

BRAKES

Hydraulic Brakes - CTS Sedan

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Brake Hose Bracket Bolt	10 N.m	89 lb in
Brake Hose Fitting Bolt - Front	52 N.m	38 lb ft
Brake Hose Fitting Bolt - Rear	49 N.m	36 lb ft
Brake Pedal Assembly Nut	25 N.m	18 lb ft
Brake Pipe Fitting - Brake Pressure Modulator Valve From Master Cylinder	32 N.m	24 lb ft
Brake Pipe Fitting - Brake Pressure Modulator Valve To Wheel	18 N.m	13 lb ft
Brake Pipe Fitting - At Master Cylinder	30 N.m	22 lb ft
Master Cylinder Nut	23 N.m	17 lb ft
Master Cylinder Reservoir Bolt	8 N.m	71 lb in
Power Brake Booster Pump Bracket M6 Bolt	10 N.m	89 lb in
Power Brake Booster Pump Bracket M12 Bolt	70 N.m	52 lb ft
Power Brake Booster Pump Nut	22 N.m	16 lb ft
Power Brake Booster Pump Bolt	10 N.m	89 lb in
Power Vacuum Brake Booster Nut	25 N.m	18 lb ft
Steering Column Brace Bolt	22 N.m	16 lb ft
Steering Column Brace Nut	9 N.m	80 lb in

BRAKE COMPONENT SPECIFICATIONS

Brake Component Specifications

Application	Specification	
	Metric	English
Front Brake Caliper Bleeder Valve	17 N.m	13 lb ft
Rear Brake Caliper Bleeder Valve	17 N.m	13 lb ft

BRAKE SYSTEM SPECIFICATIONS

Brake System Specifications

Application	Specification	
	Metric	English

Brake Pedal Travel

- Maximum specification with 445 N (100 lbs) of force applied to the pedal with the ignition OFF and the booster power reserve depleted.

69.85 mm

2.75 in

SCHEMATIC WIRING DIAGRAMS

HYDRAULIC BRAKE WIRING SCHEMATICS

Hydraulic Brake System

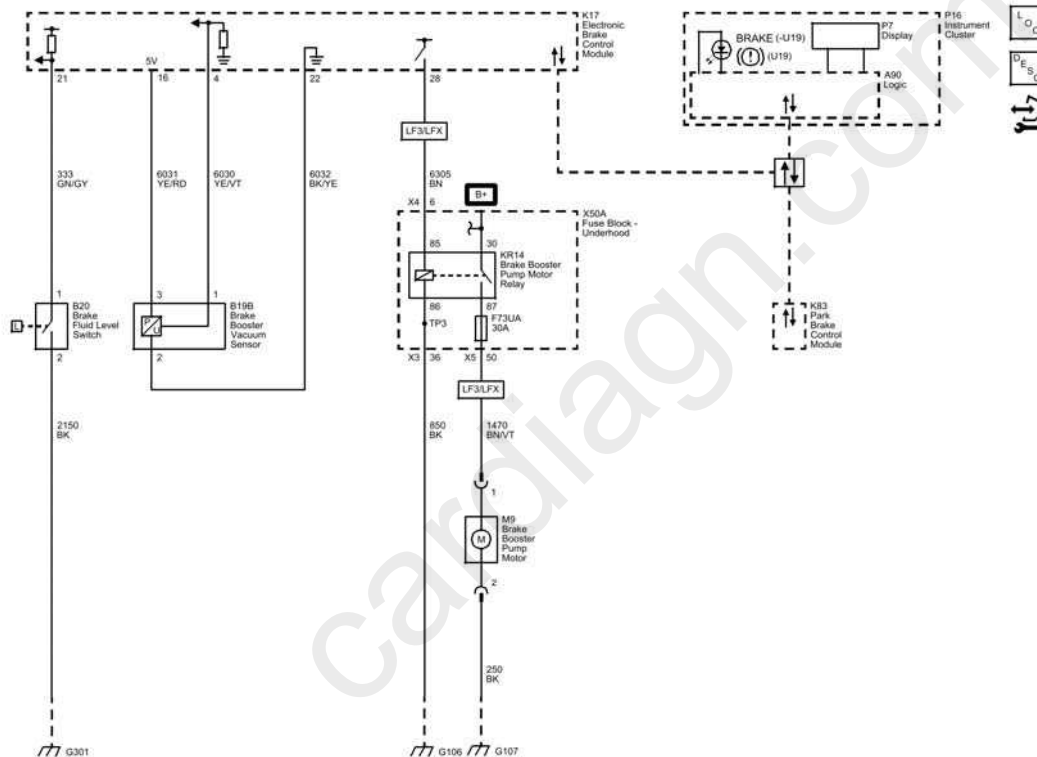


Fig. 1: Hydraulic Brake System

Courtesy of GENERAL MOTORS COMPANY

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC CODE INDEX

DIAGNOSTIC CODE INDEX

DTC	Description
DTC C0267	DTC C0267 Low Brake Fluid Indicated

<u>DTC C027B</u>	DTC C027B Brake Booster Electric Vacuum Pump
<u>DTC C0299</u>	DTC C0299 Brake Booster Large Vacuum Leak Detected
<u>DTC C1100</u>	DTC C1100 Brake Pressure Sensor 2

DTC C0267: LOW BRAKE FLUID INDICATED

Diagnostic Instructions

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

DTC Descriptor

DTC C0267

Low Brake Fluid Indicated

For symptom byte information refer to **Symptom Byte List** .

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	C0267 00	C0267 05	C0267 05	-
Ground	-	C0267 05	-	-

Circuit/System Description

The brake fluid level switch monitors the level of the brake fluid in the brake fluid reservoir. When the electronic brake control module sees the brake fluid level switch input closed, the DTC is set.

Conditions for Running the DTC

Ignition ON.

Conditions for Setting the DTC

- Low brake fluid level is detected for 5 s.
- An open is detected on the ground circuit.
- An open, short to ground, or short to voltage is detected on the signal circuit.

Action Taken When the DTC Sets

- The electronic brake control module disables the traction control and stability control for the duration of the ignition cycle.

- The traction control/stability control-active indicator turns ON.
- The brake warning indicator turns ON.

Conditions for Clearing the DTC

The condition for setting the DTC is no longer present.

Reference Information

Schematic Reference

Hydraulic Brake Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Hydraulic Brake System Description and Operation

Electrical Information Reference

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

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify that the brake fluid level is above the minimum level.
 - **If low**

Refer to **Brake Fluid Loss**.

- **If above minimum level**
2. Refer to Circuit/System Testing.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B20 Brake Fluid Level Switch. It may take up to 2 minutes for all vehicle systems to power down.

2. Test for less than 10 ohms between the ground circuit terminal 2 and ground.
 - **If 10 ohms or greater**
 1. Ignition OFF.
 2. Test for less than 2 ohms in the ground circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, repair the open/high resistance in the ground connection.
 - **If less than 10 ohms**
3. Ignition ON.
4. Verify the scan tool Brake Fluid Level Sensor parameter is OK.
 - **If the parameter is not OK**
 1. Ignition OFF, disconnect the harness connector at the K17 Electronic Brake Control Module.
 2. Test for infinite resistance between the signal circuit terminal 1 and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance, replace the K17 Electronic Brake Control Module.
 - **If the parameter is OK**
5. Install a 3 A fused jumper wire between the signal circuit terminal 1 and ground.
6. Verify the scan tool Brake Fluid Level Sensor parameter is Low.
 - **If the parameter is not Low**
 1. Ignition OFF, disconnect the harness connector at the K17 Electronic Brake Control Module, ignition ON.
 2. Test for less than 1 V between the signal circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V.
 3. Test for less than 2 ohms in the signal circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K17 Electronic Brake Control Module.
 - **If the parameter is Low**
7. Test or replace the B20 Brake Fluid Level Switch.

Repair Instructions

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

- **Brake Fluid Level Indicator Switch Replacement**
- **Control Module References** for electronic brake control module replacement, programming and setup.

DTC C027B: BRAKE BOOSTER ELECTRIC VACUUM PUMP

Diagnostic Instructions

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

DTC Descriptor

DTC C027B

Brake Booster Electric Vacuum Pump

For symptom byte information refer to **Symptom Byte List** .

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Vacuum Pump Relay B+	2	2	-	-
Vacuum Pump Relay Control	C027B 00	C027B 00	1	-
Vacuum Pump Relay Ground	-	2	-	-
Brake Booster Vacuum Sensor 5V Reference	C1100 00	C1100 00	C1100 00, C1100 01	-
Brake Booster Vacuum Sensor Signal	C1100 00, C1100 02	C1100 00	C1100 00, C1100 01	C1100 09, C1100 5A
Brake Booster Vacuum Sensor Low Reference	-	C1100 00	-	-
Brake Booster Pump Motor Control	2	2	1	-
Brake Booster Pump Motor Ground	-	2	-	-
1. Brake Booster Pump Motor Always ON 2. Brake Booster Pump Motor Always OFF				

Circuit/System Description

The brake booster vacuum sensor measures the vacuum in the brake booster assembly. The electronic brake control module supplies a 5 V reference and a low reference circuit to the brake booster vacuum sensor. The vacuum sensor supplies a voltage signal in relation to the pressure in the brake booster to the electronic brake control module. When the vacuum within the system becomes weak, the electronic brake control module turns ON the brake booster pump motor by providing ground to the brake booster pump motor relay. The relay activates and supplies battery voltage to the brake booster pump motor.

Conditions for Running the DTC

Ignition ON.

Conditions for Setting the DTC

A short to ground or open/high resistance is detected on the control circuit.

Action Taken When the DTC Sets

The DTC is stored in memory.

Conditions for Clearing the DTC

The condition for setting the DTC is no longer present.

Reference Information

Schematic Reference

Hydraulic Brake Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Brake Assist System Description and Operation

Electrical Information Reference

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

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the M9 Brake Booster Pump Motor turns ON and OFF when commanding the Brake Booster Electric Vacuum Pump On and Off with a scan tool.
 - **If the M9 Brake Booster Pump Motor does not turn ON and OFF**

Refer to Circuit/System Testing.
 - **If the M9 Brake Booster Pump Motor turn ON and OFF**
3. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the KR14 Brake Booster Pump Motor Relay, ignition ON.
2. Verify a test lamp illuminates between the B+ circuit terminal 30 and ground.
 - **If the test lamp does not illuminate and the circuit fuse is good**
 1. Ignition OFF, remove the test lamp.
 2. Test for less than 2 ohms in the B+ circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
 - **If the test lamp does not illuminate and the circuit fuse is open**
 1. Ignition OFF, remove the test lamp.
 2. Test for infinite resistance between the B+ circuit and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance,
 3. Disconnect the M9 Brake Booster Pump Motor.
 4. Test for greater than 10 ohms between the control circuit terminal 87 and ground.
 - If less than 10 ohms, repair the short to ground on the circuit.
 - If greater than 10 ohms, test or replace the M9 Brake Booster Pump Motor.
 - **If the test lamp illuminates**
3. Ignition OFF and all vehicle systems OFF. It may take up to 2 min for all vehicle systems to power down.
4. Test for less than 10 ohms between the ground circuit terminal 86 and ground.
 - **If 10 ohms or greater**
 1. Ignition OFF.
 2. Test for less than 2 ohms in the ground circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, repair the open/high resistance in the ground connection.
 - **If less than 10 ohms**
5. Connect a test lamp between the control circuit terminal 85 and the ground circuit terminal 86.
6. Verify the test lamp turns ON and OFF when commanding the Brake Booster Pump Motor On and Off with a scan tool.
 - **If the test lamp is always OFF**
 1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K17 Electronic Brake Control Module, ignition ON.
 2. Test for infinite resistance between the control circuit and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance
 3. Test for less than 2 ohms in the control circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K17 Electronic Brake Control Module.

- **If the test lamp is always ON**

1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K17 Electronic Brake Control Module.
2. Test for less than 1 V between the control circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V, replace the K17 Electronic Brake Control Module.

- **If the test lamp turns ON and OFF**

7. Verify a test lamp does not illuminate between the control circuit terminal 87 and ground.

- **If the test lamp illuminates**

Repair the short to voltage on the circuit.

- **If the test lamp does not illuminate**

8. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the M9 Brake Booster Pump Motor. It may take up to 2 minutes for all vehicle systems to power down.
9. Test for less than 10 ohms between the M9 Brake Booster Pump Motor ground circuit terminal 2 and ground.

- **If 10 ohms or greater**

1. Ignition OFF.
2. Test for less than 2 ohms in the ground circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, repair the open/high resistance in the ground connection.

- **If less than 10 ohms**

10. Connect the harness connector at the M9 Brake Booster Pump Motor.
11. Ignition ON, connect a 30 A fused jumper wire between the B+ circuit terminal 30 and the control circuit terminal 87.
12. Verify the M9 Brake Booster Pump Motor is activated.
 - **If the M9 Brake Booster Pump Motor does not activate**
 1. Ignition OFF, remove the jumper wire.
 2. Test for less than 2 ohms in the control circuit terminal 87 end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, test or replace the M9 Brake Booster Pump Motor.
 - **If the M9 Brake Booster Pump Motor activates**
13. Test or replace the KR14 Brake Booster Pump Motor Relay.

Component Testing

Relay Test

1. Ignition OFF, remove the KR14 Brake Booster Pump Motor Relay.
2. Test for 70-150 ohms between terminals 85 and 86.

- **If less than 70 ohms or greater than 150 ohms**

Replace the KR14 Brake Booster Pump Motor Relay.

- **If between 70-150 ohms**

3. Test for infinite resistance between the terminals listed below:

- 30 and 86
- 30 and 87
- 30 and 85
- 85 and 87

- **If less than infinite resistance**

Replace the KR14 Brake Booster Pump Motor Relay.

- **If infinite resistance**

4. Install a 30 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.

5. Test for less than 10 ohms between terminals 30 and 87.

- **If 10 ohms or greater**

Replace the KR14 Brake Booster Pump Motor Relay.

- **If less than 10 ohms**

6. All OK.

Repair Instructions

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

- **Power Brake Booster Pump Replacement (LTG), Power Brake Booster Pump Replacement (LFX, LF3)**
- **Control Module References** for electronic brake control module replacement, programming and setup

DTC C0299: BRAKE BOOSTER LARGE VACUUM LEAK DETECTED

Diagnostic Instructions

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

DTC Descriptor

DTC C0299

Brake Booster Large Vacuum Leak Detected

For symptom byte information refer to **Symptom Byte List** .

Circuit/System Description

The brake booster vacuum sensor measures the vacuum in the brake booster assembly. The electronic brake control module supplies a 5 V reference and a low reference circuit to the brake booster vacuum sensor. The vacuum sensor supplies a voltage signal in relation to the pressure in the brake booster to the electronic brake control module.

Conditions for Running the DTC

Engine running.

Conditions for Setting the DTC

The electronic brake control module detected a weak vacuum in the brake booster assembly for 120 s.

Action Taken When the DTC Sets

The DTC is stored in memory.

Conditions for Clearing the DTC

- A current DTC clears when the diagnostic runs and passes.
- The electronic brake control module will turn OFF the indicator in the next ignition cycle.

Reference Information

Schematic Reference

Hydraulic Brake Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Brake Assist System Description and Operation

Electrical Information Reference

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

- **Wiring Repairs**

Scan Tool Reference

Control Module References Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC C1100 is not set.
 - **If the DTC is set**

Refer to **DTC C1100**.
 - **If the DTC is not set**
3. Verify that the brake booster vacuum system has no damage, leakage or incorrect installation.
 - **If damage, leakage or incorrect installation is found**

Refer to **Brake Assist System Diagnosis**.
 - **If the inspection is OK**
4. Test or replace the B19B Brake Booster Vacuum Sensor.
5. Verify the DTC does not set while operating the vehicle under the Conditions for Running the DTC.
 - **If the DTC sets**

Replace the K17 Electronic Brake Control Module.
 - **If the DTC does not set**
6. All OK.

Repair Instructions

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

Control Module References for electronic brake control module replacement, programming and setup

DTC C1100: BRAKE PRESSURE SENSOR 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.

DTC Descriptors

DTC C1100

Brake Pressure Sensor 2

For symptom byte information refer to Symptom Byte List .

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	C1100 02	C1100 00	C1100 01	-
Signal	C1100 00	C1100 00	C1100 00	C1100 09, C1100 5A
Low Reference	-	C1100 00	-	-

Circuit/System Description

The brake booster vacuum sensor monitors the pressure in the brake booster. The electronic brake control module supplies a 5 V reference and a low reference circuit to the brake booster vacuum sensor. The vacuum sensor supplies a voltage signal in relation to the pressure in the brake booster to the electronic brake control module.

Conditions for Running the DTC

Ignition ON.

Conditions for Setting the DTC

C1100 00

- A short to ground, short to voltage or open/high resistance is detected on the signal circuit.
- An open/high resistance is detected on the 5 V reference circuit.
- An open/high resistance is detected on the low reference circuit.
- The electronic brake control module detects an erratic vacuum sensor signal.

C1100 01

A short to voltage is detected on the vacuum sensor 5 V reference circuit.

C1100 02

A short to ground is detected on the vacuum sensor 5 V reference circuit.

C1100 09

The vacuum sensor signal too fast transitions.

C1100 5A

The vacuum sensor signal is not plausible.

Action Taken When the DTC Sets

The brake warning indicator turns ON.

Conditions for Clearing the DTC

- A current DTC clears when the diagnostic runs and passes.
- The electronic control module will turn OFF the indicator in the next ignition cycle.

Reference Information

Schematic Reference

Hydraulic Brake Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Brake Assist System Description and Operation

Electrical Information Reference

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

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B19B Brake Booster Vacuum Sensor. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 10 ohms between the low reference circuit terminal 2 and ground.
 - **If 10 ohms or greater**
 1. Disconnect the harness connector at the K17 Electronic Brake Control Module.
 2. Test for less than 2 ohms in the low reference circuit end to end.

- If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K17 Electronic Brake Control Module.
 - **If less than 10 ohms**
- 3. Ignition ON.
- 4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 3 and ground.
 - **If less than 4.8 V**
 - 1. Ignition OFF, disconnect the harness connector at the K17 Electronic Brake Control Module.
 - 2. Test for infinite resistance between the 5 V reference circuit and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance
 - 3. Test for less than 2 ohms in the 5 V reference circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K17 Electronic Brake Control Module.
 - **If greater than 5.2 V**
 - 1. Ignition OFF, disconnect the harness connector at the K17 Electronic Brake Control Module, ignition ON.
 - 2. Test for less than 1 V between the 5 V reference circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V, replace the K17 Electronic Brake Control Module.
 - **If between 4.8-5.2 V**
- 5. Ignition OFF, disconnect the harness connector at the K17 Electronic Brake Control Module, ignition ON.
- 6. Test for less than 1 V between the B19B Brake Booster Vacuum Sensor signal circuit terminal 1 and ground.
 - **If greater than 1 V**

Repair the short to voltage on the circuit.
 - **If less than 1 V**
- 7. Ignition OFF.
- 8. Test for infinite resistance between the B19B Brake Booster Vacuum Sensor signal circuit terminal 1 and ground.
 - **If less than infinite resistance**

Repair the short to ground on the circuit.
 - **If infinite resistance**
- 9. Test for less than 2 ohms between the B19B Brake Booster Vacuum Sensor signal circuit terminal 1 and the K17 Electronic Brake Control Module signal circuit terminal 4.
 - **If 2 ohms or greater**

Repair the open/high resistance in the circuit.

- **If less than 2 ohms**

10. Replace the B19B Brake Booster Vacuum Sensor.

11. Verify the DTC does not set while operating the vehicle under Conditions for Running the DTC.

- **If the DTC sets**

Replace the K17 Electronic Brake Control Module.

- **If the DTC does not set**

12. All OK.

Repair Instructions

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

- **Power Vacuum Brake Booster Replacement** for Power Brake Booster Vacuum Sensor Replacement
- **Control Module References** for electronic brake control module replacement, programming and setup

SYMPTOMS - HYDRAULIC BRAKES

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

1. Perform the **Brake System Vehicle Road Test** before using the hydraulic brake symptom tables in order to duplicate the customers concern.
2. Review the system operation in order to familiarize yourself with the system functions. Refer to the following:
 - **Brake Warning System Description and Operation**
 - **Hydraulic Brake System Description and Operation**
 - **Brake Booster Vacuum Assist Description and Operation**
 - **Brake Assist System Description and Operation**
 - **ABS Description and Operation**

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the hydraulic brake system. 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:

- **Brake Booster Pump Motor Malfunction**
- **Brake Warning Indicator Malfunction**
- **Brake Pulsation**
- **Brake System Noise**
- **Braking Action Uneven - Pulls to One Side**
- **Braking Action Uneven - Front to Rear**
- **Brake Pedal Excessive Travel**
- **Brake Pedal Excessive Effort**
- **Brakes Drag**
- **Brake System Slow Release**
- **Brake Fluid Loss**

BRAKE BOOSTER PUMP MOTOR MALFUNCTION

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

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Vacuum Pump Relay B+	2	2	-	-
Vacuum Pump Relay Control	2	2	1	-
Vacuum Pump Relay Ground	-	2	-	-
Brake Booster Vacuum Sensor 5V Reference	C1100 00	C1100 00	C1100 00, C1100 01	-
Brake Booster Vacuum Sensor Signal	C1100 00, C1100 02	C1100 00	C1100 00, C1100 01	C1100 09, C1100 5A
Brake Booster Vacuum Sensor Low Reference	-	C1100 00	-	-
Brake Booster Pump Motor Control	2	2	1	-
Brake Booster Pump Motor Ground	-	2	-	-
1. Brake Booster Pump Motor Always ON 2. Brake Booster Pump Motor Always OFF				

Circuit/System Description

The brake booster vacuum sensor measures the vacuum in the brake booster assembly. The electronic brake control module supplies a 5 V reference and a low reference circuit to the brake booster vacuum sensor. The vacuum sensor supplies a voltage signal in relation to the pressure in the brake booster to the electronic brake control module. When the vacuum within the system becomes weak, the electronic brake control module turns ON the brake booster pump motor by providing ground to the brake booster pump motor relay. The relay activates and supplies battery voltage to the brake booster pump motor.

Reference Information

Schematic Reference

Hydraulic Brake Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Brake Booster Vacuum Assist Description and Operation

Electrical Information Reference

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

Scan Tool Reference

Control Module References

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC C1100 is not set.
 - **If the DTC is set**

Refer to **DTC C1100**.

- **If the DTC is not set**
3. Verify the M9 Brake Booster Pump Motor turns ON and OFF when commanding the Brake Booster Electric Vacuum Pump On and Off with a scan tool.
 - **If the M9 Brake Booster Pump Motor does not turn ON and OFF**

Refer to Circuit/System Testing.

- **If the M9 Brake Booster Pump Motor turn ON and OFF**

4. Verify that the brake booster vacuum system has no damage, leakage or incorrect installation.

- **If damage, leakage or incorrect installation is found**

Refer to **Brake Assist System Diagnosis**.

- **If the inspection is OK**

5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the KR14 Brake Booster Pump Motor Relay, ignition ON.

2. Verify a test lamp illuminates between the B+ circuit terminal 30 and ground.

- **If the test lamp does not illuminate and the circuit fuse is good**

1. Ignition OFF, remove the test lamp.

2. Test for less than 2 ohms in the B+ circuit end to end.

- If 2 ohms or greater, repair the open/high resistance in the circuit.

- If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.

- **If the test lamp does not illuminate and the circuit fuse is open**

1. Ignition OFF, remove the test lamp.

2. Test for infinite resistance between the B+ circuit and ground.

- If less than infinite resistance, repair the short to ground on the circuit.

- If infinite resistance,

3. Disconnect the M9 Brake Booster Pump Motor.

4. Test for greater than 10 ohms between the control circuit terminal 87 and ground.

- If less than 10 ohms, repair the short to ground on the circuit.

- If greater than 10 ohms, test or replace the M9 Brake Booster Pump Motor.

- **If the test lamp illuminates**

3. Ignition OFF and all vehicle systems OFF. It may take up to 2 min for all vehicle systems to power down.

4. Test for less than 10 ohms between the ground circuit terminal 86 and ground.

- **If 10 ohms or greater**

1. Ignition OFF.

2. Test for less than 2 ohms in the ground circuit end to end.

- If 2 ohms or greater, repair the open/high resistance in the circuit.

- If less than 2 ohms, repair the open/high resistance in the ground connection.

- **If less than 10 ohms**

5. Connect a test lamp between the control circuit terminal 85 and the ground circuit terminal 86.

6. Verify the test lamp turns ON and OFF when commanding the Brake Booster Pump Motor On and Off

with a scan tool.

- **If the test lamp is always OFF**

1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K17 Electronic Brake Control Module, ignition ON.
2. Test for infinite resistance between the control circuit and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance
3. Test for less than 2 ohms in the control circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K17 Electronic Brake Control Module.

- **If the test lamp is always ON**

1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K17 Electronic Brake Control Module.
2. Test for less than 1 V between the control circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V, replace the K17 Electronic Brake Control Module.

- **If the test lamp turns ON and OFF**

7. Verify a test lamp does not illuminate between the control circuit terminal 87 and ground.

- **If the test lamp illuminates**

Repair the short to voltage on the circuit.

- **If the test lamp does not illuminate**

8. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the M9 Brake Booster Pump Motor. It may take up to 2 minutes for all vehicle systems to power down.
9. Test for less than 10 ohms between the M9 Brake Booster Pump Motor ground circuit terminal 2 and ground.

- **If 10 ohms or greater**

1. Ignition OFF.
2. Test for less than 2 ohms in the ground circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, repair the open/high resistance in the ground connection.

- **If less than 10 ohms**

10. Connect the harness connector at the M9 Brake Booster Pump Motor.
11. Ignition ON, connect a 30 A fused jumper wire between the B+ circuit terminal 30 and the control circuit terminal 87.
12. Verify the M9 Brake Booster Pump Motor is activated.
 - **If the M9 Brake Booster Pump Motor does not activate**
 1. Ignition OFF, remove the jumper wire.
 2. Test for less than 2 ohms in the control circuit terminal 87 end to end.

- If 2 ohms or greater, repair the open/high resistance in the circuit.
- If less than 2 ohms, test or replace the M9 Brake Booster Pump Motor.

○ **If the M9 Brake Booster Pump Motor activates**

13. Test or replace the KR14 Brake Booster Pump Motor Relay.

Component Testing

Relay Test

1. Ignition OFF, remove the KR14 Brake Booster Pump Motor Relay.
2. Test for 70-150 ohms between terminals 85 and 86.
 - **If less than 70 ohms or greater than 150 ohms**

Replace the KR14 Brake Booster Pump Motor Relay.

- **If between 70-150 ohms**

3. Test for infinite resistance between the terminals listed below:
 - 30 and 86
 - 30 and 87
 - 30 and 85
 - 85 and 87
 - **If less than infinite resistance**

Replace the KR14 Brake Booster Pump Motor Relay.

- **If infinite resistance**

4. Install a 30 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.
5. Test for less than 10 ohms between terminals 30 and 87.
 - **If 10 ohms or greater**

Replace the KR14 Brake Booster Pump Motor Relay.

- **If less than 10 ohms**

6. All OK.

Repair Instructions

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

- **Power Brake Booster Pump Replacement (LTG), Power Brake Booster Pump Replacement (LFX, LF3)**
- **Control Module References** for electronic brake control module replacement, programming and setup.

BRAKE WARNING INDICATOR MALFUNCTION

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

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	C0267 00	C0267 05	C0267 05	-
Ground	-	C0267 05	-	-

Circuit/System Description

The electronic brake control module monitors the brake fluid level in the brake fluid reservoir. When the fluid within the brake fluid reservoir is below the MIN level, contacts within the brake fluid level switch closes causing the voltage within the signal circuit to drop. The electronic brake control module will detect the voltage drop and will send a serial data message to the instrument cluster commanding the brake warning indicator to illuminate.

Reference Information

Schematic Reference

Hydraulic Brake Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Brake Warning System Description and Operation

Electrical Information Reference

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

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify that the brake fluid level is above the minimum level.

- **If low**

Refer to **Brake Fluid Loss**.

- **If above minimum level**

2. Ignition ON.
3. Verify the scan tool Brake Fluid Level Sensor parameter is OK.

- **If the parameter is Low**

Refer to Circuit/System Testing

- **If the parameter is Ok**

4. Verify the brake warning indicator turns ON and OFF when commanding the Instrument Cluster All Indicators On and Off with a scan tool.

- **If the brake warning indicator does not turn ON and OFF**

Replace the P16 Instrument Cluster.

- **If the brake warning indicator turns ON and OFF**

5. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B20 Brake Fluid Level Switch. It may take up to 2 min for all vehicle systems to power down.

2. Test for less than 10 ohms between the ground circuit terminal 2 and ground.

- **If 10 ohms or greater**

1. Ignition OFF.

2. Test for less than 2 ohms in the ground circuit end to end.

- If 2 ohms or greater, repair the open/high resistance in the circuit.

- If less than 2 ohms, repair the open/high resistance in the ground connection.

- **If less than 10 ohms**

3. Ignition ON.

4. Verify the scan tool Brake Fluid Level Sensor parameter is OK.

- **If the parameter is not OK**

1. Ignition OFF, disconnect the harness connector at the K17 Electronic Brake Control Module.

2. Test for infinite resistance between the signal circuit terminal 1 and ground.

- If less than infinite resistance, repair the short to ground on the circuit.
- If infinite resistance, replace the K17 Electronic Brake Control Module.
- **If the parameter is OK**
- 5. Install a 3 A fused jumper wire between the signal circuit terminal 1 and ground.
- 6. Verify the scan tool Brake Fluid Level Sensor parameter is Low.
 - **If the parameter is OK**
 1. Ignition OFF, disconnect the harness connector at the K17 Electronic Brake Control Module, ignition ON.
 2. Test for less than 1 V between the signal circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V.
 3. Test for less than 2 ohms in the signal circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K17 Electronic Brake Control Module.
 - **If the parameter is Low**
- 7. Test or replace the B20 Brake Fluid Level Switch.

Repair Instructions

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

- **Brake Fluid Level Indicator Switch Replacement**
- **Control Module References** for electronic brake control module and Instrument Cluster replacement, programming and setup.

BRAKE PULSATION

Brake Pulsation

Step	Action	Yes	No
DEFINITION: Fluctuation or pulsation is felt through the brake pedal, steering wheel, seat, floor, and/or in the vehicle ONLY when braking.			
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
	1. Inspect the disc brake system for the following conditions. • Excessive thickness variation of rotor friction surfaces • Excessive assembled lateral runout (LRO) of rotor friction surfaces • Hard spots, heat checks, bluing discoloration of rotor friction surfaces;		

2	possibly due to brake drag - Excessive corrosion of rotor friction surfaces; including red, gray or black oxidation - Loose, damaged or missing caliper or lining hardware - Bent or damaged caliper or mounting component - Excessive LRO of wheel hub/axle flange; due to damage and/or loose or excessively worn bearings 2. Adjust, repair or replace components as necessary. Refer to <u>Disc Brake System Diagnosis</u>.		
	Did you find and correct a condition?	Go to Step 3	Go to <u>Diagnostic Starting Point - Vehicle</u>
3	1. Install or connect components that were removed or disconnected during diagnosis. 2. Road test the vehicle in order to confirm proper operation. Refer to <u>Brake System Vehicle Road Test</u>.		
	Is the condition still present?	Go to Step 2	System OK

BRAKE SYSTEM NOISE

Brake System Noise

Step	Action	Yes	No
DEFINITION: Vehicle exhibits abnormal noise when braking; vehicle may exhibit abnormal noise during motion just after brake pedal release.			
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
	1. Inspect the disc brake system for the following conditions. - Lining wear indicator contact with rotor - Debris trapped between rotor and splash shield or backing plate; and/or debris trapped between rotor and linings - Contaminated linings - Aftermarket linings - Glazed linings - Distorted, cracked or damaged linings		

2	• Excessively worn linings • Damaged or excessively worn caliper hardware and/or lining hardware • Incorrectly installed, loose or missing caliper hardware and/or lining hardware • Lack of lubrication or excessive corrosion on metal to metal contact surfaces • Bent or damaged splash shield or backing plate • Hard spots, heat checks, blueing discoloration of rotor friction surfaces • Glazed rotor friction surfaces • Bent or damaged caliper or mounting component 2. Adjust, repair or replace components as necessary. Refer to <u>Disc Brake System Diagnosis</u>. Did you find and correct a condition?	Go to Step 9	Go to Step 3
3	1. Inspect the brake assist system for the following conditions. • Lack of lubrication or excessively worn pushrod or pedal pivots or pivot bushings • Bent or damaged pedal pushrod, pedal, or pedal bracket • Damaged or improperly operating vacuum booster and/or check valve, if equipped • Low power steering fluid level, if equipped with hydraulic boost • Improperly tensioned, excessively worn or damaged power steering belt, if equipped with hydraulic boost • Restricted return hose from hydraulic booster, if equipped • Improperly operating hydraulic booster, if equipped • Improperly functioning power steering system, if equipped with a hydraulic booster assembly • Contaminated power steering fluid, if equipped with hydraulic boost 2. Adjust, repair or replace components as		

	necessary. Refer to <u>Brake Assist System Diagnosis</u> .		
	Did you find and correct a condition?	Go to Step 9	Go to Step 4
4	- Inspect the hydraulic brake system for the following conditions. - Improper operation of caliper pistons - Contaminated brake fluid - Adjust, repair or replace components as necessary. Refer to <u>Hydraulic Brake System Diagnosis</u>.		
	Did you find and correct a condition?	Go to Step 9	Go to Step 5
5	Is the vehicle equipped with a drum-in-rotor type of park brake system?	Go to Step 6	Go to Step 9
6	Ensure the park brake shoes are not adjusted too tightly, possibly causing a noise under certain conditions. Are the park brake shoes adjusted too tightly?	Go to Step 7	Go to Step 9
7	- Clean and inspect the park brake shoes for excessive wear and/or damage. - Inspect the drum portion of the rotors for excessive wear, blueing discoloration, heat spots, and excessive radial runout. - If any of these conditions are present, replace the affected components. - Adjust the park brake system.		
	Did you find and correct a condition?	Go to Step 9	Go to Step 8
8	Inspect the park brake system for proper operation. Refer to <u>Park Brake System Diagnosis</u> . Did you find and correct a condition?	Go to Step 9	Go to <u>Diagnostic Starting Point - Vehicle</u>
9	- Install or connect components that were removed or disconnected during diagnosis. - Road test the vehicle in order to confirm proper operation. Refer to <u>Brake System Vehicle Road Test</u>.		
	Is the condition still present?	Go to Step 2	System OK

BRAKING ACTION UNEVEN - PULLS TO ONE SIDE

Test Description

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

4

Suspension components that are not operating properly may cause a disturbance to the vehicle during application of the brake system.

5

Steering components that are not operating properly may cause a disturbance to the vehicle during application of the brake system.

Braking Action Uneven - Pulls to One Side

Step	Action	Yes	No
DEFINITION: Vehicle pulls to one side only when braking.			
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
2	- Inspect the hydraulic brake system for the following conditions. - Kinked, pinched or damaged brake pipe or flexible brake hose - Sticking or improperly operating caliper piston - Brake fluid leak - Adjust, repair or replace components as necessary. Refer to <u>Hydraulic Brake System Diagnosis</u>. Did you find and correct a condition?	Go to Step 6	Go to Step 3
3	- Inspect the disc brake system for the following conditions. - Contaminated linings - Glazed linings - Distorted, cracked or damaged linings on one side - Loose, damaged or missing caliper hardware and/or lining hardware - Incorrect linings on one side - Hard spots, heat checks, blueing discoloration of rotor friction surfaces; possibly due to brake drag - Glazed rotor friction surfaces - Bent or damaged caliper or mounting component		

	2. Adjust, repair or replace components as necessary. Refer to <u>Disc Brake System Diagnosis</u> .		
	Did you find and correct a condition?	Go to Step 6	Go to Step 4
4	1. Inspect the suspension system for the following conditions. • Incorrect tire pressures • Loose suspension component connections • Excessively worn or damaged suspension components 2. Adjust, repair or replace components as necessary. Refer to <u>Diagnostic Starting Point - Vehicle</u> .		
	Did you find and correct a condition?	Go to Step 6	Go to Step 5
5	1. Inspect the steering system for the following conditions. • Loose steering component connections • Excessively worn or damaged steering components 2. Adjust, repair or replace components as necessary. Refer to <u>Diagnostic Starting Point - Vehicle</u> .		
	Did you find and correct a condition?	Go to Step 6	Go to <u>Diagnostic Starting Point - Vehicle</u>
6	1. Install or connect components that were removed or disconnected during diagnosis. 2. Road test the vehicle in order to confirm proper operation. Refer to <u>Brake System Vehicle Road Test</u> .		
	Is the condition still present?	Go to Step 2	System OK

BRAKING ACTION UNEVEN - FRONT TO REAR

Test Descriptions

The number below refers to the step number on the diagnostic table.

4

Suspension components that are not operating properly may cause a disturbance to the vehicle during application of the brake system.

Braking Action Uneven - Front to Rear

Step	Action	Yes	No
DEFINITION: Braking action or stopping force sensitive or grabbing and/or more pronounced at the front or at the rear axle. Sensitive or grabbing brakes: Excessive brake jump-in force relative to brake pedal input.			
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
2	- Inspect the hydraulic brake system for the following conditions: - Improper operation of caliper pistons - Kinked, pinched or damaged brake pipe or flexible brake hose - Brake fluid leak - Improperly functioning proportion valve, if equipped - Improper operation of dynamic rear proportion (DRP) system, if equipped - Adjust, repair or replace components as necessary. Refer to <u>Hydraulic Brake System Diagnosis</u>. Did you find and correct a condition?	Go to Step 6	Go to Step 3
3	- Inspect the disc brake system for the following conditions: - Contaminated linings - Glazed linings - Distorted, cracked or damaged linings - Excessively worn linings - Aftermarket linings - Damaged or excessively worn caliper hardware and/or lining hardware - Hard spots, heat checks, blueing discoloration of rotor friction surfaces - Glazed rotor friction surfaces - Adjust, repair or replace components as necessary. Refer to <u>Disc Brake System Diagnosis</u>. Did you find and correct a condition?	Go to Step 6	Go to Step 4
	Inspect the suspension system for the following conditions:		

4	• Loose suspension component connections • Excessively worn or damaged suspension components 2. Adjust, repair or replace components as necessary. Refer to <u>Diagnostic Starting Point - Vehicle</u> .		
	Did you find and correct a condition?	Go to Step 6	Go to Step 5
5	1. Inspect the brake assist system for the following conditions: • Binding, bent or damaged pedal pushrod, pedal, or pedal bracket • Damaged or improperly operating vacuum booster, if equipped • Damaged or improperly operating hydraulic booster, if equipped 2. Adjust, repair or replace components as necessary. Refer to <u>Brake Assist System Diagnosis</u>.		
	Did you find and correct a condition?	Go to Step 6	Go to <u>Diagnostic Starting Point - Vehicle</u>
6	1. Install or connect components that were removed or disconnected during diagnosis. 2. Road test the vehicle in order to confirm proper operation. Refer to <u>Brake System Vehicle Road Test</u>.		
	Is the condition still present?	Go to Step 2	System OK

BRAKE PEDAL EXCESSIVE TRAVEL

Brake Pedal Excessive Travel

Step	Action	Yes	No
DEFINITION: Brake pedal travels further than expected to obtain firm pedal and/or firm pedal cannot be obtained, pedal fades away, or pedal is spongy.			
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
	Inspect the travel and feel of brake pedal applies. Perform the following: 1. Apply the brake pedal several times to fully deplete the power reserve.		

2	2. With power reserve depleted, apply the brake pedal with light, steady pressure and hold for 15 seconds. Observe pedal travel and feel. 3. Apply the brake pedal with light, steady pressure, then without pumping the pedal, reduce pressure and reapply pressure several times. Observe pedal travel and feel for each apply. 4. Apply the brake pedal slowly, then release and apply the pedal quickly. Observe pedal travel and feel for each apply. Did you complete the brake pedal travel and feel inspections?		-
3	1. Inspect the hydraulic brake system for the conditions listed, based on the following symptoms observed during the pedal travel and feel inspections: • Pedal feel was spongy ○ Air in hydraulic system ○ External brake fluid leaks ○ Soft, weak or damaged hydraulic hoses; expanding under pressure • Pedal fell away and/or traveled to or almost to floor ○ External brake fluid leaks ○ Poor brake fluid quality; low boiling point ○ Internal brake fluid leaks; improperly functioning master cylinder • Pedal was somewhat firm then dropped slightly, or pedal rose with successive applies, or pedal travel was different between slow and quick applies ○ Internal brake fluid leaks; improperly functioning master cylinder ○ Poor brake fluid quality; low boiling point • Pedal returned to rest slowly after any of the applies ○ Internally damaged flexible brake hoses; hindering fluid return ○ Binding caliper pistons	Go to Step 3	

	○ Internal brake fluid leaks; improperly functioning master cylinder 2. Repair or replace components as necessary. Refer to <u>Hydraulic Brake System Diagnosis</u>. 3. Re-inspect brake pedal apply travel and feel.		
	Did you find and correct a condition?	Go to Step 8	Go to Step 4
4	1. Inspect the disc brake system for the following conditions: • Cracked, excessively worn or damaged linings • Cracked, excessively worn or damaged rotors • Improperly operating, binding or damaged caliper hardware and/or lining hardware • Loose or missing caliper hardware and/or lining hardware • Excessive assembled lateral runout (LRO) of rotor friction surfaces • Bent or damaged caliper or mounting component 2. Adjust, repair or replace components as necessary. Refer to <u>Disc Brake System Diagnosis</u>. 3. Re-inspect brake pedal apply travel and feel.		
	Did you find and correct a condition?	Go to Step 8	Go to Step 5
5	Inspect for proper brake pedal travel. Refer to <u>Brake Pedal Travel Measurement and Inspection</u>. Is the brake pedal travel distance within the acceptable limits?	Go to Step 7	Go to Step 6
6	1. Inspect for worn, missing, misaligned, bent or damaged brake pedal system components. • For the brake pedal pushrod component inspection, refer to <u>Brake Pedal Pushrod Inspection</u>. • Inspect the brake pedal bushings for binding, excessive wear and/or damage and inspect the brake pedal for a misaligned, bent, and/or damaged condition. 2. Replace the brake pedal system components that are worn, missing, misaligned, bent or damaged.		
	Did you find and replace any worn, missing, misaligned,		

	bent or damaged brake pedal system components?	Go to Step 8	Go to Step 7
7	- Inspect the brake assist system for the following conditions: - Vacuum leaks and/or improperly operating check valve, if equipped with vacuum assist - Power steering fluid leaks, if equipped with hydraulic power assist - Damaged or improperly operating brake booster assembly - Adjust, repair or replace components as necessary. Refer to <u>Brake Assist System Diagnosis</u>. Did you find and correct a condition?	Go to Step 8	Go to <u>Diagnostic Starting Point - Vehicle</u>
8	- Install or connect components that were removed or disconnected during diagnosis. - Road test the vehicle in order to confirm proper operation. Refer to <u>Brake System Vehicle Road Test</u>. Is the condition still present?	Go to Step 2	System OK

BRAKE PEDAL EXCESSIVE EFFORT

Brake Pedal Excessive Effort

Step	Action	Yes	No
DEFINITION: Brake pedal requires an increased amount of input from the driver to obtain good braking action and/or stopping distance is increased.			
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
2	- Inspect the brake assist system for the following conditions: - Vacuum leaks, if equipped with vacuum power assist - Power steering fluid leaks, if equipped with hydraulic power assist - Lack of lubrication, binding or excessively worn pushrod or pedal pivots or pivot bushings - Bent or damaged pedal pushrod, pedal, or pedal bracket - Damaged or improperly operating brake booster assembly		

	2. Adjust, repair or replace components as necessary. Refer to <u>Brake Assist System Diagnosis</u>.		
	Did you find and correct a condition?	Go to Step 5	Go to Step 3
3	1. Inspect the hydraulic brake system for the following conditions: • Binding caliper pistons • Internally damaged flexible brake hoses; hindering fluid flow • External brake fluid leaks • Kinked or damaged flexible brake hoses and/or pipes • Internal brake fluid leaks; improperly operating master cylinder • Poor brake fluid quality; low boiling point 2. Adjust, repair or replace components as necessary. Refer to <u>Hydraulic Brake System Diagnosis</u>.		
	Did you find and correct a condition?	Go to Step 5	Go to Step 4
4	1. Inspect the disc brake system for the following conditions: • Excessively worn linings • Glazed linings • Cracked, distorted or damaged linings • Contaminated linings • Binding, damaged or excessively worn caliper hardware and/or lining hardware • Lack of lubrication or excessive corrosion on metal to metal contact surfaces • Excessively worn or corroded rotor friction surfaces • Glazed rotor friction surfaces • Hard spots, heat checks, blueing discoloration of rotor friction surfaces 2. Adjust, repair or replace components as necessary. Refer to <u>Disc Brake System Diagnosis</u>.		
	Did you find and correct a condition?	Go to Step 5	Go to <u>Diagnostic Starting Point - Vehicle</u>

5	1. Install or connect components that were removed or disconnected during diagnosis. 2. Road test the vehicle in order to confirm proper operation. Refer to <u>Brake System Vehicle Road Test</u>.		
	Is the condition still present?	Go to Step 2	System OK

BRAKES DRAG

Brakes Drag

Step	Action	Yes	No
DEFINITION: Brake system does not fully release or has delayed release; vehicle motion may be hindered by brake system without applying brakes.			
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
2	Is the vehicle equipped with an adjustable stop lamp switch and/or an adjustable cruise control release switch?	Go to Step 3	Go to Step 4
3	1. Inspect the stop lamp switch for proper adjustment to ensure that the brake pedal is fully releasing. 2. Inspect the cruise control release switch, if equipped, for proper adjustment to ensure that the brake pedal is fully releasing.		
	Did you find and correct a condition?	Go to Step 14	Go to Step 4
4	Is the vehicle equipped with a drum-in-rotor type of park brake system?	Go to Step 5	Go to Step 7
5	Ensure the park brake shoes are not adjusted too tightly, possibly causing drag under certain conditions. Are the park brake shoes adjusted too tightly?	Go to Step 6	Go to Step 7
6	1. Clean and inspect the park brake shoes for excessive wear and/or damage. 2. Inspect the drum portion of the rotors for excessive wear, blueing discoloration and heat spots. 3. If any of these conditions are present, replace the affected components. 4. Adjust the park brake system.		
	Did you find and correct a condition?	Go to Step 14	Go to Step 7
	Inspect the park brake system for proper operation.		

7	Refer to <u>Park Brake System Diagnosis</u> . Did you find and correct a condition?	Go to Step 14	Go to Step 8
8	- Inspect the disc brake system for the following conditions: - Binding, incorrectly installed or missing caliper hardware and/or lining hardware- Ensure free movement of linings and of caliper, if equipped with sliding type caliper - Lack of lubrication or excessive corrosion on metal to metal contact surfaces - Distorted or damaged linings - Damaged or excessively worn caliper hardware and/or lining hardware - Bent or damaged caliper or mounting component - Adjust, repair or replace components as necessary. Refer to <u>Disc Brake System Diagnosis</u>. Did you find and correct a condition?	Go to Step 14	Go to Step 9
9	- Separate the brake booster pushrod from the brake pedal. - Inspect the brake corners to determine if the brake drag condition is still present. Do the brake corners still exhibit the brake drag condition?	Go to Step 11	Go to Step 10
10	- Inspect the pushrod for improper positioning and/or damage. Correctly position or replace the pushrod if necessary. - Inspect the brake pedal assembly for damage and replace if necessary. Did you complete the repair or replacement?	Go to Step 14	-
11	- For vacuum boost systems, disconnect the vacuum check valve from the booster to relieve vacuum reserve. - Separate the master cylinder from the brake booster. Do not disconnect any brake pipes. - Inspect the brake corners to determine if the brake drag condition is still present. Do the brake corners still exhibit the brake drag		

	condition?	Go to Step 13	Go to Step 12
12	Replace the brake booster assembly. Did you complete the replacement?	Go to Step 14	-
13	- Inspect the hydraulic brake system for the following conditions. - Improper operation of caliper pistons - Contaminated brake fluid - Internally damaged flexible brake hoses; hindering brake release - Damaged or improperly operating master cylinder - Adjust, repair or replace components as necessary. Refer to <u>Hydraulic Brake System Diagnosis</u>. Did you find and correct a condition?	Go to Step 14	Go to <u>Diagnostic Starting Point - Vehicle</u>
14	- Install or connect components that were removed or disconnected during diagnosis. - Road test the vehicle in order to confirm proper operation. Refer to <u>Brake System Vehicle Road Test</u>. Is the condition still present?	Go to Step 2	System OK

BRAKE SYSTEM SLOW RELEASE

Brake System Slow Release

Step	Action	Yes	No
DEFINITION: Brake system releases and returns to rest slowly; vehicle motion is hindered by brake system briefly after release of brake pedal.			
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
2	- Inspect the hydraulic brake system for the following conditions: - Improper operation of caliper pistons - Internally damaged flexible brake hoses; hindering brake release - Contaminated brake fluid - Damaged or improperly operating master cylinder - Adjust, repair or replace components as		

	necessary. Refer to <u>Hydraulic Brake System Diagnosis</u> .		
	Did you find and correct a condition?	Go to Step 5	Go to Step 3
3	- Inspect the brake assist system for the following conditions: • Binding, bent or damaged pedal pushrod, pedal, or pedal bracket • Damaged or improperly operating vacuum booster, if equipped • Restricted return hose from hydraulic booster, if equipped • Damaged or improperly operating hydraulic booster, if equipped - Adjust, repair or replace components as necessary. Refer to <u>Brake Assist System Diagnosis</u>.		
	Did you find and correct a condition?	Go to Step 5	Go to Step 4
4	- Inspect the disc brake system for the following conditions: • Damaged or excessively worn caliper hardware and/or lining hardware • Distorted or damaged linings • Lack of lubrication or excessive corrosion on metal to metal contact surfaces • Bent or damaged caliper or mounting component - Adjust, repair or replace components as necessary. Refer to <u>Disc Brake System Diagnosis</u>.		
	Did you find and correct a condition?	Go to Step 5	Go to <u>Diagnostic Starting Point - Vehicle</u>
5	- Install or connect components that were removed or disconnected during diagnosis. - Road test the vehicle in order to confirm proper operation. Refer to <u>Brake System Vehicle Road Test</u>.		
	Is the condition still present?	Go to Step 2	System OK

BRAKE FLUID LOSS

Brake Fluid Loss

Step	Action	Yes	No
DEFINITION: Brake fluid level is low not related to lining wear.			
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
2	- Inspect the following hydraulic brake system components for brake fluid leaks: - Flexible brake hose connections; threaded and bolted - Flexible brake hose crimp joints - Brake pipe fittings - Caliper piston seals - Wheel cylinder piston seals, if equipped - Master cylinder reservoir - Master cylinder reservoir low pressure hose, if equipped - Brake pressure modulator valve (BPMV) assembly, if equipped - Repair or replace components as necessary. Refer to <u>Hydraulic Brake System Diagnosis</u>.		
	Did you find and correct a condition?	Go to Step 8	Go to Step 3
3	Is the vehicle equipped with a vacuum brake booster?	Go to Step 4	Go to Step 6
4	- Disconnect the vacuum check valve from the booster to relieve vacuum reserve. - Separate the master cylinder from the vacuum brake booster. Do not disconnect any brake pipes. - Inspect the rear of the master cylinder for a brake fluid leak. - Inspect for brake fluid in the vacuum brake booster.		
	Did you find a brake fluid leak?	Go to Step 5	Go to <u>Diagnostic Starting Point - Vehicle</u>
5	Replace the brake master cylinder and the vacuum brake booster. Did you complete the replacement?	Go to Step 8	-
6	- Wipe clean the external surface of the master cylinder to hydraulic brake booster area, if equipped. - Separate the master cylinder from the hydraulic brake booster, if equipped. Do not disconnect any		

	brake pipes. 3. Inspect the rear of the master cylinder for a brake fluid leak.		Go to <u>Diagnostic Starting Point - Vehicle</u>
	Did you find a brake fluid leak?	Go to Step 7	
7	Replace the brake master cylinder. Did you complete the replacement?	Go to Step 8	-
8	1. Install or connect components that were removed or disconnected during diagnosis. 2. Road test the vehicle to confirm proper operation. Refer to <u>Brake System Vehicle Road Test.</u>		
	Is the condition still present?	Go to Step 2	System OK

DISC BRAKE SYSTEM DIAGNOSIS

Test Description

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

9

Lubricant leaks from non-brake system components may come in contact with and contaminate brake system components.

10

Lubricant leaks from non-brake system components may come in contact with and contaminate brake system components.

12

Disc brake rotor shields/backing plates that come in contact with disc brake rotors may cause brake system noise.

15

Disc brake rotor thickness variation that exceeds the maximum acceptable level can cause brake pulsation.

19

Disc brake rotor thickness variation that exceeds the maximum acceptable level can cause brake pulsation.

22

Disc brake rotor assembled lateral runout (LRO) that exceeds the maximum acceptable level can lead to thickness variation.

Disc Brake System Diagnosis

Step	Action	Yes	No
DEFINITION: This diagnostic table is designed to diagnose ONLY the components of the DISC brake system in order to determine if the DISC brake system is operating properly. You will be directed by the appropriate Symptom table to go to other brake system diagnostic tables as appropriate.			
1	Were you sent here from a Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
2	Visually inspect the disc brake pads for the following conditions: Refer to <u>Front Disc Brake Pads Replacement (J55, J56)</u> , <u>Front Disc Brake Pads Replacement (J56 without F46, JE2)</u> . • Lining thickness below specifications • Uneven and/or abnormal wear- edge-to-edge and/or side-to-side • Looseness or damage-including pad hardware • Evidence of contamination from an external substance Did you find any conditions to indicate a concern with any of the front and/or rear disc brake pads?	Go to Step 3	Go to Step 12
3	Are any of the front and/or rear disc brake pads contaminated?	Go to Step 8	Go to Step 4
4	Are any of the front and/or rear disc brake pads worn unevenly?	Go to Step 7	Go to Step 5
5	Are any of the front and/or rear disc brake pads and/or pad hardware loose or damaged?	Go to Step 7	Go to Step 6
6	1. Remove and inspect the worn disc brake pads for glazing, looseness, heat spots or damage. 2. Replace the worn disc brake pads as a complete axle set. Refer to <u>Front Disc Brake Pads Replacement (J55, J56)</u> , <u>Front Disc Brake Pads Replacement (J56 without F46, JE2)</u> , and/or <u>Rear Disc Brake Pads Replacement</u> . Did you complete the inspection and replacement?	Go to Step 12	-
	CAUTION: Support the brake caliper with heavy mechanic wire, or equivalent, whenever it is		

separated from its mount and the hydraulic flexible brake hose is still connected. Failure to support the caliper in this manner will cause the flexible brake hose to bear the weight of the caliper, which may cause damage to the brake hose and in turn may cause a brake fluid leak.

NOTE:

Do NOT disconnect the hydraulic brake flex hoses from the calipers.

1. Remove the front and/or rear disc brake calipers, as appropriate, from the mounting brackets or from the suspension knuckles and support the calipers. Refer to **Front Brake Caliper Replacement (J55, J56)** , **Front Brake Caliper Replacement (J56 without F46, JE2)** , and/or **Rear Brake Caliper Replacement** .
2. Inspect the disc brake caliper mounting bracket or the suspension knuckles and the mounting/sliding hardware for the following conditions:

Refer to **Front Disc Brake Mounting and Hardware Inspection** , and/or **Rear Disc Brake Mounting and Hardware Inspection** .

