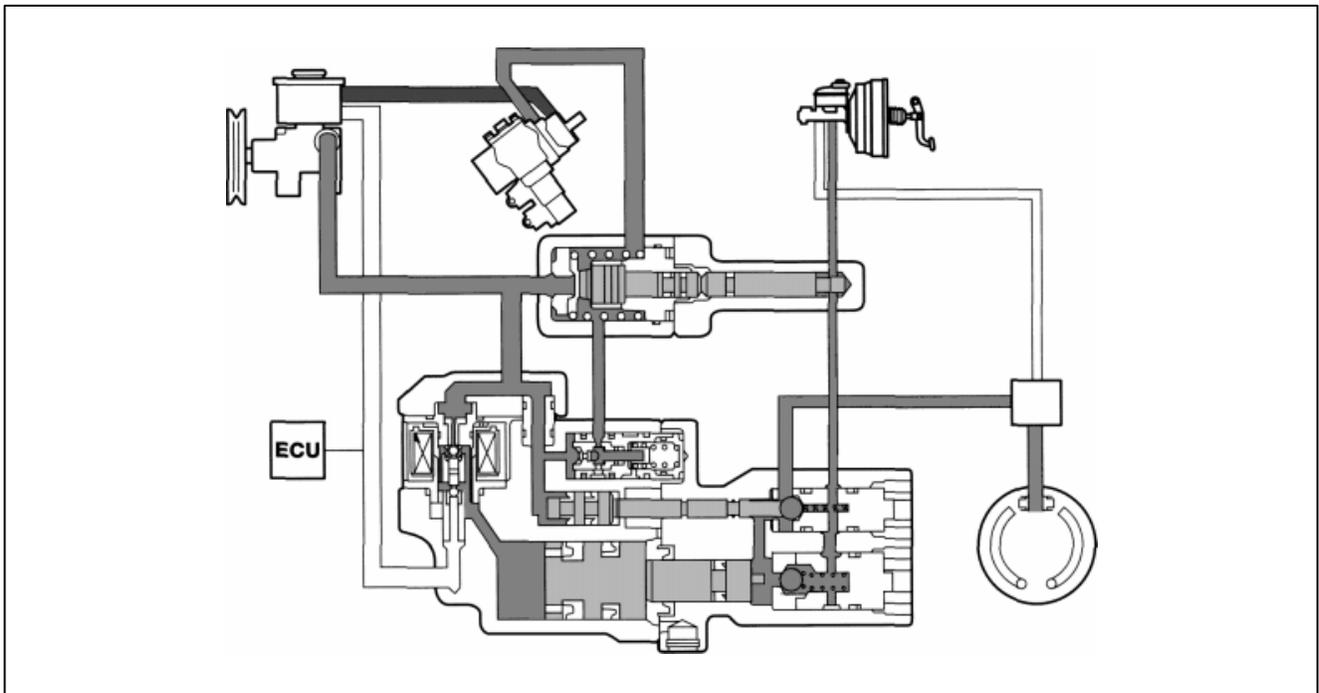


OTHER ABS ACTUATORS



Lesson Objectives

1. Describe how the solenoid controlled power steering fluid controls brake pressure in the rear wheel ABS system.
2. Describe the function of the mechanical valve in the 3-position solenoid and mechanical valve actuator.
3. Describe the three control positions of the 3-position solenoid in maintaining ABS operation.

Other Actuator Designs

Toyota uses several types of ABS actuators, each differs in how the modulation of pressure is accomplished. The function of sensors and ECU control already discussed in Section 8, do not differ.

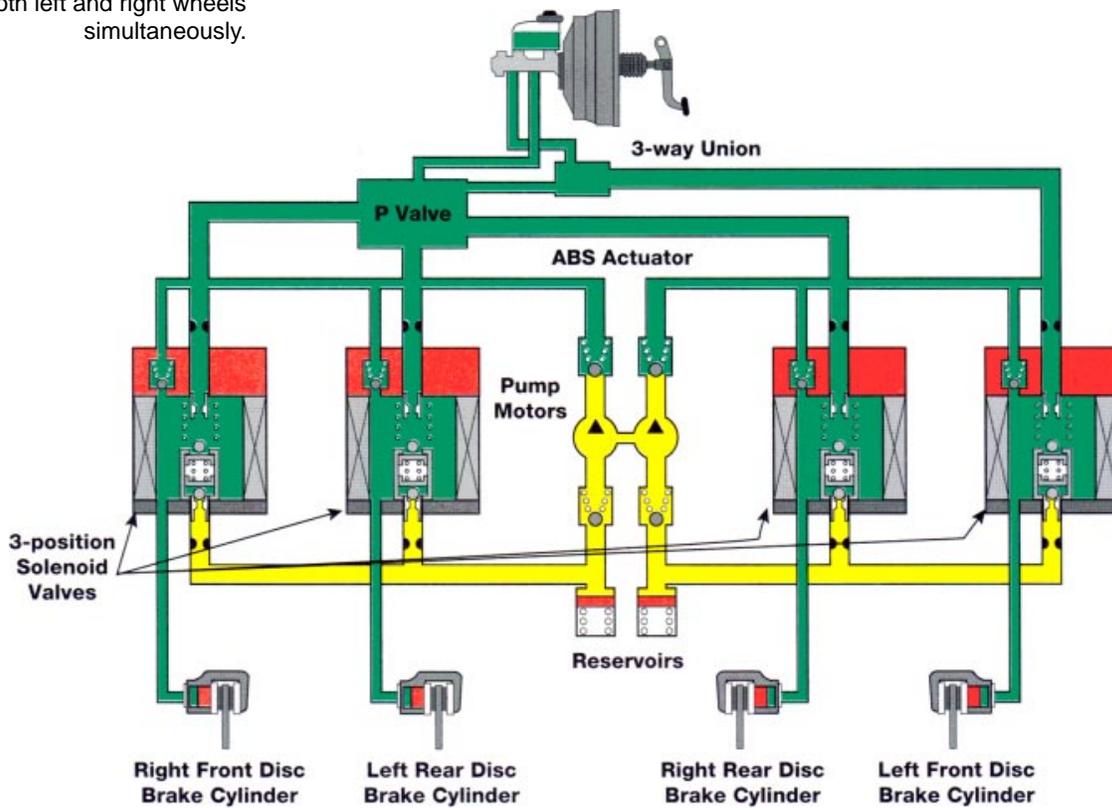
3-Position Solenoid Type

The 3-position solenoid valve uses a 3-position valve, electrical coil and check valve. As current flows through the solenoid windings, it creates a magnetic field around the 3-position valve causing it to move toward the center of the coil compressing the return spring. Current from the ABS ECU is switched in three steps; 0 amps, 2 amps and 5 amps in order to control the strength of the magnetic force in the coil.

There are four 3-position solenoid valves in the ABS actuator described here; those for the front wheels control the left and right wheels independently, while those for the rear wheels control both the left and right wheels simultaneously. The system is therefore known as a three-channel system.

3-Position Solenoid Actuator

The 3-position solenoid valves for the front wheels control the left and right wheels independently, those for the rear wheels control both left and right wheels simultaneously.



Operation During Normal Braking (ABS Not Activated)

During normal braking ABS is not activated and the 3-position valve is pushed down by a return spring. The solenoid inlet, port “A”, remains open while the outlet to the reservoir, port “B” remains closed.

