

2004 Cadillac CTS

2004 BRAKES Hydraulic Brakes - CTS

2004 BRAKES

Hydraulic Brakes - CTS

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Brake Hose to Caliper Bolt CTS	50 N.m	37 lb ft
Brake Hose to Caliper Bolt CTS-V	34 N.m	25 lb ft
Brake Master Cylinder Mounting Nuts	25 N.m	18 lb ft
Brake Pedal Assembly to Cowl Mounting Studs	25 N.m	18 lb ft
Brake Pedal Assembly to I/P Carrier Mounting Nuts	25 N.m	18 lb ft
Brake Pipe Fittings at Master Cylinder (Tube Nut)	38 N.m	28 lb ft
Brake Pipe Fitting (Tube Nut)	18 N.m	13 lb ft
Front Brake Hose Bracket to Frame Mounting Nut	14 N.m	124 lb in
Intermediate Brake Hose Assembly Mounting Nuts	14 N.m	124 lb in
Steering Column Support Bracket to Cowl Mounting Nuts	25 N.m	18 lb ft
Steering Column Support Bracket to I/P Carrier Mounting Nuts	25 N.m	18 lb ft

BRAKE COMPONENT SPECIFICATIONS

Brake Component Specifications

Application	Specification	
	Metric	English
Brake Caliper Bleeder Valve	14 N.m	124 lb in

BRAKE SYSTEM SPECIFICATIONS

Brake System Specifications

Application	Specification	
	Metric	English
Brake Pedal Travel		

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

57.0 mm

2.24 in

SCHEMATIC AND ROUTING DIAGRAMS

BRAKE WARNING SYSTEM SCHEMATICS

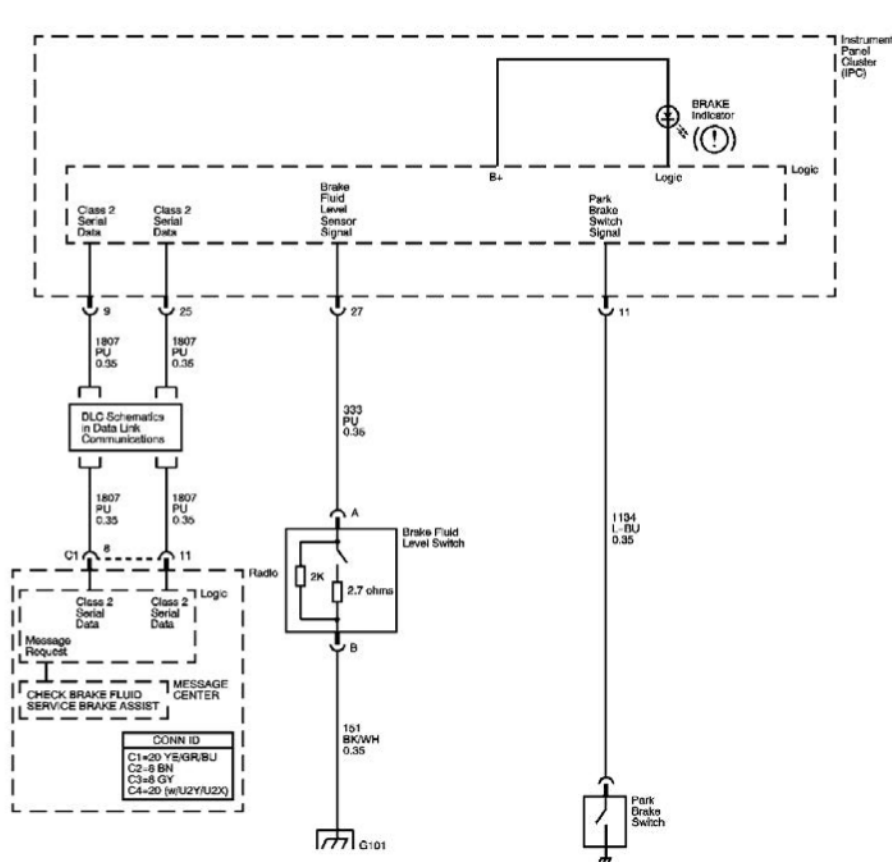


Fig. 1: Brake Warning System Schematic
Courtesy of GENERAL MOTORS CORP.

COMPONENT LOCATOR

HYDRAULIC BRAKES COMPONENT VIEWS

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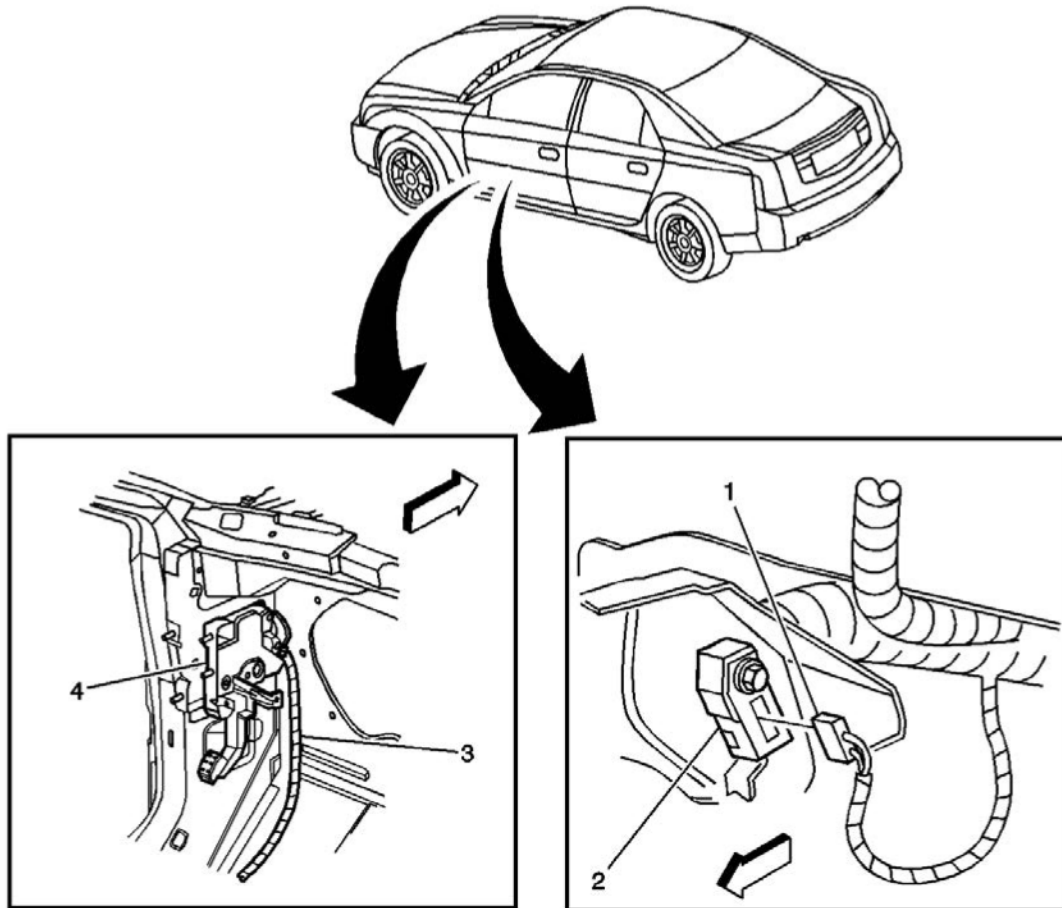


Fig. 2: Park Brake Subsystem Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 2

Callout	Component Name
1	Park Brake Switch Connector
2	Park Brake Switch
3	Park Brake Cable
4	Park Brake Assembly

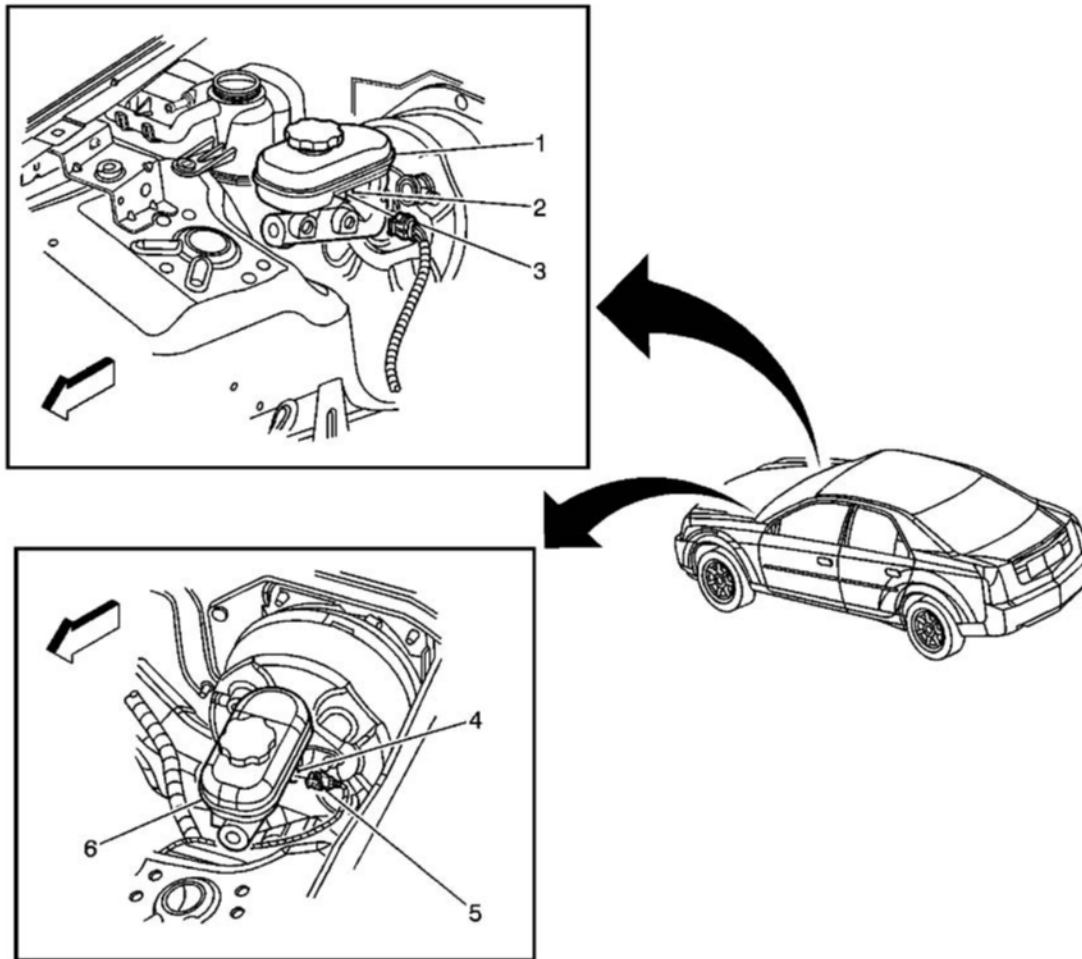


Fig. 3: Brake Fluid Level Switch
Courtesy of GENERAL MOTORS CORP.

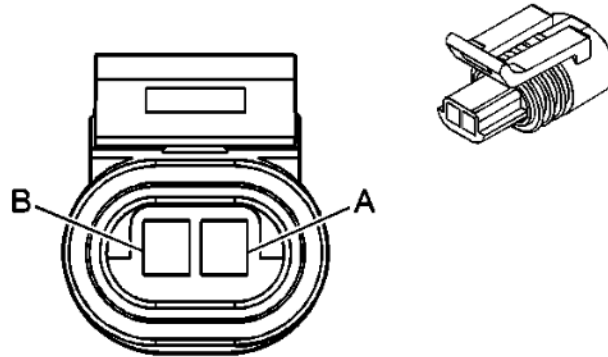
Callouts For Fig. 3

Callout	Component Name
1	Master Cylinder (RHD)
2	Brake Fluid level Switch (RHD)
3	Brake Fluid level Switch Connector (RHD)
4	Brake Fluid level Switch (LHD)
5	Brake Fluid level Switch Connector (LHD)
6	Master Cylinder (LHD)

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Brake Fluid Level Switch Connector End View

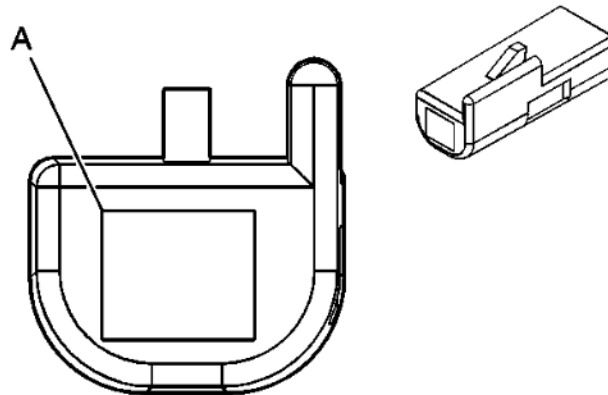


Connector Part Information

- 12162195
- 2-Way F Metri-Pack 150 Series (BK)

Pin	Wire Color	Circuit No.	Function
A	PU	333	Brake Fluid Level Sensor Signal
B	BK/WH	151	Ground

Park Brake Switch Connector End View



Connector Part Information

- 12047682
- 1-Way F Metri-Pack 150 Series (BK)

Pin	Wire Color	Circuit No.	Function
A	L-BU	1134	Park Brake Switch Signal

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - HYDRAULIC BRAKES

Begin the hydraulic brake system diagnosis with the **Diagnostic System Check - Hydraulic Brakes**. The Diagnostic System Check will provide the following information:

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

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

DIAGNOSTIC SYSTEM CHECK - HYDRAULIC BRAKES

Test Description

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

2: Lack of communication may be due to a partial malfunction of the serial data circuit or due to a total malfunction of the serial data circuit. The specified procedure will determine the particular condition.

4: The presence of DTCs which begin with "U" indicate some other module is not communicating. The specified procedure will compile the available information before tests are performed.

6: The presence of ABS DTCs indicate that the EBCM requested illumination of the red Brake indicator due to a concern in the ABS system. The presence of DTCs other than those listed are not related to this system.

Diagnostic System Check - Hydraulic Brakes

Step	Action	Yes	No
1	Install a scan tool. Does the scan tool power up?	Go to Step 2	Go to Scan Tool Does Not Power Up in Data Link Communication
	1. Turn ON the ignition, with the engine OFF. 2. Attempt to establish communication with the following control modules:		Go to Scan Tool

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2	- Electronic brake control module (EBCM) - Instrument panel cluster (IPC) Does the scan tool communicate with all control modules?	Go to Step 3	<u>Does Not Communicate with Class 2 Device</u> in Data Link Communication
3	Select the display DTCs function on the scan tool for the following control modules: - Electronic brake control module (EBCM) - Instrument panel cluster (IPC) Does the scan tool display any DTCs?	Go to Step 4	Go to <u>Symptoms - Hydraulic Brakes</u>
4	Does the scan tool display any DTCs which begin with a "U"?	Go to <u>Scan Tool Does Not Communicate with Class 2 Device</u> in Data Link Communication	Go to Step 5
5	Does the scan tool display DTC B1000, B1004, B1007, B1009, or B1020?	Go to <u>Diagnostic Trouble Code (DTC) List</u> in Body Control System	Go to Step 6
6	Does the scan tool display DTC B1327, B1328, B1513, or B1514?	Go to <u>Diagnostic Trouble Code (DTC) List</u> in Engine Electrical	Go to <u>Diagnostic Trouble Code (DTC) List</u> in Antilock Brake System

SCAN TOOL DATA LIST

Instrument Panel Cluster (IPC) Scan Tool Data List

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
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Ignition ON, engine OFF, brake fluid level normal, and park brake released.

Brake Fluid Switch	Data	OK/Low	OK
Park Brake Switch	Inputs	On/Off	Off

SCAN TOOL DATA DEFINITIONS

Brake Fluid Switch

The scan tool displays OK or Low. The status of the brake fluid level sensor signal.

Park Brake Switch

The scan displays Off or On. The status of the park brake switch signal.

DIAGNOSTIC TROUBLE CODE (DTC) LIST

Diagnostic Trouble Code (DTC) List

DTC	Diagnostic Procedure	Module(s)
C0267	<u>DTC C0267</u>	EBCM

DTC C0267

Circuit Description

The brake fluid level switch monitors the level of brake fluid in the master cylinder. When the IPC sees the brake fluid level switch input grounded, it turns ON the red Brake indicator and sends a serial data message to the EBCM that tells the EBCM that the brake fluid level is low.

Conditions for Running the DTC

The ignition is ON.

Conditions for Setting the DTC

Low brake fluid is detected for 2 seconds.

Action Taken When the DTC Sets

The red Brake warning indicator turns ON.

Conditions for Clearing the DTC

- The condition for the DTC is no longer present and the DTC is cleared with a scan tool.

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- The electronic brake control module (EBCM) automatically clears the history DTC when a current DTC is not detected in 100 consecutive drive cycles.

Diagnostic Aids

Inspect the master cylinder reservoir for the proper brake fluid level.

DTC C0267

Step	Action	Yes	No
Schematic Reference: <u>Brake Warning System Schematics</u> Connector End View Reference: <u>ABS Connector End Views</u>			
1	Did you perform the Diagnostic System Check - Hydraulic Brakes?	Go to Step 2	Go to <u>Diagnostic System Check - Hydraulic Brakes</u>
2	Inspect the brake fluid level. Is the brake fluid level OK?	Go to Step 3	Go to <u>Hydraulic Brake System Bleeding (Manual)</u> or <u>Hydraulic Brake System Bleeding (Pressure)</u>
3	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. With a scan tool, observe the Brake Fluid Switch parameter in the Instrument Panel Cluster data list. Does the scan tool indicate that the Brake Fluid Switch parameter is Low?	Go to <u>Testing for Intermittent Conditions and Poor Connections</u> in Wiring Systems	Go to Step 4
4	1. Turn OFF the ignition. 2. Disconnect the brake fluid level switch. 3. Turn ON the ignition, with the engine OFF. 4. With a scan tool, observe the Brake Fluid Switch parameter.		

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	Does the scan tool indicate that the Brake Fluid Switch parameter is Low?	Go to Step 5	Go to Step 6
5	Test the signal circuit of the brake fluid level switch for a short to ground. Refer to <u>Circuit Testing</u> and <u>Wiring Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 10	Go to Step 7
6	Inspect for poor connections at the harness connector of the brake fluid level switch. Refer to <u>Testing for Intermittent Conditions and Poor Connections</u> and <u>Connector Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 10	Go to Step 8
7	Inspect for poor connections at the harness connector of the instrument cluster (IPC). Refer to <u>Testing for Intermittent Conditions and Poor Connections</u> and <u>Connector Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 10	Go to Step 9
8	Replace the brake fluid level switch. Refer to <u>Master Cylinder Fluid Level Sensor Replacement</u> . Did you complete the repair?	Go to Step 10	-
9	IMPORTANT: Perform the setup procedure for the replacement IPC. Replace the instrument cluster (IPC). Refer to <u>Instrument Panel Cluster (IPC) Replacement</u> in Instrument Panel, Gages and Console. Did you complete the repair?	Go to Step 10	-
10	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2

SYMPTOMS - HYDRAULIC BRAKES

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

1. Perform **Diagnostic System Check - Hydraulic Brakes** before using the brake indicator

symptom tables in order to verify that all of the following are true:

- There are no DTCs set.
 - The control modules can communicate via the serial data link.
2. Review the system operation in order to familiarize yourself with the system functions. Refer to **Brake Warning System Description and Operation**

Visual/Physical Inspection

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

Intermittent

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

Symptom List

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

- **Brake Warning Indicator Always On**
- **Brake Warning Indicator Inoperative**
- 50278
- **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 WARNING INDICATOR ALWAYS ON

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Brake Warning Indicator Always On

Step	Action	Yes	No
Schematic Reference: <u>Brake Warning System Schematics</u> Connector End View Reference: <u>ABS Connector End Views</u>			
1	Did you perform the Hydraulic Brake Diagnostic System Check?	Go to Step 2	Go to <u>Diagnostic System Check - Hydraulic Brakes</u>
2	Inspect the brake fluid level. Is the brake fluid level OK?	Go to Step 3	Go to <u>Hydraulic Brake System Bleeding (Manual) or Hydraulic Brake System Bleeding (Pressure)</u>
3	1. Turn ON the ignition, with the engine OFF. 2. Release the park brake. 3. With a scan tool, observe the Park Brake Switch parameter in the Instrument Panel Cluster (IPC) data list. Does the scan tool indicate that the Park Brake Switch parameter is Off?	Go to Step 4	Go to Step 5
4	With a scan tool, observe the Brake Fluid Switch parameter in the DRP/ABS/TCS/VSES data list. Does the scan tool indicate that the Brake Fluid Switch parameter is OK?	Go to <u>Testing for Intermittent Conditions and Poor Connections</u> in Wiring Systems	Go to Step 6
5	1. Turn OFF the ignition. 2. Disconnect the park brake switch. 3. Turn ON the ignition, with the engine OFF. 4. With a scan tool, observe the Park Brake Switch parameter.		

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	Does the scan tool indicate that the Park Brake Switch parameter is Off?	Go to Step 9	Go to Step 7
6	1. Turn OFF the ignition. 2. Disconnect the brake fluid level switch. 3. Turn ON the ignition, with the engine OFF. 4. With a scan tool, observe the Brake Fluid Level parameter. Does the scan tool indicate that the Brake Fluid Switch parameter is OK?	Go to Step 10	Go to Step 8
7	Test the signal circuit of the park brake switch for a short to ground. Refer to <u>Circuit Testing</u> and <u>Wiring Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 11
8	Test the signal circuit of the brake fluid level switch for a short to ground. Refer to <u>Circuit Testing</u> and <u>Wiring Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 11
9	Inspect for poor connections at the harness connector of the park brake switch. Refer to <u>Testing for Intermittent Conditions and Poor Connections</u> and <u>Connector Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 12
10	Inspect for poor connections at the harness connector of the brake fluid level switch. Refer to <u>Testing for Intermittent Conditions and Poor Connections</u> and <u>Connector Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 13
11	Inspect for poor connections at the harness connector of the IPC. Refer to <u>Testing for Intermittent Conditions and Poor Connections</u> and <u>Connector Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 14

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12	Replace the park brake switch. Refer to <u>Park Brake Warning Lamp Switch Replacement (LHD)</u> or <u>Park Brake Warning Lamp Switch Replacement (RHD)</u> in Park Brake. Did you complete the repair?	Go to Step 15	-
13	Replace the brake fluid level switch. Refer to <u>Master Cylinder Fluid Level Sensor Replacement</u> . Did you complete the repair?	Go to Step 15	-
14	Replace the IPC. Refer to <u>Instrument Panel Cluster (IPC) Replacement</u> in Instrument Panel, Gages and Console. Did you complete the repair?	Go to Step 15	-
15	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2

BRAKE WARNING INDICATOR INOPERATIVE

Brake Warning Indicator Inoperative

Step	Action	Yes	No
Schematic Reference: <u>Brake Warning System Schematics</u> Connector End View Reference: <u>ABS Connector End Views</u> or <u>Instrument Panel, Gages, and Console Connector End Views</u> in Instrument Panel, Gages, and Console			
1	Did you perform the Hydraulic Brake Diagnostic System Check?	Go to Step 2	Go to <u>Diagnostic System Check - Hydraulic Brakes</u>
2	1. Turn OFF the ignition. 2. Turn ON the ignition, with the engine OFF. 3. Observe the red Brake indicator. Does the red Brake indicator illuminate briefly during the displays test?	Go to Step 3	Go to Step 11
3	Apply the park brake. Does the red Brake indicator illuminate?	Go to Step 4	Go to Step 5
	1. Turn OFF the ignition.		

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4	- Release the park brake. - Disconnect the brake fluid level switch. - Connect a 3 amp fused jumper wire between the signal circuit of the brake fluid level switch and the ground circuit of the brake fluid level switch. - Turn ON the ignition, with the engine OFF. Does the red Brake indicator illuminate?	Go to Step 10	Go to Step 7
5	- Turn OFF the ignition. - Disconnect the park brake switch. - Connect a 3 amp fused jumper wire between the signal circuit of the park brake switch and a good ground. - Turn ON the ignition, with the engine OFF. Does the red Brake indicator illuminate?	Go to Step 9	Go to Step 6
6	Test the signal circuit of the park brake switch for a high resistance or a open. Refer to <u>Circuit Testing</u> and <u>Wiring Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 11
7	Test the signal circuit of the brake fluid level switch for a high resistance or a open. Refer to <u>Circuit Testing</u> and <u>Wiring Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 8
8	Test the ground circuit of the brake fluid level switch for a high resistance or an open. Refer to <u>Circuit Testing</u> and <u>Wiring Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 11
	Inspect for poor case ground or poor connections at the harness connector of the park brake switch. Refer to <u>Testing for</u>		

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9	<u>Intermittent Conditions and Poor Connections</u> and <u>Connector Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 12
10	Inspect for poor connections at the harness connector of the brake fluid level switch. Refer to <u>Testing for Intermittent Conditions and Poor Connections</u> and <u>Connector Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 13
11	Inspect for poor connections at the harness connector of the IPC. Refer to <u>Testing for Intermittent Conditions and Poor Connections</u> and <u>Connector Repairs</u> in Wiring Systems. Did you find and correct the condition?	Go to Step 15	Go to Step 14
12	Replace the park brake switch. Refer to <u>Park Brake Warning Lamp Switch Replacement (LHD)</u> or <u>Park Brake Warning Lamp Switch Replacement (RHD)</u> in Park Brake. Did you complete the repair?	Go to Step 15	-
13	Replace the brake fluid level switch. Refer to <u>Master Cylinder Fluid Level Sensor Replacement</u> . Did you complete the repair?	Go to Step 15	-
14	Replace the instrument panel cluster (IPC). Refer to <u>Instrument Panel Cluster (IPC) Replacement</u> in Instrument Panel, Gages and Console. Did you complete the repair?	Go to Step 15	-
15	Operate the vehicle in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2

BRAKE PULSATION

Test Description

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

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

3: Antilock brake system operation could produce feedback through the brake pedal during application of the brake system.

Brake Pulsation

Step	Action	Yes	No
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
2	Inspect the suspension system for proper operation. Refer to <u>Diagnostic Starting Point - Suspension General Diagnosis</u> in Suspension General Diagnosis. Did you find and correct a condition?	Go to Step 6	Go to Step 3
3	Inspect the antilock brake system for proper operation. Refer to <u>Diagnostic Starting Point - Antilock Brake System</u> in Antilock Brake System. Did you find and correct a condition?	Go to Step 6	Go to Step 4
4	Inspect the disc brake system for proper operation. Refer to <u>Disc Brake System Diagnosis</u> . Did you find and correct a condition?	Go to Step 6	Go to Step 5
5	Inspect the hydraulic brake system for proper operation. Refer to <u>Hydraulic Brake System Diagnosis</u> . Did you find and correct a condition?	Go to Step 6	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
6	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

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1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
2	Inspect the disc brake system for proper operation. Refer to <u>Disc Brake System Diagnosis</u> . Did you find and correct a condition?	Go to Step 9	Go to Step 3
3	Inspect the brake assist system for proper operation. 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 proper operation. 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 8
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 8
7	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, heat spots, and excessive radial runout. 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 9	Go to Step 8
8	Inspect the park brake system for proper operation. Refer to <u>Park Brake System Diagnosis</u> in Park Brake. Did you find and correct a condition?	Go to Step 9	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
	Road test the vehicle in order to confirm proper		

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9	operation. Refer to <u>Brake System Vehicle Road Test</u> . Is the condition still present?	Go to Step 2	System OK
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BRAKING ACTION UNEVEN - PULLS TO ONE SIDE

Test Description

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

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

3: 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
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
2	Inspect the suspension system for proper operation. Refer to <u>Diagnostic Starting Point - Suspension General Diagnosis</u> in Suspension General Diagnosis. Did you find and correct a condition?	Go to Step 6	Go to Step 3
3	Inspect the steering system for proper operation. Refer to <u>Diagnostic Starting Point - Power Steering System (w/o Electro-Hydraulic Steering)</u> in Power Steering System. Did you find and correct a condition?	Go to Step 6	Go to Step 4
4	Inspect the hydraulic brake system for proper operation. Refer to <u>Hydraulic Brake System Diagnosis</u> . Did you find and correct a condition?	Go to Step 6	Go to Step 5
5	Inspect the disc brake system for proper operation. Refer to <u>Disc Brake System Diagnosis</u> . Did you find and correct a condition?	Go to Step 6	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>

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6	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
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BRAKING ACTION UNEVEN - FRONT TO REAR

Test Description

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

2: 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
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
2	Inspect the suspension system for proper operation. Refer to <u>Diagnostic Starting Point - Suspension General Diagnosis</u> in Suspension General Diagnosis. Did you find and correct a condition?	Go to Step 6	Go to Step 3
3	Inspect the hydraulic brake system for proper operation. Refer to <u>Hydraulic Brake System Diagnosis.</u> Did you find and correct a condition?	Go to Step 6	Go to Step 4
4	Inspect the disc brake system for proper operation. Refer to <u>Disc Brake System Diagnosis.</u> Did you find and correct a condition?	Go to Step 6	Go to Step 5
5	Inspect the brake assist system for proper operation. 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 - Hydraulic Brakes</u>
6	Road test the vehicle in order to confirm proper operation. Refer to <u>Brake System Vehicle</u>		

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Road Test.

Is the condition still present?

Go to **Step 2**

System OK

BRAKE PEDAL EXCESSIVE TRAVEL

Brake Pedal Excessive Travel

Step	Action	Yes	No
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
2	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 3
3	- 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. - Replace the brake pedal system components that are worn, missing, misaligned, bent or damaged. Refer to the following procedures as necessary. <u>Brake Pedal Assembly Replacement (LHD Automatic Trans)</u> or <u>Brake Pedal Assembly Replacement (RHD Automatic Trans)</u> or <u>Brake Pedal Assembly Replacement (Manual Trans Before VIN 40101964)</u> or <u>Brake</u>		

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	<u>Pedal Assembly Replacement (Manual Trans After VIN 40101964)</u> • <u>Vacuum Brake Booster Replacement (LHD)</u> or <u>Vacuum Brake Booster Replacement (RHD)</u> -for pedal pushrod replacement Did you find and replace any worn, missing, misaligned, bent or damaged brake pedal system components?	Go to Step 4	Go to Step 5
4	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 8	Go to Step 5
5	Inspect the hydraulic brake system for proper operation. Refer to <u>Hydraulic Brake System Diagnosis.</u> Did you find and correct a condition?	Go to Step 8	Go to Step 6
6	Inspect the disc brake system for proper operation. Refer to <u>Disc Brake System Diagnosis.</u> Did you find and correct a condition?	Go to Step 8	Go to Step 7
7	Inspect the brake assist system for proper operation. 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 - Hydraulic Brakes</u>
8	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

BRAKE PEDAL EXCESSIVE EFFORT

Brake Pedal Excessive Effort

Step	Action	Yes	No

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1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
2	Inspect the brake assist system for proper operation. Refer to <u>Brake Assist System Diagnosis</u> . Did you find and correct a condition?	Go to Step 5	Go to Step 3
3	Inspect the hydraulic brake system for proper operation. Refer to <u>Hydraulic Brake 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 proper operation. 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 - Hydraulic Brakes</u>
5	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

BRAKES DRAG

Brakes Drag

Step	Action	Yes	No
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</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.		

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	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, heat spots, and excessive radial runout. 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
7	Inspect the park brake system for proper operation. Refer to <u>Park Brake System Diagnosis</u> in Park Brake. Did you find and correct a condition?	Go to Step 14	Go to Step 8
8	Inspect the disc brake system for proper operation. Refer to <u>Disc Brake System Diagnosis</u> . Did you find and correct a condition?	Go to Step 14	Go to Step 9
9	1. Separate the brake booster pushrod from the brake pedal. 2. 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	Replace the brake pedal assembly. Did you complete the replacement?	Go to Step 14	-
	1. Separate the master cylinder from the brake booster. Do not disconnect any brake pipes.		

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11	2. 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 proper operation. 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 - Hydraulic Brakes</u>
14	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 SLOW RELEASE

Brake System Slow Release

Step	Action	Yes	No
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
2	Inspect the hydraulic brake system for proper operation. 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 proper operation. 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 proper operation. Refer to <u>Disc Brake System Diagnosis</u> .		Go to <u>Diagnostic Starting Point - Hydraulic</u>

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	Did you find and correct a condition?	Go to Step 5	<u>Brakes</u>
5	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

BRAKE FLUID LOSS

Brake Fluid Loss

Step	Action	Yes	No
1	Were you sent here from the Hydraulic Brake Symptom table?	Go to Step 2	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
2	Inspect the hydraulic brake system for proper operation. 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 proper operation. 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. Separate the master cylinder from the vacuum brake booster. Do not disconnect any brake pipes. Refer to <u>Master Cylinder Replacement.</u> 2. Inspect the rear of the master cylinder for a brake fluid leak. 3. 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 - Hydraulic Brakes</u>
5	Replace the brake master cylinder and the vacuum brake booster. Refer to <u>Master Cylinder Replacement</u> and <u>Vacuum Brake Booster Replacement (LHD)</u> or <u>Vacuum Brake Booster Replacement (RHD).</u> Did you complete the replacement?	Go to Step 6	-

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6	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 <u>Diagnostic Starting Point - Hydraulic</u>

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		Go to Step 2	<u>Brakes</u>
2	Visually inspect the disc brake pads for the following conditions: Refer to <u>Brake Pads Replacement - Front (CTS)</u> or <u>Brake Pads Replacement - Front (CTS-V)</u> in Disc Brakes. • 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>Brake Pads Replacement - Front (CTS)</u> or <u>Brake Pads Replacement - Front (CTS-V)</u> and/or <u>Brake Pads Replacement - Rear (CTS)</u> or <u>Brake Pads Replacement - Rear (CTS-V)</u> in Disc Brakes. Did you complete the inspection and replacement?	Go to Step 12	-

NOTE:

Support the brake caliper with heavy mechanic's 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.

IMPORTANT:

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, CTS, or from the suspension knuckles, CTS-V, and support the calipers. Refer to **Brake Caliper Replacement - Front (CTS)** or **Brake Caliper Replacement - Front (CTS-V)** and/or **Brake Caliper Replacement - Rear (CTS)** or **Brake Caliper Replacement - Rear (CTS-V)** in Disc Brakes.
2. Inspect the disc brake caliper mounting bracket, CTS, or the suspension knuckles, CTS-V, and the mounting/sliding hardware for the following conditions:

Refer to **Disc Brake Mounting and Hardware Inspection - Front (CTS)** or **Disc Brake Mounting and Hardware Inspection - Front (CTS-V)** and/or **Disc Brake Mounting and Hardware Inspection - Rear (CTS)** or **Disc Brake Mounting and Hardware Inspection - Rear (CTS-V)** in Disc Brakes.

- Binding or seized hardware
- Worn, damaged or missing hardware

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	components • Loose, bent, cracked, or damaged caliper mounting bracket, CTS, or suspension knuckle, CTS-V 3. Replace components as required. Refer to the following procedures in Disc Brakes, as required: • <u>Brake Caliper Bracket Replacement - Front (CTS)</u> • <u>Brake Caliper Bracket Replacement - Rear (CTS)</u> • <u>Disc Brake Hardware Replacement - Front (CTS)</u> or <u>Disc Brake Hardware Replacement - Front (CTS-V)</u> • <u>Disc Brake Hardware Replacement - Rear (CTS)</u> or <u>Disc Brake Hardware Replacement - Rear (CTS-V)</u> 4. Replace the unevenly-worn, loose or damaged disc brake pads as a complete axle set. Refer to <u>Brake Pads Replacement - Front (CTS)</u> or <u>Brake Pads Replacement - Front (CTS-V)</u> and/or <u>Brake Pads Replacement - Rear (CTS)</u> or <u>Brake Pads Replacement - Rear (CTS-V)</u> in Disc Brakes. Did you complete the inspection and replacement?	Go to Step 12	
	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>Brake Caliper Overhaul - Front</u>		

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8	<u>(CTS) or Brake Caliper Overhaul - Front (CTS-V) or Brake Caliper Replacement - Front (CTS) or Brake Caliper Replacement - Front (CTS-V) in Disc Brakes</u> • <u>Brake Caliper Overhaul - Rear (CTS) or Brake Caliper Overhaul - Rear (CTS-V) or Brake Caliper Replacement - Rear (CTS) or Brake Caliper Replacement - Rear (CTS-V) in Disc Brakes</u> • <u>Brake Hose Replacement - Front (CTS) or Brake Hose Replacement - Front (CTS-V)</u> • <u>Brake Hose Replacement - Intermediate (CTS) or Brake Hose Replacement - Intermediate (CTS-V)</u> • <u>Brake Hose Replacement - Rear (CTS) or Brake Hose Replacement - Rear (CTS-V)</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>Wheel Drive Shaft Outer Joint and Seal Replacement</u> in Wheel Drive Shafts. Did you find and correct the source of the leak causing contamination of the pads?	Go to Step 11	Go to Step 10
	1. Inspect the automatic transmission cooling		

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10	system lines, if equipped, for damage and evidence of an external fluid leak which may be the source of the contamination to the pads. - 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. - 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	-
	- Clean the remaining disc brake system components to remove any traces of the contaminant. NOTE: Support the brake caliper with heavy mechanic's 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. IMPORTANT: Do NOT disconnect the hydraulic brake flex hoses from the calipers. - Remove the front and/or rear disc brake calipers, as appropriate, from the mounting brackets, CTS, or the suspension knuckles, CTS-V, and support the calipers. Refer to <u>Brake Caliper Replacement - Front (CTS)</u> or <u>Brake Caliper Replacement - Front (CTS-V)</u> and/or <u>Brake Caliper Replacement - Rear (CTS)</u> or <u>Brake</u>		

Caliper Replacement - Rear (CTS-V) in Disc Brakes.

3. Inspect the disc brake caliper mounting/sliding hardware for the following conditions:

Refer to **Disc Brake Mounting and Hardware Inspection - Front (CTS)** or **Disc Brake Mounting and Hardware Inspection - Front (CTS-V)** and/or **Disc Brake Mounting and Hardware Inspection - Rear (CTS)** or **Disc Brake Mounting and Hardware Inspection - Rear (CTS-V)** in Disc Brakes.

- Binding or seized hardware
- Distorted, worn, damaged or missing hardware components

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4. Replace the caliper mounting/sliding hardware components as required. Refer to **Disc Brake Hardware Replacement - Front (CTS)** or **Disc Brake Hardware Replacement - Front (CTS-V)** and/or **Disc Brake Hardware Replacement - Rear (CTS)** or **Disc Brake Hardware Replacement - Rear (CTS-V)** in Disc Brakes.
5. Replace the contaminated disc brake pads as a complete axle set. Refer to **Brake Pads Replacement - Front (CTS)** or **Brake Pads Replacement - Front (CTS-V)** and/or **Brake Pads Replacement - Rear (CTS)** or **Brake Pads Replacement - Rear (CTS-V)** in Disc Brakes.

Did you complete the cleaning, inspection and replacement?

Go to **Step 12**

Visually inspect each of the disc brake rotor

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12	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>Disc Brake Splash Shield Replacement - Front (FE1)</u> in Disc Brakes. Did you complete the repair or replacement?	Go to Step 14	-
14	1. Check the thickness of each of the disc brake rotors. IMPORTANT: 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> in Disc Brakes. Does the disc brake rotor meet the minimum requirements for REFINISHING?	Go to Step 15	Go to Step 18
15	IMPORTANT: 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> in Disc Brakes. 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:		

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16	Refer to <u>Brake Rotor Surface and Wear Inspection</u> in Disc Brakes. • Heavy rust and/or pitting • Cracks and/or heat spots • Excessive blueing discoloration • Deep or excessive scoring beyond maximum acceptable level IMPORTANT: 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> in Disc Brakes. 2. Inspect the brake rotor thickness. Refer to <u>Brake Rotor Thickness Measurement</u> in Disc Brakes. 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 DISCARD requirements?	Go to Step 21	Go to Step 19
19	IMPORTANT: 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		

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	acceptable level. Refer to <u>Brake Rotor Thickness Variation Measurement</u> in Disc Brakes. Does the brake rotor exhibit thickness variation that exceeds the maximum acceptable level?	Go to Step 21	Go to Step 20
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> in Disc Brakes. • Heavy rust and/or pitting • Cracks and/or heat spots • Excessive blueing discoloration • Deep or excessive scoring beyond maximum acceptable level IMPORTANT: 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	IMPORTANT: 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 <u>Brake Rotor Replacement - Front</u> or <u>Brake Rotor Replacement - Rear</u> in Disc Brakes. Did you		-

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	complete the replacement?	Go to Step 24	
22	IMPORTANT: 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 <u>Brake Rotor Assembled Lateral Runout (LRO) Measurement</u> in Disc Brakes. 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 <u>Brake Rotor Assembled Lateral Runout (LRO) Correction</u> in Disc Brakes. 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 Table	-

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 - Hydraulic Brakes</u>
2	Inspect and adjust the brake fluid level in the brake master cylinder. Refer to <u>Master Cylinder Reservoir Filling</u> .		

