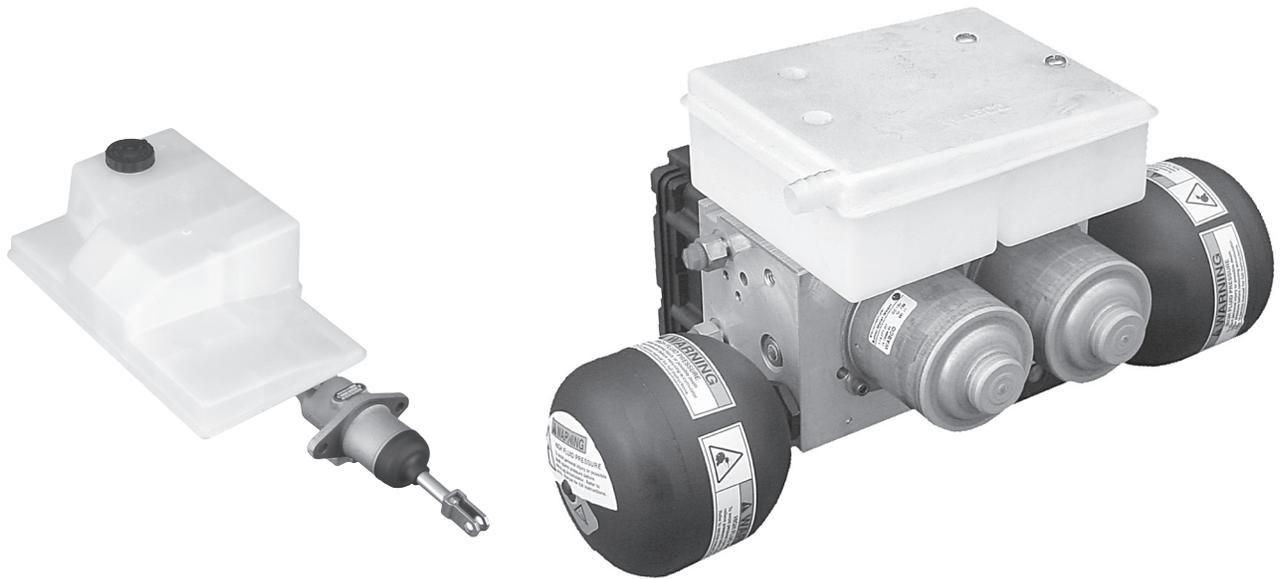




WABCO HYDRAULIC POWER BRAKE (HPB) SYSTEM

MAINTENANCE MANUAL



MM0401

WABCO

Table of Contents

Table of Contents

1	General Information.....	5
1.1	Symbols Used in this Document.....	5
1.2	How to Obtain Additional Maintenance, Service and Product Information.....	6
1.3	How to Obtain Parts and Kits.....	6
1.4	WABCO TOOLBOX PLUS™ Software.....	6
1.5	WABCO Academy.....	6
1.6	WABCO Online Product Catalog.....	7
1.7	Your Direct Contact to ZF CVS.....	7
2	Safety Information.....	8
2.1	Provisions for a safe work environment.....	8
3	Introduction.....	9
3.1	System Components.....	9
3.2	How the HPB System Works.....	13
4	Wiring Diagram.....	15
4.1	HPB Wiring Diagram for Multiplex Vehicles.....	15
4.2	HPB Connector Diagram for Multiplex Vehicles.....	16
4.3	HPB Wiring Diagram for Non-Multiplexed Vehicles.....	17
4.4	HPB Connector Diagram for Non-Multiplexed Vehicles.....	18
5	Troubleshooting and Testing.....	19
5.1	Testing the System.....	19
5.2	WABCO TOOLBOX™ Software.....	19
5.3	Hydraulic Power Brake Menus and Toolbars.....	20
5.4	Standard Testing.....	28
5.5	System Requirements and Component Tests.....	28
5.6	Checking Power, Ground and Load Test.....	29
5.7	Standard Component Testing.....	29
5.8	Vehicle Test Drive.....	30
5.9	Safety Features.....	30
5.10	Towing Procedure for Navistar CE Buses.....	31
5.11	Warning Lamps.....	32
5.12	SPN, SID, FMI Diagnostic Trouble Code List.....	34

Table of Contents

6	Removal and Installation.....	68
6.1	Hazard Alert Messages.....	68
7	Brake Bleeding Procedures.....	129
7.1	Hazard Alert Messages.....	129
7.2	Brake Bleeding Procedures.....	131
7.3	Pressure Bleed Procedures.....	131
8	Appendix.....	142
8.1	Leak Check Procedure for WABCO HPB System.....	142
8.2	System Test.....	143

Edition 1
Version 2 (02.2023)
MM0401 (en)

This publication is not subject to any update service. Information contained in this publication was in effect at the time the publication was approved for printing and is subject to change without notice or liability. ZF CV Systems North America LLC reserves the right to revise the information presented or to discontinue the production of parts described at any time.

You will find the current edition at: <https://zf.com/cvliterature>

General Information

1 General Information

1.1 Symbols Used in this Document

DANGER

Description of an immediate situation which will result in irreversible injury or death if the warning is ignored.

WARNING

Description of a possible situation which may result in irreversible injury or death if the warning is ignored.

CAUTION

Description of a possible situation which may result in irreversible injury if the warning is ignored.

NOTICE

Description of a possible situation which may result in material damage if the warning is ignored.

 Important information and/or tips

 Reference to information on the Internet

Descriptive text

– Action step

1. Action step 1 (in ascending order)

2. Action step 2 (in ascending order)

⇒ Result of an action

• Listing

 Indicating the use of a tool / WABCO tool

General Information

1.2 How to Obtain Additional Maintenance, Service and Product Information

If you have any questions about the material covered in this publication, or for more information about the WABCO product line, please contact WABCO Customer Care Center at 855-228-3203, by email at wabconacustomercenter@zf.com, or visit our website: www.zf.com/cv.

Refer to the following publications for more information on servicing WABCO's Hydraulic Power Brake (HPB) systems.

- MM38, Hydraulic ABS for Medium-Duty Trucks, Buses and Motor Home Chassis (C Version Hydraulic ABS)
- MM39, Hydraulic ABS for Medium-Duty Trucks, Buses and Motor Home Chassis (D Version Hydraulic ABS)
- MM0677, Hydraulic Anti-Lock Braking Systems (HABS) for Medium-Duty Trucks, Buses and Motor Home Chassis (E Version Hydraulic ABS)

Refer to the Society of Automotive Engineers (SAE) website to find all current SAE documents and standards applicable to WABCO products (such as SAE J447 and SAE J908 at www.sae.org).

Refer to the National Highway Traffic Safety Administration (NHTSA) website to find all current documents referenced in the manual at www.nhtsa.gov.

1.3 How to Obtain Parts and Kits

Contact the WABCO Customer Care Center at 855-228-3203 (United States and Canada); 800-953-0248 (Mexico) or email: wabconacustomercenter@zf.com.

1.4 WABCO TOOLBOX PLUS™ Software

TOOLBOX PLUS™ Software provides PC diagnostic for WABCO products and can be purchased and downloaded from <https://wabco.snapon.com>.

The software User Guide, MM19047 can be obtained by visiting our Literature Center.



Purchase and Download TOOLBOX PLUS™

<https://wabco.snapon.com>



ZF Commercial Vehicle Literature Center

<https://zf.com/cvliterature>

1.5 ZF [pro]Service



www.wabco-academy.com

General Information

1.6 WABCO Online Product Catalog



www.wabco-customercenter.com

1.7 Your Direct Contact to ZF CVS

ZF CV Systems North America LLC

1220 Pacific Drive
Auburn Hills, MI 48326

Customer Care Center: (855) 228-3203

<https://www.zf.com/products/en/cv/home/cv.html>

Safety Information

2 Safety Information

2.1 Provisions for a safer work environment

- Only experienced, trained and qualified automotive technicians should carry out work on the vehicle.
- Read this publication carefully.
- Follow all warnings, notices and instructions to help avoid personal injury and property damage.
- Always abide by the vehicle's Original Equipment Manufacturer (OEM) specifications and instructions.
- Observe all accident regulations of the repair facility as well as regional and national regulations.
- The workplace should be dry, sufficiently lit and ventilated.
- Use personal protective equipment if required (safety shoes, protective goggles, respiratory protection and ear protectors).

Read and observe all Danger, Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To help prevent serious eye injury, always wear eye protection when you perform vehicle maintenance or service.

WARNING

Park the vehicle on a level surface. Block the wheels to help prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip or fall over. Serious personal injury and damage to components can result.

WARNING

This product can expose you to chemicals including Nickel, which is known to the State of California to cause cancer and birth defects or other reproductive harm. For more information, go to www.P65Warnings.ca.gov.

Introduction

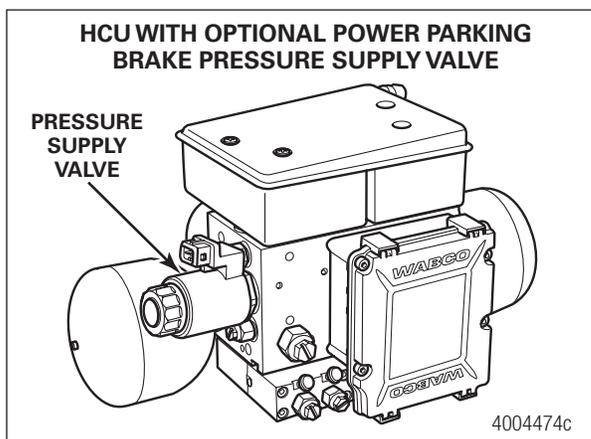
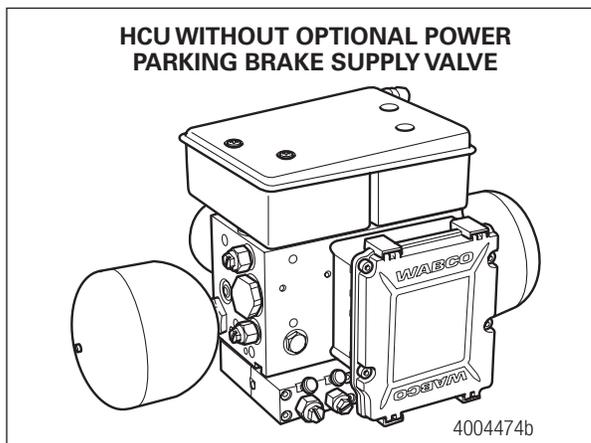
3 Introduction

WABCO's Hydraulic Power Brake (HPB) is a braking and vehicle control system for Business Class trucks, Classes 4 through 7, and buses that are equipped with hydraulic brakes. The HPB system is designed to provide the following functions:

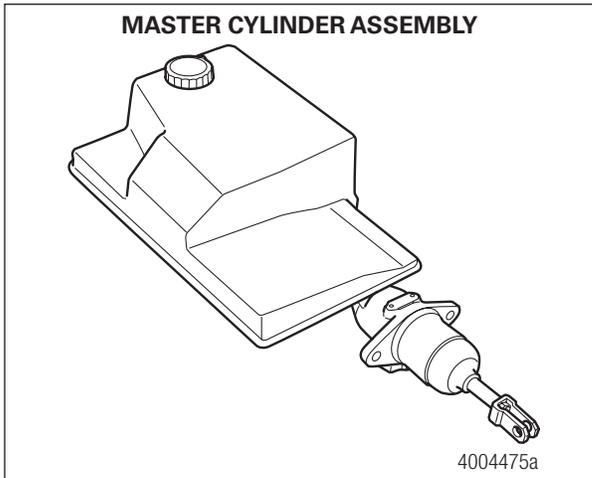
- Full power brake performance
- Brake control functions including Anti-Lock Braking System (ABS), Automatic Traction Control (ATC) and Electronic Brake force Distribution (EBD)
- Optional parking brake control

3.1 System Components

The HPB system consists of two main components — the Hydraulic Compact Unit (HCU) and a dual circuit master cylinder. The HPB system is also available with an optional parking brake pressure supply valve. The figures that follow illustrate the HPB system with and without the park brake supply valve as well as the master cylinder assembly.



Introduction



3.1.1 Hydraulic Compact Unit

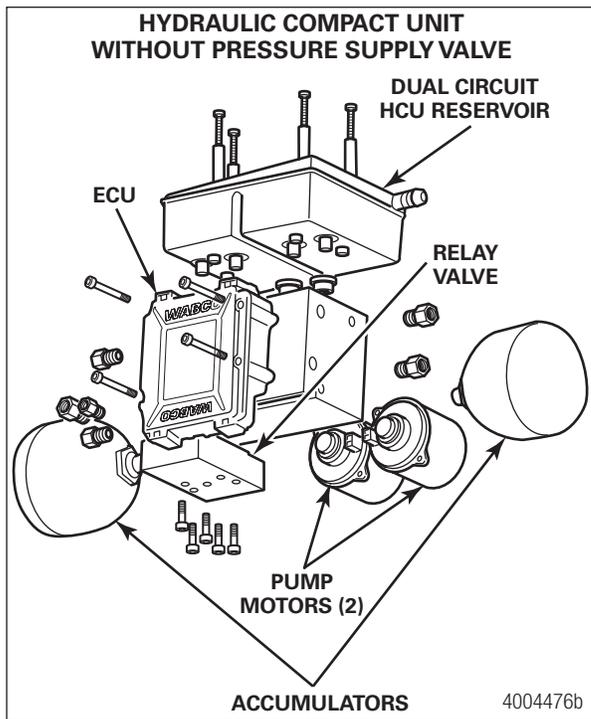
The HCU consists of an electronic control unit, two independent electric motors driving two piston pumps, two accumulators, a dual circuit fluid reservoir with integrated filters, pressure relief valves, solenoid valves and a dual circuit relay valve. The HCU is mounted to the vehicle frame rail with two brackets.

WARNING

Do not drive the vehicle if an HPB system failure has occurred. Loss of braking ability may occur, resulting in an accident and serious personal injury.

- The HCU generates the service brake pressure. Two pump motors drive the piston pumps to build hydraulic pressure. The pressure is stored in accumulators. The motors are not serviceable. The motors cannot be replaced without replacing the entire HCU.
- The accumulators are two gas-filled hydraulic accumulators. The accumulators store energy supplied by the pumps. Accumulators are sealed at the factory and are non-refillable. Accumulators may be replaced as a set without replacing the entire HCU.
- The ECU processes sensor signals and generates solenoid valve commands to reduce, maintain or increase brake pressure for control function. The ECU constantly monitors the pressure in the accumulators, using one pressure sensor per brake circuit. The ECU may be replaced without replacing the complete HCU.
- The optional pressure supply valve controls the Spring-Applied/ Hydraulic Released (SAHR) parking brake. The pressure supply valve is mounted on the HCU. The pressure supply valve may be replaced without replacing the entire HCU.
- The dual circuit HCU reservoir holds the hydraulic brake fluid. (The reservoir may be replaced without replacing the entire HCU.)
- The relay valve is mounted on the bottom of the HCU and may be replaced without replacing the entire HCU.

Introduction



3.1.2 Master Cylinder Assembly

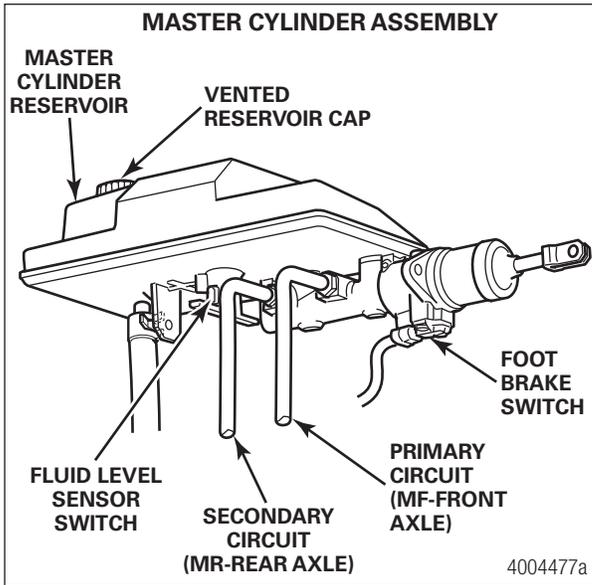
The dual circuit master cylinder in conjunction with a relay valve provides the translation of brake pedal force into hydraulic braking pressure, and sends the driver's demand signal to the HCU.

- The foot brake switch provides brake status to the ECU and eliminates the need for a brake light switch.
- The master cylinder reservoir holds the additional hydraulic brake fluid.
- The fluid sensor switch monitors fluid level in the master cylinder reservoir.
- The master cylinder reservoir and both master cylinder switches may be replaced without replacing the entire master cylinder.
- The master cylinder cap provided by ZF contains a special gore material that allows the reservoir to breathe, and serves as a filter to help prevent contaminants from getting into the reservoir. This is the only cap approved for use with WABCO HPB.



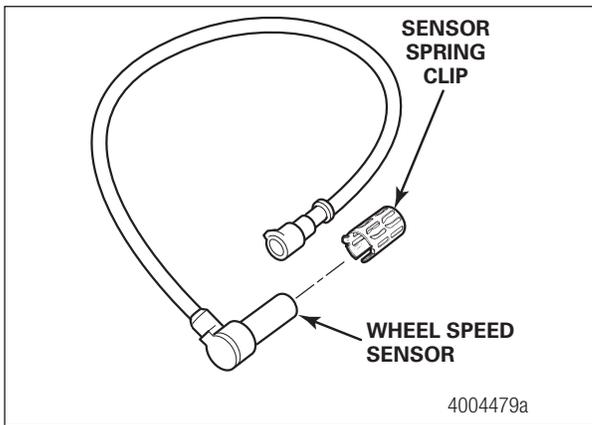
The ability of the master cylinder cap to breathe is critical to help correct brake system function. If the cap becomes contaminated, it will need to be replaced.

Introduction



3.1.3 Wheel-End Sensors

A ZF wheel speed sensor is installed at each wheel whose speed is to be monitored. These sensors generate electronic signals which are sent to the ECU. A sensor spring clip holds the wheel speed sensor in place. The sensor and sensor clip must be lubricated before installation and whenever wheel-end maintenance is performed.



3.1.4 TOOLBOX™ Software

TOOLBOX™ Software is a PC-based diagnostics program required to diagnose HPB system faults. For HPB, version 12.2 or higher is recommended. TOOLBOX™ Software is available at <https://wabco.snapon.com>.



Introduction

3.1.5 Low Pressure Hose

The Removal and Installation section of this manual contains service information for a low pressure hose which is not produced by ZF but is an integral part of the HPB system. Please contact the OEM for more information.

3.1.6 Spring-Applied Hydraulic Release (SAHR) Parking

ONLY APPLICABLE TO NAVISTAR VEHICLES



The SAHR canister is not produced by ZF and is an optional feature. Please consult the OEM for maintenance and service information. Refer to Navistar publication TSI-08-04-01.

On vehicles equipped with hydraulic parking brakes, the SAHR canister controls the force applied to the parking brake cable. Internal springs are used to apply tension to the parking brake cable, which applies the parking brake. When pressurized brake fluid is routed to the SAHR canister, the hydraulic pressure overcomes the internal springs to relax the parking brake cable, which releases the parking brake. The SAHR parking brake canister is typically located inside the driver's side frame rail, forward of the rear axles.

Vehicles not equipped with hydraulic parking brakes have mechanical or air (Spring Applied Air Released, SAAR) parking brakes. Please consult the OEM for maintenance and service information.

WARNING

Never drive the vehicle if the parking brake cable is disconnected or if the parking brake system is not operating correctly. Driving the vehicle without a correctly functioning parking brake system can result in an accident and serious personal injury.

3.1.7 Parking Brake Switch

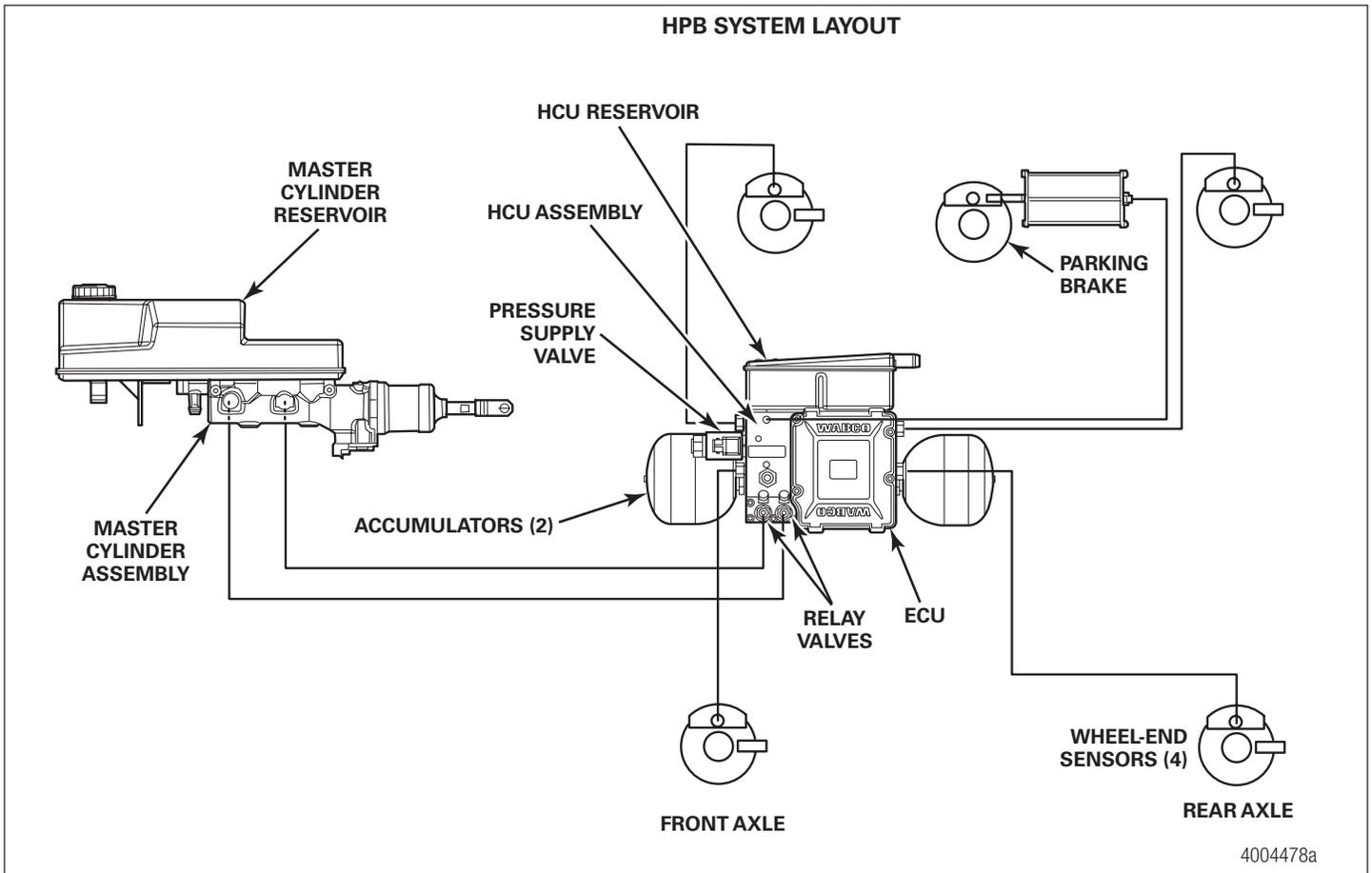
The parking brake switch (optional) is a three-position electrical switch (apply, neutral and release). It controls the driver-requested operation of the parking brake.

3.2 How the HPB System Works

WABCO's HPB system is designed to provide the energy required to actuate the brakes and control the electronic brake force distribution (EBD), ABS and ATC functions. The HCU is activated each time the ignition is turned on or whenever the driver steps on the brake pedal. If the system is equipped with the optional power park brake, the HCU also supplies the energy to release and control the service and park brakes.

The WABCO HPB system for trucks is shown below. A complete HPB system layout, with hydraulic brake lines, appears in the Appendix.

Introduction



3.2.1 Functional Description

Hydraulic energy is stored in the gas-filled hydraulic accumulators, one for each circuit. When the vehicle's ignition is turned on, internal pumps are activated and fill both accumulators with pressurized hydraulic brake fluid. Two internal sensors, one for each accumulator, measure pressure and the ECU continuously monitors and controls pressure.

During normal operation, the ECU actuates two separate power drivers for the electric motors, keeping the pressure level within the system at desired limits. Two pressure relief valves to help ensure safety against over pressurization.

When the brake pedal is applied, the master cylinder provides a hydraulic signal to the relay valve. Proportional to that signal, the accumulators release pressure to the brake calipers. When the pedal is released, brake fluid returns from the brake calipers to the reservoir, and line pressure is reduced to zero.

For ABS, wheel pressure is individually modulated by eight integrated ABS solenoid valves in the ECU/HCU.

For ATC, the normally closed ATC solenoid valve in the ECU is actuated and hydraulic energy is supplied to the sensed wheel. At the same time, the normally open ATC valve is actuated to prevent fluid flow back into the reservoir. The brake pressure is then modulated by the corresponding ABS solenoid valves.

WARNING

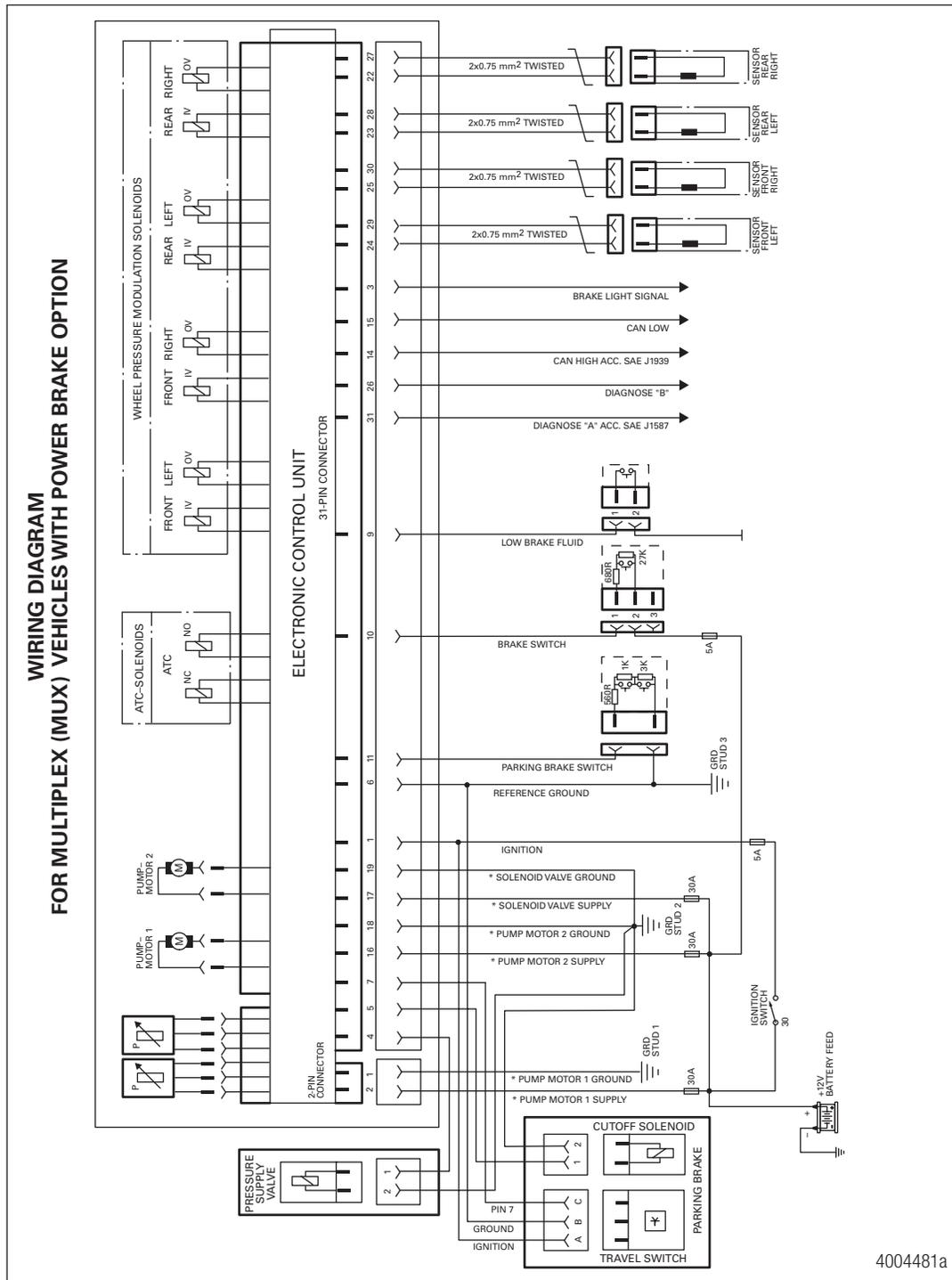
Do not install any "add-on" hydraulic devices to the HPB system. A loss of braking ability may occur, resulting in an accident and serious personal injury.

Wiring Diagram

4 Wiring Diagram

4.1 HPB Wiring Diagram for Multiplex Vehicles

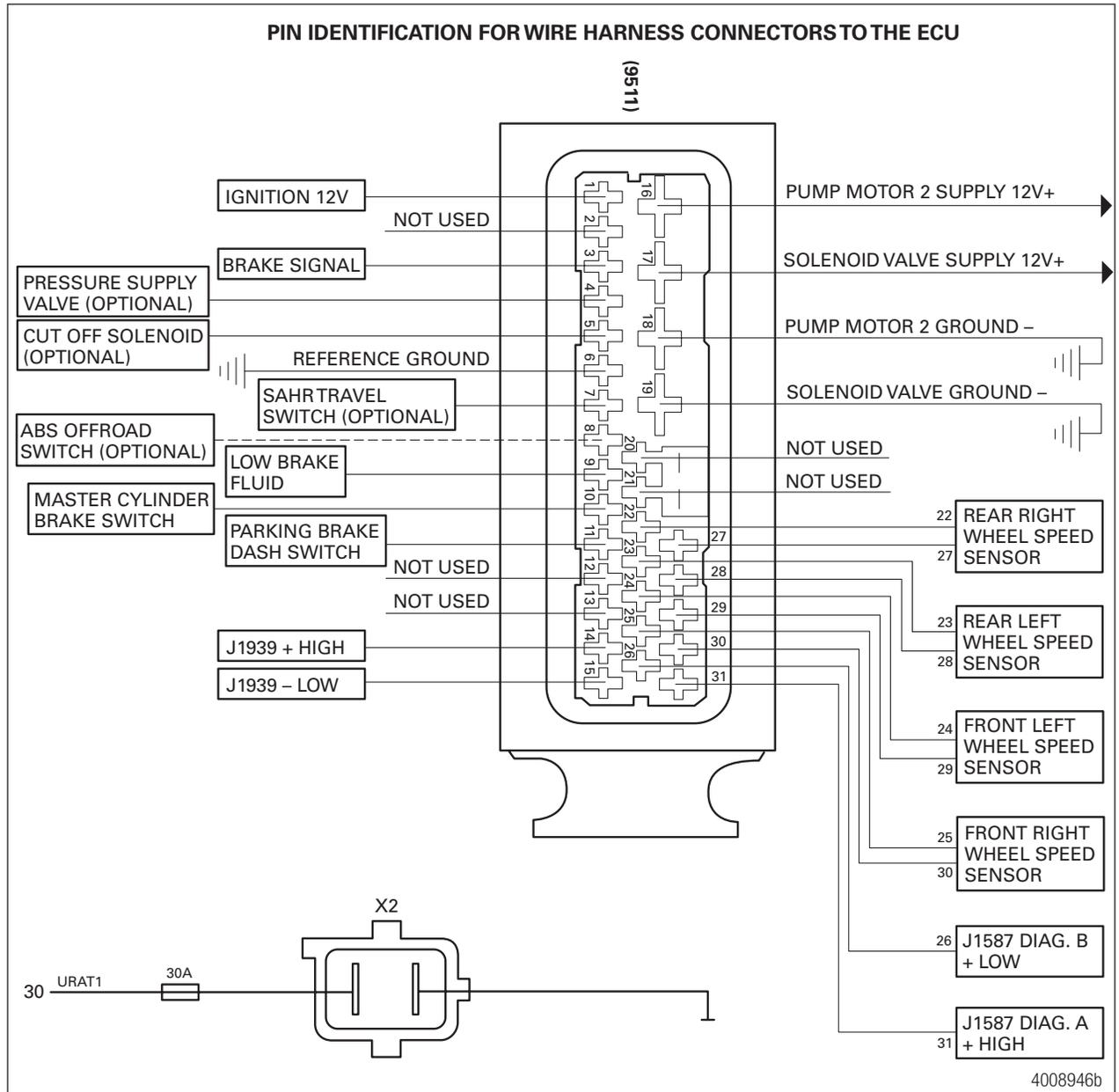
The WABCO HPB electronic control unit interface wiring diagram for multiplex vehicles as shown.



Wiring Diagram

4.2 HPB Connector Diagram for Multiplex Vehicles

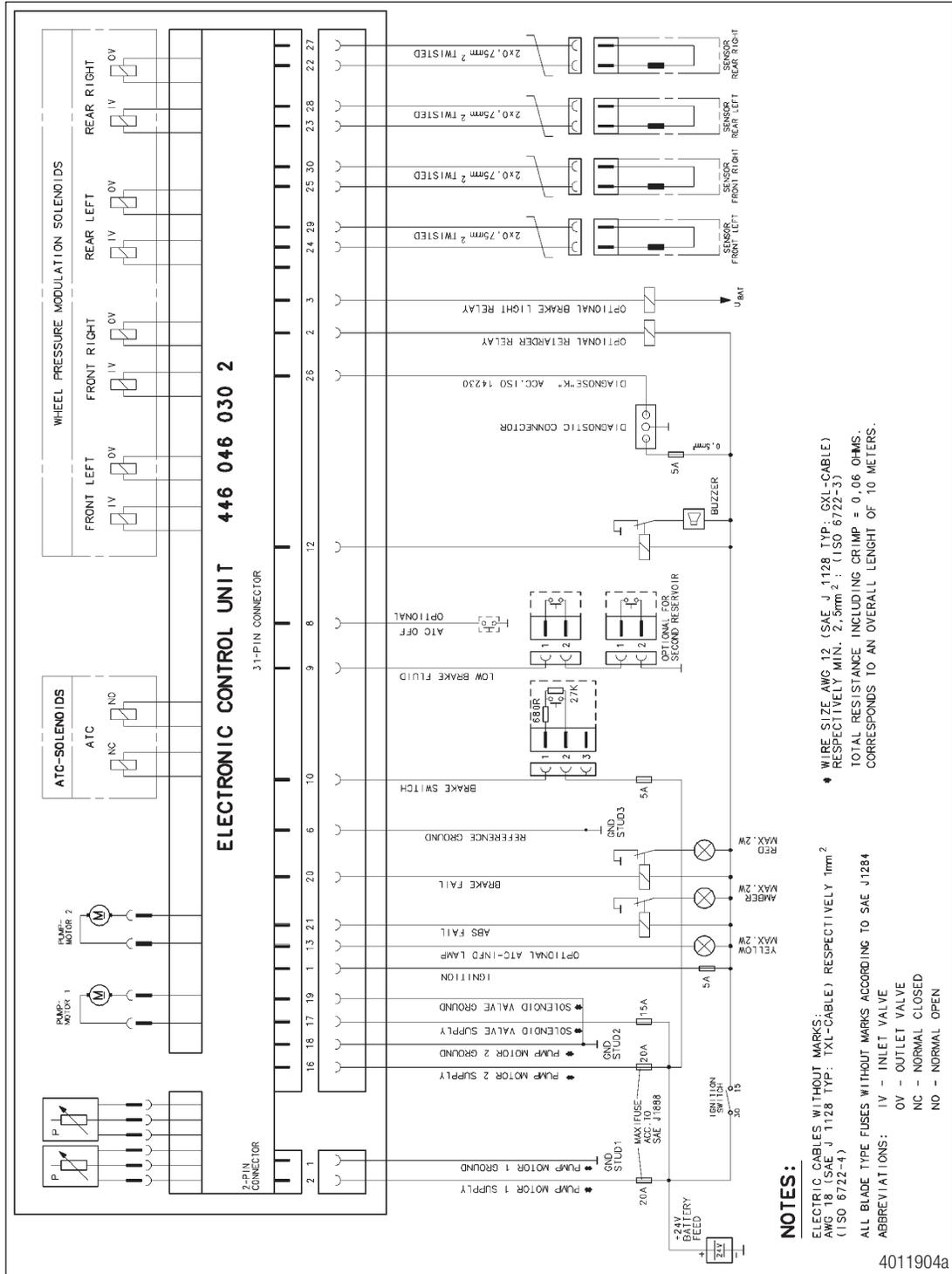
The WABCO HPB electronic control unit interface connector diagram for multiplex vehicles as shown.