- Binding or seized hardware
 - Worn, damaged or missing hardware components
 - Loose, bent, cracked, or damaged caliper mounting bracket or suspension knuckle
3. Replace components as required. Refer to the following procedures, as required:
 - **Rear Brake Caliper Bracket Replacement**
 - **Front Brake Caliper Hardware Replacement**
 - **Rear Brake Caliper Hardware Replacement**
 4. Replace the unevenly-worn, loose or damaged disc brake pads as a complete axle set. Refer to **Front Disc Brake Pads Replacement (J55, J56)** , **Front Disc Brake Pads Replacement (J56 without F46, JE2)** , and/or **Rear Disc**

	<u>Brake Pads Replacement .</u>		
	Did you complete the inspection and replacement?	Go to Step 12	
8	1. Inspect the disc brake calipers, brake hoses and brake pipes for evidence of an external brake fluid leak. 2. Replace any components found to be leaking brake fluid. Refer to the following procedures as required: • <u>Front Brake Caliper Overhaul</u> , or <u>Front Brake Caliper Replacement (J55, J56)</u> , <u>Front Brake Caliper Replacement (J56 without F46, JE2)</u> • <u>Rear Brake Caliper Overhaul</u> , or <u>Rear Brake Caliper Replacement</u> • <u>Front Brake Hose Replacement</u> • <u>Rear Brake Hose Replacement</u> • <u>Brake Pipe Replacement</u> Did you find and correct the source of the leak causing contamination of the pads?	Go to Step 11	Go to Step 9
9	1. Inspect the wheel drive shaft outer seals for damage and evidence of a grease leak. 2. Replace any wheel drive shaft seal that is found to be leaking grease which may be the source of the contamination to the pads. Refer to <u>Front Wheel Drive Shaft Replacement - Left Side</u> , and/or <u>Front Wheel Drive Shaft Replacement - Right Side</u> , and/or <u>Rear Wheel Drive Shaft Replacement (LFX,LF3)</u> , <u>Rear Wheel Drive Shaft Replacement (LTG)</u> . Did you find and correct the source of the leak causing contamination of the pads?	Go to Step 11	Go to Step 10
10	1. Inspect the automatic transmission cooling system lines, if equipped, for damage and evidence of an external fluid leak which may be the source of the contamination to the pads. 2. Inspect the power steering system hoses for damage and evidence of an external fluid leak which may be the source of the contamination to the pads. 3. Replace any components found to be leaking fluid which may be the source of the		-

	contamination to the pads.		
	Did you find and correct the source of the leak causing contamination of the pads?	Go to Step 11	
11	1. Clean the remaining disc brake system components to remove any traces of the contaminant. CAUTION: Support the brake caliper with heavy mechanic wire, or equivalent, whenever it is separated from its mount and the hydraulic flexible brake hose is still connected. Failure to support the caliper in this manner will cause the flexible brake hose to bear the weight of the caliper, which may cause damage to the brake hose and in turn may cause a brake fluid leak. NOTE: Do NOT disconnect the hydraulic brake flex hoses from the calipers. 2. Remove the front and/or rear disc brake calipers, as appropriate, from the mounting brackets or the suspension knuckles and support the calipers. Refer to <u>Front Brake Caliper Replacement (J55, J56)</u> , <u>Front Brake Caliper Replacement (J56 without F46, JE2)</u> , and/or <u>Rear Parking Brake Anchor Backing Plate Replacement</u> . 3. Inspect the disc brake caliper mounting/sliding hardware for the following conditions: Refer to <u>Front Disc Brake Mounting and Hardware Inspection</u> , and/or <u>Rear Disc Brake Mounting and Hardware Inspection</u> . • Binding or seized hardware • Distorted, worn, damaged or missing hardware components 4. Replace the caliper mounting/sliding hardware components as required. Refer to <u>Front Brake Caliper Hardware Replacement</u> , and/or <u>Rear Brake Caliper Hardware Replacement</u> . 5. Replace the contaminated disc brake pads as a		-

	complete axle set. Refer to <u>Front Disc Brake Pads Replacement (J55, J56)</u> , <u>Front Disc Brake Pads Replacement (J56 without F46, JE2)</u> , and/or <u>Rear Disc Brake Pads Replacement</u> .		
	Did you complete the cleaning, inspection and replacement?	Go to Step 12	
12	Visually inspect each of the disc brake rotor shields/backing plates, if equipped, for evidence of contact with the brake rotors. Are any of the brake rotor shields/backing plates contacting the brake rotors?	Go to Step 13	Go to Step 14
13	Repair or replace the disc brake rotor shields/backing plates as required. Refer to <u>Front Brake Shield Replacement</u> , or <u>Rear Parking Brake Anchor Backing Plate Replacement</u> . Did you complete the repair or replacement?	Go to Step 14	-
14	1. Check the thickness of each of the disc brake rotors. NOTE: Make the following determination AND ANSWER the question INDIVIDUALLY for EACH rotor. 2. Make a determination for each brake rotor if the rotor can be REFINISHED and REMAIN ABOVE the minimum requirements. Refer to <u>Brake Rotor Thickness Measurement</u> .Does the disc brake rotor meet the minimum requirements for REFINISHING?	Go to Step 15	Go to Step 18
15	NOTE: Perform the following inspection AND ANSWER the question INDIVIDUALLY for EACH rotor. Inspect each of the disc brake rotors for thickness variation that exceeds the maximum acceptable level. Refer to <u>Brake Rotor Thickness Variation Measurement</u> .Does the brake rotor exhibit thickness variation that exceeds the maximum acceptable level?	Go to Step 17	Go to Step 16
	1. Inspect each of the disc brake rotors for the following surface and wear conditions: Refer to <u>Brake Rotor Surface and Wear</u>		

16	<u>Inspection .</u> • Heavy rust and/or pitting • Cracks and/or heat spots • Excessive blueing discoloration • Deep or excessive scoring beyond maximum acceptable level NOTE: Make the following determination AND ANSWER the question INDIVIDUALLY for EACH rotor. 2. Make a determination for each brake rotor if the rotor requires refinishing based upon the results of the inspection. If the brake rotor exhibits any of the conditions listed previously, it requires refinishing. Does the brake rotor require REFINISHING?	Go to Step 17	Go to Step 22
17	1. Refinish the brake rotor. Refer to <u>Brake Rotor Refinishing .</u> 2. Inspect the brake rotor thickness. Refer to <u>Brake Rotor Thickness Measurement .</u> Were you able to REFINISH the brake rotor within the minimum requirements?	Go to Step 22	Go to Step 21
18	Is the brake rotor at or below the MINIMUM THICKNESS requirements?	Go to Step 21	Go to Step 19
19	NOTE: Perform the following inspection AND ANSWER the question INDIVIDUALLY for EACH rotor. Inspect each of the disc brake rotors for thickness variation that exceeds the maximum acceptable level. Refer to <u>Brake Rotor Thickness Variation Measurement .</u> Does the brake rotor exhibit thickness variation that exceeds the maximum acceptable level?	Go to Step 21	Go to Step 20
	1. Inspect each of the disc brake rotors for the following surface and wear conditions: Refer to <u>Brake Rotor Surface and Wear Inspection .</u>		

20	• Heavy rust and/or pitting • Cracks and/or heat spots • Excessive blueing discoloration • Deep or excessive scoring beyond maximum acceptable level NOTE: Make the following determination AND ANSWER the question INDIVIDUALLY for EACH rotor. 2. Make a determination for each brake rotor if the rotor requires replacement based upon the results of the inspection. If the brake rotor exhibits any of the conditions listed previously, it requires replacement. Does the brake rotor require REPLACEMENT?	Go to Step 21	Go to Step 22
21	NOTE: Whenever a brake rotor is replaced, the assembled lateral runout (LRO) of the rotor must be measured to ensure optimum performance of the disc brakes. Replace the brake rotor. Refer to Front Brake Rotor Replacement , or Rear Brake Rotor Replacement .Did you complete the replacement?	Go to Step 24	-
22	NOTE: Perform the following inspection AND ANSWER the question INDIVIDUALLY for EACH rotor. Inspect each of the disc brake rotors for assembled lateral runout (LRO) that exceeds the maximum acceptable level. Refer to Brake Rotor Assembled Lateral Runout Measurement .Does the brake rotor exhibit assembled LRO that exceeds the maximum acceptable level?	Go to Step 23	Go to Step 24
23	Correct the LRO for each brake rotor that was determined to have LRO exceeding the maximum acceptable level. Refer to Brake Rotor Assembled Lateral Runout Correction . Did you complete the operation?	Go to Step 24	-
24	Install or connect components that were removed or disconnected during diagnosis. Did you complete the operation?	Disc Brake System OK Return to Symptom	-

HYDRAULIC BRAKE SYSTEM DIAGNOSIS

Hydraulic Brake System Diagnosis

Step	Action	Yes	No
DEFINITION: This diagnostic table is designed to diagnose ONLY the components of the HYDRAULIC brake system in order to determine if the Hydraulic brake system is operating properly. You will be directed by the appropriate Symptom Table to go to other brake system diagnostic tables as appropriate.			
1	Were you sent here from a Brake Symptom Table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Vehicle</u>
2	Inspect and adjust the brake fluid level in the brake master cylinder. Refer to <u>Master Cylinder Reservoir Filling</u> . Was the brake fluid level low?	Go to Step 3	Go to Step 4
3	1. Inspect the brake fluid for the following conditions, indicating brake fluid contamination: • Fluid separation, indicating two types of fluid are present ○ Swirled appearance-oil-based substance ○ Layered appearance-silicone-based substance • Fluid discoloration ○ Cloudy appearance-moisture ○ Dark appearance/suspended particles in fluid-dirt, rust, corrosion, brake dust 2. Inspect the master cylinder reservoir cap diaphragm and the reservoir-to-master cylinder grommets for swelling, indicating fluid contamination.		
	Do any of the above conditions exist?	Go to Step 5	Go to Step 6
4	1. Inspect the brake fluid for the following conditions, indicating brake fluid contamination: • Fluid separation, indicating two types of fluid are present ○ Swirled appearance-oil-based substance ○ Layered appearance-silicone-based substance • Fluid discoloration ○ Cloudy appearance-moisture ○ Dark appearance/ suspended particles in fluid-dirt, rust, corrosion, brake dust		

	2. Inspect the master cylinder reservoir cap diaphragm and the reservoir-to-master cylinder grommets for swelling, indicating fluid contamination.		
	Do any of the above conditions exist?	Go to Step 5	Go to Step 12
5	1. Flush the hydraulic brake system. Refer to <u>Hydraulic Brake System Flushing</u>. 2. If the brake fluid WAS contaminated with an oil-based or a silicone-based fluid, indicated by fluid separation and/or a swollen master cylinder reservoir cap diaphragm and/or swollen reservoir-to-master cylinder grommets, perform the following steps. Refer to the procedures indicated. 1. Remove ALL of the following components listed. Each component contains internal rubber seals/linings which have been contaminated. 2. Clean out the hydraulic brake pipes using denatured alcohol, or equivalent. 3. Dry the brake pipes using non-lubricated, filtered air. 4. Repair or replace ALL of the following components listed. Each component contains internal rubber seals/linings which have been contaminated. • <u>Master Cylinder Replacement</u> • Brake master cylinder reservoir: Clean the brake master cylinder reservoir using denatured alcohol, or equivalent, then dry the reservoir using non-lubricated, filtered air, or if necessary, replace the brake master cylinder reservoir. • Replace the brake master cylinder reservoir cap diaphragm. • <u>Front Brake Hose Replacement</u> • <u>Rear Brake Hose Replacement</u> • <u>Front Brake Caliper Overhaul</u> , or <u>Front Brake Caliper Replacement (J55, J56)</u> , <u>Front Brake Caliper Replacement (J56 without F46, JE2)</u> • <u>Rear Brake Caliper Overhaul</u> , or <u>Rear Brake Caliper Replacement</u>		-

	• <u>Brake Pressure Modulator Valve Replacement</u> 3. If the brake fluid was NOT contaminated with an oil-based fluid, but WAS contaminated with water or dirt, rust, corrosion, and/or brake dust, replace the brake master cylinder reservoir cap diaphragm which may have allowed moisture or dirt to enter the system. 4. Refill and bleed the hydraulic brake system. Refer to <u>Hydraulic Brake System Bleeding (Manual)</u>, <u>Hydraulic Brake System Bleeding (Pressure)</u>. Did you complete the operation and any required repairs and/or replacements?	Go to Step 9	
6	1. Inspect the following hydraulic brake system components for external fluid leaks; repair or replace any of the components found to be leaking brake fluid. Refer to the appropriate procedures: • <u>Master Cylinder Replacement</u> • Brake master cylinder reservoir cap diaphragm • <u>Front Brake Hose Replacement</u> • <u>Rear Brake Hose Replacement</u> • <u>Brake Pipe Replacement</u> • <u>Front Brake Caliper Overhaul</u> , or <u>Front Brake Caliper Replacement (J55, J56)</u> , <u>Front Brake Caliper Replacement (J56 without F46, JE2)</u> • <u>Rear Brake Caliper Overhaul</u> , or <u>Rear Brake Caliper Replacement</u> • <u>Brake Pressure Modulator Valve Replacement</u> 2. If you repaired or replaced any of the brake system components listed, bleed the hydraulic brake system. Refer to <u>Hydraulic Brake System Bleeding (Manual)</u>, <u>Hydraulic Brake System Bleeding (Pressure)</u>. While bleeding the hydraulic brake system, observe for the following conditions: • The presence of air in the system at a bleeder valve location other than at the repair location, except if the brake master cylinder was replaced • An unrestricted and even flow of brake fluid per axle during the bleeding procedure		

	Did you find and correct a condition?	Go to Step 7	Go to Step 12
7	Was there air in the system at a bleeder valve location other than at the repair location, except if the brake master cylinder was replaced?	Go to Step 19	Go to Step 8
8	Was the flow of brake fluid unrestricted and even per axle during the bleeding procedure?	Go to Step 9	Go to Step 10
9	Inspect the hydraulic function of the brake calipers for proper operation. Was the hydraulic function of the brake calipers operating properly?	Go to Step 21	Go to Step 14
10	Was the flow of brake fluid restricted or uneven through front axle hydraulic components during the bleeding procedure?	Go to Step 13	Go to Step 11
11	Was the flow of brake fluid restricted or uneven through rear axle hydraulic components during the bleeding procedure?	Go to Step 17	-
12	Inspect the hydraulic function of the brake calipers for proper operation. Was the hydraulic function of the brake calipers operating properly?	Go to Step 15	Go to Step 13
13	Determine if the brake caliper is restricting the flow of brake fluid and/or not operating properly: 1. Raise and support the vehicle. Refer to <u>Lifting and Jacking the Vehicle</u> . 2. Remove the tire and wheel assemblies. Refer to <u>Tire and Wheel Removal and Installation</u> . 3. Open the suspected caliper bleeder valve. 4. Using a large C-clamp, compress the caliper piston and observe for an unrestricted flow of brake fluid and for free movement of the caliper piston. 5. Close the caliper bleeder valve. Was the flow of brake fluid unrestricted and did the caliper piston move freely?	Go to Step 17	Go to Step 14
14	Repair or replace any brake caliper that was not operating properly. Refer to the appropriate procedure: • <u>Front Brake Caliper Overhaul</u> , or <u>Front Brake Caliper Replacement (J55, J56)</u> , <u>Front Brake Caliper Replacement (J56 without F46, JE2)</u> • <u>Rear Brake Caliper Overhaul</u> , or <u>Rear Brake Caliper Replacement</u>		-

	Did you complete the repair and/or replacement?	Go to Step 21	
15	Bleed the hydraulic brake system to observe for the presence of air in the system and to observe for an unrestricted and even flow of brake fluid per axle during the bleeding procedure. Refer to <u>Hydraulic Brake System Bleeding (Manual), Hydraulic Brake System Bleeding (Pressure)</u> . Was there air in the system?	Go to Step 19	Go to Step 16
16	Was the flow of brake fluid unrestricted and even per axle during the bleeding procedure?	Go to Step 21	Go to Step 17
17	1. Inspect the hydraulic brake pipes and flexible brake hoses for signs of a fluid restriction; such as being bent, kinked, pinched or damaged. Refer to <u>Brake Pipe and Hose Inspection</u>. 2. Replace any of the hydraulic brake pipes and/or flexible brake hoses found to be bent, kinked, pinched or damaged. Refer to the following procedures as necessary: • <u>Front Brake Hose Replacement</u> • <u>Rear Brake Hose Replacement</u> • <u>Brake Pipe Replacement</u> 3. If none of the hydraulic brake pipes or flexible brake hoses were visibly bent, kinked, pinched or damaged, replace the hydraulic brake flex hose at the restricted location. Did you find and correct a condition?	Go to Step 21	Go to Step 18
18	Replace the brake pressure modulator valve (BPMV), in order to correct the hydraulic brake dynamic rear proportioning mechanical operation. Refer to <u>Brake Pressure Modulator Valve Replacement</u> . Did you complete the replacement?	Go to Step 21	-
19	1. Inspect the hydraulic brake system components for brake fluid seepage at a seal and/or fitting location, which may have drawn air into the system. 2. Inspect the hydraulic brake system components for evidence of a recent repair, which may have introduced air into the system. 3. Repair or replace any of the components found to be installed incorrectly or seeping brake fluid. Did you find and correct a condition?	Go to Step 21	Go to Step 20
	1. Inspect the brake master cylinder for internal fluid		

20	leaks. Refer to <u>Brake System Internal Leak Test.</u> 2. Replace the brake master cylinder if it is found to be leaking brake fluid internally. Refer to <u>Master Cylinder Replacement.</u>		
	Did you find and correct a condition?	Go to Step 21	Return to Symptom Table
21	Install or connect components that were removed or disconnected during diagnosis. Did you complete the operation?	Hydraulic Brake System OK Return to Symptom Table	-

BRAKE ASSIST SYSTEM DIAGNOSIS

Brake Assist System Diagnosis

Step	Action	Yes	No
DEFINITION: This diagnostic table is designed to diagnose ONLY the components of the brake ASSIST system in order to determine if the brake ASSIST system is operating properly. You will be directed by the appropriate Symptom table to go to other brake system diagnostic tables as appropriate.			
1	Were you sent here from a Brake Symptom table?	Go to Step 3	Go to Step 2
2	Were you sent here directly from an electrical diagnostic to investigate vacuum as a possible concern?	Go to Step 5	Go to <u>Diagnostic Starting Point - Vehicle</u>
3	Inspect for proper brake pedal travel. Refer to <u>Brake Pedal Travel Measurement and Inspection.</u> Is the brake pedal travel distance within the acceptable limits?	Go to Step 5	Go to Step 4
4	1. Inspect for worn, missing, misaligned, bent or damaged brake pedal system components. - For the brake pedal pushrod component inspection, refer to <u>Brake Pedal Pushrod Inspection.</u> - Inspect the brake pedal bushings for excessive wear and/or damage and inspect the brake pedal for a misaligned, bent and/or damaged condition. 2. Replace the brake pedal system components that are worn, missing, misaligned, bent or damaged. Did you find and replace any worn, missing, misaligned, bent or damaged brake pedal system components?	Go to Step 5	Go to <u>Hydraulic Brake System Diagnosis</u> to check for internal and external fluid leaks and air in the hydraulic brake system
	Check the engine vacuum source that supplies vacuum to the vacuum brake booster. Refer to <u>Brake System Vacuum Source Test.</u>		Go to Engine Controls Diagnostics Information to check

5	Is the vacuum reading within the acceptable limits?	Go to Step 6	for vacuum issues, including vacuum pump operation, if equipped
6	Does the condition occur during cold start-up conditions?	Go to Step 7	Go to Step 8
7	Check engine vacuum, and vacuum pump operation, if equipped, under the same cold start-up conditions. Refer to Engine Controls Diagnostics. Did you find and correct a condition?	Go to Step 22	Go to Step 9
8	During the vacuum source test, did the vacuum booster check valve operate properly?	Go to Step 10	Go to Step 9
9	Replace the vacuum booster check valve. Refer to <u>Power Brake Booster Vacuum Check Valve and Hose Replacement (LTG)</u> , <u>Power Brake Booster Vacuum Check Valve and Hose Replacement (LFX, LF3)</u> . Did you complete the replacement?	Go to Step 10	-
10	If equipped with a booster mounted separate vacuum sensor, inspect the vacuum sensor grommet for cracks, cuts, dry-rot, or damage. Does the vacuum sensor grommet exhibit any of the conditions listed?	Go to Step 11	Go to Step 12
11	Replace the vacuum sensor grommet. Did you complete the replacement?	Go to Step 12	-
12	1. If the vehicle is equipped with a vacuum sensor, install a scan tool. 2. Using the Data Display function, determine if brake booster vacuum sensor data is available within either the chassis brake controls area or the powertrain engine controls area. Is vacuum sensor data available through the scan tool?	Go to Step 13	Go to Step 16
	Perform the vacuum booster leak-down test using a scan tool: 1. Release the brake pedal. 2. Accelerate the engine to approximately 3000 RPM, then release the throttle. Wait 2-3 seconds and repeat once. 3. Turn the ignition OFF. 4. Turn the ignition ON. Do not start the engine. 5. Observe and record the vacuum sensor reading on the scan tool over a period of 60 seconds.		

13	NOTE: Vacuum readings will decrease by approximately 2.7 kPa (0.8 Hg) for every 305 m (1000 ft) of elevation above sea level. 6. Determine the rate of vacuum leak. Specification Maximum allowable vacuum leak rate: 10 kPa (3 in Hg) in 60 seconds Was the rate of vacuum leak within the specified allowable range?	Go to Step 18	Go to Step 14
14	1. Deplete the vacuum reserve by pressing the brake pedal several times, or by removing the vacuum booster check valve. 2. Separate the master cylinder from the vacuum brake booster. Do not disconnect any brake pipes. Refer to <u>Master Cylinder Replacement</u>. 3. If equipped with a vacuum seal on the rear of the master cylinder, inspect the seal for damage and correct positioning on the master cylinder. Replace the vacuum seal as necessary. 4. Carefully reinstall the master cylinder to the brake booster. Refer to <u>Master Cylinder Replacement</u>. Did you complete the operation?	Go to Step 15	-
15	Perform the vacuum booster leak-down test using a scan tool: 1. Release the brake pedal. 2. Accelerate the engine to approximately 3000 RPM, then release the throttle. Wait 2-3 seconds and repeat once. 3. Turn the ignition OFF. 4. Turn the ignition ON. Do not start the engine. 5. Observe and record the vacuum sensor reading on the scan tool over a period of 60 seconds. NOTE: Vacuum readings will decrease by approximately 2.7 kPa (0.8 Hg) for every 305		

	m (1000 ft) of elevation above sea level. 6. Determine the rate of vacuum leak. Specification Maximum allowable vacuum leak rate: 10 kPa (3 in Hg) in 60 seconds Was the rate of vacuum leak within the specified allowable range?	Go to Step 22	Go to Step 21
16	1. Separate the master cylinder from the vacuum brake booster. Do not disconnect any brake pipes. Before removing the master cylinder, first deplete the vacuum by removing the check valve or applying the brake pedal several times. Refer to <u>Master Cylinder Replacement</u>. 2. If equipped with a vacuum seal on the rear of the master cylinder, inspect the seal for damage and correct positioning on the master cylinder. 3. If equipped with a vacuum seal that is part of the booster, inspect the seal for damage. Does the vacuum seal exhibit any of the conditions listed?	Go to Step 17	Go to Step 18
17	1. If equipped with a vacuum seal on the rear of the master cylinder, replace the vacuum seal as necessary. Ensure the seal is positioned correctly during installation. 2. If equipped with a vacuum seal that requires replacement and which is part of the booster, the booster assembly must be replaced. 3. Carefully reinstall the master cylinder to the brake booster. Refer to <u>Master Cylinder Replacement</u>. Did you complete the replacement?	Go to Step 18	-
	Perform the vacuum boost functional test: 1. If still separated, reinstall the master cylinder to the booster. Refer to <u>Master Cylinder Replacement</u>. 2. If the engine was started after reinstalling the master cylinder to the booster, perform the		

18	following: With the engine OFF, depress the brake pedal several times to deplete the vacuum reserve. - Depress and maintain moderate foot pressure on the brake pedal. - Start the engine and observe pedal operation. - Observe for audible vacuum leaks. The brake pedal should fall slightly, then hold. Is there an audible vacuum leak coming from the brake pedal area?	Go to Step 21	Go to Step 19
19	Did the brake pedal fall slightly after the engine was started, then hold?	Go to Step 20	Go to Step 21
20	Perform the vacuum booster leak-down test: - Release the brake pedal. - Accelerate the engine to approximately 3000 RPM, then release the throttle. Wait 2-3 seconds and repeat once. - Turn the ignition OFF. - Wait 60 seconds. - Depress the brake pedal 2 times to check for vacuum booster available vacuum reserve. Observe pedal effort. - Both pedal applies should be assisted - The amount of assist could diminish slightly with the second apply Were both pedal applies power assisted?	Go to Step 22	Go to Step 21
21	Replace the vacuum brake booster. Refer to <u>Power Vacuum Brake Booster Replacement</u>. Did you complete the replacement?	Go to Step 22	-
22	Install or connect any components that were removed or disconnected during diagnosis. Did you complete the operation?	Brake Assist System OK Return to Symptom Table	-

BRAKE SYSTEM VEHICLE ROAD TEST

Preliminary Inspections

1. Visually inspect easily accessible brake system components for obvious damage and/or leaks which may indicate that the vehicle should not be driven until further inspections have been completed.
2. Inspect the brake master cylinder reservoir fluid level and adjust only if necessary for brake system road testing. Refer to **Master Cylinder Reservoir Filling**.
3. Inspect the tire inflation pressures and adjust as necessary.
4. Inspect the tire tread patterns to ensure that they are the same or very similar, especially per axle.
5. Ensure that the vehicle is not loaded unevenly prior to brake system road testing.

Road Testing Procedure

WARNING: Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.

1. Start the engine and allow it to idle.
2. Check to see if the brake system warning lamp remains illuminated.
3. If the brake system warning lamp remains illuminated, DO NOT proceed to test drive the vehicle until it is diagnosed and repaired. Refer to **Symptoms - Hydraulic Brakes**.
4. Select a smooth, dry, clean and level road or large lot that is as free of traffic and obstacles as possible for brake system low speed road testing.
5. With the transmission in PARK, lightly apply the brake pedal. Observe both the pedal feel and the pedal travel.
6. If the brake pedal apply felt spongy, or the pedal travel was excessive, DO NOT drive the vehicle until it is repaired.
7. If the brake pedal apply did not feel spongy and the pedal travel was not excessive, proceed to step 8.
8. Release and apply the brakes.
9. While continuing to apply the brakes, shift the transmission into DRIVE, release the brakes and allow the engine to idle the vehicle away from the stopped position. Observe for a slow release of the brake system.
10. With the aid of an assistant to observe the vehicle's performance from outside of the vehicle, drive the vehicle at a low speed and lightly apply the brakes while driving past the assistant. Have the assistant observe for brake system noise from the side of the vehicle closest to them, while you observe both the pedal effort and the pedal travel.
11. If the brake pedal apply effort was excessive, or the pedal travel was excessive, DO NOT continue to test drive the vehicle until it is repaired.
12. If the brake pedal apply effort was not excessive and the pedal travel was not excessive, proceed to step 13.
13. Drive the vehicle in the opposite direction, at the same low speed and lightly apply the brakes while driving past the assistant. Have the assistant observe for brake system noise from the side of the vehicle closest to him.
14. Drive the vehicle at a low speed and shift the transmission into NEUTRAL without applying the brakes. Observe for a rapid deceleration in vehicle speed, indicating possible brake drag.

15. Select a smooth, dry, clean and level road that is as free of heavy traffic as possible for brake system moderate speed road testing.
16. Drive the vehicle at a moderate speed. Observe for a pull and/or incorrect tracking of the vehicle without the brakes applied.
17. While continuing to drive the vehicle at a moderate speed, perform several light applies of the brakes. Observe the pedal effort and the pedal travel, observe for brake system noise, pulsation and/or brake drag.
18. If the brake pedal apply effort was excessive, or the pedal travel was excessive, DO NOT continue to test drive the vehicle until it is repaired.
19. If the brake pedal apply effort was not excessive and the pedal travel was not excessive, proceed to step 20.
20. While continuing to drive the vehicle at a moderate speed, perform several moderate applies of the brakes. Observe the pedal effort and the pedal travel, observe for brake system pulsation and/or uneven braking action - either side to side, or front to rear.

A small amount of vehicle front end dip is expected during a moderate apply of the brakes.

21. If the brake pedal apply effort was excessive, or the pedal travel was excessive, DO NOT continue to test drive the vehicle until it is repaired.

BRAKE PEDAL TRAVEL MEASUREMENT AND INSPECTION

Special Tools

CH-28662 Brake Pedal Effort Gauge

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

1. With the ignition OFF and the brakes cool, apply the brakes 3-5 times, or until the brake pedal becomes firm, in order to deplete the brake booster power reserve.

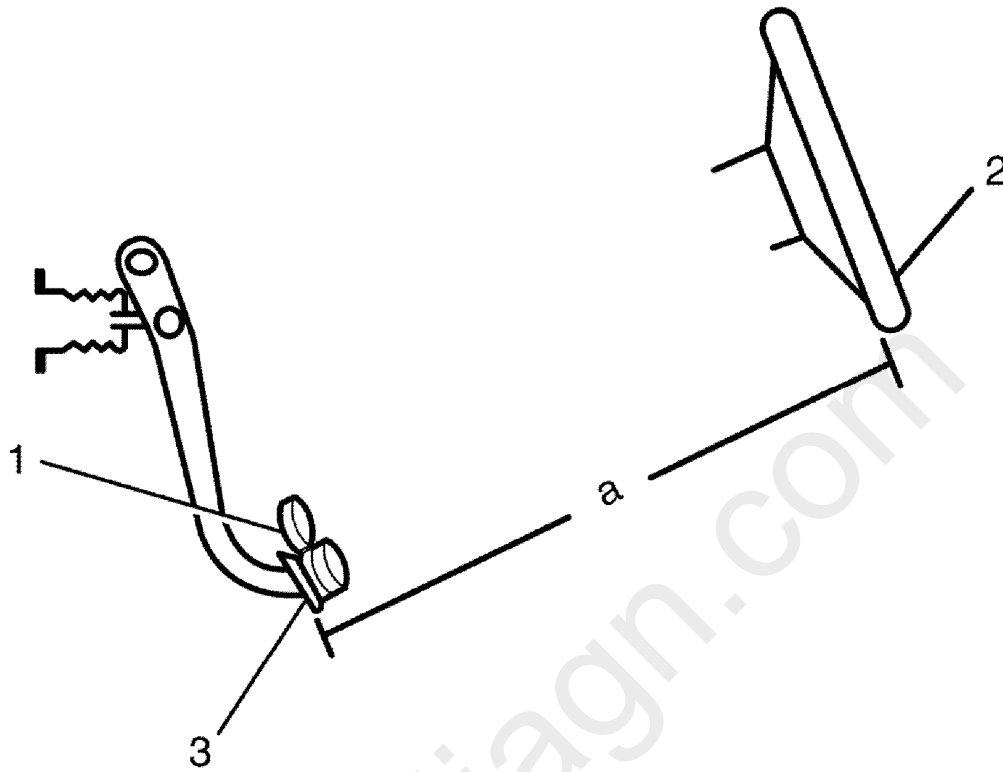


Fig. 2: Steering Wheel, Brake Pedal And Gauge
Courtesy of GENERAL MOTORS COMPANY

2. Install the **CH-28662** gauge (1), or equivalent, to the brake pedal (3).
3. Measure and record the distance (a) from the brake pedal (3) to the rim of the steering wheel (2). Note the points of measurement.

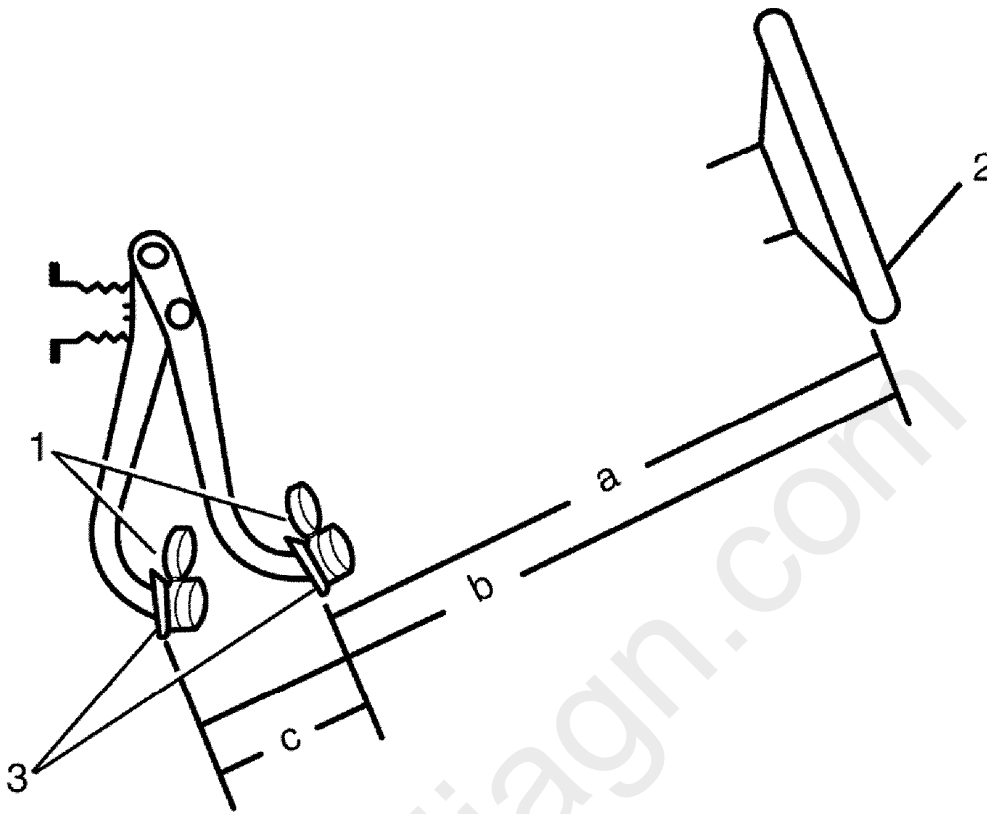


Fig. 3: Brake Pedal Components And Travel Measurement
Courtesy of GENERAL MOTORS COMPANY

4. Apply and maintain a force of 445 N (100 lb) to the brake pedal, as indicated on the **CH-28662** gauge (1), or equivalent.
5. While maintaining 445 N (100 lb) of force to the brake pedal (3), measure and record the distance (b) from the same point on the brake pedal (3) to the same point on the rim of the steering wheel (2).
6. Release the brake pedal (3) and repeat steps 4 and 5 to obtain a second measurement. After obtaining a second measurement, proceed to step 7.
7. Average the first and second measurements recorded for the 2 applies of the brakes.
8. Subtract the initial unapplied distance (a), from the average applied distance (b) to obtain the brake pedal travel measurement (c).
9. Compare the measurement obtained with the specification. Refer to **Brake System Specifications**.

BRAKE SYSTEM VACUUM SOURCE TEST

NOTE:

- Engine temperature, accessory load, and elevation level will affect engine vacuum.
- Vacuum readings will decrease by approximately 2.7 kPa (0.8 in Hg) for every 305 m (1000 ft) of elevation above sea level.

1. Disconnect the engine vacuum hose from the vacuum brake booster check valve.
2. Install a vacuum gauge to the engine vacuum hose.
3. Start the engine and allow the engine to idle until normal operating temperatures are reached.
4. With the vehicle in PARK, the engine idling, and the air conditioning (A/C) system OFF, check to see if the engine vacuum reading is within the specified normal engine vacuum range.

Specification

47-68 kPa (14-20 in Hg)

5. Turn the ignition OFF.
6. If the engine vacuum reading was within the specified normal range, proceed to step 10.
7. If the engine vacuum reading was NOT within the specified normal range, inspect the engine vacuum hose for the following conditions:
 - Loose connection to the engine
 - Collapse, deformation or contamination
 - Cracks, cuts, dry-rot
8. If any of these conditions were found with the engine vacuum hose, replace the hose, then repeat steps 2-4.
9. If none of these conditions were found with the engine vacuum hose, then there is an engine vacuum source problem, check the engine vacuum system.
10. Remove the vacuum brake booster check valve from the booster.
11. Install the check valve to the engine vacuum hose.
12. Install the vacuum gauge to the check valve.
13. Start the engine and allow the engine to idle in PARK with the A/C system OFF, until normal operating temperatures are reached.
14. Turn the ignition OFF.
15. Check to see if the engine vacuum reading is maintained within the specified normal engine vacuum range.

Specification

47-68 kPa (14-20 in Hg)

16. If the engine vacuum reading is maintained within the specified normal range, proceed to step 18.
17. If the engine vacuum reading is NOT maintained within the specified normal range, replace the brake booster check valve, then repeat steps 11-15.

18. Inspect the brake booster check valve grommet for the following conditions:
 - Loose connection to the vacuum brake booster
 - Deformation or contamination
 - Cracks, cuts, dry-rot
19. If any of these conditions were found with the check valve grommet, replace the grommet.

BRAKE SYSTEM EXTERNAL LEAK INSPECTION

WARNING: Refer to Brake Fluid Irritant Warning .

CAUTION: Refer to Brake Fluid Effects on Paint and Electrical Components Caution .

1. In order to inspect for external brake fluid leaks, first check the fluid level in the master cylinder.

While a slight brake fluid level drop can be considered a normal condition due to brake lining wear, a very low level may indicate a brake fluid leak in the hydraulic system.

If the fluid level is abnormally low, adjust the brake fluid level. Refer to Master Cylinder Reservoir Filling.

2. Start the engine and allow it to idle.
3. Apply constant, moderate foot pressure to the brake pedal.

If the brake pedal gradually falls away while under foot pressure, there may be a brake fluid leak.

4. Turn OFF the ignition.
5. Visually inspect the following brake system components for brake fluid leaks, excessive corrosion, and damage. Give particular attention to all brake pipe and flexible hose connections to ensure that there are not any slight brake fluid leaks - even though the brake pedal may feel firm and hold steady:
 - Master cylinder brake pipe fittings
 - All brake pipe connections
 - Brake pipes
 - Brake hoses and connections
 - Brake calipers and/or wheel cylinders, if equipped
6. While slight dampness around the master cylinder reservoir can be considered acceptable, brake fluid leaking from any of the brake system components requires immediate attention. If any of these components exhibit signs of brake fluid leakage, repair or replace those components. After the repair or replacement, reinspect the hydraulic brake system to assure proper function.

BRAKE SYSTEM INTERNAL LEAK TEST

WARNING: Refer to Brake Fluid Irritant Warning .

CAUTION: Refer to Brake Fluid Effects on Paint and Electrical Components Caution .

1. Start the engine and allow it to idle.
2. Apply light, steady pressure to the brake pedal. Observe both the brake pedal feel and travel.
3. Release the brakes and turn OFF the ignition.
4. If the brake pedal apply felt spongy, but the brake pedal travel was not excessive, perform the following steps:
 1. Inspect the brake system for external leaks. Refer to Brake System External Leak Inspection.
 2. Pressure bleed the brake system in order to purge any air that may be trapped in the system. Refer to Hydraulic Brake System Bleeding (Manual), Hydraulic Brake System Bleeding (Pressure).

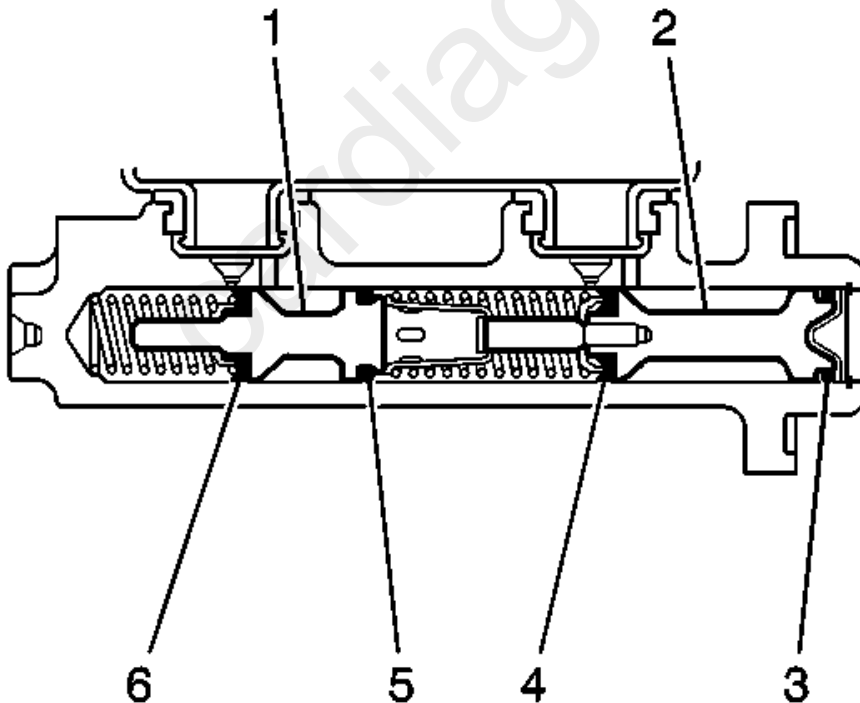


Fig. 4: Identifying Brake Master Cylinder (Cross Sectional View)

Courtesy of GENERAL MOTORS COMPANY

5. If the brake pedal apply did not feel spongy, but the brake pedal travel was excessive, perform the following steps:
 1. Loosen the master cylinder-to-brake power booster mounting nuts.
 2. Carefully pull the master cylinder away from the brake power booster just enough to inspect the mounting surface of the master cylinder.
 3. Inspect the master cylinder mounting surface at the primary piston (2) for brake fluid leaks.
6. If the master cylinder exhibits any leakage around the primary piston (2), then the primary piston primary seal (4) and/or secondary seal (3) is leaking and the master cylinder requires overhaul or replacement.
7. If the master cylinder primary piston (2) does not exhibit any leakage, pressure bleed the brake system. Refer to **Hydraulic Brake System Bleeding (Manual)**, **Hydraulic Brake System Bleeding (Pressure)**.
8. If the brake pedal apply did not feel spongy, and the brake pedal travel was initially steady and not excessive, but then gradually fell, then the master cylinder requires overhaul or replacement due to an internal leak past the secondary piston (1) from the secondary piston primary seal (6) or secondary seal (5).
9. If the brake pedal apply did not feel spongy, and the brake pedal travel was initially steady and not excessive, then fell slightly, then became steady again, then the brake pressure modulator valve (BPMV) may be leaking internally, and may require replacement.

BRAKE PIPE AND HOSE INSPECTION

WARNING: Refer to **Brake Fluid Irritant Warning** .

CAUTION: Refer to **Brake Fluid Effects on Paint and Electrical Components Caution** .

1. Visually inspect all of the brake pipes for the following conditions:
 - Kinks, improper routing, missing or damaged retainers
 - Leaking fittings, excessive corrosion
2. If any of the brake pipes exhibited any of the conditions listed, then the identified pipe, or pipes, require replacement.
3. Ensure that the vehicle axles are properly supported at ride height in order to maintain the proper relationship of the flexible brake hoses to the chassis.

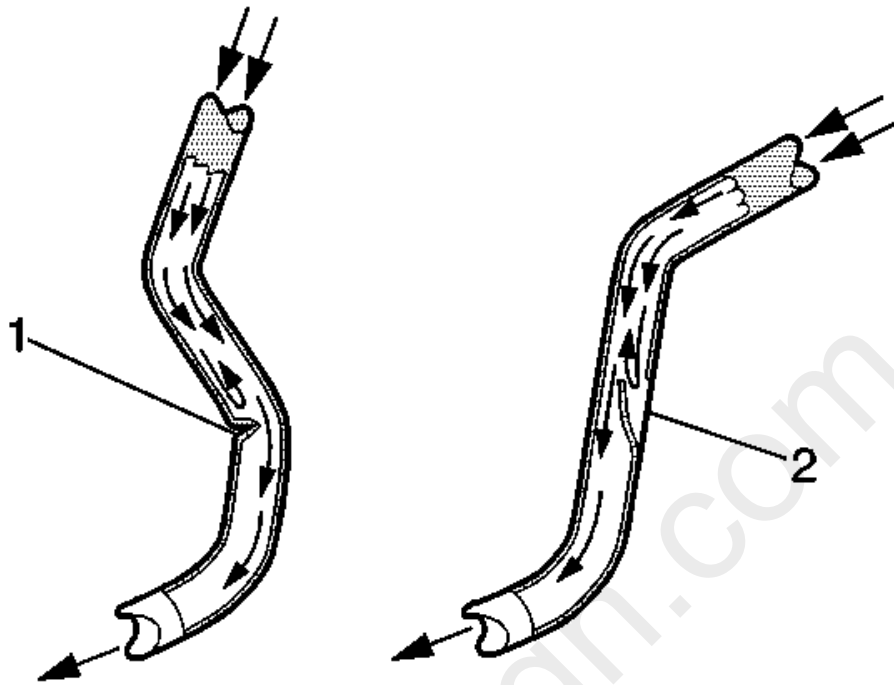


Fig. 5: Identifying Flexible Brake Hose Failure Conditions
Courtesy of GENERAL MOTORS COMPANY

4. Visually inspect all of the flexible brake hoses for the following conditions:
 - Kinks (1), improper routing, twists, chafing, missing or damaged retainers
 - Leaking connections, cracking, dry-rot, blisters, bulges
5. If any of the flexible brake hoses exhibited any of the conditions listed, then the identified flexible brake hose, or hoses require replacement.
6. Squeeze the flexible brake hoses with firm finger pressure to check for soft spots (2), indicating an internal restriction. Check the entire length of each flexible brake hose.
7. If any of the flexible brake hoses were found to have soft spots (2), then the identified flexible brake hose, or hoses require replacement.

BRAKE PEDAL PUSHROD INSPECTION

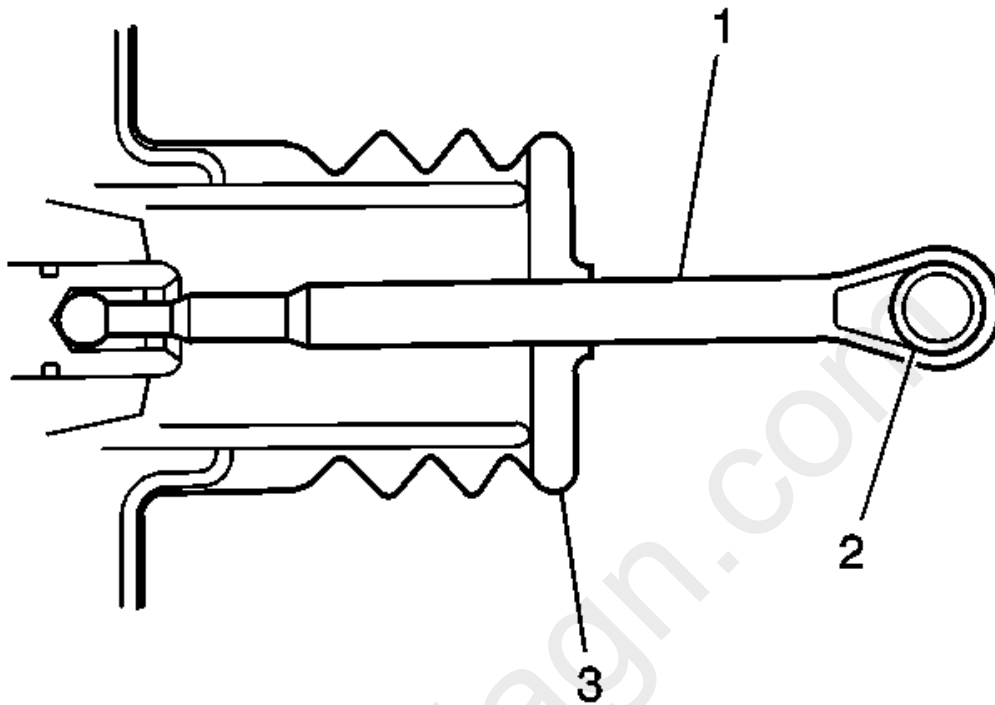


Fig. 6: View of Brake Pedal Pushrod
Courtesy of GENERAL MOTORS COMPANY

1. Disconnect the brake pedal pushrod (1) from the brake pedal.
2. Inspect the brake pedal pushrod eyelet bushing (2), if equipped, for cracks and/or excessive wear.
3. Reposition the pedal pushrod boot (3) toward the front of the vehicle to expose as much of the pedal pushrod (1) as possible.
4. Inspect the brake pedal pushrod (1) for straightness.
5. If the brake pedal pushrod eyelet bushing (2) exhibited cracks and/or excessive wear, then the bushing requires replacement.
6. If the brake pedal pushrod (1) is not straight, then the pushrod requires replacement.
7. Return the pedal pushrod boot (3) to its original position on the pedal pushrod (1).
8. Connect the brake pedal pushrod (1) to the brake pedal.

REPAIR INSTRUCTIONS

MASTER CYLINDER RESERVOIR FILLING

WARNING: Refer to Brake Fluid Irritant Warning .

CAUTION: Refer to Brake Fluid Effects on Paint and Electrical Components Caution .

1. Visually inspect the brake fluid level through the brake master cylinder reservoir.
2. If the brake fluid level is at or below the half-full point during routine fluid checks, the brake system should be inspected for wear and possible brake fluid leaks.
3. If the brake fluid level is at or below the half-full point during routine fluid checks, and an inspection of the brake system did not reveal wear or brake fluid leaks, the brake fluid may be topped-off up to the maximum-fill level.
4. If brake system service was just completed, the brake fluid may be topped-off up to the maximum-fill level.
5. If the brake fluid level is above the half-full point, adding brake fluid is not recommended under normal conditions.
6. If brake fluid is to be added to the master cylinder reservoir, clean the outside of the reservoir on and around the reservoir cap prior to removing the cap and diaphragm. Use only GM approved brake fluid from a clean, sealed brake fluid container.

MASTER CYLINDER RESERVOIR REPLACEMENT

Removal Procedure

WARNING: Refer to Brake Fluid Irritant Warning .

CAUTION: Refer to Brake Fluid Effects on Paint and Electrical Components Caution .

1. Using a suitable tool, remove and properly discard the brake fluid from the master cylinder reservoir.
2. Remove the brake fluid level indicator switch. Refer to Brake Fluid Level Indicator Switch Replacement.

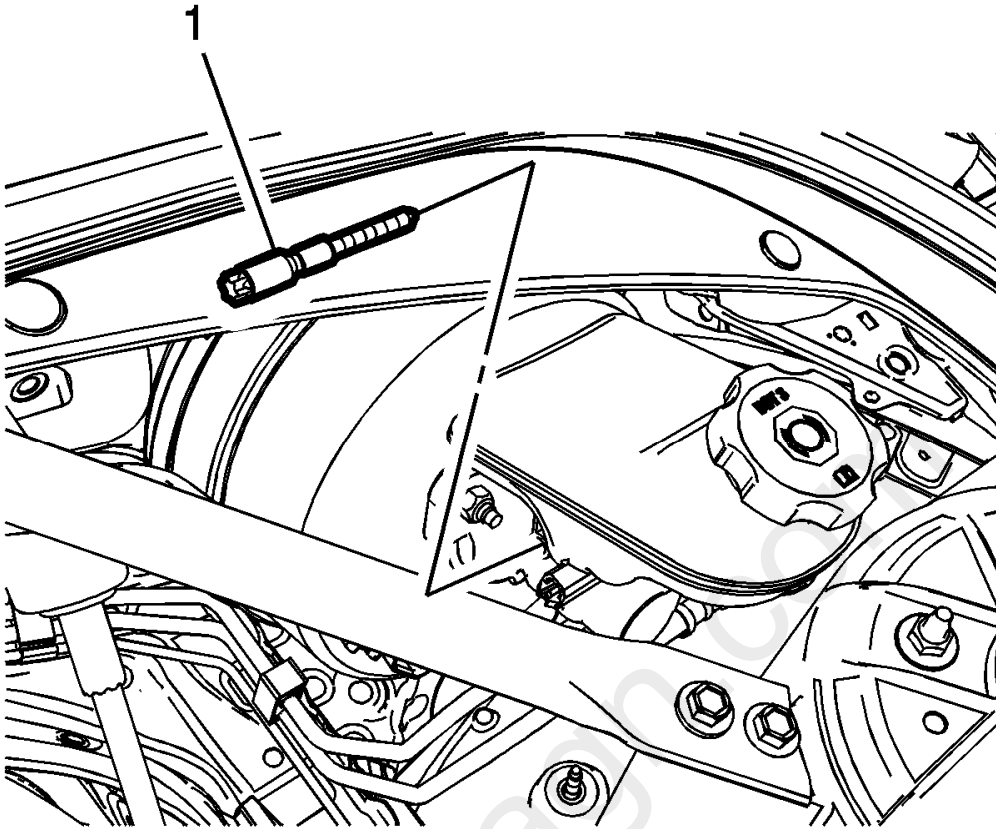


Fig. 7: Master Cylinder Reservoir Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Remove the master cylinder reservoir bolt (1).

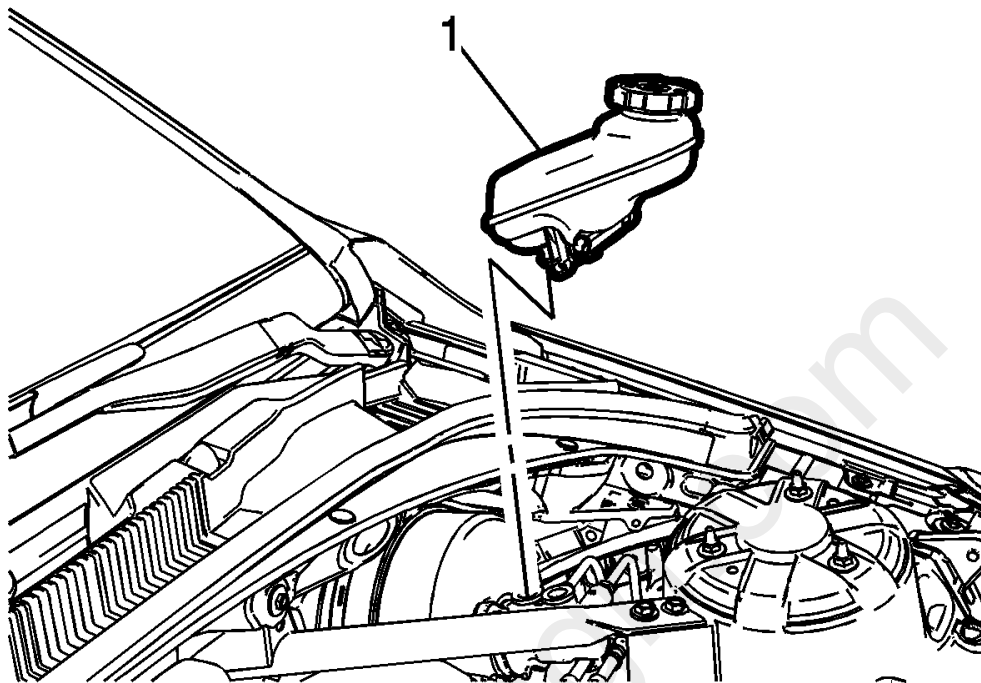


Fig. 8: Master Cylinder Reservoir
Courtesy of GENERAL MOTORS COMPANY

4. Lift the master cylinder reservoir (1) upward to release the reservoir from the reservoir seals and the master cylinder.

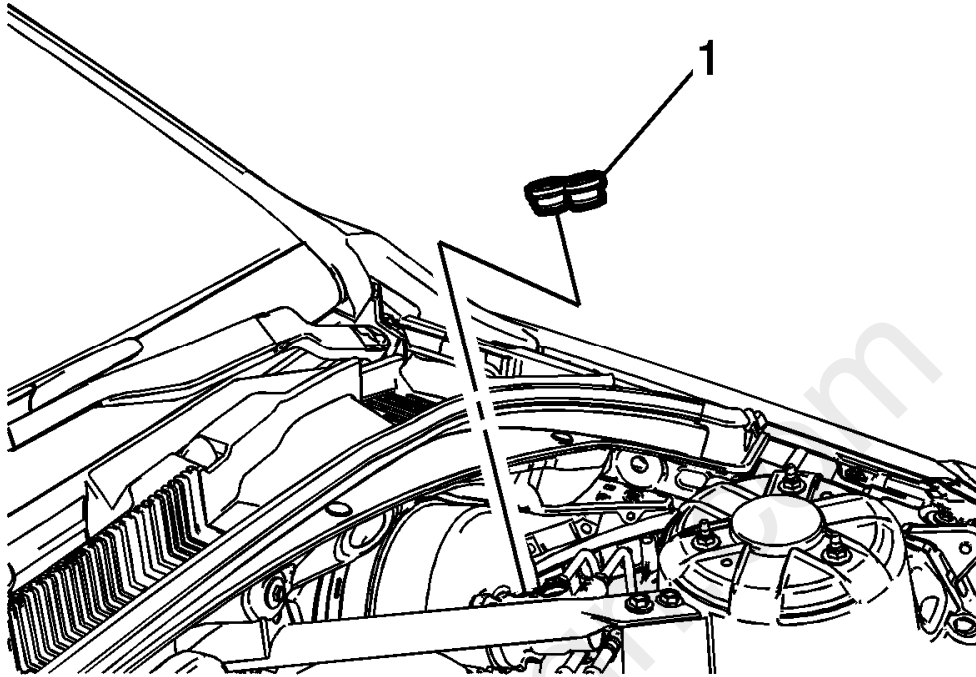


Fig. 9: Master Cylinder Reservoir Seals
Courtesy of GENERAL MOTORS COMPANY

5. Remove the 2 master cylinder reservoir seals (1).

Installation Procedure

1. Lubricate the master cylinder reservoir seals with GM approved brake fluid from a clean, sealed, brake fluid container.

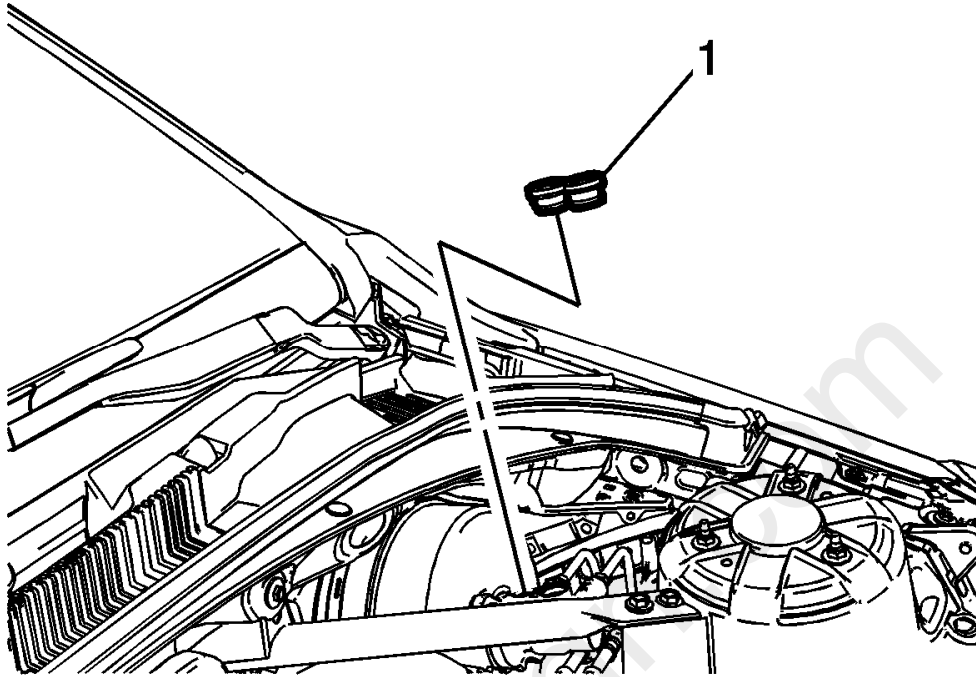


Fig. 10: Master Cylinder Reservoir Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the reservoir seals are fully seated in the master cylinder.

2. Install the 2 master cylinder reservoir seals (1).

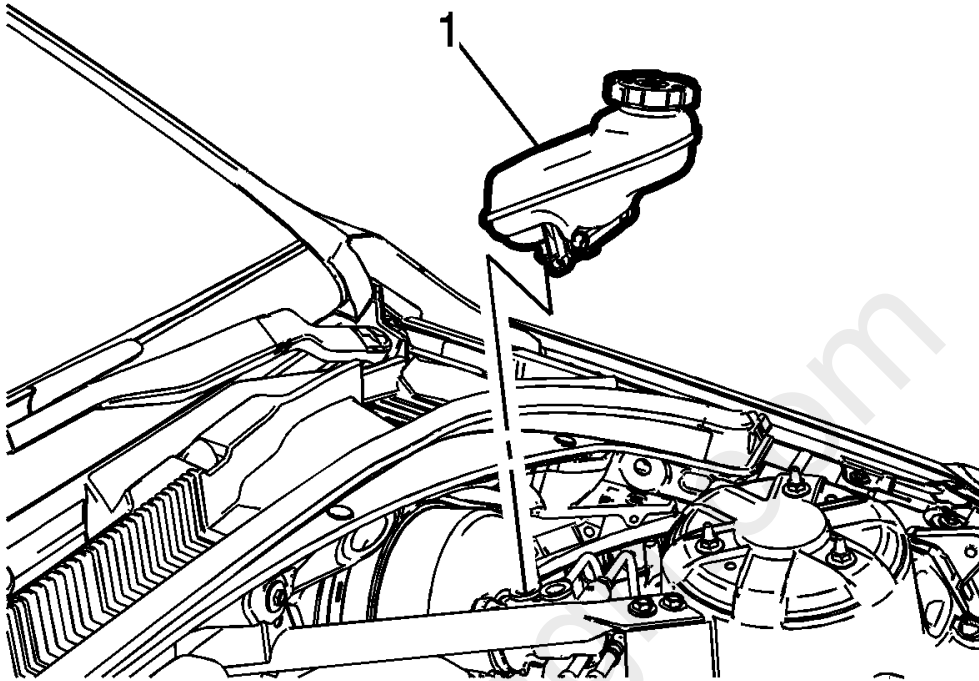


Fig. 11: Master Cylinder Reservoir
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the master cylinder reservoir is fully seated in the master cylinder.

