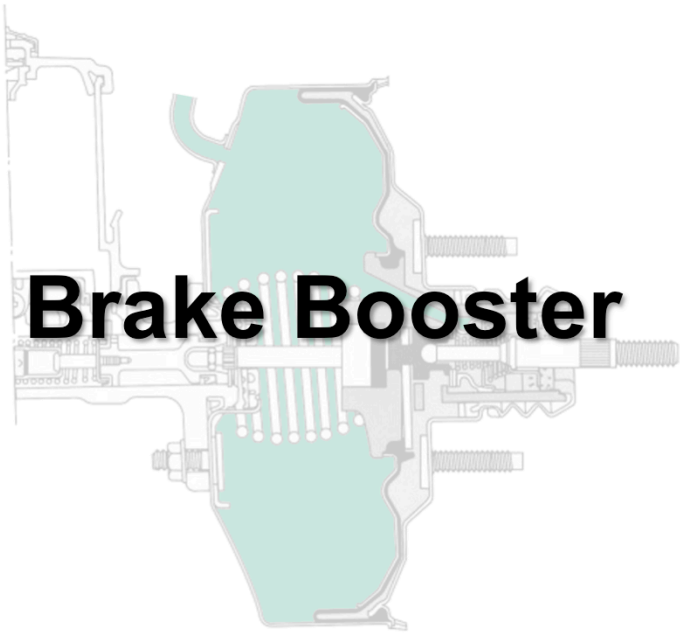
Section 7

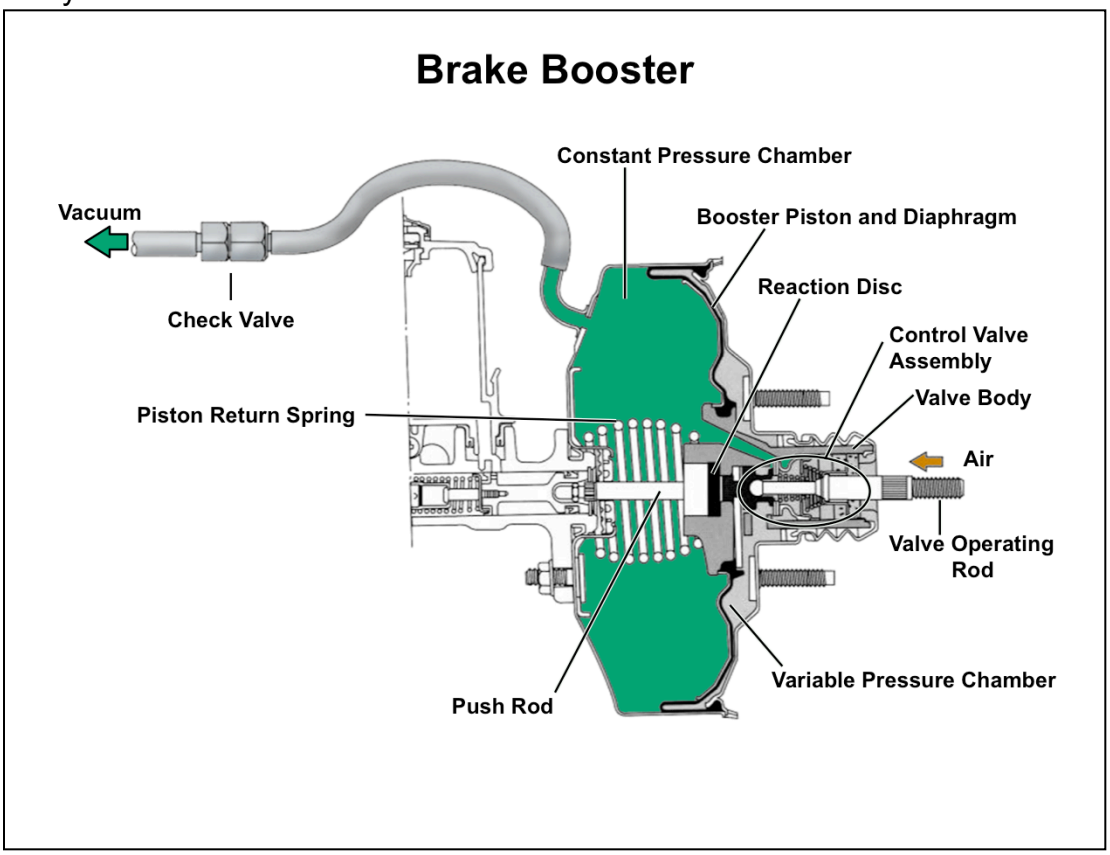


Brake Booster

Section 7 Topics

This section covers:

- Vacuum actuated brake boosters
- Mechanical brake assist
- Hydraulic brake boosters



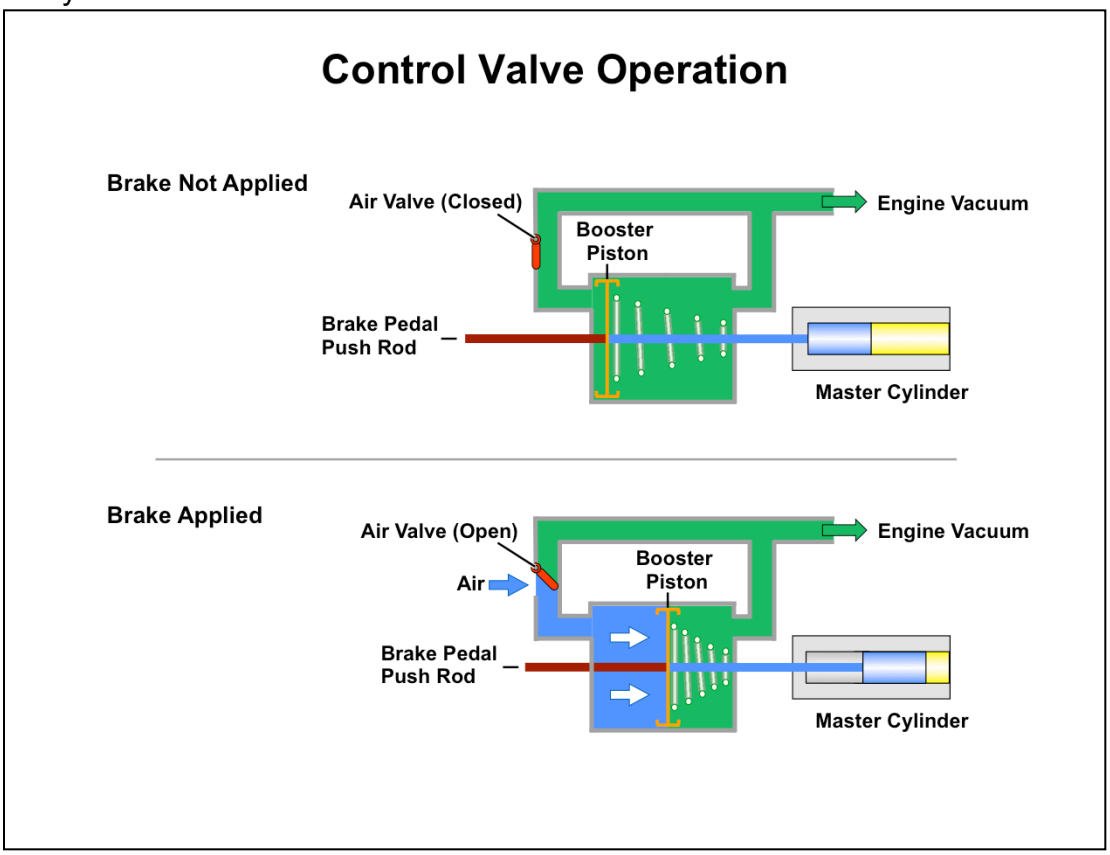
Brake Booster

The brake booster generates a greater braking force from a minimum pedal effort. It can increase pedal force by 2 to 4 times depending on diaphragm size. The booster is located between the brake pedal and the master cylinder.

Booster Construction

Components include:

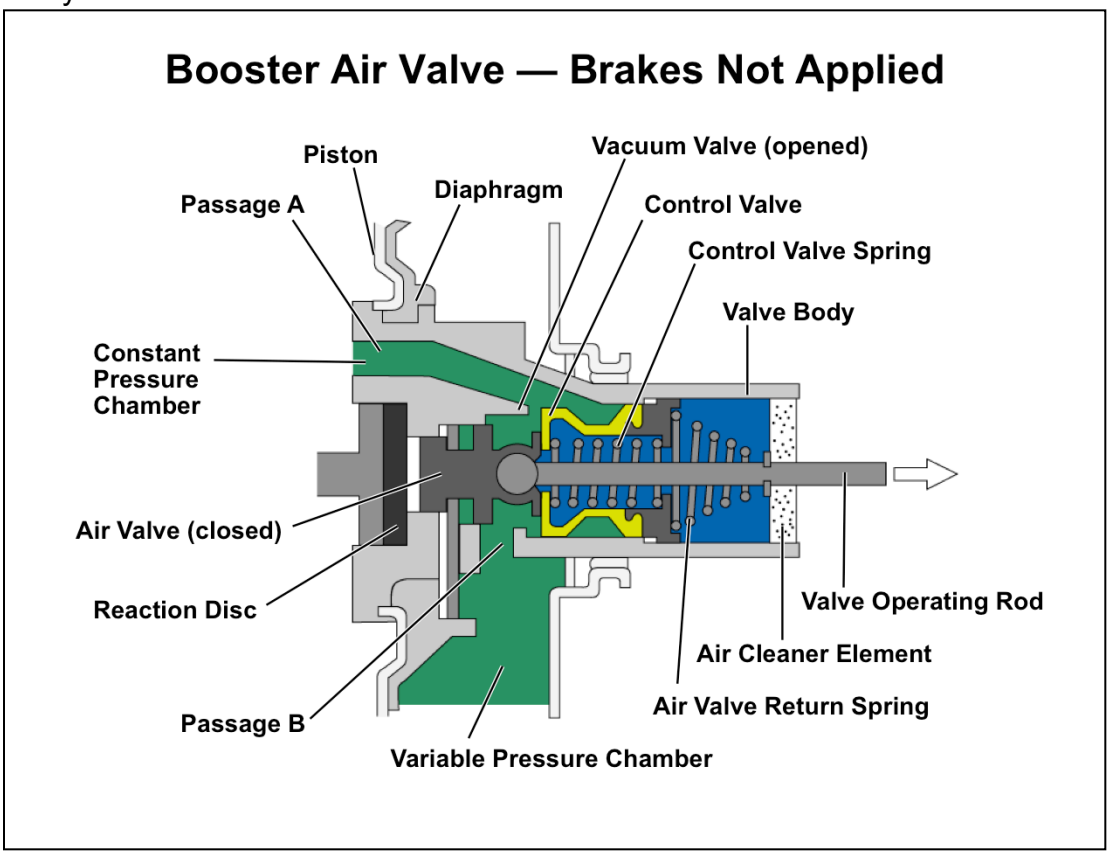
- **Body**: Divided into constant pressure chamber and variable pressure chamber.
- **Booster piston and diaphragm**: Separates the body chambers.
- **Piston return spring**: Pushes the booster piston and valve body to the right.
- **Control valve assembly**: Regulates pressure inside the variable pressure chamber.



Booster Operation The booster operates on the principle of pressure differential, with the atmospheric control valve assembly on right of diaphragm and low pressure (vacuum) on left side of diaphragm. The booster uses vacuum that is generated inside the engine intake manifold.

Control Valve Closed Vacuum is the same on both sides of piston. The spring pushes the piston to the right. The master cylinder is not applied.

Control Valve Open Atmospheric pressure (high) overcomes vacuum (low). The piston compresses the spring and applies the master cylinder.