Wiring Diagram

4.3 HPB Wiring Diagram for Non-Multiplexed Vehicles

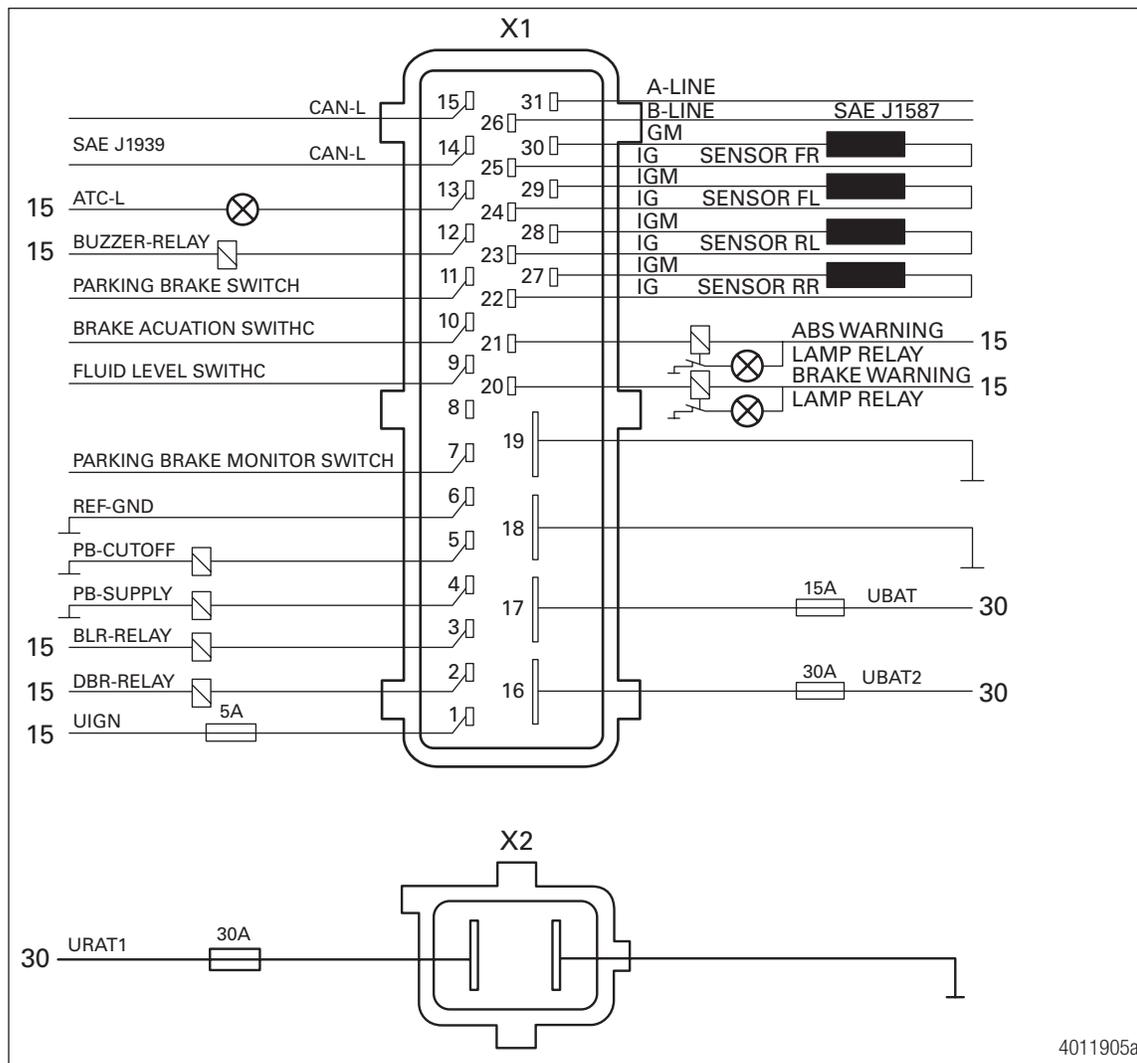
The WABCO HPB electronic control unit interface wiring diagram for non-multiplexed vehicles as shown.



Wiring Diagram

4.4 HPB Connector Diagram for Non-Multiplexed Vehicles

The WABCO HPB electronic control unit interface connector diagram for multiplex vehicles as shown.



Troubleshooting and Testing

5 Troubleshooting and Testing

5.1 Testing the System

This section contains information for testing the HPB system with TOOLBOX™ Software, and for performing standard component and electrical tests.

WARNING

To help prevent serious eye injury, always wear eye protection when you perform vehicle maintenance or service.

WARNING

Exhaust gas contains poison. When testing a vehicle with the engine running, test in a well-ventilated area or route the exhaust hose outside.

WARNING

To help avoid serious personal injury, keep away, and keep test equipment away, from all moving or hot engine parts.

WARNING

To help avoid unwanted vehicle movement when testing, set the parking brake and place the gear selector in NEUTRAL (manual transmission), or PARK (automatic transmission) unless otherwise directed. Failure to do so may result in serious personal injury.

WARNING

Do not drive the vehicle if the parking brake cable is disconnected or if the parking brake system is not operating correctly. Driving the vehicle without a correctly functioning parking brake system can result in an accident and serious personal injury.

Refer to, and follow, the vehicle manufacturer's Warnings, Cautions and service procedures.

5.2 WABCO TOOLBOX™ Software



The HPB system does not have blink code capability and WABCO TOOLBOX™ Software is needed to communicate with the system.

Use TOOLBOX™ Software to obtain Diagnostic Trouble Codes (DTC) and verify the activation of various system components.

- Turn valves, pump and retarder relay (if available) on and off (Valve Activation Menu)
- Turn indicator lamps on and off (Miscellaneous Output Activation Menu)



To obtain TOOLBOX™ Software, go to <https://wabco.snapon.com>.

Troubleshooting and Testing

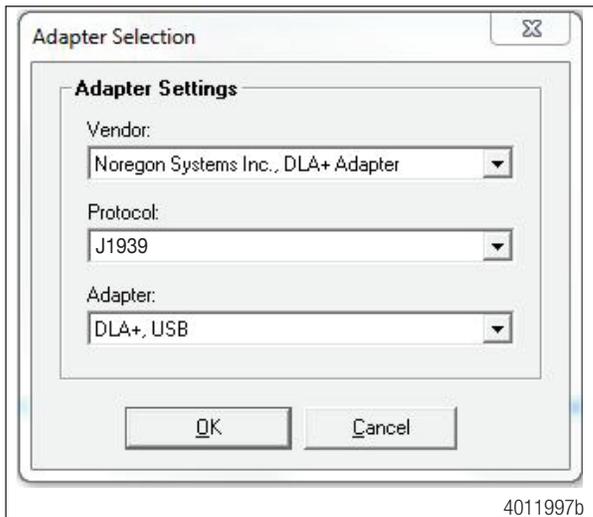
5.2.1 Connecting TOOLBOX™ Software

To connect TOOLBOX™ Software to the vehicle, a RP1210A compliant device will be needed. Once TOOLBOX™ Software is connected and open, verify the adapter settings are correct.

To access “Adapter Selection” for TOOLBOX™ Software 12.2 or higher, click on “Utilities” from the main TOOLBOX™ page or under “System Setup” in “J1707 TOOLBOX” from the main TOOLBOX page.

To access Adapter setting for TOOLBOX Plus, select Adapter Button from main screen.

Make sure the “Vendor:” and “Adapter:” drop-downs are set for the device being used and set the “Protocol:” drop-down to J1708, and click “OK”.



When switching between J1939 and J1708 communications, vehicle ignition must be cycled between sessions to correctly communicate with ECU.



TOOLBOX™ Software must be connected to the vehicle and the vehicle ignition must be ON in order to display information.

If unable to communicate with the ECU:

- Verify device and data link connections are secure.
- Verify the device is RP1210A compliant and that the comport settings (Vendor, Protocol, Adapter) in TOOLBOX™ Software are correct.
- Verify the device software and firmware is up to date.
- Check all the powers and grounds coming to the ECU including load testing.
- Check J1587 circuit at the ECU and the data link connector.

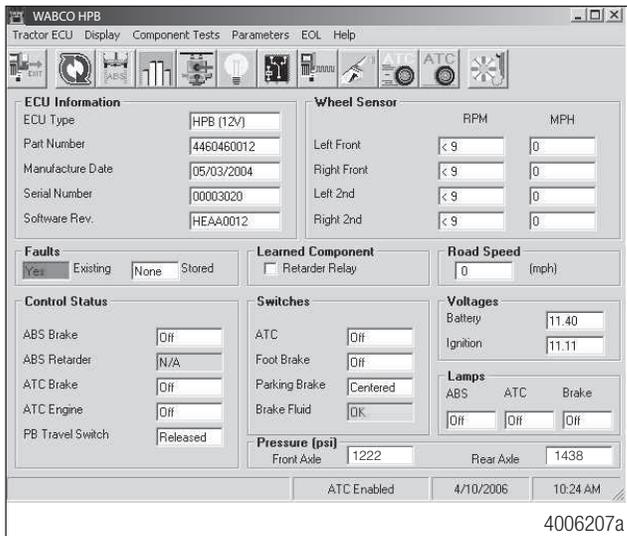
5.3 Hydraulic Power Brake Menus and Toolbars

Select Hydraulic ABS from the TOOLBOX™ Software 12.2 or higher **Main Menu**. TOOLBOX™ Software senses the type of ECU being used and displays the **HPB Main Screen**. For TOOLBOX Plus, select Hydraulic ABS for the left menu under Truck/Tractor/Bus J1708.

Troubleshooting and Testing

5.3.1 Main HPB Screen

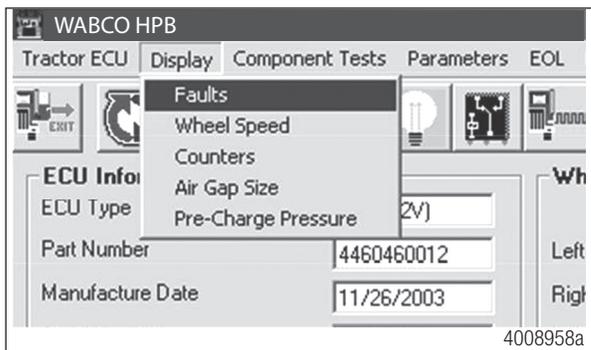
This screen provides icons and pull-down menu task selections. It also provides information about the current status of WABCO HPB.



ECU information is read once from the ECU and does not change. All other information (e.g., wheel sensors, voltages and fault information) is read and updated continuously.

5.3.2 Display

Select **Display** from the **HPB Main Screen**. A pull-down menu will appear.



5.3.3 Faults

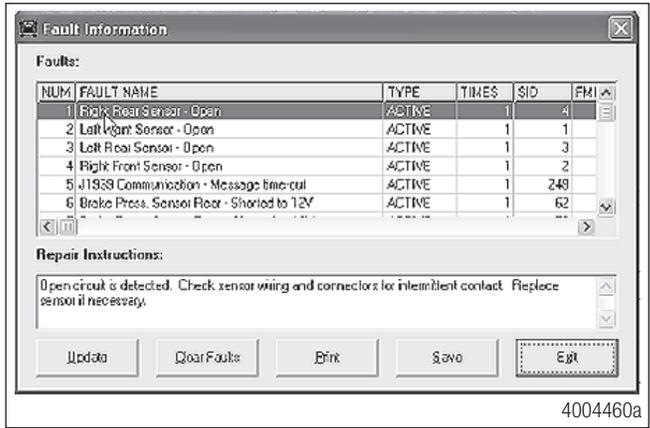
WARNING

Do not drive the vehicle if active faults are present. Driving the vehicle with active faults present can result in an accident and serious personal injury.

Select **Faults** to display the **Fault Information** screen.

Troubleshooting and Testing

i The **Fault Information** screen is also accessible from the **HPB Main Menu**.



The **Fault Information** screen contains a description of each fault, including the type of fault (Active or Stored), SID and FMI number. Repair instructions for the fault appear at the bottom of the screen.

Faults that occur after the screen is displayed will not appear until a screen update is requested. Use the Update button at the bottom of the screen to refresh the fault information table and display a new list of faults.

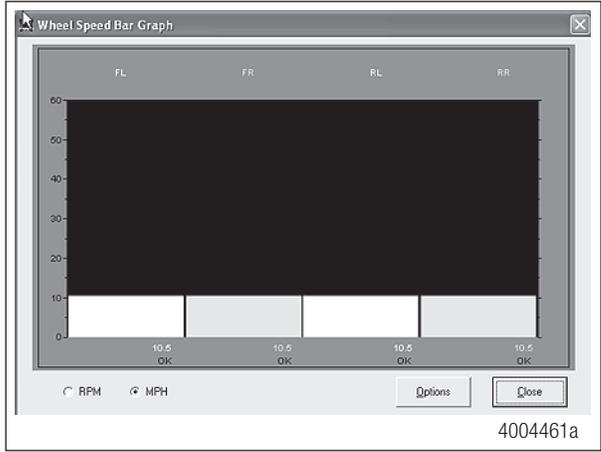
After making any required repairs, use the Clear Faults button to clear the fault. Clear each fault as it is repaired. The Update button should be used after all faults are repaired. Cycle the ignition after clearing the faults.

i When all faults are cleared, you need to drive the vehicle above 5 mph before the ABS light will go out.

Use the **Save** or **Print** button to save or print the fault information data. Select **Exit** to close this section.

5.3.4 Wheel Speed

Select **Wheel Speed** to display the **Wheel Speed** screen.

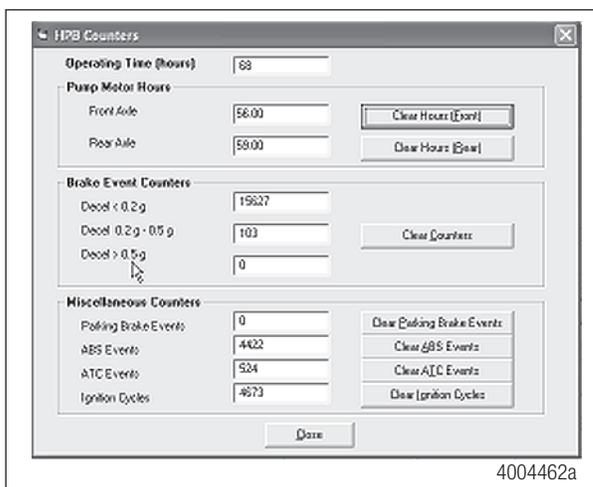


Troubleshooting and Testing

Use the **Wheel Speed** screen to verify that sensors are connected at each wheel. Speed at a sensed wheel (FL, FR, RL, RR) indicates sensors are installed, but does not verify correct sensor installation. Wheel speed sensor installation information is available in the Removal and Installation section.

5.3.5 Counters

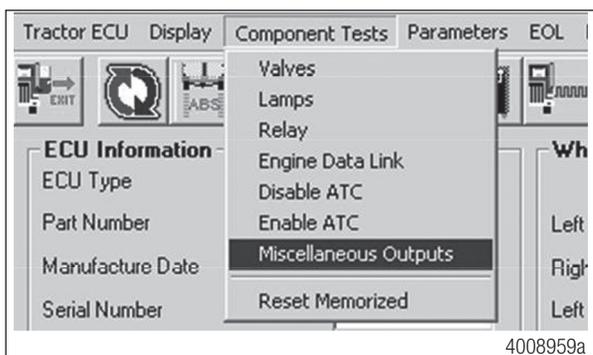
Select **Counters** to display the **Counters** screen.



The **Counters** screen provides an overview of HPB component performance (pump hours, brake events, etc.) as well as general vehicle activity such as ignition cycles. Occurrences displayed on this screen accumulate until the **Clear** button is selected.

5.3.6 Component Tests

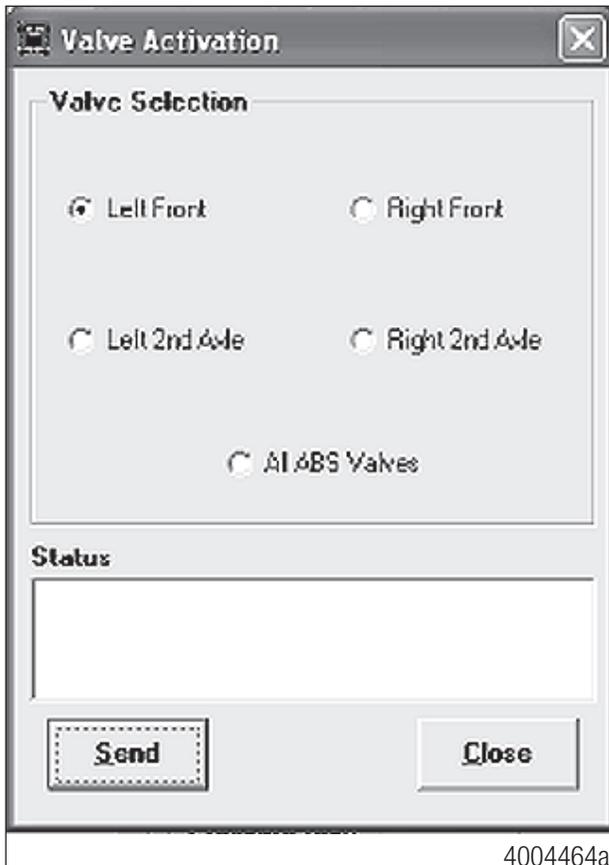
Select **Component Tests** from the HPB **Main Screen**. A pull-down menu will appear.



Troubleshooting and Testing

5.3.7 Valves

Select **Valves** to display the **Valve Activation** test screen.

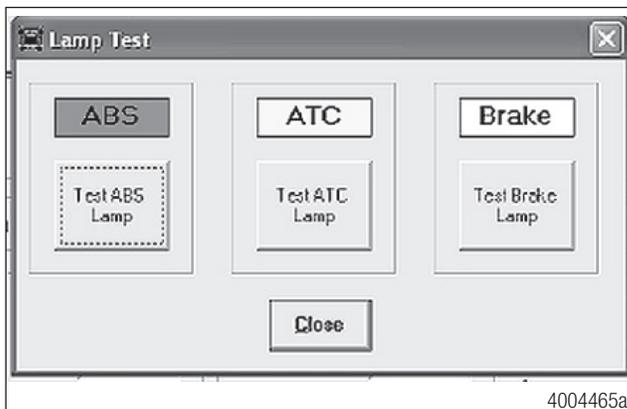


The **Valve Activation** test screen lets you activate the HPB valves to check for correct activation and to verify correct brake line installation.

Click on the valve you wish to test, then click the **Send** button to actuate the component. Component activation status appears in the **Status** box field. Select **Close** to exit this screen.

5.3.8 Lamps

Select **Lamps** to display the **Lamp Test** screen.



Troubleshooting and Testing

As each lamp is tested, check the actual lamp to verify correct operation. Select **Close** to exit this screen.

5.3.9 Parking Brake

WARNING

Park the vehicle on a level surface. Block the front and rear wheels to prevent vehicle movement. Failure to do so can result in unwanted vehicle movement causing serious personal injury.

Select **Parking Brake** to display the **Parking Brake** test screen.

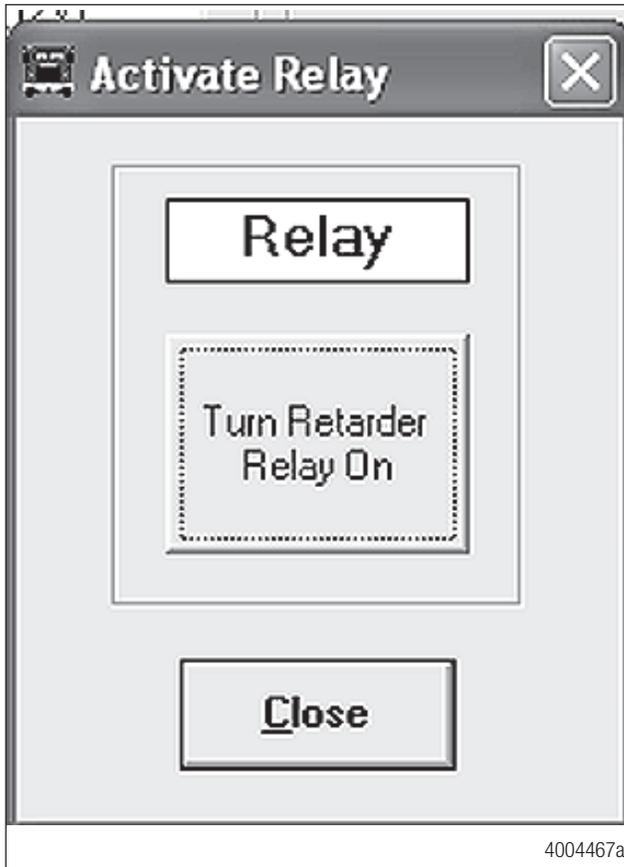


Select **Release** or **Apply**, then select **Send** to test the parking brake. Select **Close** to exit this screen.

Troubleshooting and Testing

5.3.10 Relay (Only on Non-Multiplex Vehicles)

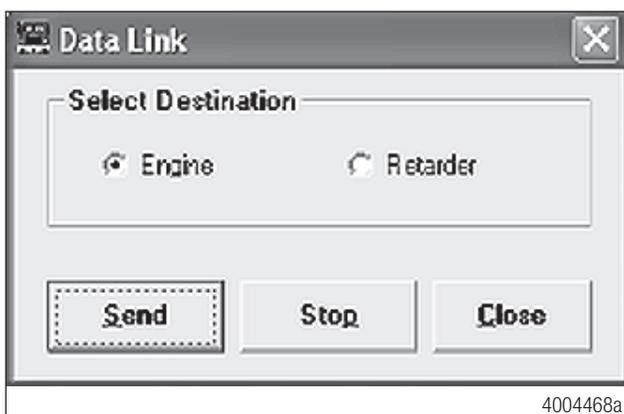
Select Relay to display the Activate Relay test screen.



This screen allows you to turn the retarder relay on or off. This is helpful in verifying correct operation, installation and wiring of the unit under test. Select **Close** to exit this screen.

5.3.11 Engine Data Link

Select **Engine Data Link** to display the **Data Link** test screen.



This screen allows you to send a "limit engine torque" command to the engine or a "disable retarder" command to the retarder.

Troubleshooting and Testing

Select the data link destination (engine or retarder), then select **Send** to test. Use the **Stop** button to end testing. Select **Close** to exit this screen. The vehicle must be running with the engine RPM increased (1000-1500 RPM) in order for this function to work.

5.3.12 Disable ATC

Select **Disable ATC** to send a command to the ECU to disable automatic traction control. ATC will remain disabled until the enable command is sent, or until the vehicle ignition is cycled. ATC must be disabled for dynamometer testing.

5.3.13 Enable ATC

Select **Enable ATC** to send a command to the ECU to enable automatic traction control. This is the normal state of the ECU.



The status bar on the HPB Main Menu reflects the current ATC status (enabled, disabled or not available).

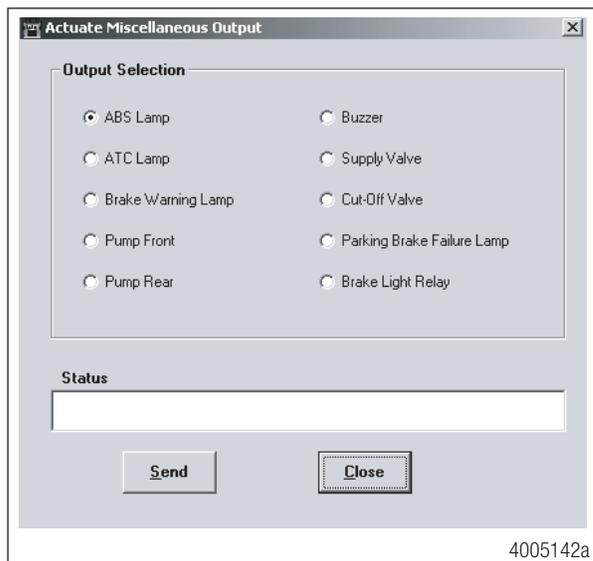
5.3.14 Miscellaneous Outputs

Select **Miscellaneous Outputs** to display the **Activate Miscellaneous Outputs** test screen.



The status bar on the HPB Main Menu reflects the current ATC status (enabled, disabled or not available).

Use TOOLBOX™ Software to test the following components: Retarder Relay (if available), Brake Light Relay (if available), Supply Valve, Cut-Off Valve, ABS Lamp, Traction Lamp, Brake Warning, Pump Front, Pump Rear, Buzzer.



This screen provides a check of several HPB components, as well as a way to check either inlet or outlet activity of the valves, pump or retarder relay.

Troubleshooting and Testing

Highlight the component you wish to test, then select the **Send** button to actuate the component. Component activation status appears in the **Status Box** field. Select **Close** to exit this screen.

5.3.15 Reset Memorized

Select **Reset Memorized** to display the **Learned Component** screen.



Relay is an automatic default and cannot be de-selected. It indicates the ECU has memorized the installed retarder relay. Once the ECU has seen a retarder, it expects to see it every time the vehicle is powered up.

5.4 Standard Testing

5.4.1 Test Equipment: Volt-Ohm Meter (VOM)

Use of a VOM with automatic polarity sensing is recommended. This eliminates the concern of the polarity of the meter leads during voltage measurements.

5.5 System Requirements and Component Tests

5.5.1 Tire Range Size

⚠ WARNING

For correct hydraulic ABS operation, front and rear tire sizes must be within 16% of each other. Do not use a tire size range that exceeds 16%. Failure to do so may cause reduced braking force and result in serious personal injury.

Calculate the tire size with the following equation:

$$\% \text{ Difference} = \left\{ \frac{\text{RPM Steer}}{\text{RPM Drive}} - 1 \right\} \times 100$$

RPM = tire revolutions per mile

Troubleshooting and Testing

5.6 Checking Power, Ground and Load Test

CAUTION

When troubleshooting or testing the ABS, be careful not to damage the connector terminals. If connector terminals are damaged, they must be replaced.

There are 2 connectors at the HPB ECU, a 2-pin connector and a 31-pin connector. When checking power and ground for any of the ECU circuits, it is recommended to check all the power and ground circuits as there are redundant powers and grounds.

Disconnect the 2-pin and 31-pin connectors and verify all the lock tabs are intact, check for any signs of damage, moisture or corrosion.

5.6.1 Ground Checks

Check all the ground wire circuits, with the key off, disconnect the 2-pin and 31-pin connectors and in the 2-pin harness connector check resistance to ground pin 1 and in the 31-pin harness connector check resistance to ground pins 6, 18, 19. All readings should be less than 1 ohm, if the readings are not in spec, you may need to review wiring diagnostics and repair with the OEM.

5.6.2 Voltage Checks

Check all the power wire circuits, with the key off, disconnect the 2-pin and 31-pin connectors. In the 2-pin harness connector, check voltage to ground pin 2 and in the 31-pin harness connector, check voltage to ground pins 1, 16, 17. All readings should be approximately 12 volts, except pin 17. There should be no voltage key off. With the key on, recheck voltage at pin 2 of the 2-pin connector and pins 1, 16, 17 of the 31-pin connector. All readings should be approximately 12 volts. If the readings are not in spec, indicating that you may need to review wiring diagnostics and repair with the OEM.

5.6.3 Load Test

A compromised wire or circuit may still be able to provide resistance and voltage readings that would be within specification for a Digital Volt Ohm Meter or test light, but might not be capable of handling enough current to allow the system to function correctly. To make sure of the integrity of the wire or circuit, a load test is necessary. With the key on load, test across pins 1-2 of the 2-pin harness connector and pins 1-6, 16-18, 17-19 of the 31-pin harness connector with a device that will draw about 5 amps (such as a Sealed Beam headlight) for approximately 10 seconds. The headlamp should be bright, if the lamp does not light, is dim or flickers, it would indicate an issue with the wiring, and you may need to review wiring diagnostics and repair with the OEM.

5.7 Standard Component Testing

5.7.1 Indicator Lamps

If the indicator lamps do not come on after the ignition is turned on, or it comes on but does not go out after three seconds, check all ABS fuses or circuit breakers and replace if necessary. After checking the indicator lamps, make repairs as necessary.

Troubleshooting and Testing

5.7.2 Sensor Adjustment

On steering axles, the sensor is typically accessible on the in-board side of the steering knuckle.

On drive axles, the sensor is typically accessible on the in-board side of the rear axle spindle.

To adjust the sensor, push the sensor in until it contacts the tooth wheel.

- Do not pry or push sensors with sharp objects.
- Sensors will self-adjust during wheel rotation.



There should be no gap at installation. During normal operation, the gap should not be greater than 0.04-inch (1.02 mm).

5.8 Vehicle Test Drive

After replacing an HPB component, use TOOLBOX™ Software to ensure there are not active faults, then test drive the vehicle as follows:

1. Turn ignition ON.



Depending on the vehicle, the ATC lamp may be labeled differently and some vehicles may not have an ATC lamp. Refer to the vehicle specification sheet for label designation.

2. Check the vehicle dash lamps:

- Most of the dash lamps for HPB come on briefly (approximately three seconds) for a bulb check, then go off. This indicates the system is O.K.
- If the ABS and ATC lamps do not go off within 3 seconds after turning the ignition ON, the system is looking for a wheel speed test. Drive the vehicle at speeds of 5-10 mph (8-16 km/h). The ABS and ATC lamps will then go off if the system is O.K.
- If the ABS and ATC lamps do not go off after the vehicle reaches a speed of 5-10 mph (8-16 km/h), this indicates there is a system fault. Perform vehicle diagnostics and make all of the necessary repairs, including appropriate bleed procedures, before returning the vehicle to service.

WARNING

Do not drive the vehicle if active faults are present. Driving the vehicle with active faults present can result in an accident and serious personal injury.

3. After all active faults have been alleviated, drive the vehicle for a short distance. Make gentle brake applications to verify brake performance.

5.9 Safety Features

5.9.1 Limp Mode

The HPB system has a feature known as “Limp Mode” In the event that power is lost at the 31-pin ECU connector or the 31-pin connector has become dislodged, power for emergency foundation braking can still be provided through the 2 pin ECU connector.

Troubleshooting and Testing

5.9.2 Dynamic Park Brake Application, If Equipped with the Hydraulic Park Brake System

In the event that the HPB system should lose all power and pressure, the park brake will automatically apply, while moving or at rest.

5.9.3 Interlocks, If Equipped with the Hydraulic Park Brake System

The HPB system with the hydraulic park brake feature may not allow the park brake to be released unless certain interlock messages are received, such as a door being left open or a wheel chair lift that is not seated correctly in the stored position. Review interlock operation and diagnostics with the OEM.

5.10 Towing Procedure for Navistar CE Buses

5.10.1 Towing Preparation: Hydraulic Powered Parking Brakes

If battery power is available:

1. Place the transmission in "N" Neutral and turn the ignition switch to the ON position.
2. While depressing the brake pedal, push and hold the Parking Brake knob to release the parking brake. If battery power has been lost, the Parking Brake cable will have to be disconnected by following the steps below.

If battery power has been lost:

Use the following procedure to disconnect the Parking Brake cable.

CAUTION

While removing the parking brake cable, only the threaded rod should rotate. If the cable is to be reused, do not allow the cable to twist during removal.

1. Block the wheels, place the transmission in "N" Neutral, and turn the ignition switch to the OFF position.
2. While using a 15 mm wrench to hold the SAHR canister shaft, loosen the jam nut on the threaded rod with a 16 mm wrench.
3. While using the 15 mm wrench to hold the canister shaft, unscrew the threaded rod using an 8 mm wrench. The rod must be unscrewed approximately 2.5 inches before the cable disconnects. The cable will exhibit some resistance while being unscrewed because it is under tension.

5.10.2 Towing Vehicle with Front Wheels Suspended

When it is necessary to tow a vehicle with the front wheels suspended, extra precautions must be taken to help avoid transmission or differential damage.

Disconnect the axle shafts at the rear axle to help prevent the wheels from driving the differential and the transmission. If axle shaft is not disconnected, remove the rear axle shafts from the axle assembly. Cover the wheel hub ends to help prevent loss of axle lubricant and entrance of contaminants.

Troubleshooting and Testing

5.10.3 Towing Vehicles with Rear Wheels Suspended

Whenever possible, it is preferable to tow a disabled vehicle from the rear by raising the rear of the chassis. When towing a vehicle with the rear of the chassis suspended, the front wheels must be locked in the straight ahead position.

5.11 Warning Lamps

INDICATOR LAMP	LAMP STATUS	SYSTEM CONDITION BEING INDICATED	RECOMMENDATION
BRAKE/BRAKE PRESSURE Note: Indicator differs by model year	STEADY ON and buzzer on	Half brake system failure. One of the two brake circuits is not generating pressure or is not generating pressure at the proper rate. Braking force from the Hydraulic Power Brake may be reduced or impaired. Use Parking Brake if necessary.	Immediately find a location to safely park the vehicle. When safely off the road and stopped, turn off ignition and ensure the vehicle transmission is in the park position. Apply Parking Brake. Do not drive until the failure has been repaired.
	FLASHING or STEADY ON* and buzzer on (*depending on model)	Full brake system failure. Both brake circuits are not generating pressure or are not generating pressure at the proper rate. Braking force from the Hydraulic Power Brake may be reduced or impaired. Use Parking Brake if necessary.	Immediately find a location to safely park the vehicle. When safely off the road and stopped, turn off ignition and ensure the vehicle transmission is in the park position. Apply Parking Brake. Do not drive until the failure has been repaired.
	OFF	System pressures are in normal operating range.	—
BRAKE FLUID	STEADY ON	Brake fluid level detected in the Master Cylinder is at or above MIN mark.	—
	OFF		Service information will display raise and lower pressures if the lift axle function is active.
ABS	STEADY ON	An ABS related fault has been detected by the ECU. The advantages provided by ABS may not be fully available.	Have vehicle repaired as soon as possible.
	OFF	No ABS related faults detected.	—
TRAC CTRL	STEADY ON	A Traction Control related fault has been detected – OR- A Traction Control event is occurring due to spinning wheels and the system is operating correctly.	If the lamp remains on for over 10 seconds, there is a high likelihood of a fault in the traction control system. Have vehicle repaired as soon as possible.
	FLASHING	Mud and Snow mode was selected using the traction control switch (switch indicator lit)	—
	OFF	ATC is operating correctly, the Mud and Snow mode has not been selected and the vehicle is not experiencing an ATC event.	—

Troubleshooting and Testing

INDICATOR LAMP	LAMP STATUS	SYSTEM CONDITION BEING INDICATED	RECOMMENDATION
PARK BRAKE	STEADY ON	Park Brake is applied.	—
	OFF	Park Brake is not applied.	—
SERVICE PARK BRAKE	FLASHING/ STEADY ON	A Park Brake related fault has been detected by the ECU. Braking force from Park Brake may be reduced or impaired.	Immediately find a location to safely park the vehicle. When safely off the road and stopped, turn off ignition and ensure the vehicle transmission is in the park position. Apply Parking Brake. Do not drive until the failure has been repaired.
	OFF	No Park Brake related faults detected.	—

NOTE: If the ABS and/or ATC lamps are flashing after the parameters have been downloaded, verify the System Check Status has been set. See “System Check Status” in “Parameter Downloading” section of this manual.

