SERVICE MANUAL SECTION

FULL POWER HYDRAULIC ABS BRAKE SYSTEM

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1. SAFETY PRECAUTIONS

This publication provides maintenance and service procedures for Meritor WABCO's full power hydraulic ABS for buses. The information contained in this publication was current at time of printing and is subject to revision without notice or liability.

1. You must understand all procedures and instructions before you begin maintenance and service procedures.
2. You must follow your company's maintenance and service guidelines.
3. You must use special tools, when required, to avoid personal injury and damage to components.

The following notations are used to alert the user of possible safety issues and to provide information that will help to prevent damage to equipment and components.

WARNING – A WARNING indicates a procedure that you must follow exactly to avoid personal injury.

CAUTION – A CAUTION indicates a procedure that you must follow exactly to avoid damaging equipment or components. Serious personal injury can also occur.

NOTE – A NOTE indicates an operation, procedure or instruction that is important for proper service. A NOTE can also supply information that will help to make service quicker and easier.

GENERAL WARNINGS/CAUTIONS FOR SERVICING THE FULL POWER BRAKE SYSTEM

WARNING – Anti-lock Brake Systems (ABS) are designed to enhance overall vehicle safety when a vehicle is driven within its normal safety limits. ABS cannot compensate for a vehicle which is being driven beyond the physical limits of control. Drivers operating an ABS equipped vehicle should employ safe driving skills and assume no additional driving risks. Failure to follow this warning could result in property damage, personal injury or death.

WARNING – Do not allow brake fluid to come into contact with eyes or skin. If brake fluid contacts eyes, flush immediately with water for at least fifteen minutes. Clean contaminated skin thoroughly.

WARNING – Failure to bleed the system whenever any hydraulic system fitting is loosened or disconnected will allow air to remain in the system. Air in hydraulic lines will greatly reduce the pressure available for braking. This can increase vehicle stopping distance which could result in property damage, personal injury or death.

WARNING – Do not reuse drained brake fluid. Hydraulic brake fluid that is removed can be contaminated and can cause system damage and/or loss of braking. Failure to follow this warning could result in property damage, personal injury or death. Properly discard hydraulic brake fluid that is removed from the brake system.

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. Non-specified hydraulic brake fluids will damage the rubber parts of the brake caliper and can cause system damage and/or, loss of braking. Failure to follow this warning could result in property damage, personal injury or death.

WARNING – 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, rotors or disks. Contaminated brake pads could cause reduced braking which could result in property damage, personal injury or death.

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 property damage, personal injury or death.

WARNING – Brake pedal feel does not necessarily indicate properly bled brakes. Brake pedal can feel firm or “normal” if properly bled between the reservoir and the HCU, and air can still exist between the HCU and the brake calipers. Failure to correctly bleed the system could cause reduced braking or loss of braking, which may result in property damage, personal injury or death.

WARNING – Block the wheels to 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. Failure to follow this warning could result in property damage, personal injury or death.

WARNING – While servicing an ATC equipped vehicle, the ATC system MUST BE DISABLED before operating the vehicle with only one drive wheel lifted off of the ground. Performing this operation on a vehicle with an active ATC system may result in the vehicle moving and falling from the jacks as power will be transferred to the wheel that is still on the ground.

The ATC system cannot be disabled by placing the dash mounted switch in the "disabled" position.

The ATC system can be TEMPORARILY disabled using the EZ-Tech service tool, running the TOOLBOX diagnostic program. Use extreme caution. When the ATC system is disabled using the EZ-Tech, it will remain disabled only until the next ignition cycle. The TOOLBOX screen will indicate when the ATC function is disabled.

Failure to follow this warning could result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the HPB system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact nor air being blown into the hydraulic ports prior to assembly to the vehicle.

CAUTION – Any form of contamination entering the system could prevent the system from operating correctly. Thoroughly clean the area around fittings before disconnecting the fittings. Always plug open ports and lines as quickly as possible.

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.

CAUTION – To prevent damage to the aluminum Hydraulic Compact Unit, all fittings and fasteners must not be overtightened. The correct torque values are listed in the procedures and/or in the Torque Table.

CAUTION – To prevent damage to the electrical system or ABS components, when welding on an ABS-equipped vehicle disconnect the electrical connectors from the ECU.

CAUTION – 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 has 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.

IMPORTANT – In all braking maintenance and overhaul procedures exercise extreme caution when handling brake fluid. The fluid is corrosive and damaging to areas (including painted surfaces) outside the braking system. If fluid spills onto other components outside the braking system, it must be cleaned up immediately.

IMPORTANT – Cover all electrical connectors near the bleeder screws carefully to make absolutely certain that no brake fluid enters the terminals or plugs.

IMPORTANT – 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.

IMPORTANT – Use only new DOT 3 or DOT 4 specified brake fluid from a sealed container to refill the system.

IMPORTANT – If a lubricant is required to aid assembly, use only the specified brake fluid from a sealed container, unless otherwise specified.

1.1. ASBESTOS AND NON-ASBESTOS FIBERS

Asbestos Fibers Warning

WARNING – The following procedures for servicing brakes are recommended to reduce exposure to asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from ArvinMeritor.

Hazard Summary

Because some brake linings contain asbestos, workers who service brakes must understand the potential hazards of asbestos and precautions for reducing risks. Exposure to airborne asbestos dust can cause serious and possibly fatal diseases, including asbestosis (a chronic lung disease) and cancer, principally lung cancer and mesothelioma (a cancer of the lining of the chest or abdominal cavities). Some studies show that the risk of lung cancer among persons who smoke and who are exposed to asbestos is much greater than the risk for non-smokers. Symptoms of these diseases may not become apparent for 15, 20 or more years after the first exposure to asbestos.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. **Separate Work Areas.**

   Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons. OSHA has set a maximum allowable level of exposure for asbestos of 0.1 f/cc as an 8-hour time-weighted average and 1.0 f/cc averaged over a 30-minute period. Scientists disagree, however, to what extent adherence to the maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling asbestos dust. OSHA requires that the following sign be posted at the entrance to areas where exposures exceed either of the maximum allowable levels: **DANGER: ASBESTOS CANCER AND LUNG DISEASE HAZARD AUTHORIZED PERSONNEL ONLY RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED IN THIS AREA**

2. **Respiratory Protection.**

   Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA for use with asbestos at all times when servicing brakes, beginning with the removal of the wheels.

3. **Procedures for Servicing Brakes.**

   a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.

   b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

   c. If an enclosed vacuum system or brake washing equipment is not available, employers may adopt their own written procedures for servicing brakes, provided that the exposure levels associated with the employer's procedures do not exceed the levels associated with the enclosed vacuum system or brake washing equipment. Consult OSHA regulations for more details.

   d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.

   e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.

4. **Cleaning Work Areas.**

   Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

5. **Worker Clean-Up.**

   After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. **Waste Disposal.**

   Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

Non-Asbestos Fibers Warning

The following procedures for servicing brakes are recommended to reduce exposure to non-asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from Meritor.

Hazard Summary

Most recently manufactured brake linings do not contain asbestos fibers. These brake linings may contain one or more of a variety of ingredients, including glass fibers, mineral wool, aramid fibers, ceramic fibers and silica that can present health risks if inhaled. Scientists disagree on the extent of the risks from exposure to these substances. Nonetheless, exposure to silica dust can cause silicosis, a non-cancerous lung disease. Silicosis gradually reduces lung capacity and efficiency and can result in serious breathing difficulty. Some scientists believe other types of non-asbestos fibers, when inhaled, can cause similar diseases of the lung. In addition, silica dust and ceramic fiber dust are known to the State of California to cause lung cancer. U.S. and international agencies have also determined that dust from mineral wool, ceramic fibers and silica are potential causes of cancer.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to non-asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. **Separate Work Areas.**

   Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons.

2. **Respiratory Protection.**

   OSHA has set a maximum allowable level of exposure for silica of 0.1 mg/m^3 as an 8-hour time-weighted average. Some manufacturers of non-asbestos brake linings recommend that exposures to other ingredients found in non-asbestos brake linings be kept below 1.0 f/cc as an 8-hour time-weighted average. Scientists disagree, however, to what extent adherence to these maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling non-asbestos dust.

Therefore, wear respiratory protection at all times during brake servicing, beginning with the removal of the wheels. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA, if the exposure levels may exceed OSHA or manufacturers' recommended maximum levels. Even when exposures are expected to be within the maximum allowable levels, wearing such a respirator at all times during brake servicing will help minimize exposure.

3. **Procedures for Servicing Brakes.**

   a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.

   b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

   c. If an enclosed vacuum system or brake washing equipment is not available, carefully clean the brake parts in the open air. Wet the parts with a solution applied with a pump-spray bottle that creates a fine mist. Use a solution containing water, and, if available, a biodegradable, non-phosphate, water-based detergent. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

   d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.

   e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.

4. **Cleaning Work Areas.**

   Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA, to minimize exposure. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

5. **Worker Clean-Up.**

   After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. **Waste Disposal.**

   Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

2. GENERAL DESCRIPTION

IMPORTANT – The vehicles covered in this manual have used two different electrical controllers. Both controllers are mounted in the same location. The original controller was known as the Electrical System Controller (ESC). The current controller is known as the Body Controller (BC). In this manual the controller will be identified as the Body Controller or the ESC/BC.

The Full Power Brake System is an electronic wheel speed monitoring and control system used on buses equipped with a hydraulic brake system. The following standard features of this system are covered in this manual.

