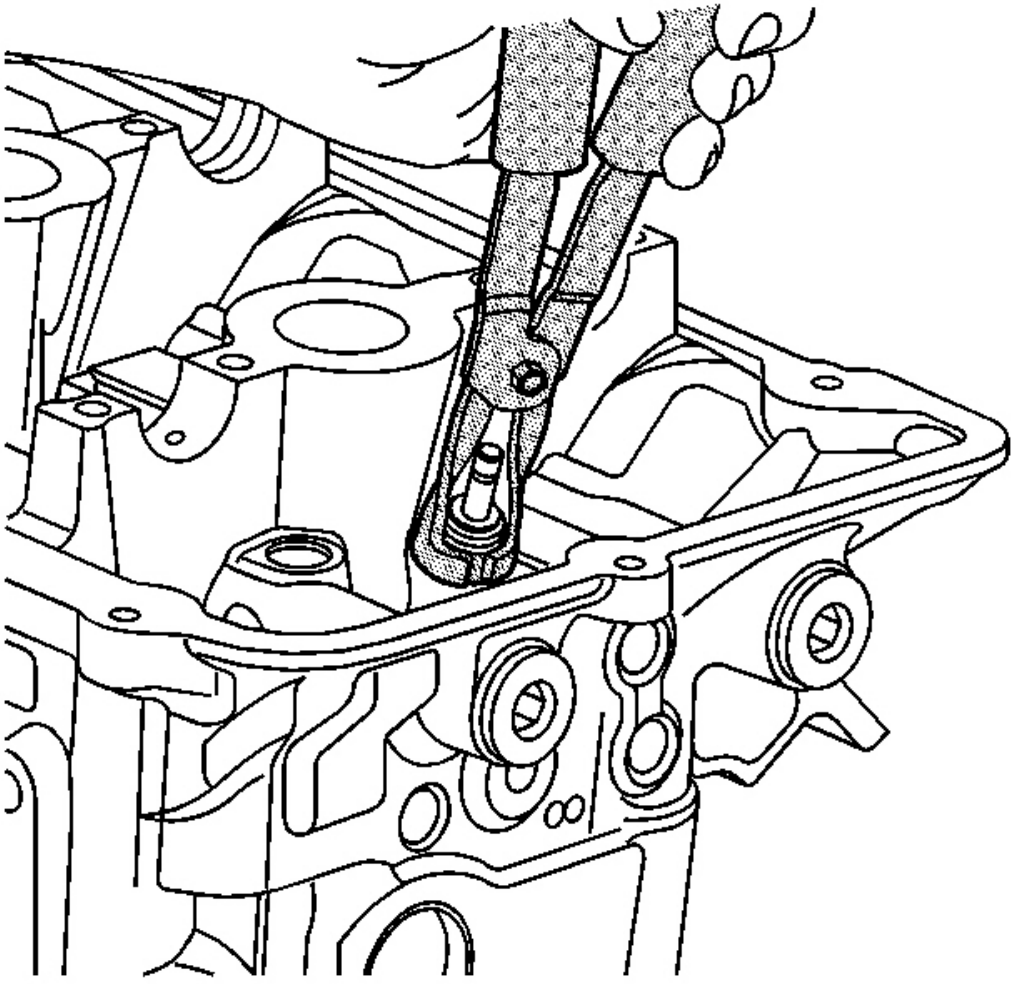


Fig. 143: Removing/Installing Valve Seal
Courtesy of GENERAL MOTORS CORP.

8. Lubricate the valve stem with clean engine oil.
9. Insert the valve into the valve guide until it bottoms on the valve seat.
10. Lubricate the new valve seal with engine oil.
11. Using the **J 38820** , install the new valve seal using the following procedure. See **Special Tools** .
    1. Place the valve lifter bore protector into the lifter bore.
    2. Mount the new valve seal in the **J 38820** . See **Special Tools** .
    3. Push and twist the new valve seal into position on the valve guide until the seal positively locks on the guide.

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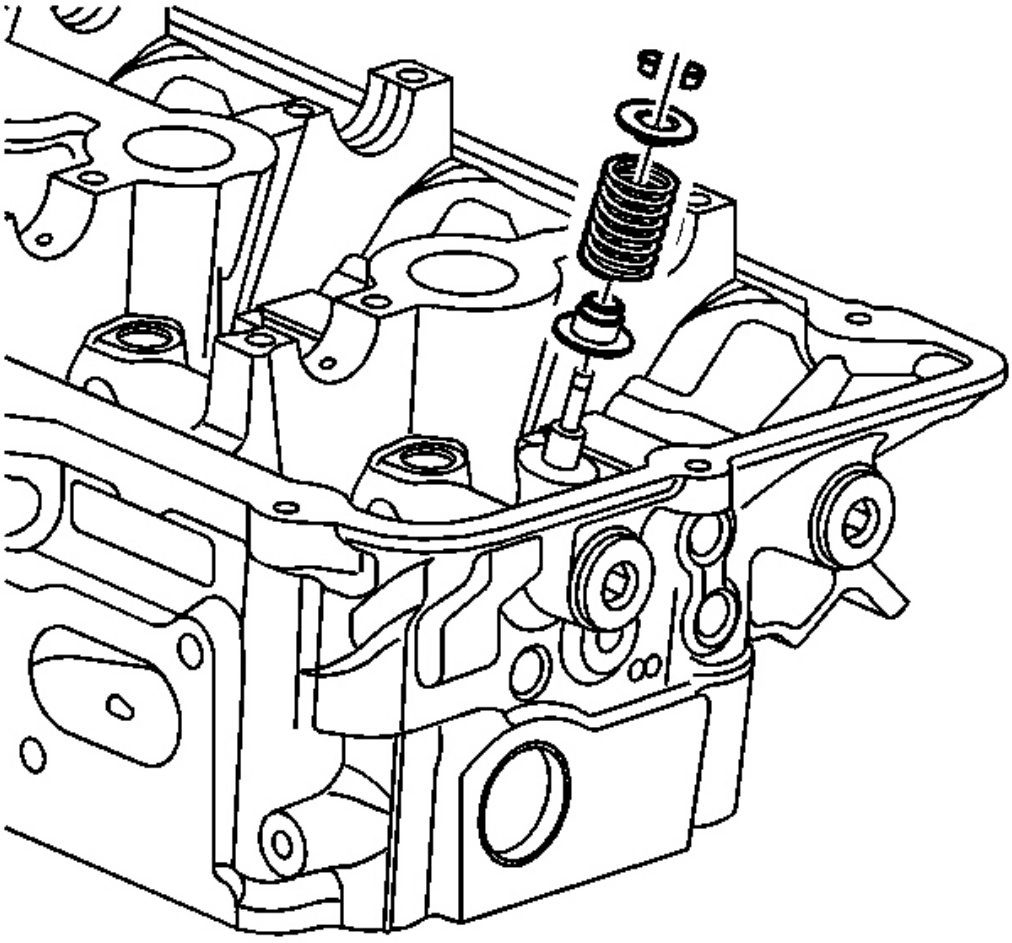


Fig. 144: View Of Valve Spring
Courtesy of GENERAL MOTORS CORP.

12. Position the valve spring on the spring seat.

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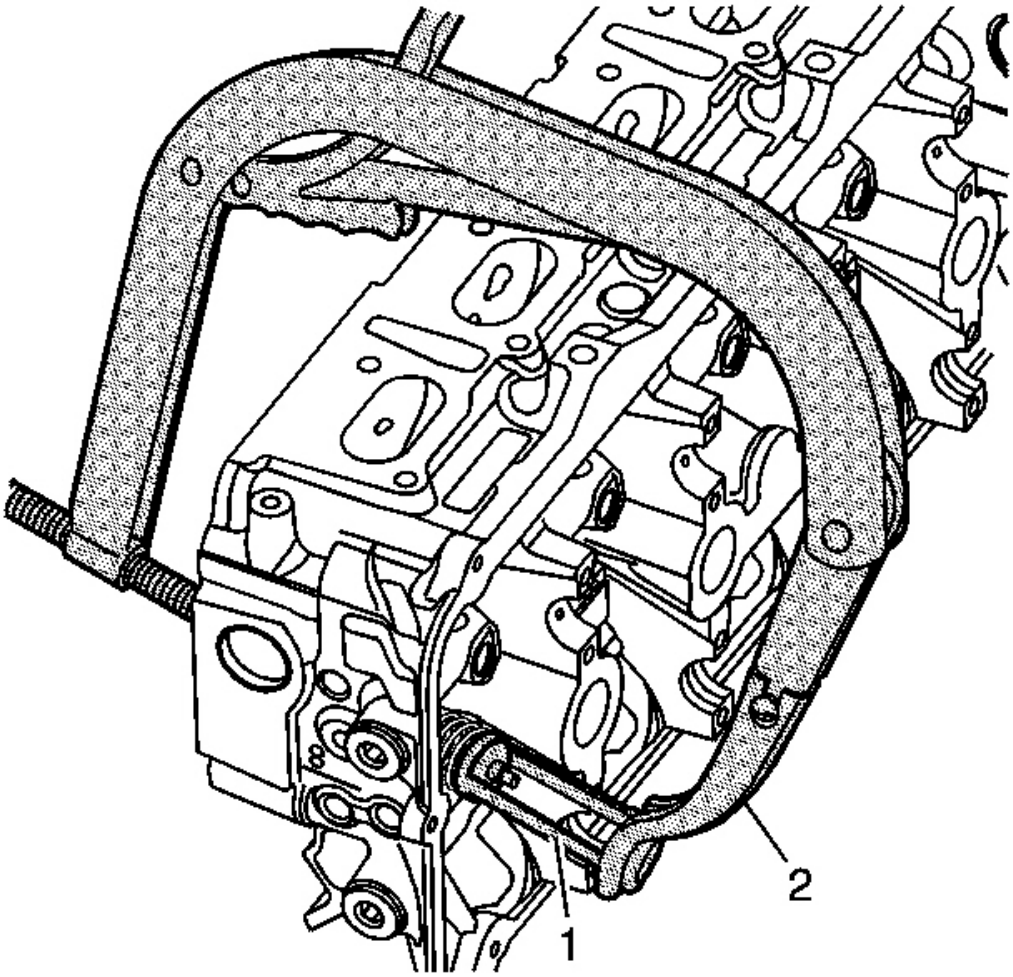


Fig. 145: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Do not compress the valve springs less than 24.0 mm (0.943 in). Contact

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between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

13. Compress the valve spring using the **J 8062** (2) and the **J 38821** (1). See **Special Tools** .

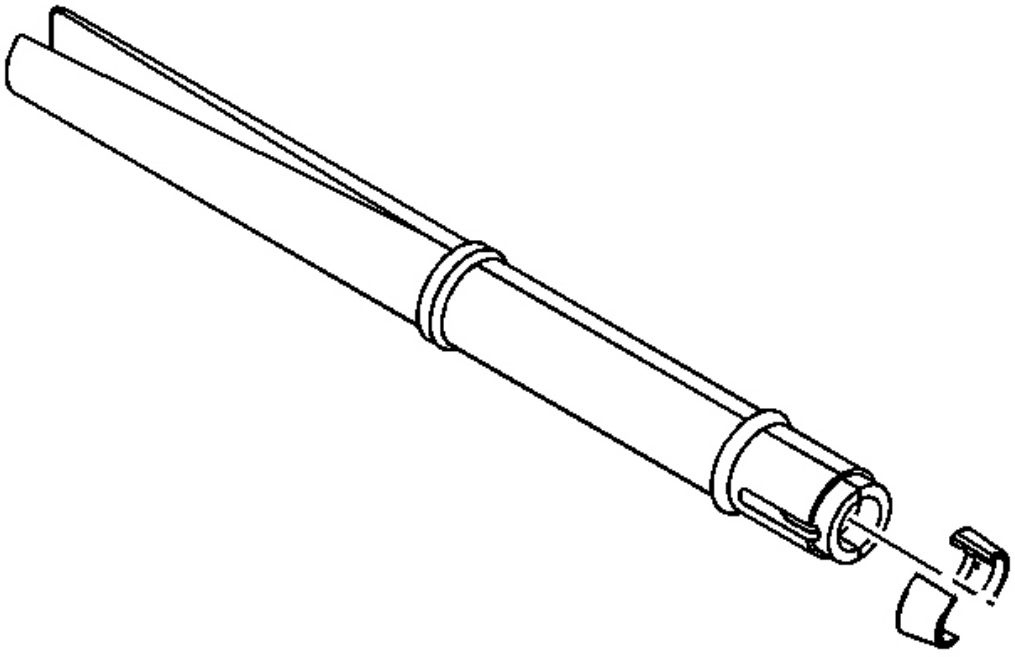


Fig. 146: View Of Valve Keepers With EN 46117
Courtesy of GENERAL MOTORS CORP.

14. With the spring compressed, install the valve keepers into the **J-43059-A** . See **Special Tools** .

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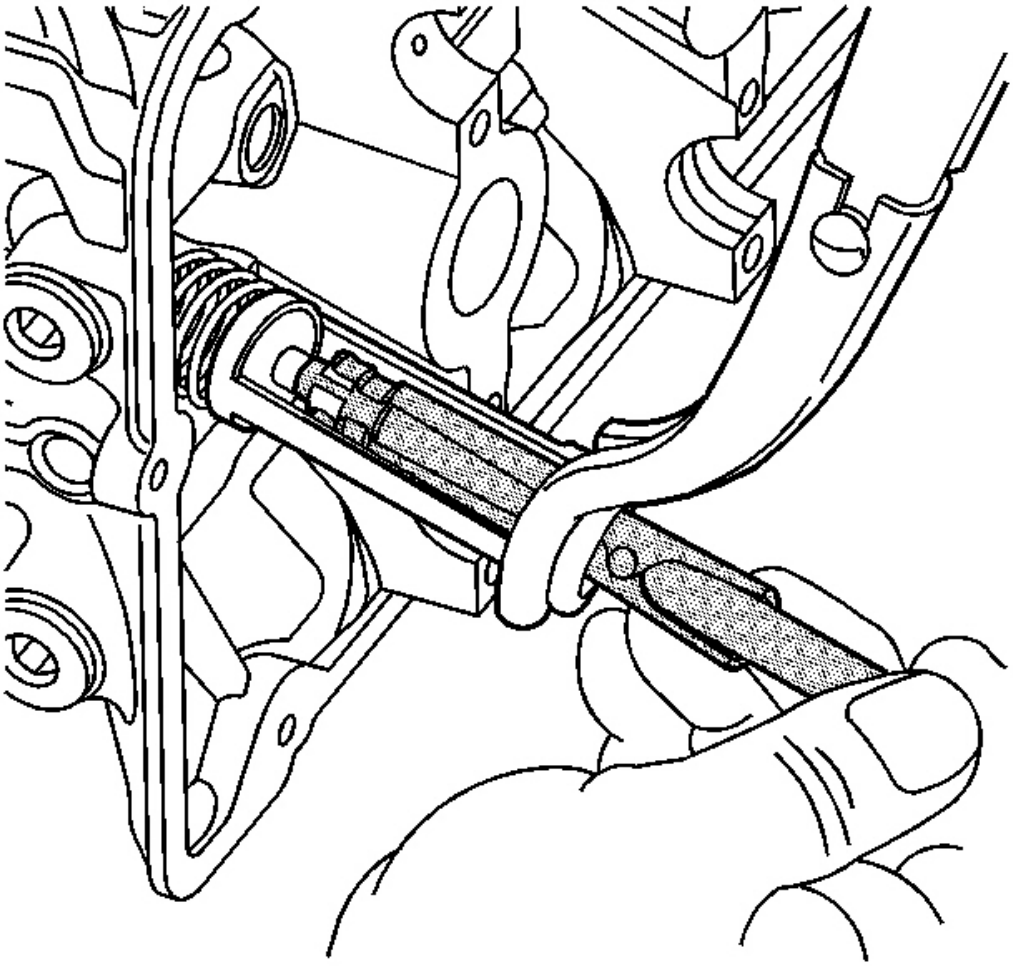


Fig. 147: Installing Valve Keepers
Courtesy of GENERAL MOTORS CORP.

15. Place the keepers into position by pushing the tool downward.
16. Release the tension on the spring compressor and remove the **J 38821** . See **Special Tools** .
17. Verify that the valve keepers are installed by placing a rag over the valve tip and tapping with a dead-blow hammer. The valve keepers and the spring should remain in place.
18. Repeat this procedure for the remaining valves.

CAMSHAFT CLEANING AND INSPECTION

TOOLS REQUIRED

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J 7872 Magnetic Base Dial Indicator

CLEANING PROCEDURE

1. Clean the camshaft in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the camshaft with compressed air.
3. Cover the camshafts with a clean oil soaked towel in order to prevent corrosion.

VISUAL INSPECTION PROCEDURE

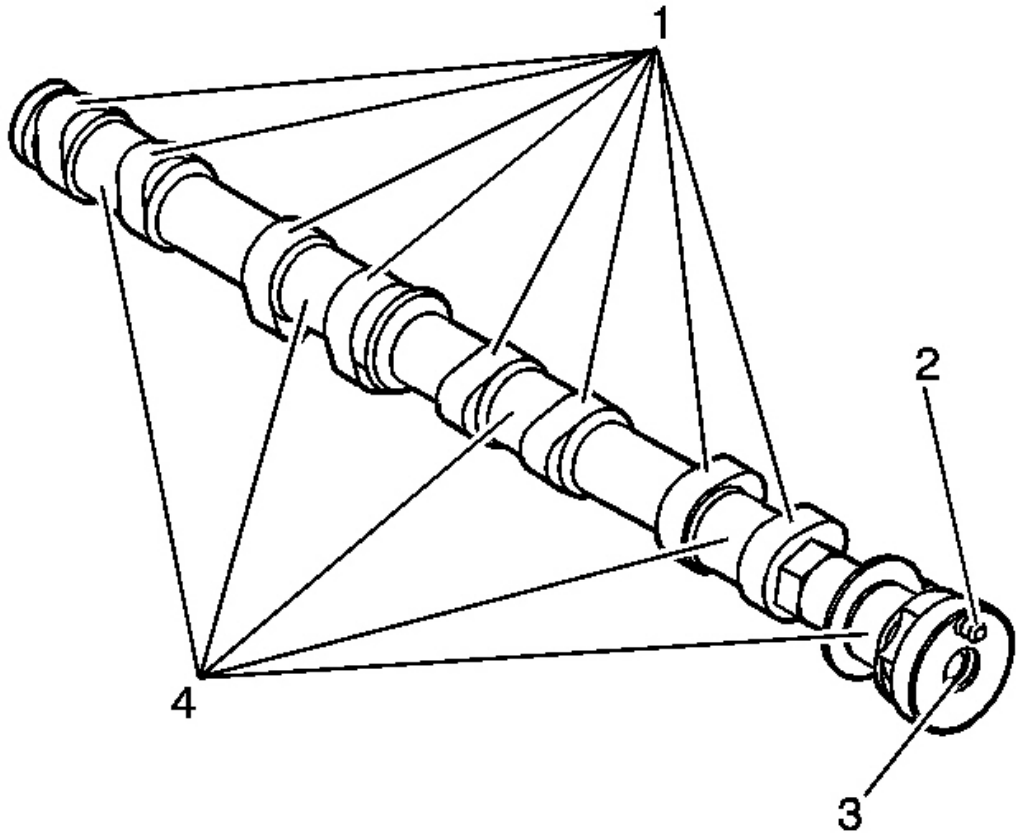


Fig. 148: Inspecting Camshaft
Courtesy of GENERAL MOTORS CORP.

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1. Inspect the camshaft sprocket locating pin (2) for damage or wear.
2. Inspect the threads (3) for the camshaft sprocket bolt.
3. Inspect the camshaft lobes (1) and journals (4) for the following conditions:
    - Excessive scoring or pitting
    - Discoloration from overheating
    - Deformation from excessive wear, especially the camshaft lobes

CAMSHAFT MEASUREMENT PROCEDURE

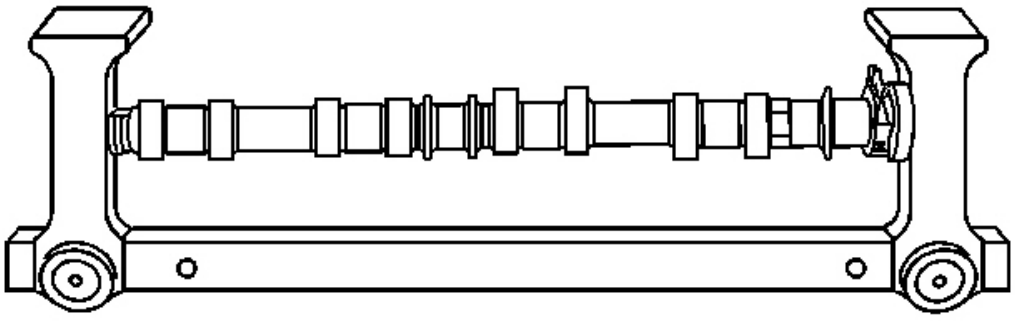


Fig. 149: Supporting Camshaft
Courtesy of GENERAL MOTORS CORP.

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

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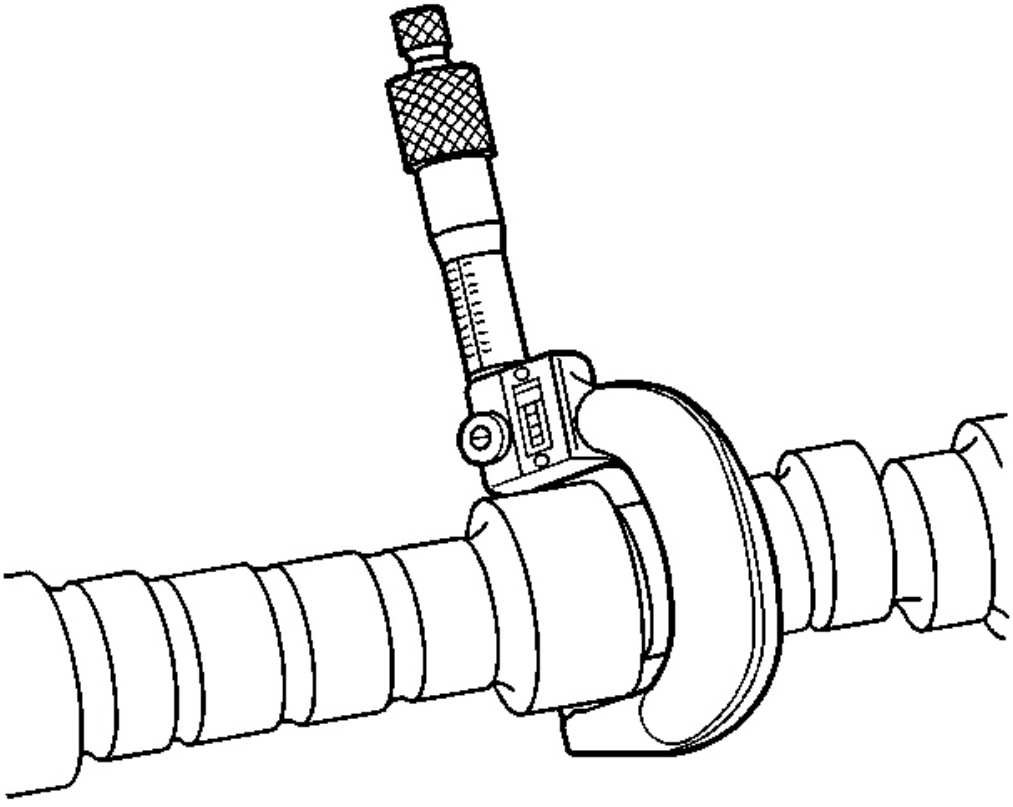


Fig. 150: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

2. Measure the camshaft journals for diameter and out-of-round using an outside micrometer.
   - If the diameter is smaller than 26.948 mm (1.061 in), replace the camshaft.
   - If the out-of-round exceeds 0.022 mm (0.0009 in), replace the camshaft.

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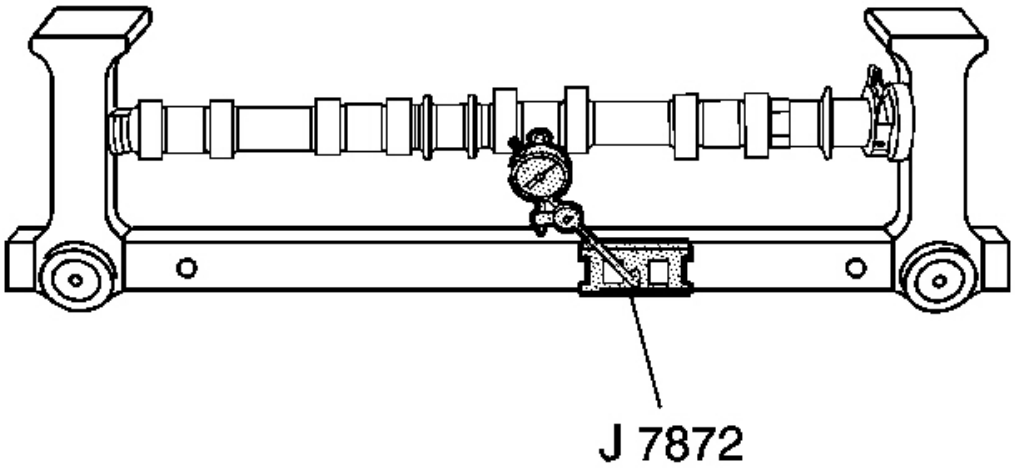


Fig. 151: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

3. Measure the camshaft runout using **J 7872** . Refer to **Engine Mechanical Specifications** .

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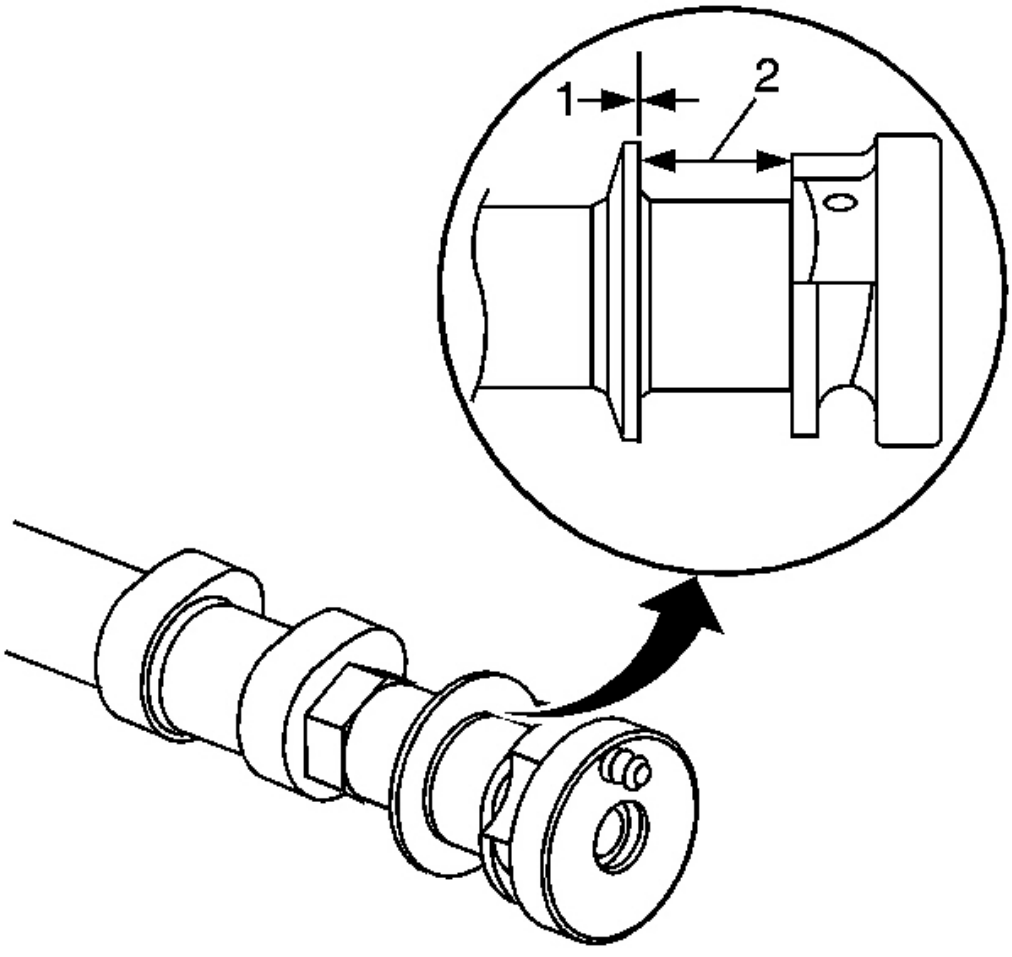


Fig. 152: Measuring Camshaft Thrust Wall Width & Surface Runout
Courtesy of GENERAL MOTORS CORP.

4. Measure the camshaft thrust wall width (1) for wear using an inside micrometer. Refer to **Engine Mechanical Specifications** .
5. Measure the camshaft thrust wall surface (2) for runout using **J 7872** . Refer to **Engine Mechanical Specifications** .
6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.

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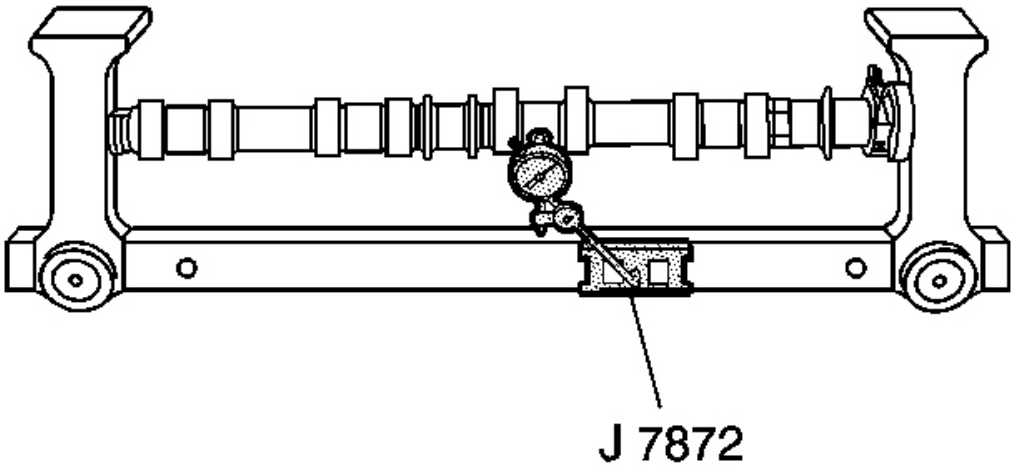


Fig. 153: Measuring Camshaft Lobes For Wear
Courtesy of GENERAL MOTORS CORP.

7. Measure the camshaft lobes for wear using the **J 7872** .

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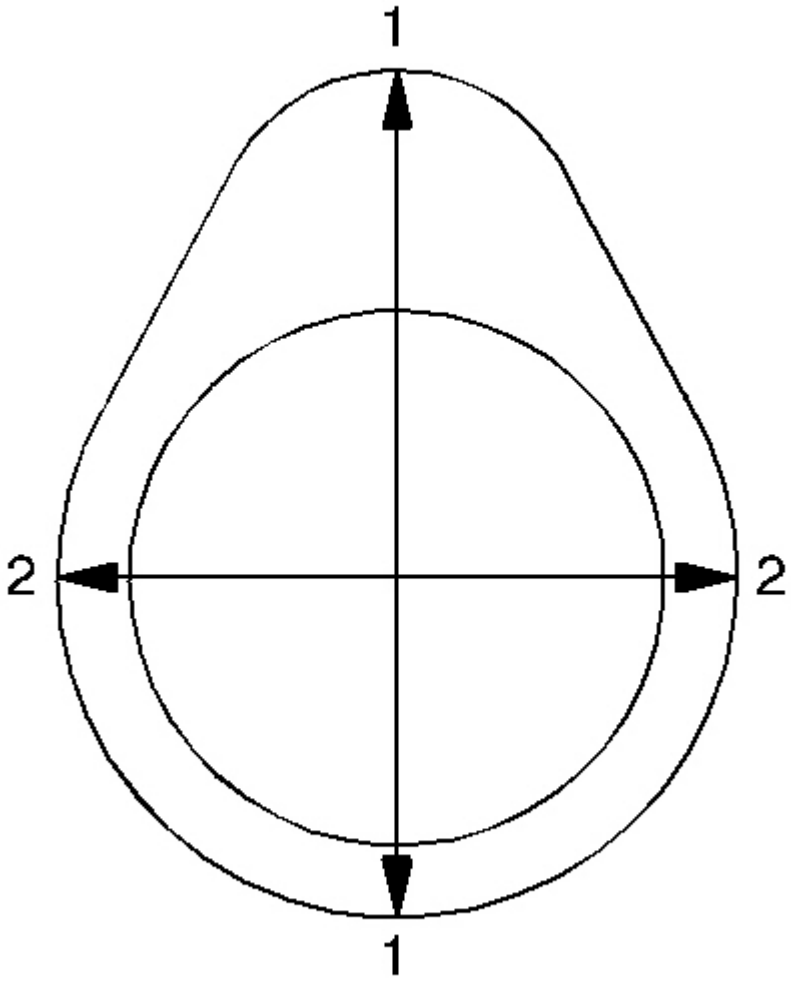


Fig. 154: Identifying Base Circle
Courtesy of GENERAL MOTORS CORP.

8. Place the **J 7872** with the indicator tip on the base circle (2) of the camshaft lobe.
    1. Place the **J 7872** dial at zero.
    2. Rotate the camshaft until the indicator tip is at the highest point on the lobe. This reading is the lift (1) of the camshaft lobe.
    3. The specifications for lift are as follows:
        - Intake camshaft: 6.166 mm (0.2428 in)
        - Exhaust camshaft: 5.944 mm (0.2336 in)

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9. If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

VALVE LIFTERS CLEANING AND INSPECTION

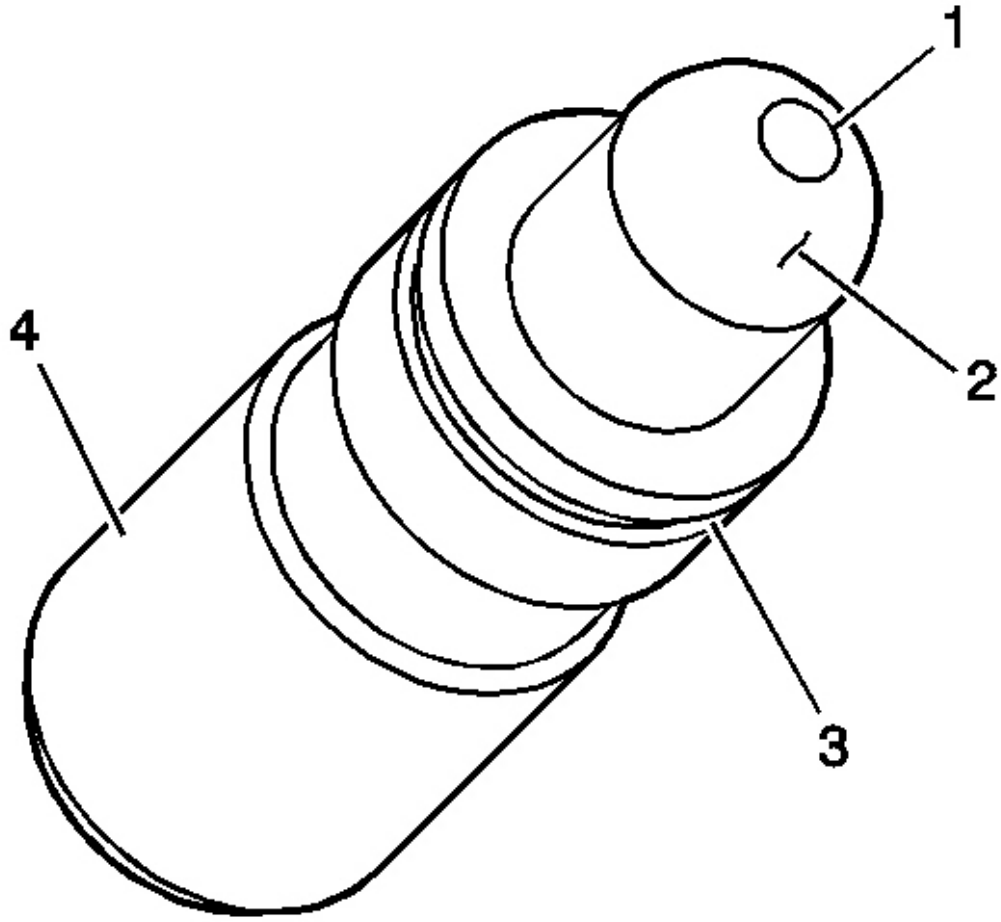


Fig. 155: View Of Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Valve Lifter Priming Notice .

1. Inspect the Stationary Hydraulic Lash Adjuster (SHLA) in the following areas:
   - A plugged oil passage (1)

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- A scored or worn camshaft follower pivot area (2)
- A damaged or broken retainer (3)
- A severely scuffed or worn SHLA body (4)

2. Replace the SHLA or SHLAs as necessary.

VALVE ROCKER ARMS CLEANING AND INSPECTION

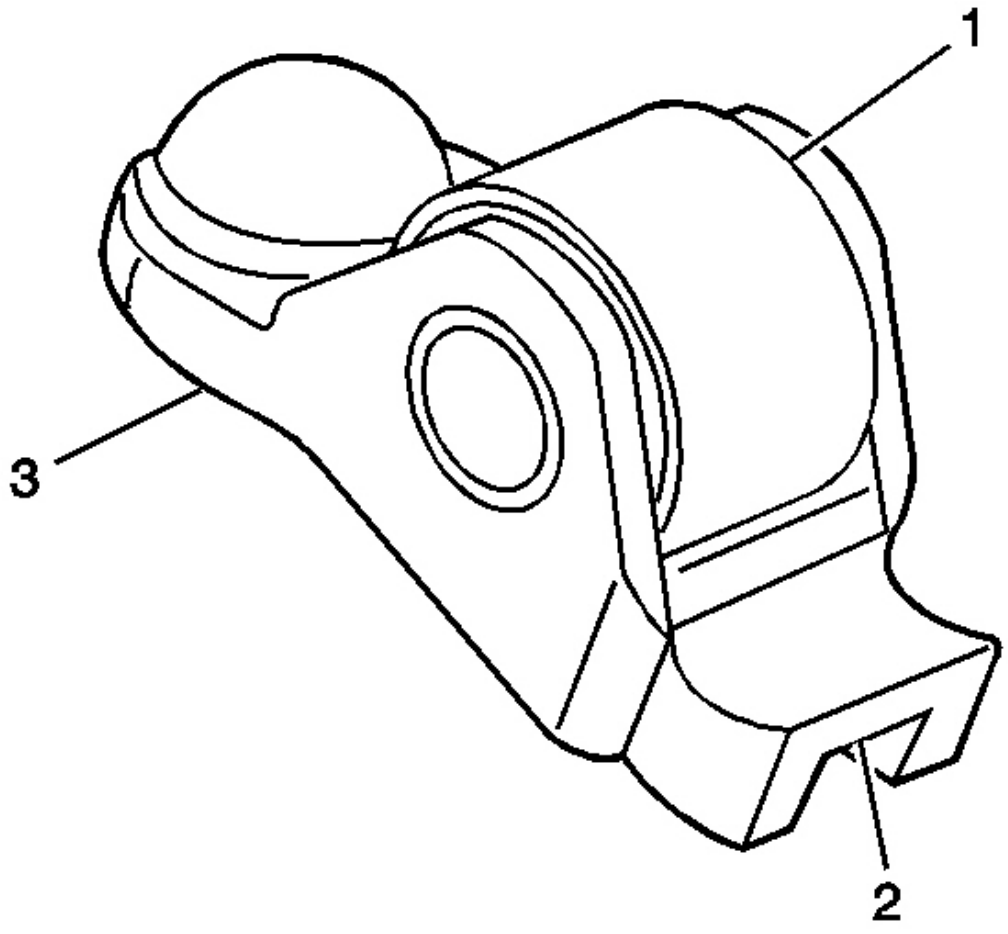


Fig. 156: Inspecting Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft follower roller (1) for the following:
   - Flat spots

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- Excessive scoring and pitting
- Ensure the roller spins freely

2. Inspect the camshaft follower valve tip area (2).
3. Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).
4. Replace the camshaft follower or followers as necessary.

CAMSHAFT INTERMEDIATE DRIVE SHAFT CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the camshaft intermediate drive shaft in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION .

2. Dry the camshaft intermediate drive shaft with compressed air.

INSPECTION PROCEDURE

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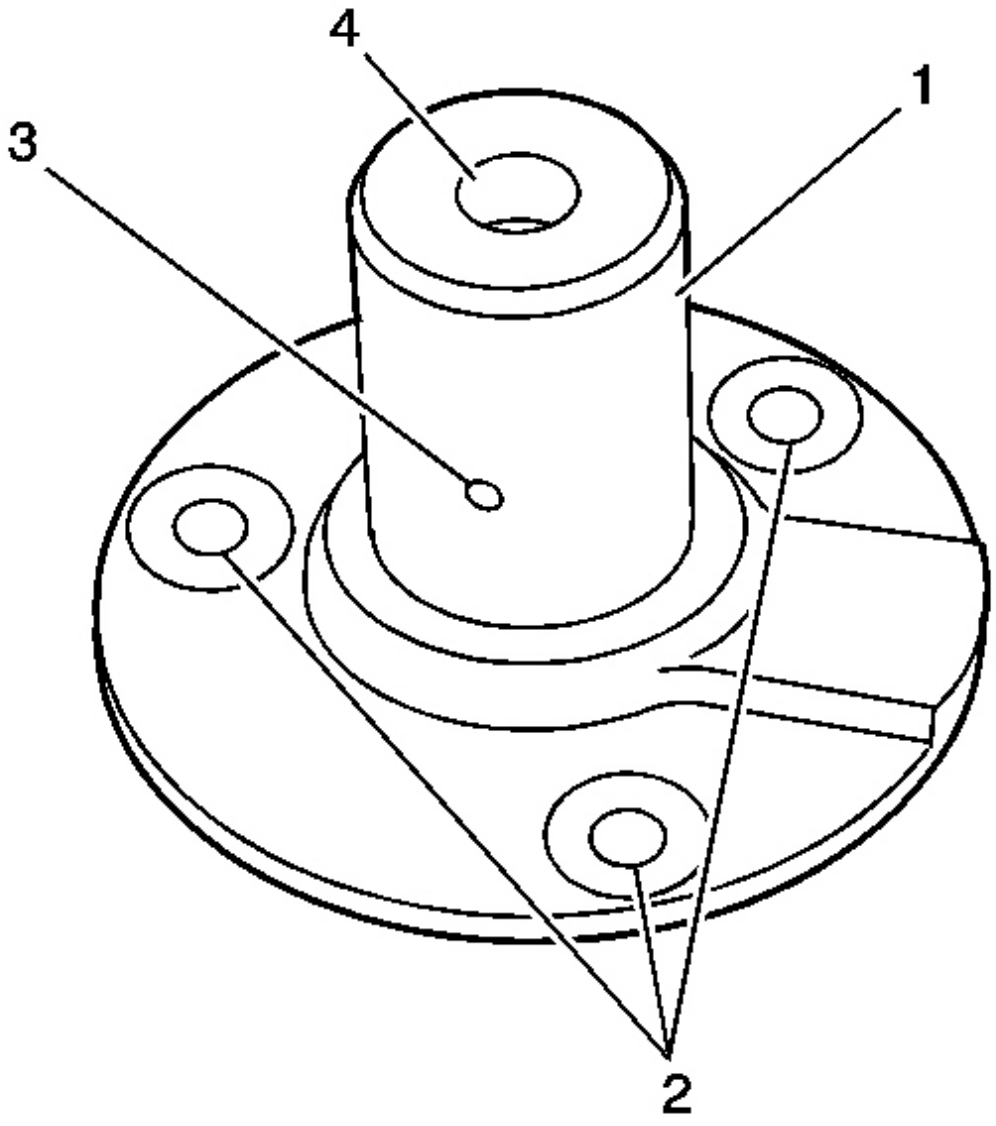


Fig. 157: Inspecting Camshaft Intermediate Drive Shaft
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft intermediate drive shaft for the following:
   - Worn or damaged hub-to-camshaft intermediate drive shaft sprocket bearing surface (1)
   - Cracks or damage to the camshaft intermediate drive shaft fastener holes (2)
   - Restrictions to the oil passage (3)

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- Damaged or stripped thread (4)

2. Repair or replace the camshaft intermediate drive shaft as necessary.

CAMSHAFT TIMING DRIVE COMPONENTS CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean all the following components with solvent:
   - Camshaft position actuator - exterior only
   - Camshaft position actuator oil control valve
   - Intermediate sprocket
   - Crankshaft sprocket
   - Primary timing chain
   - Secondary timing chains
   - Primary timing chain guide
   - Secondary timing chain guides
   - Primary timing chain shoe
   - Secondary timing chain shoes
   - Primary timing chain tensioner
   - Secondary timing chain tensioners
   - Timing component fastening bolts

CAUTION: Refer to Safety Glasses Caution .

2. Dry the timing components with compressed air.

VISUAL INSPECTION

Camshaft Position Actuators

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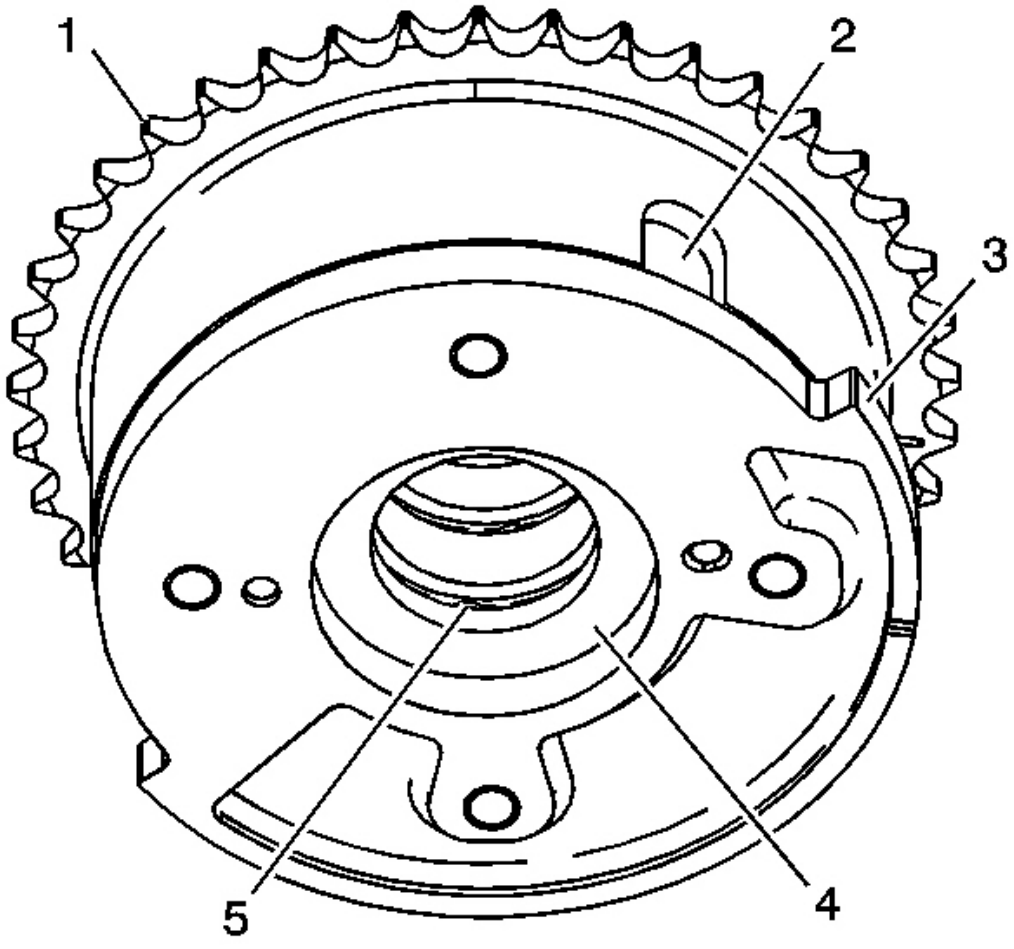


Fig. 158: Inspecting Front Of Exhaust Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the exhaust camshaft position actuators for the following:
   - Sprocket damage (1)
   - Loose or missing lock pin cover (2)
   - Reluctor/sensor wheel damage (3)
   - Camshaft position actuator oil control valve seating/sealing inner hub flange damage (4)
   - Blockage to the oil passages (5)

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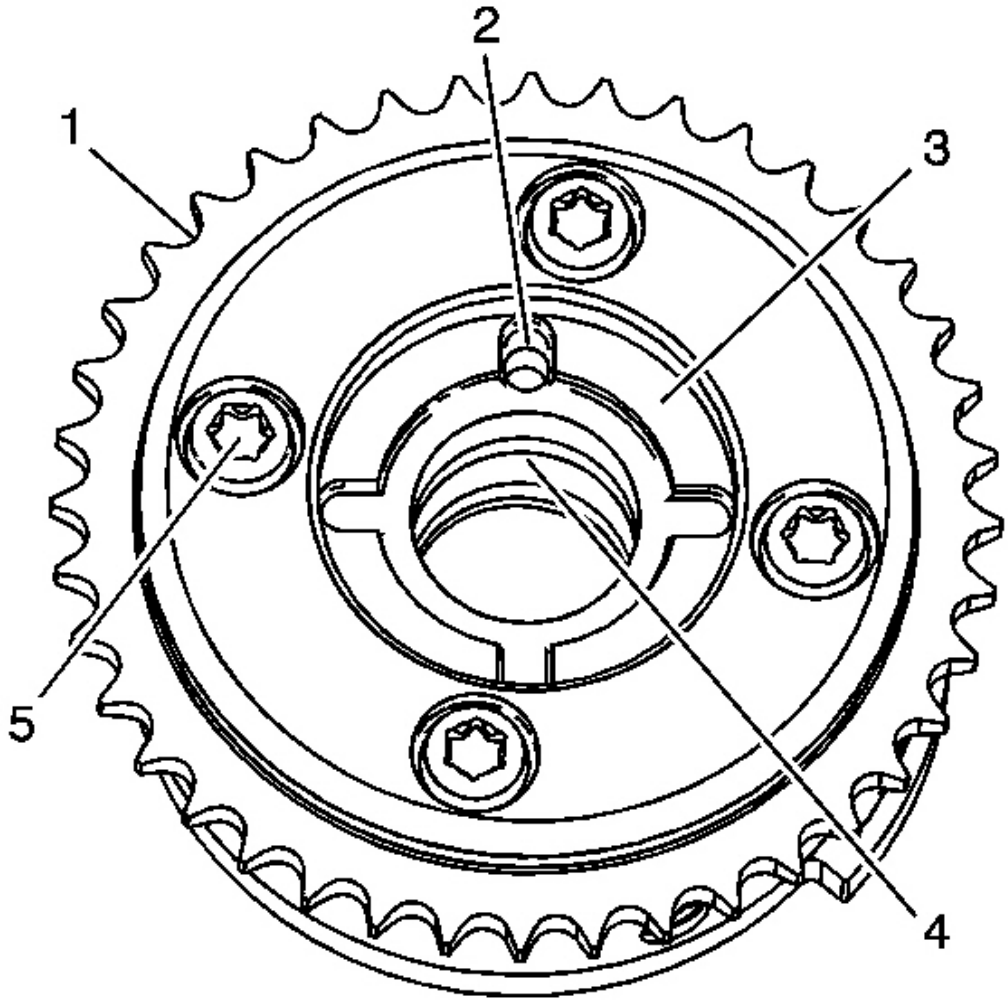


Fig. 159: Locating Camshaft Alignment Pin Hole On Back Of Actuator
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the exhaust camshaft position actuators for the following:
   - Sprocket damage (1)
   - Camshaft locating pin hole (2)
   - Camshaft seating/sealing inner hub flange damage (3)
   - Blockage to the oil passages (4)
   - Loose or missing housing bolts (5)

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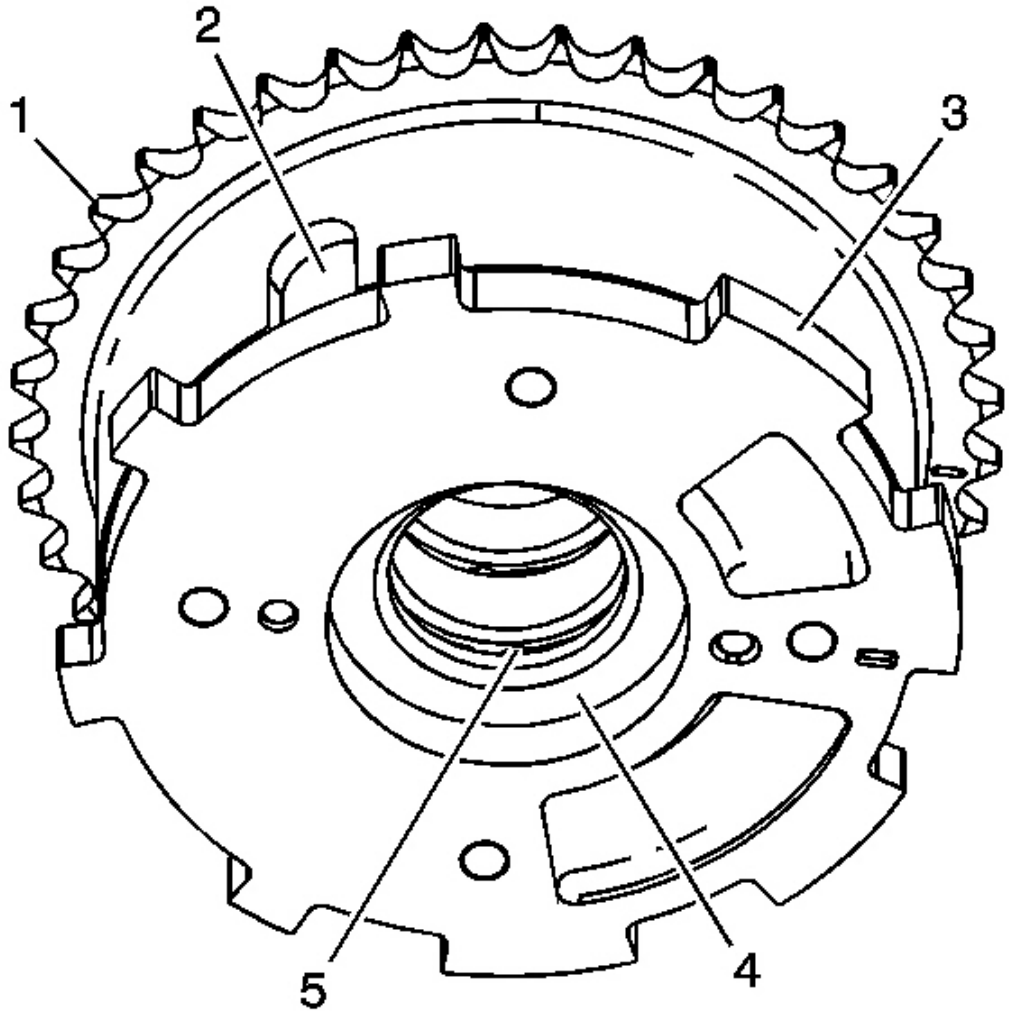


Fig. 160: Inspecting Front Of Intake Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

3. Inspect the front of the intake camshaft position actuators for the following:
    - Sprocket damage (1)
    - Loose or missing lock pin cover (2)
    - Reluctor/sensor wheel damage (3)
    - Camshaft position actuator oil control valve seating/sealing inner hub flange damage (4)
    - Blockage to the oil passages (5)

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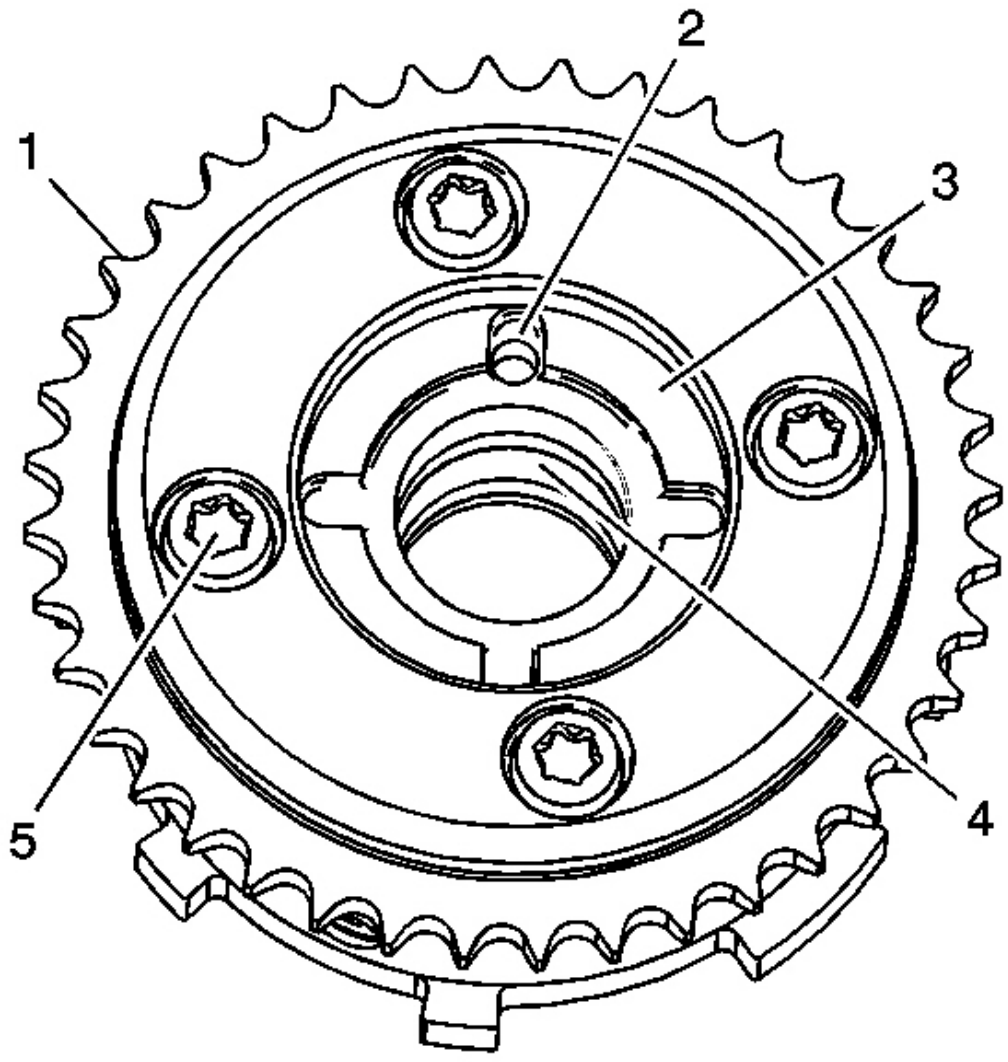


Fig. 161: Locating Camshaft Alignment Pin Hole
Courtesy of GENERAL MOTORS CORP.

4. Inspect the back of the intake camshaft position actuators for the following:
    - Sprocket damage (1)
    - Camshaft locating pin hole (2)
    - Camshaft seating/sealing inner hub flange damage (3)
    - Blockage to the oil passages (4)
    - Loose or missing housing bolts (5)

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5. Replace a damaged camshaft position actuator.

Camshaft Position Actuator Oil Control Valve

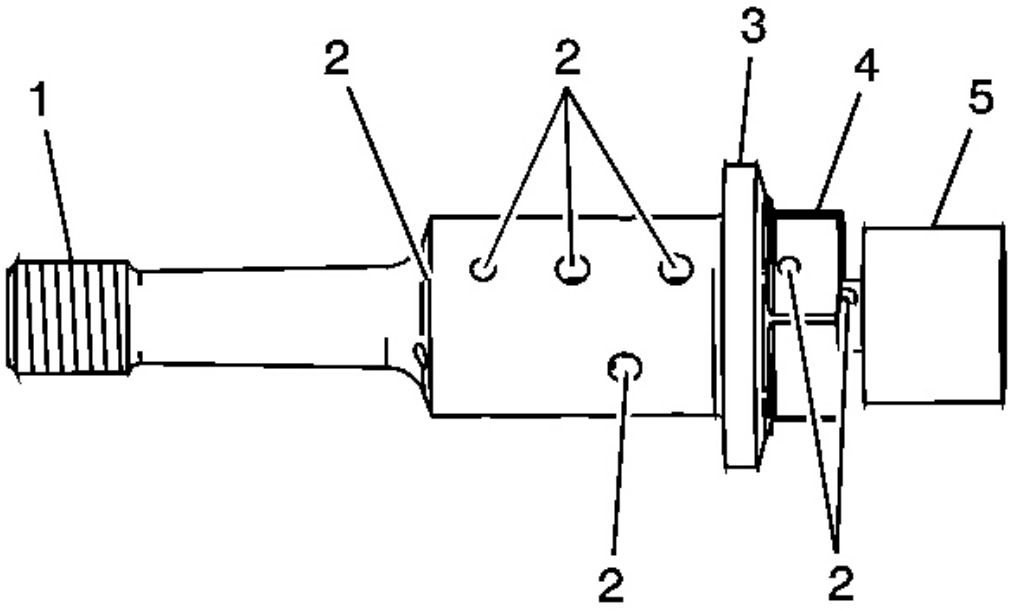


Fig. 162: Inspecting Camshaft Position Actuator Oil Control Valves
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft position actuator oil control valves for the following:
   - Thread damage (1)
   - Blockage to the oil passages (2)
   - Camshaft position actuator oil control valve seating/sealing flange damage (3)
   - Hex damage (4)
   - Spool valve head damage (5)
2. Replace a damaged camshaft position actuator oil control valve.

Intermediate Sprocket

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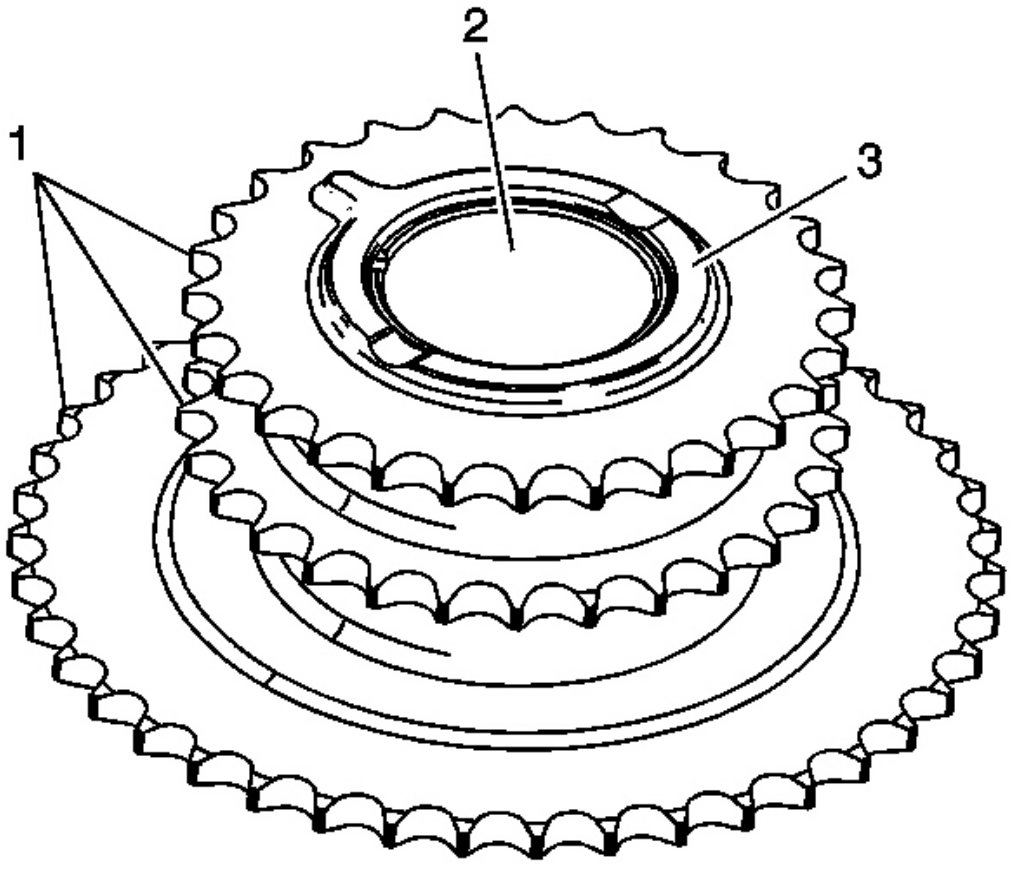


Fig. 163: Inspecting Front Of Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the intermediate sprocket for the following:
   - Sprocket damage (1)
   - Bearing bore damage (2)
   - Thrust surface damage (3)

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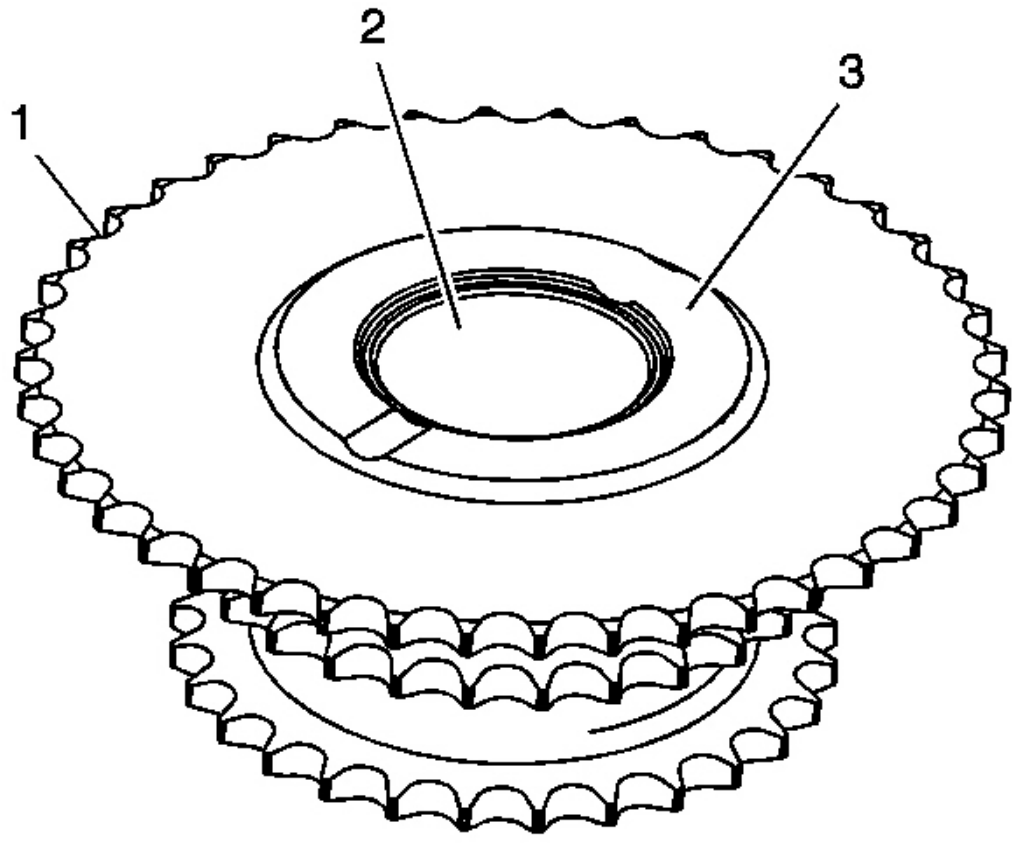


Fig. 164: Inspecting Back Of Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the intermediate sprocket for the following:
   - Sprocket damage (1)
   - Bearing bore damage (2)
   - Thrust surface damage (3)
3. Replace a damaged intermediate sprocket.

Crankshaft Sprocket

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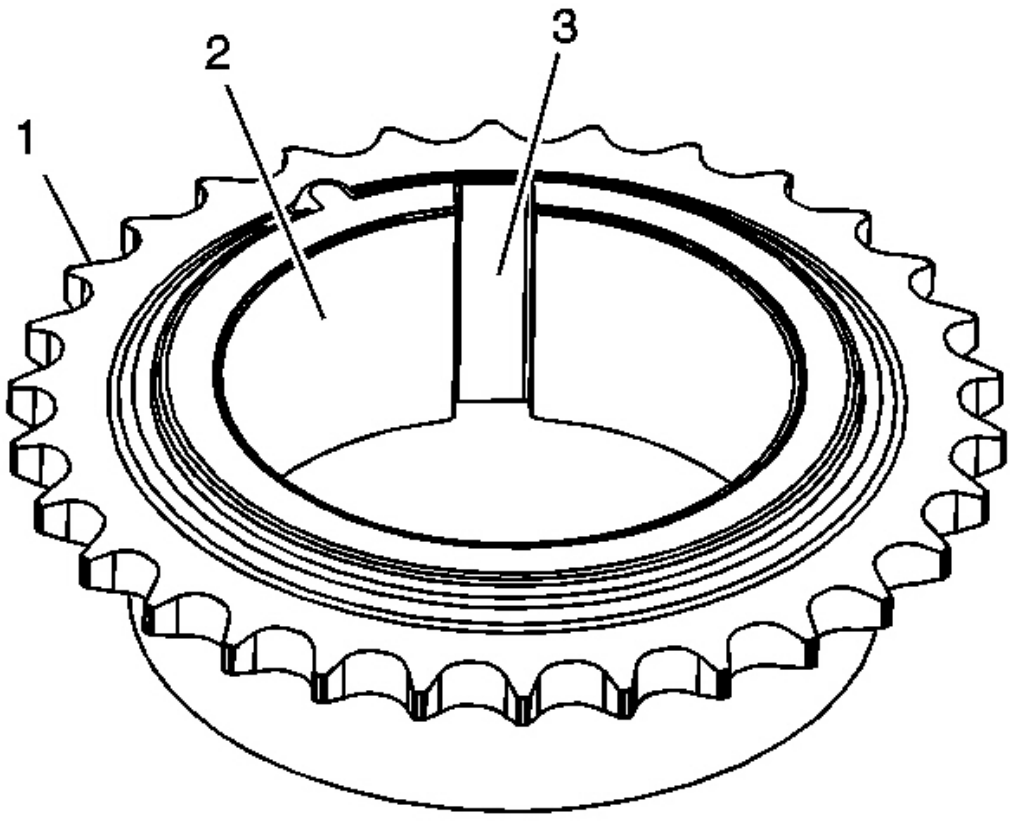


Fig. 165: Inspecting Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the intermediate sprocket for the following:
   - Sprocket damage (1)
   - Bore damage (2)
   - Keyway damage (3)
2. Replace a damaged crankshaft sprocket.

Primary and Secondary Timing Chains

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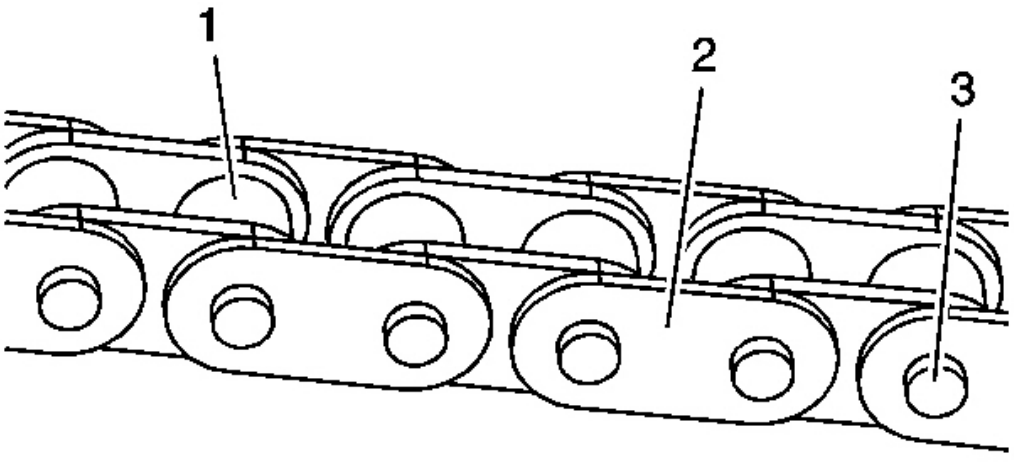


Fig. 166: Inspecting Primary And Secondary Timing Chains With Roller Chain
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary and/or secondary timing chain for the following:
   - Binding or worn rollers (1)
   - Loose links (2)
   - Loose pins (3)
2. Replace a damaged primary and/or secondary timing chains.

Primary Timing Chain Guide

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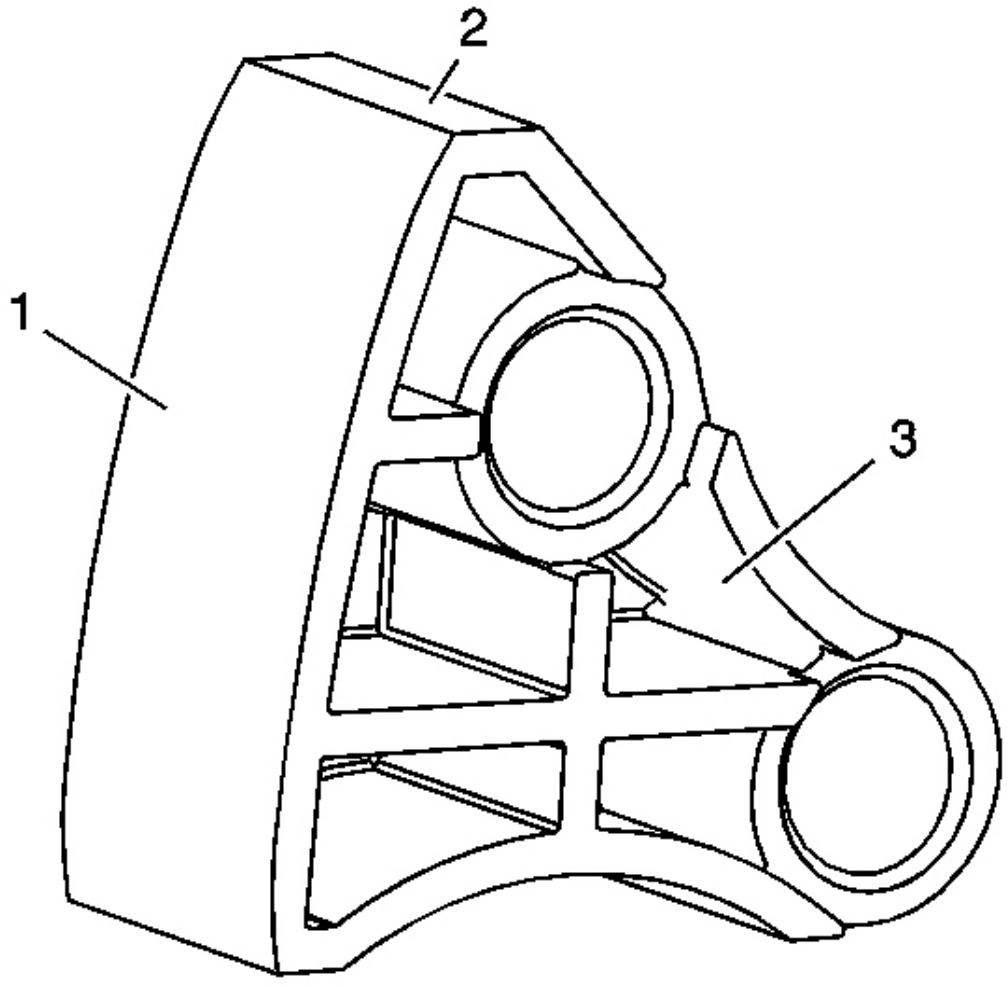


Fig. 167: Inspecting Primary Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain guide for the following:
    - Worn guide surface (1)
    - Cracked or broken guide surface (2)
    - Cracked or damaged guide base (3)
2. Replace a damaged primary timing chain guide.

Secondary Timing Chain Guides

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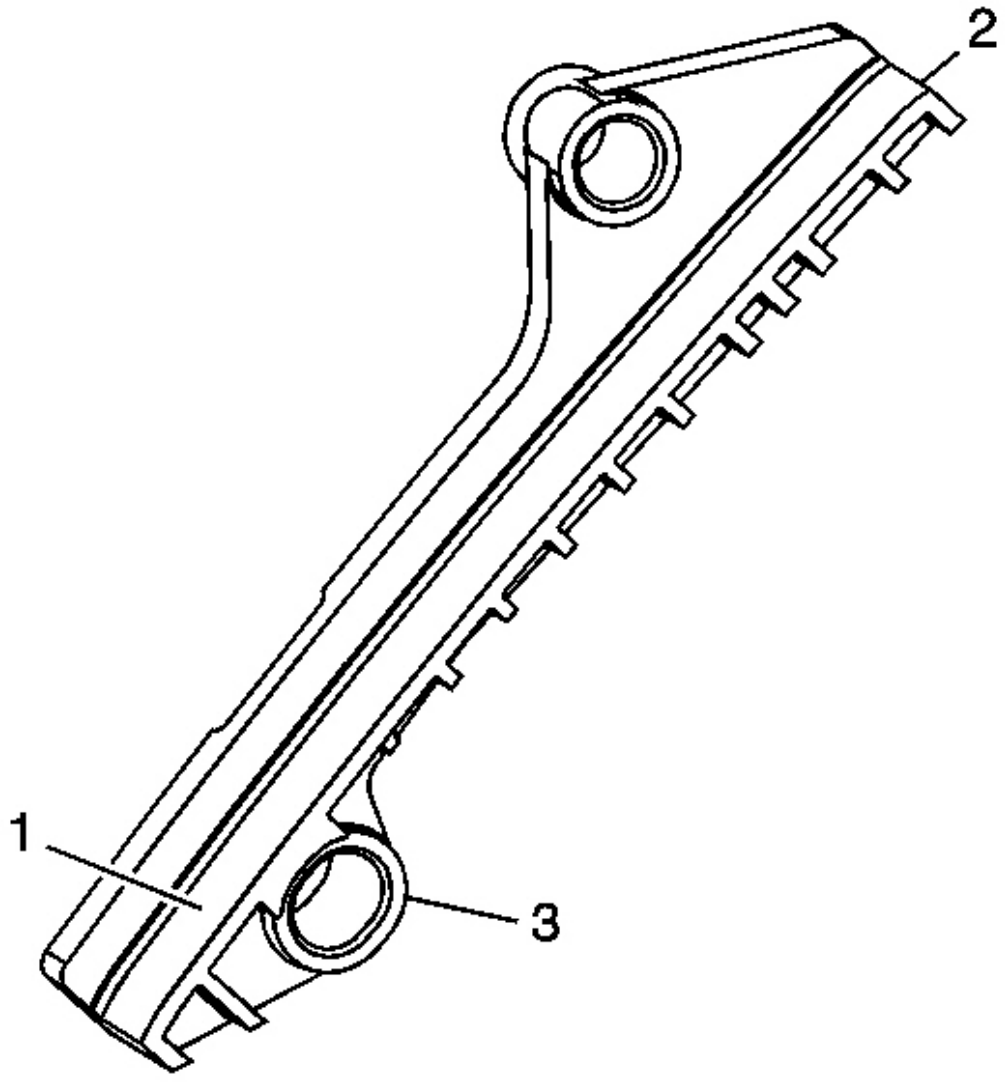


Fig. 168: Inspecting Secondary Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Inspect the secondary timing chain guides for the following:
   - Worn guide surface (1)
   - Cracked or broken guide surface (2)
   - Cracked or damaged guide base (3)
2. Replace a damaged secondary timing chain guide.

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Secondary Timing Chain Shoes

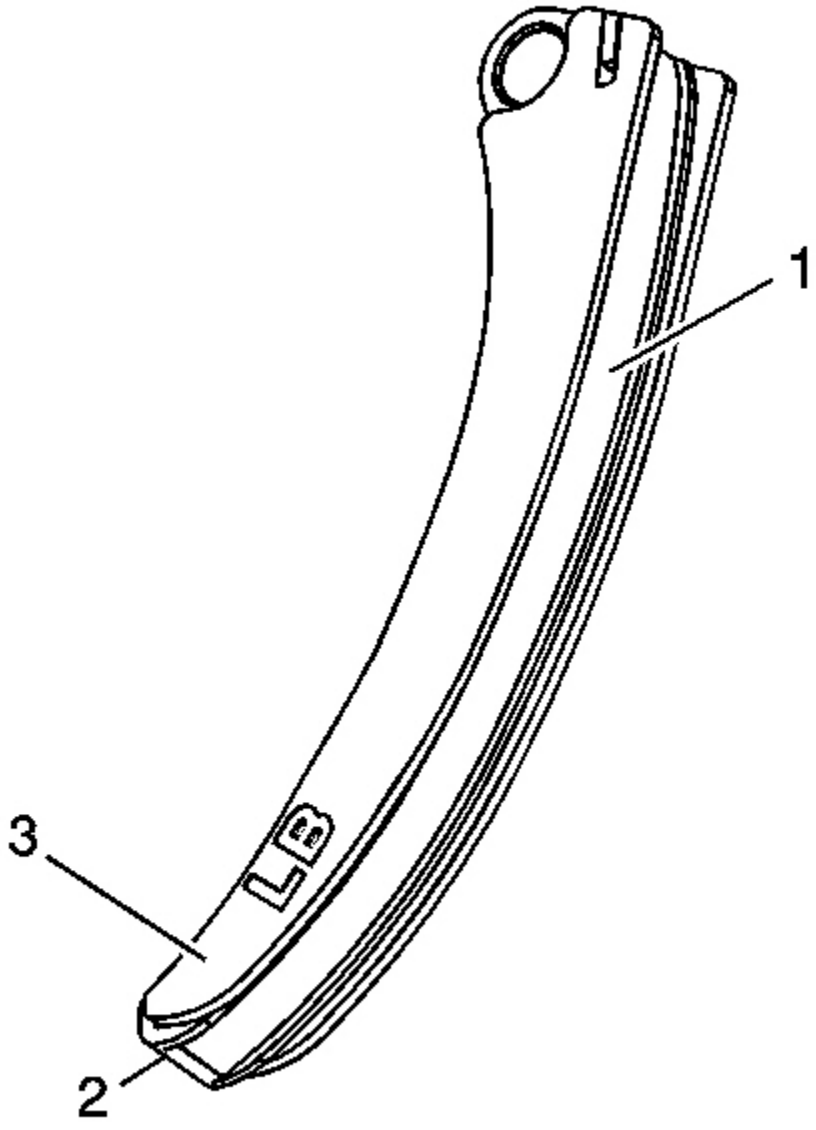


Fig. 169: Inspecting Secondary Timing Chain Shoes
Courtesy of GENERAL MOTORS CORP.

1. Inspect the secondary timing chain shoes for the following:
   - Worn shoe surface (1)

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- Cracked or broken shoe surface (2)
- Cracked or damaged shoe (3)

2. Replace a damaged secondary timing chain shoe.

Primary Timing Chain Tensioner

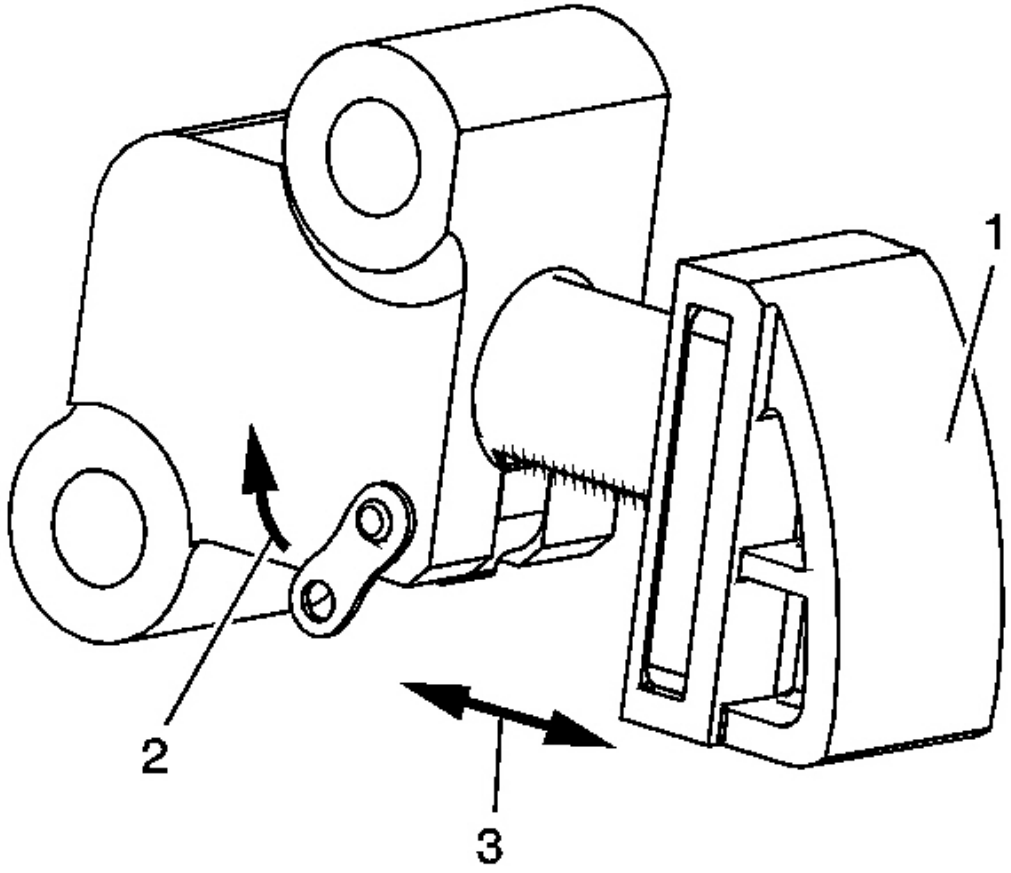


Fig. 170: Inspecting Primary Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain tensioner for worn primary timing chain tensioner shoe surface (1).
2. Inspect the primary timing chain tensioner for locked or binding timing chain tensioner. Release the locking lever (2) and ensure the plunger moves freely (3) in and out of the body of the tensioner.
3. Replace a damaged primary timing chain tensioner.

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Secondary Timing Chain Tensioners

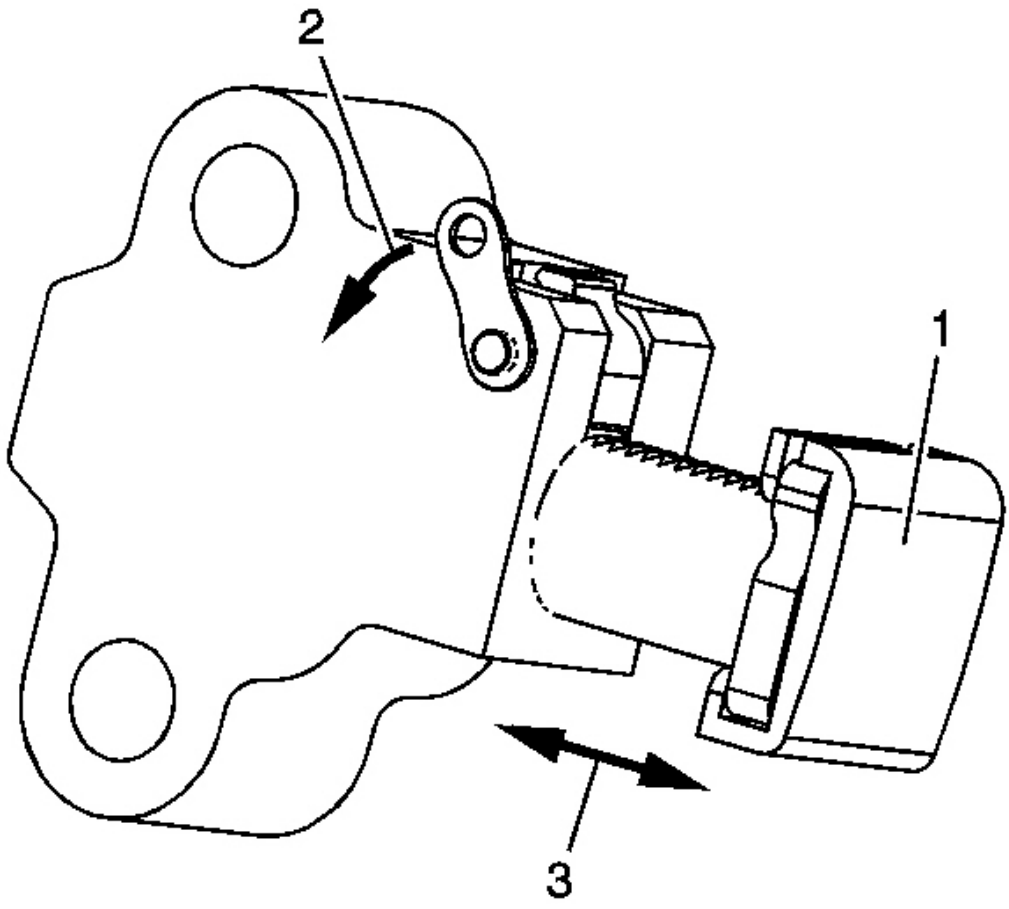


Fig. 171: Inspecting Secondary Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Inspect the secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).
2. Inspect the secondary timing chain tensioner for locked or binding timing chain tensioner. Release the locking lever (2) and ensure the plunger moves freely (3) in and out of the body of the tensioner.
3. Replace a damaged primary and/or secondary timing chain tensioner.

Timing Component Fasteners

1. Inspect the timing component fasteners.
2. Replace any damaged timing component fasteners, do not repair.

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MECHANICAL INSPECTION

Camshaft Position Actuators

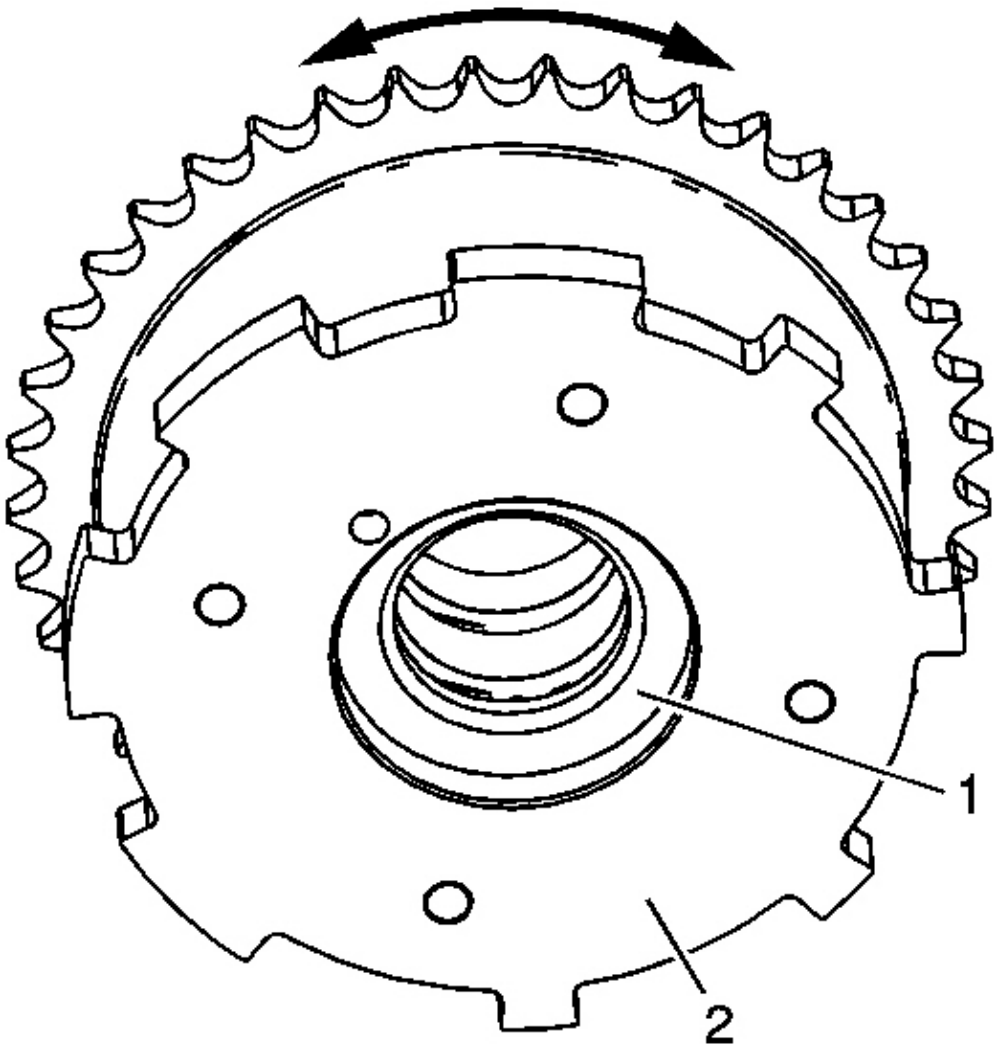


Fig. 172: Locating Intake Camshaft Position Actuator Inner Rotor Hub & Outer Housing
Courtesy of GENERAL MOTORS CORP.

CAUTION: When removing, handling or installing this component wear protective gloves. The sharp edges on the component may be very sharp and may cause injury.

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NOTE: **DO NOT clamp the component in any clamping device such as a vise or gripping tool. Clamping the component can cause external and internal damage that can affect engine and/or component performance.**

1. Inspect the intake camshaft position actuator to ensure the internal lock pin is engaged and the camshaft position actuator is parked in the home position. Attempt to rotate the inner rotor hub (1) within the outer housing (2).

   If the intake camshaft position actuator can be turned in either direction the camshaft position actuator must be replaced.

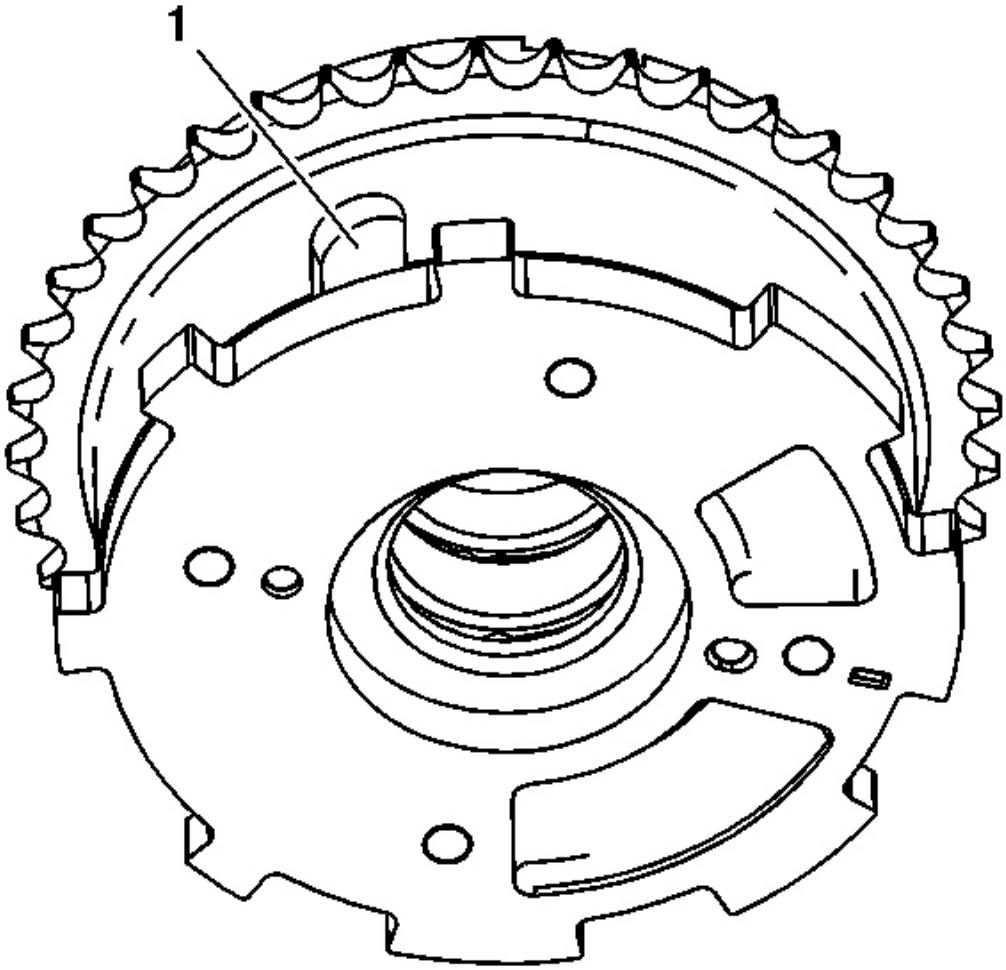


Fig. 173: Locating Intake Camshaft Position Actuator External Housing Locking Pin Cover

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Courtesy of GENERAL MOTORS CORP.

2. Locate the internal hub oil passage for the locking pin by observing the external housing locking pin cover (1). The oil passage in the hub for the locking pin is inline with the location of the locking pin cover.

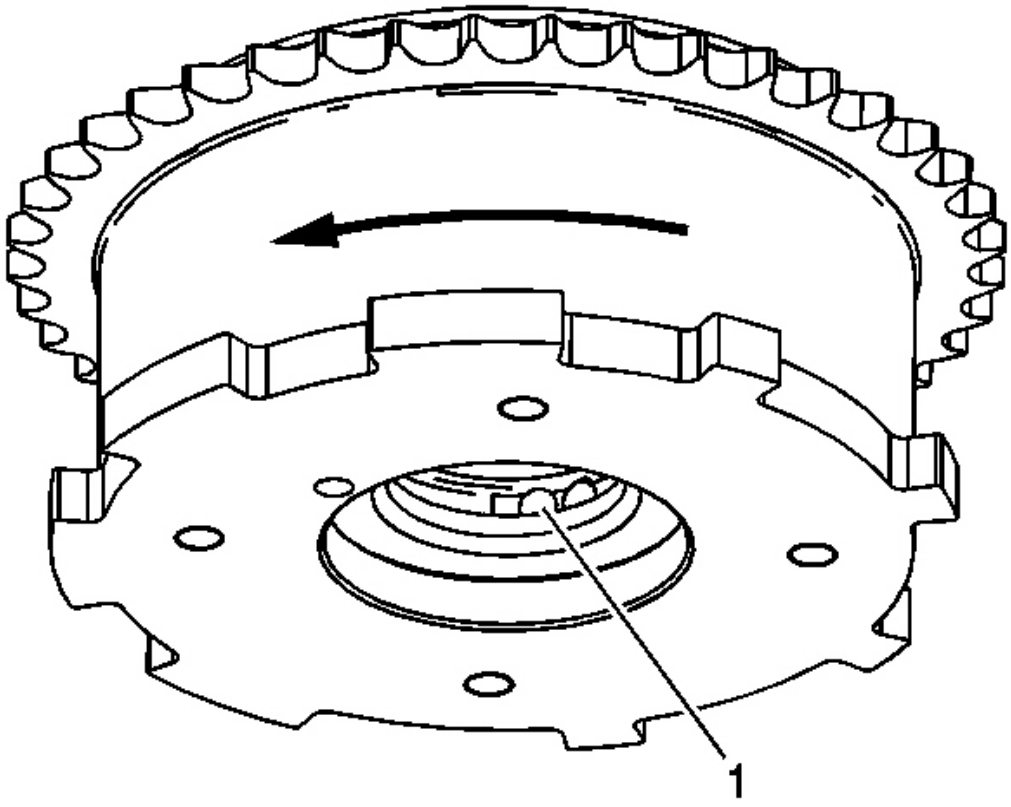


Fig. 174: Locating Intake Camshaft Position Actuator Internal Lock Pin
Courtesy of GENERAL MOTORS CORP.

3. Inspect the intake camshaft position actuator for smooth and even movement. Using a pre-bent hex key, smaller than the oil passage, depress the internal lock pin through the oil passage (1) located within the hub of the camshaft position actuator. While viewing the intake camshaft position actuator from the front and with the lock pin depressed, the outer housing should be manually moved in the clockwise direction from the inner rotor hub.

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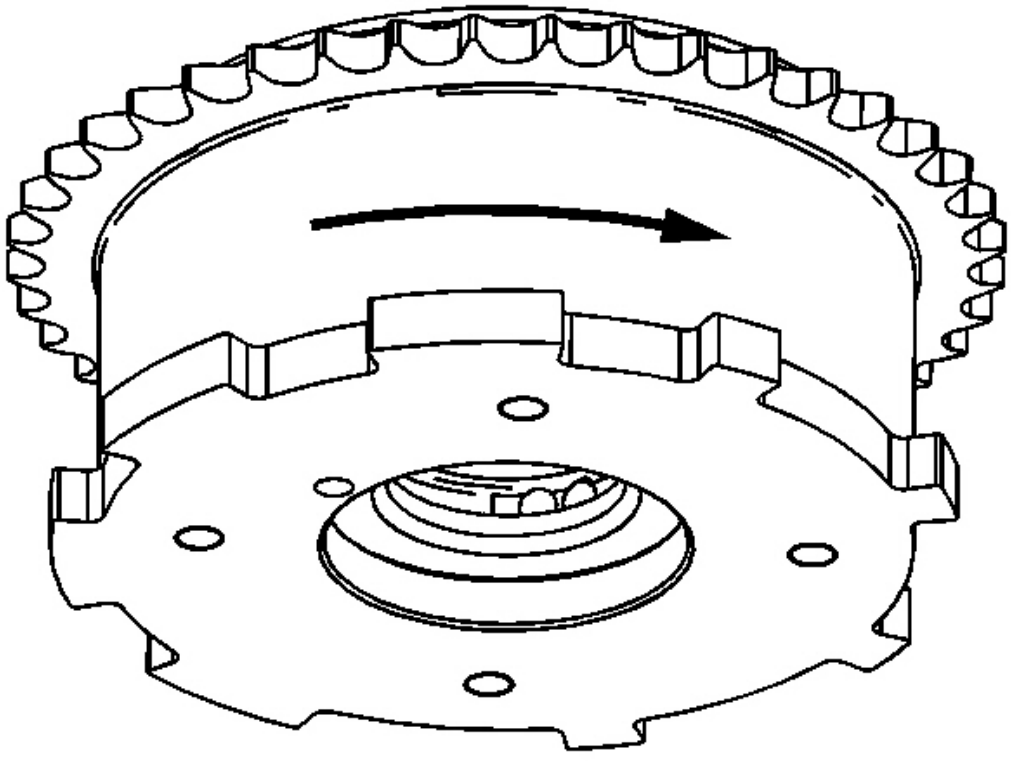


Fig. 175: Rotating Intake Camshaft Position Actuator Outer Housing Clockwise
Courtesy of GENERAL MOTORS CORP.

4. Remove the hex key from the oil passage and manually return the outer housing clockwise back to the home position. Ensure the lock pin engages when the outer housing returns to the home position.
5. If the intake camshaft position actuator does not move, the movement is not smooth and even or the lock pin does not engage in the home position replace the intake camshaft position actuator.

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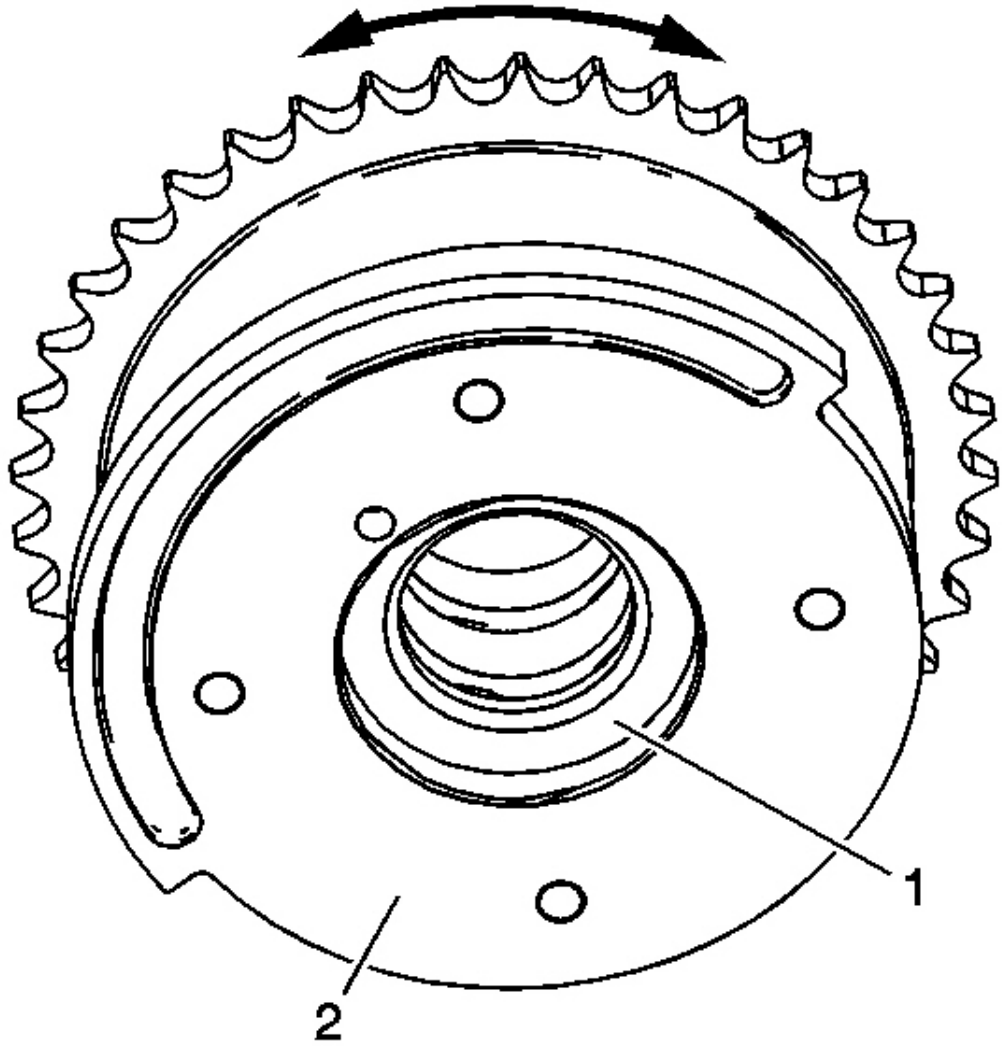


Fig. 176: Locating Exhaust Camshaft Position Actuator Inner Rotor Hub & Outer Housing
Courtesy of GENERAL MOTORS CORP.

6. Inspect the exhaust camshaft position actuator to ensure the internal lock pin is engaged and the camshaft position actuator is parked in the home position. Attempt to rotate the inner rotor hub (1) within the outer housing (2).

   If the exhaust camshaft position actuator can be turned in either direction the camshaft position actuator must be replaced.

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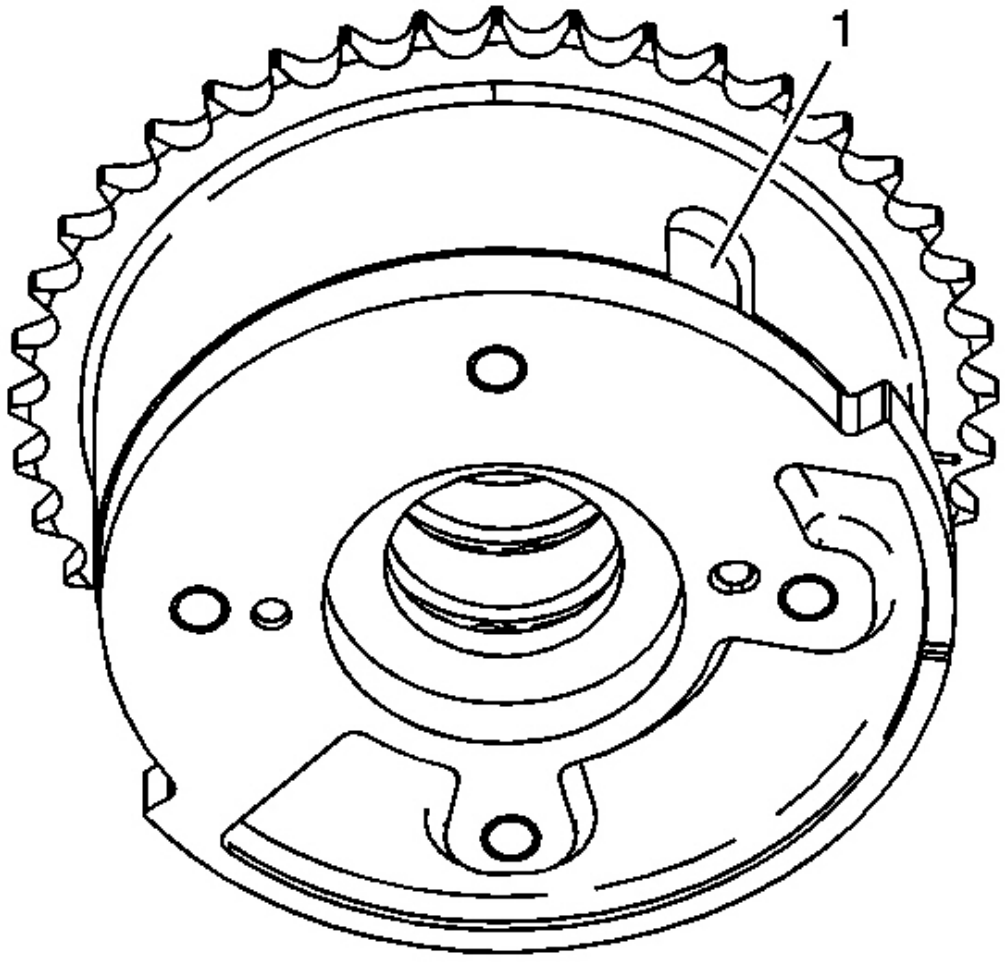


Fig. 177: Locating Exhaust Camshaft Position Actuator External Housing Locking Pin Cover
Courtesy of GENERAL MOTORS CORP.

7. Locate the internal hub oil passage for the locking pin by observing the external housing locking pin cover (1). The oil passage in the hub for the locking pin is inline with the location of the locking pin cover.

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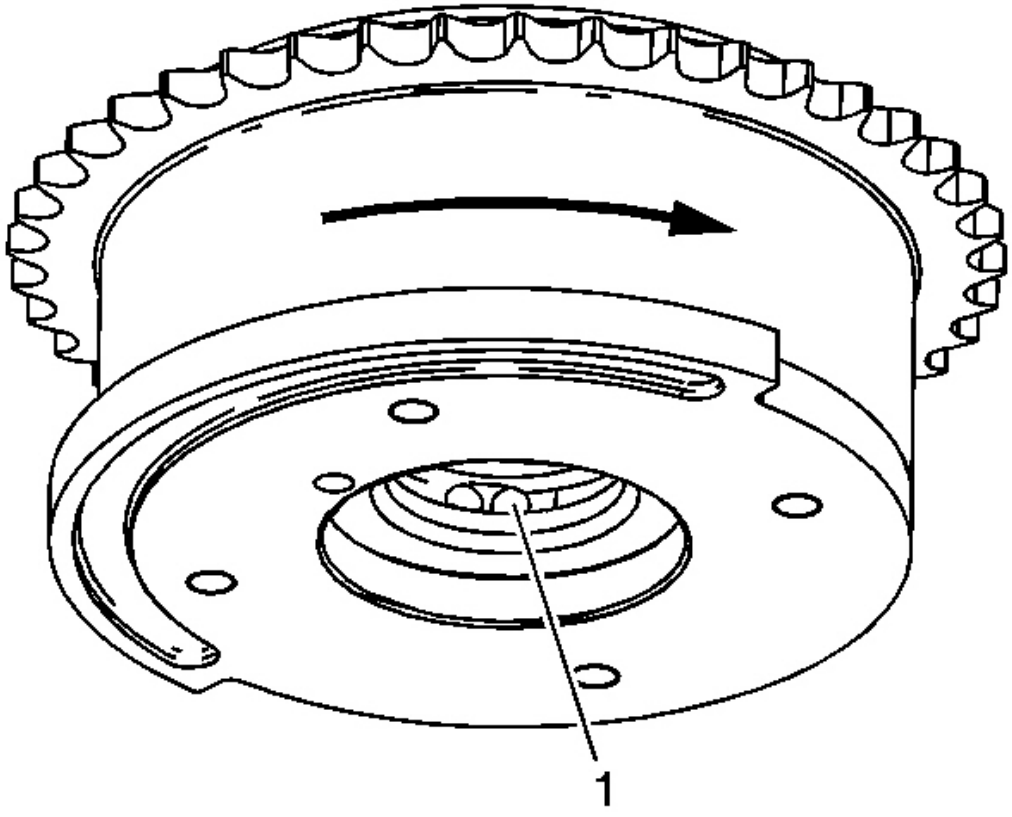


Fig. 178: Locating Exhaust Camshaft Position Actuator Internal Lock Pin
Courtesy of GENERAL MOTORS CORP.

8. Inspect the exhaust camshaft position actuators for smooth and even movement. The exhaust camshaft position actuator has return springs and the inspection will require additional assistance to perform. Using a pre-bent hex key, smaller than the oil passage, depress the internal lock pin through the oil passage (1) located within the hub of the camshaft position actuator. While viewing the exhaust camshaft position actuator from the front and with the lock pin depressed, the outer housing should be manually moved in the clockwise direction from the inner rotor hub.

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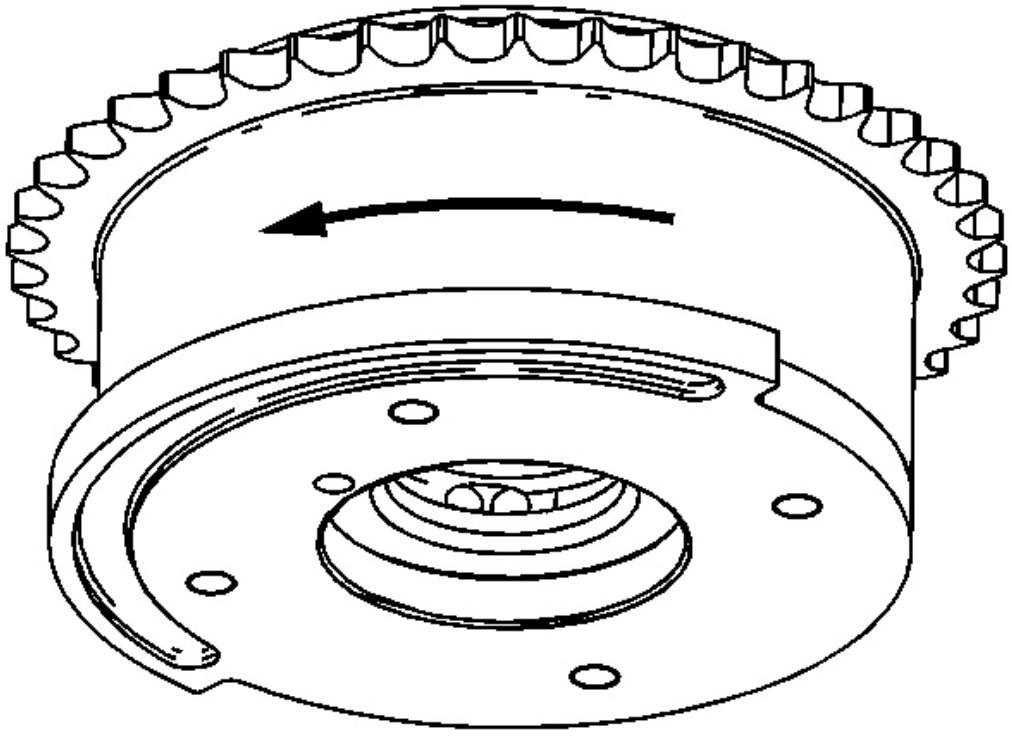


Fig. 179: Rotating Exhaust Camshaft Position Actuator Outer Housing Clockwise
Courtesy of GENERAL MOTORS CORP.

9. Remove the hex key from the oil passage and allow the outer housing to move counter clockwise back to the home position. Ensure the return springs bring the outer housing back to the home position and the lock pin engages.
10. If the exhaust camshaft position actuator does not move, the movement is not smooth and even, the return springs do not return the outer housing to the home position or the lock pin does not engage in the home position replace the exhaust camshaft position actuator.

Camshaft Position Actuator Oil Control Valve

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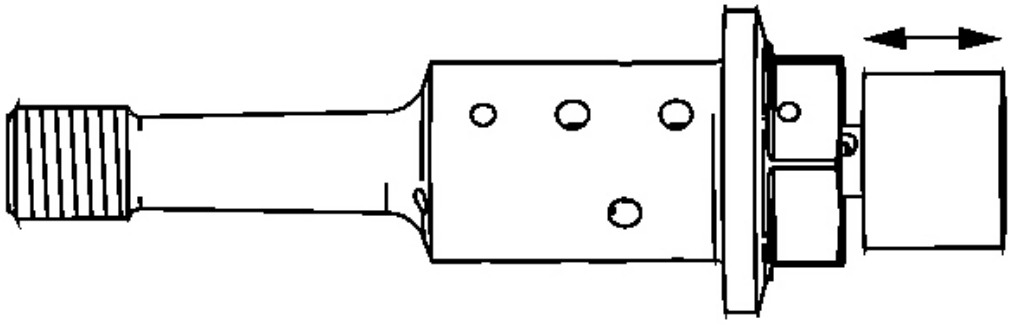


Fig. 180: Inspecting Camshaft Position Actuator Oil Control Valve For Smooth Spool Valve Movement
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT clamp the component in any clamping device such as a vise or gripping tool. Clamping the component can cause external and internal damage that can affect engine and/or component performance.

1. Inspect the camshaft position actuator oil control valves for smooth and even movement of the spool valve within the camshaft position actuator oil control valve body.

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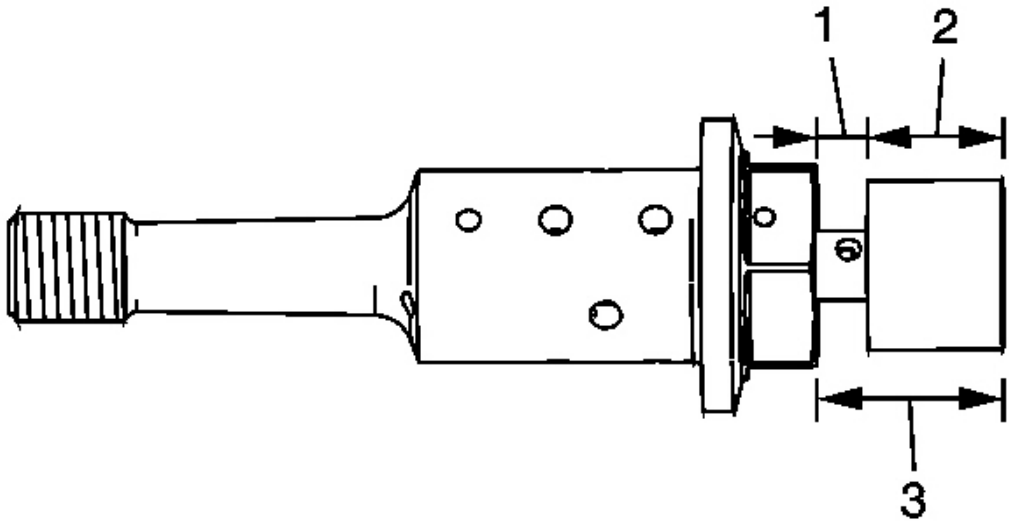
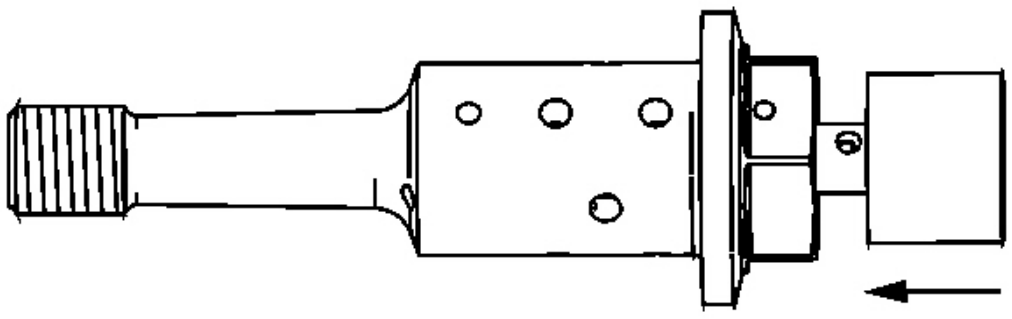


Fig. 181: Inspecting Camshaft Position Actuator Oil Control Valve For Proper Spool Valve Movement
Courtesy of GENERAL MOTORS CORP.

2. Inspect the camshaft position actuator oil control valves for proper movement of the spool valve. The valve should move a distance (2) of 4.35 mm (0.1713 in). Measure from the underside of the spool valve head. The home position is 2.25 mm (0.0886 in) above (1) the hex and the fully extended position measures 6.60 mm (0.2598 in) above (3) the hex.



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Fig. 182: Inspecting Camshaft Position Actuator Oil Control Valve For Proper Spool Valve Return
Courtesy of GENERAL MOTORS CORP.

3. Inspect the camshaft position actuator oil control valves for proper return of the spool valve to the home position by the internal spring.

CAMSHAFT POSITION ACTUATOR HOUSING DISASSEMBLE

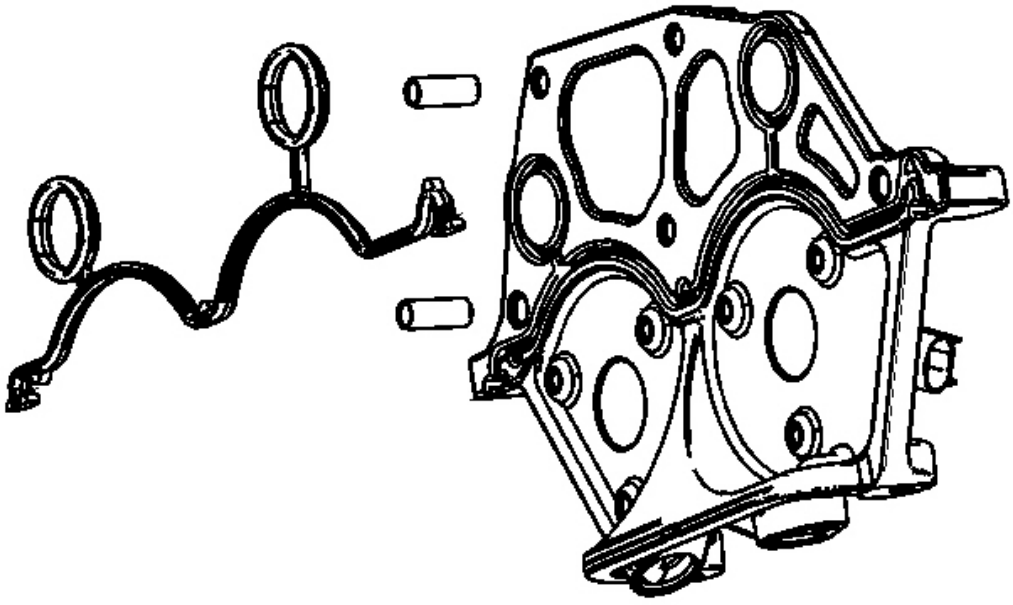


Fig. 183: View Of Camshaft Position Actuator Housing Gasket & Alignment Pins
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position actuator housing gasket and discard.
2. Remove the camshaft position actuator housing alignment pins.

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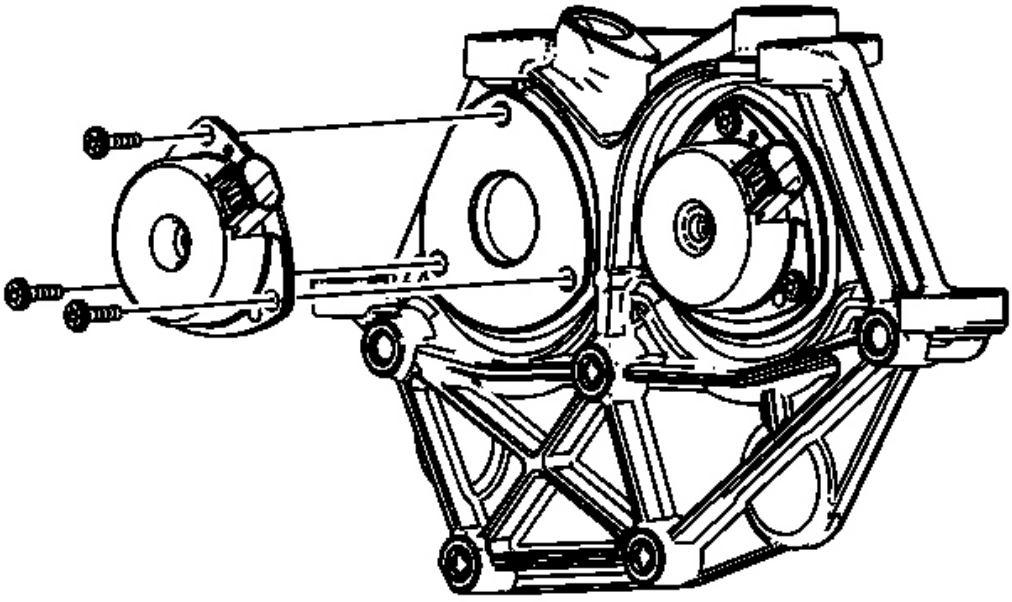


Fig. 184: View Of Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT remove the camshaft position actuator magnet unless it needs to be replaced. The camshaft position actuator magnet is precisely aligned to the camshaft position actuator oil control valve on the end of the camshaft during engine assembly. If the camshaft position actuator magnet is removed and/or needs to be replaced, it will be necessary to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve after the camshaft position actuator housing is installed to the cylinder head. Failure to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve can lead to poor engine performance and engine component damage.

3. If required, remove the camshaft position actuator magnet bolts.
4. If required, remove the camshaft position actuator magnet.
5. Remove the camshaft position actuator magnet alignment plug and discard.

CAMSHAFT POSITION ACTUATOR HOUSING CLEANING AND INSPECTION

CLEANING PROCEDURE

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1. Clean the camshaft position actuator housing components, except the camshaft position actuator magnets, with solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the camshaft position actuator housing components with compressed air.

INSPECTION PROCEDURE

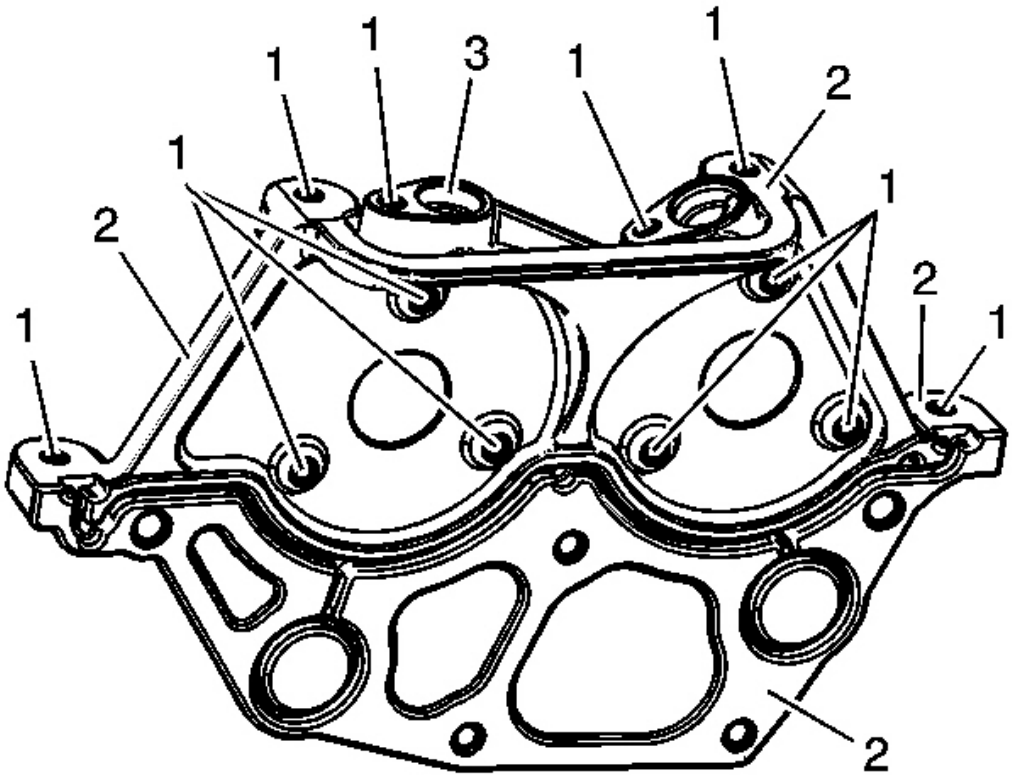


Fig. 185: Inspecting Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft position actuator housing for the following conditions:
   - The camshaft position actuator housing for damaged threads (1)
   - The camshaft position actuator housing sealing surface (2) for damage

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- The camshaft position sensor mounting bores (3) for damage

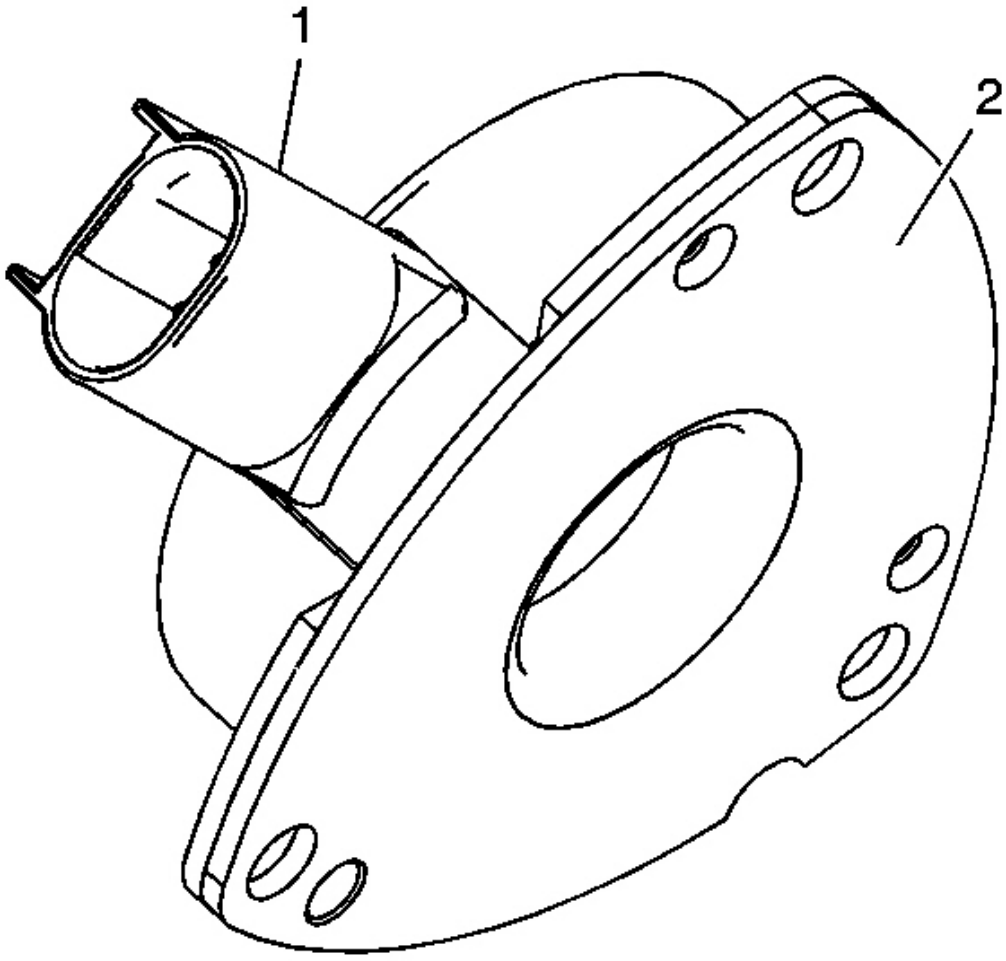


Fig. 186: Inspecting Camshaft Position Actuator Magnets
Courtesy of GENERAL MOTORS CORP.

2. Inspect the camshaft position actuator magnets for the following conditions:
   - The camshaft position actuator magnet wiring connector (1) for damage
   - The camshaft position actuator magnet sealing surface (2) for damage
3. Repair or replace the camshaft position actuator housing and/or components as necessary.

CAMSHAFT POSITION ACTUATOR HOUSING ASSEMBLE

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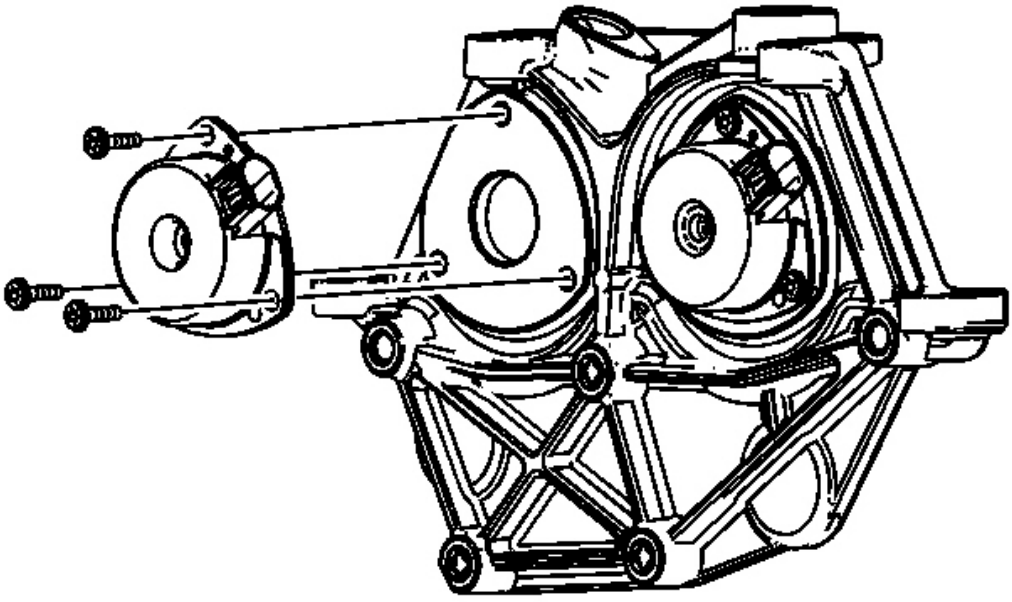


Fig. 187: View Of Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT remove the camshaft position actuator magnet unless it needs to be replaced. The camshaft position actuator magnet is precisely aligned to the camshaft position actuator oil control valve on the end of the camshaft during engine assembly. If the camshaft position actuator magnet is removed and/or needs to be replaced, it will be necessary to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve after the camshaft position actuator housing is installed to the cylinder head. Failure to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve can lead to poor engine performance and engine component damage.

1. If removed, loosely mount the camshaft position actuator magnet and bolts.
2. In order to allow for camshaft position actuator magnet to camshaft position actuator oil control valve alignment, DO NOT install the NEW camshaft position actuator magnet alignment plugs.

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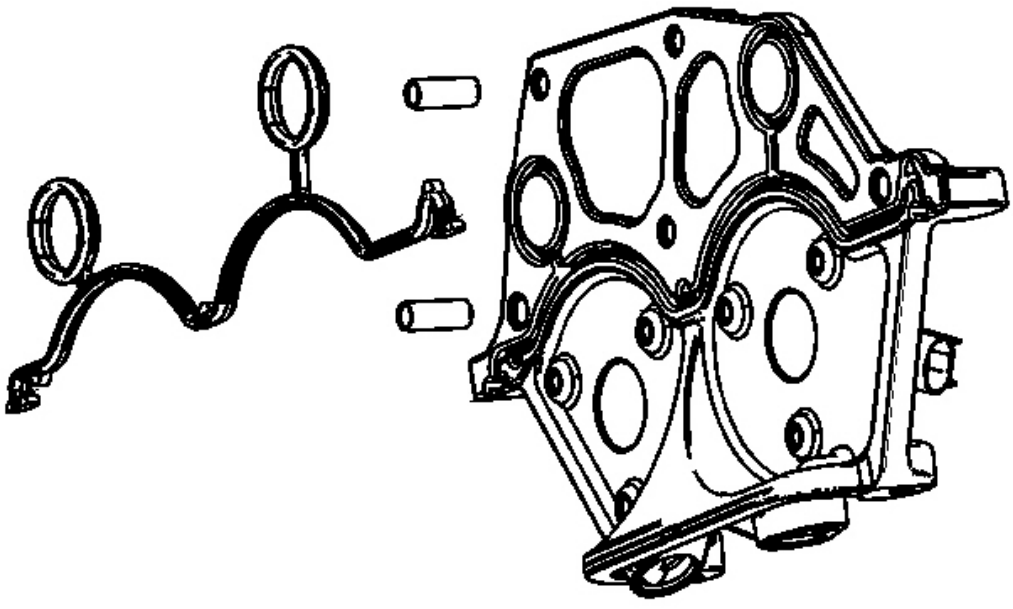


Fig. 188: View Of Camshaft Position Actuator Housing Gasket & Alignment Pins
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The camshaft position actuator housing alignment pins must be installed in order to precisely align the camshaft position actuator housing to the cylinder head.

3. Install the camshaft position actuator housing alignment pins.
4. Install the NEW camshaft position actuator housing gasket.

OIL PUMP DISASSEMBLE

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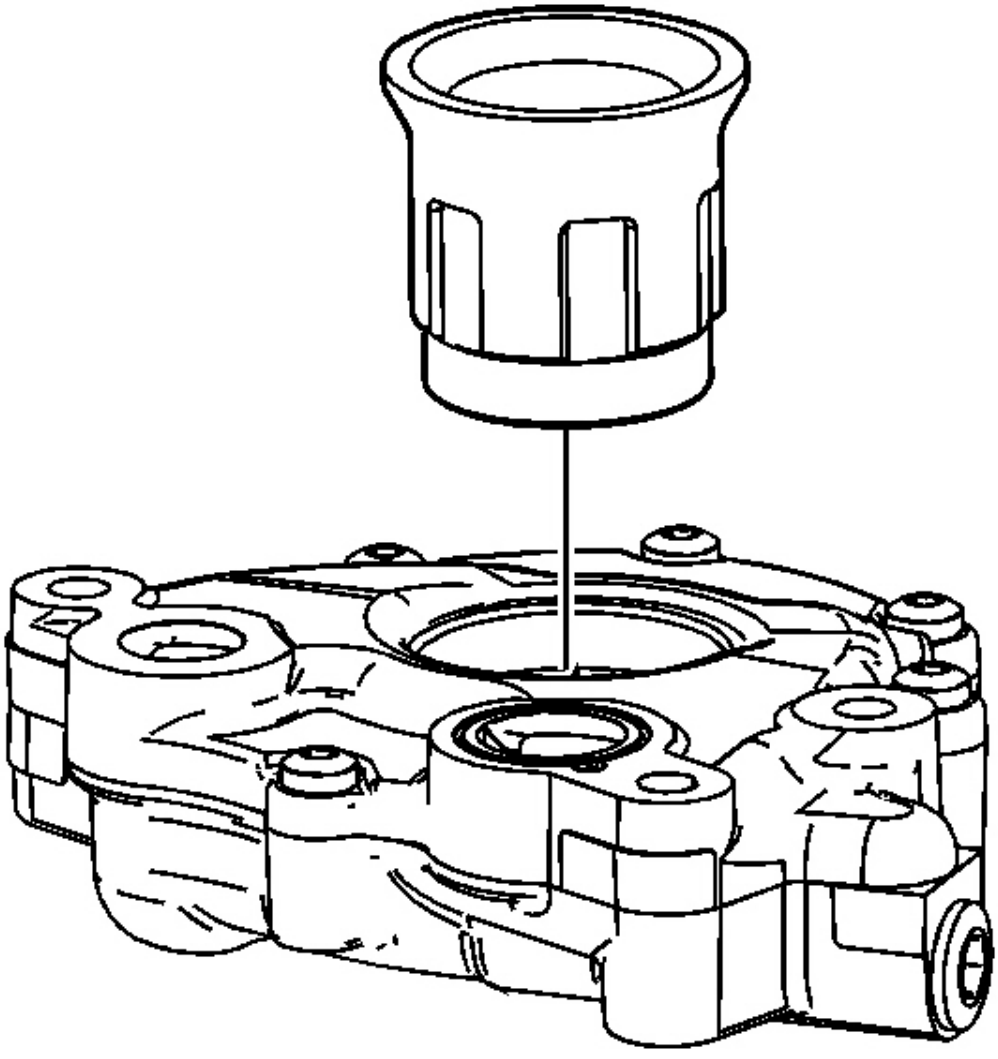


Fig. 189: View Of Oil Pump Drive Spacer
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump drive spacer.

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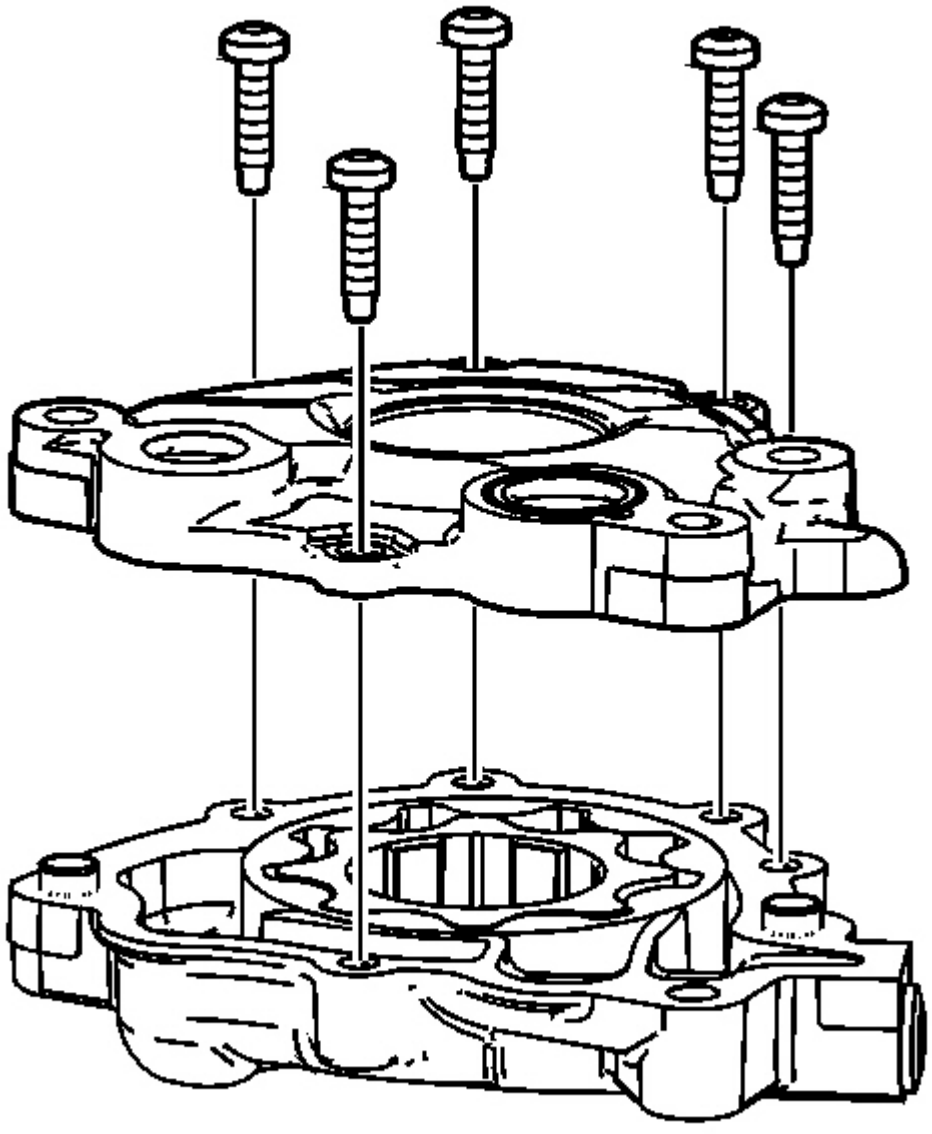


Fig. 190: View Of Oil Pump Body Cover
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump body bolts.
3. Remove the oil pump body cover.

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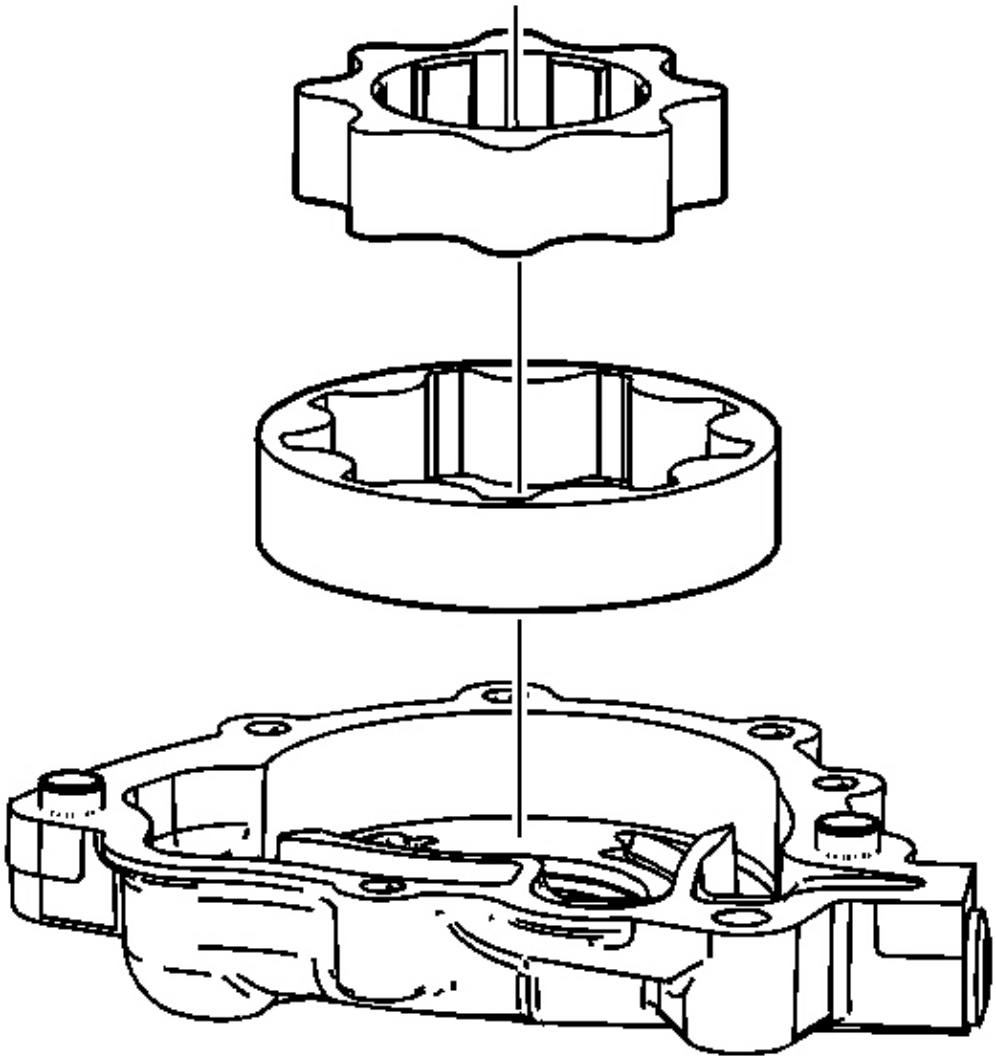


Fig. 191: View Of Oil Pump Drive & Driven Gears
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pump drive and driven gears.

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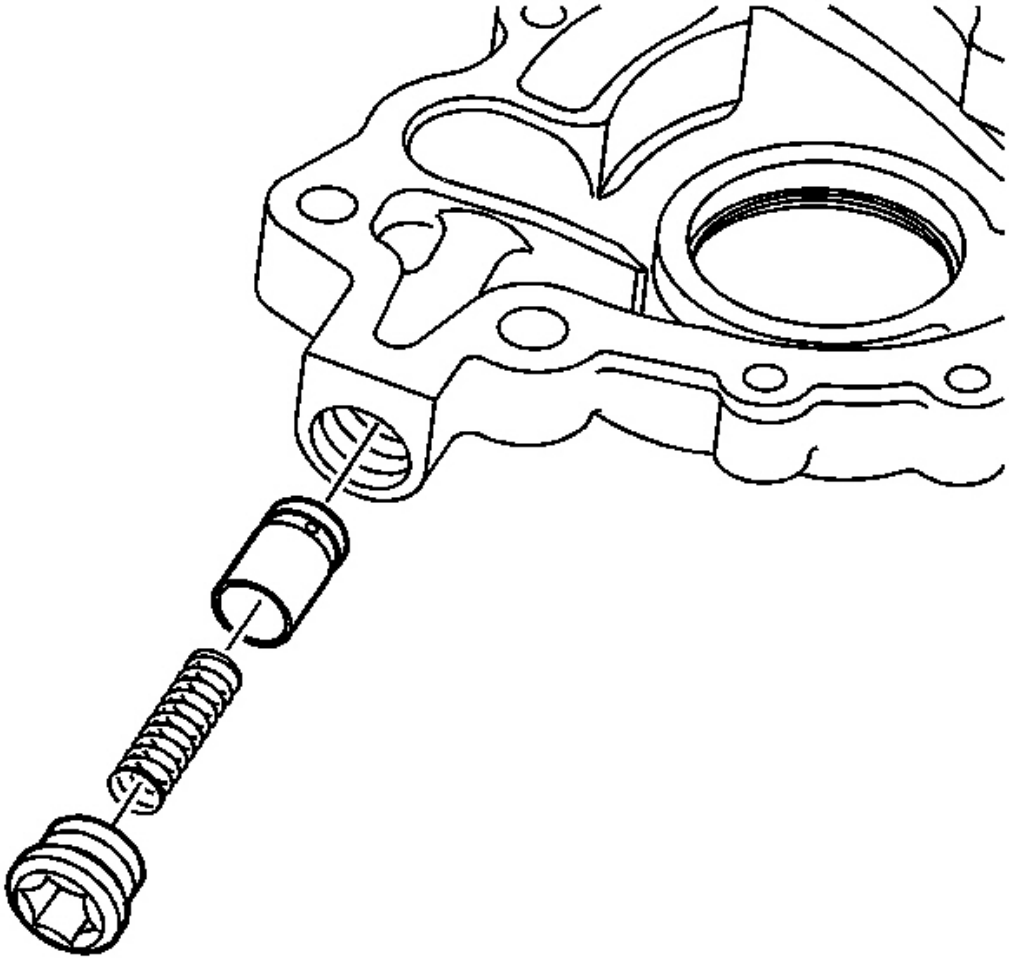


Fig. 192: View Of Oil Pump Drive Relief Valve Plug, Spring & Plunger
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pump relief valve plug, relief valve spring and relief valve plunger.

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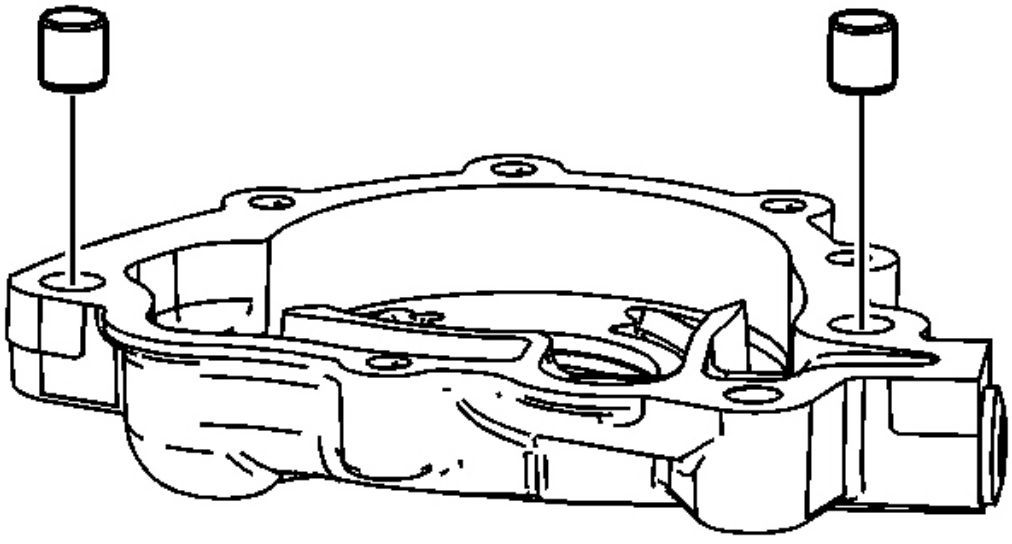


Fig. 193: View Of Oil Pump Body-To-Oil Pump Cover Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pump body to oil pump cover alignment dowels.

OIL PUMP CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the oil pump components with non-corrosive solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the oil pump components with compressed air.

INSPECTION PROCEDURE

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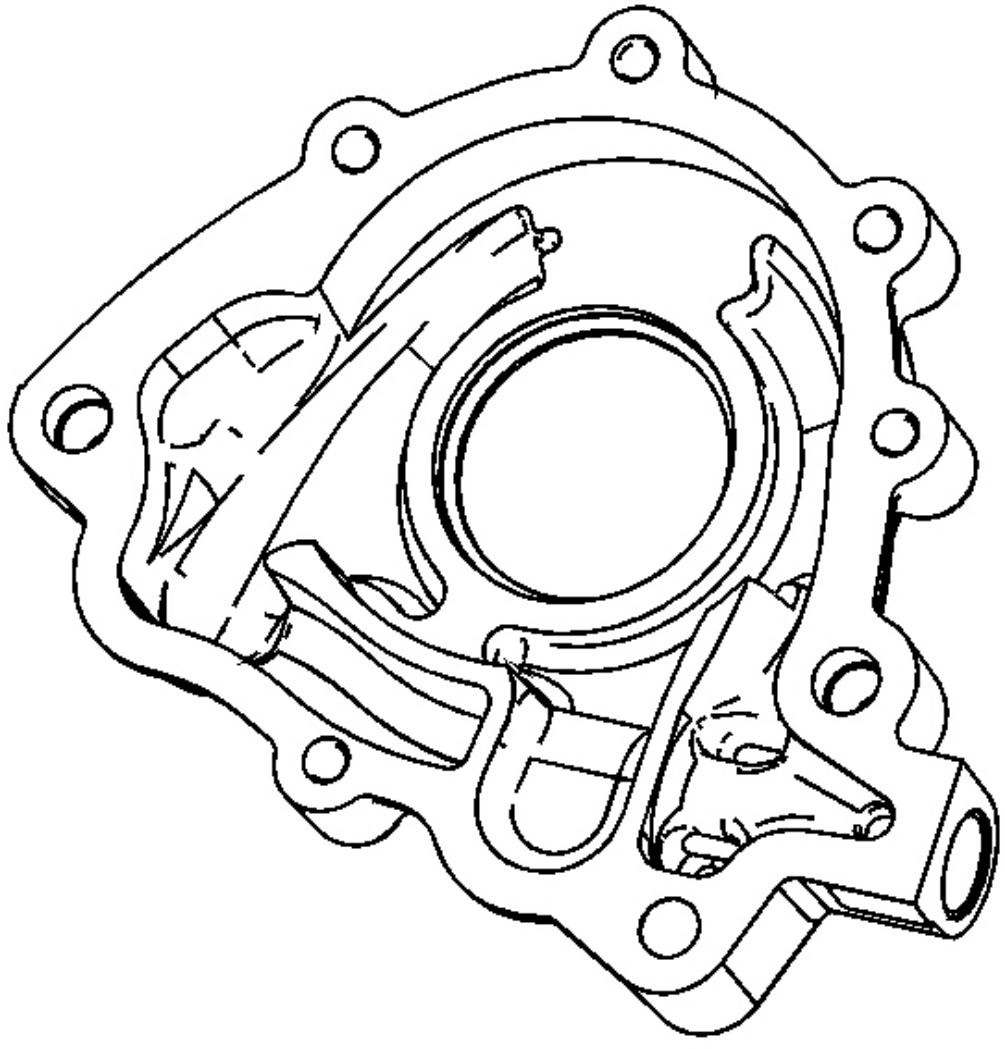


Fig. 194: Inspecting Oil Pump Body
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The internal parts of the oil pump are not serviced separately. If wear or damage is noted, replace the entire pump assembly.

1. Inspect the oil pump body for cracks, scoring, casting imperfections and damaged threads.

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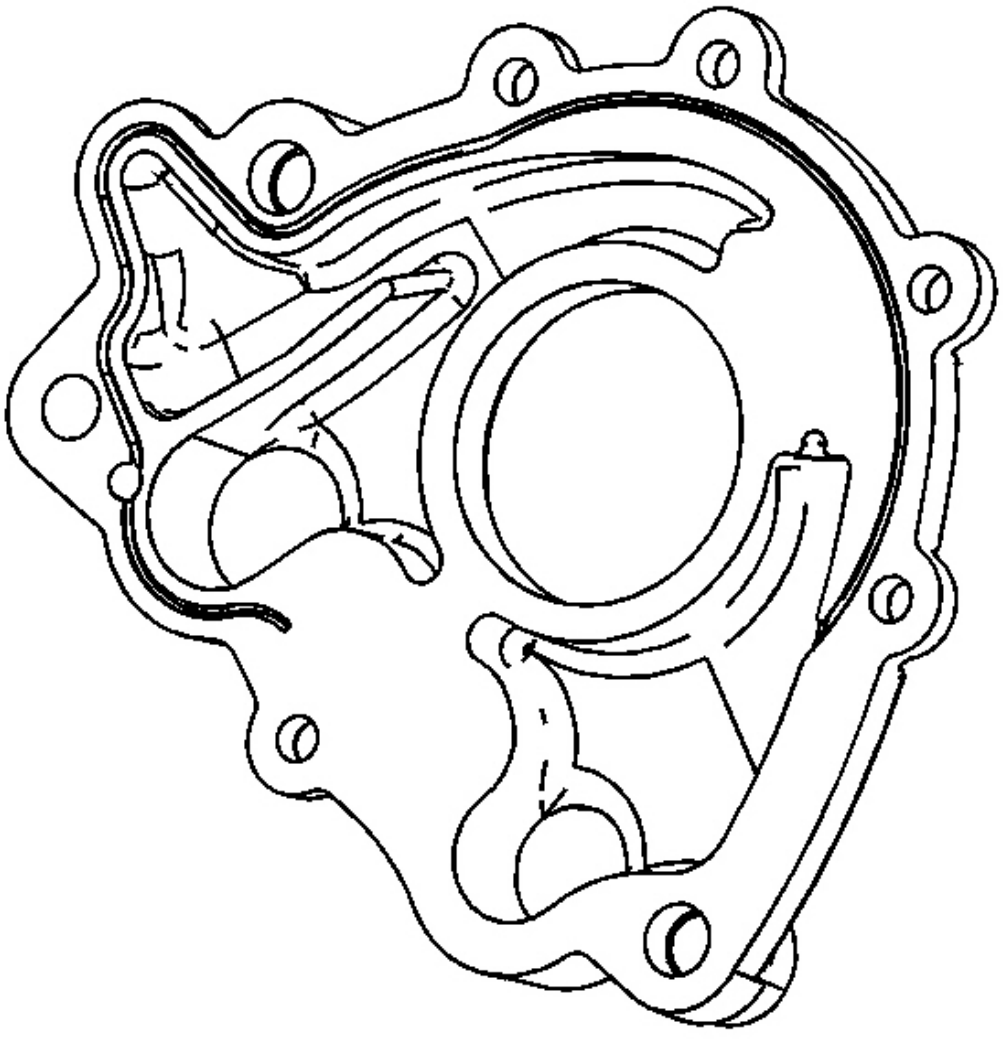


Fig. 195: Inspecting Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

2. Inspect the oil pump cover for cracks, scoring and casting imperfections.

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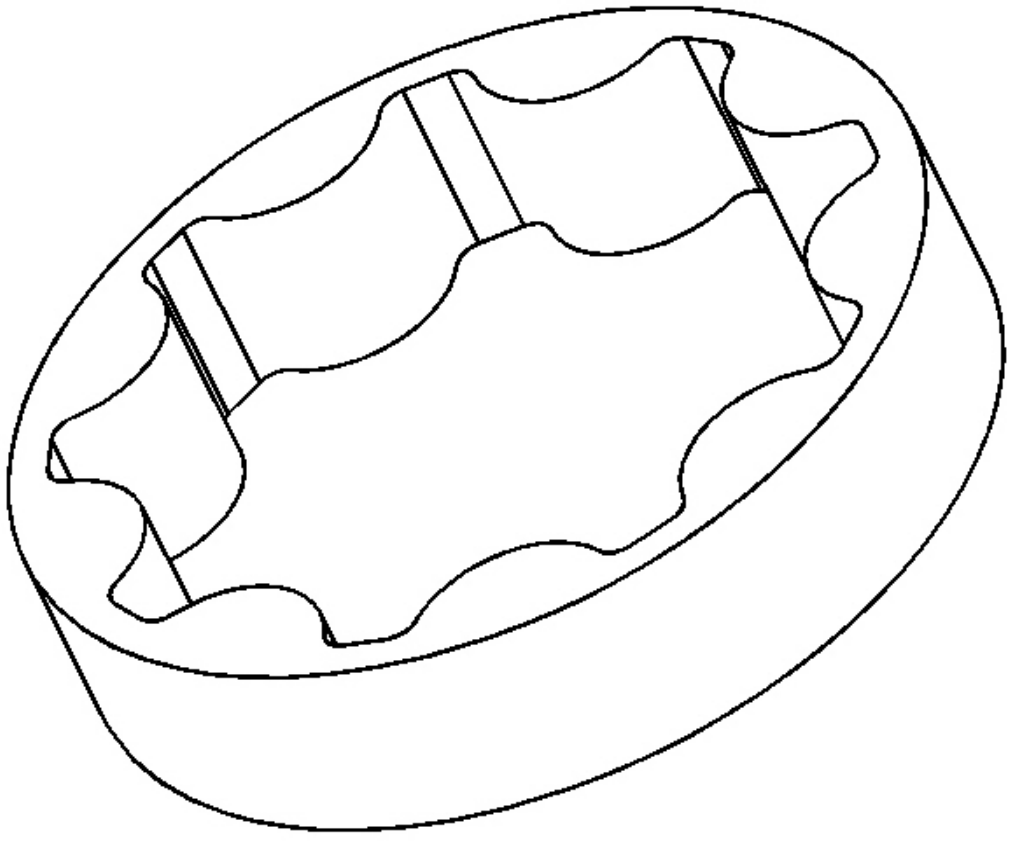


Fig. 196: Inspecting Oil Pump Driven Gear
Courtesy of GENERAL MOTORS CORP.

3. Inspect the oil pump driven gear for chipping, galling or wear.

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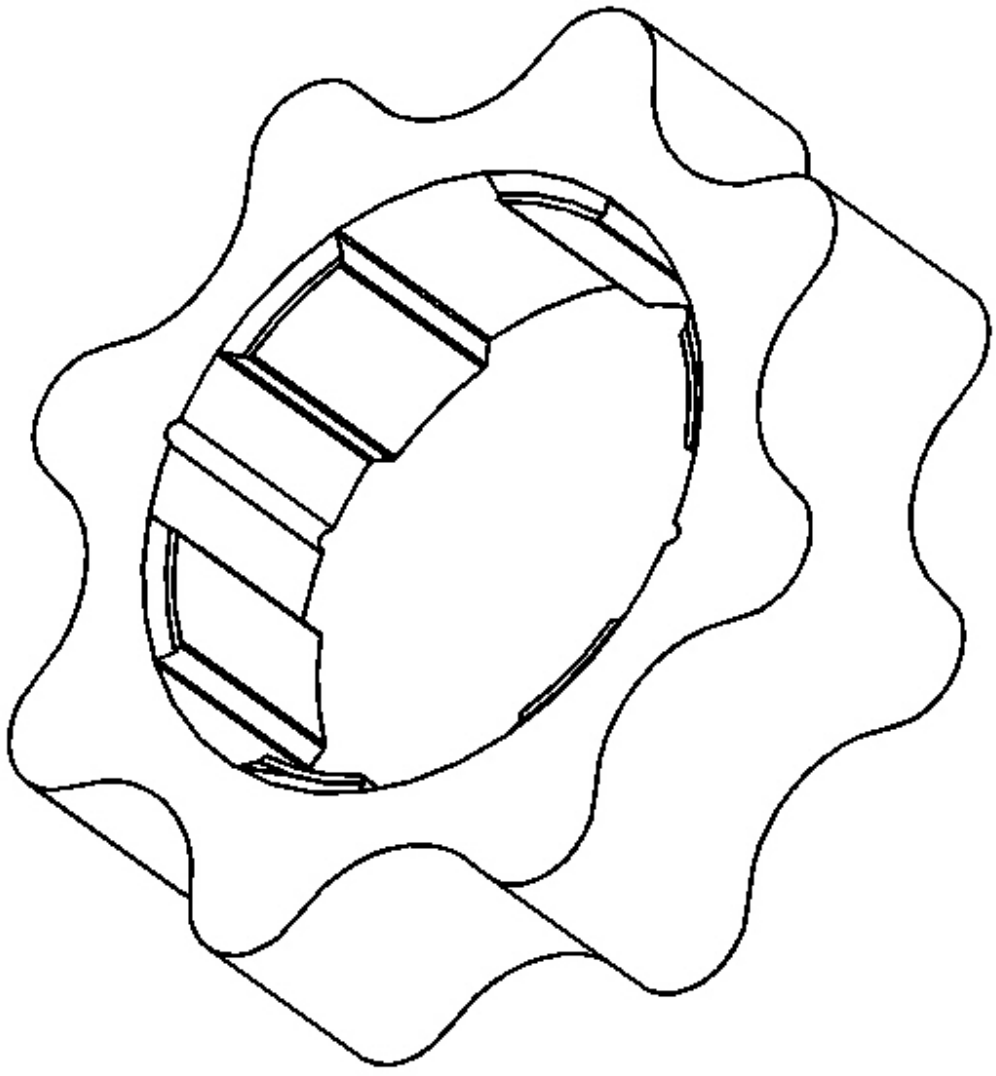


Fig. 197: Inspecting Oil Pump Drive Gear
Courtesy of GENERAL MOTORS CORP.

4. Inspect the oil pump drive gear for chipping, galling or wear.

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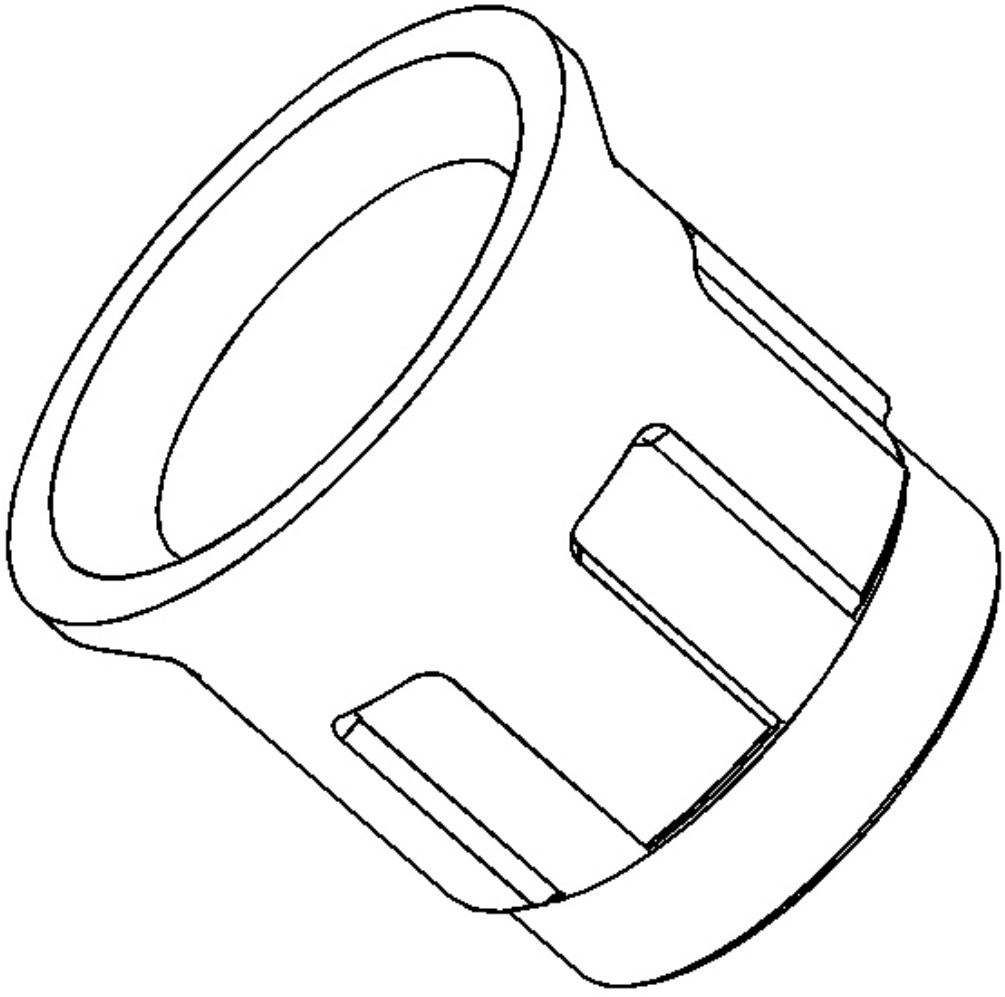


Fig. 198: Inspecting Oil Pump Drive Spacer
Courtesy of GENERAL MOTORS CORP.

5. Inspect the oil pump drive spacer for chipping, galling or wear.

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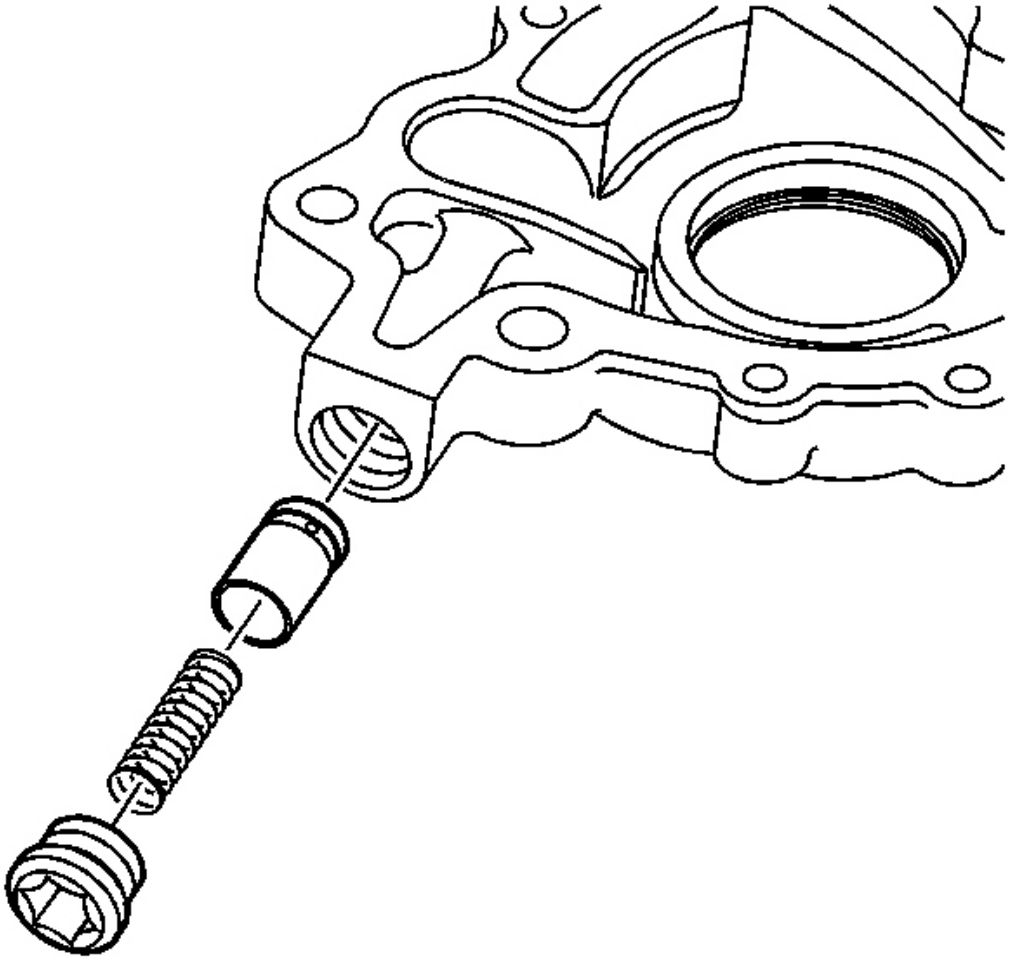


Fig. 199: Inspecting Oil Pump Relief Components
Courtesy of GENERAL MOTORS CORP.

6. Inspect the oil pump relief components for embedded particles and/or damage.

OIL PUMP ASSEMBLE

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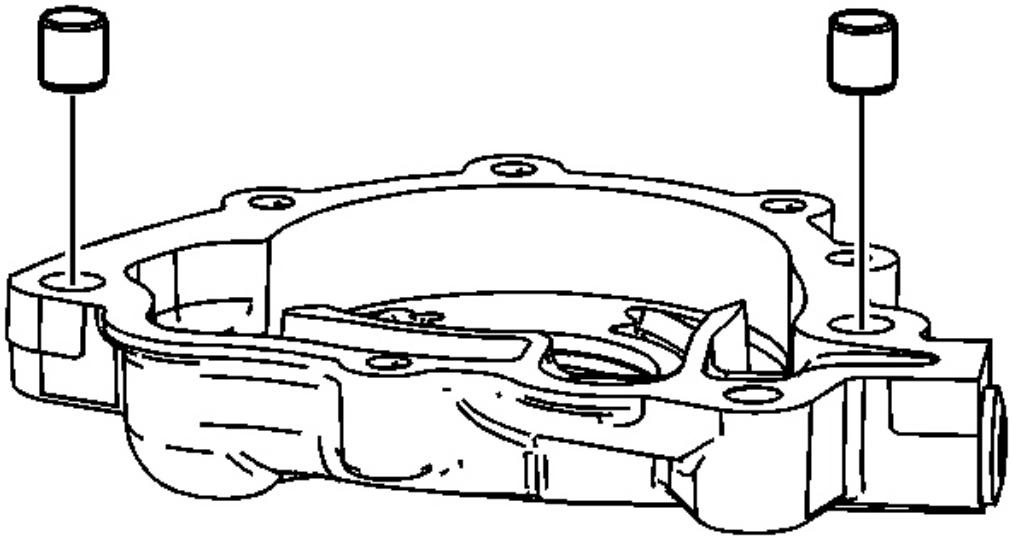


Fig. 200: View Of Oil Pump Body-To-Oil Pump Cover Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pump body to oil pump cover alignment dowels.

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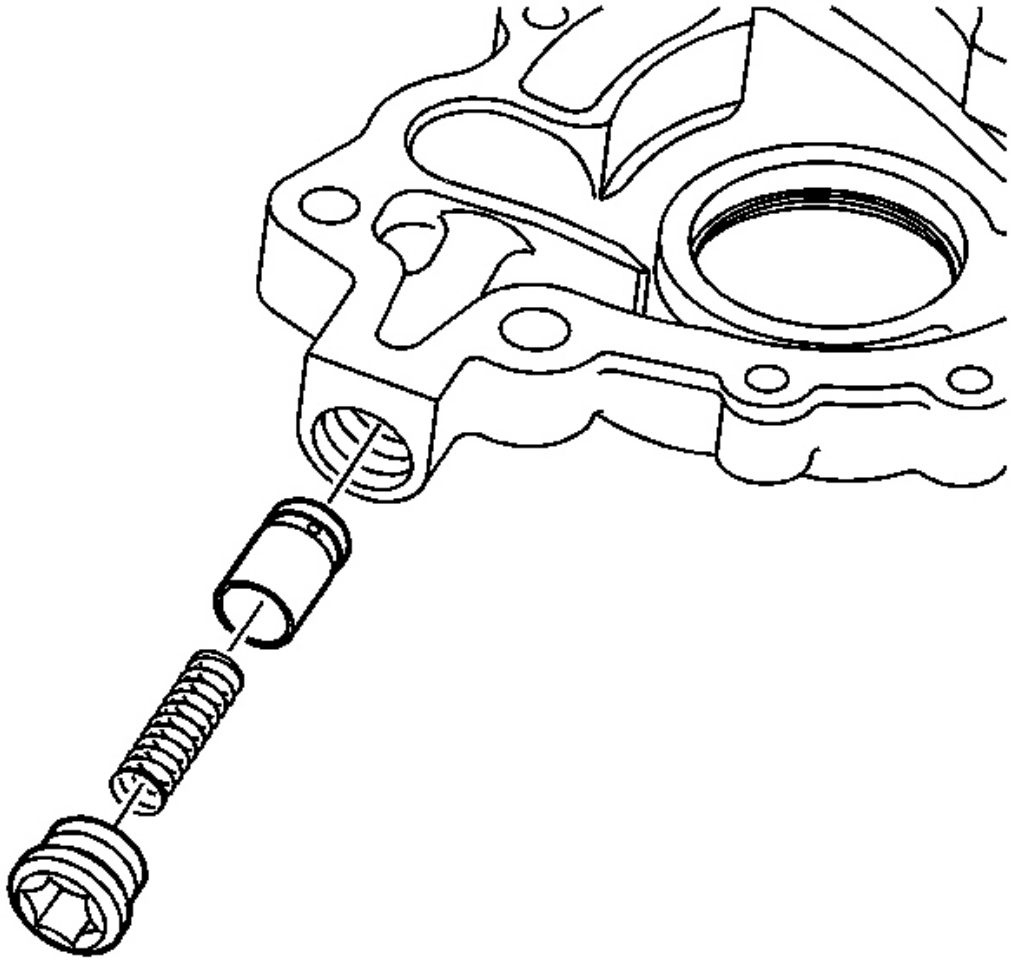


Fig. 201: View Of Oil Pump Drive Relief Valve Plug, Spring & Plunger
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

2. Install the oil pump relief valve plunger, relief valve spring and relief valve plug.

   Tighten: Tighten the oil pump relief valve plug to 12 N.m (106 lb in).

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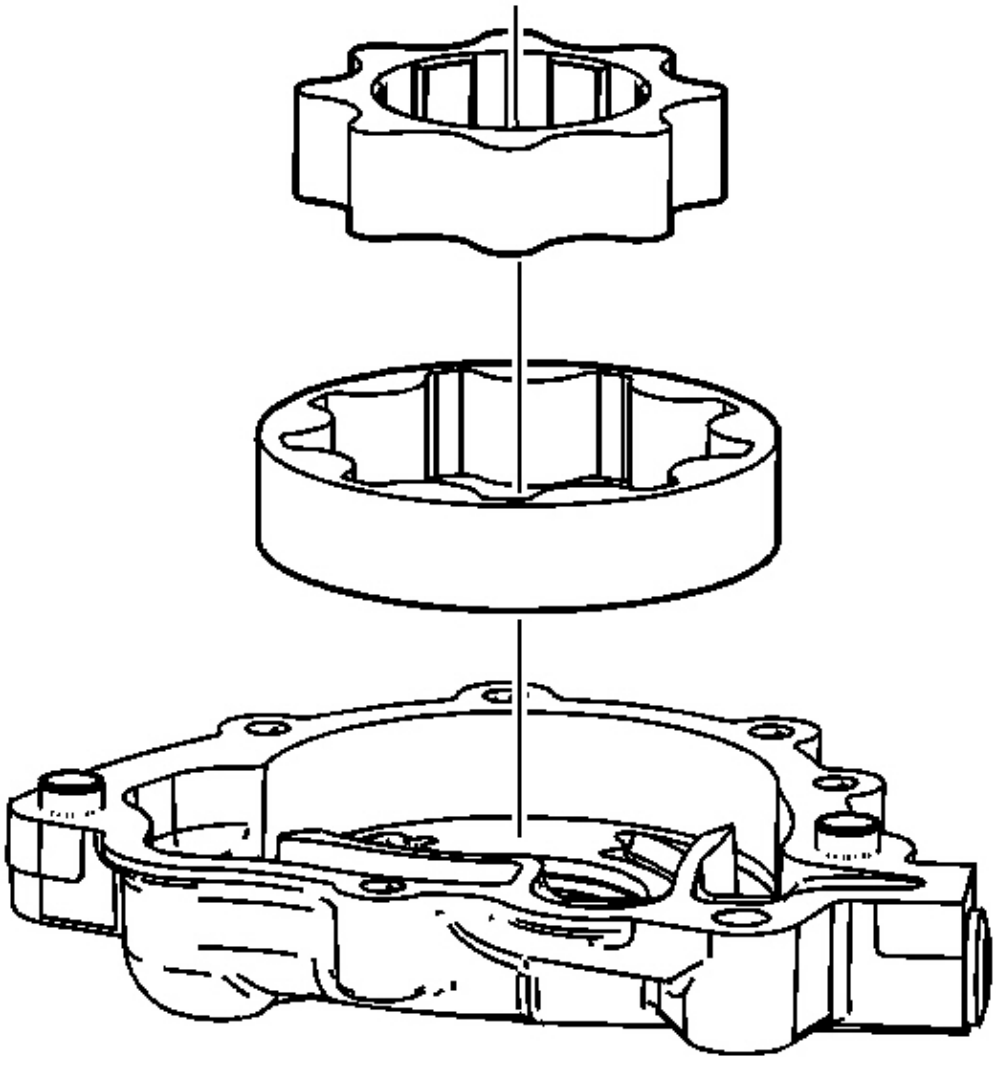


Fig. 202: View Of Oil Pump Drive & Driven Gears
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pump driven and drive gears. The outer driven gear has one chamfered edge. The chamfered edge of the driven gear must face-down into the oil pump body.
4. Pack the pump body housing with clean white petroleum jelly to ensure pump priming.

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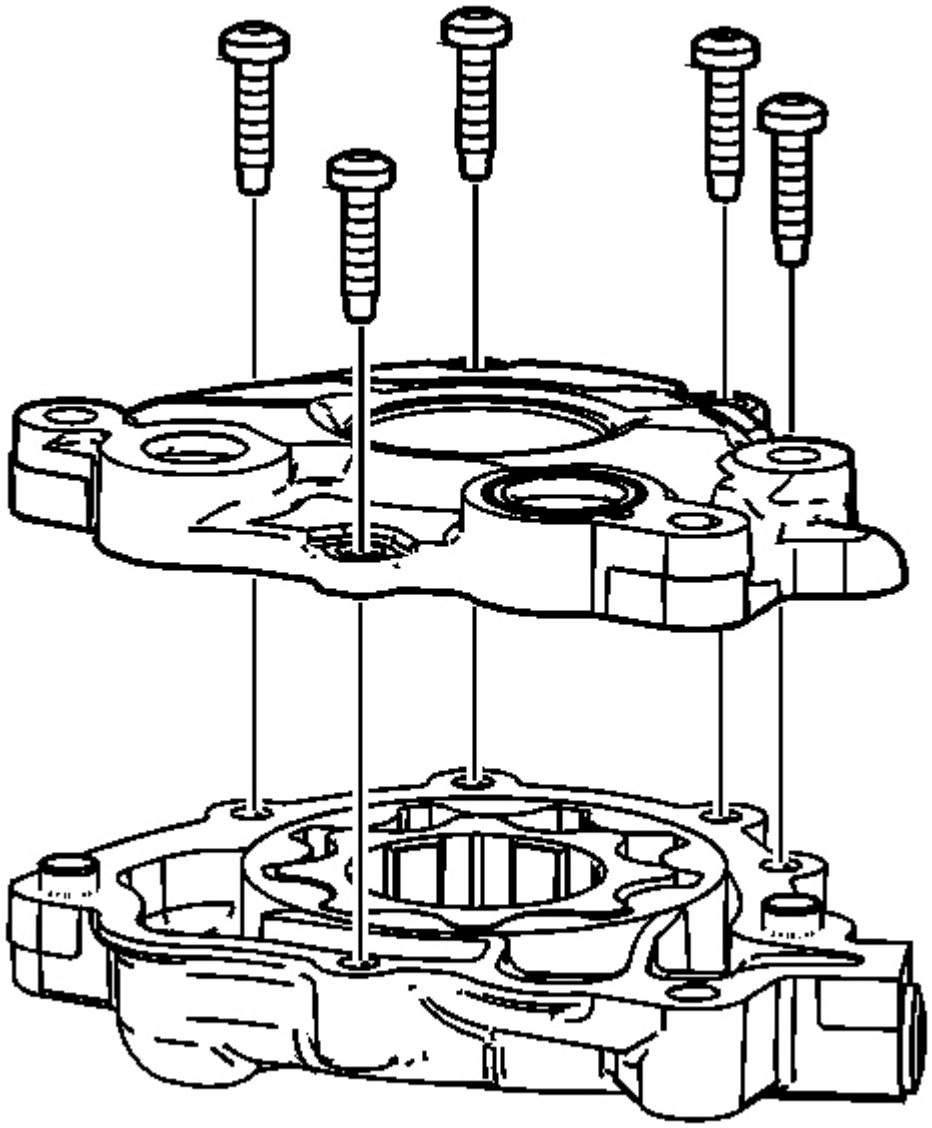


Fig. 203: View Of Oil Pump Body Cover
Courtesy of GENERAL MOTORS CORP.

5. Install the oil pump body cover.
6. Install the oil pump body bolts.

Tighten: Tighten the oil pump body bolts to 12 N.m (106 lb in).

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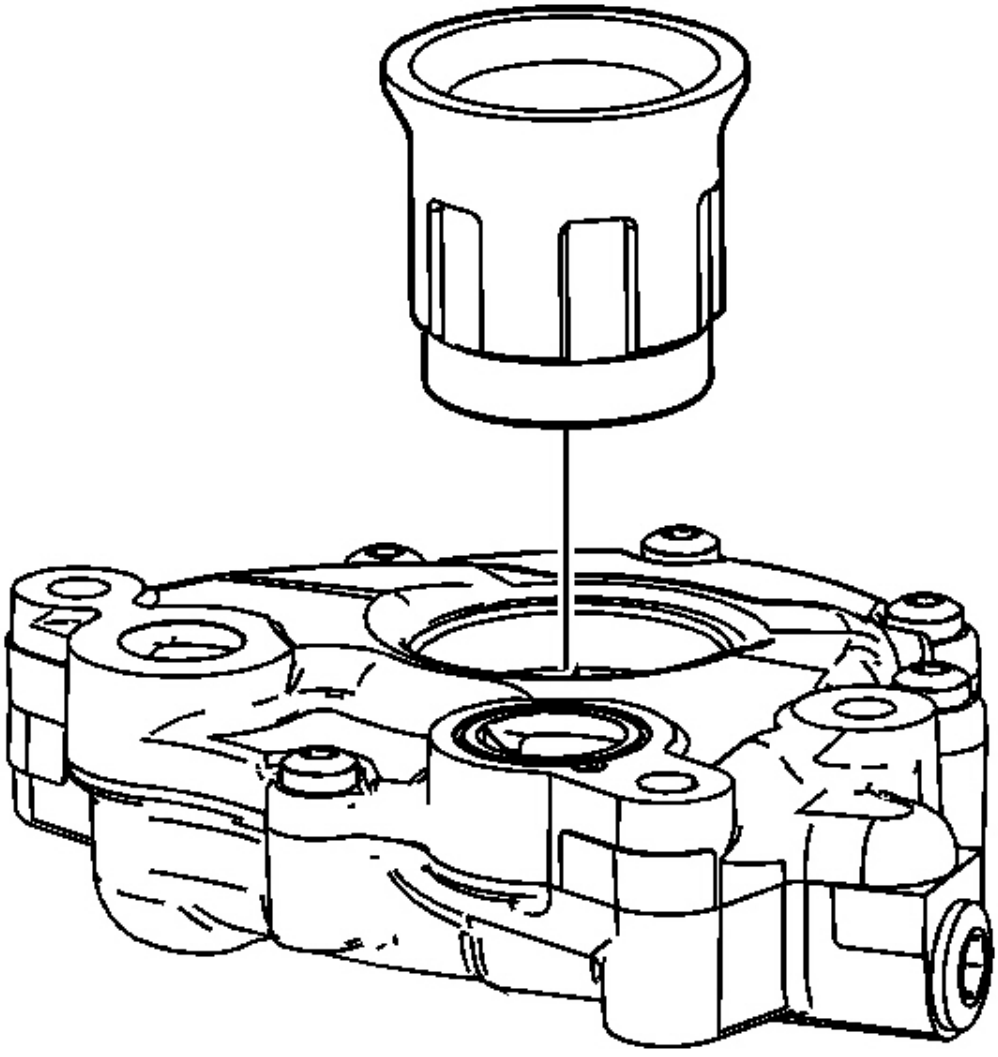


Fig. 204: View Of Oil Pump Drive Spacer
Courtesy of GENERAL MOTORS CORP.

7. Install the oil pump drive spacer.

OIL PUMP OUTLET TUBE CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the oil pump outlet with solvent.

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CAUTION: Refer to Safety Glasses Caution .

2. Dry the oil pump outlet tube with compressed air.

INSPECTION PROCEDURE

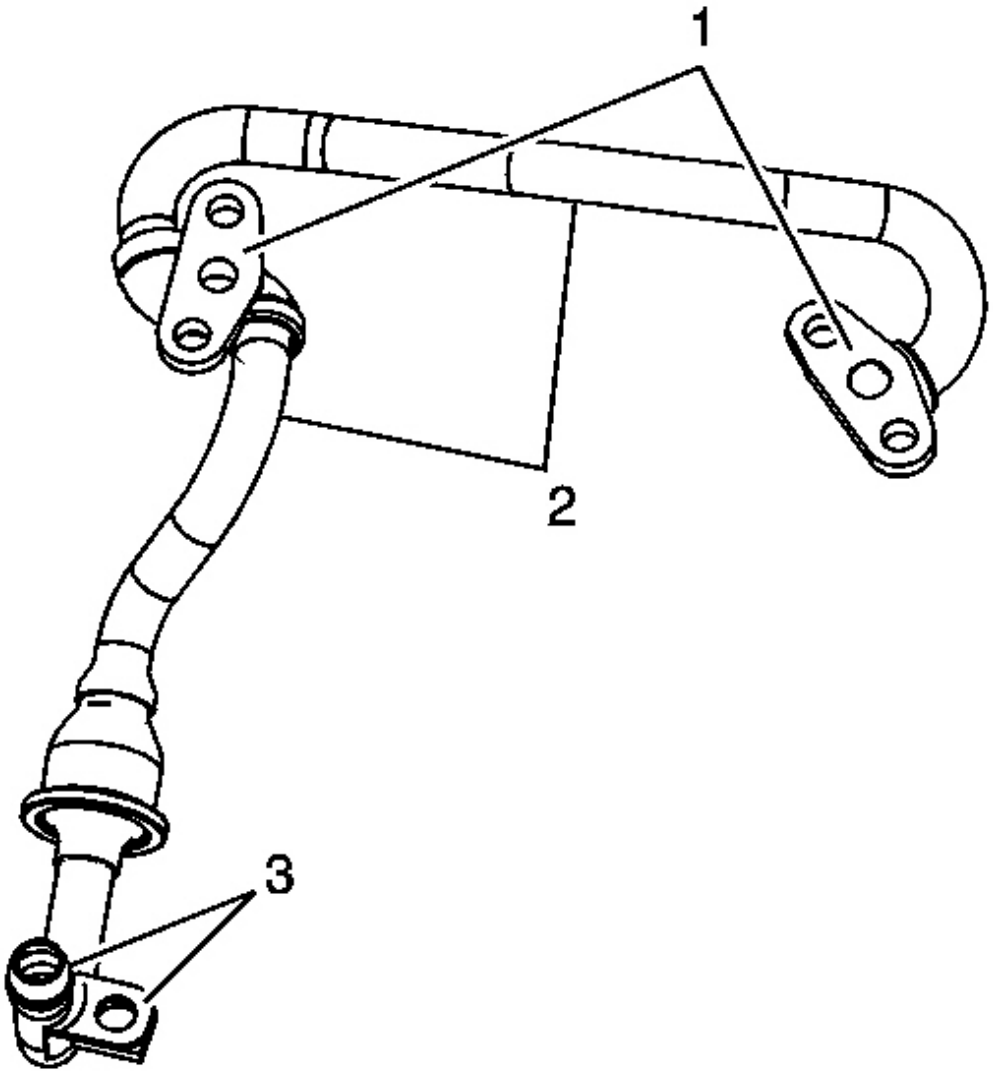


Fig. 205: Inspecting Oil Pump Outlet Tube

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Courtesy of GENERAL MOTORS CORP.

1. Inspect the mounting surfaces (1) for possible leakage paths.
2. Inspect the oil pump outlet tube pipe (2) for cracks, imperfections and/or damage.
3. Inspect the oil pump outlet tube for distortion or damage to the pipe (3) and the bracket at the oil pump outlet end.
4. Repair or replace the oil pump outlet tube as necessary.

OIL FILTER ADAPTER DISASSEMBLE

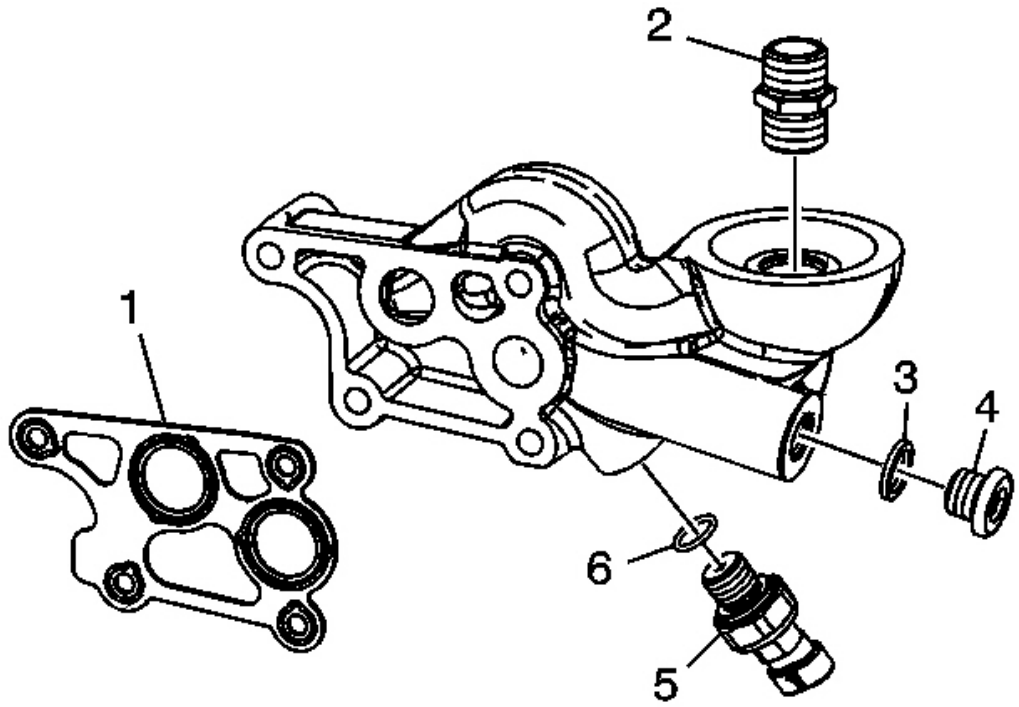


Fig. 206: Identifying Oil Filter Adapter Components
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the oil filter adapter gasket (1).
2. Remove and inspect the oil pressure switch (5).
3. Remove and discard the oil pressure switch O-ring (6).
4. Remove and inspect the oil filter adapter hole plug (4).
5. Remove and discard the oil filter adapter hole plug O-ring (3).

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6. Remove and inspect the oil filter fitting (2).

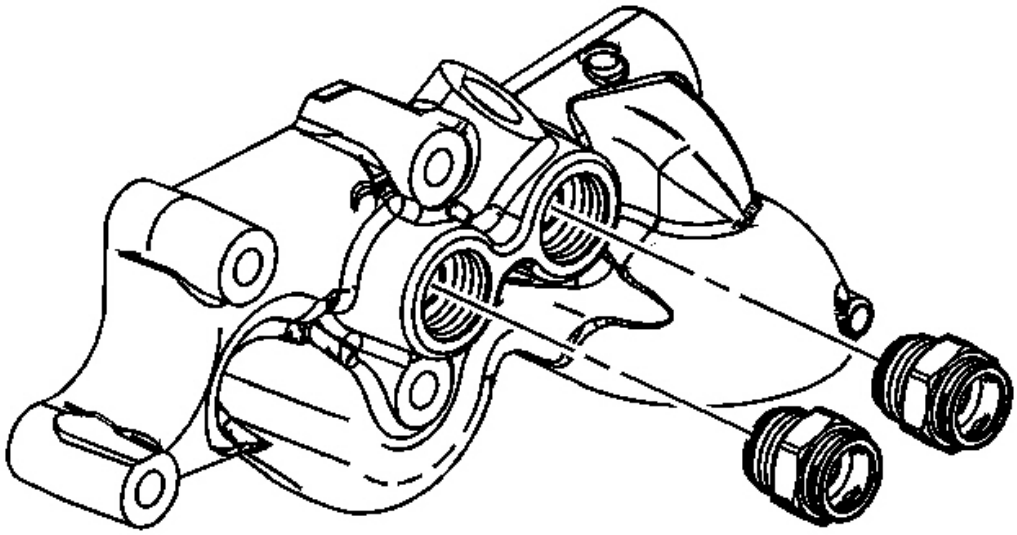


Fig. 207: View Of Oil Filter Adapter Pipe Fittings
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil filter adapter pipe fittings.

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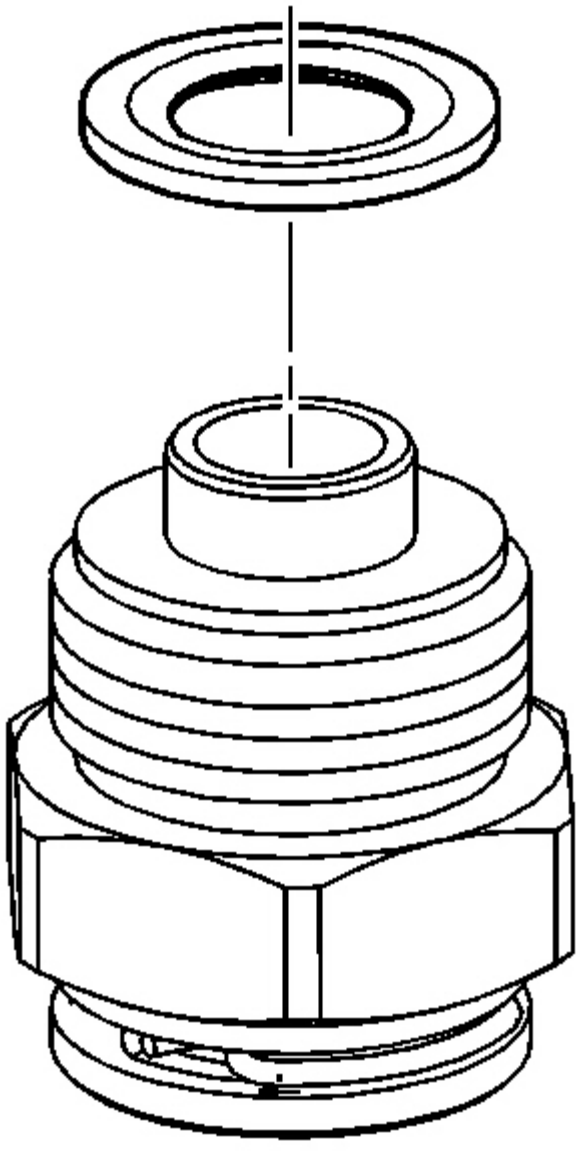


Fig. 208: View Of Oil Filter Adapter Pipe Fitting Seal
Courtesy of GENERAL MOTORS CORP.

8. Remove and discard the oil filter adapter pipe fitting seal.

OIL FILTER ADAPTER CLEANING AND INSPECTION

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CLEANING PROCEDURE

1. Clean the oil filter adapter in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the oil filter adapter with compressed air.

INSPECTION PROCEDURE

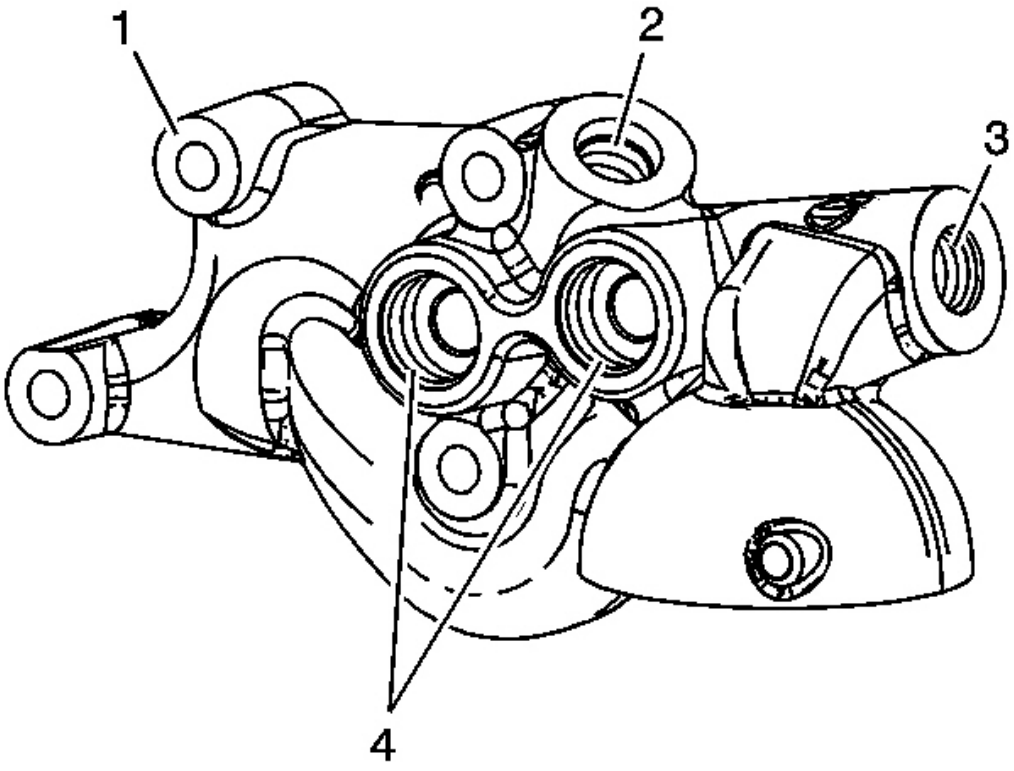


Fig. 209: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exterior of the oil filter adapter for the following:
   - Damage to the mounting holes (1)
   - Damage to the oil filter adapter plug hole threads (3)

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- Damage to the oil pressure switch hole threads (2)
- Blockage in the oil filter adapter hole passage (3)
- Damage to the oil cooler line fitting hole threads (4)
- Blockage in the oil cooler line passages (4)

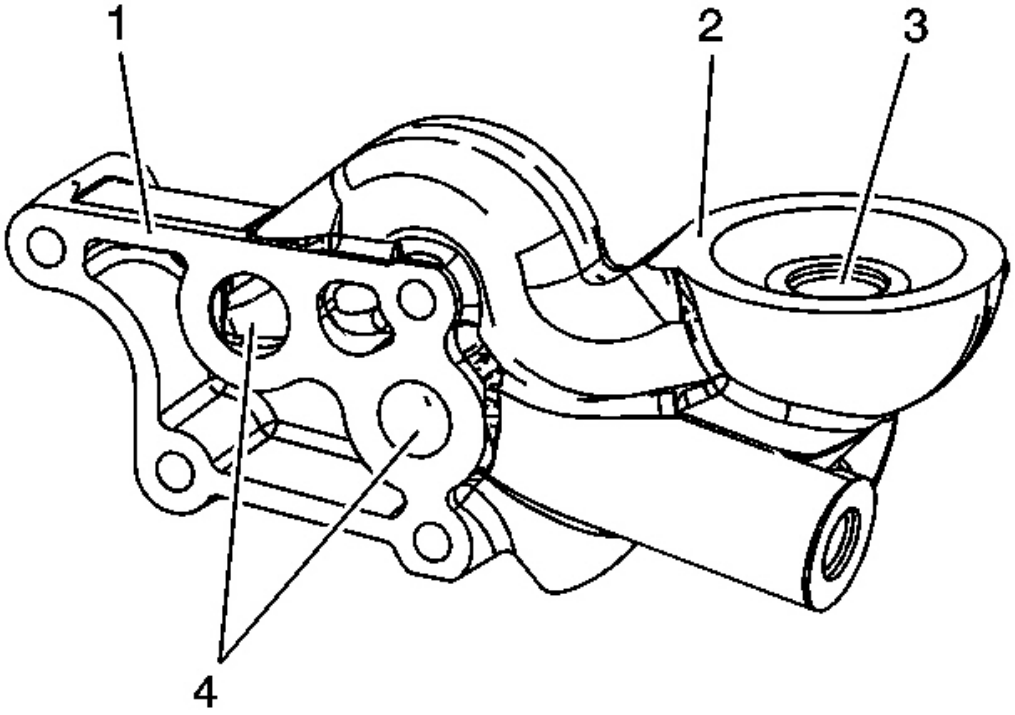


Fig. 210: Identifying Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the oil filter adapter for the following:
   - Damage to the mounting surface (1)
   - Damage to the oil filter sealing surface (2)
   - Damage to the oil filter fitting hole threads (3)
   - Blockage in the oil filter fitting hole (3)
   - Blockage to the inlet and outlet passages (4)
3. Repair or replace the oil filter adapter as necessary.

OIL FILTER ADAPTER ASSEMBLE

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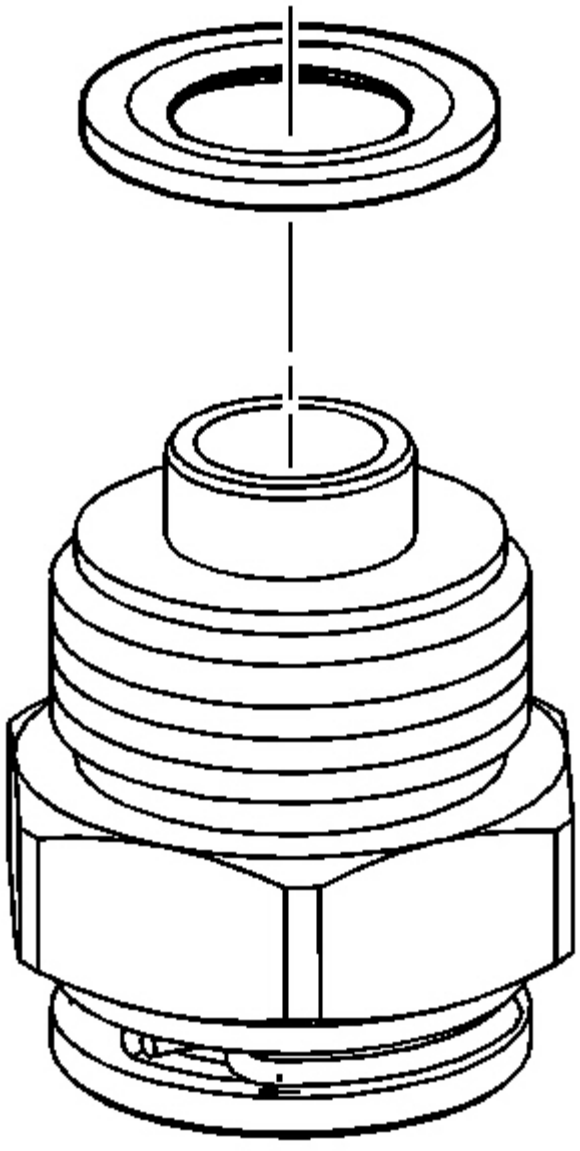


Fig. 211: View Of Oil Filter Adapter Pipe Fitting Seal
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW oil filter adapter pipe fitting seal.

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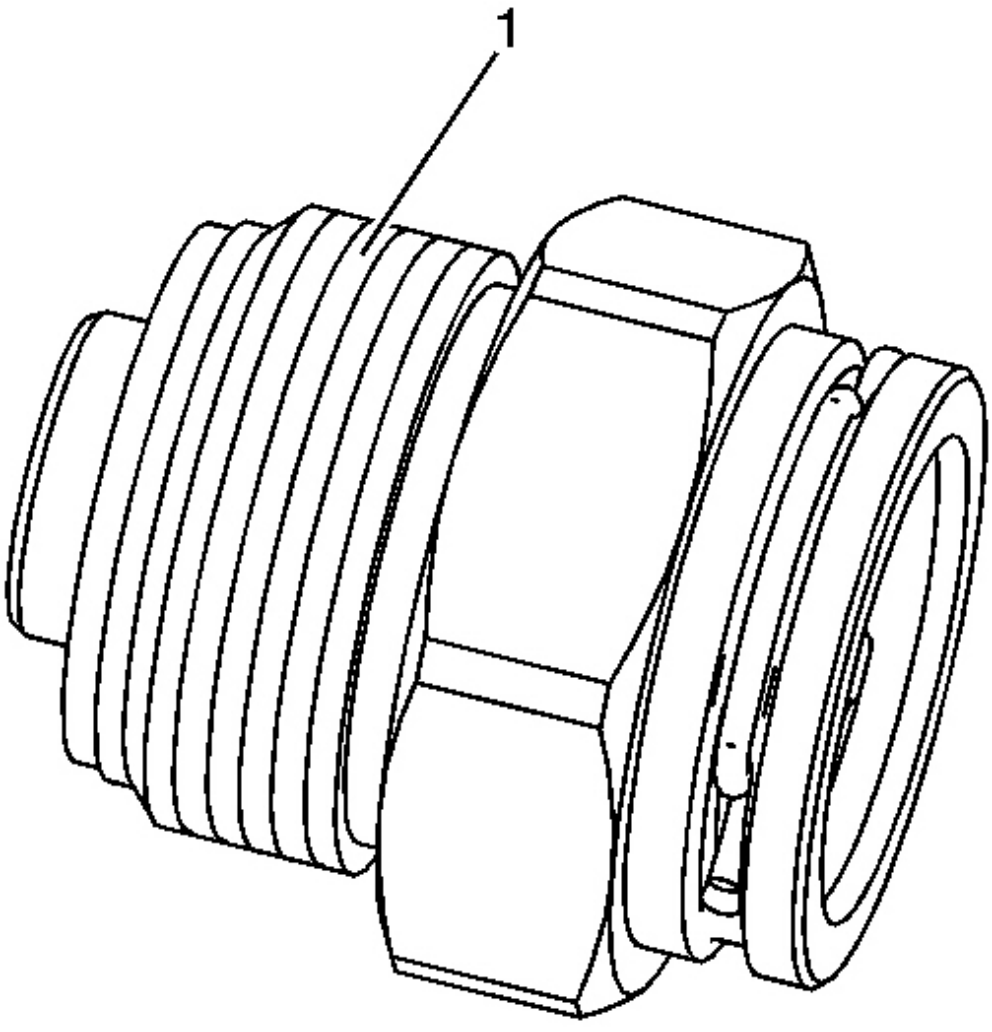


Fig. 212: Identifying Oil Filter Adapter Pipe Fitting
Courtesy of GENERAL MOTORS CORP.

2. Apply threadlocker GM P/N 89021297 (Canadian P/N 109534880) to the threads (1) of the oil filter adapter pipe fitting.

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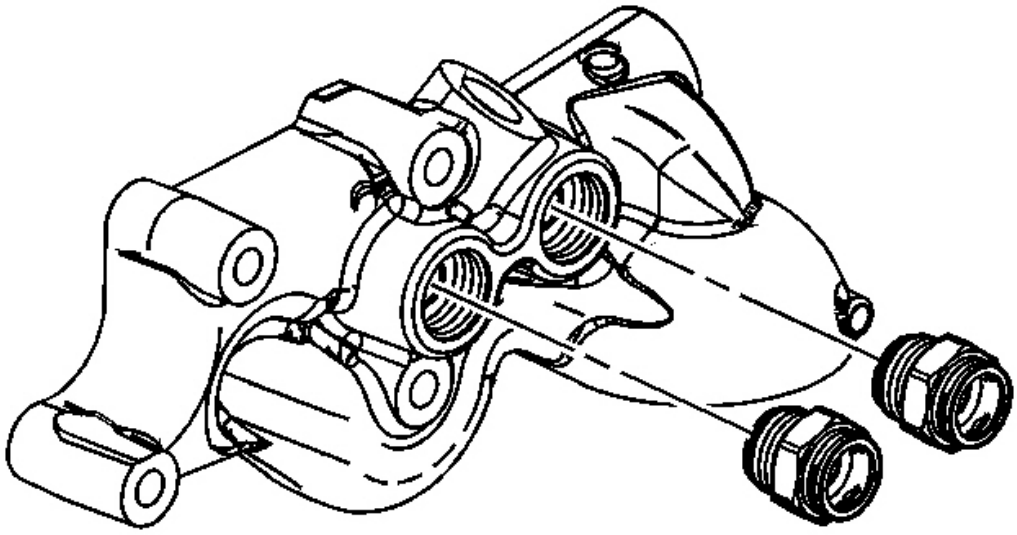


Fig. 213: View Of Oil Filter Adapter Pipe Fittings
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

3. Install the oil filter adapter pipe fittings into the oil filter adapter.

   Tighten: Tighten the oil filter adapter pipe fitting to 25 N.m (18 lb ft).

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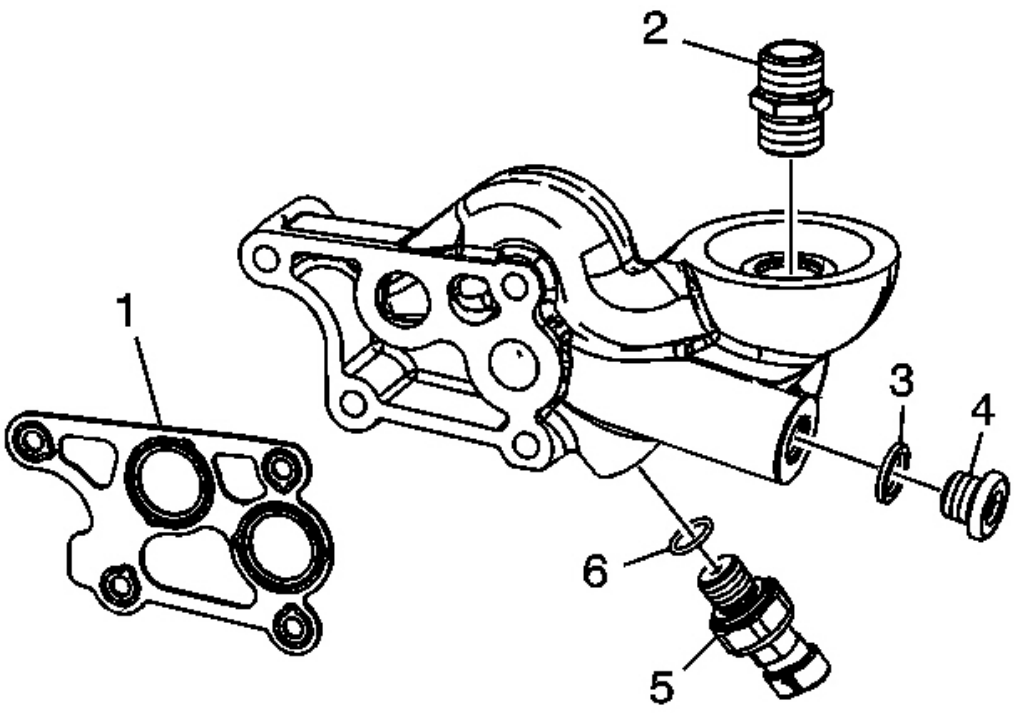


Fig. 214: Identifying Oil Filter Adapter Components
Courtesy of GENERAL MOTORS CORP.

4. Install the oil filter fitting (2).

   Tighten: Tighten the oil filter fitting to 29 N.m (21 lb ft).

5. Install a NEW O-ring (3) on the oil filter adapter hole plug (4).
6. Install the oil filter adapter hole plug (4).

   Tighten: Tighten the oil filter adapter hole plug to 65 N.m (48 lb ft).

7. Install a NEW O-ring (6) on the oil pressure switch (5).
8. Install the oil pressure switch (5).

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

9. Install the NEW oil filter adapter gasket (1).

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OIL PAN DISASSEMBLE

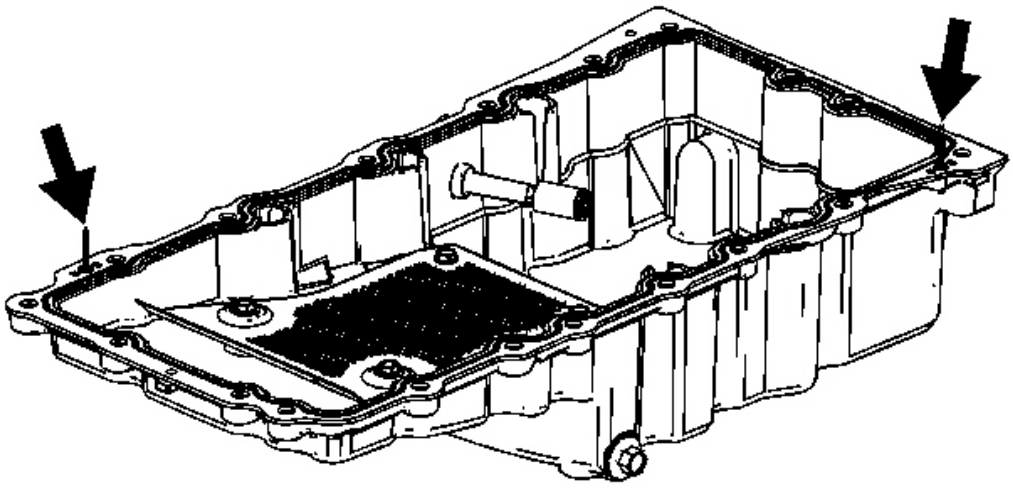


Fig. 215: Drilling Out Oil Pan Gasket Rivets
Courtesy of GENERAL MOTORS CORP.

1. Drill out the oil pan gasket rivets.

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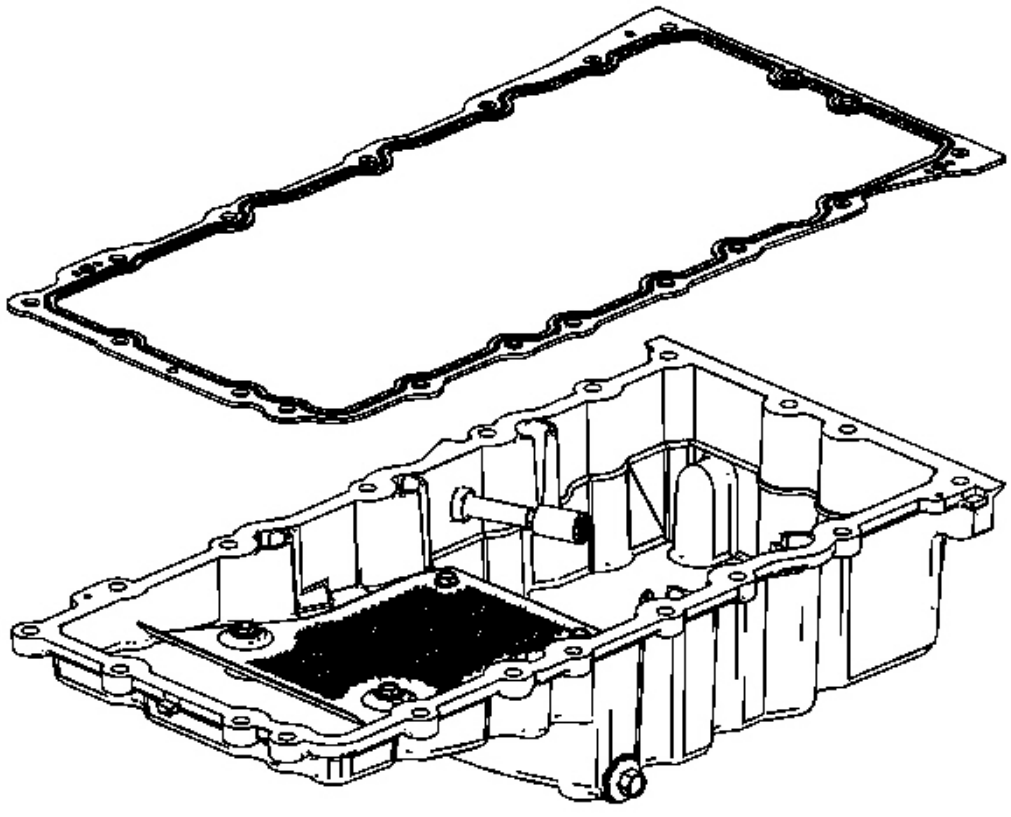


Fig. 216: Removing Oil Pan Gasket
Courtesy of GENERAL MOTORS CORP.

2. Remove and discard the oil pan gasket.

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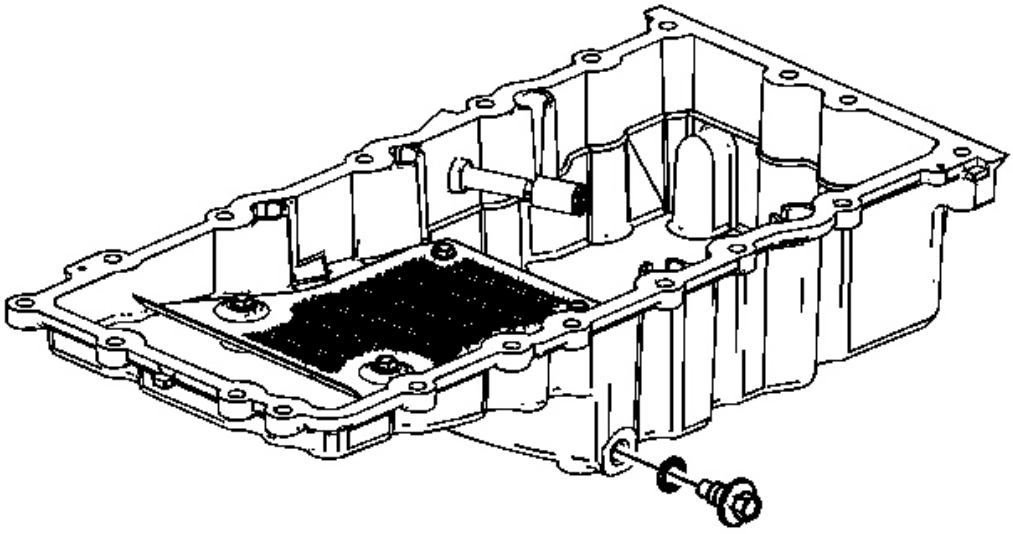


Fig. 217: Removing/Installing Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil drain plug.

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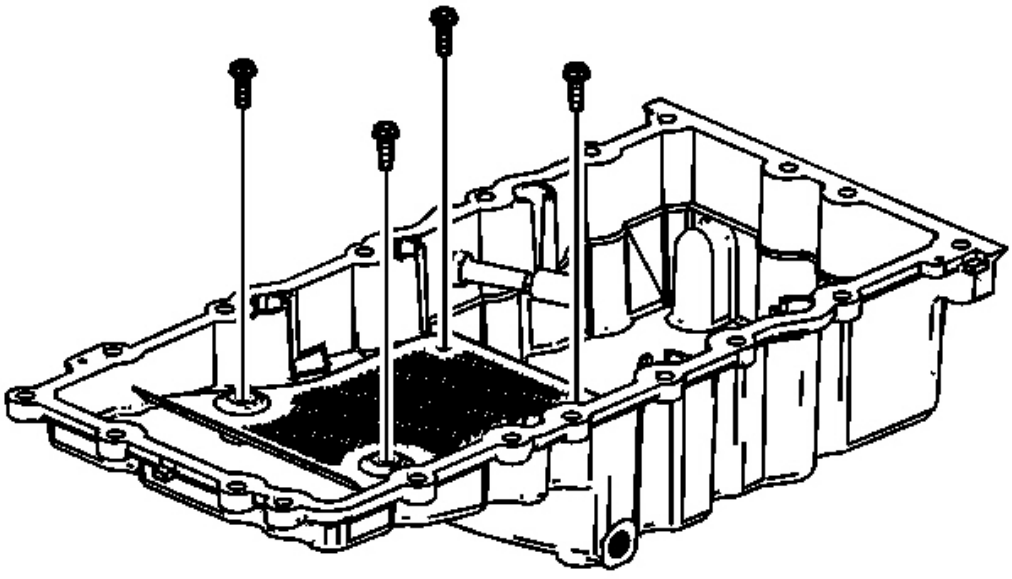


Fig. 218: Removing/Installing Oil Pan Baffle Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan baffle bolts.

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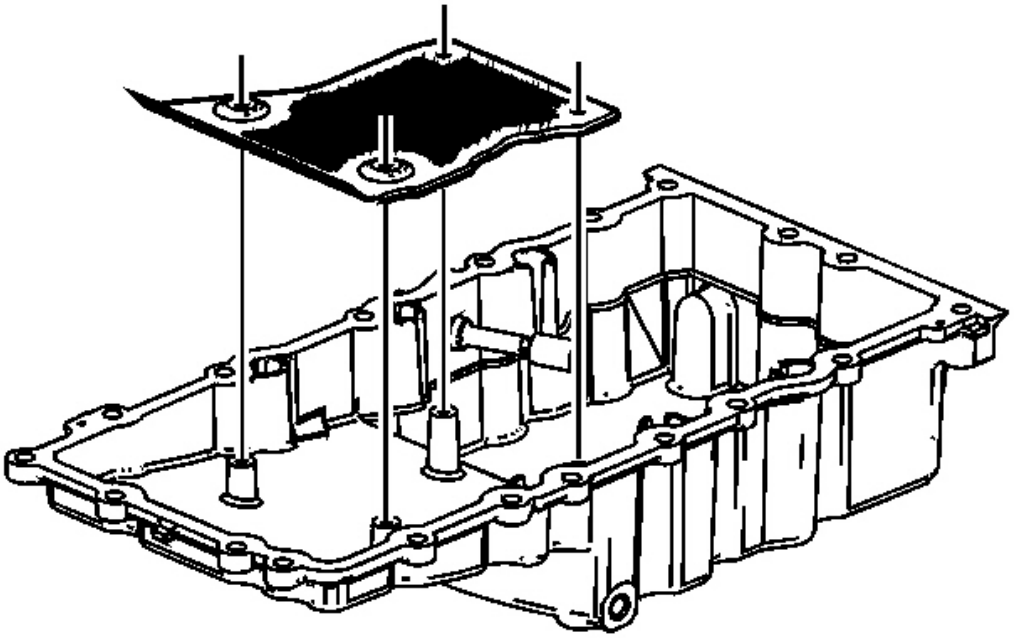


Fig. 219: Removing/Installing Oil Pan Baffle
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pan baffle.

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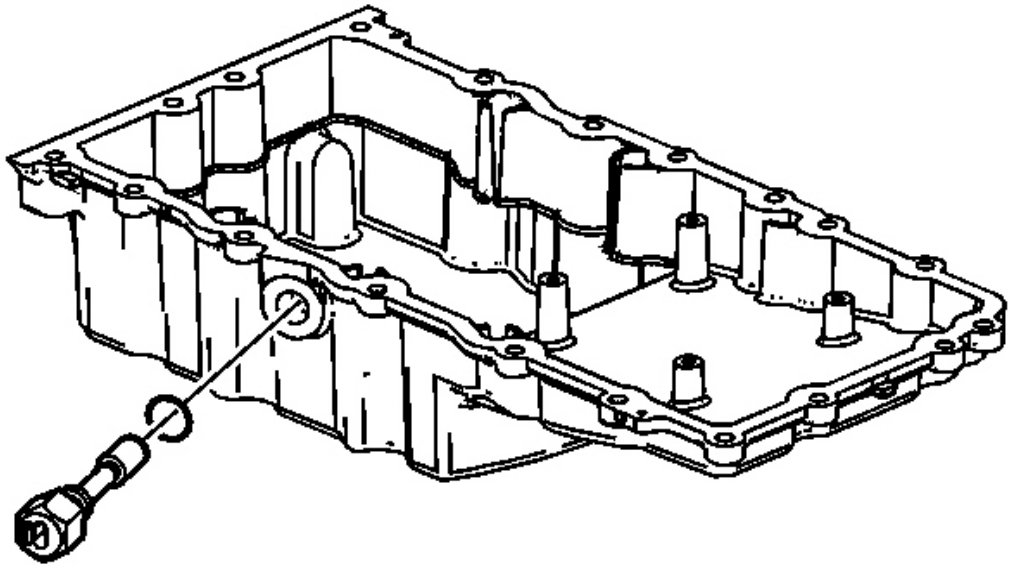


Fig. 220: Removing/Installing Oil Pan Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pan oil level sensor.
7. Remove the oil level sensor and oil drain plug O-rings and discard.

OIL PAN CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the oil pan components with solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the oil pan components with compressed air.

INSPECTION PROCEDURE

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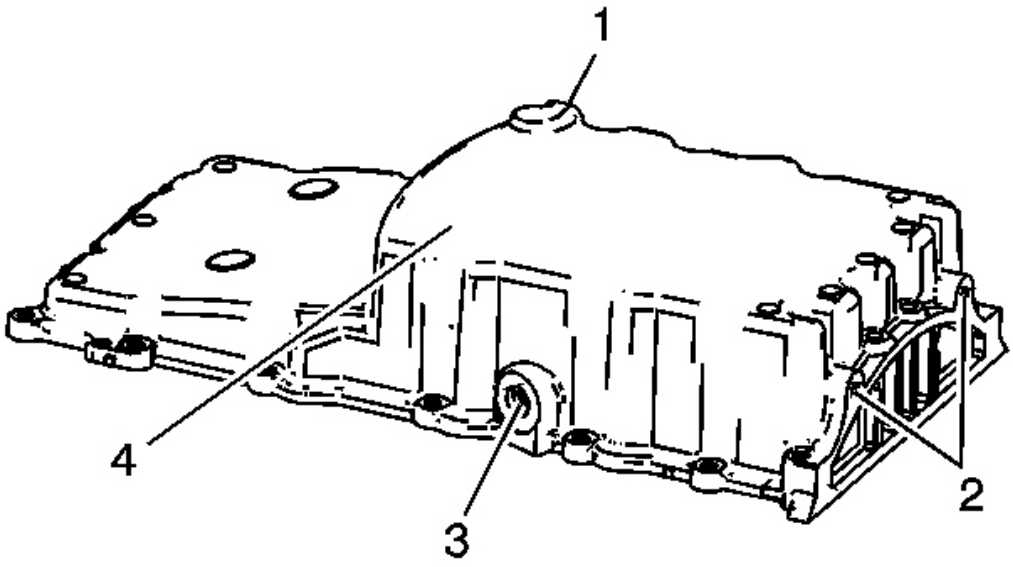


Fig. 221: Inspecting Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exterior of the oil pan for the following conditions:
   - The drain plug hole (1) for damaged threads
   - The transmission mounting holes (2) for damaged threads
   - The oil level switch hole (3) for damaged threads
   - The exterior surfaces (4) for dents or damage. An oil pan that is damaged or dented may interfere with the position of the oil pump screen or interfere with oil distribution in the oil pan sump area.

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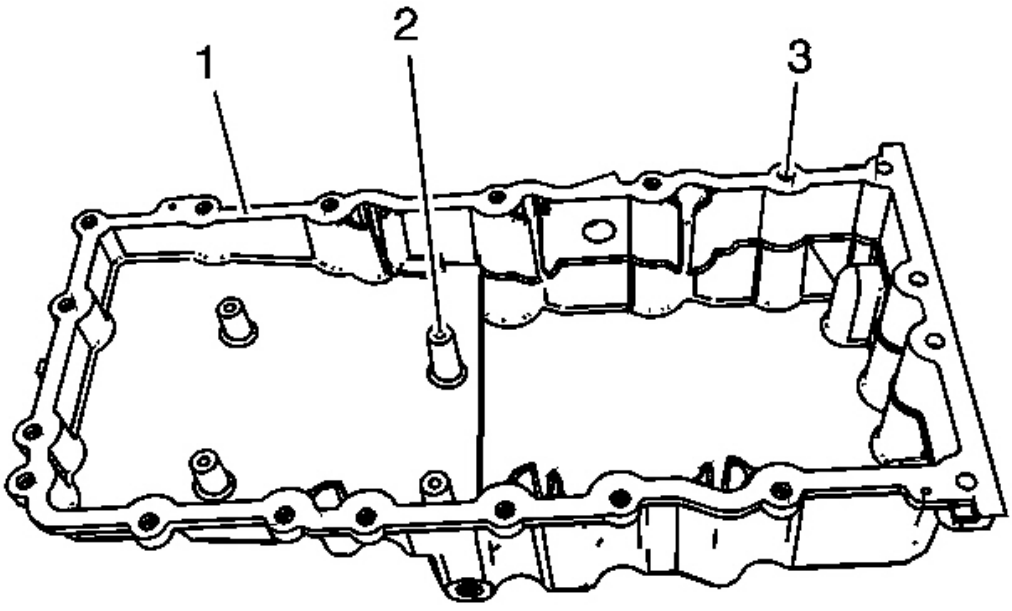


Fig. 222: Inspecting Interior Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the oil pan for the following conditions:
   - Gouges or damage to the oil pan sealing surface (1)
   - Damage to the oil pan baffle, baffle bolts and baffle mounting features (2)
   - Damage to the oil pan bolt holes (3)
3. Repair or replace the oil pan as necessary.

OIL PAN ASSEMBLE

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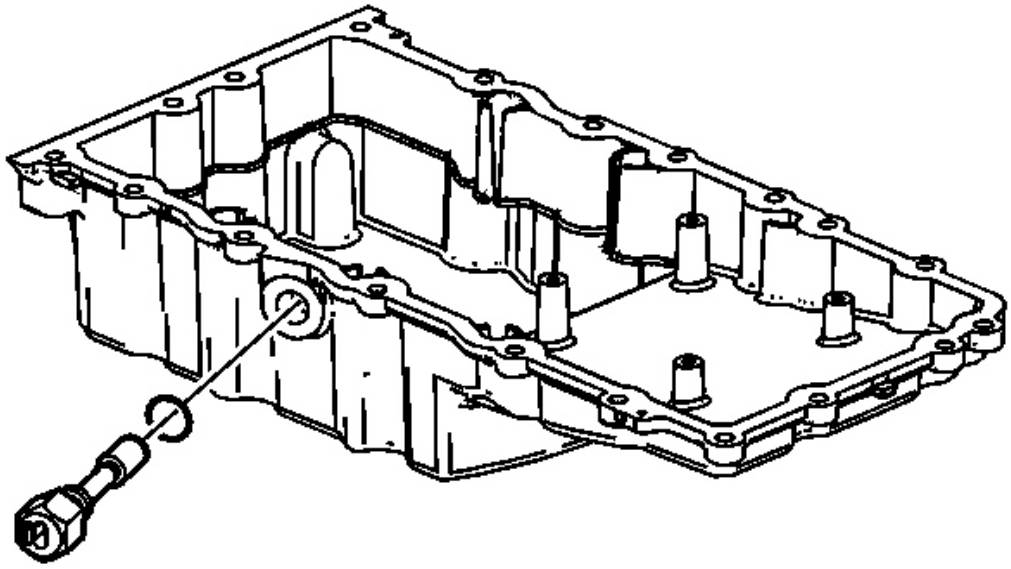


Fig. 223: Removing/Installing Oil Pan Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

1. Install NEW O-rings on the oil level sensor and oil drain plug.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil pan oil level sensor.

   Tighten: Tighten the oil pan oil level sensor to 20 N.m (15 lb ft).

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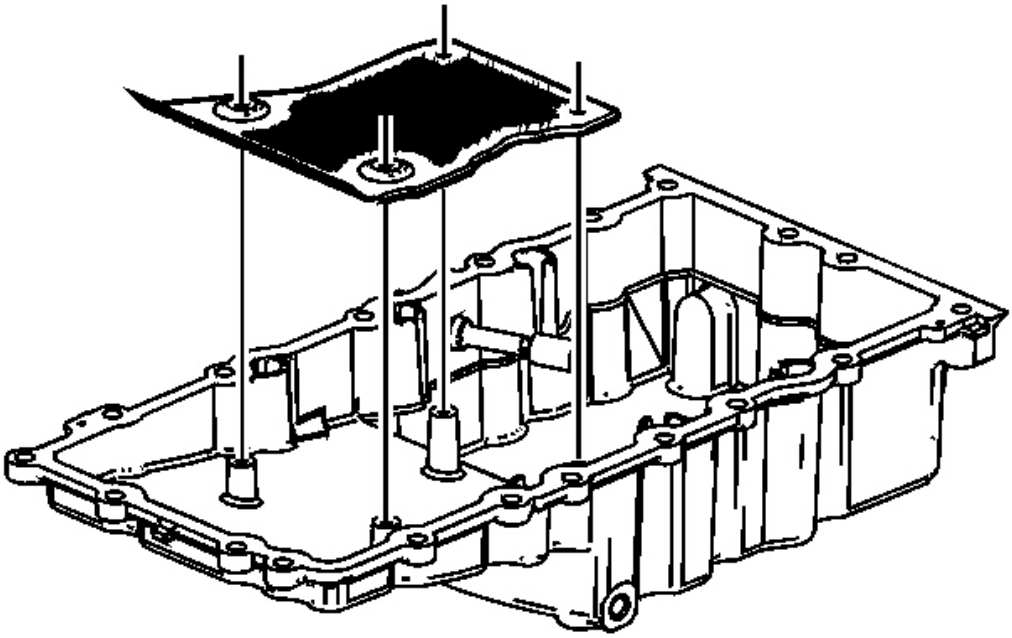


Fig. 224: Removing/Installing Oil Pan Baffle
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pan baffle.

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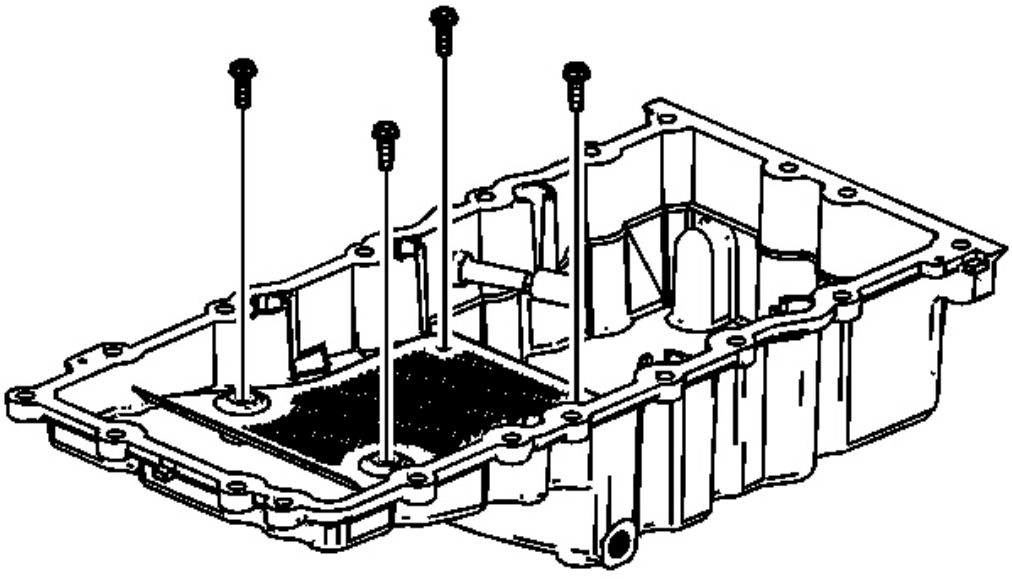


Fig. 225: Removing/Installing Oil Pan Baffle Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan baffle bolts.

   Tighten: Tighten the oil pan baffle bolts to 12 N.m (106 lb in)

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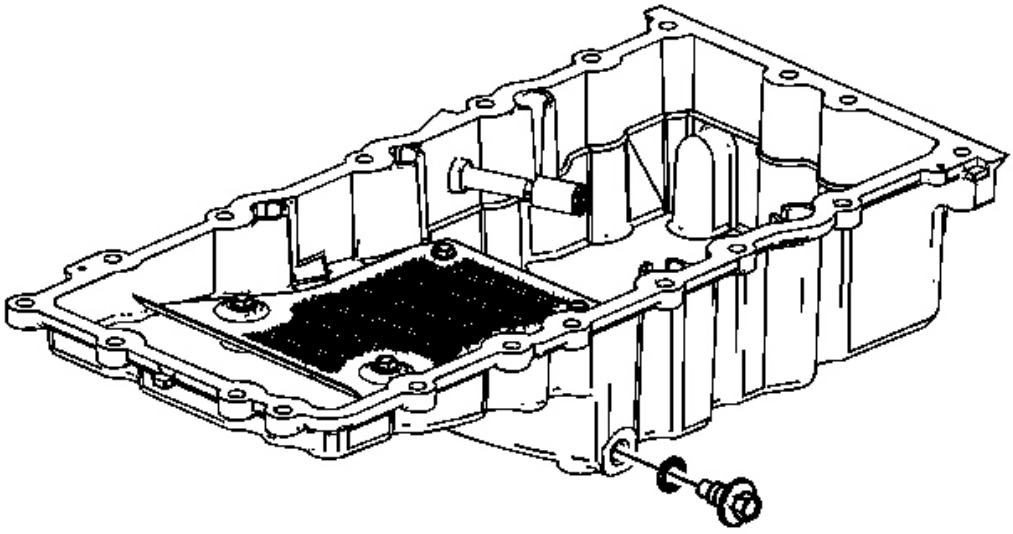


Fig. 226: Removing/Installing Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

5. Install the oil drain plug.

   Tighten: Tighten the oil drain plug to 25 N.m (18 lb ft).

OIL PUMP PIPE AND SCREEN CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the oil pump pipe and screen with solvent.

   CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the oil pump pipe and screen with compressed air.

INSPECTION PROCEDURE

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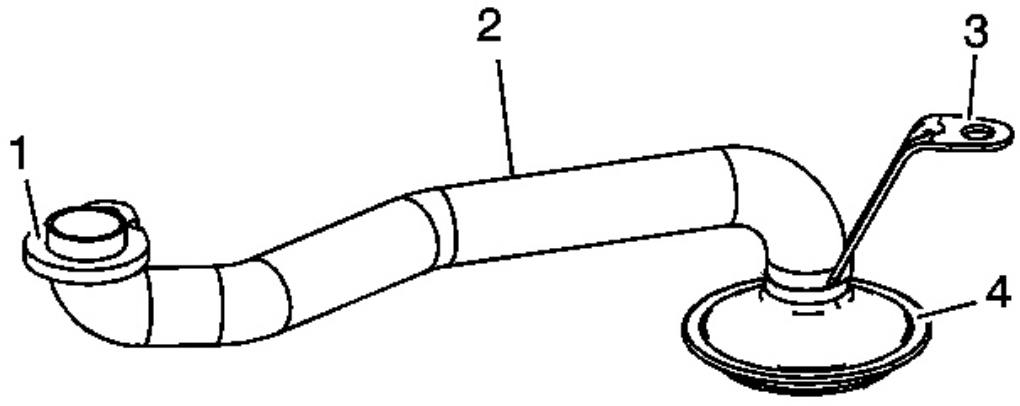


Fig. 227: Inspecting Oil Pump Pipe & Screen
Courtesy of GENERAL MOTORS CORP.

1. Inspect the mounting surface (1) for possible leakage paths.
2. Inspect the oil pump pipe tube (2) for cracks, imperfections and/or damage.
3. Inspect the oil pump pipe support bracket (3) for cracks or damage.
4. Inspect the oil pump screen (4) for blockage, foreign material, tears, cracks and/or damage.

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2007 ENGINE

Engine Mechanical - 4.4L - XLR

ENGINE FRONT COVER DISASSEMBLE

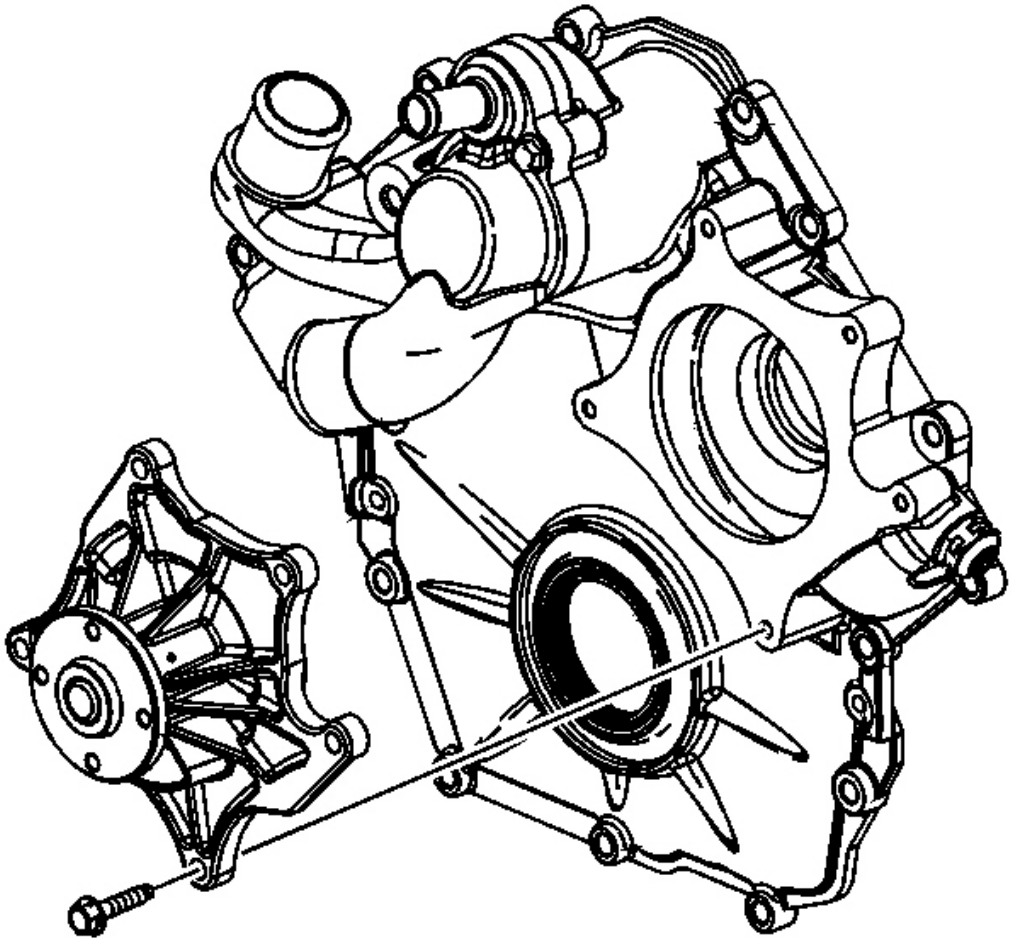


Fig. 1: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump bolts.
2. Remove the water pump.

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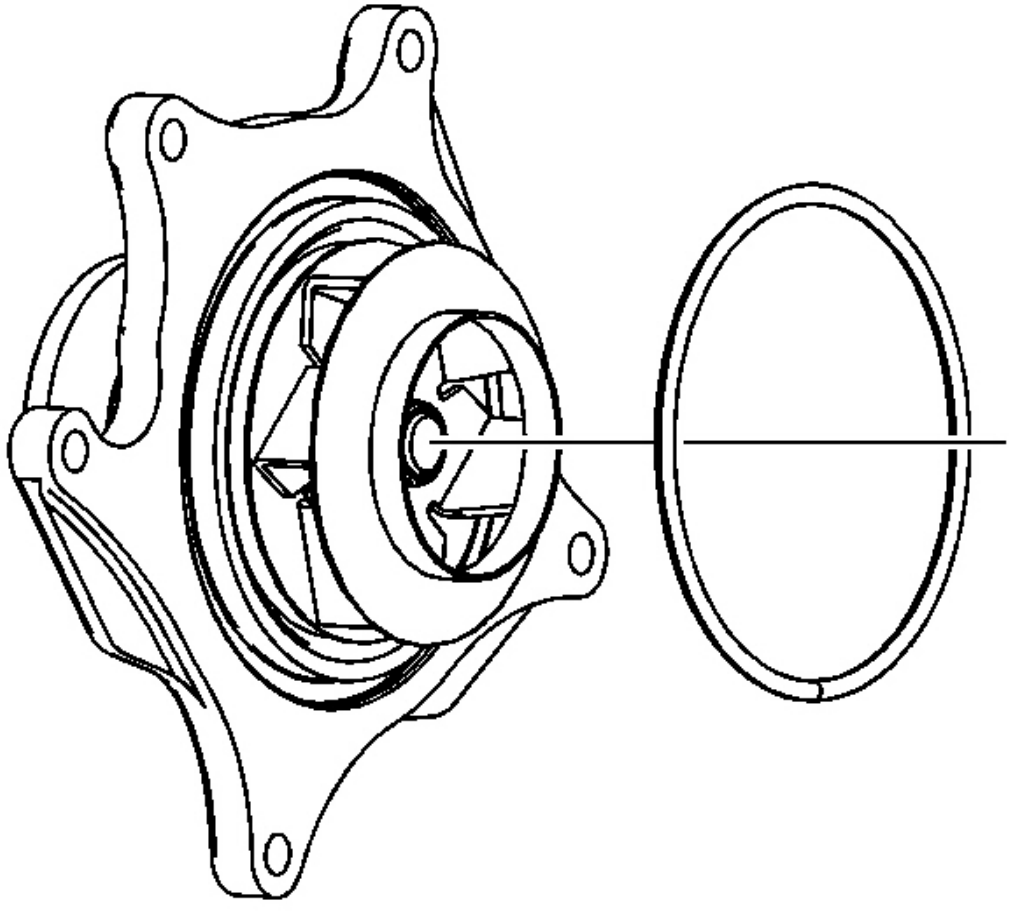


Fig. 2: View Of Water Pump O-Ring
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the water pump O-ring.

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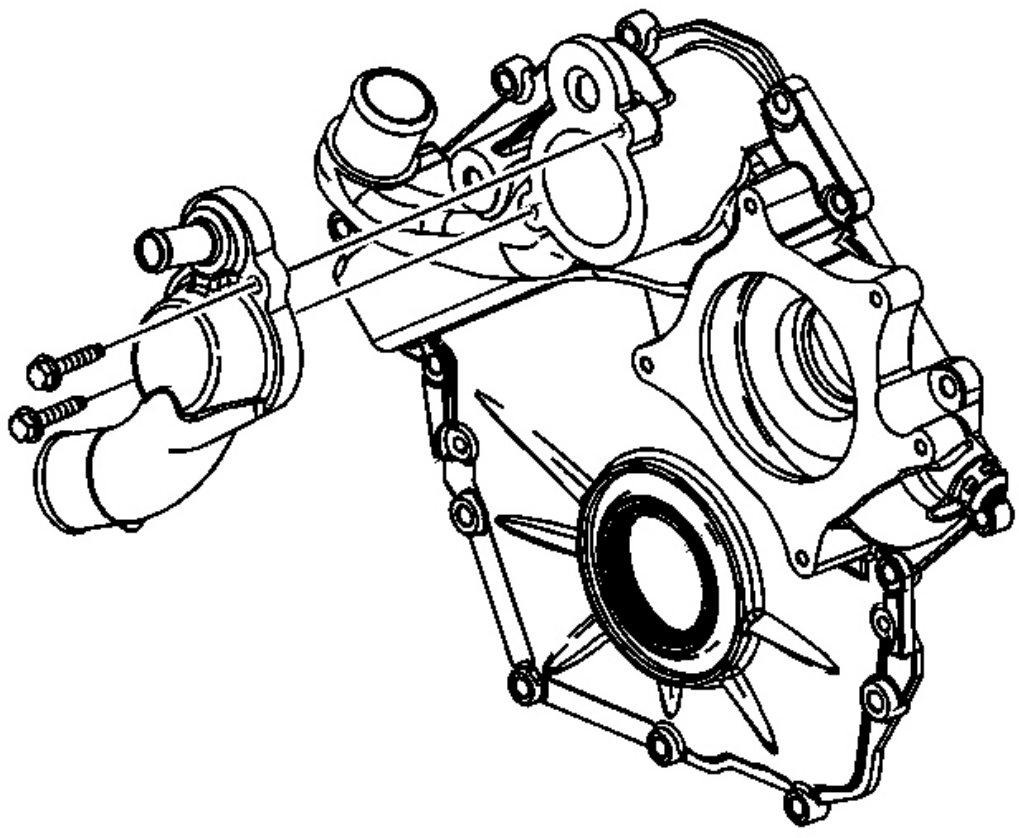


Fig. 3: View Of Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

4. Remove the thermostat housing bolts.
5. Remove the thermostat housing.

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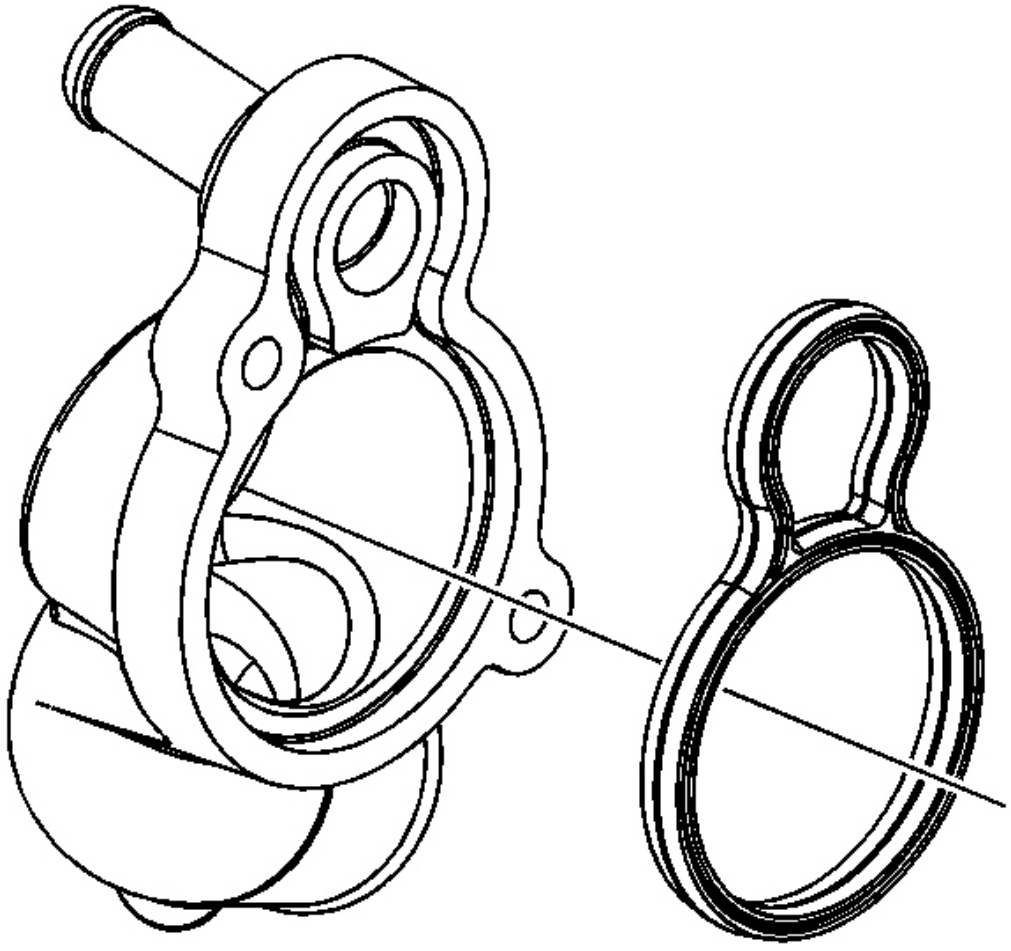


Fig. 4: View Of Thermostat Housing & Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the thermostat and gasket from the thermostat housing.

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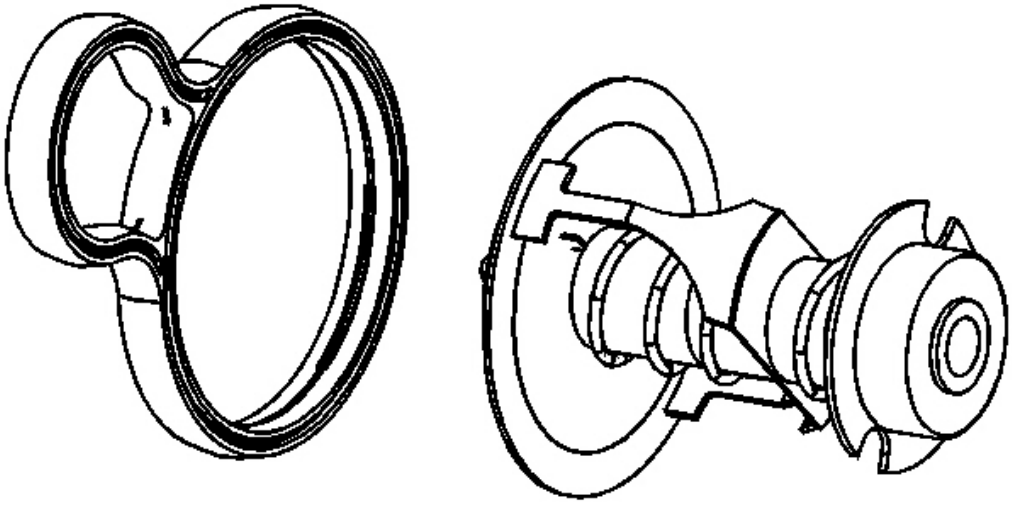


Fig. 5: View Of Thermostat Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the thermostat gasket from the thermostat and discard the thermostat gasket.

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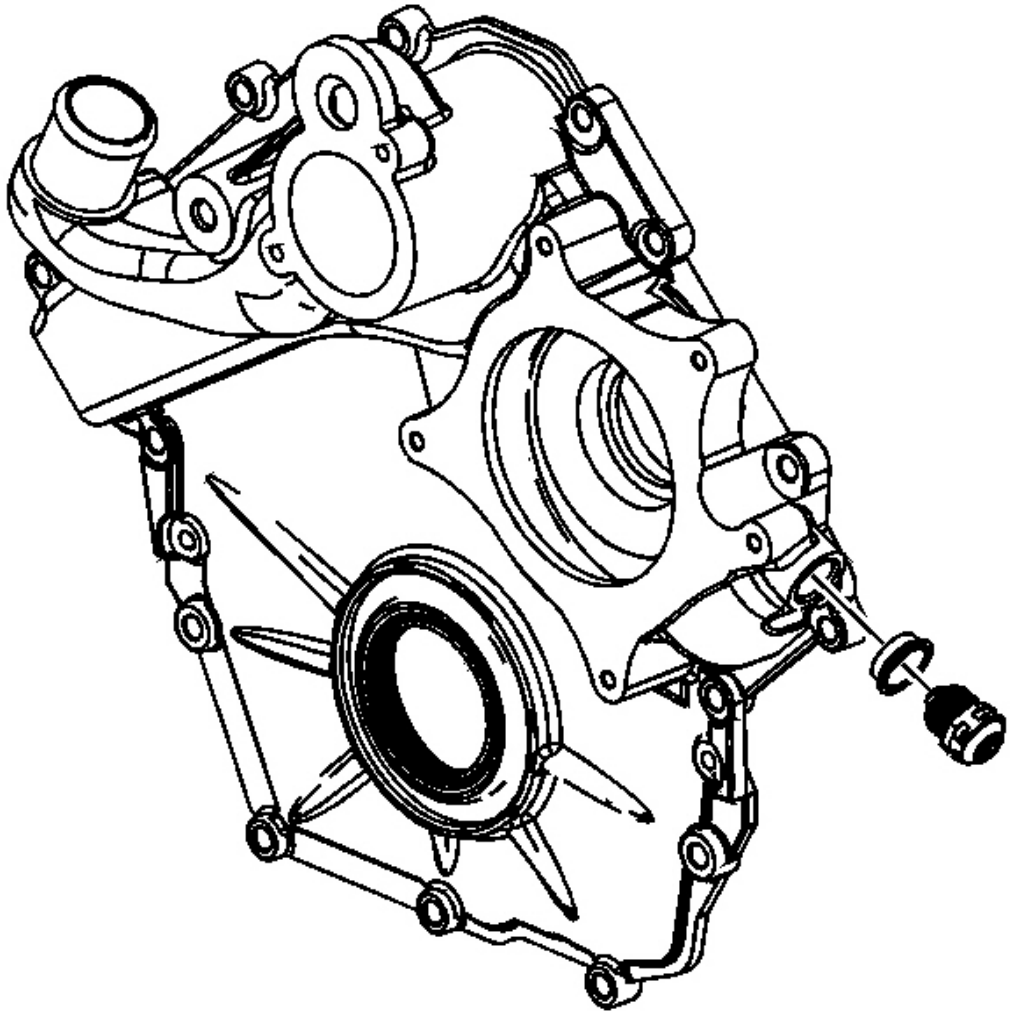


Fig. 6: Identifying Engine Front Cover Fitting
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine front cover fitting.

ENGINE FRONT COVER CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the engine front cover with solvent without the solvent contacting the crankshaft front oil seal.
2. Except for the water pump, clean the other engine front cover components with solvent.

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CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the engine front cover components with compressed air.

INSPECTION PROCEDURE

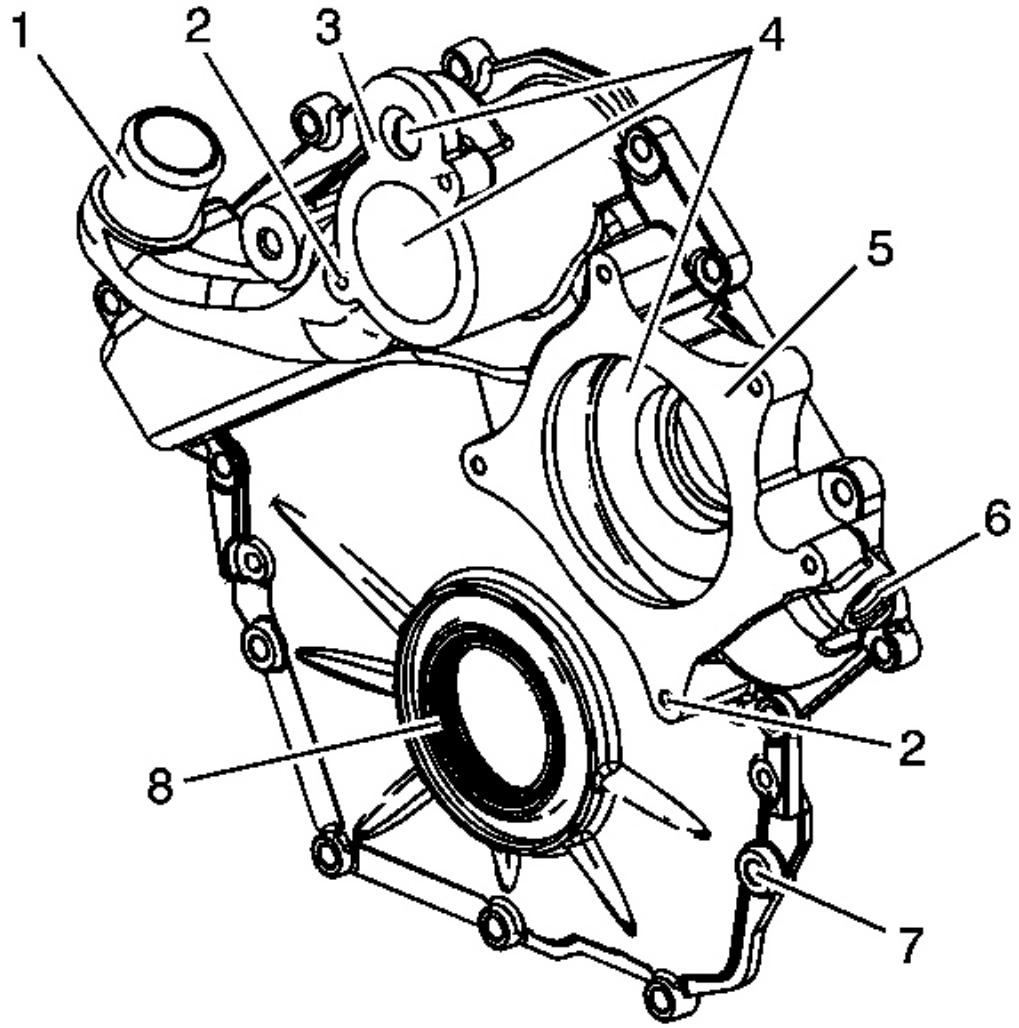


Fig. 7: Inspecting Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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1. Inspect the exterior of the engine front cover for the following conditions:
   - The water bypass hose connection (1) for damage
   - The engine front cover for damaged threads (2)
   - The thermostat gasket sealing surface (3) for damage
   - Damage to the coolant passages (4)
   - The water pump gasket sealing surface (5) for damage
   - The fitting threads (6) for damage
   - Damage to the engine front cover mounting bosses (7)
   - The crankshaft front oil seal (8) for damage

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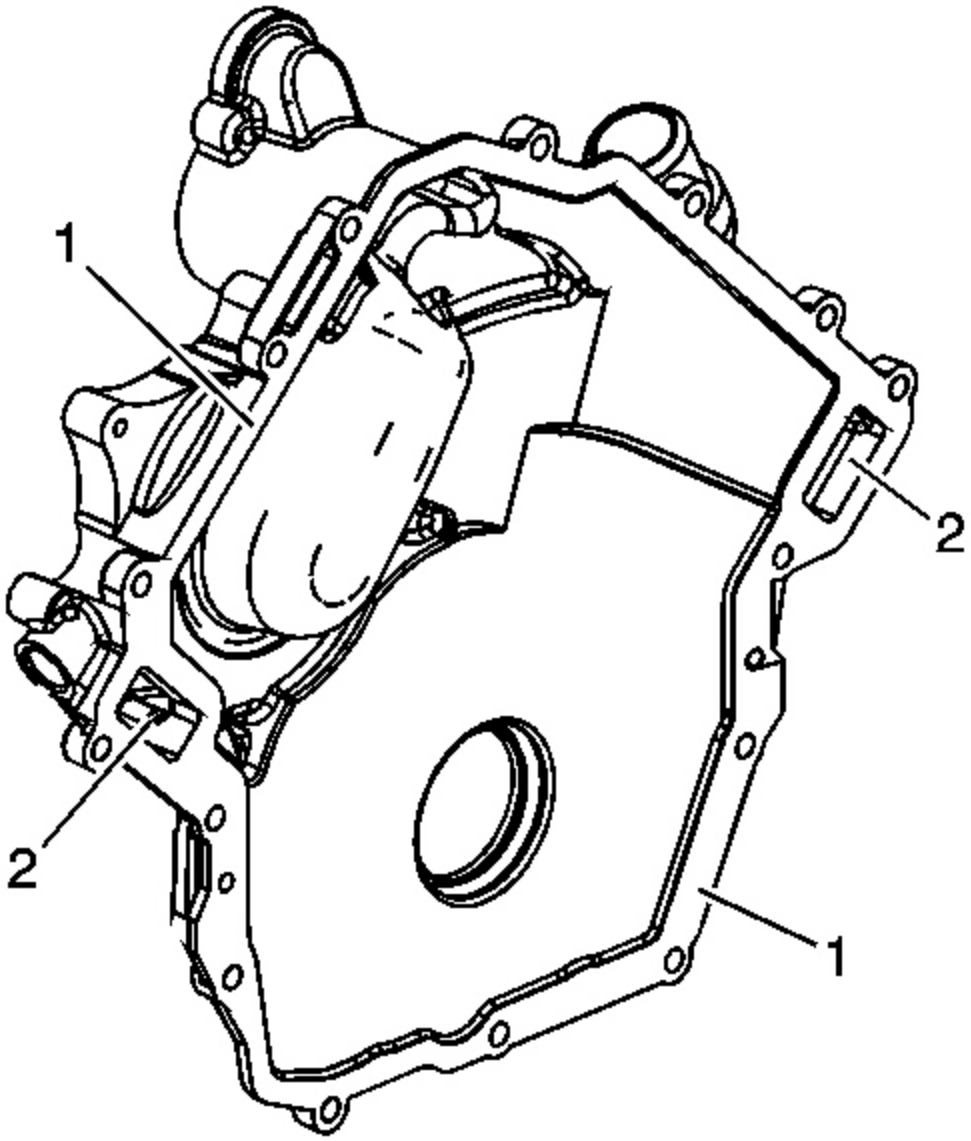


Fig. 8: View Of Engine Front Cover Inspection Points
Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the engine front cover for the following conditions:
   - Gouges or damage to the engine front cover sealing surface (1)
   - Damage to the coolant passages (2)

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3. Repair or replace the engine front cover and/or components as necessary.

WATER PUMP CLEANING AND INSPECTION

NOTE: **Do not immerse the water pump in solvent. The solvent may enter the water pump's permanently lubricated bearings and cause premature bearing failure.**

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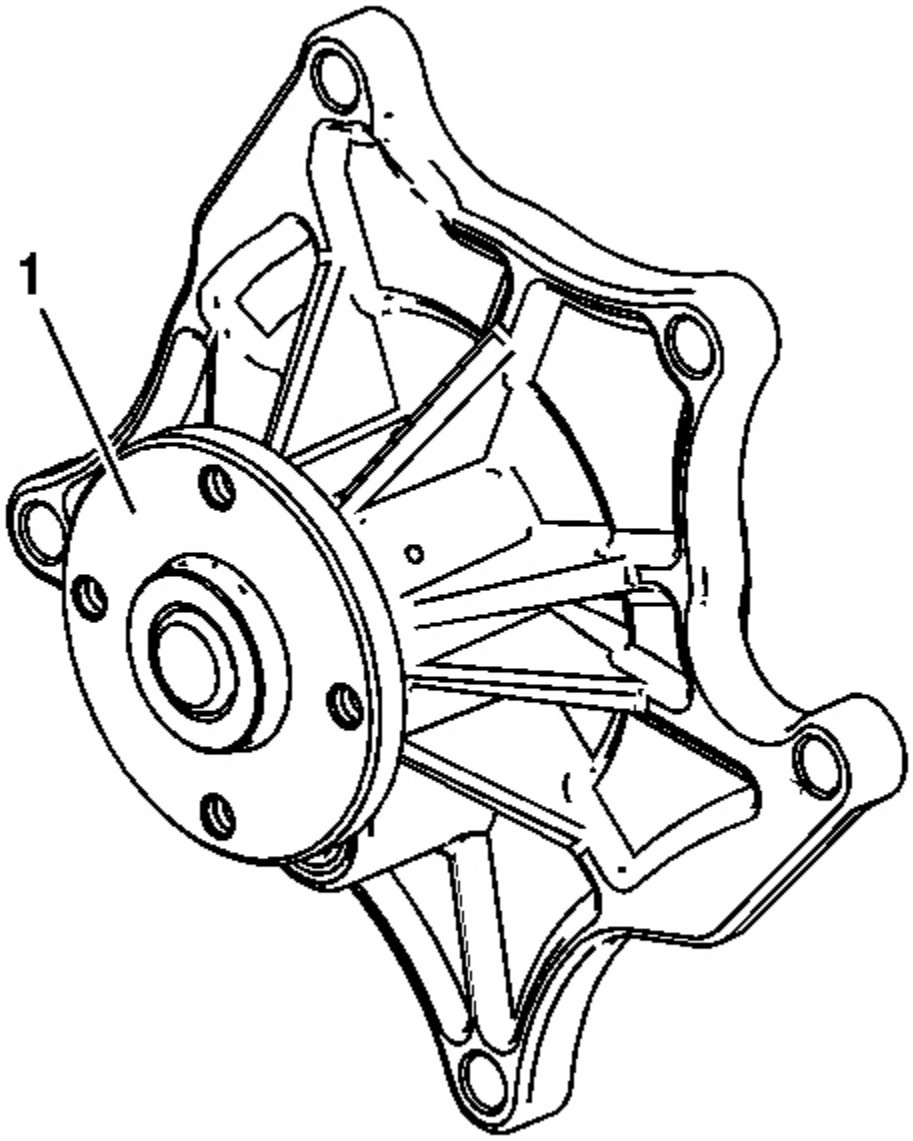


Fig. 9: Locating Water Pump Hub
Courtesy of GENERAL MOTORS CORP.

1. Rotate the water pump hub (1). The water pump hub and impeller should turn straight and smoothly. If the hub wobbles, is noisy or feels "lumpy" when turned, replace the water pump.

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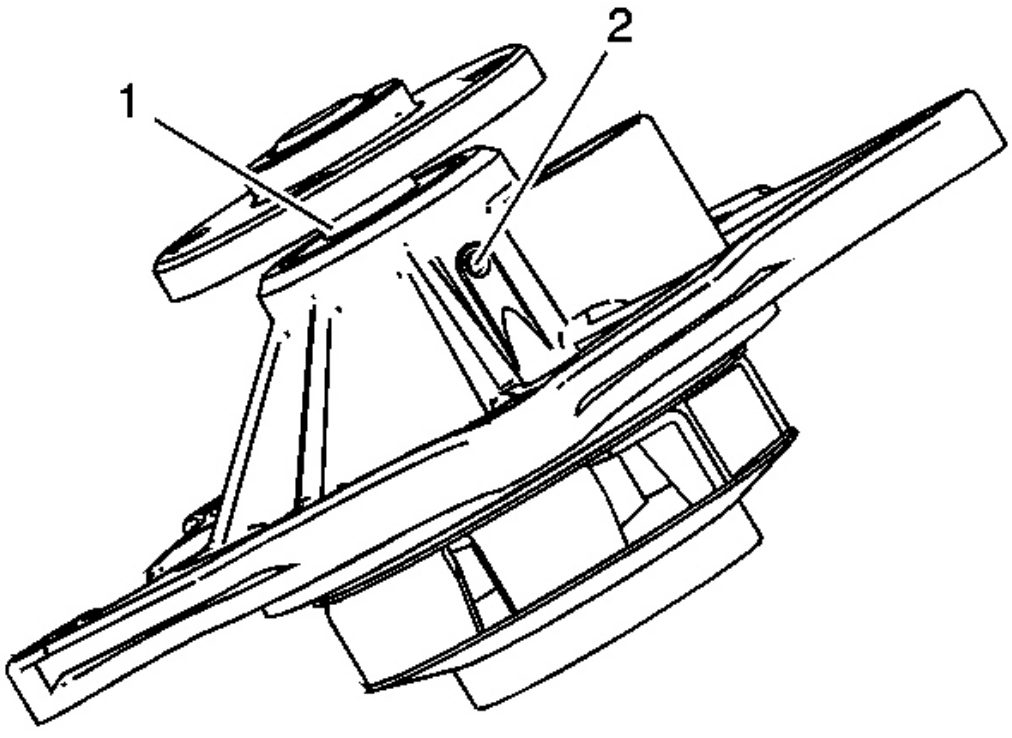


Fig. 10: Locating Water Pump Shaft & Weep Hole
Courtesy of GENERAL MOTORS CORP.

2. Examine the water pump shaft (1) and the weep hole (2) in the water pump body for signs of leakage. If coolant leakage is evident, replace the water pump.

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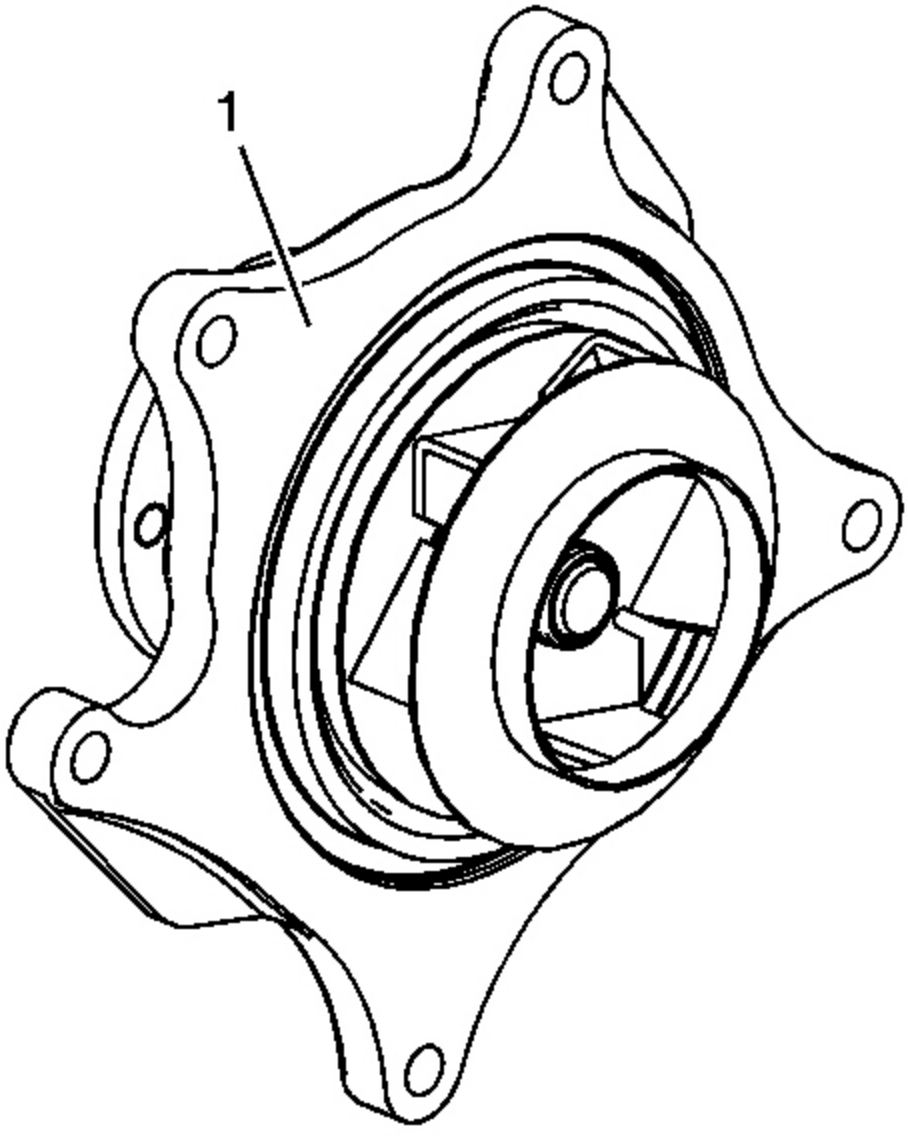


Fig. 11: Identifying Water Pump Sealing Surface
Courtesy of GENERAL MOTORS CORP.

3. Examine the water pump sealing surface (1) for imperfections. If imperfections cannot be repaired, replace the water pump.

ENGINE FRONT COVER ASSEMBLE

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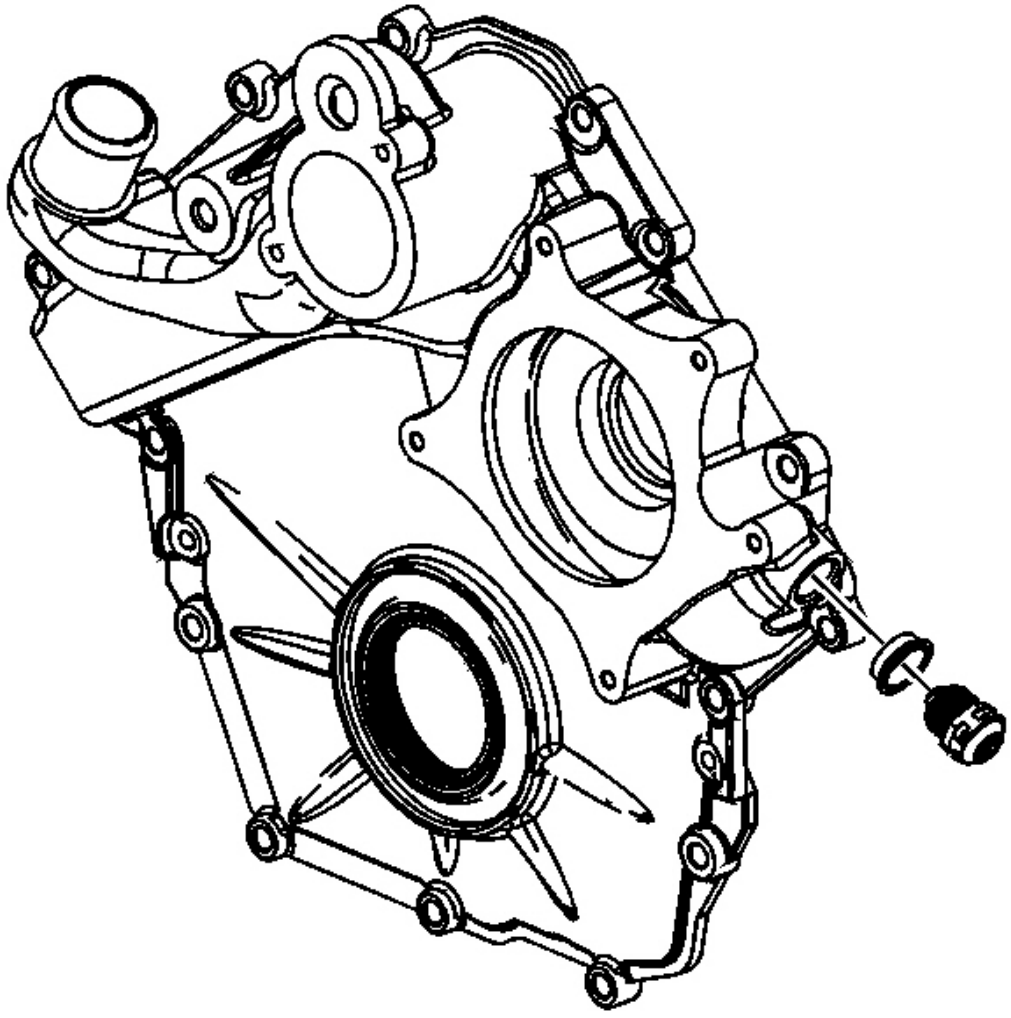


Fig. 12: Identifying Engine Front Cover Fitting
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the engine front cover fitting.

   Tighten: Tighten the engine front cover fitting to 25 N.m (18 lb ft).

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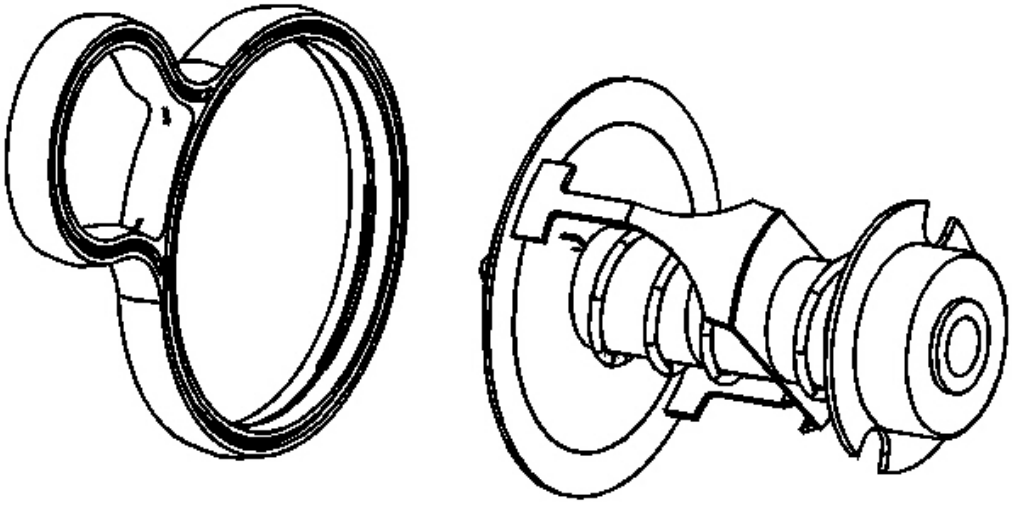


Fig. 13: View Of Thermostat Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW thermostat gasket onto the thermostat.

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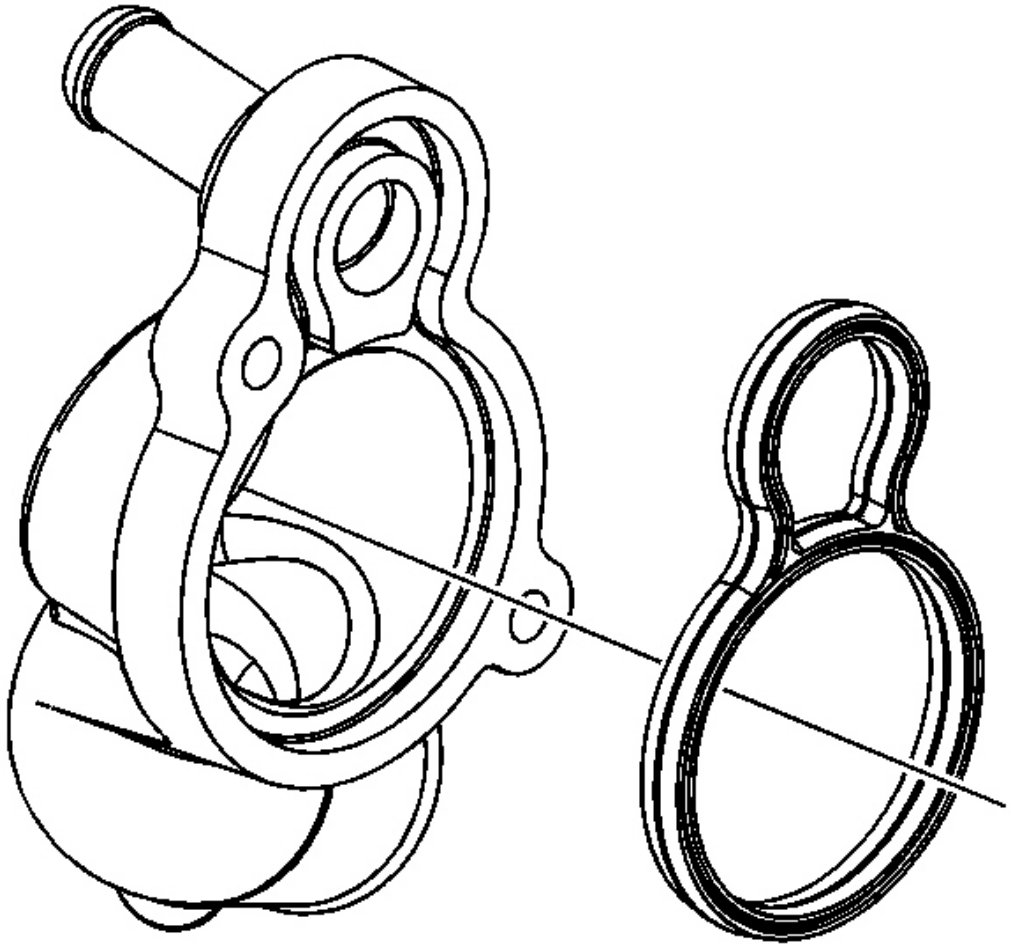


Fig. 14: View Of Thermostat Housing & Gasket
Courtesy of GENERAL MOTORS CORP.

3. Install the thermostat and gasket into the thermostat housing.

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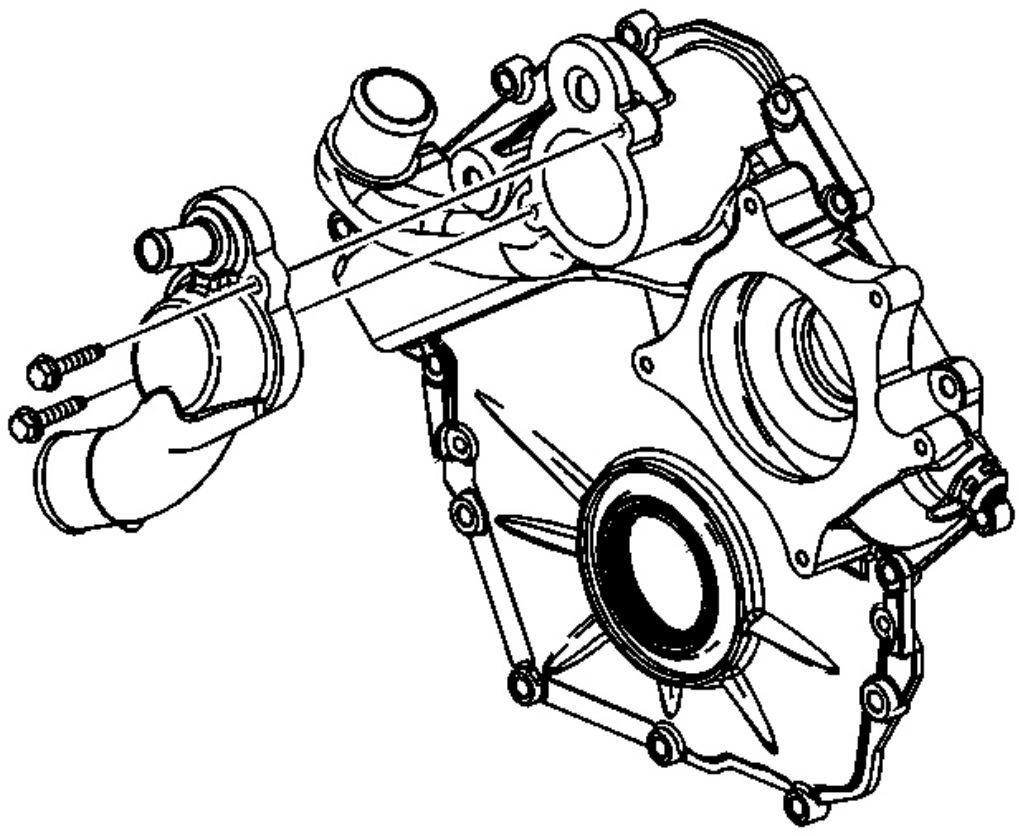


Fig. 15: View Of Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

4. Install the thermostat housing.
5. Install the thermostat housing bolts.

Tighten: Tighten the thermostat housing bolts to 10 N.m (89 lb in).