Troubleshooting and Testing

5.12 SPN, SID, FMI Diagnostic Trouble Code List

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Main Controller, Safety Controller							
629	254	12	Internal Error	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – ON Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC, and EBD Disabled	There are multiple causes. Valves may have been activated too long during diagnostic testing. Internal ECU communication is not correct.	<ul style="list-style-type: none"> Reset ECU by cycling the ignition or by using the reset option in TOOLBOX™ Software 12.2 or higher. If fault persists, check ABS ECU powers, grounds and load test. If all powers, grounds and load testing checks pass, if fault still persists, may indicate the ECU has failed.
Left Front Wheel Speed Sensor							
789	1	1	Air Gap	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Sensor air gap is too large, sensor output voltage is too low.	<ul style="list-style-type: none"> Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. Check tone ring for damage (missing teeth, corrosion).
789	1	5	Impedance	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	An open circuit or short to ground has been detected. i.e. ECU detects a disconnected wheel speed sensor.	<ul style="list-style-type: none"> Check sensor impedance and sensor wiring and connectors for intermittent contact. Check harness and/or sensor for open circuit or short to ground. Sensor resistance should measure between 900-2000 ohms.
789	1	7	Tone Ring	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Wheel speed signal drops out periodically at speeds higher than 10 kph.	<ul style="list-style-type: none"> Check tone ring for damage/missing teeth/corrosion. Check bearing play and tone ring run out.

4011920a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Left Front Wheel Speed Sensor							
789	1	8	No Trigger Detected	ABS Warning Lamp - ON Brake Warning Lamp - OFF ATC Lamp - ON Audible Warning - OFF Parking Brake Service Lamp (1939) - OFF Parking Brake Indicator Lamp - ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Wheel speed sensor signal not detected	<ul style="list-style-type: none"> • Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). • Check bearing play and tone ring and run out. Eliminate root cause for air gap extension and push sensor back in afterwards. • Check tone ring for damage (missing teeth, corrosion). • Check sensor impedance and sensor wiring and connectors for intermittent contact.
789	1	11	Brake Chatter	ABS Warning Lamp - ON Brake Warning Lamp - OFF ATC Lamp - ON Audible Warning - OFF Parking Brake Service Lamp (1939) - OFF Parking Brake Indicator Lamp - ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status	Temporary ABS Wheel Disabled Temporary ATC Disabled	Brake drags or chatters. Abnormal vibrations detected.	<ul style="list-style-type: none"> • Check foundation brakes; condition may occur even without system failure.
789	1	13	Tire Combination	ABS Warning Lamp - ON Brake Warning Lamp - OFF ATC Lamp - ON Audible Warning - OFF Parking Brake Service Lamp (1939) - OFF Parking Brake Indicator Lamp - ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Incorrect tire size. Check foundation brakes. Condition may occur without system failure.	<ul style="list-style-type: none"> • Check tire wear, inflation and verify size is within released range and change wrong tire. • Check tone ring for correct tooth count. • Check tone ring for damage/missing teeth/corrosion. • Clear fault from memory.
629	254	9	Inlet valve actuation time not plausible (75% switch on time within 5 minutes)	ABS Warning Lamp - ON Brake Warning Lamp - OFF ATC Lamp - ON Audible Warning - OFF Parking Brake Service Lamp (1939) - OFF Parking Brake Indicator Lamp - ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status	ABS Wheel Disabled ATC Disabled	An ABS modulator was activated for an abnormally long time.	<ul style="list-style-type: none"> • Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). • Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. • Check tone ring for damage/missing teeth/corrosion. • Check sensor impedance and sensor wiring and connectors for intermittent contact.

4011921a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Right Front Wheel Speed Sensor							
790	2	1	Air Gap	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Sensor air gap is too large, sensor output voltage is too low.	<ul style="list-style-type: none"> • Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). • Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. • Check tone ring for damage (missing teeth, corrosion).
790	2	5	Impedance	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	An open circuit or short to ground has been detected, i.e. ECU detects a disconnected wheel speed sensor.	<ul style="list-style-type: none"> • Check sensor impedance and sensor wiring and connectors for intermittent contact. • Check harness and/or sensor for open circuit or short to ground. Sensor resistance should measure between 900-2000 ohms.
790	2	7	Tone Ring	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Wheel speed signal drops out periodically at speeds higher than 10 kph.	<ul style="list-style-type: none"> • Check tone ring for damage/missing teeth/corrosion. • Check bearing play and tone ring run out.
790	2	8	No Trigger Detected	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Wheel speed sensor signal not detected.	<ul style="list-style-type: none"> • Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). • Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. • Check tone ring for damage (missing teeth, corrosion). • Check sensor impedance and sensor wiring and connectors for intermittent contact.

4011922a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Right Front Wheel Speed Sensor							
790	2	11	Brake Chatter	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Temporary ABS Wheel Disabled Temporary ATC Disabled	Brake drags or chatters. Abnormal vibrations detected.	<ul style="list-style-type: none"> Check foundation brakes; condition may occur even without system failure.
790	2	13	Tire Combination	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Incorrect tire size. Check foundation brakes. Condition may occur without system failure.	<ul style="list-style-type: none"> Check tire wear, inflation and verify size is within released range and change wrong tire. Check air gap and push sensor back in afterward. Check tone ring for correct tooth count. Check tone ring for damage/missing teeth/corrosion. Clear fault from memory.
629	254	9	Inlet valve actuation time not plausible (75% switch on time within 5 minutes)	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	An ABS modulator was activated for an abnormally long time.	<ul style="list-style-type: none"> Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. Check tone ring for damage/missing teeth/corrosion. Check sensor impedance and sensor wiring and connectors for intermittent contact.
Left Rear Wheel Speed Sensor							
791	3	1	Air Gap	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	Sensor air gap is too large, sensor output voltage is too low.	<ul style="list-style-type: none"> Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. Check tone ring for damage (missing teeth, corrosion).

4011923a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Left Rear Wheel Speed Sensor							
791	3	5	Impedance	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	An open circuit or short to ground has been detected. i.e ECU detects a disconnected wheel speed sensor.	<ul style="list-style-type: none"> Check sensor impedance and sensor wiring and connectors for intermittent contact. Check harness and/or sensor for open circuit or short to ground. Sensor resistance should measure between 900-2000 ohms.
791	3	7	Tone Ring	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	Wheel speed signal drops out periodically at speeds higher than 10 kph.	<ul style="list-style-type: none"> Check tone ring for damage/missing teeth/corrosion. Check bearing play and tone ring run out.
791	3	8	No Trigger Detected	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	Wheel speed sensor signal not detected.	<ul style="list-style-type: none"> Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. Check tone ring for damage (missing teeth, corrosion). Check sensor impedance and sensor wiring and connectors for intermittent contact.
791	3	11	Brake Chatter	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Temporary ABS Wheel Disabled Temporary ATC Disabled	Brake drags or chatters. Abnormal vibrations detected.	<ul style="list-style-type: none"> Check foundation brakes; condition may occur even without system failure.

4011924a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Left Rear Wheel Speed Sensor							
791	3	13	Tire Combination	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	Incorrect tire size. Check foundation brakes. Condition may occur without system failure.	<ul style="list-style-type: none"> Check tire wear, inflation and verify size is within released range and change wrong tire. Check air gap and push sensor back in afterward. Check tone ring for correct tooth count. Check tone ring for damage/missing teeth/corrosion. Clear fault from memory.
629	254	9	Inlet valve actuation time not plausible (75% switch on time within 5 minutes)	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	An ABS modulator was activated for an abnormally long time.	<ul style="list-style-type: none"> Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. Check tone ring for damage/missing teeth/corrosion. Check sensor impedance and sensor wiring and connectors for intermittent contact.
Right Rear Wheel Speed Sensor							
792	4	1	Air Gap	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	Sensor air gap is too large, sensor output voltage is too low.	<ul style="list-style-type: none"> Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. Check tone ring for damage (missing teeth, corrosion).
792	4	5	Impedance	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	An open circuit or short to ground has been detected. i.e. ECU detects a disconnected wheel speed sensor.	<ul style="list-style-type: none"> Check sensor impedance and sensor wiring and connectors for intermittent contact. Check harness and/or sensor for open circuit or short to ground. Sensor resistance should measure between 900-2000 ohms.

4011925a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Right Rear Wheel Speed Sensor							
792	4	7	Tone Ring	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	Wheel speed signal drops out periodically at speeds higher than 10 kph.	<ul style="list-style-type: none"> Check tone ring for damage/missing teeth/corrosion. Check bearing play and tone ring run out.
792	4	8	No Trigger Detected	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	Wheel speed sensor signal not detected.	<ul style="list-style-type: none"> Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. Check tone ring for damage (missing teeth, corrosion). Check sensor impedance and sensor wiring and connectors for intermittent contact.
792	4	11	Brake Chatter	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Temporary ABS Wheel Disabled Temporary ATC Disabled	Brake drags or chatters. Abnormal vibrations detected.	<ul style="list-style-type: none"> Check foundation brakes; condition may occur even without system failure.
792	4	13	Tire Combination	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	Incorrect tire size. Check foundation brakes. Condition may occur without system failure.	<ul style="list-style-type: none"> Check tire wear, inflation and verify size is within released range and change wrong tire. Check air gap and push sensor back in afterward. Check tone ring for correct tooth count. Check tone ring for damage/missing teeth/corrosion. Clear fault from memory.

4011926a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Right Rear Wheel Speed Sensor							
629	254	9	Inlet valve actuation time not plausible (75% switch on time within 5 minutes)	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Speed Signal Taken From Other Rear Wheel ATC Disabled	An ABS modulator was activated for an abnormally long time.	<ul style="list-style-type: none"> • Check air gap. The gap should not be greater than 0.040-inch (1.02 mm). • Check bearing play and tone ring run out. Eliminate root cause for air gap extension and push sensor back in afterwards. • Check tone ring for damage/missing teeth/corrosion. • Check sensor impedance and sensor wiring and connectors for intermittent contact.
Power Amp. In Valve Left Front							
932	42	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled No Service brake intervention (power park)	Inlet (IV) short to BATT detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.
932	42	5	Open Circuit	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Inlet (IV) open circuit detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.
932	42	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Inlet (IV) short to ground detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.

4011927a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Power Amp. Out Valve Left Front							
938	48	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled No Service brake intervention (power park)	Outlet (OV) short to BATT detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
938	48	5	Open Circuit	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Outlet (OV) open circuit detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
938	48	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Outlet (OV) short to ground detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.

4011928a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Power Amp. Out Valve Left Front							
933	43	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled No Service brake intervention (power park)	Inlet (IV) short to BATT detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.
933	43	5	Open Circuit	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Inlet (IV) open circuit detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.
933	43	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Inlet (IV) short to ground detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.
Power Amp. Out Valve Right Front							
939	49	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled No Service brake intervention (power park)	Outlet (OV) short to BATT detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.

4011929a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Power Amp. Out Valve Right Front							
939	49	5	Open Circuit	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Outlet (OV) open circuit detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
939	49	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Outlet (OV) short to ground detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
Power Amp. In Valve Left Rear							
934	44	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled No Service brake intervention (power park)	Inlet (IV) short to BATT detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
934	44	5	Open Circuit	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Inlet (IV) open circuit detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.

4011931a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Power Amp. In Valve Left Rear							
934	44	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Inlet (IV) short to ground detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.
Power Amp. Out Valve Left Rear							
940	50	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled No Service brake intervention (power park)	Outlet (OV) short to BATT detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.
940	50	5	Open Circuit	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Outlet (OV) open circuit detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.
940	50	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Outlet (OV) short to ground detected.	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.

4011932a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Power Amp. In Valve Right Rear							
935	45	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled No Service brake intervention (power park)	Inlet (IV) short to BATT detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
935	45	5	Open Circuit	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Inlet (IV) open circuit detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
935	45	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	Inlet (IV) short to ground detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
Power Amp. Out Valve Right Rear							
941	51	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled No Service brake intervention (power park)	Outlet (OV) short to BATT detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.

4011933a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Power Amp. Out Valve Right Rear							
941	51	5	Open Circuit	<p>ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.</p>	<p>ABS Wheel Disabled ATC Disabled</p>	<p>Outlet (OV) open circuit detected.</p>	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.
941	51	6	Short to Ground	<p>ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.</p>	<p>ABS Wheel Disabled ATC Disabled</p>	<p>Outlet (OV) short to ground detected.</p>	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.
Power Amp. ATC Normally Closed							
806	18	3	Shorted to Battery	<p>ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.</p>	<p>ABS, ATC and EBD Disabled No Service brake intervention (power park)</p>	<p>ATC short to BATT detected.</p>	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC, verify correct ECU part number.
806	18	5	Open Circuit	<p>ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.</p>	<p>ABS Wheel Disabled ATC Disabled</p>	<p>ATC open circuit detected.</p>	<ul style="list-style-type: none"> • Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check all ECU powers and grounds including load test. • If DTC persists, may indicate ECU has failed.

4011934a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Power Amp. ATC Normally Closed							
806	18	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	ATC short to ground detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
Power Amp. ATC Normally Open							
807	19	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled No Service brake intervention (power park)	ATC short to BATT detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
807	19	5	Open Circuit	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	ATC open circuit detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.
807	19	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS Wheel Disabled ATC Disabled	ATC short to ground detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test. If DTC persists, may indicate ECU has failed.

4011935a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Power Amp. Endurance Brake Relay							
801	13	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	EBD Disabled	Endurance brake relay output short to BATT detected.	<ul style="list-style-type: none"> • Check wiring and connections from the ECU to the EBR. • If DTC persists, may indicate ECU has failed.
801	13	5	Open Circuit	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	EBD Disabled	Endurance brake relay output open detected.	<ul style="list-style-type: none"> • Check wiring and connections from the ECU to the EBR. • If DTC persists, may indicate ECU has failed.
801	13	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	EBD Disabled	Endurance brake relay short to ground detected.	<ul style="list-style-type: none"> • Check wiring and connections from the ECU to the EBR. • If DTC persists, may indicate ECU has failed.
Power Amp. Brake Light Signal							
3541	100	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	N/A	Brake light signal short to BATT detected.	<ul style="list-style-type: none"> • Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. • Check wiring and connectors of Brake Light Signal relay circuit from ABS ECU to dash module for short to voltage. • Pin 3 should have 4-5 volts key off and 12 volts key on.

4011936a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Power Amp. Brake Light Signal							
3541	100	5	Open Circuit	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	N/A	Brake light signal open detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check wiring and connectors of Brake Light Signal relay circuit from ABS ECU to dash module for open circuit. Pin 3 should have 4-5 volts key off and 12 volts key on.
3541	100	6	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	N/A	Brake light signal short to ground detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check wiring and connectors of Brake Light Signal relay circuit from ABS ECU to dash module for short to ground. Pin 3 should have 4-5 volts key off and 12 volts key on.
Power Amp. Parking Brake Pressure Supply Valve							
617	234	3	Shorted to Battery	ABS Warning Lamp - OFF Brake Warning Lamp - OFF ATC Lamp - OFF Audible Warning - OFF Parking Brake Service Lamp (1939) - ON Parking Brake Indicator Lamp - ON (if applied) FLASHING (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	SAHR Backup Mode 2	Short to BATT detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check wiring and connectors of Pressure Supply Valve circuit from ABS ECU to Pressure Supply Valve for short to voltage. Check resistance of Pressure Supply Valve, should be 12 ohms. (If not in spec, indicates the Pressure Supply Valve may have failed.) Review Pressure Supply Valve harness diagnostics with the OEM. If the Pressure Supply Valve and harness pass all checks, and if DTC persists, may indicate ECU has failed.
617	234	5	Open Circuit	ABS Warning Lamp - OFF Brake Warning Lamp - OFF ATC Lamp - OFF Audible Warning - OFF Parking Brake Service Lamp (1939) - ON Parking Brake Indicator Lamp - ON (if applied) FLASHING (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	SAHR Backup Mode 2	Open detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check wiring and connectors of Pressure Supply Valve circuit from ABS ECU to Pressure Supply Valve for open circuit. Check resistance of Pressure Supply Valve, should be 12 ohms. (If not in spec, indicates the Pressure Supply Valve may have failed.) Review Pressure Supply Valve harness diagnostics with the OEM. If the Pressure Supply Valve and harness pass all checks, and if DTC persists, may indicate ECU has failed.

4011937a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Power Amp. Parking Brake Pressure Supply Valve							
617	234	6	Short to Ground	ABS Warning Lamp - OFF Brake Warning Lamp - OFF ATC Lamp - OFF Audible Warning - OFF Parking Brake Service Lamp (1939) - ON Parking Brake Indicator Lamp - ON (if applied) FLASHING (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	SAHR Backup Mode 2	Short to ground detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check wiring and connectors of Pressure Supply Valve circuit from ABS ECU to Pressure Supply Valve for short to ground. Check resistance of Pressure Supply Valve, should be 12 ohms. (If not in spec, indicates the Pressure Supply Valve may have failed.) Review Pressure Supply Valve harness diagnostics with the OEM. If the Pressure Supply Valve and harness pass all checks, and if DTC persists, may indicate ECU has failed.
Power Amp. Parking Brake Pressure Cut-Off Valve							
618	235	3	Shorted to Battery	ABS Warning Lamp - OFF Brake Warning Lamp - OFF ATC Lamp - OFF Audible Warning - OFF Parking Brake Service Lamp (1939) - ON Parking Brake Indicator Lamp - ON (if applied) FLASHING (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	Park Brake cannot be Applied if Released	Short to BATT detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check wiring and connectors of Pressure Cut-off Valve circuit from ABS ECU to Pressure Cut-off Valve for short to voltage. Review Pressure Cut-off valve and harness diagnostics and repair following OEM diagnostic TSI-08-04-01. If the Pressure Cut-off Valve and harness pass all checks, and if DTC persists, may indicate ECU has failed.
618	235	5	Open Circuit	ABS Warning Lamp - OFF Brake Warning Lamp - OFF ATC Lamp - OFF Audible Warning - OFF Parking Brake Service Lamp (1939) - ON Parking Brake Indicator Lamp - ON (if applied) FLASHING (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	SAHR Backup Mode 1	Open detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check wiring and connectors of Pressure Cut-off Valve circuit from ABS ECU to Pressure Cut-off Valve for an open. Review Pressure Cut-off valve and harness diagnostics and repair following OEM diagnostic TSI-08-04-01. If the Pressure Cut-off Valve and harness pass all checks, and if DTC persists, may indicate ECU has failed.
618	235	6	Short to Ground	ABS Warning Lamp - OFF Brake Warning Lamp - OFF ATC Lamp - OFF Audible Warning - OFF Parking Brake Service Lamp (1939) - ON Parking Brake Indicator Lamp - ON (if applied) FLASHING (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	SAHR Backup Mode 1	Short to ground detected.	<ul style="list-style-type: none"> Disconnect and inspect ECU connector for any sign of damage, moisture or corrosion, clean connectors if necessary. Check wiring and connectors of Pressure Cut-off Valve circuit from ABS ECU to Pressure Cut-off Valve for a short to ground. Review Pressure Cut-off valve and harness diagnostics and repair following OEM diagnostic TSI-08-04-01. If the Pressure Cut-off Valve and harness pass all checks, and if DTC persists, may indicate ECU has failed.

4011938a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Internal Valve Relay (provides supply voltage for ABS pressure control valves)							
818	30	3	Cannot switch off	ABS Warning Lamp - ON Brake Warning Lamp - OFF ATC Lamp - ON Audible Warning - OFF Parking Brake Service Lamp (1939) - OFF Parking Brake Indicator Lamp - ON (if applied) Flashing (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled	Internal valve relay is unable to switch off.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. If connectors and harness pass all checks, and if DTC persists, may indicate ECU has failed.
818	30	4	Valve supply voltage missing or cannot switch on	ABS Warning Lamp - ON Brake Warning Lamp - OFF ATC Lamp - ON Audible Warning - OFF Parking Brake Service Lamp (1939) - ON Parking Brake Indicator Lamp - ON (if applied) Flashing (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled No Service Brake Intervention	Internal valve relay unable to switch on.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. If connectors and harness pass all checks, and if DTC persists, may indicate ECU has failed.
ABS Warning Light Relay (if available)							
1438	23	5	Open or Grounded	ABS Warning Lamp - N/A Brake Warning Lamp - OFF ATC Lamp - ON Audible Warning - OFF Parking Brake Service Lamp (1939) - OFF Parking Brake Indicator Lamp - ON (if applied) Flashing (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	Activation of blink code switch longer than 16 seconds causes fault detection	No load detected or grounded.	<ul style="list-style-type: none"> Check wiring and connections of the ABS warning lamp circuit pin 21 of 31-pin connector. With ECU disconnected, with key ON, the voltage level shall be ~12 volts at Pin 21 to Ground. May need to review wiring diagnostics and repair with OEM. Replace relay if necessary.
Brake Warning Light Relay (if available)							
1439	101	5	Open or Grounded	ABS Warning Lamp - ON Brake Warning Lamp - N/A ATC Lamp - ON Audible Warning - OFF Parking Brake Service Lamp (1939) - OFF Parking Brake Indicator Lamp - ON (if applied) Flashing (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	Activation of blink code switch longer than 16 seconds causes fault detection	No load detected or grounded.	<ul style="list-style-type: none"> Check wiring and connections of the Brake warning lamp circuit pin 20 of 31-pin connector. With ECU disconnected, with key ON, the voltage level shall be ~12 volts at Pin 20 to Ground. May need to review wiring diagnostics and repair with OEM. Replace relay if necessary.

4011939a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Buzzer (if available)							
920	224	5	Buzzer	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – Status per failure mode Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	N/A	Buzzer circuit problem detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check wiring and connections of the Buzzer circuit pin 12 of 31-pin connector. With ECU disconnected, with key ON, the voltage level shall be ~12 volts at Pin 12 to Ground. May need to review wiring diagnostics and repair with OEM. Current-measurement with Pin12/31 short or open. Replace buzzer relay if necessary.
ECU Main Ground or Reference Ground Connection							
3540	98	2	ECU Main or Reference Ground	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – ON Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC and EBD Disabled Park Brake Status Maintained	ECU Main or Reference Ground missing or interrupted.	<ul style="list-style-type: none"> Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. Shake harness while checking ground for any loss of ground issues. Even if no issues were found during inspection, disconnect, inspect and clean connectors, reinstall per OEM guidelines.
No Ignition Voltage Although Engine Speed Is Higher than 300 rpm for 5s							
158	158	4	No Ignition Voltage	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – OFF Audible Warning – OFF Parking Brake Service Lamp (1939) – ON Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	N/A	ECU Ignition missing or interrupted.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check voltage at pin 1 shall be ~ battery voltage. Check fuse, chassis connector and ignition relay. Shake harness while checking voltage for any voltage interruptions.

4011940a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
ECU Voltage							
2597	251	3	High Voltage (>16.5 V)	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ATC Disabled	ECU supply voltage too high.	<ul style="list-style-type: none"> Check alternator and battery. Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM.
2597	251	4	Low Voltage (<10.0 V)	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – ON Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS enabled during cycling ATC Disabled ECU attempts to maintain park brake functionality	ECU supply voltage too low.	<ul style="list-style-type: none"> Check alternator and battery. Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM.
Accumulator Pressure Sensing Front Axle							
1049	59	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Signal short to BATT detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. Remove ECU and check Pressure Sensor both ECU and HCU sides and check for signs of damage, moisture or corrosion. If pressure sensor, connectors and wiring pass all checks, and if DTC persists, may indicate ECU/HCU has failed.
1049	59	4	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Signal short to ground detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. Remove ECU and check Pressure Sensor both ECU and HCU sides and check for signs of damage, moisture or corrosion. If pressure sensor, connectors and wiring pass all checks, and if DTC persists, may indicate ECU has failed. If after replacing the ECU, the DTC persists, may indicate the HCU has failed.

4011941a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Accumulator Pressure Sensing Front Axle							
1049	59	10	Abnormal High Pressure Gradient (Short Charge Time)	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Abnormal high pressure gradient detected.	<ul style="list-style-type: none"> Check accumulator pre-charge level using TOOLBOX™ Software 12.2 or higher diagnostics. <ul style="list-style-type: none"> Deplete accumulators with ignition off, wait approximately 5 seconds then turn ignition on. Do not apply the brakes, then under Display, select Pre-Charge Pressure. If the pressure is below 430 psi or 30 bar, replace the accumulator. If pressure increases rapidly, may indicate the accumulator has failed. Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Replace accumulator if necessary.
Accumulator Pressure Sensing Rear Axle							
1052	62	3	Shorted to Battery	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Signal short to BATT detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. Remove ECU and check Pressure Sensor both ECU and HCU sides and check for signs of damage, moisture or corrosion. If pressure sensor, connectors and wiring pass all checks, and if DTC persists, may indicate ECU/HCU has failed.
1052	62	4	Short to Ground	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Signal short to ground detected.	<ul style="list-style-type: none"> Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. Remove ECU and check Pressure Sensor both ECU and HCU sides and check for signs of damage, moisture or corrosion. If pressure sensor, connectors and wiring pass all checks, and if DTC persists, may indicate ECU has failed. If after replacing the ECU the DTC persists, may indicate the HCU has failed.
1052	62	10	Abnormal High Pressure Gradient (Short Charge Time)	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Abnormal high pressure gradient detected.	<ul style="list-style-type: none"> Check accumulator pre-charge level using TOOLBOX™ Software diagnostics. <ul style="list-style-type: none"> Deplete accumulators with ignition off, wait approximately 5 seconds then turn ignition on. Do not apply the brakes, then under Display, select Pre-Charge Pressure. If the pressure is below 430 psi or 30 bar, replace the accumulator. If pressure increases rapidly, may indicate the accumulator has failed. Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Replace accumulator if necessary.

4011942a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Electronic Pressure Control Front Axle							
2580	57	3	Pump motor does not operate when expected	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC & EBD Disabled	Pump motor current draw less than expected.	<ul style="list-style-type: none"> Disconnect and inspect the ECU 2-pin and 31-pin connectors for any sign of damage, moisture or corrosion, verify all lock tabs are in good condition and, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. If connectors and wiring pass all checks, and if DTC persists, may indicate ECU/HCU has failed.
2580	57	5	Supply voltage for pump motor missing	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC & EBD Disabled	Pump power.	<ul style="list-style-type: none"> Disconnect and inspect the ECU 2-pin and 31-pin connectors for any sign of damage, moisture or corrosion, verify all lock tabs are in good condition and, clean connectors if necessary. Check all ECU powers, grounds and corresponding pump motor fuse and related wiring and repair per OEM guidelines.
2580	57	4	Pump motor operates when not expected	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC & EBD Disabled	Pump motor unexpected operation.	<ul style="list-style-type: none"> Disconnect and inspect the ECU 2-pin and 31-pin connectors for any sign of damage, moisture or corrosion, verify all lock tabs are in good condition and, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. Check accumulator pre-charge level using Toolbox™. Software diagnosis. <ul style="list-style-type: none"> Deplete accumulators with ignition off, wait approximately 5 seconds then turn ignition on. Do not apply the brakes, then under Display, select Pre-Charge Pressure. If the pressure is below 430 psi or 30 bar, replace the accumulator. Verify reservoir cap is venting correctly using below procedure: <ul style="list-style-type: none"> If a hissing noise is heard when removing the cap, replace the cap. If no noise is heard, deplete accumulators using Toolbox™ Software, or disconnect the battery or pull the pump fuses and press the brake pedal a minimum of 30 times. Remove the cap. Reconnect the battery or fuses, if pulled, and measure the time it takes for the pumps to run and shut off. If the pumps run longer than 60 seconds, replace the unit. If the pumps shut off before 60 seconds is achieved and the failure disappears, replace the cap.

4011943a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Electronic Pressure Control Front Axle							
2580	57	6	Pump motor operates when not expected	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC & EBD Disabled	Motor runs after cut out pressure reached.	<ul style="list-style-type: none"> Disconnect and inspect the ECU 2-pin and 31-pin connectors for any sign of damage, moisture or corrosion, verify all lock tabs are in good condition and, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. Check accumulator pre-charge level using Toolbox™ Software diagnosis. <ul style="list-style-type: none"> Deplete accumulators with ignition off, wait approximately 5 seconds then turn ignition on. Do not apply the brakes, then under Display, select Pre-Charge Pressure. If the pressure is below 430 psi or 30 bar, replace the accumulator. Verify reservoir cap is venting correctly using below procedure: <ul style="list-style-type: none"> If a hissing noise is heard when removing the cap, replace the cap. If no noise is heard, deplete accumulators using Toolbox™ Software, or disconnect the battery or pull the pump fuses and press the brake pedal a minimum of 30 times. Remove the cap. Reconnect the battery or fuses, if pulled, and measure the time it takes for the pumps to run and shut off. If the pumps run longer than 60 seconds, replace the unit. If the pumps shut off before 60 seconds is achieved and the failure disappears, replace the cap. Check pressure in accumulators, if pressure exceeds 2435 psi, replace unit.
2580	57	7	Master cylinder brake circuit failure	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC & EBD Disabled	Brake circuit failure detected.	<ul style="list-style-type: none"> Check accumulator pre-charge level using Toolbox™ Software 12.2 or higher diagnostics. <ul style="list-style-type: none"> Deplete accumulators with ignition off, wait approximately 5 seconds then turn ignition on. Do not apply the brakes, then under Display, select Pre-Charge Pressure. If the pressure is below 430 psi or 30 bar, replace the accumulator. Check master cylinder function. <ul style="list-style-type: none"> Inspect master cylinder for leaks. Replace master cylinder if any leaks are found. Press and hold the brake pedal down. If the pedal starts to move lower, replace the master cylinder. Crack the bleeder screws on the relay valve of the HPB unit. With the bleeder screws cracked open, have someone press on the brake pedal while someone observes the fluid flow at the relay valve. If the flow is different between the two bleeder screws, replace the master cylinder.

4011944a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Electronic Pressure Control Front Axle							
2580	57	8	Diaphragm accumulator precharge level too low (detected) by short run time and high switch on frequency)	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC & EBD Disabled	Accumulator pre-charge low level detected.	<ul style="list-style-type: none"> Check accumulator pre-charge level using TOOLBOX™ Software 12.2 or higher diagnostics. Deplete accumulators with ignition off, wait approximately 5 seconds then turn ignition on. Do not apply the brakes, then under Display, select Pre-Charge Pressure. If the pressure is below 430 psi or 30 bar, replace the accumulator.
2580	57	9	Leakage too high	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC & EBD Disabled	Too high of leakage detected.	<ul style="list-style-type: none"> Check pump motor for external leakage. Count frequency of pump actuations less than 30 seconds apart with no demand from brakes or park brakes. If frequency of activation is greater than 30 seconds, decrease count by one. If count is greater than 20, failure is logged. If all checks pass, and if DTC persists, may indicate ECU has failed or HCU has failed.
2580	57	10	Extended accumulator charging time	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC & EBD Disabled	Long accumulator charging time detected.	<ul style="list-style-type: none"> Verify reservoir cap is venting correctly using below procedure: <ul style="list-style-type: none"> If a hissing noise is heard when removing the cap, replace the cap. If no noise is heard, deplete accumulators using TOOLBOX™ Software, or disconnect the battery or pull the pump fuses and press the brake pedal a minimum of 30 times. Remove the cap. Reconnect the battery or fuses, if pulled, and measure the time it takes for the pumps to run and shut off. If the pumps shut off before 60 seconds is achieved and the failure disappears, replace the cap. If the pumps run longer than 60 seconds, continue diagnostics below. Verify the fluid is not contaminated. Verify there is no air in the system. Bleed system if necessary. Verify pump operation using below procedure. <ul style="list-style-type: none"> Remove the relay valve as outlined (See Removal Hydraulic Compact Unit (HCU) Relay Valve). Remove the pump retaining plug and remove the pump from the pump bore. Confirm if the pump piston (head) is binding and sticking within the pump assembly. If yes, pump may have failed, pump replacement kit is available for repair. If no, HPB assembly may have failed.

4011945a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Electronic Pressure Control Rear Axle							
2581	60	3	Pump motor does not operate when expected	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Pump motor current draw less than expected.	<ul style="list-style-type: none"> Disconnect and inspect the ECU 2-pin and 31-pin connectors for any sign of damage, moisture or corrosion, verify all lock tabs are in good condition and, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. If connectors and wiring pass all checks, and if DTC persists, may indicate ECU/HCU has failed.
2581	60	5	Supply voltage for pump motor missing	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Pump power.	<ul style="list-style-type: none"> Disconnect and inspect the ECU 2-pin and 31-pin connectors for any sign of damage, moisture or corrosion, verify all lock tabs are in good condition and, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM.
2581	60	4	Pump motor operates when not expected	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Pump motor unexpected operation.	<ul style="list-style-type: none"> Disconnect and inspect the ECU 2-pin and 31-pin connectors for any sign of damage, moisture or corrosion, verify all lock tabs are in good condition and, clean connectors if necessary. Check all ECU powers, grounds and corresponding pump motor fuse and related wiring. Repair or replace per OEM guidelines.

4011946a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Electronic Pressure Control Rear Axle							
2581	60	6	Pump motor operates when not expected	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Pump motor runs after cut-out pressure reached.	<ul style="list-style-type: none"> Disconnect and inspect the ECU 2-pin and 31-pin connectors for any sign of damage, moisture or corrosion, verify all lock tabs are in good condition and, clean connectors if necessary. Check all ECU powers and grounds including load test, may need to review wiring diagnostics and repair with OEM. Check accumulator pre-charge level using Toolbox™ Software diagnosis. <ul style="list-style-type: none"> Deplete accumulators with ignition off, wait approximately 5 seconds then turn ignition on. Do not apply the brakes, then under Display, select Pre-Charge Pressure. If the pressure is below 430 psi or 30 bar, replace the accumulator. Verify reservoir cap is venting correctly using below procedure: <ul style="list-style-type: none"> If a hissing noise is heard when removing the cap, replace the cap. If no noise is heard, deplete accumulators using Toolbox™ Software, or disconnect the battery or pull the pump fuses and press the brake pedal a minimum of 30 times. <ul style="list-style-type: none"> Remove the cap. Reconnect the battery or fuses, if pulled, and measure the time it takes for the pumps to run and shut off. If the pumps run longer than 60 seconds, replace the unit. If the pumps shut off before 60 seconds is achieved and the failure disappears, replace the cap. Check pressure in accumulators. If pressure exceeds 2435 psi, replace unit.
2581	60	7	Master cylinder brake circuit failure	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Brake circuit failure detected.	<ul style="list-style-type: none"> Check accumulator pre-charge level using Toolbox™ Software 12.2 or higher diagnosis. <ul style="list-style-type: none"> Deplete accumulators with ignition off, wait approximately 5 seconds then turn ignition on. Do not apply the brakes, then under Display, select Pre-Charge Pressure. If the pressure is below 430 psi or 30 bar, replace the accumulator. Check master cylinder function. <ul style="list-style-type: none"> Inspect master cylinder for leaks. Replace master cylinder if any leaks are found. Press and hold the brake pedal down. If the pedal starts to move lower, replace the master cylinder. Crack the bleeder screws on the relay valve of the HPB unit. With the bleeder screws cracked open, have someone press on the brake pedal while someone observes the fluid flow at the relay valve. If the flow is different between the two bleeder screws, replace the master cylinder.
2581	60	8	Diaphragm accumulator precharge level too low (detected) by short run time and high switch on frequency)	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Accumulator pre-charge low level detected.	<ul style="list-style-type: none"> Check accumulator pre-charge level using TOOLBOX™ Software 12.2 or higher diagnostics. <ul style="list-style-type: none"> Deplete accumulators with ignition off, wait approximately 5 seconds then turn ignition on. Do not apply the brakes, then under Display, select Pre-Charge Pressure. If the pressure is below 430 psi or 30 bar, replace the accumulator.