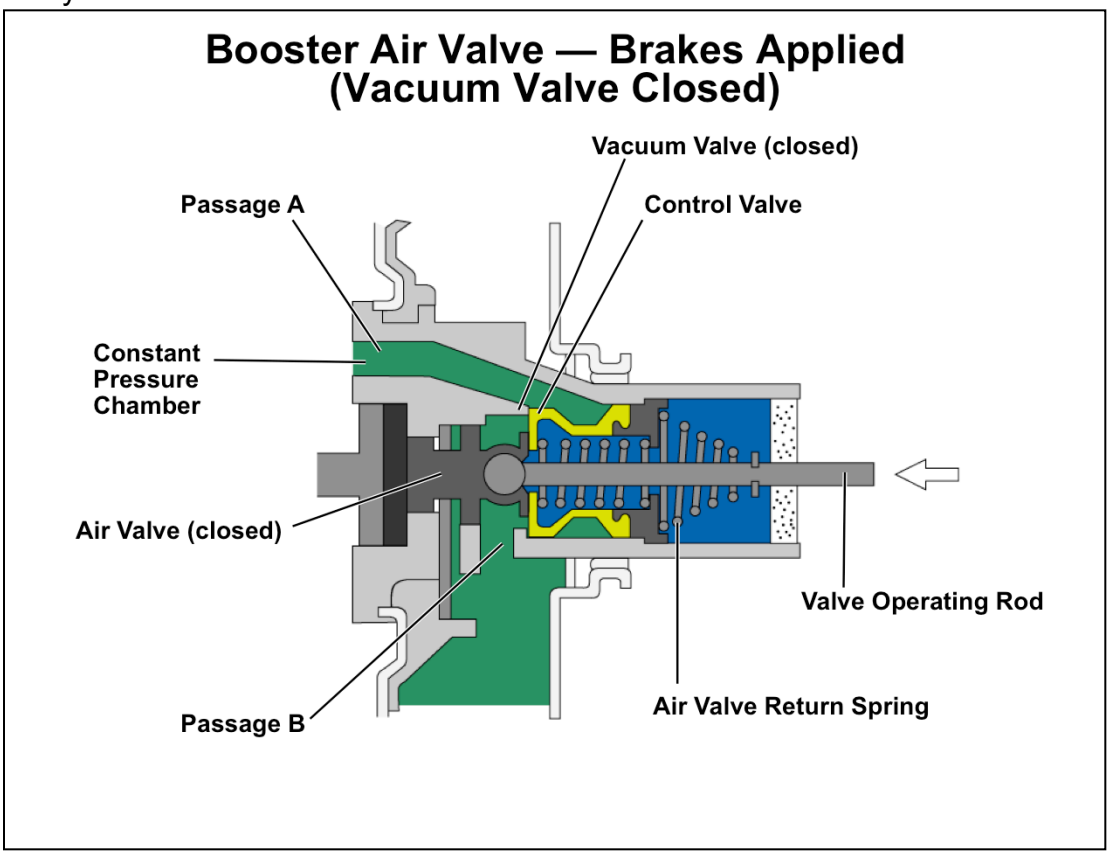


Booster Air Valve – Brakes Not Applied

Non-Operating State (Brakes Not Applied)

The constant pressure chamber is connected to a manifold vacuum source. The variable pressure chamber is exposed to vacuum through the control valve. The control valve assembly has an air valve connected to the valve operating rod.

- The air valve return spring pushes the valve operating rod to the right, which pulls the air valve to the right.
- The control valve spring pushes the control valve to left, where it seats against the air valve. This closes atmospheric pressure from the variable pressure chamber.
- When the vacuum valve and control valve open, vacuum enters the variable pressure chamber (Passage A and B open). The piston return spring moves the diaphragm to the right.

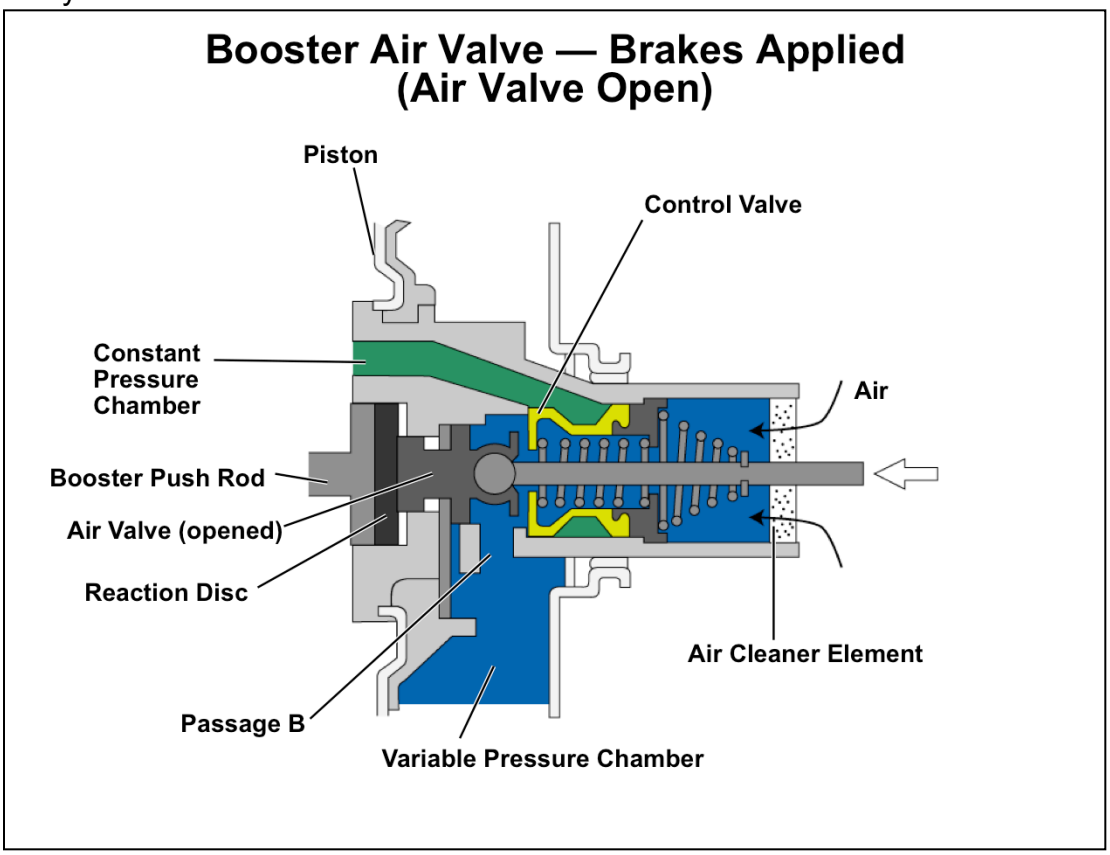


Booster Air Valve – Brakes Applied (Vacuum Valve Closed)

Operating State (Brakes Applied)

When brakes are applied, atmospheric pressure is allowed into variable pressure chamber.

- The control valve assembly operating rod pushes air valve to left. The air valve spring pushes the control valve against the vacuum valve (follows air valve). This blocks the variable chamber from the vacuum chamber.

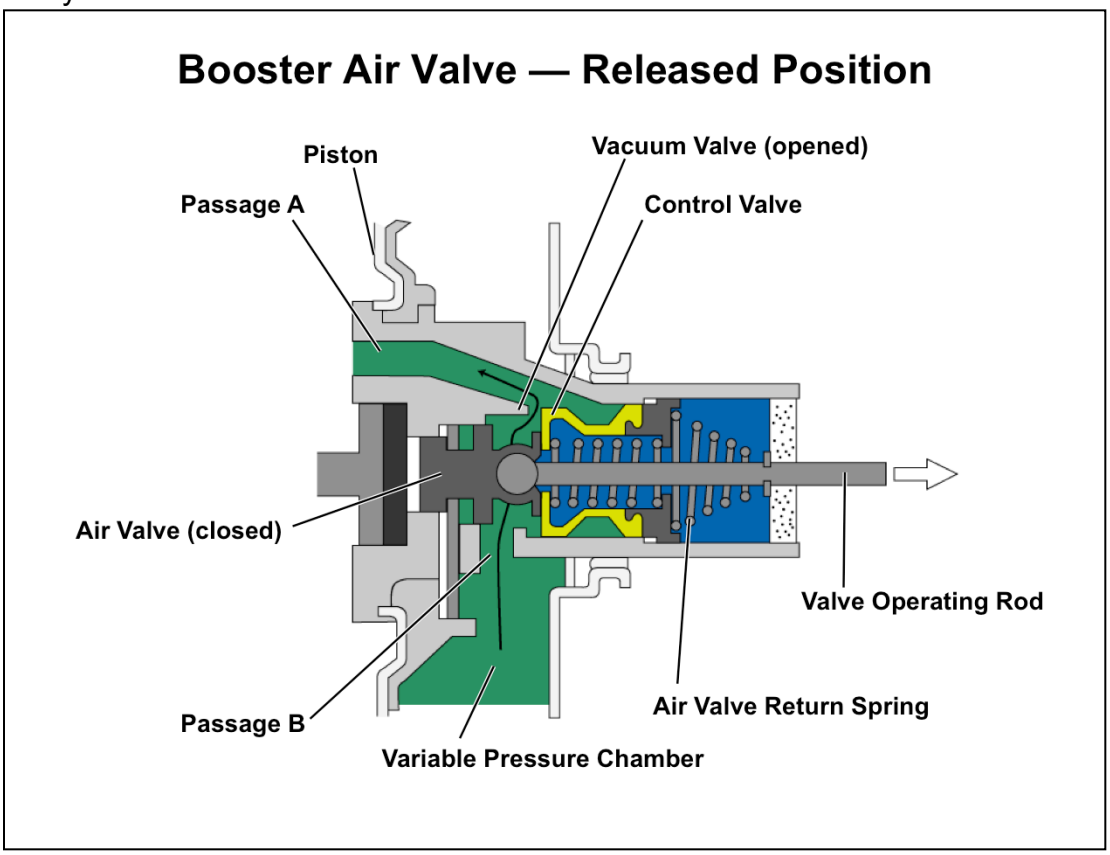


Booster Air Valve – Brakes Applied (Air Valve Open)

Operating State (Brakes Applied)

Continued pressure moves air valve away from control valve. This opens the variable chamber to atmospheric pressure.

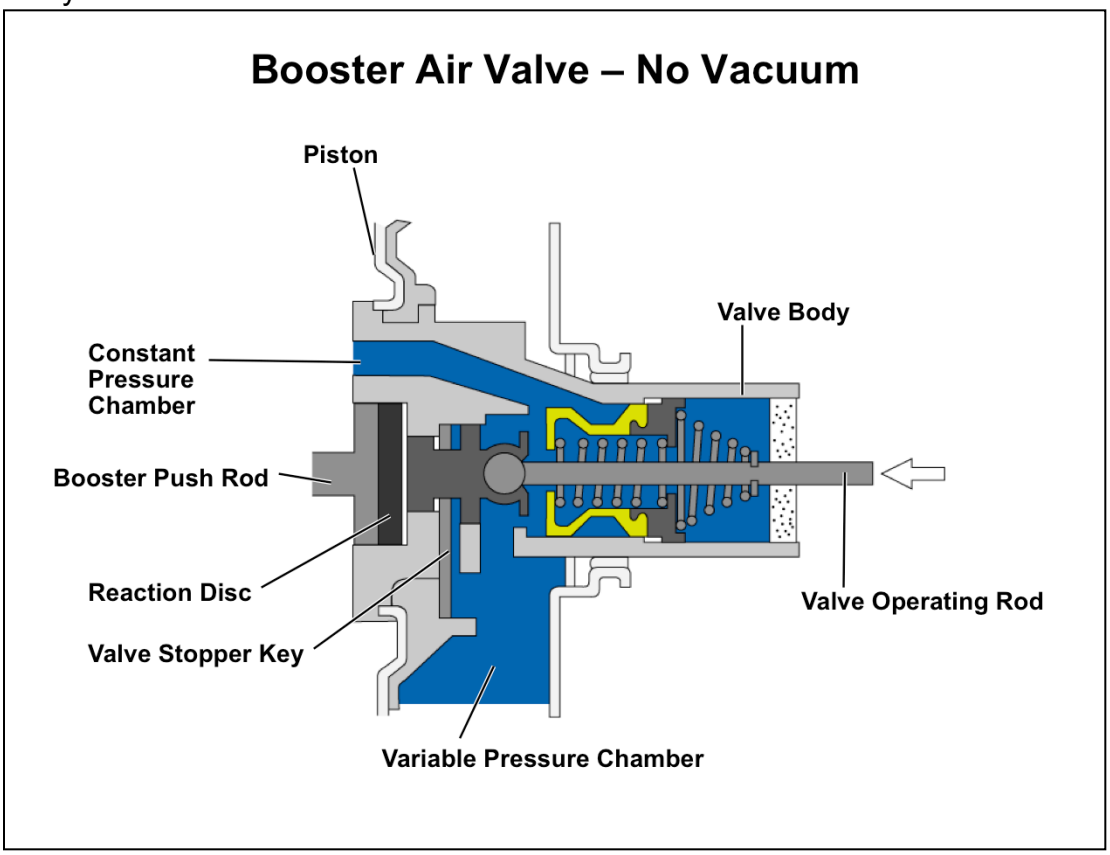
- The differential in pressure on booster piston causes booster piston to move to left.
- Piston causes reaction disc and booster push rod to exert pressure on master cylinder providing boost function.
- Position of piston is balanced between variable pressure chamber and vacuum chamber.