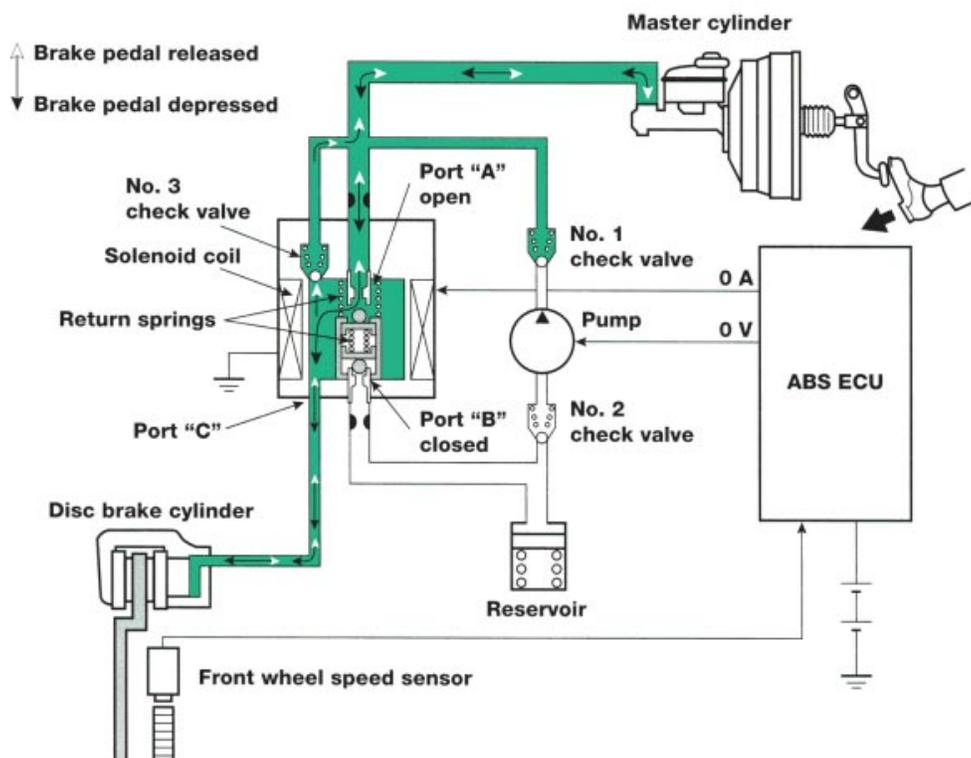
When the brake pedal is depressed, brake fluid passes from port “A” to port “C”, to the disc brake cylinder. Brake fluid is prevented from flowing into the pump by the No. 1 Check Valve located in the pump circuit.

When the brake pedal is released, the brake fluid returns from the disc brake cylinder to the brake master cylinder through port “C” to port “A” and the No. 3 Check Valve in the 3-position solenoid valve.

Normal Braking

With zero amps applied to the solenoid, port A is open, pressure is applied to the brake cylinder.

Part Name	Operation
3-Position Solenoid Valve	Port “A” Open
	Port “B” Closed
Pump Motor	Stopped



“Holding” Mode When the ECU determines that a wheel is about to lockup, it switches to the holding mode to stop the increase in hydraulic pressure. As the pressure inside the disc brake cylinder is reduced or increased, and the speed sensor indicates that the speed is at the target level, the ECU supplies a 2 ampere signal to the solenoid coil to hold the pressure in the disc brake cylinder at that level.

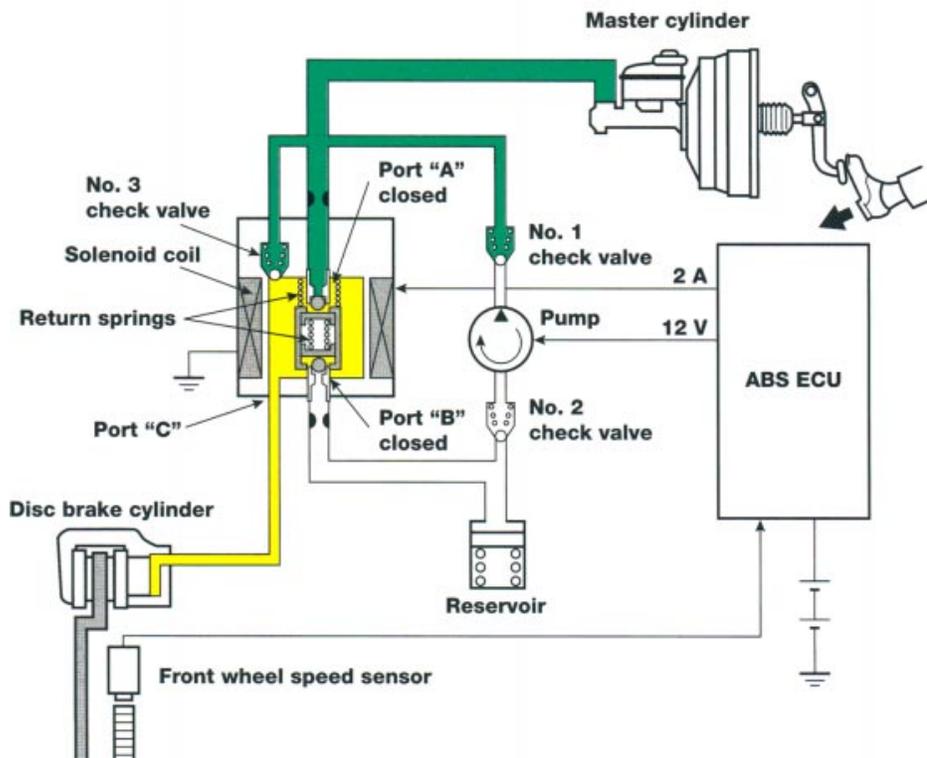
When the current supplied to the solenoid coil is reduced from 5 amperes (in the pressure reduction mode) to 2 amperes (in holding mode), the magnetic force generated in the solenoid coil also decreases. The 3-position solenoid valve then moves down to the middle position by the force of the return spring, closing port “B”.

With the ECU holding Port A closed, and pedal pressure closing check valves #1 & #3, brake caliper pressure holds steady, and cannot be increased.

“Holding” Mode

Two amps applied to the solenoid, Port A and Port B are closed, pressure remains constant.

Part Name	Operation
3-Position Solenoid Valve	Port “A” Closed
	Port “B” Closed
Pump Motor	On



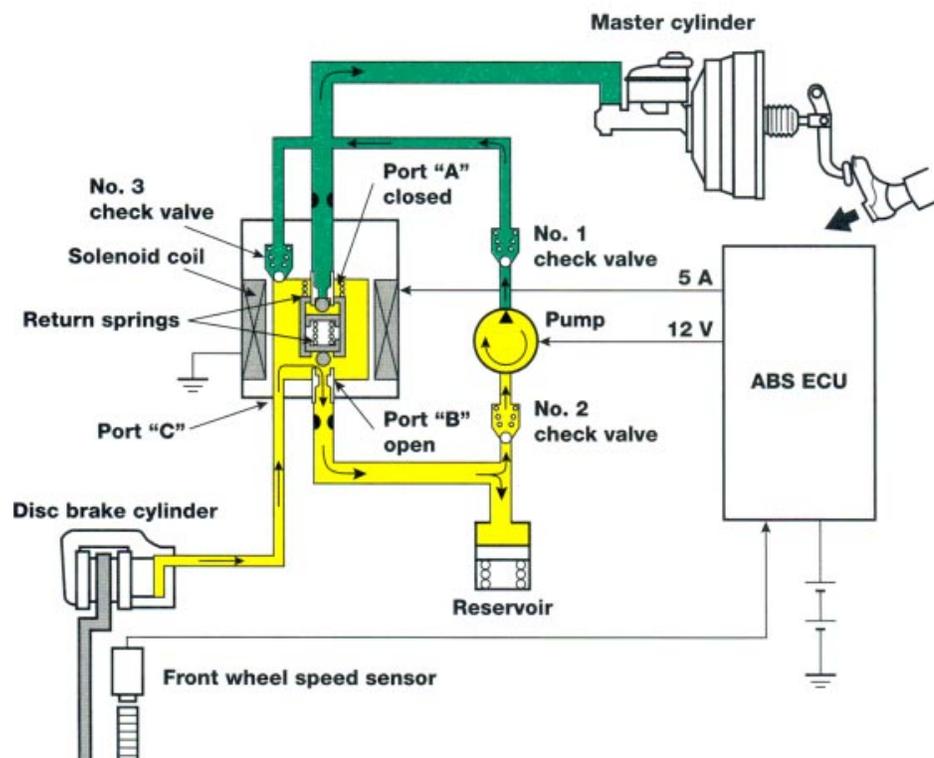
“Pressure Reduction” Mode When the wheels are about to lock, the ECU supplies a 5 ampere signal to the solenoid to close port “A” and open port “B” in the 3-position solenoid. As a result, brake fluid from the disc brake cylinder passes through port “C” to port “B” in the 3-position solenoid and flows to the reservoir. At the same time, a computer signal causes the pump to operate. Fluid stored in the reservoir is pumped to the master cylinder.