3. Firmly and squarely press the master cylinder reservoir (1) into the master cylinder.

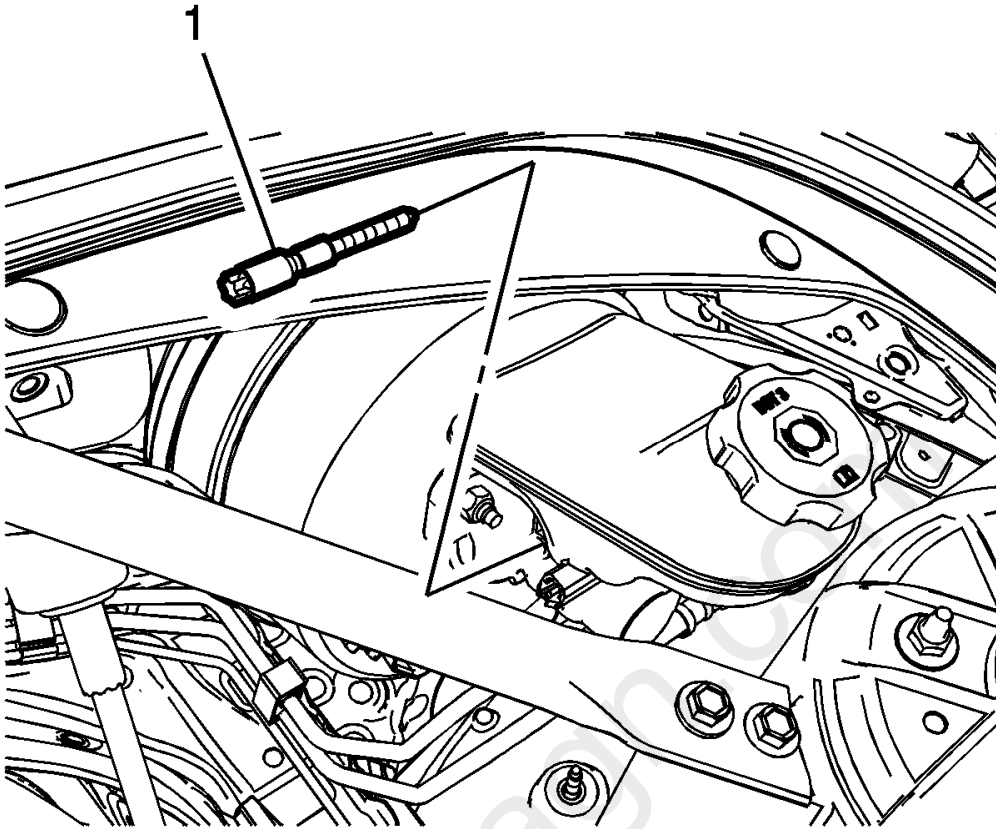


Fig. 12: Master Cylinder Reservoir Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

4. Install the master cylinder reservoir bolt (1) and tighten to 8 (71 lb in).
5. Install the brake fluid level indicator switch. Refer to Brake Fluid Level Indicator Switch Replacement.
6. Fill the master cylinder reservoir. Refer to Master Cylinder Reservoir Filling.

MASTER CYLINDER REPLACEMENT

Removal Procedure

WARNING: Refer to Brake Fluid Irritant Warning .

CAUTION: Refer to Brake Fluid Effects on Paint and Electrical Components Caution .

1. Turn the ignition switch to the OFF position.
2. Apply and release the brake pedal several times until the brake pedal becomes firm to deplete the power vacuum brake booster vacuum reserve.
3. Using a suitable tool, remove and properly dispose of the brake fluid from the master cylinder reservoir.
4. Disconnect the brake fluid level indicator switch electrical connector.

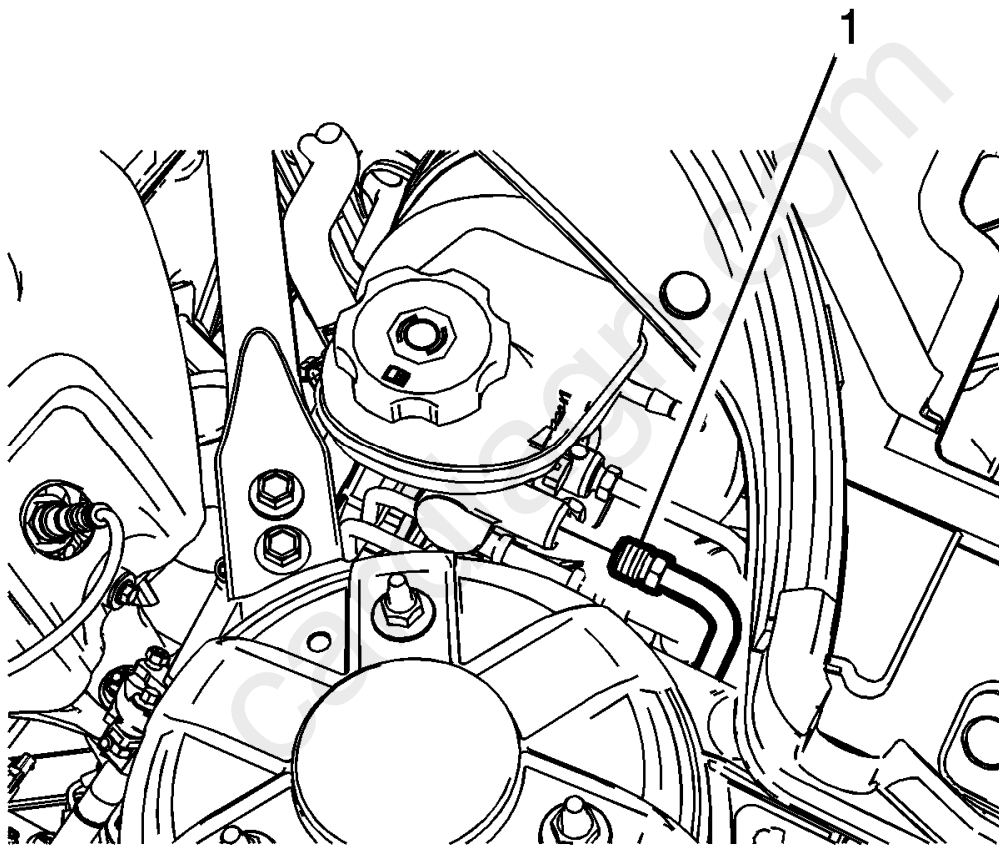


Fig. 13: Brake Pressure Modulator Valve Secondary Brake Pipe Fitting
Courtesy of GENERAL MOTORS COMPANY

5. Disconnect the brake pressure modulator valve secondary brake pipe fitting (1).
6. Cap the brake pipe fitting to prevent brake fluid loss and contamination.

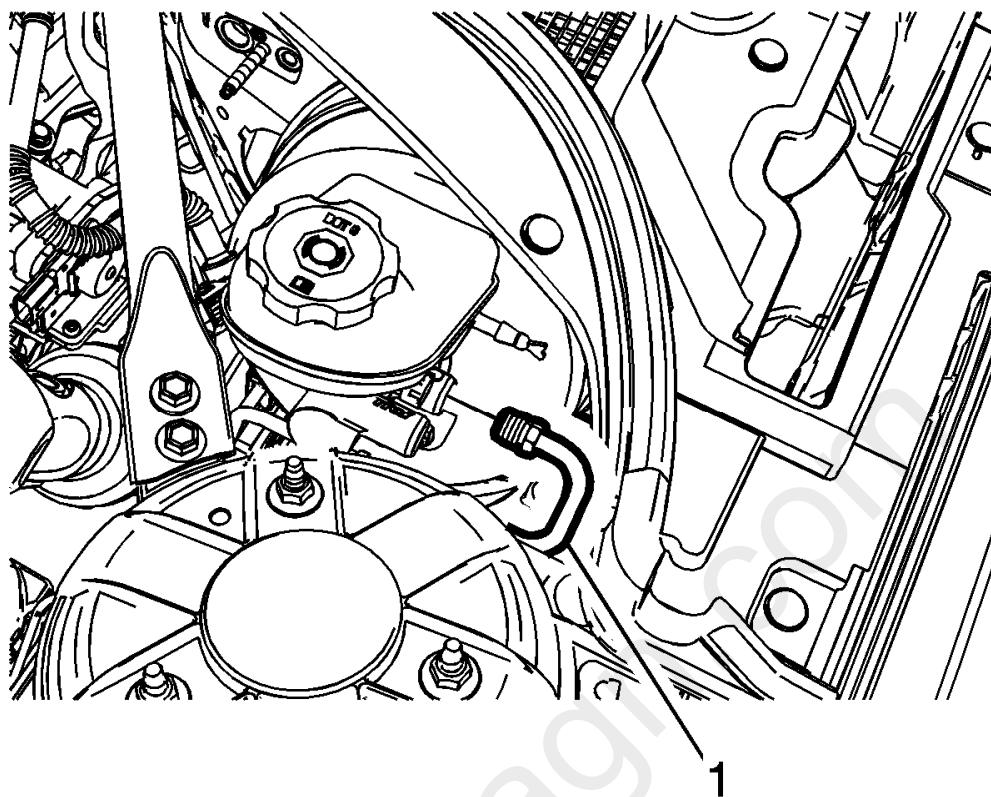


Fig. 14: Brake Pressure Modulator Valve Primary Brake Pipe Fitting
Courtesy of GENERAL MOTORS COMPANY

7. Disconnect the brake pressure modulator valve primary brake pipe fitting (1).
8. Cap the brake pipe fitting to prevent brake fluid loss and contamination.

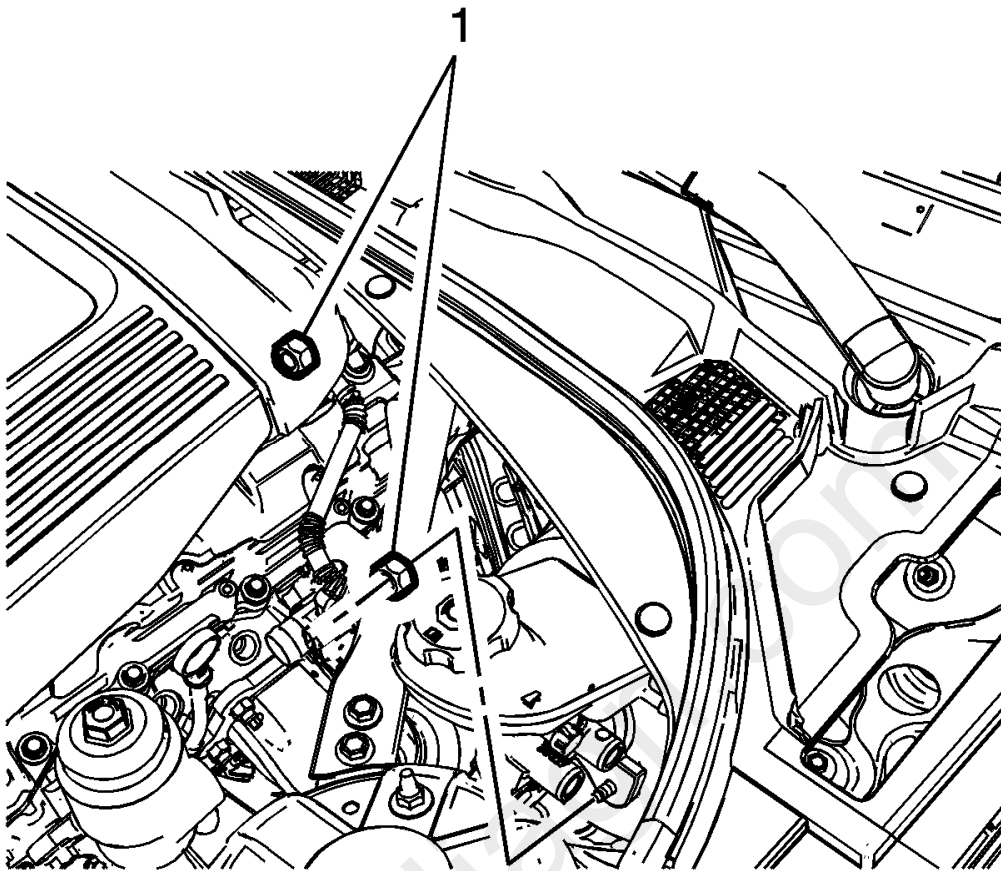


Fig. 15: Master Cylinder Nuts
Courtesy of GENERAL MOTORS COMPANY

NOTE: DO NOT reuse the master cylinder nuts.

9. Remove and discard the master cylinder nuts (1).
10. Remove the master cylinder.

Installation Procedure

1. If installing a new master cylinder, bench bleed the master cylinder. Refer to **Master Cylinder Bench Bleeding**.
2. Install the master cylinder.

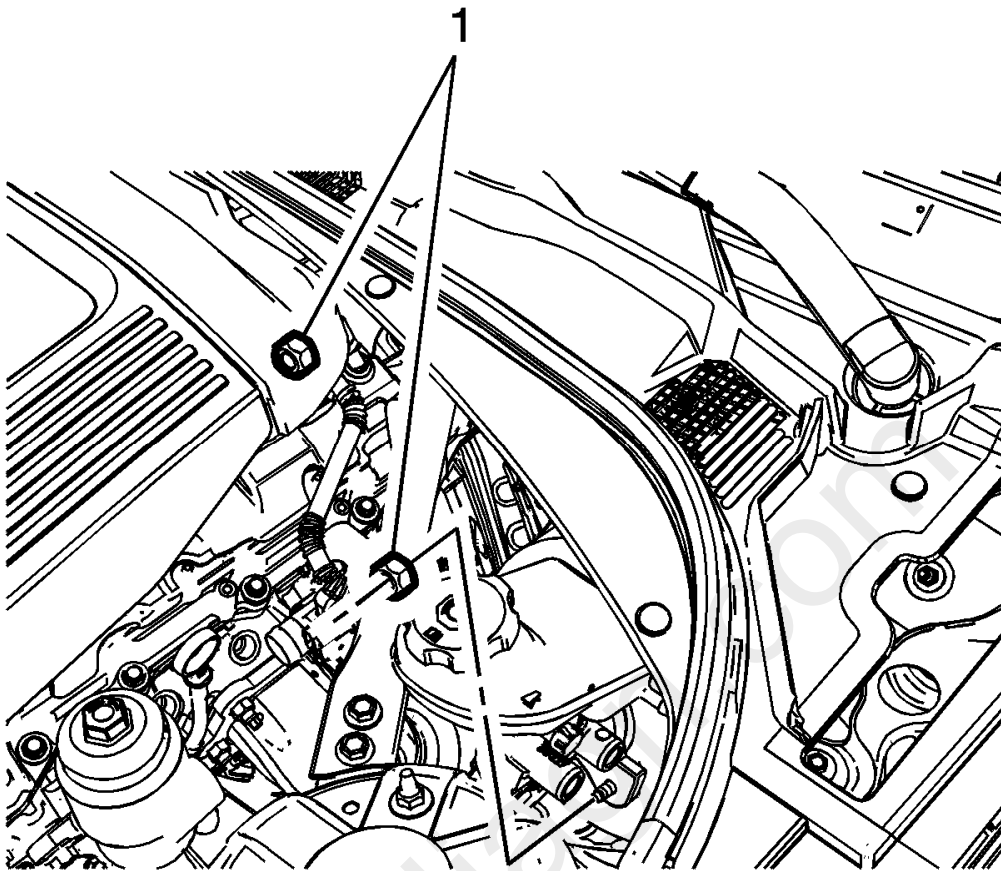


Fig. 16: Master Cylinder Nuts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

NOTE: Install NEW master cylinder nuts.

3. Install new master cylinder nuts (1) and tighten to 23 (17 lb ft).

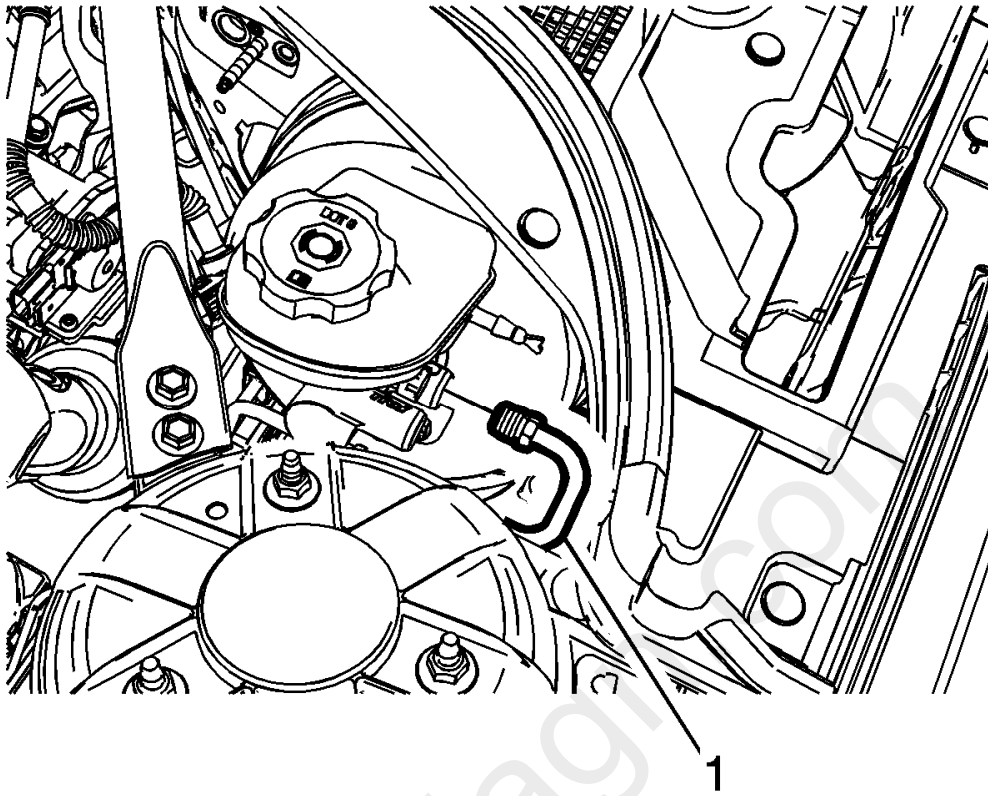


Fig. 17: Brake Pressure Modulator Valve Primary Brake Pipe Fitting
Courtesy of GENERAL MOTORS COMPANY

4. Connect the brake pressure modulator valve primary brake pipe fitting (1) and tighten to 30 (22 lb ft).

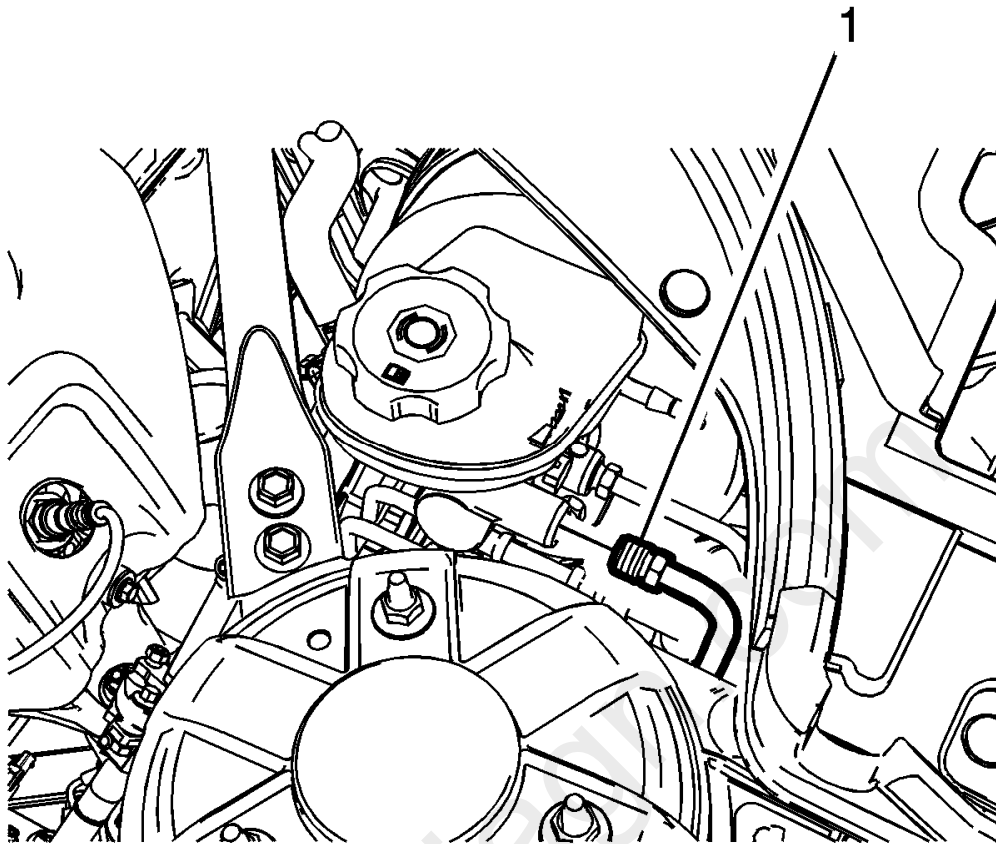


Fig. 18: Brake Pressure Modulator Valve Secondary Brake Pipe Fitting
Courtesy of GENERAL MOTORS COMPANY

5. Connect the brake pressure modulator valve secondary brake pipe fitting (1) and tighten to 30 (22 lb ft).
6. Connect the brake fluid level indicator switch electrical connector.
7. Bleed the hydraulic brake system. Refer to **Hydraulic Brake System Bleeding (Manual)**, **Hydraulic Brake System Bleeding (Pressure)**.

MASTER CYLINDER BENCH BLEEDING

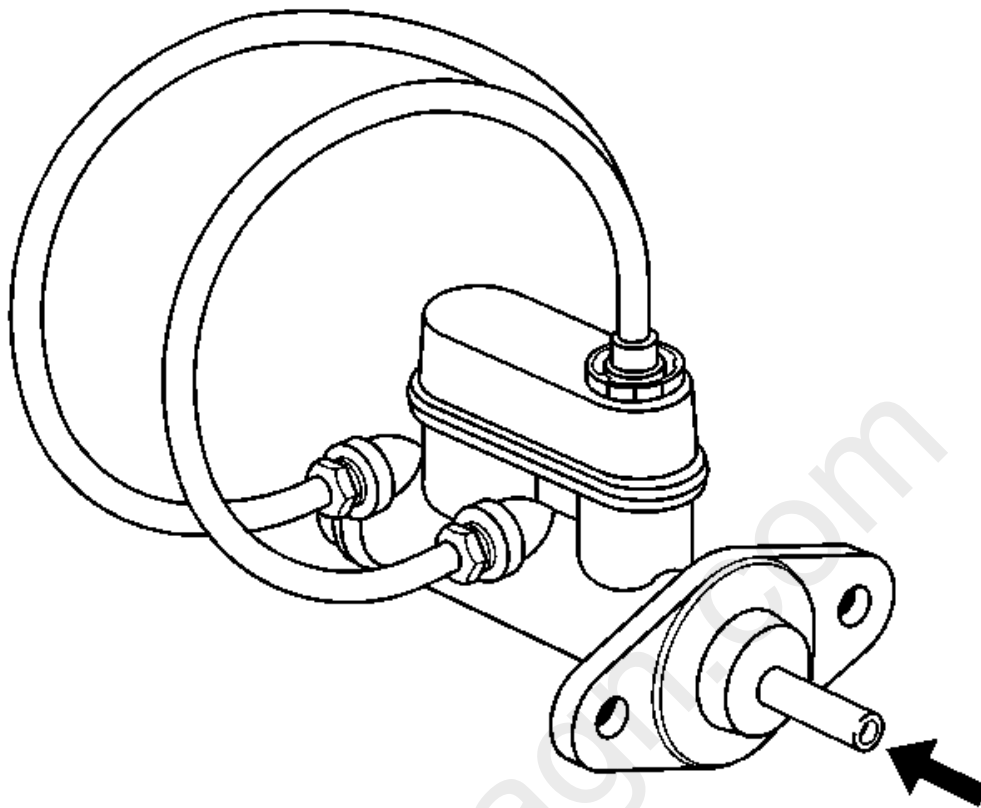


Fig. 19: Bleeding Master Cylinder
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Brake Fluid Irritant Warning .

CAUTION: Refer to Brake Fluid Effects on Paint and Electrical Components Caution .

1. Secure the mounting flange of the brake master cylinder in a bench vise so that the rear of the primary piston is accessible.
2. Remove the master cylinder reservoir cap and diaphragm.
3. Install suitable fittings to the master cylinder ports that match the type of flare seat required and also provide for hose attachment.
4. Install transparent hoses to the fittings installed to the master cylinder ports, then route the hoses into the master cylinder reservoir.

5. Fill the master cylinder reservoir to at least the half-way point with GM approved brake fluid from a clean, sealed brake fluid container. Refer to **Master Cylinder Reservoir Filling**.
6. Ensure that the ends of the transparent hoses running into the master cylinder reservoir are fully submerged in the brake fluid.
7. Using a smooth, round-ended tool, depress and release the primary piston as far as it will travel, a depth of about 25 mm (1 in), several times. Observe the flow of fluid coming from the ports.

As air is bled from the primary and secondary pistons, the effort required to depress the primary piston will increase and the amount of travel will decrease.

8. Continue to depress and release the primary piston until fluid flows freely from the ports with no evidence of air bubbles.
9. Remove the transparent hoses from the master cylinder reservoir.
10. Install the master cylinder reservoir cap and diaphragm.
11. Remove the fittings with the transparent hoses from the master cylinder ports. Wrap the master cylinder with a clean shop cloth to prevent brake fluid spills.
12. Remove the master cylinder from the vise.

BRAKE FLUID LEVEL INDICATOR SWITCH REPLACEMENT

Removal Procedure

1. Disconnect the brake fluid level indicator switch electrical connector.

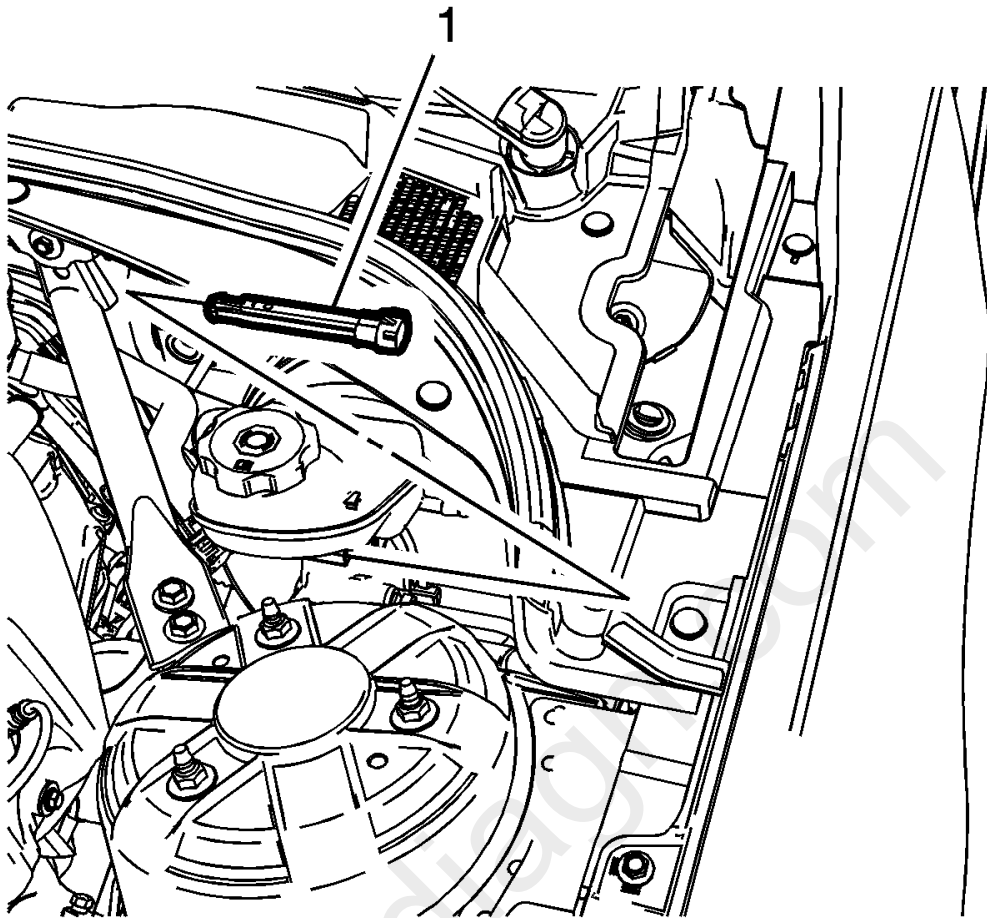


Fig. 20: Brake Fluid Level Indicator Switch
Courtesy of GENERAL MOTORS COMPANY

2. Compress the locking tabs on the inboard side of the master cylinder reservoir and remove the brake fluid level indicator switch (1).

Installation Procedure

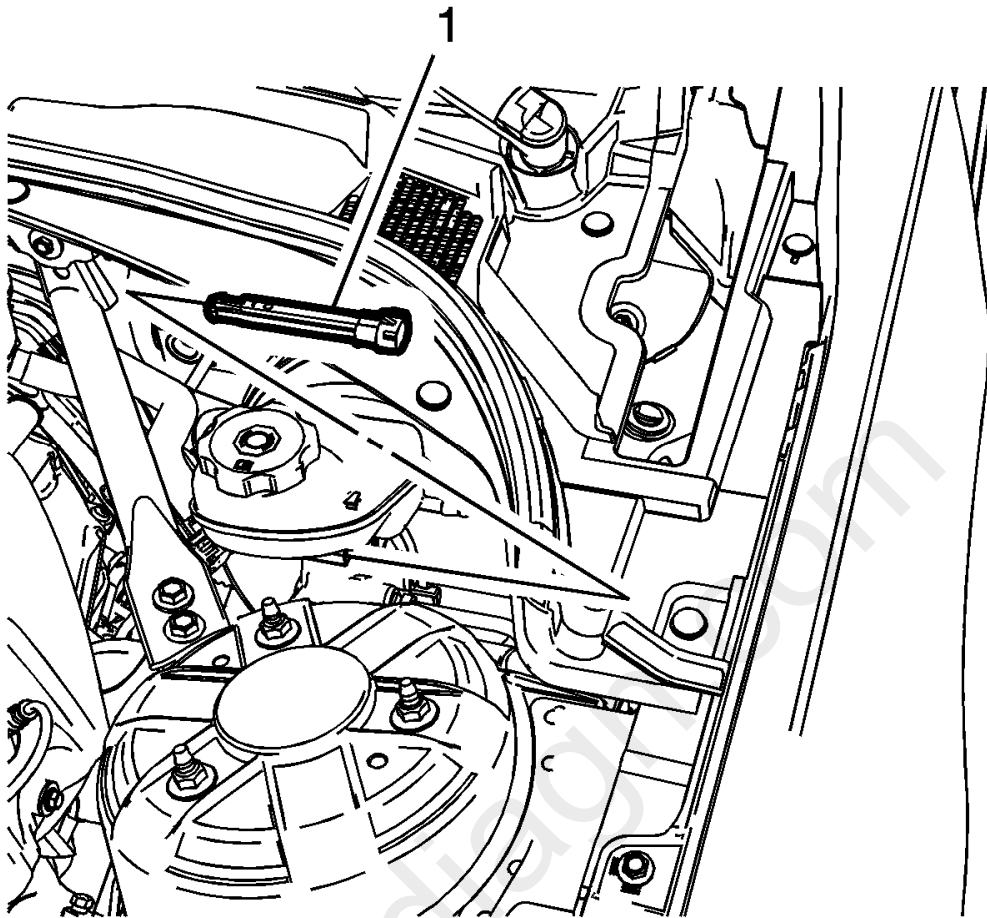


Fig. 21: Brake Fluid Level Indicator Switch
Courtesy of GENERAL MOTORS COMPANY

1. Install the brake fluid level indicator switch (1).
2. Ensure the locking tabs of the brake fluid level indicator switch are fully engaged in the master cylinder reservoir.
3. Connect the brake fluid level indicator switch electrical connector.

BRAKE PEDAL ASSEMBLY REPLACEMENT

Removal Procedure

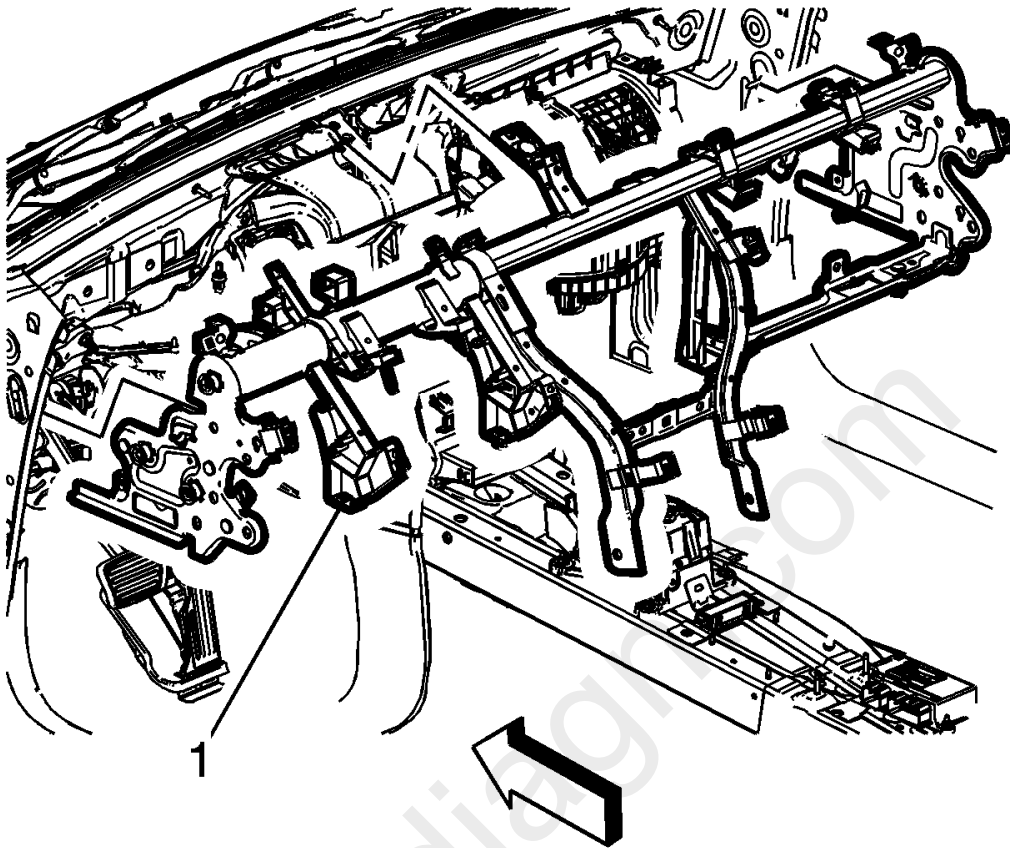


Fig. 22: Instrument Panel Tie Bar
Courtesy of GENERAL MOTORS COMPANY

1. Remove the instrument panel tie bar (1). Refer to **Instrument Panel Tie Bar Replacement** .

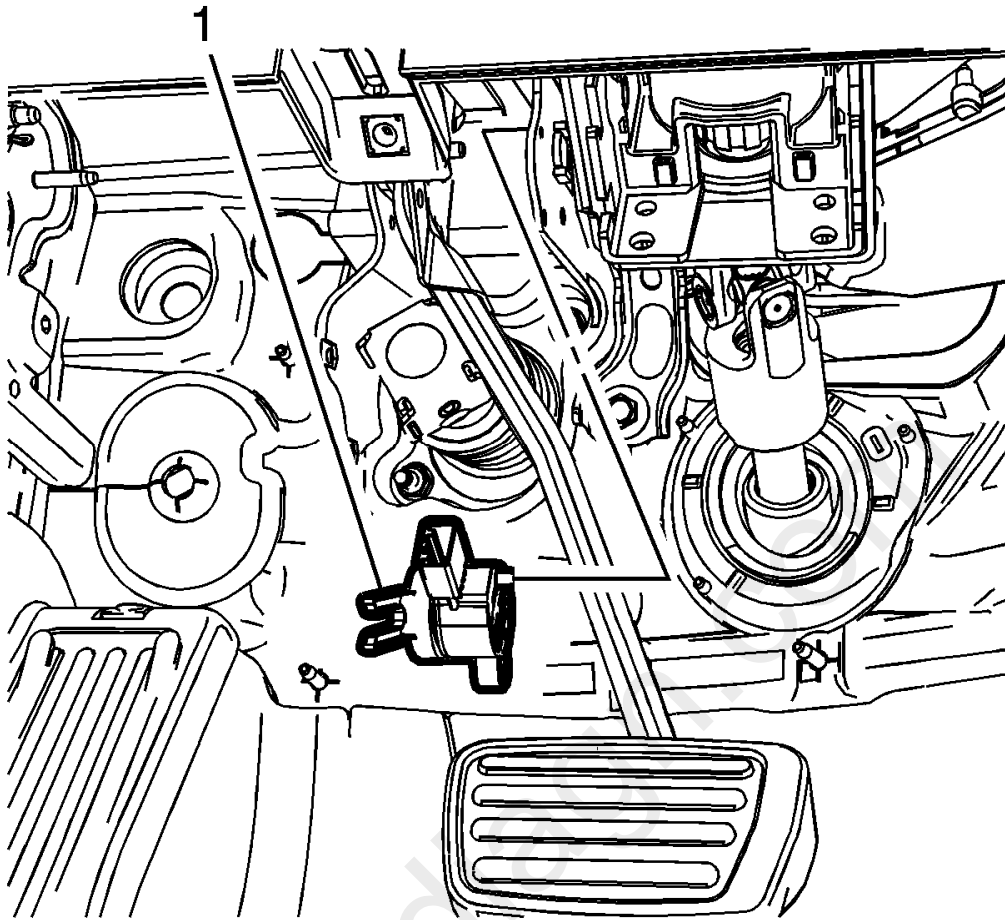


Fig. 23: Brake Pedal Position Sensor
Courtesy of GENERAL MOTORS COMPANY

2. Remove the brake pedal position sensor (1). Refer to **Brake Pedal Position Sensor Replacement** .

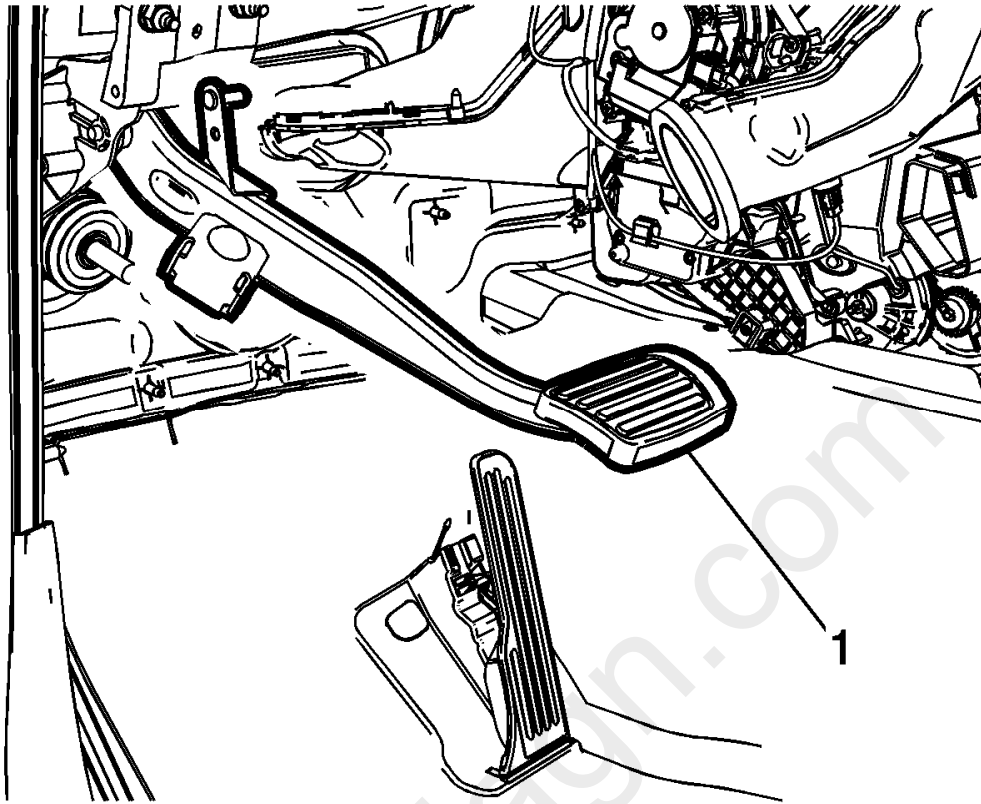


Fig. 24: Brake Pedal

Courtesy of GENERAL MOTORS COMPANY

3. Pull the brake pedal (1) rearward to release the power vacuum brake booster pushrod retainer.

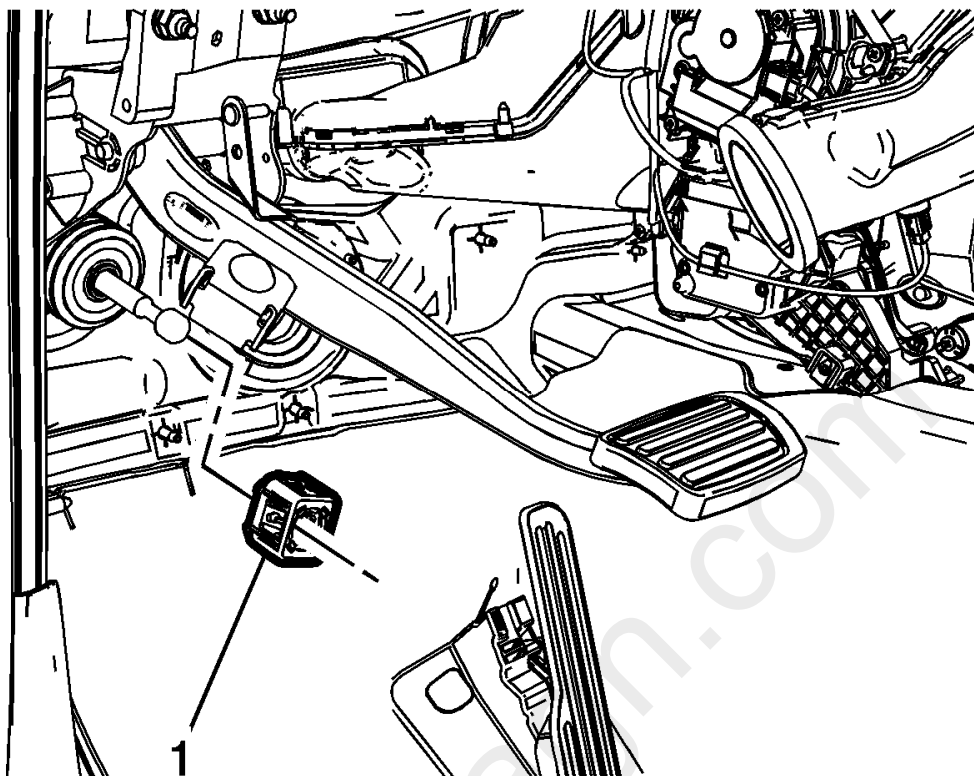


Fig. 25: Power Vacuum Brake Booster Pushrod Retainer
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not reuse the power vacuum brake booster pushrod retainer.

4. Remove and discard the power vacuum brake booster pushrod retainer (1).

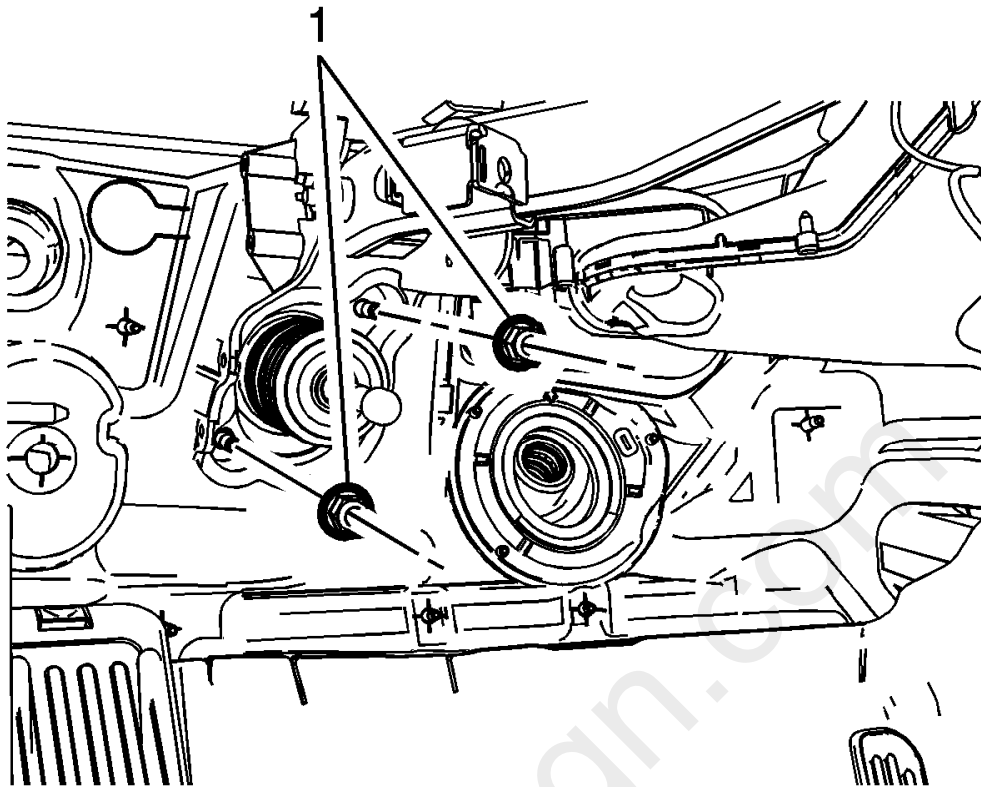


Fig. 26: Power Vacuum Brake Booster Nuts
Courtesy of GENERAL MOTORS COMPANY

5. Remove the power vacuum brake booster nuts (1).

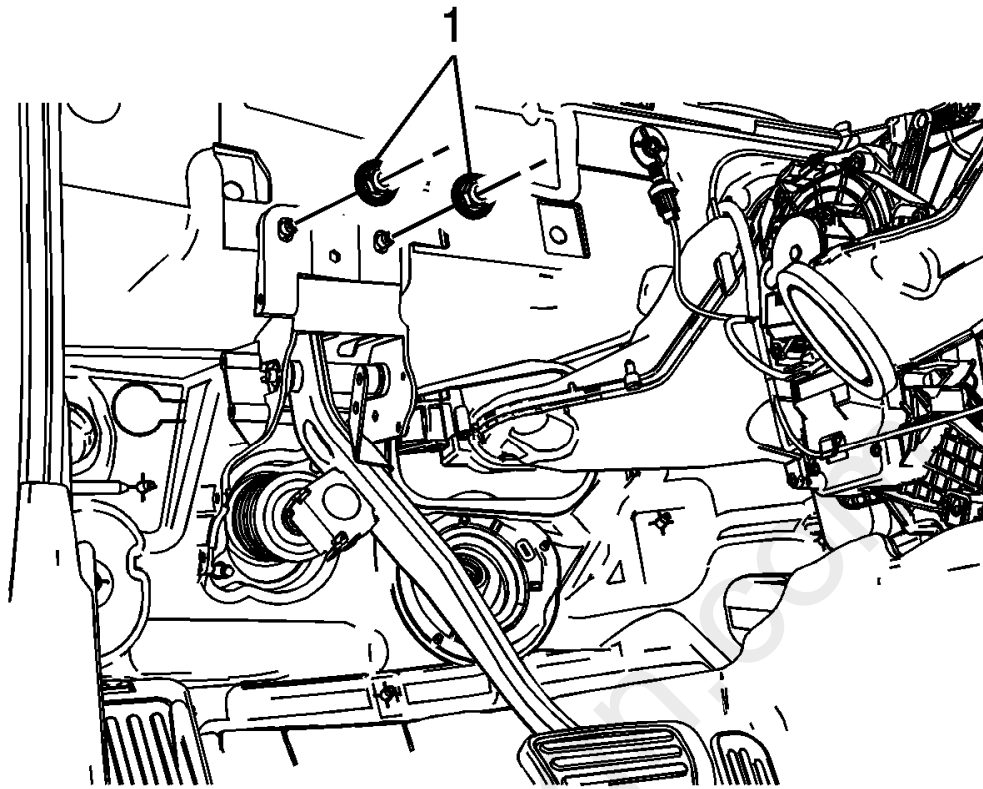


Fig. 27: Brake Pedal Assembly Nuts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the brake pedal assembly nuts (1).
7. Remove the brake pedal assembly.

Installation Procedure

1. Install the brake pedal assembly.

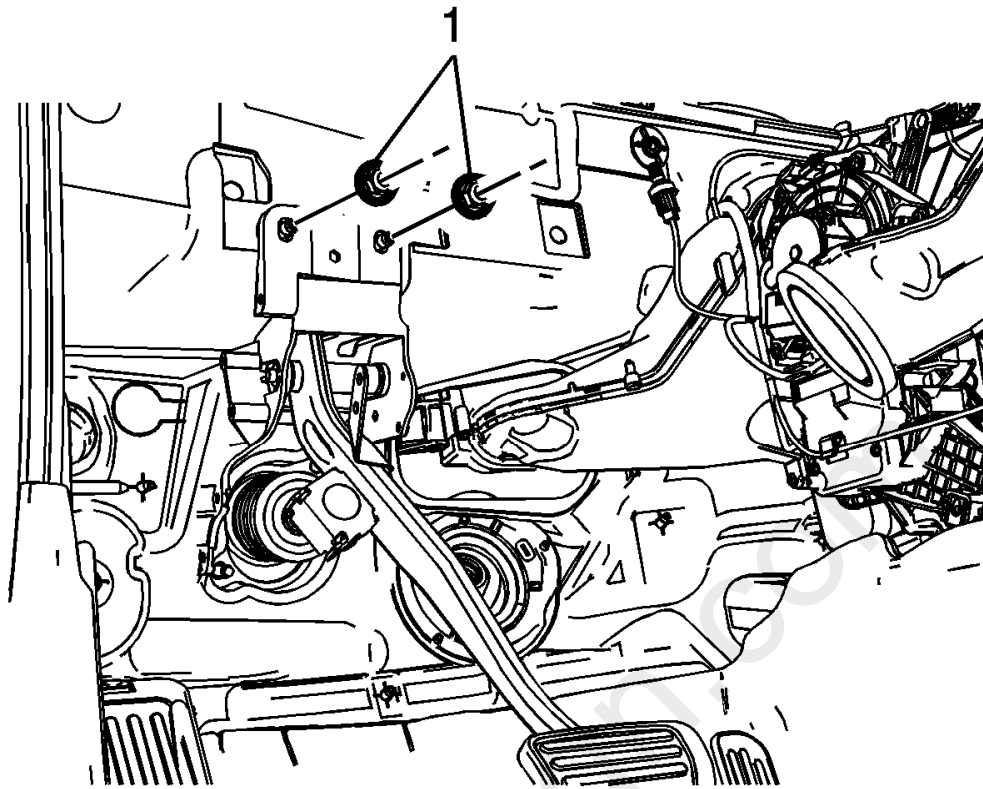


Fig. 28: Brake Pedal Assembly Nuts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install the brake pedal assembly nuts (1) and tighten to 25 (18 lb ft).

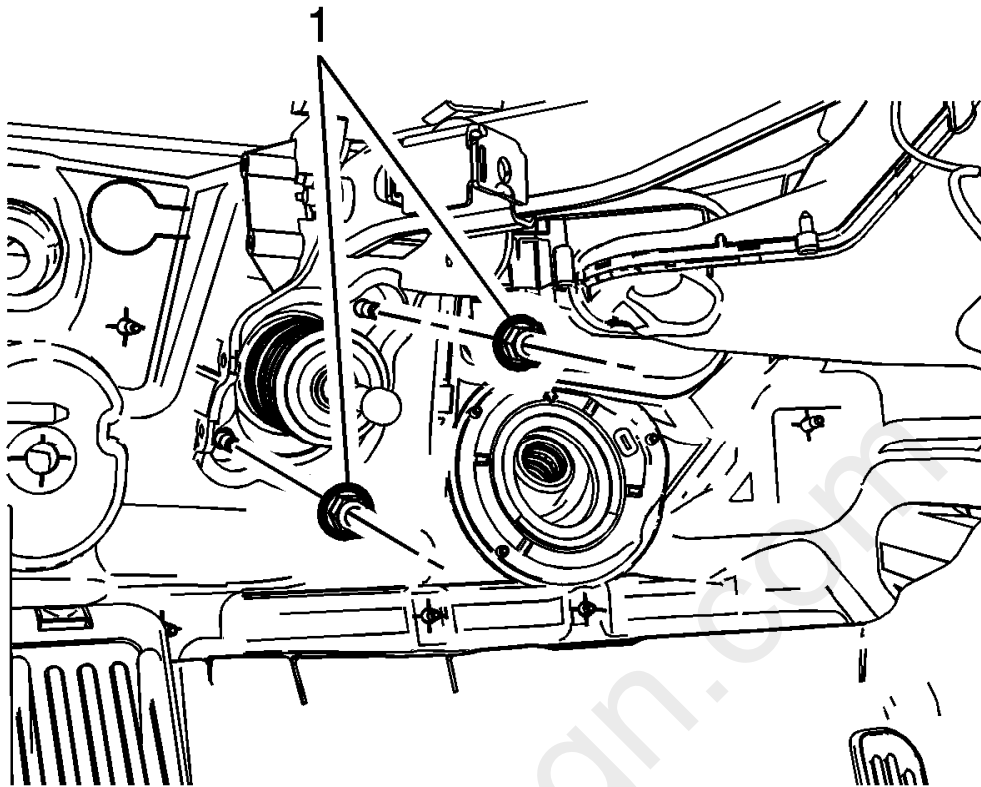


Fig. 29: Power Vacuum Brake Booster Nuts
Courtesy of GENERAL MOTORS COMPANY

3. Install the power vacuum brake booster nuts (1) and tighten to 25 (18 lb ft).

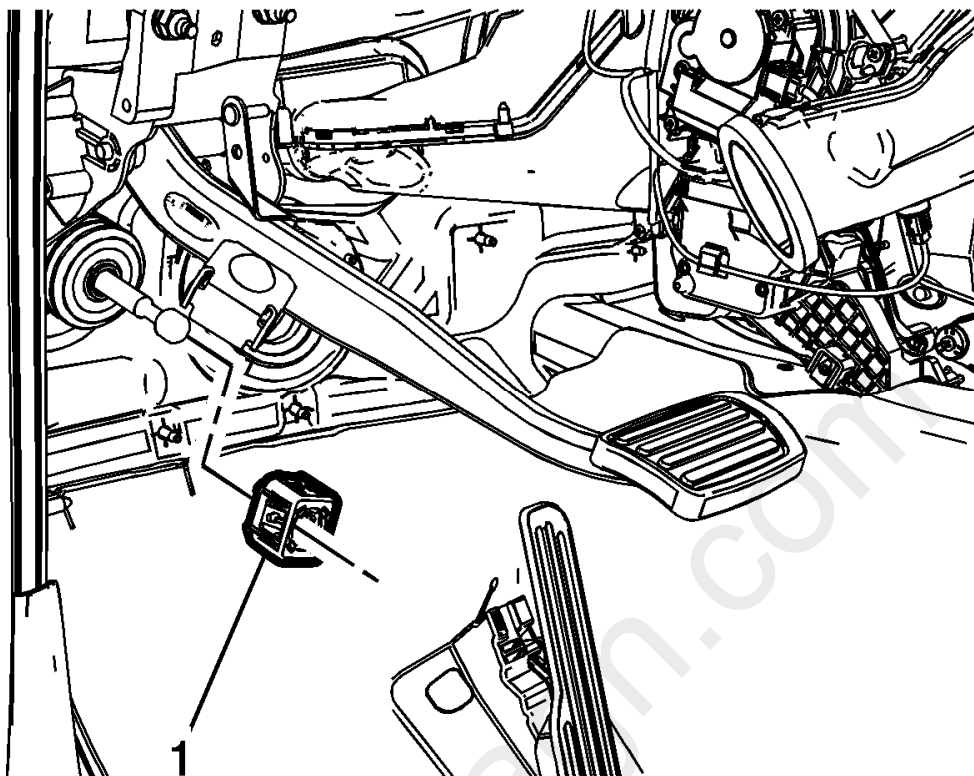


Fig. 30: Power Vacuum Brake Booster Pushrod Retainer
Courtesy of GENERAL MOTORS COMPANY

NOTE: Install a new power vacuum brake booster pushrod retainer.

4. Install a new power vacuum brake booster pushrod retainer (1) to the brake pedal.

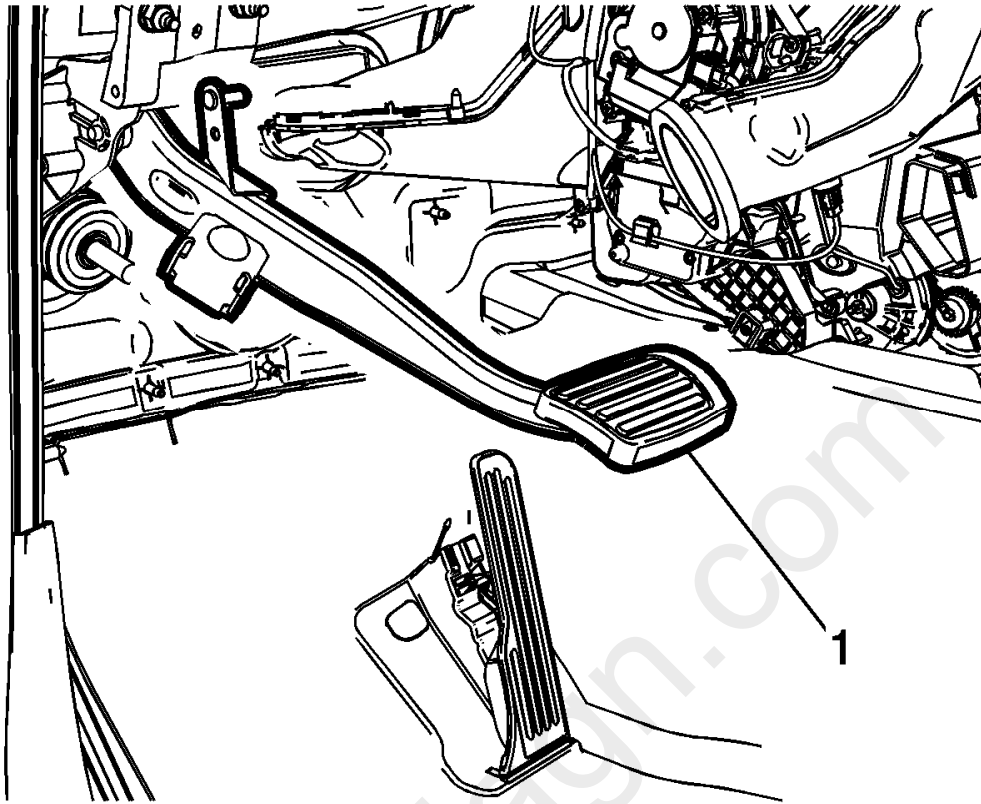


Fig. 31: Brake Pedal

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the power vacuum brake booster pushrod retainer is fully seated in the brake pedal arm.