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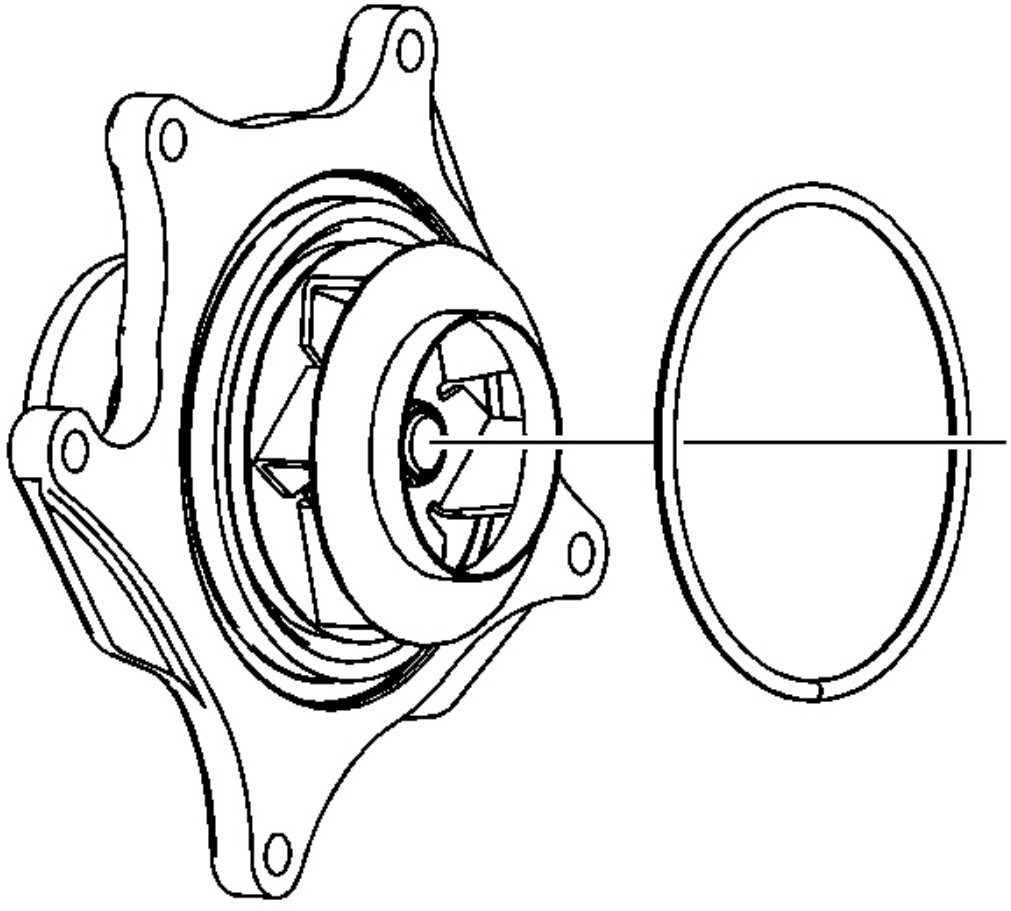


Fig. 16: View Of Water Pump O-Ring
Courtesy of GENERAL MOTORS CORP.

6. Install the NEW water pump O-ring.

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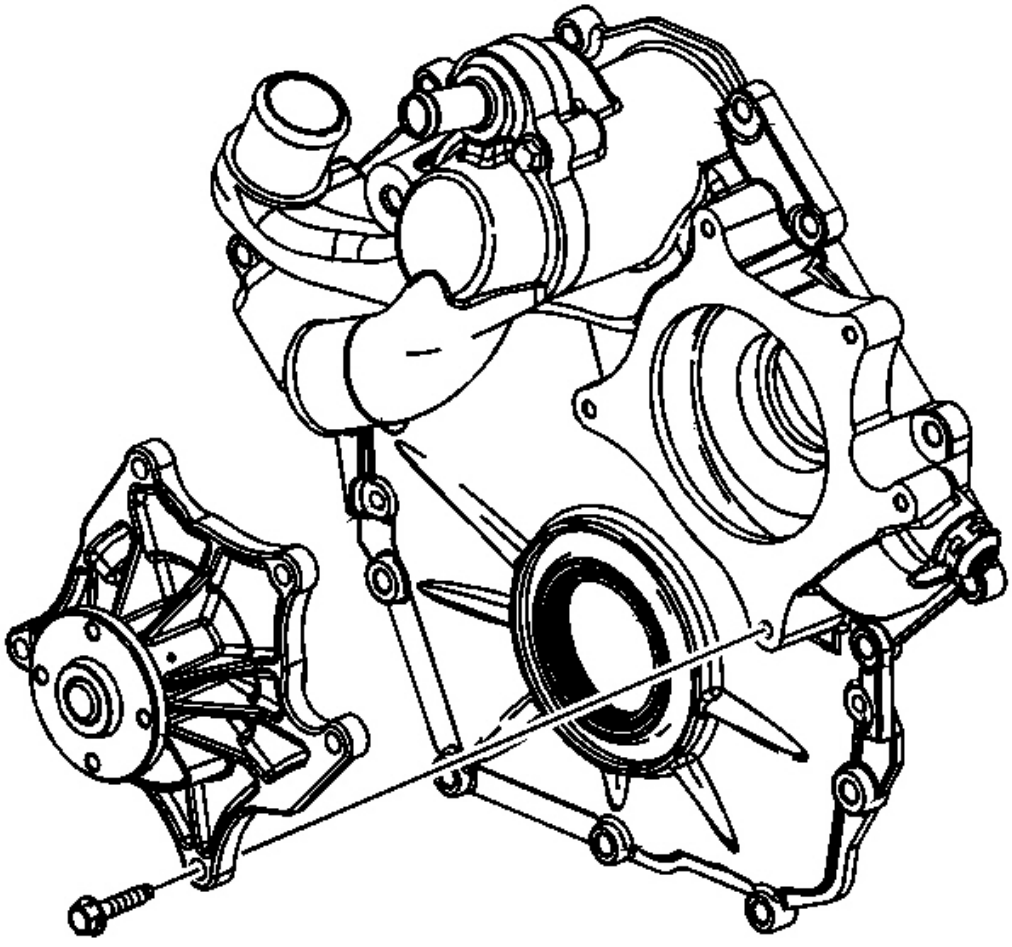


Fig. 17: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

7. Install the water pump.
8. Install the water pump bolts.

Tighten: Tighten the water pump bolts to 10 N.m (89 lb in).

CAMSHAFT COVER DISASSEMBLE

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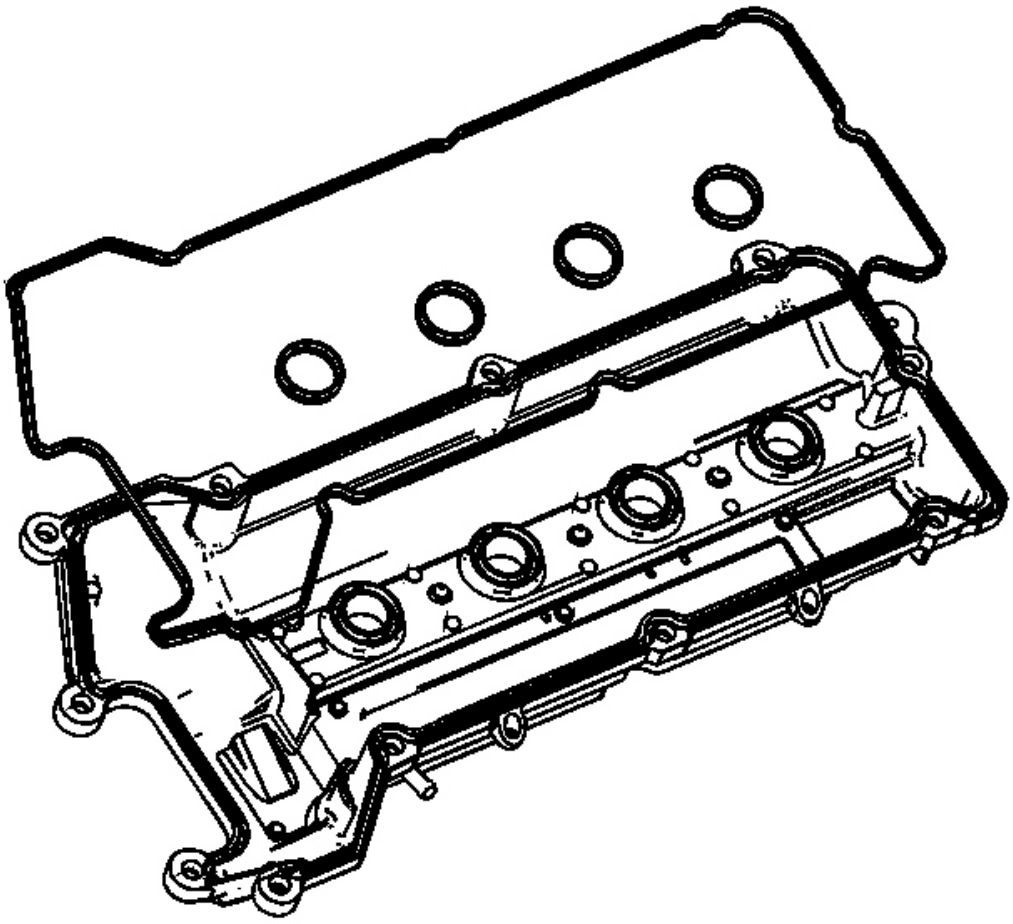


Fig. 18: View Of Left Camshaft Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the left camshaft cover gasket and discard.
2. Remove the left spark plug port seals and discard.

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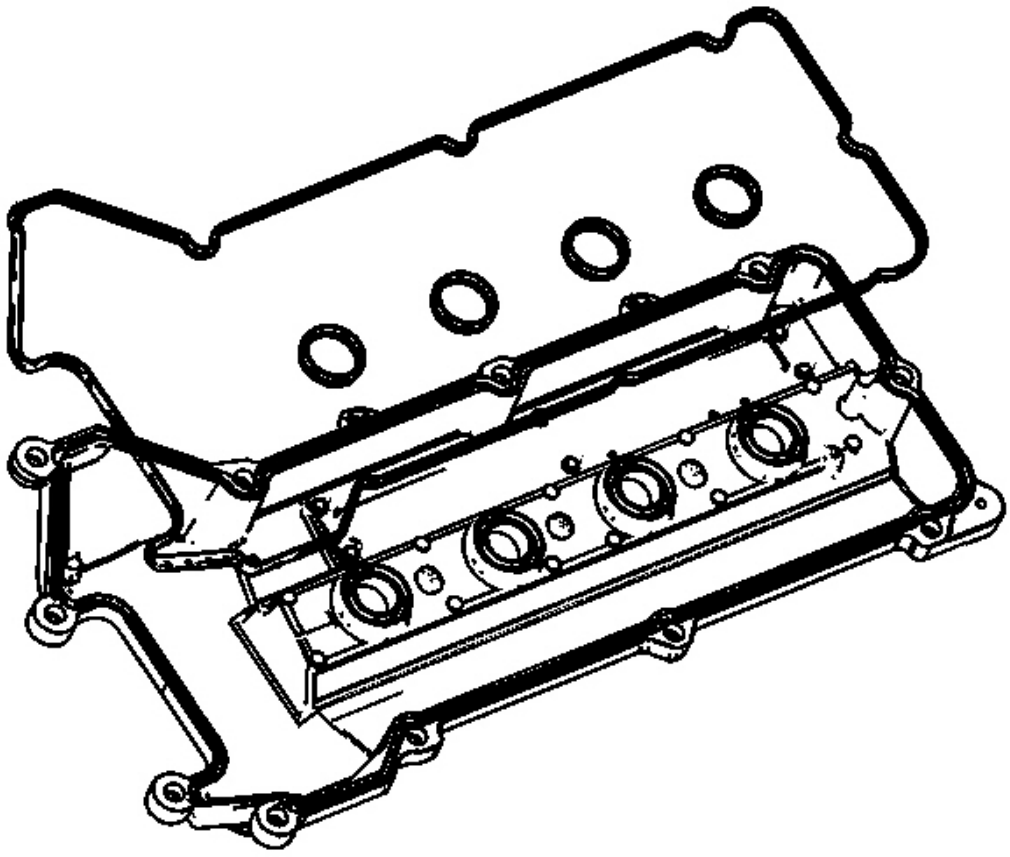


Fig. 19: View Of Right Camshaft Cover Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the right camshaft cover gasket and discard.
4. Remove the right spark plug port seals and discard.

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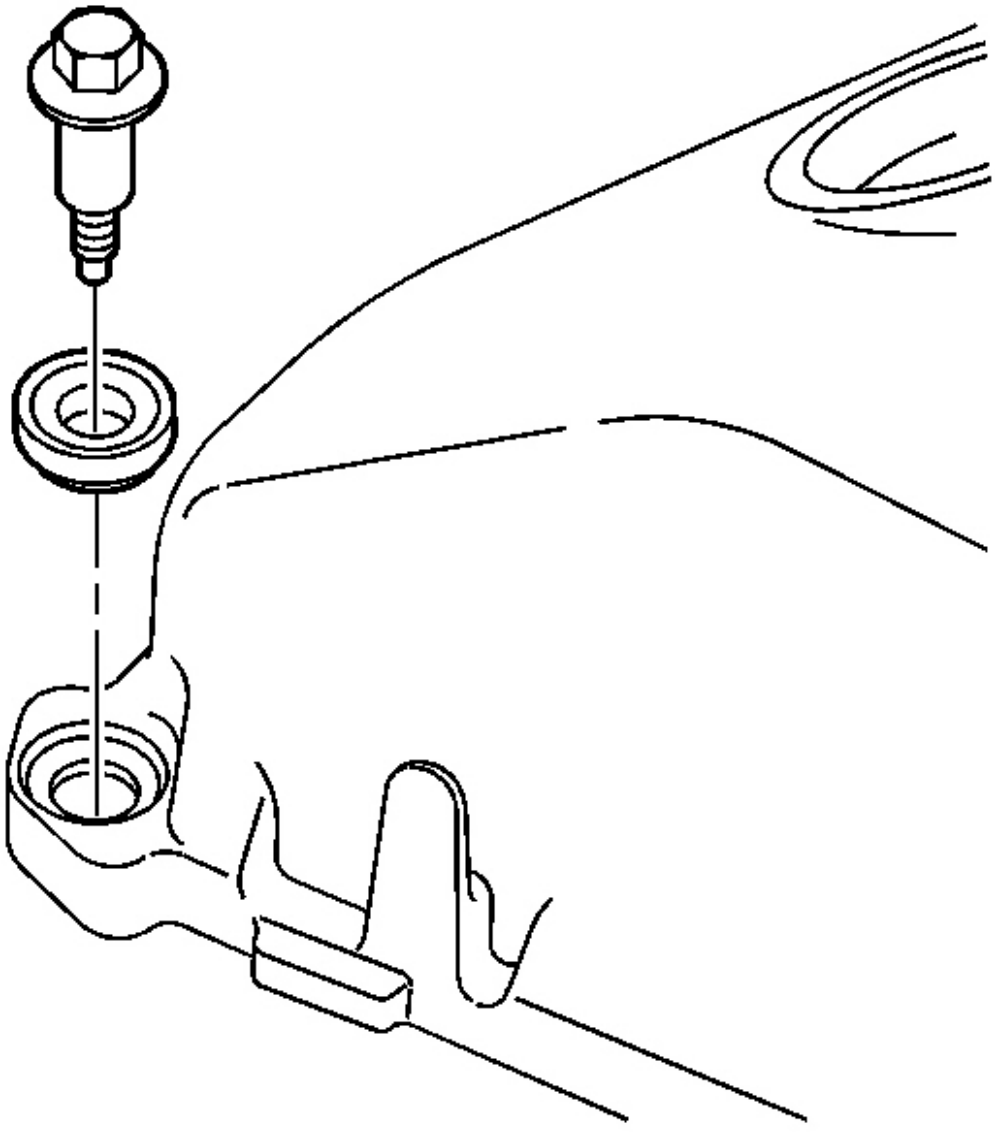


Fig. 20: View Of Camshaft Cover Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft cover bolts.
6. Remove the camshaft cover bolt grommets.

CAMSHAFT COVER CLEANING AND INSPECTION

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CLEANING PROCEDURE

1. Clean the camshaft cover in solvent.

   CAUTION: Refer to Safety Glasses Caution .

2. Dry the camshaft cover with compressed air.

INSPECTION PROCEDURE

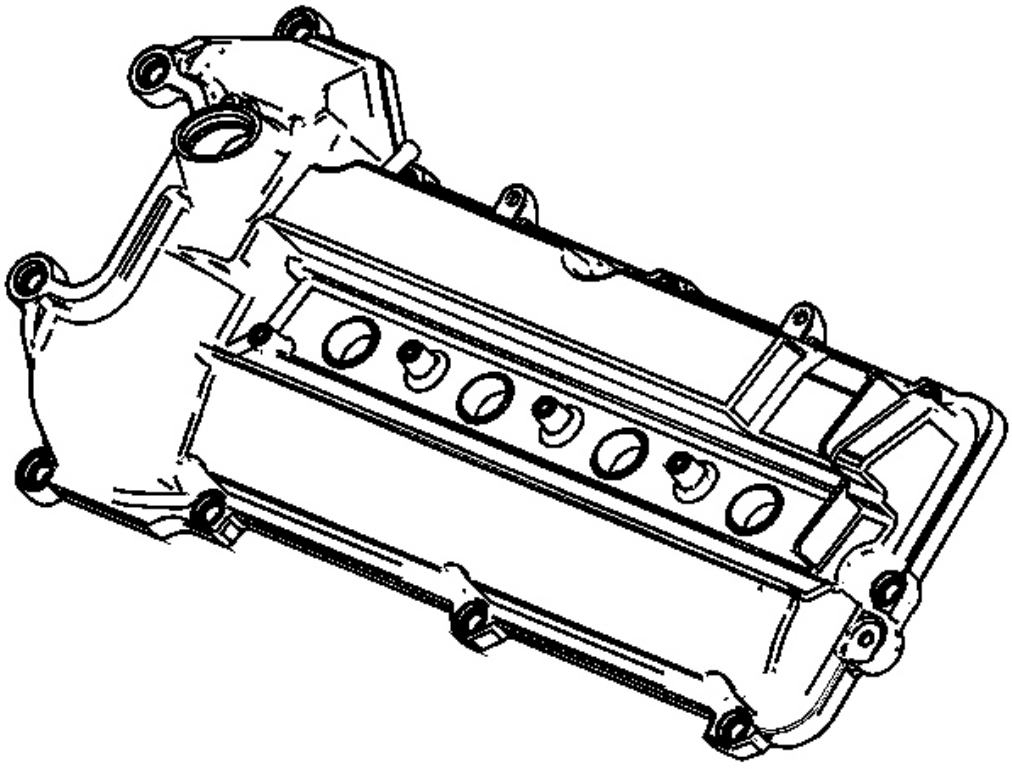


Fig. 21: Inspecting Exterior Of Left Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exterior of the left camshaft cover for the following:
   - Dents or damage

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A dented or damaged cover may:

- Leak oil
- Effect crankcase ventilation
- Interfere with the camshafts
- Interfere with the ignition coil sealing
- Allow water, condensation or debris to enter the engine

- Damaged threads for the ignition coils or ground straps
- Damaged camshaft cover bolt holes
- Damaged threads for the oil fill cap
- Damaged PCV tube fitting
- Damaged holes for the wiring harness retainers

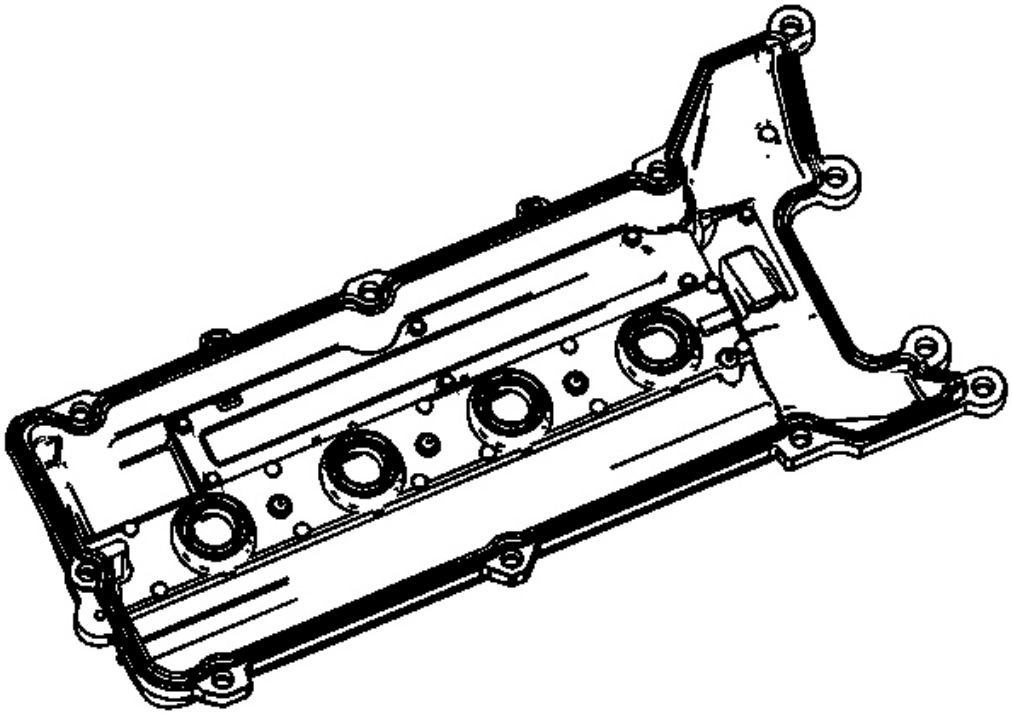


Fig. 22: Inspecting Interior Of Left Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the left camshaft cover for the following:

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- Damaged, loose or missing baffle
- Damaged, loose or missing baffle fasteners
- Restrictions to the ventilation system passages
- Damaged or warped seal groove for the camshaft cover seal and/or spark plug port seals

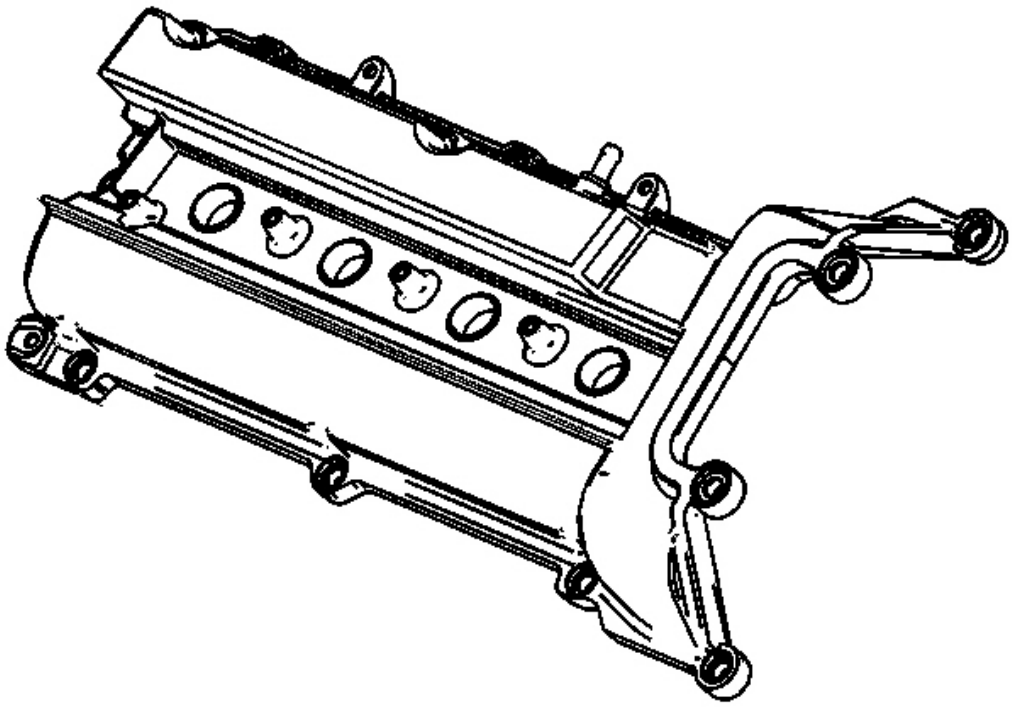


Fig. 23: Inspecting Exterior Of Right Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

3. Inspect the exterior of the right camshaft cover for the following:
   - Dents or damage

     A dented or damaged cover may:

     - Leak oil
     - Effect crankcase ventilation
     - Interfere with the camshafts
     - Interfere with ignition coil sealing
     - Allow water, condensation or debris to enter the engine

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- Damaged threads for the ignition coils or ground straps
- Damaged camshaft cover bolt holes
- Damaged PCV tube orifice fitting
- Damaged holes for the wiring harness retainers

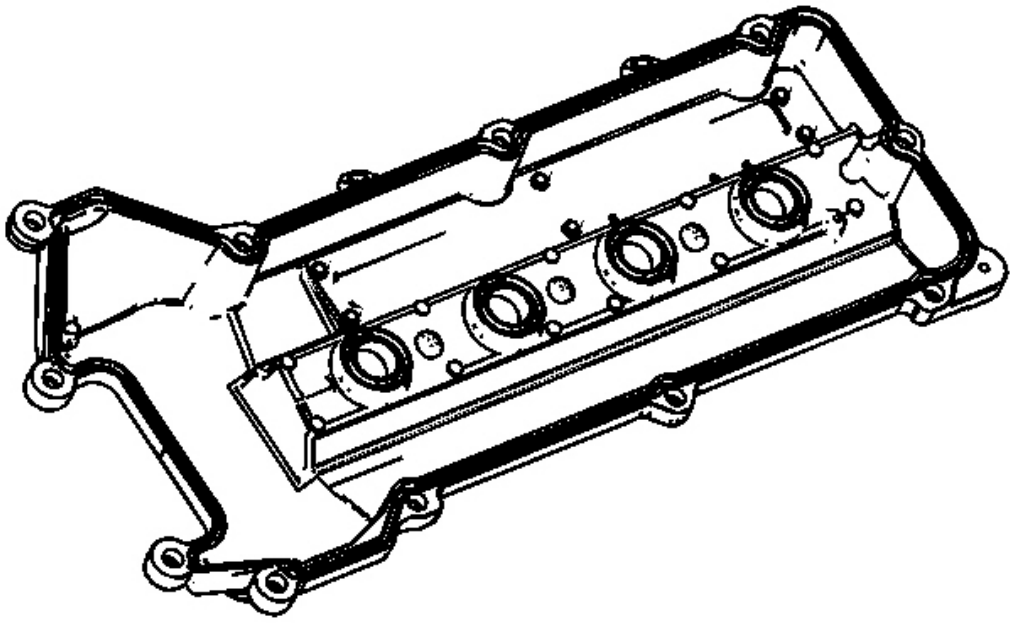


Fig. 24: Inspecting Interior Of Right Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

4. Inspect the interior of the right camshaft cover for the following:
   - Damaged, loose or missing baffle
   - Damaged, loose or missing baffle fasteners
   - Restrictions to the ventilation system passages
   - Damaged or warped seal groove for the camshaft cover seal and/or spark plug port seals
5. Inspect the following related camshaft cover components for damage:
   - Oil fill cap
   - PCV clean air tube
   - PCV dirty air tube
   - Camshaft cover bolts and grommets
   - Ground straps and bolts

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- Ignition coil bracket assembly and wiring harness

6. Repair or replace the camshaft cover and/or components as necessary.

CAMSHAFT COVER ASSEMBLE

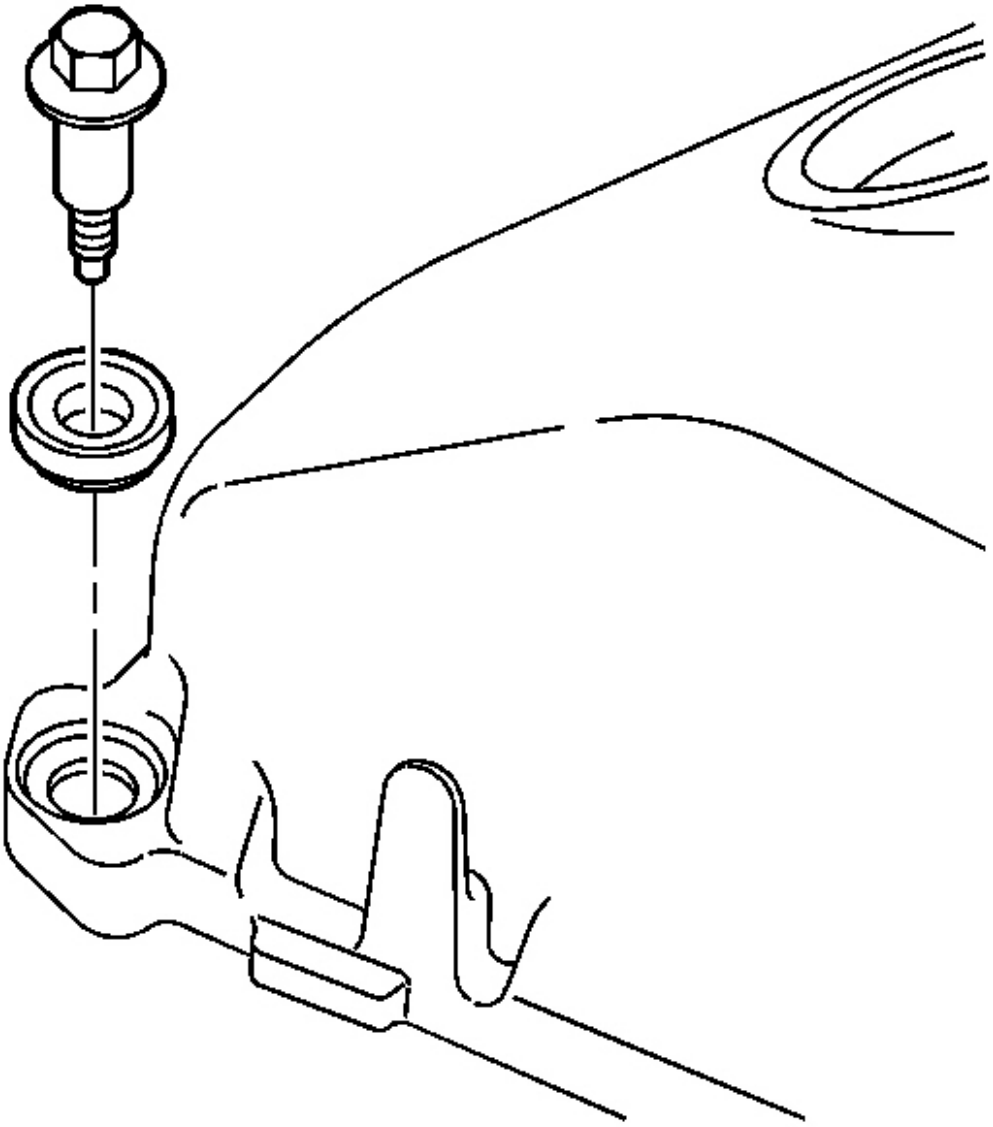


Fig. 25: View Of Camshaft Cover Bolts
Courtesy of GENERAL MOTORS CORP.

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1. Install the camshaft cover bolt grommets.
2. Install the camshaft cover bolts.

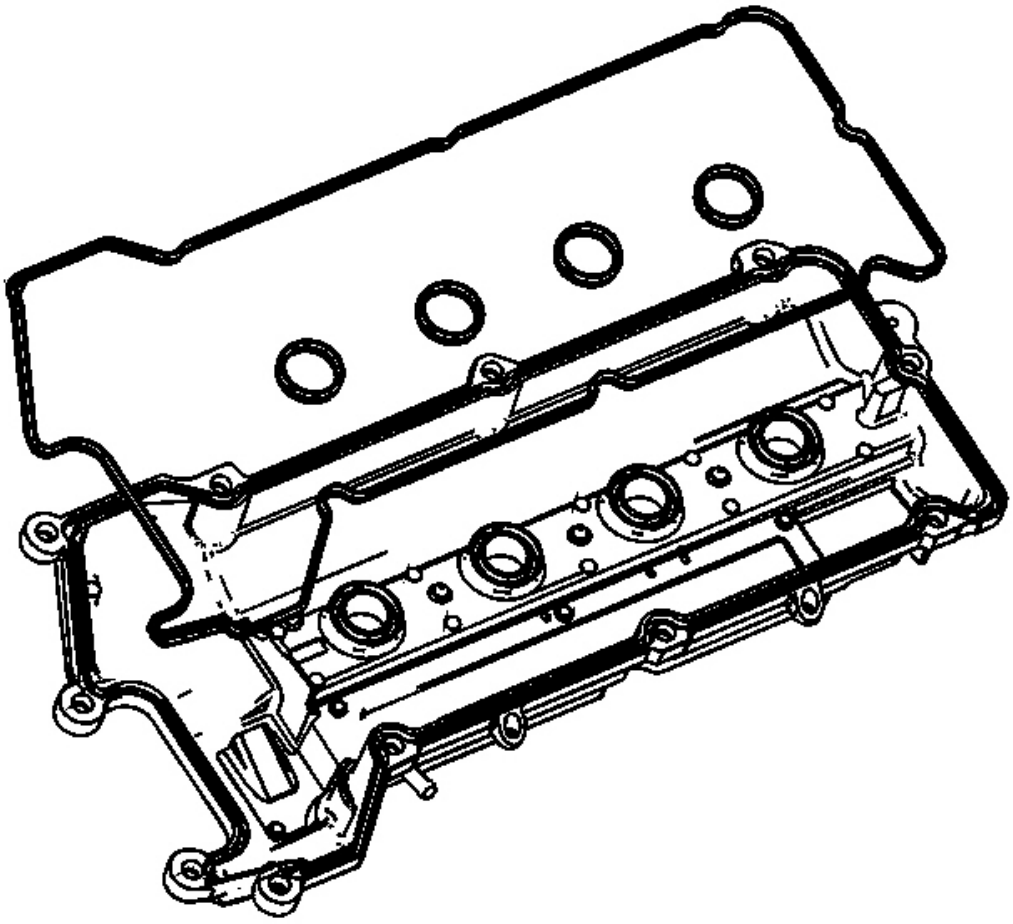


Fig. 26: View Of Left Camshaft Cover Gasket
Courtesy of GENERAL MOTORS CORP.

3. Install the NEW left camshaft cover gasket.
4. Install the NEW left spark plug port seals.

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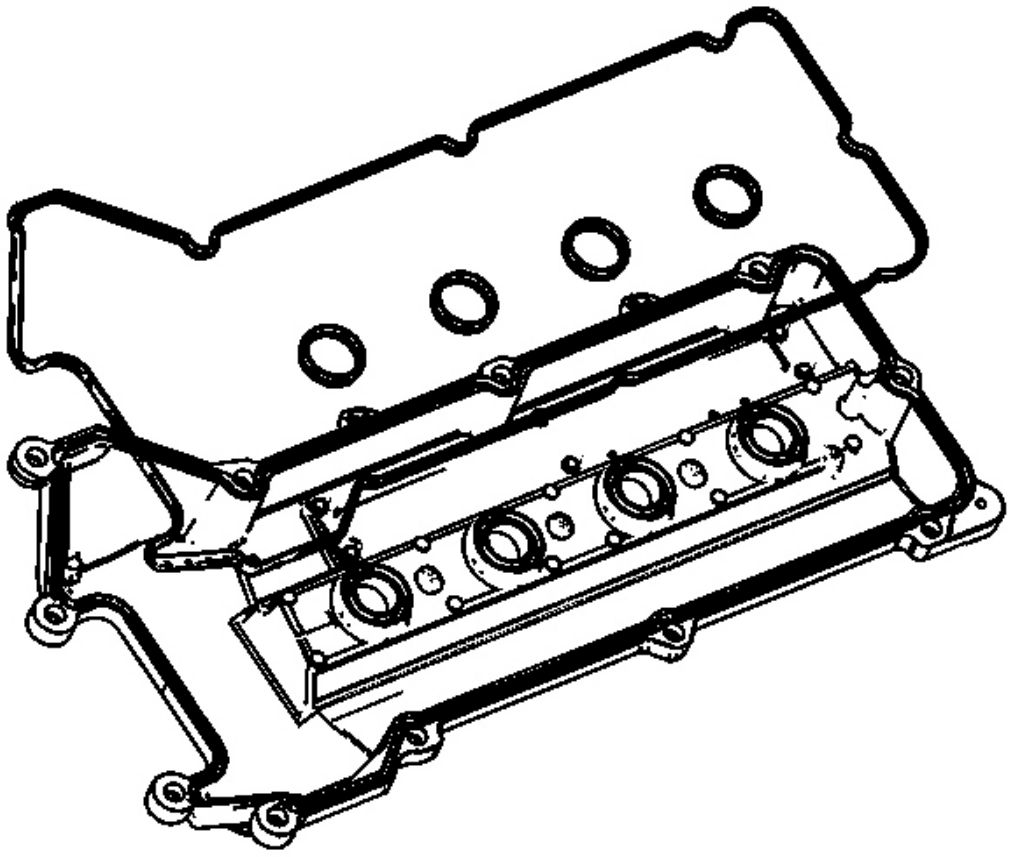


Fig. 27: View Of Right Camshaft Cover Gasket
Courtesy of GENERAL MOTORS CORP.

5. Install the NEW right camshaft cover gasket.
6. Install the NEW right spark plug port seals.

SUPERCHARGER CLEANING AND INSPECTION

TOOLS REQUIRED

- **EN-47814** Supercharger Bypass Valve Actuator Setting Tool
- **EN-47833** Supercharger Service Holding Fixture

DISASSEMBLE PROCEDURE

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IMPORTANT: In order to protect and service components, on the supercharger, ensure the EN-47833 is on the supercharger during the disassembly and assembly.

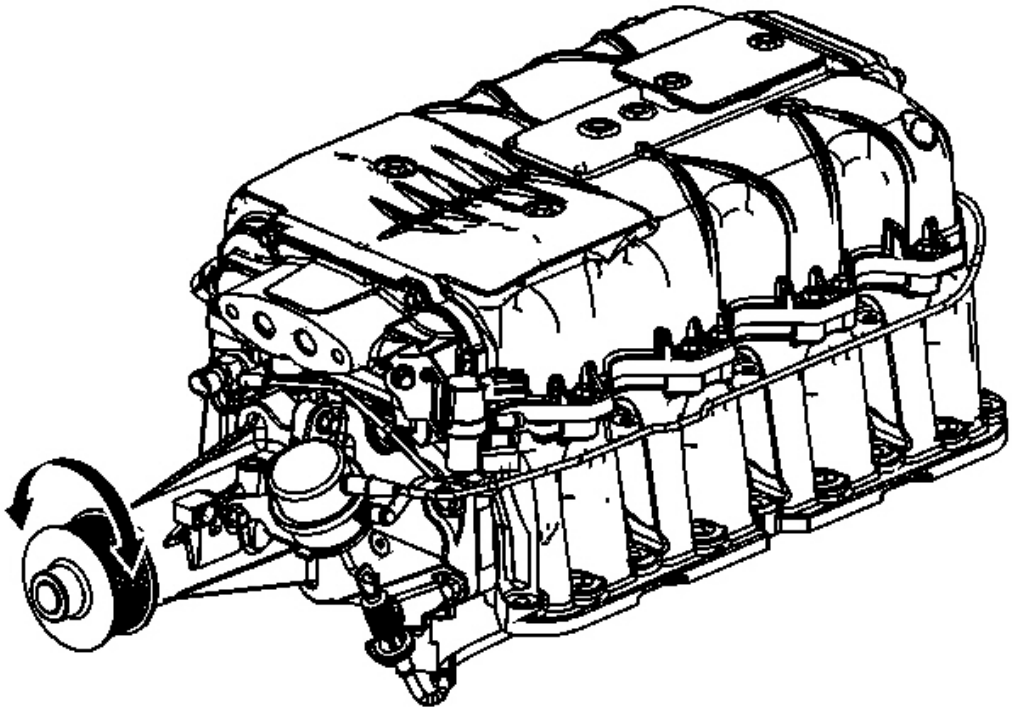


Fig. 28: View Of Supercharger
Courtesy of GENERAL MOTORS CORP.

1. Ensure the supercharger will spin.

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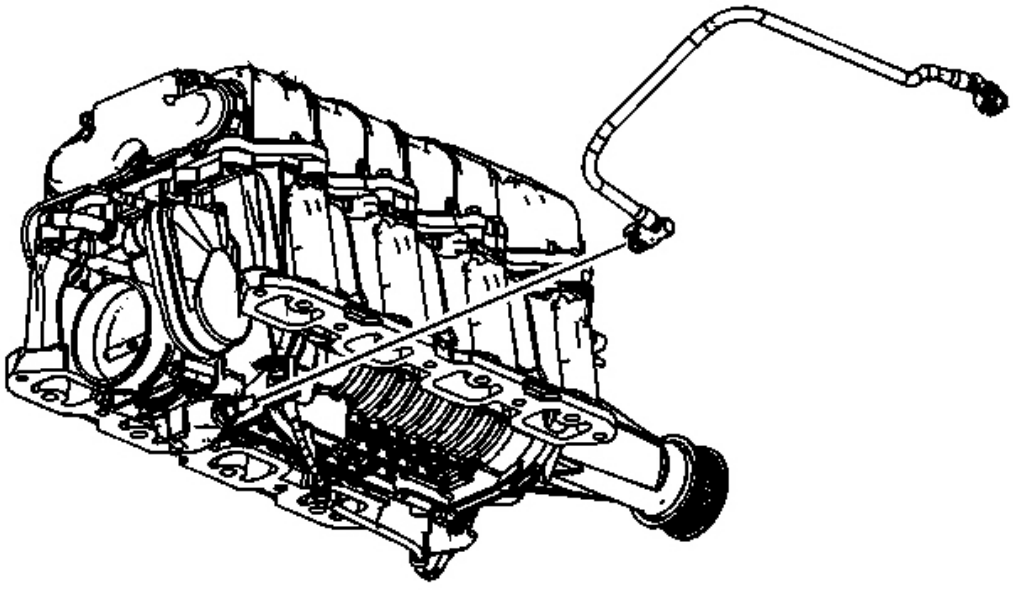


Fig. 29: Identifying PCV Dirty Air Tube
Courtesy of GENERAL MOTORS CORP.

2. Disconnect and remove the dirty air positive crankcase ventilation (PCV) tube from the supercharger.

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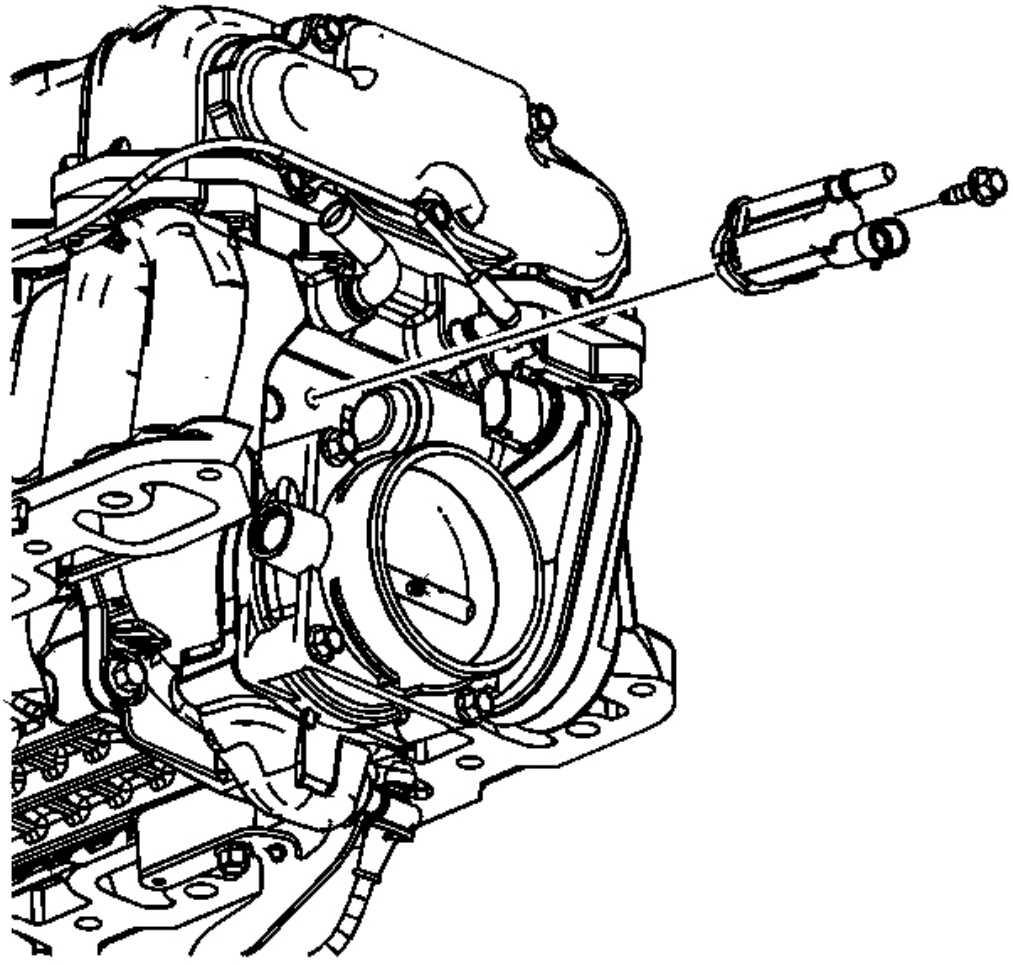


Fig. 30: View Of EVAP Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the evaporative emission (EVAP) canister purge solenoid valve bolt.
4. Remove the EVAP canister purge solenoid valve.

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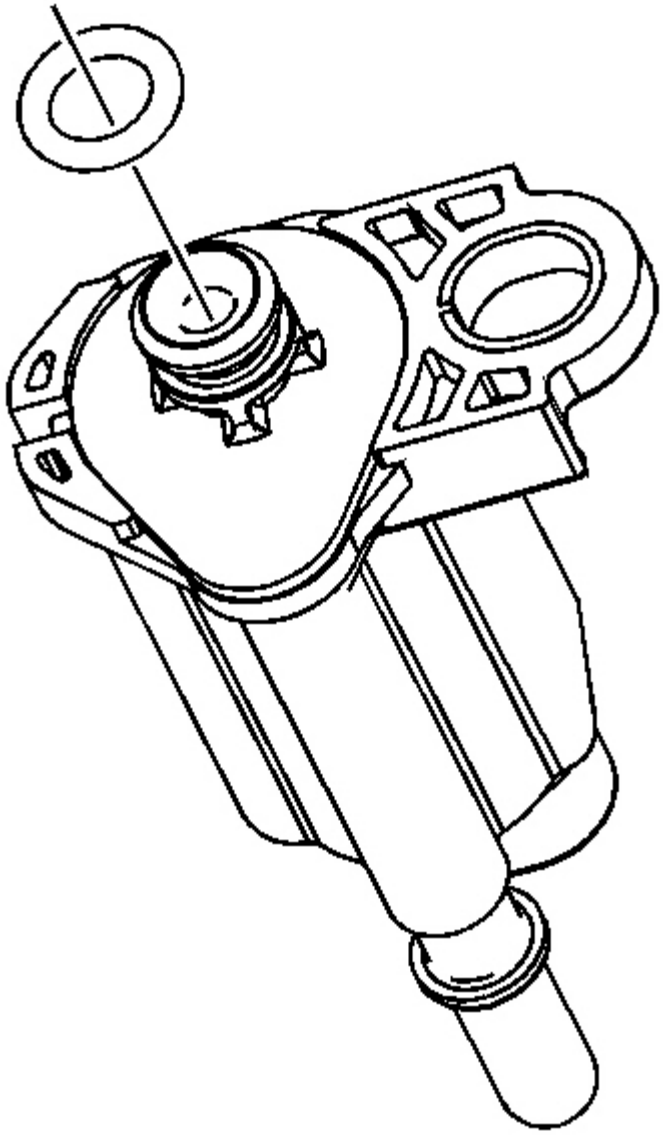


Fig. 31: View Of EVAP Canister Purge Solenoid Valve O-Ring
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the O-ring from the EVAP canister purge solenoid valve.

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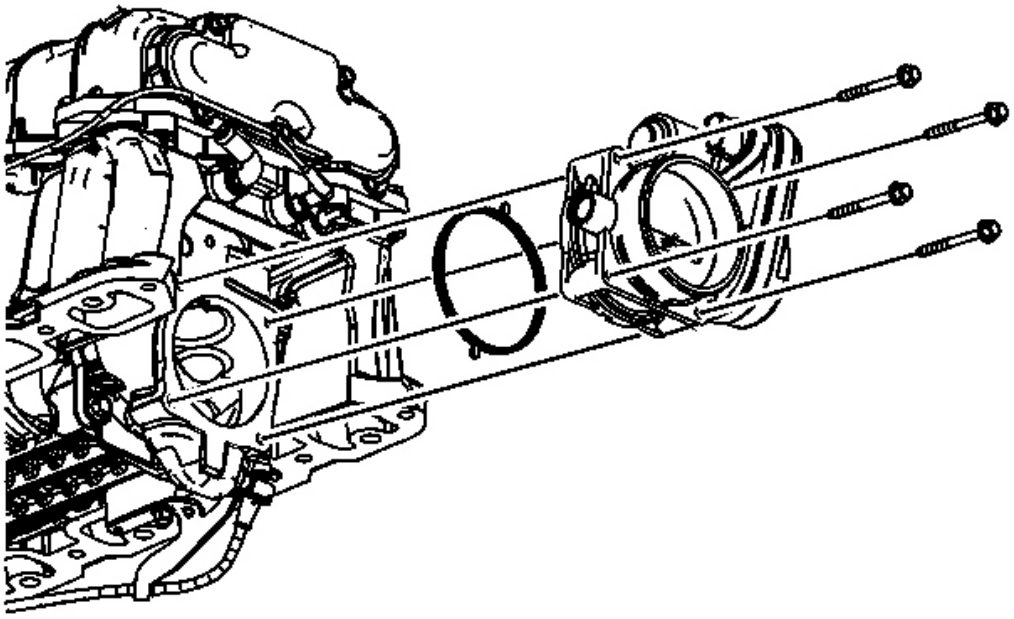


Fig. 32: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

6. Remove the throttle body bolts.
7. Remove the throttle body.
8. Remove and discard the throttle body O-ring.

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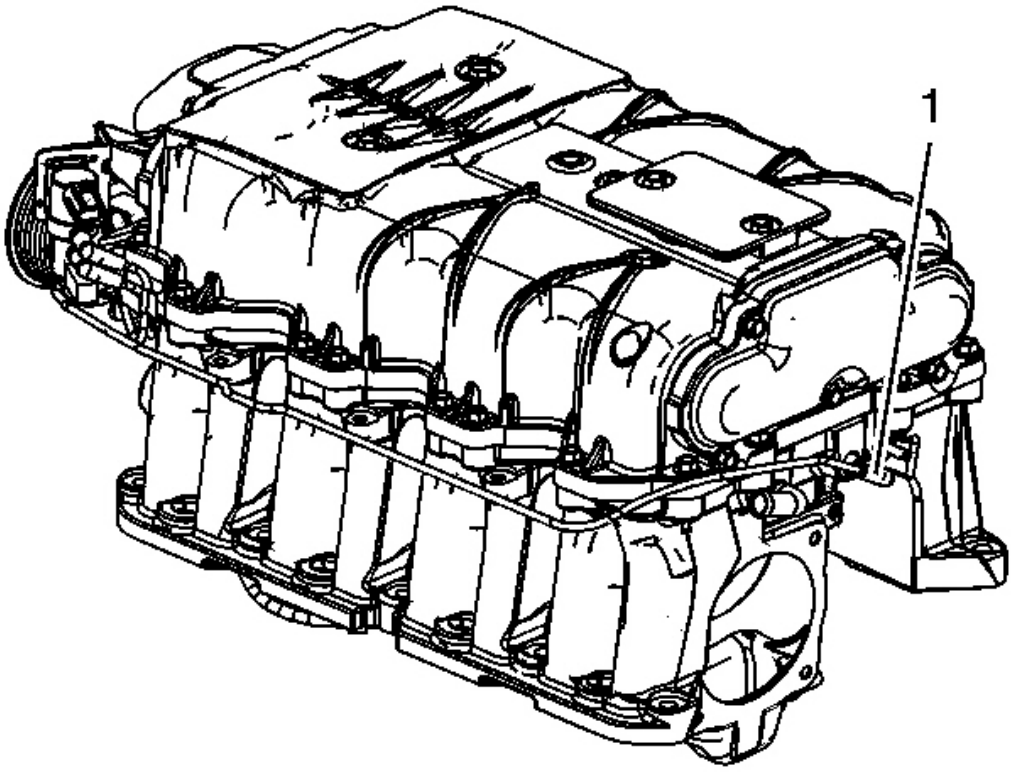


Fig. 33: View Of Supercharger Vacuum Port
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the bypass valve actuator vacuum hose at the vacuum port of the supercharger (1).

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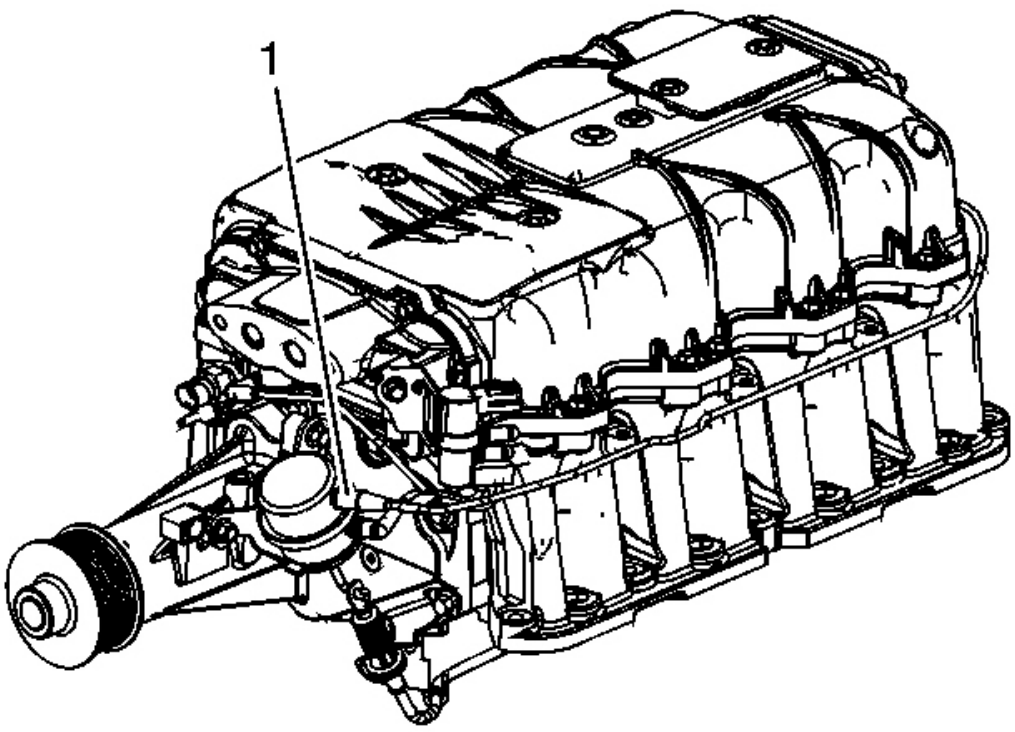


Fig. 34: View Of Supercharger Bypass Valve Actuator
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the bypass valve actuator vacuum hose at the supercharger bypass valve actuator (1).

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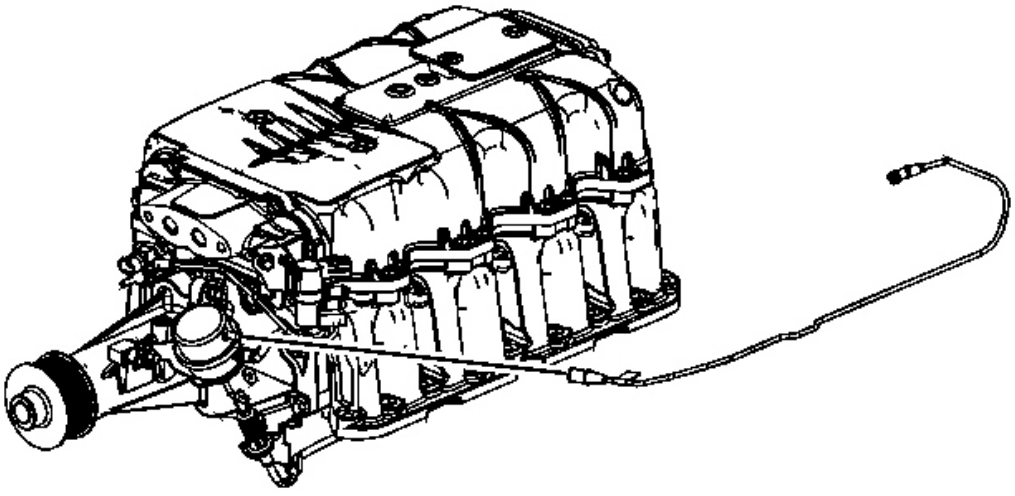


Fig. 35: View Of Bypass Valve Actuator Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

11. Remove the bypass valve actuator vacuum hose from the supercharger.

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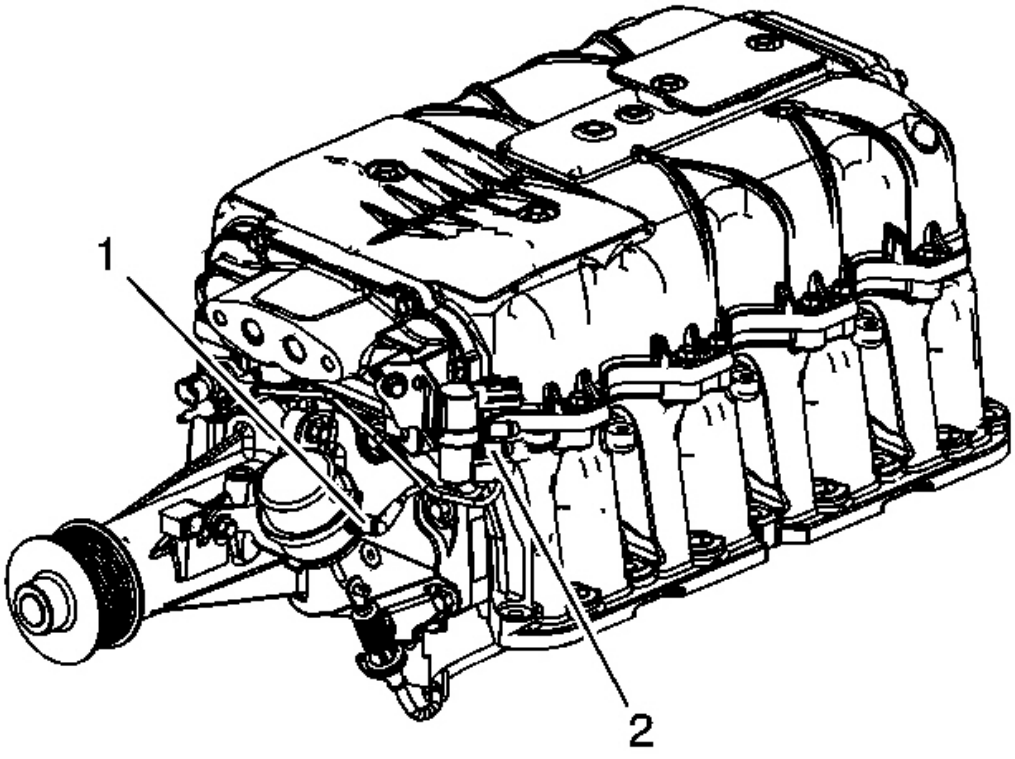


Fig. 36: View Of Supercharger Bypass Valve Actuator
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the bypass valve actuator pressure hose at the supercharger bypass valve actuator (1).
13. Disconnect the bypass valve actuator pressure hose at the charge air bypass regulator solenoid valve (2).

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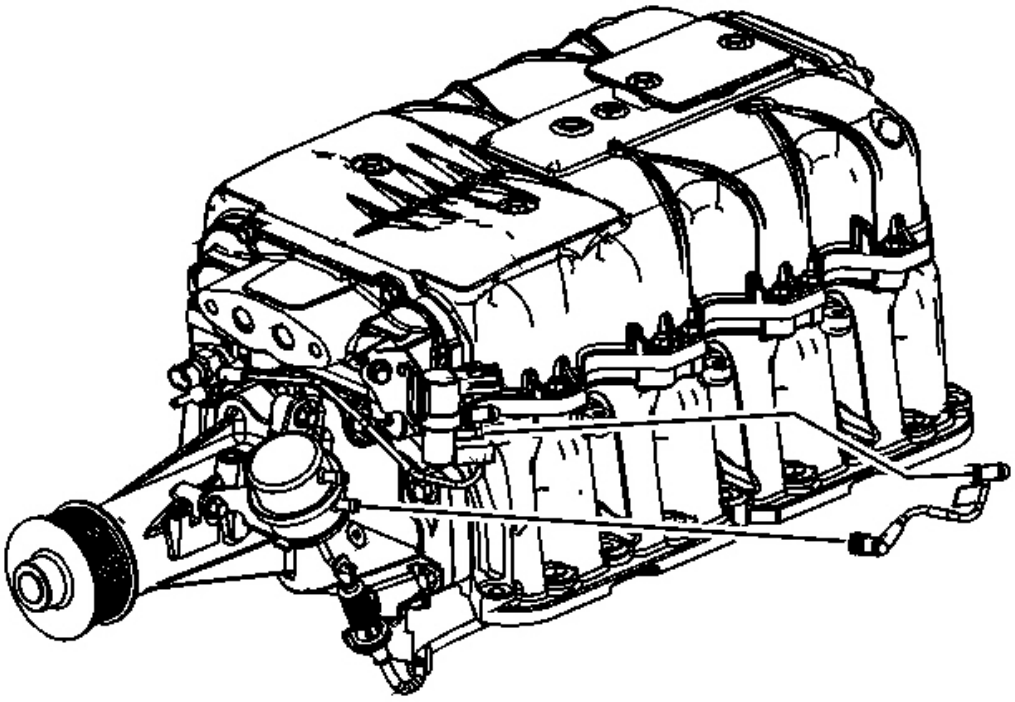


Fig. 37: View Of Bypass Valve Actuator Pressure Hose
Courtesy of GENERAL MOTORS CORP.

14. Remove the bypass valve actuator pressure hose.

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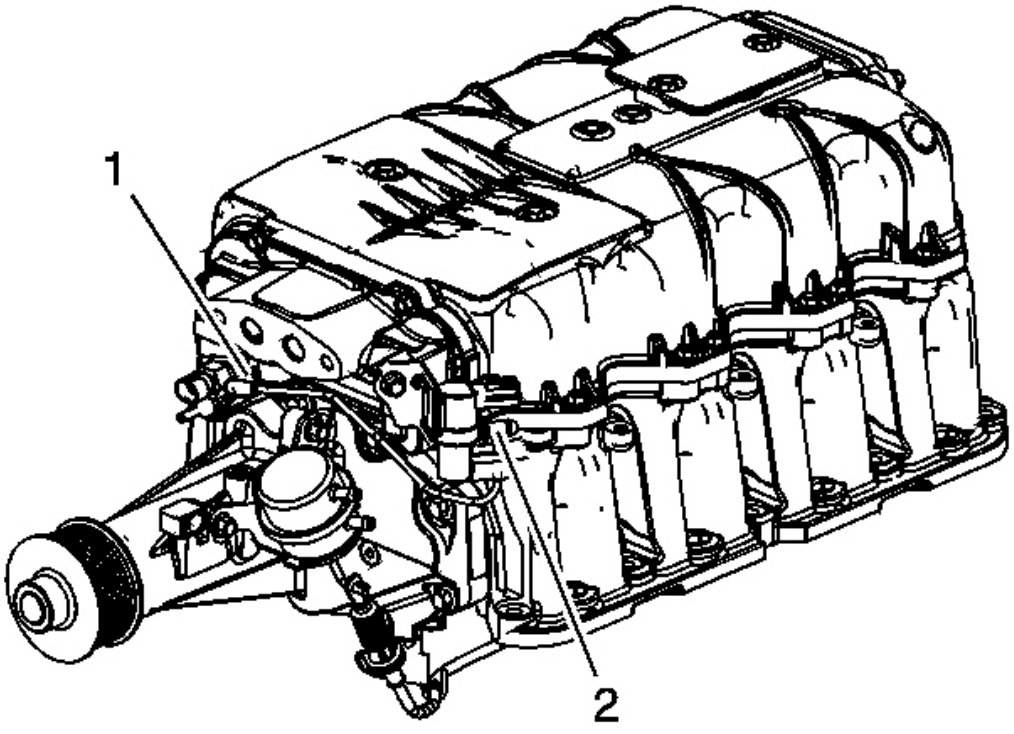


Fig. 38: View Of Charge Air Bypass Regulator Solenoid Valve Pressure Hose
Courtesy of GENERAL MOTORS CORP.

15. Disconnect the charge air bypass regulator solenoid valve pressure hose at the supercharger pressure port (1).
16. Disconnect the charge air bypass regulator solenoid valve pressure hose at the charge air bypass regulator solenoid valve (2).

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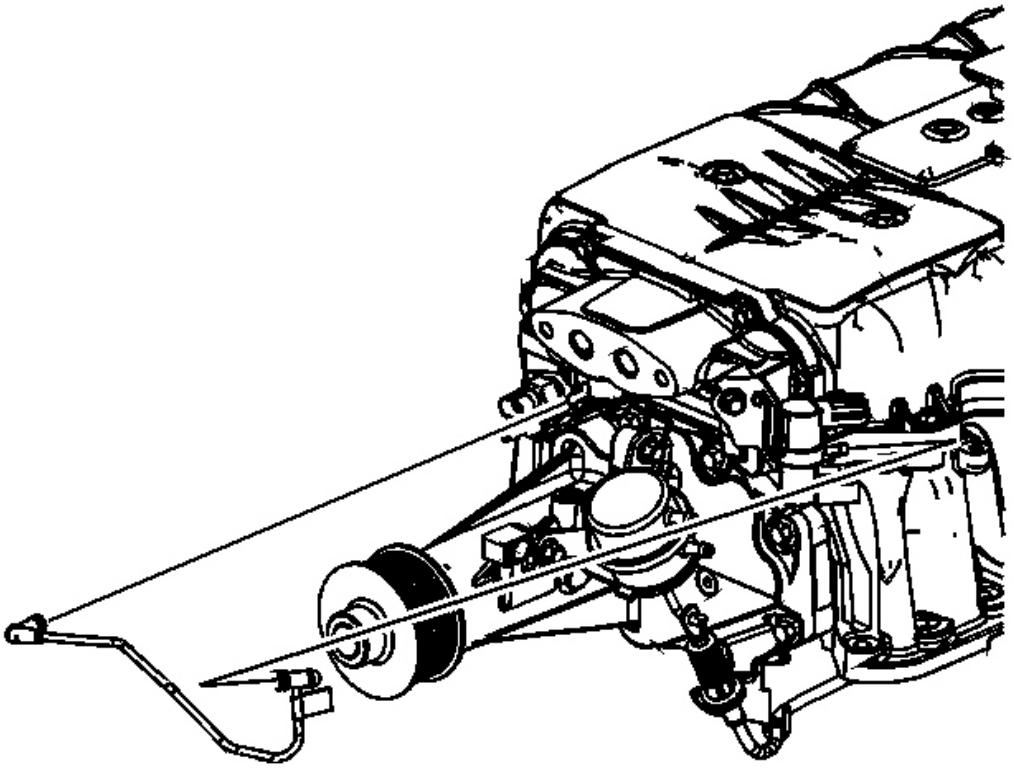


Fig. 39: Identifying Charge Air Bypass Regulator Solenoid Valve Pressure Hose
Courtesy of GENERAL MOTORS CORP.

17. Remove the charge air bypass regulator solenoid valve pressure hose.

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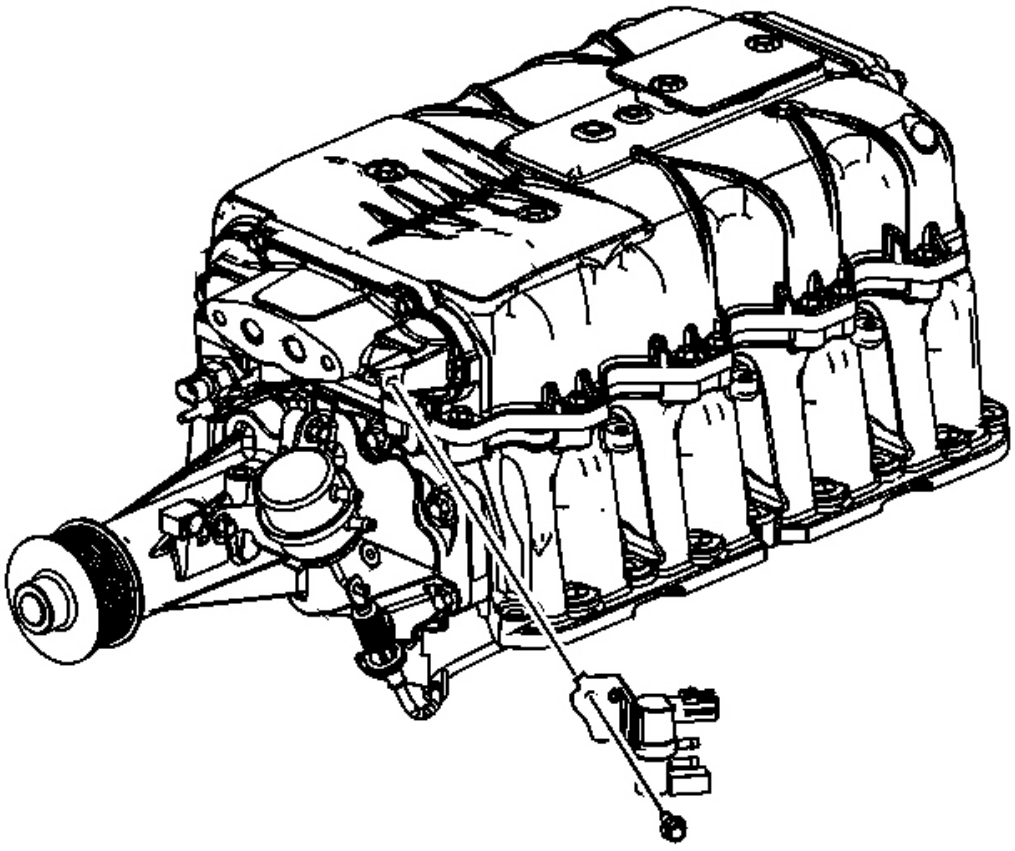


Fig. 40: View Of Supercharger Bypass Regulator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

18. Remove the charge air bypass regulator solenoid valve bolt.
19. Remove the charge air bypass regulator solenoid valve.

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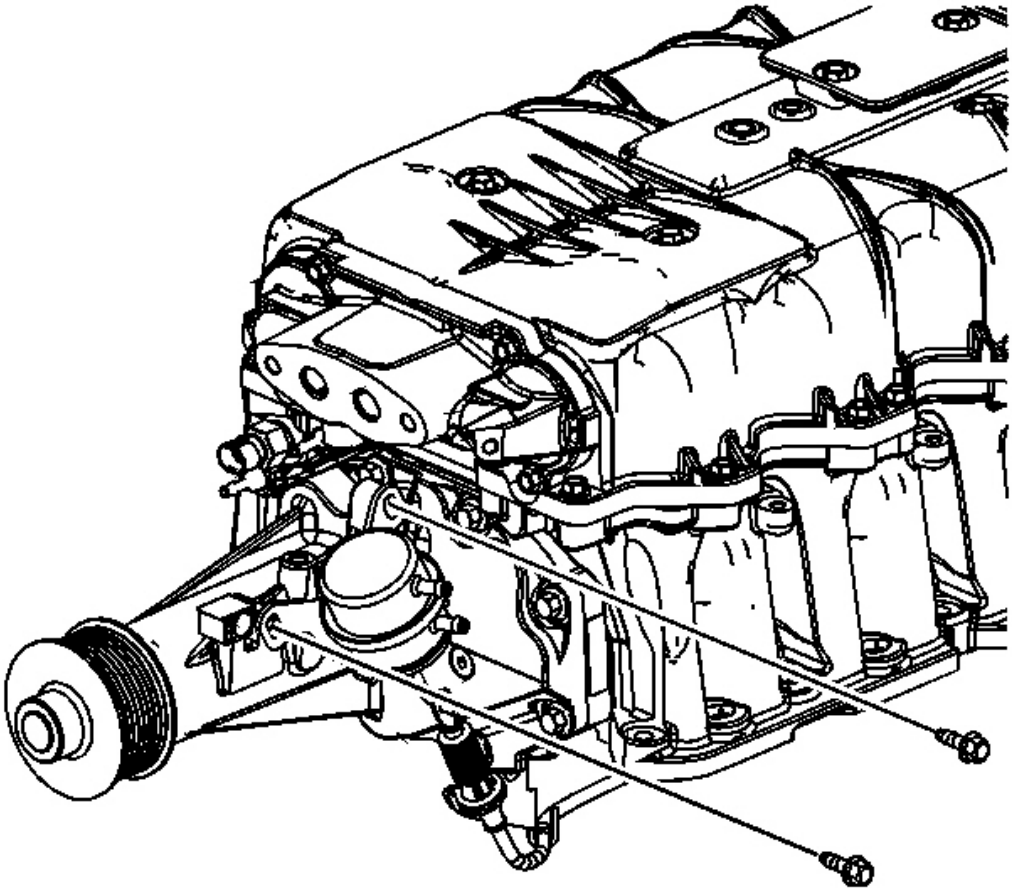


Fig. 41: Locating Bypass Valve Actuator Bolts
Courtesy of GENERAL MOTORS CORP.

20. Remove the bypass valve actuator bolts.

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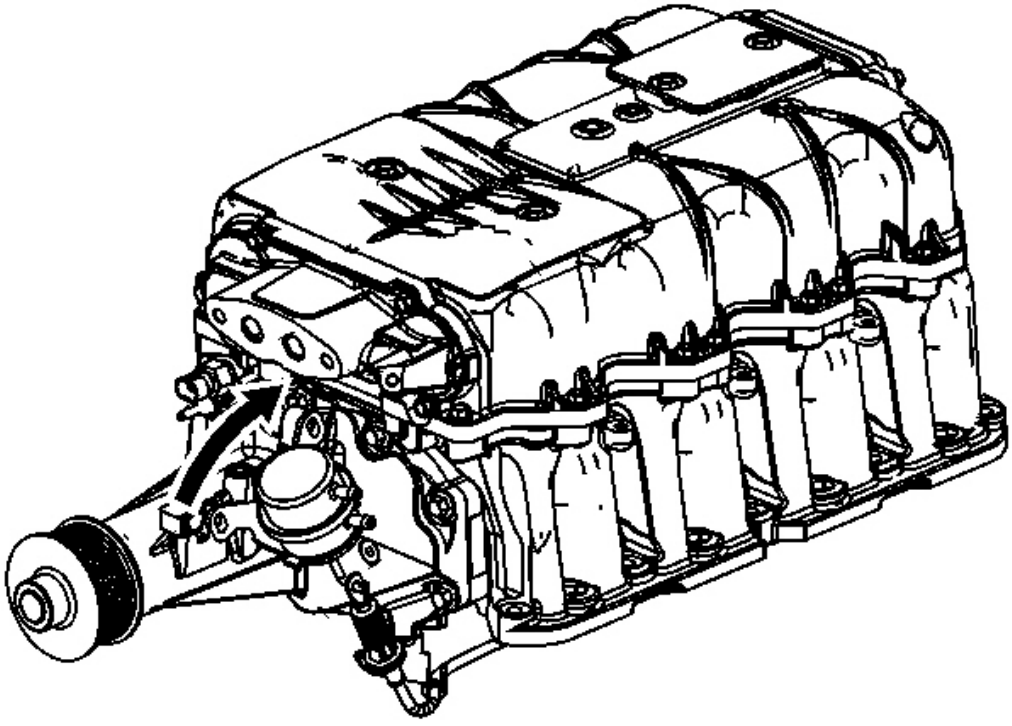


Fig. 42: Identifying Bypass Valve Actuator Cable
Courtesy of GENERAL MOTORS CORP.

21. Pivot the bypass valve actuator clockwise in order to remove the bypass valve actuator from the bypass valve actuator cable.

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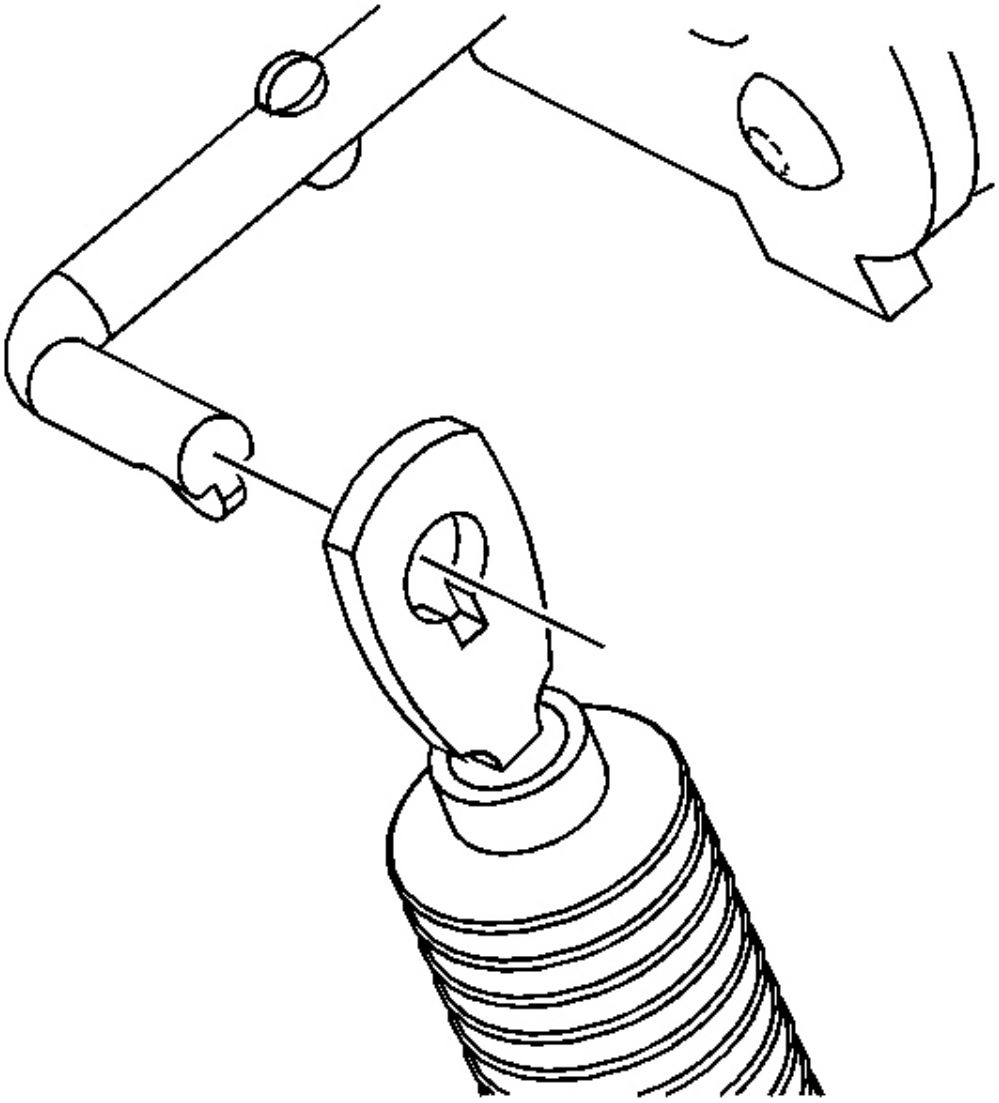


Fig. 43: View Of Bypass Valve Actuator Rod
Courtesy of GENERAL MOTORS CORP.

22. Align the tab on the bypass valve actuator rod with the slot in the bypass valve actuator cable end.

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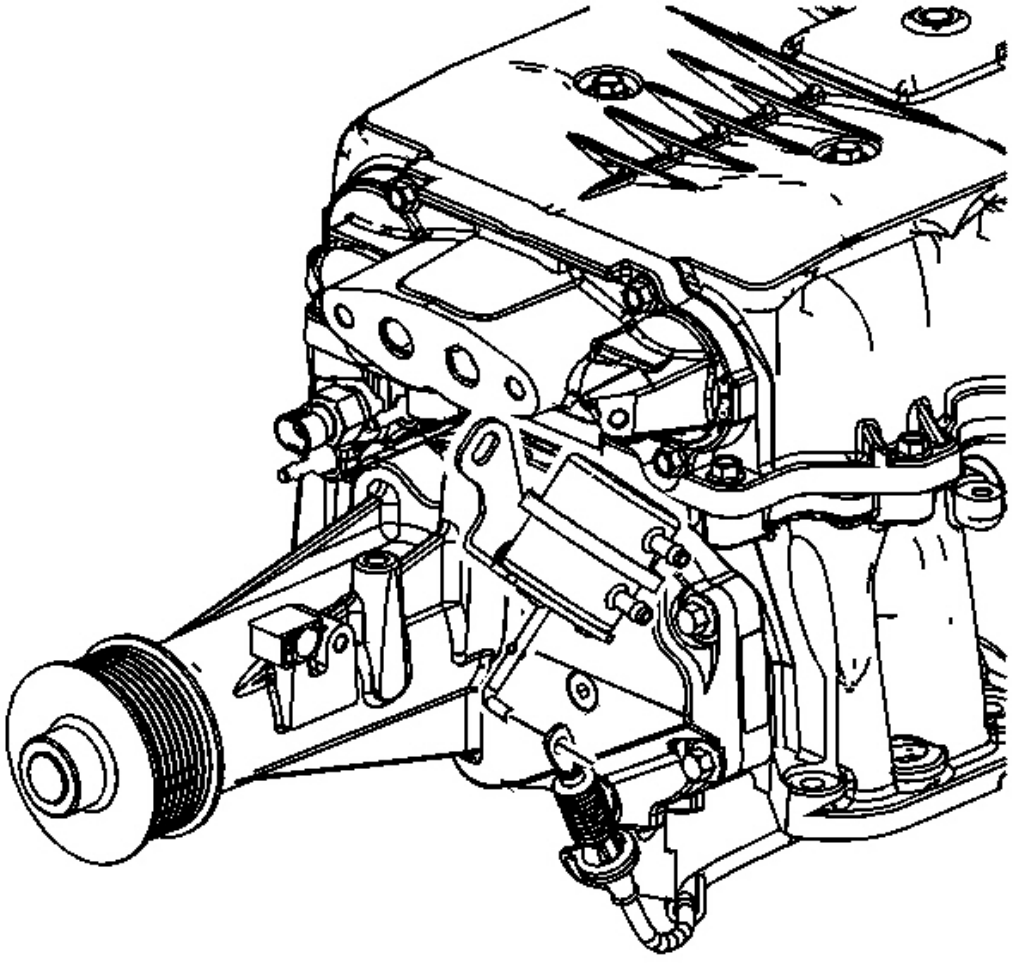


Fig. 44: View Of Bypass Valve Actuator
Courtesy of GENERAL MOTORS CORP.

23. Slide the bypass valve actuator rod out of the bypass valve actuator cable.
24. Remove the bypass valve actuator.

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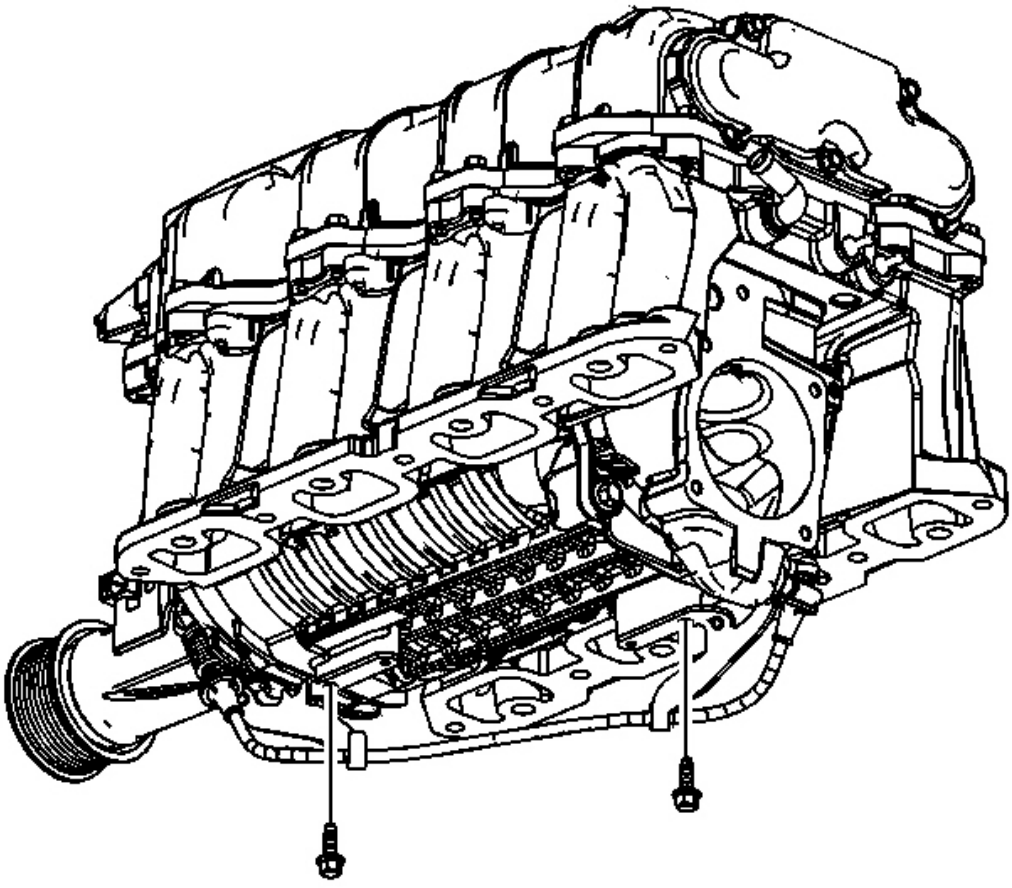


Fig. 45: View Of Bypass Valve Actuator Cable Bracket
Courtesy of GENERAL MOTORS CORP.

25. Remove the bypass valve actuator cable bracket bolts from the supercharger.

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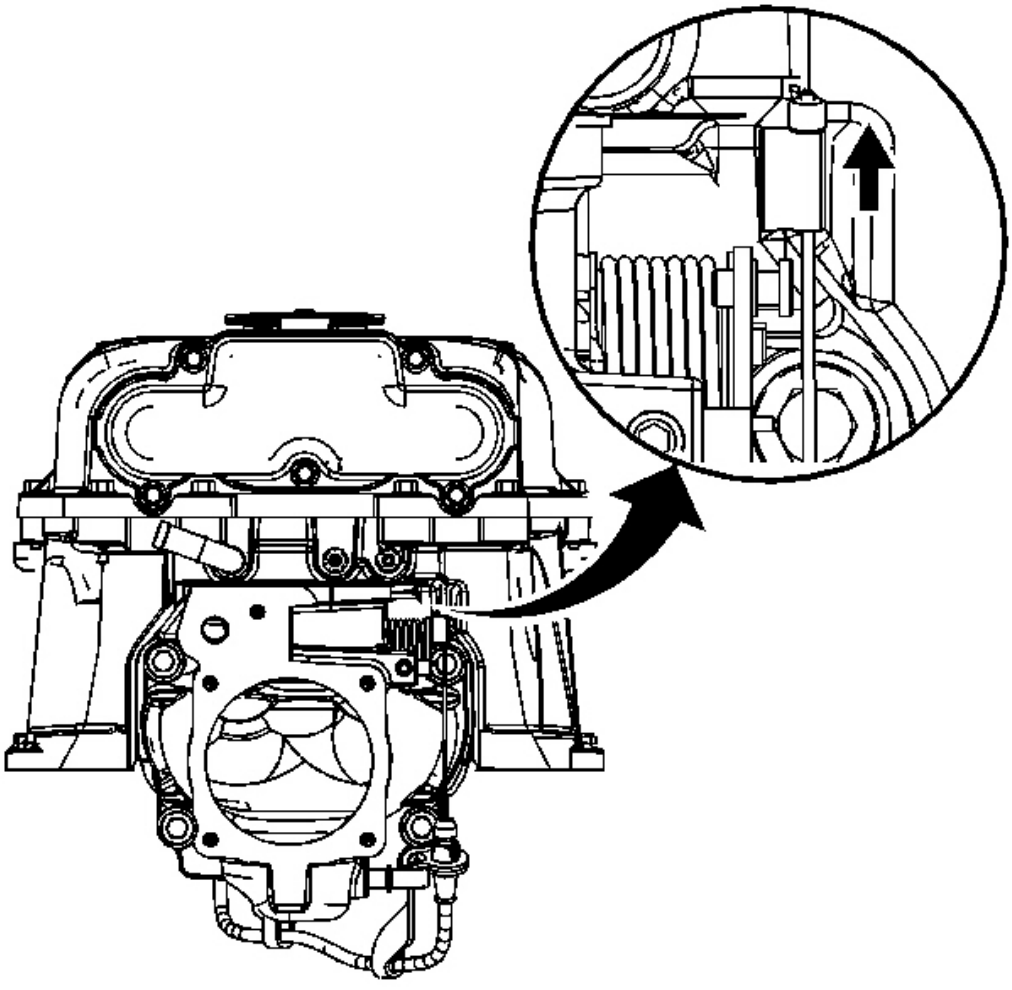


Fig. 46: Locating Bypass Valve Actuator Cable Clip
Courtesy of GENERAL MOTORS CORP.

26. Slide the bypass valve actuator cable clip off of the pin on the supercharger bypass valve.

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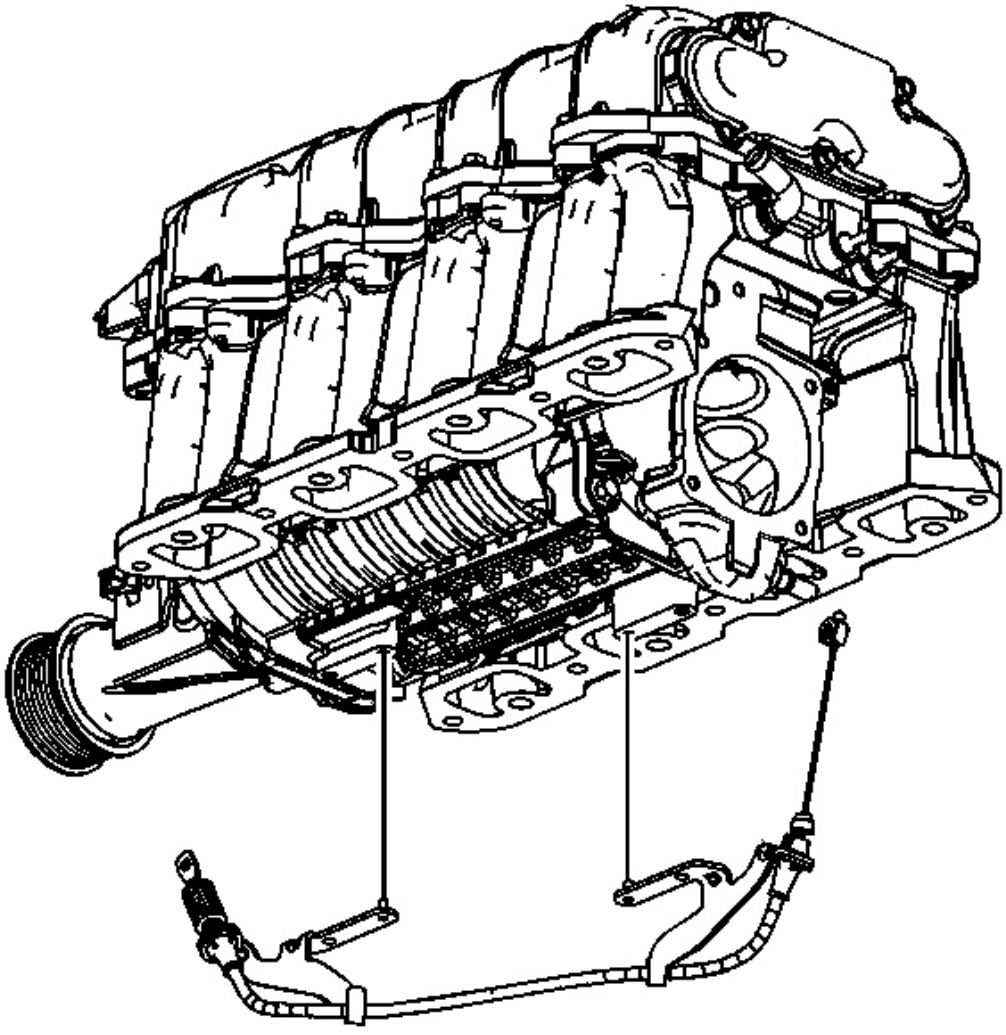


Fig. 47: View Of Bypass Valve Actuator Cable
Courtesy of GENERAL MOTORS CORP.

27. Remove the bypass valve actuator cable.

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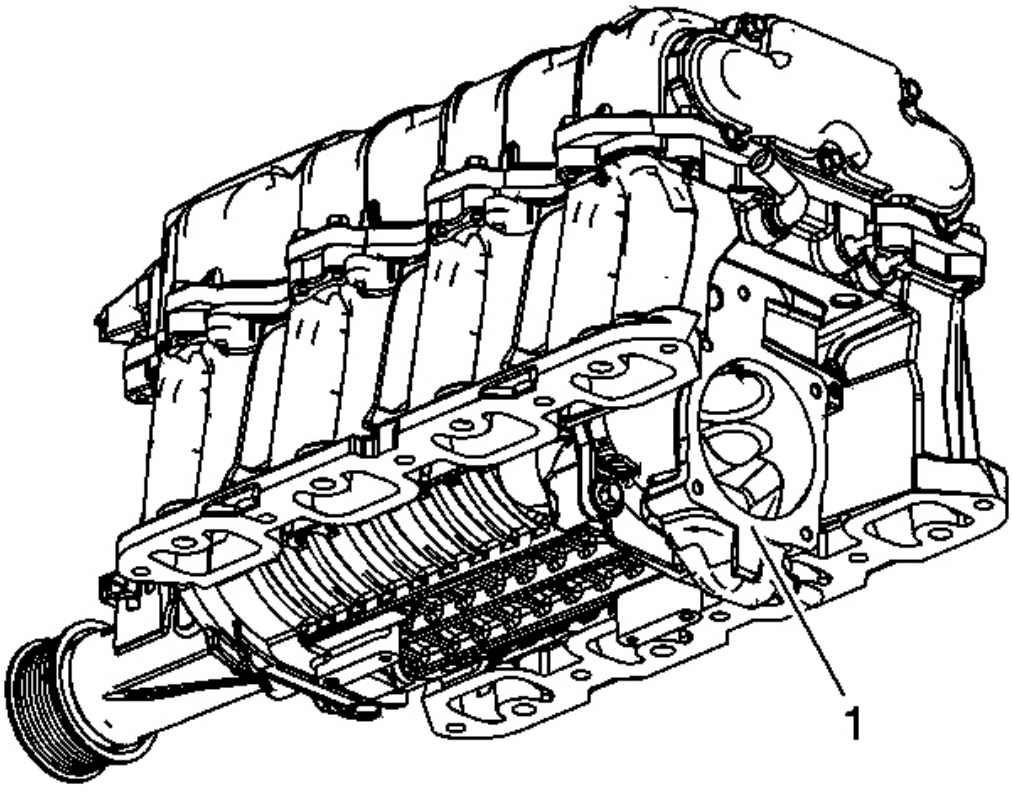


Fig. 48: Identifying Supercharger Bypass Valve
Courtesy of GENERAL MOTORS CORP.

28. Do NOT remove the supercharger bypass valve (1) from the supercharger.

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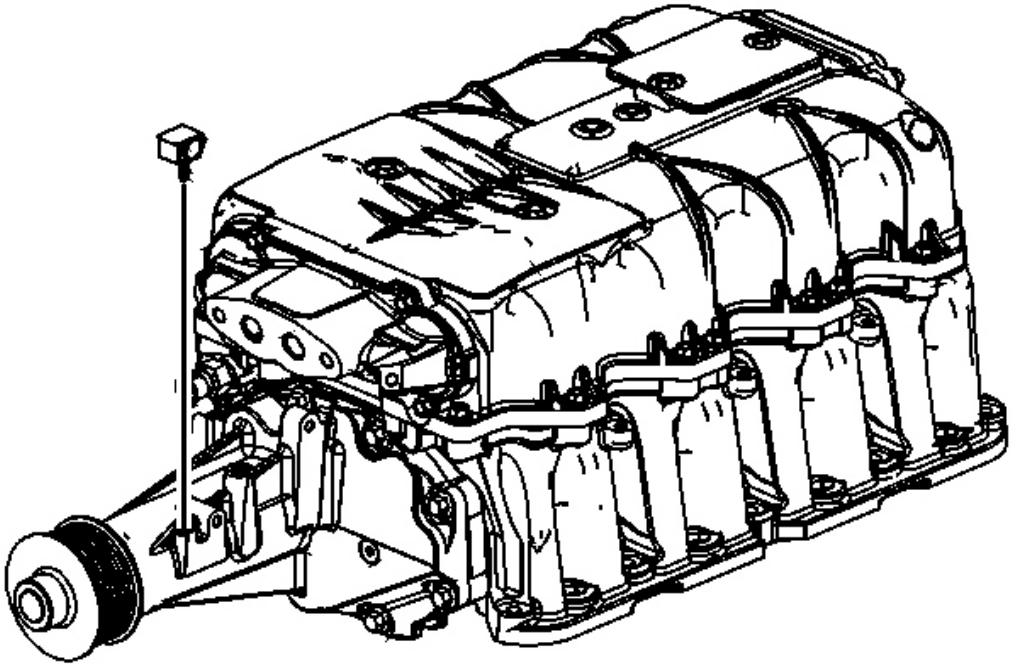


Fig. 49: Identifying Fuel Rail Crossover Tube Clip
Courtesy of GENERAL MOTORS CORP.

29. Remove the fuel injection fuel rail crossover tube clip.

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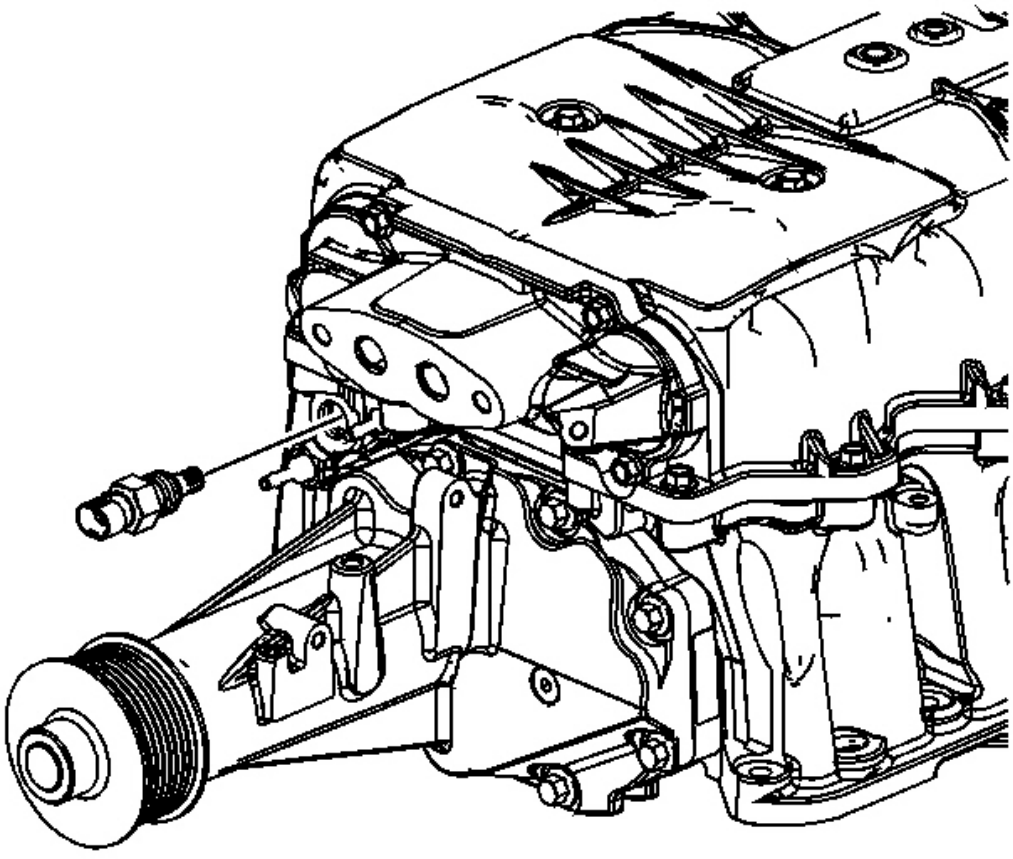


Fig. 50: Identifying IAT Sensor
Courtesy of GENERAL MOTORS CORP.

30. Remove the intake air temperature (IAT) sensor 2 from the supercharger.

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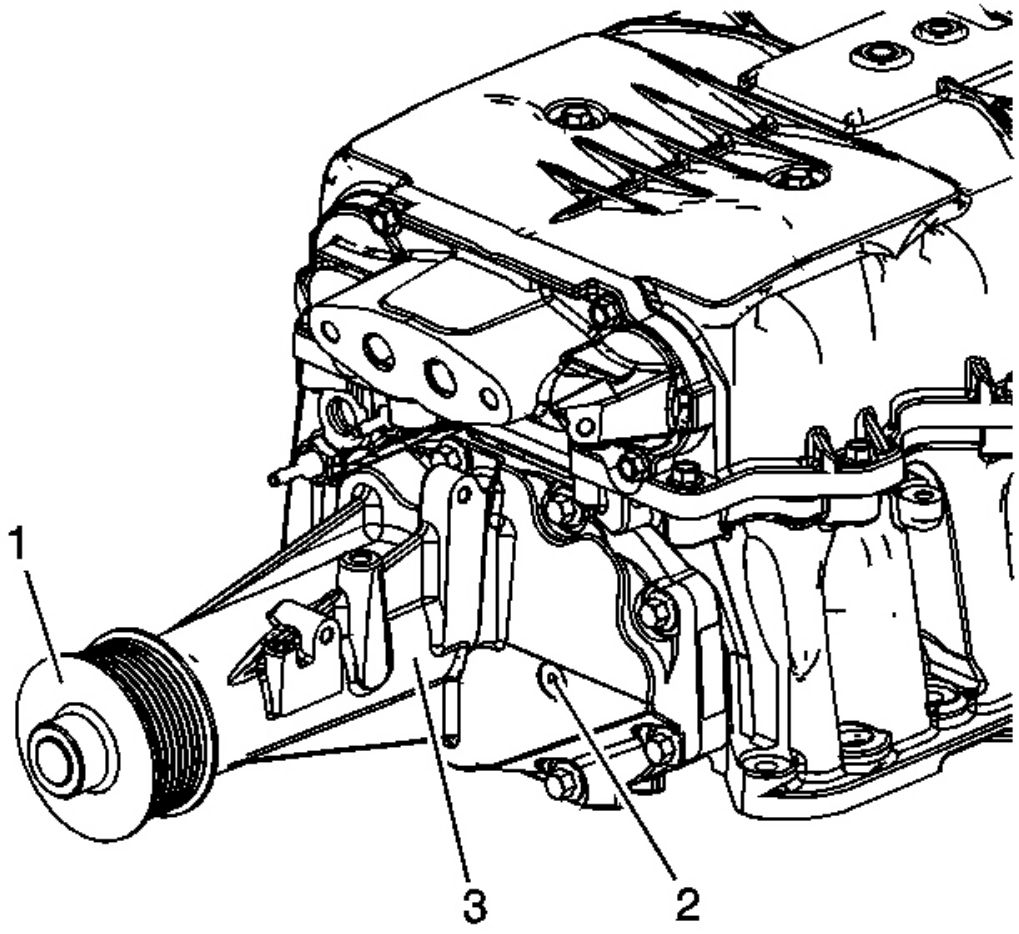


Fig. 51: View Of Supercharger Drive Pulley, Oil Level Plug & Front Housing
Courtesy of GENERAL MOTORS CORP.

31. Do NOT remove the following supercharger components:
    - Drive pulley (1)
    - Oil level plug (2)
    - Front housing (3)
    - Bearings
    - Rotors
    - Gears

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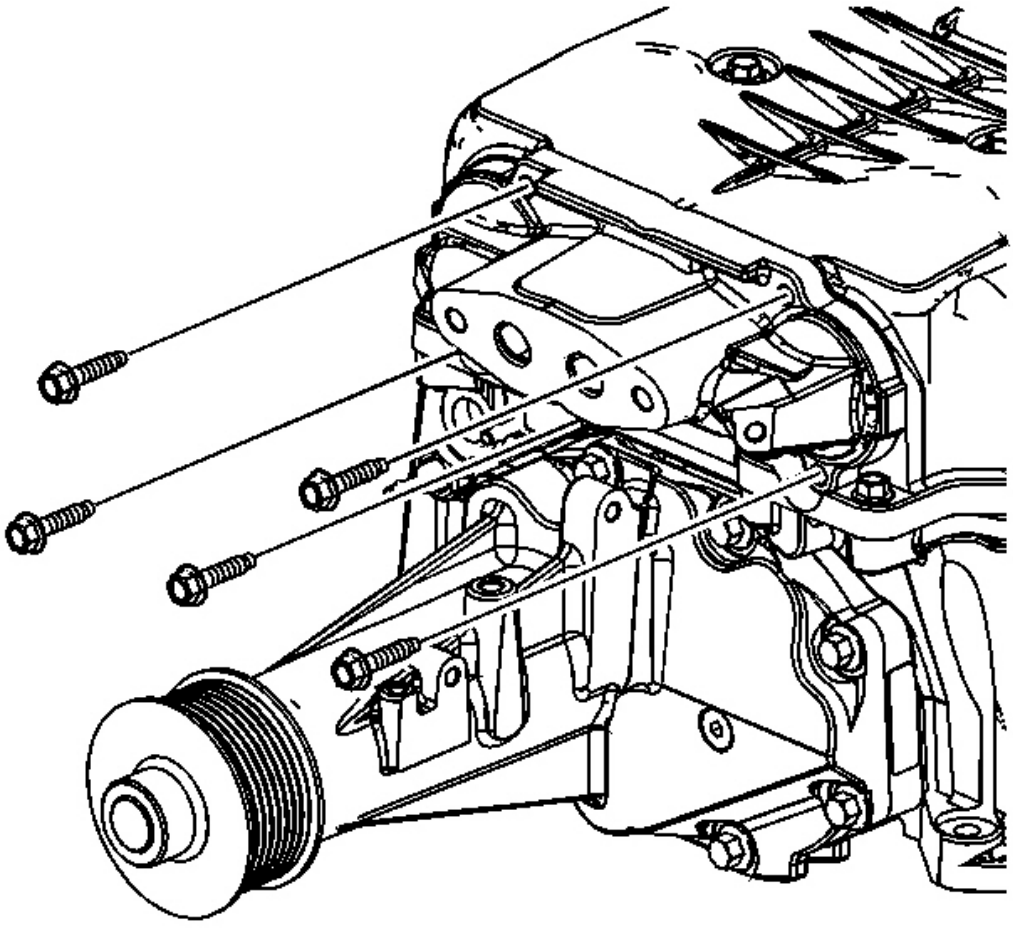


Fig. 52: Identifying Charge Air Cooler Front Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

32. Remove the charge air cooler front manifold bolts.

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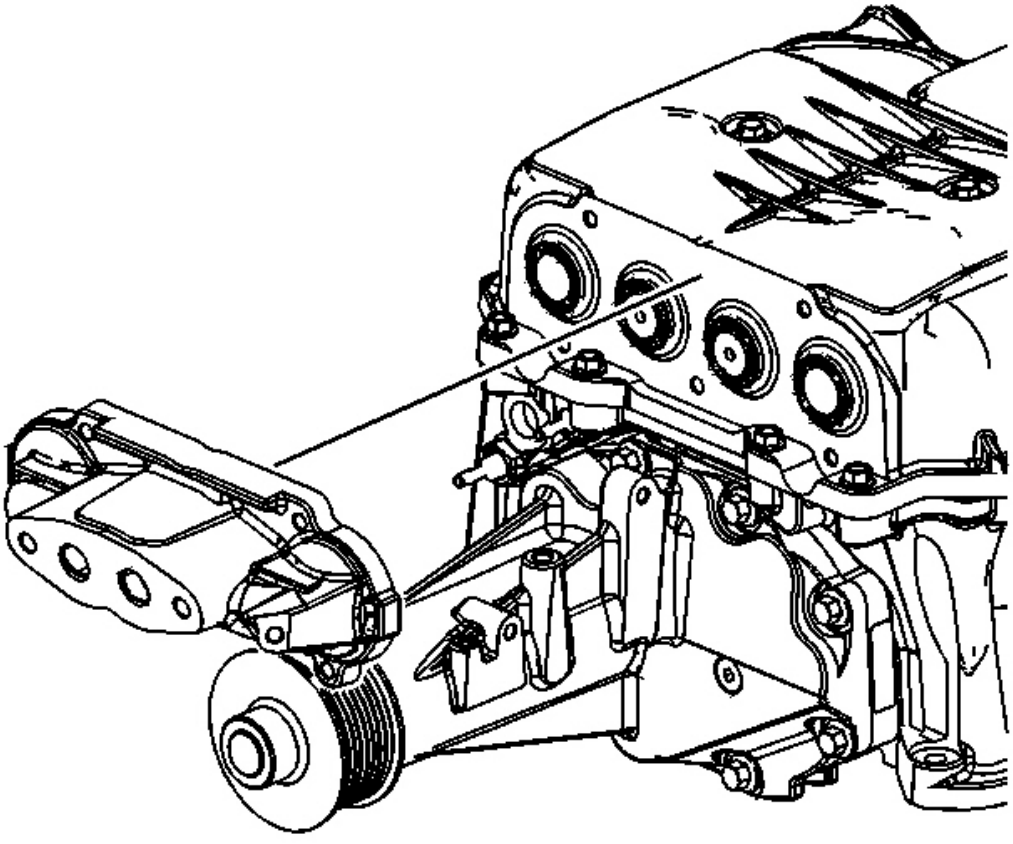


Fig. 53: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

33. Remove the charge air cooler front manifold.

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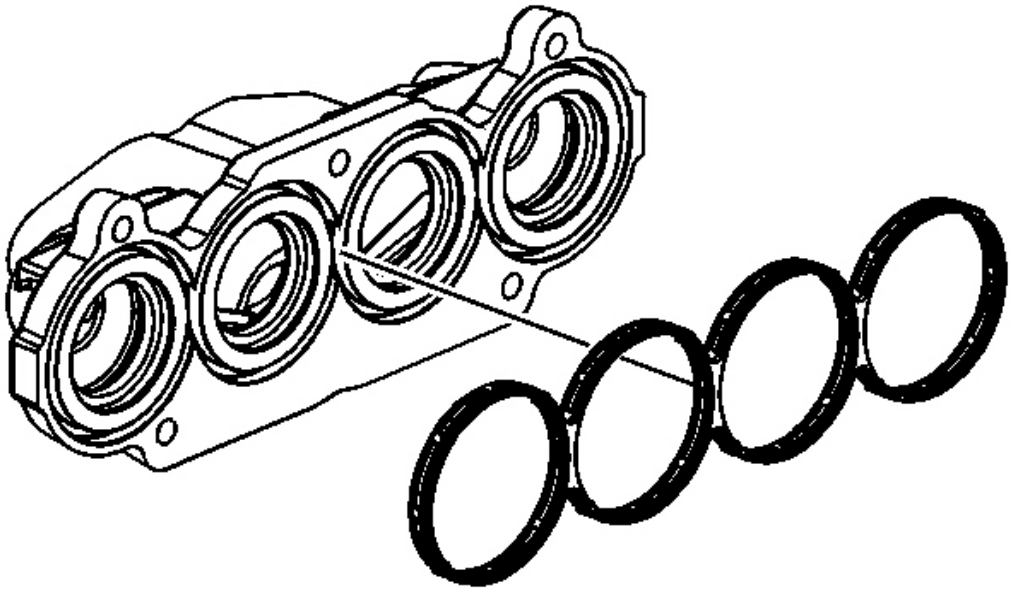


Fig. 54: View Of Charge Air Cooler Front Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

34. Remove and discard the charge air cooler front manifold gasket.

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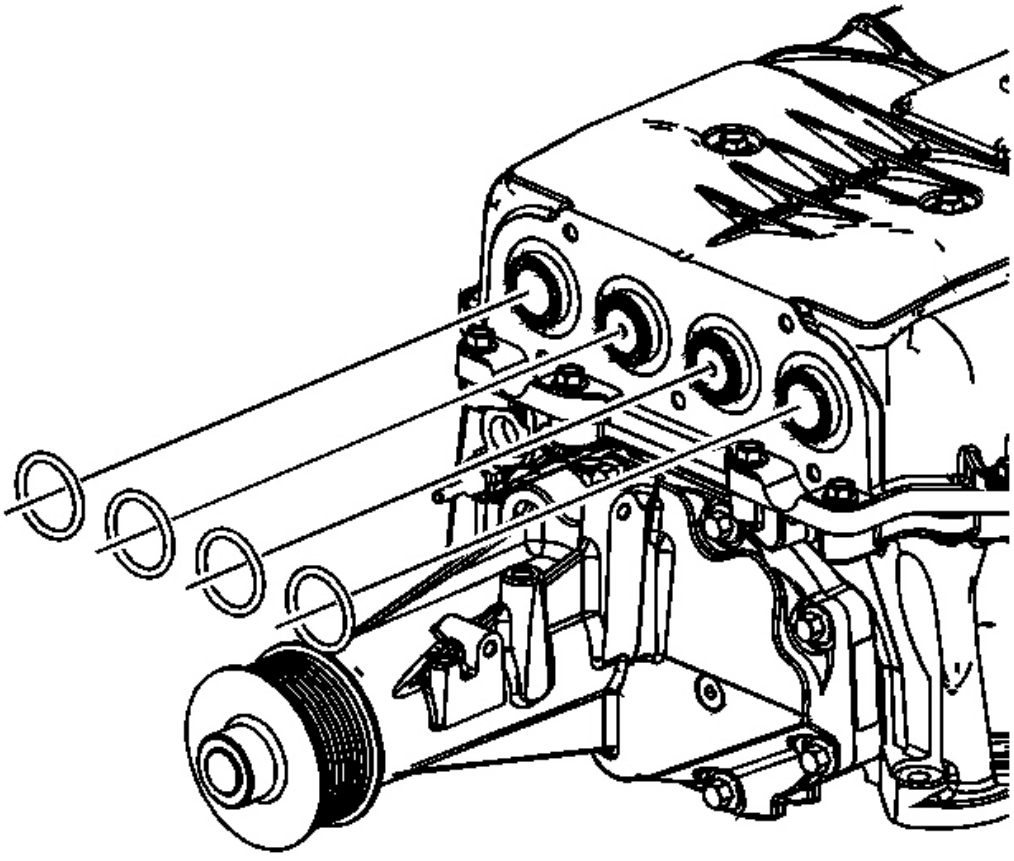


Fig. 55: View Of Charge Air Cooler Cooling Tube Front O-Rings
Courtesy of GENERAL MOTORS CORP.

35. Remove and discard the charge air cooler cooling tube front O-rings.

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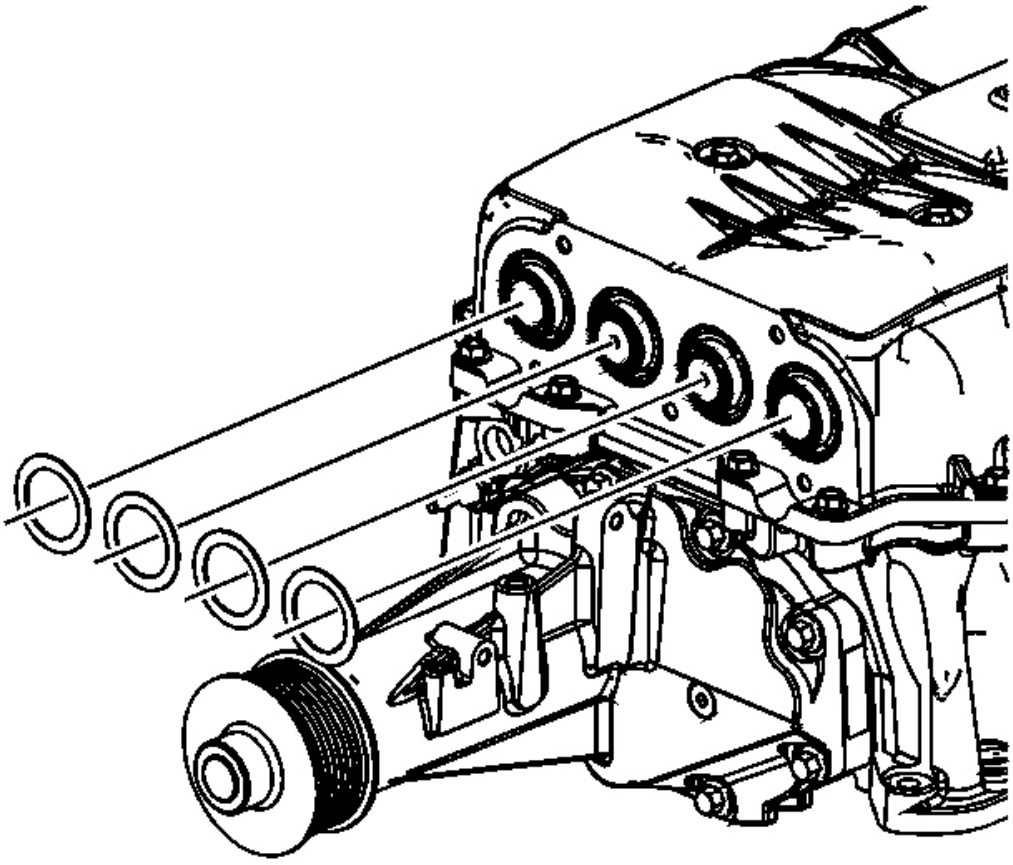


Fig. 56: View Of Charge Air Cooler Cooling Tube Front Spacers
Courtesy of GENERAL MOTORS CORP.

36. Remove the charge air cooler cooling tube front spacers.

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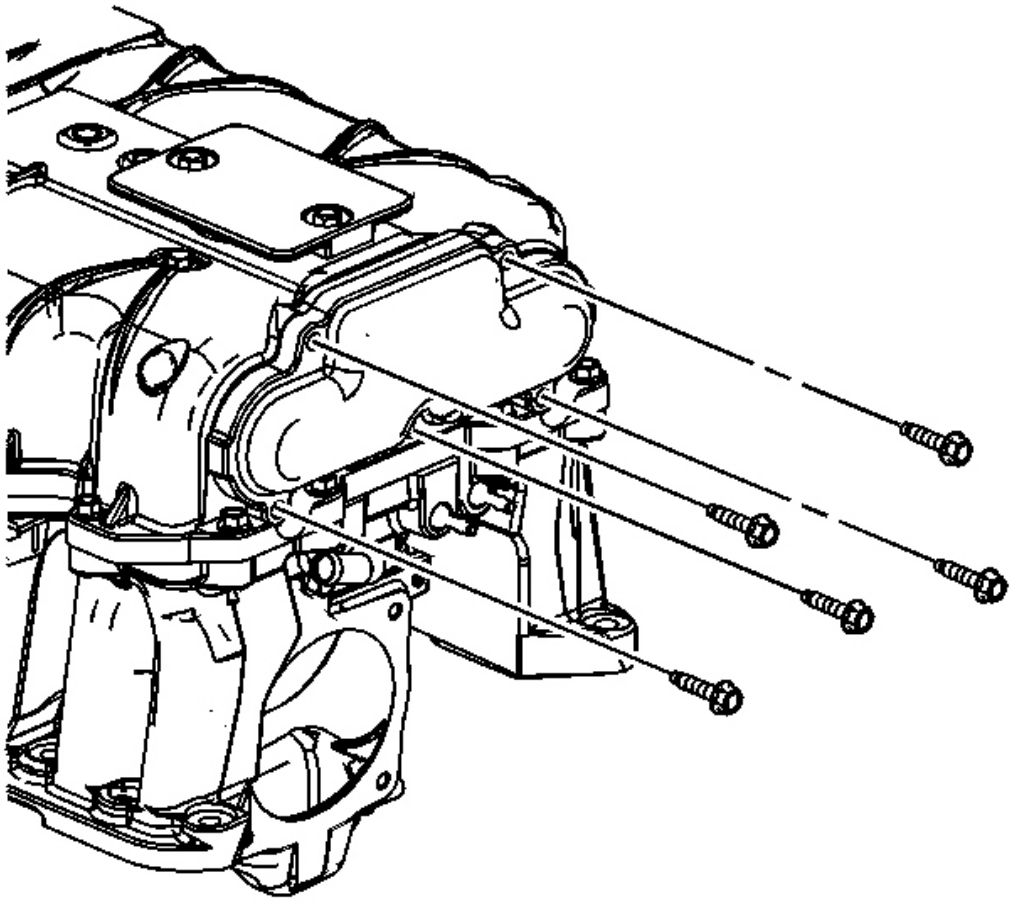


Fig. 57: Identifying Charge Air Cooler Rear Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

37. Remove the charge air cooler rear manifold bolts.

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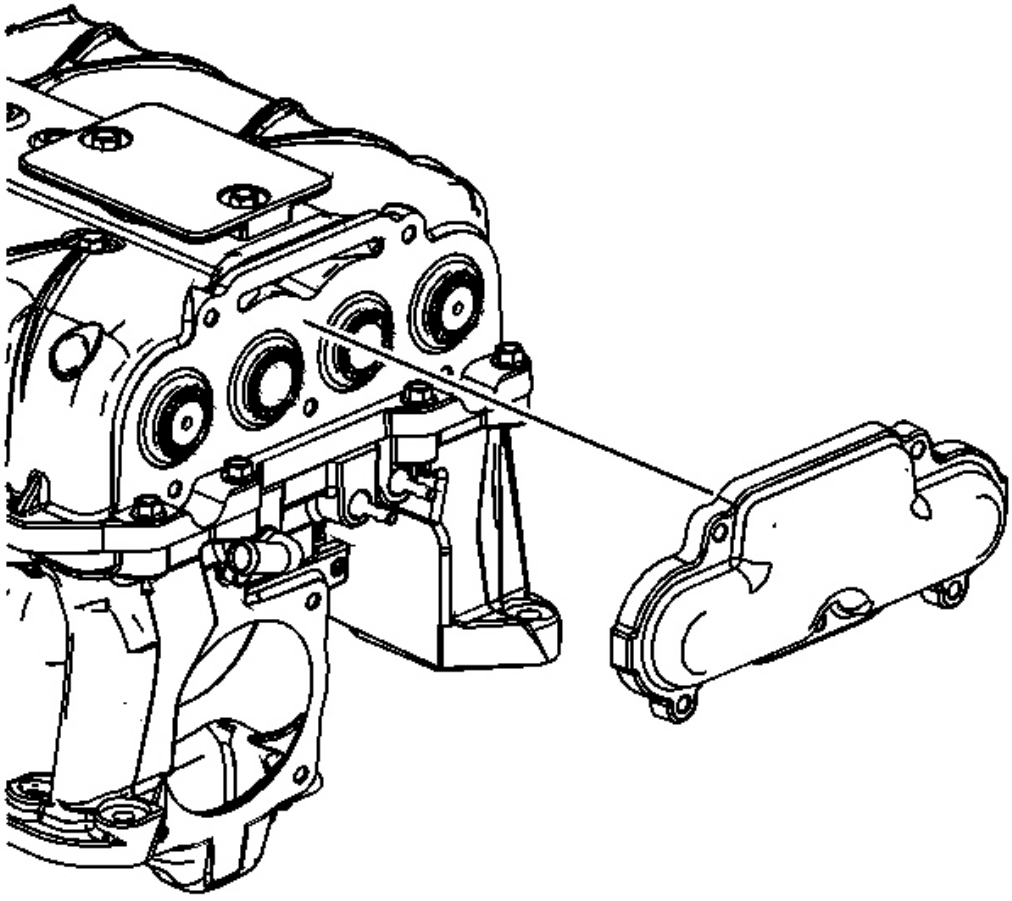


Fig. 58: Identifying Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

38. Remove the charge air cooler rear manifold.

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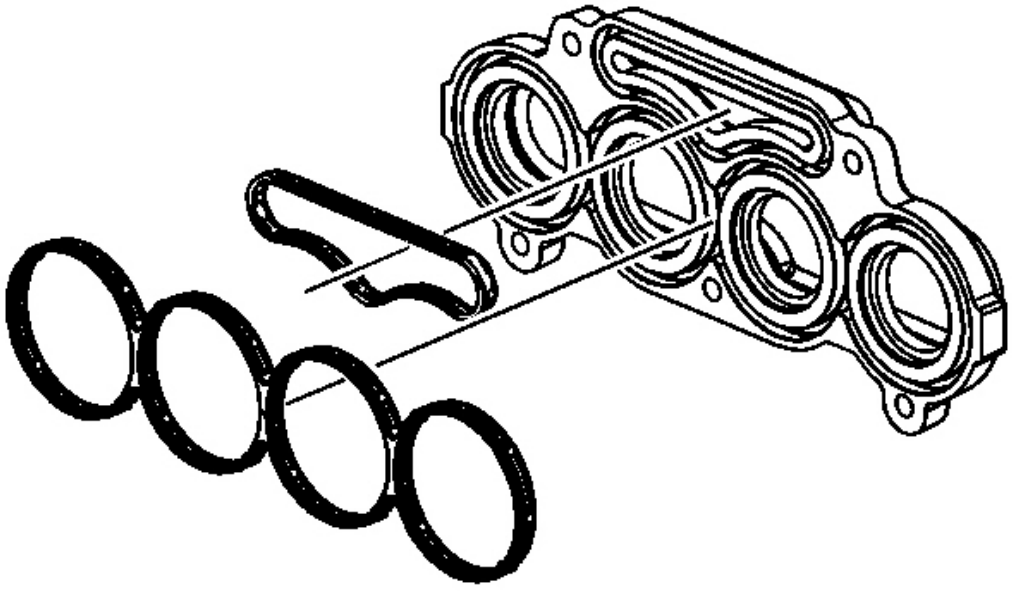


Fig. 59: View Of Charge Air Cooler Rear Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

39. Remove and discard the charge air cooler rear manifold gaskets.

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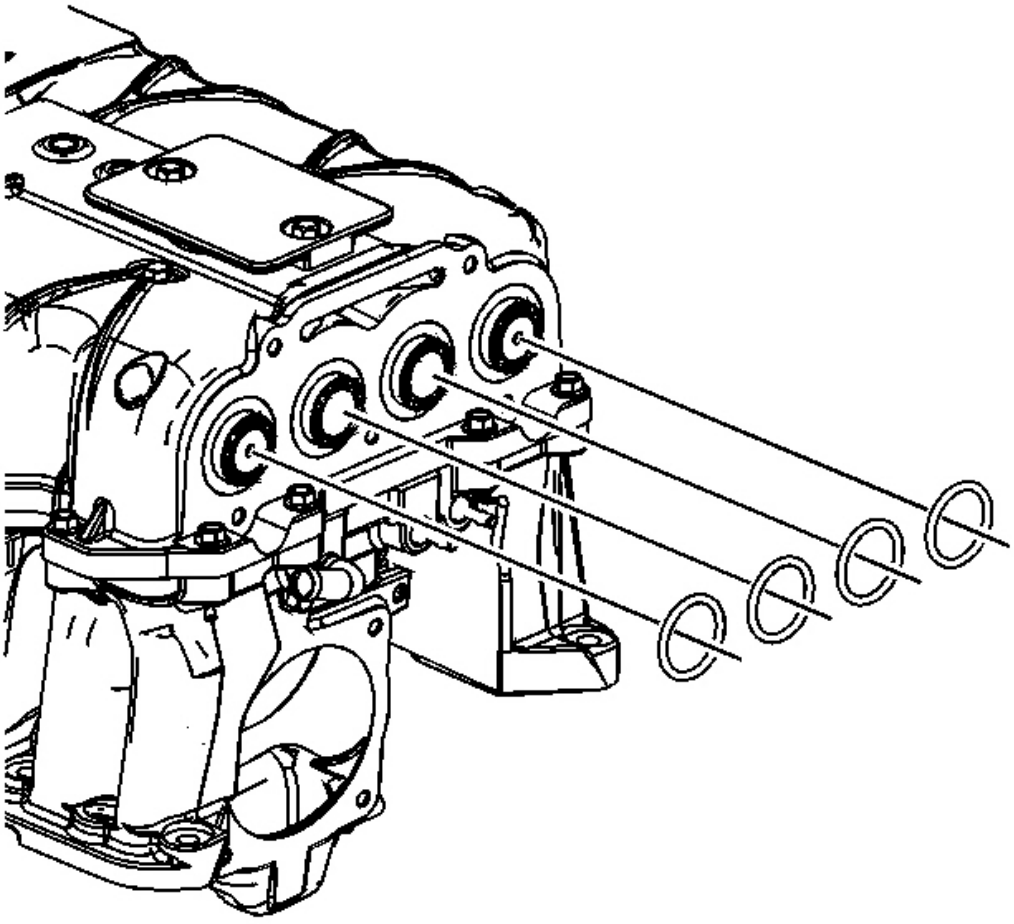


Fig. 60: View Of Charge Air Cooler Cooling Tube Rear O-Rings
Courtesy of GENERAL MOTORS CORP.

40. Remove and discard the charge air cooler cooling tube rear O-rings.

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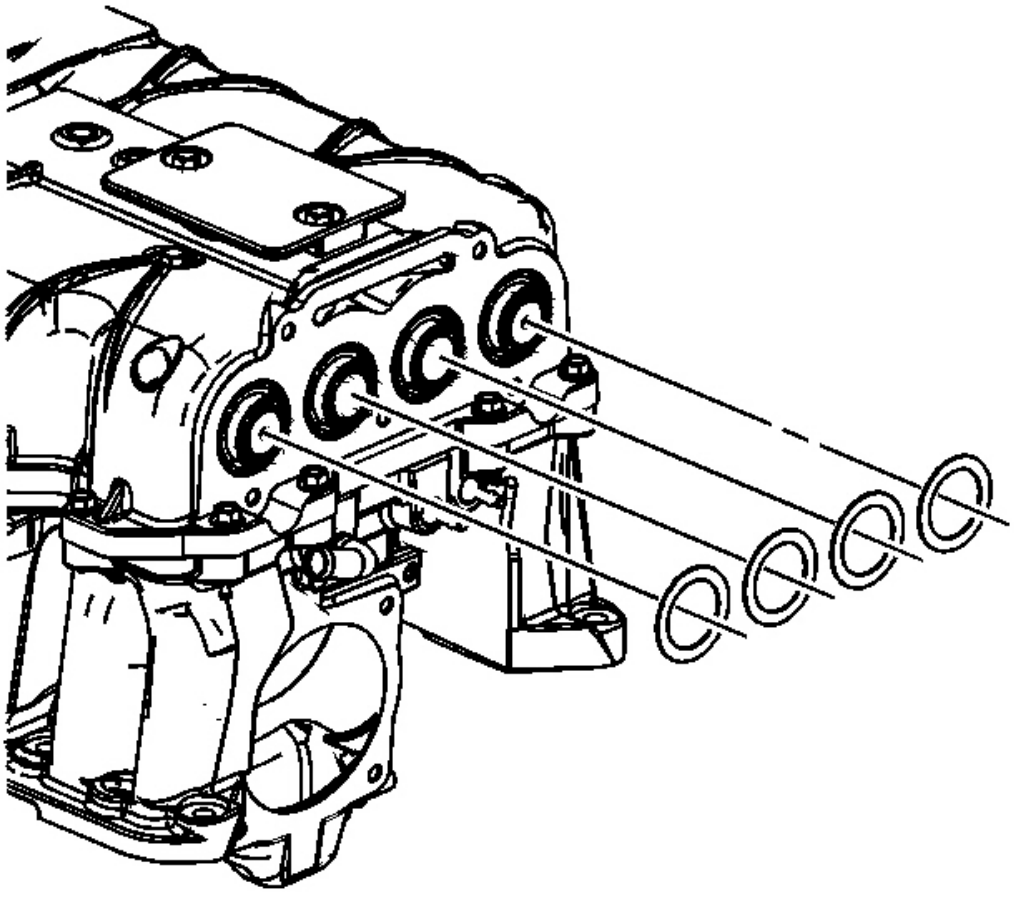


Fig. 61: View Of Charge Air Cooler Cooling Tube Rear Spacers
Courtesy of GENERAL MOTORS CORP.

41. Remove the charge air cooler cooling tube rear spacers.

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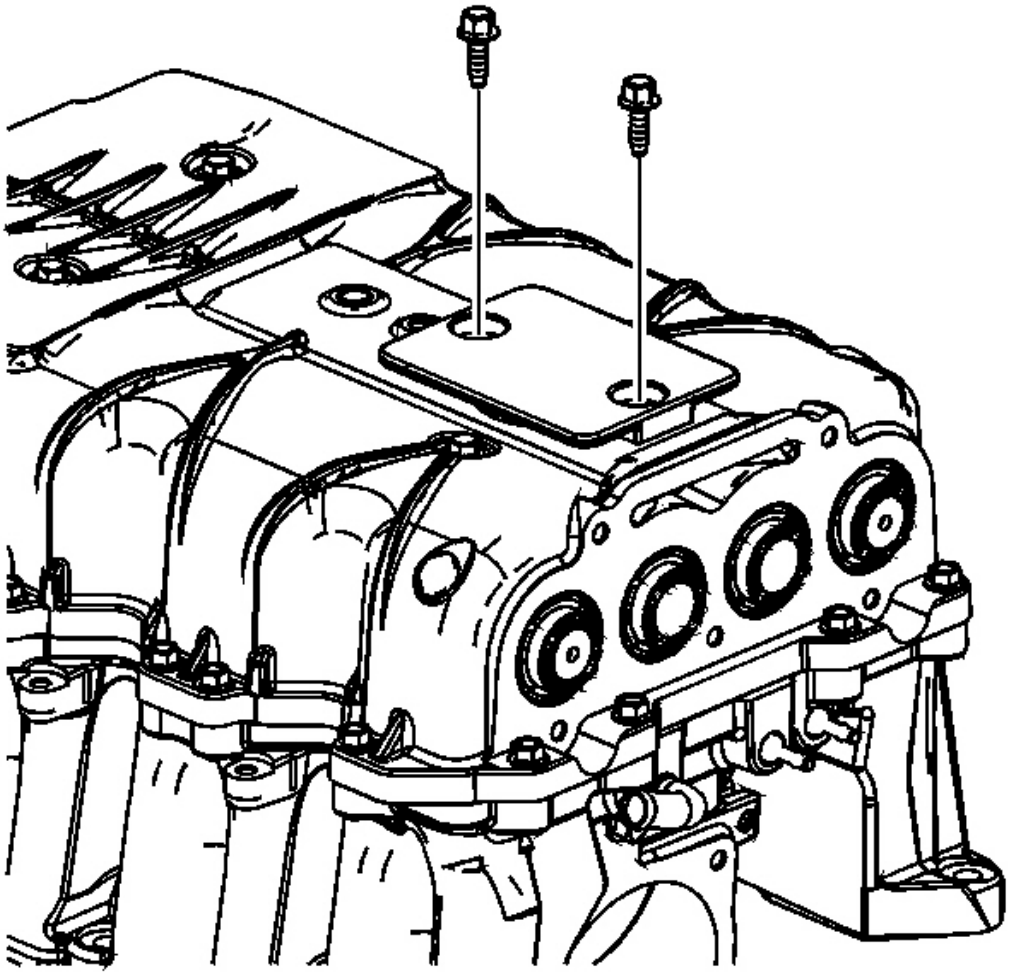


Fig. 62: View Of Charge Air Cooler Cooling Fill Cap Bolts
Courtesy of GENERAL MOTORS CORP.

42. Remove the charge air cooler cooling fill cap bolts.

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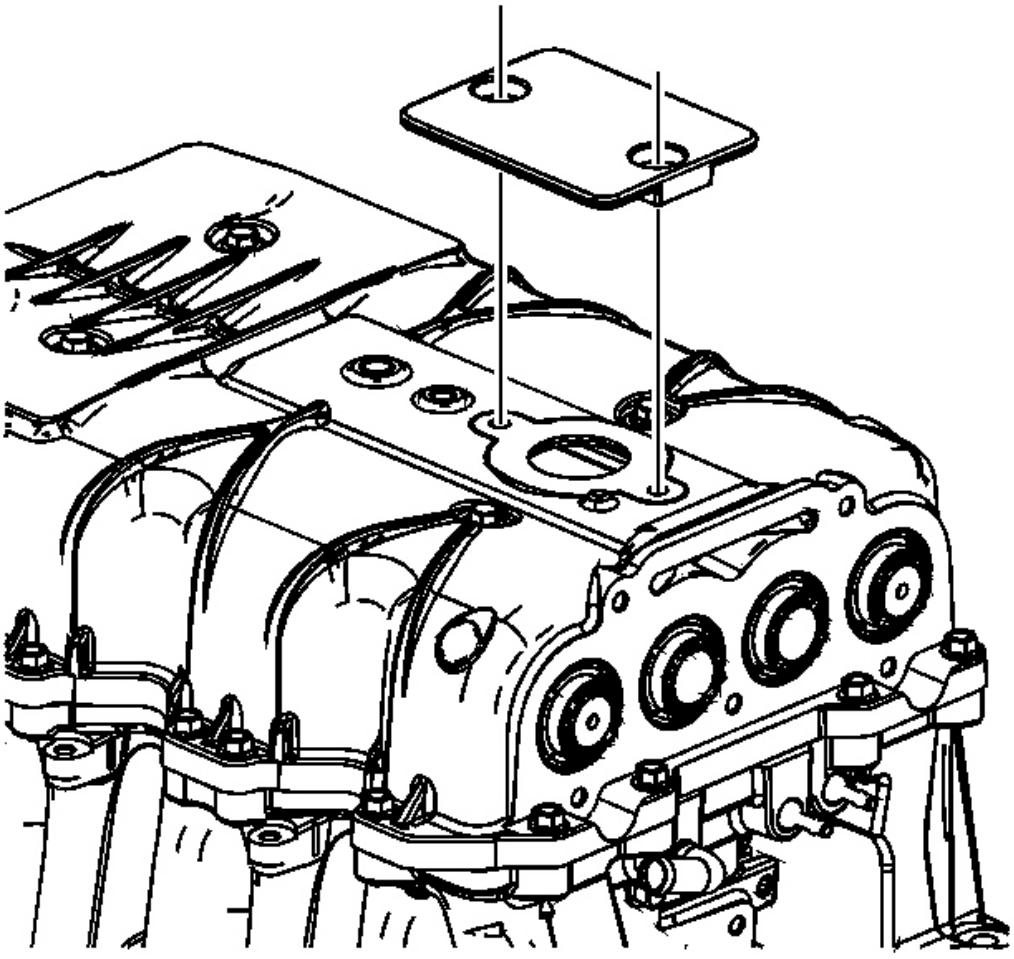


Fig. 63: View Of Charge Air Cooler Cooling Fill Cap
Courtesy of GENERAL MOTORS CORP.

43. Remove the charge air cooler cooling fill cap.

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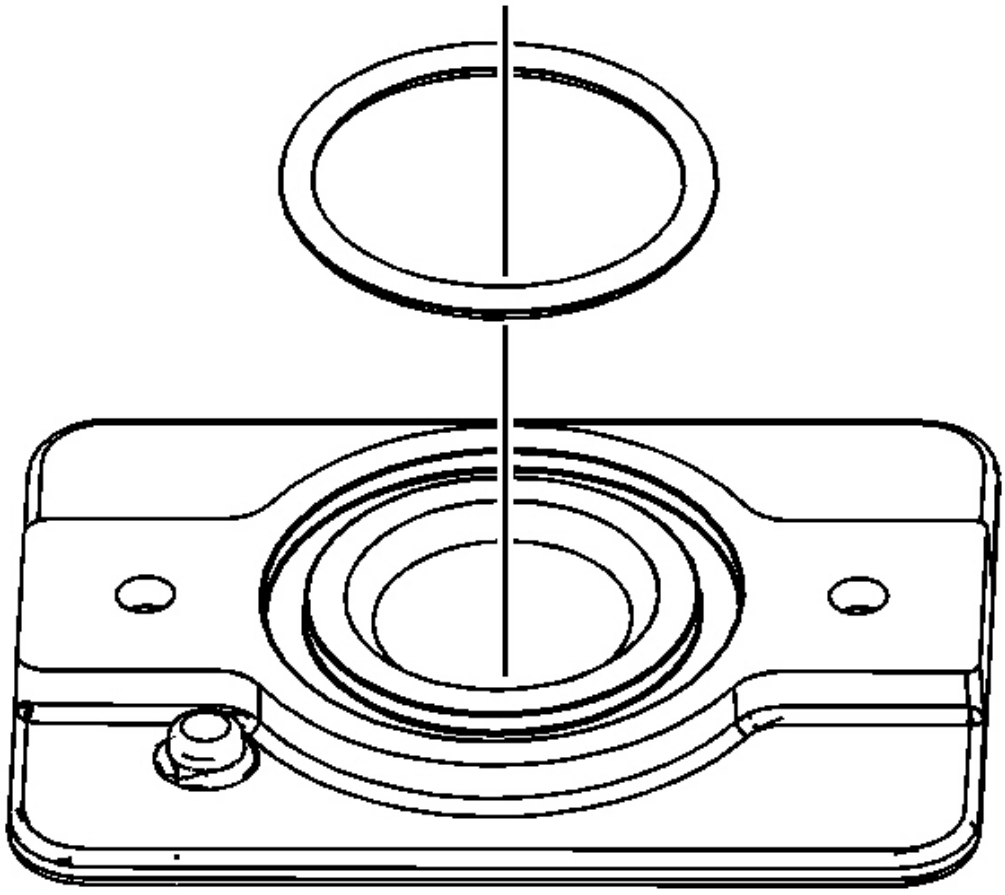


Fig. 64: View Of Charge Air Cooler Cooling Fill Cap O-Ring
Courtesy of GENERAL MOTORS CORP.

44. Remove and discard the charge air cooler cooling fill cap O-ring.

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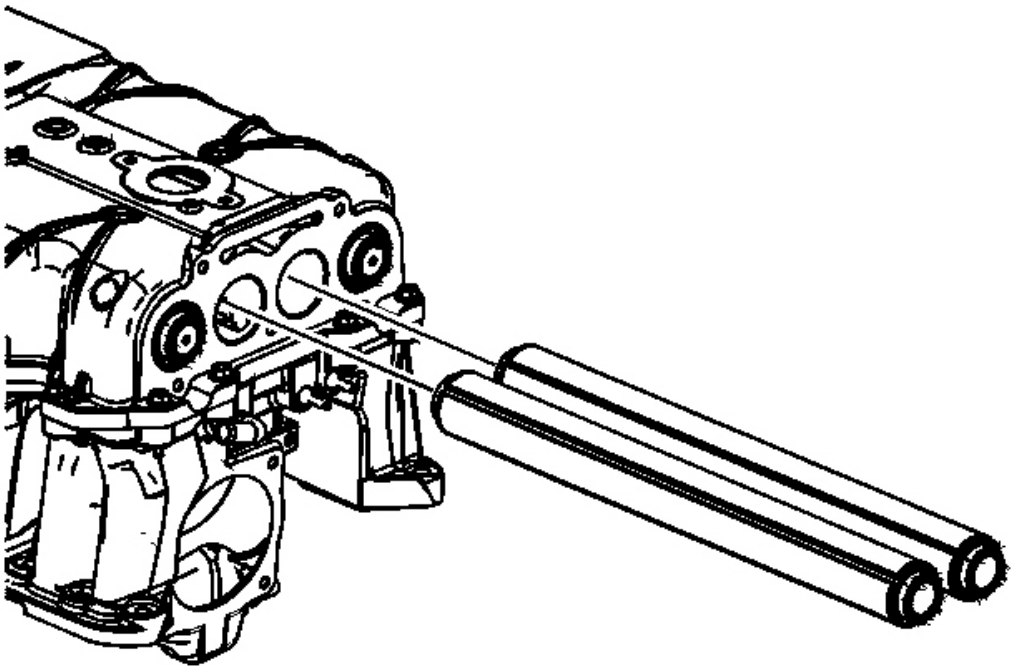


Fig. 65: View Of Inboard Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

45. Carefully remove the inboard charge air cooler cooling tubes.
46. The charge air cooler cooling tubes are fragile and must be placed in a protected area.

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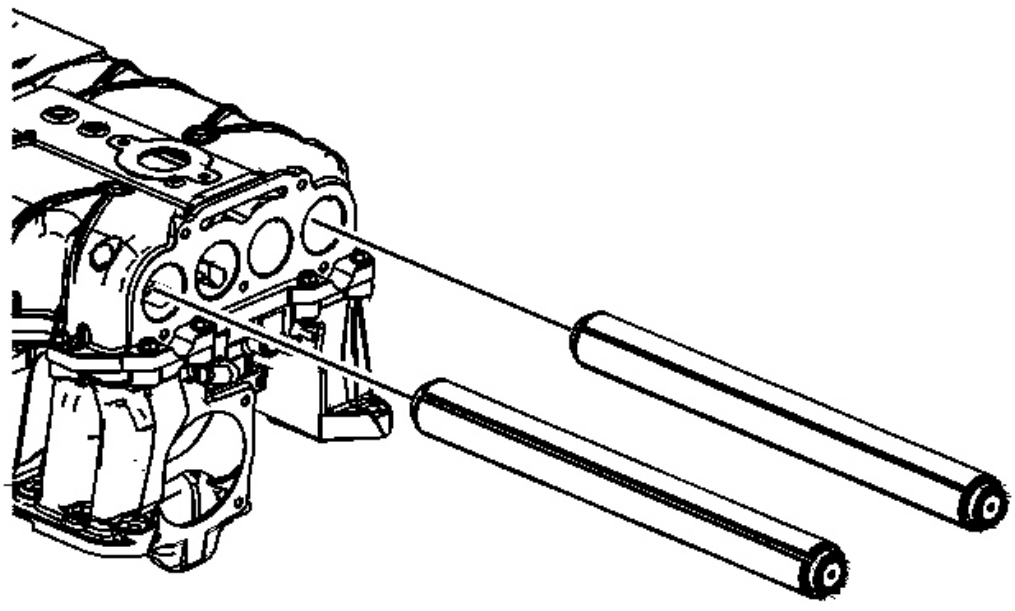


Fig. 66: View Of Outboard Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

47. Carefully remove the outboard charge air cooler cooling tubes.
48. The charge air cooler cooling tubes are fragile and must be placed in a protected area.

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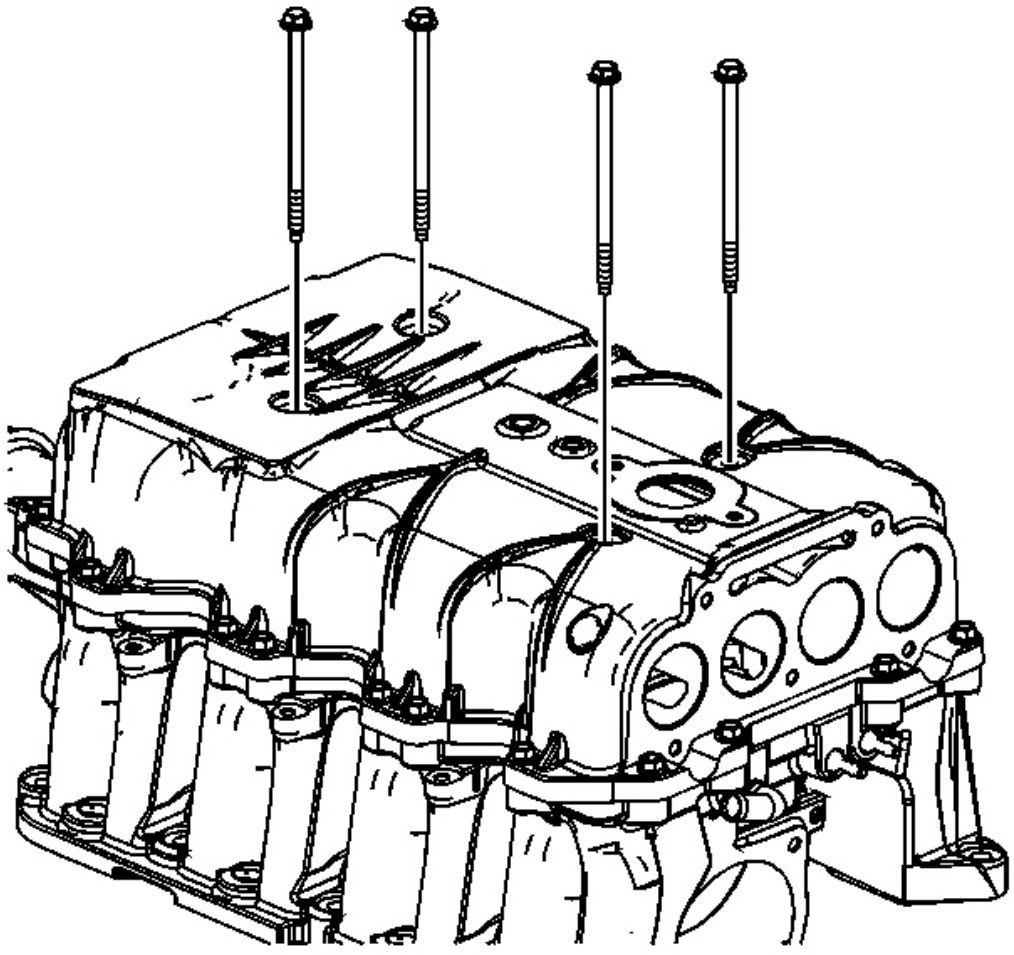


Fig. 67: Identifying Long Charge Air Cooler Bolts
Courtesy of GENERAL MOTORS CORP.

49. Remove the long charge air cooler bolts.

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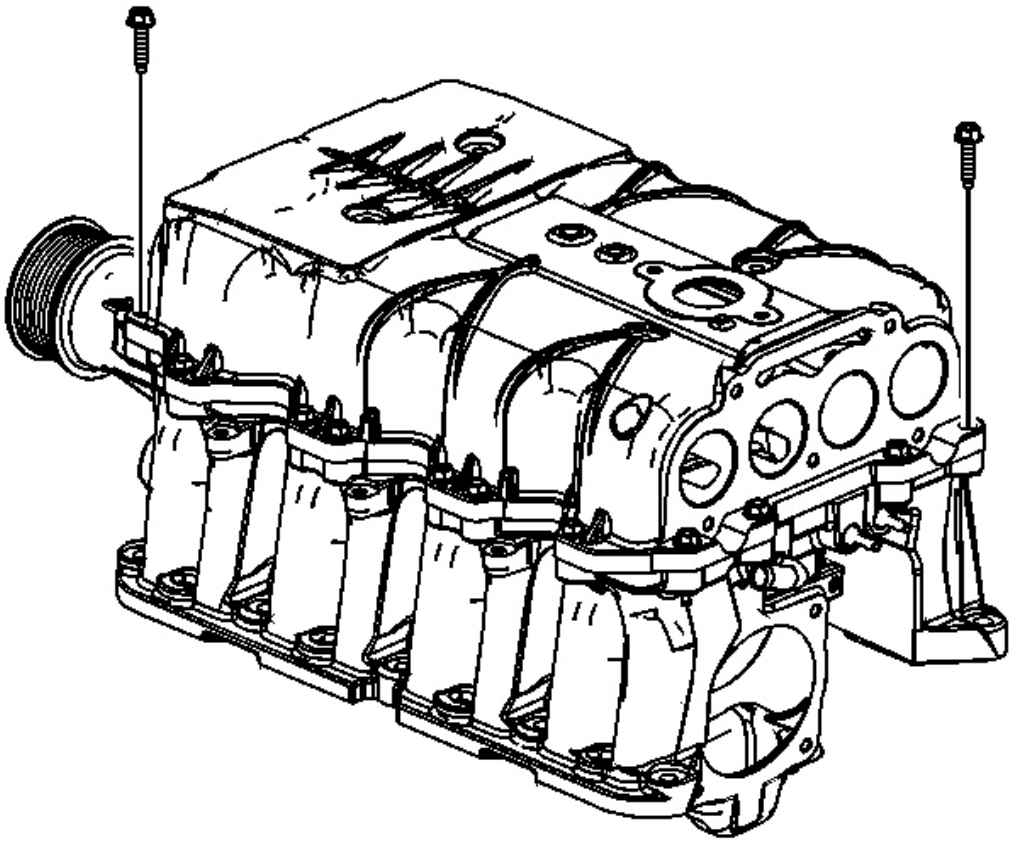


Fig. 68: View Of Short Charge Air Cooler Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

50. Remove the short charge air cooler perimeter bolts.

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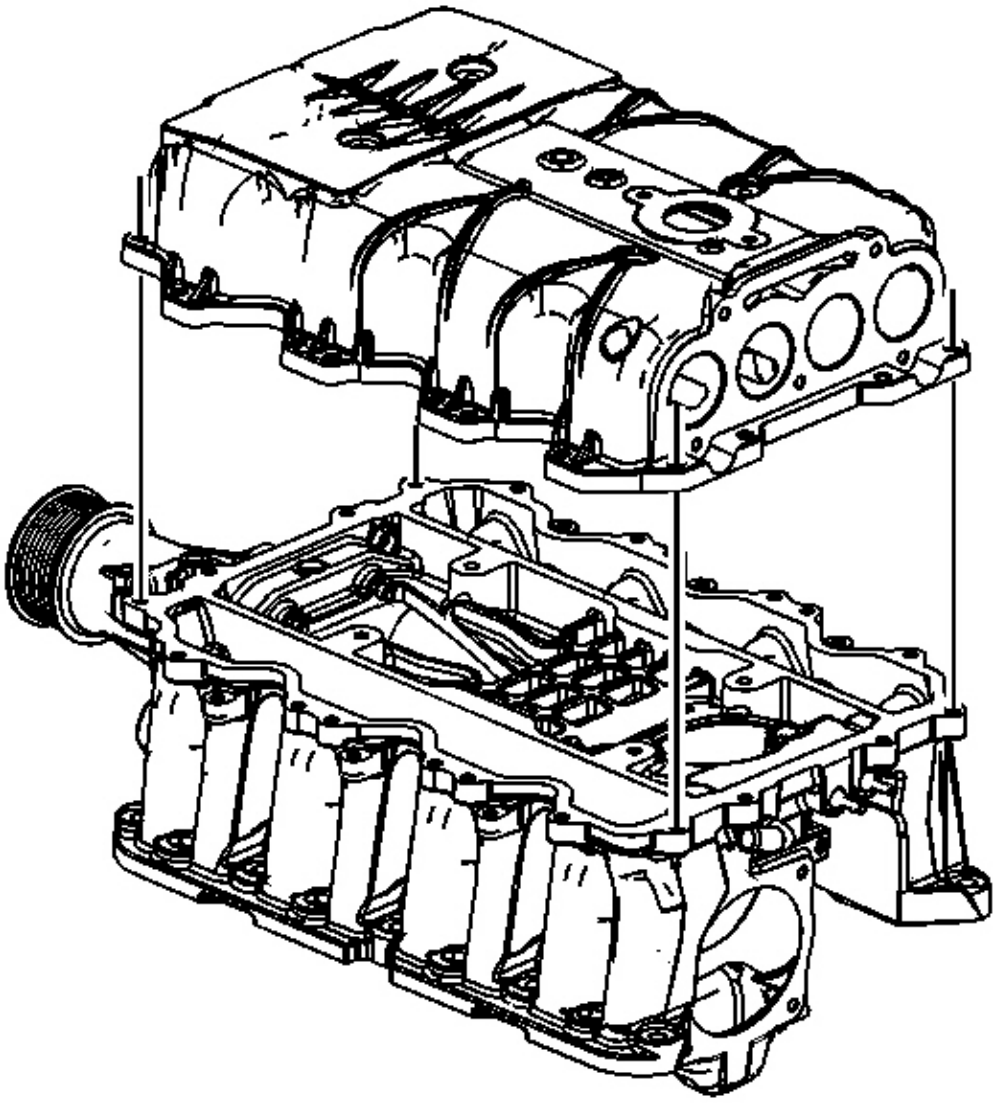


Fig. 69: View Of Charge Air Cooler Housing
Courtesy of GENERAL MOTORS CORP.

51. Remove the charge air cooler housing.

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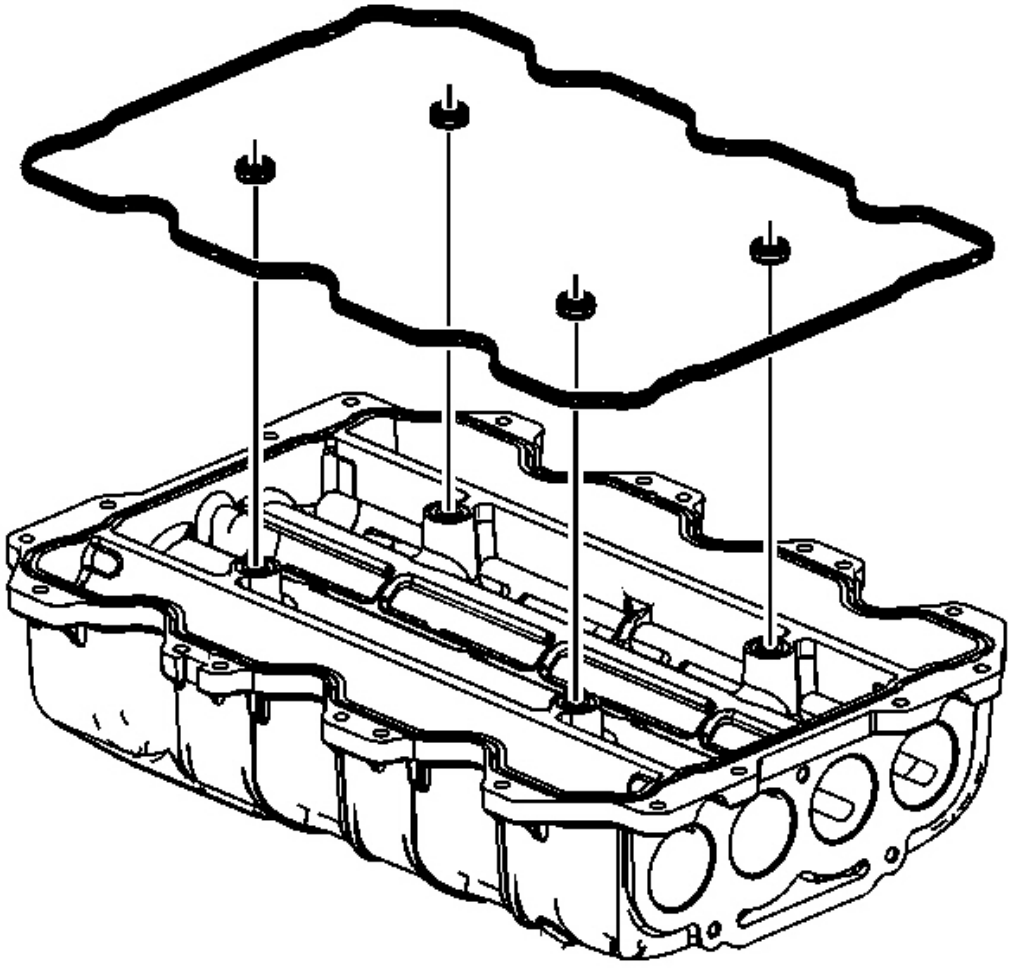


Fig. 70: View Of Charge Air Cooler Housing Perimeter Gasket
Courtesy of GENERAL MOTORS CORP.

52. Remove and discard the charge air cooler housing perimeter gasket.
53. Remove and discard the charge air cooler housing interior O-ring gaskets.

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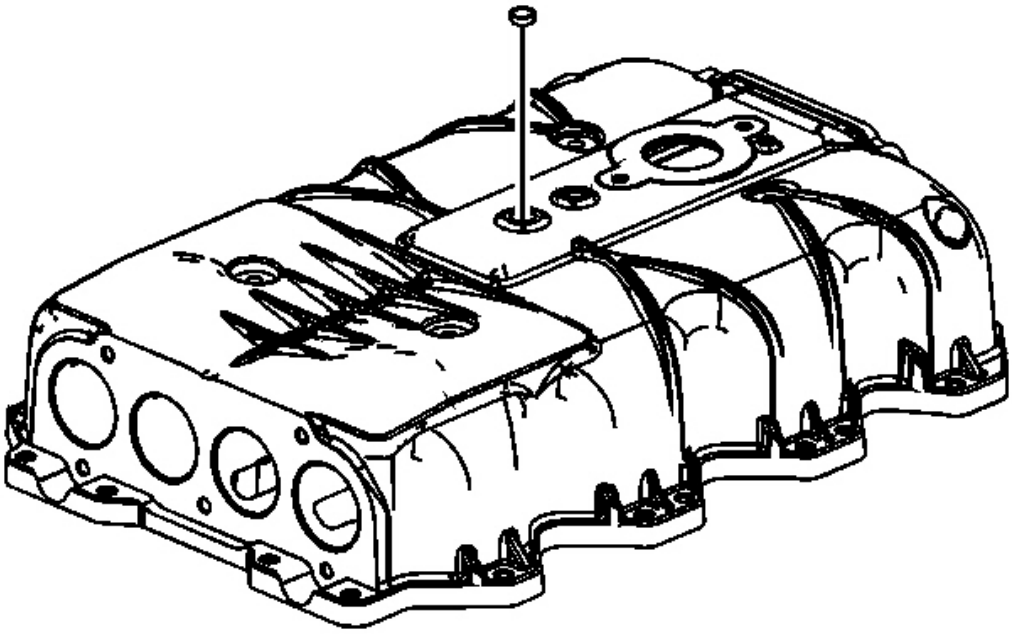


Fig. 71: View Of Charge Air Cooler Housing Expansion Plug
Courtesy of GENERAL MOTORS CORP.

54. Remove and discard the charge air cooler housing expansion plug.

CLEANING PROCEDURE

IMPORTANT: Do NOT allow any debris to enter the supercharger.

1. Remove any old thread sealant and gasket material or sealant.
2. Do NOT soak the supercharger, bypass valve actuator, charge air bypass regulator solenoid valve, EVAP solenoid, bypass cable or throttle body in solvent.
3. Carefully clean the outside of the supercharger. Do NOT allow any debris or solvent to enter the inside of the supercharger. Replace the supercharger if there is any damage to the rotors.
4. Carefully clean the outside charge air cooler cooling tube. Do NOT allow any debris to enter the inside of the tubes. Replace the tube if there are any damaged, missing or bent fins. Replace the tube if the coolant passages are blocked by debris.
5. Clean the charge air cooler housing with solvent compatible with aluminum and the painted exterior. Clean all threaded and through holes with solvent.
6. Clean the PCV, vacuum and pressure tubes.

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CAUTION: Refer to Safety Glasses Caution .

7. Carefully dry the components with compressed air.

INSPECTION PROCEDURE

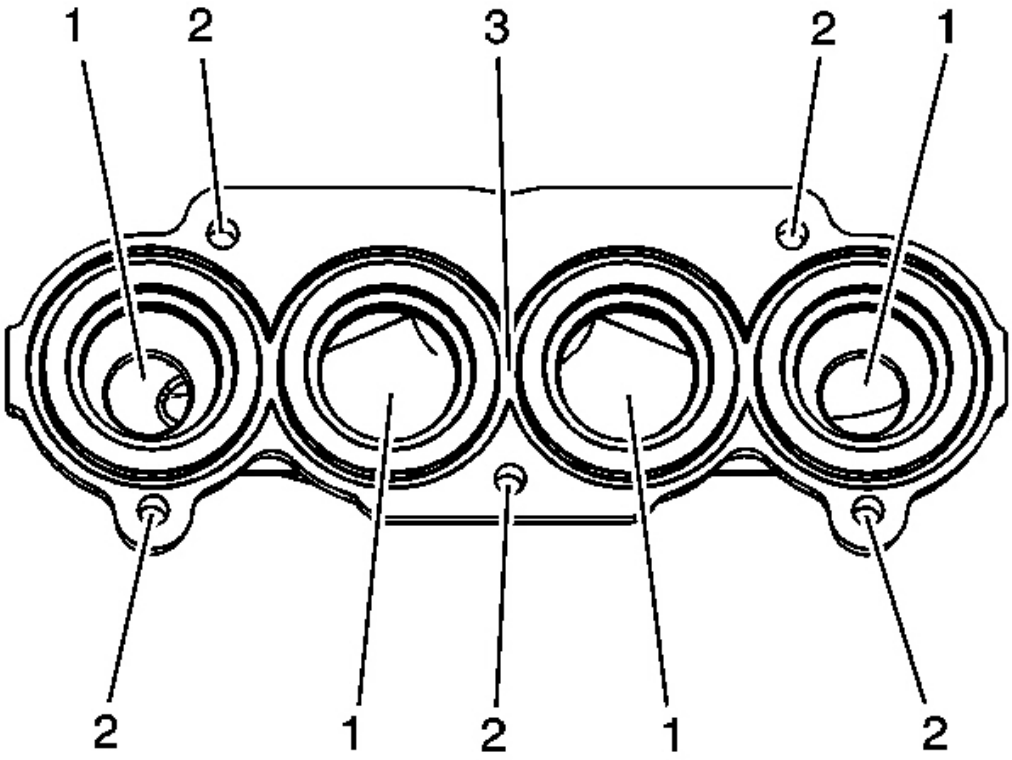


Fig. 72: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

1. Inspect the interior of the charge air cooler front manifold for the following:
   - Damage or restrictions to the coolant passages (1)
   - Damage to the bolt bosses (2)
   - Damage or corrosion to the gasket groove (3)

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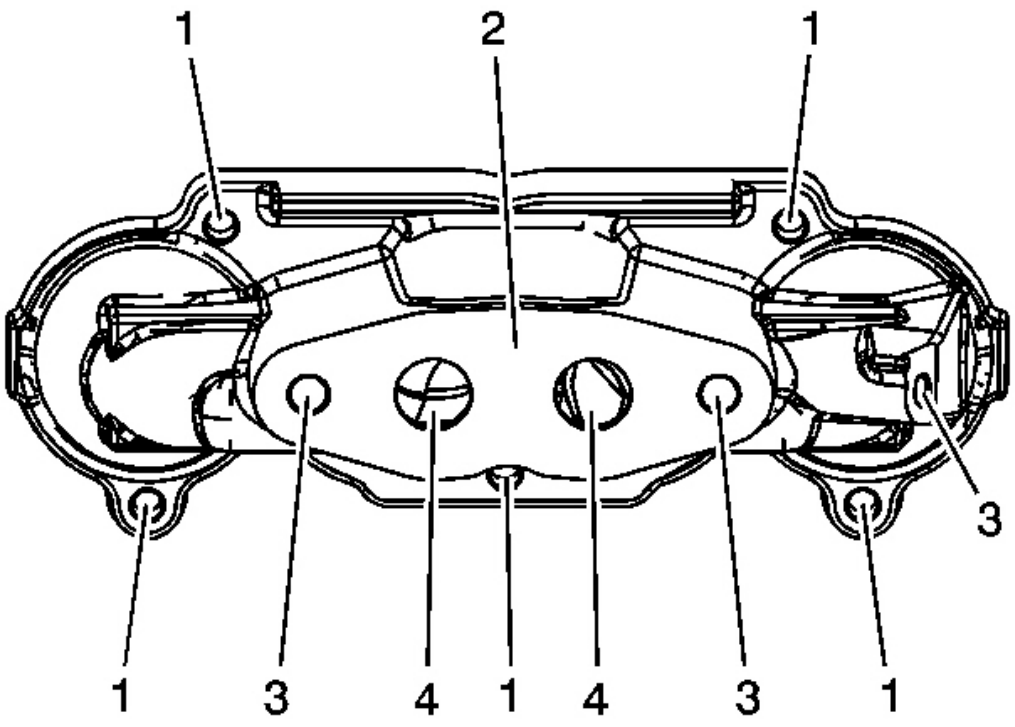


Fig. 73: View Of Exterior Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

2. Inspect the exterior of the charge air cooler front manifold for the following:
   - Damage to the bolt bosses (1)
   - Damage or corrosion to the gasket sealing surface (2)
   - Damage to the threaded holes (3)
   - Damage or restrictions to the coolant passages (4)
3. Repair or replace the charge air cooler front manifold as necessary.

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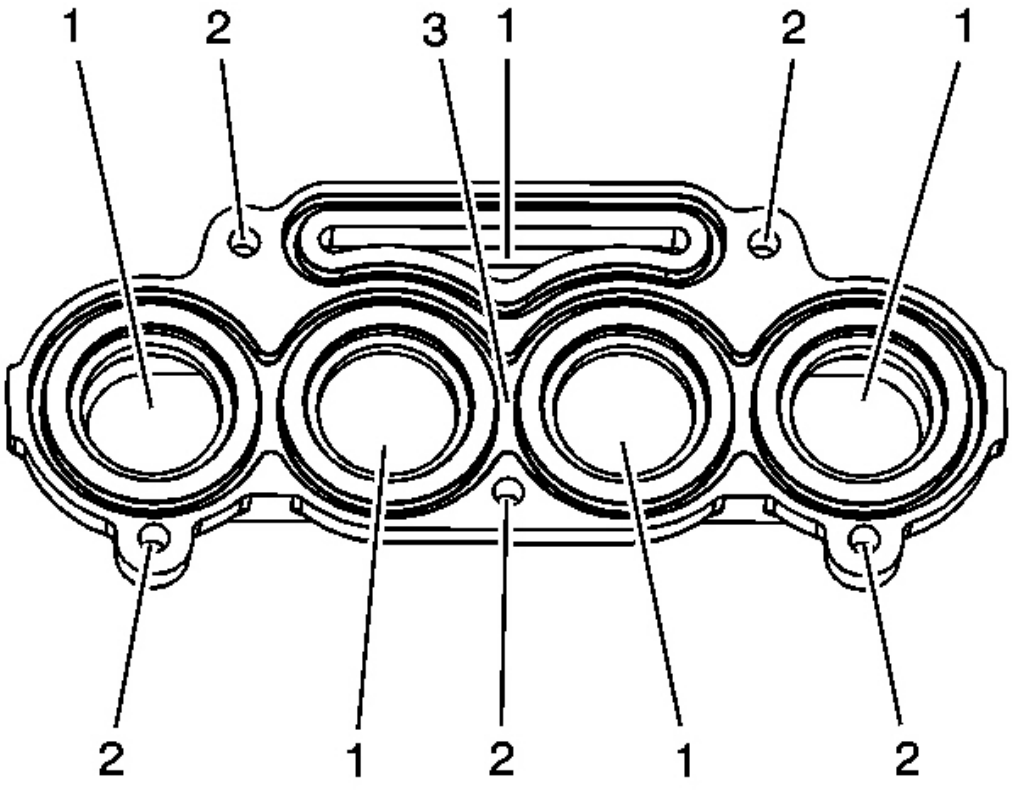


Fig. 74: View Of Interior Of Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

4. Inspect the interior of the charge air cooler rear manifold for the following:
   - Damage or restrictions to the coolant passages (1)
   - Damage to the bolt bosses (2)
   - Damage or corrosion to the gasket groove (3)

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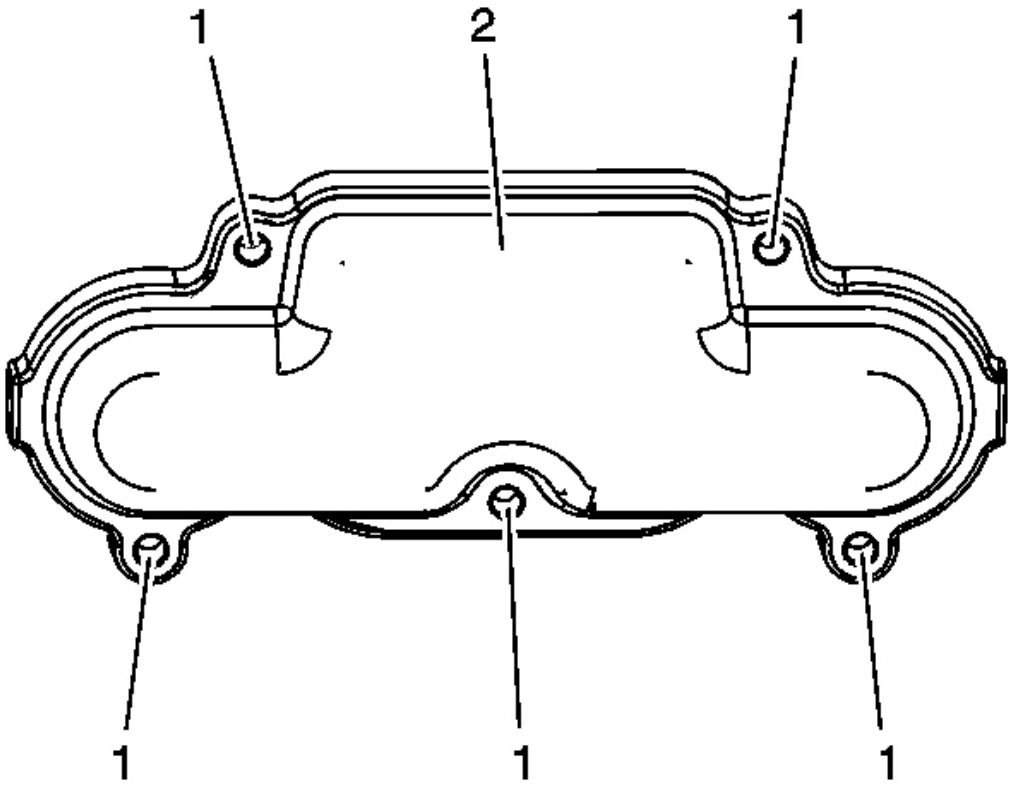


Fig. 75: View Of Exterior Of Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

5. Inspect the exterior of the charge air cooler rear manifold for the following:
   - Damage to the bolt bosses (1)
   - Damage or corrosion to the charge air cooler rear manifold (2)
6. Repair or replace the charge air cooler rear manifold as necessary.

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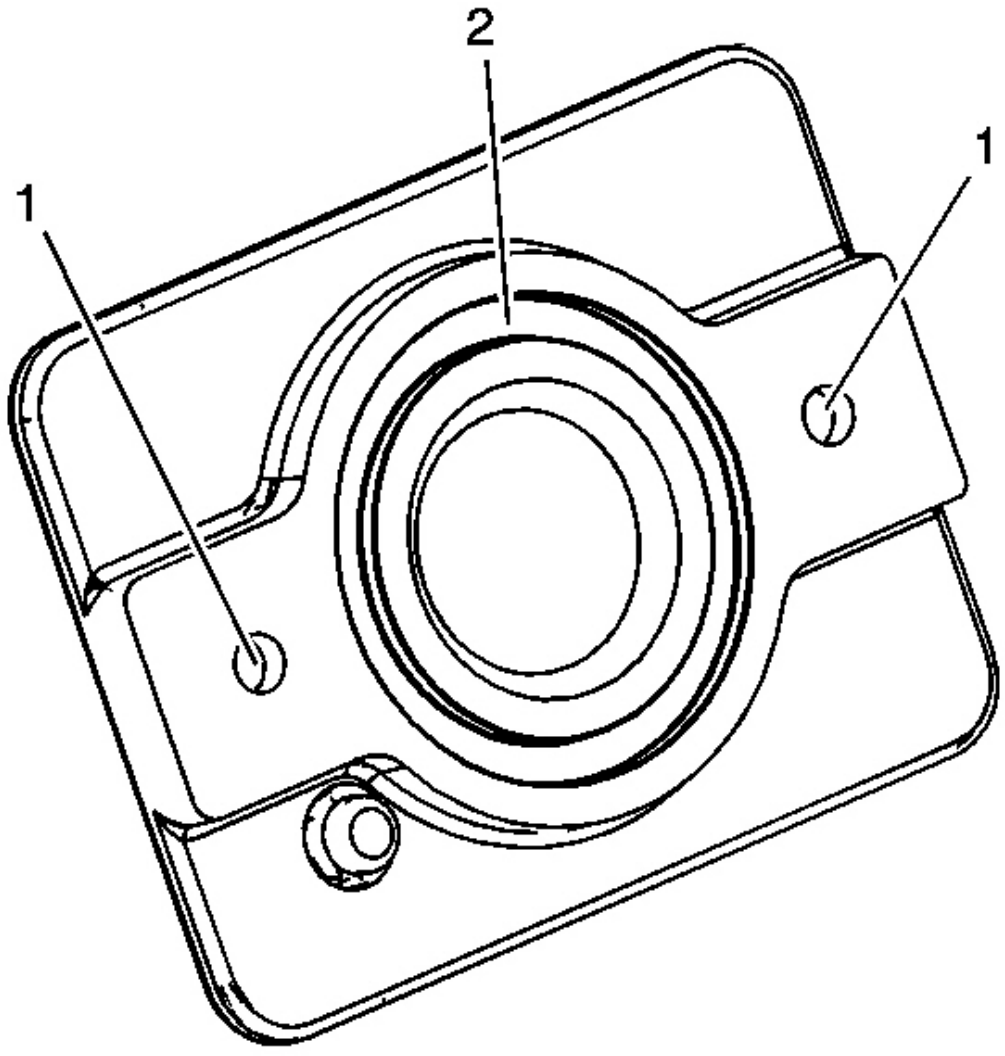


Fig. 76: View Of Charge Air Cooler Cooling Fill Cap
Courtesy of GENERAL MOTORS CORP.

7. Inspect the charge air cooler cooling fill cap for damage or corrosion (1, 2).
8. Repair or replace the charge air cooler cooling fill cap as necessary.

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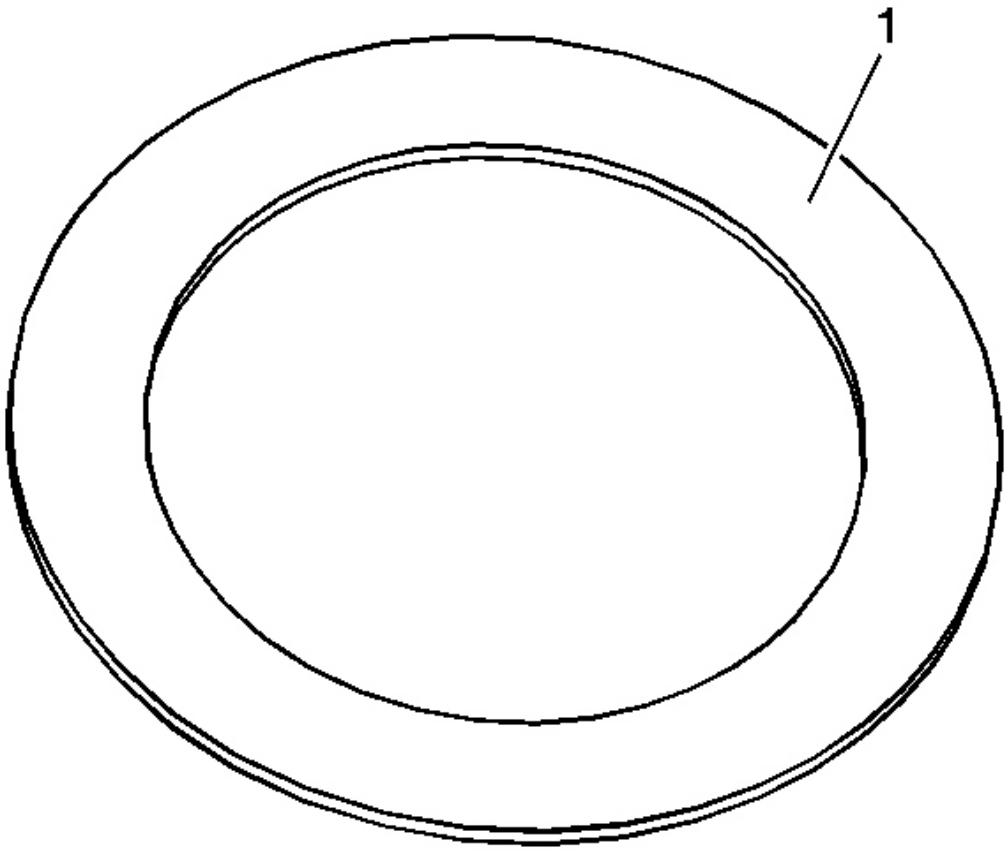


Fig. 77: View Of Charge Air Cooler Cooling Tube Spacers
Courtesy of GENERAL MOTORS CORP.

9. Inspect the charge air cooler cooling tube spacers for damage or corrosion (1).
10. Replace any damaged charge air cooler cooling tube spacers.

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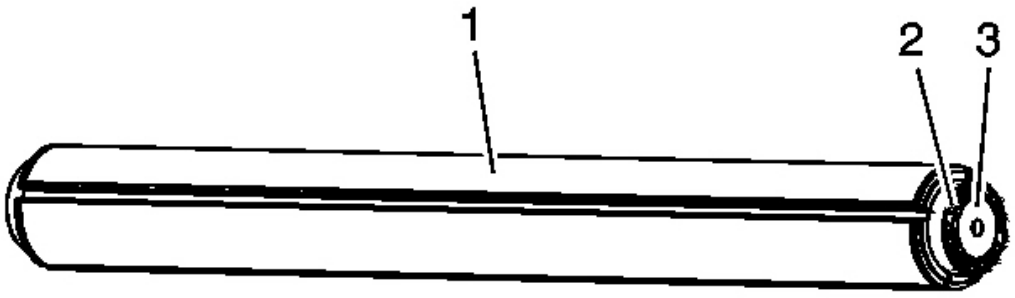


Fig. 78: View Of Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

11. Inspect the charge air cooler cooling tubes for the following:
    - Damaged, clogged, bent or missing fins (1)
    - Damage, corrosion or restrictions to the cooling passages (2)
    - Damage, corrosion, restrictions or missing diversion end plate (3)

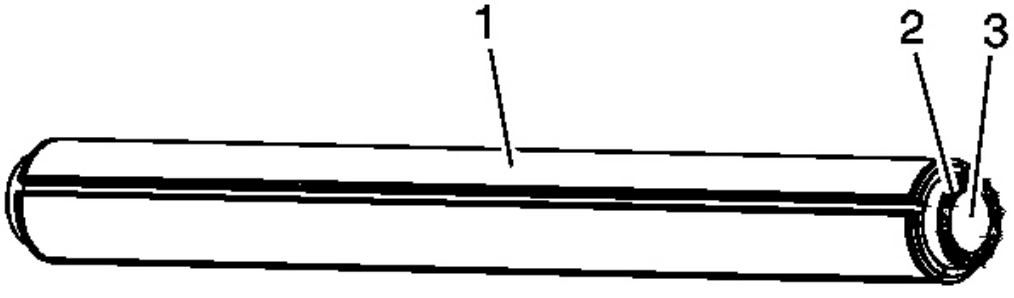


Fig. 79: Inspecting Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

12. Inspect the charge air cooler cooling tubes for the following:
    - Damaged, clogged, bent or missing fins (1)
    - Damage, corrosion or restrictions to the cooling passages (2)
    - Damage, corrosion or restrictions to the intake end (3)

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IMPORTANT: The charge air cooler cooling tubes are replaced as a set. If any one of the charge air cooler cooling tubes needs to be replaced, all the charge air cooler cooling tubes must be replaced in order to maintain consistent cooling of the charge air.

13. Replace any damaged, corroded or restricted charge air cooler cooling tube.

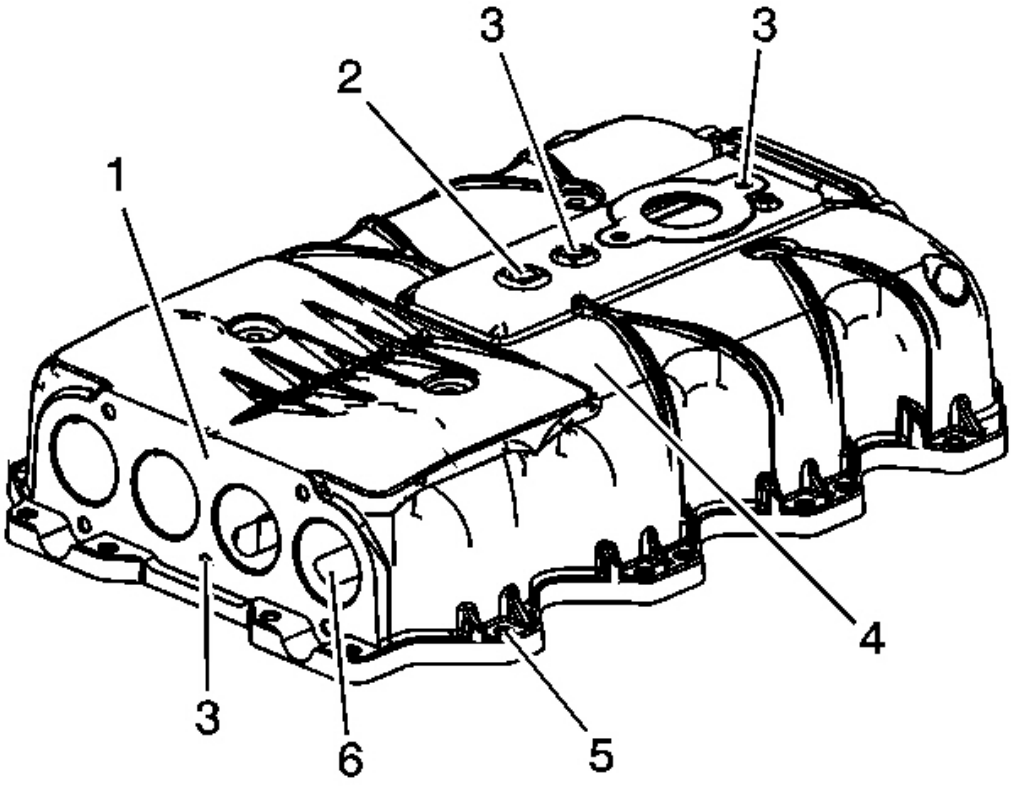


Fig. 80: View Of Charge Air Cooler Housing
Courtesy of GENERAL MOTORS CORP.

14. Inspect the charge air cooler housing for the following:
    - Damage to the sealing surface (1) for the charge air cooler front manifold
    - Damage to the bore (2) for the charge air cooler housing expansion plug
    - Damage to the threaded holes (3)
    - Damage to the exterior of the charge air cooler housing (4)
    - Damage to the bolt bosses (5)

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- Damage, corrosion, restrictions in the bores (6) for the charge air cooler cooling tubes

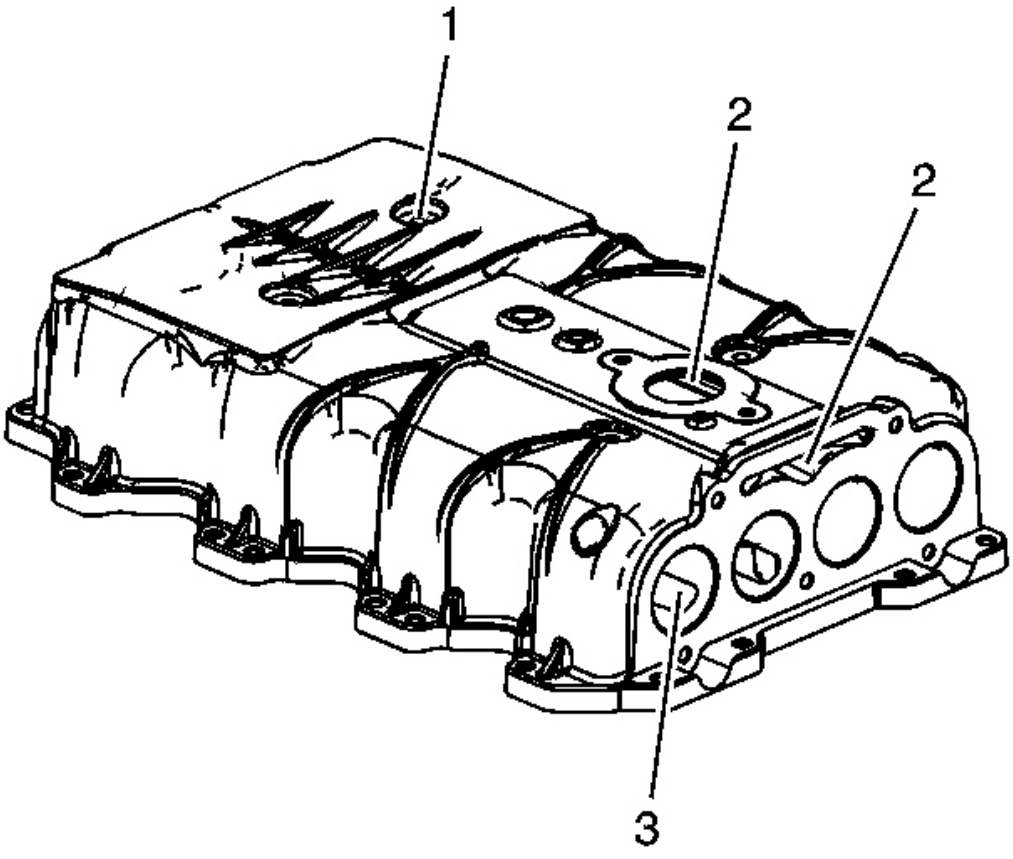


Fig. 81: View Of Charge Air Cooler Housing
Courtesy of GENERAL MOTORS CORP.

15. Inspect the charge air cooler housing for the following:
    - Damage to the bolt bosses (1)
    - Damage, corrosion, restrictions in the coolant passages (2)
    - Damage, corrosion, restrictions in the bores (3) for the charge air cooler cooling tubes

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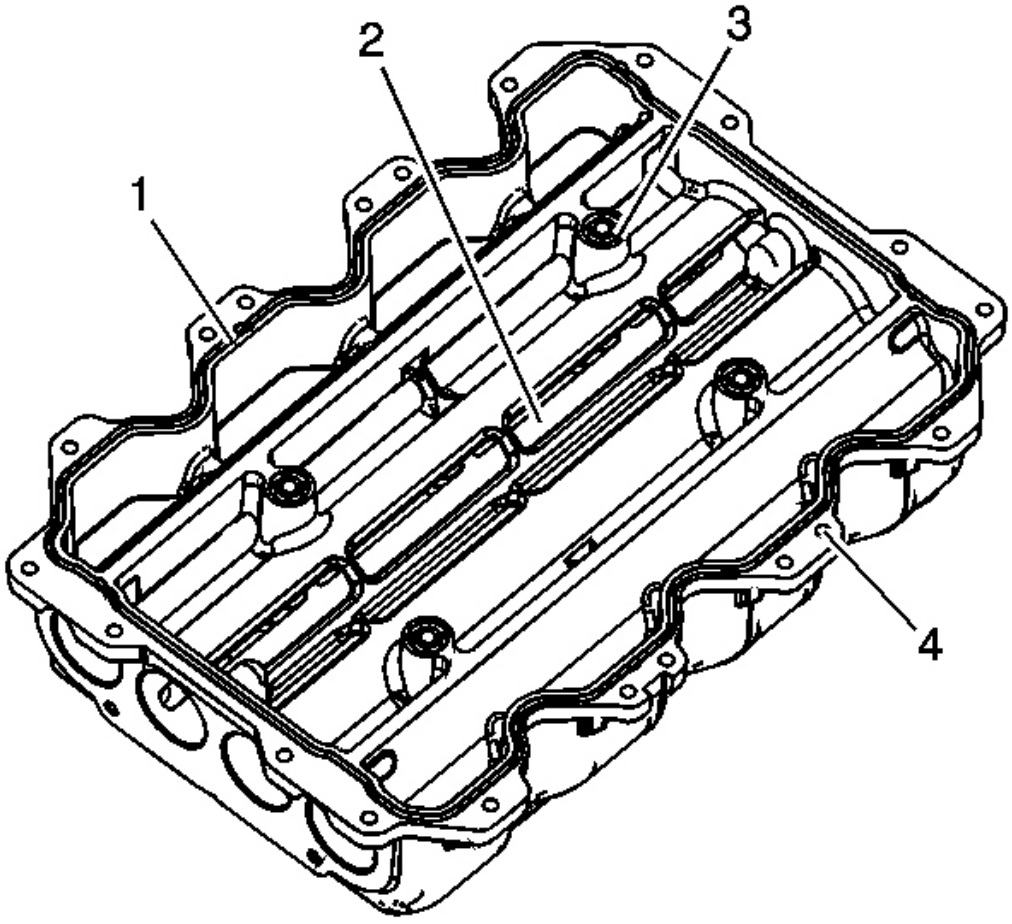


Fig. 82: View Of Interior Of Charge Air Cooler Housing
Courtesy of GENERAL MOTORS CORP.

16. Inspect the interior of the charge air cooler housing for the following:
    - Damage to the sealing grooves for the perimeter gasket (1)
    - Damage, corrosion or restrictions in the passages (2) for the charge air cooler cooling tubes
    - Damage to the sealing grooves for the interior O-ring gaskets (3)
    - Damage to the bolt bosses (4)
17. Repair or replace the charge air cooler housing as necessary.
18. Inspect the PCV, vacuum and pressure tubes for damage. Replace as necessary.

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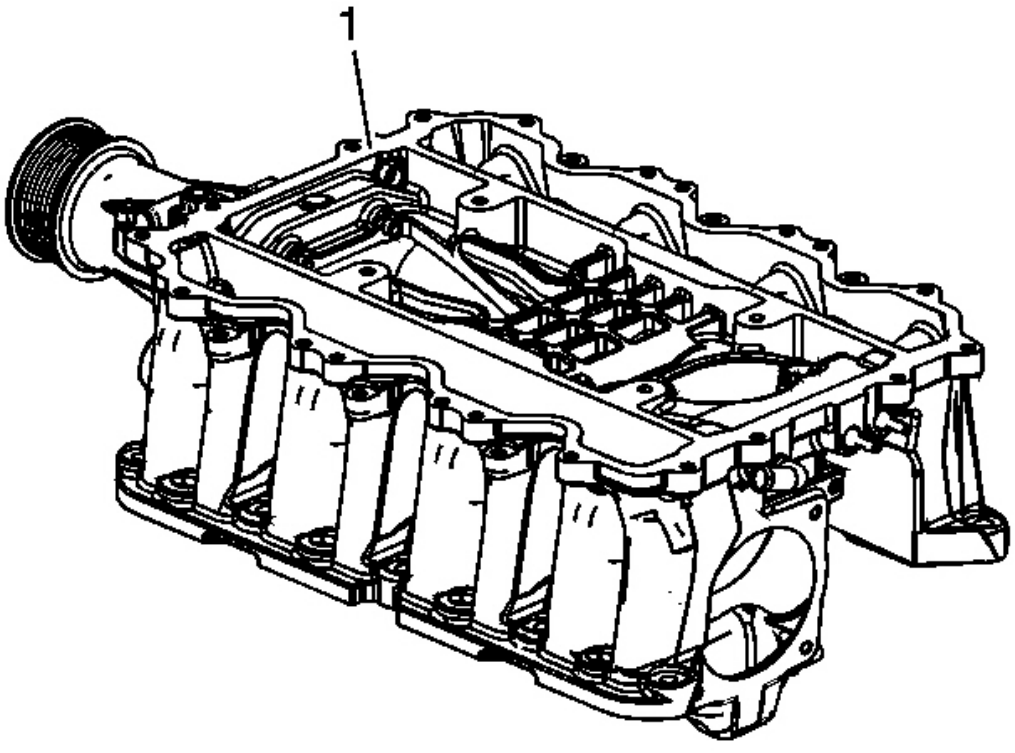


Fig. 83: Identifying Supercharger Perimeter Sealing Surface
Courtesy of GENERAL MOTORS CORP.

19. Inspect the supercharger perimeter sealing surface (1) for the charge air cooler housing for damage.

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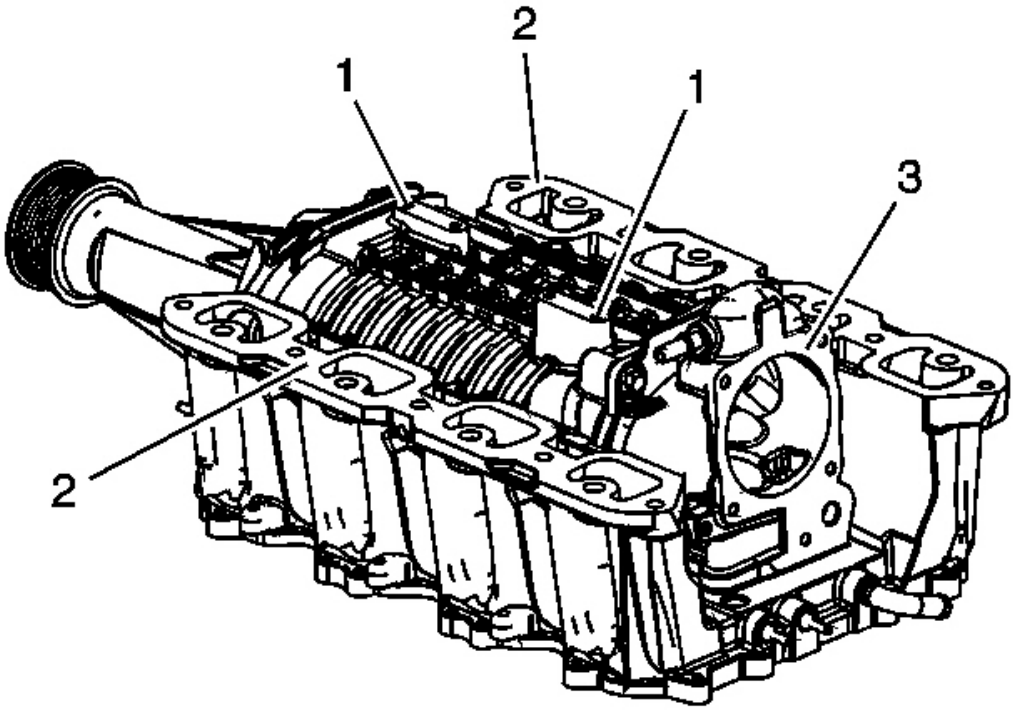


Fig. 84: View Of Bottom Of Supercharger
Courtesy of GENERAL MOTORS CORP.

20. Inspect the bottom of the supercharger for the following:
    - Damage to the threaded holes (1)
    - Damage to the supercharger gasket sealing surface (2)
    - Damage to the throttle body gasket sealing surface (3)

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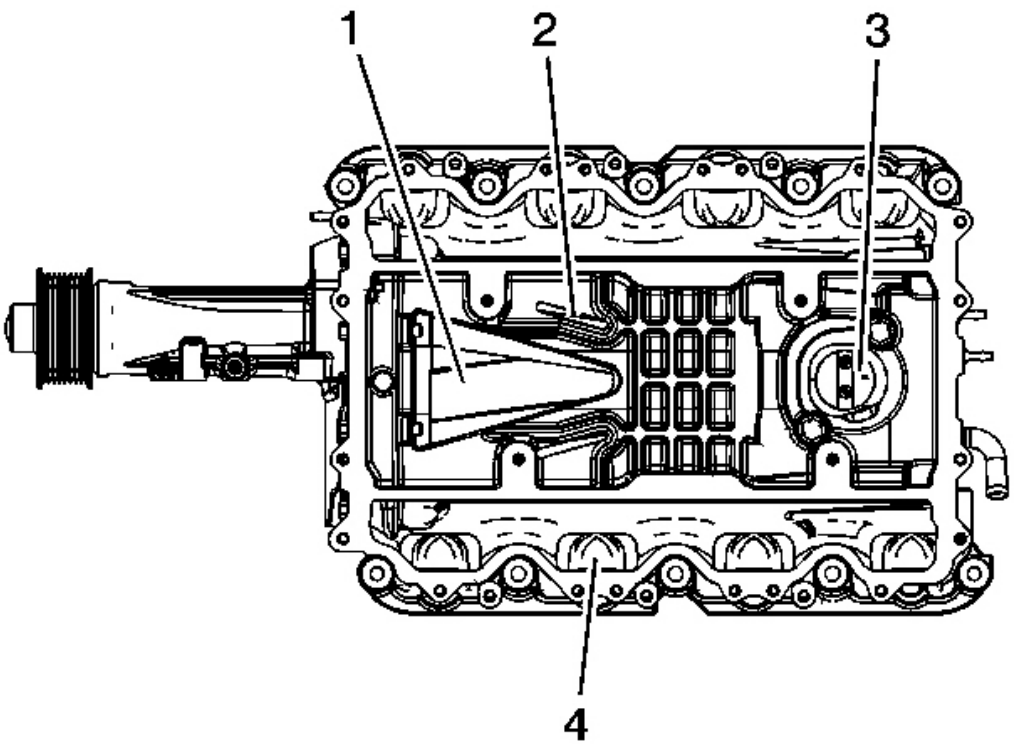


Fig. 85: View Of Interior Of Supercharger
Courtesy of GENERAL MOTORS CORP.

21. Inspect the interior of the supercharger for the following:
    - Damage to the supercharger rotors (1)
    - Restrictions in the charge air passages (2)
    - Damage or restrictions in the passages (3) for bypass valve
    - Damage or restrictions in the intake passages (4)

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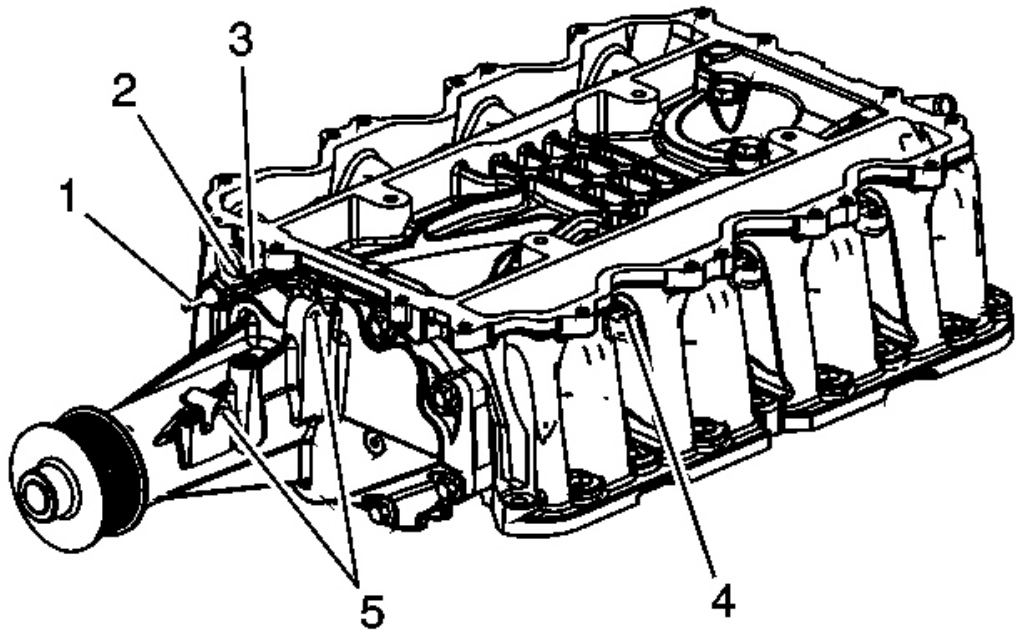


Fig. 86: View Of Supercharger
Courtesy of GENERAL MOTORS CORP.

22. Inspect the supercharger for the following:
    - Damage or restrictions to the port (1) for the manifold absolute pressure (MAP) sensor
    - Damage or restrictions in the IAT sensor 2 threaded hole (2)
    - Damage or restrictions to the pressure port (3) for the charge air bypass regulator solenoid valve tube
    - Damage to the threaded holes (4) for the fuel rail mounting studs
    - Damage to the threaded holes (5) for the bypass actuator valve

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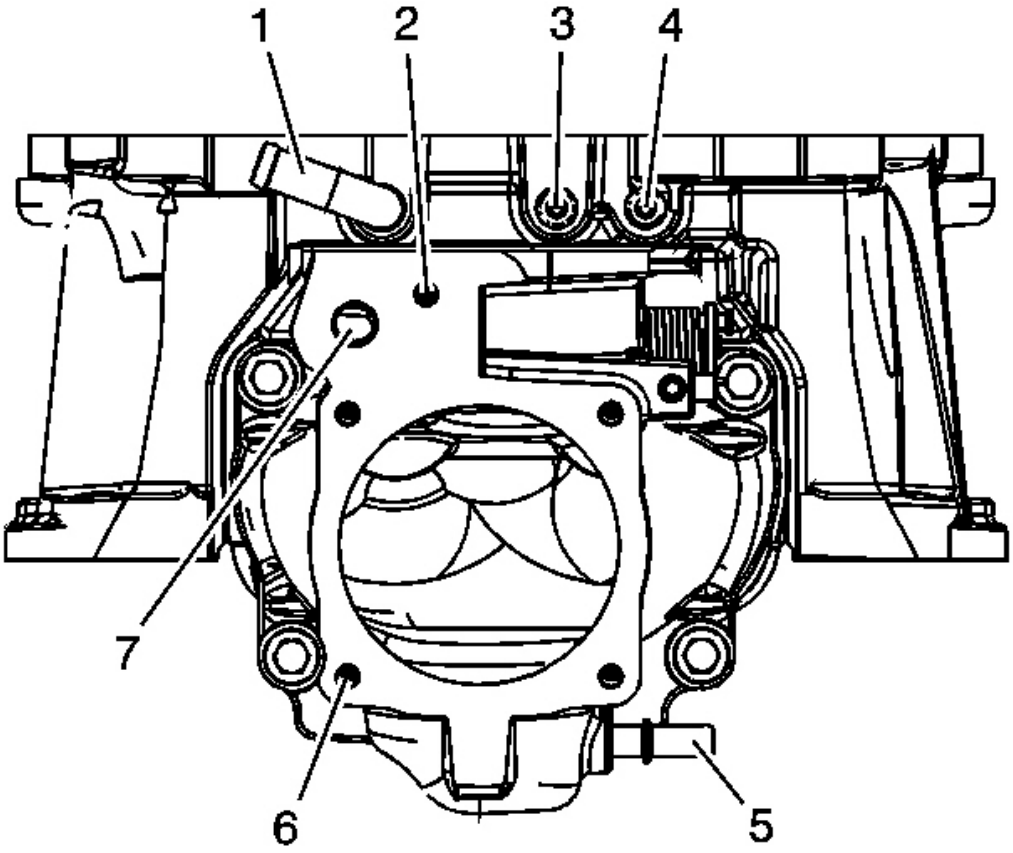


Fig. 87: Inspecting Supercharger
Courtesy of GENERAL MOTORS CORP.

23. Inspect the supercharger for the following:
    - Damage or restrictions to the port (1) for the brake booster hose
    - Damage to the threaded hole (2) for the EVAP solenoid bolt
    - Damage or restrictions to the port (3) for the bypass actuator tube.
    - Damage or restrictions to the port (4) for the supercharger inlet absolute pressure sensor tube
    - Damage or restrictions to the port (5) for the PCV dirty air tube
    - Damage to the threaded holes (6) for the throttle body bolts
    - Damage or restrictions to the port (7) for the EVAP canister purge solenoid valve

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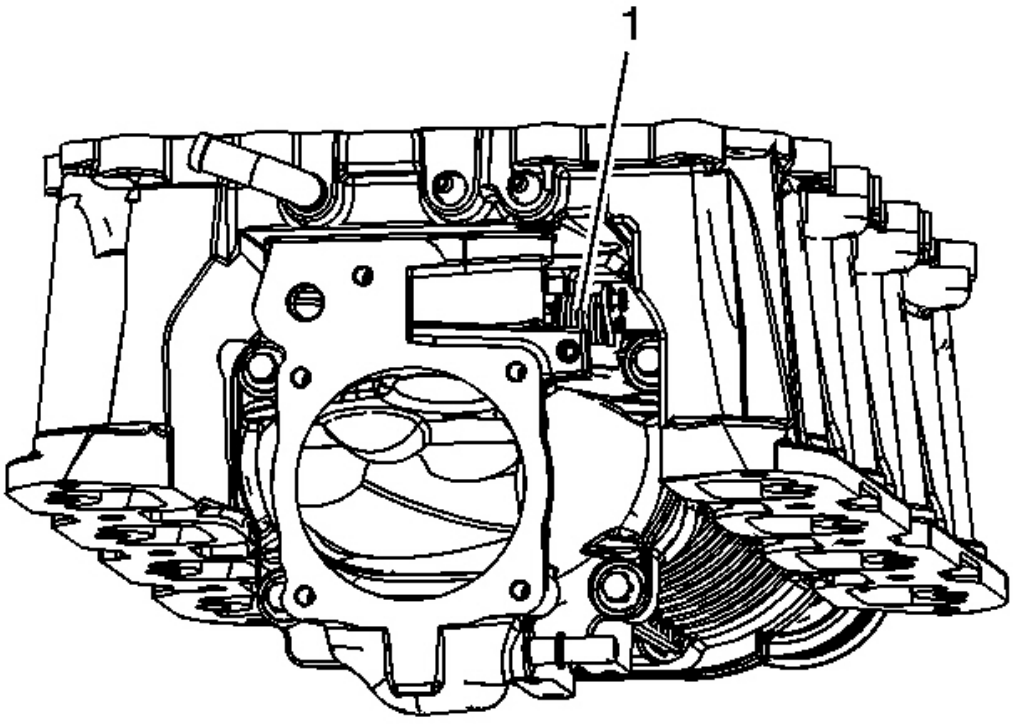


Fig. 88: Locating Bypass Valve
Courtesy of GENERAL MOTORS CORP.

24. Inspect the bypass valve for the following:
    - Rotate the bypass valve to ensure the bypass valve does not bind during opening
    - Ensure the spring (1) closes the bypass valve

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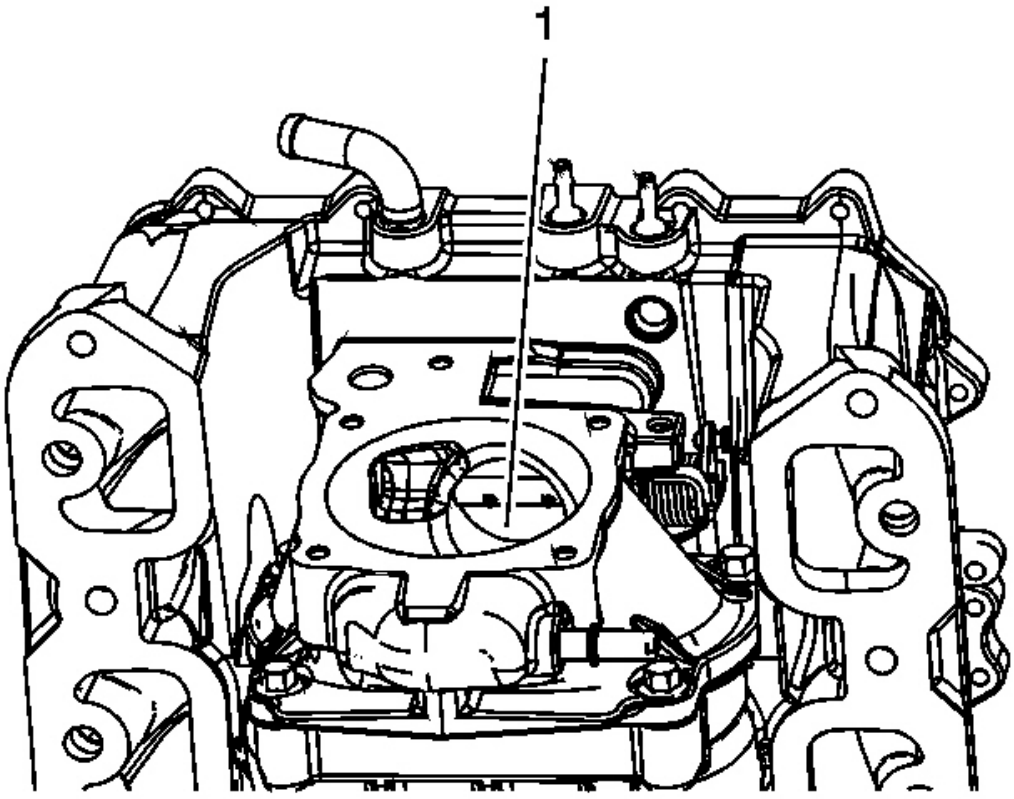


Fig. 89: View Of Bypass Valve
Courtesy of GENERAL MOTORS CORP.

25. Inspect the bypass valve (1) to ensure the valve is closing.
26. Do NOT attempt to repair the supercharger or the bypass valve. The supercharger and bypass valve are replaced as an assembly.

ASSEMBLE PROCEDURE

IMPORTANT: In order to protect and service components, on the supercharger, ensure the EN-47833 is on the supercharger during the disassembly and assembly.

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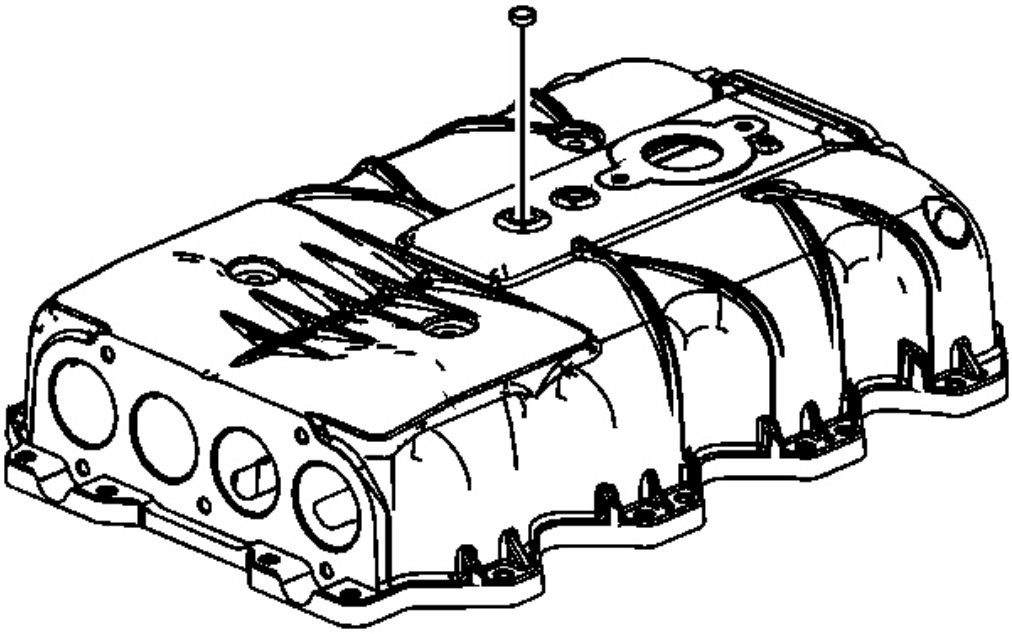


Fig. 90: View Of Charge Air Cooler Housing Expansion Plug
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW charge air cooler housing expansion plug.

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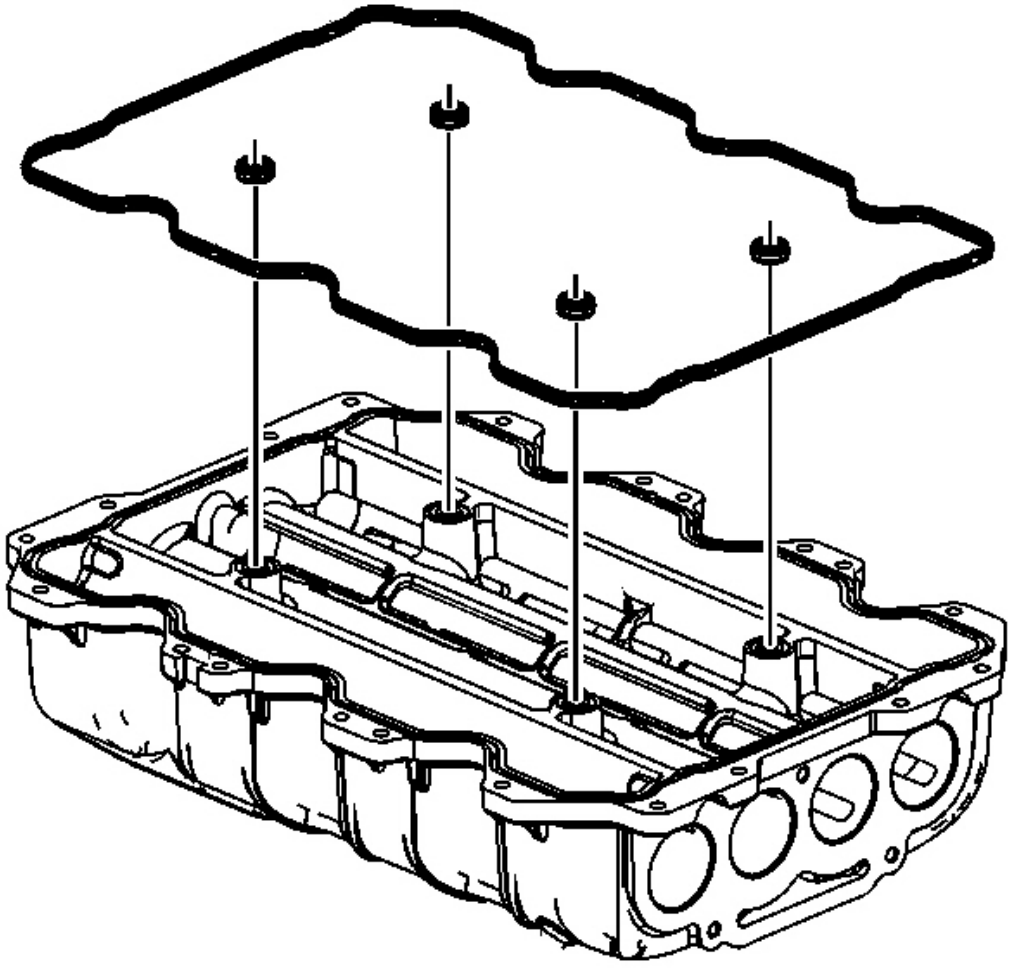


Fig. 91: View Of Charge Air Cooler Housing Perimeter Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW charge air cooler housing interior O-ring gaskets.
3. Install the NEW charge air cooler housing perimeter gasket.

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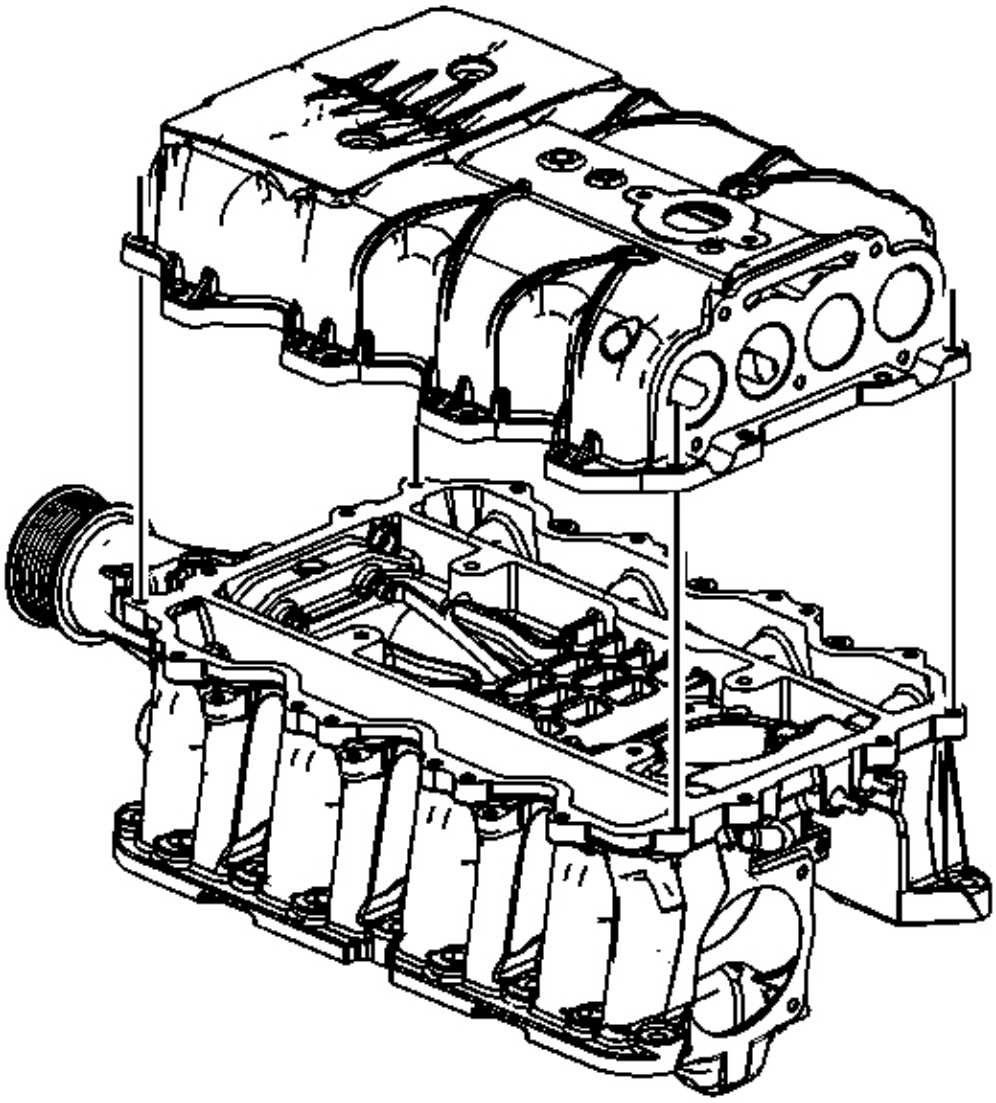


Fig. 92: View Of Charge Air Cooler Housing
Courtesy of GENERAL MOTORS CORP.

4. Install the charge air cooler housing.

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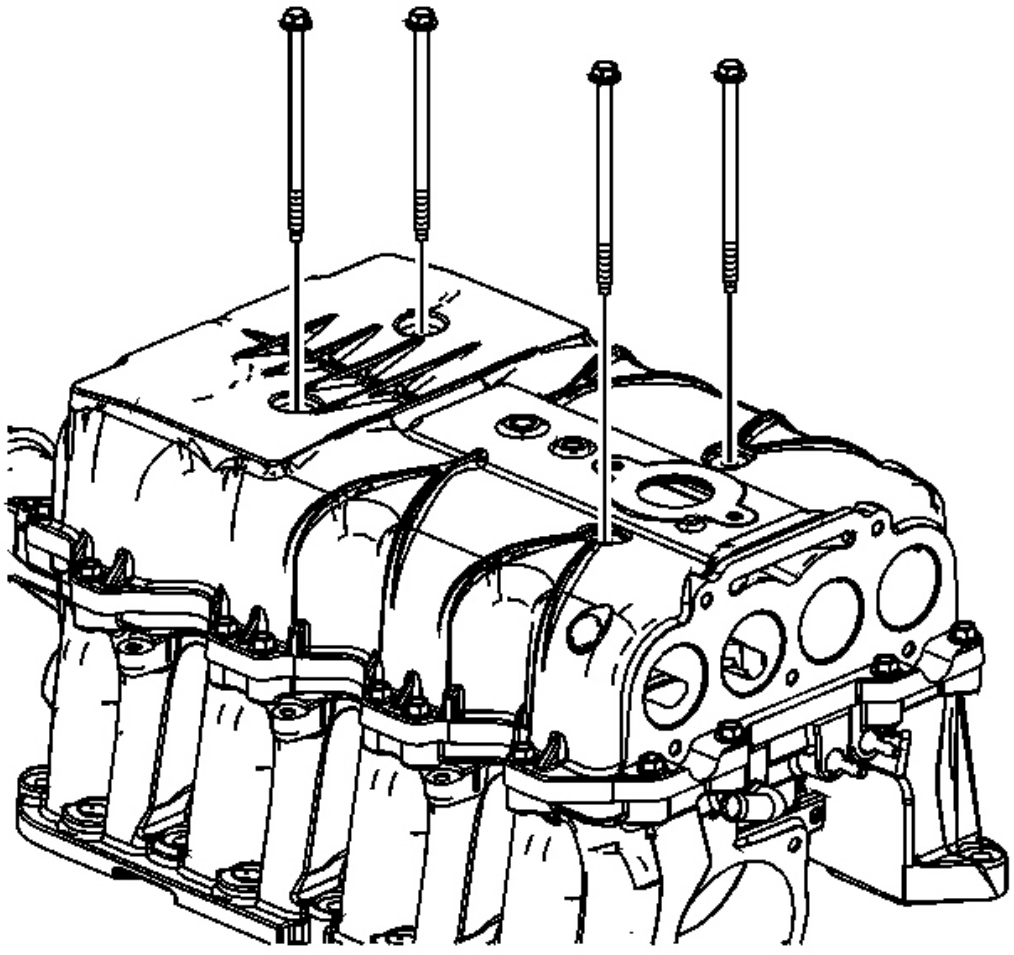


Fig. 93: Identifying Long Charge Air Cooler Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

5. Install the long charge air cooler bolts.

   Tighten: Tighten the long charge air cooler bolt to 10 N.m (89 lb in).

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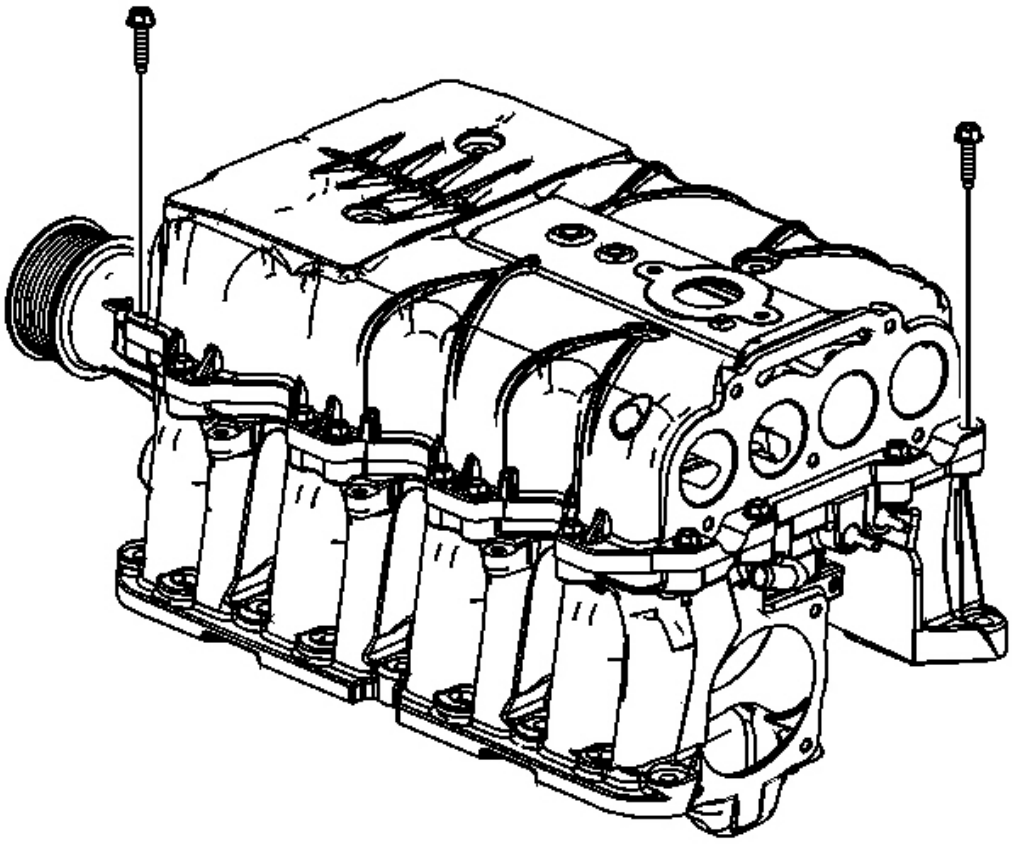


Fig. 94: View Of Short Charge Air Cooler Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the short charge air cooler perimeter bolts.

   Tighten: Tighten the short charge air cooler bolt to 10 N.m (89 lb in).

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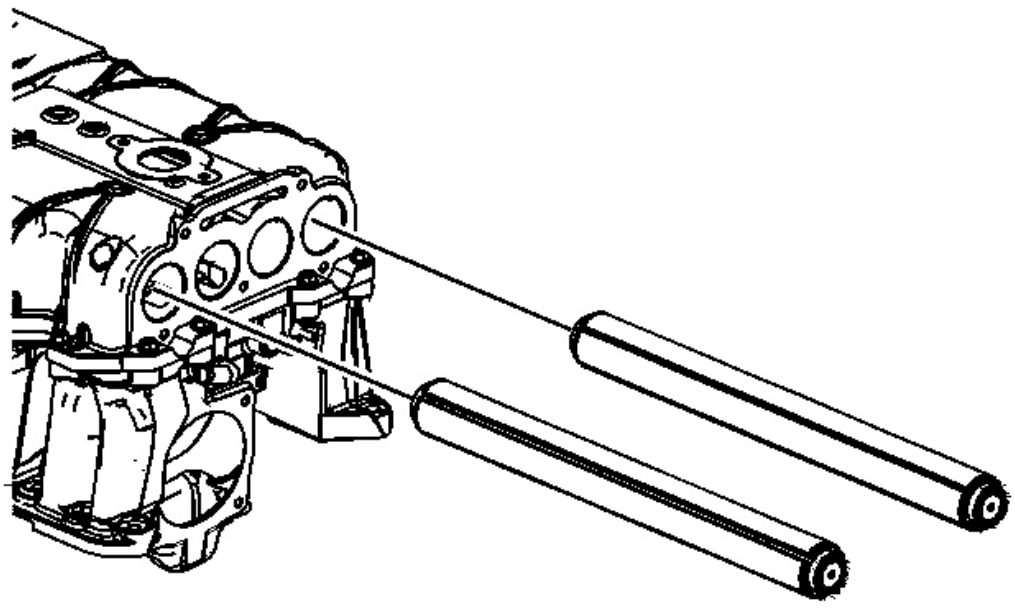


Fig. 95: View Of Outboard Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The charge air cooler cooling tubes are replaced as a set. If any one of the charge air cooler cooling tubes needs to be replaced, all the charge air cooler cooling tubes must be replaced in order to maintain consistent cooling of the charge air.

7. Carefully install the outboard charge air cooler cooling tubes.

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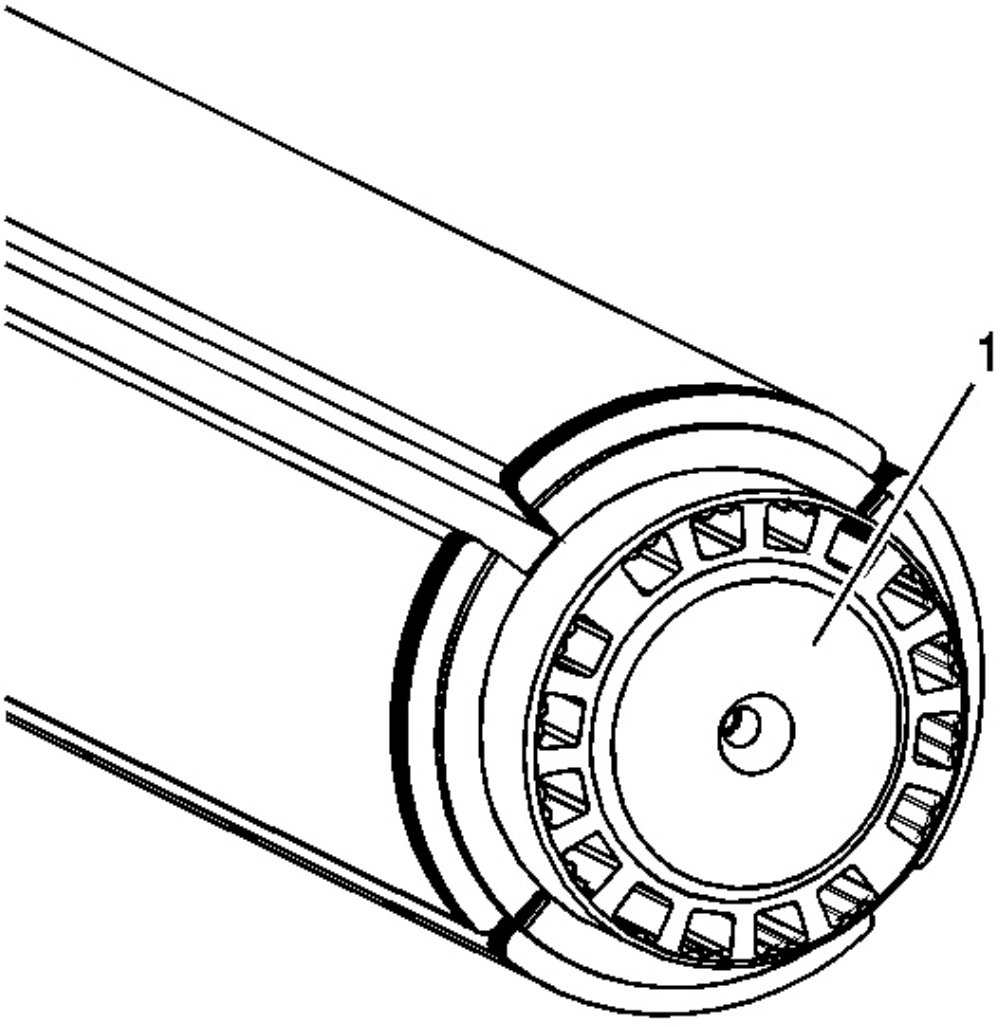


Fig. 96: Identifying Restrictor Plates
Courtesy of GENERAL MOTORS CORP.

8. The charge air cooler cooling outboard tubes are installed with the restrictor plates (1) to the back of the manifold, away from the drive belt pulley.

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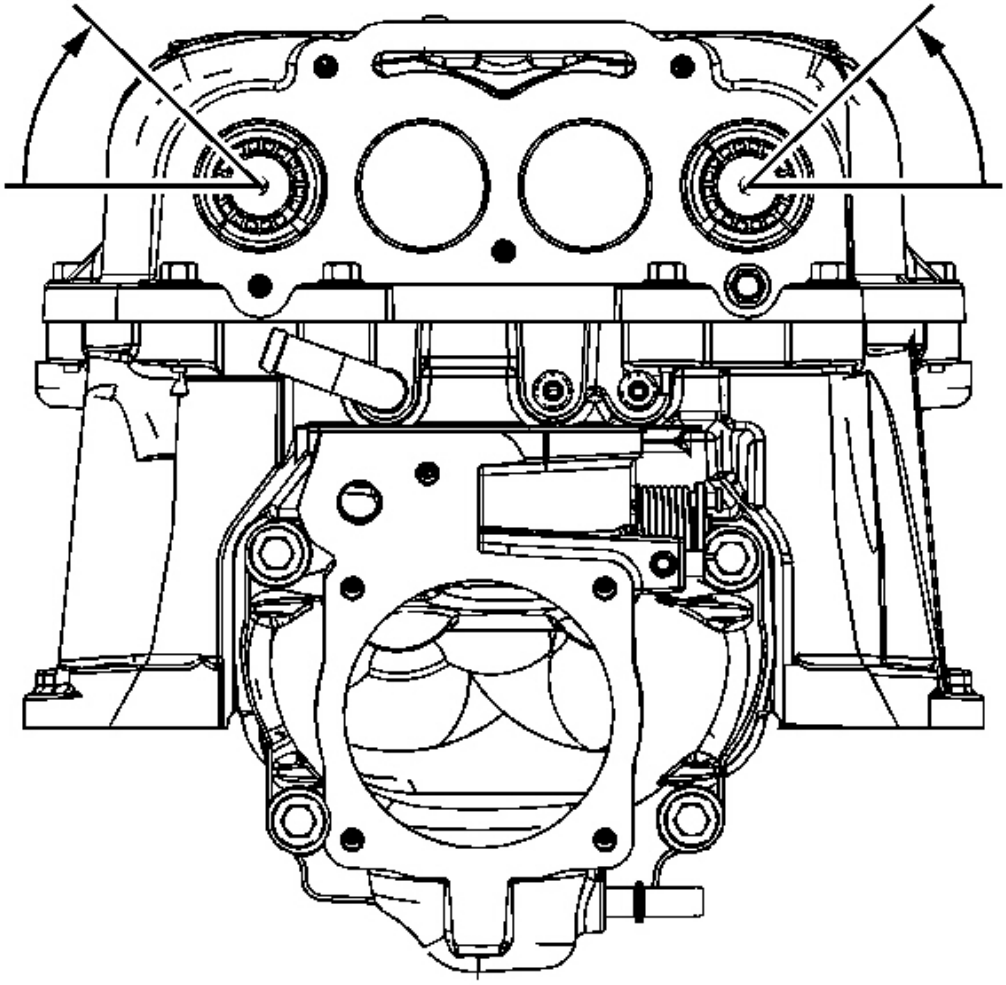


Fig. 97: Aligning Notches At Cooler Tubes
Courtesy of GENERAL MOTORS CORP.

9. Align the wide notch at a 45 degree angle up from horizontal and outboard as shown.

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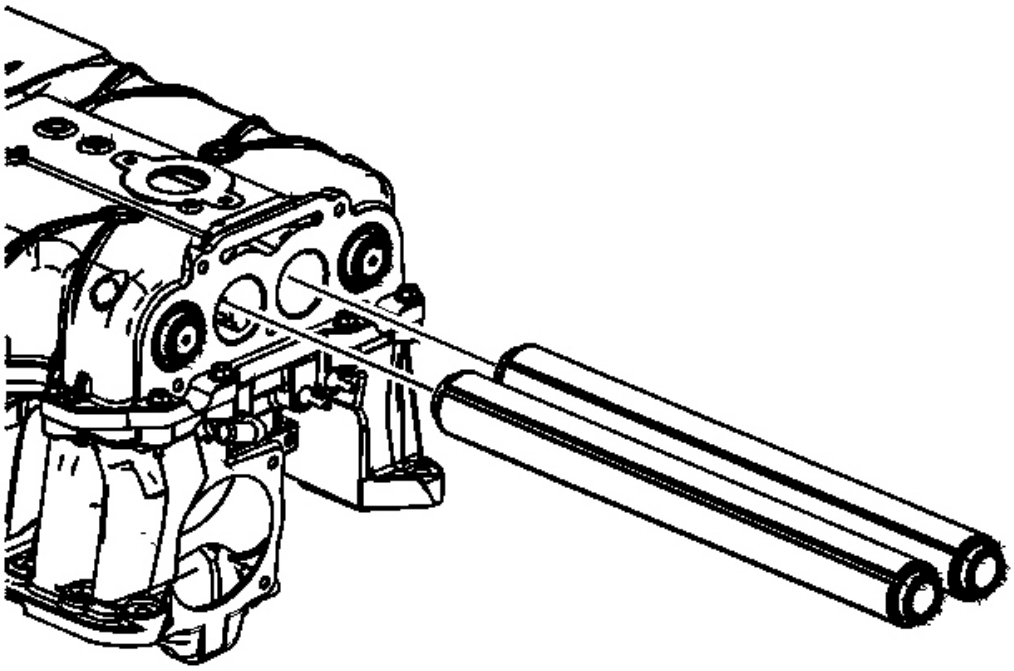


Fig. 98: View Of Inboard Charge Air Cooler Cooling Tubes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The charge air cooler cooling tubes are replaced as a set. If any one of the charge air cooler cooling tubes needs to be replaced, all the charge air cooler cooling tubes must be replaced in order to maintain consistent cooling of the charge air.

10. Carefully install the inboard charge air cooler cooling tubes.

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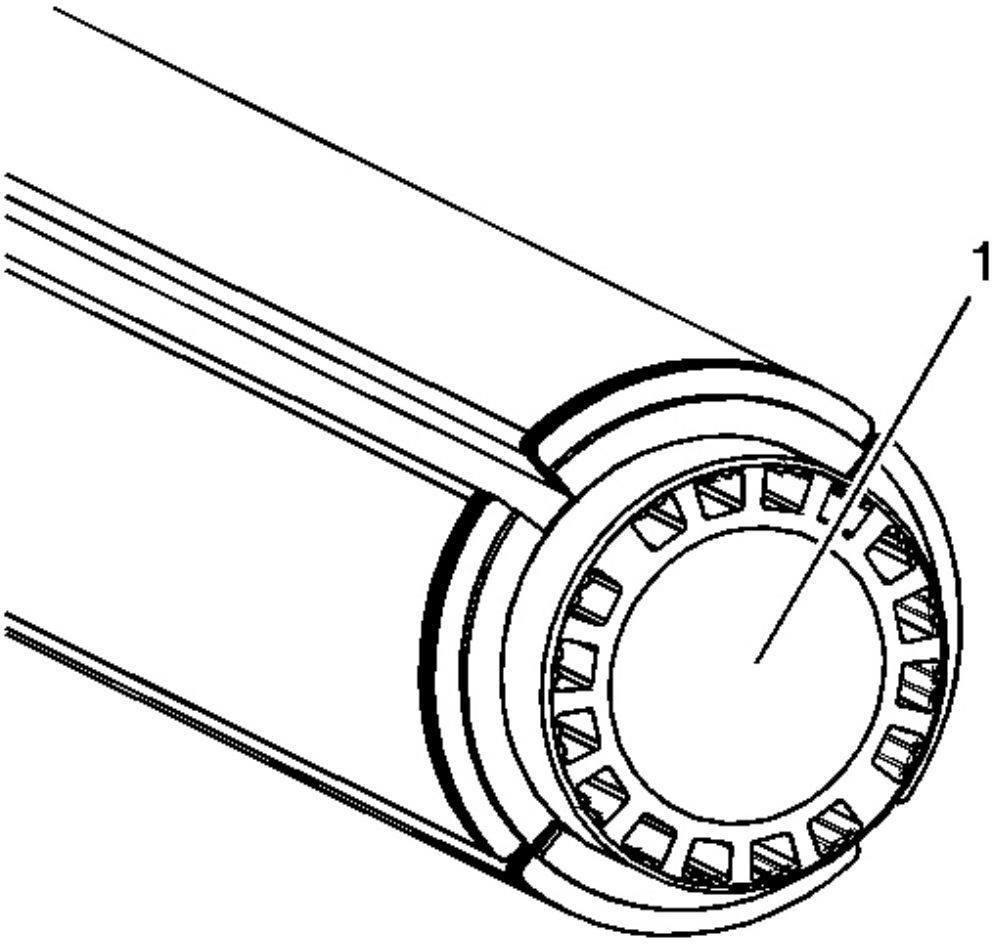


Fig. 99: View Of Charge Air Cooler Cooling Inboard Tubes
Courtesy of GENERAL MOTORS CORP.

11. The charge air cooler cooling inboard tubes are installed with the opening (1) to the back of the manifold. The restrictor plates will be to the front of the manifold, towards the drive belt pulley.

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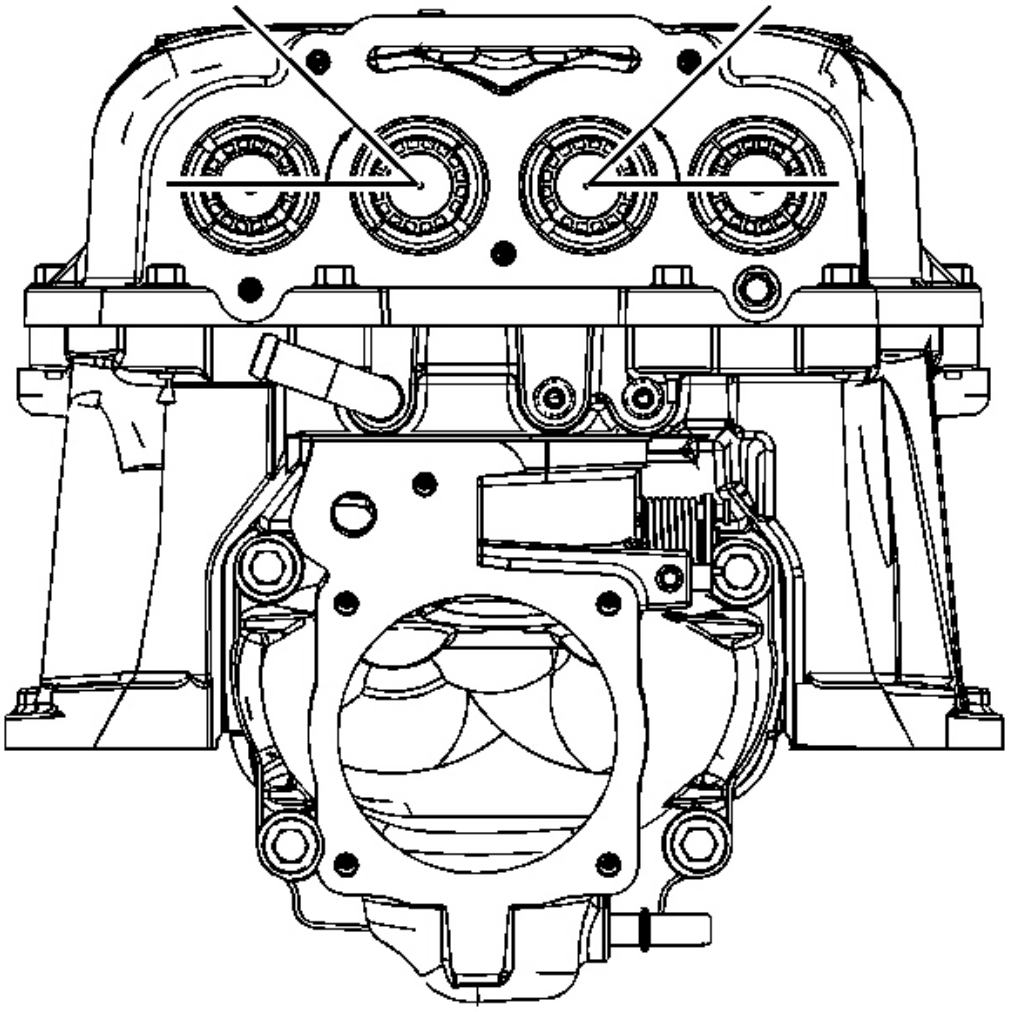


Fig. 100: Aligning Notches
Courtesy of GENERAL MOTORS CORP.

12. Align the wide notch at a 45 degree angle up from horizontal and outboard as shown.

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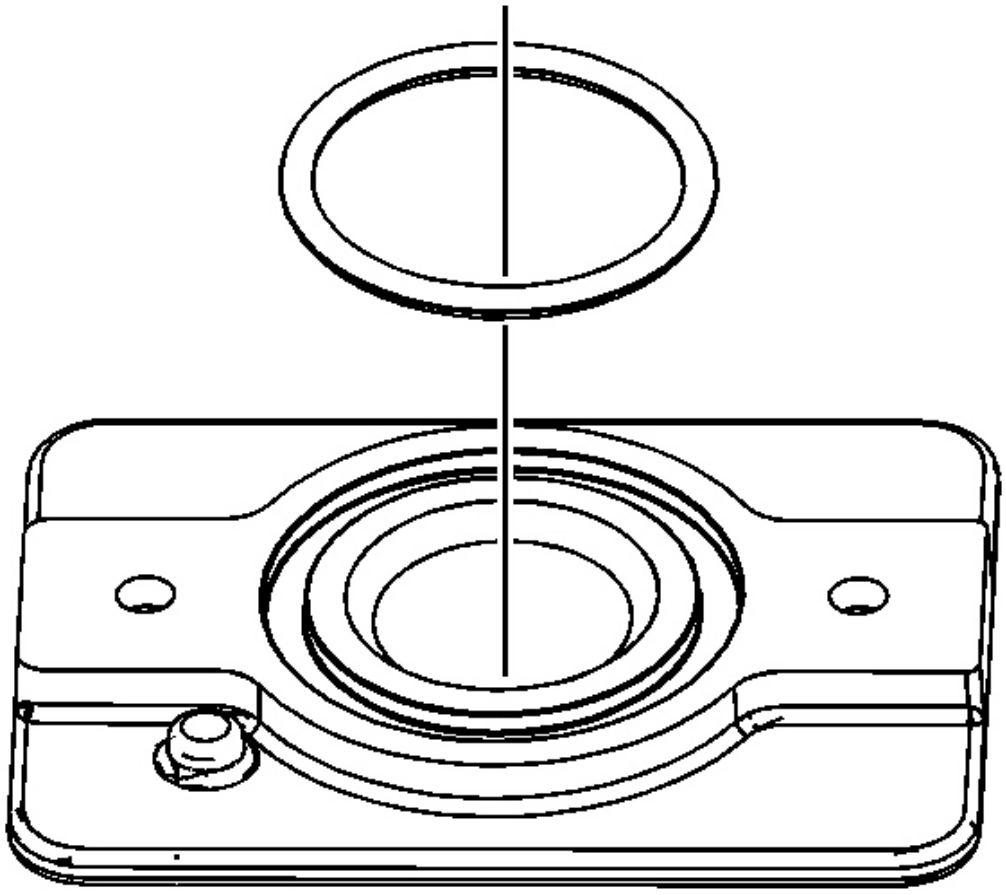


Fig. 101: View Of Charge Air Cooler Cooling Fill Cap O-Ring
Courtesy of GENERAL MOTORS CORP.

13. Install the NEW charge air cooler cooling fill cap O-ring.

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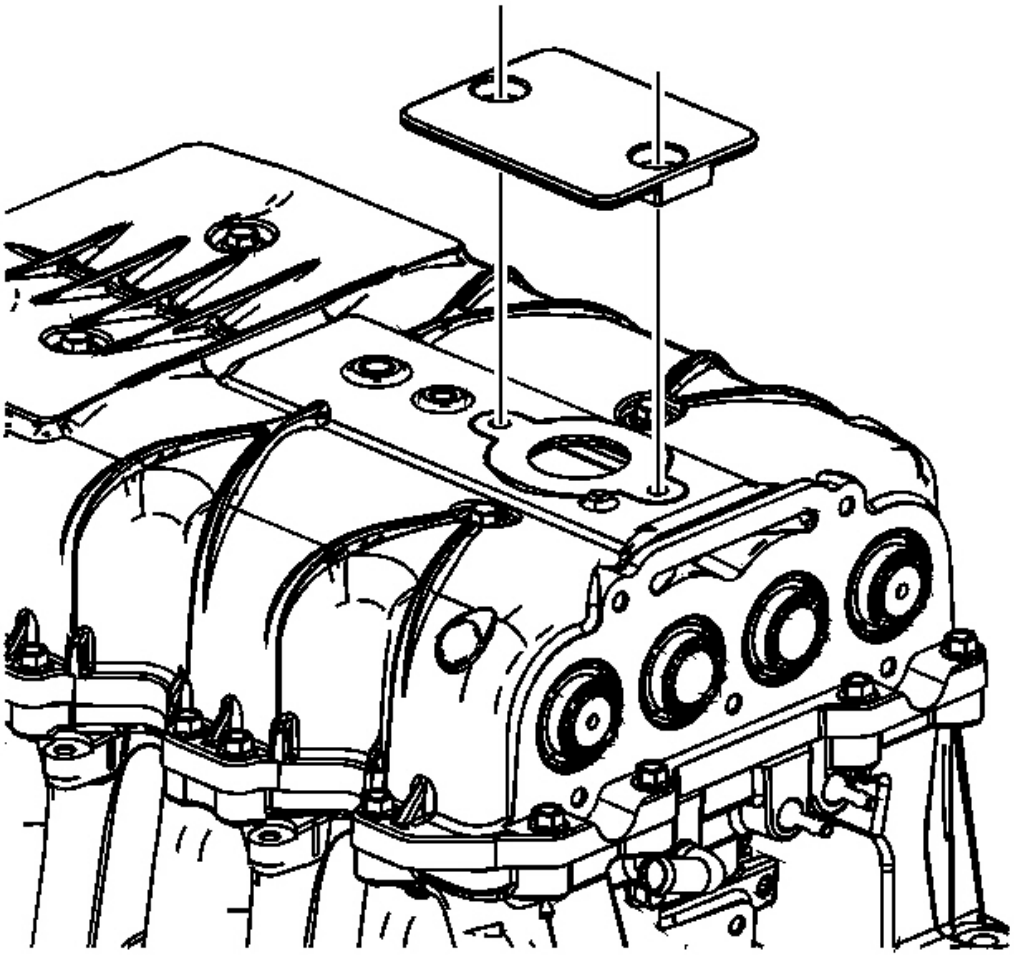


Fig. 102: View Of Charge Air Cooler Cooling Fill Cap
Courtesy of GENERAL MOTORS CORP.

14. Install the charge air cooler cooling fill cap.

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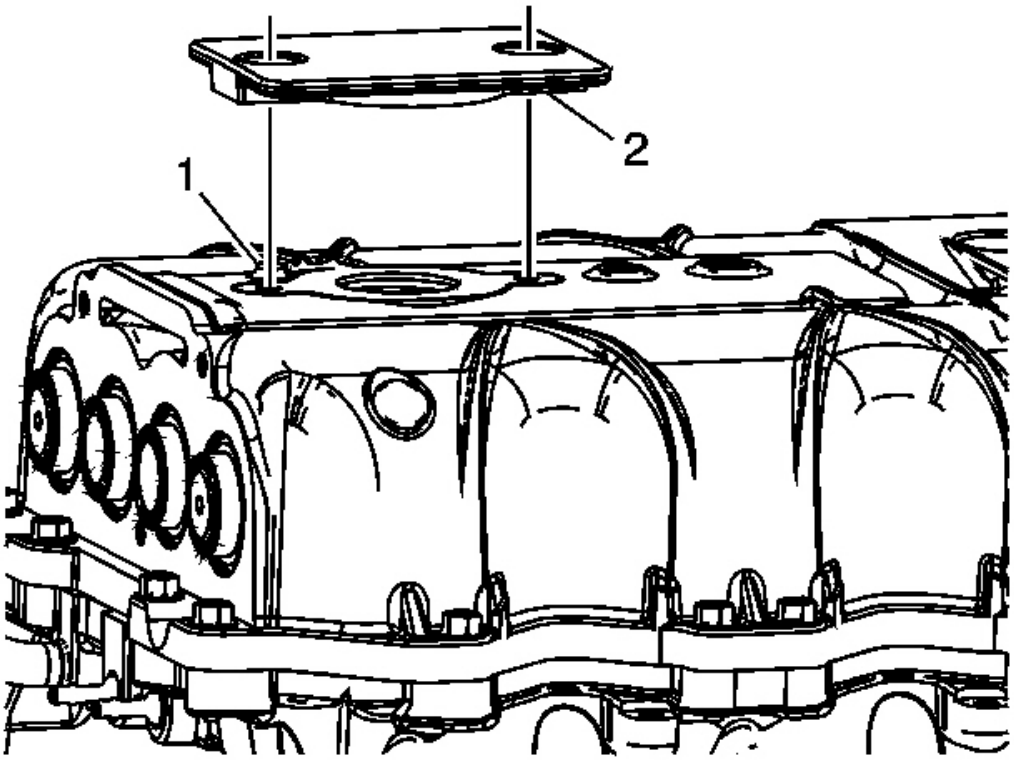


Fig. 103: View Of Charge Air Cooler Cooling Fill Cap
Courtesy of GENERAL MOTORS CORP.

15. Ensure the charge air cooler cooling fill cap is installed in the proper orientation.
    - The alignment boss (1) is at the rear of the charge air cooler manifold
    - The alignment boss (2) is at the front of the charge air cooler cooling fill cap

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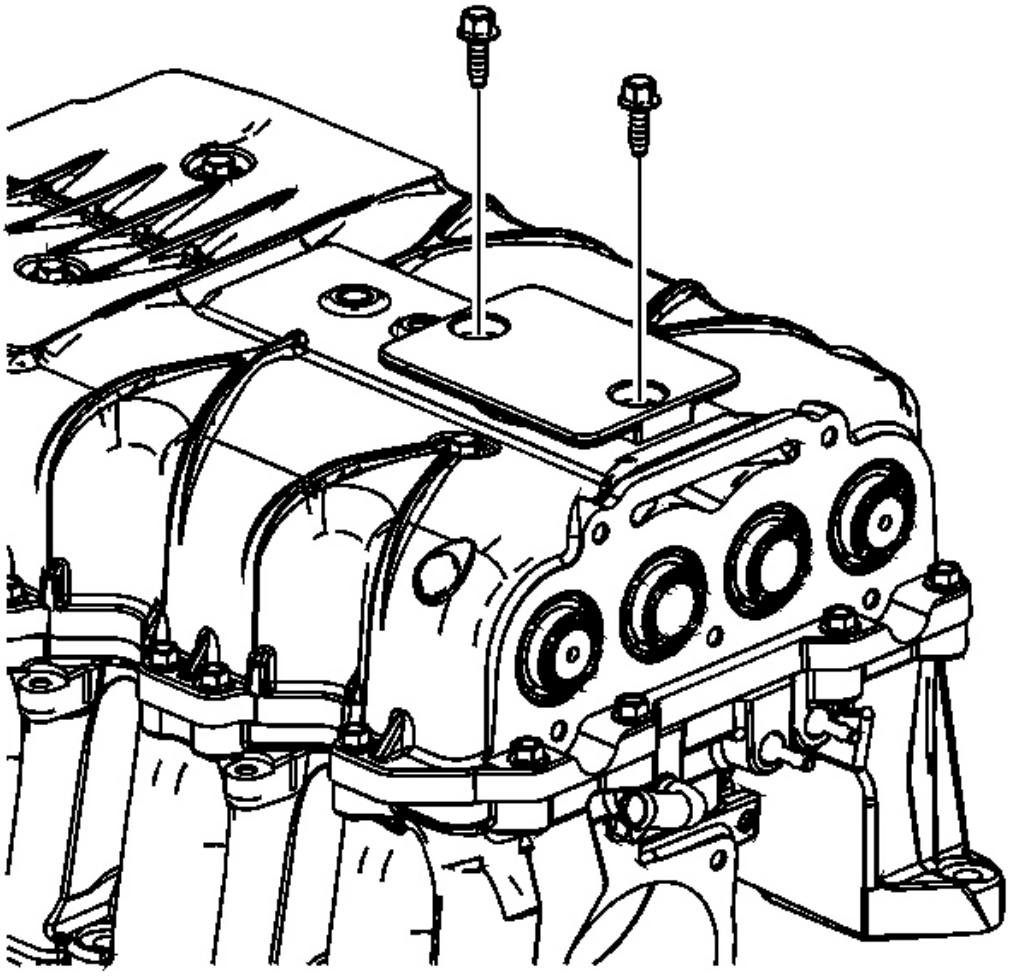


Fig. 104: View Of Charge Air Cooler Cooling Fill Cap Bolts
Courtesy of GENERAL MOTORS CORP.

16. Install the charge air cooler cooling fill cap bolts.

    Tighten: Tighten the charge air cooler cooling fill cap bolt to 10 N.m (89 lb in).

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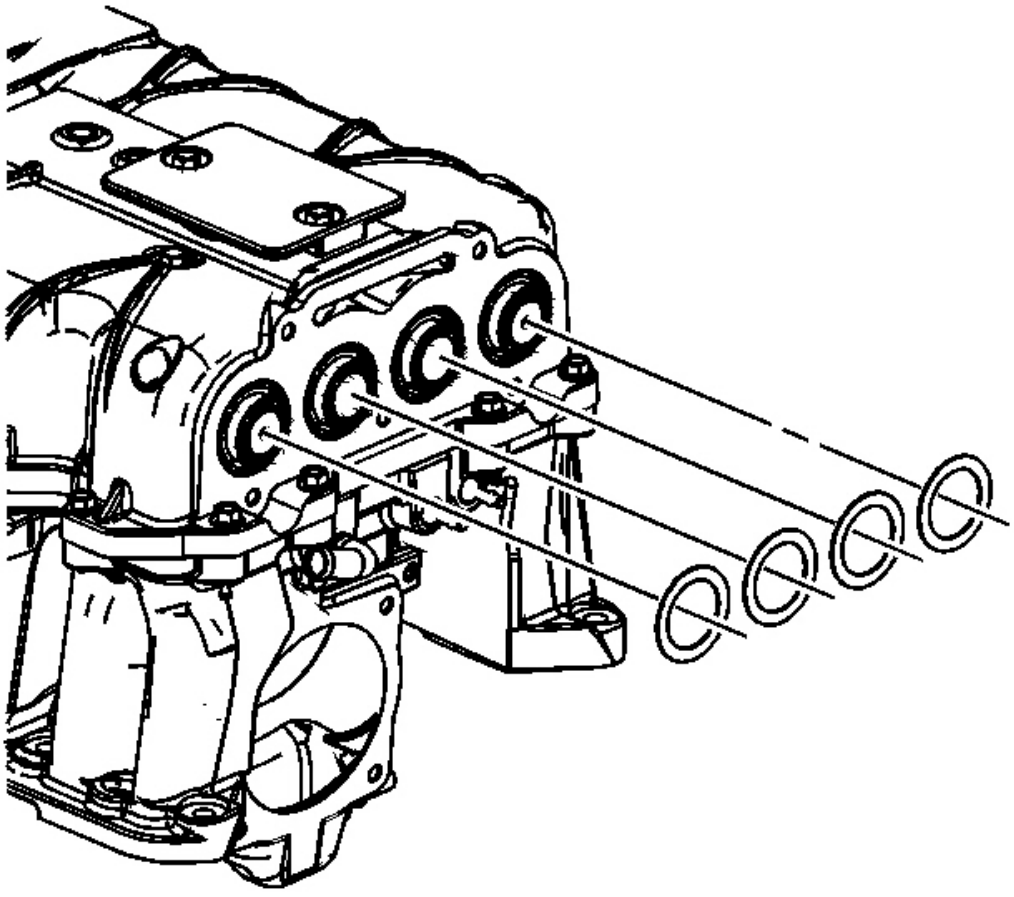


Fig. 105: View Of Charge Air Cooler Cooling Tube Rear Spacers
Courtesy of GENERAL MOTORS CORP.

17. Install the charge air cooler cooling tube rear spacers.

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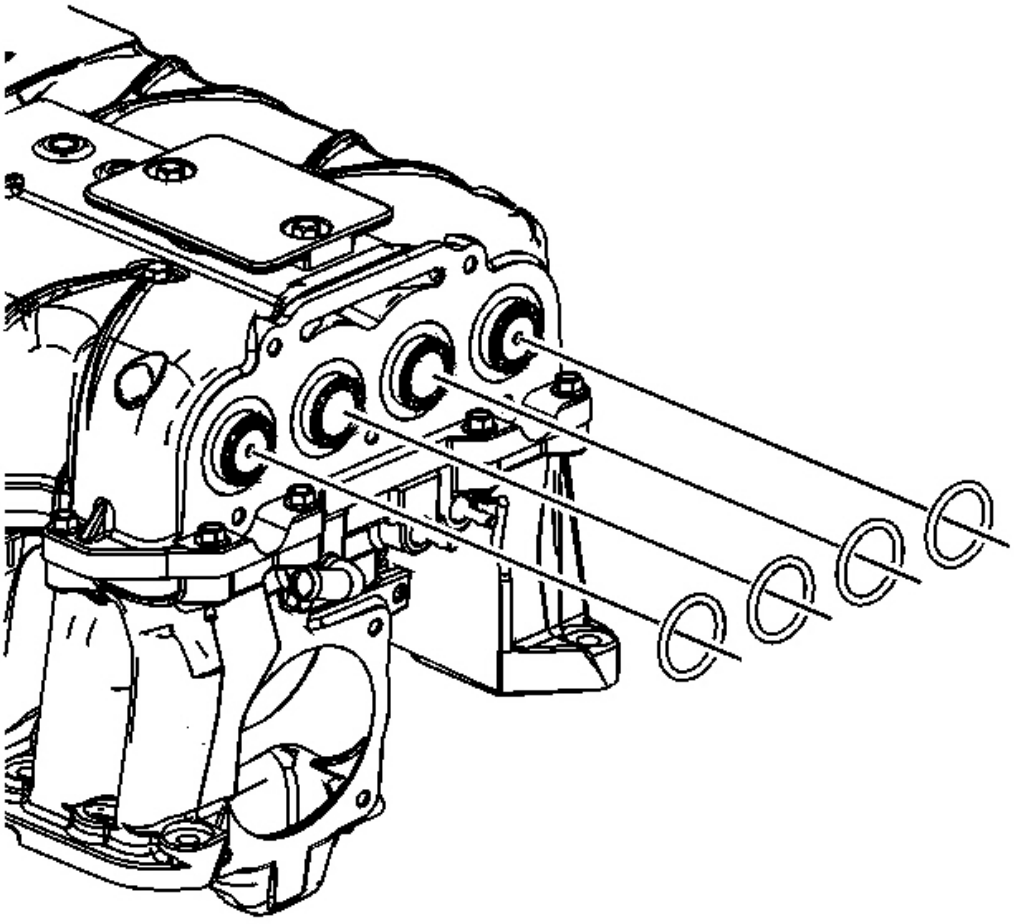


Fig. 106: View Of Charge Air Cooler Cooling Tube Rear O-Rings
Courtesy of GENERAL MOTORS CORP.

18. Install the NEW charge air cooler cooling tube rear O-rings.

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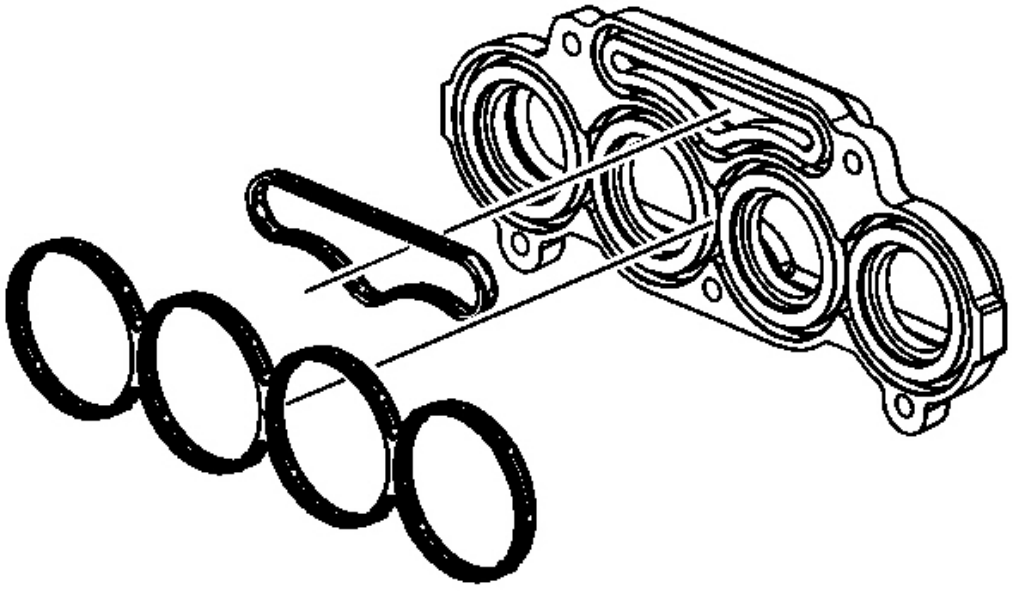


Fig. 107: View Of Charge Air Cooler Rear Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

19. Install the NEW charge air cooler rear manifold gaskets.

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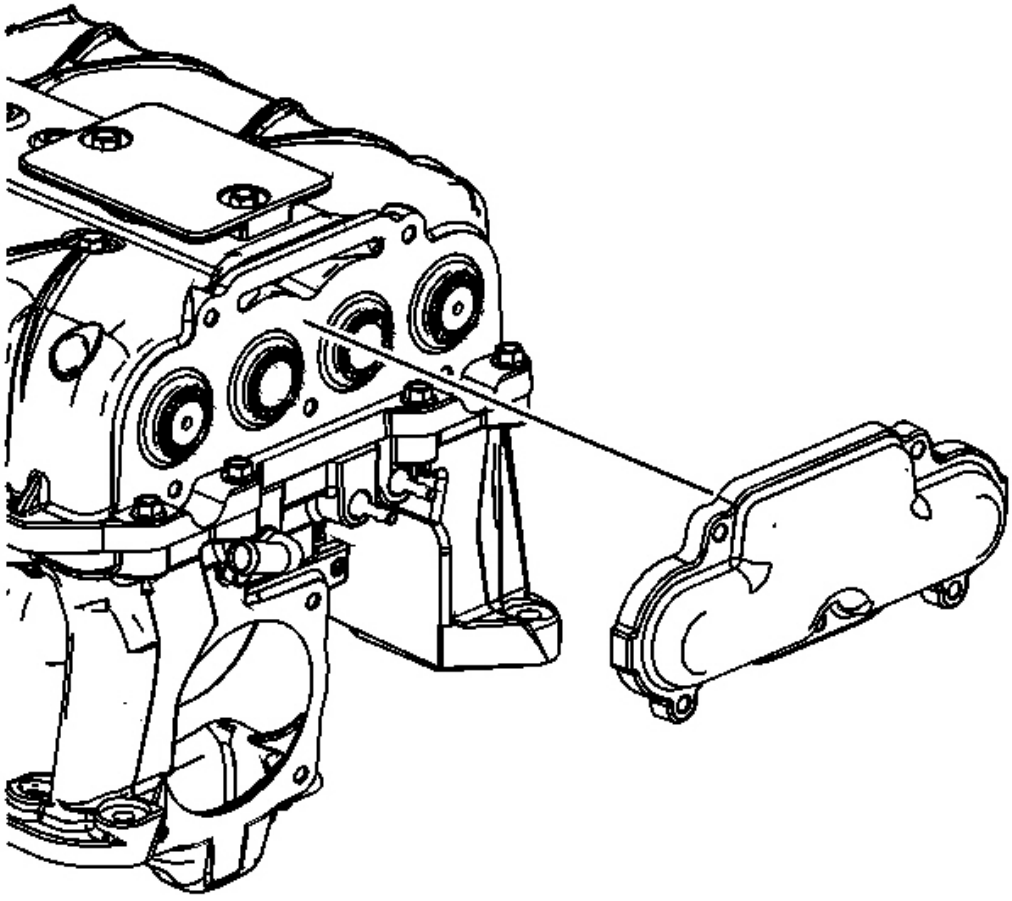


Fig. 108: Identifying Charge Air Cooler Rear Manifold
Courtesy of GENERAL MOTORS CORP.

20. Install the charge air cooler rear manifold.

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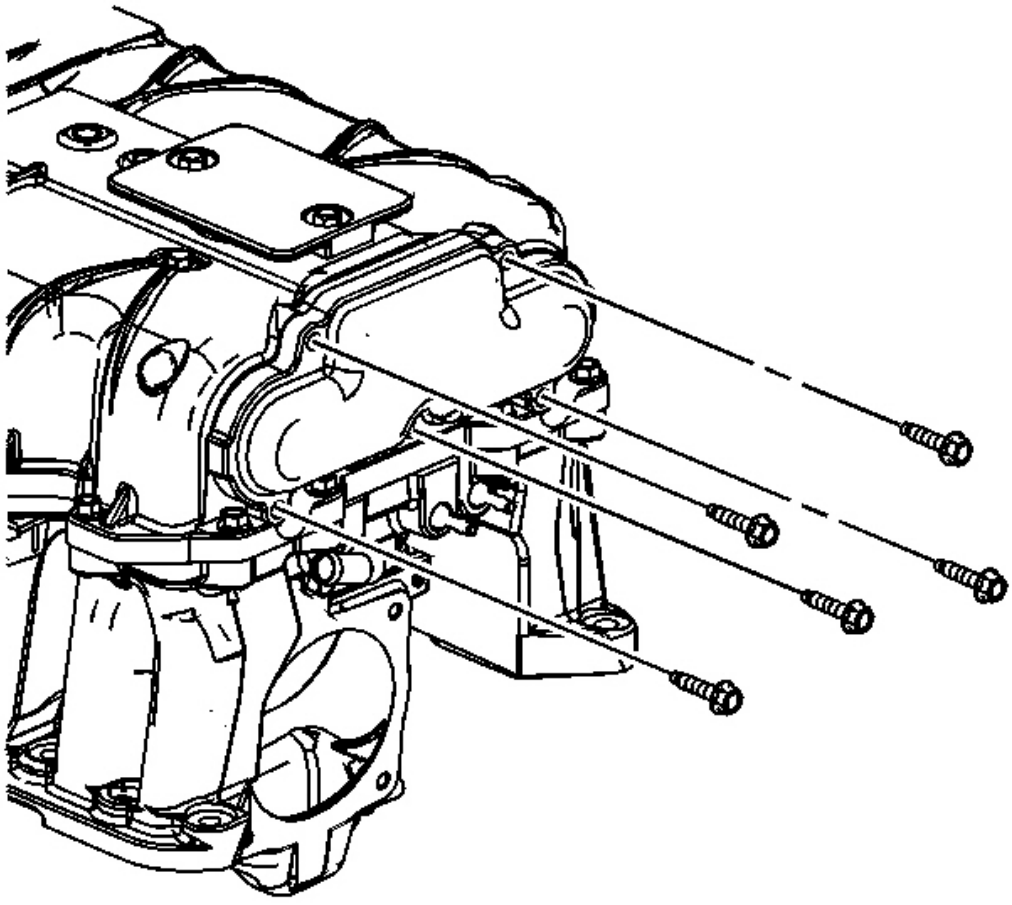


Fig. 109: Identifying Charge Air Cooler Rear Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

21. Install the charge air cooler rear manifold bolts.

    Tighten: Tighten the charge air cooler rear manifold bolt to 10 N.m (89 lb in).

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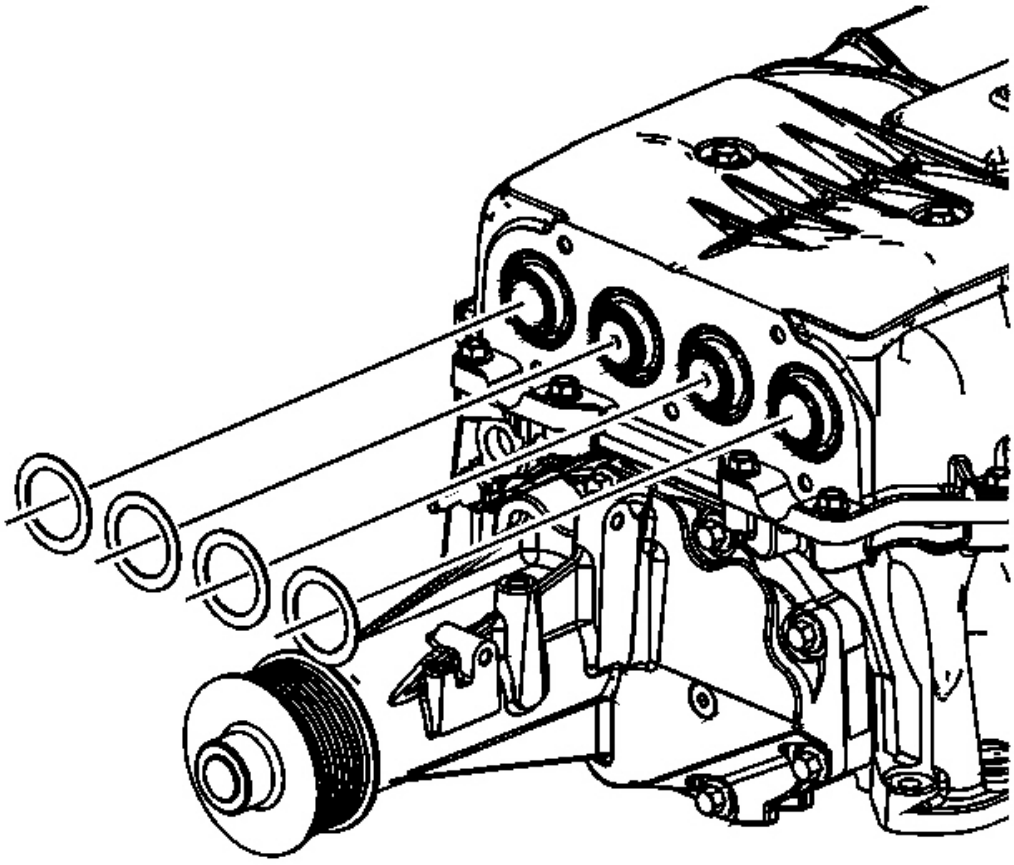


Fig. 110: View Of Charge Air Cooler Cooling Tube Front Spacers
Courtesy of GENERAL MOTORS CORP.

22. Install the charge air cooler cooling tube front spacers.

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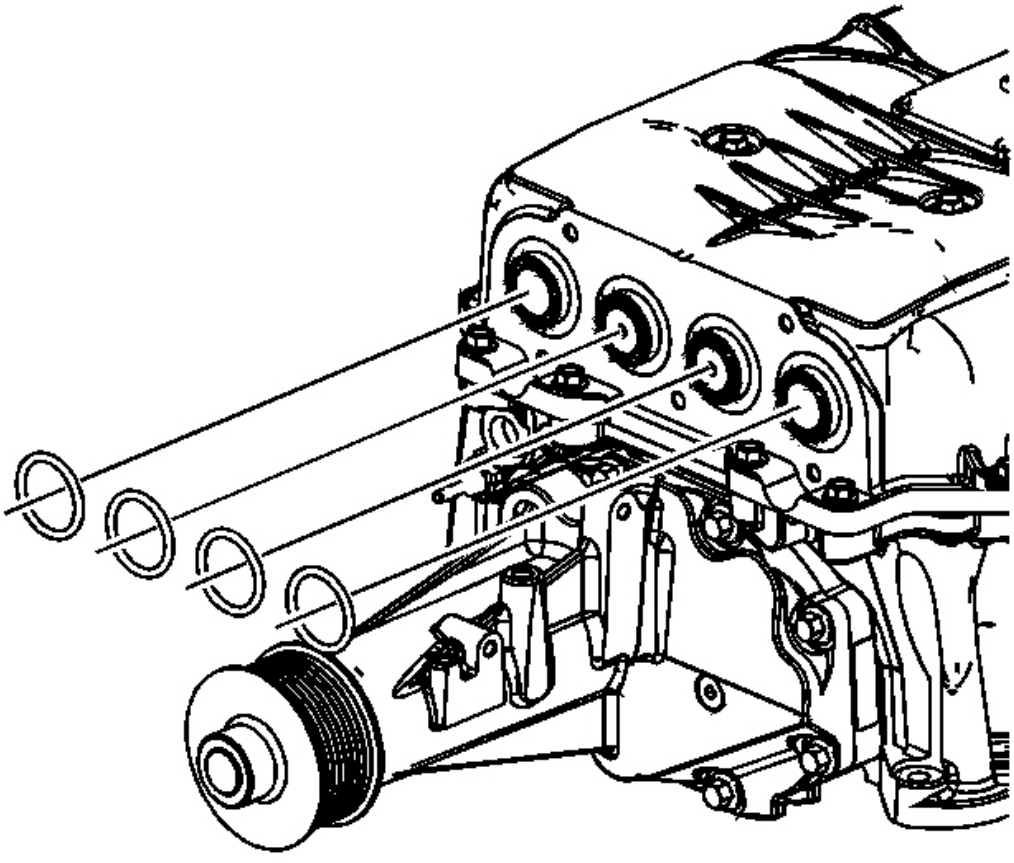


Fig. 111: View Of Charge Air Cooler Cooling Tube Front O-Rings
Courtesy of GENERAL MOTORS CORP.

23. Install the NEW charge air cooler cooling tube front O-rings.

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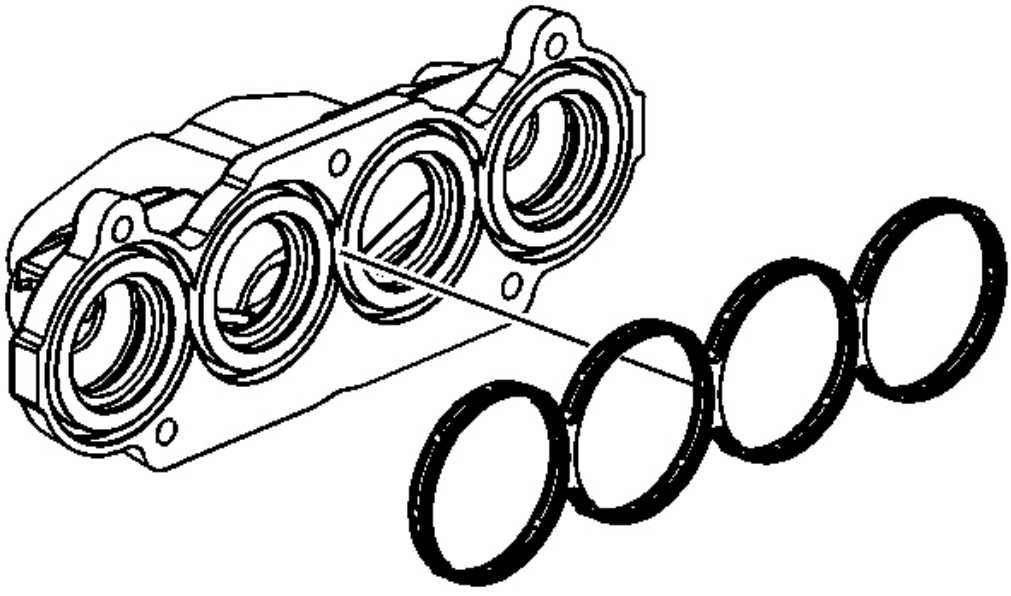


Fig. 112: View Of Charge Air Cooler Front Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

24. Install the NEW charge air cooler front manifold gasket.

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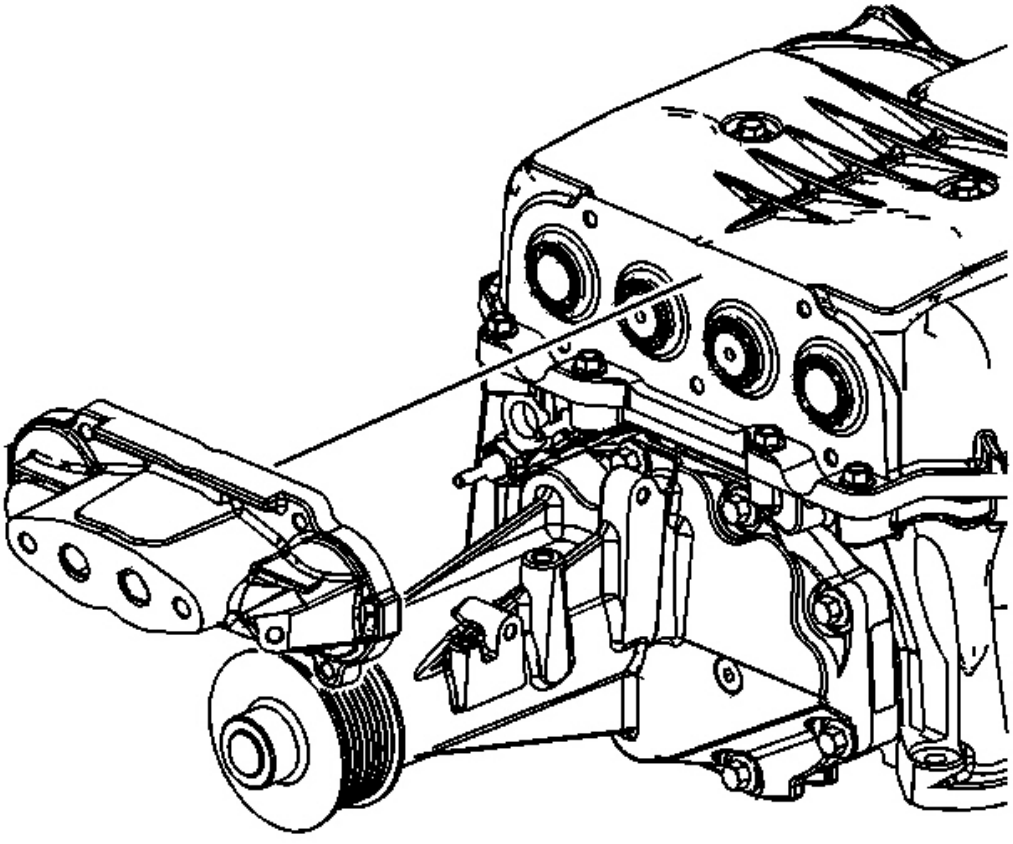


Fig. 113: View Of Charge Air Cooler Front Manifold
Courtesy of GENERAL MOTORS CORP.

25. Install the charge air cooler front manifold.

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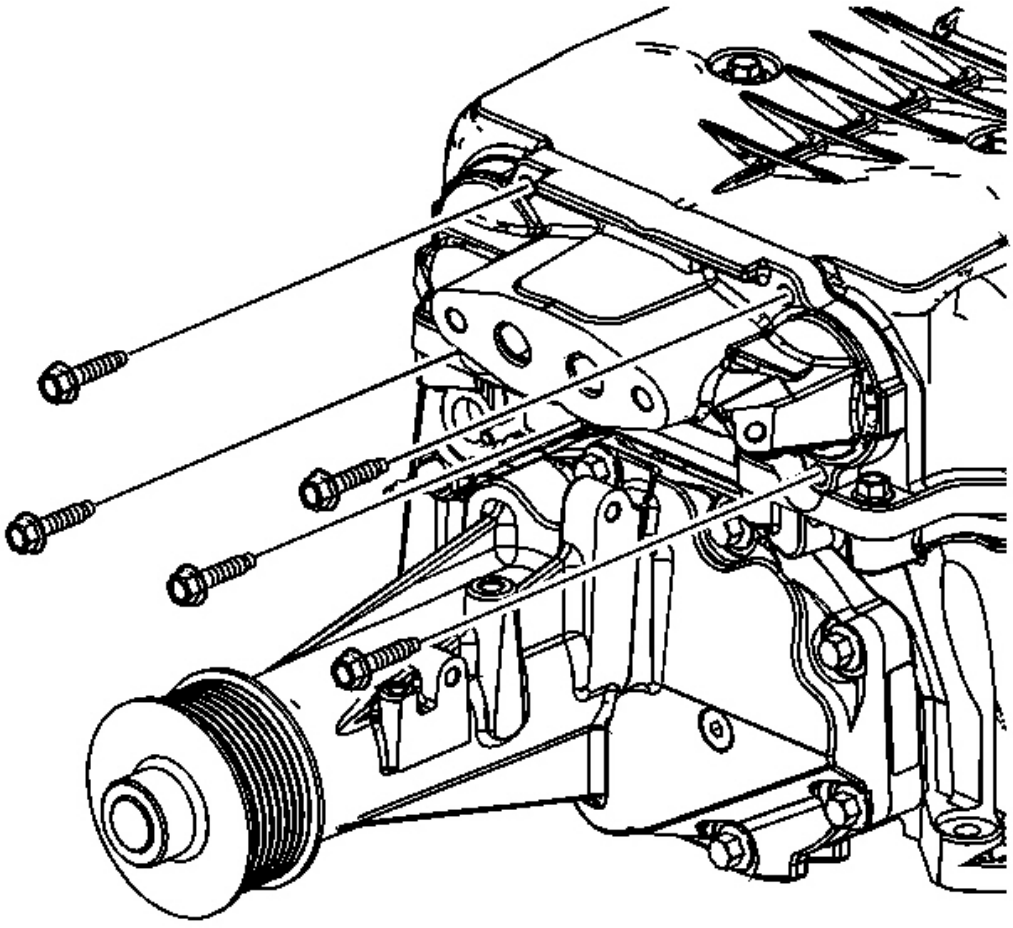


Fig. 114: Identifying Charge Air Cooler Front Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

26. Install the charge air cooler front manifold bolts.

    Tighten: Tighten the charge air cooler front manifold bolt to 10 N.m (89 lb in).

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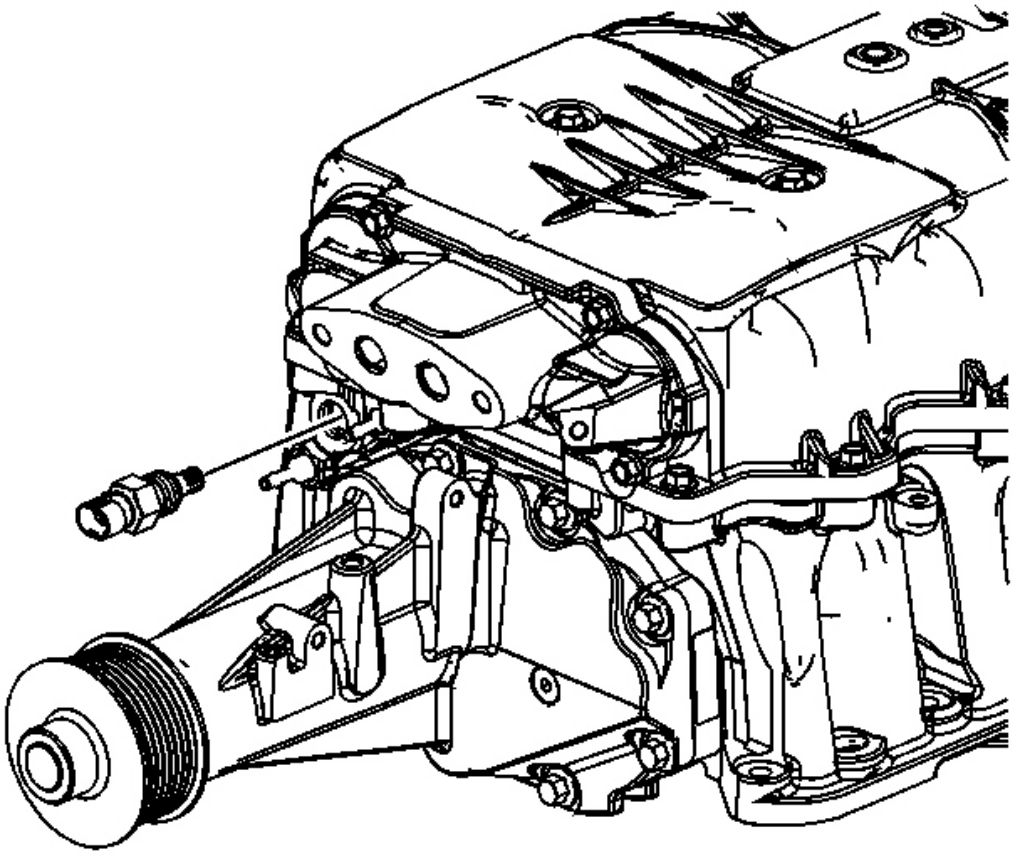


Fig. 115: Identifying IAT Sensor
Courtesy of GENERAL MOTORS CORP.

27. Coat the IAT sensor 2 threads with sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent.
28. Install the IAT sensor 2 into the supercharger.

Tighten: Tighten the IAT sensor 2 to 20 N.m (15 lb ft).