STANDARD FEATURES

- Bosch pin slide type foundation brakes.
- Electronic Brakeforce Distribution (EBD). System identifies front to rear wheel slip imbalances due to axle loading and distributes braking forces in proportion to axle loading to render a balanced brake application on the vehicle.
- Antilock Braking System (ABS).
  - — ABS prevents wheel lockup during braking.
  - — During braking, the system monitors each wheel, and reacts to any potential lockup by modulating the brake pressure for the affected wheel.
- Recording of brake system operations. Memory within the ECU circuitry maintains a record of brake system operations. These operational records may be used to more efficiently schedule preventive maintenance. Examples of some of what is recorded:
  - — number of key switch cycles and powered parking brake applies
  - — number of service brake applies identified as: ’light to moderate’, ’moderate to hard’, and ’hard to extreme’
  - — motor/pump operational hours.
- Automatic Traction Control (ATC) with J1939 engine management
  - — ATC prevents wheel spin during acceleration.
  - — During acceleration, the system monitors the wheel speeds, and may react to any loss of traction by applying a limited braking force to the affected wheel, without driver intervention.
  - — If both drive wheels begin to spin, the ATC system sends a signal to the engine to reduce engine torque and allow the drive wheels to regain traction.
  - — Dash mounted Traction Control switch, allows two levels of traction control to be selected (Normal Traction Control or Mud and Snow mode).

- Powered parking brake system (with electronic/hydraulic control circuits)
  - — Driveline parking brake drum.
  - — Electronic dash mounted switch.
  - — Various parking brake safety interlocks (specific conditions that must be met for the parking brake to be safely engaged or disengaged).
  - — Auto Apply feature (park brake applies automatically when the park position is selected on transmission shifters equipped with the P or PB position).

2.1. SERVICE BRAKES (NORMAL BRAKING)

In the normal braking mode, the full power brakes system is a hydraulic braking system that works like air brakes. Motor/pump assemblies pressurize the system by pumping brake fluid into accumulators. This is similar to the air compressor of an air brake system pressurizing the air tanks. The service brakes system is comprised of the following:

A. Master Cylinder (MC) with reservoir

B. Foundation disc brakes

C. Hydraulic Compact Unit (HCU)

D. Brake lines

E. Warning Indicators

The system is divided into two channels: the primary channel (controls front axle) and the secondary channel (controls rear axle). The motor driven pumps maintain pressure in the accumulators where it is stored to provide braking energy. The accumulator pre-charge enables a high number of reserve stops.

In the event of a brake system malfunction, one or more warning lamps will illuminate and diagnostic codes identifying the source of the malfunction will be stored in the ECU memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

2.2. NORMAL BRAKING WITH ELECTRONIC BRAKEFORCE DISTRIBUTION

A standard feature of the full power brake system is Electronic Brakeforce Distribution (EBD). This function is controlled by the ABS system. The EBD function uses the ABS components to balance the braking force between the front and rear axles.

2.3. ANTI-LOCK BRAKING SYSTEM (ABS)

WARNING – Anti-lock Brake Systems (ABS) are designed to enhance overall vehicle safety when a vehicle is driven within its normal safety limits. ABS cannot compensate for a vehicle which is being driven beyond the physical limits of control. Drivers operating an ABS equipped vehicle should employ safe driving skills and assume no additional driving risks. Failure to follow this warning could result in property damage, personal injury or death.

This ABS system is designed to provide the optimum balance between stopping distance and vehicle stability during hard braking maneuvers, or when stopping on wet or slippery surfaces. The system accomplishes this task by monitoring wheel rotation. The ABS function is controlled by the software in the ABS electronic control unit (ECU) and solenoid valves located in the Hydraulic Compact Unit (HCU). The wheel speed information is generated by the sensors mounted at each wheel end. The ECU monitors the wheel speed signals. When the ECU identifies a wheel that is about to lock, it signals the solenoid valves in the HCU to modulate the brake fluid pressure to that wheel, allowing the wheel to "recover". During an ABS event, the solenoid valves in the HCU are pulsed; that is, they open and close to control the brake pressure to the wheel end. When this occurs, drivers may notice a slight pulsation of the brake pedal.

In the event of an ABS malfunction, a warning lamp will illuminate and diagnostic codes identifying the source of the ABS malfunction will be stored in the ECU memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76). During an ABS system malfunction, the ABS function may remain partially operational. The level of ABS functionality during a malfunction depends on the type and location of the malfunction. Refer to Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76) for more information.

2.4. AUTOMATIC TRACTION CONTROL (ATC) SYSTEM

WARNING – While servicing an ATC equipped vehicle, the ATC system MUST BE DISABLED before operating the vehicle with only one drive wheel lifted off of the ground. Performing this operation on a vehicle with an active ATC system may result in the vehicle moving and falling from the jacks as power will be transferred to the wheel that is still on the ground.

The ATC system cannot be disabled by placing the dash mounted switch in the “Disabled” position.

The ATC system can be TEMPORARILY disabled using the EZ-Tech service tool, running the TOOLBOX diagnostic program. Use extreme caution. When the ATC system is disabled using the EZ-Tech, it will remain disabled only until the next ignition cycle. The TOOLBOX screen will indicate when the ATC function is disabled.

Failure to follow this warning could result in property damage, personal injury or death.

The ATC system uses the components of the ABS system, with two additional ATC solenoid valves, to prevent the driven wheels from spinning while accelerating on slippery surfaces. The ECU monitors the wheel speed to determine wheel spin (wheel is losing traction). The ECU then signals the solenoid valves in the Hydraulic Compact Unit (HCU) to deliver the brake fluid pressure to that wheel end. Braking pressure is applied to the wheel to prevent it from slipping and to transfer the driving force to the drive wheel with better traction.

When an ATC event affecting **BOTH** drive wheels occurs at speeds below 31 mph, the ATC system will also send a message to the engine controller to limit engine torque. At speeds above 31 mph all ATC events are controlled with engine torque only. No differential braking is applied above 31 mph.

NOTE – Several different traction control Mud and Snow switches have been used in these vehicles. While the switches may vary in appearance they function identically. Regardless of appearance, the switch selects the Mud and Snow mode when the switch indicator is lit. When the switch indicator is unlit, the vehicle is in the Normal ATC mode. The ATC system cannot be DISABLED using the dash mounted switch.

The dash mounted traction control Mud and Snow switch is used to select the Mud and Snow mode when the driving conditions require it. The following paragraphs describe the difference between the Mud and Snow mode and normal ATC operation.

- **Normal Traction Control (Normal Driving Conditions)**

  When the traction control switch (and vehicle) are in the normal traction control mode, the indicator on the switch and the TRAC CTRL indicator in the gauge cluster will both be unlit. (NOTE: the TRAC CTRL indicator will be on solid during an ATC event, or if an active ATC fault is detected.) In this mode differential braking is used to control traction when one drive wheel loses traction and vehicle speed is 31 mph or less. Engine torque limiting is used to control traction when both drive wheels lose traction. This is the normal operating mode and should be used for most driving conditions.

- **Mud and Snow Mode (Off-Road Driving Conditions)**

  The driver should use the traction control switch to select the Mud and Snow mode when driving in deep snow or off-road conditions. This signals the ECU to allow more wheel spin than normal. When in the Mud and Snow position, the indicator on the switch will be lit, and the TRAC CTRL indicator in the gauge cluster will be flashing. (NOTE: the TRAC CTRL indicator will be on solid during an ATC event, or if an active ATC fault is detected.) The switch should be returned to the Normal Traction Control position when the vehicle is no longer operating in deep snow or mud.

The traction control indicator (TRAC CTRL) located in the electronic gauge cluster is used to indicate the following three conditions.

- The TRAC CTRL lamp will be flashing whenever the Mud and Snow mode is selected using the traction control switch (switch indicator lit).
- The TRAC CTRL indicator will be continuously lit whenever a traction control related fault has been detected.
- If no ATC related faults have been detected, the TRAC CTRL indicator will be continuously lit only during an ATC event.

In the event of an ATC system malfunction, diagnostic codes identifying the source of the ATC malfunction will be stored in the ECU memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76). The ATC system is normally disabled when most ATC or ABS malfunctions are detected.

2.5. POWERED PARKING BRAKE

The powered parking brake system is a combination of mechanical, hydraulic, and electronic assemblies. The drum-style driveline parking brake is cable actuated. The cable tension is controlled by a Spring Applied Hydraulic Released (SAHR) canister, which is controlled by brake fluid routed to it by the Hydraulic Compact Unit (HCU). Normally the 'apply/release' input signal is provided to the HCU Electronic Control Unit (ECU) by the dash mounted park brake switch (similar to an air system park brake switch). However, because the hydraulic valves in the HCU are electronically controlled, the software in the ECU can be used to provide various parking brake features and interlocks. The following list briefly describes some of the features of the powered parking brake system.

- Key switch interlock.
  - — The parking brake applies automatically when the key is turned off and cannot be released until the key is turned on.
  - — If the key is turned off while driving, the park brake is prevented from applying until vehicle speed is less than 2 mph.
- Dynamic park brake apply protection.
  - — When the parking brake switch is pulled with the vehicle in motion, the HCU is used to apply the rear service brakes. While the rear service brakes are being applied, the ECU signals the ESC/BC to turn on the vehicle's brake lights. After the vehicle has come to a safe stop (less than 2 mph), the driveline park brake is applied. (Since the service brakes are applied initially in lieu of the driveline brake, the stop is under ABS control, preventing rear wheel lock-up.)
  - — Reduces premature wear and damage to driveline brake caused by applying the parking brake before the vehicle is completely stopped.
- Parking brake release interlocks. The parking brake is released when the dash switch is pressed and released, ONLY if the following conditions are met:
  - — The foot brake is applied.
  - — The ignition key is in the ON position.
  - — The transmission is not in the Park (P or PB) position.
  - — No major brake system faults have been detected.
- Engine control interlock. Engine intervention is used to prevent the operator from 'driving' against the parking brake when it is applied. Engine torque is reduced when the parking brake is applied.
- The travel switch on the SAHR canister and circuitry in the ECU identify actuation of the parking brake and malfunctions in the parking brake circuit.
- Auto-Apply (AA) feature. This parking brake feature is provided on vehicles equipped with a transmission shifter with a Park (P or PB) position.
  - — Automatically applies the driveline park brake when the shifter is placed in the Park position.
  - — Once applied, the parking brake can be released only if the shifter is moved out of the Park position with the foot brake applied and ignition key in the "On" position.