5. Install the brake pedal (1) to the power vacuum brake booster pushrod.

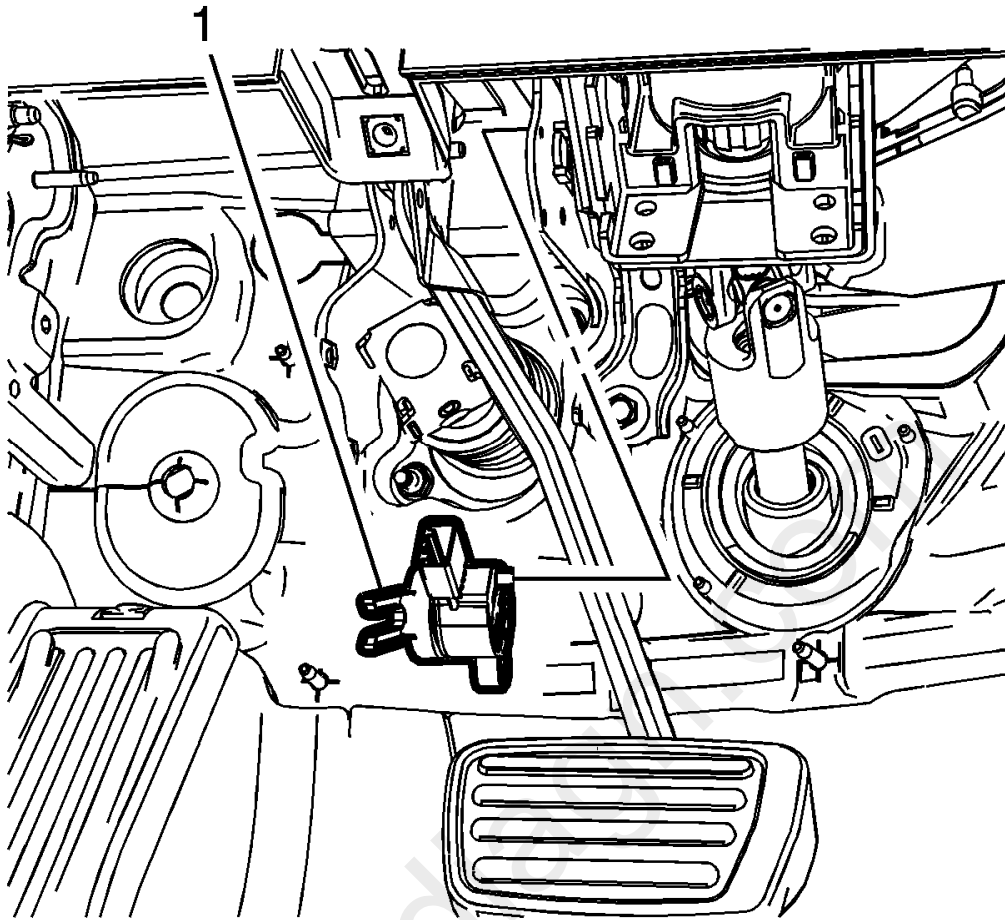


Fig. 32: Brake Pedal Position Sensor
Courtesy of GENERAL MOTORS COMPANY

6. Install the brake pedal position sensor (1). Refer to **Brake Pedal Position Sensor Replacement** .

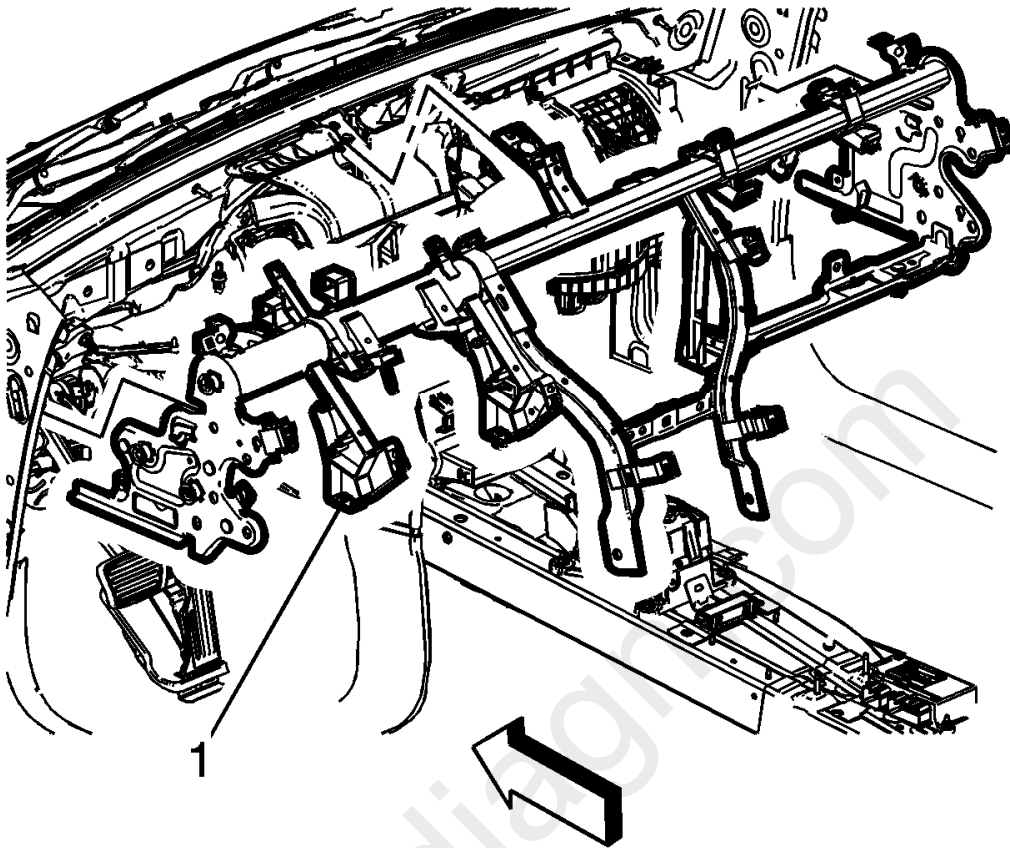


Fig. 33: Instrument Panel Tie Bar
Courtesy of GENERAL MOTORS COMPANY

7. Install the instrument panel tie bar (1). Refer to **Instrument Panel Tie Bar Replacement** .

BRAKE PRESSURE MODULATOR VALVE PRIMARY PIPE REPLACEMENT

Removal Procedure

WARNING: Refer to **Brake Fluid Irritant Warning** .

CAUTION: Refer to **Brake Fluid Effects on Paint and Electrical Components Caution** .

1. Remove the plenum front panel. Refer to **Plenum Front Panel Replacement** .
2. If equipped with the 2.0L or 2.5L engine, remove the outer fuel pump insulator. Refer to **Fuel Pump**

Insulator Replacement (Inner) , Fuel Pump Insulator Replacement (Outer) .

3. If equipped with the 3.6L engine, remove the intake manifold insulator. Refer to **Intake Manifold Insulator Replacement** .
4. Disconnect the heater inlet pipe from the heater core only. Refer to **Heater Inlet Hose Replacement (LTG)** , **Heater Inlet Hose Replacement (LFX)** , **Heater Inlet Hose Replacement (LF3)** .
5. Disconnect the heater outlet pipe from the heater core only. Refer to **Heater Outlet Hose Replacement (LTG)** , **Heater Outlet Hose Replacement (LFX)** , **Heater Outlet Hose Replacement (LF3)** .
6. Without removing the steering shafts from the vehicle, separate the upper intermediate steering shaft from the mid intermediate steering shaft. Refer to **Upper Intermediate Steering Shaft Replacement (AWD)** , **Upper Intermediate Steering Shaft Replacement (RWD)** .
7. Using a suitable tool, remove and properly dispose of the brake fluid from the master cylinder reservoir.

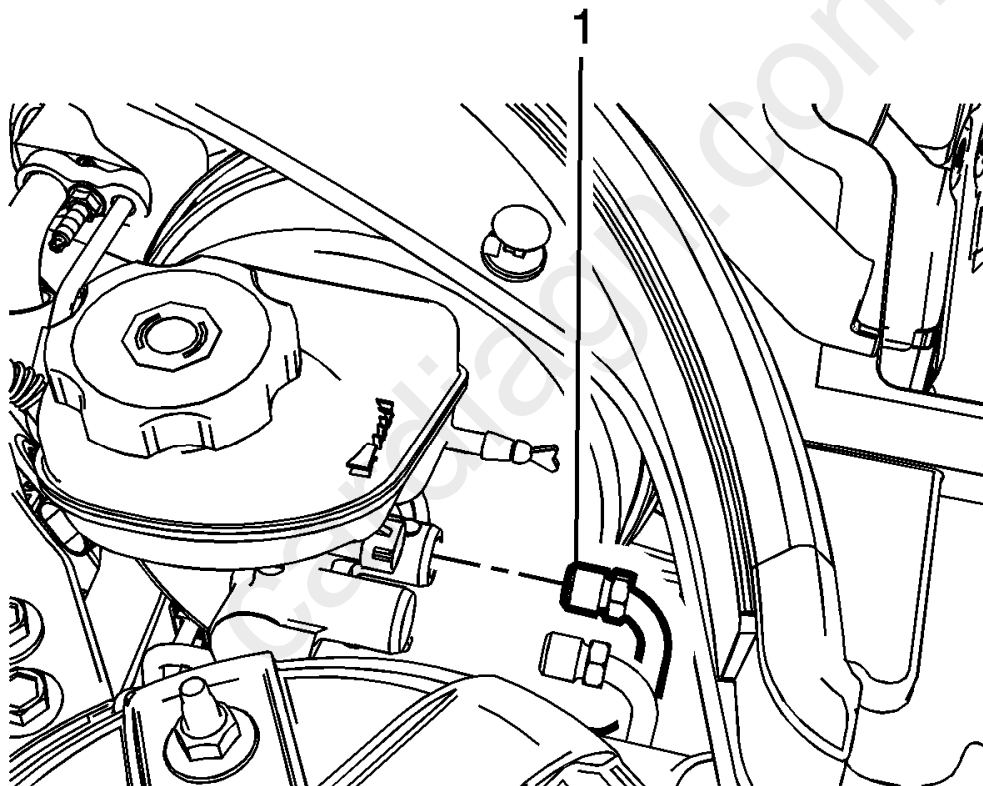


Fig. 34: Brake Pressure Modulator Valve Primary Brake Pipe Fitting
Courtesy of GENERAL MOTORS COMPANY

8. Disconnect the brake pressure modulator valve primary brake pipe fitting (1) at the master cylinder.
9. Plug the master cylinder outlet port to prevent brake fluid loss and contamination.

10. Remove the air conditioning evaporator hose assembly. Refer to **Air Conditioning Evaporator Hose Assembly Replacement (LF3, LFX)** , **Air Conditioning Evaporator Hose Assembly Replacement (LTG)** .

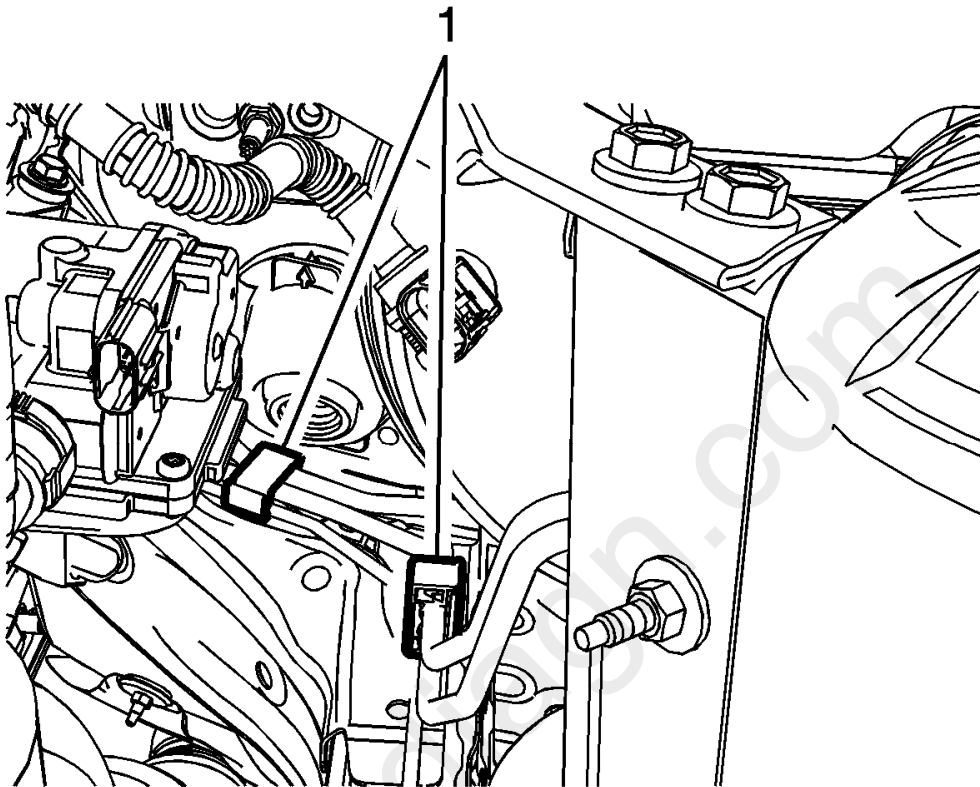


Fig. 35: Brake Pipe Retaining Clips
Courtesy of GENERAL MOTORS COMPANY

11. Release the brake pipe from the retaining clips (1).

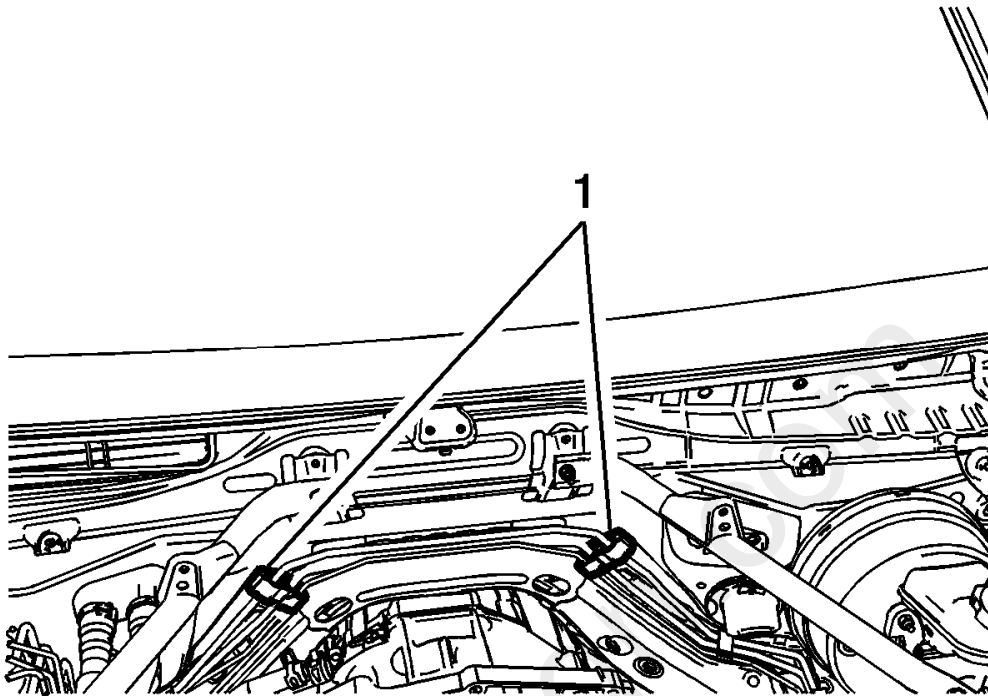


Fig. 36: Brake Pipe Clips At Cowl
Courtesy of GENERAL MOTORS COMPANY

12. Release the brake pipe from the retaining clips (1) on the cowl.

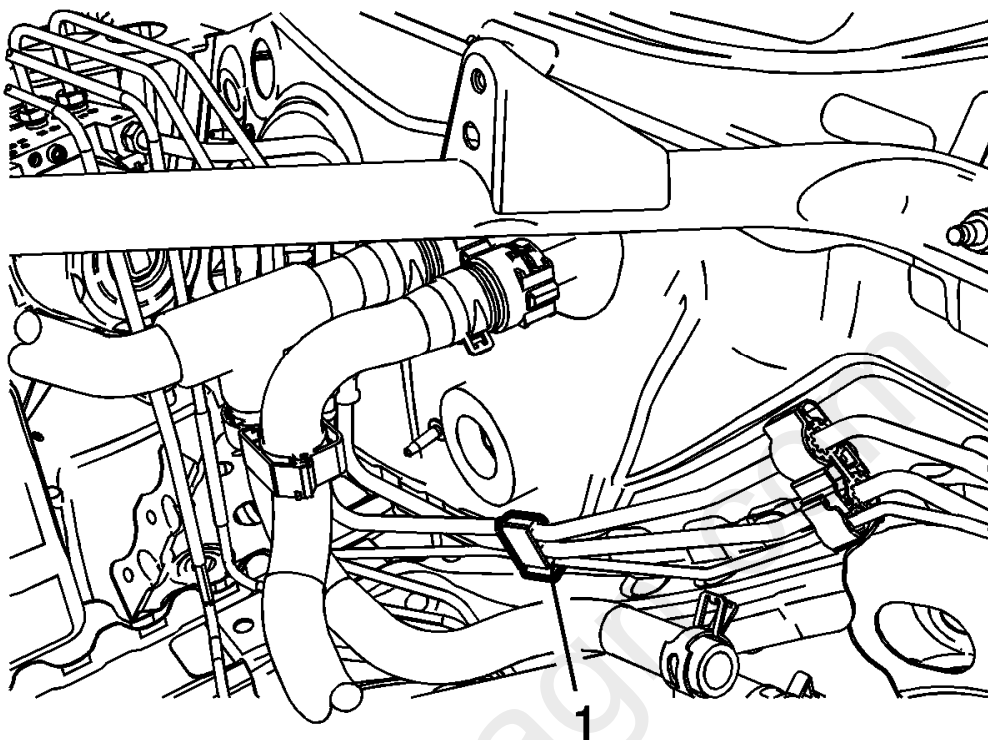


Fig. 37: Brake Pipe Retaining Clips
Courtesy of GENERAL MOTORS COMPANY

13. Release the brake pipe from the retaining clip (1).

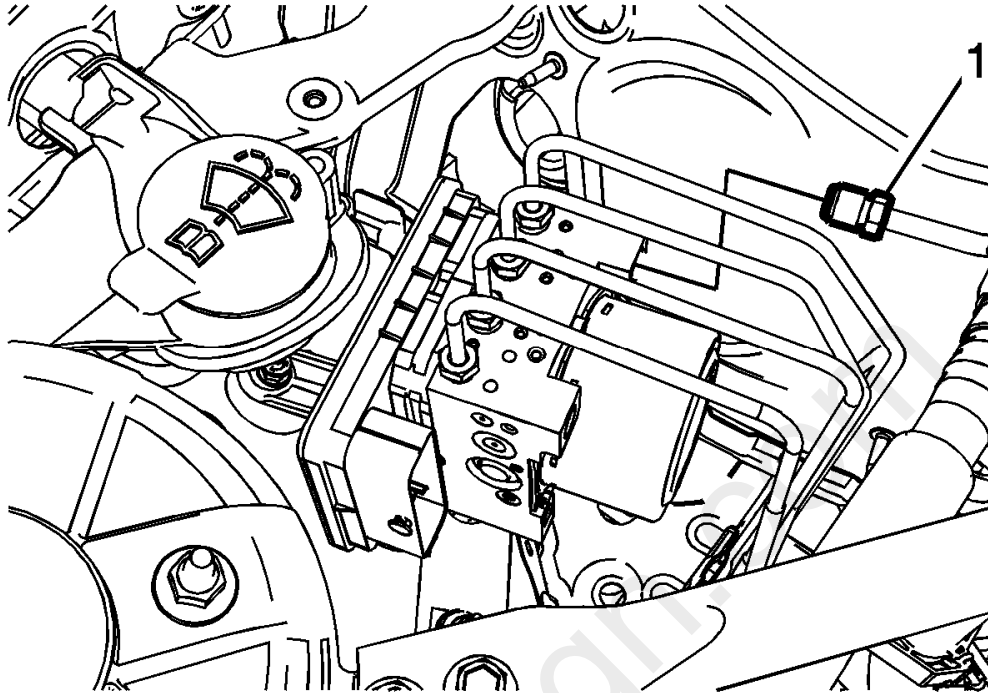


Fig. 38: Brake Pressure Modulator Valve Primary Brake Pipe Fitting
Courtesy of GENERAL MOTORS COMPANY

14. Disconnect the brake pressure modulator valve primary brake pipe fitting (1) at the brake pressure modulator valve (BPMV).
15. Plug the BPMV inlet port to prevent brake fluid loss and contamination.
16. Remove the brake pressure modulator valve primary brake pipe.

Installation Procedure

1. Install the brake pressure modulator valve primary brake pipe.

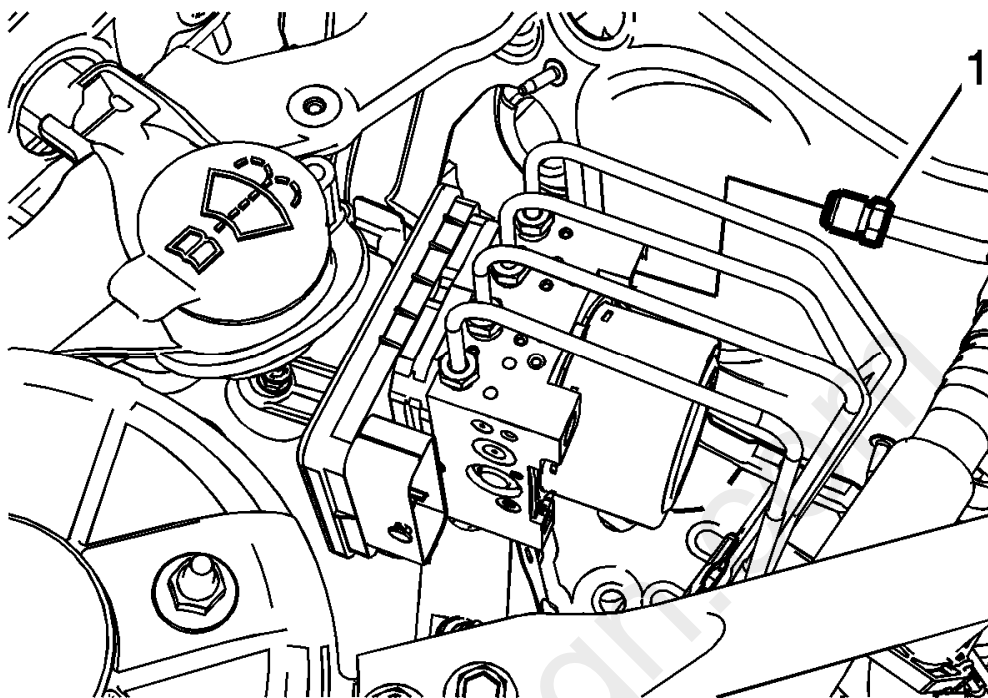


Fig. 39: Brake Pressure Modulator Valve Primary Brake Pipe Fitting
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Connect the brake pressure modulator valve primary brake pipe fitting (1) at the BPMV and tighten the fitting to 32 (24 lb ft).

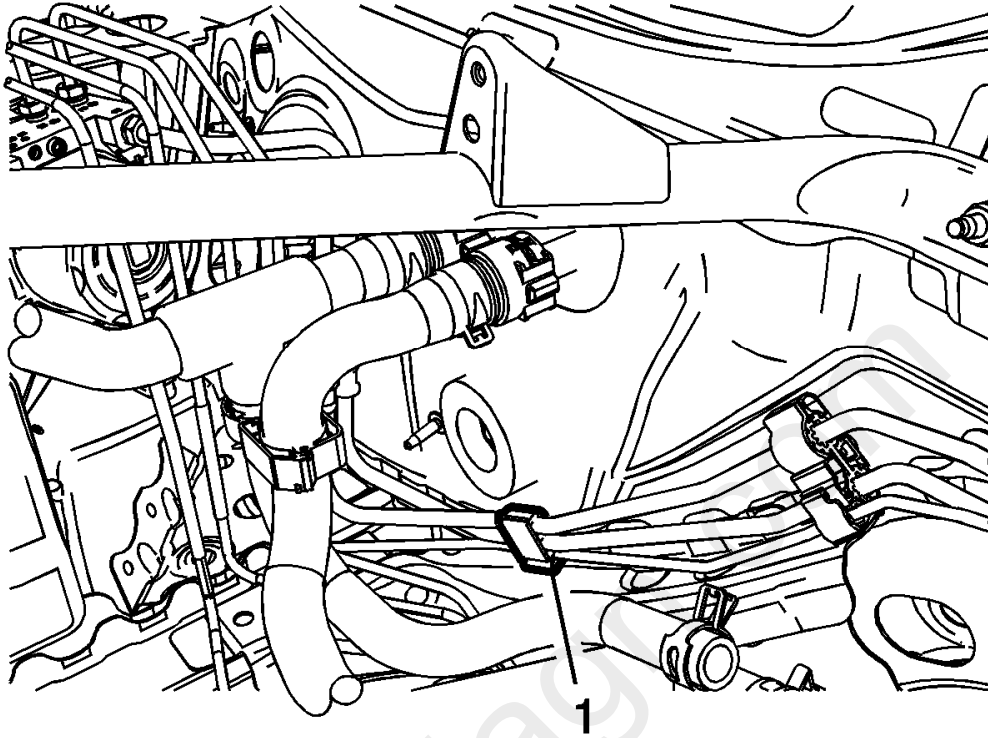


Fig. 40: Brake Pipe Retaining Clips
Courtesy of GENERAL MOTORS COMPANY

3. Secure the brake pipe to the retaining clip (1).

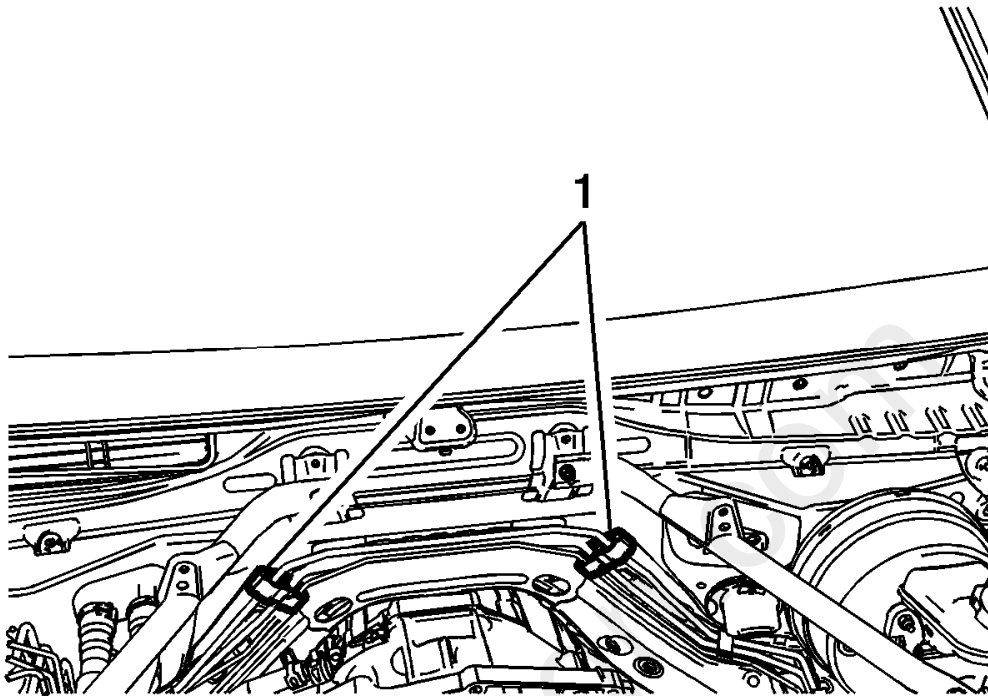


Fig. 41: Brake Pipe Clips At Cowl
Courtesy of GENERAL MOTORS COMPANY

4. Secure the brake pipe to the retaining clips (1) on the cowl.

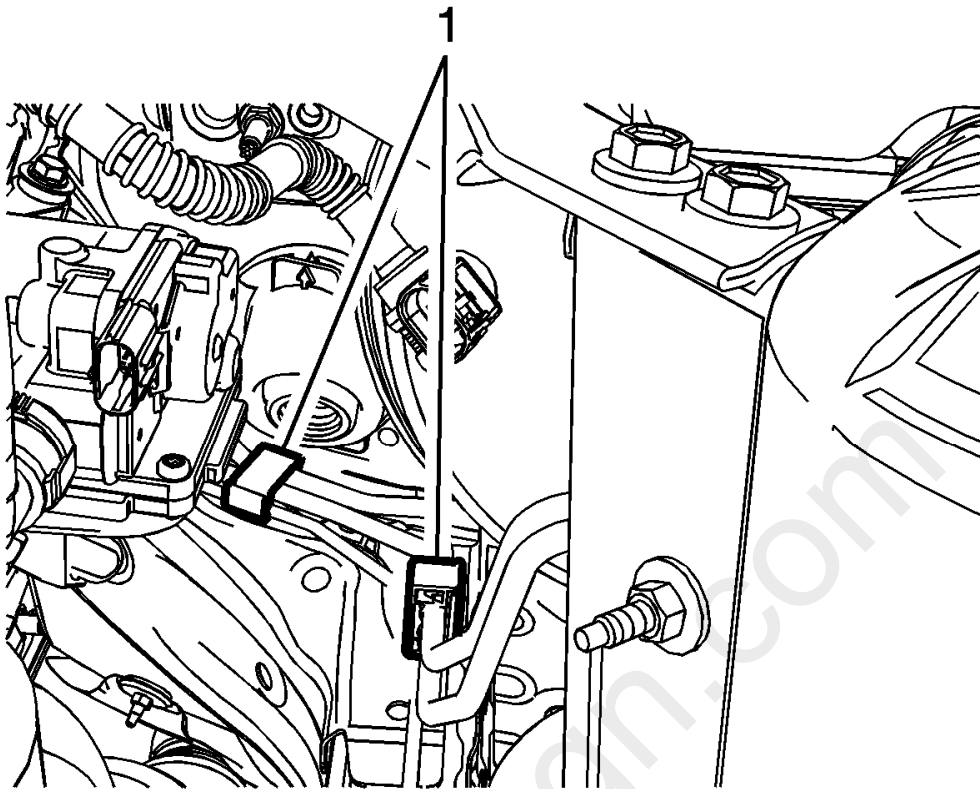


Fig. 42: Brake Pipe Retaining Clips
Courtesy of GENERAL MOTORS COMPANY

5. Secure the brake pipe to the retaining clips (1).
6. Install the air conditioning evaporator hose assembly. Refer to **Air Conditioning Evaporator Hose Assembly Replacement (LF3, LFX)** , **Air Conditioning Evaporator Hose Assembly Replacement (LTG)** .

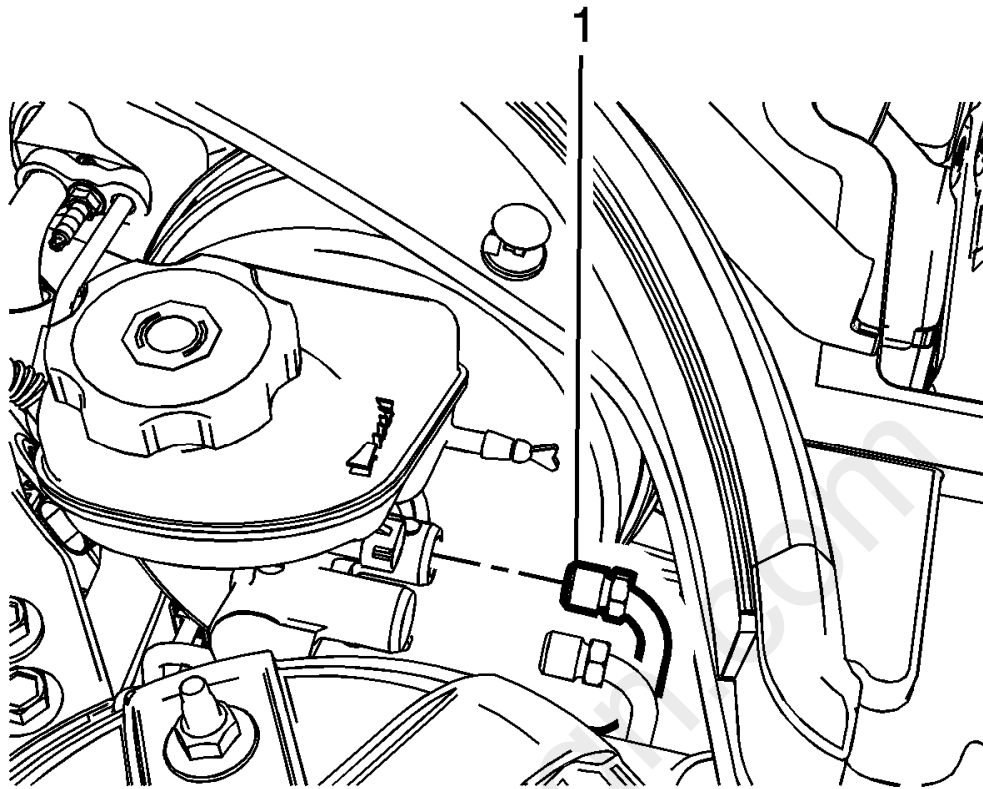


Fig. 43: Brake Pressure Modulator Valve Primary Brake Pipe Fitting
 Courtesy of GENERAL MOTORS COMPANY

7. Connect the brake pressure modulator valve primary brake pipe fitting (1) at the master cylinder and tighten the fitting to 30 (22 lb ft).
8. Install the upper intermediate steering shaft to the mid intermediate steering shaft. Refer to **Upper Intermediate Steering Shaft Replacement (AWD)** , **Upper Intermediate Steering Shaft Replacement (RWD)** .
9. Connect the heater outlet pipe to the heater core. Refer to **Heater Outlet Hose Replacement (LTG)** , **Heater Outlet Hose Replacement (LFX)** , **Heater Outlet Hose Replacement (LF3)** .
10. Connect the heater inlet pipe to the heater core. Refer to **Heater Inlet Hose Replacement (LTG)** , **Heater Inlet Hose Replacement (LFX)** , **Heater Inlet Hose Replacement (LF3)** .
11. If equipped with the 3.6L engine, install the intake manifold insulator. Refer to **Intake Manifold Insulator Replacement** .
12. If equipped with the 2.0L or 2.5L engine, install the outer fuel pump insulator. Refer to **Fuel Pump Insulator Replacement (Inner)** , **Fuel Pump Insulator Replacement (Outer)** .
13. Install the plenum front panel. Refer to **Plenum Front Panel Replacement** .

14. Bleed the hydraulic brake system. Refer to Hydraulic Brake System Bleeding (Manual), Hydraulic Brake System Bleeding (Pressure).

BRAKE PRESSURE MODULATOR VALVE SECONDARY PIPE REPLACEMENT

Removal Procedure

WARNING: Refer to Brake Fluid Irritant Warning .

CAUTION: Refer to Brake Fluid Effects on Paint and Electrical Components Caution .

1. Remove the plenum front panel. Refer to Plenum Front Panel Replacement .
2. If equipped with the 2.0L or 2.5L engine, remove the outer fuel pump insulator. Refer to Fuel Pump Insulator Replacement (Inner) , Fuel Pump Insulator Replacement (Outer) .
3. If equipped with the 3.6L engine, remove the intake manifold insulator. Refer to Intake Manifold Insulator Replacement .
4. Disconnect the heater inlet pipe from only the heater core. Refer to Heater Inlet Hose Replacement (LTG) , Heater Inlet Hose Replacement (LFX) , Heater Inlet Hose Replacement (LF3) .
5. Disconnect the heater outlet pipe from only the heater core. Refer to Heater Outlet Hose Replacement (LTG) , Heater Outlet Hose Replacement (LFX) , Heater Outlet Hose Replacement (LF3) .
6. Without removing the steering shafts from the vehicle, separate the upper intermediate steering shaft from the mid intermediate steering shaft. Refer to Upper Intermediate Steering Shaft Replacement (AWD) , Upper Intermediate Steering Shaft Replacement (RWD) .
7. Using a suitable tool, remove and properly dispose of the brake fluid from the master cylinder reservoir.

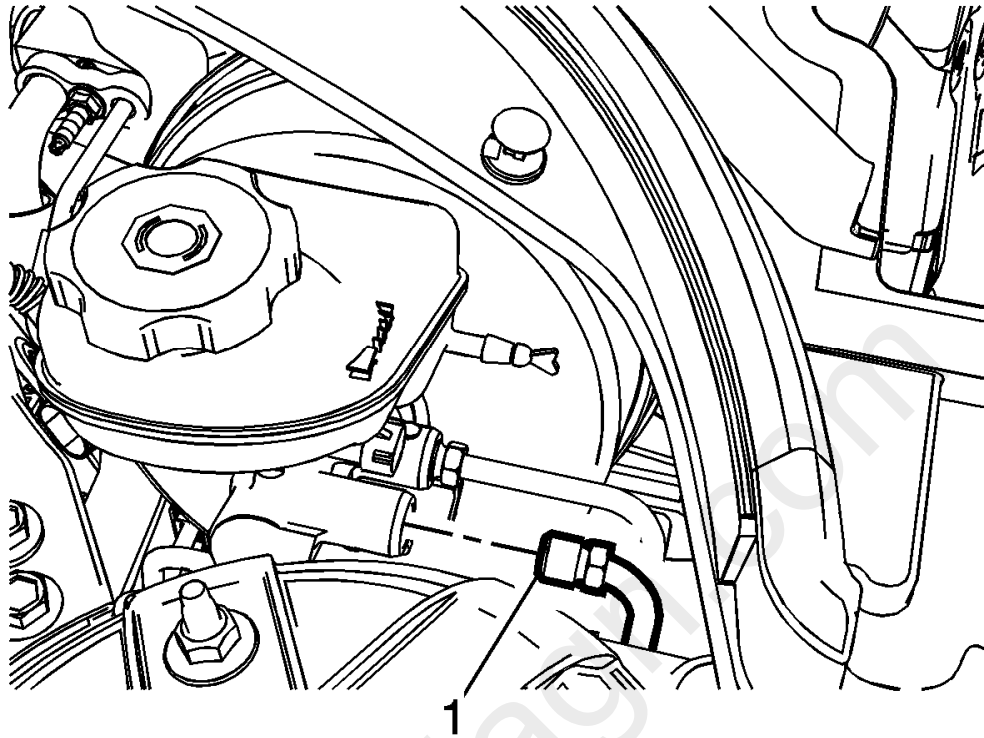


Fig. 44: Brake Pressure Modulator Valve Secondary Brake Pipe Fitting
Courtesy of GENERAL MOTORS COMPANY

8. Disconnect the brake pressure modulator valve secondary brake pipe fitting (1) at the master cylinder.
9. Plug the master cylinder outlet port to prevent brake fluid loss and contamination.
10. Remove the air conditioning evaporator hose assembly. Refer to **Air Conditioning Evaporator Hose Assembly Replacement (LF3, LFX)** , **Air Conditioning Evaporator Hose Assembly Replacement (LTG)** .

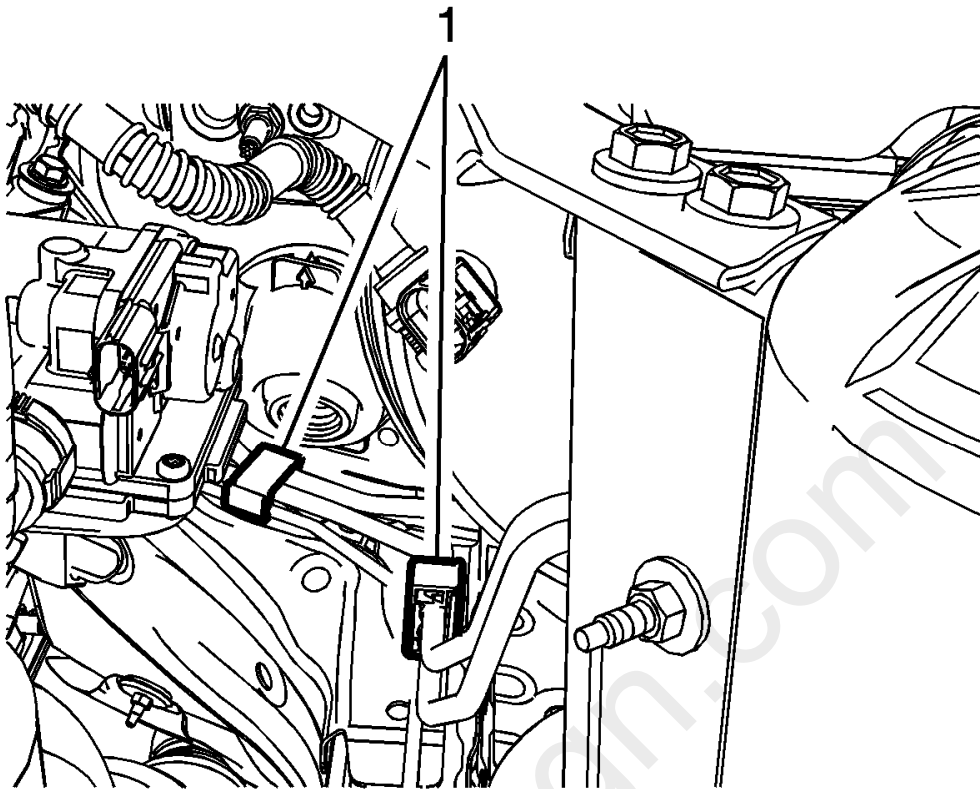


Fig. 45: Brake Pipe Retaining Clips
Courtesy of GENERAL MOTORS COMPANY

11. Release the brake pipe from the retaining clips (1).

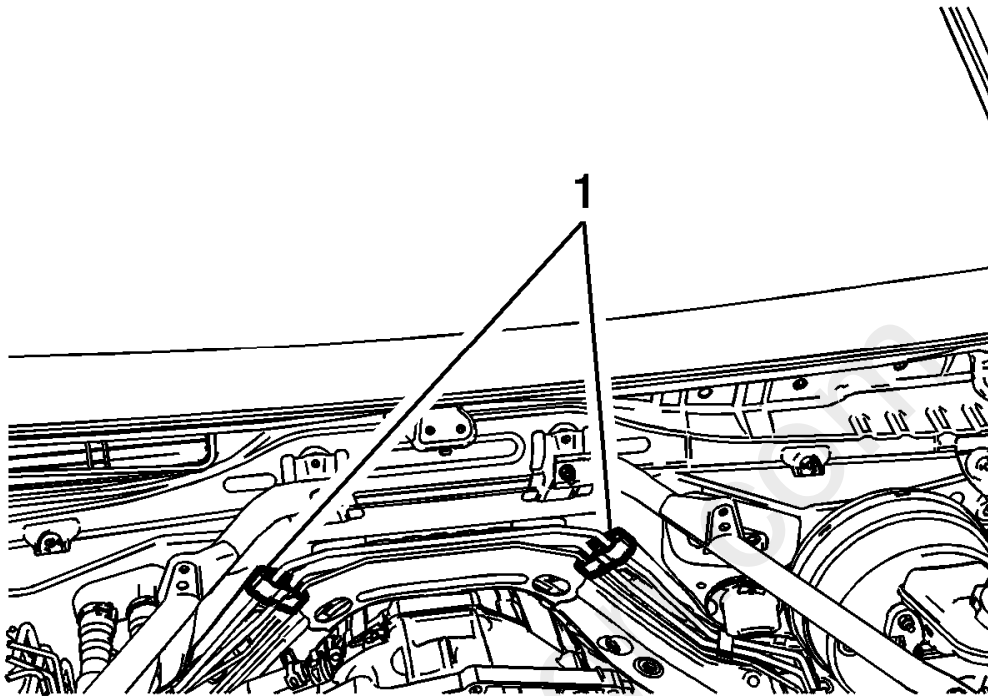


Fig. 46: Brake Pipe Retaining Clips At Cowl
Courtesy of GENERAL MOTORS COMPANY

12. Release the brake pipe from the retaining clips (1) on the cowl.

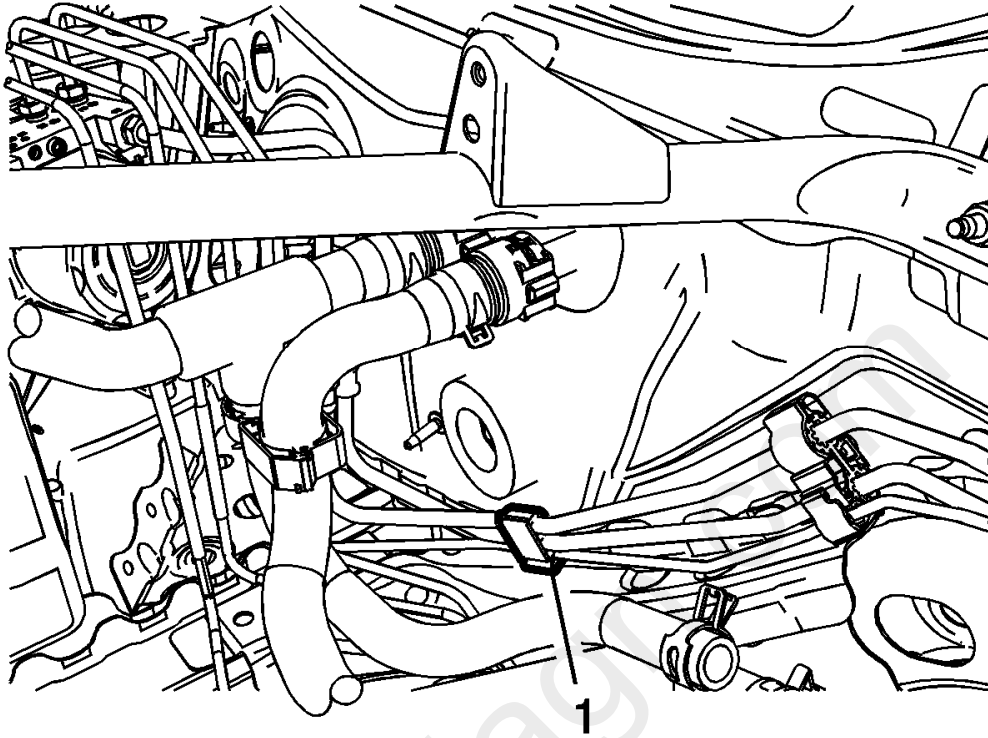


Fig. 47: Brake Pipe Retaining Clips
Courtesy of GENERAL MOTORS COMPANY

13. Release the brake pipe from the retaining clip (1).

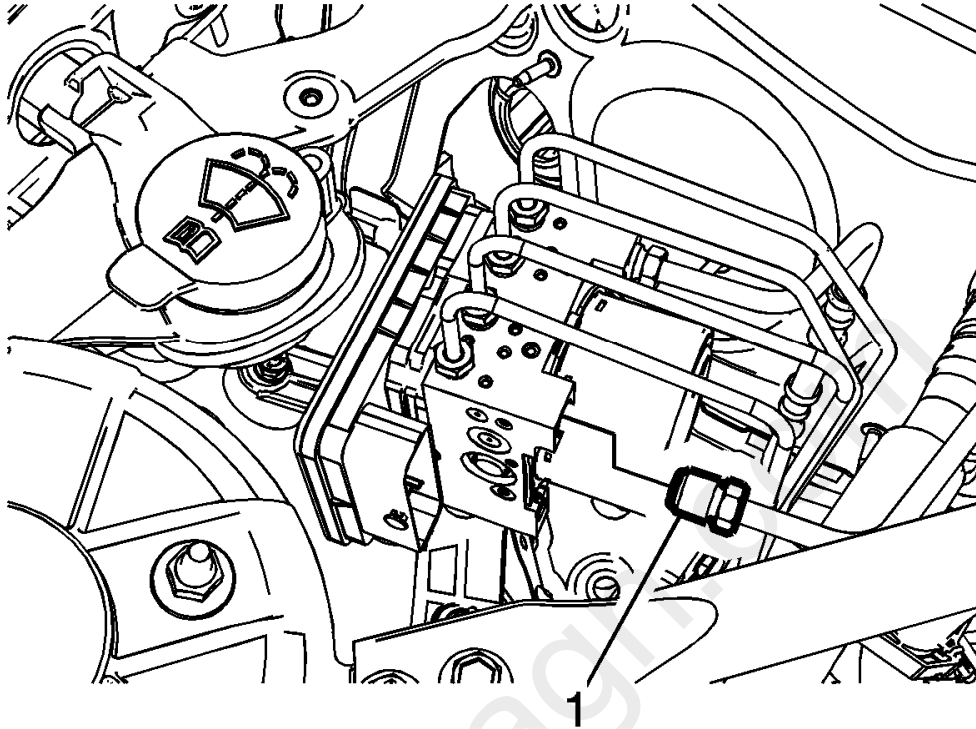


Fig. 48: Brake Pressure Modulator Valve Secondary Brake Pipe Fitting At BPMV
Courtesy of GENERAL MOTORS COMPANY

14. Disconnect the brake pressure modulator valve secondary brake pipe fitting (1) at the brake pressure modulator valve (BPMV).
15. Plug the BPMV inlet port to prevent brake fluid loss and contamination.
16. Remove the brake pressure modulator valve secondary brake pipe.

Installation Procedure

1. Install the brake pressure modulator valve secondary brake pipe.

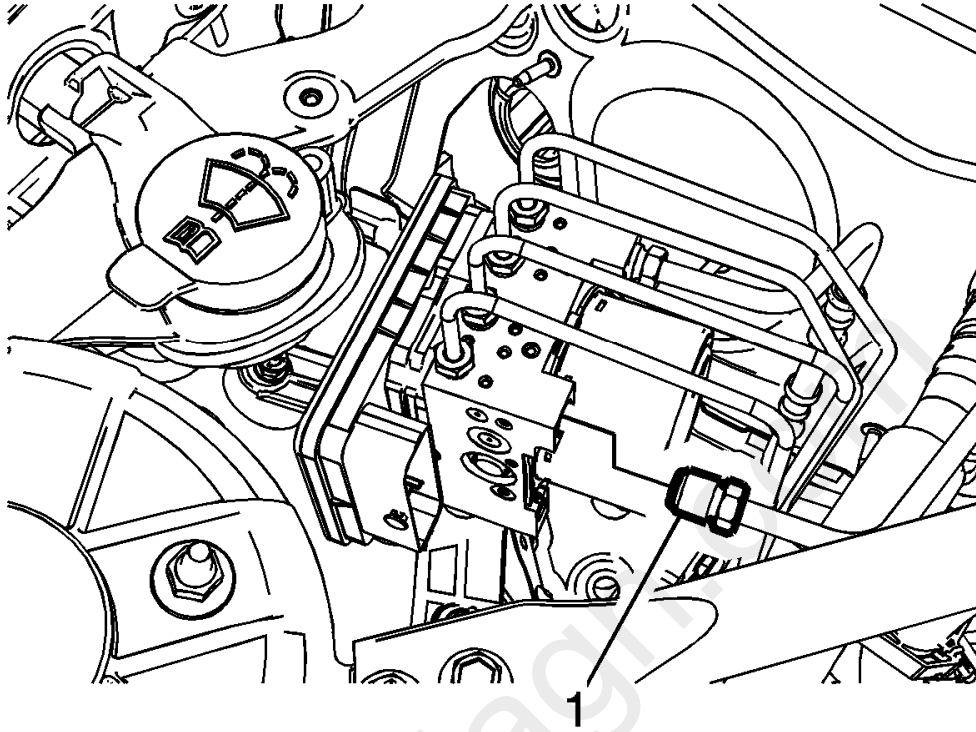


Fig. 49: Brake Pressure Modulator Valve Secondary Brake Pipe Fitting At BPMV
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Connect the brake pressure modulator valve secondary brake pipe fitting (1) at the BPMV and tighten the fitting to 32 (24 lb ft).

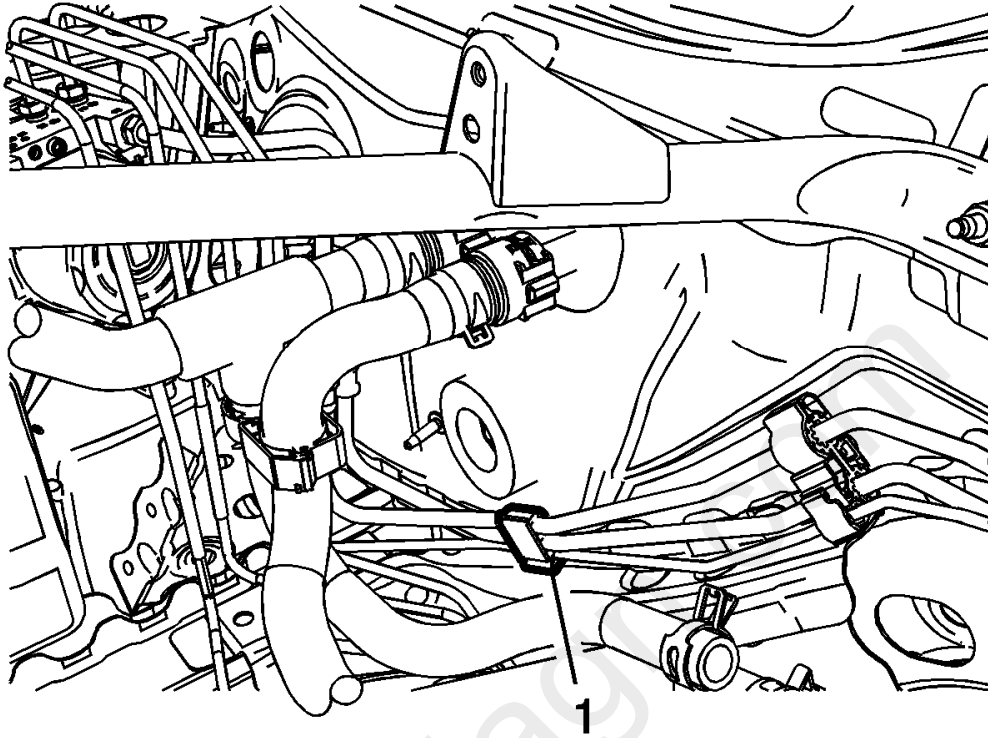


Fig. 50: Brake Pipe Retaining Clips
Courtesy of GENERAL MOTORS COMPANY

3. Secure the brake pipe to the retaining clip (1).

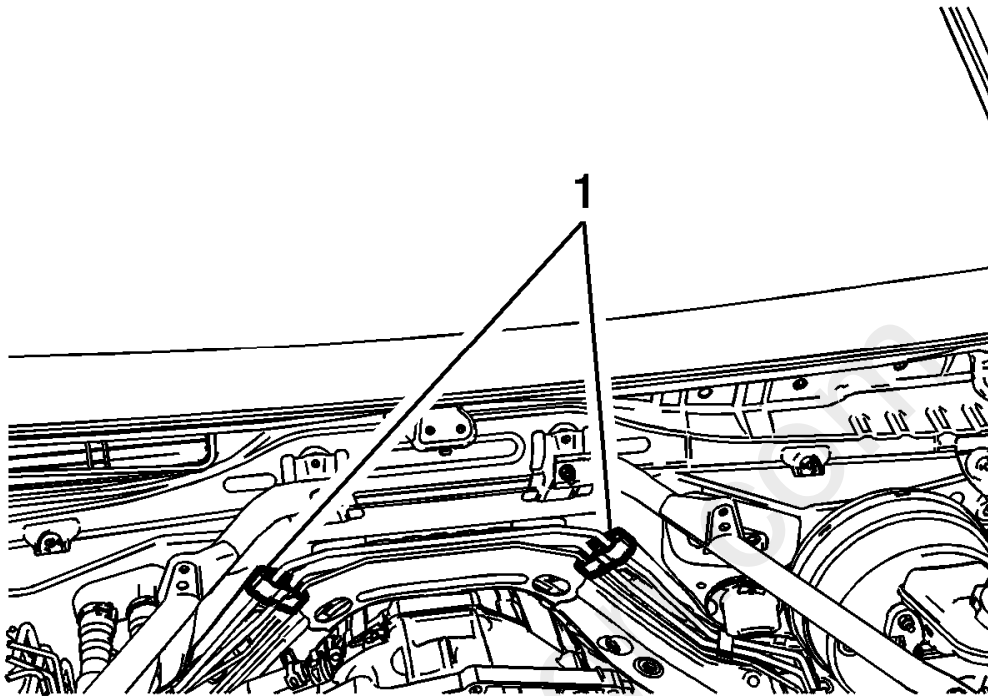


Fig. 51: Brake Pipe Retaining Clips At Cowl
Courtesy of GENERAL MOTORS COMPANY

4. Secure the brake pipe to the retaining clips (1) on the cowl.

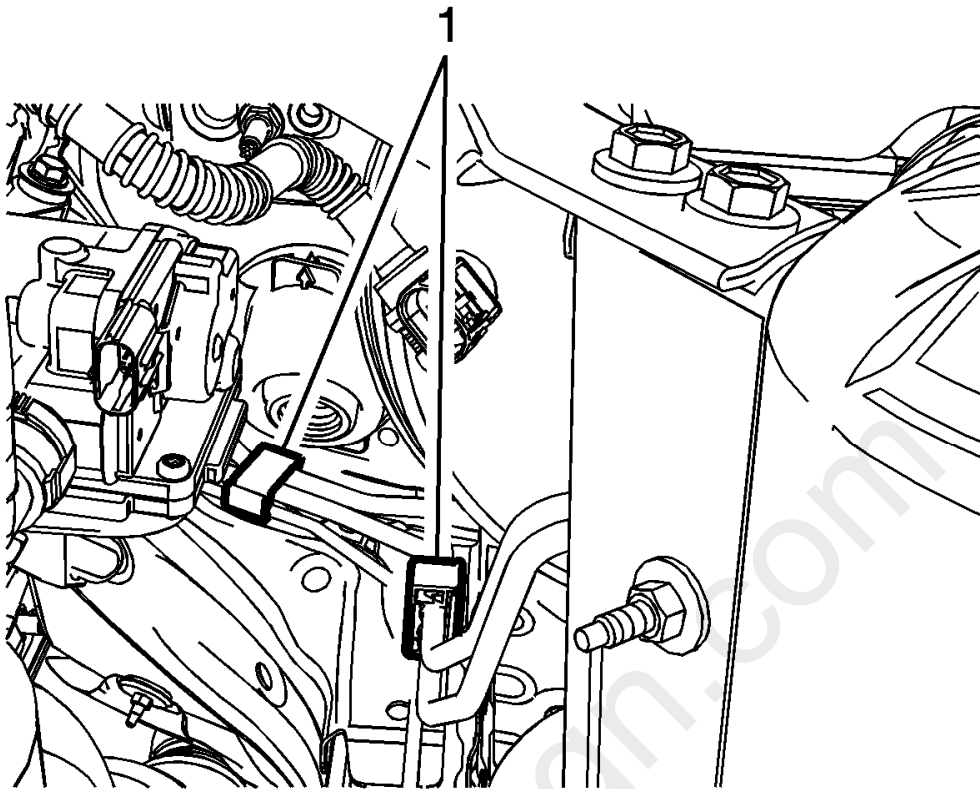


Fig. 52: Brake Pipe Retaining Clips
Courtesy of GENERAL MOTORS COMPANY

5. Secure the brake pipe to the retaining clips (1).
6. Install the air conditioning evaporator hose assembly. Refer to **Air Conditioning Evaporator Hose Assembly Replacement (LF3, LFX)** , **Air Conditioning Evaporator Hose Assembly Replacement (LTG)** .