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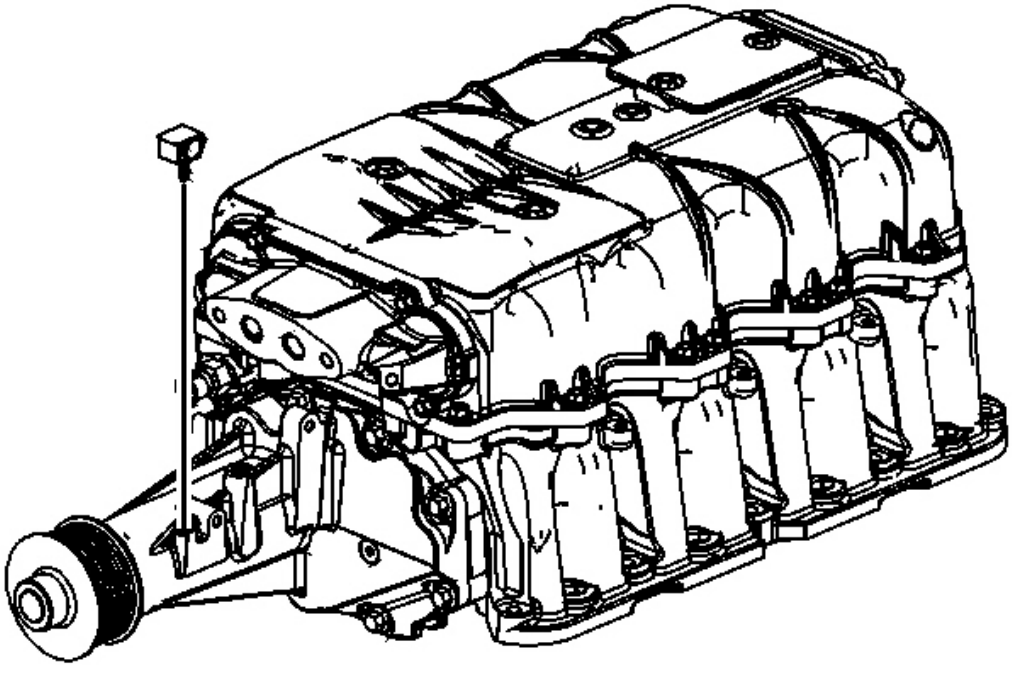


Fig. 116: Identifying Fuel Rail Crossover Tube Clip
Courtesy of GENERAL MOTORS CORP.

29. Install the fuel injection fuel rail crossover tube clip.

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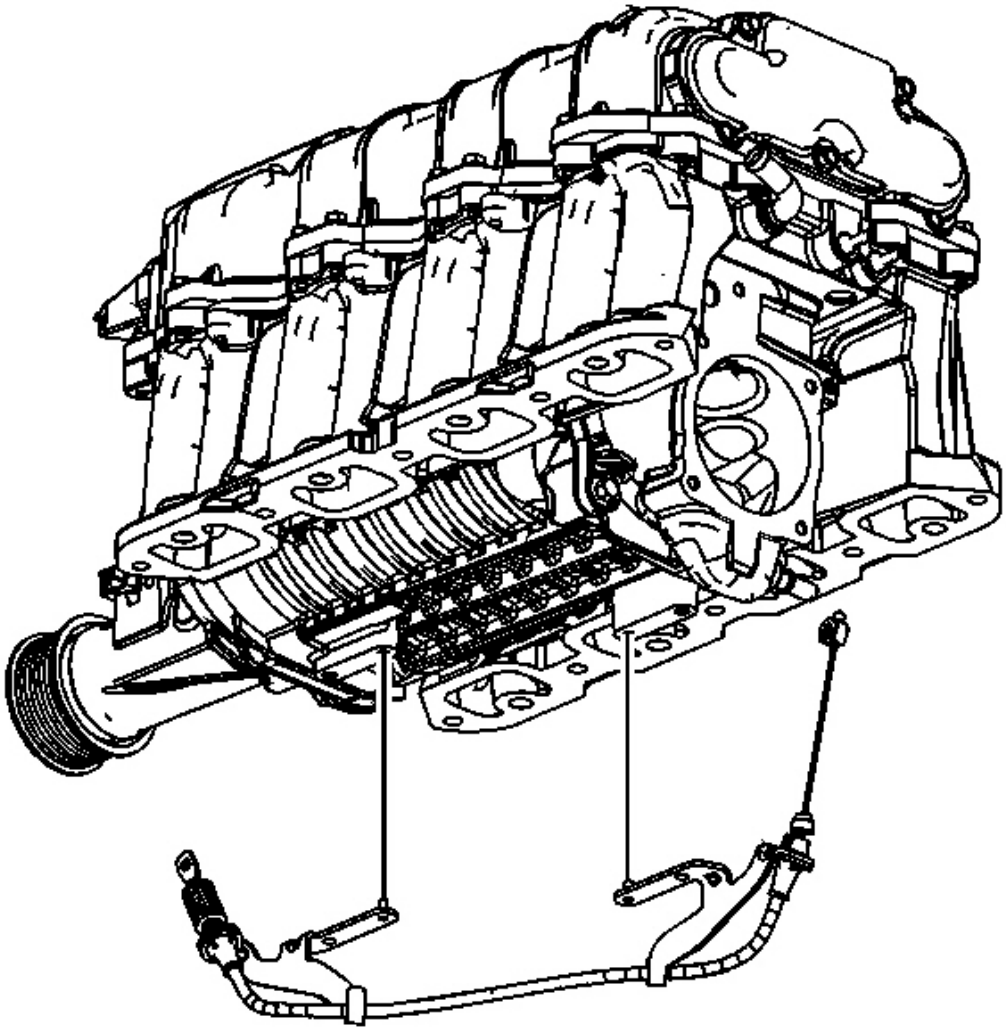


Fig. 117: View Of Bypass Valve Actuator Cable
Courtesy of GENERAL MOTORS CORP.

30. Install the bypass valve actuator cable.

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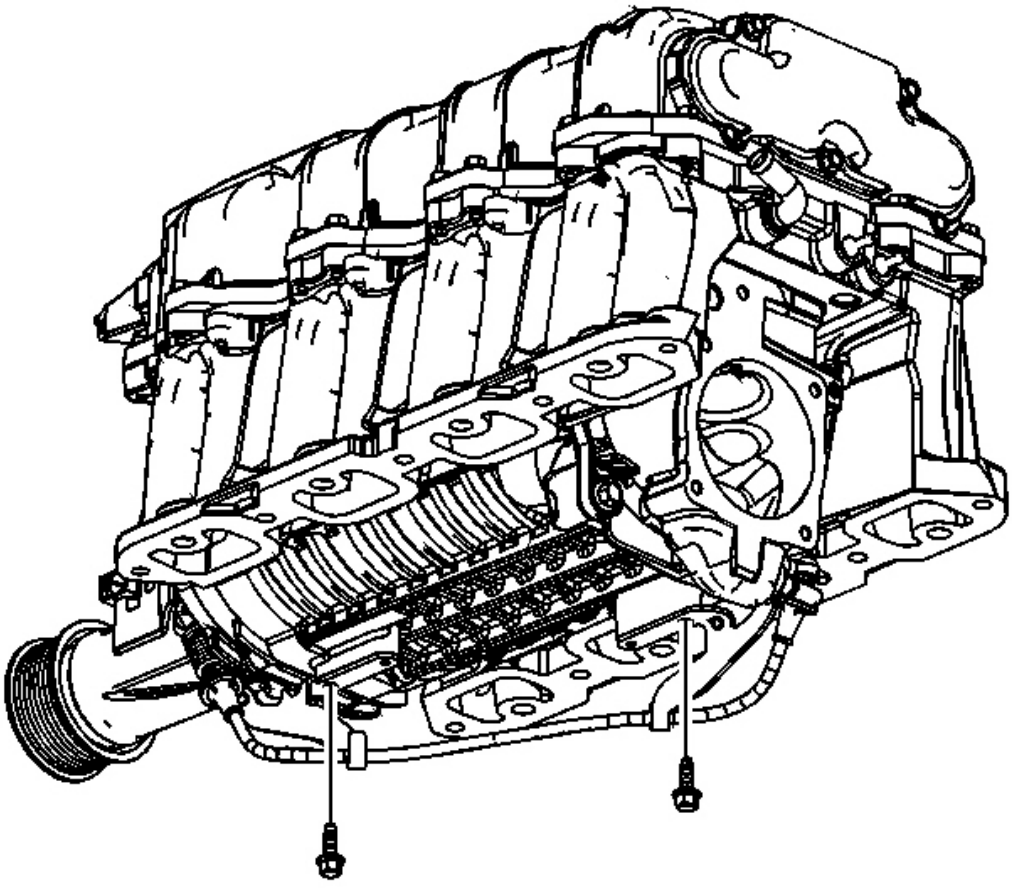


Fig. 118: View Of Bypass Valve Actuator Cable Bracket
Courtesy of GENERAL MOTORS CORP.

31. Install the bypass valve actuator cable bracket bolts to the supercharger.

    Tighten: Tighten the bypass valve actuator cable bracket bolt to 10 N.m (89 lb in).

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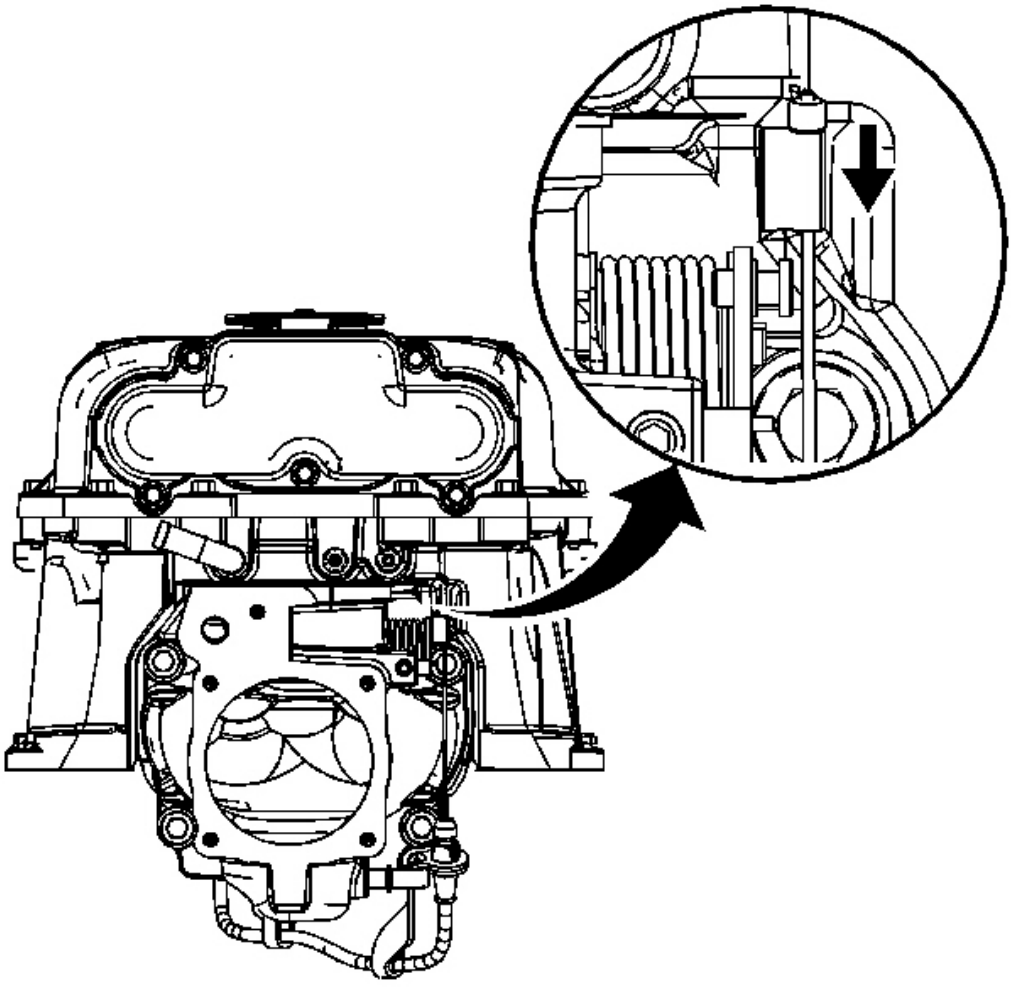


Fig. 119: Identifying Bypass Valve Actuator Cable Clip
Courtesy of GENERAL MOTORS CORP.

32. Slide the bypass valve actuator cable clip onto the pin on the supercharger bypass valve.

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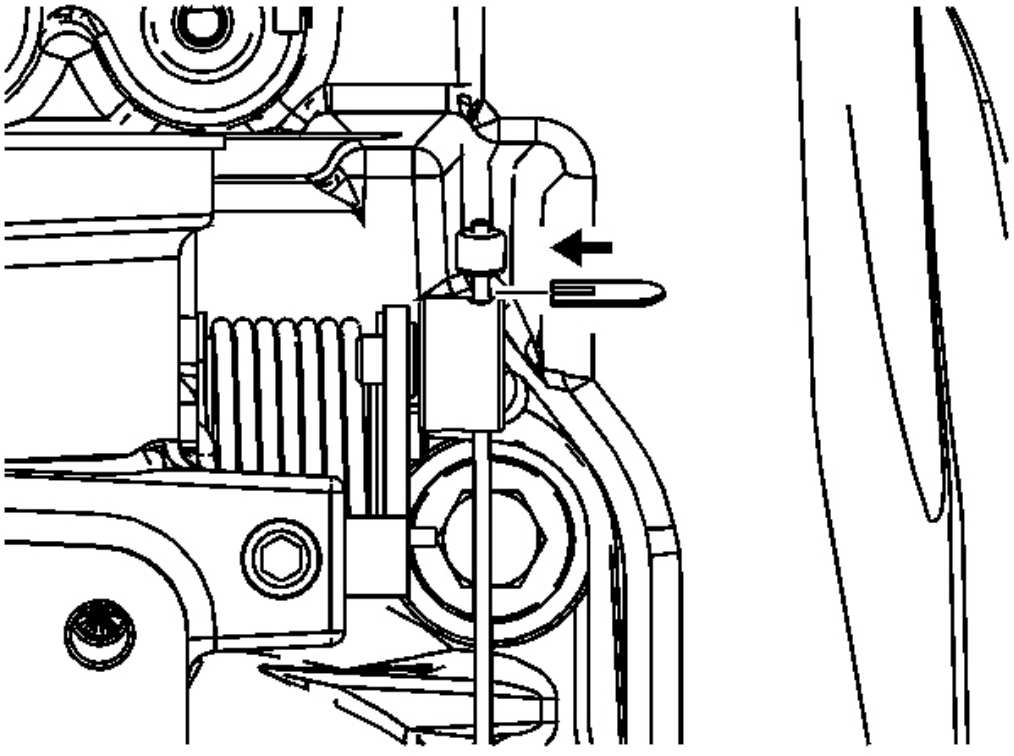


Fig. 120: Locating Retainer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Tool shown is the clip shipped with a new bypass valve actuator cable. The flat end of the EN-47814 can be used for the same purpose.

33. Pull the retainer up on the wire above the bypass valve actuator cable clip in order to install the **EN-47814** . The **EN-47814** must be used to set the necessary slack in the bypass valve actuator cable.
34. Place the **EN-47814** on the cable.

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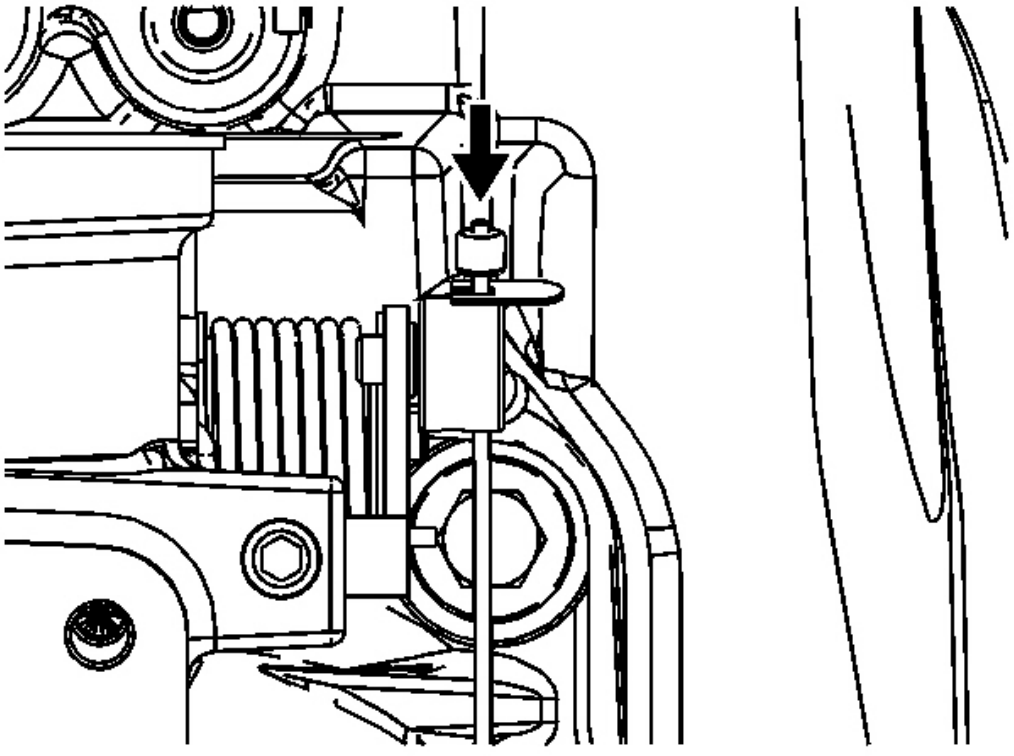


Fig. 121: Locating Retainer
Courtesy of GENERAL MOTORS CORP.

35. Ensure to eliminate the slack in the bypass valve actuator cable by pressing down on the wire retainer.

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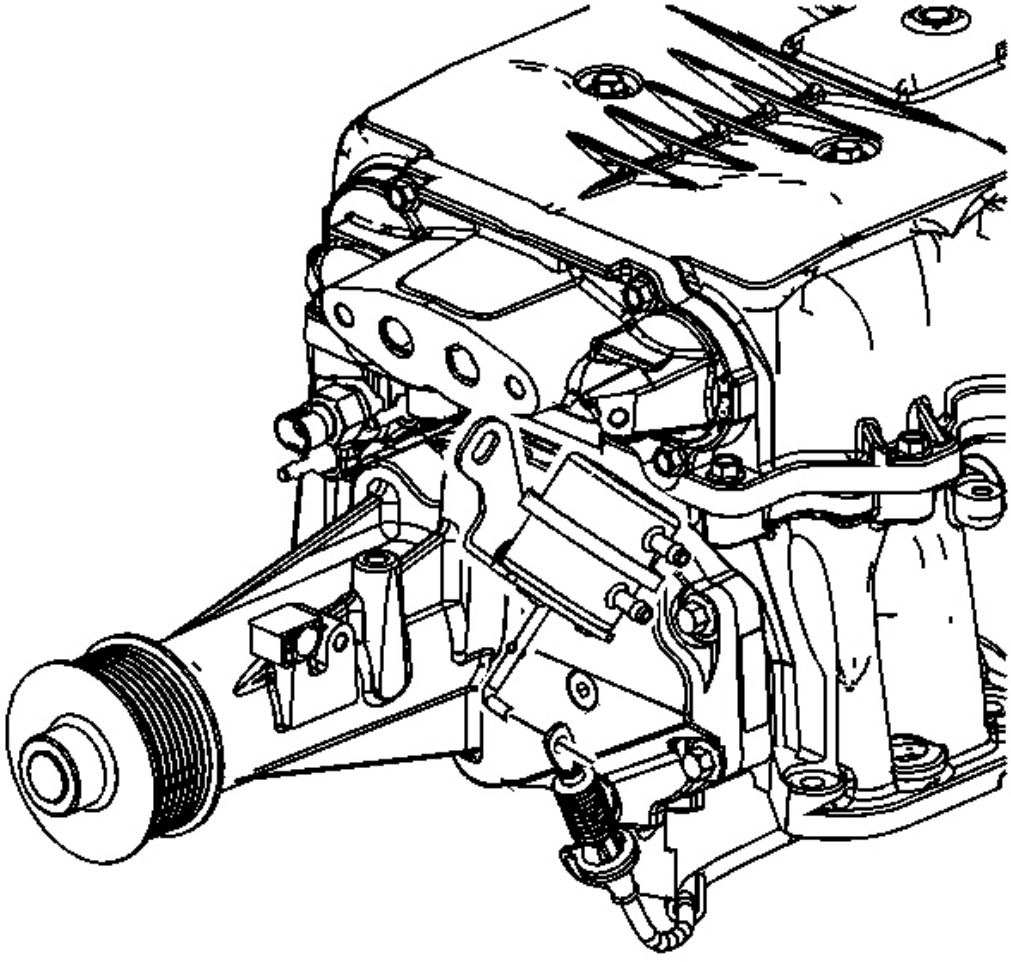


Fig. 122: View Of Bypass Valve Actuator
Courtesy of GENERAL MOTORS CORP.

36. Install the bypass valve actuator.
37. Align the bypass valve actuator rod to the bypass valve actuator cable.

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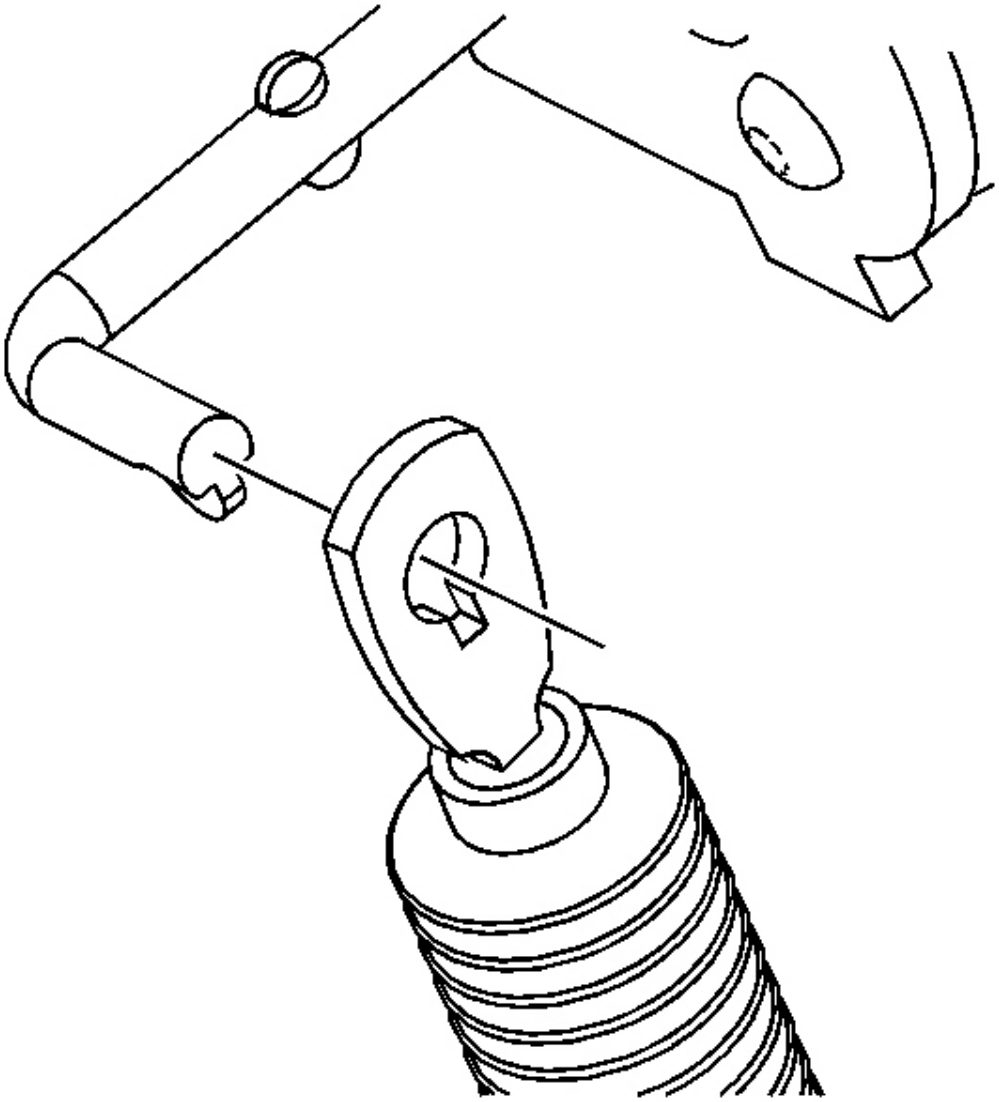


Fig. 123: View Of Bypass Valve Actuator Rod
Courtesy of GENERAL MOTORS CORP.

38. Align the tab on the bypass valve actuator rod with the slot in the bypass valve actuator cable end.
39. Slide the bypass valve actuator rod into the bypass valve actuator cable.

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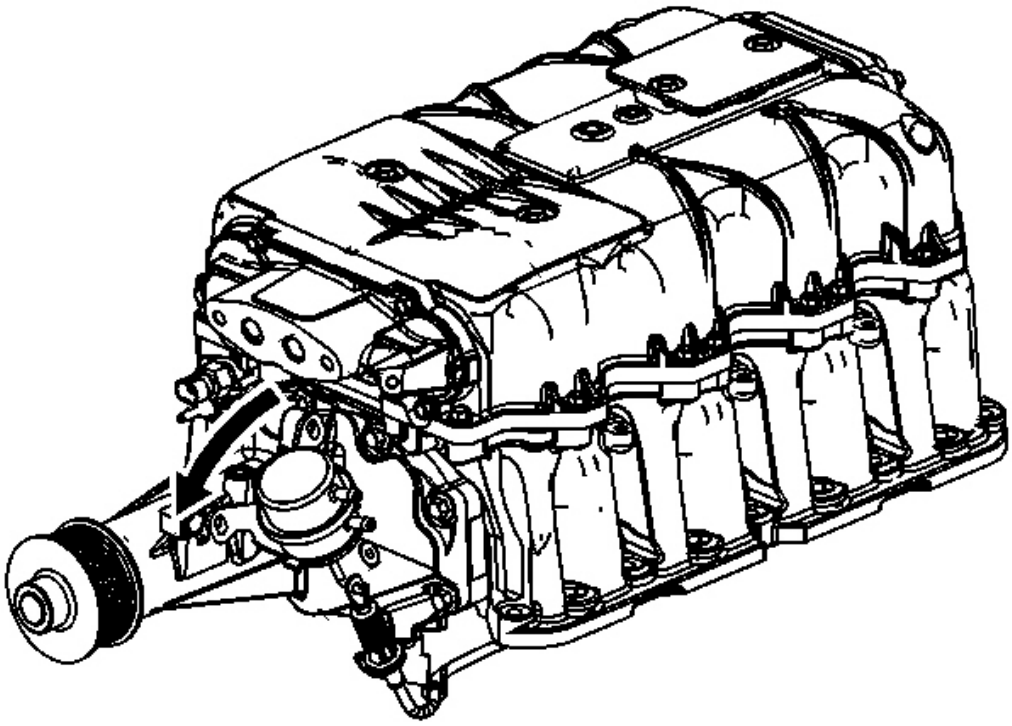


Fig. 124: View Of Bypass Valve Actuator
Courtesy of GENERAL MOTORS CORP.

40. Pivot the bypass valve actuator counterclockwise in order to install bypass valve actuator.

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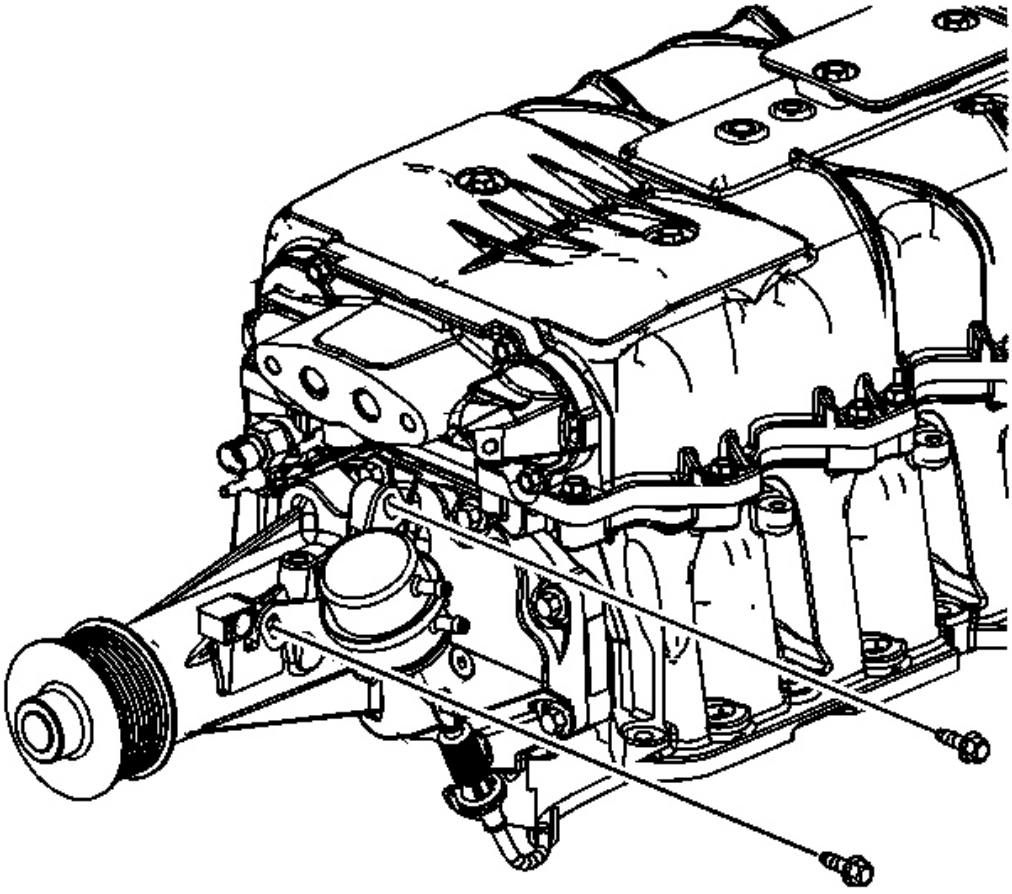


Fig. 125: Locating Bypass Valve Actuator Bolts
Courtesy of GENERAL MOTORS CORP.

41. Loosely install the bypass valve actuator bolts.

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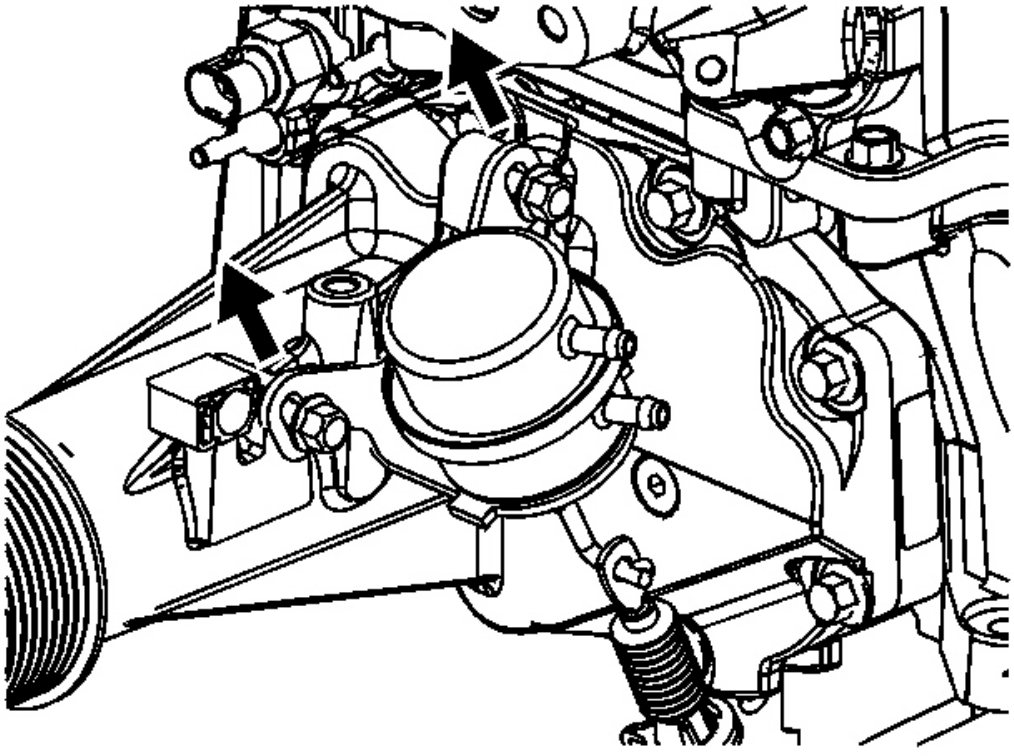


Fig. 126: Identifying Bypass Valve Actuator
Courtesy of GENERAL MOTORS CORP.

42. Pull up on the bypass valve actuator in order to eliminate any slack in the bypass valve actuator cable.

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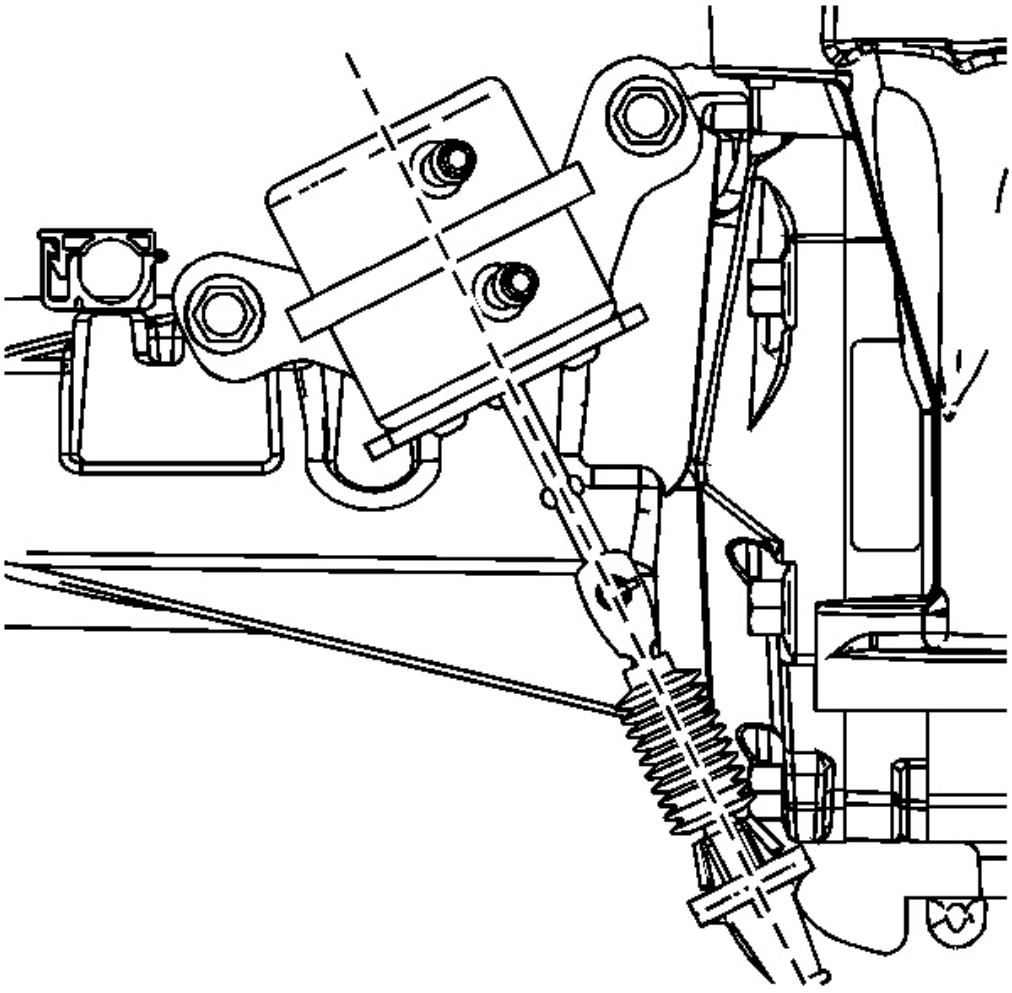


Fig. 127: Locating Bypass Valve Actuator Cable
Courtesy of GENERAL MOTORS CORP.

43. Tighten the bypass valve actuator bolts while maintaining proper alignment between the bypass valve actuator and the bypass valve actuator cable.

    Tighten: Tighten the bypass valve actuator bolt to 10 N.m (89 lb in).

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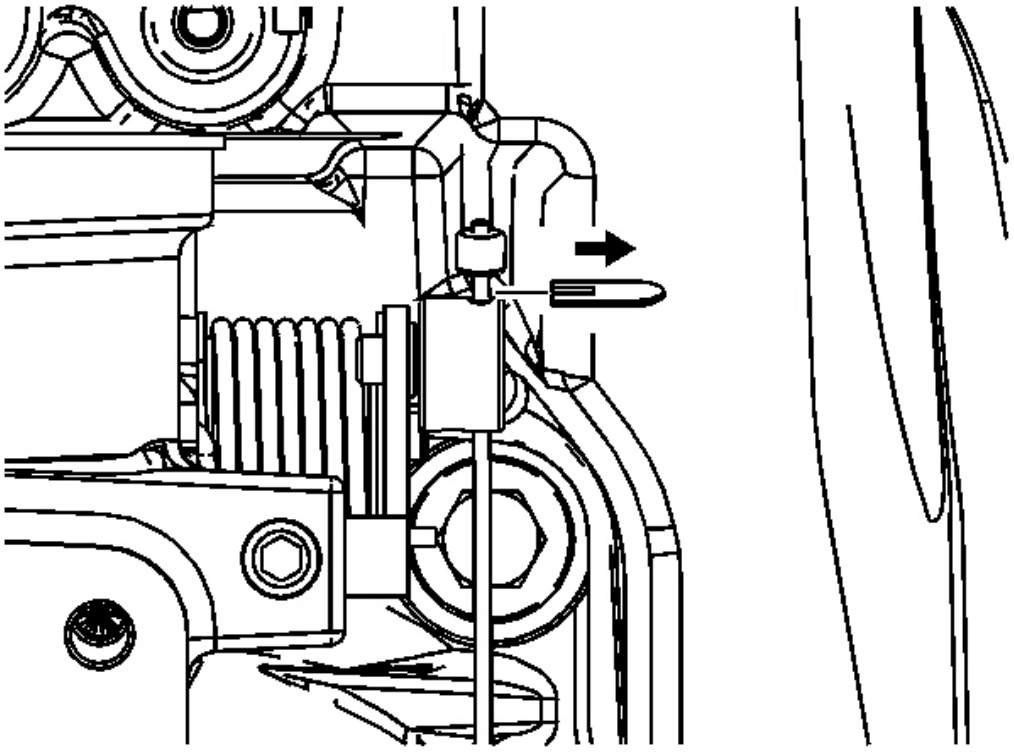


Fig. 128: Locating Retainer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Tool shown is the clip shipped with a new bypass valve actuator cable. The flat end of the EN-47814 can be used for the same purpose.

44. Remove the **EN-47814** on the bypass valve actuator cable at the bypass valve.

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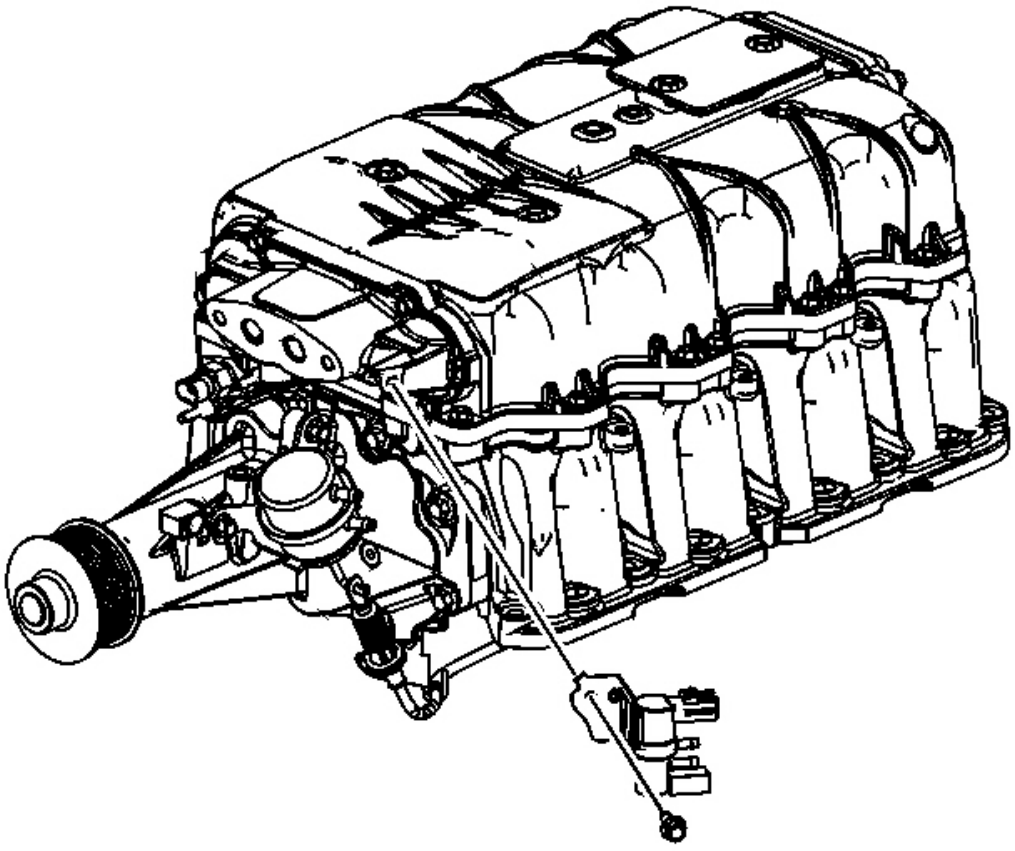


Fig. 129: View Of Supercharger Bypass Regulator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

45. Install the charge air bypass regulator solenoid valve.
46. Install the charge air bypass regulator solenoid valve bolt.

Tighten: Tighten the charge air bypass regulator solenoid valve bolt to 10 N.m (89 lb in).

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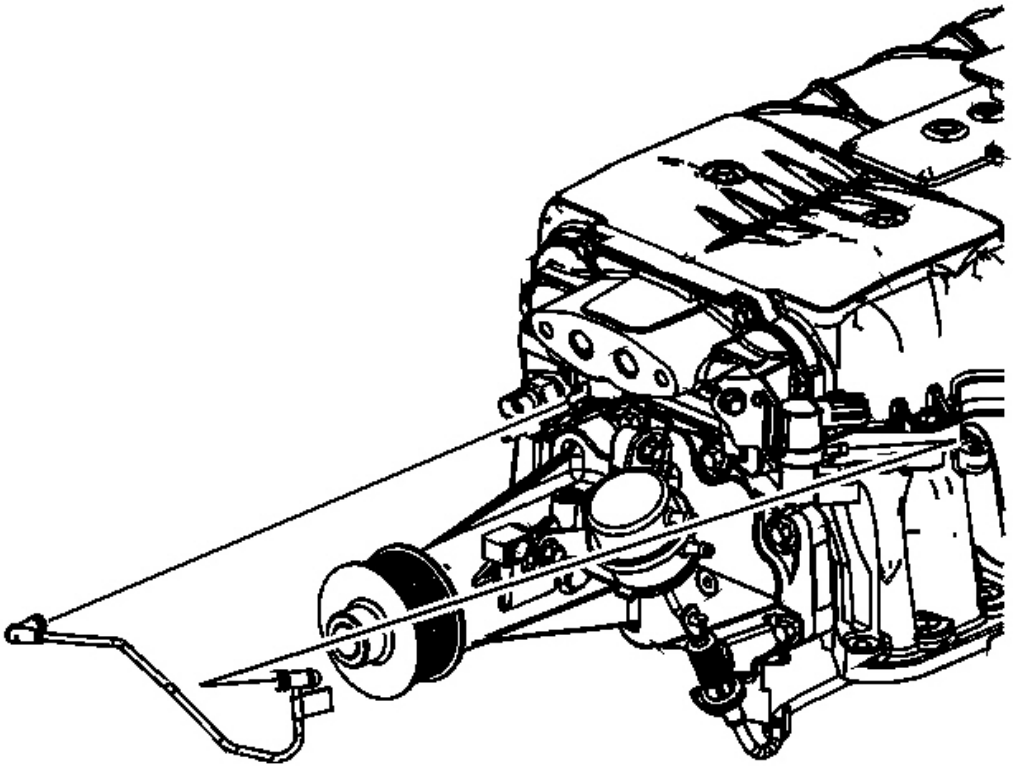


Fig. 130: Identifying Charge Air Bypass Regulator Solenoid Valve Pressure Hose
Courtesy of GENERAL MOTORS CORP.

47. Install the charge air bypass regulator solenoid valve pressure hose.

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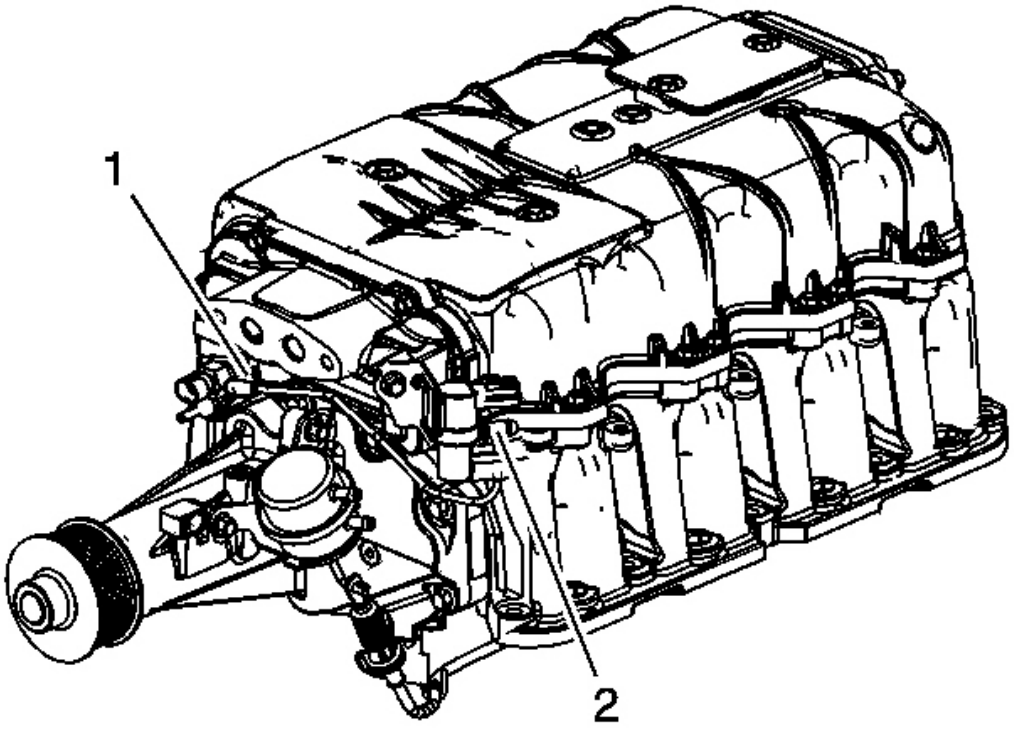


Fig. 131: View Of Charge Air Bypass Regulator Solenoid Valve Pressure Hose
Courtesy of GENERAL MOTORS CORP.

48. Connect the charge air bypass regulator solenoid valve pressure hose at the supercharger pressure port (1).
49. Connect the charge air bypass regulator solenoid valve pressure hose at the upper port of the charge air bypass regulator solenoid valve (2).

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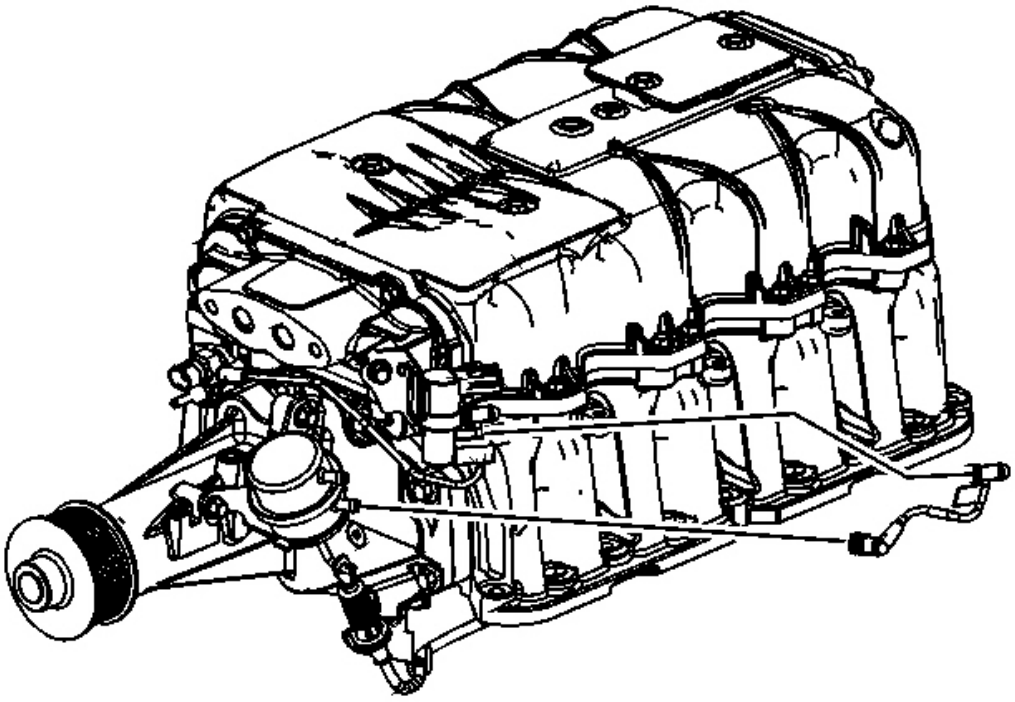


Fig. 132: View Of Bypass Valve Actuator Pressure Hose
Courtesy of GENERAL MOTORS CORP.

50. Install the bypass valve actuator pressure hose.

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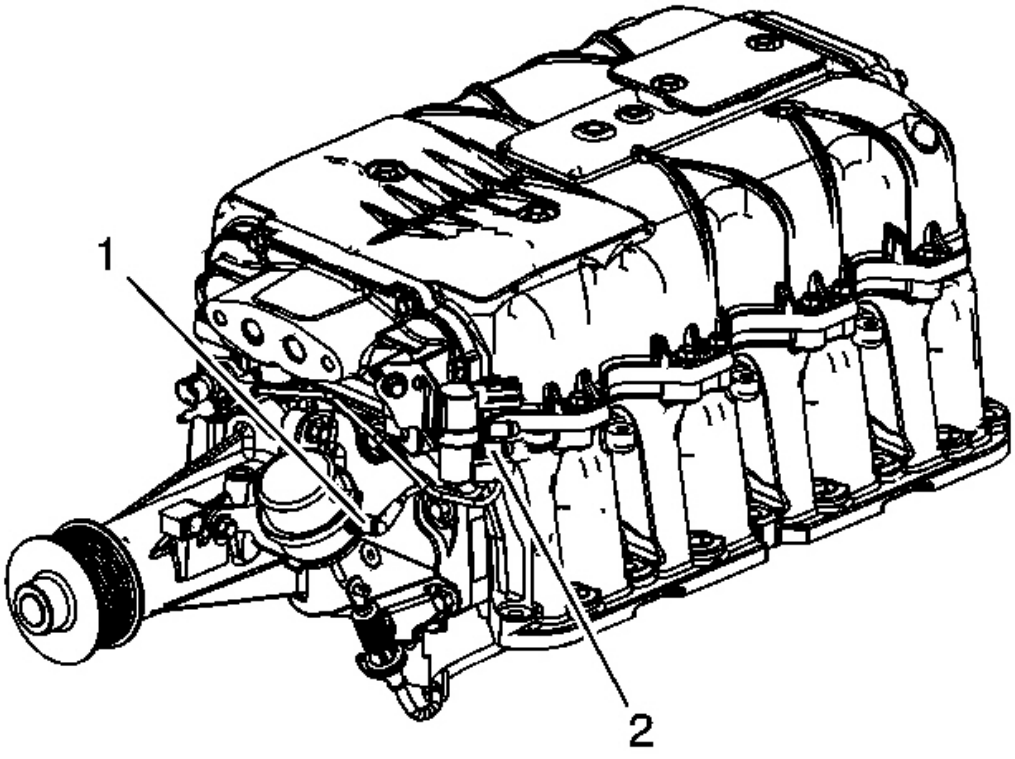


Fig. 133: View Of Supercharger Bypass Valve Actuator
Courtesy of GENERAL MOTORS CORP.

51. Connect the bypass valve actuator pressure hose at the lower port of the supercharger bypass valve actuator (1).
52. Connect the bypass valve actuator pressure hose at the lower port of the charge air bypass regulator solenoid valve (2).

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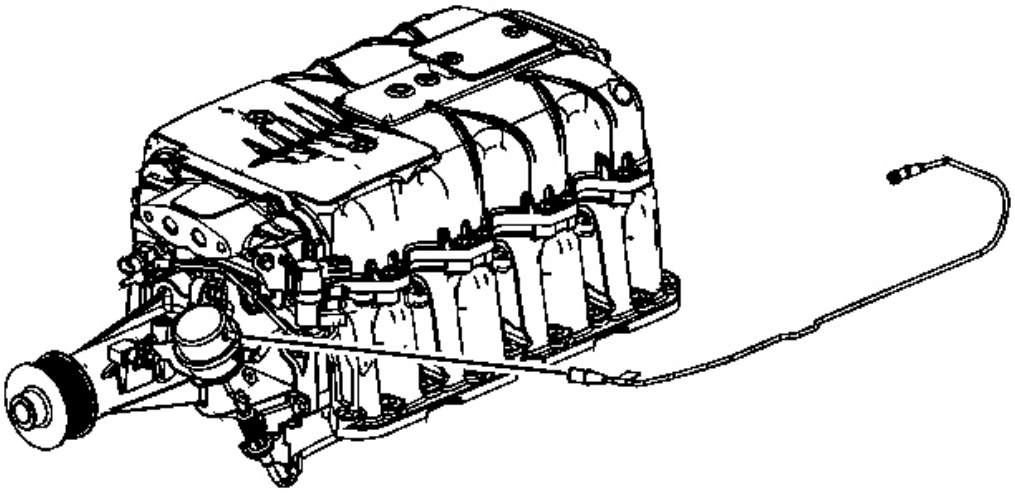


Fig. 134: View Of Bypass Valve Actuator Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

53. Install the bypass valve actuator vacuum hose to the supercharger.

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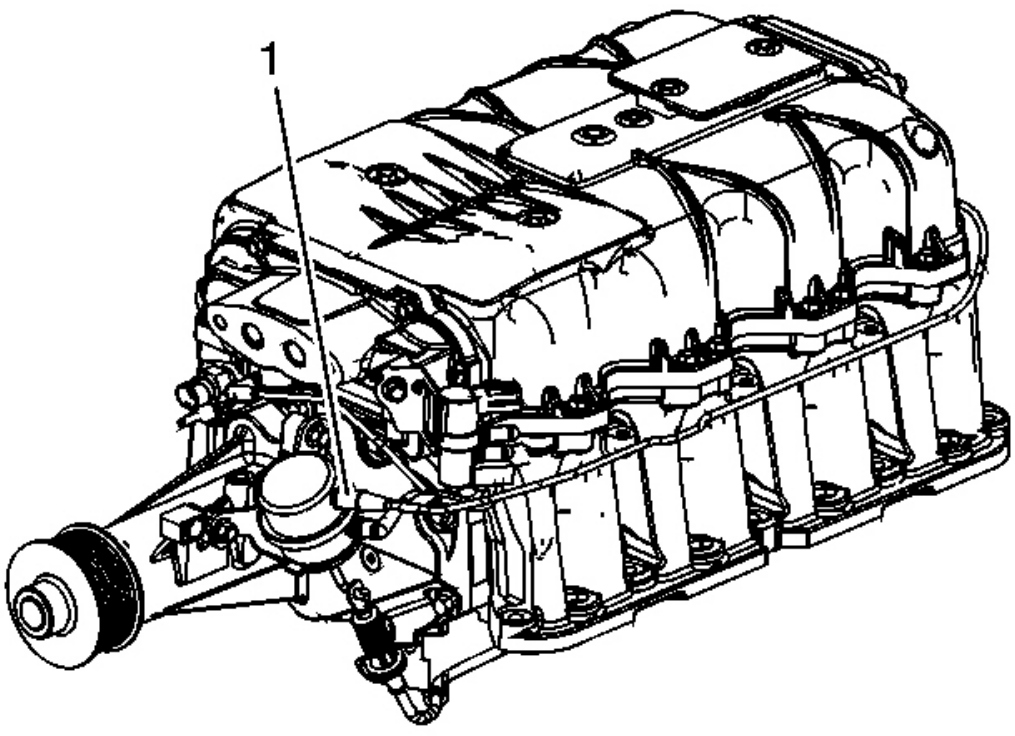


Fig. 135: View Of Supercharger Bypass Valve Actuator
Courtesy of GENERAL MOTORS CORP.

54. Connect the bypass valve actuator vacuum hose at the upper port of the supercharger bypass valve actuator (1).

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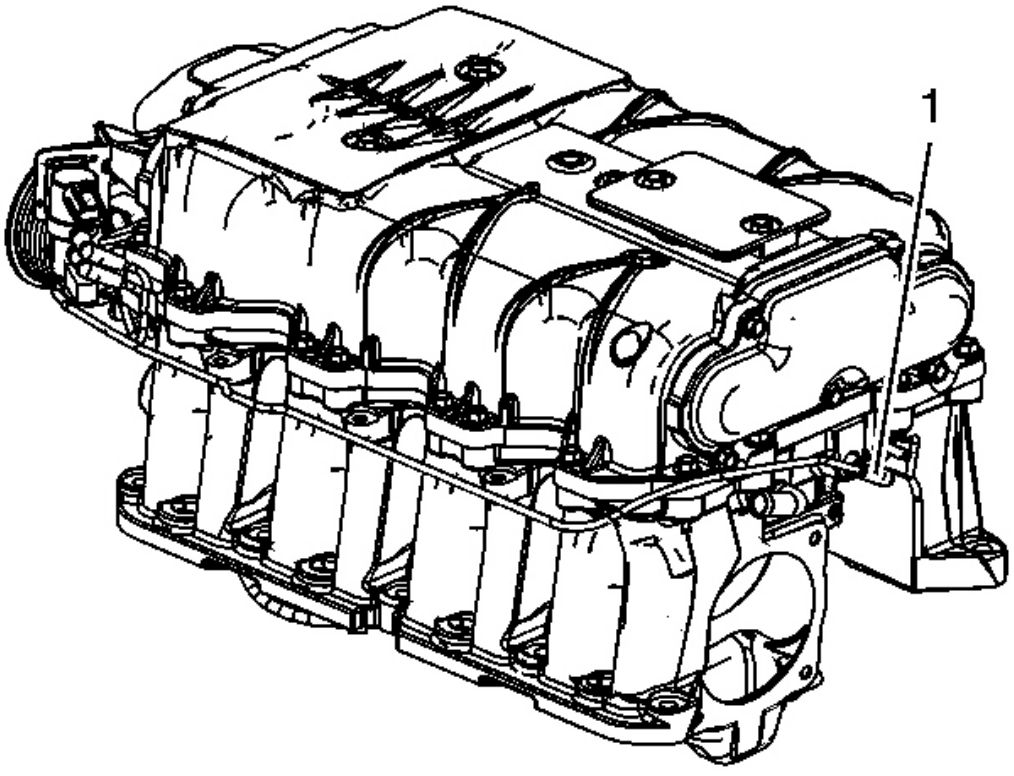


Fig. 136: View Of Supercharger Vacuum Port
Courtesy of GENERAL MOTORS CORP.

55. Connect the bypass valve actuator vacuum hose at the center small vacuum port of the supercharger (1).

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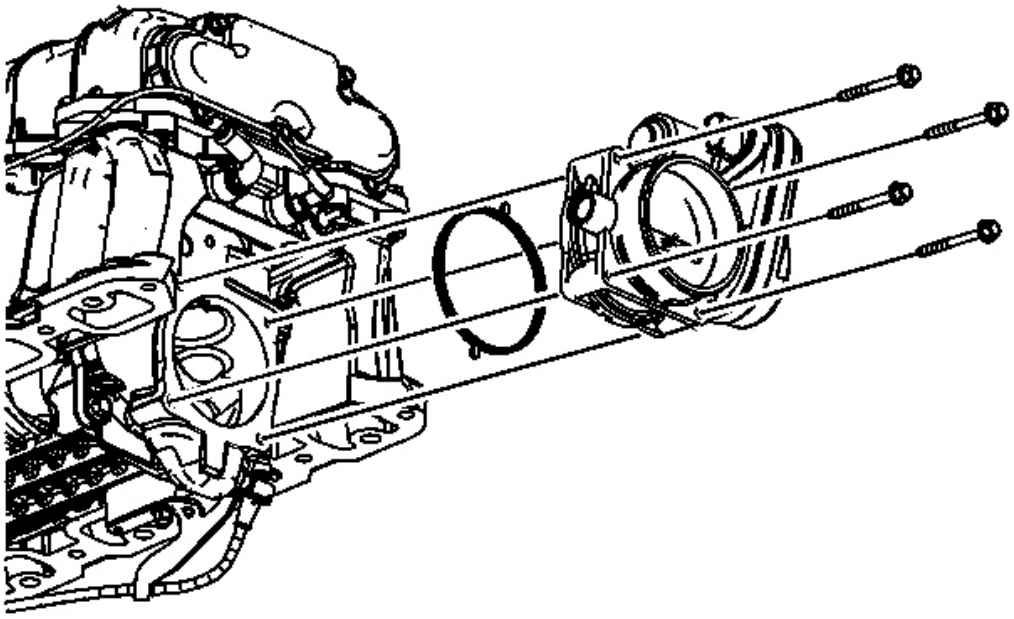


Fig. 137: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

56. Install the NEW throttle body O-ring.
57. Install the throttle body.
58. Install the throttle body bolts.

Tighten: Tighten the throttle body bolt to 10 N.m (89 lb in).

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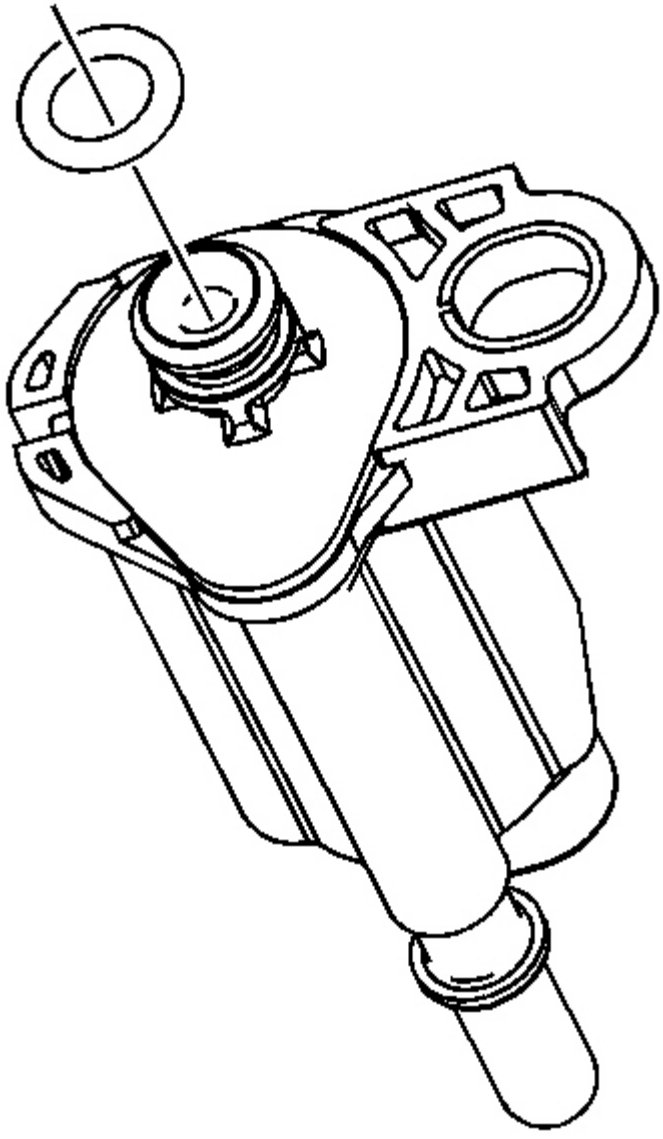


Fig. 138: View Of EVAP Canister Purge Solenoid Valve O-Ring
Courtesy of GENERAL MOTORS CORP.

59. Install the NEW O-ring onto the EVAP canister purge solenoid valve.

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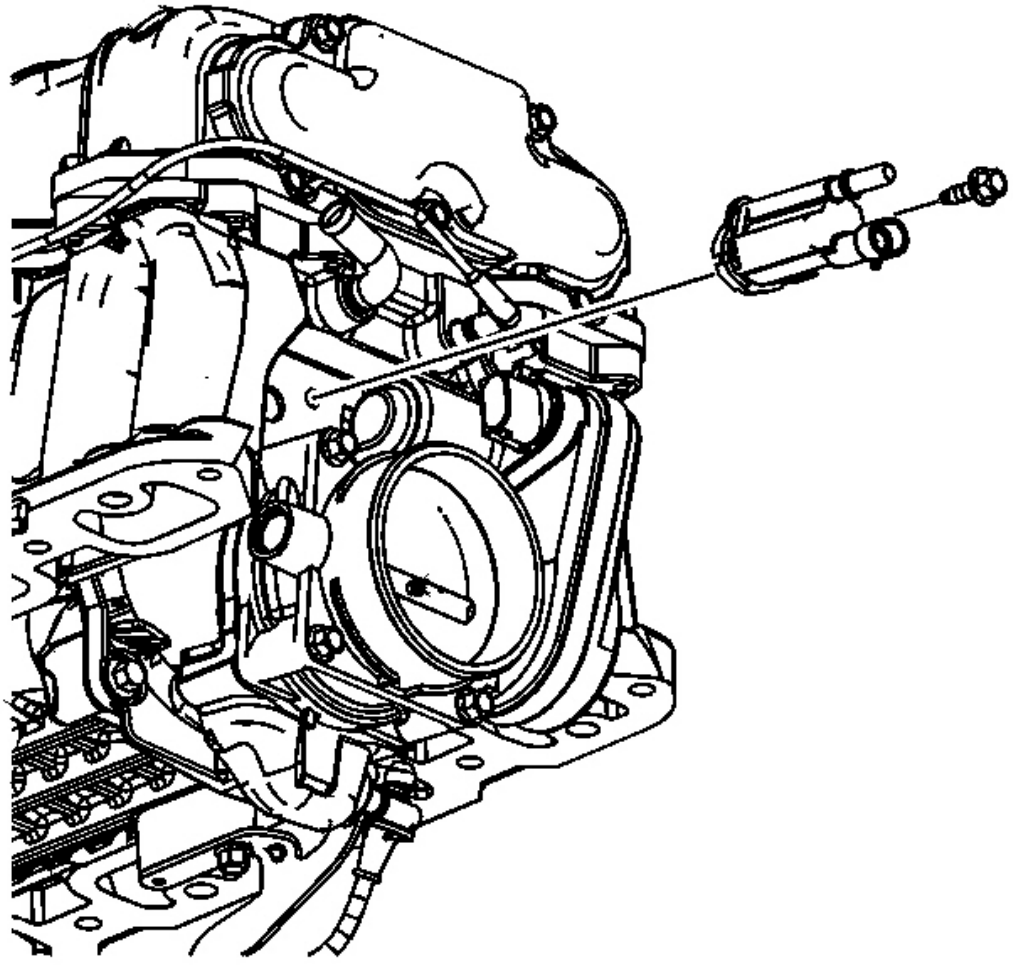


Fig. 139: View Of EVAP Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

60. Install the EVAP canister purge solenoid valve.
61. Install the EVAP canister purge solenoid valve bolt.

Tighten: Tighten the EVAP canister purge solenoid valve bolt to 10 N.m (89 lb in).

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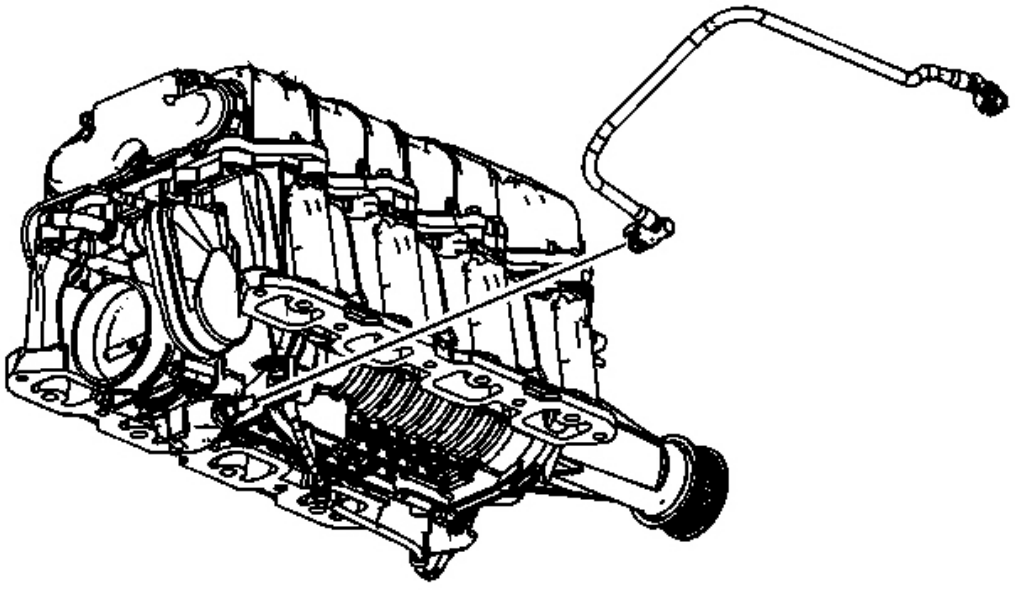


Fig. 140: Identifying PCV Dirty Air Tube
Courtesy of GENERAL MOTORS CORP.

62. Install and connect the dirty air PCV tube onto the supercharger.

EXHAUST MANIFOLD CLEANING AND INSPECTION - LEFT SIDE

CLEANING PROCEDURE

1. Clean the exhaust manifold exterior in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the exhaust manifold with compressed air.

INSPECTION PROCEDURE

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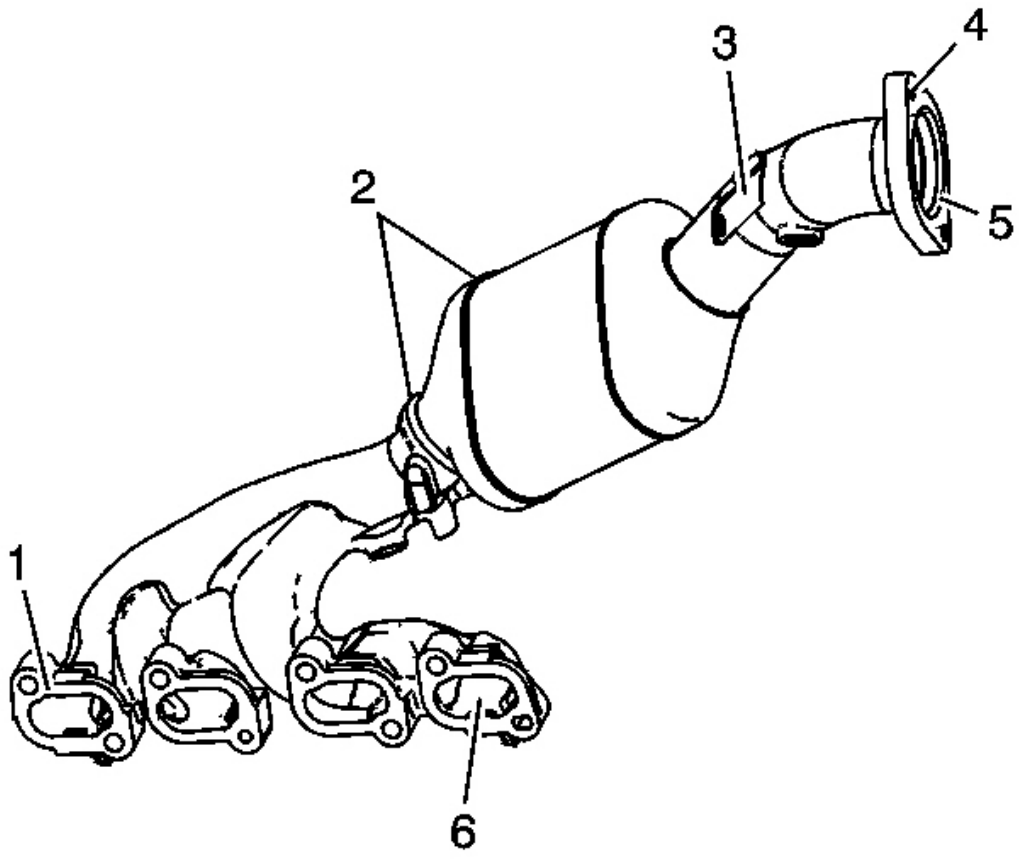


Fig. 141: Inspecting Left Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Inspect the left exhaust manifold for the following:
   - Damage to the exhaust manifold-to-cylinder head gasket sealing surface (1)
   - Damage or broken welds (2)
   - Damage to the support bracket (3)
   - Damage to the threads in the exhaust pipe flange (4)
   - Damage to the exhaust pipe flange sealing surface (5)
   - Damage or restrictions within the exhaust passages (6)

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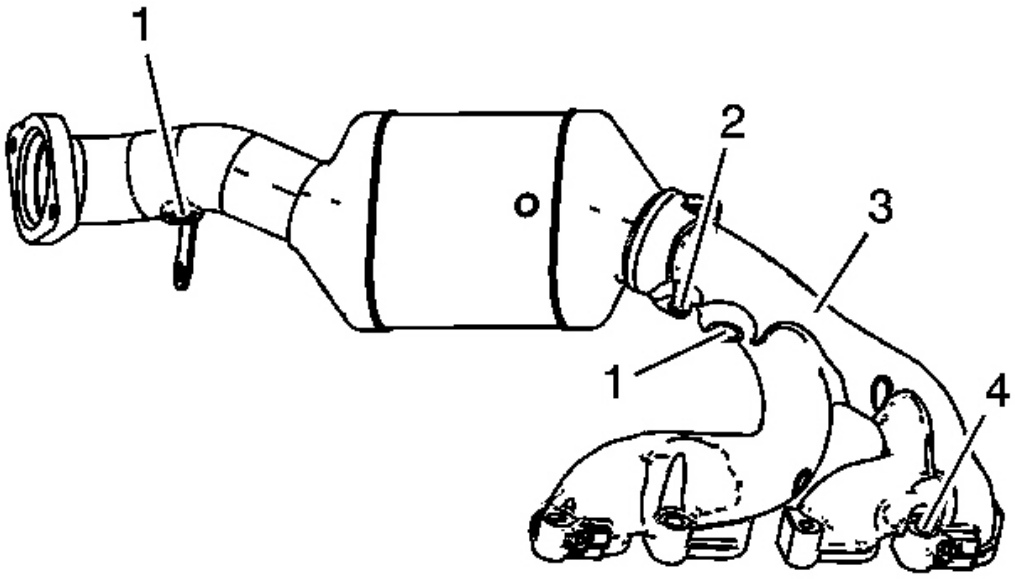


Fig. 142: Additional Inspection Areas Of Left Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

2. Inspect the left exhaust manifold for the following:
   - Damage to the oxygen sensor threaded hole (1)
   - Damage to the threads for the heat shield mounting (2)
   - Damage or excessive corrosion to the exhaust manifold exterior (3)
   - Damage to the exhaust manifold-to-cylinder head mounting holes (4)
3. Repair or replace the exhaust manifold and/or components as necessary.

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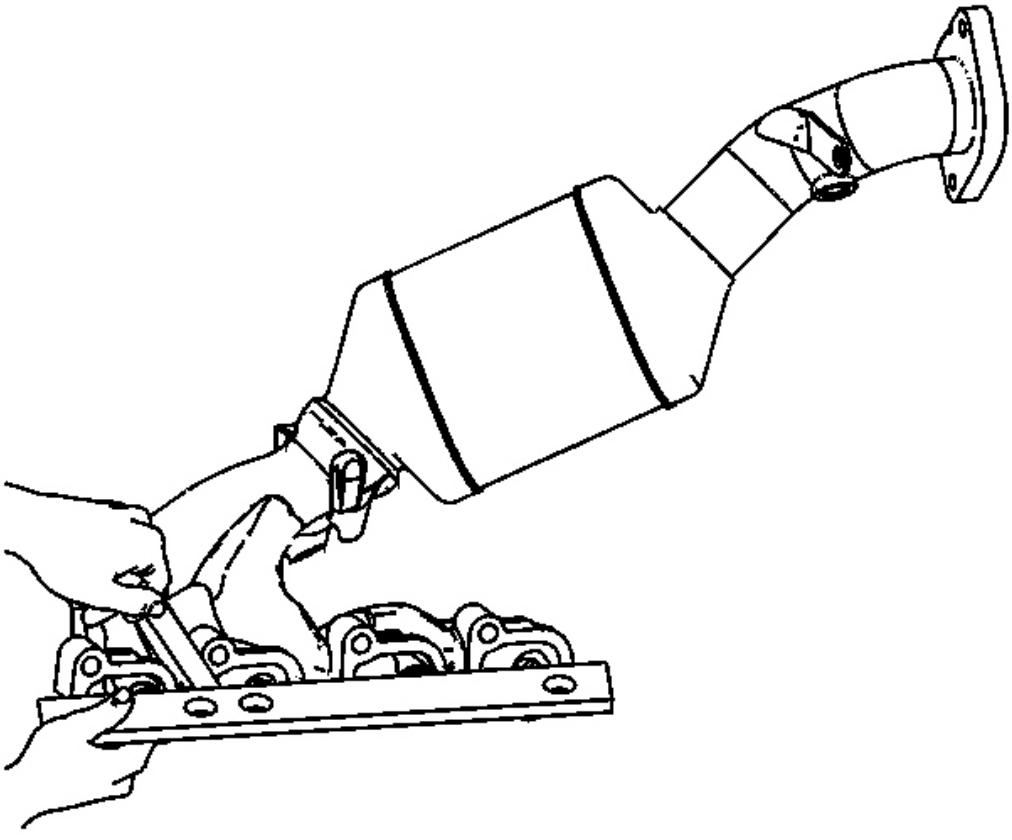


Fig. 143: Measuring Alignment & Surface Flatness Of Exhaust Manifold Flanges
Courtesy of GENERAL MOTORS CORP.

4. Measure the alignment or surface flatness of the exhaust manifold flanges, using a straight edge and a feeler gage. Exhaust manifold surface flatness must not exceed 0.254 mm (0.010 in).
5. If the surface flatness is not within specifications, the exhaust manifold is warped and must be replaced.

EXHAUST MANIFOLD CLEANING AND INSPECTION - RIGHT SIDE

CLEANING PROCEDURE

1. Clean the exhaust manifold exterior in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

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2. Dry the exhaust manifold with compressed air.

INSPECTION PROCEDURE

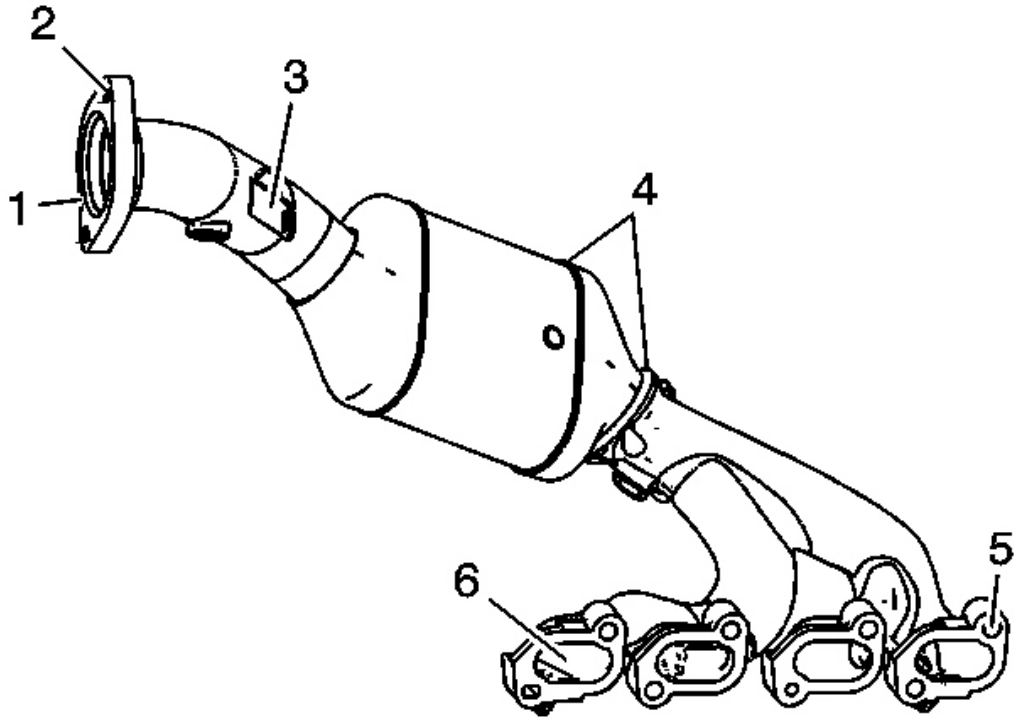


Fig. 144: Inspecting Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Inspect the right exhaust manifold for the following:
   - Damage to the exhaust pipe flange sealing surface (1)
   - Damage to the threads in the exhaust pipe flange (2)
   - Damage to the support bracket (3)
   - Damage or broken welds (4)
   - Damage to the exhaust manifold-to-cylinder head gasket sealing surface (5)
   - Damage or restrictions within the exhaust passages (6)

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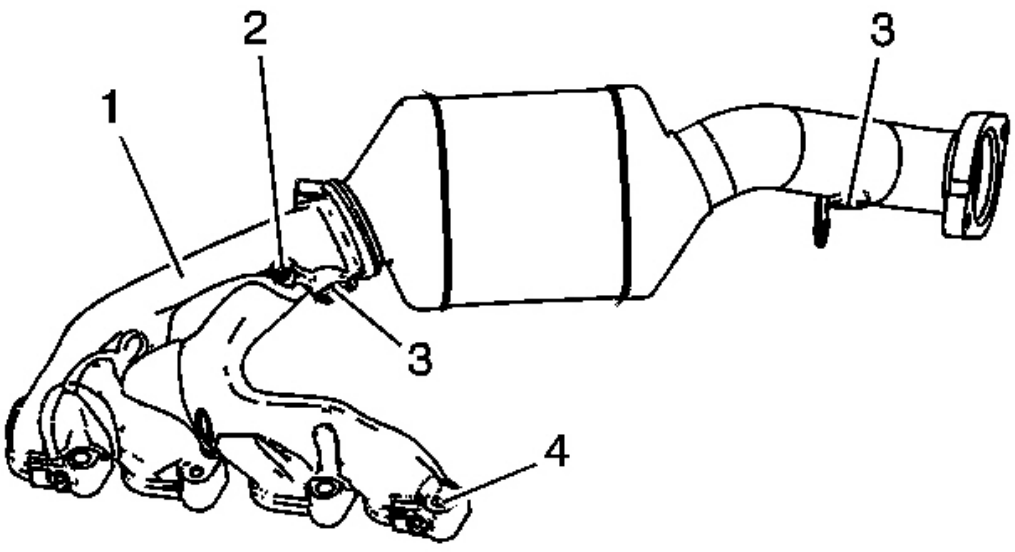


Fig. 145: Additional Inspection Areas Of Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

2. Inspect the right exhaust manifold for the following:
   - Damage or excessive corrosion to the exhaust manifold exterior (1)
   - Damage to the threads for the heat shield mounting (2)
   - Damage to the oxygen sensor threaded hole (3)
   - Damage to the exhaust manifold-to-cylinder head mounting holes (4)
3. Repair or replace the exhaust manifold and/or components as necessary.

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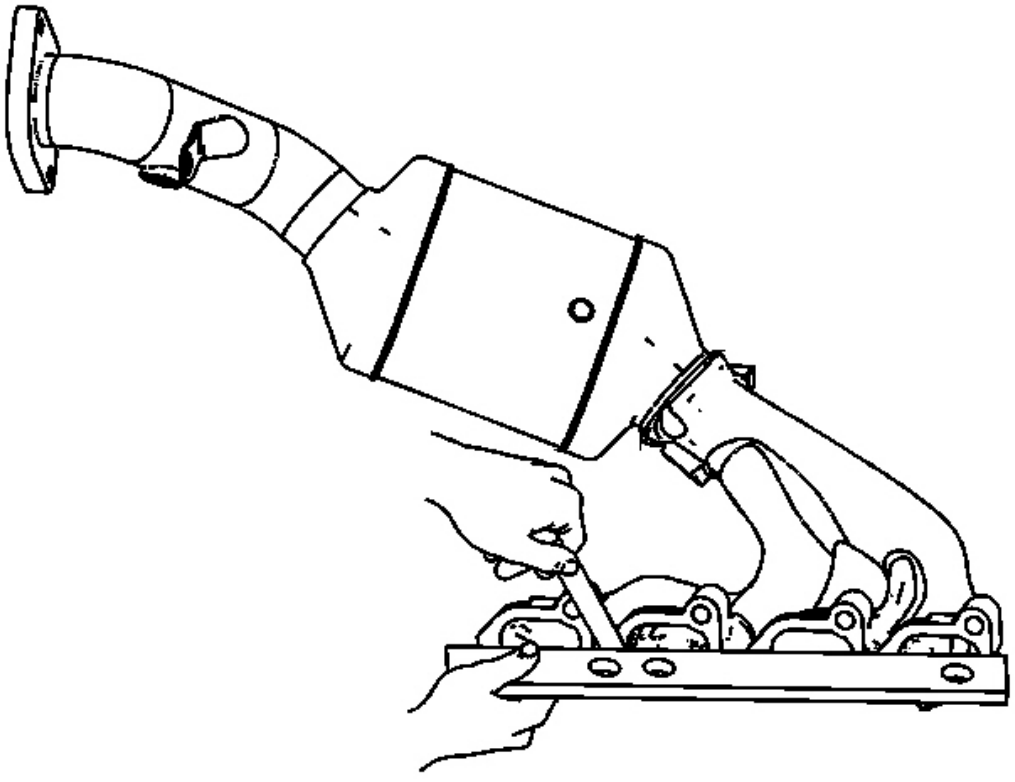


Fig. 146: Measuring Alignment & Surface Flatness Of Exhaust Manifold Flanges
Courtesy of GENERAL MOTORS CORP.

4. Measure the alignment or surface flatness of the exhaust manifold flanges, using a straight edge and a feeler gage. Exhaust manifold surface flatness must not exceed 0.254 mm (0.010 in).
5. If the surface flatness is not within specifications, the exhaust manifold is warped and must be replaced.

WATER OUTLET HOUSING DISASSEMBLE

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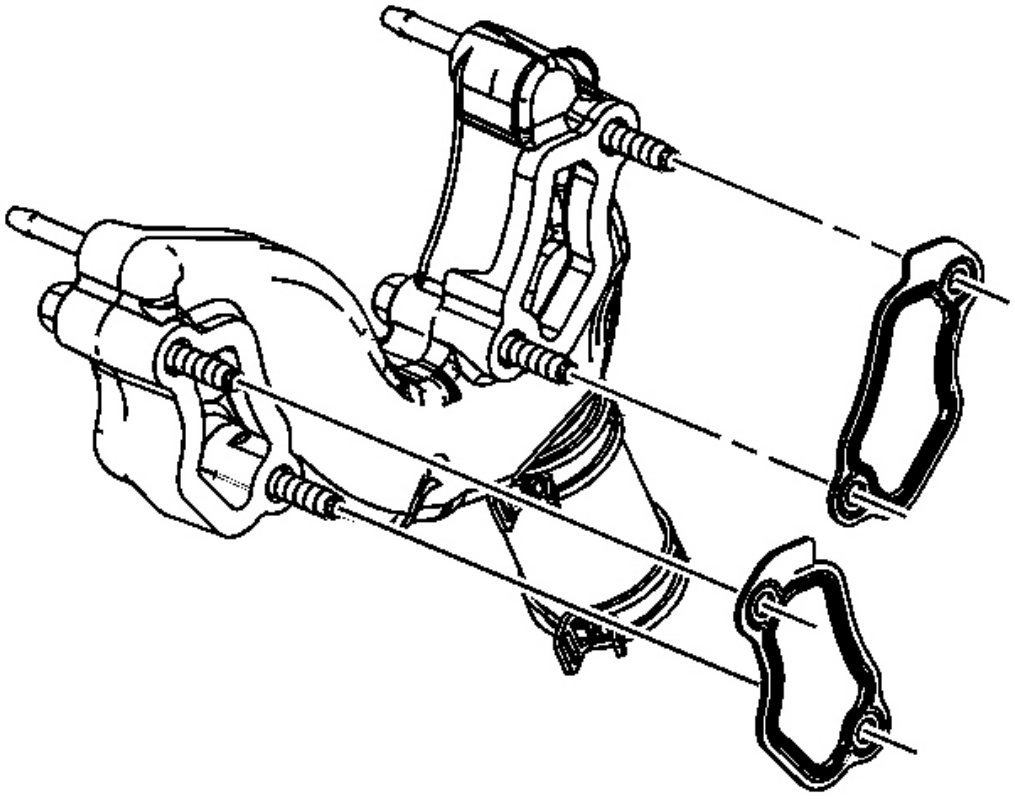


Fig. 147: View Of Water Outlet Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the water outlet gaskets.

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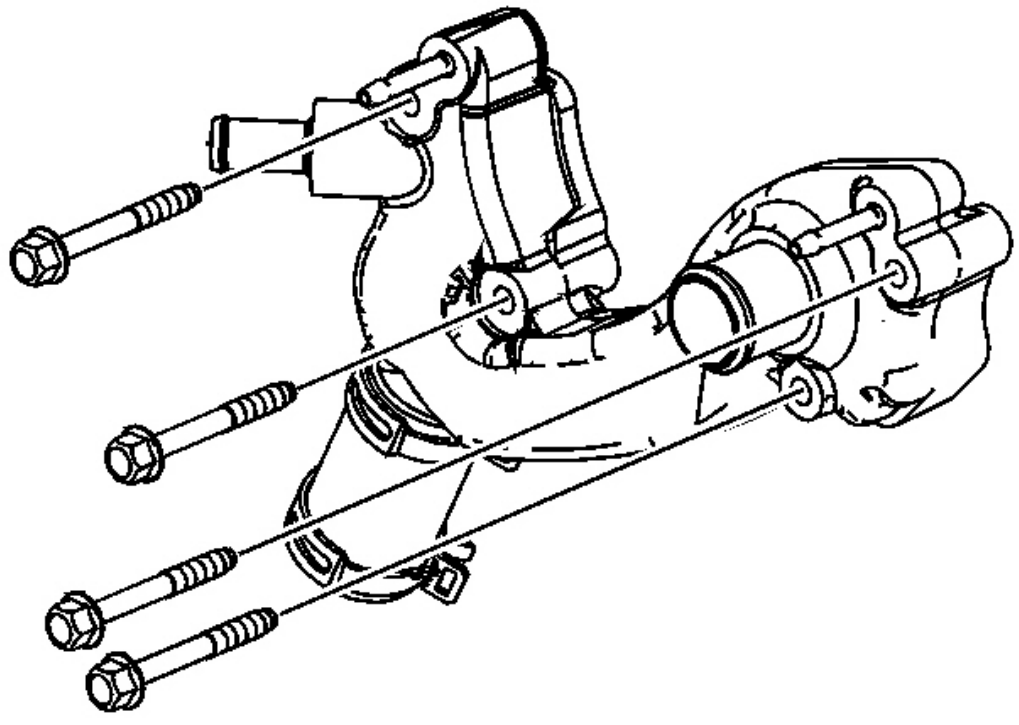


Fig. 148: Identifying Water Outlet Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the water outlet bolts

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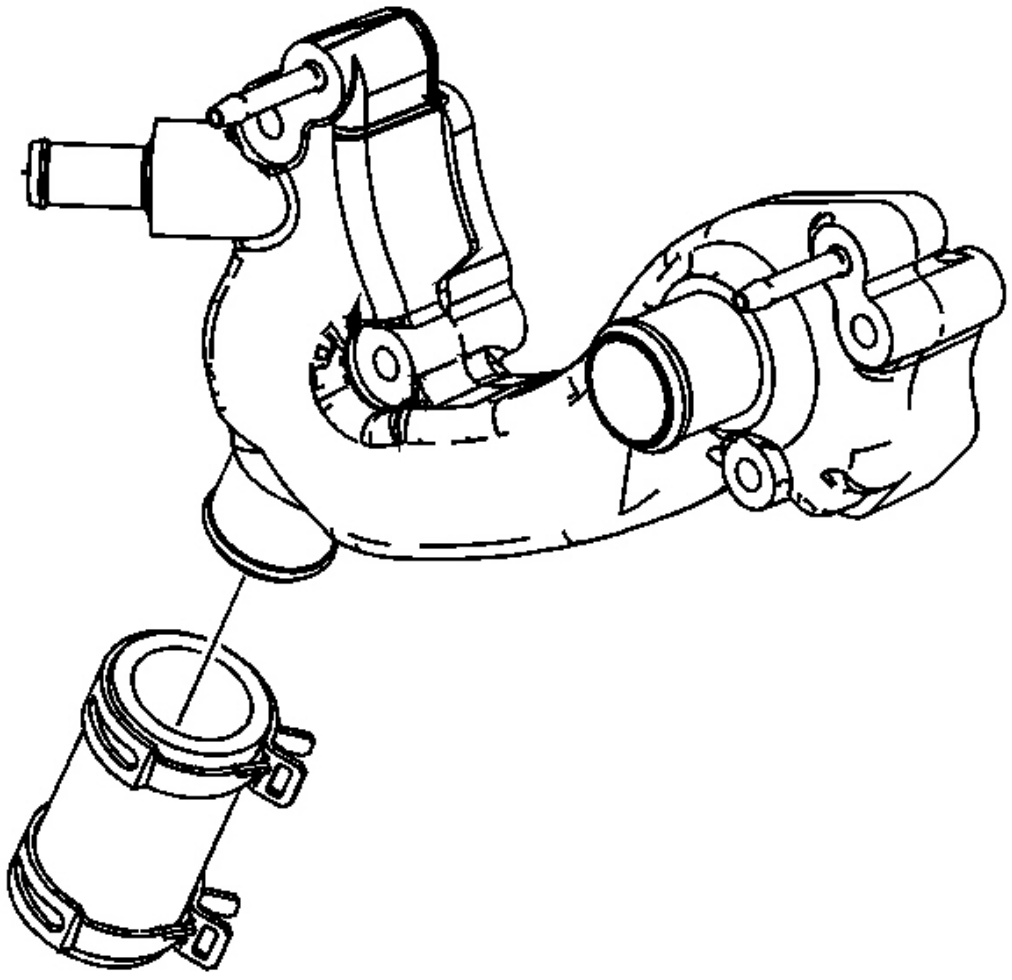


Fig. 149: Identifying Bypass Hose
Courtesy of GENERAL MOTORS CORP.

3. Release and reposition the bypass hose clamp.
4. Remove and discard the bypass hose.

WATER OUTLET HOUSING CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the water outlet housing with solvent.

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CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the water outlet housing with compressed air.

INSPECTION PROCEDURE

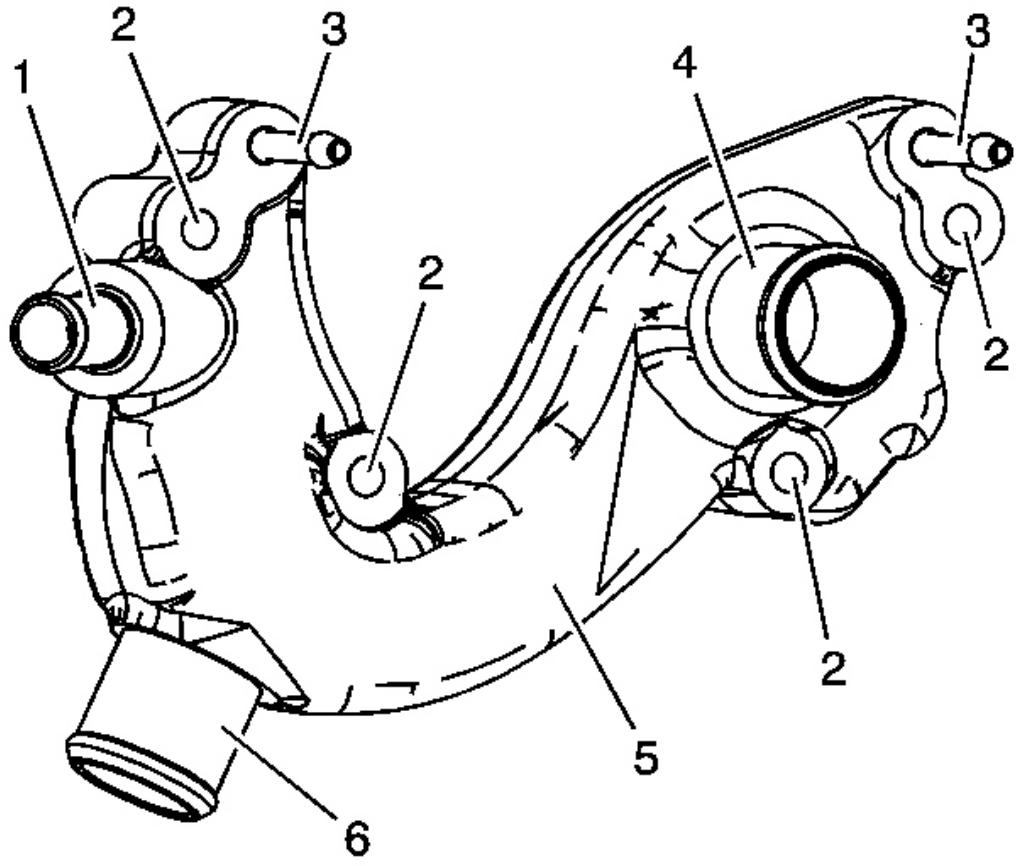


Fig. 150: Water Outlet Housing
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the water outlet housing for the following:
   - Damage or restrictions to the radiator hose connection (1)
   - Damage to the water outlet housing-to-cylinder head mounting holes (2)
   - Damage to the engine coolant air bleed fitting (3)

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- Damage or restrictions to the radiator hose connection (4)
- Damage to the water outlet housing (5)
- Damage or restrictions to the bypass hose connection (6)

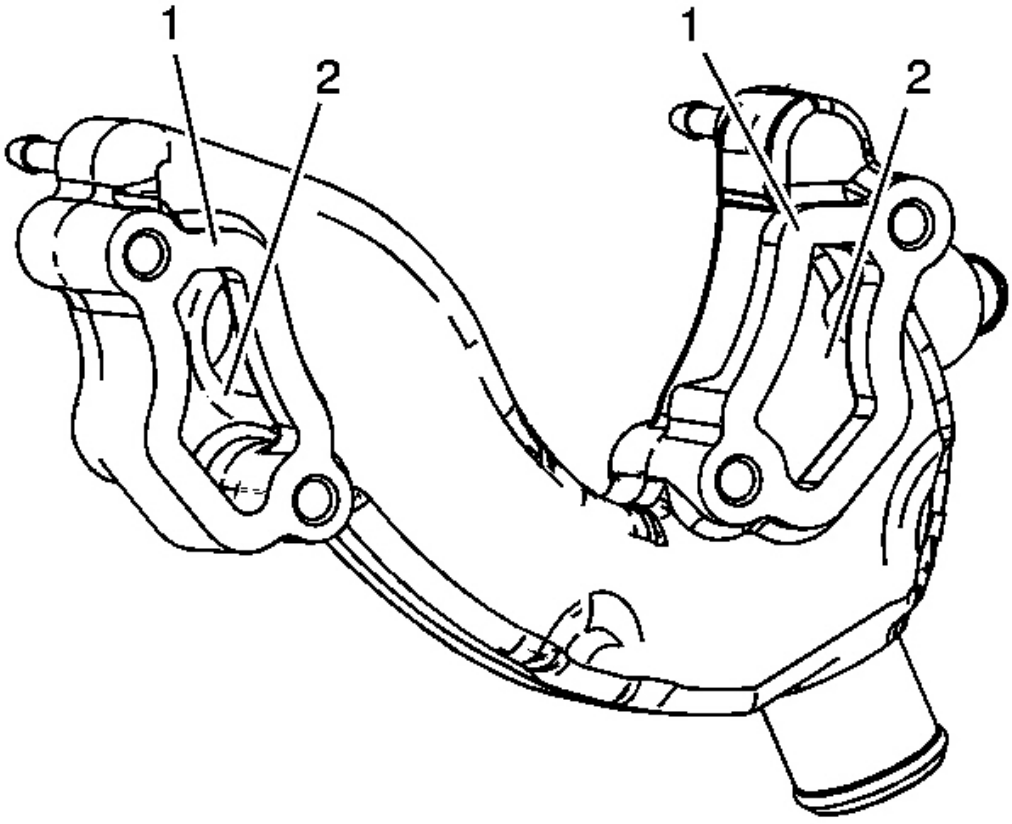


Fig. 151: Water Outlet Housing
Courtesy of GENERAL MOTORS CORP.

2. Inspect the rear of the water outlet housing for the following:
   - Damage to the gasket sealing surface (1)
   - Damage, blockage or excessive corrosion to the engine coolant passages (2)
3. Repair or replace the water outlet housing as necessary.

WATER OUTLET HOUSING ASSEMBLE

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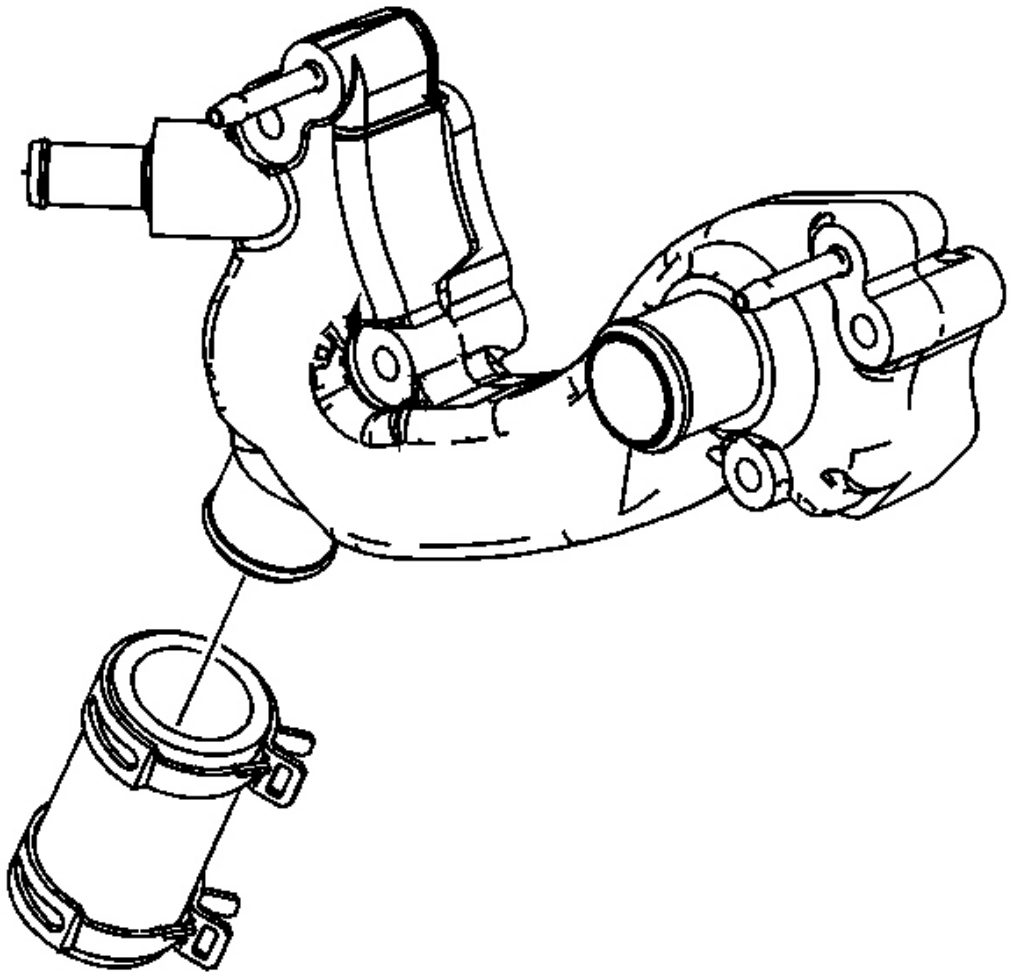


Fig. 152: Identifying Bypass Hose
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW bypass hose.

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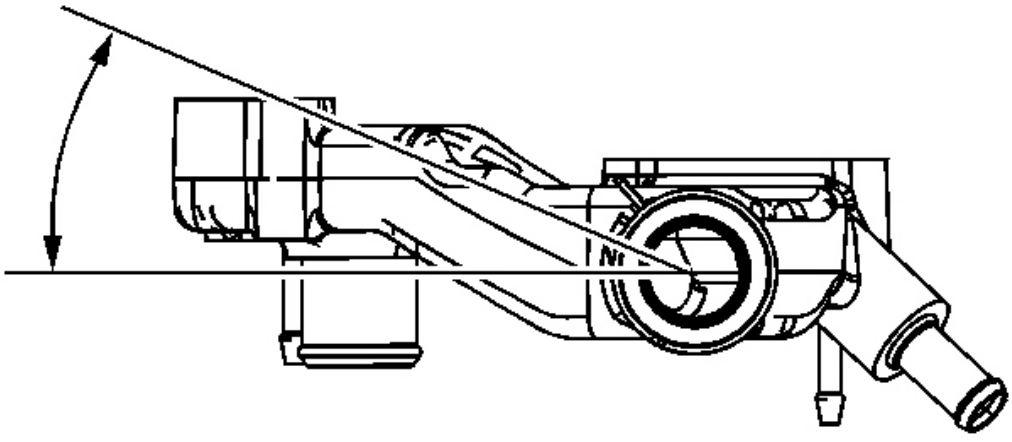


Fig. 153: Positioning Bypass Hose Clamps
Courtesy of GENERAL MOTORS CORP.

2. In order to clear the drive belt path ensure the bypass hose clamps are positioned properly.

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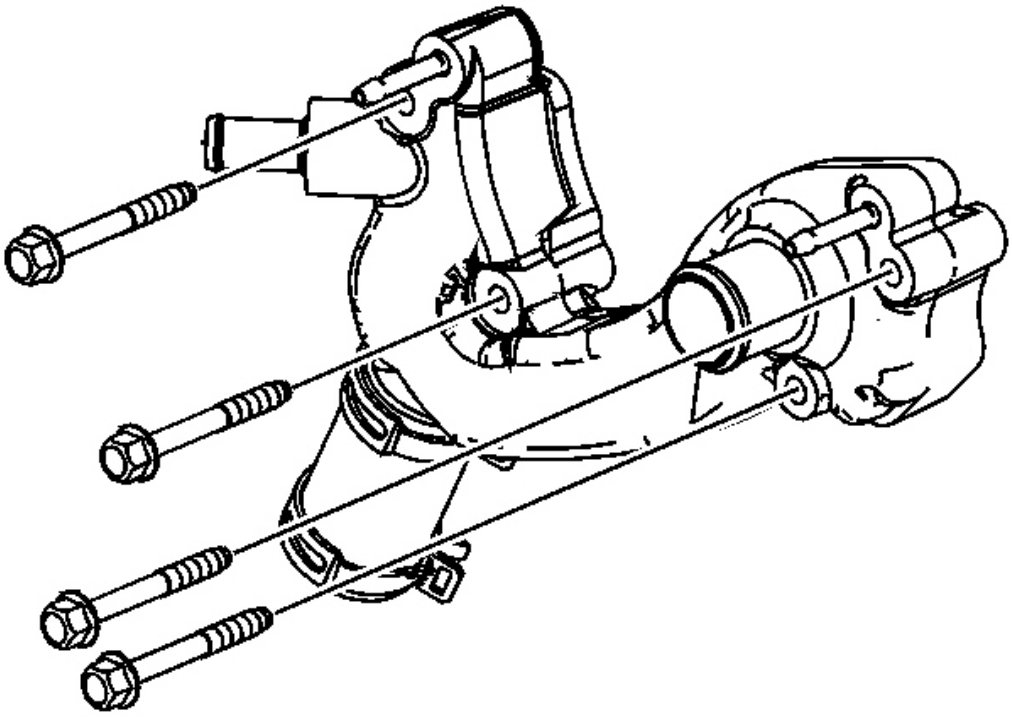


Fig. 154: Identifying Water Outlet Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the water outlet bolts.

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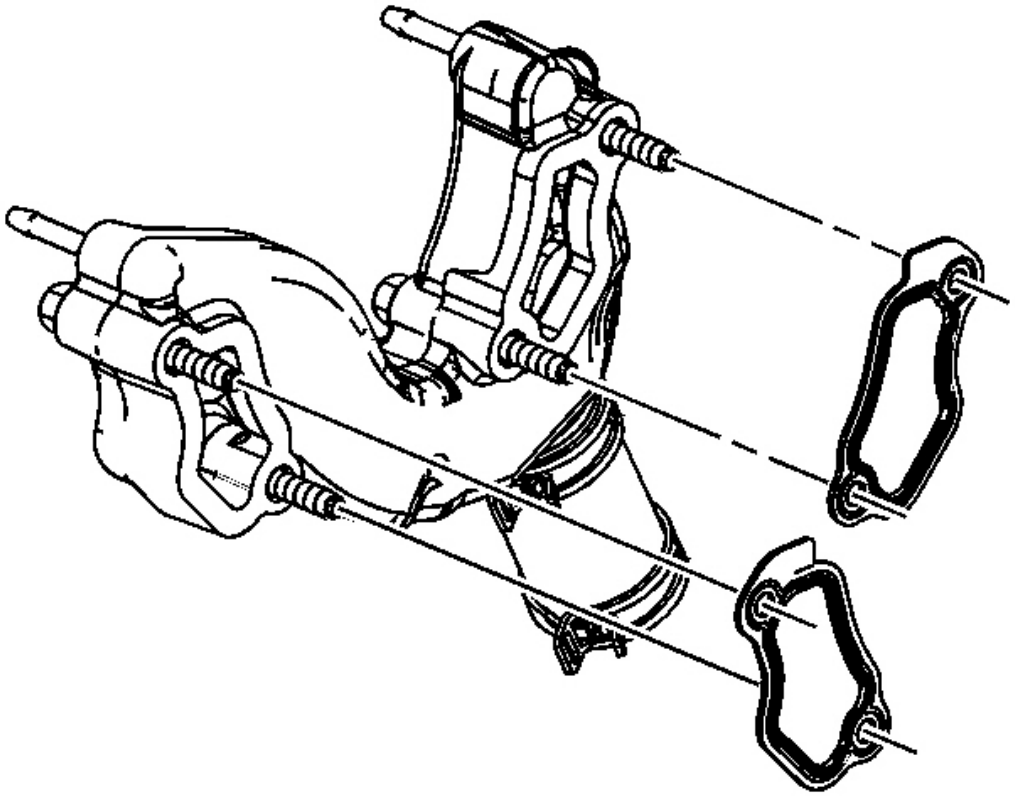


Fig. 155: View Of Water Outlet Gaskets
Courtesy of GENERAL MOTORS CORP.

4. Install the NEW water outlet gaskets.

THREAD REPAIR

TOOLS REQUIRED

Tools Required

- **J 42385-2000** Thread Insert Kit. See **Special Tools** .
- **J 42385-2030** M11 x 2. See **Special Tools** .0 Cylinder Head Bolt - Northstar/Premium V8 Thread Repair Kit
- **J 43965** Thread Repair Extension Kit. See **Special Tools** .

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert. During

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the insert installation process, the installation driver tool cold-rolls the bottom internal threads and expands the bottom external threads of the insert into the base material. This action mechanically locks the insert into place.

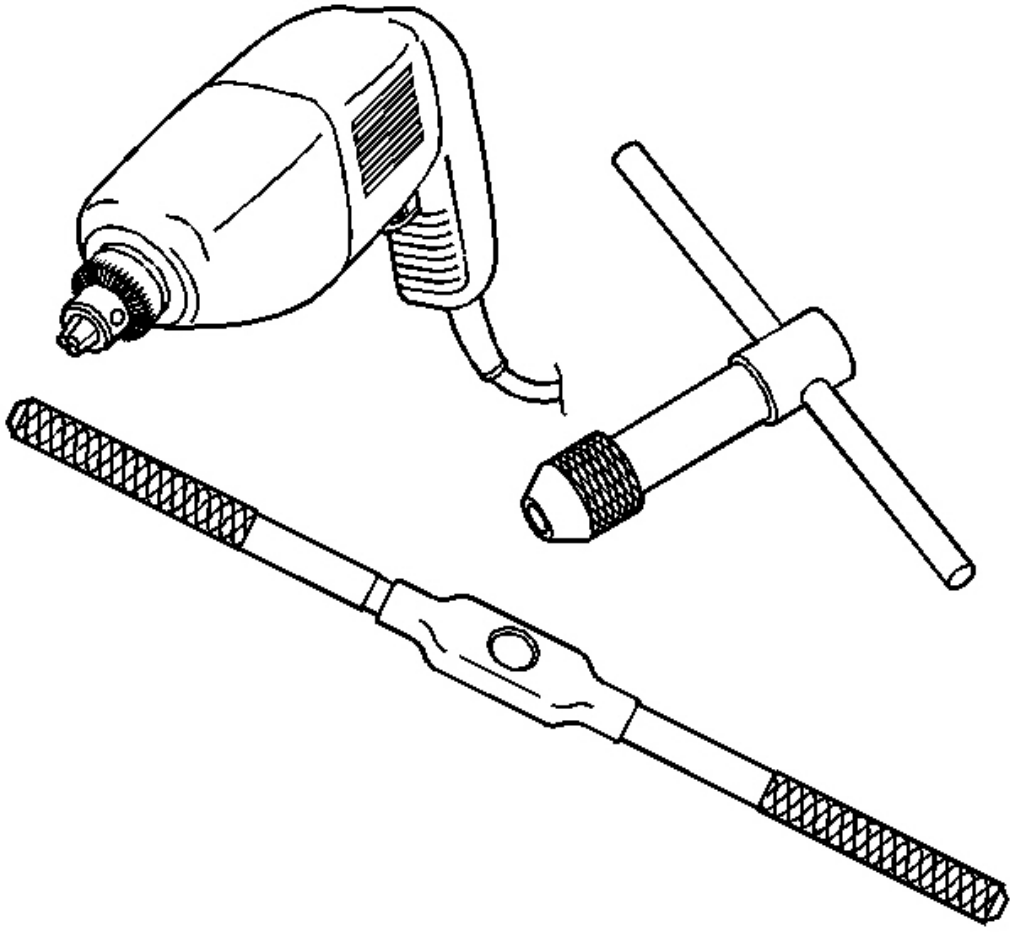


Fig. 156: View Of J 42385-400 Tool Kit
Courtesy of GENERAL MOTORS CORP.

The drill bit and counter bore tool from the tool kit **J 42385-2000** and **J 42385-2030** is designed for use with either a suitable tap wrench or drill motor. See **Special Tools** . Limited access and larger hole repair may process better using a tap wrench. An extension from kit **J 43965** may also be necessary to drive the thread repair tooling dependent on access to the hole being repaired. See **Special Tools** . Use only a tap wrench when tapping the hole and during installation of the insert.

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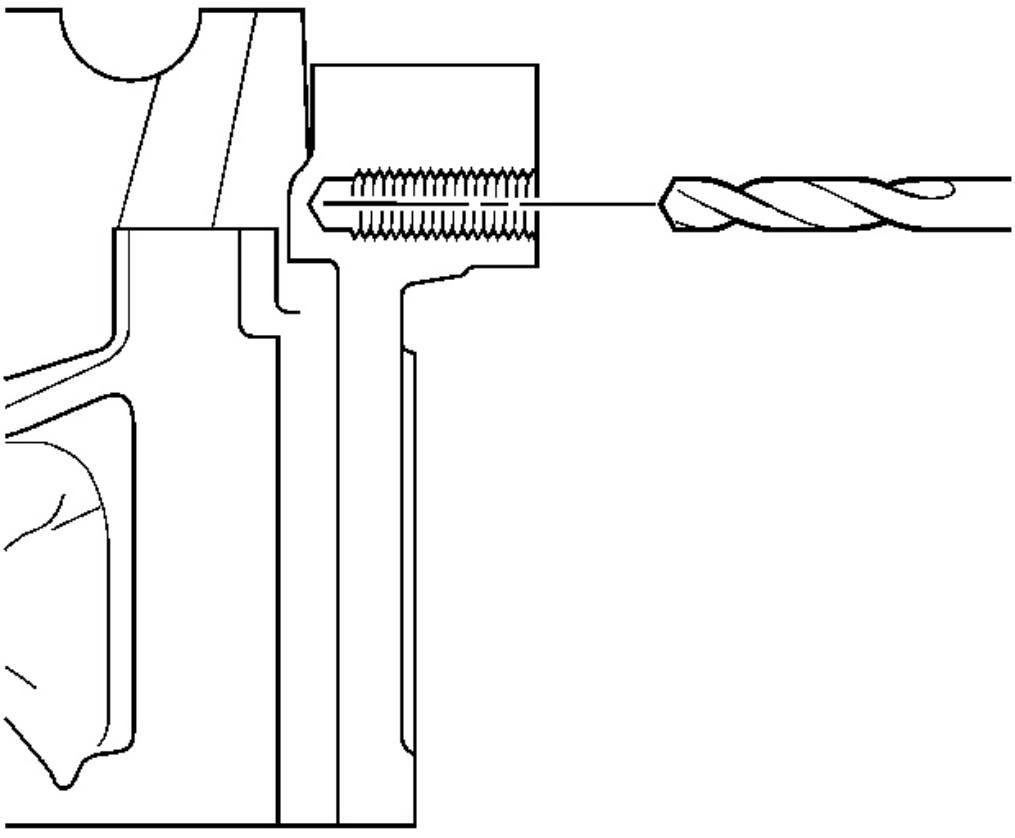


Fig. 157: Drilled Hole Centerline
Courtesy of GENERAL MOTORS CORP.

It is critical that the drilling, counterboring and tapping of the hole to be repaired follows the same centerline as the original hole.

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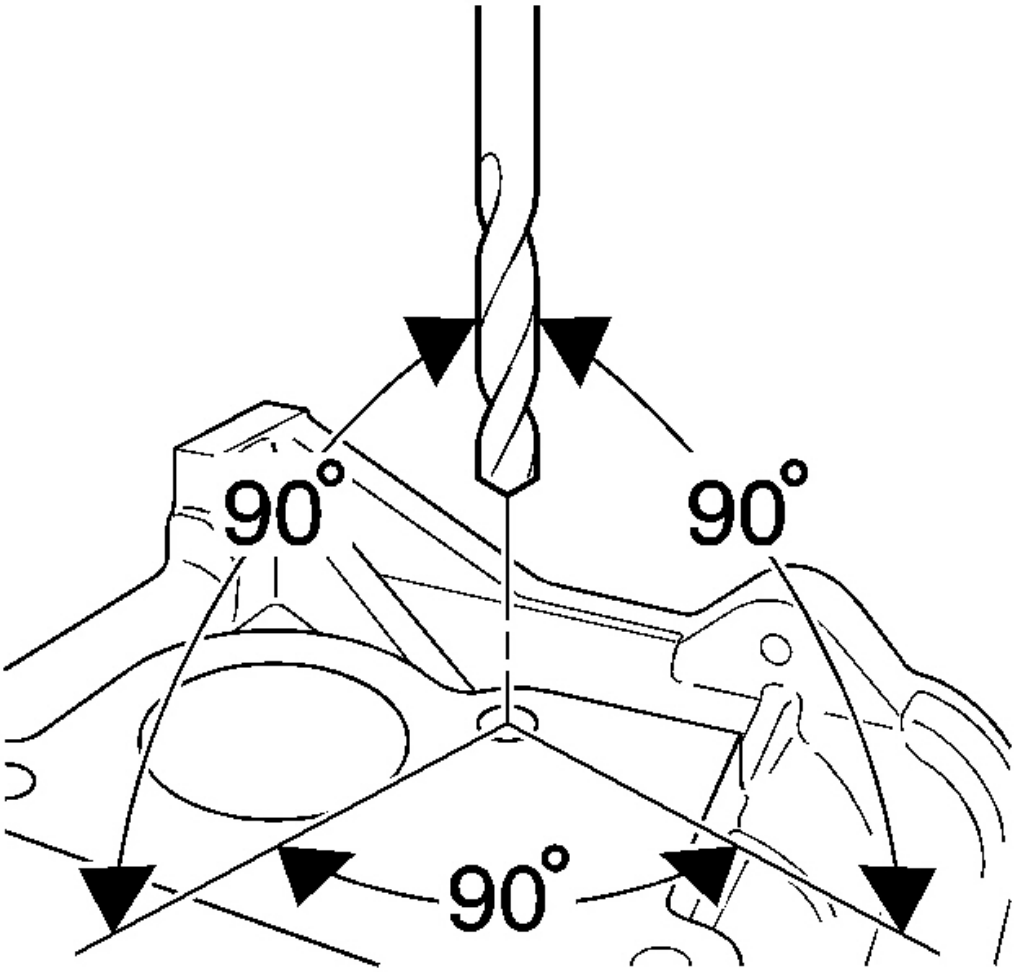


Fig. 158: Identifying Proper Drilling Angle
Courtesy of GENERAL MOTORS CORP.

During the drilling and tapping of the hole being repaired ensure the tooling is consistently machining perpendicular to the surface of the base material.

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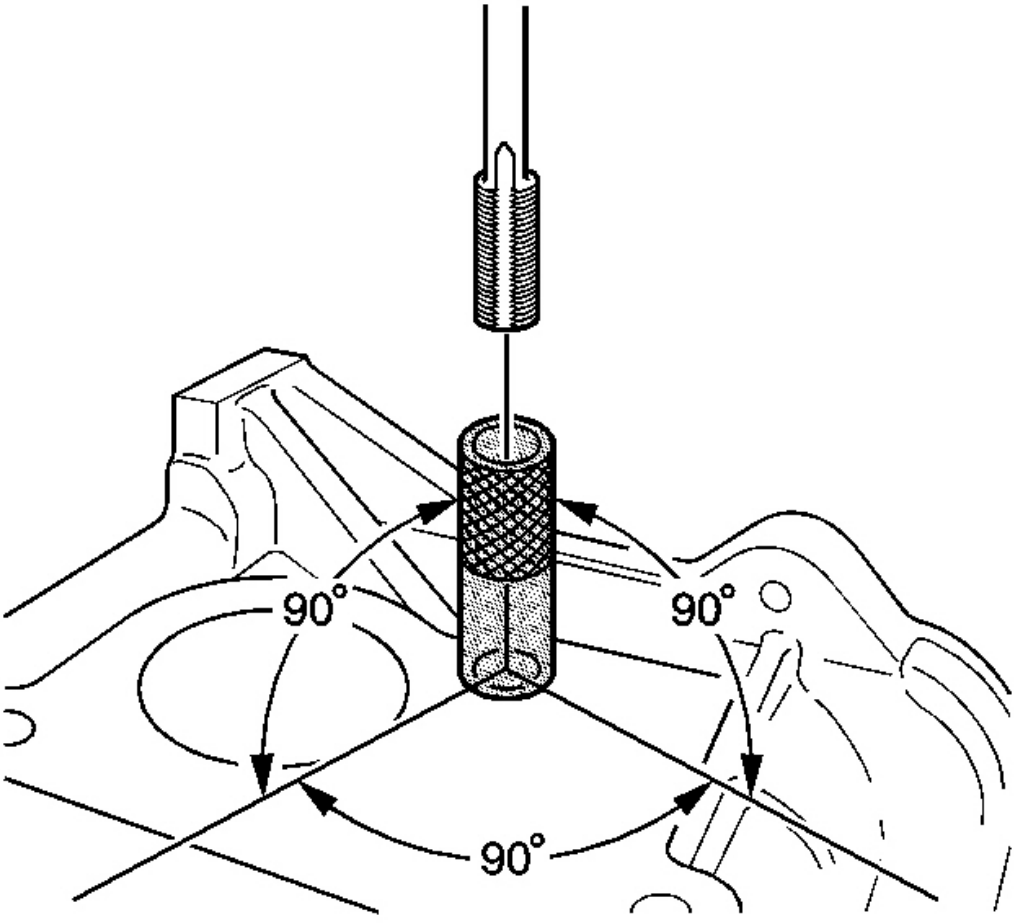


Fig. 159: View Of Tapping Guide
Courtesy of GENERAL MOTORS CORP.

If the threaded hole being repaired has a base surface perpendicular to the hole centerline, tapping guides are available to aid in tapping the hole.

Thread Repair

Tap Size	Tap Guide	Tape Size	Tape Guide	Tap Size	Tape Guide
-	J 42385-	-	J 42385-	-	J 42385-
6 x 1.0	729	10 x 1.5	731	14 x 1.5	736
8 x 1.25	730	12 x 1.5	732	20 x 1.5	737

STANDARD THREAD REPAIR - FLUSH HOLE

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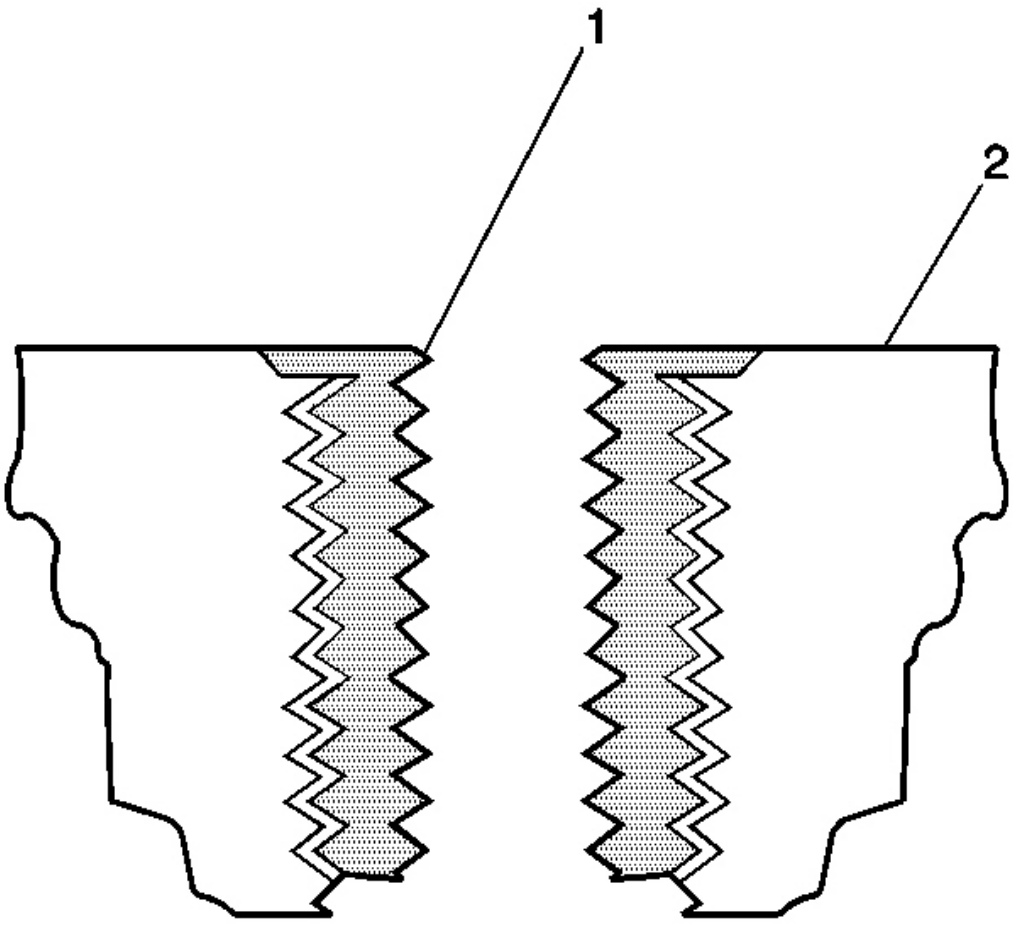


Fig. 160: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT: The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange (1) of the insert will be seated against the counterbore of the drilled/tapped hole and just below the surface (2) of the base material.

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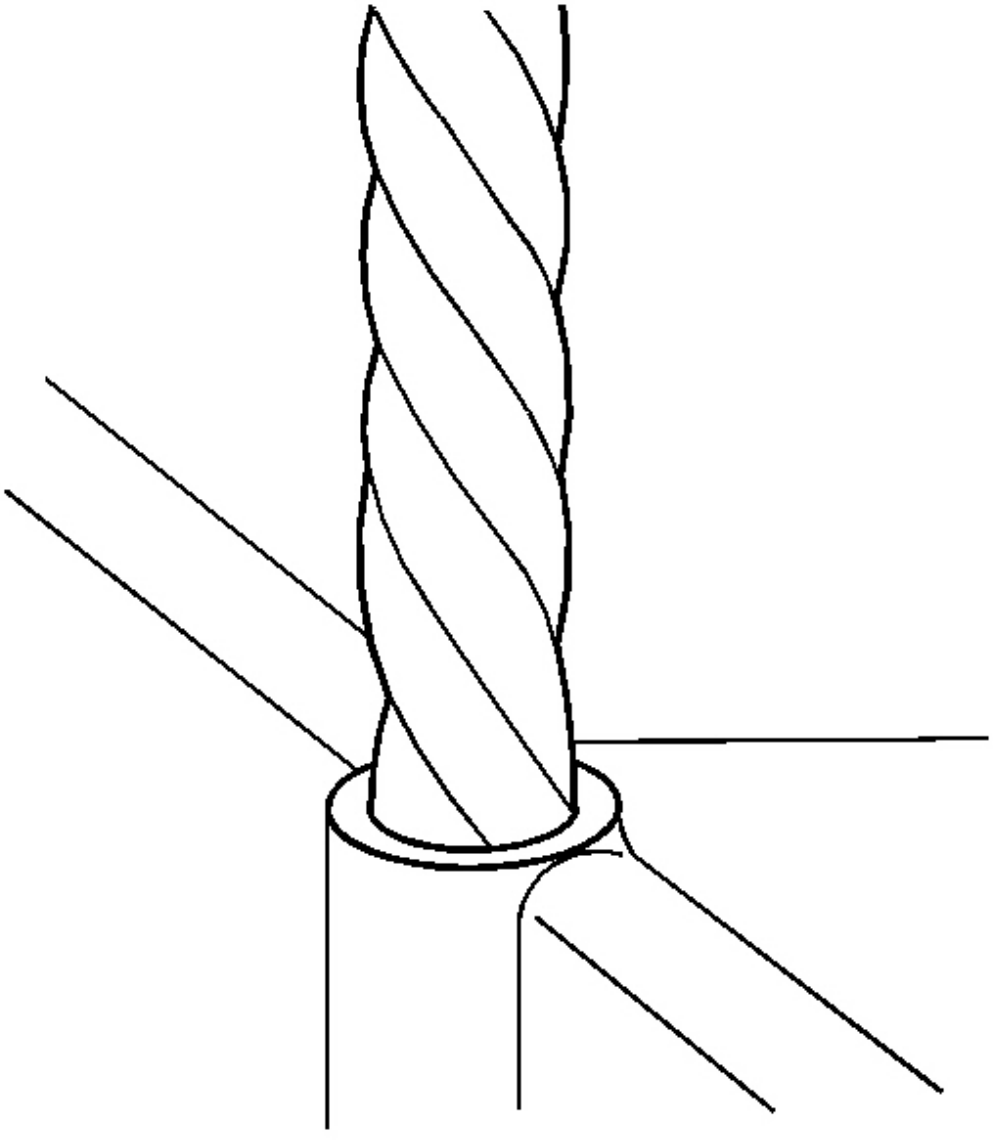


Fig. 161: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **DO NOT drill any further than the original hole depth.**

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1. Drill out the threads of the damaged hole.
   - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
   - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
   - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).

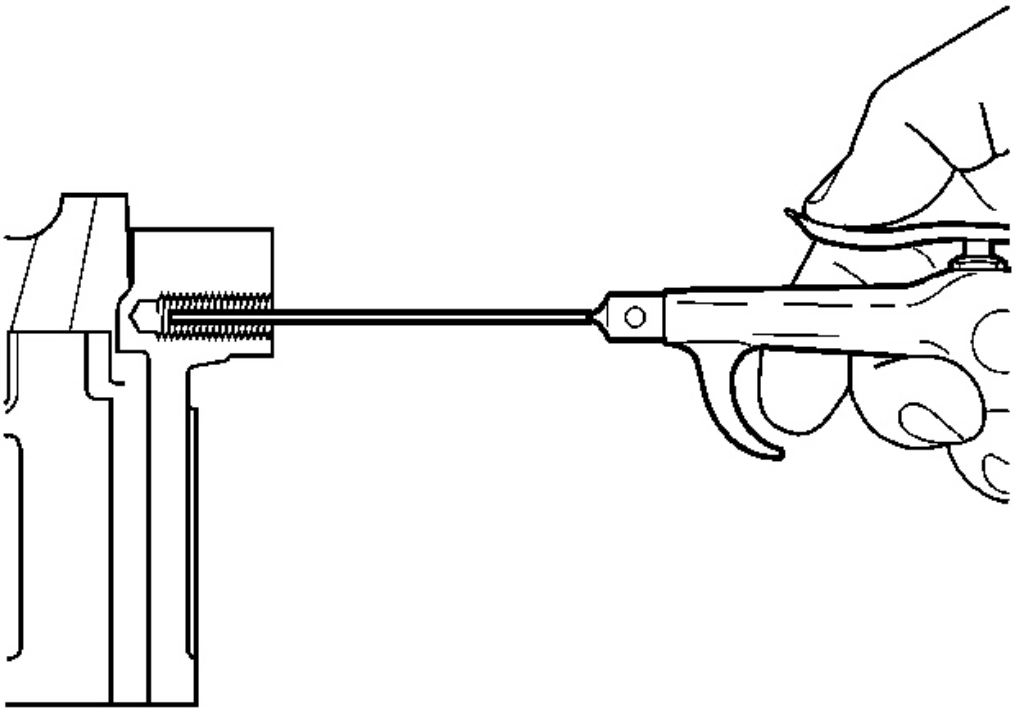


Fig. 162: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

2. Using compressed air, clean out any chips.

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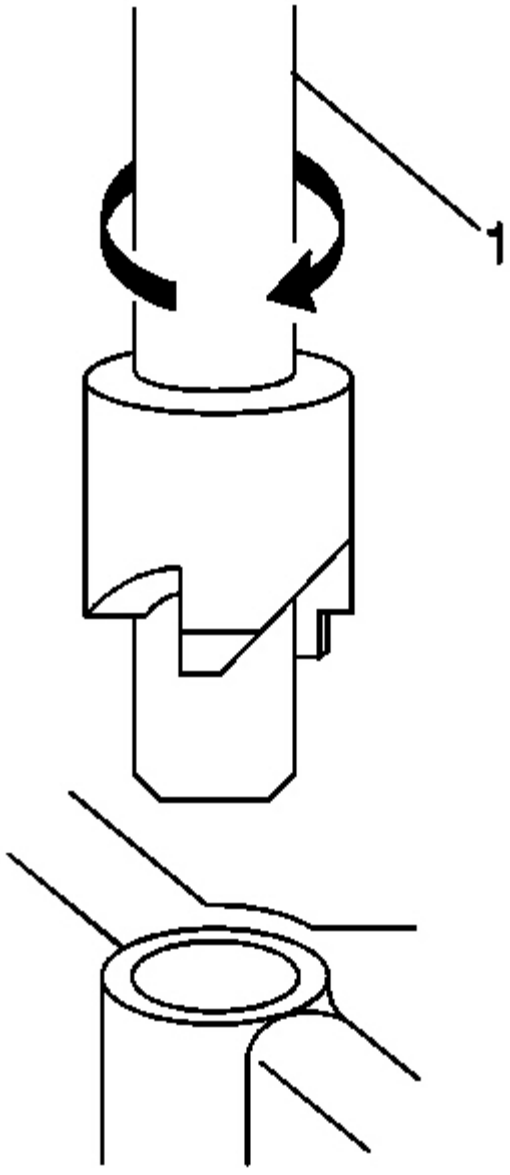


Fig. 163: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A properly counterbored hole will show a slight burnishing on the surface of the base material for 360 degrees around the drilled hole.

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3. Counterbore the drilled hole to the full depth permitted by the tool (1).

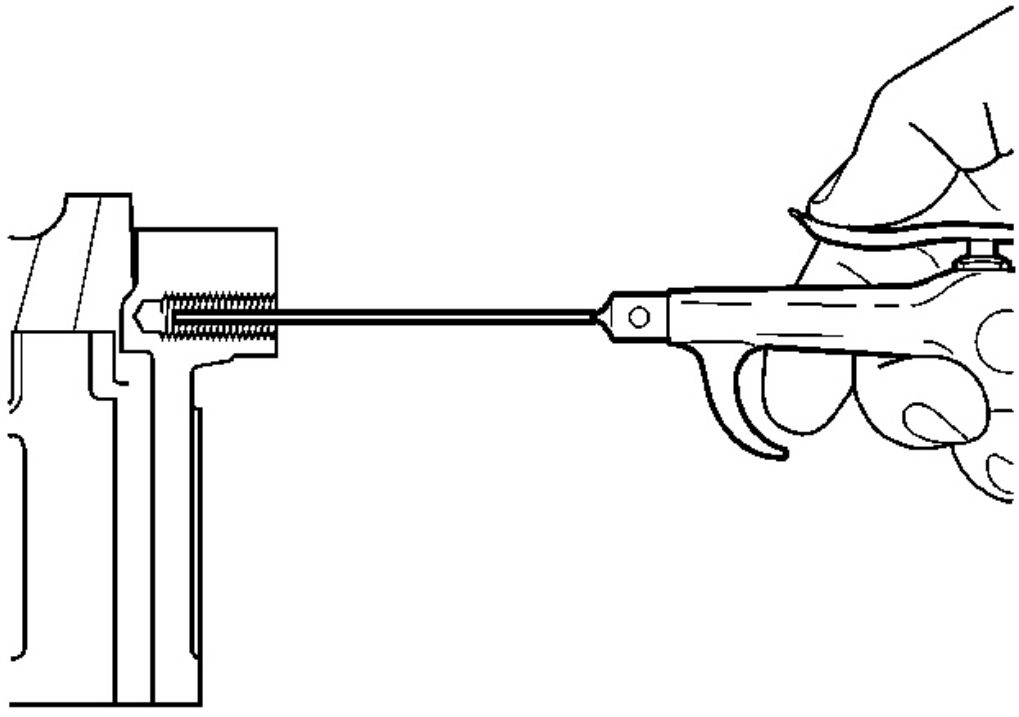


Fig. 164: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

4. Using compressed air, clean out any chips.

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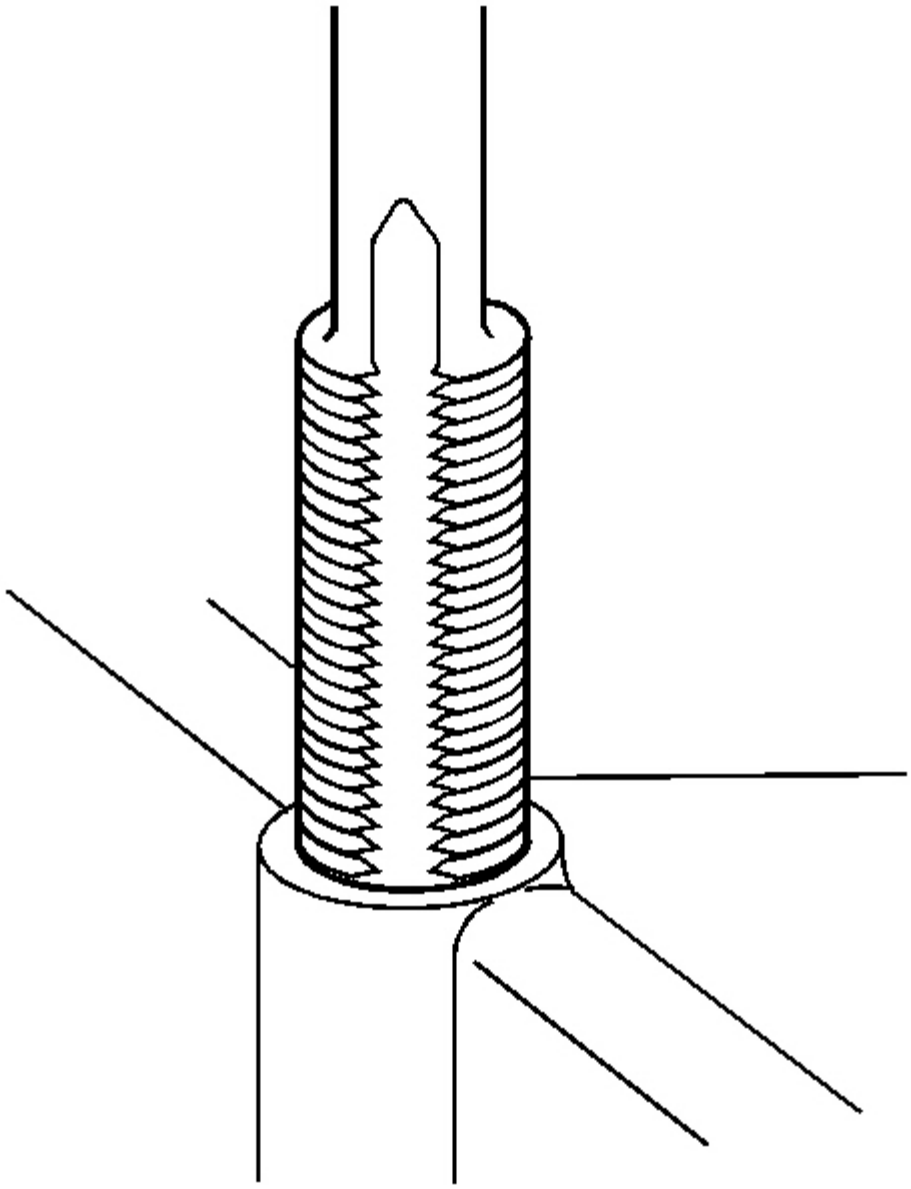


Fig. 165: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**

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- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

5. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.
   - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
   - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
   - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).

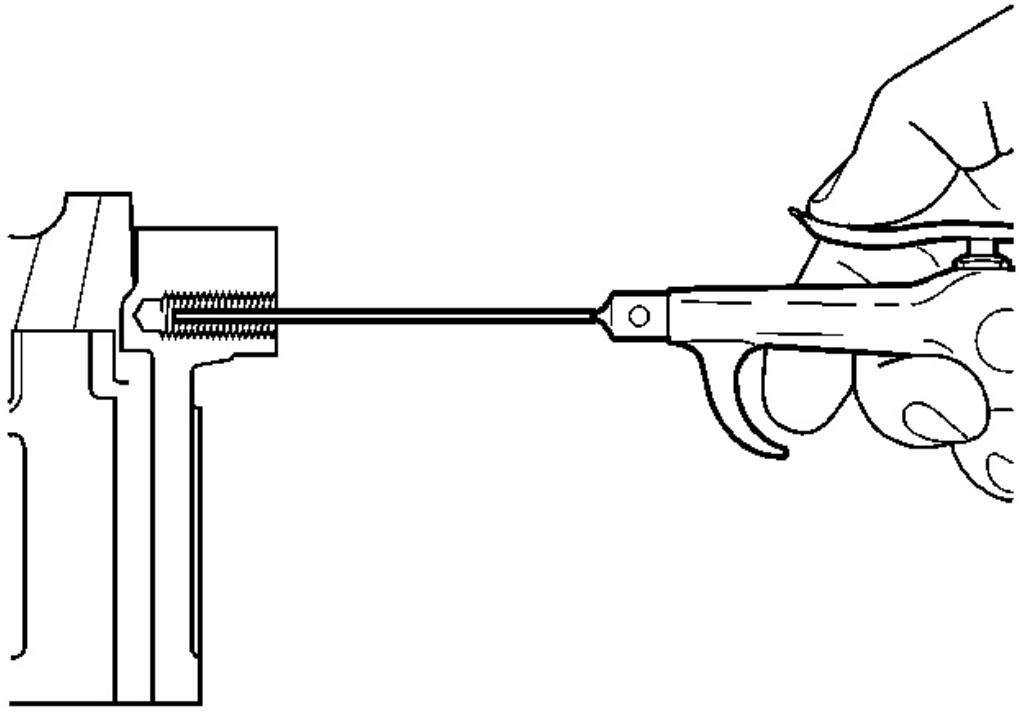


Fig. 166: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

6. Using compressed air, clean out any chips.

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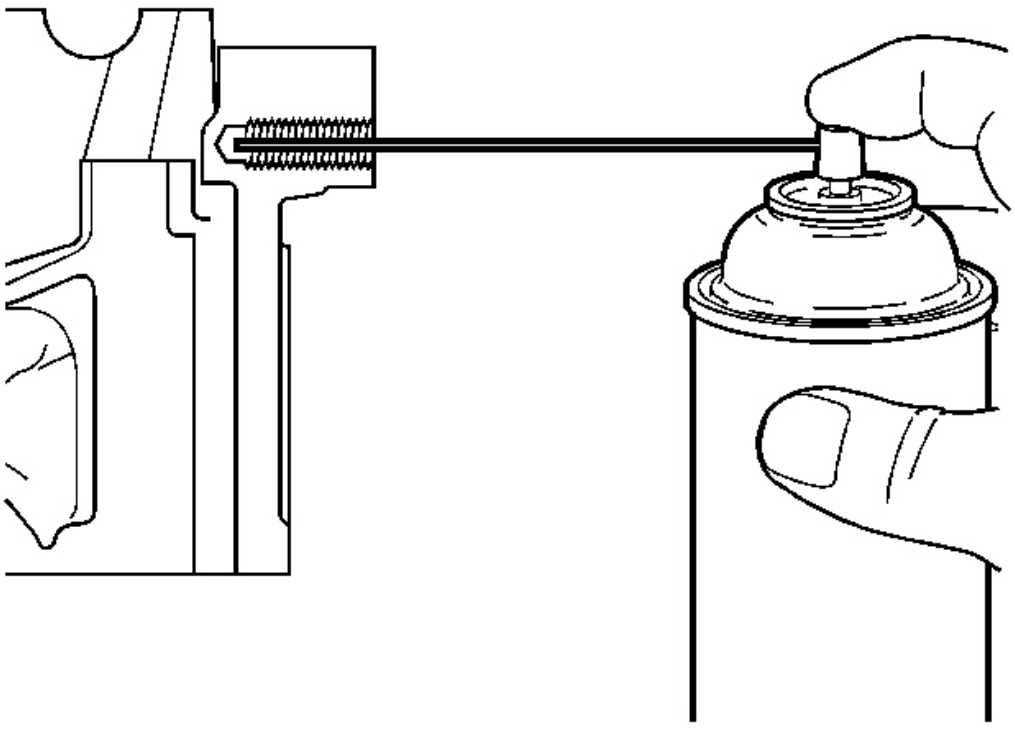


Fig. 167: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

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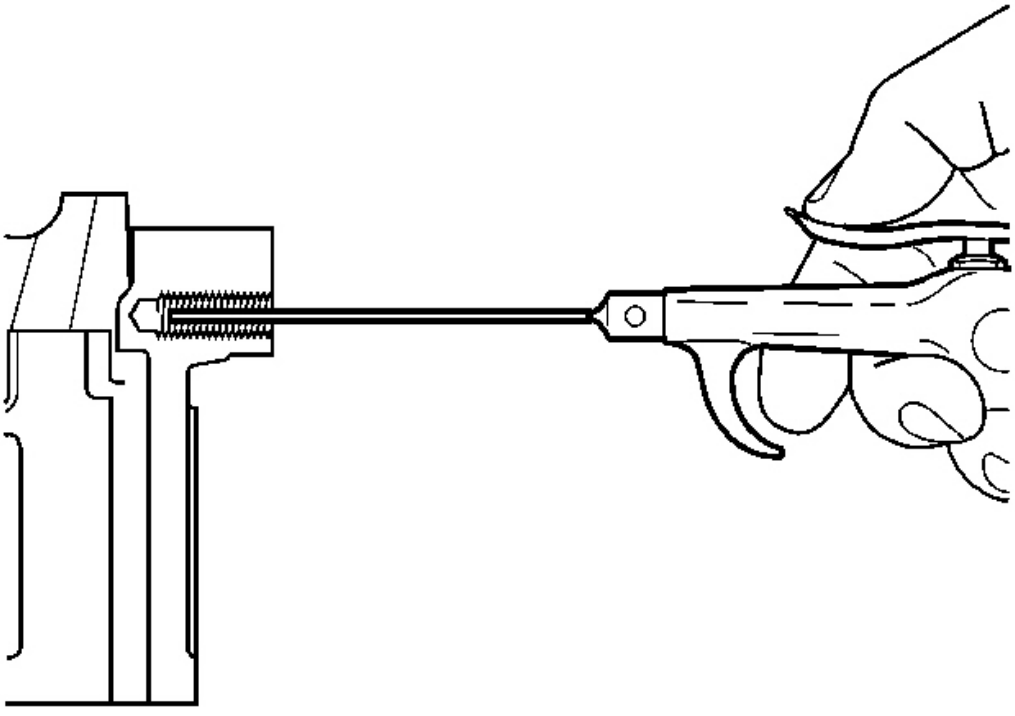


Fig. 168: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

8. Using compressed air, clean out any chips.

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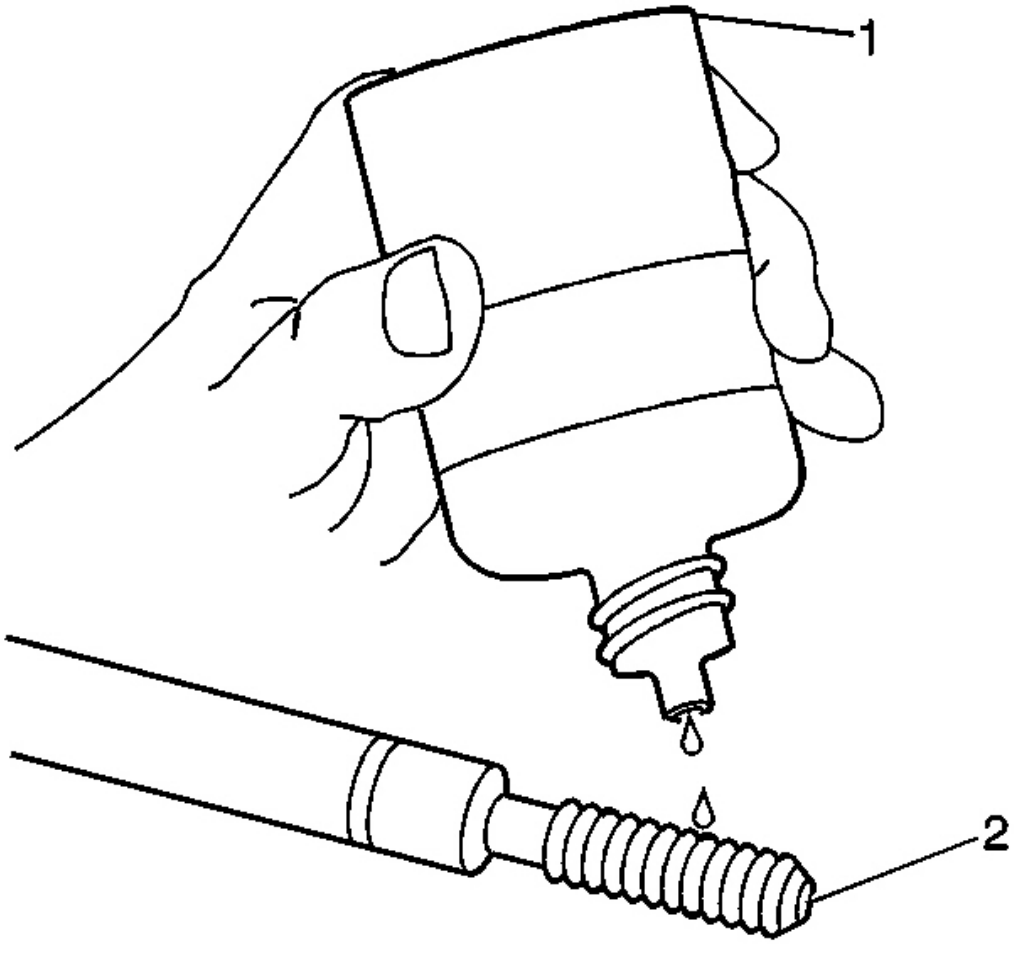


Fig. 169: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

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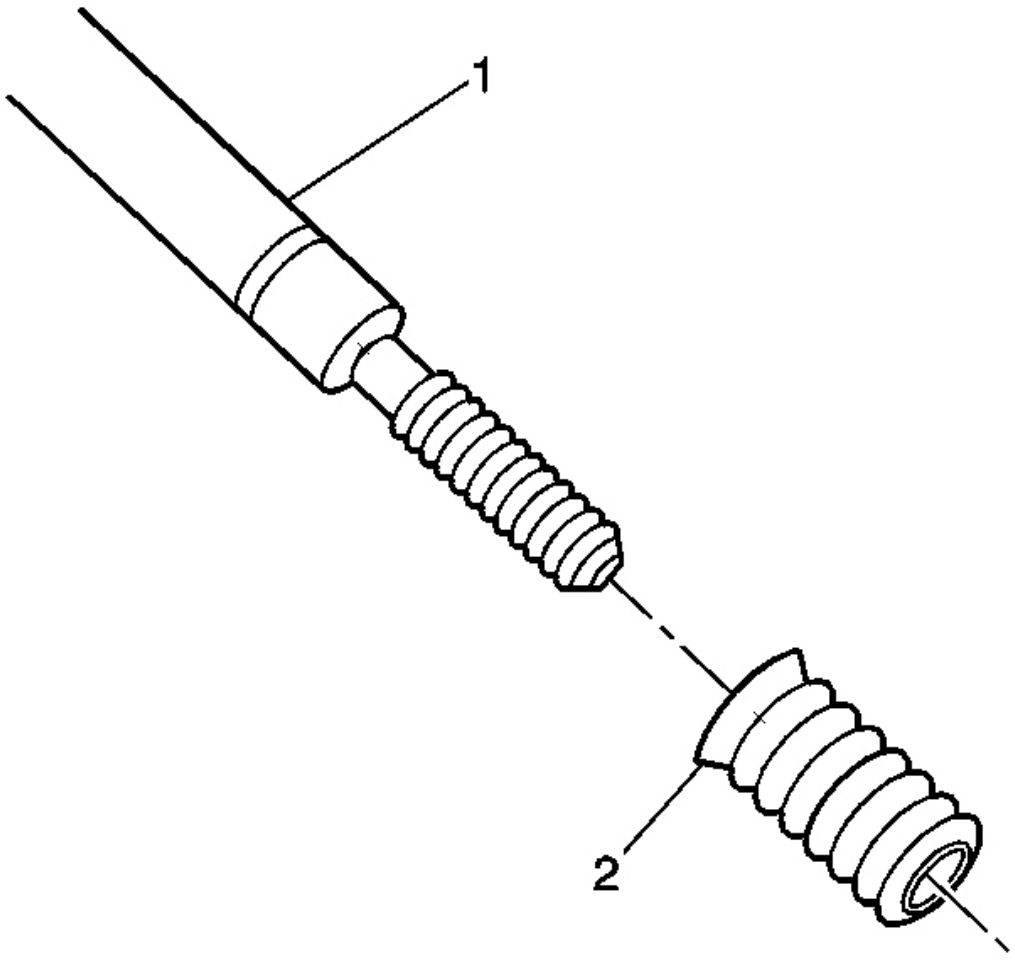


Fig. 170: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver installation tool (1).

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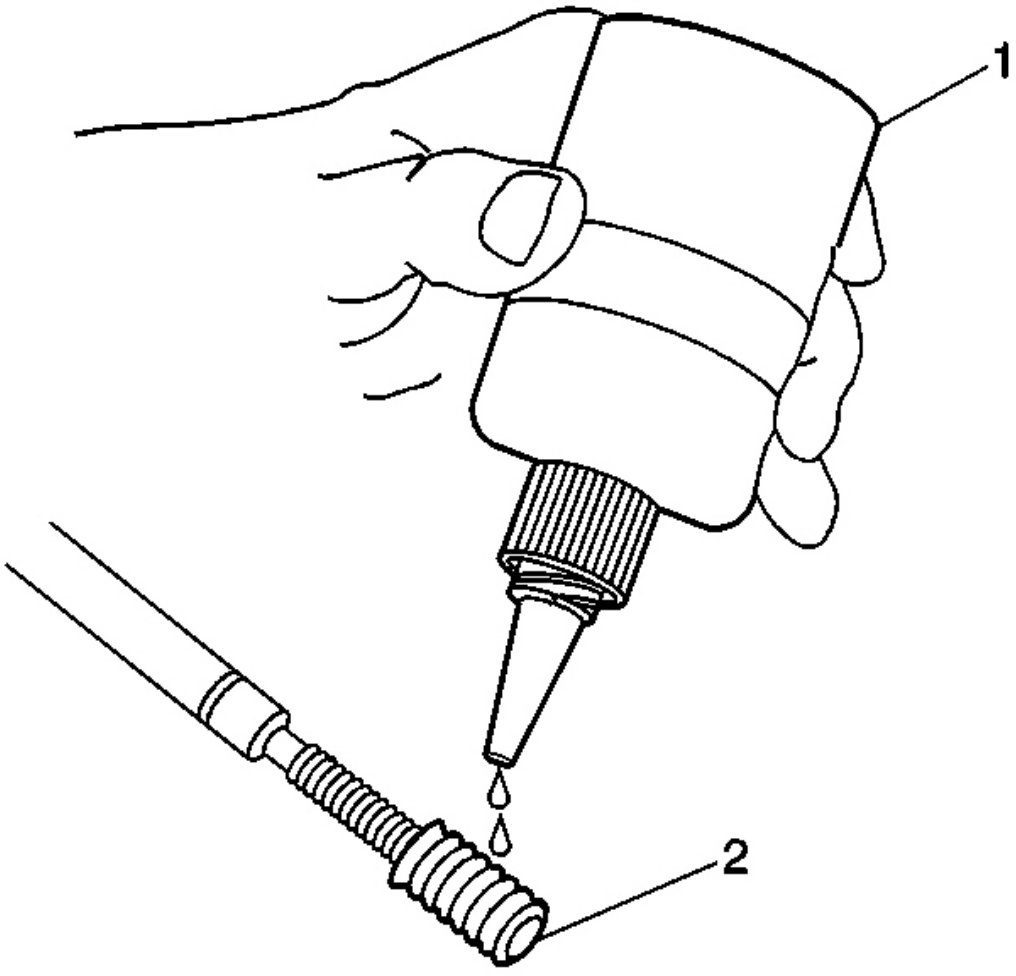


Fig. 171: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

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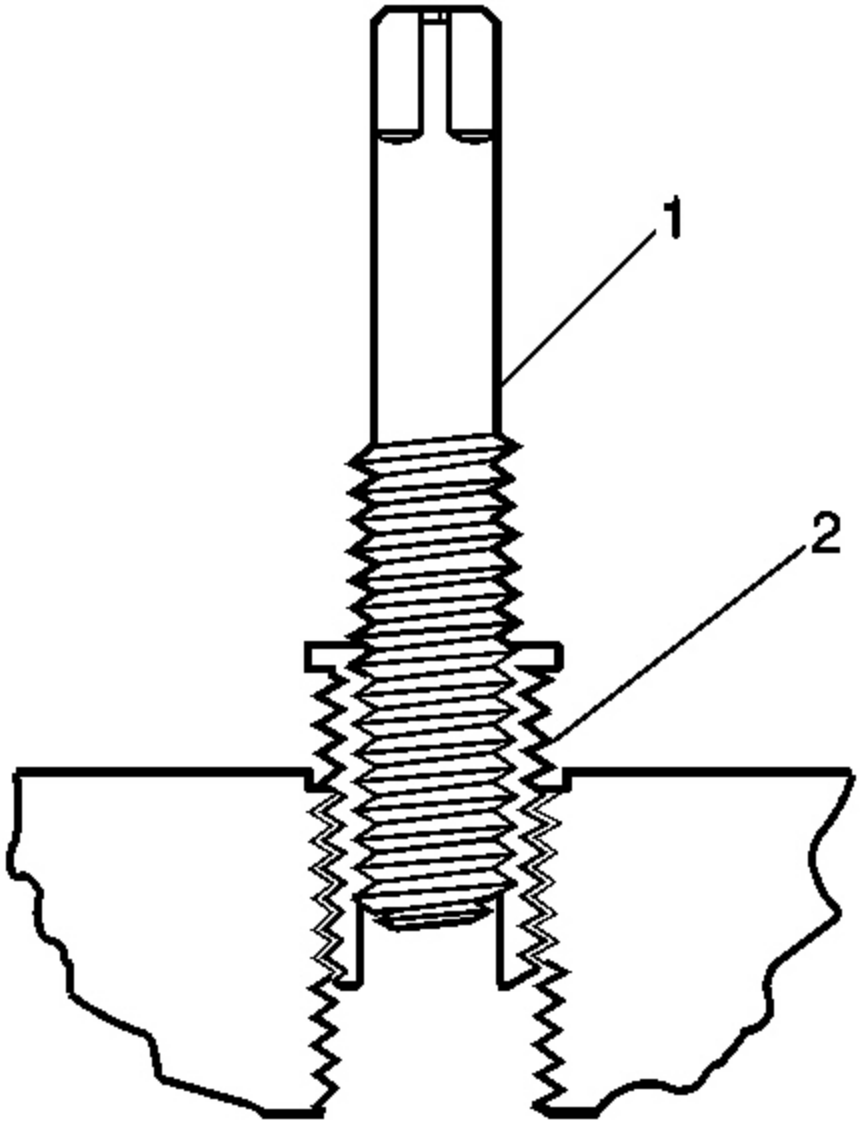


Fig. 172: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the tapped hole by hand only.

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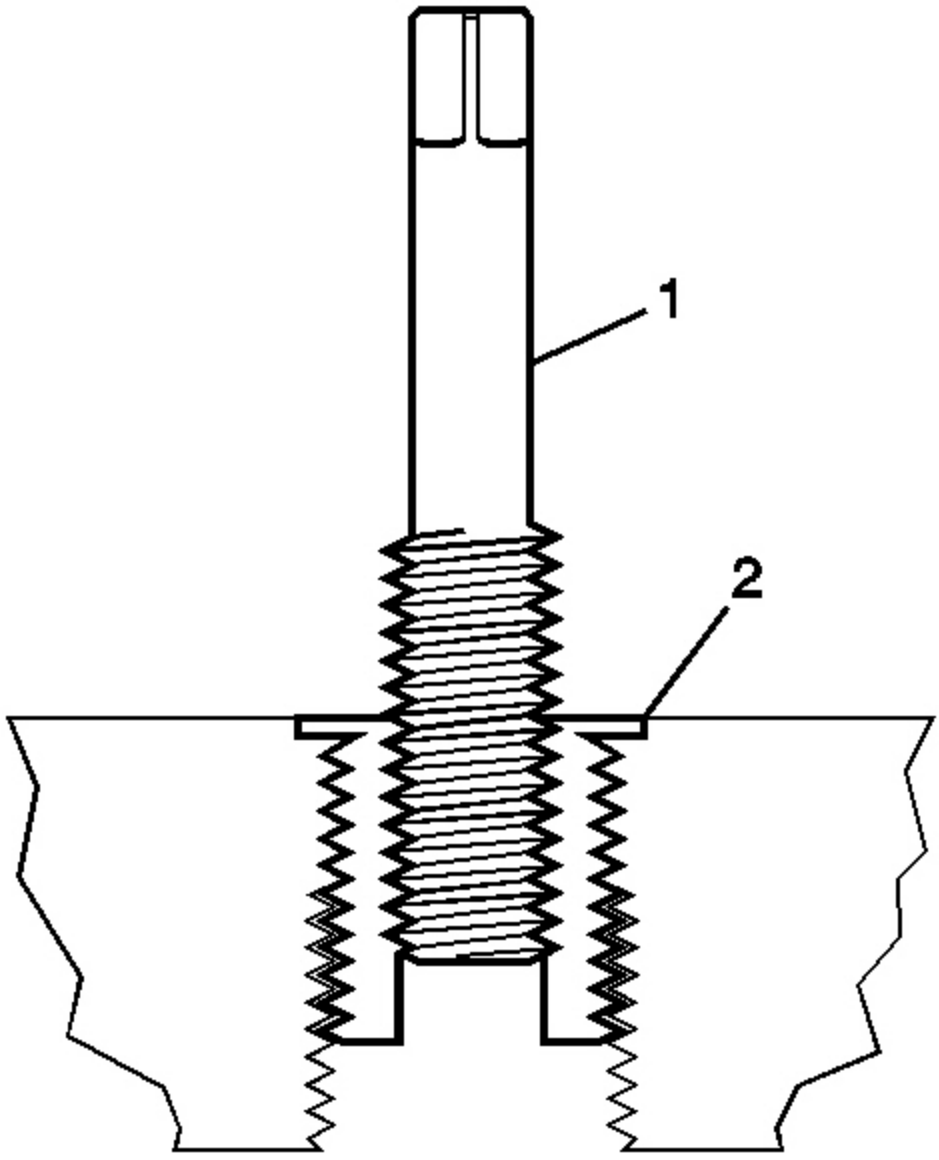


Fig. 173: Installing Insert - Standard Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface, remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or

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improper tapping.

13. Install the insert until the flange (2) of the insert contacts the counterbored surface.

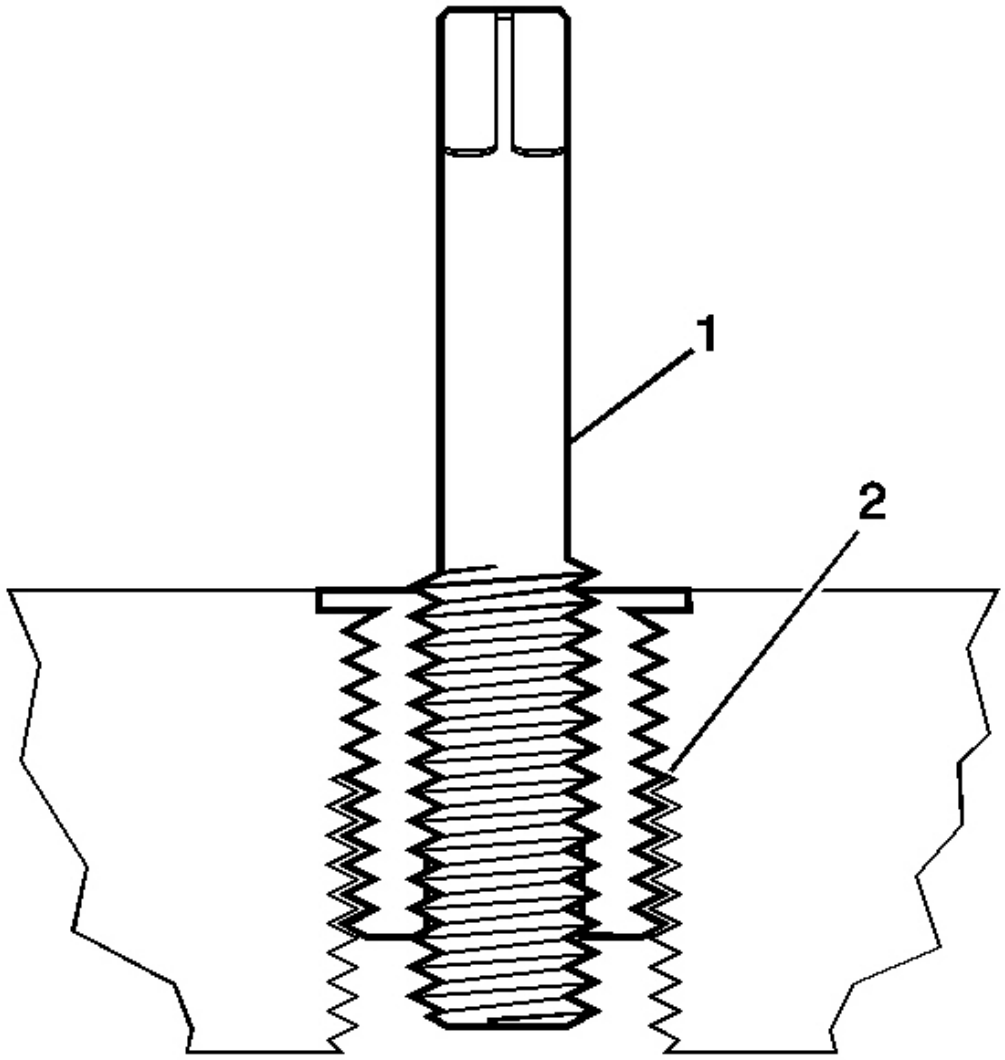


Fig. 174: View Insert And Tool - Standard Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the

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insert are being formed and the insert is mechanically locking the insert into the base material threads.

14. Continue to rotate the driver installation tool (1) through the insert (2).

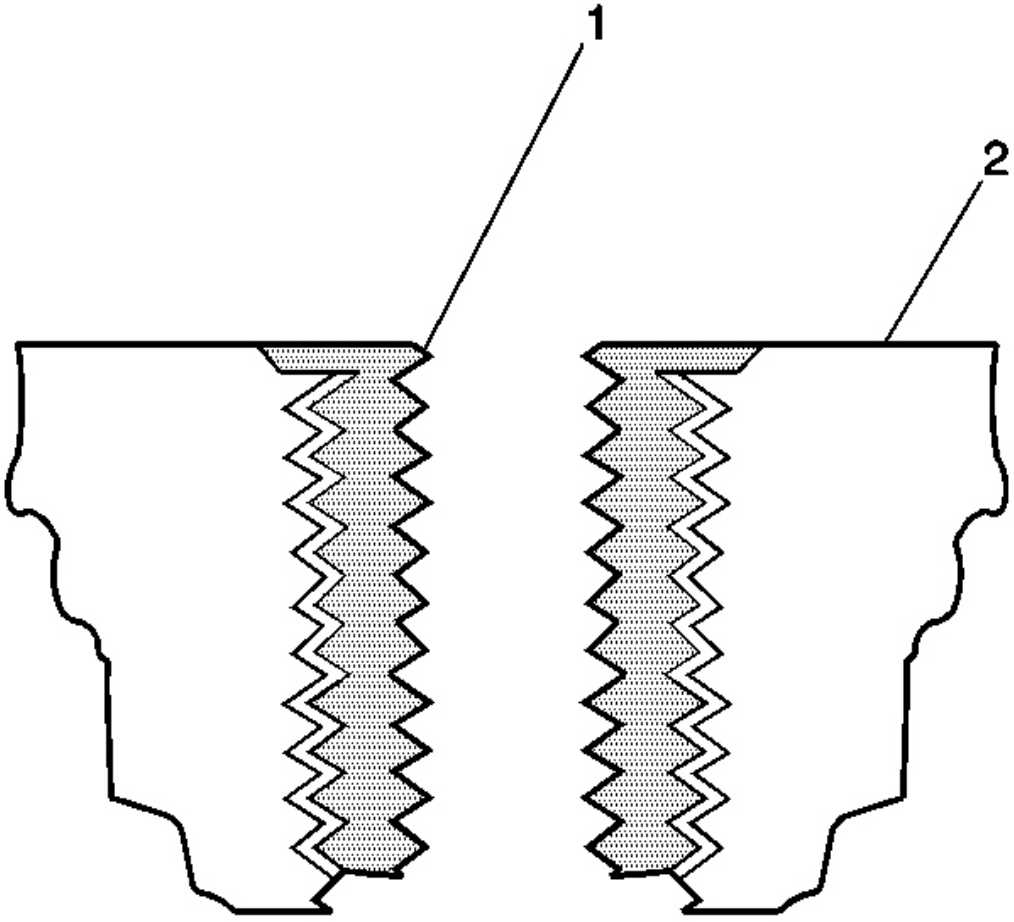


Fig. 175: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

15. Inspect the insert for proper installation into the tapped hole. A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

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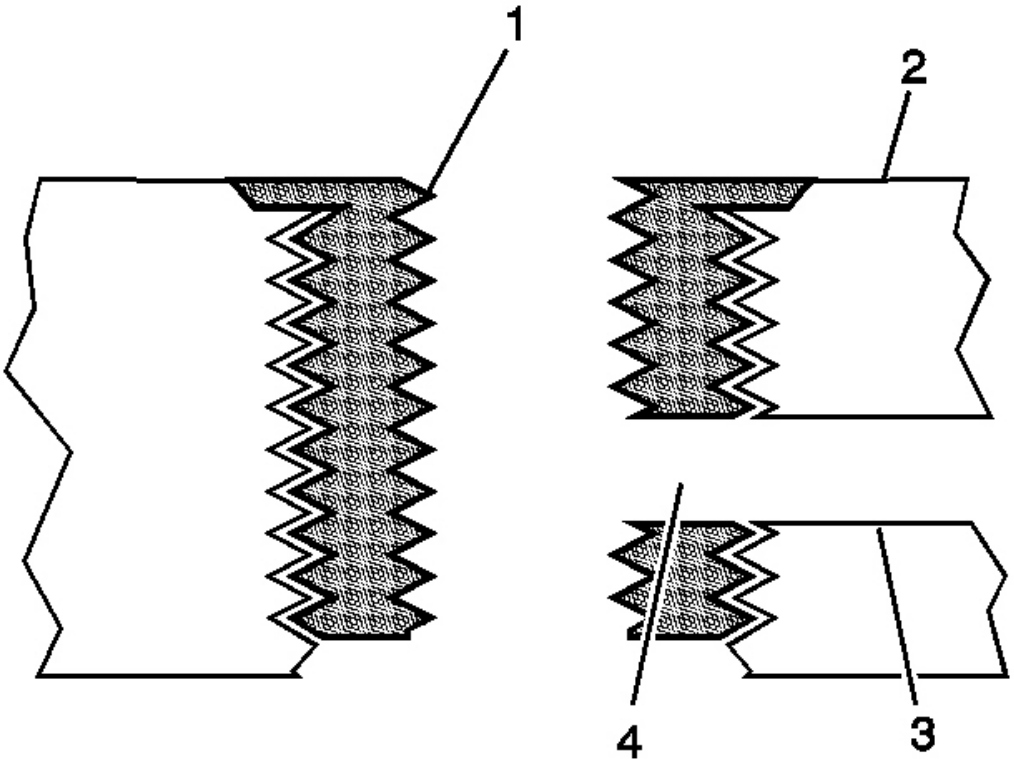


Fig. 176: View Of Restricted Engine Coolant Passages - Standard Thread Repair
Courtesy of GENERAL MOTORS CORP.

16. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

RECESSED THREAD REPAIR

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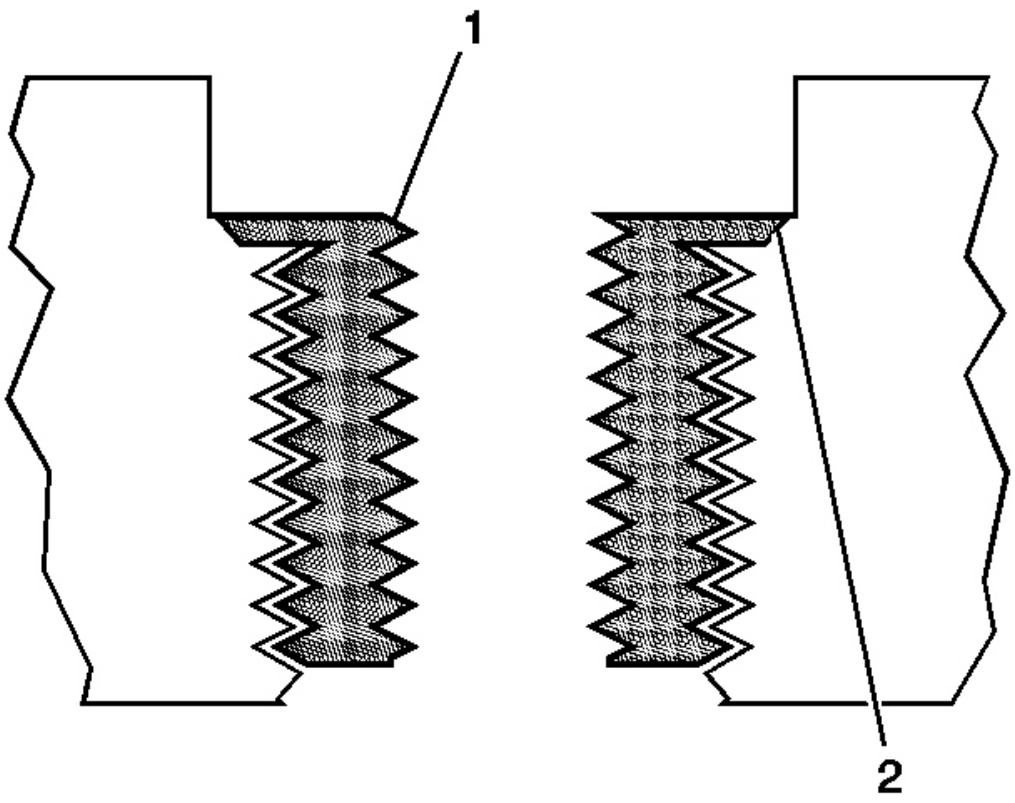


Fig. 177: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- **The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.**
- **Do NOT remove the original stop collar from a counterbore drill.**

When installed to the proper depth, the flange of the insert (1) will be seated against the counterbore (2) of the drilled/tapped hole.

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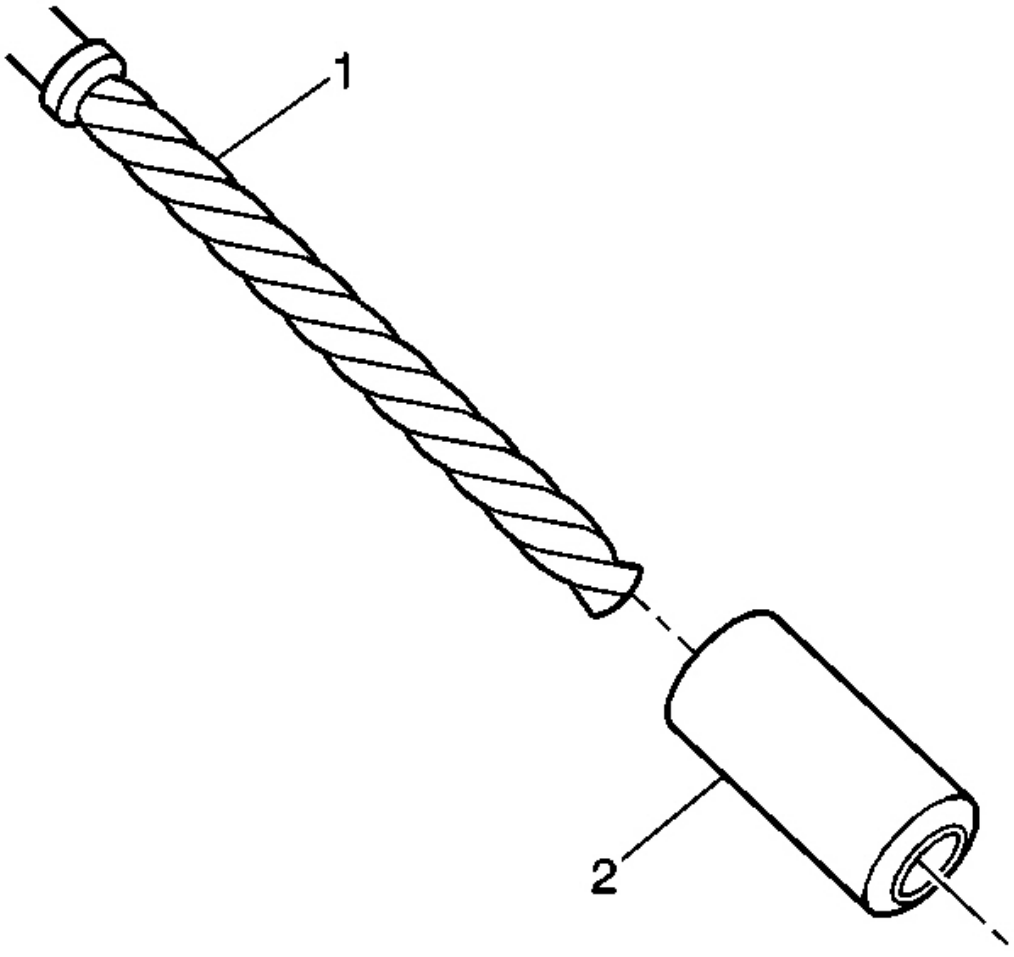


Fig. 178: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

1. Install a stop collar (2) on the counterbore drill (1), if required.

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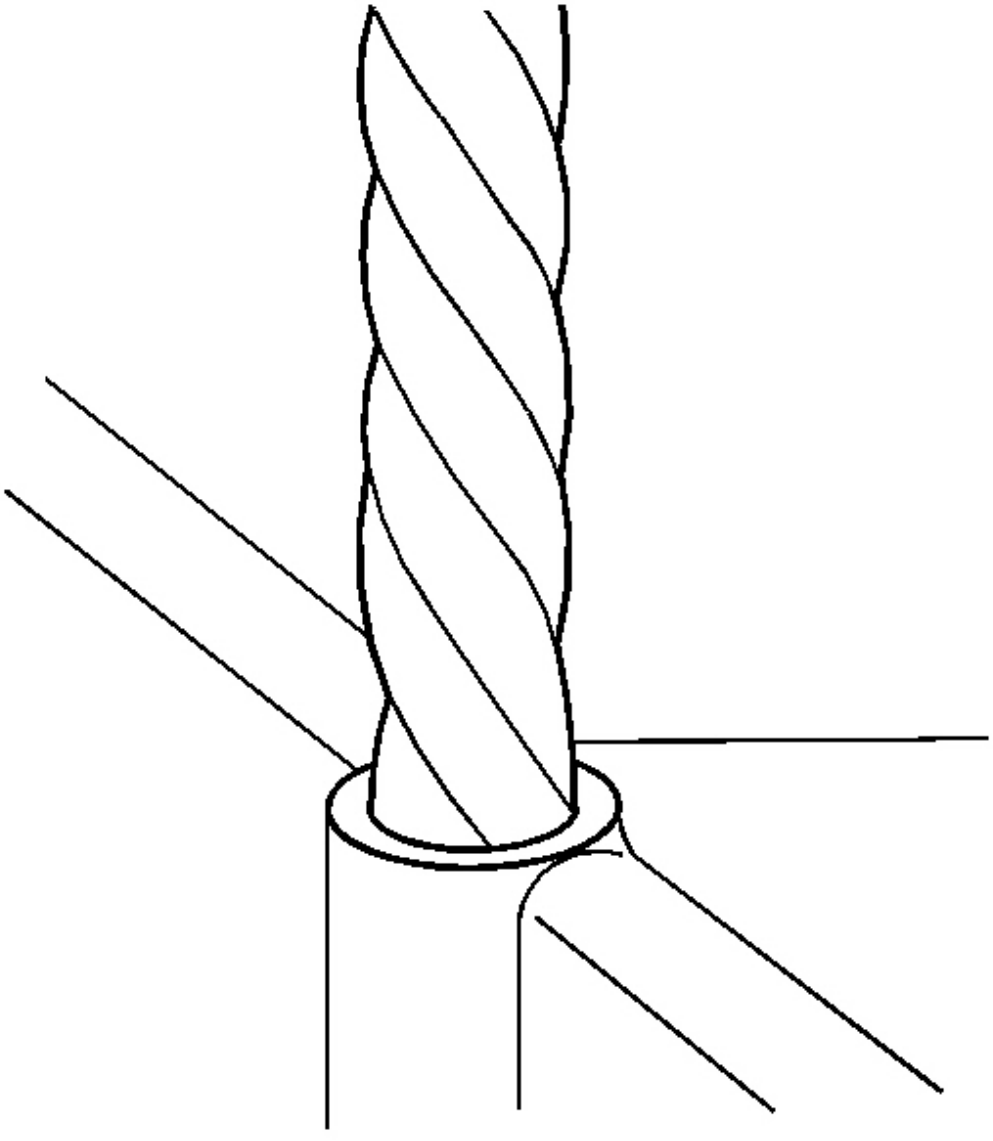


Fig. 179: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the hole until the stop collar contacts the surface of the base**

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material.

2. Drill out the threads of the damaged hole.

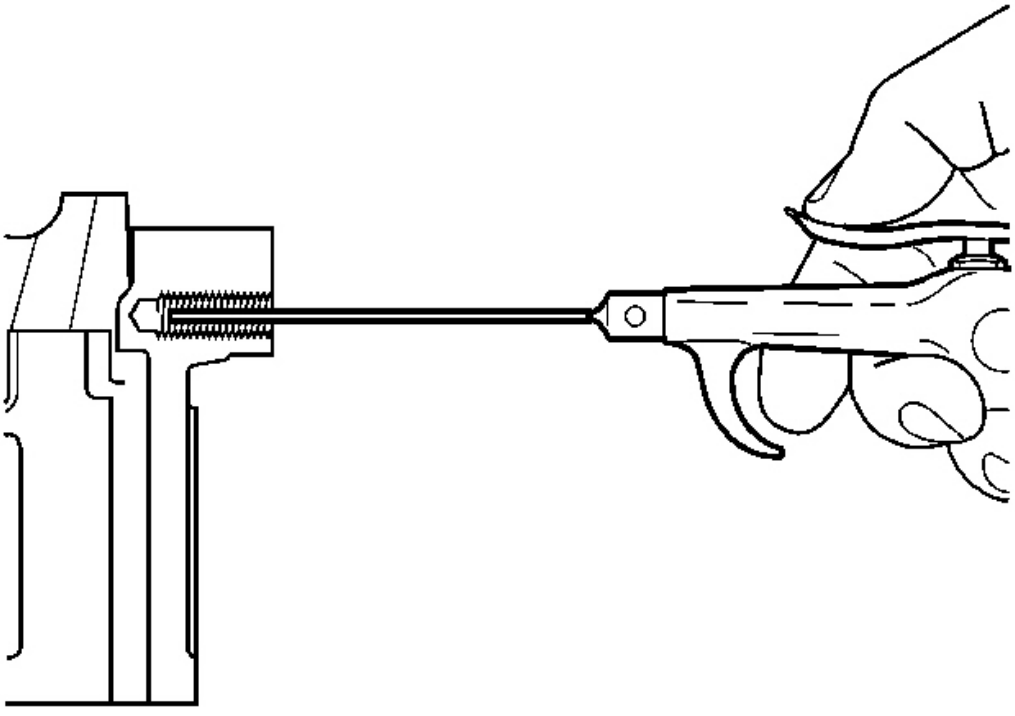


Fig. 180: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

3. Using compressed air, clean out any chips.

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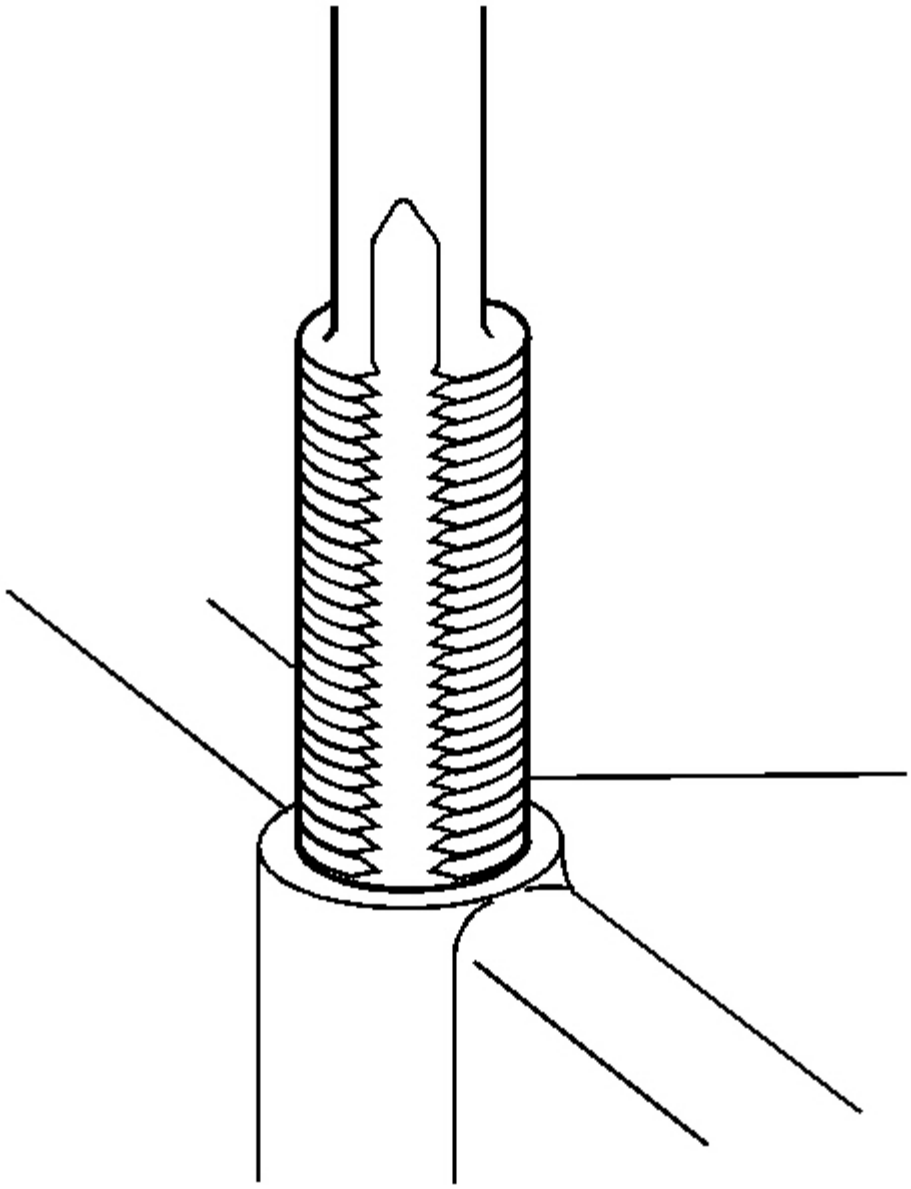


Fig. 181: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**

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- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

4. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

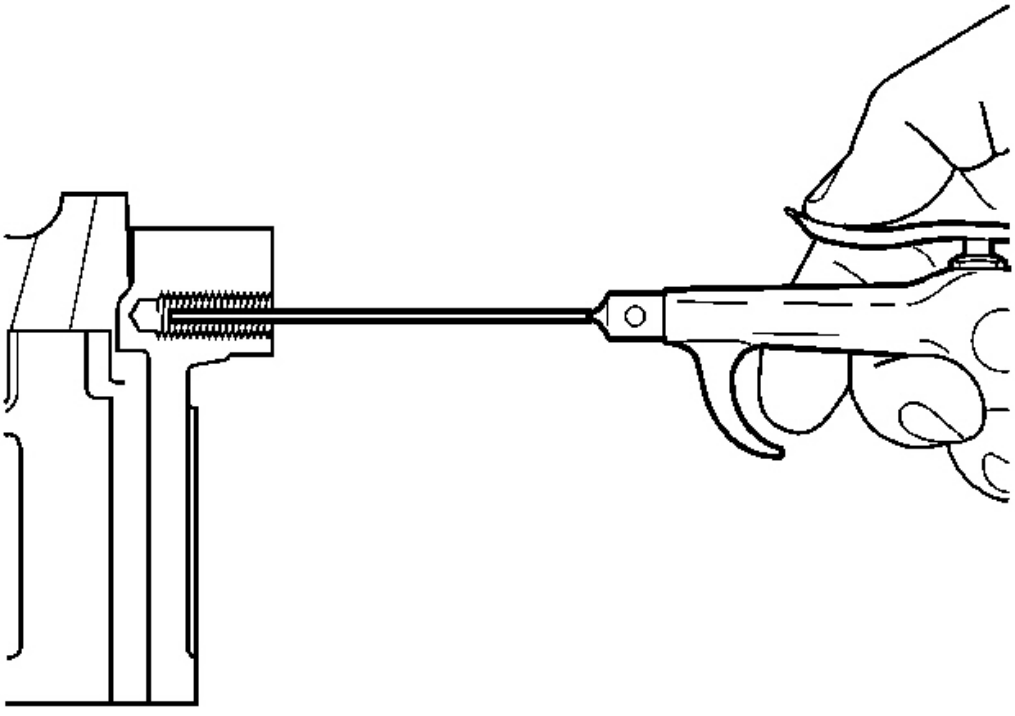


Fig. 182: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.

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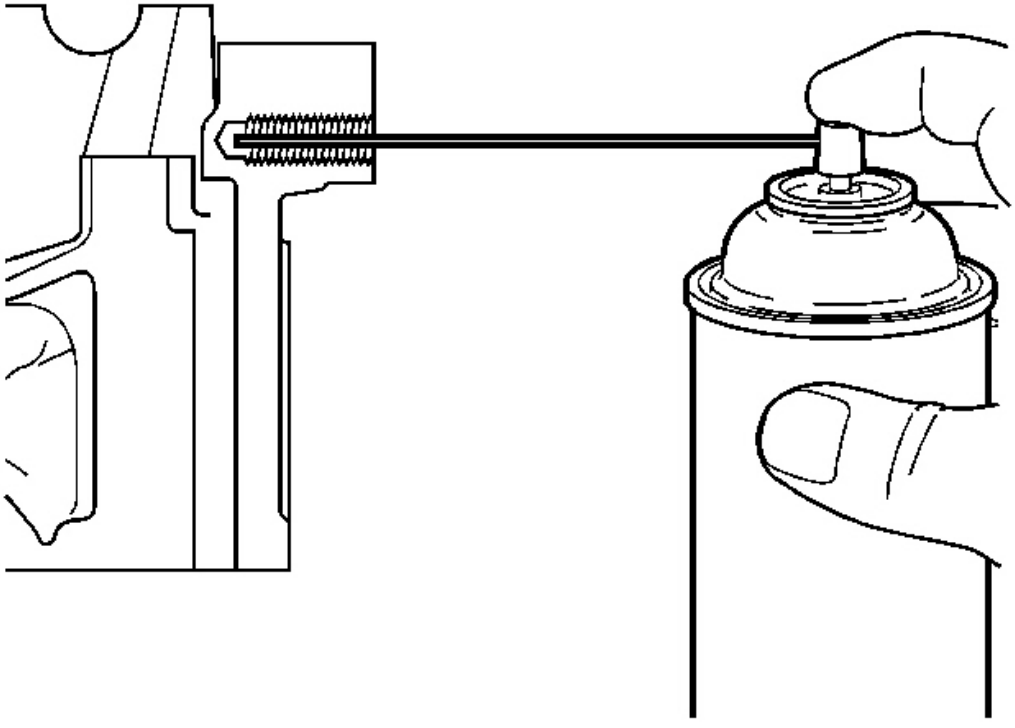


Fig. 183: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

6. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

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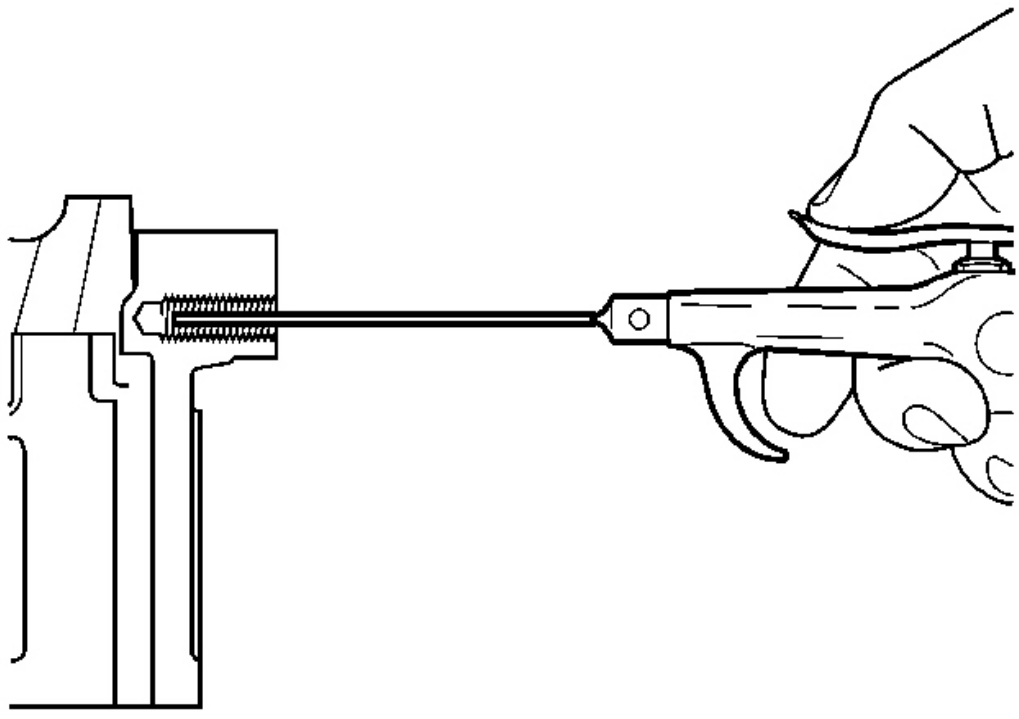


Fig. 184: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

7. Using compressed air, clean out any chips.

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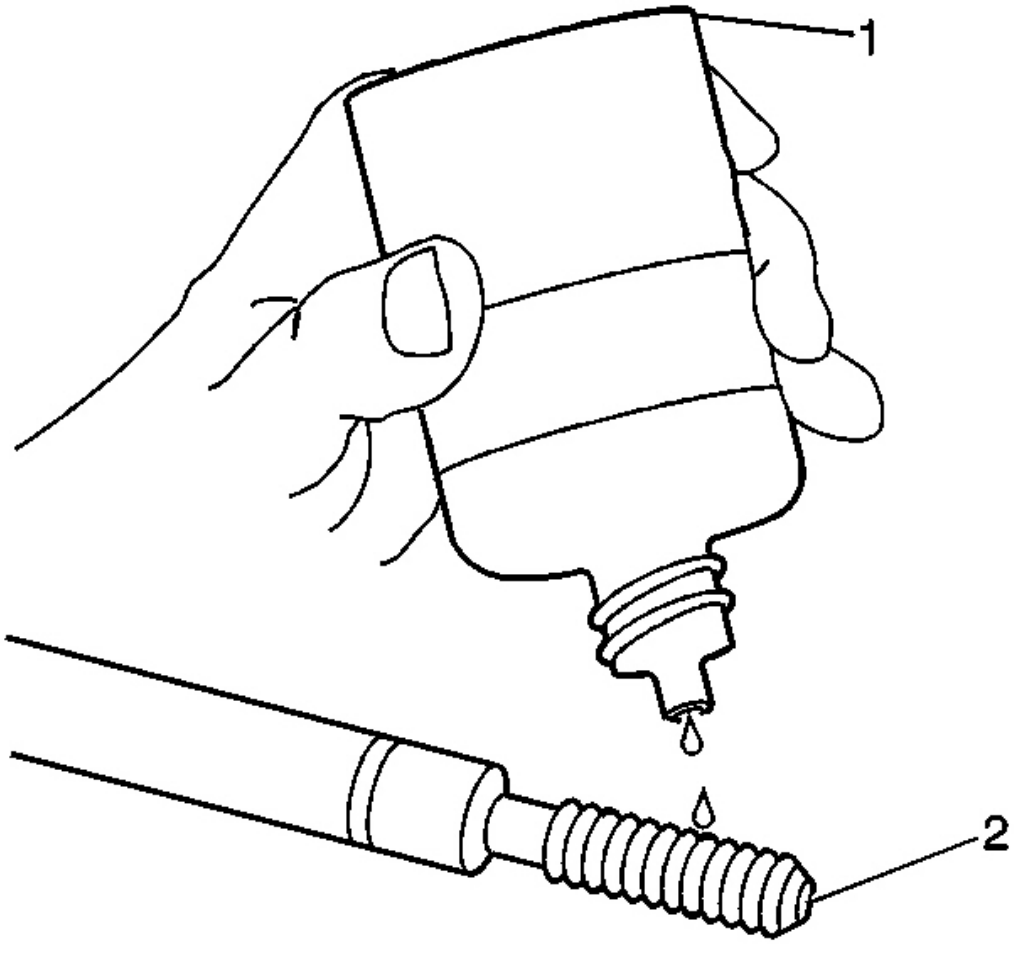


Fig. 185: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the OD of the insert.

8. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

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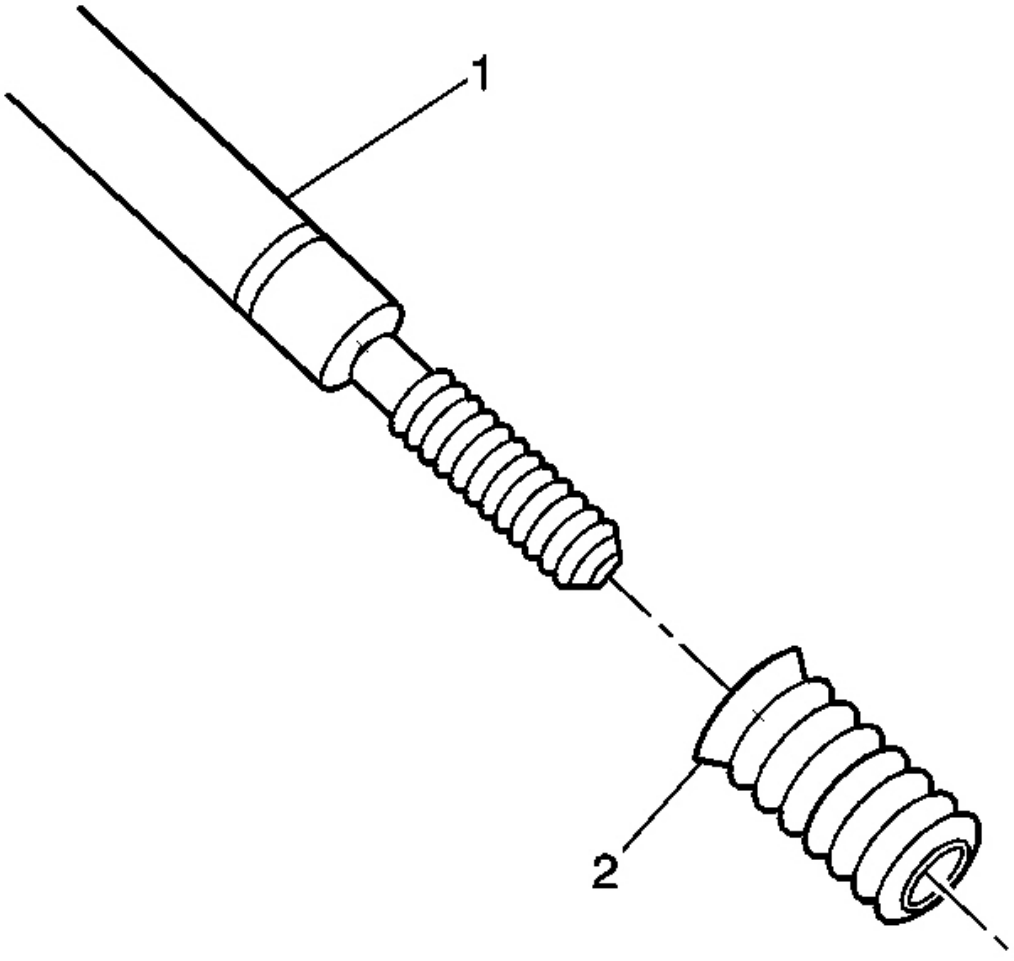


Fig. 186: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

9. Install the insert (2) onto the driver installation tool (1).

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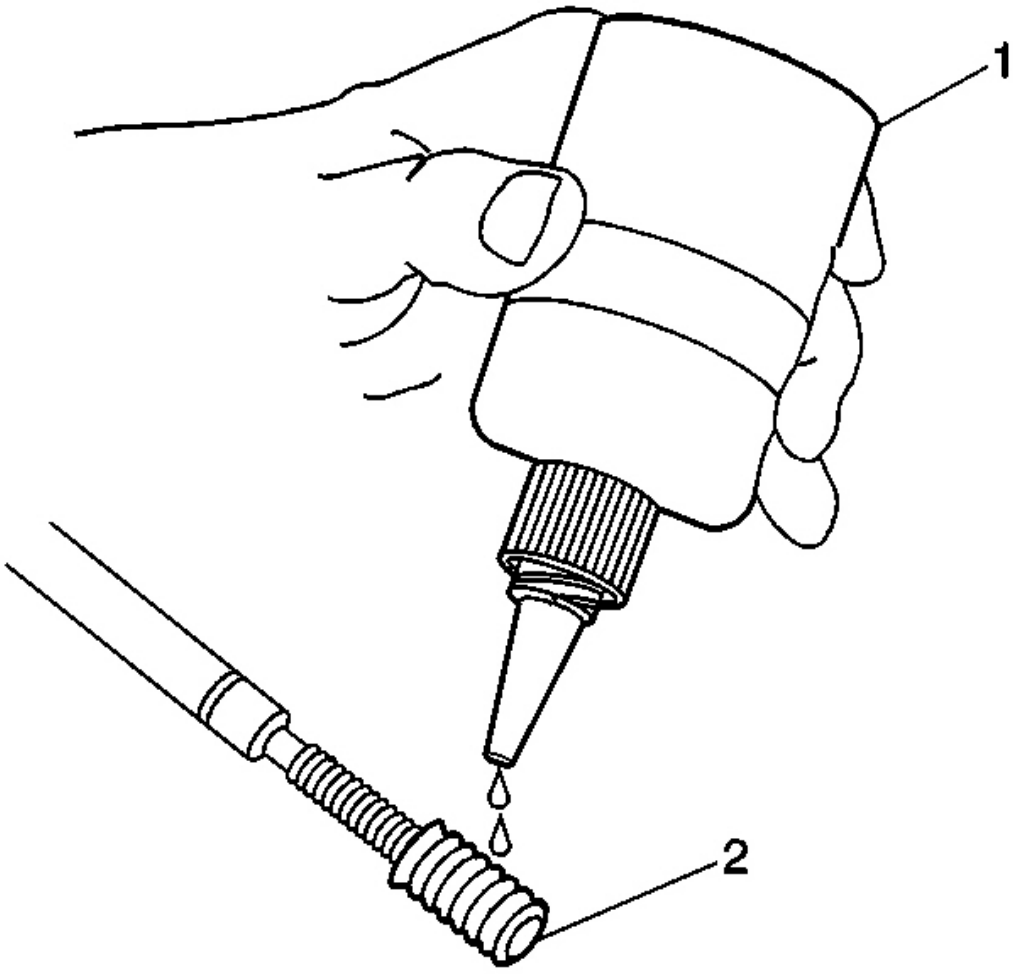


Fig. 187: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

10. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

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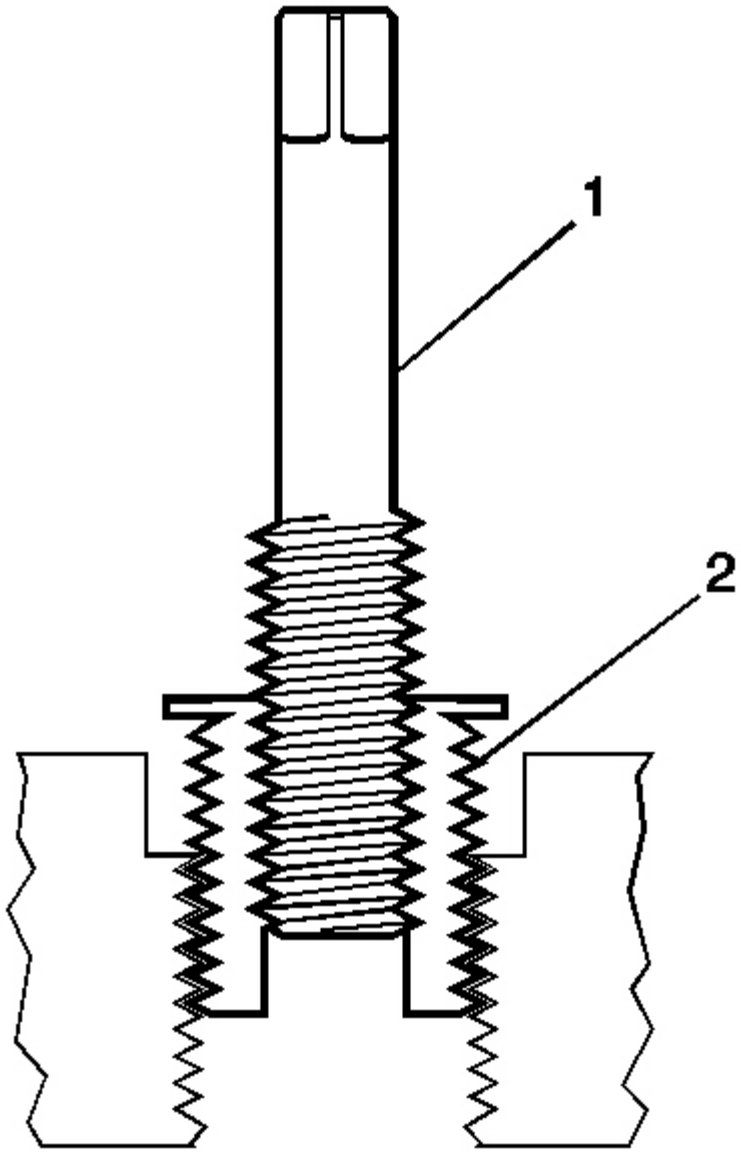


Fig. 188: Installing Insert - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) into the tapped hole by hand only.

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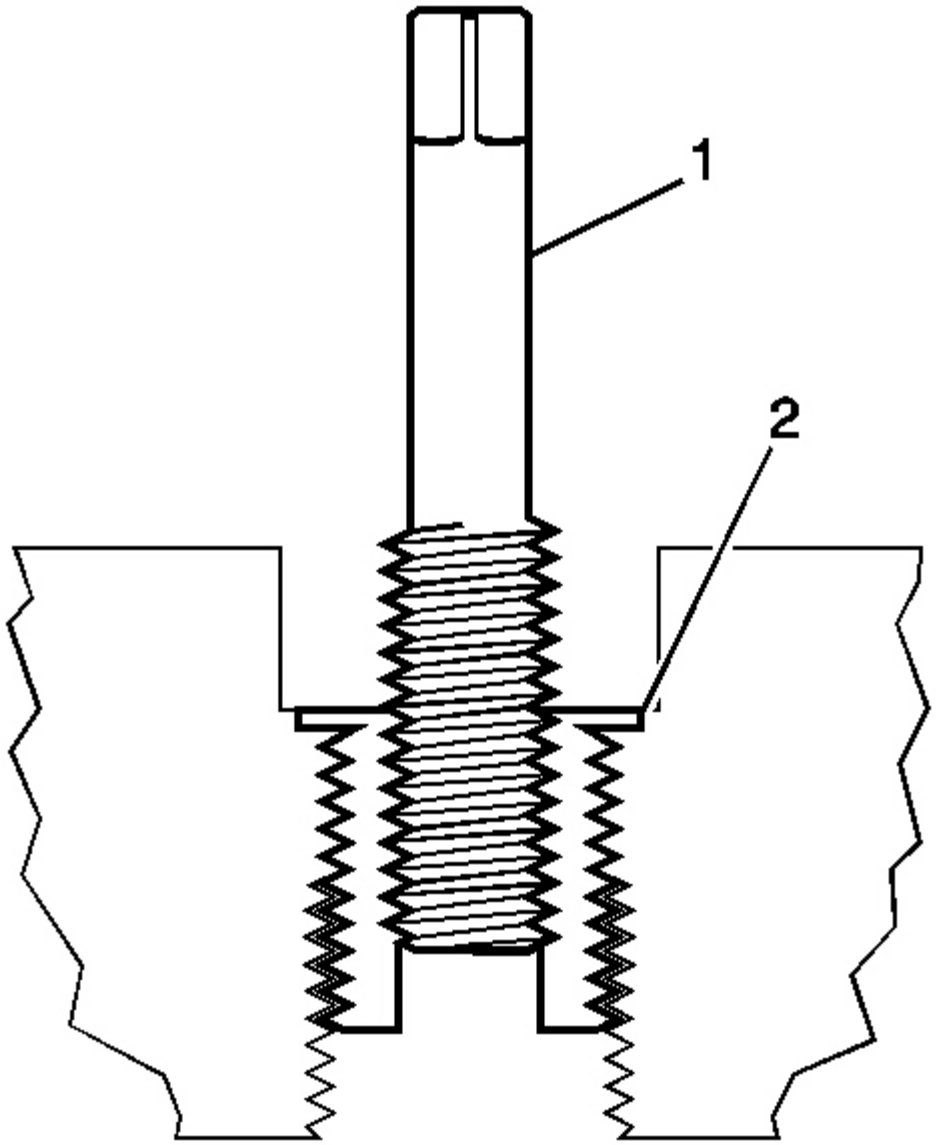


Fig. 189: View Of Installed Insert - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

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12. Install the insert until the flange (2) of the insert contacts the counterbored surface.

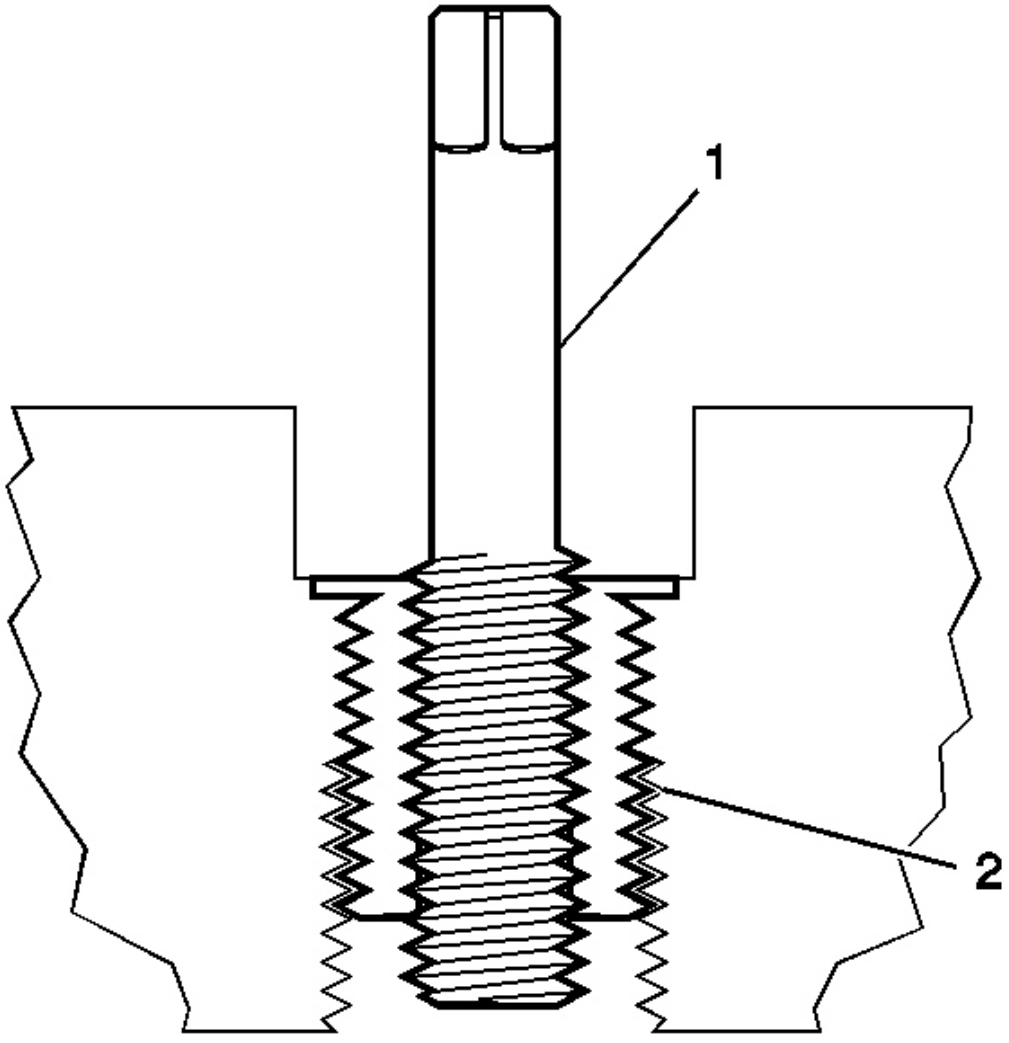


Fig. 190: Installed Insert - Recessed Thread Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

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13. Continue to rotate the driver installation tool (1) through the insert (2).

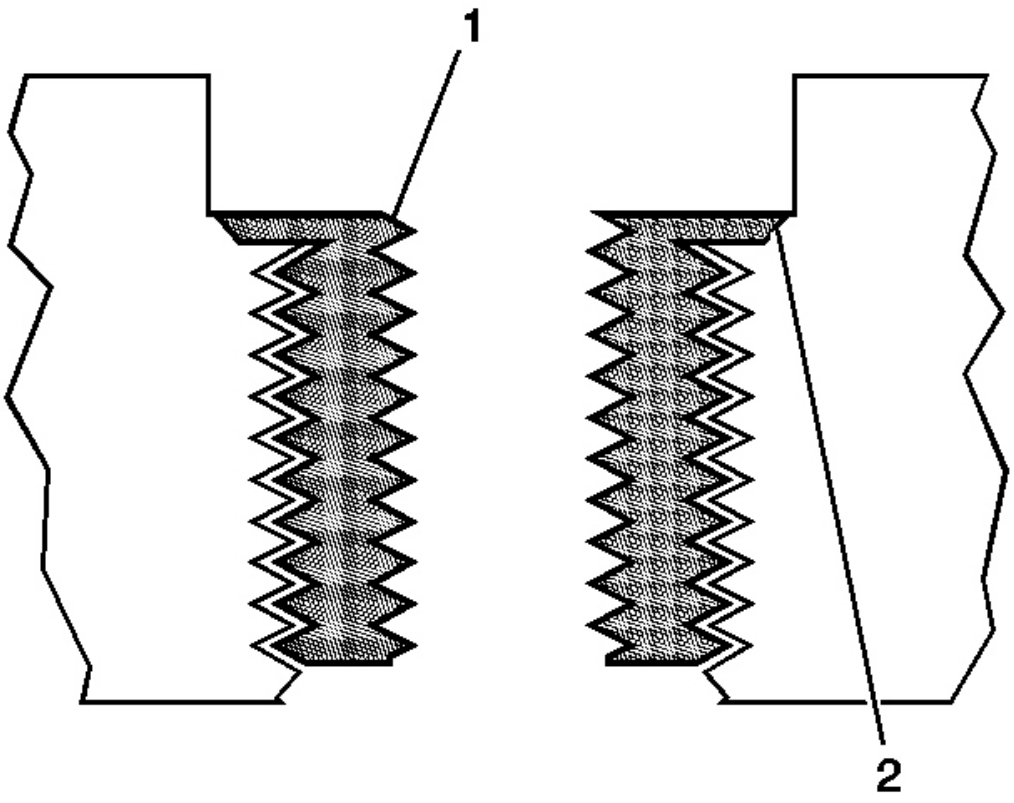


Fig. 191: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

14. Inspect the insert (1) for proper installation (2) into the tapped hole.

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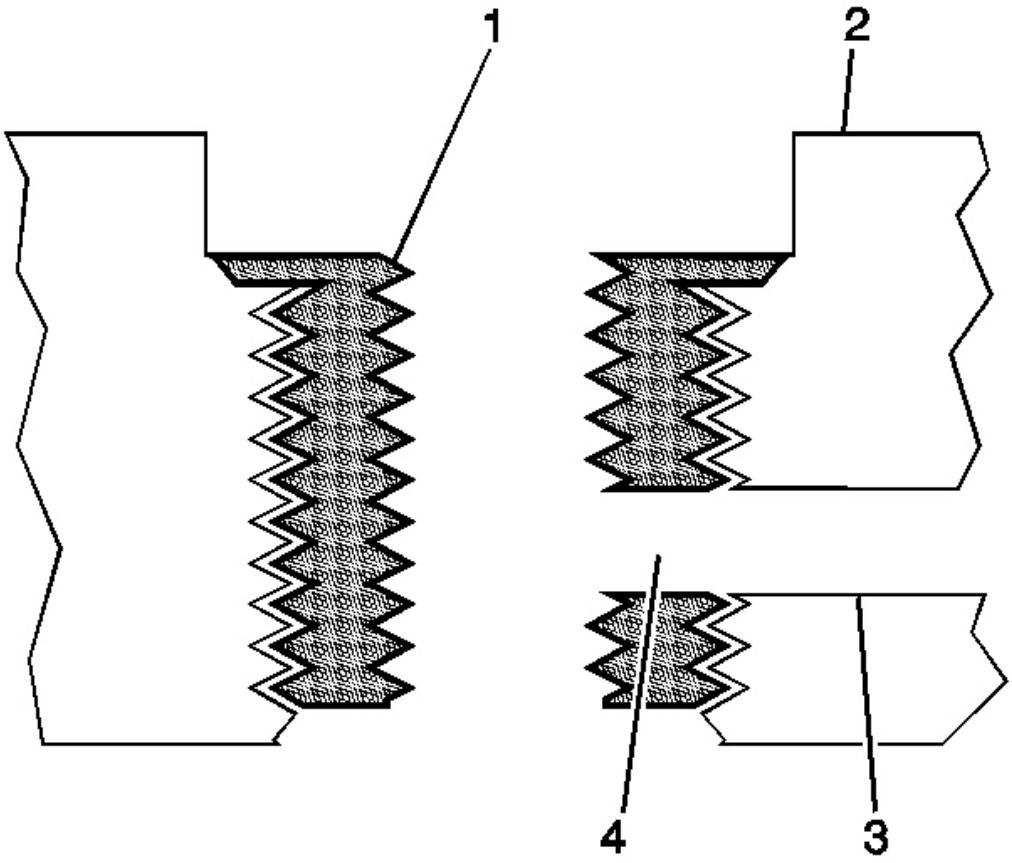


Fig. 192: View Of Restricted Engine Coolant Passage - Recessed Thread Repair
Courtesy of GENERAL MOTORS CORP.

15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

TAPERED PIPE THREAD REPAIR

The thread repair insert for tapered pipe threads is coated with a clear silver zinc coating.

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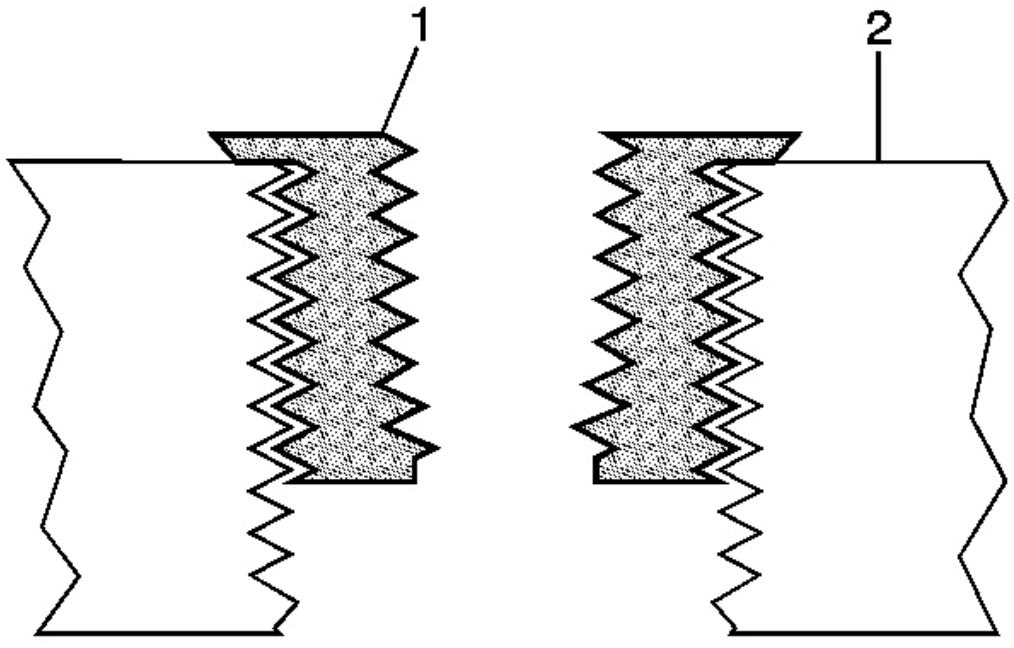


Fig. 193: Inspecting Insert For Proper Installation - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT: The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange (1) of the insert will be seated against surface (2) of the base material of the drilled/tapped hole.

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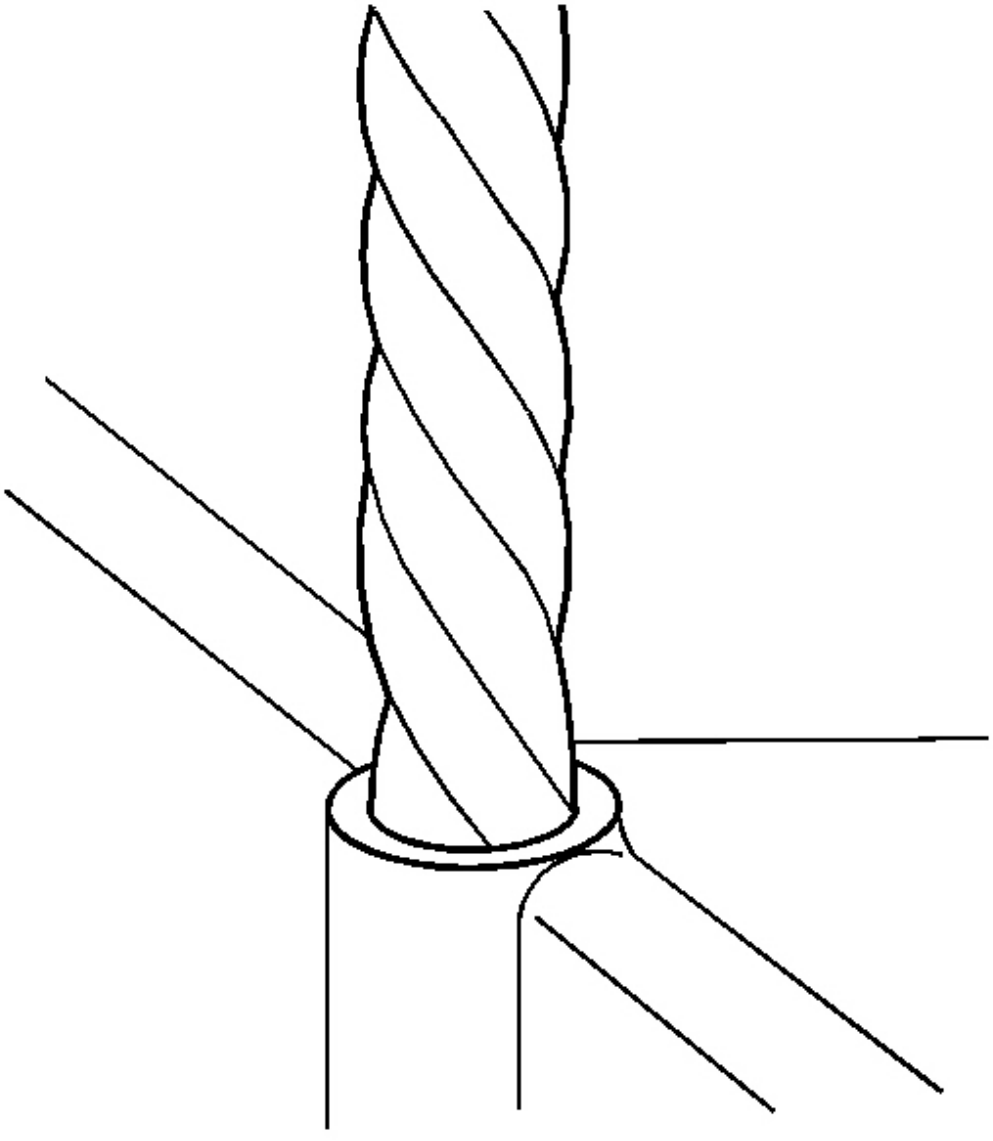


Fig. 194: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the hole until the stop collar contacts the surface of the base**

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material.

1. Drill out the threads of the damaged hole.

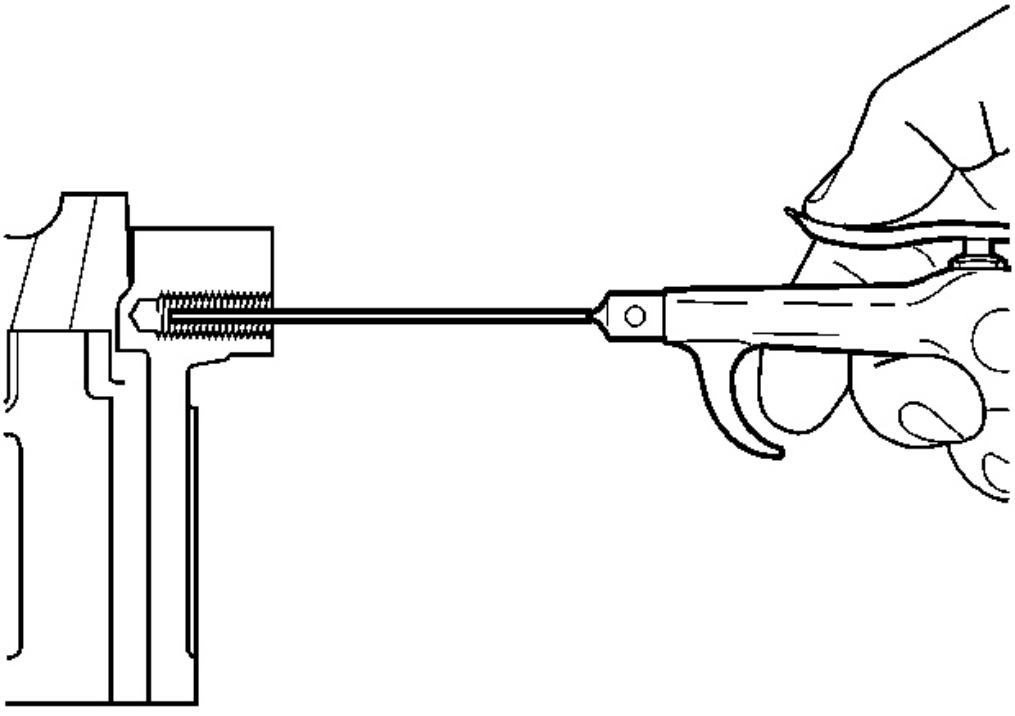


Fig. 195: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

2. Using compressed air, clean out any chips.

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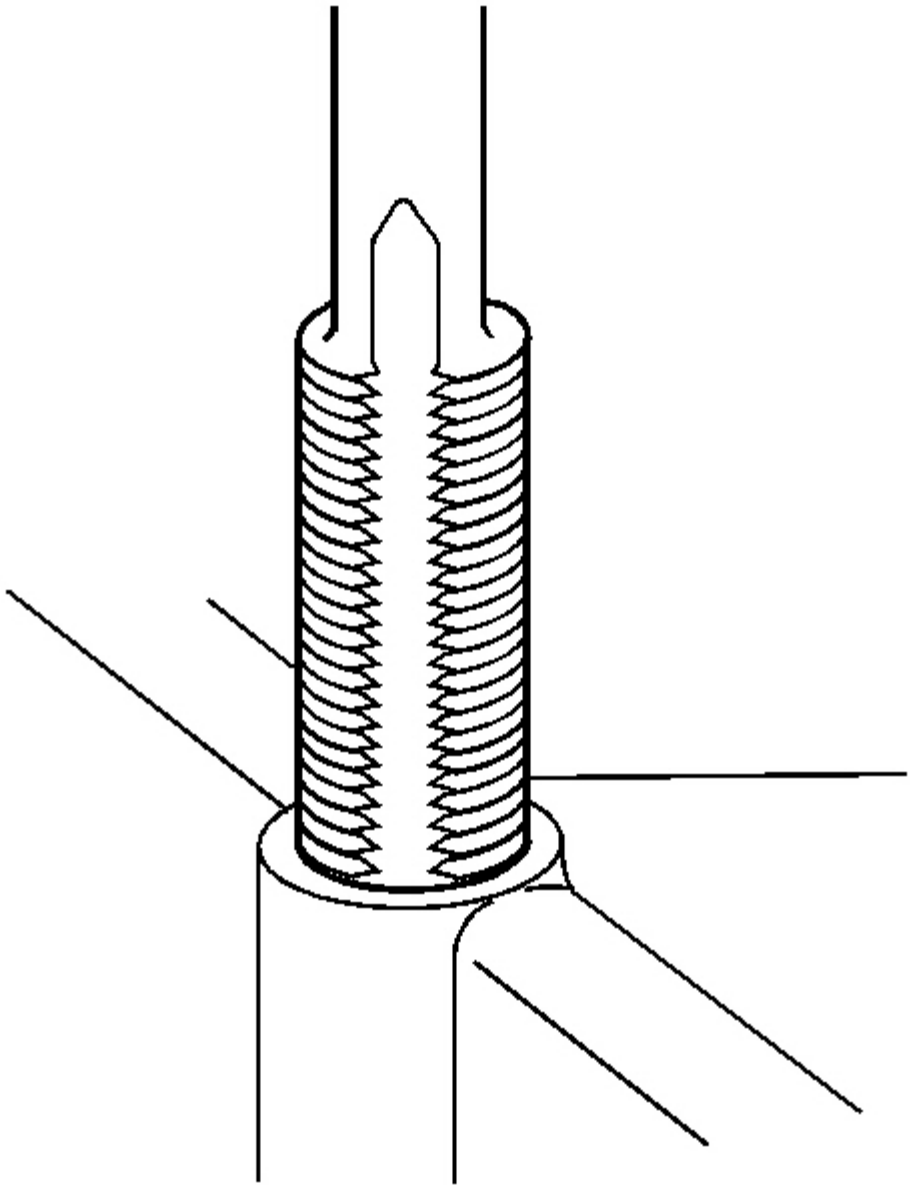


Fig. 196: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**

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- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

3. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

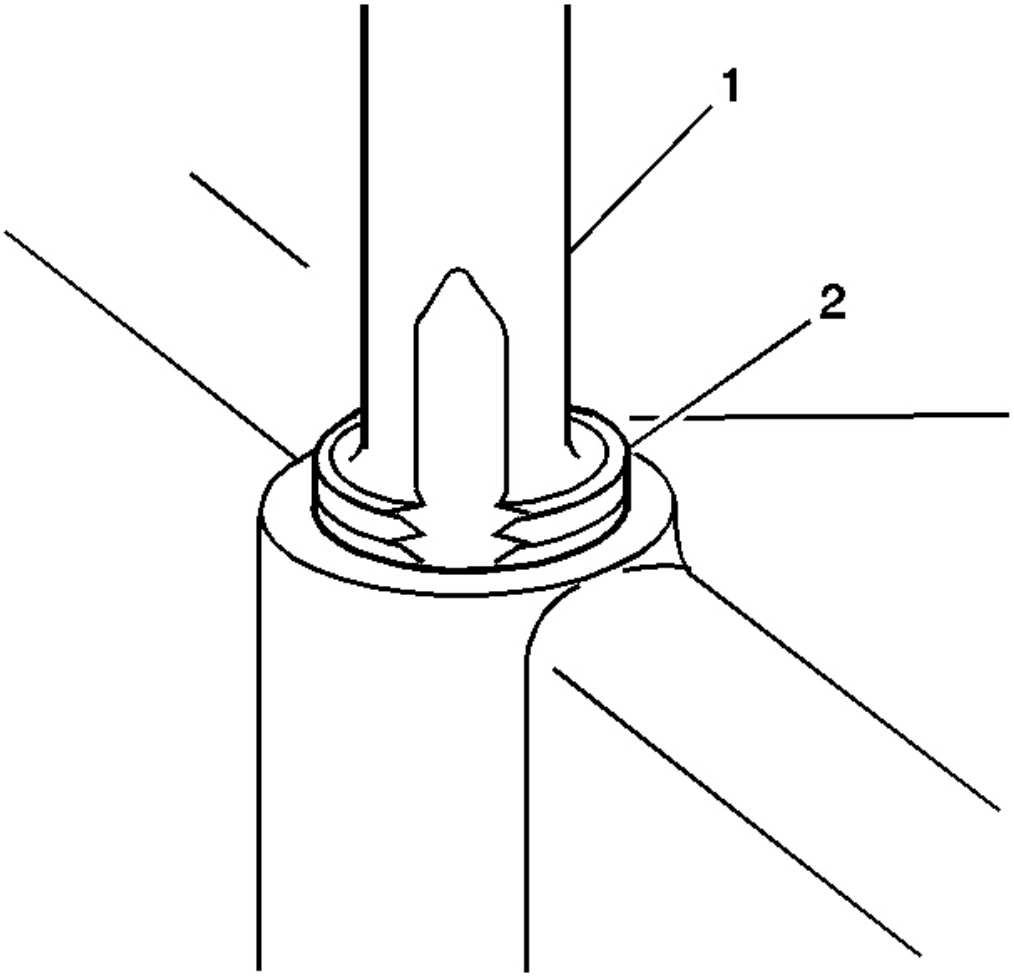


Fig. 197: View Of Proper Tapping Distance - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

4. Tap the drilled hole until the threads at the top of the tap (2) are down to the surface of the base material.

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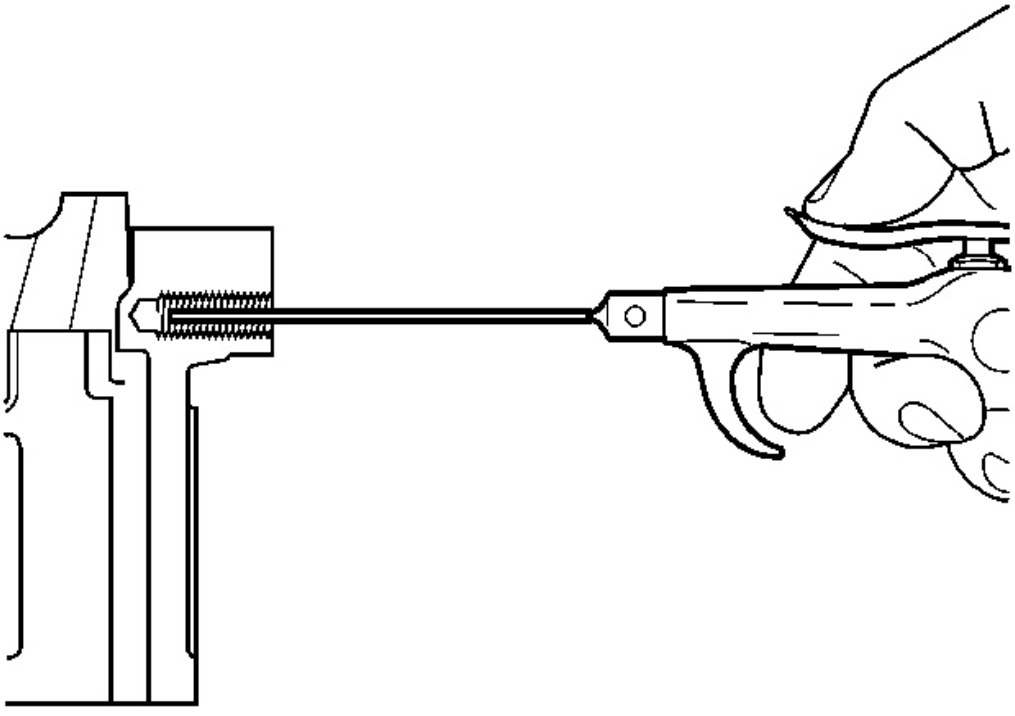


Fig. 198: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.

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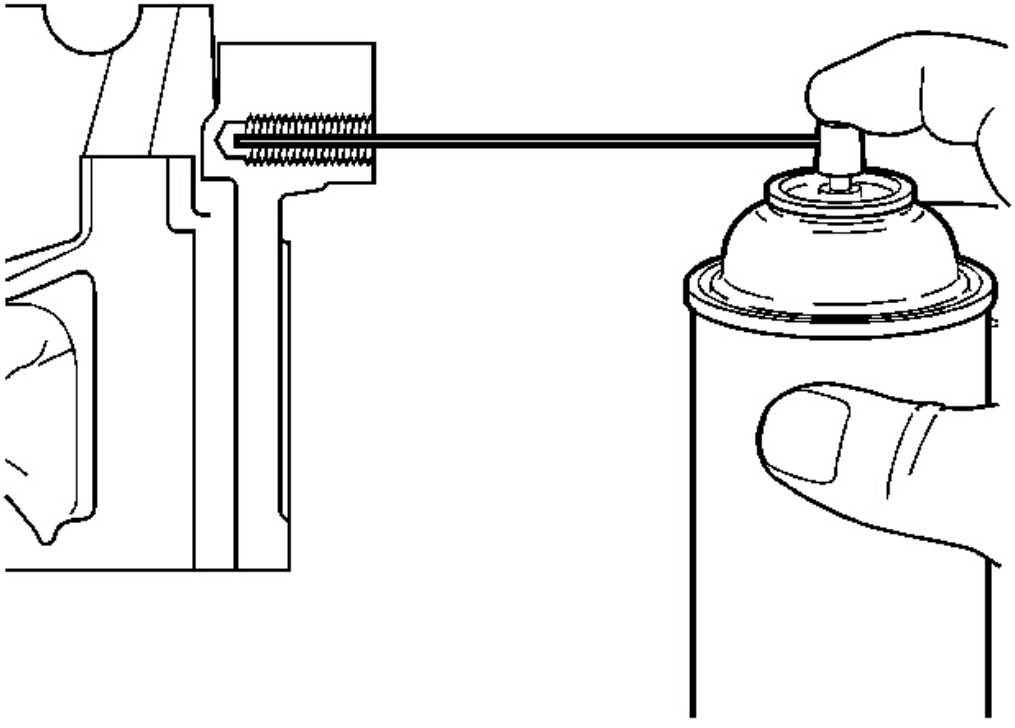


Fig. 199: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

6. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

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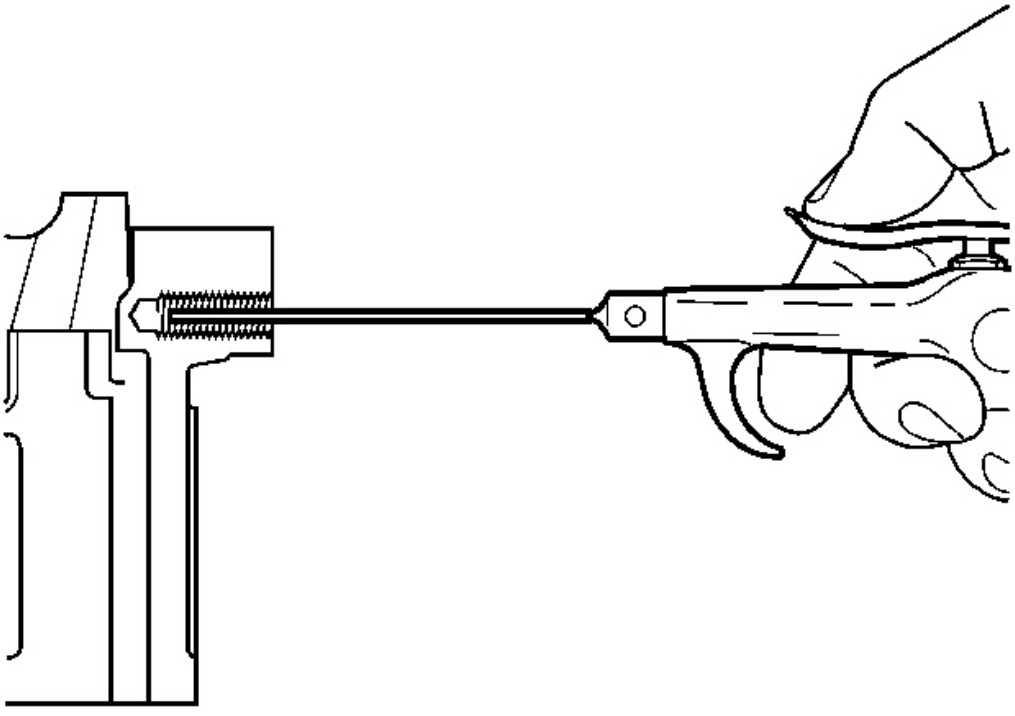


Fig. 200: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

7. Using compressed air, clean out any chips.

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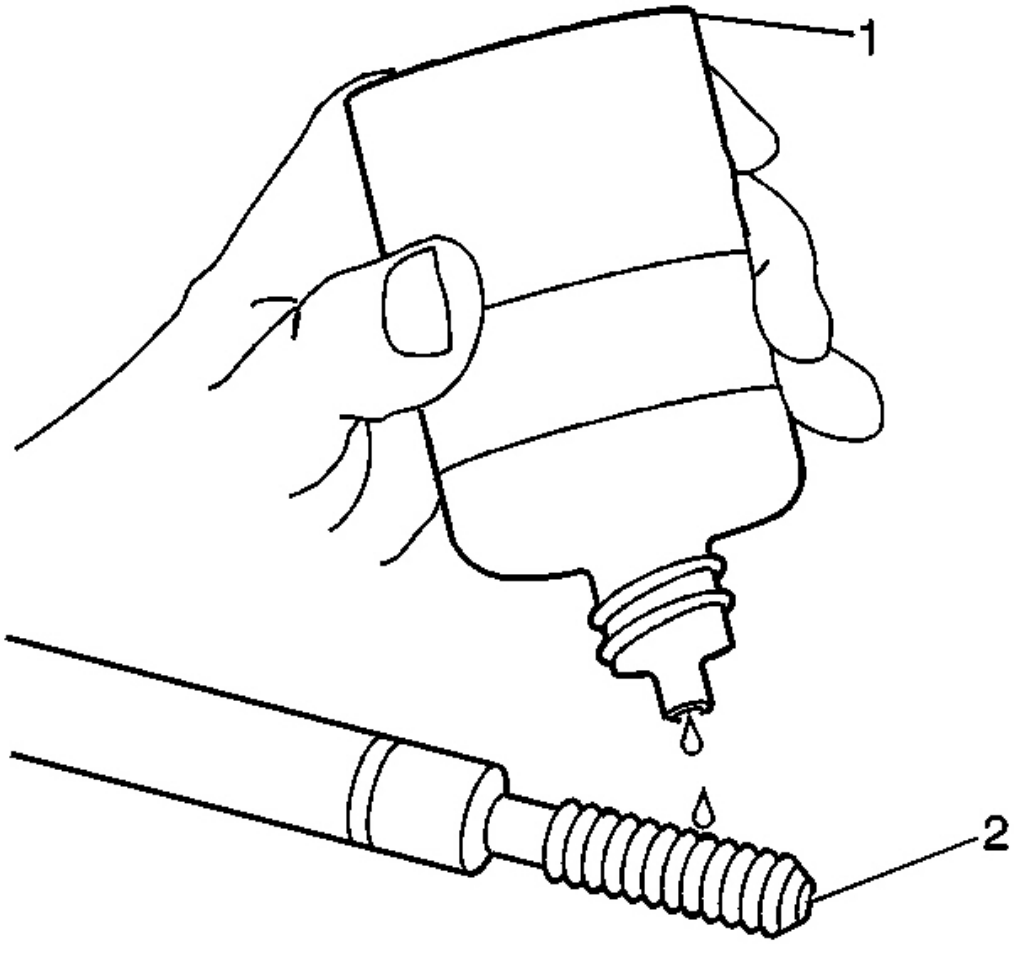


Fig. 201: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the OD of the insert.

8. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

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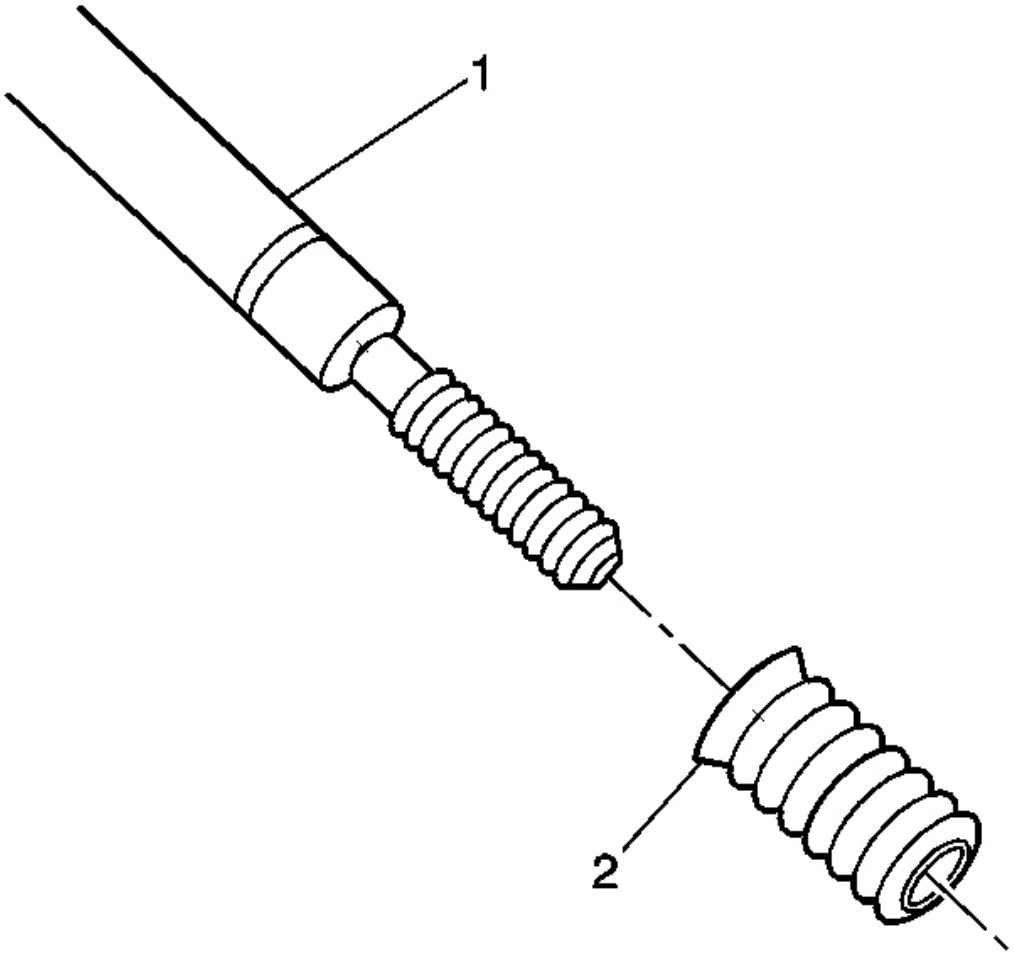


Fig. 202: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

9. Install the insert (2) onto the driver installation tool (1).

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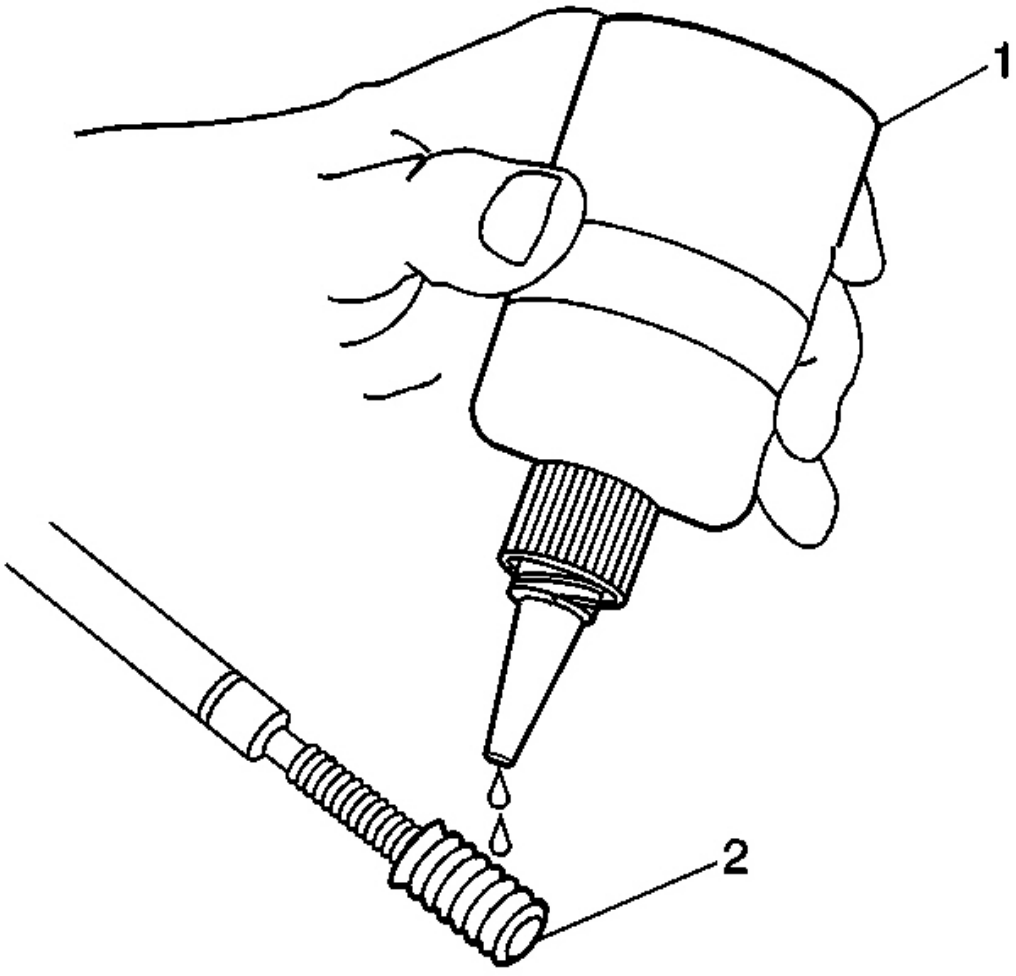


Fig. 203: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

10. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

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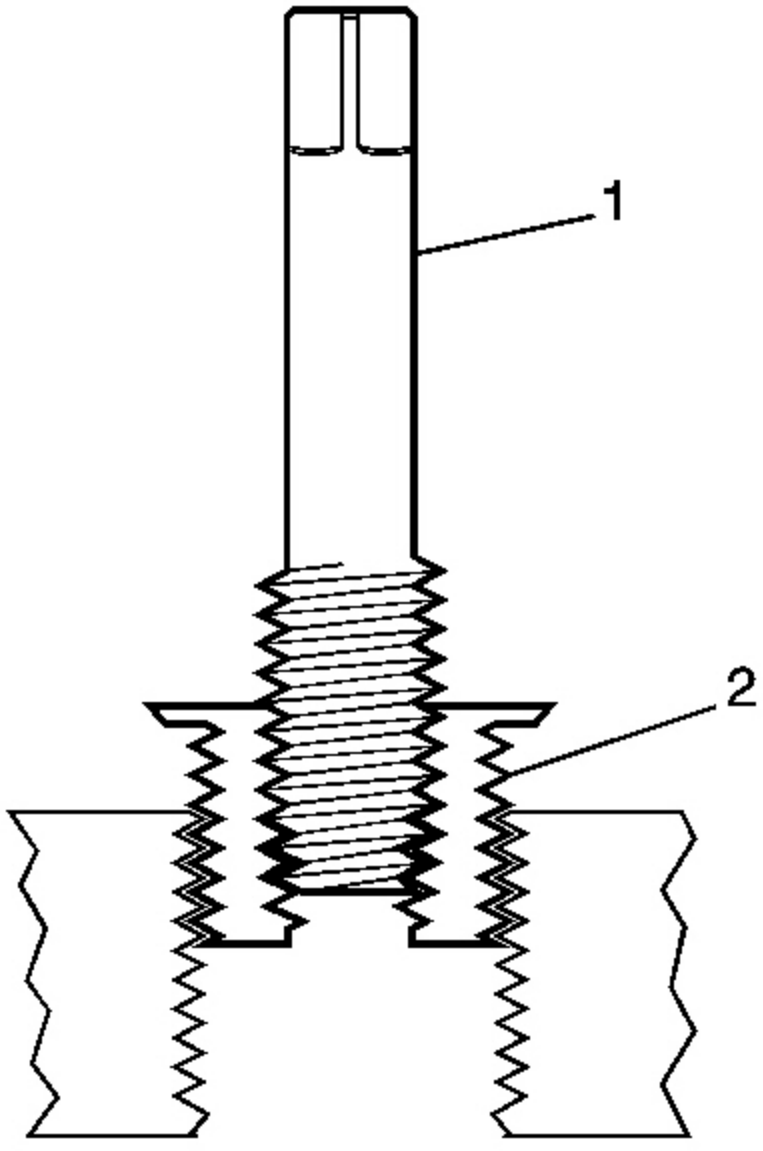


Fig. 204: Installing Insert - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) into the tapped hole by hand only.

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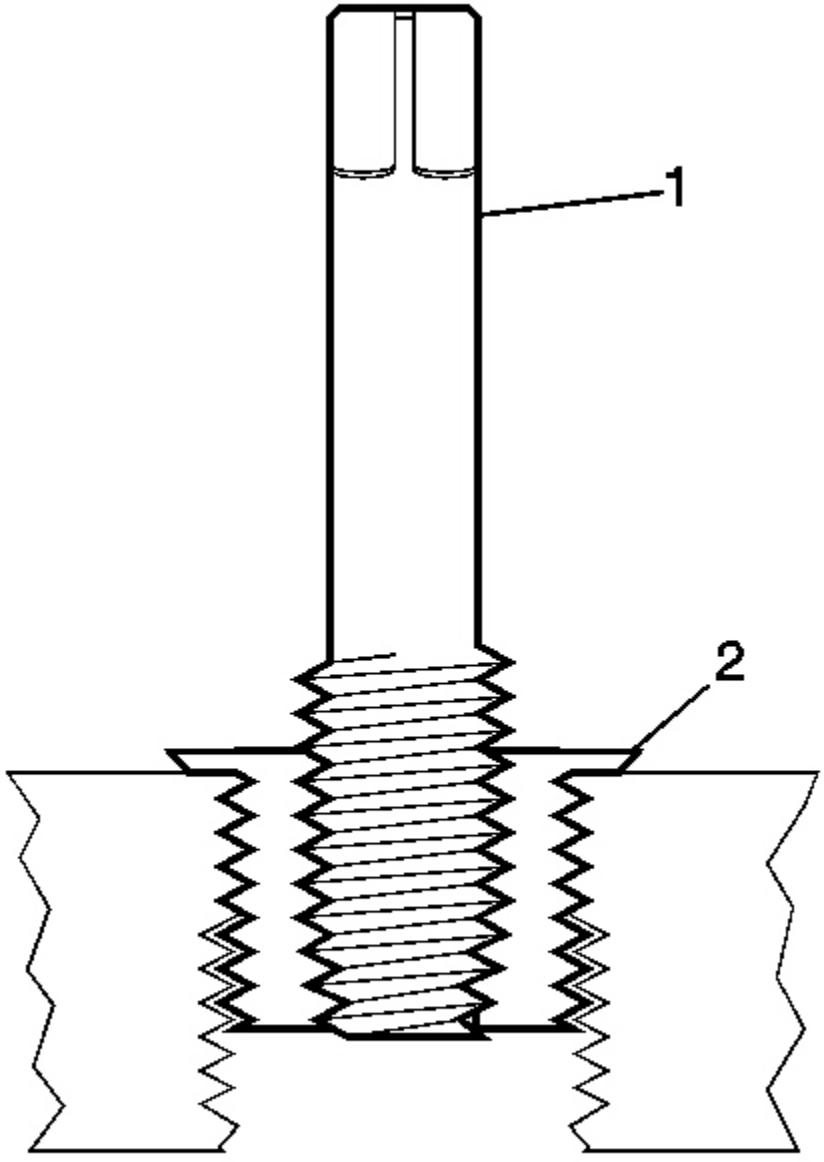


Fig. 205: Installing Insert - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the insert will not thread down until the flange contacts the surface of the base material remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper

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tapping.

12. Install the insert until the flange (2) of the insert contacts the surface of the base material.

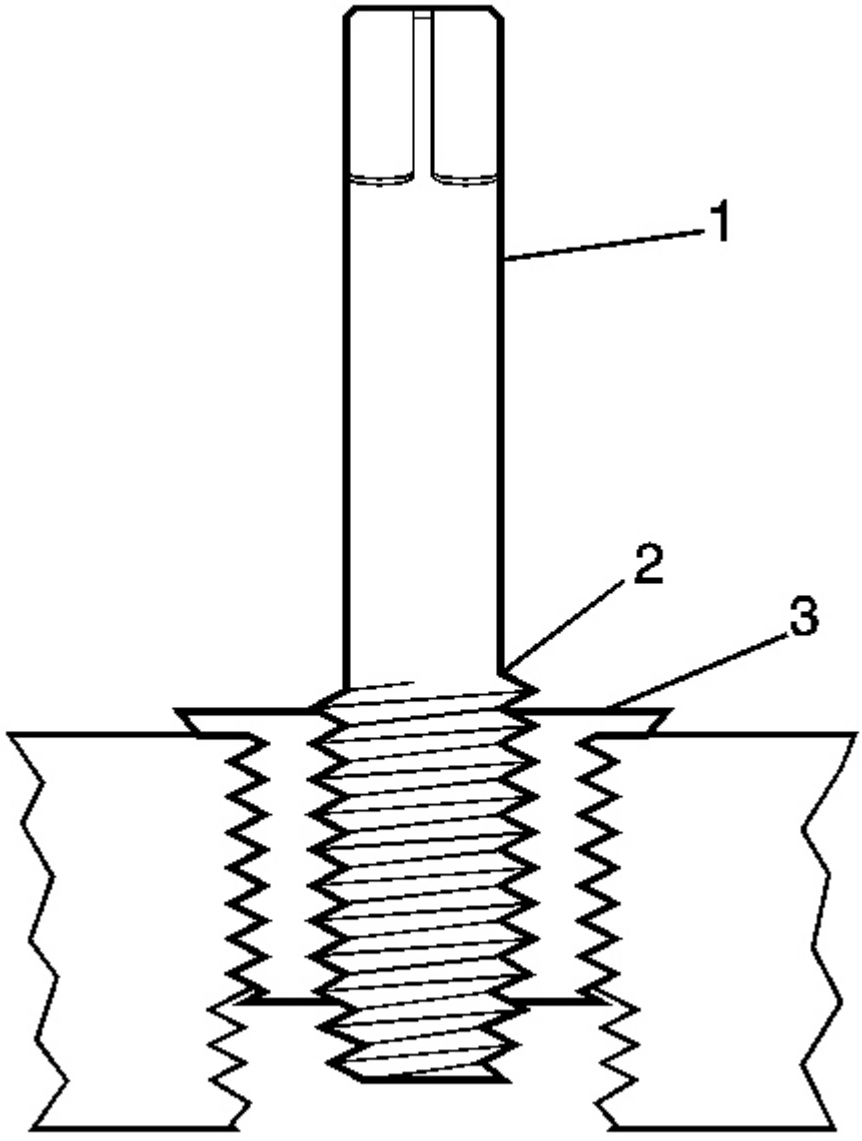


Fig. 206: Installed Insert - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

13. Continue to rotate the driver installation tool (1) until the top of the threaded section (2) is level with the top of the insert (3).

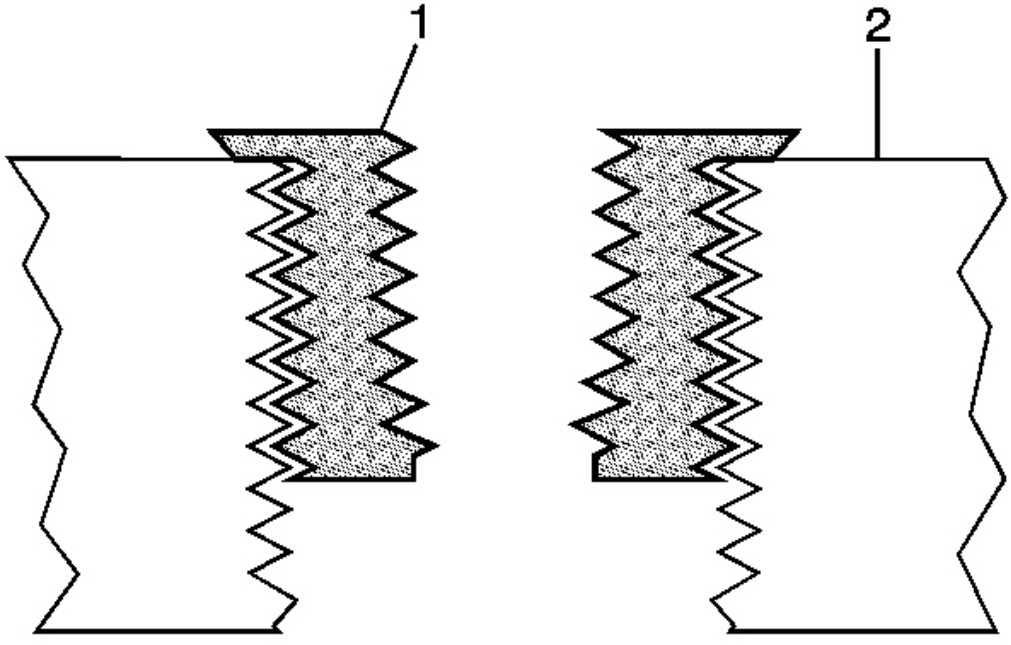


Fig. 207: Inspecting Insert For Proper Installation - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

14. Inspect the insert (1) for proper installation (2) into the tapped hole.

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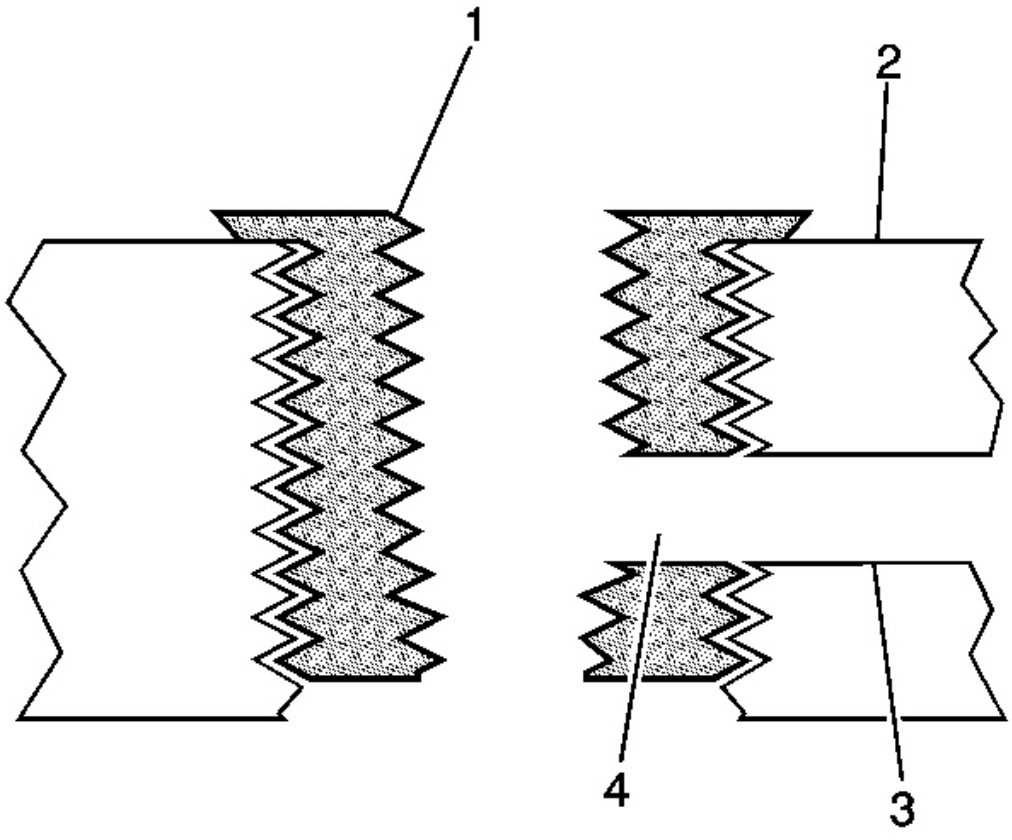


Fig. 208: View Of Restricted Engine Coolant Passages - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS CORP.

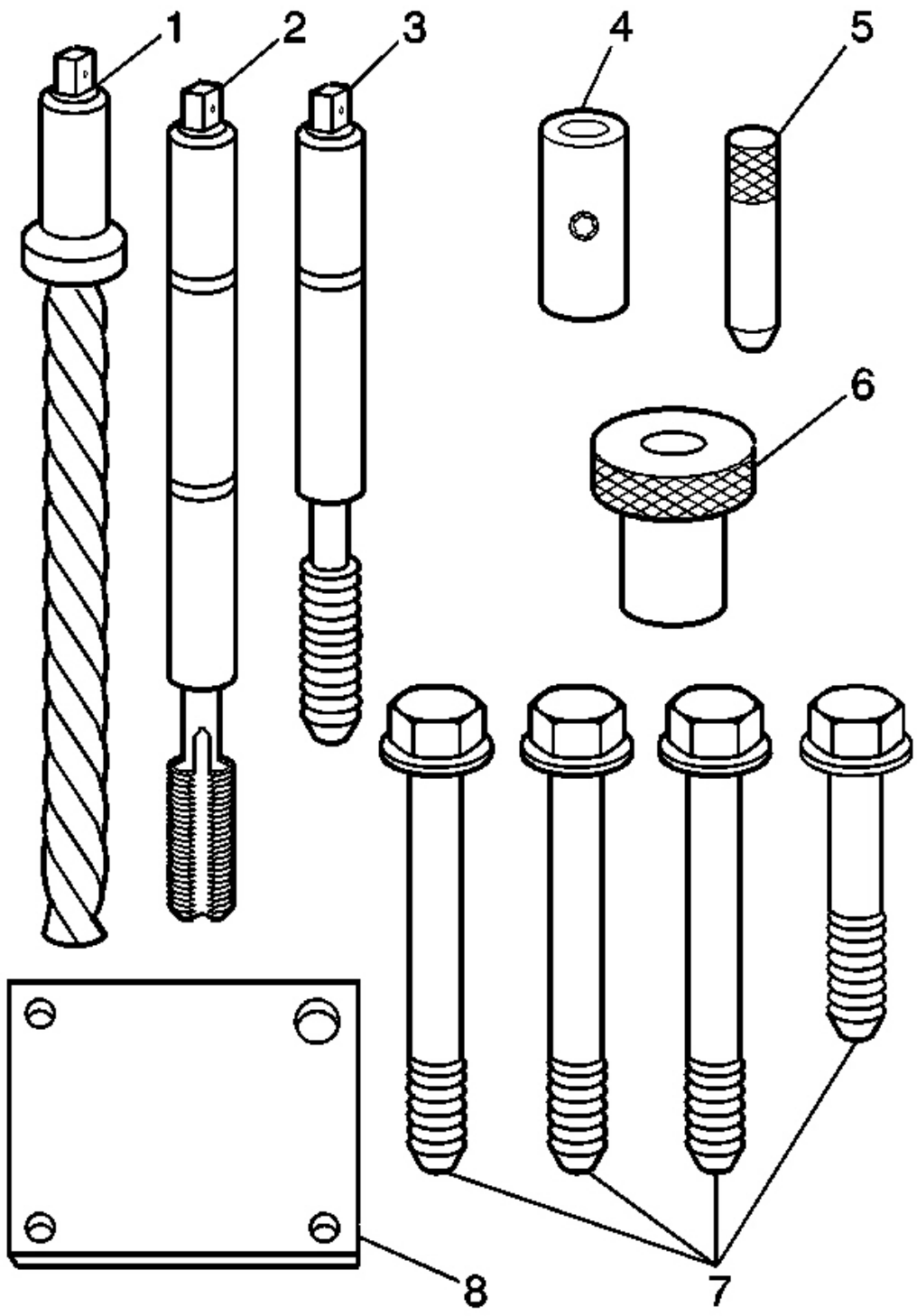
15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

CYLINDER HEAD BOLT HOLE THREAD REPAIR

Tools Required

J 42385-2030 M11 x 2. See **Special Tools** .0 Cylinder Head Bolt - Northstar/Premium V8 Thread Insert Kit

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Fig. 209: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

The cylinder head bolt hole thread repair kit **J 42385-2030** components consist of the following:

- Drill (1) J 42385-2031
- Tap (2) J 42385-2032
- Installation driver (3) J 42385-2033
- Stop collar (4) for inboard holes J 42385-2034
- Alignment pin (5) J 42385-303
- Bushing (6) J 42385-302
- Bolts (7) J 42385-2035 and J 42385-2036
- Fixture plate (8) J 42385-301

NOTE: **Ensure the cylinder head bolts, tools and inserts that are being used are the proper pitch or engine damage will occur. The thread pitch on the M11 cylinder head bolts and the engine block cylinder head bolt holes have been revised. In order to install the proper pitch insert it is important to identify which thread pitch is being used. Cylinder head bolts with a pitch of 1.5 mm have a thread length of about 48 mm (1.890 in) long. Cylinder head bolts with a pitch of 2.0 mm have a thread length of about 67 mm (2.638 in) long.**

IMPORTANT:

- **Cylinder head bolt holes with a pitch of 2.0 mm (0.08 in) use the tooling from the J 42385-2030 . See Special Tools . Cylinder head bolt holes with a pitch of 1.5 mm (5.90 in) use the tooling from the J 42385-2000 . See Special Tools .**
- **Verify the depth of the cylinder head bolt hole and the pitch of the cylinder head bolt threads. Measure the depth from the deck surface of the block to the bottom of the cylinder head hole. All cylinder head holes should use only one of the bushings. Never use both bushings to repair a block.**

With M11 bolts with a 1.5 mm pitch:

- Use the bushing J 42385-2022 for inboard holes that measure 73 mm (2.874 in) deep and outboard holes that measure 89.5 mm (3.524 in) deep.
- Use the bushing J 42385-302 for inboard holes that measure 80 mm (3.150 in) deep and outboard holes that measure 96.5 mm (3.799 in) deep.

With M11 bolts with 2.0 mm pitch:

Use the bushing J 42385-302 for inboard holes that measure 73 mm (2.874 in) deep and outboard holes that measure 89.5 mm (3.524 in) deep.

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INBOARD BOLT HOLES

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- **Remove the fixture plate prior to installing the insert with the installer tool.**
- **The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.**

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

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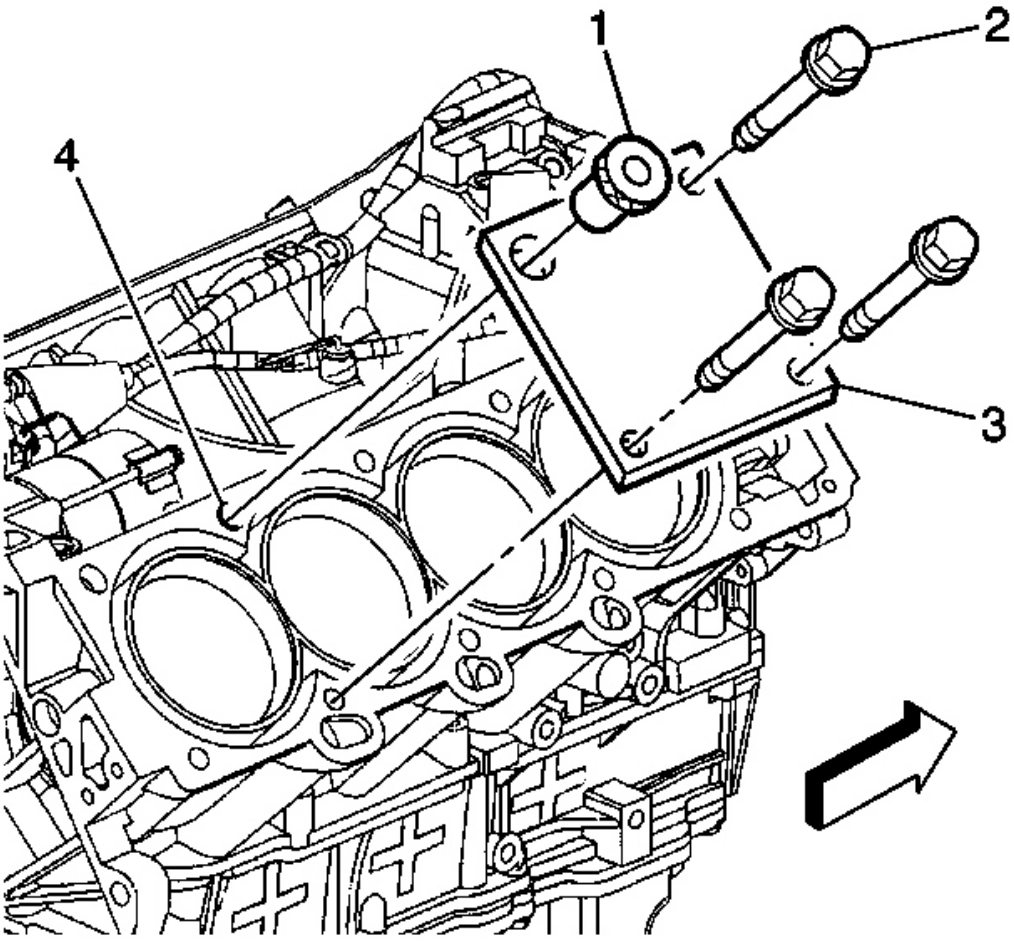


Fig. 210: View Of Fixture Plate & Components - Inboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Position the fixture plate (3) with the bushing (1) installed over the cylinder head bolt hole to be repaired (4).
2. Loosely install the fixture plate bolts (2) into the remaining cylinder head bolt holes.

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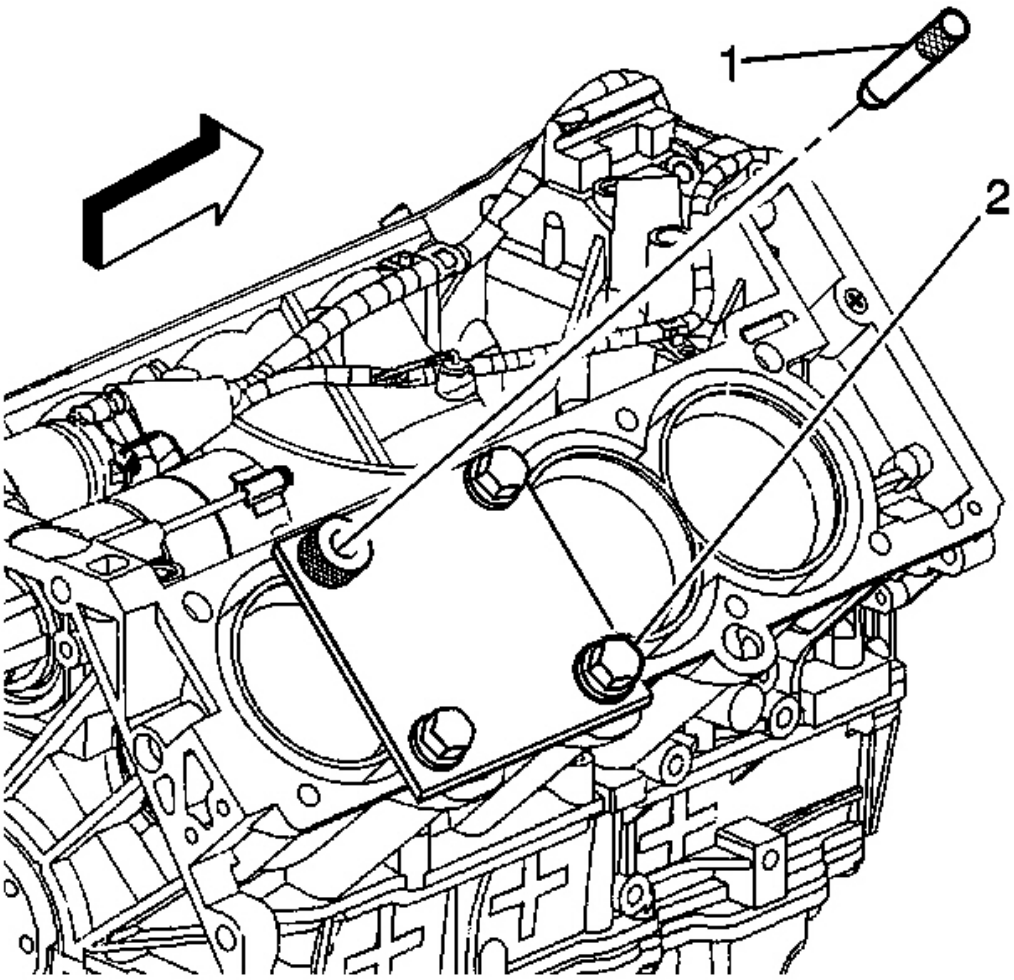


Fig. 211: Positioning Alignment Pin - Inboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the cylinder head bolt hole.
4. With the alignment pin in the desired cylinder head bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the cylinder head bolt hole.

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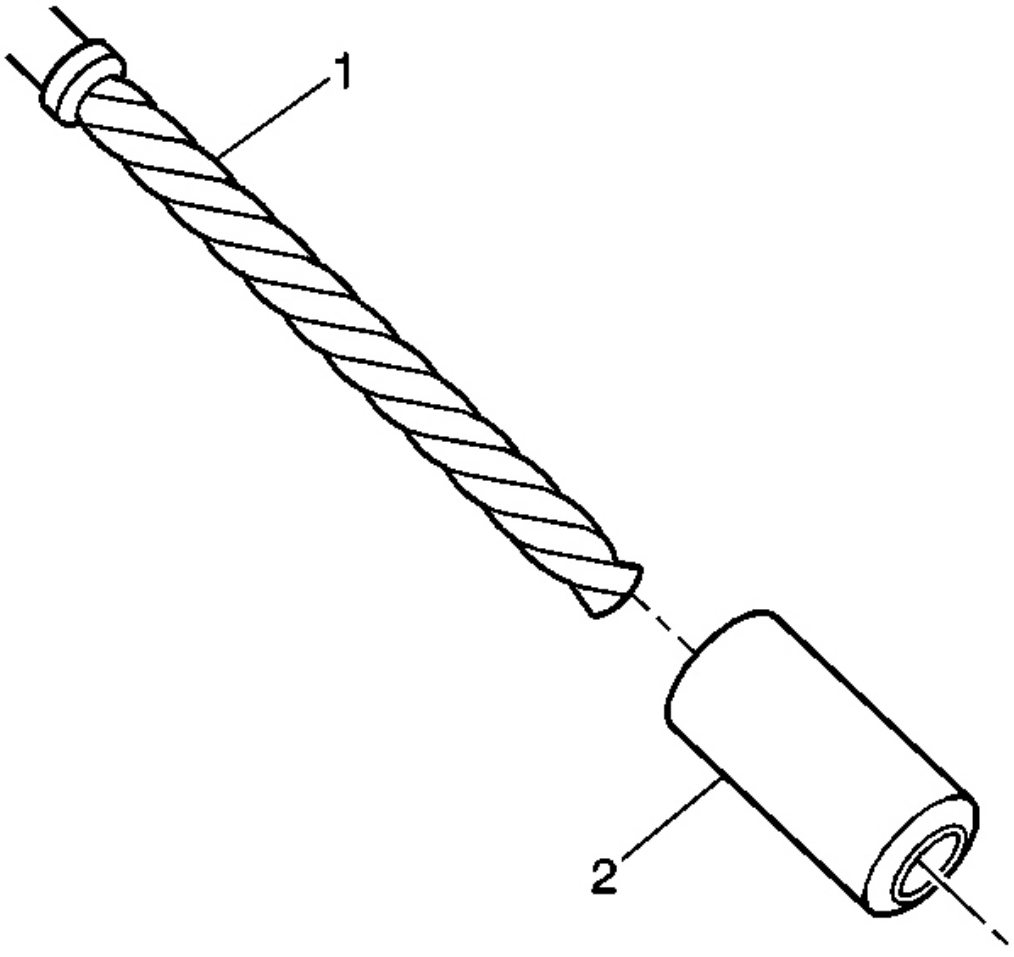


Fig. 212: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the stop collar (2) onto the drill (1).