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	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		

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	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
	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 Overhaul</u> or <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.		

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- Replace the brake master cylinder reservoir cap diaphragm.
- Brake Hose Replacement - Front (CTS) or Brake Hose Replacement - Front (CTS-V)
- Brake Hose Replacement - Intermediate (CTS) or Brake Hose Replacement - Intermediate (CTS-V)
- Brake Hose Replacement - Rear (CTS) or Brake Hose Replacement - Rear (CTS-V)
- Brake Caliper Overhaul - Front (CTS) or Brake Caliper Overhaul - Front (CTS-V) or Brake Caliper Replacement - Front (CTS) or Brake Caliper Replacement - Front (CTS-V) in Disc Brakes
- Brake Caliper Overhaul - Rear (CTS) or Brake Caliper Overhaul - Rear (CTS-V) or Brake Caliper Replacement - Rear (CTS) or Brake Caliper Replacement - Rear (CTS-V) in Disc Brakes
- Brake Pressure Modulator Valve (BPMV) Replacement (CTS) or Brake Pressure Modulator Valve (BPMV) Replacement (CTS-V) in Antilock Brake System

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 **Hydraulic Brake System Bleeding (Manual)** or **Hydraulic Brake System Bleeding (Pressure)**.

Did you complete the operation and any required repairs and/or replacements?

Go to **Step 9**

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:

- **Master Cylinder Overhaul** or **Master Cylinder Replacement**

Brake master cylinder reservoir cap diaphragm

- **Brake Hose Replacement - Front (CTS)** or **Brake Hose Replacement - Front (CTS-V)**
- **Brake Hose Replacement - Intermediate (CTS)** or **Brake Hose Replacement - Intermediate (CTS-V)**
- **Brake Hose Replacement - Rear (CTS)** or **Brake Hose Replacement - Rear (CTS-V)**
- **Brake Pipe Replacement**
- **Brake Caliper Overhaul - Front (CTS)** or **Brake Caliper Overhaul - Front (CTS-V)** or **Brake Caliper Replacement - Front (CTS)** or **Brake Caliper Replacement - Front (CTS-V)** in Disc Brakes

6	• <u>Brake Caliper Overhaul - Rear (CTS)</u> or <u>Brake Caliper Overhaul - Rear (CTS-V)</u> or <u>Brake Caliper Replacement - Rear (CTS)</u> or <u>Brake Caliper Replacement - Rear (CTS-V)</u> in Disc Brakes • <u>Brake Pressure Modulator Valve (BPMV) Replacement (CTS)</u> or <u>Brake Pressure Modulator Valve (BPMV) Replacement (CTS-V)</u> in Antilock Brake System 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> or <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. Refer to <u>Hydraulic Brake Component Operation Visual Inspection</u>. Was the hydraulic function of the brake calipers		

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	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. Refer to <u>Hydraulic Brake Component Operation Visual Inspection</u> . 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> in General Information. 2. Remove the tire and wheel assemblies. Refer to <u>Tire and Wheel Removal and Installation</u> in Tires and Wheels. 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
	Repair or replace any brake caliper that was not operating properly. Refer to the appropriate procedure: • <u>Brake Caliper Overhaul - Front (CTS)</u>		

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14	or <u>Brake Caliper Overhaul - Front (CTS-V)</u> or <u>Brake Caliper Replacement - Front (CTS)</u> or <u>Brake Caliper Replacement - Front (CTS-V)</u> in Disc Brakes • <u>Brake Caliper Overhaul - Rear (CTS)</u> or <u>Brake Caliper Overhaul - Rear (CTS-V)</u> or <u>Brake Caliper Replacement - Rear (CTS)</u> or <u>Brake Caliper Replacement - Rear (CTS-V)</u> in Disc Brakes		-
	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)</u> or <u>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>Brake Hose Replacement - Front (CTS)</u> or <u>Brake Hose Replacement - Front (CTS-V)</u> • <u>Brake Hose Replacement - Intermediate (CTS)</u> or <u>Brake Hose Replacement - Intermediate (CTS-</u>		

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	<u>V)</u> • <u>Brake Hose Replacement - Rear (CTS)</u> or <u>Brake Hose Replacement - Rear (CTS-V)</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 (BPMV) Replacement (CTS)</u> or <u>Brake Pressure Modulator Valve (BPMV) Replacement (CTS-V)</u> in Antilock Brake System. 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 leaks. Refer to <u>Brake System Internal Leak Test.</u>		

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20	2. Repair or replace the brake master cylinder if it is found to be leaking brake fluid internally. Refer to <u>Master Cylinder Overhaul</u> or <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 2	Go to <u>Diagnostic Starting Point - Hydraulic Brakes</u>
2	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 3
	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		

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3	misaligned, bent and/or damaged condition. 2. Replace the brake pedal system components that are worn, missing, misaligned, bent or damaged, refer to the following procedures as necessary: • <u>Brake Pedal Assembly Replacement (LHD Automatic Trans)</u> or <u>Brake Pedal Assembly Replacement (RHD Automatic Trans)</u> or <u>Brake Pedal Assembly Replacement (Manual Trans Before VIN 40101964)</u> or <u>Brake Pedal Assembly Replacement (Manual Trans After VIN 40101964)</u> • <u>Vacuum Brake Booster Replacement (LHD)</u> or <u>Vacuum Brake Booster Replacement (RHD)</u> ; for a bent or damaged pedal pushrod replacement Did you find and replace any worn, missing, misaligned, bent or damaged brake pedal system components?	Go to Step 4	Go to Step 5
4	Reinspect 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 8	Go to Step 5
	Check the engine vacuum source that supplies vacuum to the vacuum brake booster. Refer to <u>Brake System Vacuum Source Test</u>. Is the vacuum reading within the acceptable limits?		Go to <u>Diagnostic Starting Point - Engine Mechanical</u> in Engine Mechanical - 2.6L and 3.2L, or <u>Diagnostic Starting Point -</u>

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5		Go to Step 6	<u>Engine Mechanical</u> in Engine Mechanical - 3.6L (LY7), or <u>Diagnostic Starting Point -</u> <u>Engine Mechanical</u> in Engine Mechanical - 5.7L
6	During the vacuum source inspection, did the vacuum booster check valve operate properly?	Go to Step 8	Go to Step 7
7	Replace the vacuum booster check valve. Refer to <u>Vacuum Brake Booster Check Valve and/or Hose Replacement (LHD)</u> or <u>Vacuum Brake Booster Check Valve and/or Hose Replacement (RHD)</u> . Did you complete the replacement?	Go to Step 8	-
8	1. Pump the brake pedal several times until the brake pedal becomes hard. 2. Maintain moderate foot pressure on the brake pedal and start the engine. Observe pedal operation. Did the brake pedal drop slightly, then remain firm after the engine was started?	Go to Step 9	Go to Step 12
9	1. Release the brake pedal. 2. Turn the ignition OFF, then wait 15 seconds. 3. Pump the brake pedal two times to check for vacuum booster available vacuum reserve. Observe pedal effort. If operating properly, the vacuum brake booster should maintain assist for at least two pedal applications.		

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	Did the brake pedal effort increase significantly?	Go to Step 12	Go to Step 10
10	Inspect the brake pedal pushrod and the brake pedal for misalignment, a bent condition and/or damage. Is the brake pedal pushrod and/or the brake pedal misaligned, bent or damaged?	Go to Step 11	Go to Step 13
11	Replace the brake pedal pushrod and/or the brake pedal, as necessary. Refer to the following procedures: • <u>Brake Pedal Assembly Replacement (LHD Automatic Trans)</u> or <u>Brake Pedal Assembly Replacement (RHD Automatic Trans)</u> or <u>Brake Pedal Assembly Replacement (Manual Trans Before VIN 40101964)</u> or <u>Brake Pedal Assembly Replacement (Manual Trans After VIN 40101964)</u> • <u>Vacuum Brake Booster Replacement (LHD)</u> or <u>Vacuum Brake Booster Replacement (RHD)</u> ; for a bent or damaged pedal pushrod replacement Did you complete the replacement?	Go to Step 13	-
12	Replace the vacuum brake booster. Refer to <u>Vacuum Brake Booster Replacement (LHD)</u> or <u>Vacuum Brake Booster Replacement (RHD)</u> . Did you complete the replacement?	Go to Step 13	-
13	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

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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

CAUTION: 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

Tools Required

J 28662 Brake Pedal Effort Gauge. See **Special Tools and Equipment**.

Brake Pedal Travel Measurement and Inspection

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.
2. Install the **J 28662** to the brake pedal. See Special Tools and Equipment.

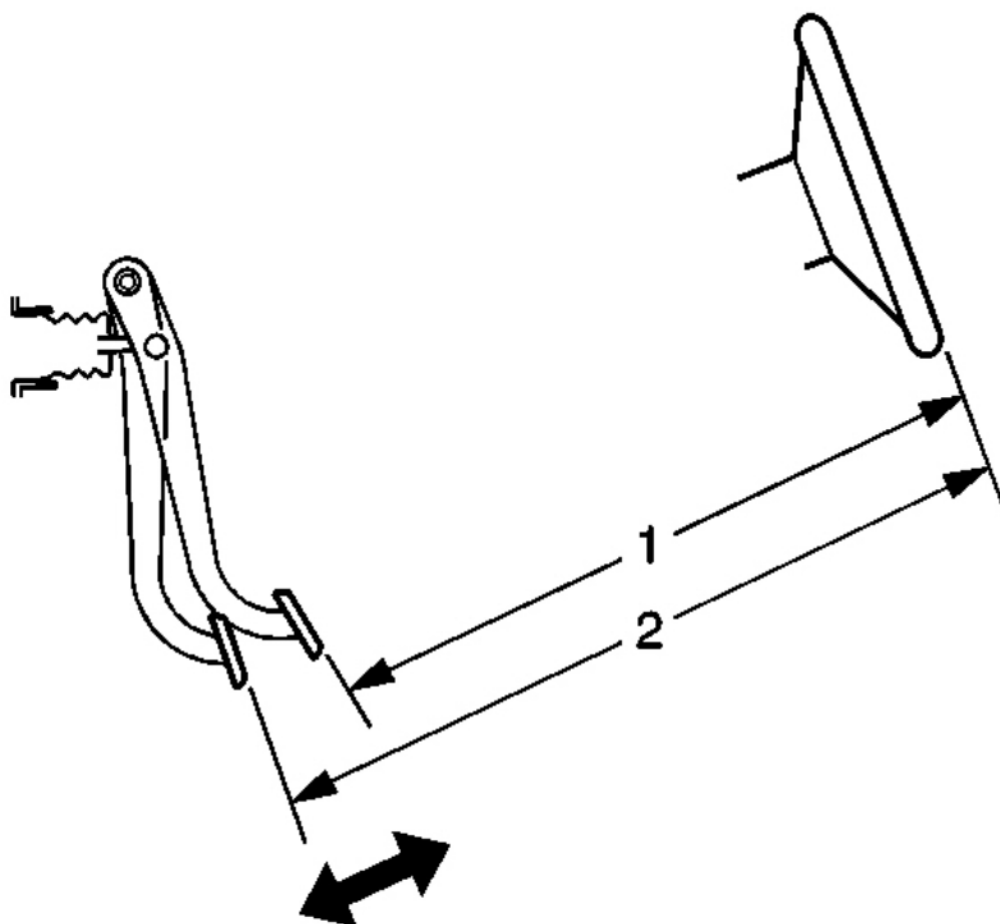


Fig. 4: Measuring Brake Pedal Travel
Courtesy of GENERAL MOTORS CORP.

3. Measure and record the distance (1) from the brake pedal to the rim of the steering wheel; note the points of measurement.
4. Apply and maintain the brakes with 445 N (100 lb) of force to the brake pedal, as indicated on the **J 28662**. See Special Tools and Equipment.

5. While maintaining 445 N (100 lb) of force to the brake pedal, measure and record the distance (2) from the same point on the brake pedal to the same point on the rim of the steering wheel.
6. Release the brakes 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 during the two applies of the brakes.
8. Subtract the initial measurement, unapplied (1), from the averaged, applied measurement (2) to obtain the brake pedal travel distance.

Specification: Maximum brake pedal travel (measured with the ignition OFF, brake booster power assist depleted, and the brakes cool): 63.5 mm (2.5 in).

BRAKE SYSTEM VACUUM SOURCE TEST

1. Disconnect the engine vacuum hose from the vacuum brake booster check valve.
2. Install a vacuum gage to the engine vacuum hose.
3. Start the engine and allow the engine to idle until normal operating temperatures are reached.
4. 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 is within the specified normal range, proceed to step 10.
7. If the engine vacuum reading is NOT within the specified normal range, inspect the engine vacuum hose for the following conditions.
 - Tight 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 gage to the check valve.

13. Start the engine and allow the engine to idle 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:
 - Firm 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

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

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.

2. If the fluid level is abnormally low, adjust the brake fluid level. Refer to Master Cylinder Reservoir Filling.
3. Start the engine and allow it to idle.
4. 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.

5. Turn OFF the ignition.
6. 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
7. 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

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

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) or Hydraulic Brake System Bleeding (Pressure).

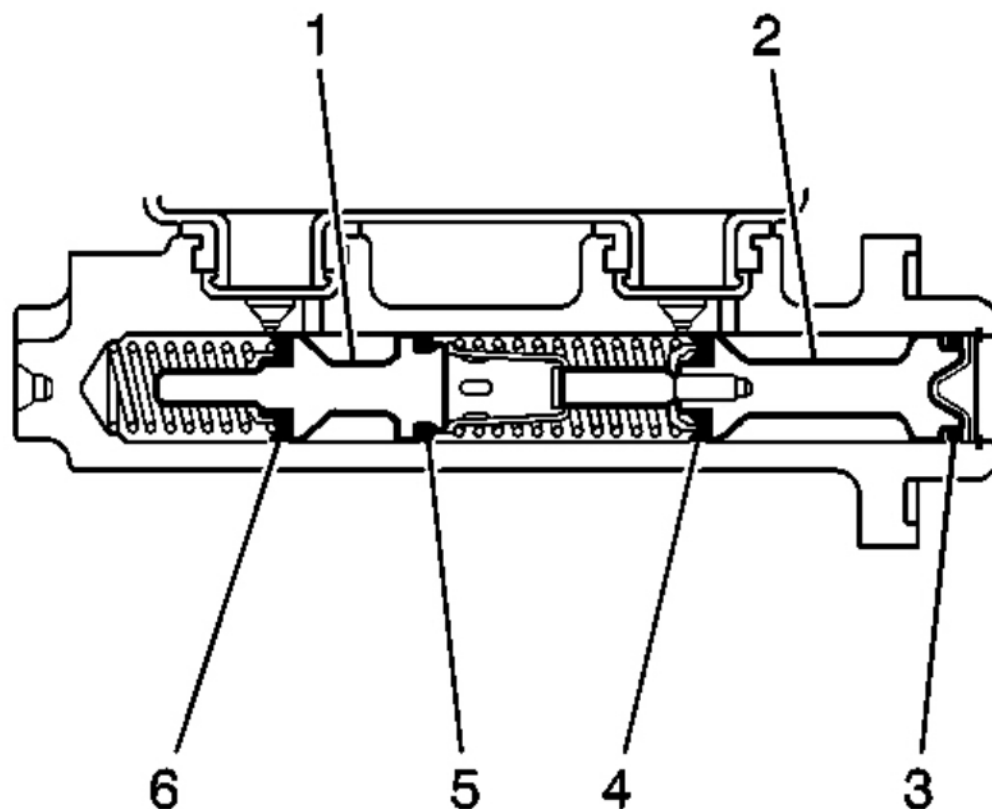


Fig. 5: Cross Sectional View Of Brake Master Cylinder
Courtesy of GENERAL MOTORS CORP.

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.

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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)** or **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.

HYDRAULIC BRAKE COMPONENT OPERATION VISUAL INSPECTION

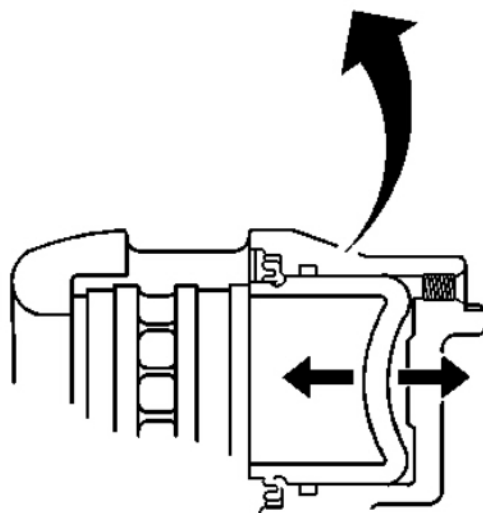
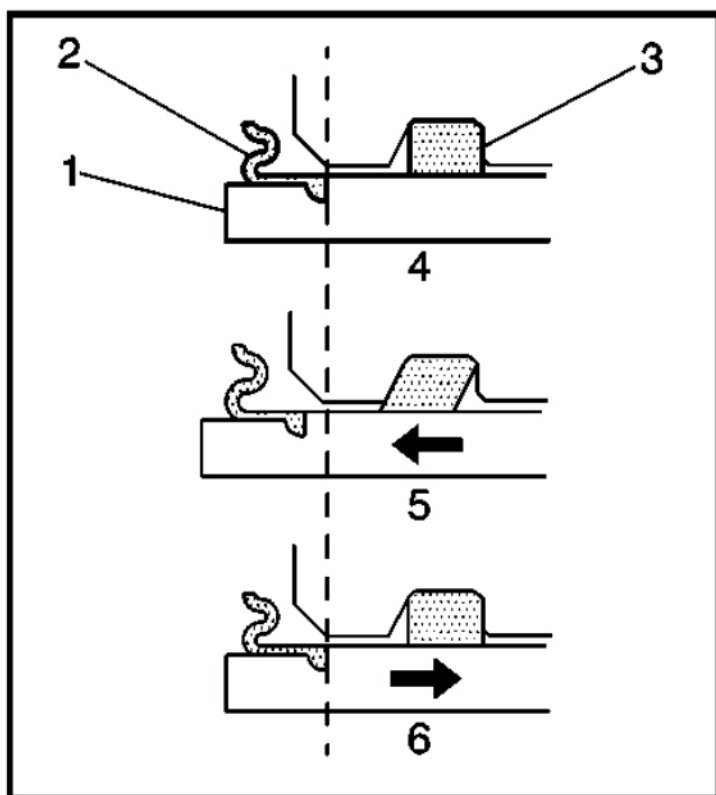


Fig. 6: Identifying Brake Caliper/Pad Inspection Areas
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

1. With the tire and wheel assemblies removed and the brake rotors retained by wheel lug nuts, visually inspect the caliper piston dust boot (2) sealing area to ensure that there are no brake fluid leaks.
2. If any evidence of a brake fluid leak is present, the brake caliper requires overhaul or replacement.
3. While the brake system is at rest (4), observe the position of the caliper piston (1) in relation to the caliper housing.
4. Have an assistant apply and release the brake pedal several times while you observe the operation of the hydraulic brake caliper.
 1. Observe the caliper piston (1) for unrestricted and even movement during each apply of the brake system (5).
 2. Observe the caliper piston (1) for an unrestricted and even return motion during each release of the brake system (6).
5. If the caliper piston (1) did not exhibit unrestricted and even movement during brake system apply and/or release, the piston square seal (3) may be worn or damaged and the caliper may require overhaul or replacement.

BRAKE PIPE AND HOSE INSPECTION

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

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.

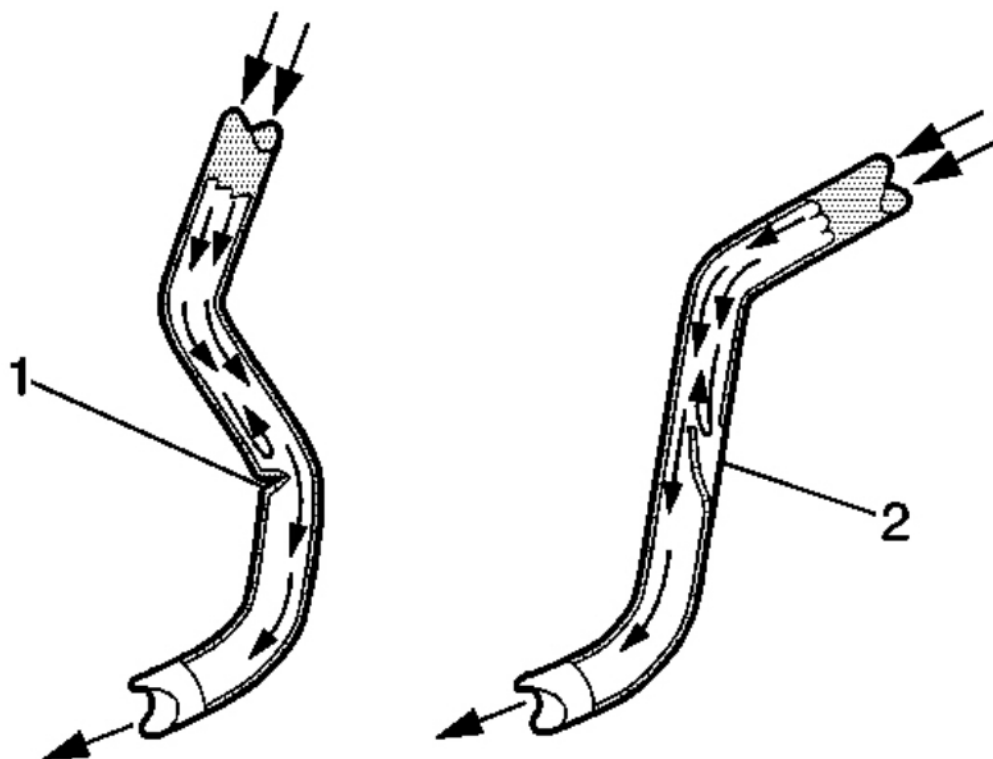


Fig. 7: Identifying Flexible Brake Hose Failure Conditions
Courtesy of GENERAL MOTORS CORP.

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.

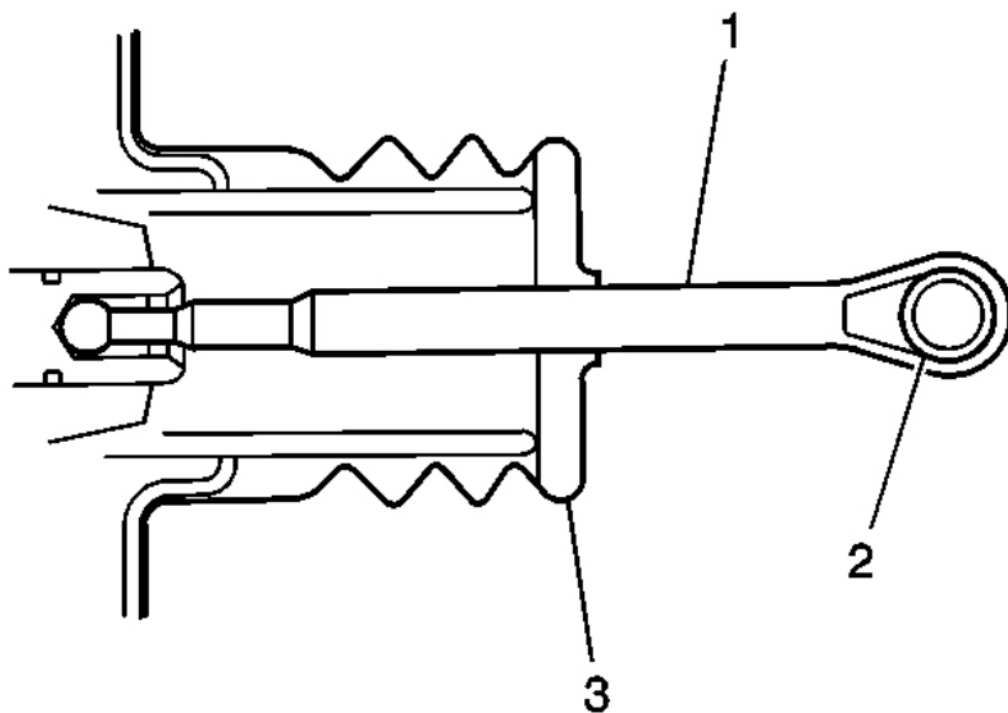
BRAKE PEDAL PUSHROD INSPECTION

Fig. 8: View of Brake Pedal Pushrod
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: When adding fluid to the brake master cylinder reservoir, use only Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container. 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.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

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 Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.

MASTER CYLINDER RESERVOIR REPLACEMENT

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

Removal Procedure

1. Remove the master cylinder from the vehicle. Refer to Master Cylinder Replacement.

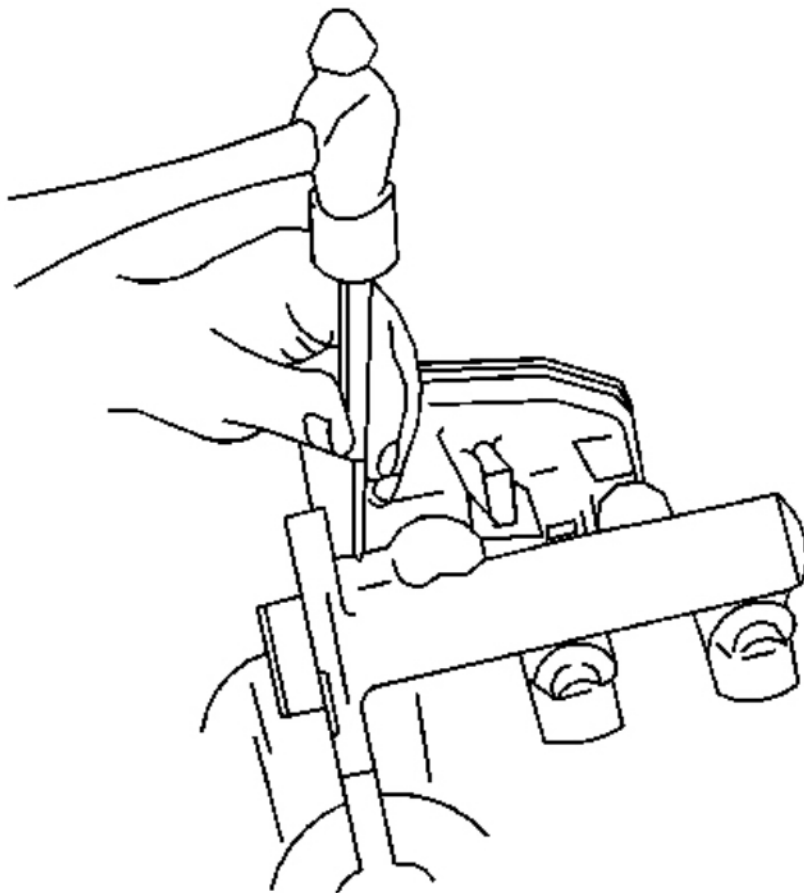


Fig. 9: Removing/Installing Reservoir Retaining Pins
Courtesy of GENERAL MOTORS CORP.

2. Remove the fluid level sensor. Refer to Master Cylinder Fluid Level Sensor Replacement.

3. Drain the brake fluid from the master cylinder reservoir.
4. Carefully tap out the reservoir retaining pins until clear of reservoir.
5. Remove the reservoir from the master cylinder.
6. Remove the seals from the master cylinder reservoir.

Installation Procedure

1. Inspect the reservoir for cracks or deformities. If found, replace the reservoir.
2. Clean the reservoir with clean denatured alcohol, or equivalent.
3. Dry the reservoir with non-lubricated, filtered air.

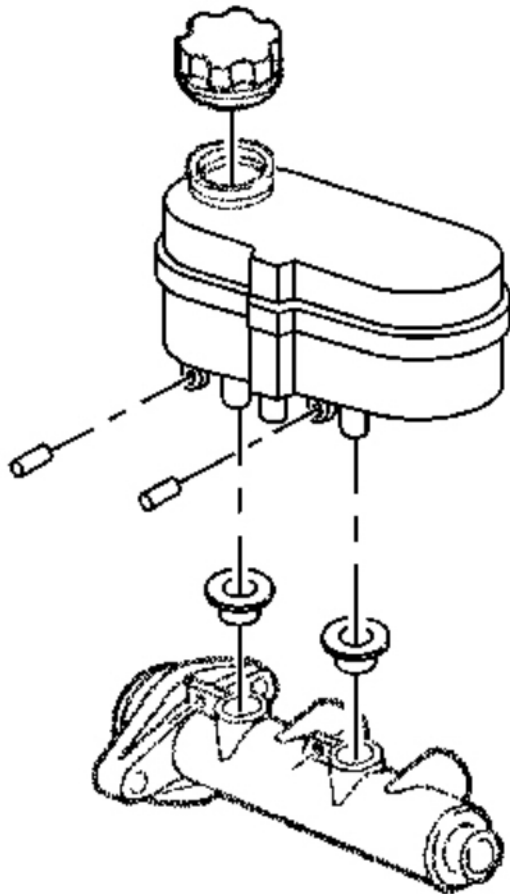


Fig. 10: Exploded View Of Master Cylinder & Reservoir
Courtesy of GENERAL MOTORS CORP.

4. Lubricate the new seals and the reservoir bayonets with new Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667) or equivalent DOT-3 brake fluid.
5. Install the seals, making sure they are fully seated.
6. Install the reservoir onto the master cylinder by pressing straight down by hand until pin holes are aligned.

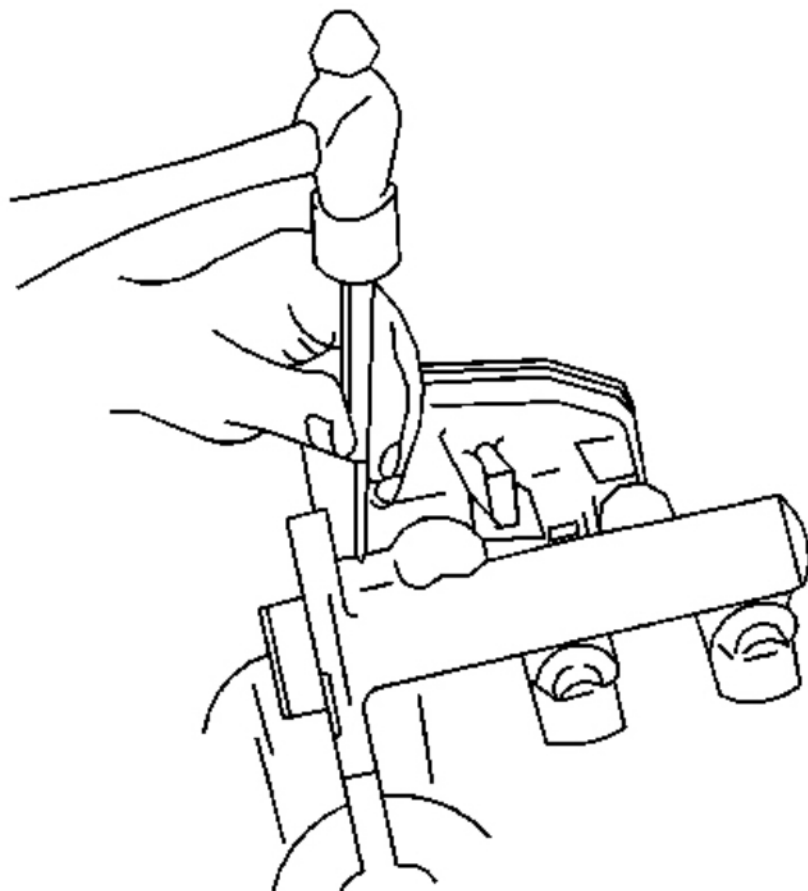


Fig. 11: Removing/Installing Reservoir Retaining Pins
Courtesy of GENERAL MOTORS CORP.

7. Carefully tap in the reservoir retaining pins to secure the reservoir.
8. Fill the master cylinder reservoir. Refer to Master Cylinder Reservoir Filling.
9. Install the brake fluid level sensor. Refer to Master Cylinder Fluid Level Sensor Replacement.
10. Install the master cylinder to the vehicle. Refer to Master Cylinder Replacement.

MASTER CYLINDER REPLACEMENT

CAUTION: Refer to in Brake Fluid Irritant Caution Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

Removal Procedure

1. Disconnect the electrical connector from the brake fluid level sensor.
2. Disconnect the brake pipes from the master cylinder.

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting end in order to prevent brake fluid loss and contamination.

3. Plug the open brake pipe fitting ends.

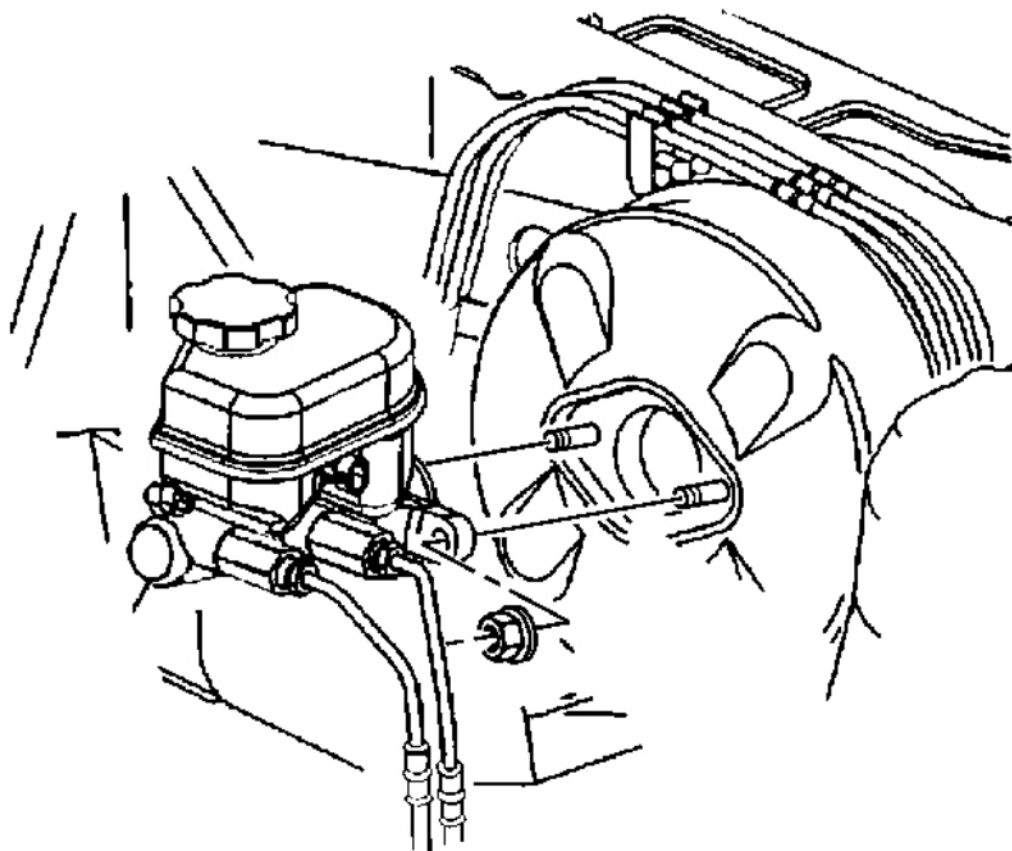


Fig. 12: Removing & Installing Master Cylinder
Courtesy of GENERAL MOTORS CORP.

4. Remove the 2 master cylinder mounting nuts.
5. Remove the master cylinder.
6. Remove the reservoir from the master cylinder if it is to be reused on a replacement master cylinder. Refer to **Master Cylinder Reservoir Replacement**.

Installation Procedure

1. Install the brake master cylinder reservoir to the master cylinder if it was removed previously. Refer to **Master Cylinder Reservoir Replacement**.
2. Bench bleed the master cylinder. Refer to **Master Cylinder Bench Bleeding**.

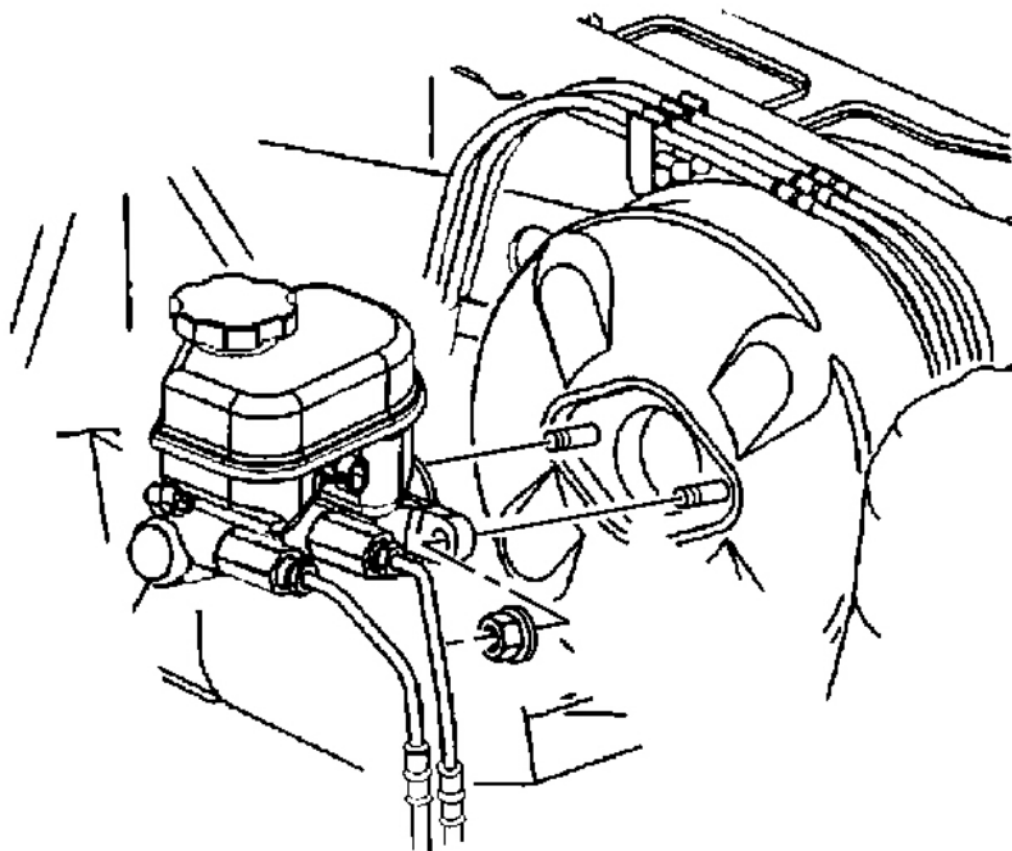


Fig. 13: Removing & Installing Master Cylinder
Courtesy of GENERAL MOTORS CORP.

3. Install the master cylinder to the vacuum brake booster.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the 2 brake master cylinder mounting nuts.

Tighten: Tighten the 2 brake master cylinder mounting nuts to 25 N.m (18 lb ft).

5. Remove the plugs from the brake pipes.
6. Install the brake pipes to the master cylinder.

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Tighten: Tighten the brake pipe fittings at the master cylinder to 38 N.m (28 lb ft).

7. Connect the electrical connector to the brake fluid level sensor.
8. Bleed the hydraulic brake system. Refer to **Hydraulic Brake System Bleeding (Manual)** or **Hydraulic Brake System Bleeding (Pressure)**.

MASTER CYLINDER OVERHAUL

CAUTION: Refer to **Brake Fluid Irritant Caution** in Cautions and Notices.