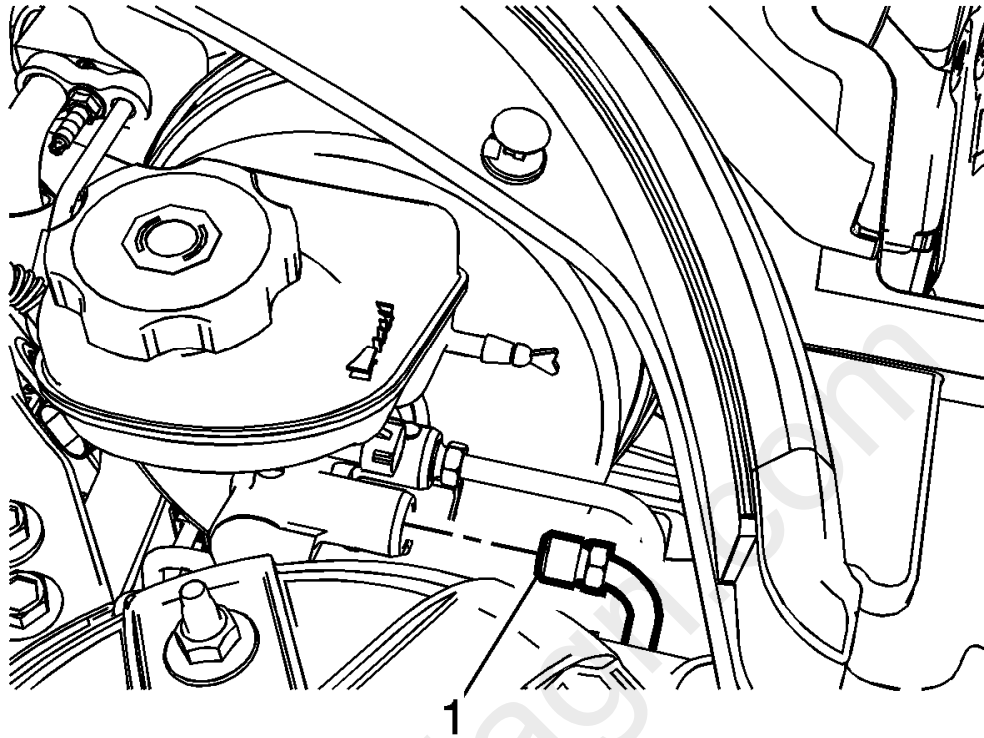


Fig. 53: Brake Pressure Modulator Valve Secondary Brake Pipe Fitting
 Courtesy of GENERAL MOTORS COMPANY

7. Connect the brake pressure modulator valve secondary brake pipe fitting (1) at the master cylinder and tighten the fitting to 30 (22 lb ft).
8. Install the upper intermediate steering shaft to the mid intermediate steering shaft. Refer to **Upper Intermediate Steering Shaft Replacement (AWD)** , **Upper Intermediate Steering Shaft Replacement (RWD)** .
9. Connect the heater outlet pipe to the heater core. Refer to **Heater Outlet Hose Replacement (LTG)** , **Heater Outlet Hose Replacement (LFX)** , **Heater Outlet Hose Replacement (LF3)** .
10. Connect the heater inlet pipe to the heater core. Refer to **Heater Inlet Hose Replacement (LTG)** , **Heater Inlet Hose Replacement (LFX)** , **Heater Inlet Hose Replacement (LF3)** .
11. If equipped with the 3.6L engine, install the intake manifold insulator. Refer to **Intake Manifold Insulator Replacement** .
12. If equipped with the 2.0L or 2.5L engine, install the outer fuel pump insulator. Refer to **Fuel Pump Insulator Replacement (Inner)** , **Fuel Pump Insulator Replacement (Outer)** .
13. Install the plenum front panel. Refer to **Plenum Front Panel Replacement** .

14. Bleed the hydraulic brake system. Refer to Hydraulic Brake System Bleeding (Manual), Hydraulic Brake System Bleeding (Pressure).

BRAKE PIPE REPLACEMENT

Special Tools

CH-45405 Brake Pipe Flaring Tool Kit

For equivalent regional tools, refer to Special Tools.

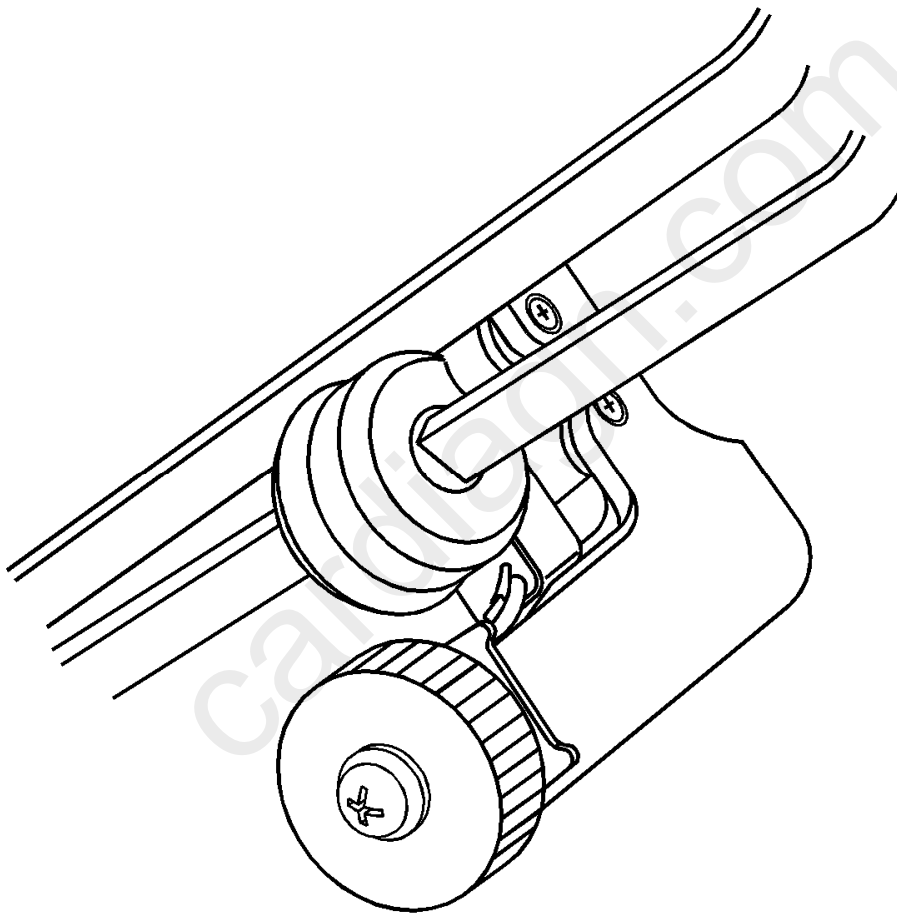


Fig. 54: Sectioning Brake Pipe Using Pipe Cutter
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Brake Fluid Irritant Warning .

WARNING: Always use double walled steel brake pipe when replacing brake

pipes. The use of any other pipe is not recommended and may cause brake system failure. Carefully route and retain replacement brake pipes. Always use the correct fasteners and the original location for replacement brake pipes. Failure to properly route and retain brake pipes may cause damage to the brake pipes and cause brake system failure.

CAUTION: Refer to Brake Fluid Effects on Paint and Electrical Components Caution .

NOTE: When servicing the brake pipes, note the following:

- If sectioning the brake pipe, use replacement pipe of the same type and outside diameter.
- Use fittings of the appropriate size and type.
- Only create flares of the same type or design as originally equipped on the vehicle.

1. Inspect the area of brake pipe to be repaired or replaced.
2. Release the brake pipe to be replaced from the retainers, as required.
3. Select an appropriate location to section the brake pipe, if necessary.
 - Allow adequate clearance in order to maneuver the **CH-45405** Brake Pipe Flaring Tool Kit.
 - Avoid sectioning the brake pipe at bends or mounting points.
4. Using a string or wire, measure the length of the pipe to be replaced including all pipe bends.
5. Add to the measurement taken the appropriate additional length required for each flare to be created.

Specification

- 6.35 mm (0.250 in) for 4.76 mm (3/16 in) diameter pipe
- 9.50 mm (0.374 in) for 6.35 mm (1/4 in) diameter pipe
- 12.67 mm (0.499 in) for 7.94 mm (5/16 in) diameter pipe

NOTE: Ensure that the brake pipe end to be flared is cut at a square, 90 degree angle to the pipe length.

6. Using the pipe cutter included in the **CH-45405** Brake Pipe Flaring Tool Kit , carefully cut the brake pipe squarely to the measured length.
7. Remove the sectioned brake pipe from the vehicle.
8. Select the appropriate size of brake pipe and tube nuts, as necessary. The brake pipe outside diameter determines brake pipe size.

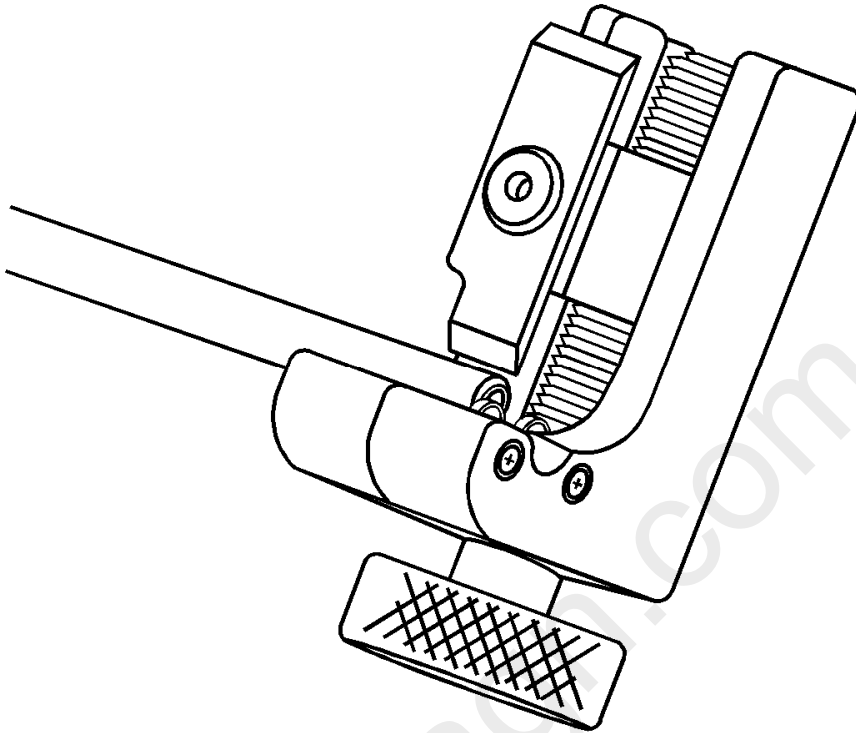


Fig. 55: Stripping Nylon Coating From Brake Pipe Ends
Courtesy of GENERAL MOTORS COMPANY

9. Strip the nylon coating from the brake pipe end to be flared, if necessary.
 - Select the appropriate blade on the coating stripping tool included in the **CH-45405** Brake Pipe Flaring Tool Kit , by unthreading the blade block from the stripping tool and installing the block with the desired blade facing the tool rollers.

Specification

- 6.35 mm (0.250 in) blade for 4.76 mm (3/16 in) diameter pipe
- 9.50 mm (0.374 in) blade for 6.35 mm (1/4 in) and 7.94 mm (5/16 in) diameter pipe
- Insert the brake pipe end to be flared into the stripping tool to the depth of the ledge on the tool rollers.
- While holding the brake pipe firmly against the stripping tool roller ledges, rotate the thumbwheel of the tool until the blade contacts the brake pipe coated surface.

NOTE: **Do not gouge the metal surface of the brake pipe.**

- Rotate the stripping tool in a clockwise direction, ensuring that the brake pipe end remains against the tool roller ledges.
- After each successive revolution of the stripping tool, carefully rotate the thumbwheel of the tool clockwise, in order to continue stripping the coating from the brake pipe until the metal pipe surface is exposed.
- Loosen the thumbwheel of the tool and remove the brake pipe.

NOTE: **Ensure that all loose remnants of the nylon coating have been removed from the brake pipe.**

- Inspect the stripped end of the brake pipe to ensure that the proper amount of coating has been removed.

Specification

- 6.35 mm (0.250 in) for 4.76 mm (3/16 in) diameter pipe
- 9.50 mm (0.374 in) for 6.35 mm (1/4 in) and 7.94 mm (5/16 in) diameter pipe

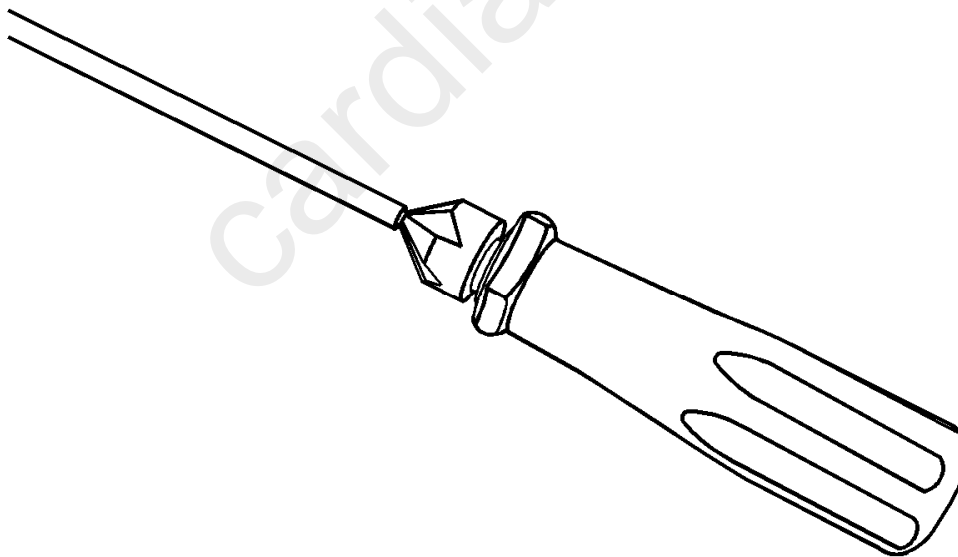


Fig. 56: Chamfering Pipe Using De-Burring Tool
Courtesy of GENERAL MOTORS COMPANY

10. Chamfer the inside and outside diameter of the pipe with the de-burring tool included in the **CH-45405** Brake Pipe Flaring Tool Kit.
11. Install the tube nuts on the brake pipe, noting their orientation.
12. Clean the brake pipe and the **CH-45405** Brake Pipe Flaring Tool Kit of lubricant, contaminants, and debris.

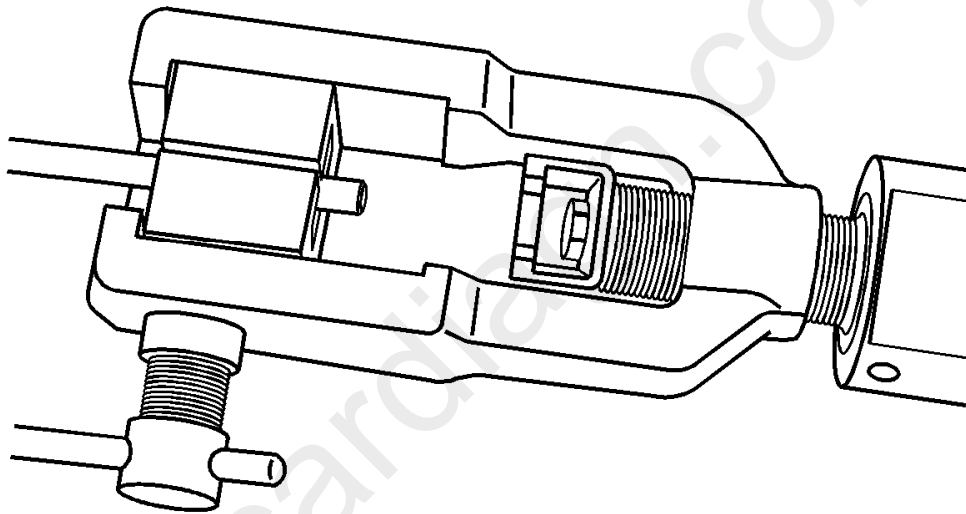


Fig. 57: Installing Die Halves Into Die Cage
Courtesy of GENERAL MOTORS COMPANY

13. Loosen the die clamping screw of the **CH-45405** Brake Pipe Flaring Tool Kit.
14. Select the corresponding die set and install the die halves into the die cage with the full, flat face of one die facing the clamping screw, and the counterbores of both dies facing the forming ram.

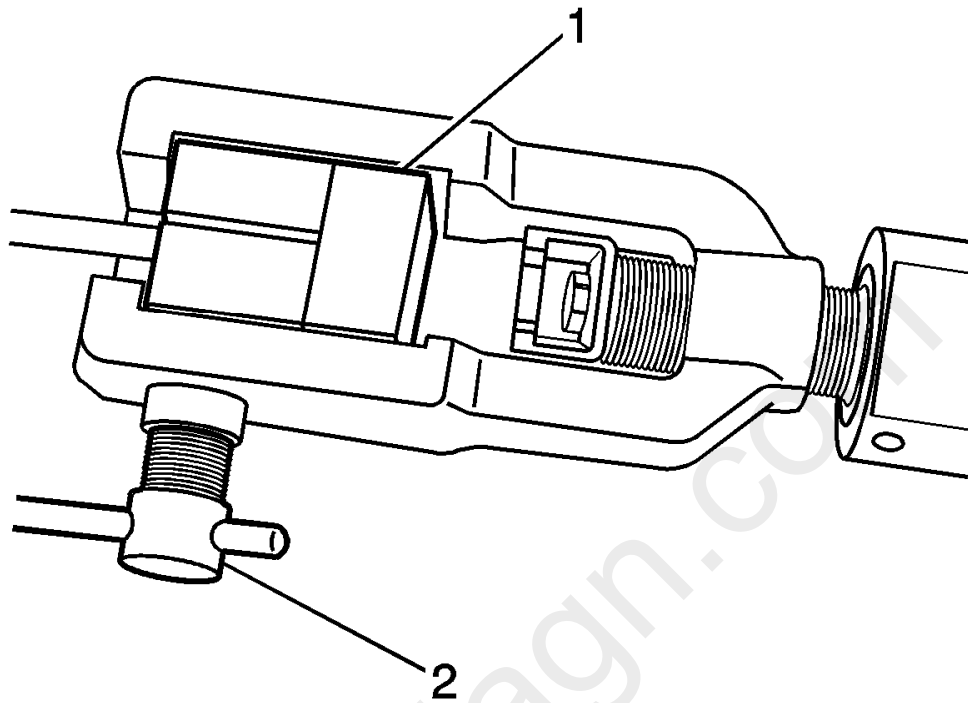


Fig. 58: View Of Clamping Screw & Unused Die
Courtesy of GENERAL MOTORS COMPANY

15. Place the flat face of an unused die (1) against the die halves in the clamping cage and hold firmly against the counterbored face of the dies.
16. Insert the prepared end of the pipe to be flared through the back of the dies until the pipe is seated against the flat surface of the unused die (1).
17. Remove the unused die (1).
18. Ensure that the rear of both dies are seated firmly against the enclosed end of the die cage.
19. Firmly hand tighten the clamping screw (2) against the dies.

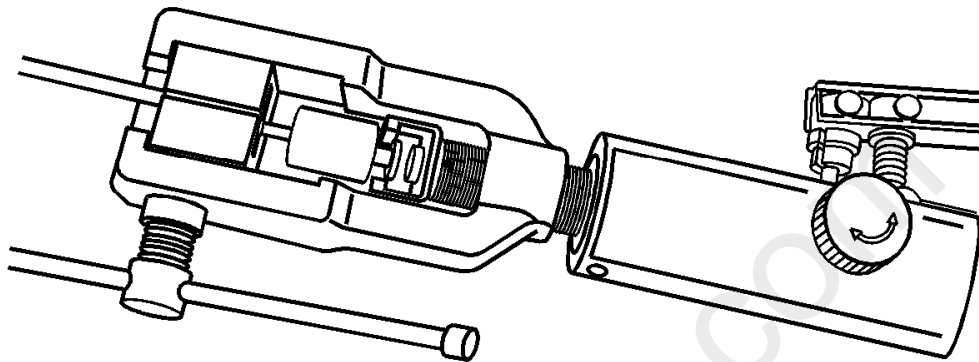


Fig. 59: Rotating J 45405 To Bottom Against Die Cage
Courtesy of GENERAL MOTORS COMPANY

20. Select the appropriate forming mandrel and place into the forming ram.
21. Rotate the hydraulic fluid control valve clockwise to the closed position.
22. Rotate the body of the **CH-45405** Brake Pipe Flaring Tool Kit until it bottoms against the die cage.

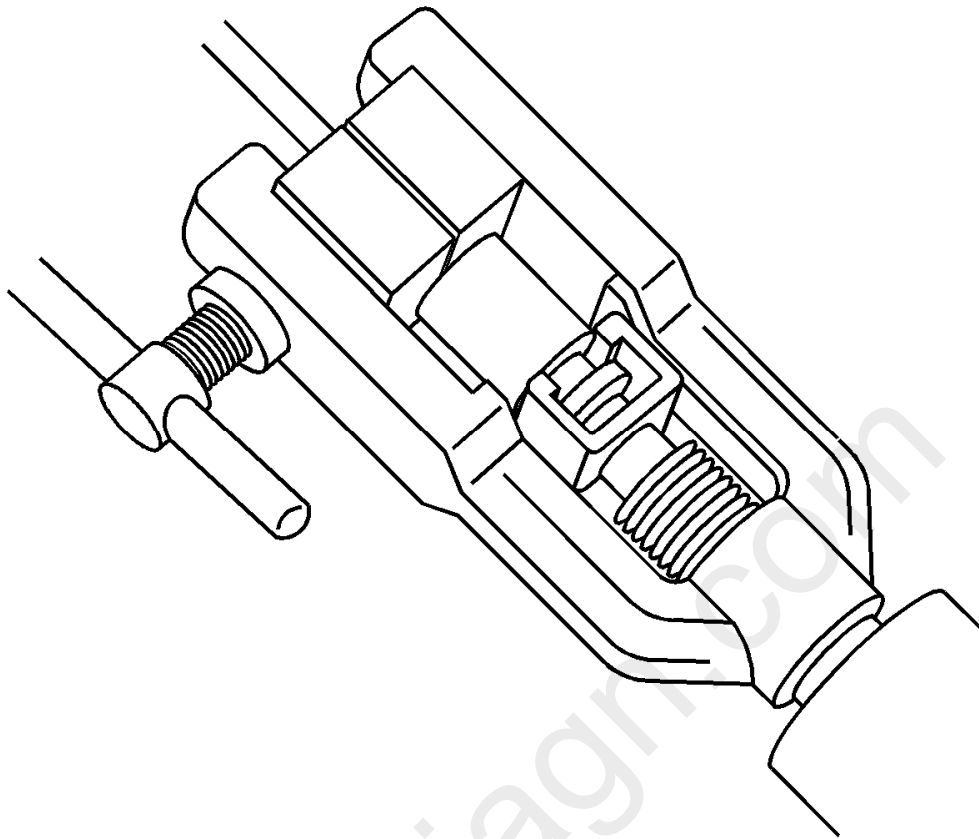


Fig. 60: Bottoming Forming Mandrel Against Clamping Dies Using Pipe Flaring Tool
Courtesy of GENERAL MOTORS COMPANY

23. While guiding the forming mandrel into the exposed end of pipe to be flared, operate the lever of the **CH-45405** Pipe Flaring Tool Kit until the forming mandrel bottoms against the clamping dies.
24. Rotate the hydraulic fluid control valve counterclockwise to the open position to allow the hydraulic forming ram to retract.

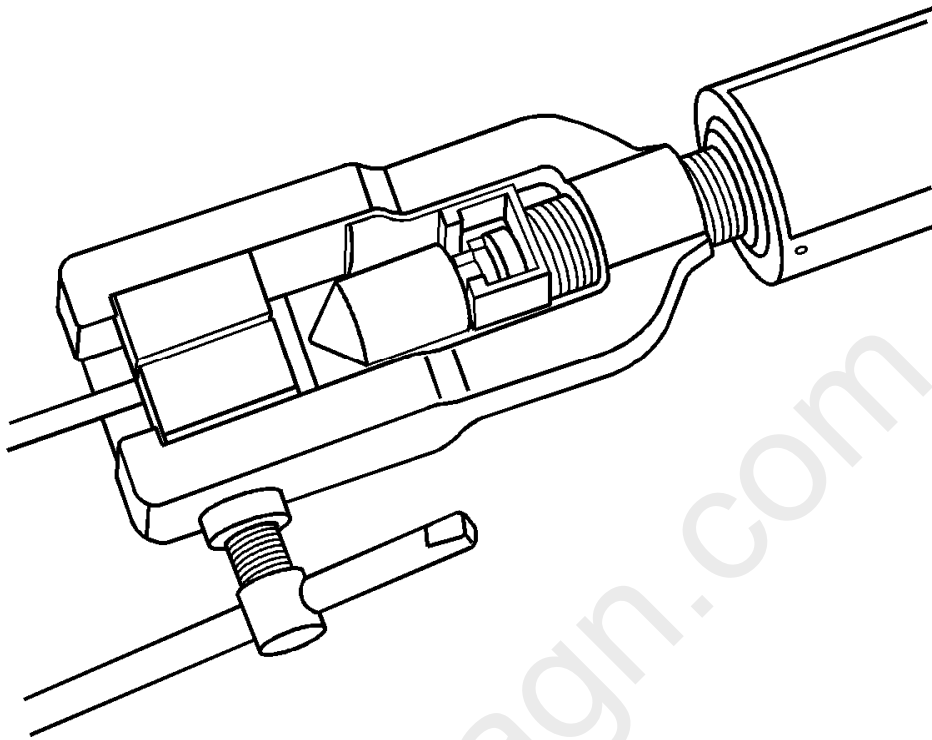


Fig. 61: Using Pipe Flaring Tool
Courtesy of GENERAL MOTORS COMPANY

25. Insert the finishing cone into the forming ram.
26. Rotate the hydraulic fluid control valve clockwise to the closed position.
27. Rotate the body of the **CH-45405** Brake Pipe Flaring Tool Kit until it bottoms against the die cage.
28. While guiding the finishing cone into the exposed end of pipe to be flared, operate the lever of the **CH-45405** Brake Pipe Flaring Tool Kit until the finishing cone bottoms against the dies.
29. Rotate the hydraulic fluid control valve counterclockwise to the open position to allow the hydraulic forming ram to retract.
30. Loosen the die clamping screw and remove the dies and pipe.
31. If necessary, lightly tap the dies until the die halves separate.

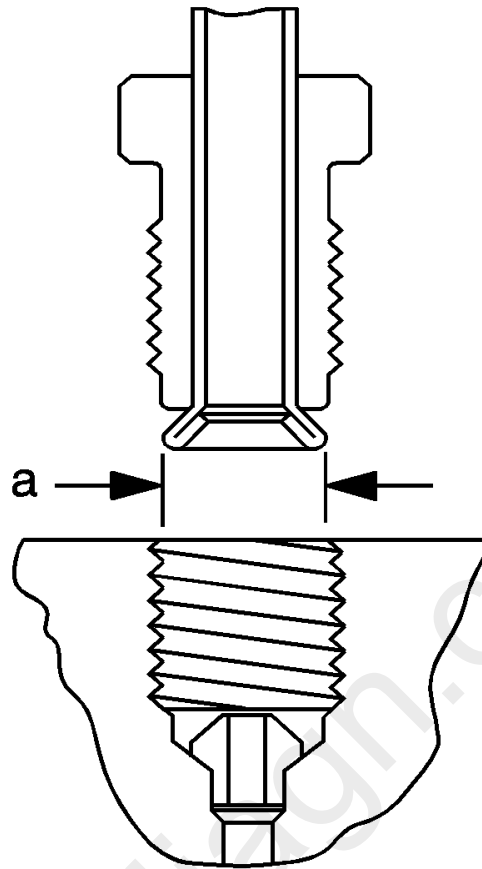


Fig. 62: Identifying Correct Brake Pipe Flare Shape & Diameter
Courtesy of GENERAL MOTORS COMPANY

32. Inspect the brake pipe flare for correct shape and diameter (a).

Specification

- 6.74-7.10 mm (0.265-0.279 in) flare diameter for 4.76 mm (3/16 in) diameter pipe
 - 8.57-9.27 mm (0.344-0.358 in) flare diameter for 6.35 mm (1/4 in) diameter pipe
 - 10.42-10.79 mm (0.410-0.425 in) flare diameter for 7.94 mm (5/16 in) diameter pipe
33. If necessary, using the removed section of brake pipe as a template, shape the new pipe with a suitable brake pipe bending tool.

NOTE: **When installing the pipe, maintain a clearance of 19 mm (3/4 in) from all moving or vibrating components.**

34. Install the pipe to the vehicle with the appropriate brake pipe unions, as required.
35. If previously released, secure the brake pipe to the retainers.

36. Bleed the hydraulic brake system. Refer to **Hydraulic Brake System Bleeding (Manual)**, **Hydraulic Brake System Bleeding (Pressure)**.
37. With the aid of an assistant, inspect the brake pipe flares for leaks by starting the engine and applying the brakes.

FRONT BRAKE HOSE REPLACEMENT

Removal Procedure

WARNING: Refer to **Brake Dust Warning** .

WARNING: Refer to **Brake Fluid Irritant Warning** .

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** .

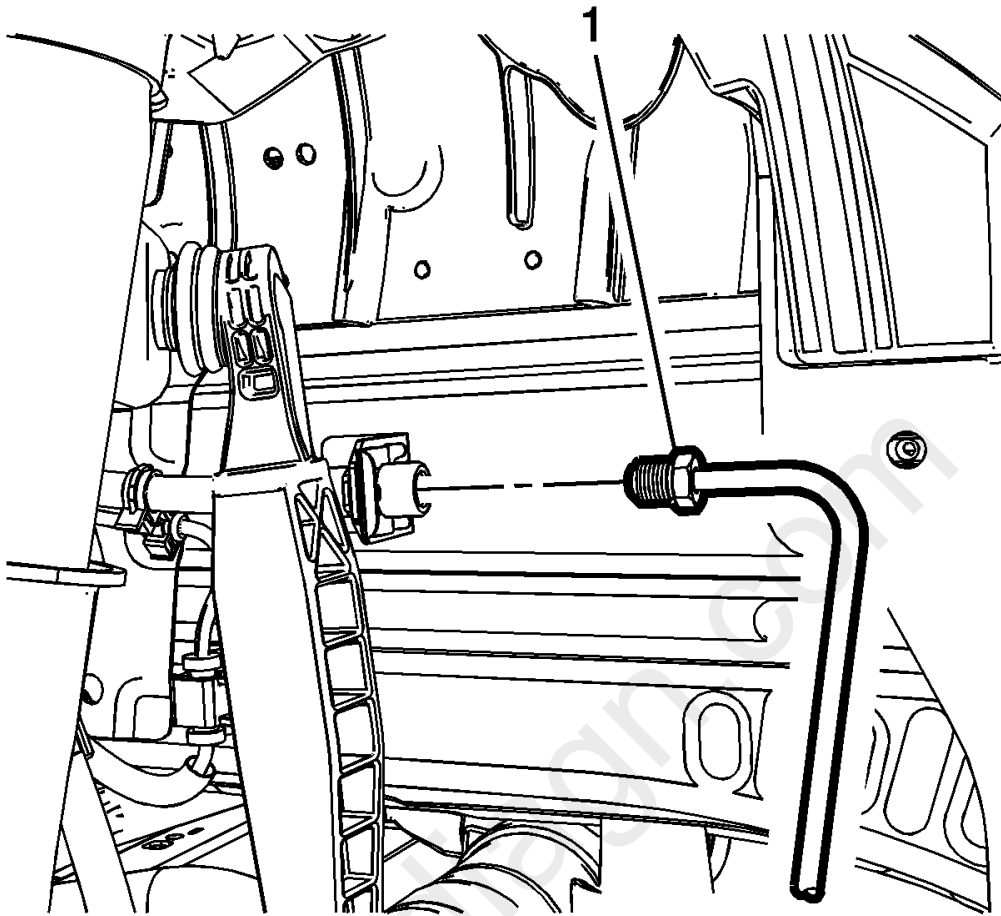


Fig. 63: Brake Pipe Fitting
Courtesy of GENERAL MOTORS COMPANY

3. Disconnect the brake pipe fitting (1) from the brake hose.
4. Cap the brake pipe fitting to prevent brake fluid loss and contamination.

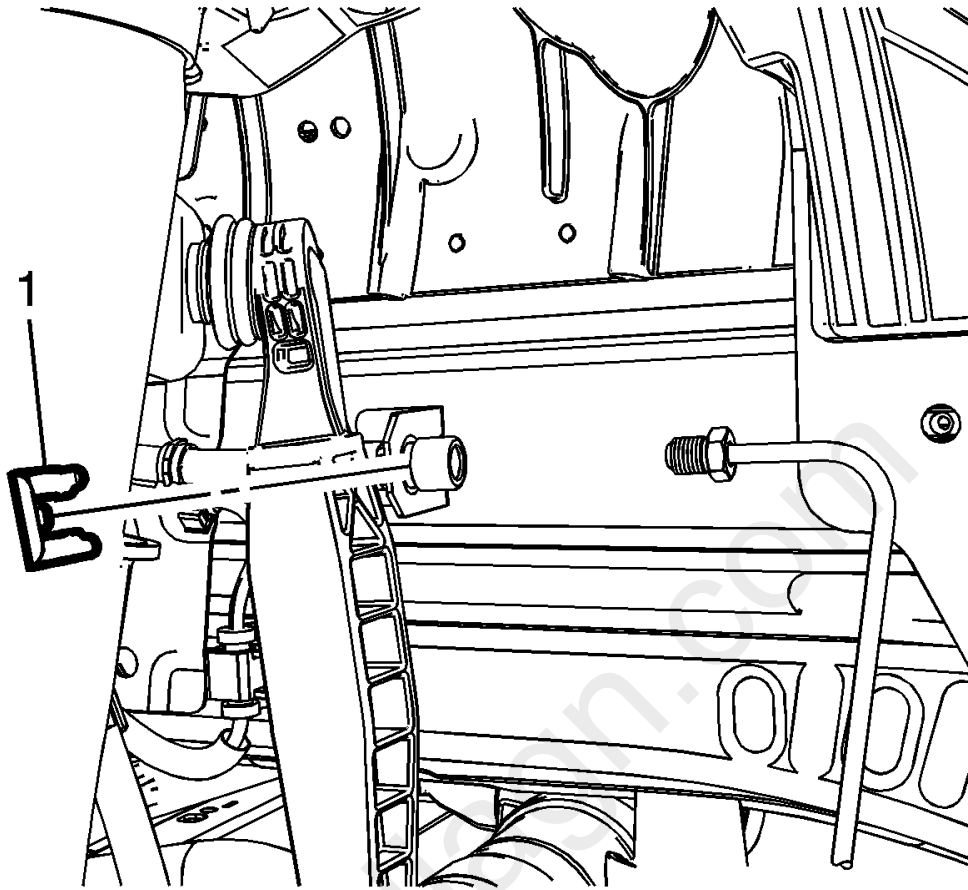


Fig. 64: Brake Hose Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

5. Remove the brake hose retaining clip (1).

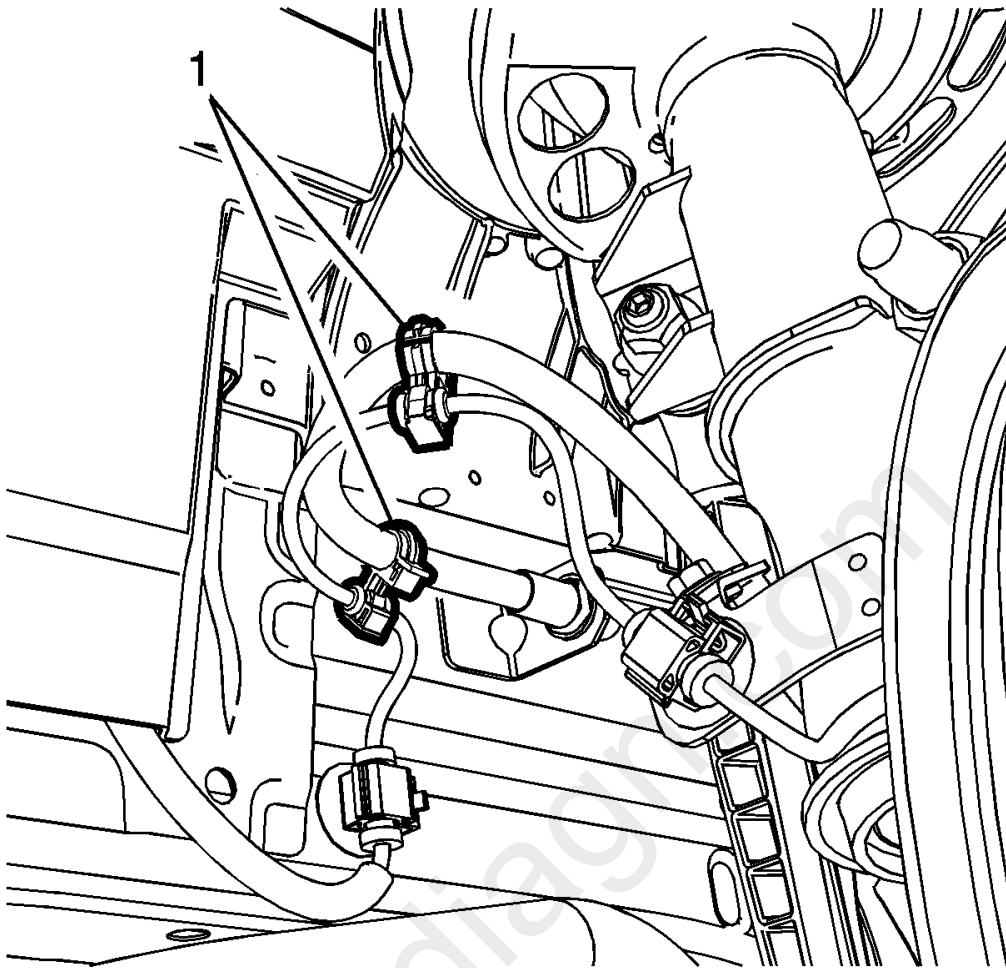


Fig. 65: Wheel Speed Sensor Harness Clips
Courtesy of GENERAL MOTORS COMPANY

6. Release the brake hose from the wheel speed sensor harness clips (1).

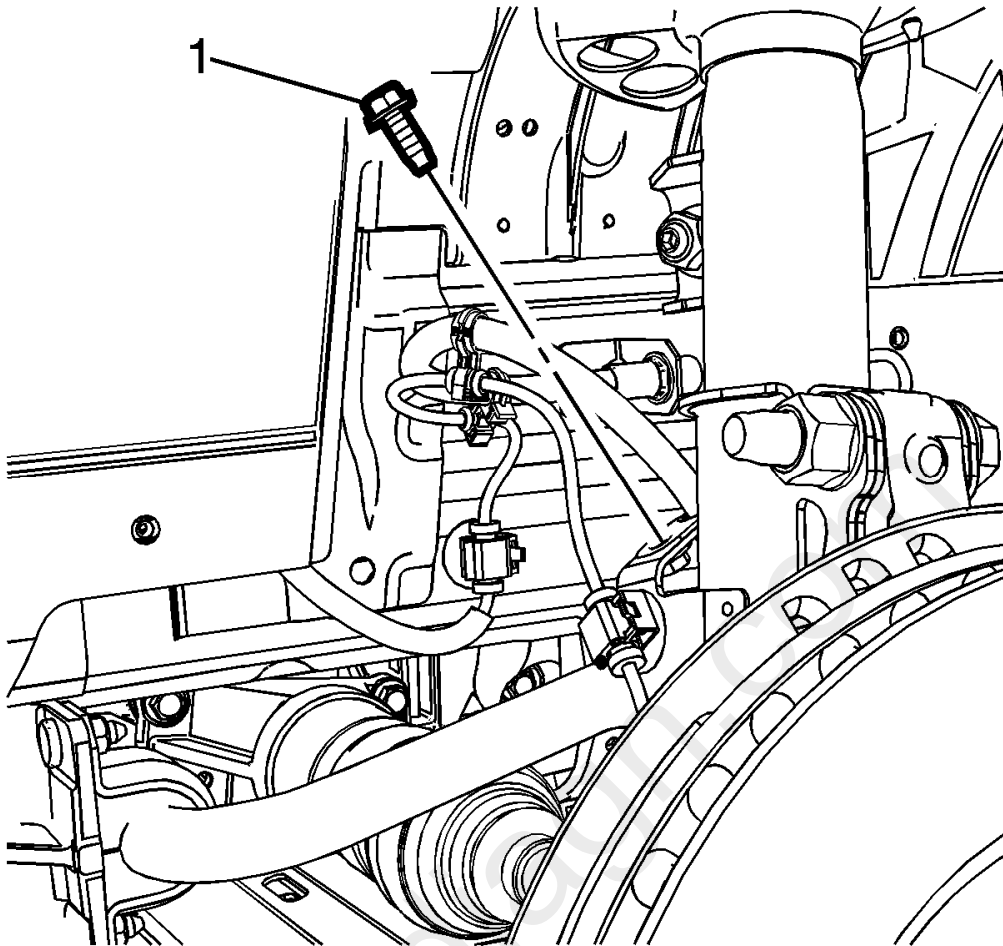


Fig. 66: Brake Hose Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Remove the brake hose bracket bolt (1).

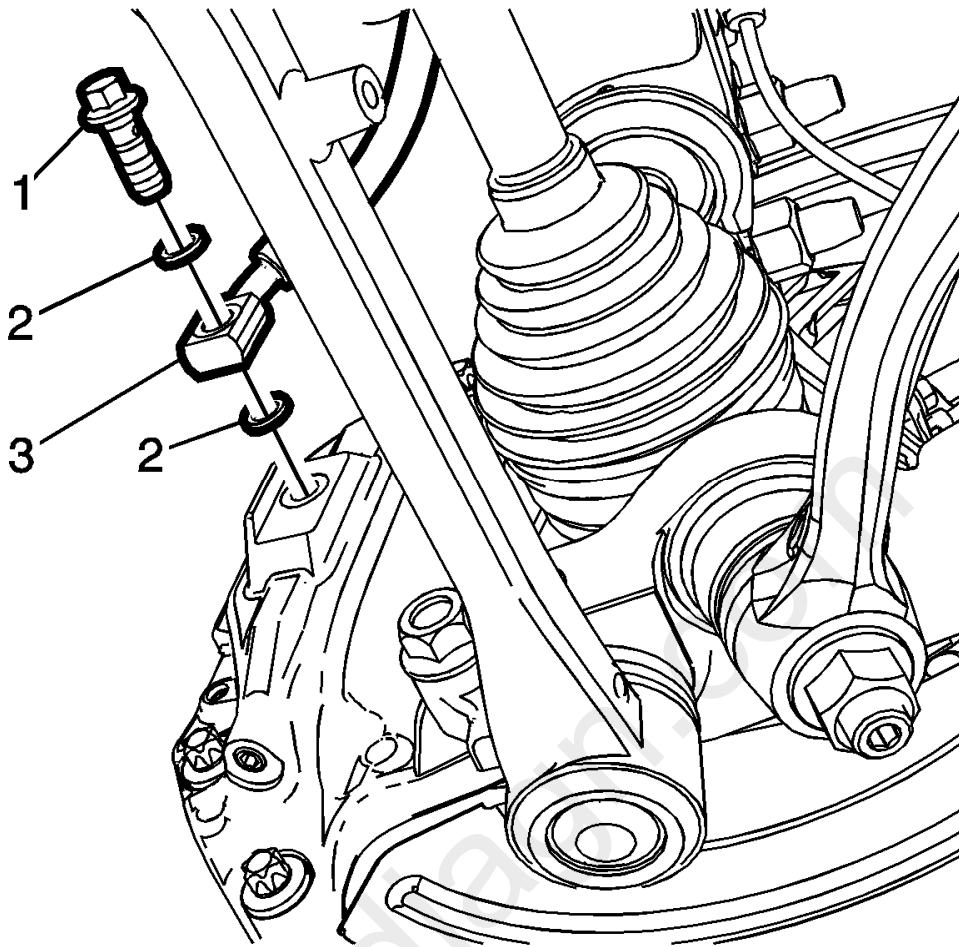


Fig. 67: Brake Hose Fitting Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Remove the brake hose fitting bolt (1).

NOTE: Do not reuse the brake hose fitting gaskets.

9. Remove and discard the brake hose fitting gaskets (2) from the brake hose fitting (3).
10. Remove the brake hose.

Installation Procedure

1. Install the brake hose.

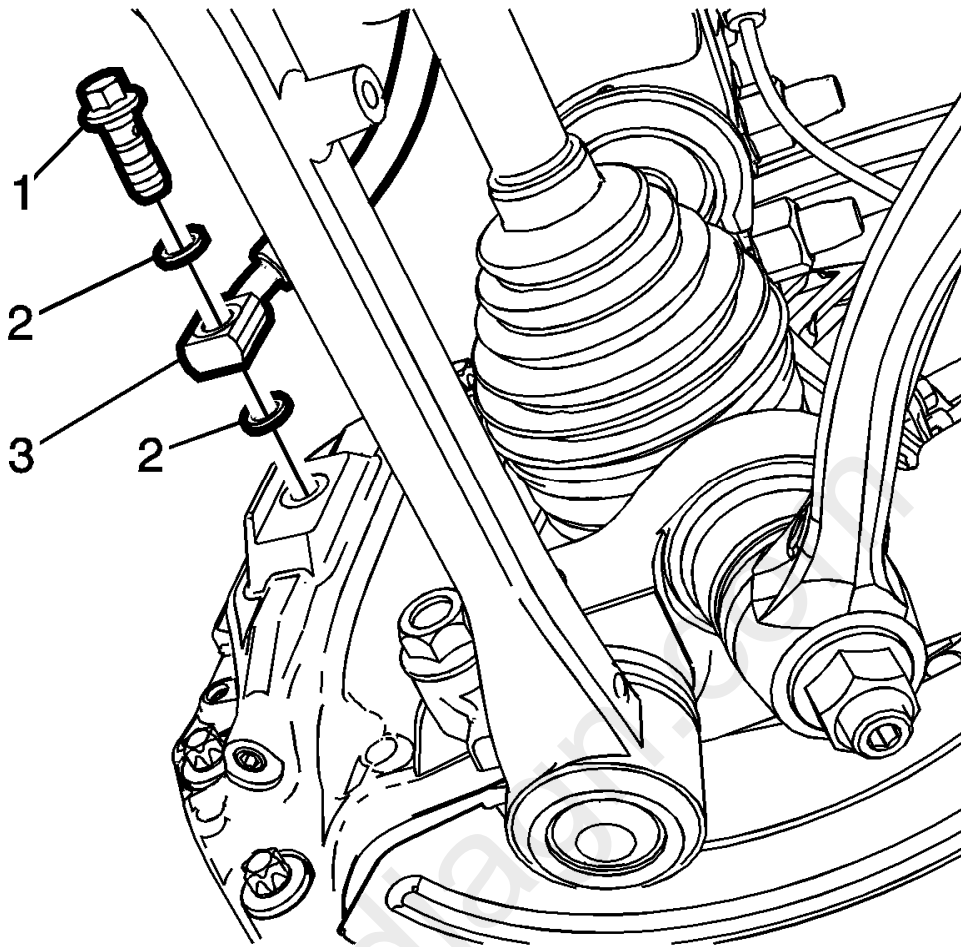


Fig. 68: Brake Hose Fitting Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Assemble the brake hose fitting bolt (1) with new brake hose fitting gaskets (2) to the brake hose fitting (3).

CAUTION: Refer to Fastener Caution .

3. Install the brake hose assembly to the brake caliper and tighten the brake hose fitting bolt to 52 (38 lb ft).

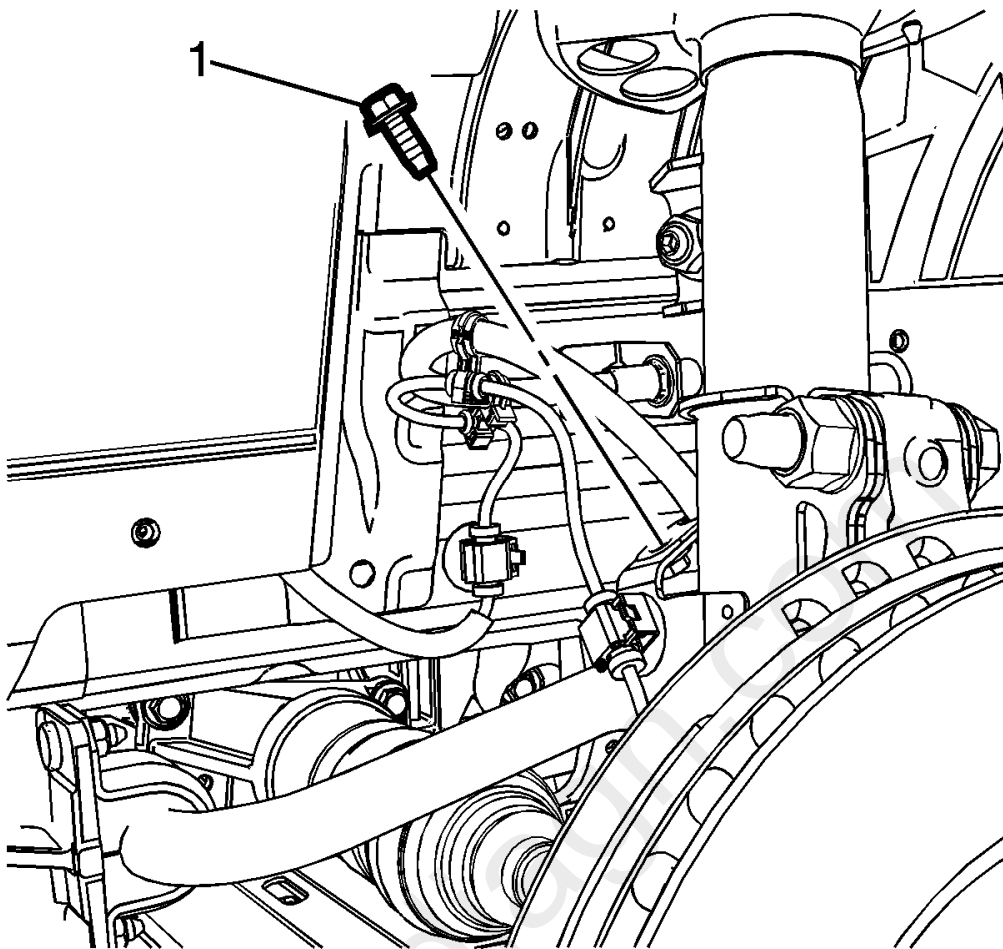


Fig. 69: Brake Hose Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Install the brake hose bracket bolt (1) and tighten to 10 (89 lb in).

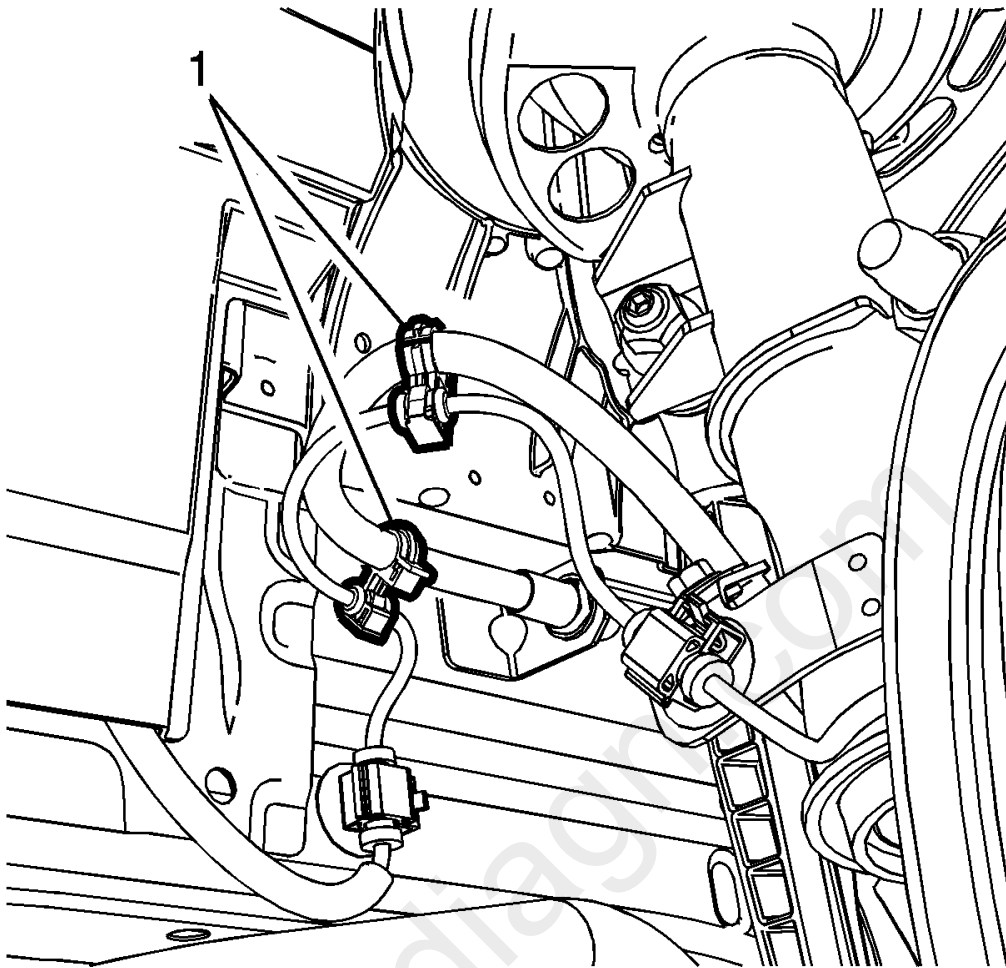


Fig. 70: Wheel Speed Sensor Harness Clips
Courtesy of GENERAL MOTORS COMPANY

5. Secure the brake to from the wheel speed sensor harness clips (1).

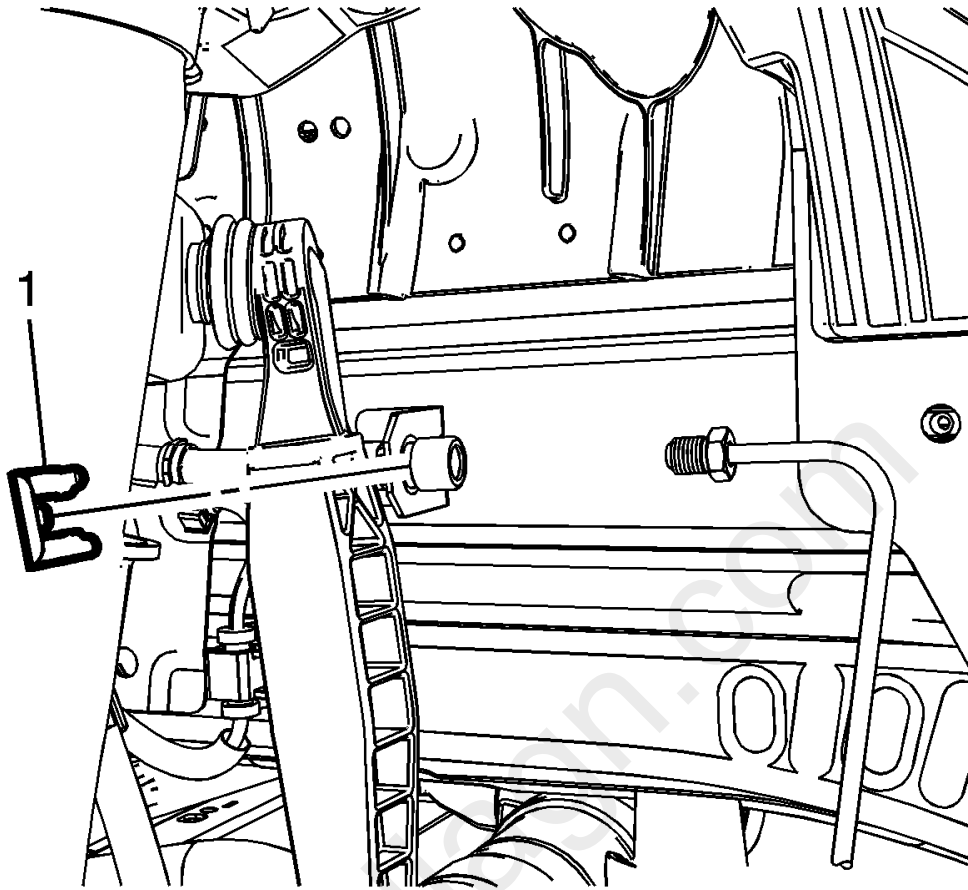


Fig. 71: Brake Hose Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

6. Install the brake hose retaining clip (1).

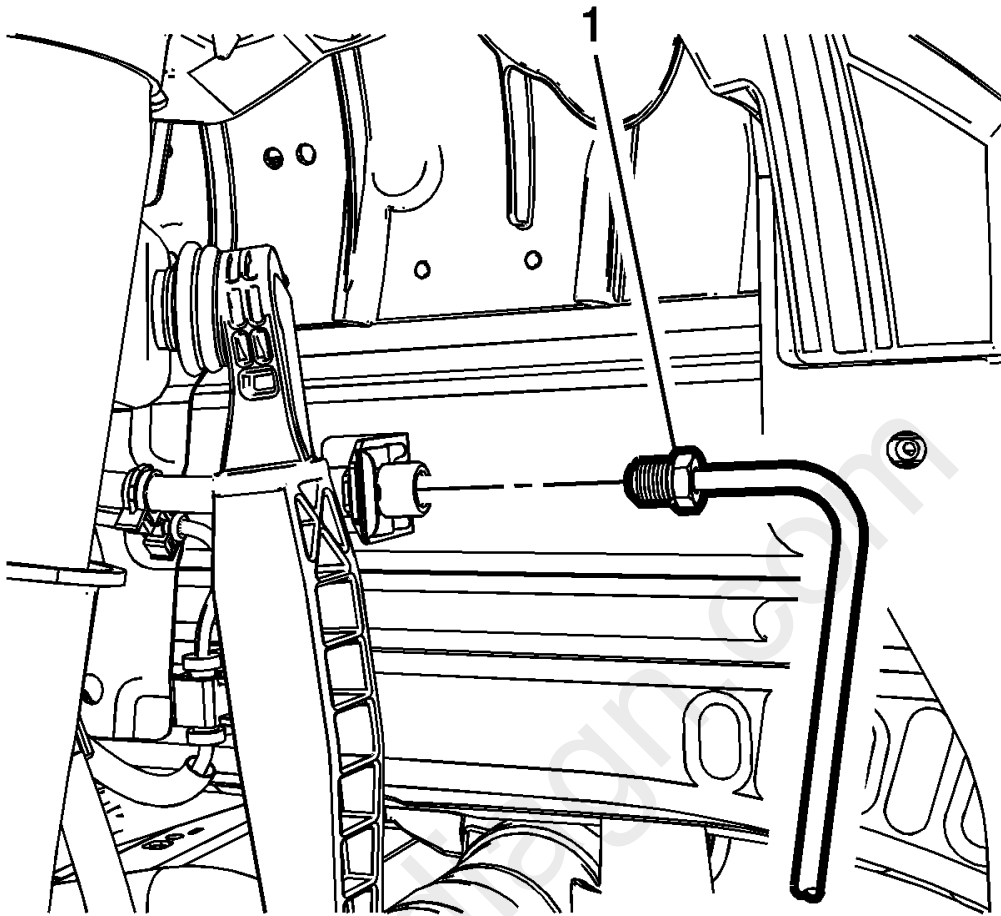


Fig. 72: Brake Pipe Fitting

Courtesy of GENERAL MOTORS COMPANY

7. Connect the brake pipe fitting (1) to the brake hose.
8. Tighten the brake pipe fitting to 18 (13 lb ft).
9. Bleed the hydraulic brake system. Refer to Hydraulic Brake System Bleeding (Manual), Hydraulic Brake System Bleeding (Pressure).
10. Install the tire and wheel assembly. Refer to Tire and Wheel Removal and Installation.