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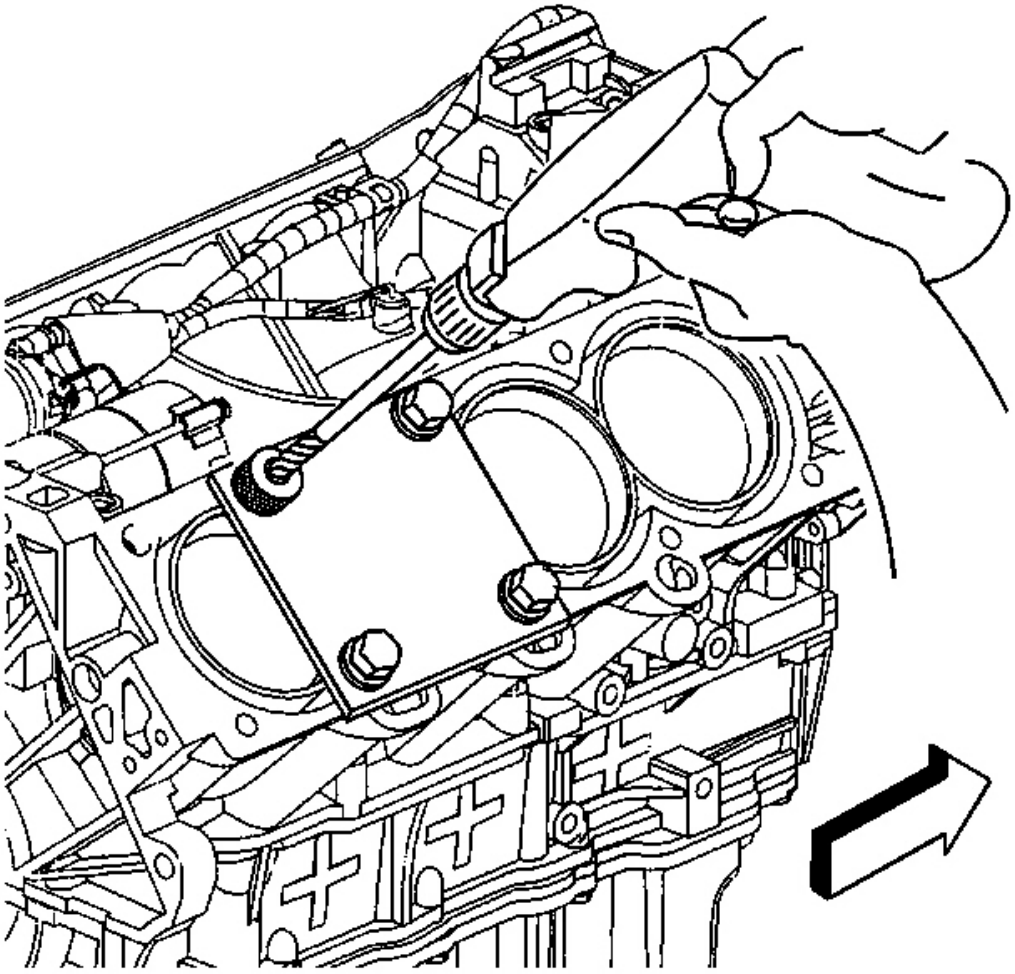


Fig. 213: Drilling Out Threads Of Damaged Hole - Inboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the hole until the stop collar contacts the top of the drill bushing.**

7. Drill out the threads of the damaged hole.

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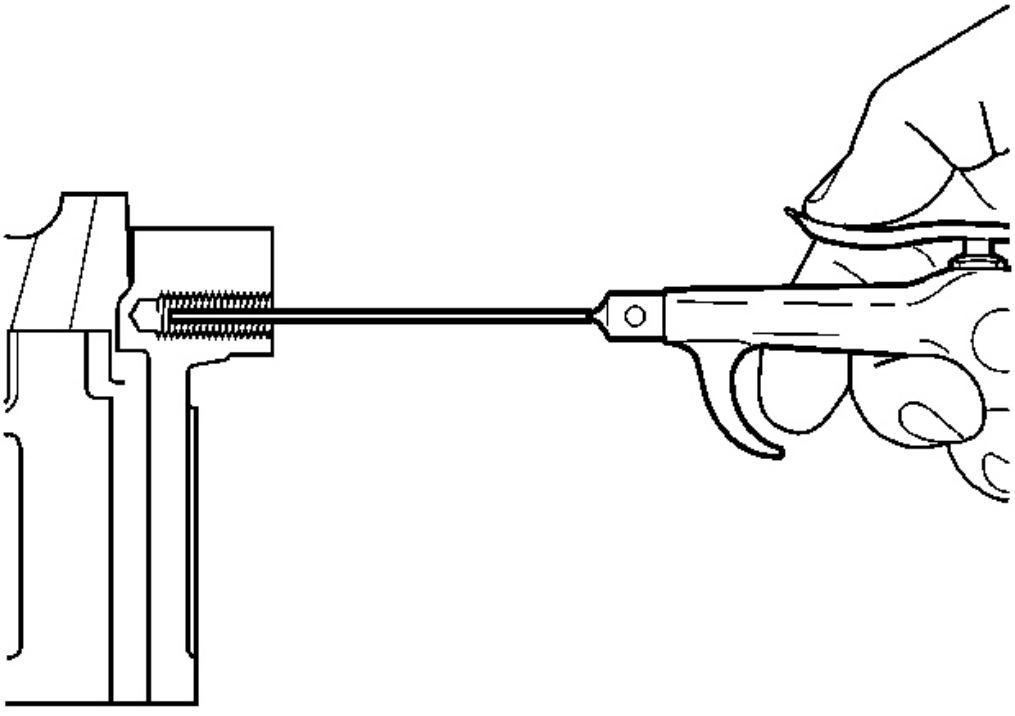


Fig. 214: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

8. Using compressed air, clean out any chips.

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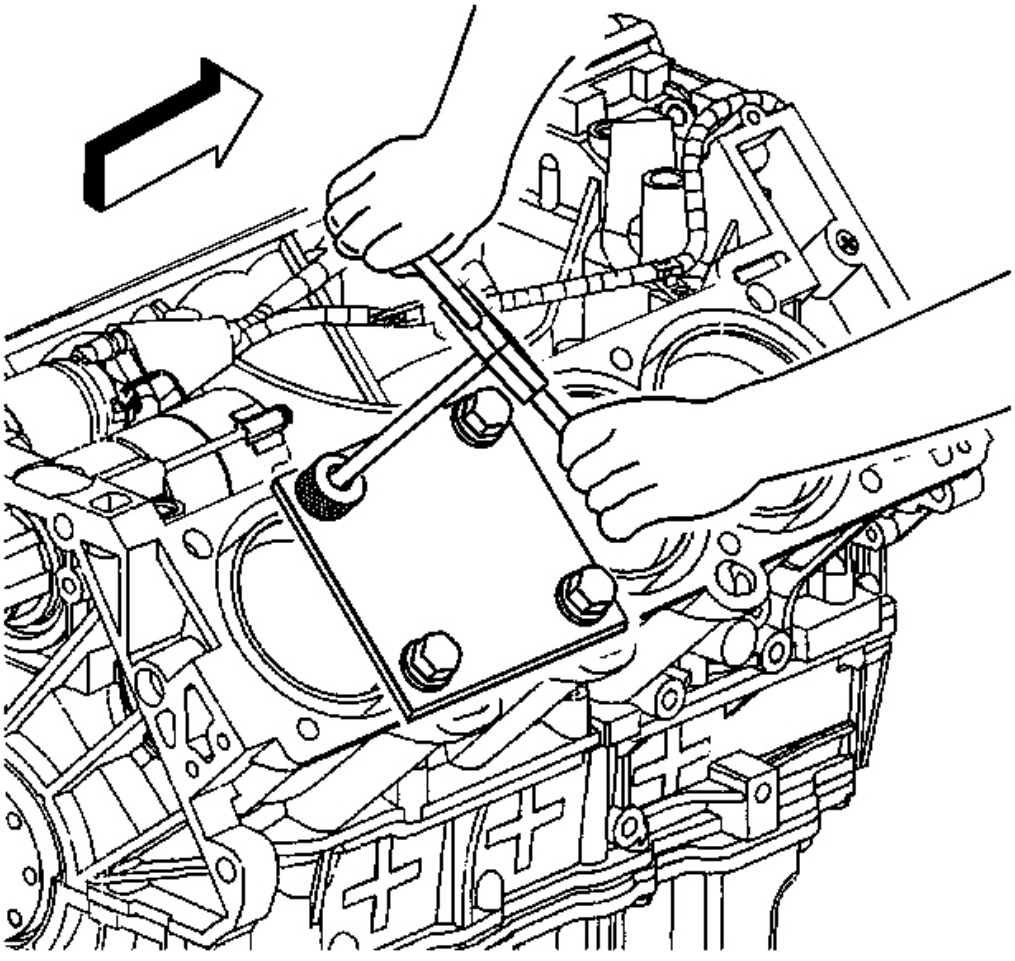


Fig. 215: Tapping Threads Using Tapping Wrench - Inboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

9. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

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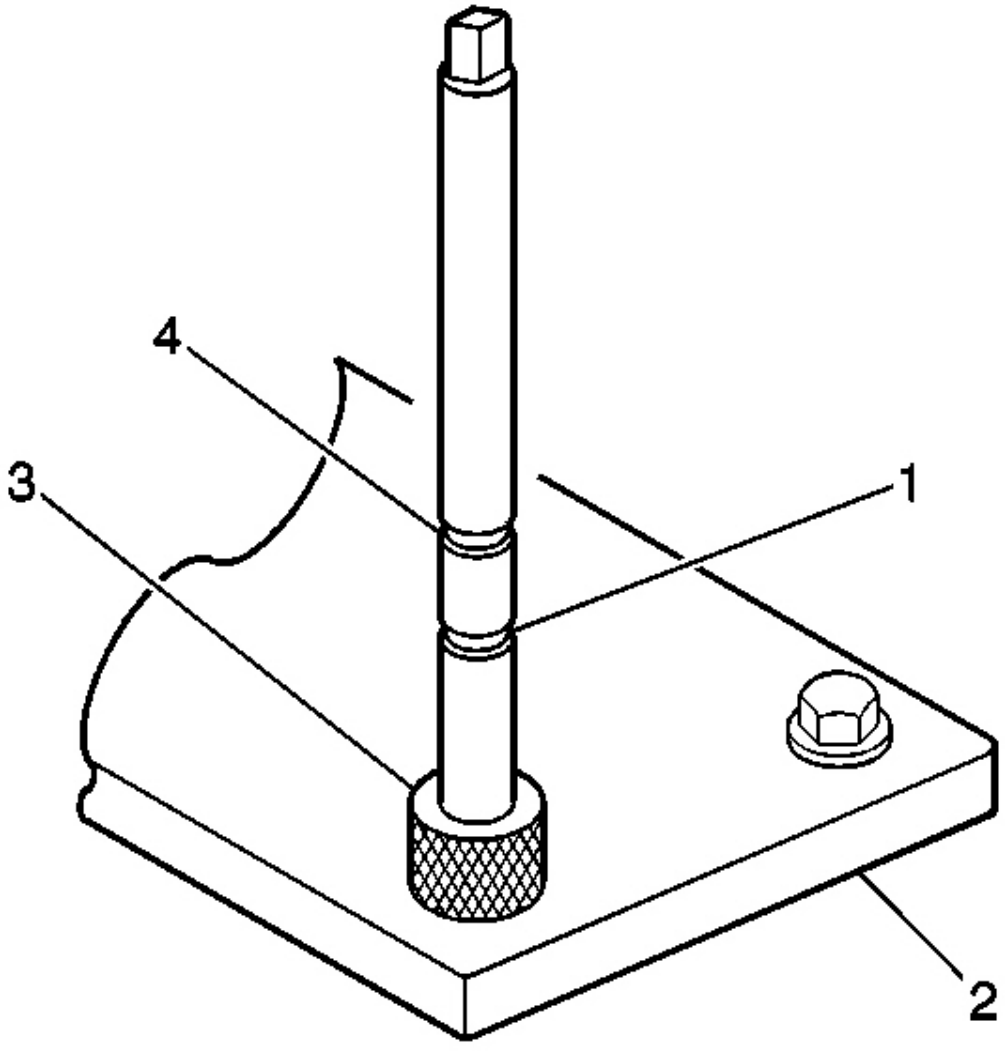


Fig. 216: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

10. In order to tap the new threads for the insert to the proper depth, rotate the tap into the cylinder head bolt hole until the first mark (1) on the tap aligns with the top of the drill bushing (3).

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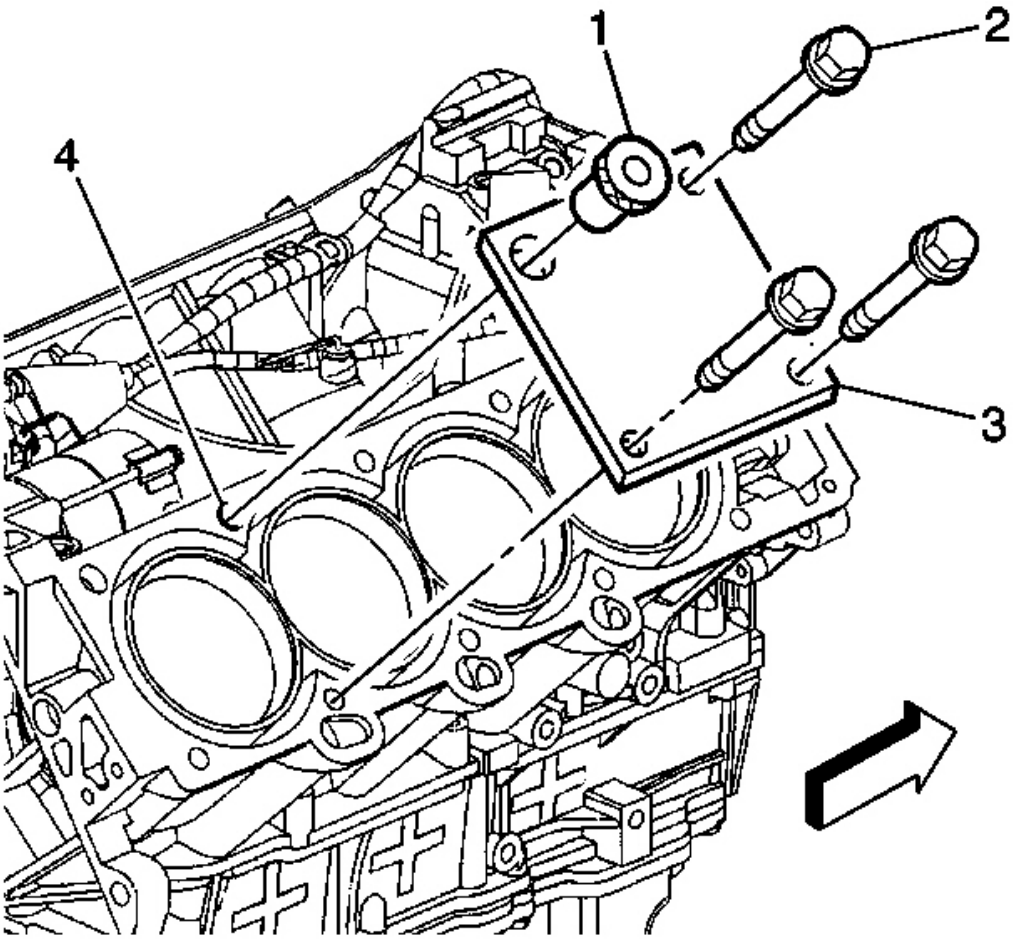


Fig. 217: View Of Fixture Plate & Components - Inboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove the fixture plate prior to installing the insert with the installer tool.

11. Remove the fixture plate bolts (2).
12. Remove the fixture plate (3) and bushing (1).

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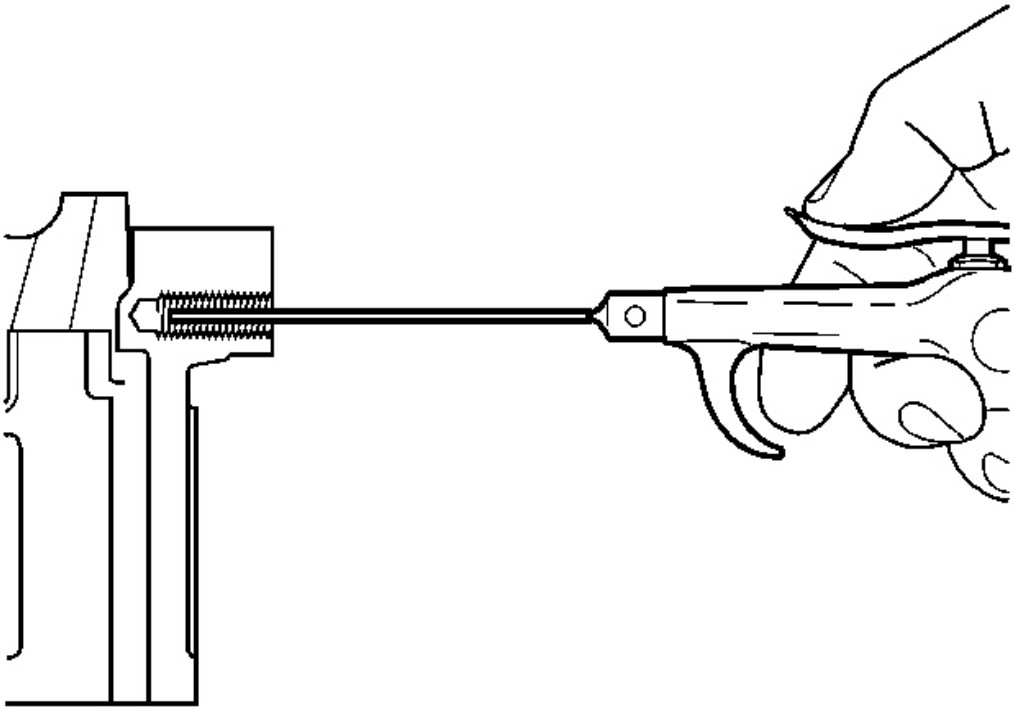


Fig. 218: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

13. Using compressed air, clean out any chips.

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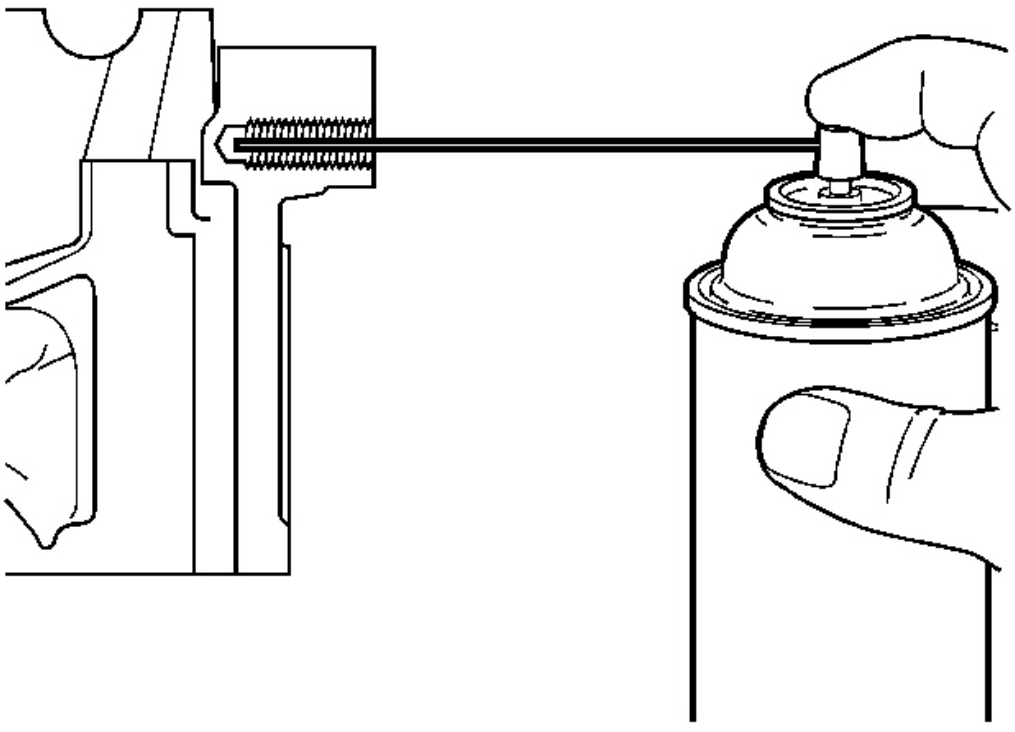


Fig. 219: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

14. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

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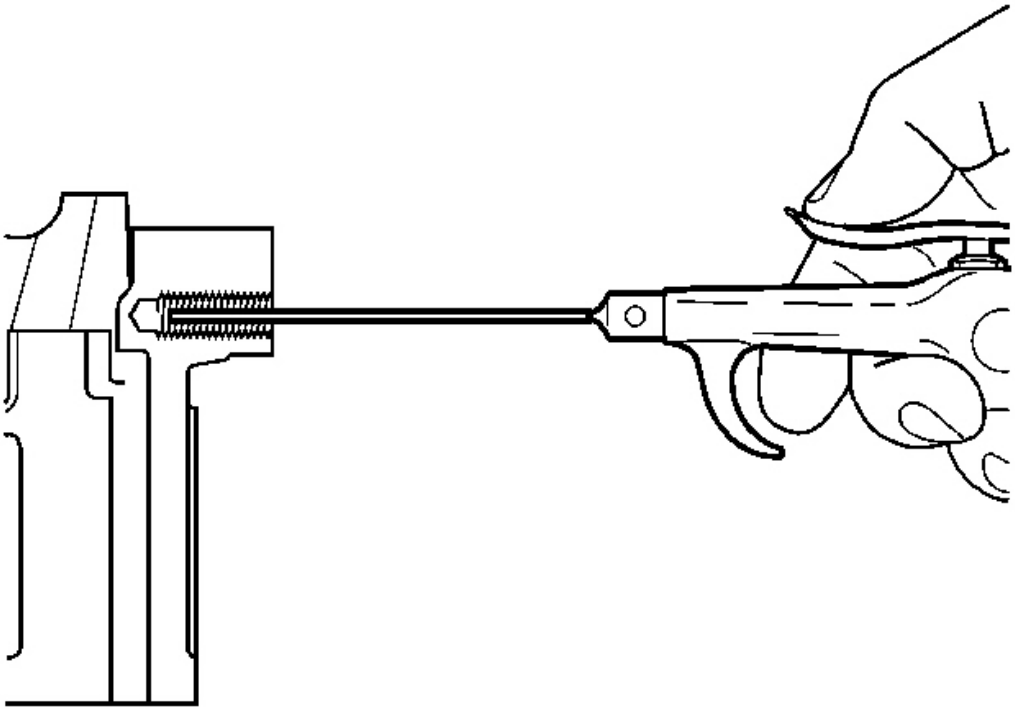


Fig. 220: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

15. Using compressed air, clean out any chips.

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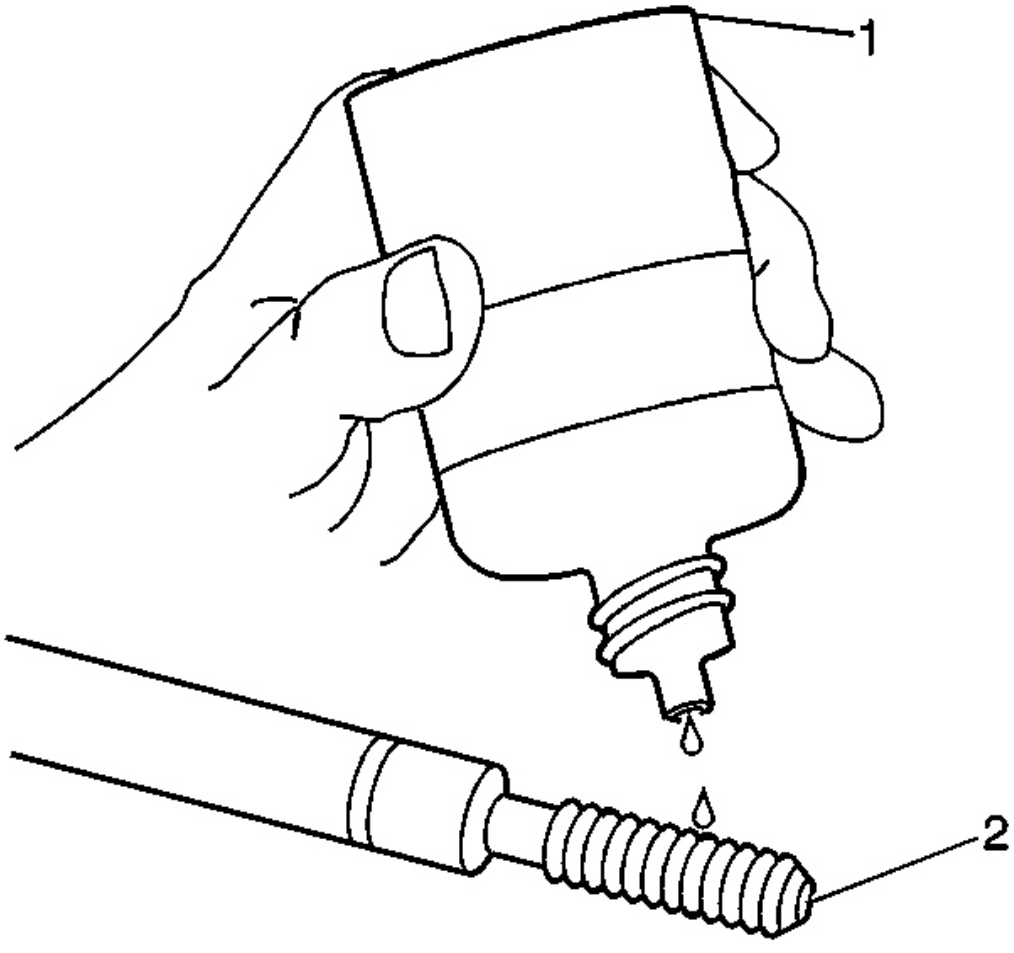


Fig. 221: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the OD of the insert.

16. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

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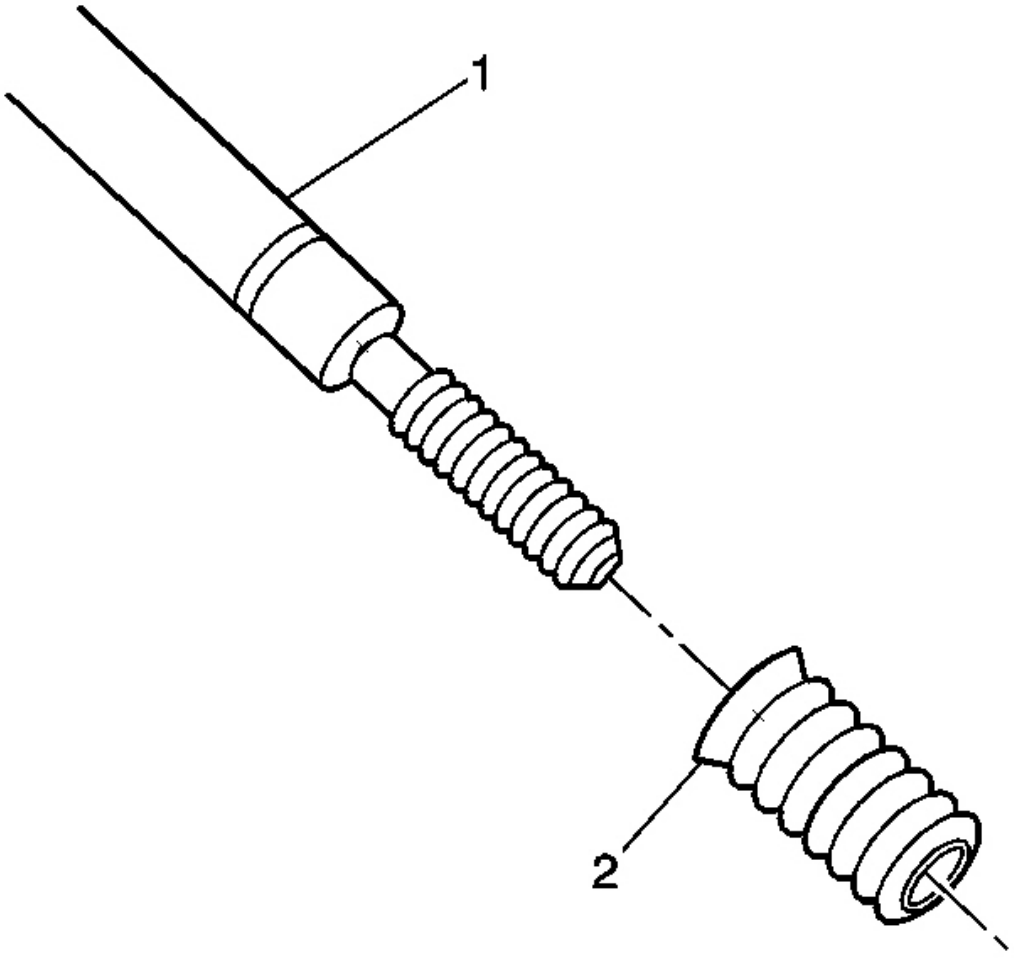


Fig. 222: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

17. Install the insert (2) onto the driver installation tool (1).

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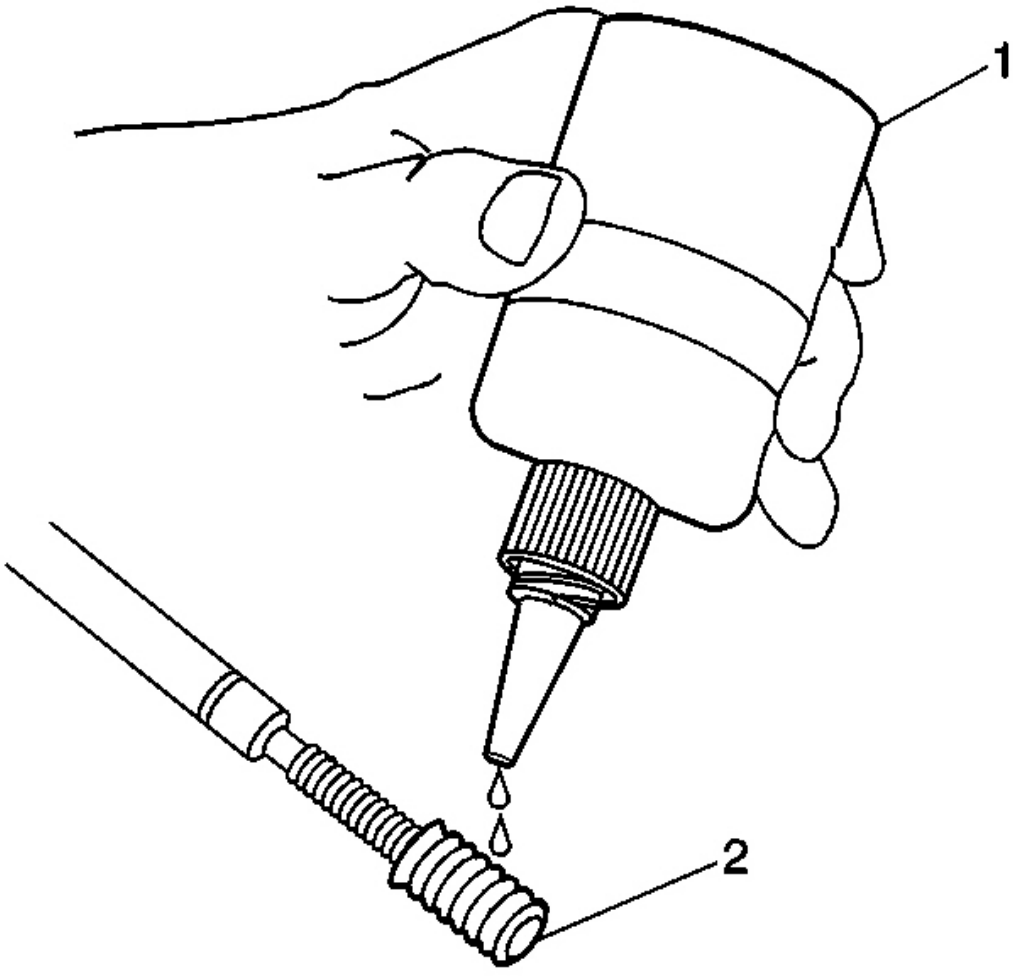


Fig. 223: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

18. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

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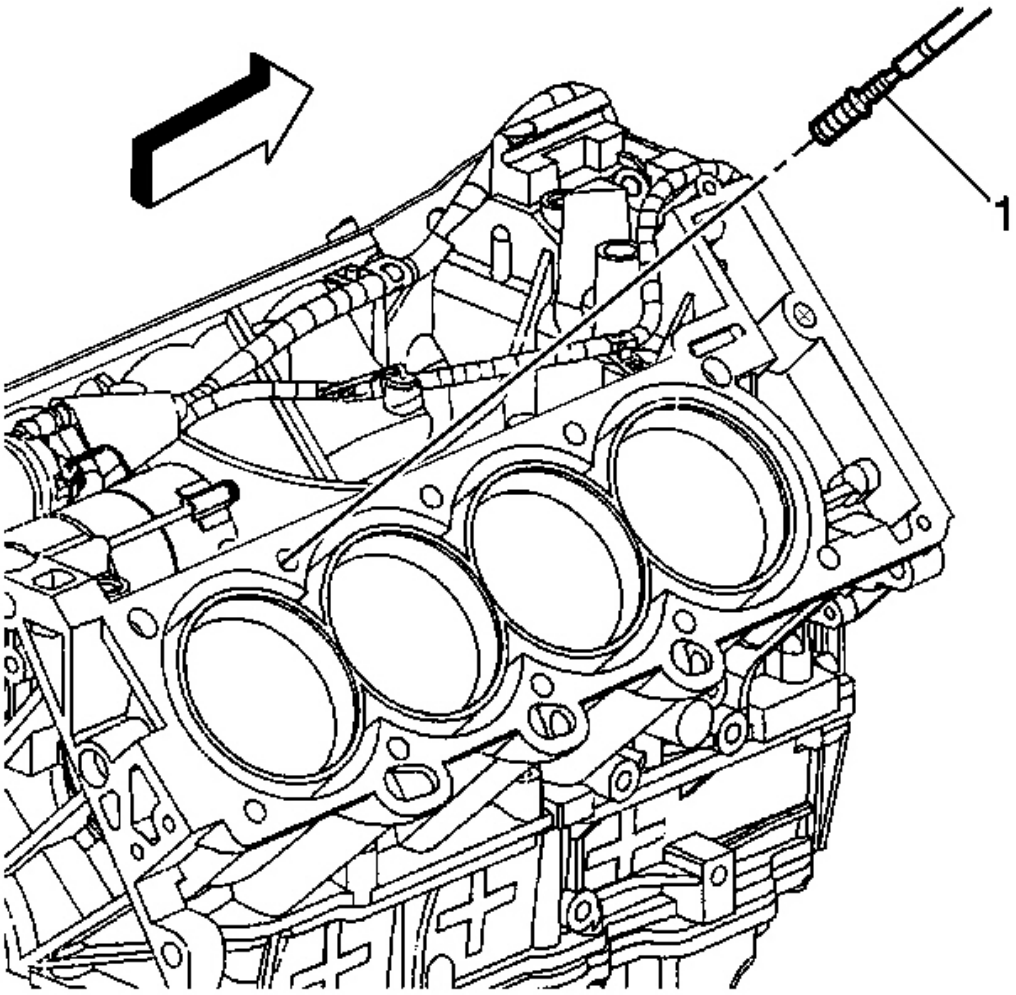


Fig. 224: Installing Insert & Installation Driver - Inboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

19. Install the insert and installation driver (1) into the tapped hole by hand only.
20. Start the insert into the threaded hole.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

21. Install the insert until the flange of the insert contacts the counterbored surface.

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IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

22. Continue to rotate the driver installation tool through the insert.
23. Inspect the insert for proper installation into the tapped hole.

OUTBOARD BOLT HOLES

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- **Remove the fixture plate prior to installing the insert with the installer tool.**
- **The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.**

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

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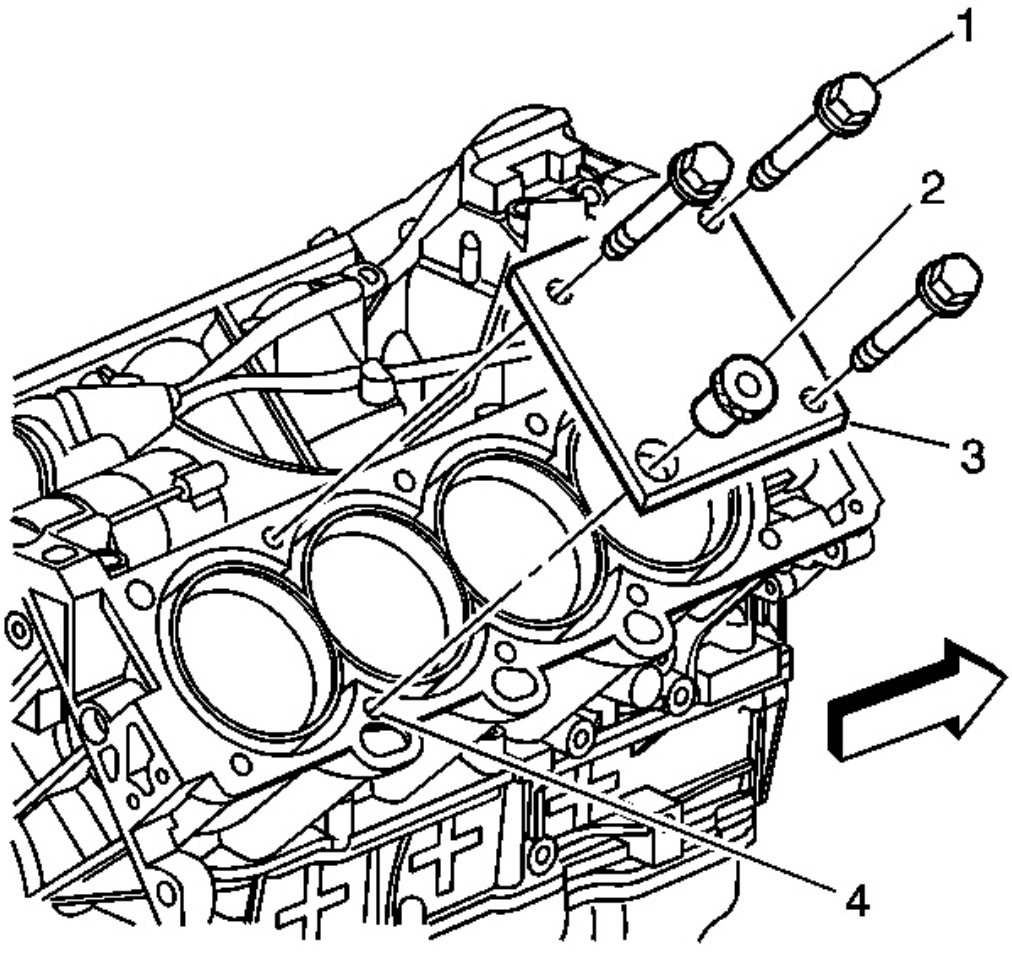


Fig. 225: View Of Fixture Plate & Components - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Position the fixture plate (3) with the bushing (2) installed over the cylinder head bolt hole to be repaired (4).
2. Loosely install the fixture plate bolts (1) into the remaining cylinder head bolt holes.

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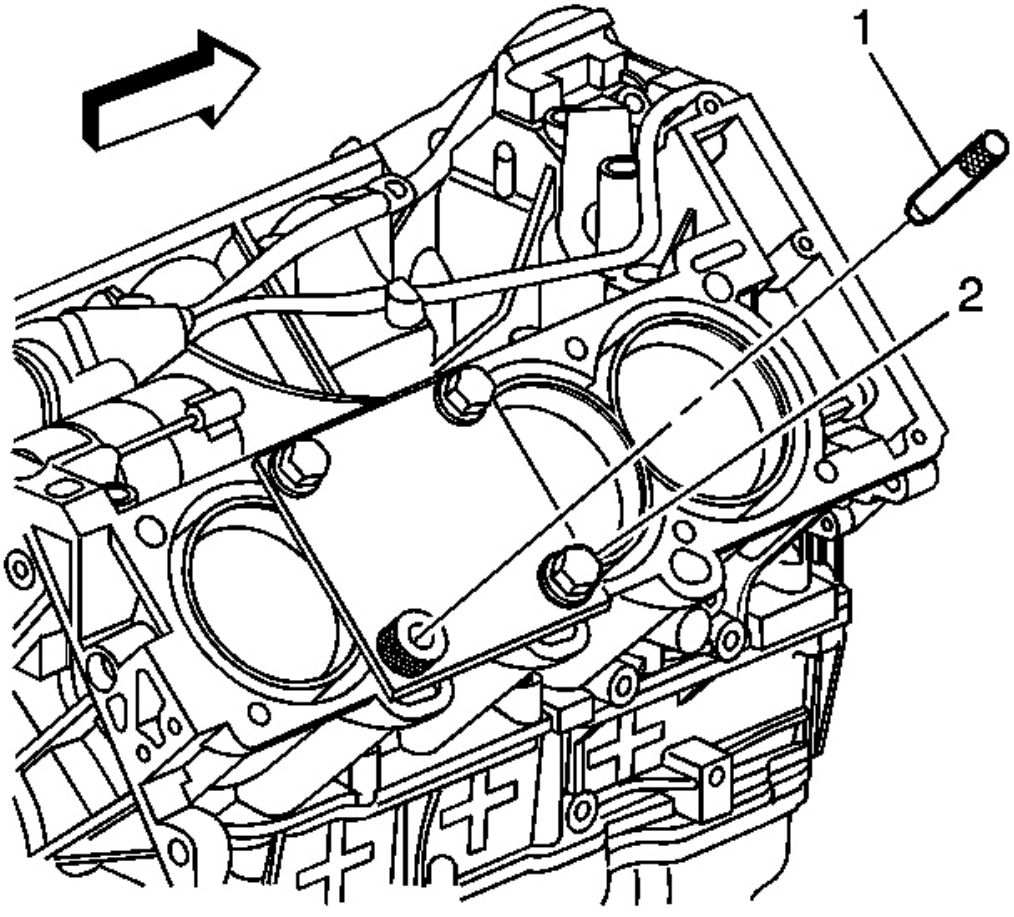


Fig. 226: Positioning Alignment Pin - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the cylinder head bolt hole.
4. With the alignment pin in the desired cylinder head bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the cylinder head bolt hole.

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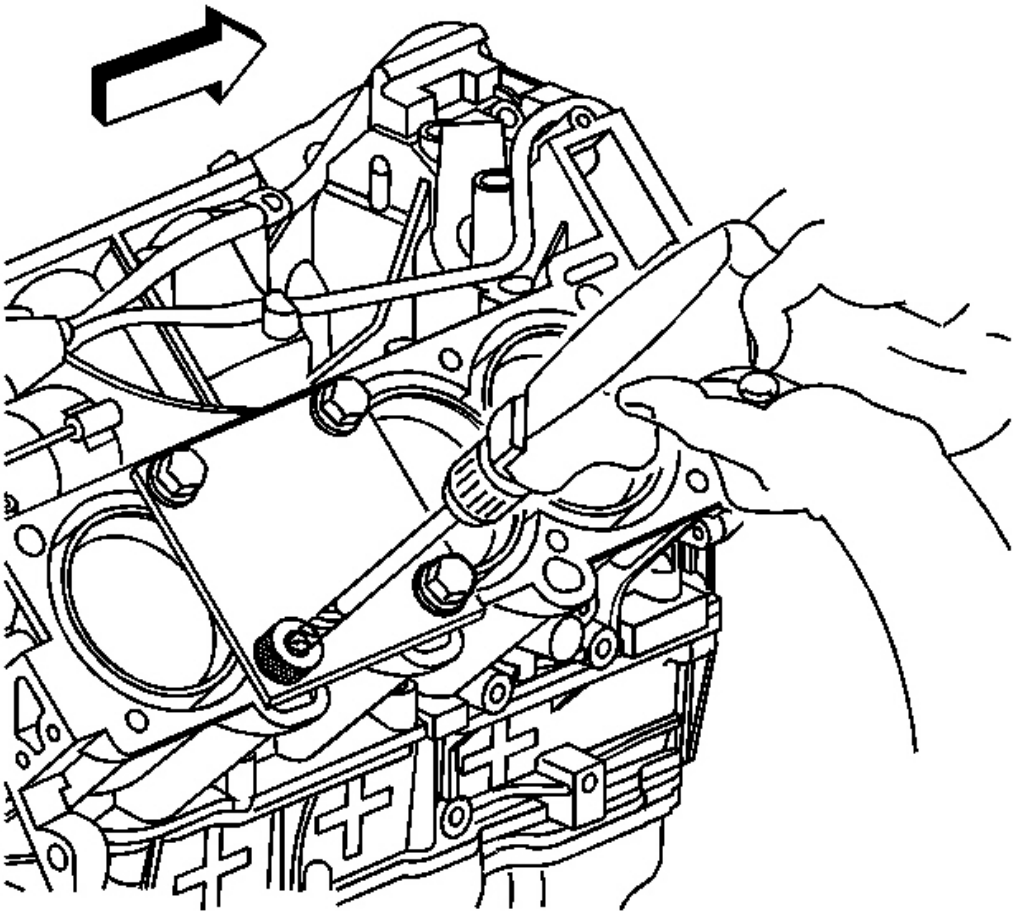


Fig. 227: Drilling Out Threads Of Damaged Hole - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the hole until the stop collar contacts the top of the drill bushing.**

6. Drill out the threads of the damaged hole.

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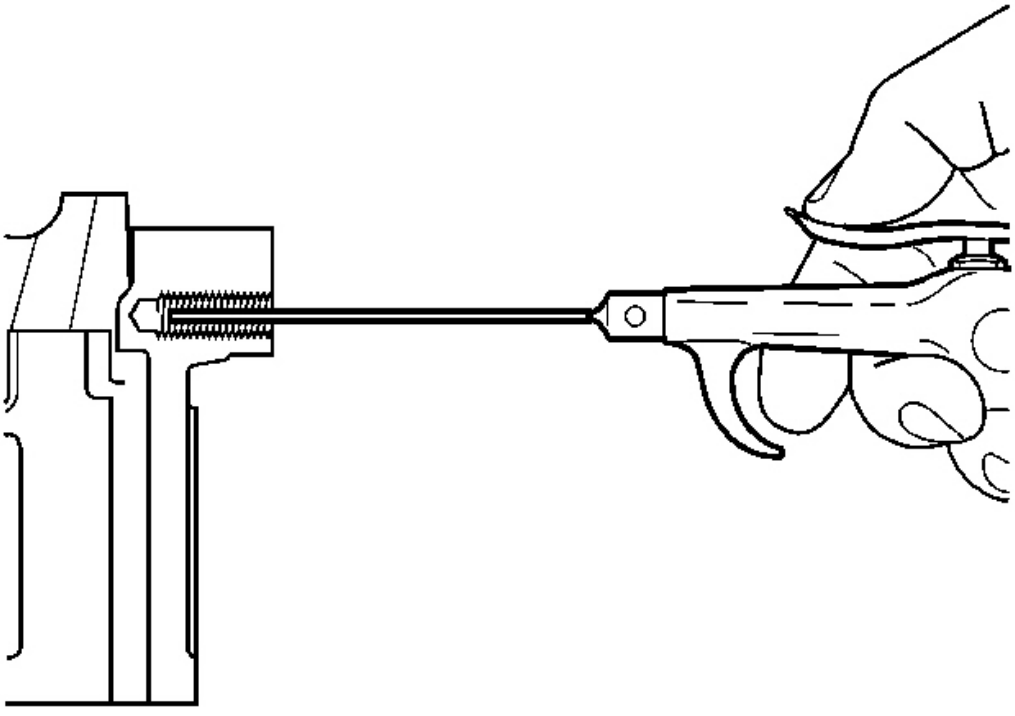


Fig. 228: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

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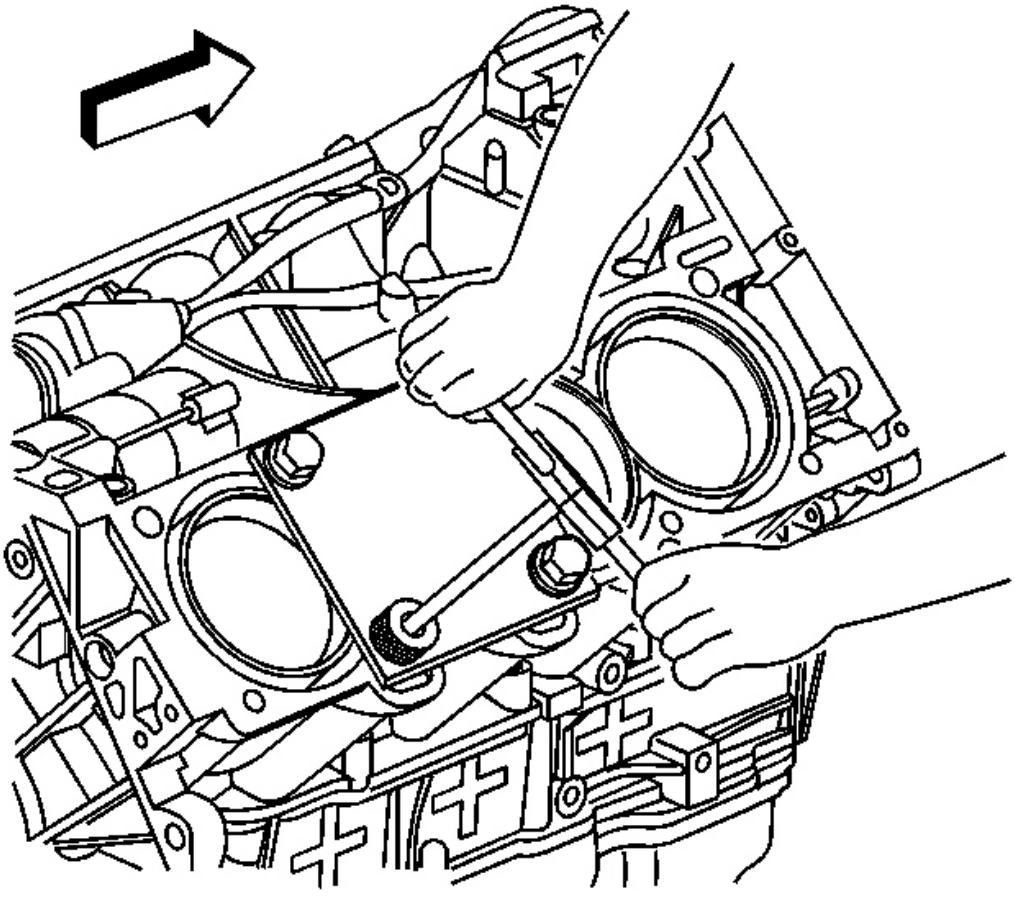


Fig. 229: Tapping Threads Using Tapping Wrench - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

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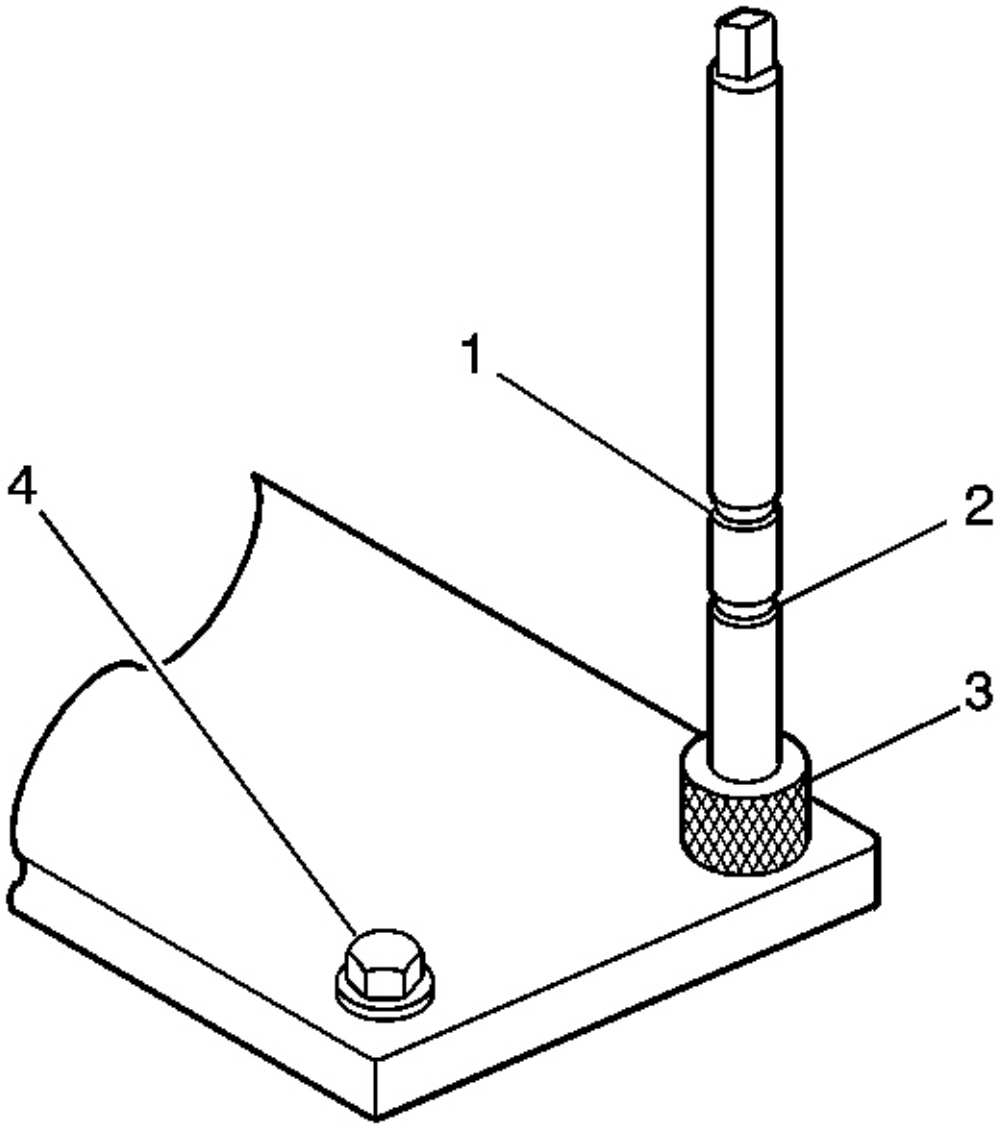


Fig. 230: Rotating Tap Into Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS CORP.

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the cylinder head bolt hole until the second mark (1) on the tap aligns with the top of the drill bushing (3).

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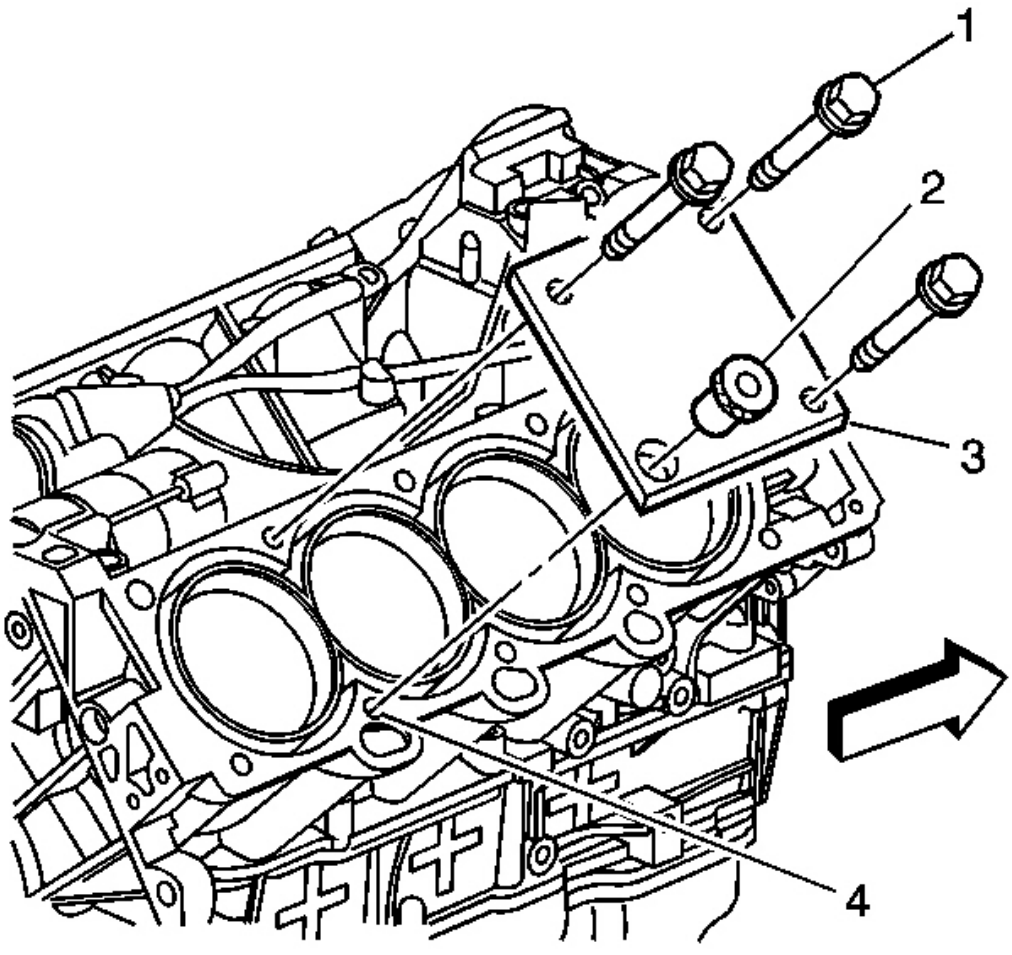


Fig. 231: View Of Fixture Plate & Components - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove the fixture plate prior to installing the insert with the installer tool.

10. Remove the fixture plate bolts (1).
11. Remove the fixture plate (3) and bushing.

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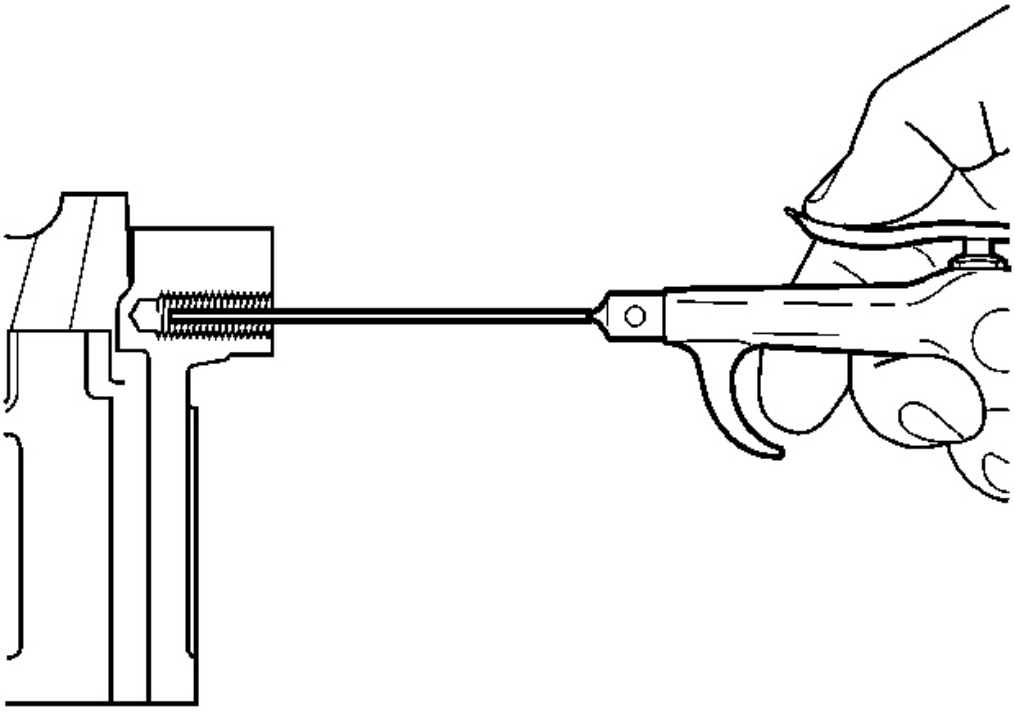


Fig. 232: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.

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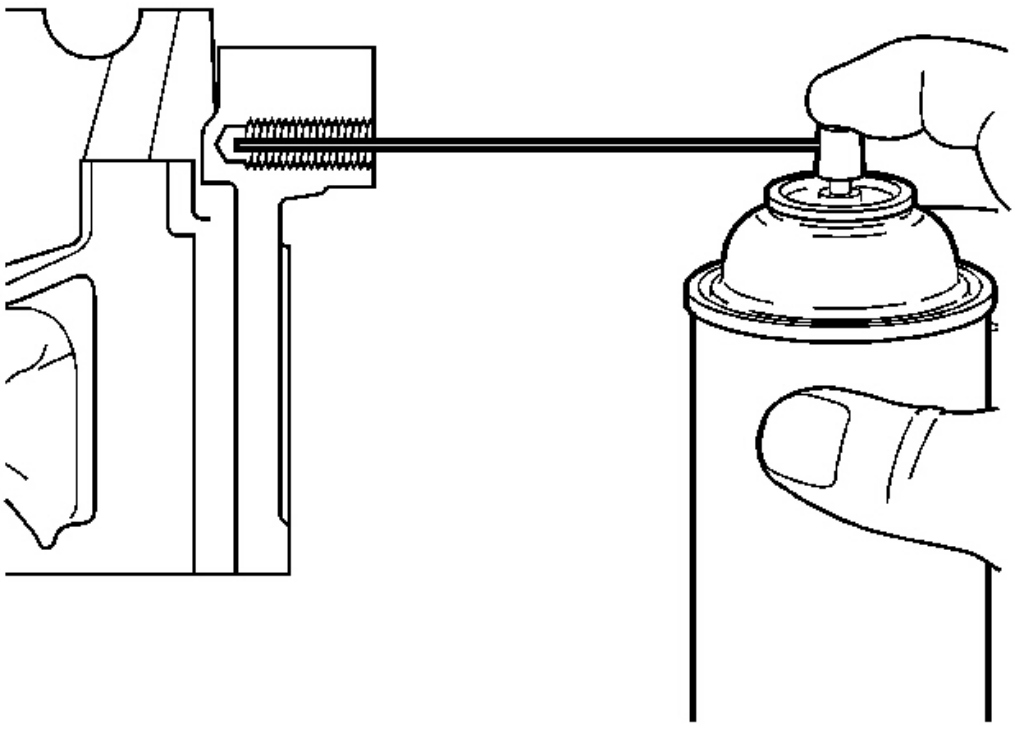


Fig. 233: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

13. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

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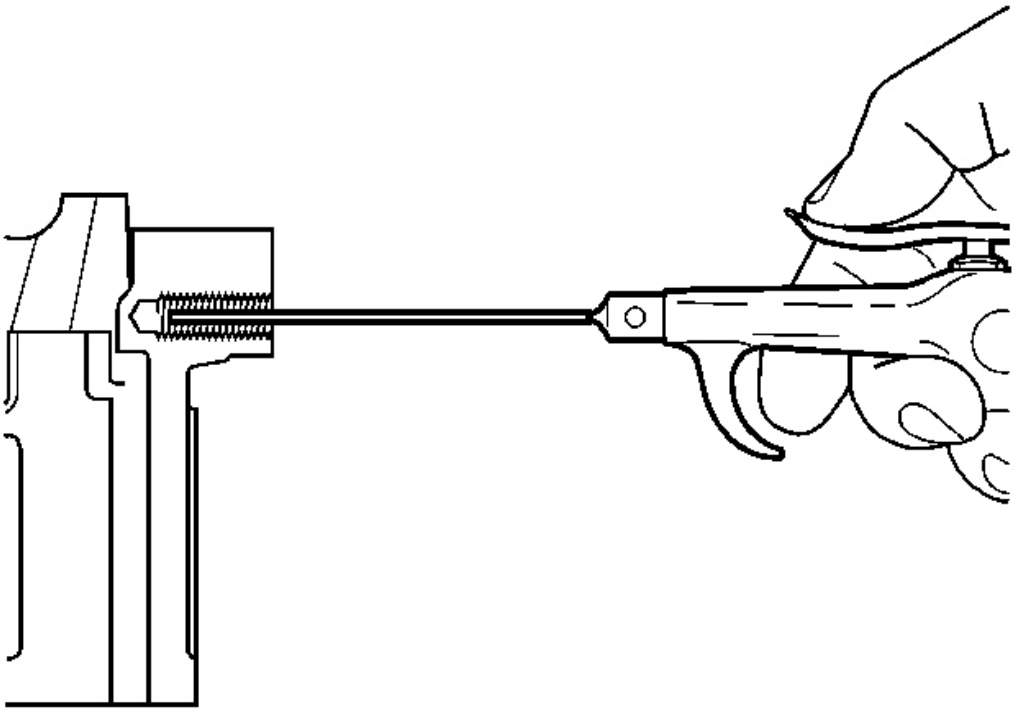


Fig. 234: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

14. Using compressed air, clean out any chips.

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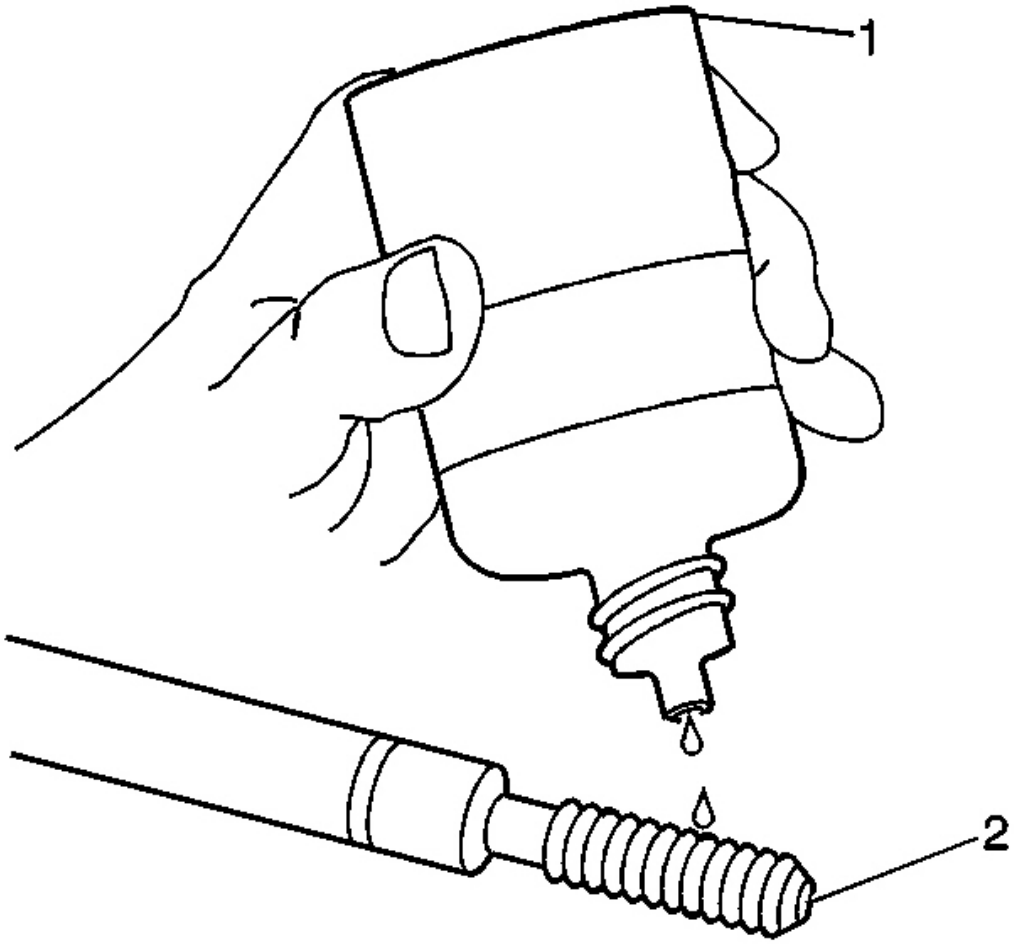


Fig. 235: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the OD of the insert.

15. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

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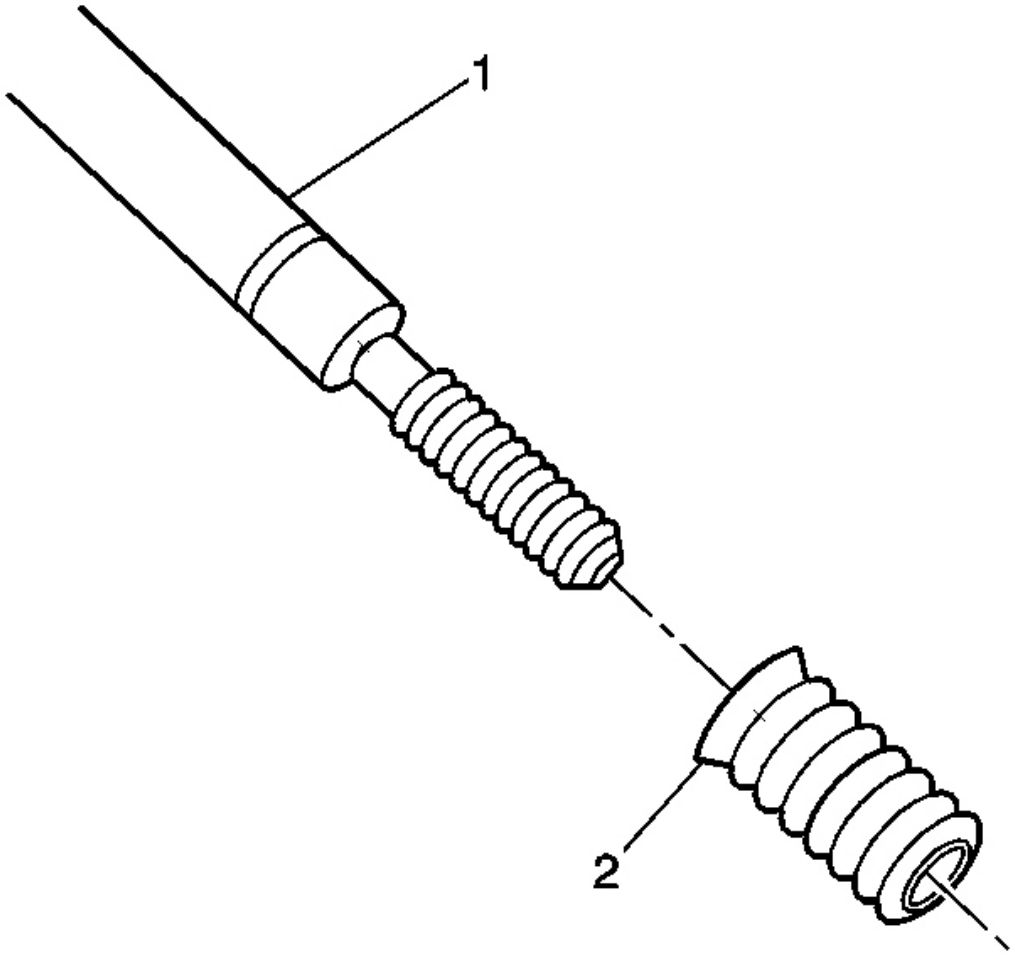


Fig. 236: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver installation tool (1).

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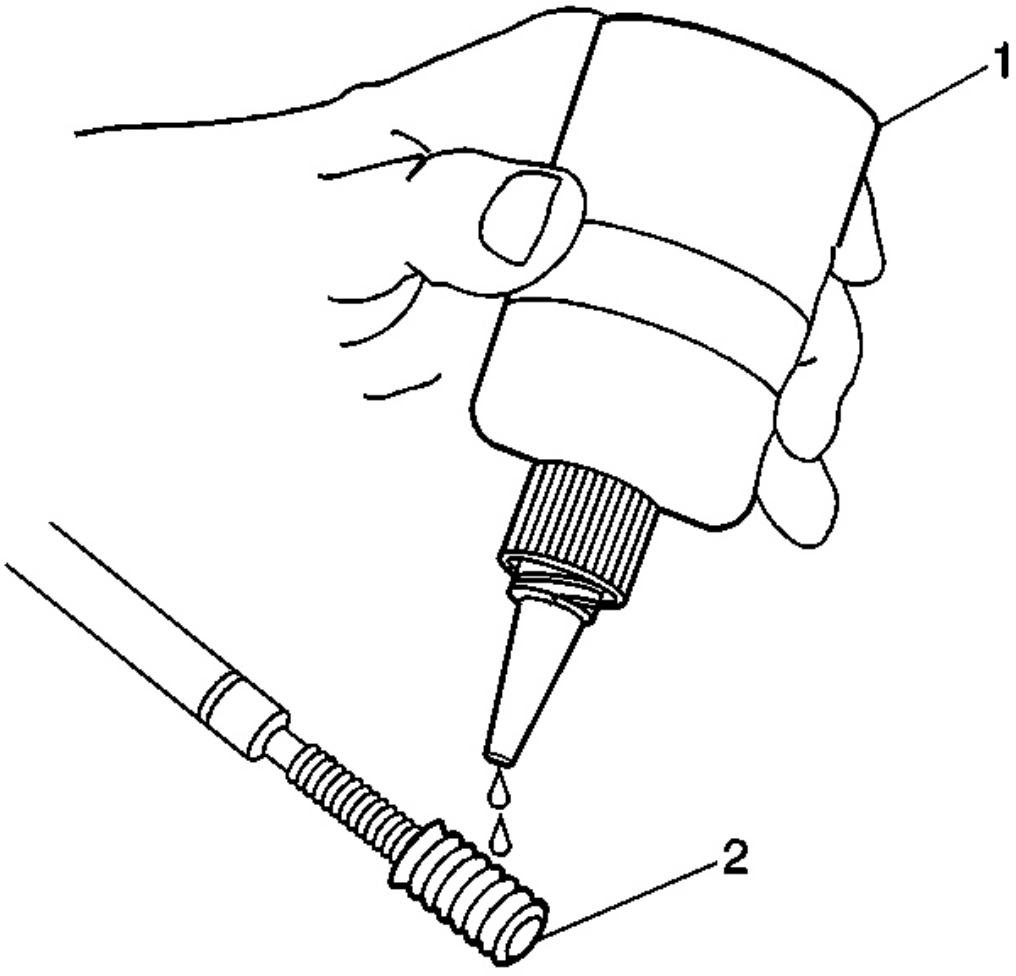


Fig. 237: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

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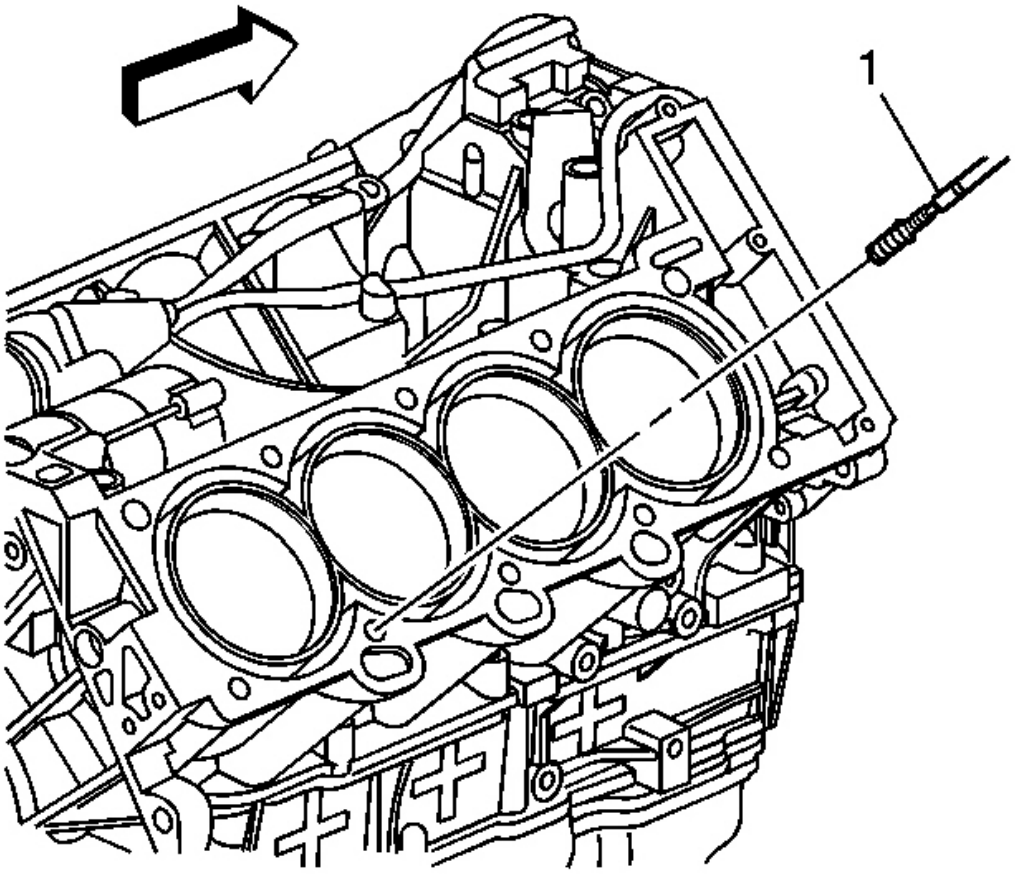


Fig. 238: Installing Insert & Installation Driver - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

18. Install the insert and installation driver (1) into the tapped hole by hand only.
19. Start the insert into the threaded hole.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

20. Install the insert until the flange of the insert contacts the counterbored surface.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the

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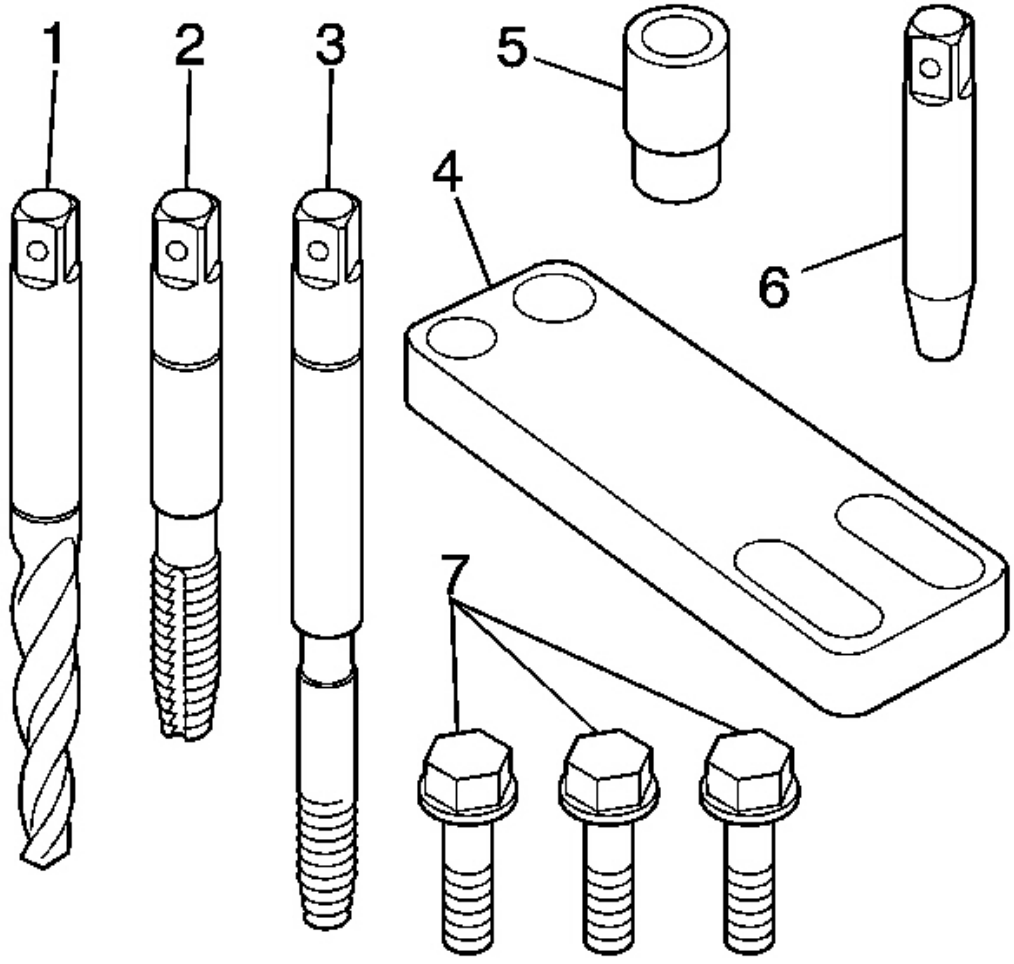
insert are being formed and the insert is mechanically locking the insert into the base material threads.

21. Continue to rotate the driver installation tool through the insert.
22. Inspect the insert for proper installation into the tapped hole.

CRANKSHAFT MAIN BOLT HOLE THREAD REPAIR

Tools Required

J 42385-2000 Thread Insert Kit. See **Special Tools** .



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Fig. 239: View Of Thread Insert Kit
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **In order to repair some crankshaft main bolt holes it will be necessary to mount the fixture plate upside down.**
- **Do NOT remove the fixture plate prior to installing the insert with the installation driver. The fixture plate remains in position throughout the thread repair process.**

The crankshaft main bearing bolt hole thread repair kit **J 42385-2000** components consist of the following:

- Drill (1) J 42385-511
- Tap (2) J 42385-512
- Installation driver (3) J 42385-513
- Fixture plate (4) J 42385-306
- Bushing (5) J 42385-307
- Alignment pin (6) J 42385-308
- Bolts (7) J 42385-510

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- **Ensure the fixture plate is installed during the machining and installation processes of the insert.**
- **The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.**

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

Repair Procedure

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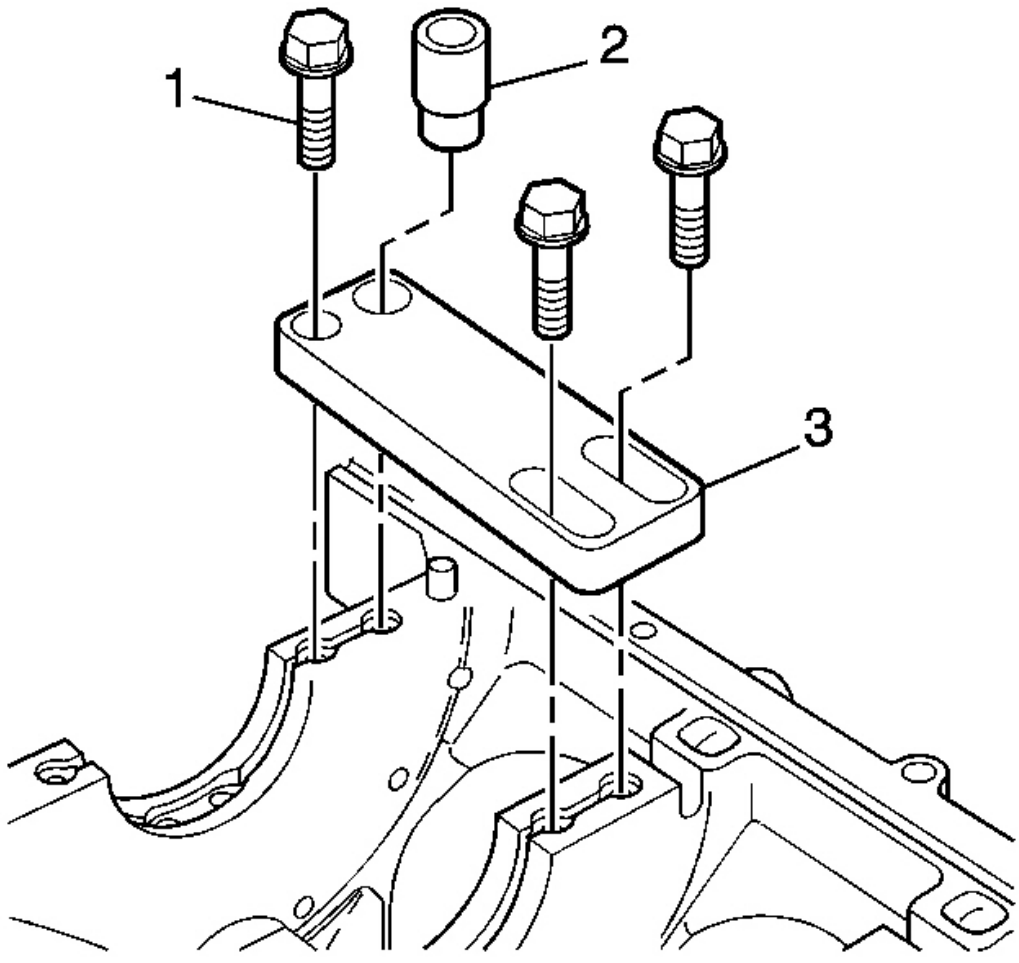


Fig. 240: View Of Fixture Plate & Components - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

1. Position the fixture plate (3) with the bushing (2), installed over the crankshaft main cap bolt hole to be repaired.
2. Loosely install the fixture plate bolts (1) into the remaining crankshaft main cap bolt holes.

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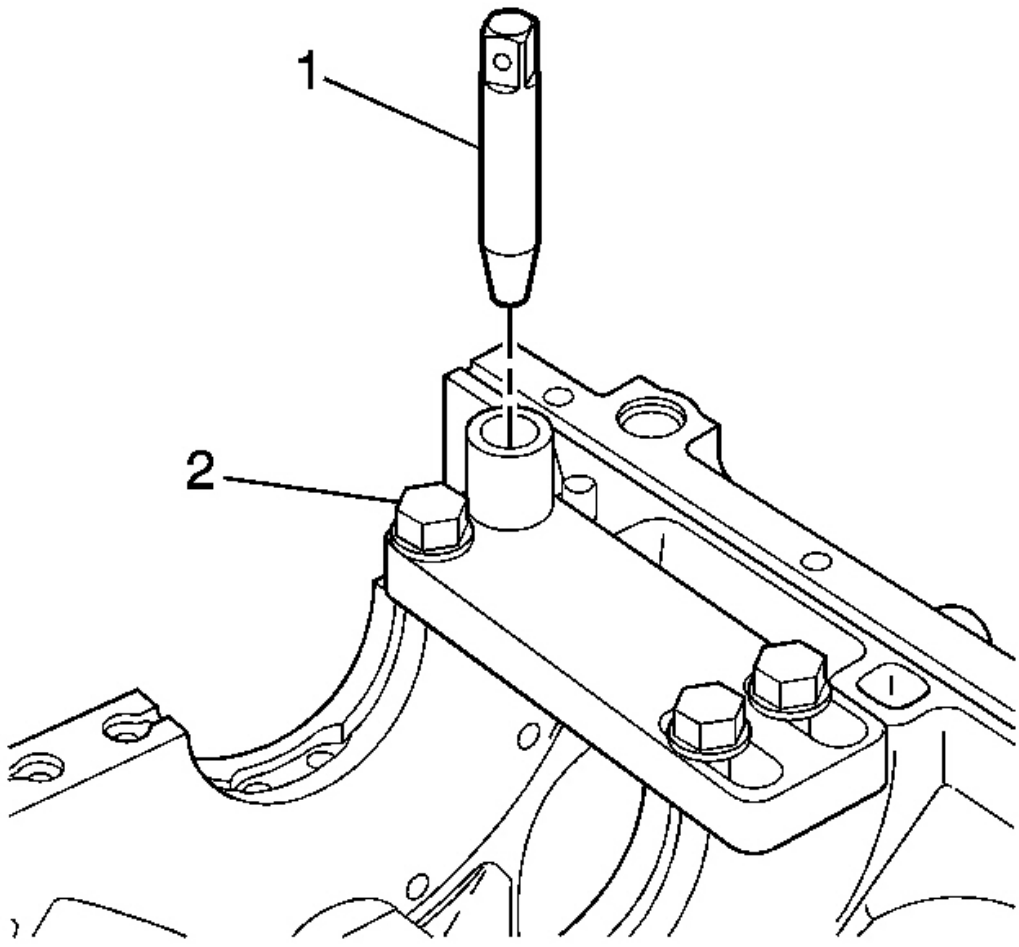


Fig. 241: Positioning Alignment Pin - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole.
4. With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the crankshaft main cap bolt hole.

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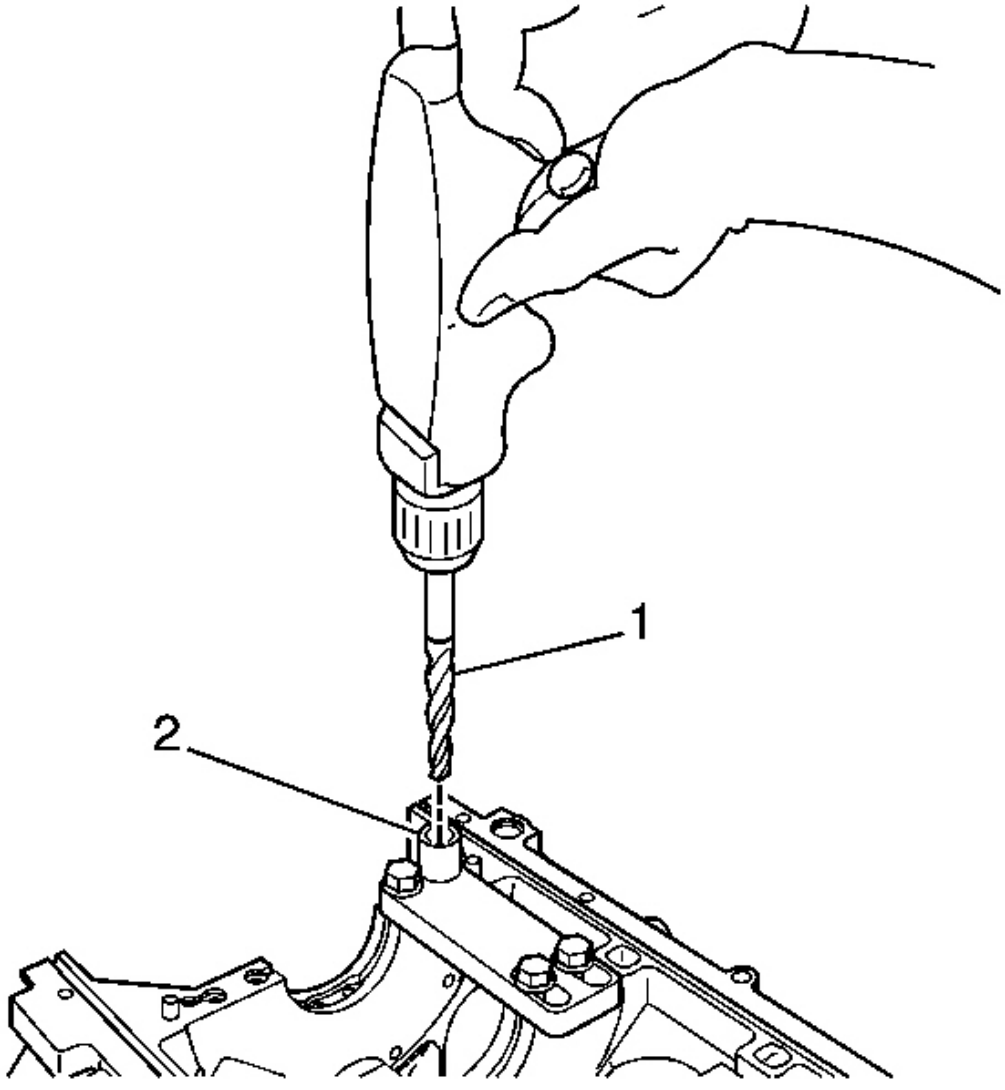


Fig. 242: Drilling Out Threads Of Damaged Hole - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).**

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6. Drill out the threads of the damaged hole.

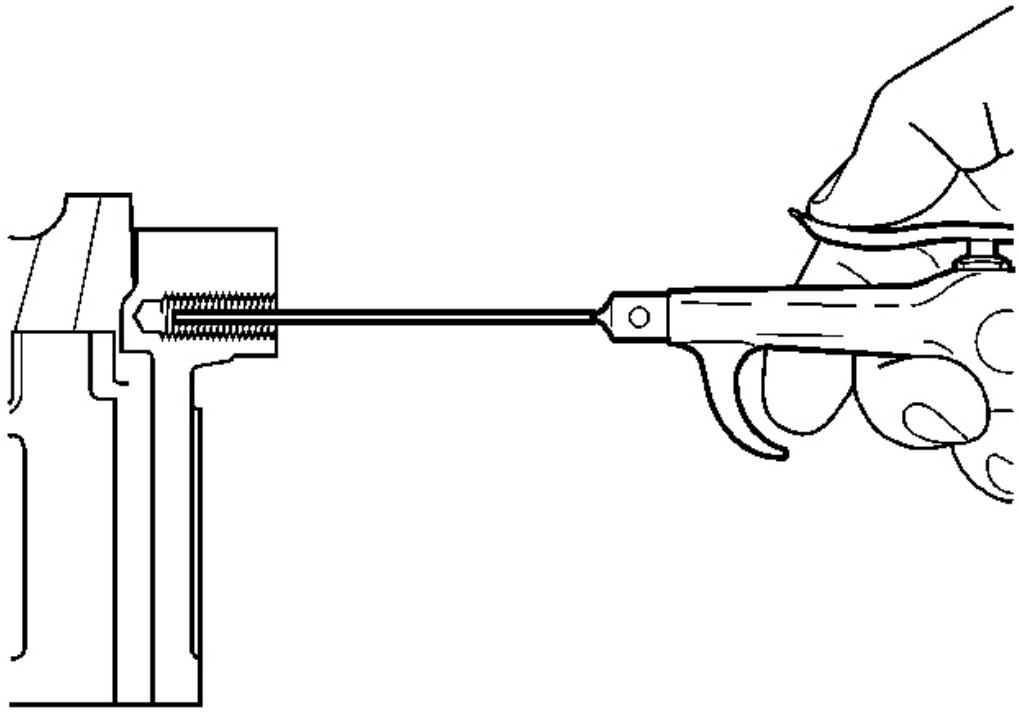


Fig. 243: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

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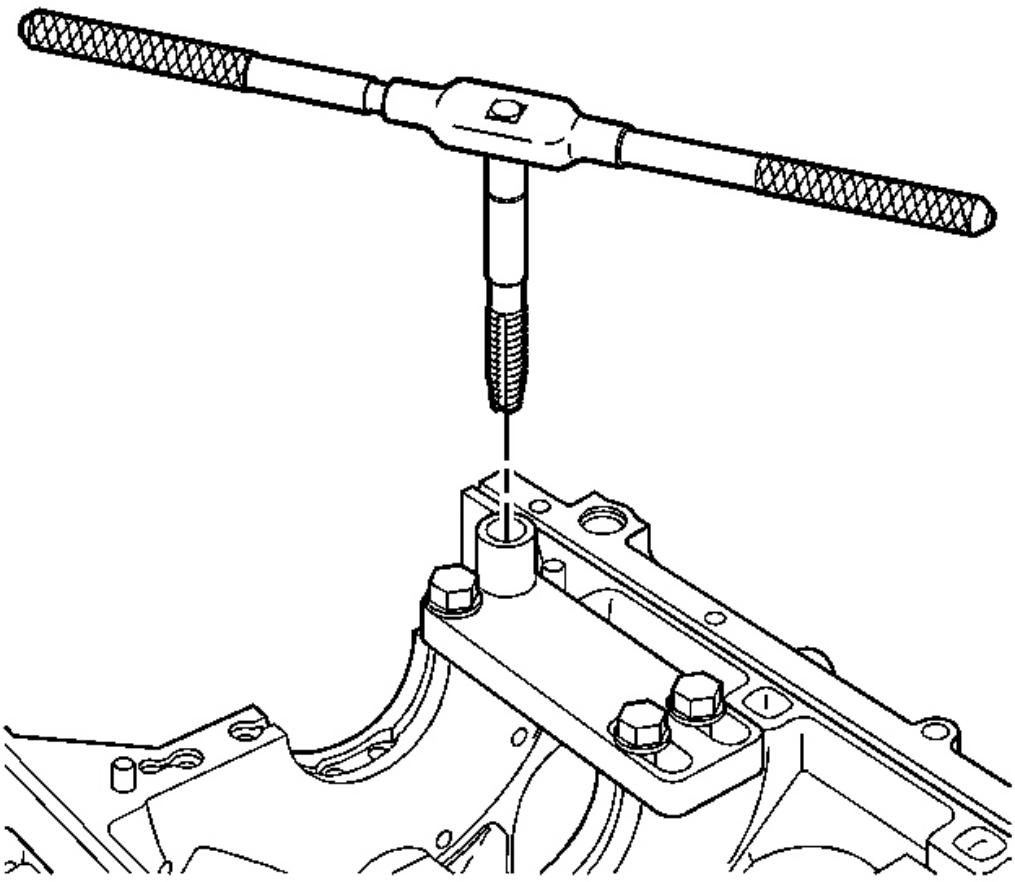


Fig. 244: Tapping Threads Using Tapping Wrench - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.**
- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

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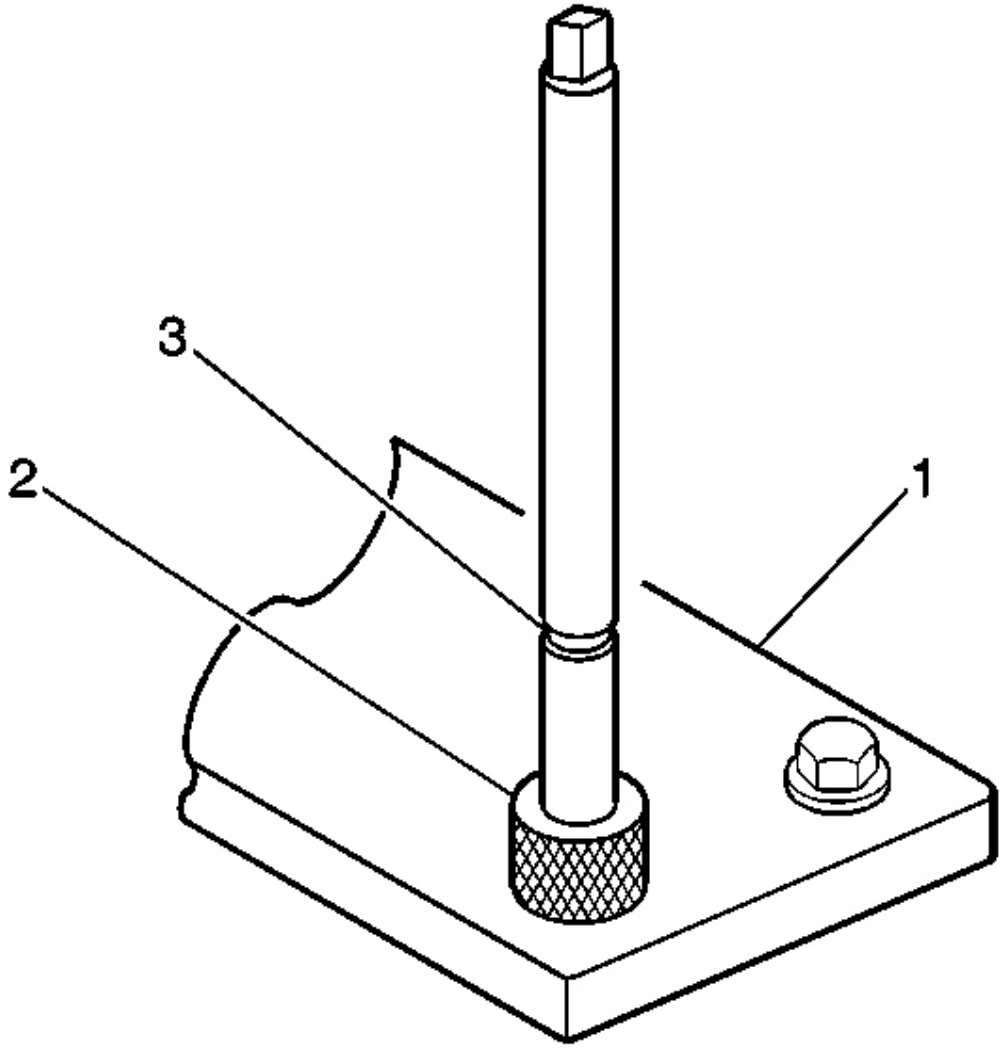


Fig. 245: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

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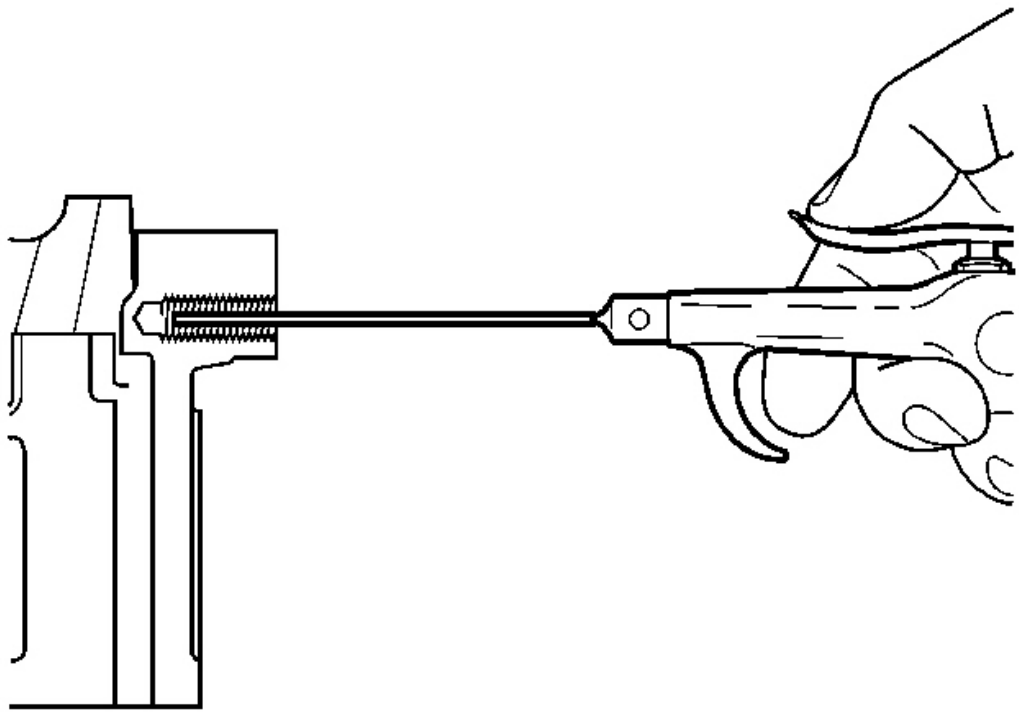


Fig. 246: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

10. Using compressed air, clean out any chips.

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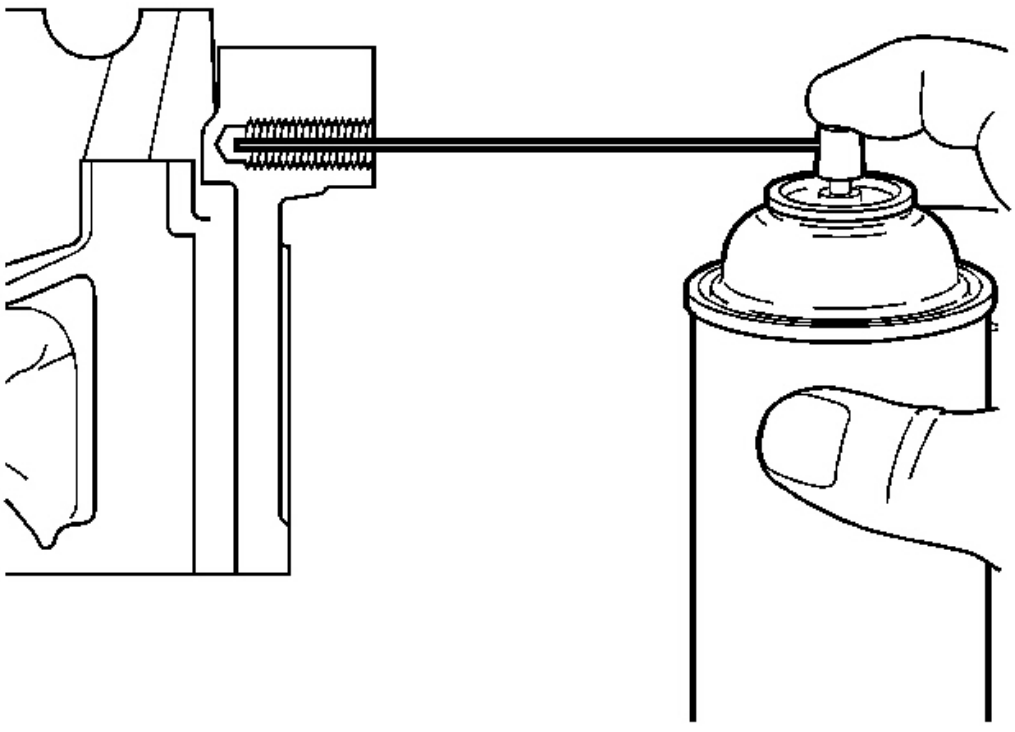


Fig. 247: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

11. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

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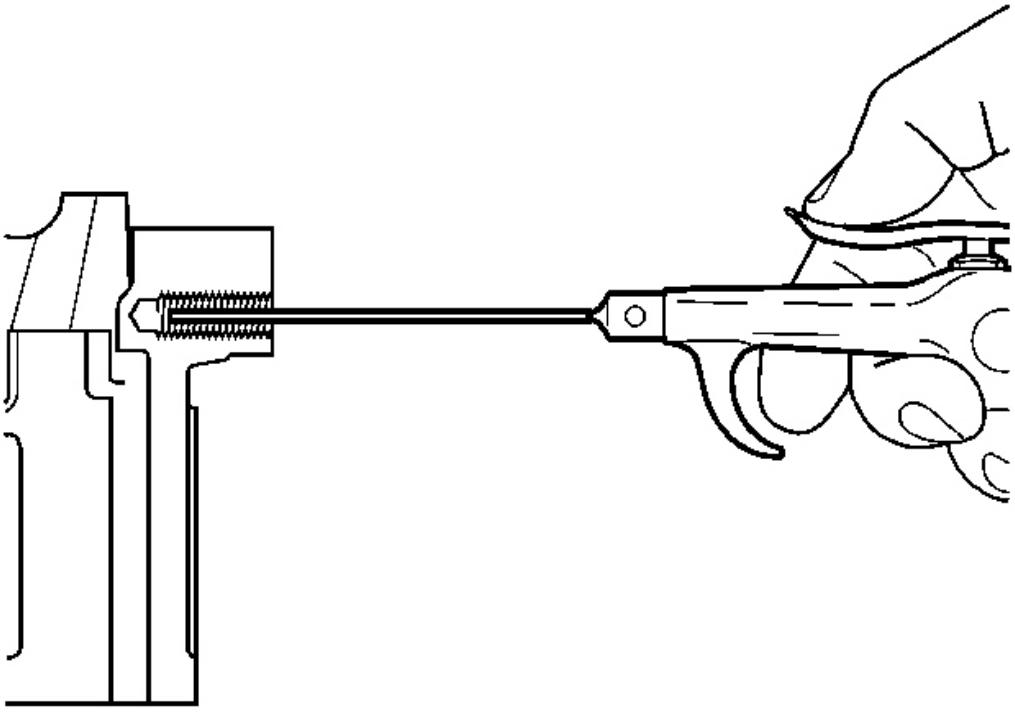


Fig. 248: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.

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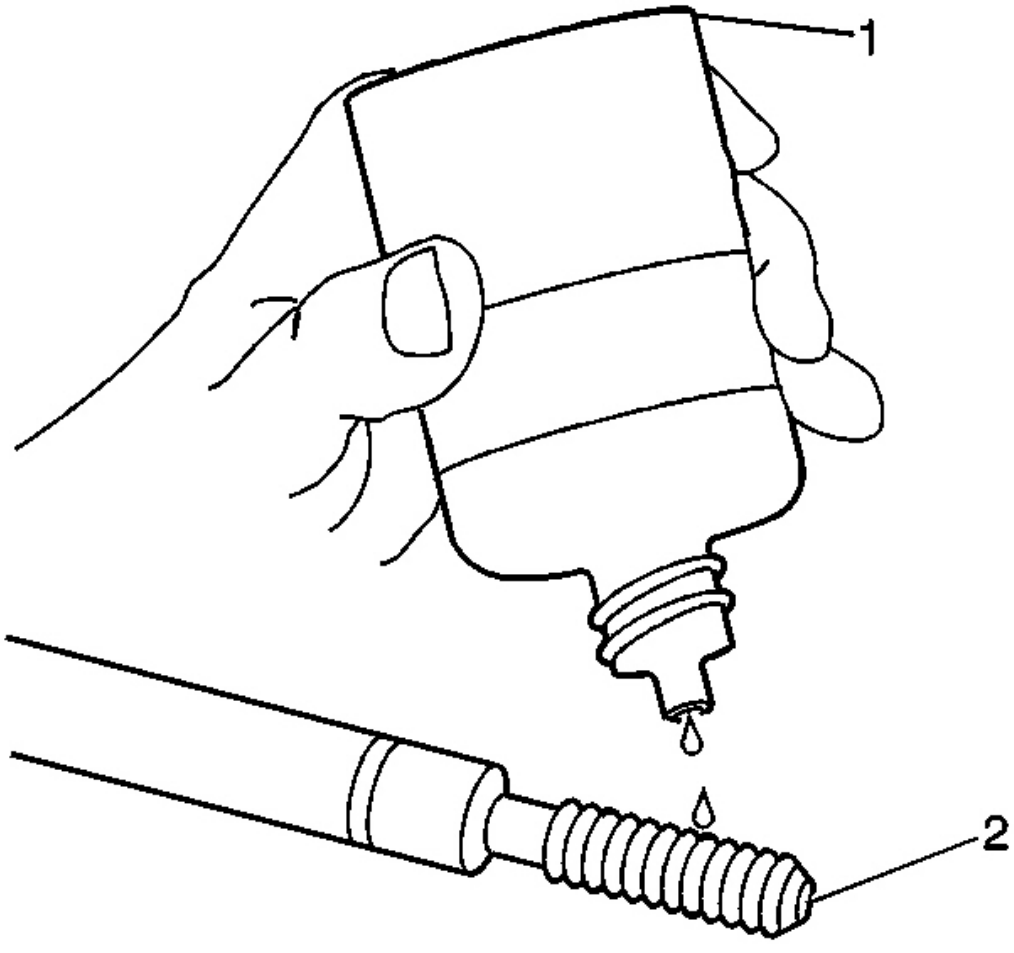


Fig. 249: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not remove the fixture plate, ensure the fixture plate is installed during the installation process of the insert.**
- **Do not allow oil or other foreign material to contact the OD of the insert.**

13. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

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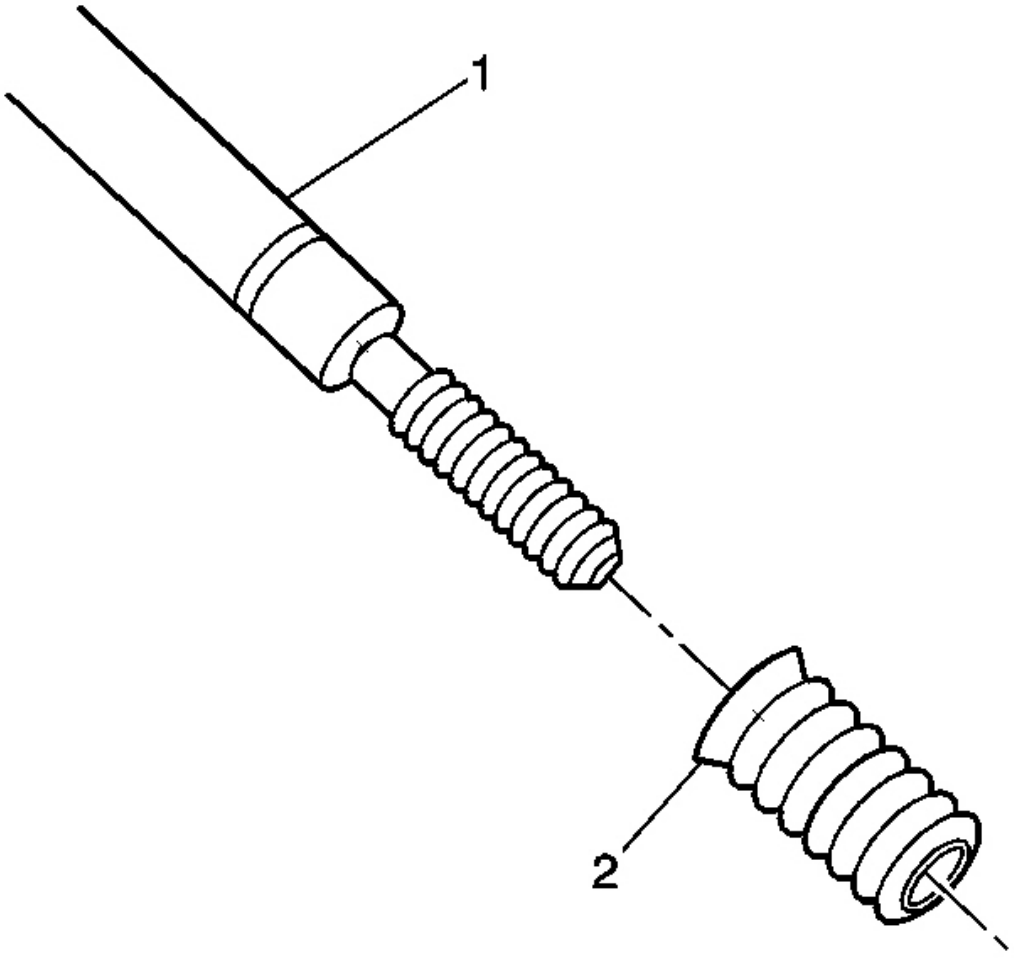


Fig. 250: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

14. Install the insert (2) onto the driver installation tool (1).

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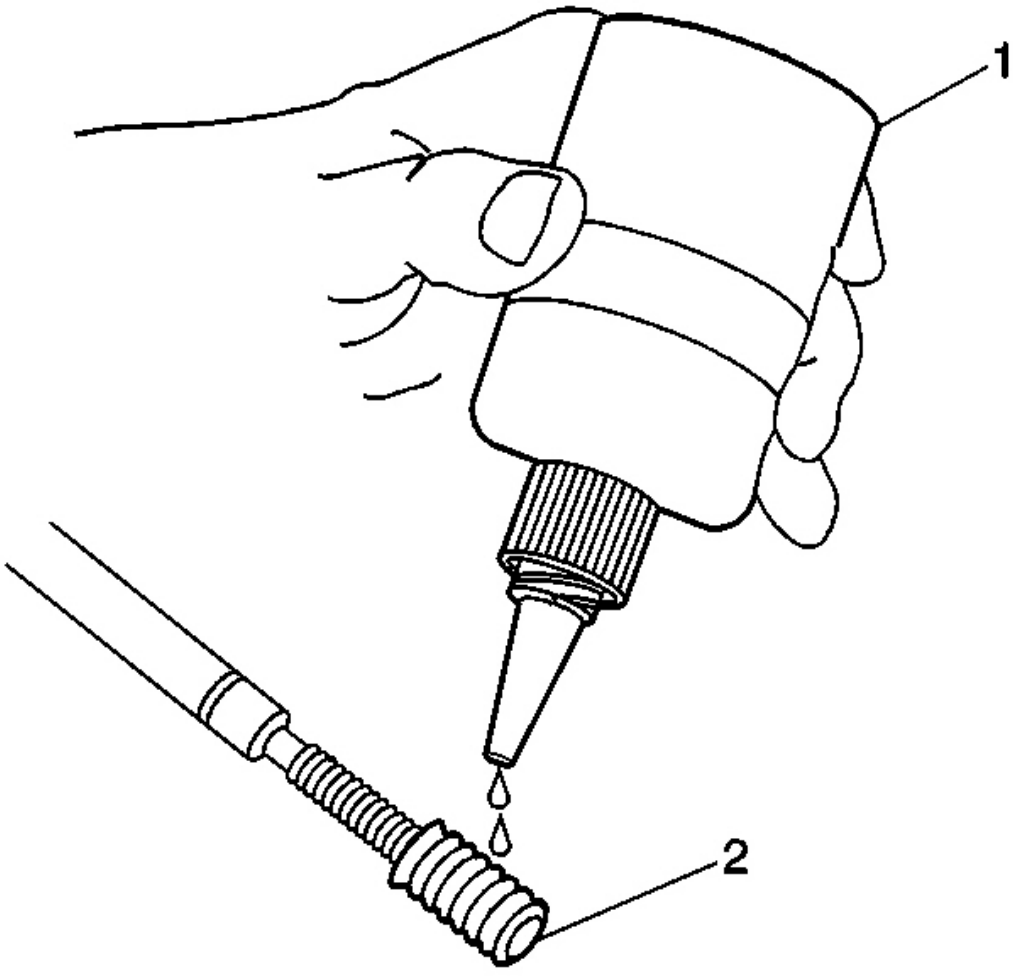


Fig. 251: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

15. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

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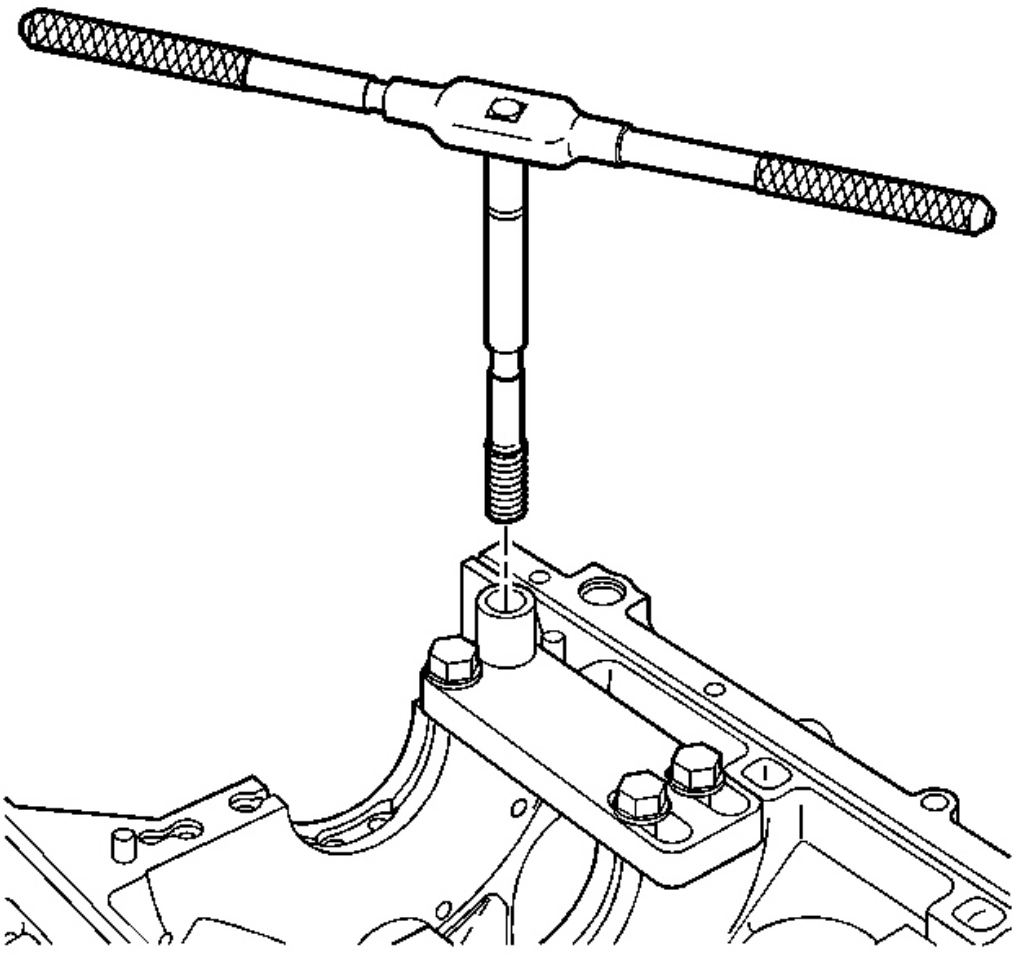


Fig. 252: Installing Insert & Installation Driver - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

16. Install the insert and installation driver into the tapped hole by hand only.
17. Start the insert into the threaded hole.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

18. Install the insert until the flange of the insert contacts the counterbored surface.

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IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

19. Continue to rotate the driver installation tool through the insert.

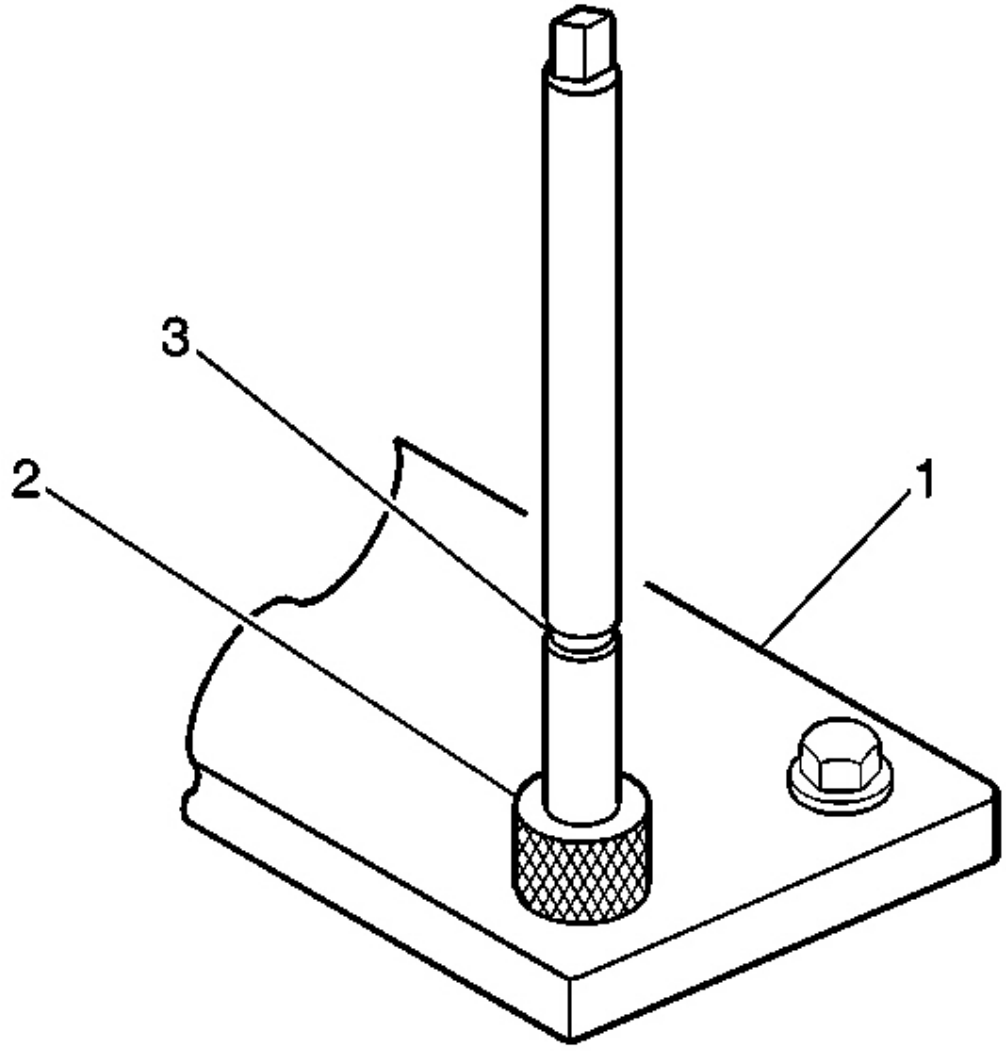


Fig. 253: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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20. Rotate the driver installation tool until the mark (3) on the driver installation tool aligns with the top of the drill bushing (2).
21. Inspect the insert for proper installation into the tapped hole.

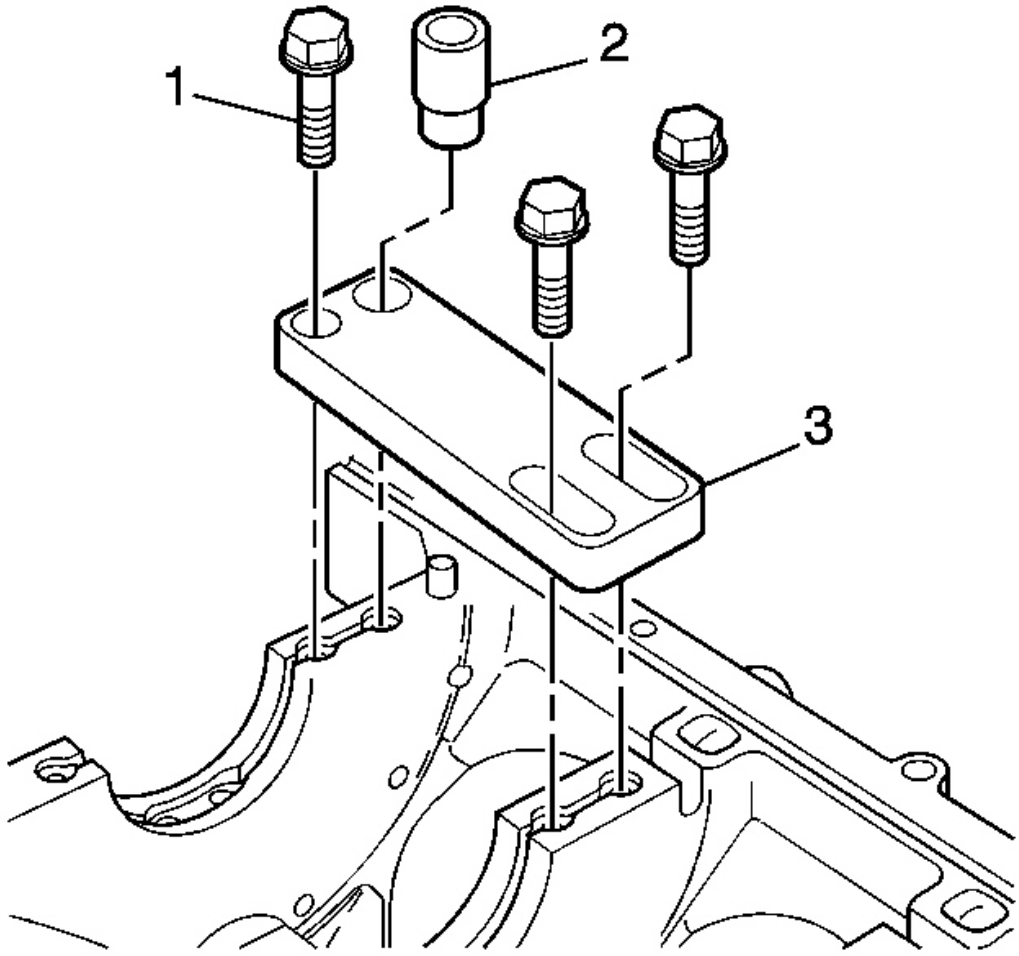


Fig. 254: View Of Fixture Plate & Components - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

22. Remove the fixture plate bolts (1).
23. Remove the fixture plate (3) and bushing (2).

SERVICE PRIOR TO ASSEMBLY

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.

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- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.

CRANKSHAFT AND BEARINGS INSTALLATION

CRANKSHAFT BEARING INSTALLATION PROCEDURE

Tools Required

J 45059 Angle Meter. See **Special Tools** .

Installation Procedure

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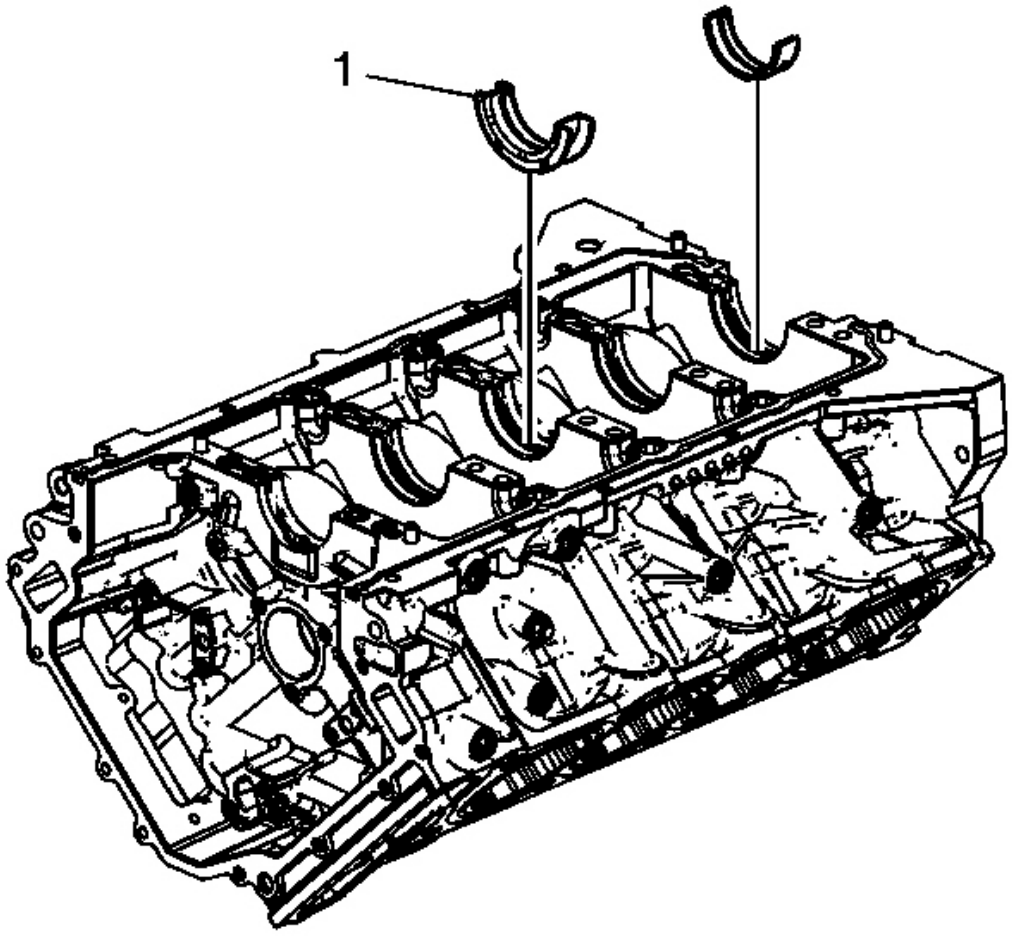


Fig. 255: View Of Thrust Bearing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the crankshaft bearings have been used in a running engine, you must replace them with NEW crankshaft bearings for reassembly.

1. Clean the upper and lower crankcase crank bore with a lint-free cloth.
2. Clean all the oil from the backside of new bearing halves.
3. Install new upper crankshaft bearings into position. The thrust bearing (1) belongs in the number three journal. Be sure the upper bearing insert contains the oil transfer hole and groove. Roll the bearing into position so that the lock tang engages the crank slot. The bearing must fit flush with the upper crankcase.

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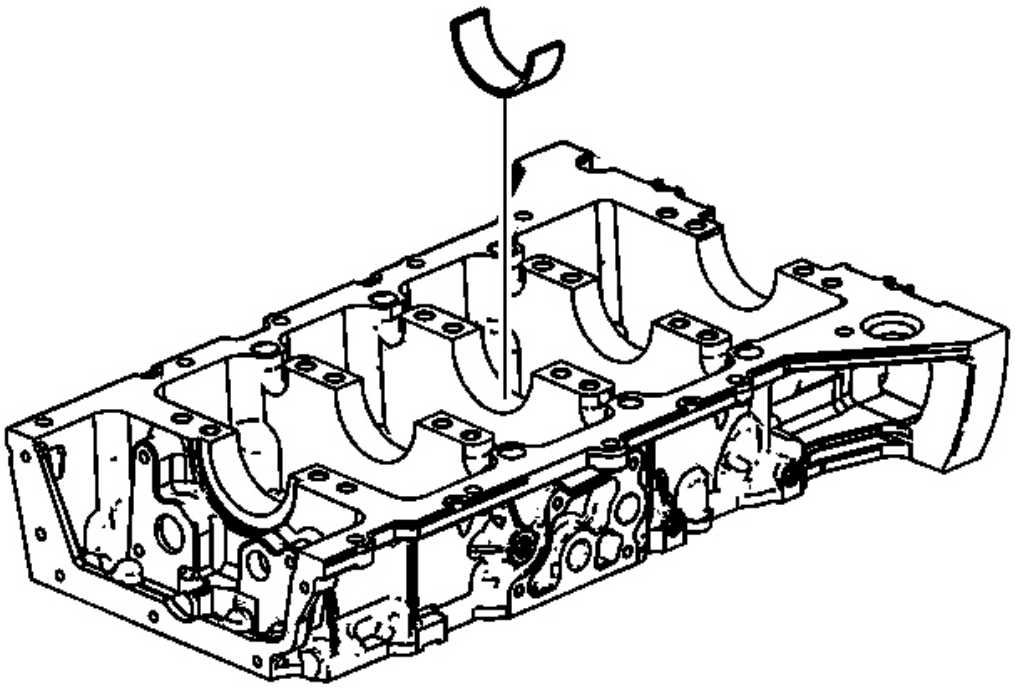


Fig. 256: View Of Lower Main Bearing Half
Courtesy of GENERAL MOTORS CORP.

4. Install new lower crankshaft bearings into position in the lower crankcase. The lower crankcase crankshaft bearings are identified by NO grooves or holes. The bearings must fit flush with the lower crankcase.
5. Apply a liberal amount of GM crankshaft prelube GM P/N 1052367, (Canadian P/N 992869) or engine oil to the upper and lower bearing surfaces.

CRANKSHAFT INSTALLATION PROCEDURE

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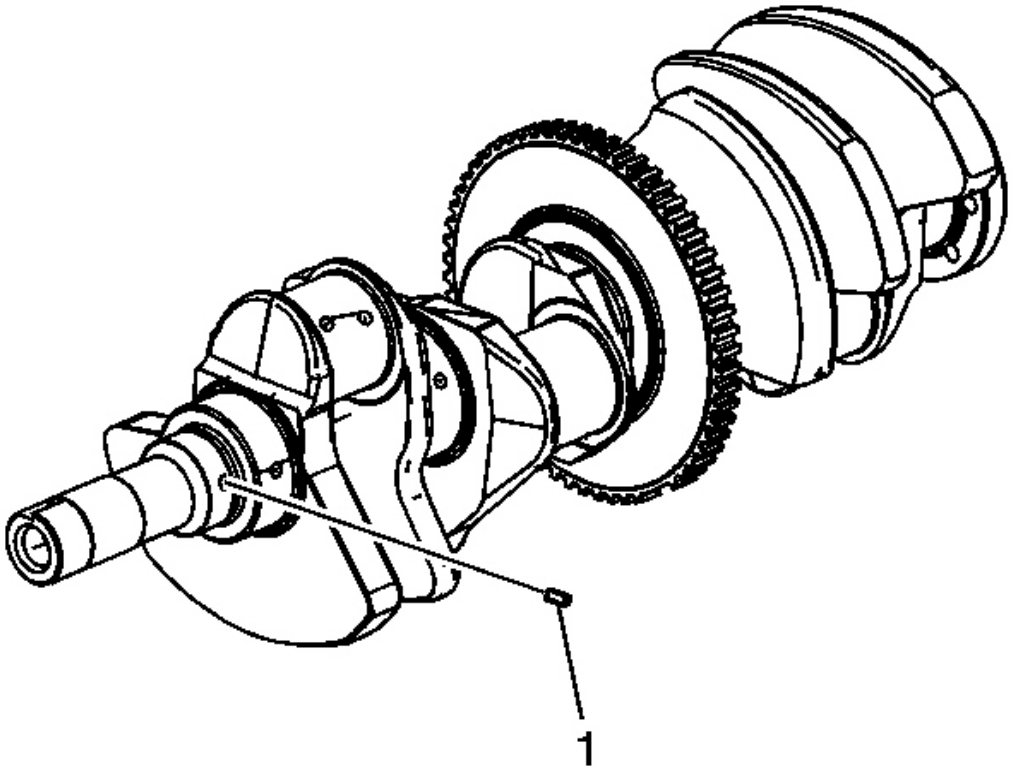


Fig. 257: View Of Crankshaft Sprocket Drive Pin
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW crankshaft sprocket drive pin (1), if removed due to damage.

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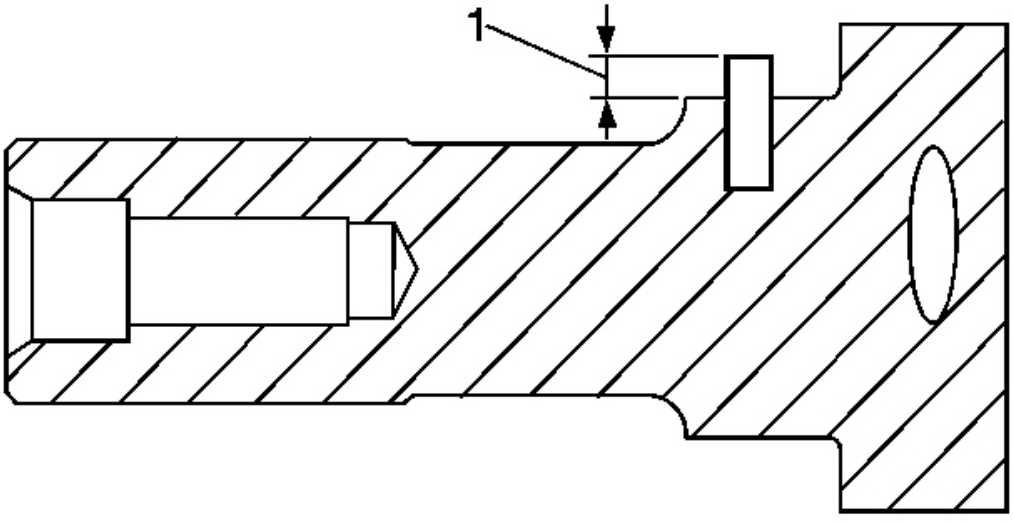


Fig. 258: Ensuring Proper Pin Height
Courtesy of GENERAL MOTORS CORP.

2. Ensure pin height (1) is 2.75-3.25 mm (0.0689-0.1280 in).

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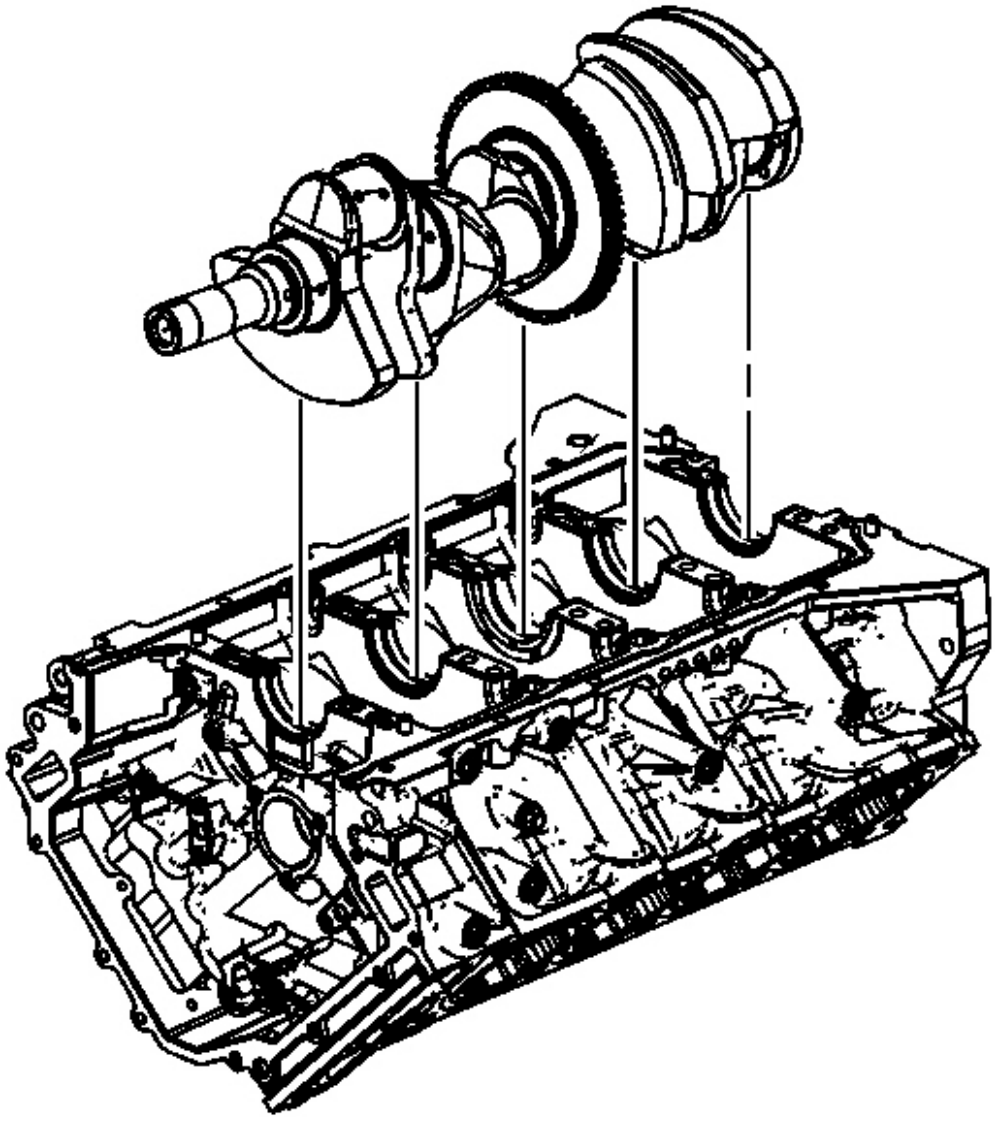


Fig. 259: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

3. Gently lower the crankshaft into position in the cylinder block.
4. Ensure the crankshaft turns without binding or noise.

CRANKSHAFT BEARING CLEARANCE MEASUREMENT PROCEDURE

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1. Place a length of fresh, room temperature plastic gaging material all the way across all the crankshaft bearing journals.

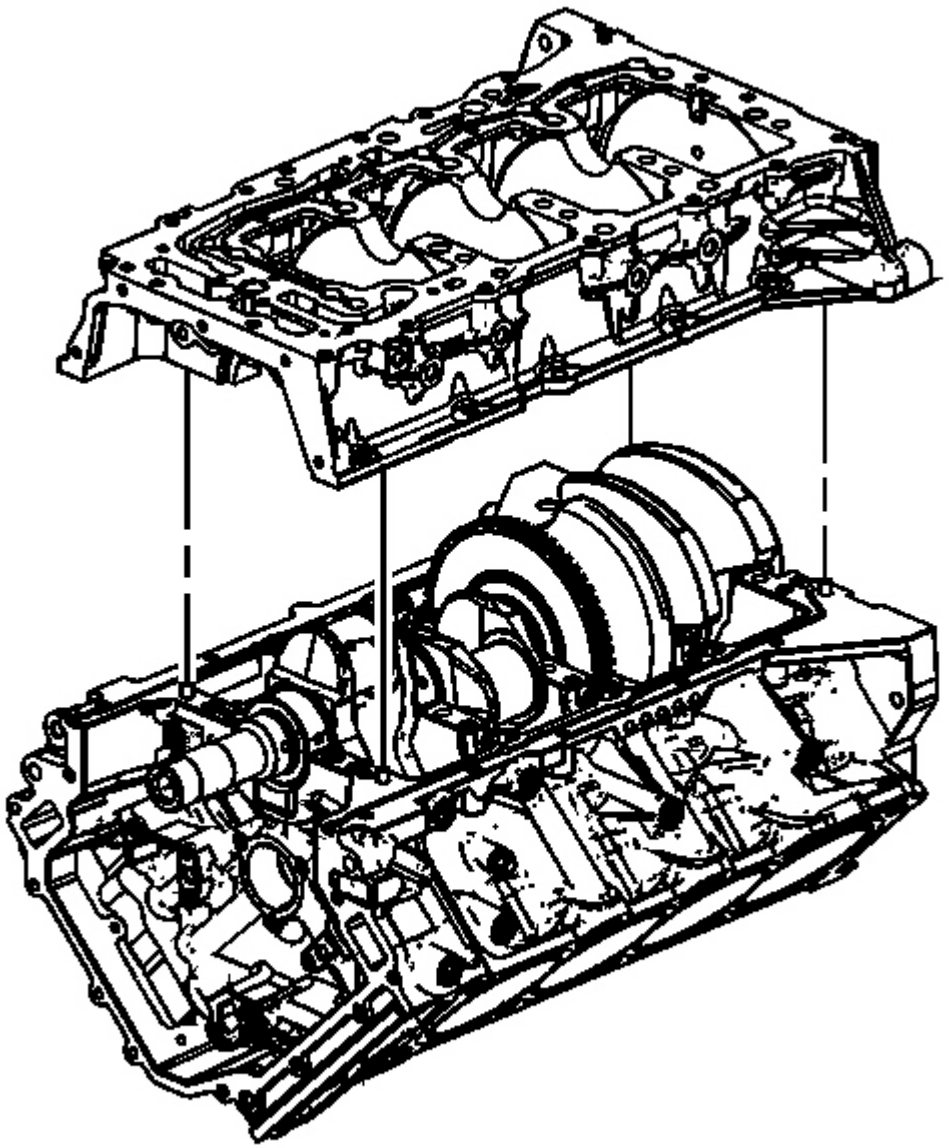


Fig. 260: View Of Lower Crankcase
Courtesy of GENERAL MOTORS CORP.

2. Align the lower crankcase with the dowel pins in the upper crankcase.

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3. Install the lower crankcase onto the upper crankcase slowly until feeling a positive stop.
4. Inspect the upper-to-lower crankcase joint in order to make sure the lower crankcase is fully seated on the cylinder block.

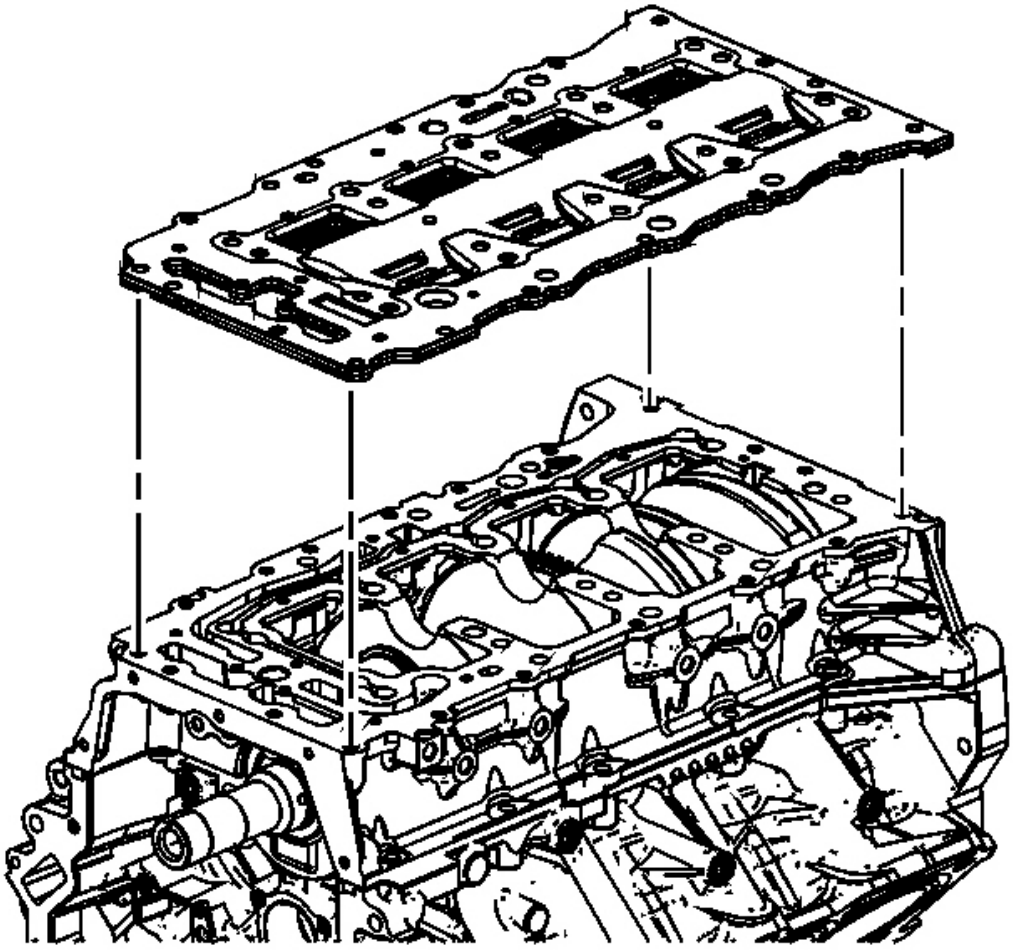


Fig. 261: View Of Oil Manifold & Oil Scraper Plate Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the old oil manifold and oil scraper plate assembly.

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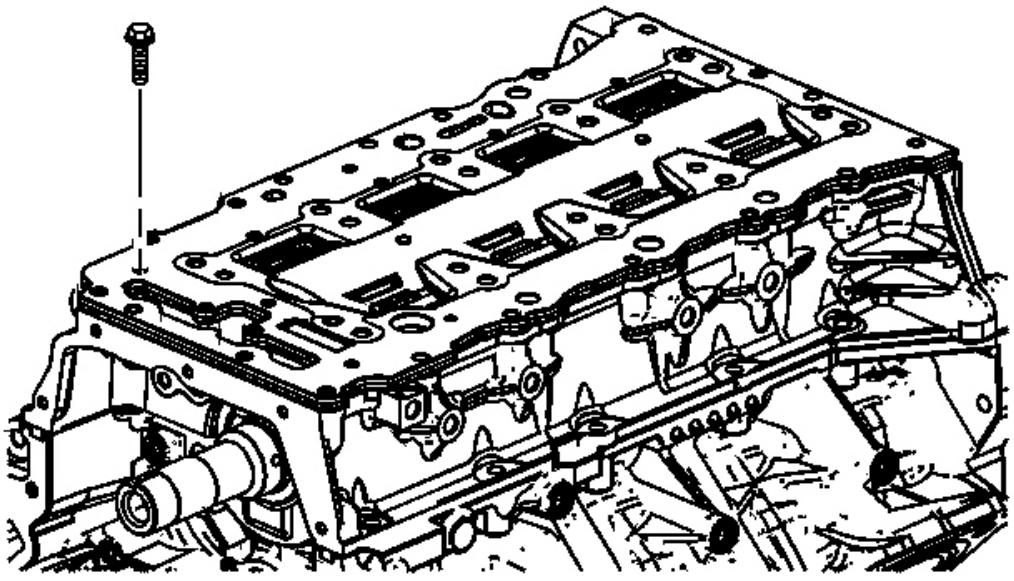


Fig. 262: View Of Oil Manifold Plate Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the oil manifold plate bolts.

   Tighten: Tighten the oil manifold plate bolts to 10 N.m (89 lb in).

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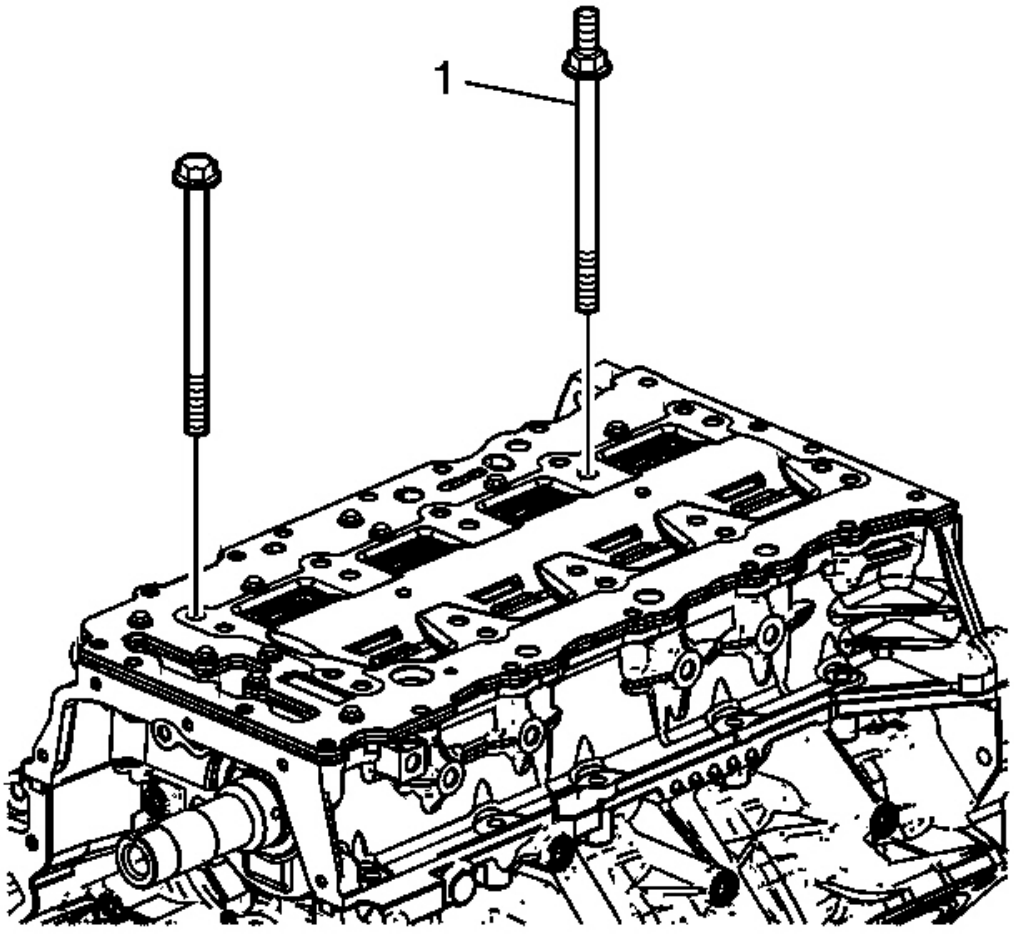


Fig. 263: View Of Single Stud-End Bolt
Courtesy of GENERAL MOTORS CORP.

7. Loosely install the main bearing bolts. The single stud-end bolt (1) used to attach the oil pump pipe and screen assembly support bracket is installed in the inboard position in the second set of main bearing bolts from the front and left bank side of the engine.

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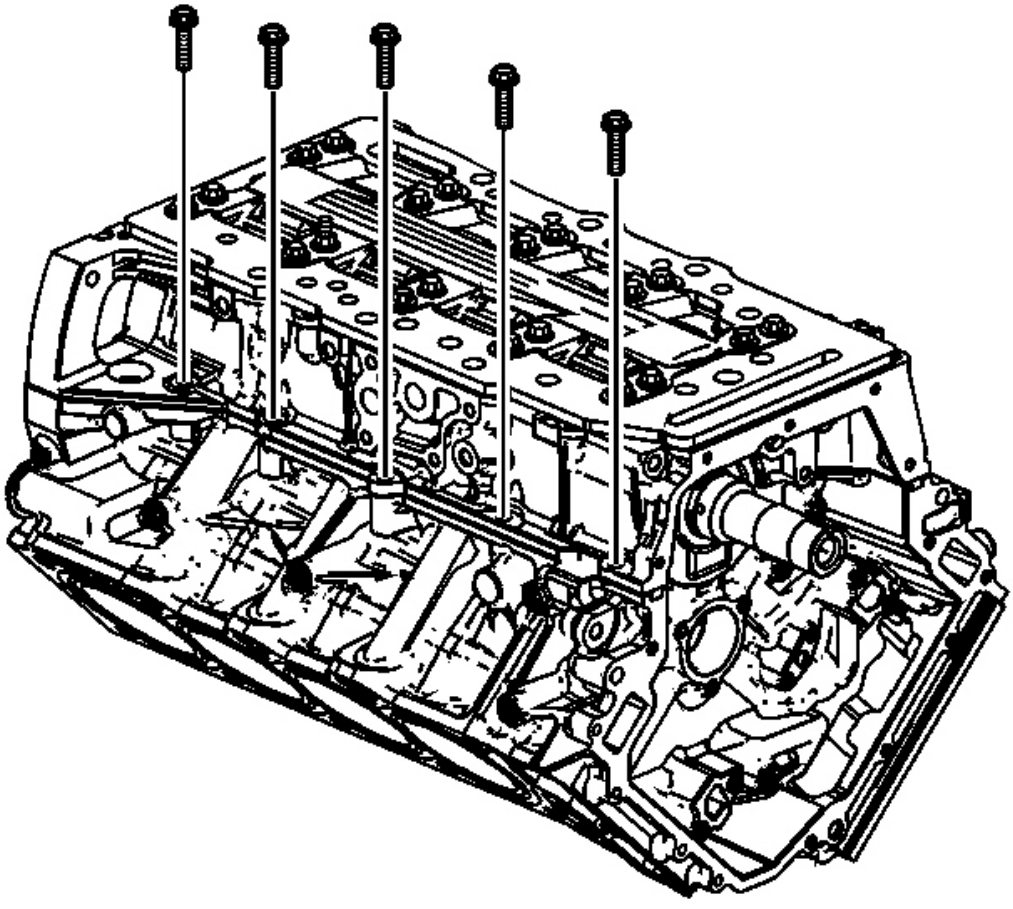


Fig. 264: View Of Lower Left Crankcase Perimeter Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the left side upper-to-lower crankcase perimeter bolts.

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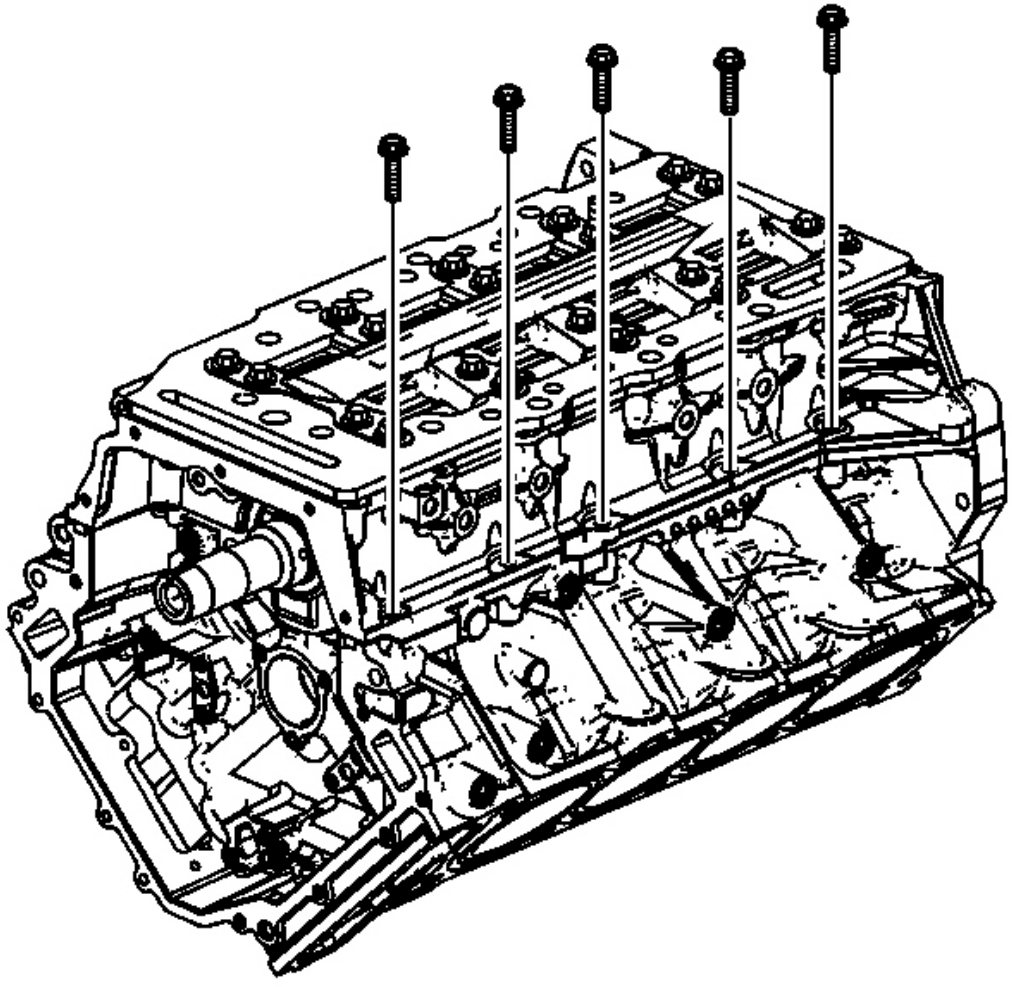


Fig. 265: View Of Right Upper-To-Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

9. Install the right side upper-to-lower crankcase perimeter bolts.

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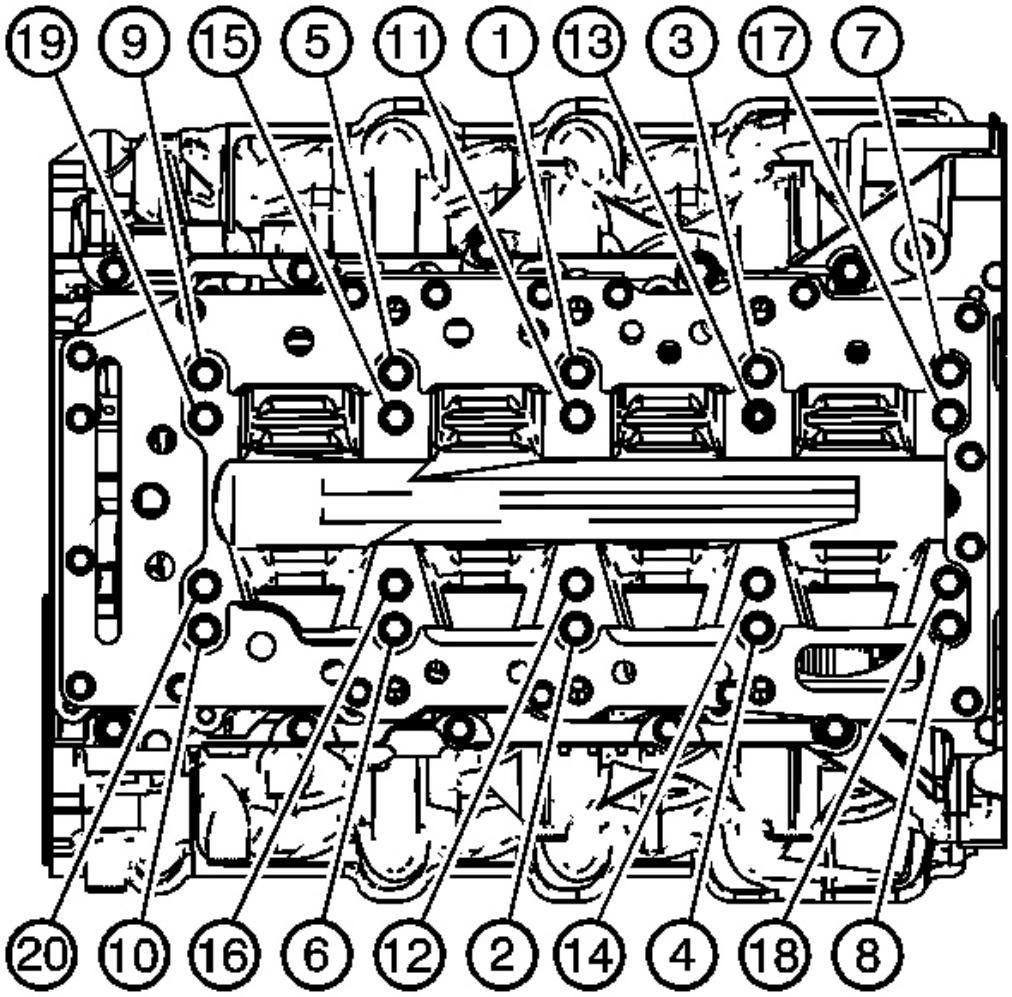


Fig. 266: Tightening Lower Crankcase Bolts
Courtesy of GENERAL MOTORS CORP.

10. Tighten the lower crankcase bolts in proper sequence.
    1. First Pass

       Tighten: Tighten the lower crankcase bearing bolts (1 through 20) to 20 N.m (15 lb ft) in the proper sequence.

    2. Final Pass

       Tighten: Tighten the lower crankcase bolts (1 through 20) an additional 65 degrees in the proper

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sequence using the **J 45059** . See **Special Tools** .

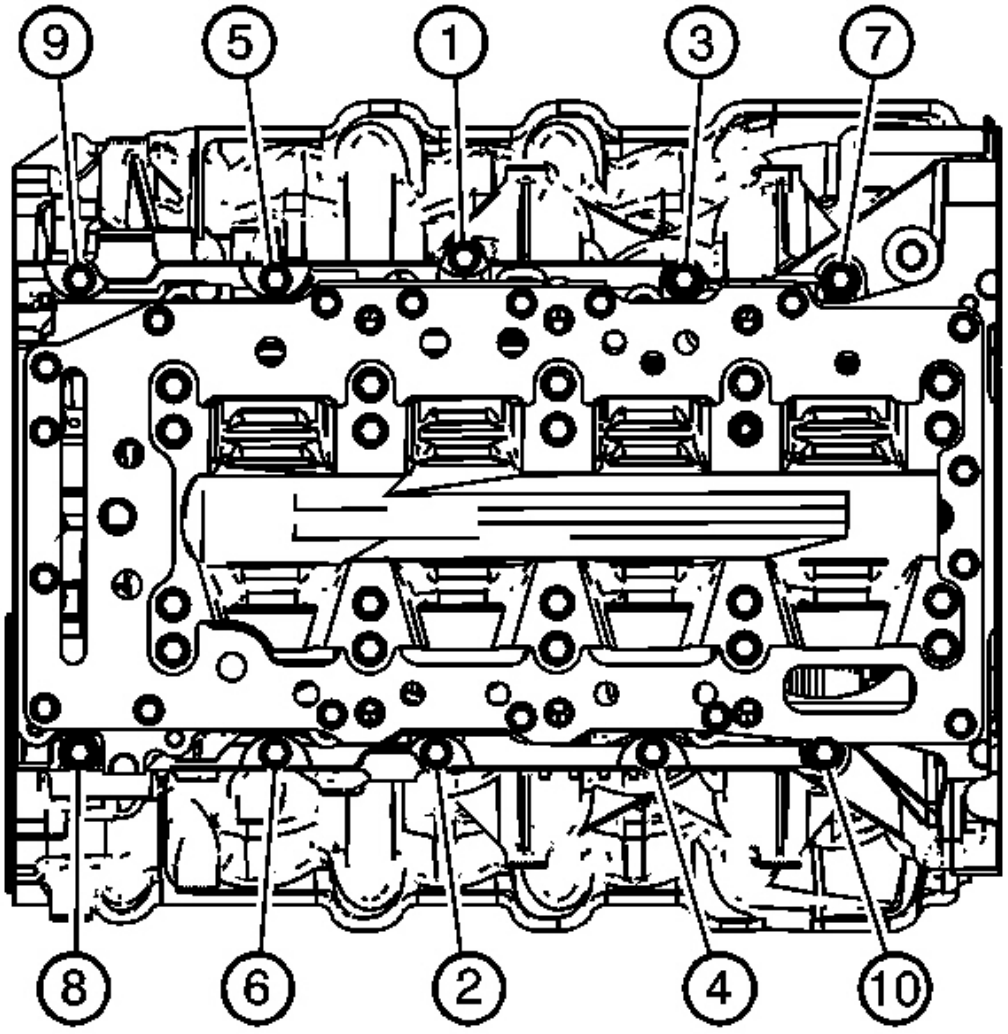


Fig. 267: Tightening Upper-To-Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

11. Tighten the upper-to-lower crankcase perimeter bolts (1 through 8).

    Tighten: Tighten the upper-to-lower crankcase perimeter bolts (1 through 8) to 30 N.m (22 lb ft).

12. Allow the assembly to sit for at least two minutes.

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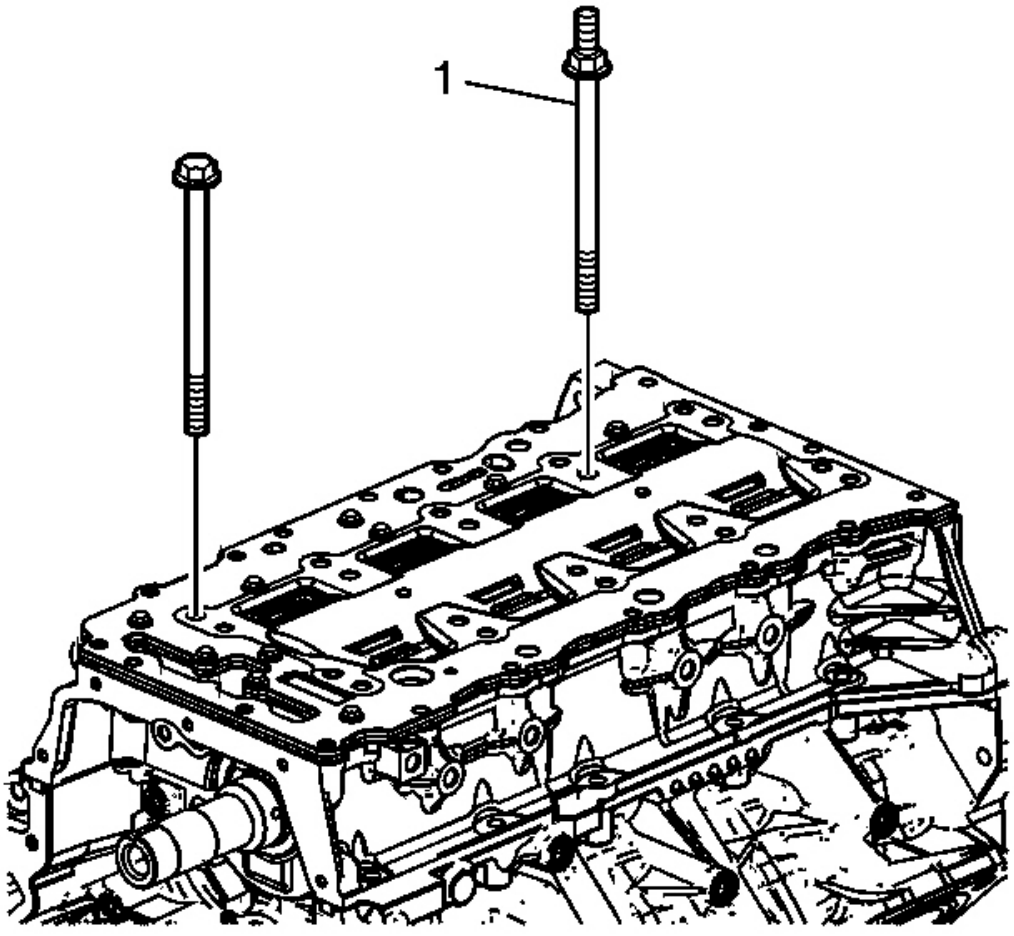


Fig. 268: View Of Single Stud-End Bolt
Courtesy of GENERAL MOTORS CORP.

13. Remove the main bearing bolts.

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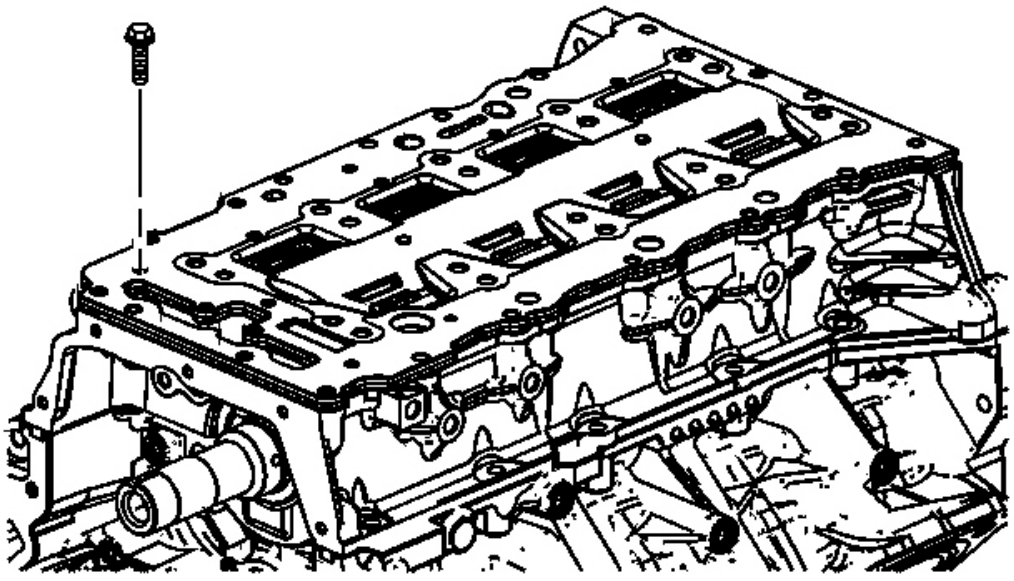


Fig. 269: View Of Oil Manifold Plate Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the oil manifold plate bolts.

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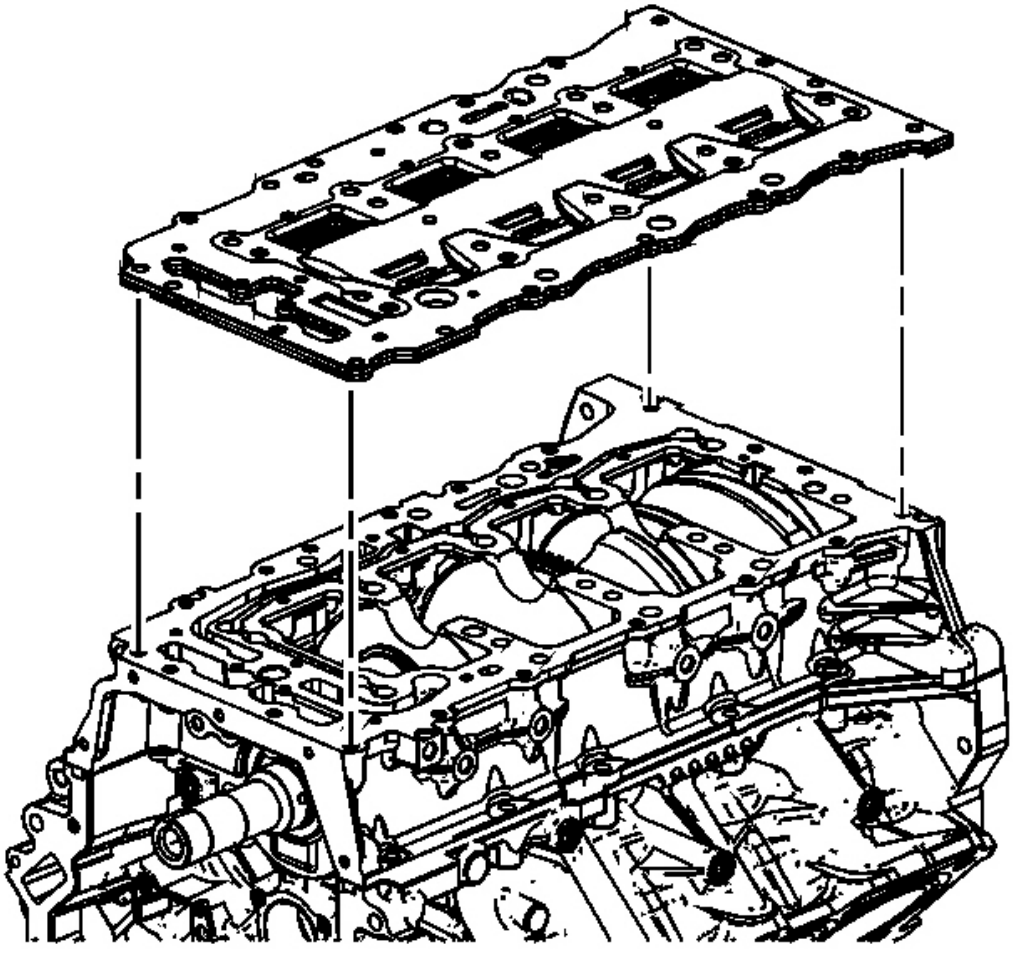


Fig. 270: View Of Oil Manifold & Oil Scraper Plate Assembly
Courtesy of GENERAL MOTORS CORP.

15. Remove the old oil manifold and oil scraper plate assembly.

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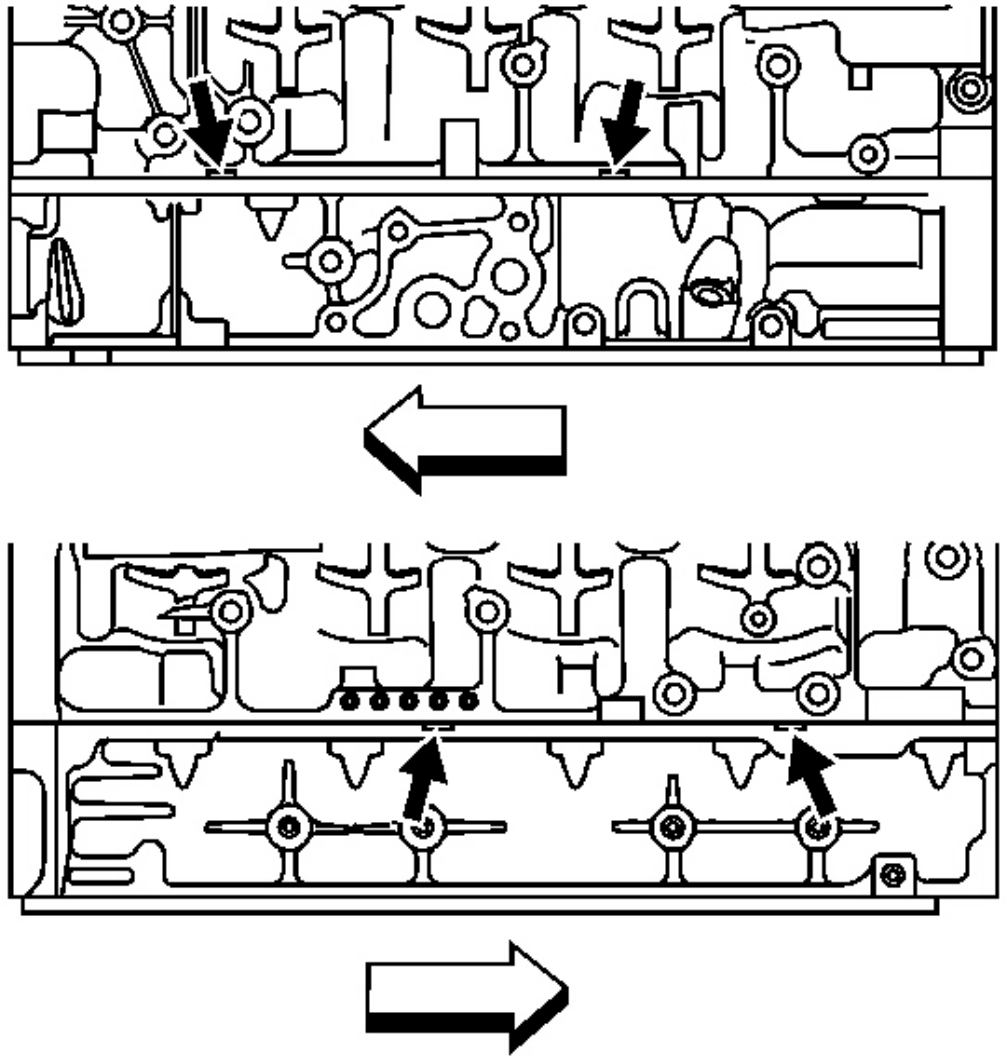


Fig. 271: Separating Crankcase Halves
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a plastic pry tool when prying case halves apart to prevent damage to the Upper and Lower Crankcase surface. Do not continue to push the pry tool in the crankcase as the Upper and Lower Crankcase halves separate. This may damage the sealing surface.

16. Working on either side of the lower crankcase, separate the crankcase halves by alternately prying in the

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grooves provided until the lower crankcase is free of the dowel pins.

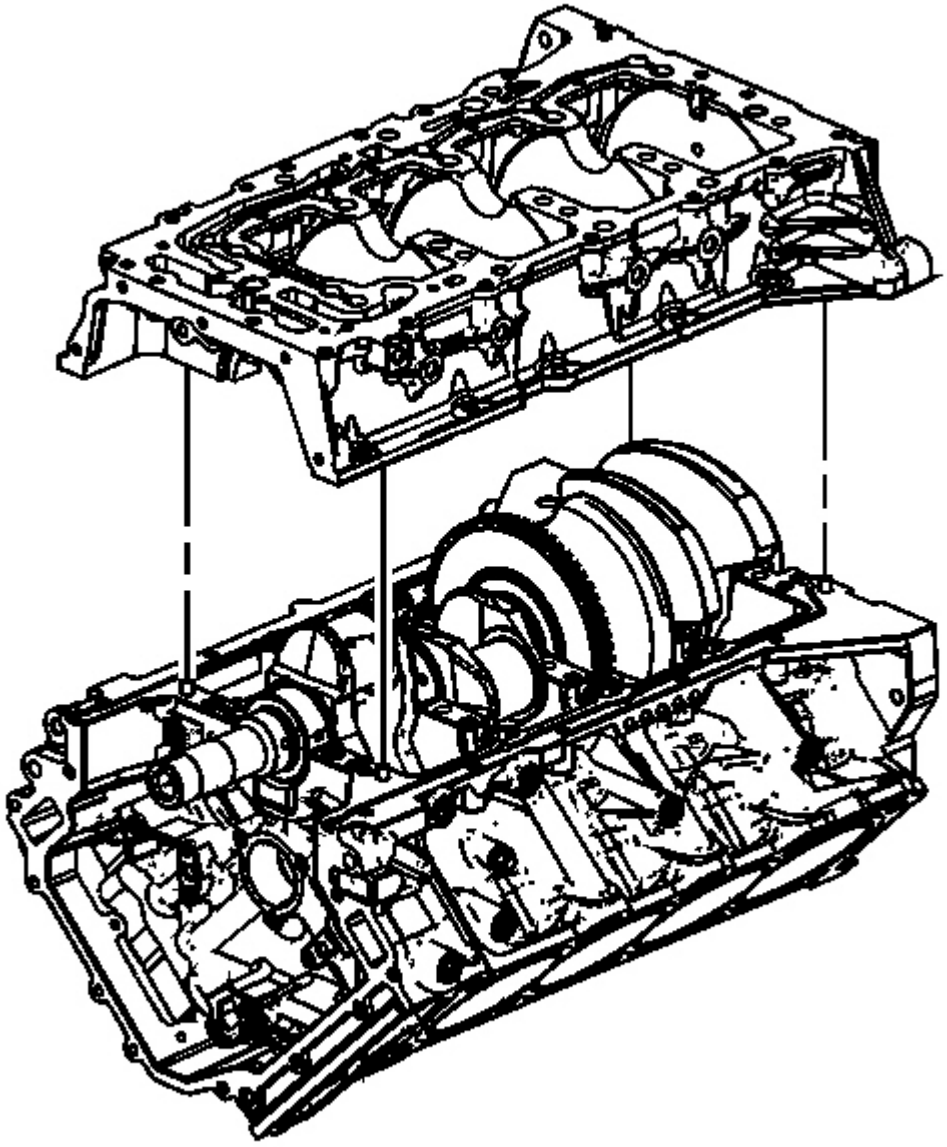


Fig. 272: View Of Lower Crankcase
Courtesy of GENERAL MOTORS CORP.

17. Remove the lower crankcase.

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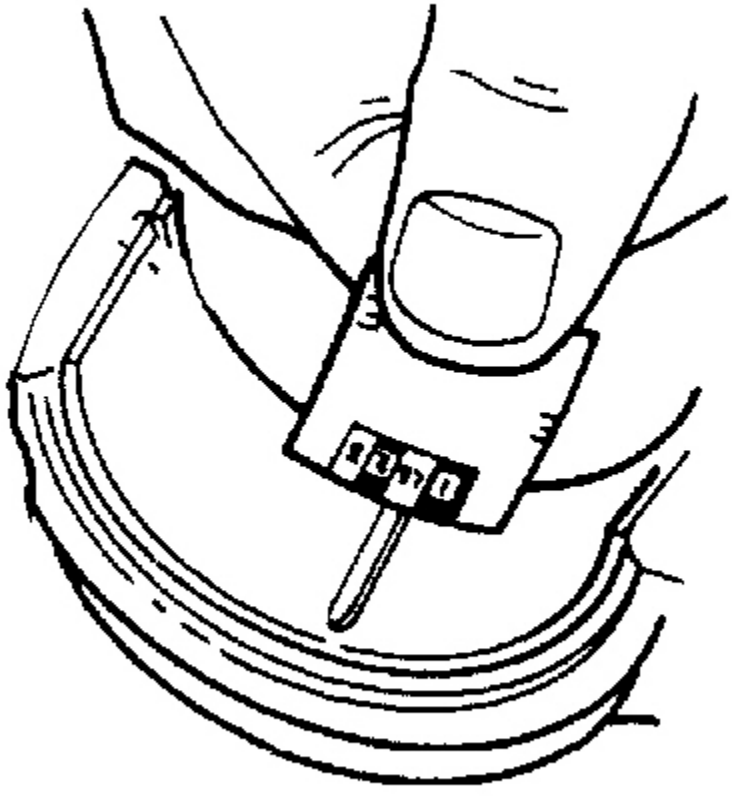


Fig. 273: Measuring Plastigage
Courtesy of GENERAL MOTORS CORP.

18. Determine the main bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gaging material container.
19. Compare your measurements with the engine mechanical specifications. If the new bearings do not provide the proper crankshaft to bearing clearance, re-measure the crankshaft journals for the correct specified size and check to make sure you have the correct new bearings. If the crankshaft journals are incorrectly sized, replace the crankshaft. No crankshaft machining is permitted and undersized bearings are not available.
20. Clean the plastic gaging material from the crankshaft bearings and/or crankshaft bearing journals using a soft lint-free cloth.
21. Coat the upper crankshaft bearings and crankshaft main bearing journals with GM crankshaft prelube GM P/N 1052367, (Canadian P/N 992869) or equivalent.

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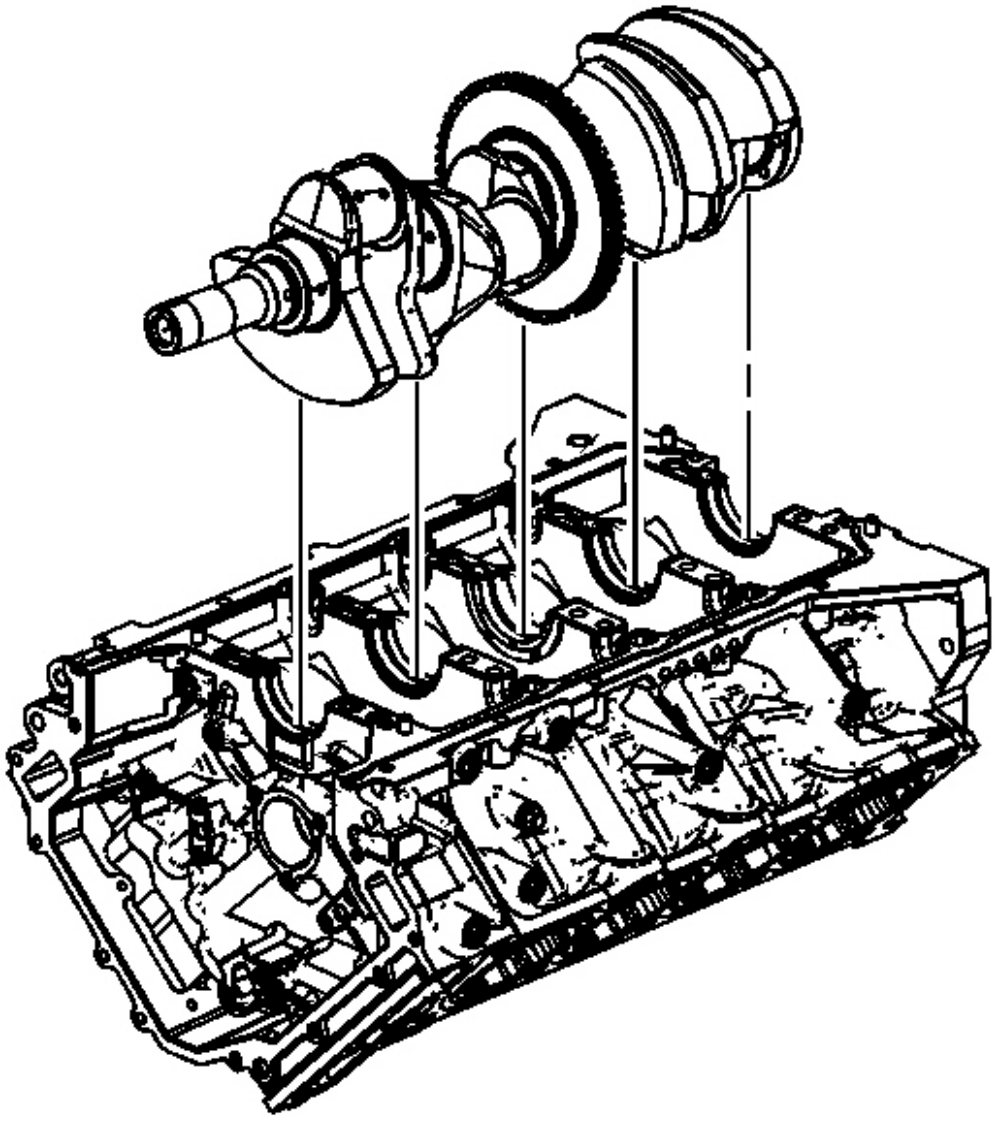


Fig. 274: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

22. Reinstall the crankshaft into position in the cylinder block.

PISTON, CONNECTING ROD AND BEARING INSTALLATION

TOOLS REQUIRED

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- **EN 46121** Connecting Rod Guide Pin Set. See **Special Tools** .
- **J 8037** Ring Compressor. See **Special Tools** .
- **J 39946** Crankshaft Socket - 4.0L and 4.6L
- **J 43690** Rod Bearing Clearance Checking Tool. See **Special Tools** .
- **J 43690-100** Rod Bearing Clearance Checking Tool - Adapter Kit. See **Special Tools** .
- **J 45059** Angle Meter. See **Special Tools** .

PISTON AND CONNECTING ROD ASSEMBLY PROCEDURE

1. Rotate the crankshaft using the **J 39946** in order to align the crankshaft connecting rod journal being serviced to BDC. See **Special Tools** .
2. Liberally lubricate the cylinder walls, piston rings and piston skirts with clean engine oil.

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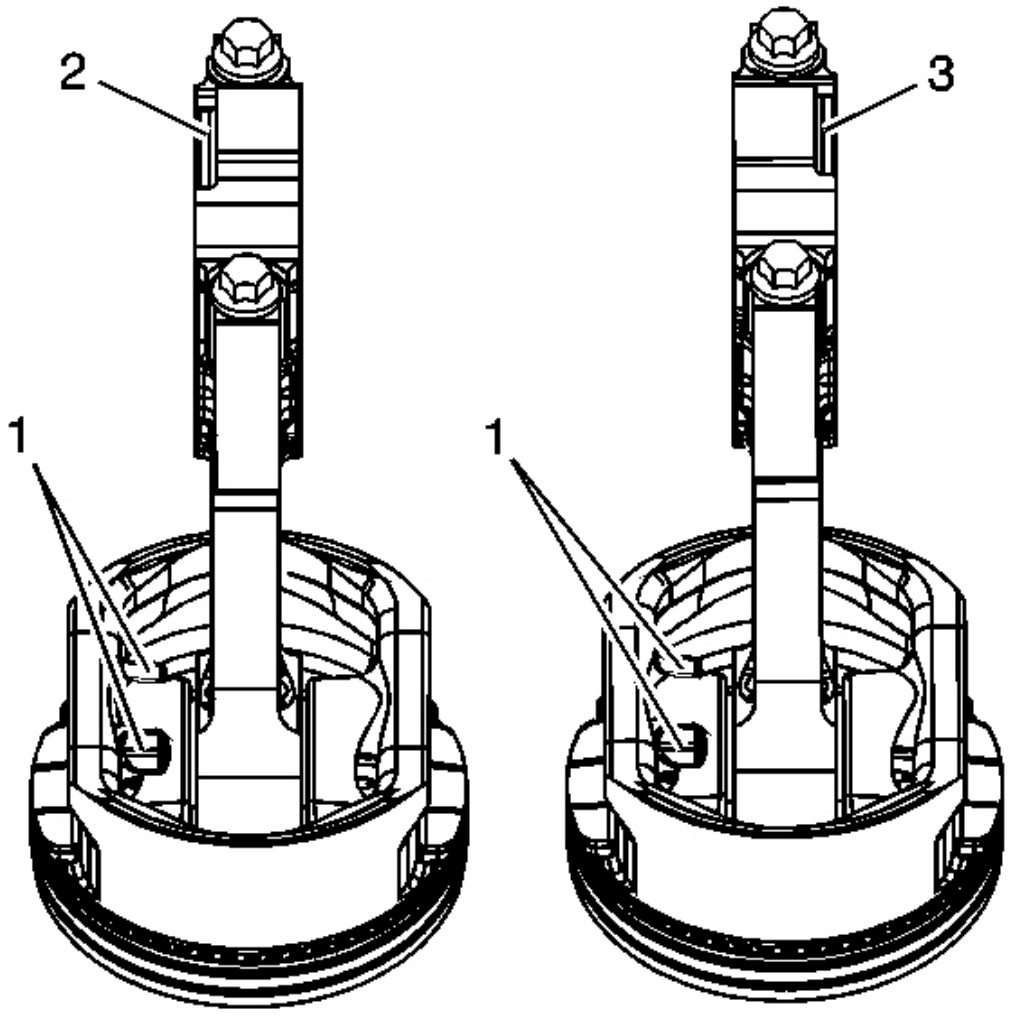


Fig. 275: Locating Piston & Connecting Rod Alignment Markings
Courtesy of GENERAL MOTORS CORP.

3. Select the correctly numbered piston/connecting rod assembly for the cylinder. Indication features showing proper piston orientation are located on the bottom of the piston and connecting rod. Ensure the connecting rod bearing tang notches in the connecting rod bearing bore are aligned to the same side.
    - The locator lugs (1) on the bottom of the piston are oriented towards the front of engine.
    - The notch (2) on the left piston assembly connecting rod cap is oriented towards the front of the engine. The piston locator lugs (1) and the connecting rod cap notch (2) in the same orientation.
    - The notch (3) on the right piston assembly connecting rod cap is oriented towards the rear of the engine. The piston locator lugs (1) and the connecting rod cap notch (3) in the opposing orientation.

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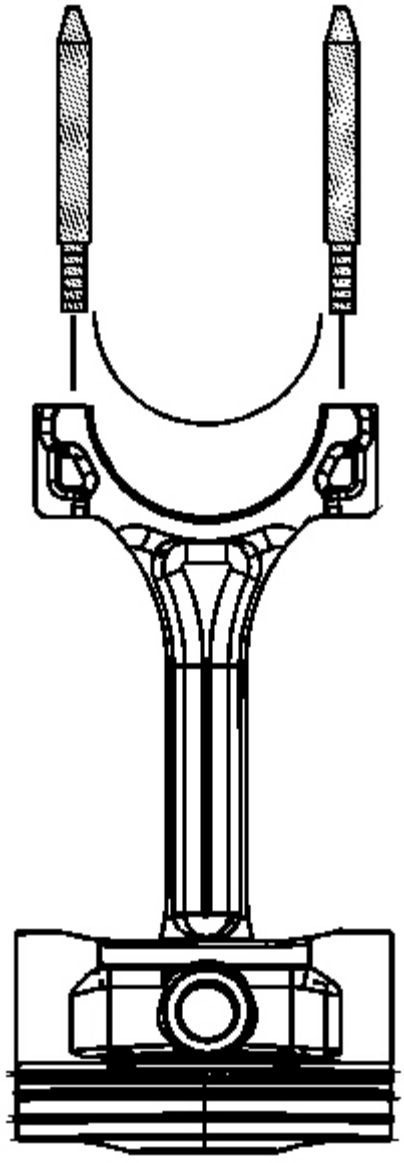


Fig. 276: Removing EN 46121
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Connecting rod bearings that have been used in a running engine, must be replaced with NEW connecting rod bearings for reassembly.

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4. Install the connecting rod bearing into the connecting rod.
5. Install the **EN 46121** into the connecting rod bolt holes. See **Special Tools** .
6. Compress the piston rings using the **J 8037** or equivalent. See **Special Tools** .

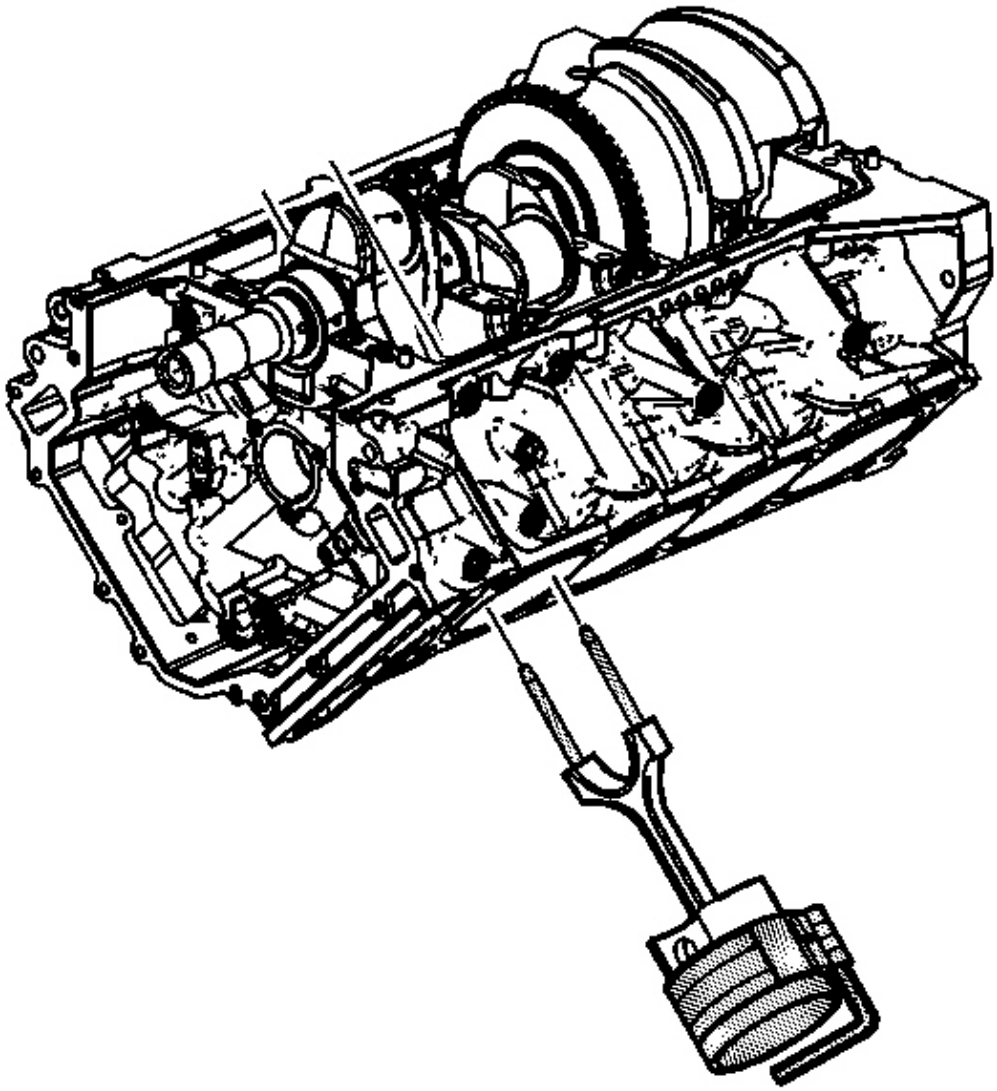


Fig. 277: Installing Piston
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Extreme care must be exercised when installing the piston and

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connecting rod in order to ensure the connecting rod does not scrape or nick the cylinder bore or the crankshaft journal surfaces.

7. Using both hands, slowly guide the piston and connecting rod assembly into the cylinder from the top and bottom of the cylinder. DO NOT allow the connecting rod to contact the cylinder wall.
8. When the **J 8037** contacts the deck surface, gently tap the piston into the cylinder using the handle end of a dead-blow hammer. See **Special Tools** . Guide the connecting rod onto the crankshaft bearing journal using the **EN 46121** while taping the piston into the cylinder. See **Special Tools** .

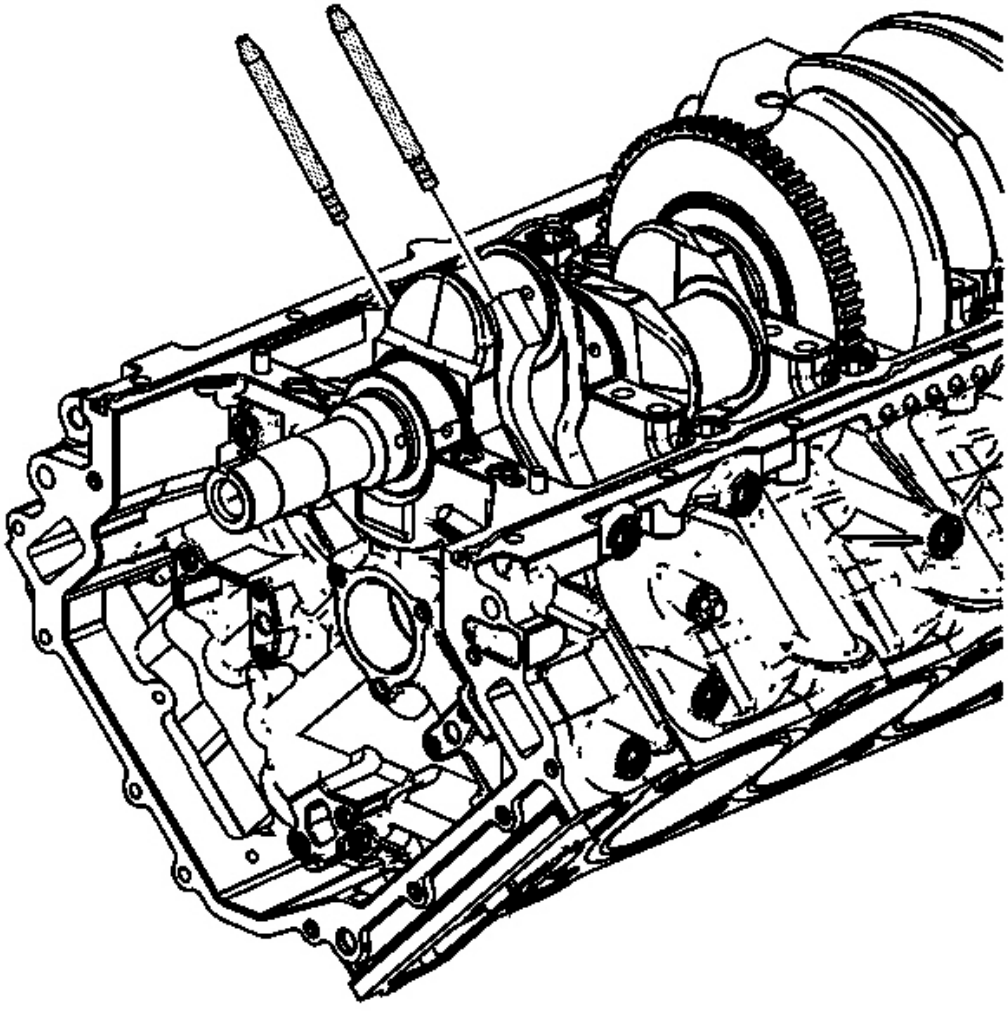


Fig. 278: Installing EN 46121
Courtesy of GENERAL MOTORS CORP.

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9. Remove the **EN 46121** from the connecting rod bolt holes. See **Special Tools** .

CONNECTING ROD BEARING CLEARANCE MEASUREMENT PROCEDURE - USING PLASTIC GAGING

IMPORTANT: Connecting rod bearings that have been used in a running engine, must be replaced with NEW connecting rod bearings for reassembly.

1. Before final assembly it is important to check the clearance of the new connecting rod bearings.
2. Place a length of fresh, room temperature plastic gaging material all the way across the entire connecting rod bearing journal.

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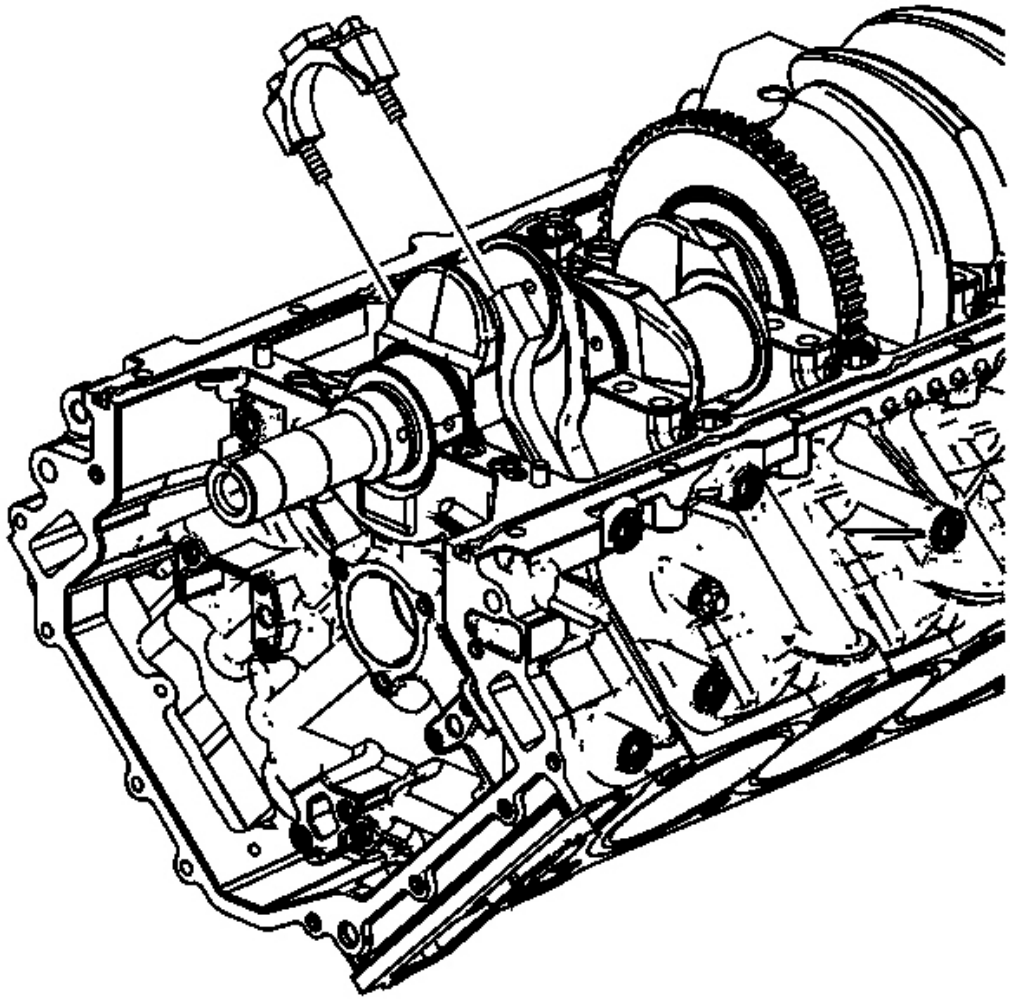


Fig. 279: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

3. Install the connecting rod end cap on its original connecting rod making sure the bearing lock tangs are aligned on the same side of the rod.

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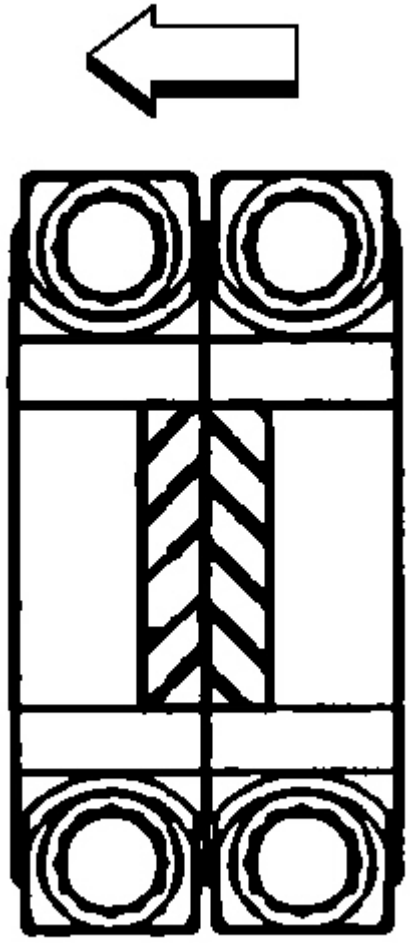


Fig. 280: View Of Paired Connecting Rod Bearing Cap Notches
Courtesy of GENERAL MOTORS CORP.

4. When properly installed, the connecting rod bearing cap notches should be paired, as shown, on the crankpin.

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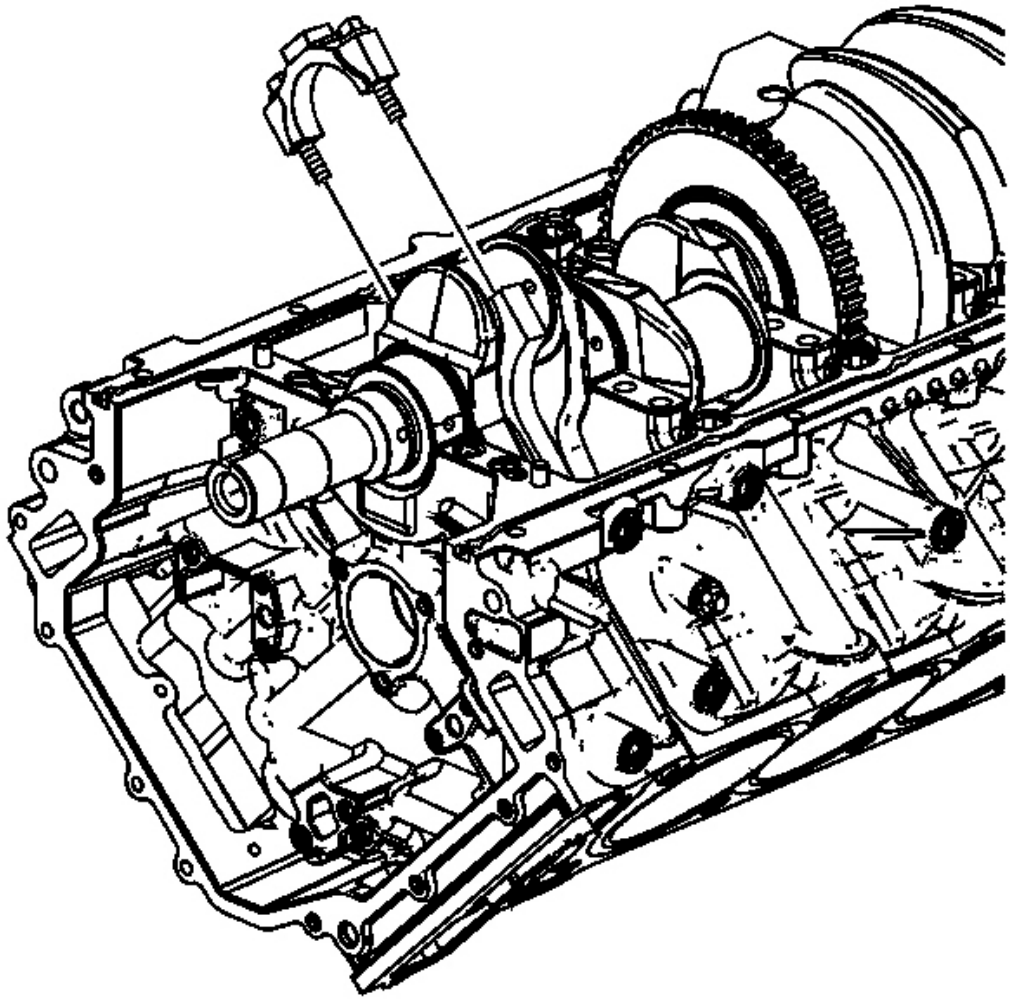


Fig. 281: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Reuse the old connecting rod bolts ONLY for measuring the connecting rod bearing clearance.

5. Lubricate connecting rod bolts with engine oil and install in the connecting rod.

   Tighten: Tighten the connecting rod bolts to 30 N.m (22 lb ft).

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6. Loosen the connecting rod bolts until the torque reading is zero.
7. Re-tighten the connecting rod bolts.
    1. First Pass

       Tighten: Tighten the connecting rod bolts to 25 N.m (18 lb ft).

    2. Final Pass

       Tighten: Tighten the connecting rod bolts an additional 110 degrees using the **J 45059** . See **Special Tools** .

8. Allow the assembly to sit for at least 2 minutes.

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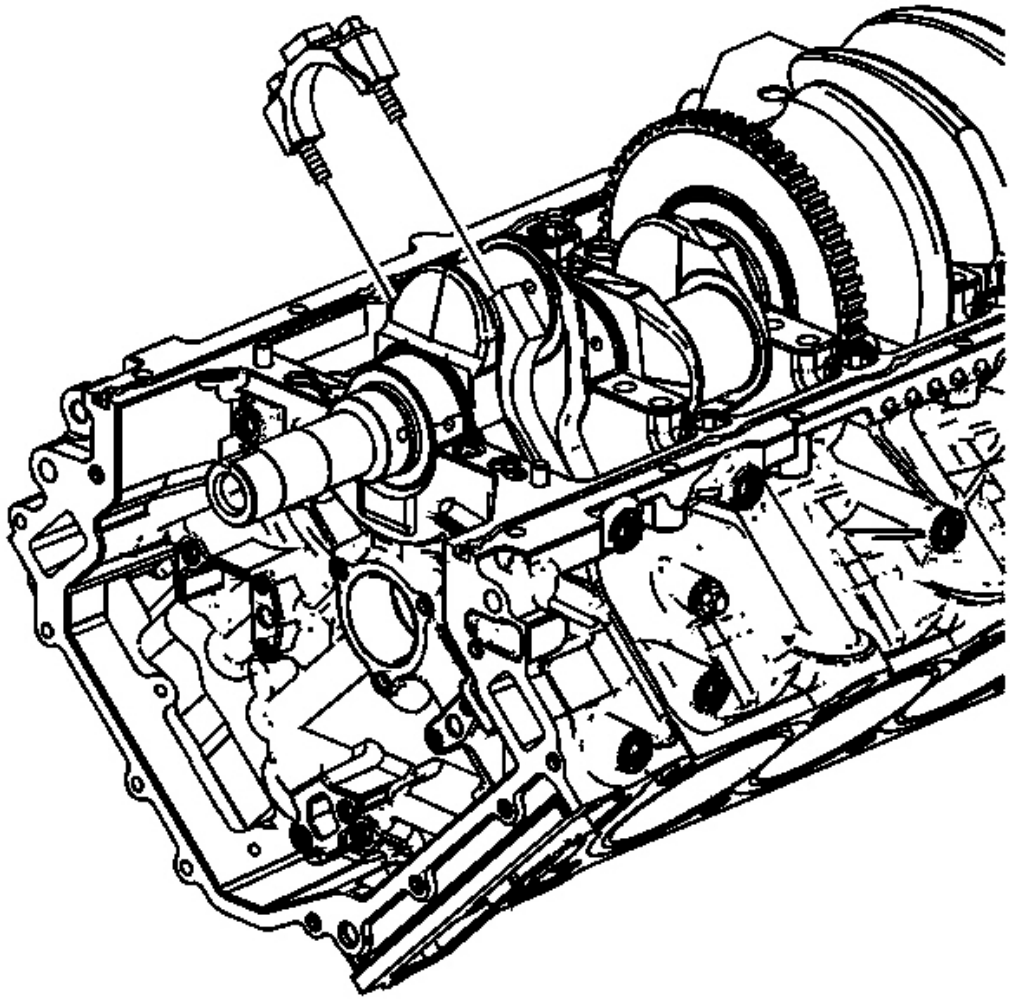


Fig. 282: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

9. Remove the connecting rod cap bolts.
10. Remove the connecting rod cap.

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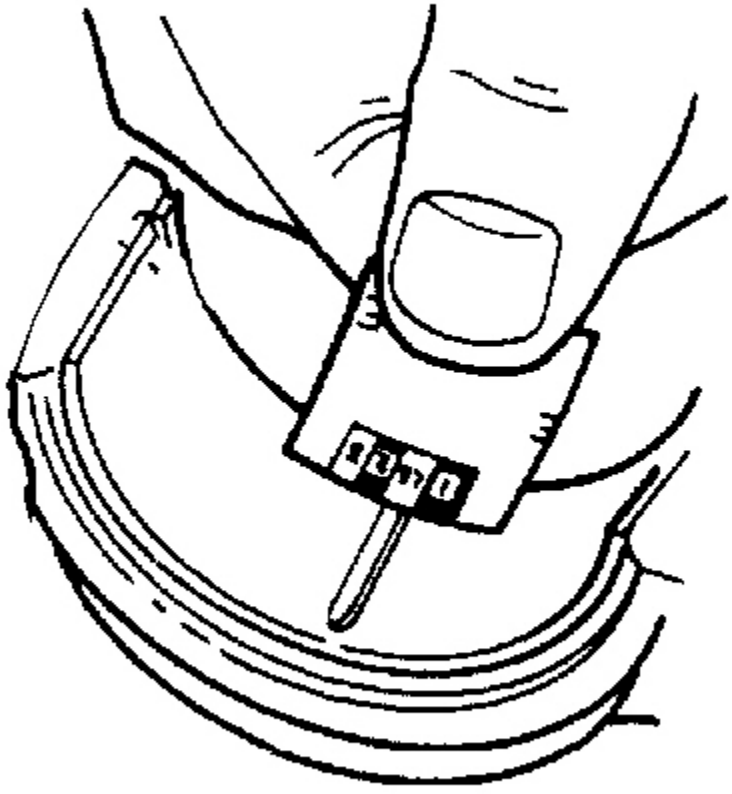


Fig. 283: Measuring Plastigage
Courtesy of GENERAL MOTORS CORP.

11. Determine the connecting rod bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gauging material container.
12. Compare the measurements with the engine mechanical specifications. Refer to **Engine Mechanical Specifications** .
13. If the new bearings do not provide the proper crankshaft to bearing clearance, re-measure the crankshaft journals for the correct specified size and check to make sure you have the correct new bearings. If the crankshaft journals are incorrectly sized, replace the crankshaft. No crankshaft machining is permitted and undersized bearings are not available.
14. Clean the plastic gaging material from the connecting rod bearing and crankshaft connecting rod bearing journal using a soft lint-free cloth.

CONNECTING ROD CLEARANCE MEASUREMENT PROCEDURE - USING J 43690 AND J 43690-100

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The **J 43690** and the **J 43690-100** have been developed as a more accurate method to measure connecting rod bearing clearances. See **Special Tools** . The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer.

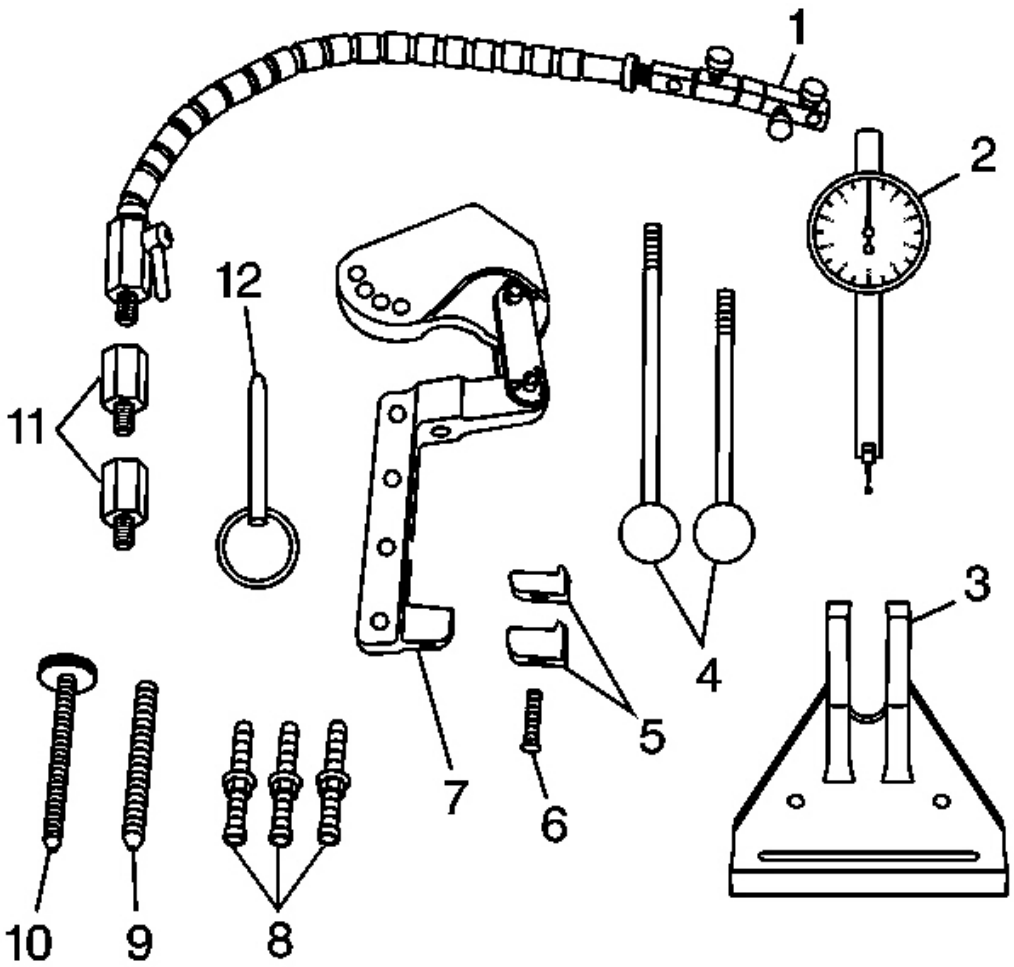


Fig. 284: Identifying Rod Bearing Clearance Checking Tool
Courtesy of GENERAL MOTORS CORP.

J 43690 Rod Bearing Clearance Checking Tool

- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)
- J 43690-2 Base (3)

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- J 43690-5, -6 Handle (4)
- J 43690-10, -11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, -7, -8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17, -18 Adapter (11)
- 280310 Pin (12)

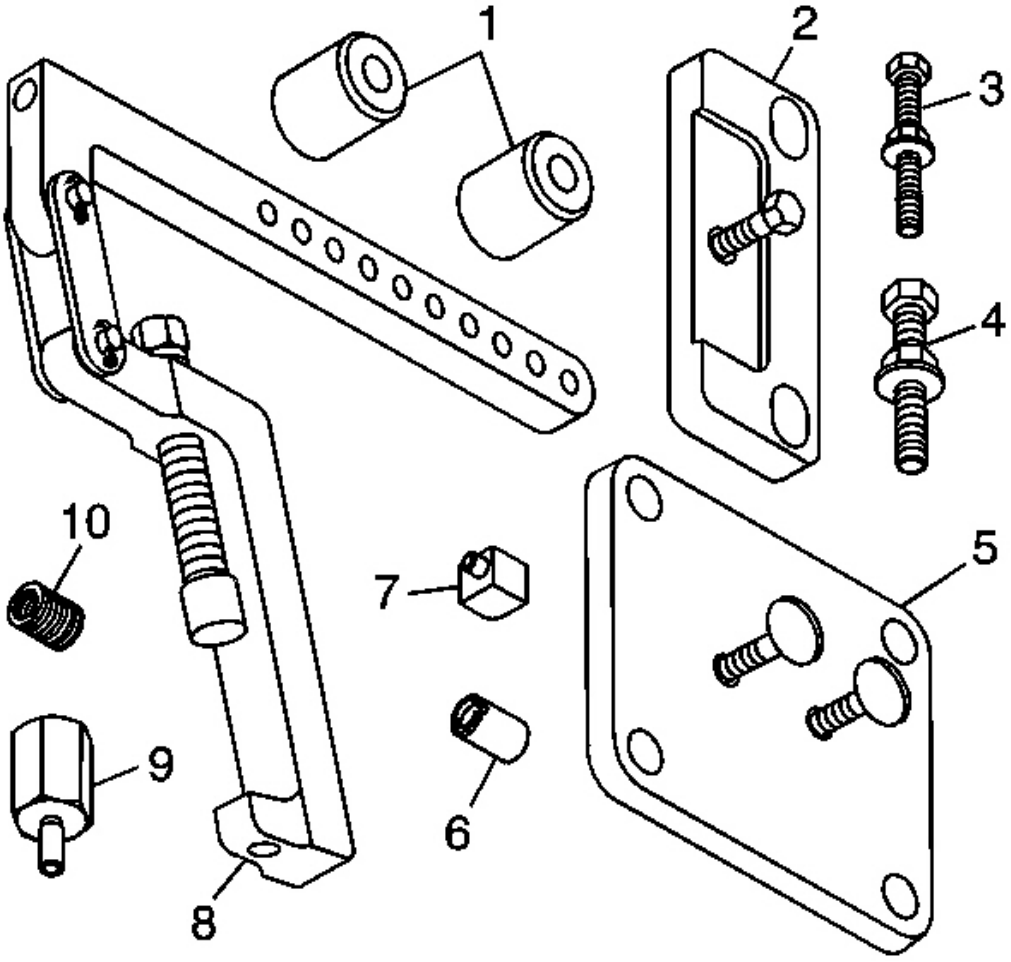


Fig. 285: Identifying Rod Bearing Clearance Tool - Adapter Kit

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Courtesy of GENERAL MOTORS CORP.

J 43690-100 Rod Bearing Clearance Tool - Adapter Kit

- J 43690-104 Spacer (1)
- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

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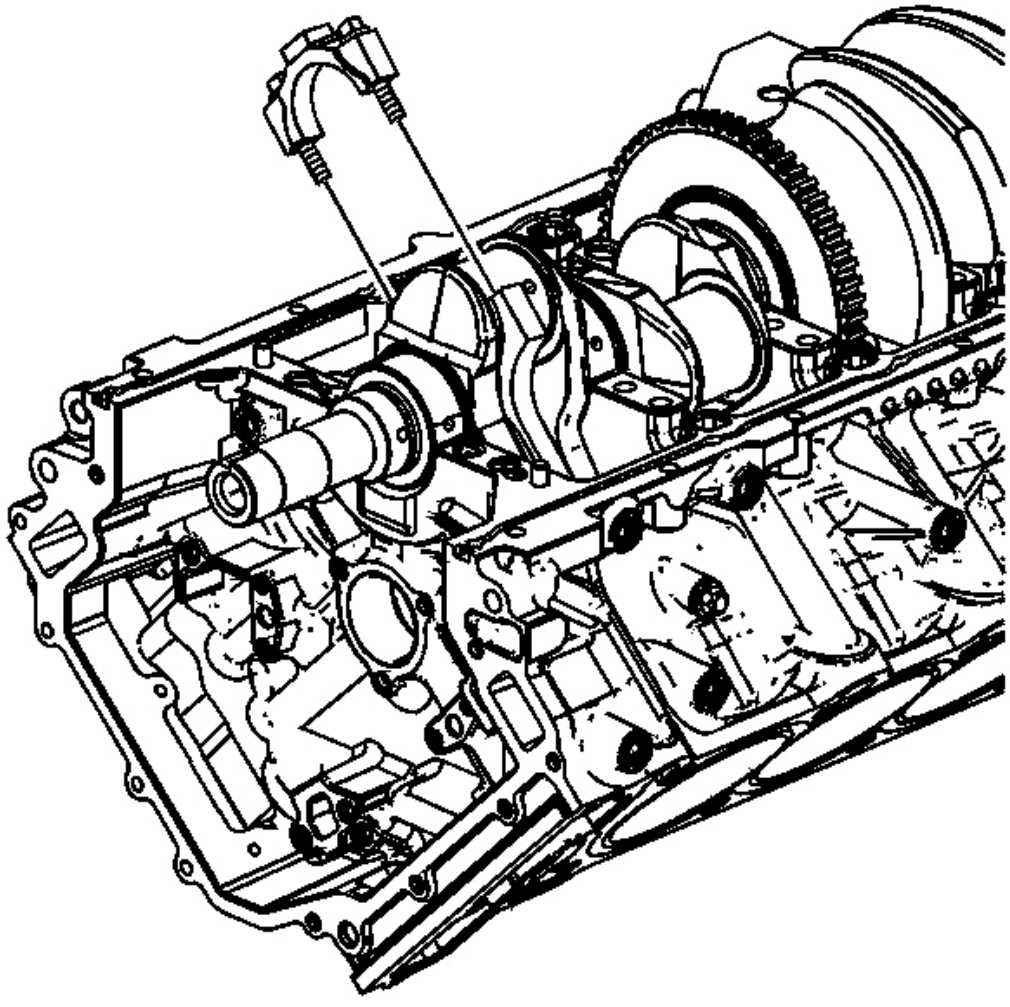


Fig. 286: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

1. Install the connecting rod end cap on its original connecting rod making sure the bearing lock tangs are aligned on the same side of the rod.

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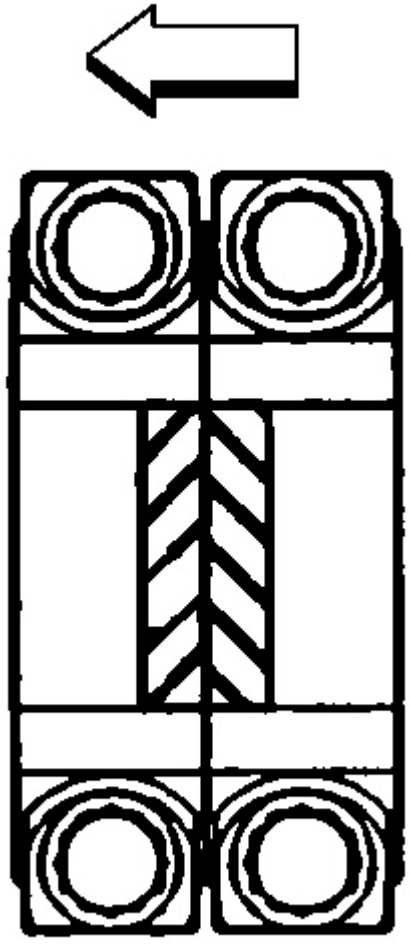


Fig. 287: View Of Paired Connecting Rod Bearing Cap Notches
Courtesy of GENERAL MOTORS CORP.

2. When properly installed, the connecting rod bearing cap notches should be paired, as shown, on the crankpin.

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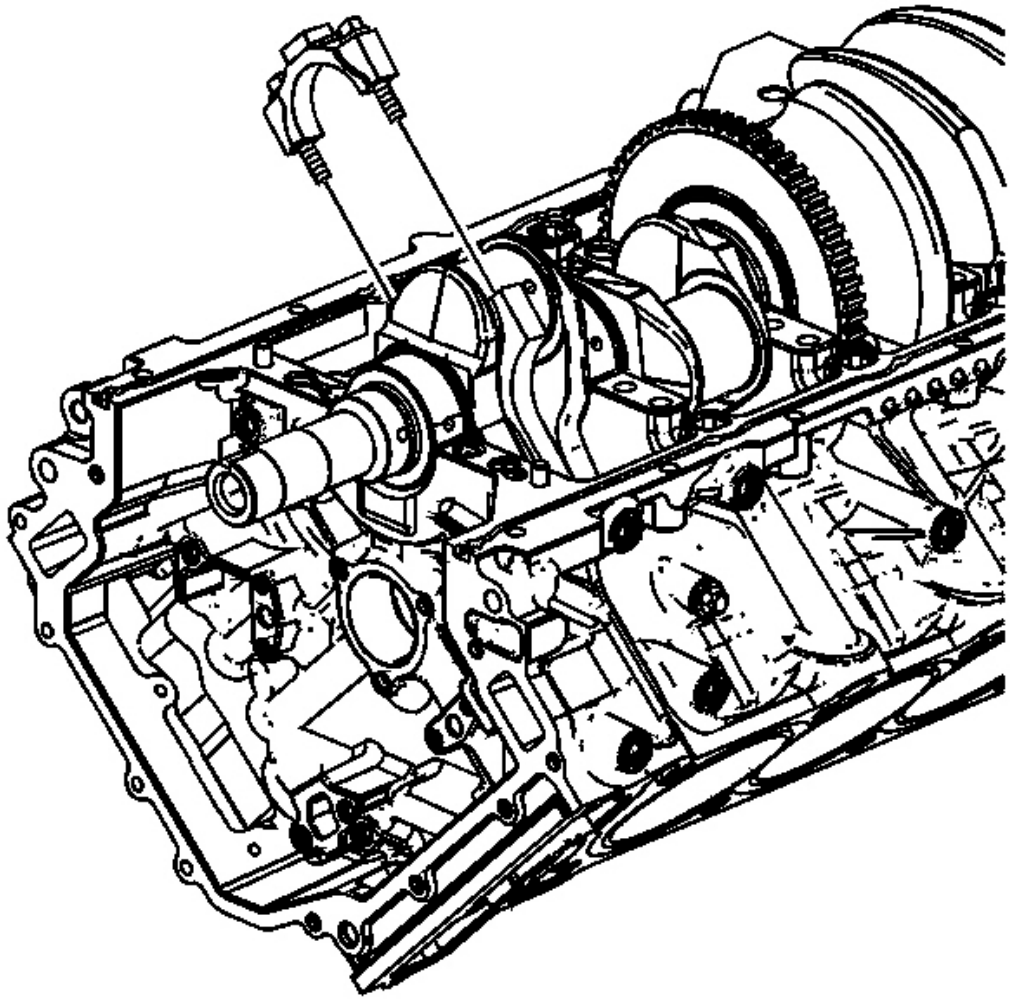


Fig. 288: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Reuse the old connecting rod bolts ONLY for measuring the connecting rod bearing clearance.

3. Lubricate connecting rod bolts with engine oil and install in the connecting rod.

   Tighten: Tighten the connecting rod bolts to 30 N.m (22 lb ft).

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4. Loosen the connecting rod bolts until the torque reading is zero.
5. Re-tighten the connecting rod bolts.
    1. First Pass

       Tighten: Tighten the connecting rod bolts to 25 N.m (18 lb ft).

    2. Final Pass

       Tighten: Tighten the connecting rod bolts an additional 110 degrees using the **J 45059** . See **Special Tools** .

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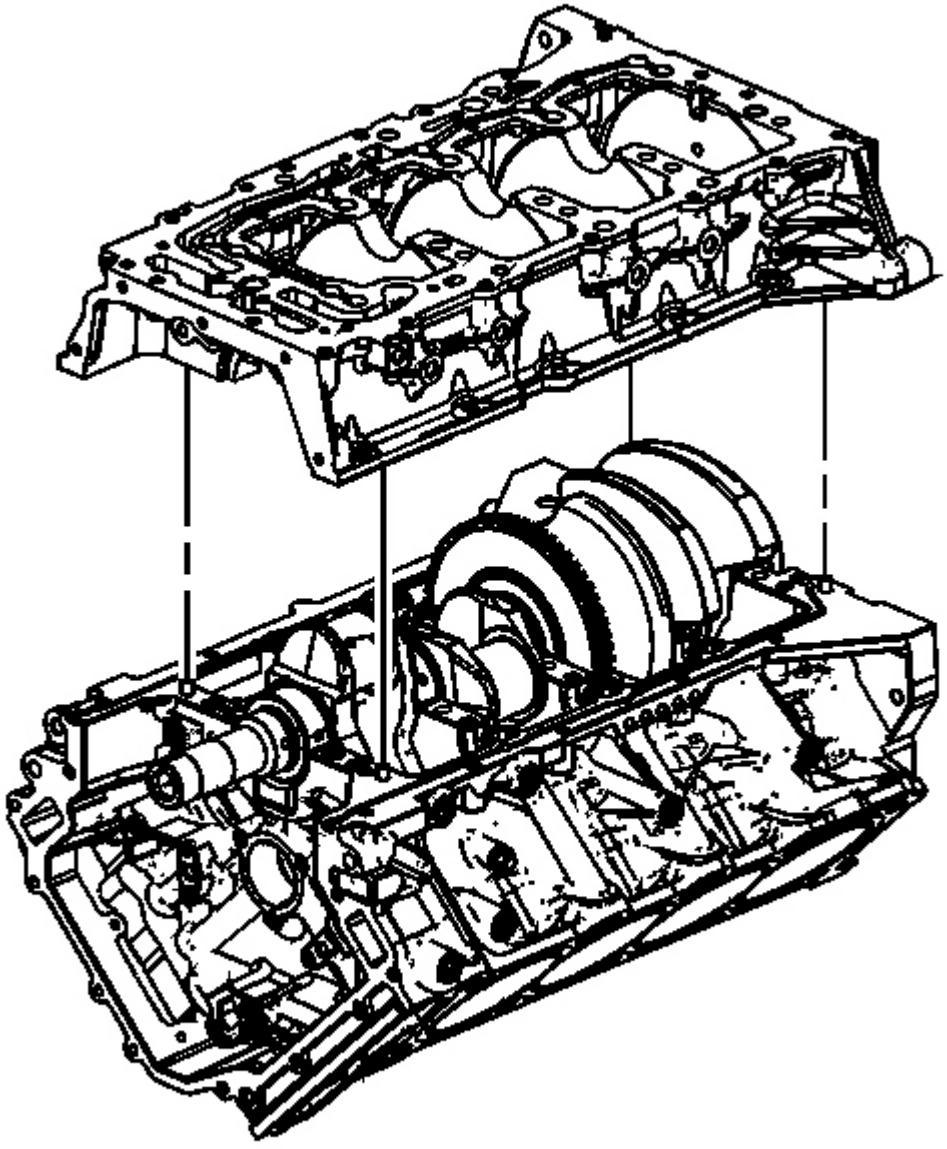


Fig. 289: View Of Lower Crankcase
Courtesy of GENERAL MOTORS CORP.

6. Align the lower crankcase with the dowel pins in the upper crankcase.
7. Install the lower crankcase onto the upper crankcase slowly until feeling a positive stop.
8. Inspect the upper-to-lower crankcase joint in order to make sure the lower crankcase is fully seated on the

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cylinder block.

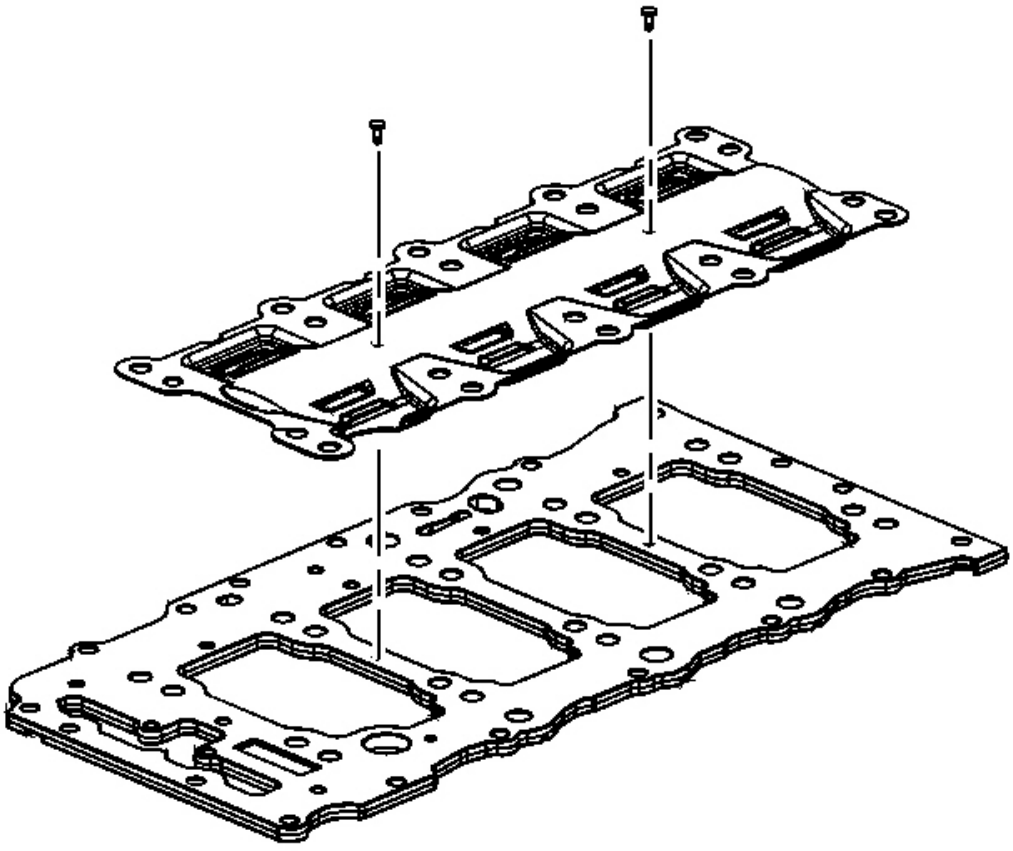


Fig. 290: View Of Oil Scraper Plate & Oil Manifold Plate
Courtesy of GENERAL MOTORS CORP.

9. In order to gain access for the **J 43690** and the **J 43690-100** remove the oil scraper plate from the old oil manifold plate, if fastened into place. See **Special Tools** .

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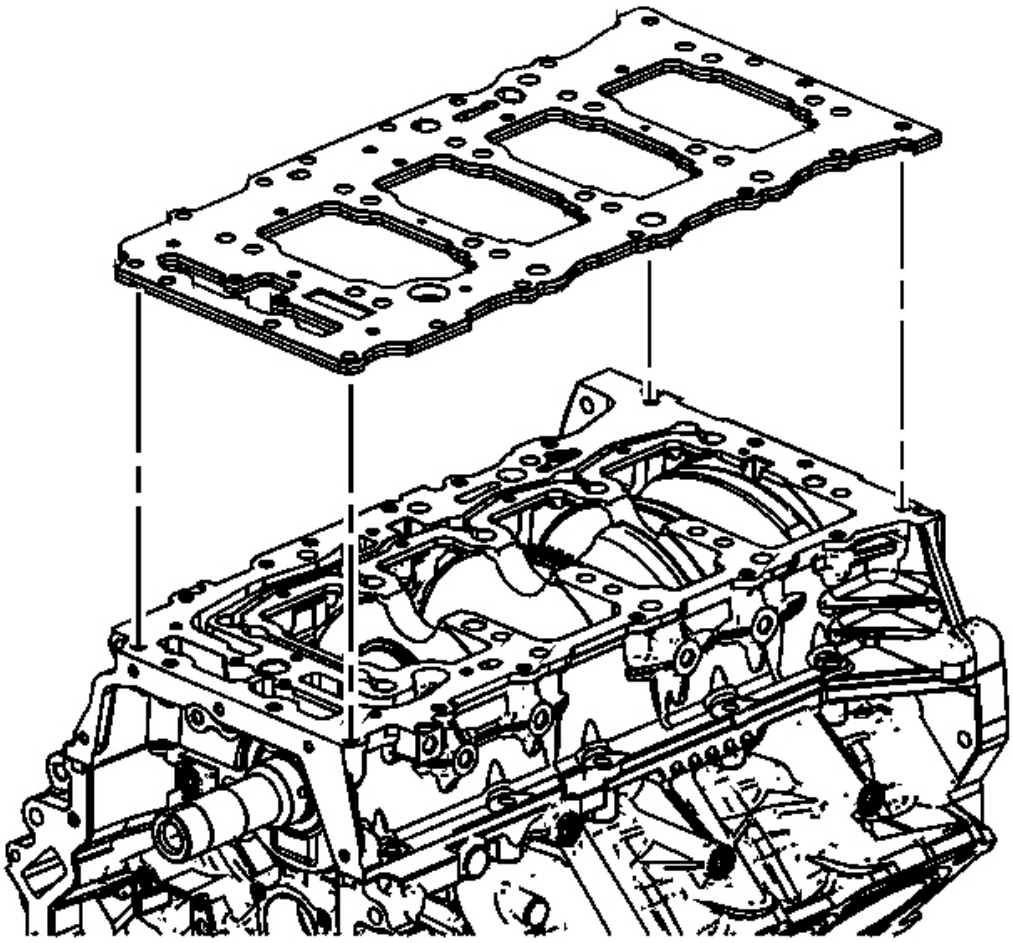


Fig. 291: View Of Oil Manifold Plate
Courtesy of GENERAL MOTORS CORP.

10. Install the oil manifold plate.

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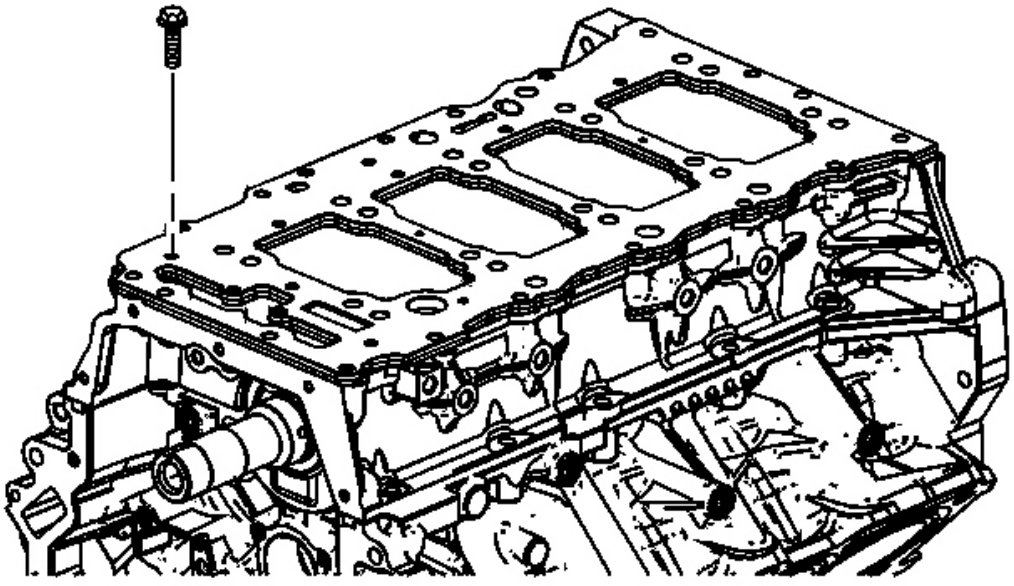


Fig. 292: View Of Oil Manifold Plate Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the oil manifold plate bolts.

    Tighten: Tighten the oil manifold plate bolts to 10 N.m (89 lb in).

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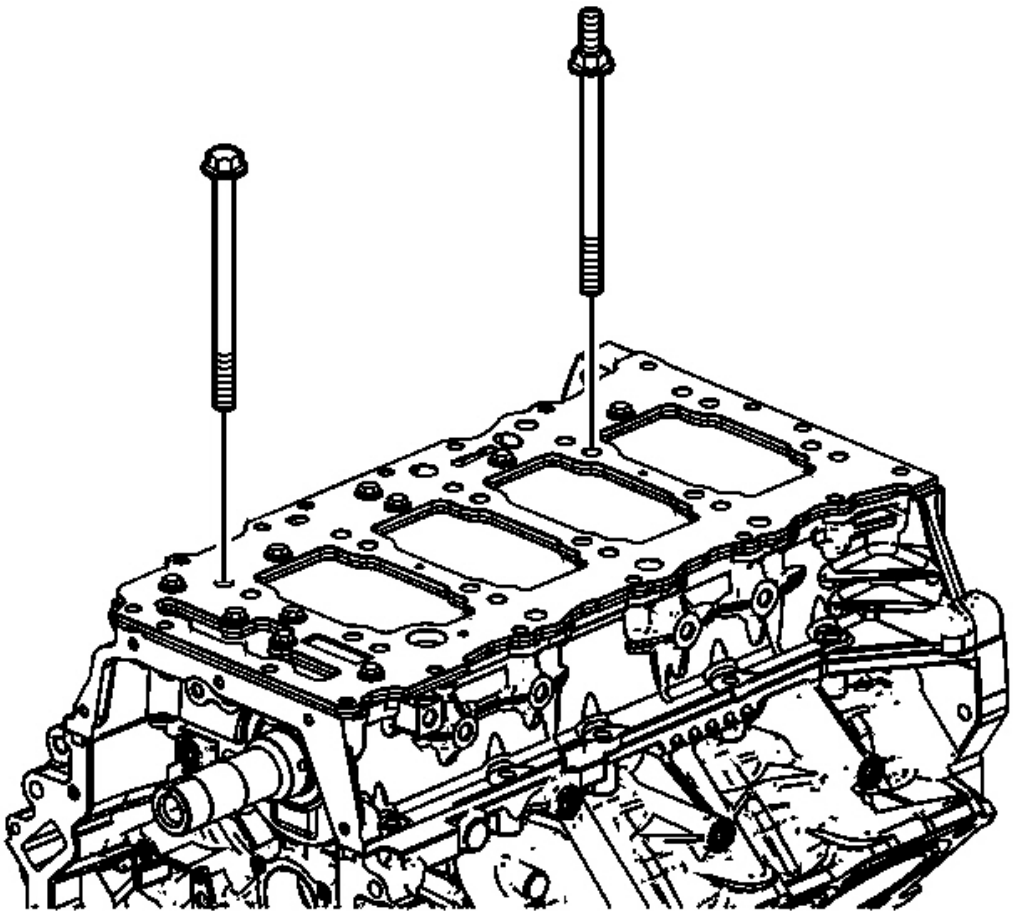


Fig. 293: View Of Lower Crankcase Main Bearing Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the lower crankcase main bearing bolts.

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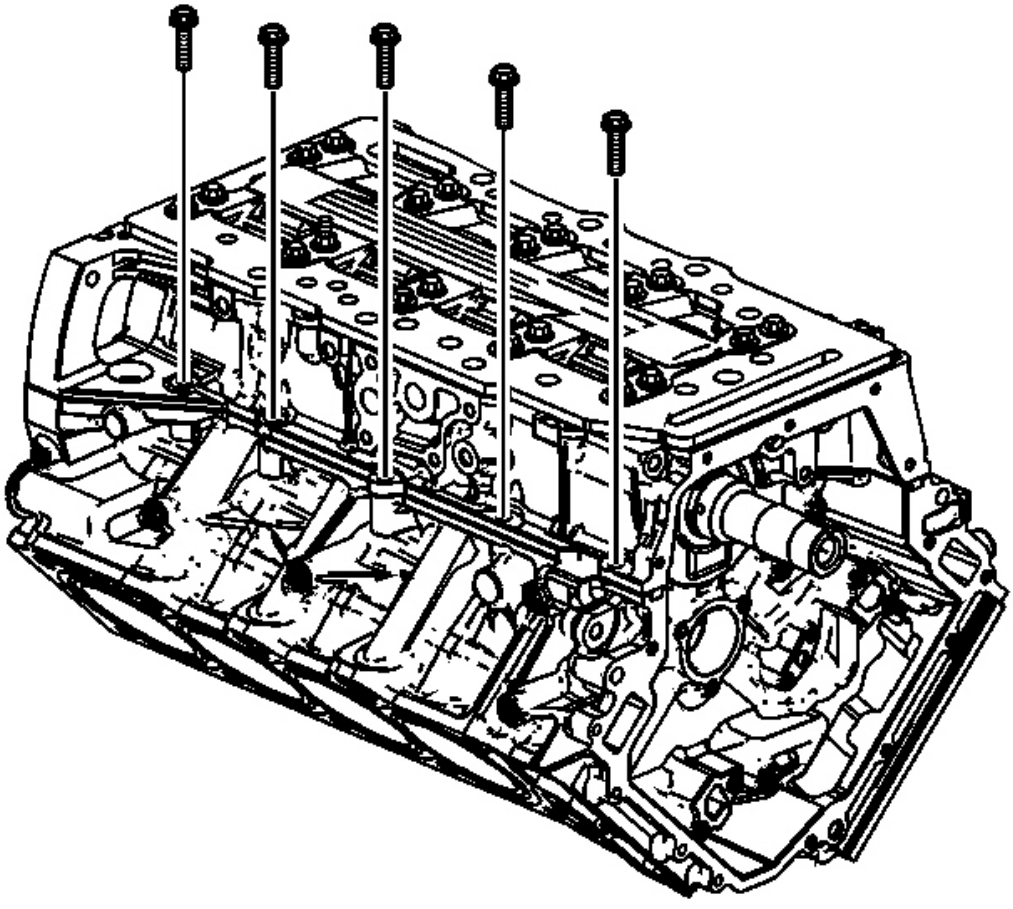


Fig. 294: View Of Lower Left Crankcase Perimeter Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

13. Install the left side upper-to-lower crankcase perimeter bolts.

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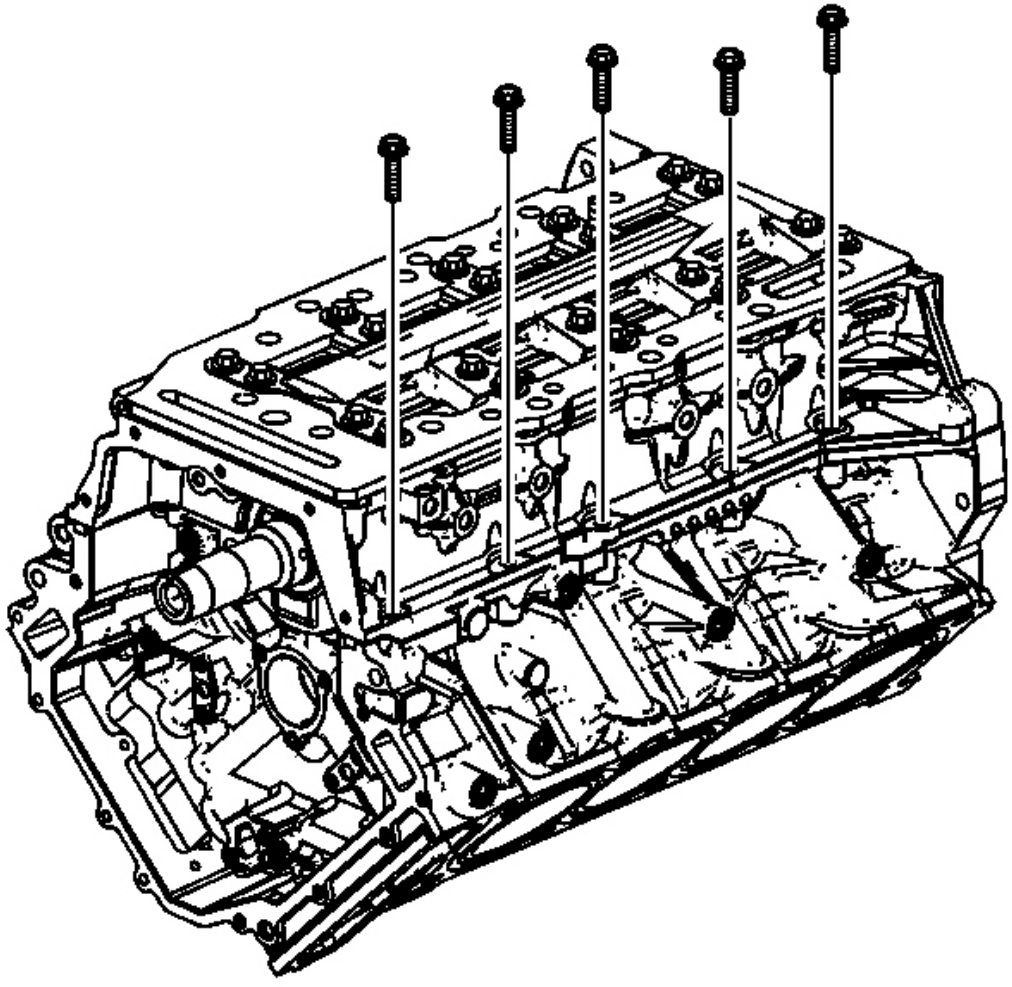


Fig. 295: View Of Right Upper-To-Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

14. Install the right side upper-to-lower crankcase perimeter bolts.

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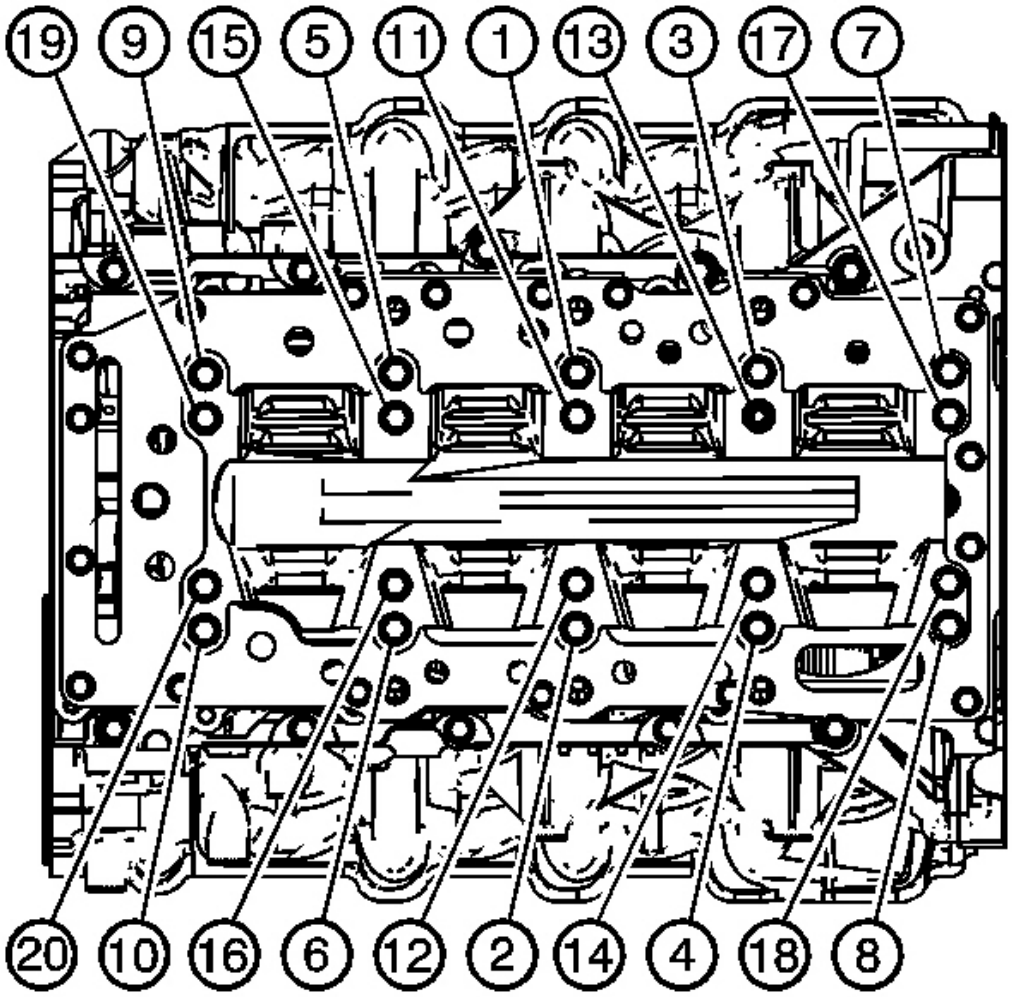


Fig. 296: Tightening Lower Crankcase Bolts
Courtesy of GENERAL MOTORS CORP.

15. Install the lower crankcase main bearing bolts.
    1. First Pass

       Tighten: Tighten the lower crankcase main bearing bolts (1-20) to 20 N.m (15 lb ft) in the proper sequence.

    2. Final Pass

       Tighten: Tighten the lower crankcase main bearing bolts (1-20) an additional 65 degrees in the

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proper sequence using the **J 45059** . See **Special Tools** .

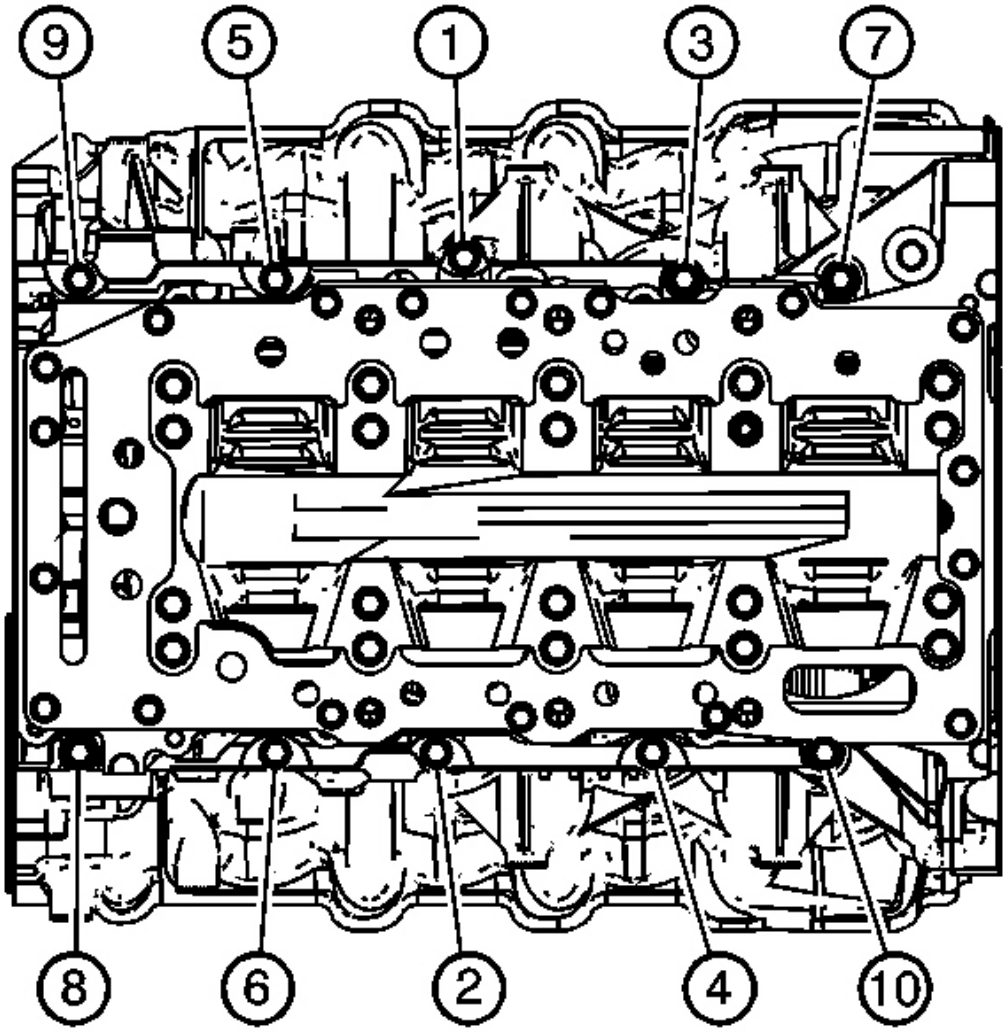


Fig. 297: Tightening Upper-To-Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

16. Tighten the upper-to-lower crankcase perimeter bolts (1-8).

    Tighten: Tighten the upper-to-lower crankcase perimeter bolts (1-8) to 30 N.m (22 lb ft) in the proper sequence.

17. Using the **J 39946** rotate the crankshaft until the crankshaft journal and the connecting rod to be

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measured is in the 12 o'clock position. See **Special Tools** .

IMPORTANT: The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.

18. Remove the crankshaft main bolts required to install the retainer plate J 43690-105.
19. Install the J 43690-105 retainer plate and crankshaft main bolts. Refer to **Lower Crankcase Installation** for tightening specifications.

IMPORTANT: Do not allow the J 43690-105 retainer plate screw to contact the reluctor ring.

20. Tighten the J 43690-105 retainer plate screw until snug in order to secure the crankshaft movement.
21. Install the foot and bolt to the J 43690-101 pivot arm assembly. Tighten the bolt until snug.
22. Install the J 43690-101 pivot arm assembly onto the connecting rod and tighten the screw securely.
23. Install the base and bolt to the oil pan rail.
24. Align the center of the base with the screw of the J 43690-101 pivot arm assembly. Tighten the bolt until snug.
25. Align the link of the J 43690-101 pivot arm assembly on a plane equal to that of the connecting rod beam.
26. Insert the pin to the base and J 43690-101 pivot arm assembly.
27. Select the adapter as required and install to the swivel base. Tighten until snug.
28. Install the swivel base to the oil pan rail.

IMPORTANT: The clamp of the swivel base and the shaft of the indicator should be free of oil or other debris. A loose or improperly clamped indicator may indicate incorrect readings.

29. Install the indicator to the swivel base. Tighten the clamp of the base until snug.

IMPORTANT: The tip of the indicator should be positioned above and NOT in contact with the end of the connecting rod.

30. Adjust the swivel base as required and position the indicator tip slightly above the connecting rod cap. Lock the swivel base in position by rotating the locking lever.
31. Rotate the fine adjustment knobs on the dial indicator end of the swivel base in order to position the tip of the indicator in contact with the connecting rod.
32. Lightly actuate the handle of the pivot arm assembly, multiple times in both directions, to ensure the oil film is removed from the connecting rod.
33. Load the handle in the forward position and zero the dial indicator. Load the handle multiple times in both directions and record the readings.
34. Refer to **Fastener Tightening Specifications** for proper clearances.
35. Remove the J 43690-105 retainer plate.

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36. Install the crankshaft main bolts. Refer to **Lower Crankcase Installation** for tightening specifications.
37. Reposition the tools and repeat steps 2-21 for all other connecting rods.
38. If clearances do not meet specifications, replace components as required.
39. Remove the lower crankcase when the procedure is complete.

CONNECTING ROD FINAL ASSEMBLY PROCEDURE

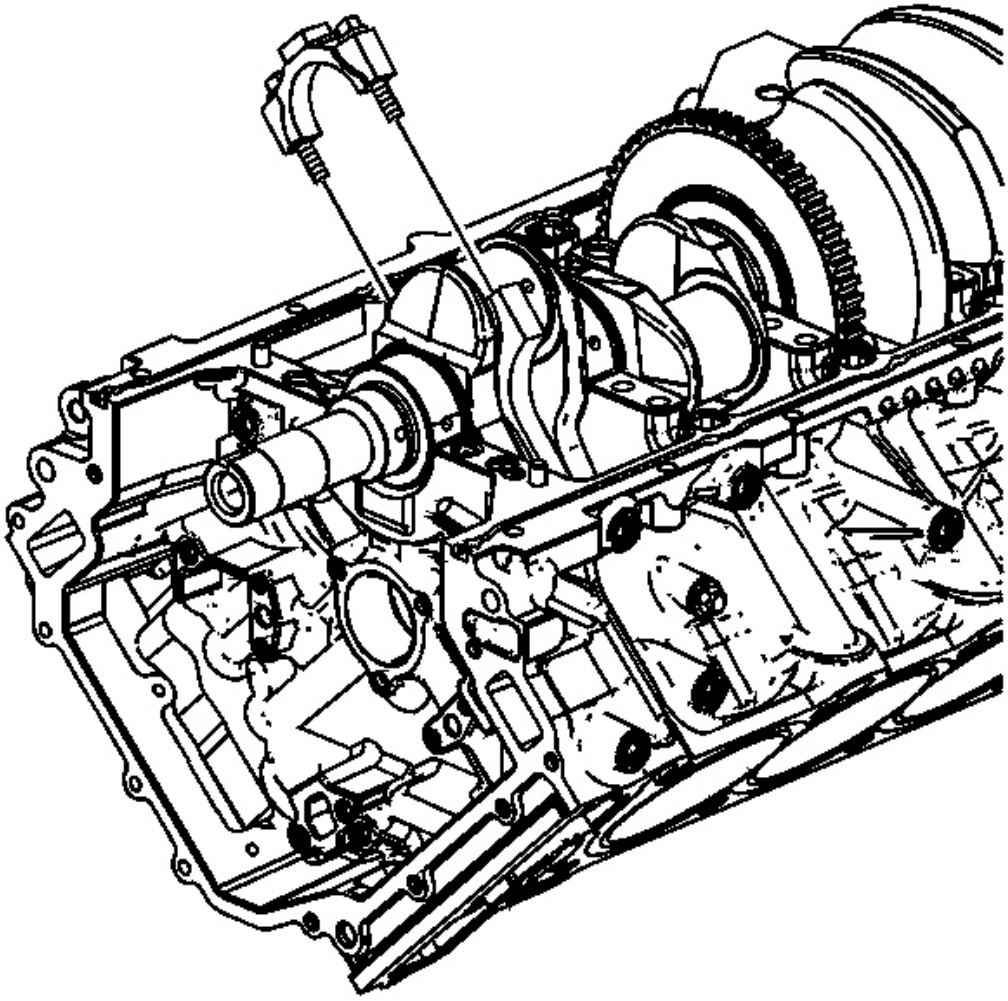


Fig. 298: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

1. Remove the connecting rod bolts.

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2. Remove the connecting rod cap.

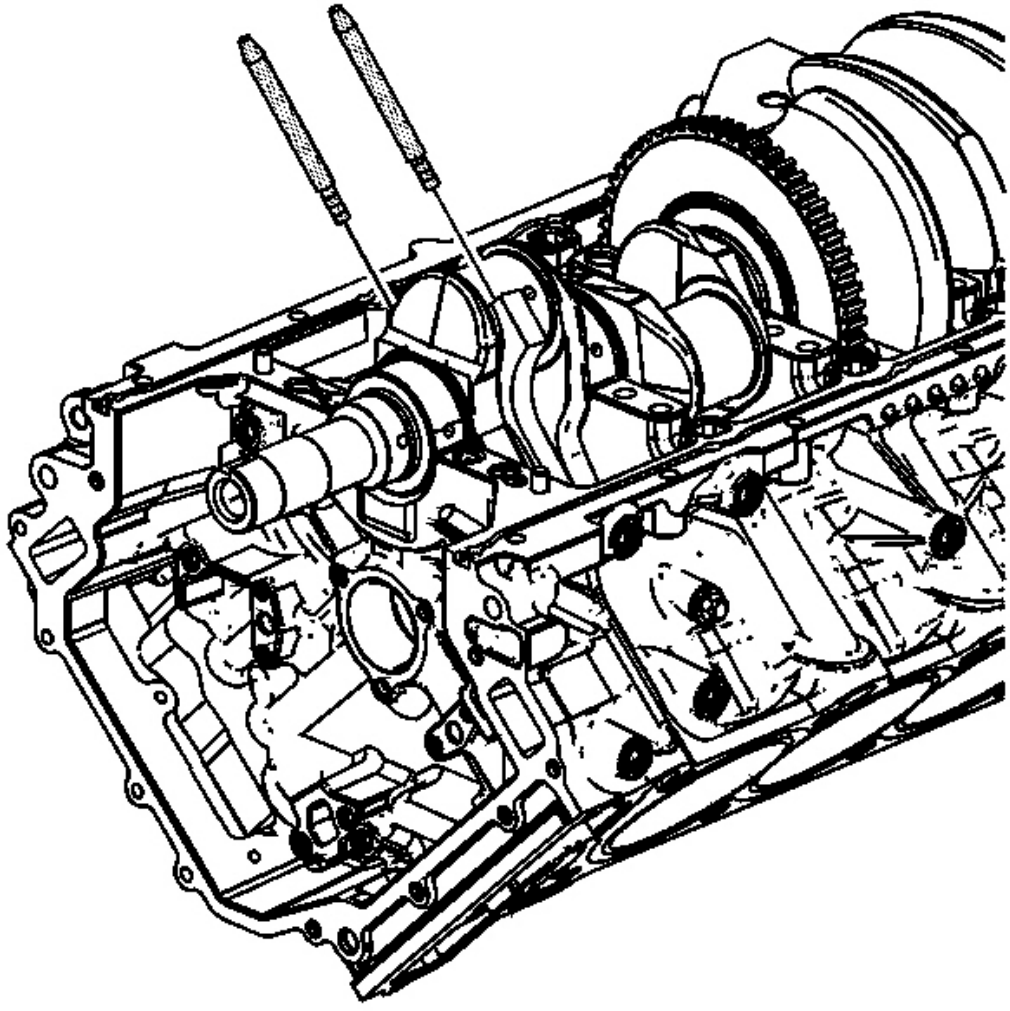


Fig. 299: Installing EN 46121
Courtesy of GENERAL MOTORS CORP.

3. Install the **EN 46121** into the connecting rod bolt holes. See **Special Tools** .
4. Back the connecting rod away from the crankshaft in order to allow for lubricant application.
5. Coat the crankshaft connecting rod bearing journal and installed connecting rod bearings with GM crankshaft prelube GM P/N 1052367, (Canadian P/N 992869) or equivalent.
6. Guide the connecting rod onto the crankshaft connecting rod bearing journal.

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7. Remove the **EN 46121** from the connecting rod bolt holes. See **Special Tools** .

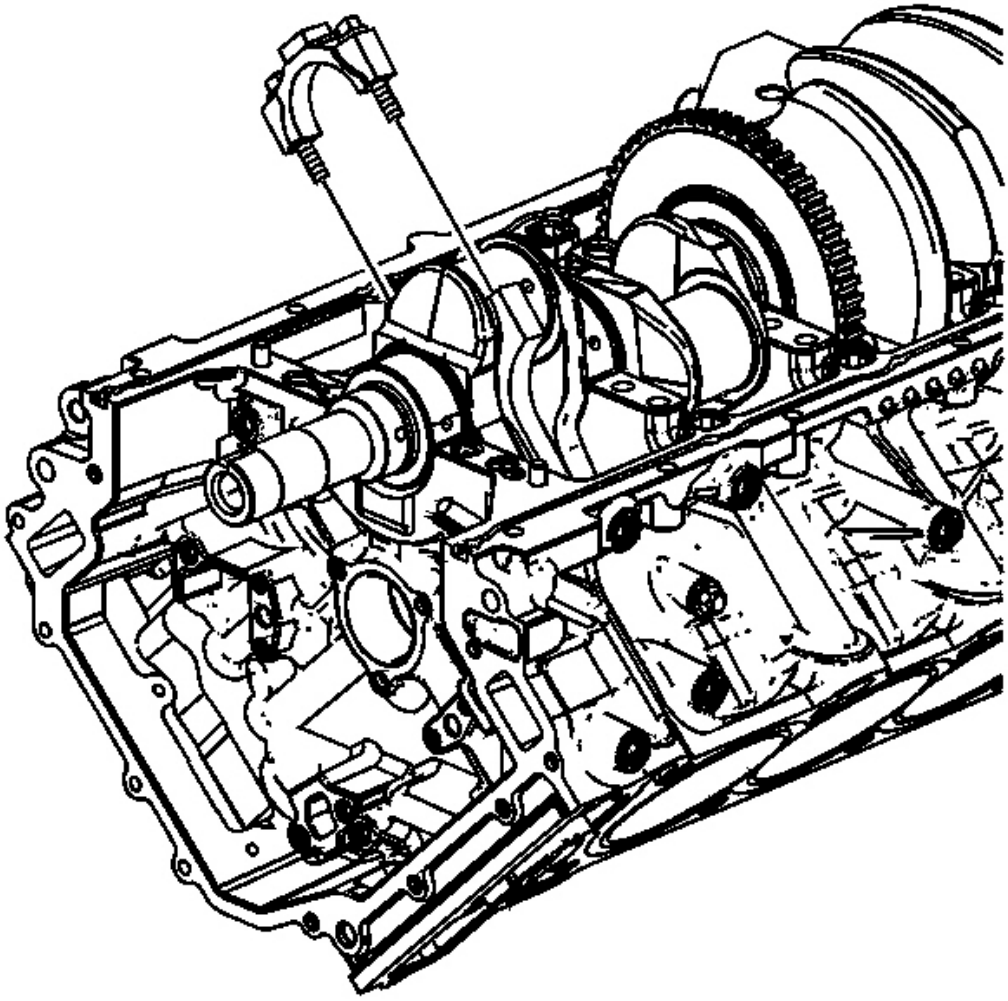


Fig. 300: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

8. Install the connecting rod end cap on its original connecting rod making sure the bearing lock tangs are aligned on the same side of the rod.

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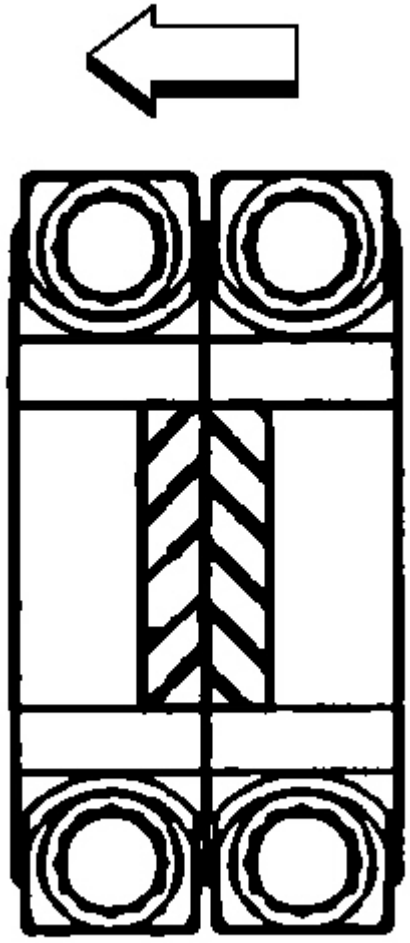


Fig. 301: View Of Paired Connecting Rod Bearing Cap Notches
Courtesy of GENERAL MOTORS CORP.

9. When properly installed, the connecting rod bearing cap notches should be paired, as shown, on the crankpin.

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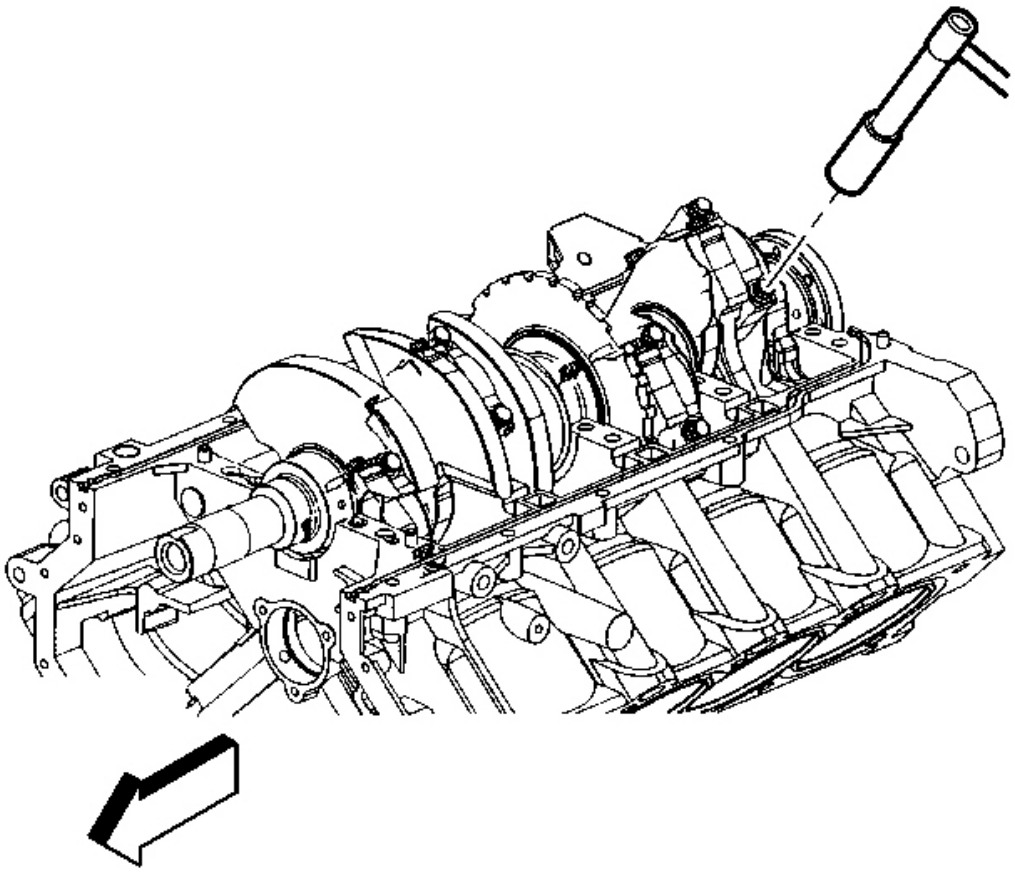


Fig. 302: Loosening Connecting Rod Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: DO NOT reuse the old connecting rod bolts.

10. Lubricate the NEW connecting rod bolts with engine oil and install in the connecting rod.

    Tighten: Tighten the NEW connecting rod bolts to 30 N.m (22 lb ft).

11. Loosen the connecting rod bolts until the torque reading is zero.
12. Re-tighten the connecting rod bolts.
    1. First Pass

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Tighten: Tighten the connecting rod bolts to 25 N.m (18 lb ft).

2. Final Pass

   Tighten: Tighten the connecting rod bolts an additional 110 degrees using the **J 45059** . See **Special Tools** .

13. During and after installation, ensure each piston is positioned properly in the correct cylinder.
14. Repeat these procedures for the piston/connecting rod assembly that is using the common crankshaft connecting rod journal.
15. Measure the connecting rod side clearance between the 2 connecting rods that share the common crankshaft connecting rod journal.
16. Compare the measurements with the engine mechanical specifications. Refer to **Engine Mechanical Specifications** .
17. If the connecting rods do not provide the proper crankshaft side clearance inspect for the following conditions:
    - If the clearance is too tight, ensure the connecting rods are not binding and can slide parallel to the crankpin. Re-measure the connecting rod widths for the correct specified size. If the connecting rods are incorrectly sized, replace the connecting rods.
    - If the clearance is too loose, re-measure the connecting rod widths for the correct specified size. If the connecting rods are incorrectly sized, replace the connecting rods.
18. Repeat these procedures for the remaining piston/connecting rod assemblies using the **J 39946** in order to rotate the crankshaft. See **Special Tools** .

LOWER CRANKCASE INSTALLATION

TOOLS REQUIRED

- **EN 46109** Guide Pins. See **Special Tools** .
- **J 39946** Crankshaft Socket - 4.0L and 4.6L
- **J 45059** Angle Meter. See **Special Tools** .

INSTALLATION PROCEDURE

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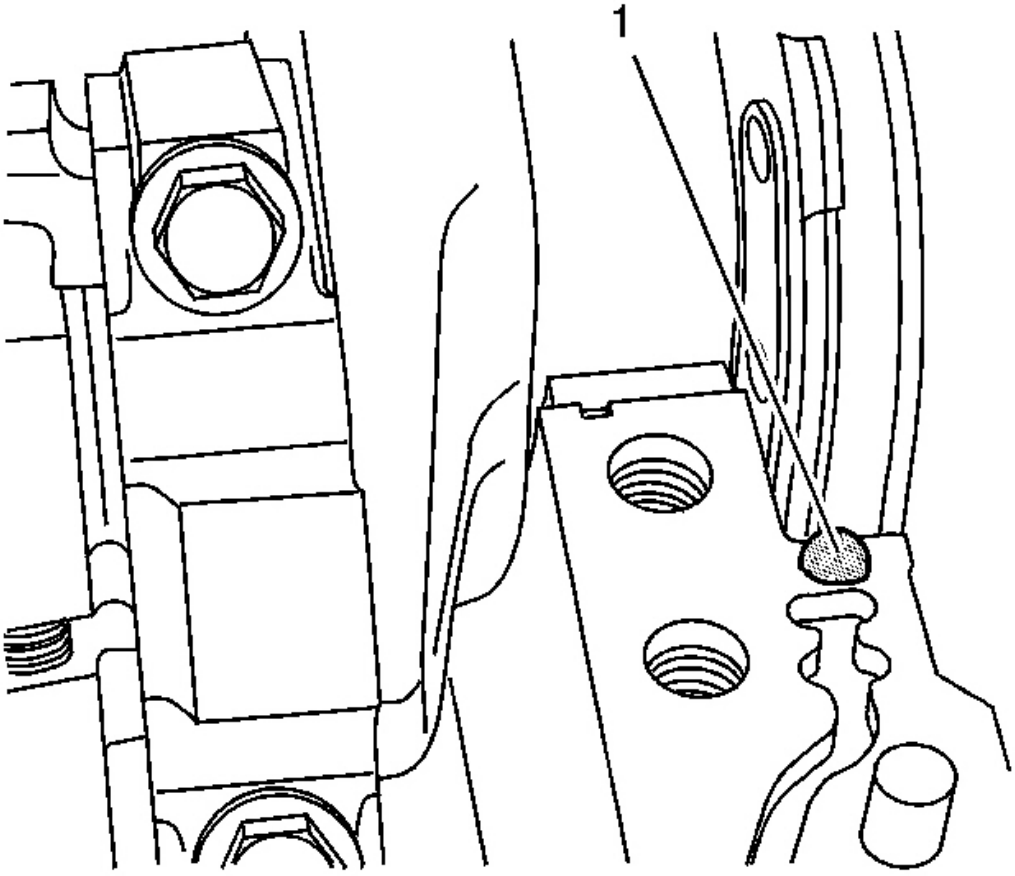


Fig. 303: Identifying RTV Sealant Application Points
Courtesy of GENERAL MOTORS CORP.

1. Place a 5 mm (0.197 in) spot of RTV sealant GM P/N 12378521 or equivalent (1) at the two points where the crankshaft rear oil seal meets the split line of the engine block.

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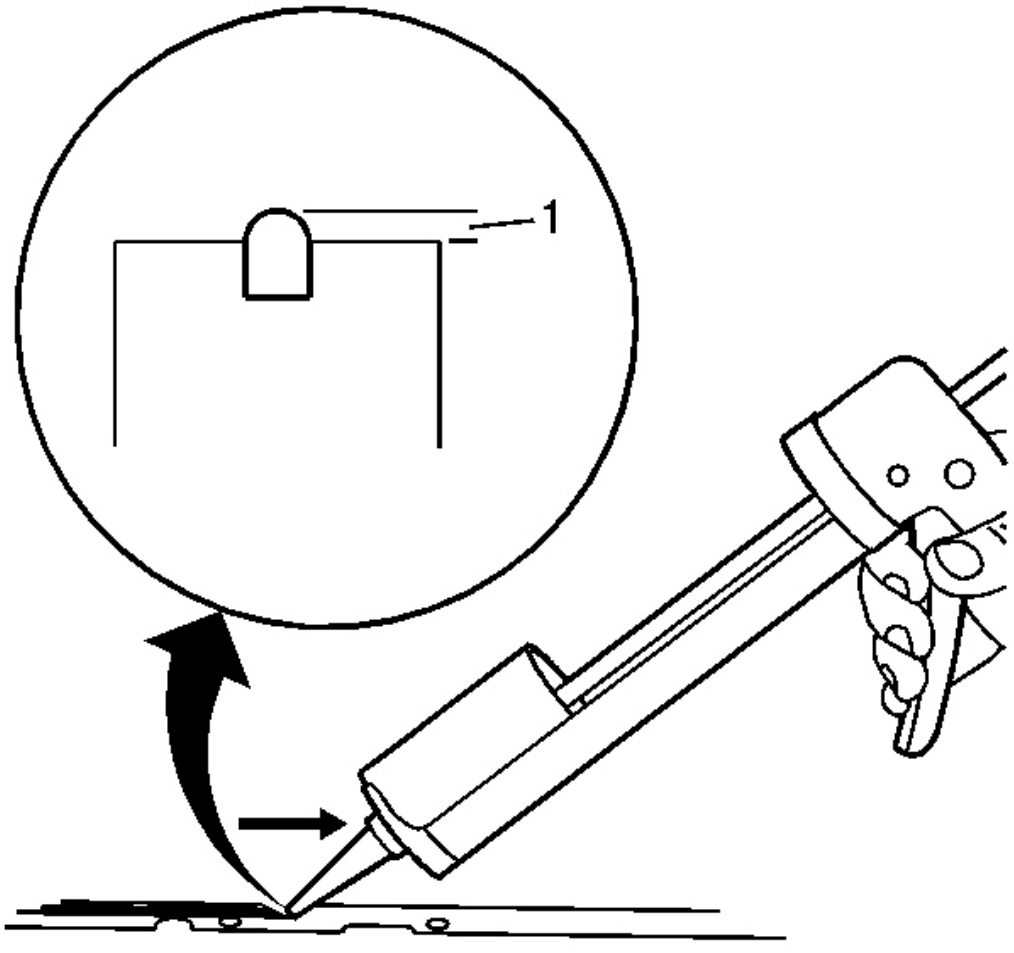


Fig. 304: Applying RTV Sealant
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure components being sealed with RTV are assembled within 20 minutes. Components assembled after the RTV has skinned-over, approximately 20 minutes, will not seal properly.

2. Completely fill and slightly overfill the engine block seal groove with a continuous bead of RTV sealant GM P/N 12378521 or equivalent.
3. Ensure the RTV sealant GM P/N 12378521 or equivalent bead is higher then the rail surface (1) by 1.0-1.5 mm (0.0394-0.0591 in).

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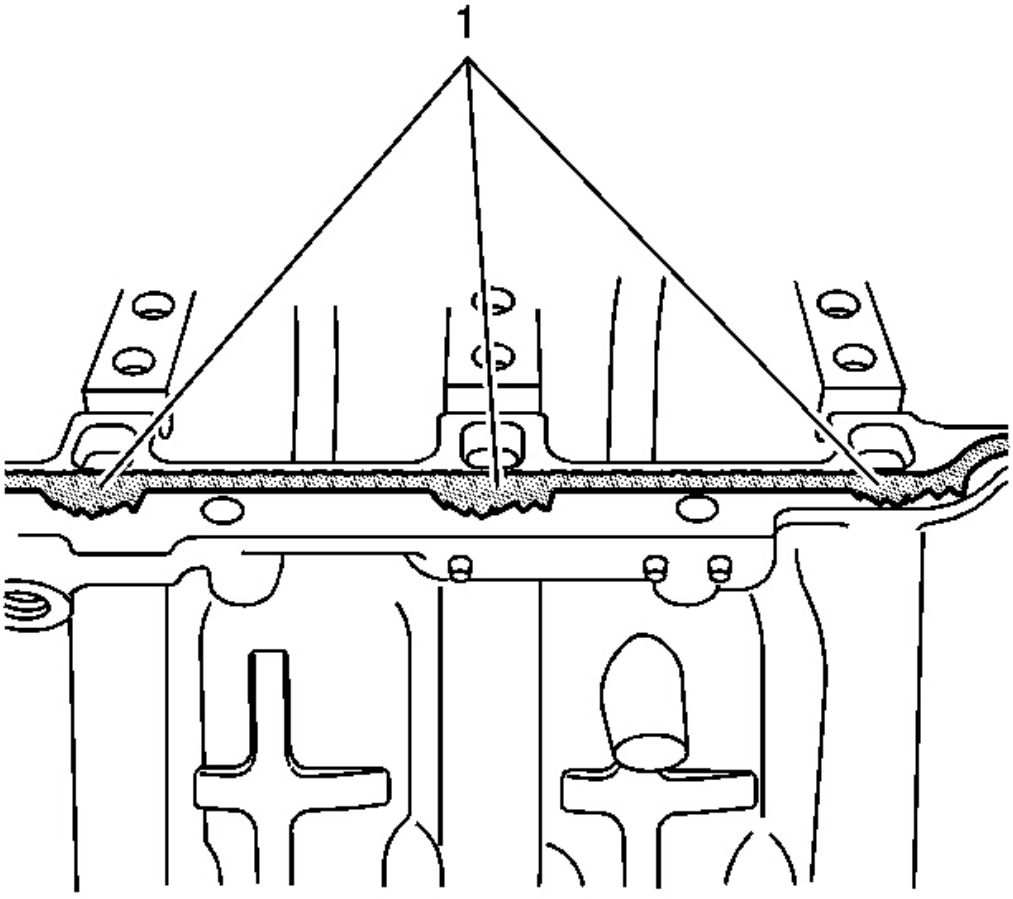


Fig. 305: Spreading RTV Sealant Near Oil Drain Back Passages
Courtesy of GENERAL MOTORS CORP.

4. Using a suitable tool spread the sealant in the area near the oil drain back passages (1) away from the oil drain back passages toward the outboard edge of the rail surface.

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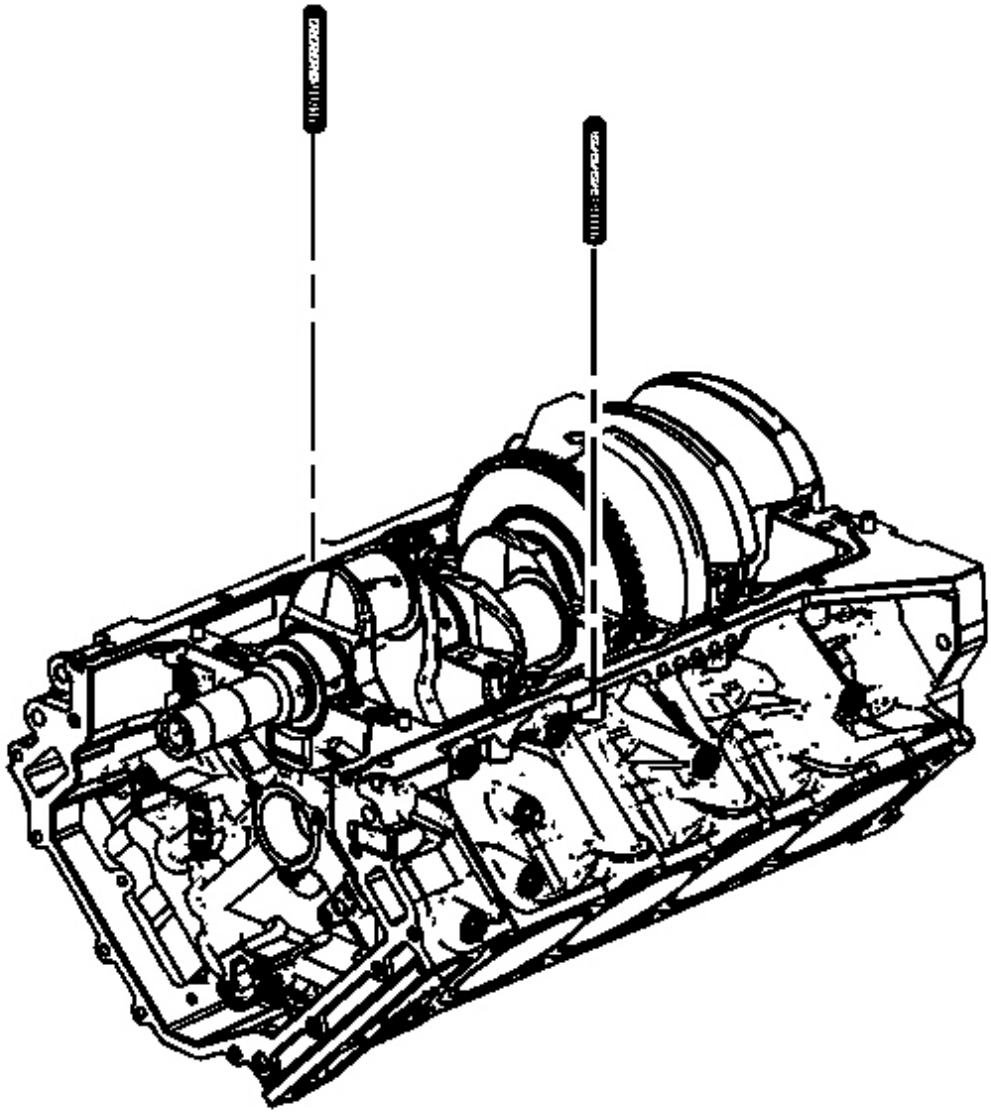


Fig. 306: View Of Guide Pins
Courtesy of GENERAL MOTORS CORP.