NOTE: Refer to **Brake Fluid Effects on Paint and Electrical Components Notice** in Cautions and Notices.

Disassembly Procedure

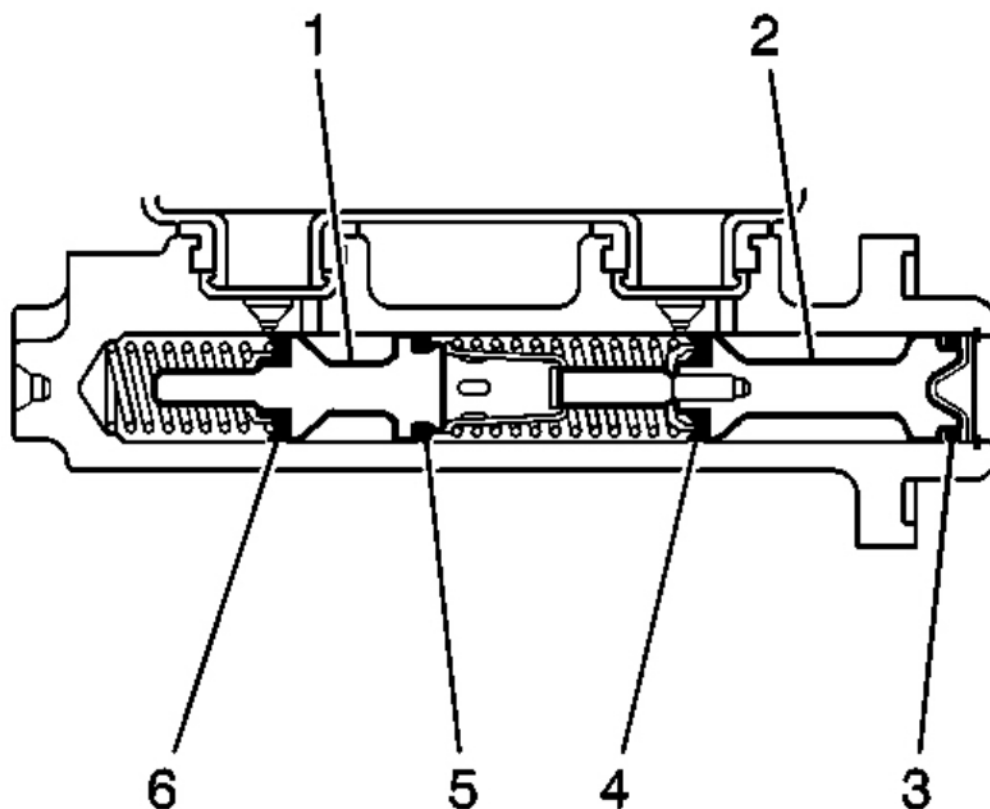


Fig. 14: Cross Sectional View Of Brake Master Cylinder
Courtesy of GENERAL MOTORS CORP.

1. Remove the brake master cylinder from the vehicle. Refer to **Master Cylinder Replacement**.
2. Secure the mounting flange of the brake master cylinder in a bench vise so that the rear of the primary piston is accessible.
3. Clean the outside of the master cylinder reservoir on and around the reservoir cap prior to removing the cap and diaphragm.
4. Remove the reservoir cap and diaphragm from the reservoir.
5. Inspect the reservoir cap and diaphragm for the following conditions. If any of these conditions are present, replace the affected components.
 - Cuts or cracks

- Nicks or deformation
6. Remove the master cylinder reservoir from the master cylinder. Refer to **Master Cylinder Reservoir Replacement**.
 7. Using a smooth, round-ended tool, depress the primary piston (2) and remove the piston retainer.
 8. Remove the primary piston assembly from the cylinder bore.
 9. Plug the cylinder inlet ports and the rear outlet port. Apply low pressure, non-lubricated, filtered air into the front outlet port, in order to remove the secondary piston (1) with the primary (6) and secondary (5) seals, and the return spring.
 10. Discard the primary piston assembly, the piston retainer, and the seals and seal retainer from the secondary piston.

Assembly Procedure

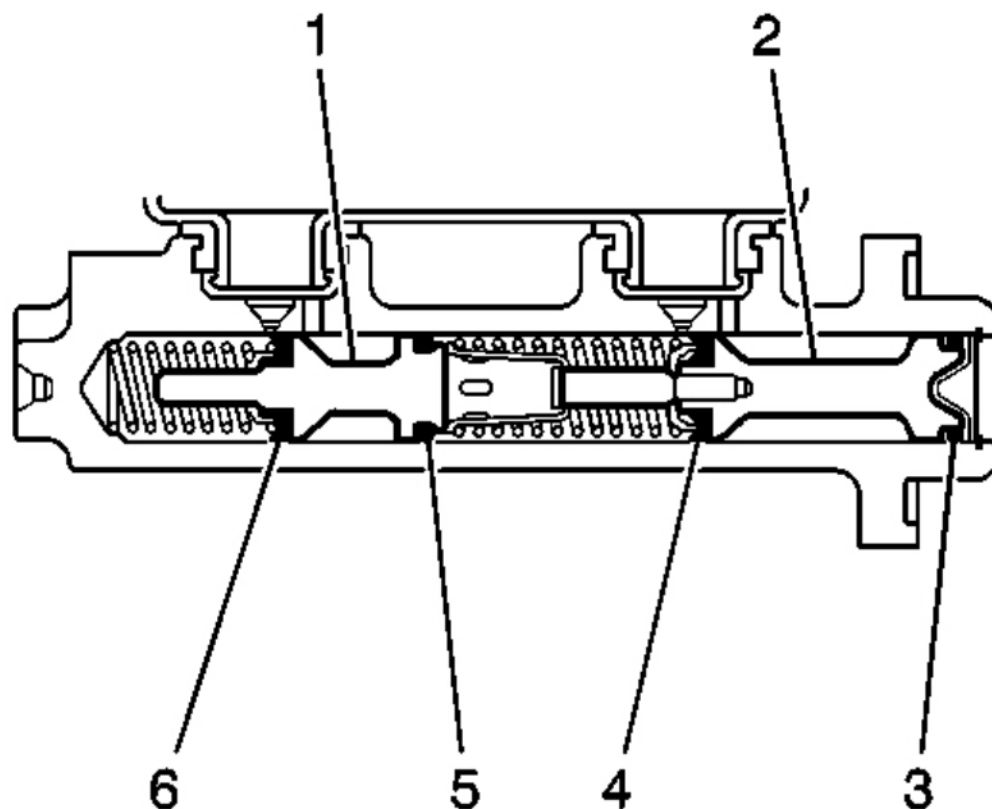


Fig. 15: Cross Sectional View Of Brake Master Cylinder
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use abrasives to clean the brake master cylinder bore.

1. Clean the interior and exterior of the master cylinder, the secondary piston (1), and the return spring in denatured alcohol, or equivalent.
2. Inspect the master cylinder bore, inlet and outlet ports, the secondary piston (1), and the return spring for cracks, scoring, pitting, and/or corrosion. Replace the master cylinder if any of these conditions exist.
3. Dry the master cylinder and the individual components with non-lubricated, filtered air.
4. Lubricate the master cylinder bore, the secondary piston (1), the return spring, and all of the individual overhaul components with Delco Supreme 11®, GM P/N 12377967 (Canadian

- P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.
5. Assemble the lubricated, new primary seal (6) and retainer, and new secondary seal (5) onto the secondary piston.
 6. Install the lubricated return spring and secondary piston assembly (1) into the cylinder bore.
 7. Install the lubricated, new primary piston assembly (2) into the cylinder bore.
 8. Using a smooth, round-ended tool, depress the primary piston (2) and install the new piston retainer.
 9. Install the master cylinder reservoir to the master cylinder. Refer to **Master Cylinder Reservoir Replacement**.
 10. Install the reservoir cap and diaphragm to the reservoir.
 11. Install the master cylinder to the vehicle. Refer to **Master Cylinder Replacement**.

MASTER CYLINDER BENCH BLEEDING

CAUTION: Refer to **Brake Fluid Irritant Caution** in Cautions and Notices.

NOTE: Refer to **Brake Fluid Effects on Paint and Electrical Components Notice** in Cautions and Notices.

NOTE: When adding fluid to the brake master cylinder reservoir, use only Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container. 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.

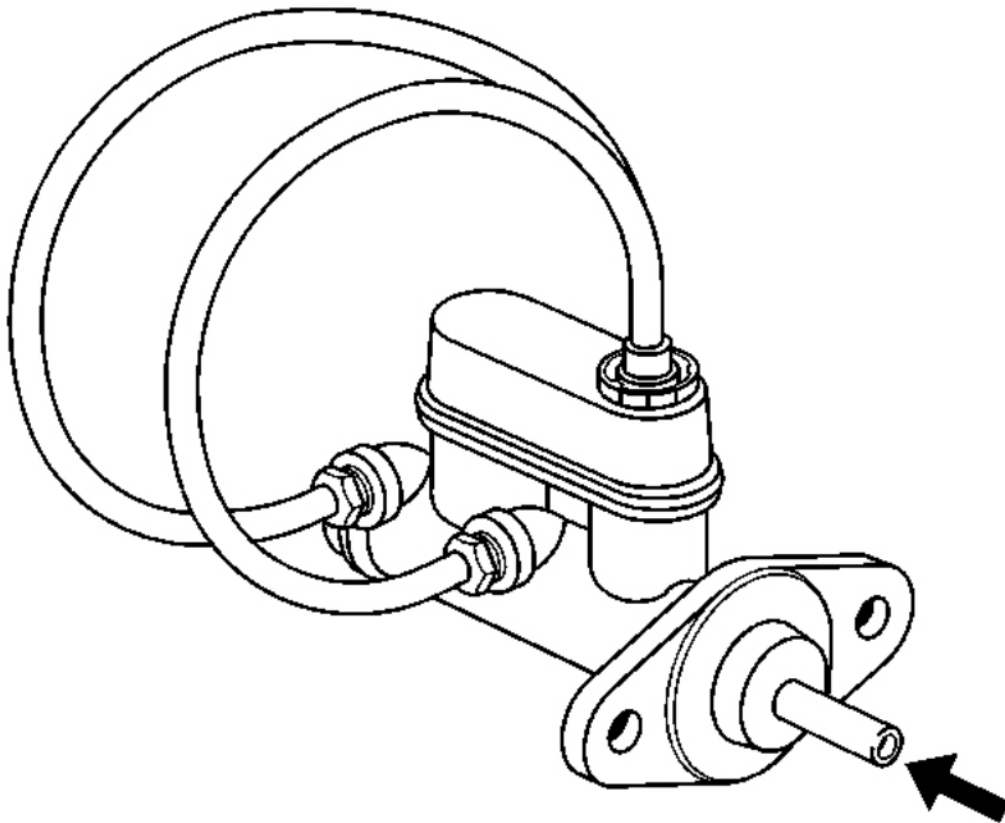


Fig. 16: Bleeding Master Cylinder
Courtesy of GENERAL MOTORS CORP.

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 Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.

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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.

MASTER CYLINDER FLUID LEVEL SENSOR REPLACEMENT

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

Removal Procedure

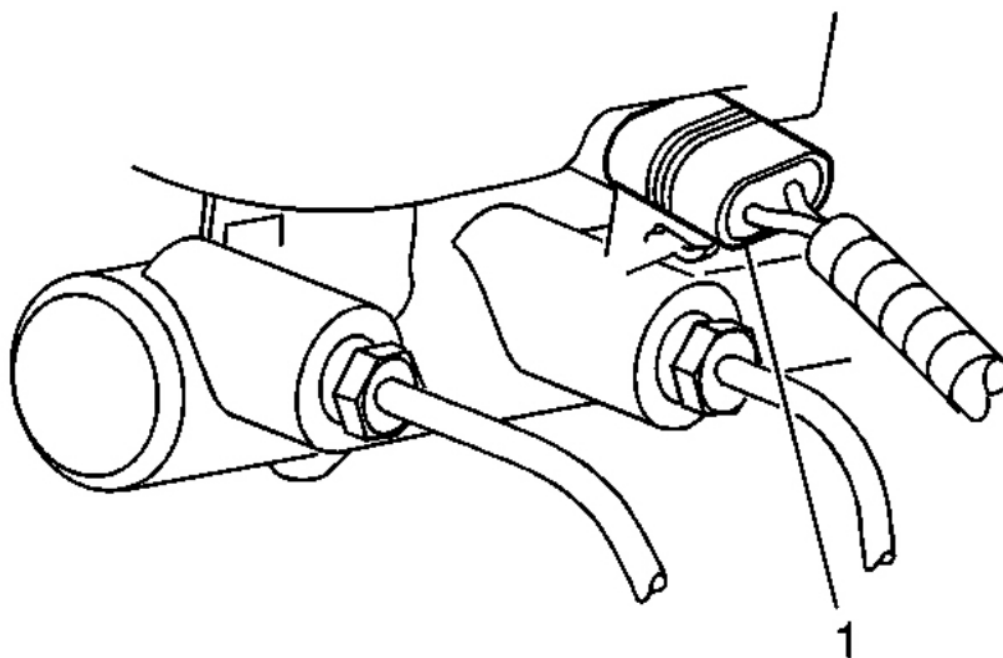


Fig. 17: View Of Brake Fluid Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the electrical connector (1) from the brake fluid level sensor.

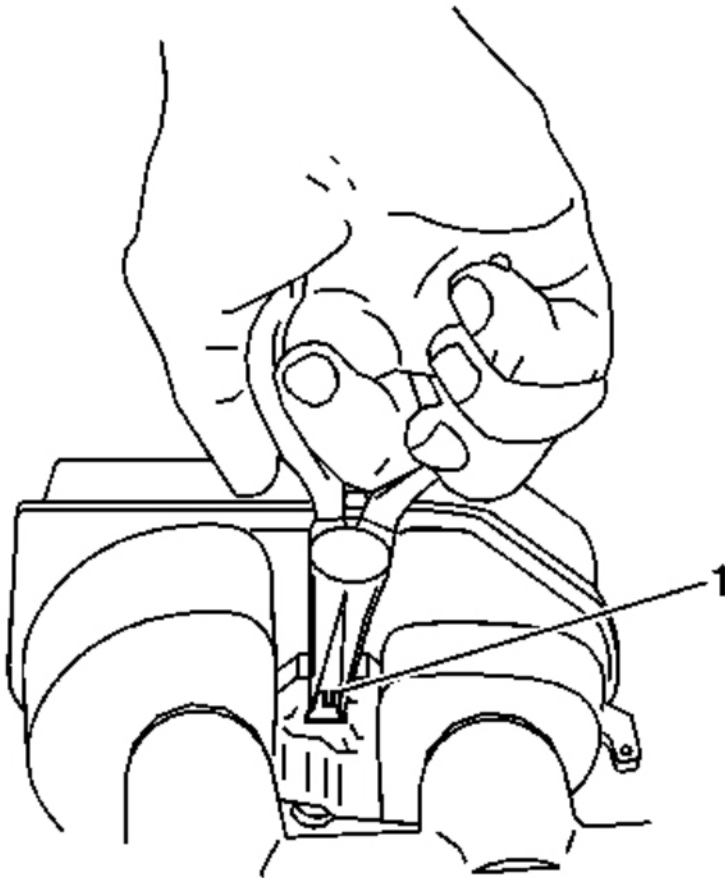


Fig. 18: Removing Brake Fluid Level Sensor
Courtesy of GENERAL MOTORS CORP.

2. Using a needle nose pliers carefully depress the retaining tabs (1) on the end of the brake fluid level sensor and press the sensor through the reservoir to remove.

Installation Procedure

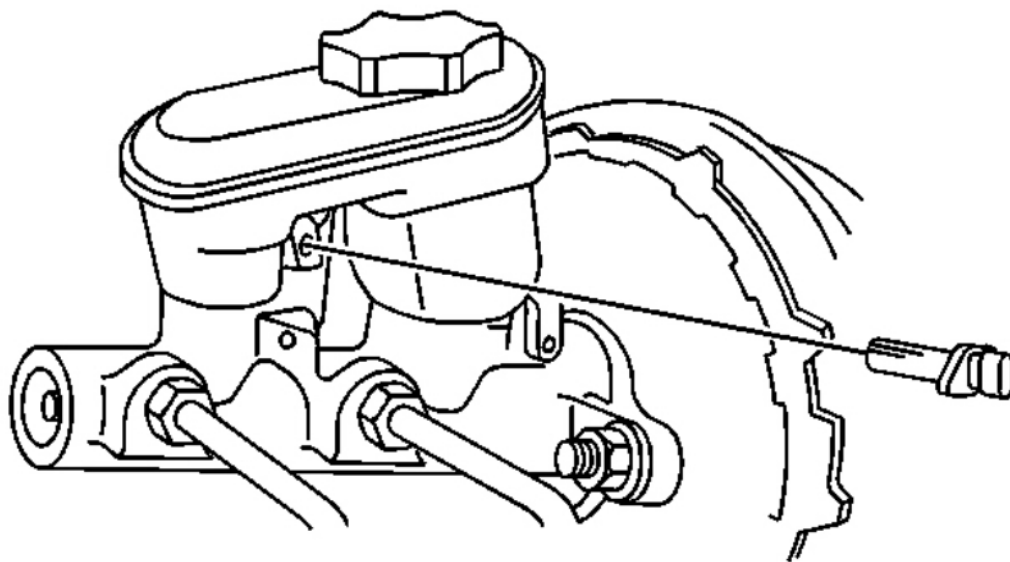


Fig. 19: Installing Brake Fluid Level Sensor
Courtesy of GENERAL MOTORS CORP.

1. Align the brake fluid level sensor to the master cylinder reservoir.
2. Press the brake fluid level sensor into the master cylinder reservoir.
3. Connect the electrical connector to the brake fluid level sensor.

BRAKE PEDAL ASSEMBLY REPLACEMENT (LHD AUTOMATIC TRANS)

Removal Procedure

1. Remove the vacuum brake booster assembly. Refer to **Vacuum Brake Booster Replacement (LHD)** or **Vacuum Brake Booster Replacement (RHD)**.
2. Remove the park brake pedal assembly. Refer to **Park Brake Pedal Assembly Replacement (LHD)** or **Park Brake Pedal Assembly Replacement (RHD)** in Park Brake.

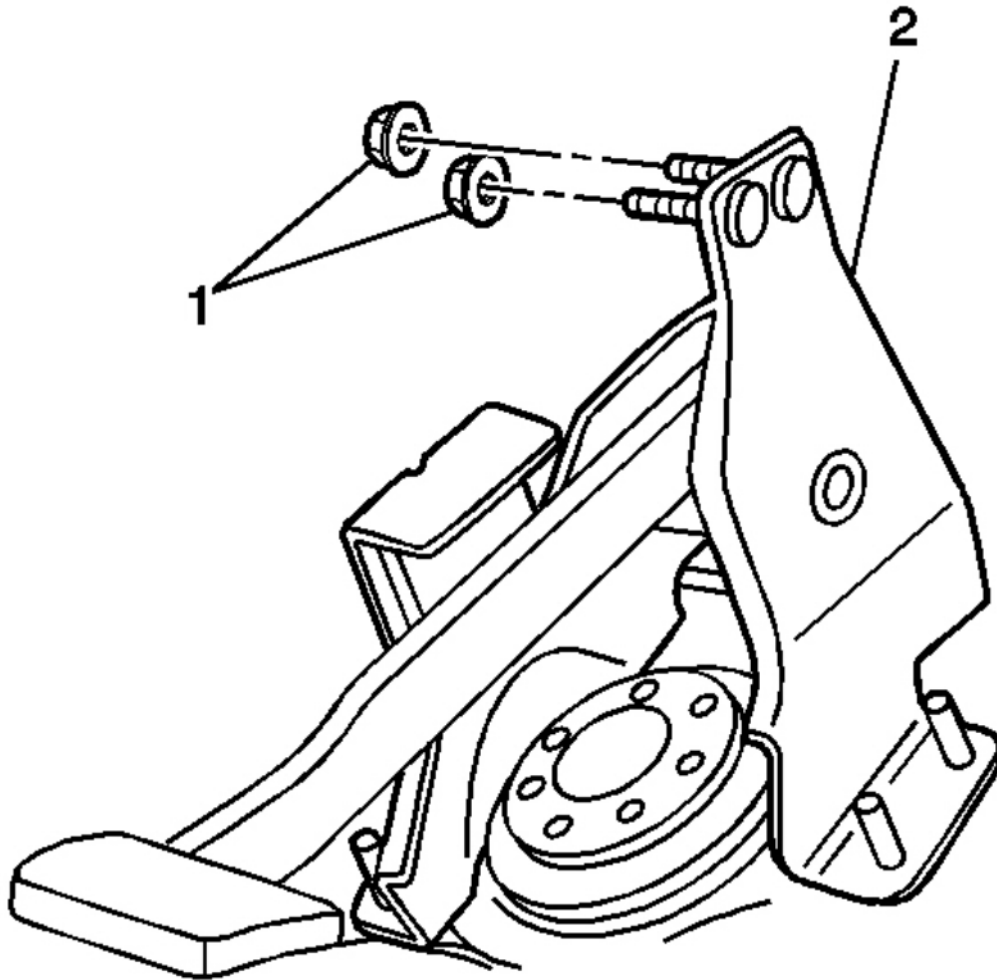


Fig. 20: Removing & Installing Brake Pedal Assembly
Courtesy of GENERAL MOTORS CORP.

3. Remove the brake pedal to cowl mounting nuts.
4. Remove the steering column support bracket to cowl mounting nut.
5. Remove the steering column support bracket to instrument panel (I/P) mounting nuts, to the right of the brake pedal.
6. Remove the brake pedal assembly to the I/P carrier mounting nuts (1).
7. Remove the vacuum brake booster mounting plate.

8. Remove the steering column support bracket to the right of the brake pedal.
9. Remove the brake pedal assembly (2).

Installation Procedure

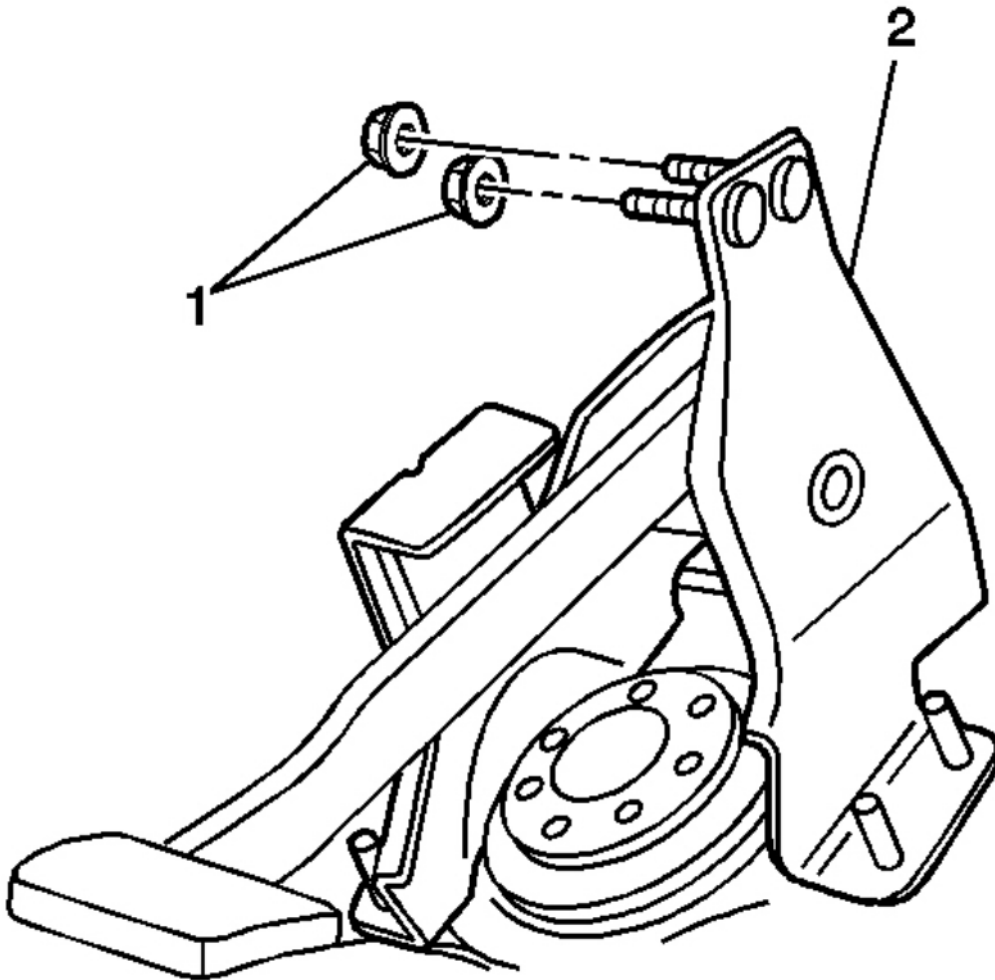


Fig. 21: Removing & Installing Brake Pedal Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the brake pedal assembly (2) to the vehicle.
2. Install the steering column support bracket to the vehicle.

3. Install the vacuum brake booster mounting plate.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the brake pedal assembly to cowl mounting nuts

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

5. Install the steering column support bracket to cowl mounting nuts

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

6. Install the brake pedal assembly to I/P carrier mounting nuts.

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

7. Install the steering column support bracket I/P carrier mounting nuts.

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

8. Install the park brake pedal assembly. Refer to Park Brake Pedal Assembly Replacement (LHD) or Park Brake Pedal Assembly Replacement (RHD) in Park Brake.
9. Install the vacuum brake booster assembly. Refer to Vacuum Brake Booster Replacement (LHD) or Vacuum Brake Booster Replacement (RHD).
10. Recalibrate the brake pedal position sensor. Refer to Brake Pedal Position Sensor Replacement in Lighting.

BRAKE PEDAL ASSEMBLY REPLACEMENT (RHD AUTOMATIC TRANS)

Removal Procedure

1. Remove the vacuum brake booster assembly. Refer to Vacuum Brake Booster Replacement (LHD) or Vacuum Brake Booster Replacement (RHD).
2. Remove the park brake pedal assembly. Refer to Park Brake Pedal Assembly Replacement (LHD) or Park Brake Pedal Assembly Replacement (RHD) in Park Brake.
3. Remove the clutch pedal assembly. Refer to Clutch Pedal Replacement (CTS) or Clutch Pedal Replacement (CTS-V) in Clutch.

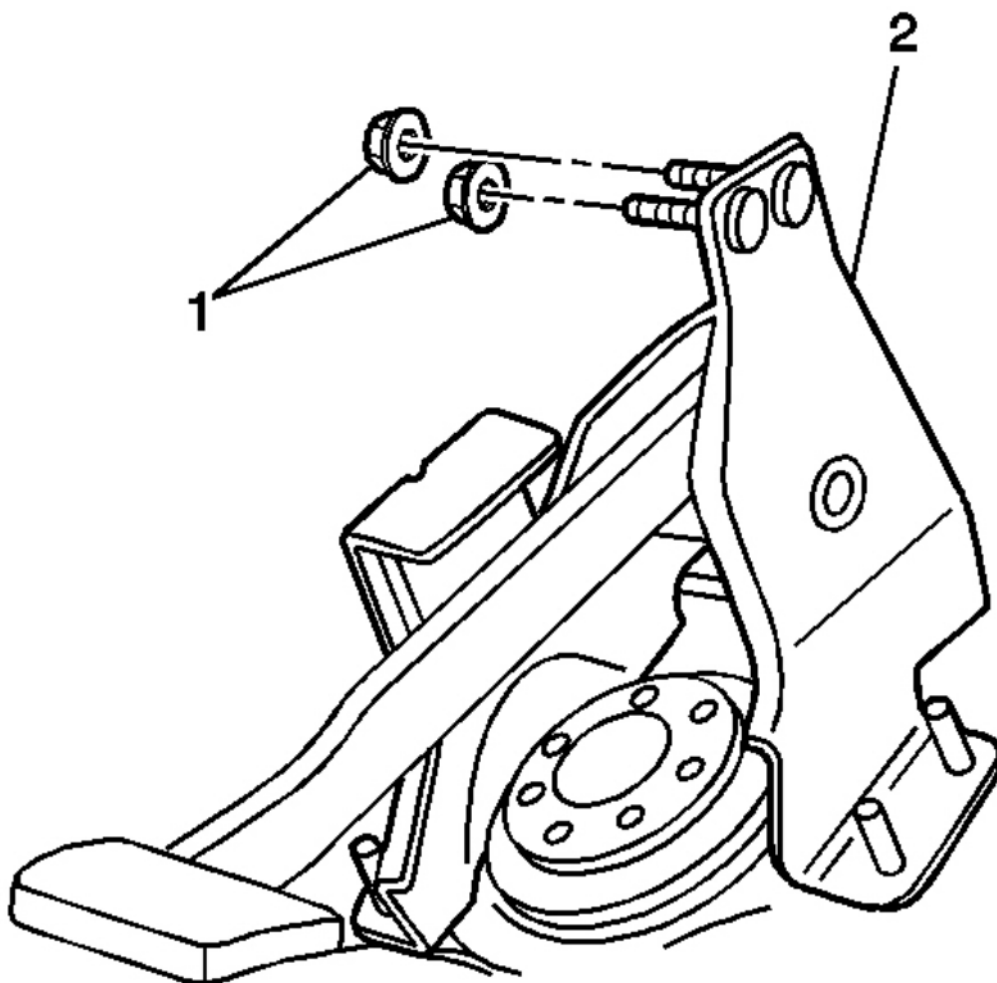


Fig. 22: Removing & Installing Brake Pedal Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the brake pedal to cowl mounting nuts.
5. Remove the steering column support bracket to cowl mounting nut.
6. Remove the steering column support bracket to instrument panel (I/P) mounting nuts, to the right of the brake pedal.
7. Remove the brake pedal assembly to the I/P carrier mounting nuts (1).
8. Remove the vacuum brake booster mounting plate.

9. Remove the steering column support bracket to the right of the brake pedal.
10. Remove the brake pedal assembly (2).

Installation Procedure

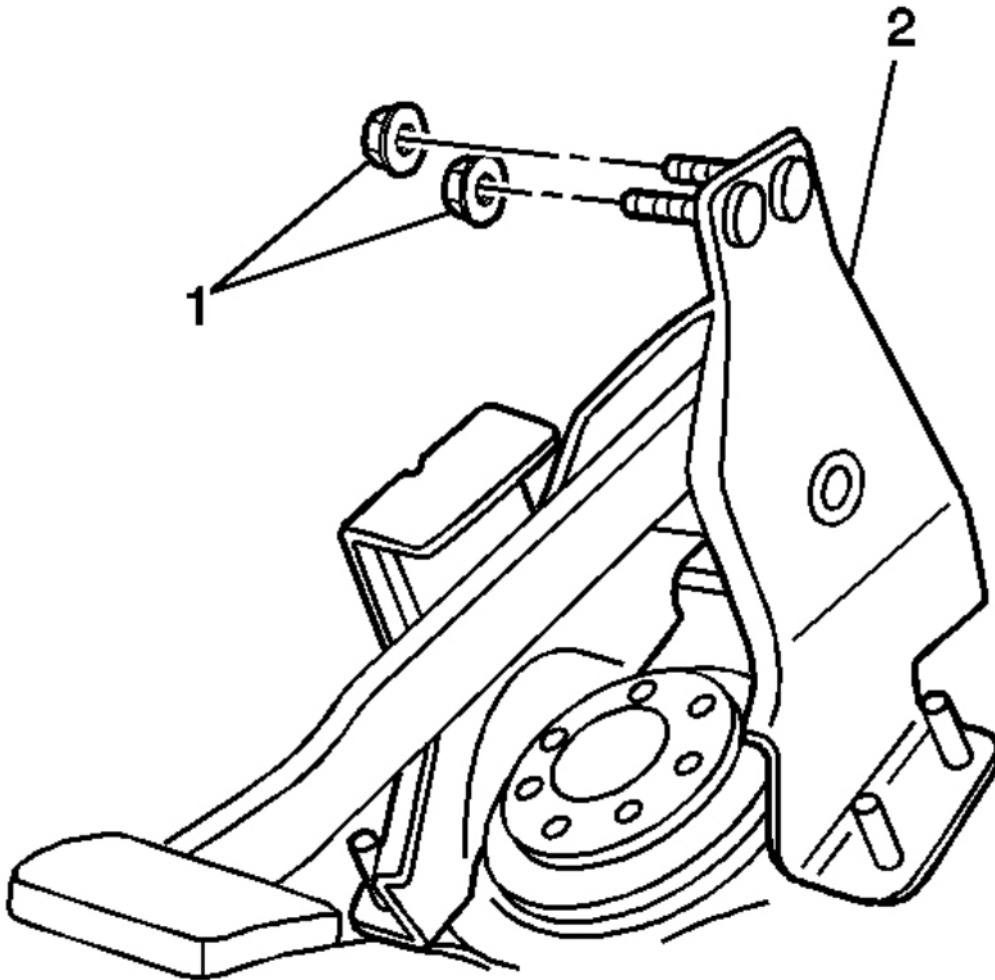


Fig. 23: Removing & Installing Brake Pedal Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the brake pedal assembly (2) to the vehicle.
2. Install the steering column support bracket to the vehicle.

3. Install the vacuum brake booster mounting plate.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the brake pedal assembly to cowl mounting nuts

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

5. Install the steering column support bracket to cowl mounting nuts

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

6. Install the brake pedal assembly to I/P carrier mounting nuts.

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

7. Install the steering column support bracket I/P carrier mounting nuts.

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

8. Install the clutch pedal assembly. Refer to Clutch Pedal Replacement (CTS) or Clutch Pedal Replacement (CTS-V) in Clutch.
9. Install the park brake pedal assembly. Refer to Park Brake Pedal Assembly Replacement (LHD) or Park Brake Pedal Assembly Replacement (RHD) in Park Brake.
10. Install the vacuum brake booster assembly. Refer to Vacuum Brake Booster Replacement (LHD) or Vacuum Brake Booster Replacement (RHD).
11. Recalibrate the brake pedal position sensor. Refer to Brake Pedal Position Sensor Replacement in Lighting.

BRAKE PEDAL ASSEMBLY REPLACEMENT (MANUAL TRANS BEFORE VIN 40101964)

Removal Procedure

1. Remove the brake pedal to cowl mounting nuts.

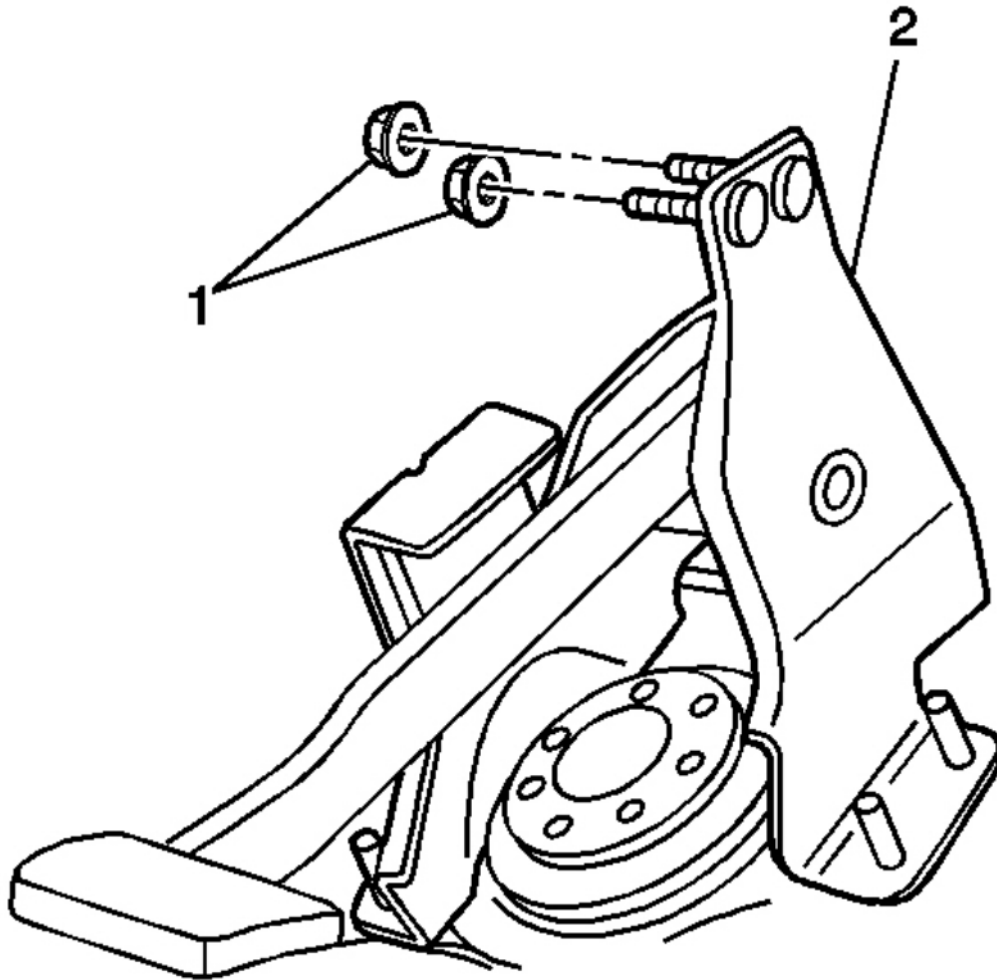


Fig. 24: Removing & Installing Brake Pedal Assembly
Courtesy of GENERAL MOTORS CORP.

2. Remove the I/P carrier assembly, to gain access to the brake pedal assembly to I/P carrier mounting nuts. Refer to **Instrument Panel (I/P) Carrier Replacement** in Instrument Panel, Gages and Console.
3. Remove the brake pedal assembly to the I/P carrier mounting nuts (1).
4. Remove the brake pedal assembly (2).

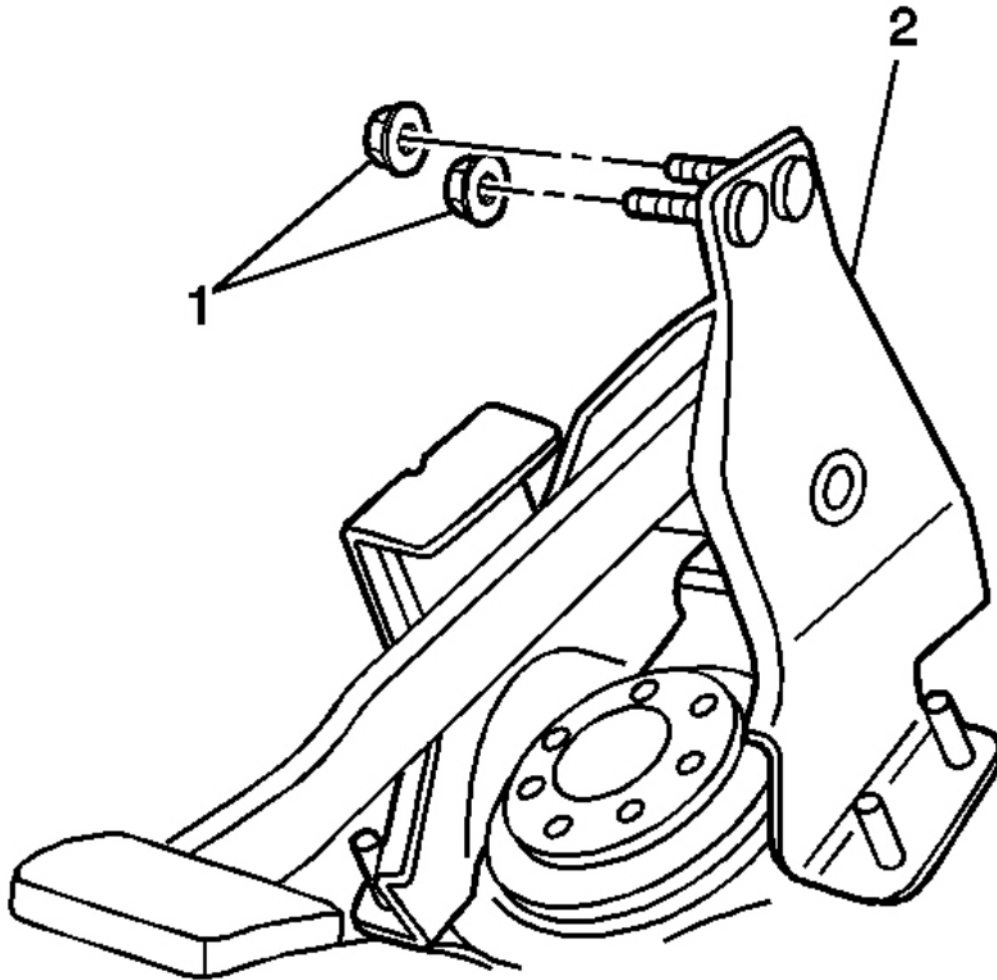


Fig. 25: Removing & Installing Brake Pedal Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the brake pedal assembly (2) to the I/P carrier.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the brake pedal assembly to I/P carrier mounting nuts.