4011947a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Electronic Pressure Control Front Axle							
2581	60	9	Leakage too high	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Too high of leakage detected.	<ul style="list-style-type: none"> Check pump motor for external leakage. Count frequency of pump actuations less than 30 seconds apart with no demand from brakes or park brakes. If frequency of activation is greater than 30 seconds, decrease count by one. If count is greater than 20, failure is logged. If all checks pass, and if DTC persists, may indicate ECU has failed or HCU has failed.
2581	60	10	Extended accumulator charging time	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Level 1 Warning ABS Disabled (Front Axle) ATC Disabled	Long accumulator charging time detected.	<ul style="list-style-type: none"> Verify reservoir cap is venting correctly using below procedure: <ul style="list-style-type: none"> - If a hissing noise is heard when removing the cap, replace the cap. - If no noise is heard, deplete accumulators using TOOLBOX™ Software, or disconnect the battery or pull the pump fuses and press the brake pedal a minimum of 30 times. - Remove the cap. - Reconnect the battery or fuses, if pulled, and measure the time it takes for the pumps to run and shut off. - If the pumps shut off before 60 seconds is achieved and the failure disappears, replace the cap. - If the pumps run longer than 60 seconds, continue diagnostics below. Verify the fluid is not contaminated. Verify there is no air in the system. Bleed system if necessary. Verify pump operation using below procedure. <ul style="list-style-type: none"> - Remove the pump retaining plug and remove the pump from the pump bore. - Confirm if the pump piston (head) is binding and sticking within the pump assembly. If yes, pump may have failed, pump replacement kit is available for repair. If no, HPB assembly may have failed.
Foot Brake Switch							
597	246	3	Out of range	ABS Warning Lamp – OFF Brake Warning Lamp – ON ATC Lamp – OFF Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Cruise control disabled ATC & EBD disabled	Brake switch range error detected.	<ul style="list-style-type: none"> Check in TOOLBOX™ Software to see if switch positions are recognized. Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check pin 10 of 31-pin harness connector circuit for open, short to voltage or ground. Check resistance of circuit and check resistance of switch (27680 ohms at rest and 680 ohms depressed). If switch reading is out of range, may indicate switch failure. If circuit readings are out of range, may indicate a wiring issue. (Review wiring diagnostics and repairs with OEM.) Verify battery voltage at pin 2 of switch harness connector. If no voltage detected or out of range, may indicate wiring or fuse issue. If brake fluid is found in switch, it indicates the master cylinder has failed.

4011948a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Foot Brake Switch							
597	246	10	Long Switch Time Detected	ABS Warning Lamp – OFF Brake Warning Lamp – ON ATC Lamp – OFF Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Cruise control disabled ATC & EBD disabled	Excessive switch activation time detected.	<ul style="list-style-type: none"> Determine if switch was being held in position too long. Check in TOOLBOX™ Software 12.2 or higher to see if switch positions are recognized. Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check pin 10 of 31-pin harness connector circuit for open, short to voltage or ground. Check resistance of circuit and check resistance of switch at rest (27680 ohms at rest and 680 ohms depressed). If switch reading is out of range, may indicate switch failure. If circuit readings are out of range, may indicate a wiring issue. (Review wiring diagnostics and repairs with OEM.) Verify battery voltage at pin 2 of switch harness connector. If no voltage detected or out of range, may indicate wiring or fuse issue. If brake fluid is found in switch, it indicates the master cylinder has failed.
Parking Brake Switch							
70	70	3	Out of range	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – OFF Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) FLASHING (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Park brake status maintained	Brake switch range error detected.	<ul style="list-style-type: none"> Check in TOOLBOX™ Software 12.2 or higher to see if switch positions are recognized. Verify parameters are correct in ECU if issue occurs after replacing the ECU. Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check pin 11 of 31-pin harness connector circuit for open, short to voltage or ground. Check resistance of circuit and check resistance of switch. Switch readings that are out of spec indicate a failed switch. <ul style="list-style-type: none"> Gen 2 switch: pushed in (560 ohms), Neutral (1560 ohms), pulled out (4560 ohms). Gen 3 switch: pushed in (1556 ohms), Neutral (4530 ohms), pulled out (556 ohms). If switch reading is out of range, may indicate switch failure. If circuit readings are out of range, may indicate a wiring issue. (Review wiring diagnostics and repairs with OEM.)
70	70	10	Long switch time detected	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – OFF Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) FLASHING (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Park brake status maintained	Excessive switch activation time detected.	<ul style="list-style-type: none"> Check in TOOLBOX™ Software 12.2 or higher to see if switch positions are recognized. Verify parameters are correct in ECU if issue occurs after replacing the ECU. Disconnect and inspect connectors for any sign of damage, moisture or corrosion, clean connectors if necessary. Check pin 11 of 31-pin harness connector circuit for open, short to voltage or ground. Check resistance of circuit and check resistance of switch. Switch readings that are out of spec indicate a failed switch. <ul style="list-style-type: none"> Gen 2 switch: pushed in (560 ohms), Neutral (1560 ohms), pulled out (4560 ohms). Gen 3 switch: pushed in (1556 ohms), Neutral (4530 ohms), pulled out (556 ohms). If switch reading is out of range, may indicate switch failure. If circuit readings are out of range, may indicate a wiring issue. (Review wiring diagnostics and repairs with OEM.)

4011949a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Parking Brake System							
619	61	3	Park brake travel switch out implausible	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – OFF Audible Warning – ON Parking Brake Service Lamp (1939) – ON Parking Brake Indicator Lamp – ON (if applied) FLASHING (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	SAHR backup mode 1	Parking brake travel switch position error detected.	<ul style="list-style-type: none"> Follow OEM diagnostic TSI-08-04-01. Check SAHR for correct mechanical functionality. Check parking brake adjustment. Check functionality of travel switch.
619	61	4	Could not be released	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – OFF Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) FLASHING (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	SAHR backup mode 1	Park brake could not be released.	<ul style="list-style-type: none"> Follow OEM diagnostic TSI-08-04-01. Check SAHR for correct mechanical functionality. Check parking brake adjustment. Check functionality of travel switch.
619	61	13	Overtravel	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – OFF Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) FLASHING (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	SAHR backup mode 1	Parking brake travel switch overtravel detected.	<ul style="list-style-type: none"> Follow OEM diagnostic TSI-08-04-01. Check SAHR for correct mechanical functionality. Check parking brake adjustment. Check functionality of travel switch.

4011950a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
J1939 Communication							
639	231	5	J1939 Data Bus Error	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – ON Parking Brake Indicator Lamp - ON (if applied) OFF (if released), Parking Brake Indicator Lamp (1939) according to SAHR status.	J1939 data errors or J1939 time out	J1939 high(+) or low (-) open or shorted.	<ul style="list-style-type: none"> Check electrical system of J1939 bus (connections, wiring). Disconnect and inspect the 31-pin connector for any sign of damage, moisture or corrosion, clean connectors if necessary. At the 31-pin harness connector, check resistance across pins 14,15 with the key off (should be 60 ohms). At the 31-pin harness connector pin 14, check voltage to ground with key on (should be 2.5 to 5 volts). At the 31-pin harness connector pin 15, check voltage to ground with key on (should be 2.5 volts or less). The readings for pins 14 and 15 may fluctuate within the range but they should never be the same and the total voltage of pins 14 and 15 should equal approximately 5 volts. May need to review J1939 circuit diagnostics and repair with the OEM.
639	231	12	J1939 Internal Error	ABS Warning Lamp – ON Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – ON Parking Brake Indicator Lamp – ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status.	N/A	Internal fault.	<ul style="list-style-type: none"> Disconnect and inspect the 31-pin connector for any sign of damage, moisture or corrosion, clean connectors if necessary. At the 31-pin harness connector, check resistance across pins 14,15 with the key off (should be 60 ohms). At the 31-pin harness connector pin 14, check voltage to ground with key on (should be 2.5 to 5 volts). At the 31-pin harness connector pin 15, check voltage to ground with key on (should be 2.5 volts or less). The readings for pins 14 and 15 may fluctuate within the range but they should never be the same and the total voltage of pins 14 and 15 should equal approximately 5 volts. May need to review J1939 circuit diagnostics and repair with the OEM. If all J1939 checks pass, may indicate a failed ECU.
639	231	9	J1939 Message Time Out	ABS Warning Lamp – (ON if engine retarder time out. Else OFF) Brake Warning Lamp - OFF ATC Lamp – (ON if Engine Controller (EEC1) or System Controller message time out. Else OFF) Audible Warning - OFF Parking Brake Service Lamp (1939) – (ON if transmission ECU, selected gear (ETC2). Else OFF) Parking Brake Indicator Lamp - ON (if applied) OFF (if released) Parking Brake Indicator Lamp (1939) according to SAHR status	N/A	Incorrect message received or Time Out detected fault.	<ul style="list-style-type: none"> Check electrical system of J1939 bus (connections, wiring). Disconnect and inspect the 31-pin connector for any sign of damage, moisture or corrosion, clean connectors if necessary. At the 31-pin harness connector, check resistance across pins 14,15 with the key off (should be 60 ohms). At the 31-pin harness connector pin 14, check voltage to ground with key on (should be 2.5 to 5 volts). At the 31-pin harness connector pin 15, check voltage to ground with key on (should be 2.5 volts or less). The readings for pins 14 and 15 may fluctuate within the range but they should never be the same and the total voltage of pins 14 and 15 should equal approximately 5 volts. May need to review J1939 circuit diagnostics and repair with the OEM. May have unusual or erratic sensor readings for 2 or more sensors, check sensor adjustment, wheel end play and tone rings for issues.

4011951a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
J1939 Communication							
639	231	2	ATC Switches (EBC1)	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	N/A	Problem with the ATC switch or circuit has been detected.	<ul style="list-style-type: none"> Check electrical system of J1939 bus (connections, wiring), and review ATC switch circuit diagnostics and repair, with the OEM. Verify the ECU parameters are correct.
Special System Conditions							
N/A	N/A	N/A	Low Fluid Level	ABS Warning Lamp – OFF Brake Warning Lamp – ON (for hardwired systems) ATC Lamp – OFF Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Brake Fluid Indicator Lamp Enabled (on non-hardwired systems)	Low fluid level detected.	<ul style="list-style-type: none"> Inspect and repair leaks. Return fluid to operating levels (see "Filling the Hydraulic Power Brake (HPB) Master Cylinder Reservoir" section in this manual).
N/A	N/A	N/A	Pressure level below 1525 PSI in circuit 1 or circuit 2	ABS Warning Lamp – ON Brake Warning Lamp – ON ATC Lamp – ON Audible Warning – ON Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS, ATC & EBD disabled PB release request postponed until both pressure levels exceed 1525 psi.	Low pressure level in circuit 1 or circuit 2 detected.	N/A
N/A	N/A	N/A	Parking brake applied	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – OFF Audible Warning – ON (500 ms) Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON	Engine torque limited to 50% auto trans/20% manual trans if engine intervention possible.	Application of park brake.	N/A

4011952a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Special System Conditions							
N/A	N/A	N/A	Park brake release rejected due to following: Pressure level below 1525 psi in any circuit. Shift inhibit active. Foot brake switch not actuated on auto trans in park on vehicle. Transmission in park on auto trans vehicle.	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – OFF Audible Warning – ON (500 ms) Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON Parking Brake Indicator Lamp (1939) according to SAHR status.	PB release request rejected	Pressure level below 1525 psi in any circuit detected. Shift inhibit active detected. Foot brake switch not actuated on auto trans vehicle detected. Transmission in park on auto trans vehicle detected.	N/A
N/A	N/A	N/A	Service brake intervention due to parking brake application request during vehicle driving	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – OFF Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	Actuate brake signal output in order to illuminate brake lights	Service brake intervention due to parking brake application request during vehicle driving detected.	N/A
N/A	N/A	N/A	ATC off-road switch applied	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – FLASHING at 0.33 Hz Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ATC enabled with increased thresholds	ATC off-road switch activation detected.	<ul style="list-style-type: none"> During a vehicle acceleration event where wheel slip is detected, the ABS ECU may derate the engine or modulate the rear brakes as needed in order to improve traction. In some road and off-road conditions more wheel slip is desired, by activating the "Off-Road" (or Deep Mud and Snow) switch, more wheel slip is allowed. While the system is in the "Off-Road" mode, the ATC lamp will flash. To exit "Off-Road", turn the switch off or cycle the key.

4013079a

Troubleshooting and Testing

SPN	SID	FMI	Description	Warning Light	System Reaction	Cause	Action
Special System Conditions							
N/A	N/A	N/A	ATC Event	ABS Warning Lamp – OFF Brake Warning Lamp – OFF ATC Lamp – ON Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ATC activation	ATC event detected.	<ul style="list-style-type: none"> During a vehicle acceleration event where wheel slip is detected, the ABS ECU may derate the engine or modulate the rear brakes as needed in order to improve traction.
N/A	N/A	N/A	Sensor failure detected during previous drive cycle	ABS Warning Lamp – ON (until all wheels speeds pass sensor test) Brake Warning Lamp – OFF ATC Lamp – ON (until all wheels speeds pass sensor test) Audible Warning – OFF Parking Brake Service Lamp (1939) – OFF Parking Brake Indicator Lamp – OFF Brake Indicator Lamp – ON (if applied) OFF (if released). Parking Brake Indicator Lamp (1939) according to SAHR status.	ABS & ATC disabled until all wheel speeds pass sensor test	Sensor failure detected during previous drive cycle.	<ul style="list-style-type: none"> Repair wheel end sensor failure.

4013080a

Removal and Installation

6 Removal and Installation

6.1 Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To help prevent serious eye injury, always wear eye protection when you perform vehicle maintenance or service.

WARNING

Park the vehicle on a level surface. For vehicle equipped with manual parking brakes, apply the parking brakes. Ensure that the ignition is turned off. Block the front and rear wheels to help prevent the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.

WARNING

Release all air from the air systems before you remove any components. Pressurized air can cause serious personal injury.

WARNING

The full power brake system is a pressurized system that achieves pressures of up to 2320 psi. This pressure is not reduced by switching the ignition off or removing battery power. Prior to servicing this system, the depressurization procedures must be performed exactly as presented. Failure to depressurize the system may result in personal injury or death.

WARNING

Thoroughly clean the area around the HCU fittings before beginning the removal procedure to help avoid contaminating the system. As hoses and brake lines are removed, plug all open ports and lines. Contamination may cause loss of braking force or brake failure, and result in serious personal injury.

CAUTION

The HPB hydraulic power brake system is a complex device that provides optimum efficiency and operation. If the system sustains damage, or a component malfunctions and requires replacement, the replacement procedures provided by ZF must be followed exactly with the associated steps performed in the order presented.

Removal and Installation

CAUTION

Hydraulic brake fluid is a caustic substance. Contact with the hydraulic brake fluid can cause skin irritation. Do not let hydraulic brake fluid touch any painted surfaces, as it will remove the paint. Hydraulic brake fluid may also damage certain non-metal surfaces. Do not let fluid contact brake pads, shoes, rotors or discs.

CAUTION

Before disposing of used components, verify the warranty status. Contact the WABCO Customer Care Center at 855-228-3203 for instructions.

6.2 Removal

6.2.1 Hydraulic Compact Unit

WARNING

Park the vehicle on a level surface. For vehicle equipped with manual parking brakes, apply the parking brakes. Ensure that the ignition is turned off. Block the front and rear wheels to help prevent the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.

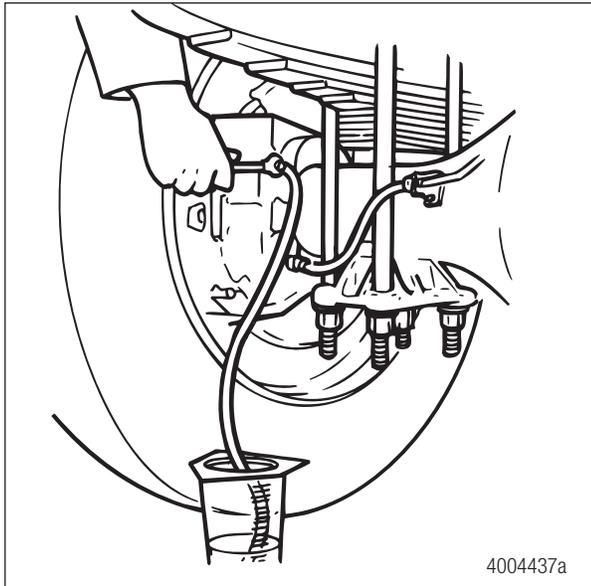


The following general guidelines are provided to facilitate the removal of the HCU from the vehicle.

- Two people are needed to perform this procedure.
 - For the HCU drain procedure in Step 11, TOOLBOX™ Software version 12.2 or higher is required. If you do not have this version of TOOLBOX™ Software, go to <https://wabco-snapon.com>.
 - In some vehicles it may be necessary to move non-HPB system components, such as the air tank, in order to access the HPB part. If this is necessary, refer to the vehicle manufacturer's manual for information before moving the component.
 - HPB systems may include automatic parking brakes. If your vehicle is equipped with manual parking brakes, refer to the manual parking brake procedures. To determine the type of parking brake on the vehicle, refer to the vehicle specification sheet.
 - Bleed the brake and master cylinder circuits. Bleed procedures appear in Section 7 of this manual.
 - After installing HPB components or making system repairs, use TOOLBOX™ Software 12.2 or higher to remove the error code from the ECU memory. Instructions for using TOOLBOX™ Software 12.2 or higher appear in Section 5 of this manual.
1. Park the vehicle on a level surface. Apply the parking brake. Ensure that the ignition is turned OFF.
 2. Block the front and rear tires to help prevent the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
 3. Disconnect the battery.
 4. Use a clean rag to carefully clean the surface of the HCU and the surrounding area.

Removal and Installation

5. Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. As an alternate method, connect the vehicle to a computer that has TOOLBOX™ Software version 12.2 or higher installed. From the **HPB Main menu**, select **EOL** to enable the end of line test. From the pull-down options, select **Deplete Accumulators** to start the procedure. To ensure the system is depressurized, perform the following check on both the front and rear axles.
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.
 - c. Use a wrench to open the bleeder fitting screw.



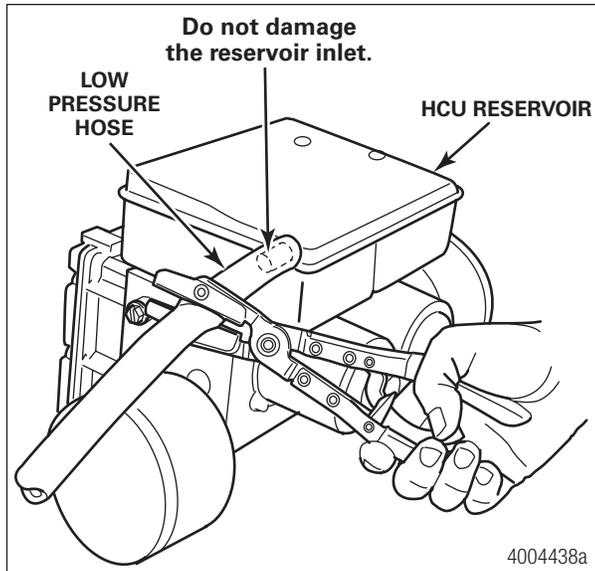
- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
 - e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw to the torque value specified by the component manufacturer.
6. Repeat Steps A-E for the second axle.



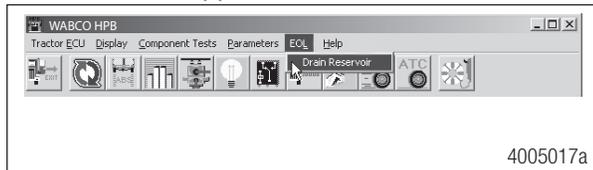
Be careful not to damage the HCU reservoir inlet when attaching the pinch clamp. If damaged, it will need to be replaced.

Removal and Installation

- Attach hose clamp pliers to the low pressure hose at the HCU reservoir inlet. Clamp the rubber hose at least 3 inches (76 mm) away from the entrance to the HCU reservoir. Use care to help avoid damage to the plastic reservoir nipple inside the hose.



- Loosen the two support brackets and any retaining hardware that holds the middle section of the low pressure hose to the chassis. The bolts must be loose enough to allow movement of the hose during the HCU removal.
- To help prevent brake fluid from damaging the vehicle or floor paint, or from seeping into the ground, position a container beneath the work area to collect any drained or spilled brake fluid.
- Disconnect the low pressure hose from the HCU reservoir. Plug both the low pressure hose and the HCU reservoir inlet to help prevent system contamination.
- Before removing the HCU assembly from the vehicle, drain the fluid from the HCU reservoir. To do this:
 - Reconnect the battery.
 - Attach a bleeder bottle to one wheel end at the **front** axle.
 - Connect the vehicle to a computer that has TOOLBOX™ Software, version 12.2 or higher, installed.
 - From the **HPB Main Menu**, select **EOL** to enable the End of Line test. The pull-down option, **Drain Reservoir**, will appear. Click on **Drain Reservoir** to start the drain procedure.

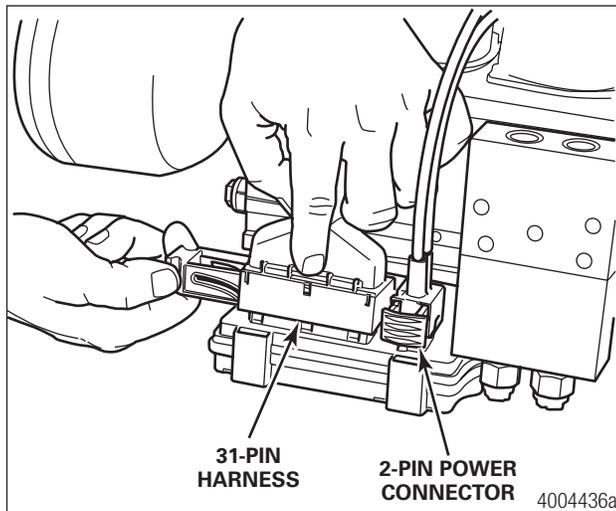


- Open the bleeder screw.
- Apply and hold the brake pedal down until no more fluid runs out.
- Tighten the bleeder screw.

Attach a bleeder bottle to one wheel end at the rear axle. Repeat Steps D-G for the **rear** axle.

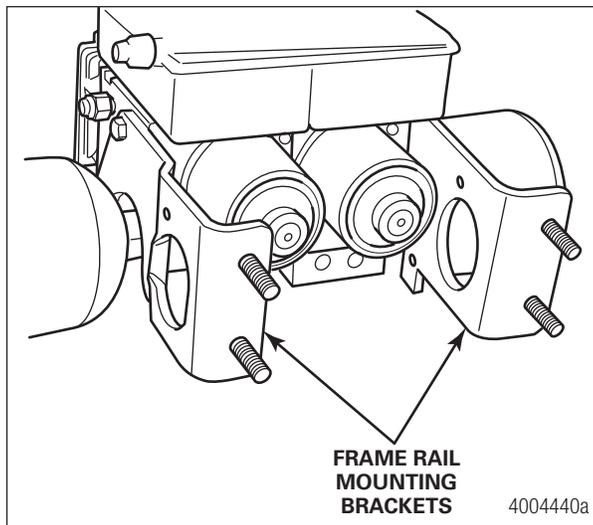
Removal and Installation

12. Disconnect the battery.
13. Disconnect the brake lines from the HCU. There are at least six brake lines; seven if the system is equipped with power parking brakes. Plug the brake lines and ports on the HCU to help prevent system contamination. Mark the brake lines to ensure correct positioning during reassembly.
14. Open the latches on the two-pin power connector and the 31-pin harness attached to the ECU. After the latch is released, remove the connectors from the ECU.
If the vehicle is equipped with hydraulic parking brakes, disconnect the pressure supply valve electrical connector on the HCU. Refer to the Parking Brake Pressure Supply Valve removal and installation procedures in this section.



If space does not permit removing the HCU with the mounting brackets attached, skip Step 15 and proceed to Step 16.

15. While supporting the HCU, loosen and remove the four nuts (two per side) that hold the HCU mounting brackets to the frame rail of the vehicle. Remove the HCU, with mounting brackets attached, from the vehicle.



16. Loosen and remove the two bolts that hold the HCU to the front mounting bracket. Then, loosen and remove the two bolts that hold the HCU to the rear mounting bracket.

Removal and Installation

17. Remove the mounting brackets from the HCU.
18. Examine the four bushings inside the brackets for potential deformations. Replace if necessary.
19. Verify the warranty status. If the HCU is under warranty, return it to ZF.

6.3 Installation

6.3.1 Hydraulic Compact Unit

CAUTION

The replacement HCU is pre-charged with brake fluid to ensure successful bleeding. To help prevent fluid loss, do not remove the protective caps until you are ready to connect the brake lines. Damage to components can result.



Before installation, the replacement HCU must be fitted with the HCU reservoir. Refer to the HCU reservoir installation information in this section.



ZF recommends that you install the replacement HCU in the same location as the old one.



Bleeding the master cylinder, brake caliper and spring-applied/hydraulic release (SAHR) circuits is required during installation of the HCU. Refer to Section 5.



Examine the four bushings inside the brackets for potential deformations before attaching the HCU to the brackets. Replace if necessary.

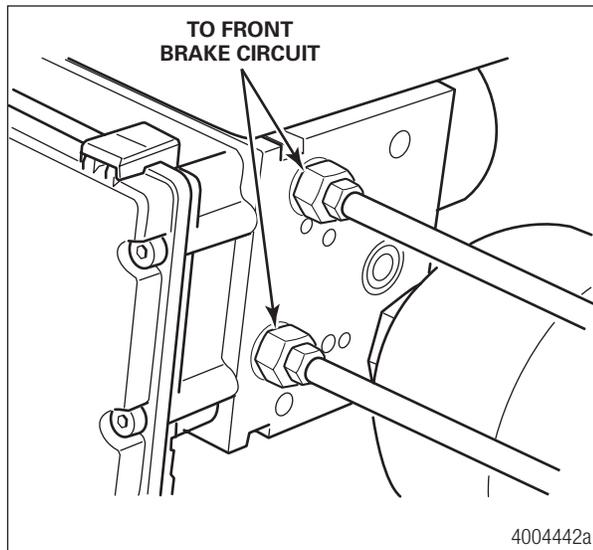
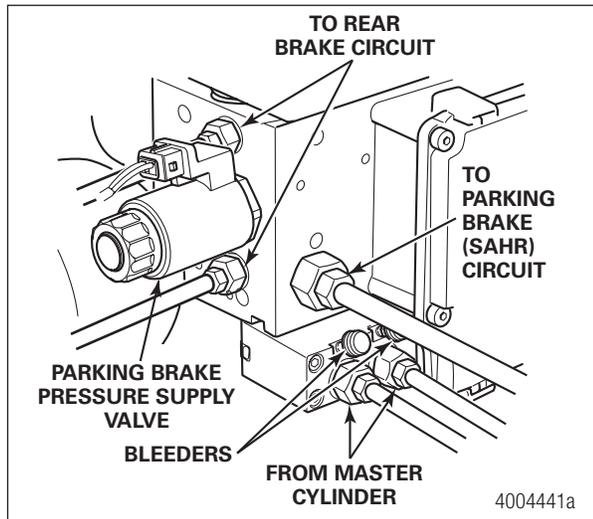


If space does not permit installing the HCU with the mounting brackets attached, perform Step 2 first, then perform Step 1.

1. Ensure that the ignition is off and the battery is disconnected.
2. Position the HCU between the mounting brackets. While supporting the HCU, install the four replacement bolts that attach the HCU to the mounting brackets. Tighten the bolts to 32-34 ft-lb (43-46 Nm).
3. Attach the two mounting brackets to the frame rail of the vehicle. Tighten the nuts to 79.7-99.6 ft-lb (108-135 Nm).

Removal and Installation

4. Connect the brake lines. Remove the protective cover before attaching the line. Check the line markers to ensure correct installation on the HCU.
 - Four lines leading to the wheel ends
 - Two lines leading to the master cylinder
 - One line leading to the parking brake (if equipped)



5. Connect the low pressure hose from the master cylinder reservoir to the HCU reservoir and secure the connection with a hose clamp. Once the connection is secure, remove the pinch clamp installed during the removal of the old HCU.
6. Tighten the two support brackets (hose clamps) that secure the low pressure hose to the vehicle chassis.
7. Fill the brake system with new brake fluid from a sealed container until the fluid level in the master cylinder reservoir stabilizes at the Max mark. Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications sheet to determine which fluid to use.

Removal and Installation

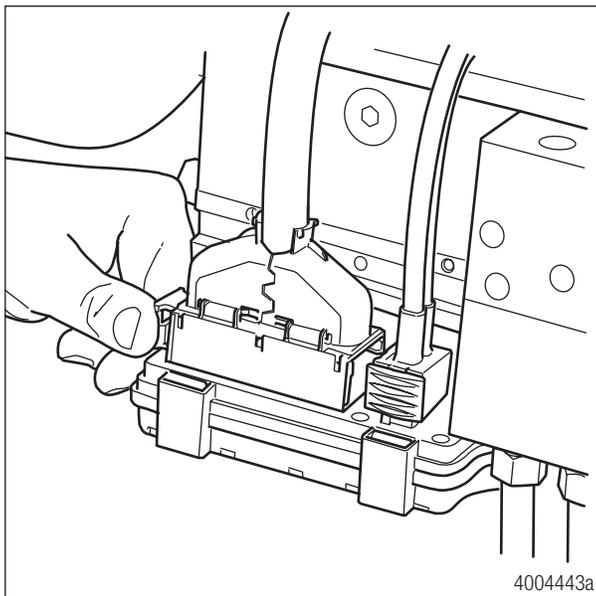
i Temporarily open one caliper bleeder screw or the SAHR bleeder screw, if applicable, to expedite the filling process. The open bleeder screw facilitates the expelling of the air from the system. Close the bleeder screw when filling is complete.

⚠ WARNING

Electrical connectors must be correctly installed with the latch pushed in to lock the connection to prevent them from coming loose or disconnecting. Failure to securely connect and correctly latch the help connectors could result in loss of braking functions during vehicle operation. Serious personal injury can result.

8. Attach the 31-pin harness and then the two-pin power connector to the ECU. Push the latch into position to lock the connection.

If the vehicle is equipped with a hydraulic parking brake, attach the pressure supply valve connector. Refer to the Parking Brake Pressure Supply Valve removal and installation procedures in this section.



9. Proceed with pressure filling and bleeding the brake caliper circuits, and the SAHR circuit, if applicable. Refer to Section 5 for procedures.
10. If a new complete ECU/HCU assembly was installed, it will be necessary to download the parameters into the ECU.

i To make sure of correct ABS performance, the correct parameters must be downloaded into the ECU. Parameters are OEM and VIN number specific and should not be swapped vehicle to vehicle.

Refer to the “Parameter Downloading” section in this manual.

Removal and Installation

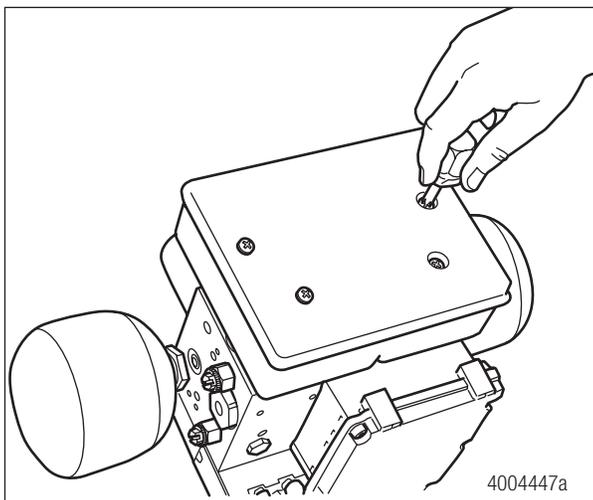
6.4 Removal

6.4.1 HCU Reservoir

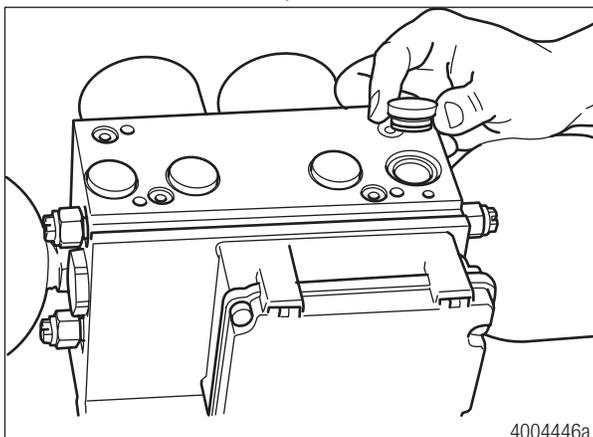


The removal of the entire HCU assembly is necessary in order to remove the HCU reservoir. Refer to the hydraulic compact unit removal procedure in this section.

1. Remove the HCU assembly from the vehicle. Refer to the hydraulic compact unit removal procedure in this section.
2. Inspect the area between the body of the HCU and the HCU reservoir to ensure the area is free from any dirt or other contaminants. Clean if necessary. Do not allow any contaminants to enter the HCU ports.
3. Use a number 4 Phillips-head screwdriver to remove the four HCU reservoir mounting screws. Then, remove the reservoir from the HCU.



4. Verify the warranty status. If the reservoir is under warranty, return it to ZF.
5. Remove the old rubber grommets from the four ports. Do not allow any dirt or other contaminants from these grommets to enter the HCU ports. If contaminated, the unit must be replaced.
6. Seal the HCU reservoir ports.



7. With the ports plugged, clean the top of the HCU.

Removal and Installation

6.5 Installation

6.5.1 HCU Reservoir

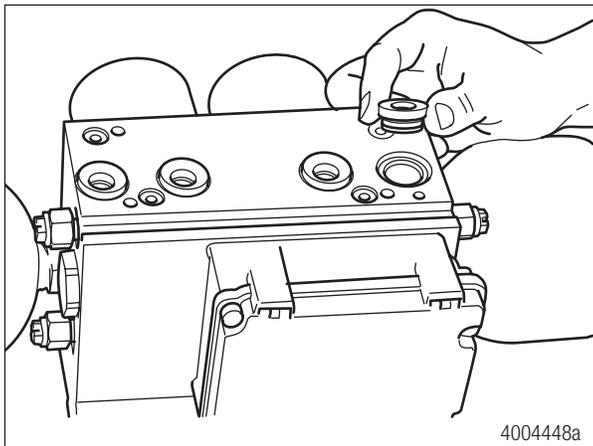
WARNING

To ensure correct assembly, use only the four seals and four screws included in the HCU reservoir replacement kit. Do not reuse the seals or screws from the old reservoir. Failure to do so may cause reduced braking force and result in serious personal injury.