5. To prevent shifting of the lower crankcase install one of the **EN 46109** into a bolt hole in each rail. See **Special Tools** .

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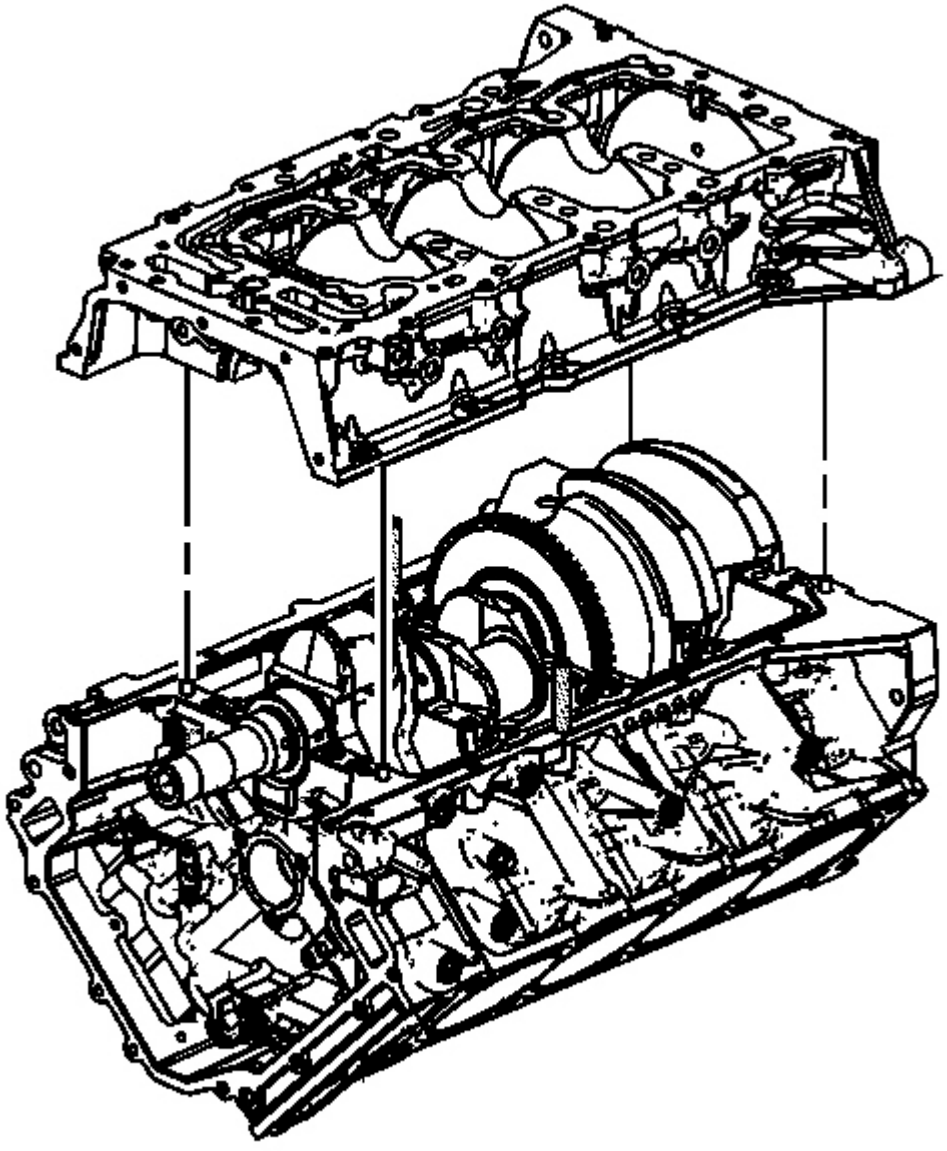


Fig. 307: View Of Lower Crankcase
Courtesy of GENERAL MOTORS CORP.

6. Install the cleaned lower crankcase onto the engine.

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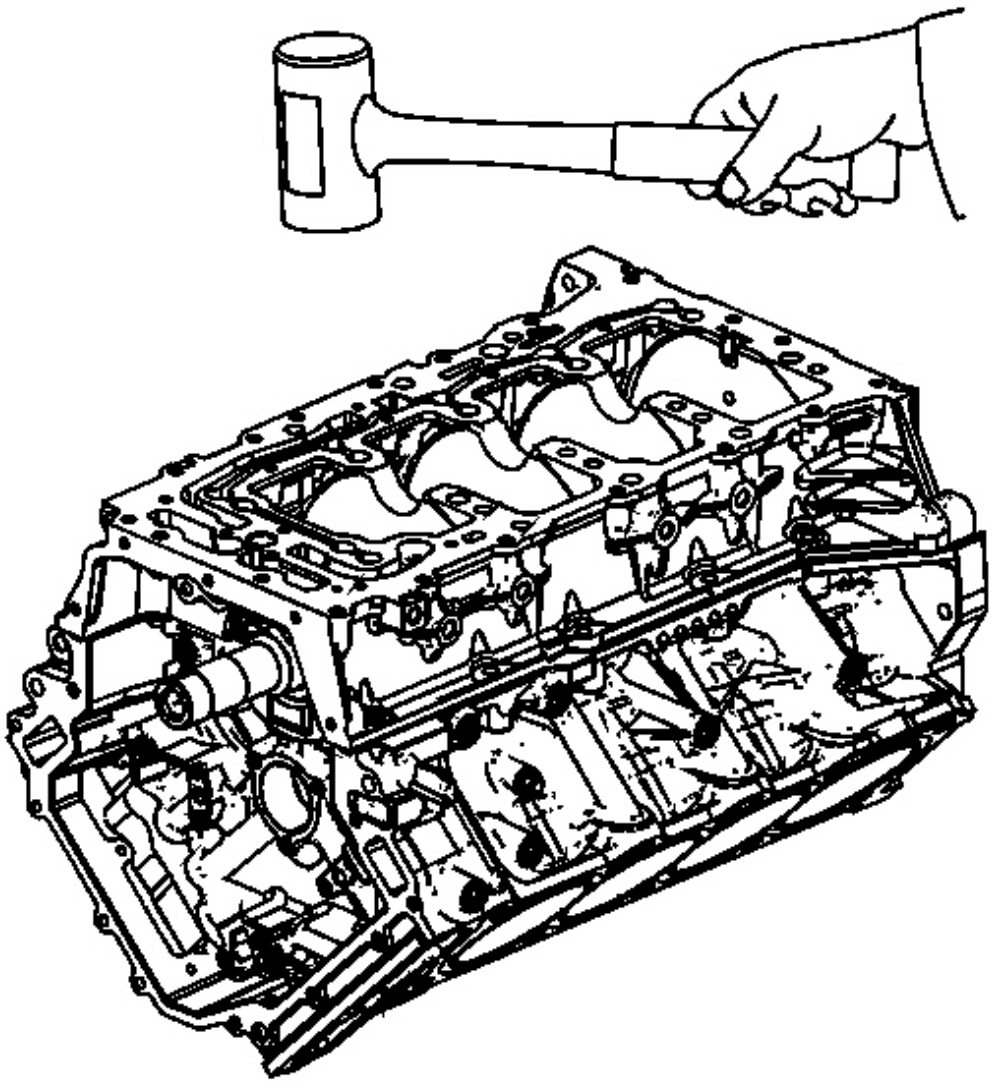


Fig. 308: Tapping Lower Crankcase Into Position
Courtesy of GENERAL MOTORS CORP.

7. Using a rubber mallet gently tap the lower crankcase into position.
8. Remove both of the **EN 46109** . See **Special Tools** .

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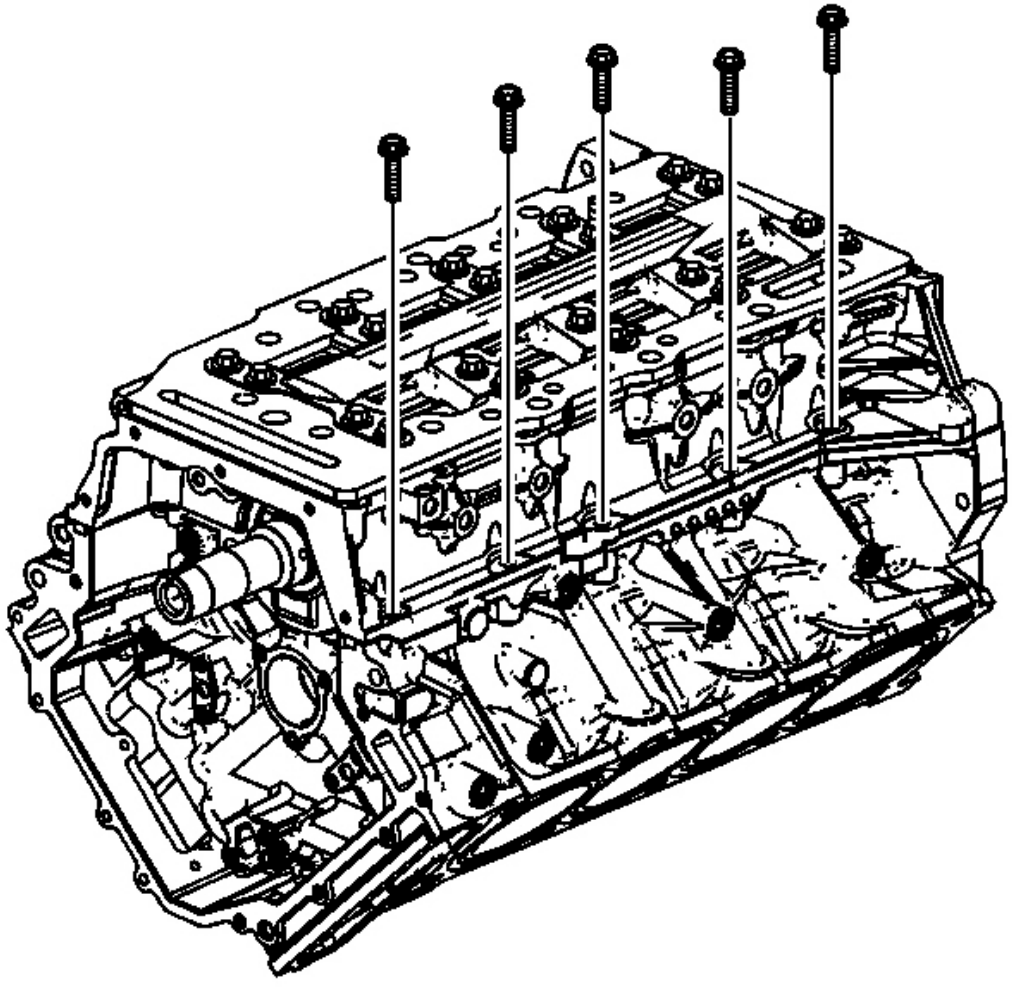


Fig. 309: View Of Right Upper-To-Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

9. Loosely install the crankcase perimeter bolts on the right side.

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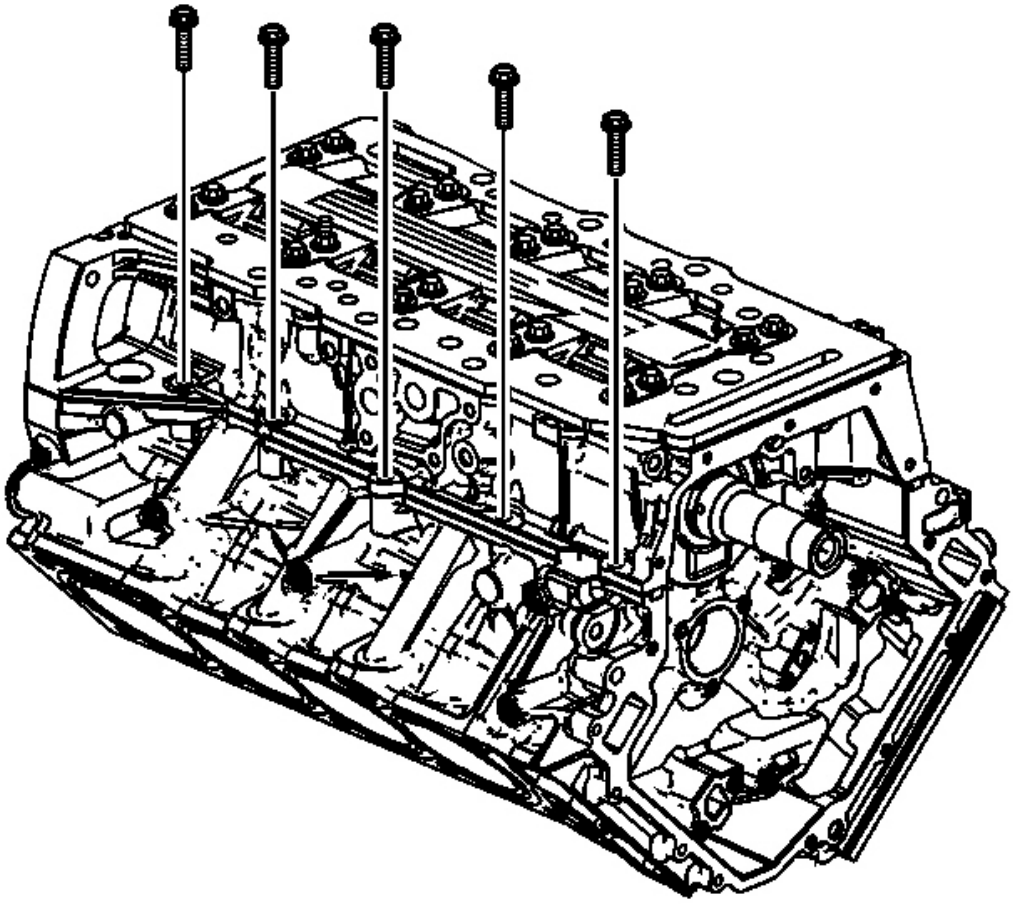


Fig. 310: View Of Lower Left Crankcase Perimeter Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

10. Loosely install the crankcase perimeter bolts on the left side.

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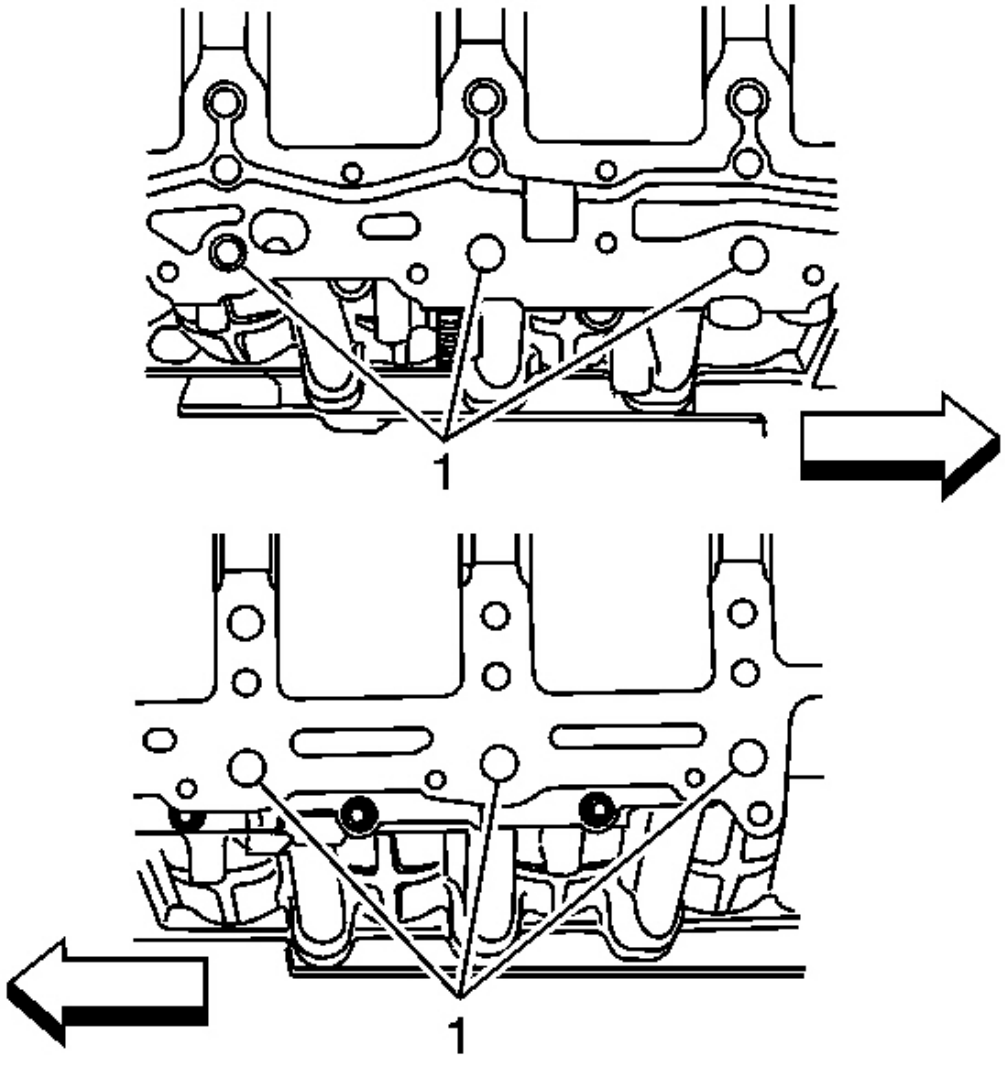


Fig. 311: Locating Oil Drain Back Passages
Courtesy of GENERAL MOTORS CORP.

11. Using a small long blade screwdriver clean out any sealant in the oil drain back passages (1).

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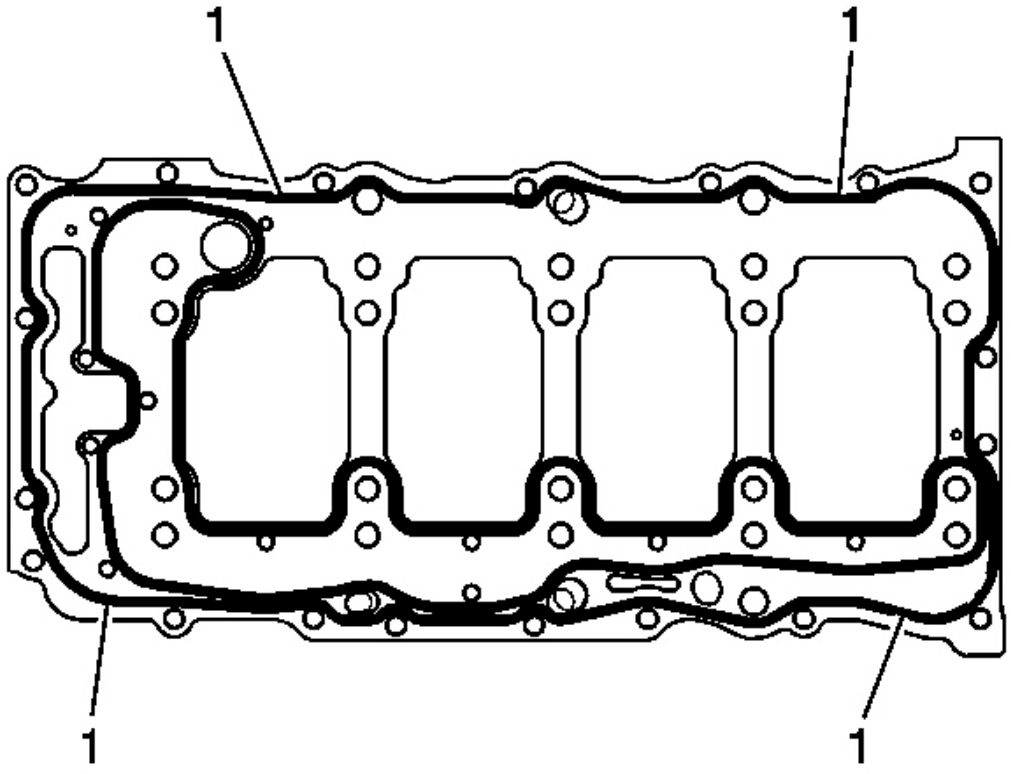


Fig. 312: View Of Proper Sealant Application Locations
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure components being sealed with RTV are assembled within 20 minutes. Components assembled after the RTV has skinned-over, approximately 20 minutes, will not seal properly.

IMPORTANT: DO NOT apply sealant to the inner seal of the oil distribution plate.

12. Using a NEW oil distribution plate, remove the outer seal (1) if installed and completely fill and slightly overfill the outer seal groove (1) with a continuous bead of RTV sealant GM P/N 12378521 (Canada P/N 88901148) or equivalent. Ensure the RTV sealant bead is higher than the plate surface by 1.0-1.5 mm (0.0394-0.0591 in).

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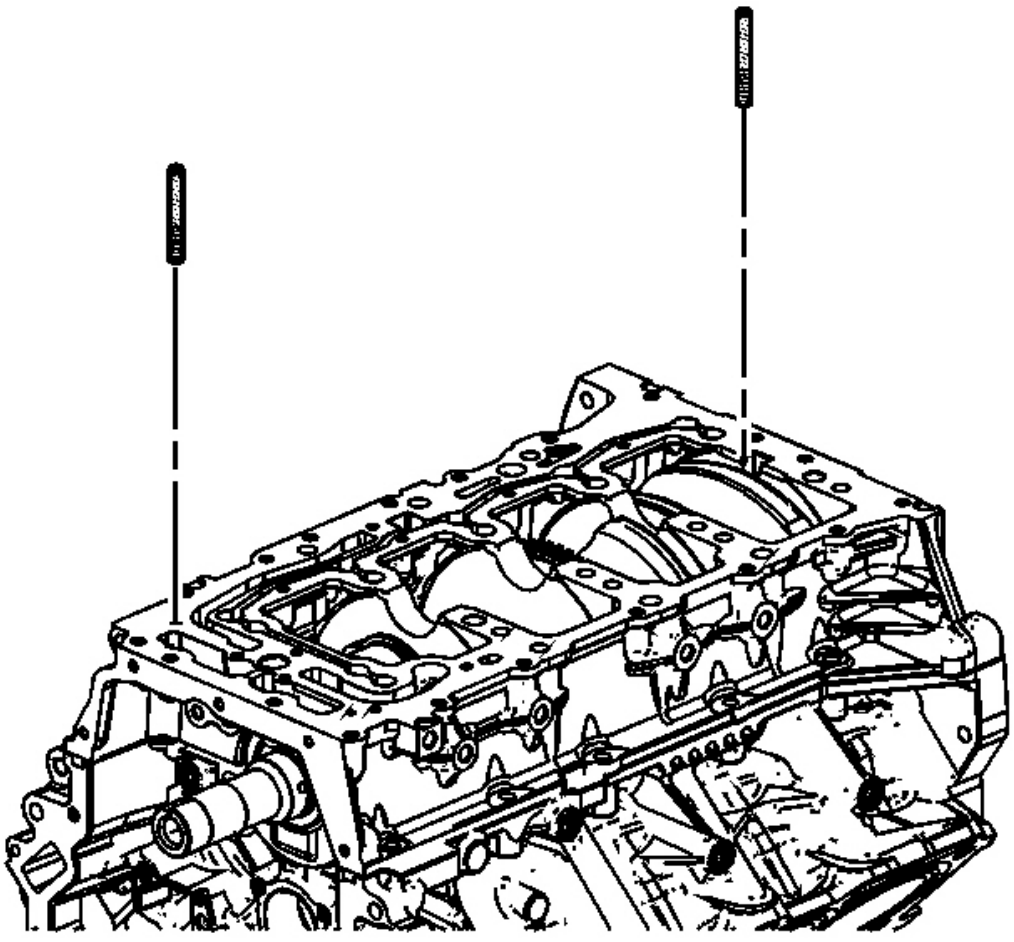


Fig. 313: View Of Guide Pins
Courtesy of GENERAL MOTORS CORP.

13. To prevent shifting of the oil distribution plate install one of the **EN 46109** into a bolt hole in each side of the lower crankcase. See **Special Tools** .

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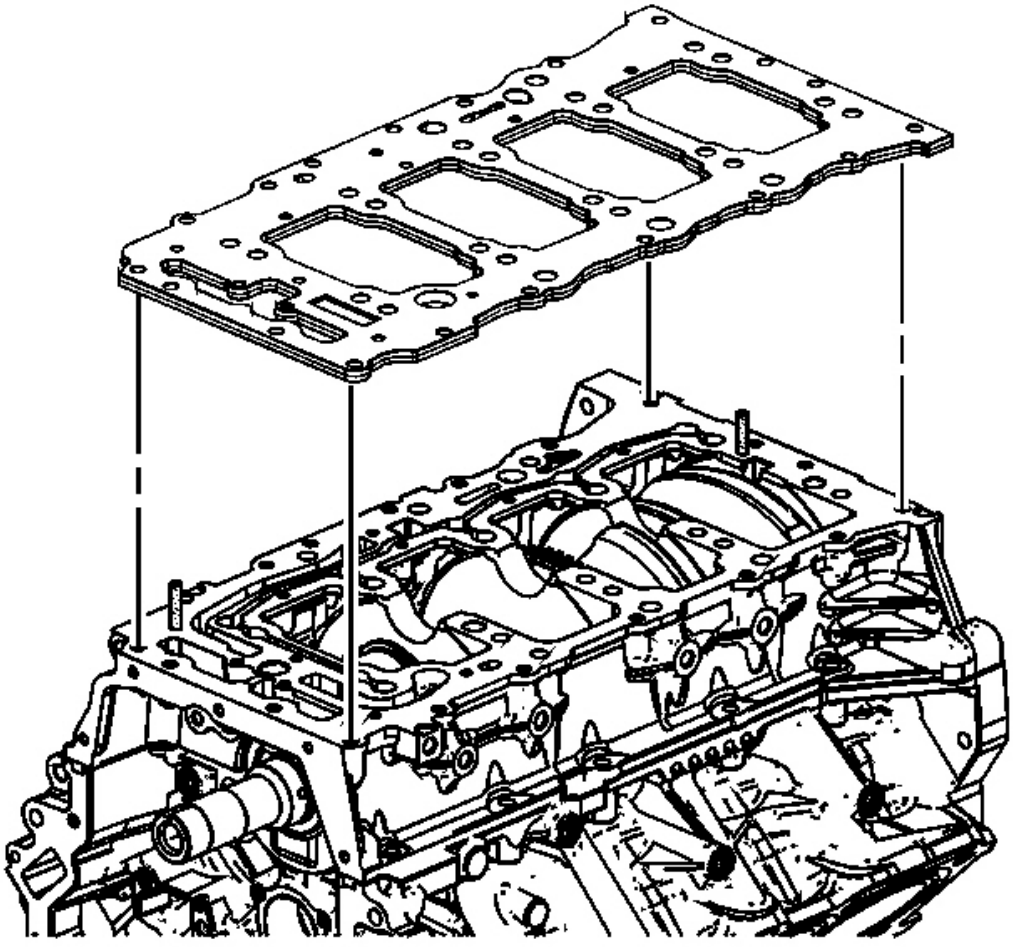


Fig. 314: View Of Oil Distribution Plate
Courtesy of GENERAL MOTORS CORP.

14. Install the NEW oil distribution plate.
15. Remove both of the **EN 46109** . See **Special Tools** .

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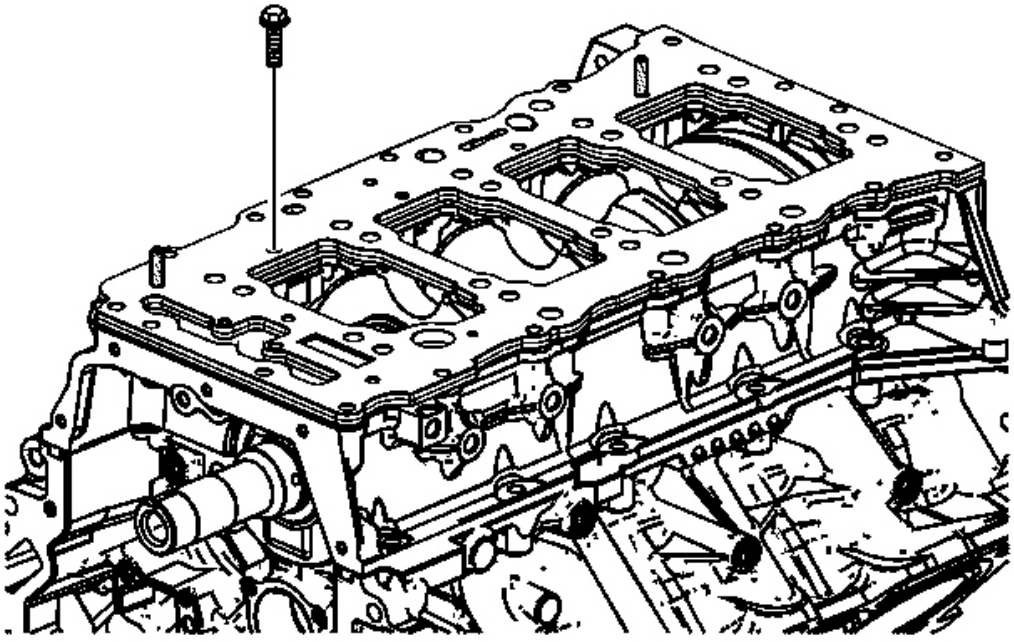


Fig. 315: View Of Oil Distribution Plate Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice.

16. Install the oil distribution plate bolts.

    Tighten: Tighten the oil distribution plate bolts to 10 N.m (89 lb in).

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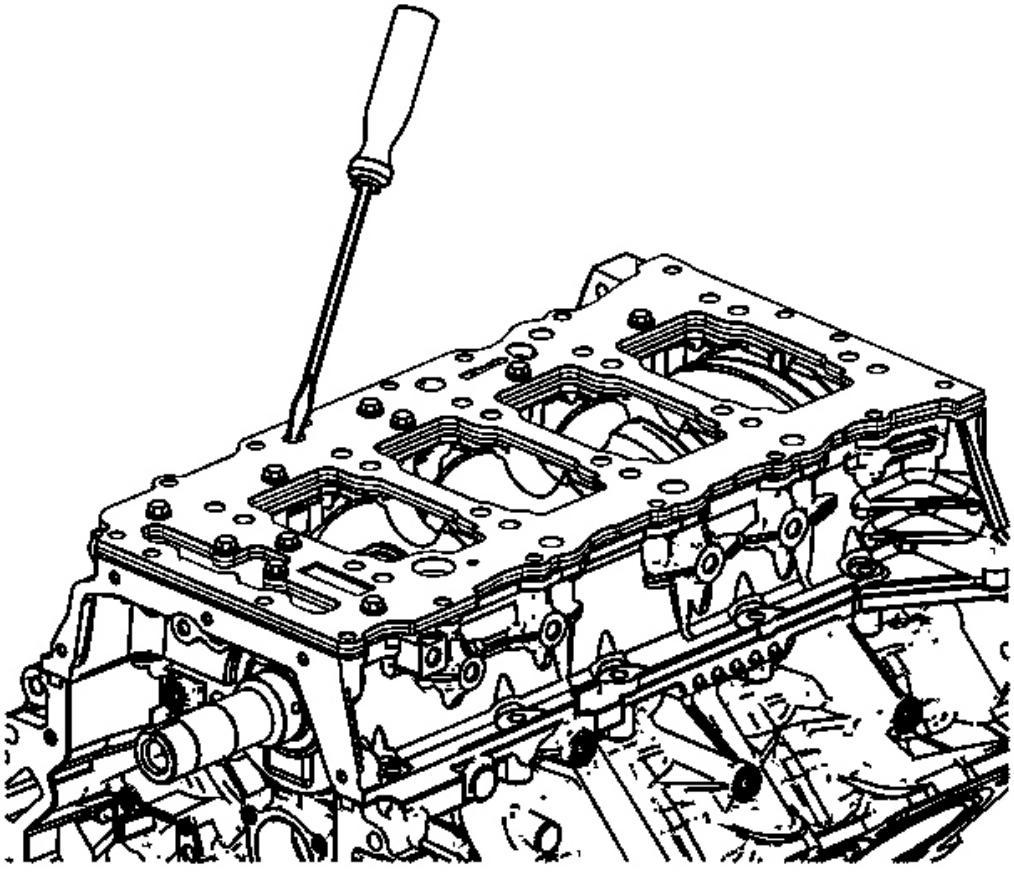


Fig. 316: Cleaning Sealant In Oil Drain Back Passages
Courtesy of GENERAL MOTORS CORP.

17. Using a small long blade screwdriver clean out any sealant in the oil drain back passages.

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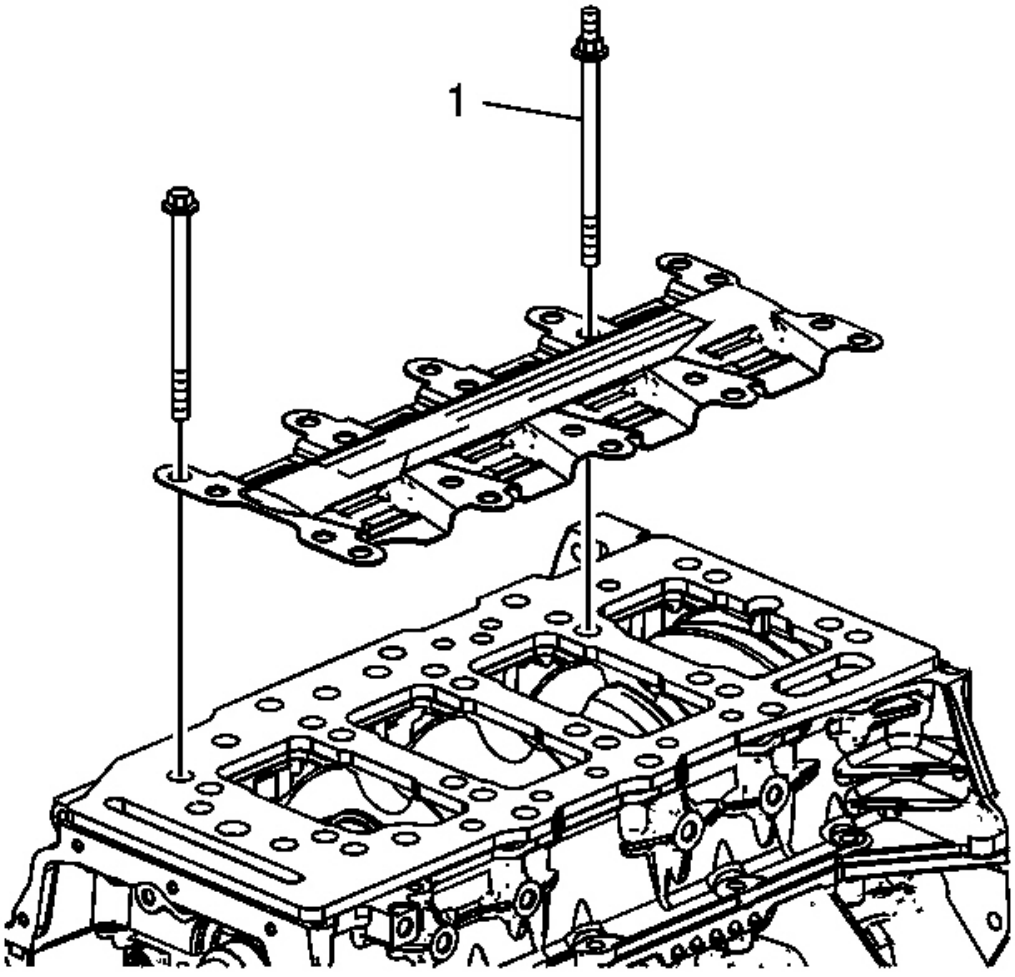


Fig. 317: View Of Oil Pump Pick-Up Mounting Single Stud-Head Bolt
Courtesy of GENERAL MOTORS CORP.

18. Install the crankshaft oil scraper plate.
19. Install the main bearing bolts. Ensure the stud-head bolt (1) used for the oil suction tube support bracket is placed in the proper position.

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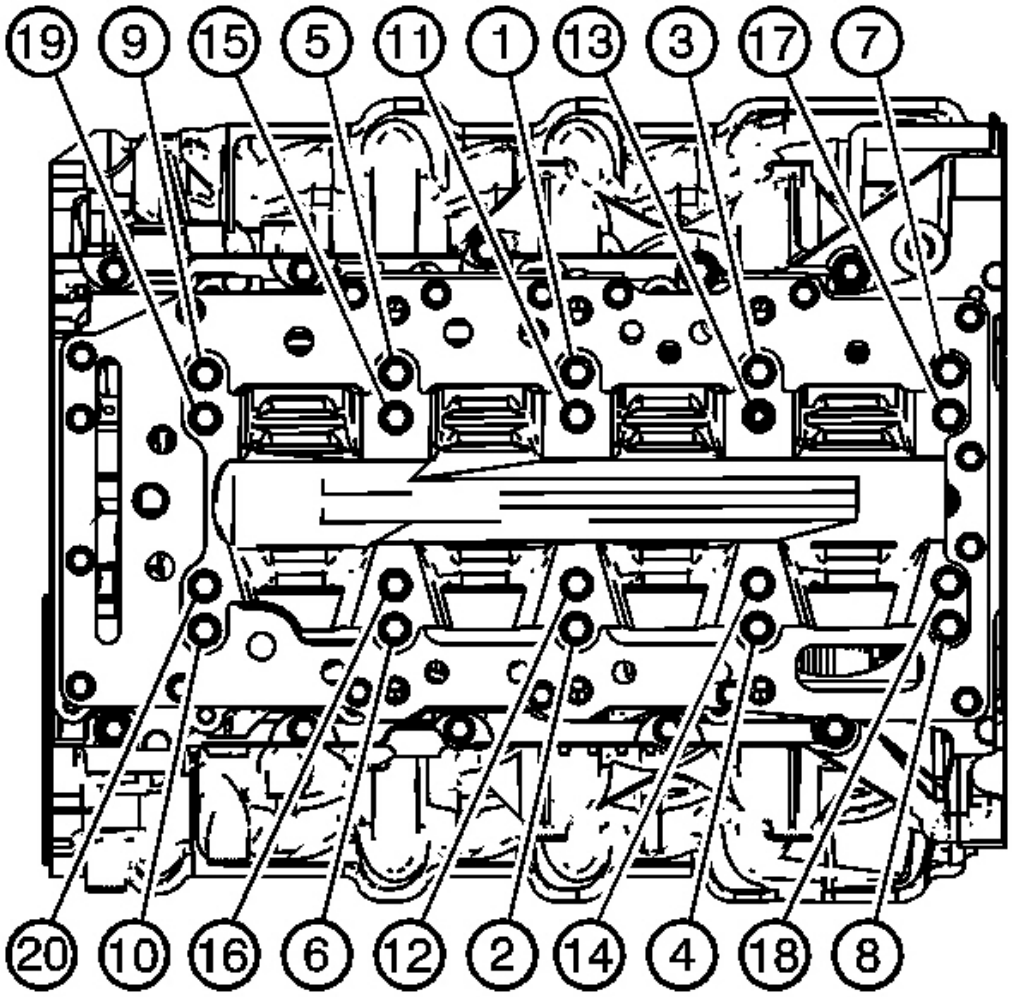


Fig. 318: Tightening Lower Crankcase Bolts
Courtesy of GENERAL MOTORS CORP.

20. Tighten the main bearing bolts in the proper sequence.
    1. First Pass

       Tighten: Tighten the main bearing bolts (1-20) to 20 N.m (15 lb ft) in the proper sequence.

    2. Final Pass

       Tighten: Tighten the main bearing bolts (1-20) an additional 65 degrees in the proper sequence using the **J 45059** . See **Special Tools** .

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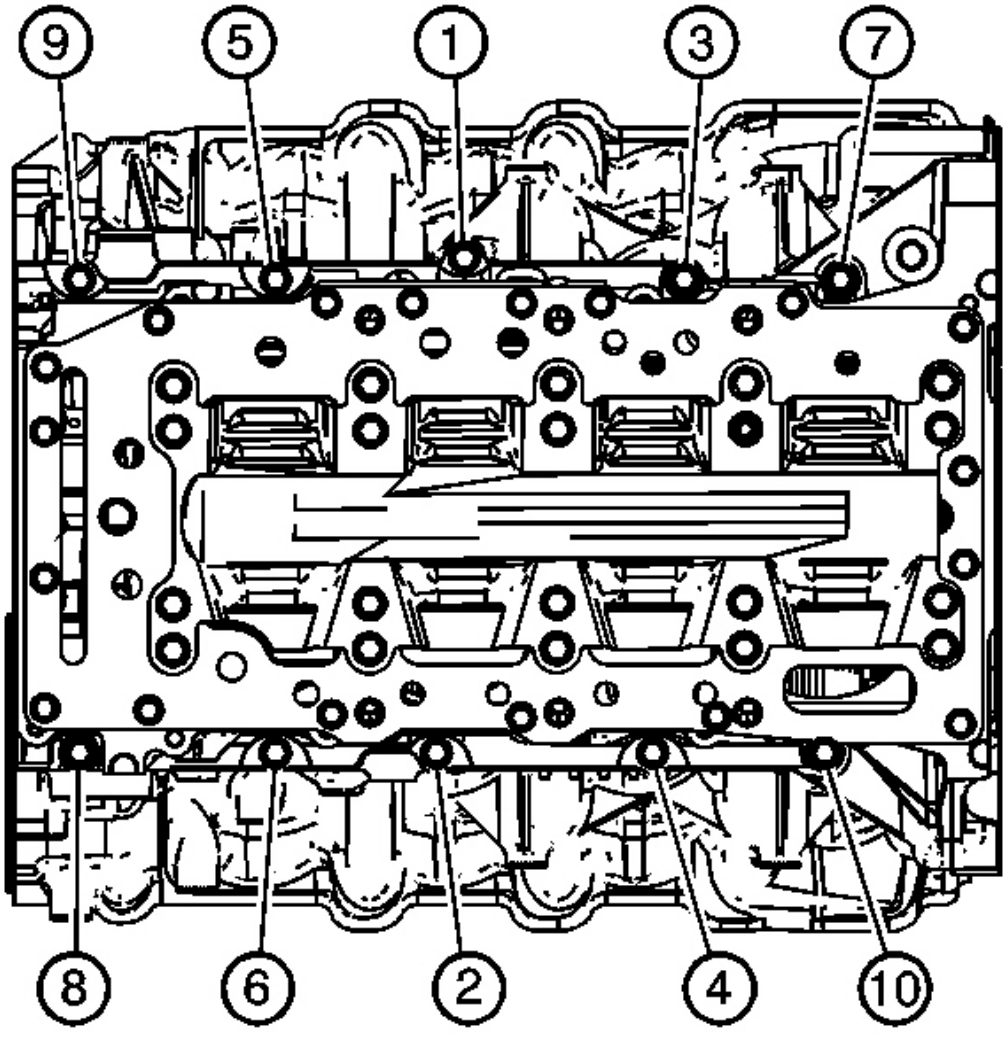


Fig. 319: Tightening Upper-To-Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

21. Tighten the crankcase perimeter bolts in sequence shown.

    Tighten: Tighten the crankcase perimeter bolts to 30 N.m (22 lb ft).

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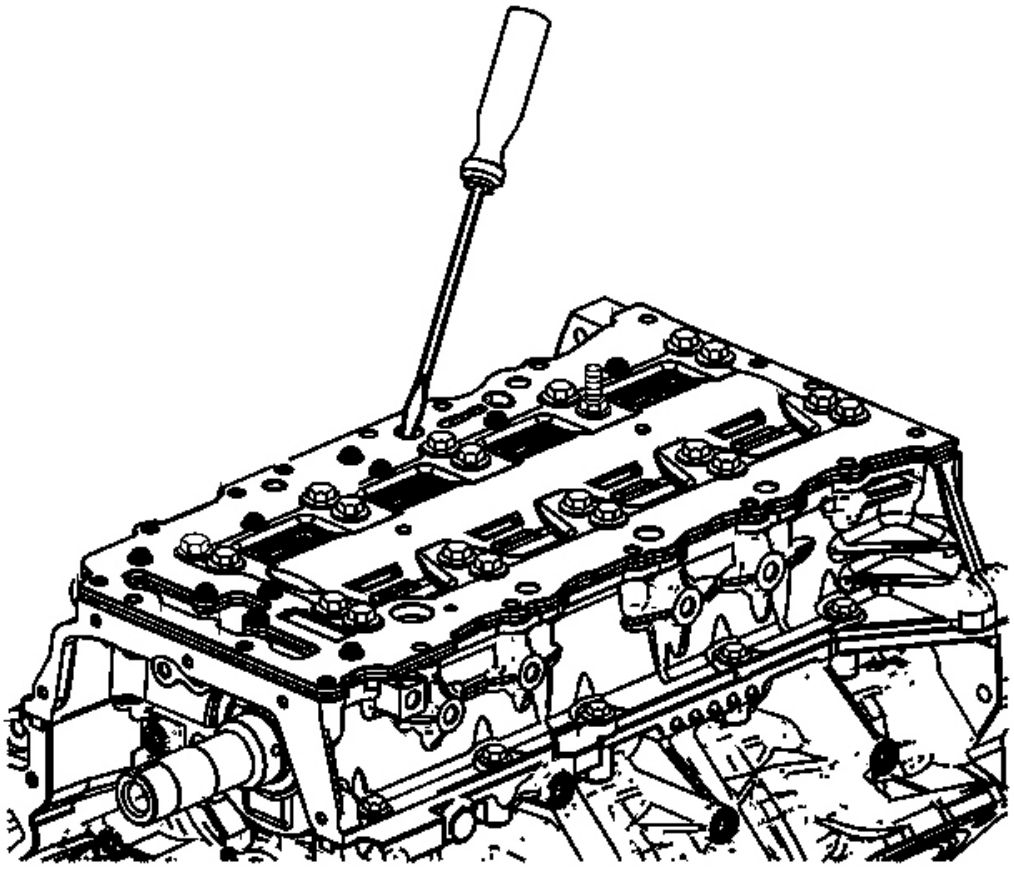


Fig. 320: Clearing Sealant From Oil Drain Back Passages
Courtesy of GENERAL MOTORS CORP.

22. Using a small long blade screwdriver verify that the threaded holes for the oil pan bolts and the oil drain back passages are clear of sealant.
23. Using the **J 39946** rotate the crankshaft until the number one piston is at top dead center (TDC) and the crankshaft key way is approximately at the 7 o'clock position. See **Special Tools** .

OIL PUMP PIPE AND SCREEN ASSEMBLY INSTALLATION

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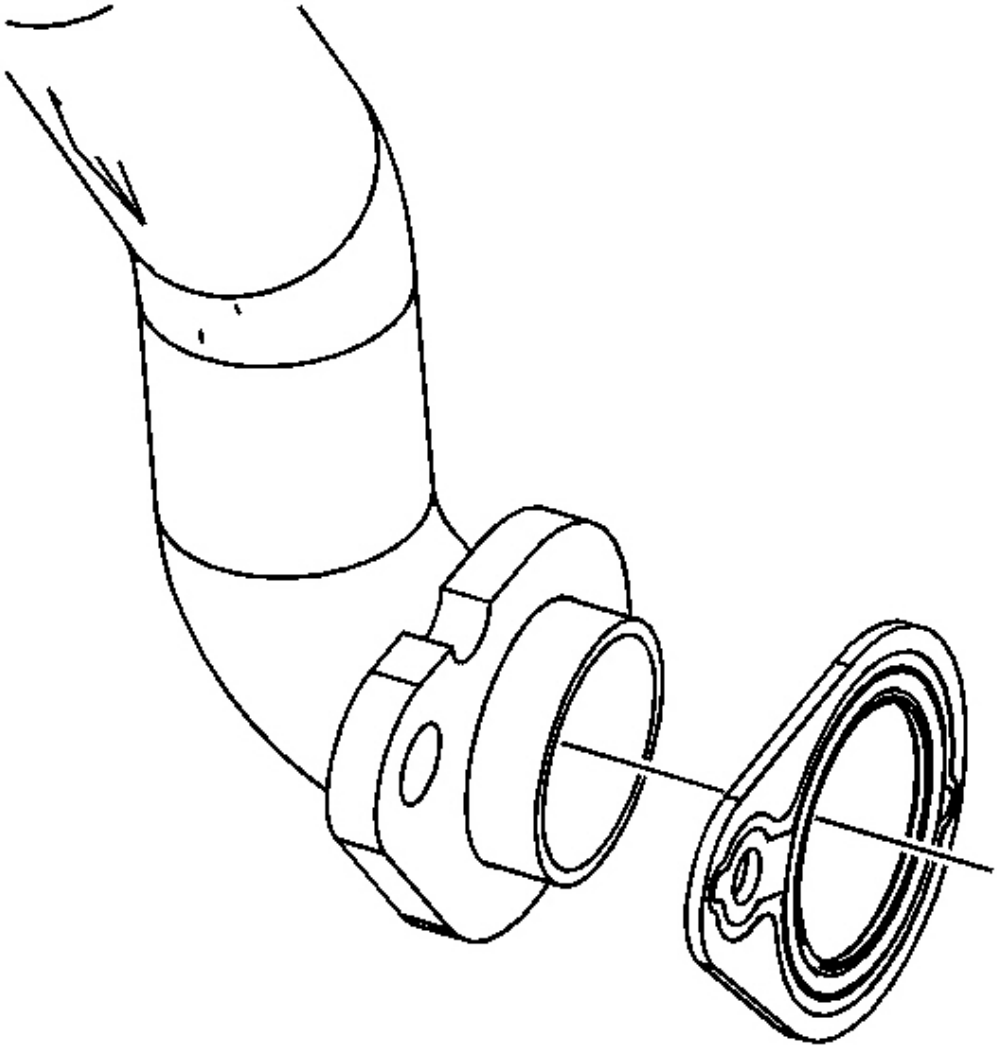


Fig. 321: View Of Oil Pump Pipe Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install NEW oil pump pipe gasket on oil pump pipe.

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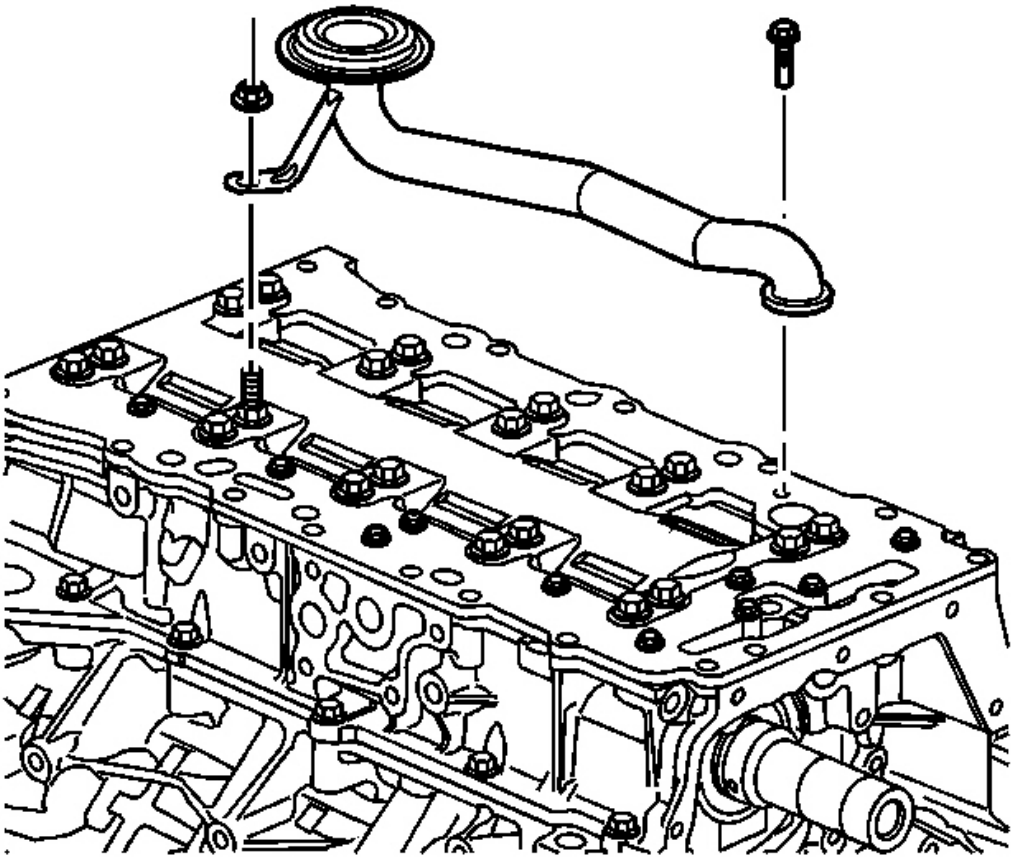


Fig. 322: View Of Oil Pump Pipe
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil pump pick-up retaining bolt and nut.

Tighten:

- Tighten the oil pump pick-up tube nut to 24 N.m (18 lb ft).
- Tighten the oil pump pick-up tube bolt to 10 N.m (89 lb in).

OIL PAN INSTALLATION

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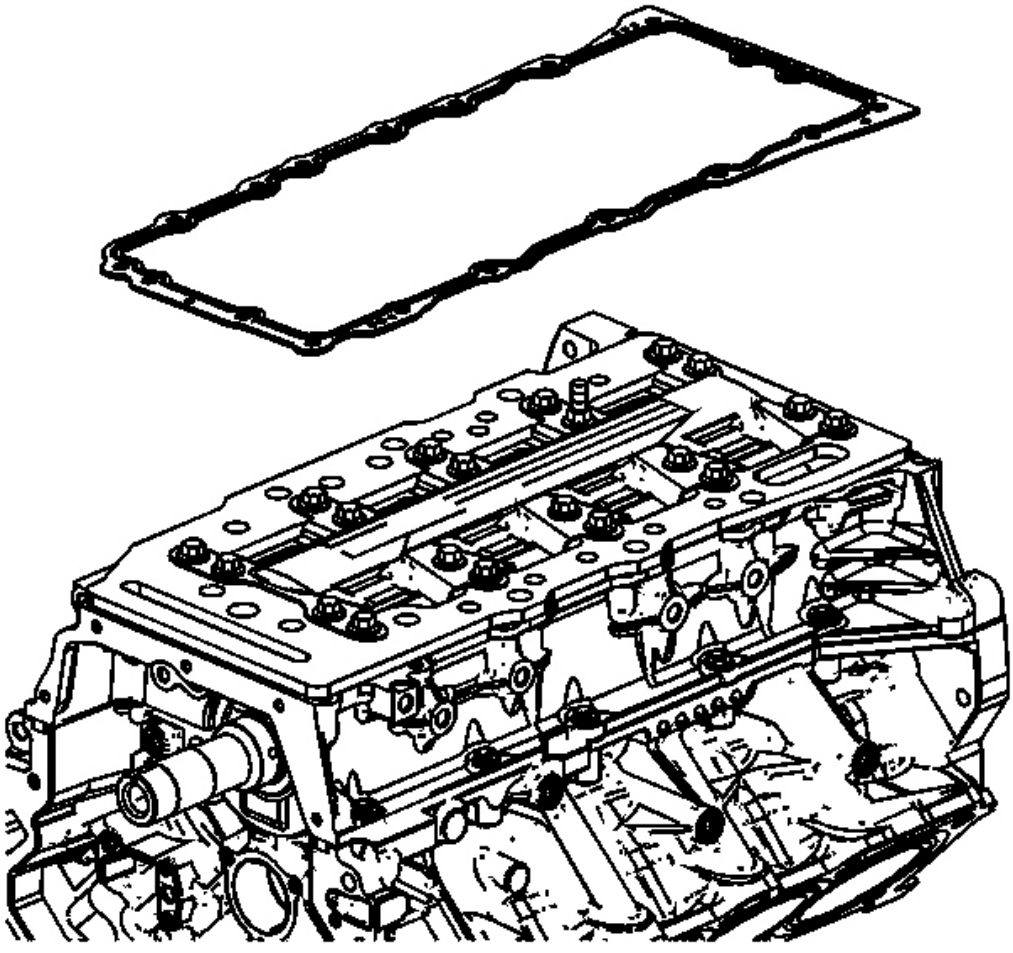


Fig. 323: View Of Oil Pan Gasket
Courtesy of GENERAL MOTORS CORP.

1. Place a NEW oil pan gasket in place on the oil manifold plate.

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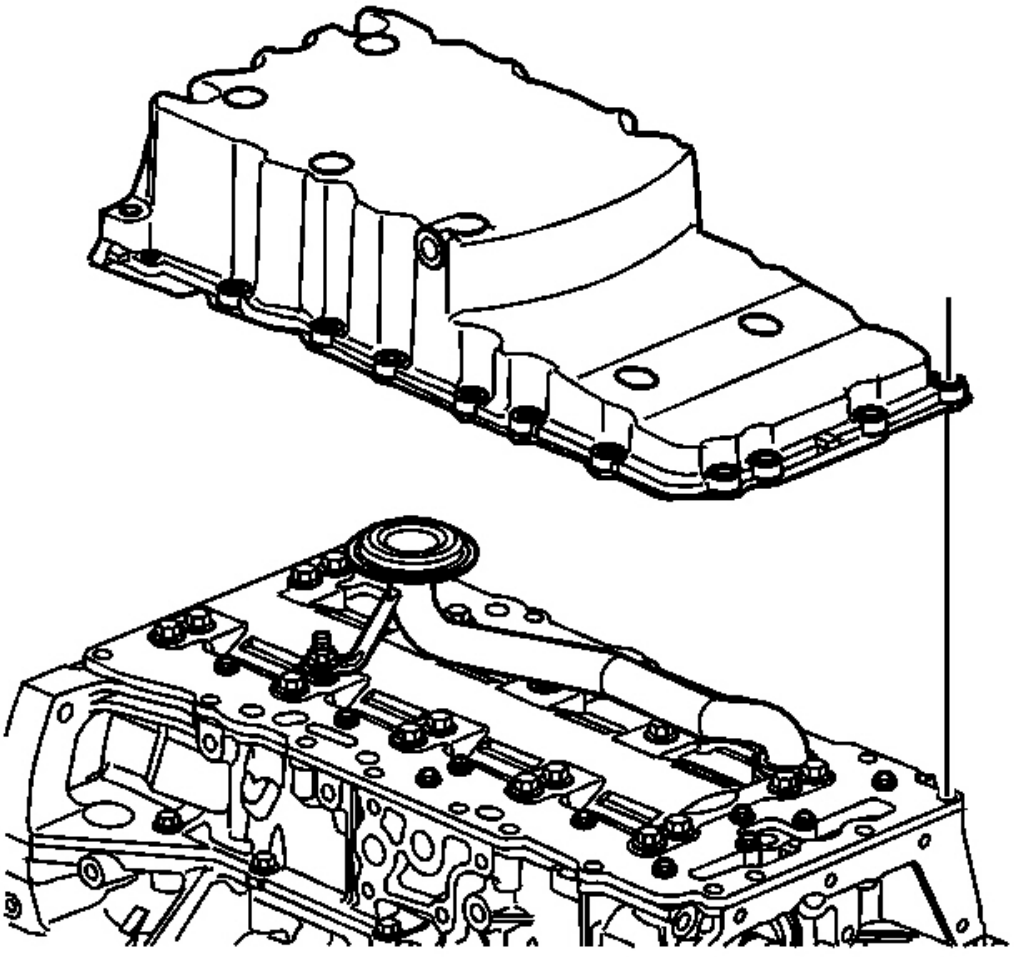


Fig. 324: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

2. Position the oil pan onto the lower crankcase.

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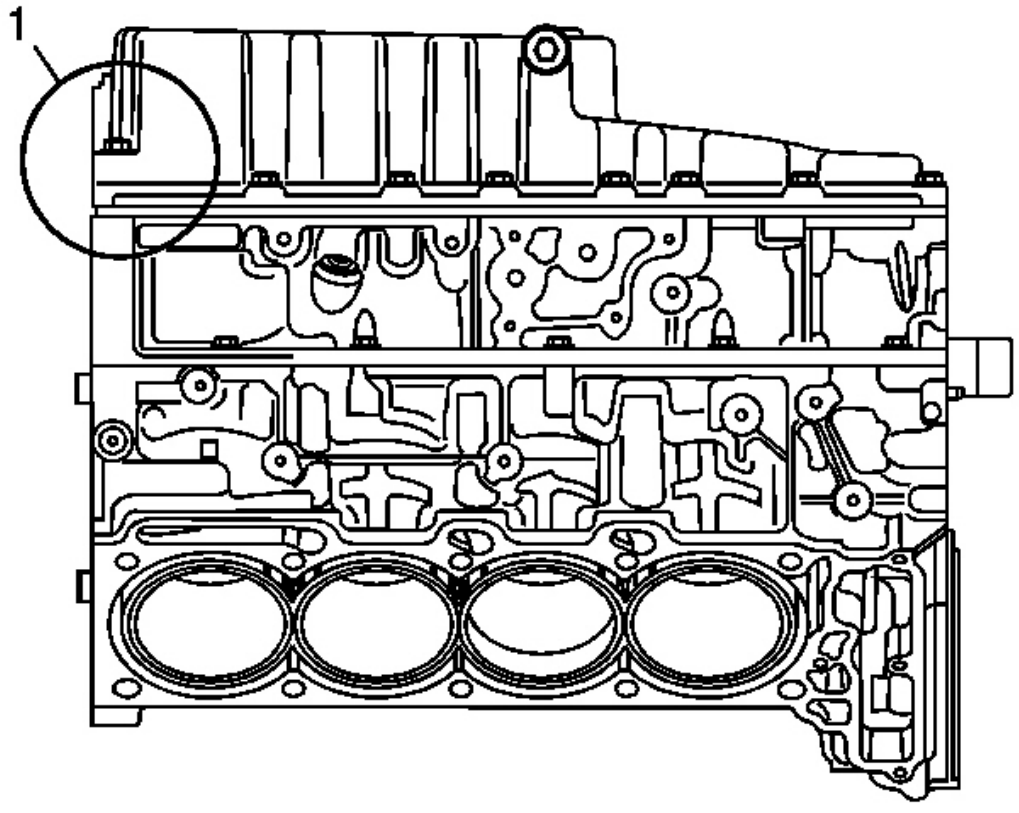


Fig. 325: View Of Rear Face Of Engine Block
Courtesy of GENERAL MOTORS CORP.

3. The oil pan must be held flush to 0.50 mm (0.020 in) forward of the rear face of the engine block (1).

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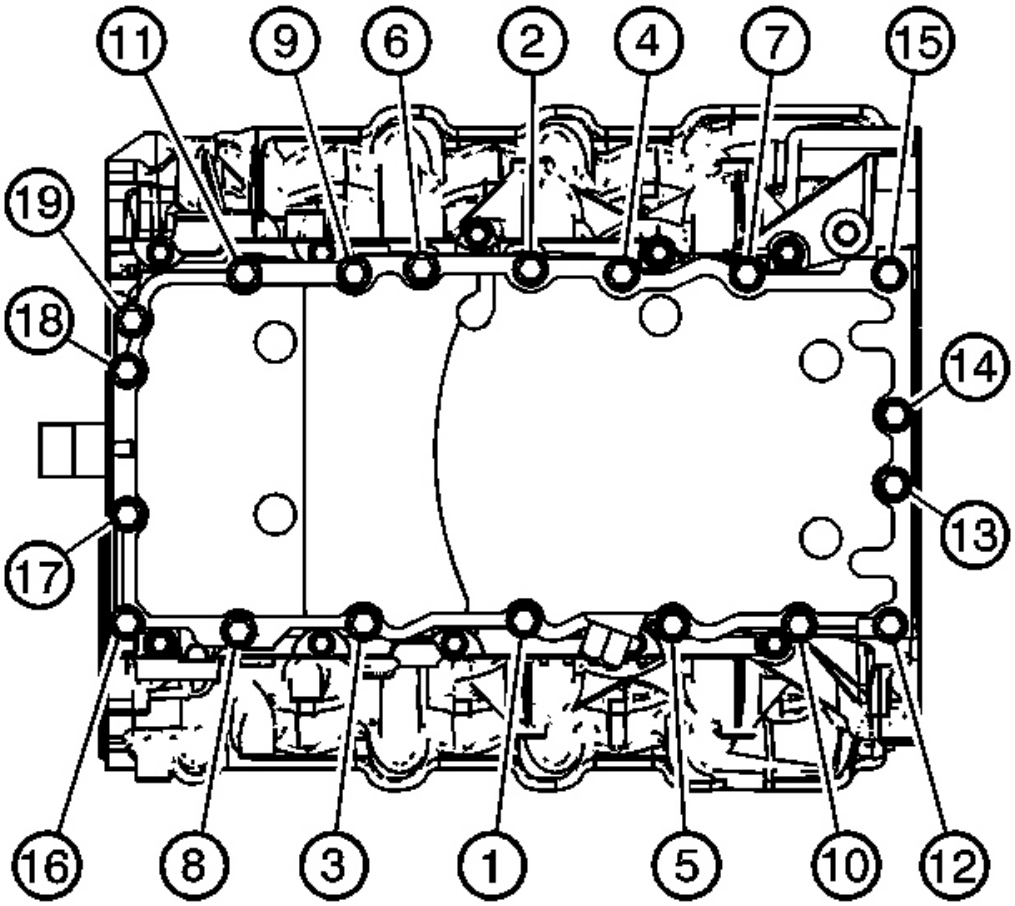


Fig. 326: View Of Oil Pan Retaining Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan bolts in the sequence shown.
    1. First Pass

        Tighten: Tighten the oil pan bolts to 15 N.m (11 lb ft) in the sequence shown.

    2. Final Pass

        Tighten: Tighten the oil pan bolts to 25 N.m (18 lb ft) in the sequence shown.

5. Clean off any sealant that has protruded to the exterior of the engine.
6. Install the oil drain plug.

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Tighten: Tighten the oil drain plug to 25 N.m (18 lb ft).

7. Rotate the engine so that the engine valley is facing upward.

CYLINDER HEAD INSTALLATION - LEFT SIDE

TOOLS REQUIRED

J 45059 Angle Meter. See **Special Tools** .

INSTALLATION PROCEDURE

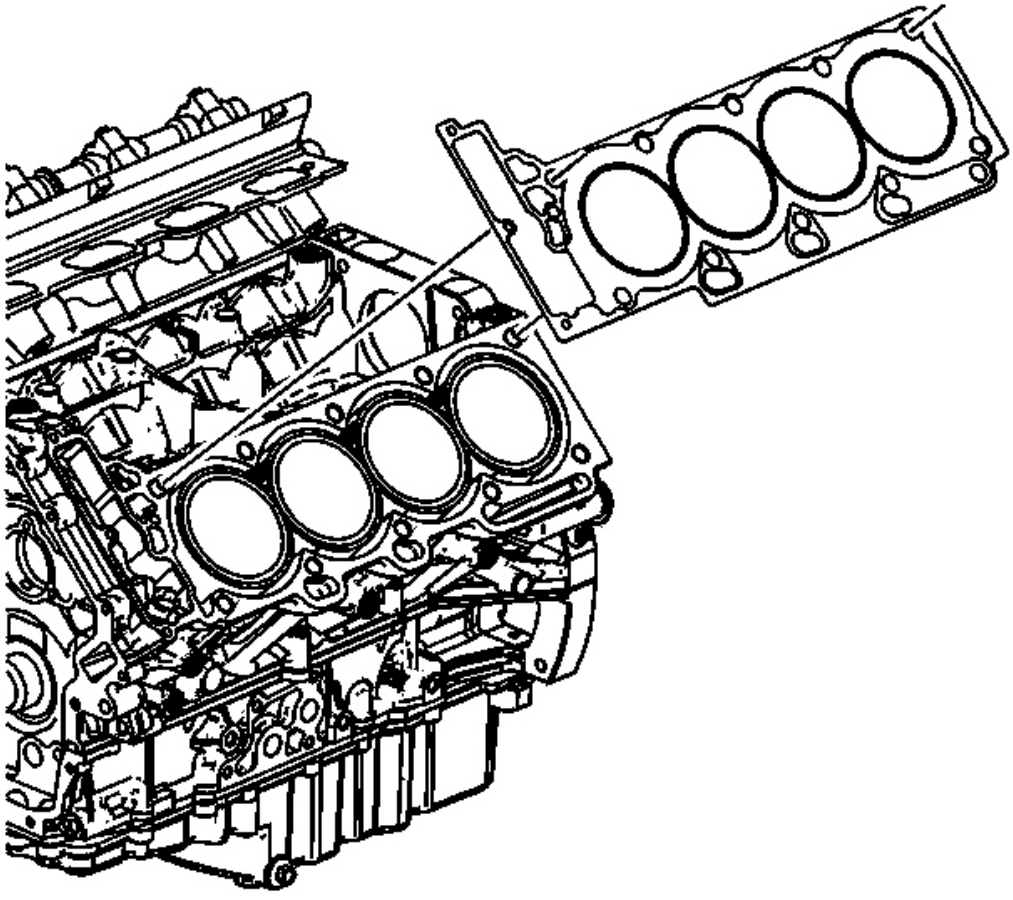


Fig. 327: View Of Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

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1. Ensure all the cylinder head locating pins are securely mounted in the cylinder block deck face.

IMPORTANT: Failure to remove all the old thread sealant material from the cylinder block could cause false torque readings.

2. Ensure any old thread sealant material is removed from the cylinder head bolt holes in the cylinder block.
3. Install a new left cylinder head gasket using the deck face locating pins for retention.

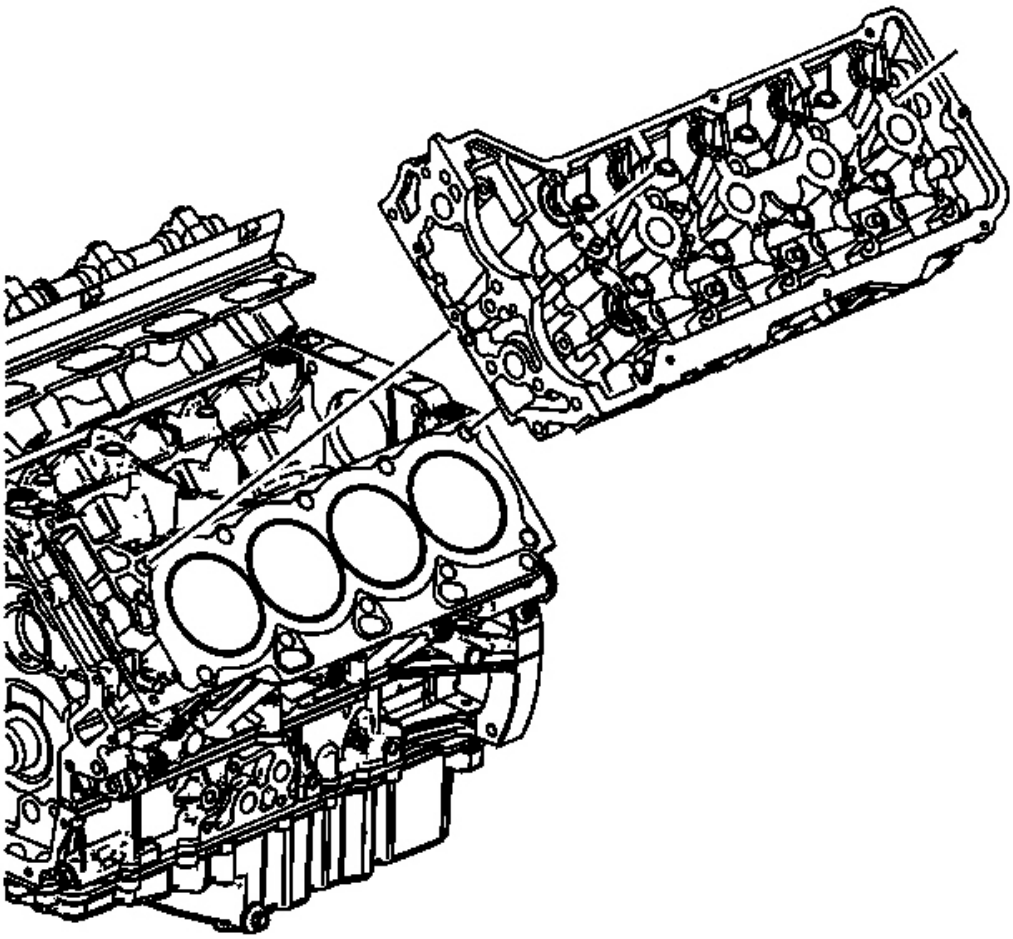


Fig. 328: View Of Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Align the cylinder head with the deck face locating pins.
5. Place the cylinder head in position on the deck face.

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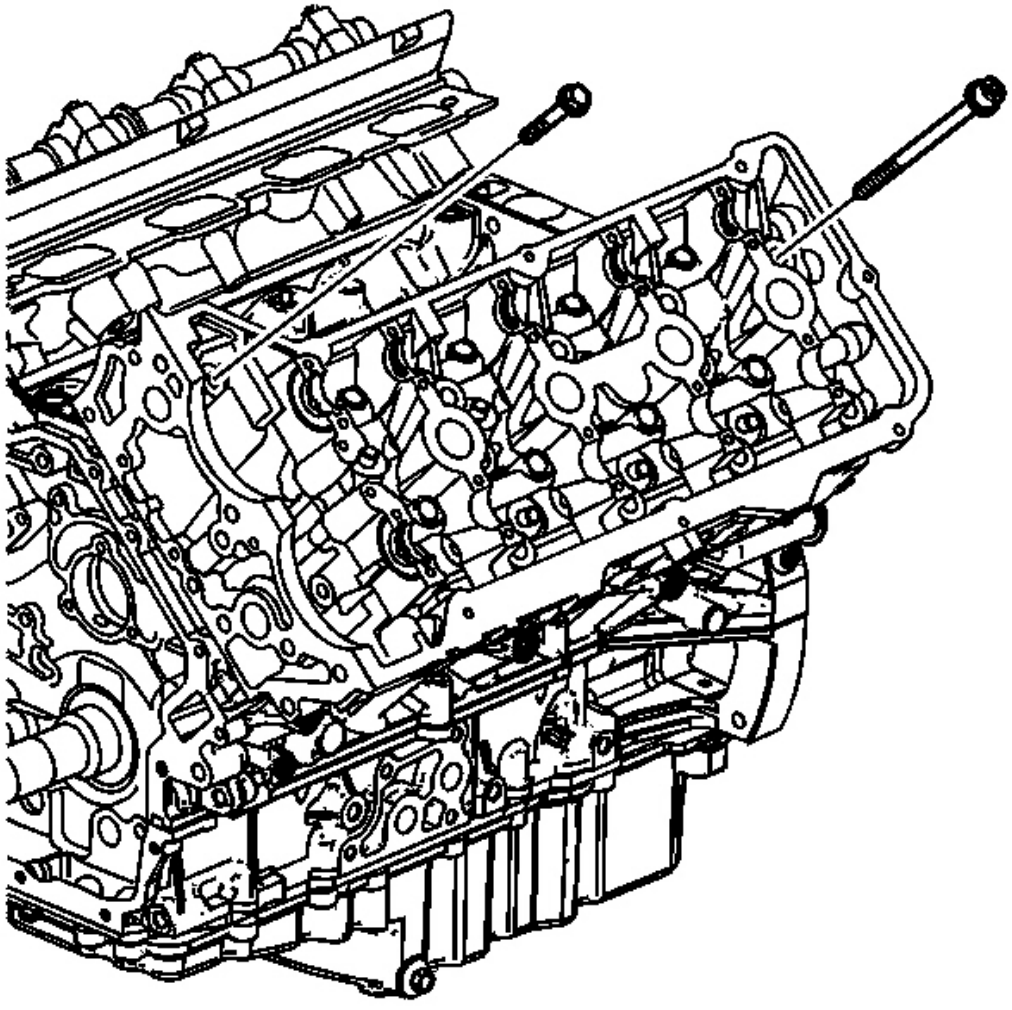


Fig. 329: View Of Left Cylinder Head M6 External Drive Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the old M11 cylinder head bolts.

6. Install new M11 cylinder head bolts in the cylinder head.
7. Install the M6 cylinder head bolts at the front of the cylinder head.

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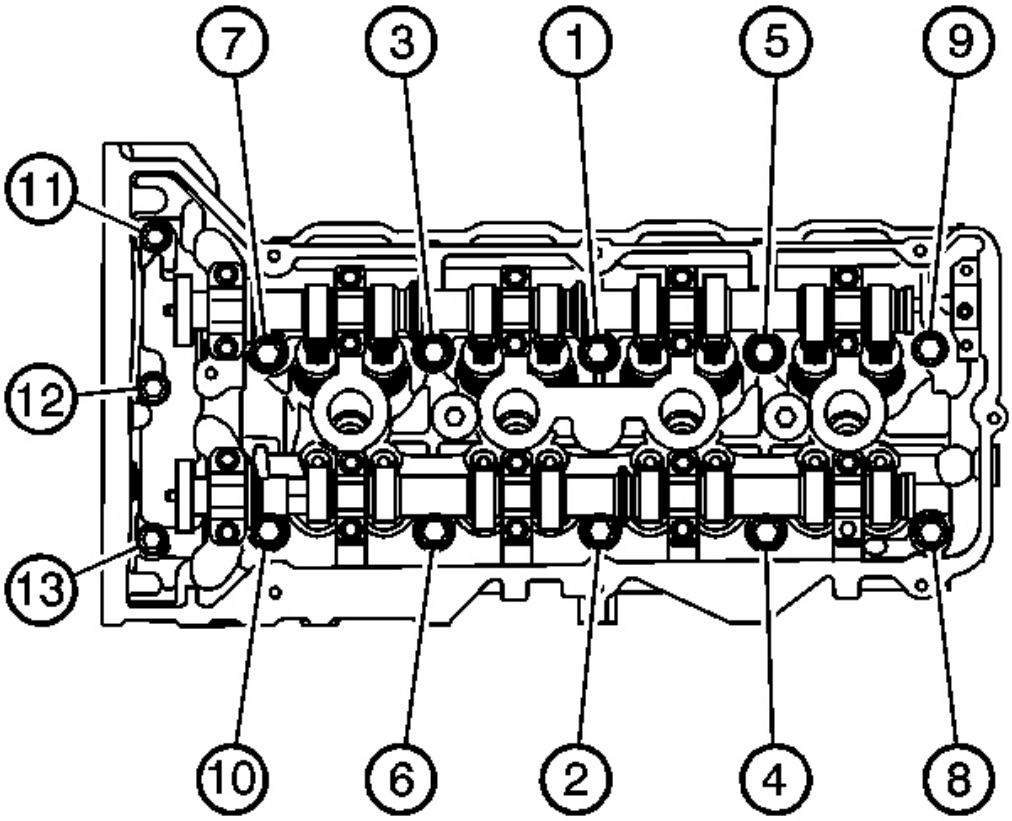


Fig. 330: Tightening Left Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

NOTE: **Ensure the cylinder head bolts that are being used are the proper pitch or engine damage will occur. The thread pitch on the M11 cylinder head bolts and the engine block cylinder head bolt holes have been revised. In order to prevent engine damage it is important to identify which thread pitch is being used. Cylinder head bolts with a pitch of 1.5 mm have a thread length of about 48 mm (1.890 in) long. Cylinder head bolts with a pitch of 2.0 mm have a thread length of about 67 mm (2.638 in) long.**

8. Tighten the left cylinder head bolts in the sequence shown.
    1. First Pass

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Tighten: Tighten the left cylinder head M11 cylinder head bolts to 30 N.m (22 lb ft) in the sequence shown.

2. Second Pass

   Tighten: Using the **J 45059** , tighten the left cylinder head M11 cylinder head bolts an additional 60 degrees in the sequence shown. See **Special Tools** .

3. Third Pass

   Tighten: Repeat the sequence turning each bolt another 60 degrees.

4. Fourth Pass

   Tighten: Repeat the sequence turning each bolt another 60 degrees.

5. Final Pass

   Tighten: Repeat the sequence again turning each bolt a final 40 degrees, total 220 degrees.

9. Tighten the M6 bolts at the front of the cylinder head.

   Tighten: Tighten the M6 cylinder head bolts to 12 N.m (106 lb in).

VALVE LIFTER INSTALLATION - LEFT SIDE

TOOLS REQUIRED

J 39946 Crankshaft Socket - 4.0L and 4.6L

INSTALLATION PROCEDURE

1. Ensure the crankshaft is in the TDC position for the number one cylinder using the **J 39946** . See **Special Tools** .

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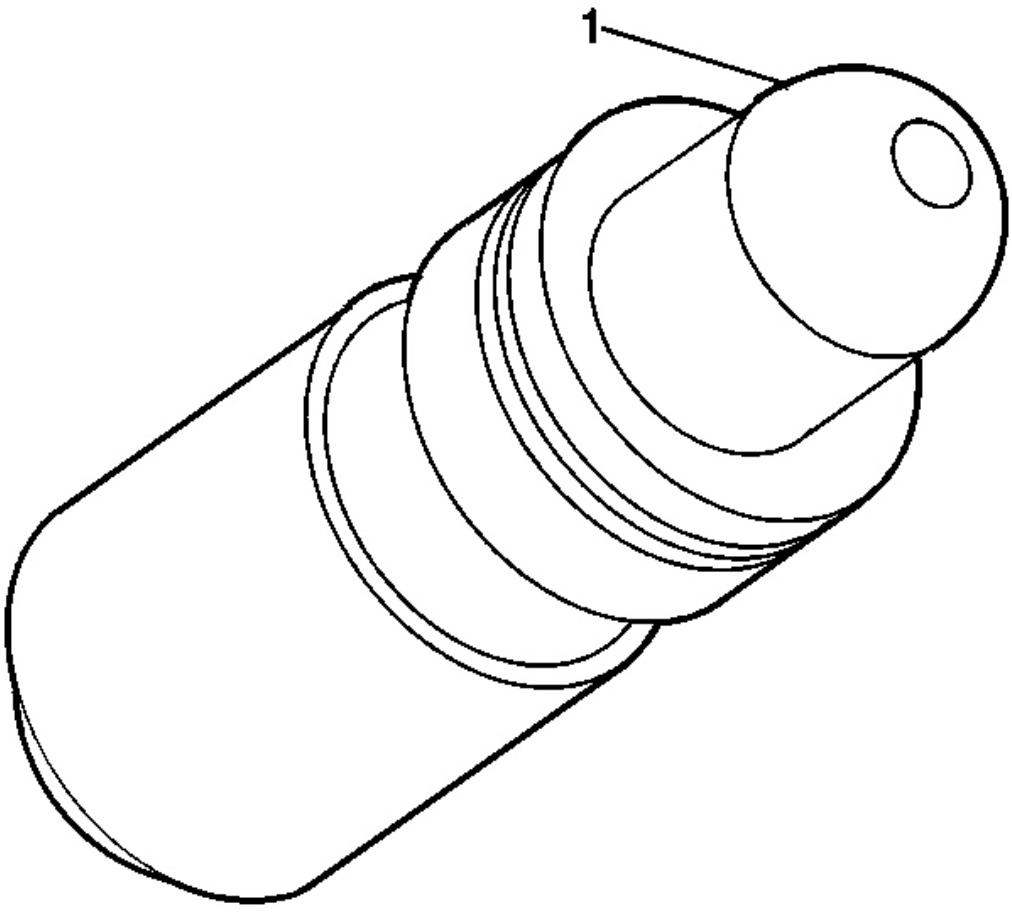


Fig. 331: View Of Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Valve Lifter Priming Notice .

2. Fill the Stationary Hydraulic Lash Adjuster (SHLA) with clean engine oil GM P/N 12378006 or equivalent. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.
3. Lubricate the SHLA bores of the cylinder head with clean engine oil GM P/N 12378006 or equivalent.

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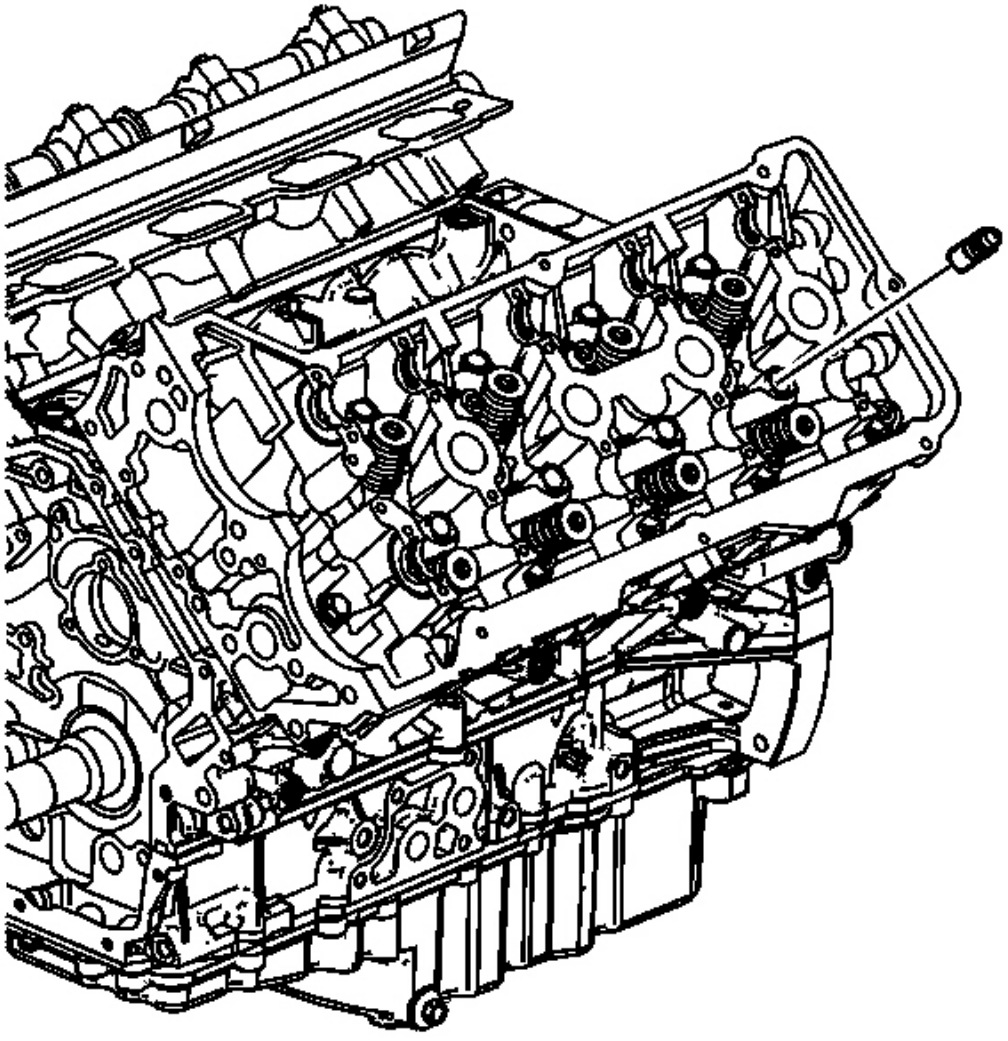


Fig. 332: View Of Left Valve Lifter
Courtesy of GENERAL MOTORS CORP.

4. Install the SHLAs.
5. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the SHLA sphere.

VALVE ROCKER ARM INSTALLATION - LEFT SIDE

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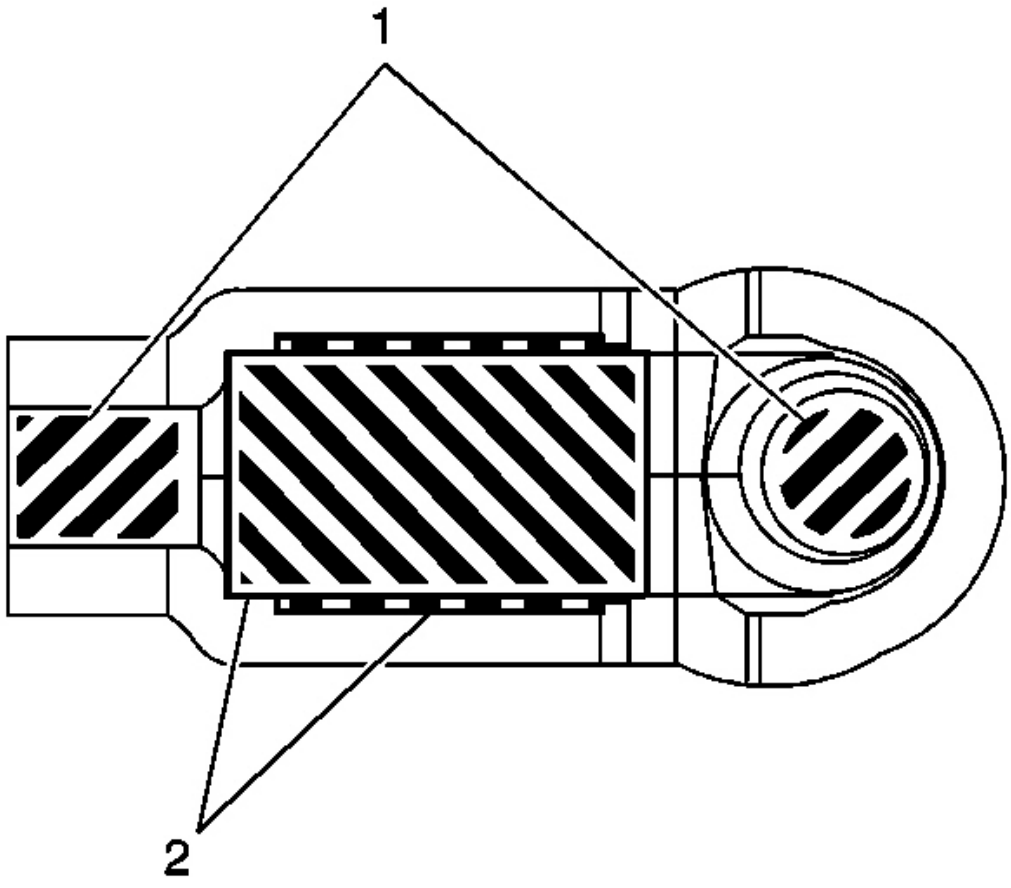


Fig. 333: Identifying Roller Pivot Pocket (2) & Valve Slot Areas (1) Of Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

1. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the roller (2), pivot pocket and valve slot areas (1) of the camshaft followers.

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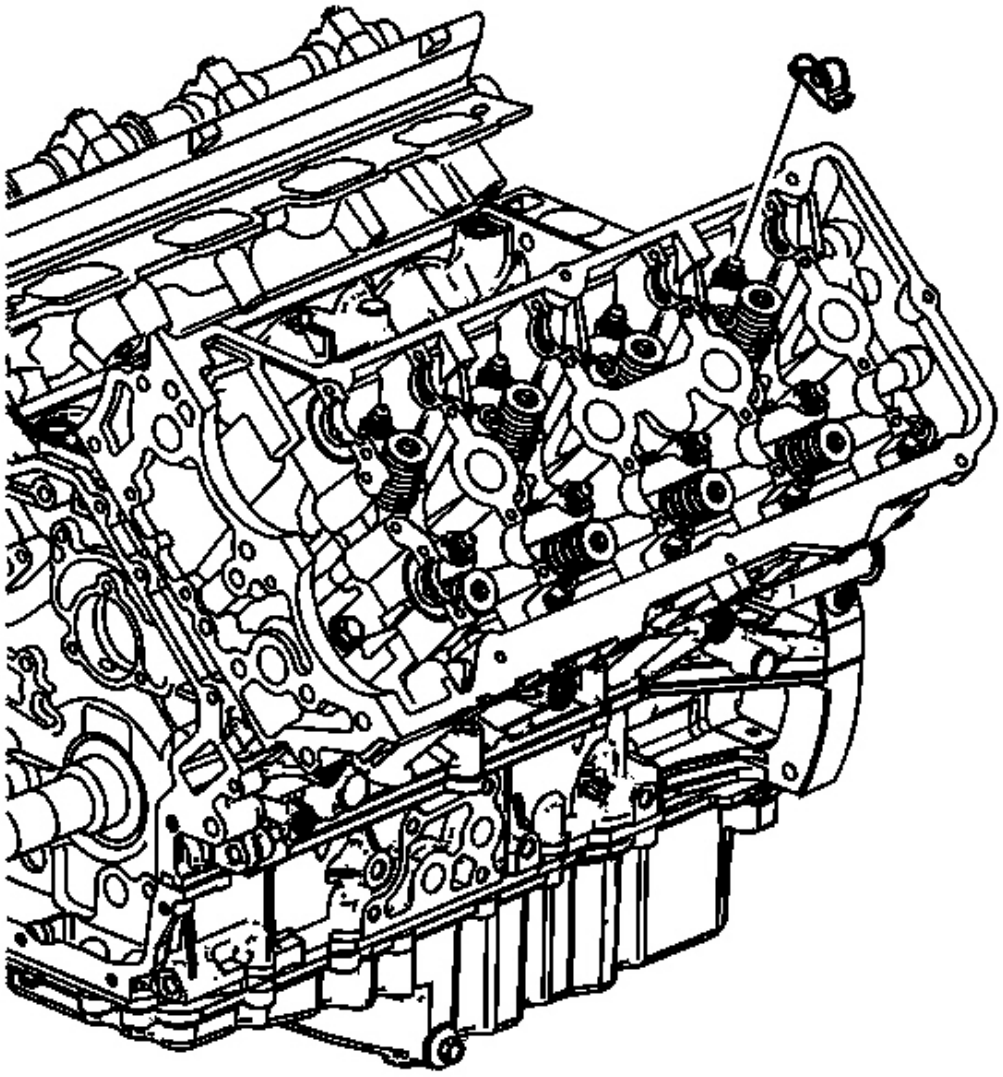


Fig. 334: View Of Left Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

2. Place the camshaft followers in position on the valve tip and SHLA. The rounded head of the follower

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goes on the SHLA while the flat end goes on the valve tip.

EXHAUST CAMSHAFT INSTALLATION - LEFT SIDE

TOOLS REQUIRED

J 45059 Angle Meter. See **Special Tools** .

INSTALLATION PROCEDURE

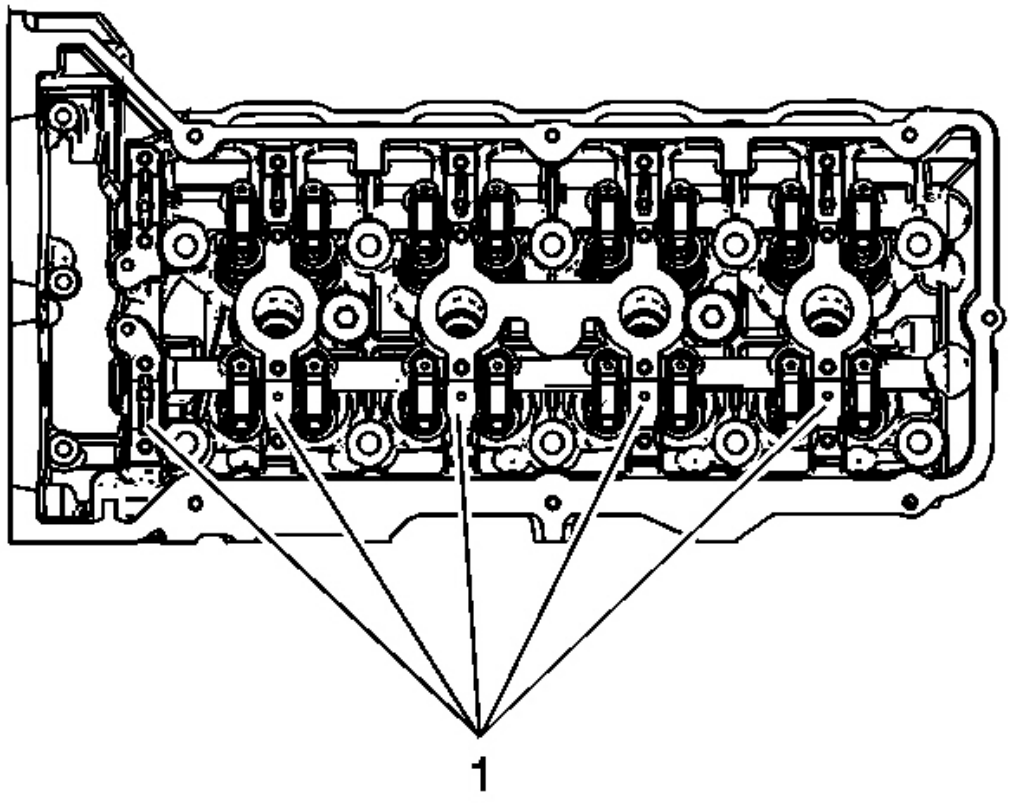


Fig. 335: Locating Left Exhaust Camshaft Bearing Journals
Courtesy of GENERAL MOTORS CORP.

1. Clean the camshaft journals, camshaft and the camshaft caps with a clean, lint-free cloth.
2. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the camshaft bearing journals (1).

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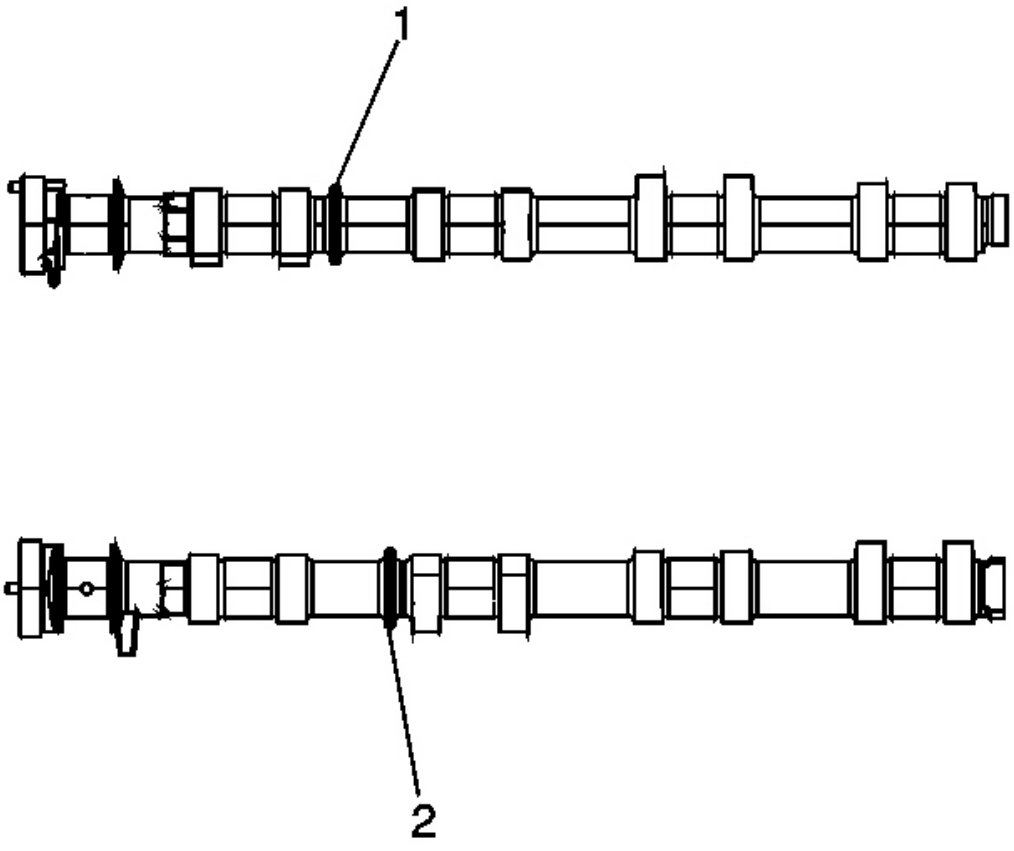


Fig. 336: Applying Lubricant To Camshaft Bearing Journals
Courtesy of GENERAL MOTORS CORP.

3. Select the proper camshaft by the identifying ring cast into the left exhaust camshaft (2).

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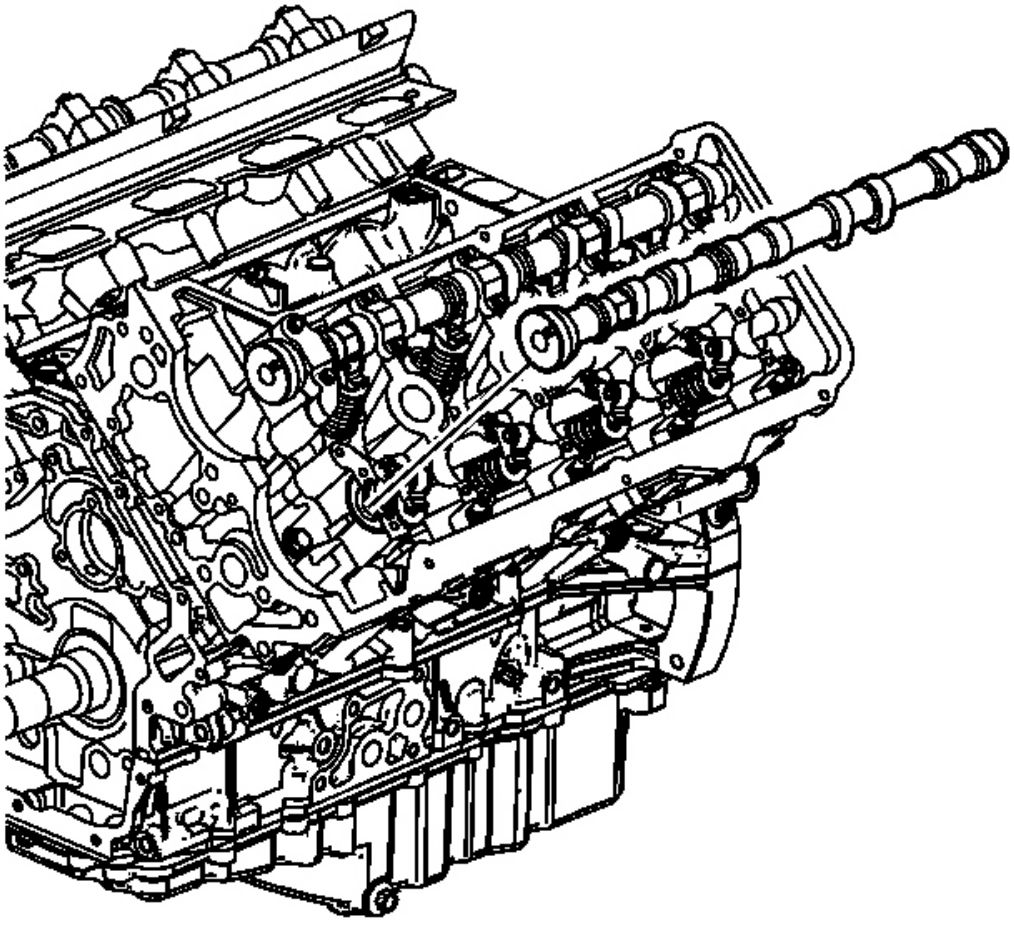


Fig. 337: View Of Left Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the camshaft lobes and the camshaft journals.

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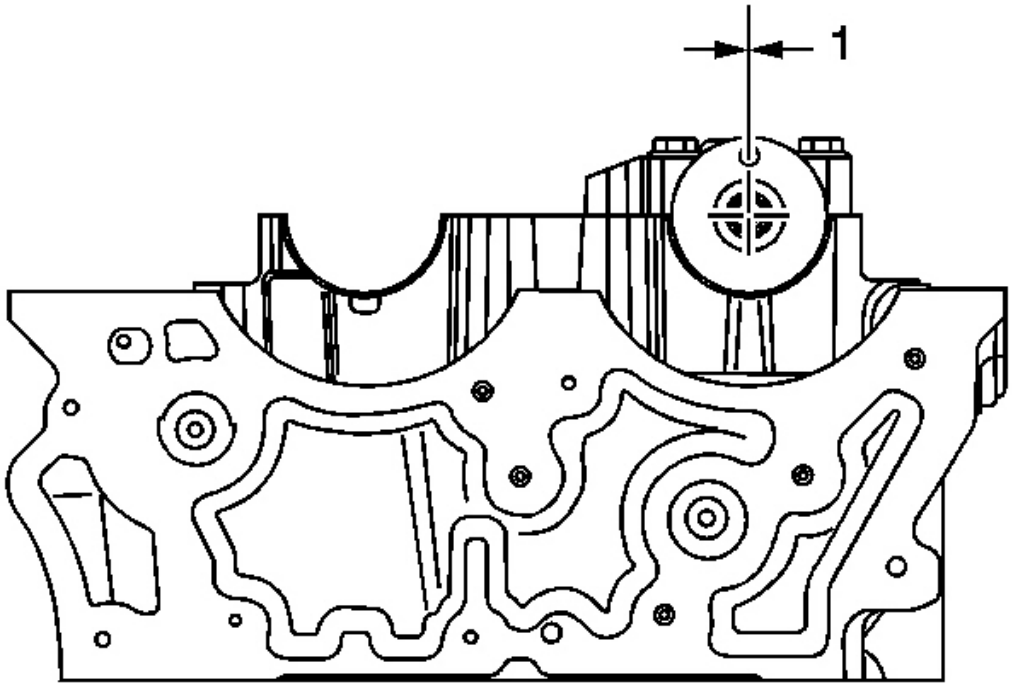


Fig. 338: Aligning Left Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure each valve rocker arm is properly aligned to the valve tip, the valve lifter and the camshaft lobe. Inspect the alignment prior to and after the camshaft caps are tightened to specifications.

5. Place the camshaft in the camshaft journals with the camshaft sprocket drive pins near the top of their rotation (1) and the camshaft lobes in a neutral position. The camshaft can be identified by a stamping near the rear journal. For example: L-EXH is defined as Left Bank Exhaust.

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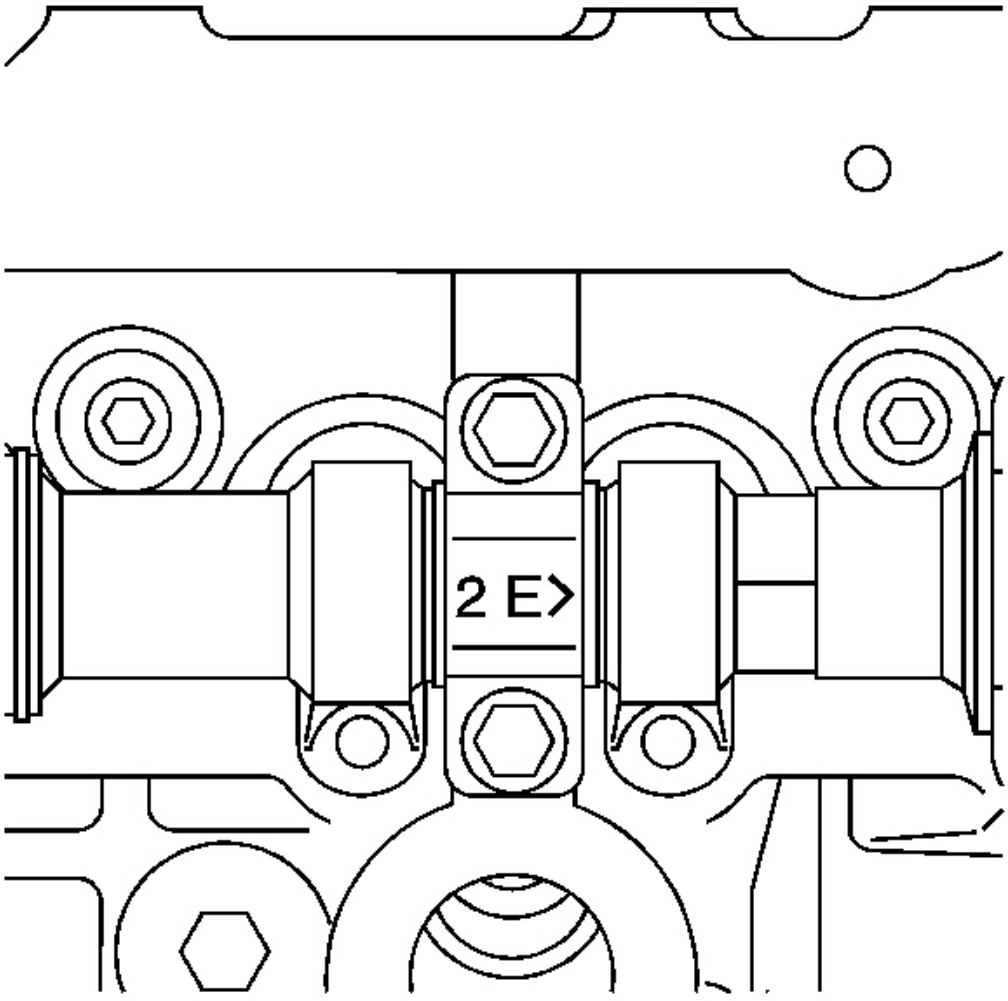


Fig. 339: View Of Exhaust Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS CORP.

6. Observe the markings on the camshaft bearing caps. Each camshaft bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The arrow should point toward the front of the engine.
   - The number indicates the position from the front of the engine.
   - The "E" indicates the exhaust camshaft.
7. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the left exhaust camshaft bearing cap journals.

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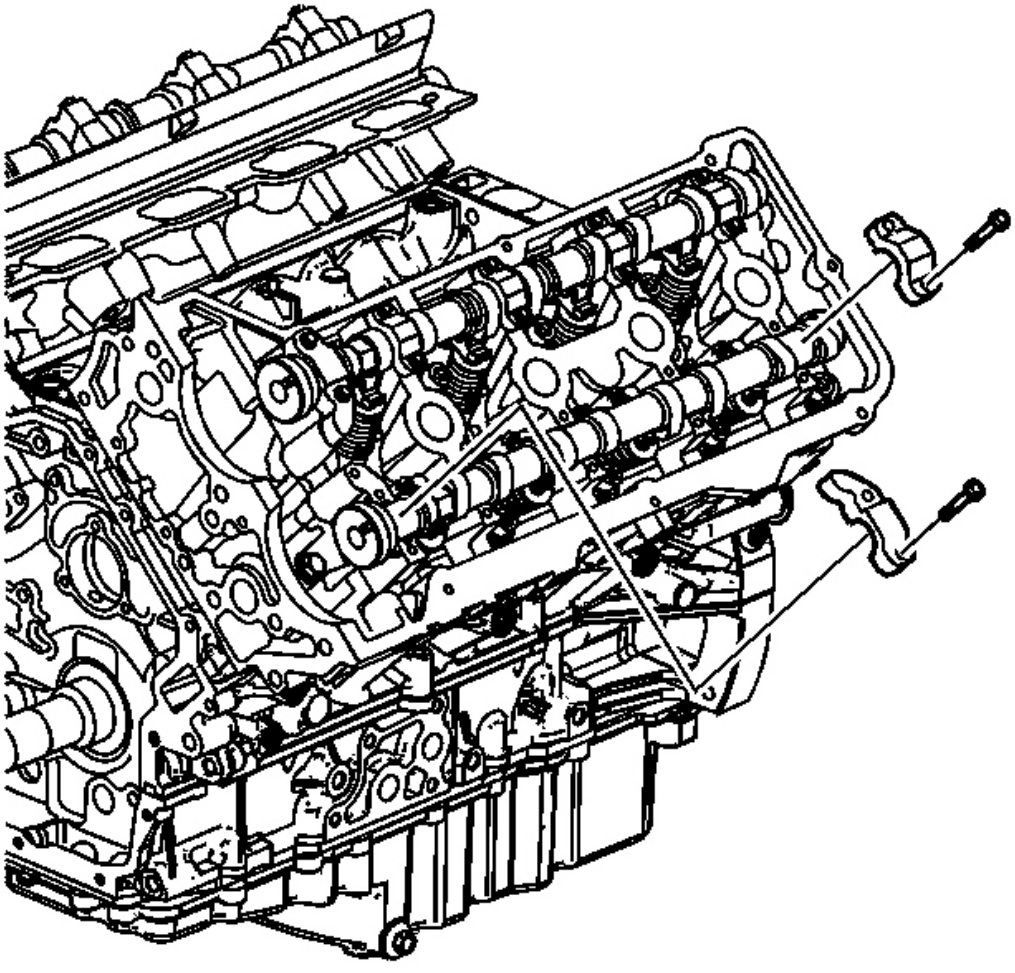


Fig. 340: View Of Left Exhaust Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the left exhaust camshaft bearing caps according to the identifications marks.
9. Hand start all the left exhaust camshaft bearing cap bolts.

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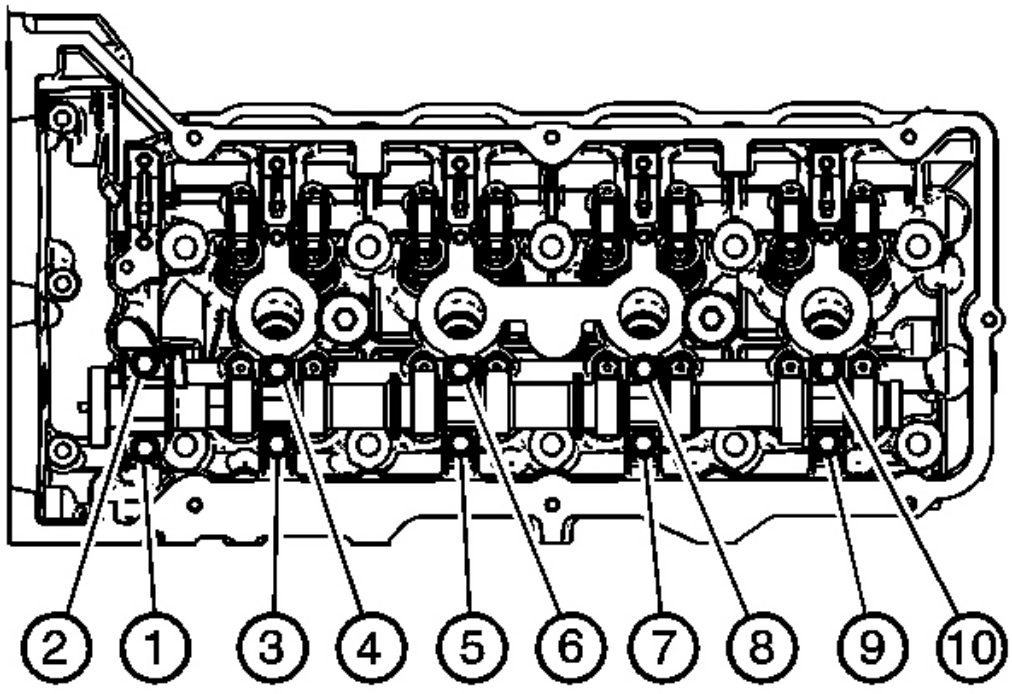


Fig. 341: Tightening Left Cylinder Head Exhaust Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Ensure each valve rocker arm is properly aligned to the valve tip, the valve lifter and the camshaft lobe. Inspect the alignment prior to and after the camshaft caps are tightened to specifications.

10. Install the left cylinder head exhaust camshaft bearing cap bolts.
    1. First Pass

       Tighten: Tighten the camshaft bearing cap bolts to 5 N.m (44 lb in).

    2. Final Pass

       Tighten: Tighten the camshaft bearing cap bolts an additional 30 degrees using the **J 45059** . See **Special Tools** .

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INTAKE CAMSHAFT INSTALLATION - LEFT SIDE

TOOLS REQUIRED

J 45059 Angle Meter. See **Special Tools** .

INSTALLATION PROCEDURE

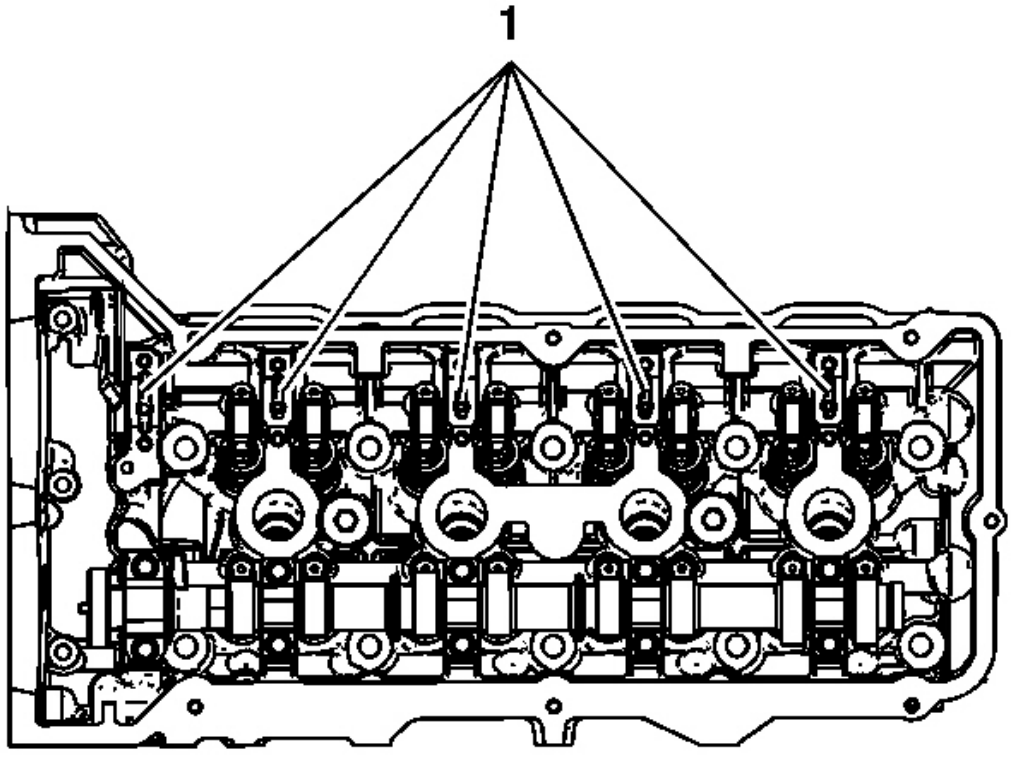


Fig. 342: Locating Left Intake Camshaft Bearing Journals
Courtesy of GENERAL MOTORS CORP.

1. Clean the camshaft journals, camshaft and the camshaft caps with a clean, lint-free cloth.
2. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the camshaft bearing journals (1).

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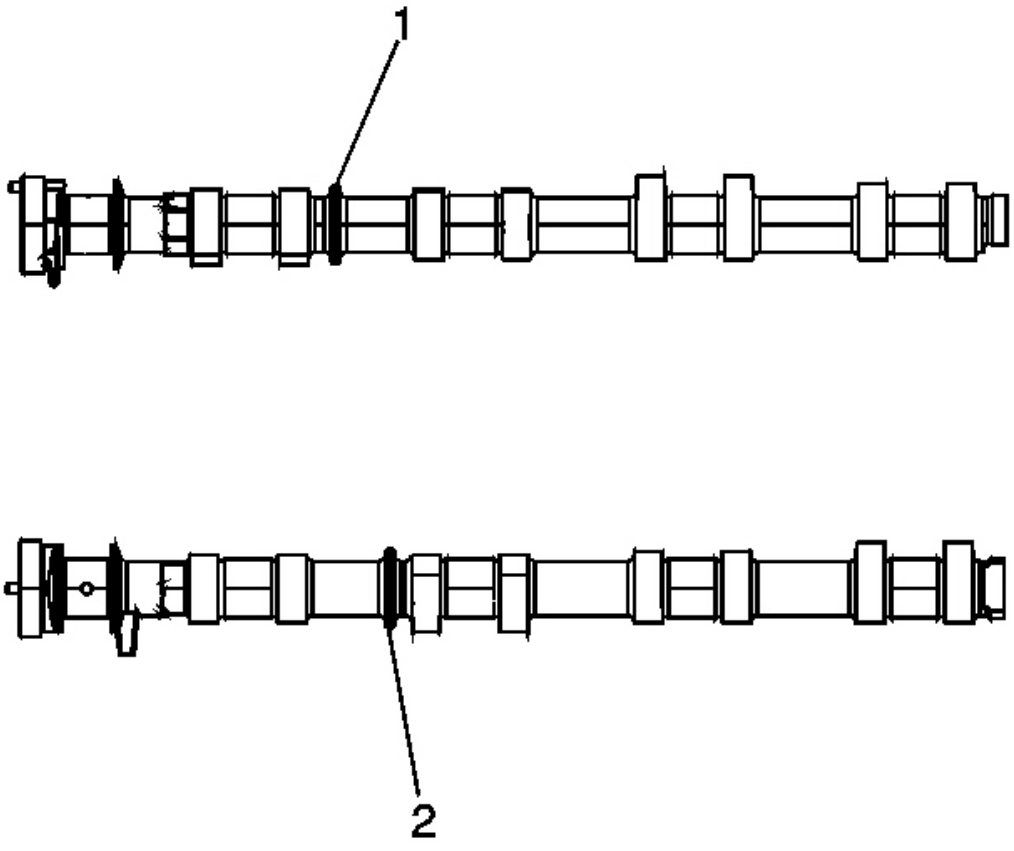


Fig. 343: Applying Lubricant To Camshaft Bearing Journals
Courtesy of GENERAL MOTORS CORP.

3. Select the proper camshaft by the identifying ring cast into the left intake camshaft (1).

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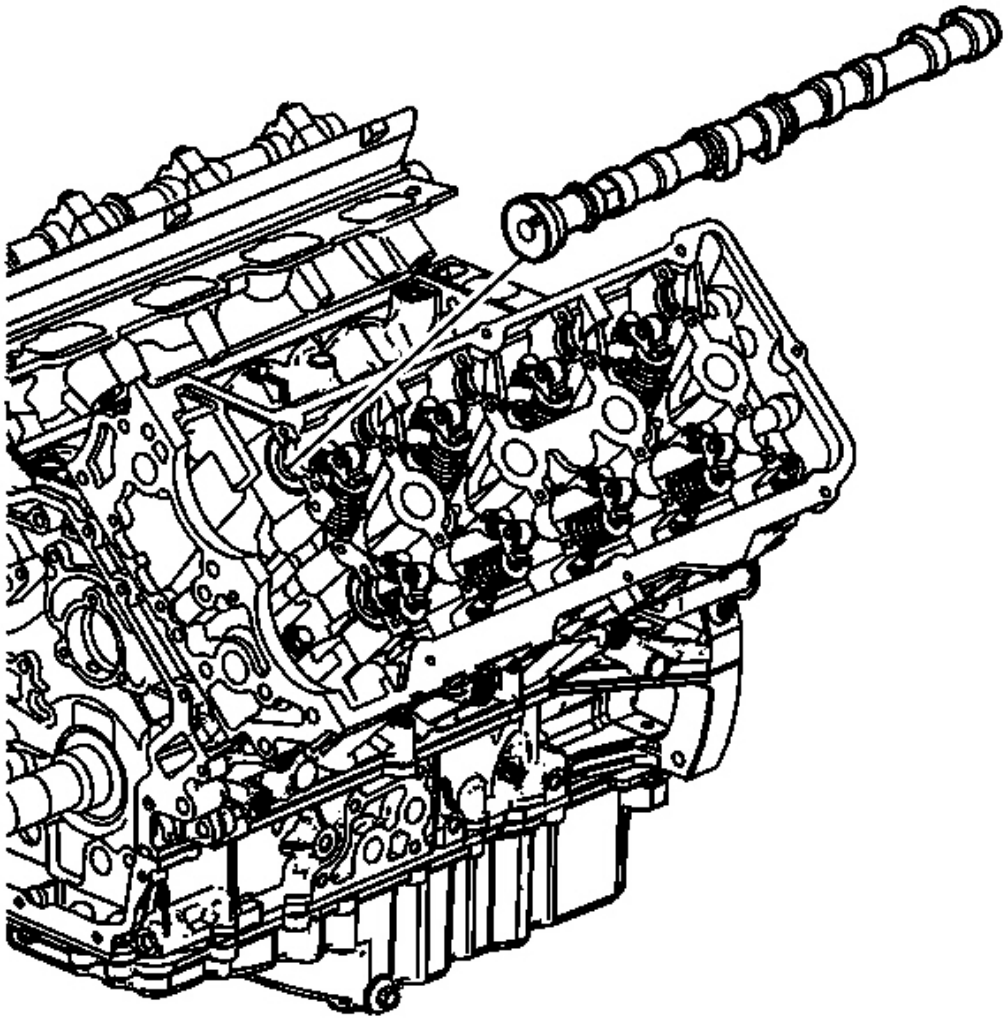


Fig. 344: View Of Left Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the camshaft lobes and the camshaft journals.

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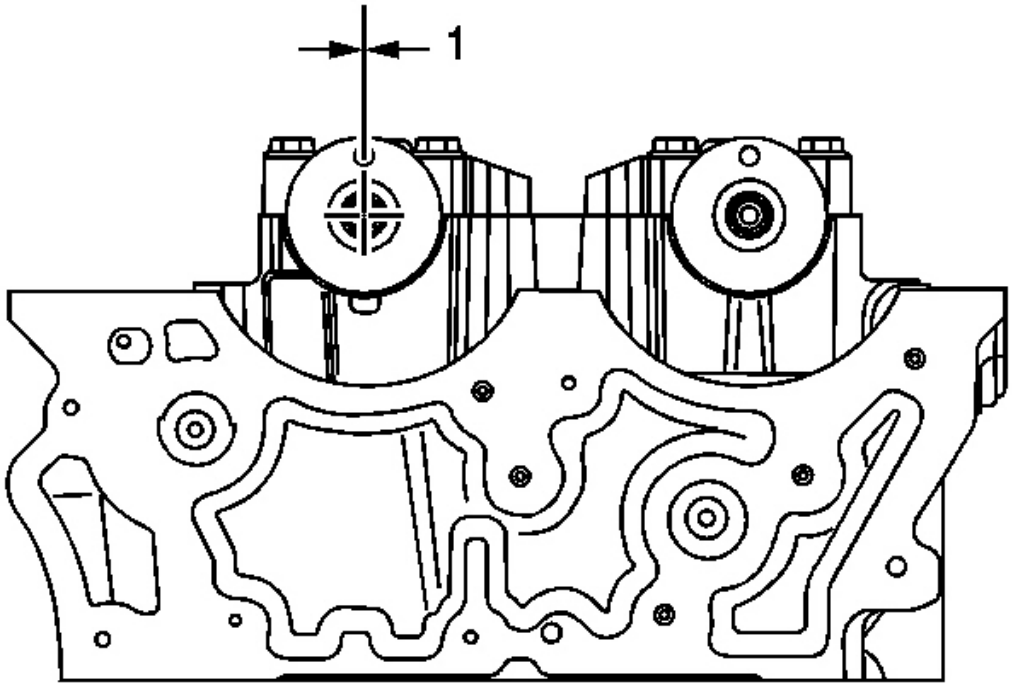


Fig. 345: Aligning Left Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure each valve rocker arm is properly aligned to the valve tip, the valve lifter and the camshaft lobe. Inspect the alignment prior to and after the camshaft caps are tightened to specifications.

5. Place the camshaft in the camshaft journals with the camshaft sprocket drive pins near the top of their rotation (1) and the camshaft lobes in a neutral position. The camshaft can be identified by a stamping near the rear journal. For example: L-INT is defined as Left Bank Intake.

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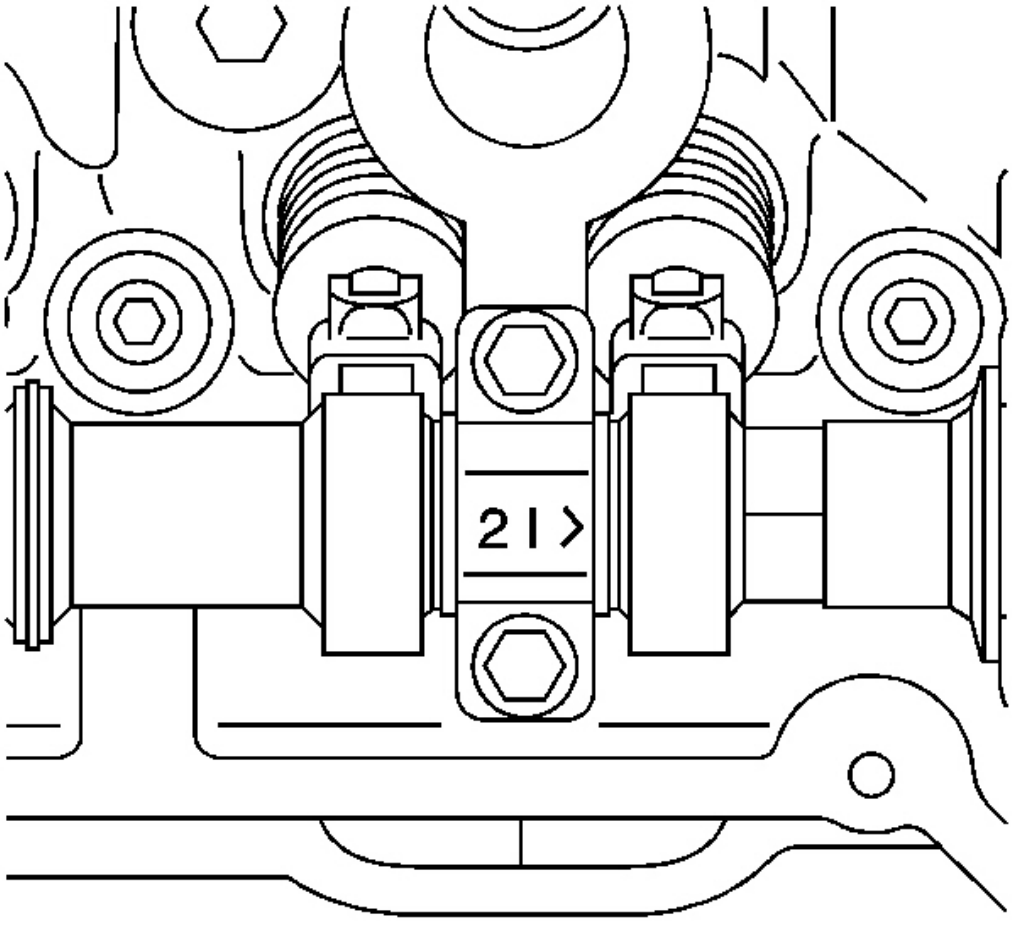


Fig. 346: View Of Intake Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS CORP.

6. Observe the markings on the camshaft bearing caps. Each camshaft bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The arrow should point toward the front of the engine.
   - The number indicates the position from the front of the engine.
   - The "I" indicates the intake camshaft.
7. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the left intake camshaft bearing cap journals.

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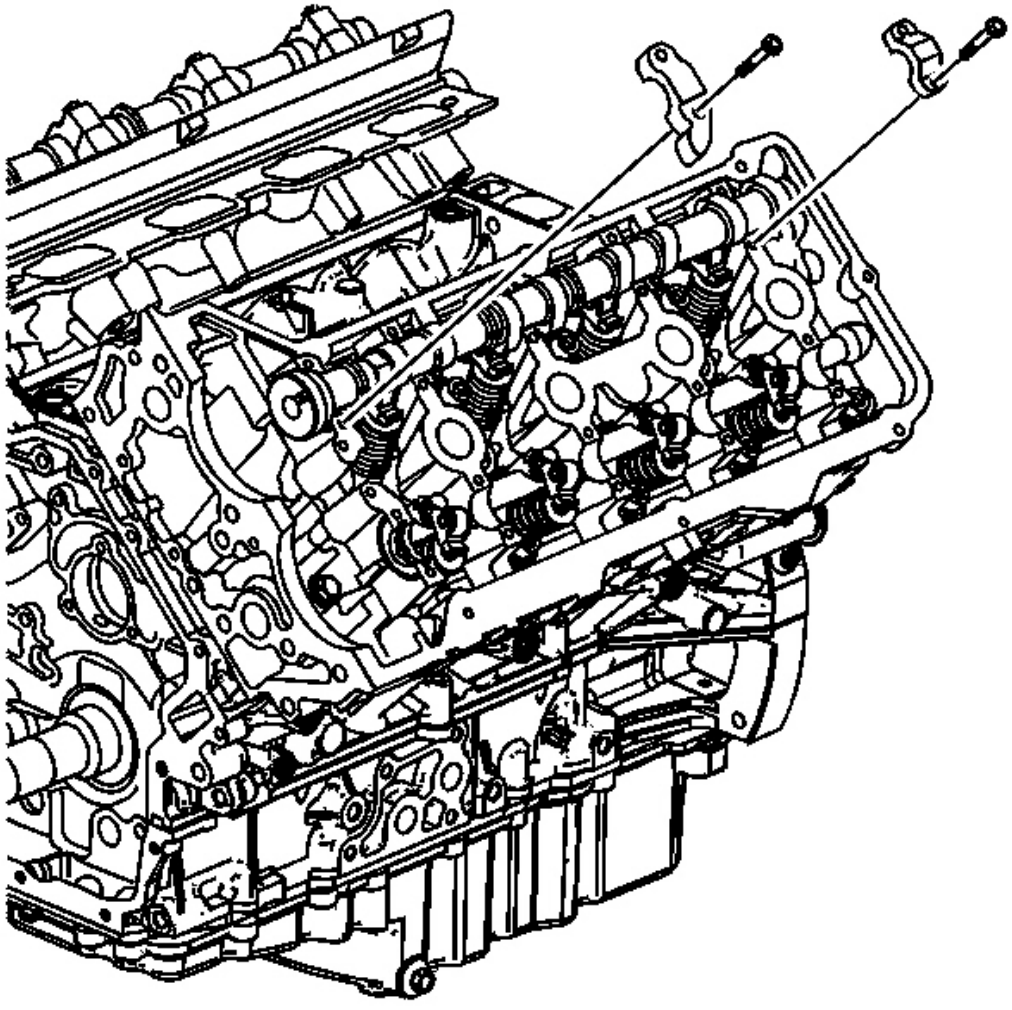


Fig. 347: View Of Left Intake Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

8. Install the left intake camshaft bearing caps according to the identifications marks.
9. Hand start all the left intake camshaft bearing cap bolts.

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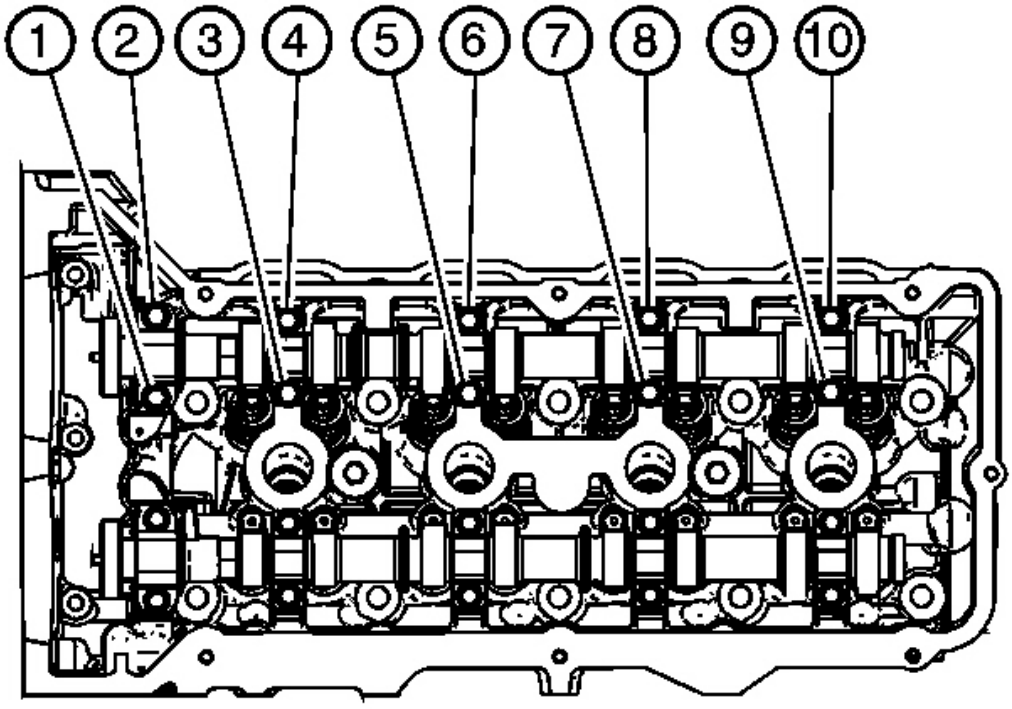


Fig. 348: Tightening Left Cylinder Head Intake Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Ensure each valve rocker arm is properly aligned to the valve tip, the valve lifter and the camshaft lobe. Inspect the alignment prior to and after the camshaft caps are tightened to specifications.

10. Install the left cylinder head intake camshaft bearing cap bolts.
    1. First Pass

       Tighten: Tighten the camshaft bearing cap bolts to 5 N.m (44 lb in).

    2. Final Pass

       Tighten: Tighten the camshaft bearing cap bolts an additional 30 degrees using the **J 45059** . See **Special Tools** .

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CYLINDER HEAD INSTALLATION - RIGHT SIDE

TOOLS REQUIRED

J 45059 Angle Meter. See **Special Tools** .

INSTALLATION PROCEDURE

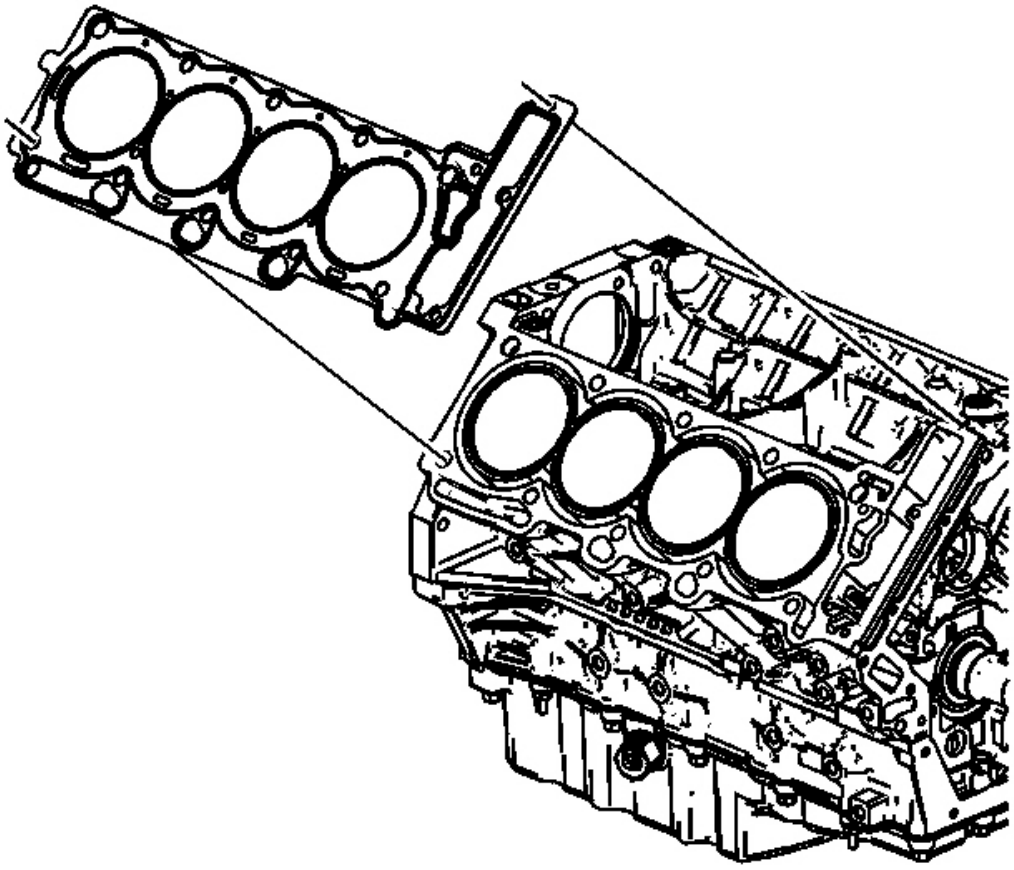


Fig. 349: View Of Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Ensure all the cylinder head locating pins are securely mounted in the cylinder block deck face.

IMPORTANT: Failure to remove all the old thread sealant material from the cylinder block could cause false torque readings.

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2. Ensure any old thread sealant material is removed from the cylinder head bolt holes in the cylinder block.
3. Install a new right cylinder head gasket using the deck face locating pins for retention.

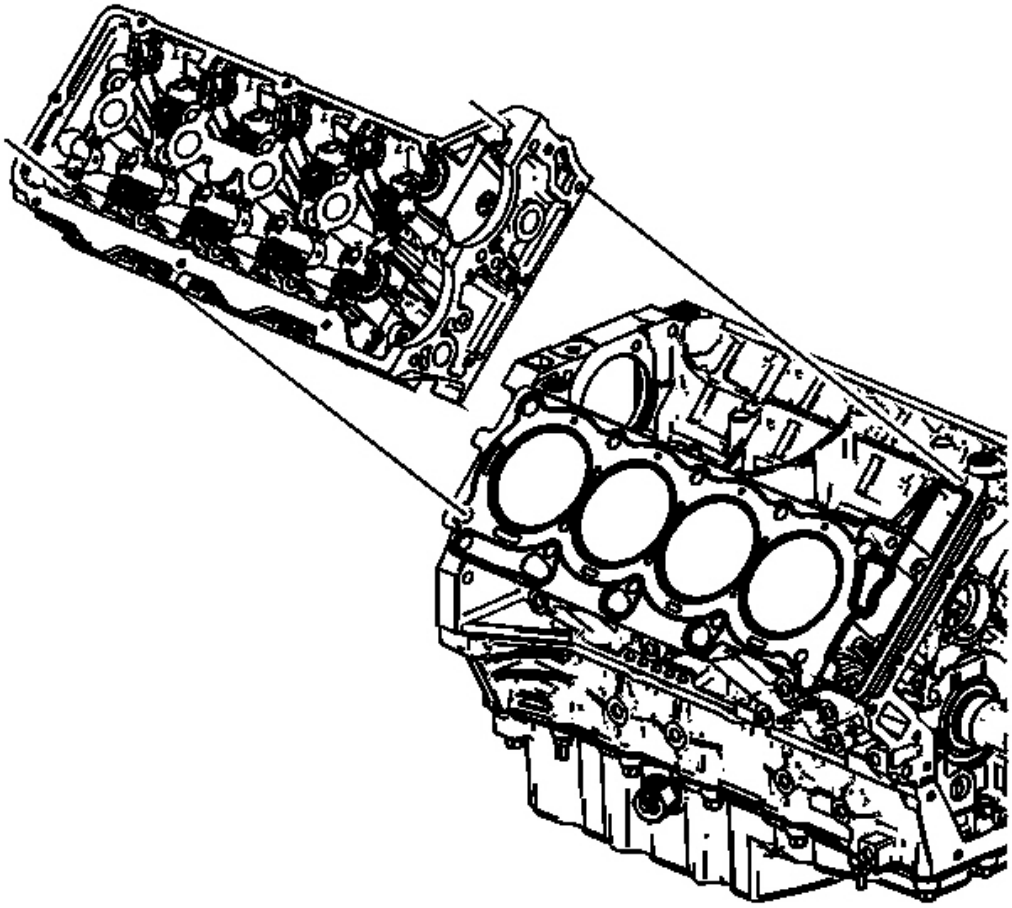


Fig. 350: View Of Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Align the cylinder head with the deck face locating pins.
5. Place the cylinder head in position on the deck face.

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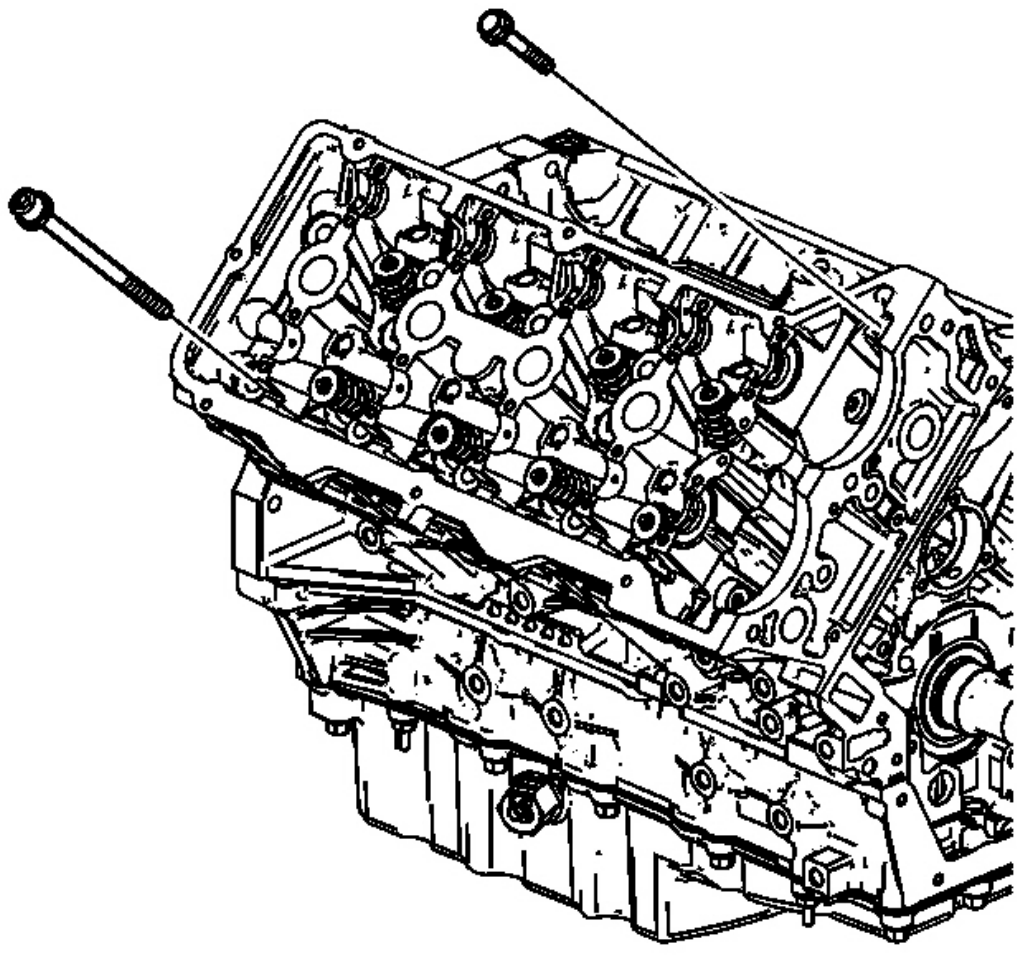


Fig. 351: View Of Right Cylinder Head M6 External Drive Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the old M11 cylinder head bolts.

6. Install new M11 cylinder head bolts in the cylinder head.
7. Install the M6 cylinder head bolts at the front of the cylinder head.

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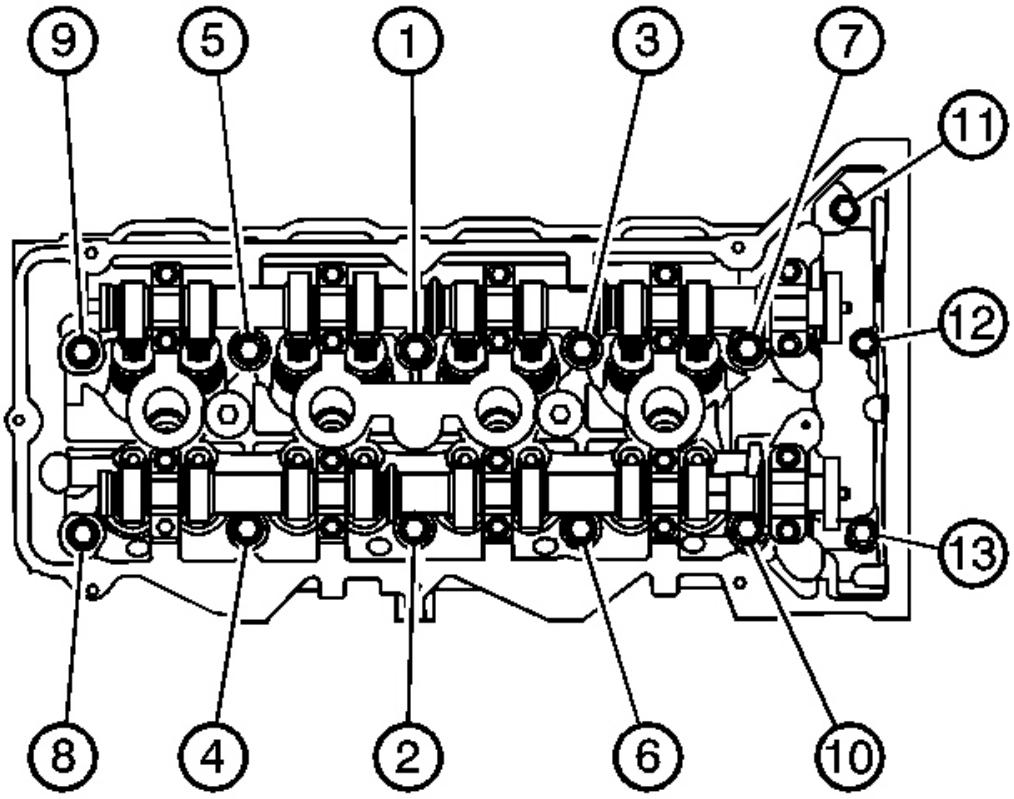


Fig. 352: Tightening Right Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

NOTE: **Ensure the cylinder head bolts that are being used are the proper pitch or engine damage will occur. The thread pitch on the M11 cylinder head bolts and the engine block cylinder head bolt holes have been revised. In order to prevent engine damage it is important to identify which thread pitch is being used. Cylinder head bolts with a pitch of 1.5 mm have a thread length of about 48 mm (1.890 in) long. Cylinder head bolts with a pitch of 2.0 mm have a thread length of about 67 mm (2.638 in) long.**

8. Tighten the right cylinder head bolts in the sequence shown.
    1. First Pass

    Tighten: Tighten the right cylinder head M11 cylinder head bolts to 30 N.m (22 lb ft) in the

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sequence shown.

2. Second Pass

   Tighten: Using the **J 45059** , tighten the right cylinder head M11 cylinder head bolts an additional 60 degrees in the sequence shown. See **Special Tools** .

3. Third Pass

   Tighten: Repeat the sequence turning each bolt another 60 degrees.

4. Fourth Pass

   Tighten: Repeat the sequence turning each bolt another 60 degrees.

5. Final Pass

   Tighten: Repeat the sequence again turning each bolt a final 40 degrees, total 220 degrees.

9. Tighten the M6 bolts at the front of the cylinder head.

   Tighten: Tighten the M6 cylinder head bolts to 12 N.m (106 lb in).

VALVE LIFTER INSTALLATION - RIGHT SIDE

TOOLS REQUIRED

J 39946 Crankshaft Socket - 4. See **Special Tools** .0 L and 4.6 L

INSTALLATION PROCEDURE

1. Ensure the crankshaft is in the TDC position for the number one cylinder using the **J 39946** . See **Special Tools** .

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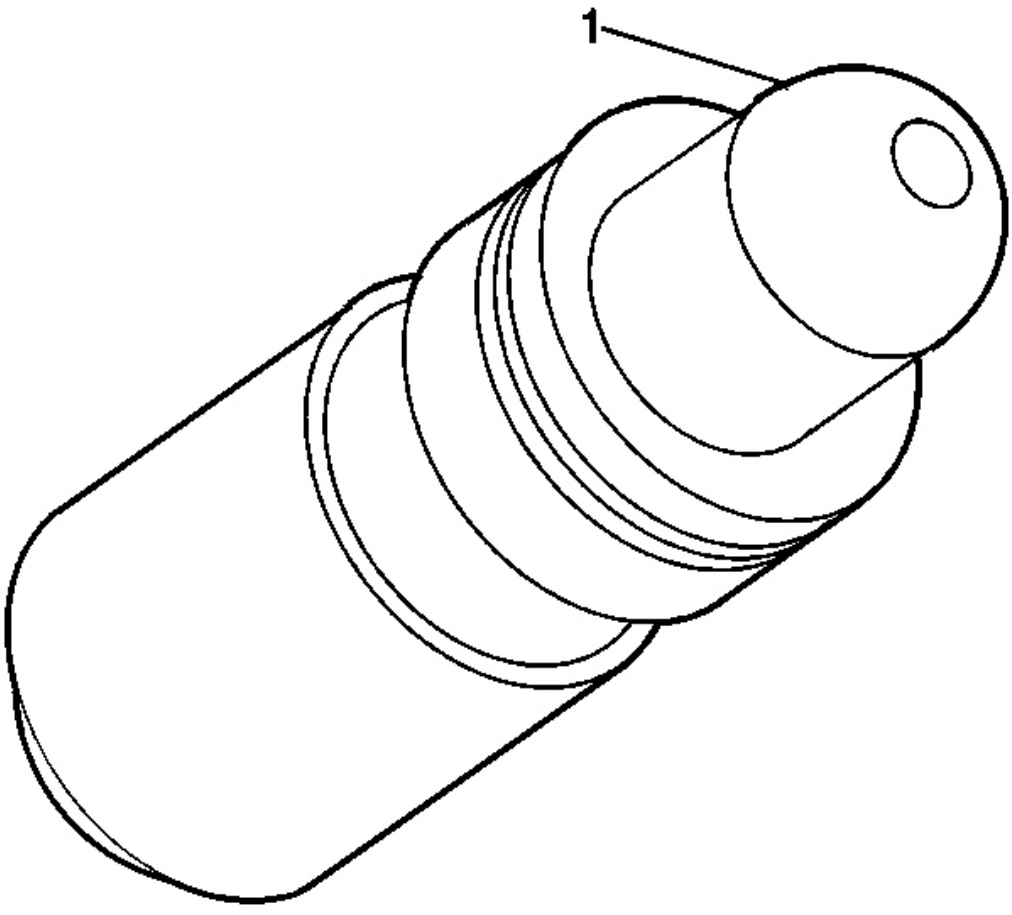


Fig. 353: View Of Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Valve Lifter Priming Notice .

2. Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil GM P/N 12378006 or equivalent. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.
3. Lubricate the SHLA bores of the cylinder head with clean engine oil GM P/N 12378006 or equivalent.

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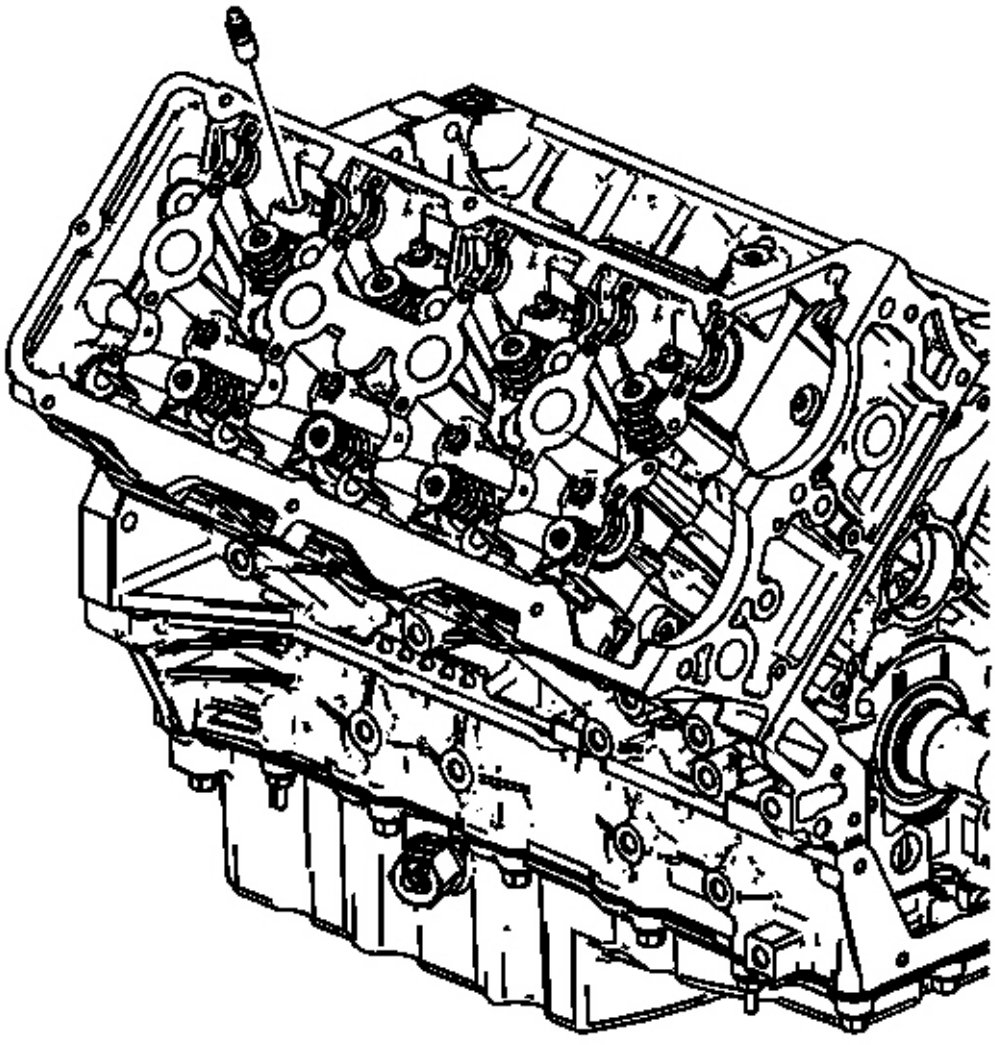


Fig. 354: View Of Right Valve Lifter
Courtesy of GENERAL MOTORS CORP.

4. Install the SHLAs.
5. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the SHLA sphere.

VALVE ROCKER ARM INSTALLATION - RIGHT SIDE

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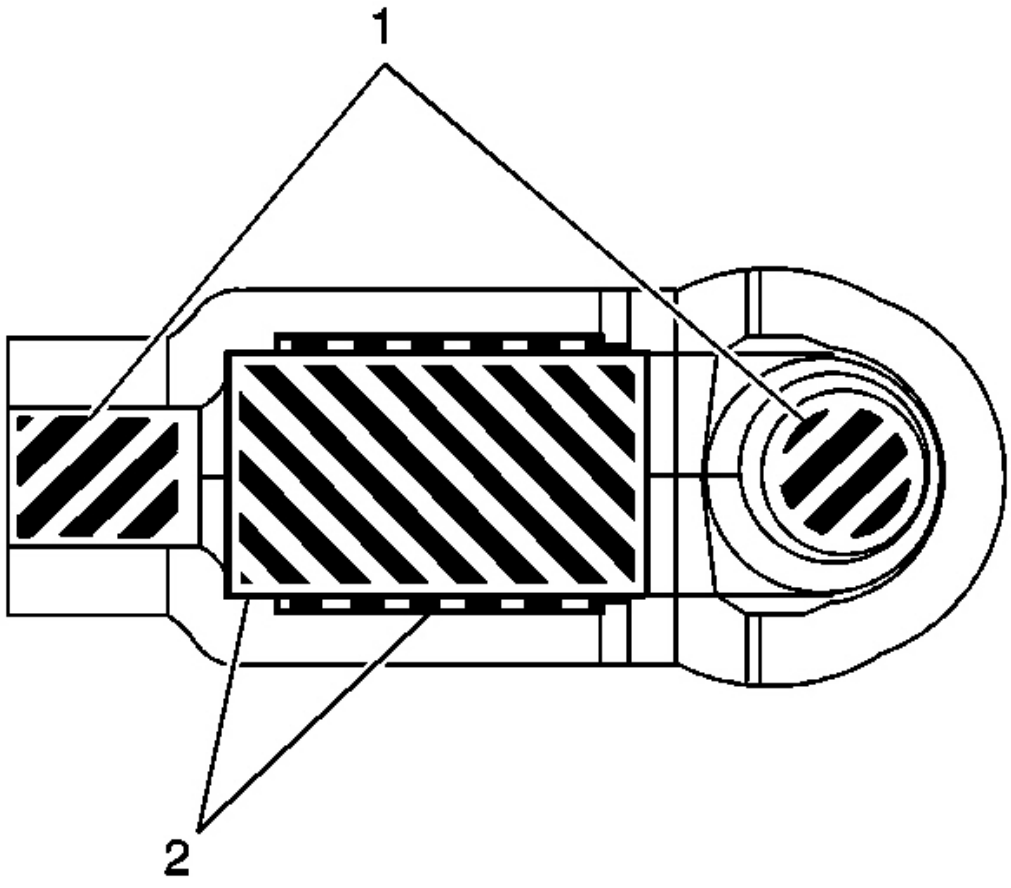


Fig. 355: Identifying Roller Pivot Pocket (2) & Valve Slot Areas (1) Of Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

1. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the roller (2), pivot pocket and valve slot areas (1) of the camshaft followers.

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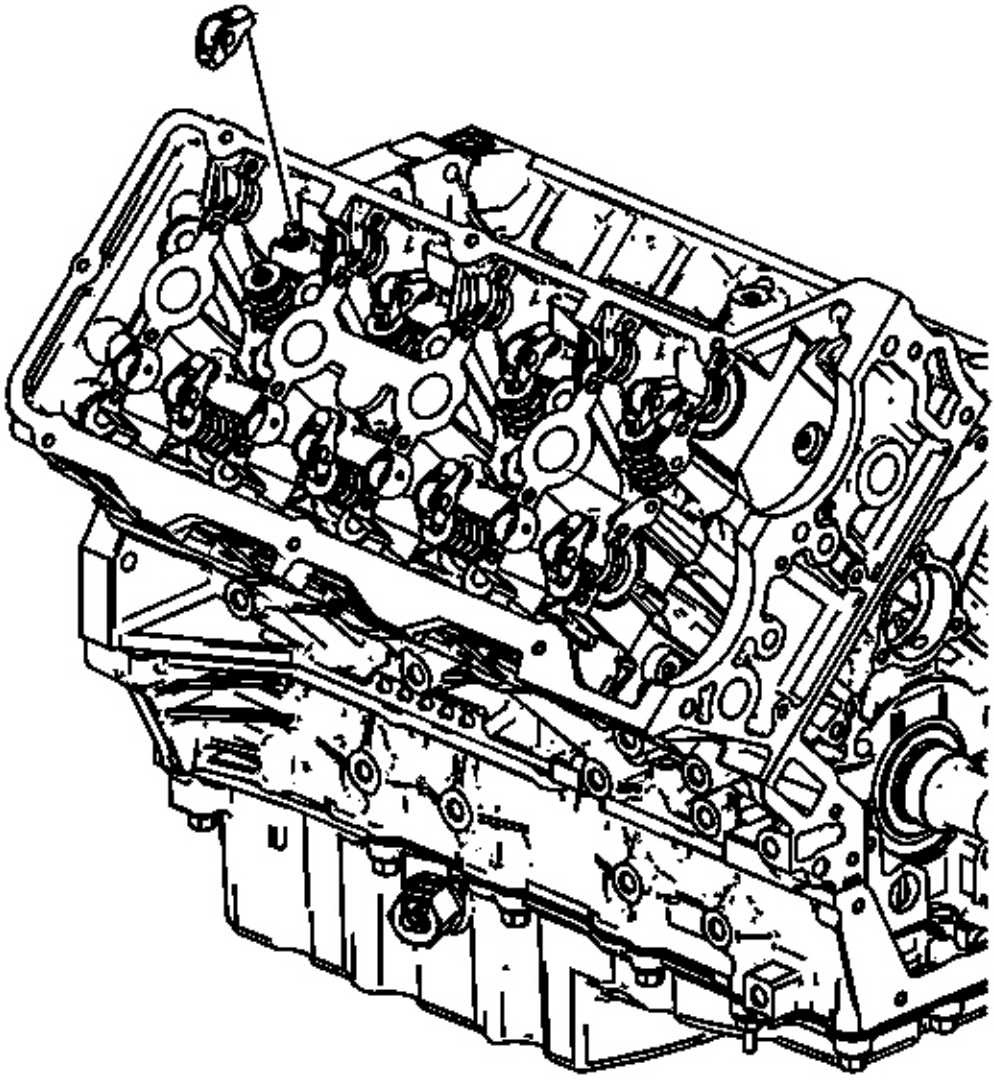


Fig. 356: View Of Right Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

2. Place the camshaft followers in position on the valve tip and SHLA. The rounded head of the follower

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goes on the SHLA while the flat end goes on the valve tip.

EXHAUST CAMSHAFT INSTALLATION - RIGHT SIDE

TOOLS REQUIRED

J 45059 Angle Meter. See **Special Tools** .

INSTALLATION PROCEDURE

1. Clean the camshaft journals, camshaft and the camshaft caps with a clean, lint-free cloth.

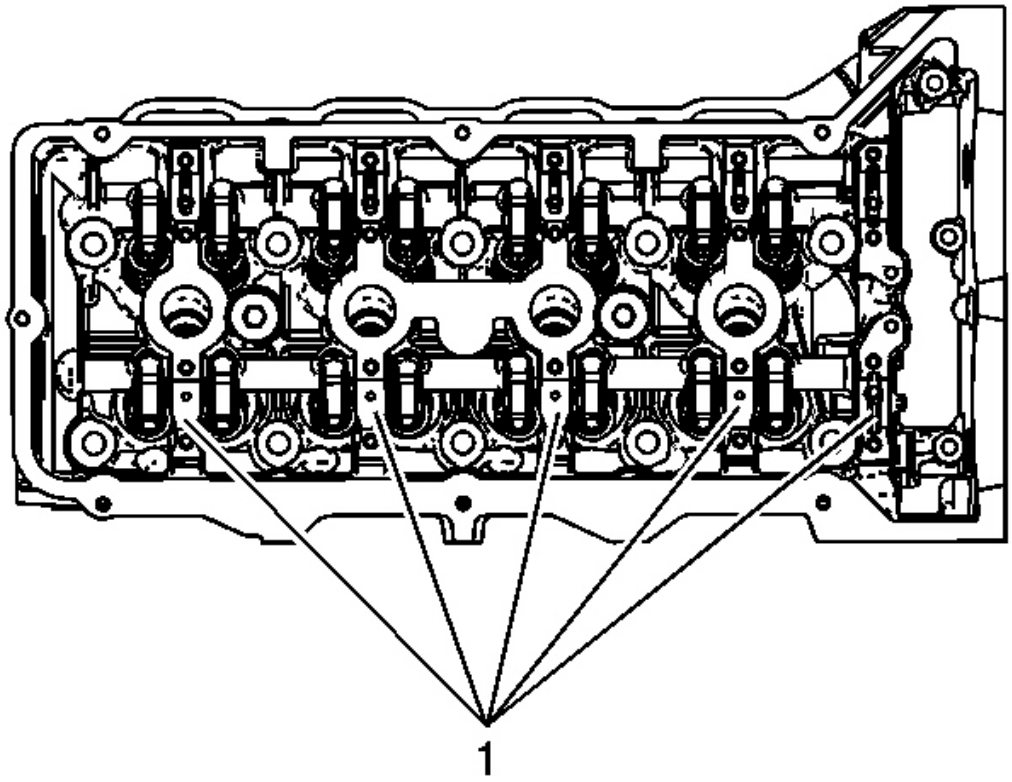


Fig. 357: Locating Right Exhaust Camshaft Bearing Journals
Courtesy of GENERAL MOTORS CORP.

2. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the camshaft bearing journals (1).

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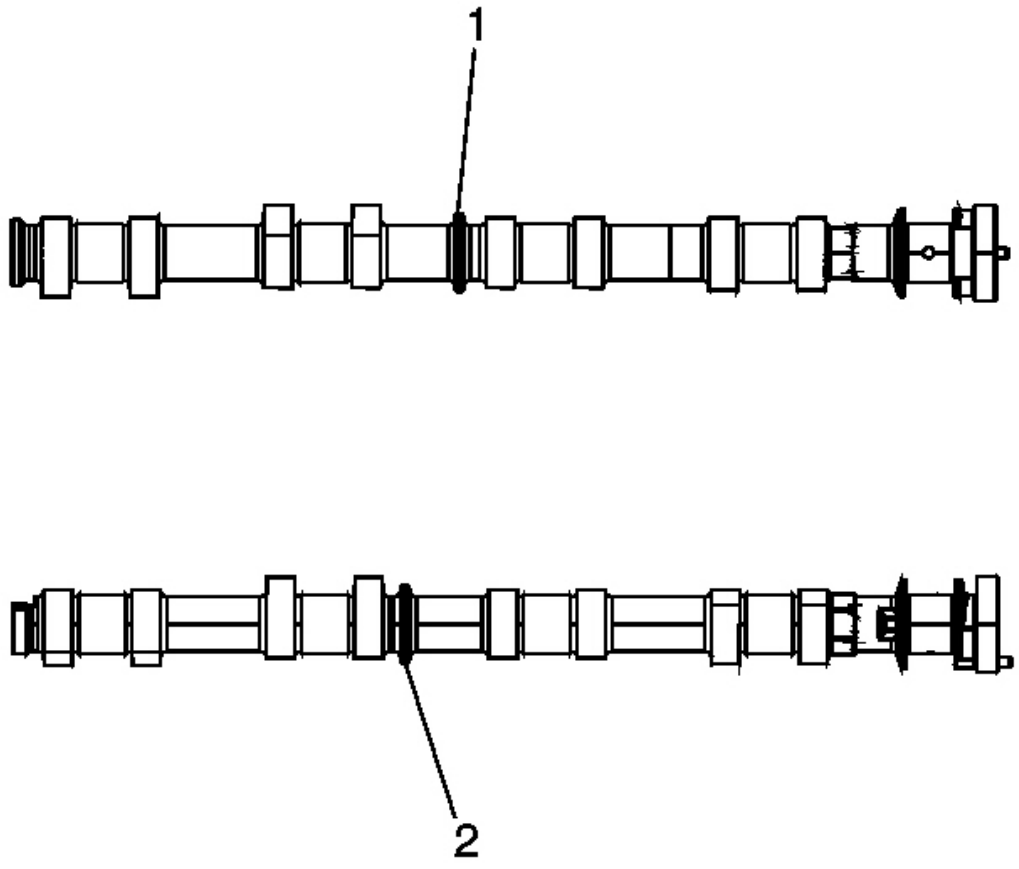


Fig. 358: Applying Lubricant To Camshaft Bearing Journals
Courtesy of GENERAL MOTORS CORP.

3. Select the proper camshaft by the identifying ring cast into the right exhaust camshaft (2).

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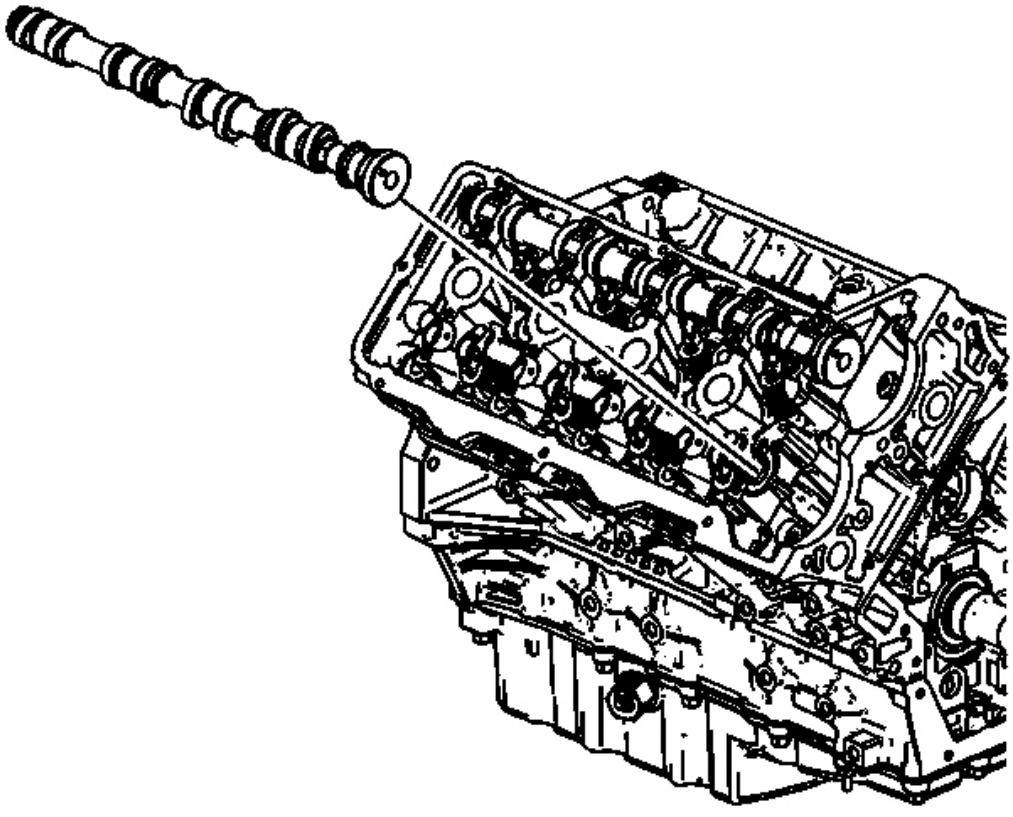


Fig. 359: View Of Right Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the camshaft lobes and the camshaft journals.

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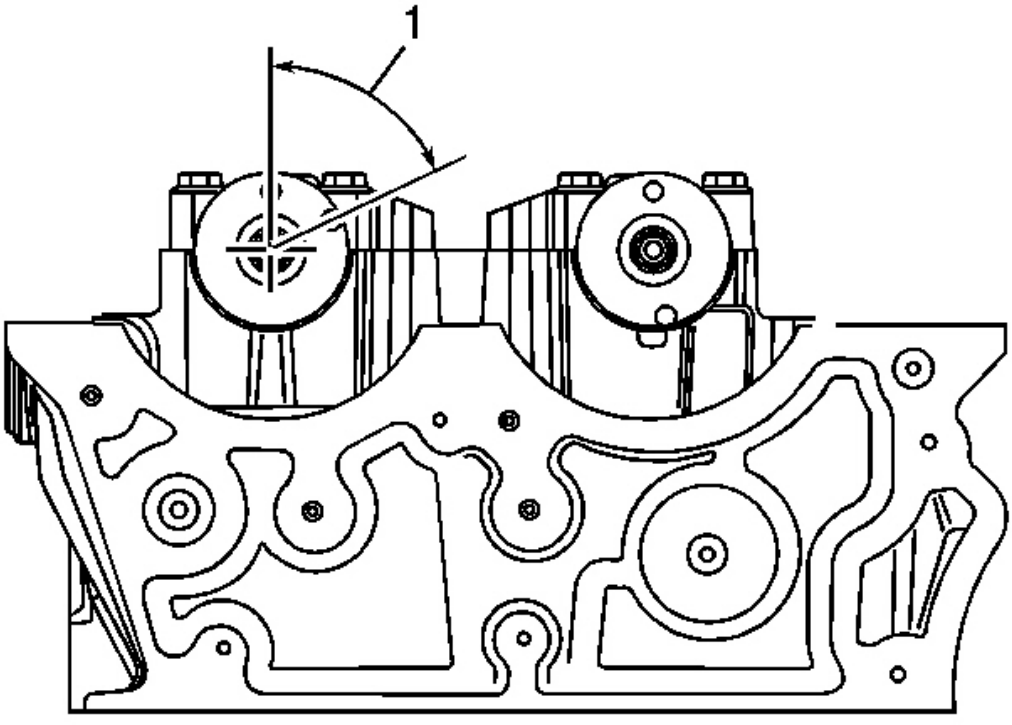


Fig. 360: Aligning Right Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure each valve rocker arm is properly aligned to the valve tip, the valve lifter and the camshaft lobe. Inspect the alignment prior to and after the camshaft caps are tightened to specifications.

5. Place the camshaft in the camshaft journals with the camshaft sprocket drive pins near the 45 to 60 degree location (1), clockwise from the top of their rotation and the camshaft lobes in a neutral position. The camshaft can be identified by a stamping near the rear journal. For example: R-EXH is defined as Right Bank Exhaust.

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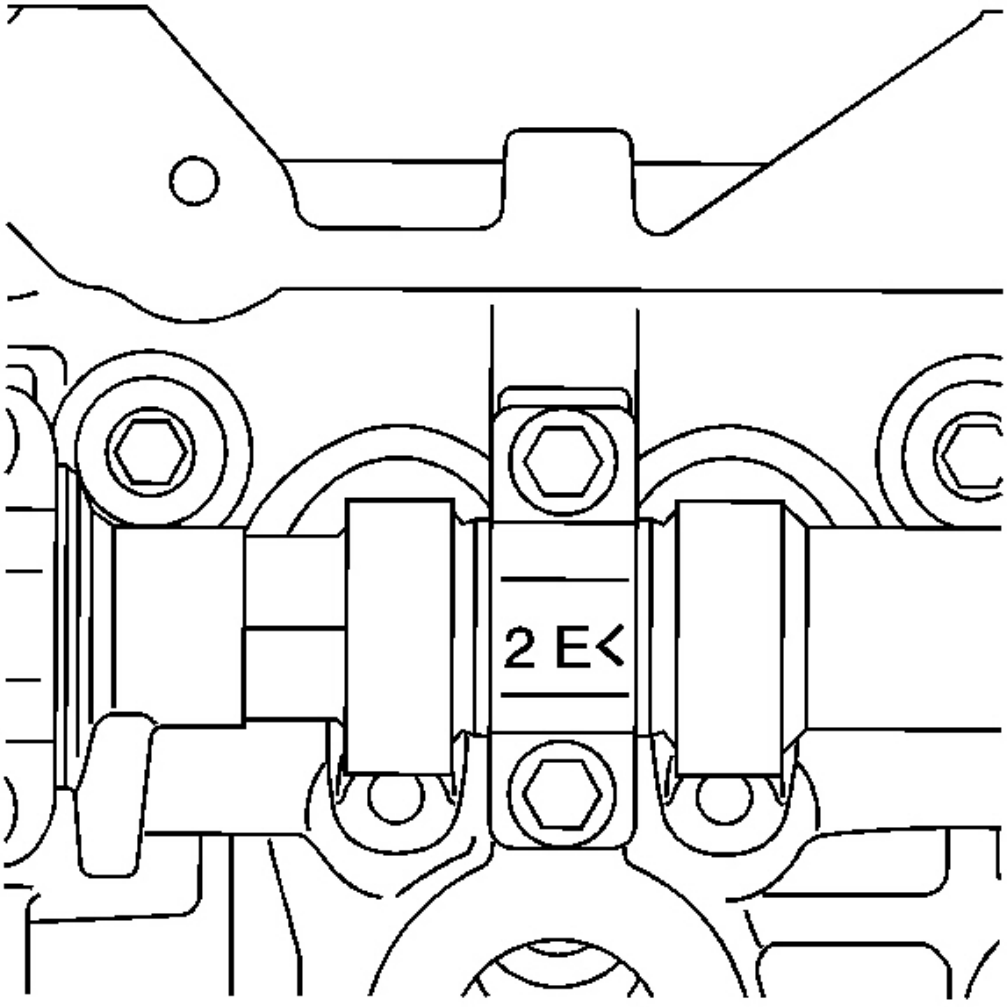


Fig. 361: View Of Exhaust Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS CORP.

6. Observe the markings on the camshaft bearing caps. Each camshaft bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The arrow should point toward the front of the engine.
   - The number indicates the position from the front of the engine.
   - The "E" indicates the exhaust camshaft.
7. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the right exhaust camshaft bearing cap journals.

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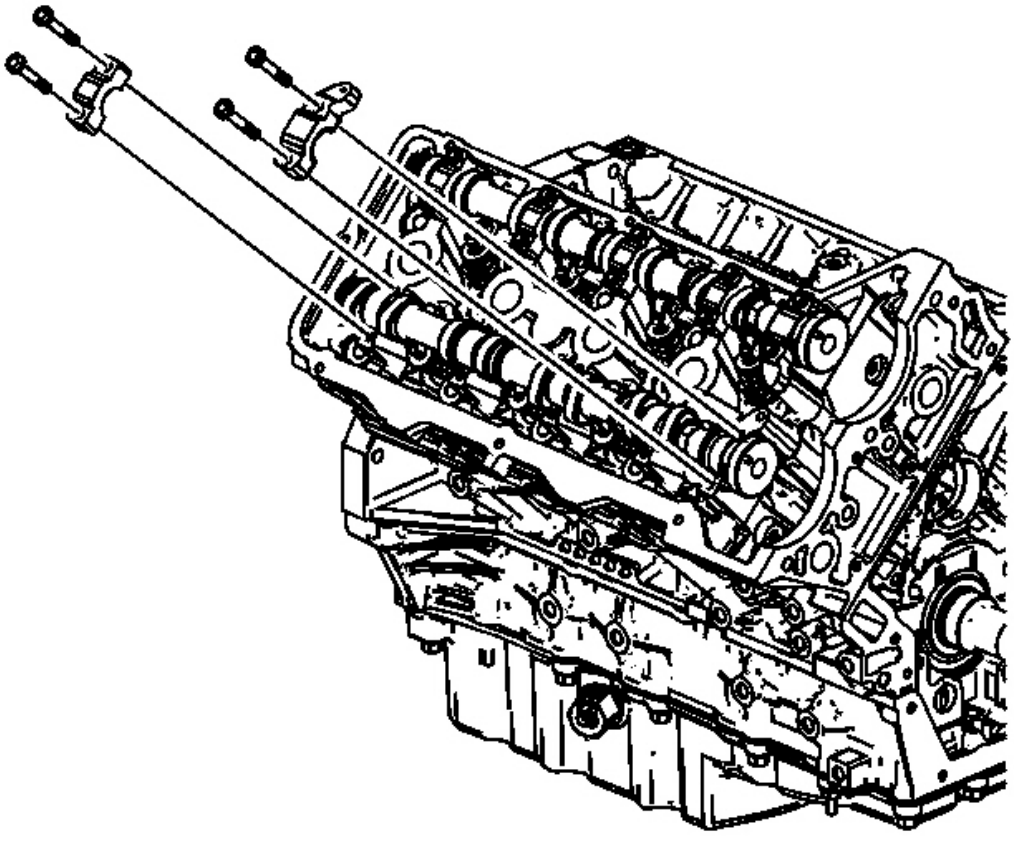


Fig. 362: View Of Right Exhaust Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

8. Install the right exhaust camshaft bearing caps according to the identifications marks.
9. Hand start all the right exhaust camshaft bearing cap bolts.

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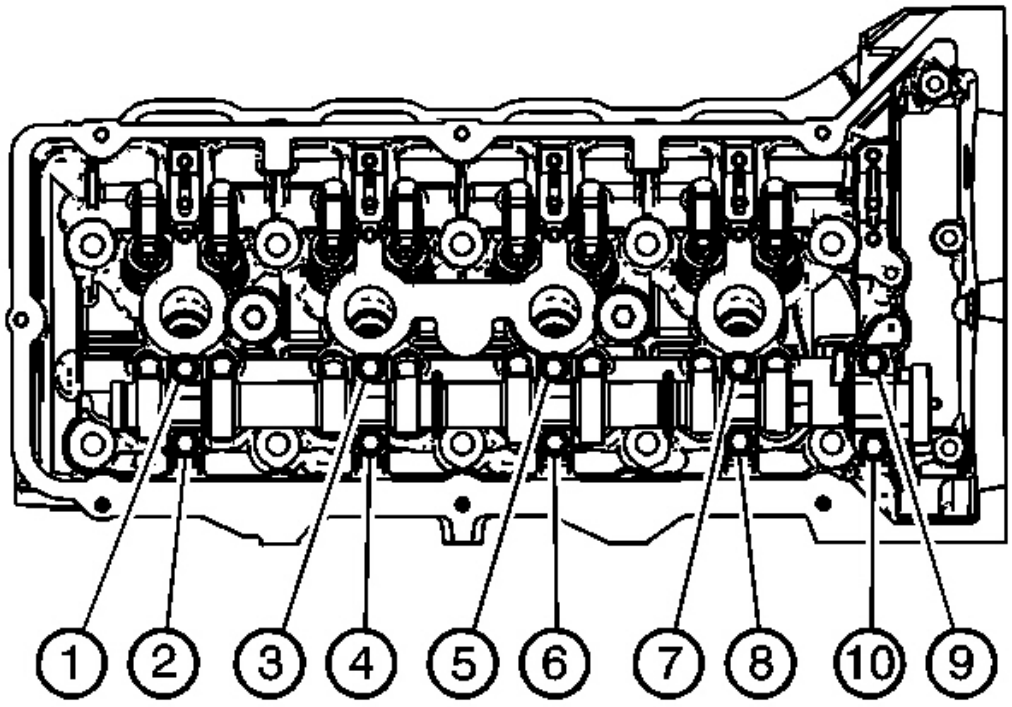


Fig. 363: Tightening Right Cylinder Head Exhaust Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

IMPORTANT: **Ensure each valve rocker arm is properly aligned to the valve tip, the valve lifter and the camshaft lobe. Inspect the alignment prior to and after the camshaft caps are tightened to specifications.**

10. Install the right cylinder head exhaust camshaft bearing cap bolts.
    1. First Pass

       Tighten: Tighten the camshaft bearing cap bolts to 5 N.m (44 lb in).

    2. Final Pass

       Tighten: Tighten the camshaft bearing cap bolts an additional 30 degrees using the **J 45059** . See **Special Tools** .

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INTAKE CAMSHAFT INSTALLATION - RIGHT SIDE

TOOLS REQUIRED

J 45059 Angle Meter. See **Special Tools** .

INSTALLATION PROCEDURE

1. Clean the camshaft journals, camshaft and the camshaft caps with a clean, lint-free cloth.

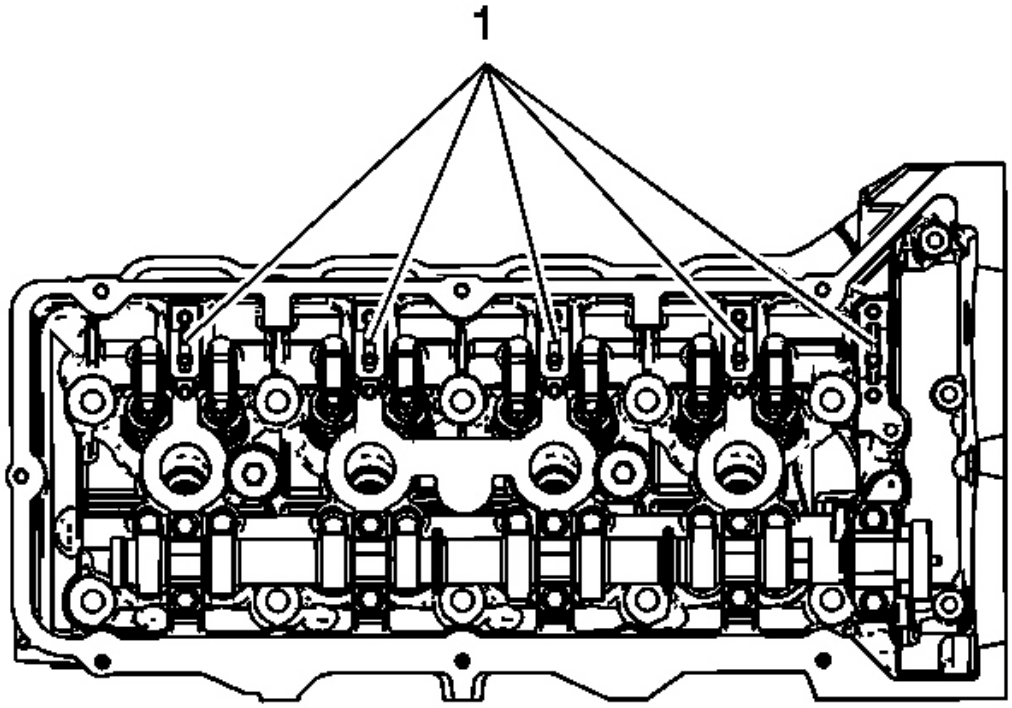


Fig. 364: Locating Right Intake Camshaft Bearing Journals
Courtesy of GENERAL MOTORS CORP.

2. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the camshaft bearing journals (1).

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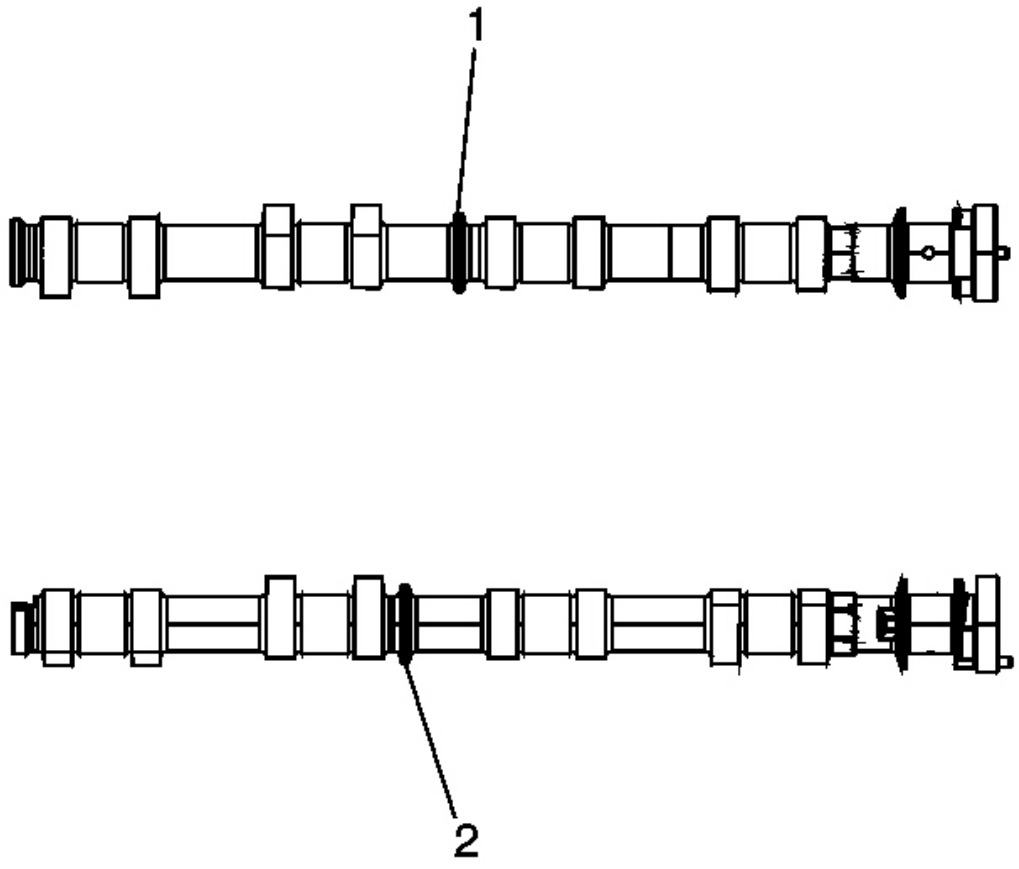


Fig. 365: Applying Lubricant To Camshaft Bearing Journals
Courtesy of GENERAL MOTORS CORP.

3. Select the proper camshaft by the identifying ring cast into the right intake camshaft (1).

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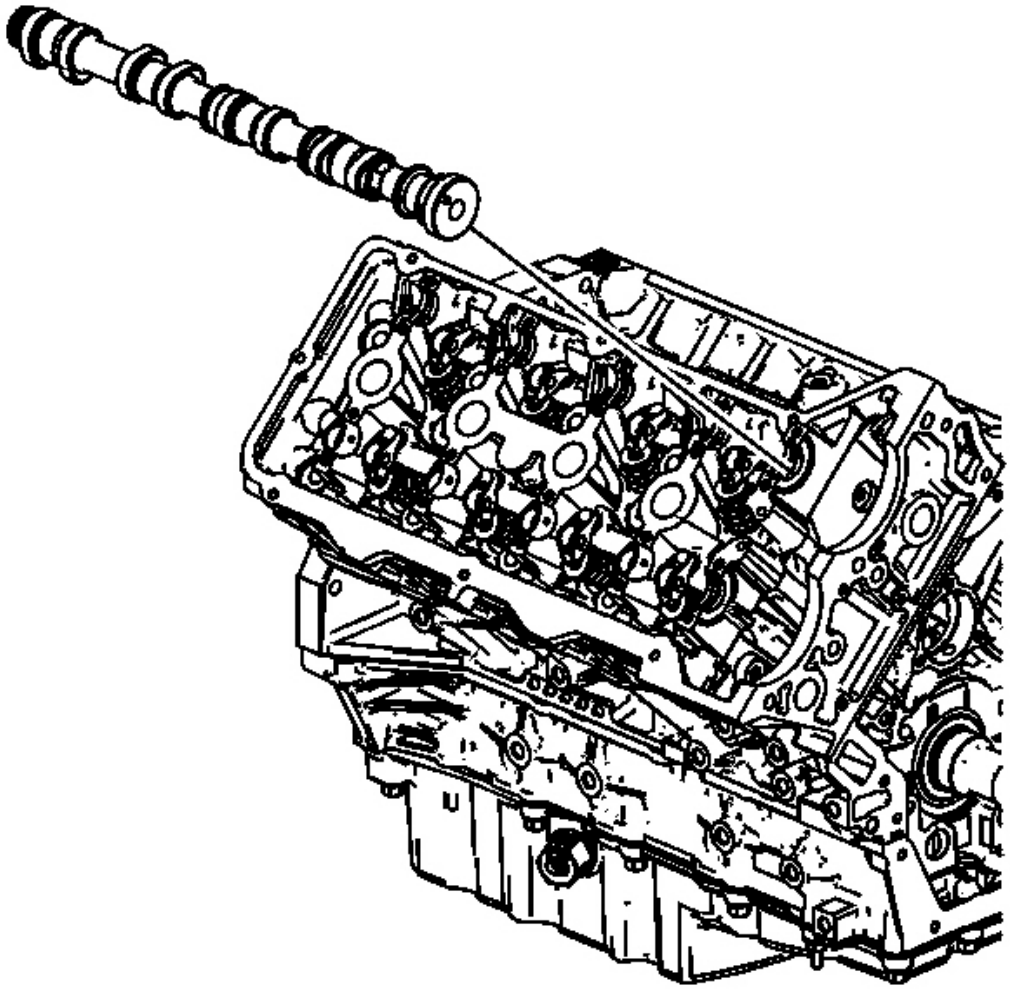


Fig. 366: View Of Right Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the camshaft lobes and the camshaft journals.

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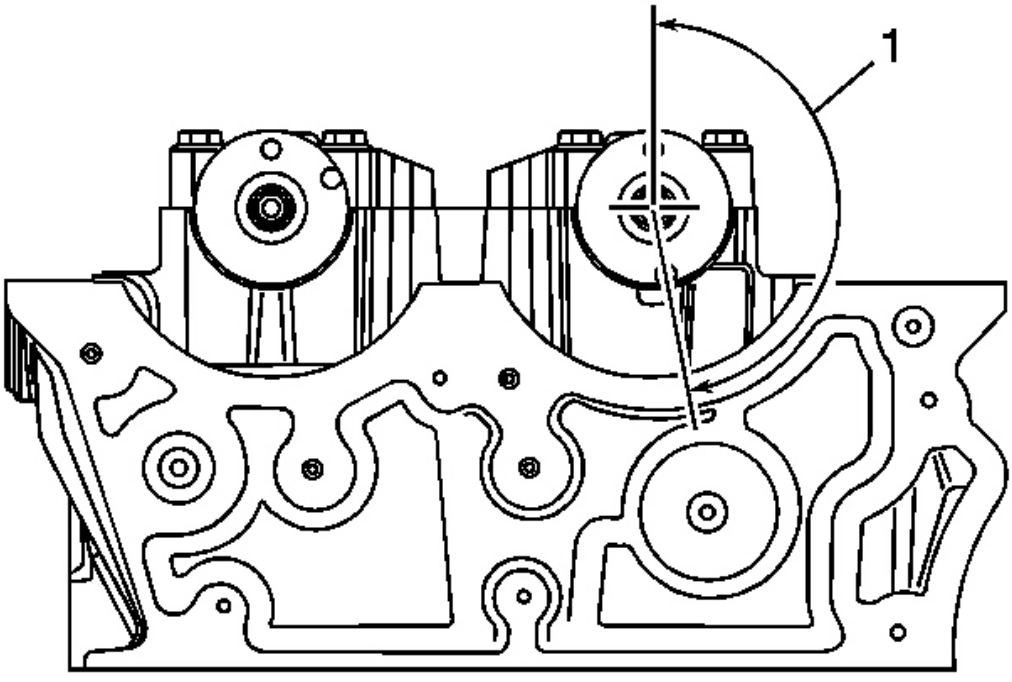


Fig. 367: Aligning Right Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure each valve rocker arm is properly aligned to the valve tip, the valve lifter and the camshaft lobe. Inspect the alignment prior to and after the camshaft caps are tightened to specifications.

5. Place the camshaft in the camshaft carriers with the camshaft sprocket drive pins near the 45 to 60 degree location (1), clockwise from the top of their rotation and the camshaft lobes in a neutral position. The camshafts can be identified by a stamping near the rear journal. For example: L-EXH is defined as Left Bank Exhaust.

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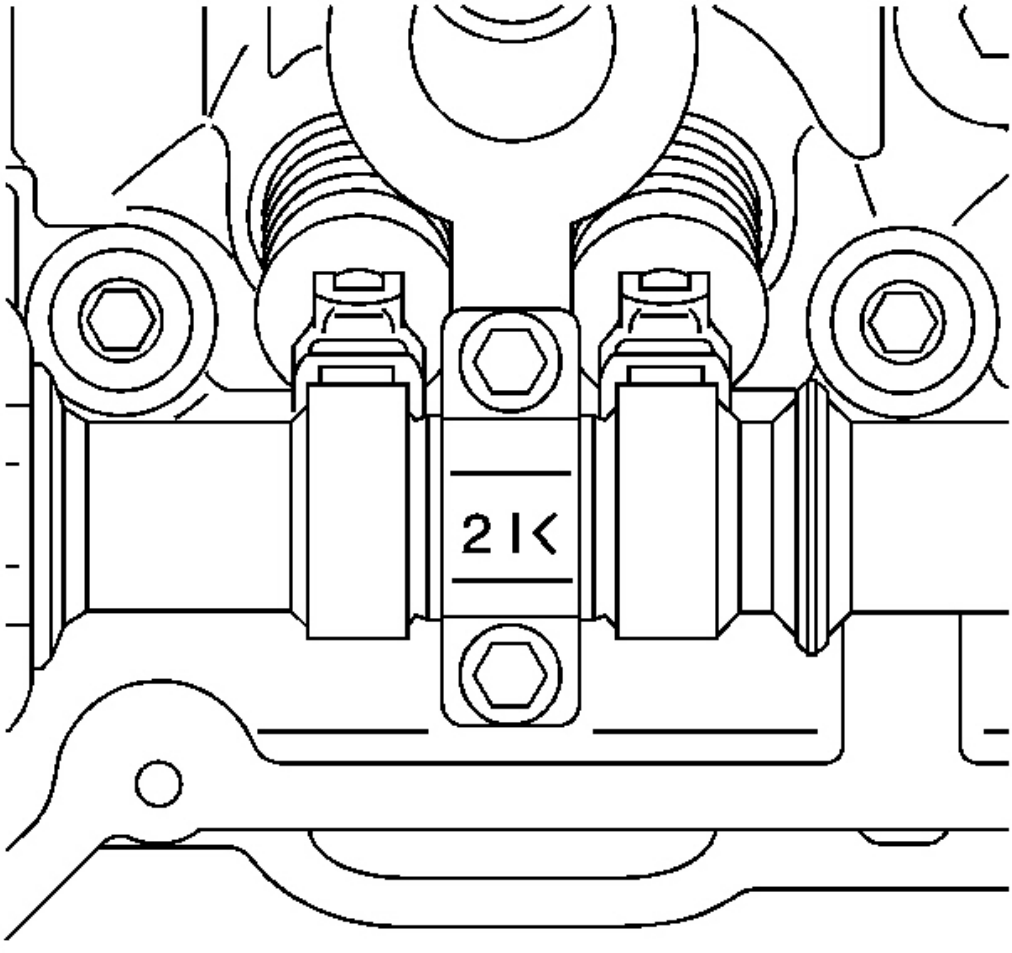


Fig. 368: View Of Intake Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS CORP.

6. Observe the markings on the camshaft bearing caps. Each camshaft bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The arrow should point toward the front of the engine.
   - The number indicates the position from the front of the engine.
   - The "I" indicates the intake camshaft.
7. Apply a liberal amount of lubricant GM P/N 12345001 or equivalent to the right intake camshaft bearing cap journals.

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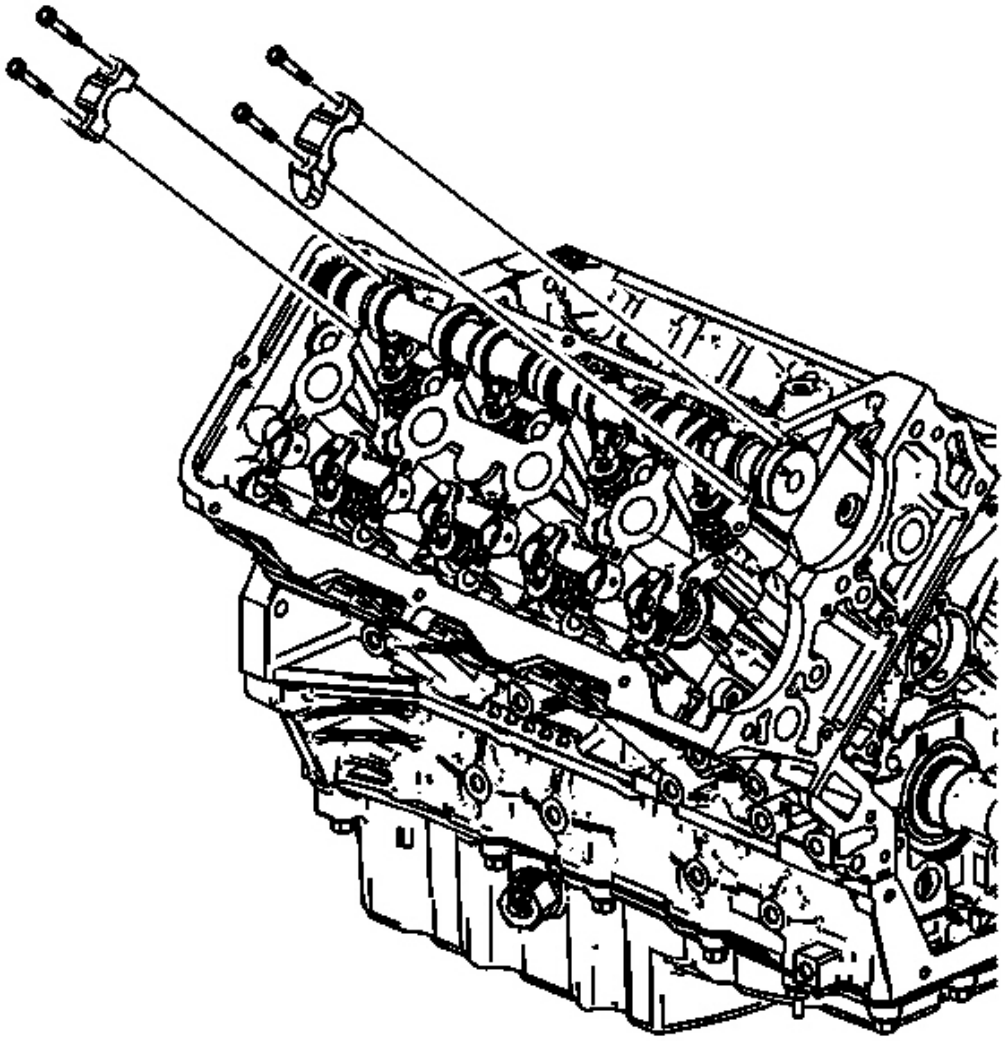


Fig. 369: View Of Right Intake Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

8. Install the right intake camshaft bearing caps according to the identifications marks.
9. Hand start all the right intake camshaft bearing cap bolts.

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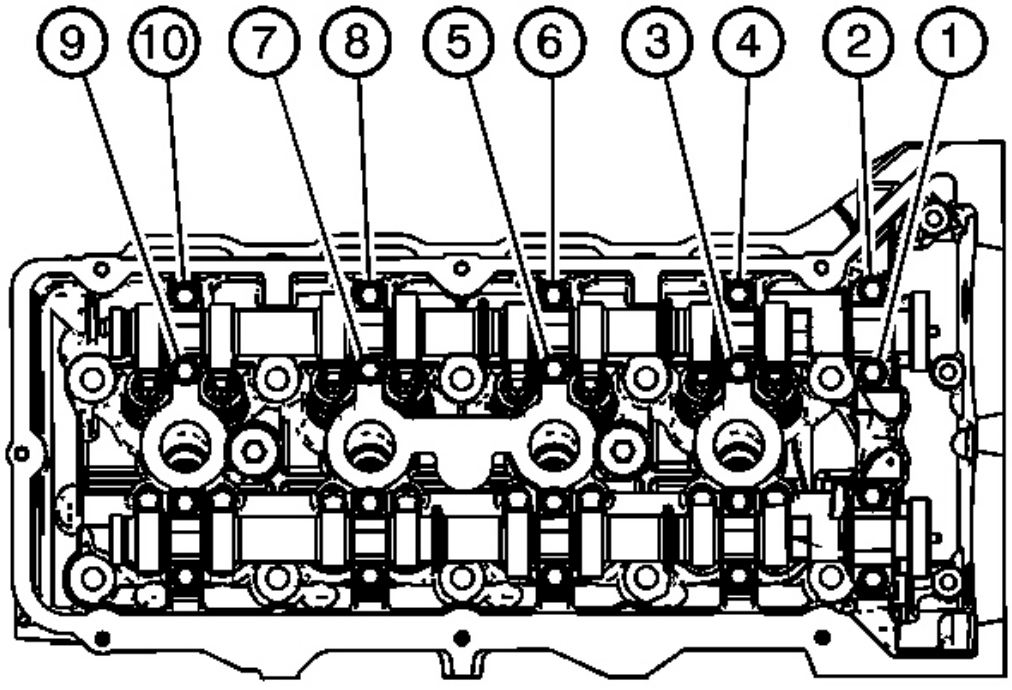


Fig. 370: Tightening Right Cylinder Head Intake Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Ensure each valve rocker arm is properly aligned to the valve tip, the valve lifter and the camshaft lobe. Inspect the alignment prior to and after the camshaft caps are tightened to specifications.

10. Install the right cylinder head intake camshaft bearing cap bolts.
    1. First Pass

       Tighten: Tighten the camshaft bearing cap bolts to 5 N.m (44 lb in).

    2. Final Pass

       Tighten: Tighten the camshaft bearing cap bolts an additional 30 degrees using the **J 45059** . See **Special Tools** .

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CAMSHAFT INTERMEDIATE DRIVE SHAFT INSTALLATION

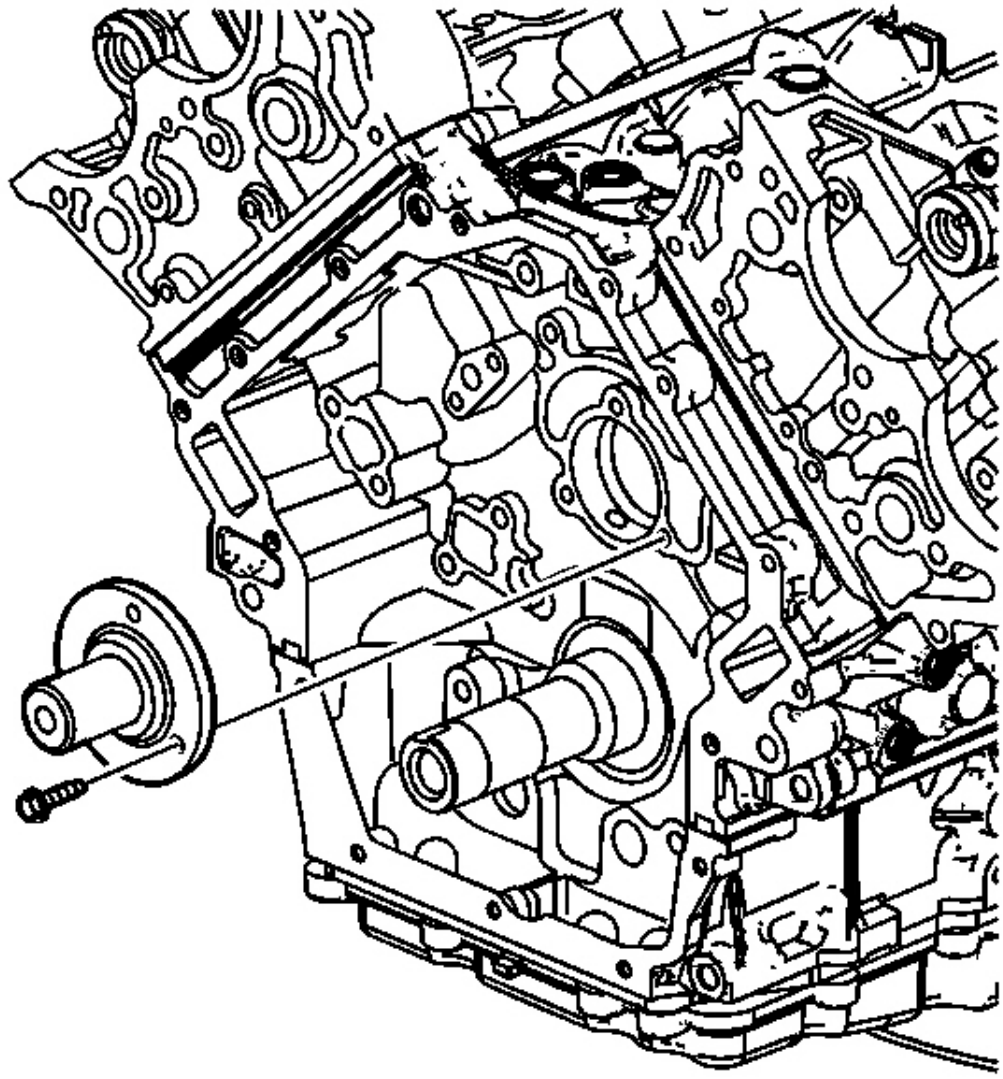


Fig. 371: View Of Intermediate Sprocket Shaft & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

Install the intermediate sprocket shaft and the retaining bolts.

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Tighten: Tighten the intermediate sprocket shaft bolts to 15 N.m (11 lb ft).

PRIMARY CAMSHAFT DRIVE CHAIN INSTALLATION

TOOLS REQUIRED

J 39946 Crankshaft Socket - 4.0L and 4.6L

INSTALLATION PROCEDURE

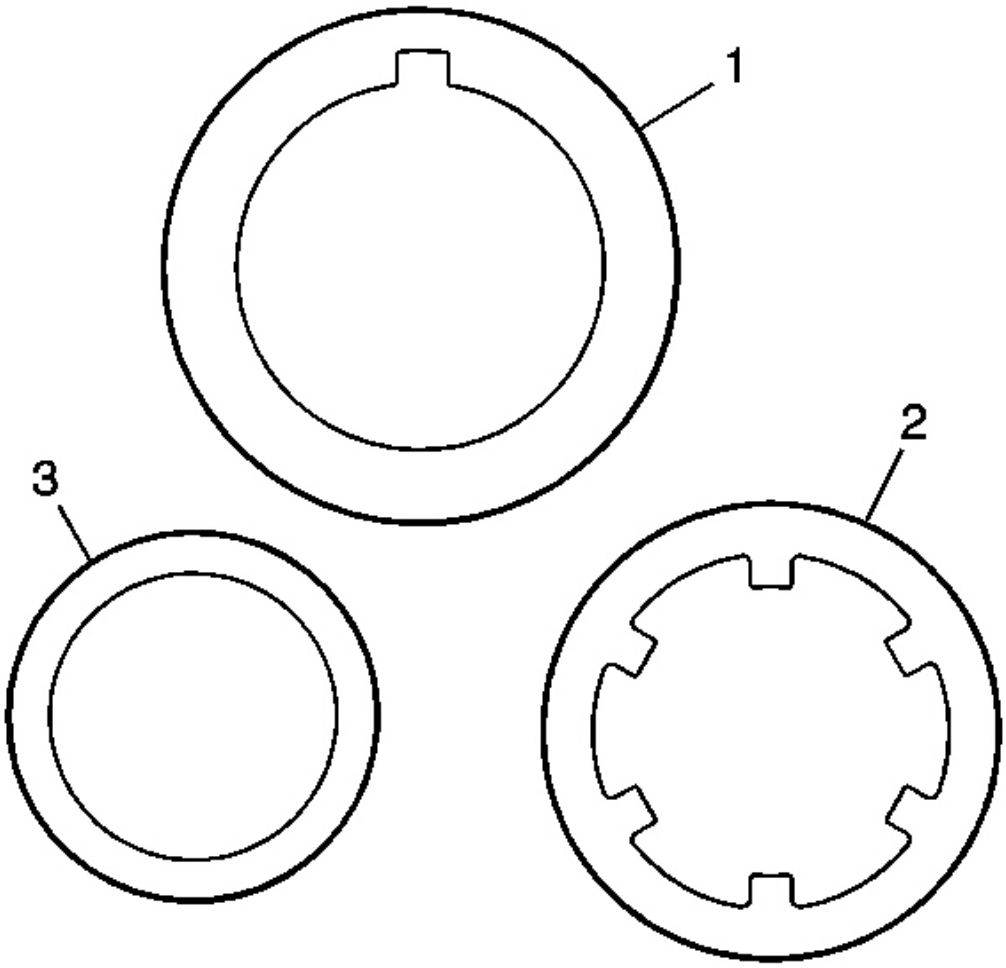


Fig. 372: View Of Friction Washers
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: Ensure the proper friction washer is installed in the correct position.

1. Select the crankshaft to crankshaft sprocket friction washer (1). The outer diameter is 63.5 mm (2.5000 in), an inner diameter of 45.25 mm (1.7815 in) and a notch to clear the crankshaft pin.

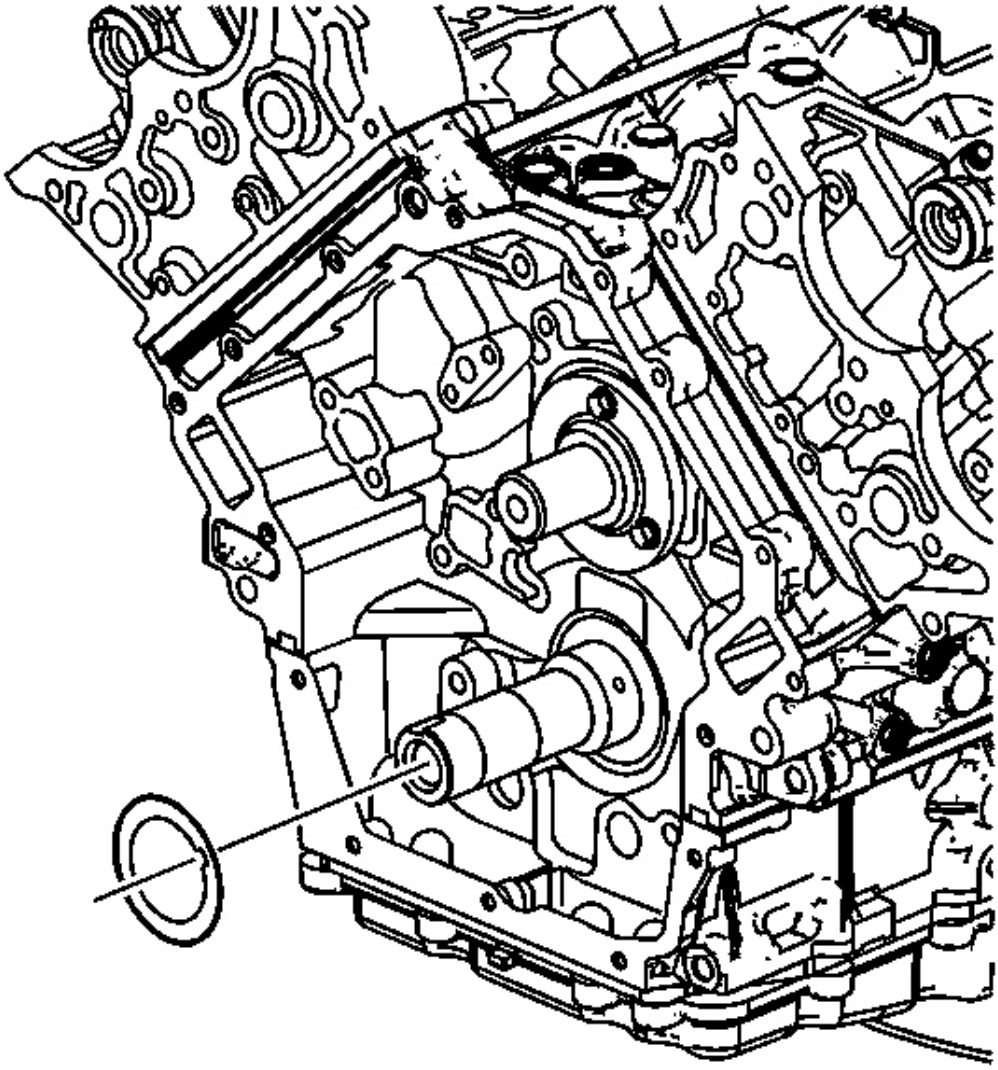


Fig. 373: View Of Crankshaft To Crankshaft Sprocket Friction Washer
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft to crankshaft sprocket friction washer.

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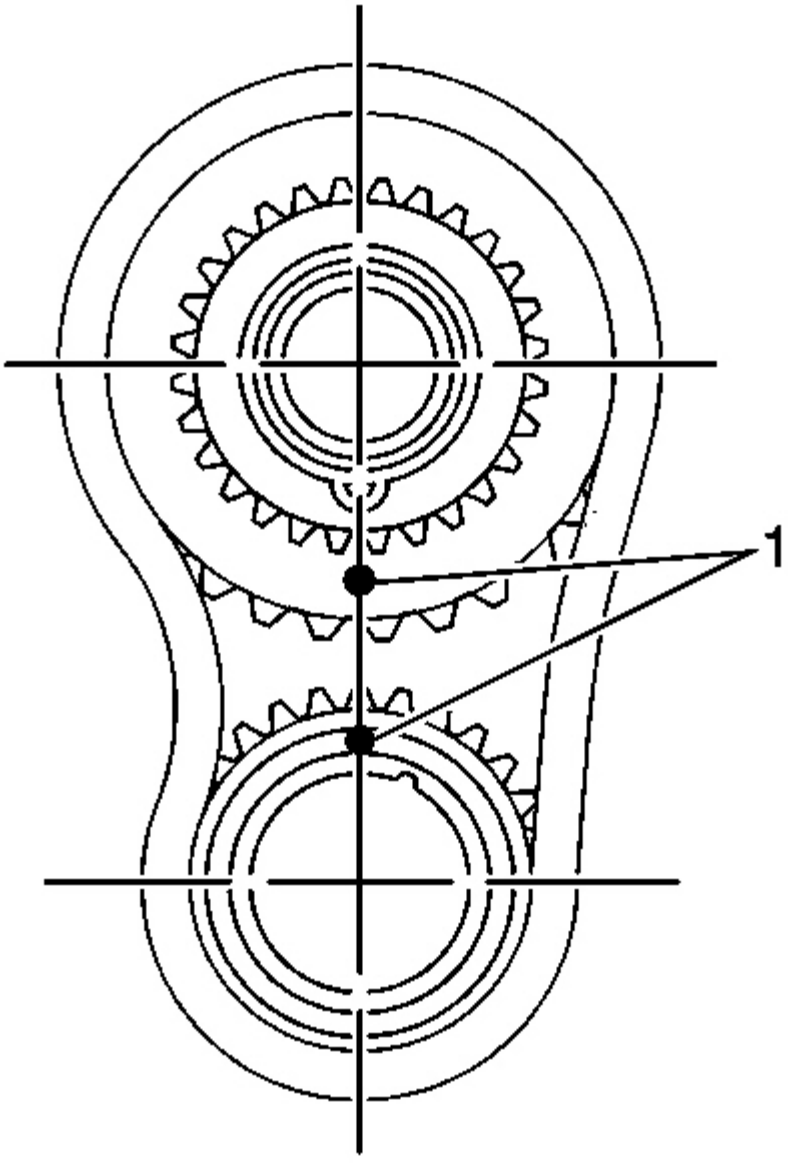


Fig. 374: Aligning Timing Marks Of Camshaft Intermediate & Crankshaft Sprockets
Courtesy of GENERAL MOTORS CORP.

3. Install the primary camshaft drive chain on the camshaft intermediate drive shaft sprocket and crankshaft sprocket.
4. Align the timing marks (1) of the camshaft intermediate drive shaft sprocket and crankshaft sprocket.

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Ensure the marks are aligned vertically.

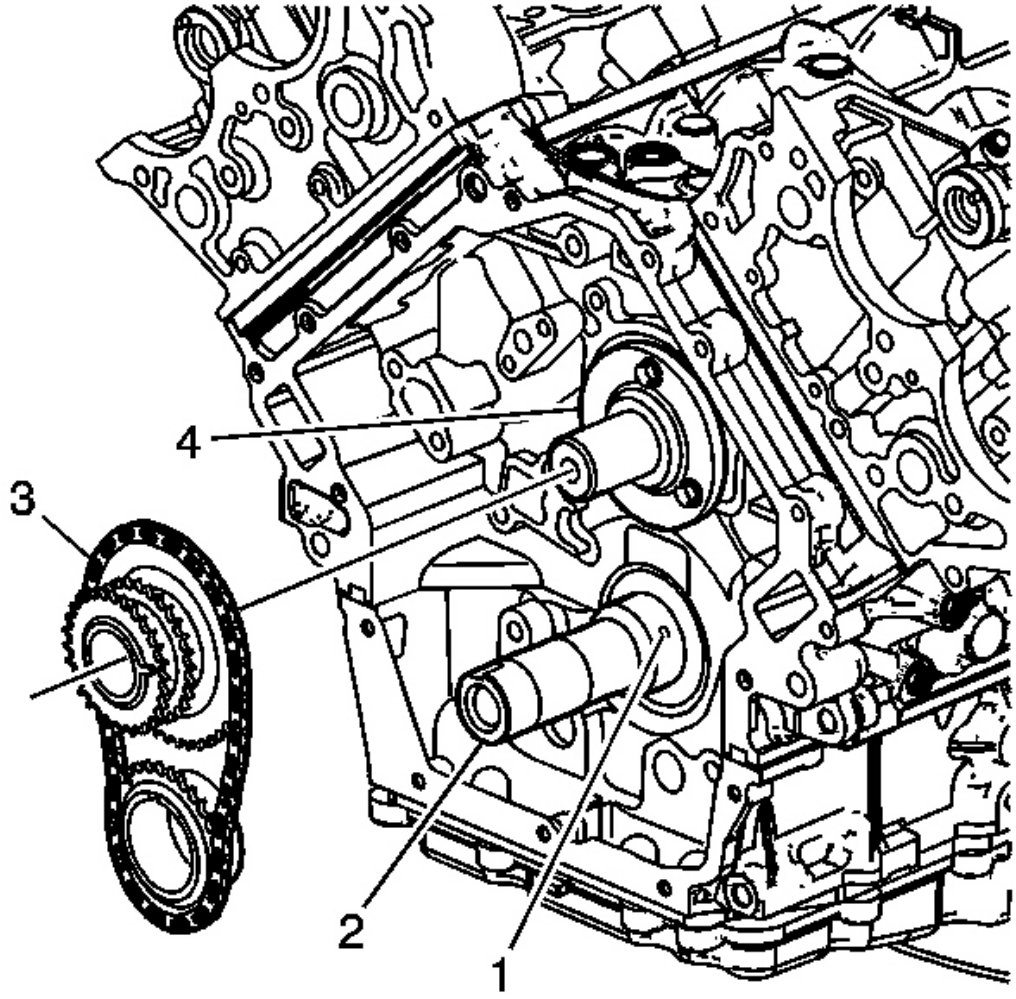


Fig. 375: View Of Primary Camshaft Drive Chain, Intermediate Drive Shaft Sprocket & Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

5. Ensure the number one piston is at Top Dead Center (TDC) and the crankshaft pin (1) is approximately at the one o'clock position using the **J 39946** . See **Special Tools** .
6. Install the primary camshaft drive chain, camshaft intermediate drive shaft sprocket and crankshaft sprocket as an assembly (3) onto the camshaft intermediate drive shaft (4) and the crankshaft (2).

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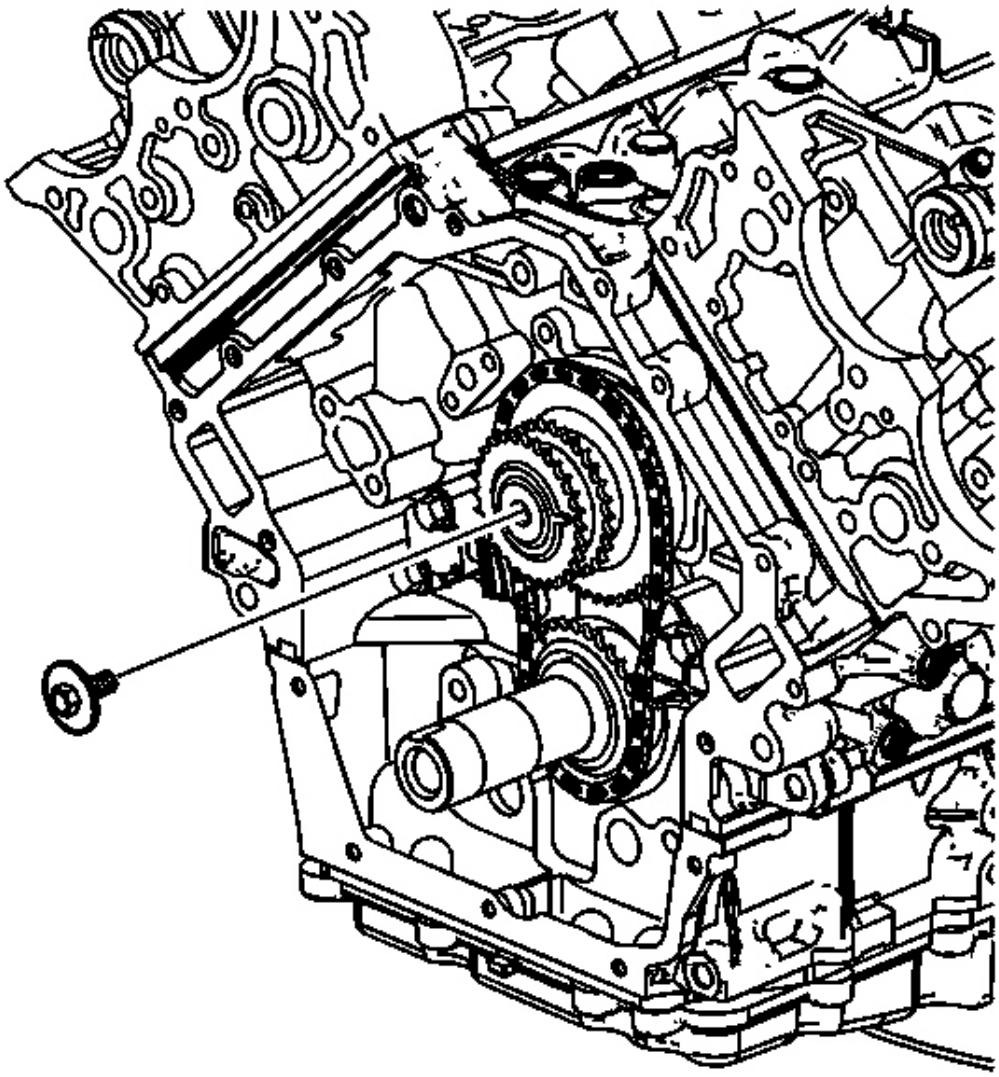


Fig. 376: View Of Camshaft Intermediate Sprocket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

7. Install the camshaft intermediate drive shaft sprocket bolt.

   Tighten: Tighten the camshaft intermediate drive shaft sprocket bolt to 60 N.m (44 lb ft).

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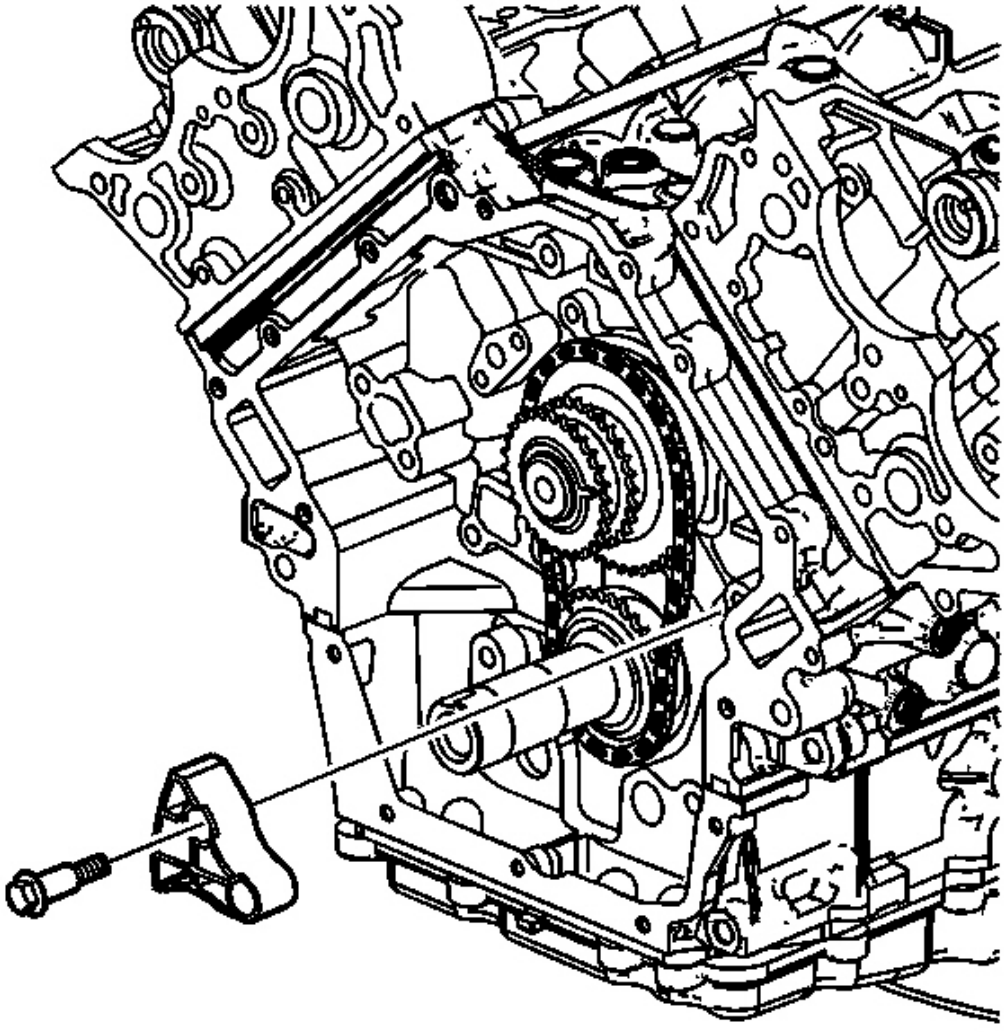


Fig. 377: View Of Primary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

8. Install the primary camshaft drive chain guide.
9. Install the primary camshaft drive chain guide bolts.

Tighten: Tighten the primary camshaft drive chain guide bolts to 25 N.m (18 lb ft).

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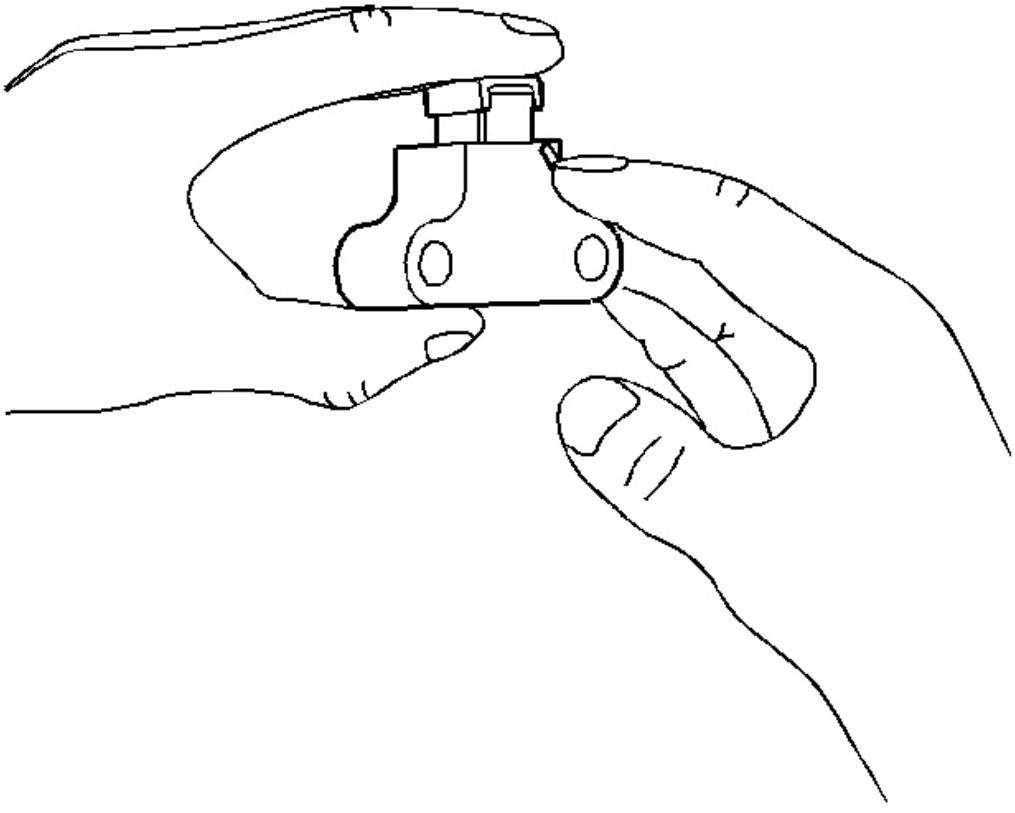


Fig. 378: Collapsing Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

10. Collapse the primary camshaft drive chain tensioner using the following procedure:
    1. Rotate the ratchet release lever counterclockwise and hold.
    2. Collapse the primary camshaft drive chain tensioner shoe and hold.
    3. Release the ratchet lever and slowly release the pressure on the shoe.
11. When the ratchet lever moves to the first detent a click should be heard and felt. Insert a pin through the hole in the release lever in order to lock the primary camshaft drive chain tensioner shoe in the collapsed position.

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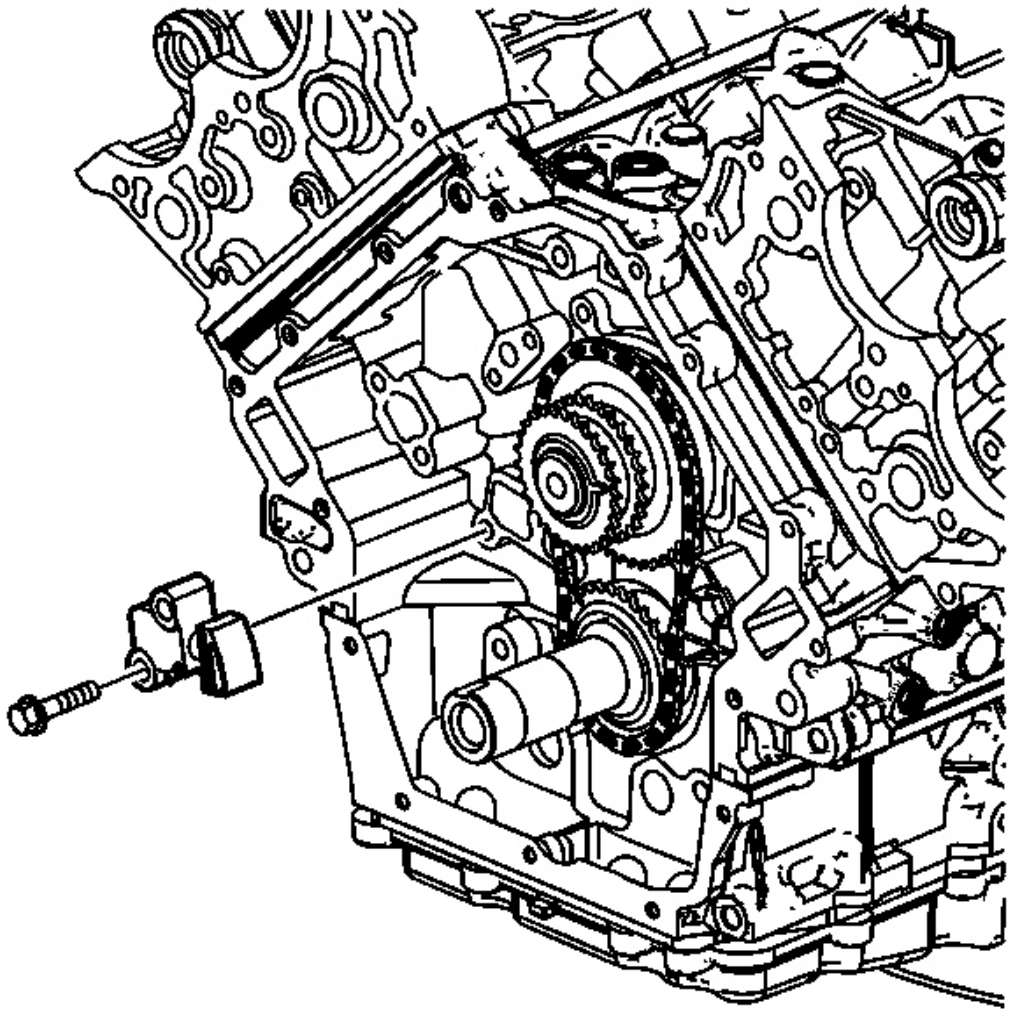


Fig. 379: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the primary camshaft drive chain tensioner release lever is facing out.

12. Install the primary camshaft drive chain tensioner.
13. Install the primary camshaft drive chain tensioner bolts.

Tighten: Tighten the primary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).

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14. Remove the pin in the release lever locking the primary camshaft drive chain tensioner.

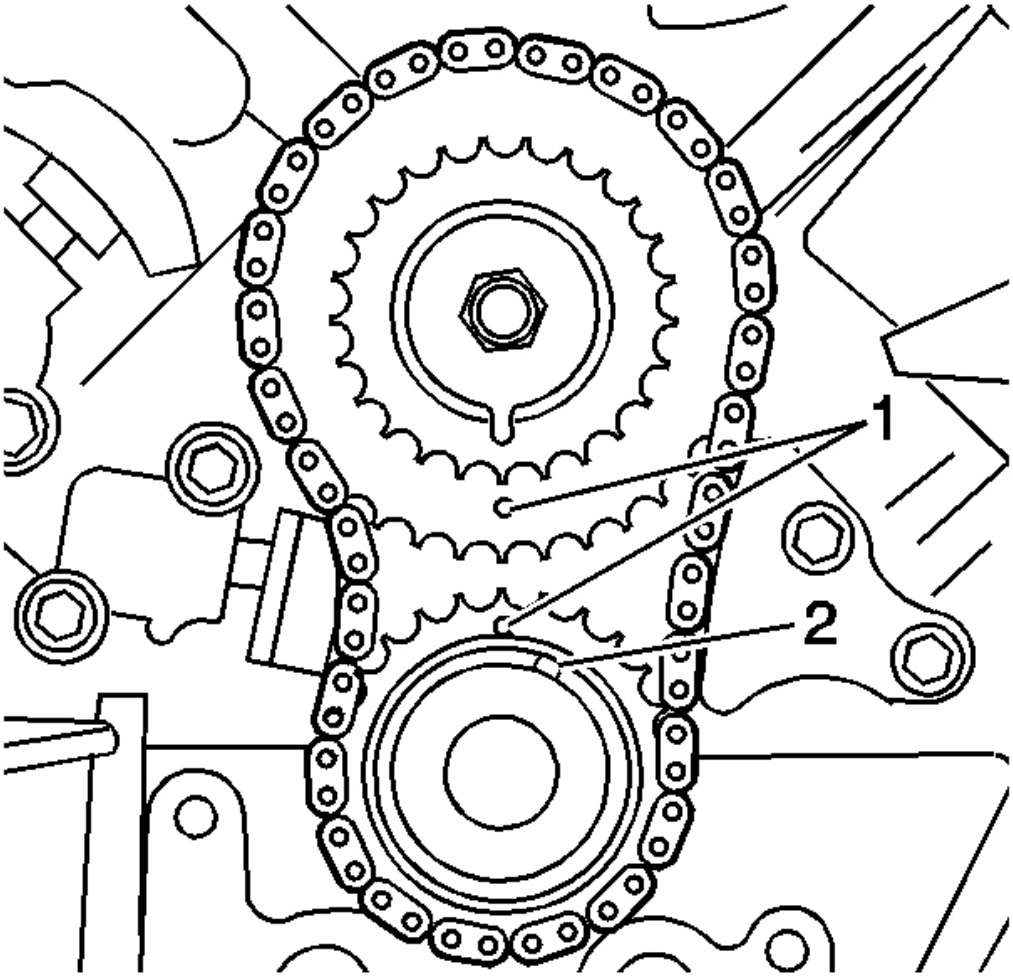


Fig. 380: Ensuring Vertical Timing Mark Alignment
Courtesy of GENERAL MOTORS CORP.

15. Ensure the timing marks (1) are aligned vertically.

OIL PUMP OUTLET TUBE INSTALLATION

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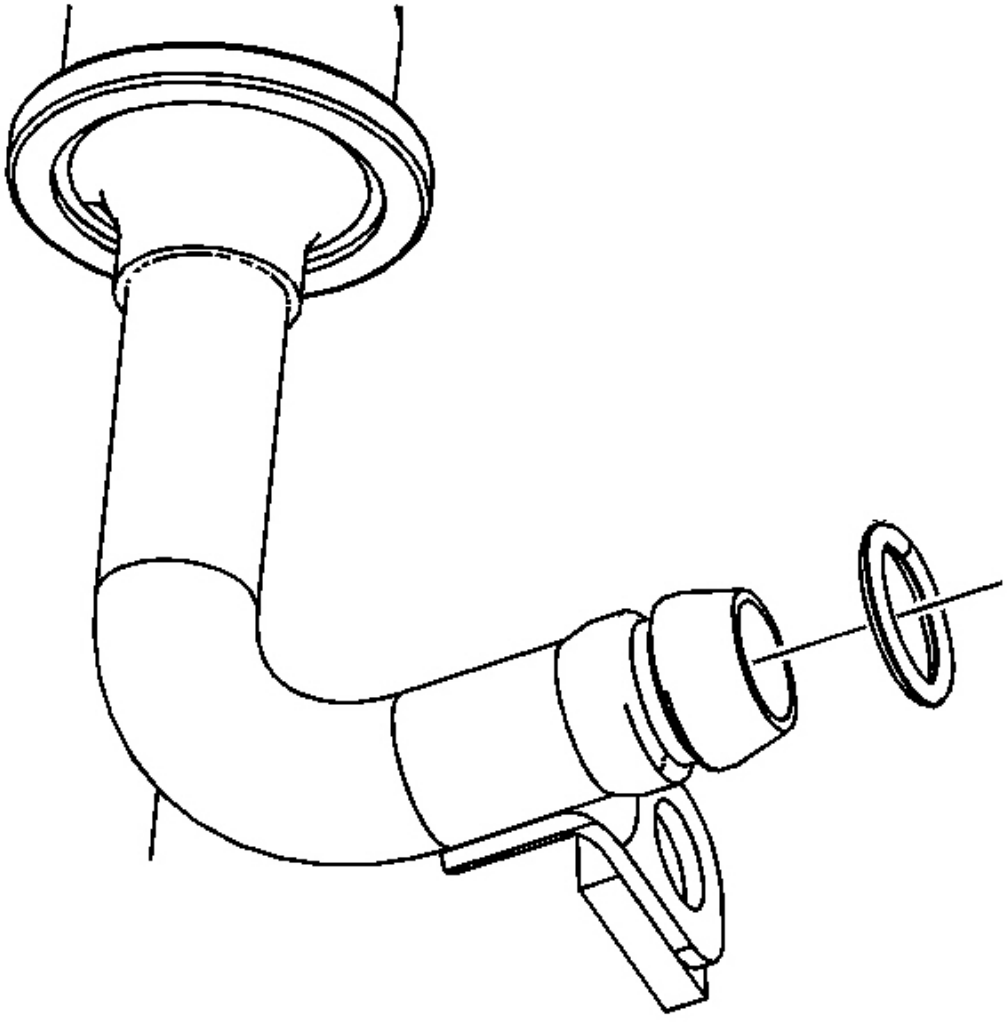


Fig. 381: View Of Oil Outlet Tube O-Ring
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW O-ring on the oil outlet tube.
2. Apply lubricant to the O-ring.

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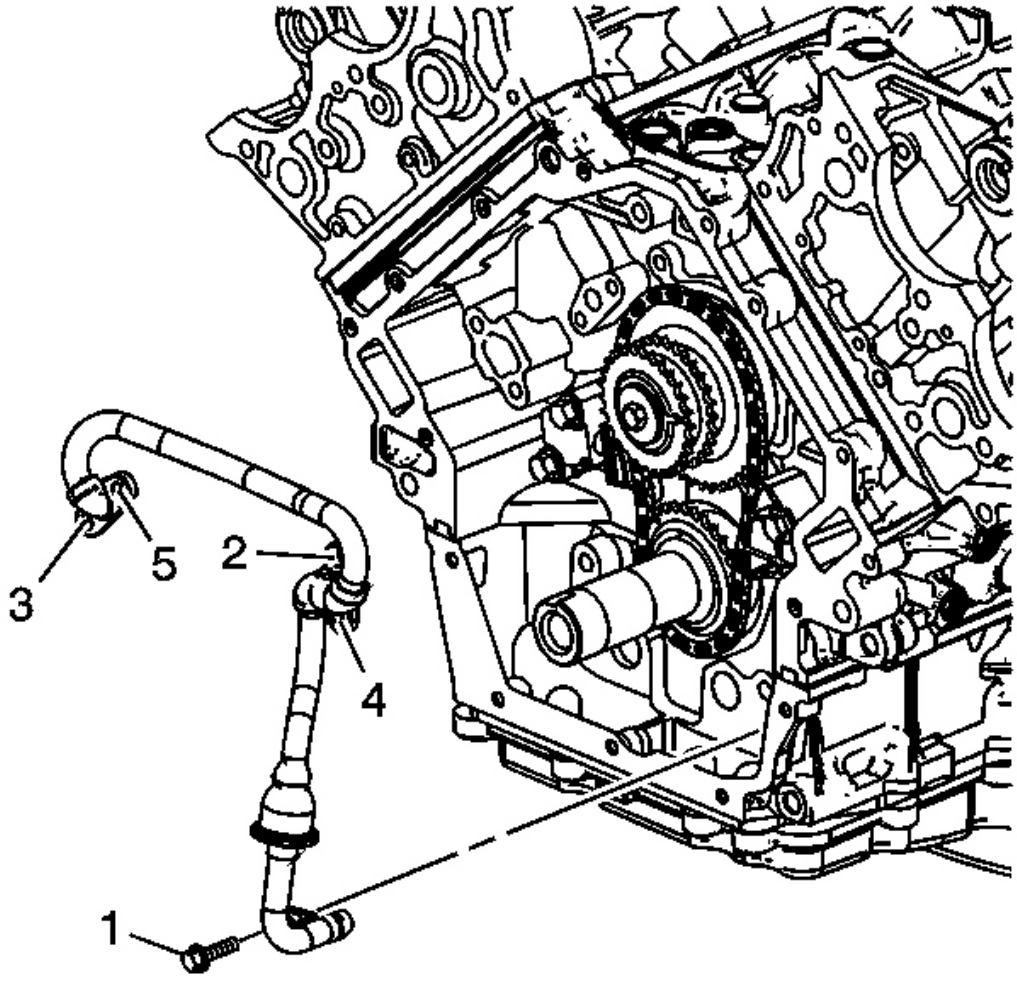


Fig. 382: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the oil outlet tube.

NOTE: **Refer to Fastener Notice .**

4. Install the oil outlet tube bolts (1-5).

Tighten: Tighten the oil outlet tube bolts to 10 N.m (89 lb in).

SECONDARY CAMSHAFT DRIVE CHAIN INSTALLATION - LEFT SIDE

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TOOLS REQUIRED

EN 46328 Camshaft Holding Tool. See **Special Tools** .

INSTALLATION PROCEDURE

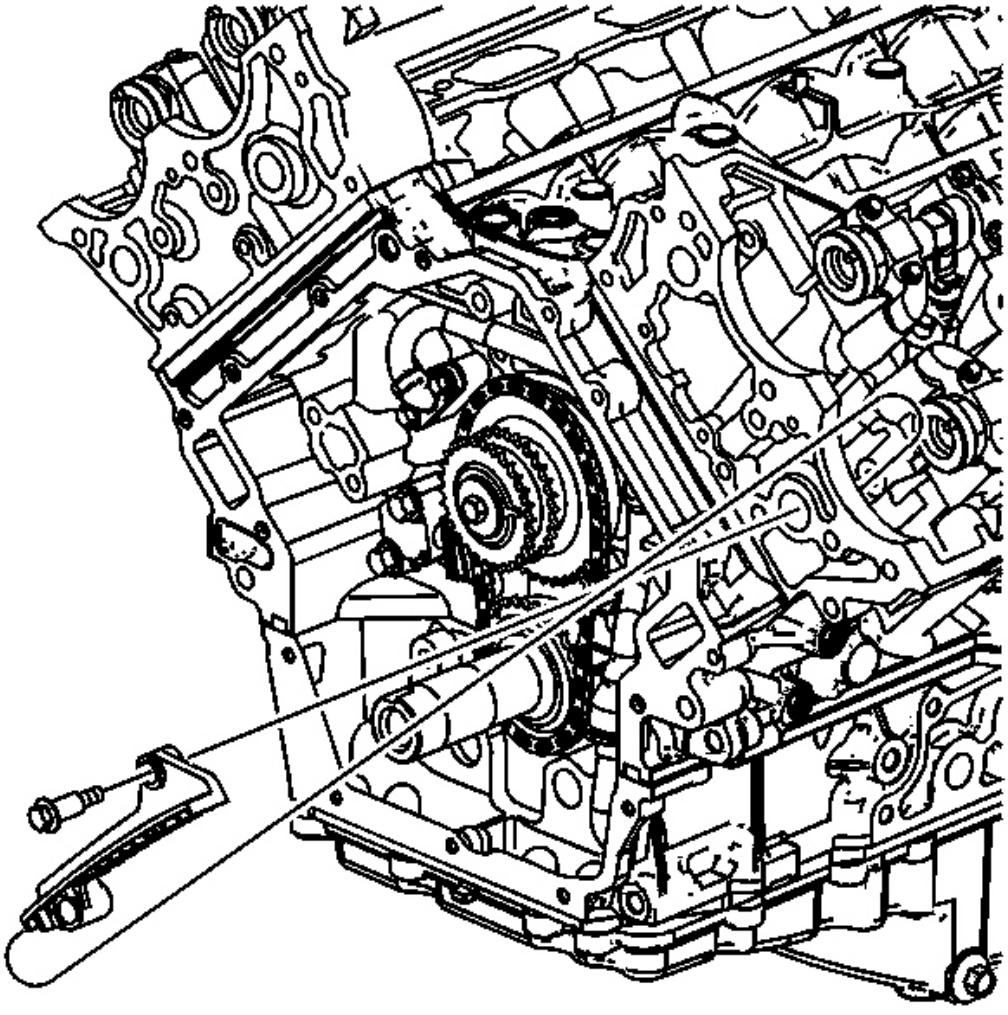


Fig. 383: View Of Left Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Install the left secondary camshaft drive chain guide.
2. Loosely install the lower left secondary camshaft drive chain guide bolt.

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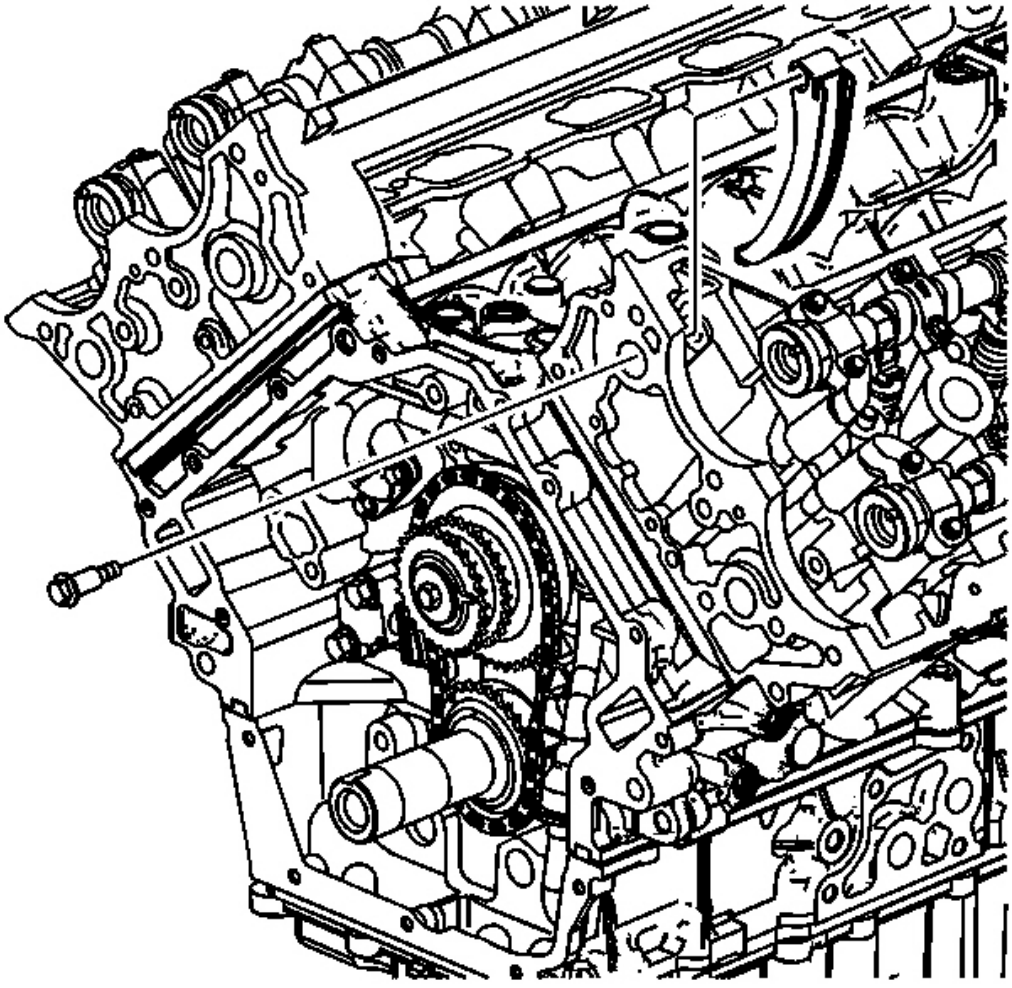


Fig. 384: View Of Left Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

3. Install the left secondary camshaft drive chain shoe.

NOTE: **Refer to Fastener Notice .**

4. Install the left secondary camshaft drive chain shoe bolt.

Tighten: Tighten the left secondary camshaft drive chain shoe bolt to 25 N.m (18 lb ft).

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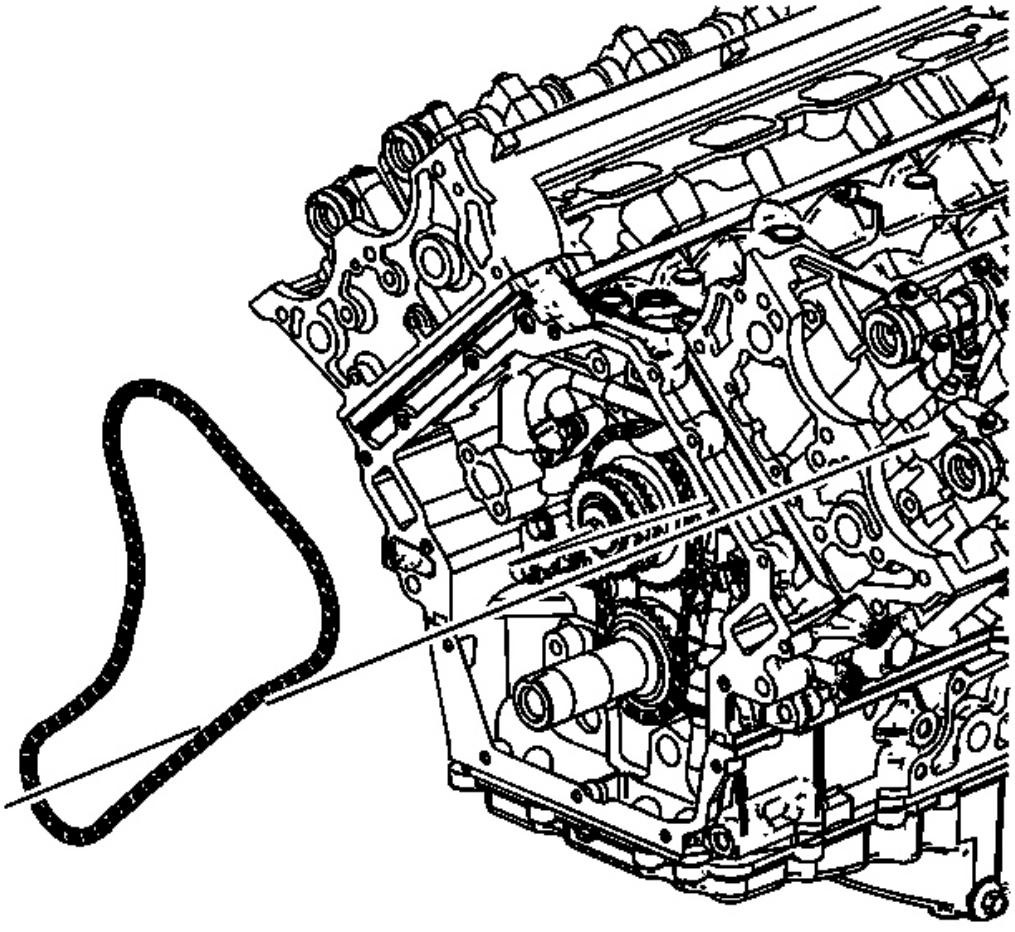


Fig. 385: View Of Left Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

5. Install the left secondary camshaft drive chain by sliding the chain down through the left cylinder head and placing the chain on the end of the camshafts.
6. Route the left secondary camshaft drive chain around the inner row of the intermediate drive chain sprocket teeth.

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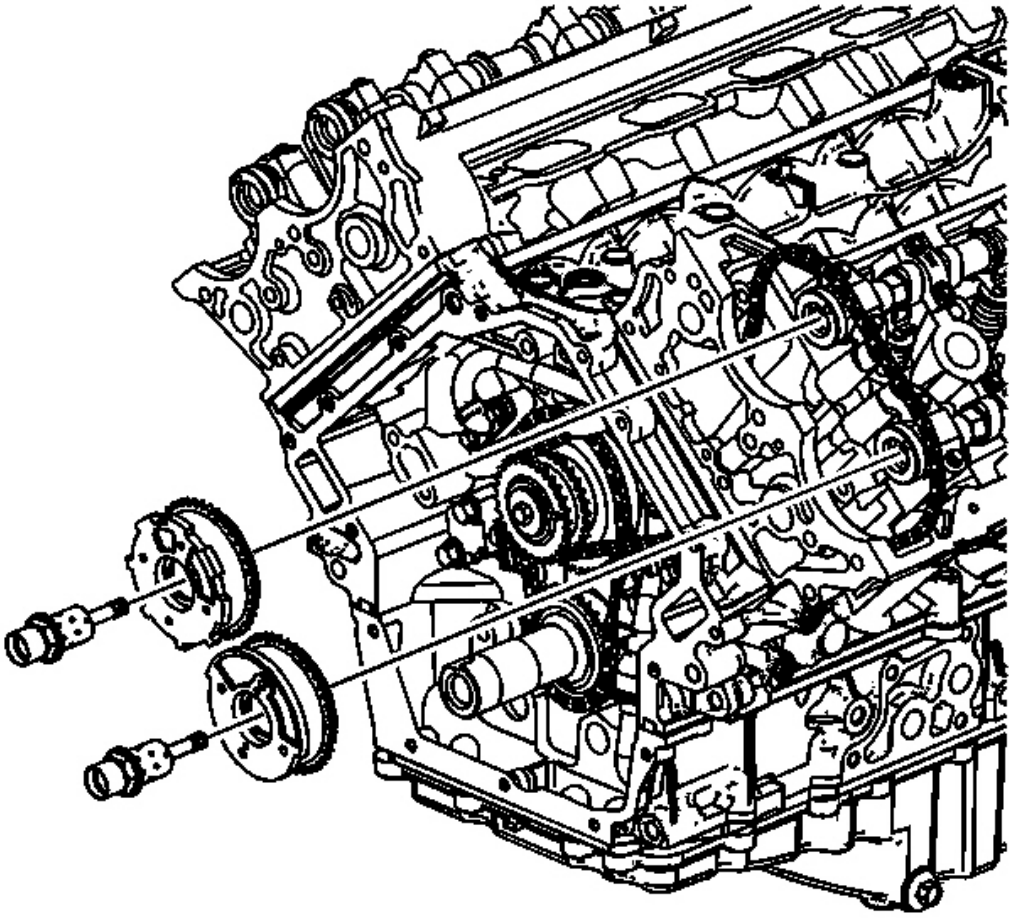


Fig. 386: View Of Left Camshaft Position Actuators
Courtesy of GENERAL MOTORS CORP.

7. Install the left intake and exhaust camshaft position actuators into the left secondary camshaft drive chain.

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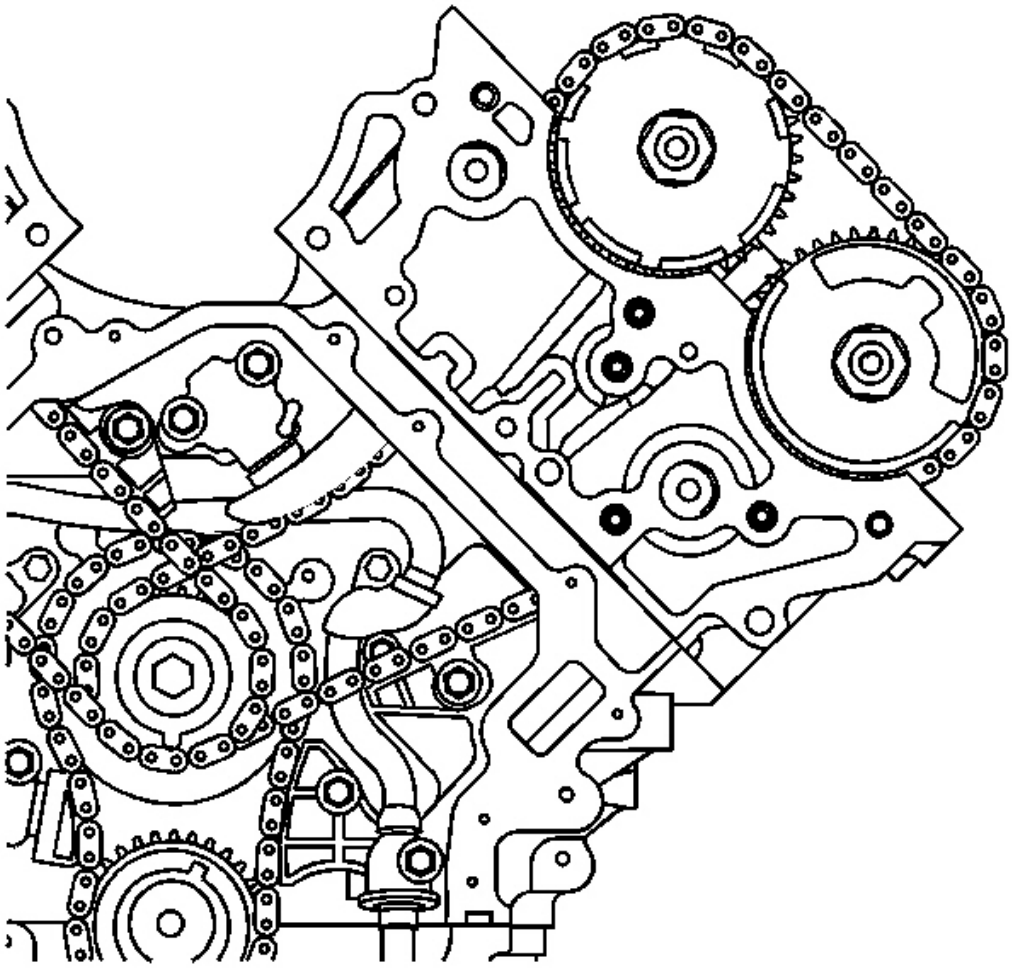


Fig. 387: View Of Left Camshaft Sprockets
Courtesy of GENERAL MOTORS CORP.

8. Install the left intake and exhaust camshaft sprockets onto the camshafts. The camshaft sprocket notch marked "LI" which indicates left intake, engages the intake camshaft pin and the camshaft sprocket notch marked "LE" which indicates left exhaust, engages the exhaust camshaft pin.

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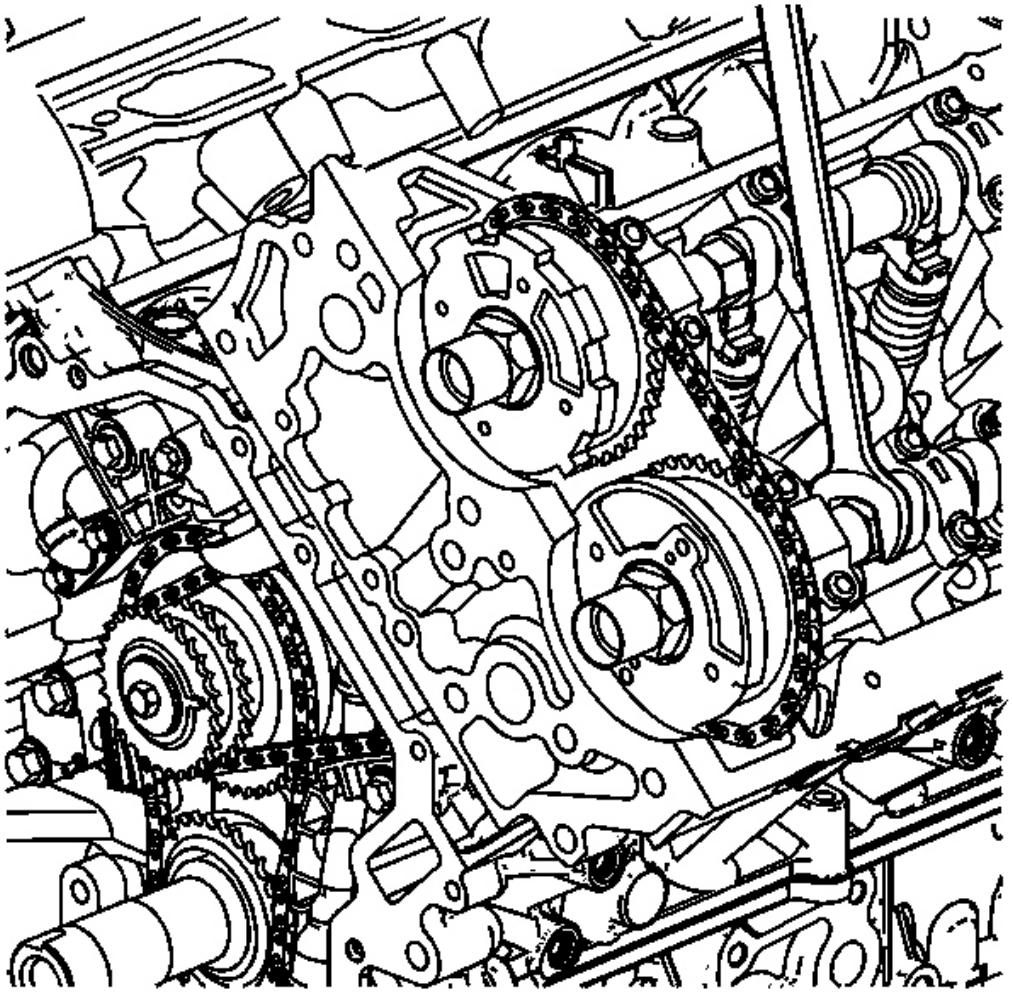


Fig. 388: Aligning Left Sprocket Notch To Camshaft Pin
Courtesy of GENERAL MOTORS CORP.

9. If necessary, use an open wrench on the hex cast near the front of each camshaft to help align the sprocket notch to the camshaft pin.
10. Loosely install the left intake and exhaust camshaft position actuator oil control valves.

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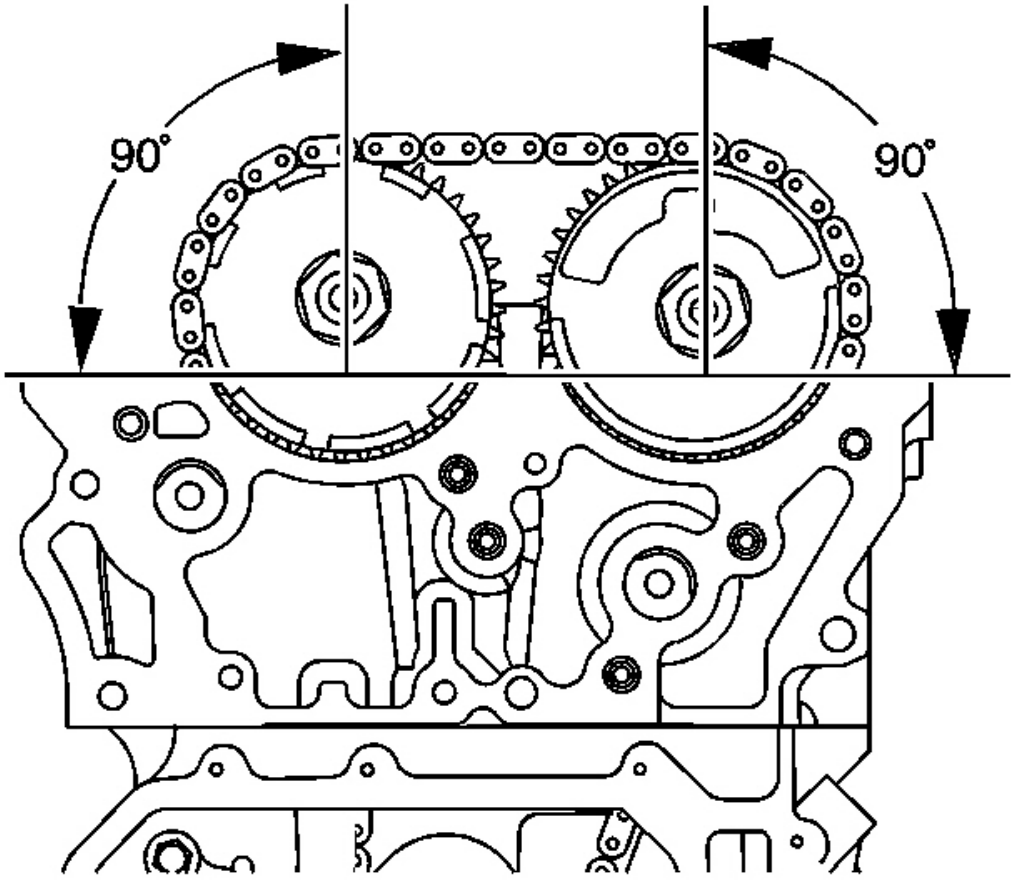


Fig. 389: Ensuring Proper Alignment Of Left Camshaft Sprocket Notches & Pins
Courtesy of GENERAL MOTORS CORP.

11. Ensure the perpendicular alignment of the left intake and exhaust camshaft sprocket notches and camshaft pins to the cylinder head.

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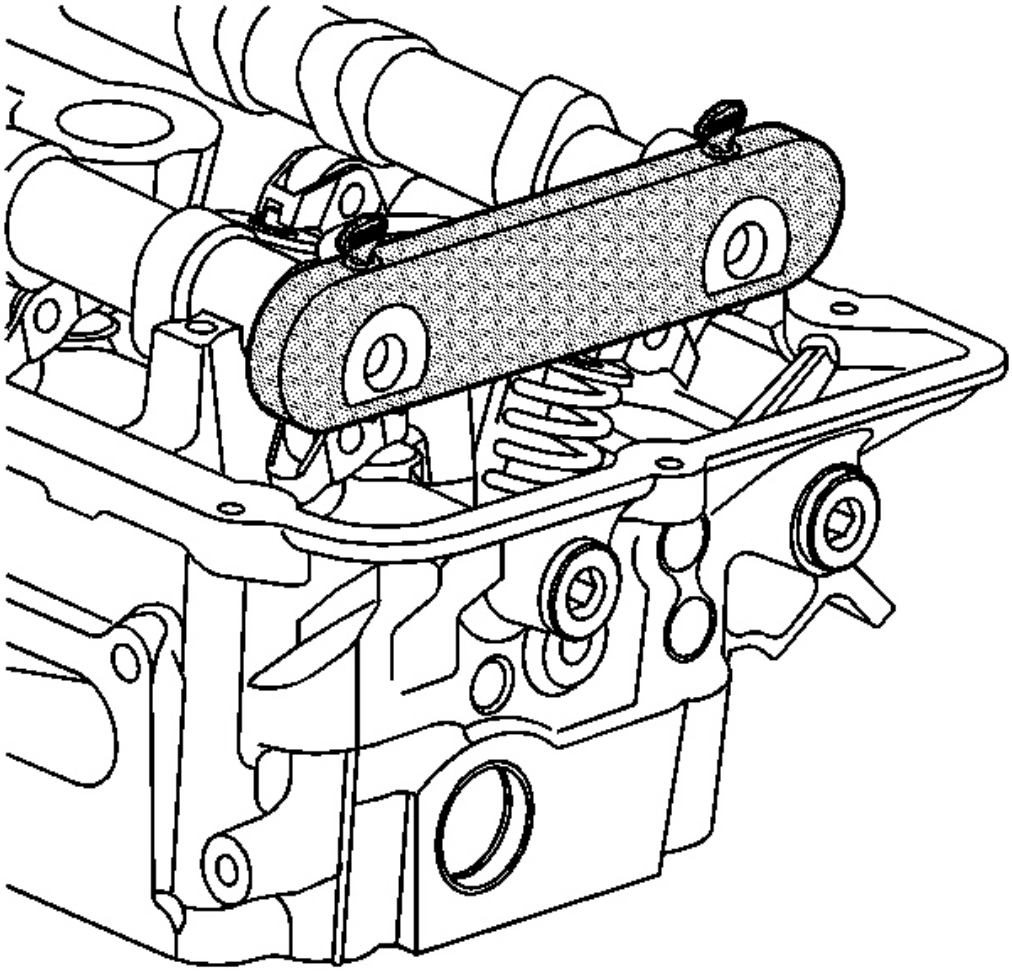


Fig. 390: Installing EN 46328 On Left Cylinder Head Camshafts
Courtesy of GENERAL MOTORS CORP.

12. Install the **EN 46328** to the left cylinder head camshafts. See **Special Tools** .

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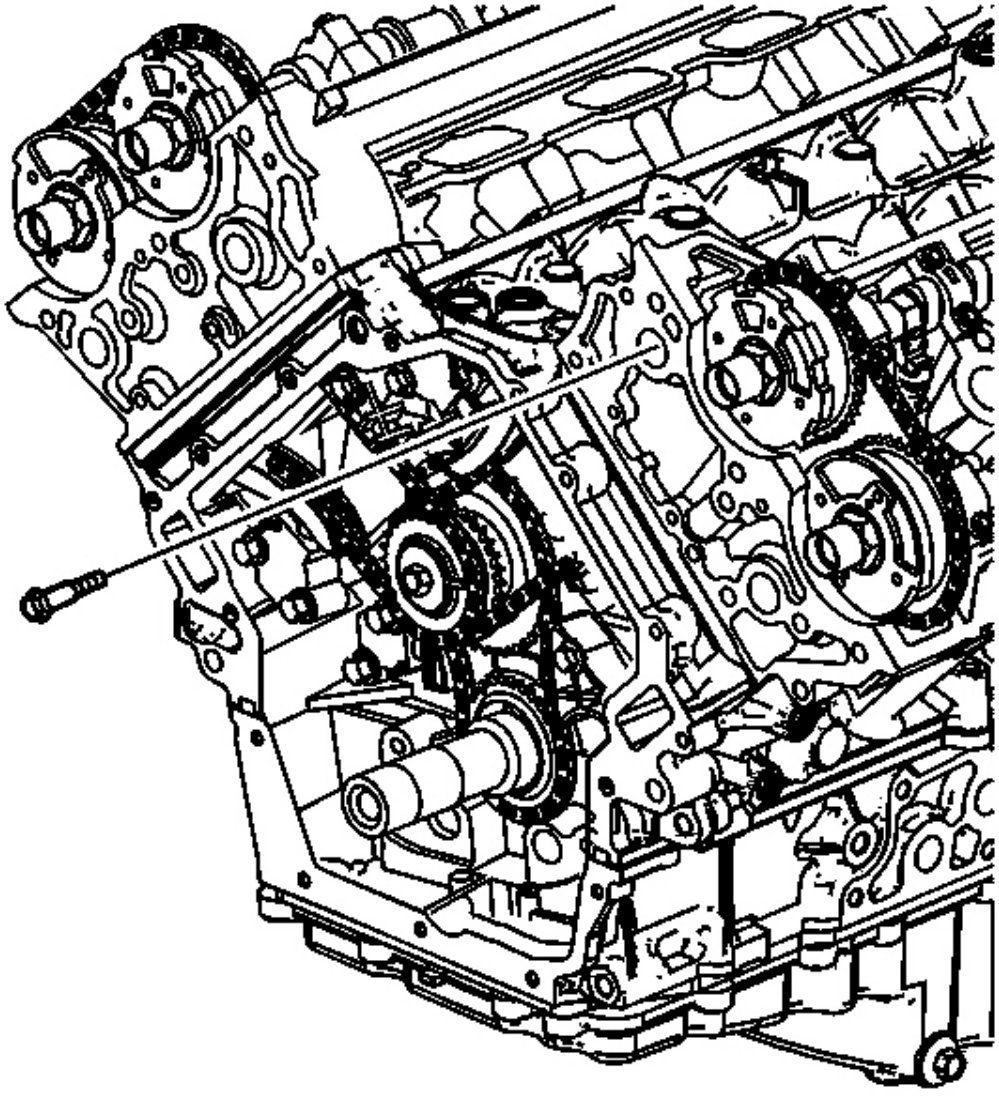


Fig. 391: View Of Upper Left Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

13. Install the upper left secondary camshaft drive chain guide bolt.

    Tighten: Tighten BOTH the upper and lower left secondary camshaft drive chain guide bolts to 25 N.m (18 lb ft).

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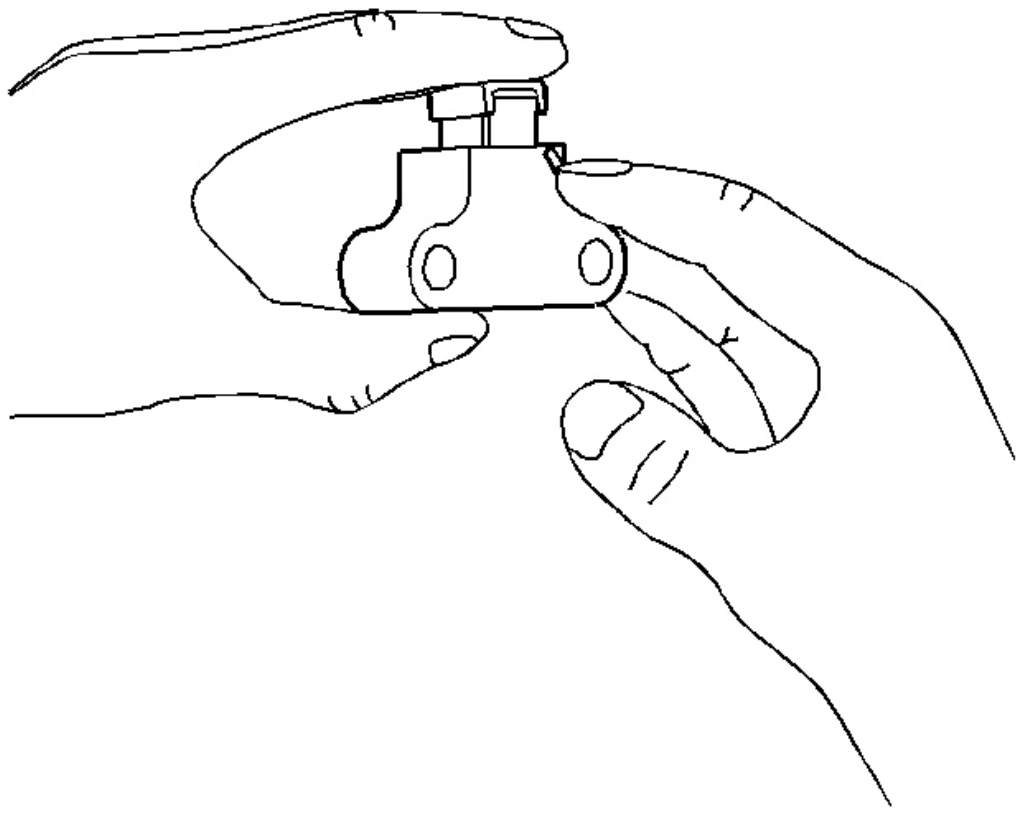


Fig. 392: Collapsing Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

14. Collapse the left secondary camshaft drive chain tensioner using the following procedure:
    1. Rotate the ratchet release lever counterclockwise and hold.
    2. Collapse the left secondary camshaft drive chain tensioner shoe and hold.
    3. Release the ratchet lever and slowly release the pressure on the shoe.
15. When the ratchet lever moves to the first detent a click should be heard and felt. Insert a pin through the hole in the release lever in order to lock the left secondary camshaft drive chain tensioner shoe in the collapsed position.

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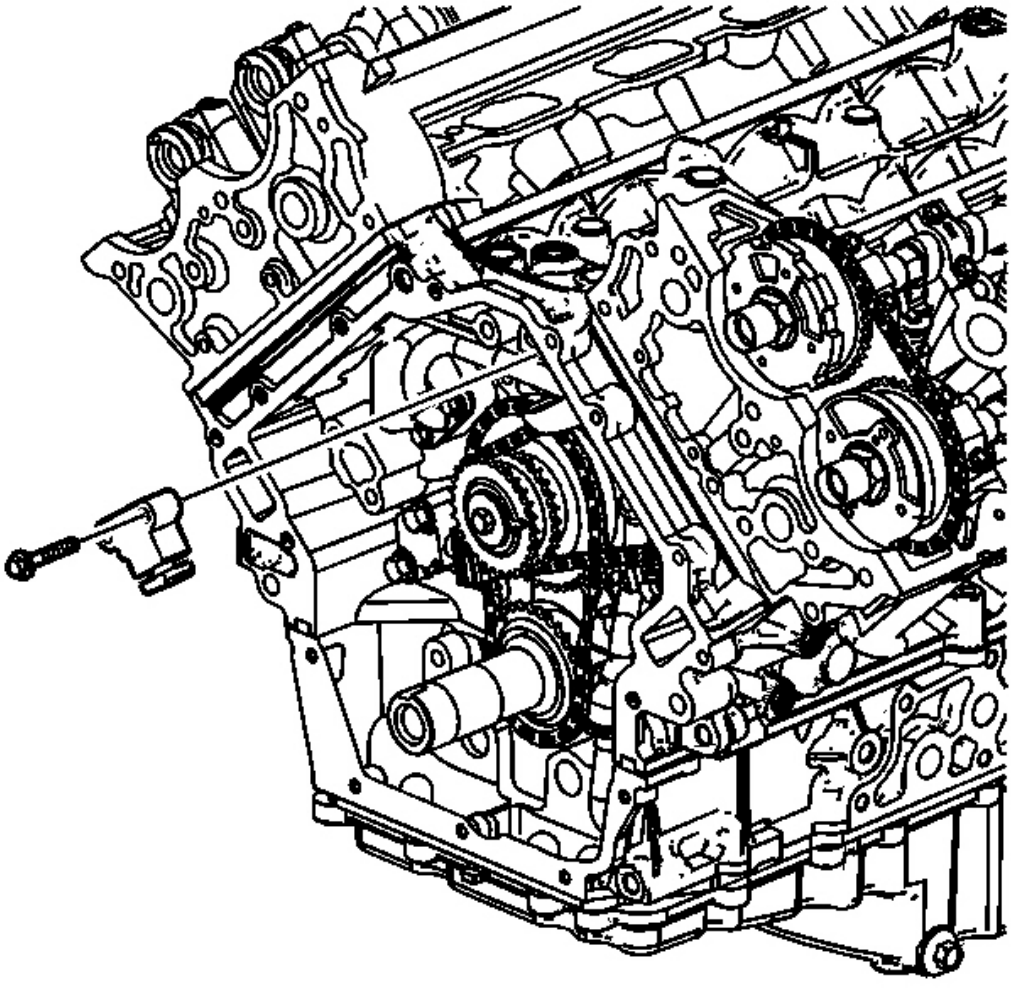


Fig. 393: View Of Left Secondary Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the left secondary camshaft drive chain tensioner release lever is facing out.

16. Install the left secondary camshaft drive chain tensioner.
17. Install the left secondary camshaft drive chain tensioner bolts.

    Tighten: Tighten the left secondary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).

18. Remove pin from left secondary camshaft drive chain tensioner lever.

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SECONDARY CAMSHAFT DRIVE CHAIN INSTALLATION - RIGHT SIDE

TOOLS REQUIRED

EN 46328 Camshaft Holding Tool. See **Special Tools** .

INSTALLATION PROCEDURE

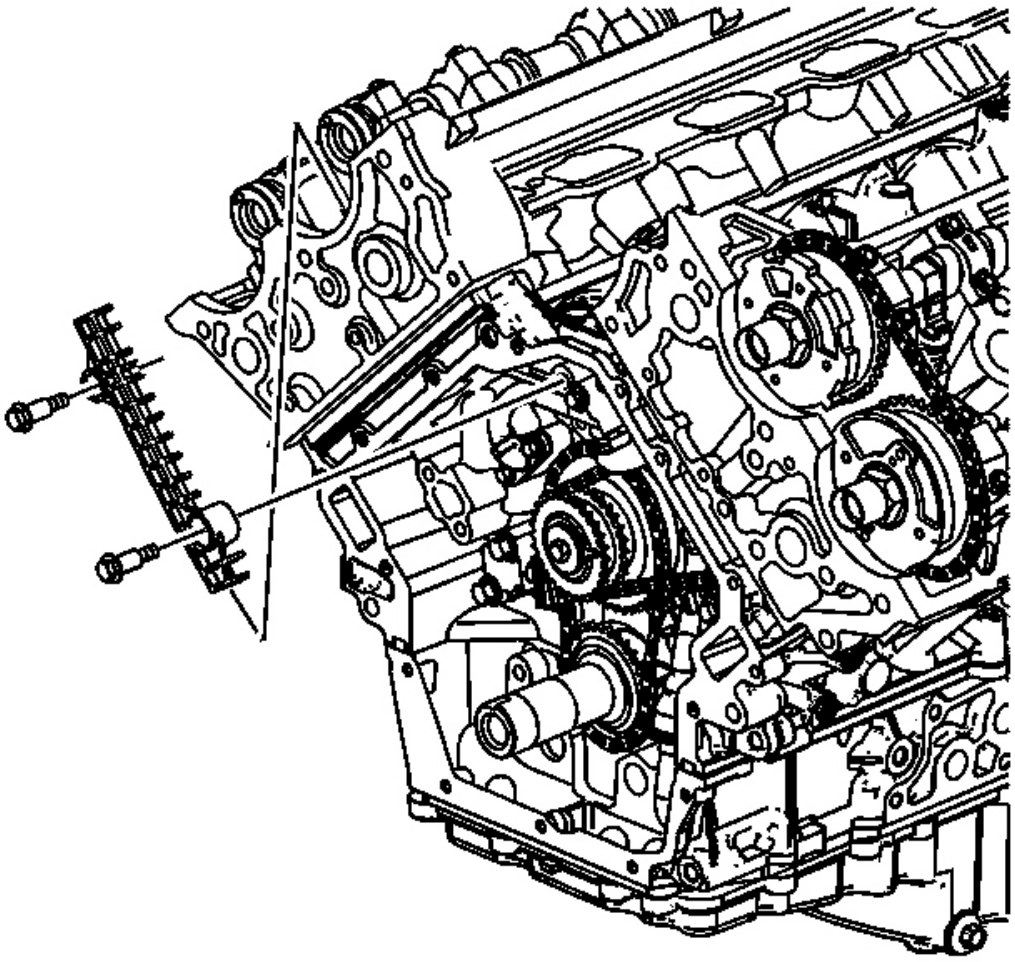


Fig. 394: View Of Right Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Install the right secondary camshaft drive chain guide.
2. Loosely install the lower right secondary camshaft drive chain guide bolt.

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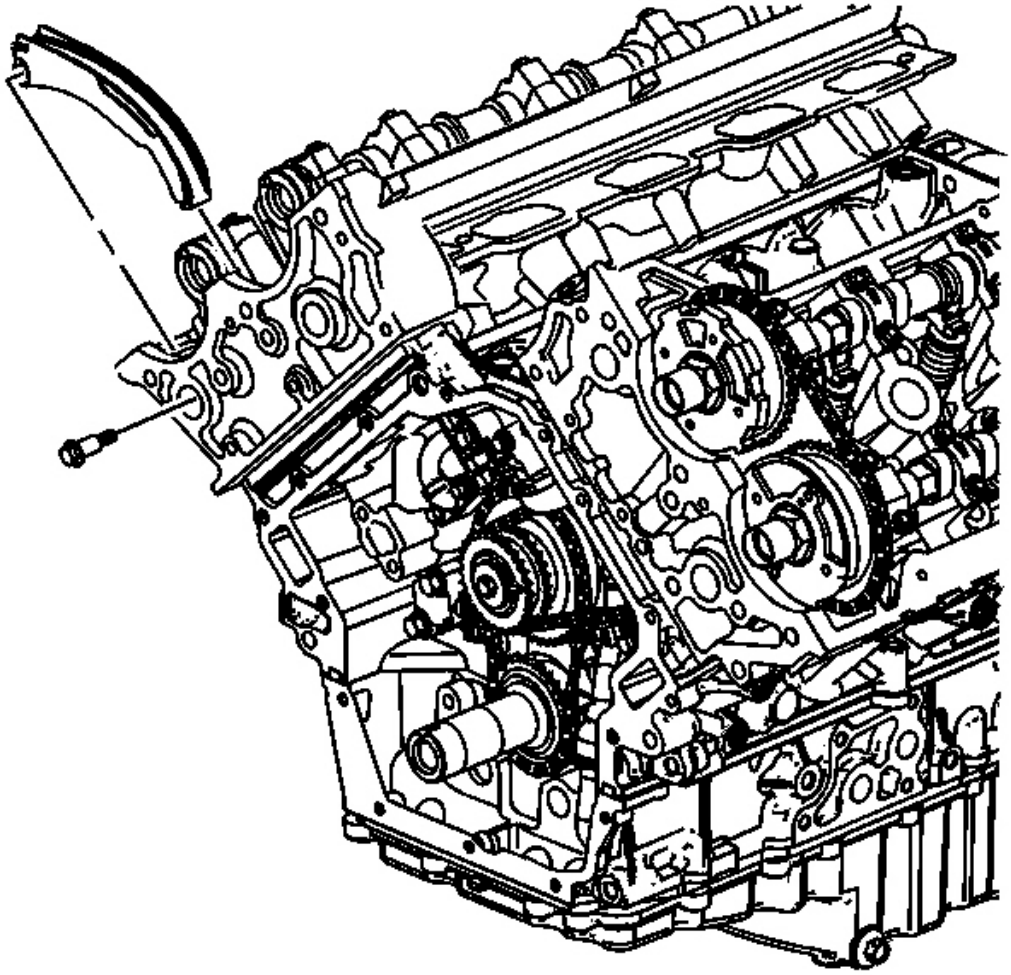


Fig. 395: View Of Right Secondary Camshaft Drive Timing Chain Shoe
Courtesy of GENERAL MOTORS CORP.