The forced return of pressure from the brake caliper circuit to the master cylinder forces the pedal up slightly. This causes the driver to feel the ABS system operation.

“Pressure Reduction” Mode

Five amps applied to solenoid, port A closed, port B open, allowing pressure from wheel cylinder to flow to the reservoir.

Part Name	Operation
3-Position Solenoid Valve	Port “A” Closed
	Port “B” Open
Pump Motor	On



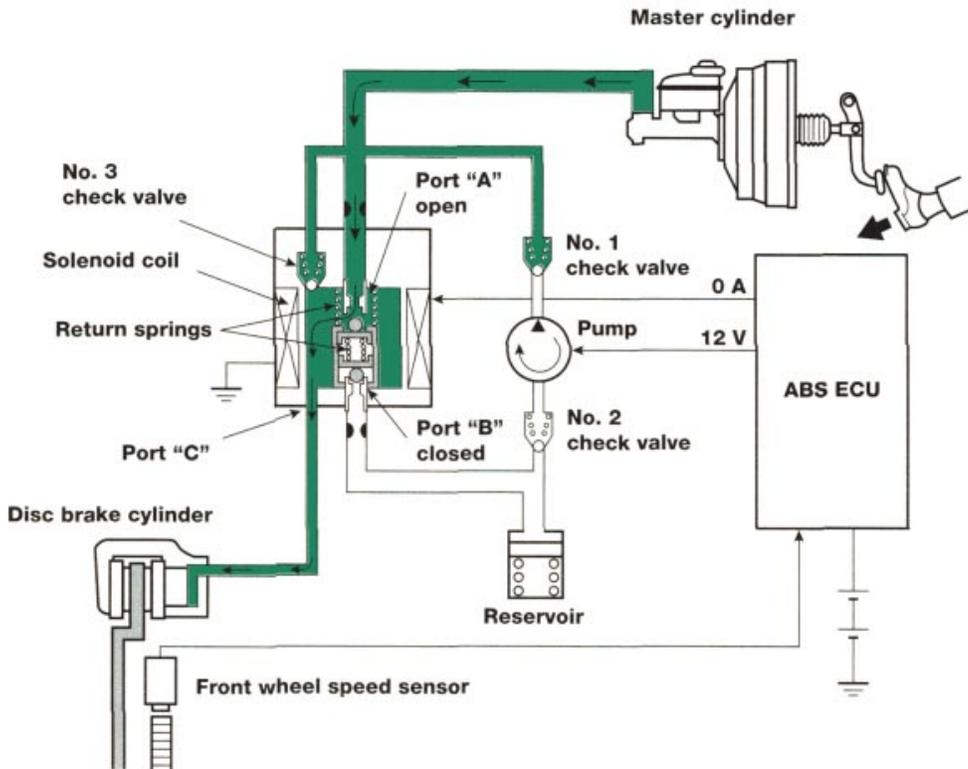
“Pressure Increase” Mode When the pressure in the disc brake cylinder needs to be increased to apply more braking force, the ECU stops sending current to the solenoid coil. This opens port “A” of the 3-position valve and closes port “B”. This allows the fluid in the master cylinder to pass from port “C” in the three-position solenoid valve to the disc brake cylinder. The hydraulic pressure increase rate is controlled by the repetition of the pressure increase and holding modes.

Brake caliper pressure will increase as long as the driver continues to apply pedal pressure.

“Pressure Increase” Mode

Zero amps applied to solenoid, Port A open allowing pressure application at wheel cylinder.

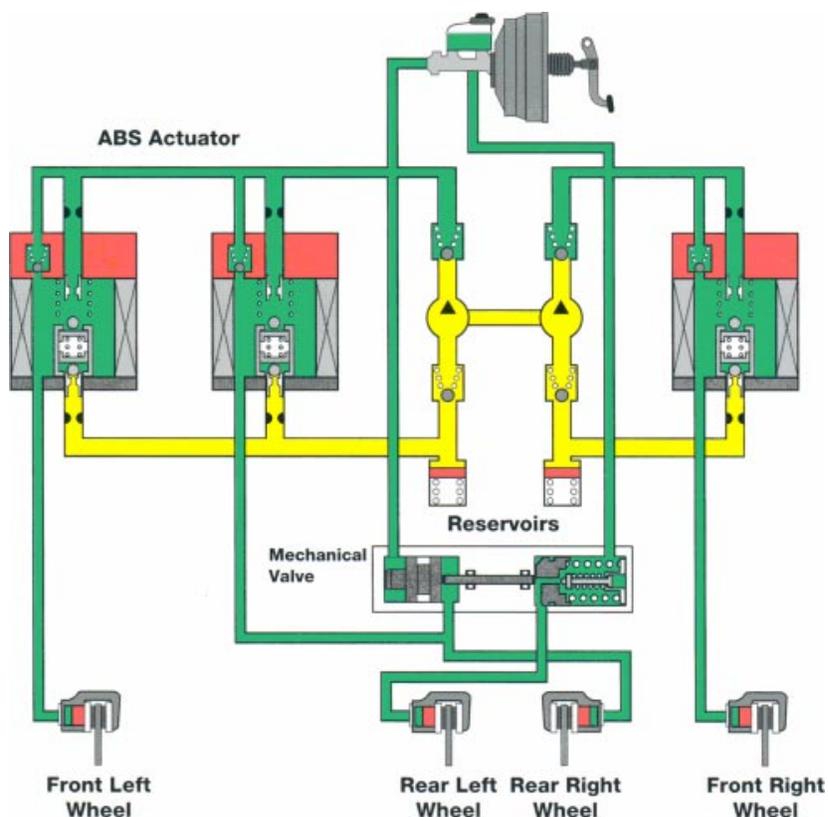
Part Name	Operation
3-Position Solenoid Valve	Port “A” Open
	Port “B” Closed
Pump Motor	On



3-Position Solenoid and Mechanical Valve This actuator is fundamentally the same as the 3-position solenoid type just discussed. It consists of three, 3-position solenoid valves, a mechanical valve, pump and reservoir. The solenoid that controls pressure to the right rear wheels also uses a mechanical valve that controls pressure to the left rear wheel. This actuator was first introduced on the 1994 Camry produced by Toyota Motor Manufacturing (TMM) in Georgetown, Kentucky and later in the Avalon.