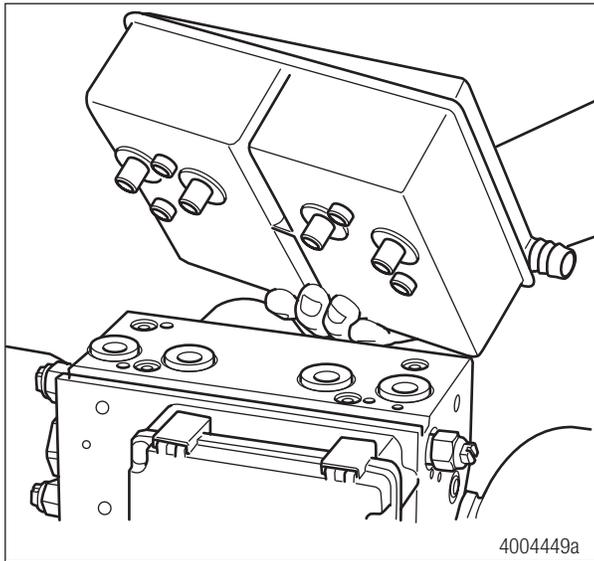
Bleeding the master cylinder, brake caliper and spring-applied/hydraulic release (SAHR) circuits is required during installation of the HCU. Refer to Section 5.

1. Inspect the top of the HCU to ensure it is clean and free from debris or other contaminants.
2. Remove the plugs from the reservoir ports on the HCU.
3. Install the four new black rubber grommets from the replacement kit into the ports on the top of the HCU.

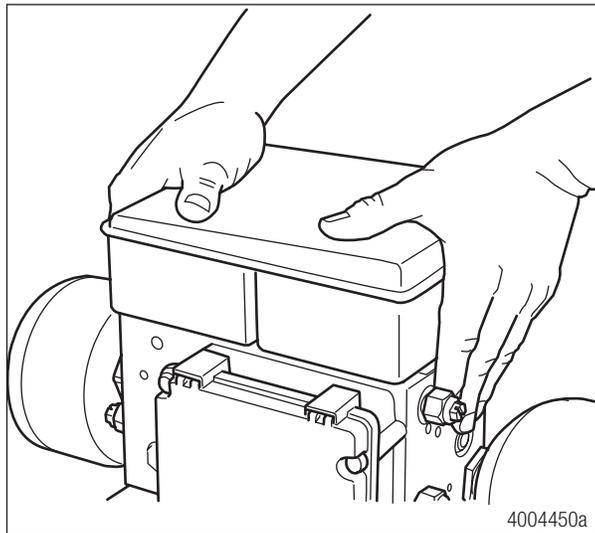


4. Use new, clean brake fluid from a sealed container to lubricate the reservoir grommets. Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.
5. Position the reservoir on the HCU and verify orientation: The mounting screw holes must line up and the inlet port for the low pressure hose must face the front of the HCU.

Removal and Installation



6. Install the new reservoir by pressing it carefully and completely into the grommets in the ports.



7. Use the four new mounting screws to attach the reservoir to the HCU. Using a number 4 Phillips-head screwdriver, tighten the screws to 43-60 in-lb (5-7 Nm).
8. Reinstall the HCU assembly on the vehicle. Refer to the hydraulic compact unit installation procedure in this section.

Removal and Installation

6.6 Removal

6.6.1 HCU Accumulators

WARNING

To help prevent serious eye injury, always wear eye protection when you perform vehicle maintenance or service.

WARNING

Park the vehicle on a level surface. For vehicle equipped with manual parking brakes, apply the parking brakes. Block the front and rear wheels to help prevent the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.

WARNING

Release all air from the air systems before you remove any components. Pressurized air can cause serious personal injury.

WARNING

It is possible for the removed accumulator to retain an internal pressure of up to 1087 psi. To eliminate any removed accumulator from posing a safety hazard, depressurize the accumulator and disable its pressure chamber.

WARNING

The full power brake system is a pressurized system that achieves pressures of up to 2320 psi. This pressure is not reduced by switching the ignition off or removing battery power. Prior to servicing this system, the depressurization procedures must be performed exactly as presented. Failure to depressurize the system may result in personal injury or death.

WARNING

Thoroughly clean the area around the HCU fittings before beginning the removal procedure to help avoid contaminating the system. As hoses and brake lines are removed, plug all open ports and lines. Contamination may cause loss of braking force or brake failure, and result in serious personal injury.

CAUTION

The HPB hydraulic power brake system is a complex device that provides optimum efficiency and operation. If the system sustains damage, or a component malfunctions and requires replacement, the vehicle owner is strongly advised to contact the nearest dealer for professional assistance and repair. If location and circumstances prevent consulting the dealer, and components must be replaced, the replacement procedures provided by ZF must be followed exactly with the associated steps performed in the order presented.

Removal and Installation

CAUTION

Hydraulic brake fluid is a caustic substance. Contact with the hydraulic brake fluid can cause skin irritation, using proper personal protection equipment is advised. Do not let hydraulic brake fluid touch any painted surfaces, as it will remove the paint. Hydraulic brake fluid may also damage certain non-metal surfaces. Do not let fluid contact brake pads, shoes, rotors or discs.

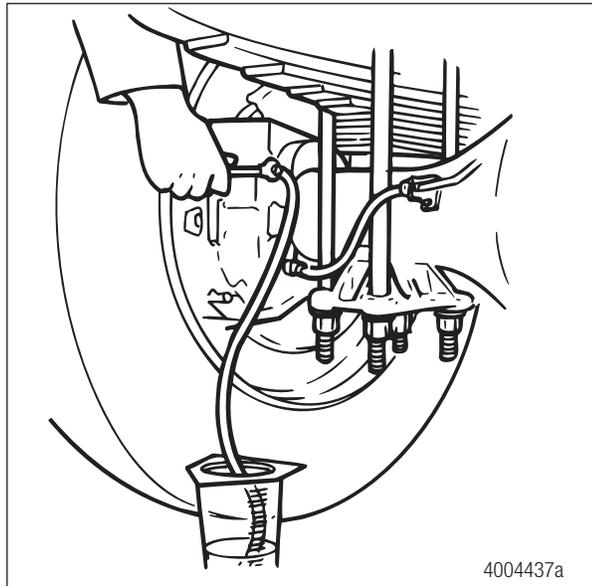


The following general guidelines are provided to facilitate the removal of the accumulators from the HPB.

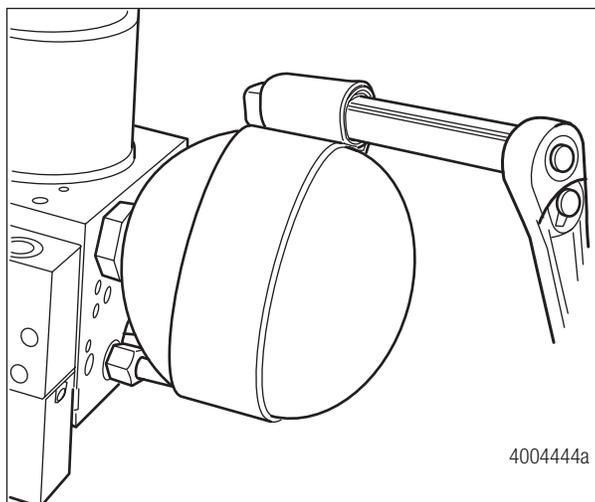
- Accumulators are precharged with gas pressure to 1087 psi and have a limited shelf life. When replacing an accumulator, note and record the expiration date of the replacement accumulator.
 - Used accumulators must be depressurized before disposal. Follow Steps 10A-10D to perform this procedure.
 - ZF recommends replacing both accumulators at the same time.
 - It is not necessary to remove the entire HCU to replace the accumulators.
 - Replacing the accumulators does not require any brake bleed procedures.
 - **Accumulators still under warranty must be returned without depressurizing. Drilling accumulators will void the warranty.**
 - Two people are needed to perform this procedure.
 - After installing HBP components or making system repairs, use TOOLBOX™ Software to remove the error code from the ECU memory. Instructions for using TOOLBOX™ Software appear in Section 5 of this manual.
1. Park the vehicle on a level surface. For vehicles with manual parking brakes, apply the parking brakes.
 2. Block the front and rear tires to help prevent vehicle movement. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
 3. Disconnect the battery.
 4. Use a clean rag to carefully wipe the surface of the HCU and the surrounding area.
 5. Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure the system is depressurized, perform the following check on both the front and rear axles.
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.

Removal and Installation

- c. Use a wrench to open the bleeder fitting screw.



- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
- e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw to the torque value specified by the component manufacturer.
6. Repeat Steps A-E for the second axle.
7. To help prevent brake fluid from damaging the vehicle or floor paint, or from seeping into the ground, position a container beneath the work area to collect any drained or spilled brake fluid.
8. Use a strap wrench to remove the accumulator. The accumulator has a right-hand thread.



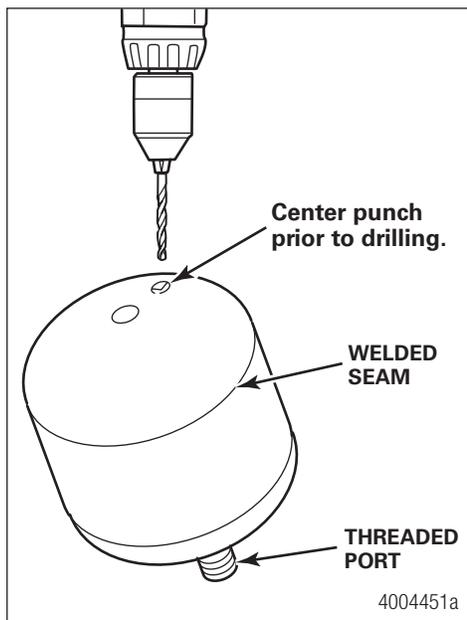
9. Use a clean rag to clean the counterbore on the HCU. Inspect the counterbore to ensure that the O-ring seal was removed. Plug the counterbore to help prevent contaminants from entering the HCU.
10. Determine the warranty status of the accumulators. If the accumulators are under warranty, do not perform Step 11 (depressurizing the accumulators). Return the accumulators to ZF. If the accumulators are not under warranty, the accumulators **MUST** be depressurized before disposal (Step 11).

Removal and Installation

WARNING

A slight hissing sound may be heard when the wall of the accumulator is pierced. Metal shavings may be blown away from the hole during this procedure. Wear protective goggles, not glasses, to protect the eyes.

11. Use the following steps to depressurize the accumulator and disable the internal pressure chamber before disposing of the accumulators.
 - a. Securely position the accumulator on a drill press table. Use a vise or clamp that will allow the accumulator to be correctly positioned. The drilling point will be on the opposite side of the welded seam from the threaded port.
 - b. Center punch the accumulator.
 - c. Use a 3 mm or 1/8-inch drill bit to slowly and carefully drill approximately 1/2-inch (12.7 mm) into the accumulator.



- d. After releasing the internal pressure, correctly dispose of the accumulator.
 - Repeat Steps A-D to depressurize the second accumulator.

6.7 Installation

6.7.1 HCU Accumulators

WARNING

Failure to bleed the system whenever any hydraulic system fitting is loosened or disconnected will allow air to remain in the system. This will help prevent the hydraulic pressure in the brake system from rising enough to apply the brakes correctly. This will cause the stopping distance to increase and can result in serious personal injury.

Removal and Installation

WARNING

Correctly discard hydraulic brake fluid that is removed from the brake system. Hydraulic brake fluid that is removed can be contaminated and, if used, can cause damage, loss of braking and serious personal injury.

WARNING

Use only the type of hydraulic brake fluid specified by the equipment manufacturer. Do not use or mix different types of hydraulic brake fluid. The incorrect hydraulic brake fluid will damage the rubber parts of the brake caliper and can cause damage, loss of braking and serious personal injury.

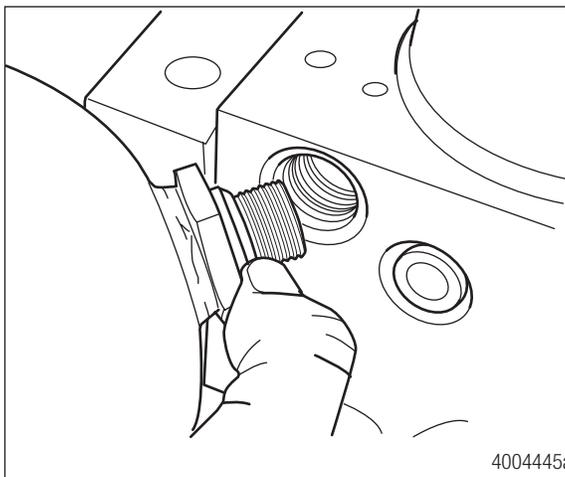
WARNING

A new accumulator is precharged to a pressure of 1087 psi. Do not puncture or pierce the accumulator. Puncturing or piercing the accumulator may result in personal injury or death.



Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.

1. Remove the plug from the accumulator counterbore on the HCU. Clean the counterbore and the surrounding area. The old accumulator O-rings should have been removed from the counterbore during removal of the accumulators. Verify that the O-ring was removed.
2. Use clean brake fluid from a sealed container to lubricate the O-ring on the new accumulator. Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.
3. Place the new accumulator and O-ring into the counterbore. After positioning, use a torque wrench with a strap wrench attachment to tighten to 43.4-50 ft-lb (60-70 Nm). Do not overtighten.



4. Repeat Steps 1-3 to replace the second accumulator.
5. Check the fluid level in the master cylinder reservoir. Fluid level should be at the MAX mark. If not, fill the reservoir to the MAX mark with new brake fluid from a sealed container. Use only DOT 3 or DOT 4 brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.

Removal and Installation



Never add fluid above the MAX mark regardless of the state of the accumulator.

6. Connect the battery.
7. Turn the ignition to ON. The HCU pump motors will start up and fill the accumulators. Approximate running time is 45 seconds.

If the HCU pump motors fail to deliver a sufficient amount of fluid, the ECU module will control the HCU pump motors in a self priming procedure. The HCU pump motors should stop within three minutes, with the brake warning light and the buzzer OFF. If there are problems building pressure after bleeding and powering up the system, increase the pressure setting of the pressure bleeder equipment to 29-40 psi (2-2.75 bar), and cycle the ignition off for 10 seconds, then back on.

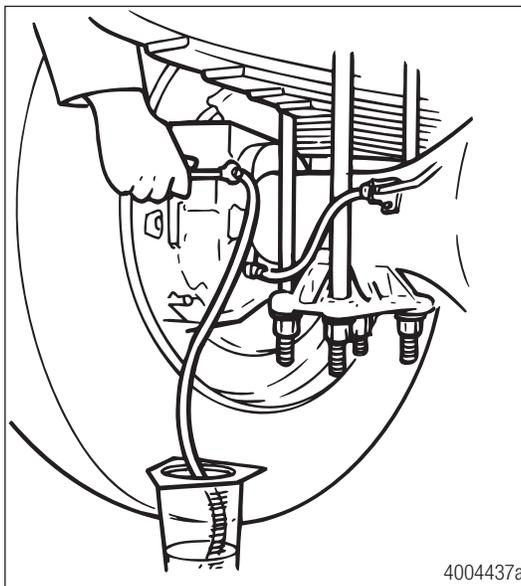


Pressure should be left on the system during the first key-on (attempt to build pressure).

8. When the pumps stop running and the system is fully charged, the fluid level in the master cylinder reservoir should be between MIN and MAX marks.
9. Check the accumulator connections for leaks. If there are no leaks, go to Step 11.

If there are leaks, depressurize the system before making the necessary repairs. Use the following procedure to depressurize the system:

- Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure that the system is depressurized, perform the following check on both the front and rear axles:
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.
 - c. Use a wrench to open the bleeder fitting screw.



Removal and Installation

- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
 - e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw to the torque value specified by the component manufacturer.
 - Repeat Steps A-E for the second axle.
10. After making the repairs, check the fluid level in the master cylinder reservoir to make sure it is at the MAX mark when both accumulators are fully depleted. Refill as necessary, using only the recommended DOT 3 or DOT 4 hydraulic brake fluid, as described above. Refer to Section 5 for detailed instructions on how to correctly fill the master cylinder reservoir.



Never add fluid above the MAX mark regardless of the state of the accumulator.

11. Use TOOLBOX™ Software to cancel the diagnostic code for the accumulator. Refer to Section 5 for TOOLBOX™ Software instructions.
12. Perform the Deplete Accumulators function two times. Refer to the procedure in this section.
13. Remove the wheel blocks.
14. Test drive the vehicle. Refer to the test drive procedure in Section 5 of this manual.

6.8 Removal

6.8.1 Electronic Control Unit (ECU)

WARNING

To help prevent serious eye injury, always wear eye protection when you perform vehicle maintenance or service.

WARNING

Park the vehicle on a level surface. For vehicle equipped with manual parking brakes, apply the parking brakes. Block the front and rear wheels to help prevent vehicle movement. Failure to do so can result in unwanted vehicle movement causing serious personal injury.

WARNING

Release all air from the air systems before you remove any components. Pressurized air can cause serious personal injury.

WARNING

The full power brake system is a pressurized system that achieves pressures of up to 2320 psi. This pressure is not reduced by switching the ignition off or removing battery power. Prior to servicing this system, the depressurization procedures must be performed exactly as presented. Failure to depressurize the system may result in personal injury or death.

Removal and Installation

⚠ CAUTION

The HPB hydraulic power brake system is a complex device that provides optimum efficiency and operation. If the system sustains damage, or a component malfunctions and requires replacement, the replacement procedures provided by ZF must be followed exactly with the associated steps performed in the order presented.

⚠ CAUTION

Hydraulic brake fluid is a caustic substance. Contact with the hydraulic brake fluid can cause skin irritation, using proper personal protection equipment is advised. Do not let hydraulic brake fluid touch any painted surfaces, as it will remove the paint. Hydraulic brake fluid may also damage certain non-metal surfaces. Do not let fluid contact brake pads, shoes, rotors or discs.

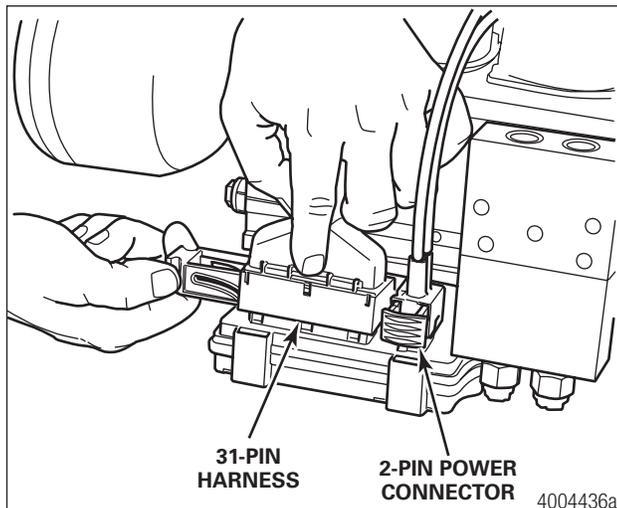


Do not open the ECU. Opening the ECU to gain access to the internal components will void the warranty.



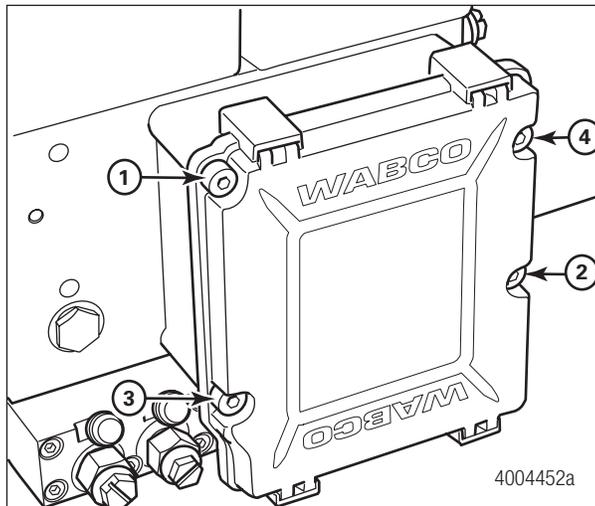
The following general guidelines are provided to facilitate the safe removal of the ECU module from the HCU assembly.

- It is not necessary to remove the entire HCU to replace the Electronic Control Unit (ECU).
 - After replacing the ECU, new system parameters must be entered. Refer to Section 5 of this manual for parameter entry procedures.
 - When only the ECU is replaced, bleeding the system is not necessary.
1. Park the vehicle on a level surface. For vehicles with manual parking brakes, apply the parking brakes.
 2. Block the front and rear tires to help prevent vehicle movement. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
 3. Disconnect the battery.
 4. Use a clean rag to carefully wipe the surface of the HCU and the surrounding area.
 5. Open the latches on the two-pin power connector and the 31-pin harness attached to the ECU. After the latch is released, remove the connectors from the ECU.



Removal and Installation

6. Use a 4 mm Allen wrench to loosen and remove the four mounting screws that attach the ECU module to the HCU. Remove the screws in the sequence shown.

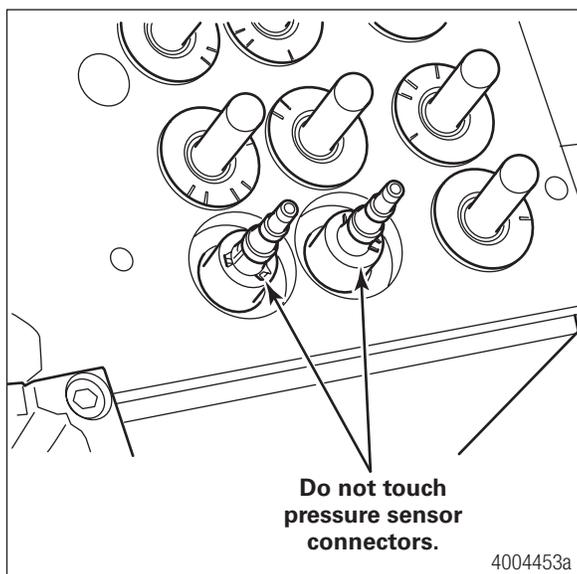


7. Carefully remove the ECU by lifting straight out. To avoid damaging the HCU, do not twist the ECU during removal. Determine the warranty status of the ECU. If the ECU is under warranty, return it to ZF. If it is not under warranty, discard the used ECU.

⚠ CAUTION

Do not touch the pressure sensor connectors. The connectors are sensitive and can be damaged by static electrical shock.

8. Use a clean rag to carefully clean the area around the valves formerly covered by the ECU. Do not touch the two pressure sensor connectors.



9. Remove and discard the orange seals from the two pressure sensors. Do not touch the two pressure sensor connectors.

Removal and Installation

6.9 Installation

6.9.1 Electronic Control Unit (ECU)

CAUTION

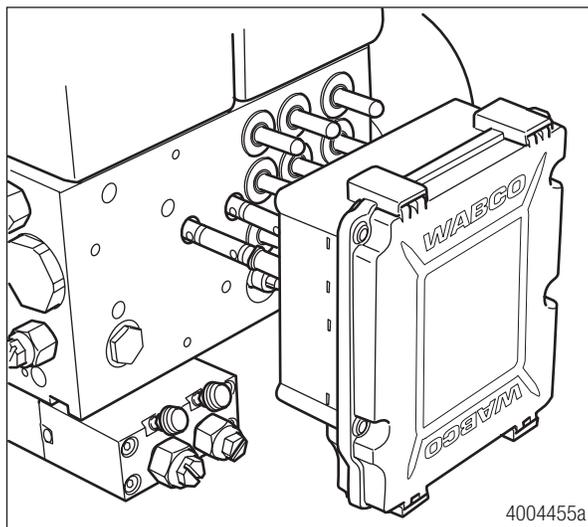
Do not touch the pressure sensor connectors. The connectors are sensitive and can be damaged by static electrical shock.

1. Remove the replacement orange seals from the ECU replacement kit. Install the seals onto the replacement ECU.

CAUTION

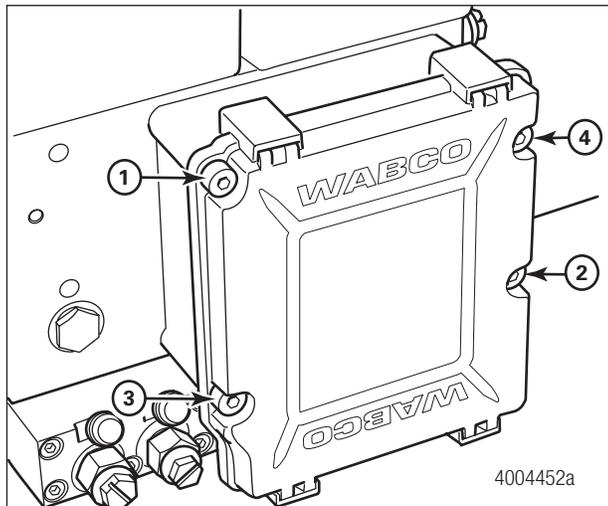
Excessive force in positioning the ECU onto the HCU will damage the ECU housing. Do not force the ECU into position. Use a gentle, even pressure when positioning the ECU.

2. Position the ECU onto the HCU valves. Apply gentle pressure to seat the ECU. Motor connectors must achieve full depth into the housing. The gap between the HCU and ECU must not exceed 0.08-inch (2 mm).



Removal and Installation

- Use a 4 mm Allen wrench to tighten the four mounting screws that attach the ECU to the HCU. Tighten to 14 in-lb (1.5 Nm). Do not exceed this torque. The metal sleeves on the ECU housing must rest flat on the body of the HCU. Tighten the screws using the correct sequence.

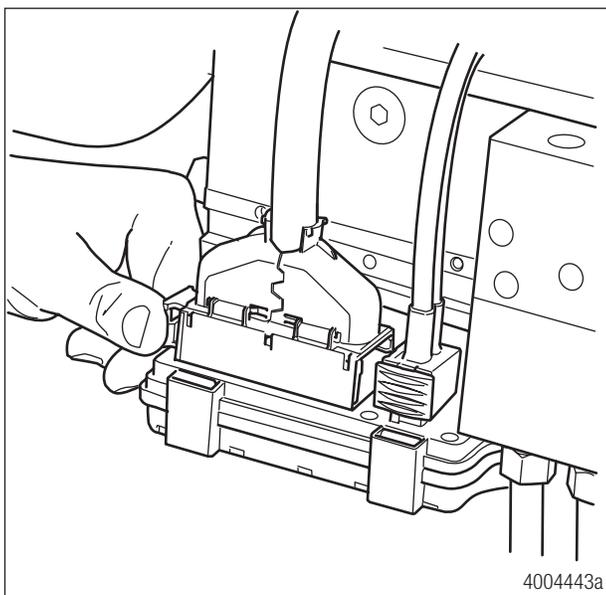


- When the ECU is correctly installed with the metal sleeves flat on the HCU, tighten the bolts to 21-30 in-lb (2.5-3.5 Nm).

WARNING

Electrical connectors must be correctly installed with the latch pushed in to lock the connection to prevent them from coming loose or disconnecting. Failure to securely connect and correctly latch the connectors could result in loss of braking functions during vehicle operation. Serious personal injury can result.

- Attach the 31-pin harness and then the two-pin power connector to the ECU. Push the latch into position to lock the connection.



Removal and Installation

6. Connect the battery.
7. If the original ECU was just reinstalled, test drive the vehicle. Refer to the “Test Drive Procedure” in this manual.
8. If a new ECU was installed, it will be necessary to download the parameters into the ECU.



To make sure of correct ABS performance, the correct parameters must be downloaded into the ECU. Parameters are OEM and VIN number specific and should not be swapped vehicle to vehicle. Refer to the “Parameter Downloading” Section.

6.9.2 Parameter Downloading

After Installing a new ECU or a new ECU/HCU assembly, it will be necessary to download the parameters into the ECU.



To make sure of correct ABS performance, the correct parameters must be downloaded into the ECU. Parameters are OEM and VIN number specific and should not be swapped vehicle to vehicle.



TOOLBOX™ Software 12.2 or higher will be needed to enter the HPB system parameters into the ABS ECU.

For Navistar vehicles, it is recommended to go to the Navistar ISIS website to download the parameters per VIN using the TOOLBOX™ Software. Contact Navistar for assistance.

For Non-Navistar vehicles, the parameters may be entered manually. To manually enter the parameters, it will be necessary to save a parameter file to the computer and then using TOOLBOX™ Software extract the parameters from the computer and download them into the ABS ECU.

When downloading parameters, it should be noted that there are 2 series of ABS ECUs, Release 1 and Release 2.

Release 1: These ECUs were original equipment on most vehicles built prior to 2009 and only have a 5-parameter capability.

Release 2: These ECUs are original equipment on most vehicles built 2009 to present and have a 10-parameter capability. TOOLBOX™ Software versions 12.2 or higher must be used.

6.9.2.1 Manual Downloading

Obtain Parameter Data Set Numbers

To create a parameter file, you must obtain the correct VIN-specific parameter data set numbers using the following procedure.

If you are able to communicate with the original ECU, try to obtain the parameter data set numbers as follows.

1. Open TOOLBOX™ Software and go to the HPB main page and click on “Parameters” in the toolbar.
2. Select “read parameters” from the drop-down menu and write down the “10” settings; i.e. Data 1: “1”, Data 2: “15”.

If you are unable to communicate with the original ECU, it will be necessary to contact the OEM or ZF to obtain the parameter data set numbers.

Removal and Installation

Create a New File to Calibrate ECU Parameters

Once the parameter data set numbers have been obtained, you must create a new file to calibrate the ECU parameters using the following procedure.

1. Open "Notepad" as follows.
 - a. Click the computer "Start" icon and type "run" into the search window.
 - b. Click "run" and enter "Notepad" into the search window and click "OK". This will bring up a blank "Notepad" page.
2. Once the Notepad page has been brought up, type the VIN on the first line and press enter to move down to the next line.
3. Type the 10 data set numbers on each line below (example: 1<enter>15<enter>) do not hit enter after the 10th (last) entry. Use the data sets that were saved from the original ECU. If the 10 data set numbers could not be obtained from the original ECU, it will be necessary to contact the OEM or ZF to obtain the correct parameter data set numbers.



If the parameter file was obtained from the OEM, it may be necessary to remove the underscores from the file name for TOOLBOX™ Software to recognize it.

4. Once the VIN and data set numbers have been entered, click "File" and "Save as". In the File Save window, save the file as follows.

Save in:

For TOOLBOX™ Software 10 or lower

Windows XP or Vista: "C:\ Program Files\WABCO\WINNT\HPB"

Windows 7: "C:\ Program Files (x86)\WABCO\WINNT\HPB"

For TOOLBOX™ Software 11

Windows XP or Vista: "C:\ Program Files\
WABCO\TOOLBOX\HPB"

For TOOLBOX PLUS™ Software

Windows 7, 8, 10:
"C:\ Program Files (x86)\WABCO\TOOLBOX\HPB"

File name: "MW ABS Param.dat"

Save As Type: "All files"

Encoding: "ANSI" This is usually the default setting.

5. Click Save. The parameter file will now be saved to the computer.

Extract the File and Save It to the ABS ECU

Use the following procedure to extract the file from the computer and save it to the ABS ECU.

1. Turn the ignition on.
2. Connect the computer to the vehicle.

Removal and Installation

3. Open TOOLBOX™ Software and go to the HPB main page and click on “Parameters” in the toolbar.
4. A drop-down menu will appear. Click on “Write Parameters”
5. A window will appear displaying the VIN, verify the VIN number is correct.
6. Click the Download button. Once the process is complete, a message of “Success” will appear.
7. Close out of TOOLBOX™ Software and turn the ignition off for a few minutes.

Verify the Parameters

Use the following procedure to verify the parameters were saved correctly.

1. Turn the ignition on.
2. Connect the computer to the vehicle.
3. Open TOOLBOX™ Software and go to the HPB main page and click on “Parameters” in the toolbar.
4. Click on “Read Parameters” and compare the parameters that are displayed with the parameters that were entered. They should be identical.
5. Test drive the vehicle. Refer to the Test Drive procedure in Section 5 of this manual.

6.9.2.2 Password Failed

If during the Parameter download process a “Password Failed” message should appear, it indicates several attempts have been made on the same key cycle. To correct this issue, close out of TOOLBOX™ Software and cycle the key off for a few minutes and reattempt downloading the parameters.

6.9.2.3 System Check Status (ABS and or ATC Lamps Flashing after Downloading the Parameters)

After downloading the parameters, there may be no active or stored DTC listed but the ABS lamp may start flashing. If the vehicle also has ATC, the ABS and ATC lamps will flash alternately, commonly referred to as Railroading. To correct this issue, perform the following.

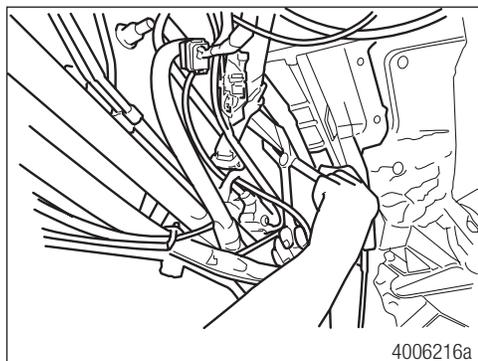
1. Open the TOOLBOX™ Software and bring up the opening/ main HPB page
2. Press and hold down the Ctrl, Alt and Shift keys, then tap the F12 key. Observe the upper toolbar and the word “Utility” will appear. Release the keys.
3. Click on the word “Utility” and a drop-down menu will appear.
4. Scroll through the menu and click on “System Check Status”.
5. The System Check Status window will appear showing the Current Status which will display Status Not Set.
6. Click on the “Set Status” button and the lights will stop flashing. The lamps may remain on solid until the vehicle sees wheel speed above 4 mph.
7. Close out of TOOLBOX™ Software and cycle the key off for a few minutes.
8. Test drive the vehicle. Refer to the Test Drive procedure in Section 5 of this manual.

Removal and Installation

6.10 Removal

6.10.1 Hydraulic Compact Unit (HCU) Relay Valve

1. Wear eye protection.
2. Park the vehicle on a level surface. Block the wheels to help prevent the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
3. Disconnect the battery.
4. Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure the system is depressurized, perform the following check on both the front and rear axles.
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.
 - c. Use a wrench to open the bleeder fitting screw.
 - d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
 - e. With the brake pedal still applied, use a torque wrench to close the bleeder fitting screw.
5. Use a torque wrench to tighten the bleeder fitting screw to the torque value specified by the component manufacturer.
6. Repeat Step 4 and Step 5 for the other axle.
7. Use hose clamp pliers to clamp the rubber hose at least three-inches (76 mm) away from the entrance to the HCU reservoir. Use care to avoid damage to the plastic reservoir nipple inside the hose.

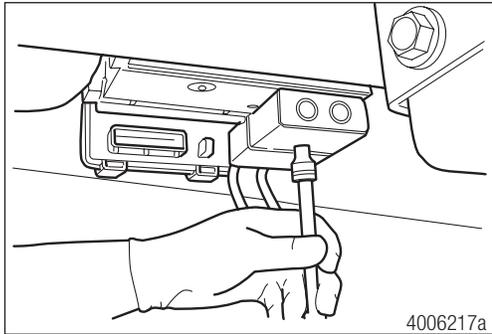


Avoid bending or kinking the brake lines while disconnecting and handling other components.