In the event of a parking brake system malfunction, the SERVICE PARK BRAKE lamp will flash and an alarm will sound for approximately 20 seconds. After 20 seconds the alarm will stop and the lamp will remain illuminated (continuous). In addition, diagnostic codes identifying the source of the malfunction will be stored in the ECU memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

2.6. WARNING INDICATORS

Six indicators located in the Electronic Gauge Cluster (EGC), are used to display the status of the brake system. Refer to FIGURE 1. Four of the indicators identify conditions that may require service. In addition to the warning indicators, a buzzer is sounded for certain conditions. In the event that a lit indicator is the result of a malfunction, diagnostic codes identifying the source of the malfunction will be stored in the ECU memory. Retrieval of the diagnostic codes is explained in the diagnostic section of this manual. Although

the following table lists possible malfunctions for each warning indicator, some malfunctions will result in more than one indicator being lit.

Table 1 Warning Indicators

INDICATOR	SYSTEM CONDITION BEING INDICATED
BRAKE / **BRAKE PRESSURE** **(RED)**	Indicator differs by model year.
- SOLID ON	Half system failure. A sensor in the HCU has detected low pressure (<1550 psi) in the accumulator for either the front or rear brake circuit. Warning buzzer is also sounded. If the fault is detected in the front brake circuit, once the parking brake has been set, it will not release until this fault is repaired and the ignition is cycled. (Cycling the ignition will change the DTC status from 'active' to 'stored'.)
- FLASHING	Full system failure. A sensor in the HCU has detected low pressure (<1550 psi) in the accumulators for both the front and rear brake circuits. Warning buzzer is also sounded. Once vehicle speed drops below 25 mph, engine limiting will limit the vehicle speed to 25 mph or less. In addition, once the parking brake has been set, it will not release until this fault is repaired and the ignition is cycled. (Cycling the ignition will change the DTC status from 'active' to 'stored'.)
- OFF	System pressures are in normal range.
BRAKE FLUID **(RED)**	
- SOLID ON	Low brake fluid level detected in the Master Cylinder reservoir.
- OFF	Brake fluid level detected in the Master Cylinder reservoir is at or above MIN.
ABS **(AMBER)**	
- SOLID ON	An ABS related fault has been detected by the ECU. -OR- Communications between the ECU and the ESC/BC have been lost. -OR- The ECU is not receiving power.
- OFF	No ABS related faults have been detected by the ECU.
PARK BRAKE **(RED)**	
- SOLID ON	Park brake is applied. A single chime is also sounded when the park brake is applied.

Table 1 Warning Indicators (cont.)

INDICATOR	SYSTEM CONDITION BEING INDICATED
- OFF	Park brake is not applied.
SERVICE PARK BRAKE **(RED)** - FLASHING/ SOLID ON	A park brake related fault has been detected by the ECU. Initially, the indicator will flash and an alarm will sound for 20 seconds. After 20 seconds the indicator will remain on continuously and the alarm will stop.
- OFF	No park brake faults detected by the ECU.
TRAC CTRL **(GREEN)** - SOLID ON	The TRAC CTRL indicator will be continuously lit whenever: A traction control related fault has been detected. - OR - The ATC system is operating correctly, and an ATC event is occurring.
- FLASHING	The TRAC CTRL indicator will be flashing whenever the Mud and Snow mode has been selected using the traction control switch (switch indicator lit).
- OFF	The ATC system is operating correctly, the Mud and Snow mode has not been selected, and the vehicle is not experiencing an ATC event.

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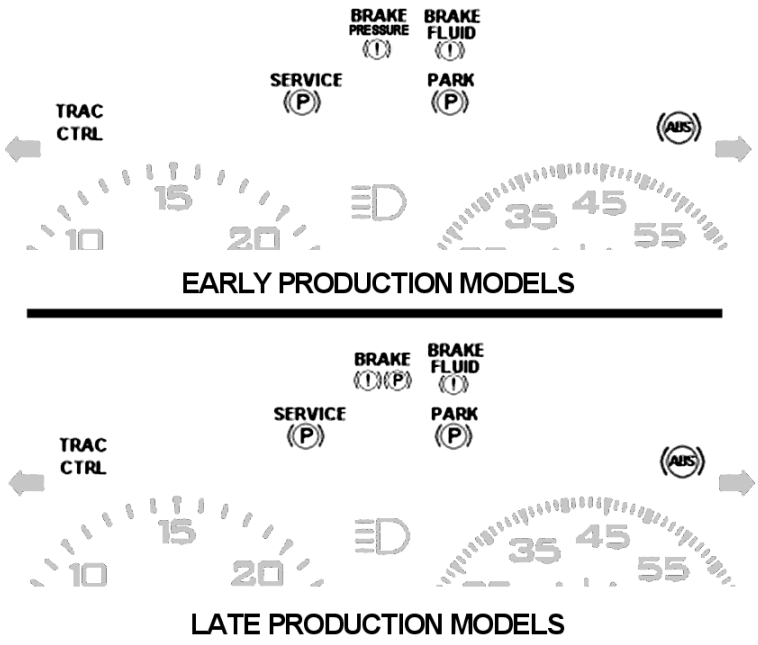

Figure 1 Indicators Used for the Full Power Brake System

2.7. SYSTEM LAYOUT

A component location diagram of a typical Full Power Brakes system is illustrated in FIGURE 2. A schematic diagram of the system is provided in FIGURE 3. The Master Cylinder is mounted to the engine side of the cowl, in front of the driver. The wheel speed sensors are located at the wheel ends with the calipers and rotors. The Body Controller (ESC/BC) is mounted to the inside of the cowl, behind the instrument panel. The PARK BRAKE switch for the powered parking brake is located near the center of the dash. The Hydraulic Compact Unit is mounted on the inside of the left frame rail, behind the driver's position. The Spring Apply Hydraulic Release (SAHR) parking brake canister is mounted on the inside of the left frame rail, just ahead of the rear axle. The parking brake drum is located where the driveshaft connects to the rear axle.

A low pressure hose connects the reservoir on the HCU to the reservoir on the master cylinder. This allows both reservoirs to be filled from the master cylinder location. Refer to FIGURE 4.

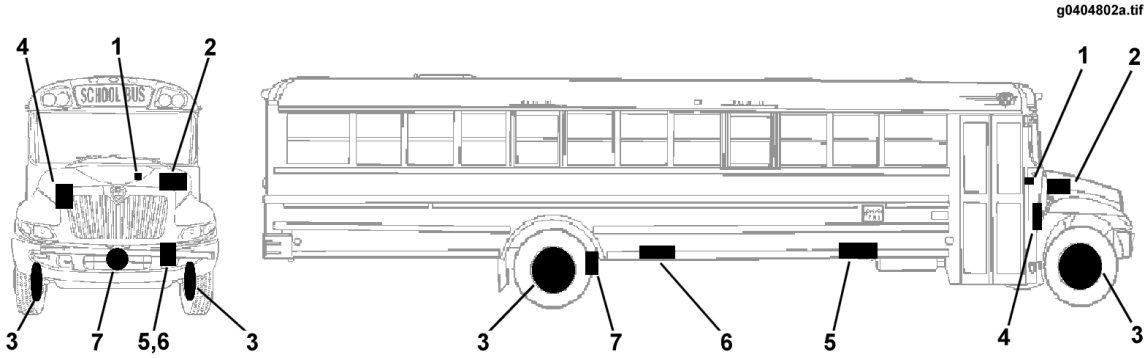

Figure 2 Full Power Brake System Component Layout

1. PARK BRAKE SWITCH
2. MASTER CYLINDER/RESERVOIR ASSEMBLY
3. FOUNDATION BRAKES (ROTORS, CALIPERS, WHEEL SPEED SENSORS)
4. ELECTRICAL SYSTEM CONTROLLER / BODY CONTROLLER (ESC/BC)
5. HYDRAULIC COMPACT UNIT INCL/ELECTRONIC CONTROL UNIT
6. SPRING APPLY HYDRAULIC RELEASE (SAHR) PARK BRAKE CANISTER
7. DRIVELINE PARKING BRAKE DRUM