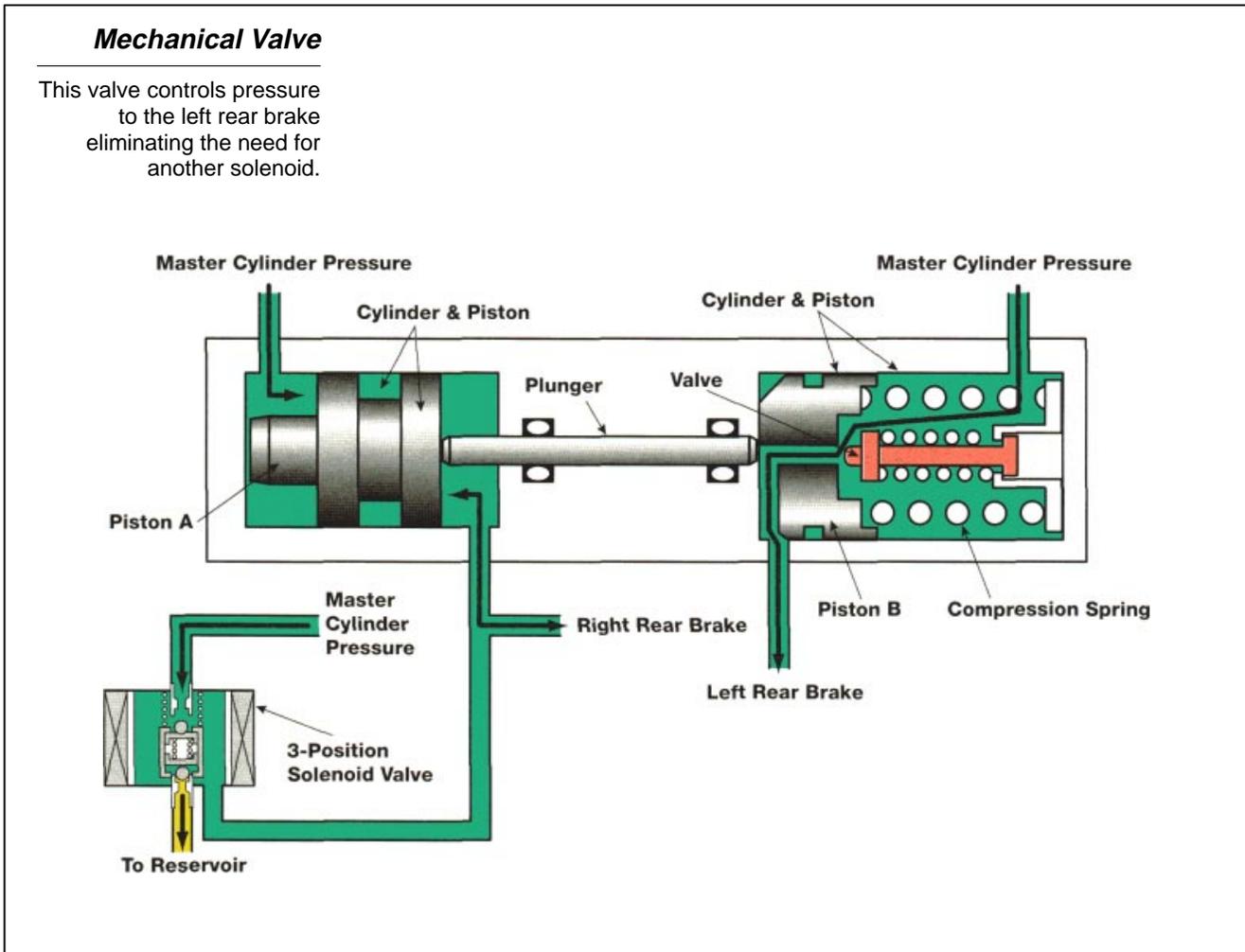
3-Position Solenoid and Mechanical Valve Actuator

The solenoid which controls pressure to the rear wheels also uses a mechanical valve which controls pressure to the left rear wheel.



Mechanical Valve Construction The mechanical valve consists of two sets of cylinders and pistons and a plunger to link their movement. Piston A monitors the pressure from the master cylinder on its left side and monitors pressure to the right rear brake circuit from the 3-position solenoid valve on its right side. Piston A moves based on differences in pressure since piston surface areas are equal.

Any movement of piston A is traced by piston B through the plunger. In addition a spring loaded valve opens and closes the master cylinder passage to the left rear brake. Piston B is spring loaded to the left which leaves the valve unseated and the fluid path open.

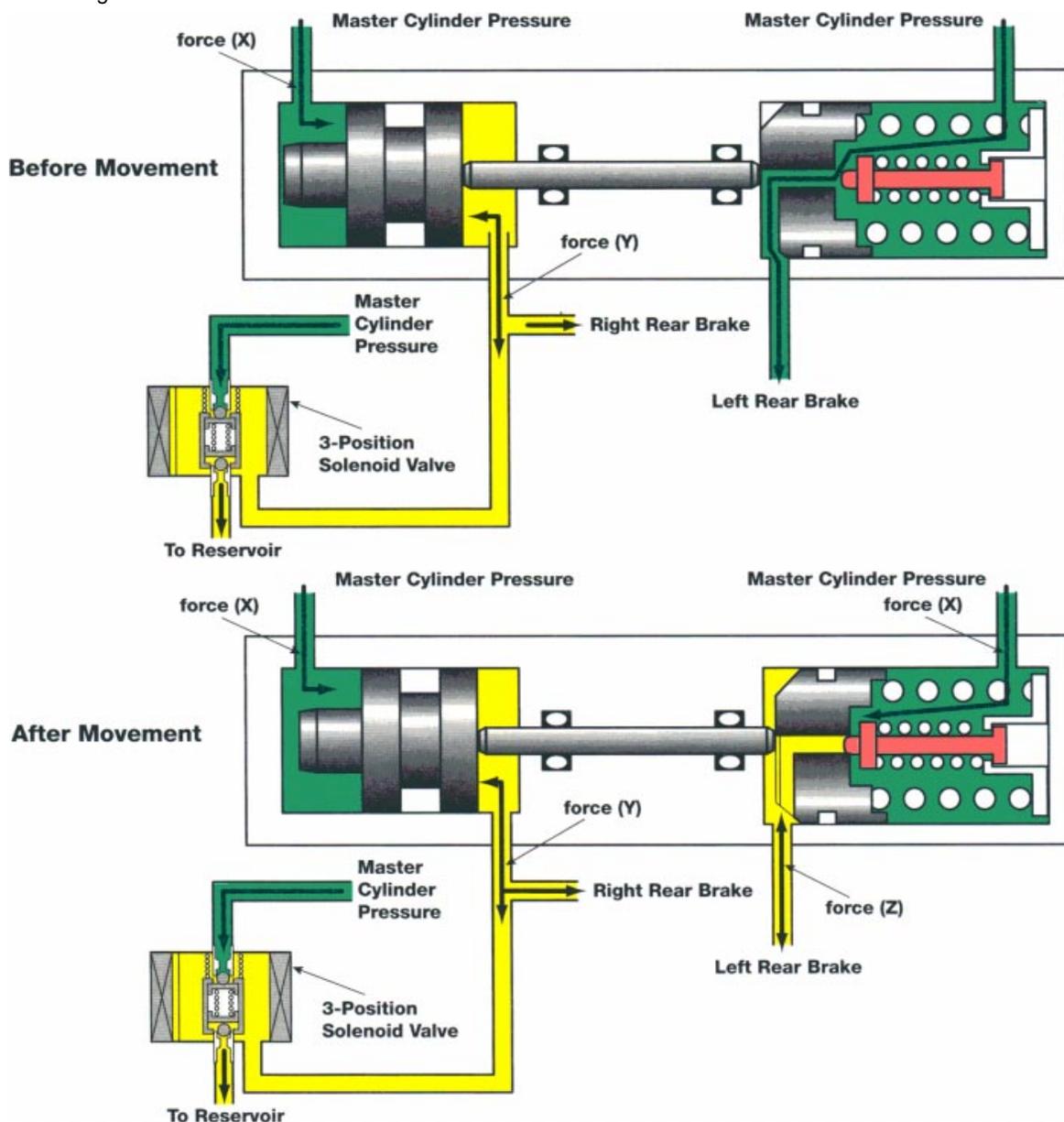


Pressure Increase Mode The pressure increase mode is also the normal braking position for brake operation without ABS, as shown in the illustration above. Pressure from the master cylinder is equal to the pressure coming through the 3-position solenoid to the right rear brake cylinder. Piston A does not move and is held to the left by the spring acting on piston B. Pressure increase comes from the master cylinder through the brake pedal pressure.