Booster Air Valve – Release Position

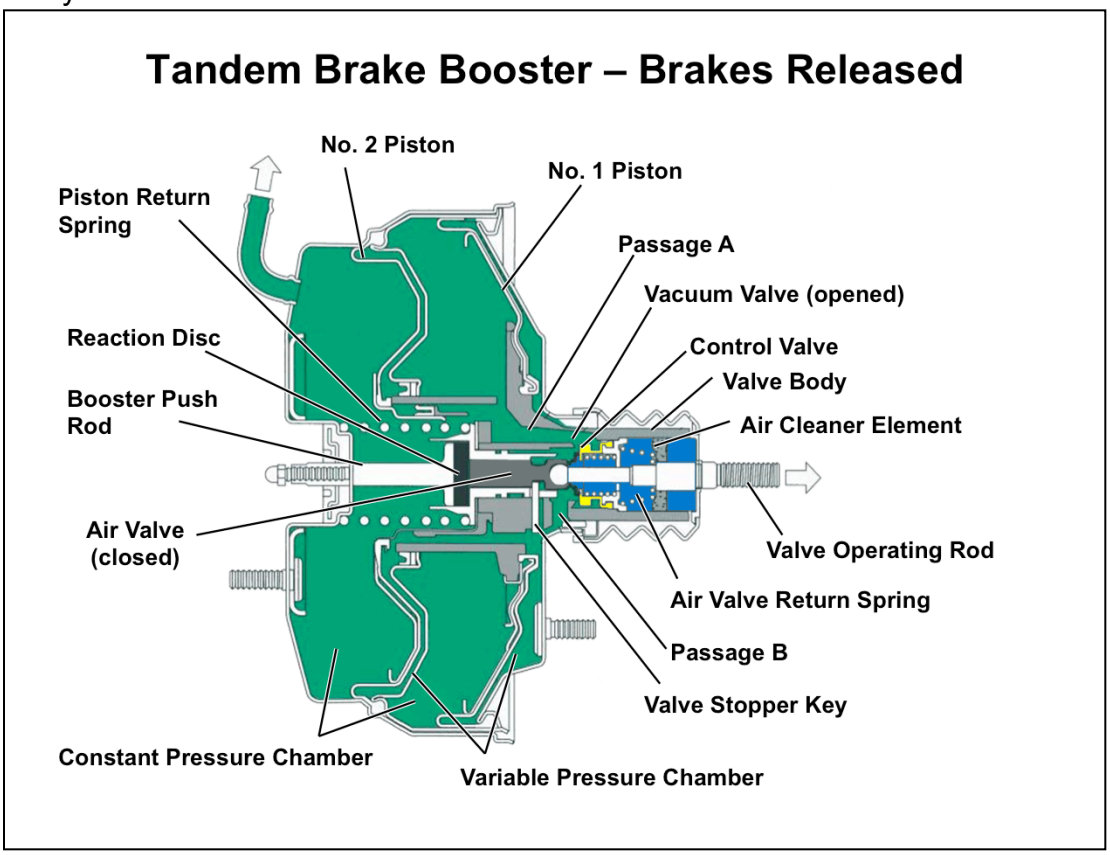
When the brakes are released, the valve operating rod and air valve are moved to the right by the air valve return spring and the master cylinder.

- The air valve contacts control valve, blocking atmospheric pressure.
- The control valve moves away from vacuum valve. This opens the variable pressure chamber and constant pressure chamber.
- The booster piston is pushed back to the right by the diaphragm spring.



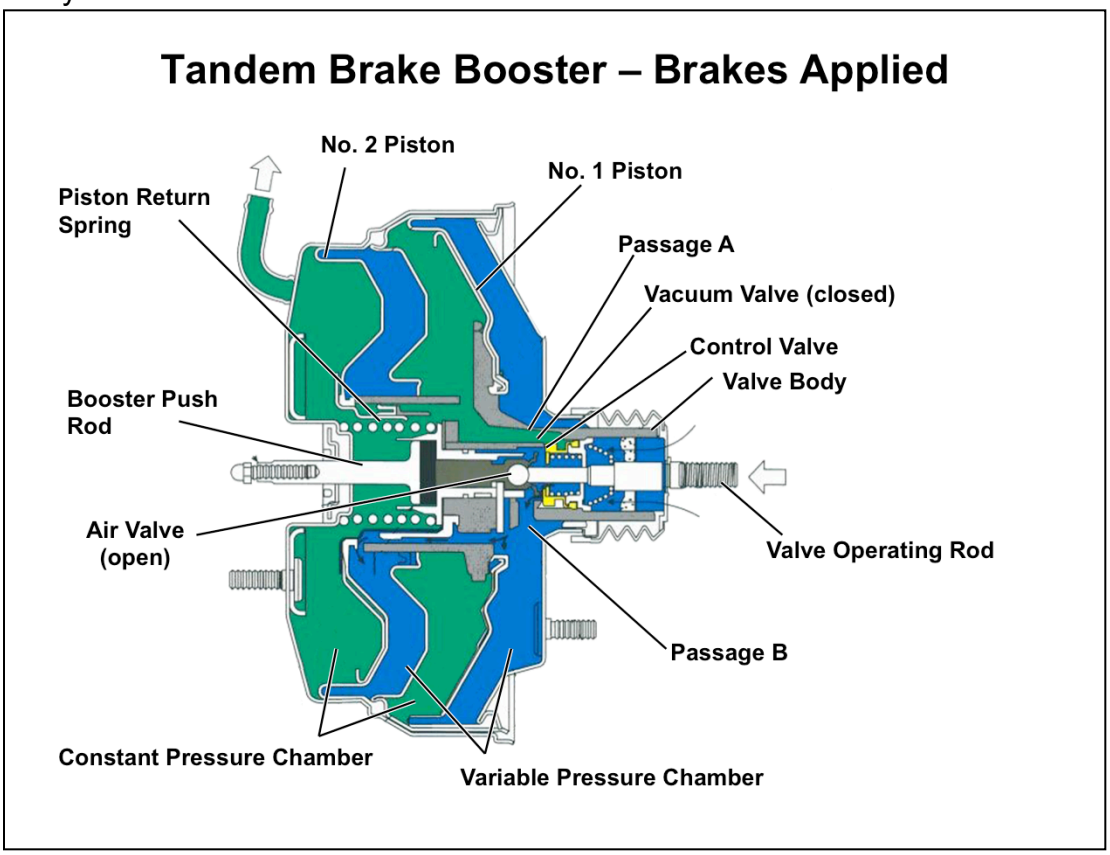
Booster Air Valve – No Vacuum

If there is no pressure difference between the two chambers, the booster cannot create any assist. The brakes will be applied mechanically, requiring greater driver effort.



Tandem Brake Booster – Brakes Released

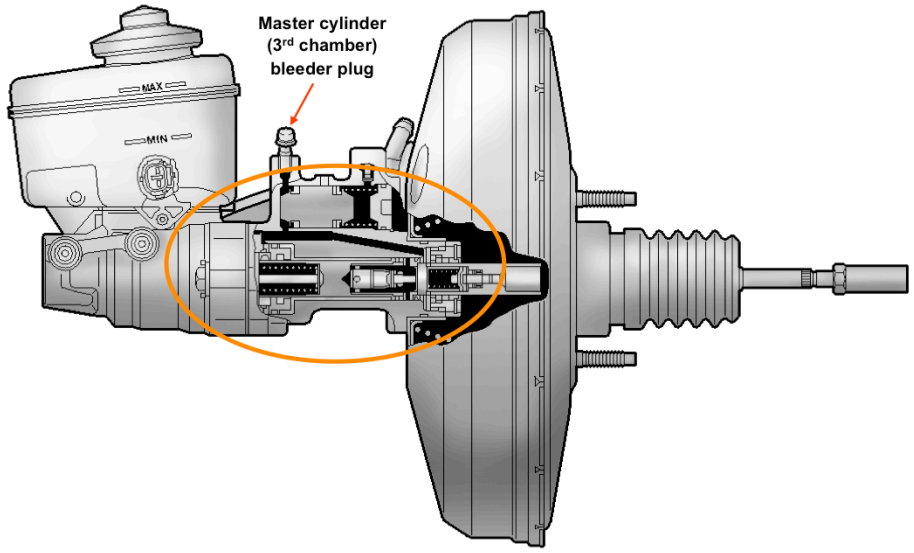
The tandem brake booster design is a compact and powerful unit. Its two constant pressure chambers and two variable pressure chambers provide a large surface area in a smaller package.



Tandem Brake Booster – Brakes Applied

The booster air valve operates the same as previously described.

Brake Pressure Conversion Unit



Service Tip: If the master cylinder was disassembled or if the reservoir became empty, bleed the air out of the master cylinder. Note that it is necessary to run the engine at idle while bleeding.

Brake Pressure Conversion Unit

The brake pressure conversion unit, located between the brake master cylinder and the brake booster, enables the master cylinder to generate higher pressure in the event of brake booster malfunction.

If a booster malfunctions on a conventional brake booster and master cylinder assembly, the driver must exert much more effort on the brake pedal to cause enough pressure at the master cylinder to slow the vehicle.

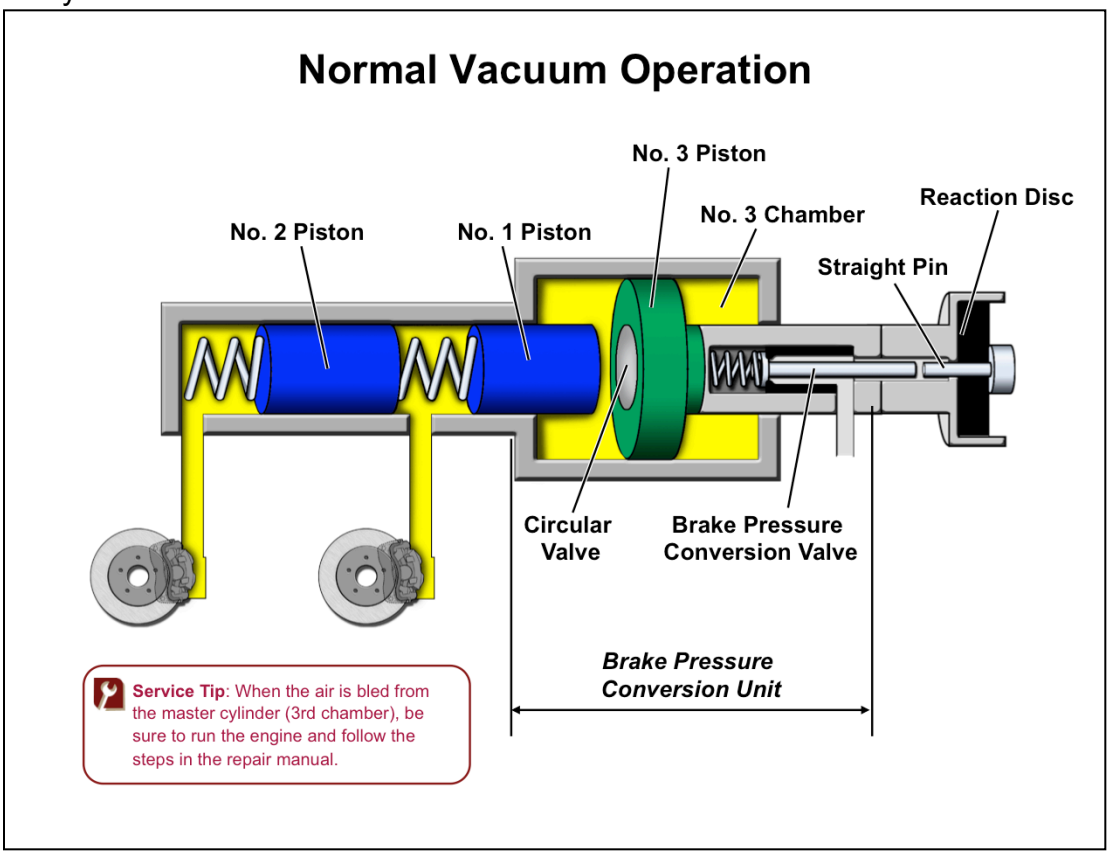
This is found on vehicles such as the Sienna, Tundra and Tacoma Double Cab but with a remote reservoir.