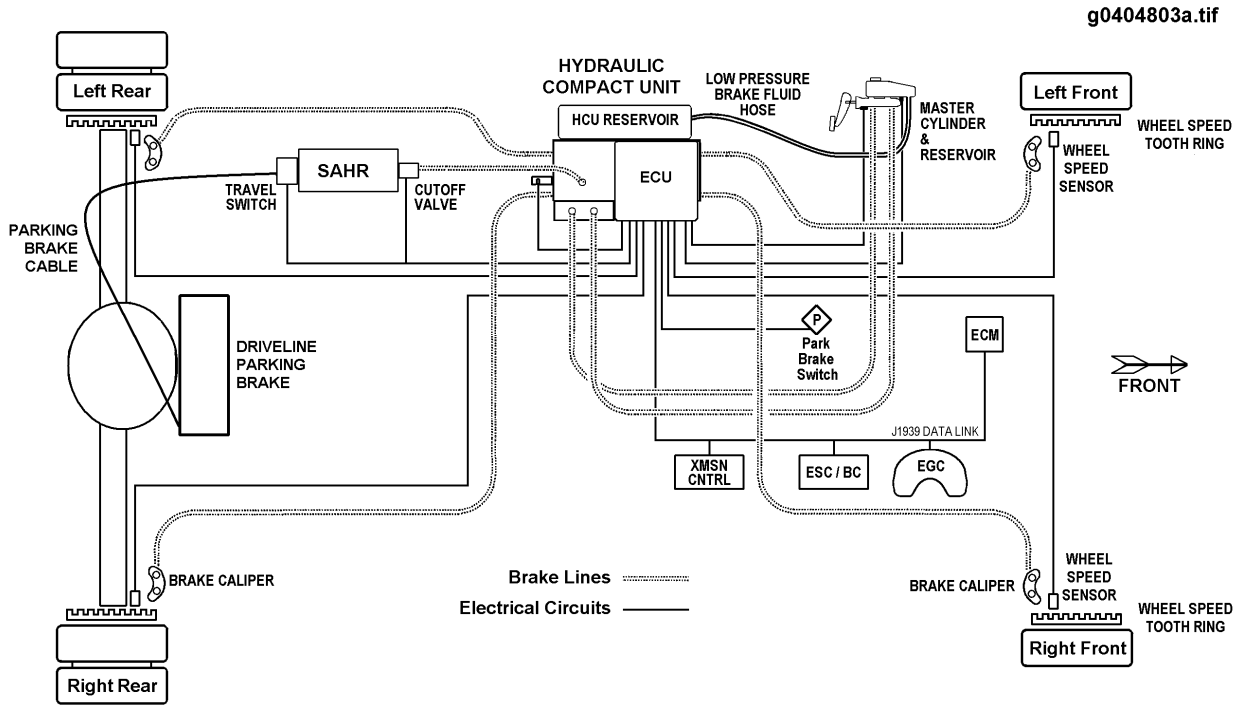

Figure 3 Schematic Diagram of the Full Power Brake System

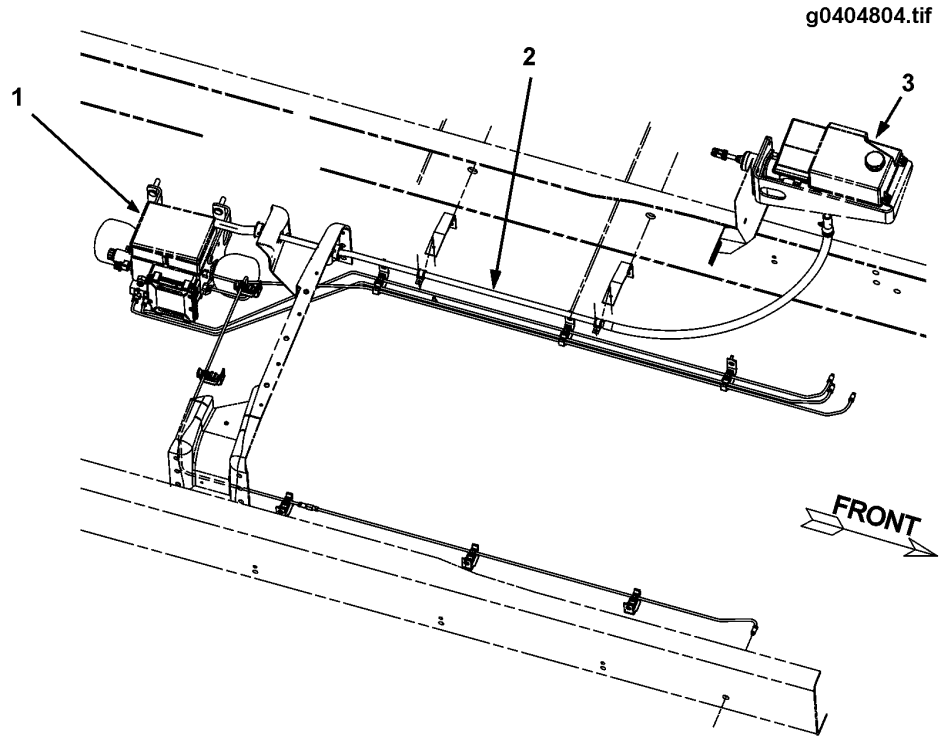

Figure 4 Low Pressure Hose Connecting Master Cylinder and Hydraulic Compact Unit

1. HYDRAULIC COMPACT UNIT (HCU)
2. LOW PRESSURE HOSE
3. MASTER CYLINDER

2.8. SYSTEM COMPONENTS

The Full Power Brake system is comprised of the following components. Each is described, in greater detail, in the following paragraphs.

- Master Cylinder and Reservoir
- Hydraulic Compact Unit (HCU)
- Electronic Control Unit (ECU)
- Foundation Brakes (Rotors and Calipers)
- Wheel Speed Sensors
- Body Controller (ESC/BC)
- Spring Applied Hydraulically Released (SAHR) Park Brake Canister
- Driveline Parking Brake Drum
- Traction Control (Mud and Snow) Switch
- Park Brake Switch
- Electronic Gauge Cluster (EGC)

Master Cylinder and Reservoir

The master cylinder is mounted to the engine side of the cowl directly in front of the driver (see FIGURE 5 and FIGURE 6). It consists of a dual channel (primary and secondary) piston assembly, providing separate circuits for the front and rear brakes. The master cylinder also contains the spring pack that returns the brake pedal to its up position, and provides the correct pedal 'feel' to the driver. The purpose of the master cylinder is to translate the pedal force applied by the driver into the hydraulic pilot signals that are routed to the relay valve, attached to the hydraulic compact unit. The switch that detects a brake actuation (brake light switch) is mounted to the master cylinder and is replaceable without draining any brake fluid.

The reservoir mounted to the top of the master cylinder provides the fill port for the entire brake system. This is accomplished by a low pressure hose that connects the master cylinder reservoir to the reservoir on top of the HCU. Internal baffles in the reservoir provide a protected volume of brake fluid for the master cylinder circuit, in the event of a leak in the remainder of the system. An external sensor mounted to the bottom of the reservoir detects when the brake fluid level is low. This sensor is replaceable without draining any brake fluid.

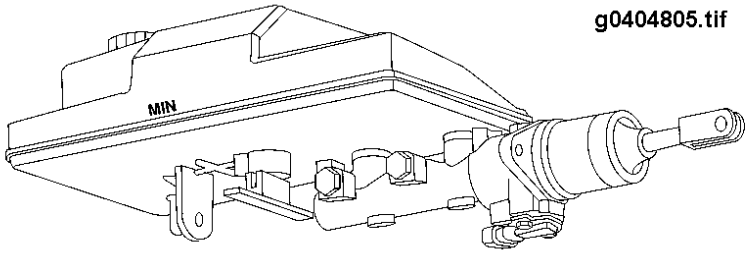

Figure 5 Master Cylinder and Reservoir

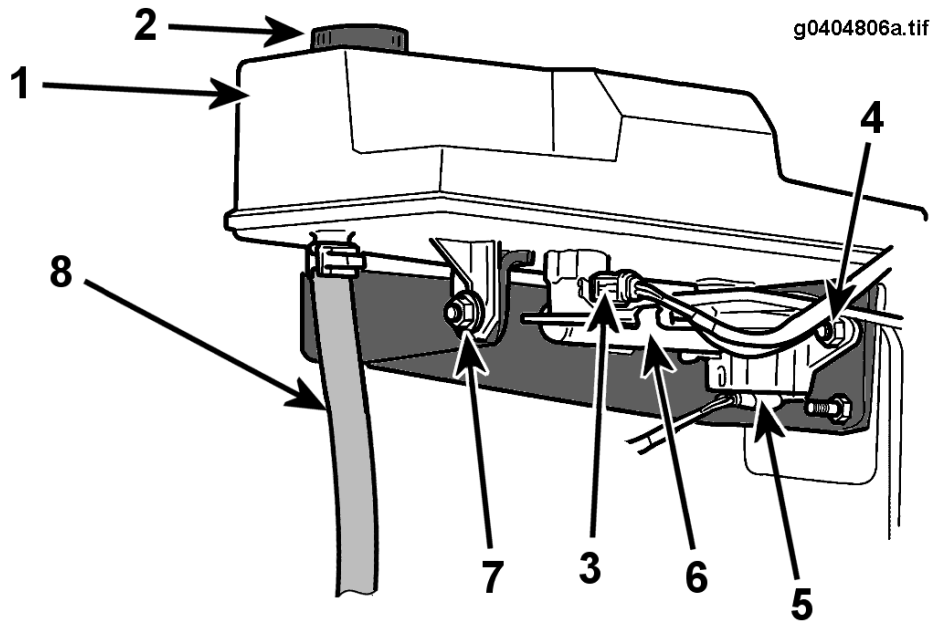

Figure 6 Master Cylinder and Components

1. RESERVOIR
2. FILL CAP
3. FLUID LEVEL SENSOR CONNECTOR
4. MASTER CYLINDER MOUNTING NUT
5. BRAKE LIGHT SWITCH CONNECTOR
6. MASTER CYLINDER BODY
7. RESERVOIR MOUNTING NUT
8. LOW PRESSURE HOSE

Hydraulic Compact Unit (HCU)

The HCU is mounted to the inside of the left frame rail, behind the driver's position, and is the heart of the Full Power Brakes system (see FIGURE 7 and FIGURE 8). The HCU responds to hydraulic inputs from the master cylinder. The ECU is mounted to the HCU, but will be described in more detail separately. Like the master cylinder, the HCU is divided into front and rear hydraulic channels. However, the electronically controlled ABS valves of the HCU allow independent control of the braking force at each of the four wheel ends during an ABS event.

A port on the HCU provides the route for brake fluid to and from the Spring Apply Hydraulic Release (SAHR) parking brake canister. This port is controlled by the Pressure Supply Valve (PSV) which is mounted on the rear of the HCU. The ECU controls the PSV.