3. Install the right secondary camshaft drive chain shoe.

NOTE: **Refer to Fastener Notice .**

4. Install the right secondary camshaft drive chain shoe bolt.

Tighten: Tighten the right secondary camshaft drive chain shoe bolt to 25 N.m (18 lb ft).

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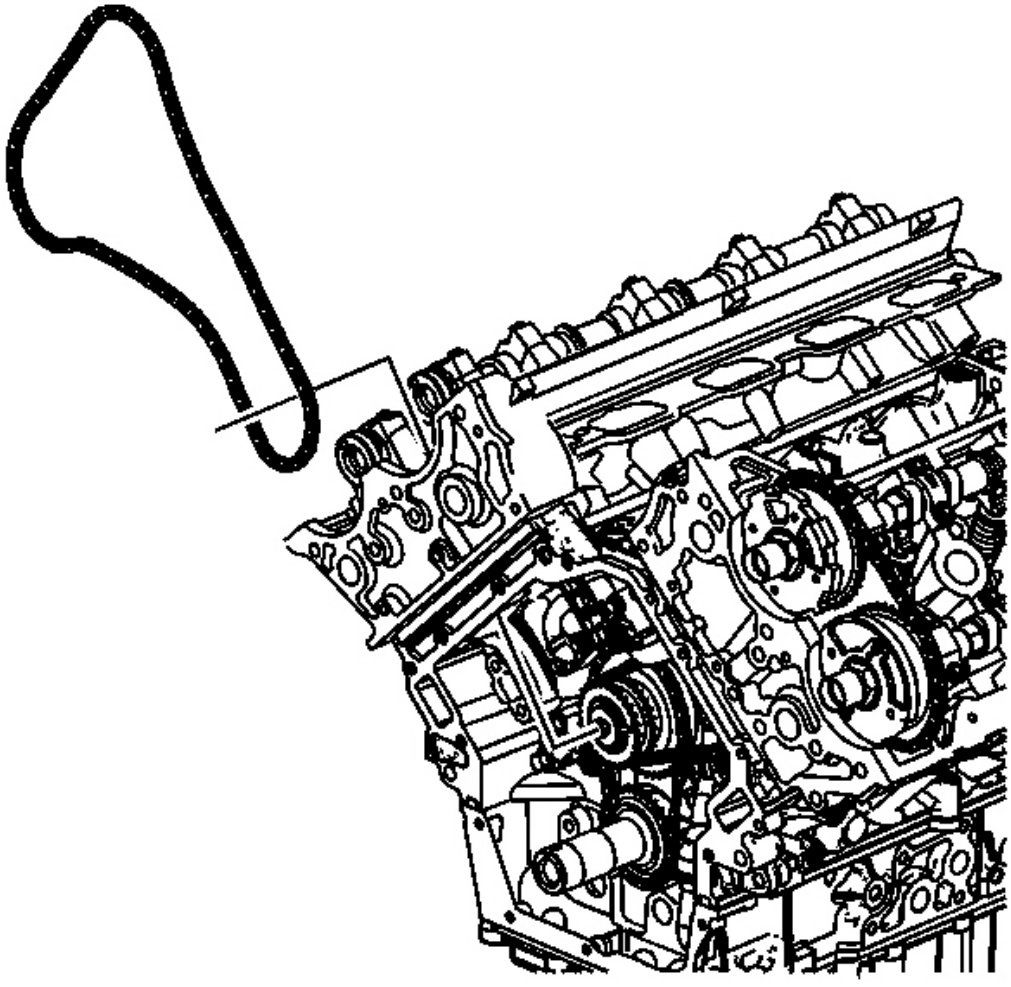


Fig. 396: View Of Right Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

5. Install the right secondary camshaft drive chain by sliding the chain down through the right cylinder head and placing the chain on the end of the camshafts.
6. Route the right secondary camshaft drive chain around the outer row of the intermediate drive chain sprocket teeth.

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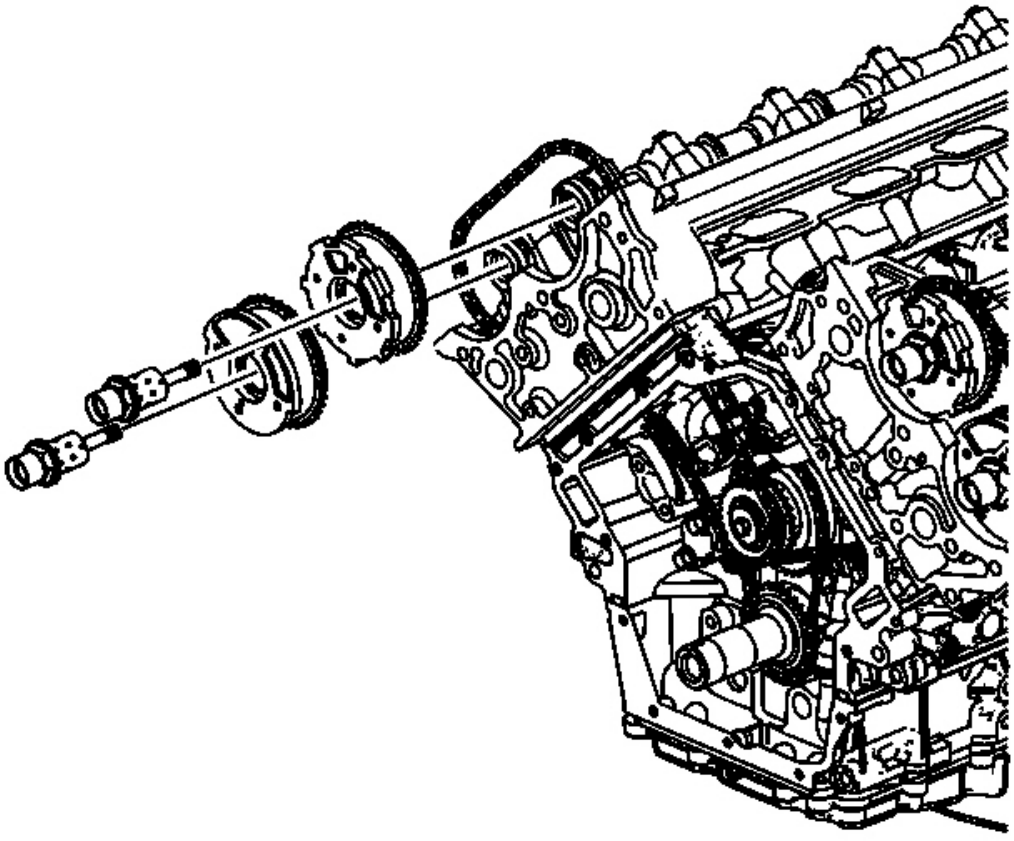


Fig. 397: View Of Right Camshaft Position Actuators
Courtesy of GENERAL MOTORS CORP.

7. Install the right intake and exhaust camshaft position actuators into the right secondary camshaft drive chain.

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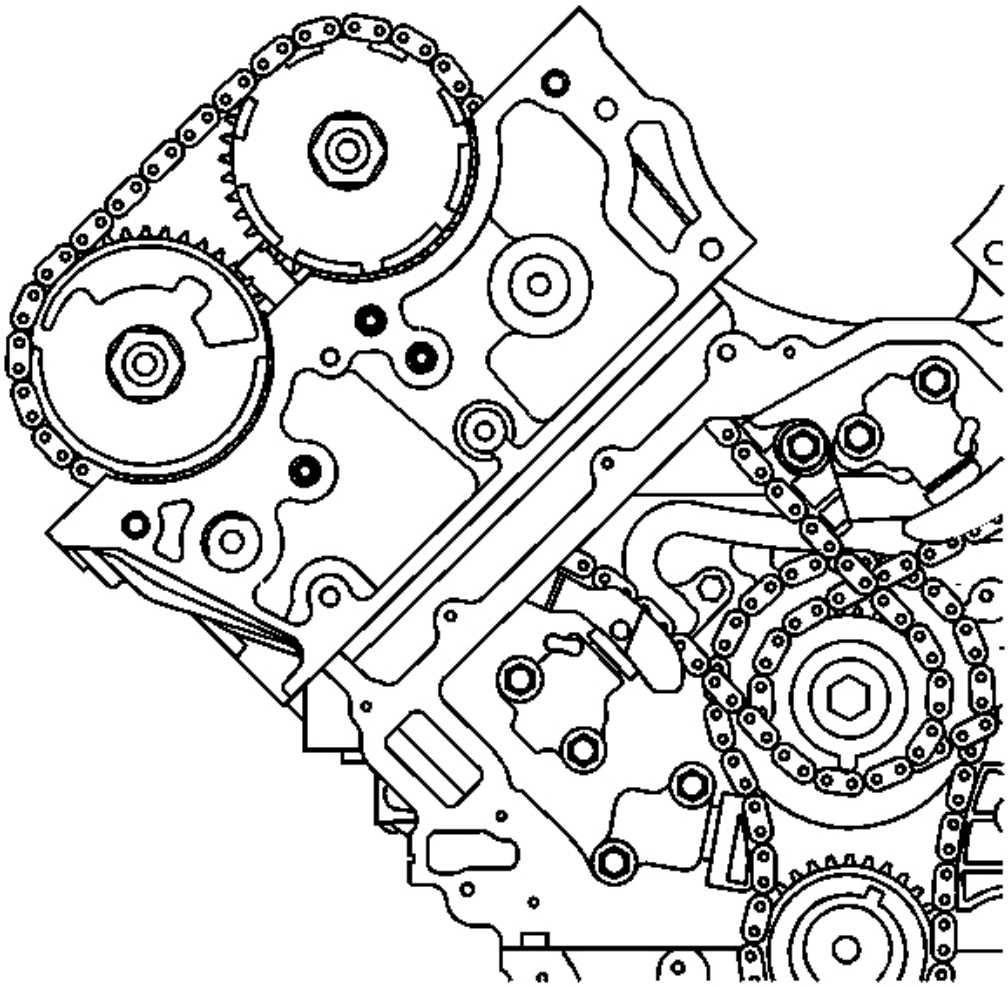


Fig. 398: Installing Right Camshaft Actuators
Courtesy of GENERAL MOTORS CORP.

8. Install the right intake and exhaust camshafts onto the camshafts. The camshaft sprocket notch marked "RI" which indicates right intake, engages the intake camshaft pin and the camshaft sprocket notch marked "RE" which indicates right exhaust, engages the exhaust camshaft pin.

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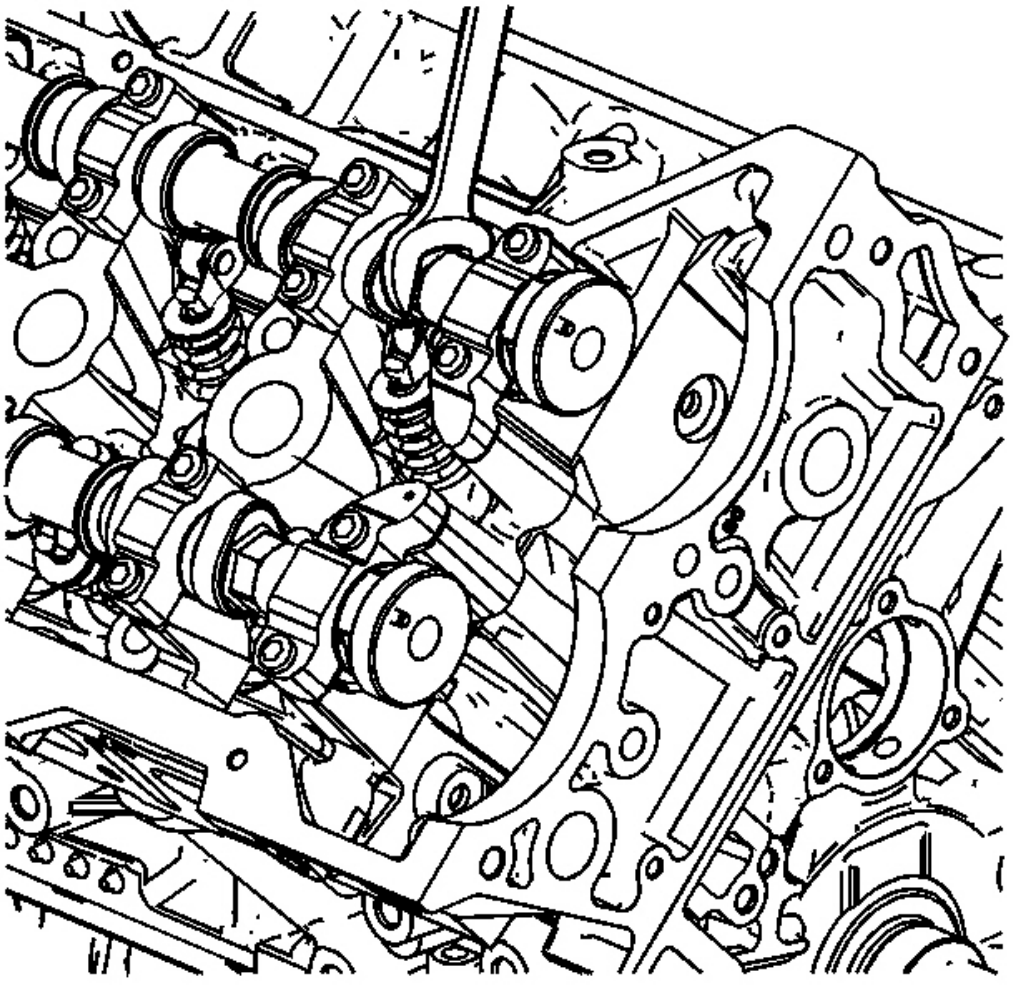


Fig. 399: Aligning Right Sprocket Notch To Camshaft Pin
Courtesy of GENERAL MOTORS CORP.

9. If necessary, use an open wrench on the hex cast near the front of each camshaft to help align the sprocket notch to the camshaft pin.
10. Loosely install the right intake and exhaust camshaft position actuator oil control valves.

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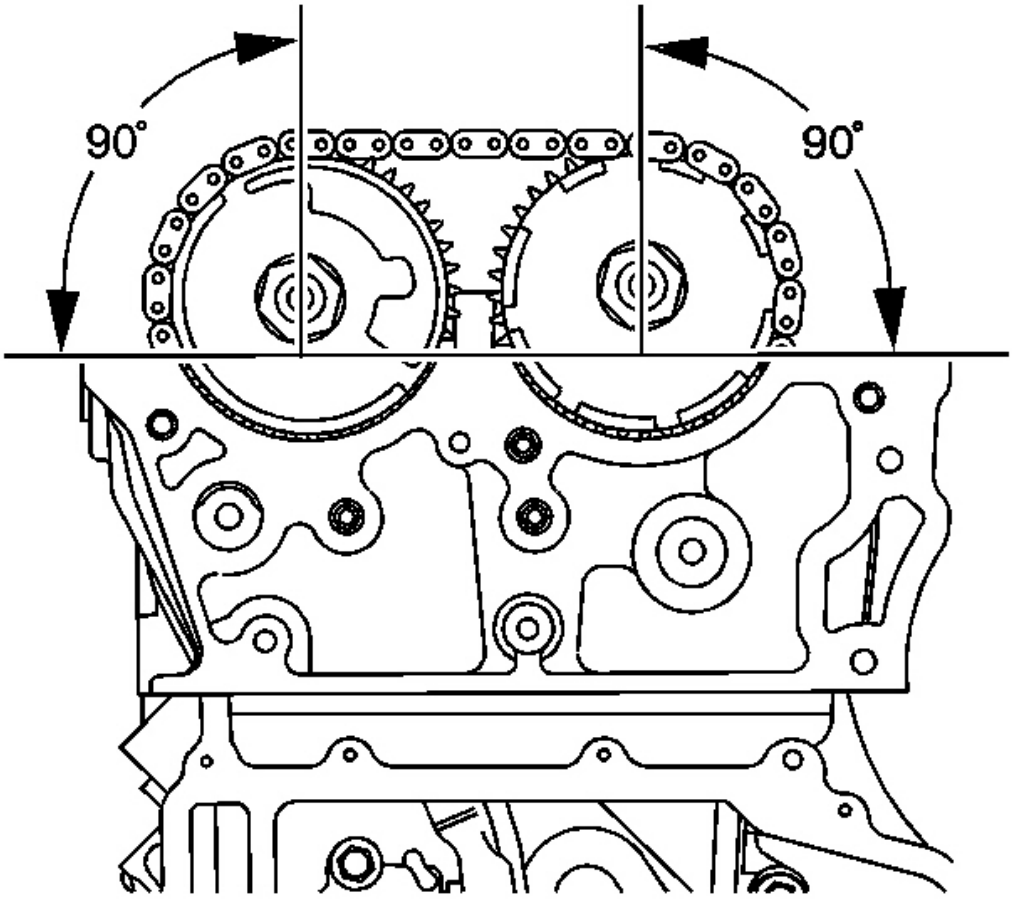


Fig. 400: Ensuring Proper Alignment Of Right Camshaft Sprocket Notches & Pins
Courtesy of GENERAL MOTORS CORP.

11. Ensure the perpendicular alignment of the right intake and exhaust camshaft sprocket notches and camshaft pins to the cylinder head.

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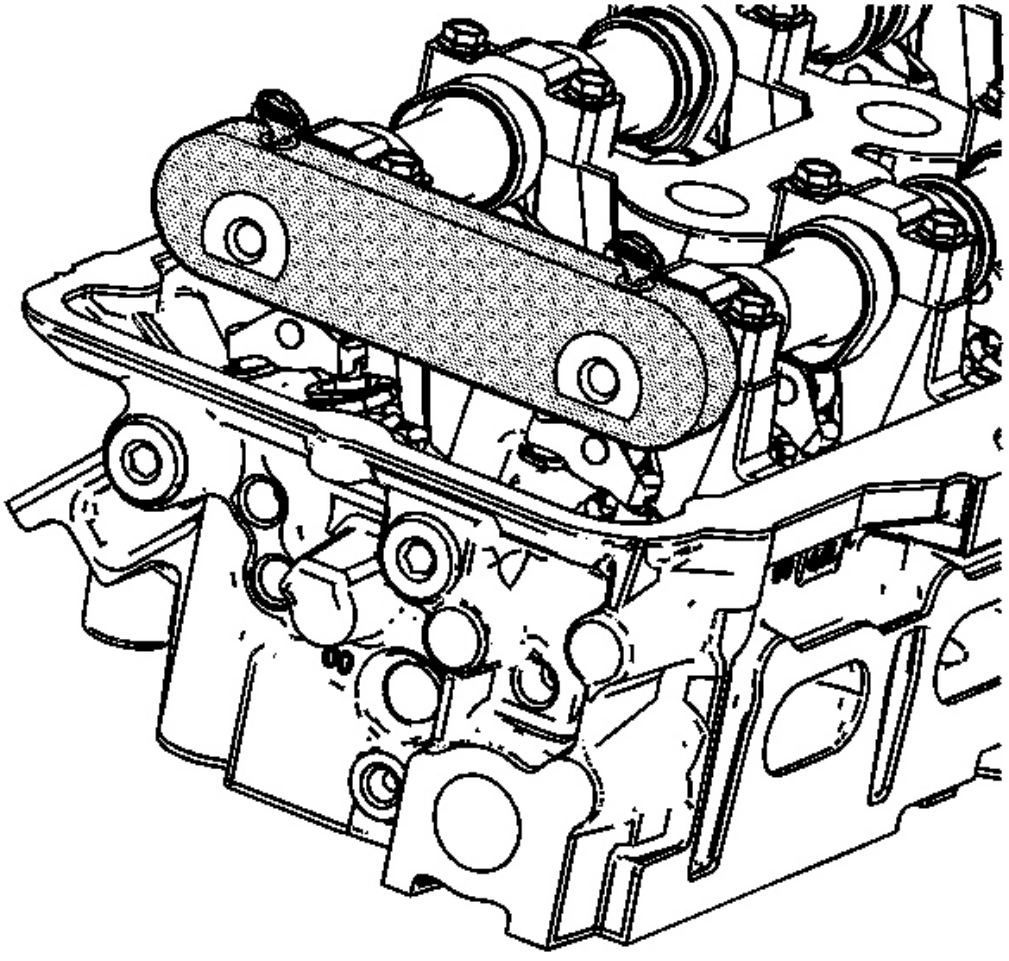


Fig. 401: Installing EN 46328 On Right Cylinder Head Camshafts
Courtesy of GENERAL MOTORS CORP.

12. Install the **EN 46328** to the right cylinder head camshafts. See **Special Tools** .

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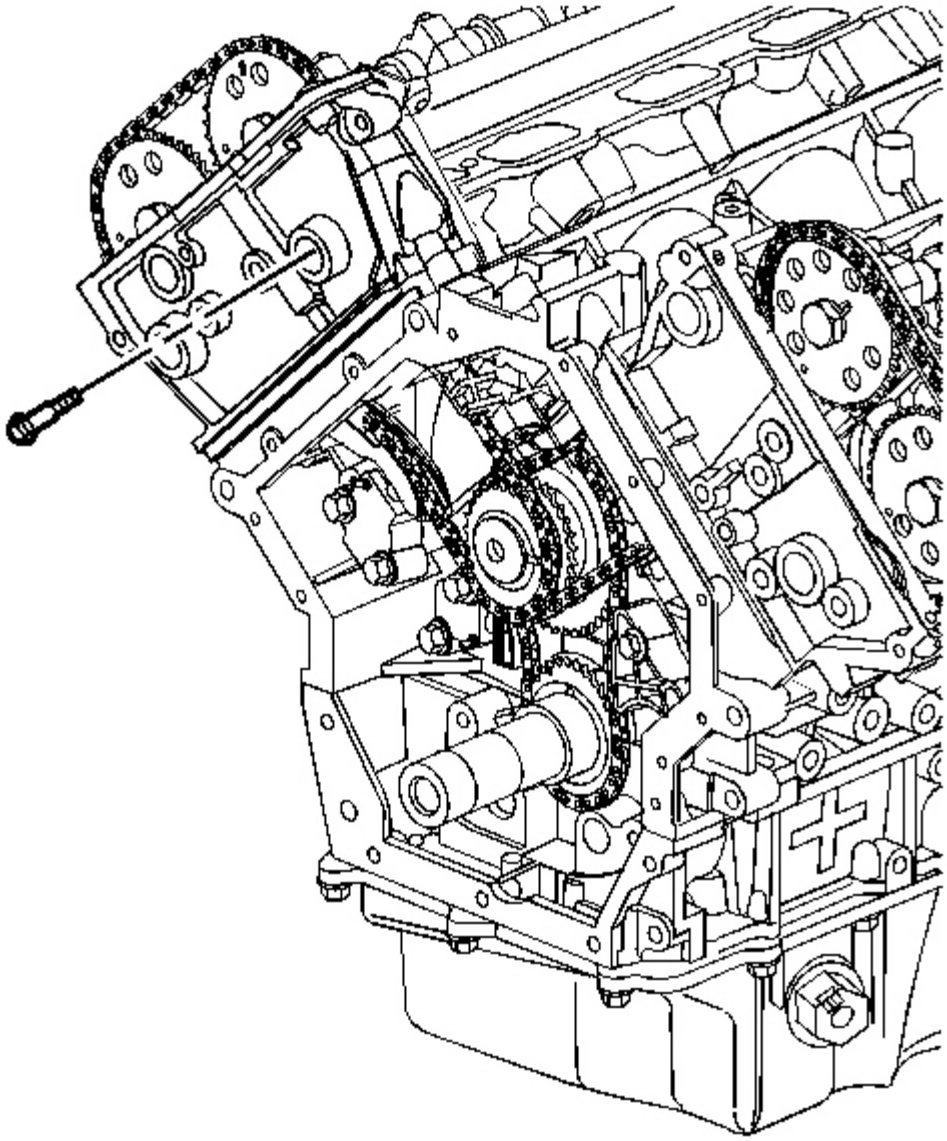


Fig. 402: View Of Upper Right Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

13. Install the upper right secondary camshaft drive chain guide bolt.

    Tighten: Tighten BOTH the upper and lower right secondary camshaft drive chain guide bolts to 25 N.m (18 lb ft).

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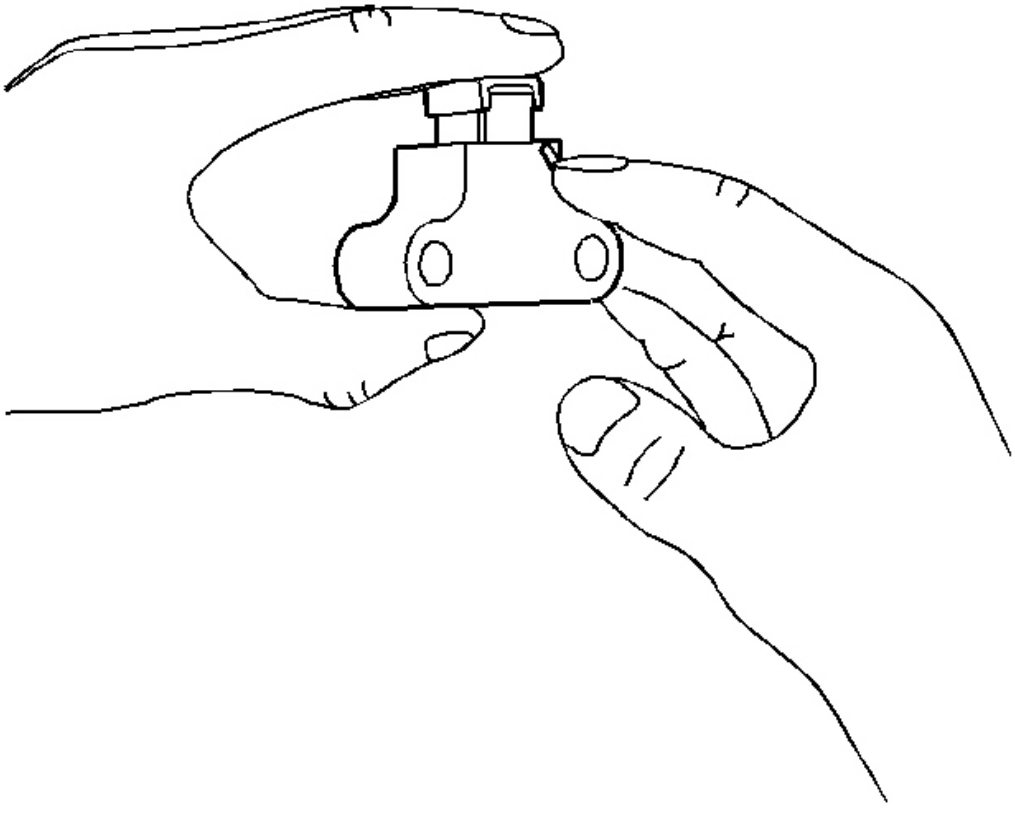


Fig. 403: Collapsing Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

14. Collapse the right secondary camshaft drive chain tensioner using the following procedure:
    1. Rotate the ratchet release lever counter-clockwise and hold.
    2. Collapse the right secondary camshaft drive chain tensioner shoe and hold.
    3. Release the ratchet lever and slowly release the pressure on the shoe.
15. When the ratchet lever moves to the first detent a click should be heard and felt. Insert a pin through the hole in the release lever in order to lock the right secondary camshaft drive chain tensioner shoe in the collapsed position.

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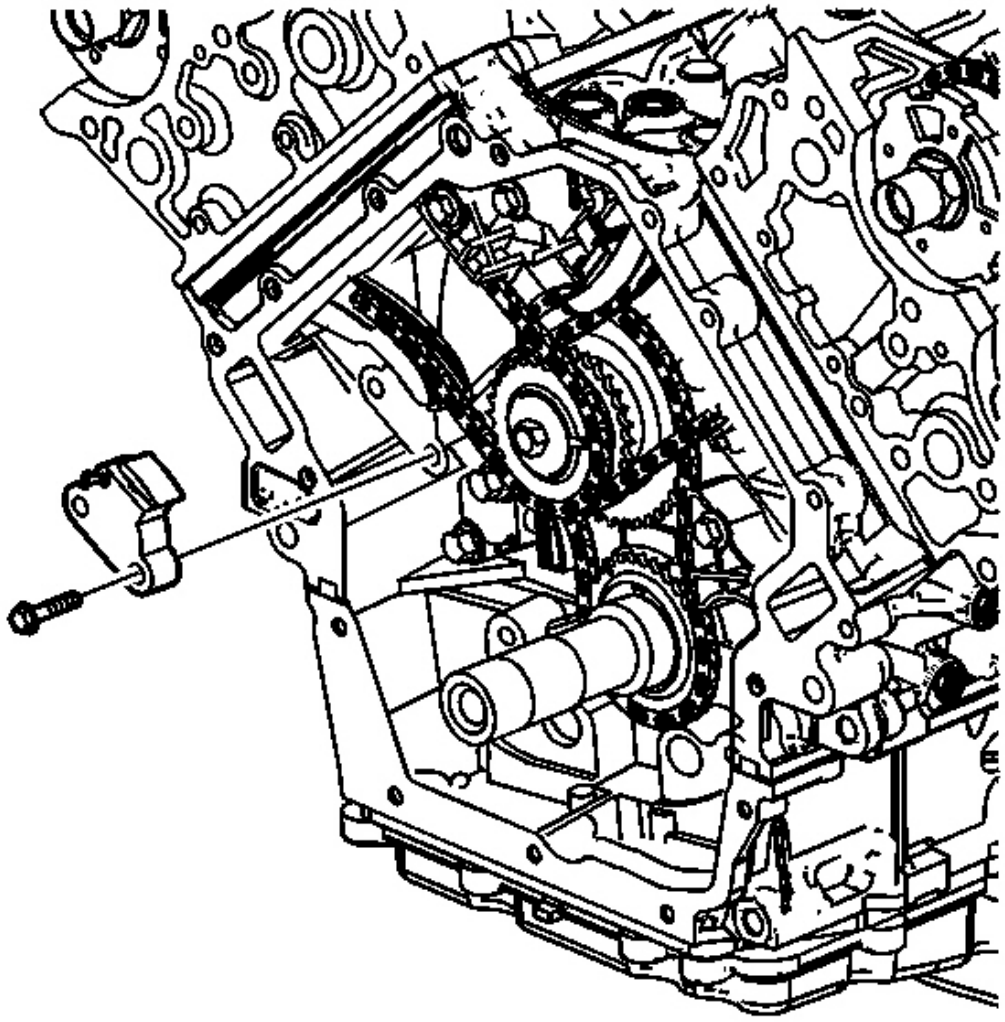


Fig. 404: View Of Right Secondary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the right secondary camshaft drive chain tensioner release lever is facing out.

16. Install the right secondary camshaft drive chain tensioner.
17. Install the right secondary camshaft drive chain tensioner bolts.

Tighten: Tighten the right secondary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).

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18. Remove pin from right secondary camshaft drive chain tensioner lever.

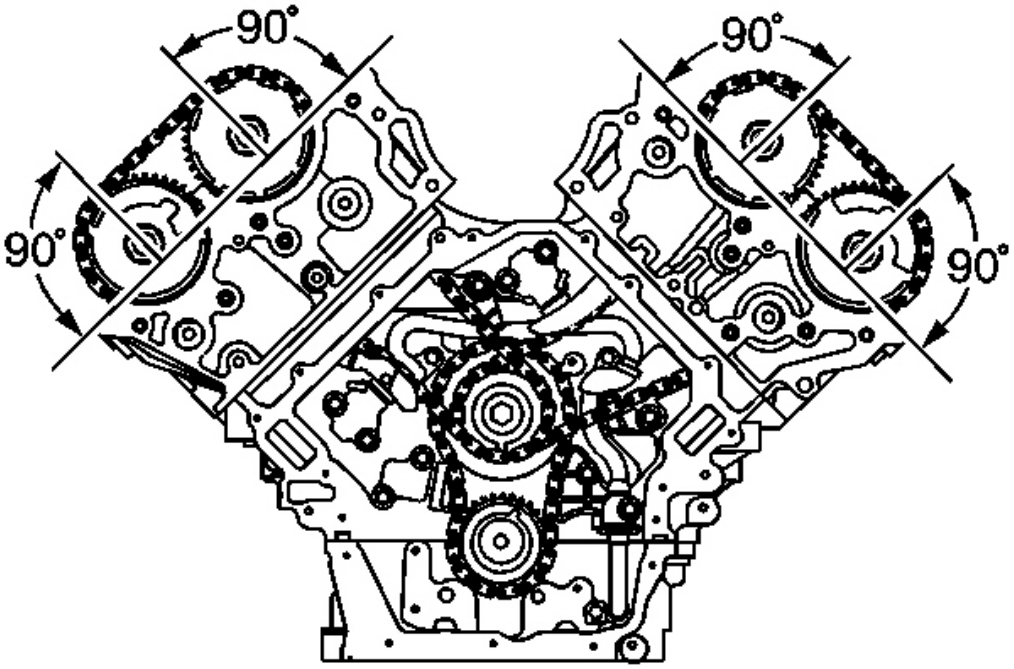


Fig. 405: Ensuring Correct Alignment Of All Secondary Timing Components
Courtesy of GENERAL MOTORS CORP.

19. Ensure the correct alignment of all secondary timing components.

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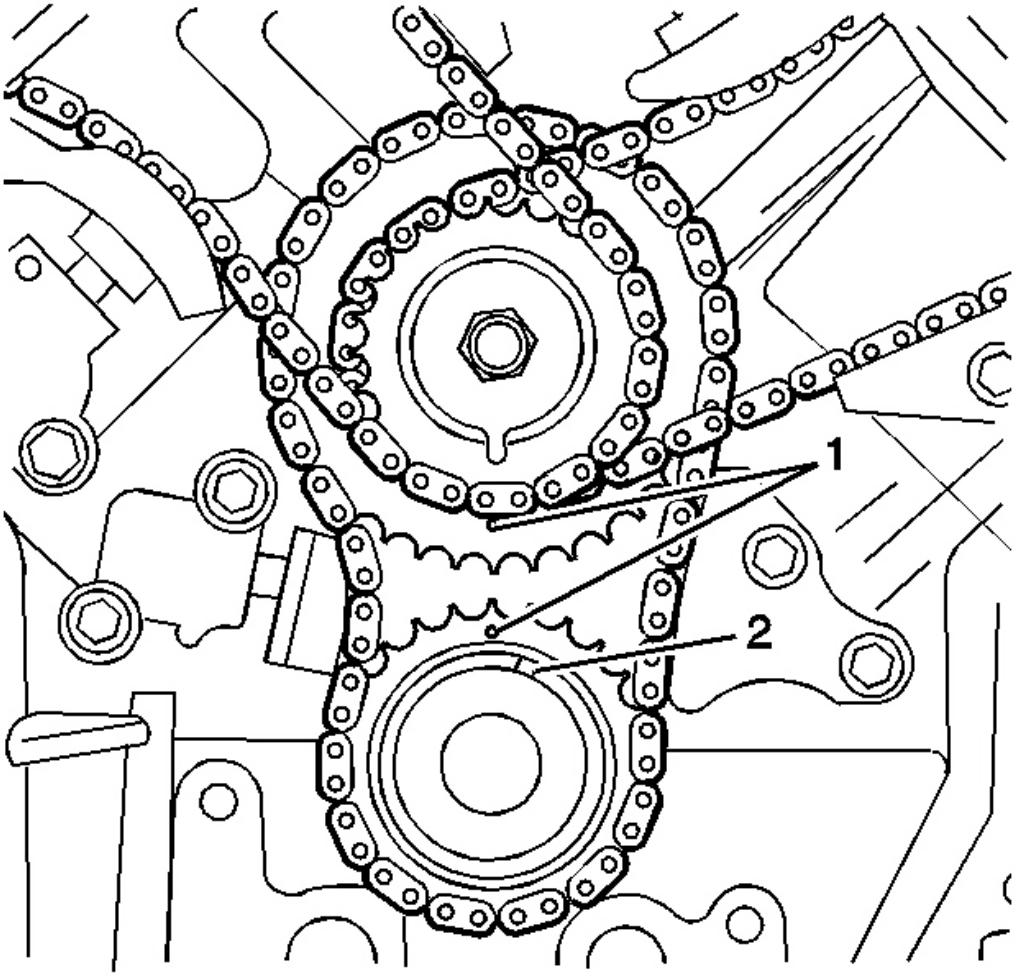


Fig. 406: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

20. Ensure the correct alignment of all primary timing components (1, 2).

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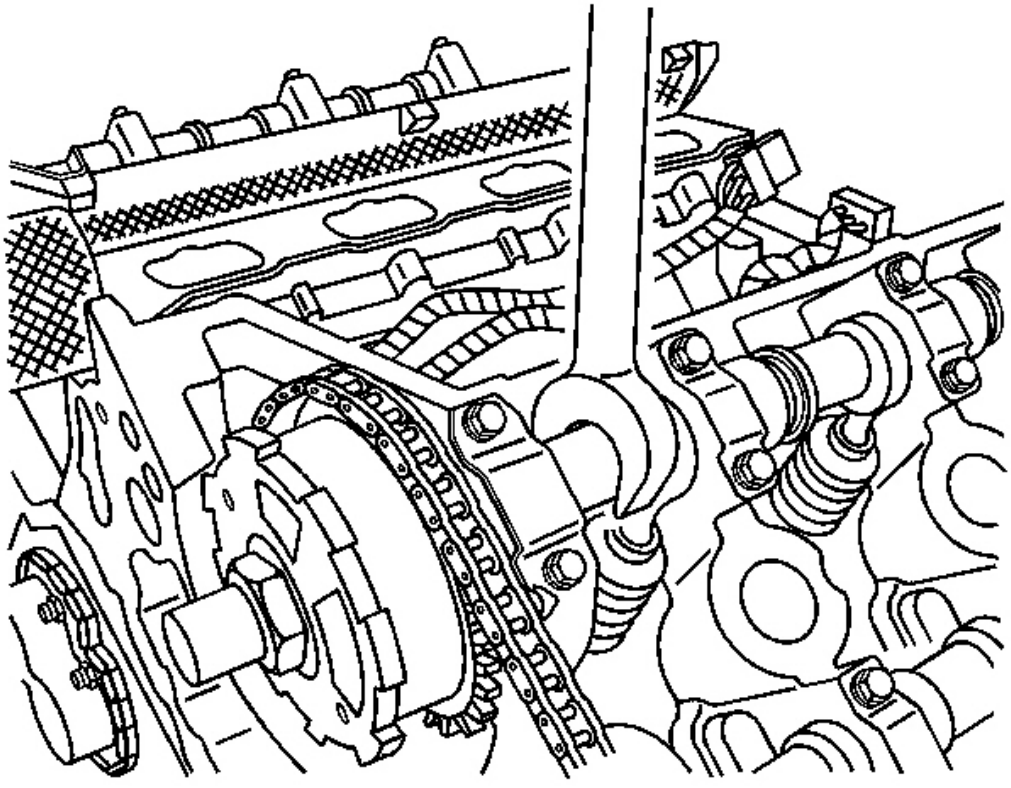


Fig. 407: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice .**

21. Use an open end wrench on the hex cast into the left intake camshaft, in order to prevent the camshaft from rotating, when tightening the camshaft position actuator oil control valve on the left intake camshaft.
22. Tighten the camshaft position actuator oil control valve on the left intake camshaft.

Tighten: Tighten the camshaft position actuator oil control valve to 120 N.m (89 lb ft).

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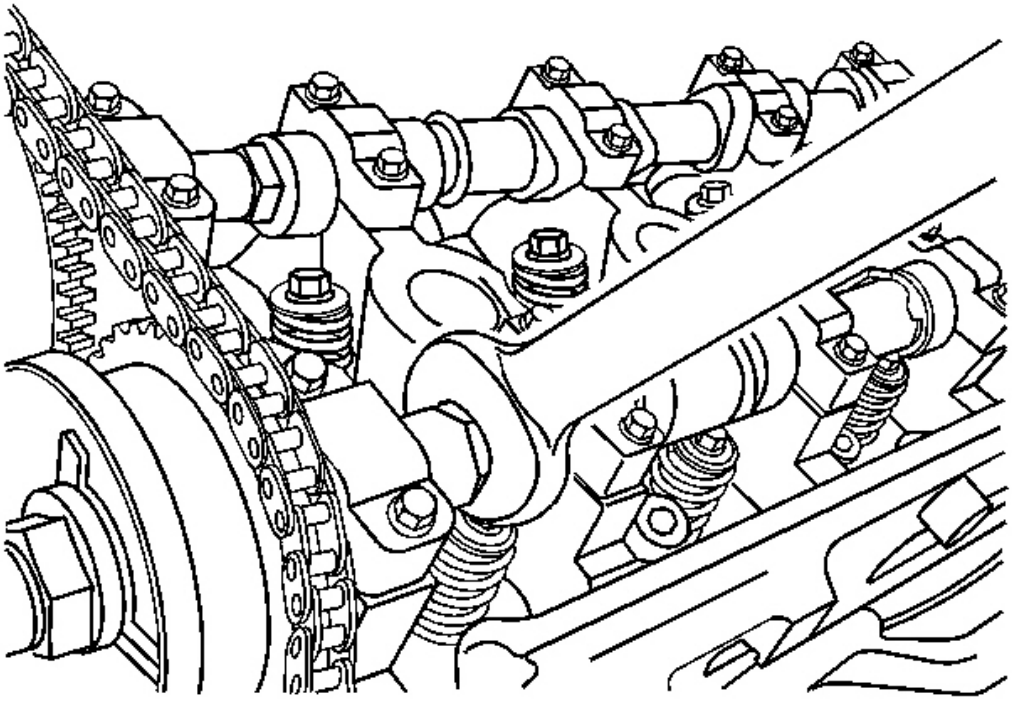


Fig. 408: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

23. Use an open end wrench on the hex cast into the left exhaust camshaft, in order to prevent the camshaft from rotating, when tightening the camshaft position oil actuator control valve on the left exhaust camshaft.
24. Tighten the camshaft position oil actuator control valve on the left exhaust camshaft.

    Tighten: Tighten the camshaft position actuator oil control valve to 120 N.m (89 lb ft).

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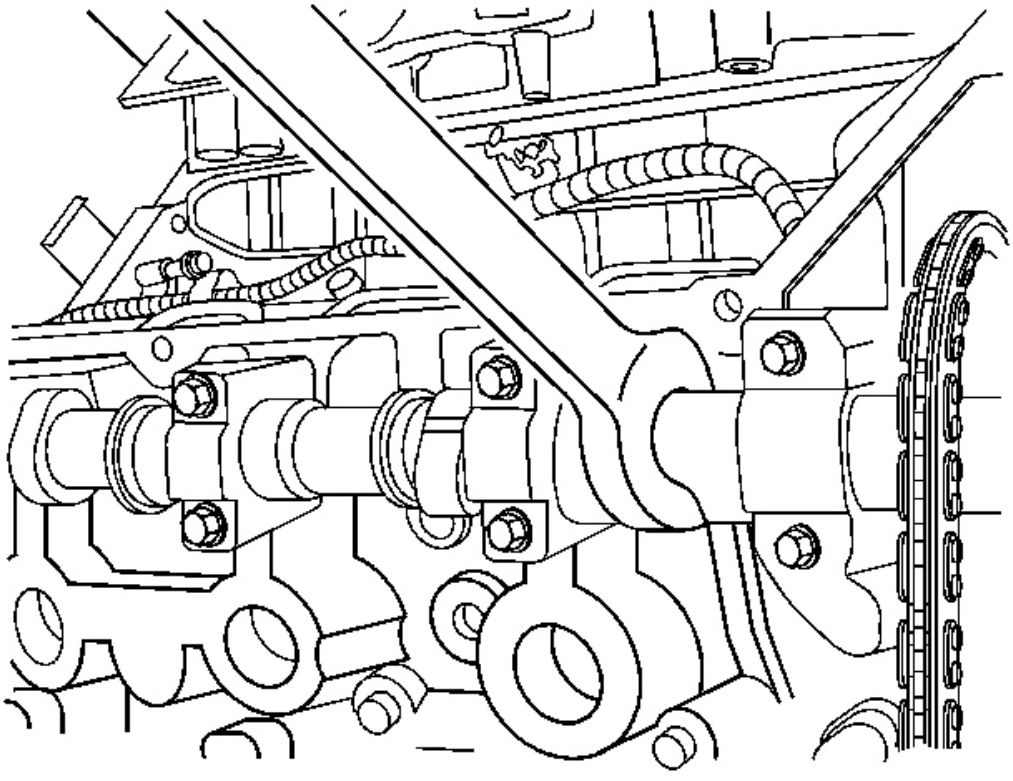


Fig. 409: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

25. Use an open end wrench on the hex cast into the right intake camshaft, in order to prevent the camshaft from rotating, when tightening the camshaft position actuator oil control valve on the right intake camshaft.
26. Tighten the camshaft position actuator oil control valve on the right intake camshaft.

    Tighten: Tighten the camshaft position actuator oil control valve to 120 N.m (89 lb ft).

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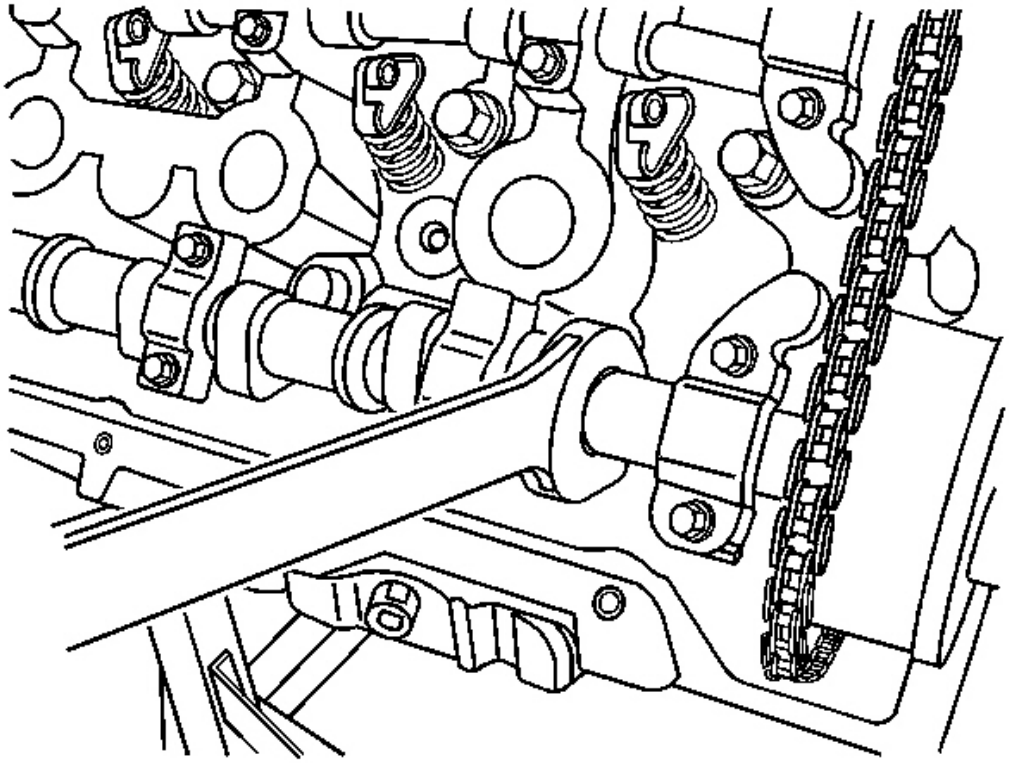


Fig. 410: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

27. Use an open end wrench on the hex cast into the right exhaust camshaft, in order to prevent the camshaft from rotating, when tightening the camshaft position actuator oil control valve on the right exhaust camshaft.
28. Tighten the camshaft position actuator oil control valve on the right exhaust camshaft.

    Tighten: Tighten the camshaft position actuator oil control valve to 120 N.m (89 lb ft).

OIL PUMP INSTALLATION

TOOLS REQUIRED

- **EN-48036** Oil Pump Alignment Tool. See **Special Tools** .
- **J 45059** Angle Meter. See **Special Tools** .

INSTALLATION PROCEDURE

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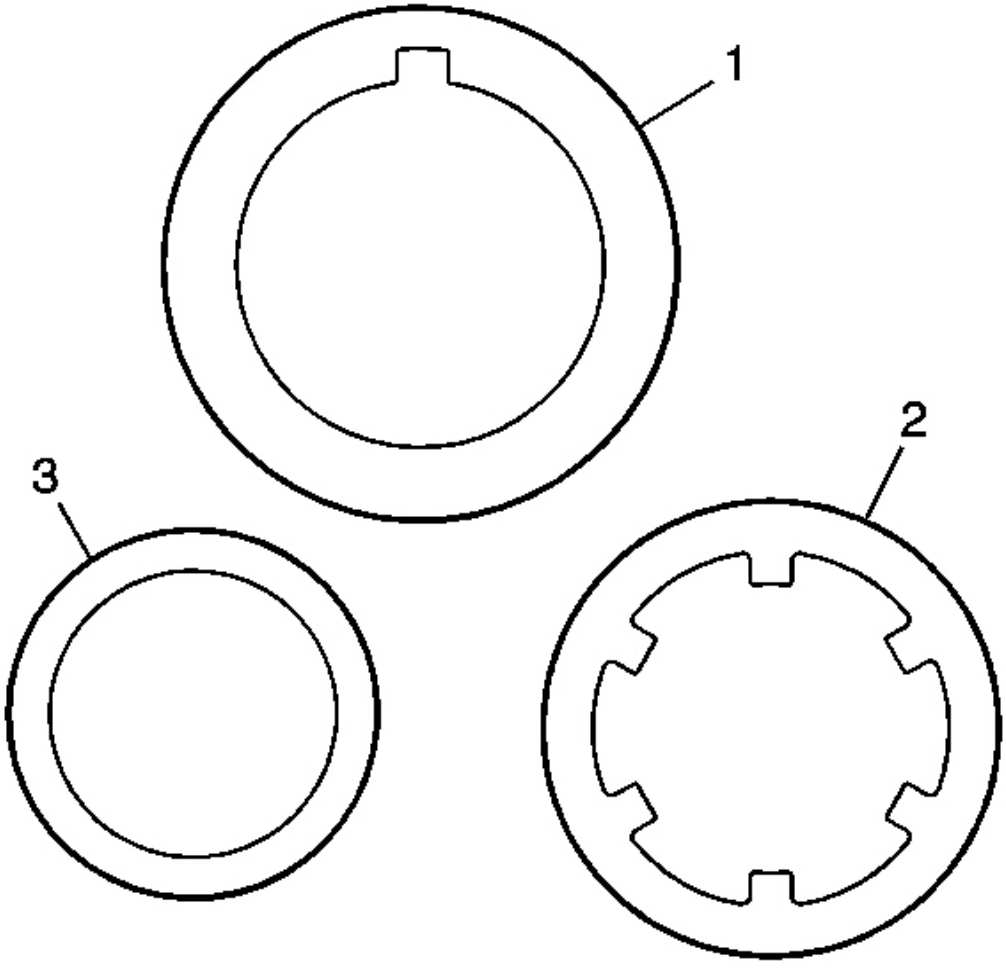


Fig. 411: View Of Friction Washers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the proper friction washer is installed in the correct position.

1. Select the crankshaft sprocket to oil pump drive friction washer (2). The outer diameter is 55.0 mm (2.1654 in) and an inner diameter, including tabs, of 35.0 mm (1.3780 in).

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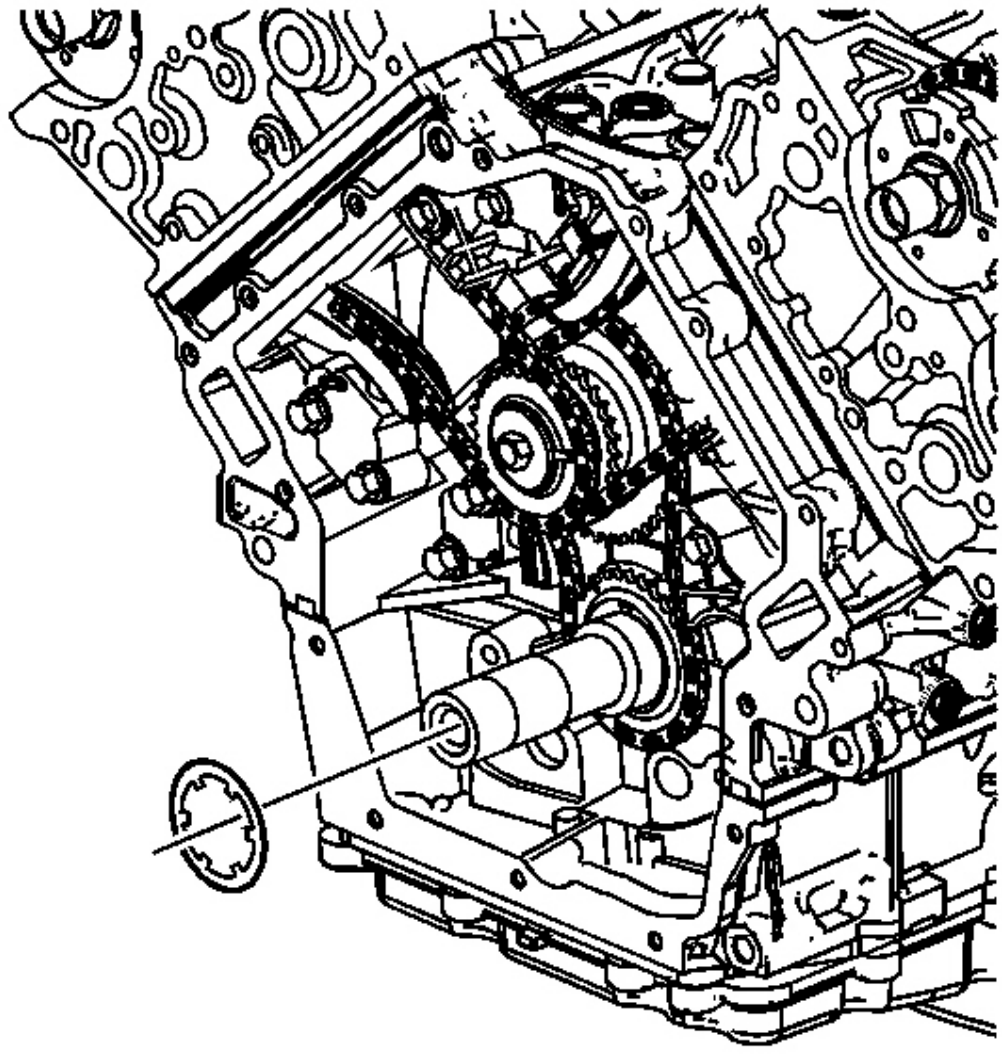


Fig. 412: View Of Crankshaft Sprocket To Oil Pump Drive Friction Washer
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft sprocket to oil pump drive friction washer.

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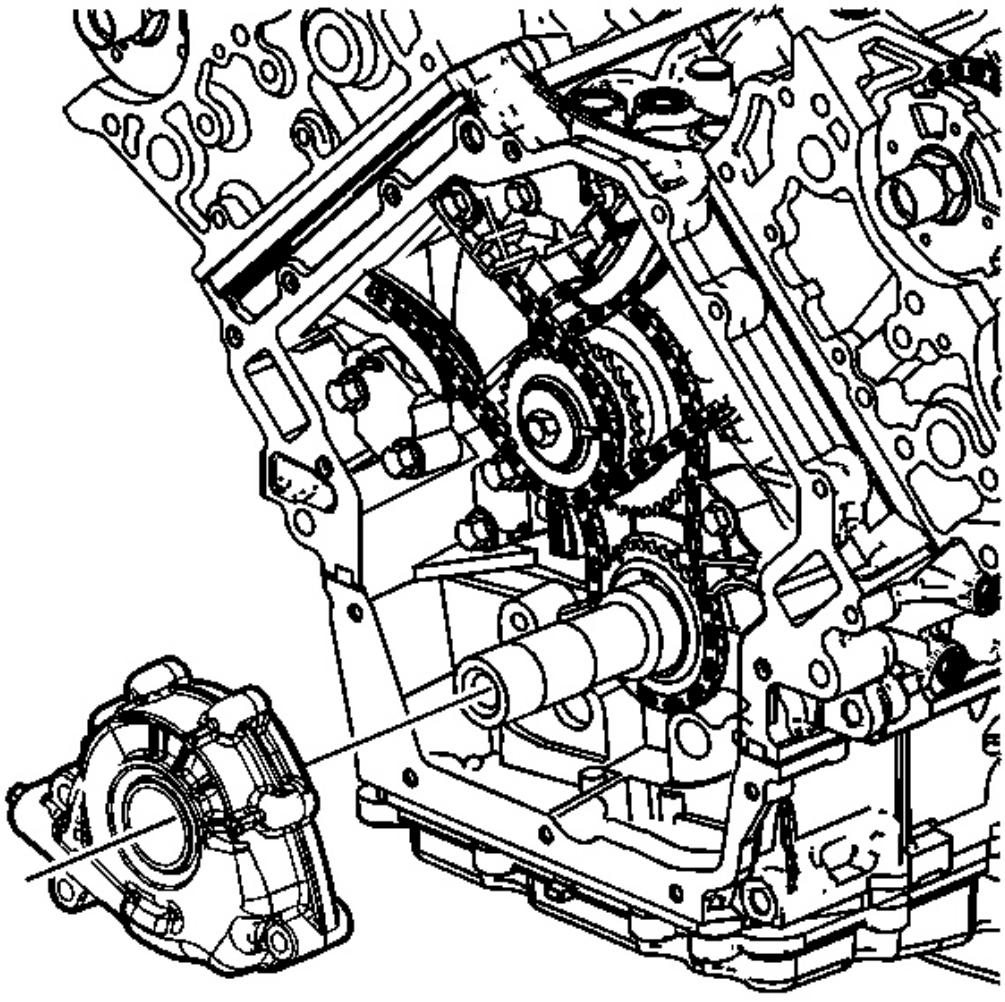


Fig. 413: View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pump.

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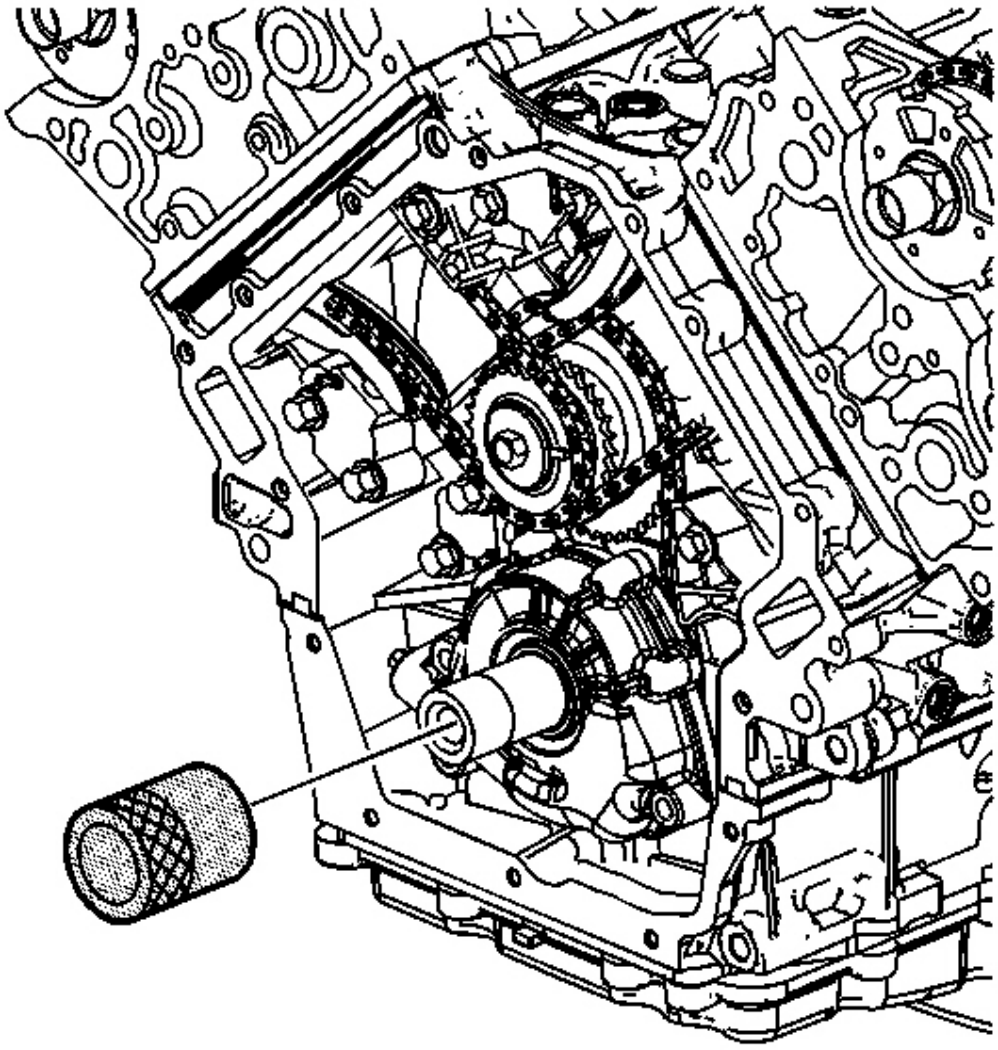


Fig. 414: EN-48036 Oil Pump Alignment Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: The EN 48036 must be used during the installation of the oil pump. Failure to use the EN 48036 to align the oil pump to the crankshaft can lead to oil pump damage and severe engine damage.

4. Install the **EN-48036** over the crankshaft nose and up to the oil pump. See **Special Tools** .

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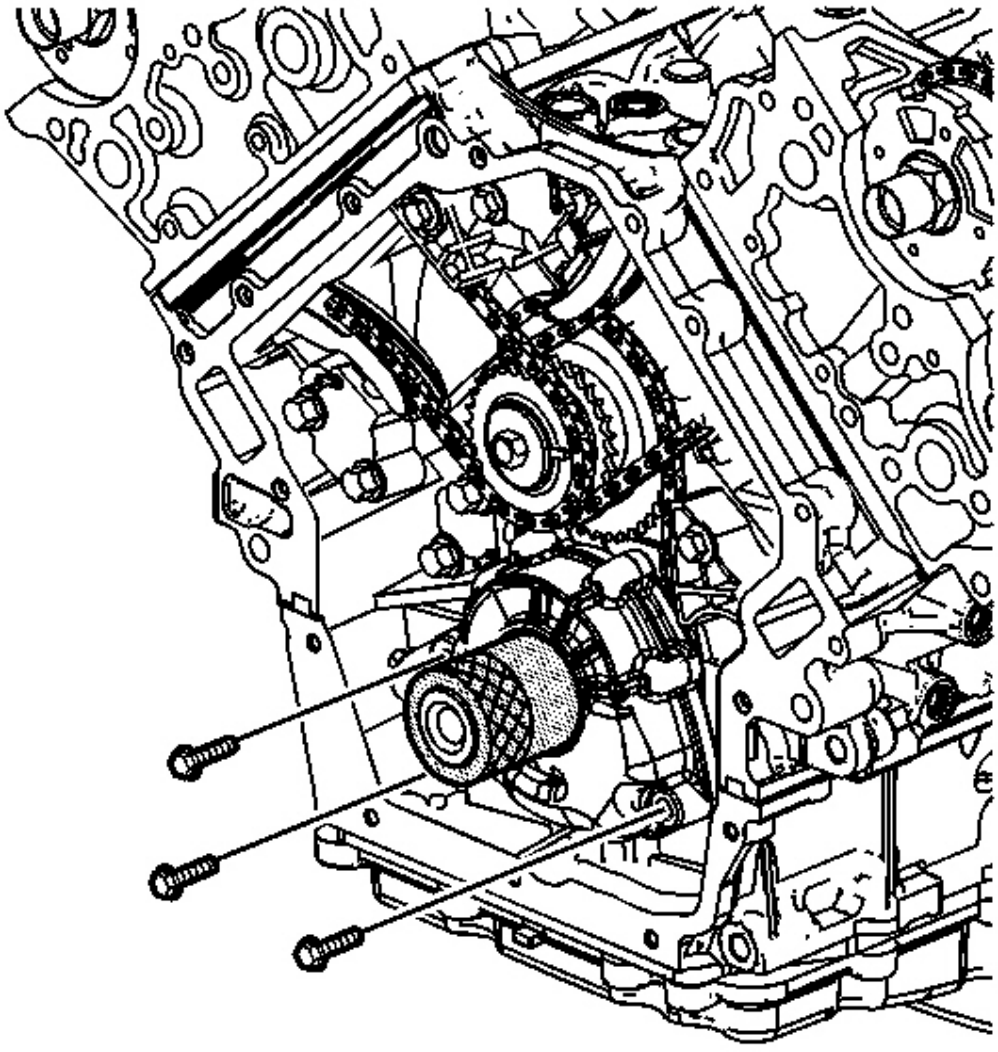


Fig. 415: Oil Pump Bolts
Courtesy of GENERAL MOTORS CORP.

5. Loosely install the oil pump bolts.

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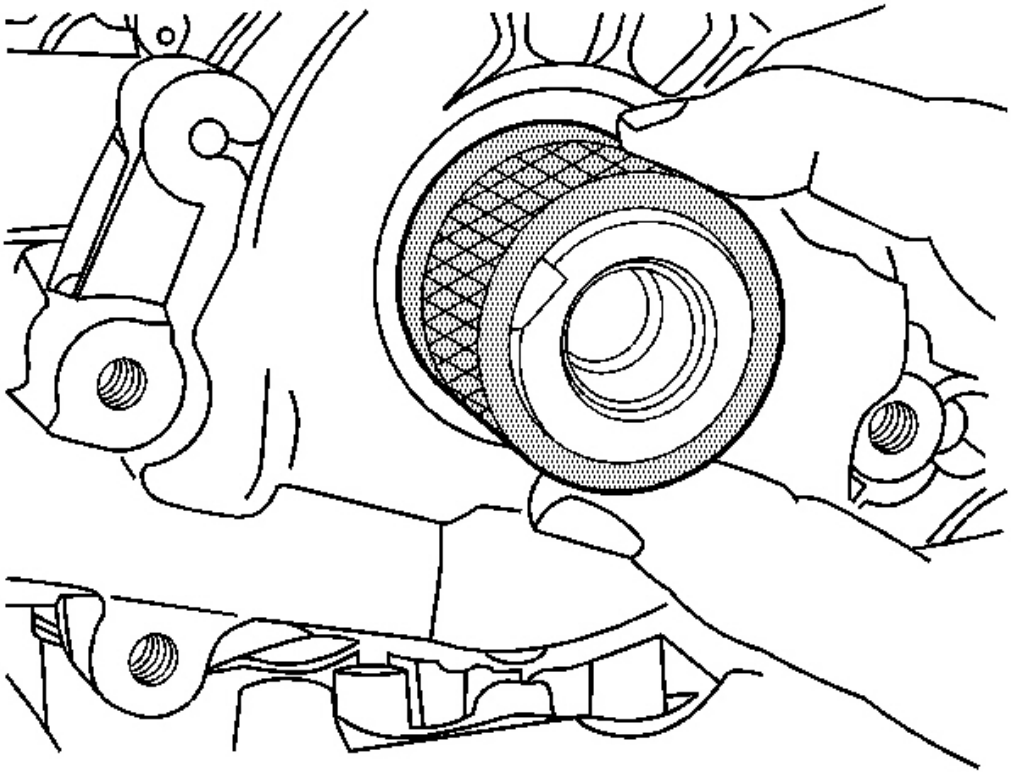


Fig. 416: Aligning Oil Pump To Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

6. Apply force by hand to the **EN-48036** against the oil pump in order to align the oil pump to the oil pump drive. See **Special Tools** .

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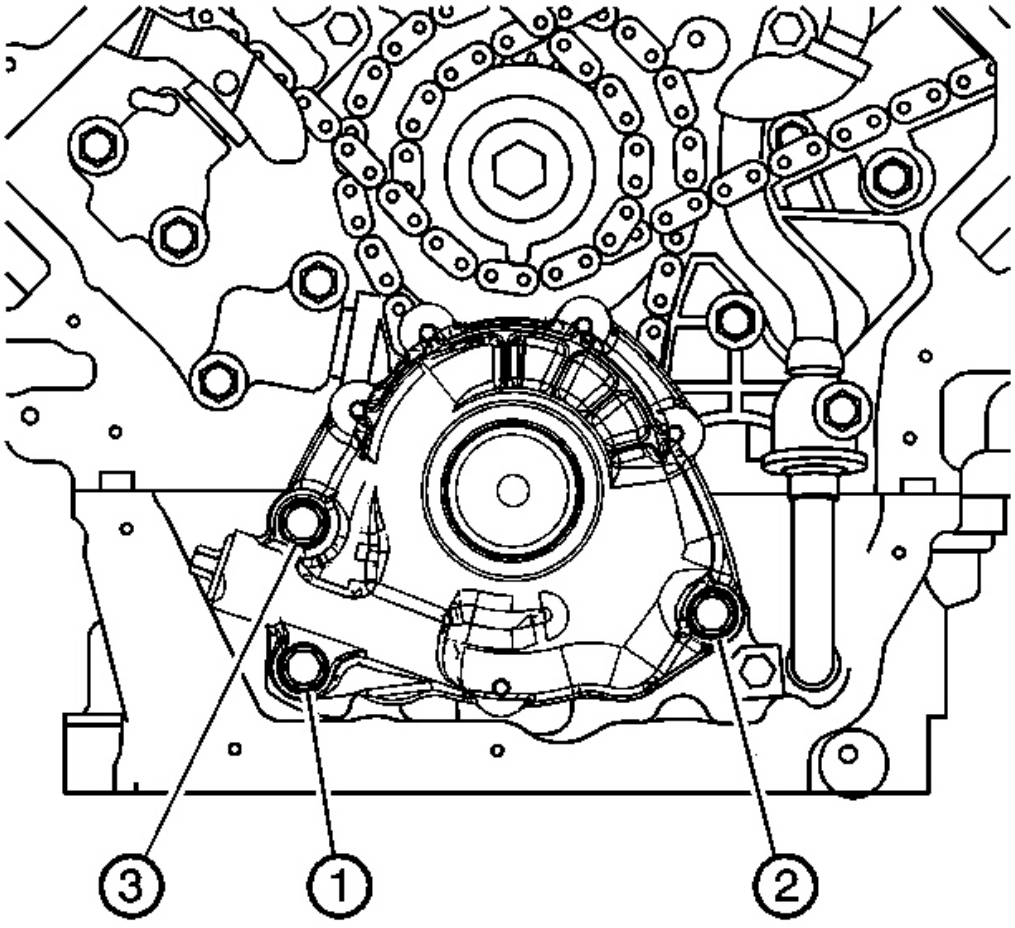


Fig. 417: Identifying Oil Pump Mounting Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

7. While keeping hand force on the **EN-48036** tighten the oil pump bolts in sequence (1, 2, 3) as shown. See **Special Tools** .
   1. First Pass

      Tighten: Tighten the oil pump bolts in sequence to 10 N.m (89 lb in).

   2. Final Pass

      Tighten: Tighten the oil pump bolts in sequence an additional 35 degrees using the **J 45059** . See

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Special Tools .

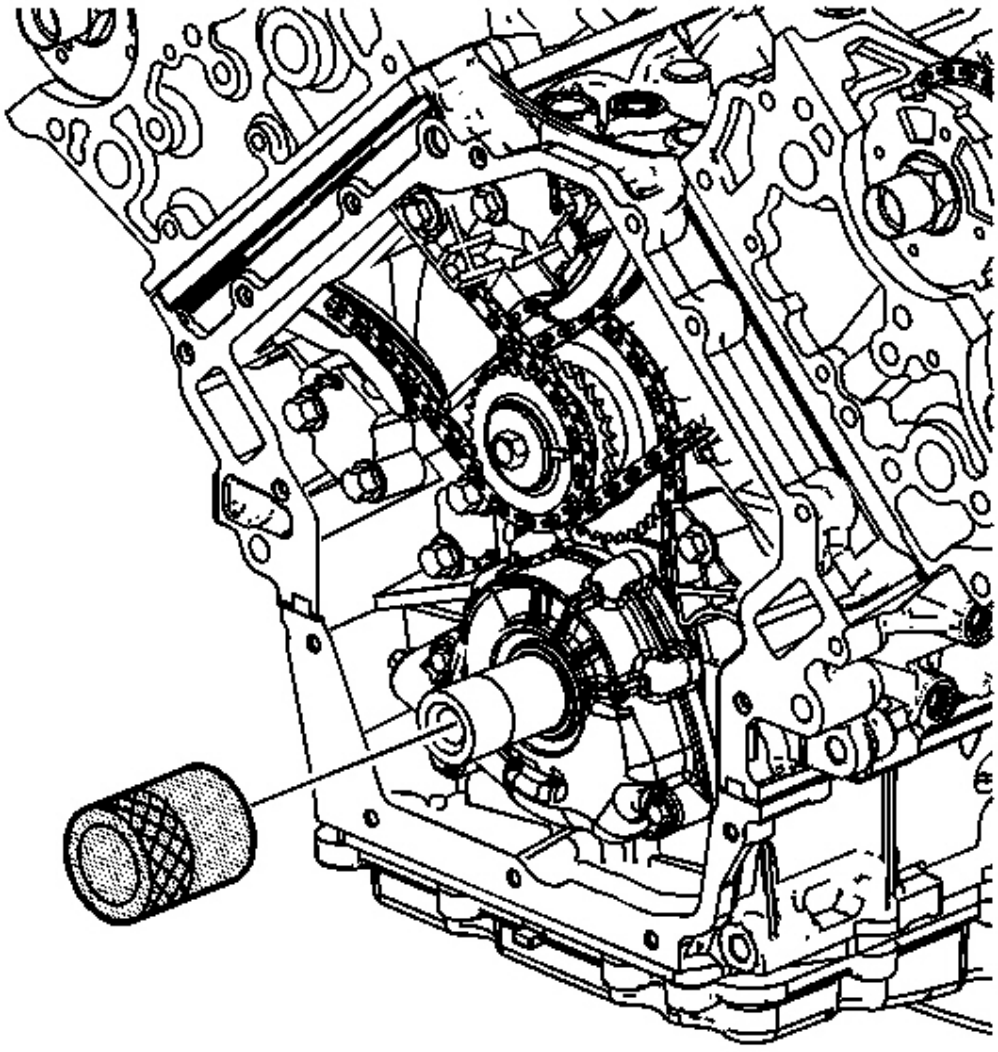


Fig. 418: View Of EN-48036
Courtesy of GENERAL MOTORS CORP.

8. Remove the **EN-48036** . See **Special Tools** .

ENGINE FRONT COVER INSTALLATION

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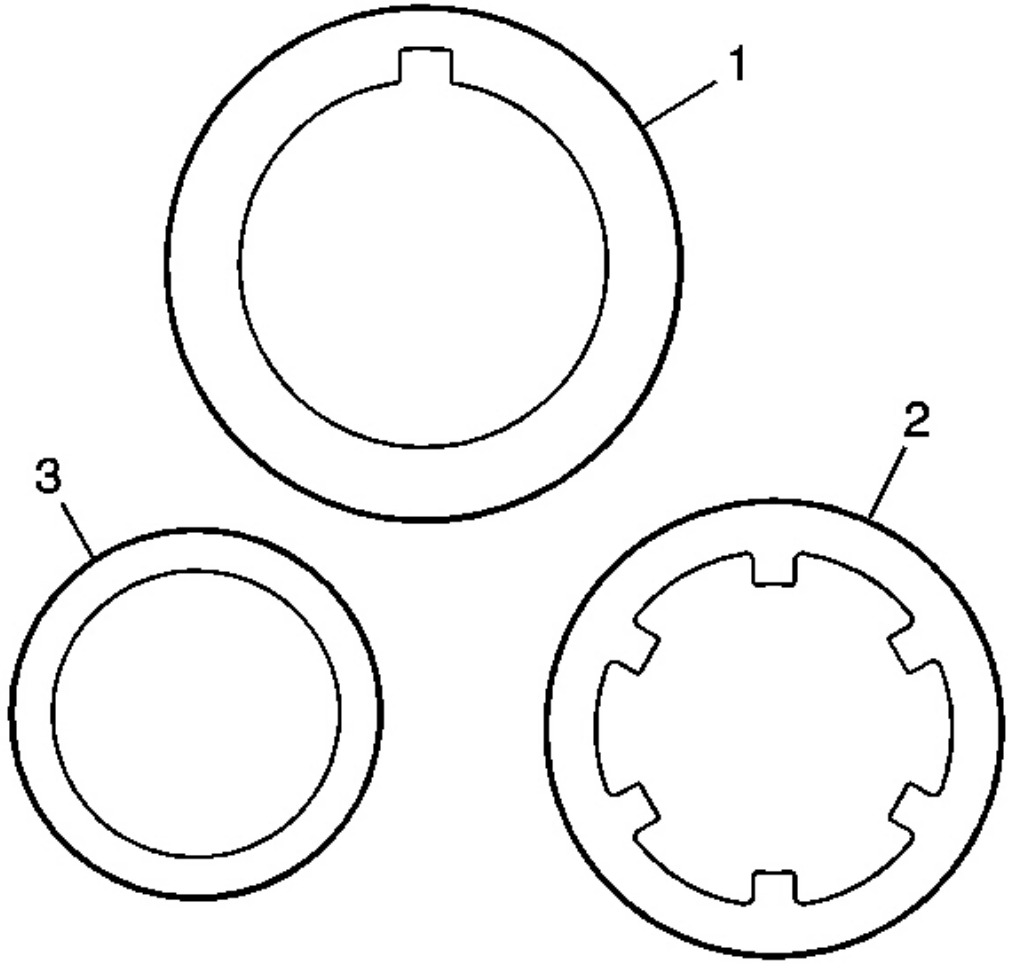


Fig. 419: View Of Friction Washers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the proper friction washer is installed in the correct position.

1. Select the oil pump drive to crankshaft balancer friction washer (3). The outer diameter is 45.5 mm (1.7913 in) and an inner diameter of 35.25 mm (1.3878 in).

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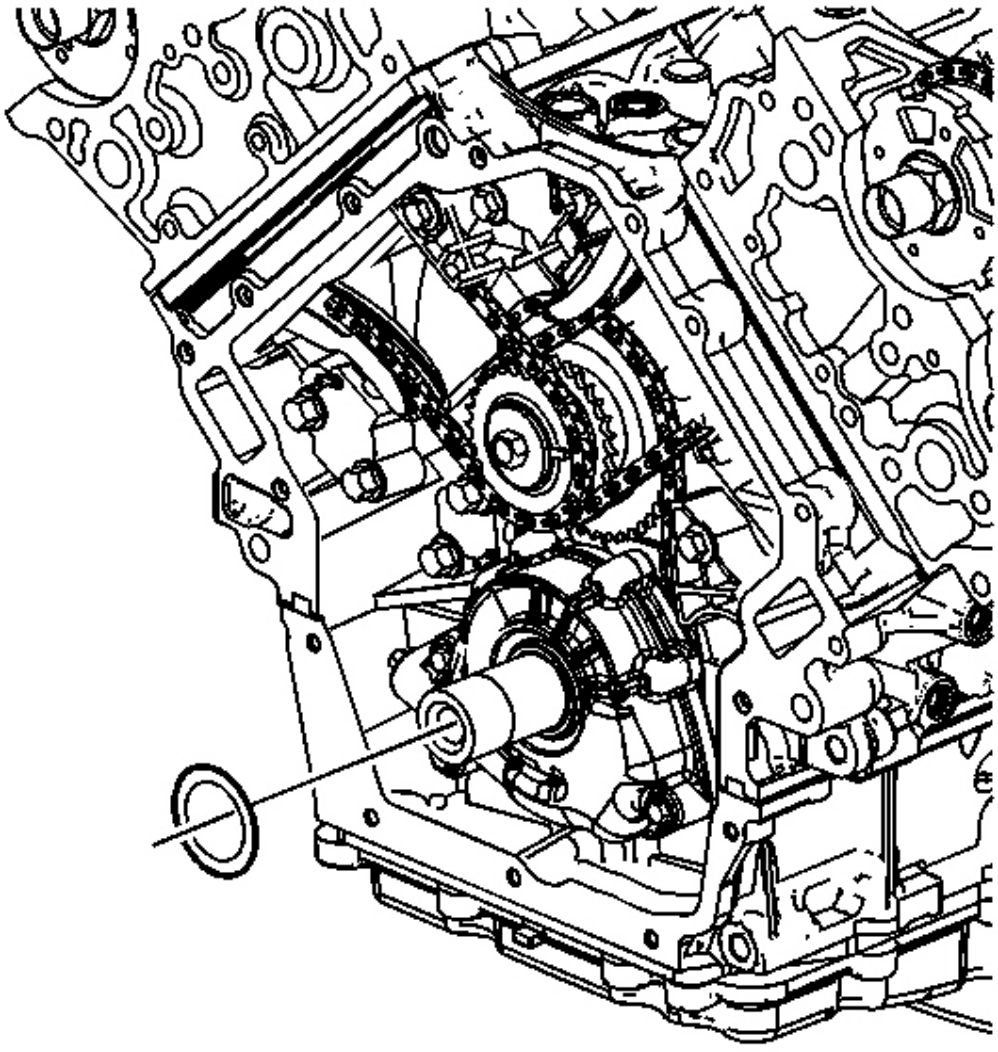


Fig. 420: View Of Oil Pump Drive To Crankshaft Balancer Friction Washer
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pump drive to crankshaft balancer friction washer.

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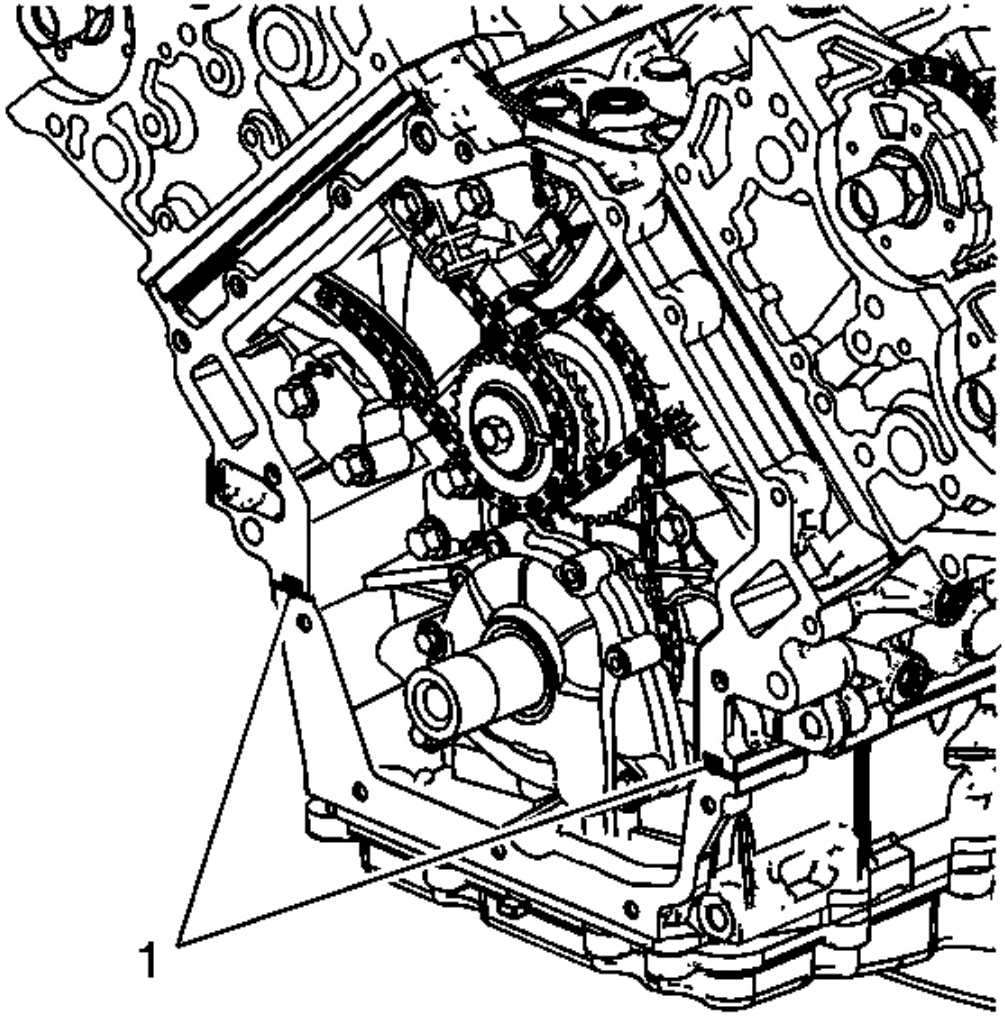


Fig. 421: Applying Sealant To Split Line Of Crankcases
Courtesy of GENERAL MOTORS CORP.

3. Place a small amount of sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent at the split line of the upper and lower crankcases (1).

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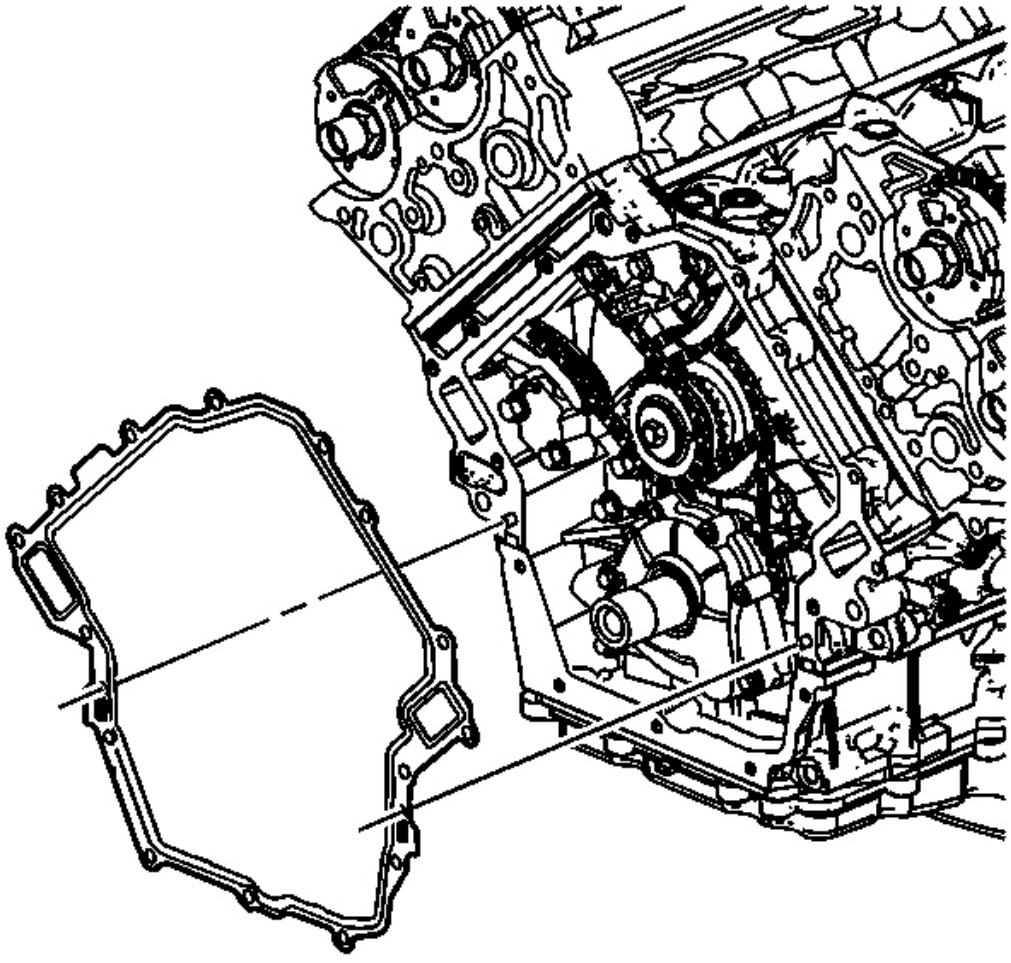


Fig. 422: View Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

4. Place the NEW engine front cover gasket over the crankcase dowel pins.

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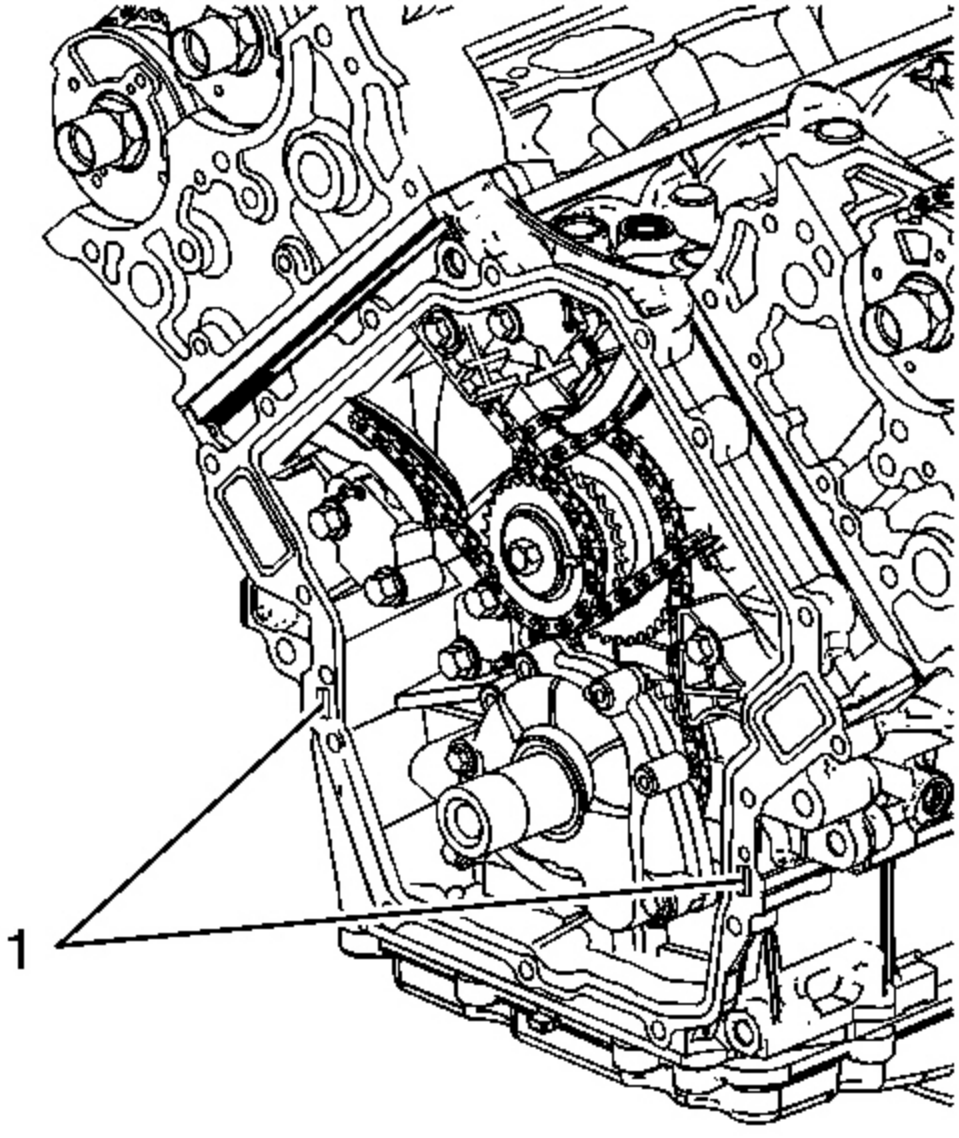


Fig. 423: Identifying Split Line Of Upper And Lower Crankcases
Courtesy of GENERAL MOTORS CORP.

5. Place a small amount of sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent at the engine front cover gasket pad area located on top of the split line of the upper and lower crankcases (1).

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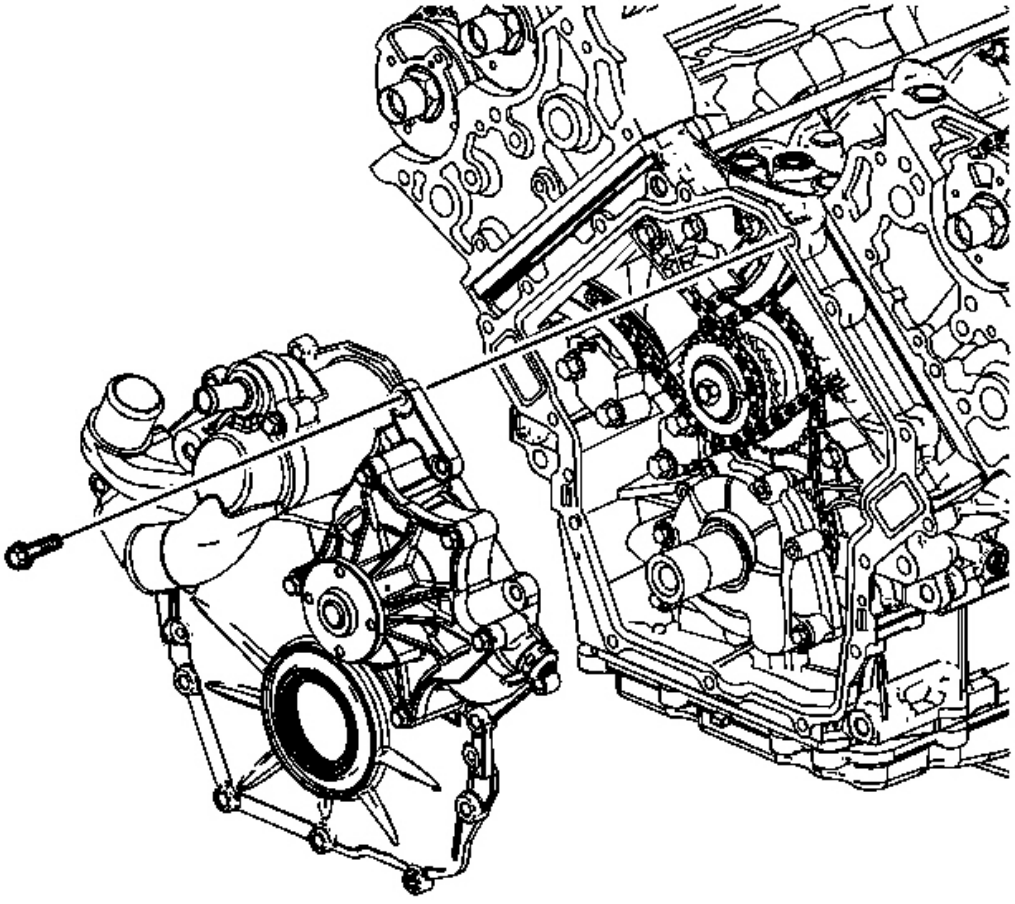


Fig. 424: View Of Engine Front Cover Bolt
Courtesy of GENERAL MOTORS CORP.

6. Place the engine front cover in position on the crankcase.
7. Apply the thread locking compound GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the engine front cover bolts.
8. Install the engine front cover bolts.

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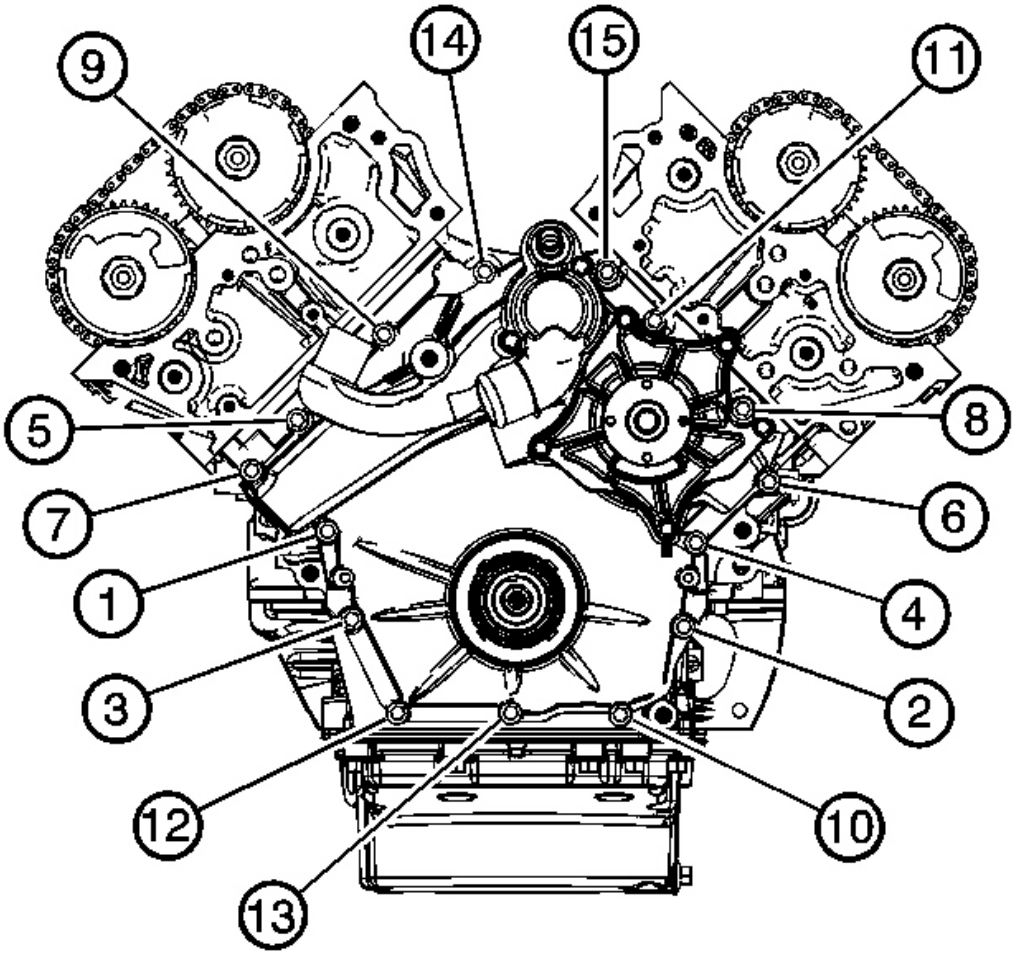


Fig. 425: Engine Front Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

9. Tighten the engine front cover bolts in the sequence shown.

   Tighten: Tighten the engine front cover bolts in proper sequence to 15 N.m (11 lb ft).

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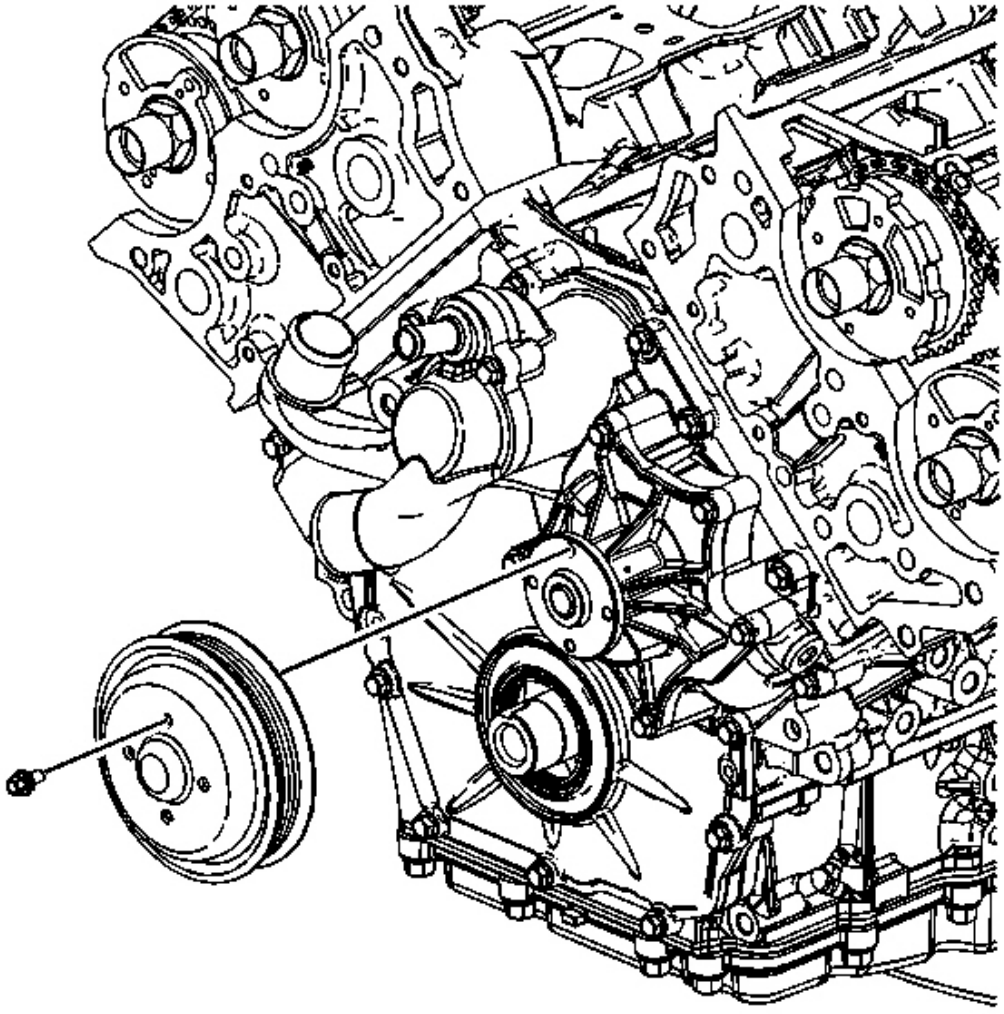


Fig. 426: View Of Water Pump Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

10. Install the water pump pulley.
11. Install the water pump pulley bolts.

Tighten: Tighten the water pump pulley bolt to 10 N.m (89 lb in).

CAMSHAFT POSITION ACTUATOR HOUSING INSTALLATION - RIGHT SIDE

TOOLS REQUIRED

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EN 46109 Guide Pin Set. See **Special Tools** .

INSTALLATION PROCEDURE

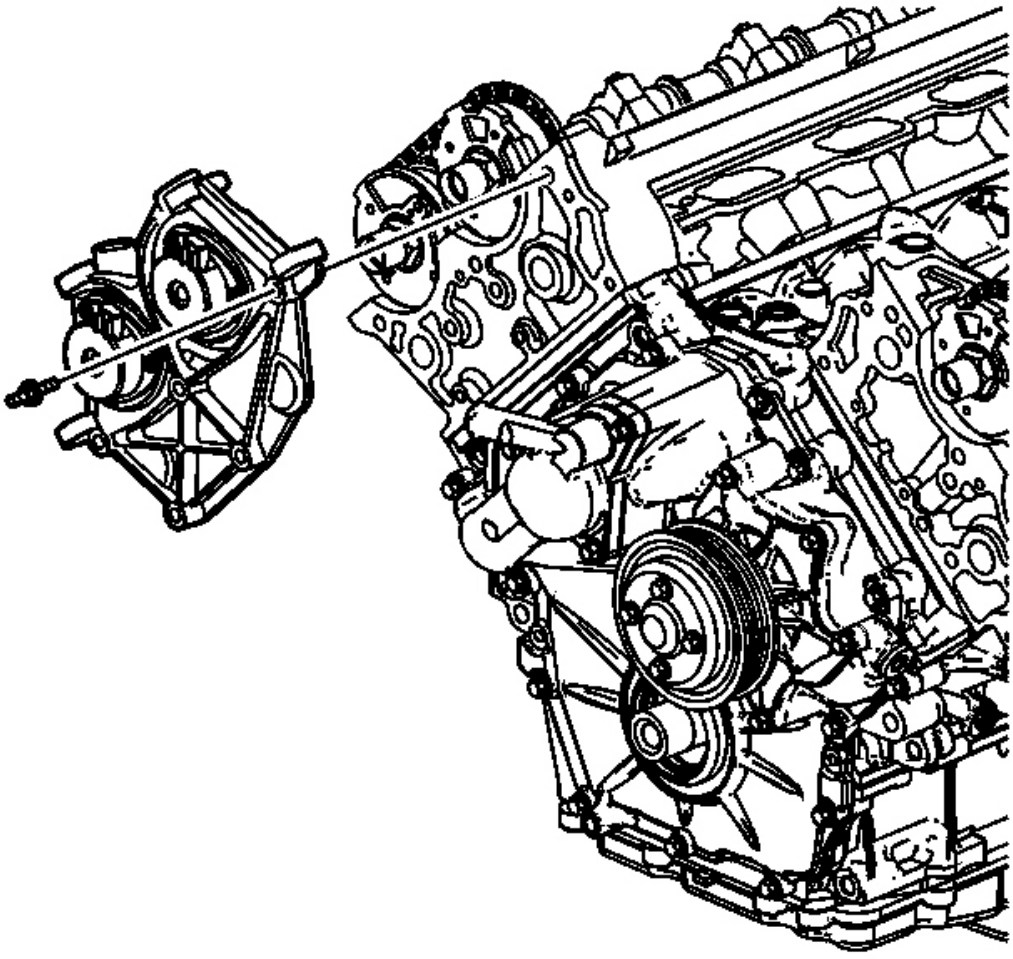


Fig. 427: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT remove the camshaft position actuator magnet unless it needs to be replaced. The camshaft position actuator magnet is precisely aligned to the camshaft position actuator oil control valve on the end of the camshaft during engine assembly. If the camshaft position actuator magnet is removed and/or needs to be replaced, it will be necessary to realign the camshaft position actuator magnet to the camshaft position actuator oil

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control valve after the camshaft position actuator housing is installed to the cylinder head. Failure to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve can lead to poor engine performance and engine component damage.

1. Install the right camshaft position actuator housing.

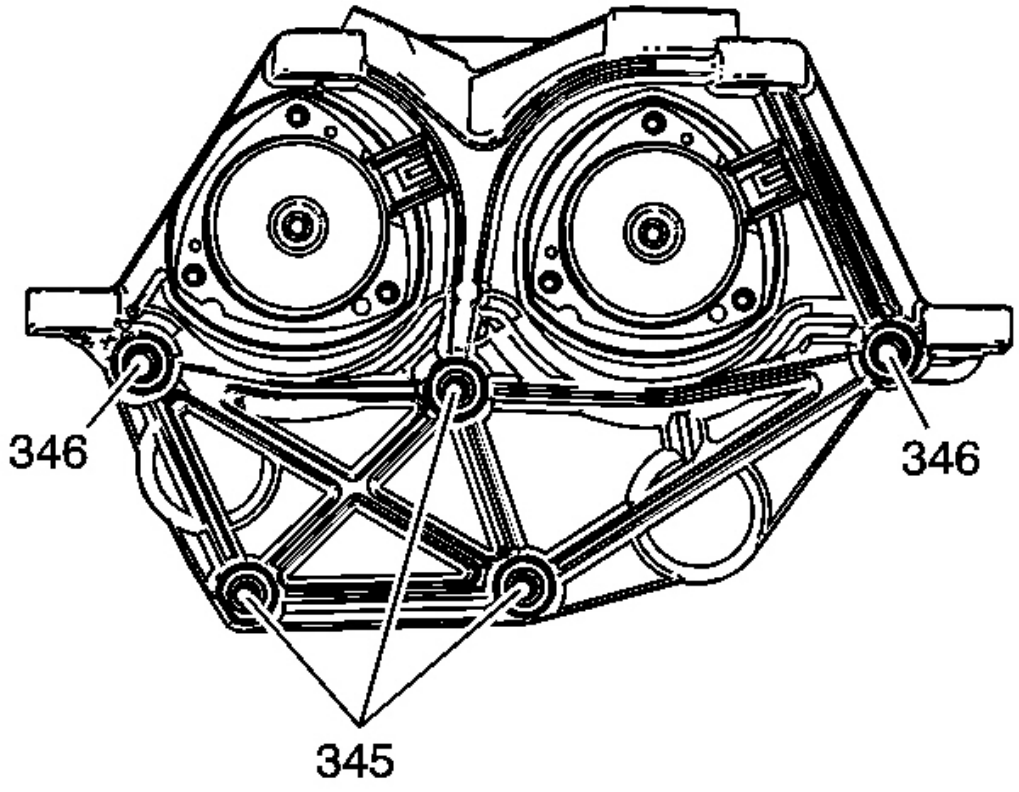


Fig. 428: Locating Right Camshaft Position Actuator Housing Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install the right camshaft position actuator housing short studs (345) and long studs (346).

Tighten: Tighten the right camshaft position actuator housing studs to 10 N.m (89 lb in).

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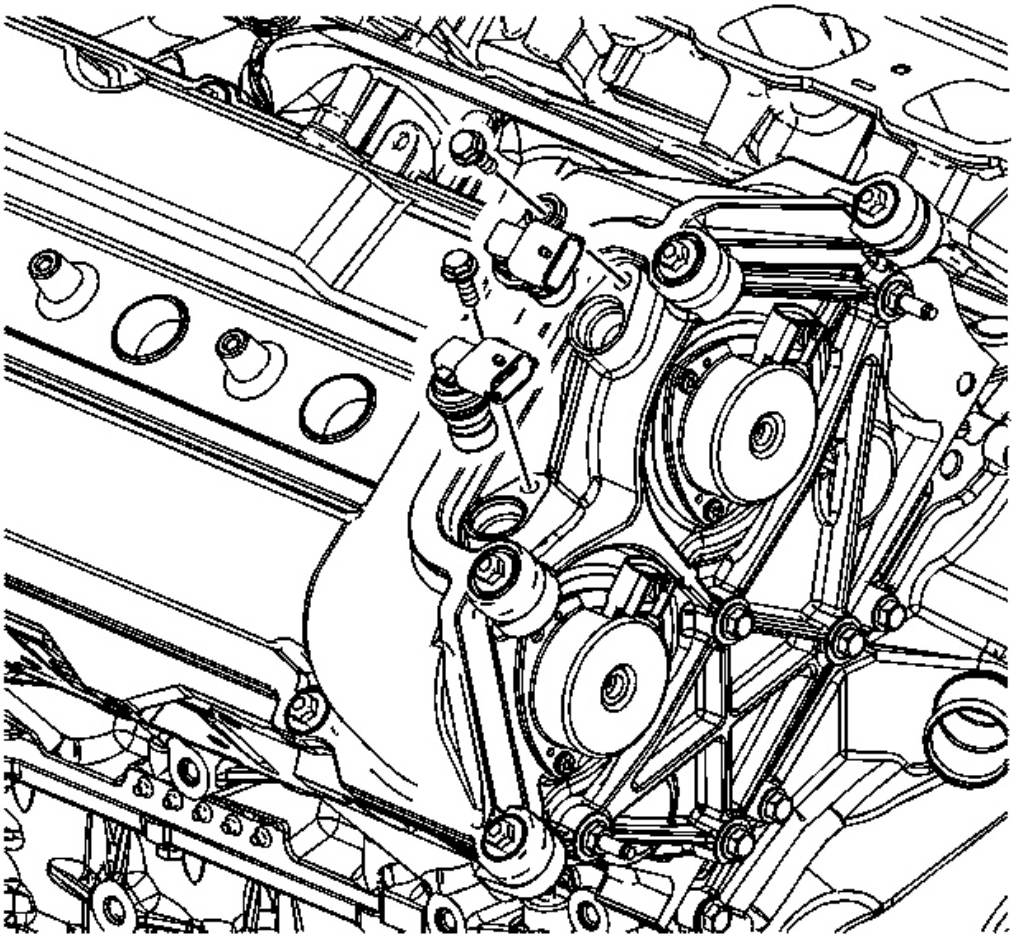


Fig. 429: View Of Right Intake Camshaft Sensor & Right Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

3. Install the right camshaft position sensors.
4. Install the right camshaft position sensor bolts.

Tighten: Tighten the right camshaft position sensor bolts to 10 N.m (89 lb in).

CAMSHAFT POSITION ACTUATOR MAGNET ALIGNMENT

1. If the camshaft position actuator magnet has been removed or is being replaced the camshaft position actuator magnet will need to be resealed to the camshaft position actuator housing and realigned to the camshaft position actuator oil control valve.

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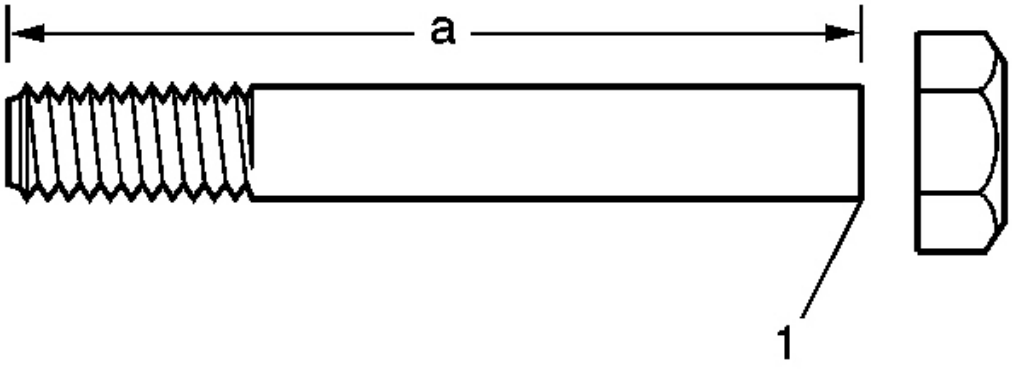


Fig. 430: Creating Loading Pins
Courtesy of GENERAL MOTORS CORP.

2. Use the 2 6 mm (0.236 in) pins, EN 46109-1, from the **EN 46109** or make 2 loading pins from 2 6 mm (0. See **Special Tools** .236 in) bolts at least 75 mm (3.00 in) long (a) with the hex head removed (1).

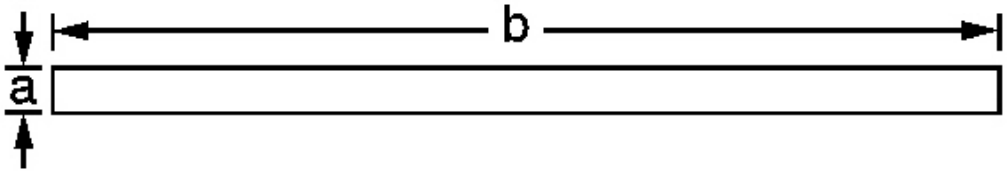


Fig. 431: Making Alignment Pin
Courtesy of GENERAL MOTORS CORP.

3. Make an alignment pin from 15/64 inch drill rod (a) with a diameter of 5.954 mm (0.2344 in) and at least 75 mm (3.00 in) long (b).

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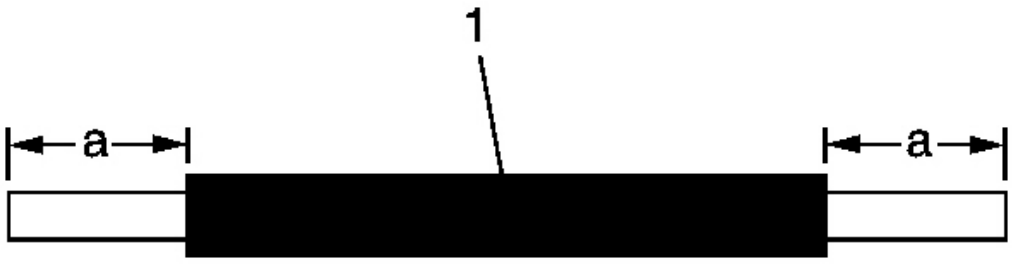


Fig. 432: Creating A Stop On Alignment Pin
Courtesy of GENERAL MOTORS CORP.

4. To verify proper insertion distance create a stop (1) on the alignment pin by placing tape or shrink tubing 13 mm (0.5118 in) from the end (a) that will be inserted through the camshaft position actuator magnet.

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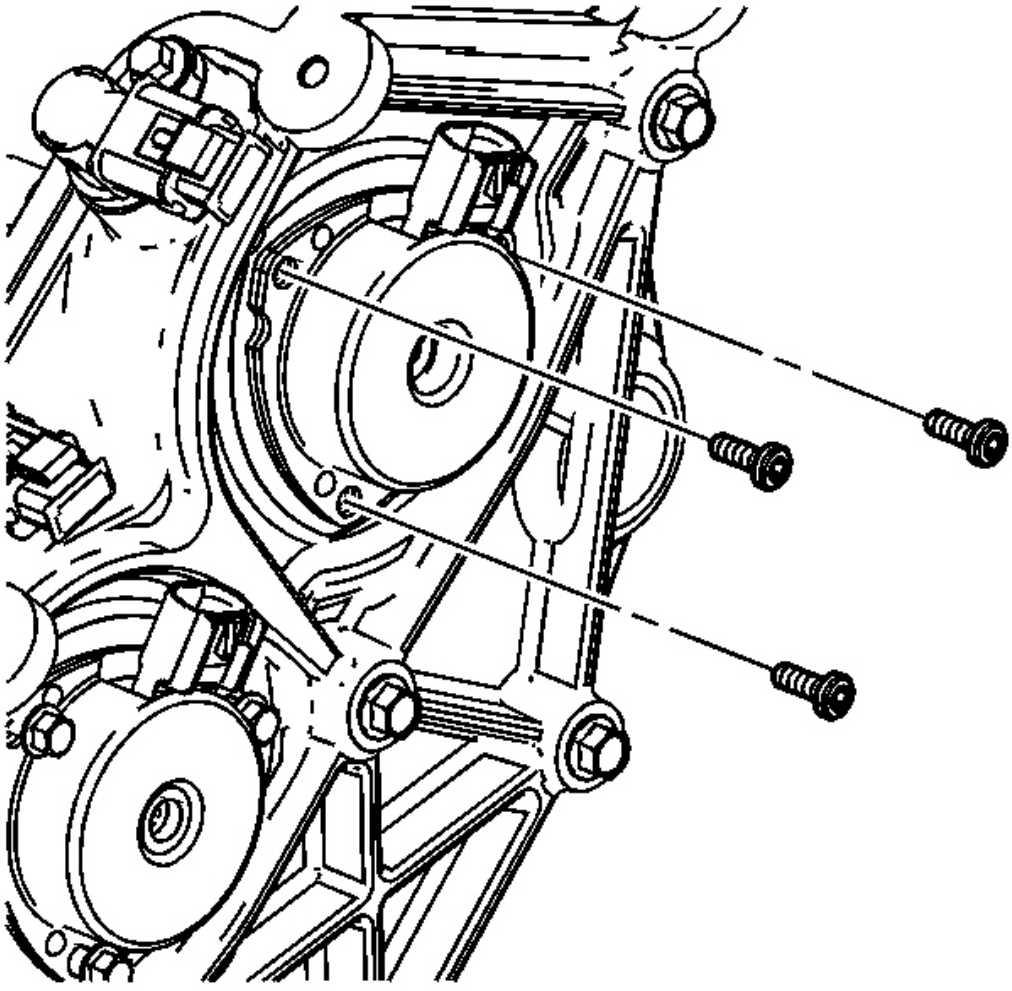


Fig. 433: View Of Camshaft Position Actuator Magnet Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft position actuator magnet bolts.

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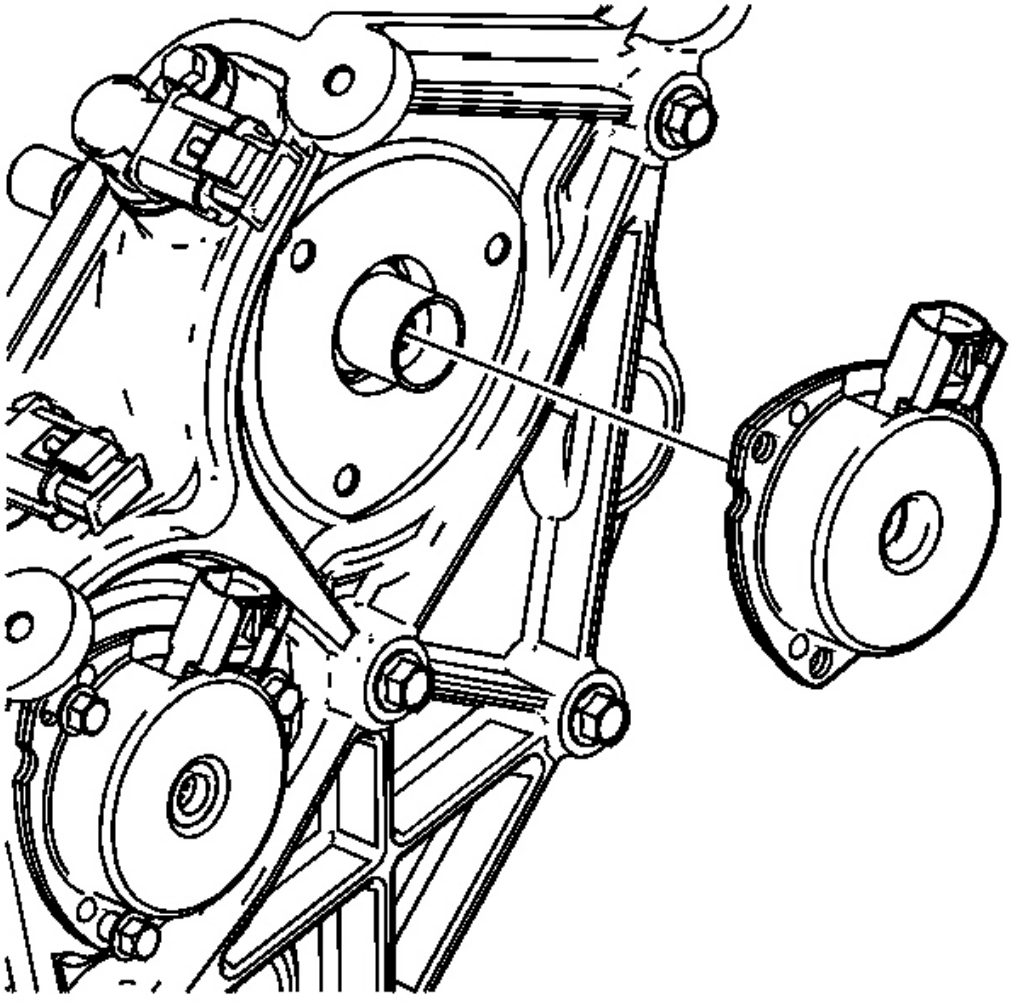


Fig. 434: View Of Camshaft Position Actuator Magnet
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft position actuator magnet.

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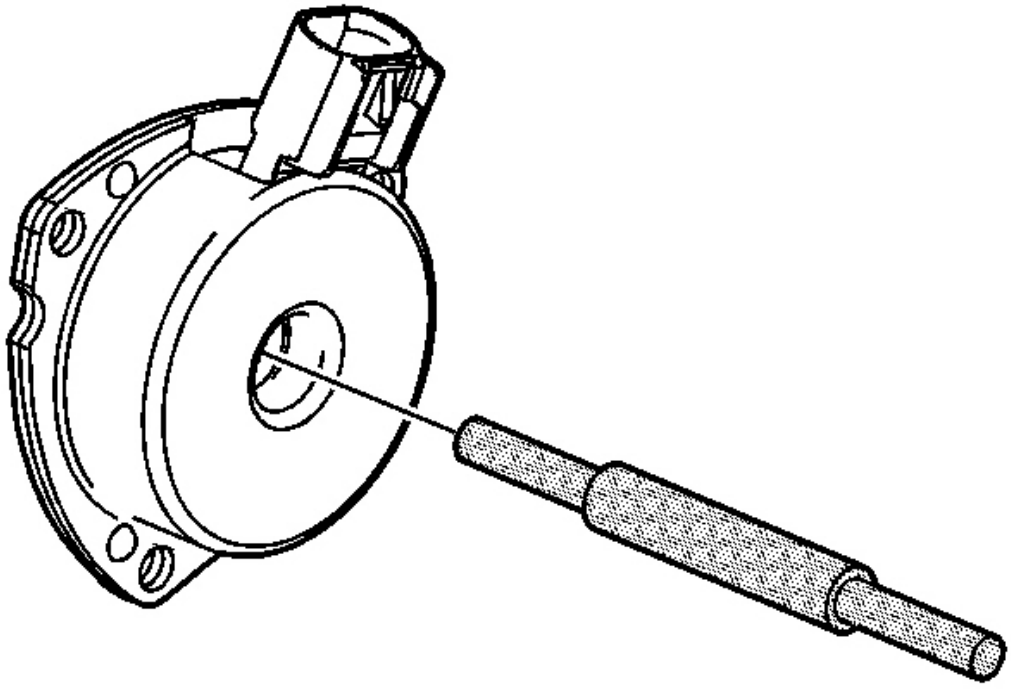


Fig. 435: Verifying That Alignment Pin Will Pass Through Camshaft Position Actuator Magnet Alignment Hole
Courtesy of GENERAL MOTORS CORP.

7. Verify that the alignment pin will pass through the camshaft position actuator magnet alignment hole.

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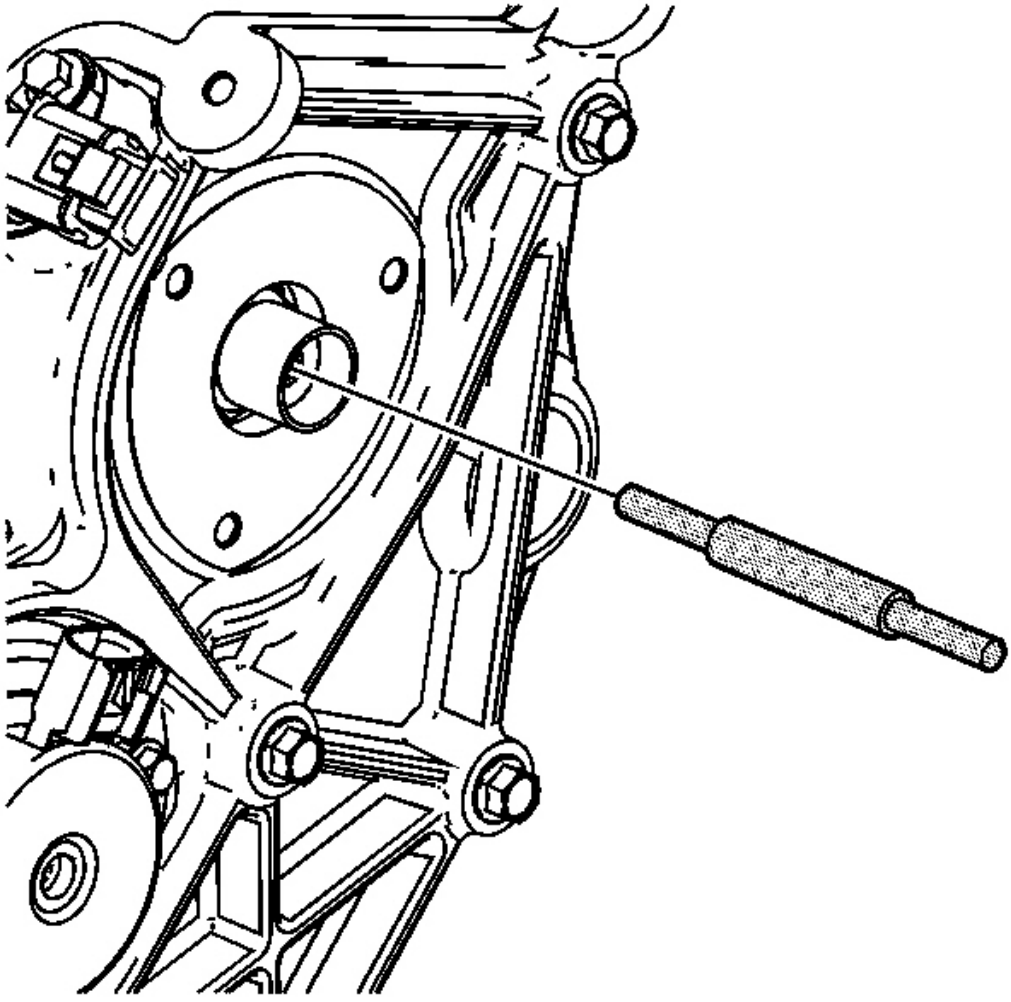


Fig. 436: Verifying That Alignment Pin Will Pass Through Camshaft Position Actuator Oil Control Valve Alignment Hole
Courtesy of GENERAL MOTORS CORP.

8. Verify that the alignment pin will fit into the alignment hole in the camshaft position actuator oil control valve.

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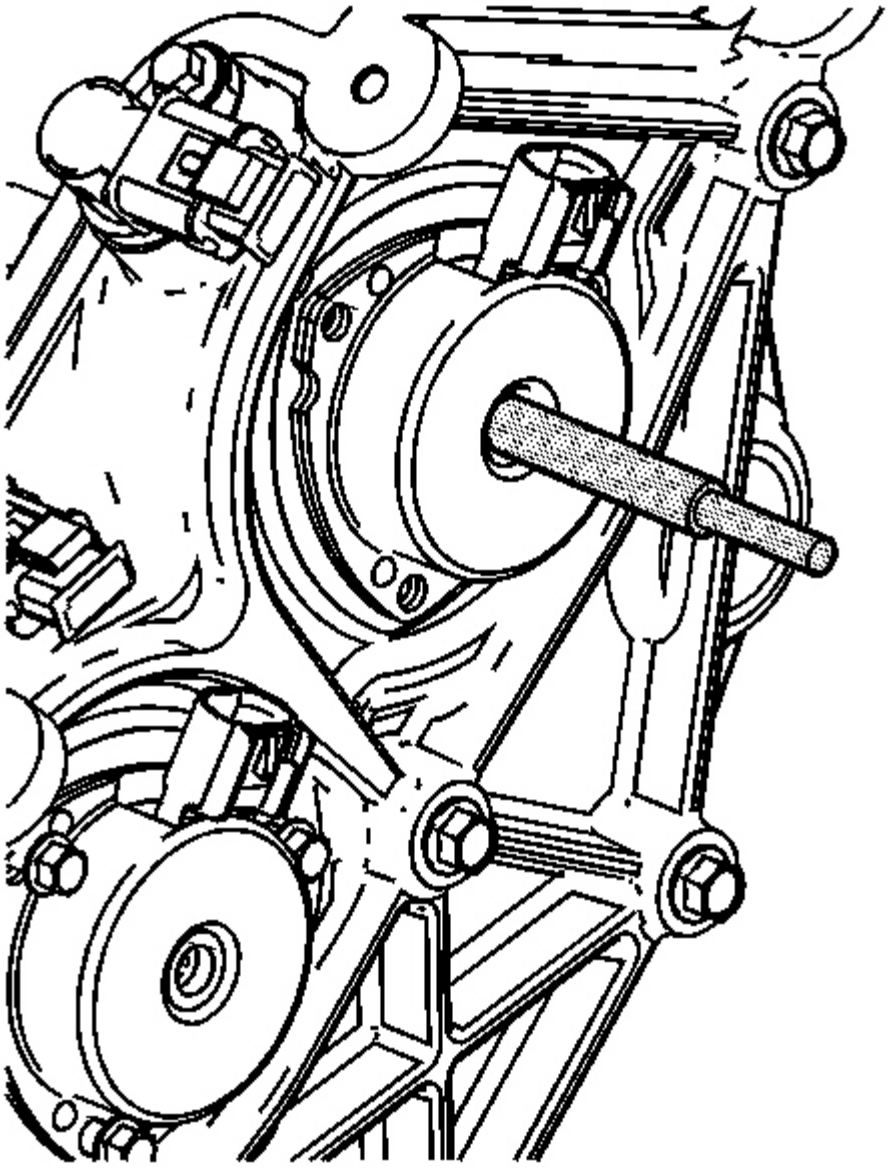


Fig. 437: Verifying Alignment Pin Stop Distance
Courtesy of GENERAL MOTORS CORP.

9. Place the camshaft position actuator magnet into place and verify the alignment pin will insert through the camshaft position actuator magnet and into the camshaft position actuator oil control valve to verify alignment pin stop distance.

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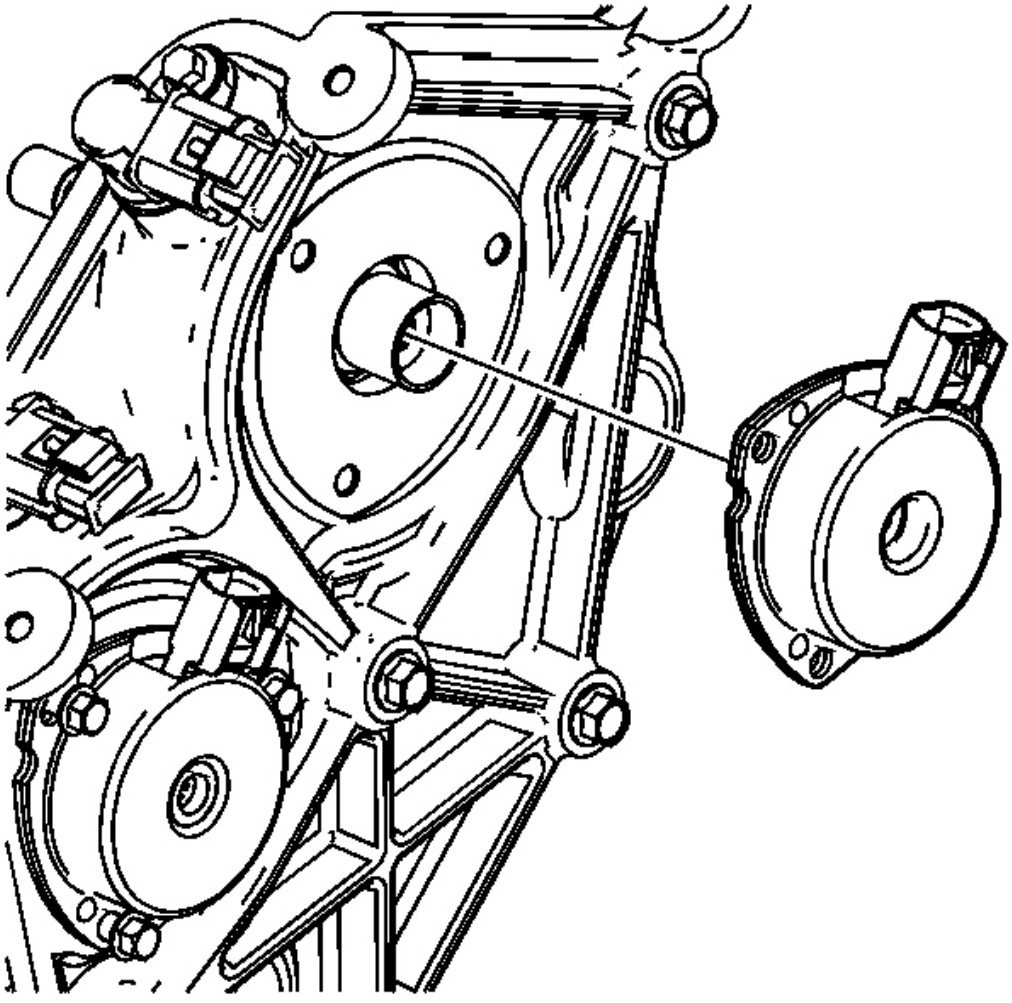


Fig. 438: View Of Camshaft Position Actuator Magnet
Courtesy of GENERAL MOTORS CORP.

10. Remove the camshaft position actuator magnet.

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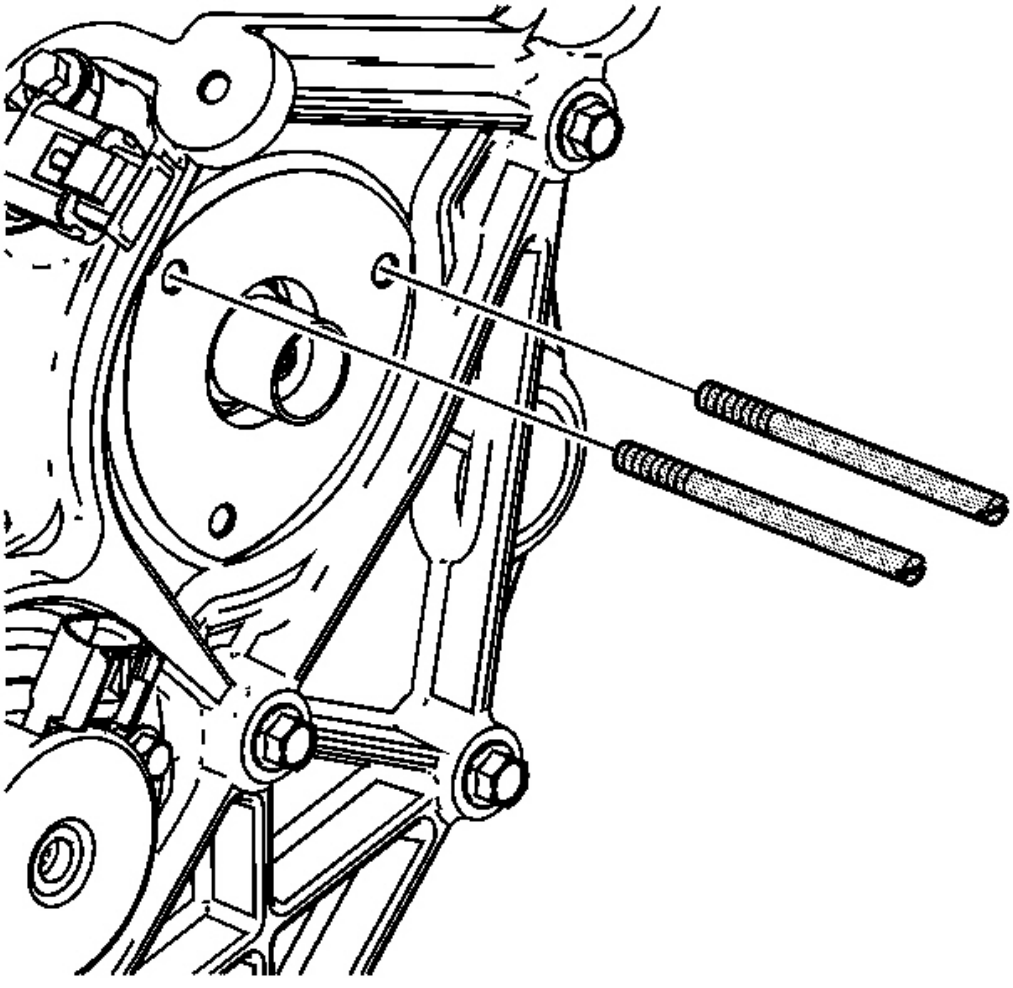


Fig. 439: Installing Loading Pins
Courtesy of GENERAL MOTORS CORP.

11. Install the 2 6 mm (0.236 in) loading pins in 2 of the camshaft position actuator magnet bolt holes in the camshaft position actuator housing.

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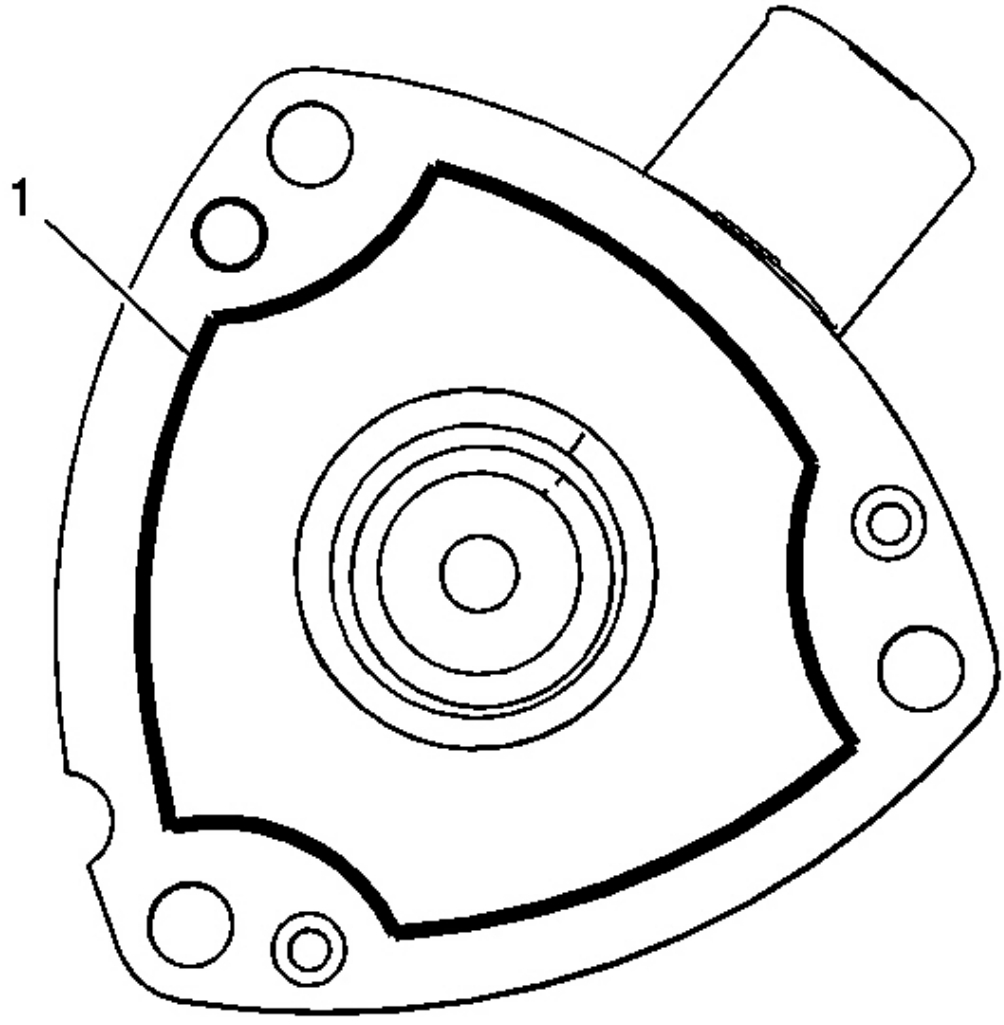


Fig. 440: Applying Sealant Around Flange Of Camshaft Position Actuator Magnet
Courtesy of GENERAL MOTORS CORP.

12. Apply a 2 mm (0.079 in) bead (1) of RTV sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent around the flange of the camshaft position actuator magnet as shown.

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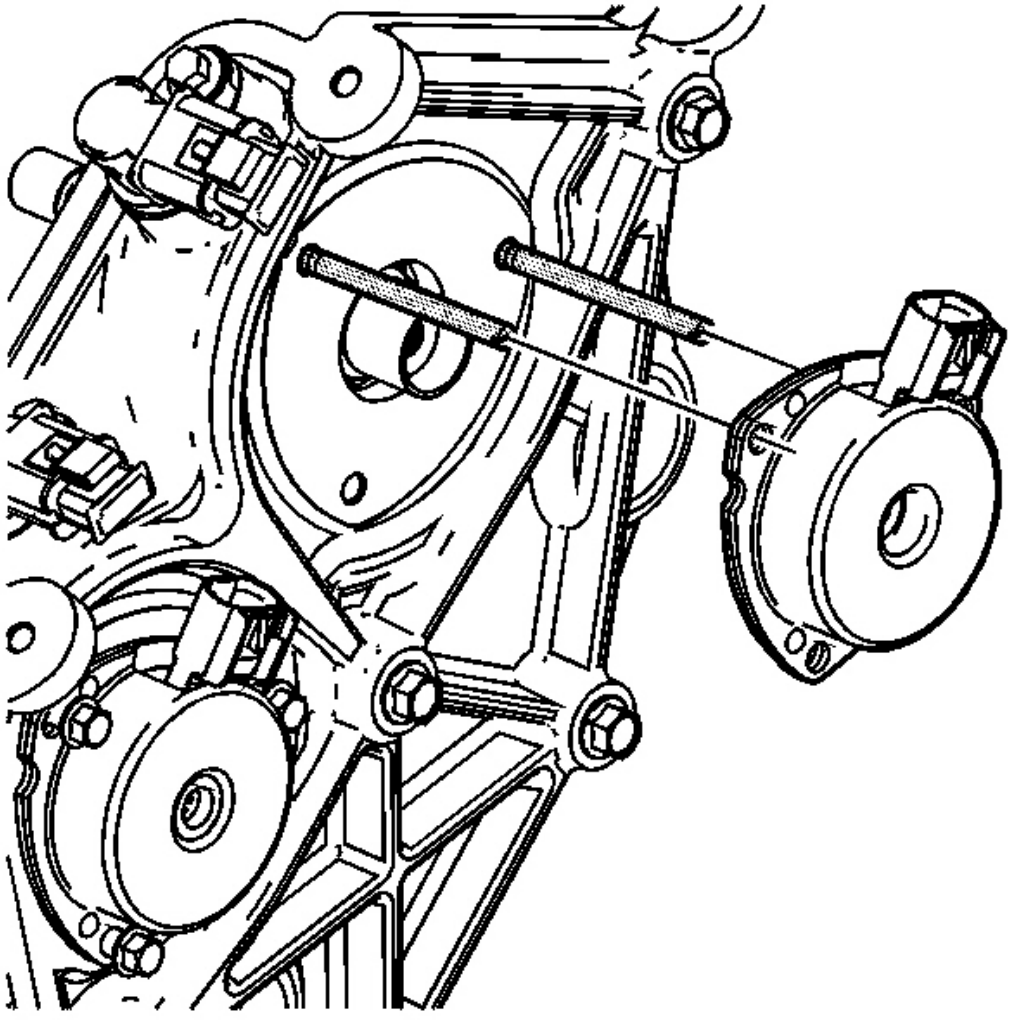


Fig. 441: Sliding Camshaft Position Actuator Magnet Over Loading Pins
Courtesy of GENERAL MOTORS CORP.

13. Slide the camshaft position actuator magnet over the 6 mm (0.236 in) loading pins.

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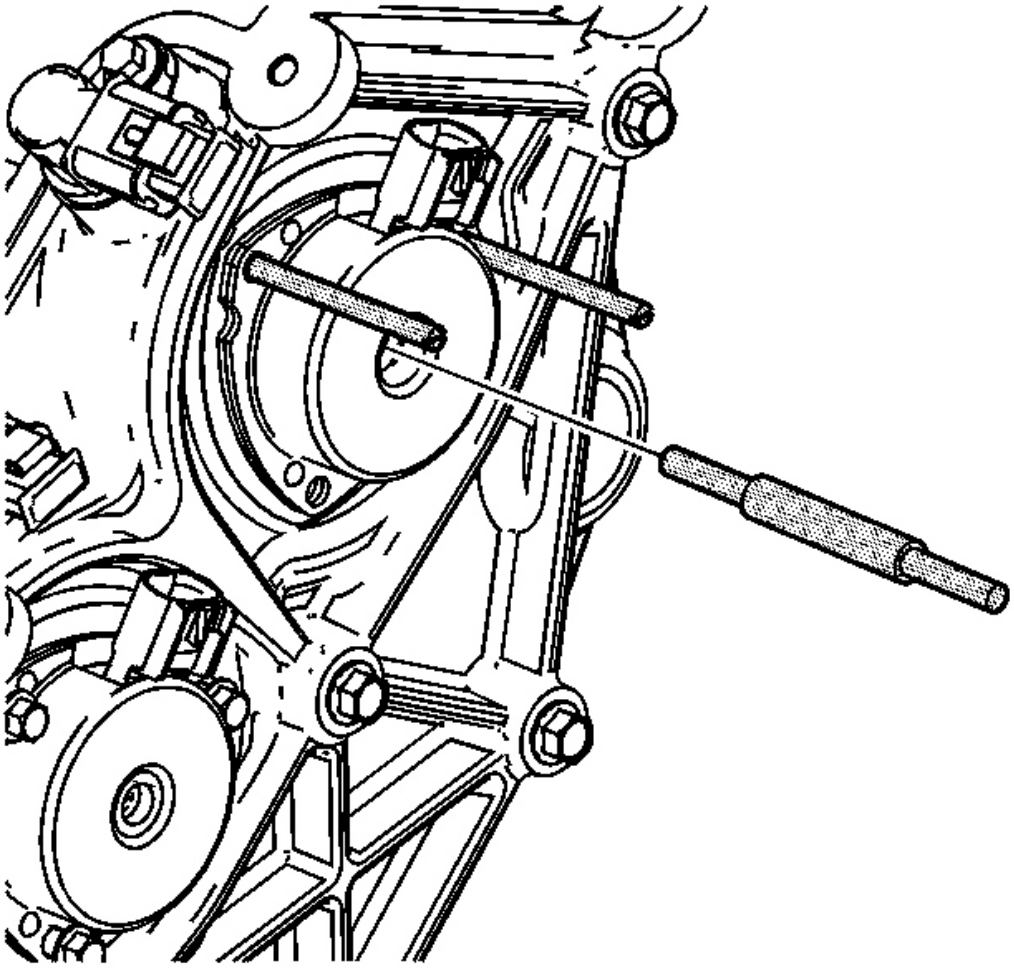


Fig. 442: Aligning Camshaft Position Actuator Magnet
Courtesy of GENERAL MOTORS CORP.

14. In order to align the camshaft position actuator magnet to the camshaft position actuator oil control valve, install the alignment pin through the camshaft position actuator magnet and into the camshaft position actuator oil control valve alignment hole.

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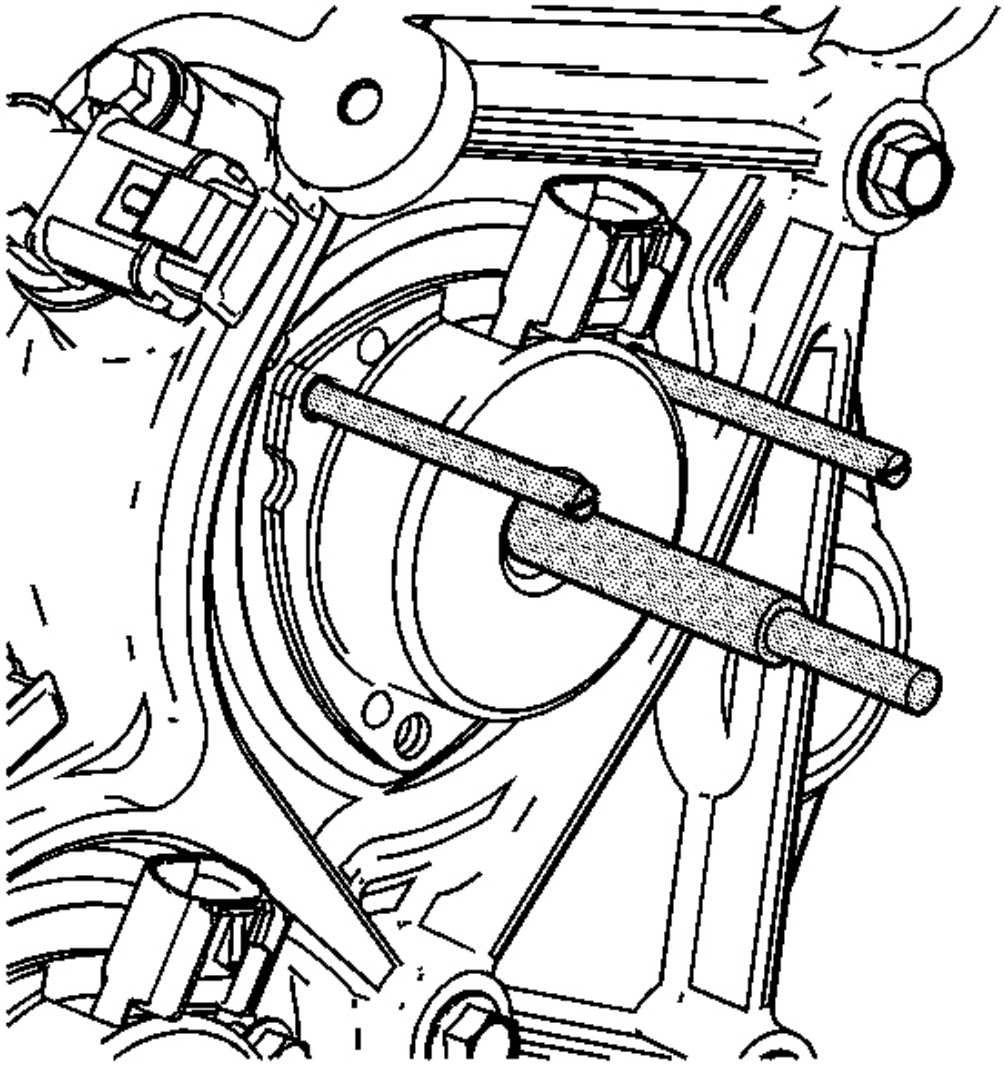


Fig. 443: Inserting Alignment Pin
Courtesy of GENERAL MOTORS CORP.

15. Verify that the alignment pin has been inserted into the camshaft position actuator oil control valve alignment hole by observing the stop has reached the hole in the camshaft position actuator magnet.

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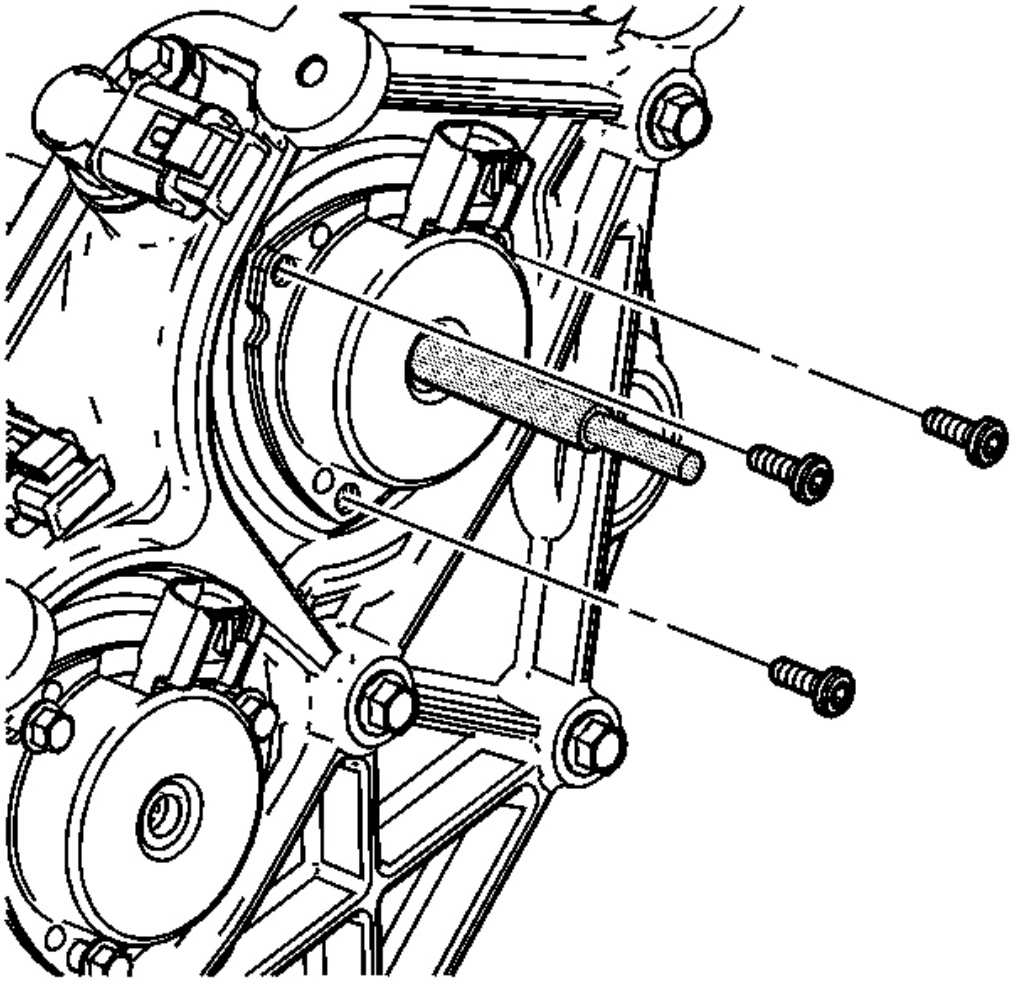


Fig. 444: Installing Camshaft Position Actuator Magnet Bolts
Courtesy of GENERAL MOTORS CORP.

16. With the alignment pin still installed, remove the loading pins and install the camshaft position actuator magnet bolts.

    Tighten: Tighten the camshaft position actuator magnet bolts to 8 N.m (71 lb in).

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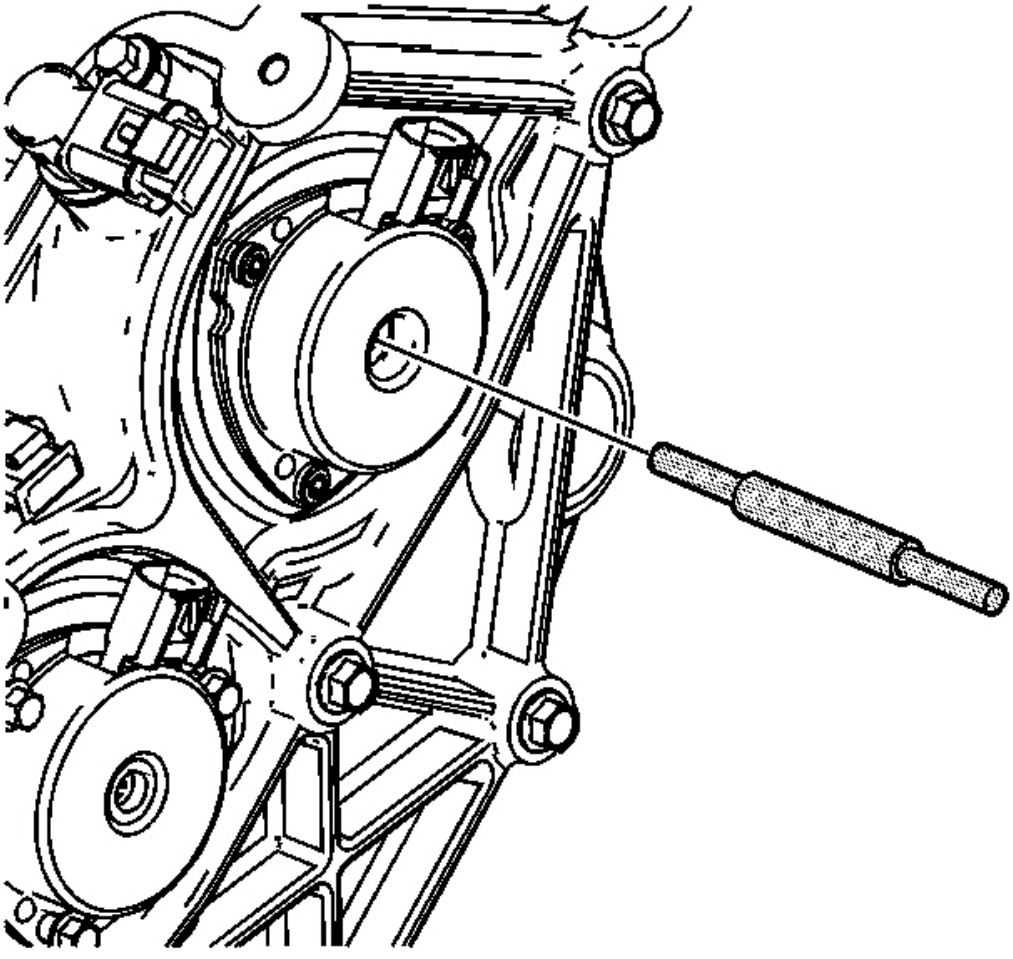


Fig. 445: Removing Alignment Pin
Courtesy of GENERAL MOTORS CORP.

17. Remove the alignment pin.

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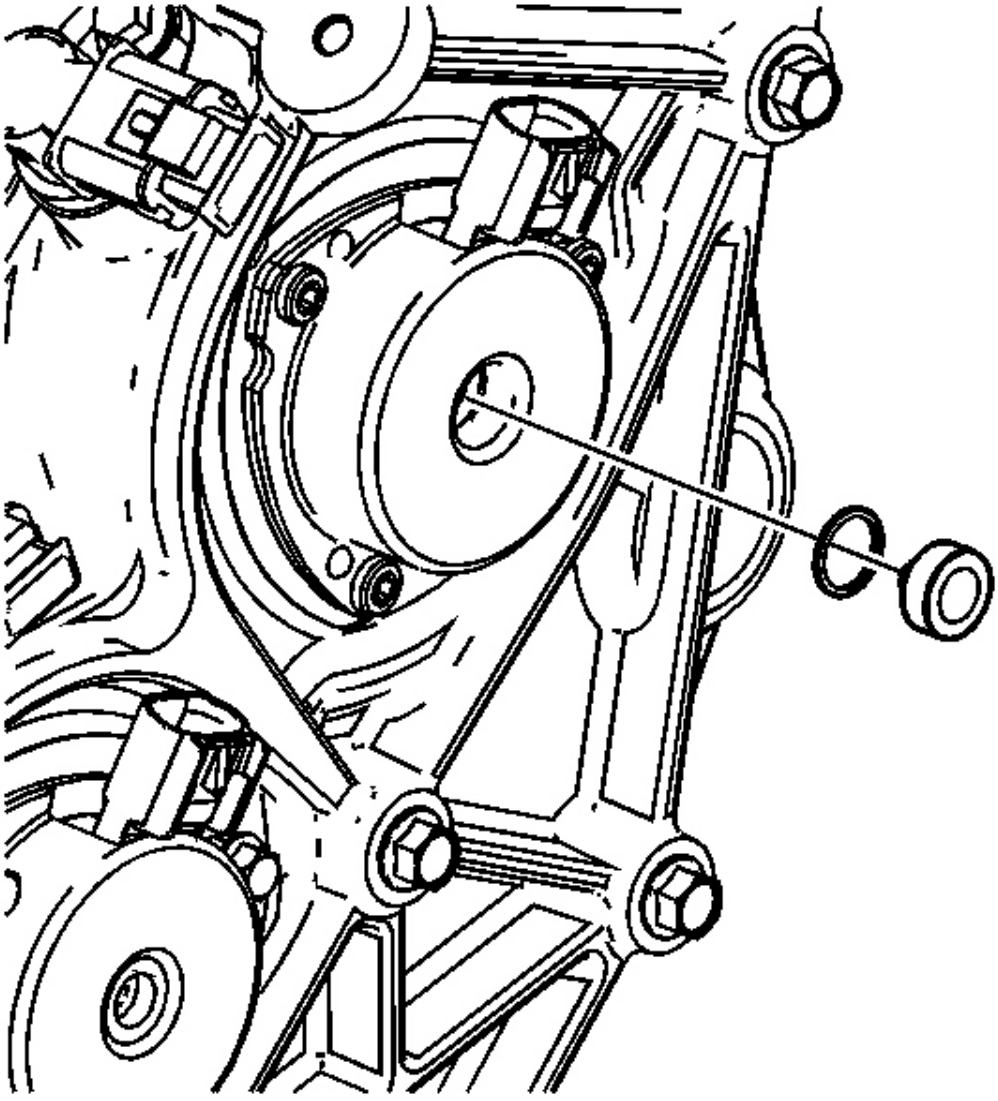


Fig. 446: View Of Camshaft Position Actuator Magnet Plug
Courtesy of GENERAL MOTORS CORP.

18. Install a NEW camshaft position actuator magnet plug.
19. Repeat steps 10 through 18 for any remaining camshaft position actuator magnets that have been removed.

CAMSHAFT COVER INSTALLATION - RIGHT SIDE

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TOOLS REQUIRED

EN 46328 Camshaft Holding Tool. See **Special Tools** .

INSTALLATION PROCEDURE

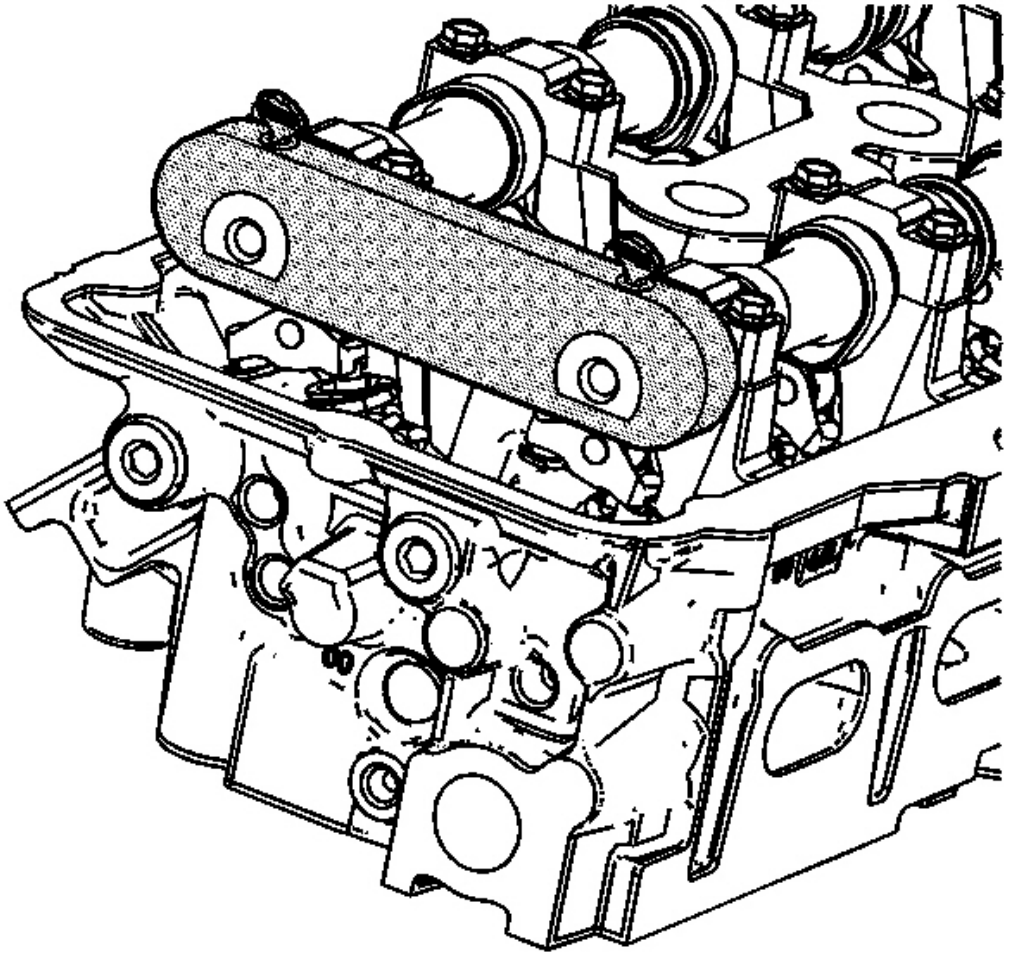


Fig. 447: Installing EN 46328 On Right Cylinder Head Camshafts
Courtesy of GENERAL MOTORS CORP.

1. Remove the **EN 46328** from the right camshafts. See **Special Tools** .

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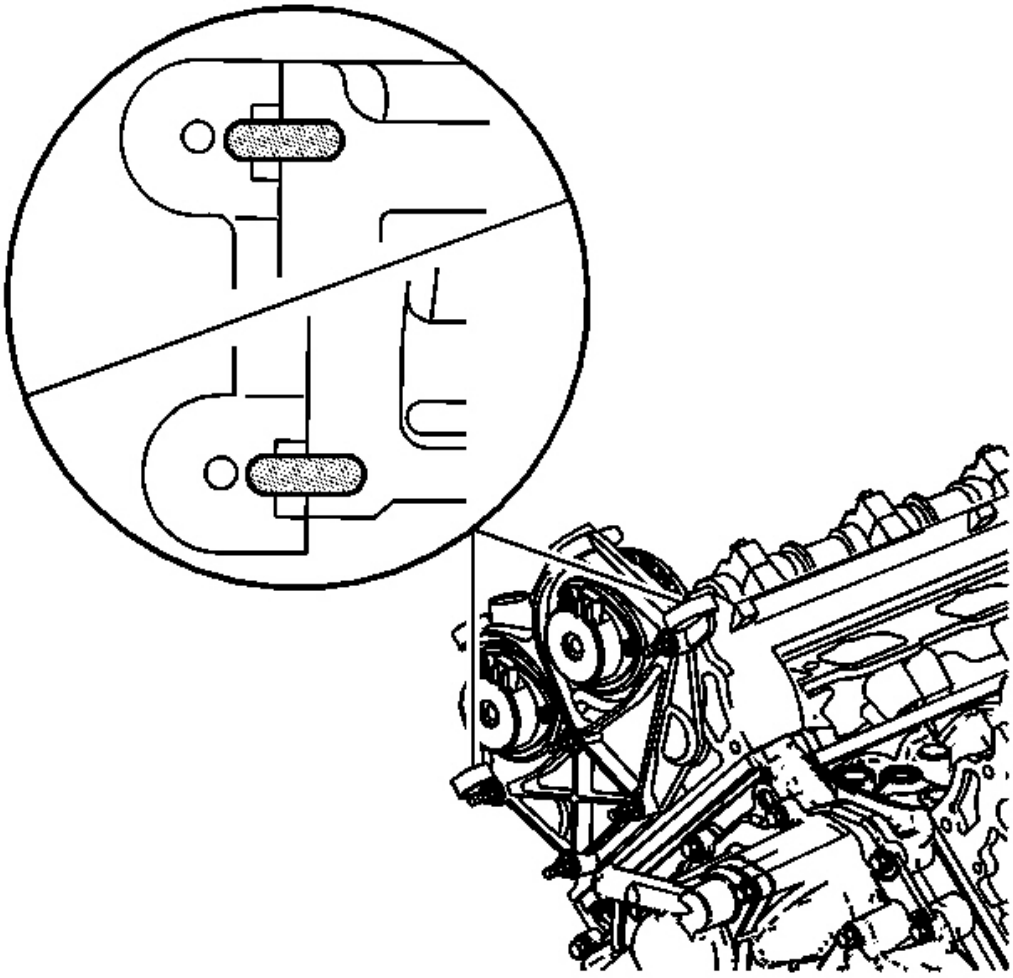


Fig. 448: Applying Sealant At Split Line Of Right Cylinder Head & CMP Actuator Housings
Courtesy of GENERAL MOTORS CORP.

2. Place a small amount of sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent at the split line of the right cylinder head and the right camshaft position actuator housings.

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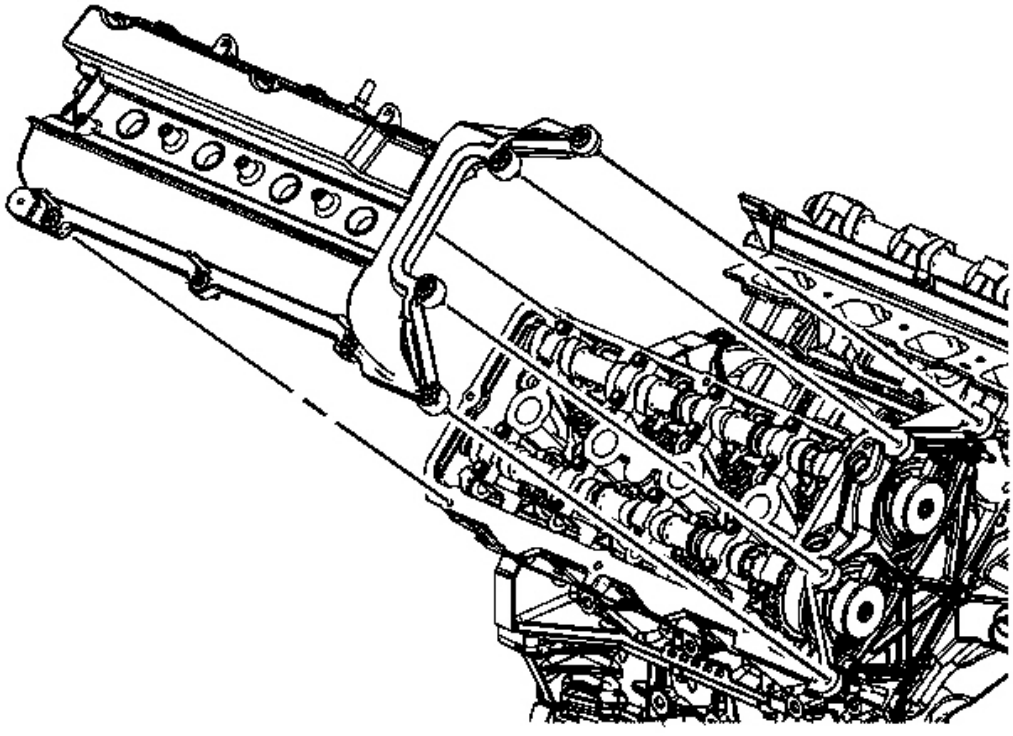


Fig. 449: View Of Right Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be careful to prevent the exposed section of the camshaft cover seal from being damaged by the edge of the cylinder head casting.

3. Install the right camshaft cover.

   NOTE: Refer to Fastener Notice .

4. Install the right camshaft cover bolts.

   Tighten: Tighten the right camshaft cover bolts to 10 N.m (89 lb in).

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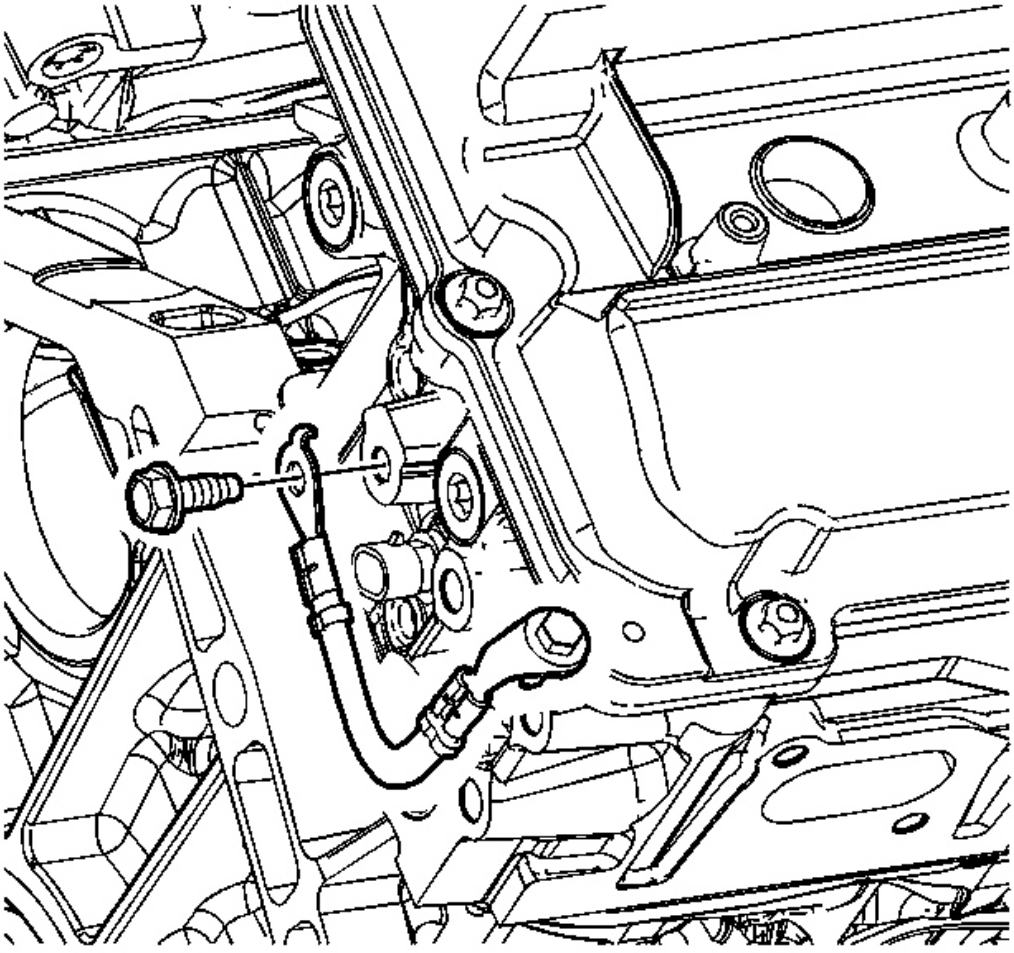


Fig. 450: View Of Ground Strap, Right Camshaft Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the bolts connecting the right camshaft cover ground strap to the right cylinder head and the right camshaft cover.

   Tighten:

   - Tighten the right ground strap bolt into the camshaft cover to 10 N.m (89 lb in).
   - Tighten the right ground strap bolt into the cylinder head to 25 N.m (18 lb ft).

IGNITION COIL MODULE INSTALLATION - RIGHT SIDE

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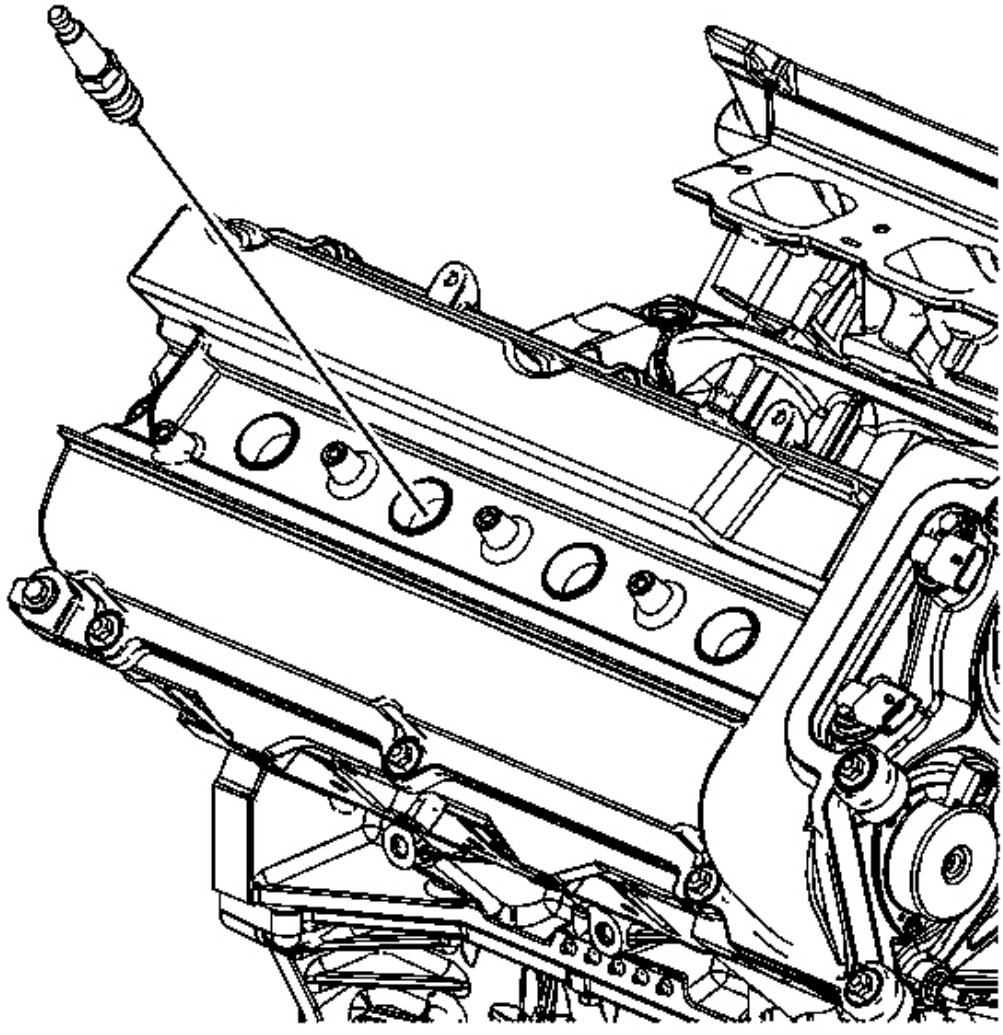


Fig. 451: Identifying Spark Plug Location
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

1. Install the right spark plugs.

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

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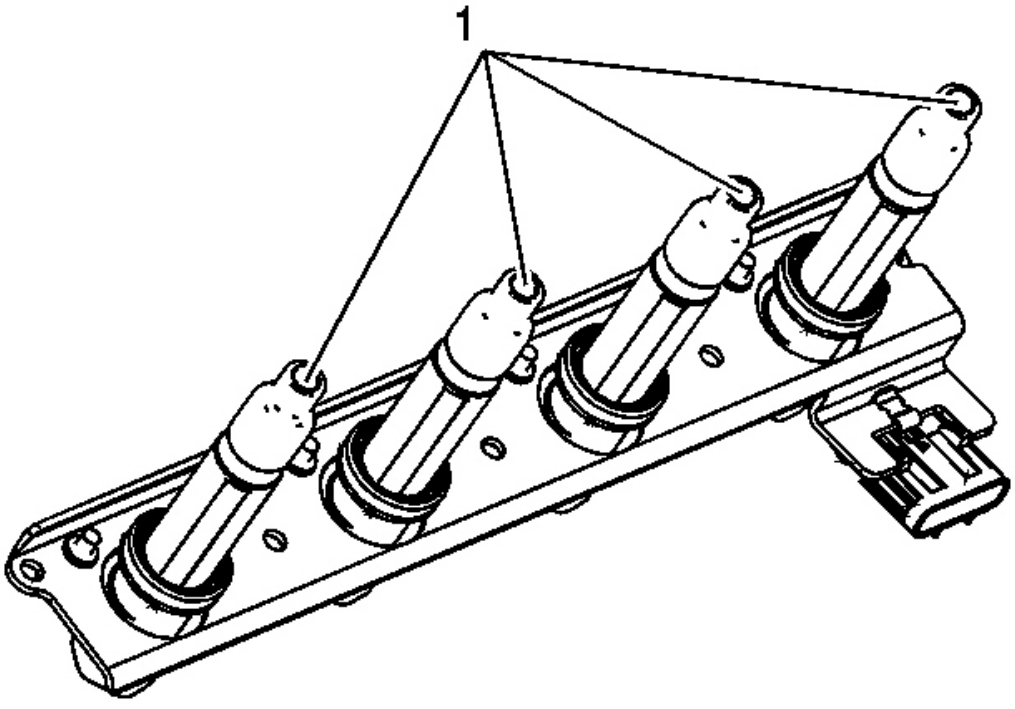


Fig. 452: Identifying Spark Plug Boots
Courtesy of GENERAL MOTORS CORP.

2. Apply a small amount of dielectric grease GM P/N 12345579, (Canadian P/N 1974984), to each spark plug boot (1) of the ignition coil assembly.

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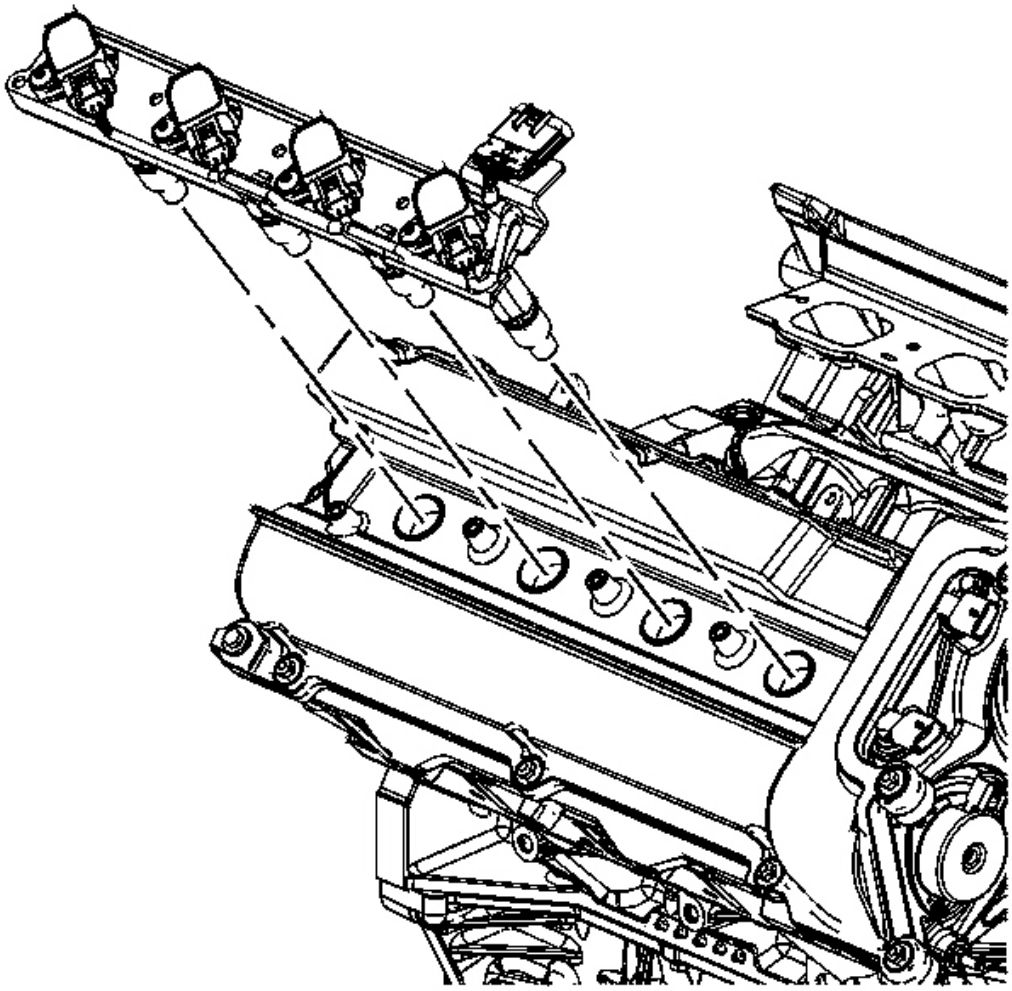


Fig. 453: View Of Ignition Coil Assembly
Courtesy of GENERAL MOTORS CORP.

3. Carefully, install the right ignition coil assembly.

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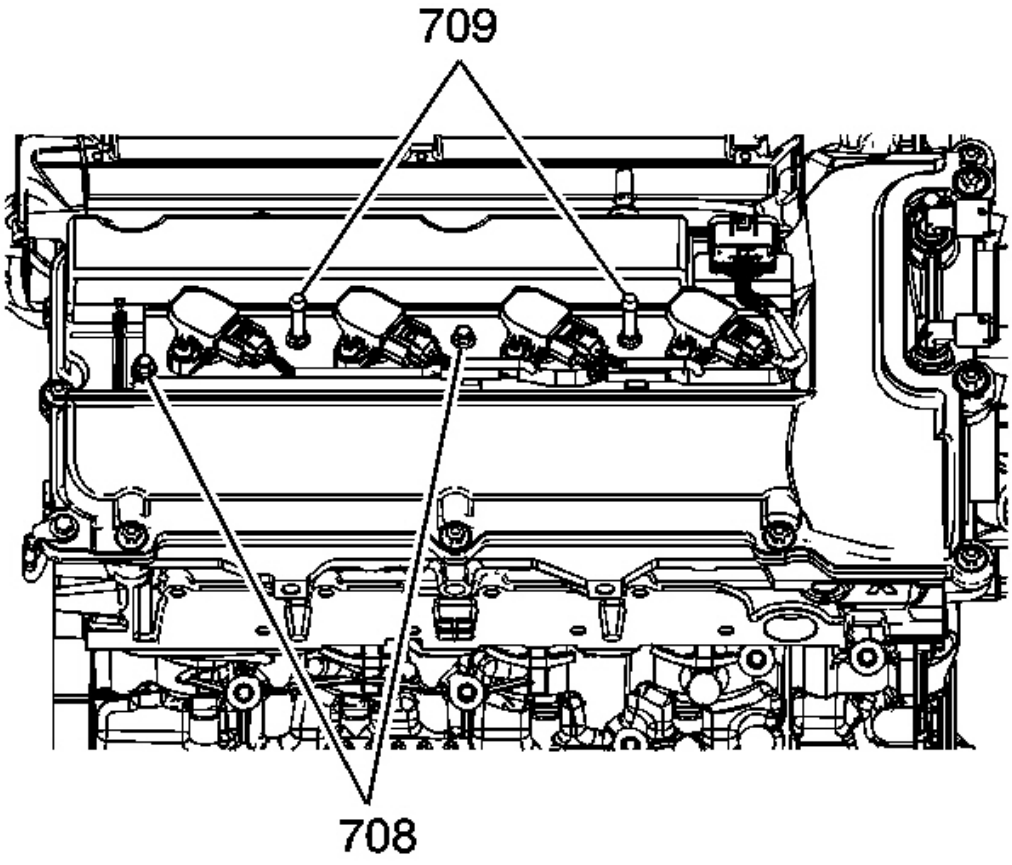


Fig. 454: Identifying Ignition Coil Assembly Bolts & Ball Studs
Courtesy of GENERAL MOTORS CORP.

4. Install the ignition coil assembly bolts (708) and ball studs (709).

   Tighten: Tighten the right ignition cassette bolts and ball studs to 10 N.m (89 lb in).

CAMSHAFT POSITION ACTUATOR HOUSING INSTALLATION - LEFT SIDE

TOOLS REQUIRED

EN 46109 Guide Pin Set. See **Special Tools** .

INSTALLATION PROCEDURE

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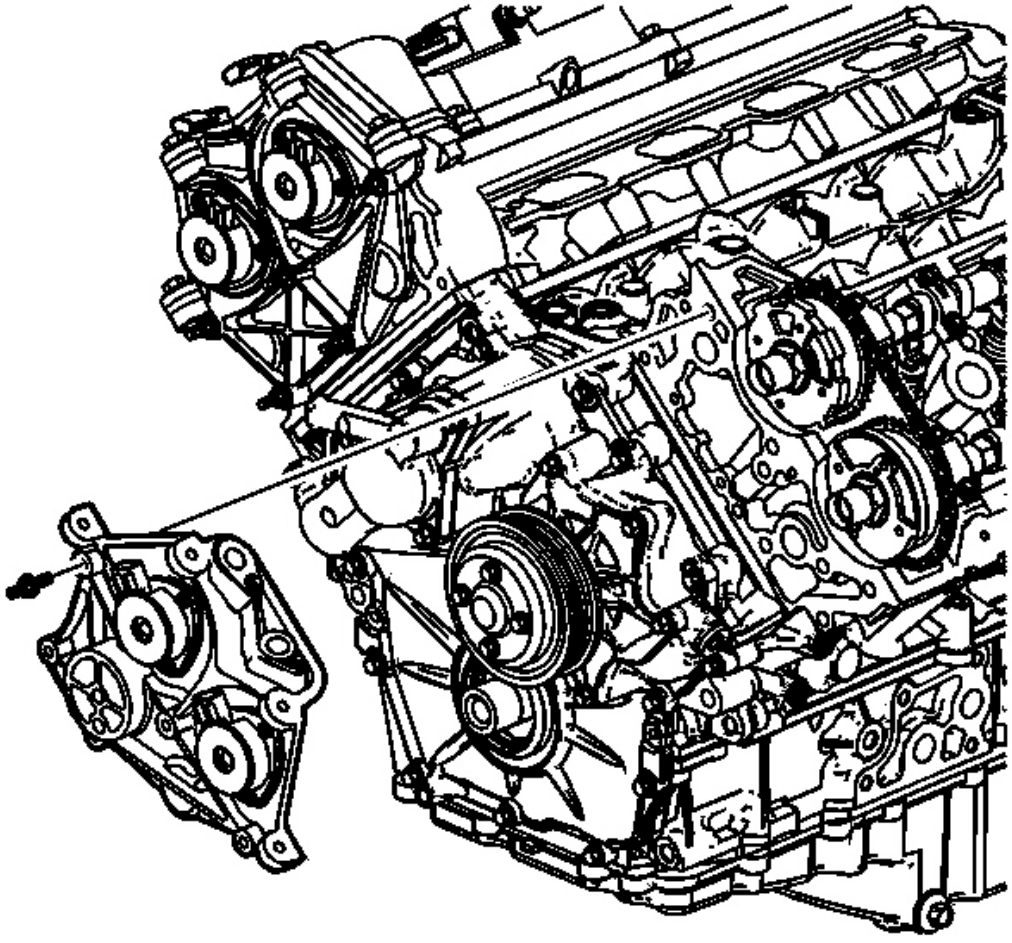


Fig. 455: View Of Left CMP Actuator Housing Removal
Courtesy of GENERAL MOTORS CORP.

NOTE: **DO NOT remove the camshaft position actuator magnet unless it needs to be replaced. The camshaft position actuator magnet is precisely aligned to the camshaft position actuator oil control valve on the end of the camshaft during engine assembly. If the camshaft position actuator magnet is removed and/or needs to be replaced, it will be necessary to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve after the camshaft position actuator housing is installed to the cylinder head. Failure to realign the camshaft position actuator magnet to the camshaft position actuator oil control valve can lead to poor engine performance and engine component damage.**

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1. Install the left camshaft position actuator housing.

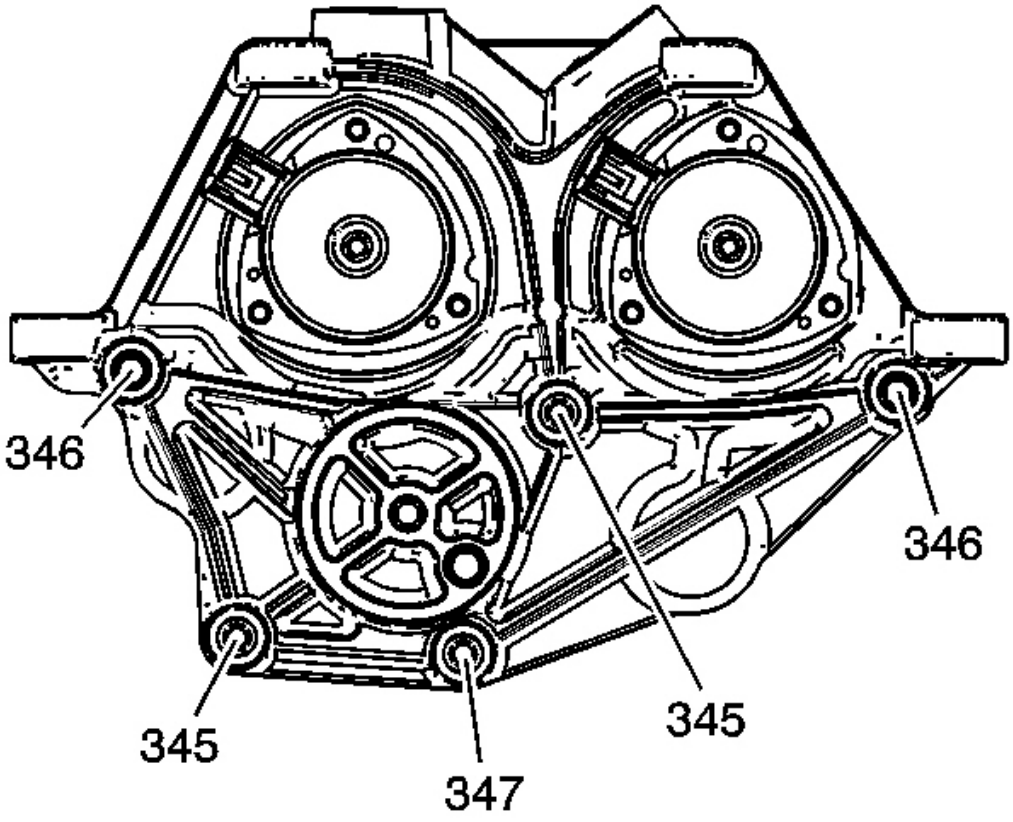


Fig. 456: Locating Left Camshaft Position Actuator Housing Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the left camshaft position actuator housing bolt (347), short studs (345) and long studs (346).

   Tighten: Tighten the left camshaft position actuator housing bolts and studs to 10 N.m (89 lb in).

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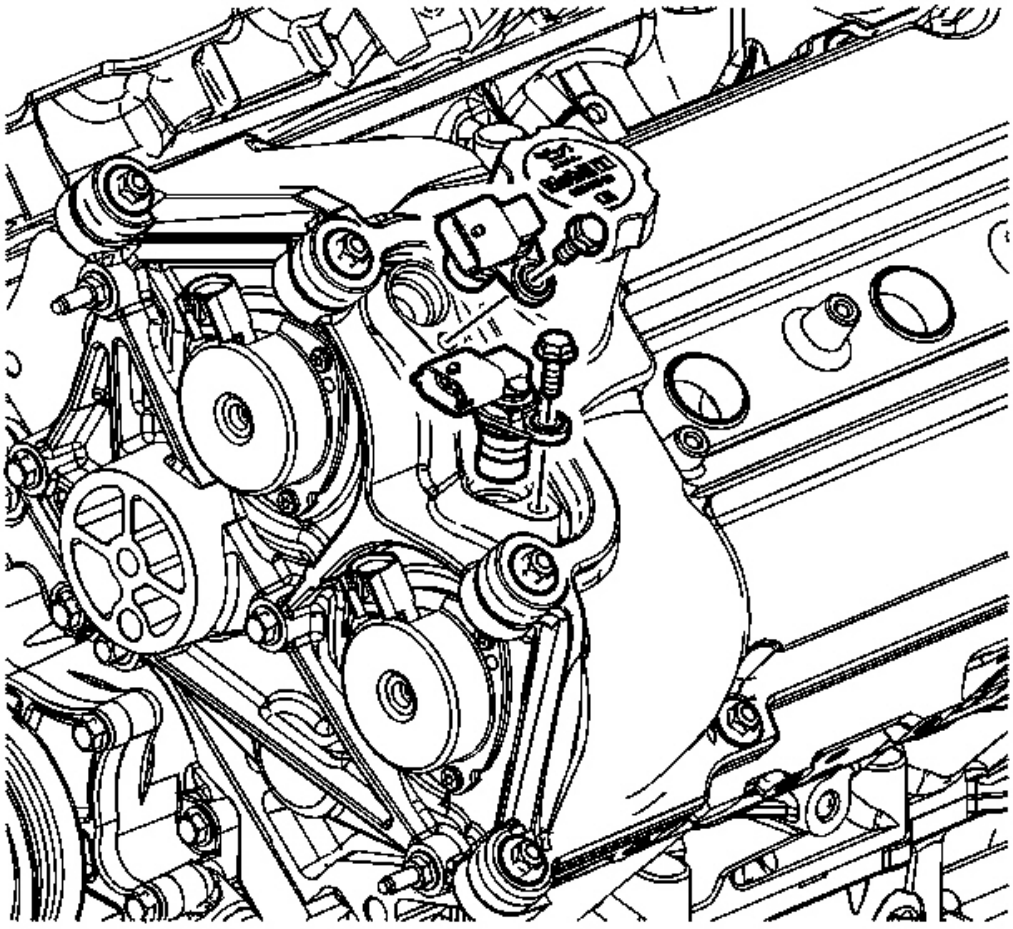


Fig. 457: View Of Left Intake Camshaft Sensor & Left Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

3. Install the left camshaft position sensors.
4. Install the left camshaft position sensor bolts.

Tighten: Tighten the left camshaft position sensor bolts to 10 N.m (89 lb in).

CAMSHAFT POSITION ACTUATOR MAGNET ALIGNMENT

1. If the camshaft position actuator magnet has been removed or is being replaced the camshaft position actuator magnet will need to be resealed to the camshaft position actuator housing and realigned to the camshaft position actuator oil control valve.

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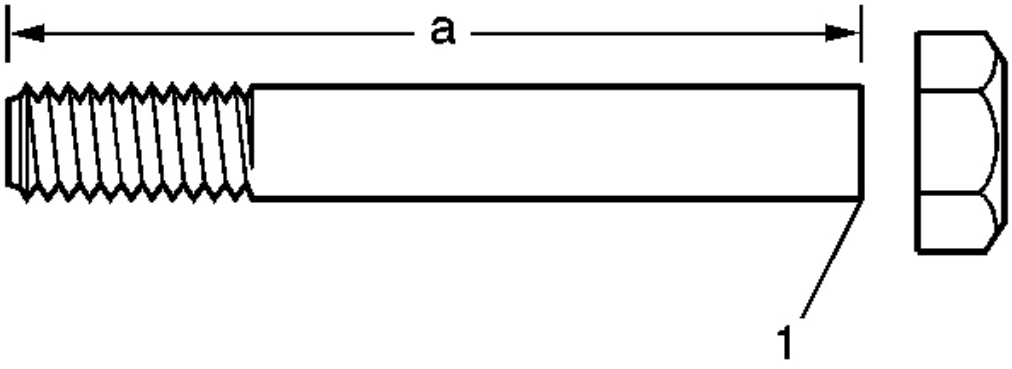


Fig. 458: Creating Loading Pins
Courtesy of GENERAL MOTORS CORP.

2. Use the 2 6 mm (0.236 in) pins, EN 46109-1, from the **EN 46109** or make 2 loading pins from 2 6 mm (0. See **Special Tools** .236 in) bolts at least 75 mm (3.00 in) long (a) with the hex head removed (1).

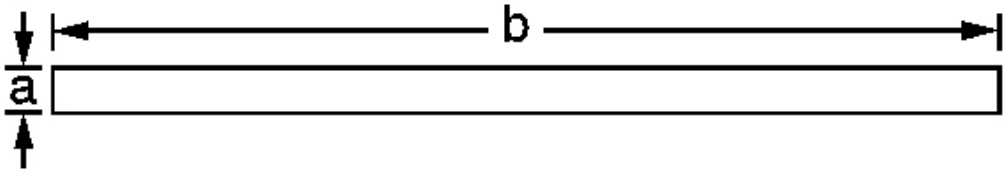


Fig. 459: Making Alignment Pin
Courtesy of GENERAL MOTORS CORP.

3. Make an alignment pin from 15/64 inch drill rod (a) with a diameter of 5.954 mm (0.2344 in) and at least 75 mm (3.00 in) long (b).

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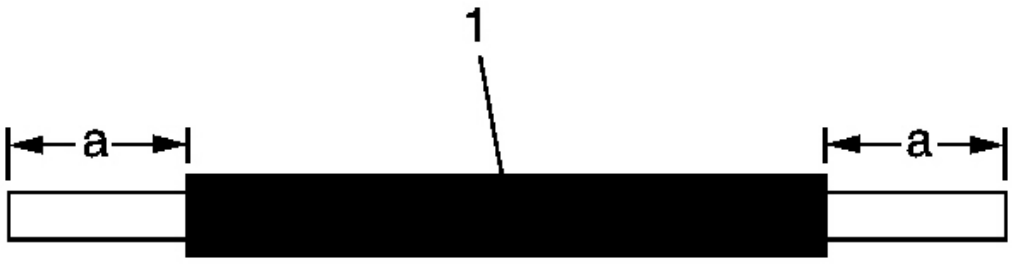


Fig. 460: Creating A Stop On Alignment Pin
Courtesy of GENERAL MOTORS CORP.

4. To verify proper insertion distance create a stop (1) on the alignment pin by placing tape or shrink tubing 13 mm (0.5118 in) from the end (a) that will be inserted through the camshaft position actuator magnet.

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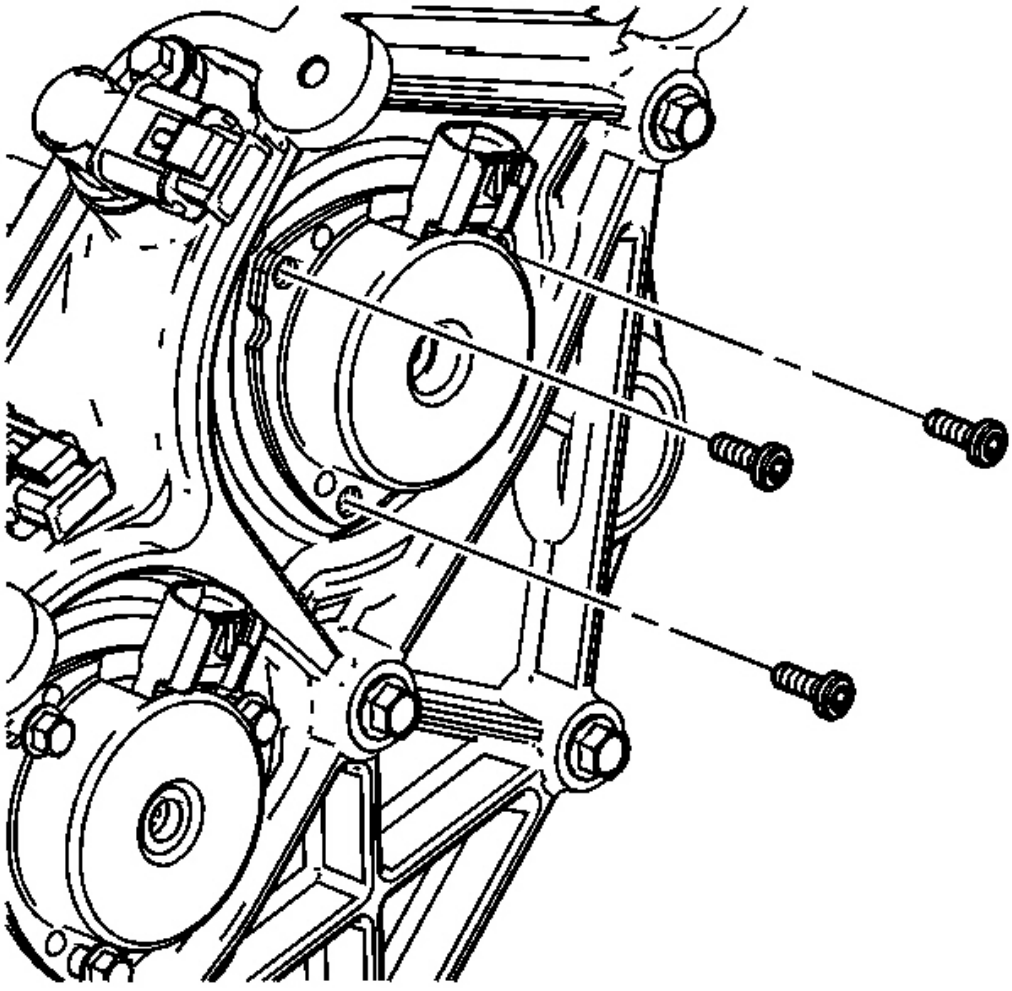


Fig. 461: View Of Camshaft Position Actuator Magnet Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft position actuator magnet bolts.

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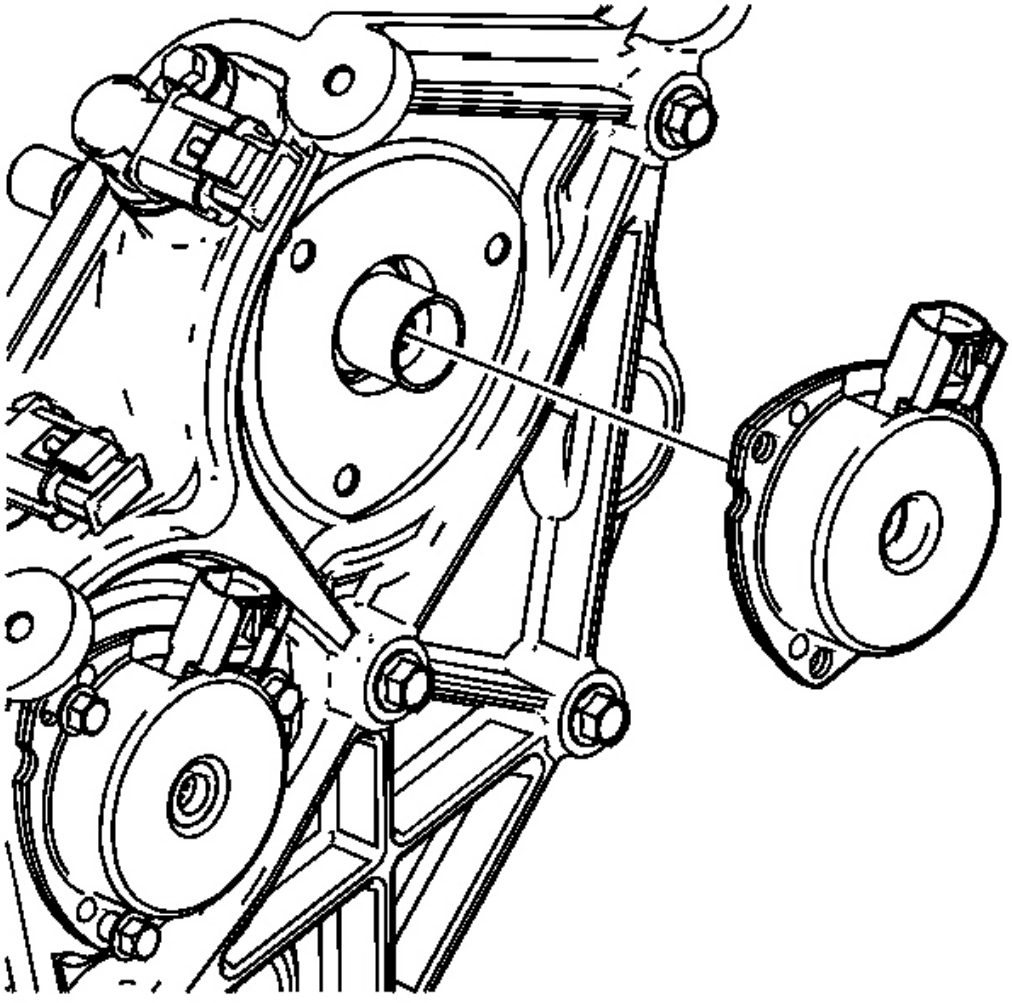


Fig. 462: View Of Camshaft Position Actuator Magnet
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft position actuator magnet.

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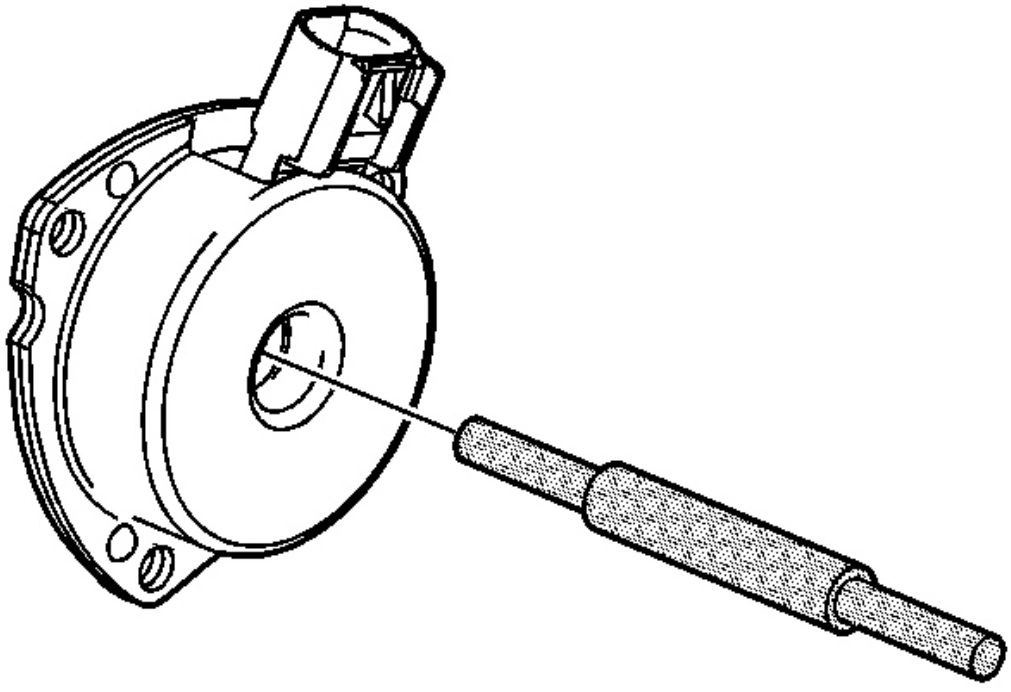


Fig. 463: Verifying That Alignment Pin Will Pass Through Camshaft Position Actuator Magnet Alignment Hole
Courtesy of GENERAL MOTORS CORP.

7. Verify that the alignment pin will pass through the camshaft position actuator magnet alignment hole.

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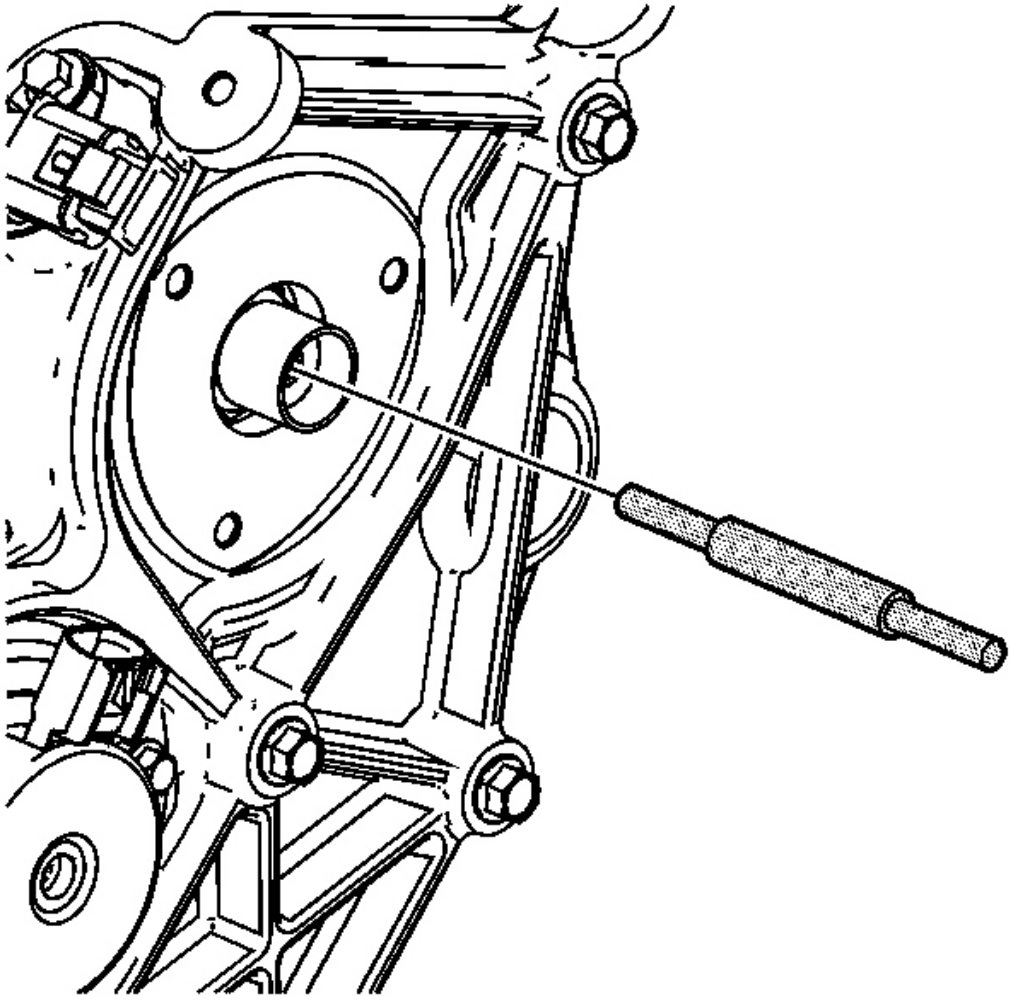


Fig. 464: Verifying That Alignment Pin Will Pass Through Camshaft Position Actuator Oil Control Valve Alignment Hole
Courtesy of GENERAL MOTORS CORP.

8. Verify that the alignment pin will fit into the alignment hole in the camshaft position actuator oil control valve.

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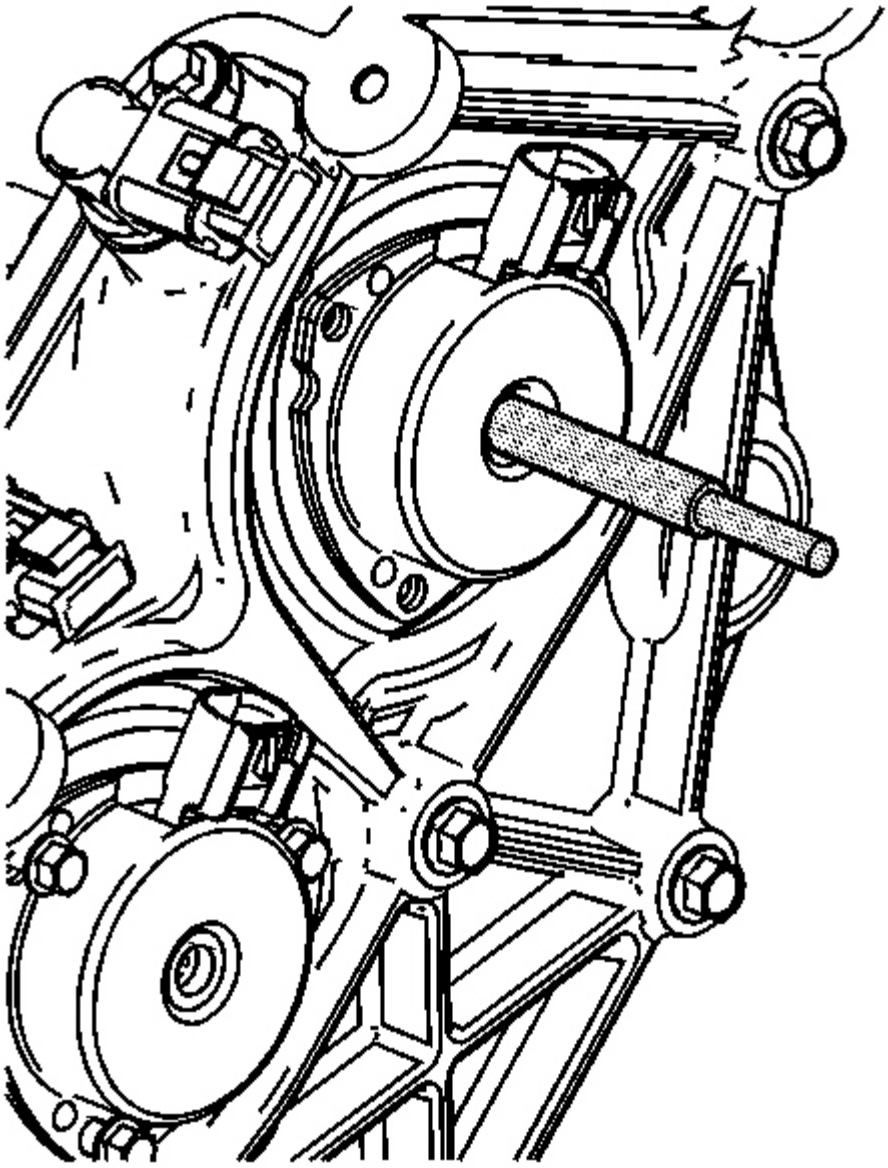


Fig. 465: Verifying Alignment Pin Stop Distance
Courtesy of GENERAL MOTORS CORP.

9. Place the camshaft position actuator magnet into place and verify the alignment pin will insert through the camshaft position actuator magnet and into the camshaft position actuator oil control valve to verify alignment pin stop distance.

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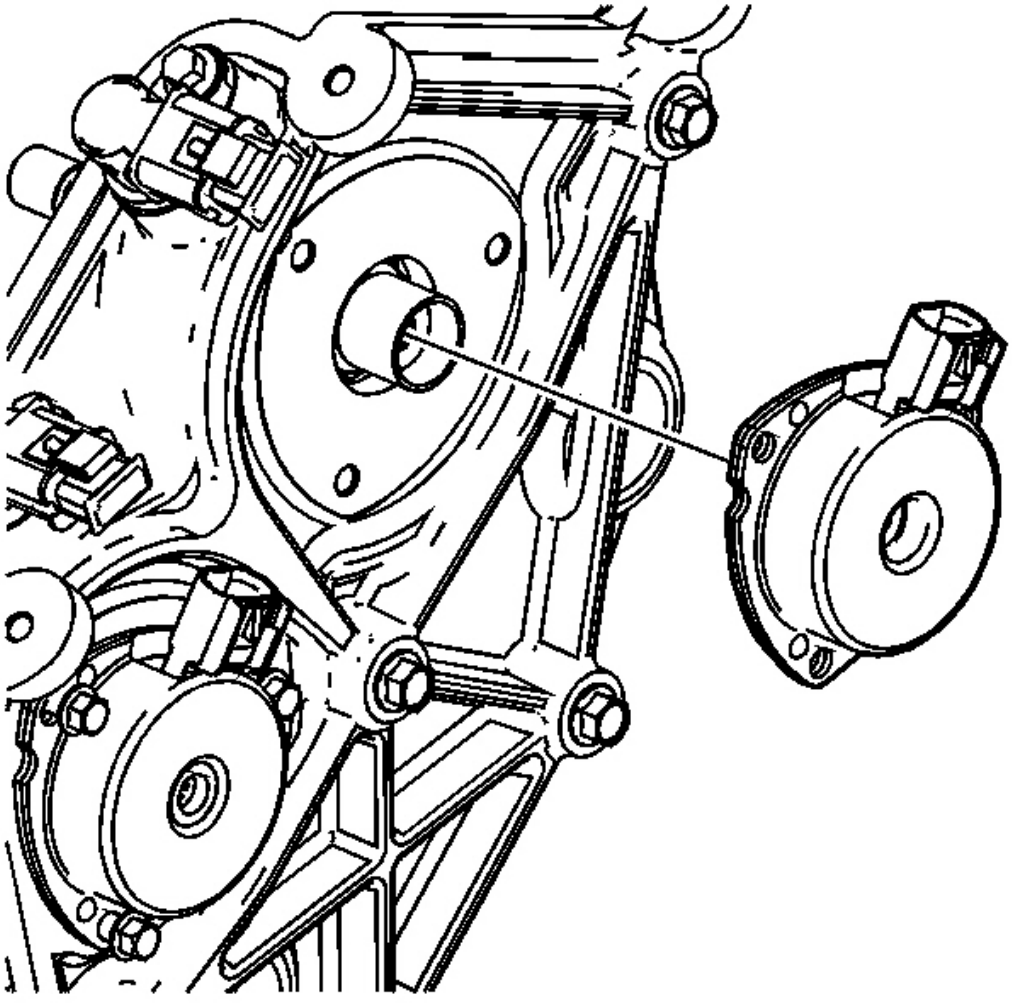


Fig. 466: View Of Camshaft Position Actuator Magnet
Courtesy of GENERAL MOTORS CORP.

10. Remove the camshaft position actuator magnet.

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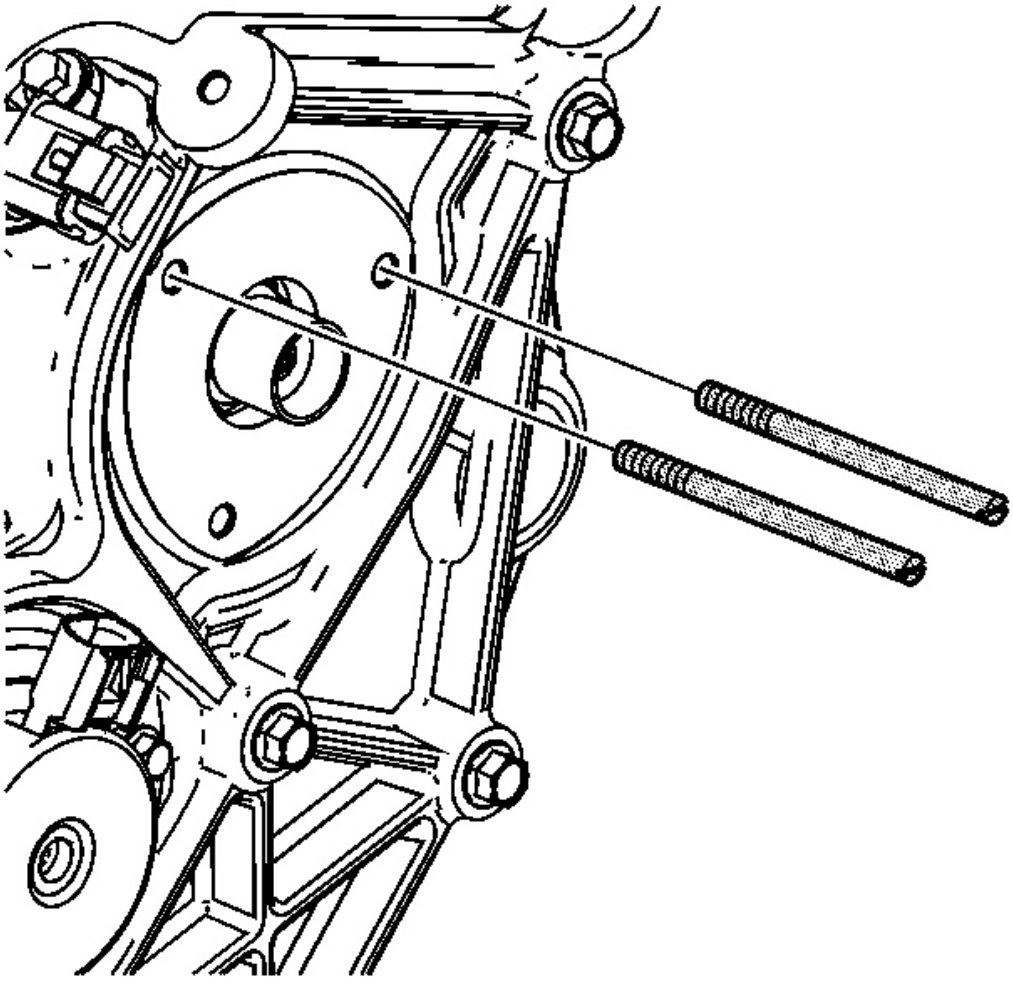


Fig. 467: Installing Loading Pins
Courtesy of GENERAL MOTORS CORP.

11. Install the 2 6 mm (0.236 in) loading pins in 2 of the camshaft position actuator magnet bolt holes in the camshaft position actuator housing.

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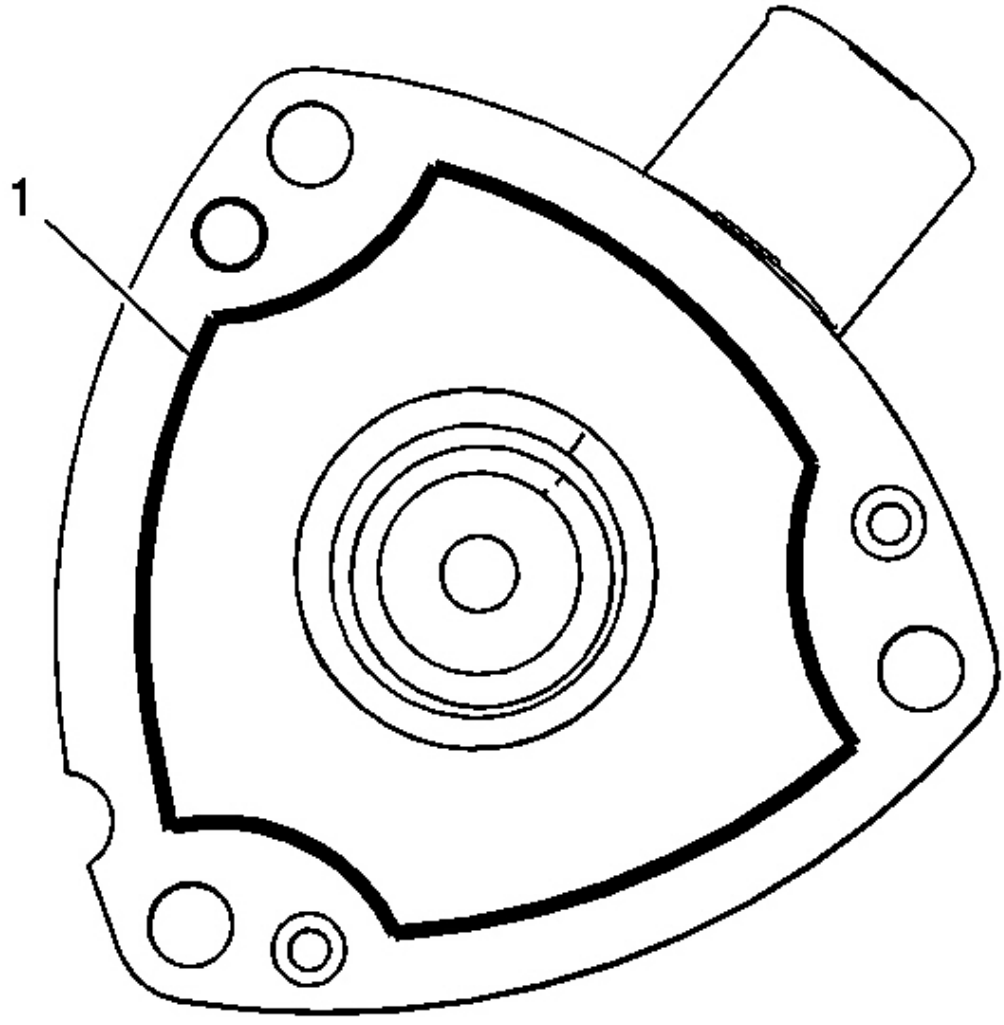


Fig. 468: Applying Sealant Around Flange Of Camshaft Position Actuator Magnet
Courtesy of GENERAL MOTORS CORP.

12. Apply a 2 mm (0.079 in) bead (1) of RTV sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent around the flange of the camshaft position actuator magnet as shown.

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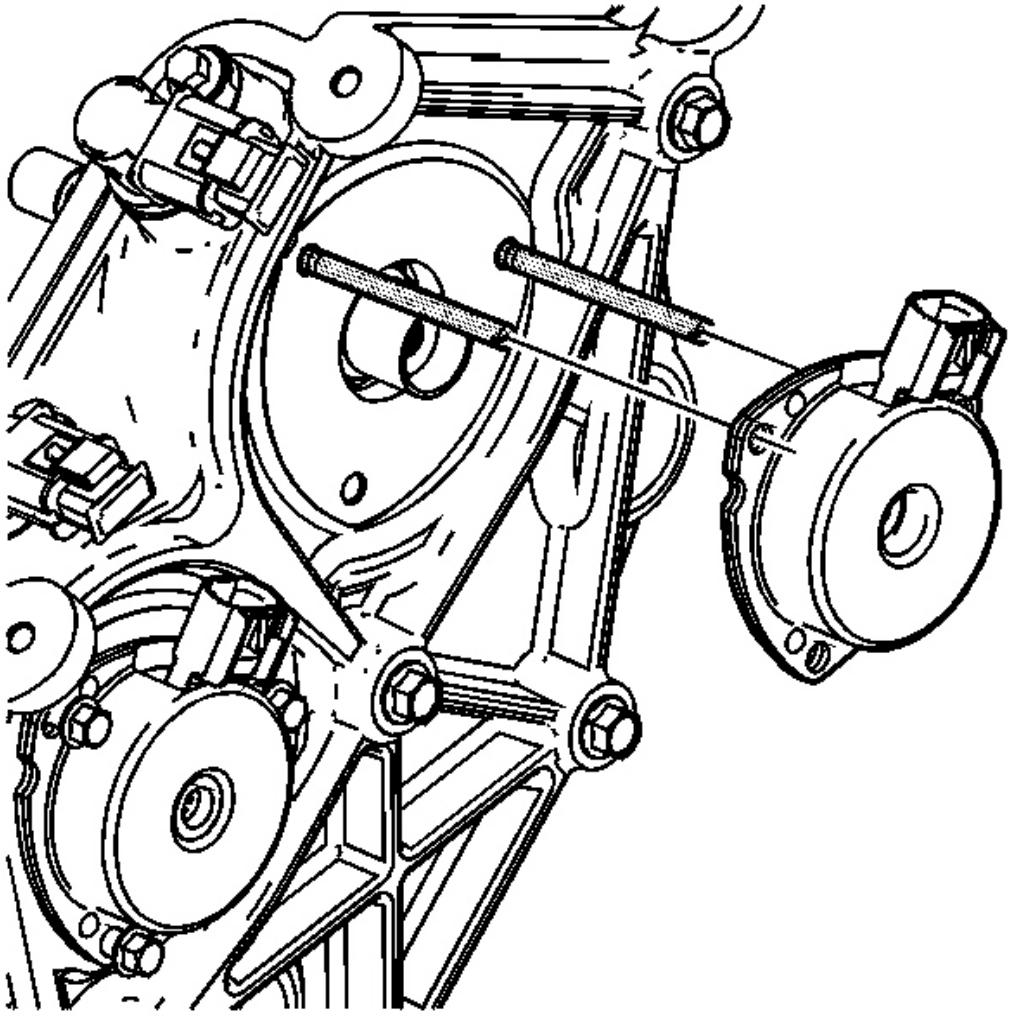


Fig. 469: Sliding Camshaft Position Actuator Magnet Over Loading Pins
Courtesy of GENERAL MOTORS CORP.

13. Slide the camshaft position actuator magnet over the 6 mm (0.236 in) loading pins.

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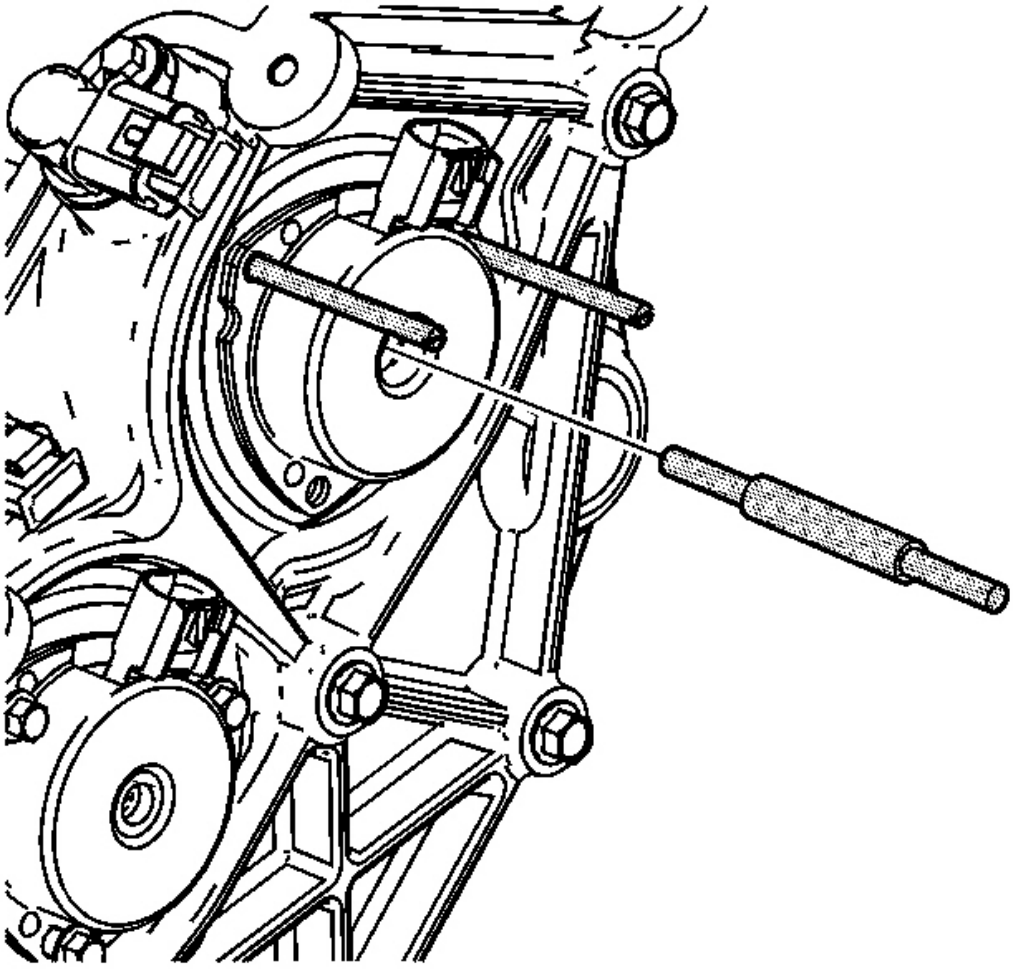


Fig. 470: Aligning Camshaft Position Actuator Magnet
Courtesy of GENERAL MOTORS CORP.

14. In order to align the camshaft position actuator magnet to the camshaft position actuator oil control valve, install the alignment pin through the camshaft position actuator magnet and into the camshaft position actuator oil control valve alignment hole.

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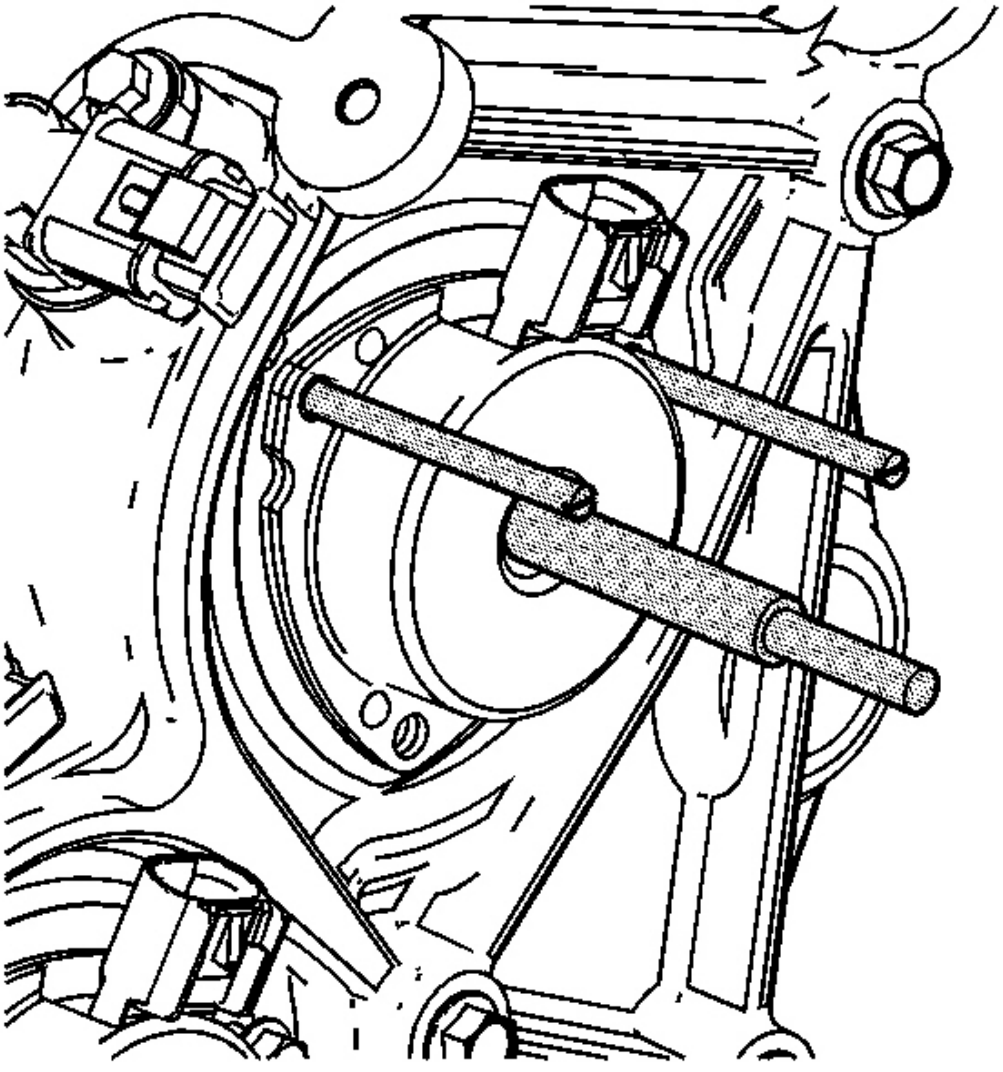


Fig. 471: Inserting Alignment Pin
Courtesy of GENERAL MOTORS CORP.

15. Verify that the alignment pin has been inserted into the camshaft position actuator oil control valve alignment hole by observing the stop has reached the hole in the camshaft position actuator magnet.

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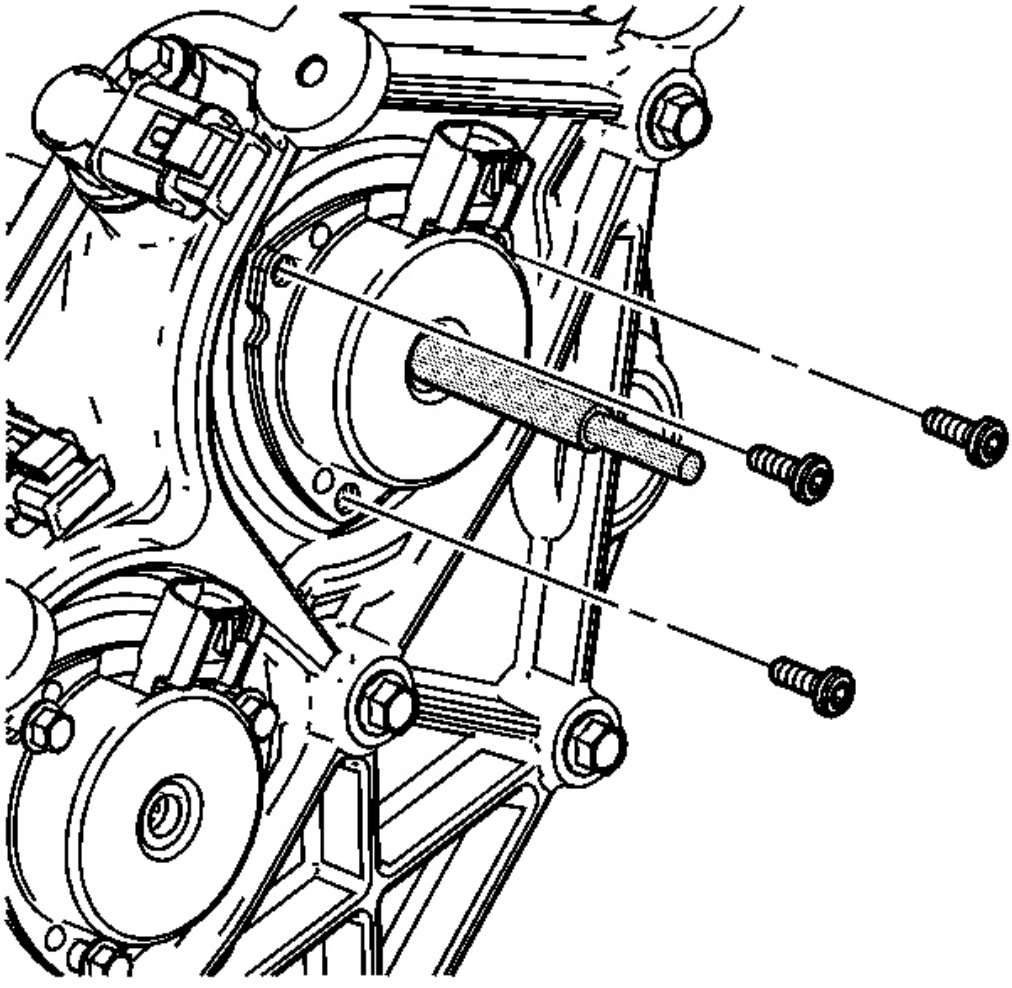


Fig. 472: Installing Camshaft Position Actuator Magnet Bolts
Courtesy of GENERAL MOTORS CORP.

16. With the alignment pin still installed, remove the loading pins and install the camshaft position actuator magnet bolts.

    Tighten: Tighten the camshaft position actuator magnet bolts to 8 N.m (71 lb in).

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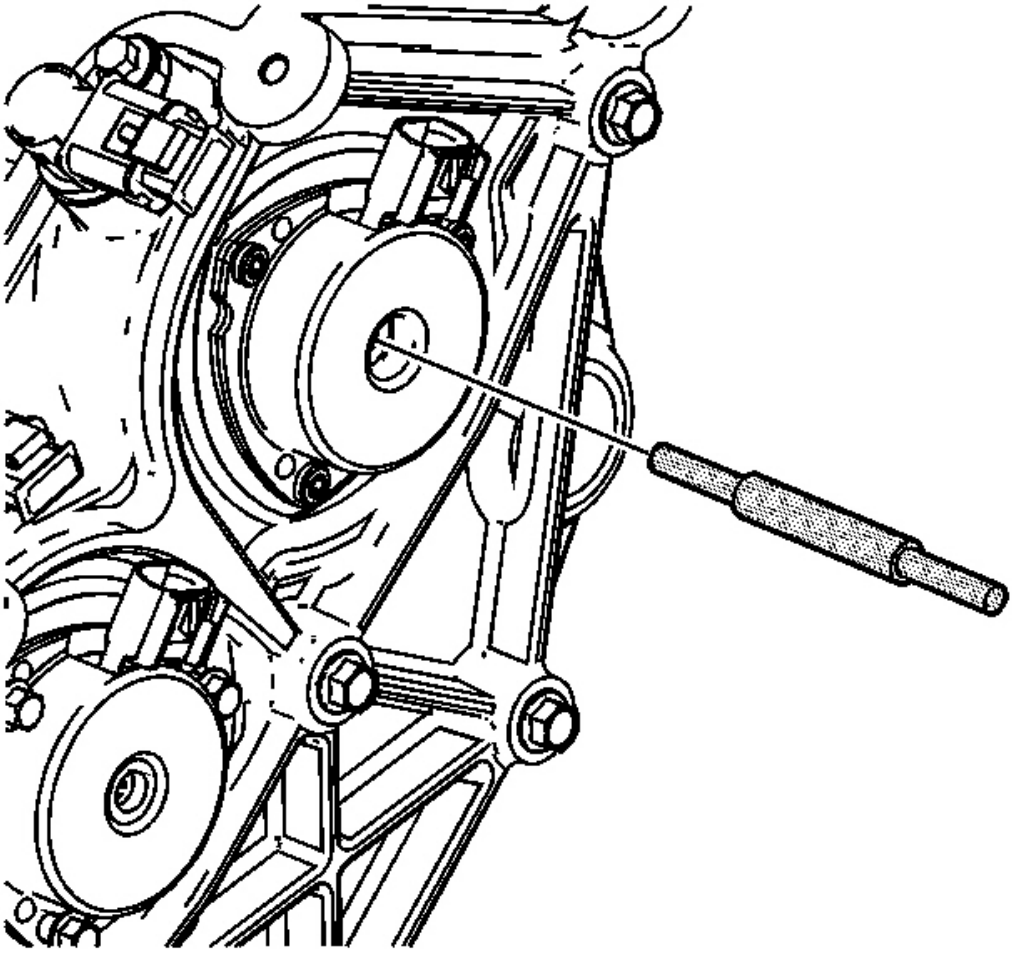


Fig. 473: Removing Alignment Pin
Courtesy of GENERAL MOTORS CORP.

17. Remove the alignment pin.

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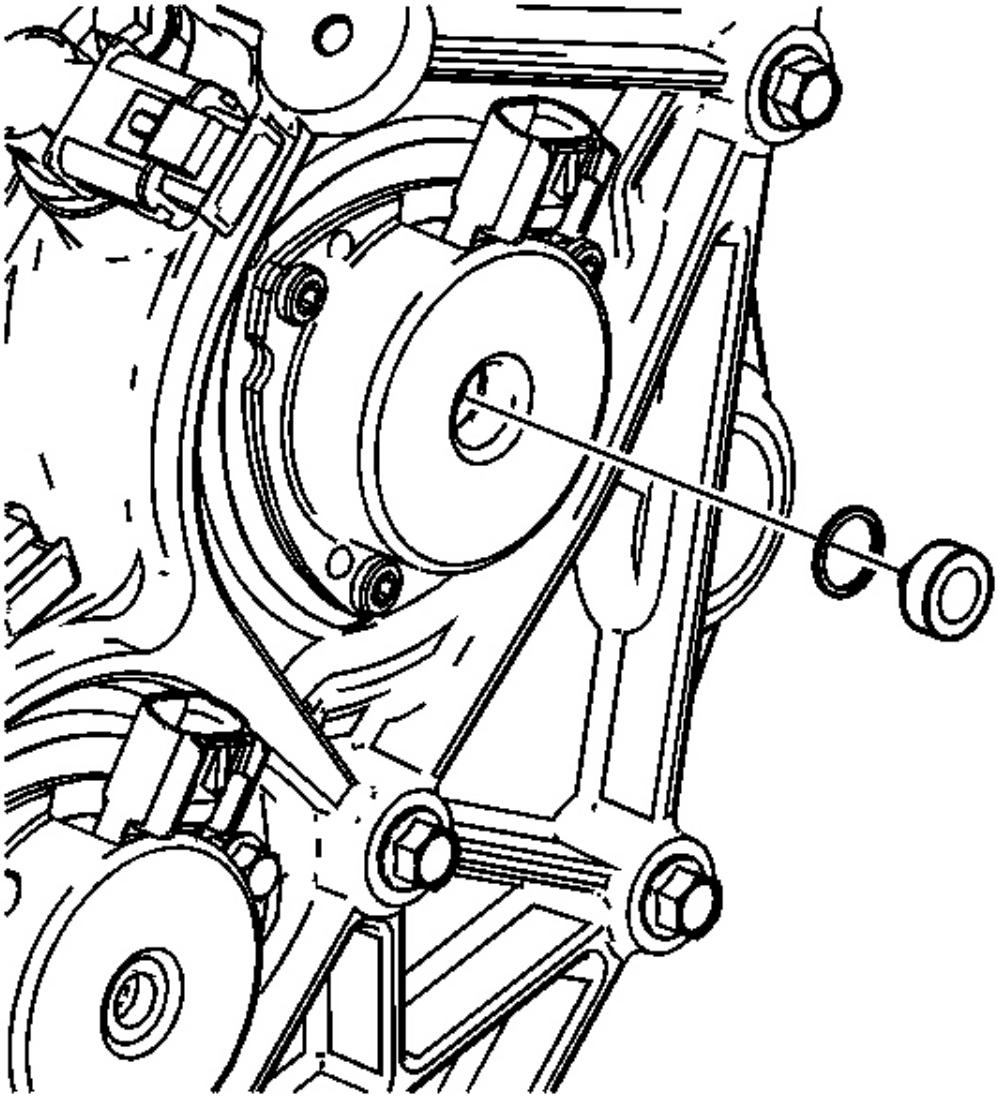


Fig. 474: View Of Camshaft Position Actuator Magnet Plug
Courtesy of GENERAL MOTORS CORP.

18. Install a NEW camshaft position actuator magnet plug.
19. Repeat steps 10 through 18 for any remaining camshaft position actuator magnets that have been removed.

CAMSHAFT COVER INSTALLATION - LEFT SIDE

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TOOLS REQUIRED

EN 46328 Camshaft Holding Tool. See **Special Tools** .

INSTALLATION PROCEDURE

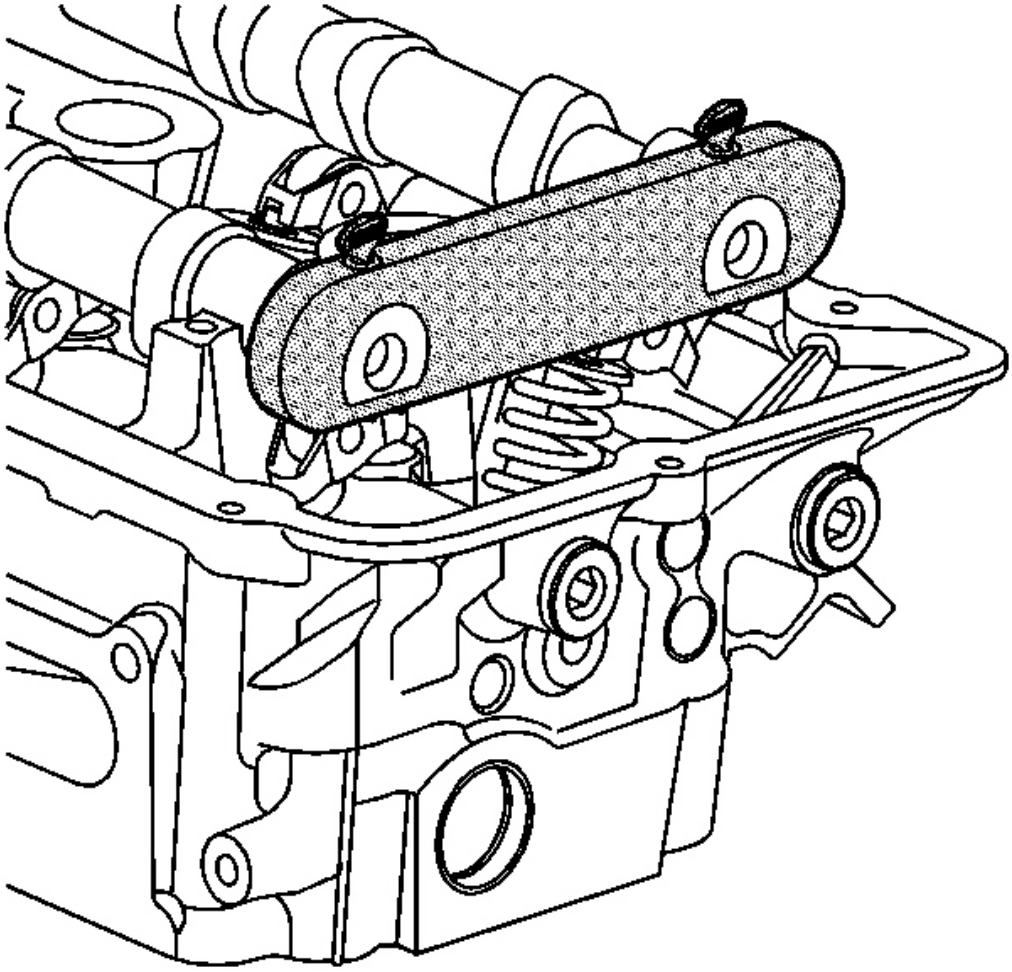


Fig. 475: Installing EN 46328 On Left Cylinder Head Camshafts
Courtesy of GENERAL MOTORS CORP.

1. Remove the **EN 46328** from the left camshafts. See **Special Tools** .

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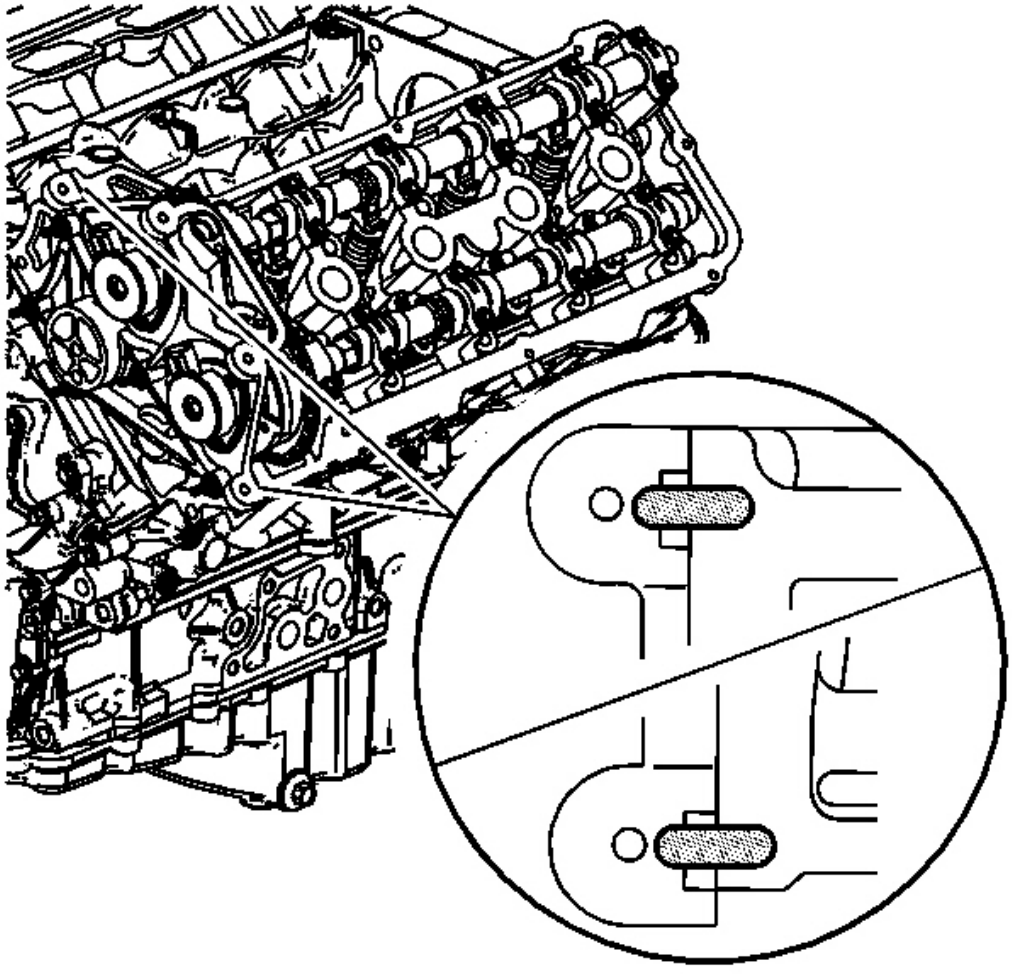


Fig. 476: Applying Sealant At Split Line Of Left Cylinder Head & Camshaft Position Actuator Housings
Courtesy of GENERAL MOTORS CORP.

2. Place a small amount of sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent at the split line of the left cylinder head and the left camshaft position actuator housings.

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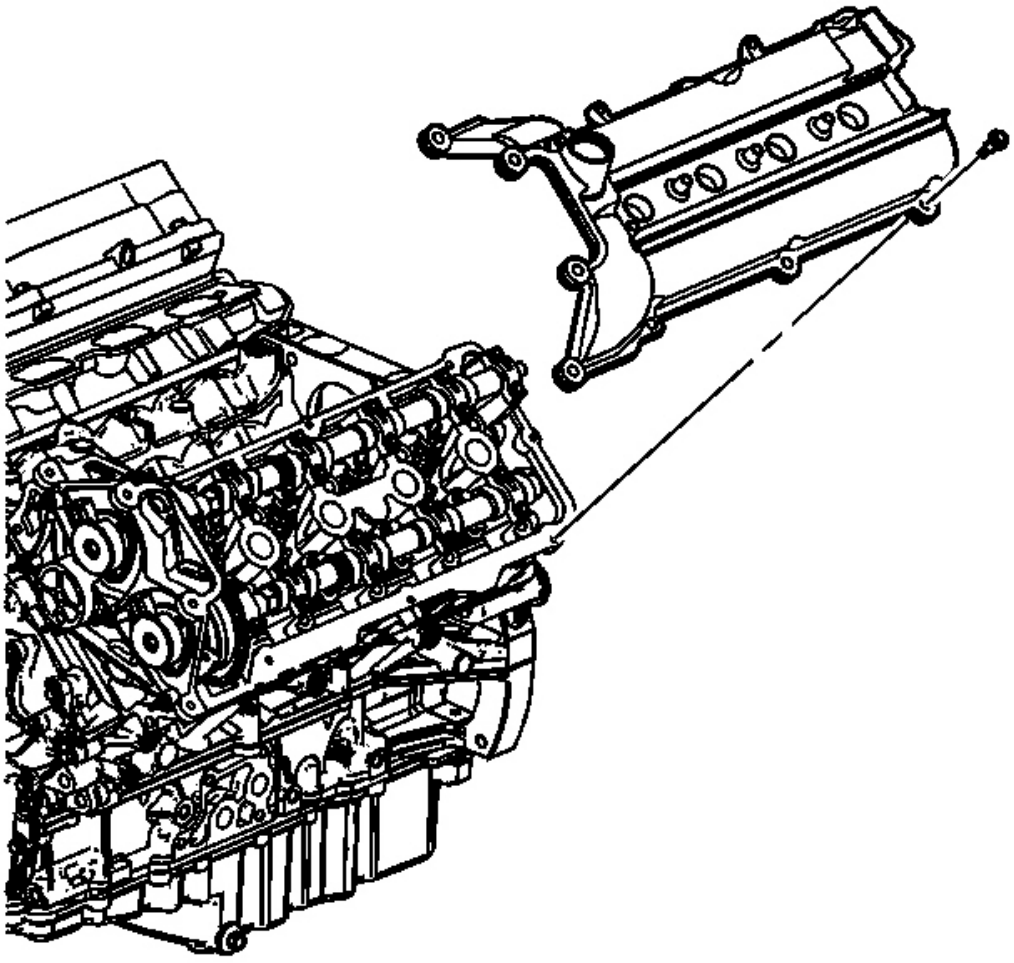


Fig. 477: View Of Left Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be careful to prevent the exposed section of the camshaft cover seal from being damaged by the edge of the cylinder head casting.

3. Install the left camshaft cover.

NOTE: Refer to Fastener Notice .

4. Install the left camshaft cover bolts.

Tighten: Tighten the left camshaft cover bolts to 10 N.m (89 lb in).

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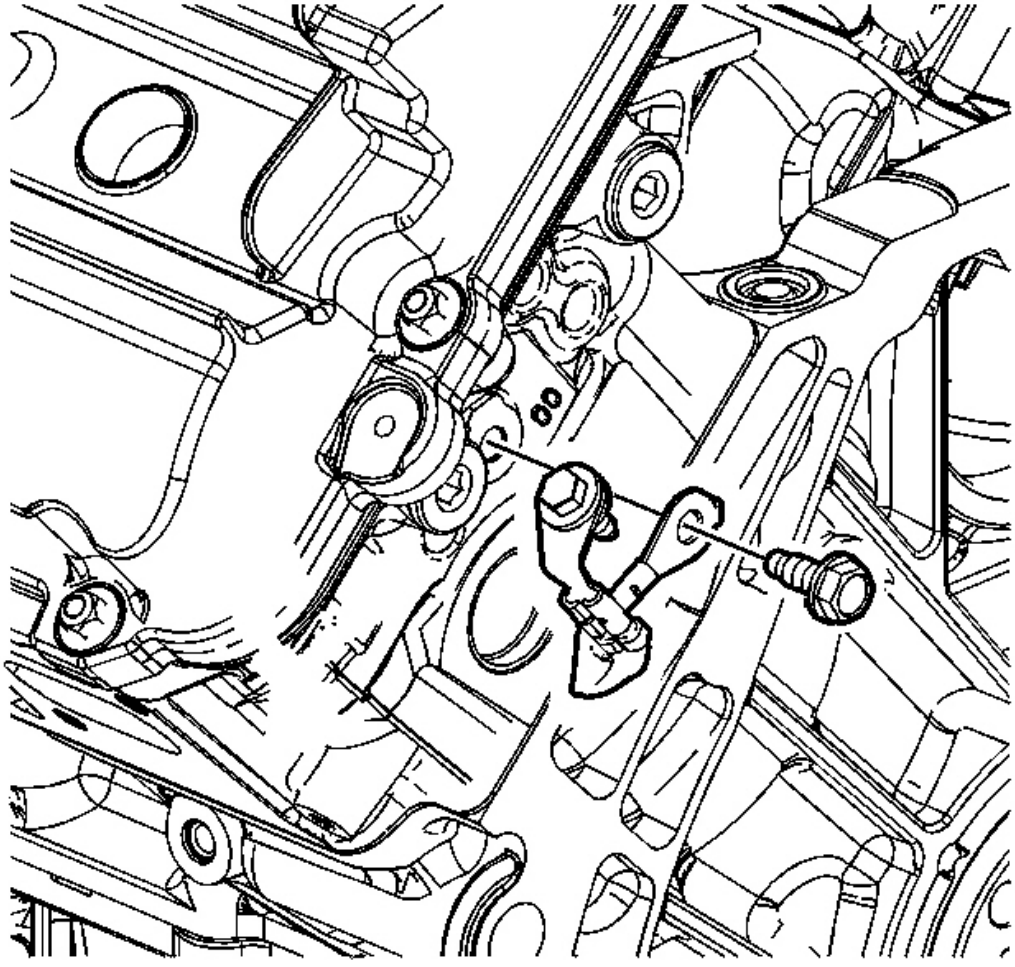


Fig. 478: View Of Left Camshaft Cover Ground Strap & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the bolts connecting the left camshaft cover ground strap to the left cylinder head and the left camshaft cover.

   Tighten:

   - Tighten the left ground strap bolt into the camshaft cover to 10 N.m (89 lb in).
   - Tighten the left ground strap bolt into the cylinder head to 25 N.m (18 lb ft).

IGNITION COIL MODULE INSTALLATION - LEFT SIDE

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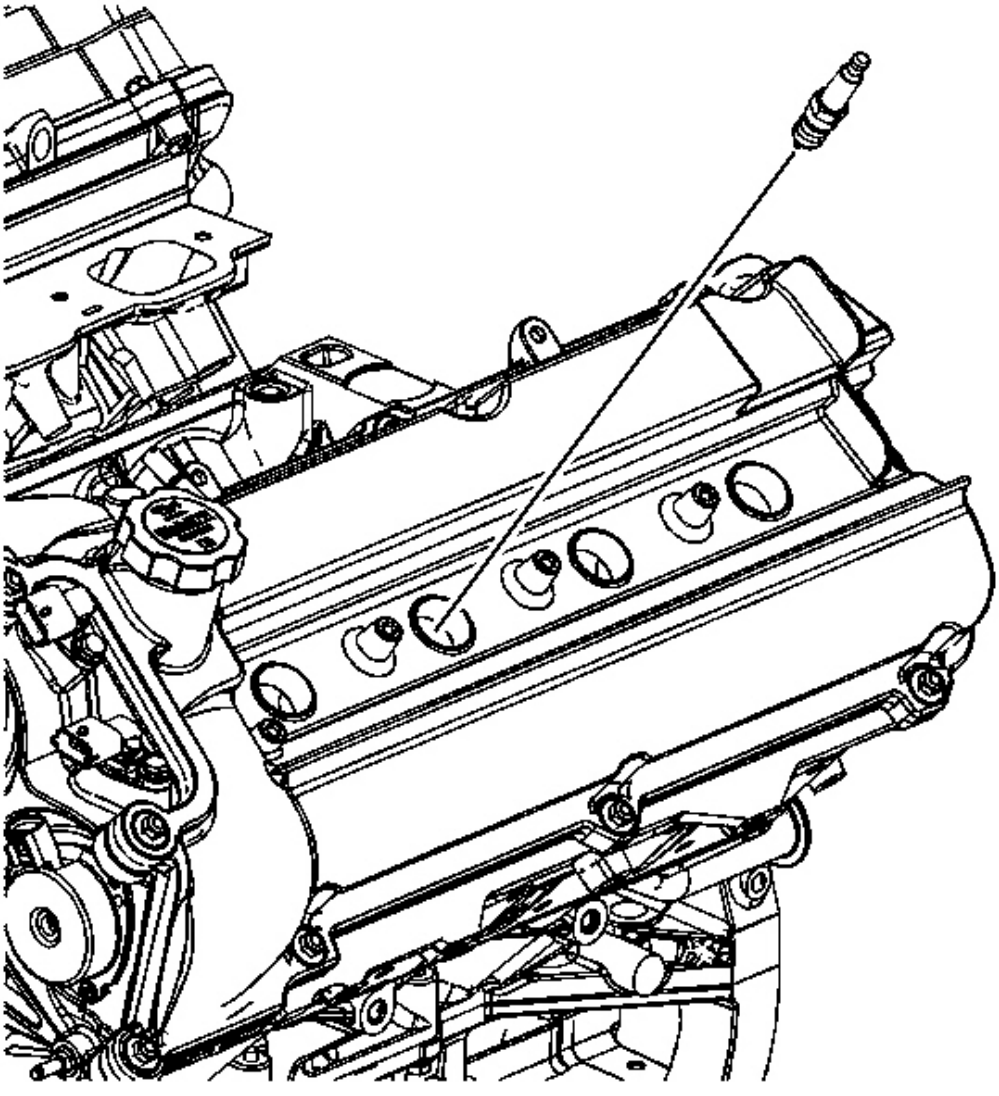


Fig. 479: Locating Spark Plugs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the left spark plugs.

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

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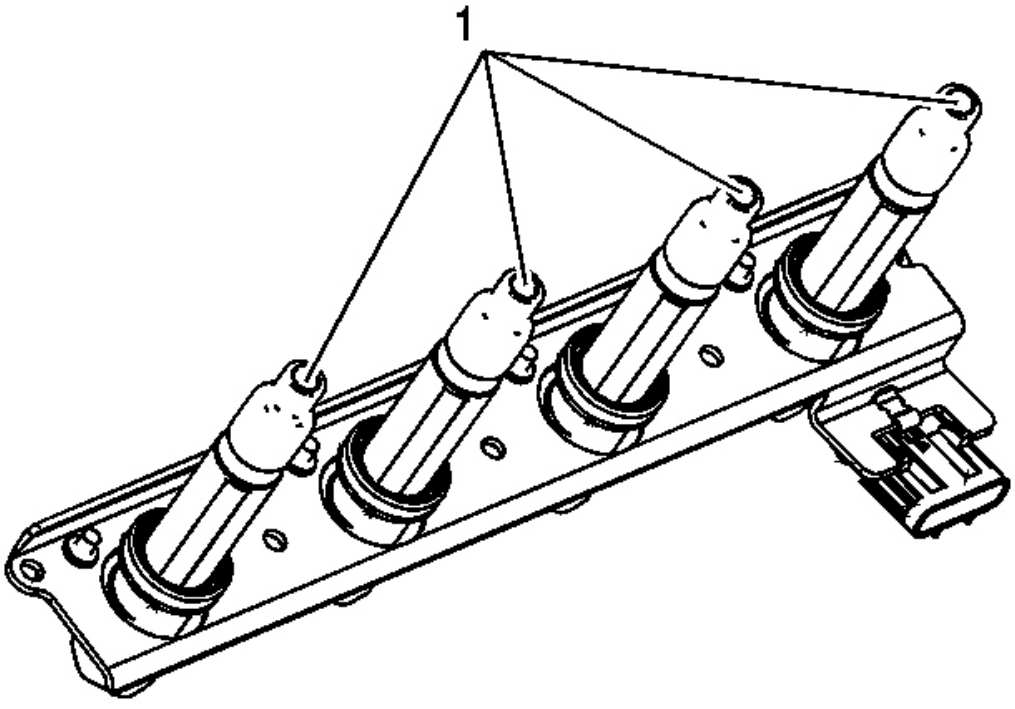


Fig. 480: Identifying Spark Plug Boots
Courtesy of GENERAL MOTORS CORP.

2. Apply a small amount of dielectric grease GM P/N 12345579, (Canadian P/N 1974984), to each spark plug boot (1) of the ignition coil assembly.

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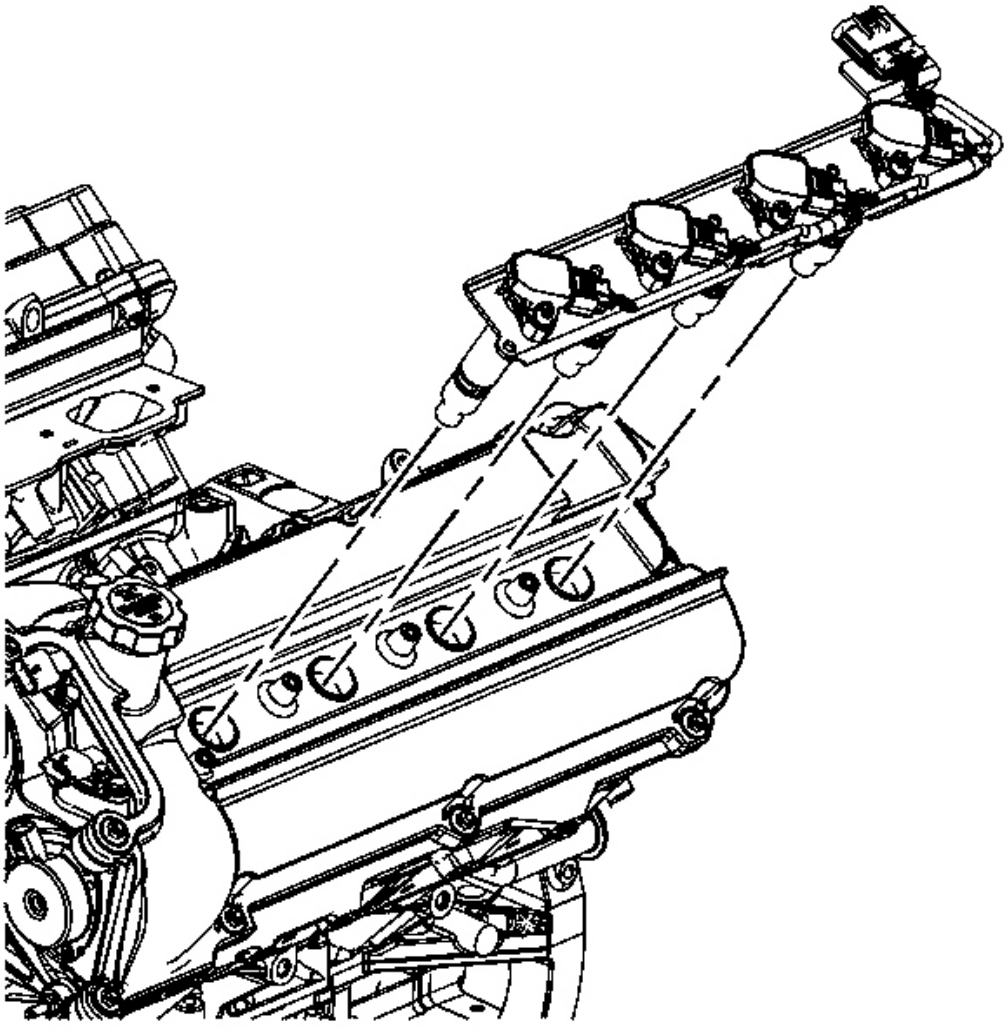


Fig. 481: Identifying Coil Assembly
Courtesy of GENERAL MOTORS CORP.

3. Carefully, install the left ignition coil assembly.

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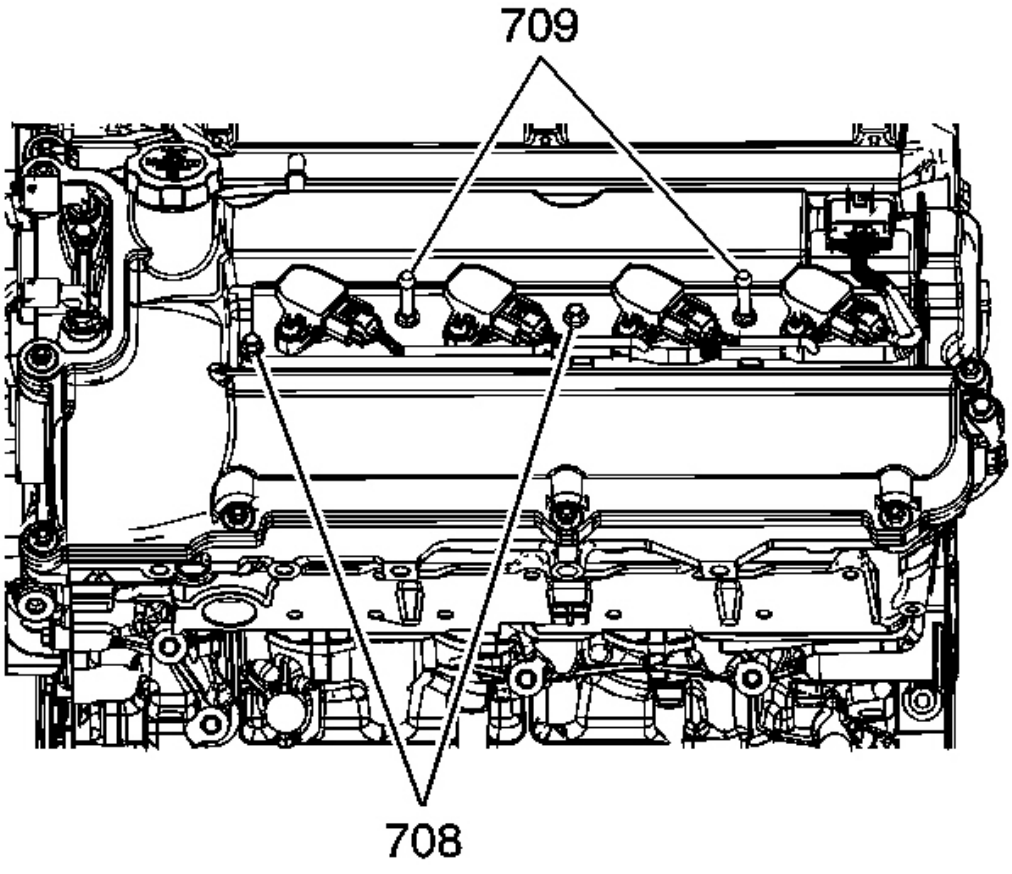


Fig. 482: Identifying Left Ignition Coil Assembly Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

4. Install the left ignition coil assembly bolts (708) and ball studs (709).

   Tighten: Tighten the left ignition coil assembly bolts (708) and ball studs (709) to 10 N.m (89 lb in).

OIL FILTER ADAPTER INSTALLATION

1. Install a NEW gasket to the oil filter adapter.

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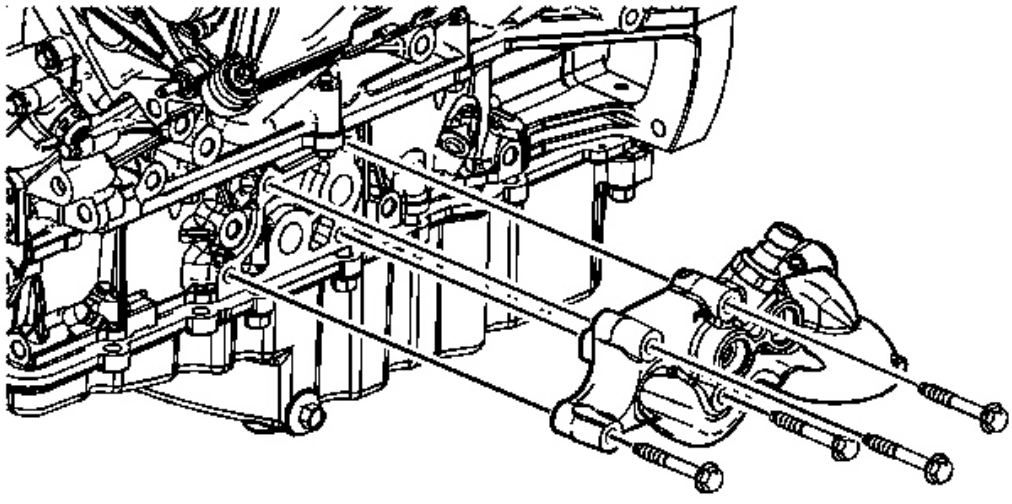


Fig. 483: View Of Oil Filter Adapter Bolts
Courtesy of GENERAL MOTORS CORP.

2. Position the oil filter adapter on the crankcase.

NOTE: **Refer to Fastener Notice .**

3. Install the oil filter adapter bolts.

Tighten: Tighten the oil filter adapter bolts to 25 N.m (18 lb ft).

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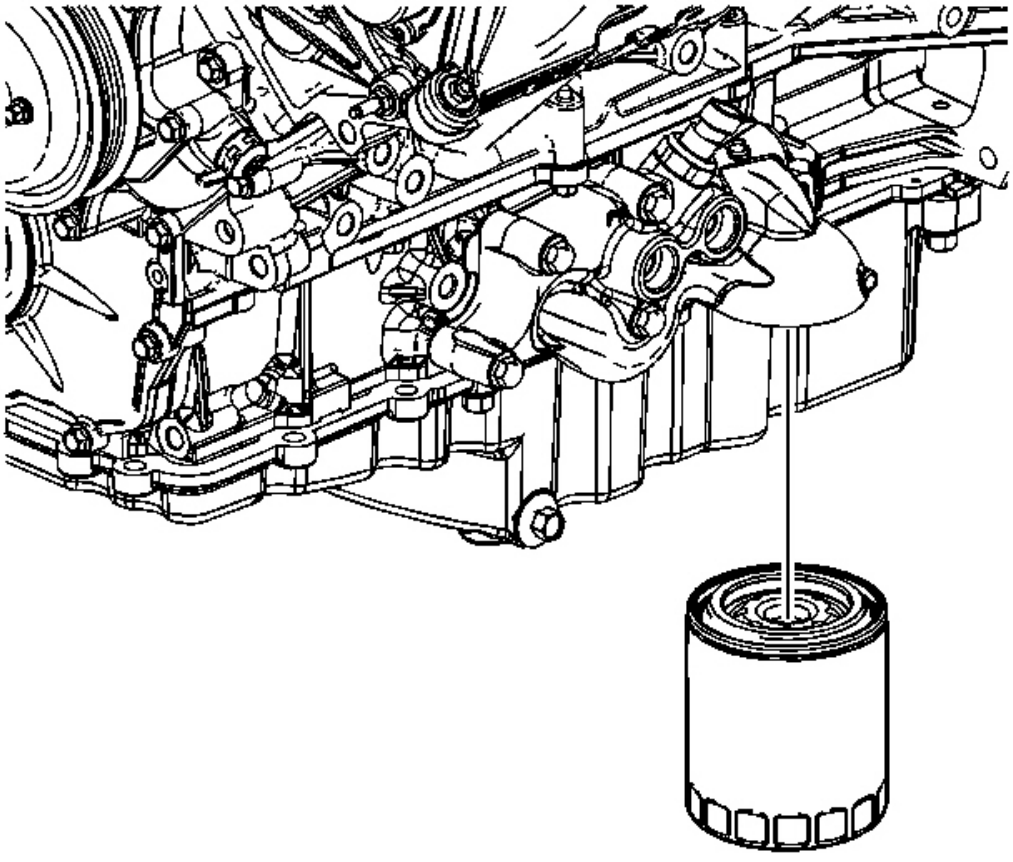


Fig. 484: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

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

4. Fill the oil filter with oil.
5. Install the oil filter.

Tighten: Tighten the oil filter to 32 N.m (24 lb ft).

OIL LEVEL INDICATOR AND TUBE INSTALLATION

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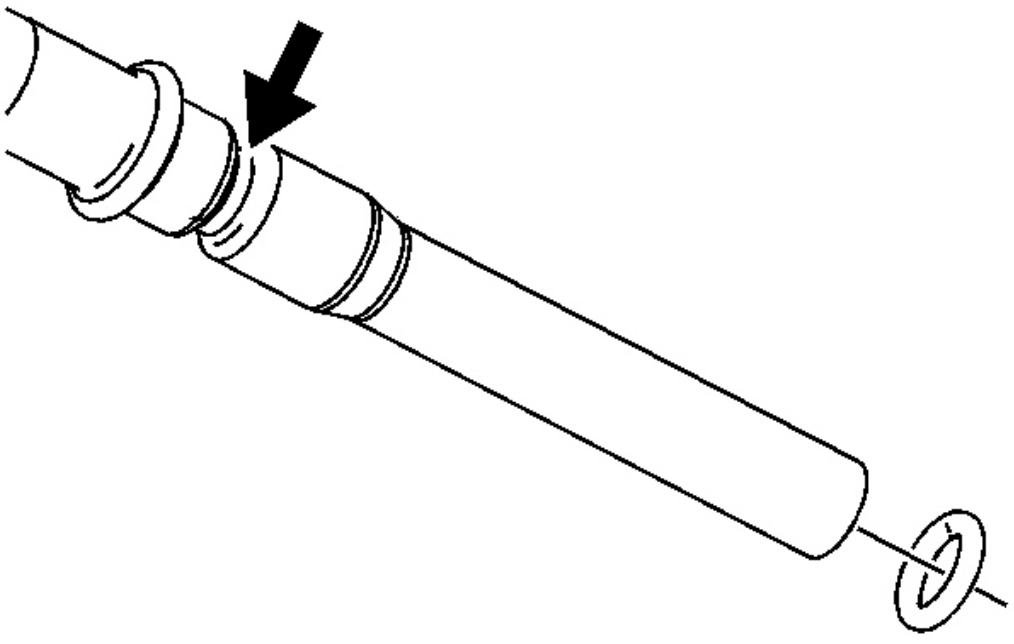


Fig. 485: View Of Oil Level Indicator Tube O-Ring
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW O-ring on the oil level indicator tube.

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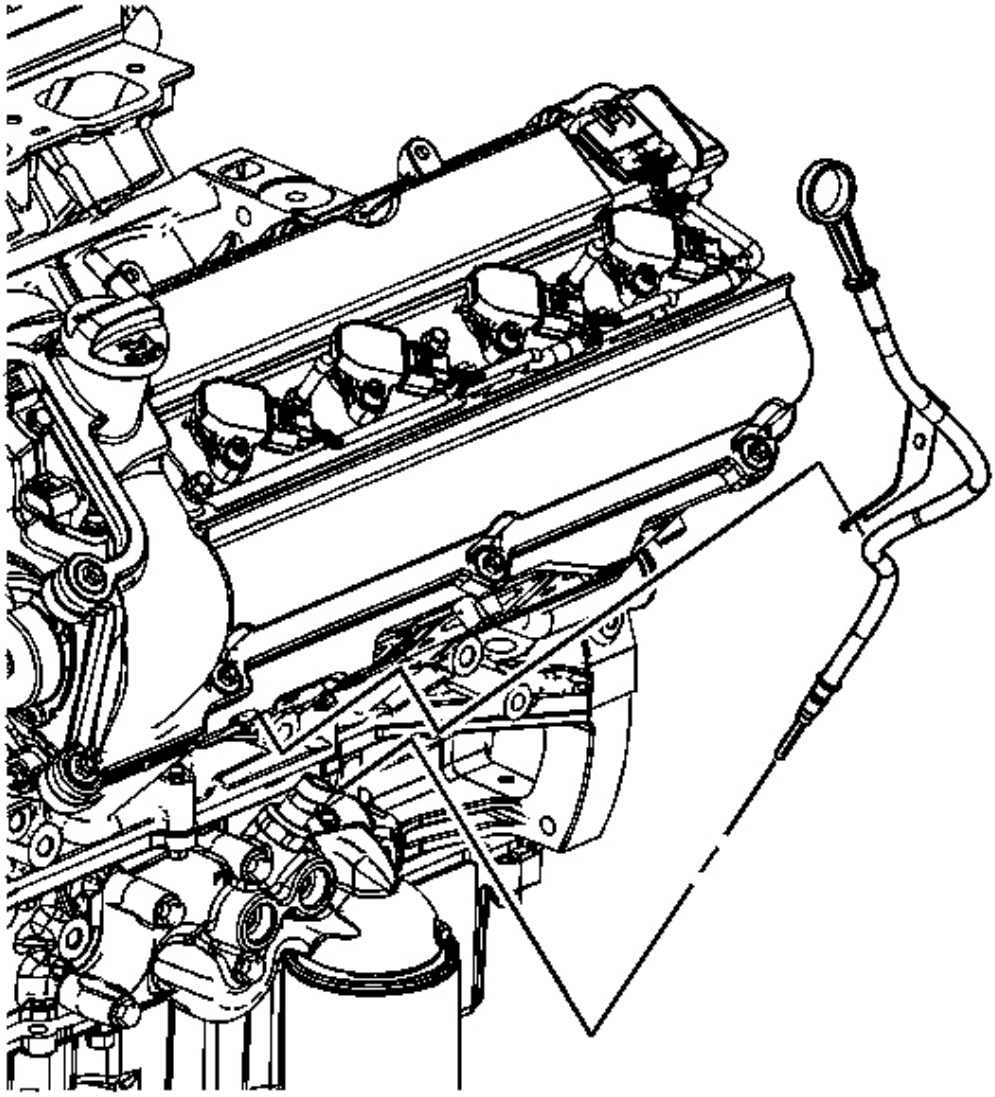


Fig. 486: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

2. Install the oil level indicator tube.

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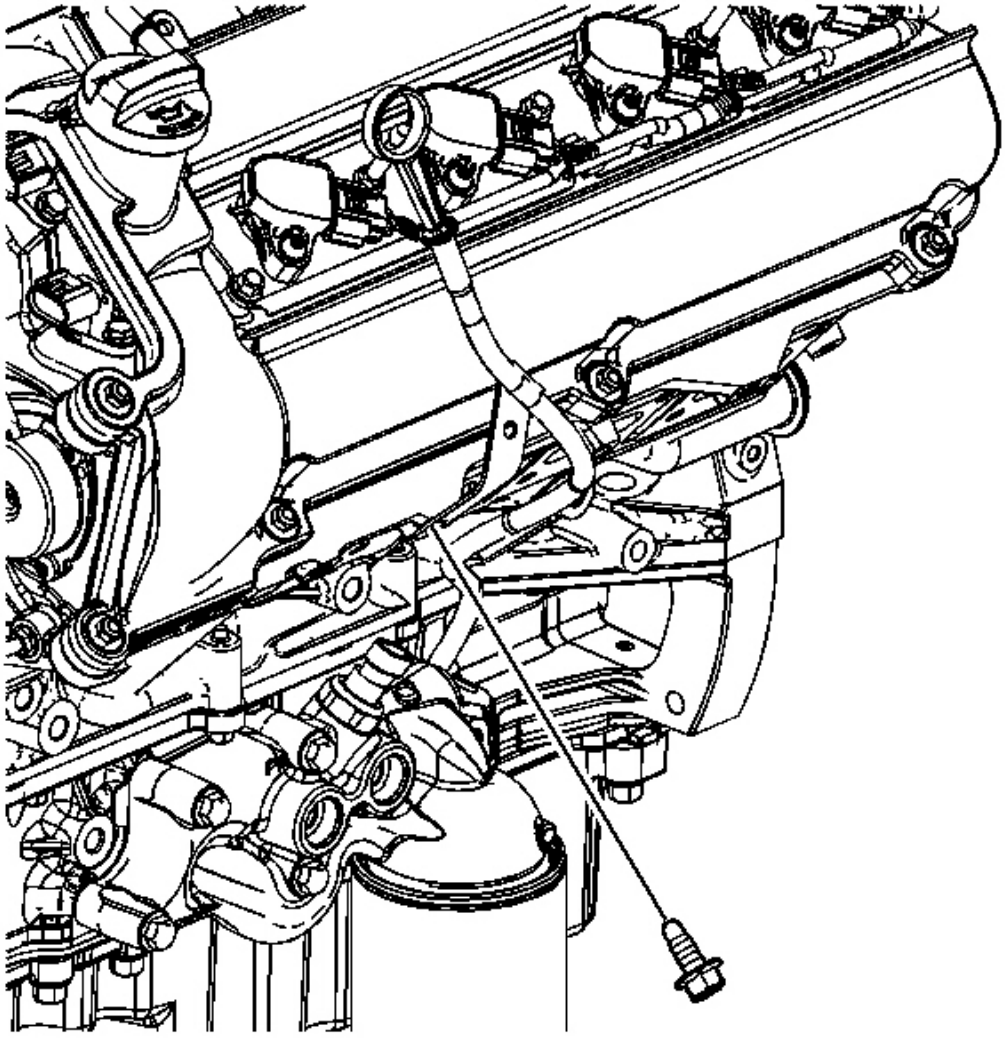


Fig. 487: Identifying Oil Level Indicator Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the oil level indicator tube bolt.