If the master cylinder was disassembled or if the reservoir became empty, bleed the air out of the master cylinder. Note that it is necessary to run the engine at idle while bleeding.

SERVICE TIP

The No. 3 chamber must be bled during brake system service. Check the appropriate Repair Manual for the exact procedure to follow. A typical procedure includes these three steps:

- Bleed air from the brake system at each wheel.
- With the engine running, bleed air from No. 3 chamber.
- With the engine off, bleed air at each wheel a second time.



Normal Vacuum Operation

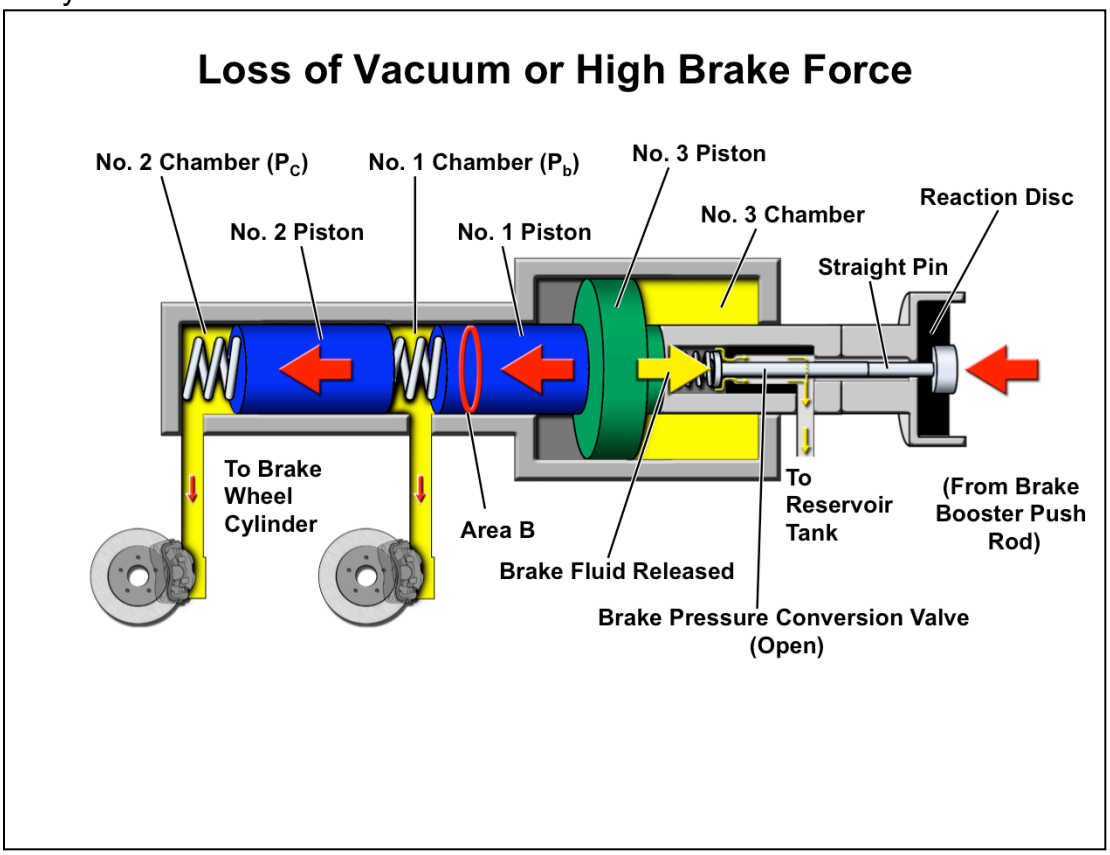
The conversion unit has a large-diameter piston located in the No. 3 chamber and positioned between the primary master cylinder piston and the brake booster push rod.

When the booster push rod pushes the No. 3 piston, it causes hydraulic pressure to build on the primary piston. Referring back to basic hydraulic theory, the apply piston (No. 3) is larger than the working piston (No. 1), so the force applied to the working piston is reduced for normal braking.

The brake pressure conversion valve controls the brake fluid in chamber 3. It is spring-loaded in closed position. The straight pin located to the right of the push rod extends through the reaction disc (made of rubber), leaving a gap between the straight pin and the pressure conversion valve.

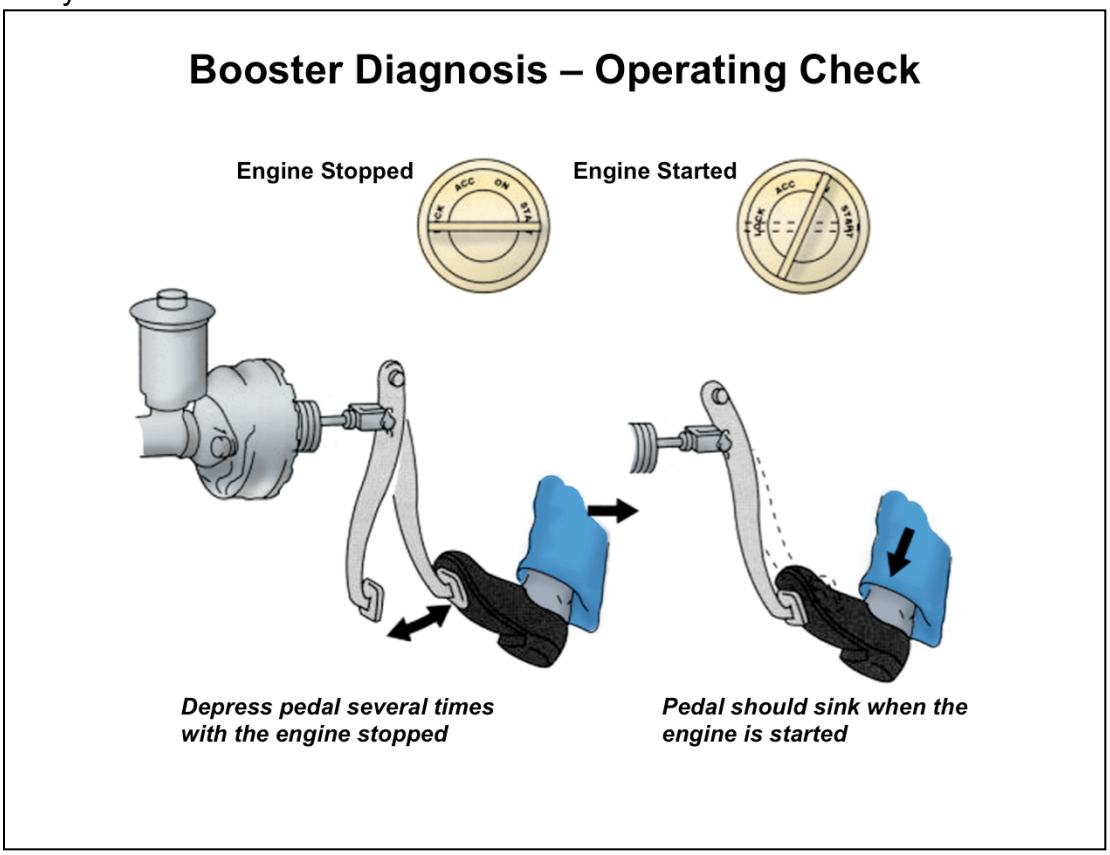
SERVICE TIP

When the air is bled from the master cylinder (3rd chamber), be sure to run the engine and follow the steps in the repair manual.



Loss of Vacuum or High Brake Force

When there is no vacuum to the brake booster, additional driver force is required to stop the vehicle. This force compresses the reaction disc, allowing the straight pin to contact the brake pressure conversion valve and bleed off the fluid in the No. 3 chamber. The No. 3 piston then provides full braking force to all wheel cylinders.



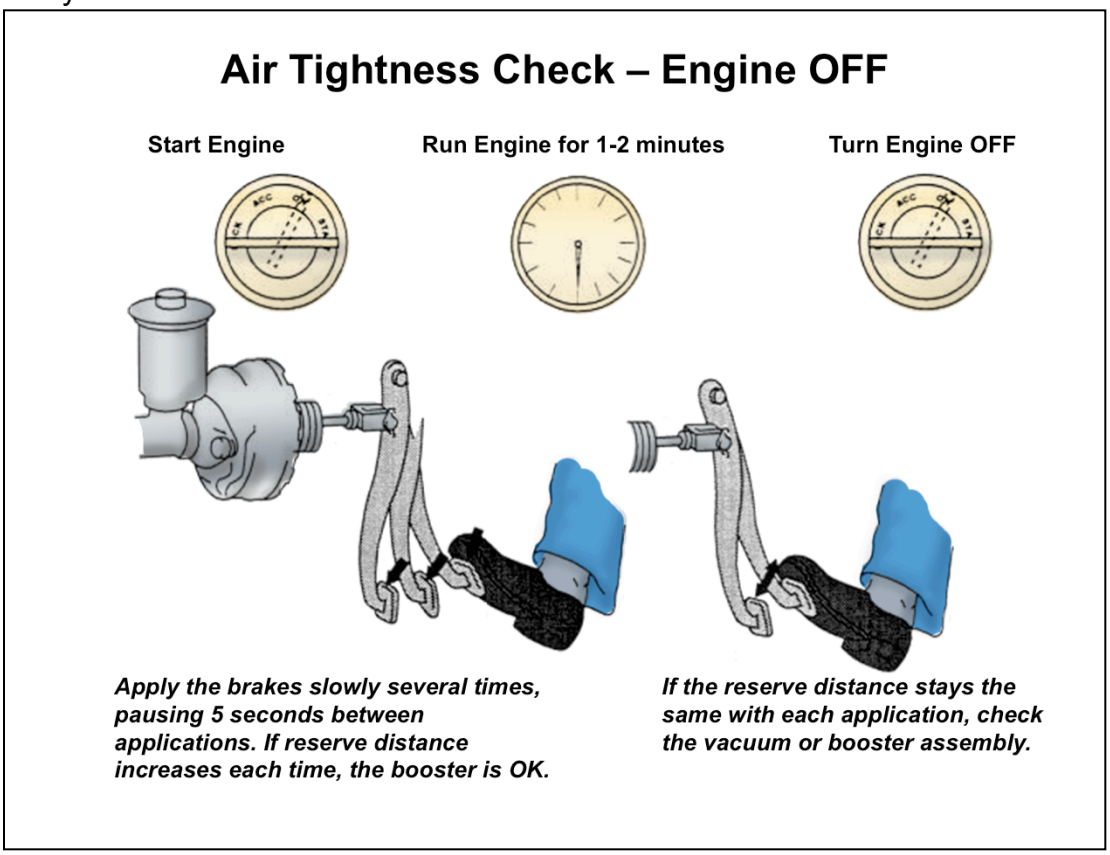
Booster Diagnosis – Operating Check

With the engine stopped, pump the brakes several times. Then depress the brake pedal and start the engine. As vacuum enters the booster:

- Brake pedal should sink down slightly (normal operation).

If the brake pedal does not go down:

- Check vacuum source.
- If vacuum source is OK, the booster is malfunctioning.