It is worth noting that the accumulator, pump motor, and relay valve connection located to the rear of the HCU are part of the front axle brake circuit (see FIGURE 9). Likewise, the rear half of the reservoir is also part of the front axle circuit. The components located to the front of the HCU are part of the rear axle circuit. However, the brake tubes feeding the front axle circuits are connected to the front of the HCU; and the rear axle circuits are fed by tubes connected to the rear of the HCU.

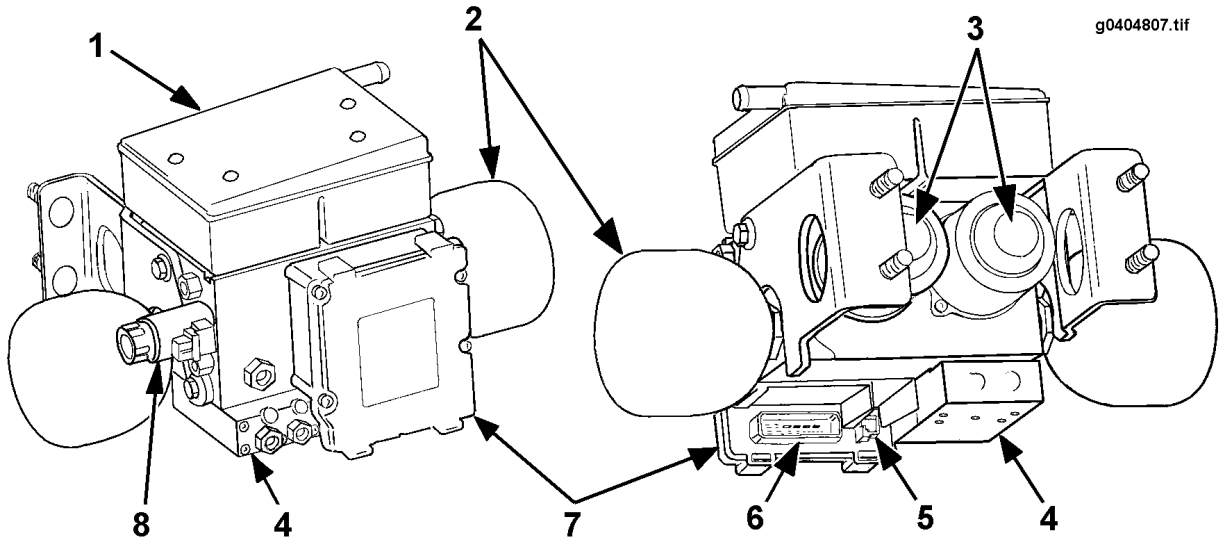

Figure 7 Hydraulic Compact Unit

1. RESERVOIR
2. ACCUMULATORS
3. PUMP MOTORS
4. RELAY VALVE
5. 2-PIN CONNECTOR
6. 31-PIN CONNECTOR
7. ELECTRONIC CONTROL UNIT (ECU)
8. PRESSURE SUPPLY VALVE WITH CONNECTOR

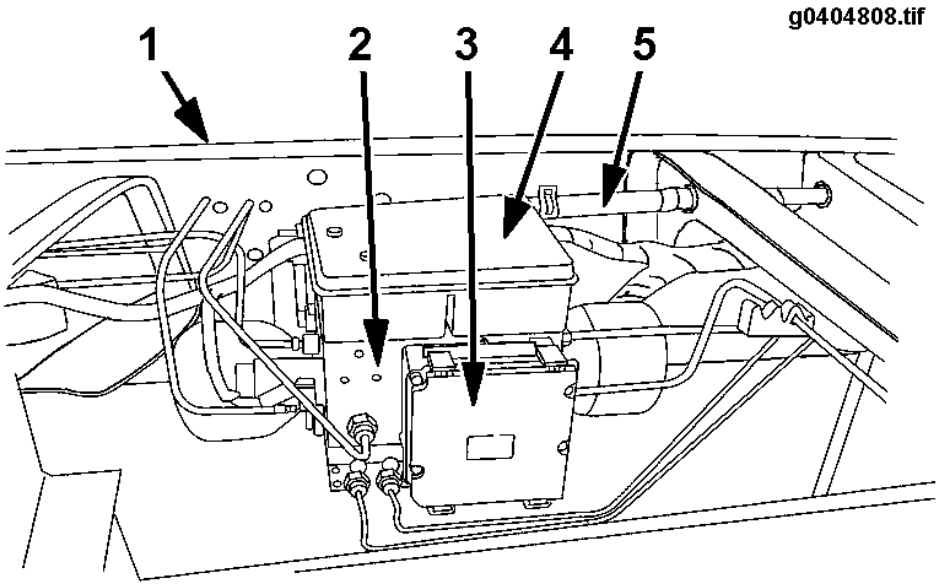

Figure 8 Hydraulic Compact Unit Mounted to Left Frame Rail

1. FRAME RAIL – LEFT
2. HYDRAULIC COMPACT UNIT
3. ELECTRONIC CONTROL UNIT
4. RESERVOIR
5. LOW PRESSURE HOSE

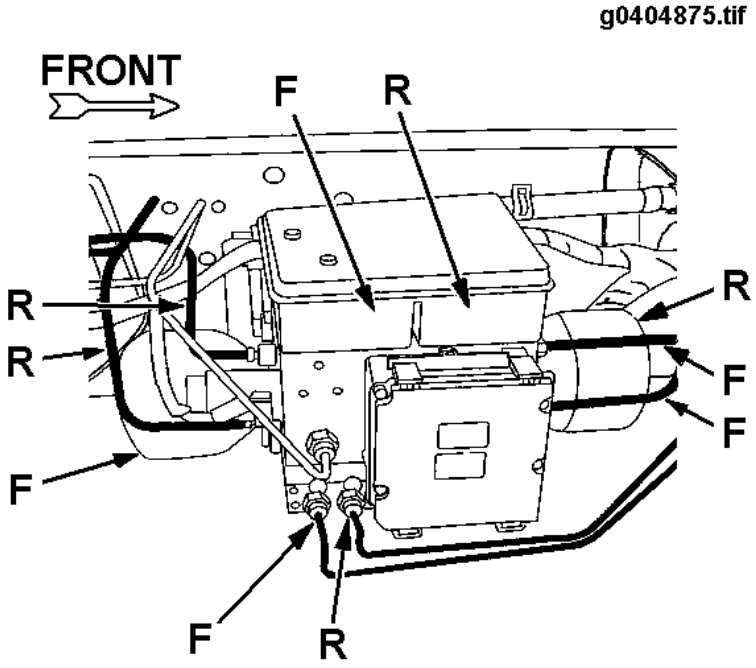

Figure 9 Brake Circuits in the HCU

F – PART OF FRONT AXLE (PRIMARY) BRAKE CIRCUIT
R – PART OF REAR AXLE (SECONDARY) BRAKE CIRCUIT

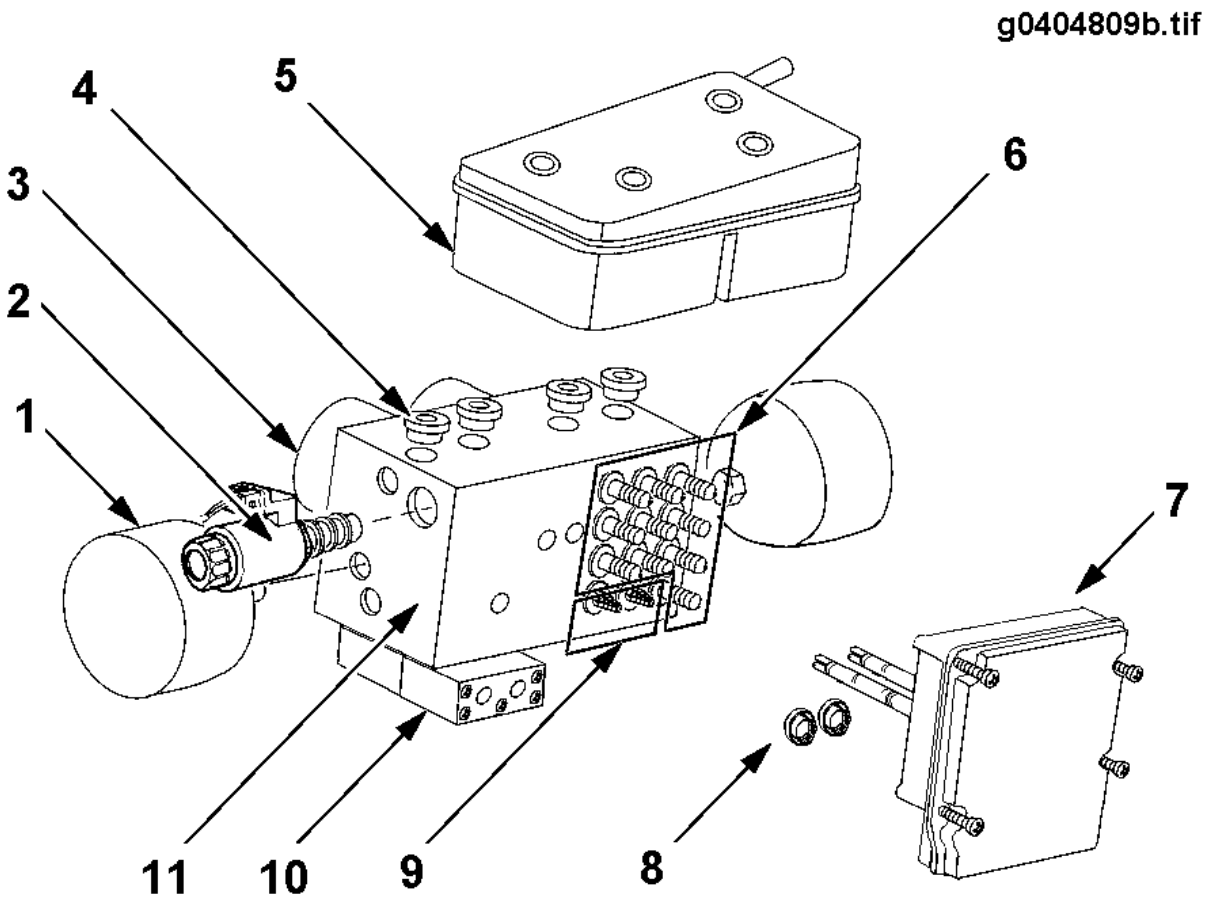

Figure 10 Hydraulic Compact Unit Exploded View

1. ACCUMULATOR (2)
2. PRESSURE SUPPLY VALVE (PSV)
3. PUMP MOTOR (2)
4. SEALS FOR HCU RESERVOIR (4)
5. HCU RESERVOIR
6. SOLENOID VALVES (8 ABS AND 2 ATC)
7. ELECTRONIC CONTROL UNIT (ECU)
8. O-RING SEALS FOR PRESSURE SENSORS (2)
9. PRESSURE SENSORS (2)
10. RELAY VALVE ASSEMBLY
11. HCU BODY