Pressure Hold Mode When the 3-position solenoid goes into the hold position, it blocks hydraulic fluid and pressure in the circuit between the solenoid, the right rear brake cylinder and the right side of piston A. With pressure in the right rear brake held, pressure from the master cylinder increases, causing piston A to move right. The piston forces the plunger to move piston B to the right, blocking fluid from the left rear brake cylinder. This action mirrors the pressure hold on the right rear cylinder.

Pressure Hold Mode

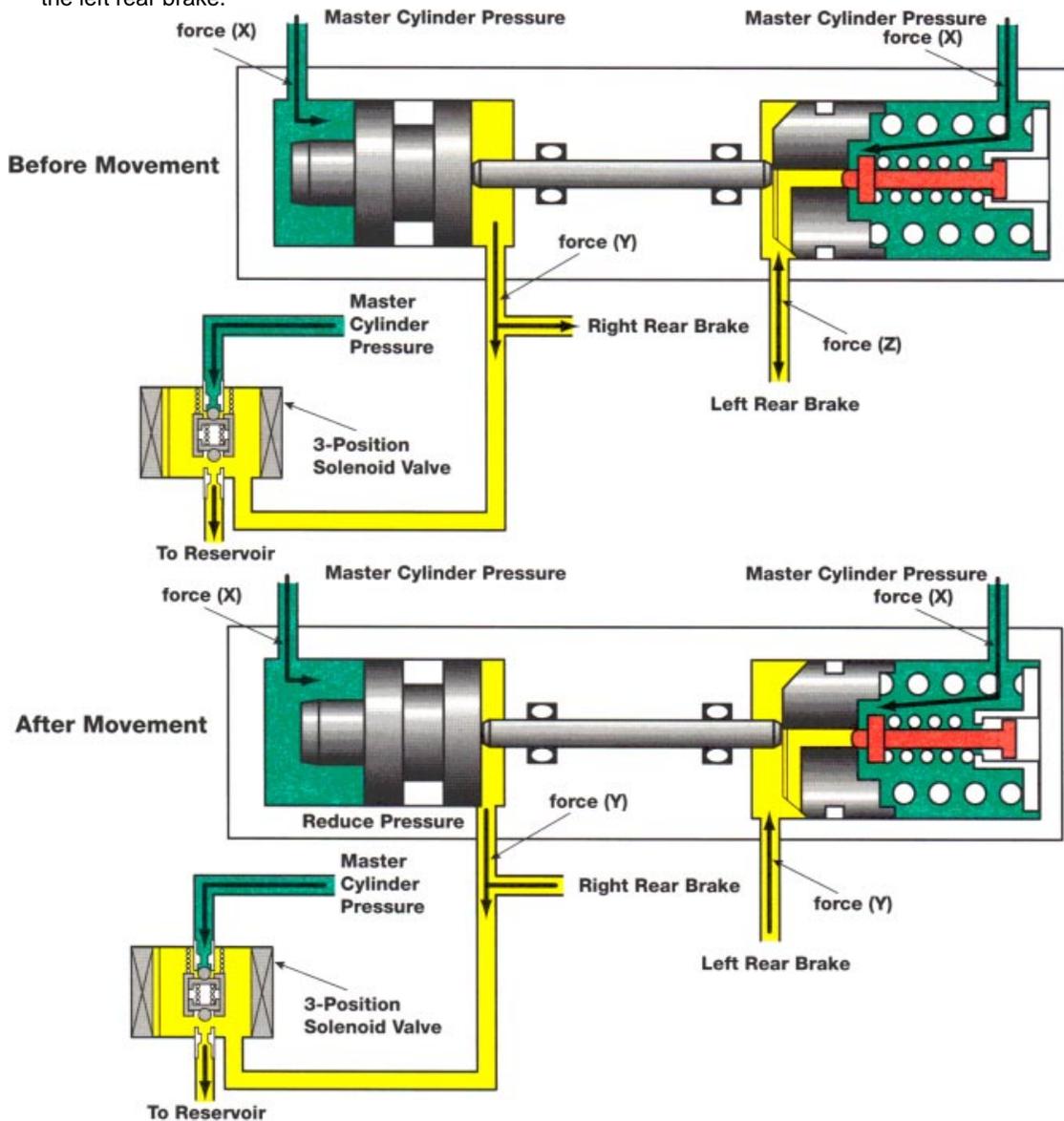
The Mechanical Valve causes pressure at the left rear brake to mirror the pressure to the right rear brake.



Pressure Reduction Mode The 3-position solenoid goes into the reduction position venting hydraulic fluid and pressure in the circuit between the solenoid, the right rear brake cylinder and the right side of piston A. Pressure from the master cylinder increases causing piston A to move right forcing the plunger to move piston B to the right compressing the spring. The movement of piston B increases the area volume in the left rear brake cylinder hydraulic circuit. This action mirrors the pressure reduction in the right rear brake cylinder.

Pressure Reduction Mode

Pressure reduction is accomplished by the movement of piston B creating an increase in volume to the circuit to the left rear brake.



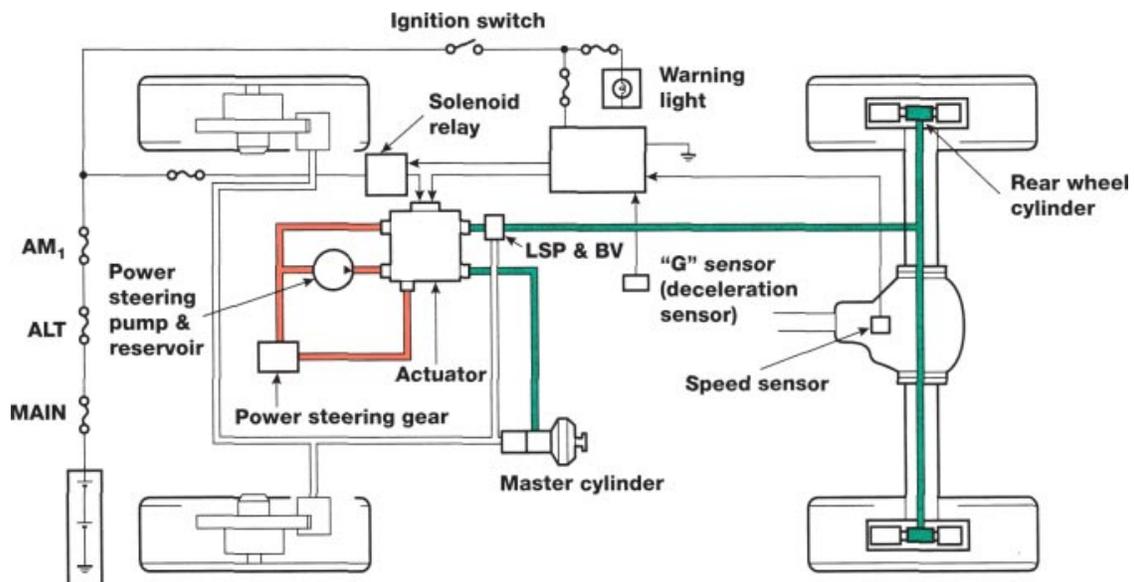
Power Steering Pressure Controls Brake Pressure

This system was an option on '90 - '94 Trucks, 4Runners and T100's. It represents the greatest departure from the systems we have studied to this point. The following summary highlights the unique features of this system:

- Controls the rear wheels only.
- Single 2-position solenoid in the actuator.
- Uses a deceleration sensor and a single speed sensor.
- Power steering pressure is used to control brake pressure.