Tighten: Tighten the oil level indicator tube bolt to 50 N.m (37 lb ft).

CRANKSHAFT REAR OIL SEAL INSTALLATION

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TOOLS REQUIRED

- **EN-48072** Sealant Applicator. See **Special Tools** .
- **J 45930-A** Crankshaft Rear Oil Seal Installer. See **Special Tools** .

INSTALLATION PROCEDURE

IMPORTANT: The EN-48072 must be used to ensure even application of the sealant in the bore and to prevent blockage of the drain back hole. See Special Tools .

IMPORTANT: Ensure components that are being sealed with RTV sealant are assembled within 20 minutes. Components assembled after the RTV sealant has skinned-over, approximately 20 minutes, will not bond properly.

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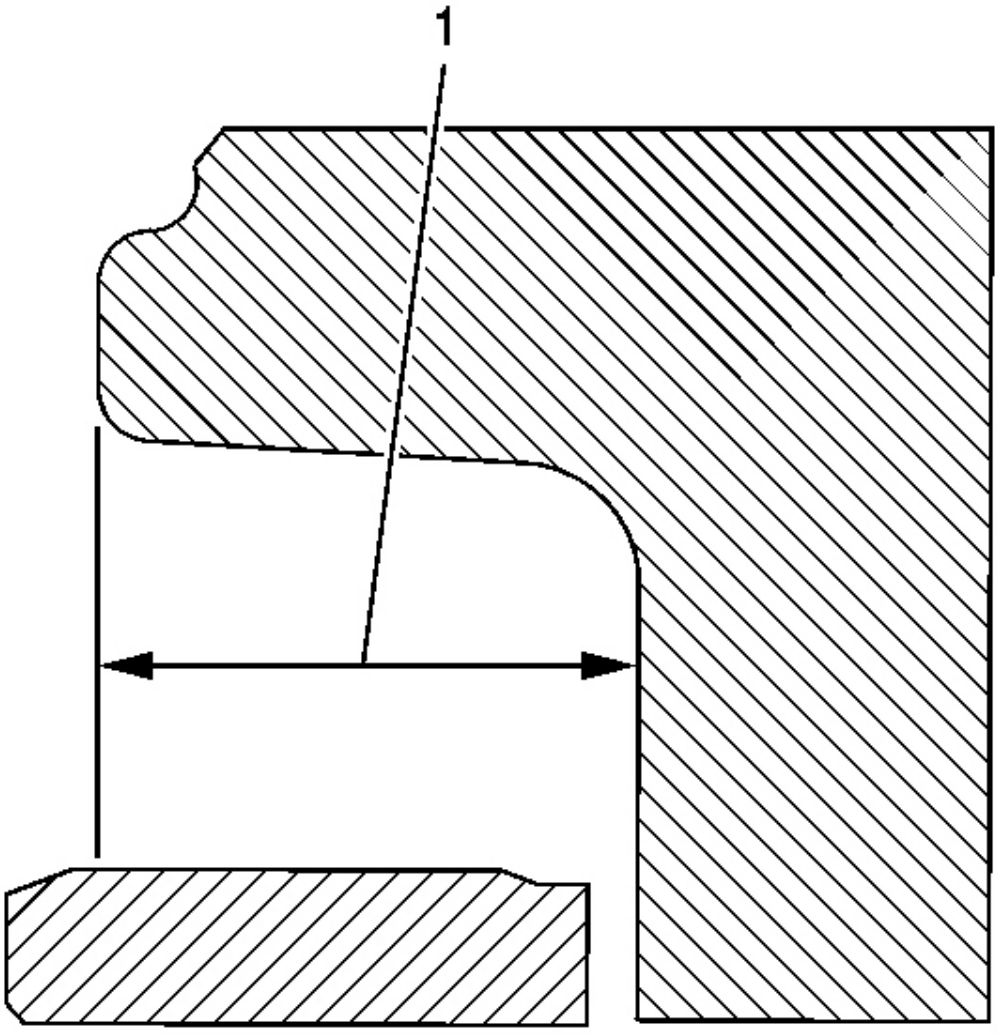


Fig. 488: Checking Oil Seal Bore Depth
Courtesy of GENERAL MOTORS CORP.

1. Ensure the engine block where the crankshaft rear oil seal is installed is a deep bore (1).
    - A deep bore of approximately 15 mm (0.5906 in) was used on engines from March 1, 1996 and later.
    - A shallow bore of approximately 8 mm (0.3150 in) was used on engines from 1993 thru February 29, 1996. This block would use a lip-style crankshaft rear oil seal and the **J 38817-A** for installation.

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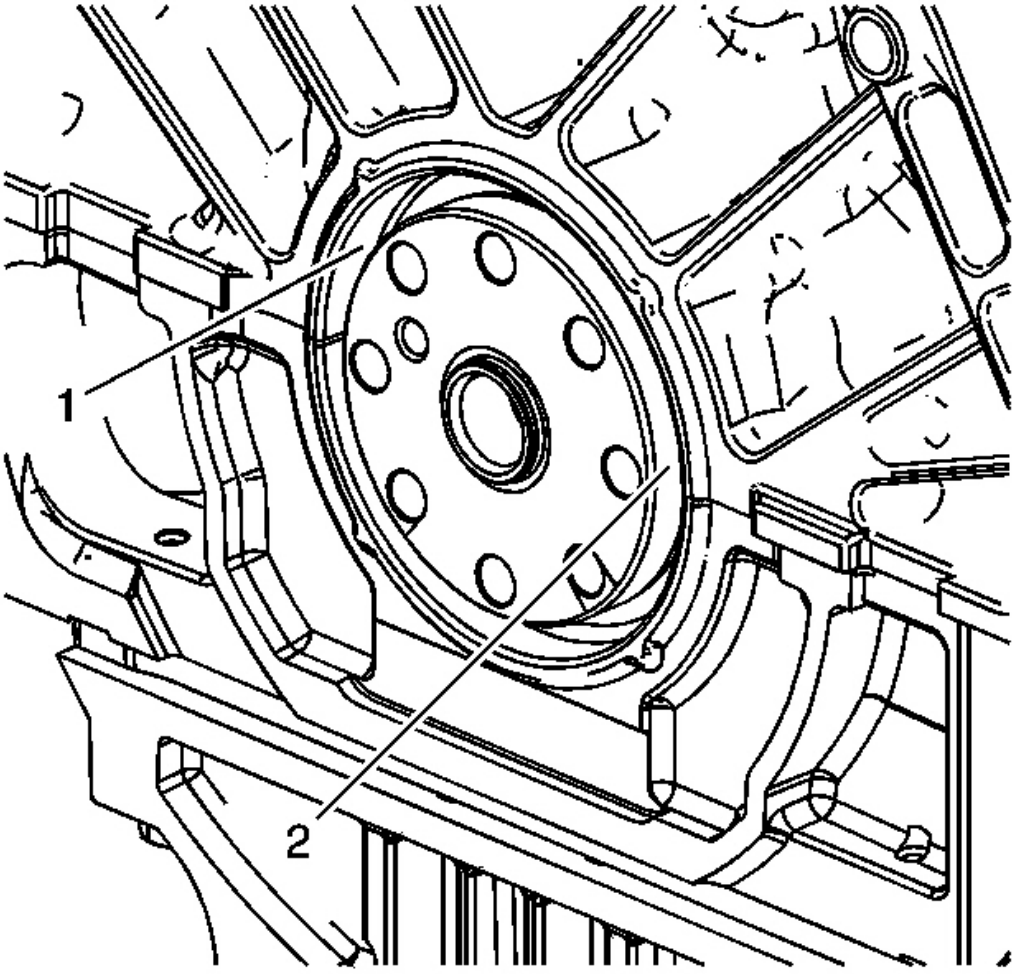


Fig. 489: Inspecting Engine Block Bore & Crankshaft Flange
Courtesy of GENERAL MOTORS CORP.

2. Inspect the engine block bore (1) and the crankshaft flange (2) for the damage. Repair or replace any damaged components.

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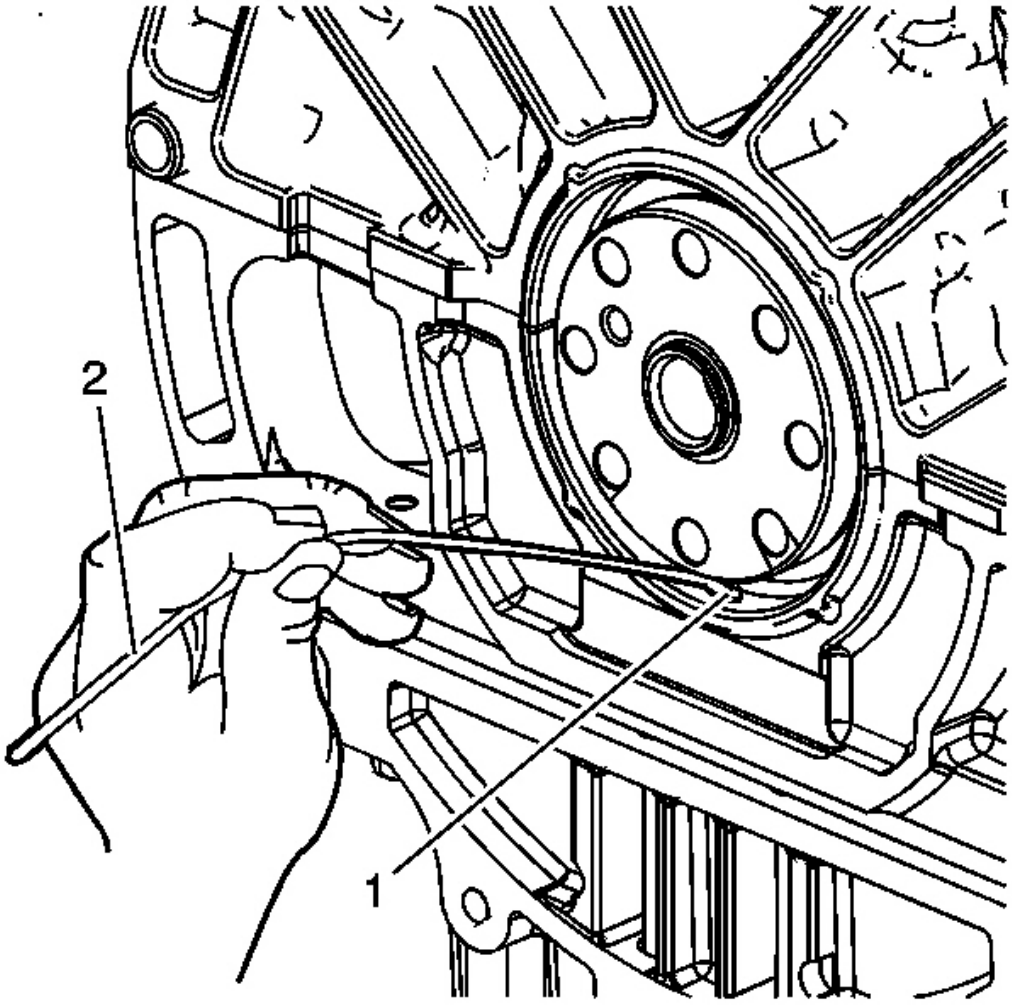


Fig. 490: Cleaning Debris From Crankshaft Rear Oil Seal Drain
Courtesy of GENERAL MOTORS CORP.

3. Ensure the oil drain-back hole is clear of debris using a wire or an unbound plastic tie wrap.

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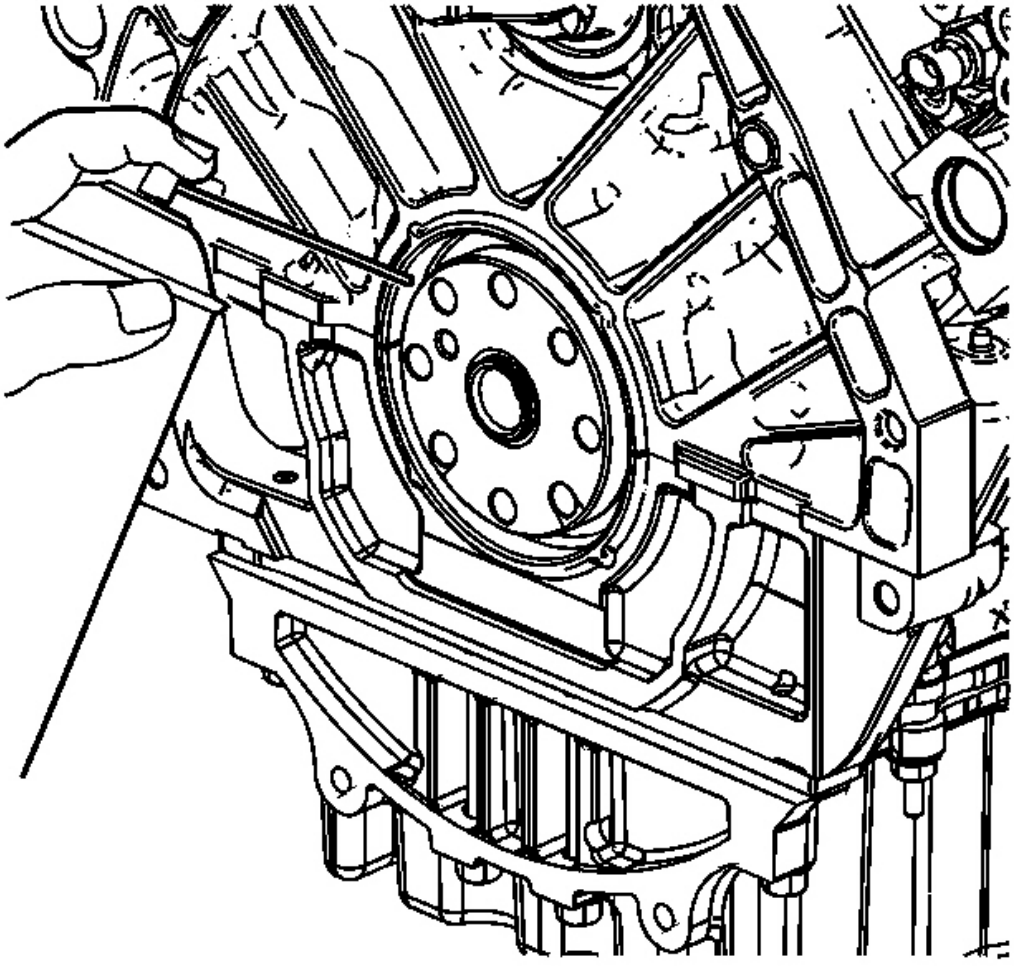


Fig. 491: Cleaning Bore In Block With Cleaner Solvent
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to ensure proper bonding of the sealant the bore must be clean and dry.

4. Clean the bore in the block with cleaner solvent GM P/N 12378392 or 12346139 (Canadian P/N 88901247).

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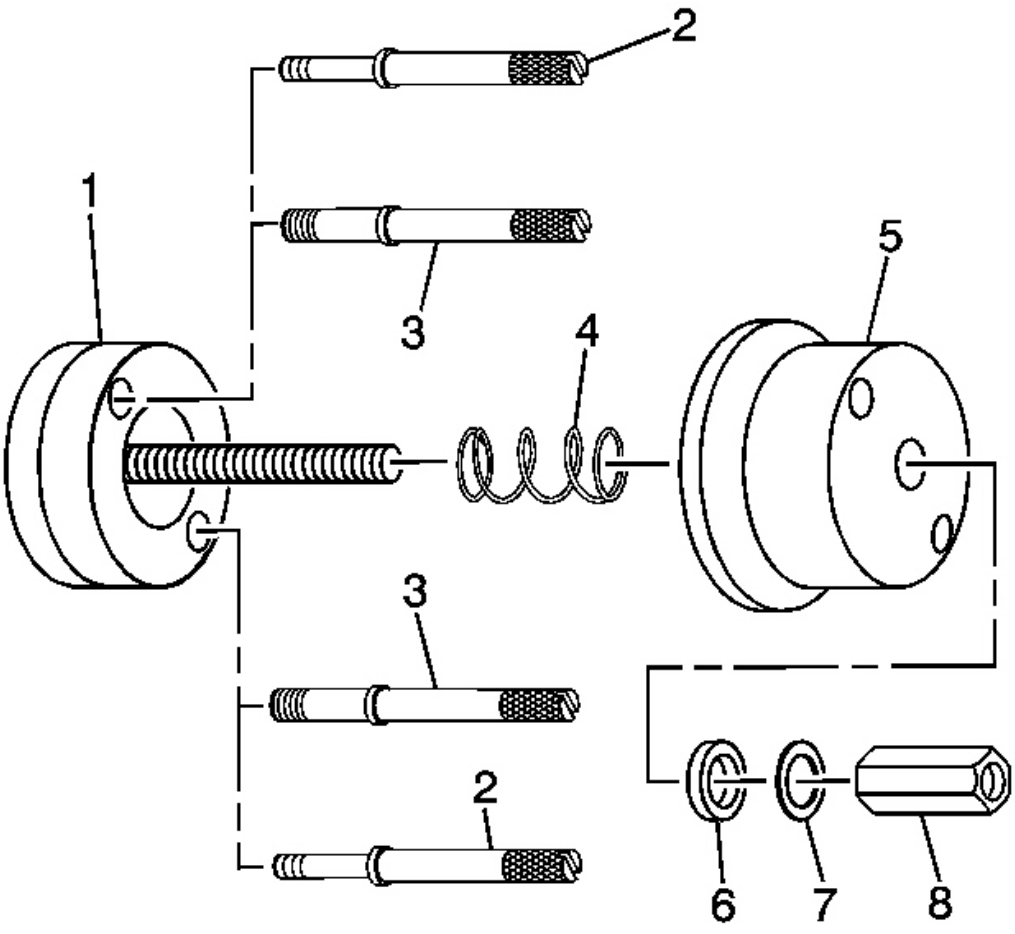


Fig. 492: View Of J 45930-A Tool Set
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Northstar engines 2005 and older have an 8 x 1.25 mm flywheel/flexplate crankshaft bolt hole thread. Northstar engines 2006 and later have an 11 x 1.5 mm flywheel/flexplate crankshaft bolt hole thread.

5. Remove the proper sized bolts from the **J 45930-A** . See **Special Tools** . Use the bolts (2) 8 mm or the bolts (3) 11 mm.

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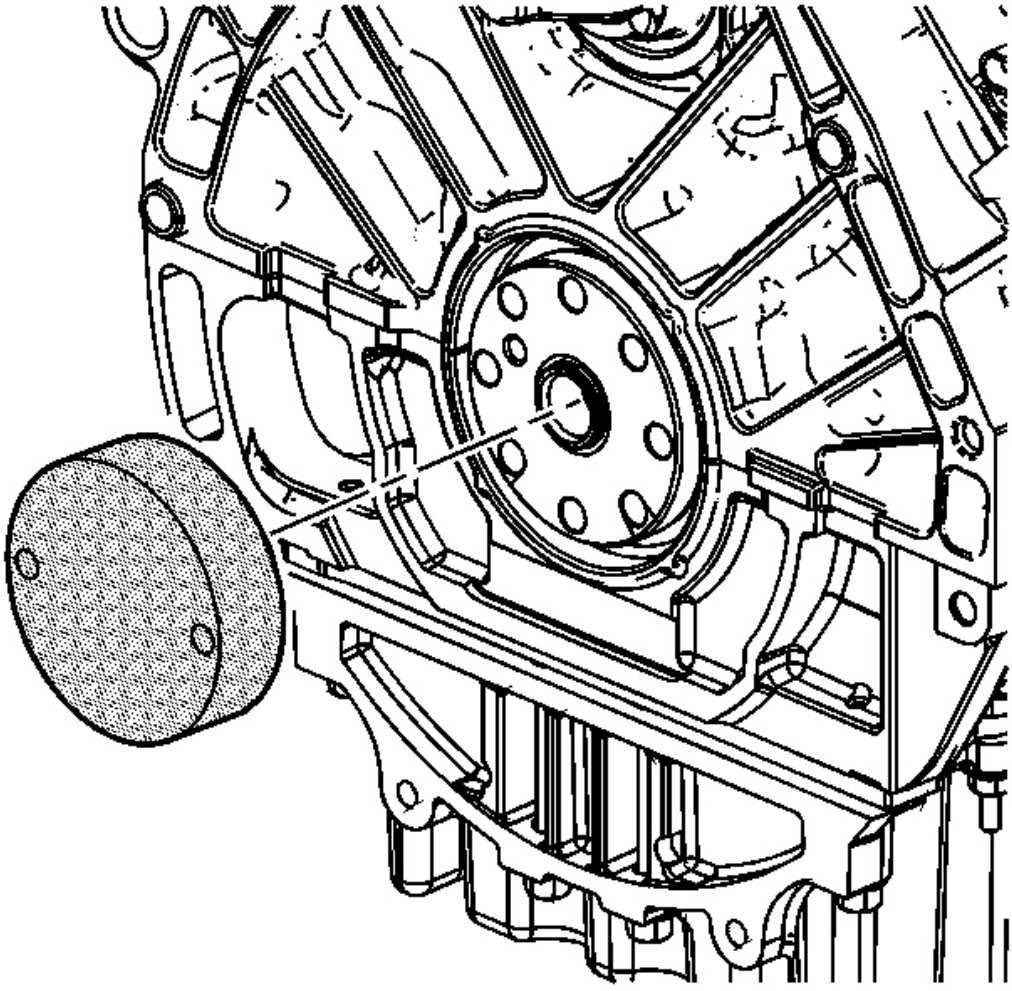


Fig. 493: View Of EN-48072 Pilot Base
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN-48072** pilot base onto the crankshaft. See **Special Tools** . The hub on the crankshaft will fit into the recess on the inboard side of the **EN-48072** pilot base. See **Special Tools** .

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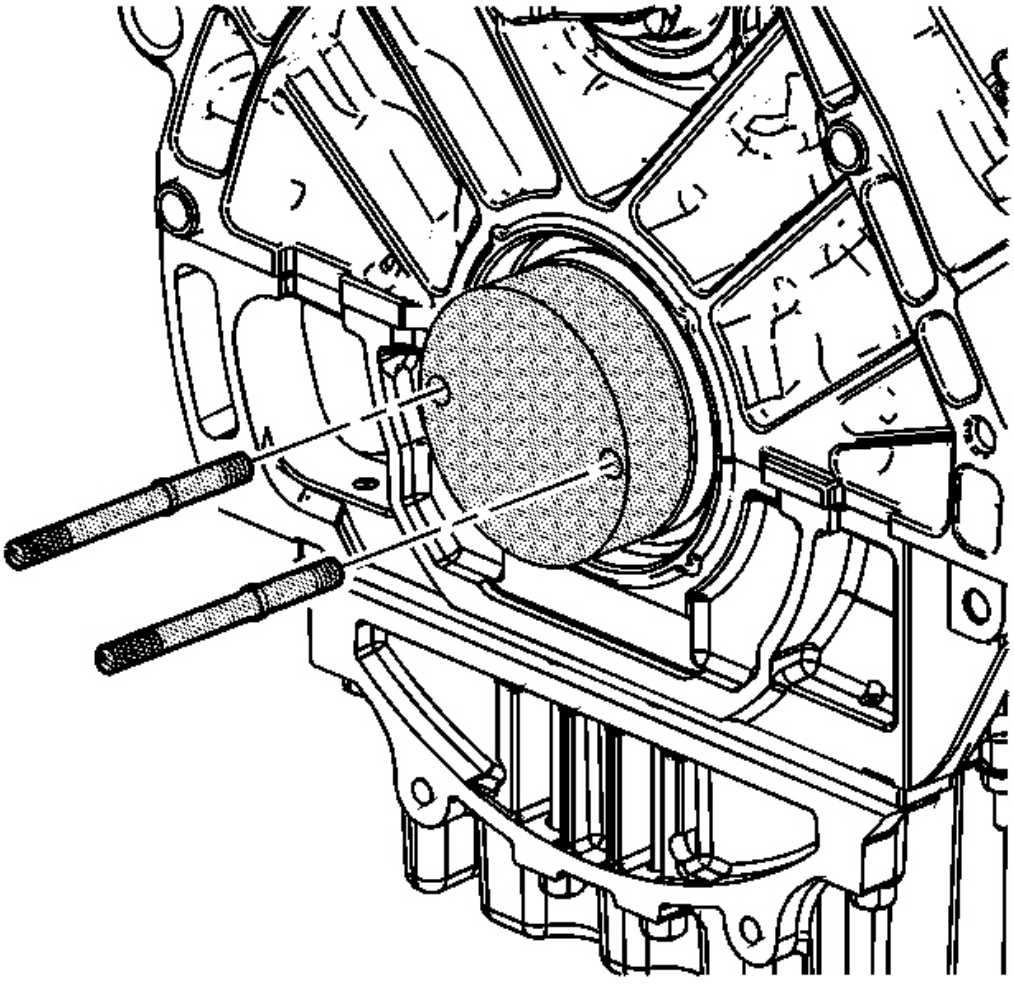


Fig. 494: View Of J 45930-A Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Northstar engines 2005 and older have an 8 x 1.25 mm flywheel/flexplate crankshaft bolt hole thread. Northstar engines 2006 and later have an 11 x 1.5 mm flywheel/flexplate crankshaft bolt hole thread.

7. Use the proper bolts from the **J 45930-A** to retain the **EN-48072** pilot base in place. See **Special Tools** .

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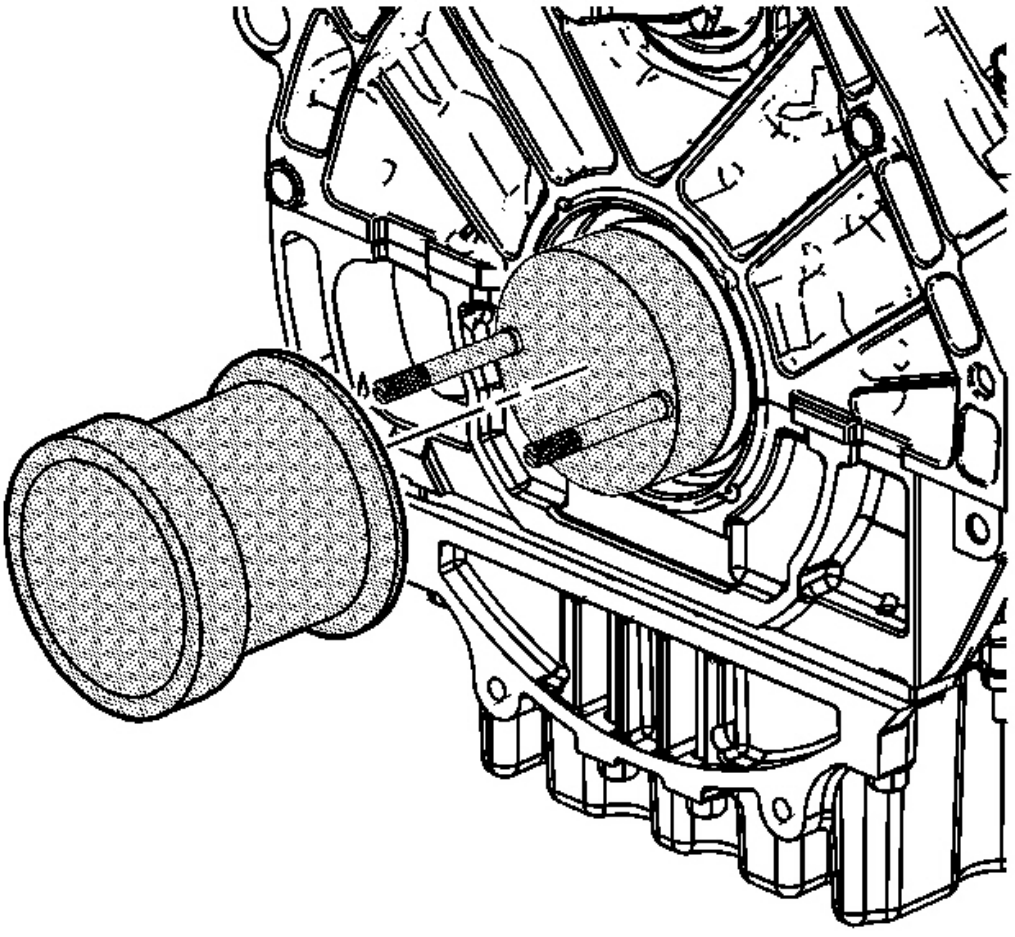


Fig. 495: View Of EN-48072 Applicator Housing
Courtesy of GENERAL MOTORS CORP.

8. Install the **EN-48072** applicator housing over the **EN-48072** pilot base. See **Special Tools** . Ensure the **EN-48072** applicator housing bottoms in the bore of the block. See **Special Tools** .

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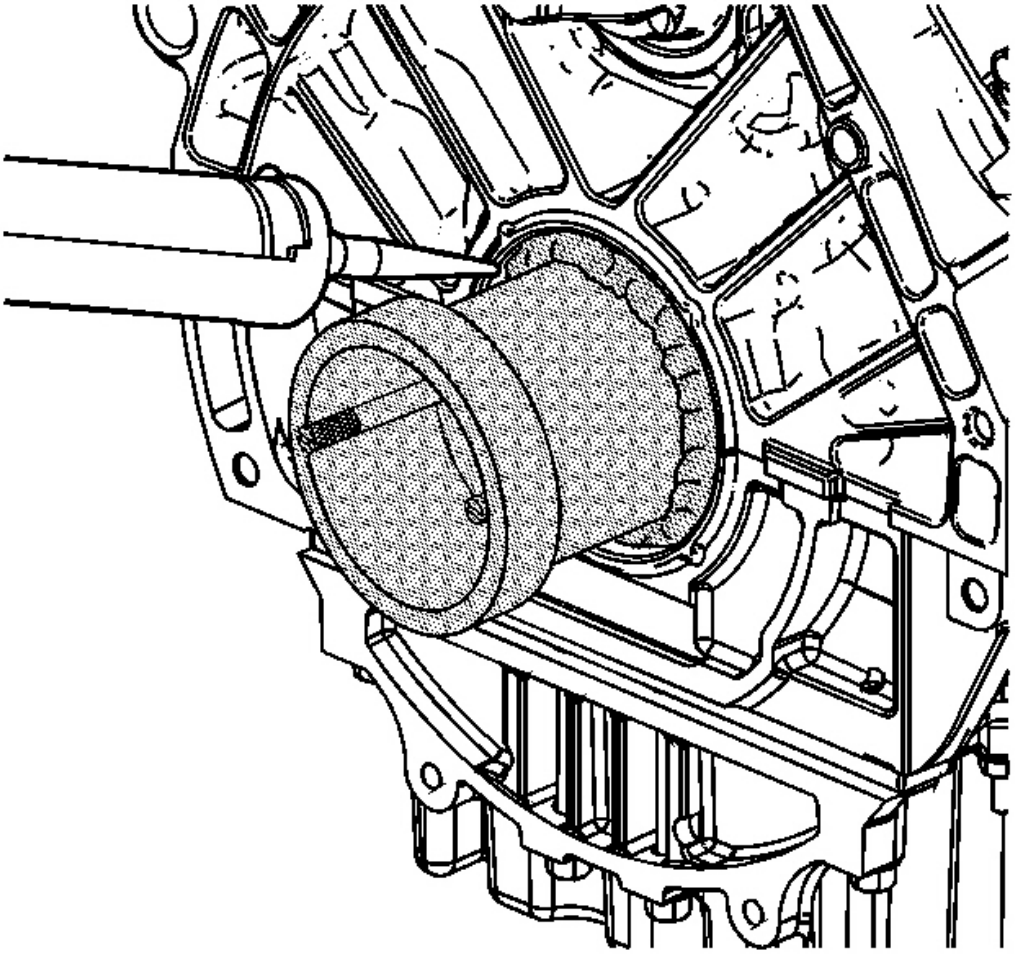


Fig. 496: Applying Sealant
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The sealant must not block the drain back hole. Blockage of the drain back hole can lead to oil leakage.

9. Apply the sealant GM P/N 12378521 (Canadian P/N 88901148) to the bore outer diameter in the block. Ensure the sealant does not block the drain hole.

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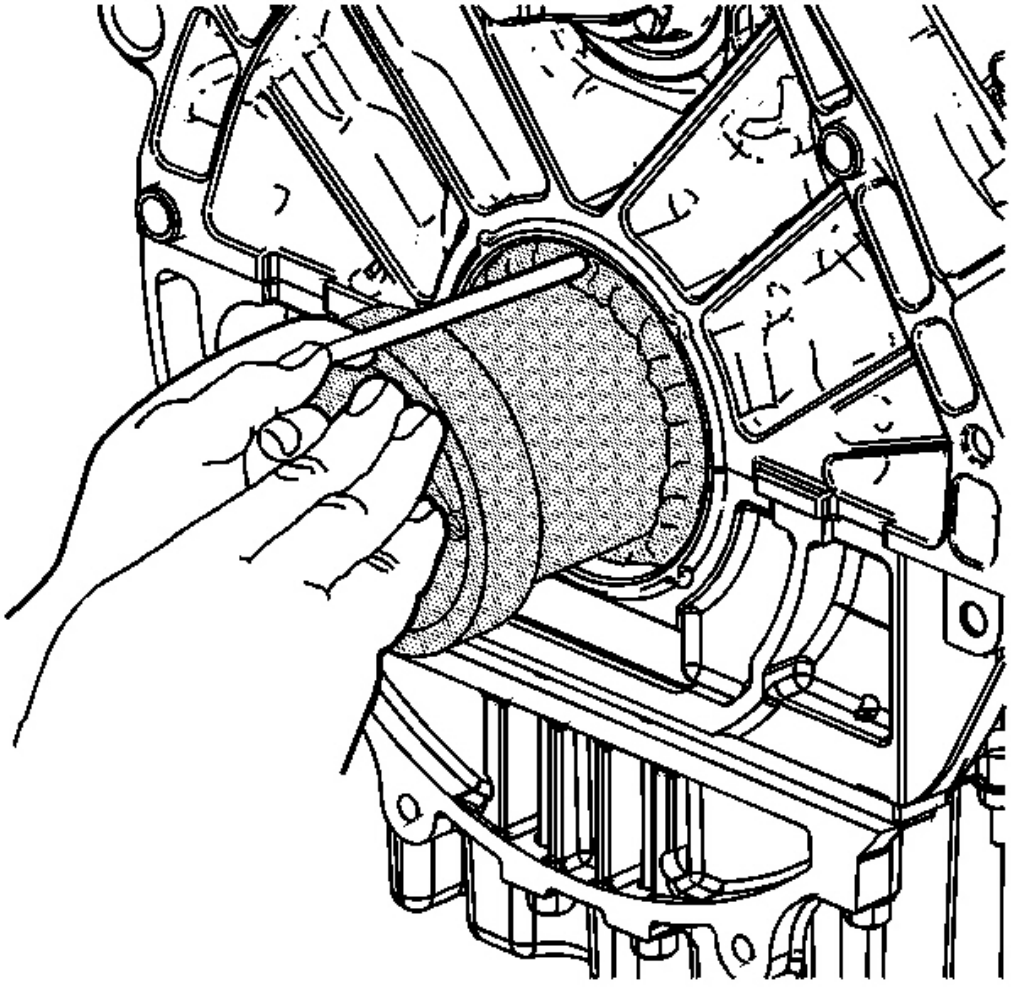


Fig. 497: Spreading Sealant
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Apply steady even pressure to the EN-48072 applicator housing. See Special Tools .

10. Using a suitable tool spread the sealant within the bore to ensure an even coating across the bore.

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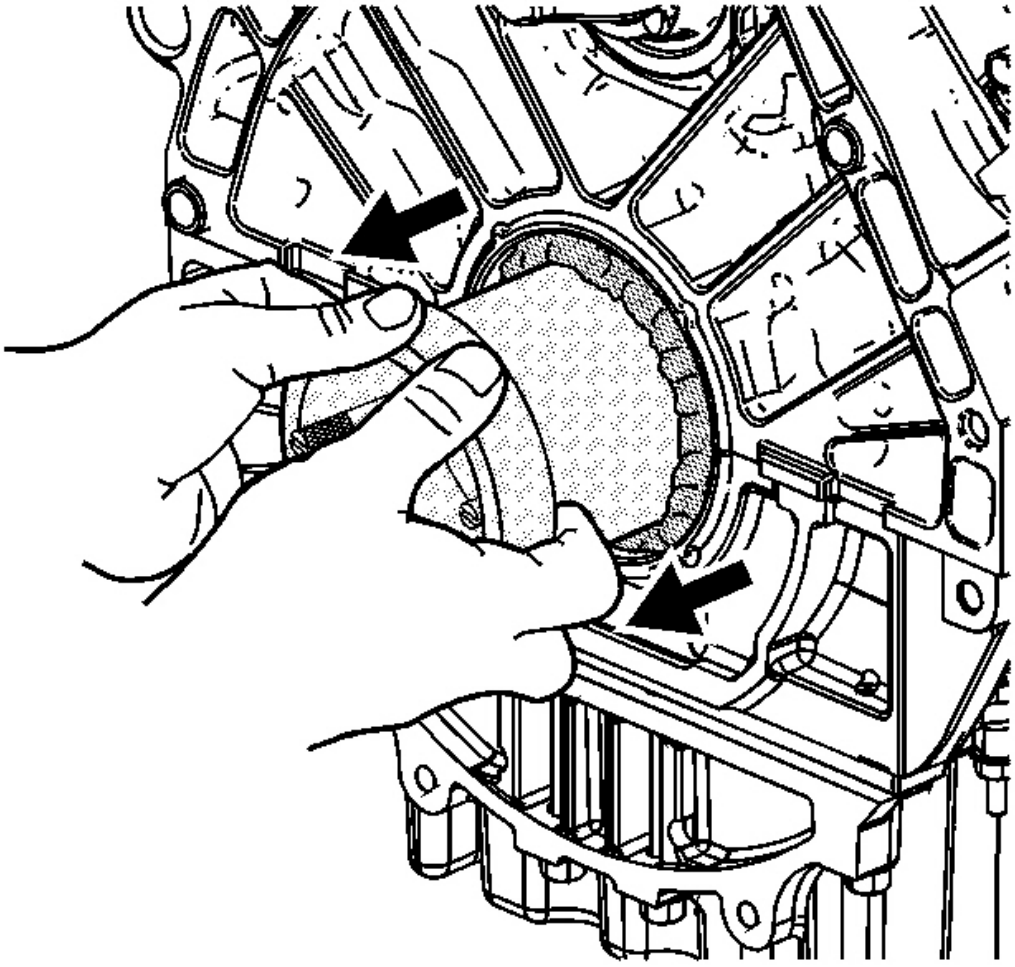


Fig. 498: Pulling EN-48072 Applicator Housing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to apply an even coat of the sealant do not twist or turn the EN-48072 applicator housing as it is pulled away from the bottom of the bore. See Special Tools .

11. Using both hands, slowly and evenly, pull the **EN-48072** applicator housing out of the bore and remove it from the **EN-48072** pilot base. See **Special Tools** .

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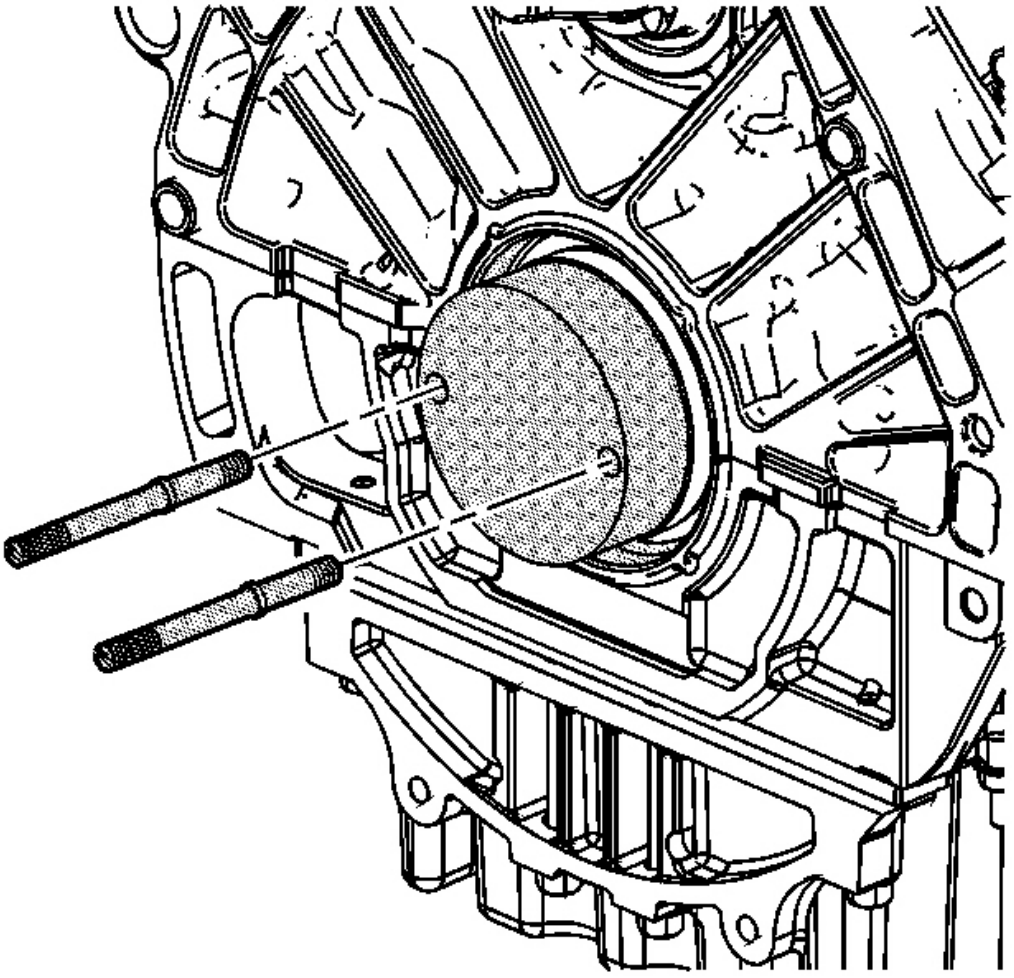


Fig. 499: View Of J 45930-A Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the **J 45930-A** bolts from the **EN-48072** pilot base. See **Special Tools** .

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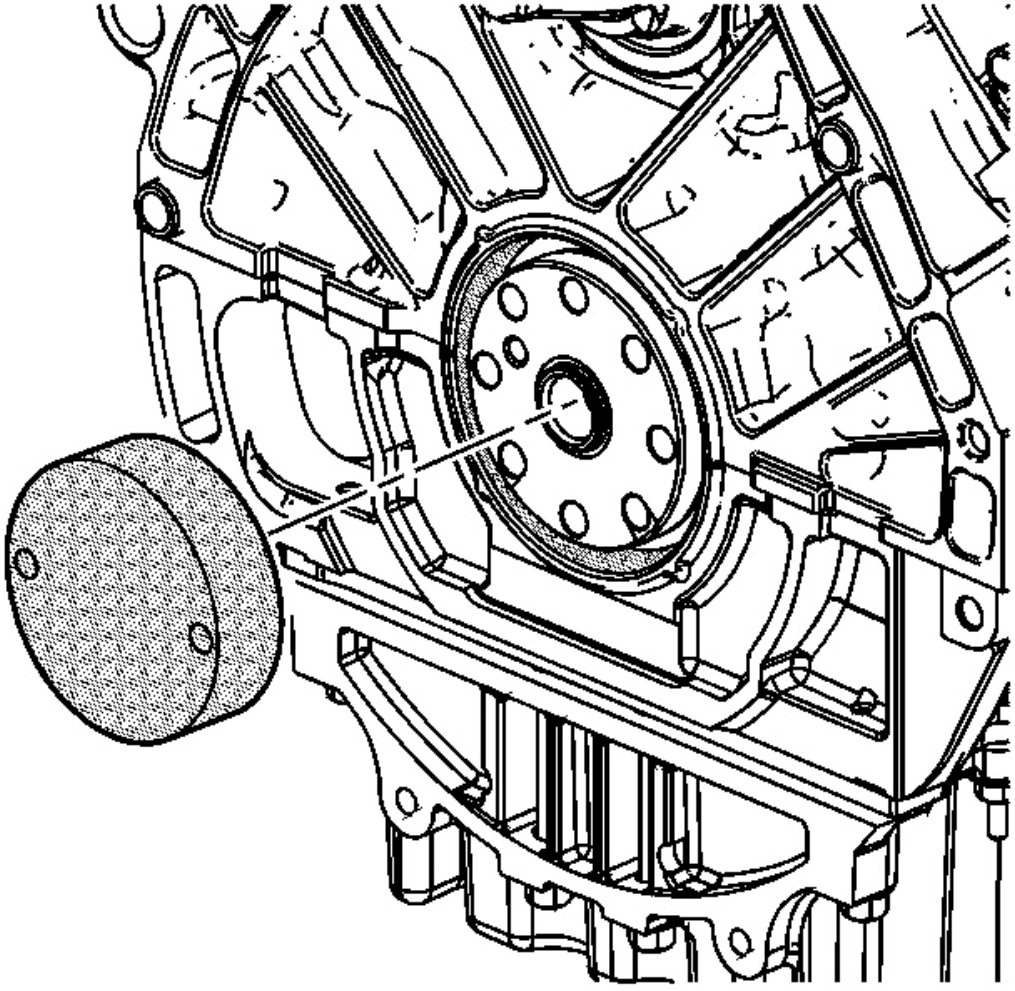


Fig. 500: View Of EN-48072 Pilot Base
Courtesy of GENERAL MOTORS CORP.

13. Remove the **EN-48072** pilot base. See **Special Tools** .

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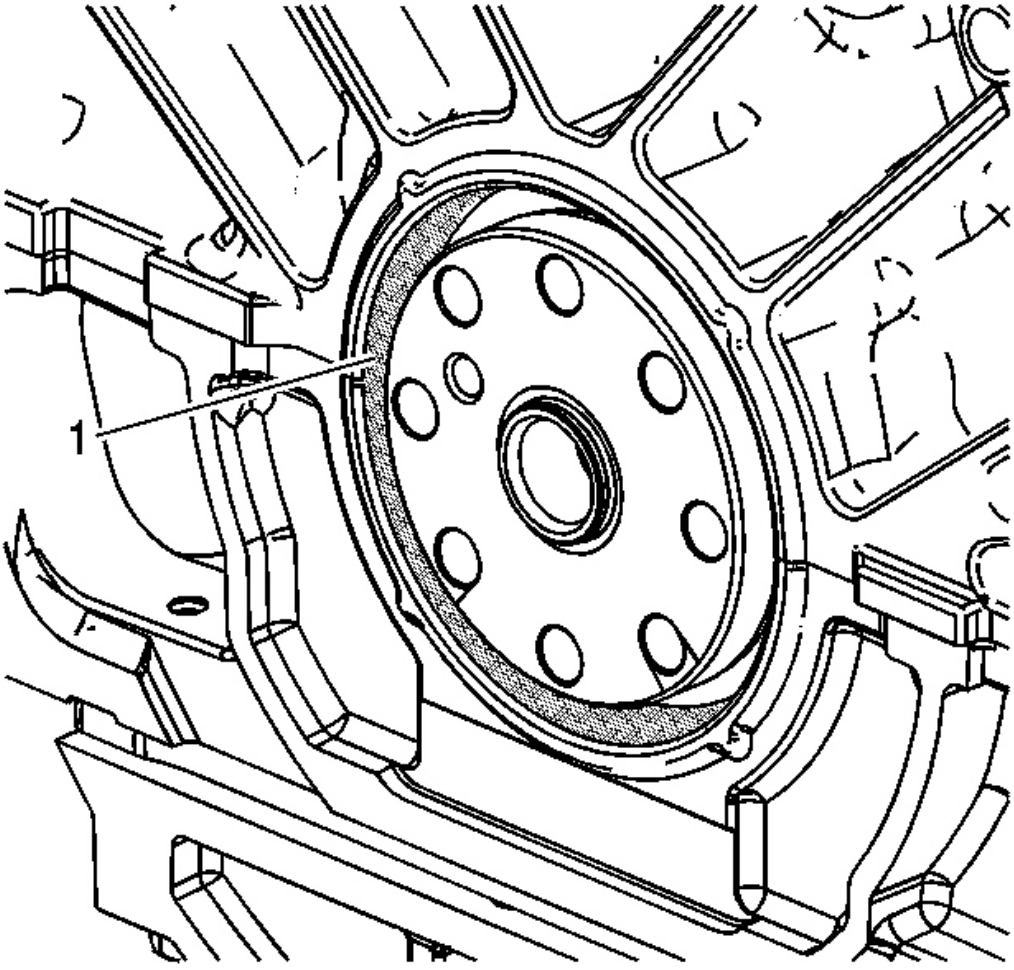


Fig. 501: Inspecting Sealant Distribution
Courtesy of GENERAL MOTORS CORP.

14. Ensure that the sealant (1) is evenly spread across the bore of the block.

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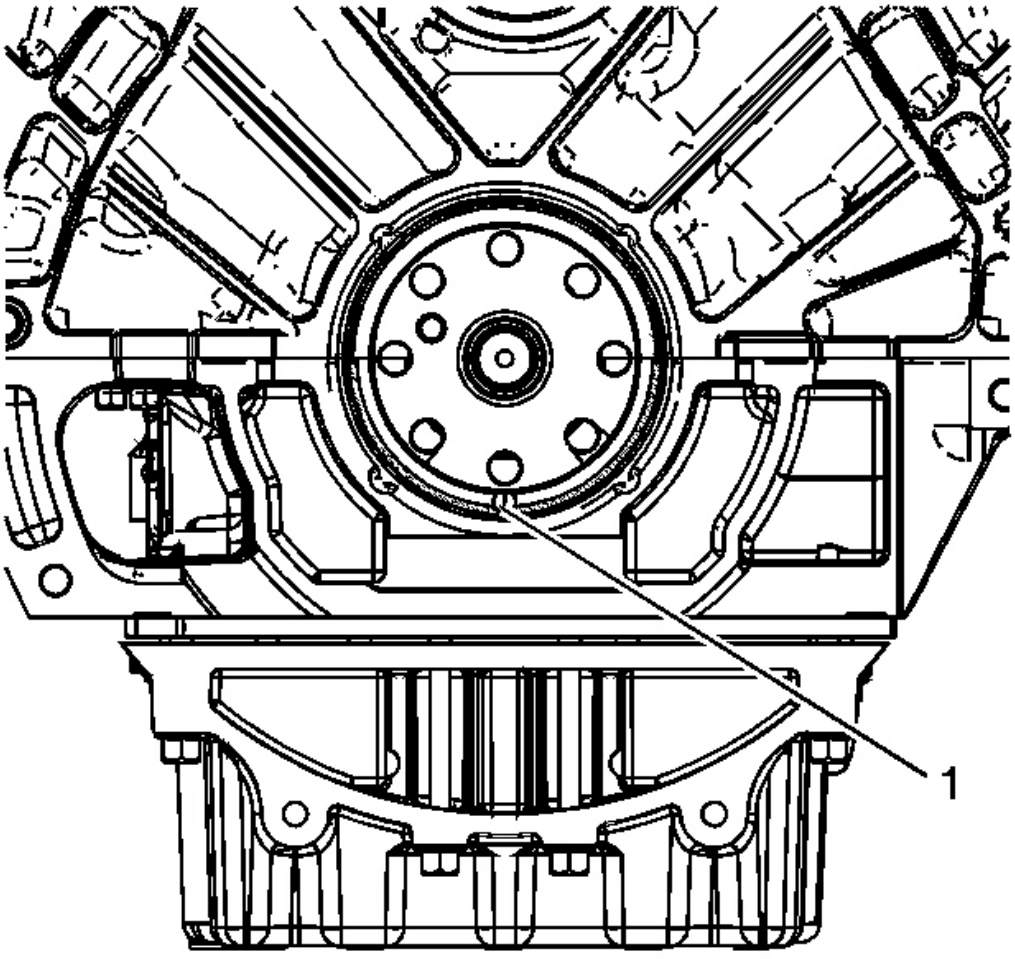


Fig. 502: Inspecting Drain Back Hole
Courtesy of GENERAL MOTORS CORP.

15. Ensure the drain back hole (1) is clear of the sealant.

NOTE: **The cassette seal is installed onto the crankshaft with a press fit that requires over 135 Nm (100 lb ft) of force to remove or install. This high force requires the use of special tools to remove and install the seal. Use of any other tools during removal or installation can lead to damage to the seal or other components. An improperly installed or damaged seal can leak oil and can lead to engine damage. Use of the J 38817-A to install the cassette seal can damage the tool and cause improper seal installation and/or seal damage.**

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IMPORTANT: Beginning with the model year 2006 the flywheel/flexplate crankshaft bolt hole thread was changed from 8 x 1.25 mm to 11 x 1.5 mm. The J 45930-A will service the cassette seals installed on engines from March 1, 1996 to 2006. See Special Tools . If a J 45930 is to be used on a 2006 or later engine the update kit, J 45930-10, must be used to convert the J 45930 to a J 45930-A .

IMPORTANT: Crankshaft rear oil seal and engine flywheel installation requires adequate space for installation. If the engine stand does not allow suitable space to use the J 45930-A install the crankshaft rear oil seal and engine flywheel with the engine properly supported on the floor or on a bench. See Special Tools .

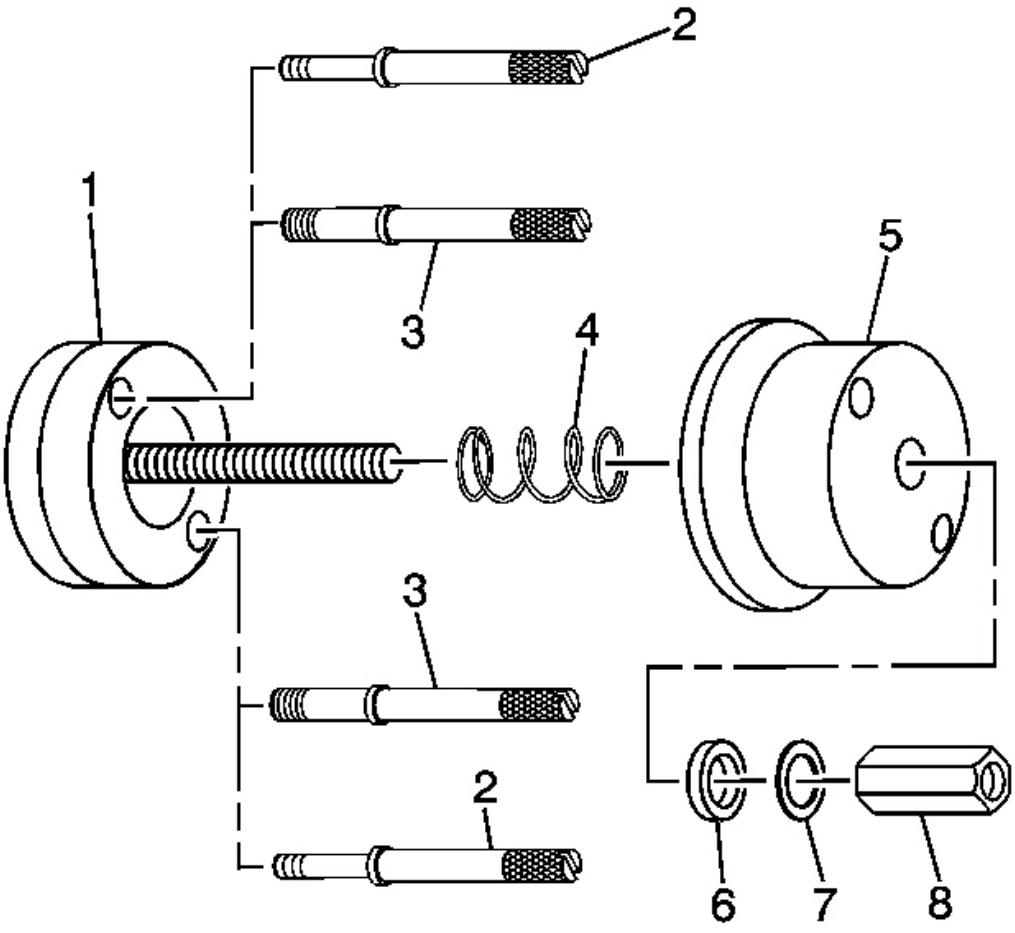


Fig. 503: View Of J 45930-A Tool Set

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Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Northstar engines 2005 and older have an 8 x 1.25 mm flywheel/flexplate crankshaft bolt hole thread. Northstar engines 2006 and later have an 11 x 1.5 mm flywheel/flexplate crankshaft bolt hole thread.

16. Ensure the proper size of bolt (2) 8 mm or (3) 11 mm is being installed in the **J 45930-A** . See **Special Tools** .

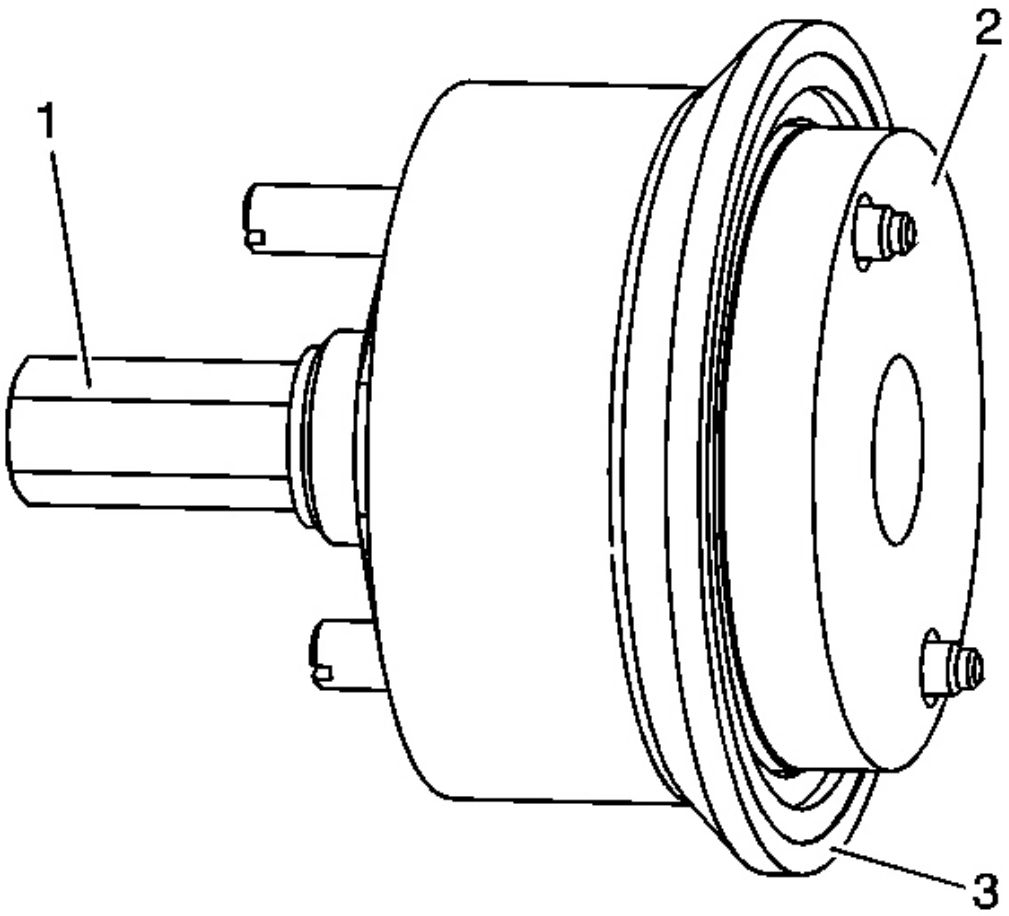


Fig. 504: View Of J 45930-A Crankshaft Rear Oil Seal Installer
Courtesy of GENERAL MOTORS CORP.

17. Turn the center nut (1) of the **J 45930-A** until the center hub (2) protrudes approximately 15 mm (0. See **Special Tools** .591 in) beyond the outer plate (3).

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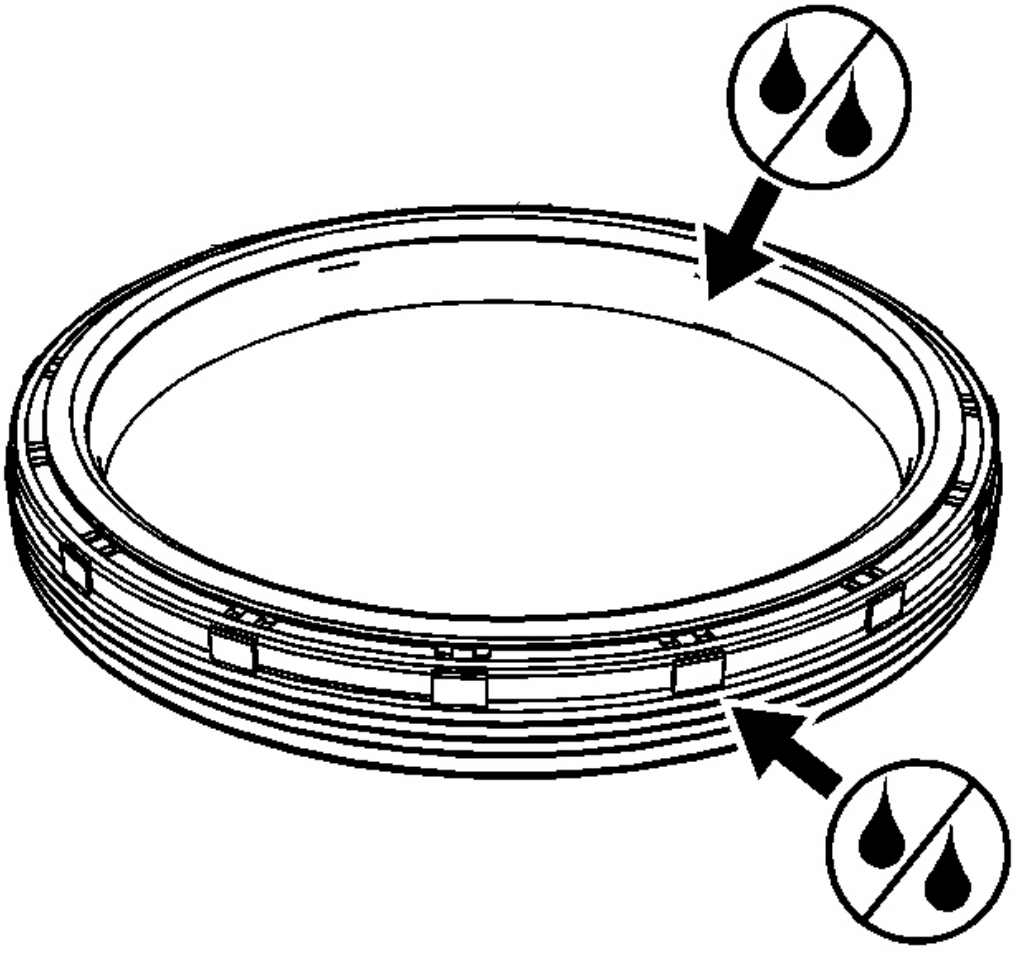


Fig. 505: Identifying Rear Seal Lubrication Points
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT use any lubricant in order to install the crankshaft rear oil seal. Do not use any lubricant on the coating pre-applied to the inner diameter of the crankshaft rear oil seal. The coating is a sealant that must not be contaminated. Do not use any lubricant on the outer diameter of the crankshaft rear oil seal. The sealant applied to the bore of the engine block will not properly bond to a lubricated crankshaft rear oil seal.

18. Do not lubricate any part of the new cassette style crankshaft rear oil seal.

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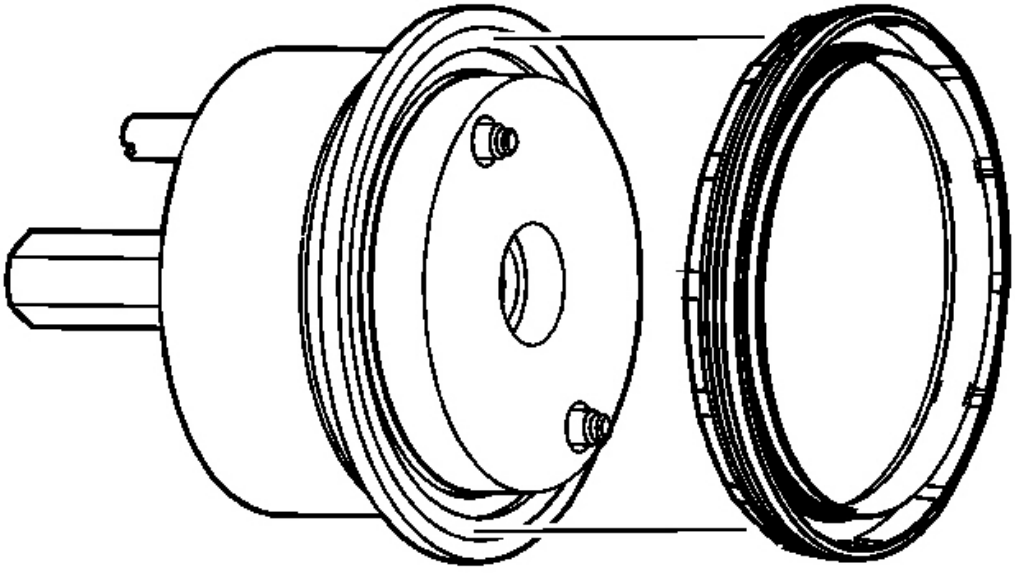


Fig. 506: Positioning Rear Seal Onto Crankshaft Rear Oil Seal Installer
Courtesy of GENERAL MOTORS CORP.

19. Install the new cassette style crankshaft rear oil seal onto the center hub of the **J 45930-A** . See **Special Tools** .

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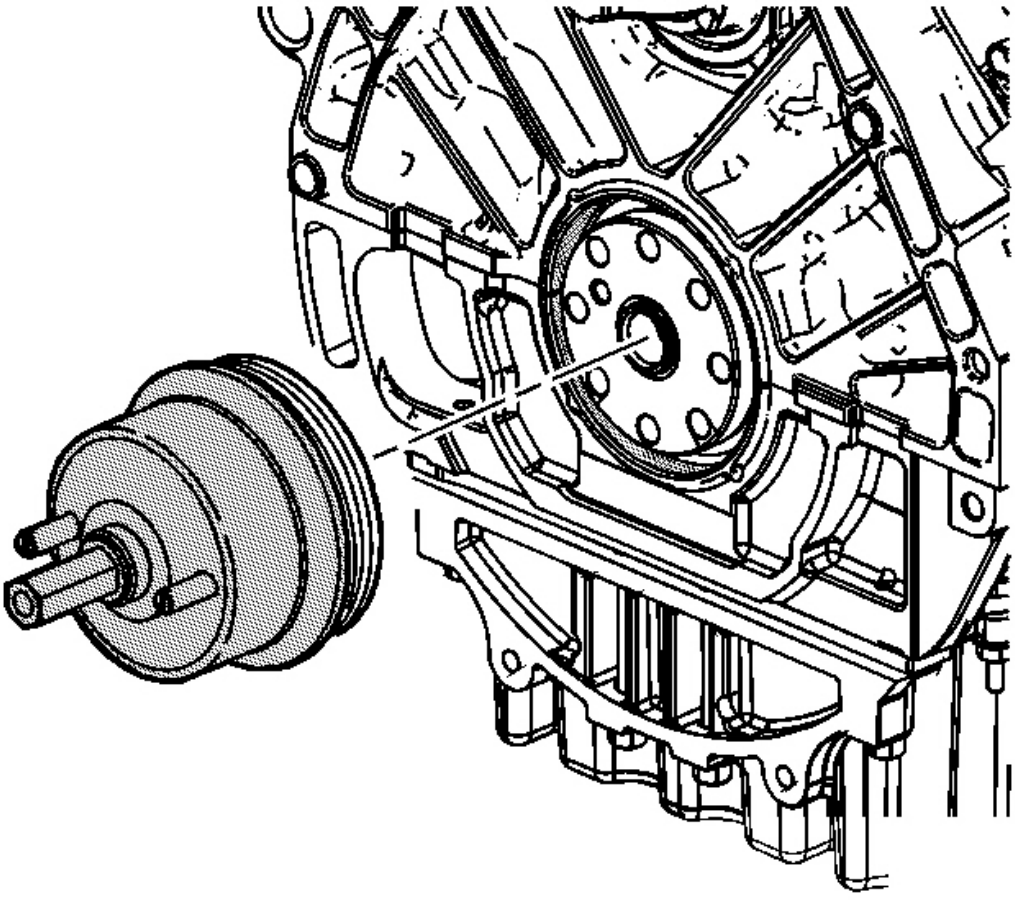


Fig. 507: Identifying J 45930-A Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

20. Thread the two **J 45930-A** mounting bolts into the crankshaft flywheel bolt holes. See **Special Tools** .

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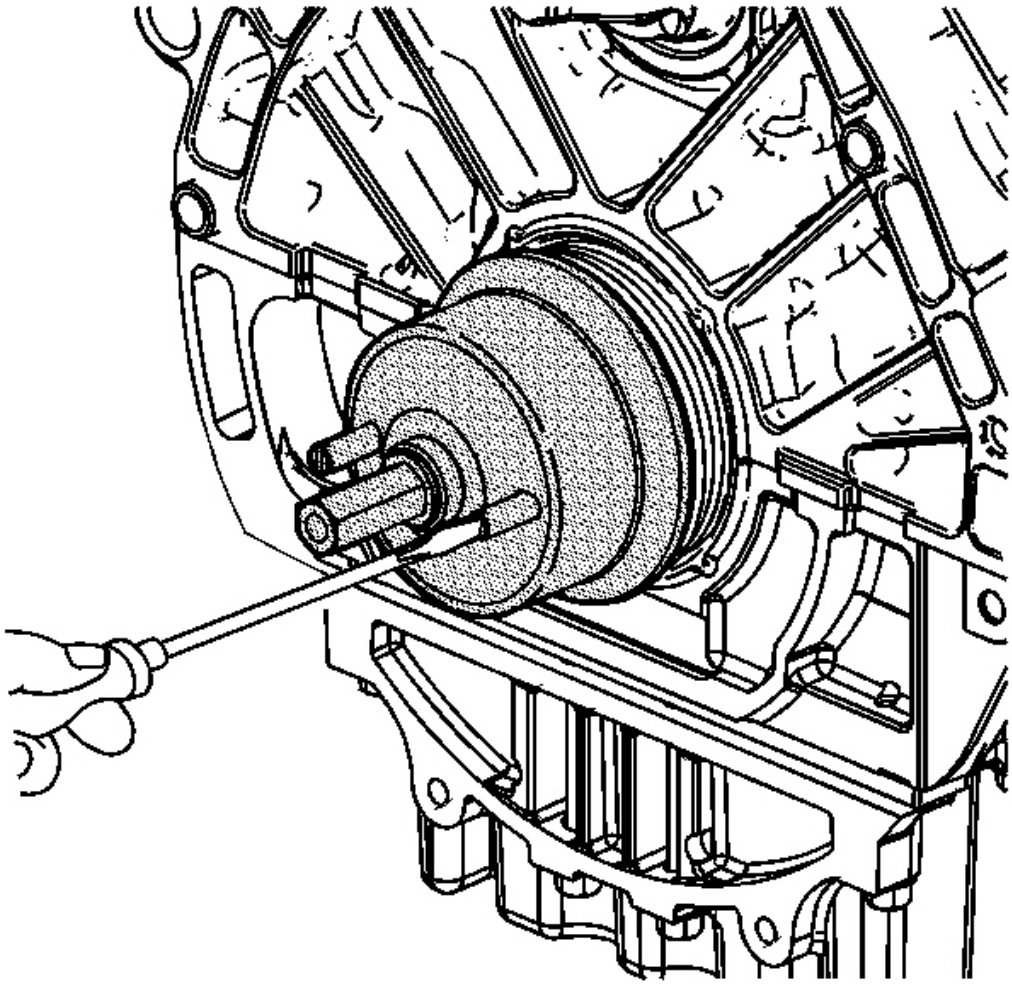


Fig. 508: Mounting J 45930-A To Crankshaft
Courtesy of GENERAL MOTORS CORP.

21. Tighten the two mounting bolts until the **J 45930-A** is firmly mounted on the crankshaft. See **Special Tools** .

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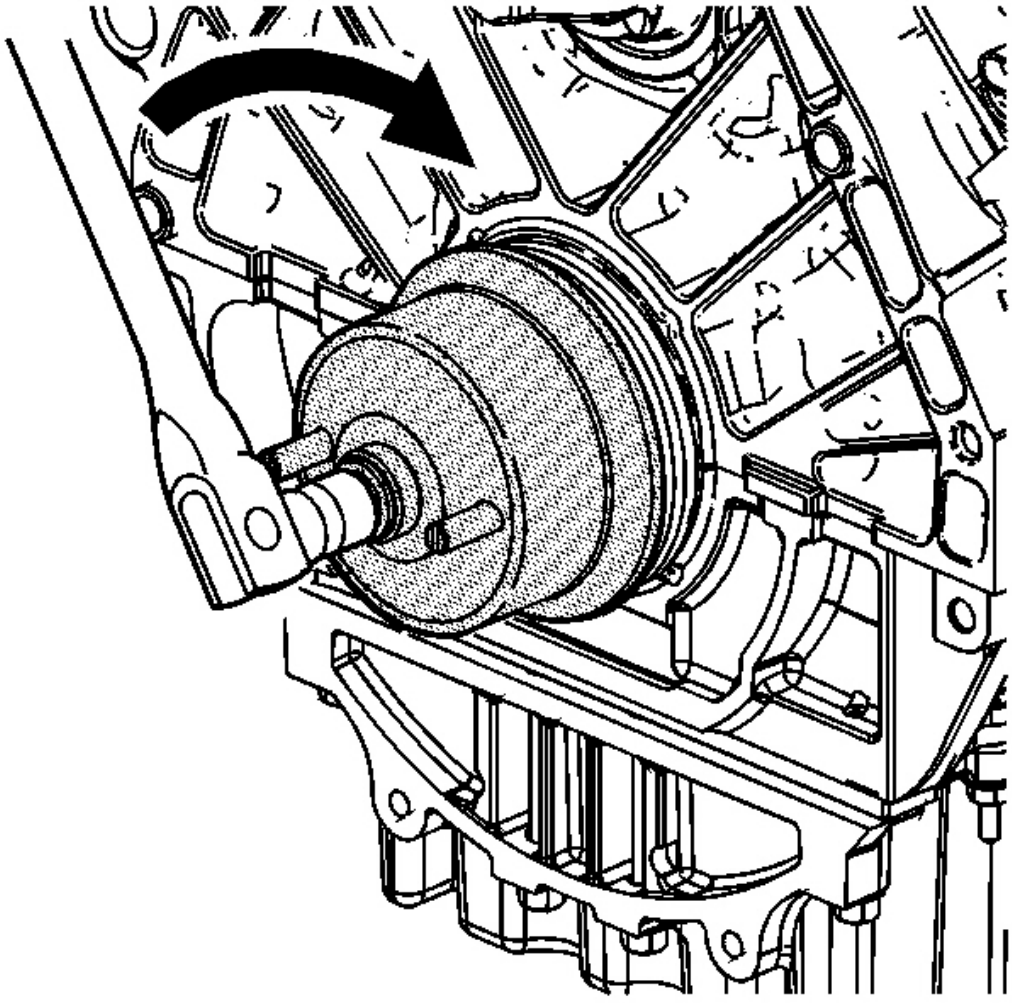


Fig. 509: Installing New Cassette Style Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

22. Install the new cassette style crankshaft rear oil seal by turning the nut of the **J 45930-A** until the drive portion of the **J 45930-A** bottoms against the crankcase. See **Special Tools** .

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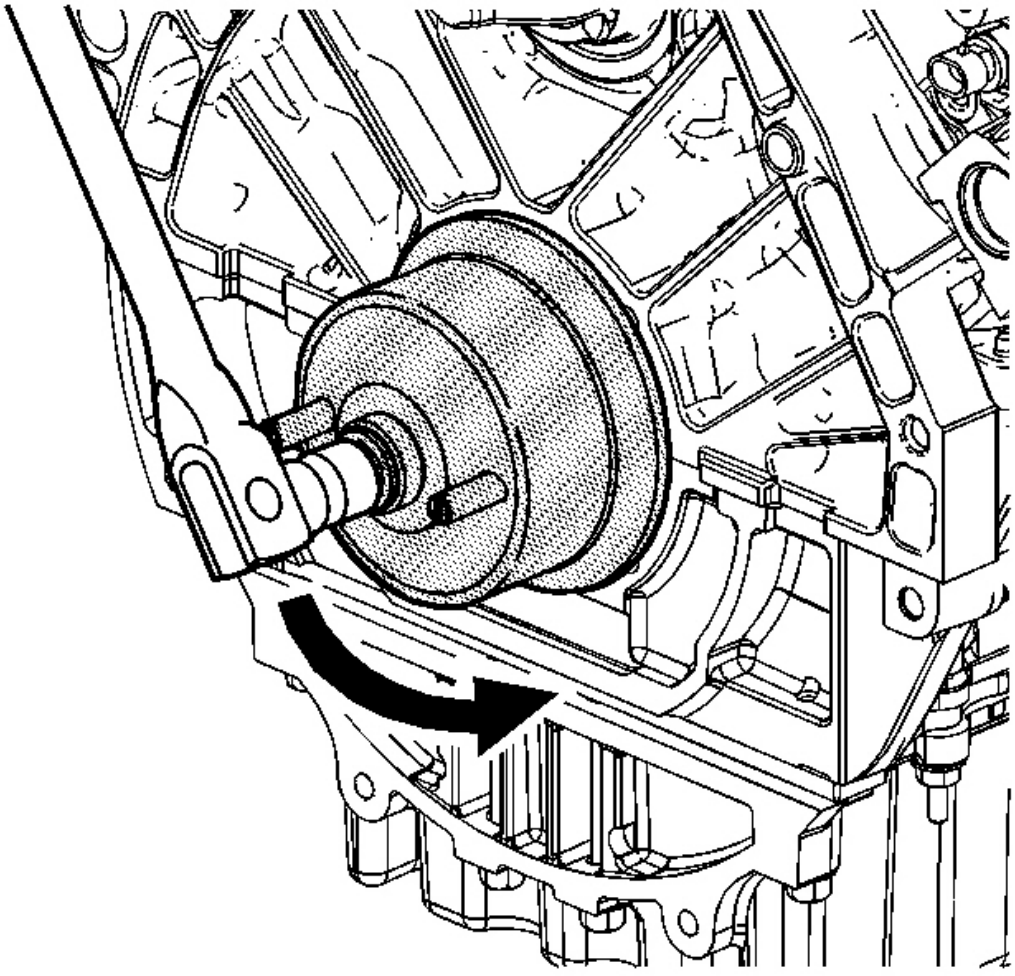


Fig. 510: Loosening Center Nut To Release Pressure On Crankcase
Courtesy of GENERAL MOTORS CORP.

23. Loosen the center nut to release pressure on the crankcase.

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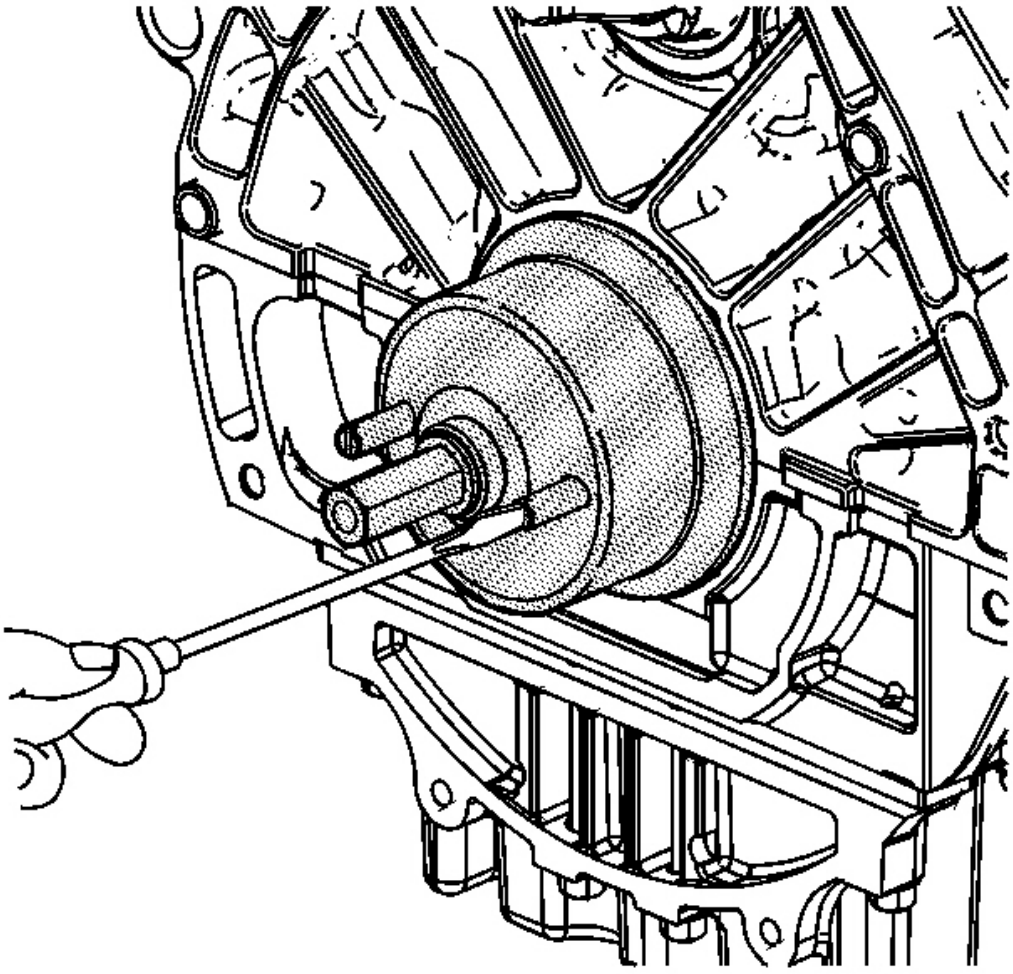


Fig. 511: Loosening Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

24. Loosen the two mounting bolts.

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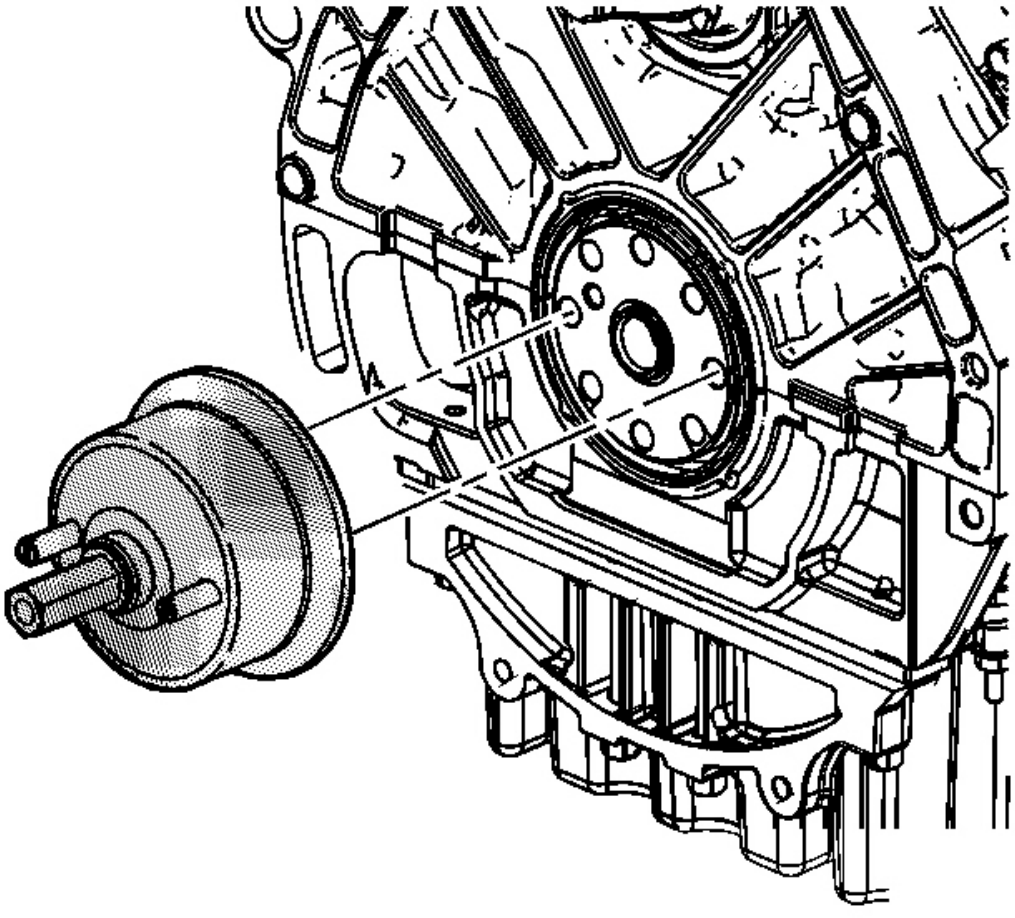


Fig. 512: View Of J 45930-A
Courtesy of GENERAL MOTORS CORP.

25. Remove the **J 45930-A** from the crankshaft. See **Special Tools** .
26. Wipe off any excessive sealant from the block.

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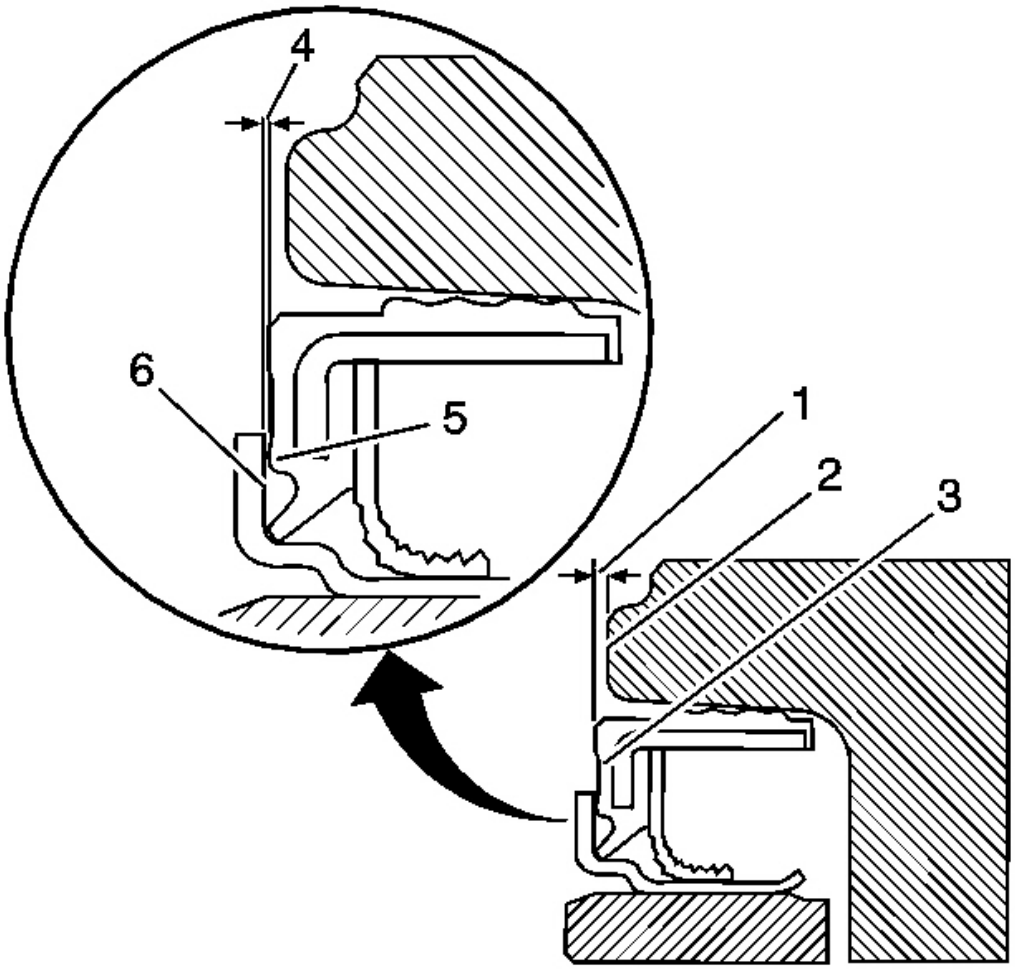


Fig. 513: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

27. Ensure the new cassette style crankshaft rear oil seal is installed properly.
    - The outer surface of the seal (3) should be 0.500-0.800 mm (0.0197-0.0315 in) (1) below the surface of the engine block (2).
    - The inner surface of the sleeve (6) should be 0.400-0.900 mm (0.0158-0.0354 in) (4) below the surface of the outer surface of the seal (5).
    - The installed seal and sleeve need to be parallel to the block by 0.000-0.500 mm (0.000-0.0197 in).
28. Clean all tools to remove any residual sealant.

ENGINE FLYWHEEL INSTALLATION

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TOOLS REQUIRED

- **J 45059** Angle Meter. See **Special Tools** .
- **EN 46326** Flywheel Holding Tool. See **Special Tools** .

INSTALLATION PROCEDURE

1. Apply sealant, GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the engine flywheel bolts.

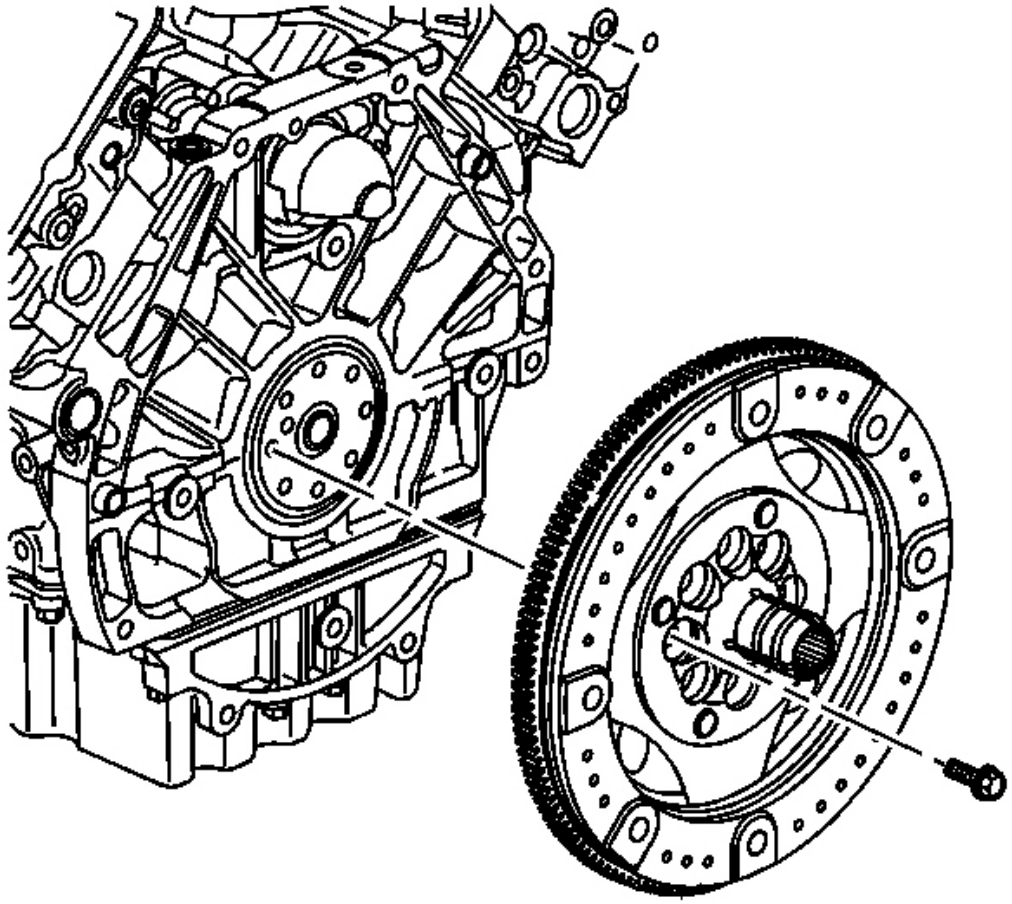


Fig. 514: View Of Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Place the engine flywheel in position on the crankshaft.
3. Slip one bolt into the engine flywheel.

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4. Install the bolt in a location at the top of its rotation allowing the engine flywheel to hang in position.

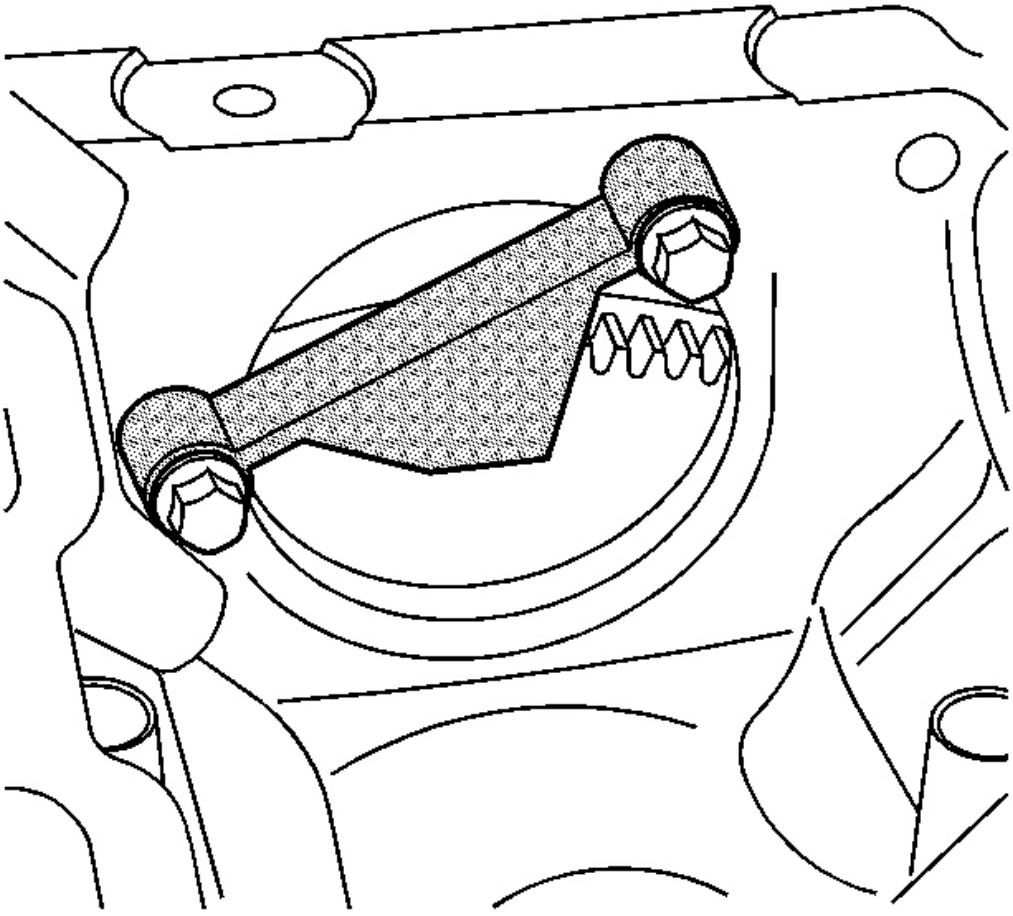


Fig. 515: View Of Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

5. Install the **EN 46326** to the engine block. See **Special Tools** .

NOTE: **Refer to Fastener Notice .**

6. Install the remaining engine flywheel bolts.
   1. First Pass

      Tighten: Tighten the engine flywheel bolts to 30 N.m (22 lb ft).

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2. Final Pass

   Tighten: Tighten the engine flywheel bolts an additional 50 degrees using the **J 45059** . See **Special Tools** .

CRANKSHAFT BALANCER INSTALLATION

TOOLS REQUIRED

- **EN 46326** Flywheel Holding Tool. See **Special Tools** .
- **J 41998-B** Crankshaft Balancer Installer. See **Special Tools** .
- **J 45059** Angle Meter. See **Special Tools** .

INSTALLATION PROCEDURE

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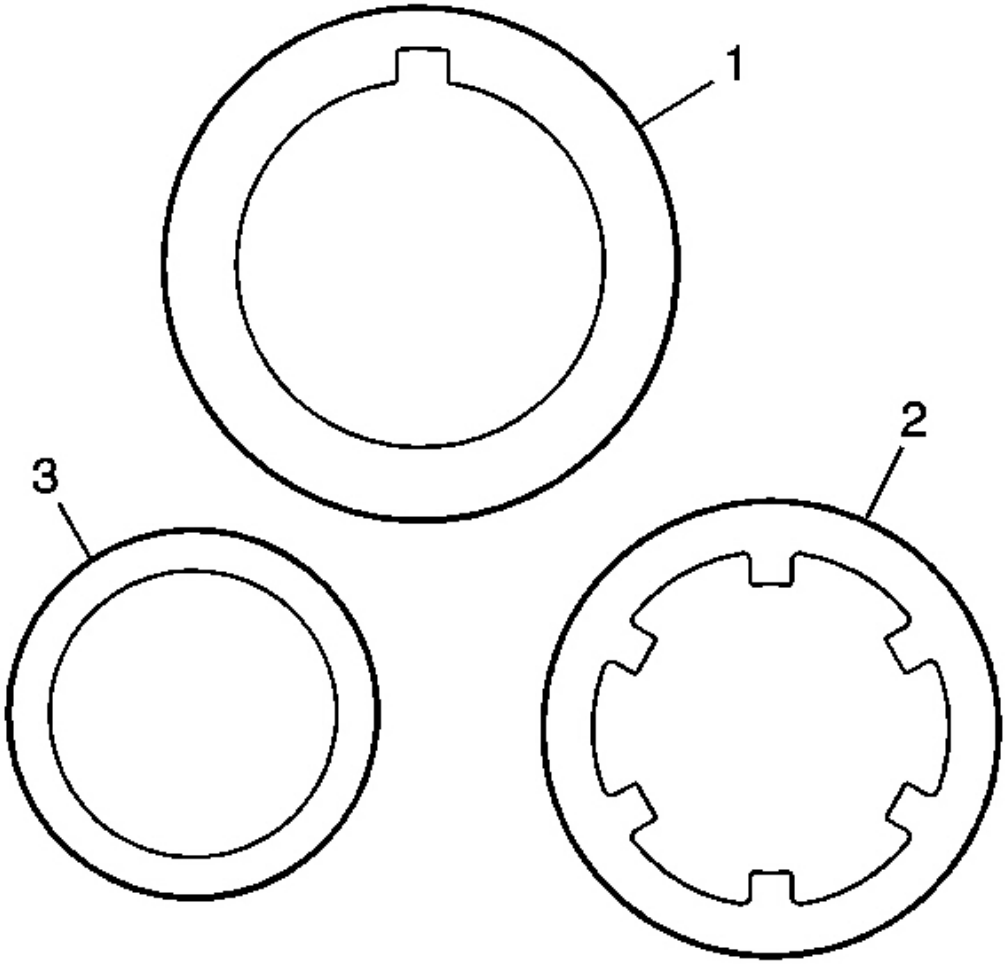


Fig. 516: View Of Friction Washers
Courtesy of GENERAL MOTORS CORP.

1. Ensure the friction washer (3) has been installed prior to installing the crankshaft balancer.

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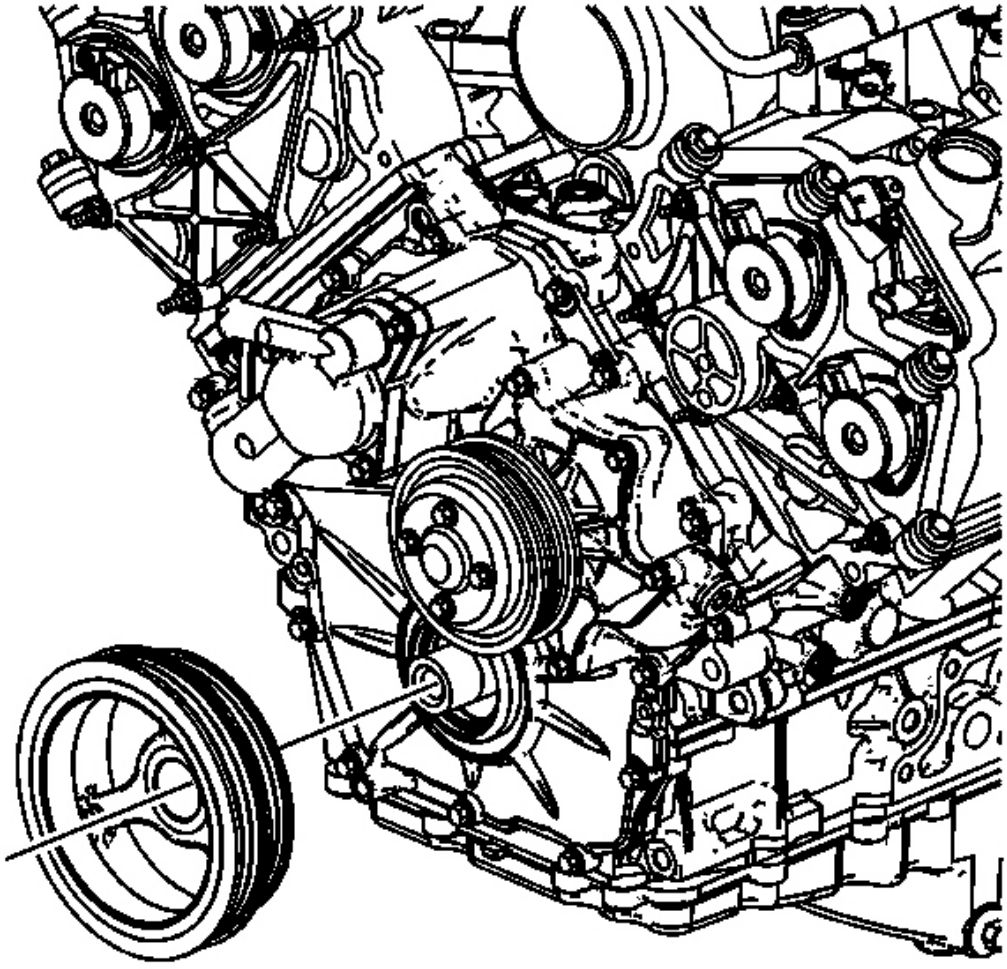


Fig. 517: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

2. Position the crankshaft balancer on the nose of the crankshaft.

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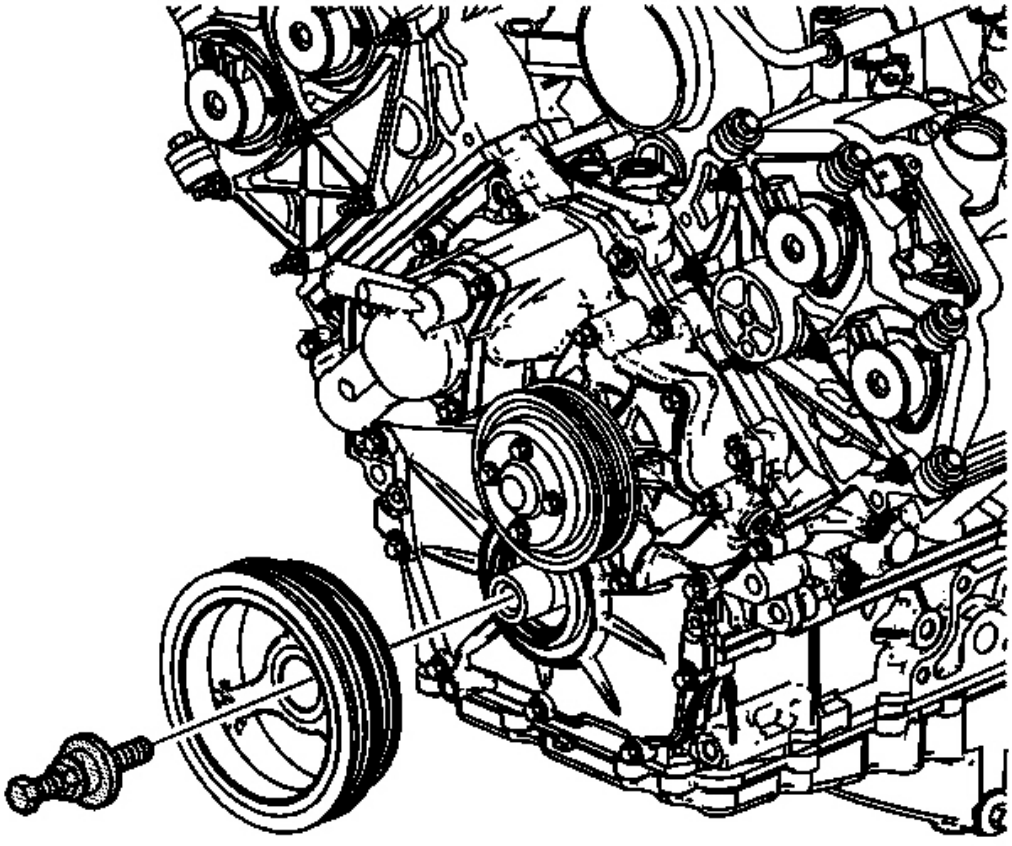


Fig. 518: Pressing Crankshaft Balancer In Place Using J 41998-B
Courtesy of GENERAL MOTORS CORP.

3. Press the crankshaft balancer in place using the **J 41998-B** . See **Special Tools** .

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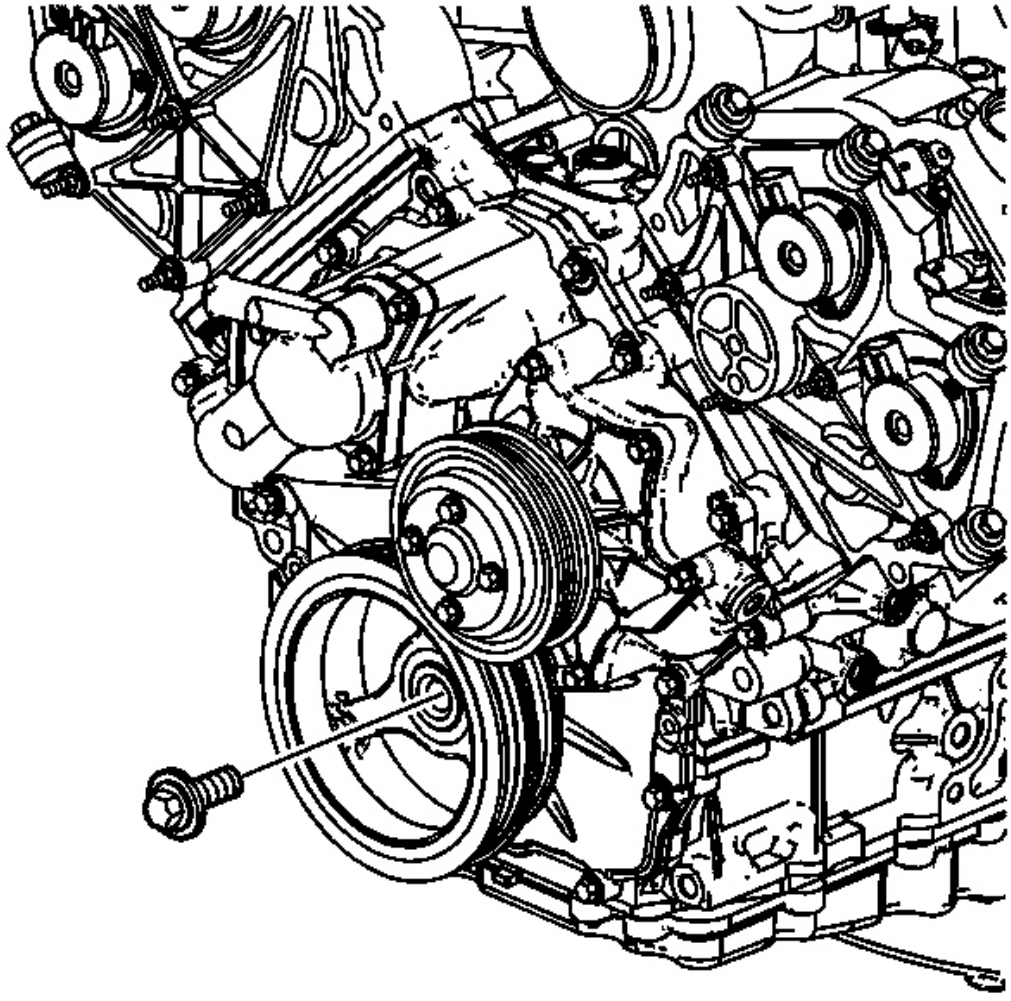


Fig. 519: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

4. Clean the crankshaft balancer bolt threads.
5. Apply engine oil to the crankshaft balancer bolt threads.

NOTE: Refer to Fastener Notice .

6. Install the crankshaft balancer bolt.
    1. First Pass

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Tighten: Tighten the crankshaft balancer bolt to 100 N.m (74 lb ft).

2. Final Pass

   Tighten: Tighten the crankshaft balancer bolt an additional 120 degrees using the **J 45059** . See **Special Tools** .

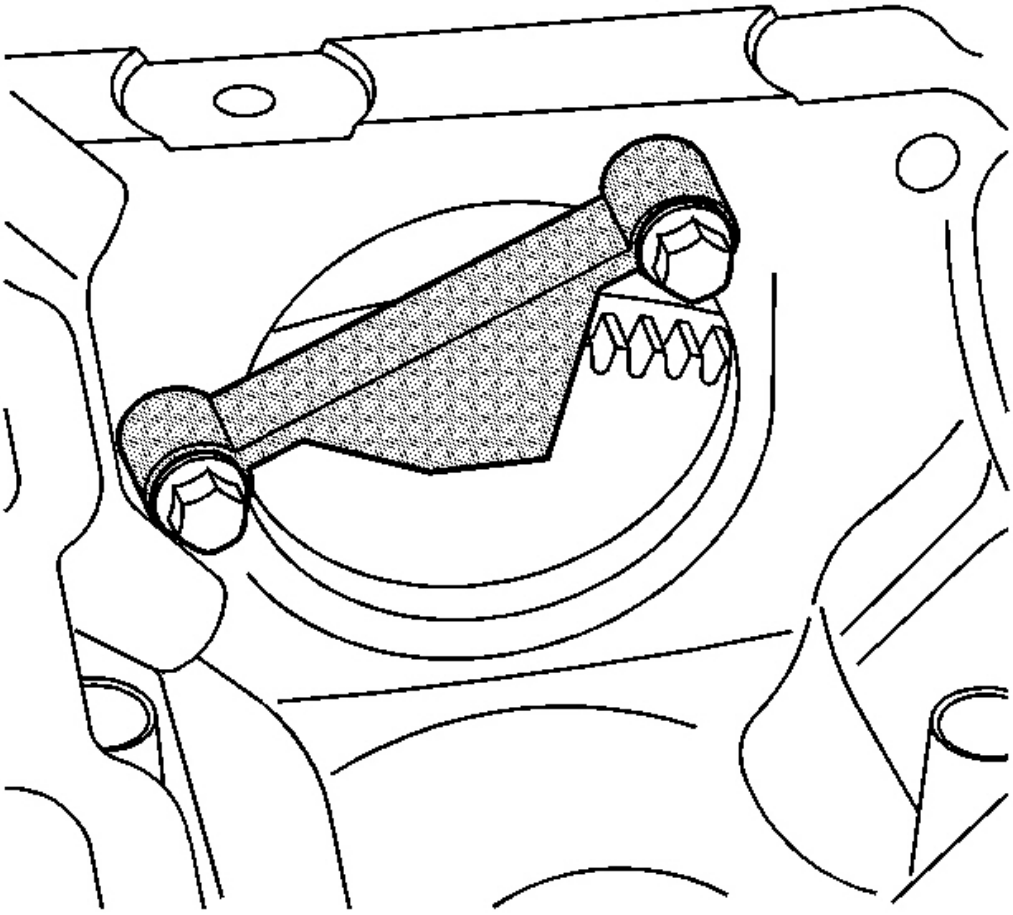


Fig. 520: View Of Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

7. Remove the **EN 46326** from the engine block. See **Special Tools** .

STARTER INSTALLATION

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1. If installing a NEW starter motor, transfer the cables from the old starter motor.
2. Install the positive battery cable to the starter motor stud.

NOTE: **Refer to Fastener Notice .**

3. Install the starter motor stud nut.

   Tighten: Tighten the starter motor stud nut to 9.5 N.m (84 lb in).

4. Install the solenoid wiring harness to the starter solenoid stud.
5. Install the starter solenoid stud nut.

   Tighten: Tighten the starter solenoid stud nut to 3.4 N.m (30 lb in).

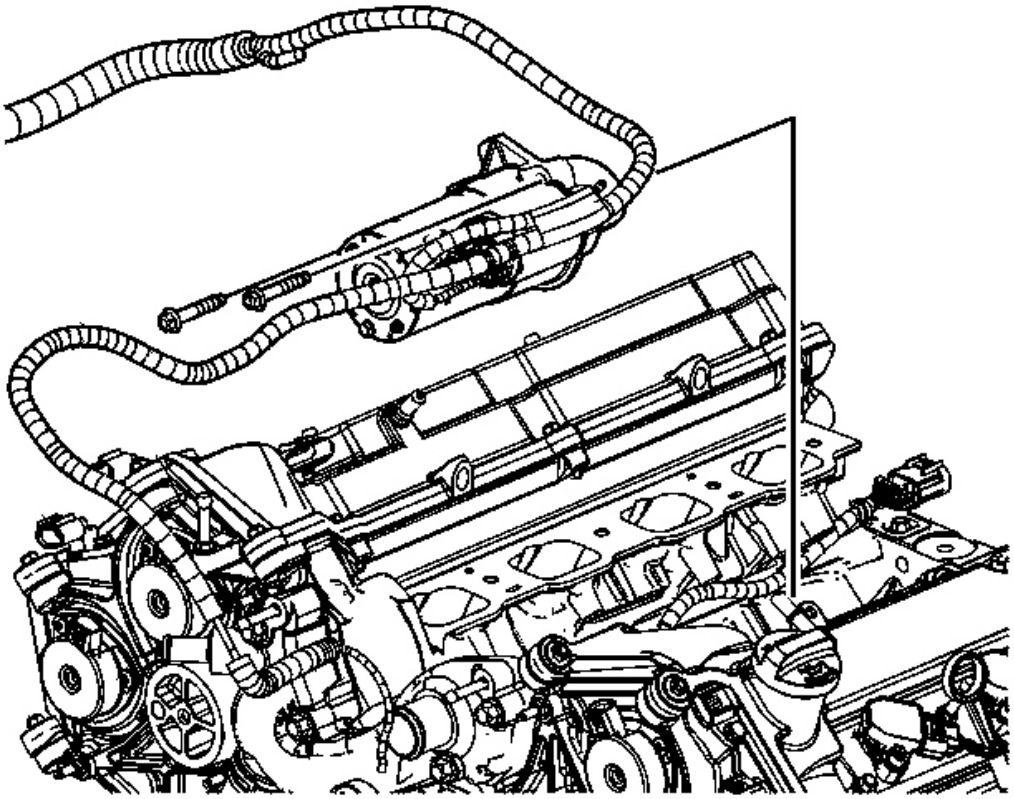


Fig. 521: View Of Starter Motor Bolts
Courtesy of GENERAL MOTORS CORP.

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6. Position the starter motor in position.
7. Install the starter motor bolts.

   Tighten: Tighten the starter motor bolt to 30 N.m (22 lb ft).

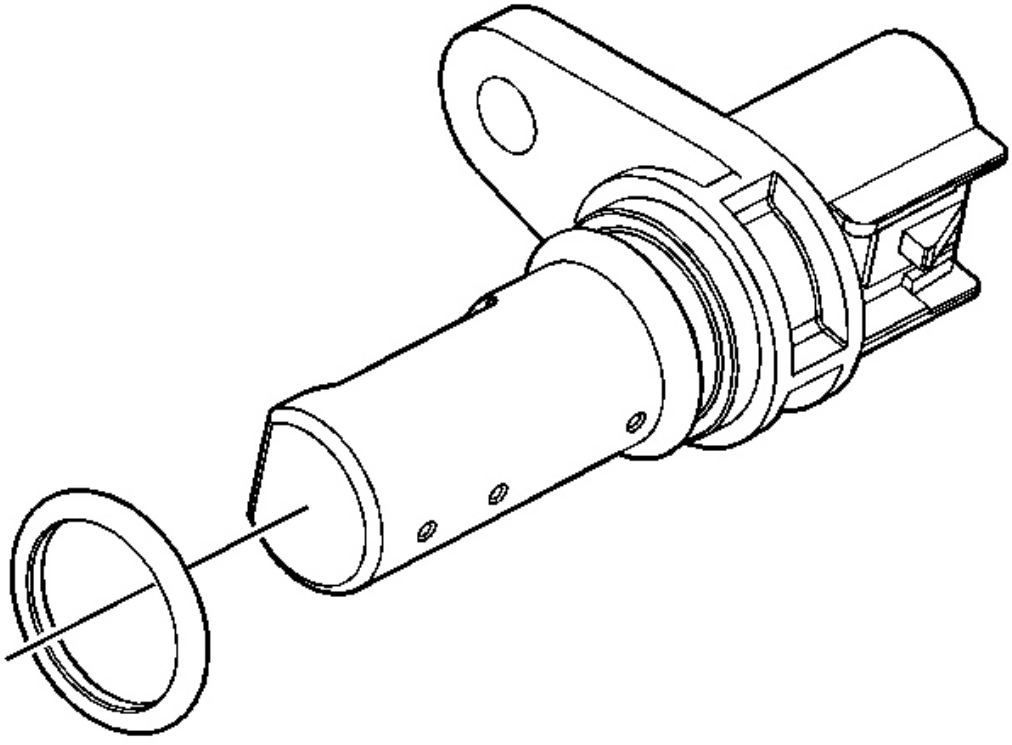


Fig. 522: View Of Crankshaft Position Sensor O-Ring
Courtesy of GENERAL MOTORS CORP.

8. Install a NEW O-ring on the crankshaft position sensor.

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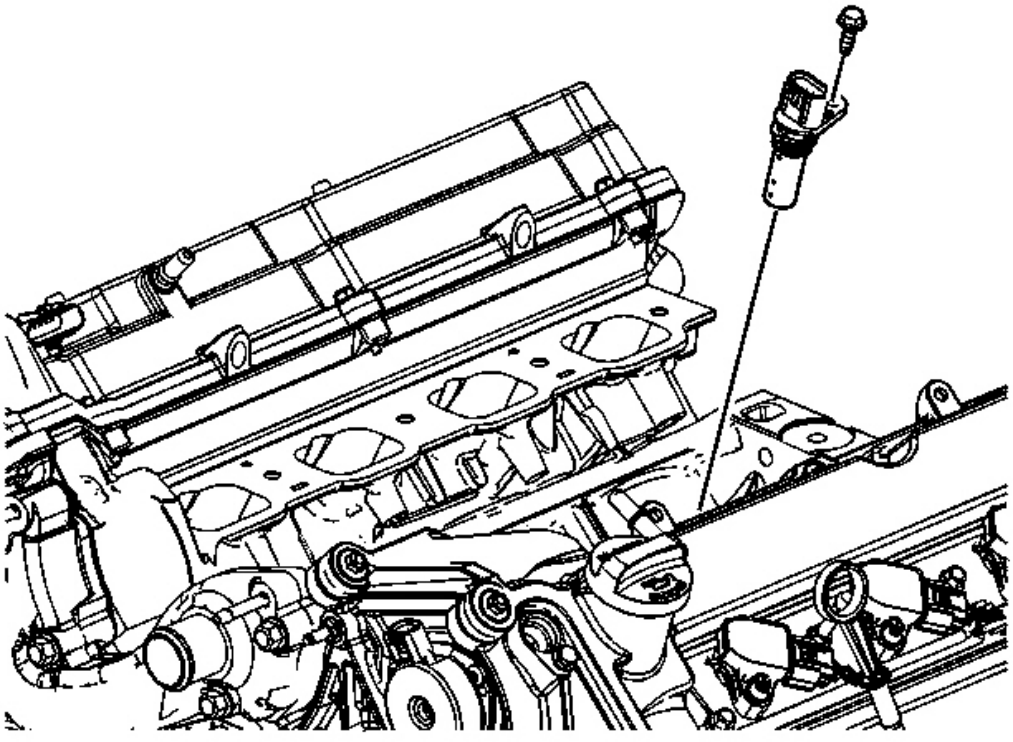


Fig. 523: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

9. Install the crankshaft position sensor.
10. Install the crankshaft position sensor bolt.

Tighten: Tighten the crankshaft position sensor bolt to 10 N.m (89 lb in).

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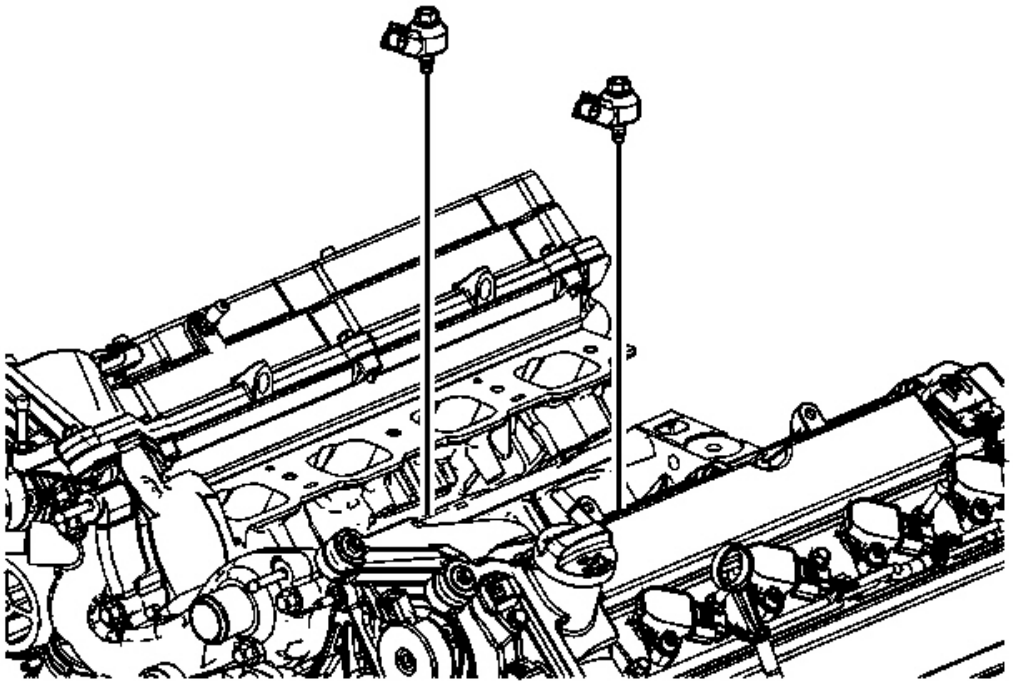


Fig. 524: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

11. Install the knock sensors.
12. Install the knock sensor bolts.

Tighten: Tighten the knock sensor bolts to 10 N.m (89 lb in).

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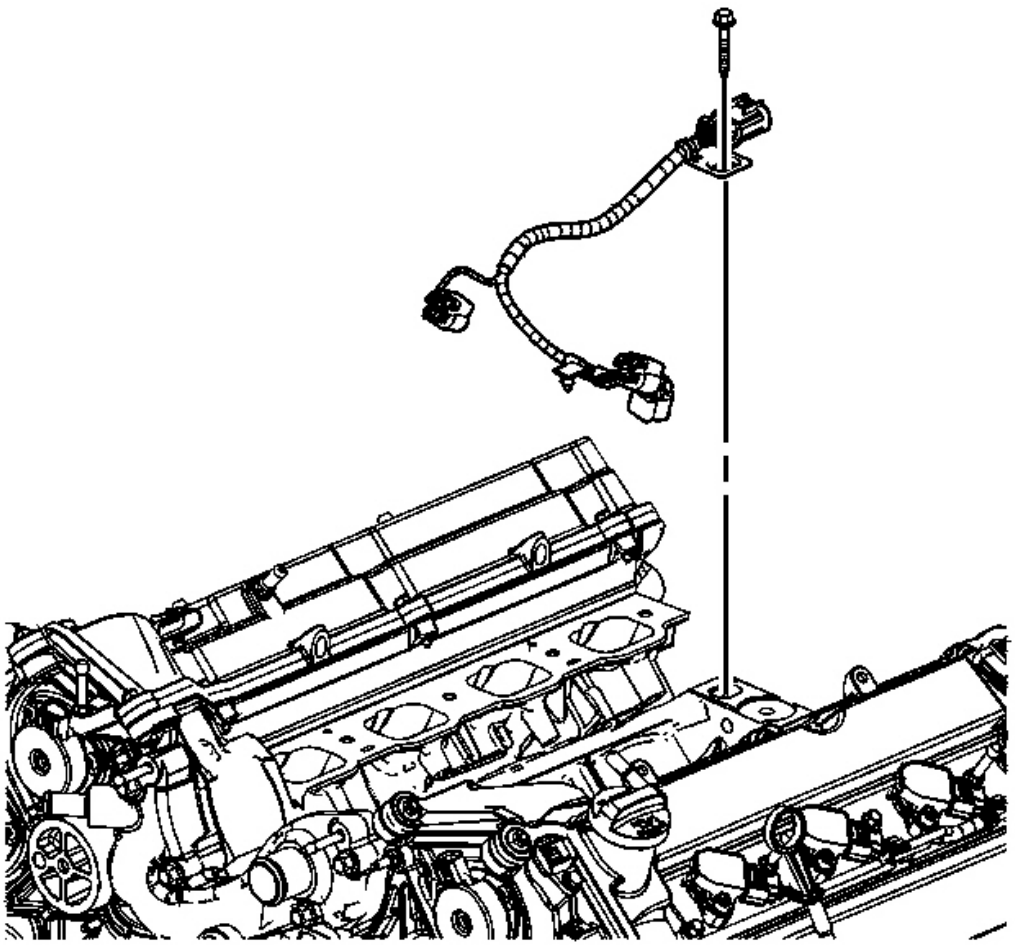


Fig. 525: Identifying Knock And Crankshaft Position Sensor Wiring Harness Bolt
Courtesy of GENERAL MOTORS CORP.

13. Install the knock and crankshaft position sensor wiring harness.
14. Connect the knock and crankshaft position sensor wiring harness brackets to the center, back and front of the block valley.
15. Install the knock and crankshaft position sensor wiring harness bolt.

    Tighten: Tighten the knock and crankshaft position sensor wiring harness bolt to 10 N.m (89 lb in).

16. Connect the knock and crankshaft position sensor wiring harness to the knock sensors and crankshaft position sensor.

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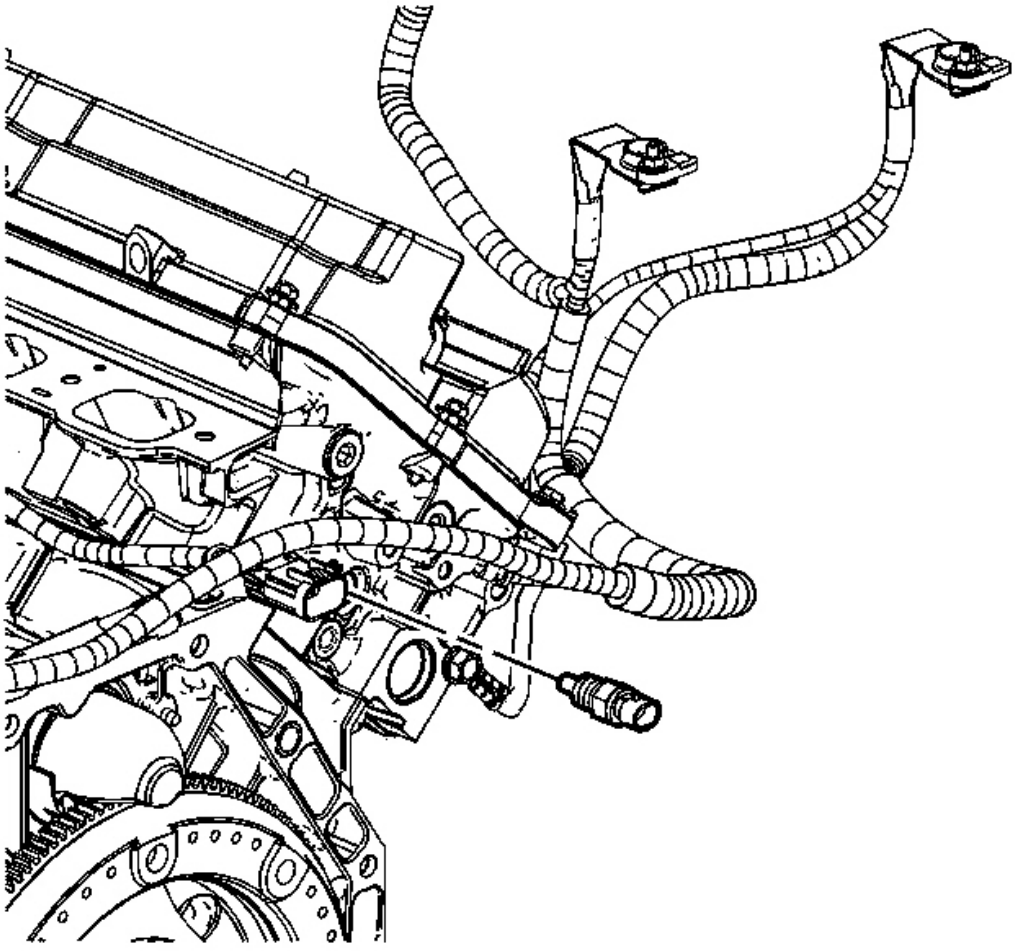


Fig. 526: Locating ECT Sensor
Courtesy of GENERAL MOTORS CORP.

17. Install the ECT sensor to the right cylinder head.

    Tighten: Tighten the ECT sensor to 20 N.m (15 lb ft).

WATER OUTLET HOUSING INSTALLATION

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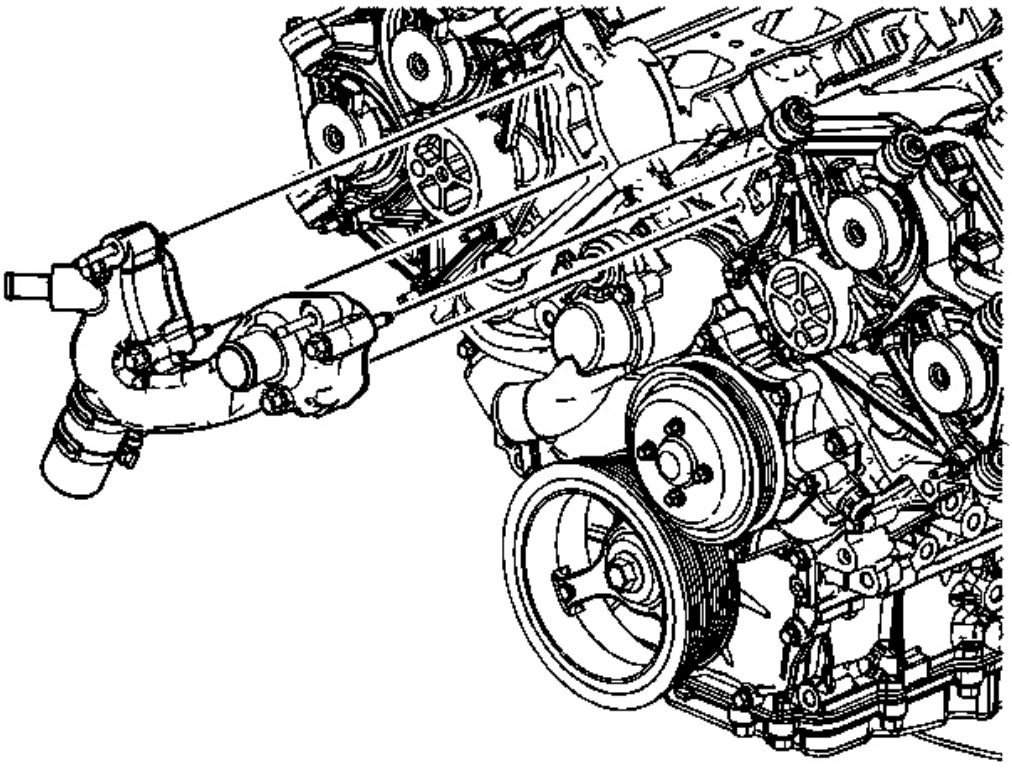


Fig. 527: View Of Water Outlet Housing
Courtesy of GENERAL MOTORS CORP.

1. Place the water outlet housing in place while fitting the bypass hose to the engine front cover.

NOTE: **Refer to Fastener Notice**

2. Install the water outlet housing bolts to the cylinder heads.

Tighten: Tighten the water outlet housing bolts to 25 N.m (18 lb ft).

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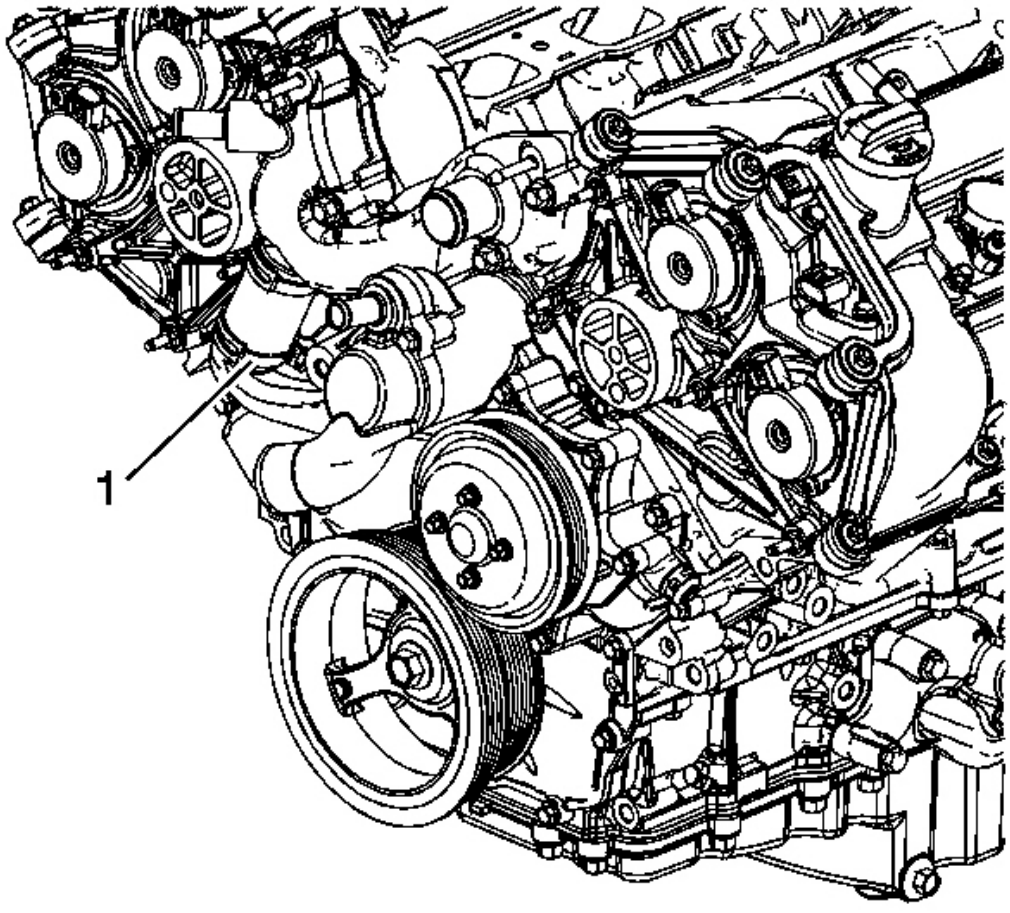


Fig. 528: Identifying Bypass Hose Clamp
Courtesy of GENERAL MOTORS CORP.

3. Reposition the clamp (1) on the bypass hose. Ensure the clamp release mechanism of the clamps are oriented towards the engine front cover and away from the drive belt path.

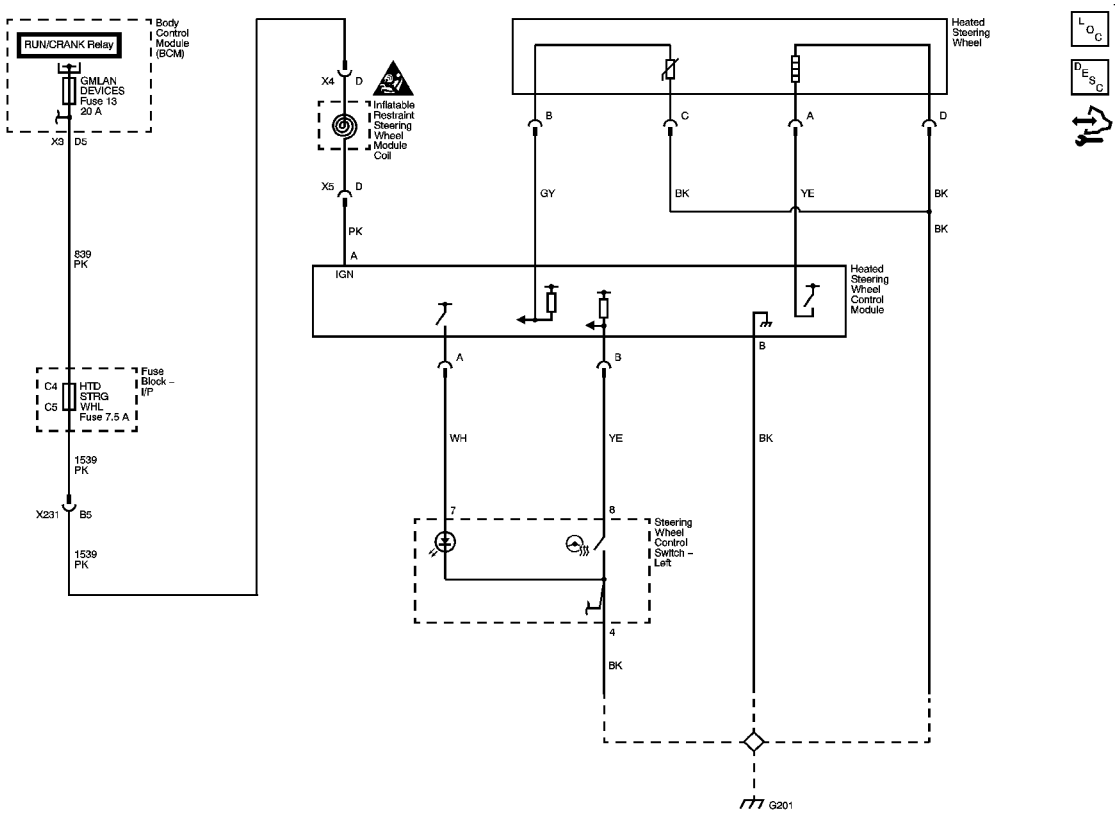
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Fastener Tightening Specifications

Application	Specification	
	Metric	English
Column Support Bracket Bolts	24 N·m	17 lb ft
Dampener Screws	1.5 N·m	13 lb in
Intermediate Shaft to the Steering Column Pinch Bolt	48 N·m	35 lb ft
Intermediate Shaft to the Steering Gear Pinch Bolt	34 N·m	25 lb ft
Intermediate Shaft to the Steering Gear Pinch Bolt Shield Screw	3.5 N·m	31 lb in
Steering Column Bottom Bracket Screw	3 N·m	27 lb in
Steering Column Support Screws	18N·m	13 lb ft
Steering Column Trim Cover Screws Lower	3 N·m	27 lb in
Steering Column Trim Cover Screw Upper	1 N·m	9 lb in
Steering Wheel Control Harness Retainer And Screw	2.3 N·m	20 lb in
Steering Wheel Control Switch Assembly Screws	2.3 N·m	20 lb in
Steering Wheel and Column Lower To Upper Intermediate Shaft Retaining Bolts	48 N·m	35 lb ft
Steering Wheel Nut	41 N·m	30 lb ft
Telescope Bracket Fasteners	8 N·m	71 lb in
Tilt Actuator Assembly Retainer Screws	9 N·m	80 lb in
Turn Signal Multifunction Switch Screws	3.4 N·m	30 lb in
Telescope Actuator Screws LH (Nearest Steering Wheel)	1.4 N·m	12 lb in
Telescope Actuator Screws RH (Nearest Engine)	5 N·m	44 lb in

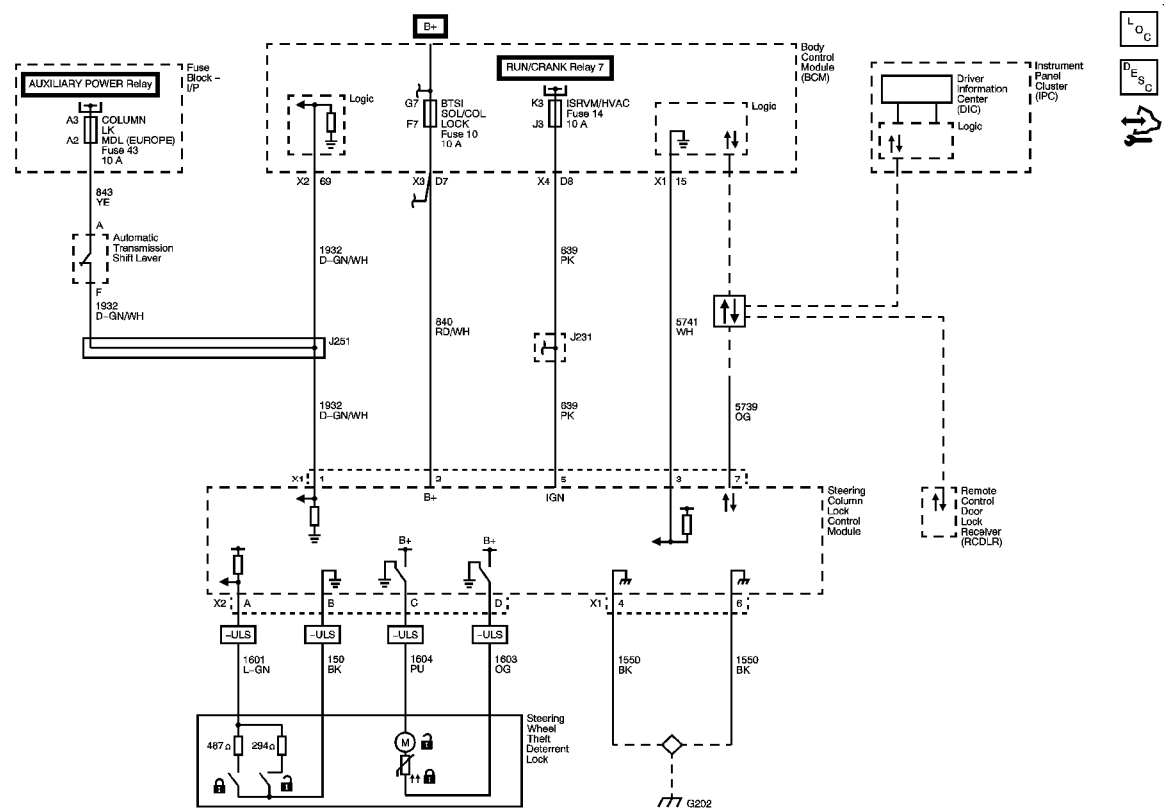
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Steering Wheel Schematics



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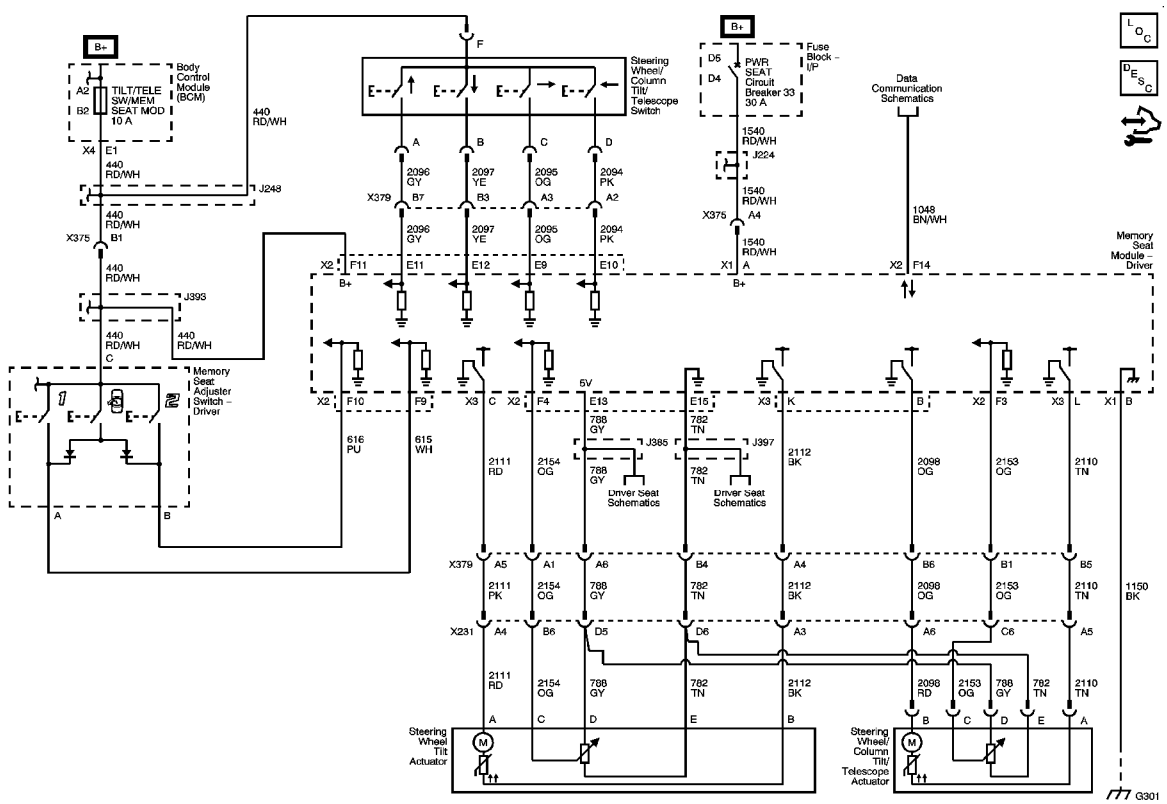
Column Lock Schematics



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Tilt/Telescoping Steering Column Schematics

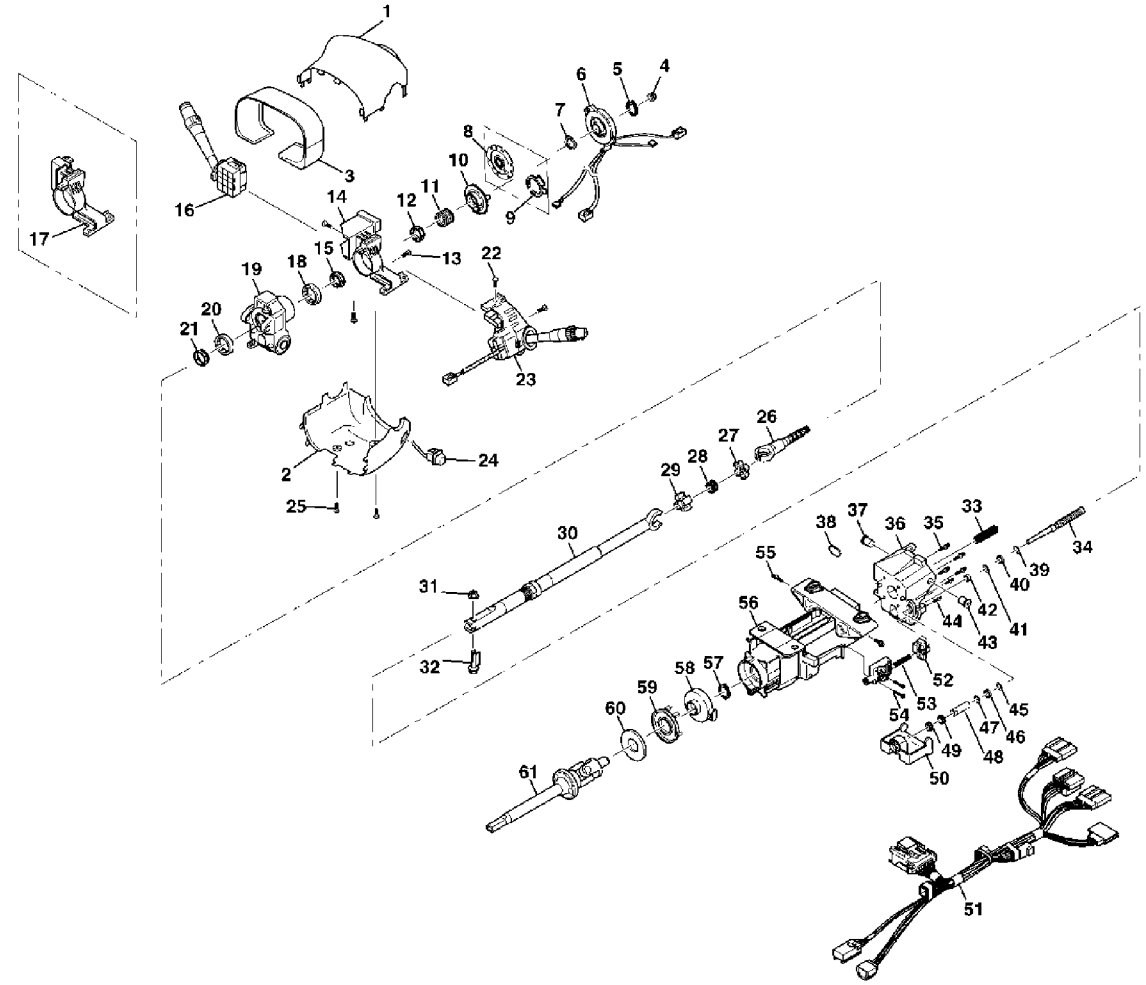
Tilt/Telescoping Steering Column



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Steering Column Disassembled View



(1) Upper Trim Cover (Kit)
(2) Lower Trim Cover (Kit)
(3) Steering Column Closeout Shroud
(4) Flanged Prevailing Torque Nut
(5) Retaining Ring
(6) SIR Coil
(7) Wave Washer
(8) Shaft Lock Shield Assembly (Export)
(9) Cam Orientation Plate
(10) Turn Signal Cancel Cam Assembly
(11) Upper Bearing Spring
(12) Upper Bearing Inner Race Seat

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(13) Pan Head Tapping Screw
(14) Switch Mounting Bracket
(15) Inner Race
(16) Washer Wiper Switch Assembly
(17) Switch Mounting Bracket
(18) Bearing Assembly
(19) Steering Column Tilt Head Assembly
(20) Bearing Assembly
(21) Inner Race
(22) Pan Head Tapping Screw
(23) Turn Signal and Multifunction Switch Assembly
(24) Power TNT Toggle Switch Assembly
(25) Pan Head Tapping Screws
(26) Race and Upper Shaft Assembly
(27) Centering Sphere (Kit)
(28) Joint Preload Spring (Kit)
(29) Centering Sphere (Kit)
(30) Lower Steering Shaft Assembly
(31) Pinch Bolt
(32) Bolt and Retainer Assembly
(33) Tilt Spring
(34) Lead Screw
(35) TORX Head Screw
(36) Tilt Support Assembly
(37) Pivot Pin
(38) Tilt Bumper
(39) Thrust Washer
(40) Thrust Bearing
(41) Thrust Washer
(42) Bearing Roller
(43) Pivot Pin
(44) TORX Head Screw
(45) Thrust Washer
(46) Thrust Bearing
(47) Thrust Washer
(48) Tilt Dampener Spacer
(49) Tilt Dampener Seal
(50) Lower Shield Assembly
(51) Steering Column Wiring Assembly
(52) Jacket Screw LH Telescoping Nut
(53) Jacket Screw Telescoping Actuator Assembly
(54) Pan Head Tapping Screw
(55) Pan Head Tapping Screw
(56) Telescoping Jacket Assembly
(57) Retaining Ring

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(58) Steering Wheel Position Sensor
(59) Sensor Retainer
(60) Steering Shaft Seal
(61) Intermediate Steering Shaft Assembly

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Intermediate Steering Shaft Replacement

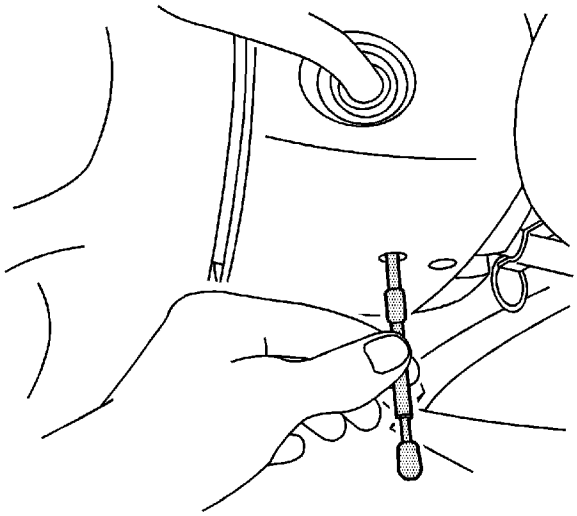
Tools Required

J 42640 Steering Column Lock Pin

Removal Procedure

1. Turn the steering wheel far enough to the left to gain access to the upper to lower intermediate shaft bolts.

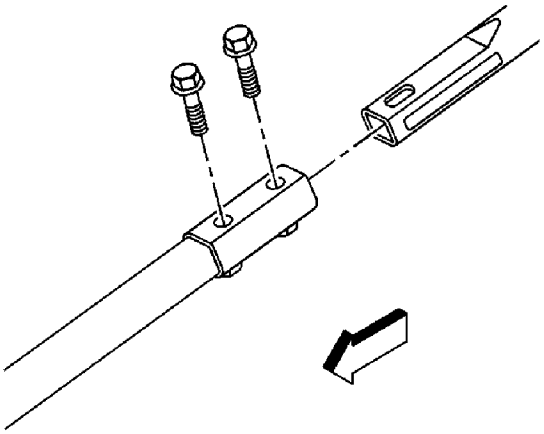
   Notice: The wheels of the vehicle must be straight ahead and the steering column in the LOCK position before disconnecting the steering column or intermediate shaft from the steering gear. Failure to do so will cause the SIR coil assembly to become uncentered, which may cause damage to the coil assembly.



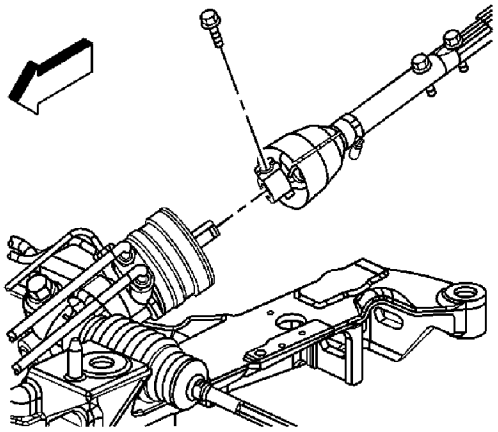


2. Insert J 42640 into the steering column access hole in order to lock the steering column. This will maintain the correct orientation.

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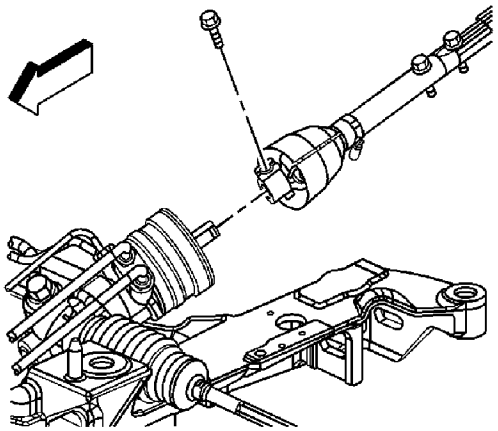


3. Remove the upper to lower intermediate shaft bolts.
4. Remove the lower coupling shield.



5. Remove the lower coupling pinch bolt.
6. Remove the lower coupling from the steering gear.
7. Slide the lower intermediate shaft from the upper intermediate shaft.
8. Remove the lower intermediate shaft from the vehicle.

Installation Procedure

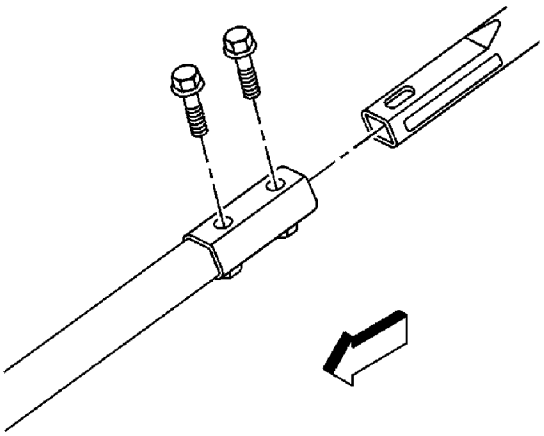


1. Slide the lower intermediate shaft over the upper intermediate shaft.
2. Connect the lower intermediate shaft coupler to the steering gear.

Notice: Refer to Fastener Notice in the Preface section.

3. Install the lower coupling pinch bolt into the lower coupling.

Tighten
Tighten the bolt to 34 N·m (25 lb ft).



4. Install the lower to upper intermediate shafts retaining bolts.

Tighten
Tighten the bolts to 48 N·m (35 lb ft).

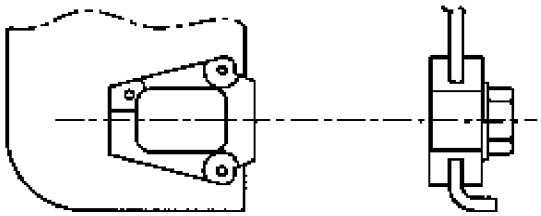
5. Install the lower steering coupling shield.

Tighten
Tighten the lower steering coupling shield screw to 3.5 N·m (31 lb in).

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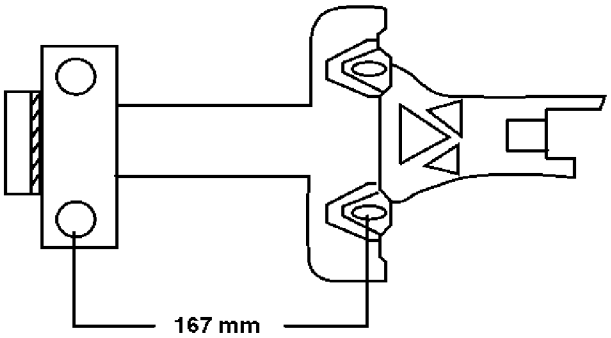
Steering Column Accident Damage Inspection

Inspection Procedure

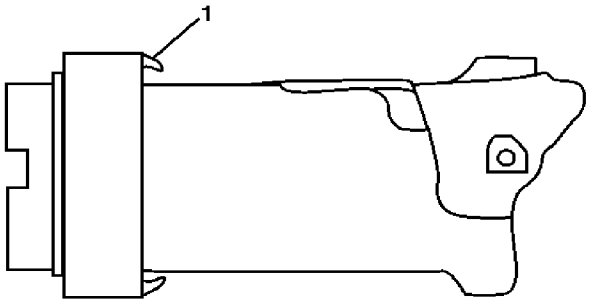


1. Vehicles involved in accidents involving the following conditions may also have a damaged or misaligned steering column:
   - Frame damage
   - Major body or sheet metal damage
   - Where the steering column has been impacted
   - Where supplemental inflatable restraint systems deployed
2. Inspect the capsules on the steering column bracket assembly. All capsules must be securely seated in the bracket slots and checked for any loose conditions when pushed or pulled by hand.
3. Observe how the bracket is attached to the jacket assembly.
   - If the capsules are not securely seated and the bracket is bolted to the jacket assembly, replace only the bracket.
   - If the capsules are not securely seated and the bracket is welded to the jacket assembly, replace only the jacket assembly.

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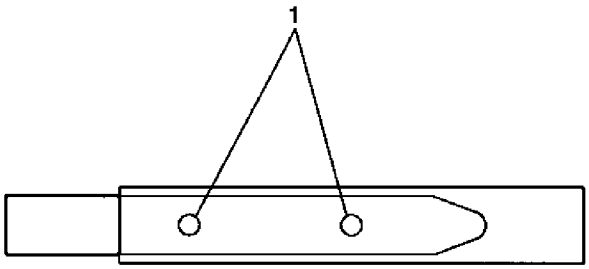


4. Inspect for jacket assembly collapse by measuring the distance as shown in the graphic. Replace the jacket assembly if the measured dimensions are not within specifications.



5. Inspect for tab (1) breakage on the bearing and adapter assembly.

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6. Visually inspect the steering shaft for sheared injected plastic (1). If the steering shaft shows sheared plastic, replace the steering shaft.
7. Any frame damage that could cause a bent steering shaft must have the steering shaft runout checked. Using a dial indicator at the lower end of the steering shaft, rotate the steering wheel. The runout must not exceed 1.60 mm (0.06 in).

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Steering Column Trim Cover Replacement

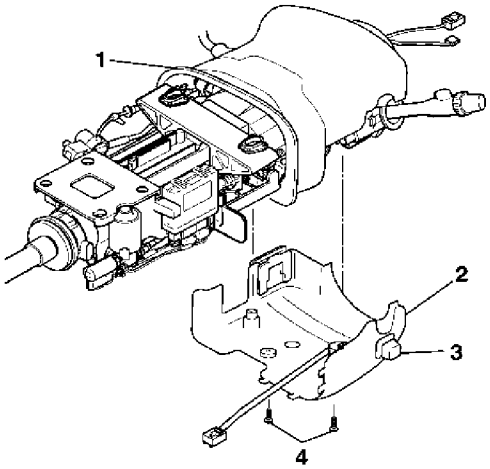
Removal Procedure

Caution: Refer to SIR Caution in the Preface section.

1. Disable the SIR system. Refer to SIR Disabling and Enabling .

Caution: Refer to Battery Disconnect Caution in the Preface section.

2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection .
3. Remove the steering wheel. Refer to Steering Wheel Replacement .
4. Remove the knee bolster. Refer to Driver Knee Bolster Panel Replacement .



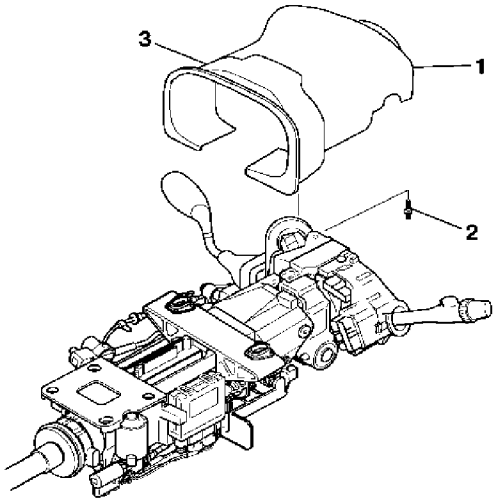


5. Remove the retaining screws (4) from the lower steering column trim cover.
6. Disconnect the closeout shroud from the lower trim cover.

Notice: Avoid damaging the steering column electronic lock harness by gently removing the plugs installed in the I/P beam. Do NOT twist, pull, bend, cut, or incorrectly route the harness. Damage to the harness will require replacement of the entire electronic lock.

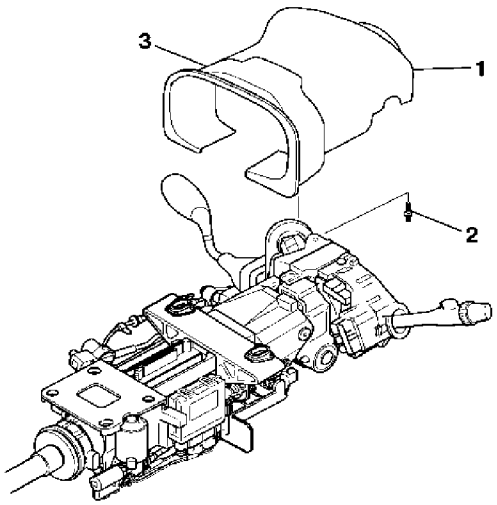
7. Disconnect the electrical connector for the power tilt and telescopic switch.
8. Remove the electrical connector for the telescopic switch from the lower trim cover.

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9. Remove the retaining screw (2) from the upper steering column trim cover (1).
10. Remove the upper trim cover.
11. Remove the closeout shroud from the upper trim cover.

Installation Procedure

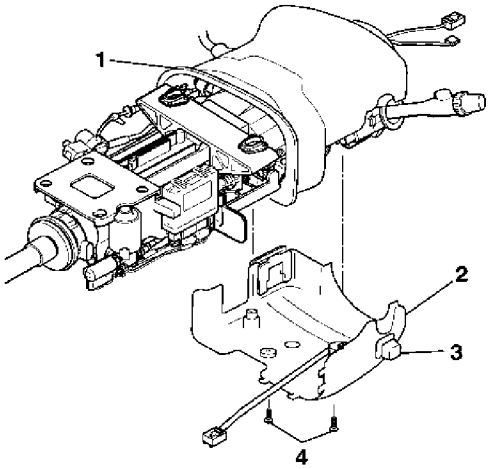


1. Install the upper steering column trim cover (1) to the closeout shroud (3).
2. Install the upper trim cover (1) to the steering column.

   Notice: Refer to Fastener Notice in the Preface section.

3. Install the retaining screw to the upper trim cover.

Tighten
Tighten the screw to 1 N·m (9 lb in).



4. Install the lower steering column trim cover and ensure that the tabs (2) on the lower trim cover engage with the tabs on the upper trim cover. Snap the covers together.
5. Connect the lower trim cover to the closeout shroud.
6. Install the retaining screws to the lower trim cover.

Tighten
Tighten the screws to 3 N·m (27 lb in).

Notice: Avoid damaging the steering column electronic lock harness by gently removing the plugs installed in the I/P beam. Do NOT twist, pull, bend, cut, or incorrectly route the harness. Damage to the harness will require replacement of the entire electronic lock.

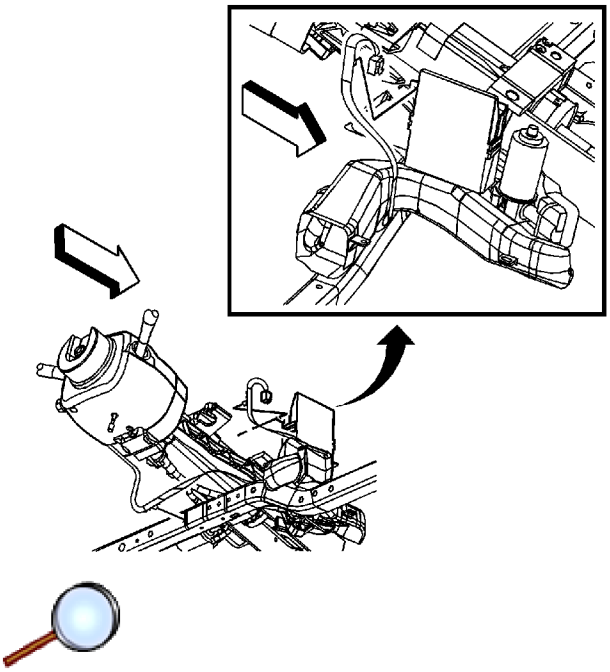
7. Install the knee bolster. Refer to Driver Knee Bolster Panel Replacement .
8. Install the steering wheel. Refer to Steering Wheel Replacement .
9. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection .
10. Enable the SIR system. Refer to SIR Disabling and Enabling .

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Steering Column Lock Control Module Replacement

Removal Procedure

Caution: Refer to SIR Caution in the Preface section.

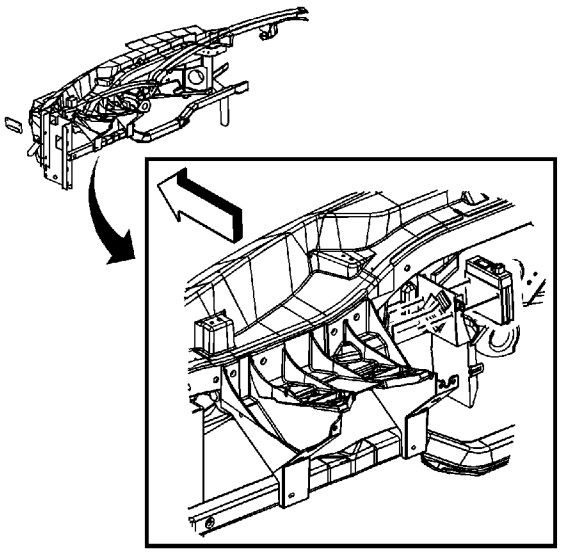


1. Disable the SIR system. Refer to SIR Disabling and Enabling.

Notice: Avoid damaging the steering column electronic lock harness by gently removing the plugs installed in the I/P beam. Do NOT twist, pull, bend, cut, or incorrectly route the harness. Damage to the harness will require replacement of the entire electronic lock.

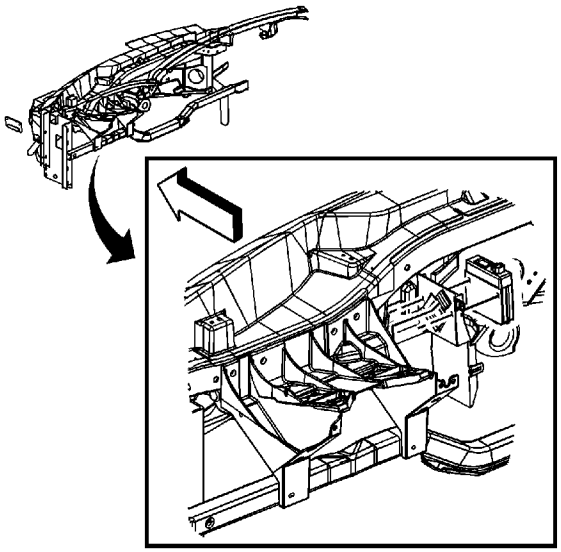
2. Remove the instrument panel (I/P) carrier. Refer to Instrument Panel Carrier Replacement.
3. Disconnect the electrical connectors at the lock module.

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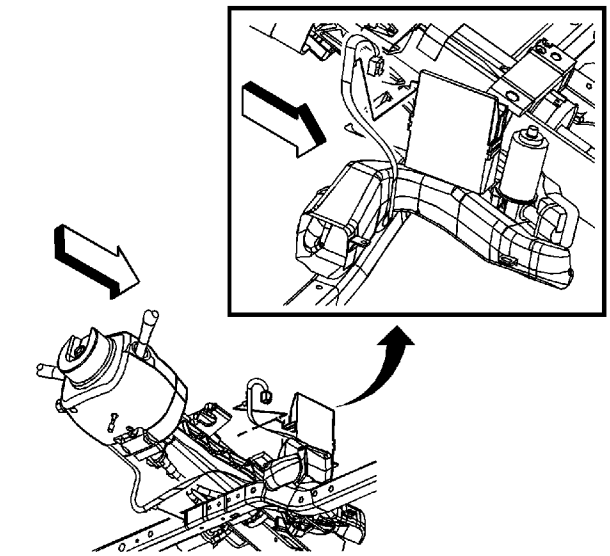


4. Remove the lock module by pulling the module up to release the retaining clips and sliding the module upward.

Installation Procedure



1. Install the control module to the retaining bracket on the steering column.
2. Connect the electrical connector to the lock module.



3. Install the I/P carrier. Refer to Instrument Panel Carrier Replacement.
4. Enable the SIR system. Refer to SIR Disabling and Enabling.
5. Program the lock control module. Refer to Control Module References for programming and setup information.

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Telescoping Steering Column Calibration

Tilt/Telescoping Soft Stops

After replacement of the driver position module (DPM), it is necessary to program the tilt/telescoping soft stops. Each soft stop is a programmable end of travel that is set approximately 1.3 cm (0.5 in) from the mechanical end of travel. The steering column has a soft stop set at each end of the telescoping in/out and tilt up/down movement. The system uses soft stops to prevent wear on the system by ensuring that the steering column movement stops before it reaches its mechanical end of travel in any direction. The soft stops are initially programmed at the factory. The stop positions may be reprogrammed, which is necessary any time the DPM, the tilt actuator or telescope actuators replaced, as described in the following procedure.

Tilt/Telescoping Soft Stop Programming Procedure

1. Turn ON the ignition, with the engine OFF.
2. Connect a scan tool to the vehicle.
3. Select Vehicle Control Systems.
4. Select Computer/Integrating Systems.
5. Select Module Replacement/Setup.
6. Select DPM.
7. Select Column Calibration.
8. Follow the scan tool on-screen instructions.

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Control Module Setup (SCLCM Setup)

Important:

- When replacing a steering column lock control module (SCLCM) with a GM SPO Replacement Part, insure the procedure to setup a new SCLCM is performed.
- When replacing a SCLCM with a GM SPO Replacement Part, the new SCLCM will learn the incoming fuel continue password of the remote control door lock receiver (RCDLR) immediately upon the next ignition switch from OFF to CRANK.

Set Up Steering Column Lock Control Module

1. Turn ON the ignition, with the engine OFF.
2. Connect a scan tool to the vehicle.
3. With a scan tool, select Vehicle Control Systems.
4. Select Computer/Integrating Systems.
5. Select Module Setup.
6. Select Steering Column Lock Module, or SCLM (Export Only).
7. Select SCLM Setup.
8. Follow the scan tool on-screen instructions.

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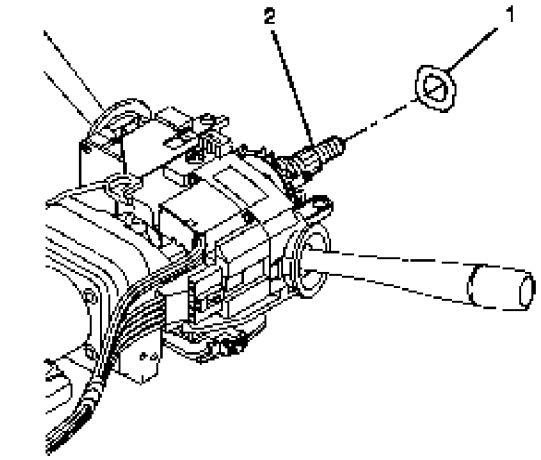
Turn Signal Cancel Cam and Steering Shaft Upper Bearing Spring Replacement

Tools Required

- J 23653-SIR Steering Column Lock Plate Compressor
- J 42137 Steering Column Lock Plate Compressor Adapter

Removal Procedure

Caution: Refer to SIR Caution in the Preface section.

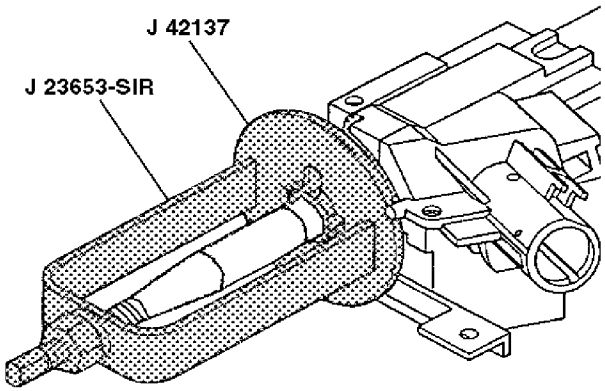


1. Disable the SIR system. Refer to SIR Disabling and Enabling.

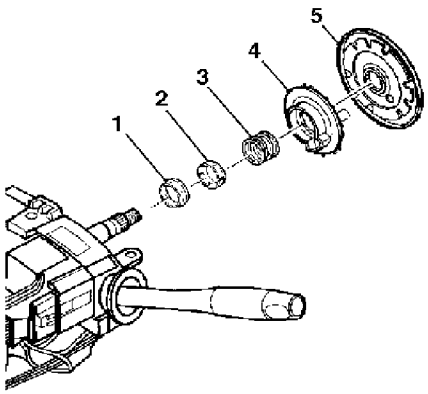
   Important: Let the SIR coil hang freely after removal.

2. Remove the SIR coil from the steering column. Refer to Inflatable Restraint Steering Wheel Module Coil Replacement.
3. Remove the wave washer (1) from the steering shaft assembly (2).

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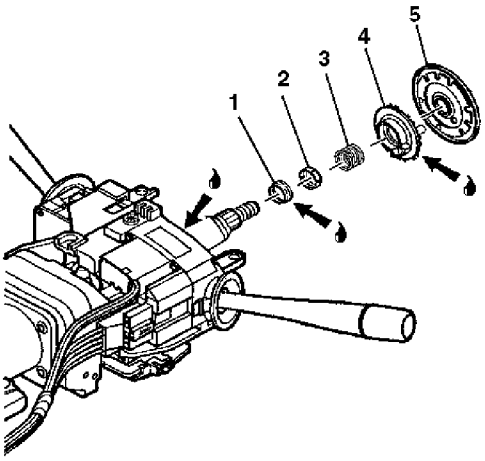


4. Compress the cam orientation plate using J 23653-SIR and J 42137 .
5. Remove the bearing retainer from the steering shaft assembly.
6. Remove J 23653-SIR and J 42137 .
7. Dispose of the bearing retainer.

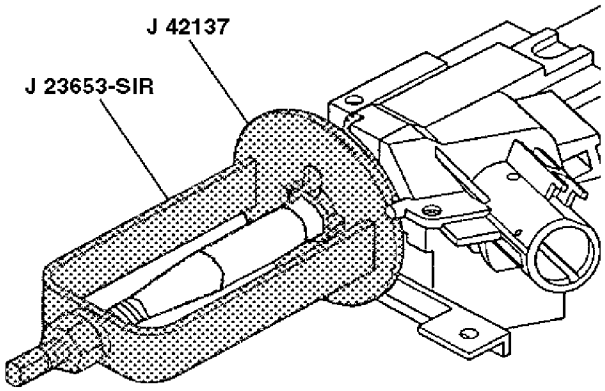


8. Remove the following from the steering shaft:
   8.1. Shaft lock shield (5)
   8.2. Turn signal cancel cam assembly (4)
   8.3. Upper bearing spring (3)
   8.4. Upper bearing inner race seat (2)
   8.5. Inner race (1)

Installation Procedure

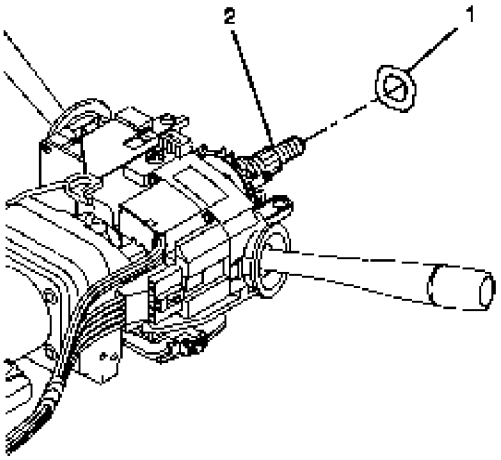


1. Install the following to the steering shaft:
   1.1. Inner race (1)
   1.2. Upper bearing inner race seat (2)
   1.3. Upper bearing spring (3)
   1.4. Turn signal cancel cam assembly (4)
   1.5. Shaft lock shield (5)



2. Install a new bearing retainer onto the steering shaft assembly.

3. Compress the cam orientation plate using J 23653-SIR and J 42137 to install the bearing retainer.
4. Remove J 23653-SIR and J 42137 from the steering shaft assembly.





5. Install the wave washer (1) onto the steering shaft assembly (2).
6. Install the SIR coil. Refer to Inflatable Restraint Steering Wheel Module Coil Replacement.
7. Enable the SIR system. Refer to SIR Disabling and Enabling.

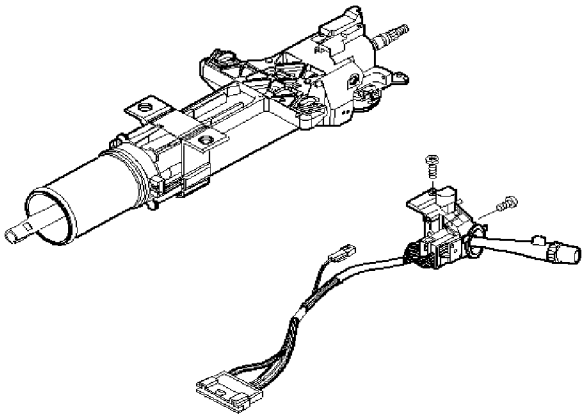
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Turn Signal Multifunction Switch Replacement

Removal Procedure

Caution: Refer to SIR Caution in the Preface section.

1. Disable the SIR system. Refer to SIR Disabling and Enabling.
2. Remove the steering column trim covers. Refer to Steering Column Trim Covers Replacement .





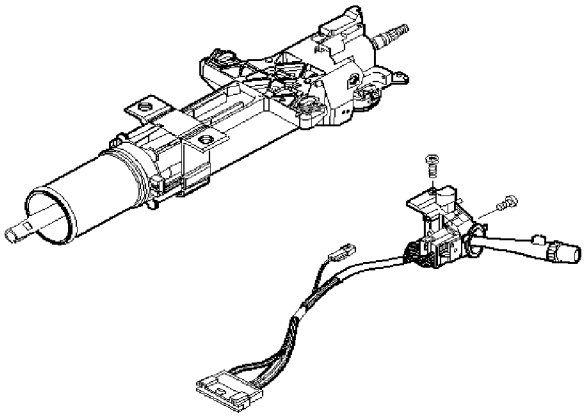
3. Remove the retaining screws from the multifunction switch.
4. Disconnect the multifunction switch electrical connections.
5. Remove the multifunction switch.

Installation Procedure

1. Connect the multifunction switch electrical connectors.
2. Install the multifunction switch to the steering column.

Notice: Refer to Fastener Notice in the Preface section.

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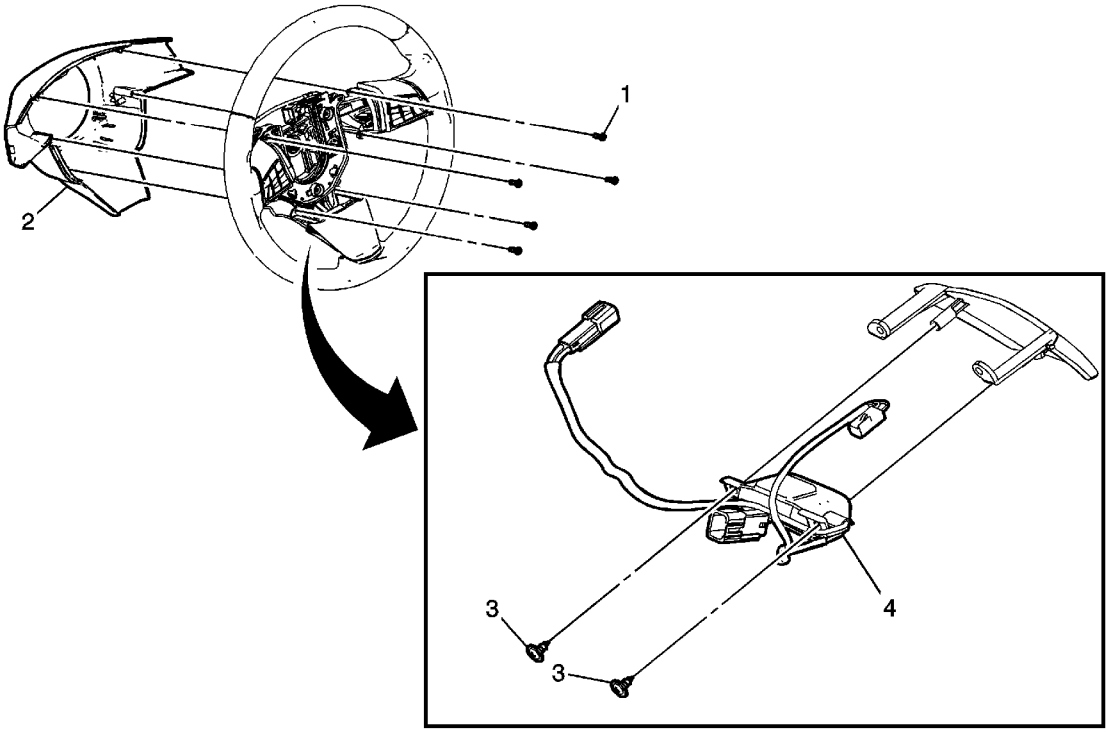


3. Install the retaining screws to the multifunction switch.

   Tighten
   Tighten the screws to 3.4 N·m (30 lb in).

4. Install the steering column trim covers. Refer to Steering Column Trim Covers Replacement .
5. Enable the SIR system. Refer to SIR Disabling and Enabling.

Steering Wheel Heat Control Module Replacement



Callout	Component Name
Preliminary Procedure Remove the steering wheel. Refer to Steering Wheel Replacement.	
1	Steering Wheel Back Cover Bolt (Qty: 6) **Notice:** Refer to Fastener Notice in the Preface section. **Tighten** 2.5 N·m (22 lb in)
2	Steering Wheel Back Cover **Procedure** Release any plastic retaining tabs as needed.
3	Steering Wheel Heat Control Module Bolt (Qty: 2) **Tighten** 2.5 N·m (22 lb in)
	Steering Wheel Heat Module

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4	**Procedure** Disconnect any electrical connectors as needed.

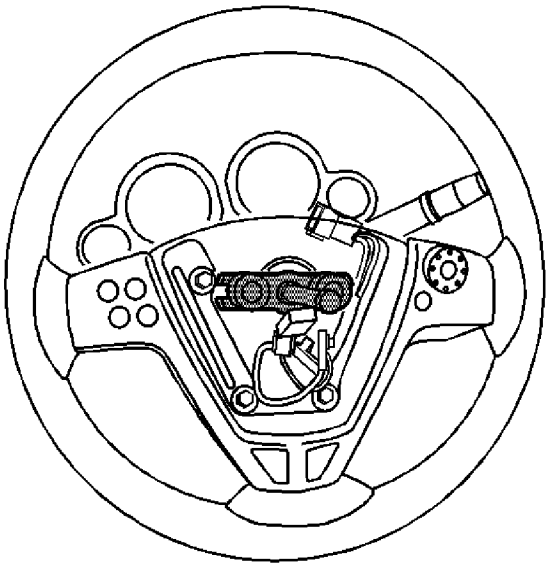
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Steering Wheel Replacement

Tools Required

- J 1859-A Steering Wheel Puller
- J 36541-A Steering Wheel Puller Legs
- J 42640 Steering Column Lock Pin

Removal Procedure

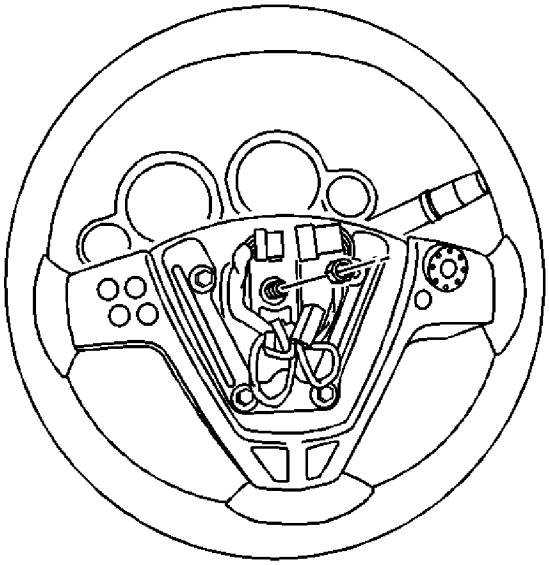




1. Remove the steering wheel inflator module. Refer to Inflatable Restraint Steering Wheel Module Replacement .
2. Remove the horn electrical connector.
3. Install J 42640 to the steering column.
4. Remove the steering wheel set nut.
5. Discard the steering wheel set nut.
6. Install J 36541-A and J 1859-A to the steering wheel.
7. Tighten the puller center screw against steering column shaft until the steering wheel slides off the steering column shaft.
8. Remove J 36541-A and J 1859-A from the steering wheel.

Installation Procedure

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1. Install the steering wheel to the steering column, observing the alignment marks.

   Notice: Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Fasteners requiring replacement or fasteners requiring the use of thread locking compound or sealant are identified in the service procedure. Do not use paints, lubricants, or corrosion inhibitors on fasteners or fastener joint surfaces unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems.

2. Install a new steering wheel set nut.

   Tighten
   Tighten the nut to 41 N·m (30 lb ft).

3. Remove J 42640 from the steering column.
4. Connect the horn electrical connector.
5. Install the steering wheel inflator module. Refer to Inflatable Restraint Steering Wheel Module Replacement .

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Repairing Scratched Wood Steering Wheels

Repair Procedure

1. Remove the steering wheel. Refer to Steering Wheel Replacement .
2. Wash the wood section of the wheel with wax and grease remover.
3. Mask off the non-wood area of the steering wheel.

Important: Do NOT sand through the clear.

4. Sand with 400 grit sand paper first. Finish sanding with 600 grit.
5. Wash the wood section of the wheel again with wax and grease remover.
6. Clear coat the steering wheel using the appropriate information in the body repair section.
7. Install the steering wheel. Refer to Steering Wheel Replacement .

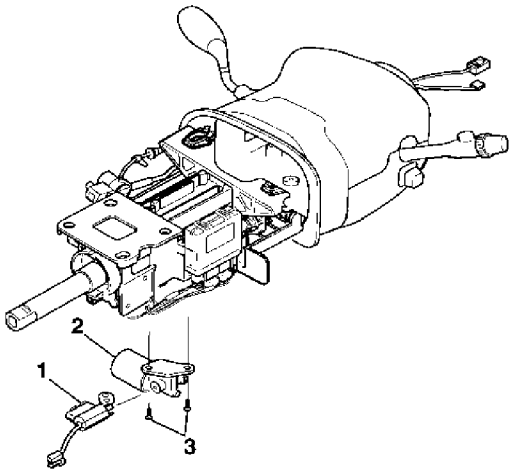
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Tilt Actuator Assembly Replacement

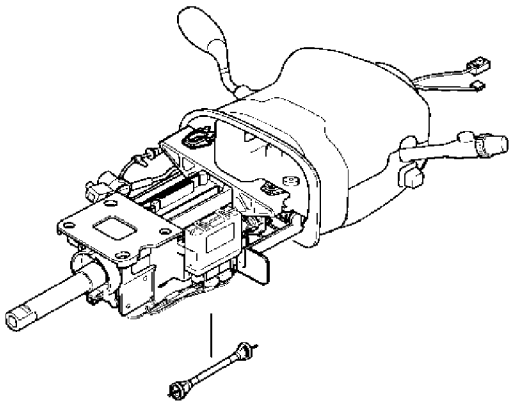
Removal Procedure

Caution: Refer to SIR Caution in the Preface section.



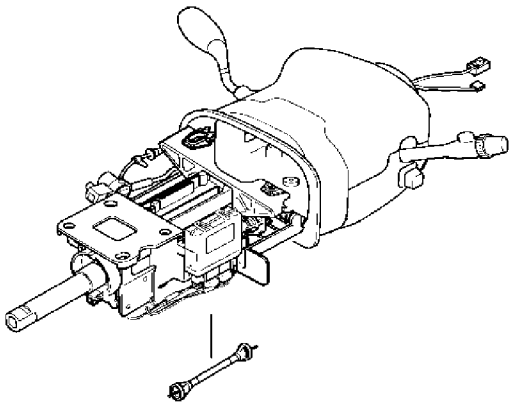
1. Disable the SIR system. Refer to SIR Disabling and Enabling.
2. Remove the knee bolster. Refer to Driver Knee Bolster Panel Replacement.
3. Remove the lower trim cover. Refer to Steering Column Trim Covers Replacement .
4. Disconnect the electrical connector from the tilt actuator assembly.
5. Remove the fasteners (3) from the tilt actuator assembly.
6. Remove the tilt actuator assembly (2) from the steering column.
7. Remove the potentiometer housing (1) from the tilt actuator assembly.

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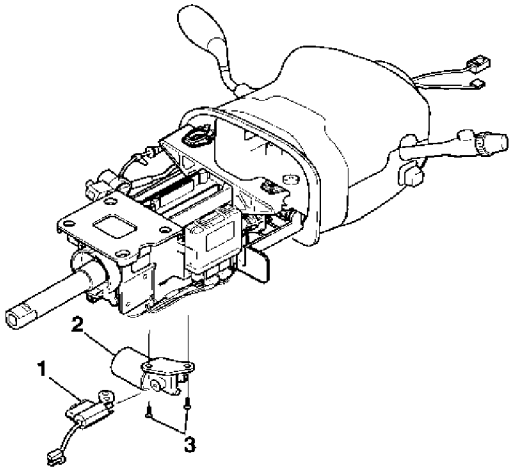


8. Disconnect the tilt cable from the tilt actuator assembly.

Installation Procedure



1. Install the black end of the tilt actuator cable assembly to the steering column.



2. Install the potentiometer housing (1) to the tilt actuator assembly (2).
3. Install the white end of the tilt actuator cable to the tilt actuator assembly.

Notice: Refer to Fastener Notice in the Preface section.

4. Install the tilt actuator assembly and the retaining screws.

Tighten
Tighten the screws to 9 N·m (80 lb in).

5. Connect the electrical connector to the tilt actuator.
6. Install the lower trim cover. Refer to Steering Column Trim Covers Replacement .
7. Install the knee bolster. Refer to Driver Knee Bolster Panel Replacement.
8. Enable the SIR system. Refer to SIR Disabling and Enabling.

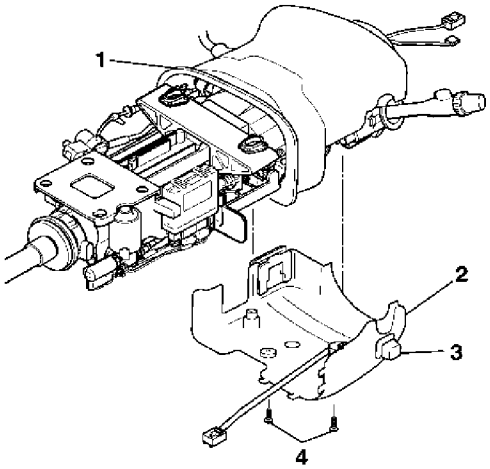
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Telescope Actuator Switch Replacement

Removal Procedure

Caution: Refer to SIR Caution in the Preface section.

1. Disable the SIR system. Refer to SIR Disabling and Enabling.
2. Remove the knee bolster. Refer to Driver Knee Bolster Panel Replacement.

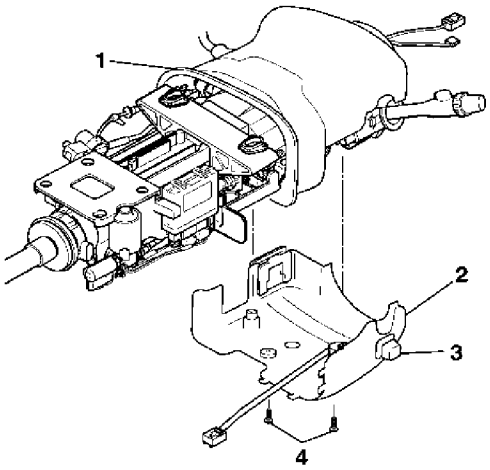


3. Remove the retaining screws (4) from the lower steering column trim cover.
4. Disconnect the lower trim cover from the closeout shroud.
5. Disconnect the telescope actuator switch electrical connector.
6. Remove the telescope actuator switch from the lower trim cover.

Installation Procedure

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1. Install the telescope actuator switch to the lower steering column trim cover.
2. Connect the telescope actuator switch electrical connector to the steering column control module.
3. Connect the lower trim cover to the closeout shroud.

Notice: Refer to Fastener Notice in the Preface section.

4. Install the retaining screws (4) to the lower steering column trim cover.

Tighten
Tighten the screws to 3 N·m (27 lb in).

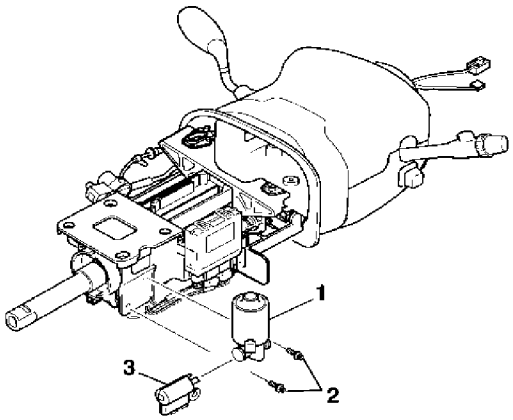
5. Install the knee bolster. Refer to Driver Knee Bolster Panel Replacement.
6. Enable the SIR system. Refer to SIR Disabling and Enabling.

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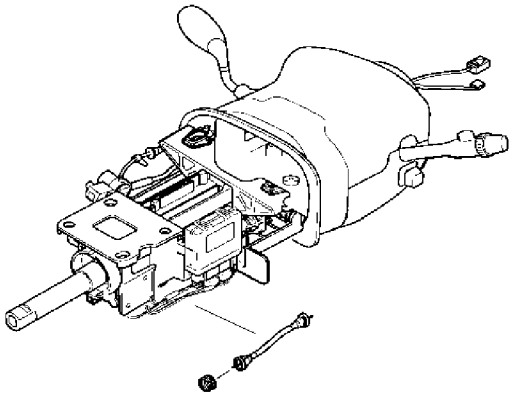
Telescope Actuator Assembly Replacement

Removal Procedure

Caution: Refer to SIR Caution in the Preface section.



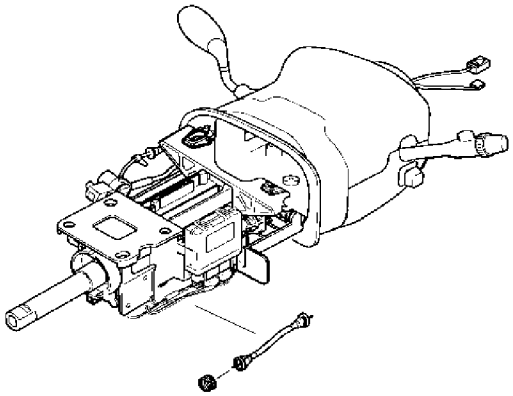
1. Disable the SIR system. Refer to SIR Disabling and Enabling.
2. Remove the knee bolster. Refer to Driver Knee Bolster Panel Replacement.
3. Disconnect the electrical connector from the telescope actuator assembly.
4. Remove the fasteners (2) from the telescope actuator assembly.
5. Remove the telescope actuator assembly (1) from the steering column.
6. Remove the potentiometer housing (3) from the telescope actuator assembly.



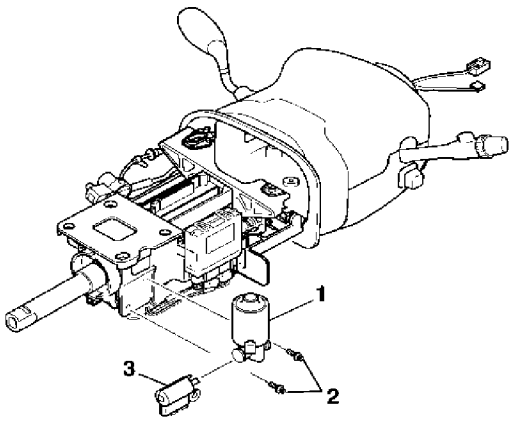
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7. Disconnect the telescope cable from the telescope actuator assembly.

Installation Procedure



1. Install the white end of the telescope actuator cable assembly to the steering column.
2. Install the black end of the telescope actuator cable to the telescope actuator assembly.



3. Install the potentiometer housing (3) to the telescope actuator assembly (1).
4. Install the telescope actuator assembly.

Notice: Refer to Fastener Notice in the Preface section.

5. Install the retaining screws to the telescope actuator assembly.

   Tighten

   - Tighten the screws to 1.4 N·m (12 lb in).
   - Tighten the screws to 5 N·m (44 lb in).

6. Connect the electrical connector to the telescope assembly actuator.
7. Install the knee bolster. Refer to Driver Knee Bolster Panel Replacement.
8. Enable the SIR system. Refer to SIR Disabling and Enabling.

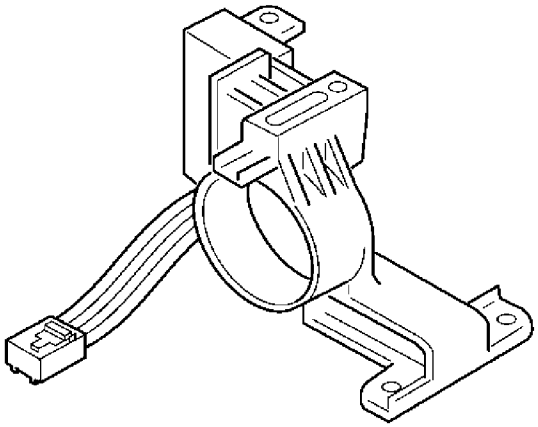
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Steering Column Electronic Lock Replacement

Removal Procedure

Caution: Refer to SIR Caution in the Preface section.

1. Disable the SIR system. Refer to SIR Disabling and Enabling.
2. Remove the steering column from the vehicle. Refer to Steering Column Replacement .
3. Remove the turn signal cancel cam. Refer to Turn Signal Cancel Cam and Steering Shaft Upper Bearing Spring Replacement.
4. Remove the windshield wiper wash and switch assembly. Refer to Windshield Wiper and Washer Switch Replacement .
5. Remove the multifunction switch assembly. Refer to Turn Signal Multifunction Switch Replacement .

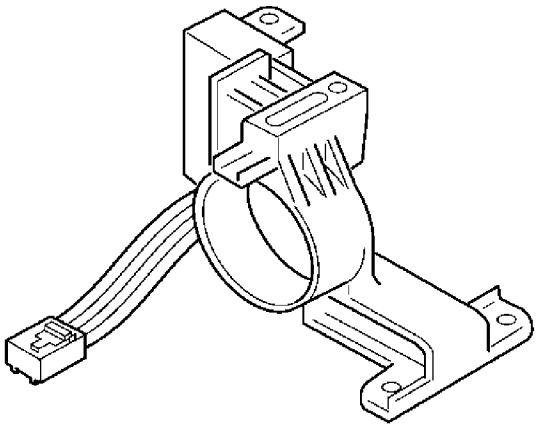


Notice: Avoid damaging the steering column electronic lock harness by gently removing the plugs installed in the I/P beam. Do NOT twist, pull, bend, cut, or incorrectly route the harness. Damage to the harness will require replacement of the entire electronic lock.

6. Remove the wire harness straps from the wire harness.
7. Remove the electronic lock module lead from the wire harness assembly.
8. Remove the electronic lock module from the steering column.

Installation Procedure

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1. Install the electronic lock module onto the steering column.

   Notice: Avoid damaging the steering column electronic lock harness by gently removing the plugs installed in the I/P beam. Do NOT twist, pull, bend, cut, or incorrectly route the harness. Damage to the harness will require replacement of the entire electronic lock.

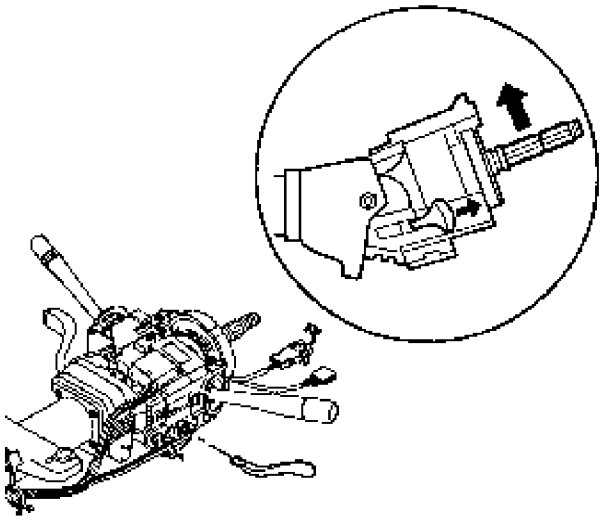
2. Feed the electronic column lock lead into the wire harness assembly.
3. Install new wire harness straps.
4. Install the turn signal cancel cam. Refer to Turn Signal Cancel Cam and Steering Shaft Upper Bearing Spring Replacement .
5. Install the windshield wiper wash and switch assembly. Refer to Windshield Wiper and Washer Switch Replacement.
6. Install the multifunction switch assembly. Refer to Turn Signal Multifunction Switch Replacement .
7. Install the steering column into the vehicle. Refer to Steering Column Replacement .
8. Enable the SIR system. Refer to SIR Disabling and Enabling .

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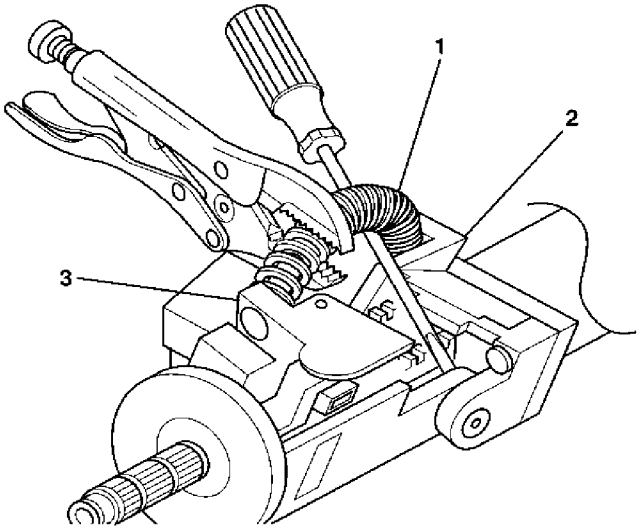
Steering Column Tilt Spring Replacement

Removal Procedure

Caution: Refer to SIR Caution in the Preface section.



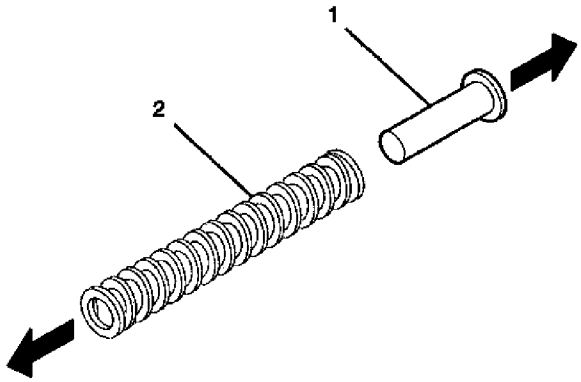
1. Disable the SIR system. Refer to SIR Disabling and Enabling.
2. Remove the upper and lower trim covers. Refer to Steering Column Trim Covers Replacement .
3. Install the tilt lever onto the steering column tilt head assembly.
4. Use the tilt lever to tilt the column to the UP position.



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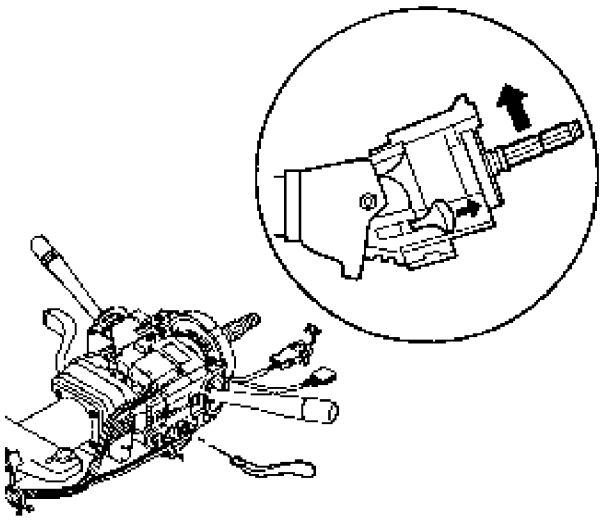
Caution: The tilt spring and the spring guide are under pressure. The tilt spring and the spring guide may become a projectile. Secure the spring with locking pliers during removal. Secure the spring with locking pliers during installation. Bodily injury may result during removal and installation of the tilt spring and the spring guide. Always use caution during removal and installation of the tilt spring and the spring guide.

5. Remove the tilt spring (1) from the steering column support assembly (2) and from the steering column tilt head assembly (3) by using the following procedure:
   5.1. Pry up the tilt spring (1) until a bulge occurs and most of the tilt spring tension is removed.
   5.2. Secure the tilt spring (1) with locking pliers.
   5.3. Continue prying up the tilt spring (1) until the tilt spring disengages from the post on the steering column support assembly (2) and from the steering column tilt head assembly (3).

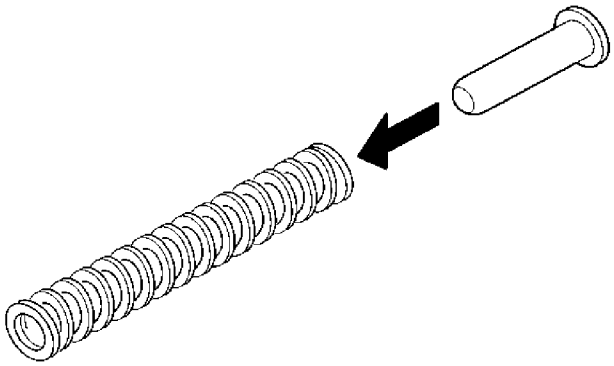


6. Remove the spring guide (1) from the tilt spring (2).

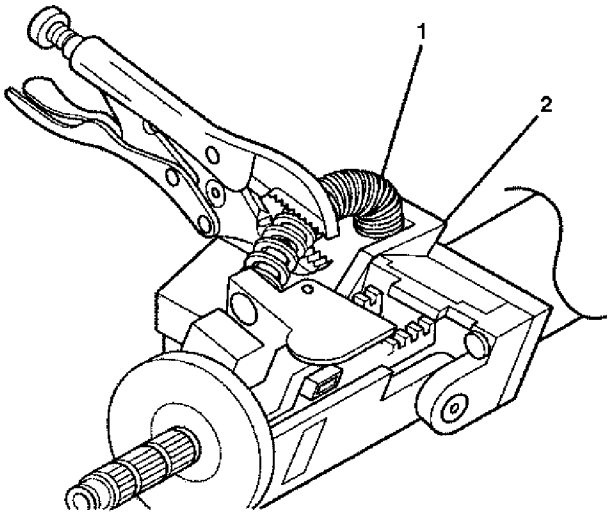
Installation Procedure



1. Use the tilt lever to tilt the column to the UP position.



2. Install the spring guide into the tilt spring.



Caution: The tilt spring and the spring guide are under pressure. The tilt spring and the spring guide may become a projectile. Secure the spring with locking pliers during removal. Secure the spring with locking pliers during installation. Bodily injury may result during removal and installation of the tilt spring and the spring guide. Always use caution during removal and installation of the tilt spring and the spring guide.

3. Install the tilt spring (1) onto the steering column support assembly (2) and onto the steering column tilt head assembly by using the following procedure:
   3.1. Install the tilt spring (1) onto the steering column tilt head assembly.
   3.2. Install the tilt spring (1) onto the post on the steering column support assembly (2).
4. Install the upper and lower trim covers. Refer to Steering Column Trim Covers Replacement .
5. Enable the SIR system. Refer to SIR Disabling and Enabling.

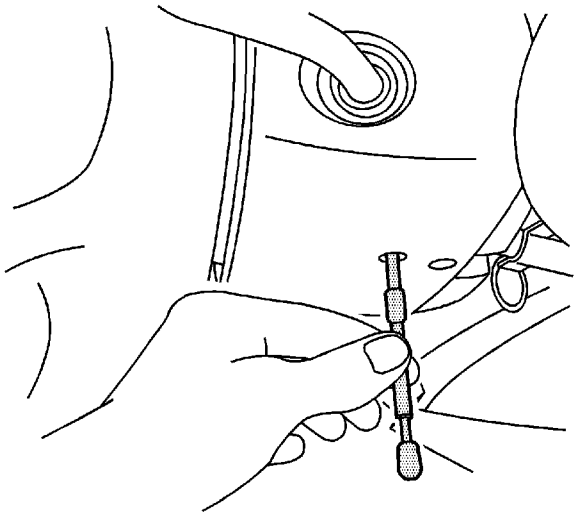
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Steering Column Replacement

Tools Required

J 42640 Steering Column Lock Pin

Removal Procedure



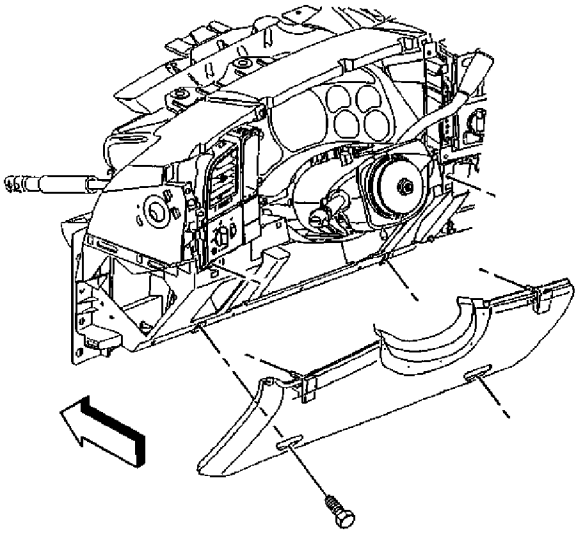
Important: If the steering column connectors are disconnected with the ignition in the ON position, the body control module (BCM) will enter a fail enable mode and prevent steering column lock operations. The PCM will also inhibit vehicle motion by disabling fuel. To clear the BCM fail enable mode, disconnect the BCM #25 for 15 seconds.

1. Disable the SIR system. Refer to SIR Disabling and Enabling .
2. Disconnect the battery. Refer to Battery Negative Cable Disconnection and Connection .

Notice: The wheels of the vehicle must be straight ahead and the steering column in the LOCK position before disconnecting the steering column or intermediate shaft from the steering gear. Failure to do so will cause the SIR coil assembly to become uncentered, which may cause damage to the coil assembly.

3. Insert the J 42640 .

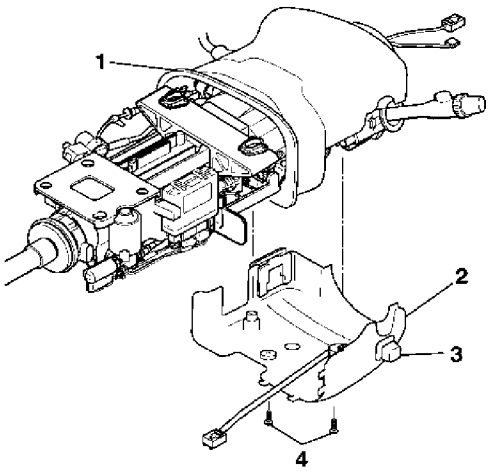
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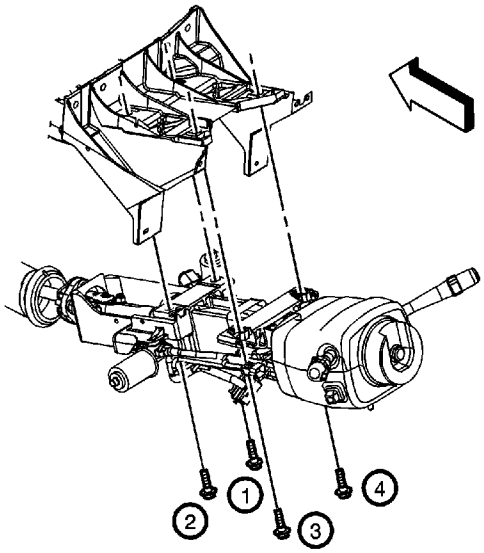
4. Remove the knee bolster panel. Refer to Driver Knee Bolster Bracket Replacement .

Notice: Avoid damaging the steering column electronic lock harness by gently removing the plugs installed in the I/P beam. Do NOT twist, pull, bend, cut, or incorrectly route the harness. Damage to the harness will require replacement of the entire electronic lock.

5. Disconnect the steering column electrical connectors.



6. Remove the lower steering column shroud. Refer to Steering Column Trim Covers Replacement .
7. Remove the heater duct.
8. Remove the telescoping motor. Refer to Telescope Actuator Assembly Replacement .
9. Remove the tilt motor and bracket assembly. Refer to Tilt Actuator Assembly Replacement .
10. Remove the intermediate shaft to column through bolt.

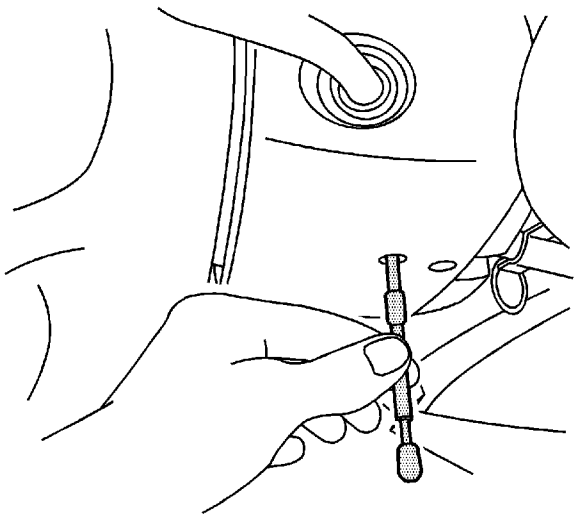


11. Remove the mounting bolts (1, 2, 3, 4) from the steering column.

Notice: Once the steering column is removed from the vehicle, the column is extremely susceptible to damage. Dropping the column assembly on the end could collapse the steering shaft or loosen the plastic injections, which maintain column rigidity. Leaning on the column assembly could cause the jacket to bend or deform. Any of the above damage could impair the columns collapsible design. Do NOT hammer on the end of the shaft, because hammering could loosen the plastic injections, which maintain column rigidity. If you need to remove the steering wheel, refer to the Steering Wheel Replacement procedure in this section.

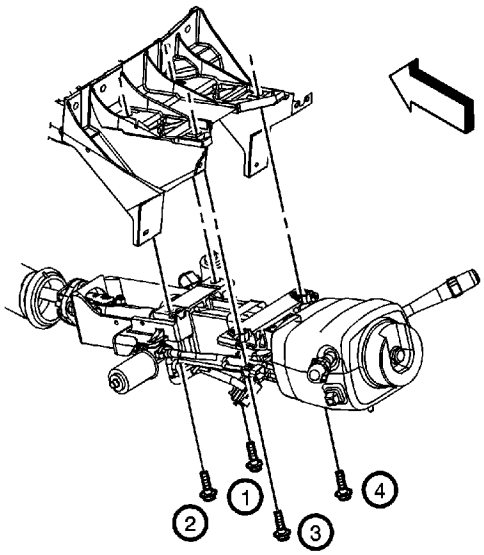
12. With the aid of an assistant, remove the steering column.

Installation Procedure



1. With the aid of an assistant, install the steering column.
2. Install the 2 of the steering column mounting bolts.
3. Install the pinch bolt for the intermediate shaft to steering column. Finger tighten the bolt only.

Notice: Refer to Fastener Notice in the Preface section.



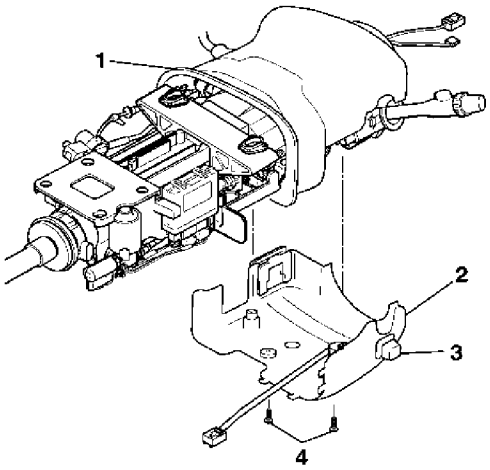
4. Install the reminding steering column bolts and tighten in sequence.

Tighten
Tighten the mounting bolts to 24 N·m (18 lb ft).

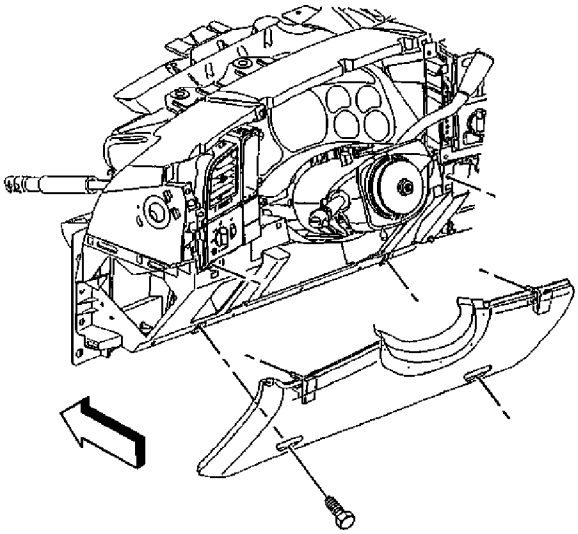
5. Tighten the pinch bolt to specifications.

Tighten
Tighten the pinch bolt to 48 N·m (35 lb ft).

6. Install the tilt motor and bracket assembly. Refer to Tilt Actuator Assembly Replacement .
7. Install the telescoping motor. Refer to Telescope Actuator Assembly Replacement .
8. Reconnect the steering column electrical connectors.
9. Install the heater duct.



10. Install the lower steering column shroud. Refer to Steering Column Trim Covers Replacement .



11. Install the knee bolster panel. Refer to Driver Knee Bolster Bracket Replacement .
12. Remove the J 42640 .
13. Reconnect the battery. Refer to Battery Negative Cable Disconnection and Connection .
14. Enable the SIR system. Refer to SIR Disabling and Enabling .

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Lower Bearing and Steering Column Jacket Replacement

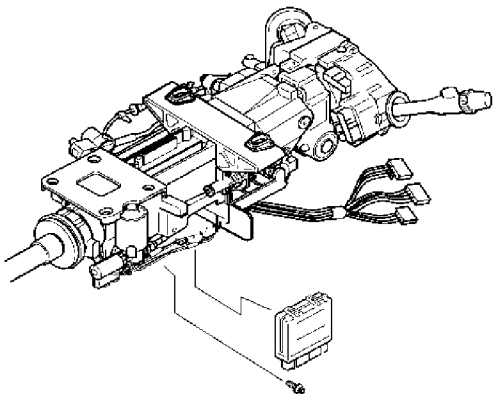
Tools Required

J 21854-01 Pivot Pin Remover

Removal Procedure

Caution: Refer to SIR Caution in the Preface section.

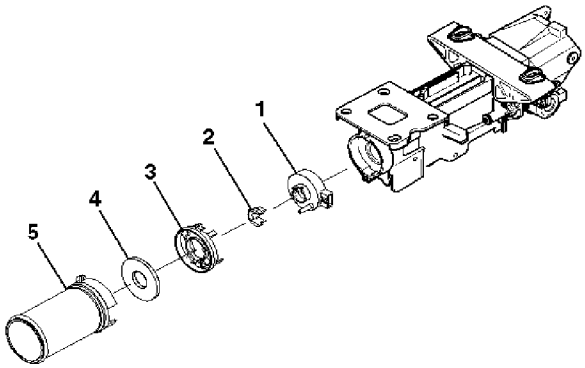
1. Disable the SIR coil. Refer to SIR Disabling and Enabling .
2. Remove the steering wheel from the column. Refer to Steering Wheel Replacement .
3. Remove the steering column from the vehicle. Refer to Steering Column Replacement .
4. Remove the turn signal and multifunction switch assembly only. Refer to Turn Signal Multifunction Switch Replacement .
5. Remove the wire harness assembly only. Refer to Steering Column Wiring Harness Assembly Replacement .
6. Remove the telescope drive motor assembly and cable only. Refer to Telescope Actuator Assembly Replacement .
7. Remove the tilt drive motor assembly and cable only. Refer to Tilt Motor Replacement .



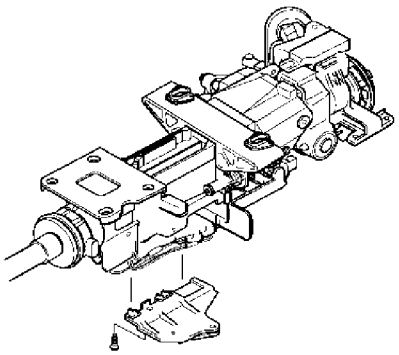


8. Remove 1 TORX® head screw from the control module.
9. Slide the control module out from the steering column.

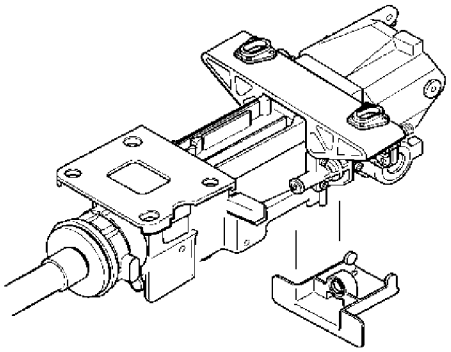
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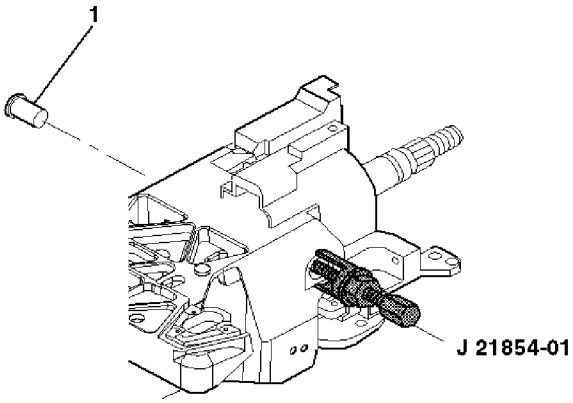
10. Remove the following components:
    10.1. The boot seal (5)
    10.2. The steering shaft seal (4)
    10.3. The sensor retainer (3)
    10.4. The sensor locator (2)
11. The steering wheel position sensor (1). Refer to Steering Wheel Position Sensor Centering .



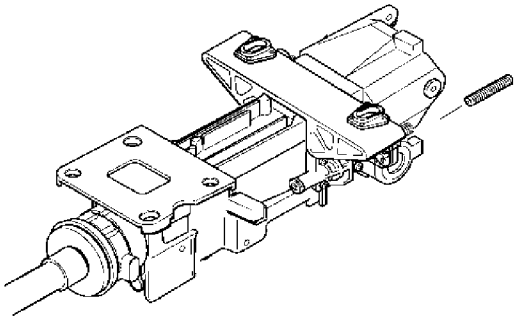
12. Remove 1 TORX® head screw from the bottom of the gearshift and tilt motor bracket.
13. Remove the bracket.



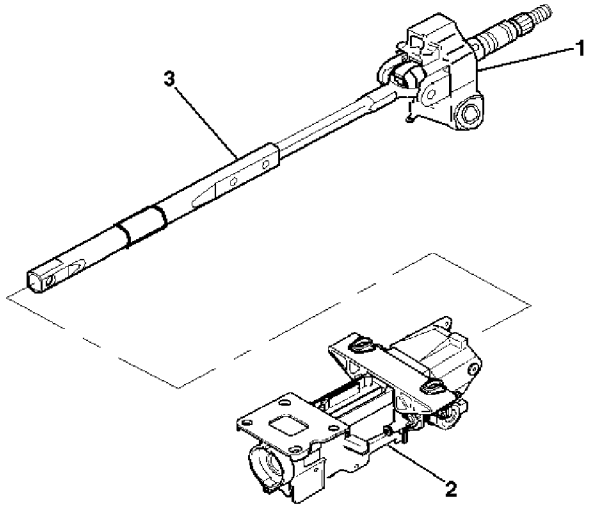
14. Gently pry the lower shield assembly off of the steering column.



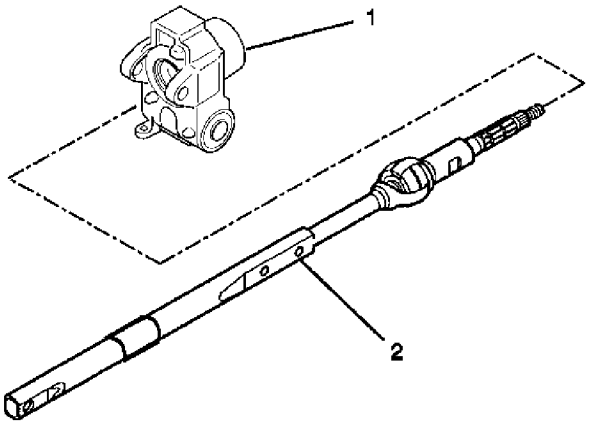
15. Remove 2 pivot pins (1) from the steering column support assembly using J 21854-01 .



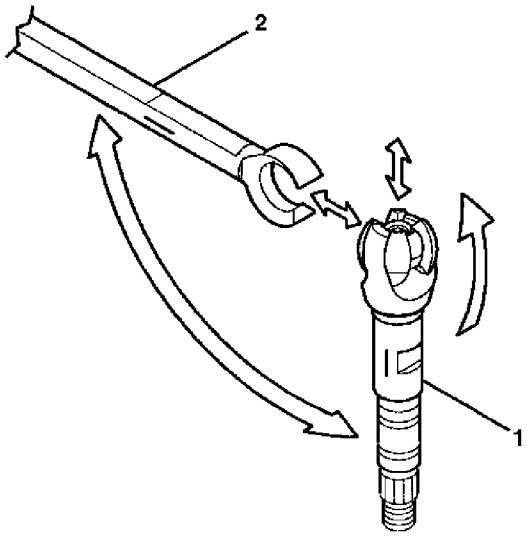
16. Unscrew the lead screw.



17. Remove the tilt head assembly (1) from the steering column support assembly (2) with the steering shaft (3) still attached.

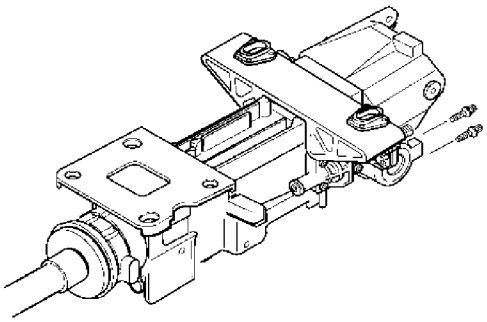


18. Remove the tilt head assembly (1) from the steering shaft assembly (2).



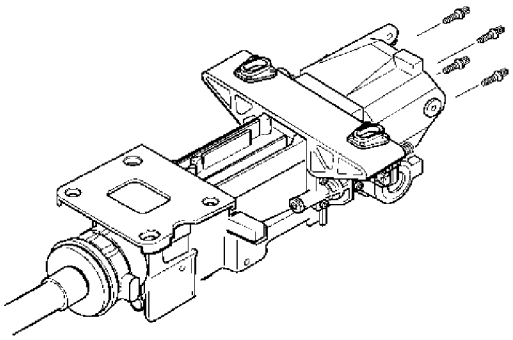
Important: Mark the race and upper shaft (1) and the lower steering shaft (2) to ensure proper assembly. Failure to assemble properly will cause the steering wheel to be turned 180 degrees.

19. Tilt the upper shaft assembly 90 degrees to the steering shaft assembly and disengage.





20. Remove 2 TORX® screws from the dampener.

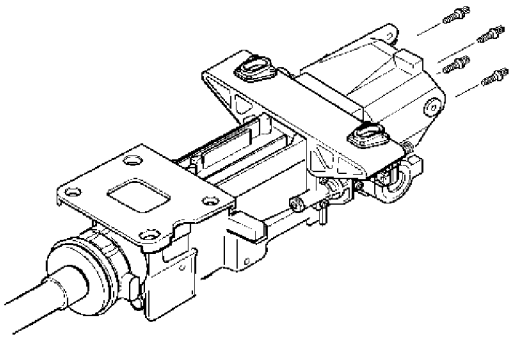




21. Remove and discard 4 support screws from the steering column support.
22. Remove the steering column support.
23. Inspect the steering column for accident damage.

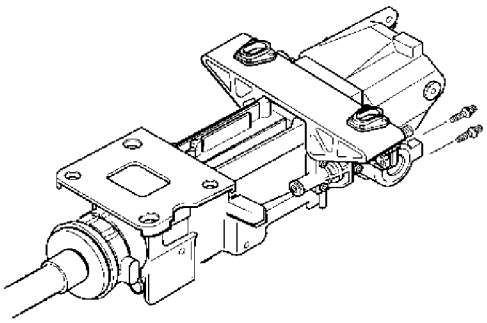
Installation Procedure

Notice: Refer to Fastener Notice in the Preface section.



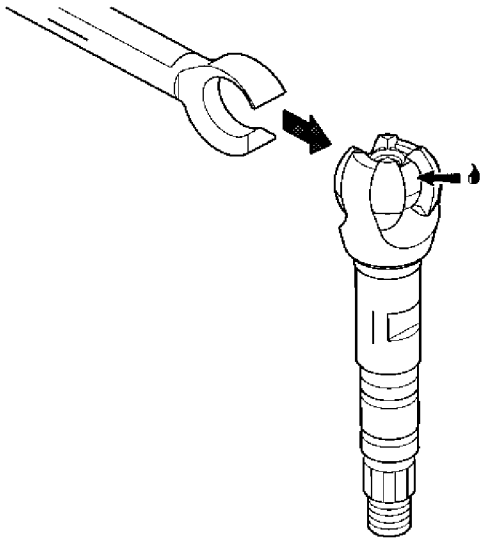
1. Install the steering column support and secure the support using 4 support screws.

   Tighten
   Tighten the screws to 18 N·m (13 lb ft).



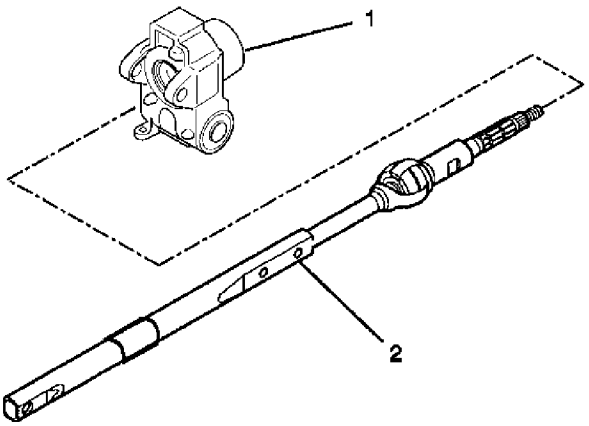
2. Install 2 TORX® screws into the dampener.

   Tighten
   Tighten the screws to 1.5 N·m (13 lb in).

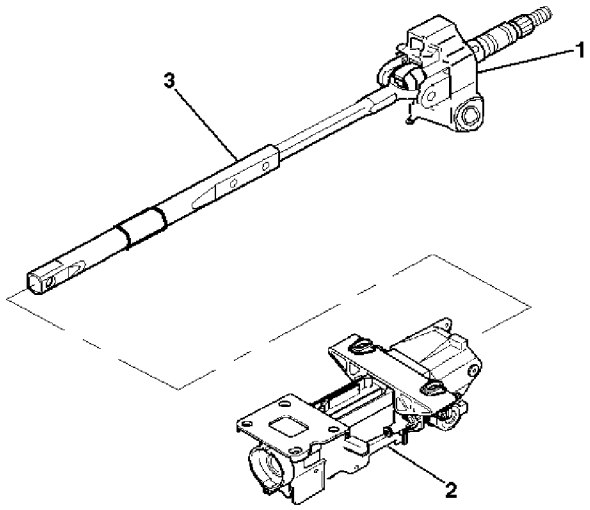


Important: Use the alignment marks from the disassemble procedure. Failure to assemble properly will cause the steering wheel to be turned 180 degrees.

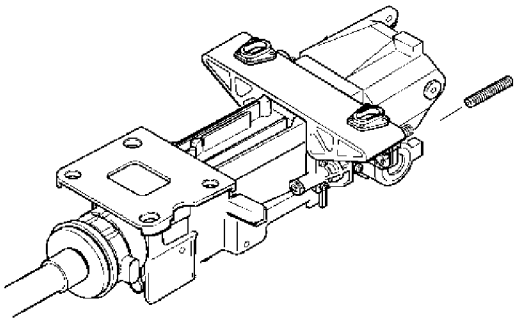
3. Apply GM P/N 12345718 (Canadian P/N 10953516) to the race and upper shaft assembly.
4. Align the marks on the race and upper shaft assembly with the lower shaft assembly.
5. Install the lower shaft assembly to the race and upper shaft assembly.



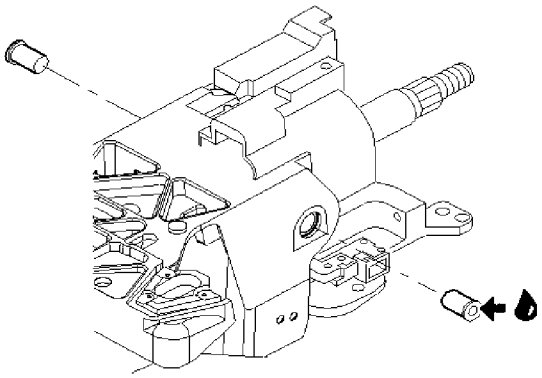
6. Install the steering shaft assembly (2) into the tilt head assembly (1).



7. Install the tilt head assembly (1) and the steering shaft assembly (3) into the jacket assembly (2).

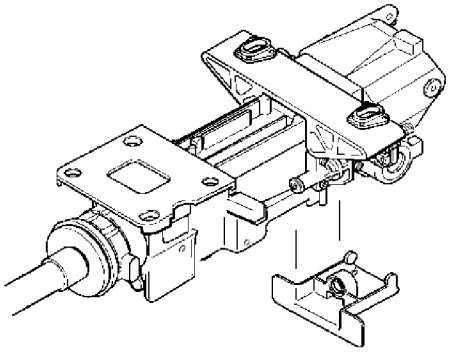


8. Install the lead screw.

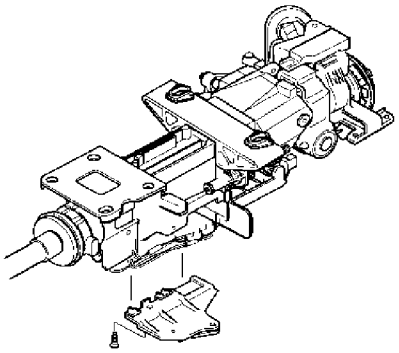


9. Lubricate the pivot pins with GM P/N 12345718 (Canadian P/N 10953516).

   Install the 2 pivot pins onto the steering column support assembly.

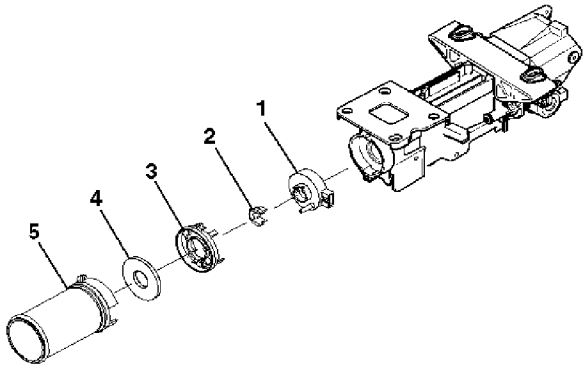


10. Align and snap the lower shield assembly onto the steering column.



11. Install the bracket.
12. Install 1 TORX® head screw to the bottom of the gearshift and tilt motor bracket.

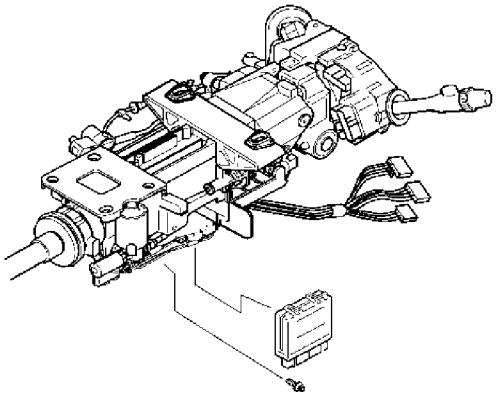
Tighten
Tighten the screw to 3 N·m (27 lb in).



13. Install the following components:
    13.1. The steering wheel position sensor (1). Refer to Steering Wheel Position Sensor Centering .
    13.2. The sensor locator (2)
    13.3. The sensor retainer (3)

13.4. The steering shaft seal (4)

13.5. The boot seal (5)



14. Slide the control module into position.
15. Install 1 retaining screw.

Tighten
Tighten the screw to 5 N·m (44 lb in).

Caution: Improper routing of the wire harness assembly may damage the inflatable restraint steering wheel module coil. This may result in a malfunction of the coil, which may cause personal injury.

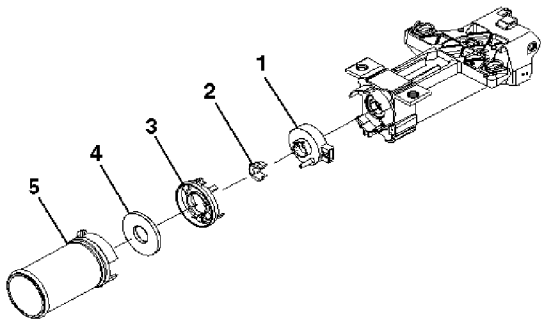
16. Install the tilt drive motor assembly and cable only. Refer to Tilt Motor Replacement .
17. Install the telescope drive motor assembly and cable only. Refer to Telescope Actuator Assembly Replacement .
18. Install the turn signal and multifunction switch assembly only. Refer to Turn Signal Multifunction Switch Replacement .
19. Install the wire harness assembly only. Refer to Steering Column Wiring Harness Assembly Replacement .
20. Install the steering column into the vehicle. Refer to Steering Column Replacement .
21. Install the steering wheel onto the steering column. Refer to Steering Wheel Replacement .
22. Enable the SIR system. Refer to SIR Disabling and Enabling.

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Steering Wheel Position Sensor Replacement

Removal Procedure

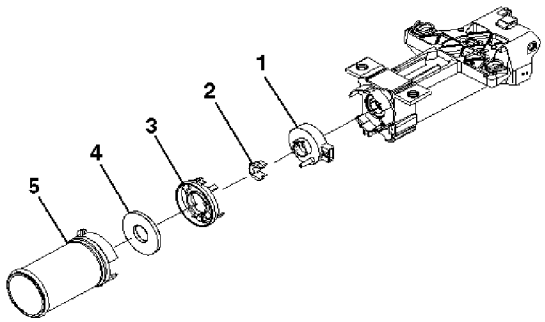
Caution: Refer to SIR Caution in the Preface section.



1. Disable the SIR system. Refer to SIR Disabling and Enabling.
2. Remove the steering column from the vehicle. Refer to Steering Column Replacement .
3. Remove the following from the steering shaft:
   3.1. The boot seal (5)
   3.2. The steering shaft seal (4)
   3.3. The sensor retainer (3)
   3.4. The sensor locator (2)
4. Remove the steering wheel position sensor (1). Refer to Steering Wheel Position Sensor Centering .

Installation Procedure

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1. Install the following onto the steering shaft:
   1.1. The steering wheel position sensor (1) Refer to Steering Wheel Position Sensor Centering .
   1.2. The sensor locator (2)
   1.3. The sensor retainer (3)
   1.4. The steering shaft seal (4)
   1.5. The boot seal (5)
2. Install the steering column into the vehicle. Refer to Steering Column Replacement .
3. Enable the SIR system. Refer to SIR Disabling and Enabling.

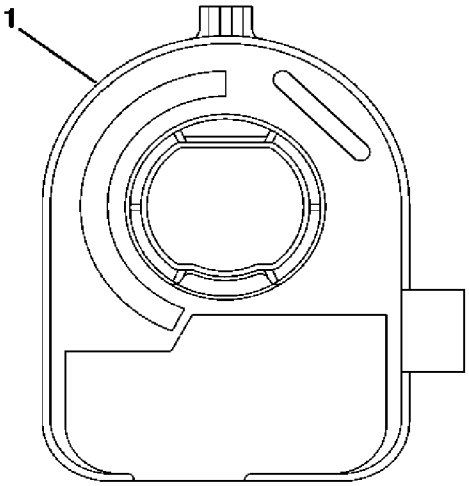
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Steering Wheel Position Sensor Centering

Removal Procedure

Important: Identify the type of steering wheel position sensor from the illustrations shown BEFORE removing the sensor from the steering column. Once you have identified the steering wheel position sensor, follow the instructions listed in the removal procedure.

1. Verify the type of steering wheel position sensor.



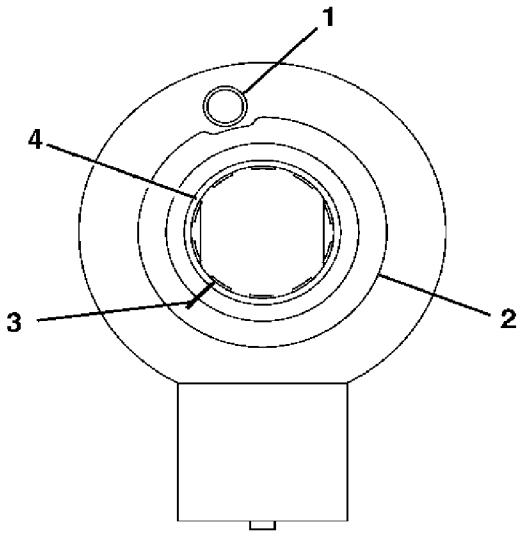


2. From the technicians point of view, the FRONT of the sensor (1) connector will be on the right.

Important: If reusing the existing sensor, you do not have to align the sensor before removal. Centering is not required when it is time to reinstall.

3. Remove the connector from the sensor.
4. Remove the sensor (1) from the adapter and bearing assembly.
5. To install the sensor, proceed to step 1 in the installation section.

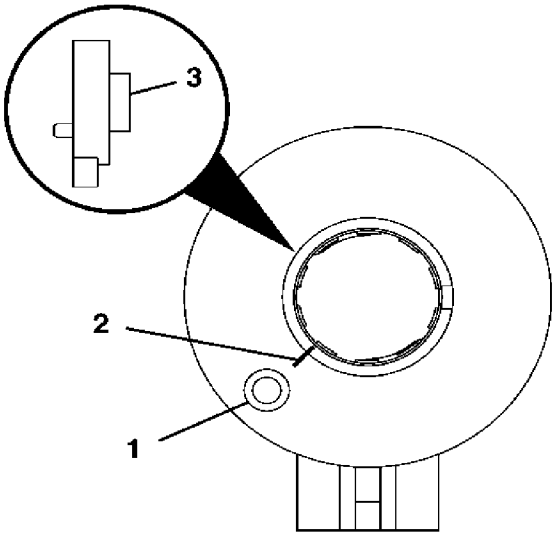
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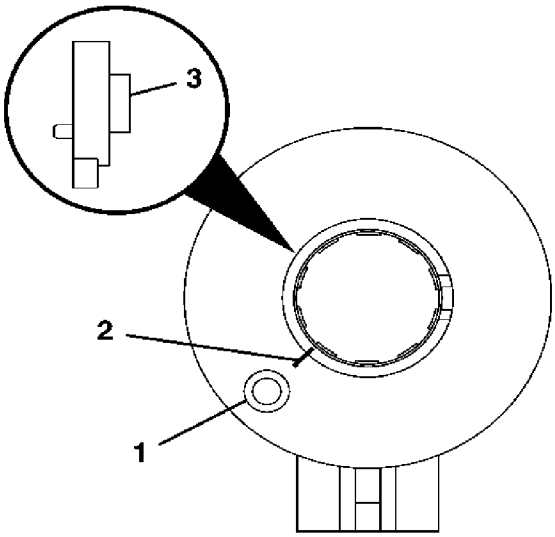
6. From the technicians point of view, the FRONT of the sensor will have:
   - A foam ring (2)
   - A pin hole (1) for centering the pin--Note the location of the pin hole.
   - A flush rotor flange cuff (4)

Important: If reusing the existing sensor, you must make an alignment mark on the rotor flange cuff (3) before removing the sensor. Failure to do so will cause misalignment when installing the sensor. A new sensor will be required if misaligned.

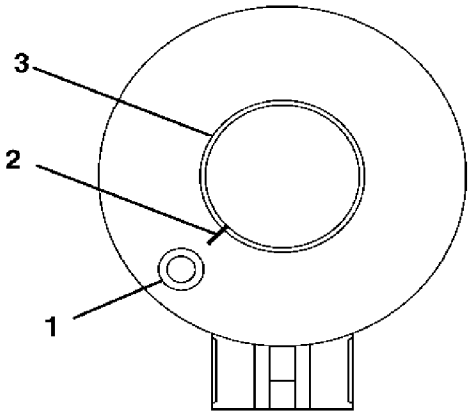
7. Make an alignment mark on the flush rotor flange cuff (3).
8. Remove the connector from the sensor.
9. Remove the sensor from the adapter and bearing assembly.
10. To install the sensor, proceed to step 5 in the installation procedure.



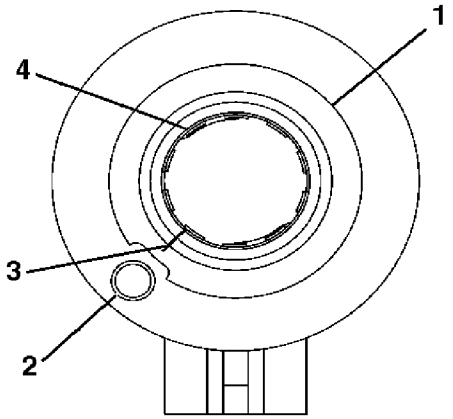
11. From the technicians point of view, the FRONT of the sensor will have:
    - A raised rotor flange cuff (3)
    - An alignment mark (2) on the rotor flange cuff (3) for installation
    - A pin hole (1) for the centering pin--Note the location of the pin hole.
12. Remove the connector from the sensor.
13. Remove the sensor from the adapter and bearing assembly.
14. To install the sensor, proceed to step 9 in the installation procedure.



15. From the technicians point of view, the FRONT of the sensor will have:
    - A raised rotor flange cuff (3)
    - An alignment mark (2) on the rotor flange cuff (3) for installation
    - A pin hole (1) for the centering pin--Note location of the pin hole.
    - A sensor clip in FRONT of the sensor
16. Remove the connector from the sensor.
17. Remove the sensor clip from the sensor.
18. Remove the sensor from the adapter and bearing assembly.
19. To install the sensor, proceed to step 13 in the installation procedure.



20. From the technicians point of view, the FRONT of the sensor will have:
    - A flush rotor flange cuff (3)
    - A pin hole (1) for the centering pin--Note the location of the pin hole.
    - An alignment mark (2) on the flush rotor flange cuff (3) for installation
21. Remove the connector from the sensor.
22. Remove the sensor from the adapter and bearing assembly.
23. To install the sensor, proceed to step 17 in the installation procedure.

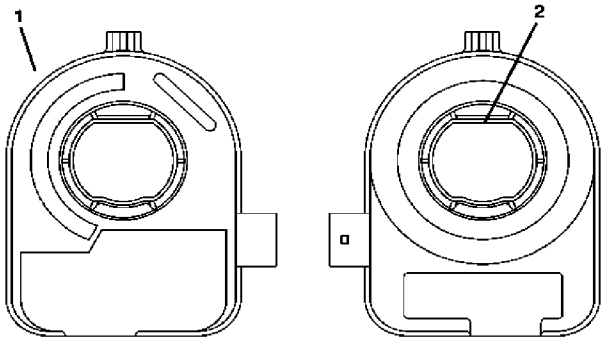


24. From the technicians point of view, the FRONT of the sensor will have:
    - A flush rotor flange cuff (4)
    - A pin hole (2) for the centering pin--Note the location of the pin hole.
    - An alignment mark (3) on the flush rotor flange cuff (4) for installation

- A foam ring (1)

25. Remove the connector from the sensor.
26. Remove the sensor from the adapter and bearing assembly.
27. To install the sensor, proceed to step 21 in the installation procedure.

Installation Procedure



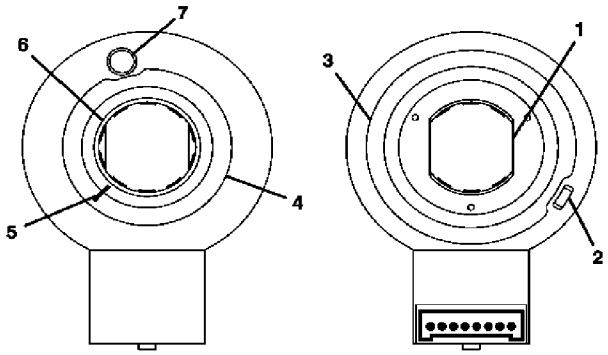


Important: If reusing the existing sensor, no centering of the sensor is required.

1. If installing a new sensor, it will come with a pin installed in the sensor. Do not remove the pin until the sensor is seated.
2. From the technicians point of view, the FRONT of the sensor (1) connector will be on your right.

   From the technicians point of view, the BACK of the sensor (2) connector will be on your left.

3. Looking at the FRONT of the sensor, align the sensor with the steering shaft and install into the adapter and bearing assembly.
4. Install the connector to the sensor.



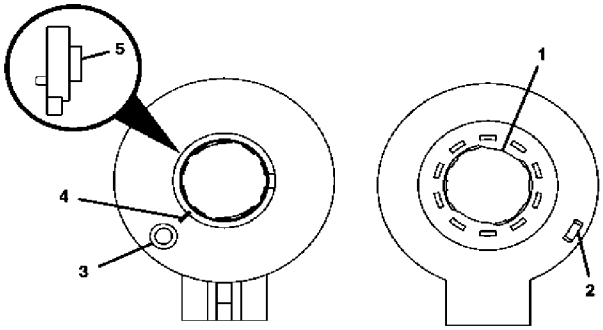


5. From the technicians point of view, the FRONT of the sensor will have:
   - A foam ring (4)
   - A pin hole (7) for the centering pin--Note the location of the pin hole.
   - A flushed rotor flange cuff (6)
   - An alignment mark (5) for installation
6. From the technicians point of view, the BACK of the sensor will have:
   - Double D flats (1)
   - A foam ring (3)
   - An alignment tab (2) for installing into the adapter and bearing assembly
   - A view of the inside of the connector

Important: If reusing the existing sensor, you must align the marks on the flush rotor flange cuff before installation. The alignment mark must stay aligned until the sensor is seated into the adapter and bearing assembly.

If installing a new sensor, it will come with a pin installed in the sensor. Do not remove the pin until the sensor is seated. If the new sensor did not come with a pin installed, you must reorder a new sensor.

7. Looking at the FRONT of the sensor, align the sensor with the steering shaft and install into the adapter and bearing assembly.
8. Install the connector to the sensor.



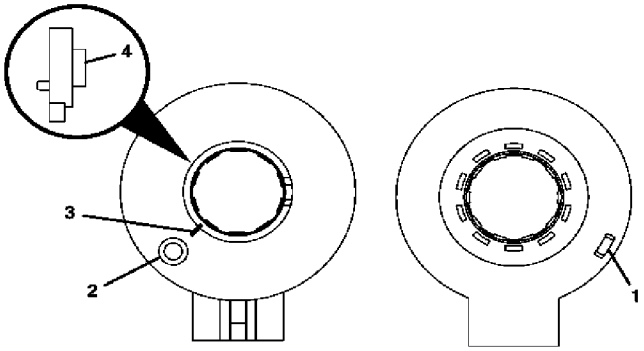


9. From the technicians point of view, the FRONT of the sensor will have:
   - A pin hole (3) for the centering pin--Note location of the pin hole.
   - A raised rotor flange cuff (5)
   - An alignment mark (4) for installation
10. From the technicians point of view, the BACK of the sensor will have:
   - Double D flats (1)
   - An alignment tab (2) for installing into the adapter and bearing assembly

Important: If reusing the existing sensor, you must align the marks on the raised rotor flange cuff before installation. The alignment mark must stay aligned until the sensor is seated into the adapter and bearing assembly.

If installing a new sensor, it will come with a pin installed in the sensor. Do not remove the pin until the sensor is seated. If the new sensor did not come with a pin installed, you must reorder a new sensor.

11. Looking at the FRONT of the sensor, align the sensor with the steering shaft and install into the adapter and bearing assembly.
12. Install the connector to the sensor.



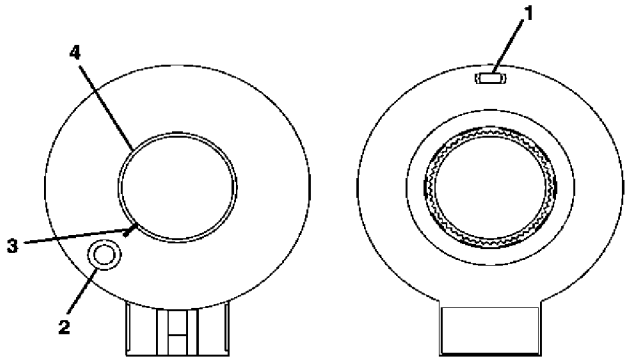


13. From the technicians point of view, the FRONT of the sensor will have:
    - A pin hole (2) for the centering pin--Note the location of the pin hole.
    - A raised rotor flange cuff (4)
    - An alignment mark (3) for installation
14. From the technicians point of view, the BACK of the sensor will have an alignment tab (1) for installation. This sensor does not have double D flats.

    Important: If reusing the existing sensor, you must align the marks on the raised rotor flange cuff before installation. The alignment mark must stay aligned until the sensor is seated into the adapter and bearing assembly.

    If installing a new sensor, it will come with a pin installed in the sensor. Do not remove the pin until the sensor is seated. If the new sensor did not come with a pin installed, you must reorder a new sensor.

15. Looking at the FRONT of the sensor, align the sensor with the steering shaft and install into the adapter and bearing assembly.
16. Install the connector to the sensor.



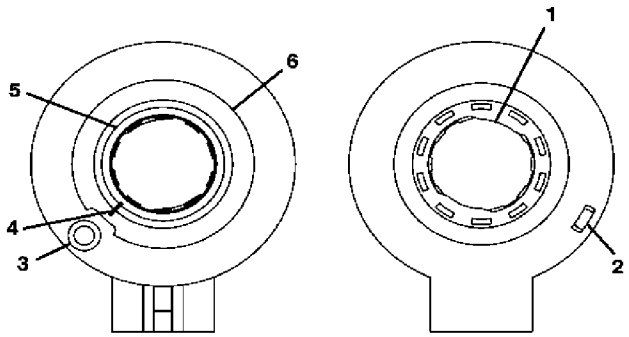


17. From the technicians point of view, the FRONT of the sensor will have:
    - A pin hole (2) for the centering pin--Note the location of the pin hole.
    - A flush rotor flange cuff (4)
    - An alignment mark (3) for installation
18. From the technicians point of view, the BACK of the sensor will have an alignment tab (1) for installation. This sensor does not have double D flats.

    Important: If reusing the existing sensor, you must align the marks on the flush rotor flange cuff before installation. The alignment mark must stay aligned until the sensor is seated into the adapter and bearing assembly.

    If installing a new sensor, it will come with a pin installed in the sensor. Do not remove the pin until the sensor is seated. If the new sensor did not come with a pin installed, you must reorder a new sensor.

19. Looking at the FRONT of the sensor, align the sensor with the steering shaft and install into the adapter and bearing assembly.
20. Install the connector to the sensor.





21. From the technicians point of view, the FRONT of the sensor will have:
    - A pin hole (3) for the centering pin--Note location of the pin hole.
    - A flush rotor flange cuff (5)
    - An alignment mark (4) for installation
    - A foam ring (6)
22. From the technicians point of view, the BACK of the sensor will have:
    - Double D flats (1)
    - An alignment tab (2) for installing into the adapter and bearing assembly

Important: If reusing the existing sensor, you must align the marks on the flush rotor flange cuff before installation. The alignment mark must stay aligned until the sensor is seated into the adapter and bearing assembly.

If installing a new sensor, it will come with a pin installed in the sensor. Do not remove the pin until the sensor is seated. If the new sensor did not come with a pin installed, you must reorder a new sensor.

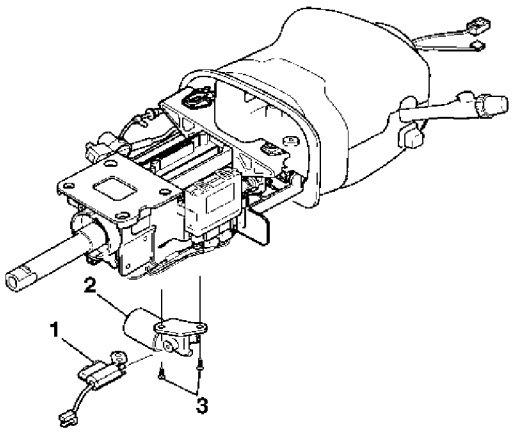
23. Looking at the FRONT of the sensor, align the sensor with the steering shaft and install into the adapter and bearing assembly.
24. Install the connector to the sensor.

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Tilt Motor Replacement

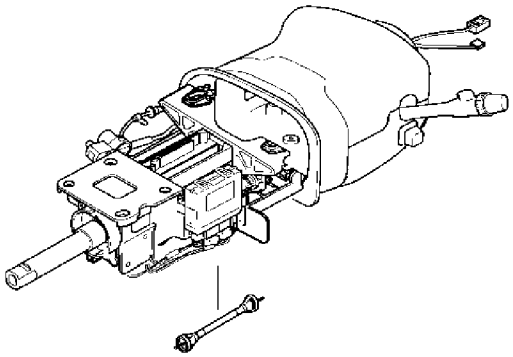
Removal Procedure

Caution: Refer to SIR Caution in the Preface section.



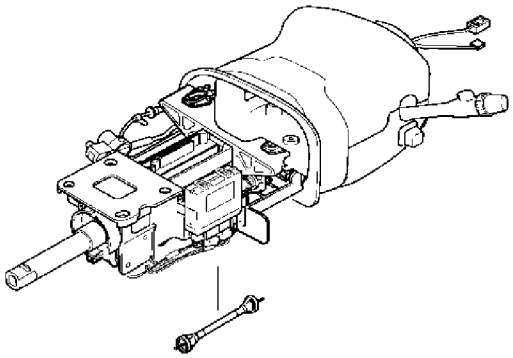
1. Disable the SIR coil. Refer to SIR Disabling and Enabling.
2. Remove the steering wheel from the column. Refer to Steering Wheel Replacement .
3. Remove the steering column from the vehicle. Refer to Steering Column Replacement .
4. Inspect the steering column for accident damage. Refer to Steering Column Accident Damage Inspection .
5. To remove the tilt drive motor assembly (2) perform the following procedure:
   5.1. Disconnect the connectors of the tilt drive motor assembly (2).
   5.2. Remove the 2 TORX® head screws (3).
   5.3. Remove the tilt drive motor assembly (2).
   5.4. Pull off the potentiometer housing (1).

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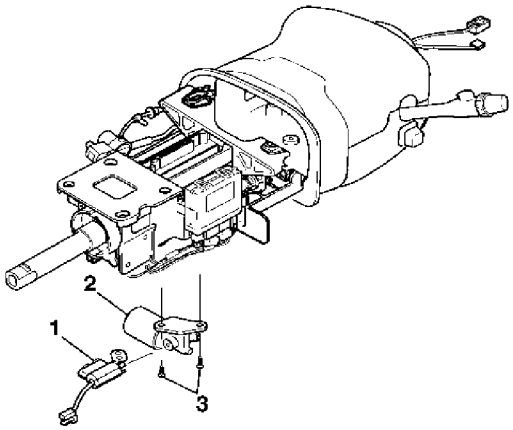


6. To remove the tilt cable assembly perform the following procedure:
   6.1. With locking pliers squeeze the white end of the tilt cable assembly to remove from the tilt drive motor assembly.
   6.2. Pull the black end to separate the tilt cable assembly from the steering column.

Installation Procedure



1. Install the black end of the tilt cable assembly to the steering column.
2. Install the white end of the tilt cable assembly to the tilt drive motor assembly.



3. Snap on the potentiometer housing. (1).
4. Install the tilt drive motor assembly (2) to the steering column.

Notice: Refer to Fastener Notice in the Preface section.

5. Install 2 TORX® head screws (3).

Tighten
Tighten the screws to 1.5 N·m (13 lb in).

Caution: Refer to SIR Inflator Module Coil Caution in the Preface section.

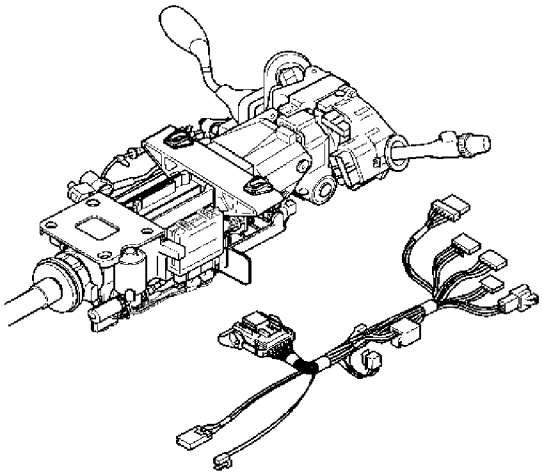
6. Connect the connectors of the tilt drive motor assembly (2).
7. Install the steering column into the vehicle. Refer to Steering Column Replacement .
8. Install the steering wheel onto the steering column. Refer to Steering Wheel Replacement .
9. Enable the SIR system. Refer to SIR Disabling and Enabling.

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Steering Column Wiring Harness Assembly Replacement

Removal Procedure

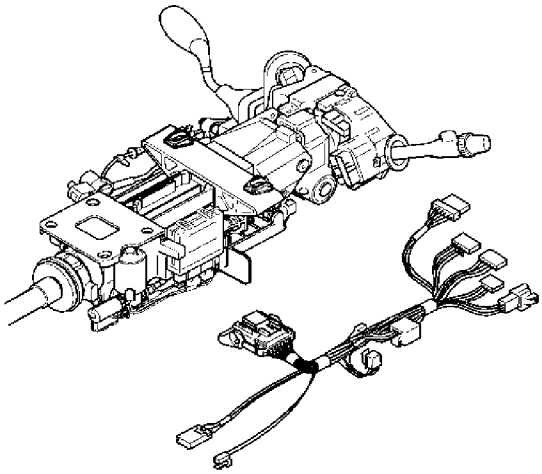
Caution: Refer to SIR Caution in the Preface section.



1. Disable the SIR coil. Refer to SIR Disabling and Enabling.
2. Remove the steering wheel from the column. Refer to Steering Wheel Replacement .
3. Remove the steering column from the vehicle. Refer to Steering Column Replacement .
4. Inspect the steering column for accident damage. Refer to Steering Column Accident Damage Inspection .
5. Remove the upper and lower trim cover. Refer to Steering Column Trim Covers Replacement .
6. Disconnect all connectors attached to the wire harness assembly.
7. Slide the bulkhead connector out from the column shift and tilt motor bracket assembly.

Installation Procedure

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Caution: Improper routing of the wire harness assembly may damage the inflatable restraint steering wheel module coil. This may result in a malfunction of the coil, which may cause personal injury.

1. Slide the bulkhead connector into the column shift and tilt motor bracket assembly.
2. Connect all of the connectors to the wire harness assembly.
3. Install the upper and lower trim cover. Refer to Steering Column Trim Covers Replacement .
4. Install the steering column into the vehicle. Refer to Steering Column Replacement .
5. Install the steering wheel onto the steering column. Refer to Steering Wheel Replacement .
6. Enable the SIR system. Refer to SIR Disabling and Enabling.

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2007 TRANSMISSION

Shift Lock Control - XLR

SCHEMATIC AND ROUTING DIAGRAMS

SHIFT LOCK CONTROL SCHEMATICS

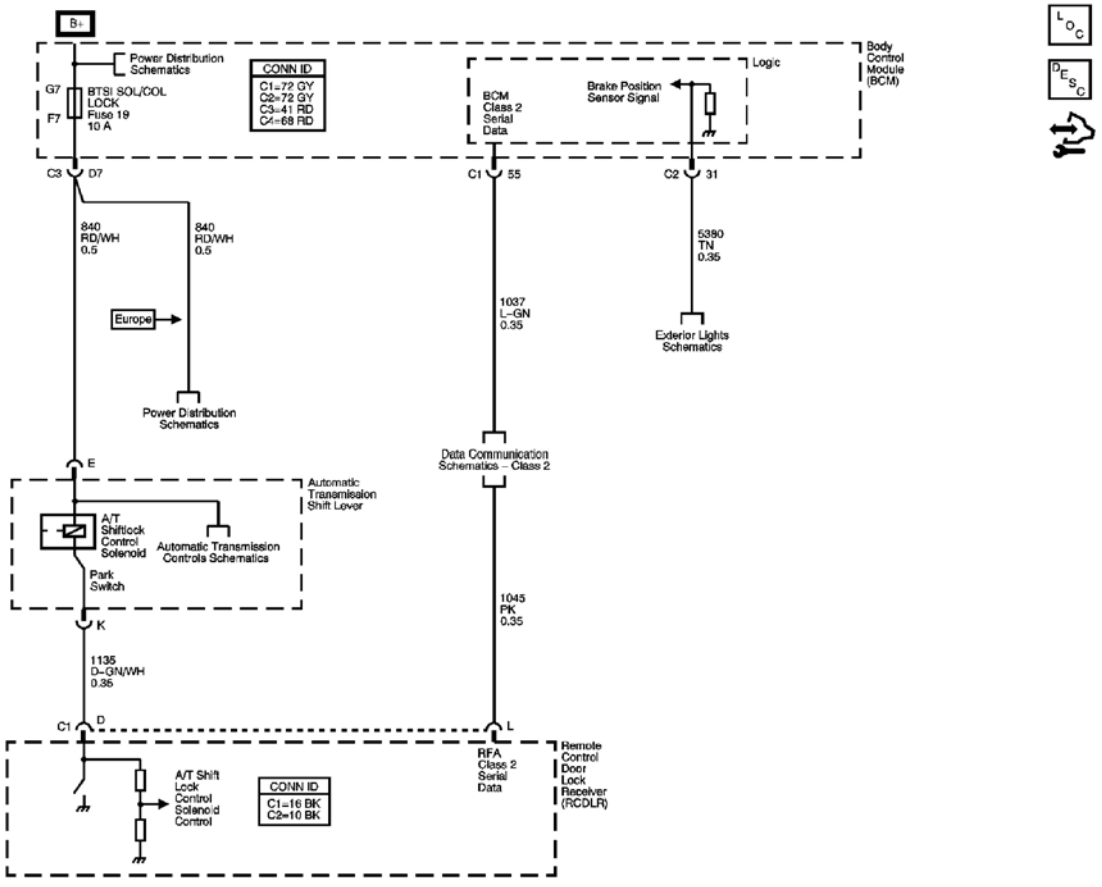


Fig. 1: Shift Lock Control Schematic
Courtesy of GENERAL MOTORS CORP.

COMPONENT LOCATOR

SHIFT LOCK CONTROL COMPONENT VIEWS

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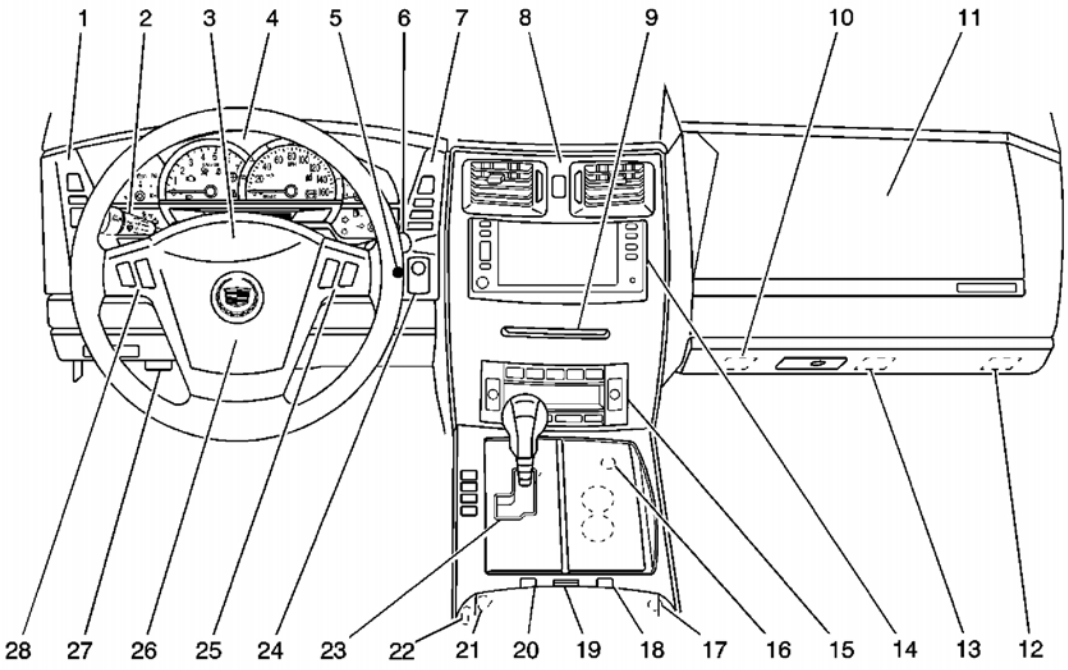


Fig. 2: Identifying Instrument Panel And Passenger Compartment Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 2

Callout	Component Name
1	Dimmer/Head Up Display (HUD) Switch
2	Turn Signal/Multifunction Switch
3	Inflatable Restraint Steering Wheel Module
4	Instrument Panel Cluster (IPC)
5	Air Temperature Sensor - Inside
6	Windshield Wiper/Washer Switch
7	Driver Information Center (DIC) Switch
8	Hazard Switch
9	CD Changer
10	Valet Switch
11	Inflatable Restraint I/P Module
12	Inflatable Restraint I/P Module Disable Switch
13	I/P Compartment Lamp
14	Radio
15	HVAC Control Module
16	Cigar Lighter
17	Courtesy Lamp Switch - Console
18	Folding Top Switch

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19	Inflatable Restraint I/P Module Disable Switch LED
20	Traction Control Switch
21	Auxiliary Power Outlet
22	Courtesy Lamp - Console
23	Automatic Transmission Shift Lever
24	Ignition Mode Switch
25	Steering Wheel Controls - Right
26	Horn Switch
27	Data Link Connector (DLC)
28	Steering Wheel Controls - Left

SHIFT LOCK CONTROL CONNECTOR END VIEWS

Automatic Transmission Shift Lever

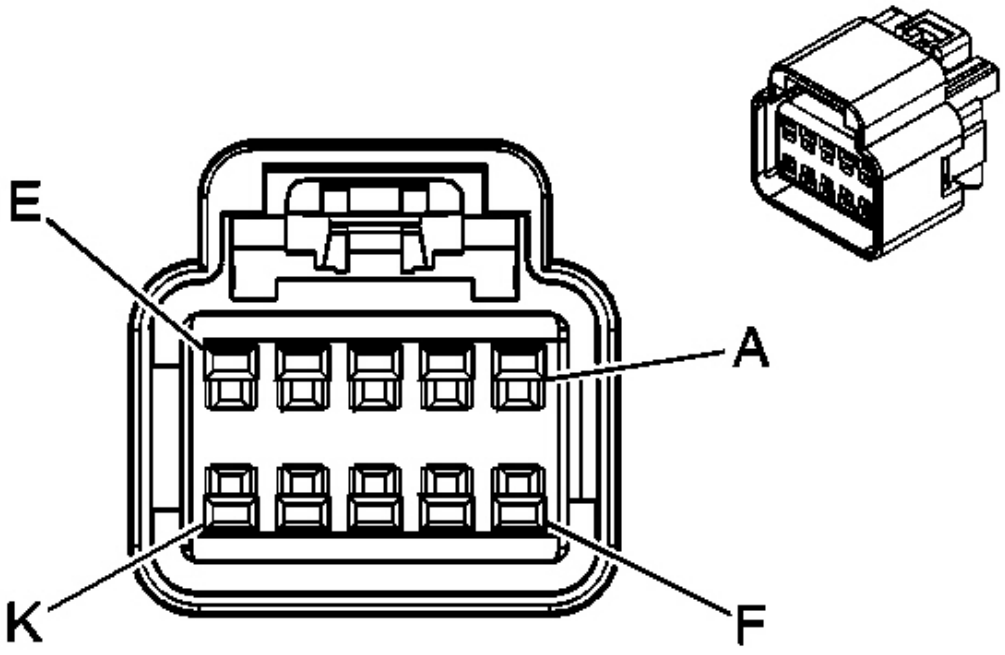


Fig. 3: Automatic Transmission Shift Lever Connector End View
Courtesy of GENERAL MOTORS CORP.

Shift Lock Control Connector Parts Information

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Connector Part Information

- OEM: 15332153
- Service: 88986440
- Description: 10-Way F GT 150 Series (BK)

Terminal Part Information

- Terminal/Tray: 12191812/19
- Core/Insulation Crimp: E/C
- Release Tool/Test Probe: 15315247/J-35616-2A (GY)

Automatic Transmission Shift Lever Connector Terminal Identification

Pin	Wire Color	Circuit No.	Function
A	D-GN	1399	RAP Relay Coil Supply Voltage
	YE	843	Accessory Voltage (Export)
B	D-GN	5525	Tap Up/Tap Down Enable Signal
C	GY/BK	1458	Instrument Panel Lamp Supply Voltage (4)
D	PK	1039	Ignition 1 Voltage
E	RD/WH	840	Battery Positive Voltage
F	D-GN/WH	1932	Shift Select Switch Park Signal
	D-GN/WH	1932	Shift Select Switch Park Signal (Export)
G	BK	1550	Ground
H	PU	5526	Tap Up/Tap Down Switch Signal
J	GY/BK	1357	Instrument Panel Lamp Control
K	D-GN/WH	1135	Brake Transmission Shift Interlock Solenoid Supply Voltage

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - AUTOMATIC TRANSMISSION SHIFT LOCK CONTROL

Begin the system diagnosis with **Diagnostic System Check - Vehicle** . The Diagnostic System Check - Vehicle will provide the following information:

- The identification of the control modules which command the system
- The ability of the control modules to communicate through the serial data circuit
- The identification of any stored diagnostic trouble codes (DTCs) and their status

The use of the Diagnostic System Check - Vehicle will identify the correct procedure for diagnosing the system and where the procedure is located.

SCAN TOOL DATA LIST

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Remote Control Door Lock Receiver (RCDLR)

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
Operating Conditions: Ignition ON, with the engine OFF. Transmission shift lever in the PARK position, Brake pedal released.			
Battery Voltage	Data	0-15 volts	12.5 volts
Ignition 1	Inputs	ON/OFF	ON
Shift Lock Solenoid Command	Data	UNLOCK/LOCK	LOCK
Shift Lock Solenoid State	Data	UNLOCK/LOCK	LOCK

Transmission Control Module (TCM)

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
Operating Conditions: Ignition ON, with the engine OFF. Transmission shift lever in the PARK position.			
IMS A/B/C/P	Transmission Data	Park, Park/Reverse, Reverse, Reverse/Neutral, Neutral, Neutral/Drive 4, Drive 4, Drive 4/Drive 3, Drive 3, Drive 3/Drive 2, Drive 2, Drive 2/Drive 1, Drive 1, Invalid, Open	PARK
TCC Brake Switch	Transmission Data	Closed/Open	Closed

SCAN TOOL DATA DEFINITIONS

Remote Control Door Lock Receiver (RCDLR)

Battery Voltage

Display indicates battery voltage. Measured in volts.

Shift Lock Solenoid Command

The scan tool displays the commanded state of the solenoid when the brake pedal is applied or released the scan tool displays LOCK/UNLOCK

Shift Lock Solenoid State

The scan tool displays LOCK/UNLOCK the actual feedback state of the shift lock solenoid monitored by the RCDLR.

Transmission Control Module (TCM)

TCC Brake Switch

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Displays ON or OFF status of the TCC Brake switch.

IMS A/B/C/P

Displays PARK/NEUTRAL/INVALID/REVERSE/DRIVE or LOW or HI for the state of each of the four inputs from the IMS. LOW displayed indicates a low voltage signal (0 volts) being monitored at the TCM. HI displayed indicates a high voltage signal (B+) being monitored at the TCM.

DTC B2710

Circuit Description

The remote control door lock receiver (RCDLR) controls the automatic transmission shift lock solenoid by providing a ground for the solenoid. The RCDLR utilizes a smart driver to control the ground to the automatic transmission shift lock solenoid. The smart driver monitors the voltage and current flow of the control circuit.

DTC Descriptor

This diagnostic procedure supports the following DTC:

DTC B2710 Gearshift Lock Circuit

Conditions for Running the DTC

- The ignition switch is in the ON position.
- The brake pedal is depressed.
- The transmission is in the PARK position.

Conditions for Setting the DTC

The RCDLR will set the code if the voltage level at the shift lock control output is greater than 8 volts for more than 0.375 second while the output is active.

Action Taken When the DTC Sets

The RCDLR will not attempt to ground the control circuit of the automatic transmission shift lock solenoid until the next key cycle.

Conditions for Clearing the DTC

- A current DTC B2710 will clear when the malfunction is no longer present and the ignition switch is cycled.
- All RCDLR history codes will clear after 100 ignition cycles with no current codes active during the 100 ignition cycles.

Diagnostic Aids

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- If the automatic transmission shift lock solenoid control circuit is shorted to ground, the automatic transmission shift lock solenoid will be inoperative. The vehicle will shift out of PARK without depressing the brake pedal.
- Perform the tests while wiggling the wires and connectors. This may often cause an intermittent malfunction to appear. Refer to **Testing for Intermittent Conditions and Poor Connections** .

Test Description

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

2: Listen for an audible click when the automatic transmission shift lock solenoid operates.

3: Tests for voltage at the ignition 1 voltage circuit of the automatic transmission shift lock control solenoid.

4: Verifies that the RCDLR is providing a ground to the automatic transmission shift lock solenoid.

5: Tests if ground is constantly being applied to the automatic transmission shift lock solenoid.

DTC B2710

Step	Action	Yes	No
Schematic Reference: Shift Lock Control Schematics **Connector End View Reference: Shift Lock Control Connector End Views** or **Remote Function Connector End Views**			
1	Did you perform the Diagnostic System Check - Vehicle?	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Install a scan tool. 2. Press and release the brake pedal several times. 3. With a scan tool, observe the shift lock solenoid command parameter in the remote control door lock receiver (RCDLR) data list. Does the shift lock solenoid command parameter change from UNLOCK/LOCK each time the brake pedal is applied and released?	Go to **Testing for Intermittent Conditions and Poor Connections**	Go to **Step 3**
3	1. Turn OFF the ignition. 2. Disconnect the automatic transmission shift lock solenoid. 3. Connect a test lamp between the shift lock solenoid supply voltage circuit at the connector of the shift lock solenoid and a good ground. 4. Turn ON the ignition, with the engine OFF.		

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	Does the test lamp illuminate?	Go to **Step 4**	Go to **Step 10**
4	1. Turn ON the ignition, with the engine OFF. 2. Connect a test lamp between the shift lock solenoid supply voltage circuit and the shift lock solenoid control circuit at the connector of the shift lock solenoid. 3. Press and release the brake pedal several times. Does the test lamp turn ON and OFF each time the brake pedal is applied and released ?	Go to **Step 8**	Go to **Step 5**
5	Does the test lamp remain illuminated?	Go to **Step 6**	Go to **Step 7**
6	Test the control circuit of the automatic transmission shift lock solenoid for a short to ground. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 9**
7	Test the control circuit of the automatic transmission shift lock solenoid for a open or a short to battery voltage. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 9**
8	Inspect for poor connections at the harness connector of the automatic transmission shift lock solenoid. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 11**
9	Inspect for poor connections at the harness connector of the remote control door lock receiver (RCDLR). Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
10	Repair the open or short to ground in the automatic transmission shift lock solenoid supply voltage circuit. Refer to **Circuit Testing** and **Wiring Repairs** . Did you complete the repair?	Go to **Step 13**	-
11	Replace the automatic transmission floor shift control. Refer **Automatic Transmission Control Replacement** . Did you complete the replacement?	Go to **Step 12**	-
	Replace the RCDLR. Refer to **Control Module References** for replacement, setup and		

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12	programming. Did you complete the replacement?	Go to **Step 12**	-
13	1. Use the scan tool in order to clear the DTCs. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC reset?	Go to **Step 2**	System OK

SYMPTOMS - AUTOMATIC TRANSMISSION SHIFT LOCK CONTROL

IMPORTANT: The following steps must be completed before using the symptom tables.

1. Perform the **Diagnostic System Check - Vehicle** before using the Symptom Tables in order to verify that all of the following are true:
   - There are no DTCs set.
   - The control modules can communicate via the serial data link.
2. Review the system operation in order to familiarize yourself with the system functions. Refer to **Automatic Transmission Shift Lock Control Description and Operation**.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the automatic transmission shift lock control. Refer to **Checking Aftermarket Accessories** .
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

Intermittent

Faulty electrical connections or wiring may be the cause of intermittent conditions. Refer to **Testing for Intermittent Conditions and Poor Connections** .

Symptom List

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

- **Shift Lever Does Not Move with Brake Pedal Depressed**
- **Shift Lever Can Be Moved without Brake Pedal Depressed**

SHIFT LEVER DOES NOT MOVE WITH BRAKE PEDAL DEPRESSED

Shift Lever Does Not Move with Brake Pedal Depressed

Step	Action	Yes	No
Schematic Reference: Shift Lock Control Schematics			

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Connector End View Reference: **Shift Lock Control Connector End Views** or **Remote Function Connector End Views**

DEFINITION: Transmission shift lever does not move out of the PARK position with the ignition ON and the brake pedal depressed.

1	Did you perform the Diagnostic System Check - Vehicle?	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Apply the parking brake and block the wheels. 2. Turn ON the ignition, with the engine OFF. 3. Press and hold the brake pedal, attempt to move the shift lever out of the PARK position. Does the shift lever move out of the PARK position?	Go to **Testing for Intermittent Conditions and Poor Connections**	Go to **Step 3**
3	1. Turn OFF the ignition. 2. Install a scan tool. 3. Turn ON the ignition, with the engine OFF. 4. Press and hold the brake pedal. 5. With a scan tool, observe the Shift Lock Solenoid Command parameter in the remote control door lock receiver (RCDLR) data list. Does the scan tool display an Unlocked status?	Go to **Step 5**	Go to **Step 4**
4	With a scan tool, observe the Stop Lamp Status parameter in the body control module (BCM) data list. Does the brake switch status indicate ON?	Go to **Step 8**	Go to **Stop Lamps Malfunction**
5	1. Turn OFF the ignition. 2. Connect a test lamp at the shift lock solenoid supply voltage circuit at the connector of the shift lock solenoid and a good ground. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	Go to **Step 6**	Go to **Step 10**
	1. Turn OFF the ignition. 2. Disconnect the harness connector of the automatic transmission shift lock solenoid. 3. Connect a test lamp between the shift lock solenoid supply voltage circuit and the shift		

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6	lock solenoid control circuit at the connector of the shift lock solenoid. 4. Turn ON the ignition, with the engine OFF. 5. Press and release the brake pedal several times. Does the test lamp turn ON and OFF with each command?	Go to **Step 8**	Go to **Step 7**
7	Test the control circuit of the automatic transmission shift lock solenoid for an open or short to voltage. Refer to **Circuit Testing** and **Wiring Repairs** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 9**
8	Inspect for poor connections at the harness connector of the automatic transmission shift lock control solenoid. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 11**
9	Inspect for poor connections at the harness connector of the RCDLR. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
10	Repair the open or short to ground in the automatic transmission shift lock solenoid voltage supply circuit. Refer to **Circuit Testing** and **Wiring Repairs** . Did you complete the repair?	Go to **Step 13**	-
11	Replace the automatic transmission floor shift control. Refer to **Automatic Transmission Control Replacement** . Did you complete the replacement?	Go to **Step 13**	-
12	Replace the RCDLR. Refer to **Control Module References** for replacement, setup and programming. Did you complete the replacement?	Go to **Step 13**	-
13	Operate the system in order to verify the repair. Did you find and correct the condition?	System OK	Go to **Step 2**

SHIFT LEVER CAN BE MOVED WITHOUT BRAKE PEDAL DEPRESSED

Shift Lever Can Be Moved without Brake Pedal Depressed

Step	Action	Yes	No
Schematic Reference: Shift Lock Control Schematics			

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Connector End View Reference: **Shift Lock Control Connector End Views** or **Remote Function Connector End Views**

DEFINITION: Transmission shift lever does not lock in the PARK position with the ignition ON and the brake pedal not depressed.