Refer to FIGURE 10 for an exploded view of the HCU. The HCU is comprised of:

A. two precharged accumulators pre-charged to 1087 psi (Figure 10, item 1; also refer to FIGURE 11) **(NOTE: The accumulators are physically mounted to the HCU, but may be replaced separately.)**

- provide independent front and rear brake channel pump/motor accumulator circuits
- act as storage devices for the pressurized brake fluid that provides the braking force
- are pressurized by the pump/motor circuits to between 1770 psi and 2320 psi during normal operation
- may be replaced separately from HCU, and must be replaced in pairs (the accumulators are not rechargeable)

B. the Pressure Supply Valve (PSV) (Figure 10, item 2) **(NOTE: The PSV is physically mounted to the HCU, but must be replaced separately. It is NOT supplied with a replacement HCU kit.)**

- controls the brake fluid routed to and from the park brake (SAHR) canister, as directed by the ECU
- prevents unexpected park brake application if the cut-off valve malfunctions

C. two hydraulic pumps driven by electric motors (E-motors) (Figure 10, item 3)

- provide independent front and rear brake channel pump/motor circuits
- are controlled by the ECU, based on readings of the fluid pressure transducers (in the HCU)
- pressurizes the accumulators as directed by the ECU
- pumps (located in HCU body) may be replaced separately from HCU
- E-motors are not replaceable separately, repair requires replacement of the HCU

D. the HCU reservoir (Figure 10, item 5)

- supplied brake fluid by a low pressure hose from the master cylinder reservoir
- contains an internal baffle to separate the fluid supply for the front and rear hydraulic channels
- contains two supply ports for the front and rear axle circuits
- may be replaced separately from the HCU

E. the ten ABS/ATC solenoid control valves (Figure 10, item 6)

- eight ABS solenoid valves that control the brake fluid pressure applied to each wheel caliper during ABS and ATC events (one inlet valve and one outlet valve per wheel)
- two ATC solenoid valves that work in conjunction with the ABS valves to control the brake fluid pressure to each wheel during an ATC event
- cannot be replaced separately, repair requires replacement of the HCU assembly

F. the Electronic Control Unit (ECU) (Figure 10, item 7)

- may be replaced separately from the HCU
- The ECU is described separately in the following paragraph.

G. the two pressure transducers (Figure 10, item 9)

- monitor the brake fluid pressure stored in the accumulators
- cannot be replaced separately, repair requires replacement of the HCU assembly

H. the dual circuit relay valve (Figure 10, item 10)

- routes brake fluid from the pressurized accumulator circuits to the wheel ends in proportion to the pilot signals received from the master cylinder during braking
- connects the wheel ends to the reservoir when not braking
- actuated by the ATC valves during an ATC event
- may be replaced separately

I. the HCU body (Figure 10, item 11)

- provides brake fluid routing passages for the primary, secondary, and park brake circuits
- houses two pressure relief valves for safety against overpressure
- components (except pumps) are not replaceable separately, repair requires replacement of the HCU assembly

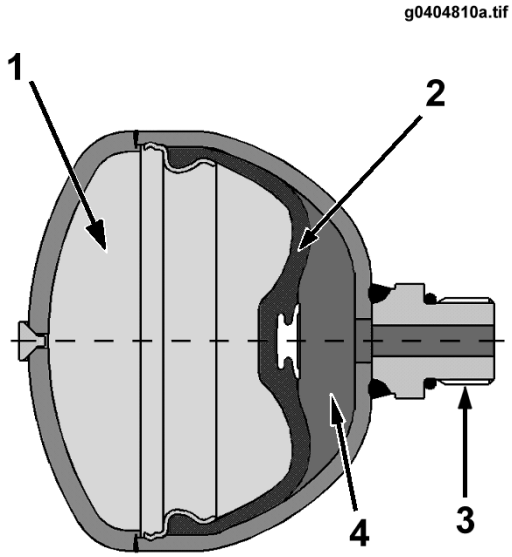

Figure 11 Cutaway View of Accumulator

1. PRESSURIZED GAS PRECHARGE AREA
2. DIAPHRAGM
3. THREADED PORT
4. PRESSURIZED FLUID AREA

Electronic Control Unit (ECU)

The ECU is mounted to the side of the HCU, and is the brains of the brake system (see FIGURE 12). It provides all of the electronic control required for normal braking, ABS operation, ATC operation, and park brake operation. The ECU interfaces with the other brake system components, as well as the vehicle electrical system, through waterproof connectors. The 2-pin and 31-pin connectors are part of the ECU housing.

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

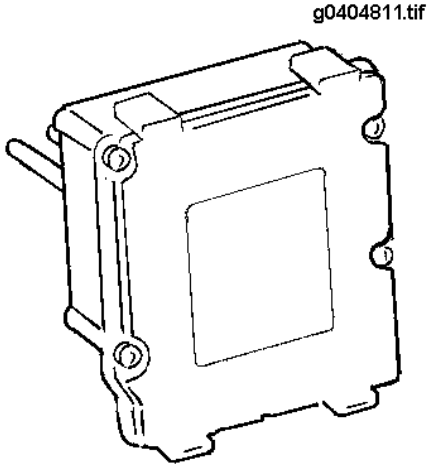

Figure 12 Electronic Control Unit (ECU)

The ECU has various programmable parameters that can vary according to vehicle wheelbase and configuration. The default parameter settings are programmed at the factory. To ensure that a replacement ECU has the correct settings, use only the correct replacement part number. Then, refer to ISIS to complete the programming of the replacement ECU, based on the VIN number of the vehicle.

During ALL operational modes, the ECU:

- monitors status of the fluid level sensor, and outputs a signal if fluid is low
- maintains the correct accumulator pressure by monitoring the pressure transducers, and cycling the motor/pumps as necessary
- provides fault detection, stores fault codes, and signals the ESC/BC to turn on warning indicators
- stores a set of counters in memory for reference during diagnostics, or to plan preventive maintenance
- monitors status of the dash-mounted traction control switch, and selects the ATC mode indicated by the switch position. Selects between ATC Normal mode and ATC Mud and Snow mode.
- monitors signals from wheel speed sensors to determine if ATC operation is necessary
- provides ATC fault detection, stores fault codes, and turns on TRAC CTRL warning indicator if necessary
- monitors status of the dash-mounted park brake switch. If all of the interlock conditions are correct, the park brake circuit is energized or de-energized based on the actuation of that switch.
- monitors status of park brake travel switch, and outputs a signal if brake is applied or a malfunction is detected

During normal braking operation, the ECU:

- monitors status of master cylinder brake switch (actuated by brake pedal), and outputs a signal indicating brake actuation
- monitors signals from wheel speed sensors to determine if ABS operation is necessary

During ABS operation, the ECU:

- monitors status of master cylinder brake switch (to verify that the brake pedal is depressed)
- monitors signals from wheel end sensors to determine which wheels require ABS operation
- controls the ABS solenoid valves for the wheels requiring ABS operation

During ATC operation, the ECU:

- monitors status of master cylinder brake switch (to verify that the brake pedal is not depressed)
- processes sensor signals and generates solenoid valve commands to apply differential braking of slipping drive wheel(s) during an ATC event (if vehicle speed is 31 mph or less)
- sends a signal to the engine controller (ECM), to limit engine torque, during an ATC event, if both drive wheels begin to lose traction
- outputs a signal to the vehicle ESC/BC, during an ATC event. The ESC/BC sends a signal to the gauge cluster to continuously light the TRAC CTRL indicator.

Foundation Brakes (Rotors and Calipers)

The foundation brakes are from an earlier brake system. Service information covering the rotors and calipers can be found in existing service manual s04047.

Wheel Speed Sensors

The wheel speed sensors are magnetic coil/pickup type sensors located at each wheel end (see FIGURE 13 and FIGURE 14). Each sensor is positioned near a tooth ring (also known as a tone ring or exciter ring) which is attached to the wheel hub (see FIGURE 15). As the wheel spins, the teeth (and the spaces between them) pass through the magnetic field of the sensor, causing the sensor to produce voltage pulses. The voltage pulses (signal) from each wheel speed sensor are routed to the ECU to indicate the relative speed of each wheel. The frequency of the wheel speed signal is directly proportional to the speed of the wheel. Broken or missing teeth, or corrosion between the teeth, can cause an inaccurate wheel speed signal.