Tighten: Tighten the brake pedal assembly to I/P carrier mounting nuts to 25 N.m (18 lb ft).

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3. Install the I/P assembly. Refer to **Instrument Panel (I/P) Carrier Replacement** in Instrument Panel, Gages and Console.
4. Install the brake pedal assembly to cowl mounting nuts

Tighten: Tighten the brake pedal assembly to cowl mounting nuts to 25 N.m (18 lb ft).

5. Recalibrate the brake pedal position sensor. Refer to **Brake Pedal Position Sensor Replacement** in Lighting.

BRAKE PEDAL ASSEMBLY REPLACEMENT (MANUAL TRANS AFTER VIN 40101964)

Removal Procedure

1. Remove the vacuum brake booster assembly. Refer to **Vacuum Brake Booster Replacement (LHD)** or **Vacuum Brake Booster Replacement (RHD)**.
2. Remove the park brake pedal assembly. Refer to **Park Brake Pedal Assembly Replacement (LHD)** or **Park Brake Pedal Assembly Replacement (RHD)** in Park Brake.
3. Remove the clutch pedal assembly. Refer to **Clutch Pedal Replacement (CTS)** or **Clutch Pedal Replacement (CTS-V)** in Clutch.

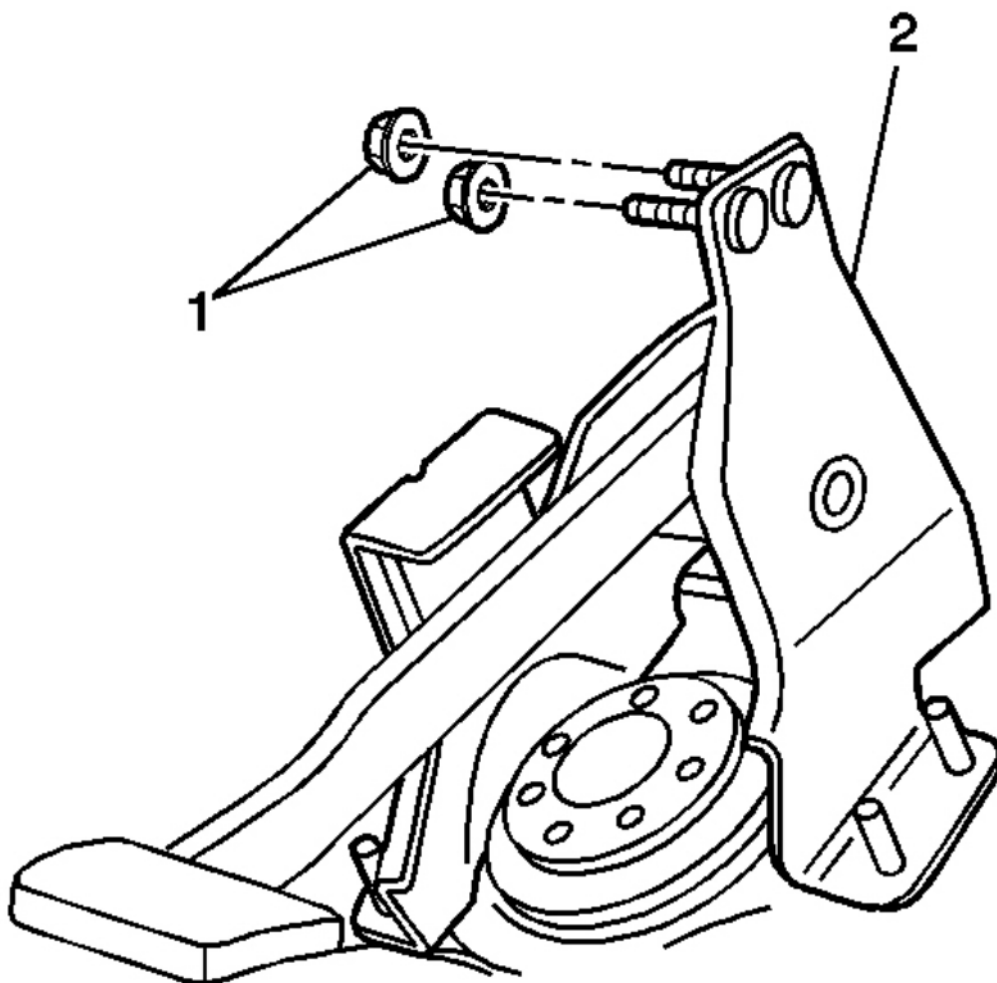


Fig. 26: Removing & Installing Brake Pedal Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the brake pedal to cowl mounting nuts.
5. Remove the steering column support bracket to cowl mounting nut.
6. Remove the steering column support bracket to instrument panel (I/P) mounting nuts, to the right of the brake pedal.
7. Remove the brake pedal assembly to the I/P carrier mounting nuts (1).
8. Remove the vacuum brake booster mounting plate.

9. Remove the steering column support bracket to the right of the brake pedal.
10. Remove the brake pedal assembly (2).

Installation Procedure

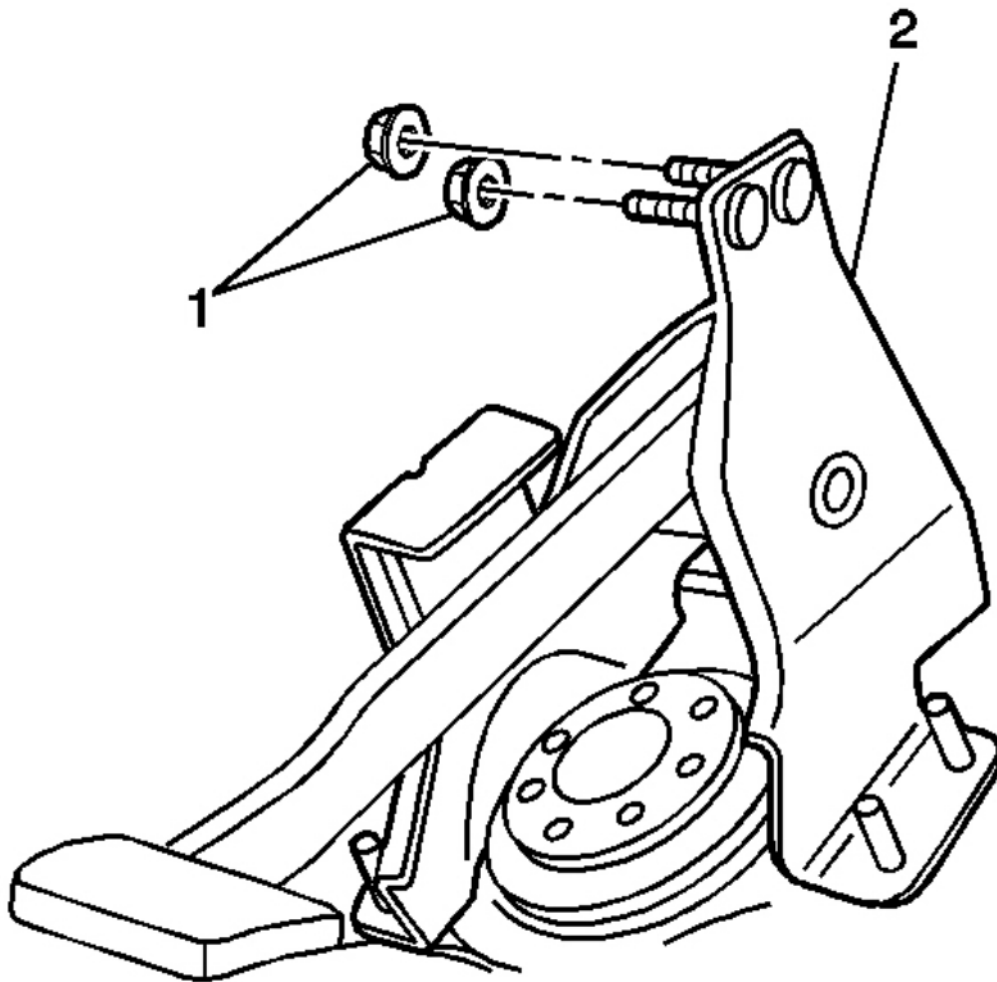


Fig. 27: Removing & Installing Brake Pedal Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the brake pedal assembly (2) to the vehicle.
2. Install the steering column support bracket to the vehicle.

3. Install the vacuum brake booster mounting plate.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the brake pedal assembly to cowl mounting nuts

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

5. Install the steering column support bracket to cowl mounting nuts

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

6. Install the brake pedal assembly to I/P carrier mounting nuts.

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

7. Install the steering column support bracket I/P carrier mounting nuts.

Tighten: Tighten the nuts to 25 N.m (18 lb ft).

8. Install the clutch pedal assembly. Refer to Clutch Pedal Replacement (CTS) or Clutch Pedal Replacement (CTS-V) in Clutch.
9. Install the park brake pedal assembly. Refer to Park Brake Pedal Assembly Replacement (LHD) or Park Brake Pedal Assembly Replacement (RHD) in Park Brake.
10. Install the vacuum brake booster assembly. Refer to Vacuum Brake Booster Replacement (LHD) or Vacuum Brake Booster Replacement (RHD).
11. Recalibrate the brake pedal position sensor. Refer to Brake Pedal Position Sensor Replacement in Lighting.

BRAKE PIPE REPLACEMENT

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

CAUTION: 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.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

Tools Required

J 45405 Brake Pipe Flaring Kit. See Special Tools and Equipment.

IMPORTANT: 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.

Brake Pipe Replacement

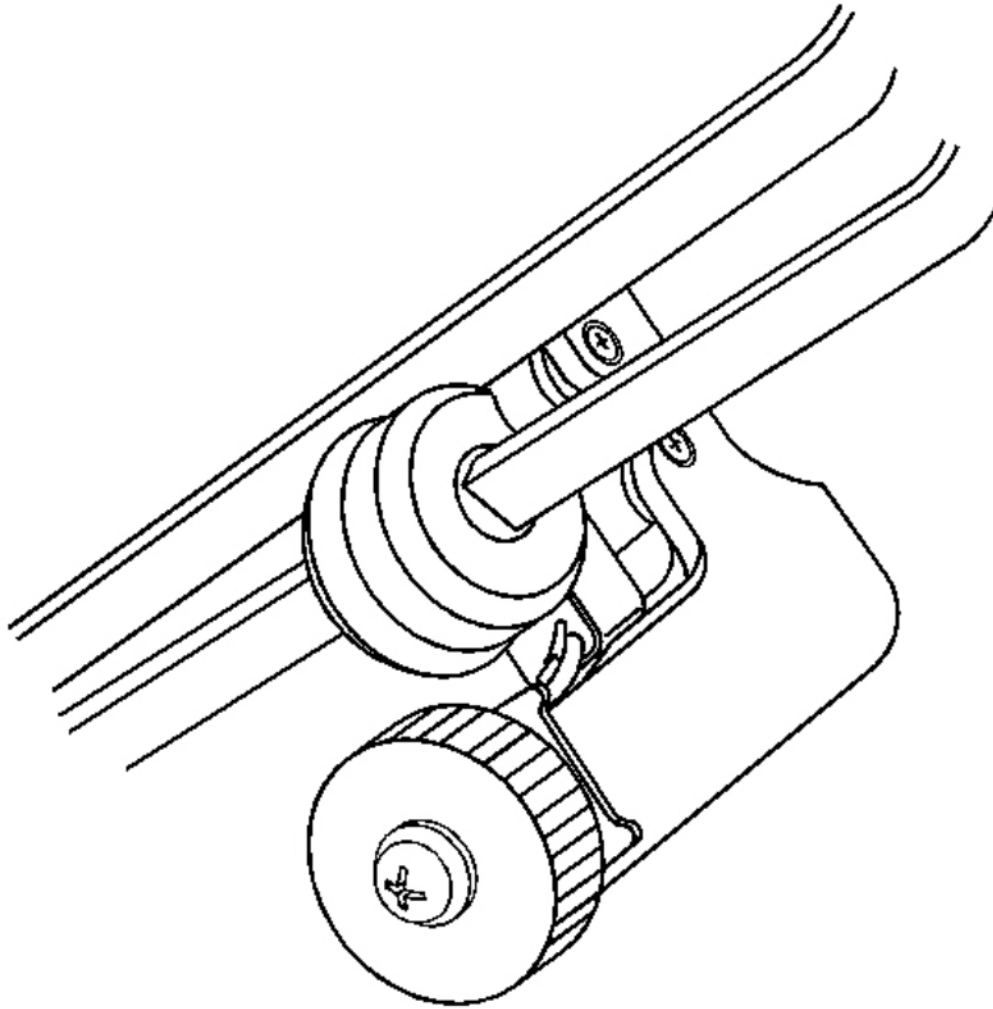


Fig. 28: Sectioning Brake Pipe Using Pipe Cutter
Courtesy of GENERAL MOTORS CORP.

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 **J 45405** . See **Special Tools and Equipment**.
 - Avoid sectioning the brake pipe at bends or mounting points.

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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

IMPORTANT: 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 **J 45405** , carefully cut the brake pipe squarely to the measured length. See **Special Tools and Equipment**.
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.

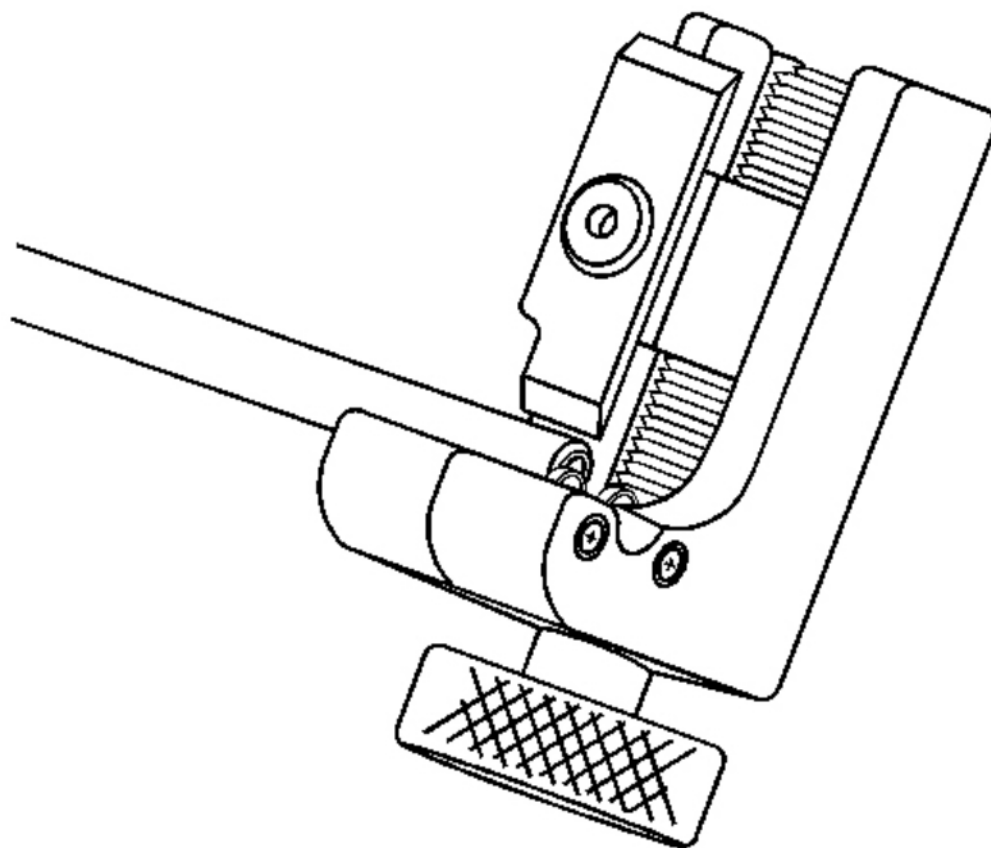


Fig. 29: Stripping Nylon Coating From Brake Pipe Ends
Courtesy of GENERAL MOTORS CORP.

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 **J 45405** , by unthreading the blade block from the stripping tool and installing the block with the desired blade facing the tool rollers. See **Special Tools and Equipment**.

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) 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.

IMPORTANT: 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.

IMPORTANT: 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) diameter pipe

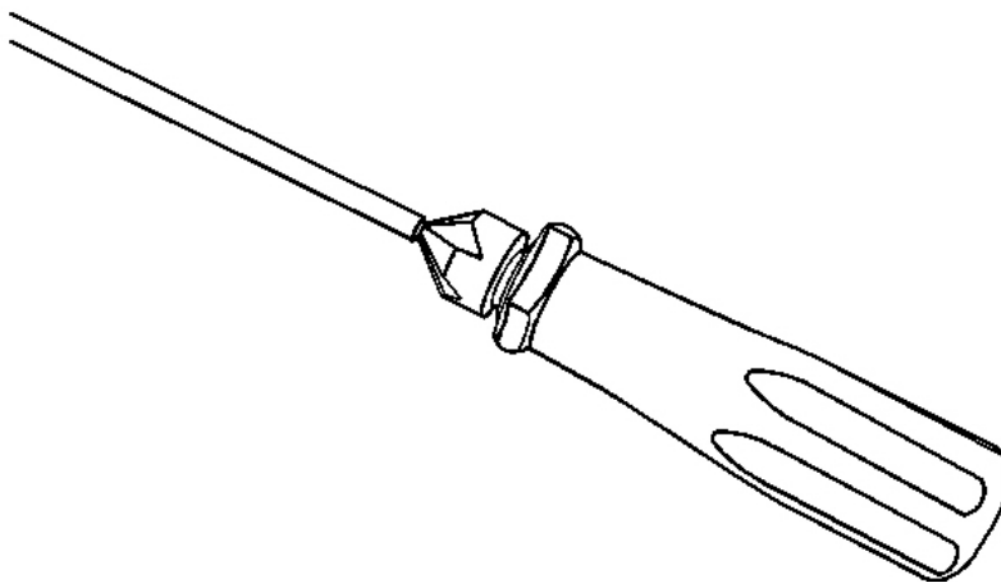


Fig. 30: Chamfering Pipe Using De-Burring Tool
Courtesy of GENERAL MOTORS CORP.

10. Chamfer the inside and outside diameter of the pipe with the de-burring tool included in the **J 45405** . See **Special Tools and Equipment**.
11. Install the tube nuts on the brake pipe, noting their orientation.
12. Clean the brake pipe and the **J 45405** of lubricant, contaminants, and debris. See **Special Tools and Equipment**.

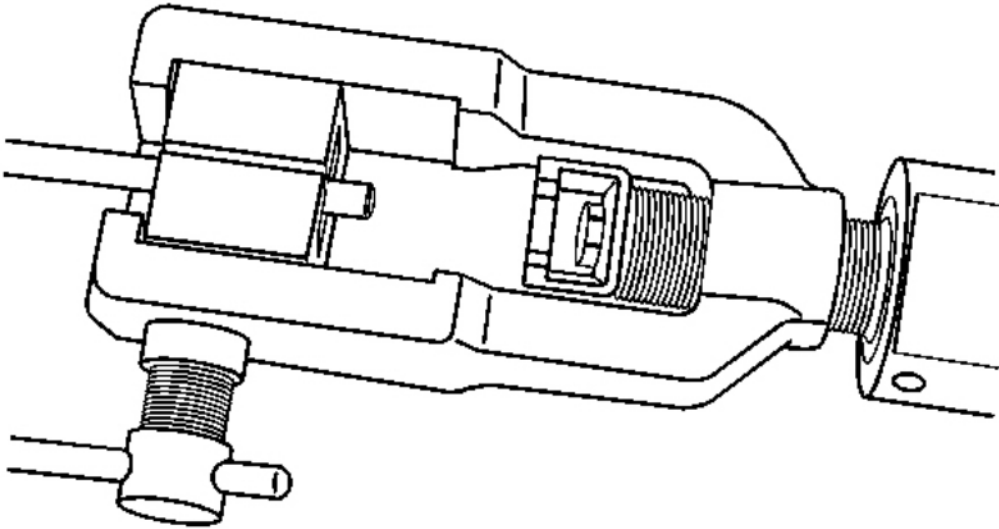


Fig. 31: Installing Die Halves Into Die Cage
Courtesy of GENERAL MOTORS CORP.

13. Loosen the die clamping screw of the **J 45405** . See **Special Tools and Equipment**.
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.

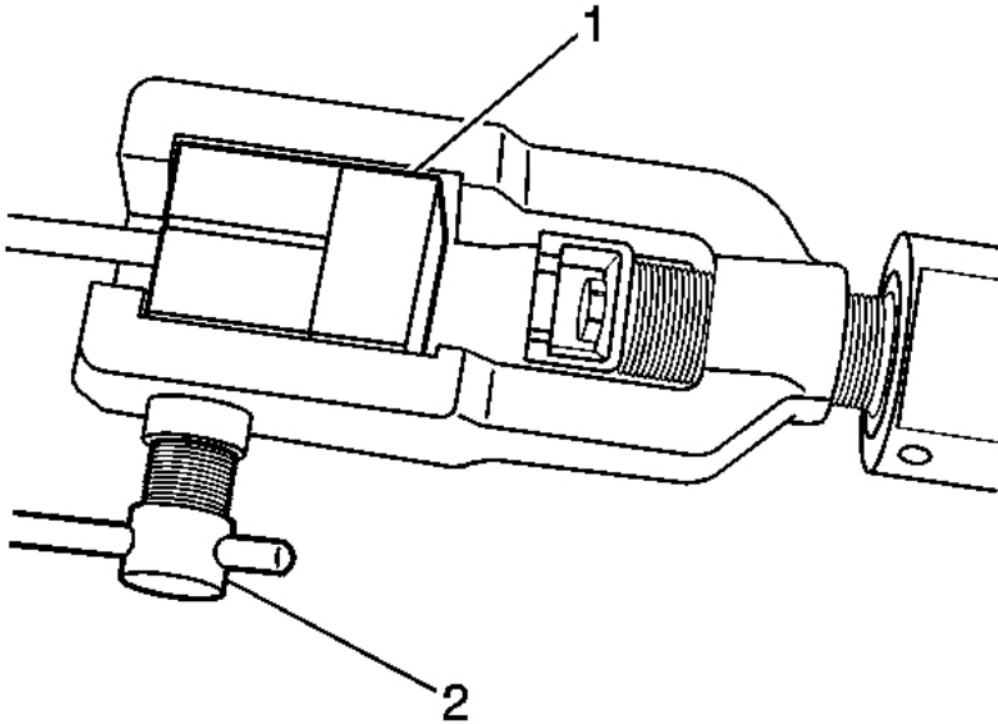


Fig. 32: View Of Clamping Screw & Unused Die
Courtesy of GENERAL MOTORS CORP.

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.

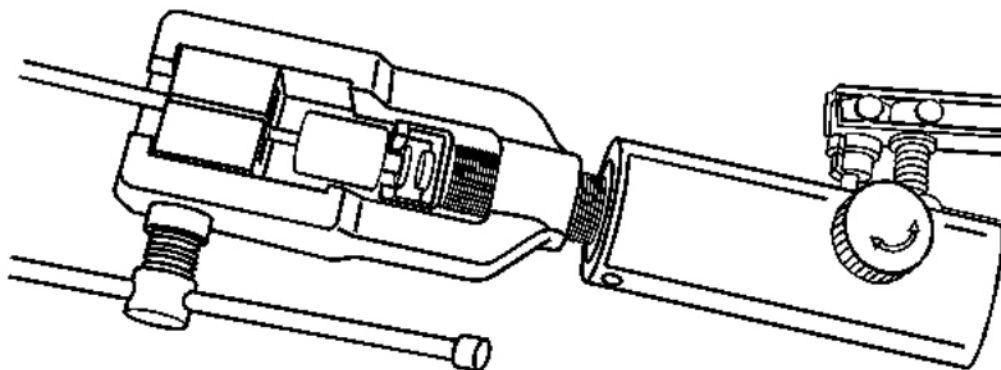


Fig. 33: Rotating J 45405 To Bottom Against Die Cage
Courtesy of GENERAL MOTORS CORP.

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 **J 45405** until it bottoms against the die cage. See **Special Tools and Equipment**.

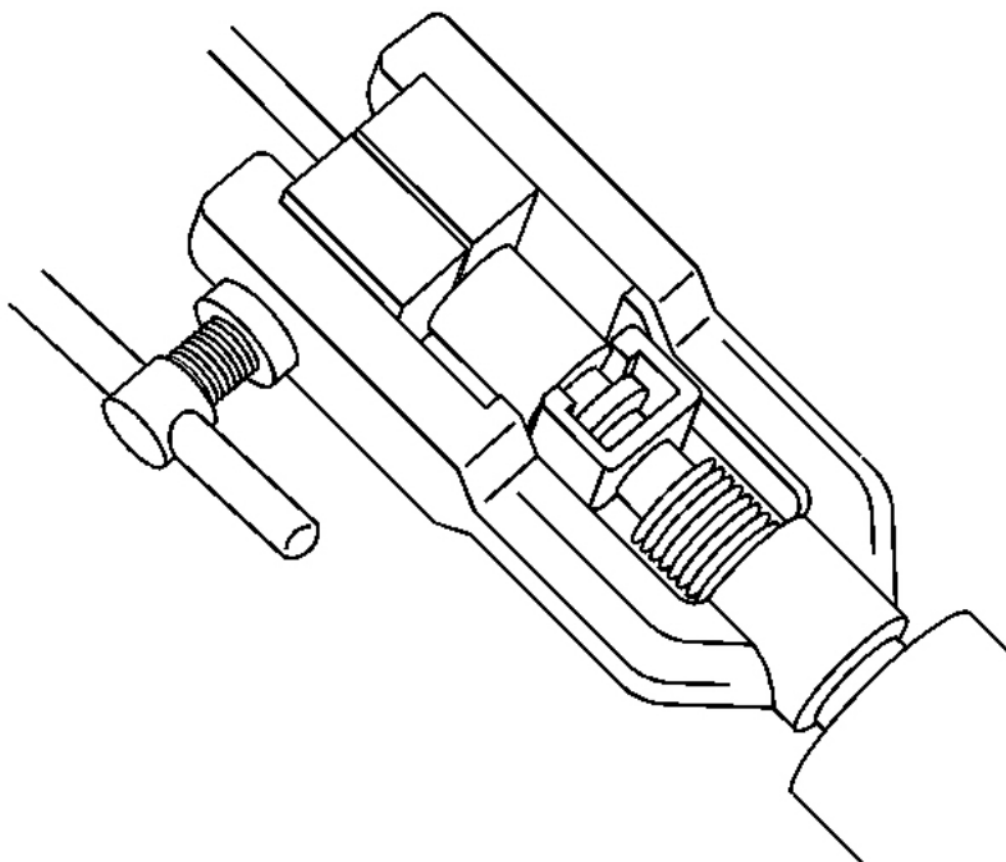


Fig. 34: Bottoming Forming Mandrel Against Clamping Dies Using Pipe Flaring Tool

Courtesy of GENERAL MOTORS CORP.

23. While guiding the forming mandrel into the exposed end of pipe to be flared, operate the lever of the **J 45405** until the forming mandrel bottoms against the clamping dies. See **Special Tools and Equipment**.
24. Rotate the hydraulic fluid control valve counterclockwise to the open position to allow the hydraulic forming ram to retract.

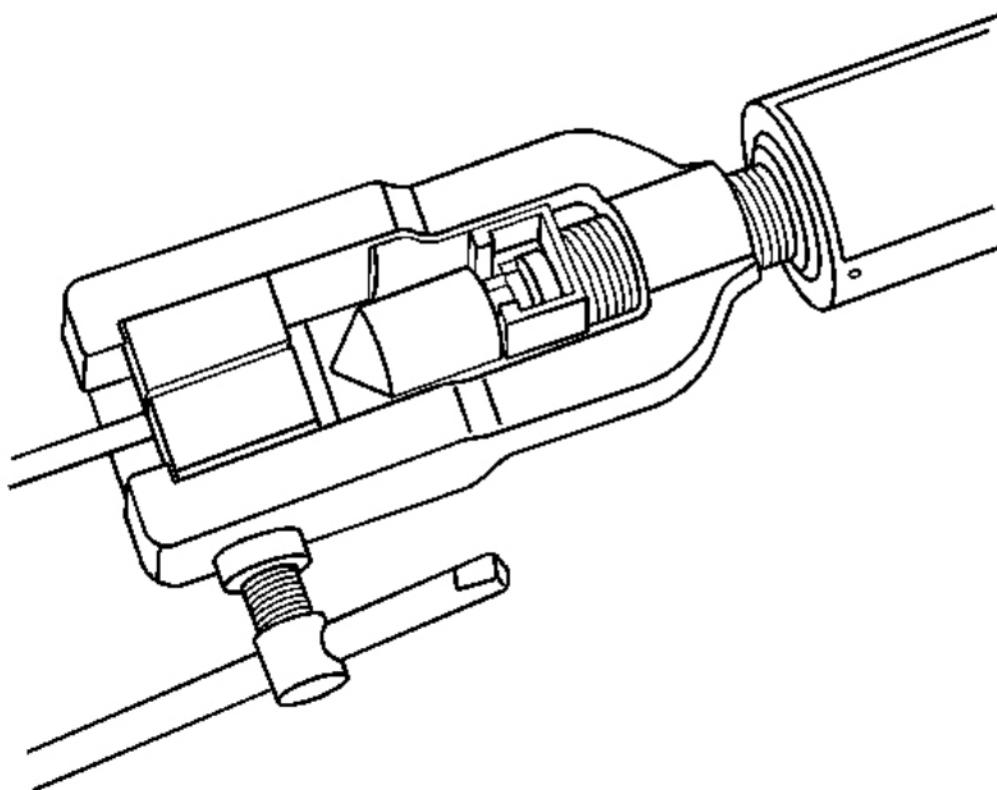


Fig. 35: Using Pipe Flaring Tool
Courtesy of GENERAL MOTORS CORP.

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 **J 45405** until it bottoms against the die cage. See **Special Tools and Equipment**.
28. While guiding the finishing cone into the exposed end of pipe to be flared, operate the lever of the **J 45405** until the finishing cone bottoms against the dies. See **Special Tools and Equipment**.
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.

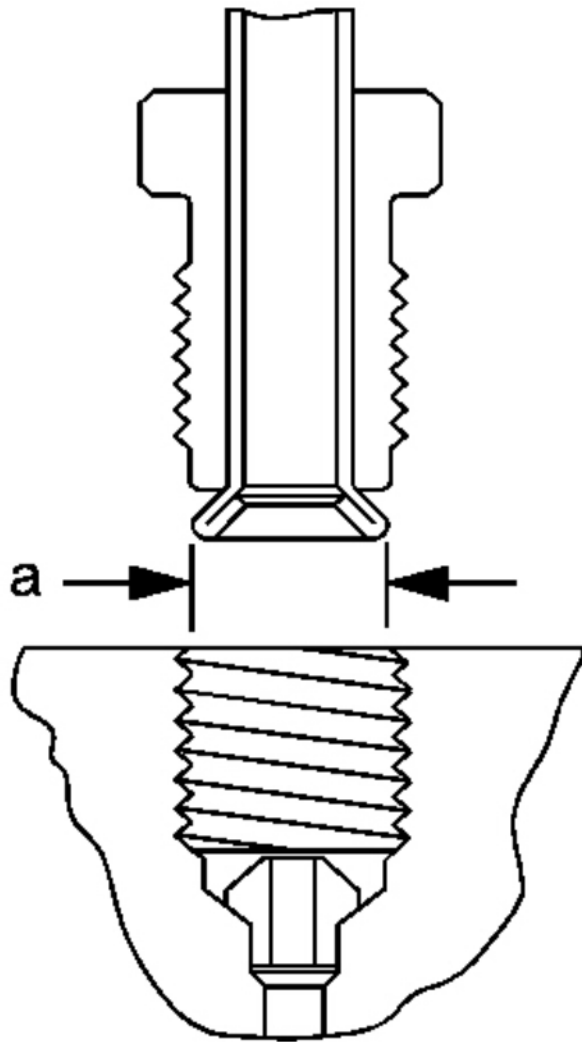


Fig. 36: Identifying Correct Brake Pipe Flare Shape & Diameter
Courtesy of GENERAL MOTORS CORP.

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

Specification:

- 6.92 mm (0.272 in) $\pm$ 0.18 mm (0.007 in) flare diameter for 4.76 mm (3/16 in) diameter pipe

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- 8.92 mm (0.351 in) +/- 0.18 mm (0.007 in) flare diameter for 6.35 mm (1/4 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.

IMPORTANT: 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) or 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.

BRAKE HOSE REPLACEMENT - FRONT (CTS)

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

Removal Procedure

1. Raise and suitably support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Remove the tire and wheel assembly. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
3. Clean all dirt and foreign material from the brake hose and the brake pipe fittings.

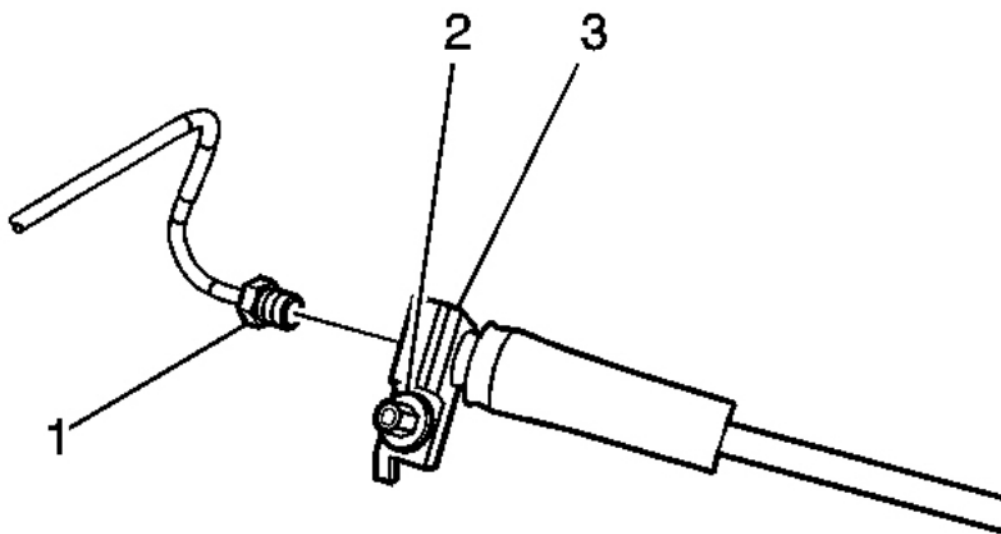


Fig. 37: Identifying Brake Pipe Fitting, Brake Hose Bracket-To-Frame Mounting Nut & Brake Hose

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting end in order to prevent brake fluid loss and contamination.

4. Disconnect the brake pipe fitting (1) from the brake hose (3), than cap or plug the brake pipe fitting end.
5. Loosen the brake hose bracket-to-frame mounting nut (2).
6. Remove the brake hose and bracket (3) from the frame.

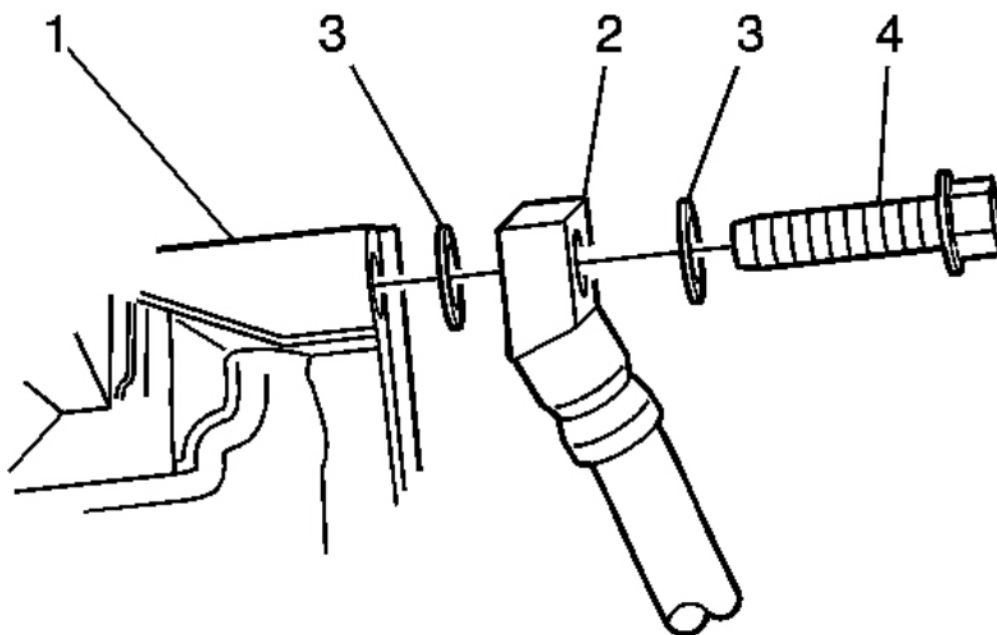


Fig. 38: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

7. Remove the brake hose to caliper bolt (4) from the brake caliper (1).
8. Remove the brake hose (2) from the brake caliper.
9. Place a shop towel on a hard surface.
10. Tap the threaded end of the brake hose to caliper bolt (4) on the shop towel to remove the gasket (3) from the bolt (4)
11. Remove and discard the two copper brake hose gaskets (3). These gaskets may be stuck to the brake caliper (1) and/or the brake hose end (2).

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting end in order to prevent brake fluid loss and/or contamination.

12. Install a rubber plug into the brake hose to caliper bolt hole of the brake caliper.

1. Remove the rubber plug from the brake hose to caliper bolt hole of the brake caliper.

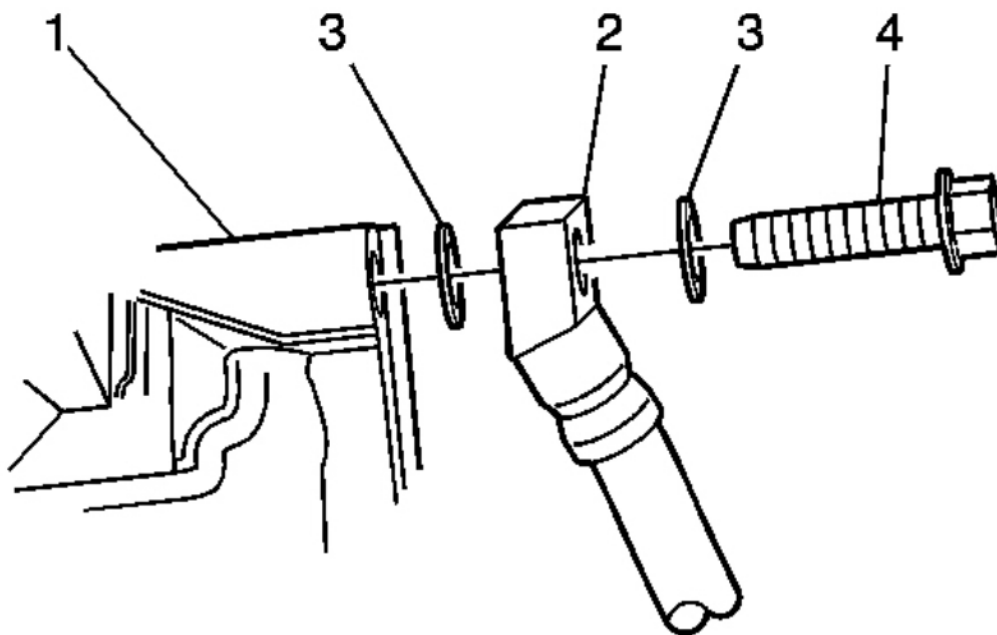


Fig. 39: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install NEW copper brake hose gaskets.