REAR BRAKE HOSE REPLACEMENT

Removal Procedure

WARNING: Refer to Brake Dust Warning.

WARNING: Refer to Brake Fluid Irritant Warning.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** .

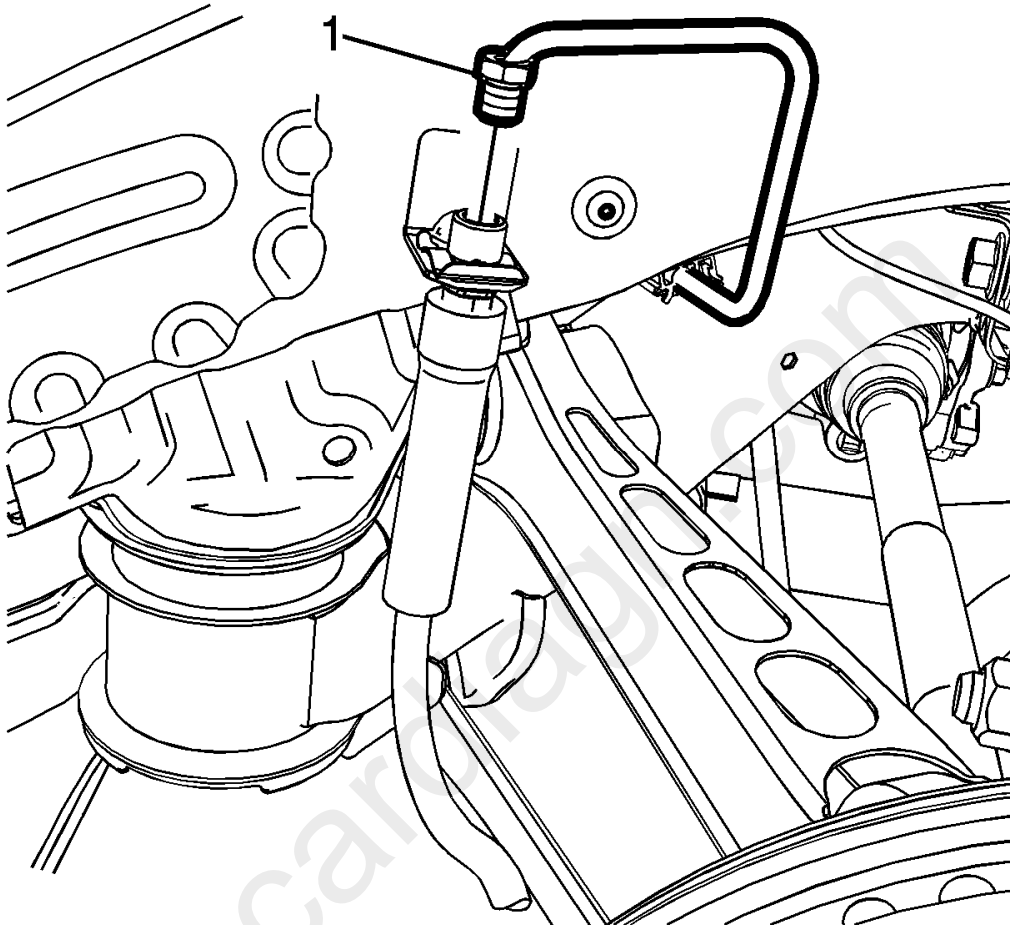


Fig. 73: Brake Pipe Fitting At Brake Hose
Courtesy of GENERAL MOTORS COMPANY

3. Disconnect the brake pipe fitting (1) from the brake hose.
4. Cap the brake pipe fitting to prevent brake fluid loss and contamination.

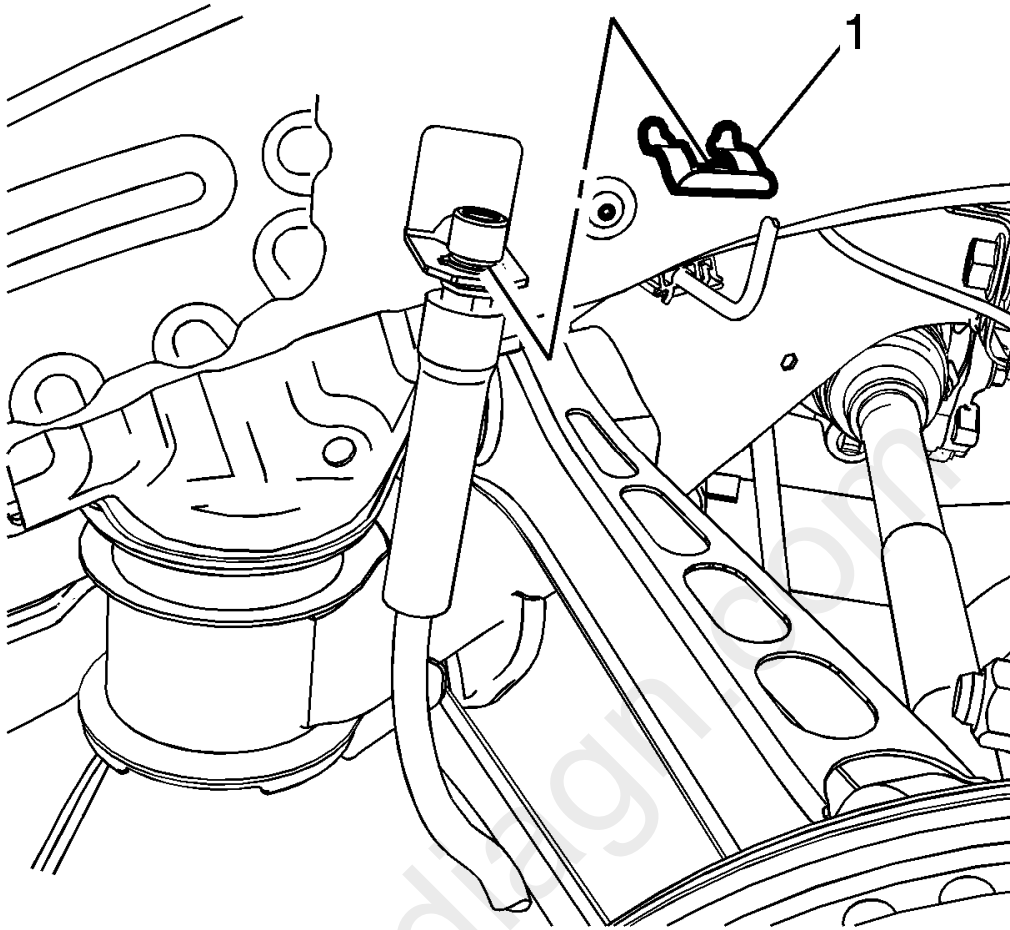


Fig. 74: Brake Hose Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

5. Remove the brake hose retaining clip (1).

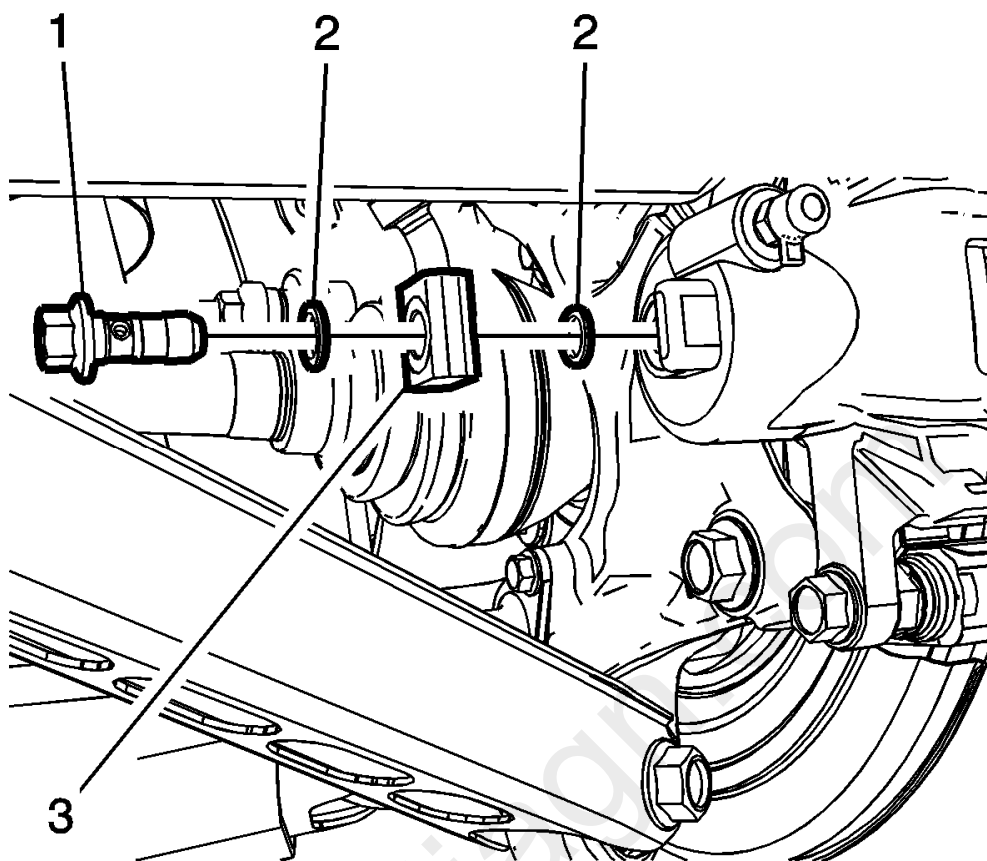


Fig. 75: Brake Hose Fitting Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not reuse the brake hose fitting gaskets.

6. Remove and discard the brake hose fitting gaskets (1) by removing the brake hose fitting bolt (2) from the brake hose fitting (3).
7. Remove the brake hose from the vehicle.

Installation Procedure

1. Install the brake hose to the vehicle.

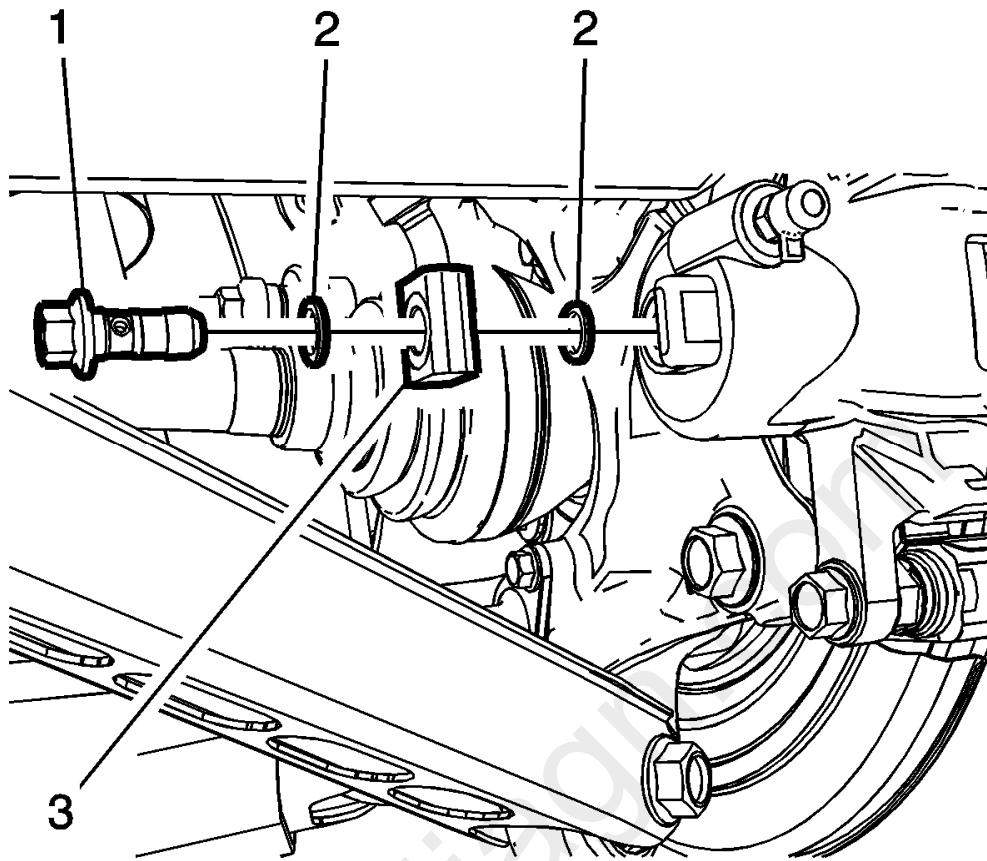


Fig. 76: Brake Hose Fitting Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Assemble new brake hose fitting gaskets (1) to the brake hose fitting bolt (2) and the brake hose fitting (3).

CAUTION: Refer to Fastener Caution .

3. Install the brake hose assembly to the brake caliper and tighten the brake hose fitting bolt to 49 (36 lb ft).

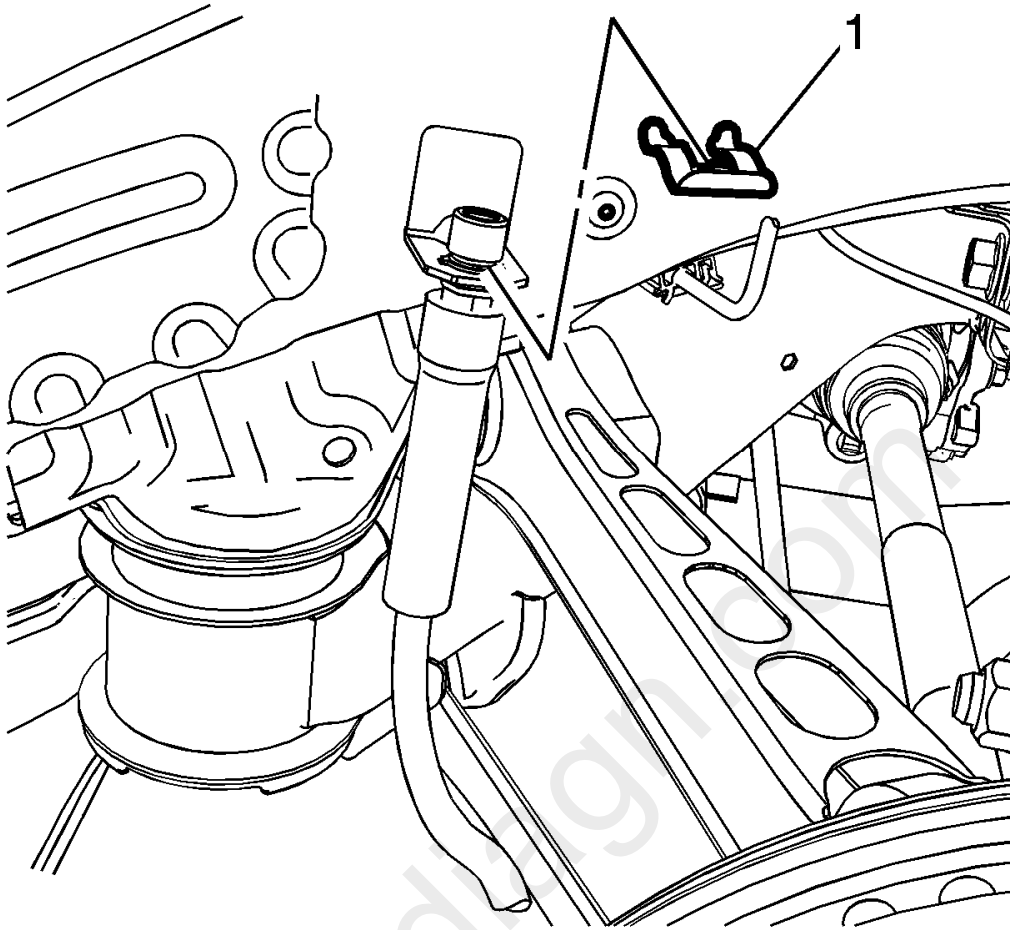


Fig. 77: Brake Hose Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

4. Install the brake hose retaining clip (1).

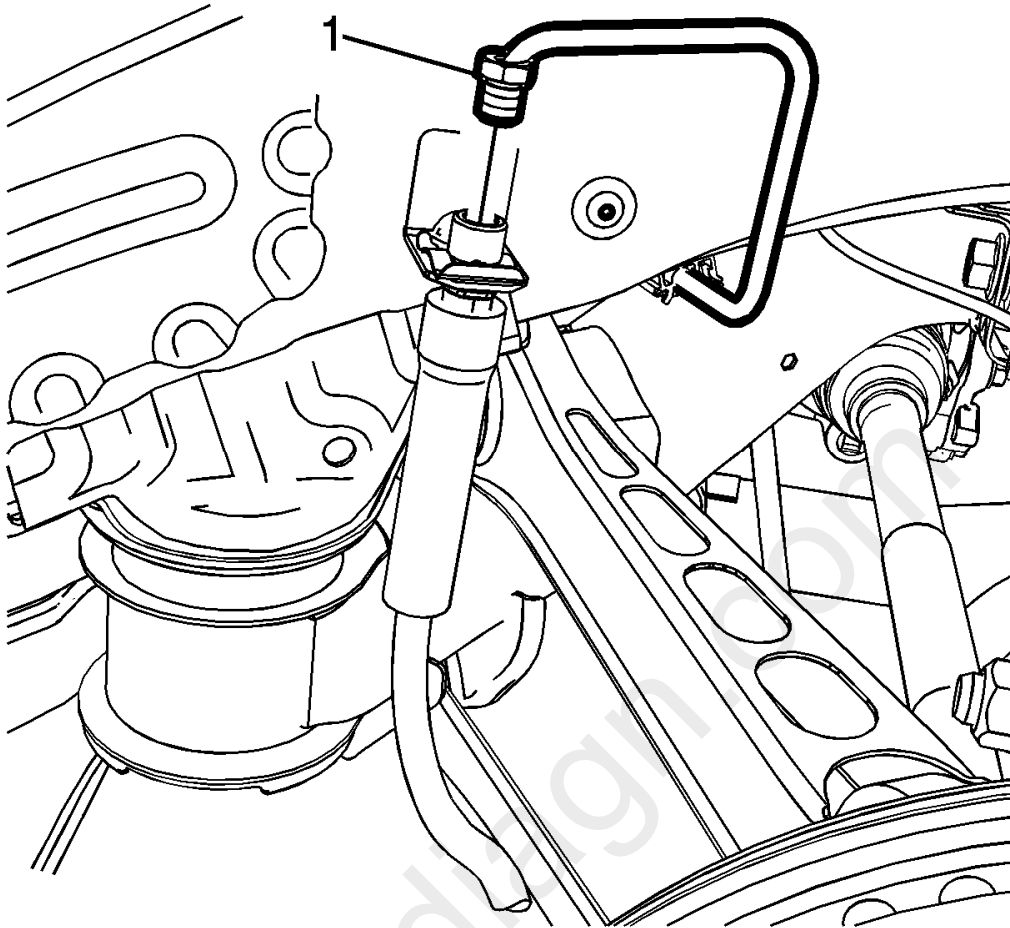


Fig. 78: Brake Pipe Fitting At Brake Hose
Courtesy of GENERAL MOTORS COMPANY

5. Connect the brake pipe fitting (1) to the brake hose.
6. Tighten the brake pipe fitting to 18 (13 lb ft).
7. Bleed the hydraulic brake system. Refer to **Hydraulic Brake System Bleeding (Manual)**, **Hydraulic Brake System Bleeding (Pressure)**.
8. Install the tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** .

HYDRAULIC BRAKE SYSTEM BLEEDING (MANUAL)

WARNING: Refer to **Brake Fluid Irritant Warning** .

CAUTION: Refer to **Brake Fluid Effects on Paint and Electrical Components Caution** .

CAUTION: Only use products that comply with GM specifications and check manufacturer information respectively. We recommend the use of GM genuine products. Instructions must be followed at all times. The use of any type of fluid other than the recommended type of brake fluid, may cause contamination which could result in damage to the internal rubber seals and/or rubber linings of hydraulic brake system components.

If hydraulic components were serviced on only one wheel hydraulic circuit, perform the following procedure.

Bleeding a Single Hydraulic Brake Circuit

1. With the ignition OFF and the brakes cool, apply the brakes 3-5 times, or until the brake pedal effort increases significantly, in order to deplete the brake booster power reserve.
2. Place a clean shop cloth beneath the brake master cylinder to catch brake fluid spills.
3. Clean the outside of the reservoir on and around the reservoir cap prior to removing the cap and diaphragm.
4. Fill the brake master cylinder reservoir to the maximum-full level with GM approved brake fluid from a clean, sealed brake fluid container. Add brake fluid as needed to ensure that the brake master cylinder reservoir remains at least half-full throughout the bleed procedure. The reservoir cap must be installed at all times except when filling the reservoir. Refer to **Fluid and Lubricant Recommendations** .
5. Install a proper box-end wrench onto the wheel hydraulic circuit bleeder valve which has been serviced.
6. Install a transparent hose over the end of the bleeder valve.
7. Submerge the open end of the transparent hose into a transparent container partially filled with brake fluid from a clean, sealed brake fluid container.
8. Have an assistant slowly press the brake pedal fully and maintain steady pressure on the pedal.
9. Loosen the bleeder valve to purge air from the wheel hydraulic circuit.
10. Tighten the bleeder valve, then have the assistant slowly release the brake pedal.
11. Wait 15 seconds, then repeat steps 8-10 until all air is purged from the wheel hydraulic circuit.
12. After all air has been purged from the hydraulic circuit, tighten the bleeder valve and install the dust cap.
13. Fill the brake master cylinder reservoir to the maximum-fill level with GM approved brake fluid from a clean, sealed brake fluid container.
14. Slowly press and release the brake pedal. Observe the brake pedal feel.
15. If the brake pedal feels spongy, perform the Bleeding the Complete Brake Hydraulic System procedure:
16. Turn the ignition key ON, with the engine OFF. Check to see if the brake system warning lamp remains illuminated.

NOTE: DO NOT allow the vehicle to be driven until it is diagnosed and repaired.

17. If the brake system warning lamp remains illuminated, refer to **Diagnostic Starting Point - Vehicle** .

Bleeding the Complete Brake Hydraulic System

1. With the ignition OFF and the brakes cool, apply the brakes 3-5 times, or until the brake pedal effort

increases significantly, in order to deplete the brake booster power reserve.

2. Place a clean shop cloth beneath the brake master cylinder to catch brake fluid spills.
3. Clean the outside of the reservoir on and around the reservoir cap prior to removing the cap and diaphragm.
4. Fill the brake master cylinder reservoir to the maximum-full level with GM approved brake fluid from a clean, sealed brake fluid container. Add brake fluid as needed to ensure that the brake master cylinder reservoir remains at least half-full throughout the bleed procedure. The reservoir cap must be installed at all times except when filling the reservoir. Refer to **Fluid and Lubricant Recommendations**.
5. If the master cylinder was replaced, the master cylinder must be bench bled. Refer to **Master Cylinder Bench Bleeding**.
6. If the brake pipes have been removed from the master cylinder, the following steps must be performed.
 1. With the rear brake pipe installed securely to the master cylinder, loosen and separate the front brake pipe fitting from the front port of the brake master cylinder.
 2. Allow a small amount of brake fluid to gravity bleed from the open port of the master cylinder. Capture and properly dispose of the brake fluid in an approved container.
 3. Install the front brake pipe fitting to the front port of the brake master cylinder and tighten the fitting. Refer to **Fastener Tightening Specifications**.
 4. Have an assistant slowly press the brake pedal fully and maintain steady pressure on the pedal.
 5. Loosen the front brake pipe fitting from the front port of the brake master cylinder to purge air from the master cylinder port.
 6. Tighten the front brake pipe fitting, then have the assistant slowly release the brake pedal.
 7. Wait 15 seconds, then repeat steps 6.4-6.6 until all air is purged from the front brake pipe fitting of the front port of the master cylinder.
 8. After all air is purged from the front port of the brake master cylinder, tighten the front master cylinder brake pipe fitting. Refer to **Fastener Tightening Specifications**.
 9. With the front brake pipe fitting installed securely to the front port of the brake master cylinder, loosen and separate the rear brake pipe fitting from the rear port of the brake master cylinder.
 10. Repeat steps 6.2-6.7 for the rear port of the brake master cylinder.
 11. After all air is purged from the rear port of the brake master cylinder, tighten the rear master cylinder brake pipe fitting. Refer to **Fastener Tightening Specifications**.
 12. Slowly press and release the brake pedal. Observe the brake pedal feel.
 13. If the brake pedal feels spongy, proceed to step 7.
 14. If the brake pedal feels firm, proceed to step 24.
7. If the brake pipes have been removed from the brake pressure modulator valve (BPMV) assembly, if equipped, or the brake proportion valve assembly, if equipped, air must be purged from each port of the respective assembly beginning with the feed pipes from the master cylinder.
 1. Loosen and separate one of the master cylinder brake pipe fittings from the inlet port of the assembly to be bled.
 2. Allow a small amount of brake fluid to gravity bleed from the open port of the assembly. Capture and properly dispose of the brake fluid in an approved container.
 3. Install the brake pipe fitting and to the inlet port of the assembly and tighten securely.

4. Have an assistant slowly press the brake pedal fully and maintain steady pressure on the pedal.
5. Loosen the same brake pipe fitting to purge air from the open port of the assembly.
6. Tighten the brake pipe fitting, then have the assistant slowly release the brake pedal.
7. Wait 15 seconds, then repeat steps 7.4-7.6 until all air is purged from the brake pipe fitting of the assembly.
8. Repeat steps 7.1-7.7 for all of the remaining ports of the assembly.
9. After bleeding each port of the assembly, tighten all of the brake pipe fittings on the assembly. Refer to **Fastener Tightening Specifications**.
10. Fill the master cylinder reservoir to the maximum-full level with GM approved brake fluid from a clean, sealed brake fluid container.
11. Slowly press and release the brake pedal. Observe the brake pedal feel.
12. If the brake pedal feels spongy, proceed to step 8.
13. If the brake pedal feels firm, proceed to step 24.
8. Install a proper box-end wrench onto the RIGHT REAR wheel hydraulic circuit bleeder valve.
9. Install a transparent hose over the end of the bleeder valve.
10. Submerge the open end of the transparent hose into a transparent container partially filled with GM approved brake fluid from a clean, sealed brake fluid container.
11. Have an assistant slowly press the brake pedal fully and maintain steady pressure on the brake pedal.
12. Loosen the bleeder valve to purge air from the wheel hydraulic circuit.
13. Tighten the bleeder valve, then have the assistant slowly release the brake pedal.
14. Wait 15 seconds, then repeat steps 11-13 until all air is purged from the wheel hydraulic circuit.
15. Tighten the RIGHT REAR hydraulic wheel circuit bleeder valve securely.
16. Install a proper box-end wrench onto the LEFT REAR wheel hydraulic circuit bleeder valve, then repeat steps 9-14..
17. Install a proper box-end wrench onto the RIGHT FRONT wheel hydraulic circuit bleeder valve, then repeat steps 9-14..
18. Install a proper box-end wrench onto the LEFT FRONT wheel hydraulic circuit bleeder valve, then repeat steps 9-14..
19. After completing the final wheel hydraulic circuit bleeding procedure, tighten all of the wheel hydraulic circuit bleeder valves and install the bleeder valve dust caps.
20. Fill the master cylinder reservoir to the maximum-full level with GM approved brake fluid from a clean, sealed brake fluid container.
21. Slowly press and release the brake pedal. Observe the brake pedal feel.
22. If the brake pedal feels spongy, perform the following procedure.
 1. If equipped with antilock brakes, install a scan tool and perform the **Antilock Brake System Automated Bleed** to remove air which may be trapped in the BPMV.
 2. Inspect the hydraulic brake system for external leaks. Refer to **Brake System External Leak Inspection**.
 3. Repeat the Bleeding the Complete Brake Hydraulic System procedure.
23. If the brake pedal still feels spongy, pressure bleed the hydraulic brake system. Refer to **Hydraulic Brake**

System Bleeding (Manual), Hydraulic Brake System Bleeding (Pressure)

24. Turn the ignition switch ON with the engine OFF. Check to see if the brake system warning lamp remains illuminated.

NOTE: **DO NOT allow the vehicle to be driven until the brake system is diagnosed and repaired.**

25. If the brake system warning lamp remains illuminated, refer to **Diagnostic Starting Point - Vehicle** .

HYDRAULIC BRAKE SYSTEM BLEEDING (PRESSURE)

WARNING: Refer to **Brake Fluid Irritant Warning** .

CAUTION: Refer to **Brake Fluid Effects on Paint and Electrical Components Caution** .

CAUTION: Only use products that comply with GM specifications and check manufacturer information respectively. We recommend the use of GM genuine products. Instructions must be followed at all times. The use of any type of fluid other than the recommended type of brake fluid, may cause contamination which could result in damage to the internal rubber seals and/or rubber linings of hydraulic brake system components.

If hydraulic components were serviced on only one wheel hydraulic circuit, perform the following procedure.

Bleeding a Single Hydraulic Brake Circuit

1. With the ignition OFF and the brakes cool, apply the brakes 3-5 times, or until the brake pedal effort increases significantly, in order to deplete the brake booster power reserve.
2. Place a clean shop cloth beneath the brake master cylinder to catch brake fluid spills.
3. Clean the outside of the reservoir on and around the reservoir cap prior to removing the cap and diaphragm.
4. Fill the brake master cylinder reservoir to the maximum-full level with GM approved brake fluid from a clean, sealed brake fluid container. Refer to **Fluid and Lubricant Recommendations** .

NOTE: **The pressure bleeding equipment must be the diaphragm type. The rubber diaphragm between the air supply and the brake fluid prevents air, moisture, oil, and other contaminants from entering the hydraulic system.**

5. Following the brake pressure bleeder manufacturer's instructions, fill the brake pressure bleeder with GM approved brake fluid from a clean, sealed brake fluid container.
6. Install the appropriate master cylinder reservoir adapter and connect the brake pressure bleeder.

7. Charge the brake pressure bleeder air tank to 170-200 kPa/1.7-2.0 bar (25-30 psi), or as recommended by the brake pressure bleeder manufacturer's instructions.
8. Open the brake pressure bleeder fluid tank valve to allow pressurized brake fluid to enter the brake hydraulic system.

NOTE: **Any brake fluid leaks identified require repair prior to completing this procedure.**

9. Wait approximately 30 seconds, then inspect the entire hydraulic brake system for external brake fluid leaks.
10. Install a proper box-end wrench onto the wheel hydraulic circuit bleeder valve which has been serviced.
11. Install a transparent hose over the end of the bleeder valve.
12. Submerge the open end of the transparent hose into a transparent container partially filled with brake fluid from a clean, sealed brake fluid container.
13. Loosen the bleeder valve to purge air from the wheel hydraulic circuit.
14. Allow fluid to flow until air bubbles stop flowing from the bleeder.
15. After all air has been purged from the hydraulic circuit, tighten the bleeder valve and install the dust cap.

NOTE: **The brake reservoir may have residual pressure after the bleeding operation is complete. Wrap a clean shop towel around the bleeder adapter and all hose connections before disconnecting the pressure bleeding equipment to prevent brake fluid from contacting and damaging vehicle components and painted surfaces.**

16. Close the brake pressure bleeder fluid tank valve then disconnect the brake pressure bleeder from the master cylinder reservoir bleeder adapter.
17. Remove the master cylinder reservoir bleeder adapter from the master cylinder reservoir.
18. Fill the brake master cylinder reservoir to the maximum-fill level with GM approved brake fluid from a clean, sealed brake fluid container.
19. Slowly press and release the brake pedal. Observe the brake pedal feel.
20. If the brake pedal feels spongy, perform the Bleeding the Complete Brake Hydraulic System procedure:
21. Turn the ignition key ON, with the engine OFF. Check to see if the brake system warning lamp remains illuminated.

NOTE: **DO NOT allow the vehicle to be driven until it is diagnosed and repaired.**

22. If the brake system warning lamp remains illuminated, refer to **Diagnostic Starting Point - Vehicle** .

Bleeding the Complete Brake Hydraulic System

1. With the ignition OFF and the brakes cool, apply the brakes 3-5 times, or until the brake pedal effort increases significantly, in order to deplete the brake booster power reserve.
2. Place a clean shop cloth beneath the brake master cylinder to catch brake fluid spills.

3. Clean the outside of the reservoir on and around the reservoir cap prior to removing the cap and diaphragm.
4. Fill the brake master cylinder reservoir to the maximum-full level with GM approved brake fluid from a clean, sealed brake fluid container. Refer to **Fluid and Lubricant Recommendations**.
5. If the master cylinder was replaced, the master cylinder must be bench bled. Refer to **Master Cylinder Bench Bleeding**.
6. If the brake pipes have been removed from the master cylinder, the following steps must be performed.
 1. With the rear brake pipe installed securely to the master cylinder, loosen and separate the front brake pipe fitting from the front port of the brake master cylinder.
 2. Allow a small amount of brake fluid to gravity bleed from the open port of the master cylinder. Capture and properly dispose of the brake fluid in an approved container.
 3. Install the front brake pipe fitting to the front port of the brake master cylinder and tighten the fitting.
 4. Have an assistant slowly press the brake pedal fully and maintain steady pressure on the pedal.
 5. Loosen the front brake pipe fitting from the front port of the brake master cylinder to purge air from the master cylinder port.
 6. Tighten the front brake pipe fitting, then have the assistant slowly release the brake pedal.
 7. Wait 15 seconds, then repeat steps 6.4-6.6 until all air is purged from the front brake pipe fitting of the front port of the master cylinder.
 8. After all air is purged from the front port of the brake master cylinder, tighten the front master cylinder brake pipe fitting. Refer to **Fastener Tightening Specifications**.
 9. With the front brake pipe fitting installed securely to the front port of the brake master cylinder, loosen and separate the rear brake pipe fitting from the rear port of the brake master cylinder.
 10. Repeat steps 6.2-6.7 for the rear port of the brake master cylinder.
 11. After all air is purged from the rear port of the brake master cylinder, tighten the rear master cylinder brake pipe fitting. Refer to **Fastener Tightening Specifications**.
 12. Slowly press and release the brake pedal. Observe the brake pedal feel.
 13. If the brake pedal feels spongy, proceed to step 7.
 14. If the brake pedal feels firm, proceed to step 24.
7. If the brake pipes have been removed from the brake pressure modulator valve (BPMV) assembly, if equipped, or the brake proportion valve assembly, if equipped, air must be purged from each port of the respective assembly beginning with the feed pipes from the master cylinder.
 1. Loosen and separate one of the master cylinder brake pipe fittings from the inlet port of the assembly to be bled.
 2. Allow a small amount of brake fluid to gravity bleed from the open port of the assembly. Capture and properly dispose of the brake fluid in an approved container.
 3. Install the brake pipe fitting and to the inlet port of the assembly and tighten securely.
 4. Have an assistant slowly press the brake pedal fully and maintain steady pressure on the pedal.
 5. Loosen the same brake pipe fitting to purge air from the open port of the assembly.
 6. Tighten the brake pipe fitting, then have the assistant slowly release the brake pedal.
 7. Wait 15 seconds, then repeat steps 7.4-7.6 until all air is purged from the brake pipe fitting of the

assembly.

8. Repeat steps 7.1-7.7 for all of the remaining ports of the assembly.
9. After bleeding each port of the assembly, tighten all of the brake pipe fittings on the assembly. Refer to **Fastener Tightening Specifications**.
10. Fill the master cylinder reservoir to the maximum-full level with GM approved brake fluid from a clean, sealed brake fluid container.
11. Slowly press and release the brake pedal. Observe the brake pedal feel.
12. If the brake pedal feels spongy, proceed to step 8.
13. If the brake pedal feels firm, proceed to step 24.

NOTE: **The pressure bleeding equipment must be the diaphragm type. The rubber diaphragm between the air supply and the brake fluid prevents air, moisture, oil, and other contaminants from entering the hydraulic system.**

8. Following the brake pressure bleeder manufacturer's instructions, fill the brake pressure bleeder with GM approved brake fluid from a clean, sealed brake fluid container.
9. Install the appropriate master cylinder reservoir adapter and connect the brake pressure bleeder.
10. Charge the brake pressure bleeder air tank to 170-200 kPa/1.7-2.0 bar (25-30 psi), or as recommended by the brake pressure bleeder manufacturer's instructions.
11. Open the brake pressure bleeder fluid tank valve to allow pressurized brake fluid to enter the brake hydraulic system.

NOTE: **Any brake fluid leaks identified require repair prior to completing this procedure.**

12. Wait approximately 30 seconds, then inspect the entire hydraulic brake system for external brake fluid leaks.
13. Install a proper box-end wrench onto the RIGHT REAR wheel hydraulic circuit bleeder valve.
14. Install a transparent hose over the end of the bleeder valve.
15. Submerge the open end of the transparent hose into a transparent container partially filled with GM approved brake fluid from a clean, sealed brake fluid container.
16. Have an assistant slowly press the brake pedal fully and maintain steady pressure on the brake pedal.
17. Loosen the bleeder valve to purge air from the wheel hydraulic circuit.
18. Tighten the bleeder valve, then have the assistant slowly release the brake pedal.
19. Wait 15 seconds, then repeat steps 11-13 until all air is purged from the wheel hydraulic circuit.
20. Tighten the RIGHT REAR hydraulic wheel circuit bleeder valve securely.
21. Install a proper box-end wrench onto the LEFT REAR wheel hydraulic circuit bleeder valve, then repeat steps 9-14.
22. Install a proper box-end wrench onto the RIGHT FRONT wheel hydraulic circuit bleeder valve, then repeat steps 9-14.
23. Install a proper box-end wrench onto the LEFT FRONT wheel hydraulic circuit bleeder valve, then repeat steps 9-14.

24. After completing the final wheel hydraulic circuit bleeding procedure, tighten all of the wheel hydraulic circuit bleeder valves and install the bleeder valve dust caps.
25. Close the brake pressure bleeder fluid tank valve.

NOTE: The brake reservoir may have residual pressure after the bleeding operation is complete. Wrap a clean shop towel around the bleeder adapter and all hose connections before disconnecting the pressure bleeding equipment to prevent brake fluid from contacting and damaging vehicle components and painted surfaces.

26. Remove the brake pressure bleeding equipment from the vehicle.
27. Fill the brake master cylinder reservoir to the maximum-full level with GM approved brake fluid from a clean, sealed brake fluid container. Refer to **Fluid and Lubricant Recommendations** .
28. Slowly press and release the brake pedal. Observe the brake pedal feel.
29. If the brake pedal feels spongy, perform the following procedure.
 1. If equipped with antilock brakes, install a scan tool and perform the **Antilock Brake System Automated Bleed** to remove air which may be trapped in the BPMV.
 2. Inspect the hydraulic brake system for external leaks. Refer to **Brake System External Leak Inspection**.
 3. Repeat the Bleeding the Complete Brake Hydraulic System procedure.
30. If the brake pedal still feels spongy, pressure bleed the hydraulic brake system. Refer to **Hydraulic Brake System Bleeding (Manual)**, **Hydraulic Brake System Bleeding (Pressure)** .
31. Turn the ignition switch ON with the engine OFF. Check to see if the brake system warning lamp remains illuminated.

NOTE: DO NOT allow the vehicle to be driven until the brake system is diagnosed and repaired.

32. If the brake system warning lamp remains illuminated, refer to **Diagnostic Starting Point - Vehicle** .

HYDRAULIC BRAKE SYSTEM FLUSHING

WARNING: Refer to **Brake Fluid Irritant Warning** .

CAUTION: Refer to **Brake Fluid Effects on Paint and Electrical Components Caution** .

1. Inspect the brake fluid for the following conditions, indicating brake fluid contamination:
 - Fluid separation, indicating 2 types of fluid are present; a substance other than the recommended brake fluid has been introduced into the brake hydraulic system
 - Swirled appearance - oil-based substance

- Layered appearance - silicone-based substance
- Fluid discoloration, indicating the presence of moisture or particles that have been introduced into the brake hydraulic system
 - Cloudy appearance - moisture
 - Dark appearance/suspended particles in fluid - dirt, rust, corrosion, brake dust
- 2. Inspect the master cylinder reservoir cap diaphragm and the reservoir-to-master cylinder grommets for swelling, indicating brake fluid contamination.
- 3. If the brake fluid WAS contaminated with an oil-based or a silicone-based substance, indicated by fluid separation and/or a swollen master cylinder reservoir cap diaphragm and/or swollen reservoir-to-master cylinder grommets, perform the following:
 1. Remove ALL of the following components listed from the vehicle. Each component contains internal rubber seals/linings which have been contaminated by the contaminated brake fluid in the brake hydraulic system.

Refer to the procedures indicated:

- **Master Cylinder Reservoir Replacement**
- **Master Cylinder Replacement**
- **Front Brake Hose Replacement**
- **Rear Brake Hose Replacement**
- **Front Brake Caliper Replacement (J55, J56) , Front Brake Caliper Replacement (J56 without F46, JE2)**
- **Rear Brake Caliper Replacement**
- **Brake Pressure Modulator Valve Replacement**
- 2. Clean out all the hydraulic brake pipes using denatured alcohol, or equivalent.
- 3. Dry the brake pipes using non-lubricated, filtered air.
- 4. Repair or replace ALL of the following components listed and install them to the vehicle. Each component contains internal rubber seals/linings which have been contaminated by the contaminated brake fluid in the brake hydraulic system.

Refer to the procedures indicated:

- **Master Cylinder Replacement** ; also perform the following:

Clean the brake master cylinder reservoir using denatured alcohol, or equivalent, then dry the reservoir using non-lubricated, filtered air. Inspect the reservoir for cracks and/or damage and replace if necessary. Refer to **Master Cylinder Reservoir Replacement**.

Replace the brake master cylinder reservoir cap diaphragm.

- **Front Brake Hose Replacement**
- **Rear Brake Hose Replacement**
- **Front Brake Caliper Replacement (J55, J56) , Front Brake Caliper Replacement (J56**

without F46, JE2)

- **Rear Brake Caliper Replacement**
- **Brake Pressure Modulator Valve Replacement**

4. If the brake fluid was NOT contaminated with an oil-based or a silicone-based substance, but WAS contaminated with water or dirt, rust, corrosion, and/or brake dust, replace the brake master cylinder reservoir cap diaphragm. The diaphragm may have allowed the moisture or particles to enter the hydraulic system.
5. Fill the brake master cylinder reservoir to the maximum-fill level with approved brake fluid from a clean, sealed brake fluid container as specified in the owners manual.
6. Pressure bleed the hydraulic brake system. Begin the procedure with the pressure bleeder reservoir filled to the maximum-fill level with the correct brake fluid as indicated. Refer to **Hydraulic Brake System Bleeding (Manual)**, **Hydraulic Brake System Bleeding (Pressure)**.

POWER VACUUM BRAKE BOOSTER REPLACEMENT

Removal Procedure

1. With the engine OFF, apply and release the brake pedal several times until the pedal becomes firm to deplete the power vacuum brake booster vacuum reserve.
2. Remove the left front end sheet metal diagonal brace. Refer to **Front End Sheet Metal Diagonal Brace Replacement - Left Side**.

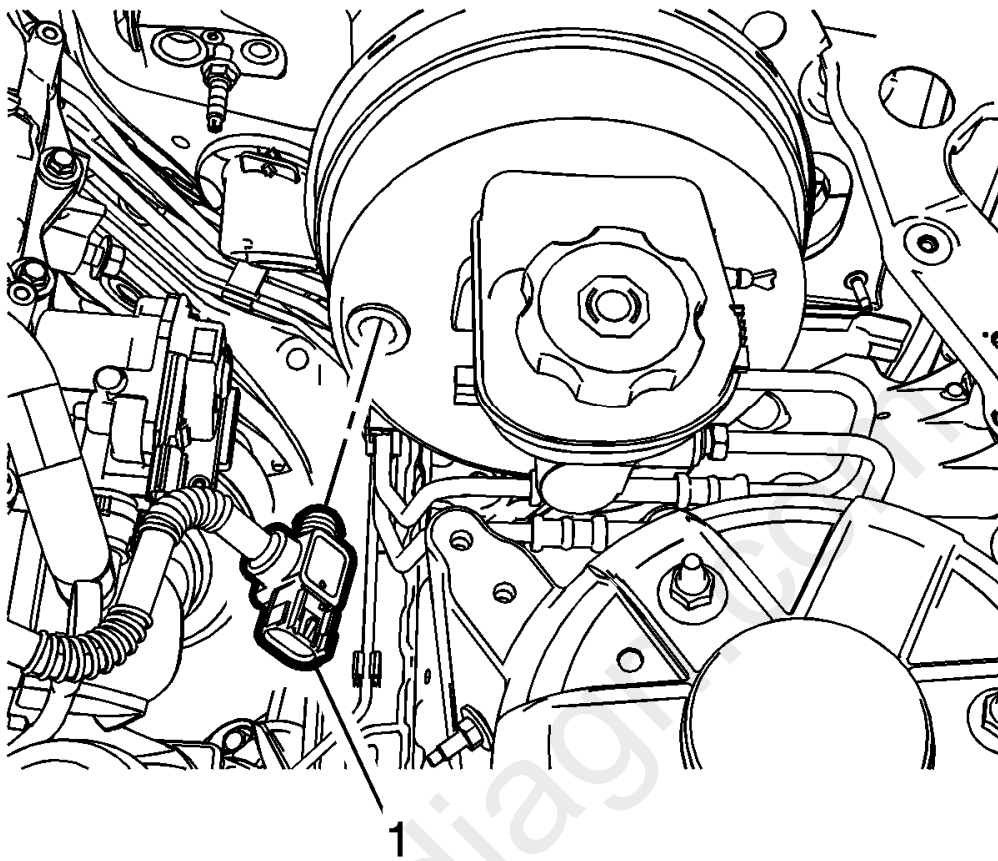


Fig. 79: Brake Vacuum Booster Check Valve
Courtesy of GENERAL MOTORS COMPANY

3. Disconnect the power brake booster vacuum sensor electrical connector.
4. Remove the power brake booster vacuum sensor (1) and hose assembly from the power vacuum brake booster and position aside.
5. Remove the master cylinder. Refer to **Master Cylinder Replacement**.
6. Remove the brake pedal position sensor. Refer to **Brake Pedal Position Sensor Replacement**.

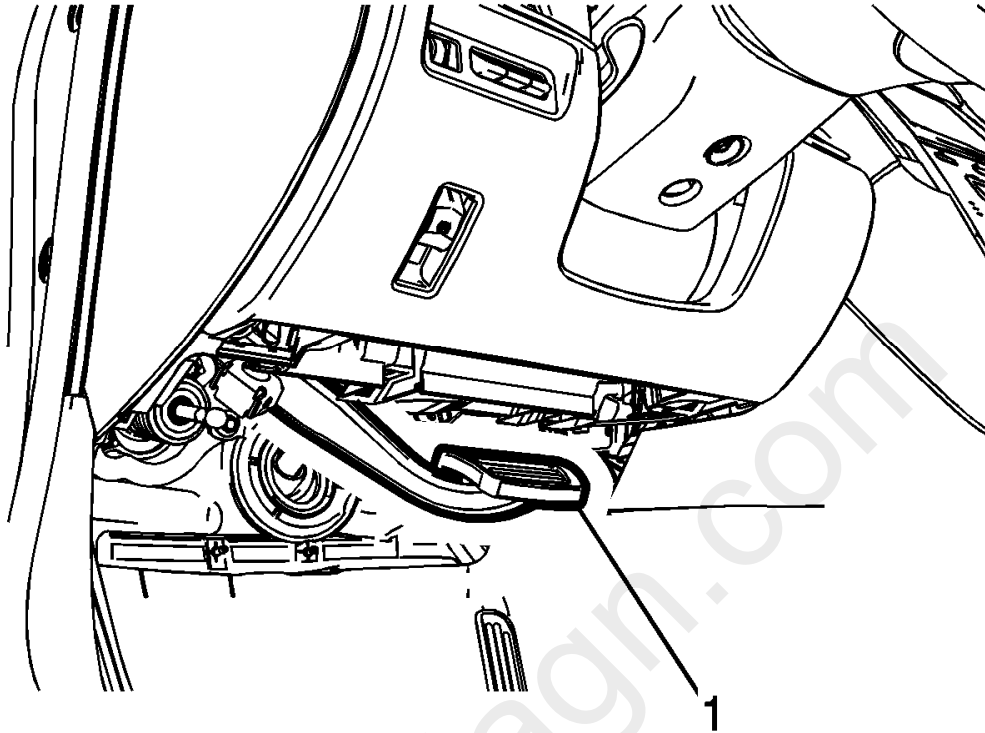


Fig. 80: Brake Pedal

Courtesy of GENERAL MOTORS COMPANY

7. Release the brake pedal (1) from the power vacuum brake booster pushrod by lifting the pedal upward.

NOTE: **Do not reuse the brake pedal retainer.**

8. Remove and discard the power brake booster pushrod retainer.

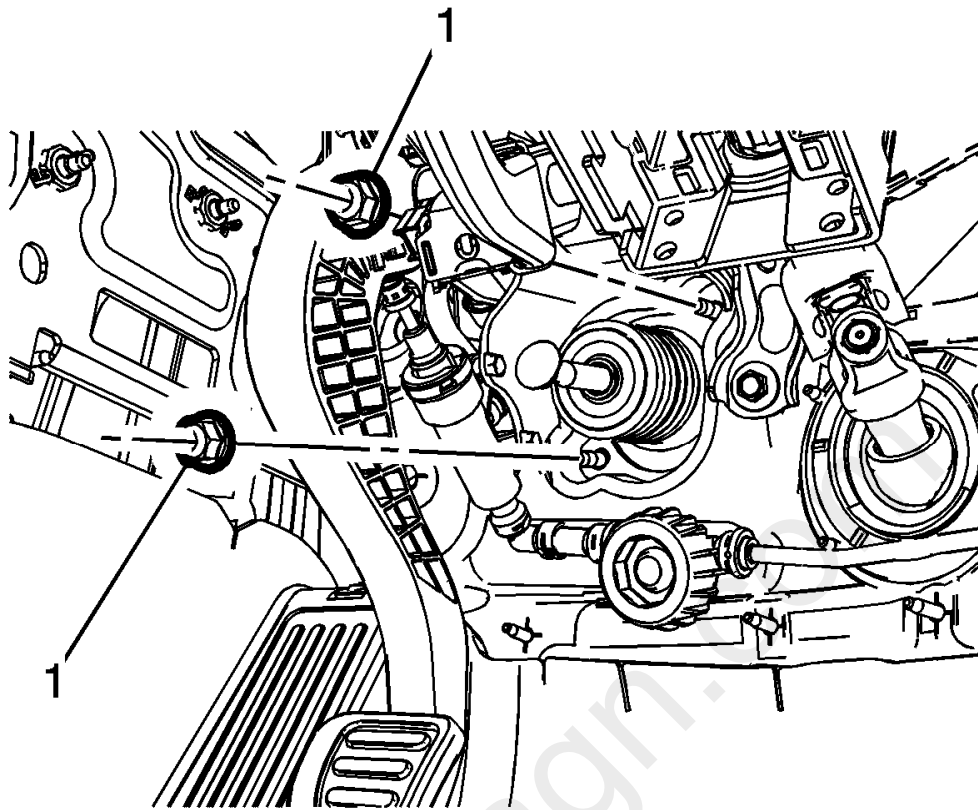


Fig. 81: Power Vacuum Brake Booster Nuts
Courtesy of GENERAL MOTORS COMPANY

9. Remove the power vacuum brake booster nuts (1).

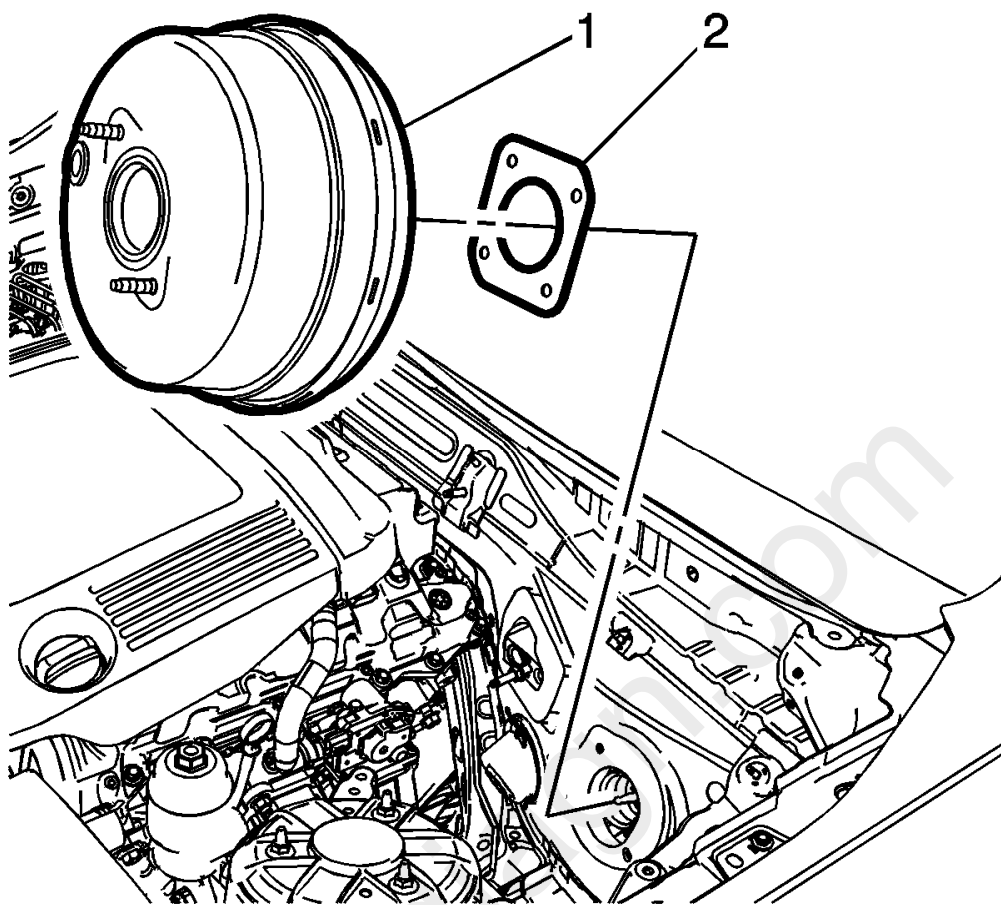


Fig. 82: Power Vacuum Brake Booster
Courtesy of GENERAL MOTORS COMPANY

10. Remove the power vacuum brake booster (1).
11. Inspect the power vacuum brake booster gasket (2) for damage and replace, if necessary.