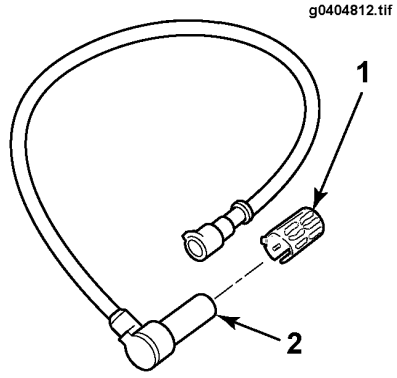

Figure 13 Typical Wheel Speed Sensor

1. BUSHING (SPRING CLIP)
2. WHEEL SPEED SENSOR

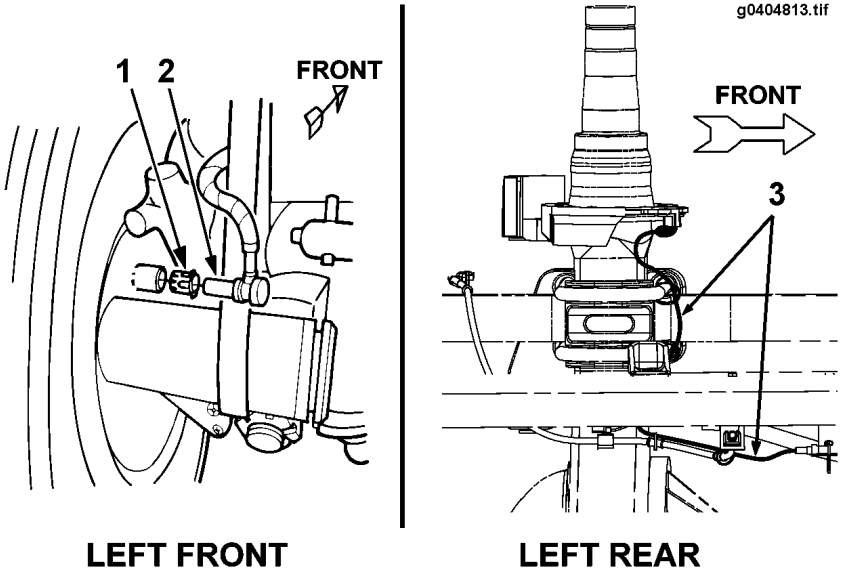

Figure 14 Typical Speed Sensor Locations

1. FRONT SENSOR BUSHING
2. FRONT SENSOR
3. REAR SENSOR CABLE

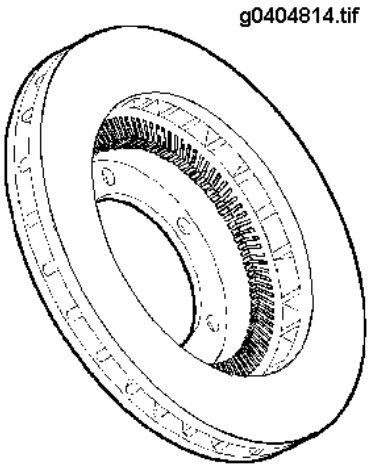

Figure 15 Rotor with Tooth Ring

Electrical System Controller / Body Controller (ESC/BC)

The ESC/BC is located on the inside surface of the cowl, behind the dash. While the Electronic Control Unit (ECU) is the brains of the brake system, the ESC/BC is the brains of the vehicle electrical system. Some electrical signals used by the ECU are communicated through the ESC/BC. Also, to turn on warning and status indicators, the ECU must communicate with the gauge cluster through the ESC/BC.

Spring Applied Hydraulically Released (SAHR) Park Brake Canister

The SAHR canister is located inside the driver's side frame rail, just forward of the rear axle (see FIGURE 16 and FIGURE 17). The SAHR canister is the component that controls the tension 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, hydraulic pressure overcomes the internal springs to relax the parking brake cable, which releases the parking brake.

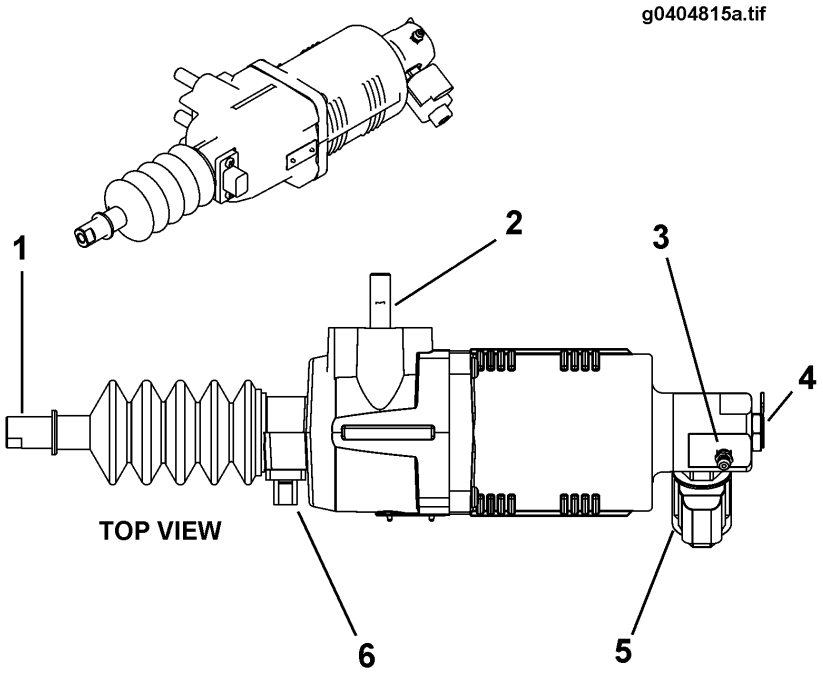

Figure 16 Spring Applied Hydraulically Released (SAHR) Park Brake Canister

1. OUTPUT SHAFT
2. MOUNTING STUDS
3. BLEED PORT
4. BRAKE FLUID PORT
5. CUT-OFF SOLENOID VALVE
6. TRAVEL SWITCH

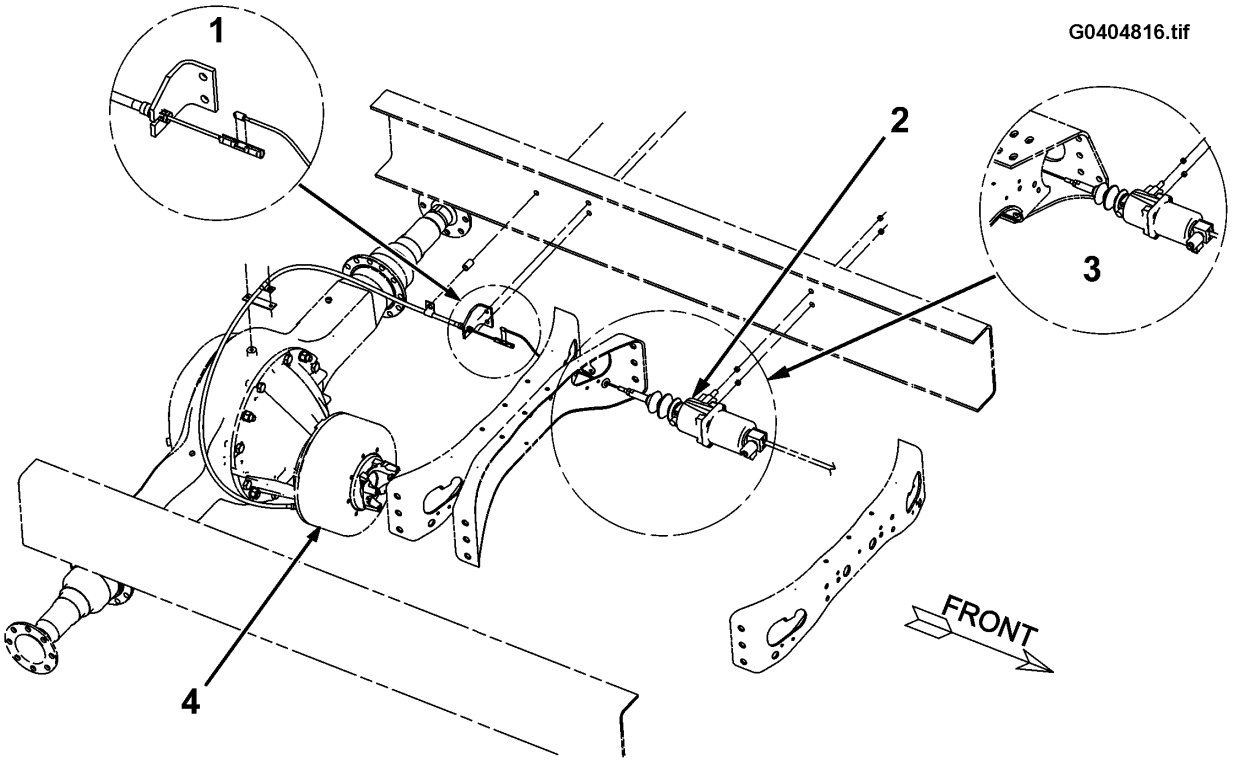

Figure 17 Location of SAHR Canister and Related Components

1. CONNECTION AT BRAKE CABLE UNION
2. SAHR CANISTER
3. CABLE ROUTING WITH ALTERNATE CROSSMEMBER
4. DRIVELINE PARKING BRAKE DRUM

Driveline Parking Brake Drum

The cable actuated, drum type parking brake is located where the driveshaft is connected to the rear axle yoke (see FIGURE 17). Refer to manual S04044 for more complete service information on the driveline parking brake drum assembly.

Traction Control (Mud and Snow) Switch

WARNING – While servicing an ATC equipped vehicle, the ATC system MUST BE DISABLED before operating the vehicle with only one drive wheel lifted off of the ground. Performing this operation on a vehicle with an active ATC system may result in the vehicle moving and falling from the jacks as power will be transferred to the wheel that is still on the ground.