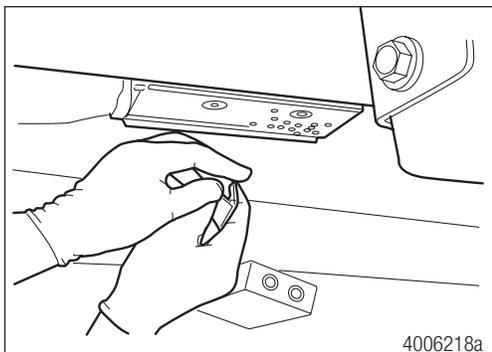
8. Disconnect the two master cylinder brake lines from the relay valve. Plug the two lines to help prevent contamination.

Removal and Installation

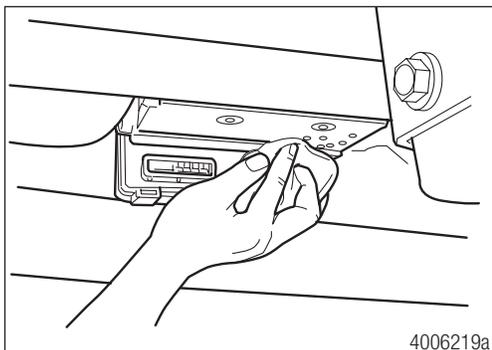
9. Use a 4 mm socket wrench to loosen and remove the five Allen-head screws that secure the relay valve to the hydraulic compact unit (HCU).



10. Carefully lower and remove the relay valve.
11. Remove and discard the rubber-coated seal plate. **Do not reuse this plate.** During installation, use the new seal plate included with the relay valve replacement kit.



12. Use denatured alcohol and lint-free rags to clean the valve mounting surface. Ensure there is no rubber sticking to the HCU. Do not allow rubber or other debris to fall into the HPB bore holes.

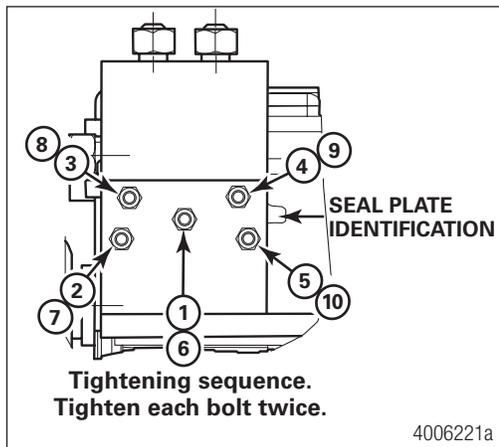


Removal and Installation

6.11 Installation

6.11.1 Hydraulic Compact Unit (HCU) Relay Valve

1. Place a screw into the center mounting hole of the relay valve. Use a hex-head socket tool for positioning. Place the new relay valve seal onto the relay valve using the screw to align the seal. The orientation should match. Position the relay valve against the HCU. Thread the screw into the HCU.



2. Place the remaining four screws into the mounting holes on the relay valve. Hand tighten all five screws.
3. Use a torque wrench to tighten all five screws to 71 in-lb (8 Nm) following the numbered sequence.
4. Attach the master cylinder brake lines. Remove the hose clamp from the low pressure hose.
5. Fill the brake system with new brake fluid from a sealed container until the fluid level in the master cylinder reservoir stabilizes at the MAX mark. Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications sheet to determine which fluid to use.



Temporarily open one caliper bleeder screw or the SAHR bleeder screw, if applicable, to expedite the filling process. The open bleeder screw facilitates the expelling of the air from the system. Close the bleeder screw when filling is complete.

6. Proceed with pressure filling and bleeding the master cylinder circuit. Refer to Section 5 for procedures.
7. Proceed with pressure filling and bleeding the brake caliper circuits, and the SAHR circuit if applicable. Refer to Section 5 for procedures.

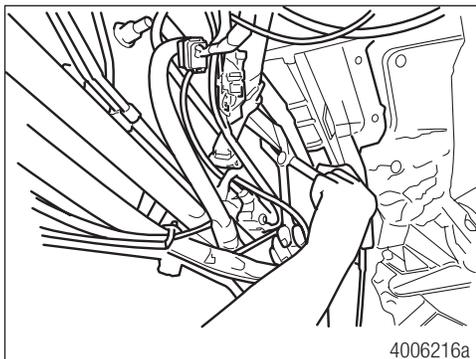
Removal and Installation

6.12 Removal

6.12.1 Hydraulic Compact Unit (HCU) Pump

Before removing the pump, ensure the replacement pump is readily accessible.

1. Wear eye protection.
2. Park the vehicle on a level surface. Block the wheels to help prevent the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
3. Disconnect the battery.
4. Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure the system is depressurized:
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.
 - c. Use a wrench to open the bleeder fitting screw.
 - d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
 - e. With the brake pedal still applied, use a torque wrench to close the bleeder fitting screw.
5. Use a torque wrench to tighten the bleeder fitting screw to the torque value specified by the component manufacturer.
6. Repeat Step 4 and Step 5 for the other axle.
7. Use hose clamp pliers to clamp the rubber hose at least three-inches (76.2 mm) away from the entrance to the HCU reservoir. Use care to avoid damage to the plastic reservoir nipple inside the hose.

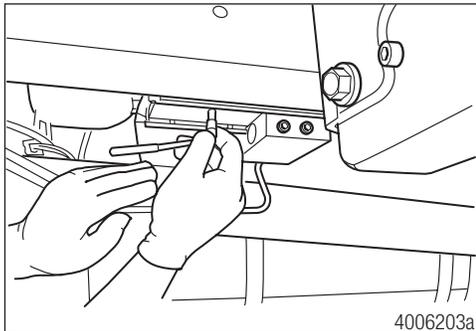


Avoid bending or kinking the brake lines while disconnecting and handling other components.

8. For a rear axle pump, proceed to Step 9. For a front axle pump, carefully remove the relay valve from the HCU to gain access to the pump. **Do not kink or bend the brake lines while removing the relay valve.**

Removal and Installation

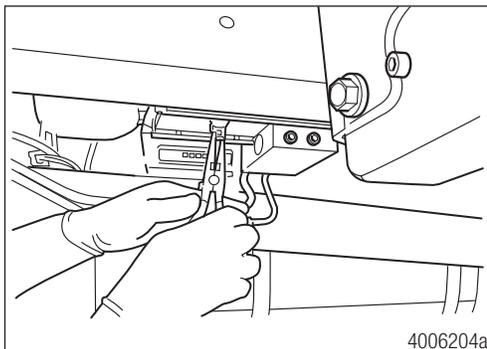
9. Prepare the replacement pump. Lubricate both pump O-rings with brake fluid. Actuate the pump several times by depressing the spring-loaded pump button by hand. The initial force required to actuate the pump and depress the pump button may be high at first. However, after the first actuation, the force should be reduced.
10. Use a 6 mm hex-head socket wrench to remove the pump retaining plug from the HCU cavity. To help minimize fluid spill, keep the replacement pump within reach and prepared for installation.



CAUTION

Use care when removing the pump to help prevent damage to the O-rings.

11. Use needle nose pliers with a good grip to remove the pump from the bore. Use care to help prevent damage to the O-rings. Avoid sliding the needle nose pliers on the pump. This can produce metal filings or contaminants which can enter the pump bore. Do not leave any foreign material in the pump bore.



12. Inspect the bore holes to verify that no foreign material such as rubber, rag lint or metal filings have entered the bore holes. If necessary, remove foreign material with a lint-free swab.
13. Install the replacement pump. Refer to the installation procedure. **If you are replacing both pumps, do not remove the second pump before installing the first replacement pump.**

Removal and Installation

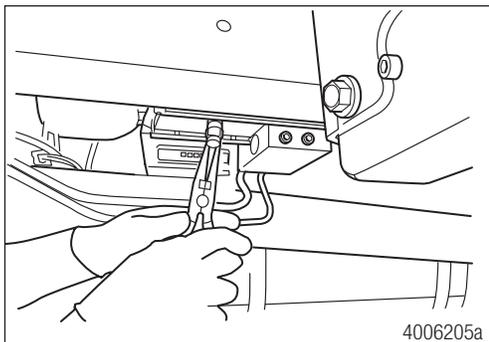
6.13 Installation

6.13.1 Hydraulic Compact Unit (HCU) Pump

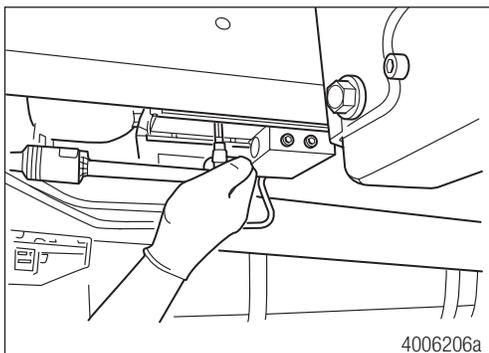
CAUTION

Use care when installing the pump to help prevent damage to the O-rings.

1. Use light hand pressure to slowly seat the pump into the bore. Use care not to damage the O-rings.



2. Insert the pump retaining plug into the threaded hole. Use a 6 mm hex-head socket wrench to tighten the plug to 195 ± 18 in-lb (22 ± 2 Nm).



3. Repeat the procedure for removing and installing the second pump (if replacing both pumps).
4. If the front axle pump was replaced, install the relay valve. Refer to TP0672, Hydraulic Compact Unit (HCU) Pump Relay Valve Replacement, for the correct procedures.
5. Remove the hose clamp from the rubber hose.
6. Proceed with pressure filling and bleeding the master cylinder circuit. Refer to Section 5 for procedures.
7. Proceed with pressure filling and bleeding the brake caliper circuits, and the SAHR circuit if applicable. Refer to Section 5 for procedures.

Removal and Installation

6.14 Removal

6.14.1 Master Cylinder Replacement Information

Before removing the master cylinder assembly or the master cylinder reservoir, verify the components to be replaced:

- Master cylinder and reservoir
- Master cylinder only, reusing reservoir
- Master cylinder reservoir only, reusing master cylinder

ZF sells replacement kits specific to each of these three replacements. Make sure the replacement kit is available **before** you begin the removal.

If the current reservoir is to be reused, you will need to be careful when removing the master cylinder and reservoir assembly from the vehicle, and when you separate the components. If the reservoir is damaged in any way, it is not reusable.

- The master cylinder replacement kit contains a master cylinder travel switch, grommets and roll pins. It does not include the master cylinder reservoir.
- The master cylinder reservoir replacement kit contains a master cylinder reservoir with a fluid level switch and four rubber grommets.

6.14.2 Master Cylinder

CAUTION

To help avoid damage to the system while working on the brake system, do not apply the foot pedal unless instructed to do so.

- Two people are needed to perform this procedure.
- In some vehicles it may be necessary to move non-HPB system components, such as the air tank, in order to access the HPB part. If this is necessary, refer to the vehicle manufacturer's manual for information before moving the component.
- Bleeding the master cylinder circuit is required during installation of the master cylinder. Bleed procedures appear in Section 5 of this manual.
- After installing HPB components or making system repairs, use TOOLBOX™ Software to remove the error code from the ECU memory. Instructions for using TOOLBOX™ Software appear in Section 5 of this manual.



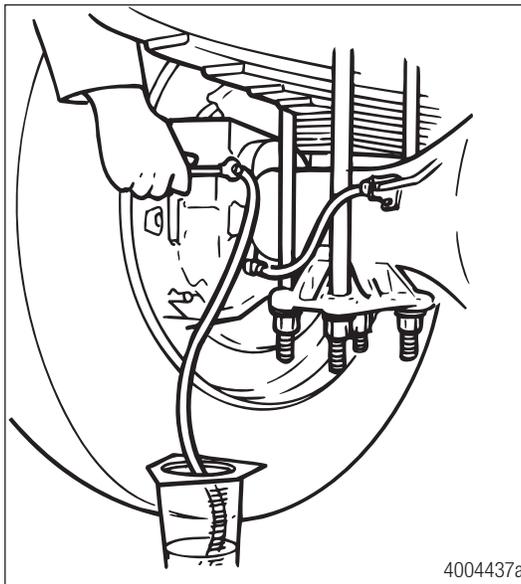
Removing the master cylinder involves removing the master cylinder reservoir. If the old reservoir is going to be installed onto the new master cylinder, care must be taken during the removal process not to damage the reservoir. Do not install a damaged reservoir.

1. Park the vehicle on a level surface. For vehicles with manual parking brakes, apply the parking brakes.
2. Block the front and rear tires to help prevent vehicle movement. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
3. Disconnect the battery.
4. Use a clean rag to carefully clean the outside of the master cylinder and master cylinder reservoir.

Removal and Installation

i Both the foot brake switch and the fluid level sensor switch can be replaced without draining the brake fluid. If you are replacing either of these switches, follow the procedures given in this manual.

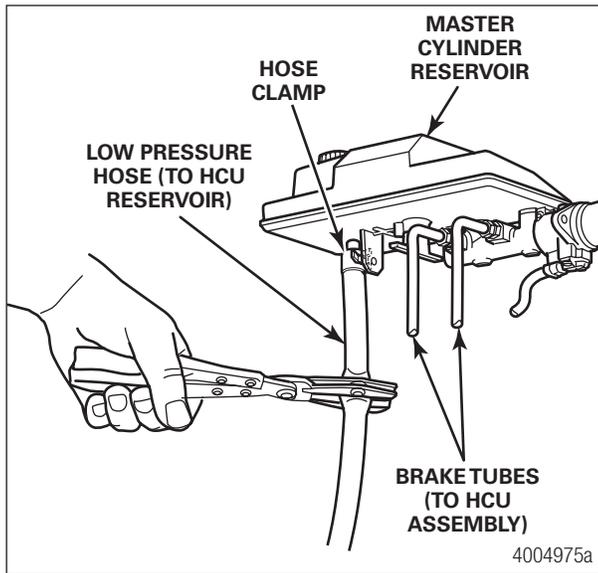
5. Disconnect the foot brake switch on the master cylinder and the fluid level switch on the master cylinder reservoir.
6. Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure the system is depressurized, perform the following check on both the front and rear axles:
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.
 - c. Use a wrench to open the bleeder fitting screw.



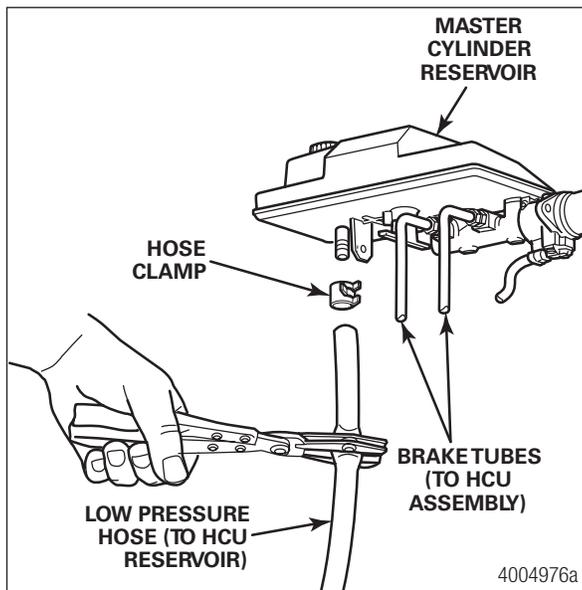
- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
 - e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw to the torque value specified by the component manufacturer.
- Repeat Steps A-E for the second axle.
7. Attach a pinch clamp to the low pressure hose near the outlet of the master cylinder reservoir. Do not damage the reservoir outlet.

i Be careful not to damage the HCU reservoir outlet when attaching the pinch clamp. If damaged, it will need to be replaced.

Removal and Installation



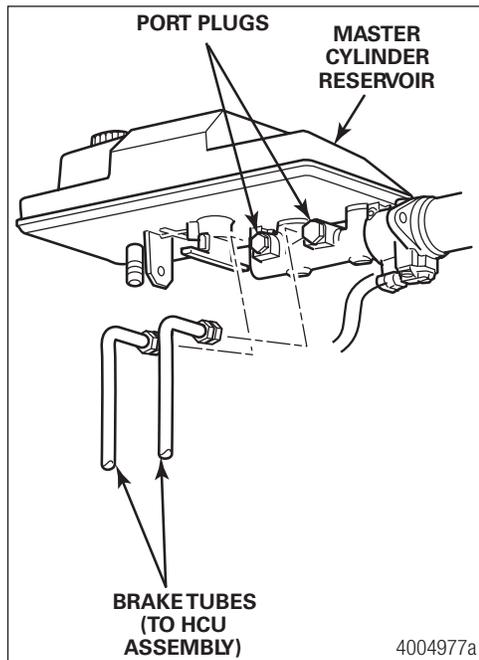
8. To help prevent brake fluid from damaging the vehicle or floor paint, or from seeping into the ground, position a container beneath the work area to collect any drained or spilled brake fluid.
9. Remove the hose clamp.
10. Disconnect the low pressure hose from the master cylinder reservoir. All of the fluid coming out of the master cylinder reservoir, approximately one gallon (3.4 liters), should drain into the container. Remove the cap from the master cylinder reservoir to improve the draining process. Plug the low pressure hose to prevent system contamination.



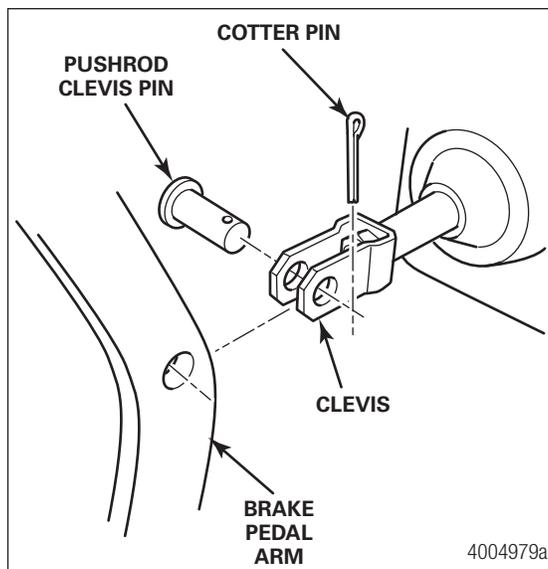
Some brake fluid may remain in protected areas of the master cylinder reservoir.

Removal and Installation

11. When the reservoir is empty, replace the cap on the master cylinder reservoir and plug the reservoir outlet to prevent any excess fluid from spilling during removal.
12. Disconnect the two brake tubes from the master cylinder. Plug the brake tubes and the master cylinder ports to protect them from contamination.



13. Disconnect the master cylinder pushrod clevis pin from the brake pedal.



14. Loosen and remove the two bolts that hold the master cylinder assembly to the bracket on the fire wall. Remove the master cylinder and master cylinder reservoir assembly from the vehicle.

Removal and Installation

15. If the master cylinder reservoir is undamaged and is going to be reused, follow these steps to remove the undamaged reservoir from the old master cylinder.
 - a. Remove the nut from the front bolt. Use a punch to drive out the two roll pins. Use care and support the tabs while you drive out the pins.
 - b. Lift the reservoir off the master cylinder.
 - c. Pour any fluid remaining in the reservoir into a suitable container.
 - d. Plug the reservoir outlet ports to prevent contamination to the system.
16. Verify the warranty status. If the master cylinder is under warranty, return it to ZF.

6.15 Installation

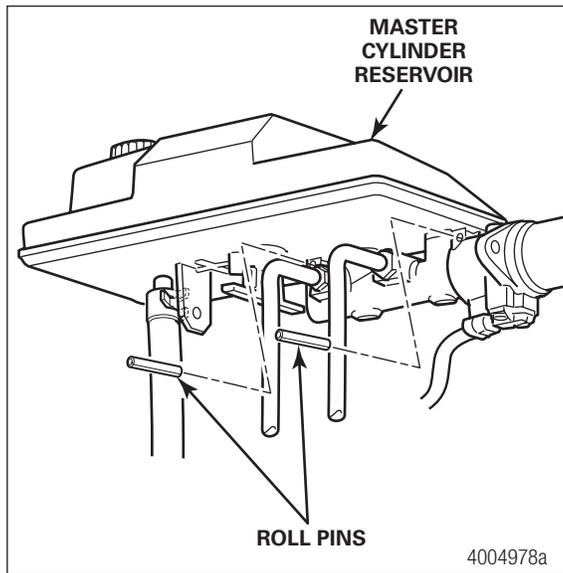
6.15.1 Master Cylinder

WARNING

To help prevent serious eye injury, always wear eye protection when you perform vehicle maintenance or service.

- Two people are needed to perform this procedure.
 - In some vehicles it may be necessary to move non-HPB system components, such as the air tank, in order to access the HPB part. If this is necessary, refer to the vehicle manufacturer's manual for information before moving the component.
 - Bleeding the master cylinder circuit is required during installation of the master cylinder. Bleed procedures appear in Section 5 of this manual.
 - After installing HPB components or making system repairs, use TOOLBOX™ Software to remove the error code from the ECU memory. Instructions for using TOOLBOX™ Software appear in Section 5 of this manual.
1. Attach the original or replacement reservoir to the new master cylinder, as follows.
 - a. Install two new rubber grommet seals into the inlet ports of the master cylinder. Use new brake fluid from a sealed container to lubricate the seals. Use DOT 3 or DOT 4 brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.
 - b. Install the original or replacement reservoir by carefully pressing it fully into the grommets.
 - c. Install two new roll pins from the replacement kit. Drive the pins through the holes in the master cylinder boss and the reservoir mounting tab holes. Support the back of the tabs as you install each pin.
 - d. Install the nut on the front bolt.

Removal and Installation

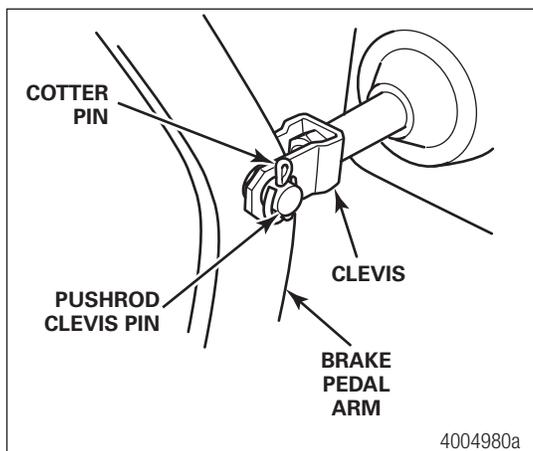


2. Use the two mounting nuts included in the replacement kit to attach the master cylinder assembly to the bracket on the fire wall. Tighten the bolts to 50 ft-lb (70 Nm).

DANGER

Failure to correctly install the clevis pin as described may result in damage to the pushrod, abnormal brake pedal feel and/or loss of brakes during vehicle operation.

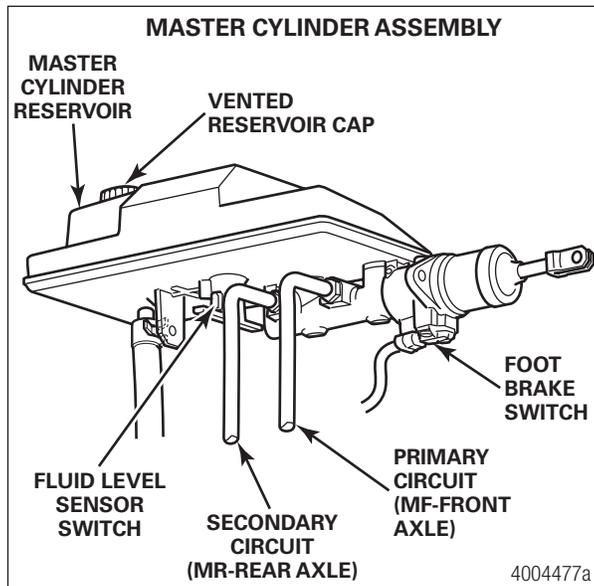
3. Connect the master cylinder pushrod clevis pin to the pedal assembly. The clevis pin must be installed into the same hole on the brake pedal as it was before the old master cylinder was removed. Secure the cotter pin.



4. Connect the brake tubes to the master cylinder. Tighten the fittings to 10.8-14.4 ft-lb (15-20 Nm).
5. Connect the low pressure hose to the master cylinder reservoir and secure the connection with a hose clamp.
6. Remove the pinch clamp from the low pressure hose.

Removal and Installation

7. Connect the foot brake switch on the master cylinder and the fluid level sensor switch under the reservoir.



8. Bleed the master cylinder circuit. Refer to Section 5.
9. Fill the master cylinder reservoir to the MAX mark with new brake fluid from a sealed container. Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.
10. Connect the battery.
11. Turn the ignition ON. The HCU pump motors will start up and fill the accumulators. Approximate running time is 45 seconds. If the HCU pump motors fail to deliver a sufficient amount of fluid, the ECU module will control the HCU pump motors in a self priming procedure. The HCU pump motors should stop within three minutes, with the brake warning light and the buzzer OFF. If there are problems building pressure after bleeding and powering up the system, increase the pressure setting of the pressure bleeder equipment to 29-40 psi (2-2.75 bar), and cycle the ignition off for 10 seconds, then back on.



Pressure should be left on the system during the first key-on (attempt to build pressure).

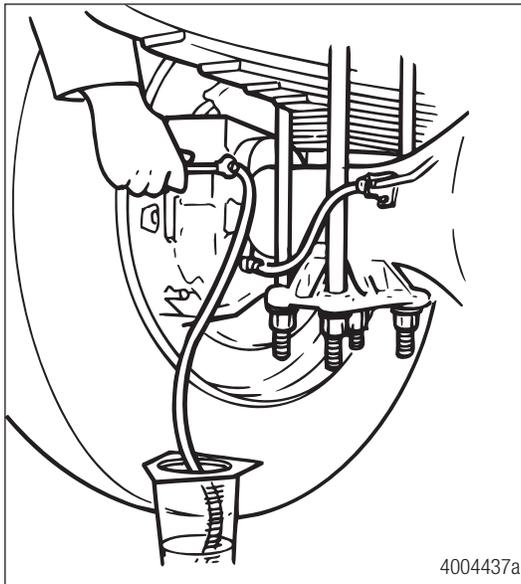
12. Depress the brake pedal rapidly four times to activate both HCU pump motors.
13. After the pumps stop running and the system is completely charged, the brake fluid level in the master cylinder reservoir should be between the MIN and MAX marks. Adjust if necessary. Refer to Section 5 for detailed instructions on how to correctly fill the master cylinder reservoir.
14. Check the system for leaks. If there are no leaks, go to Step 17.

If there are leaks, depressurize the system before making the necessary repairs. Use the following procedure to depressurize the system.

- Remove the two maxi-fuses for the pump motors or disconnect the battery.
- Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure that the system is depressurized, perform the following check on both the front and rear axles:

Removal and Installation

- a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
- b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the open end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.
- c. Use a wrench to open the bleeder fitting screw.



- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
- e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw to the torque value specified by the component manufacturer.
 - Repeat Steps A-E for the second axle.
15. After making the repairs, check the fluid level in the master cylinder reservoir to make sure it is at the MAX mark. Refill as necessary, using only the recommended DOT 3 or DOT 4 hydraulic brake fluid, as described above.
16. Reinstall the two maxi-fuses for the pump motors or reconnect the battery.
17. Use TOOLBOX™ Software to clear the diagnostic code for the master cylinder. Refer to Section 5 for TOOLBOX™ Software instructions.
18. Remove the wheel blocks.
19. Test drive the vehicle. Refer to the test drive procedure in Section 5 of this manual.

Removal and Installation

6.16 Removal

6.16.1 Master Cylinder Reservoir

WARNING

The full power brake system is a pressurized system that achieves pressures of up to 2320 psi. This pressure is not reduced by switching the ignition off or removing battery power. Prior to servicing this system, the depressurization procedures must be performed exactly as presented. Failure to depressurize the system may result in personal injury or death.

CAUTION

To help avoid damage to the system while working on the brake system, do not apply the foot pedal unless instructed to do so.



It is not necessary to remove the complete master cylinder assembly when replacing the reservoir.

- Two people are needed to perform this procedure.
- In some vehicles it may be necessary to move non-HPB system components, such as the air tank, in order to access the HPB part. If this is necessary, refer to the vehicle manufacturer's manual for information before moving the component.
- Bleeding the master cylinder circuit is required during installation of the master cylinder reservoir. Bleed procedures appear in Section 5 of this manual.
- After installing HPB components or making system repairs, use TOOLBOX™ Software to remove the error code from the ECU memory. Instructions for using TOOLBOX™ Software appear in Section 5 of this manual.

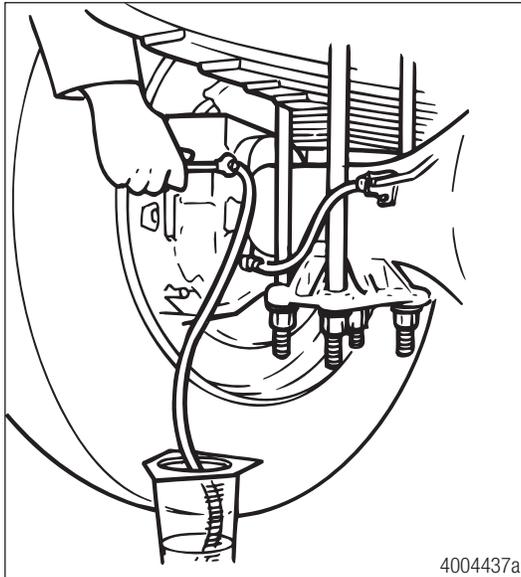
WARNING

Park the vehicle on a level surface. For vehicles with manual parking brakes, apply the parking brakes. Block the front and rear tires to help prevent vehicle movement. Failure to do so can result in unwanted vehicle movement causing serious personal injury.

1. Park the vehicle on a level surface. For vehicles with manual parking brakes, apply the parking brakes.
2. Block the front and rear tires to help prevent vehicle movement. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
3. Remove the two maxi-fuses for the pump motors or disconnect the battery.
4. Use a clean rag to carefully clean the outside of the master cylinder and master cylinder reservoir.
5. Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure the system is depressurized, perform the following check on both the front and rear axles.
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.

Removal and Installation

- c. Use a wrench to open the bleeder fitting screw to the torque value specified by the component manufacturer.

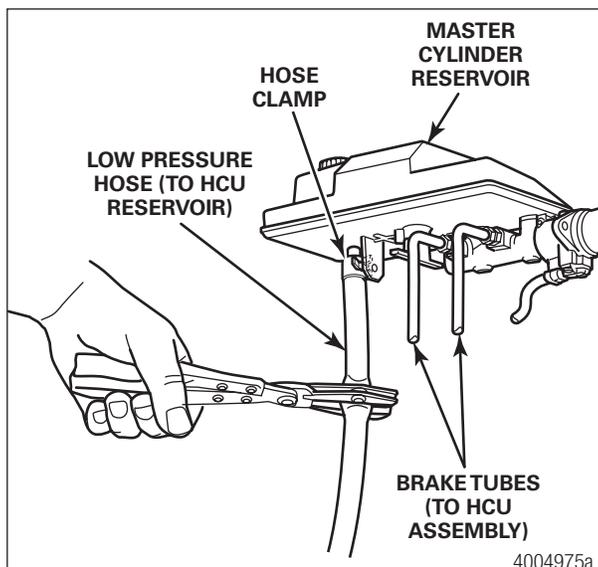


- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
- e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw.

Repeat Steps A-E for the second axle.

6. Attach a pinch clamp to the low pressure hose near the outlet to the master cylinder reservoir. Do not damage the reservoir outlet.

i Be careful not to damage the HCU reservoir outlet when attaching the pinch clamp. If damaged, it will need to be replaced.



Removal and Installation

7. To help prevent brake fluid from damaging the vehicle or floor paint, or from seeping into the ground, position a container beneath the work area to collect any drained or spilled brake fluid.
8. Remove the hose clamp from the low pressure hose.
9. Disconnect the low pressure hose from the master cylinder reservoir. All of the fluid coming out of the master cylinder reservoir, approximately one gallon (3.4 liters), should drain into the container. Remove the cap from the master cylinder reservoir to improve the draining process. Plug the low pressure hose to help prevent system contamination.
10. Remove the reservoir from the master cylinder assembly, as follows.
 - a. Disconnect the fluid level switch.
 - b. Remove the nut from the front bolt. Use a punch to drive out the two roll pins.
 - c. Lift the reservoir off the master cylinder.
 - d. Plug the reservoir outlet ports to help prevent contamination to the system.
 - e. Pour any remaining fluid into a container that can withstand the effects of brake fluid.
 - f. Close the reservoir outlet ports to help prevent spillage.
11. Verify the warranty status. If the master cylinder reservoir is under warranty, return it to ZF.

6.17 Installation

6.17.1 Master Cylinder Reservoir

WARNING

To help prevent serious eye injury, always wear eye protection when you perform vehicle maintenance or service.

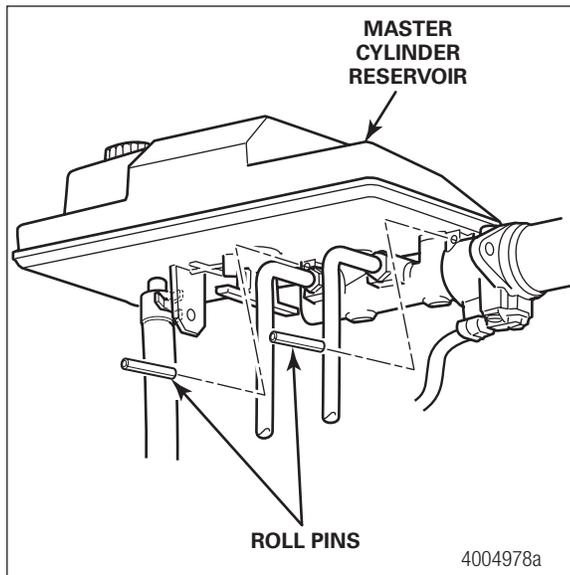
WARNING

Do not install a damaged reservoir. A damaged reservoir will result in loss of hydraulic brake fluid which can lead to loss of braking force. Serious personal injury can result.

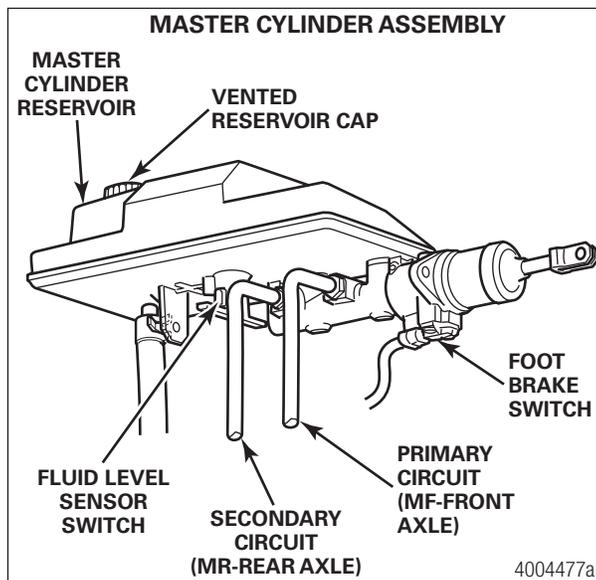
- Two people are needed to perform this procedure.
 - In some vehicles it may be necessary to move non-HPB system components, such as the air tank, in order to access the HPB part. If this is necessary, refer to the vehicle manufacturer's manual for information before moving the component.
 - Bleeding the master cylinder circuit is required during installation of the master cylinder reservoir. Bleed procedures appear in Section 5 of this manual.
 - After installing HPB components or making system repairs, use TOOLBOX™ Software to remove the error code from the ECU memory. Instructions for using TOOLBOX™ Software appear in Section 5 of this manual.
1. Attach the replacement reservoir to the new master cylinder, as follows.
 - a. Install the new rubber grommets in the two inlet ports of the master cylinder. Use new brake fluid from a sealed container to lubricate the seals. Use DOT 3 or DOT 4 brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.