Rear Wheel ABS Diagram

The ECU uses input from the single speed sensor and deceleration sensor to control rear wheel brake pressure.

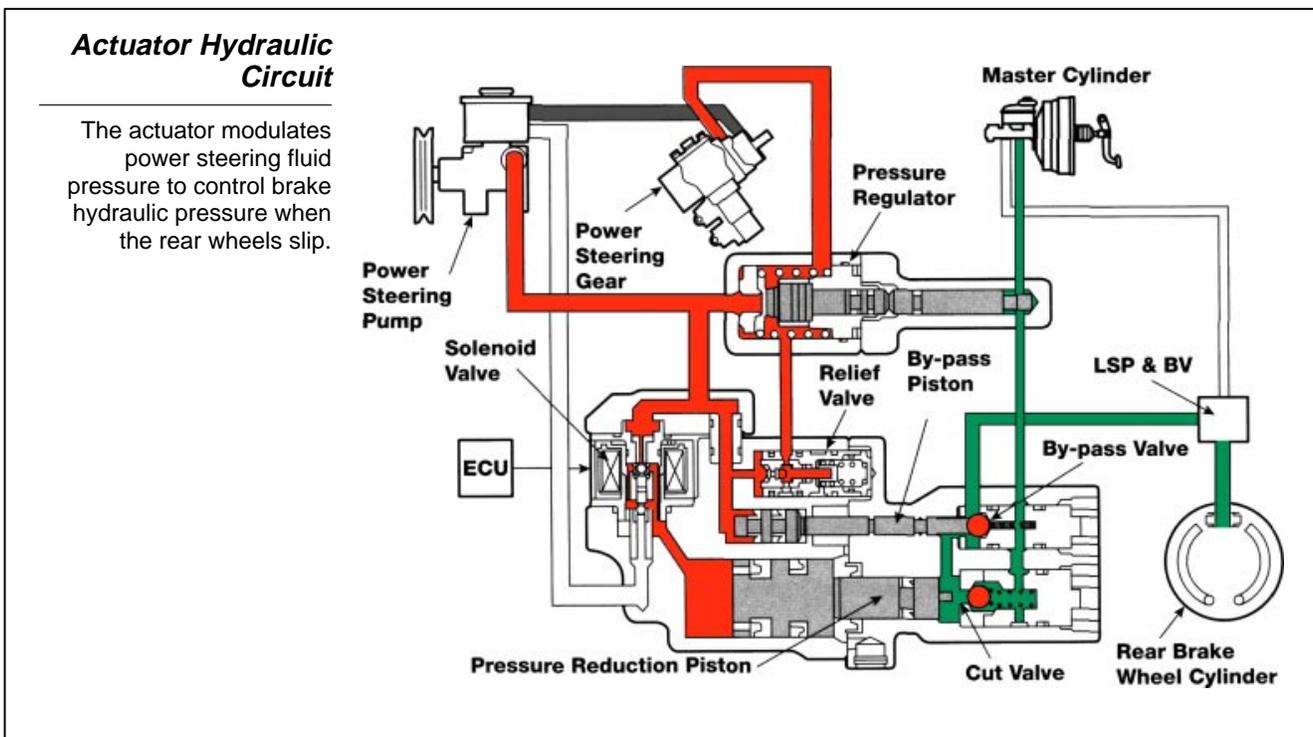


A single 2-position solenoid controls the hydraulic pressure from the power steering to control brake pressure. This system uses only one speed sensor, mounted on top of the ring gear on the differential case. For this reason, a deceleration ("G") sensor is necessary for the ECU to sense the deceleration rate to help determine the slip rate of the rear wheels.

The actuator modulates power steering fluid pressure to control brake hydraulic pressure when the rear wheels slip while the brakes are applied. Modulation is accomplished by the ECU controlled two-position solenoid based on input from the deceleration sensor and speed sensor.

The actuator is made up of several components each having a specific function:

- **Solenoid valve** is controlled by the ABS ECU and modulates the power steering pressure on the pressure reduction piston.
- **Pressure regulator valve** regulates the power steering pressure in relation to brake pressure. Brake pressure acting on the right side of the valve compressing the spring would raise power steering pressure. (Located in the Actuator)
- **Relief valve** relieves the power steering pressure if it gets too high in the actuator.
- **By-pass piston** opens and closes the by-pass valve according to power steering pressure. It constantly monitors power steering pressure to keep the by-pass valve closed. If the power steering pressure is lost, the by-pass valve opens to allow brake pressure to by-pass actuator control.
- **Pressure reduction piston** opens and closes the cut and by-pass valve to direct the brake fluid. Changes the brake pressure to the rear wheels by increasing or decreasing the volume in its bore.
- **Cut valve and By-pass valve** controls the path of brake fluid depending on mode of operation.



Control of the brake fluid pressure acting on the rear brake cylinders is carried out in three modes:

- pressure holding.
- pressure reduction.
- pressure increase.

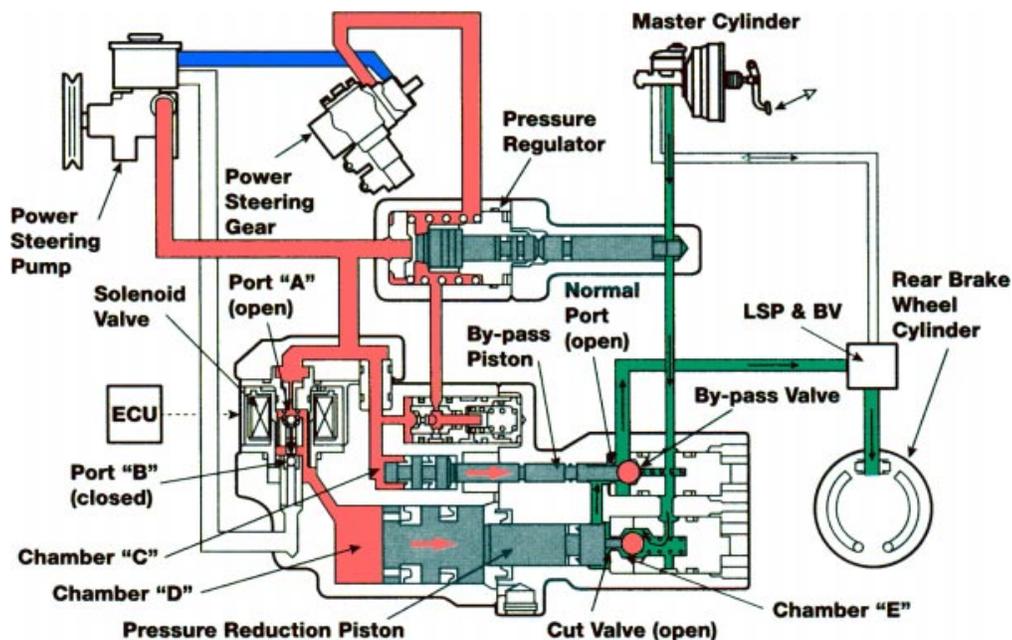
Operation During Normal Braking

The rear-wheel anti-lock brake system is not activated during normal braking. In this mode the power steering fluid pressure acts on chambers "C" and "D" pushing both the by-pass valve and cut valve toward the right. This causes the cut valve to open and the normal port on the left side of the by-pass valve to open.