Installation Procedure

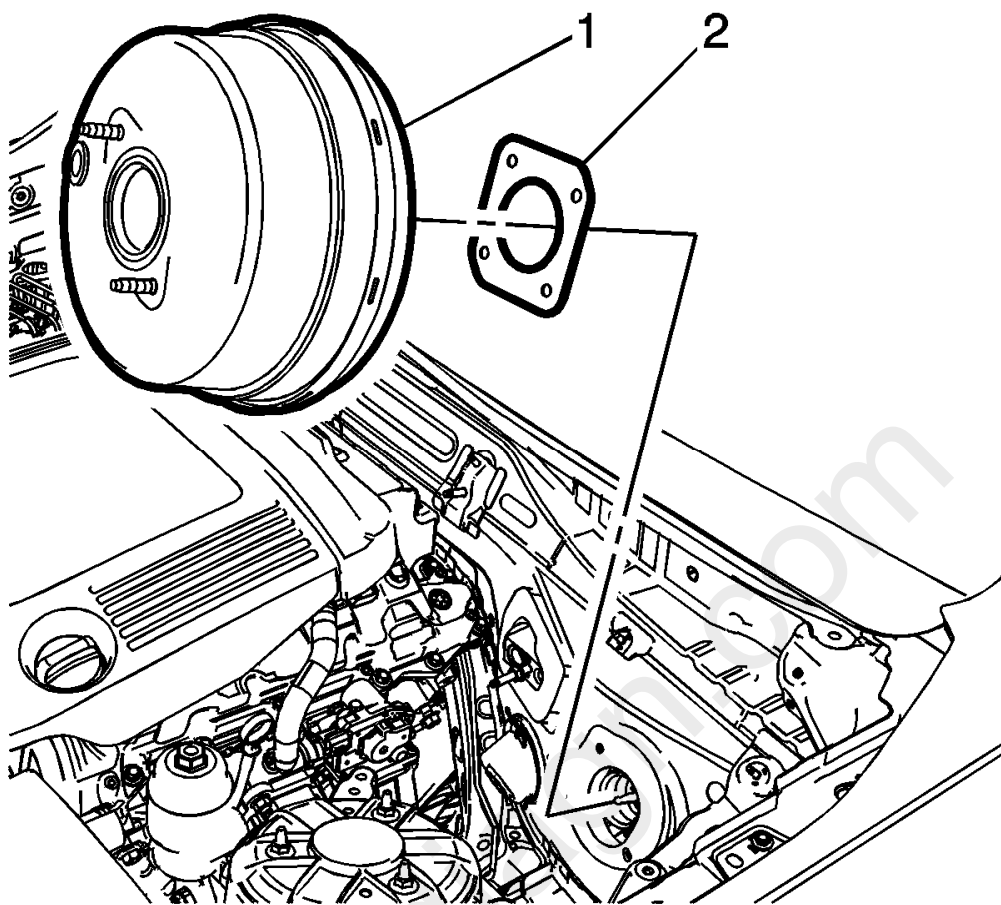


Fig. 83: Power Vacuum Brake Booster
Courtesy of GENERAL MOTORS COMPANY

1. Install the power vacuum brake booster (1) and gasket (2).

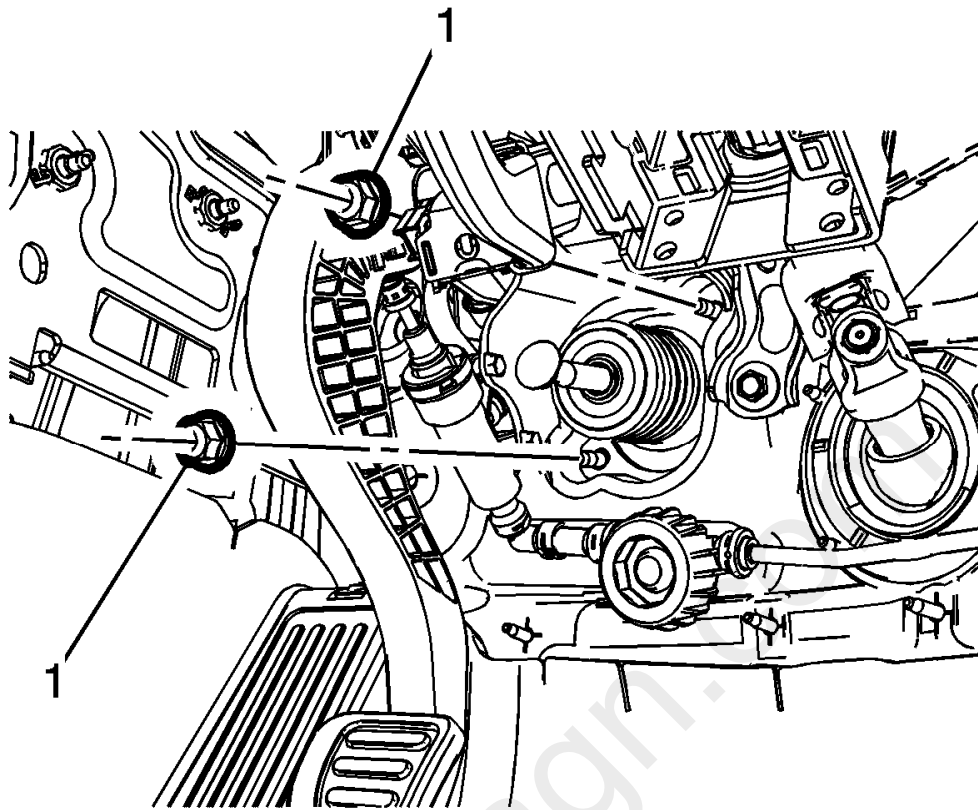


Fig. 84: Power Vacuum Brake Booster Nuts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install the power vacuum brake booster nuts (1) and tighten to 25 (18 lb ft).

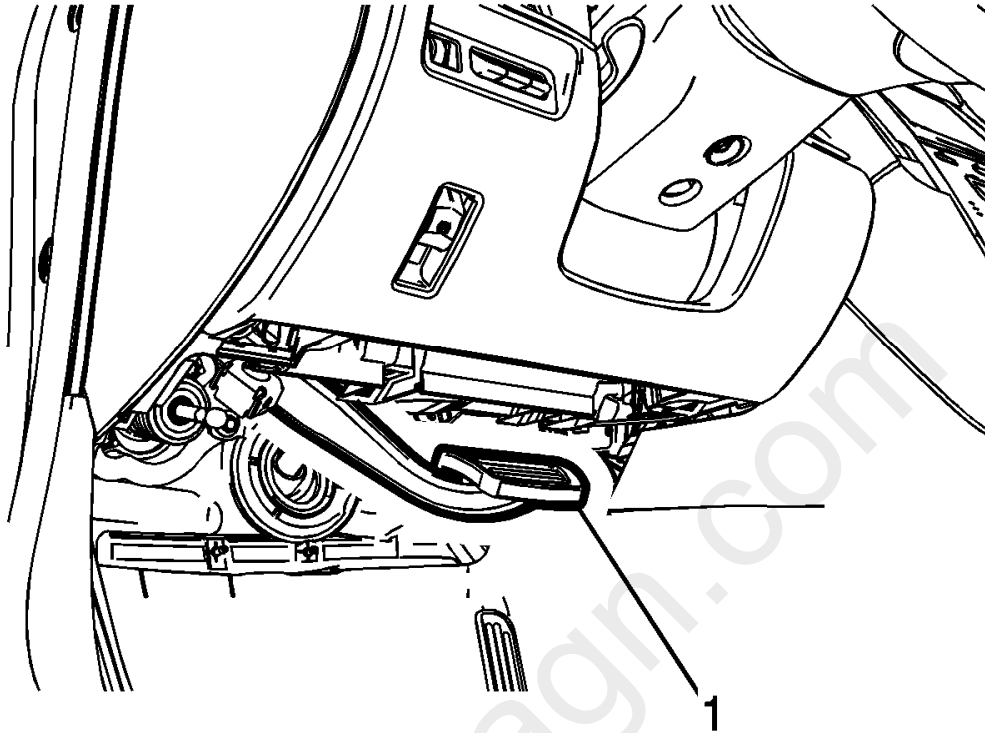


Fig. 85: Brake Pedal

Courtesy of GENERAL MOTORS COMPANY

NOTE: Install a new power brake booster pushrod retainer.

3. Install a new power brake booster pushrod retainer to the brake pedal arm.
4. Install the brake pedal (1) to the power brake booster pushrod.
5. Install the brake pedal position sensor. Refer to **Brake Pedal Position Sensor Replacement** .
6. Install the master cylinder. Refer to **Master Cylinder Replacement**.

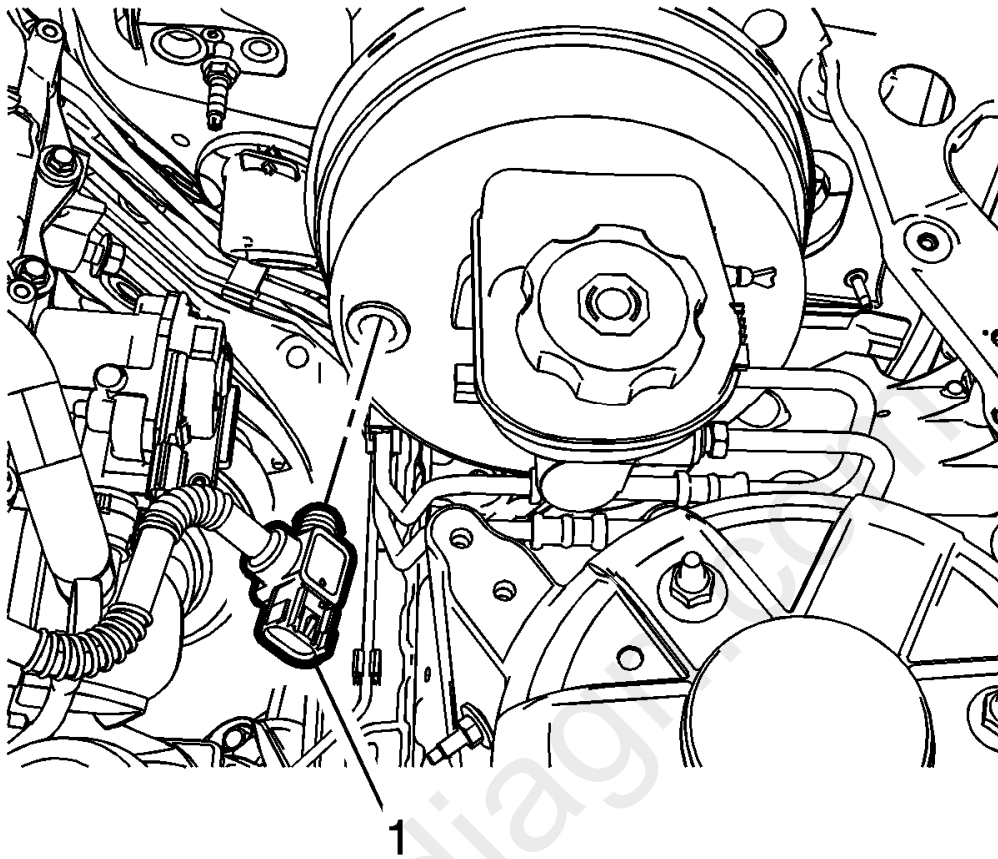


Fig. 86: Brake Vacuum Booster Check Valve
Courtesy of GENERAL MOTORS COMPANY

NOTE: A small amount of denatured alcohol may be used as a lubricant for assembly. Do not use soap.

7. Install the power brake booster vacuum sensor (1) to the power vacuum brake booster.
8. Connect the power brake booster vacuum sensor electrical connector.
9. Install the left front end sheet metal diagonal brace. Refer to **Front End Sheet Metal Diagonal Brace Replacement - Left Side** .

POWER BRAKE BOOSTER VACUUM CHECK VALVE AND HOSE REPLACEMENT (LTG)

Removal Procedure

1. Apply the brake pedal several times until the pedal becomes firm to deplete the vacuum reserve in the brake booster.
2. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .

3. Remove the outer fuel pump insulator. Refer to **Fuel Pump Insulator Replacement (Outer)** .
4. Disconnect the power brake booster vacuum sensor electrical connector.

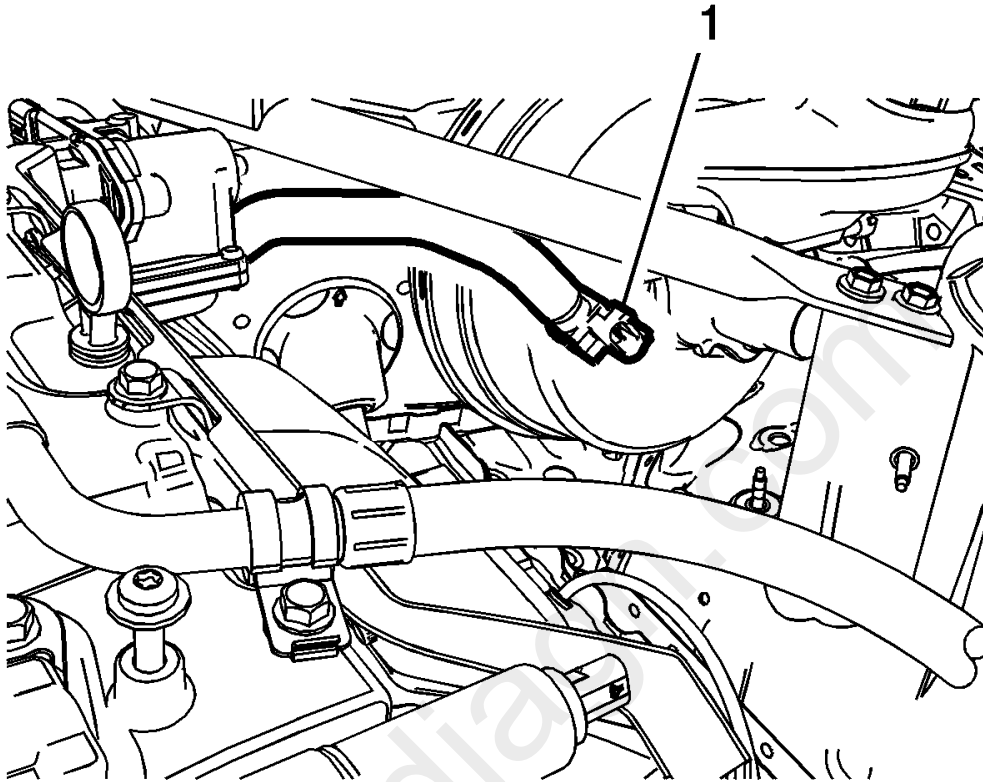


Fig. 87: Power Brake Booster Vacuum Sensor And Hose
Courtesy of GENERAL MOTORS COMPANY

5. Remove the power brake booster vacuum sensor and hose (1) from the power brake booster.

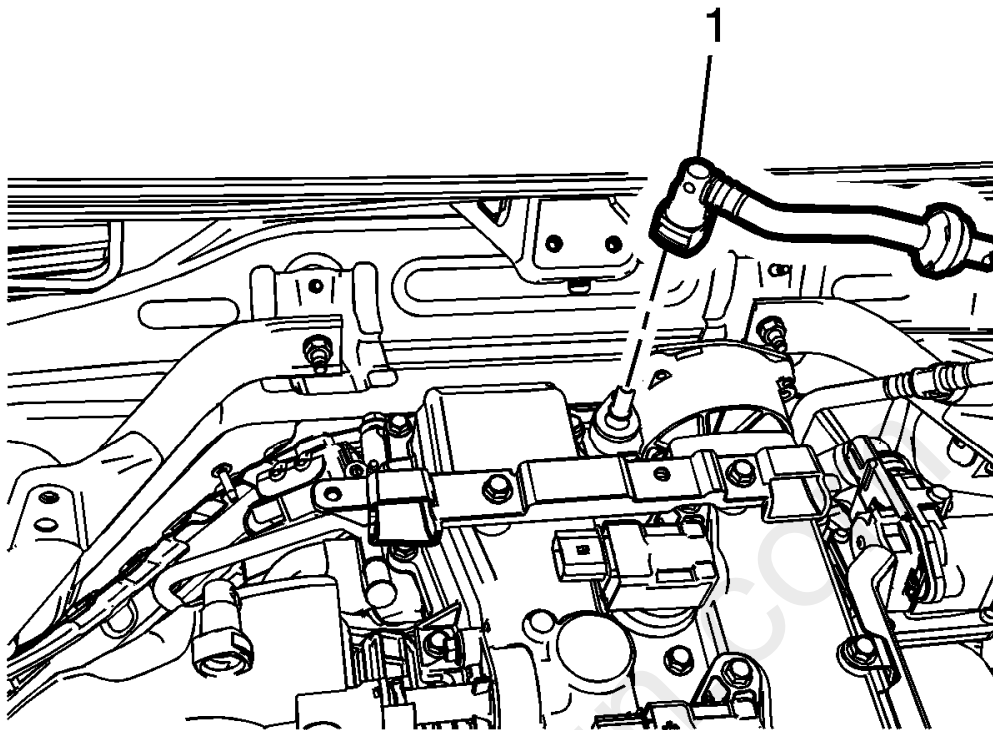


Fig. 88: Power Brake Booster Vacuum Hose Quick Connect
Courtesy of GENERAL MOTORS COMPANY

6. Release the power brake booster vacuum hose quick connect (1) from the power brake booster vacuum pump.

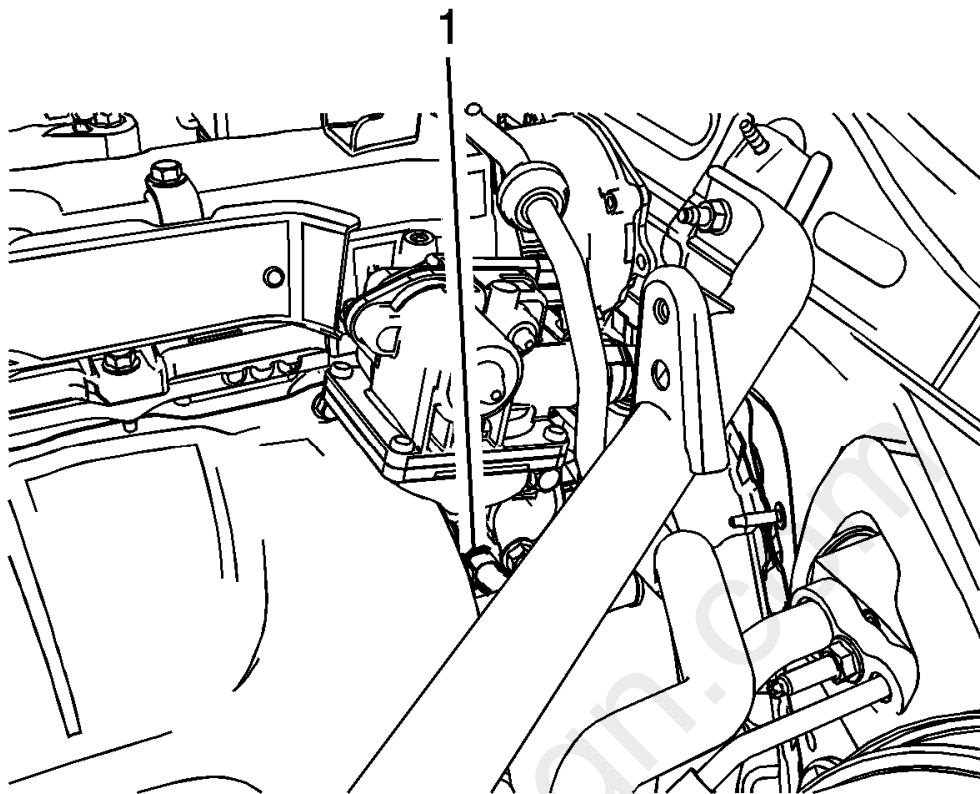


Fig. 89: Power Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

7. Release the power brake booster vacuum hose from the clip (1).

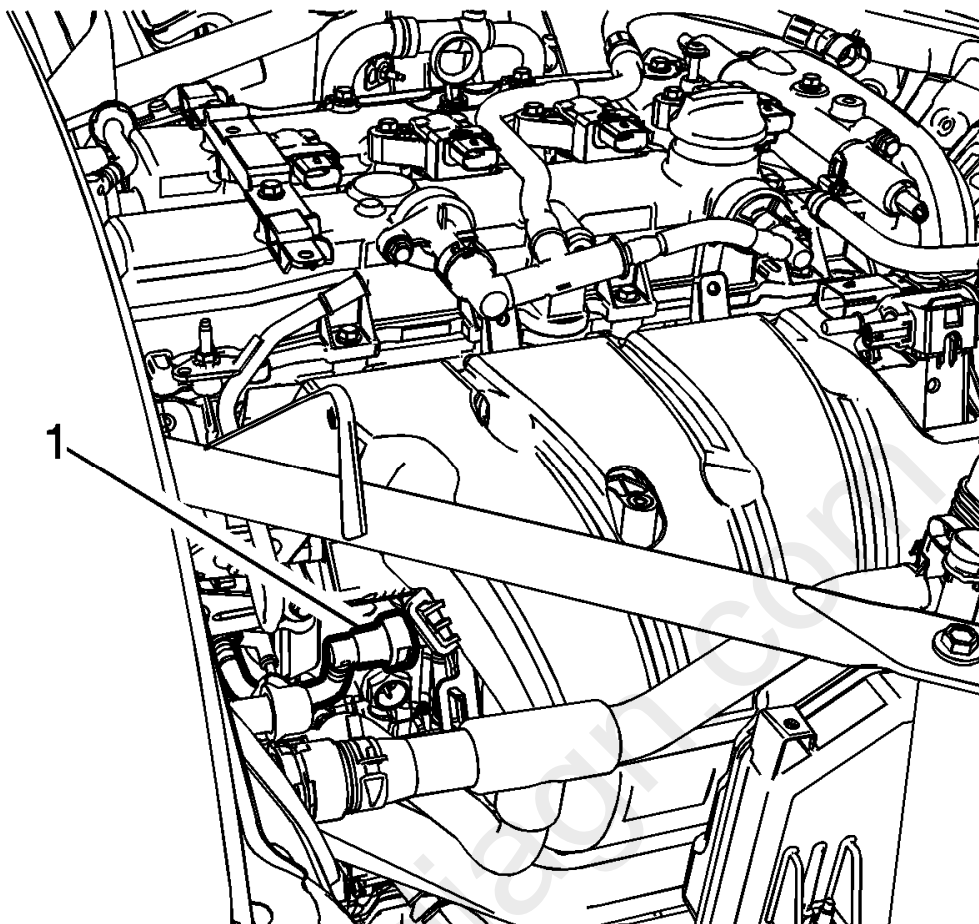


Fig. 90: Quick Connect At Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

8. Release the quick connect (1) and remove the power brake booster vacuum hose from the vacuum port on the intake manifold.

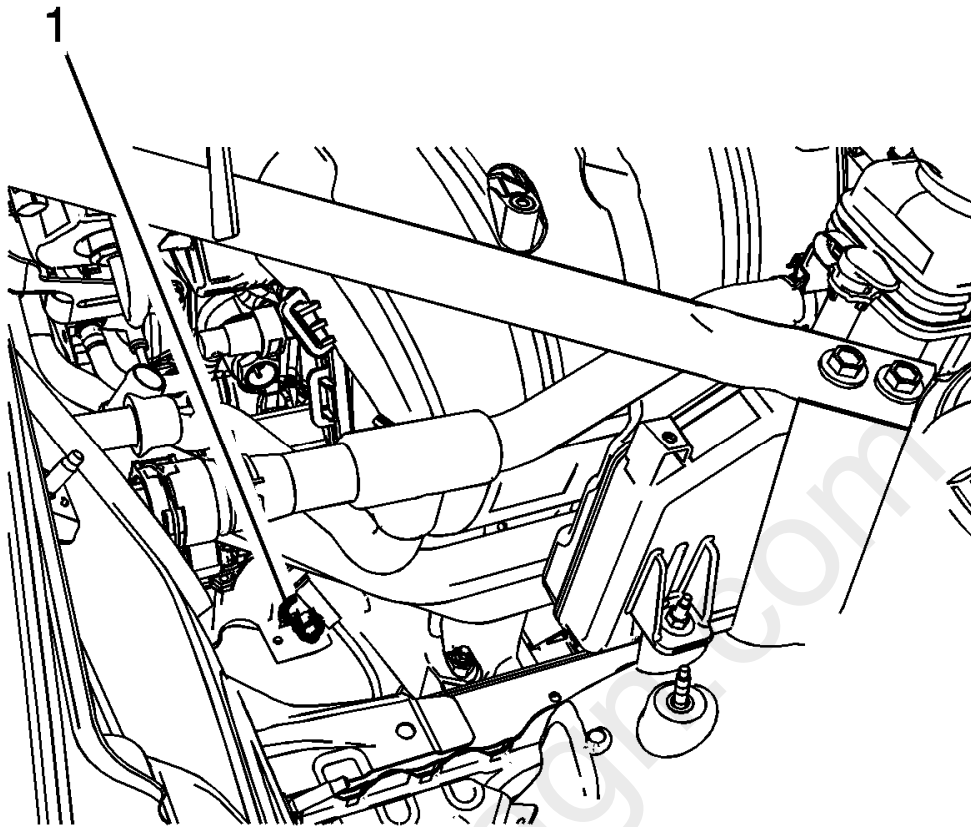


Fig. 91: Vacuum Pipe At Power Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

9. Disconnect the vacuum pipe (1) from the power brake booster vacuum hose.
10. Remove the power brake booster vacuum hose and check valve assembly from the vehicle.

Installation Procedure

1. Install the power brake booster vacuum hose and check valve assembly to the vehicle.

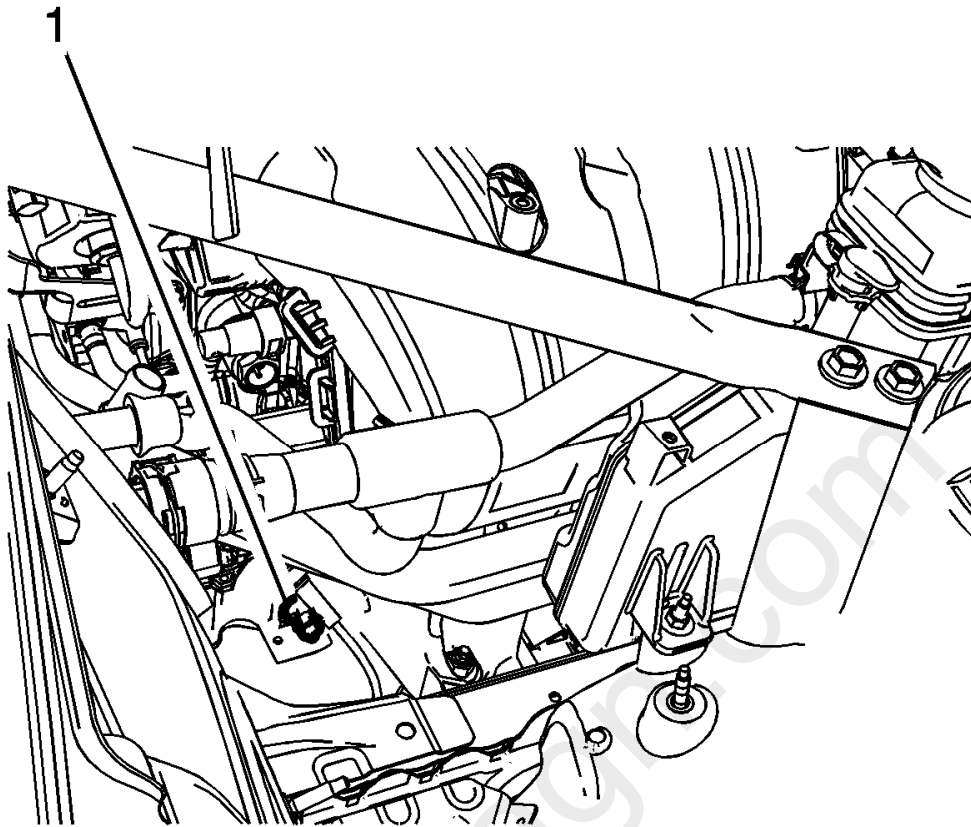


Fig. 92: Vacuum Pipe At Power Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

2. Connect the vacuum pipe (1) to the power brake booster vacuum hose.

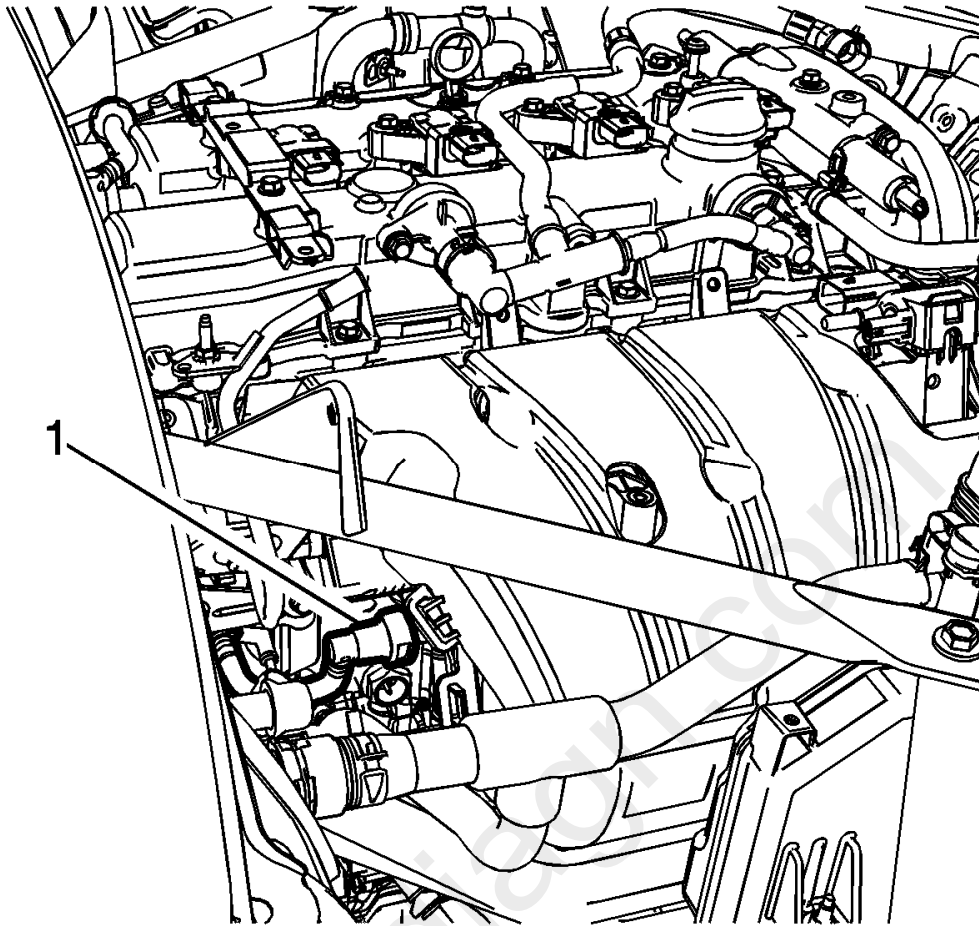


Fig. 93: Quick Connect At Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

3. Install the power brake booster vacuum hose to the vacuum port on the intake manifold and connect the quick connect (1).

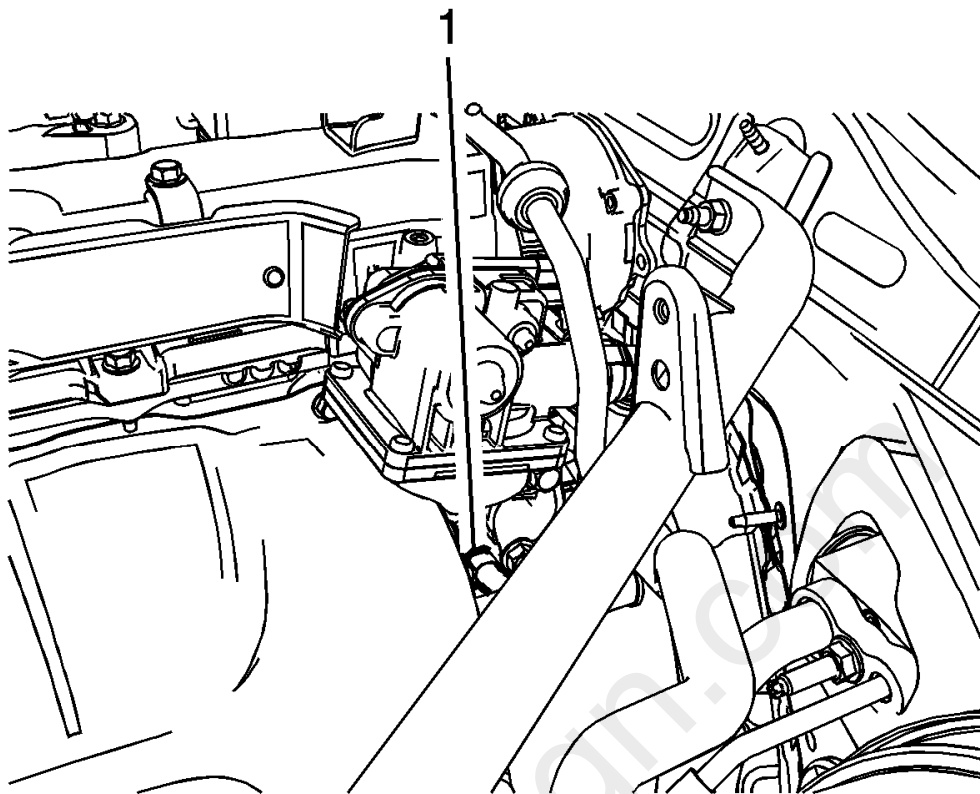


Fig. 94: Power Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

4. Install the power brake booster vacuum hose to the clip (1).

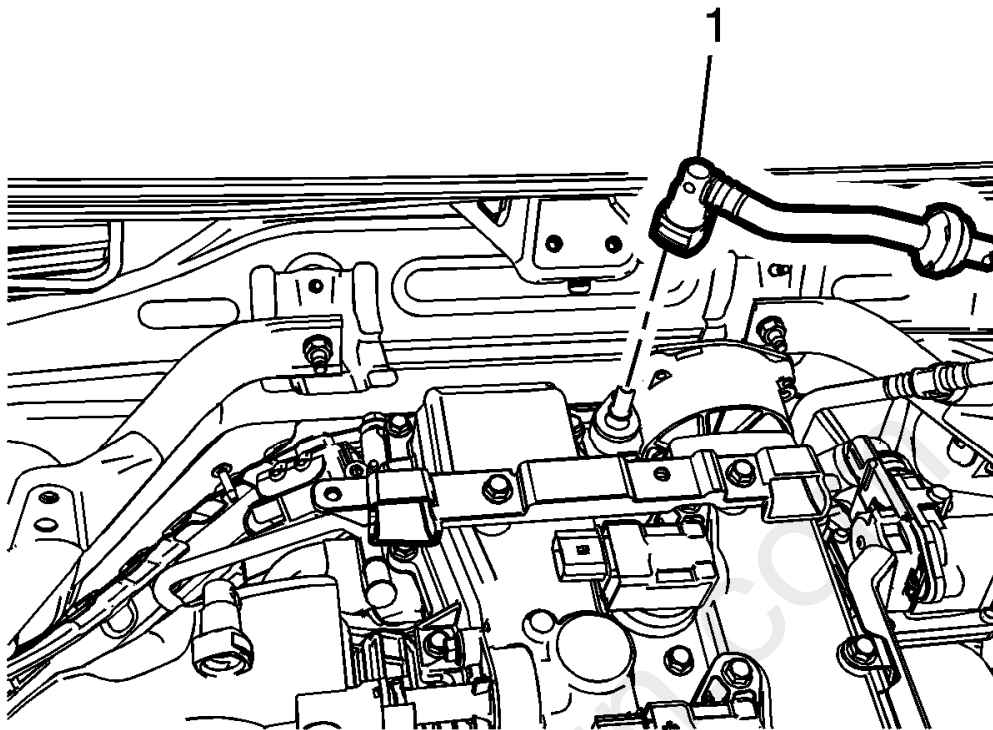


Fig. 95: Power Brake Booster Vacuum Hose Quick Connect
Courtesy of GENERAL MOTORS COMPANY

5. Install the power brake booster vacuum hose quick connect (1) to the power brake booster vacuum pump.

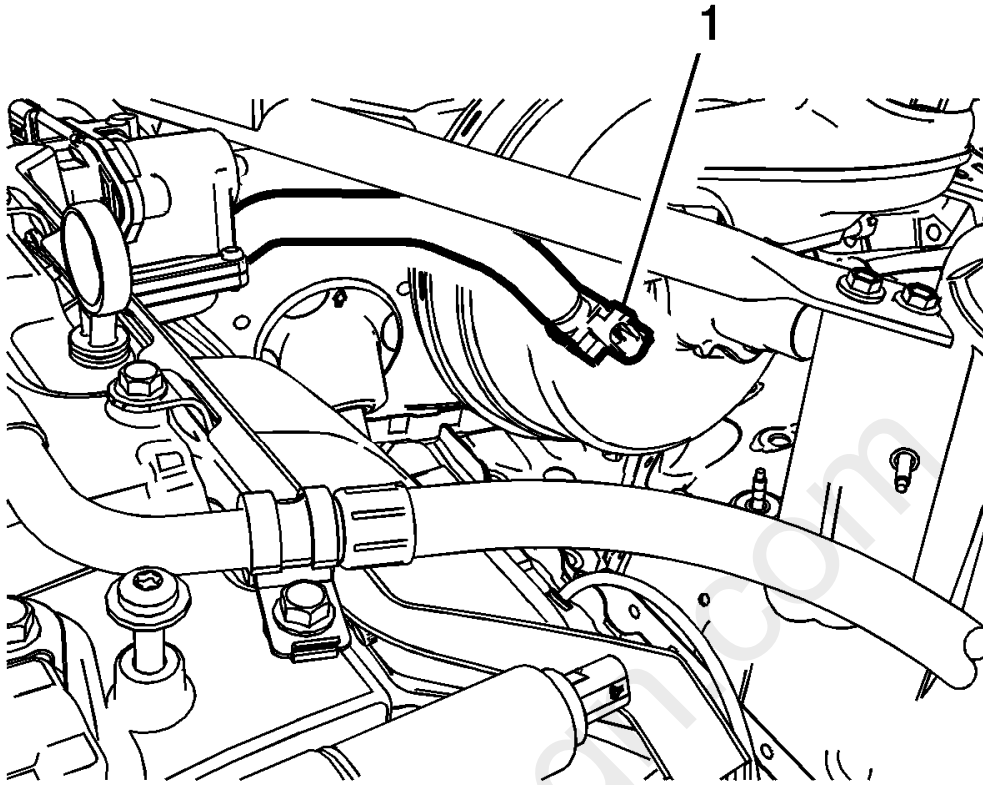


Fig. 96: Power Brake Booster Vacuum Sensor And Hose
Courtesy of GENERAL MOTORS COMPANY

NOTE: A small amount of denatured alcohol may be used as a lubricant for assembly. Do not use soap.

6. Install the power brake booster vacuum sensor and hose (1) to the power brake booster.
7. Connect the power brake booster vacuum sensor electrical connector.
8. Install the outer fuel pump insulator. Refer to **Fuel Pump Insulator Replacement (Outer)** .
9. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .

POWER BRAKE BOOSTER VACUUM CHECK VALVE AND HOSE REPLACEMENT (LFX, LF3)

Removal Procedure

1. Apply the brake pedal several times until the pedal becomes firm to deplete the vacuum reserve in the brake booster.
2. Remove the intake manifold insulator. Refer to **Intake Manifold Insulator Replacement** .

3. Disconnect the power brake booster vacuum sensor electrical connector.

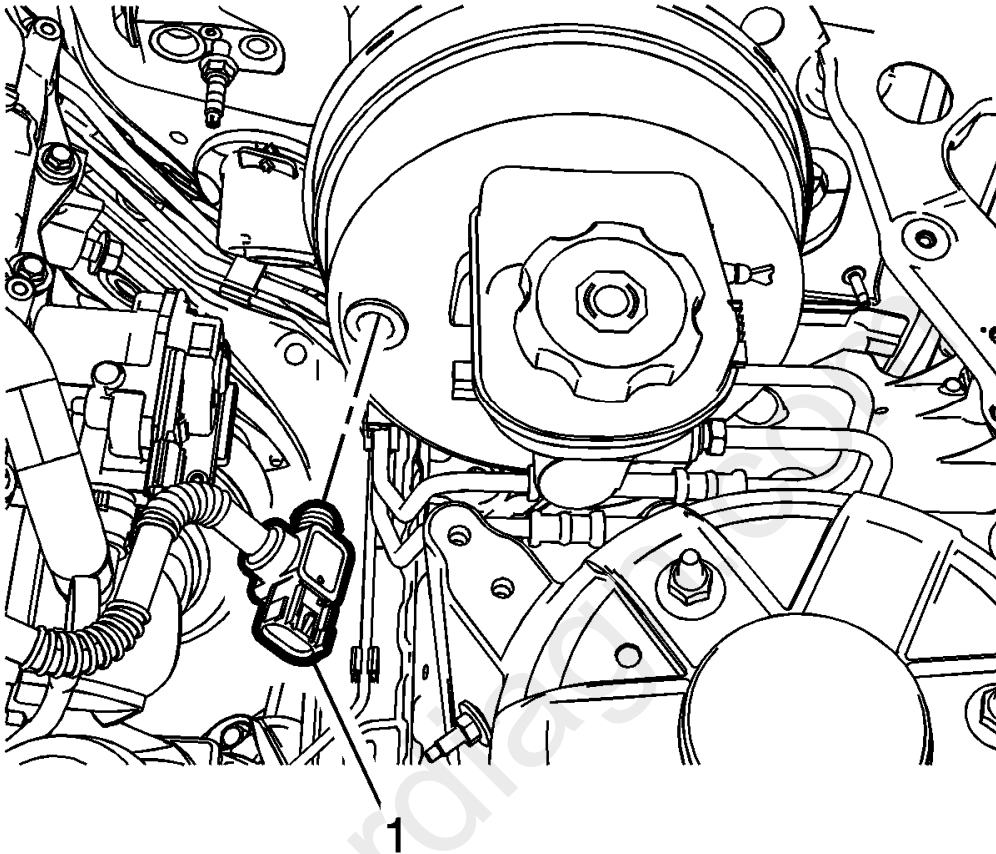


Fig. 97: Brake Vacuum Booster Check Valve
Courtesy of GENERAL MOTORS COMPANY

4. Remove the check valve (1) from the power brake booster.

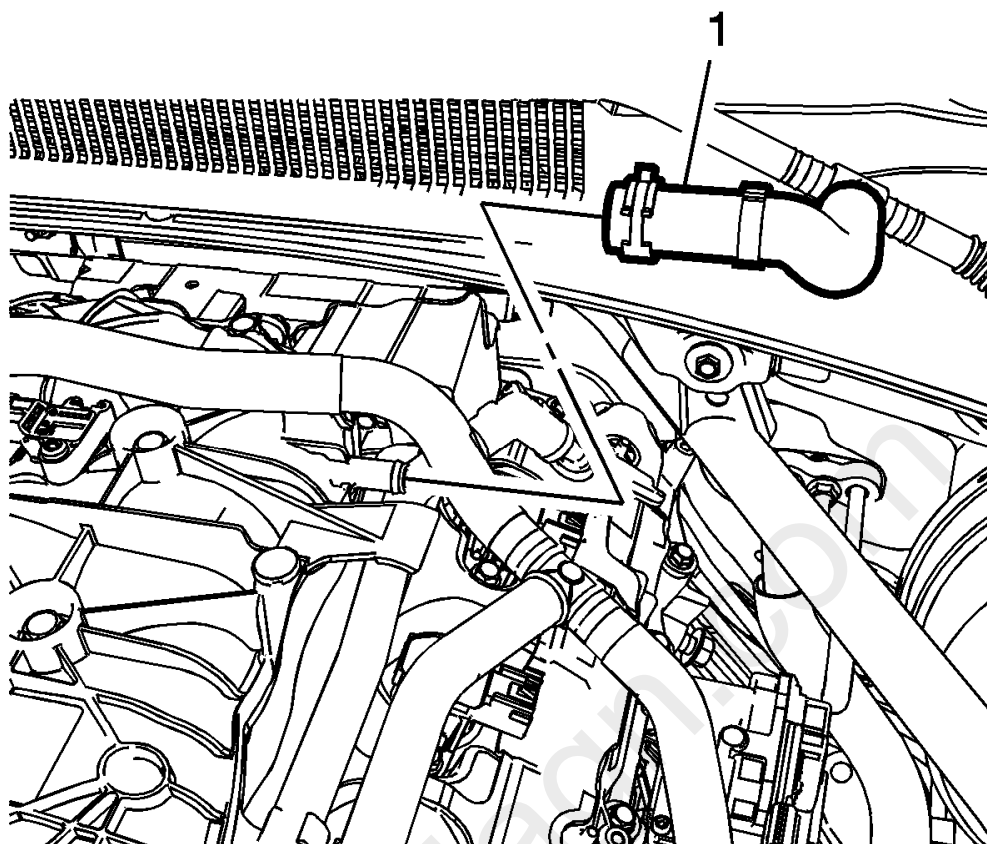


Fig. 98: Power Brake Booster Vacuum Hose At Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

5. Release the clamp and remove the power brake booster vacuum hose (1) from the vacuum port on the intake manifold.

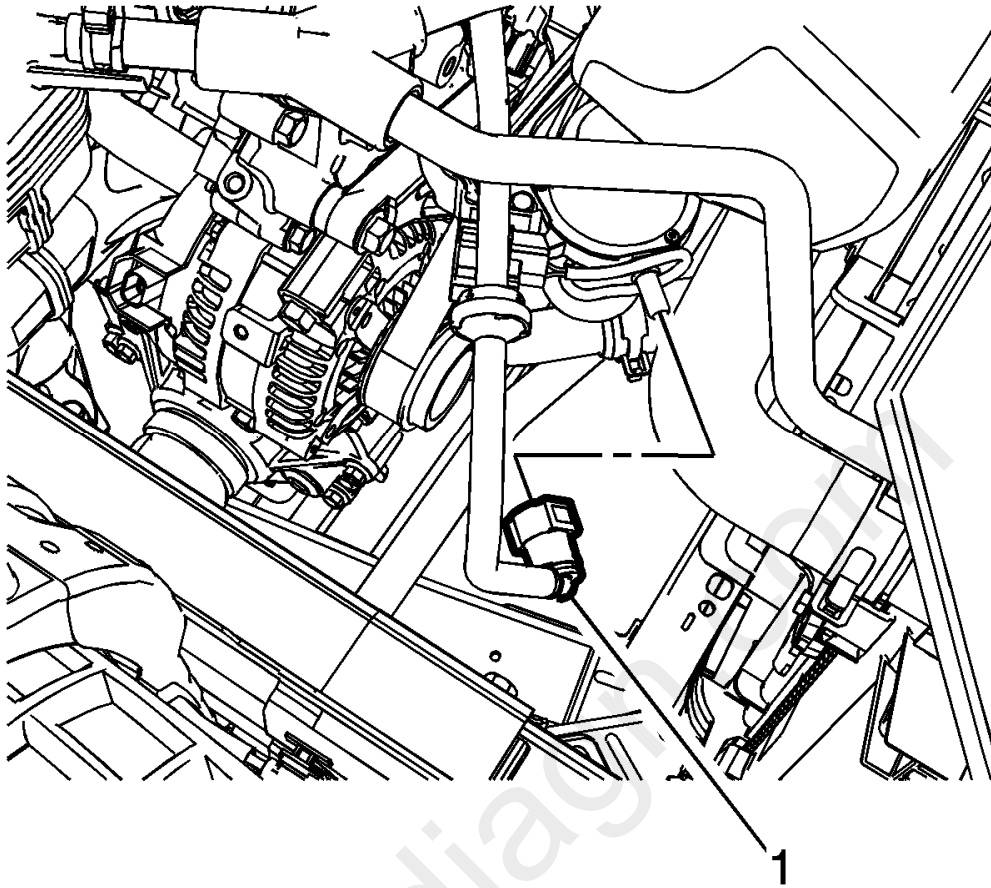


Fig. 99: Power Brake Booster Vacuum Hose Quick Connect
Courtesy of GENERAL MOTORS COMPANY

6. Release the power brake booster vacuum hose quick connect (1) from the power brake booster pump.
7. Remove the power brake booster vacuum hose and check valve assembly from the vehicle.

Installation Procedure

1. Install the power brake booster vacuum hose and check valve assembly to the vehicle.

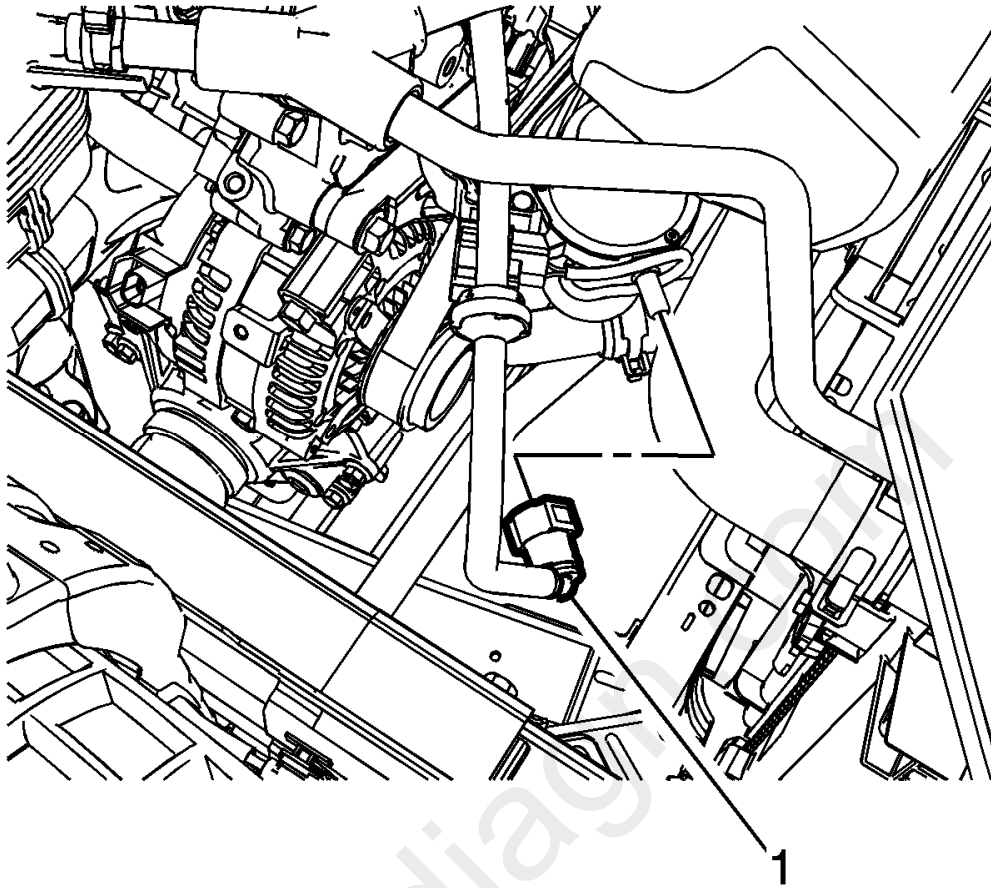


Fig. 100: Power Brake Booster Vacuum Hose Quick Connect
Courtesy of GENERAL MOTORS COMPANY

2. Install the power brake booster vacuum hose quick connect (1) to the power brake booster pump.

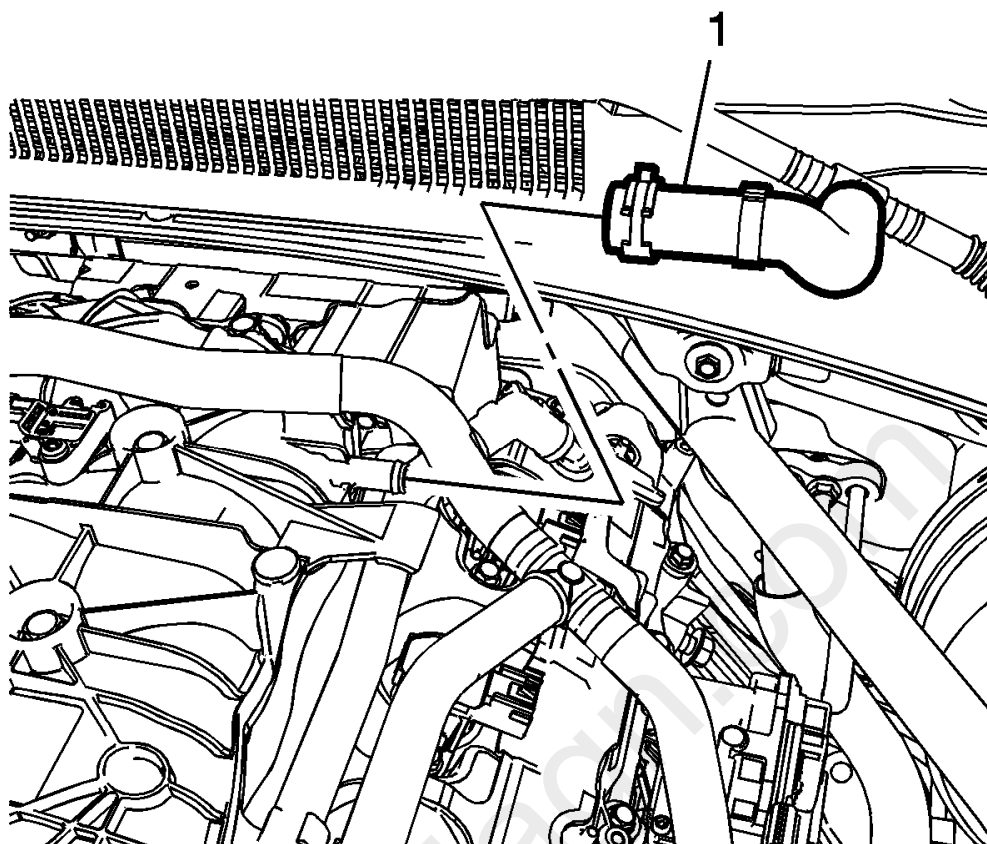


Fig. 101: Power Brake Booster Vacuum Hose At Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

3. Release the clamp and install the power brake booster vacuum hose (1) to the vacuum port on the intake manifold.

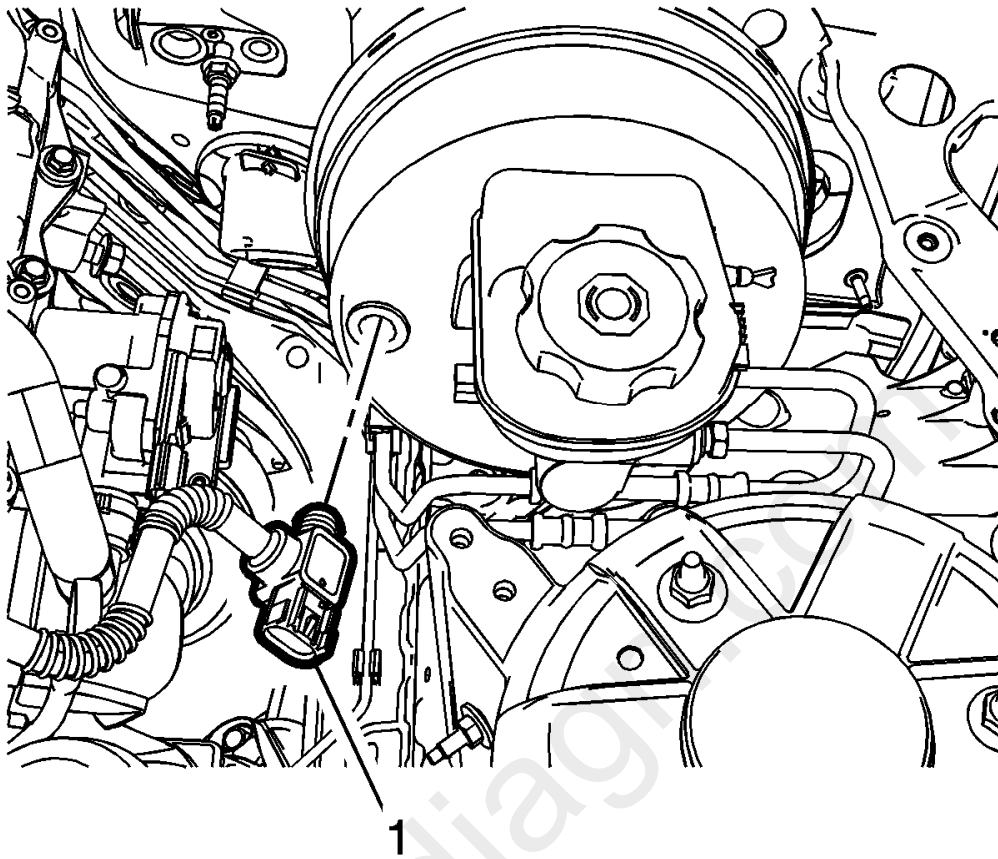


Fig. 102: Brake Vacuum Booster Check Valve
Courtesy of GENERAL MOTORS COMPANY

NOTE: A small amount of denatured alcohol may be used as a lubricant for assembly. Do not use soap.

4. Install the check valve (1) to the power brake booster.
5. Connect the power brake booster vacuum sensor electrical connector.
6. Install the intake manifold insulator. Refer to **Intake Manifold Insulator Replacement** .

POWER BRAKE BOOSTER PUMP REPLACEMENT (LTG)

Removal Procedure

1. Apply the brake pedal several times until the pedal becomes firm to deplete the vacuum reserve in the brake booster.
2. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .
3. Remove the outer fuel pump insulator. Refer to **Fuel Pump Insulator Replacement (Outer)** .