2. Assemble the brake hose (2), the NEW copper brake hose gaskets (3), and the brake hose bolt (4) to the brake hose (2).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the brake hose (2) to caliper bolt (4) to the brake caliper (1).

Tighten: Tighten the brake hose to caliper bolt to 50 N.m (37 lb ft).

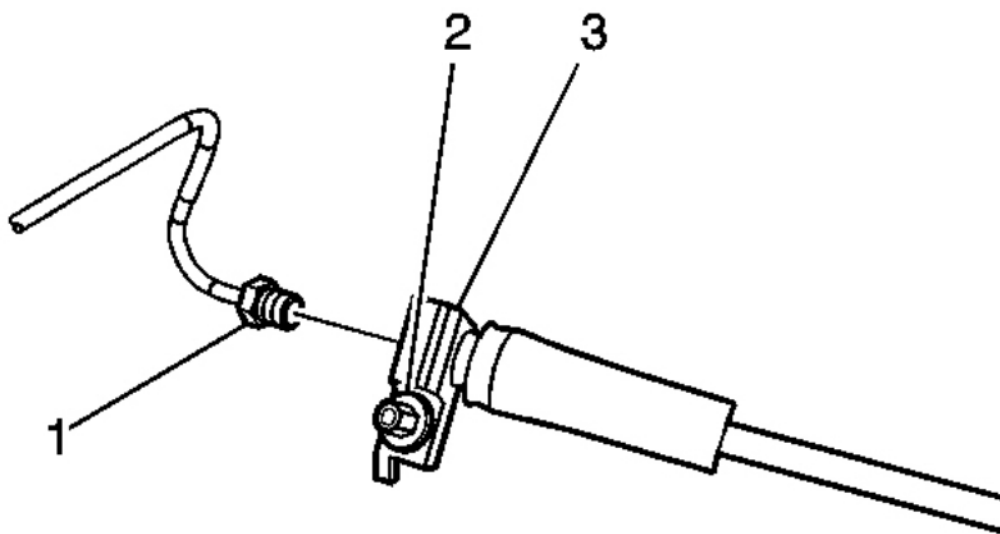


Fig. 40: Identifying Brake Pipe Fitting, Brake Hose Bracket-To-Frame Mounting Nut & Brake Hose

Courtesy of GENERAL MOTORS CORP.

4. Install the brake hose and bracket to the frame.

Tighten: Tighten the nut to 14 N.m (37 in lb).

5. Remove the rubber cap or plug from the exposed brake pipe fitting end.
6. Install the brake pipe fitting (1) to the brake hose (3).

Tighten: Tighten the brake pipe fitting to 18 N.m (13 lb ft).

7. Bleed the hydraulic brake system. Refer to **Hydraulic Brake System Bleeding (Manual)** or **Hydraulic Brake System Bleeding (Pressure)**.
8. Install the tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
9. Lower the vehicle.

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

Removal Procedure

1. Raise and suitably support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Remove the tire and wheel assembly. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
3. Clean all dirt and foreign material from the brake hose and the brake pipe fittings.

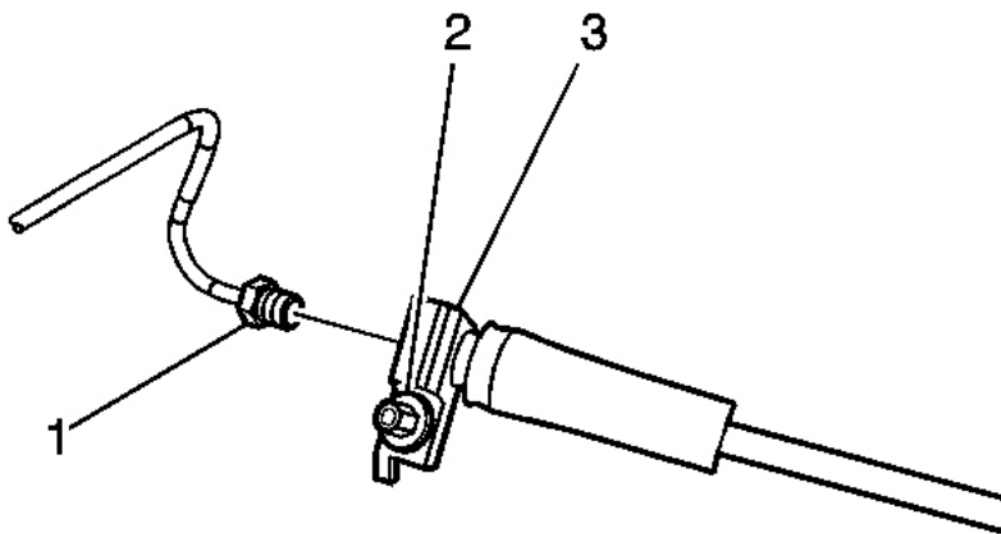


Fig. 41: Identifying Brake Pipe Fitting, Brake Hose Bracket-To-Frame Mounting Nut & Brake Hose

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting end in order to prevent brake fluid loss and contamination.

4. Disconnect the brake pipe fitting (1) from the brake hose (3), than cap or plug the brake pipe fitting end.
5. Loosen the brake hose bracket-to-frame mounting nut (2).
6. Remove the brake hose and bracket (3) from the frame.

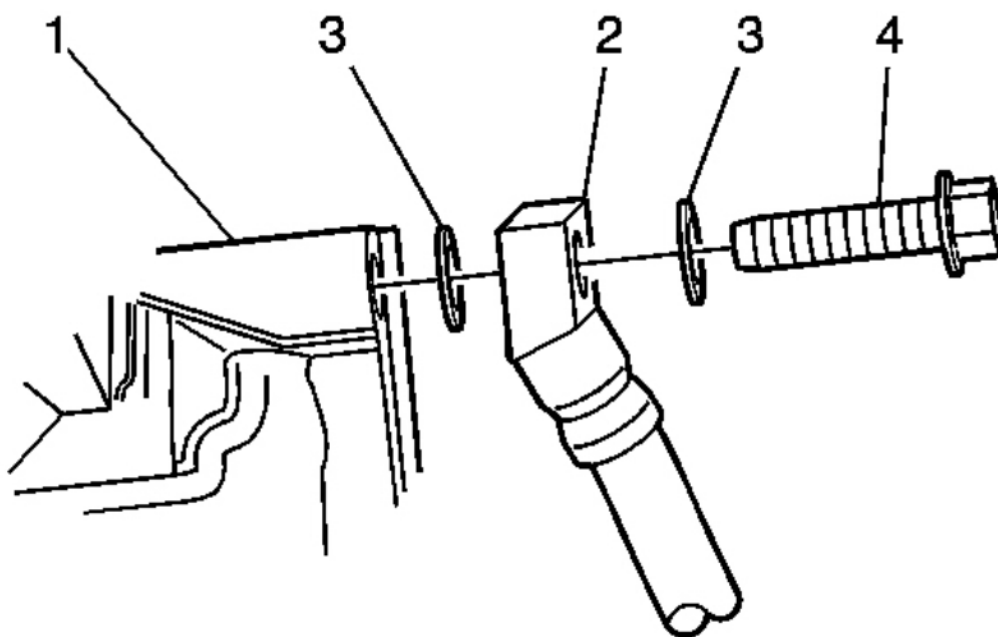


Fig. 42: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

7. Remove the brake hose to caliper bolt (4) from the brake caliper (1).
8. Remove the brake hose (2) from the brake caliper.
9. Place a shop towel on a hard surface.
10. Tap the threaded end of the brake hose to caliper bolt (4) on the shop towel to remove the gasket (3) from the bolt (4)
11. Remove and discard the two copper brake hose gaskets (3). These gaskets may be stuck to the brake caliper (1) and/or the brake hose end (2).

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting

end in order to prevent brake fluid loss and/or contamination.

12. Install a rubber plug into the brake hose to caliper bolt hole of the brake caliper.

Installation Procedure

1. Remove the rubber plug from the brake hose to caliper bolt hole of the brake caliper.

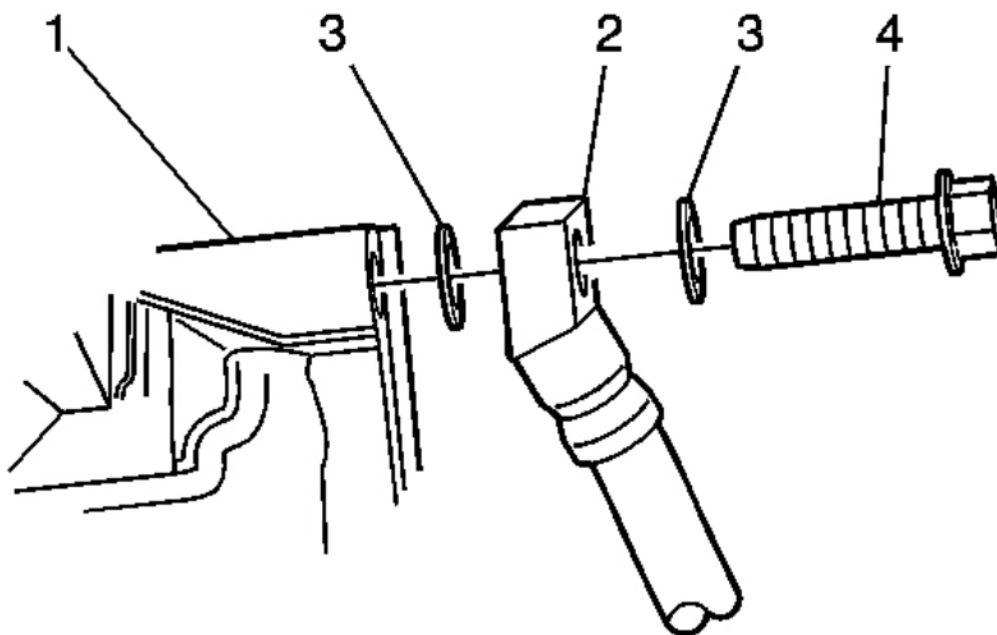


Fig. 43: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install NEW copper brake hose gaskets.

2. Assemble the brake hose (2), the NEW copper brake hose gaskets (3), and the brake hose bolt (4) to the brake hose (2).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the brake hose (2) to caliper bolt (4) to the brake caliper (1).

Tighten: Tighten the brake hose to caliper bolt to 34 N.m (25 lb ft).

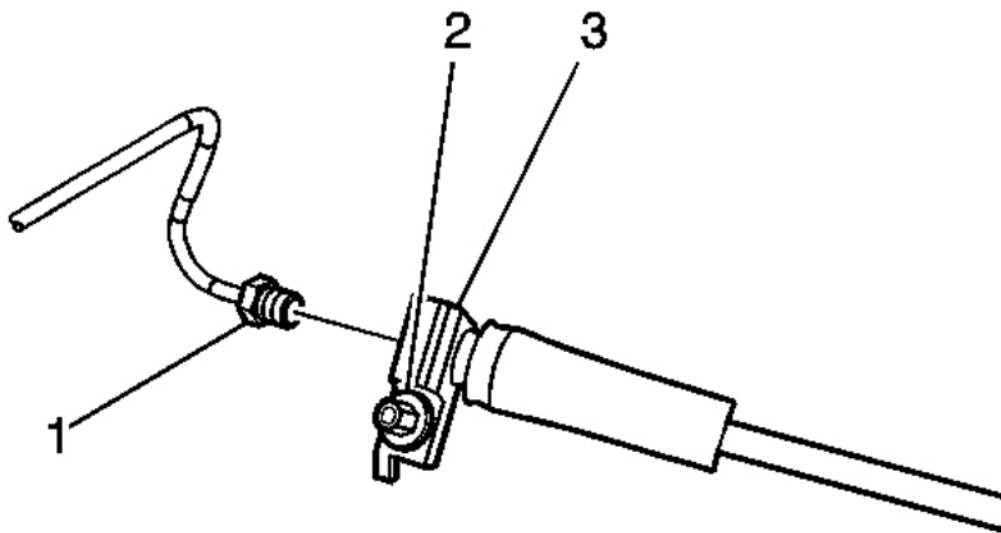


Fig. 44: Identifying Brake Pipe Fitting, Brake Hose Bracket-To-Frame Mounting Nut & Brake Hose

Courtesy of GENERAL MOTORS CORP.

4. Install the brake hose and bracket to the frame.

Tighten: Tighten the nut to 14 N.m (124 lb in).

5. Remove the rubber cap or plug from the exposed brake pipe fitting end.
6. Install the brake pipe fitting (1) to the brake hose (3).

Tighten: Tighten the brake pipe fitting to 18 N.m (13 lb ft).

7. Bleed the hydraulic brake system. Refer to **Hydraulic Brake System Bleeding (Manual)** or **Hydraulic Brake System Bleeding (Pressure)**.
8. Install the tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
9. Lower the vehicle.

BRAKE HOSE REPLACEMENT - INTERMEDIATE (CTS)**Removal Procedure**

IMPORTANT: The intermediate brake hose assembly is serviced as an assembly.

1. Raise and suitably support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Remove the right rear tire and wheel assembly. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
3. Clean all dirt and foreign material from the brake hose and the brake pipe fittings.

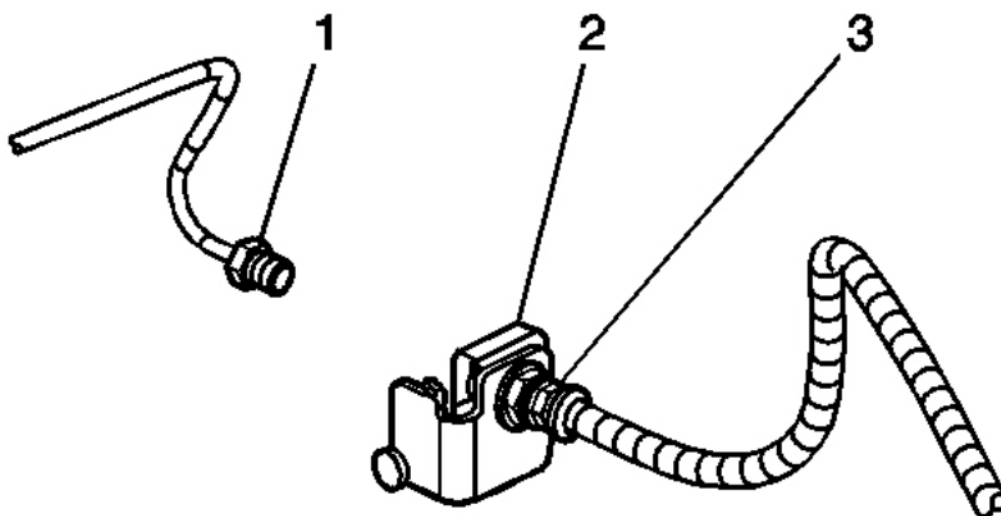


Fig. 45: Disconnecting/Reconnecting Brake Line Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting end in order to prevent brake fluid loss and/or contamination.

4. Disconnect the crossover brake pipe fitting (1) from the intermediate brake hose assembly (3) and cap or plug the brake pipe fitting end.

5. Lift the retaining clip (2) over the end of the brake hose.
6. Using a flat-bladed tool, remove the brake hose retainer (2) from the rear frame assembly.
7. Disconnect the (2) brake pressure modulator valve (BMPV) brake pipe fittings from the intermediate brake hose assembly and cap or plug the brake pipe fitting ends.

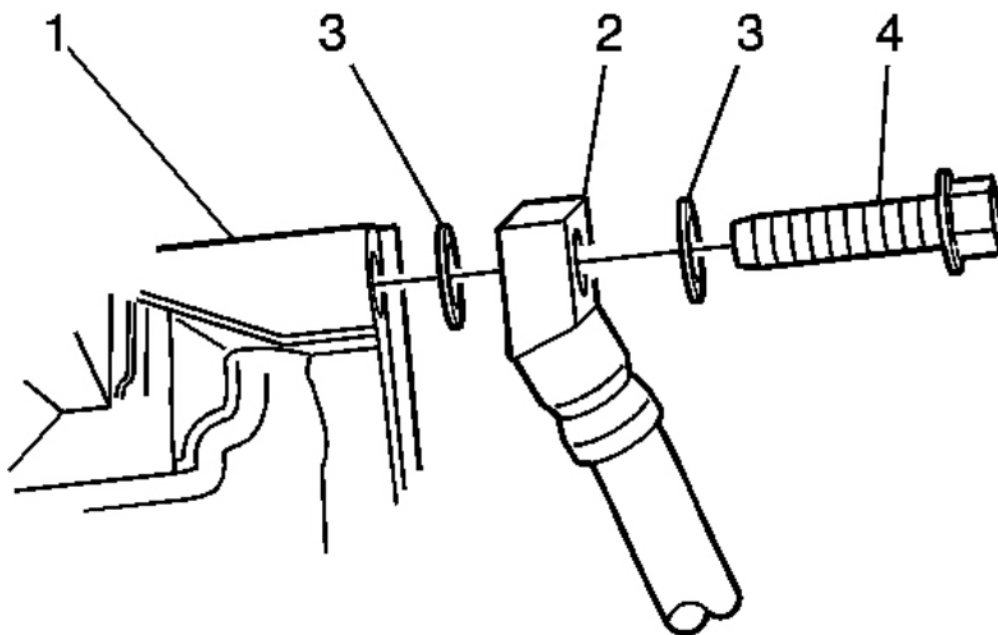


Fig. 46: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the brake hose to caliper bolt (4) from the brake caliper (1).
9. Disconnect the brake hose from the brake caliper.
10. Place a shop towel on a hard surface.
11. Tap the threaded end of the brake hose to caliper bolt (4) on the shop towel to remove the gasket (3) from the bolt (4)
12. Remove and discard the two copper brake hose gaskets (3). These gaskets may be stuck to the brake caliper (1) and/or the brake hose end (2).

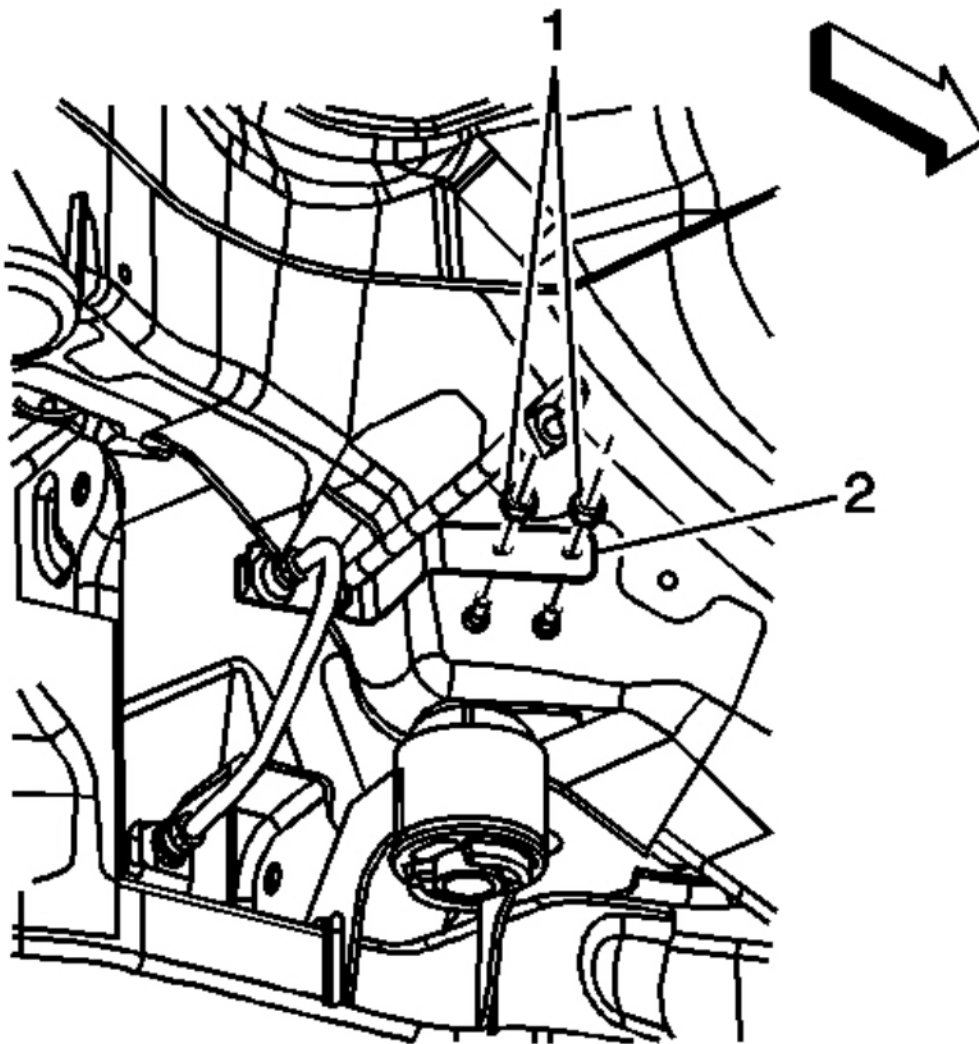


Fig. 47: View Of Intermediate Brake Hose Assembly & Mounting Nuts
Courtesy of GENERAL MOTORS CORP.

13. Remove the intermediate brake hose assembly mounting nuts (1) from the studs.
14. Remove the intermediate brake hose assembly (2) from the vehicle.

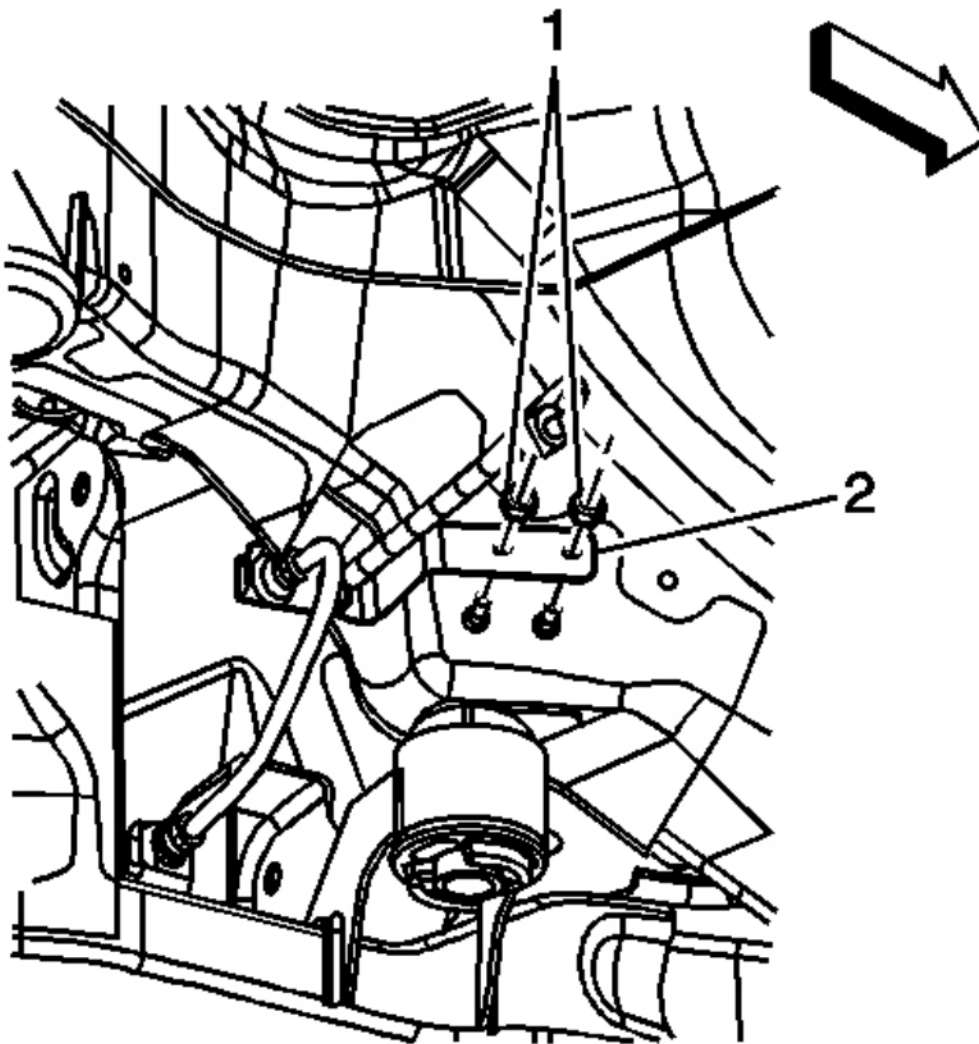


Fig. 48: View Of Intermediate Brake Hose Assembly & Mounting Nuts
Courtesy of GENERAL MOTORS CORP.

NOTE: Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.

1. Install the intermediate brake hose assembly (2) to the mounting studs.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the intermediate brake hose assembly mounting nuts (1) to the mounting studs.

Tighten: Tighten the intermediate brake hose assembly mounting nuts to 14 N.m (124 lb in).

3. Remove the caps and/or plugs from the (2) (BPMV) to intermediate brake pipe fittings.
4. Connect the (2) (BMPV) brake pipe fittings to the intermediate brake hose assembly.
5. Remove the rubber plug from the brake hose to caliper bolt hole of the brake caliper.

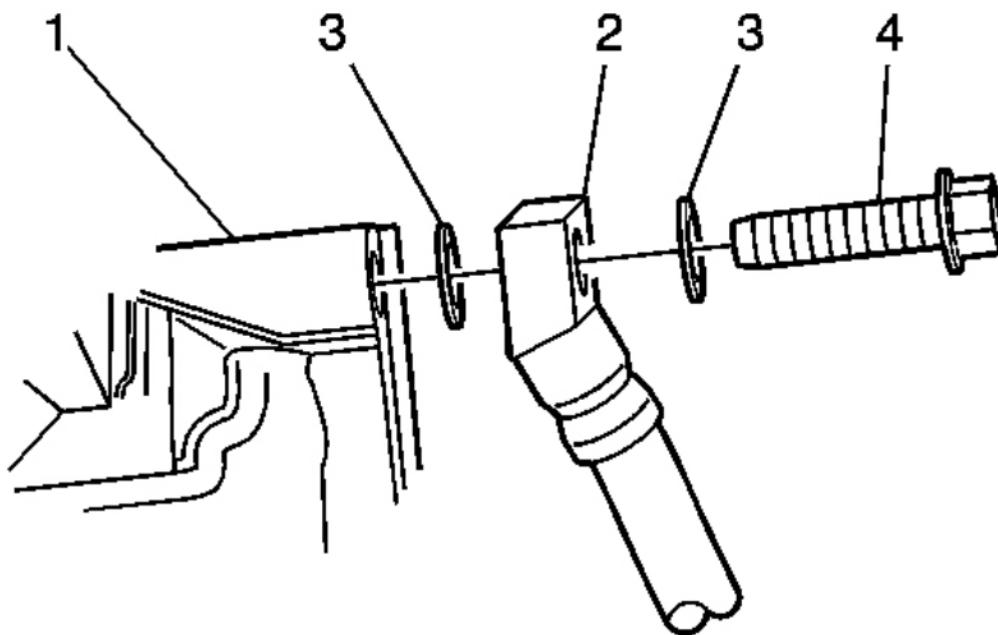


Fig. 49: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install NEW copper brake hose gaskets.

6. Assemble the brake hose (2), the NEW copper brake hose gaskets (3), and the brake hose bolt (4) to the brake hose (2).

7. Install the brake hose (2) to caliper bolt (4) to the brake caliper (1).

Tighten: Tighten the brake hose to caliper bolt to 50 N.m (37 lb ft).

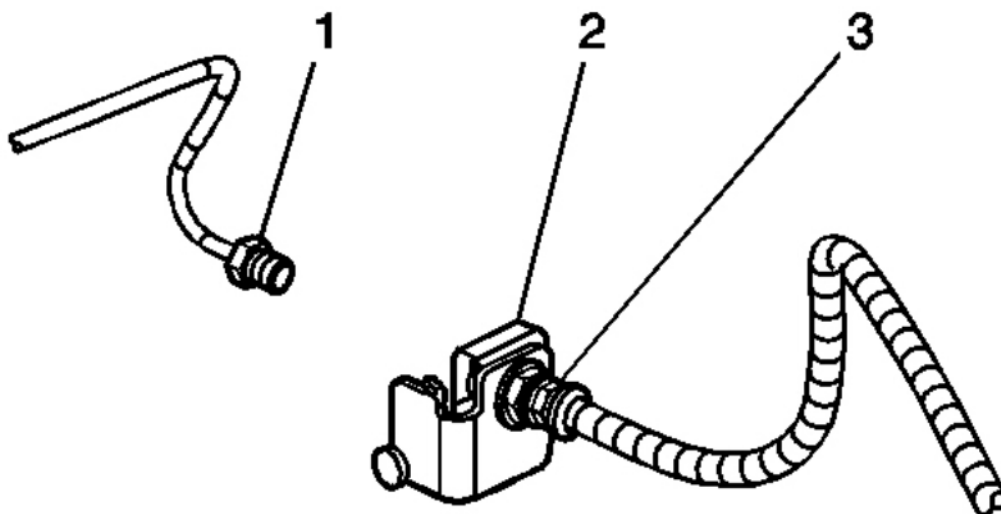


Fig. 50: Disconnecting/Reconnecting Brake Line Fitting
Courtesy of GENERAL MOTORS CORP.

8. Remove the rubber cap and/or plug from the crossover brake pipe end.
9. Using a flat-bladed tool, install the brake hose retainer (2) to the rear frame assembly.
10. Connect the crossover brake pipe fitting (1) to the intermediate brake hose assembly (3).

Tighten: Tighten the brake pipe fittings to 18 N.m (13 lb ft).

11. Bleed the hydraulic brake system. Refer to Hydraulic Brake System Bleeding (Manual) or Hydraulic Brake System Bleeding (Pressure).
12. Install the tire and wheel assembly. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
13. Lower the vehicle.

BRAKE HOSE REPLACEMENT - INTERMEDIATE (CTS-V)

Removal Procedure

IMPORTANT: The intermediate brake hose assembly is serviced as an assembly.

1. Raise and suitably support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Remove the right rear tire and wheel assembly. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
3. Clean all dirt and foreign material from the brake hose and the brake pipe fittings.

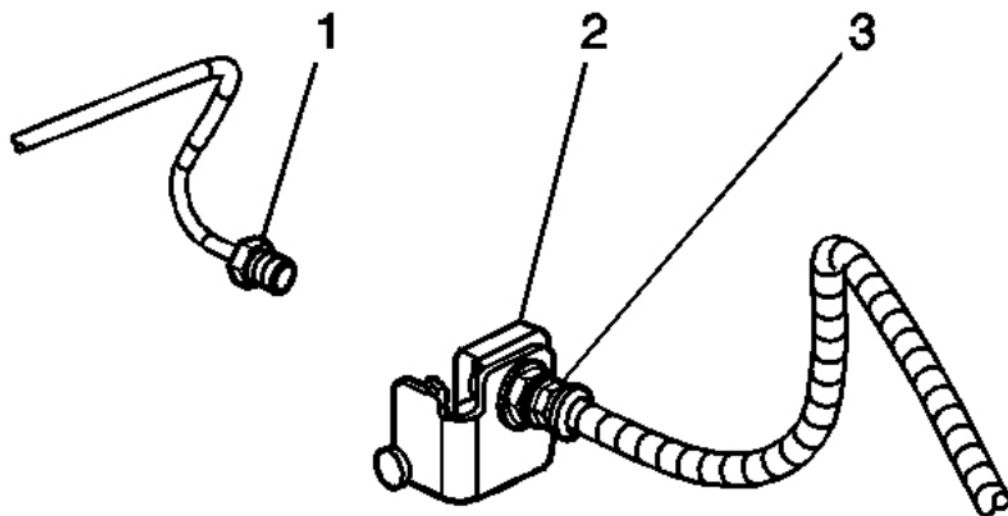


Fig. 51: Disconnecting/Reconnecting Brake Line Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting end in order to prevent brake fluid loss and/or contamination.

4. Disconnect the crossover brake pipe fitting (1) from the intermediate brake hose assembly (3) and cap or plug the brake pipe fitting end.
5. Lift the retaining clip (2) over the end of the brake hose.
6. Using a flat-bladed tool, remove the brake hose retainer (2) from the rear frame assembly.
7. Disconnect the (2) brake pressure modulator valve (BMPV) brake pipe fittings from the

intermediate brake hose assembly and cap or plug the brake pipe fitting ends.

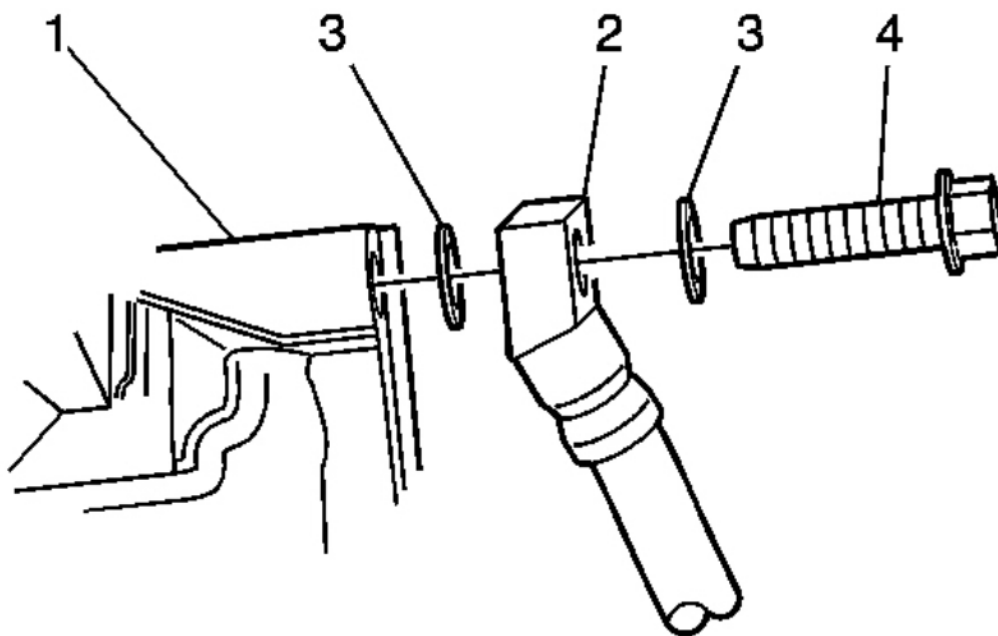


Fig. 52: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the brake hose to caliper bolt (4) from the brake caliper (1).
9. Disconnect the brake hose from the brake caliper.
10. Place a shop towel on a hard surface.
11. Tap the threaded end of the brake hose to caliper bolt (4) on the shop towel to remove the gasket (3) from the bolt (4)
12. Remove and discard the two copper brake hose gaskets (3). These gaskets may be stuck to the brake caliper (1) and/or the brake hose end (2).

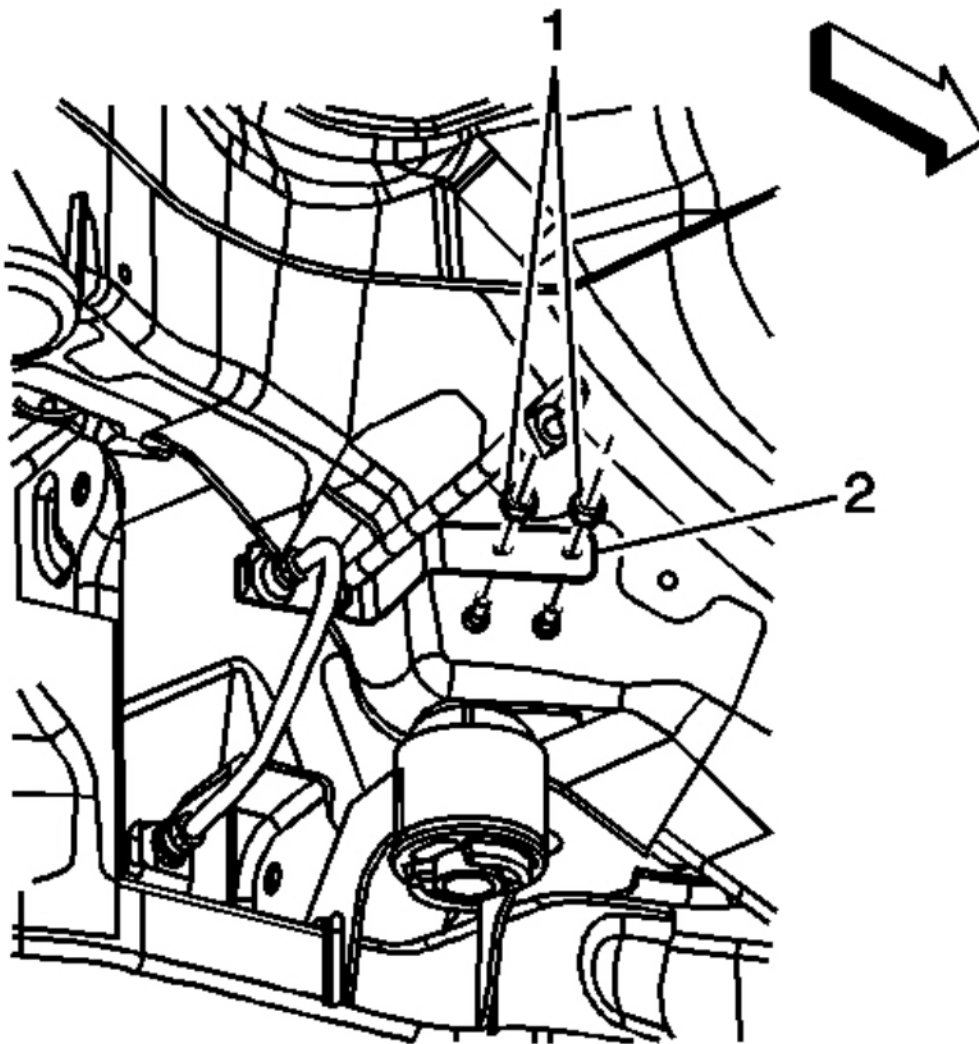


Fig. 53: View Of Intermediate Brake Hose Assembly & Mounting Nuts
Courtesy of GENERAL MOTORS CORP.

13. Remove the intermediate brake hose assembly mounting nuts (1) from the studs.
14. Remove the intermediate brake hose assembly (2) from the vehicle.

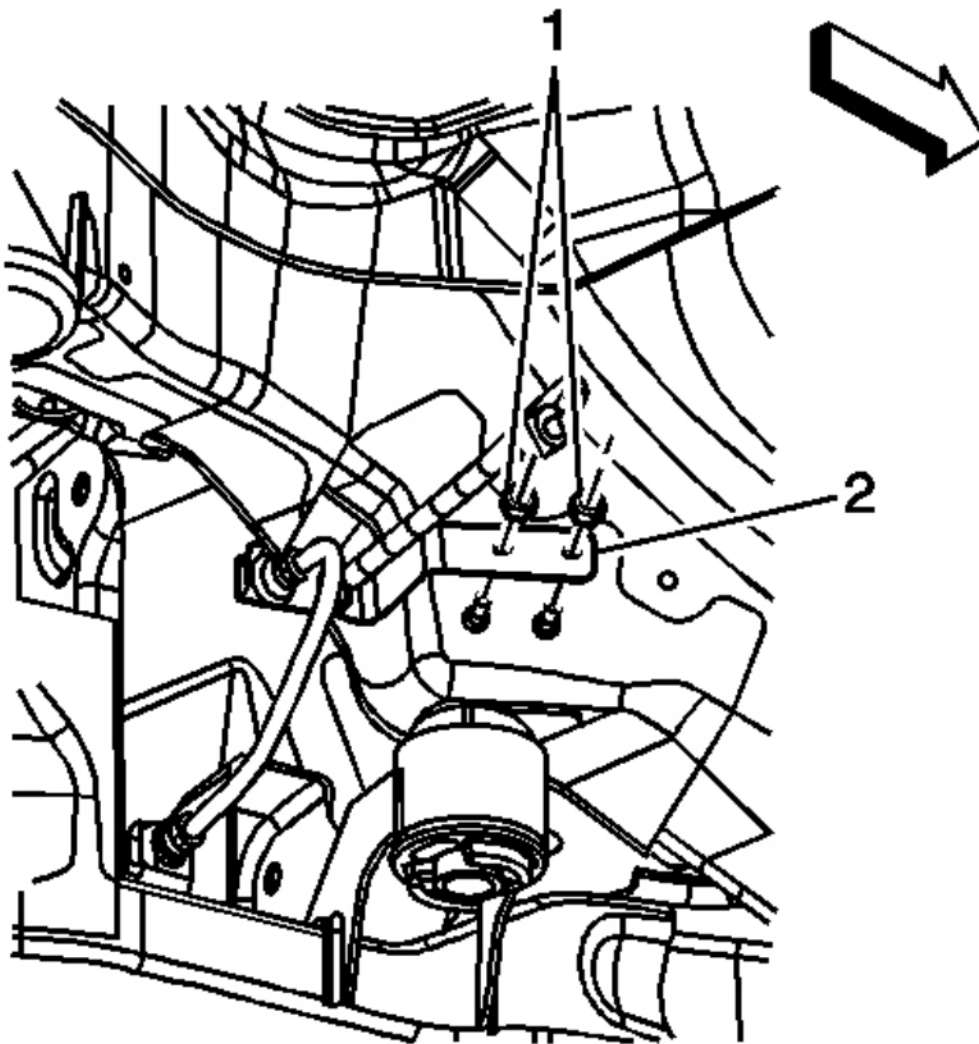


Fig. 54: View Of Intermediate Brake Hose Assembly & Mounting Nuts
Courtesy of GENERAL MOTORS CORP.