When the brake pedal is depressed, the master cylinder fluid pressure rises. The brake fluid passes from the cut valve to the normal port in the by-pass valve, and is sent to the rear brake wheel cylinders.

Normal Braking

Power steering fluid pressure acts on chambers "C" and "D" pushing both the by-pass valve and cut valve toward the right.

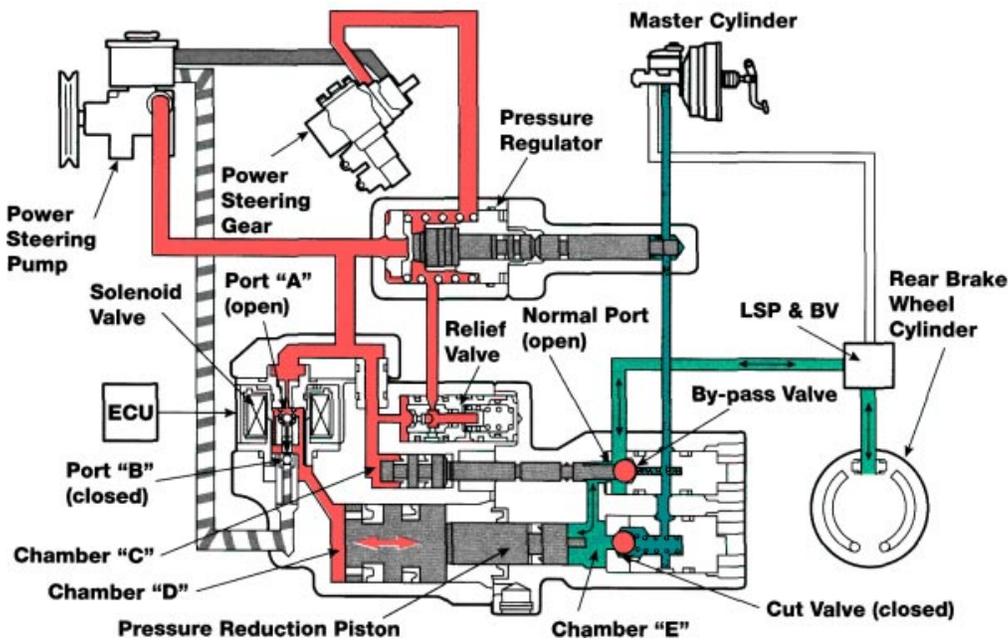


Holding Mode This system does not have a specific holding mode: instead, rear brake cylinder pressure hold mode is maintained by the ECU quickly pulsing the solenoid valve ON and OFF between pressure increase and pressure reduction modes. The ECU maintains the pressure to the rear wheel cylinders within a narrow range as it continues to monitor wheel speed.

Holding Mode

The holding mode is maintained by the ECU quickly pulsing the solenoid valve ON and OFF between pressure increase and reduction to maintain the brake pressure to the rear brakes.

Part Name	Operation	
	Pressure Increase	Pressure Reduction
Solenoid Valve	Port "A" Open	Port "A" Close
	Port "B" Close	Port "B" Open
Cut Valve	Close	←
By-pass Valve	Normal Port Open	←



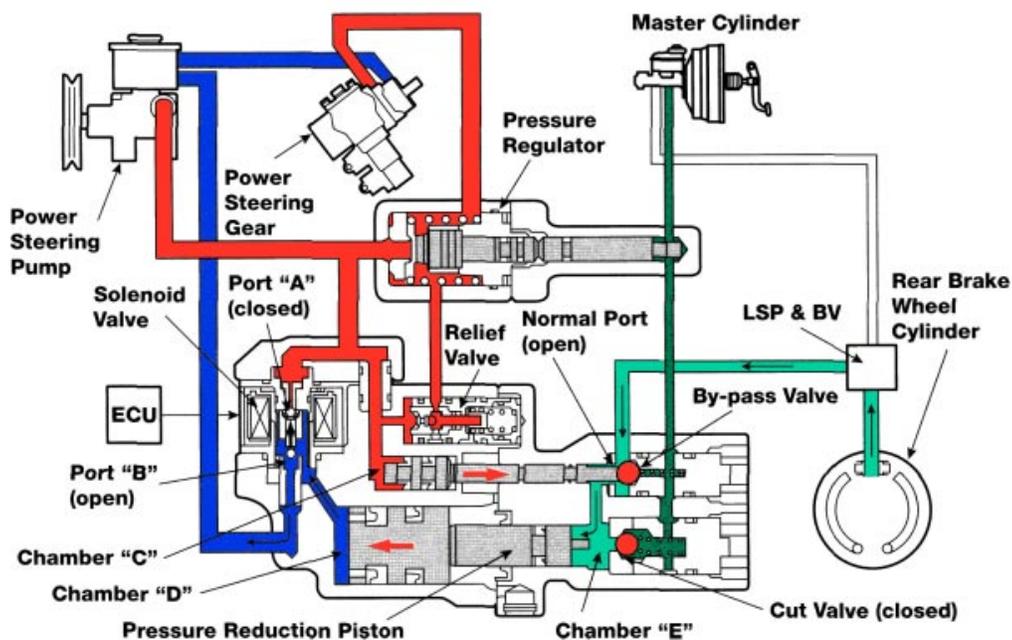
Pressure Reduction Mode When the rear wheel begins to lock-up, the ECU energizes the solenoid coil, generating a magnetic force. The plunger moves upward and port “A” closes while port “B” opens. As a result, the power steering fluid acting on chamber “D” returns to the power steering reservoir. This causes the pressure reduction piston to move to the left, first closing the cut valve, then causing the brake fluid pressure, acting on the rear brake wheel cylinders, to accumulate in chamber “E”.

As a result, the pressure level inside the rear brake wheel cylinders decreases to prevent wheel locking.

Pressure Reduction Mode

The solenoid plunger moves upward and port “A” closes while port “B” opens. As a result, the power steering fluid acting on chamber “D” returns to the reservoir.

Part Name	Operation
Solenoid Valve	Port “A” Close
	Port “B” Open
Cut Valve	Close
By-pass Valve	Normal Port Open