Air Tightness Check

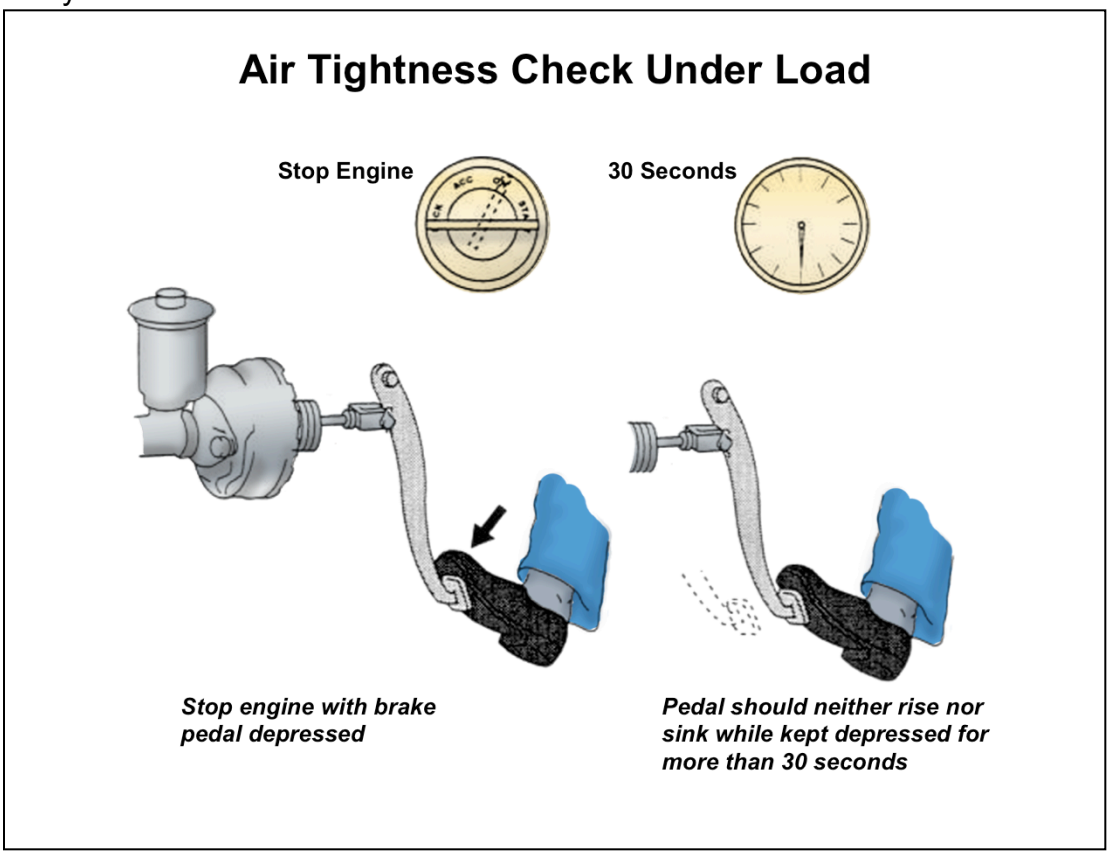
Start engine and run it for 2 minutes, then turn engine OFF. Apply the brakes several times, pausing 5 seconds between applications:

- If reserve distance increases each time, the booster has good air tightness.

If reserve distance does not increase each time:

- Check the vacuum check valve function.
- If vacuum source and vacuum check valve are OK, then booster is malfunctioning.

The booster is required to provide a series of power-assisted stops after a loss of engine operation (specified under FMVSS).

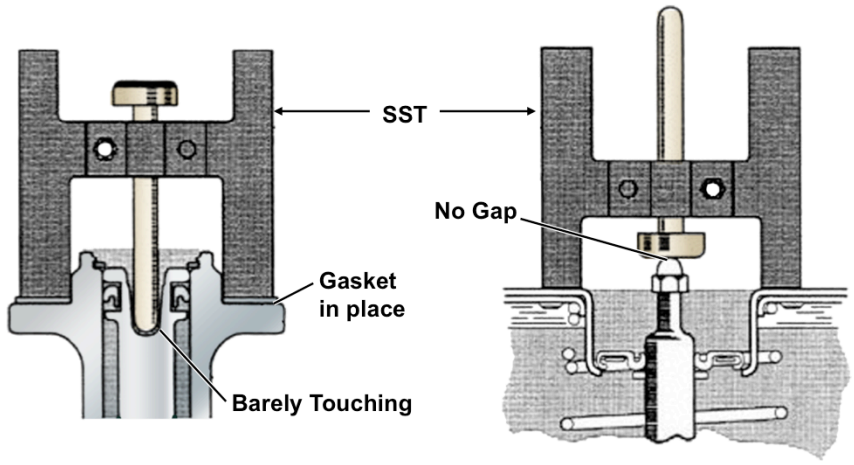


Air Tightness Check Under Load

Depress the brake pedal with the engine running. Then stop the engine and continue to hold the brake pedal down.

- After 30 seconds, brake pedal position should not change (normal operation).
- Reserve distance remains unchanged while vacuum is maintained in constant pressure chamber.
- If the pedal rises, there is atmospheric pressure entering the constant pressure chamber.
- If the pedal sinks, check the master cylinder for an internal leak.

Booster Push Rod Gauge



Establishing Piston Depth *Adjusting Booster Push Rod*

Service Tip: If your diagnosis indicates that the gap between the master cylinder piston & booster push rod needs adjustment, use the booster push rod gauge to measure and adjust the clearance between both components.

Booster Push Rod Gauge

Booster Push Rod Adjustment

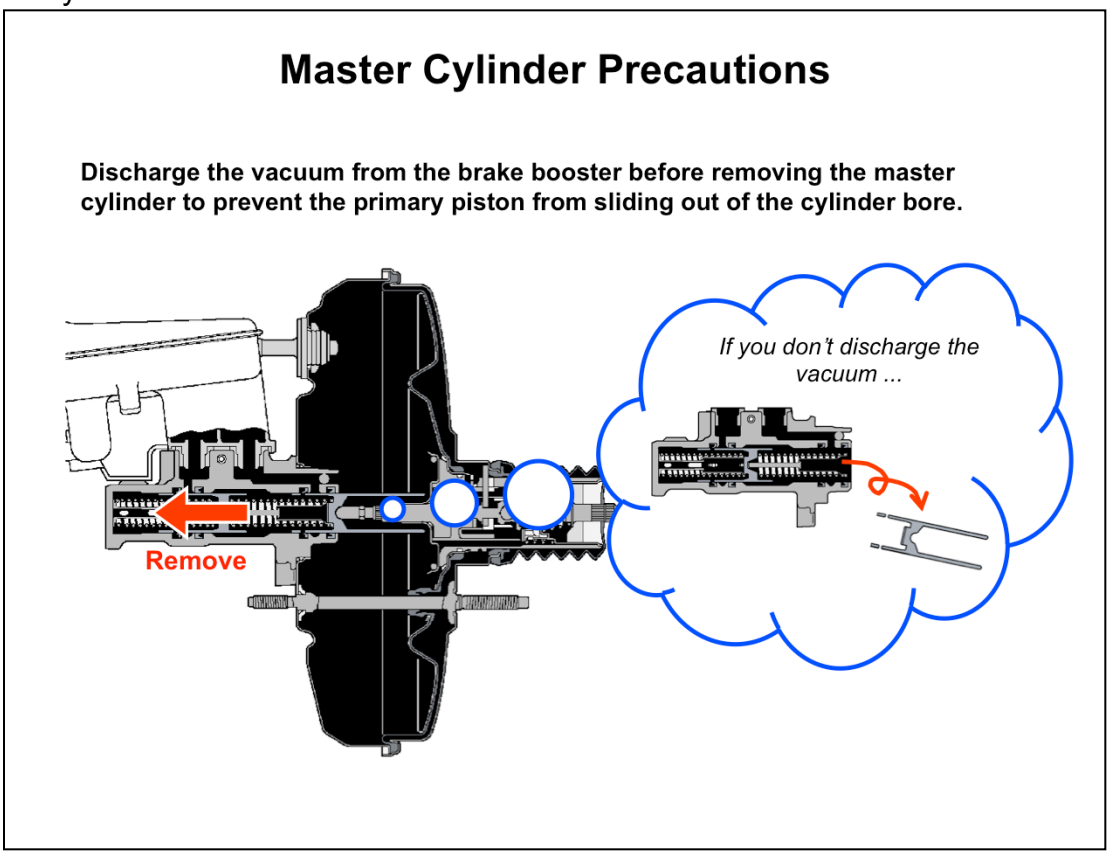
Check this adjustment any time the master cylinder or booster is replaced. It ensures the correct gap between the master cylinder piston and booster push rod. If not correctly adjusted:

- If the gap is too small, the brakes may drag and, with enough heat buildup, the brakes may lock. Dragging also results in premature brake wear.
- If the gap is too large, there will be reduced pedal reserve distance and a slight delay in brake application.

Before adjustment, check the brake pedal free play to make sure the booster is not partially applied.

Use Special Service Tool (SST) Brake booster push rod gauge (SST #09737-00013-01):

- Set SST on master cylinder with a new gasket.
- Lower pin until tip slightly touches the piston.
- Turn the SST over and set it on booster (must have vacuum charge – start engine).
- Adjust booster push rod length for zero clearance (refer to repair manual for details).

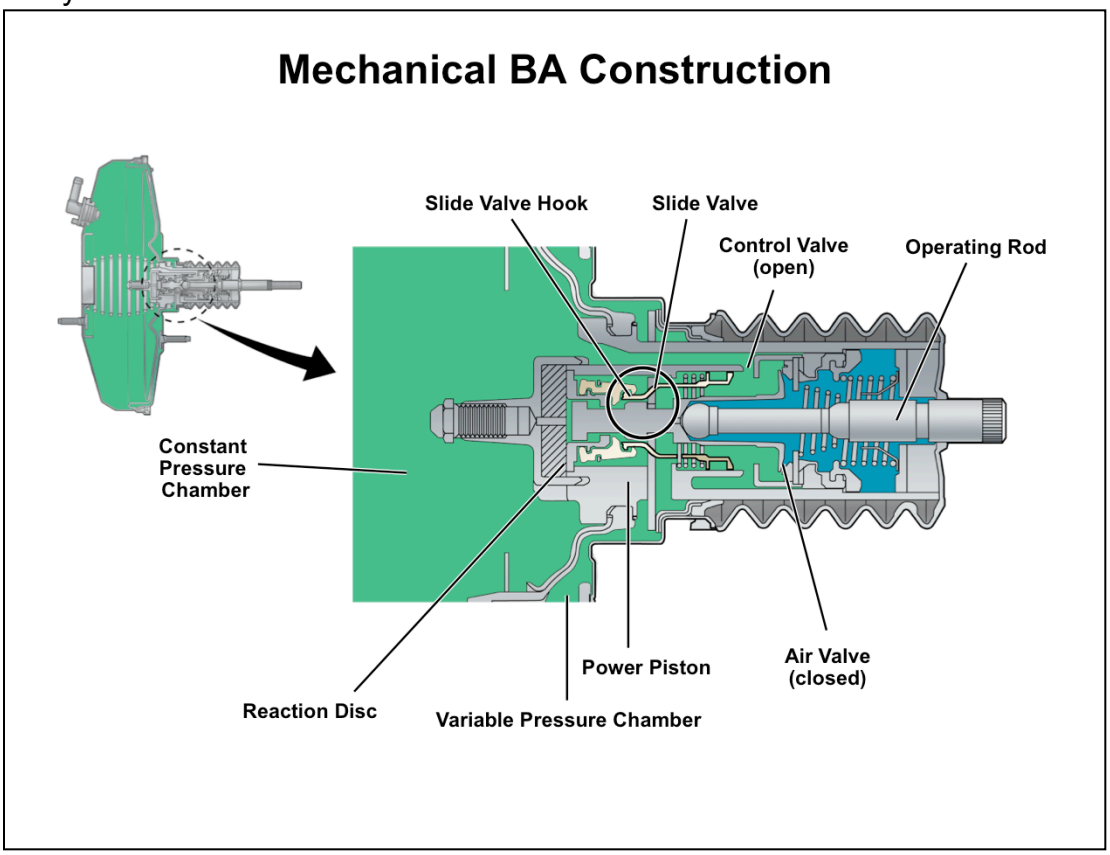


Master Cylinder Precautions

The structure of the master cylinder allows the primary piston to slip out of the cylinder bore when the master cylinder is removed from the power booster unless vacuum is discharged from the booster first, as follows:

- Before removing the master cylinder from brake booster, discharge vacuum by depressing the brake pedal several times.
- When installing the master cylinder, make sure it is kept horizontal to prevent primary piston from sliding out of the cylinder bore.