NOTE: Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.

1. Install the intermediate brake hose assembly (2) to the mounting studs.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the intermediate brake hose assembly mounting nuts (1) to the mounting studs.

Tighten: Tighten the intermediate brake hose assembly mounting nuts to 14 N.m (124 lb in).

3. Remove the caps and/or plugs from the (2) (BPMV) to intermediate brake pipe fittings.
4. Connect the (2) (BMPV) brake pipe fittings to the intermediate brake hose assembly.
5. Remove the rubber plug from the brake hose to caliper bolt hole of the brake caliper.

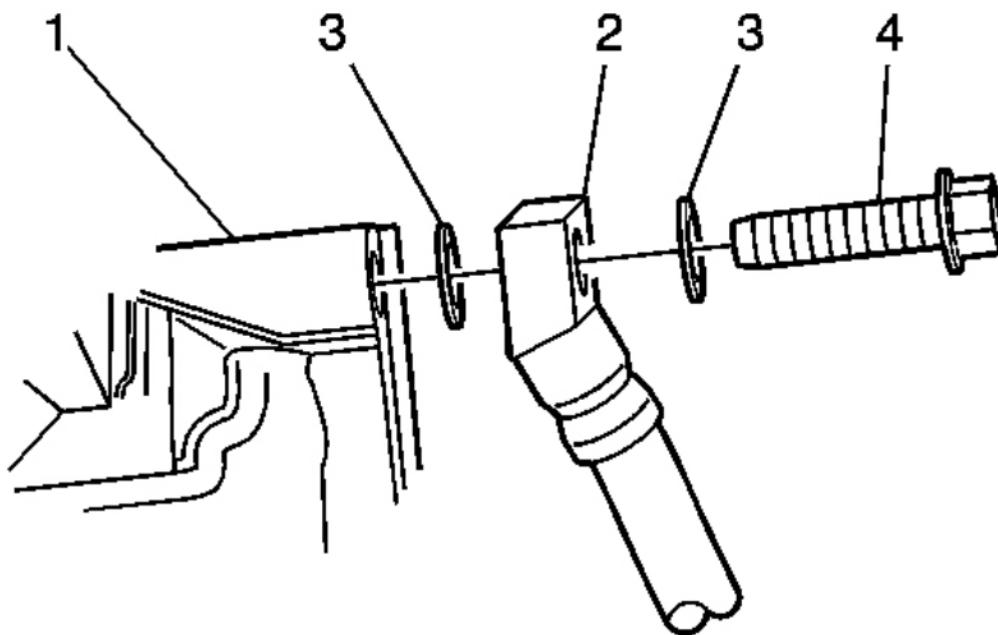


Fig. 55: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install NEW copper brake hose gaskets.

6. Assemble the brake hose (2), the NEW copper brake hose gaskets (3), and the brake hose bolt (4) to the brake hose (2).

7. Install the brake hose (2) to caliper bolt (4) to the brake caliper (1).

Tighten: Tighten the brake hose to caliper bolt to 34 N.m (25 lb ft).

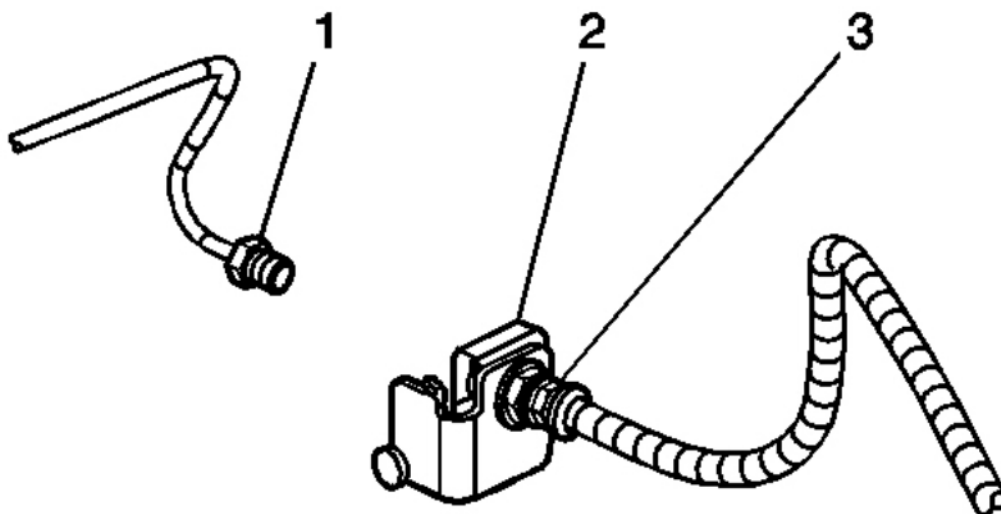


Fig. 56: Disconnecting/Reconnecting Brake Line Fitting
Courtesy of GENERAL MOTORS CORP.

8. Remove the rubber cap and/or plug from the crossover brake pipe end.
9. Using a flat-bladed tool, install the brake hose retainer (2) to the rear frame assembly.
10. Connect the crossover brake pipe fitting (1) to the intermediate brake hose assembly (3).

Tighten: Tighten the brake pipe fittings to 18 N.m (13 lb ft).

11. Bleed the hydraulic brake system. Refer to Hydraulic Brake System Bleeding (Manual) or Hydraulic Brake System Bleeding (Pressure).
12. Install the tire and wheel assembly. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
13. Lower the vehicle.

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

Removal Procedure

IMPORTANT: The right rear brake hose is replaced as an assembly, with the intermediate brake hose assembly.

1. Raise and suitably support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Remove the left tire and wheel assembly. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
3. Clean all dirt and foreign material from the brake hose and the brake pipe fittings.

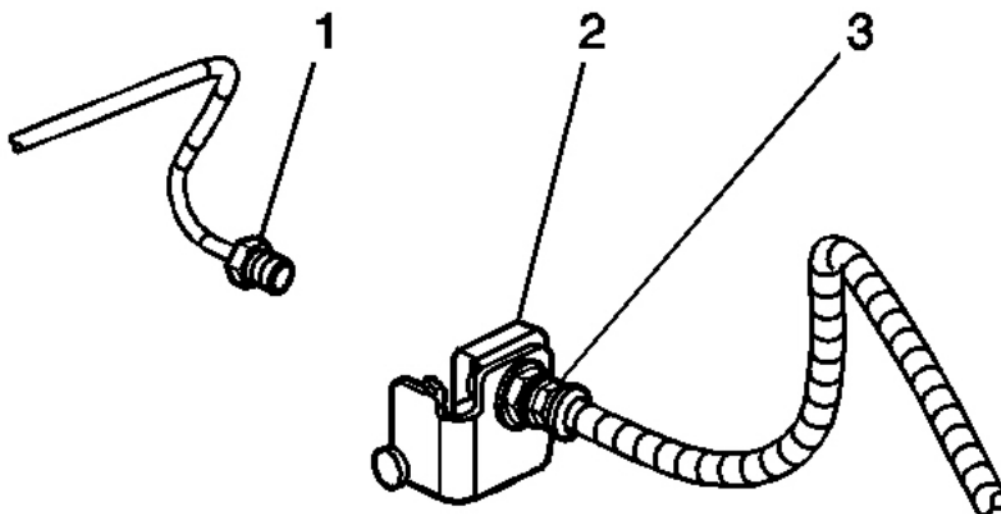


Fig. 57: Disconnecting/Reconnecting Brake Line Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting

end in order to prevent brake fluid loss and/or contamination.

4. Disconnect the brake hose (3) from the crossover pipe fitting (1).
5. Lift the retaining clip over the end of the brake hose.
6. Using a flat-bladed tool, remove the brake hose retainer (2) from the brake hose (3).

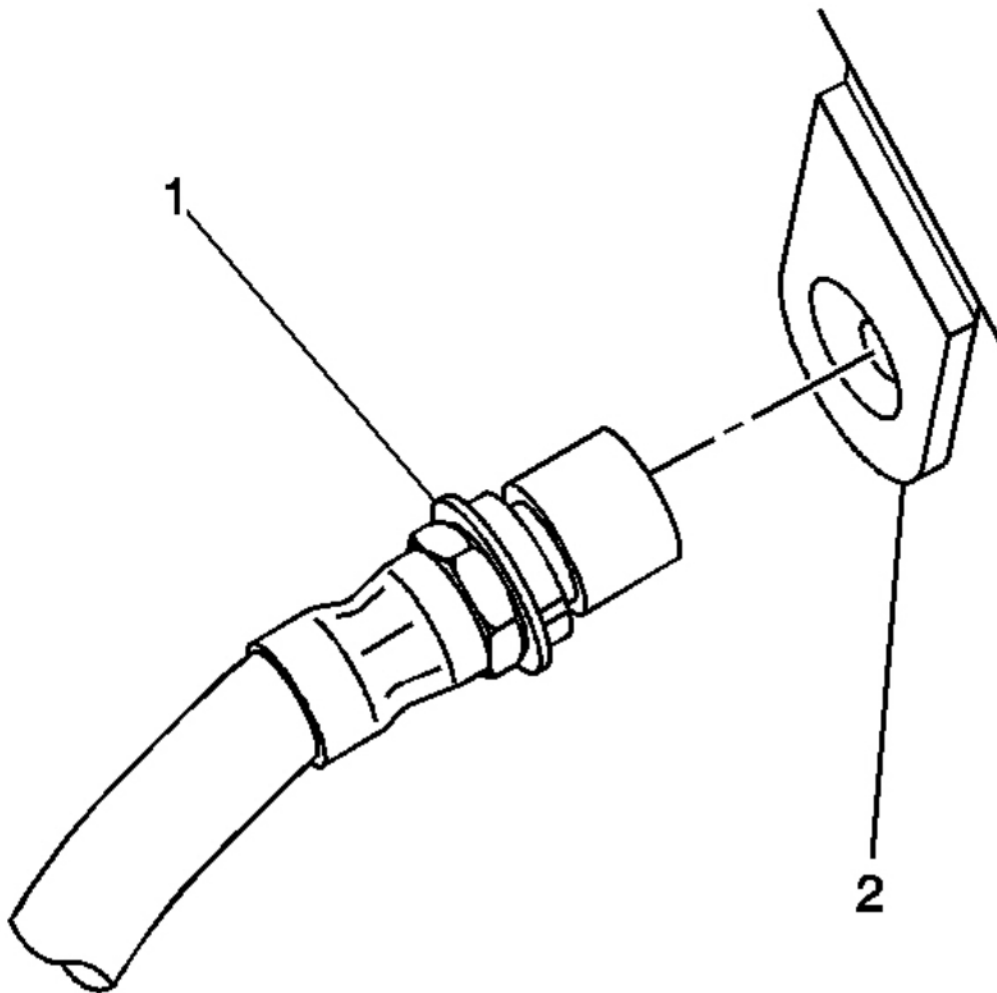


Fig. 58: Identifying Brake Hose
Courtesy of GENERAL MOTORS CORP.

7. Remove the brake hose (1) from the frame assembly (2).

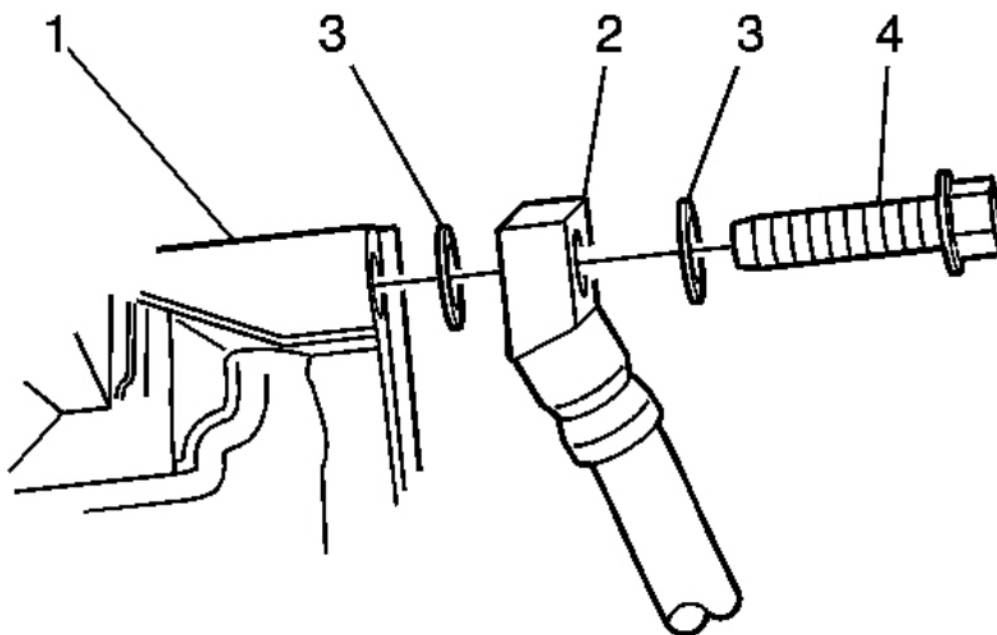


Fig. 59: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

8. Remove the brake hose to caliper bolt (4) from the brake caliper (1).
9. Remove the brake hose (2) from the vehicle.
10. Place a shop towel on a hard surface.
11. Tap the threaded end of the brake hose to caliper bolt (4) on the shop towel to remove the gasket (3) from the bolt.
12. Remove and discard the two copper brake hose gaskets (3). These gaskets may be stuck to the brake caliper (1) and/or the brake hose end (2).

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting end in order to prevent brake fluid loss and/or contamination.

13. Install a rubber plug into the brake hose to caliper bolt hole of the brake caliper.

1. Remove the rubber plug from the brake hose to caliper bolt hole of the brake caliper.

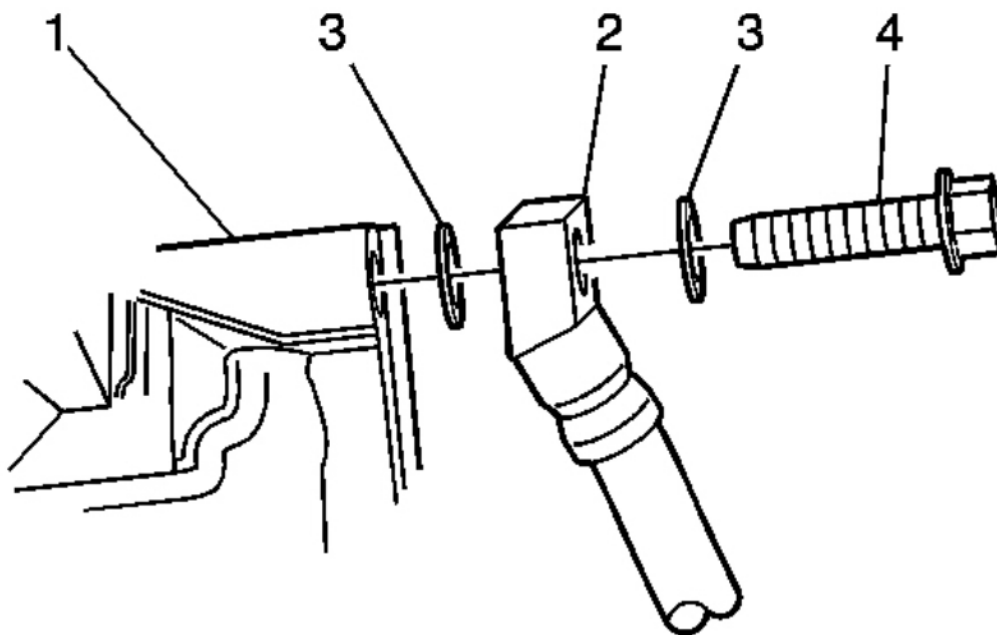


Fig. 60: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install NEW copper brake hose gaskets.

2. Assemble the brake hose, the NEW copper brake hose gaskets (3) and the brake hose bolt (4) to the brake hose (2).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the brake hose to caliper bolt (4) to the brake caliper (1).

Tighten: Tighten the brake hose to caliper bolt to 50 N.m (37 lb ft).

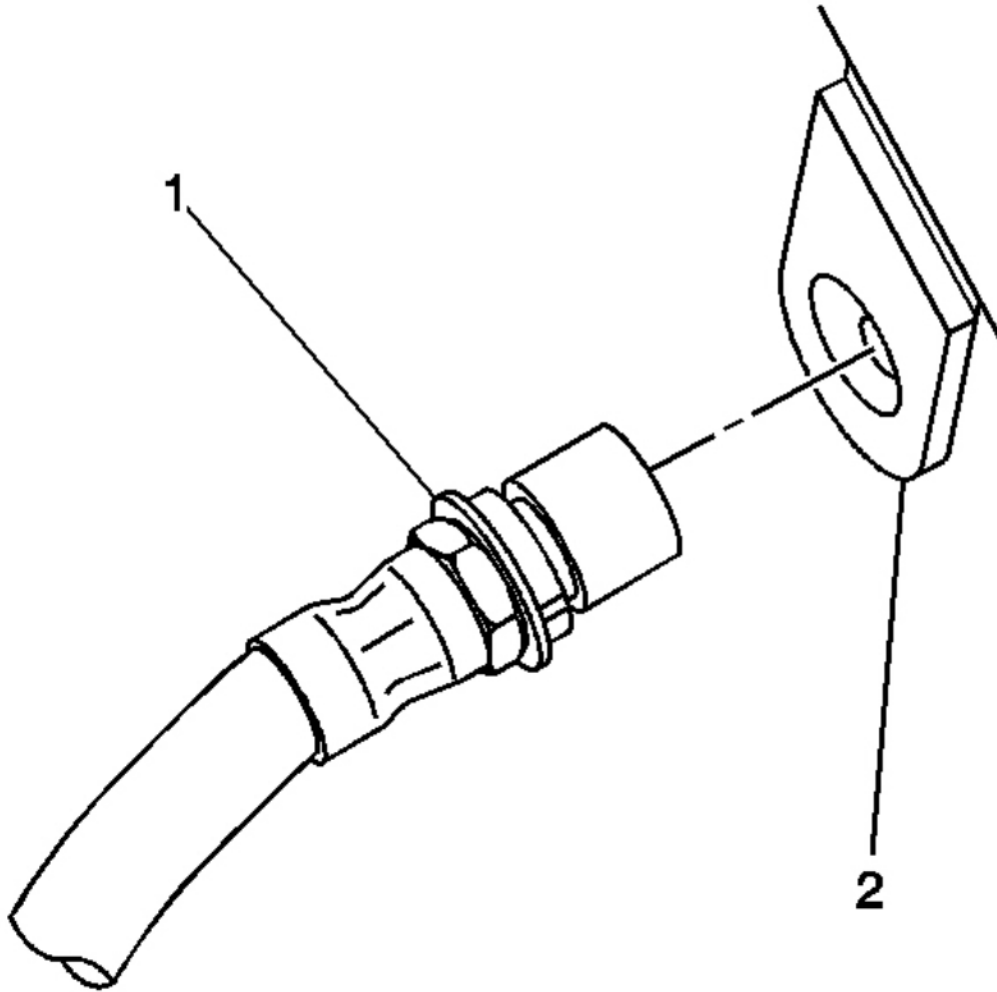


Fig. 61: Identifying Brake Hose

Courtesy of GENERAL MOTORS CORP.

NOTE: Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.

4. Install the brake hose (1) to the frame assembly (2).

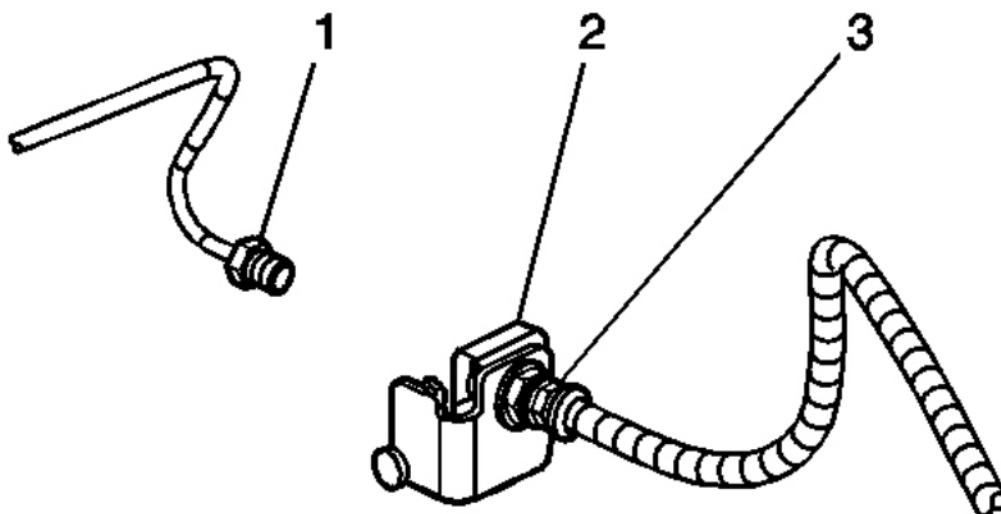


Fig. 62: Disconnecting/Reconnecting Brake Line Fitting
Courtesy of GENERAL MOTORS CORP.

5. Install the brake hose retainer (1) to the brake hose (3).
6. Remove the rubber cap or plug from the crossover pipe fitting end.
7. Install the brake pipe fitting (1) to the brake hose (3).

Tighten: Tighten the brake pipe fitting to 18 N.m (13 lb ft).

8. Bleed the hydraulic brake system. Refer to Hydraulic Brake System Bleeding (Manual) or Hydraulic Brake System Bleeding (Pressure).
9. Install the left tire and wheel assembly. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
10. Lower the vehicle.

BRAKE HOSE REPLACEMENT - REAR (CTS-V)

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components

Notice in Cautions and Notices.**Removal Procedure**

IMPORTANT: The right rear brake hose is replaced as an assembly, with the intermediate brake hose assembly.

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Remove the left tire and wheel assembly. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
3. Clean all dirt and foreign material from the brake hose and the brake pipe fittings.

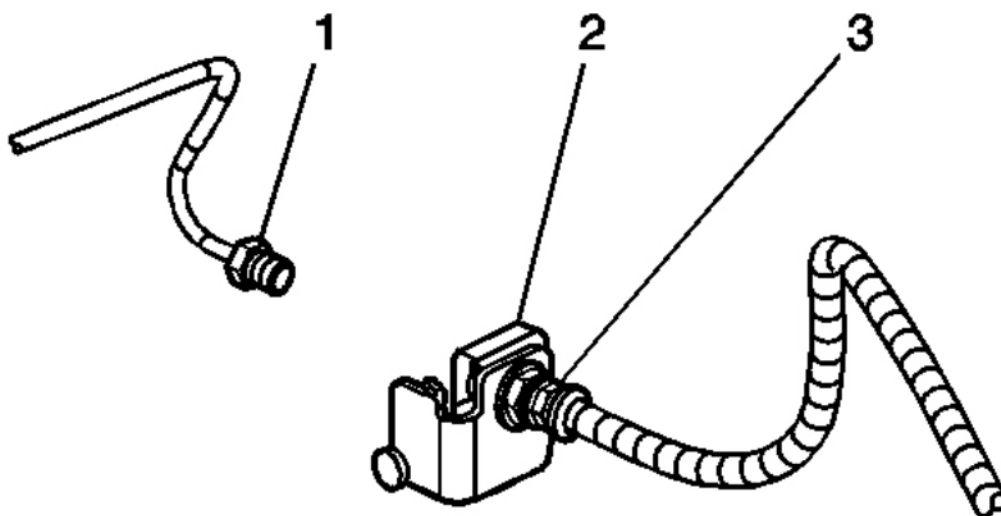


Fig. 63: Disconnecting/Reconnecting Brake Line Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting end in order to prevent brake fluid loss and/or contamination.

4. Disconnect the brake hose (3) from the crossover pipe fitting (1).
5. Lift the retaining clip over the end of the brake hose.

6. Using a flat-bladed tool, remove the brake hose retainer (2) from the brake hose (3).

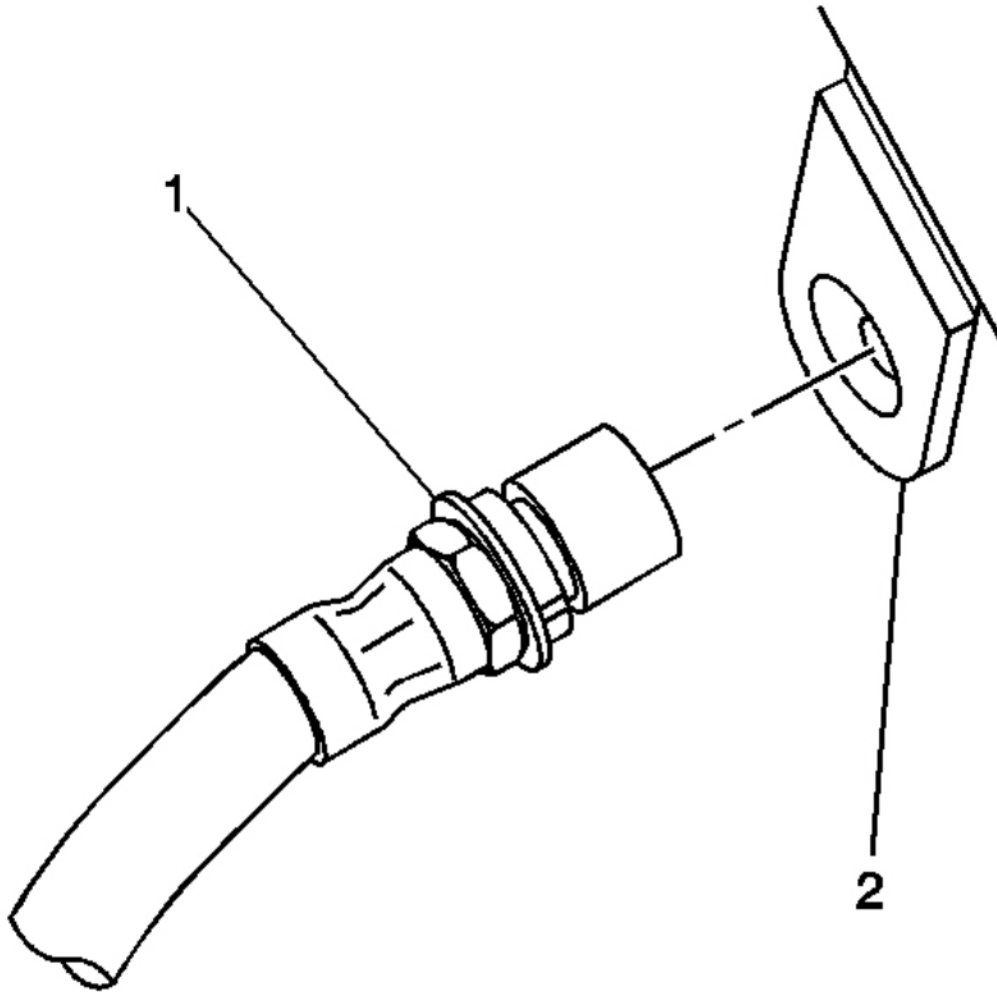


Fig. 64: Identifying Brake Hose
Courtesy of GENERAL MOTORS CORP.

7. Remove the brake hose (1) from the frame assembly (2).

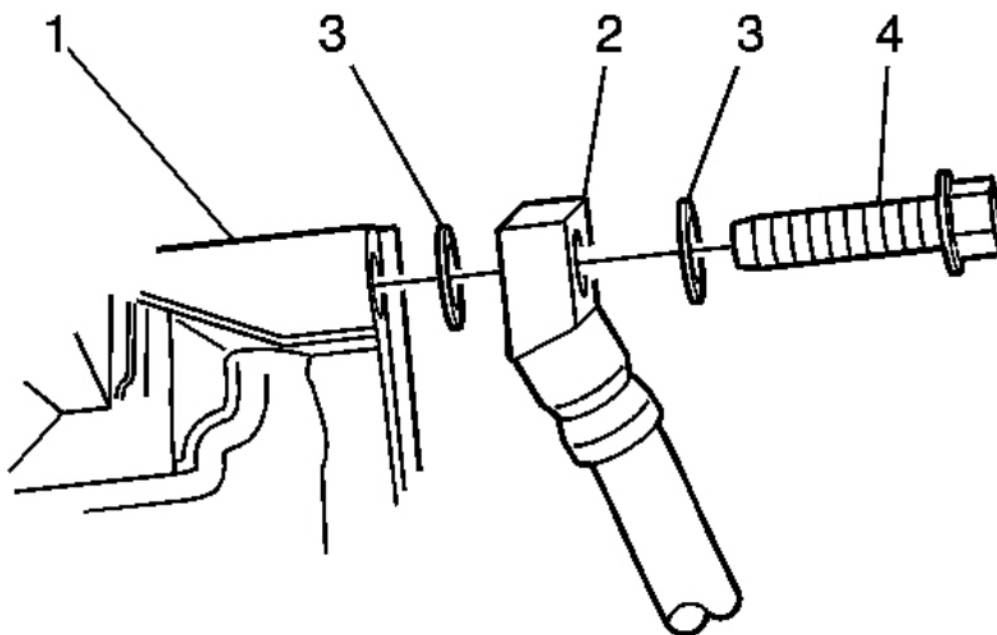


Fig. 65: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

8. Remove the brake hose to caliper bolt (4) from the brake caliper (1).
9. Remove the brake hose (2) from the vehicle.
10. Place a shop towel on a hard surface.
11. Tap the threaded end of the brake hose to caliper bolt (4) on the shop towel to remove the gasket (3) from the bolt.
12. Remove and discard the two copper brake hose gaskets (3). These gaskets may be stuck to the brake caliper (1) and/or the brake hose end (2).

IMPORTANT: Install a rubber cap or plug to the exposed brake pipe fitting end in order to prevent brake fluid loss and/or contamination.

13. Install a rubber plug into the brake hose to caliper bolt hole of the brake caliper.

NOTE: When installing the left rear brake hose to the caliper, the brake hose must be installed with the body of the hose positioned downward. The brake hose must be routed away from the left rear strut. Failure to route the hose correctly may cause the hose to rub on the strut, which may damage the hose and in turn may cause a brake fluid leak.

1. Remove the rubber plug from the brake hose to caliper bolt hole of the brake caliper.

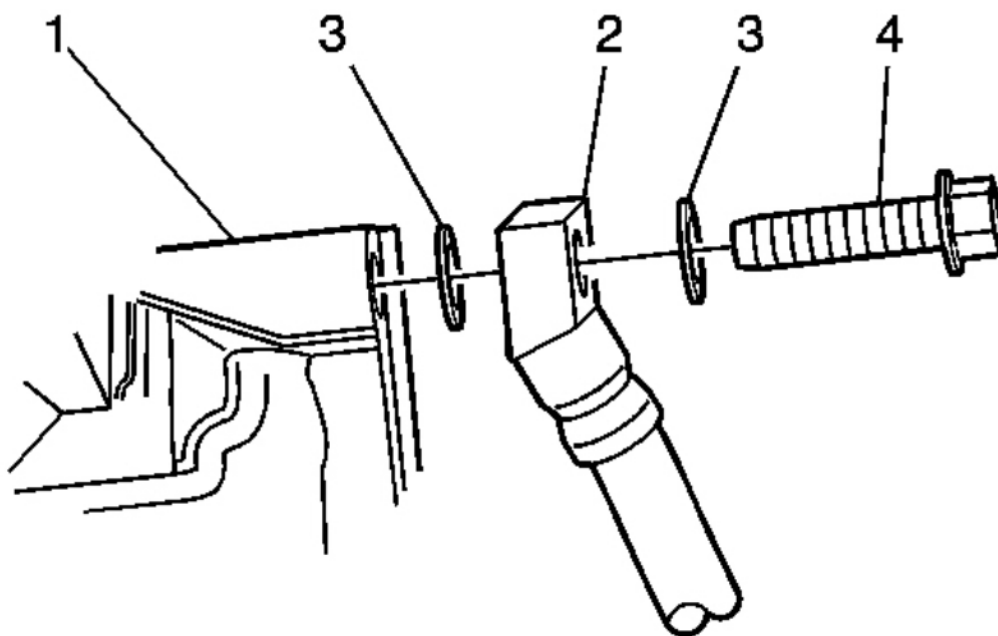


Fig. 66: View Of Brake Hose Banjo Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install NEW copper brake hose gaskets.

2. Assemble the brake hose, the NEW copper brake hose gaskets (3) and the brake hose bolt (4) to the brake hose (2).

Ensure that the brake hose is installed with the body of hose positioned down.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the brake hose to caliper bolt (4) to the brake caliper (1).

Tighten: Tighten the brake hose to caliper bolt to 34 N.m (25 lb ft).

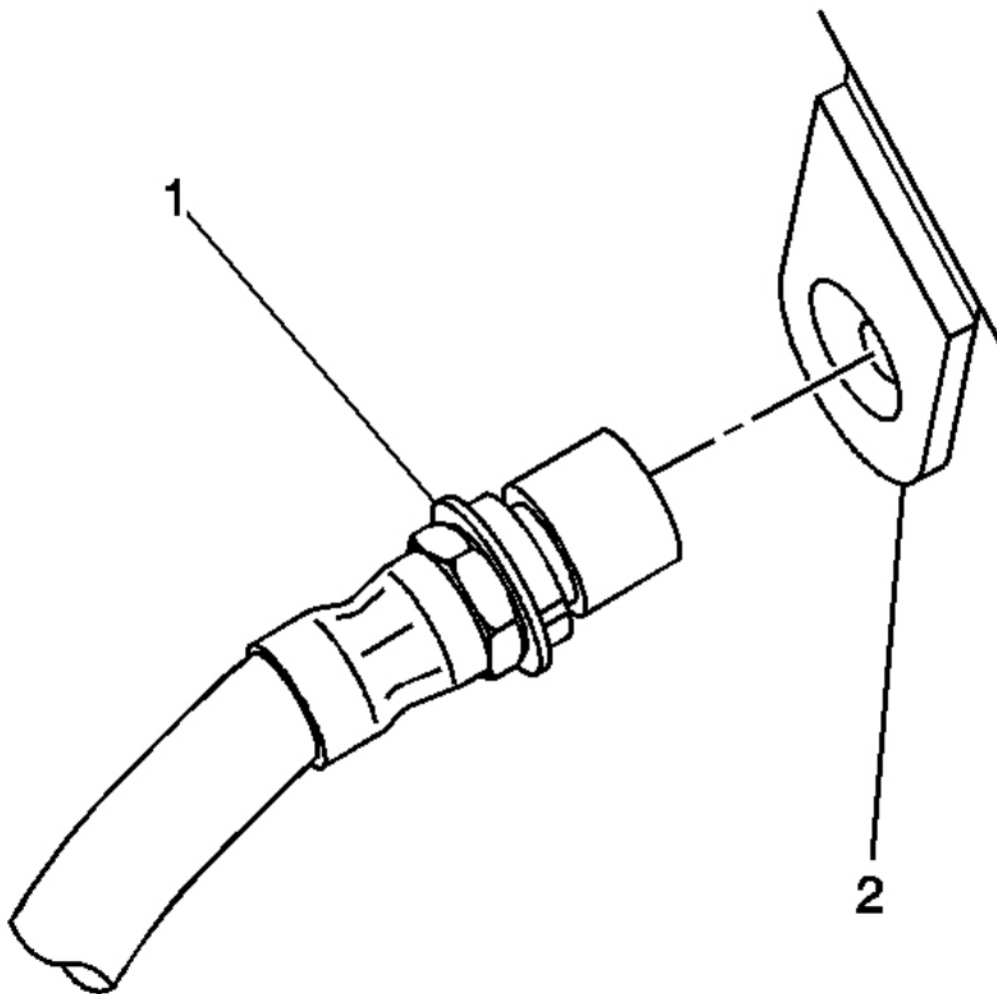


Fig. 67: Identifying Brake Hose
Courtesy of GENERAL MOTORS CORP.

NOTE: Make sure the brake hose is not twisted or kinked after

installation. Damage to the hose could result.

4. Install the brake hose (1) to the frame assembly (2).

Ensure that the brake hose is routed away from the strut assembly.

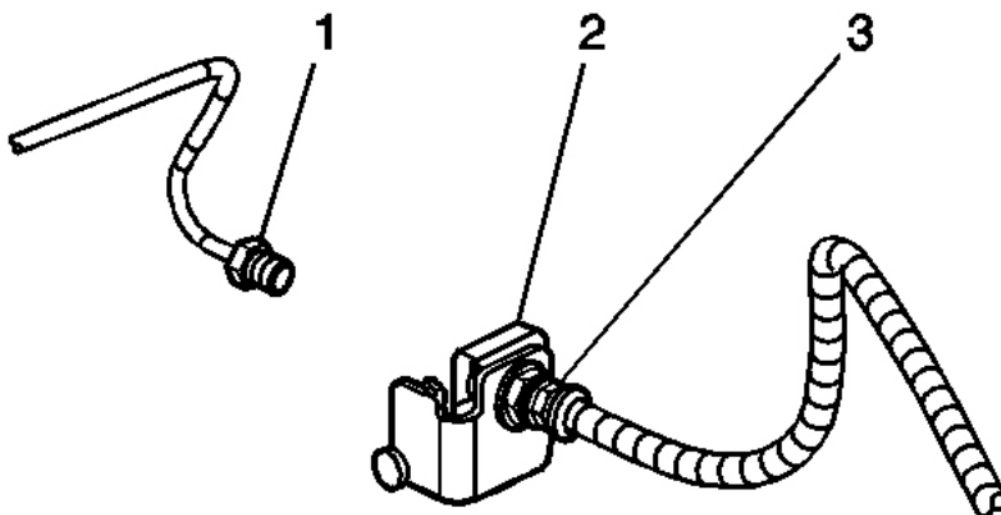


Fig. 68: Disconnecting/Reconnecting Brake Line Fitting
Courtesy of GENERAL MOTORS CORP.

5. Install the brake hose retainer (1) to the brake hose (3).
6. Remove the rubber cap or plug from the crossover pipe fitting end.
7. Install the brake pipe fitting (1) to the brake hose (3).

Tighten: Tighten the brake pipe fitting to 18 N.m (13 lb ft).

8. Bleed the hydraulic brake system. Refer to **Hydraulic Brake System Bleeding (Manual)** or **Hydraulic Brake System Bleeding (Pressure)**.
9. Install the left tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
10. Lower the vehicle.

HYDRAULIC BRAKE SYSTEM BLEEDING (MANUAL)

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: When adding fluid to the brake master cylinder reservoir, use only Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container. 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.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

1. Place a clean shop cloth beneath the brake master cylinder to prevent brake fluid spills.
2. 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.
3. If you have performed a brake master cylinder bench bleeding on this vehicle, or if you disconnected the brake pipes from the master cylinder, you must perform the following steps:
 1. Ensure that the brake master cylinder reservoir is full to the maximum-fill level. If necessary, add Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.