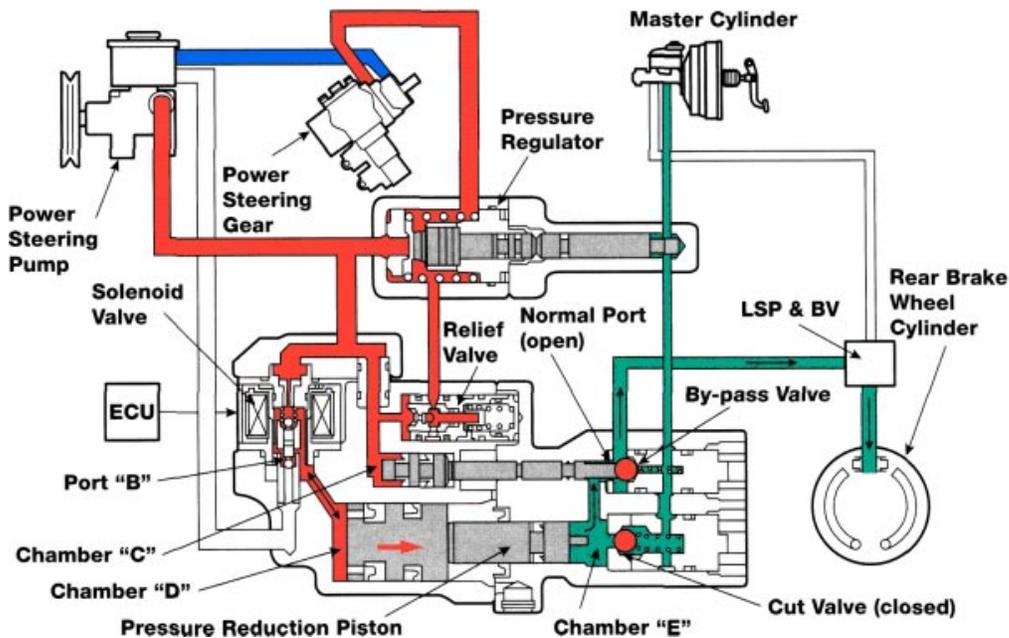


Pressure Increase Mode When the fluid pressure in the rear brake wheel cylinders needs to be increased to apply more braking force, the ECU changes the ratio in which the solenoid valve is turned on and off. In the pressure increase mode, the brake fluid pressure in the rear wheel brake cylinders is increased while the solenoid valve is switched on and off repeatedly. By extending the amount of time the solenoid is switched off in the on/off cycle, the amount of time port "A" is open and port "B" is closed is extended and this causes the pressure in chamber "E" to rise gradually. The cut valve remains closed during the operation. The pressure reduction piston is moved gradually to the right and increases the brake fluid pressure acting on the rear brake wheel cylinders.

Pressure Increase Mode

By extending the amount of time the solenoid is switched off in the on/off cycle, the amount of time port "A" is open and port "B" is closed is extended and this causes the pressure in chamber "E" to rise gradually.

Part Name	Operation	
	Pressure Increase	Pressure Reduction
Solenoid Valve	Port "A" Open	Port "A" Close
	Port "B" Close	Port "B" Open
Cut Valve	Close	←
By-pass Valve	Normal Port Open	←



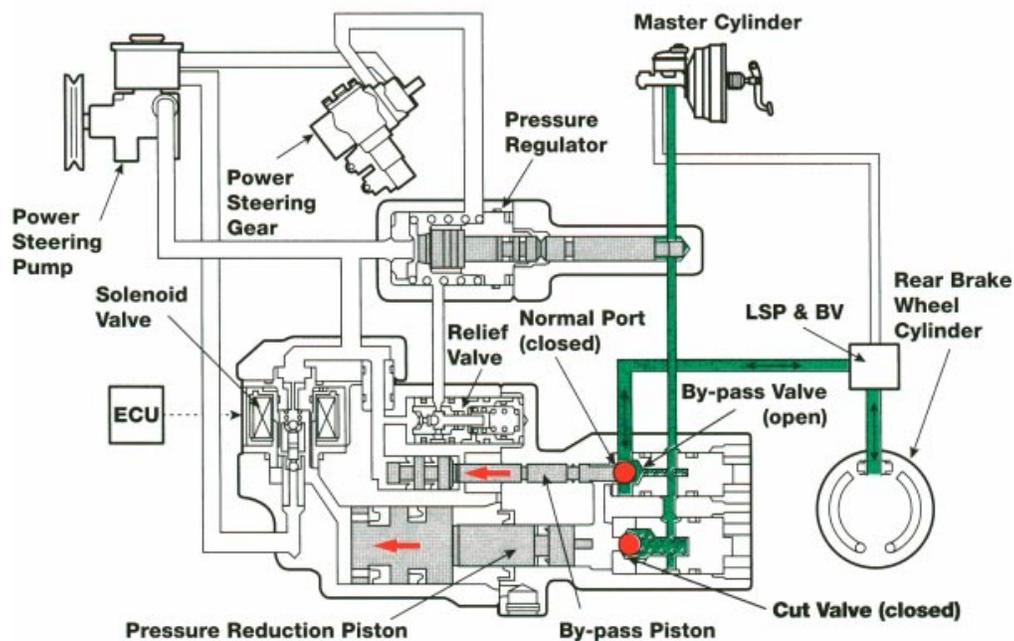
Fail-safe Mode In the event power steering fluid pressure is insufficient, the By-pass Piston and Pressure Reduction Piston move to the left by brake hydraulic pressure. This causes the Cut Valve and the Normal Port of the Bypass Valve to close. With the Normal Port closed, the By-pass Port is open allowing the master cylinder to apply pressure to the wheel cylinder.

In the event of a malfunction in the signal system to the ABS ECU, the solenoid relay is shut OFF. The spring loaded Solenoid Valve allows power steering pressure to move the Pressure Reduction piston and By-pass Piston to the right opening the Cut Valve. The brake system operates as a normal brake system without ABS.

Fail-safe Mode

Allows brake fluid to by-pass the actuator control in the event of power steering pressure loss.

Part Name	Operation
Cut Valve	Close
By-pass Valve	By-pass Port Open



Bleeding the Rear Wheel Antilock Brake System

Rear wheel ABS requires a special bleeding procedure when a component of the steering system or the actuator is replaced. A typical procedure is outlined here however, check the appropriate Repair Manual as procedures may vary:

- Bleed the power steering system using the conventional method.
- Bleed the brake system with the engine running.
- Bleed the brake system with the engine OFF.
- Bleed the power steering system using the brake actuator checker.

The conventional method of bleeding the power steering system requires that the reservoir be full.

- Run the engine at 1000 rpm or less.
- Turn the steering wheel from lock to lock three or four times.
- The fluid in the reservoir should not be foamy or cloudy indicating presence of air.

After the brakes are bled connect the ABS actuator checker.

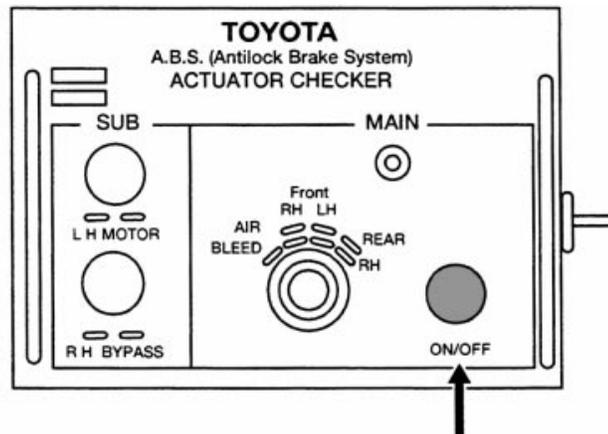
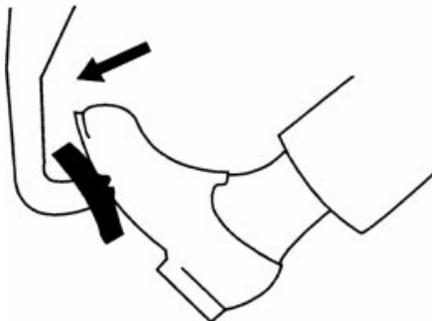
- Run the engine at idle.
- Turn the selector switch on the actuator checker to "AIR BLEED".
- Strongly depress the brake pedal and hold it.
- Push the ON/OFF switch five times for three seconds each time while holding the brake pedal down.

CAUTION

Do not press the ON/OFF switch before depressing the brake pedal and do not release the brake pedal while the ON/OFF switch is ON or damage to the master cylinder piston cups may occur.

Rear Wheel ABS Bleeding

Bleeding the ABS requires bleeding both the power steering system as well as the brake system.





Notes

A large grid area for taking notes, consisting of a fine grid of lines.