This is found on 2003- Sequoia, 2007- Tundra and 2007- Camry.



Mechanical BA Construction

Mechanical BA Operation

On systems with mechanical BA, a Brake Assist mechanism is added to the normal brake booster. During normal braking, the brake booster functions as a conventional booster. During emergency braking, two additional components within the control valve assembly come into play:

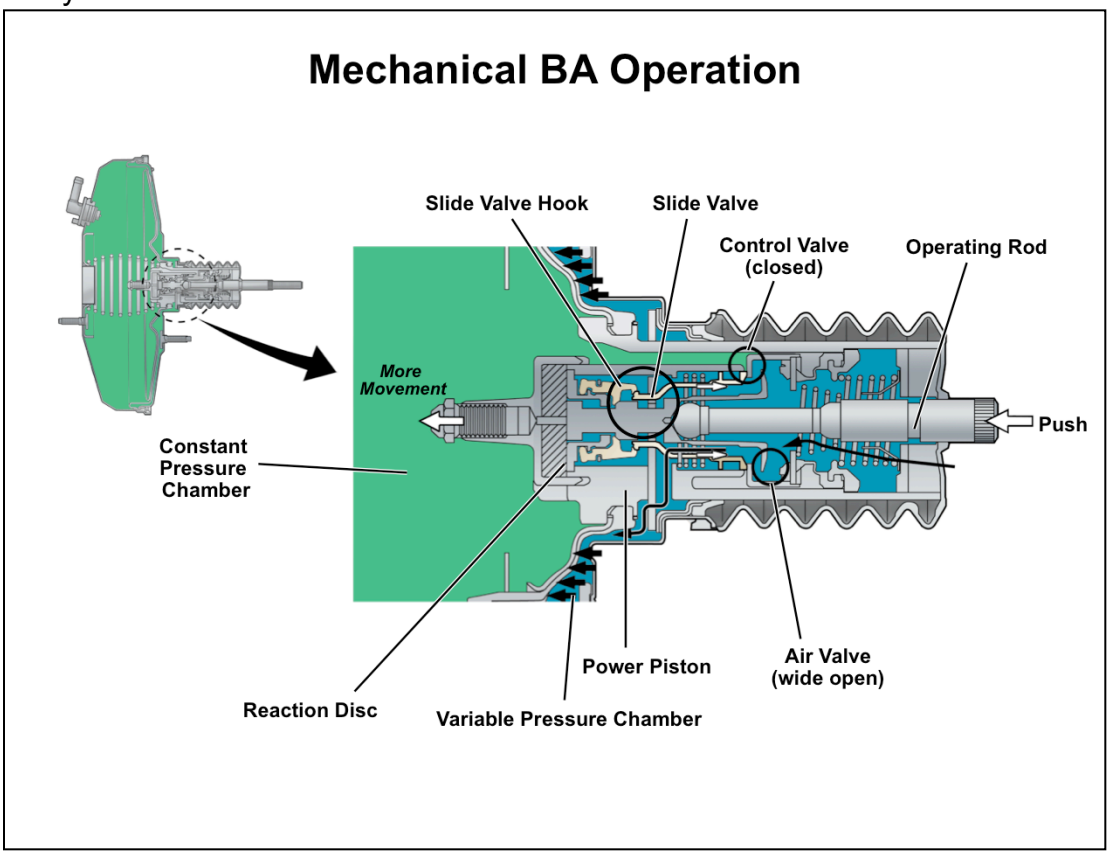
- Slide valve
- Slide valve hook

Normal Braking

During normal braking:

- The operating rod moves to the left and opens the air valve, allowing atmospheric pressure into the variable pressure chamber.
- At the same time, the two springs on the right close the control valve.
- Pressure within the variable pressure chamber causes the power piston to apply the master cylinder.

This is found on Highlander and recent model Camry.

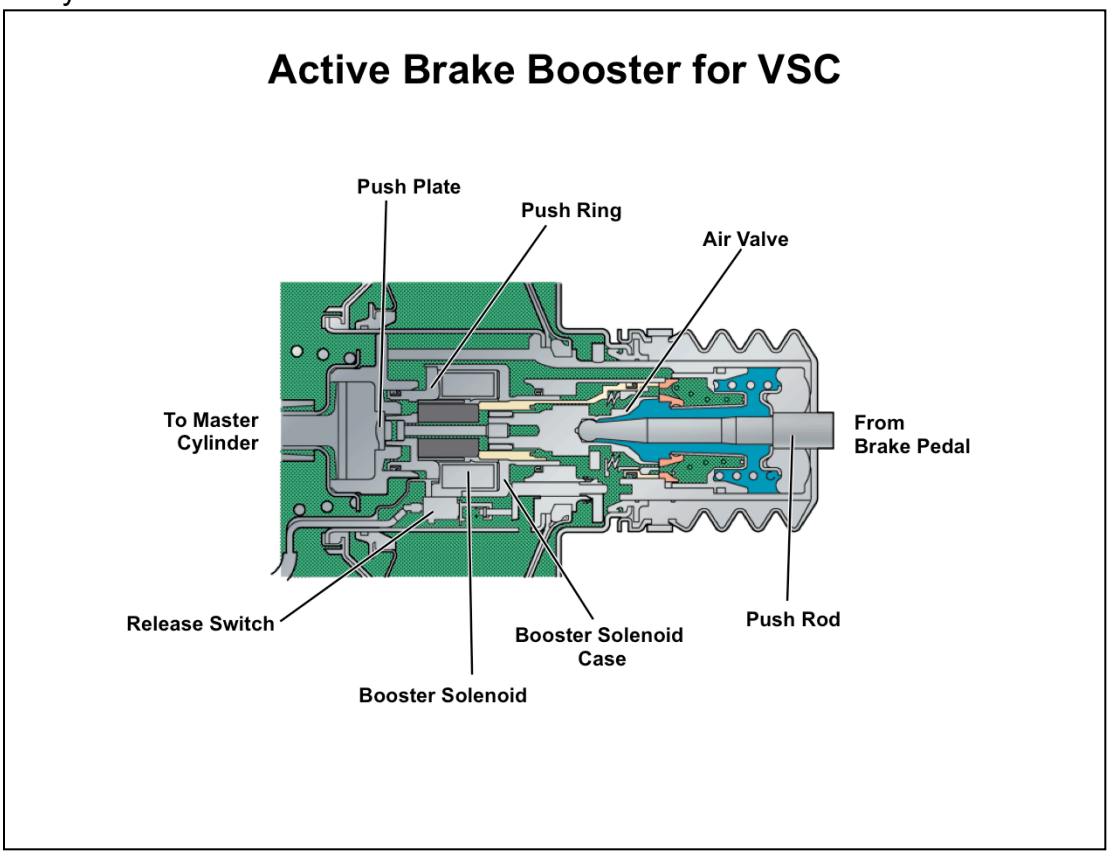


Mechanical BA Operation

Brake Assist Braking

When the brakes are applied rapidly:

- The operating rod moves more quickly than the power piston speed so that the air valve pushes the slide valve hook.
- The slide valve separates from the slide valve hook and the spring pushes it to the right, closing the control valve.
- The air valve opens wider, increasing the volume of atmospheric pressure entering the variable pressure chamber and so increasing the force of the power piston as it engages the master cylinder.

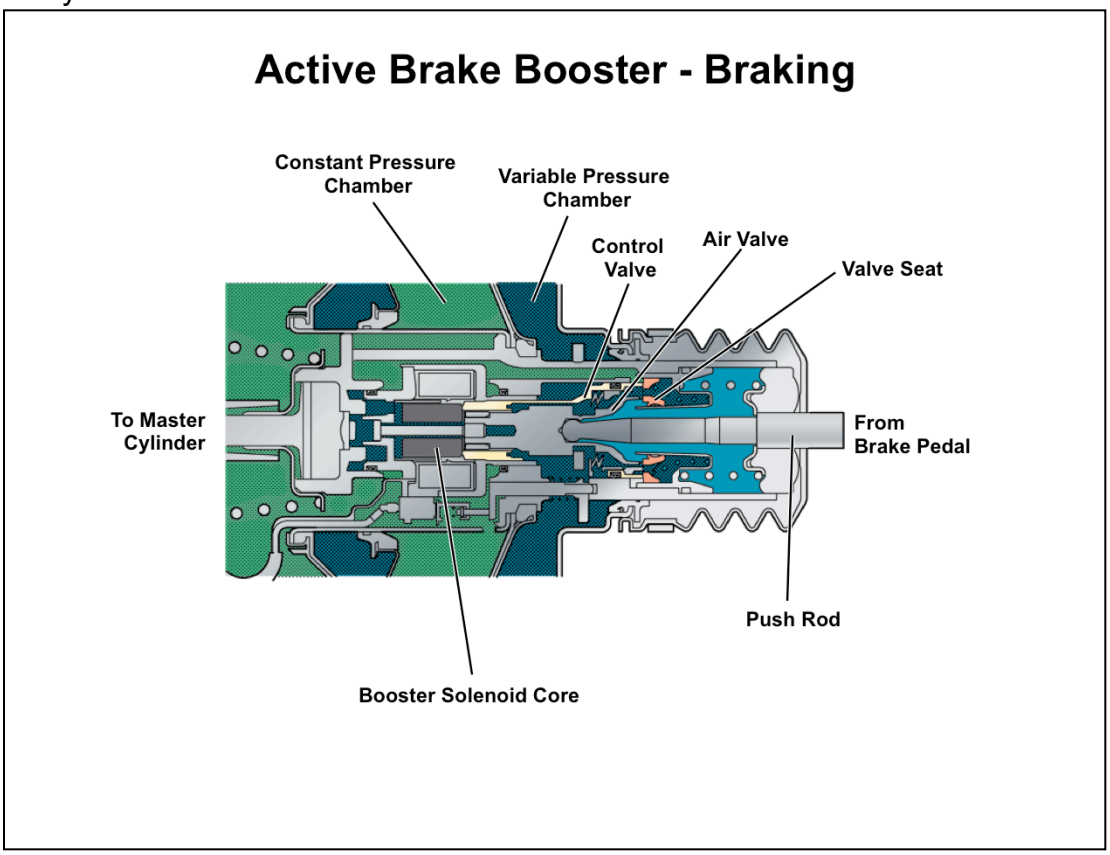


Active Brake Booster for VSC

An active brake booster consists of a double diaphragm brake booster with a booster solenoid that is activated only during Vehicle Stability Control (VSC) system operation. The booster solenoid is controlled by the Skid Control ECU, and it can open the air valve when VSC is needed to provide boosted hydraulic pressure to the ABS actuator. Additional components include the control valve, booster solenoid assembly (case and core), release switch, pedal stroke sensor, push ring, and push plate.

Normal Braking

During normal braking, the active brake booster works like a typical brake booster. The air valve opens, allowing atmospheric pressure to enter the variable pressure chamber, increasing hydraulic pressure. The release switch opens, indicating to the Skid Control ECU that the brake pedal has been applied.