Removal and Installation

- b. Install the replacement reservoir by carefully pressing it fully into the grommets.
- c. Install the two new roll pins from the replacement kit. Drive the pins through the holes in the master cylinder boss and the reservoir mounting tab holes. Support the back of the tabs as you install each pin.
- d. Install the nut on the front bolt.



2. Connect the low pressure hose to the reservoir.
3. Remove the pinch clamp from the low pressure hose.
4. Connect the fluid level switch on the master cylinder reservoir.



5. Fill the master cylinder reservoir to the MAX mark with new brake fluid from a sealed container. Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.
6. Bleed the master cylinder circuit. Follow the instructions for bleeding the master cylinder circuit that appear in Section 5 of this manual.

Removal and Installation

7. After bleeding, ensure that the fluid level in the master cylinder is at the MAX mark. If brake fluid in the reservoir is above or below the MAX mark, remove or add brake fluid as necessary until the MAX mark level is achieved. Never add fluid above the MAX mark.
8. Install the two maxi fuses or connect the battery.
9. Turn the ignition ON. The HCU pump motors will start up and fill the accumulators. Approximate running time is 45 seconds.

If the HCU pump motors fail to deliver a sufficient amount of fluid, the ECU module will control the HCU pump motors in a self priming procedure. The HCU pump motors should stop within three minutes, with the brake warning light and the buzzer OFF. If there are problems building pressure after bleeding and powering up the system, increase the pressure setting of the pressure bleeder equipment to 29-40 psi (2-2.75 bar), and cycle the ignition off for 10 seconds, then back on.

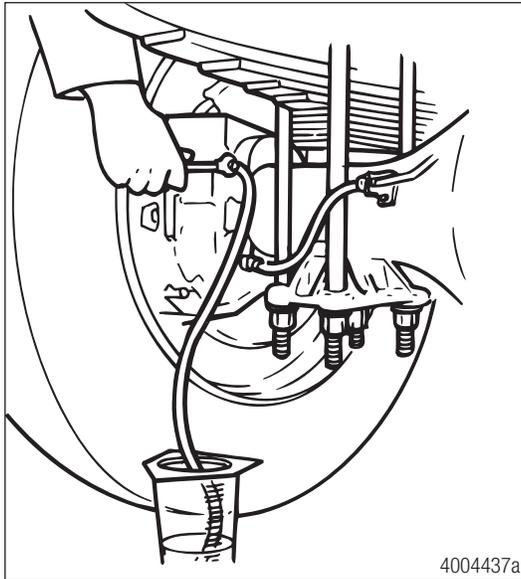


Pressure should be left on the system during the first key-on (attempt to build pressure).

10. Depress the brake pedal rapidly four times to activate both HCU pump motors.
11. With the system fully charged, the brake fluid level will be between the MIN and MAX marks on the master cylinder reservoir. Adjust if necessary. Refer to Section 5 for detailed instructions on how to correctly fill the master cylinder reservoir.
12. Check the system for leaks. If there are no leaks, go to Step 15.
If there are leaks, depressurize the system before making the necessary repairs. Use the following procedure to depressurize the system:
 - Remove the two maxi-fuses for the pump motors or disconnect the battery.
 - Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure that the system is depressurized, perform the following check on both the front and rear axles:
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.

Removal and Installation

- c. Use a wrench to open the bleeder fitting screw to the torque value specified by the component manufacturer.



- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
- e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw.
 - Repeat Steps A-E for the second axle.
13. After making the repairs, check the fluid level in the master cylinder reservoir to make sure it is at the MAX mark. Refill as necessary with new brake fluid from a sealed container. Use only the recommended DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.
14. Reinstall the two maxi-fuses for the pump motors or reconnect the battery.
15. Use TOOLBOX™ Software to cancel the diagnostic code for the master cylinder reservoir. Refer to Section 5 for TOOLBOX™ Software instructions.
16. Remove the wheel blocks.
17. Test drive the vehicle. Refer to the test drive procedure in Section 5 of this manual.

6.18 Removal

6.18.1 Master Cylinder Foot Brake Switch

WARNING

Park the vehicle on a level surface. Block the wheels to help prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface.
2. Apply the parking brake and block the wheels.

Removal and Installation

3. Disconnect the foot brake switch.
4. Remove the two machine screws securing the foot brake switch to the base of the master cylinder.
5. Remove the foot brake switch.
6. Remove and discard the paper gasket (models built prior to 2006) from the master cylinder, or O-ring (models built in 2006 and after) from the foot brake switch.
7. Verify the warranty status.

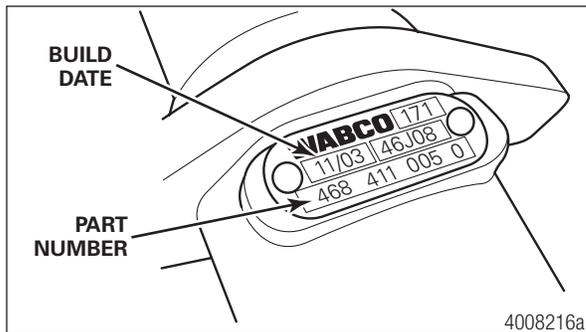


When removing and inspecting the foot brake travel switch, if brake fluid from the master cylinder is found in the switch or switch cavity, it indicates that the master cylinder has failed.

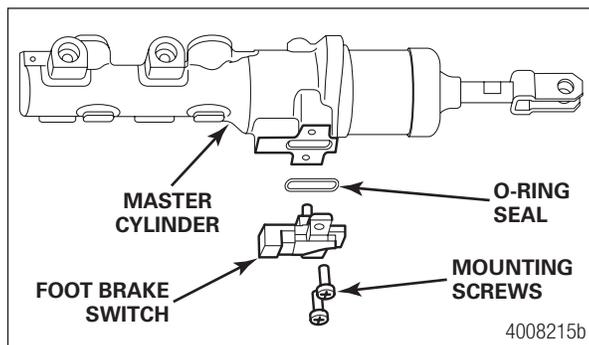
6.19 Installation

6.19.1 Master Cylinder Foot Brake Switch

If the master cylinder tag displays a build date prior to 01.01.2006 as shown on the tag, replace the entire master cylinder with the current design used in vehicles built after 01.01.2006.



1. Clean the surface of the master cylinder base and install the O-ring seal on the foot brake switch.
2. Install the foot brake switch to the base of the master cylinder. Tighten the two screws to 26.5-35.4 in-lb (3-4 Nm).



3. Connect the foot brake switch.
4. Remove the safety stands and wheel blocks.
5. Test drive the vehicle. Refer to the test drive procedure in Section 5 of this manual.

Removal and Installation

6.20 Removal

6.20.1 Master Cylinder Fluid Level Sensor Switch

⚠ WARNING

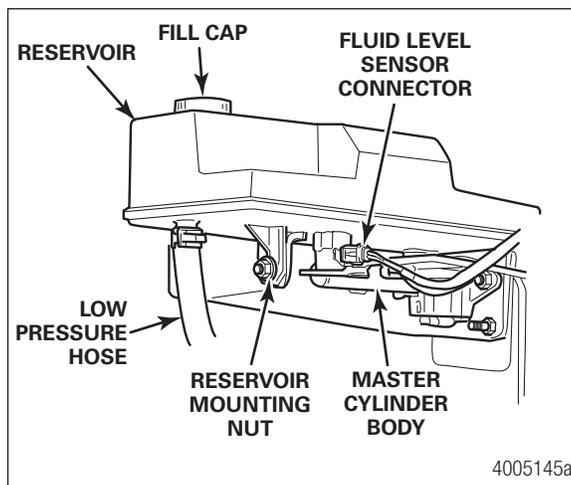
Park the vehicle on a level surface. Block the wheels to help prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface.
2. Apply the parking brake and block the wheels.
3. Remove the electrical connector from the fluid level sensor.
4. Squeeze the tabs together to remove the fluid level sensor from its mounting location on the master cylinder reservoir.
5. Verify the warranty status. If the switch is under warranty, return it to ZF.

6.21 Installation

6.21.1 Master Cylinder Fluid Level Sensor

1. Install the fluid level sensor in the same direction as the switch you removed.



2. Connect the fluid level sensor connector.
3. Remove the safety stands and wheel blocks.
4. Test drive the vehicle. Refer to the test drive procedure in Section 5 of this manual.

Removal and Installation

6.22 Removal

6.22.1 Parking Brake Pressure Supply Valve

WARNING

The full power brake system is a pressurized system that achieves pressures of up to 2320 psi. This pressure is not reduced by switching the ignition off or removing battery power. Prior to servicing this system, the depressurization procedures must be performed exactly as presented. Failure to depressurize the system may result in personal injury or death.



It is not necessary to remove the entire HCU assembly from the vehicle when replacing the parking brake valve.

- Two people are needed to perform this procedure.
- In some vehicles it may be necessary to move non-HPB system components, such as the air tank, in order to access the HPB part. If this is necessary, refer to the vehicle manufacturer's manual for information before moving the component.
- Bleeding the SAHR circuit is required during installation of the parking brake pressure supply valve. Bleed procedures appear in Section 5 of this manual.
- After installing HPB components or making system repairs, use TOOLBOX™ Software to remove the error code from the ECU memory. Instructions for using TOOLBOX™ Software appear in Section 5 of this manual.

WARNING

Park the vehicle on a level surface. Block the front and rear tires to help prevent vehicle movement. Failure to do so can result in unwanted vehicle movement causing serious personal injury.

1. Park the vehicle on a level surface.
2. Block the front and rear tires to help prevent vehicle movement. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
3. Disconnect the battery.
4. Use a clear rag to carefully wipe the surface of the HCU and the surrounding area.

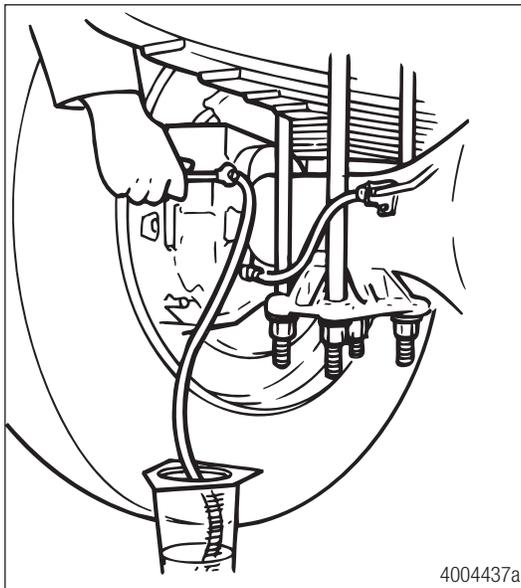


For convenience, Step 5 may be performed one axle at a time.

5. Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure that the system is depressurized, perform the following check on both the front and rear axles:
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.

Removal and Installation

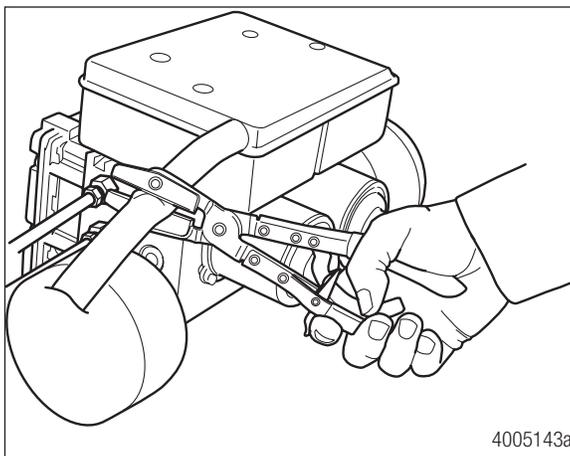
- c. Use a wrench to open the bleeder fitting screw to the torque value specified by the component manufacturer.



- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
- e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw.
 - Repeat Steps A-E for the second axle.
6. Disconnect the electrical connection from the parking brake pressure supply valve.
7. Attach a pinch clamp to the low pressure hose at the HCU reservoir.



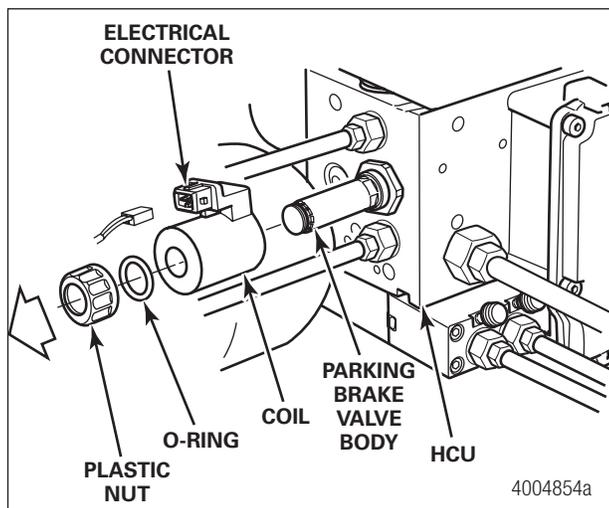
Be careful not to damage the HCU reservoir inlet when attaching the pinch clamp. If damaged, it will need to be replaced.



8. To help prevent brake fluid from damaging the vehicle or floor paint, or from seeping into the ground, position a container beneath the work area to collect any drained or spilled brake fluid.

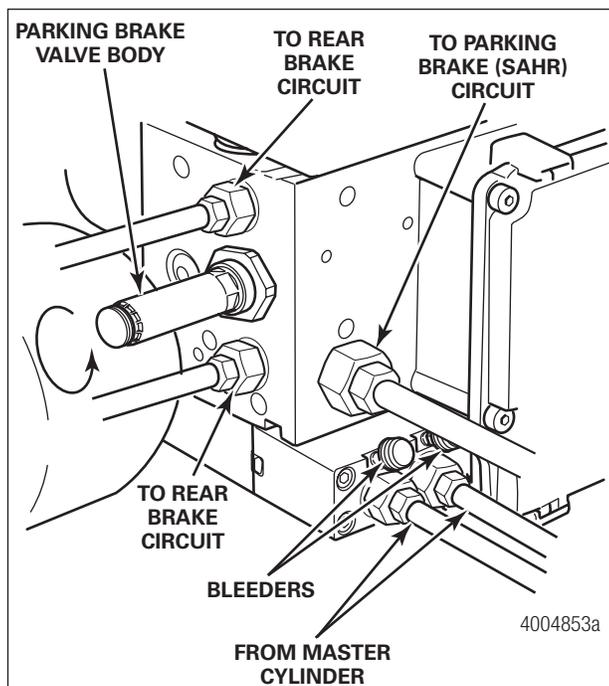
Removal and Installation

9. Unscrew the black plastic nut by hand from the pressure supply valve. Remove the coil and O-ring.



Do not use a 17 mm wrench to remove the pressure supply valve. The Snap-On Tool specified in Step 10 must be used.

10. Use a socket, Snap-On Tools part number A121, to remove the pressure supply valve from the hydraulic compact unit.



11. Plug the open port to help prevent contaminants from entering the system.
12. Verify the warranty status. If the pressure supply valve is under warranty, return it to ZF.

Removal and Installation

6.23 Installation

6.23.1 Parking Brake Pressure Supply Valve

⚠ WARNING

The full power brake system is a pressurized system that achieves pressures of up to 2320 psi. This pressure is not reduced by switching the ignition off or removing battery power. Prior to servicing this system the depressurization procedures must be performed exactly as presented. Failure to depressurize the system may result in personal injury or death.

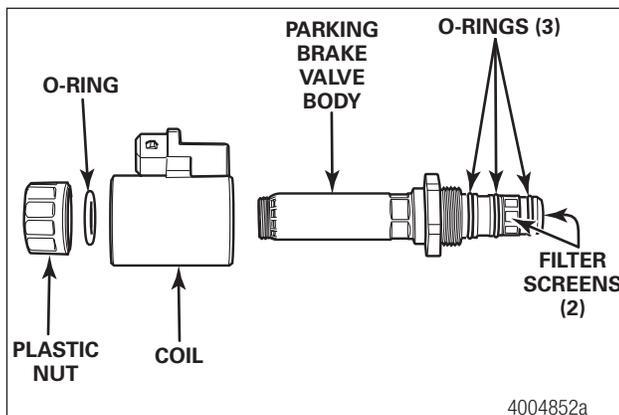
- Two people are needed to perform this procedure.
- In some vehicles it may be necessary to move non-HPB system components, such as the air tank, in order to access the HPB part. If this is necessary, refer to the vehicle manufacturer's manual for information before moving the component.
- Bleeding the SAHR circuit is required during installation of the parking brake pressure supply valve. Bleed procedures appear in Section 5 of this manual.
- After installing HPB components or making system repairs, use TOOLBOX™ Software to remove the error code from the ECU memory. Instructions for using TOOLBOX™ Software appear in Section 5 of this manual.

⚠ CAUTION

When installing the new parking brake pressure supply valve assembly, be careful not to damage the valve body O-rings and filter screens.

i To help prevent leakage, the three O-rings and two filter screens must be in place.

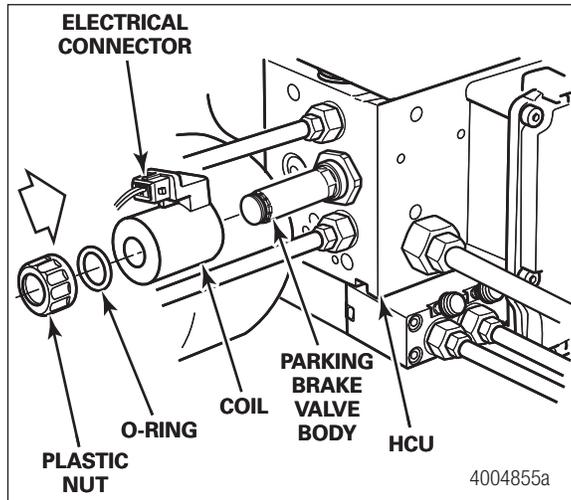
1. Remove the coil from the new pressure supply valve.



2. Use a clean rag to carefully clean the outside of the hydraulic compact unit.
3. Use new, clean lubricant to lubricate the O-rings on the new parking brake valve. Use only DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.

Removal and Installation

4. Position the new pressure supply valve onto the hydraulic compact unit. Use a socket, Snap-On Tools part number A121, to tighten the valve to 27-34 ft-lb (40-50 Nm).



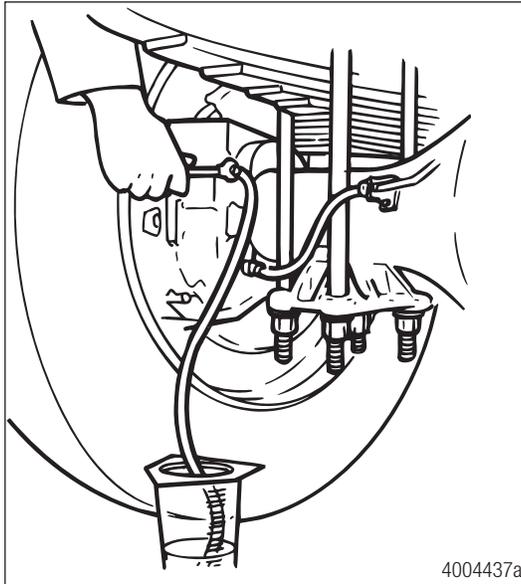
5. Place the coil, O-ring and plastic nut onto the pressure supply valve. Use a 12-point socket wrench to tighten the black plastic nut to 26.5 in-lb (3 Nm).
6. Attach the electrical connector to the parking brake valve.
7. Remove the pinch clamp from the low pressure hose.
8. Fill the master cylinder reservoir to the MAX mark with new brake fluid from a sealed container. Use only DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.
9. Connect the battery.
10. Turn the ignition switch ON. The HCU pump motors will start up and fill the accumulators. Approximate running time is 45 seconds.
11. Bleed the spring-applied/hydraulic release (SAHR) parking brake circuit. Follow the instructions for bleeding the SAHR circuit that appears in Section 5 of this manual.
12. After bleeding the SAHR circuit, ensure that the brake fluid level in the master cylinder reservoir is at the MAX mark. If the brake fluid in the reservoir is above or below the MAX mark, remove or add brake fluid as necessary until the MAX mark level is achieved. Never add fluid above the MAX mark. Refer to Section 5 for detailed instructions on how to correctly fill the master cylinder reservoir.
13. Check the system for leaks. If there are no leaks, go to Step 16.

If there are leaks, depressurize the system before making the necessary repairs. Use the following procedures to depressurize the system:

- Remove the two maxi-fuses for the pump motors or disconnect the battery.
- Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure that the system is depressurized, perform the following check on both the front and rear axles:
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.

Removal and Installation

- c. Use a wrench to open the bleeder fitting screw.



- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
- e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw to the torque value specified by the component manufacturer.
- Repeat Steps A-E for the second axle.
14. After making the repairs, check the fluid level in the master cylinder reservoir to make sure it is at the MAX mark. Refill as necessary with new clean brake fluid from a sealed container. Use only the recommended DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.
15. Reinstall the two maxi-fuses for the pump motors or reconnect the battery.
16. Use TOOLBOX™ Software to cancel the diagnostic code for the pressure supply valve. Refer to Section 5 for TOOLBOX™ Software instructions.
17. Remove the wheel blocks.
18. Test drive the vehicle. Refer to the test drive procedure in Section 5 of this manual.

6.24 Removal

6.24.1 Low Pressure Hose

WARNING

The full power brake system is a pressurized system that achieves pressures of up to 2320 psi. This pressure is not reduced by switching the ignition off or removing battery power. Prior to servicing this system, the depressurization procedures must be performed exactly as presented. Failure to depressurize the system may result in personal injury or death.

Removal and Installation

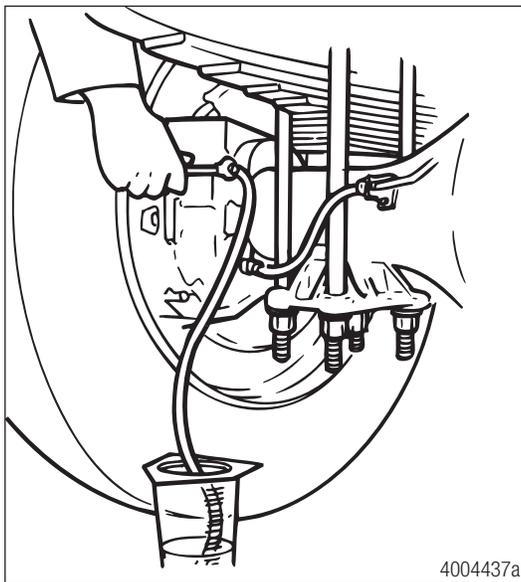
i ZF does not manufacture low pressure hoses. Refer to the vehicle manufacturer for specific installation and service information. The following removal and installation procedures are included to assist you in servicing WABCO's HPB system.

1. Park the vehicle on a level surface.

⚠ WARNING

Block the front and rear tires to help prevent the vehicle from moving. Unwanted vehicle movement can result in serious personal injury.

2. Block the front and rear tires to help prevent vehicle movement.
3. Disconnect the battery.
4. Use a clean rag to carefully wipe the surface of the HCU and the master cylinder reservoir.
5. Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure the system is depressurized, perform the following check on both the front and rear axles.
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.
 - b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.
 - c. Use a wrench to open the bleeder fitting screw.



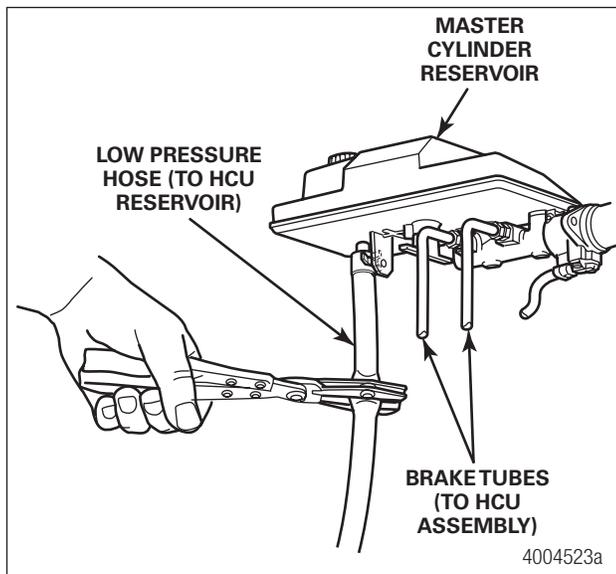
- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
- e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw to the torque value specified by the component manufacturer.

Repeat Steps A-E for the second axle.

Removal and Installation

6. Attach a pinch clamp to the low pressure hose near the outlet of the master cylinder reservoir. Do not damage the reservoir outlet.

i Be careful not to damage the HCU reservoir outlet when attaching the pinch clamp. If damaged, it will need to be replaced.



7. Remove the clamps that hold the middle section of the low pressure hose to the chassis. Note the position of the clamps for installation of the new hose.
8. To help prevent brake fluid from damaging the vehicle or floor paint, or from seeping into the ground, position a container beneath the work area to collect any drained or spilled brake fluid.
9. Remove the hose clamp and remove the hose from the master cylinder reservoir.

i Some brake fluid may remain in protected areas of the master cylinder reservoir.

10. Remove the cap from the master cylinder reservoir to assist draining. When the reservoir is empty, replace the cap on the master cylinder reservoir and plug the reservoir outlet to prevent any excess fluid from spilling during removal. Approximately one gallon (3.4 liters) should drain into the container.
11. Remove the hose clamp and remove the hose from the HCU.
12. Remove the "P" clamps and remove the hose from the vehicle.

Removal and Installation

6.25 Installation

6.25.1 Low Pressure Hose

- When replacing the low pressure hose, bleeding the system is not necessary.
 - To help prevent contamination of the system, keep the hose ends sealed until you are ready to connect them.
1. Remove the plug from the HCU reservoir.
 2. Remove the plugs from the ends of the new hose.



When installing the hose clamps that hold the middle portion of the low pressure hose to the vehicle, use the same location as was used for the original installation.

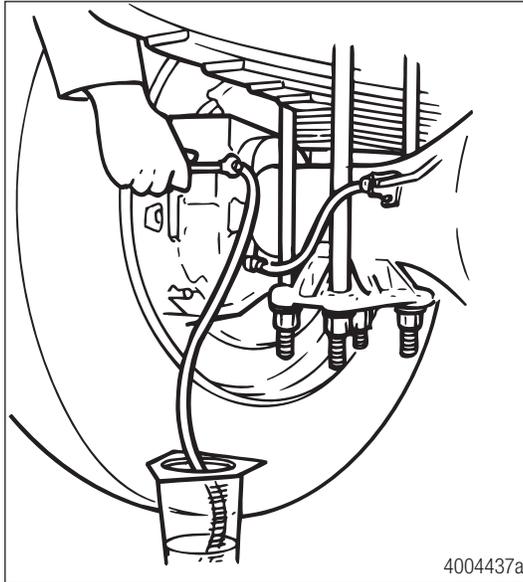
3. Attach the new hose to the HCU reservoir and master cylinder reservoir. Reuse the “P” clamps to attach the middle portion of the hose to the vehicle frame. Make sure the new hose does not contact any sharp edges or hot components.
4. Fill the master cylinder reservoir with new brake fluid from a sealed container. The fluid level must be at the MAX mark. Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.
5. Connect the battery.
6. Turn the ignition ON. The HCU pump motors will start up and fill the accumulators. Approximate running time is 45 seconds.
7. Turn the ignition OFF and disconnect the battery.
8. Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. This will purge any trapped air from the hose.
9. After the fluid level is stabilized, ensure the fluid level in the master cylinder reservoir is at the MAX mark. If the brake fluid in the reservoir is above or below the MAX mark, remove or add fluid as necessary until the MAX mark level is achieved. Never add fluid above the MAX mark. Refer to Section 5 for detailed instructions on how to correctly fill the master cylinder reservoir.
10. Connect the battery.
11. Turn the ignition ON. The HCU pump motors will start up and fill the accumulators. Approximate running time is 45 seconds.
12. Pump the brakes rapidly four times to activate both HCU pump motors. After the pumps stop, the brake fluid will be between the MIN and MAX marks on the master cylinder reservoir.
13. Check the system for leaks. If there are no leaks, go to Step 15.

If there are leaks, depressurize the system before making the necessary repairs. Use the following procedure to depressurize the system.

- Remove the two maxi-fuses for the pump motors or disconnect the battery.
- Apply the brake pedal a **minimum** of 30 times to decrease pressure in the system. To ensure that the system is depressurized, perform the following check on both the front and rear axles:
 - a. Remove the protective cover from the end of the bleeder fitting on one brake caliper.

Removal and Installation

- b. Attach a bleeder bottle hose to the bleeder fitting at the wheel end. Submerge the free end of the bleeder hose into the bleeder bottle. Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.
- c. Use a wrench to open the bleeder fitting screw.



- d. Apply and hold the brake pedal down until no more brake fluid runs out. Do not release the brake pedal.
- e. With the brake pedal still applied, use a torque wrench to tighten the bleeder fitting screw to the torque value specified by the component manufacturer.
 - Repeat Steps A-E for the second axle.
14. After making the repairs check the fluid level in the master cylinder reservoir to make sure it is at the MAX mark. Refill as necessary, using only the recommended DOT 3 or DOT 4 hydraulic brake fluid, as described above. Never add fluid above the MAX mark.
15. Reinstall the two maxi-fuses for the pump motors or reconnect the battery.
16. Remove the wheel blocks.
17. Test drive the vehicle. Refer to the test drive procedure in Section 5 of this manual.

6.26 Lubrication

6.26.1 Wheel Speed Sensor Specification

ZF specifications call for a sensor lubricant with the following characteristics.

Lube must be mineral oil-based and contain molydisulfide. It should have excellent anti-corrosion and adhesion characteristics and be capable of continuous function in a temperature range of -40° to 300°F (-40° to 150°C).

- Lubricants approved for use on WABCO brand sensors and spring clips are:
 - Mobilith SHC-220 (Mobil)
 - TEK 662 (Roy Dean Products)

Removal and Installation

- Staburags NBU 30 PTM (Klüber Lubrication)
- Valvoline EP 633
- Klüberplex BE 31-512 (Klüber Lubrication)
- Urethyn-EZ (Fuchs Lubritech)
- Unirex N3 (ESSO)
- ECO-Li-Plus (BPW)
- Molykote P40 (Dow Corning)
- Moly-Fortified Multi-Purpose Grease (Ford) (Valvoline/USA)

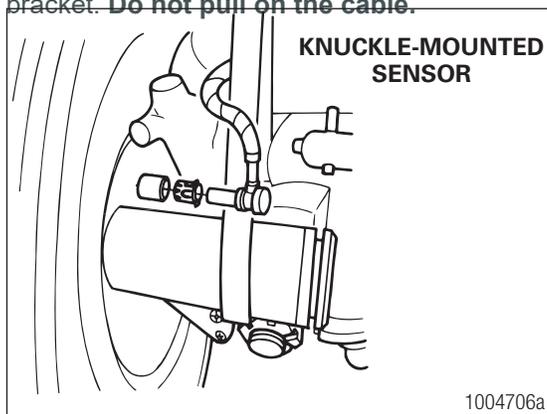
6.27 Removal

6.27.1 Front Axle Wheel Speed Sensor

WARNING

Park the vehicle on a level surface. Block the wheels to help prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface. Apply the parking brakes. Block the rear tires to help prevent the vehicle from moving. If necessary, raise the front tires off the ground. Place safety stands under the axle.
2. Disconnect the fasteners that hold the sensor cable to the other components.
3. Disconnect the sensor cable from the chassis harness.
4. Remove the sensor from the sensor holder. Twist and pull the sensor to remove it from the sensor bracket. **Do not pull on the cable.**

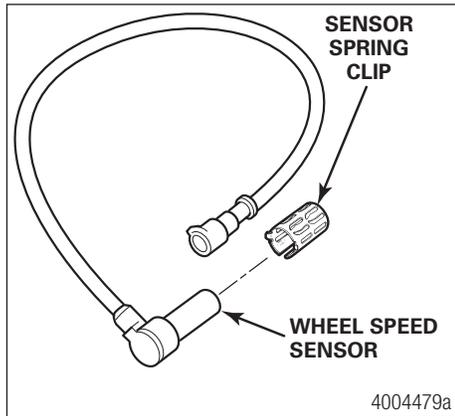


5. Remove the sensor spring clip.



When replacing the wheel speed sensor, the sensor spring clip must also be replaced.

Removal and Installation



6.28 Installation

6.28.1 Front Axle Wheel Speed Sensor

1. Connect the sensor cable to the chassis harness.
2. Install the fasteners used to hold the sensor cable in place.
3. Apply a ZF-recommended lubricant to the sensor spring clip and sensor.
4. Install the sensor spring clip. Verify that the spring clip tabs are on the inboard side of the vehicle.
5. With the tabs on the inboard side, push the sensor spring clip into the bushing in the steering knuckle until the clip stops.
6. Push the sensor completely into the sensor spring clip until it contacts the tooth wheel.

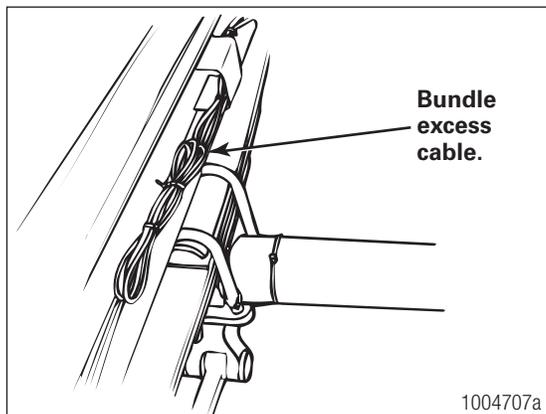


After installation, there should be no gap between the sensor and the tooth wheel. During normal operation, a gap of up to 0.04-inch (1.016 mm) is allowable.

CAUTION

Overtightening the tie wraps may damage the cables.

7. Fasten the sensor cable with tie wraps every 12 inches. Do not overtighten the tie wraps. Correctly bundle and store any excess cable in the sub-frame.



Removal and Installation

8. Remove the blocks and safety stands.
9. Test drive the vehicle. Refer to the test drive procedure in Section 5 of this manual.

6.29 Removal

6.29.1 Rear Axle Wheel Speed Sensor

WARNING

Park the vehicle on a level surface. Block the wheels to help prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Apply the parking brake. Block the front tires to prevent vehicle movement.
2. Raise the rear tires off the ground. Place safety stands under the axle.
3. If the rear tire must be removed to gain access to the sensor, release the parking brake to release the brake shoe.

Remove the wheel and tire assembly from the axle.

4. Remove the sensor from the mounting block in the axle housing. Use a twisting motion if necessary. **Do not pull on the cable.**
5. Disconnect the sensor cable from the chassis harness.
6. Remove the sensor cable from any cable clamps or clips.
7. Remove the sensor spring clip from the sensor bracket.



When replacing the wheel speed sensor, the sensor spring clip must also be replaced.