1	Did you perform the Diagnostic System Check - Vehicle?	Go to **Step 2**	Go to **Diagnostic System Check - Vehicle**
2	1. Apply the parking brake and block the wheels. 2. Turn ON the ignition, with the engine OFF. 3. Attempt to move the shift lever out of the PARK position without pressing the brake pedal. Does the shift lever move out of the PARK position?	Go to **Step 3**	Go to **Testing for Intermittent Conditions and Poor Connections**
3	1. Turn OFF the ignition. 2. Install a scan tool. 3. Turn ON the ignition, with the engine OFF. 4. Ensure brake pedal is released. 5. With a scan tool, observe the shift lock solenoid command parameter in the remote control door lock receiver (RCDLR) data list. Does the scan tool display a Lock status?	Go to **Step 4**	Go to **Step 5**
4	With a scan tool, observe the Stop Lamp Status parameter in the body control module (BCM) data list. Does the Stop Lamp Status indicate OFF?	Go to **Step 8**	Go to **Stop Lamps Malfunction**
5	1. Turn OFF the ignition. 2. Disconnect the electrical connector of the shift lock solenoid. 3. Apply the parking brake and block the wheels. 4. Turn ON the ignition, with the engine OFF. 5. Attempt to move the shift lever out of the PARK position. Does the shift lever move out of the park position?	Go to **Step 7**	Go to **Step 6**
6	Test the shift lock solenoid control circuit for a short to ground. Refer to **Circuit Testing** and		

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	Wiring Repairs . Did you find and correct the condition?	Go to **Step 11**	Go to **Step 8**
7	Inspect for poor connections at the harness connector of the automatic transmission shift lock solenoid. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 11**	Go to **Step 9**
8	Inspect for poor connections at the harness connector of the RCDLR. Refer to **Testing for Intermittent Conditions and Poor Connections** and **Connector Repairs** . Did you find and correct the condition?	Go to **Step 11**	Go to **Step 10**
9	Replace the automatic transmission floor shift control. Refer to **Automatic Transmission Control Replacement** . Did you complete the replacement?	Go to **Step 11**	-
10	Replace the RCDLR. Refer to **Control Module References** for replacement, setup and programming. Did you complete the replacement?	Go to **Step 11**	-
11	Operate the system in order to verify the repair. Did you find and correct the condition?	System OK	Go to **Step 2**

DESCRIPTION AND OPERATION

AUTOMATIC TRANSMISSION SHIFT LOCK CONTROL DESCRIPTION AND OPERATION

The automatic transmission shift lock control system is a safety device that prevents an inadvertent shift out of PARK when the engine is running. The driver must press the brake pedal before moving the shift lever out of the PARK position. The system consists of the following components:

- The automatic transmission shift lock control solenoid
- The remote control door lock receiver (RCDLR)
- The transmission control module (TCM)

With the ignition in the ON position, battery positive voltage is supplied to the automatic transmission shift lock control solenoid located within the shift lever assembly. The automatic transmission shift lock control solenoid receives a ground from the RCDLR. The RCDLR receives input thought data communications from the TCM indicating transmission gear position and brake pedal position. With the shift lever in the PARK position the internal park switch of the shift lever assembly closes allowing current to flow to the RCDLR. When the RCDLR receives a data communication that the brake pedal is depressed and the transmission is in the PARK position the RCDLR supplies a ground the shift lock control solenoid control circuit. This energizes the solenoid and allows the shift lever to be moved out of the PARK position. With the shift lever out of the PARK position the internal park switch in the shift lever assemble opens, this de-energies the shift lock control

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solenoid.

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2007 SYSTEM WIRING DIAGRAMS

Cadillac - XLR

USING MITCHELL1'S WIRING DIAGRAMS

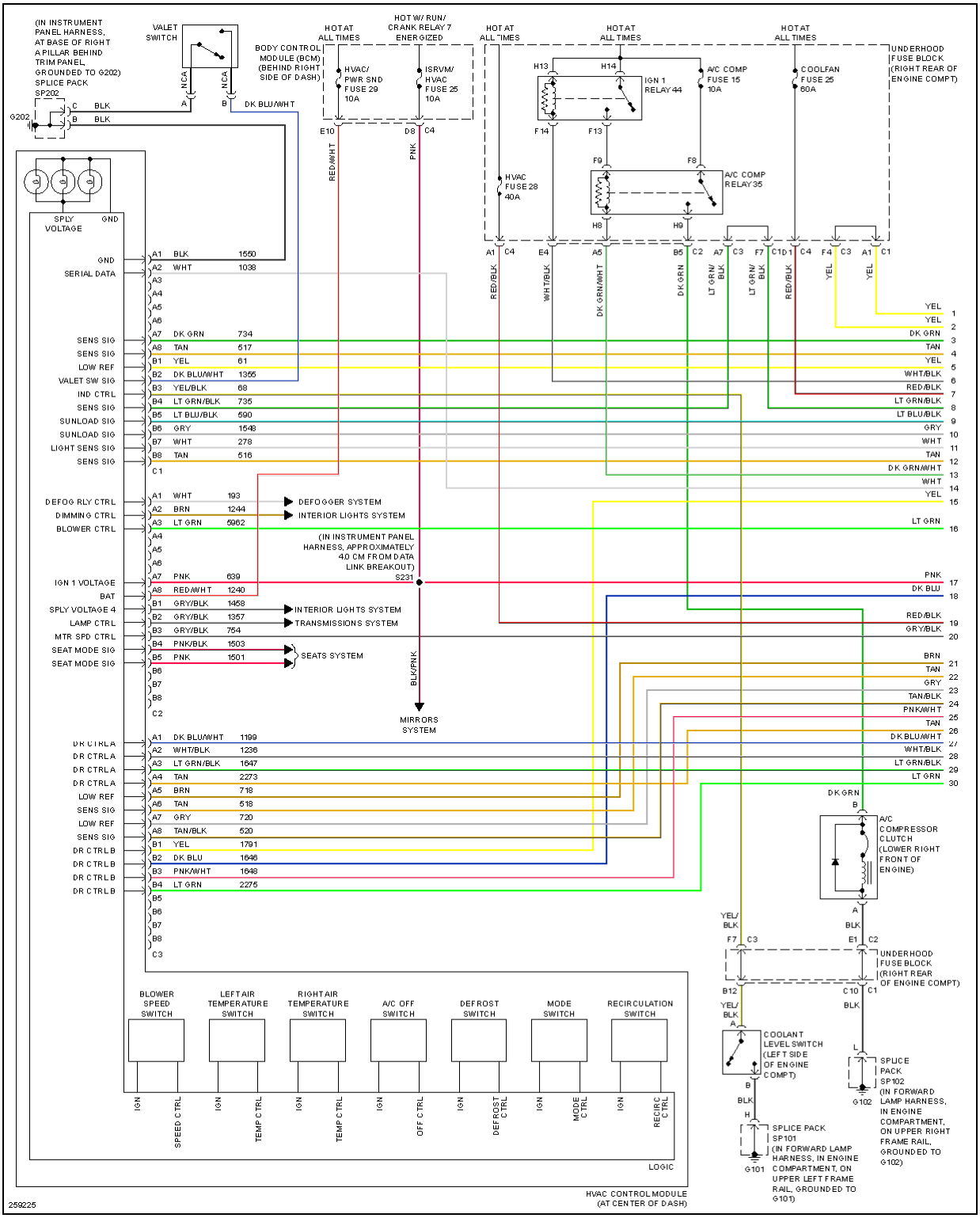
For information on using these wiring diagrams, see **USING MITCHELL1'S SYSTEM WIRING DIAGRAMS** article.

AIR CONDITIONING

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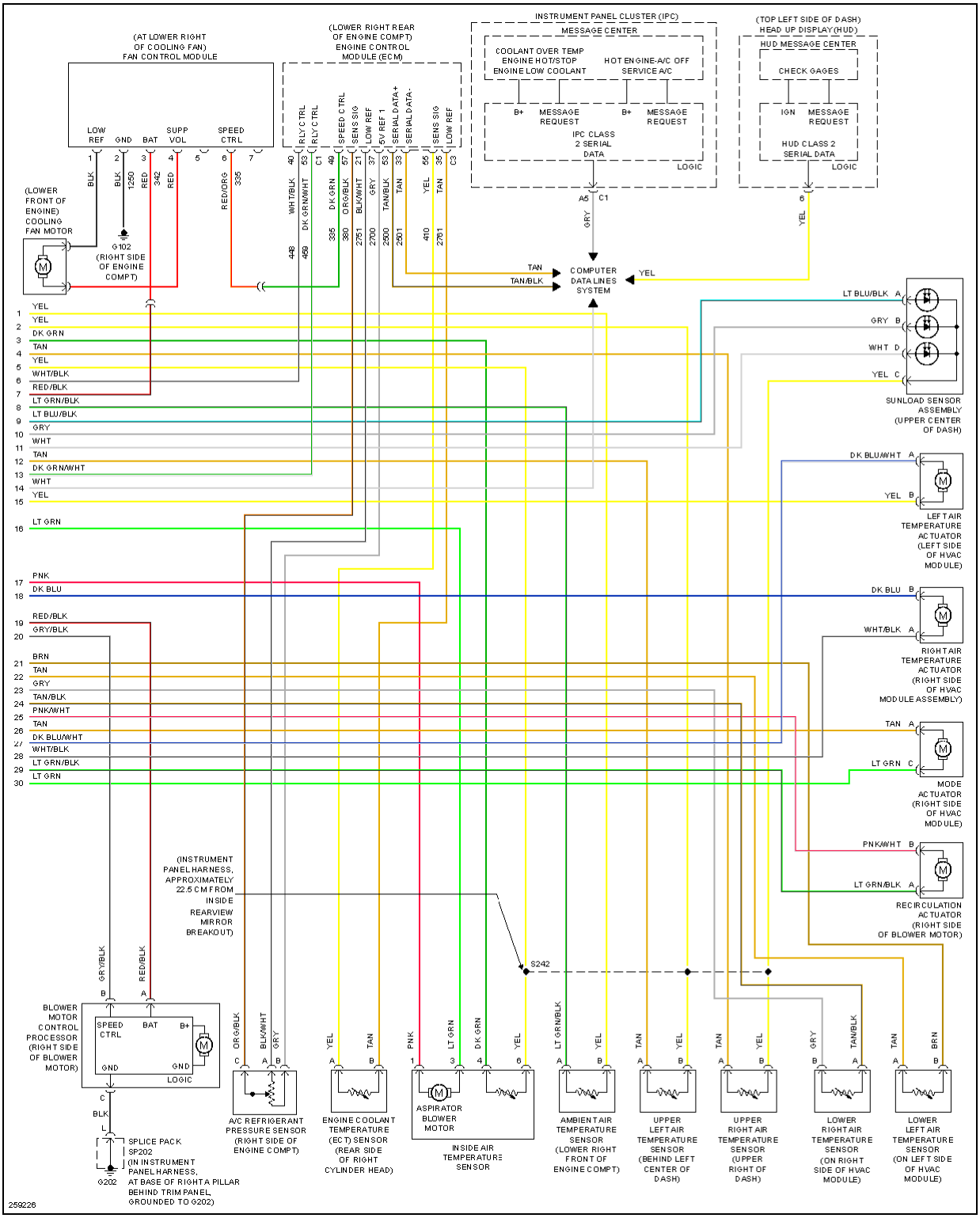
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Fig. 1: Automatic A/C Circuit (1 of 2)

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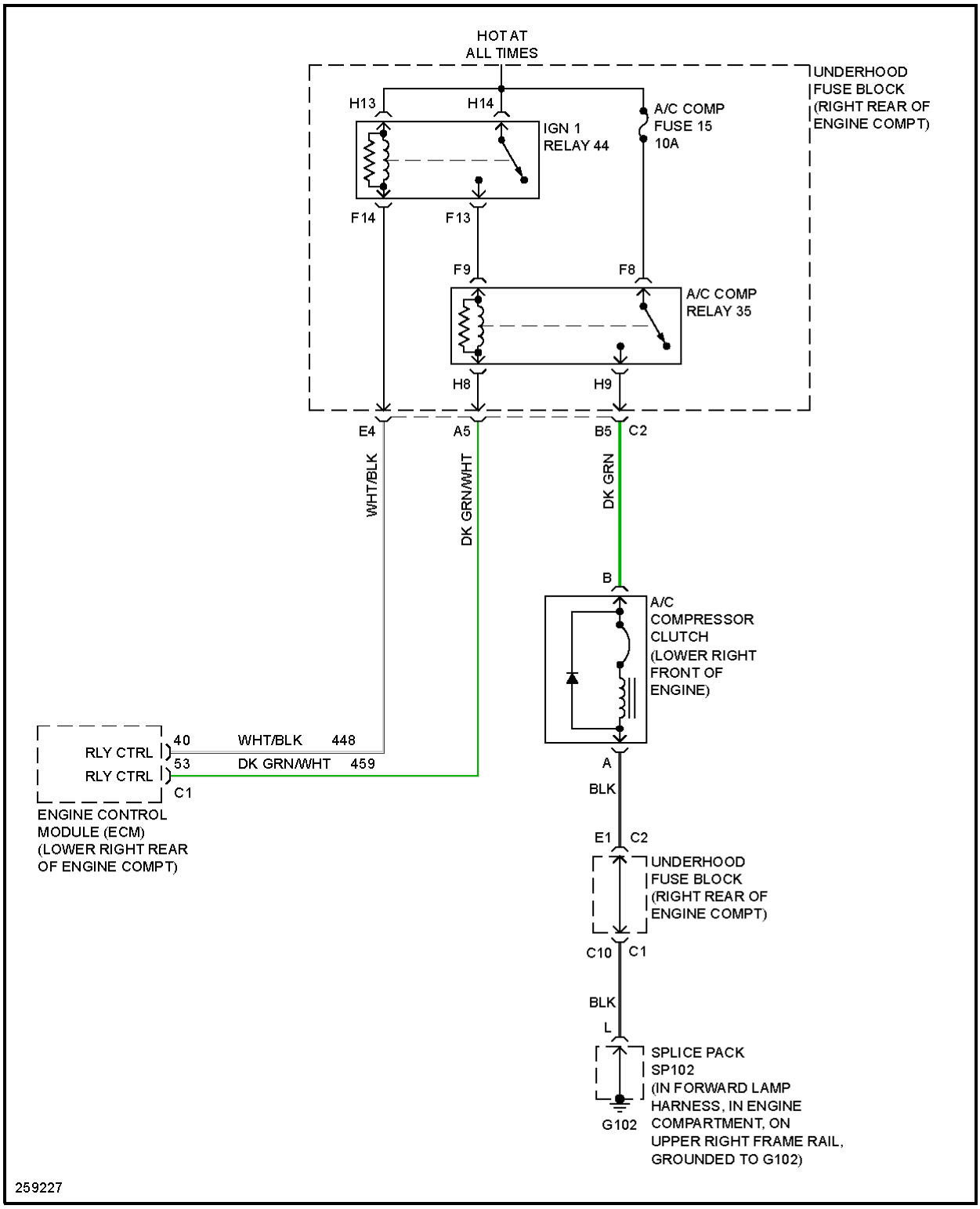
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Fig. 2: Automatic A/C Circuit (2 of 2)

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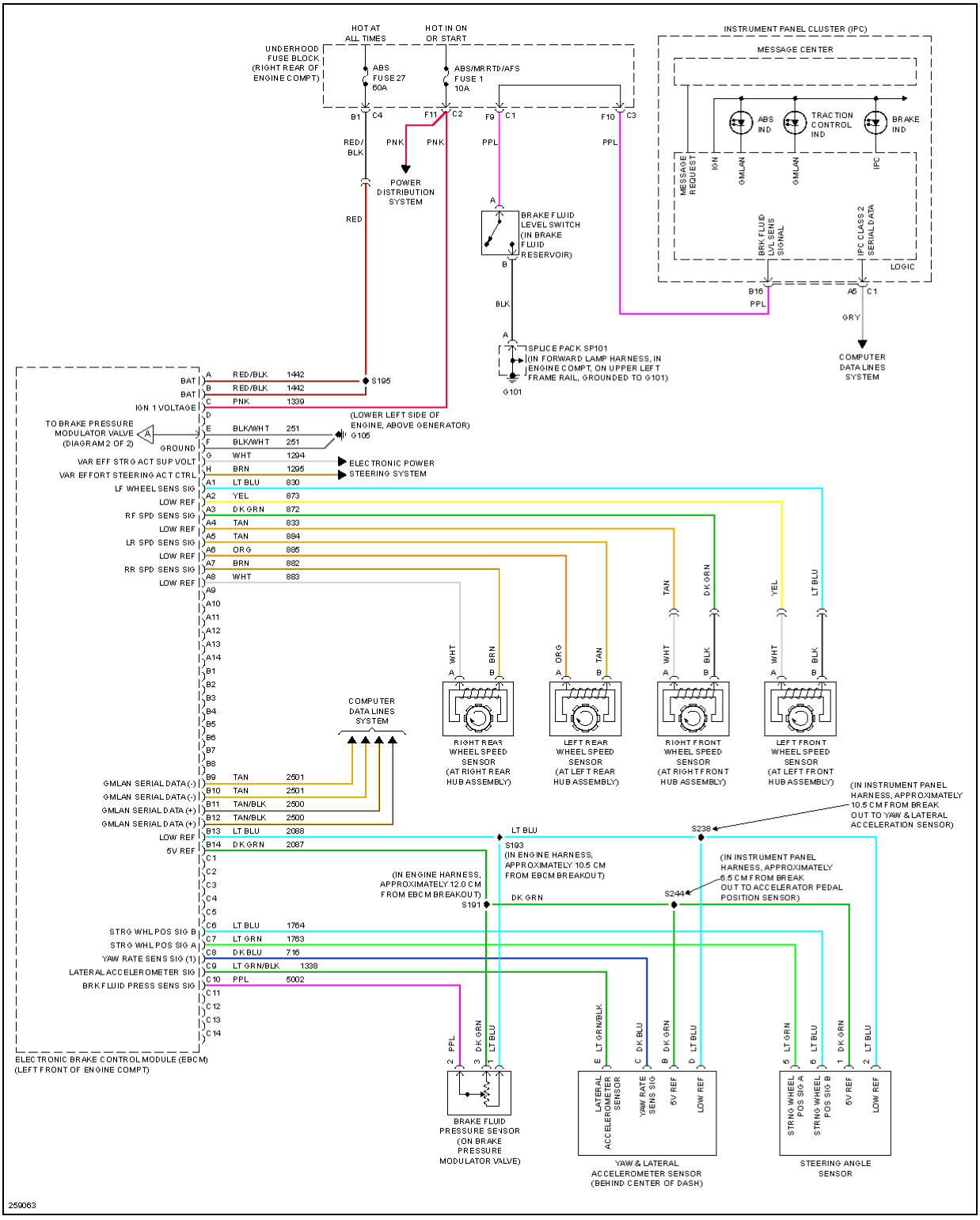
Fig. 3: Compressor Circuit

ANTI-LOCK BRAKES

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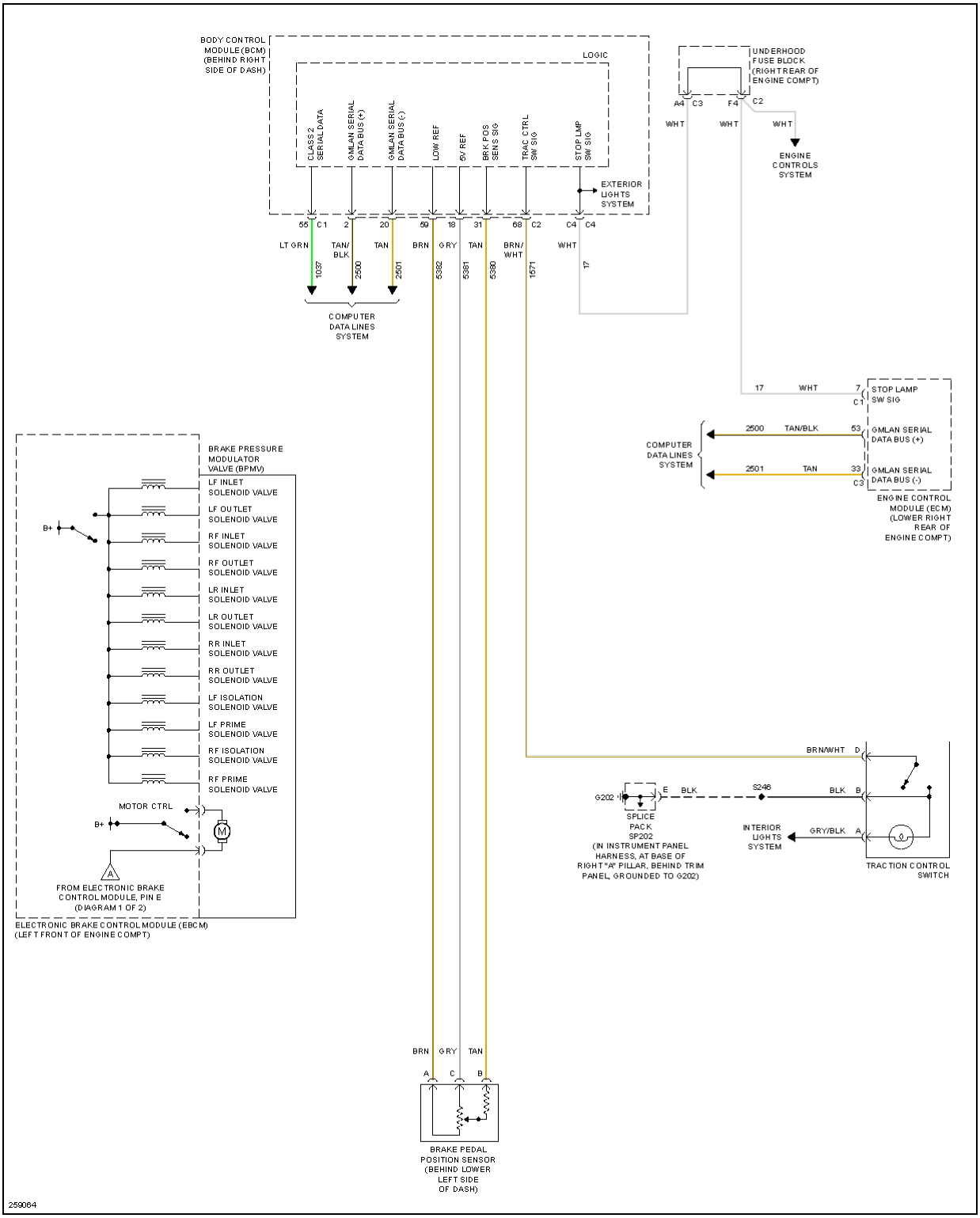
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Fig. 4: Anti-lock Brakes Circuit (1 of 2)

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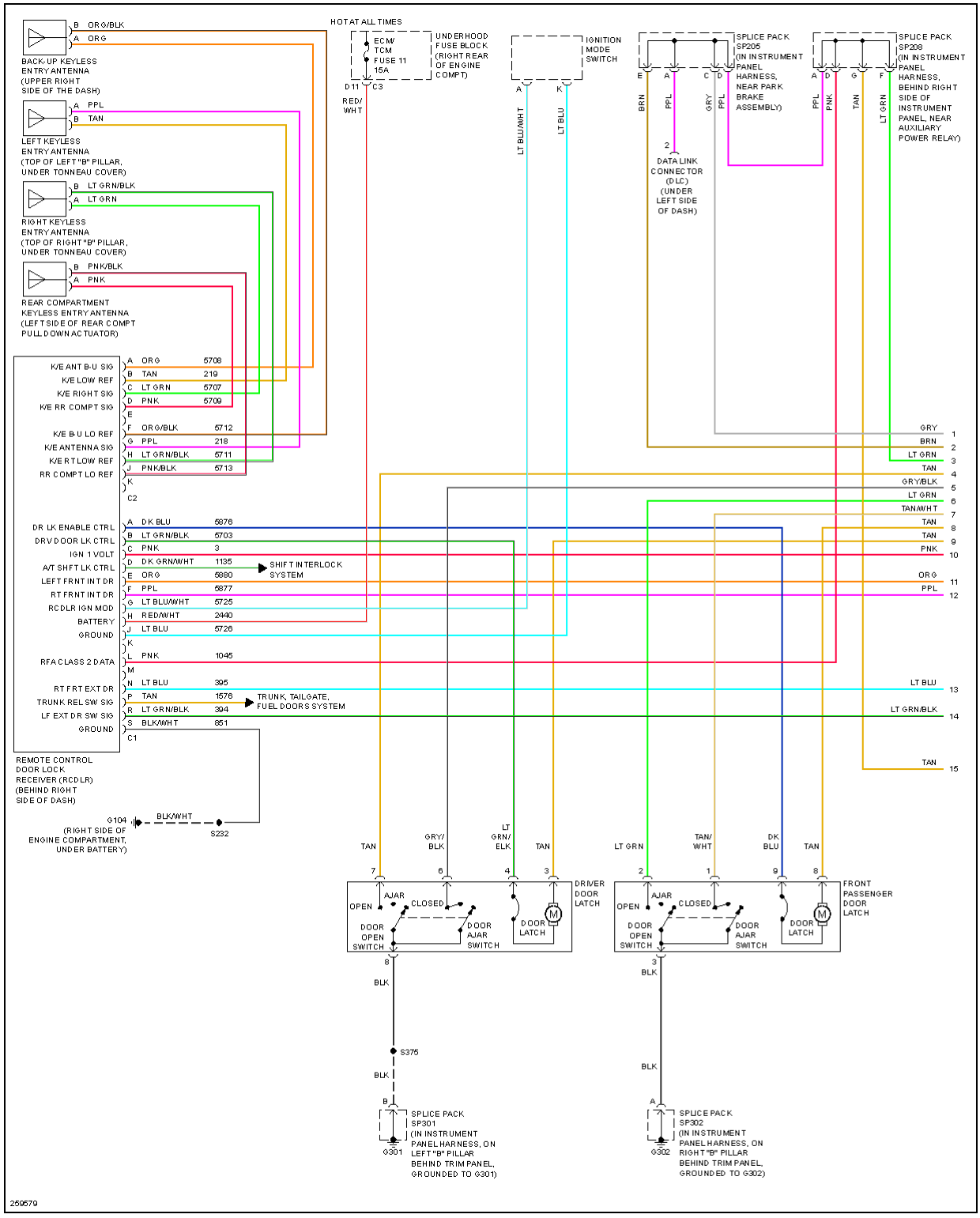
Fig. 5: Anti-lock Brakes Circuit (2 of 2)

ANTI-THEFT

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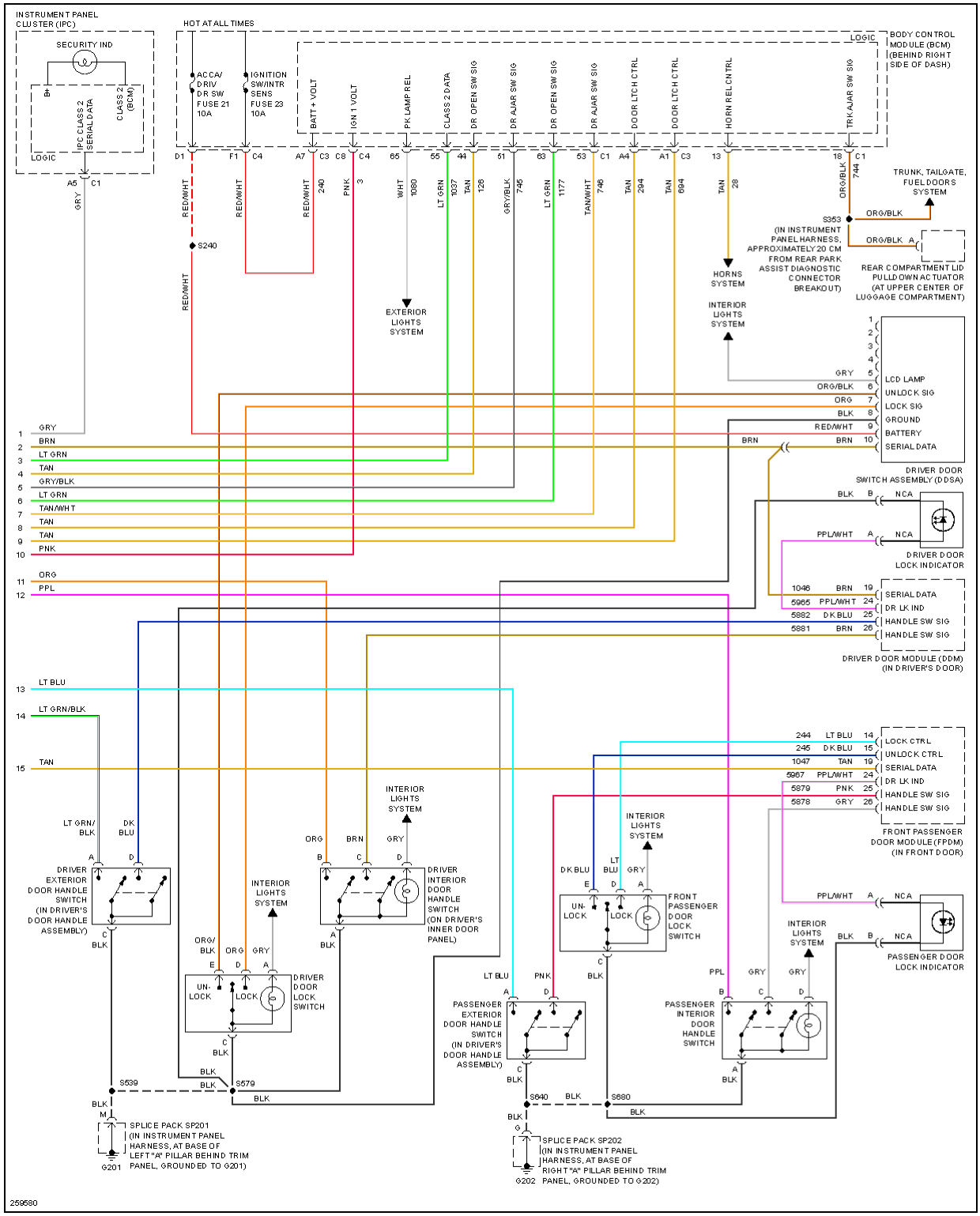
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Fig. 6: Anti-theft Circuit (1 of 2)

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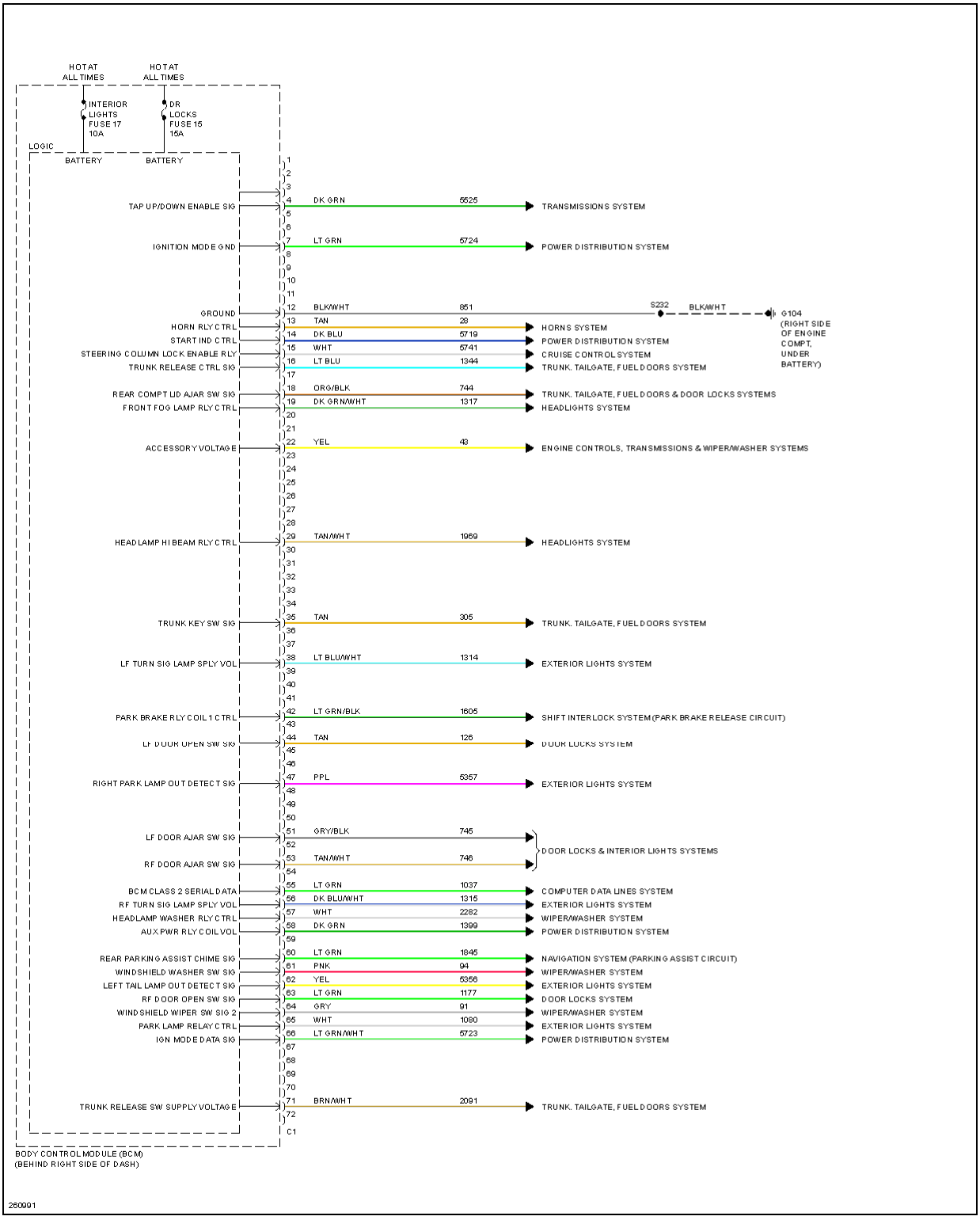


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Fig. 7: Anti-theft Circuit (2 of 2)

BODY CONTROL MODULES

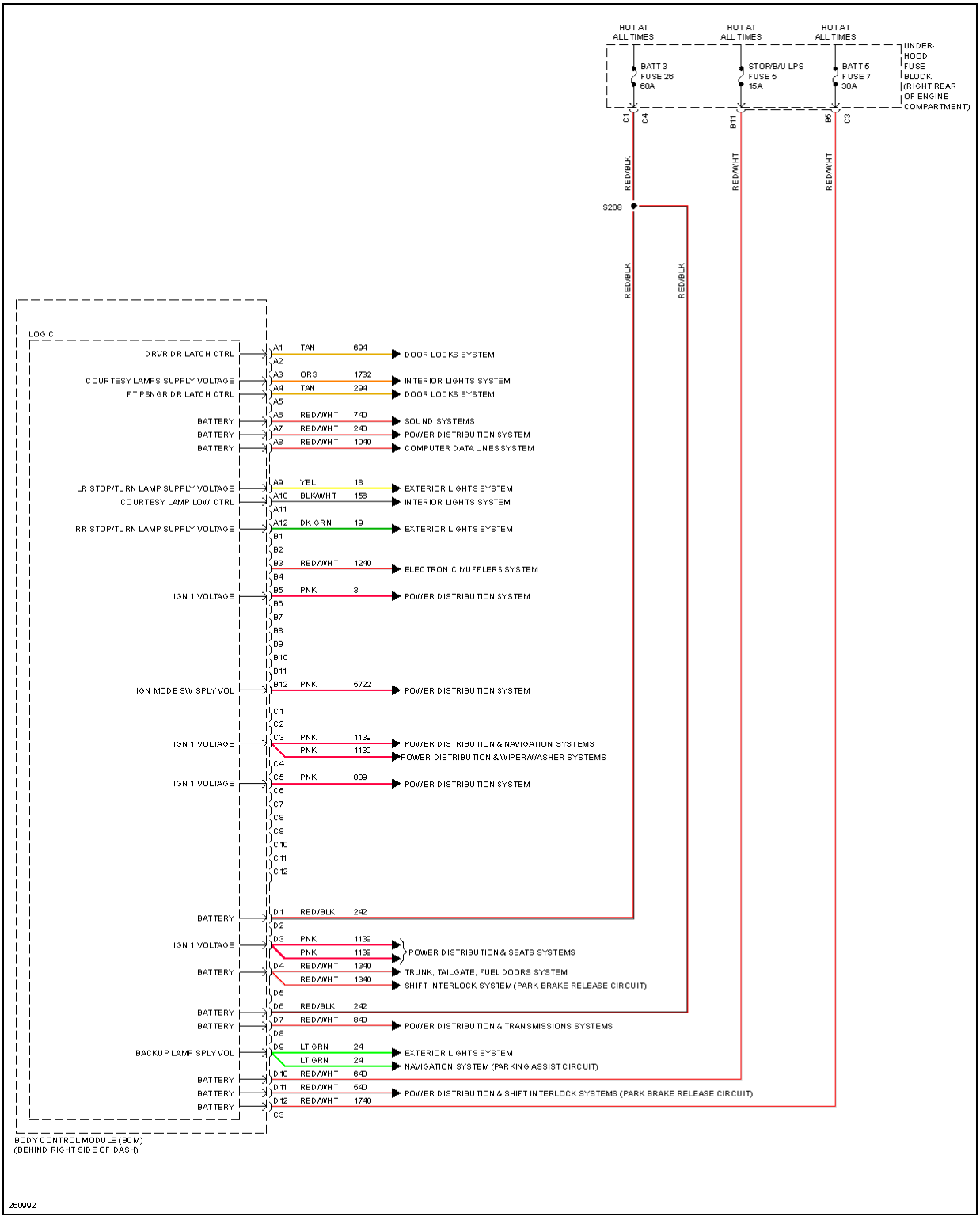
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Fig. 8: Body Control Modules Circuit (1 of 4)

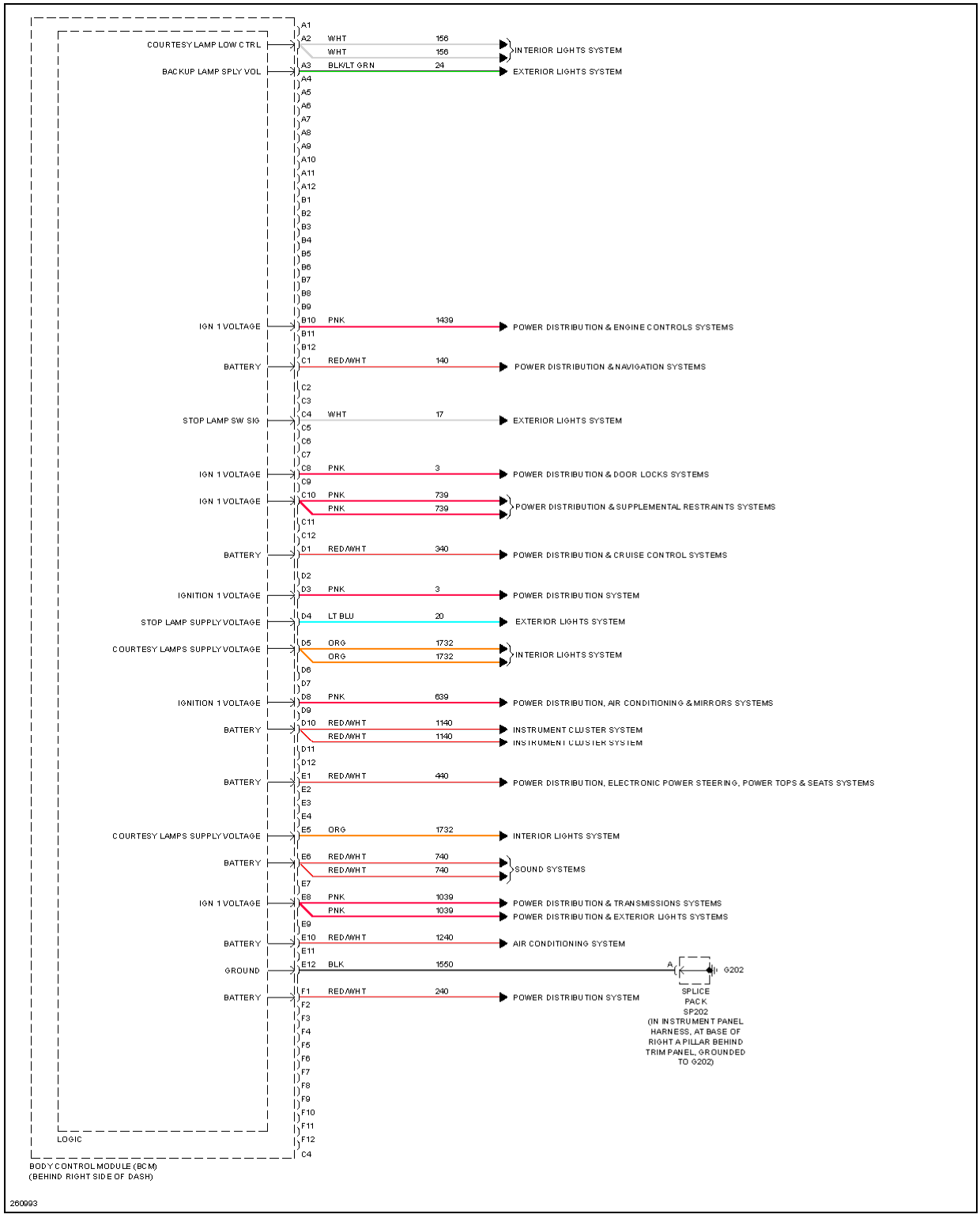
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Fig. 9: Body Control Modules Circuit (2 of 4)

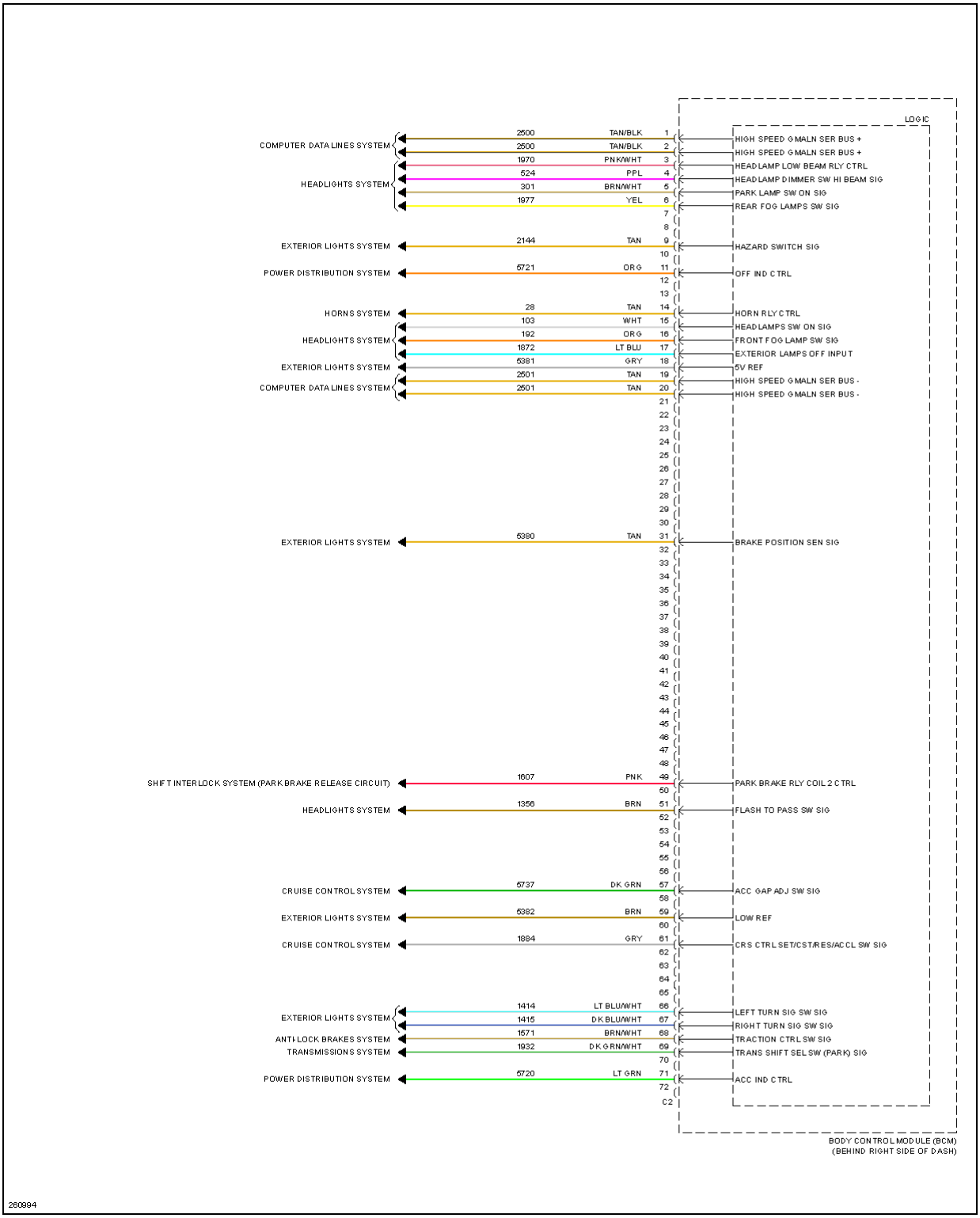
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Fig. 10: Body Control Modules Circuit (3 of 4)

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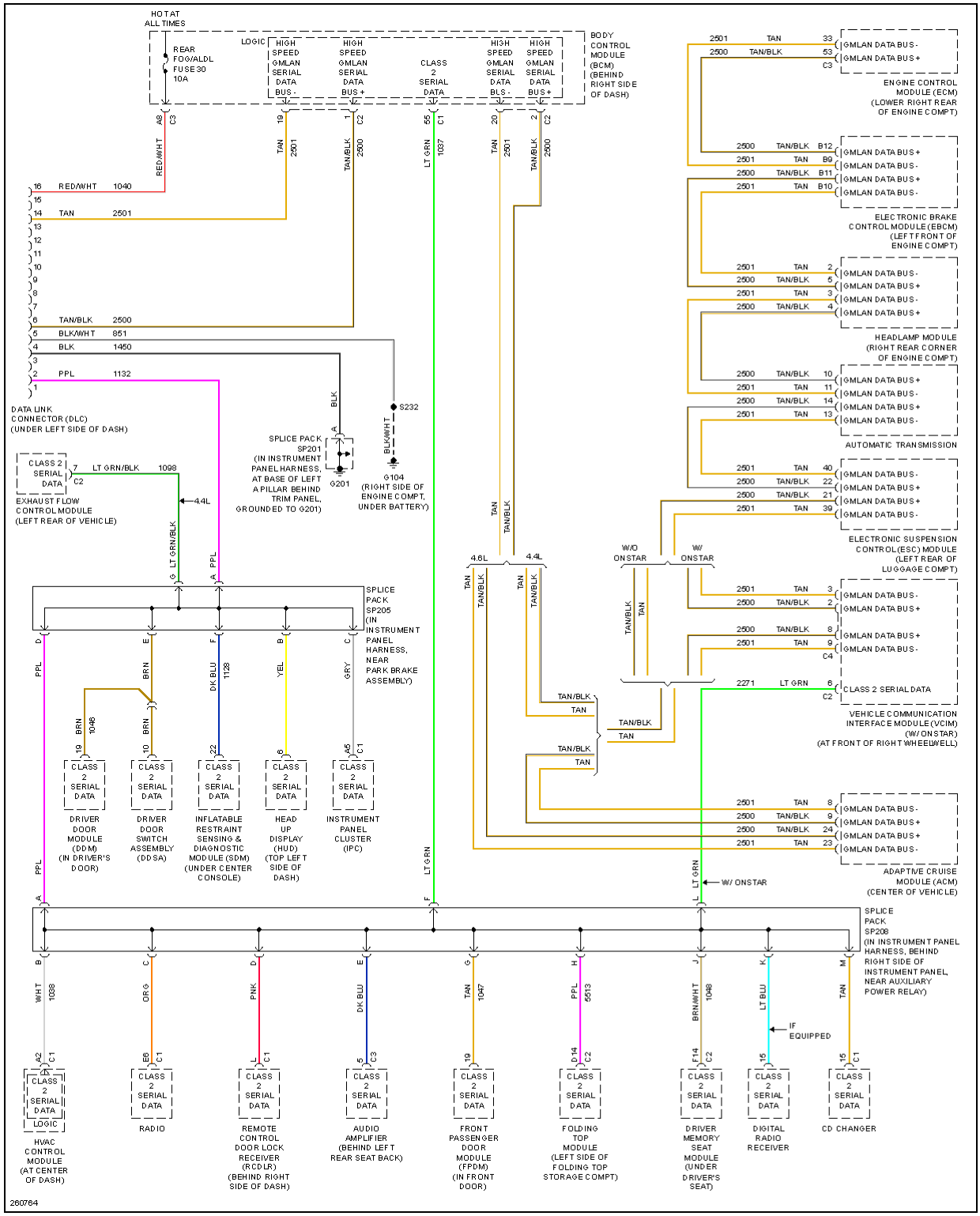
Fig. 11: Body Control Modules Circuit (4 of 4)

COMPUTER DATA LINES

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2007 SYSTEM WIRING DIAGRAMS Cadillac - XLR

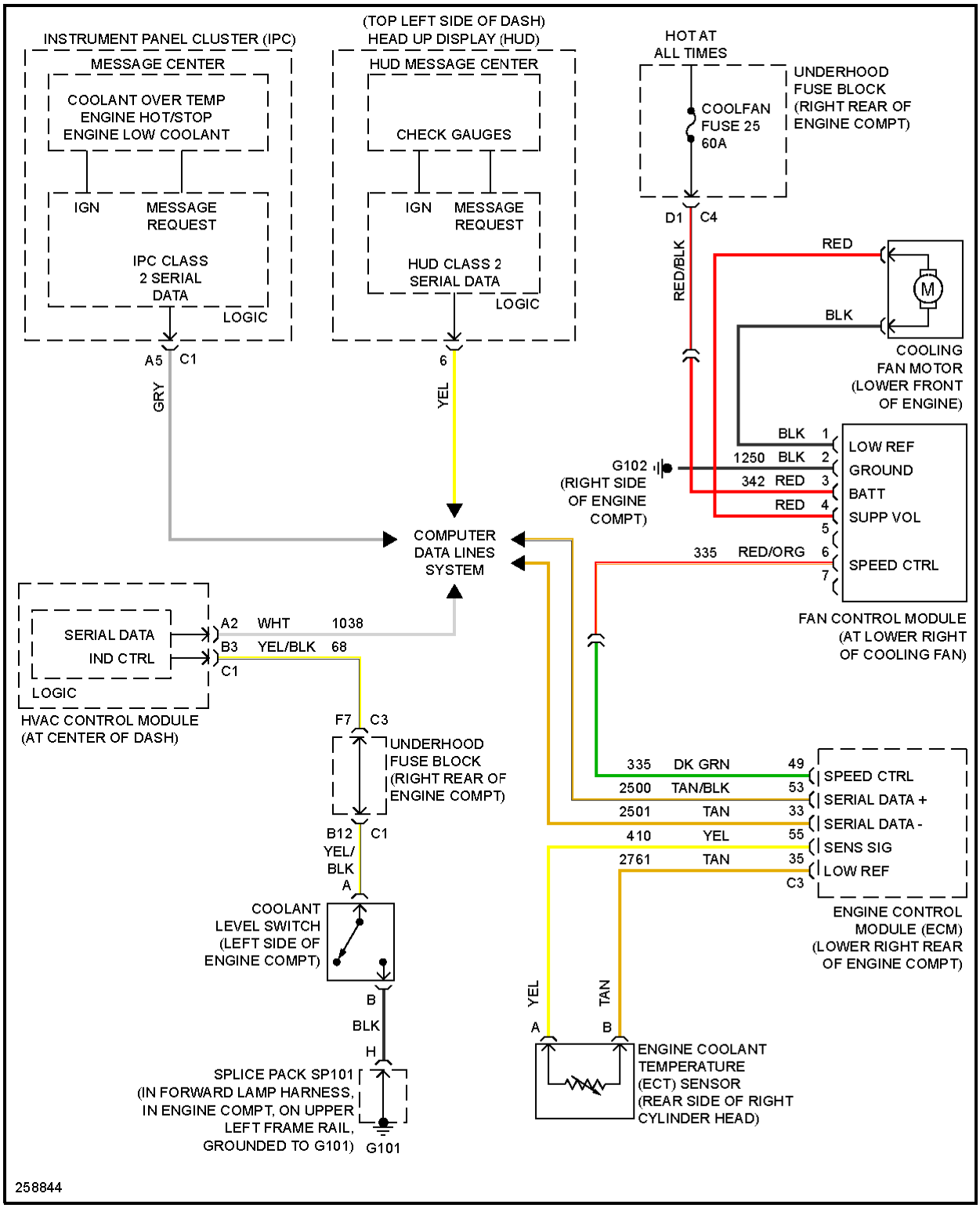


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Fig. 12: Computer Data Lines Circuit

COOLING FAN

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Fig. 13: Cooling Fan Circuit

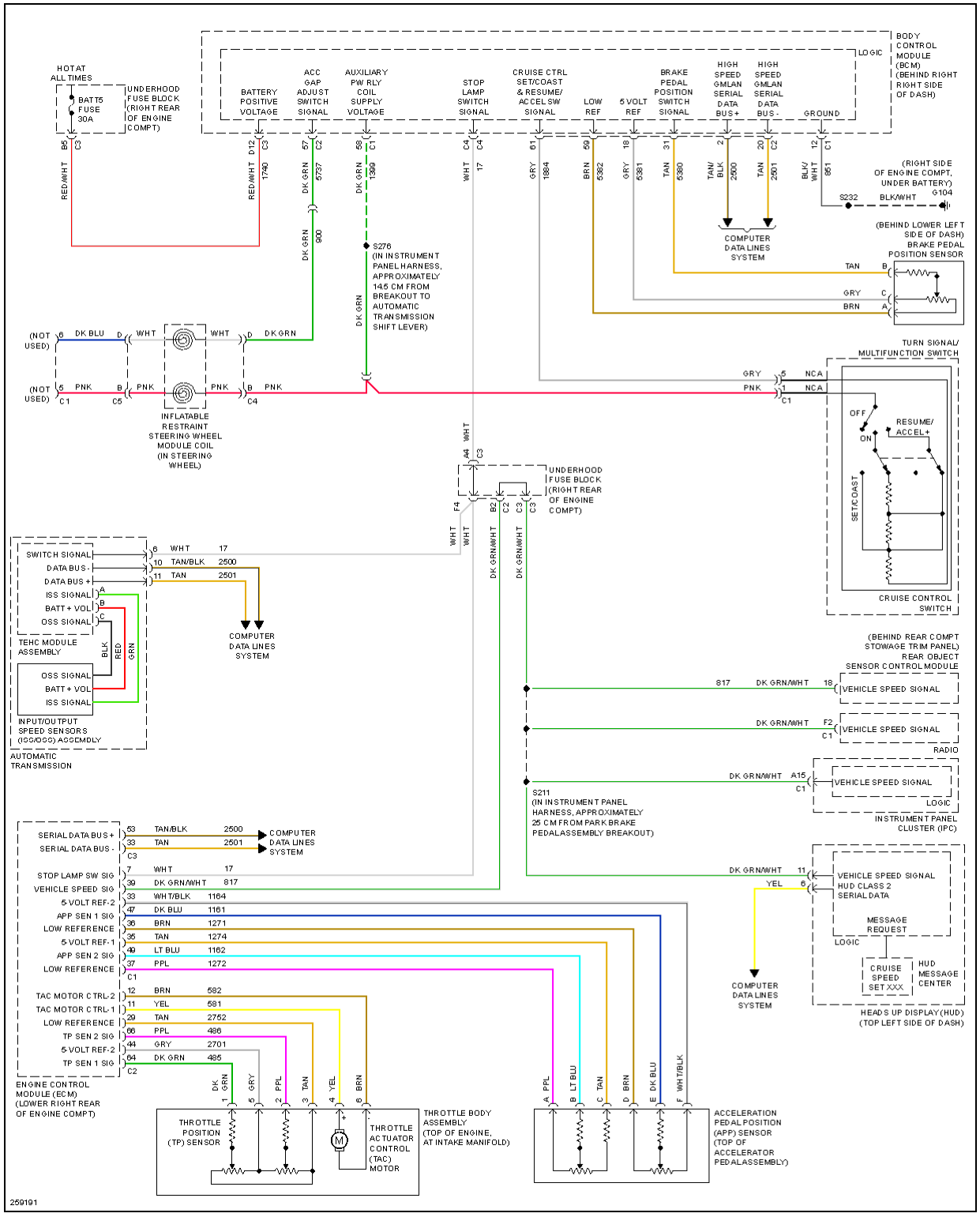
CRUISE CONTROL

4.4L VIN D

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2007 SYSTEM WIRING DIAGRAMS Cadillac - XLR



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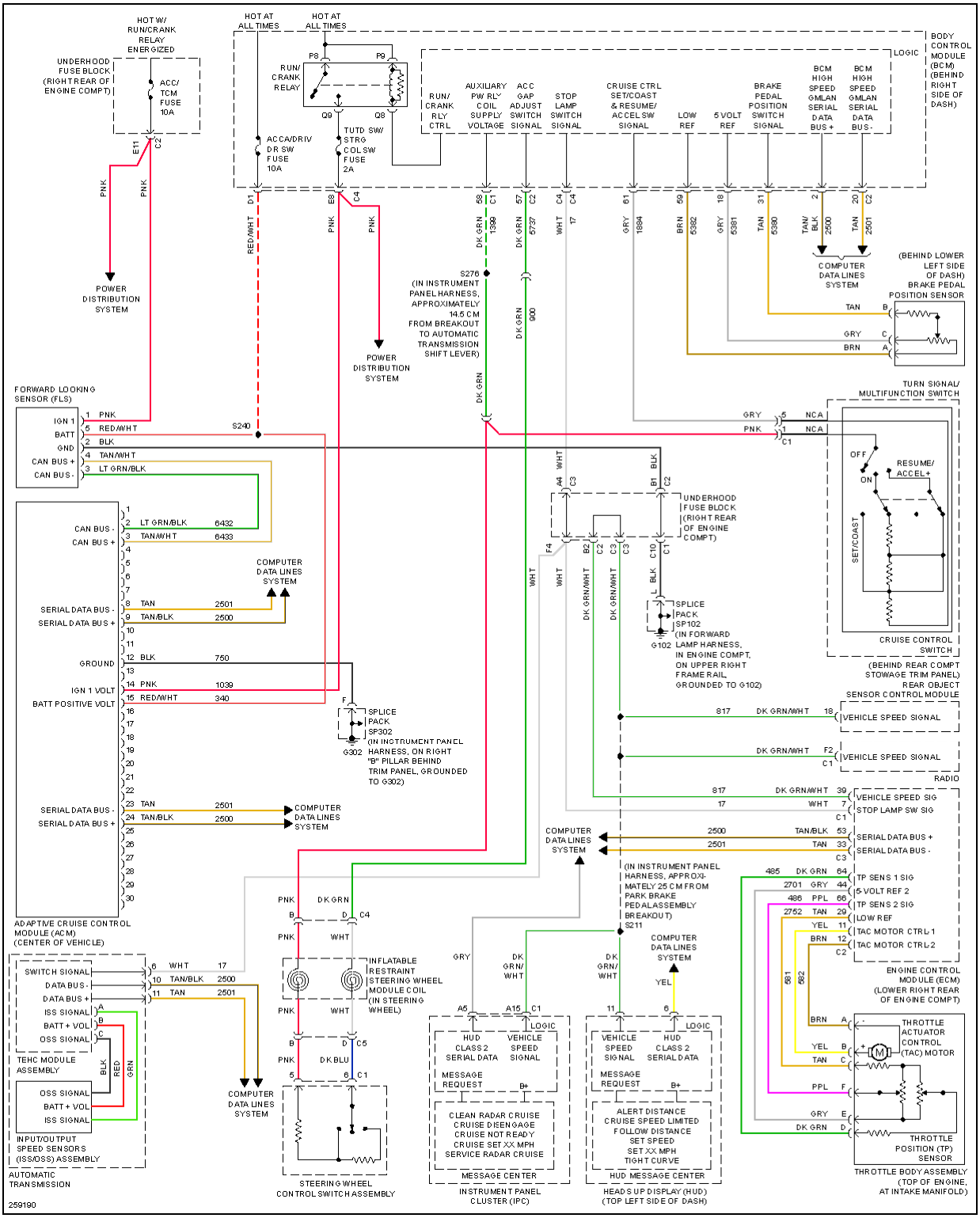
Fig. 14: 4.4L VIN D, Conventional Cruise Control Circuit

4.6L VIN A

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2007 SYSTEM WIRING DIAGRAMS Cadillac - XLR

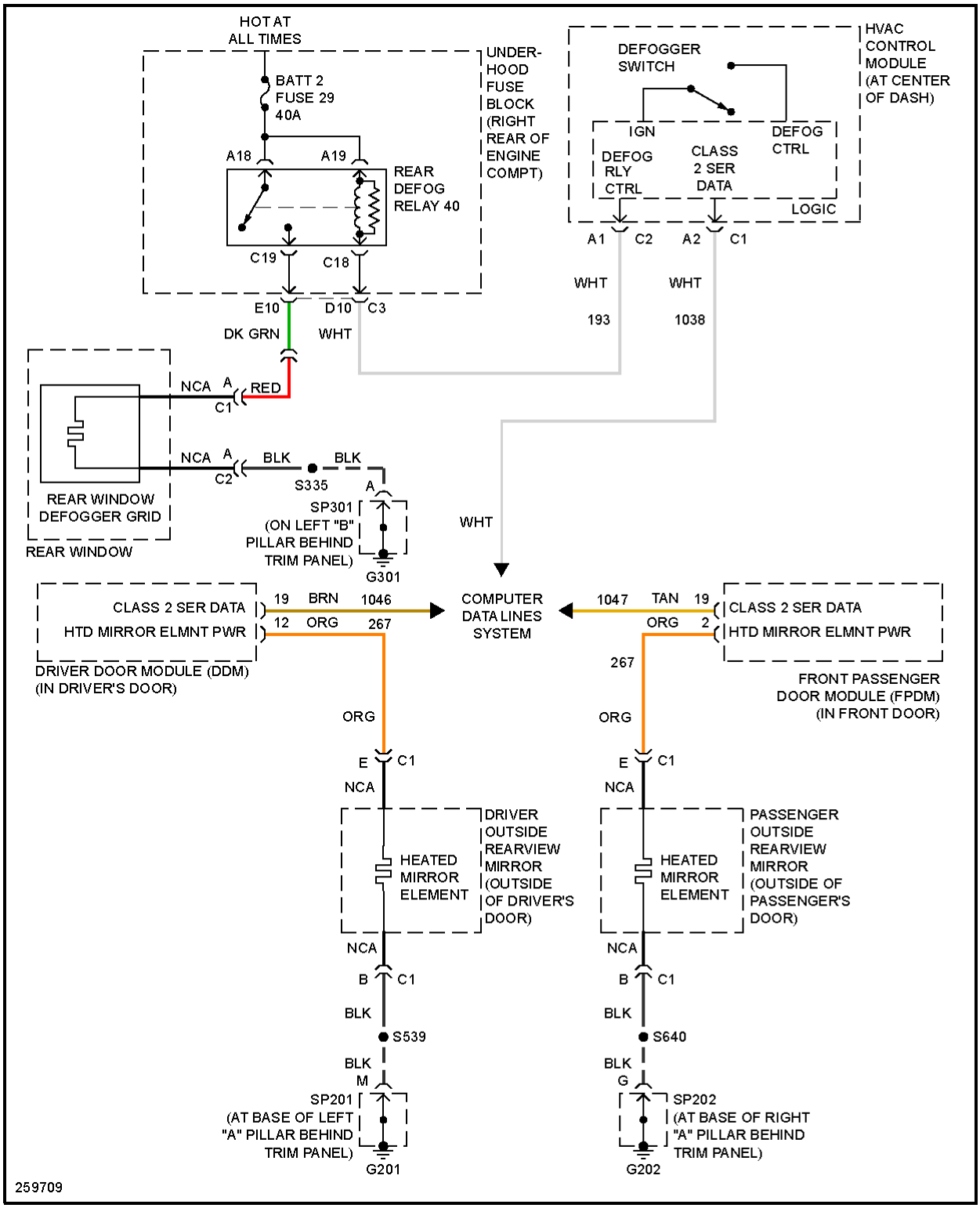


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Fig. 15: 4.6L VIN A, Adaptive Cruise Control Circuit

DEFOGGERS

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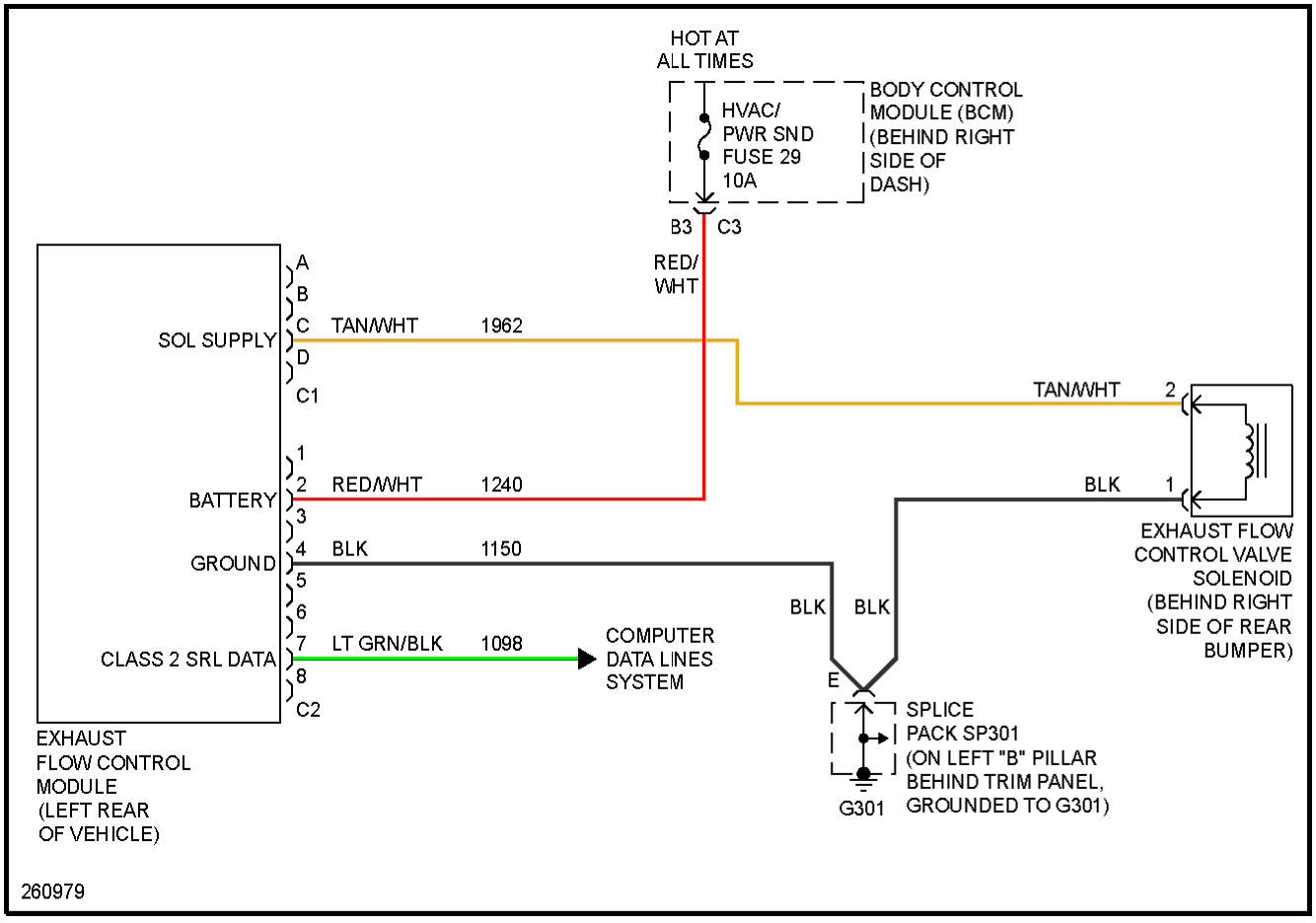


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Fig. 16: Defoggers Circuit

ELECTRONIC MUFFLER

Automotive-Manual.net

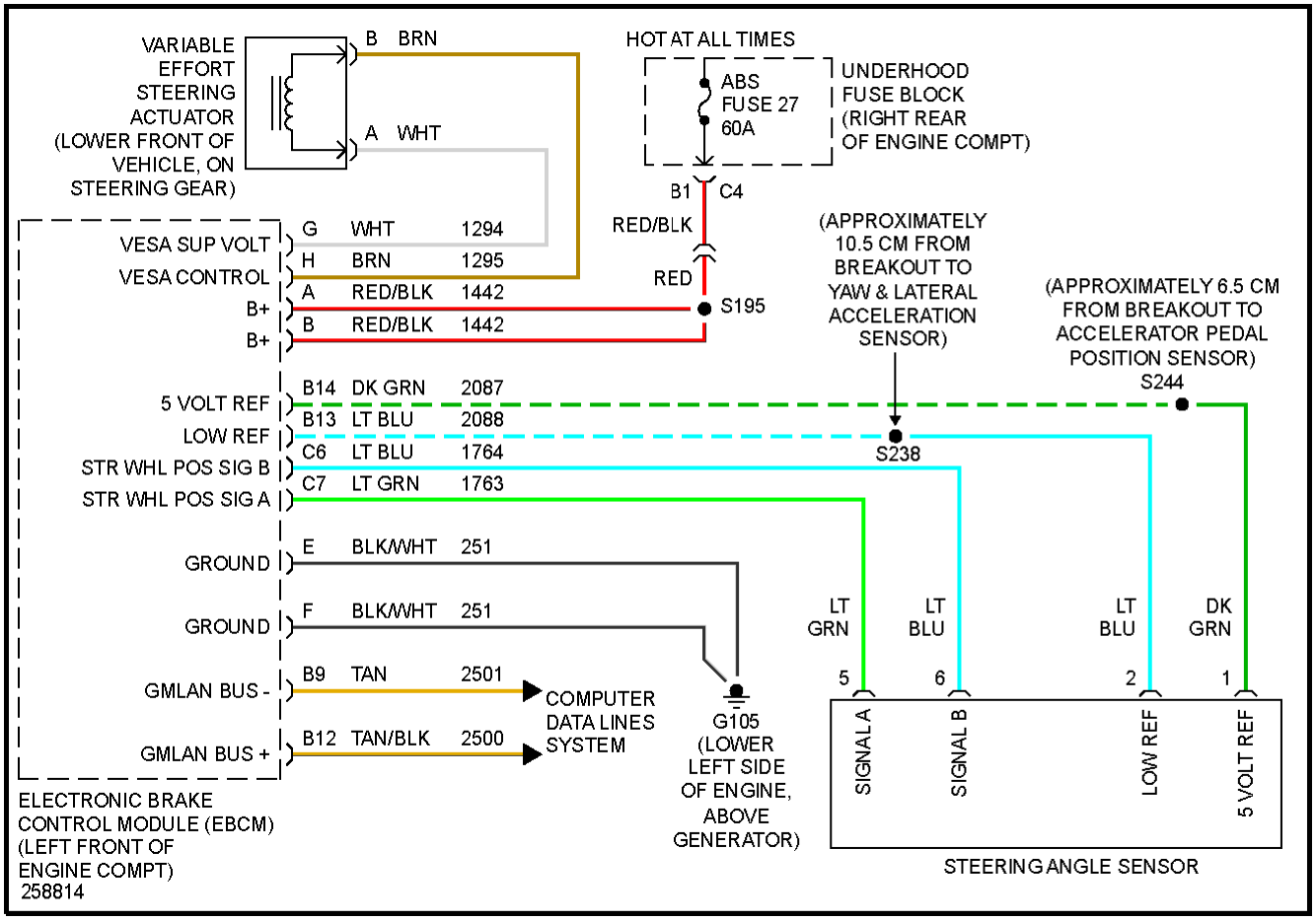


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Fig. 17: Electronic Muffler Circuit

ELECTRONIC POWER STEERING

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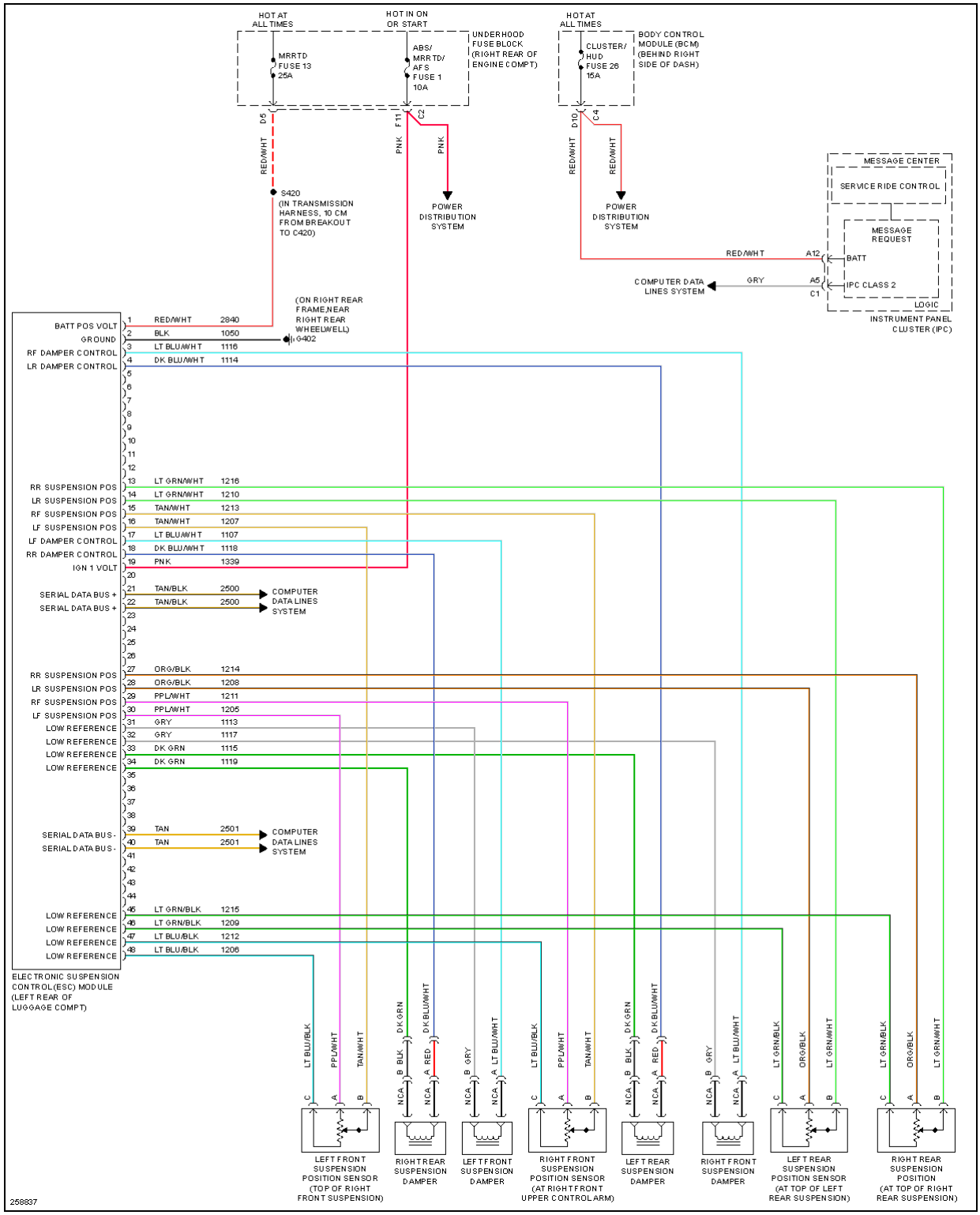


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Fig. 18: Electronic Power Steering Circuit

ELECTRONIC SUSPENSION

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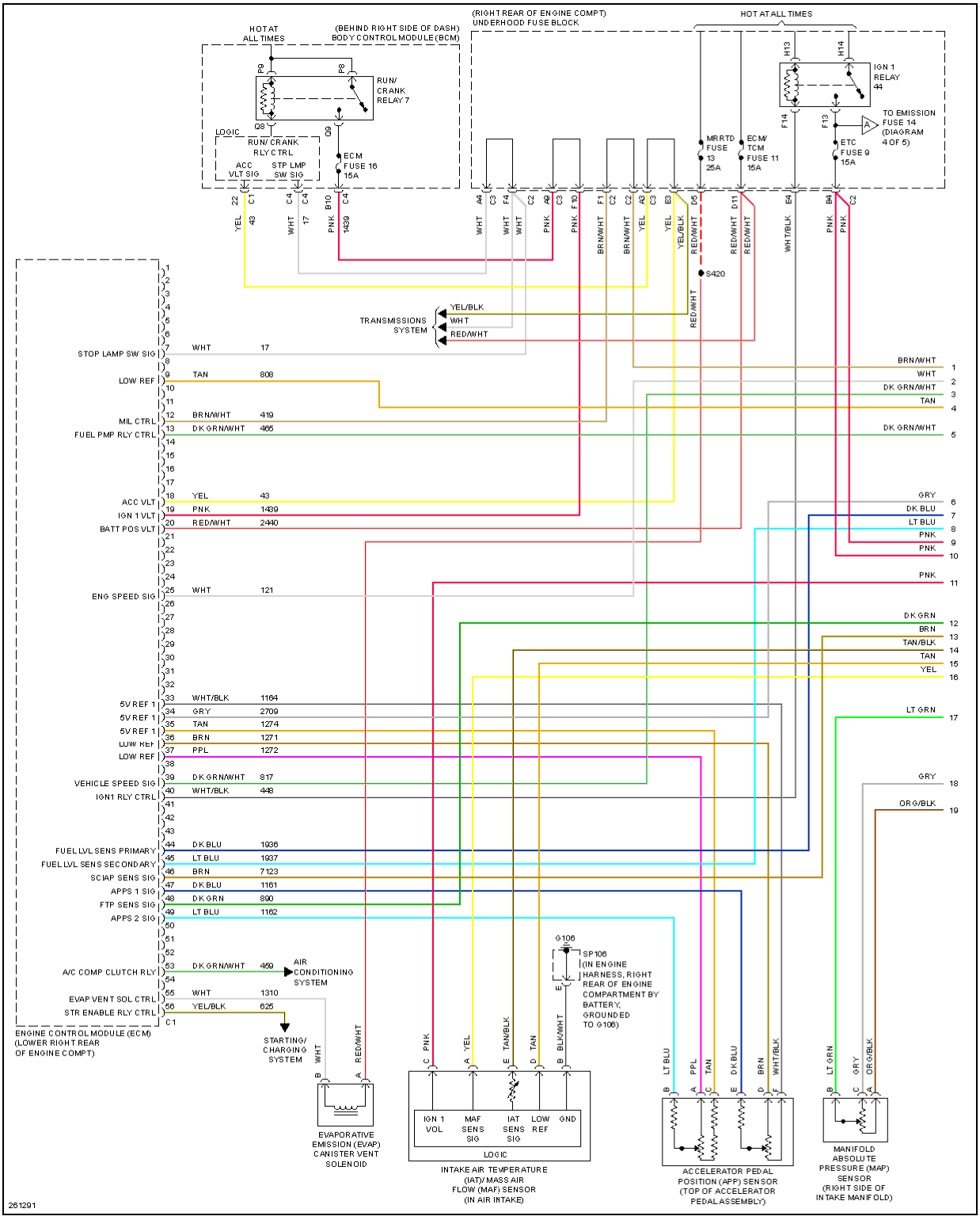
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Fig. 19: Electronic Suspension Circuit

ENGINE PERFORMANCE

4.4L VIN D

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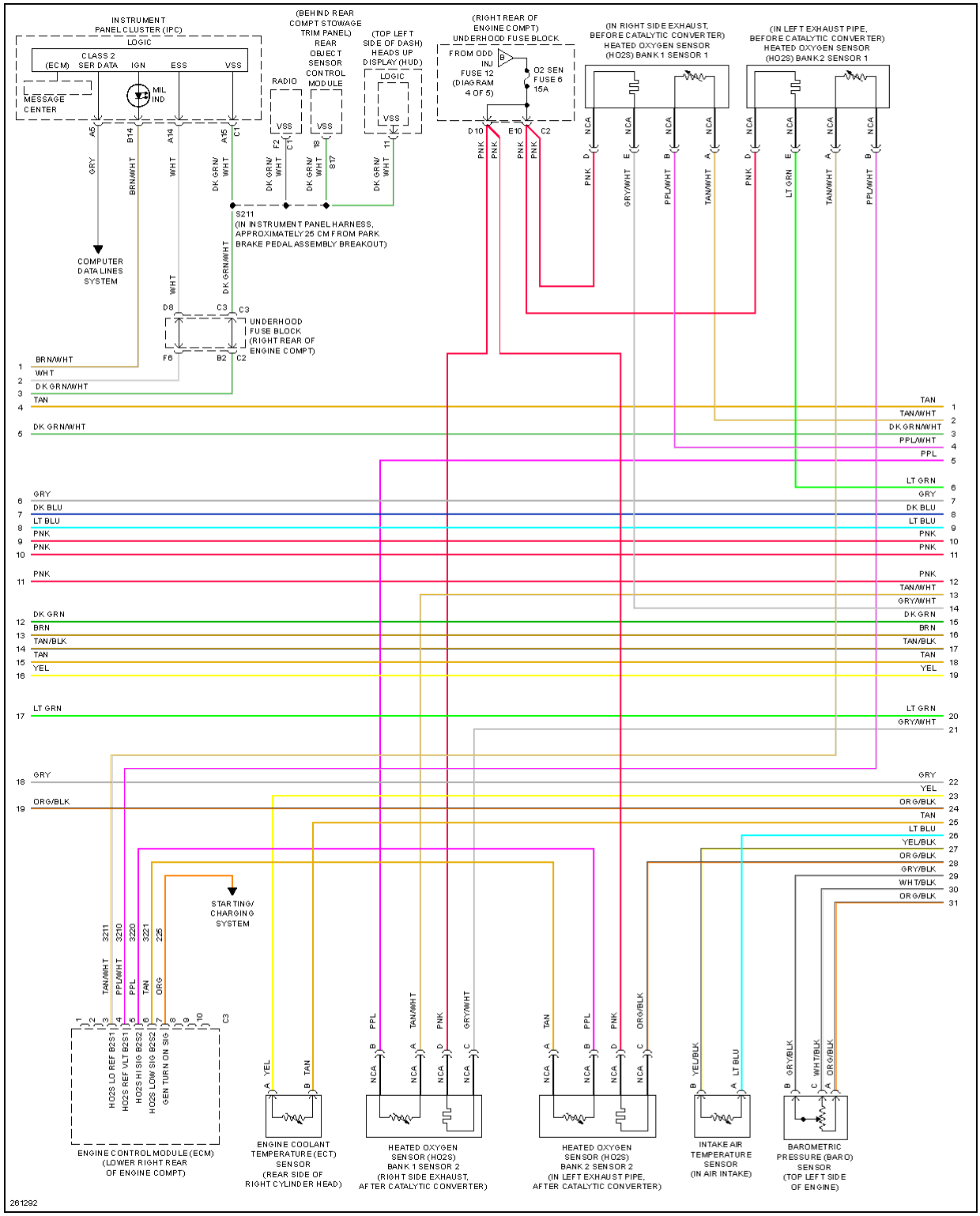
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Fig. 20: 4.4L VIN D, Engine Performance Circuit (1 of 5)

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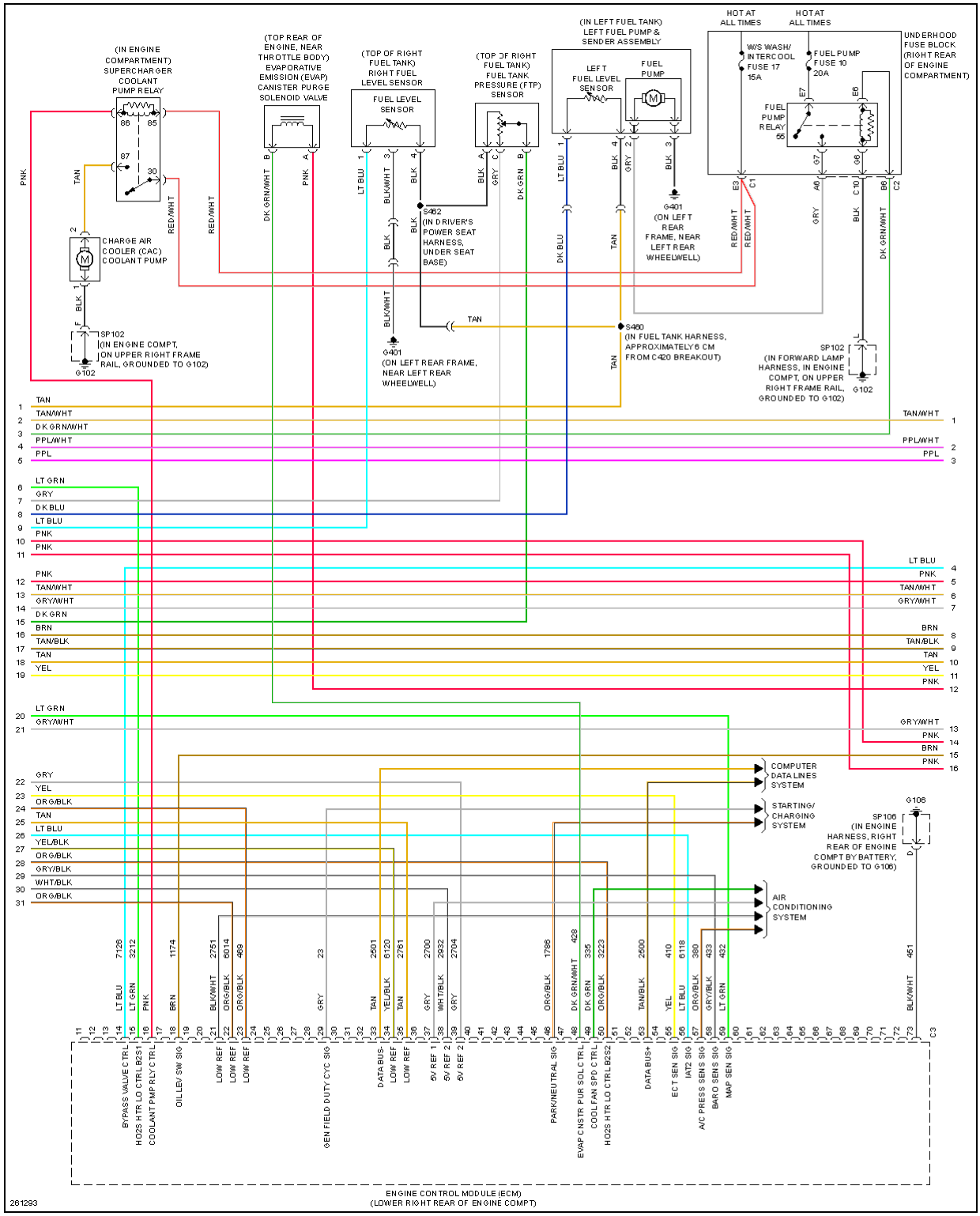
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Fig. 21: 4.4L VIN D, Engine Performance Circuit (2 of 5)

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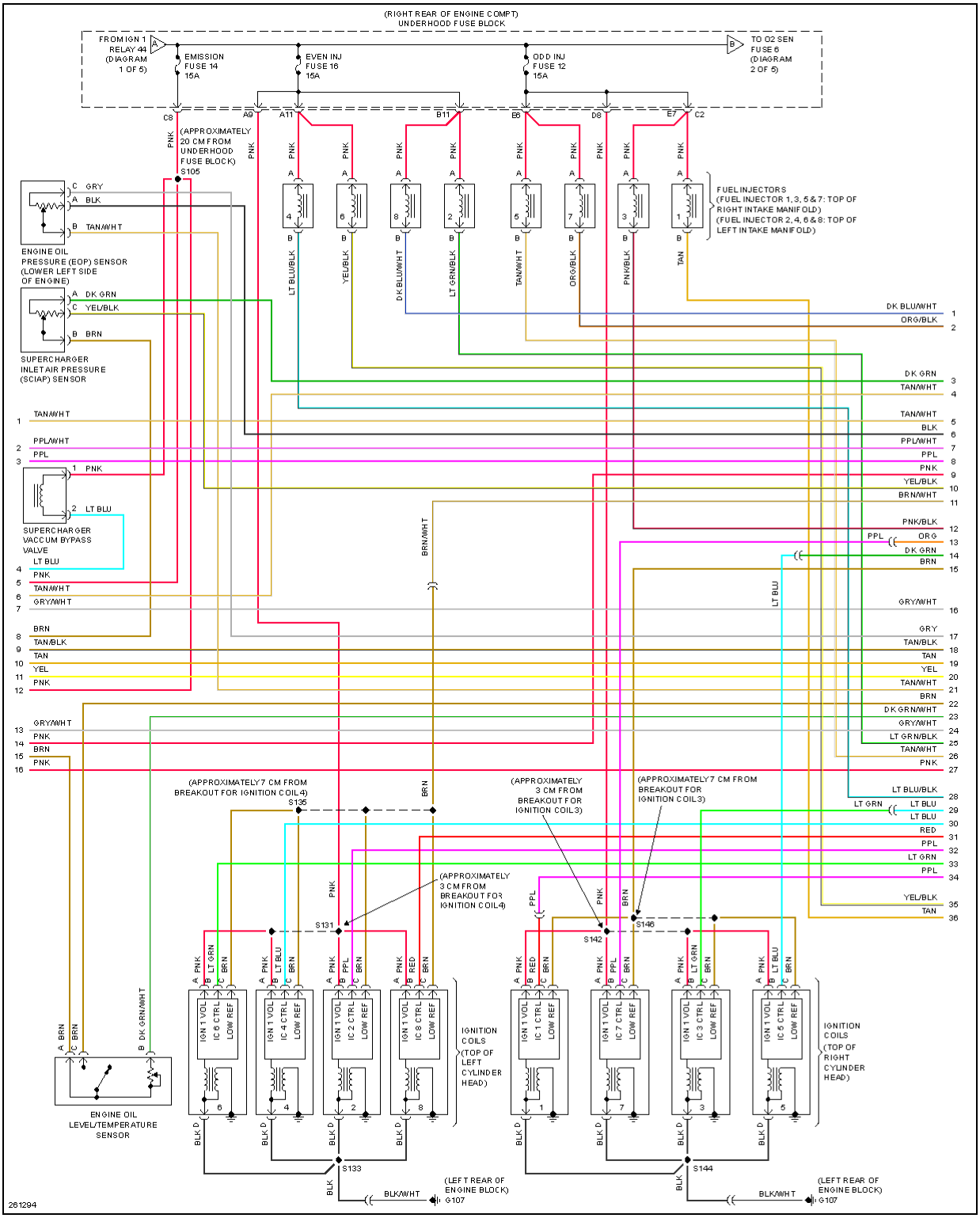
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Fig. 22: 4.4L VIN D, Engine Performance Circuit (3 of 5)

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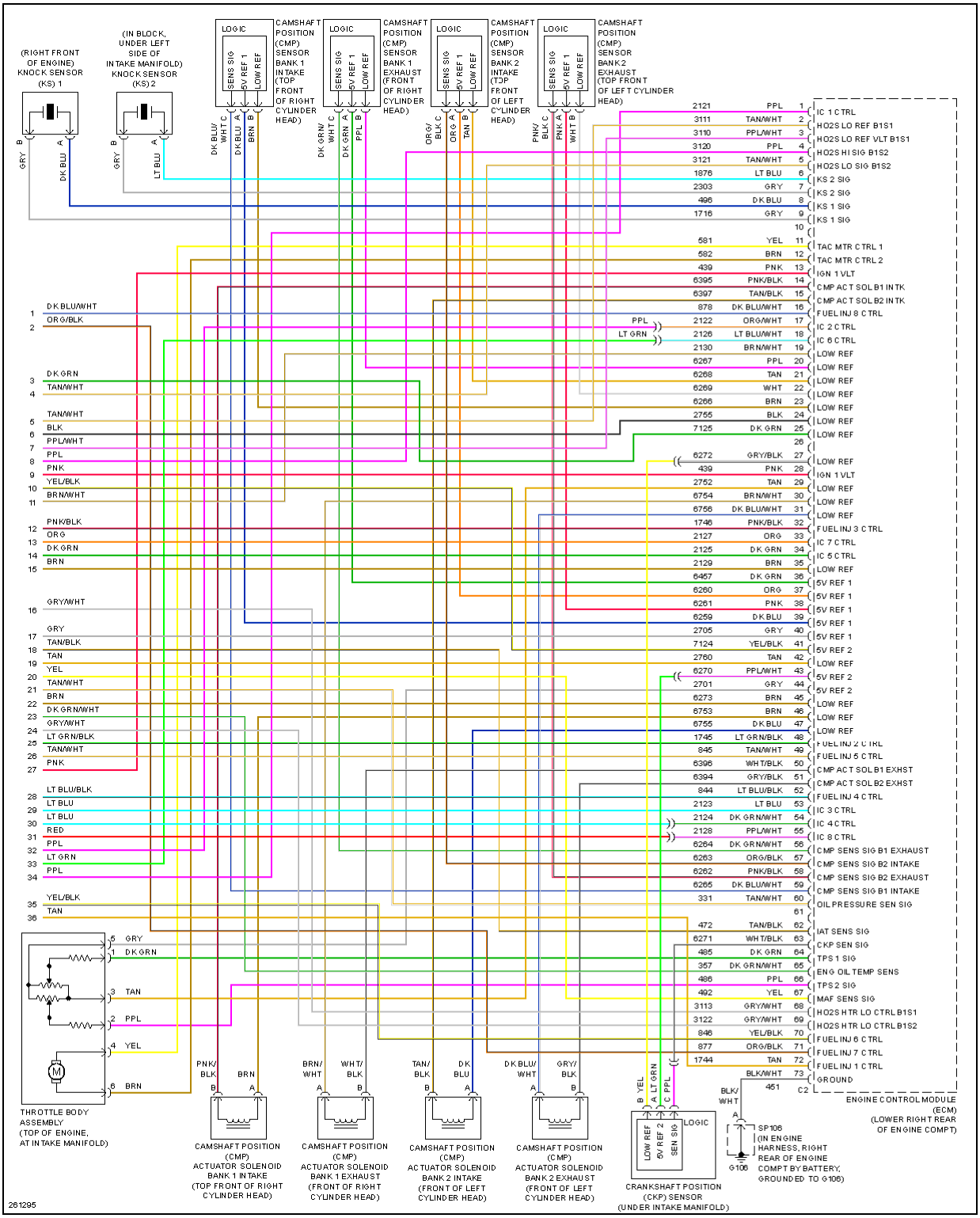
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Fig. 23: 4.4L VIN D, Engine Performance Circuit (4 of 5)

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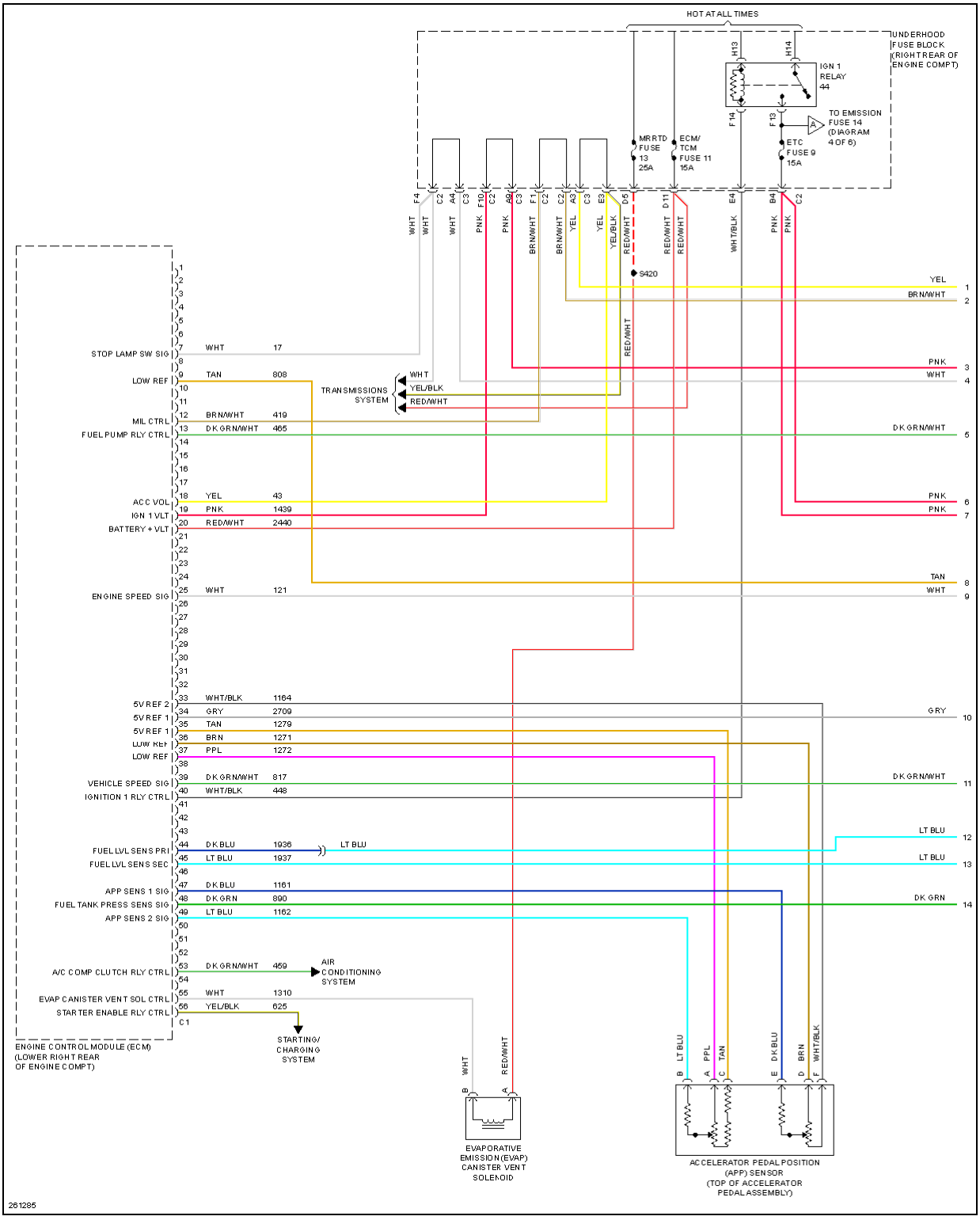


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Fig. 24: 4.4L VIN D, Engine Performance Circuit (5 of 5)

4.6L VIN A

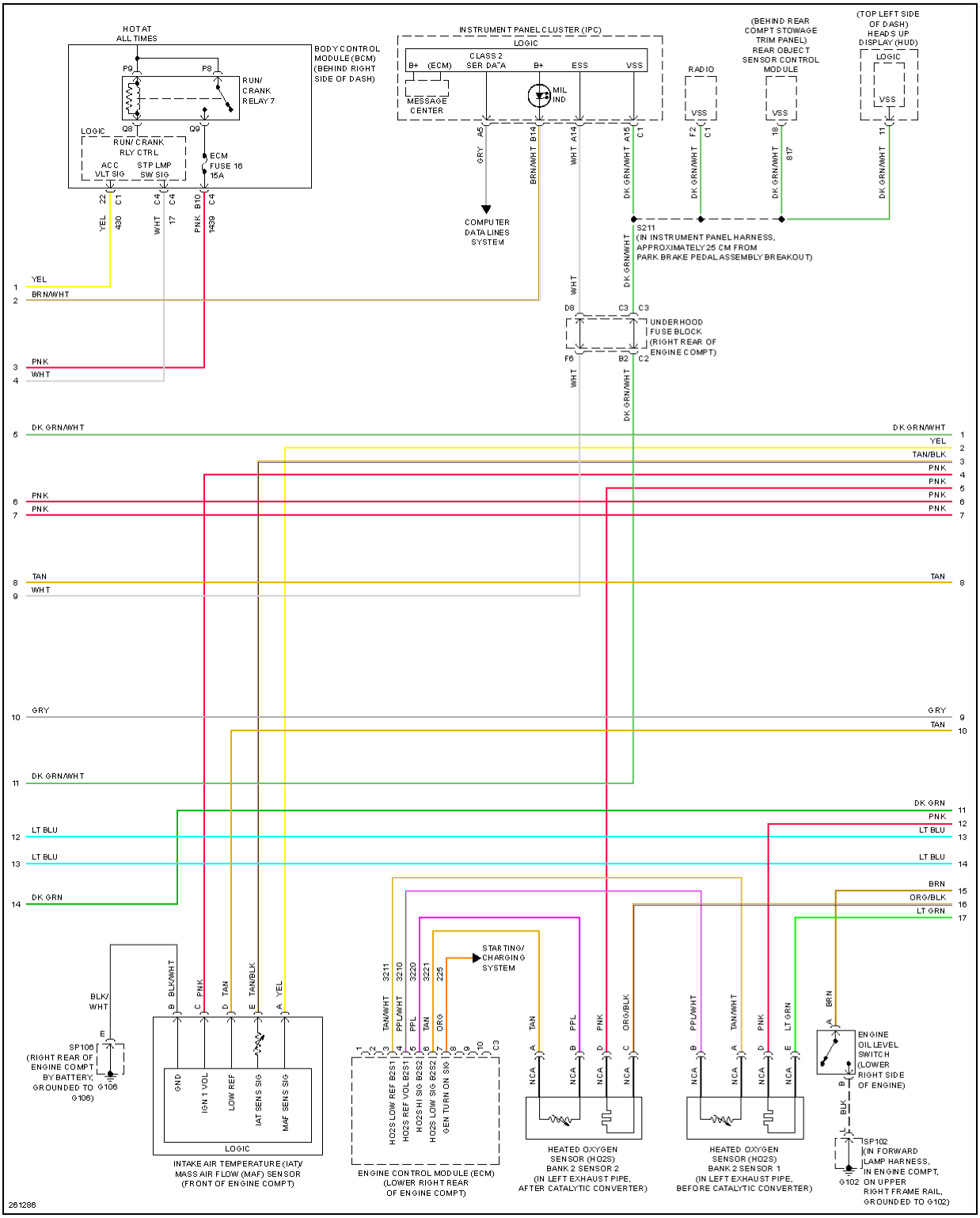
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Fig. 25: 4.6L VIN A, Engine Performance Circuit (1 of 6)

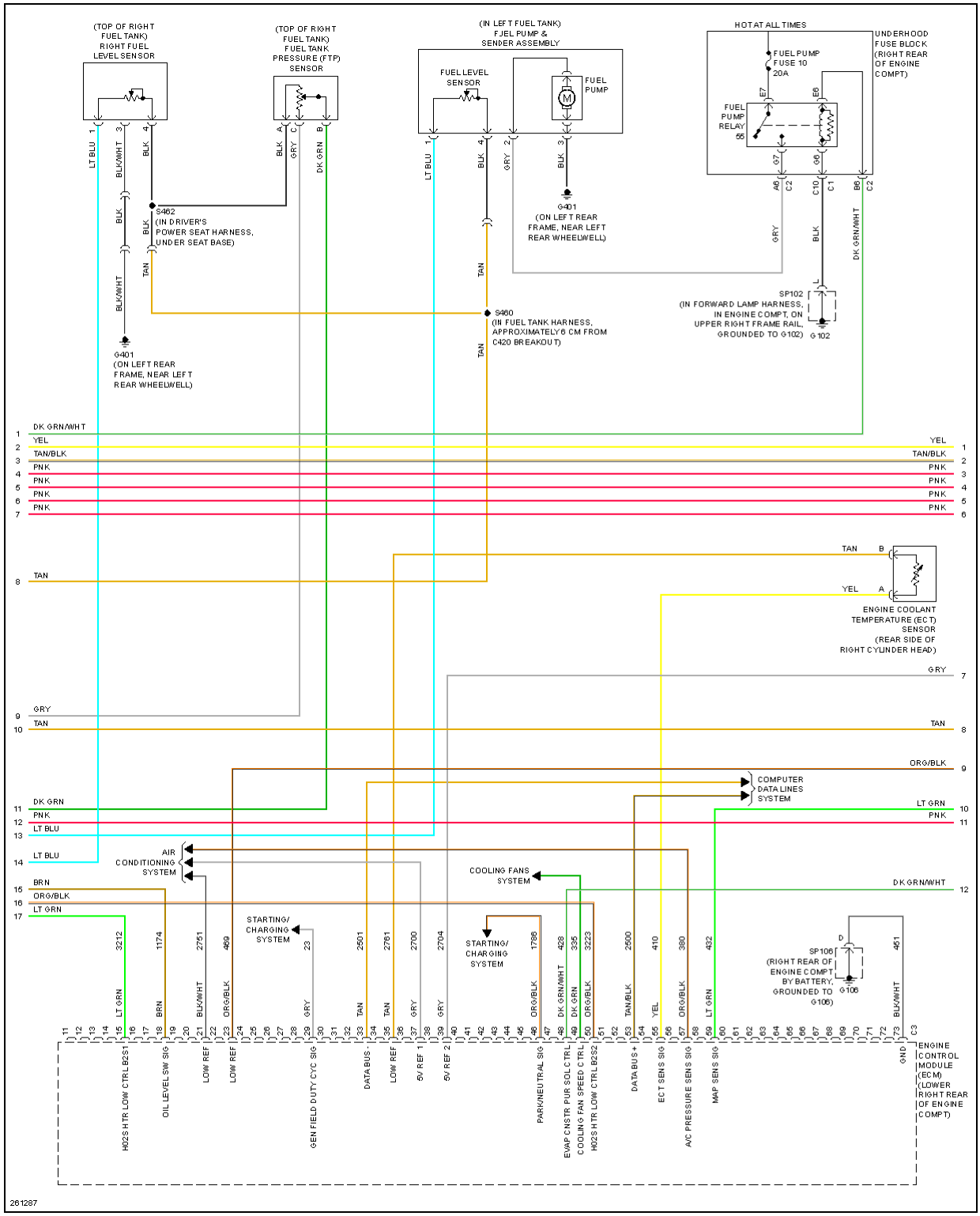
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Fig. 26: 4.6L VIN A, Engine Performance Circuit (2 of 6)

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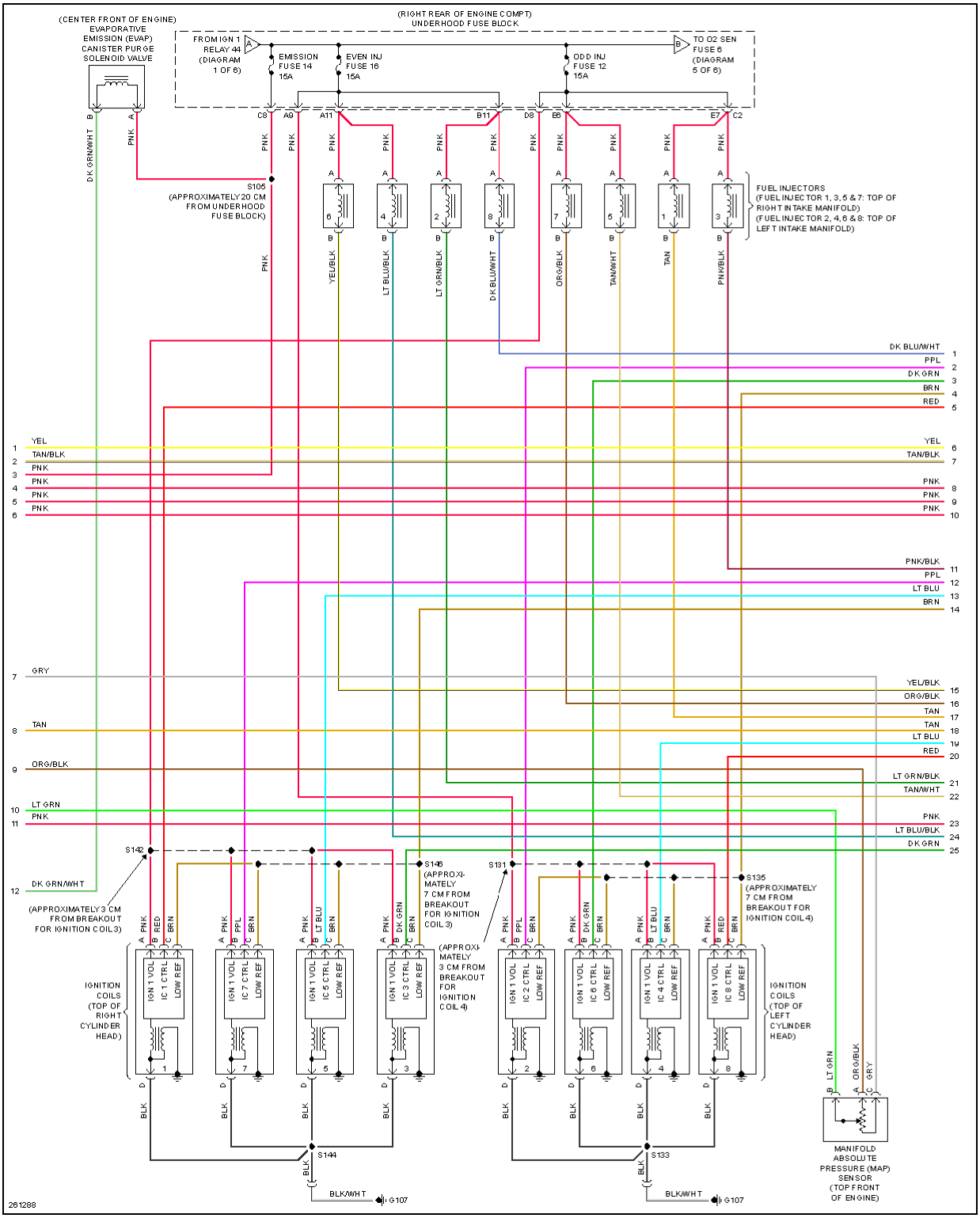
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Fig. 27: 4.6L VIN A, Engine Performance Circuit (3 of 6)

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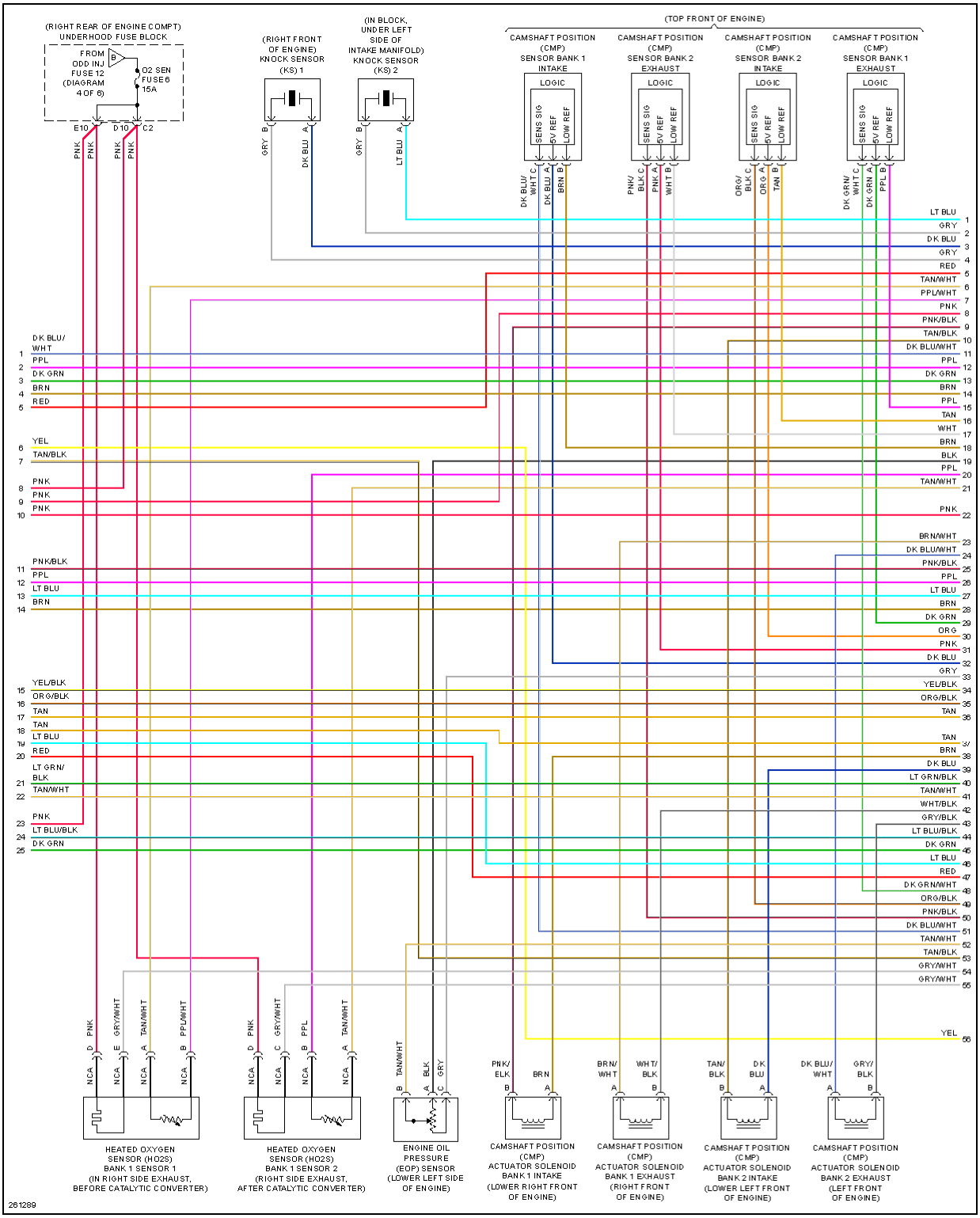
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Fig. 28: 4.6L VIN A, Engine Performance Circuit (4 of 6)

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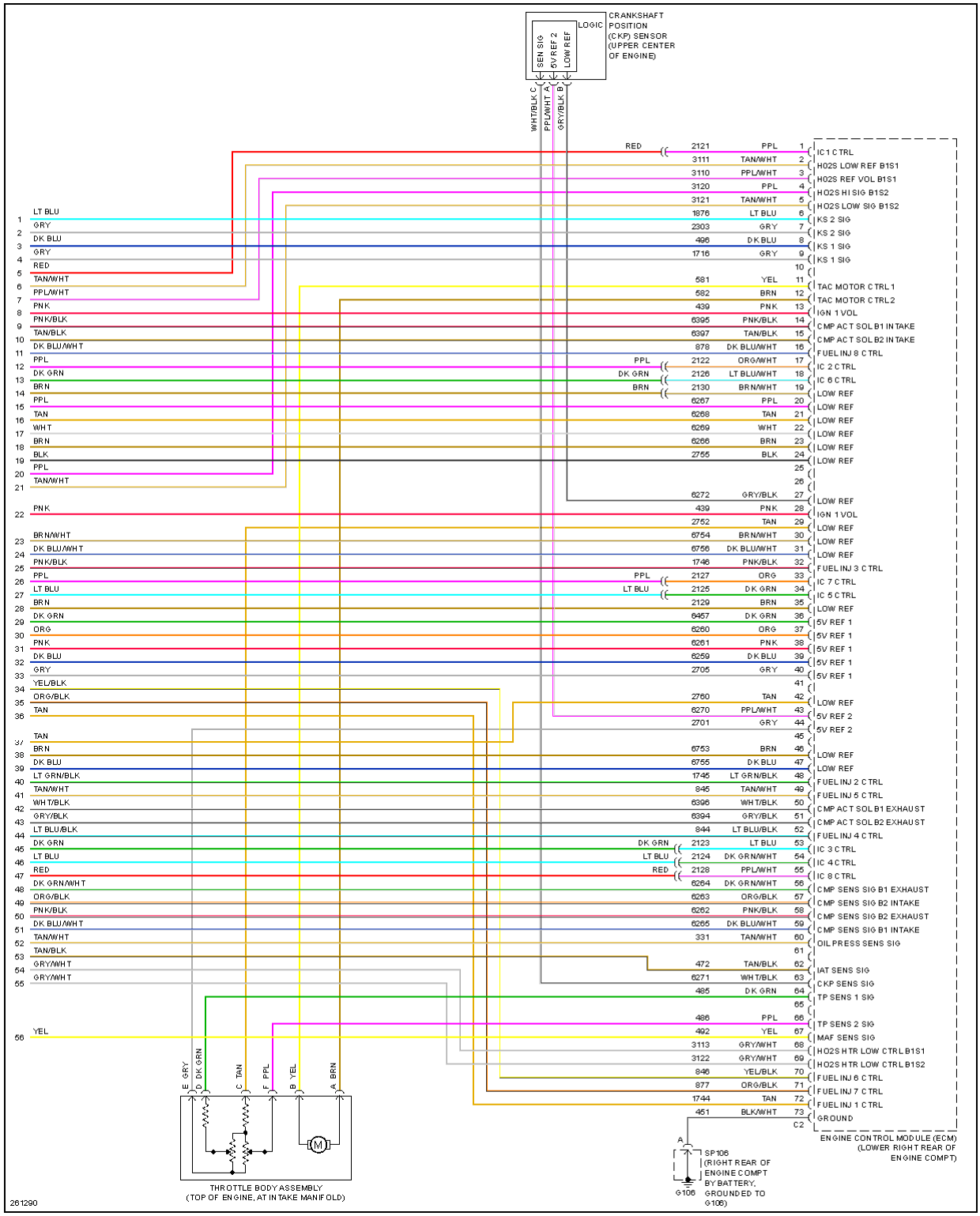
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Fig. 29: 4.6L VIN A, Engine Performance Circuit (5 of 6)

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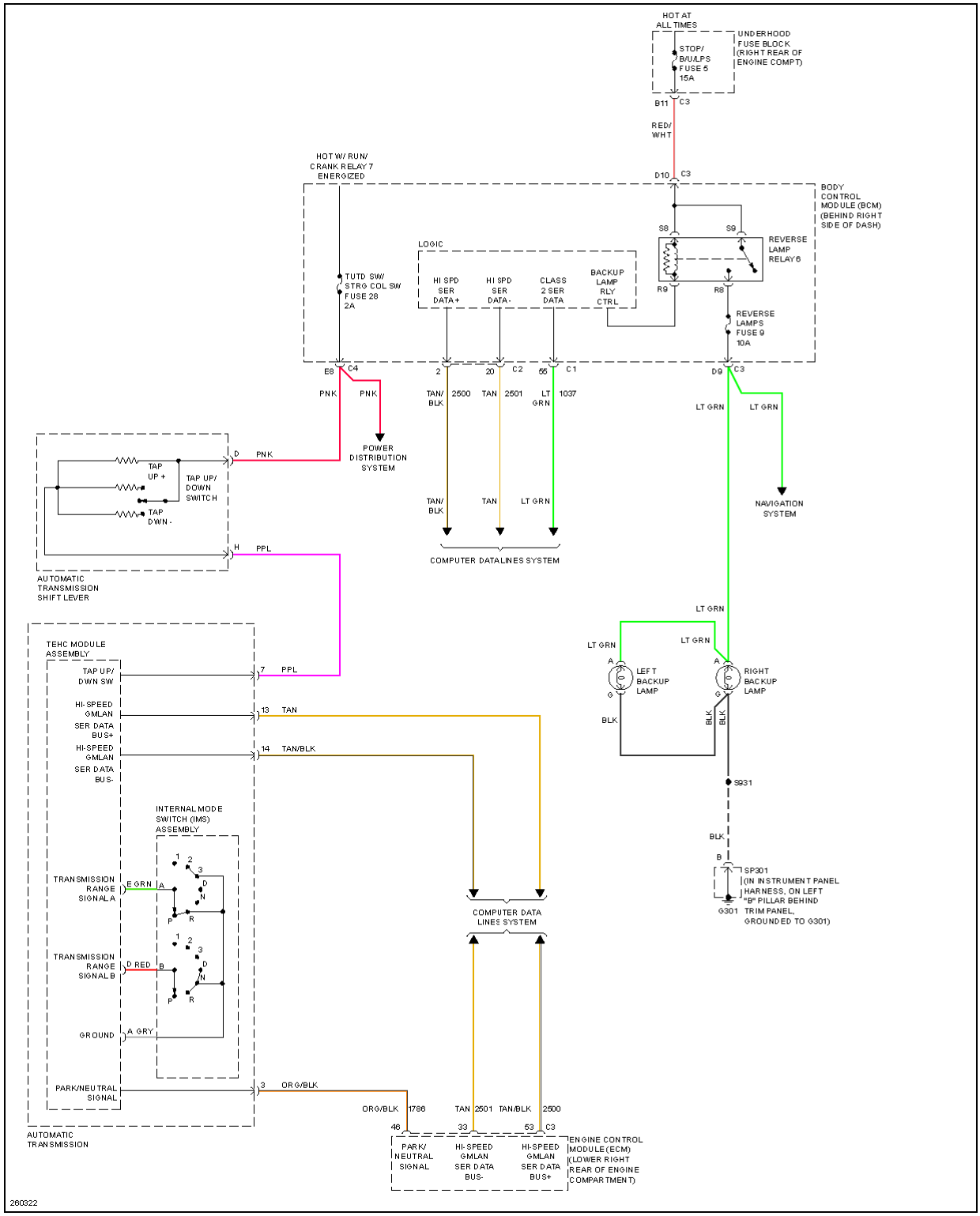
Fig. 30: 4.6L VIN A, Engine Performance Circuit (6 of 6)

EXTERIOR LIGHTS

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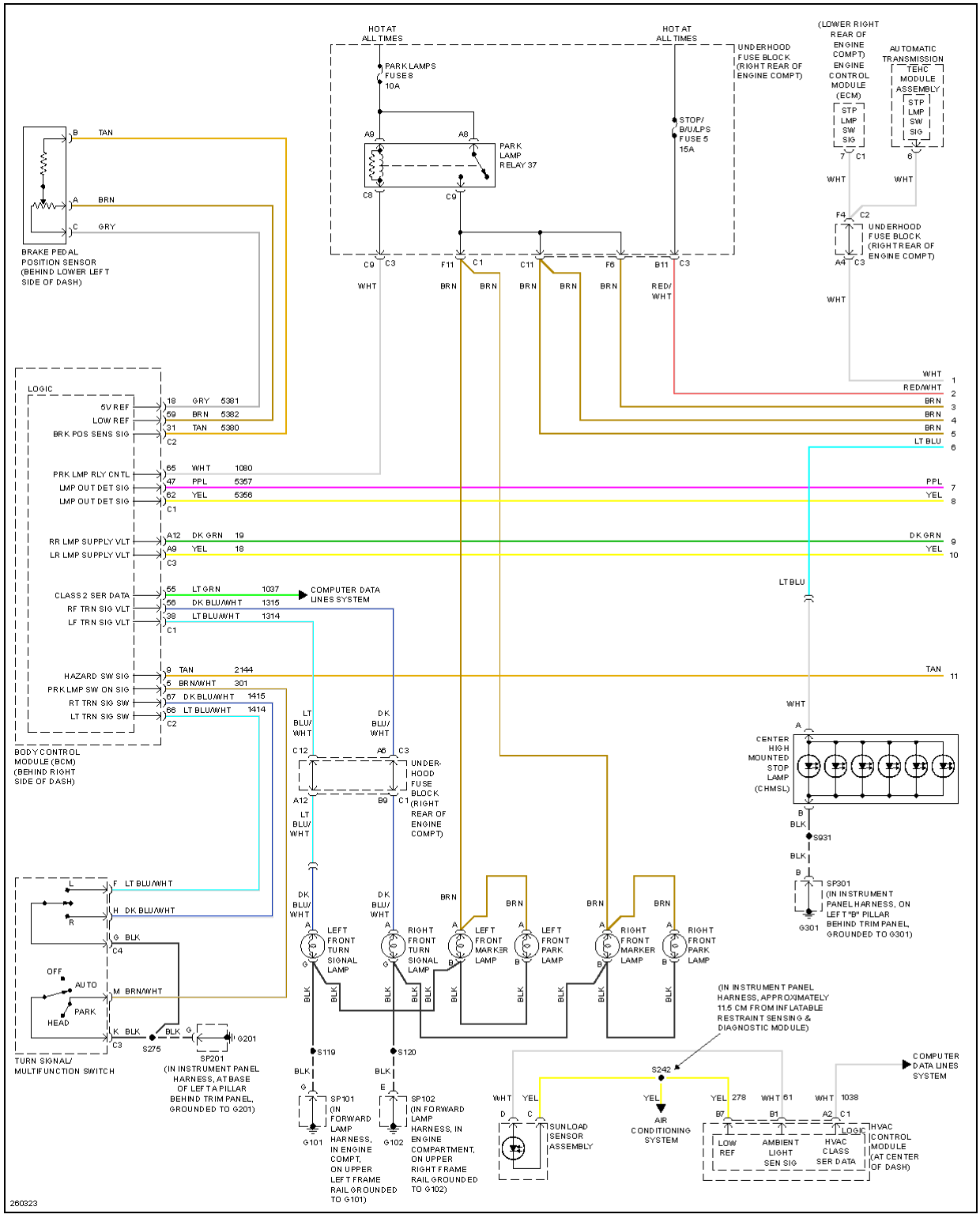
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Fig. 31: Back-up Lamps Circuit

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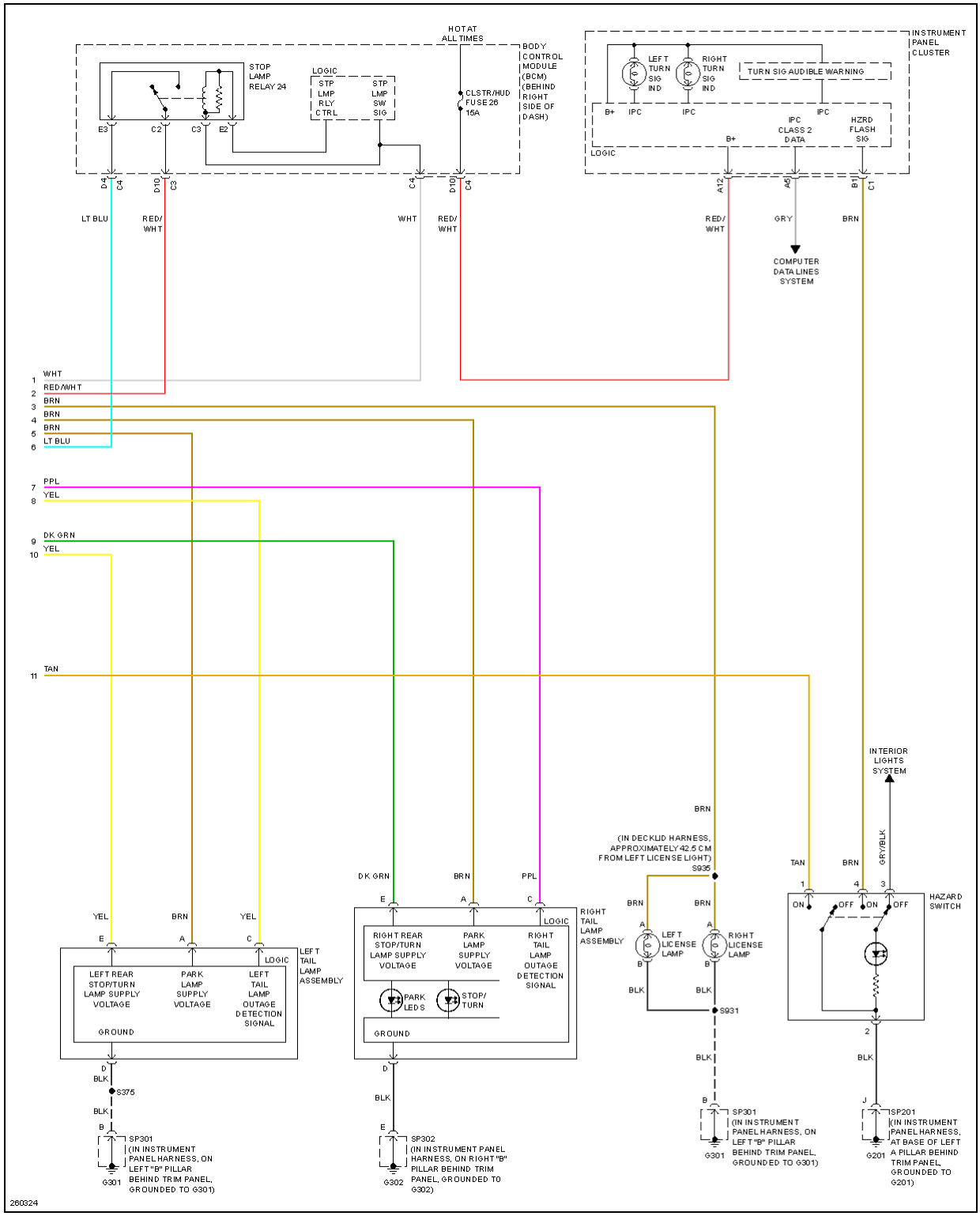
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Fig. 32: Exterior Lamps Circuit (1 of 2)

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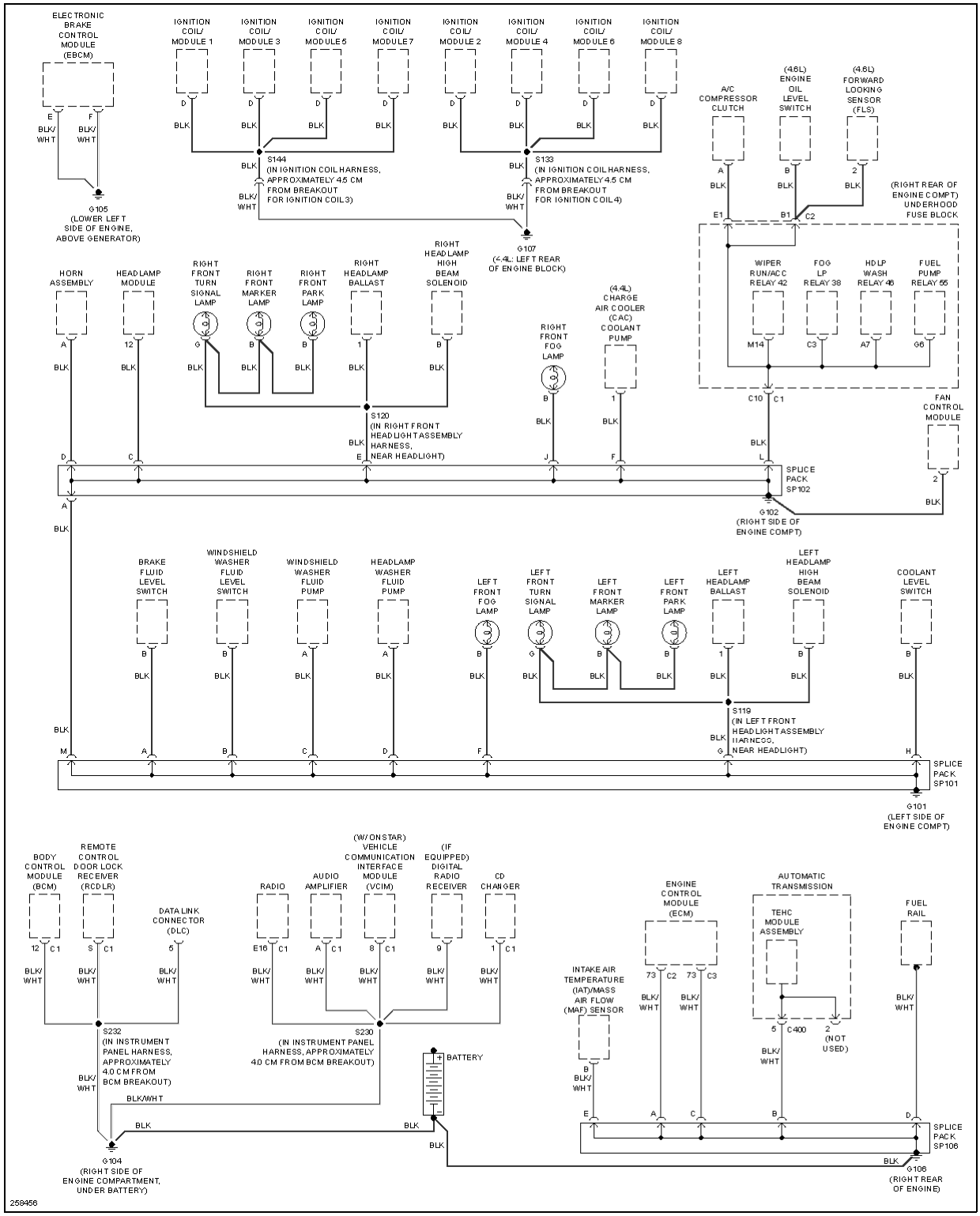


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Fig. 33: Exterior Lamps Circuit (2 of 2)

GROUND DISTRIBUTION

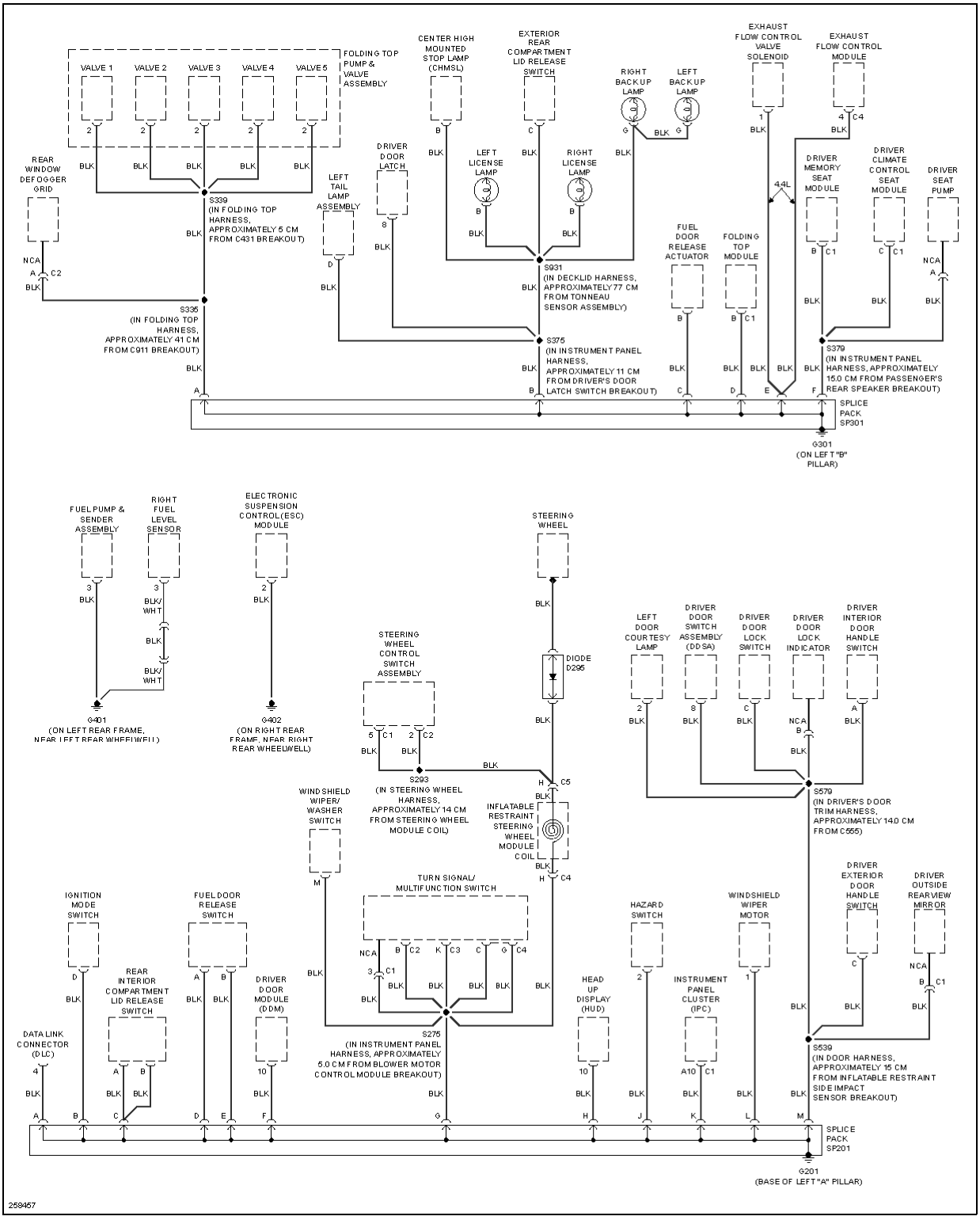
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Fig. 34: Ground Distribution Circuit (1 of 3)

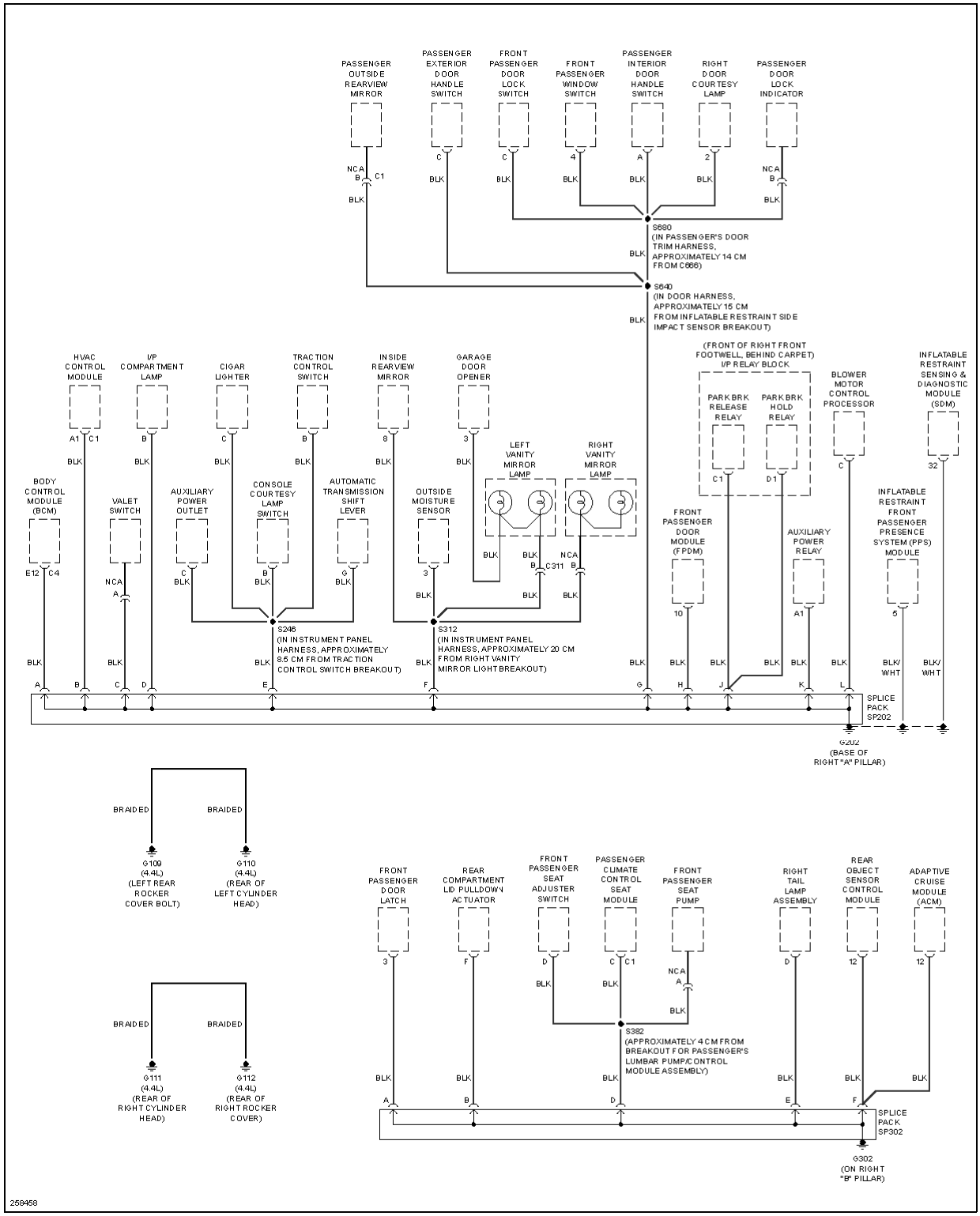
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Fig. 35: Ground Distribution Circuit (2 of 3)

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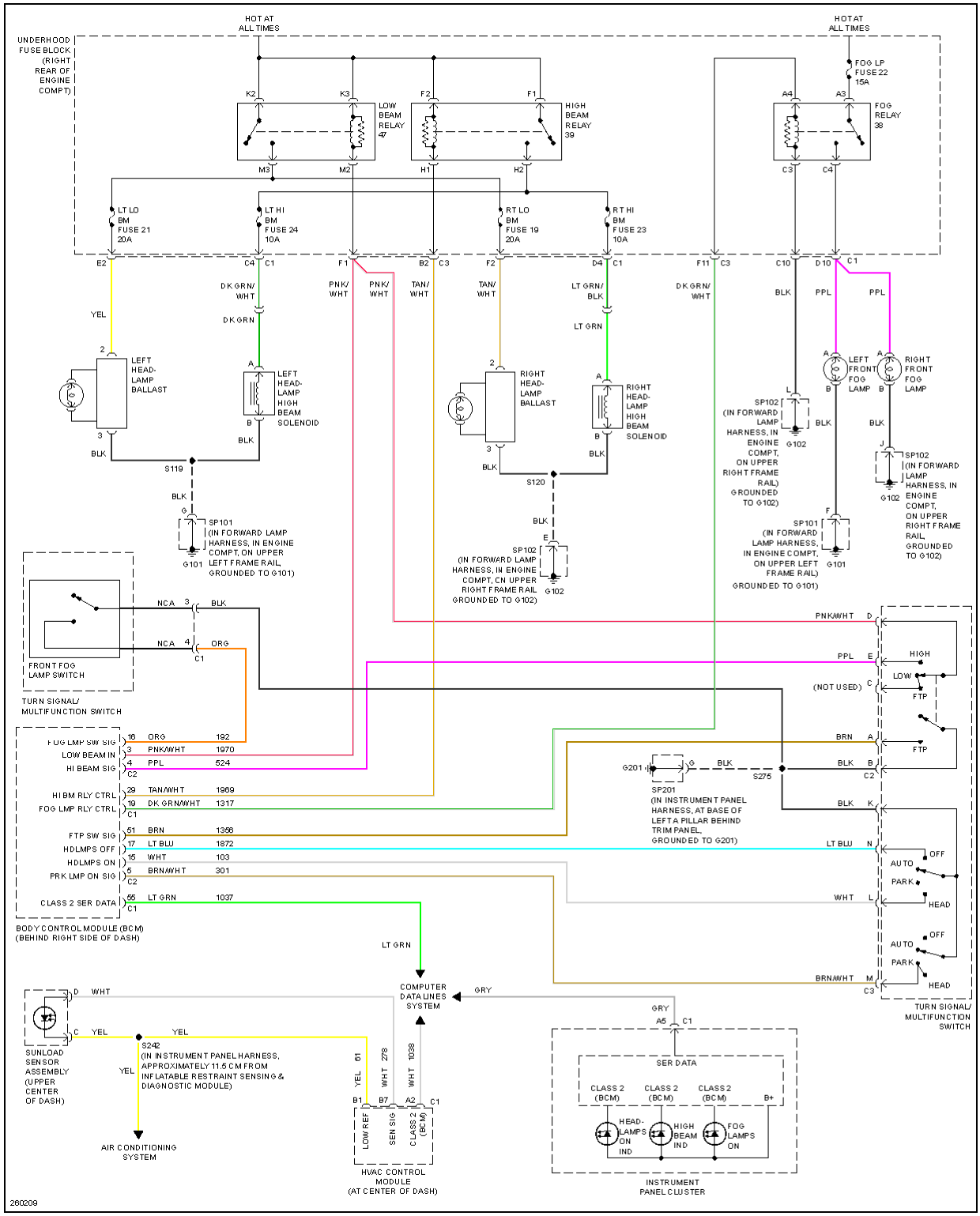


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Fig. 36: Ground Distribution Circuit (3 of 3)

HEADLIGHTS

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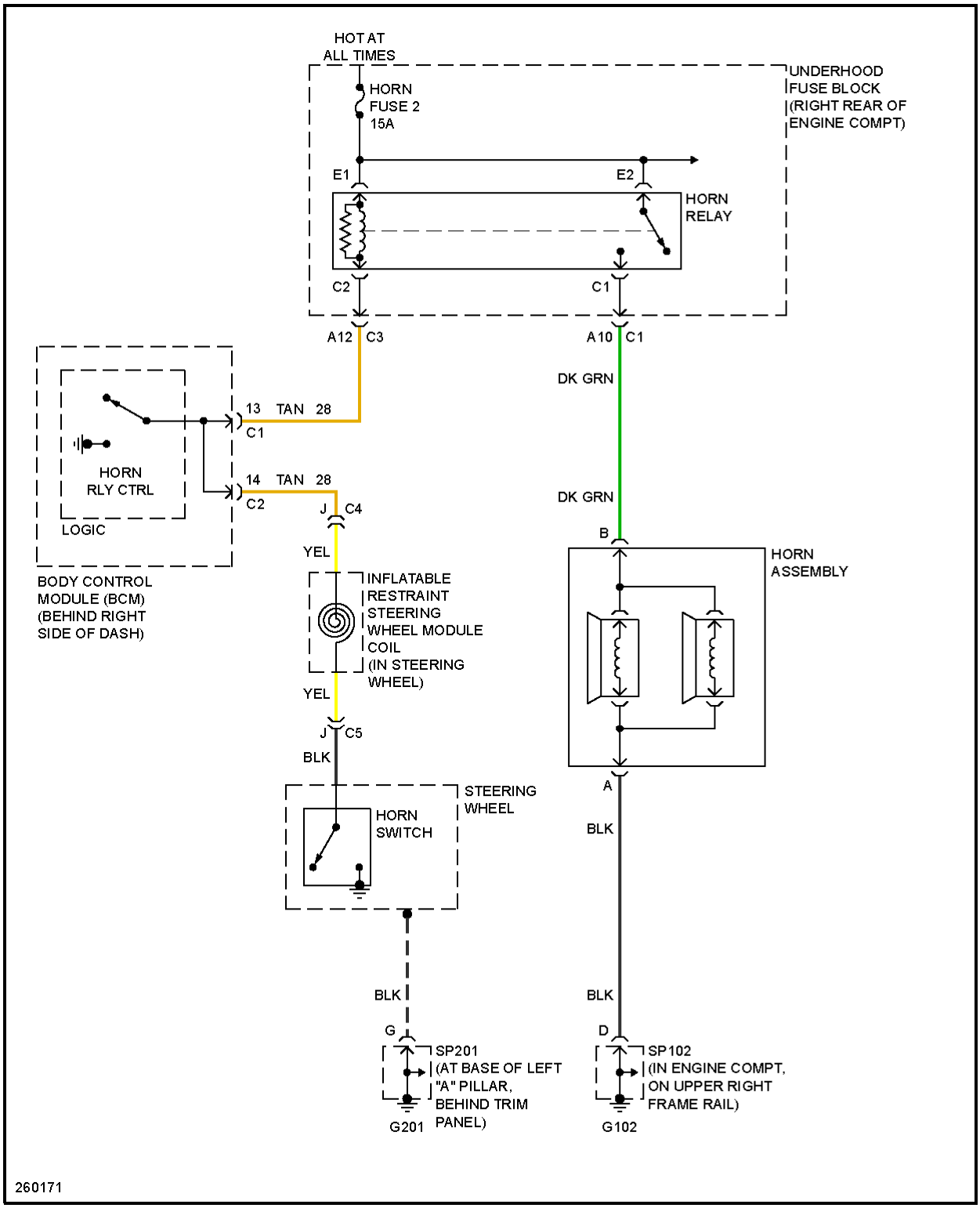


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Fig. 37: Headlights Circuit

HORN

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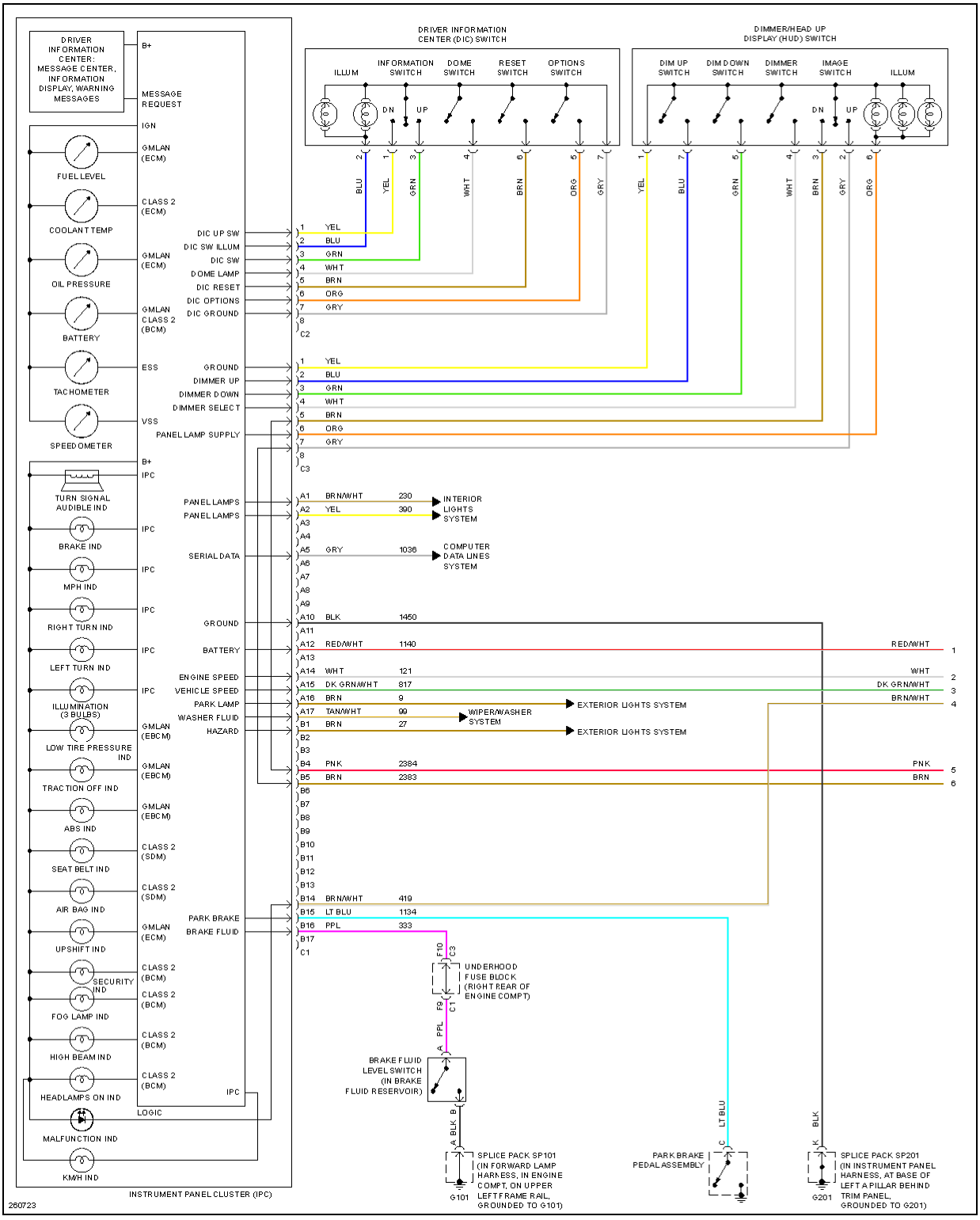
Fig. 38: Horn Circuit

INSTRUMENT CLUSTER

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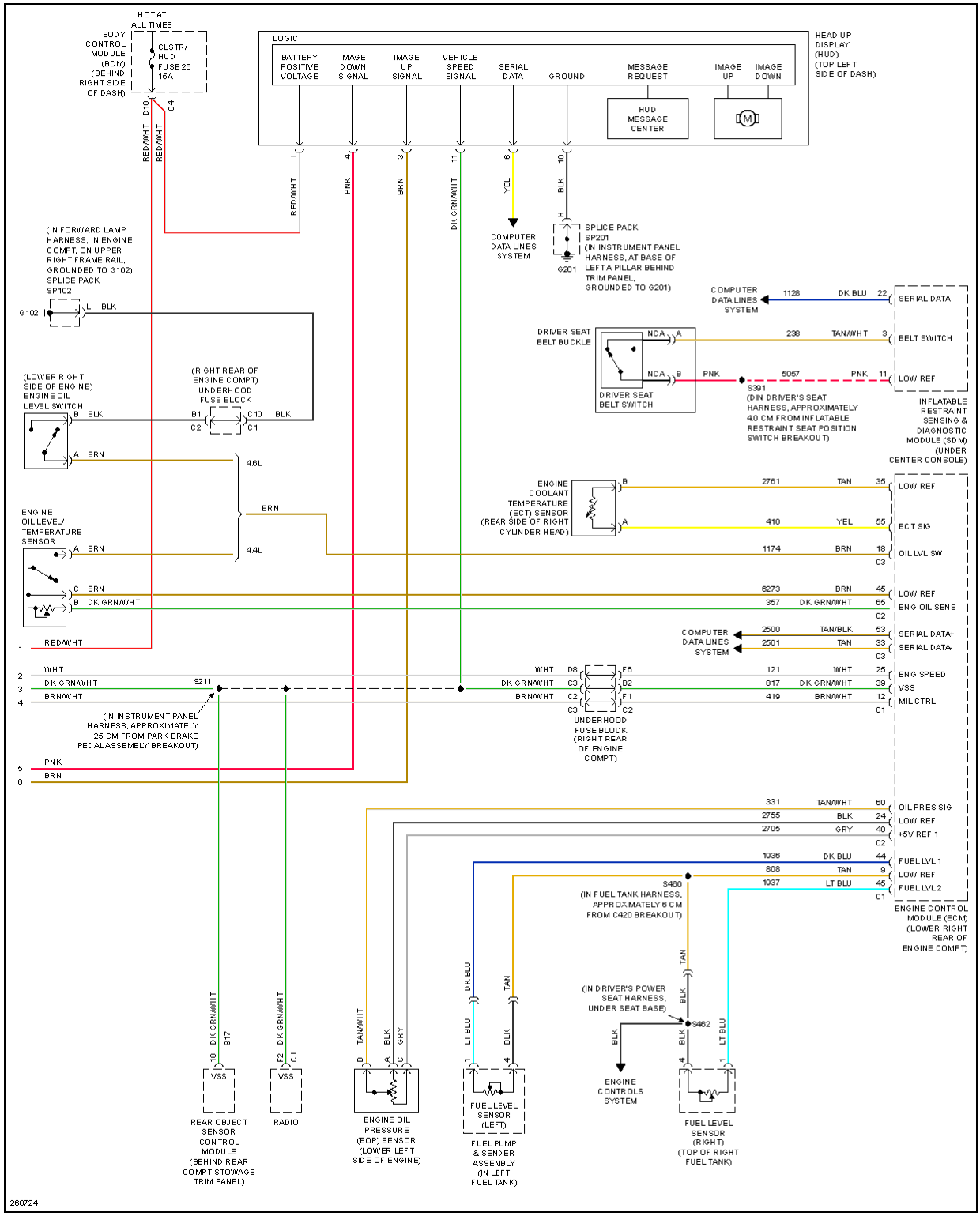
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Fig. 39: Instrument Cluster Circuit (1 of 2)

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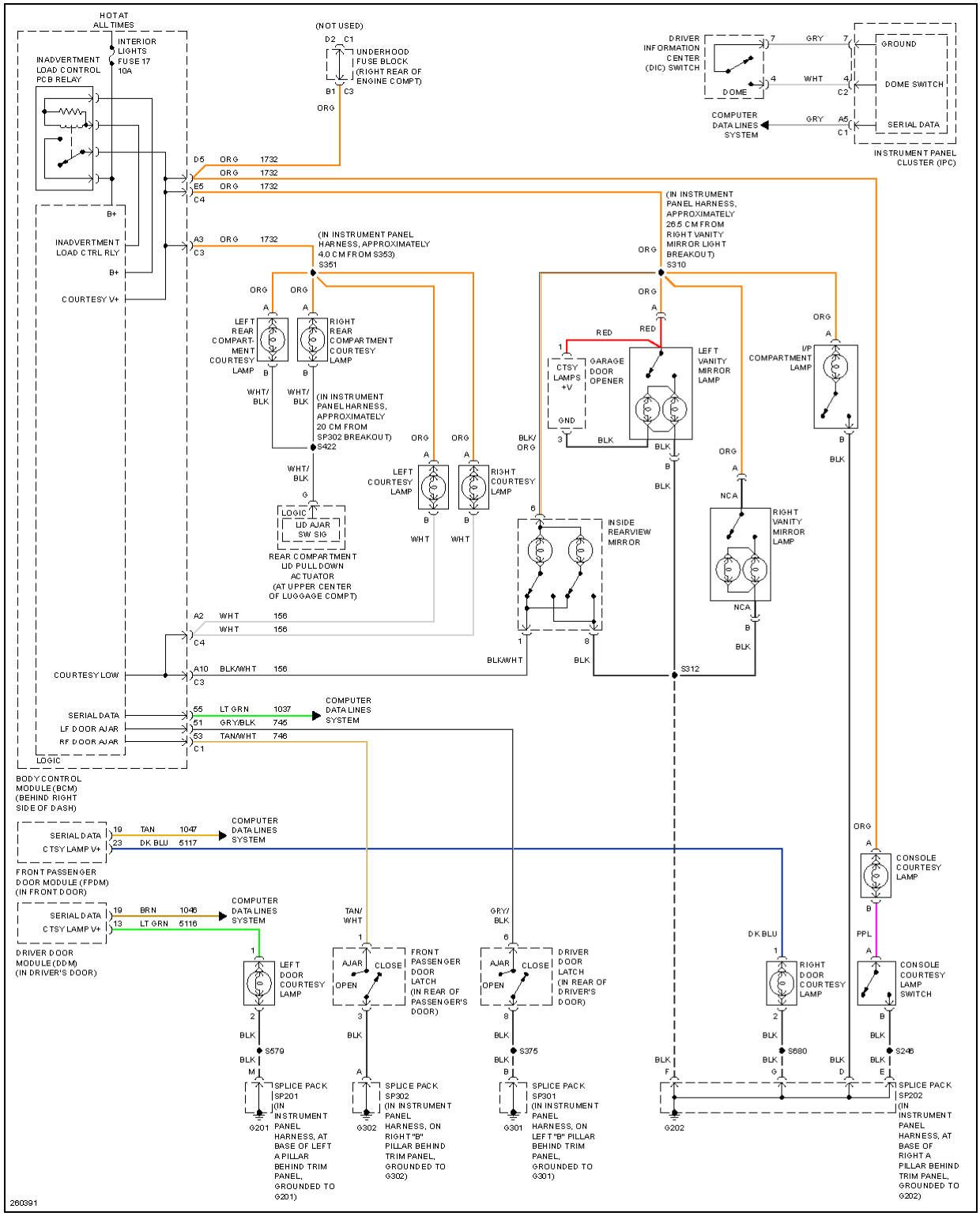


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Fig. 40: Instrument Cluster Circuit (2 of 2)

INTERIOR LIGHTS

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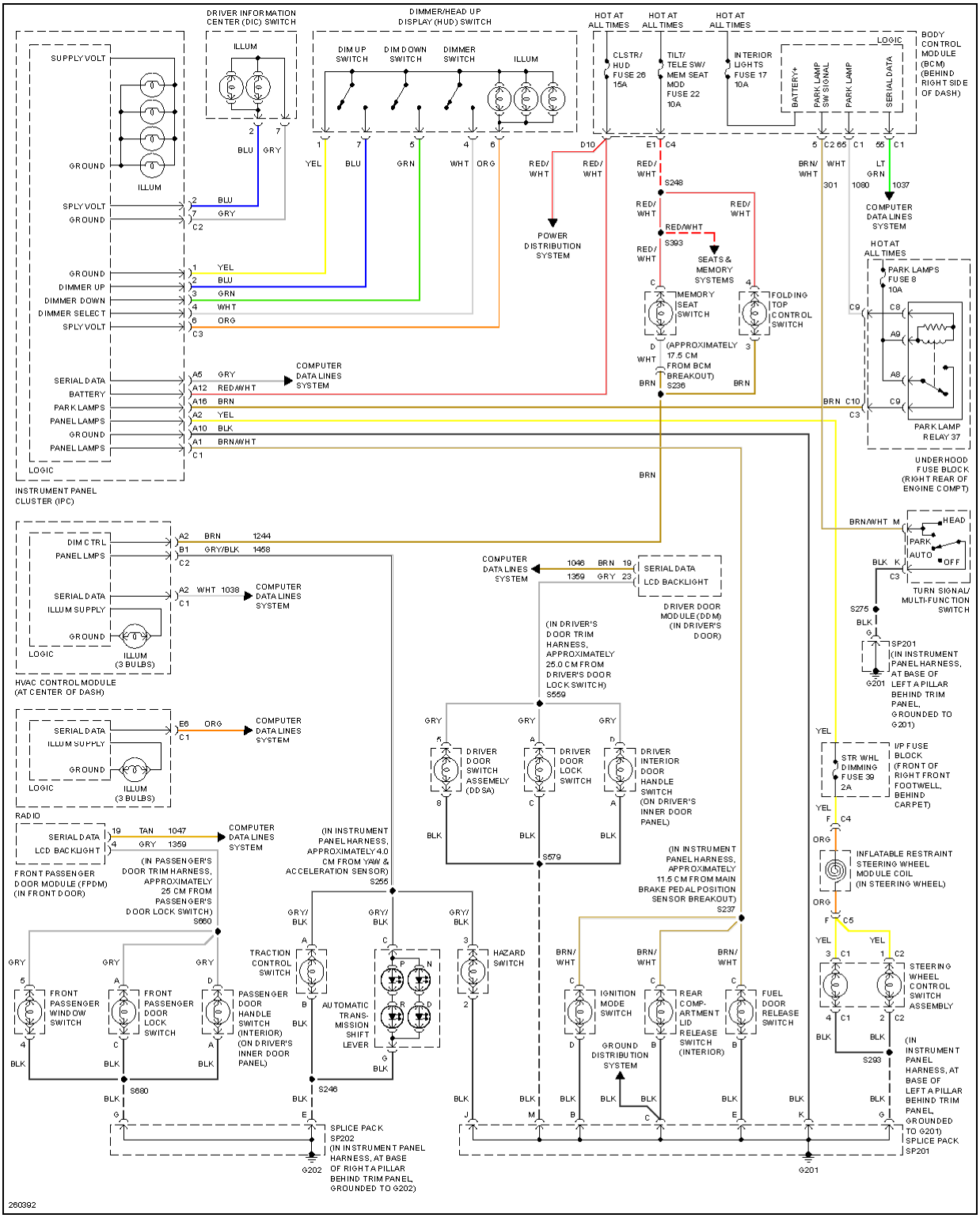
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Fig. 41: Courtesy Lamps Circuit

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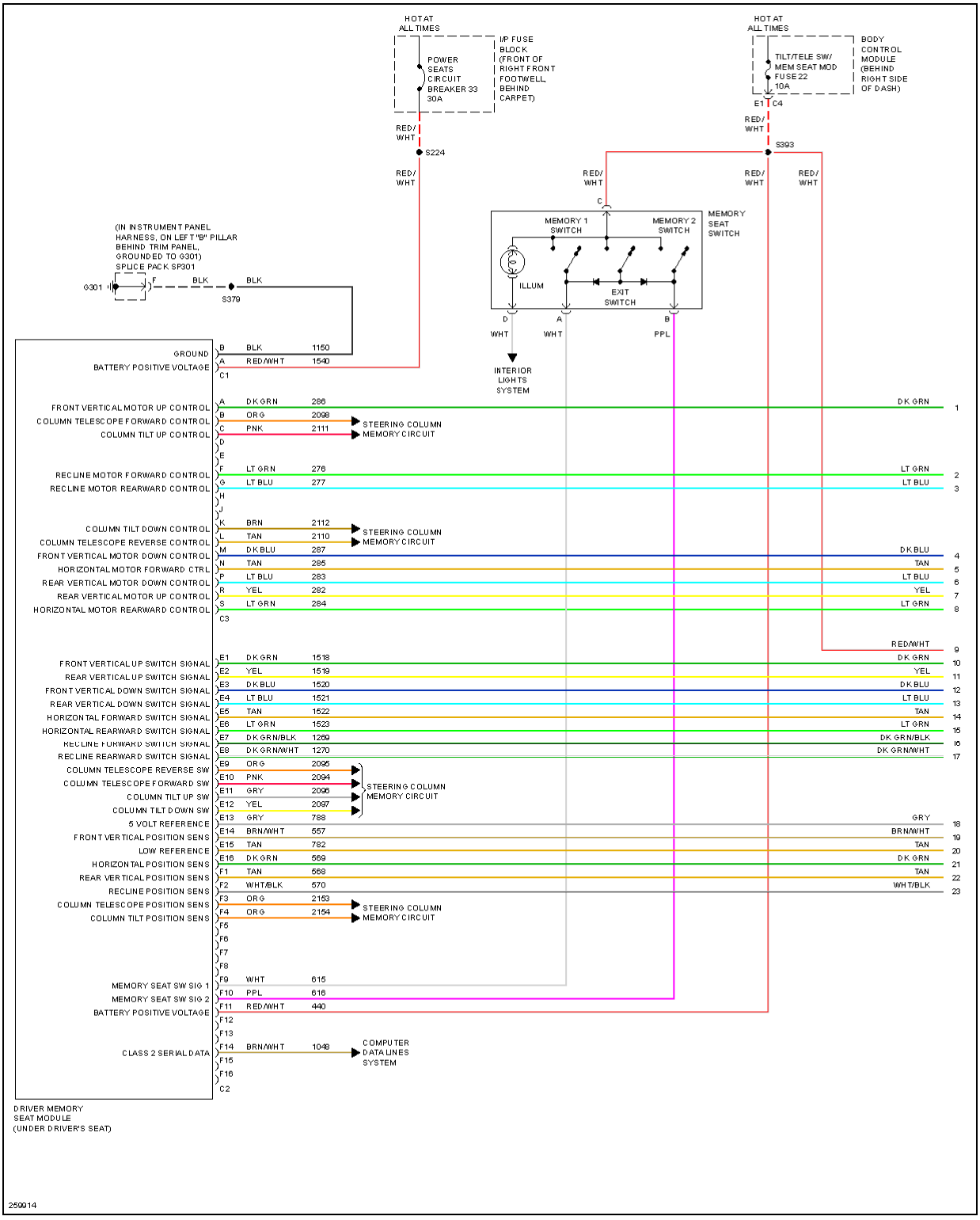


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Fig. 42: Instrument Illumination Circuit

MEMORY SYSTEMS

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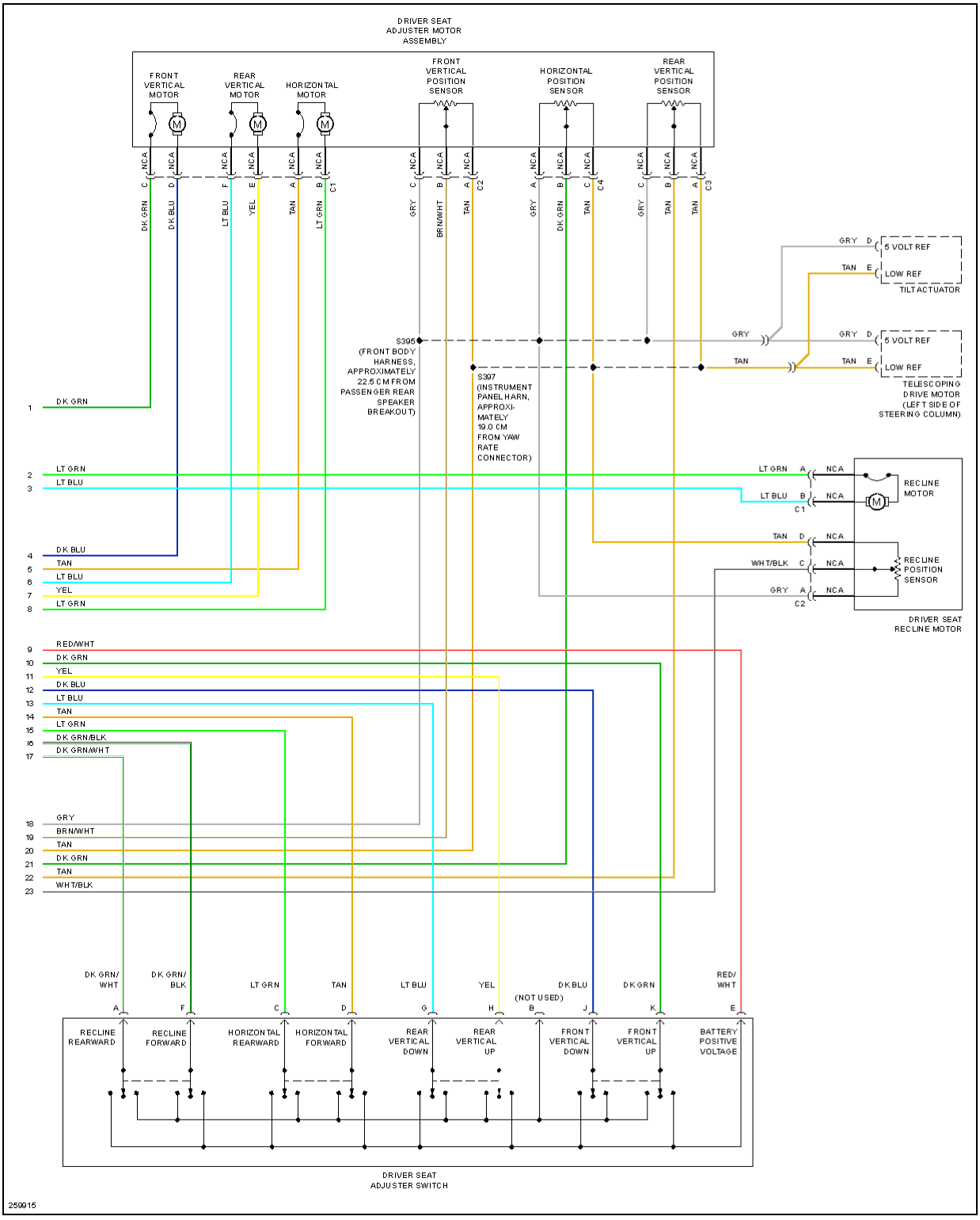
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Fig. 43: Driver"s Memory Seat Circuit (1 of 2)

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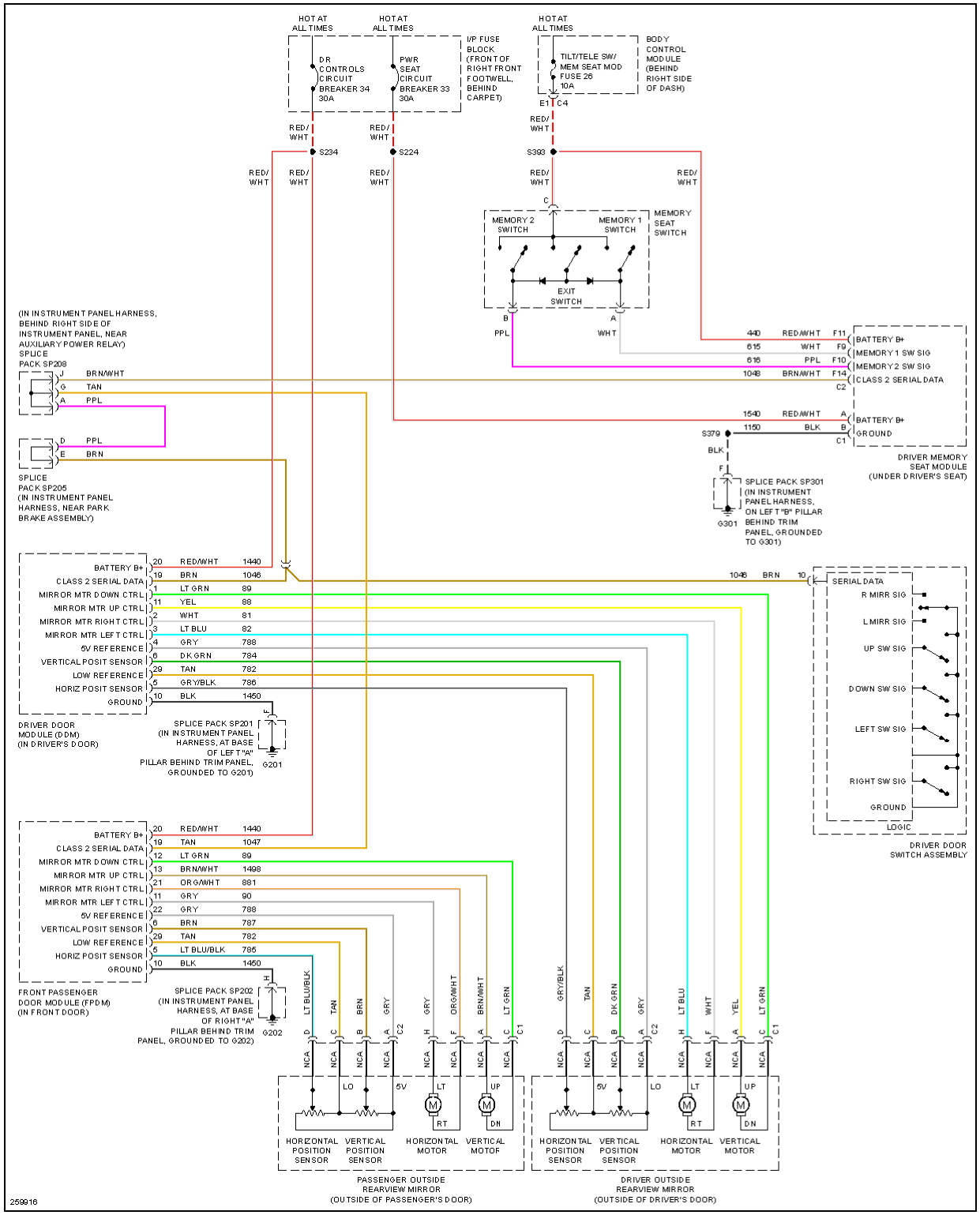
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Fig. 44: Driver"s Memory Seat Circuit (2 of 2)

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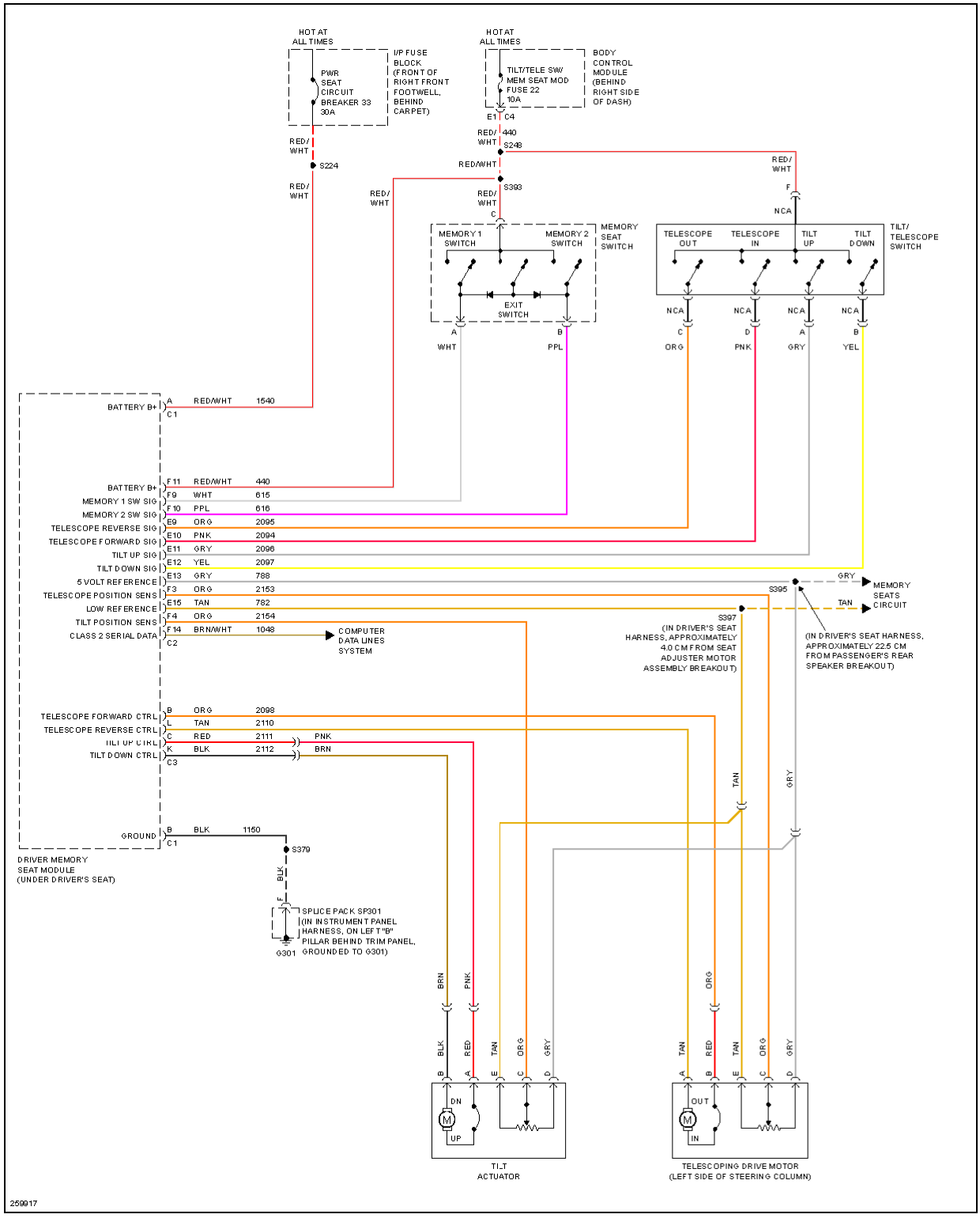
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Fig. 45: Memory Mirrors Circuit

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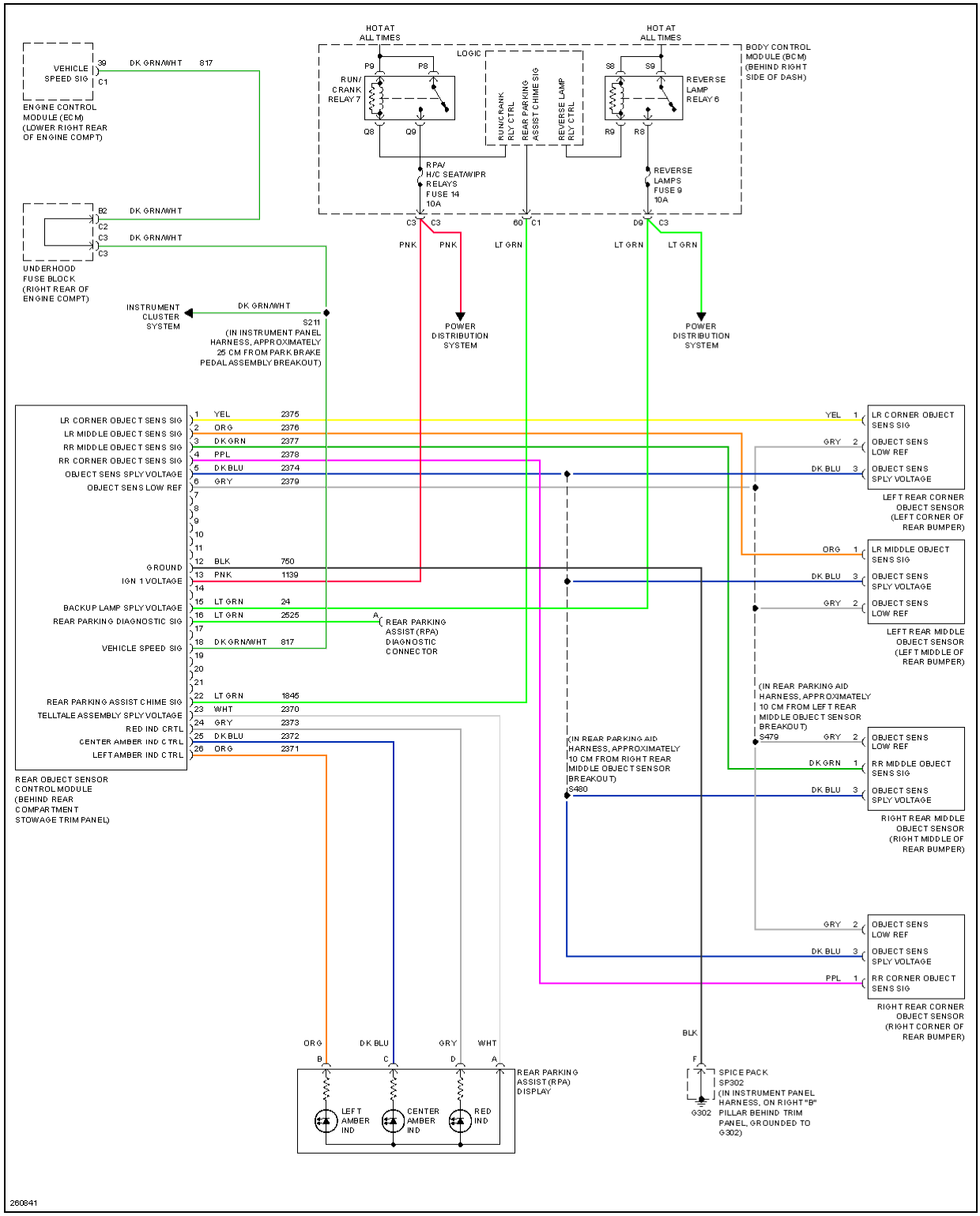


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Fig. 46: Steering Column Memory Circuit

NAVIGATION

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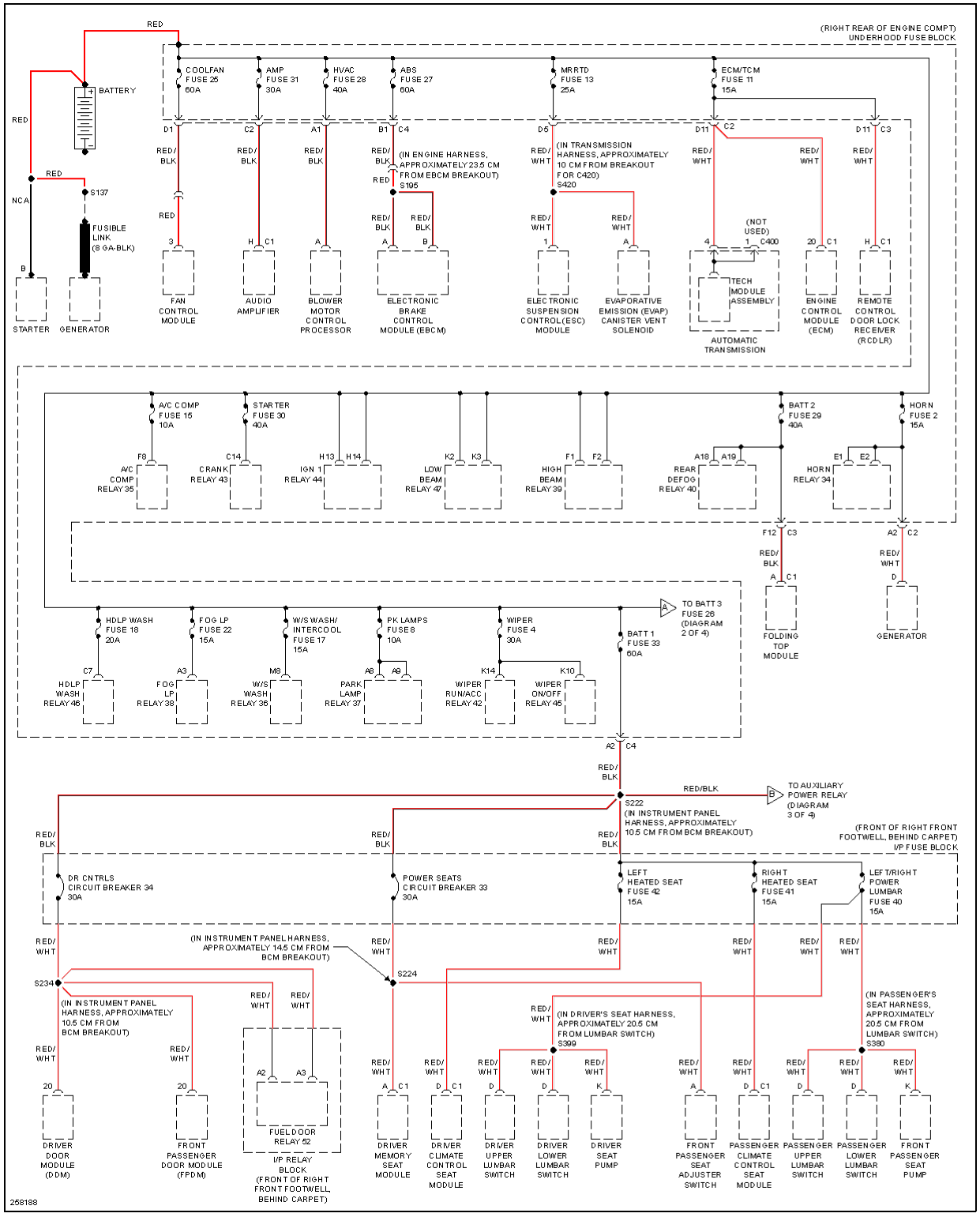
Fig. 47: Parking Assistant Circuit

POWER DISTRIBUTION

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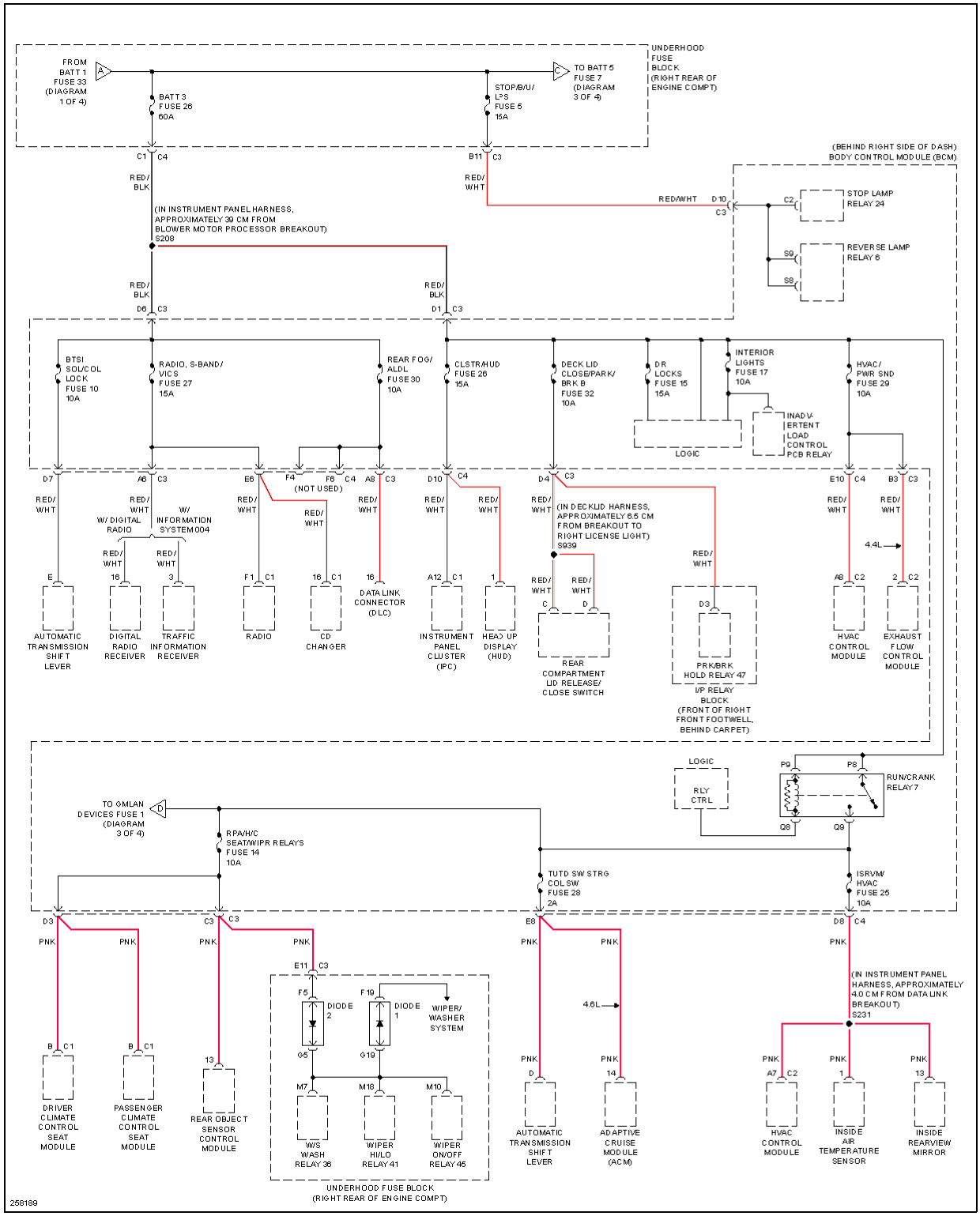
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Fig. 48: Power Distribution Circuit (1 of 4)

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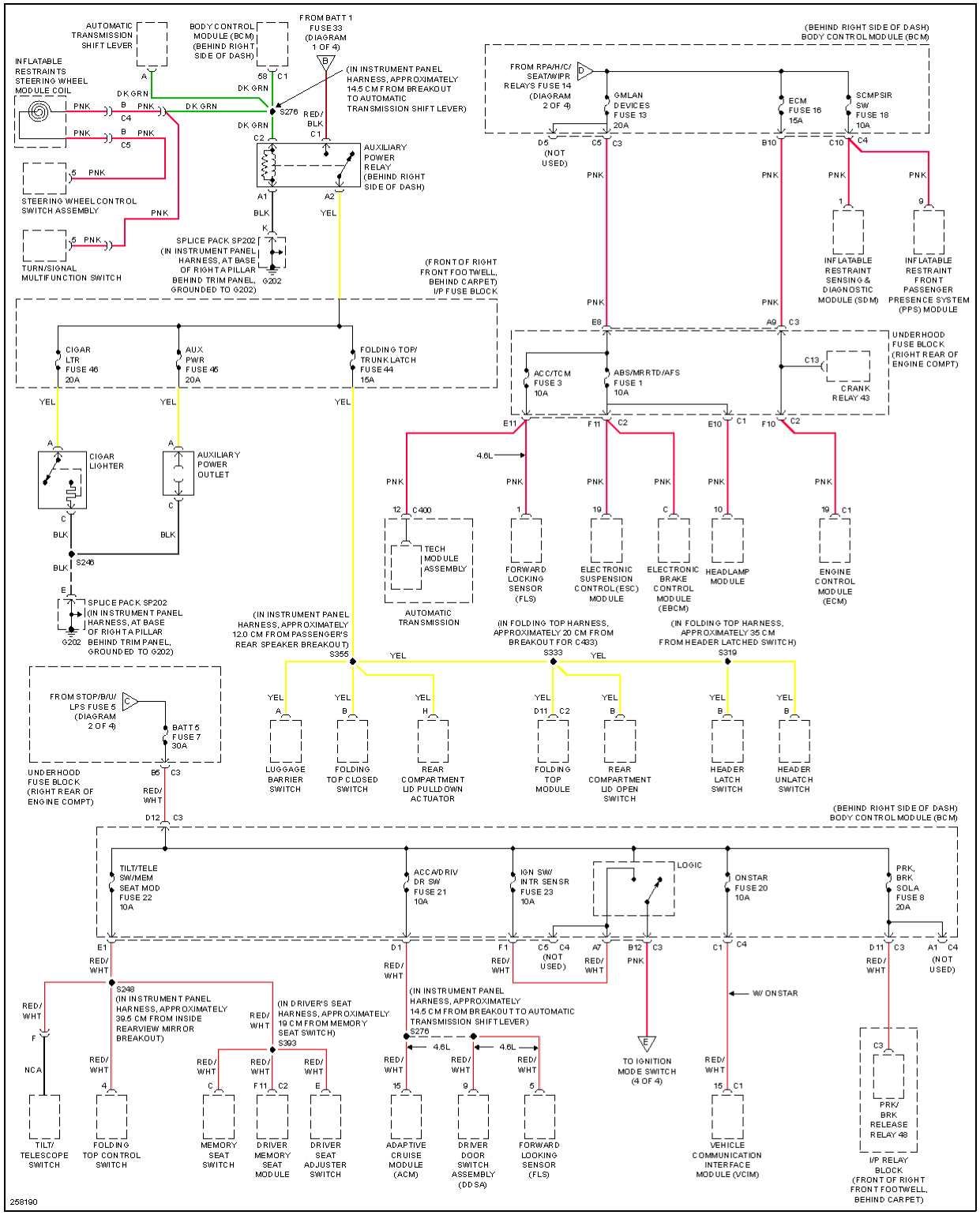
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Fig. 49: Power Distribution Circuit (2 of 4)

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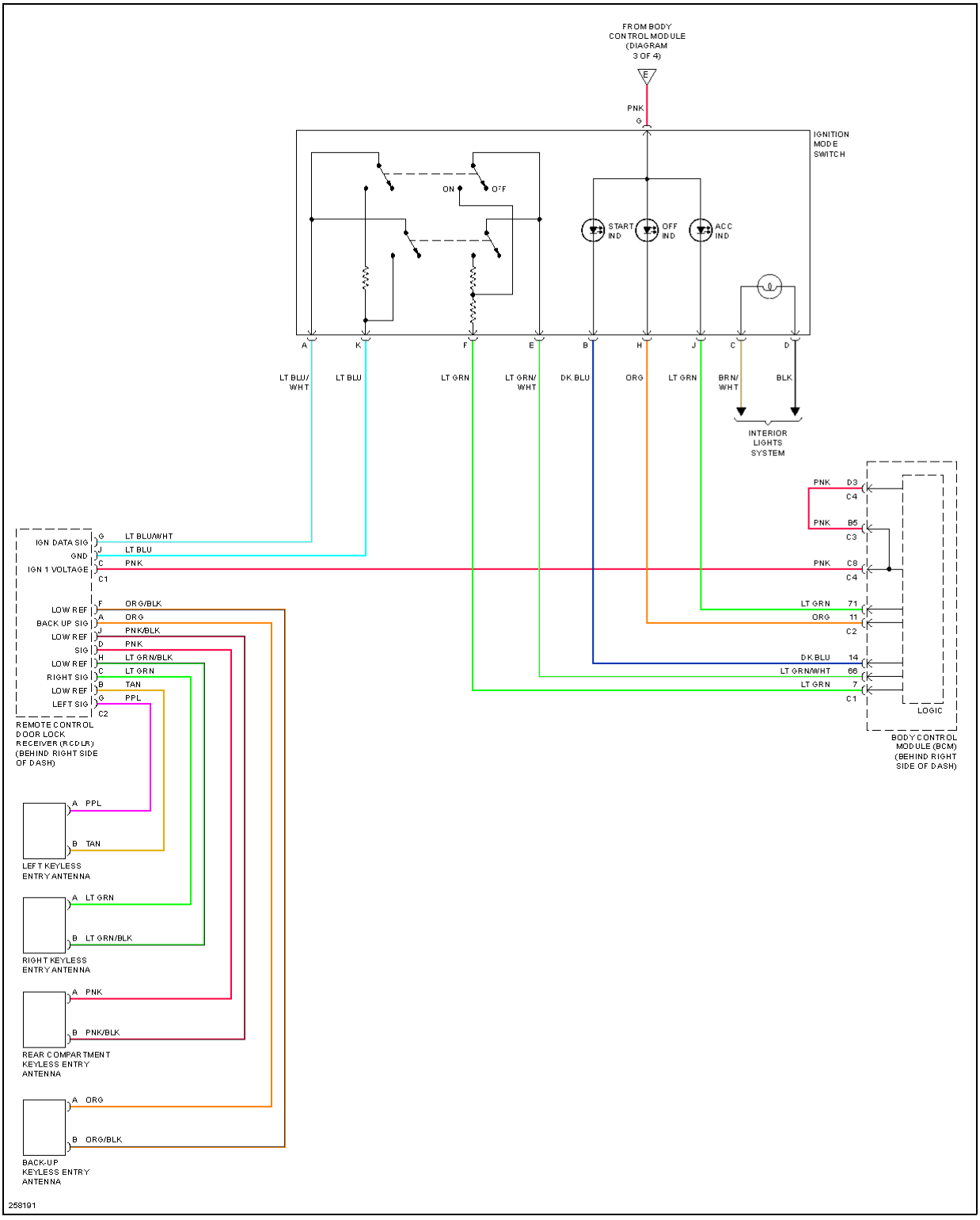
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Fig. 50: Power Distribution Circuit (3 of 4)

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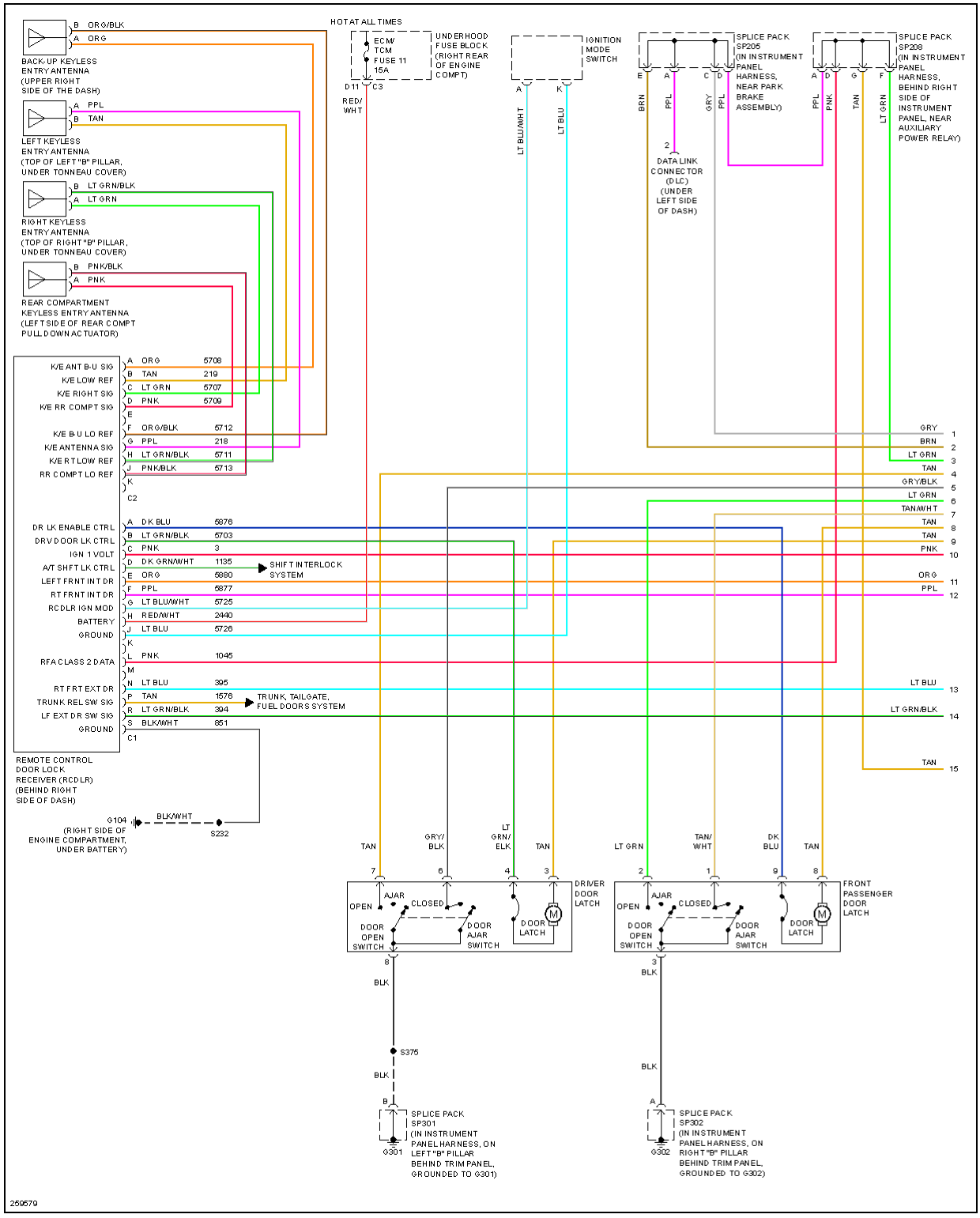
Fig. 51: Power Distribution Circuit (4 of 4)

POWER DOOR LOCKS

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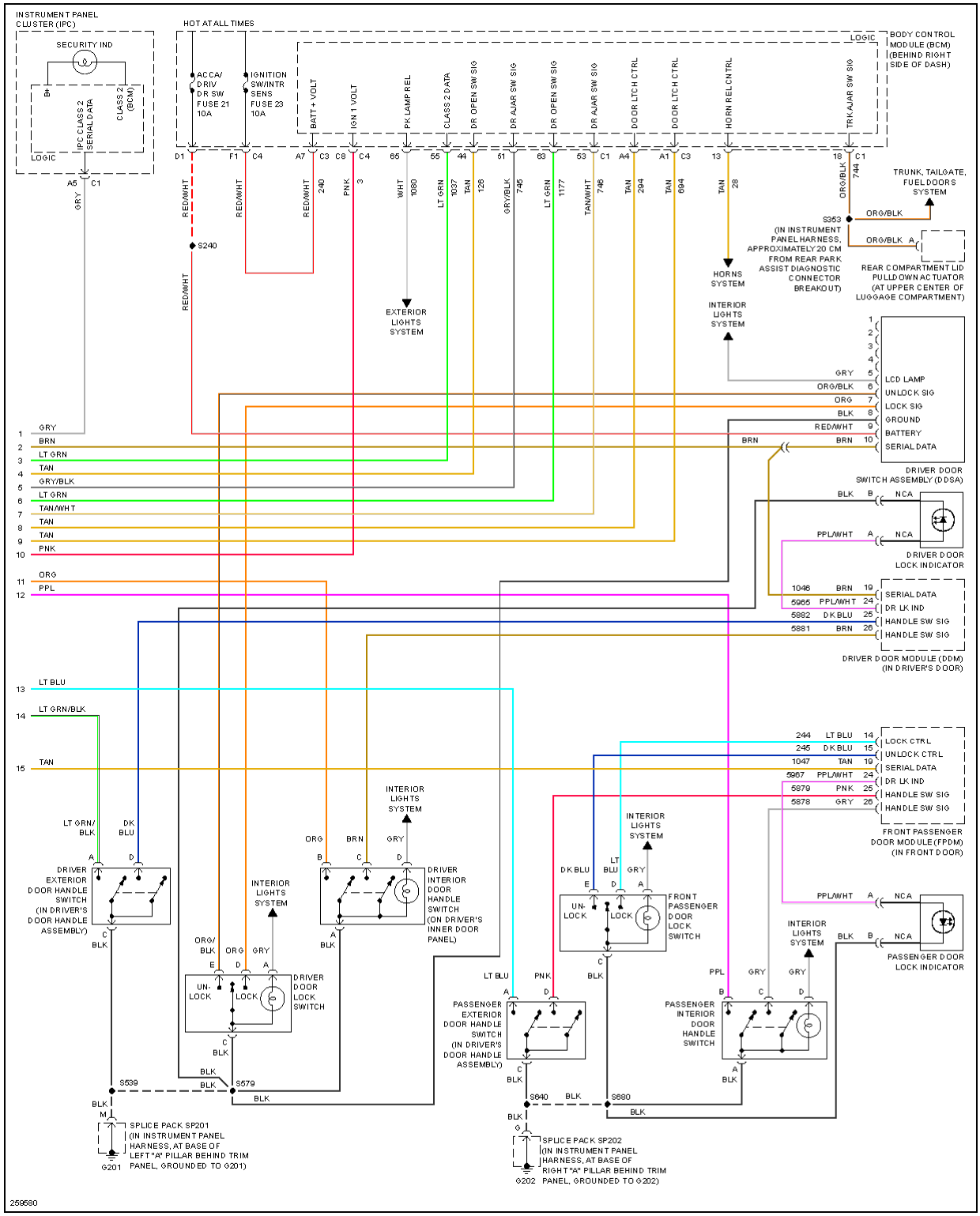
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Fig. 52: Power Door Locks Circuit (1 of 2)

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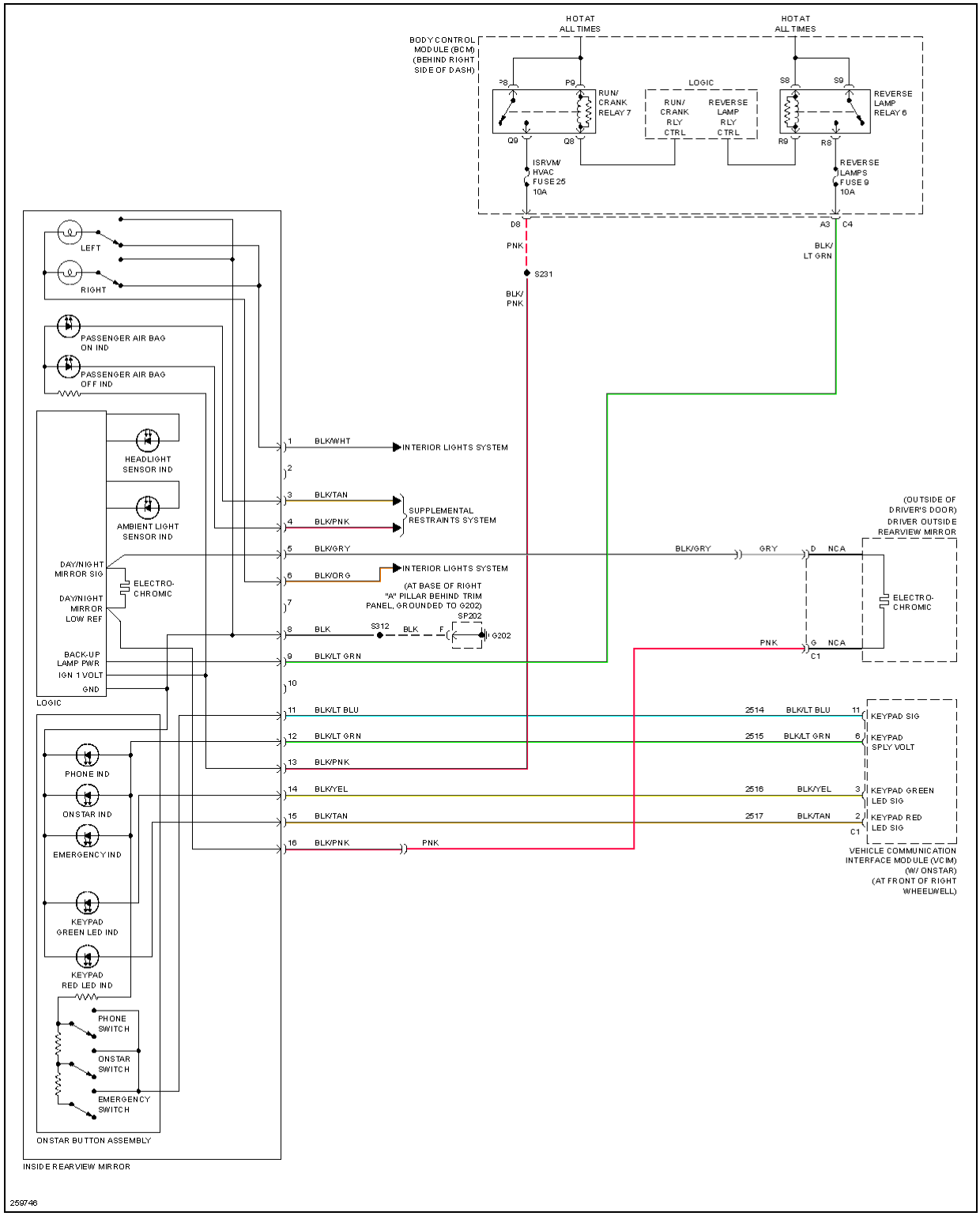


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Fig. 53: Power Door Locks Circuit (2 of 2)

POWER MIRRORS

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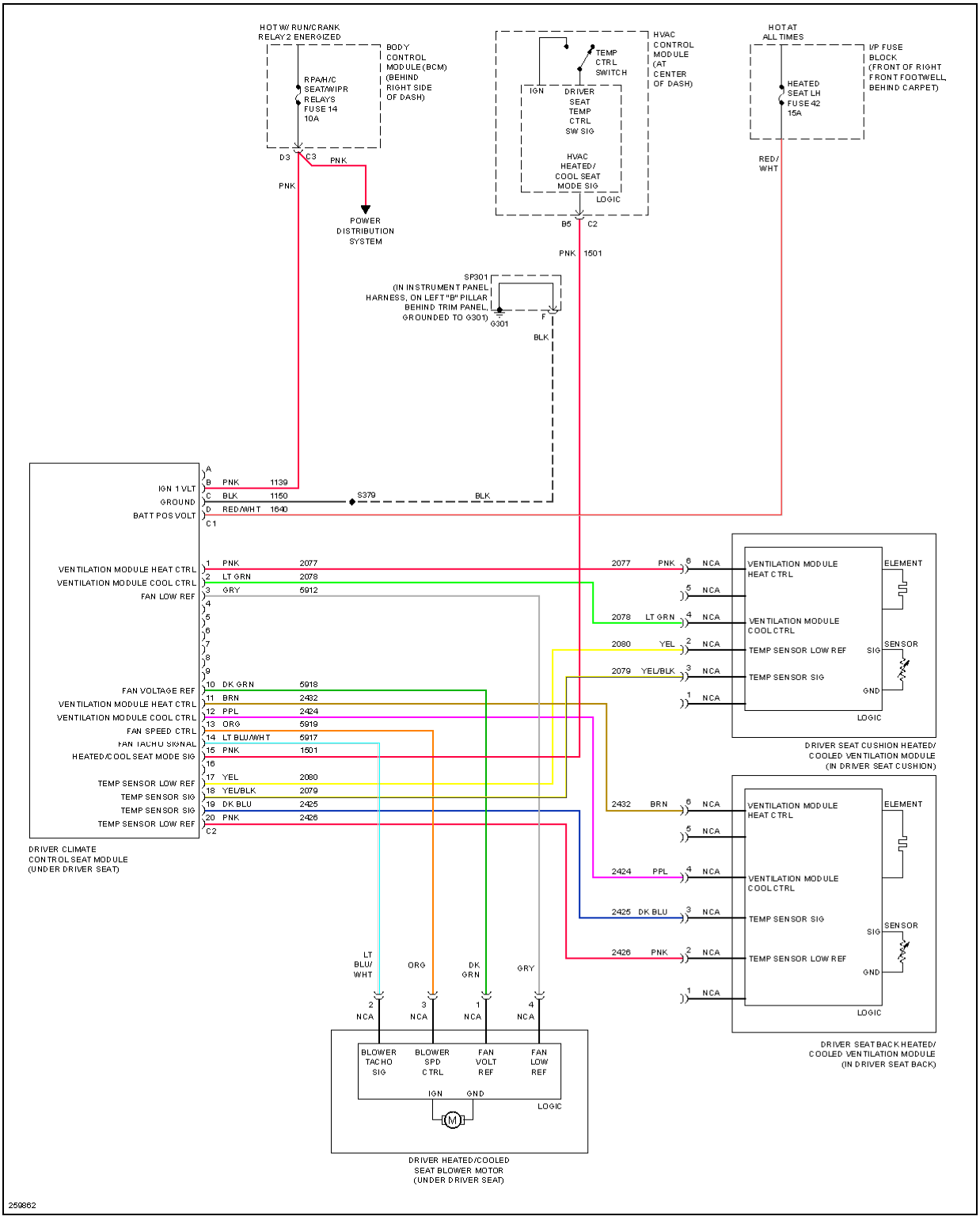


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Fig. 54: Electrochromic Mirror Circuit

POWER SEATS

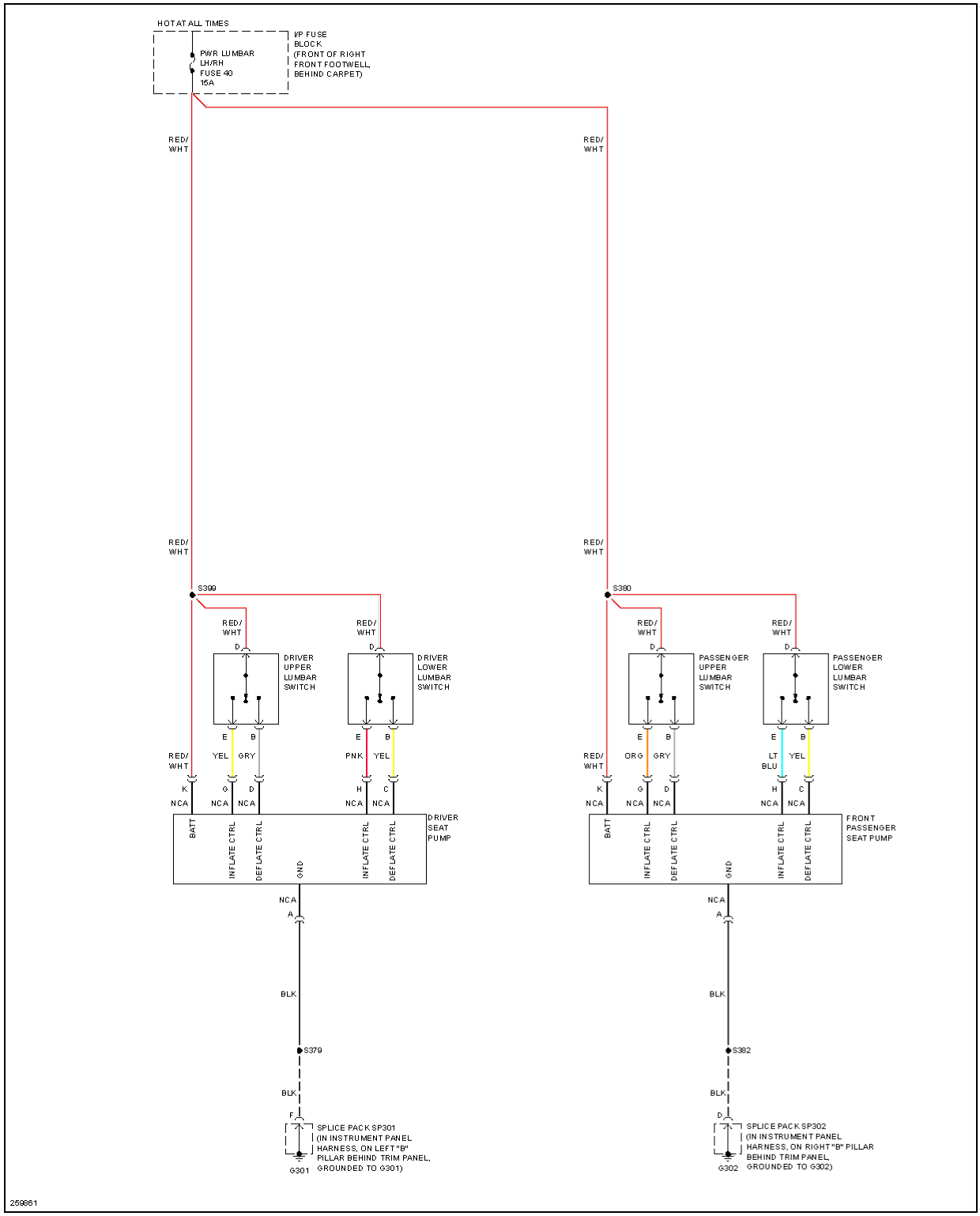
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Fig. 55: Driver Climate Control Seat Circuit

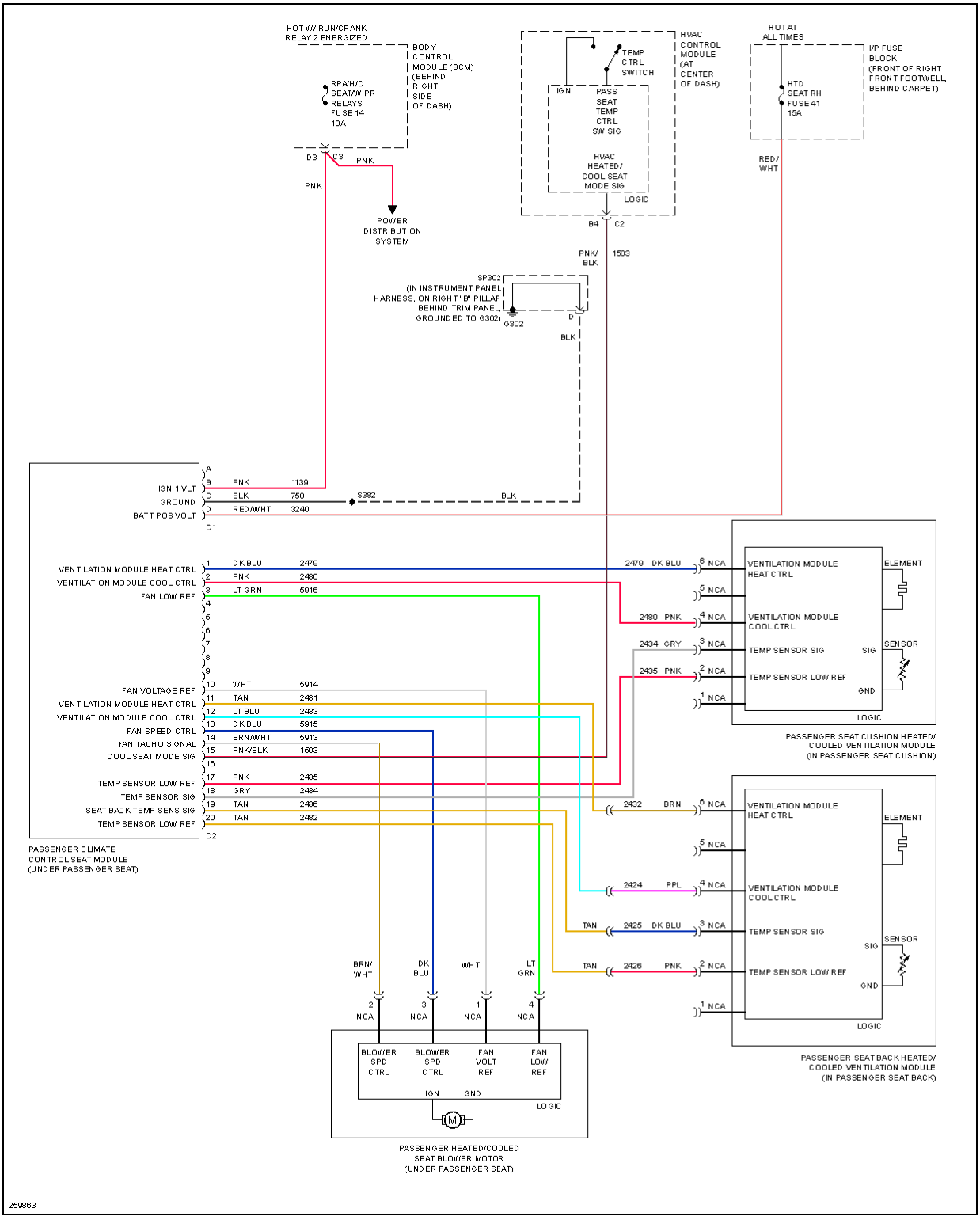
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Fig. 56: Lumbar Circuit

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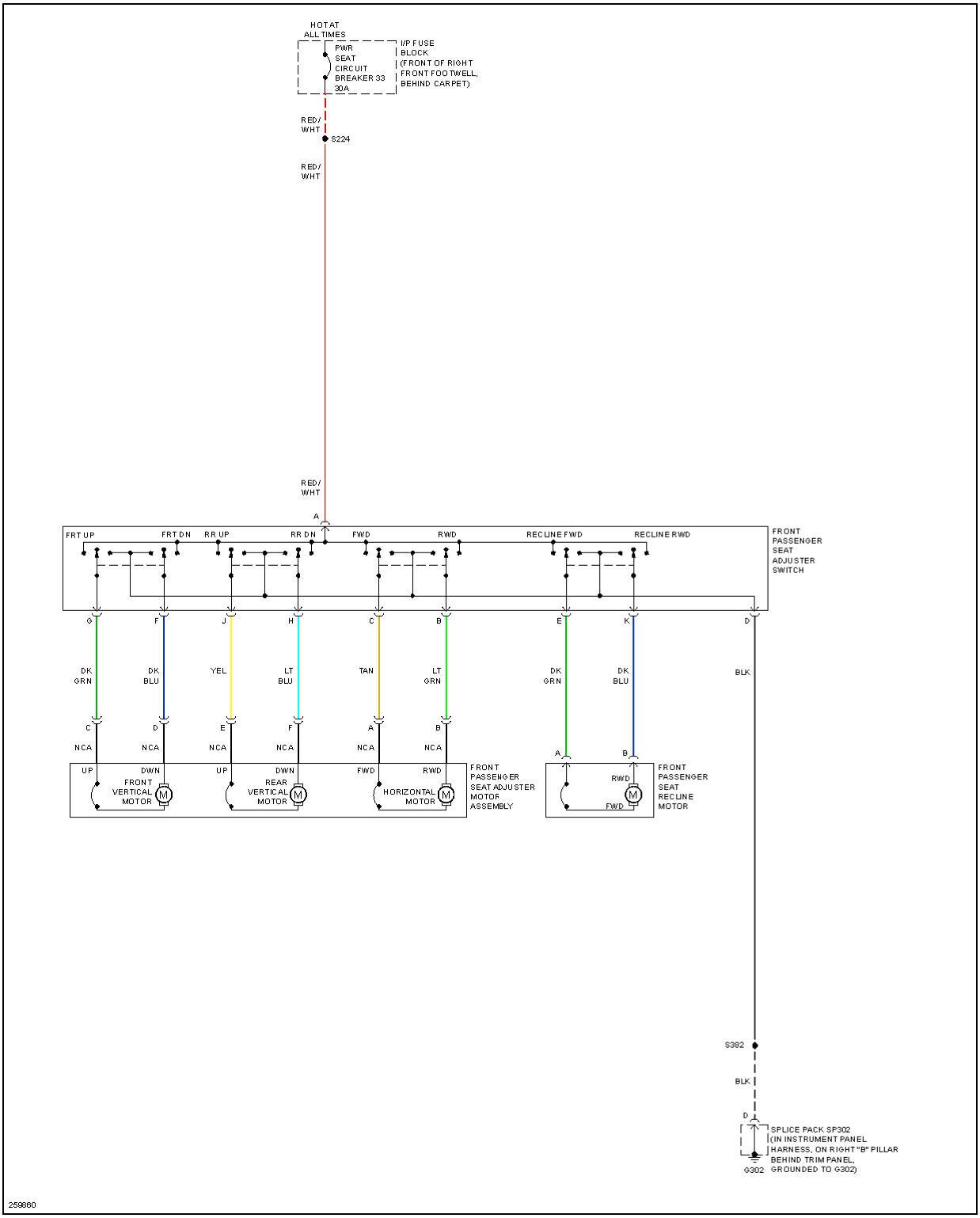
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Fig. 57: Passenger Climate Control Seat Circuit

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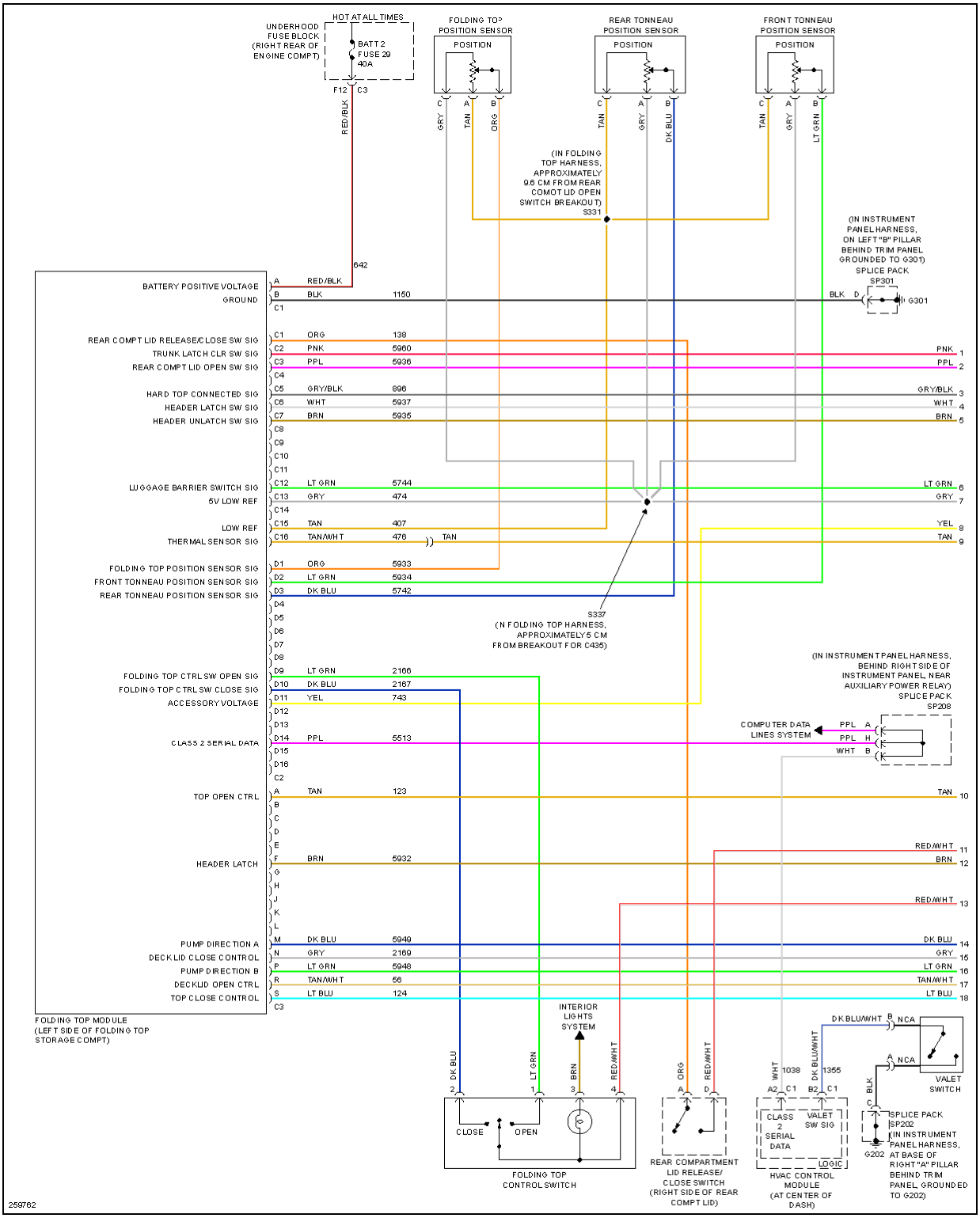
Fig. 58: Passenger Power Seat Circuit

POWER TOP/SUNROOF

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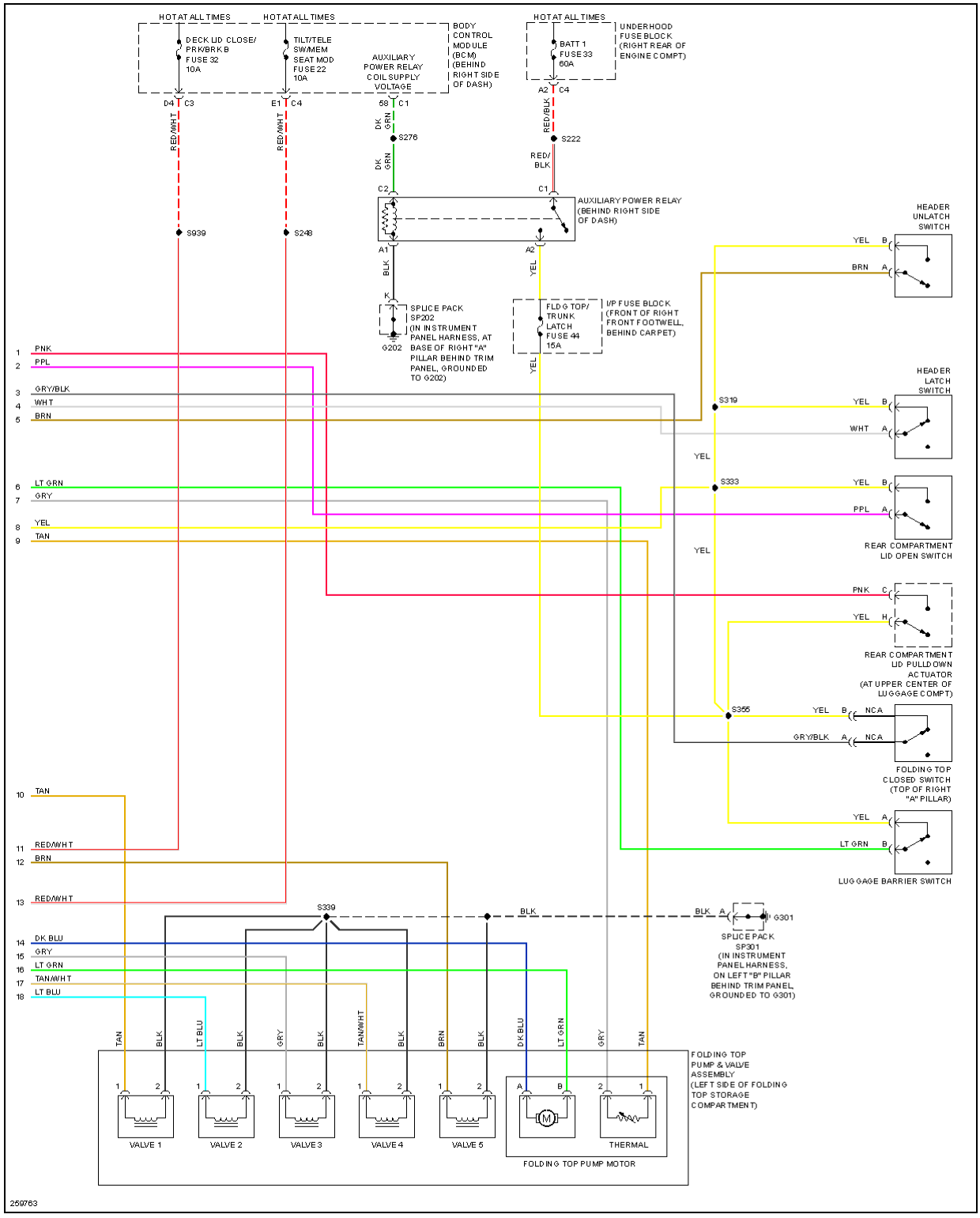
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Fig. 59: Power Top/Sunroof Circuit (1 of 2)

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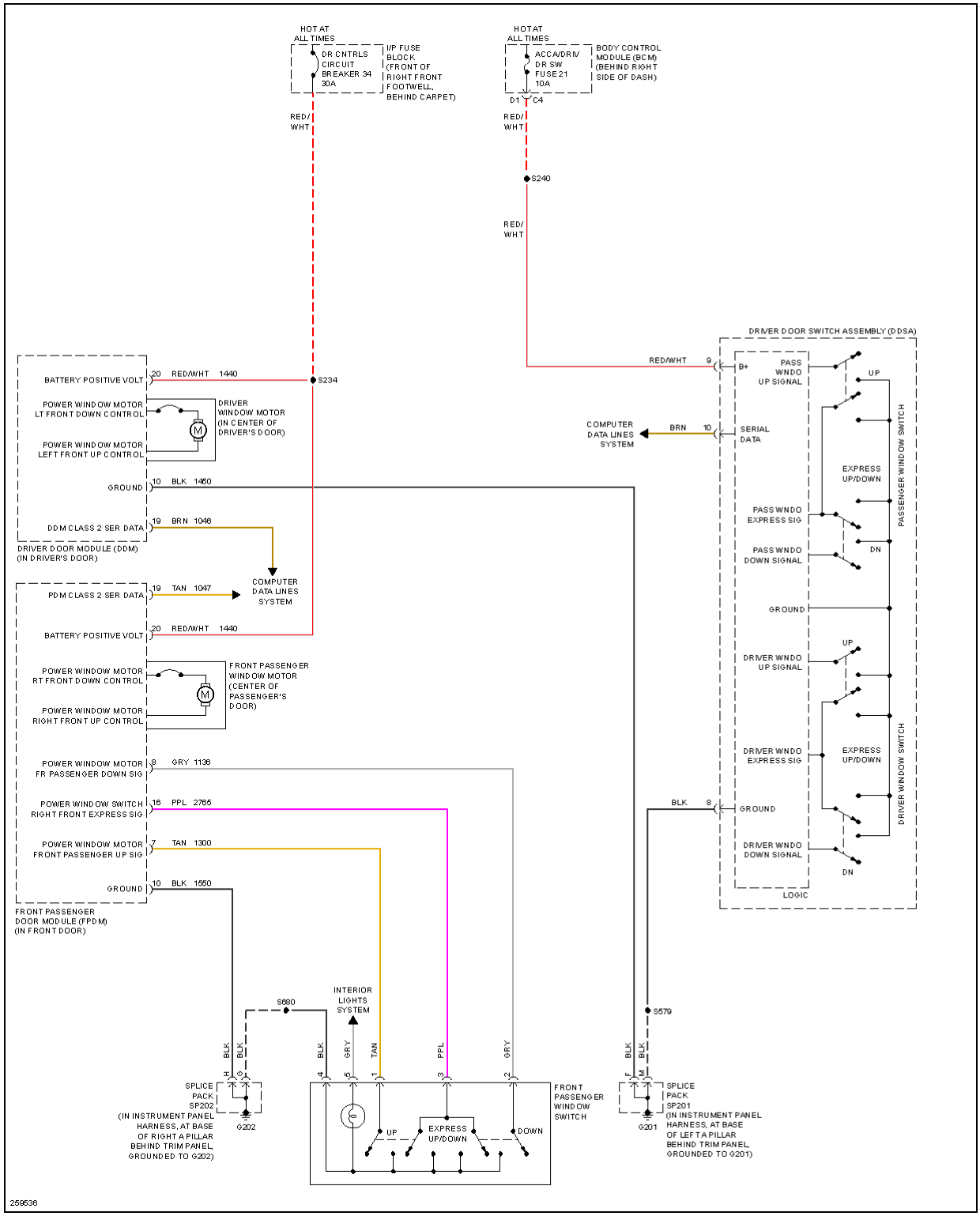


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Fig. 60: Power Top/Sunroof Circuit (2 of 2)

POWER WINDOWS

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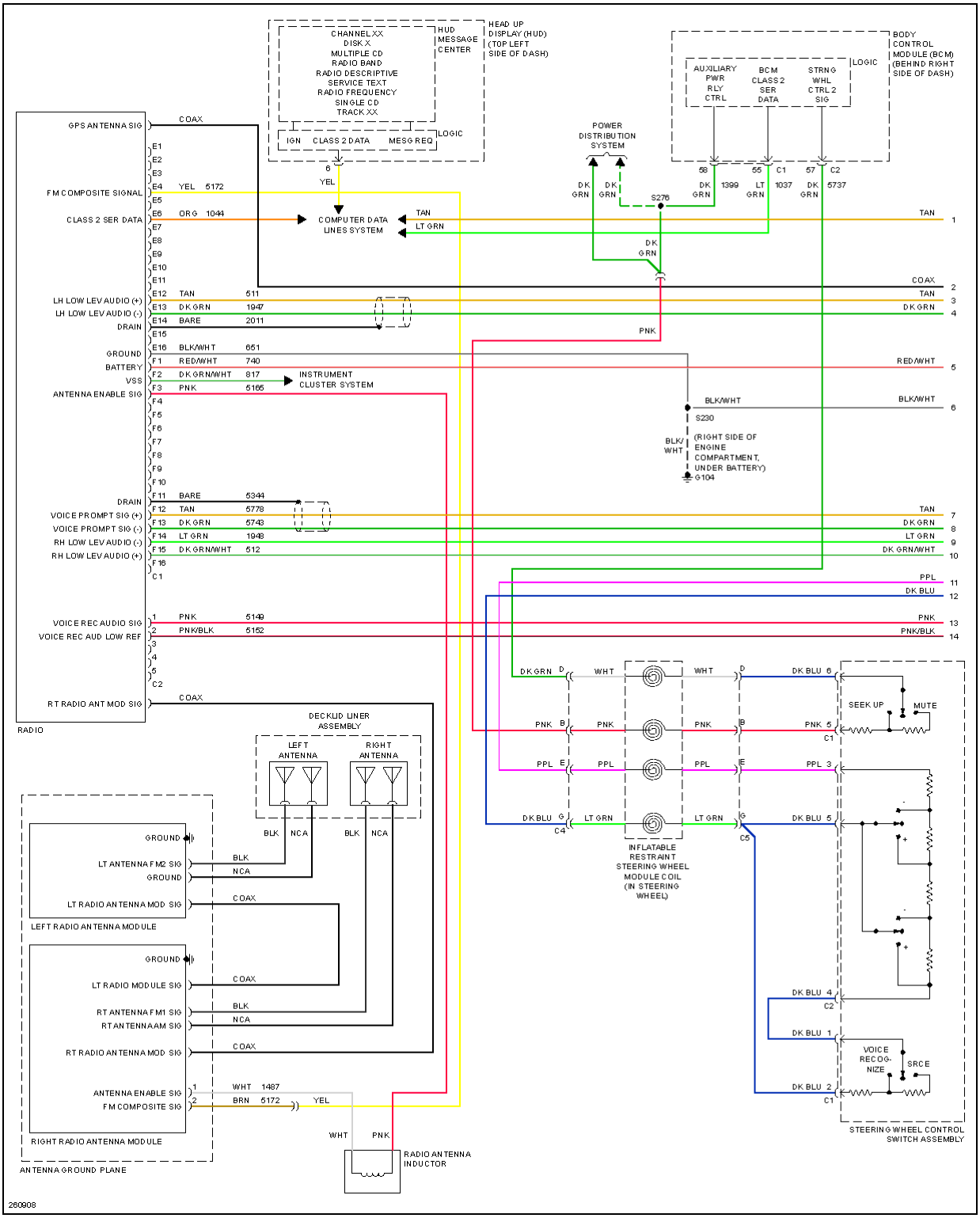


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Fig. 61: Power Windows Circuit

RADIO

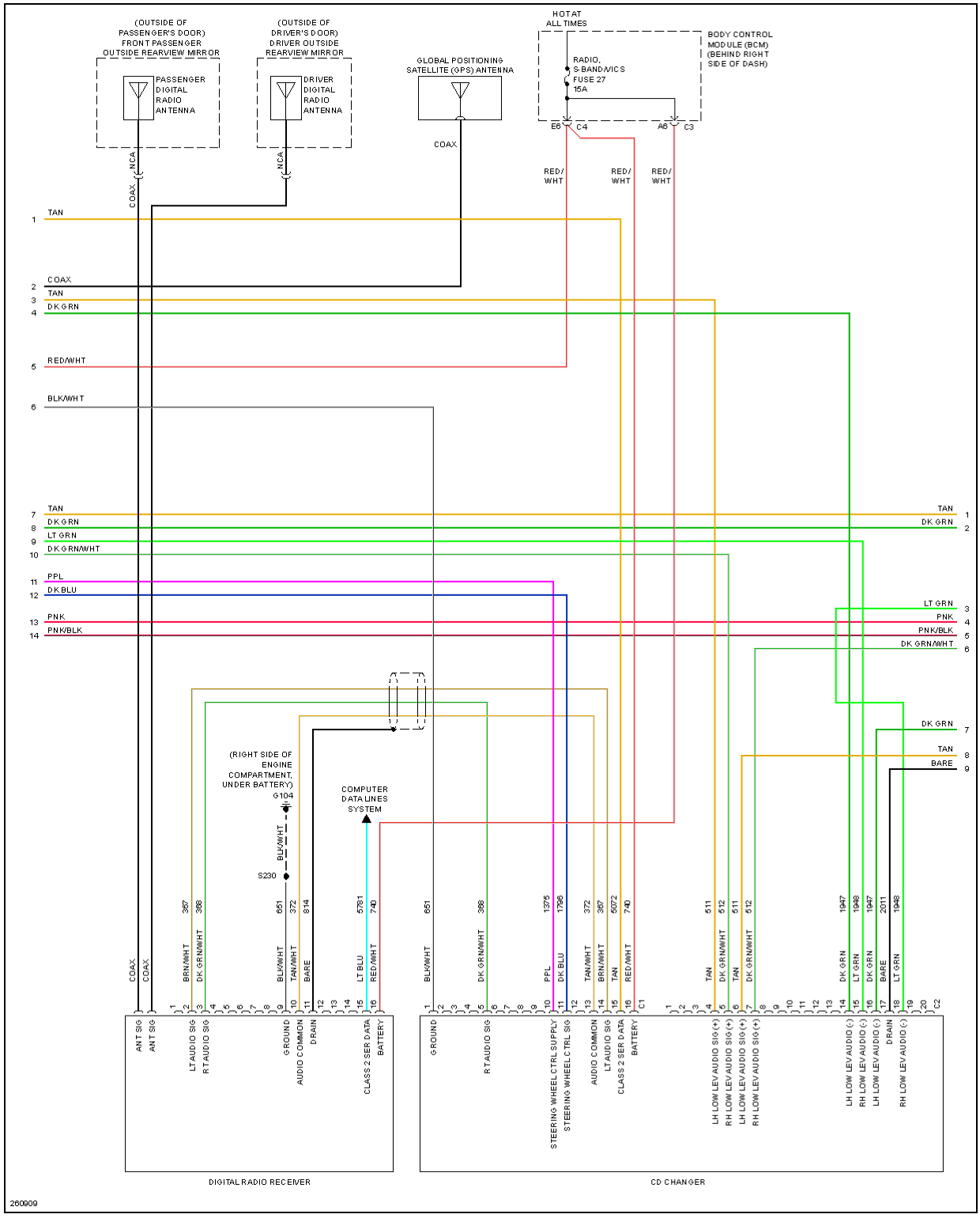
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Fig. 62: Radio Circuit (1 of 3)

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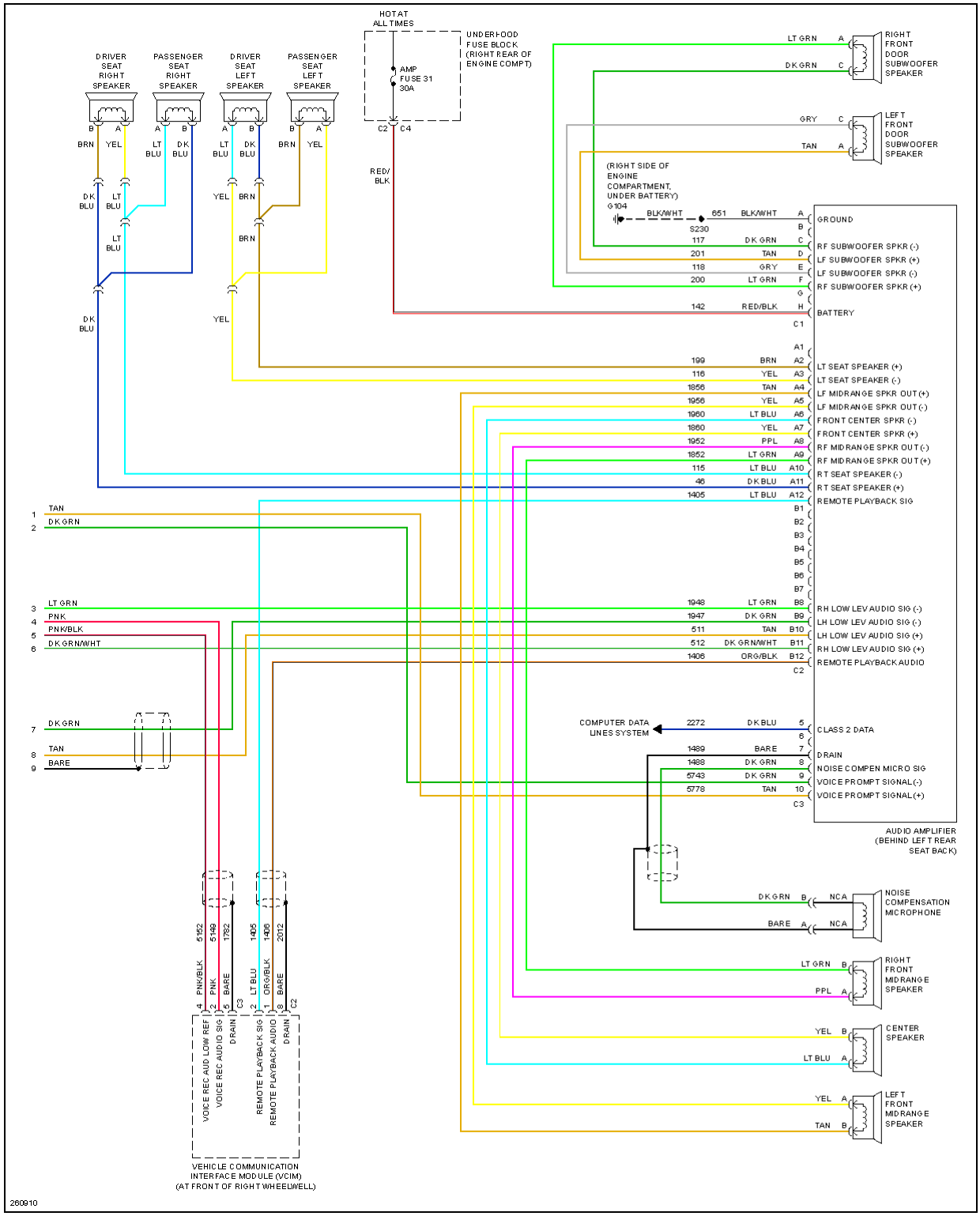
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Fig. 63: Radio Circuit (2 of 3)

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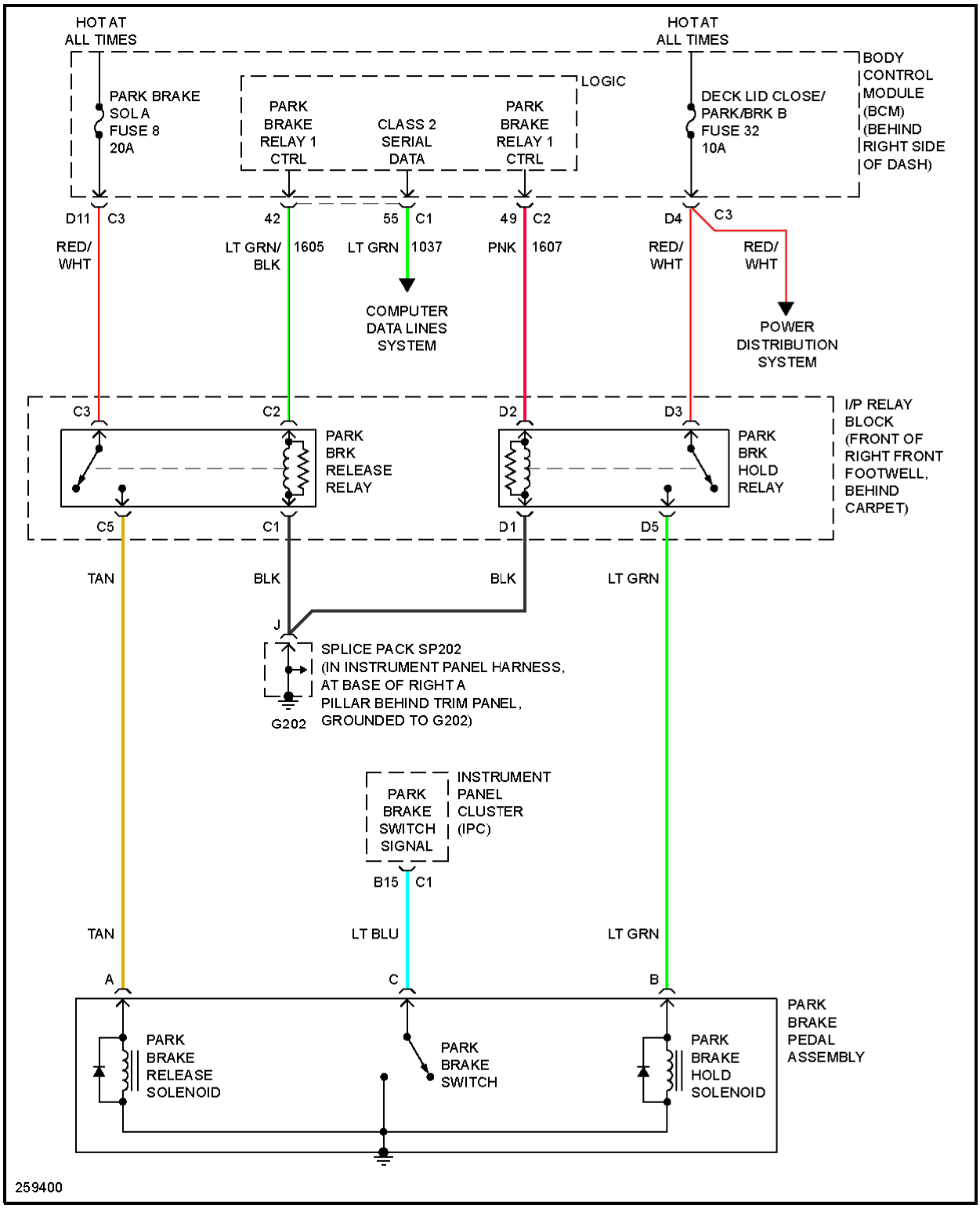


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Fig. 64: Radio Circuit (3 of 3)

SHIFT INTERLOCK

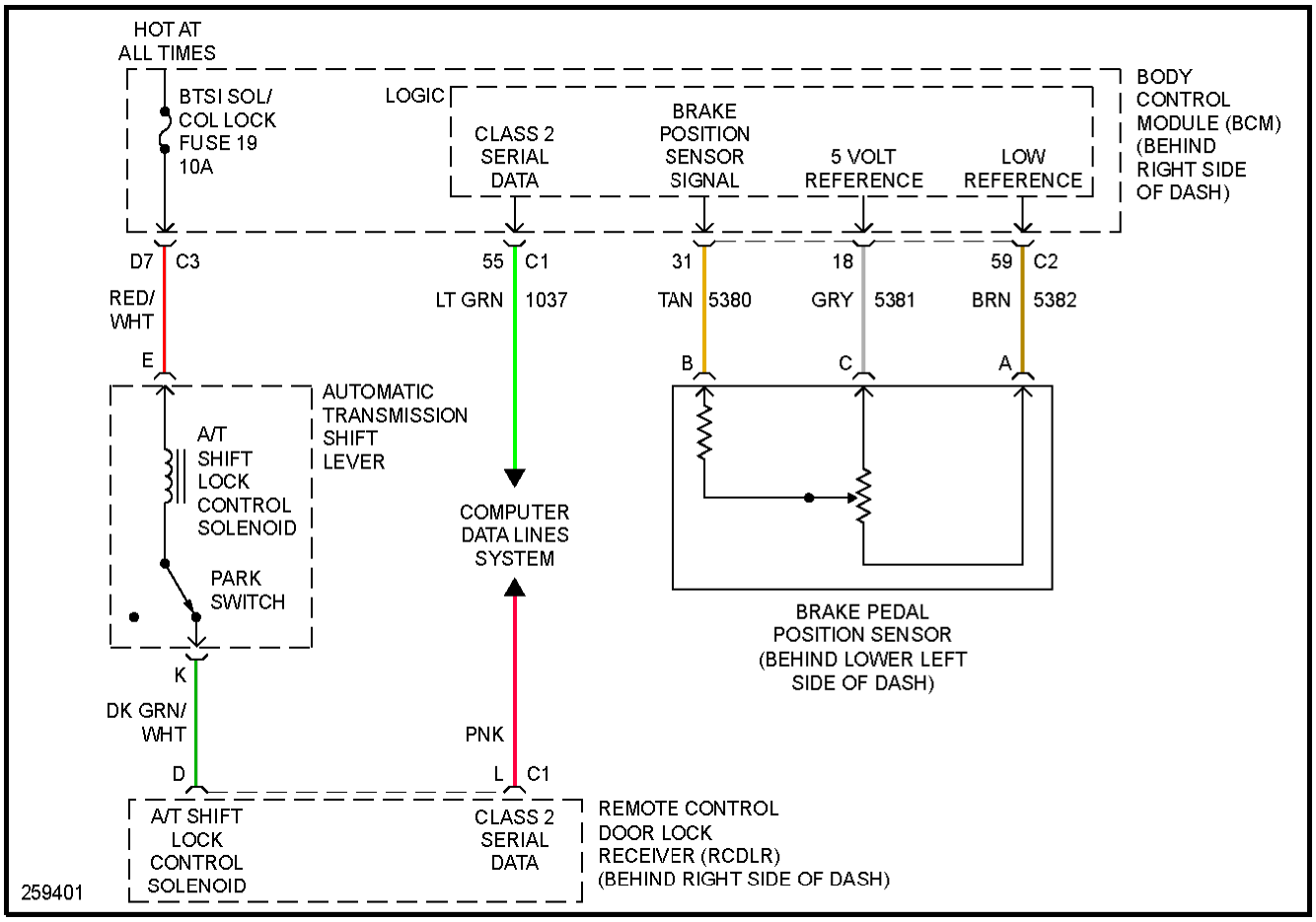
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Fig. 65: Park Brake Release Circuit

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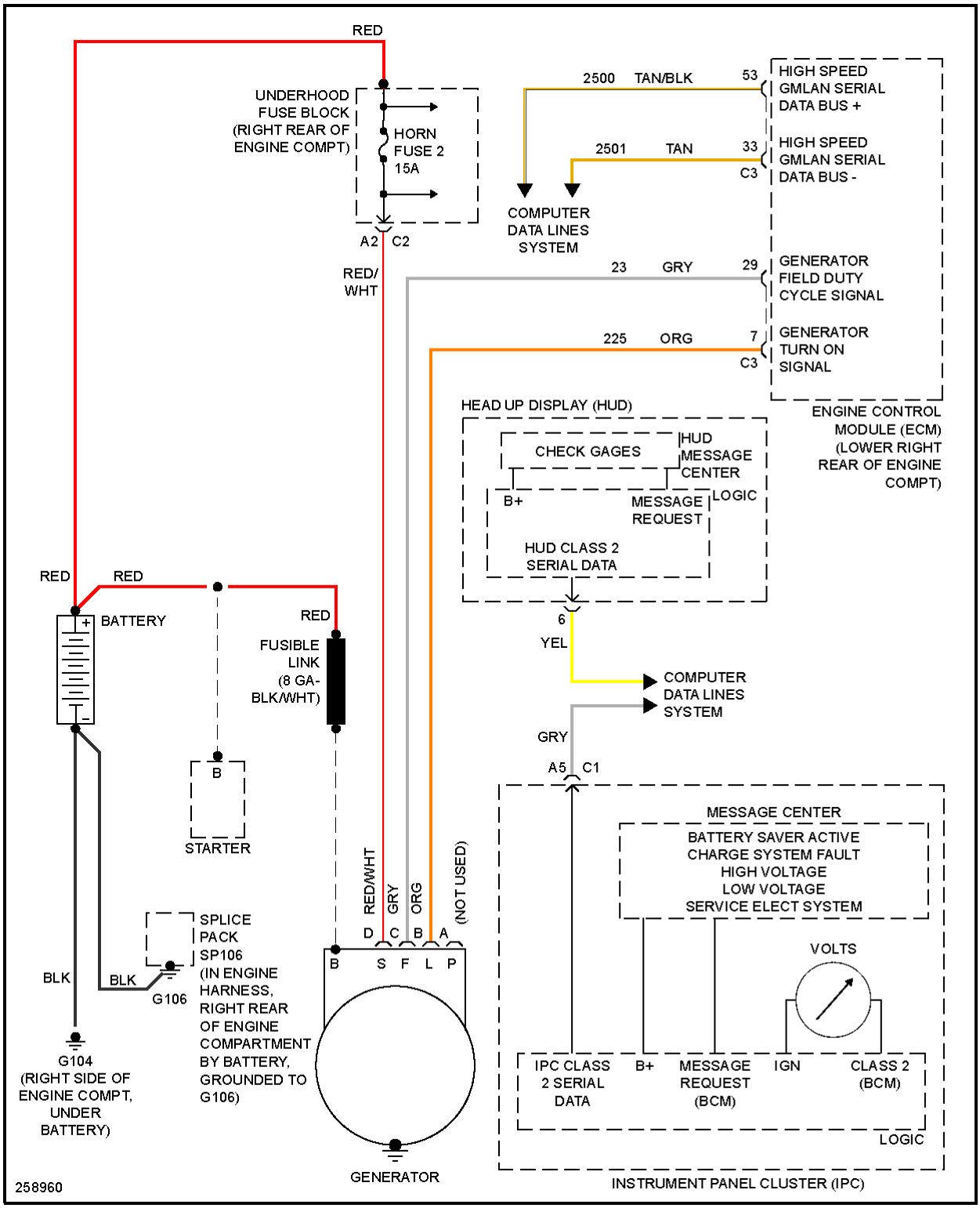
Fig. 66: Shift Interlock Circuit

STARTING/CHARGING

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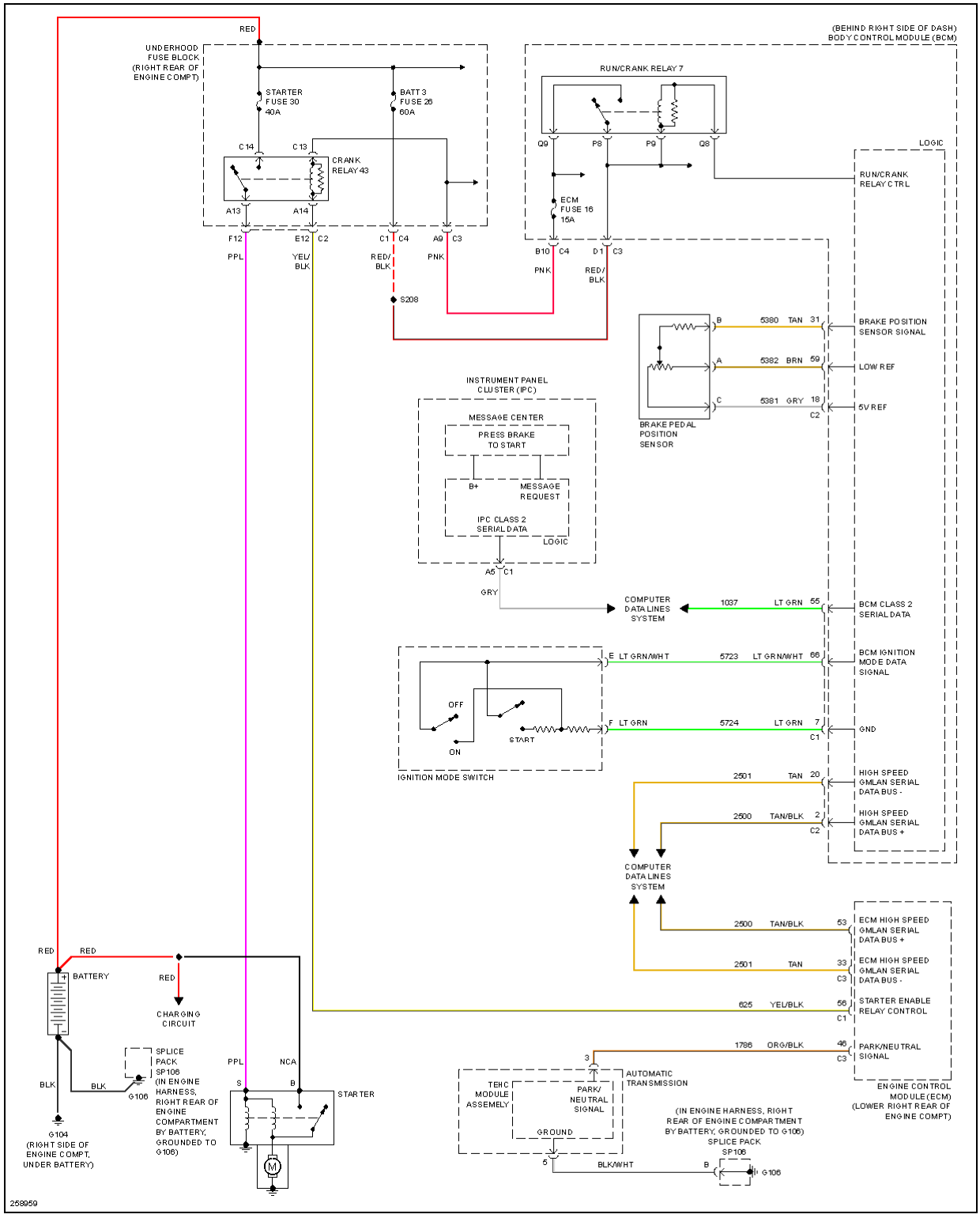
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Fig. 67: Charging Circuit

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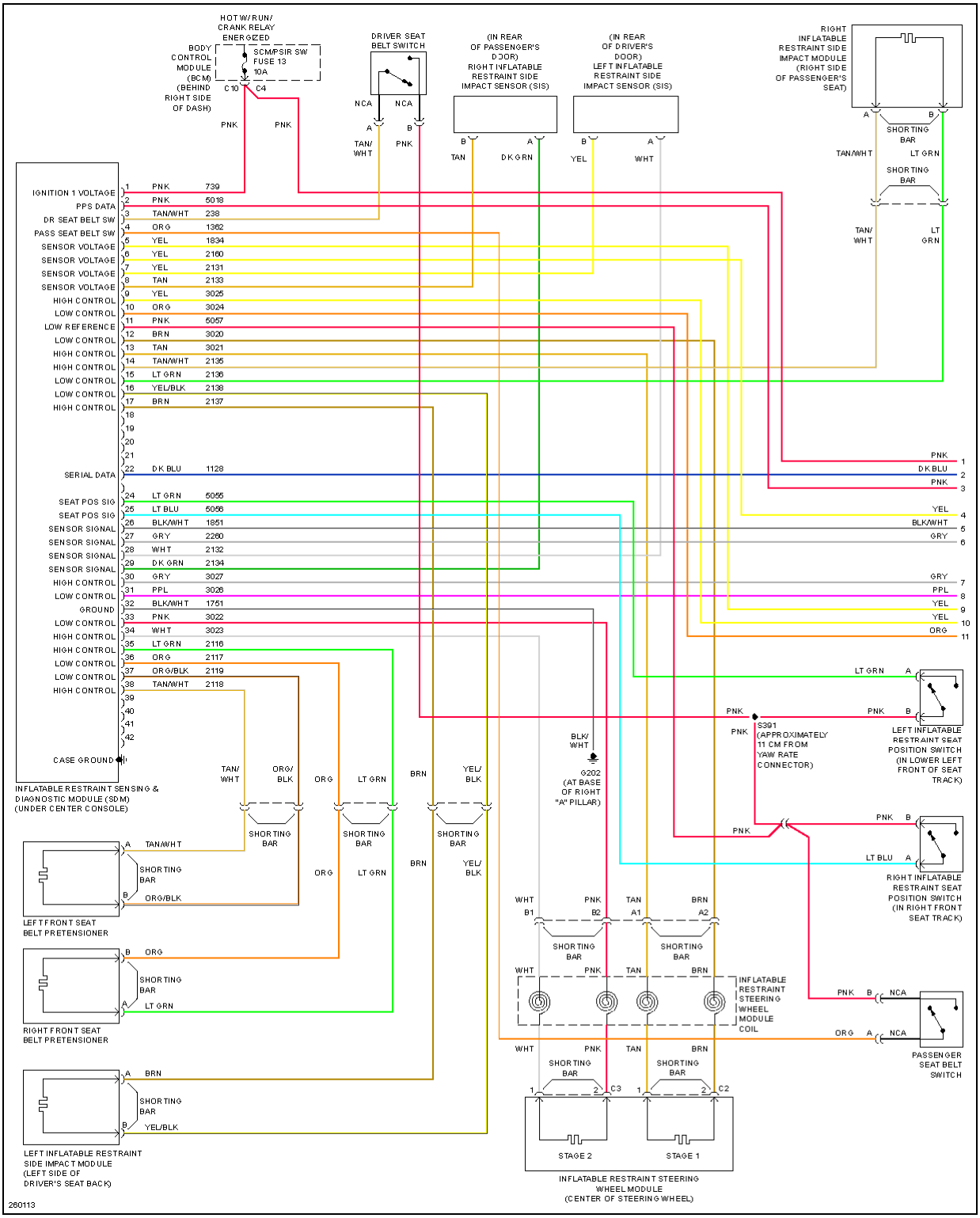
Fig. 68: Starting Circuit

SUPPLEMENTAL RESTRAINTS

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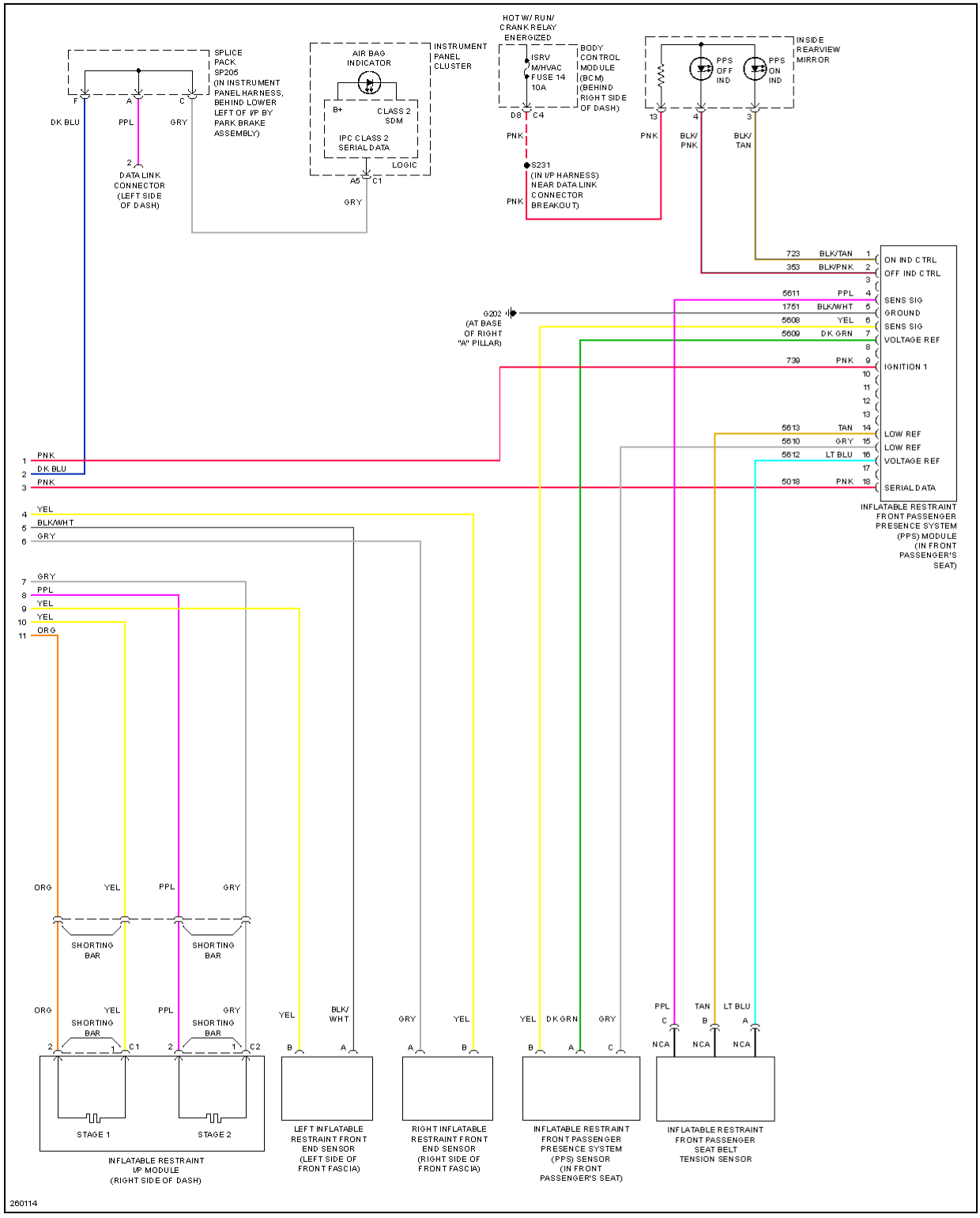
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Fig. 69: Supplemental Restraints Circuit (1 of 2)

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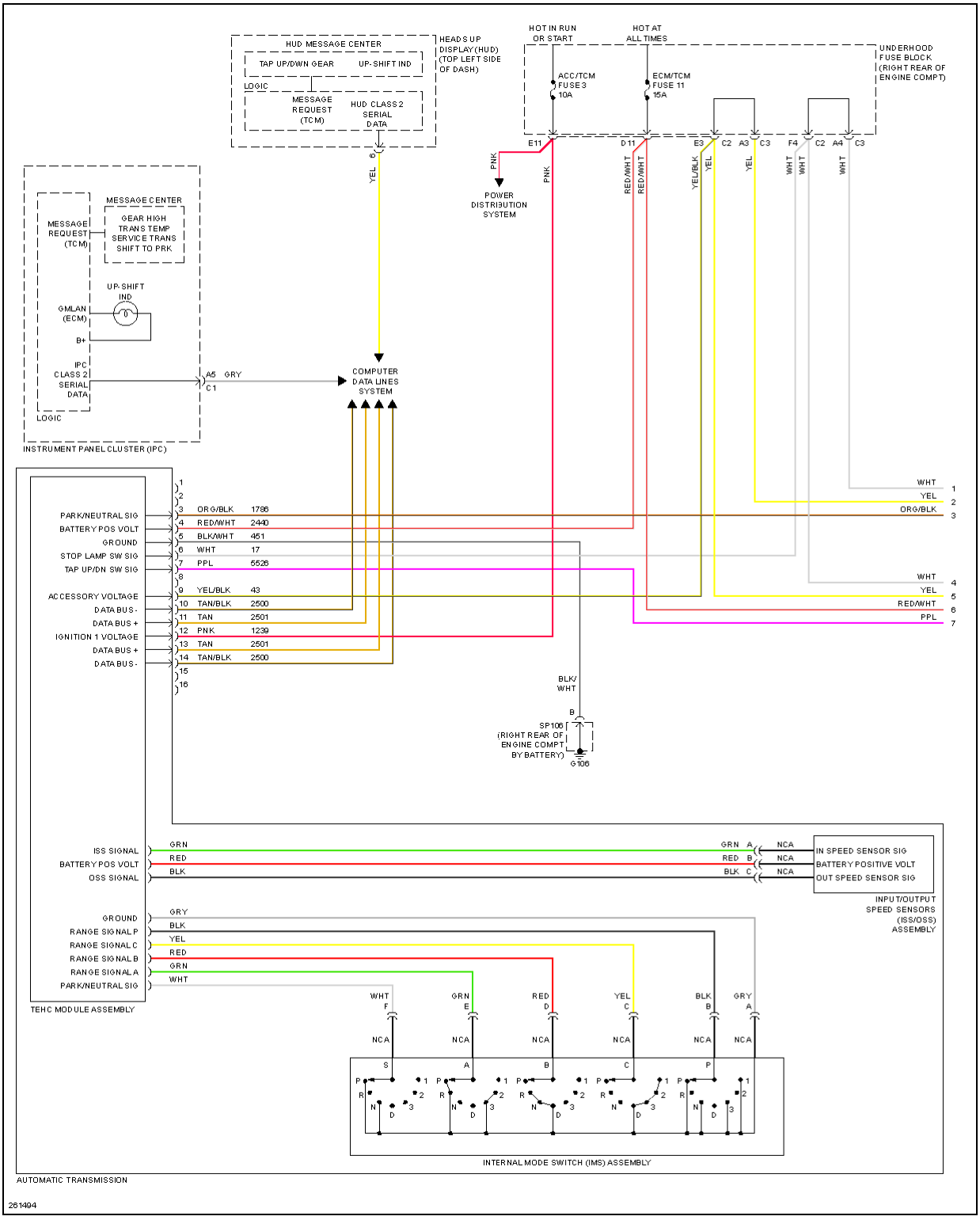
Fig. 70: Supplemental Restraints Circuit (2 of 2)

TRANSMISSION

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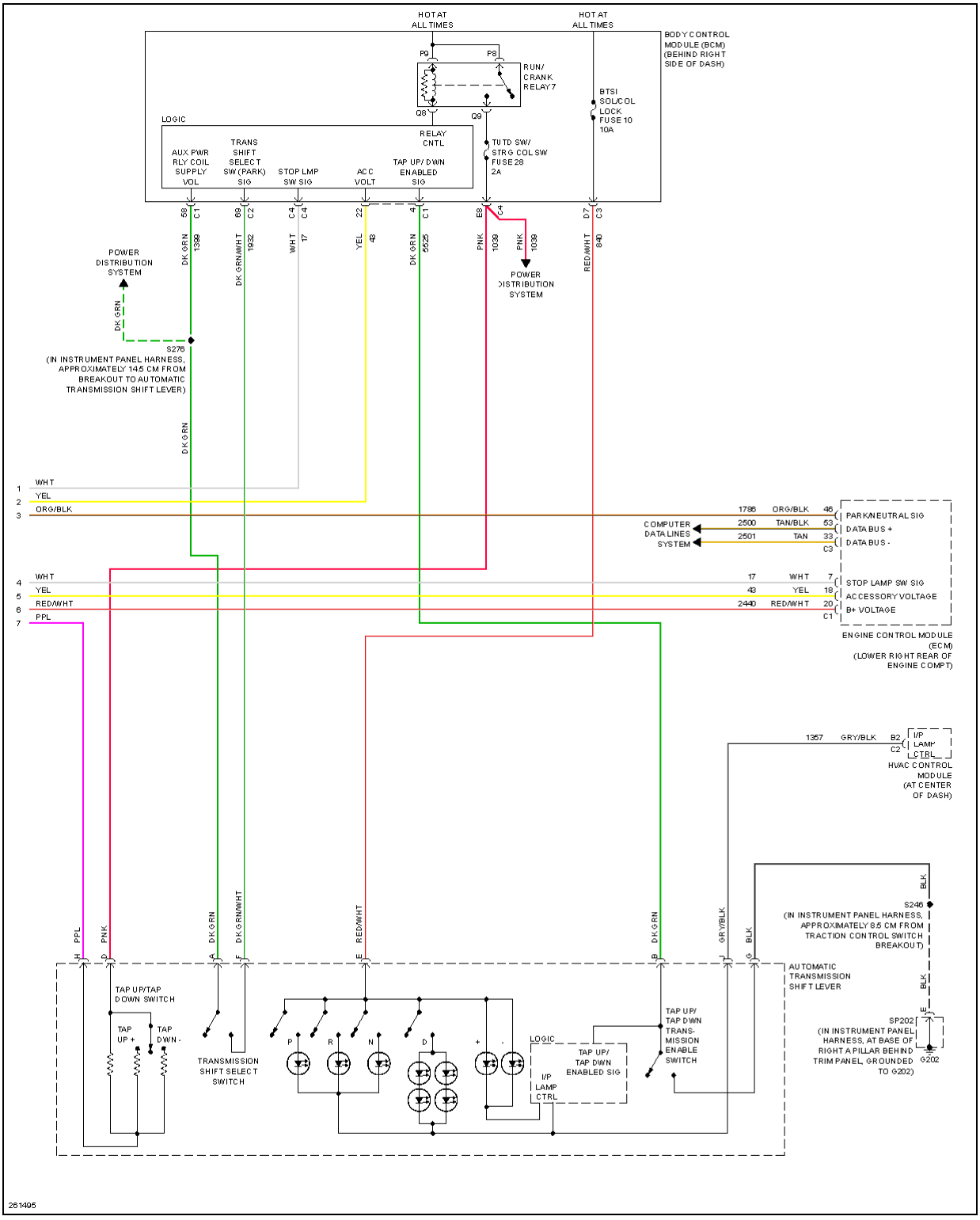
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Fig. 71: A/T Circuit (1 of 2)

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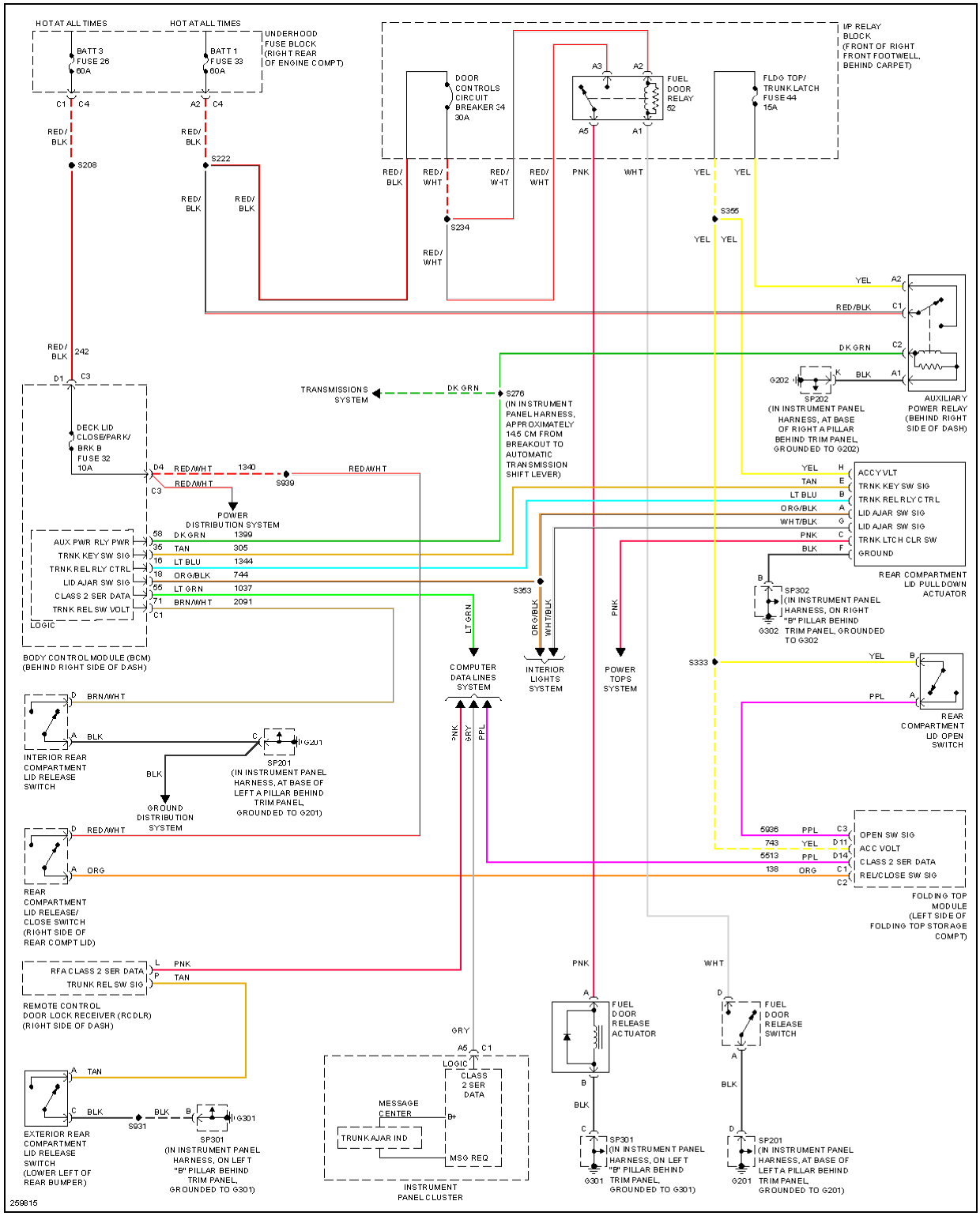
Fig. 72: A/T Circuit (2 of 2)

TRUNK, TAILGATE, FUEL DOOR

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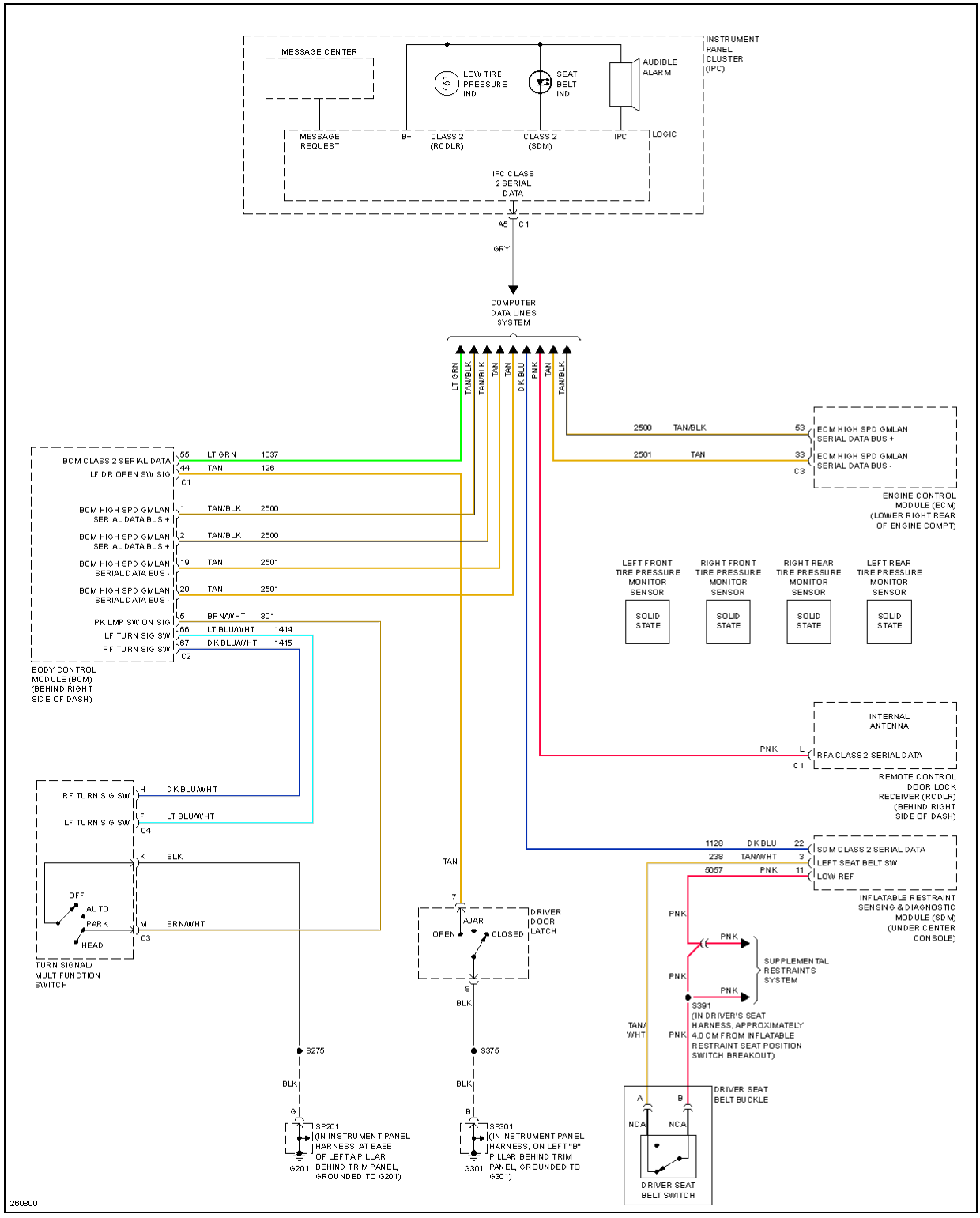


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Fig. 73: Trunk & Fuel Door Release Circuit

WARNING SYSTEMS

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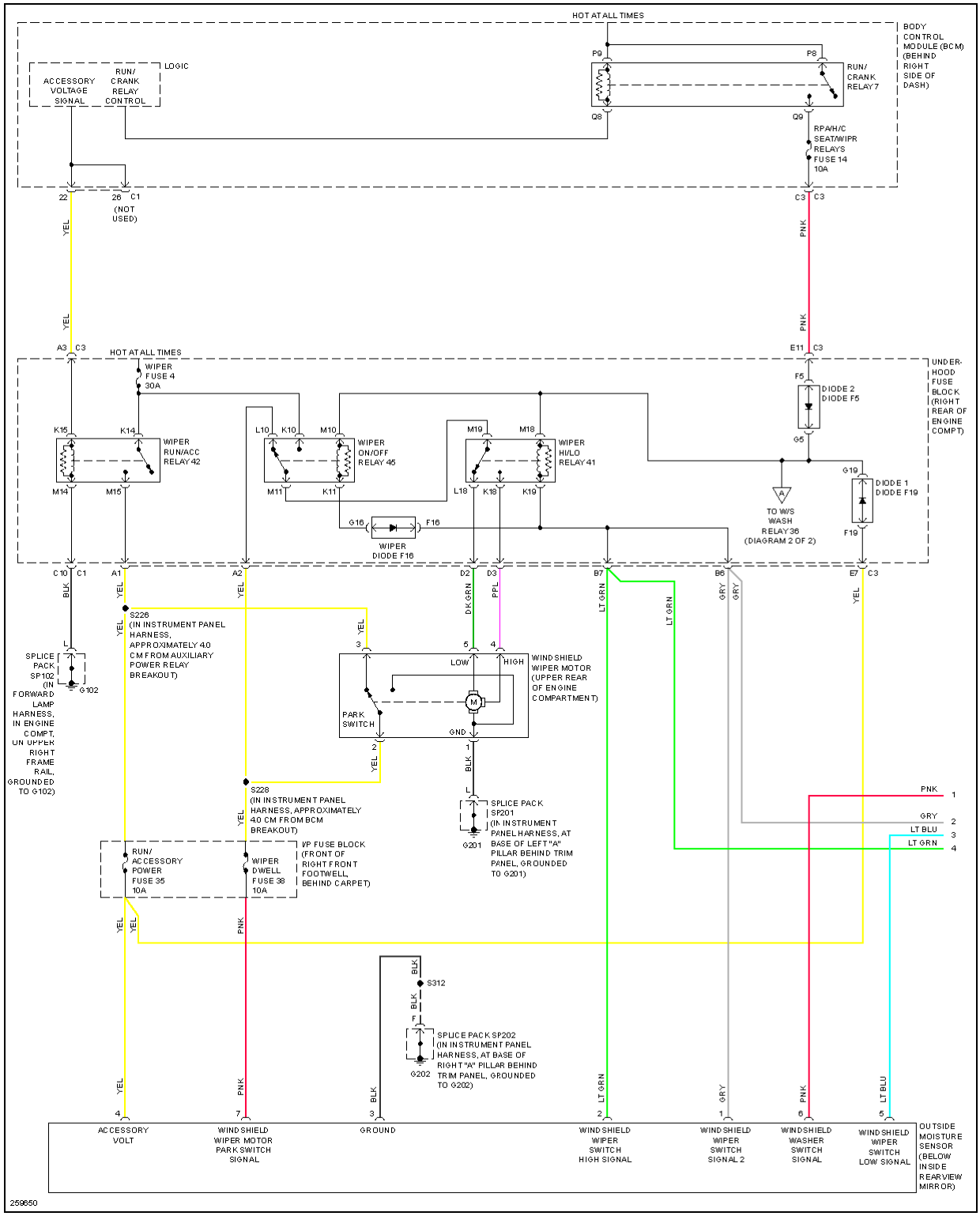


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Fig. 74: Warning Systems Circuit

WIPER/WASHER

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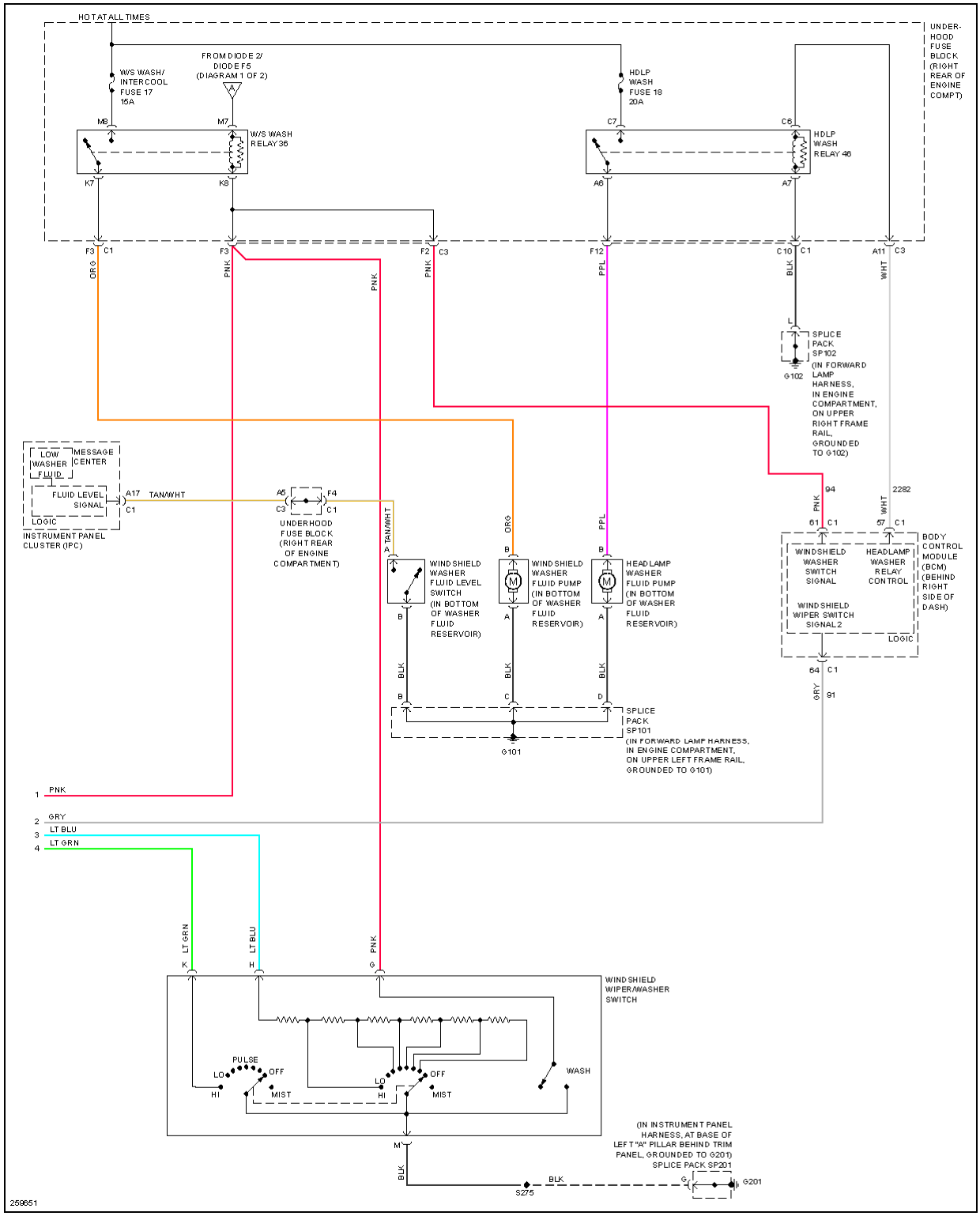
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Fig. 75: Front Wiper/Washer & Headlamp Washer Circuit (1 of 2)

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Fig. 76: Front Wiper/Washer & Headlamp Washer Circuit (2 of 2)