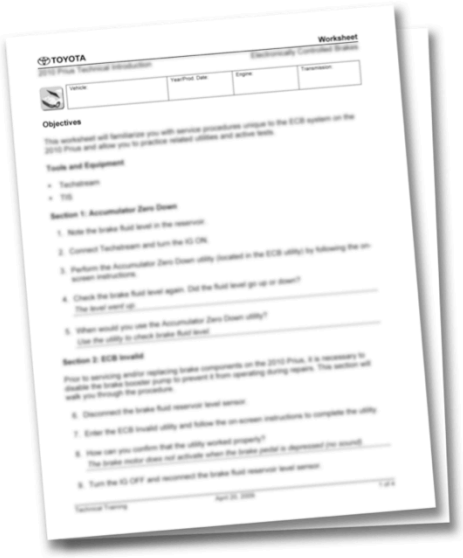


Active Brake Booster – Braking

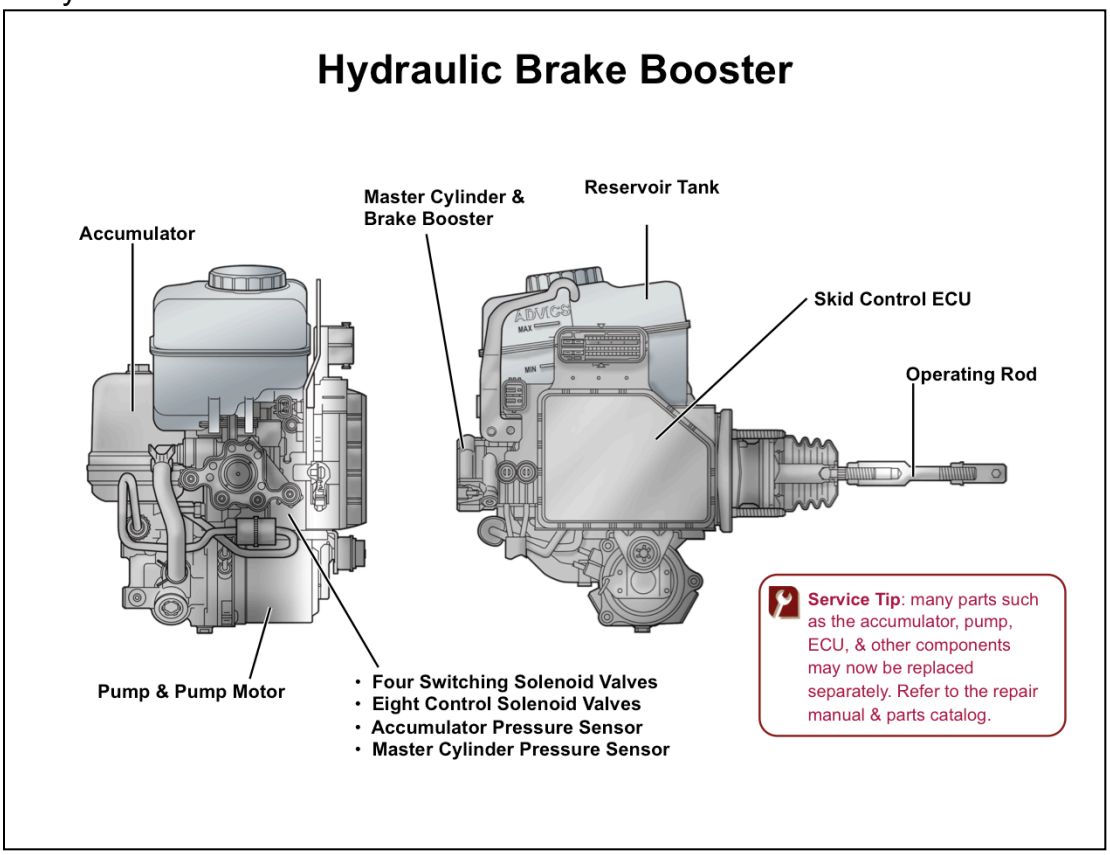
During VSC operation, the Skid Control ECU turns on the booster solenoid, opening the air valve. Atmospheric pressure enters the variable pressure chamber and brake hydraulic pressure is increased. This can occur even if the driver is not pressing on the brake pedal.

Brake Booster Worksheets

- **Worksheets:**
  - **Booster Checks**
  - **Booster Push Rod Adjustment**


TOYOTA
Worksheet
2010 Prius Technical Introduction
Electronically Controlled Brakes
Vehicle
Year/Prod. Date
Engine
Transmission
Objectives
This worksheet will familiarize you with service procedures unique to the ECB system on the 2010 Prius and allow you to practice related utilities and active tests.
Tools and Equipment
• Techstream
• TIS
Section 1: Accumulator Zero Down
1. Note the brake fluid level in the reservoir.
2. Connect Techstream and turn the IG ON.
3. Perform the Accumulator Zero Down utility (located in the ECB utility) by following the on-screen instructions.
4. Check the brake fluid level again. Did the fluid level go up or down?
The level went up.
5. When would you use the Accumulator Zero Down utility?
Use the utility to check brake fluid level.
Section 2: ECB Invalid
Prior to servicing and/or replacing brake components on the 2010 Prius, it is necessary to disable the brake booster pump to prevent it from operating during repairs. This section will walk you through the procedure.
6. Disconnect the brake fluid reservoir level sensor.
7. Enter the ECB Invalid utility and follow the on-screen instructions to complete the utility.
8. How can you confirm that the utility worked properly?
The brake motor does not activate when the brake pedal is depressed (no sound).
9. Turn the IG OFF and reconnect the brake fluid reservoir level sensor.
Technical Training
April 20, 2009
1 of 4

Notes:



Hydraulic Brake Booster

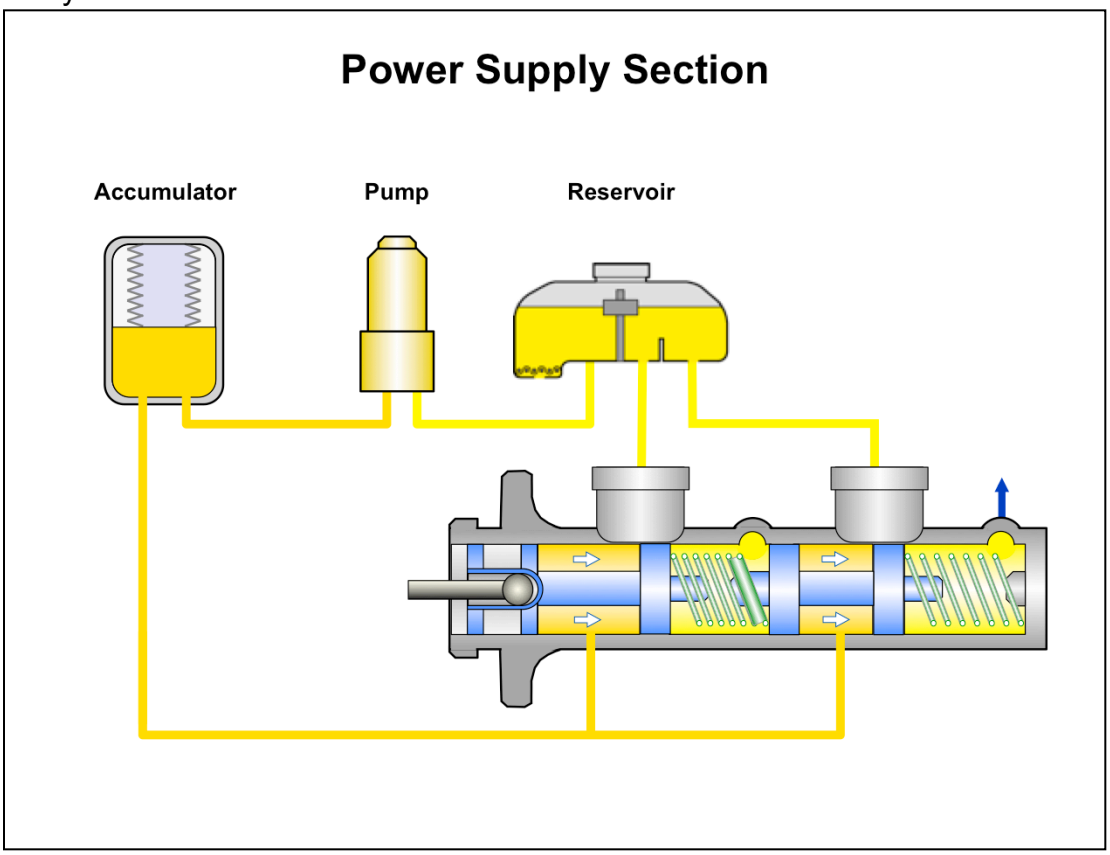
The hydraulic brake booster combines the master cylinder, accumulator, ABS actuator, and Skid Control ECU into a single assembly. It provides power assist to the brakes during normal braking and controls ABS as well as ABS-based systems such as TRAC, VSC, DAC, and HAC (if so equipped).

Early models had the ECU mounted under the dashboard separate from the hydraulic brake booster.

The hydraulic brake booster has three sections: power supply, brake pressure generation, and brake control.

- The power supply components include the pump and pump motor, relief valve, reservoir tank, brake fluid level warning switch, accumulator, and accumulator pressure sensor.
- Brake pressure generation components include the master cylinder with brake booster and master cylinder pressure sensor.
- Brake control components include the Skid Control ECU, four switching solenoid valves, and eight control solenoid valves.

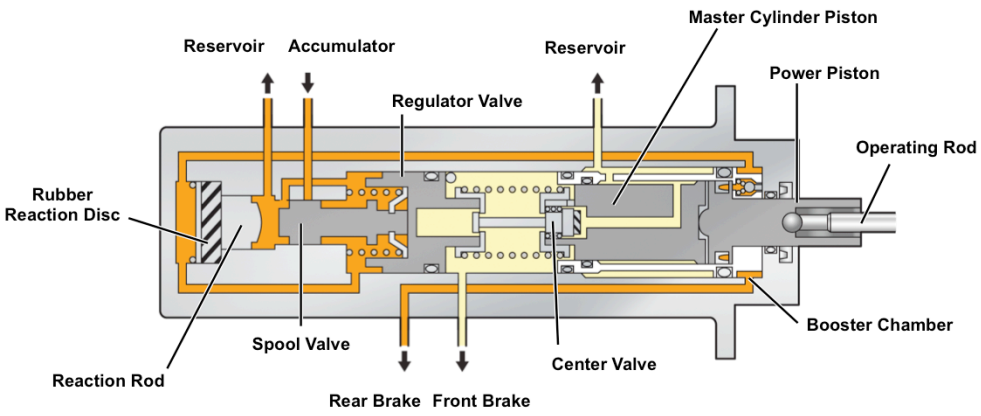
This is available on 4Runner, Land Cruiser, Tacoma, and Tundra.



Power Supply Section

The power supply section monitors hydraulic pressure in the accumulator. Brake fluid is stored in the reservoir, where the brake fluid level warning switch monitors fluid level. The accumulator is charged with high-pressure nitrogen gas and stores hydraulic pressure generated by the pump. The accumulator pressure sensor measures hydraulic pressure and provides input to the Skid Control ECU. The ECU controls the pump to maintain hydraulic pressure. If pressure is too low, the ECU turns on all brake warning and indicator lights and sounds the warning buzzer.

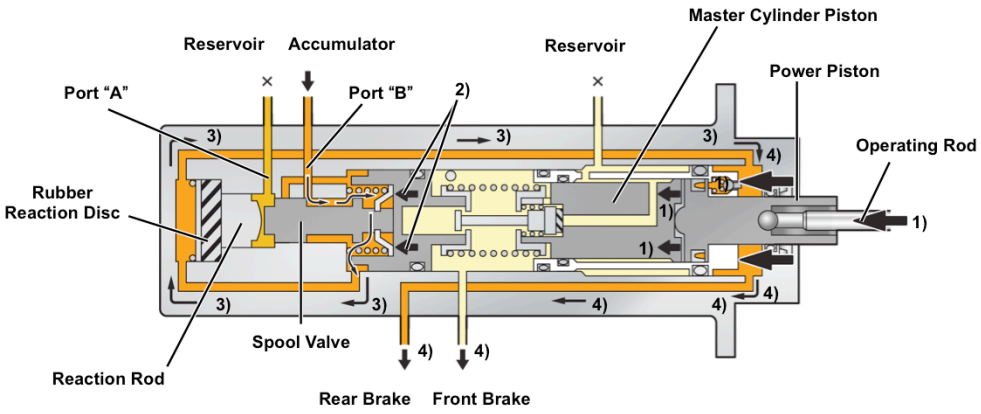
Master Cylinder/Brake Booster Construction



Master Cylinder and Brake Booster Construction and Operation

The master cylinder, brake booster, and regulator functions are located within the master cylinder body. The brake booster consists of the operation rod, power piston, and booster chamber. The master cylinder piston is made up of two piston diameters; a small-diameter piston fits within the sleeve that makes up the large-diameter piston. The regulator consists of a regulator piston, return spring, spool valve, reaction rod, and rubber reaction disc.

Pressure Increase



1) Pressure from the operating rod is applied to the master cylinder piston.
2) Pressure from the master cylinder piston is transferred to the regulator valve and the spool valve.
3) The spool valve moves and allows pressurized brake fluid from the accumulator to enter the circuit.
4) Accumulator pressure is applied to the rear brakes, and is transferred to the power piston to boost pressure to the front brakes.