6.30 Installation

6.30.1 Rear Axle Wheel Speed Sensor

1. Connect the new sensor cable to the chassis harness.
2. Apply a ZF-recommended lubricant to the spring clip.
3. Press the sensor spring clip into the sensor bracket, located on the rear axle, until it stops. Verify that the tabs are on the inboard side.
4. Apply a ZF-recommended lubricant to the sensor.
5. Push the sensor completely into the spring clip until it contacts the tooth wheel.



After installation, there should be no gap between the sensor and the tooth wheel. During normal operation, a gap of up to 0.04-inch (1.016 mm) is allowable.

Removal and Installation

6. Reattach the sensor cable to the cable clamps or clips.

CAUTION

Overtightening the tie wraps may damage the cables.

7. Fasten the sensor cable with tie wraps every 12 inches. Do not overtighten the tie wraps. Correctly bundle and store excess cable in the sub-frame.
8. Use TOOLBOX™ Software to remove the error code from the ECU memory.
9. Replace the tire and remove the safety stands. Lower the vehicle and remove the blocks from the front tires.
10. Test drive the vehicle. Refer to the test drive procedure in Section 5 of this manual.

Brake Bleeding Procedures

7 Brake Bleeding Procedures

7.1 Hazard Alert Messages

The following brake bleeding procedures explain how to bleed the hydraulic power brake system during installation, or in the event of air in the brake system.

When performing bleed procedures, read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To help prevent serious eye injury, always wear eye protection when you perform vehicle maintenance or service.

WARNING

Park the vehicle on a level surface. Block the wheels to help prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

WARNING

Failure to bleed the system whenever any hydraulic system fitting is loosened or disconnected will allow air to remain in the system. This will help prevent the hydraulic pressure in the brake system from rising enough to apply the brakes correctly. This will cause the stopping distance to increase and can result in serious personal injury.

WARNING

Never reuse hydraulic brake fluid that has been removed from a vehicle. Hydraulic brake fluid that has been removed can be contaminated and can cause damage, loss of braking and serious personal injury. Always discard hydraulic brake fluid in accordance with applicable environmental requirements.

WARNING

Use only the type of hydraulic brake fluid specified by the equipment manufacturer. Do not use or mix different types of hydraulic brake fluid. The incorrect hydraulic brake fluid will damage the rubber parts of the brake caliper and can cause damage, loss of braking and serious personal injury.

WARNING

Do not let the brake master cylinder fluid get below the minimum level during the bleeding operation. Keep the master cylinder reservoir filled with new DOT-approved brake fluid, as specified by the original equipment manufacturer. Failure to keep the brake reservoir level above minimum could result in more air entering system, making it impossible to effectively bleed the system.

Brake Bleeding Procedures

WARNING

Never add fluid above the MAX mark on the HPB master cylinder reservoir regardless of the charging state of the accumulators. When the system is totally or partially depressurized during service or overnight parking, fluid stored in the accumulators is returned to the master cylinder reservoir. If the reservoir was previously filled above the MAX mark, a fluid spill could occur when these conditions exist. Overfilling the master cylinder reservoir may cause damage to the cap and other components, resulting in impaired braking performance and could result in an accident and serious personal injury.

CAUTION

Hydraulic brake fluid is a caustic substance. Contact with hydraulic brake fluid can cause skin irritation. Do not let hydraulic brake fluid touch any painted surfaces, as it will remove the paint. Hydraulic brake fluid may also damage certain non-metal surfaces. Do not let fluid get on brake pads, shoes, rotors or disks.

Observe the following when working on the braking system.

WARNING

Prior to working on the braking system, all bleeder screws and the master cylinder cap must be cleaned thoroughly; cleanliness of fluid and areas around the service points have to be maintained. Do not use mineral oil-based fluid for this cleaning. Using mineral oil-based fluid can contaminate brake fluid and could damage the interior of the components and cause a system malfunction. Cover all electrical connectors near the bleeder screws carefully to make certain that no brake fluid enters the terminals or plugs. Failure to do so may cause loss of braking resulting in serious personal injury.



After removing a component or disconnecting a brake tube connection, block off ports and brake tubes with appropriate plugs to prevent the ingress of dirt and unnecessary loss of fluid.

Use only new specified brake fluid from a sealed container to refill the system. Refer to the specification on the Master Cylinder (MC) reservoir or in the vehicle service manual.

If a lubricant is required to aid assembly, use only the specified brake fluid from a sealed container. Do not use any other assembly lubricant.

During bleeding procedures, brake fluid level must not be allowed to fall below the MIN mark on the master cylinder reservoir. The master cylinder reservoir should be regularly checked and filled to the MAX mark.

Perform the bleeding procedure exactly as described in the instructions. Perform the reservoir top-off procedure, when bleeding is complete. Refer to technical publication TP09121, Filling the Hydraulic Power Brake (HPB) Master Cylinder Reservoir, for instructions on filling the master cylinder. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

After completing all desired brake service operations, test the braking system for function and check for leakage.

Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use.

Brake Bleeding Procedures

7.2 Brake Bleeding Procedures

The pressure-assisted brake bleeding procedures described here may be used with any fill and bleed equipment capable of filling the system and creating pressure in the master cylinder reservoir.

WARNING

ZF does not recommend using manual bleeding procedures. Manual bleeding procedures could result in loss of braking, resulting in serious personal injury.

7.3 Pressure Bleed Procedures

7.3.1 Master Cylinder Circuit

1. Park the vehicle on a level surface. Apply the parking brake and block the wheels to help prevent the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
2. Turn the ignition OFF and remove the two 30-amp Maxi fuses for the brake system motors. Refer to the vehicle manufacturer's specifications to determine where the fuses are located.
3. Connect the diagnostic laptop to the diagnostic connector located in the cab, under the instrument panel. Set the ignition key to ON and open the TOOLBOX™ Software program.
4. Deplete pressure in the accumulators. There are two ways of depressurizing the system as follows.
 - a. Fully depress the brake pedal a minimum of 30 times. The pressure in each brake circuit can be monitored using the TOOLBOX™ Software. Ensure that the pressure in each accumulator is at 0 psi.
 - b. While fully depressing the brake pedal, select the Deplete Accumulators function from the TOOLBOX™ Software EOL pull-down menu. The pedal must remain fully depressed during the entire process, until the TOOLBOX™ Software displays the completion message. Ensure that the pressure in both accumulators is reading zero on the diagnostic main screen then release the brake pedal.
5. Turn the ignition OFF.
6. Verify that the brake fluid level in the master cylinder reservoir is not below MIN level.



During bleeding procedures, brake fluid level must not be allowed to fall below the MIN mark on the master cylinder reservoir. The master cylinder reservoir should be regularly checked and filled to the MAX mark with new specified brake fluid from a sealed container. Do not add fluid above the MAX mark.

7. Prepare the pressure bleeder device according to the instructions provided with the equipment.

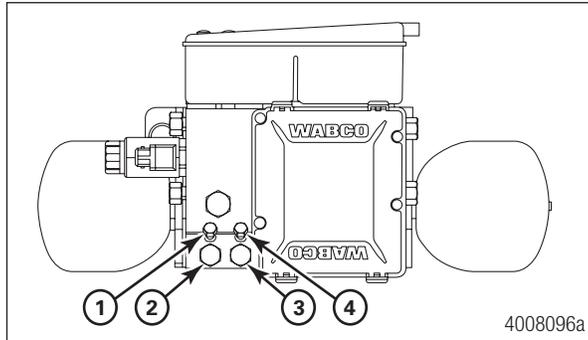


The pressurized fill and bleed equipment used can be either “air over fluid” or “fluid over air” type.

8. Install a suitable adapter from the fill and bleed equipment to the master cylinder reservoir filler neck. Verify that the adapter and bleed equipment are securely tightened onto the master cylinder reservoir filler neck.

Brake Bleeding Procedures

- Remove the rubber caps from the two relay valve bleeder screws located on the hydraulic control unit (HCU).



- 1 BLEEDER PORT — PRIMARY MASTER CYLINDER CIRCUIT
- 2 MASTER CYLINDER INPUT PORT — PRIMARY CIRCUIT
- 3 MASTER CYLINDER INPUT PORT — SECONDARY CIRCUIT
- 4 BLEEDER PORT — SECONDARY MASTER CYLINDER CIRCUIT

- Fit the bleeder hose onto one relay valve bleeder screw located on the hydraulic compact unit.
- Submerge the free end of the bleeder hose into the partially filled bleed bottle.
- Apply 35 psi (2.4 bar) of pressure from the fill and bleed equipment to the master cylinder reservoir.
- Open one of the relay valve bleeder screws until the fluid begins to flow (about 3/4 turn). Allow the fluid to run until 8.5 ounces (250 cc) has been collected. Take note of the fluid level in the bottle before starting.
- When no further air bubbles enter the bleed bottle, close the bleeder screw. Remove the bleeder hose and tighten the bleeder screw to 35.4 to 39.8 lb-in (4 to 4.5 Nm).



Verify the fluid level in the master cylinder reservoir. During bleeding procedures, the brake fluid must not be allowed to fall below the MIN mark on the master cylinder reservoir. The master cylinder reservoir should be regularly checked during the bleeding procedures and filled to the MAX mark.

- Repeat Steps 13 and 14 with the second bleeder screw.
- Ensure that the brake fluid level in the master cylinder reservoir is at the MAX mark. If the brake fluid in the reservoir is above or below the MAX mark, remove or add fluid as necessary until the MAX mark level is achieved. Never add fluid above the MAX mark. Refer to Section 5 for detailed instructions on how to correctly fill the master cylinder reservoir.
- If brake caliper circuit bleeding is required, refer to the procedure in this section.
- If brake caliper circuit bleeding is NOT required, install the two 30-amp pump motor fuses and turn the ignition ON with 35 psi (2.4 bar) pressure applied to the master cylinder reservoir. The HCU pump motors will start up automatically and fill the accumulators. Approximate running time is 45 seconds. The brake light and buzzer will turn OFF.
- Release the pressure from the master cylinder reservoir.
- Remove the bleed equipment.

Brake Bleeding Procedures

21. Install the master cylinder reservoir cap.
22. Using the diagnostic laptop and the TOOLBOX™ Software program, clear all the inactive fault codes.



If faults remain, they should be diagnosed prior to releasing the vehicle to service.

23. Turn the ignition OFF and disconnect the diagnostic laptop from the diagnostic connector.
24. Check the system for external leaks.
25. Remove the wheel blocks.

7.3.2 Brake Caliper Circuit



If the vehicle has “Quadraulic” calipers, refer to the “Quadraulic Brake Caliper Bleeding Procedure” in this section.



If you are bleeding the front calipers, it is critical that you bleed the SAHR circuit also, if equipped.

WARNING

Park the vehicle on a level surface. Apply the parking brake and block the wheels to help prevent the vehicle from moving. Unwanted vehicle movement can result in serious personal injury.

1. Park the vehicle on a level surface. Apply the parking brake and block the wheels to help prevent the vehicle from moving.
2. Turn the ignition OFF and remove the two 30-amp Maxi fuses for the brake system motors. Refer to the vehicle manufacturer’s specifications to determine where the fuses are located.
3. Connect the diagnostic laptop to the diagnostic connector located in the cab, under the instrument panel. Set the ignition key to ON and open the TOOLBOX™ Software program.
4. Deplete pressure in the accumulators. There are two ways of depressurizing the system as follows.
 - a. Fully depress the brake pedal a minimum of 30 times. The pressure in each brake circuit can be monitored using the TOOLBOX™ Software. Ensure that the pressure in each accumulator is at 0 psi.
 - b. While fully depressing the brake pedal, select the Deplete Accumulators function from the TOOLBOX™ Software EOL pull-down menu. The pedal must remain fully depressed during the entire process, until the TOOLBOX™ Software displays the completion message. Ensure that the pressure in both accumulators is reading zero on the diagnostic main screen then release the brake pedal.
5. Turn the ignition OFF.
6. Verify that the brake fluid level in the master cylinder reservoir is not below MAX level.



During bleeding procedures, brake fluid level must not be allowed to fall below the MIN mark on the master cylinder reservoir. The master cylinder reservoir should be regularly checked and filled to the MAX mark with new specified brake fluid from a sealed container.

Brake Bleeding Procedures

7. Prepare the pressure bleeder device according to the instructions provided with the equipment.

i The pressurized fill and bleed equipment used can be either “air over fluid” or “fluid over air” type.

8. Install a suitable adapter from the fill and bleed equipment to the master cylinder reservoir filler neck. Verify that the adapter and bleed equipment are securely tightened onto the master cylinder reservoir filler neck.

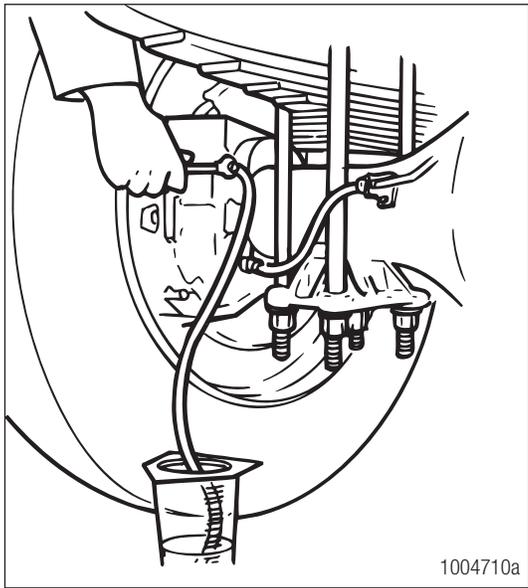
i If all wheel ends are to be bled, use the following bleeding order: right rear, left rear, right front, left front.

9. Fit the bleeder hose onto the caliper bleeder screw at one wheel end.

10. Submerge the free end of the bleeder hose into the bleed bottle.

11. Apply 35 psi (2.4 bar) of pressure from the fill and bleed equipment to the master cylinder reservoir.

12. Open one caliper bleeder screw until fluid begins to flow (3/4 turn). Allow the fluid to run until 8.5 ounces (250 cc) has been collected. Take note of the fluid level in the bottle before starting.



13. If no further air bubbles enter the bleed bottle, close the bleeder screw. Remove the bleeder hose and tighten the bleeder screw to the torque value specified by the component manufacturer.

i Refer to the vehicle manufacturer’s specifications for specific information about bleeding the calipers. Some calipers have multiple bleeder screws and require removal of the wheels and tires to access the bleeder screws. Each bleeder screw must be bled.

i Verify the fluid level in the master cylinder reservoir. During bleeding procedures, the brake fluid must not be allowed to fall below the MIN mark on the master cylinder reservoir. The master cylinder reservoir should be regularly checked

14. Repeat Steps 9-13 with the other calipers in the specified order.

Brake Bleeding Procedures

15. If the vehicle is equipped with a power parking brake – SAHR canister, then bleed the SAHR circuit now using Steps 9-13 of the Spring-Applied/Hydraulic-Release (SAHR) Parking Brake Circuit pressure bleed procedure in this section.
16. Ensure that the brake fluid level in the master cylinder reservoir is at the MAX mark. If the brake fluid in the reservoir is above or below the MAX mark, remove or add fluid as necessary until the MAX mark level is achieved. Never add fluid above the MAX mark. Refer to Section 5 for detailed instructions on how to correctly fill the master cylinder reservoir.
17. Install the two 30-amp pump motor fuses and turn the ignition ON with 35 psi (2.4 bar) of pressure applied to the master cylinder reservoir. The HCU pump motors will start up automatically and fill the accumulators. Approximate running time is 45 seconds. The brake light and buzzer will turn OFF.
18. Release the pressure from the master cylinder reservoir.
19. Remove the bleed equipment.
20. Install the master cylinder reservoir cap.
21. Using the diagnostic laptop and the TOOLBOX™ program, while fully holding the brake pedal depressed, select the Deplete Accumulators function from the TOOLBOX™ Software EOL pull-down menu. The pedal must remain fully depressed during the entire process, until the TOOLBOX™ Software displays the dialog box that will indicate the completion of the function. Ensure that the pressure in both accumulators is reading zero on the diagnostic main screen, then release the brake pedal.



The DEplete ACCUMULATORS function performs a cycle of releasing the pressure and charging the pressure back up in each brake circuit. This cycle helps clear air from the HCU into the reservoir.

22. Repeat Step 21 two times.
23. Using the diagnostic laptop and the TOOLBOX™ Software program, clear all the inactive fault codes.



If faults remain, they should be diagnosed prior to releasing the vehicle to service.

24. Turn ignition OFF and disconnect the diagnostic laptop from the diagnostic connector.
25. Check the system for external leaks.
26. Remove wheel blocks.

7.3.3 Quadrauc Brake Caliper Bleeding Procedure

This bleed sequence refers to bleeding the caliper and does not consider the hydraulic application system requirements. Identify your vehicle hydraulic application system type and refer to that service manual before you perform any brake service.

WARNING

You must adhere to the hydraulic application system bleeding procedures to help prevent death, serious personal injury or damage to components.



If you are bleeding the front calipers, it is critical that you bleed the SAHR circuit also, if equipped.

Refer to the manufacturer's service information for ABS bleeding instructions.

1. Check the master cylinder reservoir and fill, if necessary, with DOT 3 or DOT 4 brake fluid.

Brake Bleeding Procedures

2. Bleed the brakes in the following order: right rear, left rear, right front and left front.

CAUTION

When you bleed a four-piston caliper, monitor the brake fluid level to ensure you do not drain the system. Add brake fluid to the reservoir as needed to help prevent damage to components during operation. Always install new brake fluid into the caliper. Discard old brake fluid. Do not reuse it. Damage to components can result.



Each four-piston caliper is equipped with two bleed screws. To help ensure air is removed from a caliper, the bleed sequence is inboard, outboard, and repeat inboard.

3. Install a section of clear, flexible tubing with a 1/4-inch inner diameter over the inboard bleeder. Insert the other end of the tubing into a container to collect the purged brake fluid. Discard the brake fluid. Do not reuse old brake fluid.
4. If a pressurized bleeding system is not required by the vehicle manufacturer's service procedures, apply and hold the brakes to pressurize the system.
5. Repeat the procedure for the outboard bleed screw.
6. Repeat the procedure for the inboard bleed screw.
7. Tighten the bleed screws to specification. Refer to Section 8.
8. Test the brakes prior to returning the vehicle to service.

7.3.4 Spring-Applied/Hydraulic Release Parking Brake Circuit

WARNING

Before bleeding the circuit, you must disconnect the parking brake cable from the spring-applied/hydraulic release (SAHR) canister. This is to ensure that the SAHR piston achieves the full stroke and forces most of the fluid volume out of the SAHR canister, thus moving potential entrapped air into the bleeder screw area. Refer to the vehicle manufacturer instructions for how to disconnect the parking brake cable.

WARNING

The parking brake cable must be reconnected before operating the vehicle. Never drive the vehicle if the parking brake cable is disconnected or the parking brake system is not operating correctly. Driving the vehicle without a correctly functioning parking brake system can result in an accident and serious personal injury.

1. Park the vehicle on a level surface. Apply the parking brake and block the wheels to help prevent the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
2. Turn the ignition OFF and remove the two 30-amp Maxi fuses for the brake system motors. Refer to the vehicle manufacturer's specifications to determine where the fuses are located.
3. Connect the diagnostic laptop to the diagnostic connector located in the cab, under the instrument panel. Set the ignition key to ON and open the TOOLBOX™ Software program.
4. Deplete pressure in the accumulators. There are two ways of depressurizing the system as follows.

Brake Bleeding Procedures

- a. Fully depress the brake pedal a minimum of 30 times. The pressure in each brake circuit can be monitored using the TOOLBOX™ Software. Ensure that the pressure in each accumulator is at 0 psi.
 - b. While fully depressing the brake pedal, select the Deplete Accumulators function from the TOOLBOX™ Software EOL pull-down menu. The pedal must remain fully depressed during the entire process, until the TOOLBOX™ Software displays the completion message. Ensure that the pressure in both accumulators is reading zero on the diagnostic main screen then release the brake pedal.
5. Turn the ignition OFF.
 6. Verify that the brake fluid level in the master cylinder reservoir is not below MAX level.



During bleeding procedures, brake fluid level must not be allowed to fall below the MIN mark on the master cylinder reservoir. The master cylinder reservoir should be regularly checked during bleeding procedures and filled to the MAX mark with new specified brake fluid from a sealed container.

7. Prepare the pressure bleeder device according to the instructions provided with the equipment.



The pressurized fill and bleed equipment used can be either “air over fluid” or “fluid over air” type.

8. Install a suitable adapter from the fill and bleed equipment to the master cylinder reservoir filler neck. Verify that the adapter and bleed equipment are securely tightened onto the master cylinder reservoir filler neck.
9. Fit the bleeder hose onto the bleeder screw on the SAHR chamber.
10. Submerge the free end of the bleeder hose into the bleed bottle.
11. Apply 35 psi (2.4 bar) of pressure from the fill and bleed equipment to the master cylinder.
12. Open the SAHR bleeder screw until fluid begins to flow (3/4 turn). Allow the fluid to run until 8.5 ounces (250 cc) has been collected. Take note of the fluid level in the bottle before starting.
13. If no further air bubbles enter the bleed bottle, close the bleeder screw. Remove the bleeder hose and tighten the bleeder screw to specified torque. Refer to the vehicle manufacturer’s specifications for the correct torque value.
14. Ensure that the brake fluid level in the master cylinder reservoir is at the MAX mark. If the brake fluid in the reservoir is above or below the MAX mark, remove or add fluid as necessary until the MAX mark level is achieved. Never add fluid above the MAX mark. Refer to Section 5 for detailed instructions on how to correctly fill the master cylinder reservoir.
15. Install the two 30-amp pump motor fuses and turn the ignition ON with 35 psi (2.4 bar) of pressure applied to the master cylinder reservoir. The HCU pump motors will start up automatically and fill the accumulators. Approximate running time is 45 seconds. The brake light and buzzer will turn OFF.
16. Release the pressure from the master cylinder reservoir.
17. Remove the bleed equipment.
18. Install the master cylinder reservoir cap.
19. Connect the parking brake cable to the SAHR canister. Refer to the vehicle manufacturer’s instructions for how to connect and correctly adjust the parking brake cable. Verify correct application and release at the parking brake.
20. Using the diagnostic laptop and the TOOLBOX™ Software program, clear all the inactive fault codes.

Brake Bleeding Procedures

21. Turn ignition OFF and disconnect the diagnostic laptop from the diagnostic connector.
22. Check the system for external leaks.
23. Remove wheel blocks.

7.3.5 Changing Hydraulic Brake Fluid

1. Park the vehicle on a level surface. Apply the parking brake and block the wheels to help prevent the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
2. Turn the ignition OFF and remove the two 30-amp Maxi fuses for the brake system motors. Refer to the vehicle manufacturer's specifications to determine where the fuses are located.
3. Connect the diagnostic laptop to the diagnostic connector located in the cab, under the instrument panel. Set the ignition key to ON and open the TOOLBOX™ Software program.
4. Deplete pressure in the accumulators. There are two ways of depressurizing the system as follows:
 - a. Fully depress the brake pedal a minimum of 30 times. The pressure in each brake circuit can be monitored using the TOOLBOX™ Software. Ensure that the pressure in each accumulator is at 0 psi.
 - b. While fully depressing the brake pedal, select the Deplete Accumulators function from the TOOLBOX™ Software EOL pull-down menu. The pedal must remain fully depressed during the entire process, until the TOOLBOX™ Software displays the completion message. Ensure that the pressure in both accumulators is reading zero on the diagnostic main screen then release the brake pedal.
5. Turn the ignition OFF.
6. Prepare the pressure bleeder device according to the instructions provided with the equipment.



The pressurized bleed equipment used for this drain procedure must be the “air over hydraulic” type.

7. Install a suitable adapter from the fill and bleed equipment to the master cylinder reservoir filler neck. Verify that the adapter and bleed equipment are securely tightened onto the master cylinder reservoir filler neck.
8. Apply 35 psi (2.4 bar) of pressure from the fill and bleed equipment to the master cylinder.
9. Fit the bleeder hose onto the caliper bleeder screw at one wheel end.
10. Submerge the free end of the bleeder hose into the bleed bottle.
11. Open the bleeder screw until fluid begins to flow (3/4 turn). Allow the fluid to run until the circuit is completely drained and no more fluid comes out.
12. Close the bleeder screw.
13. Repeat Steps 8-12 for:
 - a. the remaining calipers,
 - b. the two relay bleeder screws, and
 - c. the SAHR bleeder screw, if equipped
14. Release the pressure from the master cylinder reservoir.
15. Remove the bleed equipment.

Brake Bleeding Procedures

16. Fill the master cylinder reservoir up to the MAX mark with new specified brake fluid from a sealed container. Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle manufacturer's specifications to determine which fluid to use.



You can speed up the filling process by opening the bleeder screw of one of the rear calipers. This will allow better brake fluid flow into the system by expelling the air through the bleeder screw. Close the bleeder screw when no further air is exiting the bleeder screw.

17. Bleed the master cylinder circuit using the master cylinder bleeding procedure in this section.
18. Bleed the rest of the brake system using the brake caliper circuit bleeding procedure and the SAHR circuit bleeding procedure, if applicable, in this section.

7.3.6 Brake Fluid Replacement Requirement

For the correct functioning of the ABS, seals and components, ZF recommends replacing brake fluid every two (2) years on all vehicles equipped with ZF HPB system. This is done to minimize exposure to contaminated brake fluid. To replace the brake fluid, please follow the instructions indicated under the "Changing Hydraulic Brake Fluid" section of this manual.



While changing the brake fluid according to instructions provided in this manual, please read and observe all Warning and Caution hazard alert messages published onwards from Page 52 under Section 5, apart from those published below.

7.3.7 Filling the Hydraulic Power Brake (HPB) Master Cylinder Reservoir

WARNING

Before you service the Hydraulic Power Brake (HPB) system, you must perform the depressurization procedures exactly as presented. The HPB system is a pressurized system that reaches levels of up to 2,320 psi (160 bar). This pressure is not reduced by switching the ignition off or removing battery power. If you do not depressurize the system, serious personal injury or death can result.

WARNING

Never add fluid above the MAX mark regardless of the charging state of the accumulators. When the system is totally or partially depressurized during service or overnight parking, fluid stored in the accumulators is returned to the master cylinder reservoir. If the reservoir was previously filled above the MAX mark, a fluid spill could occur. Overfilling the master cylinder reservoir may cause damage to the cap and other components, resulting in poor braking performance and serious personal injury.



The ability for the master cylinder to breath is critical to correct brake system function. If the cap becomes contaminated, it will need to be replaced.

WARNING

To help prevent serious eye injury, always wear eye protection when you perform vehicle maintenance or service.

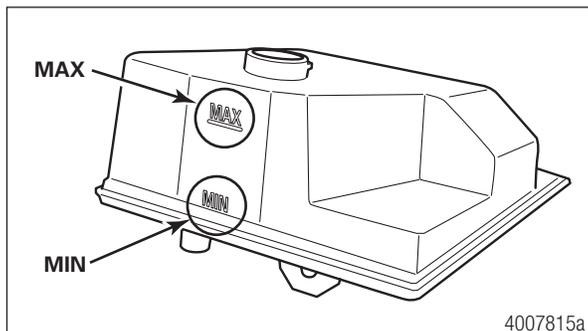
Brake Bleeding Procedures

WARNING

Park the vehicle on a level surface. Block the wheels to help prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Ensure vehicle is on a level surface and apply the parking brake.
2. Block the wheels to help prevent the vehicle from moving.
3. Set the ignition key to OFF and remove the two 30-amp fuses that provide power to the brake system motors. The fuses are in the fuse panel located on the engine side of the cowl.
4. Remove master cylinder cap.
5. Connect a laptop computer containing TOOLBOX™ Software to the diagnostic connector.
6. Turn the ignition key to ON and start the TOOLBOX™ Software.
7. Depressurize the system as follows:
 - a. Depress the brake pedal a minimum of 30 times.
 - b. Use the EZ-TECH® and TOOLBOX™ Software to verify that pressure at both accumulators is at 0 psi.

During this process, brake fluid will return to the master cylinder reservoir from the accumulators. Monitor the reservoir fluid level to ensure it does not overflow.
8. Turn the ignition key to OFF.
9. With the accumulator pressure decreased, verify that the brake fluid level is at the MAX mark on the master cylinder reservoir. If brake fluid in the reservoir is above or below the MAX mark, remove or add brake fluid as necessary until the MAX mark level is achieved. If brake fluid needs to be added, ensure that it is from a clean, sealed container. Never add fluid above the MAX mark.
10. Reinstall the 30-amp motor fuses and turn the ignition ON. Both motors will start running until both circuits reach the cut-off pressure at approximately 2000 psi (138 bar).
11. Monitor the pressure in each circuit using the TOOLBOX™ Software.
12. When both motors stop, ensure that the pressure level in each circuit reached the cut-off level. This will decrease the brake fluid level in the master cylinder reservoir.
13. With the system completely charged, the brake fluid level will be between the MIN and MAX marks on the master cylinder reservoir.



Brake Bleeding Procedures

WARNING

Never reuse hydraulic brake fluid that has been removed from a vehicle. Hydraulic brake fluid that has been removed can be contaminated and can cause damage, loss of braking and serious personal injury. Always discard hydraulic brake fluid in accordance with applicable environmental requirements. Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specification sheet to determine which fluid to use. Do not use or mix different types of hydraulic brake fluid. The incorrect hydraulic brake fluid will damage the rubber parts of the brake caliper and can cause damage, loss of braking and serious personal injury.

Appendix

8 Appendix

8.1 Leak Check Procedure for WABCO HPB System

8.1.1 Check the HPB System for Brake Fluid Leaks

With Pressure Removed:

1. Park the vehicle on a level surface. For vehicles with manual parking brakes, apply the parking brake. Block the wheels to keep the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
2. Deplete system pressure. Refer to the appropriate section in this manual for instructions.
3. Inspect the entire hydraulic brake system including brake lines and line fitting connections for the presence of brake fluid damage or other evidence of a leak.
 - If a leak is identified, perform the following.
 - a. Clean and dry the entire area.
 - b. Determine the source of the leak.
 - c. Make the necessary repairs.
4. If the hydraulic system is compromised by exposure to air, it is necessary to bleed the affected circuit. Refer to the appropriate section in this manual.

With Pressure Applied:

If there was no evidence of a leak when the system was checked with the pressure removed, apply pressure to the system and recheck for leaks. Two people are required to perform this check.

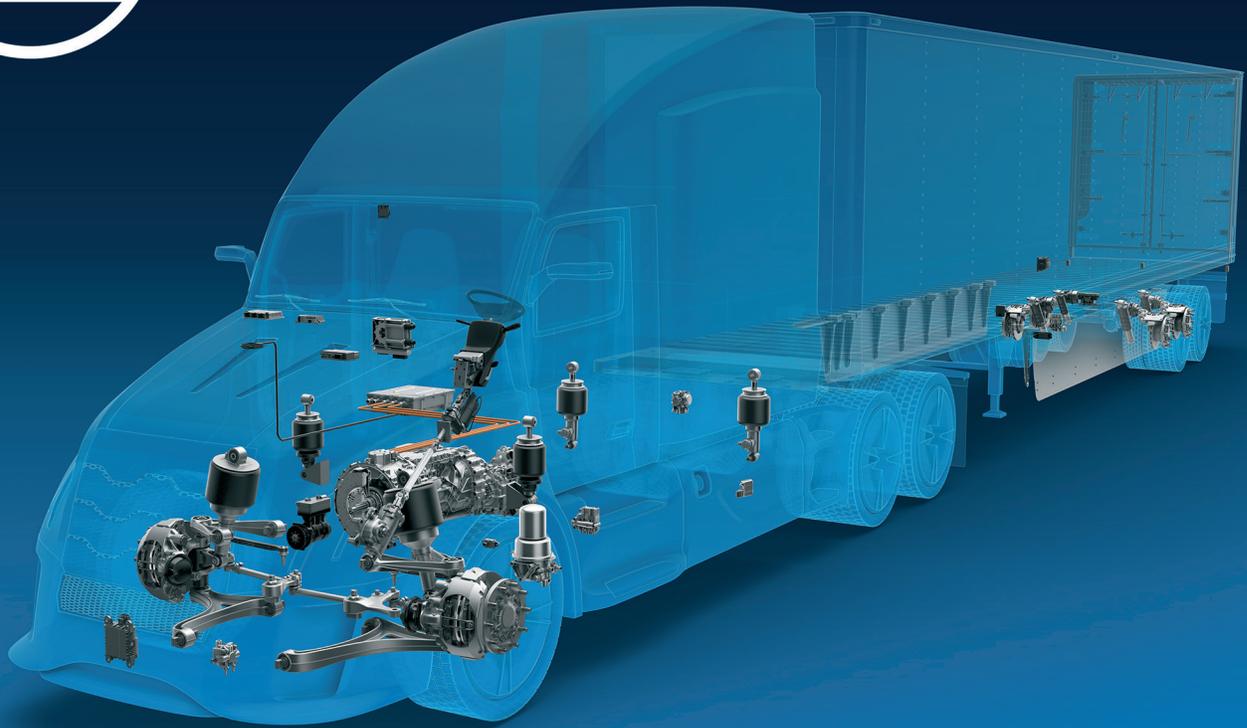
1. With the vehicle parked on a level surface, depress the brake pedal and hold to deliver brake pressure to the calipers.
2. Inspect the entire hydraulic brake system including brake lines and line fitting connections for the presence of brake fluid damage or other evidence of a leak.
 - If a leak is identified, perform the following.
 - a. Clean and dry the entire area.
 - b. Determine the source of the leak.
 - c. Deplete system pressure. Refer to the appropriate section in this manual for instructions.
 - d. Make the necessary repairs.
3. If the hydraulic system is compromised by exposure to air, it is necessary to bleed the affected circuit. Refer to the appropriate section in this manual.

Appendix

8.2 System Test

After all necessary repairs have been made and the system has been bled, verify the hydraulic circuits are connected correctly. Two people are required to perform this test.

1. Park the vehicle on a level surface.
2. Block the front tires to keep the vehicle from moving. Failure to do so can result in unwanted vehicle movement causing serious personal injury.
3. Raise the rear wheels. Place supports under the rear axle.
4. Depress the brake pedal. Attempt to turn the rear wheels one at a time. They should not move with the brakes applied.
5. Connect the vehicle to a PC with TOOLBOX™ Software installed. Use TOOLBOX™ Software to activate the solenoid valves for the left rear wheel. You should be able to turn this wheel by hand when the solenoids activate. Repeat this check for the right rear wheel. Go to Step 6.
6. Remove the axle stands from under the rear axle to lower the vehicle.
7. Remove the blocks from the front tires and place them in front of the rear tires.
8. Raise the front tires. Place supports under the front axle.
9. Repeat Steps 4 and 5.
10. Remove the axle stands from under the front axle to lower the vehicle.
11. Make any necessary repairs. If any plumbing changes were made, bleed the system again.



**For further details, contact the
WABCO Customer Care Center at 855-228-3203.**

About CVS Division

ZF's Commercial Vehicle Solutions (CVS) division is helping shape the future of commercial transportation ecosystems. Our mission is to be the preferred global technology partner to the commercial vehicle industry. Powerfully combining ZF's commercial vehicle systems expertise, extensive technology portfolio and global operations, the division serves the full commercial vehicle industry value chain. As the automotive industry progresses towards an increasingly autonomous, connected, and electrified (ACE) future, ZF's CVS division innovates, integrates and supplies components and advanced control systems that help make commercial vehicles and fleets operate more safely and sustainably. CVS unites ZF's former Commercial Vehicle Technology and Commercial Vehicle Control Systems divisions, the latter being formed following ZF's acquisition of WABCO in Spring 2020.

For more information, visit: www.zf.com/cv

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