If removal of the reservoir cap and diaphragm is necessary, clean the outside of the reservoir on and around the cap prior to removal.
 2. With the rear brake pipe installed securely to the master cylinder, loosen and separate the front brake pipe from the front port of the brake master cylinder.
 3. Allow a small amount of brake fluid to gravity bleed from the open port of the master cylinder.
 4. Reconnect the brake pipe to the master cylinder port and tighten securely.
 5. Have an assistant slowly depress the brake pedal fully and maintain steady pressure on the pedal.
 6. Loosen the same brake pipe to purge air from the open port of the master cylinder.
 7. Tighten the brake pipe, then have the assistant slowly release the brake pedal.

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8. Wait 15 seconds, then repeat steps 3.3-3.7 until all air is purged from the same port of the master cylinder.
9. With the front brake pipe installed securely to the master cylinder - after all air has been purged from the front port of the master cylinder - loosen and separate the rear brake pipe from the master cylinder, then repeat steps 3.3-3.8.
10. After completing the final master cylinder port bleeding procedure, ensure that both of the brake pipe-to-master cylinder fittings are properly tightened.
4. Fill the brake master cylinder reservoir with Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container. Ensure that the brake master cylinder reservoir remains at least half-full during this bleeding procedure. Add fluid as needed to maintain the proper level.

Clean the outside of the reservoir on and around the reservoir cap prior to removing the cap and diaphragm.

5. Install a proper box-end wrench onto the RIGHT REAR wheel hydraulic circuit, inboard (CTS-V), bleeder valve.
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 Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.
8. Have an assistant slowly depress 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 same wheel hydraulic circuit.
12. For CTS-V models, repeat steps 5-11 for the outboard bleeder valve.
13. With the right rear wheel hydraulic circuit bleeder valve, or valves (CTS-V), tightened securely - after all air has been purged from the right rear hydraulic circuit - install a proper box-end wrench onto the LEFT FRONT wheel hydraulic circuit, inner (CTS-V), bleeder valve.
14. Install a transparent hose over the end of the bleeder valve, then repeat steps 7-11.
15. For CTS-V models, repeat steps 5-11 for the outboard bleeder valve.
16. With the left front wheel hydraulic circuit bleeder valve, or valves (CTS-V), tightened securely - after all air has been purged from the left front hydraulic circuit - install a proper box-end wrench onto the LEFT REAR wheel hydraulic circuit, inner (CTS-V), bleeder

valve.

17. Install a transparent hose over the end of the bleeder valve, then repeat steps 7-11.
18. For CTS-V models, repeat steps 5-11 for the outboard bleeder valve.
19. With the left rear wheel hydraulic circuit bleeder valve, or valves (CTS-V), tightened securely - after all air has been purged from the left rear hydraulic circuit - install a proper box-end wrench onto the RIGHT FRONT wheel hydraulic circuit, inner (CTS-V), bleeder valve.
20. Install a transparent hose over the end of the bleeder valve, then repeat steps 7-11.
21. For CTS-V models, repeat steps 5-11 for the outboard bleeder valve.
22. After completing the final wheel hydraulic circuit bleeding procedure, ensure that each of the 4 wheel hydraulic circuit bleeder valves, or 8 bleeder valves (CTS-V), are properly tightened.
23. Fill the brake master cylinder reservoir to the maximum-fill level with Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.
24. Slowly depress and release the brake pedal. Observe the feel of the brake pedal.
25. If the brake pedal feels spongy, repeat the bleeding procedure again. If the brake pedal still feels spongy after repeating the bleeding procedure, perform the following steps:
 1. Inspect the brake system for external leaks. Refer to **Brake System External Leak Inspection**.
 2. Pressure bleed the hydraulic brake system in order to purge any air that may still be trapped in the system.
26. Turn the ignition key ON, with the engine OFF. Check to see if the brake system warning lamp remains illuminated.

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

27. If the brake system warning lamp remains illuminated. Refer to **Symptoms - Hydraulic Brakes**.

HYDRAULIC BRAKE SYSTEM BLEEDING (PRESSURE)

Tools Required

- **J 29532** Diaphragm Type Brake Pressure Bleeder, or equivalent. See **Special Tools and Equipment**.

- **J 35589-A** Master Cylinder Bleeder Adapter. See Special Tools and Equipment.

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: When adding fluid to the brake master cylinder reservoir, use only Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container. 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.

NOTE: Refer to Brake Fluid Effects on Paint and Electrical Components Notice in Cautions and Notices.

1. Place a clean shop cloth beneath the brake master cylinder to prevent brake fluid spills.
2. 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.
3. If you have performed a brake master cylinder bench bleeding on this vehicle, or if you disconnected the brake pipes from the master cylinder, you must perform the following steps:
 1. Ensure that the brake master cylinder reservoir is full to the maximum-fill level. If necessary, add Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.

If removal of the reservoir cap and diaphragm is necessary, clean the outside of the reservoir on and around the cap prior to removal.

2. With the rear brake pipe installed securely to the master cylinder, loosen and separate the front brake pipe from the front port of the brake master cylinder.
3. Allow a small amount of brake fluid to gravity bleed from the open port of the master cylinder.
4. Reconnect the brake pipe to the master cylinder port and tighten securely.
5. Have an assistant slowly depress the brake pedal fully and maintain steady pressure on the pedal.
6. Loosen the same brake pipe to purge air from the open port of the master cylinder.

7. Tighten the brake pipe, then have the assistant slowly release the brake pedal.
 8. Wait 15 seconds, then repeat steps 3.3-3.7 until all air is purged from the same port of the master cylinder.
 9. With the front brake pipe installed securely to the master cylinder - after all air has been purged from the front port of the master cylinder - loosen and separate the rear brake pipe from the master cylinder, then repeat steps 3.3-3.8.
 10. After completing the final master cylinder port bleeding procedure, ensure that both of the brake pipe-to-master cylinder fittings are properly tightened.
4. Fill the brake master cylinder reservoir to the maximum-fill level with Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.

Clean the outside of the reservoir on and around the reservoir cap prior to removing the cap and diaphragm.

5. Install the **J 35589-A** to the brake master cylinder reservoir. See **Special Tools and Equipment**.
6. Check the brake fluid level in the **J 29532** , or equivalent. See **Special Tools and Equipment**. Add Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container as necessary to bring the level to approximately the half-full point.
7. Connect the **J 29532** , or equivalent, to the **J 35589-A** .
8. Charge the **J 29532** , or equivalent, air tank to 175-205 kPa (25-30 psi).
9. Open the **J 29532** , or equivalent, fluid tank valve to allow pressurized brake fluid to enter the brake system. See **Special Tools and Equipment**.
10. Wait approximately 30 seconds, then inspect the entire hydraulic brake system in order to ensure that there are no existing external brake fluid leaks.

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

11. Install a proper box-end wrench onto the RIGHT REAR wheel hydraulic circuit, inboard (CTS-V), bleeder valve.
12. Install a transparent hose over the end of the bleeder valve.
13. Submerge the open end of the transparent hose into a transparent container partially filled with Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.
14. Loosen the bleeder valve to purge air from the wheel hydraulic circuit. Allow fluid to flow

until air bubbles stop flowing from the bleeder, then tighten the bleeder valve.

15. For CTS-V models, repeat steps 11-14 for the outboard bleeder valve.
16. With the right rear wheel hydraulic circuit bleeder valve, or valves (CTS-V), tightened securely - after all air has been purged from the right rear hydraulic circuit - install a proper box-end wrench onto the LEFT FRONT wheel hydraulic circuit, inboard (CTS-V), bleeder valve.
17. Install a transparent hose over the end of the bleeder valve, then repeat steps 13-14.
18. For CTS-V models, repeat steps 11-14 for the outboard bleeder valve.
19. With the left front wheel hydraulic circuit bleeder valve, or valves (CTS-V), tightened securely - after all air has been purged from the left front hydraulic circuit - install a proper box-end wrench onto the LEFT REAR wheel hydraulic circuit, inner (CTS-V), bleeder valve.
20. Install a transparent hose over the end of the bleeder valve, then repeat steps 13-14.
21. For CTS-V models, repeat steps 11-14 for the outboard bleeder valve.
22. With the left rear wheel hydraulic circuit bleeder valve, or valves (CTS-V), tightened securely - after all air has been purged from the left rear hydraulic circuit - install a proper box-end wrench onto the RIGHT FRONT wheel hydraulic circuit, inner (CTS-V), bleeder valve.
23. Install a transparent hose over the end of the bleeder valve, then repeat steps 13-14.
24. For CTS-V models, repeat steps 11-14 for the outboard bleeder valve.
25. After completing the final wheel hydraulic circuit bleeding procedure, ensure that each of the 4 wheel hydraulic circuit bleeder valves, or 8 bleeder valves (CTS-V), are properly tightened.
26. Close the **J 29532** , or equivalent, fluid tank valve, then disconnect the **J 29532** , or equivalent, from the **J 35589-A** .
27. Remove the **J 35589-A** from the brake master cylinder reservoir. See **Special Tools and Equipment**.
28. Fill the brake master cylinder reservoir to the maximum-fill level with Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.
29. Slowly depress and release the brake pedal. Observe the feel of the brake pedal.
30. If the brake pedal feels spongy perform the following steps:
 1. Inspect the brake system for external leaks. Refer to **Brake System External Leak Inspection**.
 2. Using a scan tool, perform the antilock brake system automated bleeding procedure to remove any air that may have been trapped in the BPMV. Refer to **ABS Automated**

Bleed Procedure in Antilock Brake System.

31. Turn the ignition key ON, with the engine OFF. Check to see if the brake system warning lamp remains illuminated.

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

32. If the brake system warning lamp remains illuminated. Refer to **Symptoms - Hydraulic Brakes**.

HYDRAULIC BRAKE SYSTEM FLUSHING

CAUTION: Refer to Brake Fluid Irritant Caution in Cautions and Notices.

NOTE: When adding fluid to the brake master cylinder reservoir, use only Delco Supreme 11®, GM P/N 12377967 (Canadian P/N 992667), or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container. 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.

NOTE: Refer to **Brake Fluid Effects on Paint and Electrical Components Notice** in Cautions and Notices.

1. Inspect the brake fluid for the following conditions, indicating brake fluid contamination:
 - Fluid separation, indicating two 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 Replacement**
 - **Brake Hose Replacement - Front (CTS)** or **Brake Hose Replacement - Front (CTS-V)**
 - **Brake Hose Replacement - Intermediate (CTS)** or **Brake Hose Replacement - Intermediate (CTS-V)**
 - **Brake Hose Replacement - Rear (CTS)** or **Brake Hose Replacement - Rear (CTS-V)**
 - **Brake Caliper Replacement - Front (CTS)** or **Brake Caliper Replacement - Front (CTS-V)** in Disc Brakes
 - **Brake Caliper Replacement - Rear (CTS)** or **Brake Caliper Replacement - Rear (CTS-V)** in Disc Brakes
 - **Brake Pressure Modulator Valve (BPMV) Replacement (CTS)** or **Brake Pressure Modulator Valve (BPMV) Replacement (CTS-V)** in Antilock Brake System
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 Overhaul** or **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.

- Brake Hose Replacement - Front (CTS) or Brake Hose Replacement - Front (CTS-V)
 - Brake Hose Replacement - Intermediate (CTS) or Brake Hose Replacement - Intermediate (CTS-V)
 - Brake Hose Replacement - Rear (CTS) or Brake Hose Replacement - Rear (CTS-V)
 - Brake Caliper Overhaul - Front (CTS) or Brake Caliper Overhaul - Front (CTS-V) or Brake Caliper Replacement - Front (CTS) or Brake Caliper Replacement - Front (CTS-V) in Disc Brakes
 - Brake Caliper Overhaul - Rear (CTS) or Brake Caliper Overhaul - Rear (CTS-V) or Brake Caliper Replacement - Rear (CTS) or Brake Caliper Replacement - Rear (CTS-V) in Disc Brakes
 - Brake Pressure Modulator Valve (BPMV) Replacement (CTS) or Brake Pressure Modulator Valve (BPMV) Replacement (CTS-V) in Antilock Brake System
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 which 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 Delco Supreme 11® (GM P/N 12377967) or equivalent DOT-3 brake fluid from a clean, sealed brake fluid container.
 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) or Hydraulic Brake System Bleeding (Pressure).

VACUUM BRAKE BOOSTER REPLACEMENT (LHD)

Tools Required

J 22805-B Brake Booster Holder. See Special Tools and Equipment.

Removal Procedure

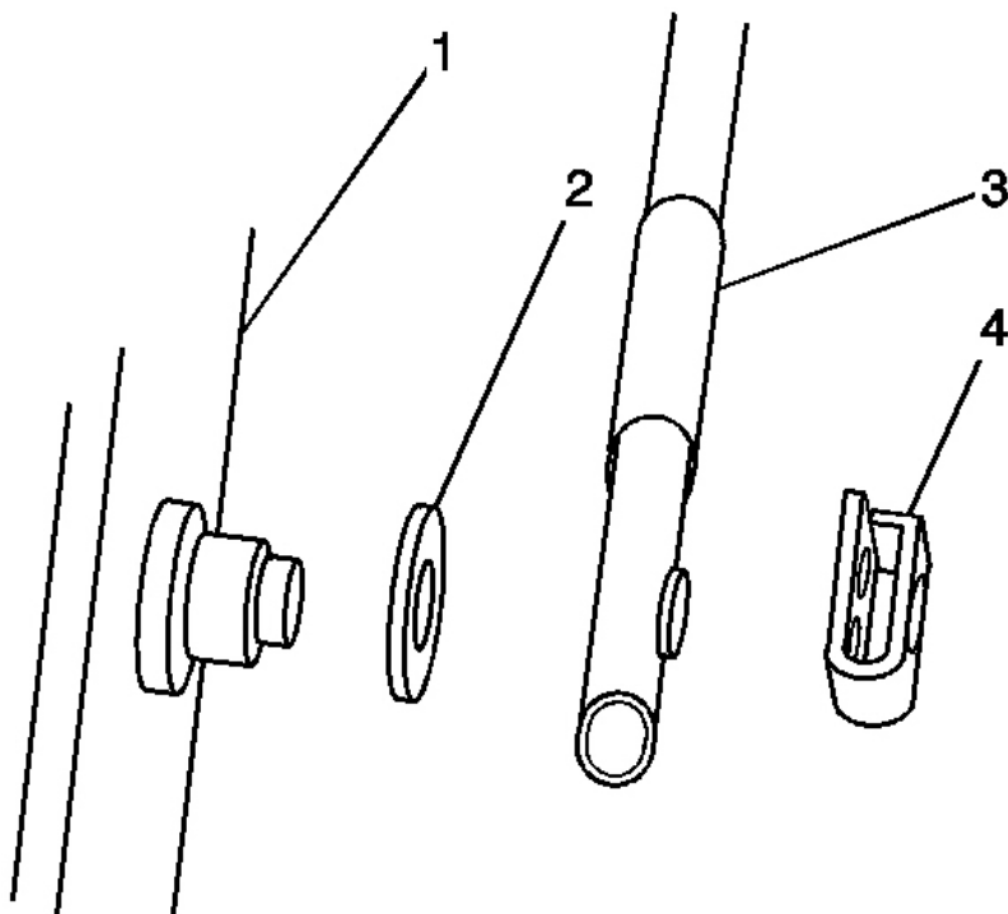


Fig. 69: Removing & Installing Vacuum Brake Booster Pushrod
Courtesy of GENERAL MOTORS CORP.

1. Remove the left closeout/insulator panel. Refer to **Closeout/Insulator Panel Replacement - Left** in Instrument Panel Gages, and Console.
2. Remove the vacuum brake booster push rod retaining clip (4).
3. Remove the vacuum brake booster pushrod (3) from the brake pedal.
4. If equipped with a cross vehicle brace, remove the cross vehicle brace. Refer to **Brace Replacement - Cross Vehicle** in Body Front End.

IMPORTANT: It is not necessary to disconnect the clutch pipes from the

clutch master cylinder.

5. If equipped with a clutch remove the clutch master cylinder. Refer to **Clutch Master Cylinder Replacement (CTS)** or **Clutch Master Cylinder Replacement (CTS-V)** in Clutch.

IMPORTANT: It is not necessary to disconnect the brake pipes from the master cylinder.

6. Remove the master cylinder from the vacuum brake booster and position the master cylinder aside. Refer to **Master Cylinder Replacement**.
7. Remove the air inlet grille panel, to access the vacuum brake booster locking tab. Refer to **Air Inlet Grille Panel Replacement (LHD)** or **Air Inlet Grille Panel Replacement (RHD)** in Body Front End.

IMPORTANT: It is not necessary to drain the coolant or disconnect the surge tank outlet hose from the surge tank.

8. Disconnect the surge tank inlet hose and position out of the way. Refer to **Surge Tank Replacement (LHD M 35)** or **Surge Tank Replacement (RHD)** or **Surge Tank Replacement (LHD M 82 LY7)** or **Surge Tank Replacement (LHD M 82)** or **Surge Tank Replacement (LHD M35 LS6)** or **Surge Tank Replacement (LS6)** in Engine Cooling.
9. Remove the coolant surge tank bolts and position the coolant surge tank out of the way. Refer to **Surge Tank Replacement (LHD M 35)** or **Surge Tank Replacement (RHD)** or **Surge Tank Replacement (LHD M 82 LY7)** or **Surge Tank Replacement (LHD M 82)** or **Surge Tank Replacement (LHD M35 LS6)** or **Surge Tank Replacement (LS6)** in Engine Cooling.
10. Connect the surge tank inlet hose to prevent coolant loss.
11. Disconnect the vacuum brake booster check valve from the vacuum brake booster and position out of the way.
12. Attach the **J 22805-B** to the vacuum brake booster using the master cylinder mounting nuts. See **Special Tools and Equipment**.

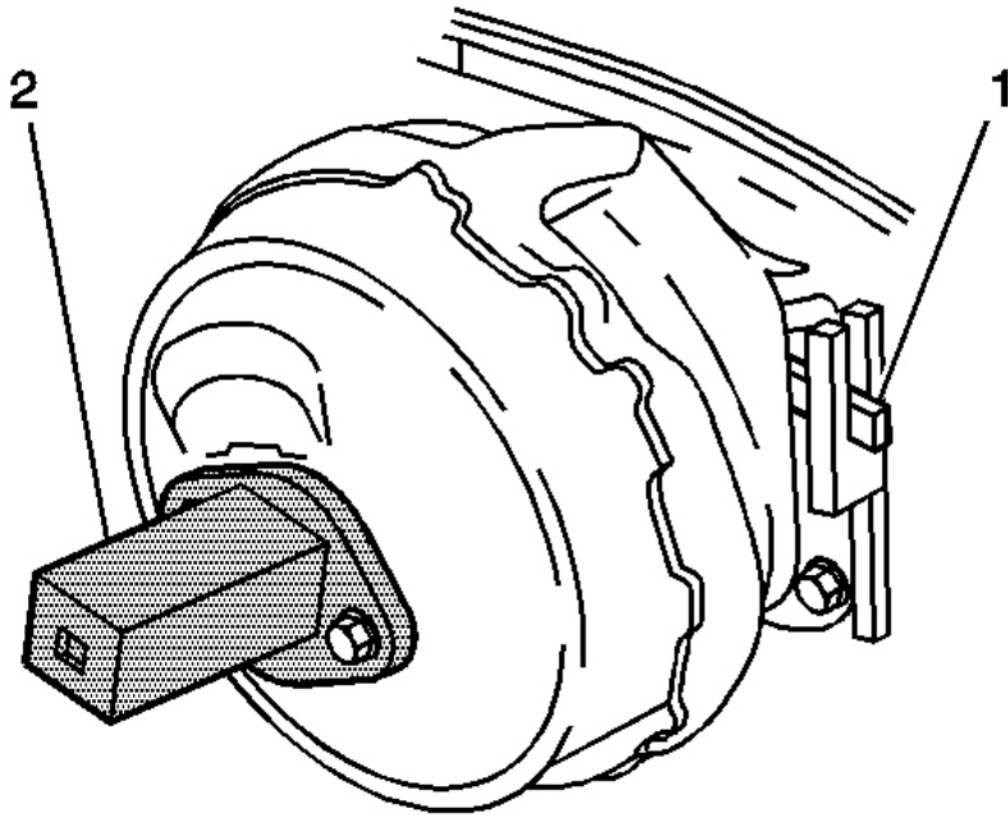


Fig. 70: Identifying Special Tool J 22805-B
Courtesy of GENERAL MOTORS CORP.

13. Unlock the vacuum brake booster from the front of the cowl.

Use a flat bladed tool to depress the vacuum brake booster locking tab (1) out of the cowl mounting flange, while turning the vacuum brake booster counter clockwise with a ratchet on the **J 22805-B** (2). See **Special Tools and Equipment**.

14. Carefully remove the vacuum brake booster from the cowl mounting flange.
15. Support the vacuum brake booster.

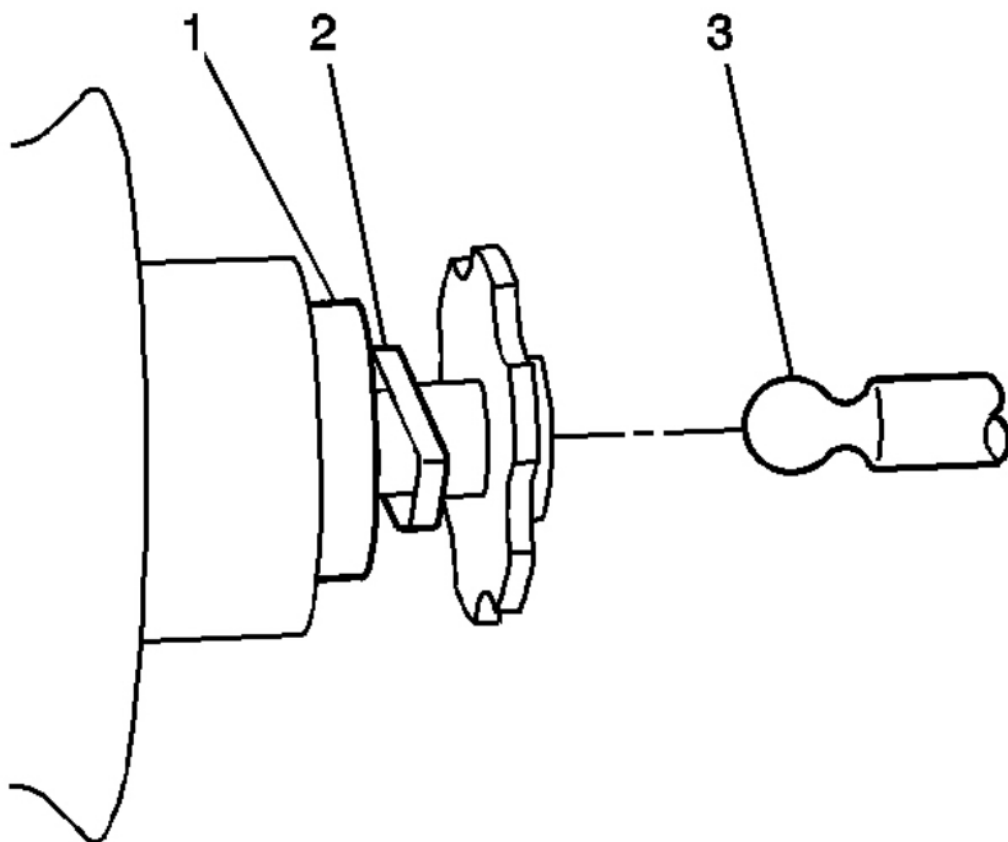


Fig. 71: Removing & Installing Pushrod
Courtesy of GENERAL MOTORS CORP.

16. Carefully push the vacuum brake booster foam filter (1) in enough to access the vacuum brake booster retaining clip (2).
17. Carefully lift the longer leg of the retaining clip (2) upward.
18. Carefully remove the pushrod (3) from the vacuum brake booster.

Installation Procedure

NOTE: Internal components of this booster are not serviceable. The housing must not be unstaked and separated. Separating the housing will cause permanent deformation, preventing the booster from holding proper volume.

NOTE: Inspect the locking flanges on booster and mounting plate. Replace the booster and mounting plate if the locking flanges are bent or damaged.

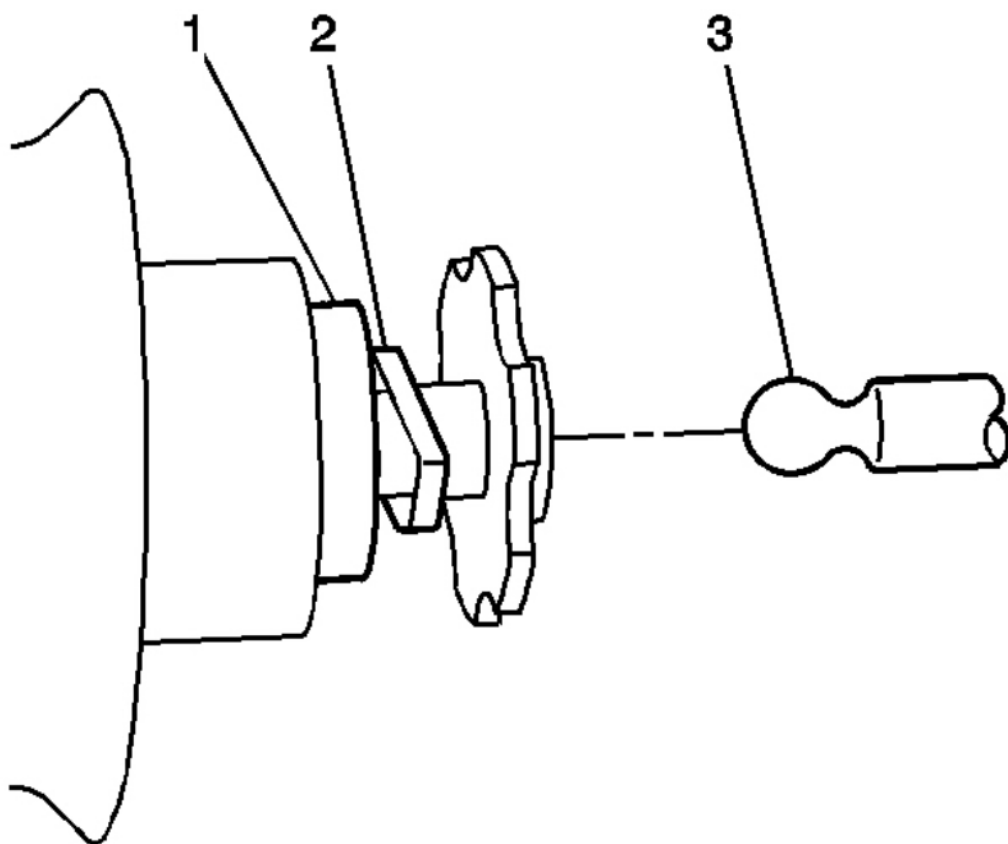


Fig. 72: Removing & Installing Pushrod
Courtesy of GENERAL MOTORS CORP.

1. Carefully install the vacuum brake booster to the vacuum brake booster pushrod (3).

IMPORTANT: Ensure that the long leg of the retainer clip is in the machined groove of the pushrod (3).

2. Carefully push the vacuum brake booster on to the pushrod until the long leg of the retaining clip seats into the machined groove of the pushrod.

3. Install the vacuum brake booster through the dust boot on the cowl.
4. Position the vacuum brake booster on the cowl counter clockwise from the final installation position so that the locking flanges on the vacuum brake booster and on the cowl mounting flange engage.

IMPORTANT: Ensure that the locking tab and the flanges are in the fully engaged position.

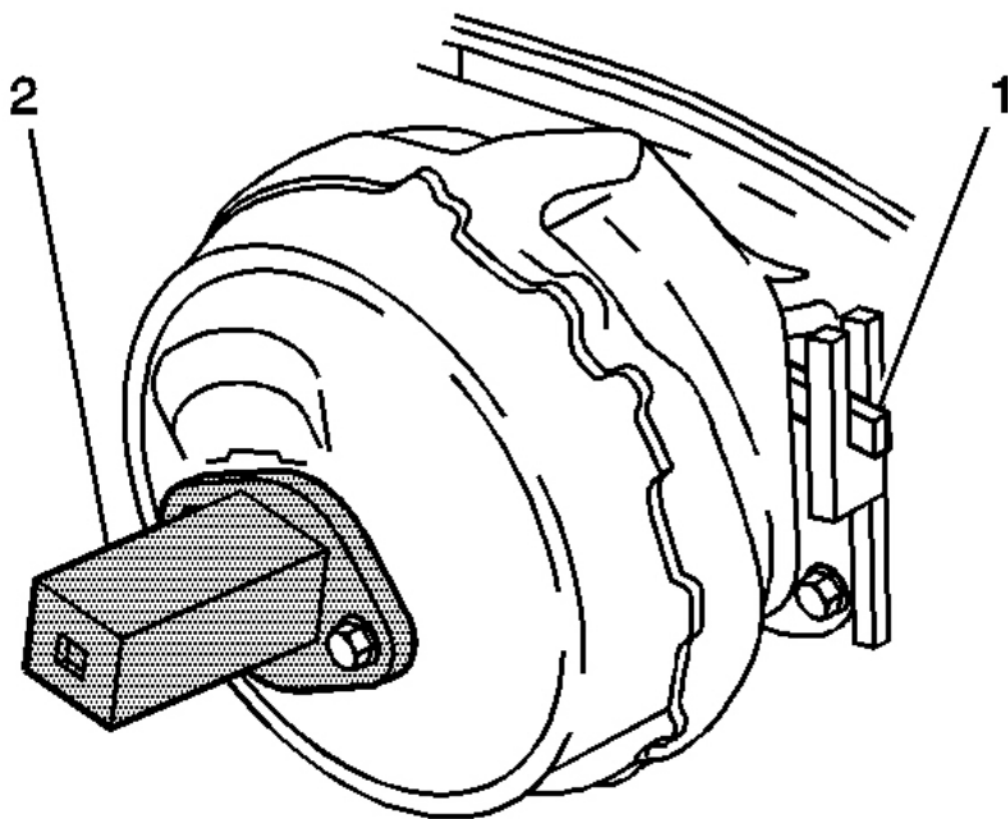


Fig. 73: Identifying Special Tool J 22805-B
Courtesy of GENERAL MOTORS CORP.

5. Turn the vacuum brake booster clockwise with a ratchet on the **J 22805-B** (2). DO NOT use a flat bladed tool in the locking tab to install the vacuum brake booster. When the vacuum brake booster is correctly installed, the locking tab (1) slides up the flange and

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engages the locking notch.

6. Remove the **J 22805-B** (2) from the installed vacuum brake booster. See **Special Tools and Equipment**.
7. Reposition and connect the vacuum hose and check valve assembly to the booster.
8. Remove the surge tank inlet hose from the surge tank.
9. Install the coolant surge tank. Refer to **Surge Tank Replacement (LHD M 35)** or **Surge Tank Replacement (RHD)** or **Surge Tank Replacement (LHD M 82 LY7)** or **Surge Tank Replacement (LHD M 82)** or **Surge Tank Replacement (LHD M35 LS6)** or **Surge Tank Replacement (LS6)** in Engine Cooling.
10. Install the surge tank inlet hose. Refer to **Surge Tank Replacement (LHD M 35)** or **Surge Tank Replacement (RHD)** or **Surge Tank Replacement (LHD M 82 LY7)** or **Surge Tank Replacement (LHD M 82)** or **Surge Tank Replacement (LHD M35 LS6)** or **Surge Tank Replacement (LS6)** in Engine Cooling.
11. Install the air inlet grille panel. Refer to **Air Inlet Grille Panel Replacement (LHD)** or **Air Inlet Grille Panel Replacement (RHD)** in Body Front End.
12. Install the master cylinder to the vacuum brake booster. Refer to **Master Cylinder Replacement**.
13. If equipped with a clutch install the clutch master cylinder. Refer to **Clutch Master Cylinder Replacement (CTS)** or **Clutch Master Cylinder Replacement (CTS-V)** in Clutch.
14. If equipped with a cross vehicle brace, install the cross vehicle brace. Refer to **Brace Replacement - Cross Vehicle** in Body Front End.

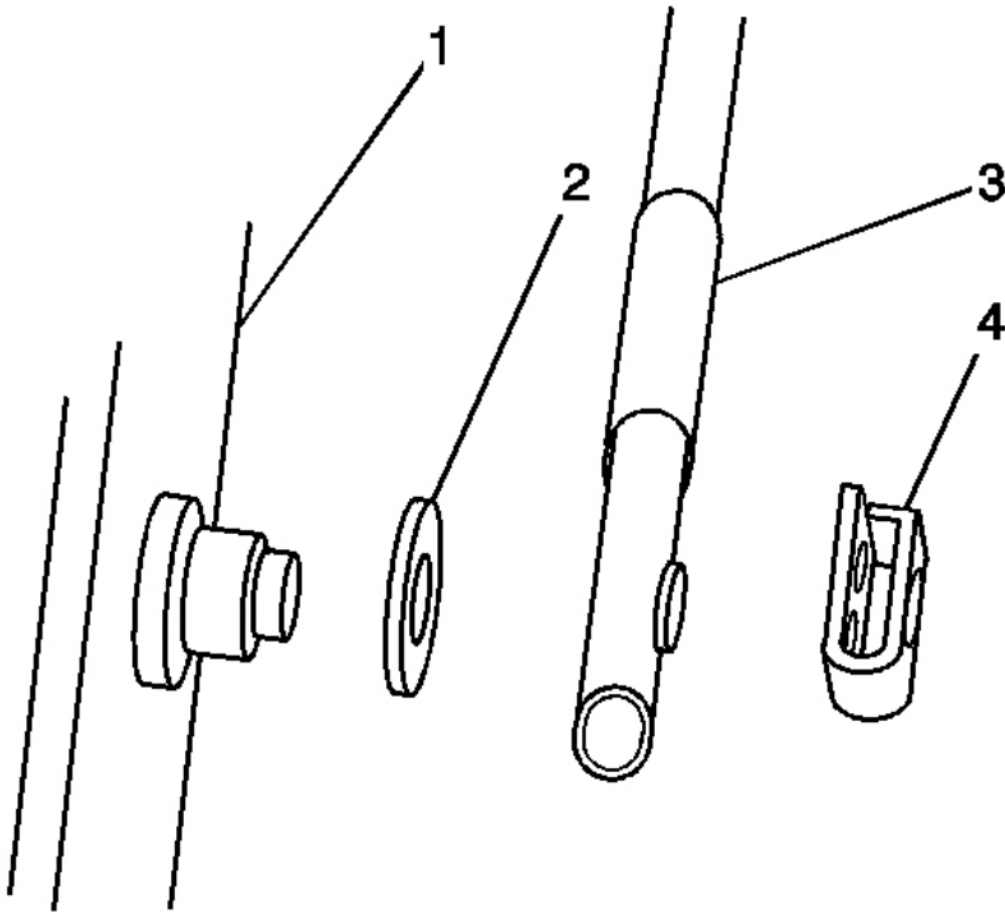


Fig. 74: Removing & Installing Vacuum Brake Booster Pushrod
Courtesy of GENERAL MOTORS CORP.

15. Install the vacuum brake booster pushrod (3) to the brake pedal.
16. Install the vacuum brake booster push rod retaining clip (4) to the brake pedal.
17. Install the left closeout/insulator panel. Refer to **Closeout/Insulator Panel Replacement - Left** in Instrument Panel Gages, and Console.

VACUUM BRAKE BOOSTER REPLACEMENT (RHD)

Tools Required

J 22805-B Brake Booster Holder. See Special Tools and Equipment.

Removal Procedure

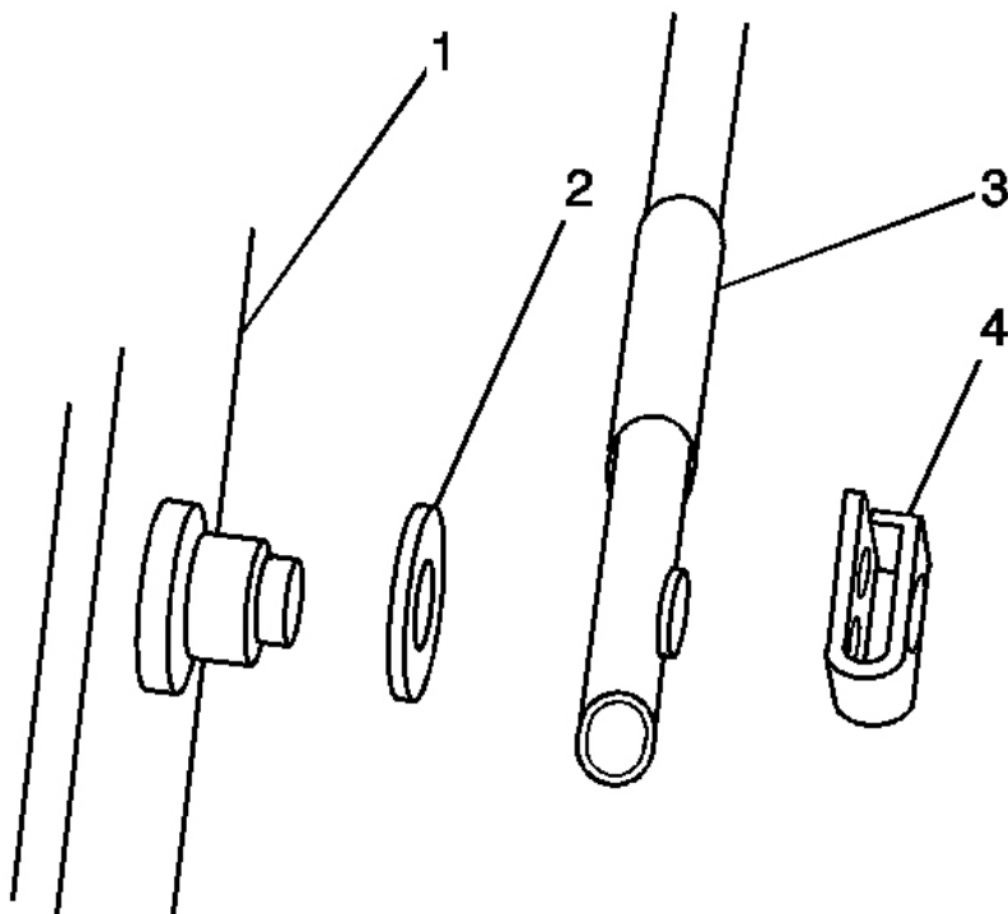


Fig. 75: Removing & Installing Vacuum Brake Booster Pushrod
Courtesy of GENERAL MOTORS CORP.

1. Remove the left closeout/insulator. Refer to Closeout/Insulator Panel Replacement - Right in Instrument Panel Gages, and Console.
2. Remove the vacuum brake booster pushrod retaining clip (4).
3. Remove the vacuum brake booster pushrod (3) from the brake pedal assembly.
4. If equipped with a cross vehicle brace, remove the cross vehicle brace. Refer to Brace

Replacement - Cross Vehicle in Body Front End.

IMPORTANT: It is not necessary to disconnect the brake pipes from the master cylinder.

5. Remove the master cylinder from the vacuum brake booster and position the master cylinder aside. Refer to **Master Cylinder Replacement**.
6. Remove the air inlet grille panel, to gain access to the vacuum brake booster locking tab. Refer to **Air Inlet Grille Panel Replacement (LHD)** or **Air Inlet Grille Panel Replacement (RHD)** in Body Front End.

IMPORTANT: It is not necessary to drain the coolant or disconnect the surge tank outlet hose from the coolant surge tank.

7. Remove the coolant surge tank inlet hose from the surge tank. Refer to **Surge Tank Replacement (LHD M 35)** or **Surge Tank Replacement (RHD)** or **Surge Tank Replacement (LHD M 82 LY7)** or **Surge Tank Replacement (LHD M 82)** or **Surge Tank Replacement (LHD M35 LS6)** or **Surge Tank Replacement (LS6)** in Engine Cooling.
8. Remove the coolant surge tank bolts and position the coolant surge tank out of the way. Refer to **Surge Tank Replacement (LHD M 35)** or **Surge Tank Replacement (RHD)** or **Surge Tank Replacement (LHD M 82 LY7)** or **Surge Tank Replacement (LHD M 82)** or **Surge Tank Replacement (LHD M35 LS6)** or **Surge Tank Replacement (LS6)** in Engine Cooling.
9. Install the coolant surge tank inlet hose to the coolant surge tank to prevent coolant loss.
10. Disconnect the vacuum brake booster check valve from the vacuum brake booster and position out of the way.
11. Attach the **J 22805-B** to the vacuum brake booster using the master cylinder retaining nuts. See **Special Tools and Equipment**.