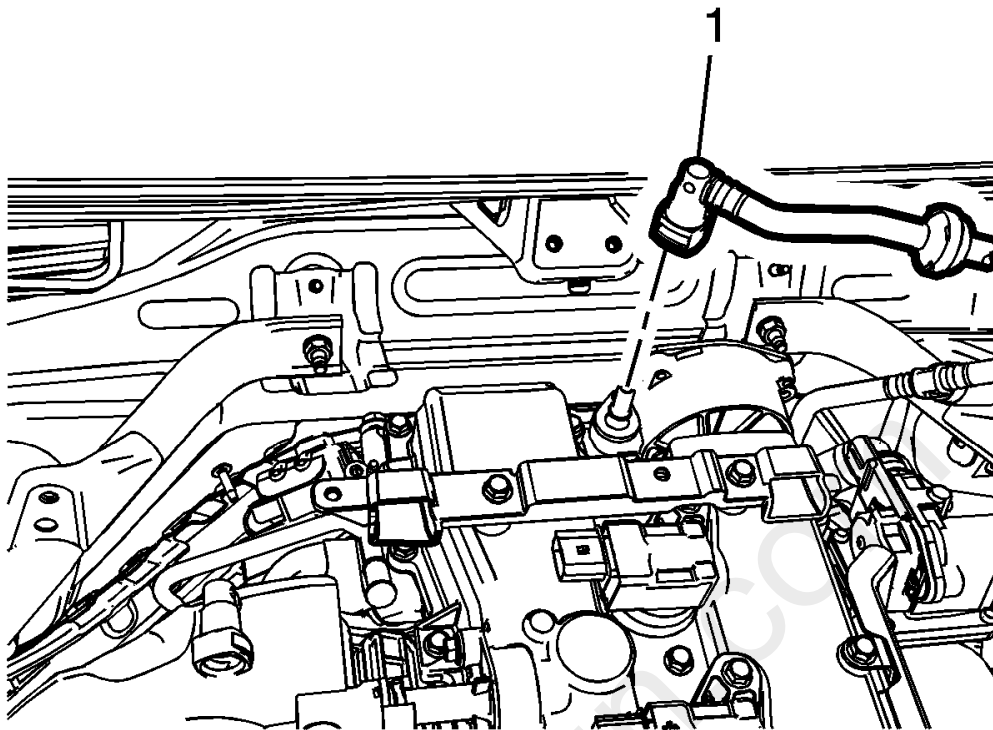


Fig. 103: Power Brake Booster Vacuum Hose Quick Connect
Courtesy of GENERAL MOTORS COMPANY

4. Release the power brake booster vacuum hose quick connect (1) from the power brake booster vacuum pump.

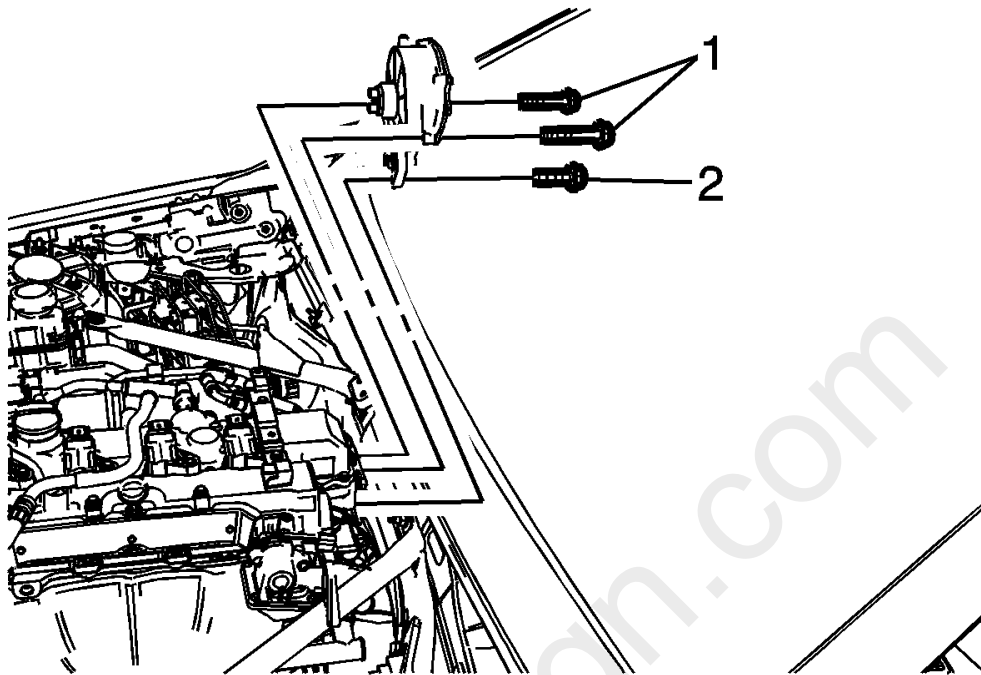


Fig. 104: Upper Bolts At Power Brake Booster Pump
Courtesy of GENERAL MOTORS COMPANY

5. Remove the upper bolts (1) from the power brake booster pump.
6. Remove the lower bolt (2) from the power brake booster pump and remove the pump.

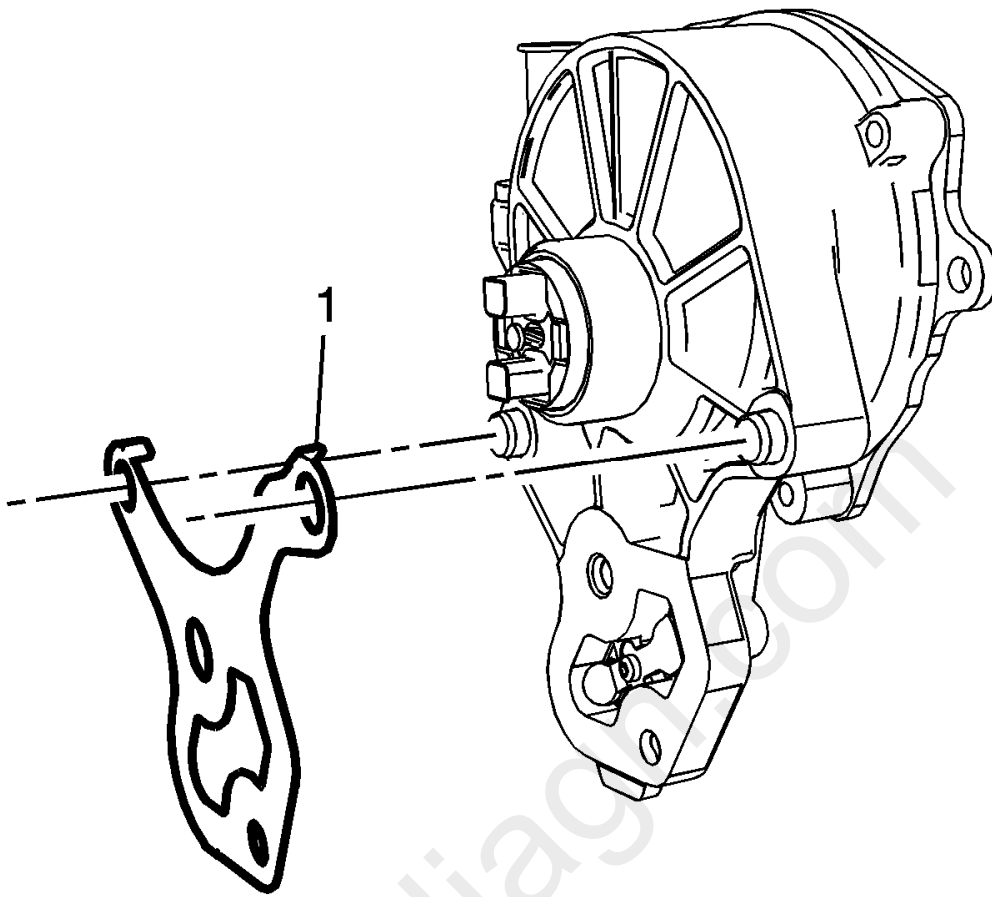


Fig. 105: Power Brake Booster Pump Gasket
Courtesy of GENERAL MOTORS COMPANY

7. Remove the power brake booster pump gasket (1).

Installation Procedure

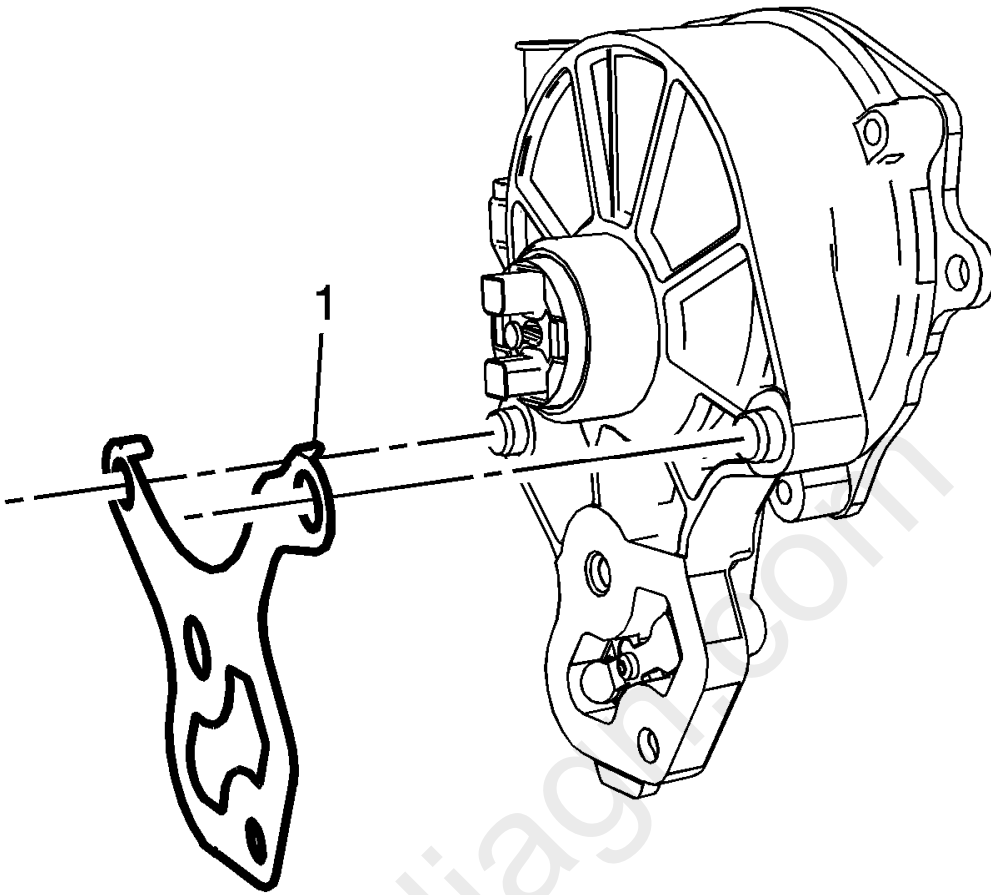


Fig. 106: Power Brake Booster Pump Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Install the power brake booster pump gasket (1).

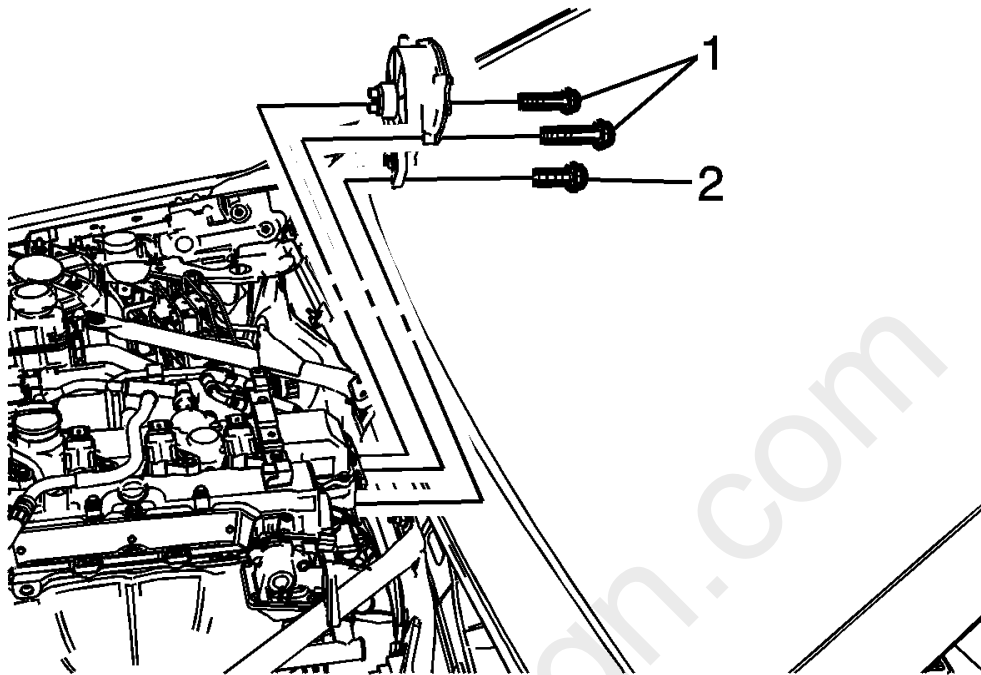


Fig. 107: Upper Bolts At Power Brake Booster Pump
Courtesy of GENERAL MOTORS COMPANY

2. Install the power brake booster pump to the engine.

CAUTION: Refer to Fastener Caution .

3. Install the upper bolts (1) to the power brake booster pump and tighten to 10 (89 lb in).
4. Install the lower bolt (2) to the power brake booster pump and tighten to 10 (89 lb in).

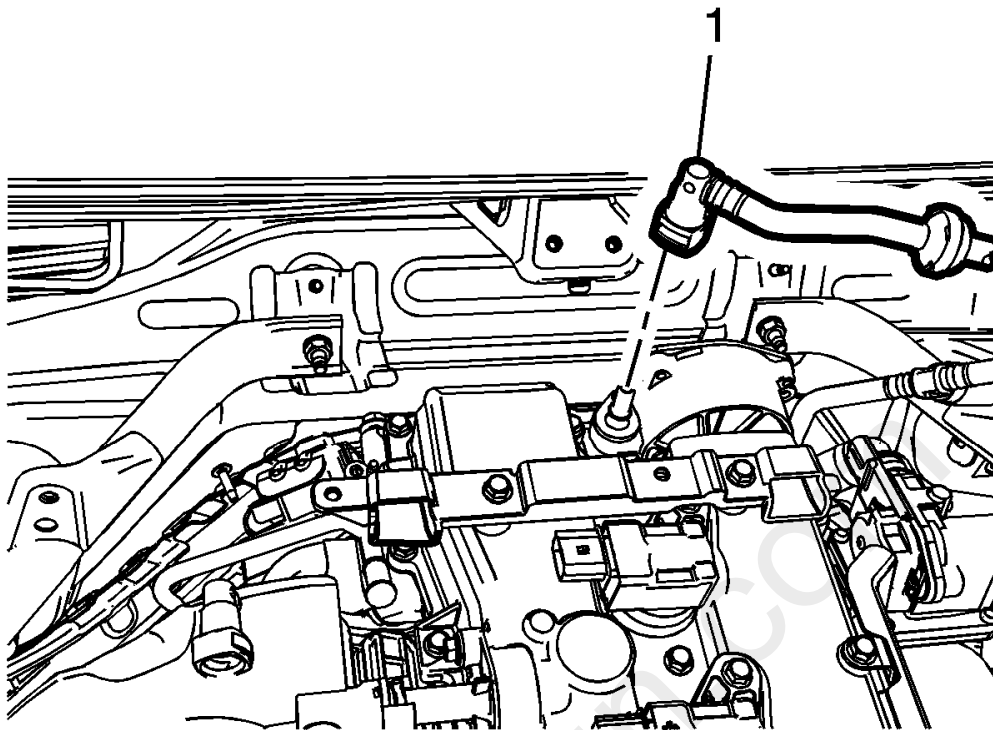


Fig. 108: Power Brake Booster Vacuum Hose Quick Connect
Courtesy of GENERAL MOTORS COMPANY

5. Install the power brake booster vacuum hose quick connect (1) to the power brake booster vacuum pump.
6. Install the outer fuel pump insulator. Refer to **Fuel Pump Insulator Replacement (Outer)** .
7. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .

POWER BRAKE BOOSTER PUMP REPLACEMENT (LFX, LF3)

Removal Procedure

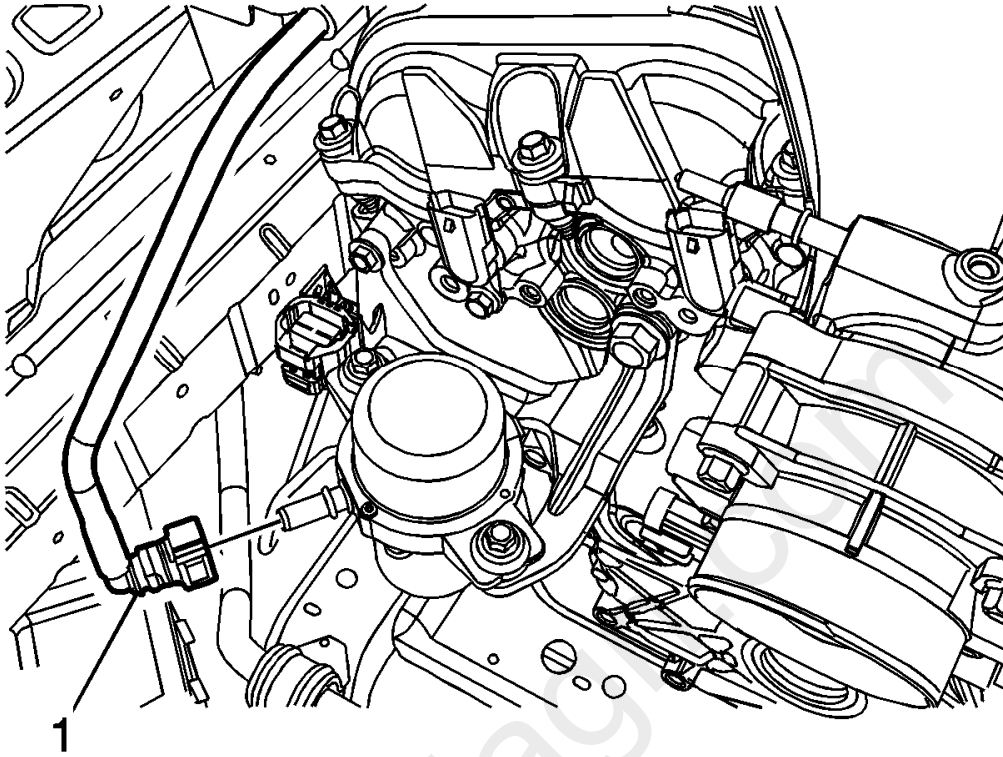


Fig. 109: Power Brake Booster Vacuum Hose Quick Connect At Power Brake Booster Vacuum Pump (LFX)

Courtesy of GENERAL MOTORS COMPANY

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (LFX)** , **Air Cleaner Outlet Duct Replacement (LF3)** .
2. Release the power brake booster pump hose quick connect (1).
3. Disconnect the power brake booster pump hose from the auxiliary pump.
4. Unclip the booster pump hose retainer from the booster pump bracket, reposition the hose.
5. Disconnect the power brake booster pump electrical connector.

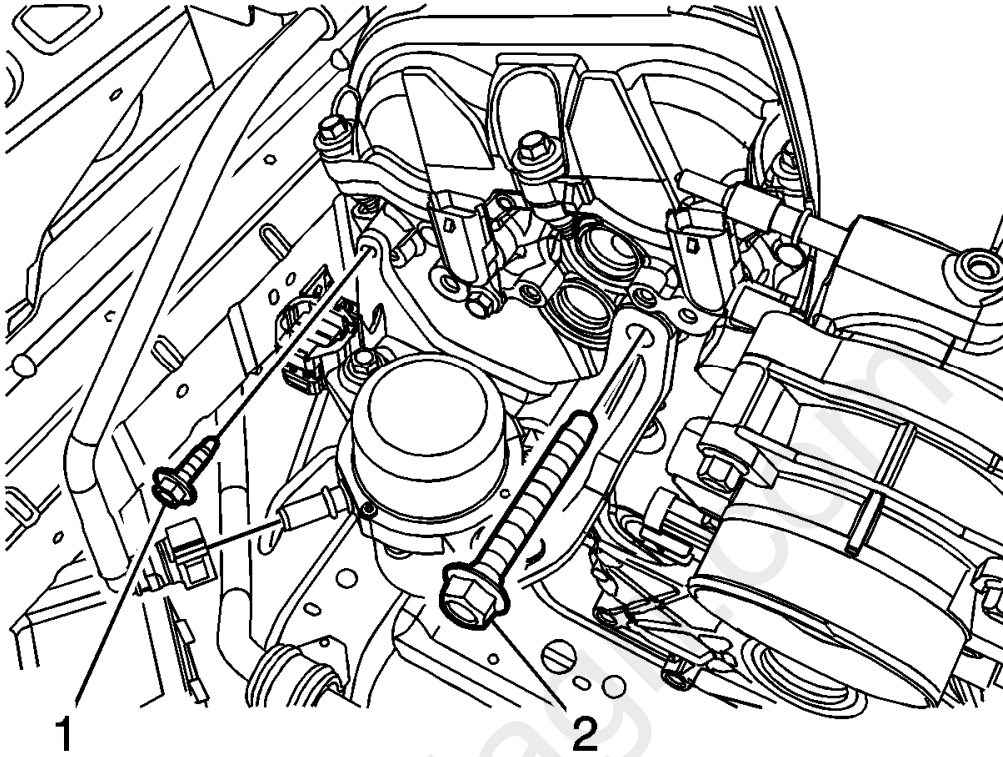


Fig. 110: Power Brake Booster Vacuum Pump Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the power brake booster pump bracket M6 bolt (1).
7. Remove the power brake booster pump bracket M12 bolt (2).
8. Remove the power brake booster pump from the engine.

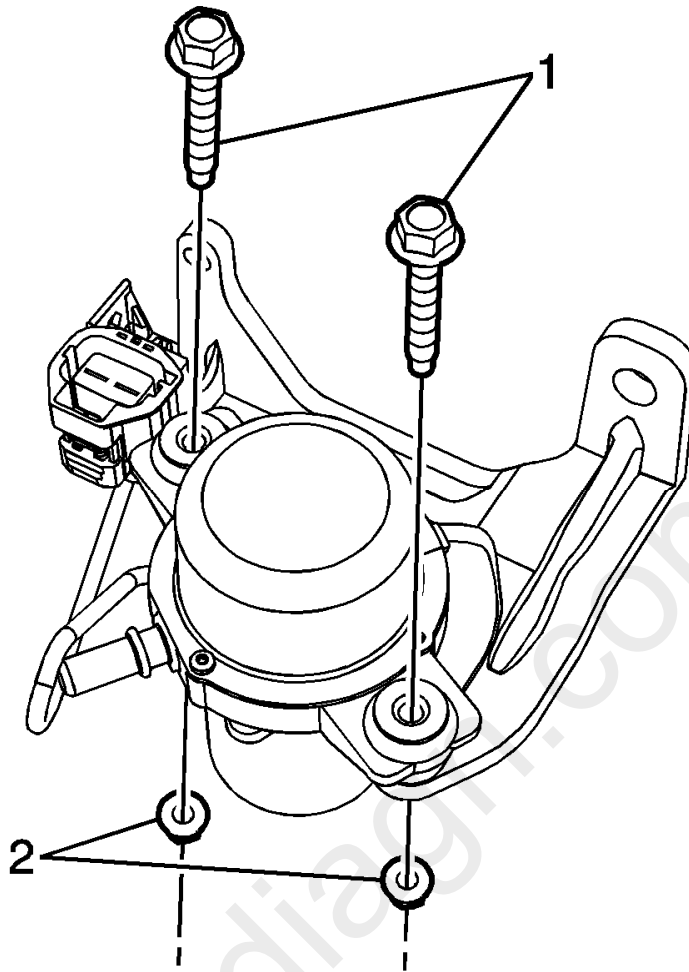


Fig. 111: Power Brake Booster Vacuum Pump Bolts & Nuts
Courtesy of GENERAL MOTORS COMPANY

9. Remove the power brake booster pump bolts (1) and nuts (2).
10. Release the power brake booster pump electrical harness connector retainer from the bracket.

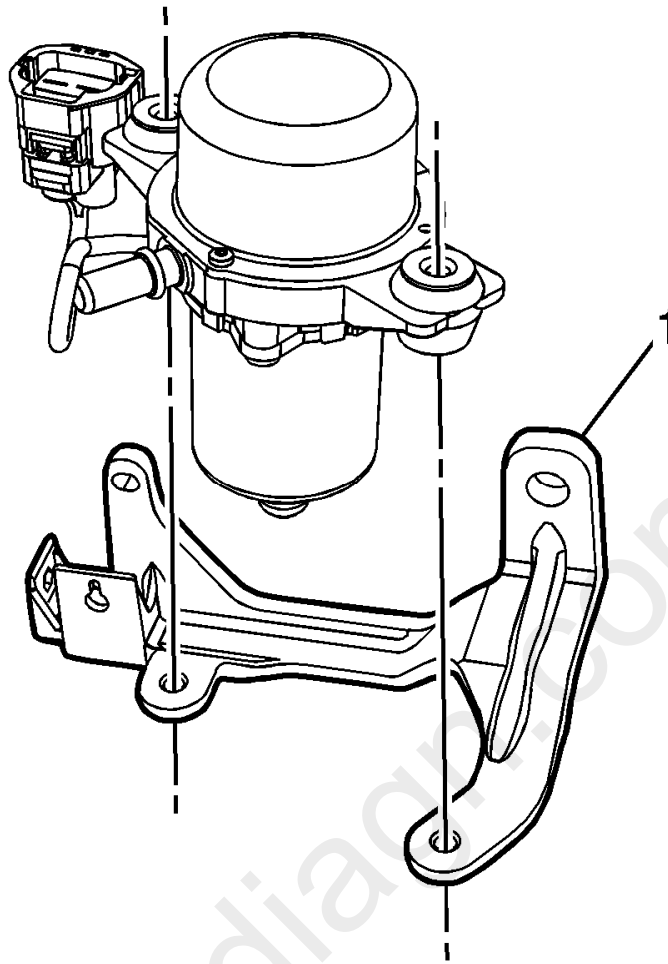


Fig. 112: Power Brake Booster Vacuum Pump Bracket
Courtesy of GENERAL MOTORS COMPANY

11. Remove the power brake booster pump bracket (1).

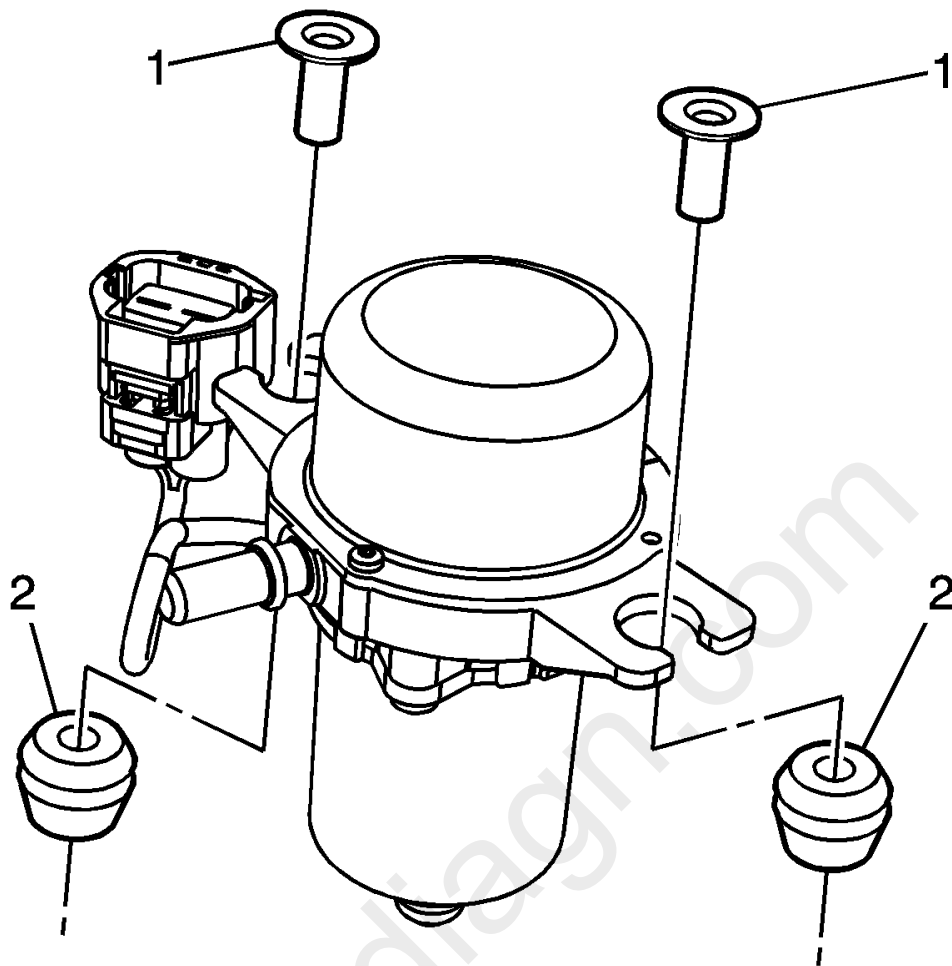


Fig. 113: Power Brake Booster Vacuum Pump Insulators & Sleeves
Courtesy of GENERAL MOTORS COMPANY

12. Remove the power brake booster pump insulator sleeves (1).
13. Remove the power brake booster pump insulators (2).

Installation Procedure

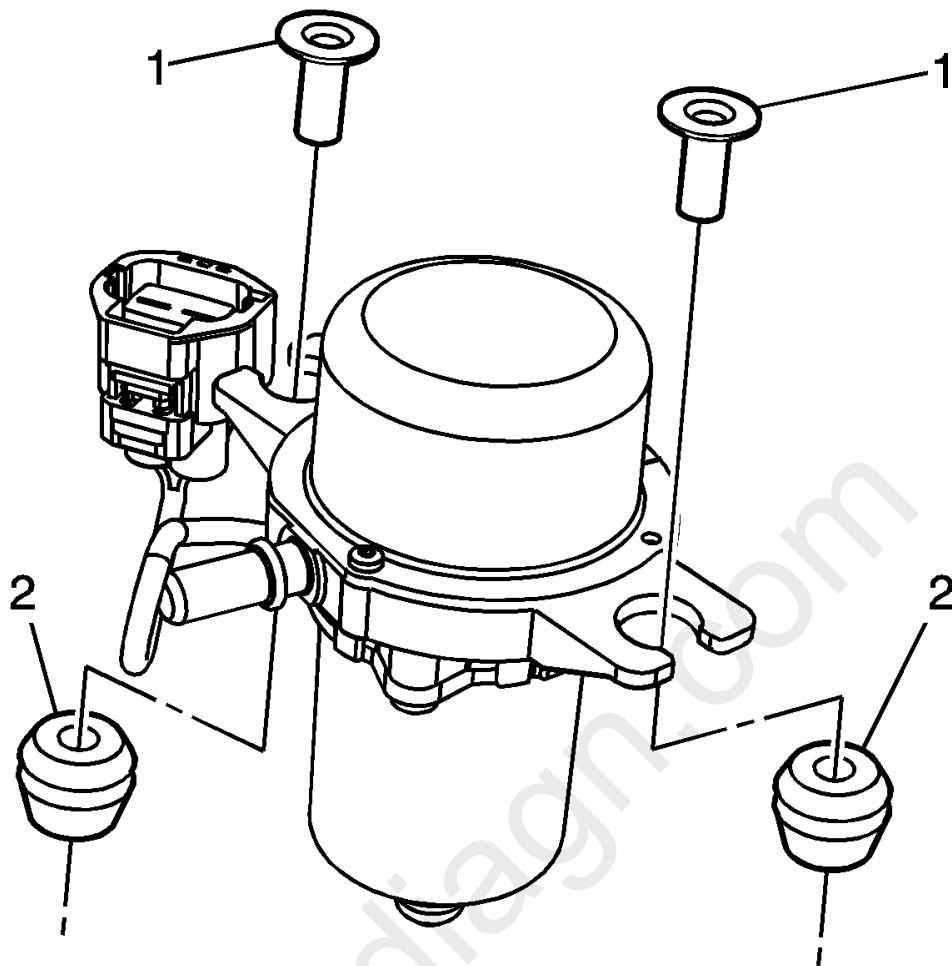


Fig. 114: Power Brake Booster Vacuum Pump Insulators & Sleeves
Courtesy of GENERAL MOTORS COMPANY

1. Assemble the power brake booster pump sleeves (1) to the insulators (2).
2. Install the power brake booster pump insulators.

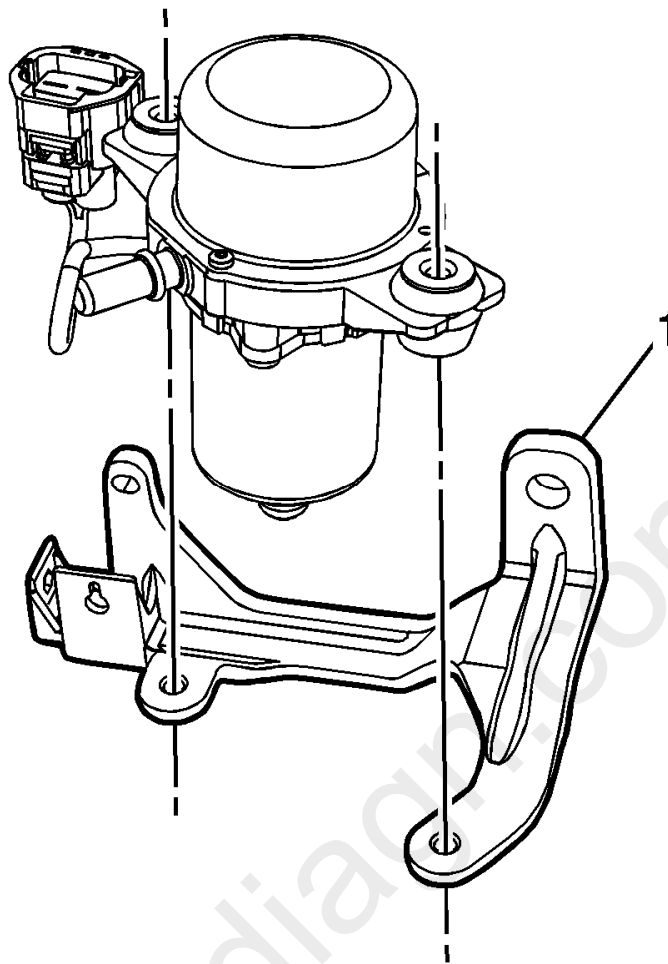


Fig. 115: Power Brake Booster Vacuum Pump Bracket
Courtesy of GENERAL MOTORS COMPANY

3. Install the power brake booster pump bracket (1).

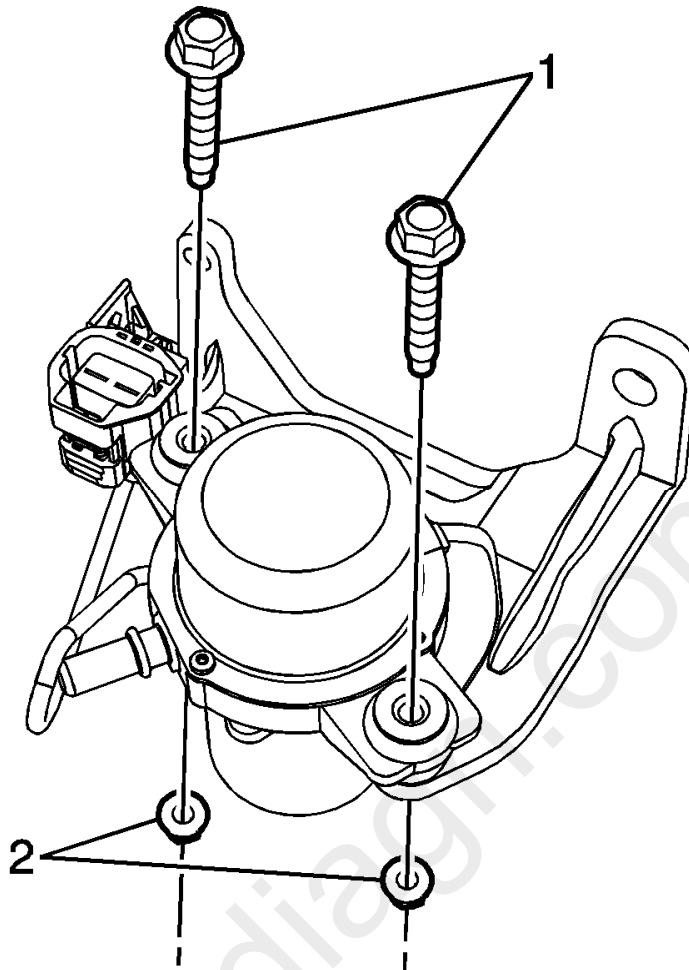


Fig. 116: Power Brake Booster Vacuum Pump Bolts & Nuts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

4. Install the power brake booster pump bolts (1) and nuts (2) and tighten to 22 (16 lb ft).
5. Install the power brake booster pump electrical harness connector retainer to the bracket.

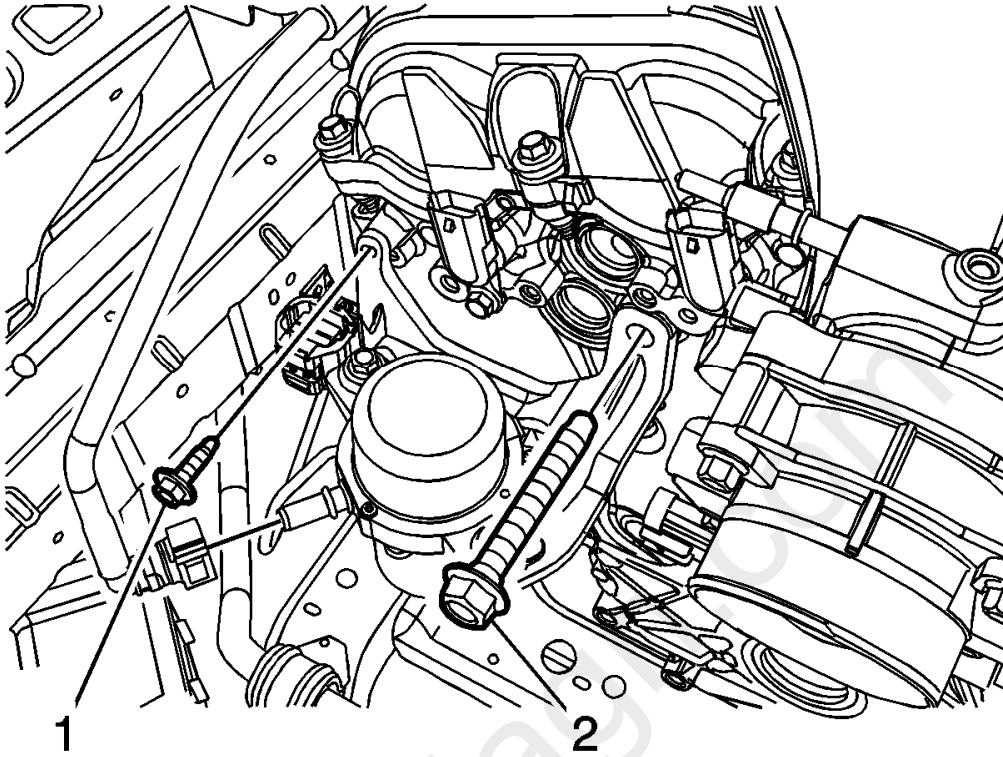


Fig. 117: Power Brake Booster Vacuum Pump Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Position the power brake booster pump to the engine.
7. Loosely install the power brake booster pump bracket M6 bolt (1).
8. Loosely install the power brake booster pump bracket M12 bolt (2).
9. Tighten the power brake booster pump bracket M6 bolt to 10 (89 lb in).
10. Tighten the power brake booster pump bracket M12 bolt to 70 (52 lb ft).

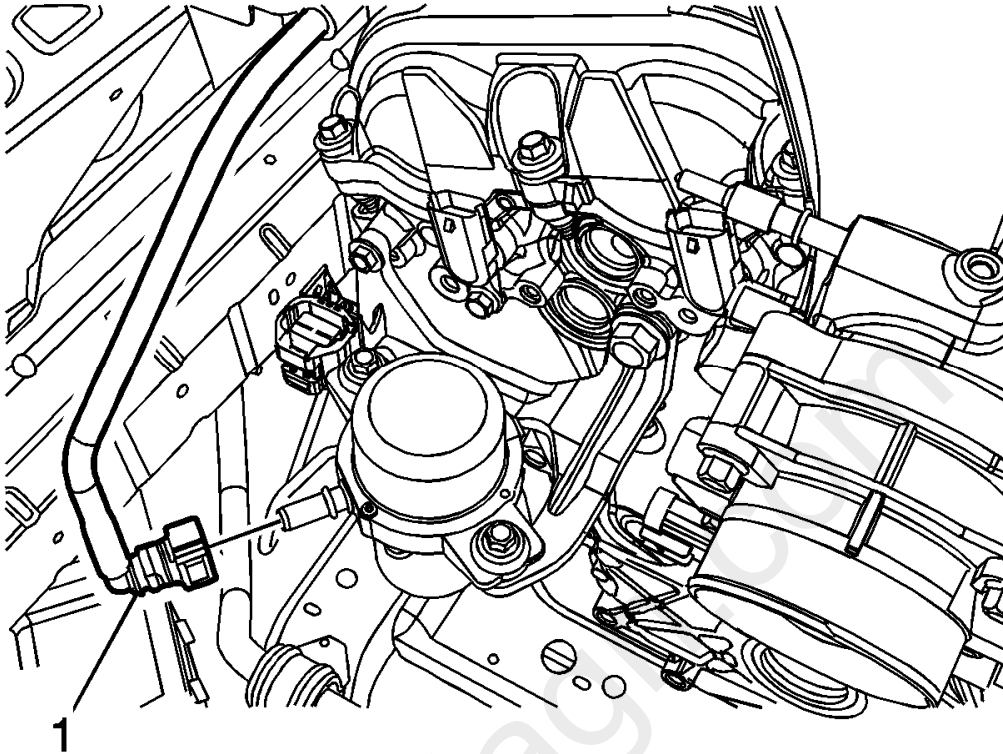


Fig. 118: Power Brake Booster Vacuum Hose Quick Connect At Power Brake Booster Vacuum Pump (LFX)

Courtesy of GENERAL MOTORS COMPANY

11. Install the power brake booster pump hose.
12. Connect the power brake booster pump hose quick connect (1).
13. Connect the power brake booster pump electrical connector.
14. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (LFX)** , **Air Cleaner Outlet Duct Replacement (LF3)** .

DESCRIPTION AND OPERATION

BRAKE ASSIST SYSTEM DESCRIPTION AND OPERATION

System Component Description

The brake assist system consists of the following:

Brake Pedal

Multiplies the braking effort applied by the driver.

Brake Pedal Pushrod

Transfers multiplied input force received from the brake pedal to the vacuum brake booster.

Vacuum Brake Booster

Uses source vacuum to decrease effort required by the driver when applying the brakes.

Vacuum Brake Booster Control Valve

Regulates the vacuum/atmospheric pressure within the vacuum brake booster. The calibration of the control valve gives more powerful vacuum assistance during low brake pedal pressure.

Vacuum Source

The source vacuum is either derived from the intake manifold or delivered from a pump, mechanically or electrically driven. For further information refer to **Brake Booster Vacuum Assist Description and Operation**.

Vacuum Source Delivery System

Enables delivery and retention of source vacuum for vacuum brake booster.

System Operation

Brake system input force from the driver is multiplied by the brake pedal and transferred by the pedal pushrod to the hydraulic brake master cylinder. Effort required to apply the brake system is reduced by the operation of the vacuum brake booster.

At rest, source vacuum is applied to both sides of each of the diaphragms in the dual booster. Return springs maintain the booster in a rest position.

When brake system force is applied, vacuum to the rear of the diaphragms is cut off, and air at atmospheric pressure is admitted in its place. The vacuum acts to pull the diaphragms forward, while the atmospheric pressure acts to push from behind. As a result, the amount of effort required by the driver is reduced. When input force is removed, vacuum again replaces atmospheric pressure within the vacuum power brake booster to help return the booster to rest. Return springs maintain the system in a rest position.

BRAKE BOOSTER VACUUM ASSIST DESCRIPTION AND OPERATION

System Component Description

The brake booster vacuum assist system consists of the following:

Auxiliary Brake Booster Pump

The auxiliary brake booster pump is a secondary vacuum supply to the brake booster to maintain sufficient vacuum needed for brake assist.

Vacuum Brake Booster

Uses source vacuum to decrease effort required by driver when applying the brake.

When brake system input force is applied, air at atmospheric pressure is admitted to the rear of both vacuum diaphragms, providing a decrease in brake pedal effort required. When input force is removed, vacuum replaces atmospheric pressure within the booster.

Vacuum Source

Vacuum is supplied by engine vacuum or by the auxiliary brake booster pump.

Brake Booster Vacuum Sensor

The brake booster vacuum sensor is mounted on the vacuum brake booster and provides feedback to the electronic brake control module relative to the amount of vacuum available for the vacuum brake booster. When the vehicle is equipped with Stop/Start System the brake booster vacuum sensor provides also feedback to the engine control module.

System Operation

The electronic brake control module (EBCM) actuates the auxiliary brake booster pump to generate additional vacuum to the vacuum brake booster if low vacuum is detected by brake booster vacuum sensor.

BRAKE WARNING SYSTEM DESCRIPTION AND OPERATION

Brake Warning Indicator

Brake Warning Block Diagram

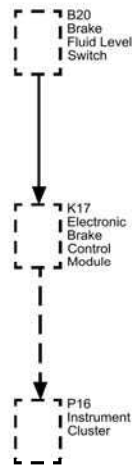


Fig. 119: Brake Warning Block Diagram
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
HW	Hard-Wired
DA	Serial Data
P16	P16 Instrument Cluster
B20	B20 Brake Fluid Level Switch
K17	K17 Electronic Brake Control Module

The instrument cluster turns the brake warning indicator ON when the following occurs:

- The instrument cluster performs the bulb check. The brake warning indicator illuminates for 5 s.
- When the electronic brake control module (EBCM) detects low brake fluid level it sets DTC C0267 and sends a serial data message to the instrument cluster, which will illuminate the red brake indicator.

Driver Information Center Messages

When the electronic brake control module (EBCM) detects low brake fluid level it sets DTC C0267 and sends a serial data message to the driver information center , which will display Brake Fluid Low message.

HYDRAULIC BRAKE SYSTEM DESCRIPTION AND OPERATION

System Component Description

The hydraulic brake system consists of the following:

Hydraulic Brake Master Cylinder Fluid Reservoir

Contains supply of brake fluid for the hydraulic brake system.

Hydraulic Brake Master Cylinder

Converts mechanical input force into hydraulic output pressure.

Hydraulic output pressure is distributed from the master cylinder through 2 hydraulic circuits, supplying diagonally-opposed wheel apply circuits.

Hydraulic Brake Pressure Balance Control System

Regulates brake fluid pressure delivered to hydraulic brake wheel circuits, in order to control the distribution of braking force.

Pressure balance control is achieved through dynamic rear proportioning (DRP), which is a function of the ABS modulator.

Hydraulic Brake Pipes and Flexible Brake Hoses

Carries brake fluid to and from hydraulic brake system components.

Hydraulic Brake Wheel Apply Components

Converts hydraulic input pressure into mechanical output force.

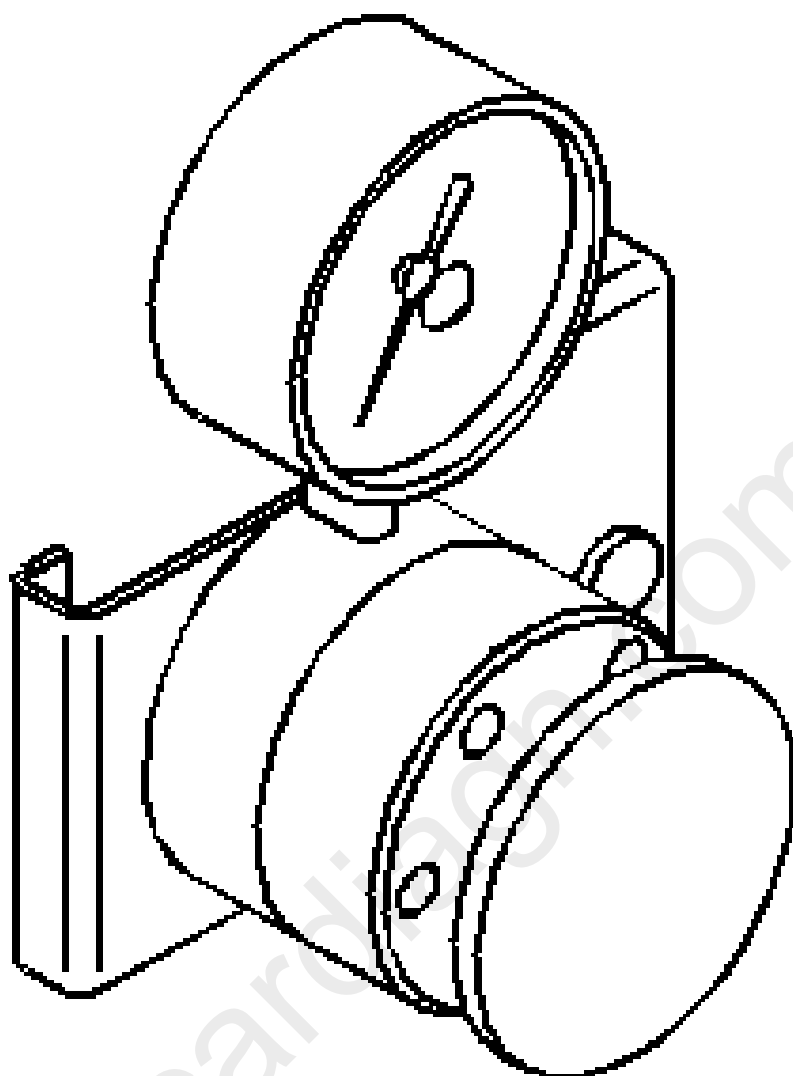
System Operation

Mechanical force is converted into hydraulic pressure by the master cylinder, regulated to meet braking system demands by the pressure balance control system, and delivered to the hydraulic brake wheel circuits by the pipes and flexible hoses. The wheel apply components then convert the hydraulic pressure back into mechanical force which presses linings against rotating brake system components.

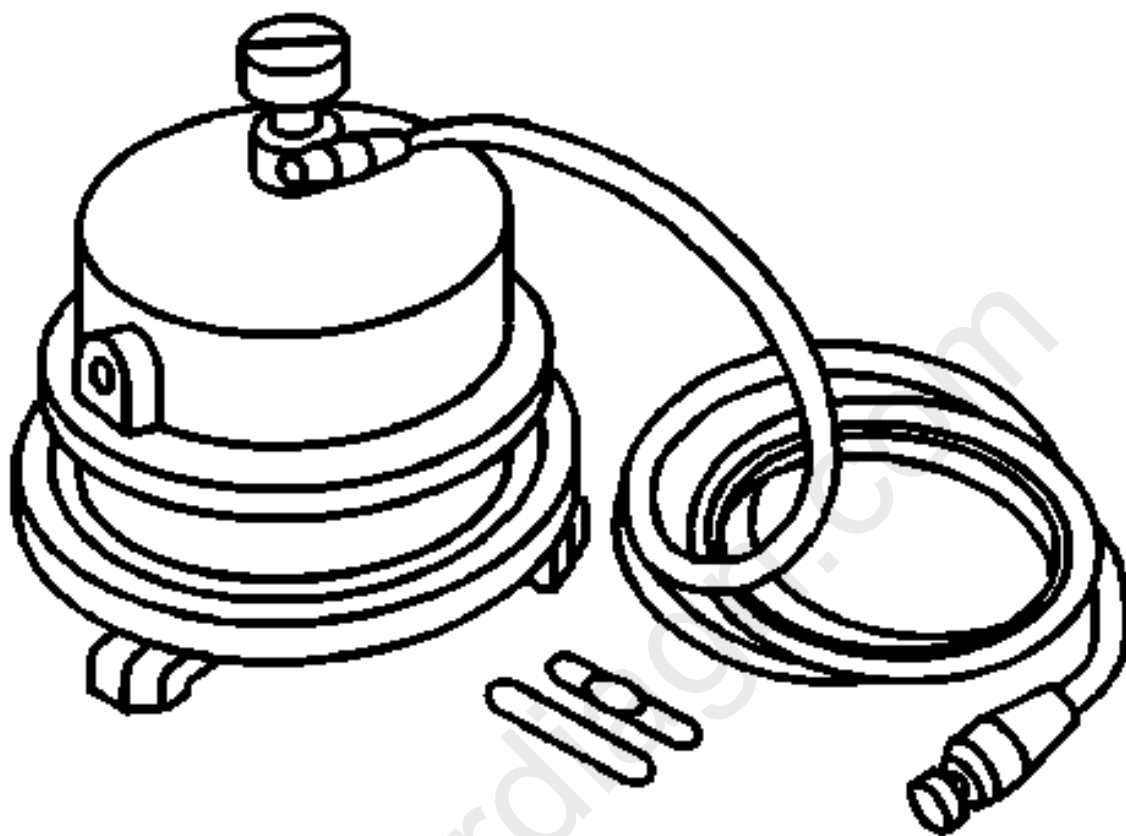
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

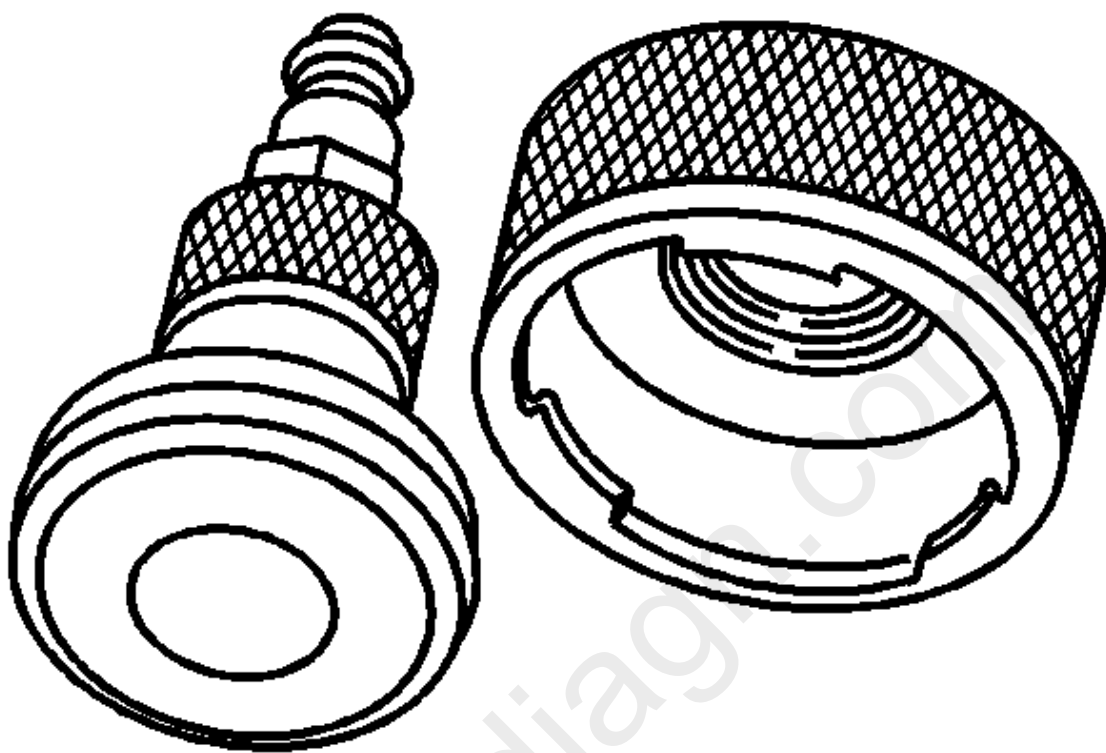
Illustration	Tool Number/ Description



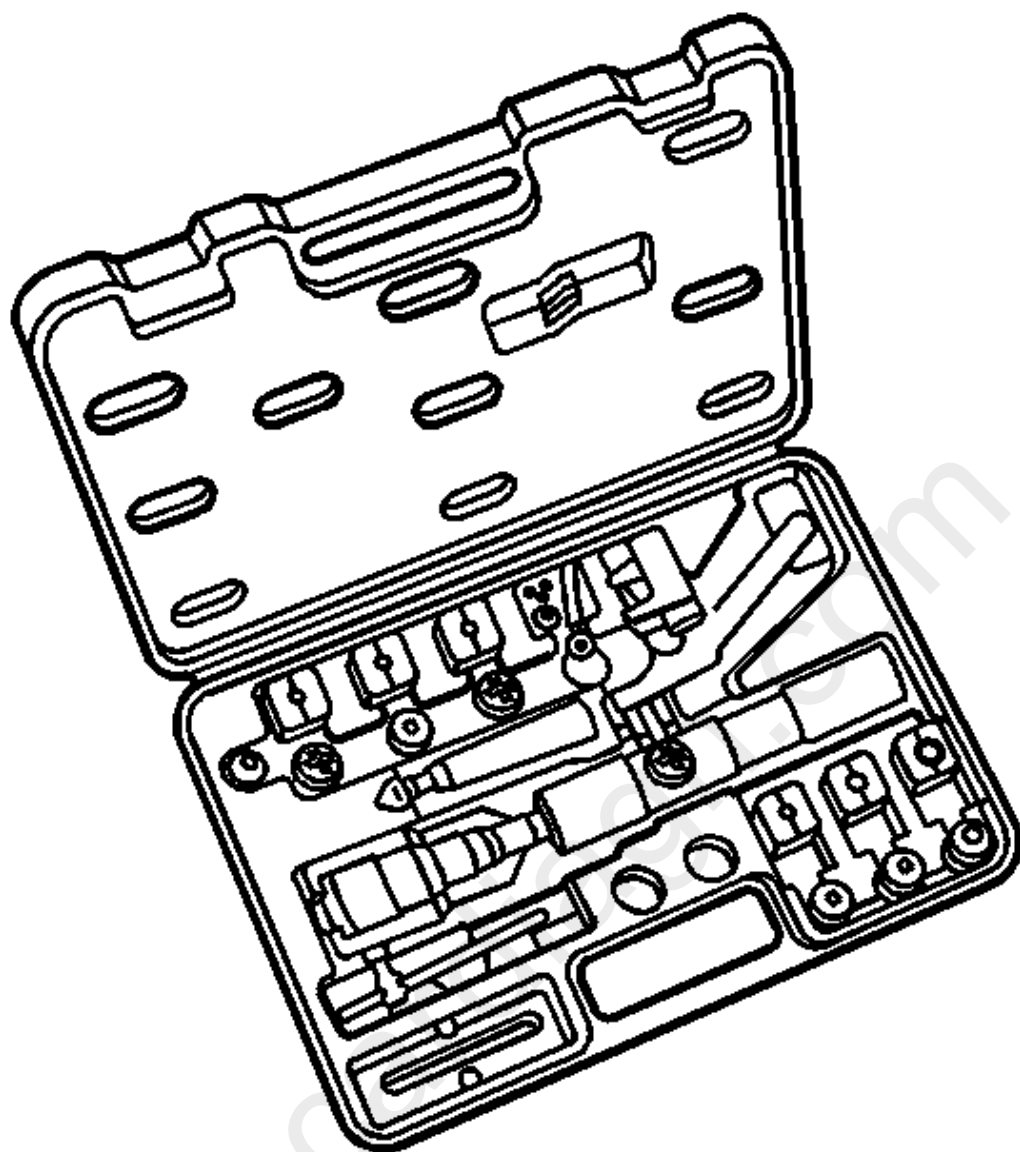
CH 28662
J 28662
Brake Pedal
Effort
Gauge



CH 29532-
A
J 29532-B
Pressure
Brake
Bleeder



CH 44894-
A
J 44894-A
Brake
Bleeder
Adapter



CH 45405
J 45405
Brake Pipe
Flaring Kit