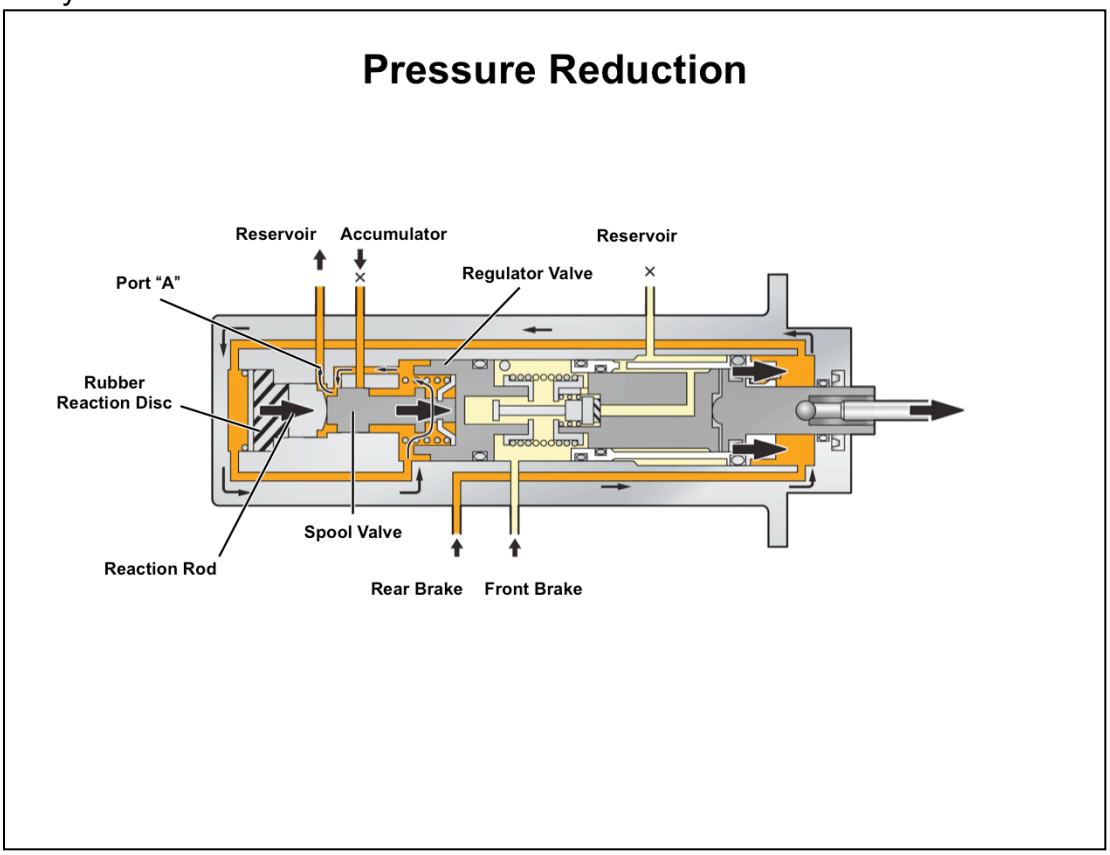
Pressure Increase

When apply pressure is low, brake pedal force is transmitted to the operation rod, then to the power piston, and then to the master cylinder piston (small-diameter piston). The spring tension of the master cylinder's return spring is higher than that of the regulator piston's return spring, so the regulator piston gets pushed before the volume in the master cylinder becomes compressed.

The regulator piston pushes the spool valve to close port A (between the reservoir tank and booster chamber) and open port B (between the accumulator and booster chamber). Pressurized brake fluid enters the booster chamber and is transmitted to the large-diameter master cylinder piston, adding power assist to driver pedal effort.

The power assist works against the master cylinder's return spring, compressing the volume in the master cylinder and increasing pressure to the front brakes. At the same time, the pressure in the booster chamber increases pressure to the rear brakes.

During the initial stage of brake operation, only low booster pressure is applied to the rubber reaction disc. Therefore, a return force is not applied to the spool valve via the reaction rod.

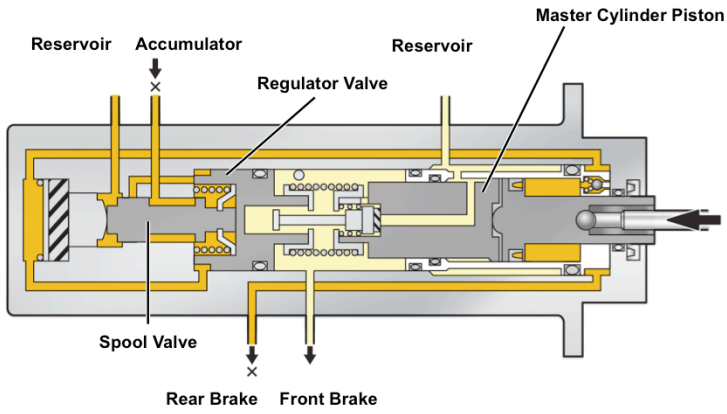


Pressure Reduction

When the driver reduces pressure on the brake pedal, master cylinder pressure decreases. The regulator piston's return force increases proportionately, causing the regulator piston and spool valve to retract. As a result, port A opens between the reservoir tank and the booster chamber.

Booster pressure is reduced to match the new brake pedal force. This process is repeated to reduce booster pressure and master cylinder pressure as the driver continues to reduce brake pedal force.

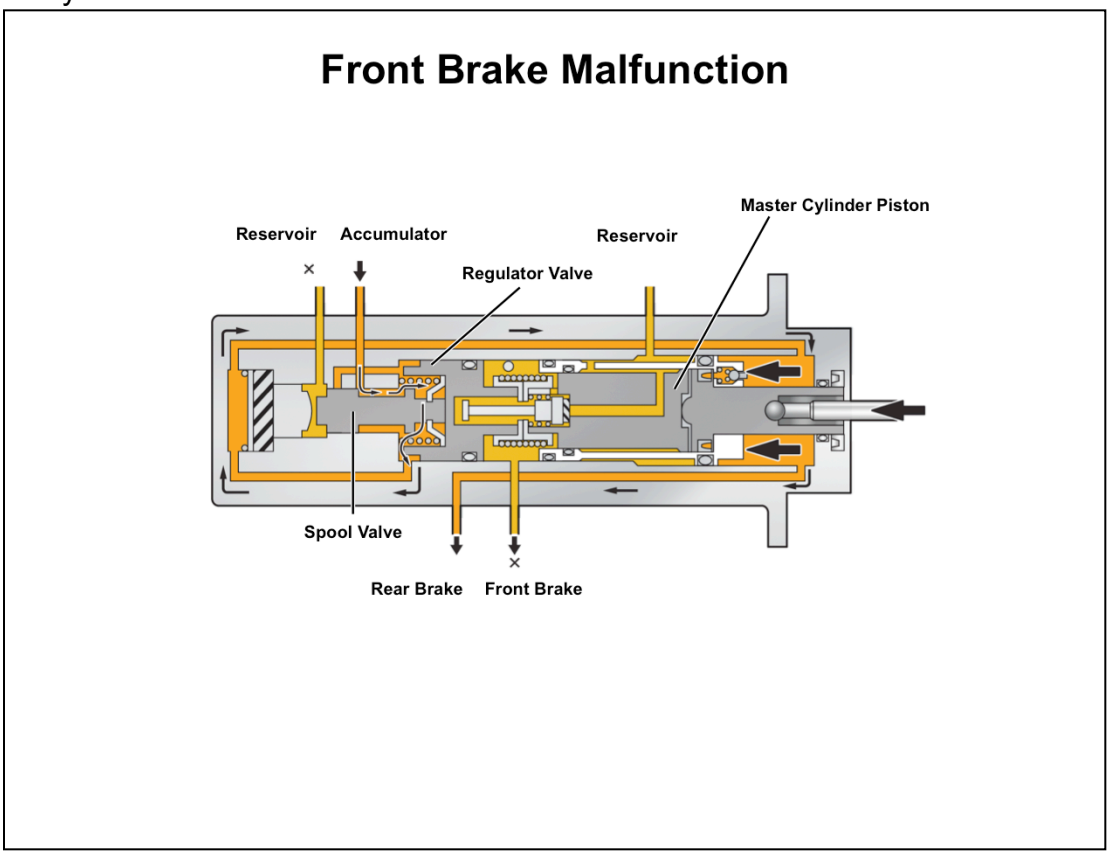
Power Supply Malfunction



Power Supply Malfunction

If a malfunction reduces accumulator pressure, no hydraulic pressure will be supplied to the booster chamber. Power assist is no longer available, and the pressure to the rear brakes cannot be increased.

Since there is no pressurized brake fluid in the large-diameter master cylinder piston, the piston does not move from its original position. However, force applied to the brake pedal will still move the small-diameter master cylinder, increasing pressure to the front brakes.



Front Brake Malfunction

If the front brake system malfunctions, booster chamber pressure moves the master cylinder piston, but hydraulic pressure to the front brakes does not increase. The piston moves until it hits the regulator piston and moves the spool valve, opening accumulator pressure to the rear brakes.

Fluid Level Check and System Bleeding

- **To check fluid level**, turn the ignition OFF and pump the brake pedal **40*** times to return accumulator brake fluid to the reservoir.
- **Bleed brake booster** if the master cylinder is disassembled, any brake line is disconnected from the master cylinder, or the reservoir is emptied.
- **Bleed air at each wheel** as you would with a non-ABS brake system. The accumulator provides fluid to the rear brakes continuously.

Notes:
* The number of times varies by model. Refer to the repair manual for details.
Do not allow the reservoir fluid level to go below the MIN mark during bleeding.
Air in the rear brake circuit will not cause the pedal to feel spongy.

Hydraulic Brake Booster Service and Precautions

Fluid Level Check

Before checking brake fluid level, turn the ignition OFF and pump the brake pedal 40 times to release pressure from the accumulator and return brake fluid to the reservoir (Note on some models the number of times the brake pedal must be pumped may vary. Refer to the repair manual for details). Fluid level should be at the maximum level mark on the reservoir.

Brake Booster Bleeding

Bleed the brake booster if the master cylinder is disassembled, any brake line is disconnected from the master cylinder, or the reservoir is emptied. To bleed the brake booster, turn the ignition ON and wait until the pump motor stops (30 to 40 seconds). Then turn the ignition OFF and pump the brake pedal 40 times.

High pressure Precaution - vehicles equipped with an integrated ABS accumulator/ master cylinder/ modulator/ pump can generate significant hydraulic pressure. Therefore Do Not Open any brake lines or perform service without 1st depressurizing the system (refer to the specific RM for details).

Brake System Bleeding

Before and during brake system bleeding, check the reservoir fluid level. Turn the ignition ON and wait until the pump motor stops (30 to 40 seconds). Bleed air at each wheel, using the brake pedal to apply pressure as you would with a non-ABS brake system. The accumulator provides fluid to the rear brakes continuously. Close the bleeding screw when the fluid is free of air bubbles .

CAUTION Do not allow the reservoir fluid level to go below the MIN mark during bleeding.

NOTE Air in the rear brake circuit will not cause the pedal to feel spongy.

Master Cylinder Solenoid Bleeding

To bleed the master cylinder solenoid, connect Techstream to DLC3, turn ignition ON, and access ACTIVE TEST mode.

- Loosen a rear wheel cylinder bleeder plug.
- Select TRAC Solenoids SRMF & SRMR to activate them to force fluid to rear wheel cylinders.
- Techstream automatically stops active test after 2 seconds. Repeat as needed to remove all air from fluid lines.

CAUTION: Do not depress brake pedal during solenoid active test.

Master Cylinder Solenoid Bleeding

Connect the Techstream to DLC3, turn the ignition ON, and access the ACTIVE TEST mode.

Loosen a rear wheel cylinder bleeder plug.

Select TRAC solenoids SRMF and SRMR (this activates the solenoids and forces fluid to the rear wheel cylinders). To protect the solenoids, Techstream automatically stops the active test after 2 seconds. You may need to repeat the active test several times to remove all the air from the fluid lines.

CAUTION

Do not depress the brake pedal during the solenoid active test.