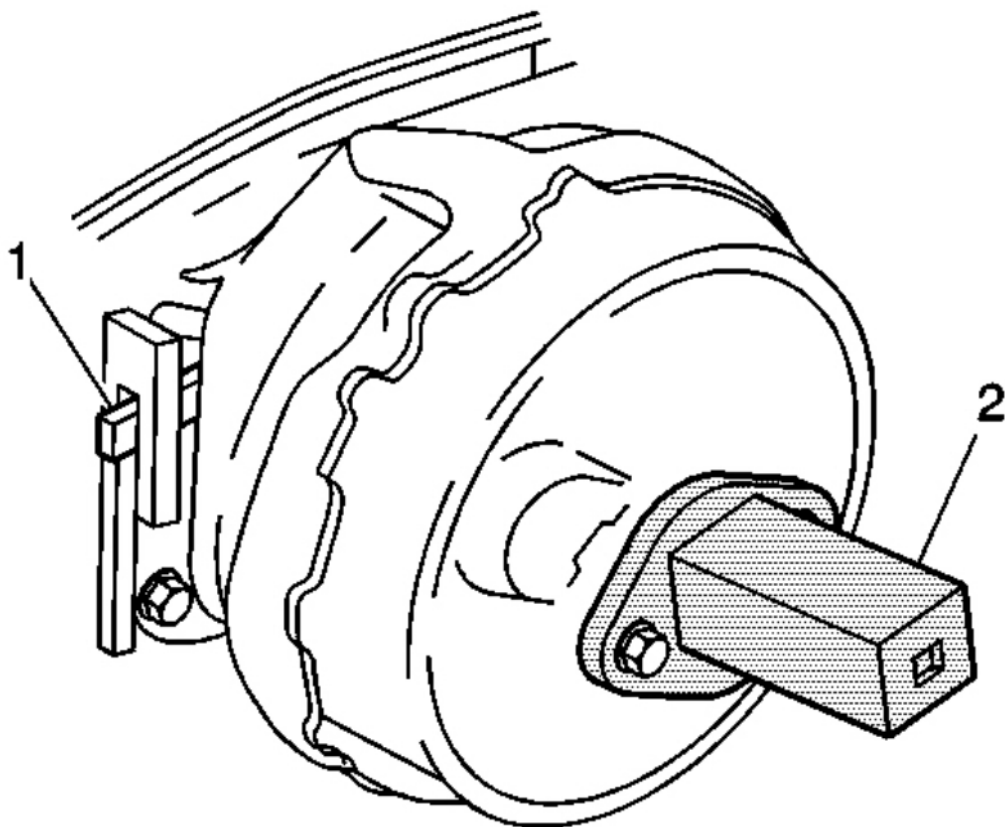


Fig. 76: Locking/Unlocking Booster To Cowl
Courtesy of GENERAL MOTORS CORP.

12. Unlock the booster from the front of the cowl.

Use a flat bladed tool to depress the vacuum brake booster locking tab (1) out of the cowl mounting flange, while turning the vacuum brake booster counterclockwise with a ratchet on the **J 22805-B** (2). See **Special Tools and Equipment**.

13. Carefully remove the vacuum brake booster from the cowl mounting flange.
14. Support the vacuum brake booster.

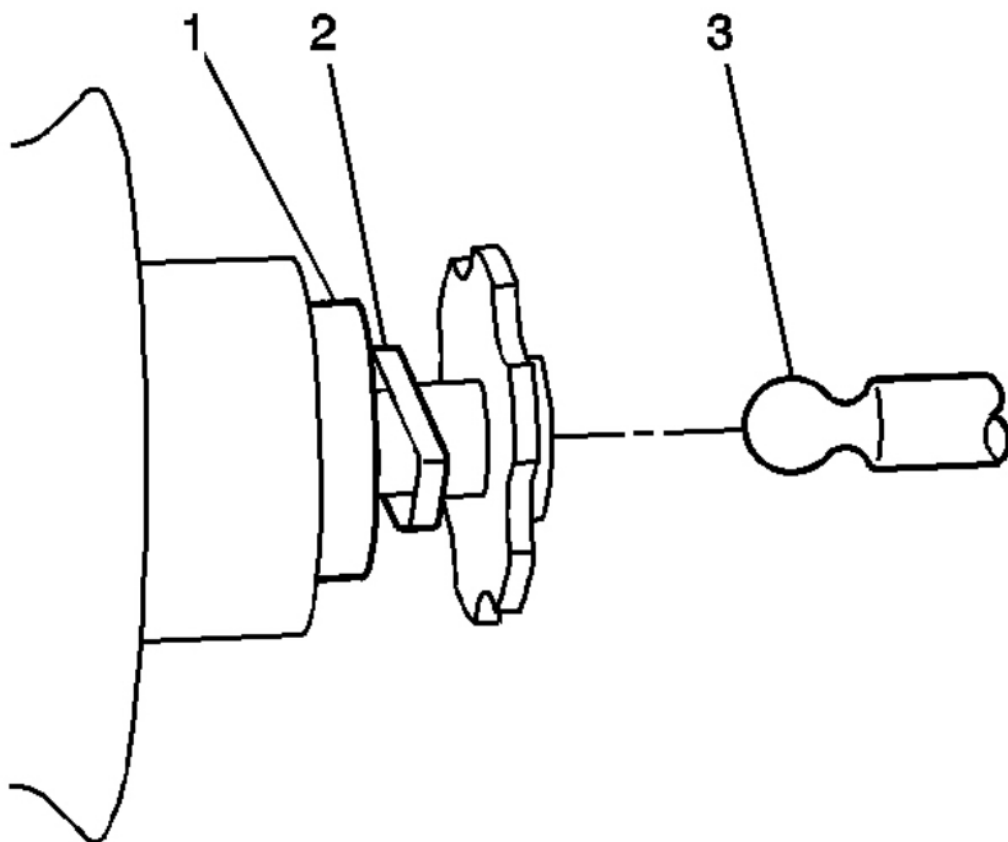


Fig. 77: Removing & Installing Pushrod
Courtesy of GENERAL MOTORS CORP.

15. Carefully push the vacuum brake booster foam filter (1) in enough to access the vacuum brake booster retaining clip (2).
16. Carefully lift the longer leg of the retaining clip (2) upward.
17. Carefully remove the vacuum brake booster pushrod (3) from the vacuum brake booster.

Installation Procedure

NOTE: Internal components of this booster are not serviceable. The housing must not be unstaked and separated. Separating the housing will cause permanent deformation, preventing the booster from holding proper volume.

NOTE: Inspect the locking flanges on booster and mounting plate. Replace the booster and mounting plate if the locking flanges are bent or damaged.

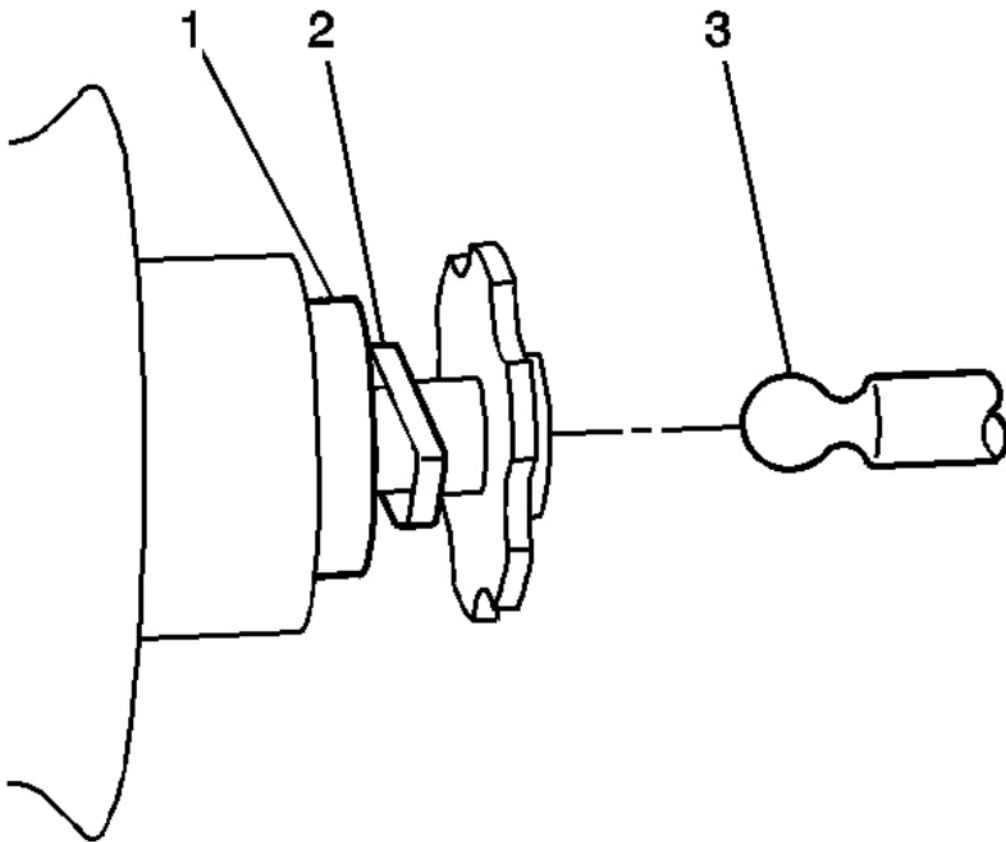


Fig. 78: Removing & Installing Pushrod
Courtesy of GENERAL MOTORS CORP.

1. Carefully install the vacuum brake booster to the vacuum brake booster pushrod (3).

IMPORTANT: Ensure that the long leg of the retainer clip is in the machined groove of the pushrod (3).

2. Carefully push the vacuum brake booster pushrod on to the vacuum brake booster until the long leg of the retaining clip seats into the machined groove of the pushrod.

3. Position the vacuum brake booster on the cowl counterclockwise from the final installation position so that the locking flanges on the vacuum brake booster and on the cowl mounting flange engage.

IMPORTANT: Ensure that the locking tab and the flanges are in the fully engaged position.

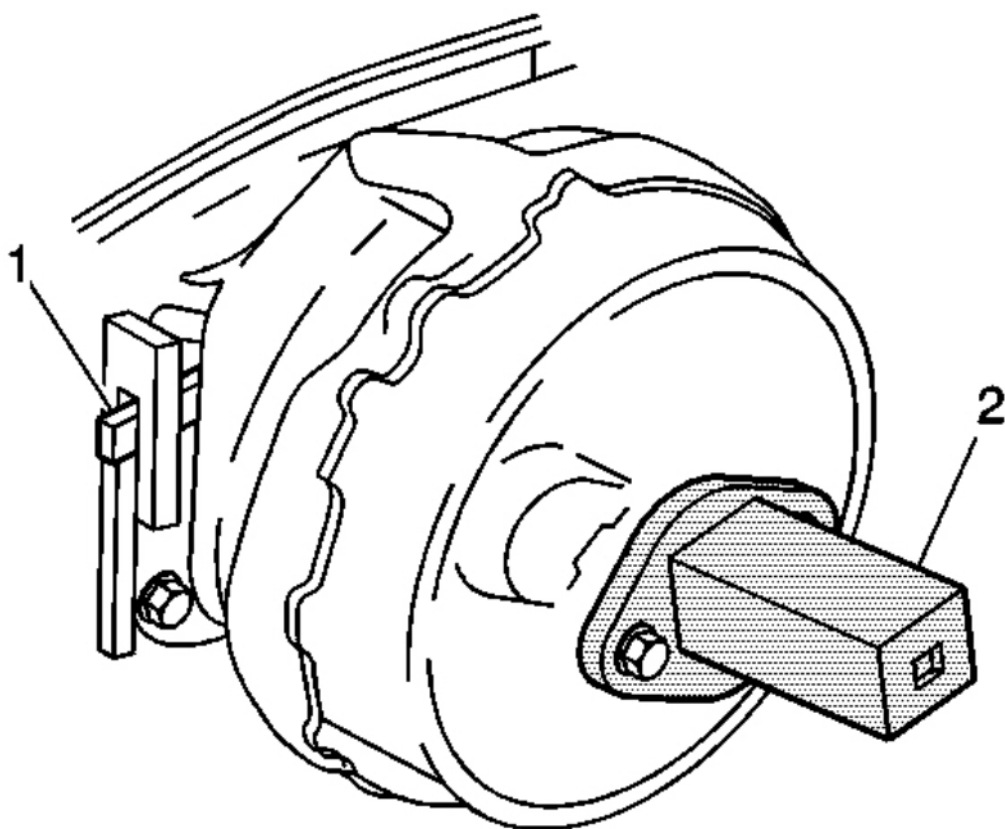


Fig. 79: Locking/Unlocking Booster To Cowl
Courtesy of GENERAL MOTORS CORP.

4. Turn the vacuum brake booster clockwise with a ratchet on the **J 22805-B (2)**. DO NOT use a flat bladed tool in the locking tab to install the vacuum brake booster. When the vacuum brake booster is correctly installed, the locking tab (1) slides up the flange and engages the locking notch.

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2004 BRAKES Hydraulic Brakes - CTS

5. Remove the **J 22805-B** (2) from the installed vacuum brake booster.
6. Reposition and connect the vacuum hose and check valve assembly to the vacuum brake booster.
7. Remove the coolant surge tank inlet hose from the coolant surge tank.
8. Install the coolant surge tank. Refer to **Surge Tank Replacement (LHD M 35)** or **Surge Tank Replacement (RHD)** or **Surge Tank Replacement (LHD M 82 LY7)** or **Surge Tank Replacement (LHD M 82)** or **Surge Tank Replacement (LHD M35 LS6)** or **Surge Tank Replacement (LS6)** in Engine Cooling.
9. Install the air inlet grille panel. Refer to **Air Inlet Grille Panel Replacement (LHD)** or **Air Inlet Grille Panel Replacement (RHD)** in Body Front End.
10. Install the master cylinder to the vacuum brake booster. Refer to **Master Cylinder Replacement**.
11. If equipped with a cross vehicle brace, install the cross vehicle brace. Refer to **Brace Replacement - Cross Vehicle** in Body Front End.

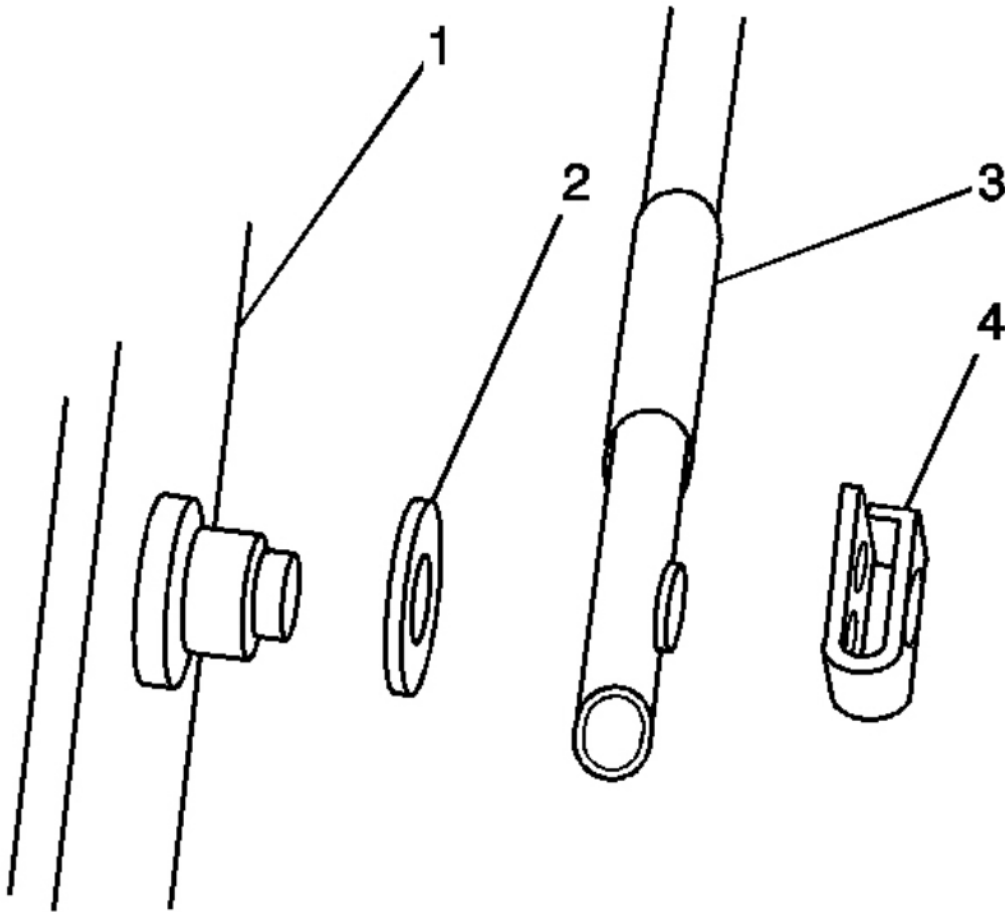


Fig. 80: Removing & Installing Vacuum Brake Booster Pushrod
Courtesy of GENERAL MOTORS CORP.

12. Install the vacuum brake booster pushrod (3) to the brake pedal assembly.
13. Install the vacuum brake booster pushrod retaining clip (4).
14. Install the left closeout/insulator panel. Refer to **Closeout/Insulator Panel Replacement - Right** in Instrument Panel Gages, and Console.

VACUUM BRAKE BOOSTER CHECK VALVE AND/OR HOSE REPLACEMENT (LHD)

Removal Procedure

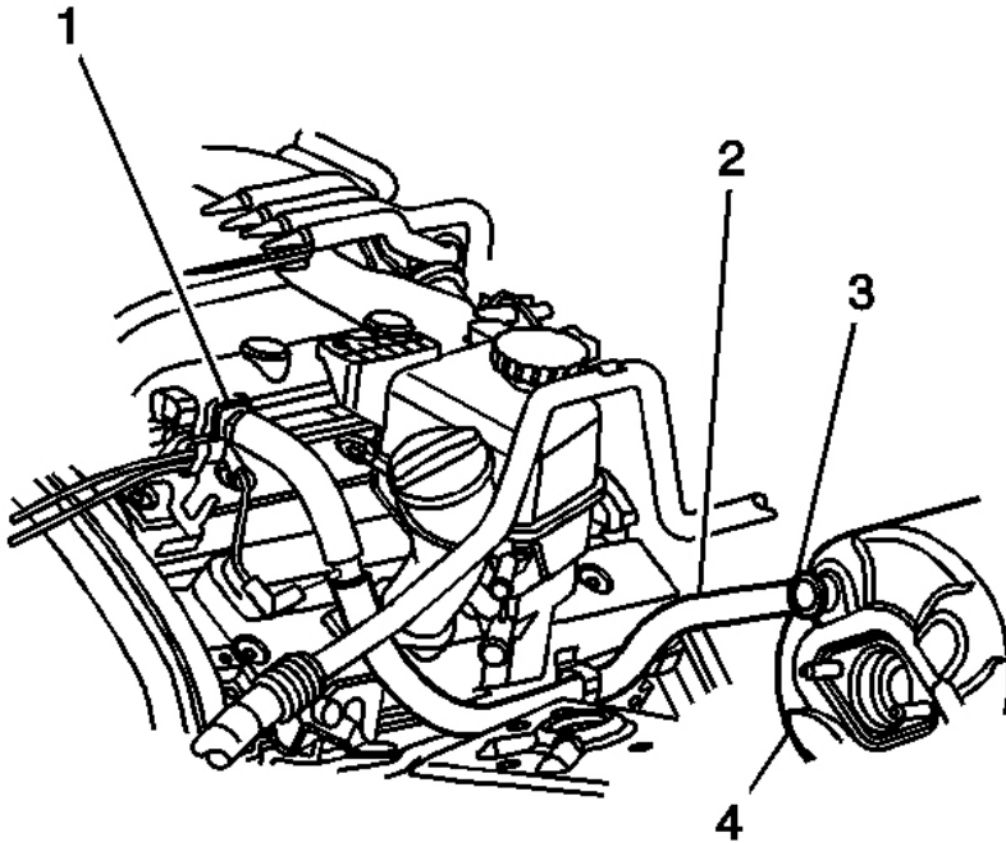


Fig. 81: Identifying Vacuum Brake Booster Check Valve & Hose
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the vacuum hose (2) and the brake booster vacuum check valve (3) from vacuum brake booster (4).
2. Remove the vacuum hose retainer from the power steering reservoir.
3. Disconnect the vacuum hose (2) from the intake manifold vacuum port (1).

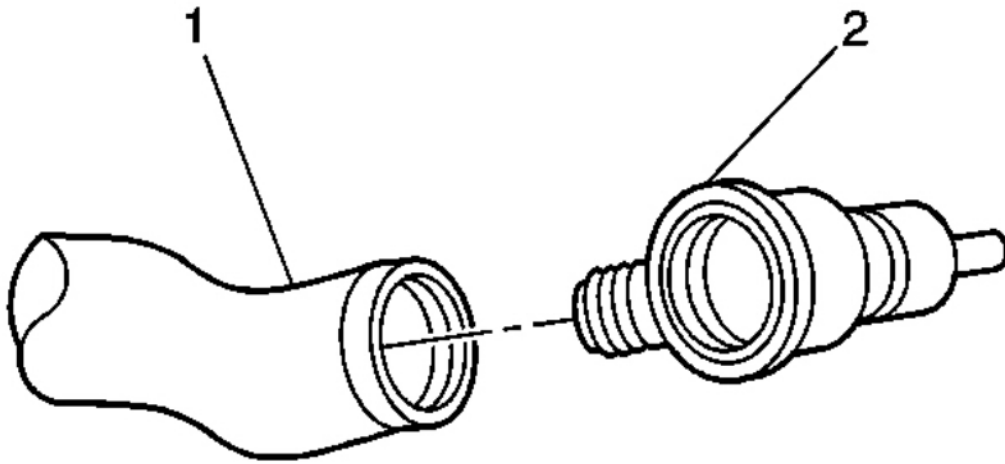


Fig. 82: View Of Vacuum Brake Booster Check Valve And Vacuum Brake Booster Hose

Courtesy of GENERAL MOTORS CORP.

4. Remove the brake booster vacuum check valve (2) from the brake booster vacuum hose (1).

Installation Procedure

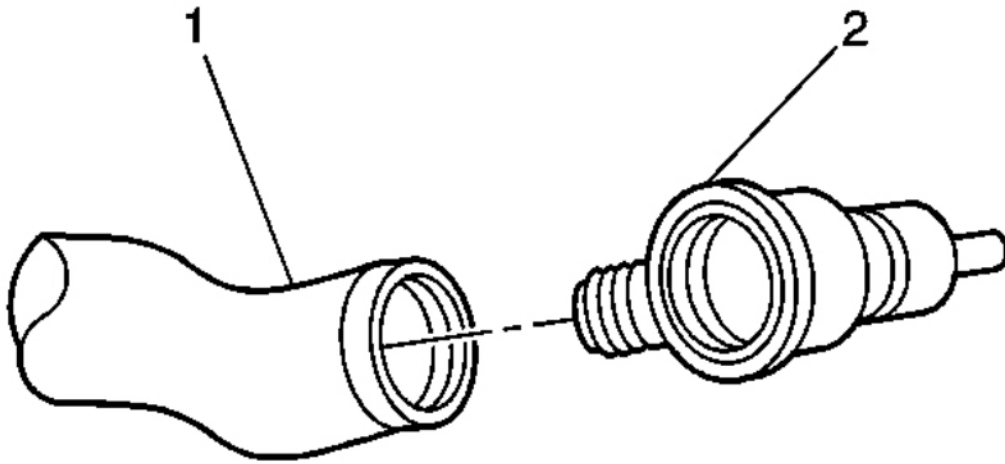


Fig. 83: View Of Vacuum Brake Booster Check Valve And Vacuum Brake Booster Hose

Courtesy of GENERAL MOTORS CORP.

1. Install the brake booster vacuum check valve (2) to the brake booster vacuum hose (1).

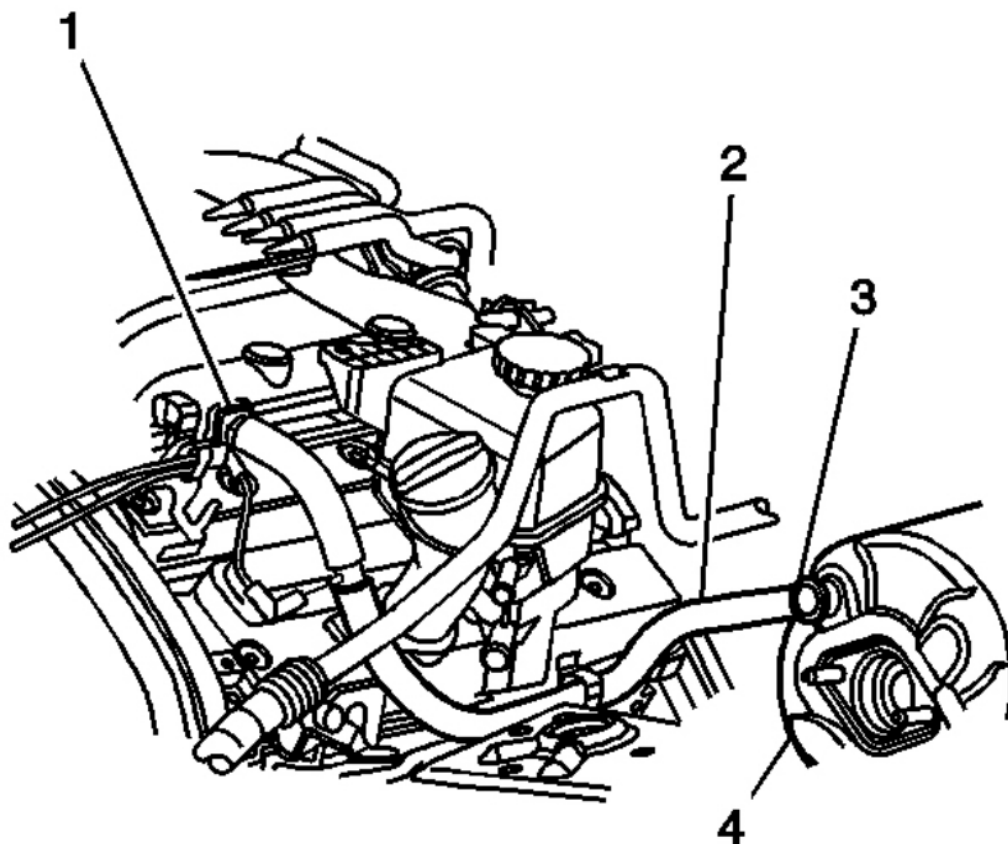


Fig. 84: Identifying Vacuum Brake Booster Check Valve & Hose
Courtesy of GENERAL MOTORS CORP.

2. Connect the vacuum hose (2) to the intake manifold vacuum port (1).
3. Install the vacuum hose retainer to the power steering reservoir.
4. Connect the vacuum hose (2) and vacuum brake booster check valve (3) to vacuum brake booster (4).

VACUUM BRAKE BOOSTER CHECK VALVE AND/OR HOSE REPLACEMENT (RHD)

Removal Procedure

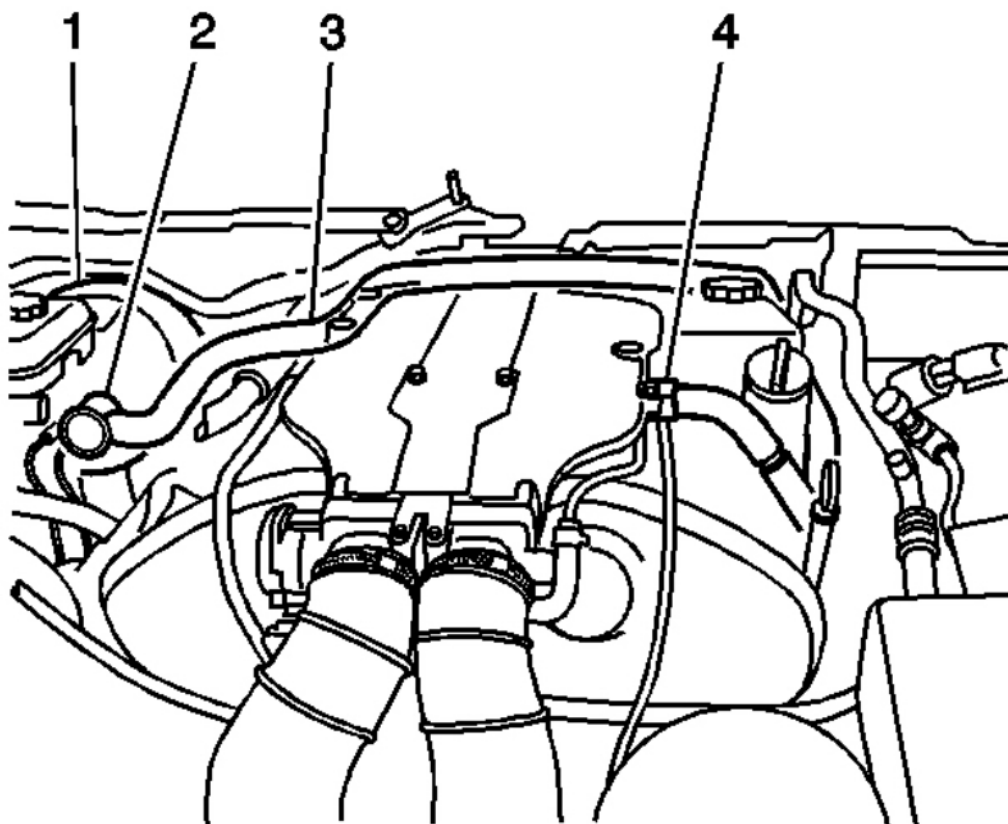


Fig. 85: Identifying Vacuum Brake Booster Check Valve & Hose
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the vacuum hose (3) and the brake booster vacuum check valve (2) from vacuum brake booster (1).
2. Remove the vacuum hose retainer from the power steering reservoir.
3. Remove the vacuum hose retainer from the rear of the plenum.
4. Disconnect the vacuum hose (3) from the intake manifold vacuum port (4).

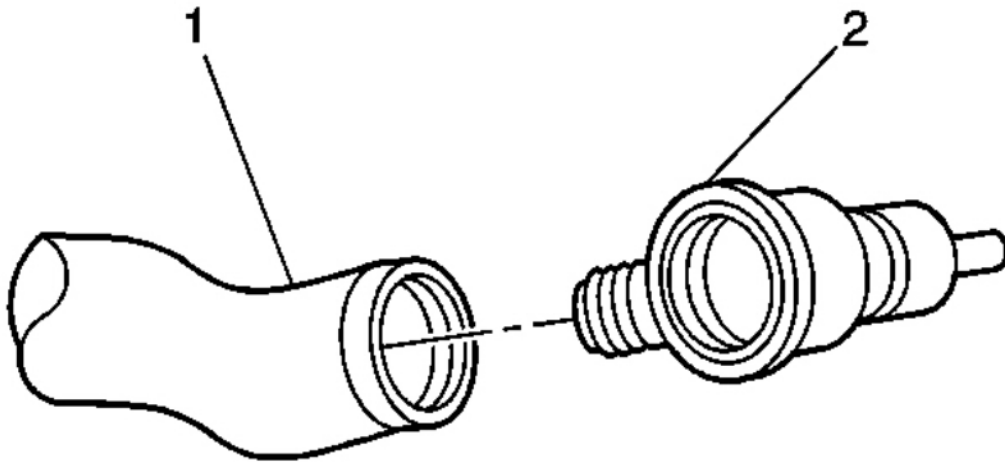


Fig. 86: View Of Vacuum Brake Booster Check Valve And Vacuum Brake Booster Hose

Courtesy of GENERAL MOTORS CORP.

5. Remove the brake booster vacuum check valve (2) from the brake booster vacuum hose (1).

Installation Procedure

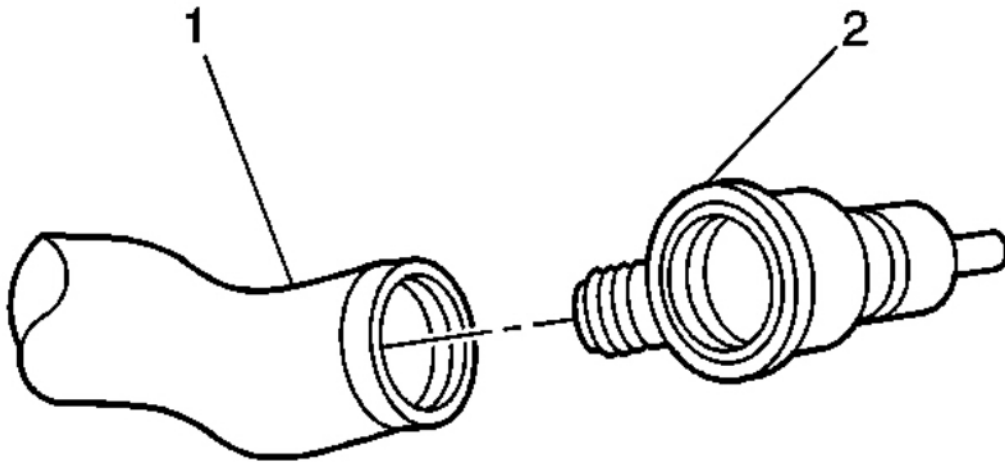


Fig. 87: View Of Vacuum Brake Booster Check Valve And Vacuum Brake Booster Hose

Courtesy of GENERAL MOTORS CORP.

1. Install the brake booster vacuum check valve (2) to the brake booster vacuum hose (1).

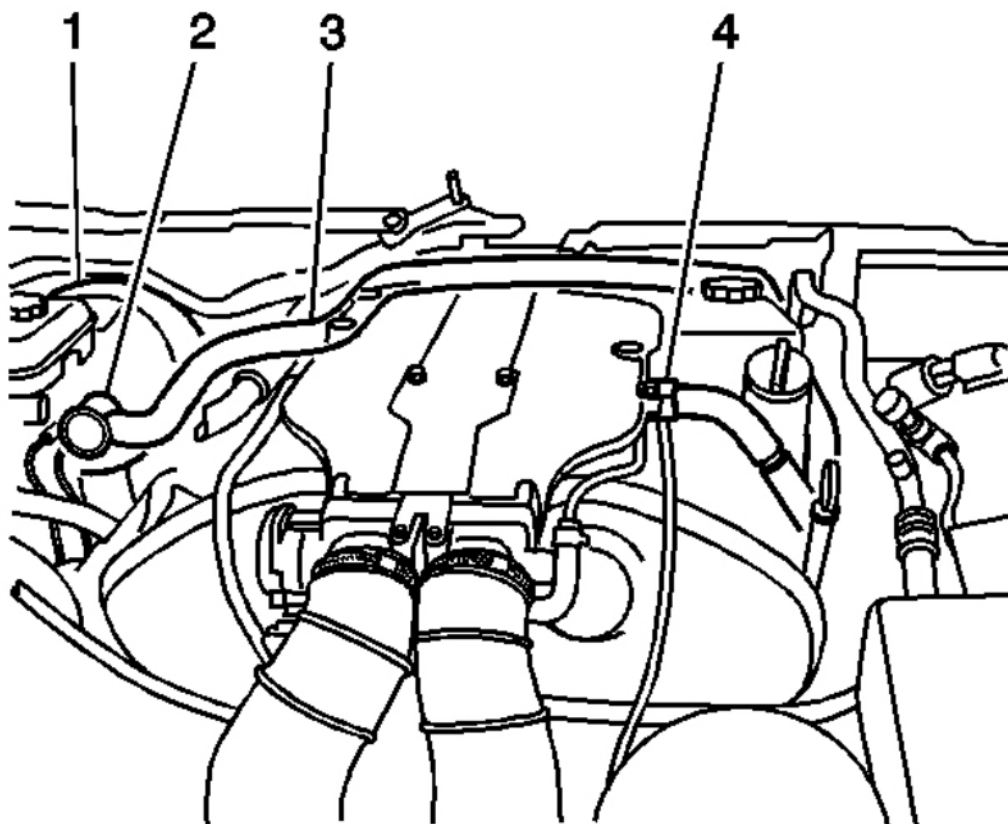


Fig. 88: Identifying Vacuum Brake Booster Check Valve & Hose
Courtesy of GENERAL MOTORS CORP.

2. Connect the vacuum hose (3) to the intake manifold vacuum port (4).
3. Install the vacuum hose retainer to the power steering reservoir.
4. Install the vacuum hose retainer to the rear of the plenum.
5. Connect the vacuum hose (3) and vacuum brake booster check valve (2) to vacuum brake booster (1).

DESCRIPTION AND OPERATION

BRAKE WARNING SYSTEM DESCRIPTION AND OPERATION

Brake System Indicators

BRAKE

The IPC illuminates the BRAKE indicator and sends a serial data message in order to activate an audible warning when the following occurs:

- The IPC detects that the park brake is applied-signal circuit is low.
- The IPC detects a low brake fluid condition-signal circuit is low.
- The electronic brake control module (EBCM) detects a malfunction with the antilock brake system. The IPC receives a serial data message from the EBCM requesting illumination.
- The IPC detects a loss of communications with the EBCM and the discrete back-up ABS indicator signal is open.
- The IPC performs the displays test at the start of each ignition cycle. The indicator illuminates for approximately 5 seconds.

CHECK BRAKE FLUID

The IPC illuminates the CHECK BRAKE FLUID indicator in the DIC and sends a serial data message in order to activate an audible warning when the IPC detects a that the brake fluid level is below the normal operating range.

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 two 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. Refer to **ABS Description and Operation** in Antilock Brake System for specific information on the operation of DRP.

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.

BRAKE ASSIST SYSTEM DESCRIPTION AND OPERATION

System Component Description

The brake assist system consists of the following:

Brake Pedal

Receives, multiplies and transfers brake system input force from driver.

Brake Pedal Pushrod

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

Vacuum Brake Booster

Uses source vacuum to decrease effort required by driver when applying brake system input force.

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

Supplies force used by vacuum brake booster to decrease brake pedal effort.

Vacuum Source Delivery System

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

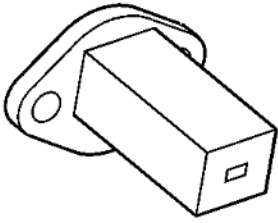
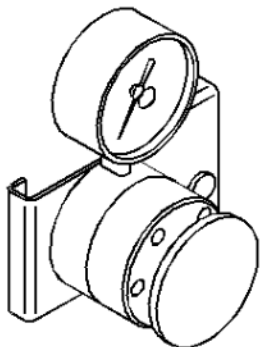
System Operation

Brake system input force 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 vacuum brake booster.

SPECIAL TOOLS AND EQUIPMENT

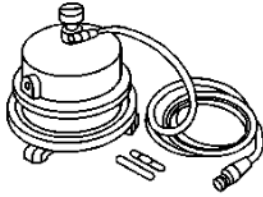
SPECIAL TOOLS

Special Tools

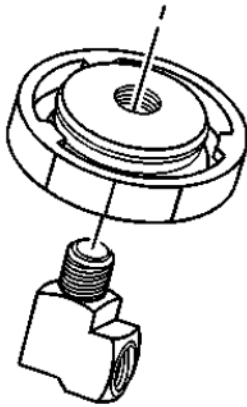
Illustration	Tool Number/ Description
	J 22805-B Brake Booster Holder
	J 28662 Brake Pedal Effort Gage

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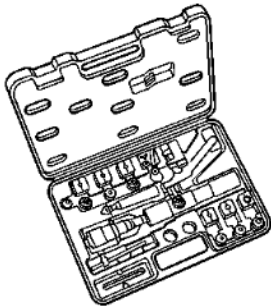
2004 BRAKES Hydraulic Brakes - CTS



J 29532
Diaphragm Pressure Bleeder



J 35589-A
Master Cylinder Bleeder Adapter



J 45405
Flaring Tool