The ATC system cannot be disabled by placing the dash mounted switch in the "disabled" position.

The ATC system can be TEMPORARILY disabled using the EZ-Tech service tool, running the TOOLBOX diagnostic program. Use extreme caution. When the ATC system is disabled using the EZ-Tech, it will remain disabled only until the next ignition cycle. The TOOLBOX screen will indicate when the ATC function is disabled.

Failure to follow this warning could result in property damage, personal injury or death.

NOTE – Several different traction control Mud and Snow switches have been used in these vehicles. While the switches may vary in appearance they function identically. Regardless of appearance, the switch selects the Mud and Snow mode when the switch indicator is lit. When the switch indicator is unlit, the vehicle is in the Normal ATC mode. The ATC system cannot be DISABLED using the dash mounted switch.

The dash mounted traction control Mud and Snow switch (see FIGURE 18) is used to select the Mud and Snow mode when the driving conditions require it. The following paragraphs describe the difference between the Mud and Snow mode and normal ATC operation.

- **Normal Traction Control (Normal Driving Conditions)**

  When the traction control switch (and vehicle) are in the normal traction control mode, the indicator on the switch and the TRAC CTRL indicator in the gauge cluster will both be unlit. (NOTE: the TRAC CTRL indicator will be on solid during an ATC event, or if an active ATC fault is detected.) In this mode differential braking is used to control traction when one drive wheel loses traction and vehicle speed is 31 mph or less. Engine torque limiting is used to control traction when both drive wheels lose traction. This is the normal operating mode and should be used for most driving conditions.

- **Mud and Snow Mode (Off-Road Driving Conditions)**

  The driver should use the traction control switch to select the Mud and Snow mode when driving in deep snow or off-road conditions. This signals the ECU to allow more wheel spin than normal. When in the Mud and Snow position, the indicator on the switch will be lit, and the TRAC CTRL indicator in the gauge cluster will be flashing. (NOTE: the TRAC CTRL indicator will be on solid during an ATC event, or if an active ATC fault is detected.) The switch should be returned to the Normal Traction Control position when the vehicle is no longer operating in deep snow or mud.

For complete system electrical diagrams, refer to the applicable ELECTRICAL CIRCUIT DIAGRAMS manual listed in ISIS. For information concerning troubleshooting the electrical circuits in the full power brakes system, refer to the applicable ELECTRICAL SYSTEM TROUBLESHOOTING guide listed in ISIS.

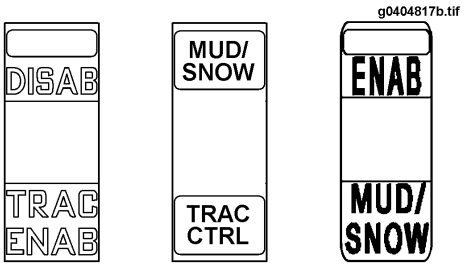

Figure 18 Typical Traction Control Switches

Park Brake Switch

The Park Brake switch (see FIGURE 19) is located on the dash. The ECU monitors the status of this switch. Whenever the switch is pushed in or pulled out the ECU responds by applying or releasing the parking brake. For complete system electrical diagrams, refer to the applicable ELECTRICAL CIRCUIT DIAGRAMS manual listed in ISIS. For information concerning troubleshooting the electrical circuits in the full power brakes system, refer to the applicable ELECTRICAL SYSTEM TROUBLESHOOTING guide listed in ISIS.

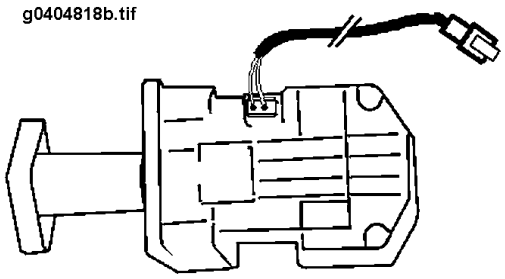

Figure 19 Park Brake Switch Assembly

Electronic Gauge Cluster (EGC)

The EGC contains all of the indicators used to display the status of the Full Power Brakes system (see FIGURE 20). The warning buzzer that activates under certain conditions, is also located in the EGC. There is no direct communication between the EGC and the full power brakes ECU. To control an indicator, the ECU must communicate with the ESC/BC, which then communicates with the EGC.

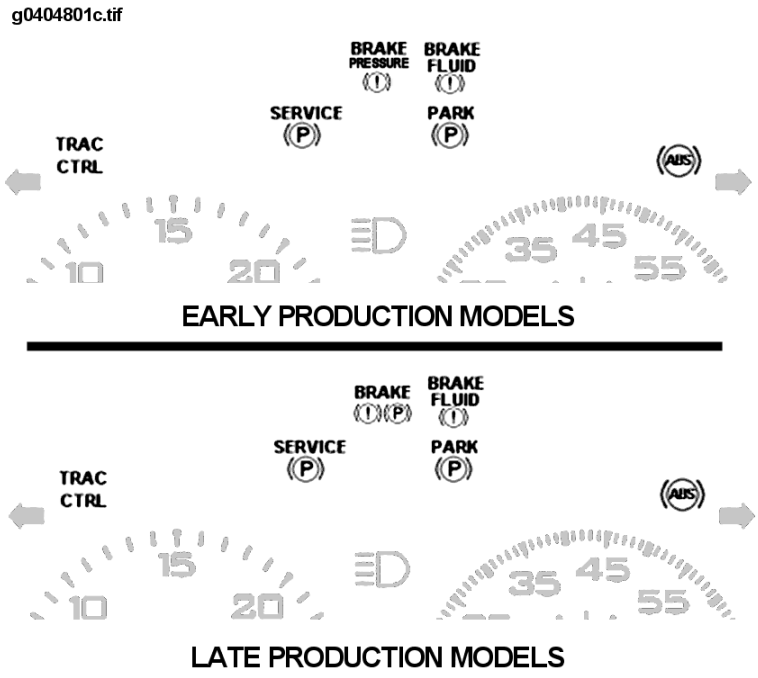

Figure 20 Indicators Used for the Full Power Brakes System

Brake / Brake Pressure Indicator (Indicator Differs by Model Year)

The BRAKE Pressure indicator is located in the instrument panel gauge cluster (see FIGURE 20). The indicator lights to indicate that the pressure in all or part of the system has dropped below a minimum level (approximately 1550 psi). Low pressure detected in half of the system (front or rear circuit only) will be indicated by a solid on indicator. Low pressure detected in the full system (both front and rear circuits) will be indicated by a flashing indicator. Every time the indicator is lit, the warning buzzer sounds, and a diagnostic code is generated by the ECU and stored in memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

A bulb check occurs each time the ignition switch is turned to the RUN position. The indicator should turn on for about three seconds then turn off.

Brake Fluid Indicator

The BRAKE FLUID indicator (see FIGURE 20) lights to indicate that the brake fluid level in the master cylinder reservoir is below the minimum level. A bulb check occurs each time the ignition switch is turned to the RUN position. The indicator should turn on for about three seconds then turn off.

ABS Indicator

The ABS indicator (see FIGURE 20) lights when a malfunction has been detected in the ABS system. Every time the indicator is lit, a diagnostic code is generated by the ECU and stored in memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

A bulb check occurs each time the ignition switch is turned to the RUN position. The indicator should turn on for about three seconds then turn off.

TRAC CTRL Indicator

The traction control indicator (TRAC CTRL) is located in the electronic gauge cluster (see FIGURE 20). A bulb check occurs each time the ignition switch is turned to the RUN position. The indicator should turn on for about three seconds then turn off. This indicator indicates the following three conditions.

- The TRAC CTRL lamp will be flashing whenever the Mud and Snow mode is selected using the traction control switch (switch indicator lit).
- The TRAC CTRL indicator will be lit continuously whenever a traction control related fault has been detected. Every time a fault is detected, a diagnostic code is generated by the ECU and stored in memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).
- If no ATC related faults have been detected, the TRAC CTRL indicator will be continuously lit only during an ATC event.

Park Brake Indicator

The PARK BRAKE indicator (see FIGURE 20) lights whenever the parking brake has been applied. (A single chime is also sounded.)

A bulb check occurs each time the ignition switch is turned to the RUN position. The indicator will be turned on for about three seconds by the ESC/BC; then will remain on (park brake is applied) until the park brake is released.

Service Park Brake Indicator

The SERVICE PARK BRAKE indicator (see FIGURE 20) lights when a malfunction has been detected in the powered parking brake system. Initially, the indicator will flash and an alarm will sound for 20 seconds. After 20 seconds the indicator will remain on continuously and the alarm will stop. Every time the indicator is lit, a diagnostic code is generated by the ECU and stored in memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

A bulb check occurs each time the ignition switch is turned to the RUN position. The indicator should turn on for about three seconds then turn off.

3. OPERATION

IMPORTANT – The vehicles covered in this manual have used two different electrical controllers. Both controllers are mounted in the same location. The original controller was known as the Electrical System Controller (ESC). The current controller is known as the Body Controller (BC). In this manual the controller will be identified as the Body Controller or the ESC/BC.

The full power brakes system operates in three different main modes: normal braking, ABS braking, and Automatic Traction Control (ATC). In general, the HCU ECU monitors the wheel speed sensors and other system parameters to determine which operational mode is necessary. FIGURE 21 shows a physical representation of the brake system hydraulic and electrical circuits. FIGURE 22 shows the hydraulic circuits within the HCU in detail. It is important to note that the relay valves are hydraulically controlled while all of the other valves are electronically controlled solenoid valves. In this section we will describe how the components of the system control the foundation brakes during each of the three operational modes. In addition, the operation of the parking brake circuits will be described.

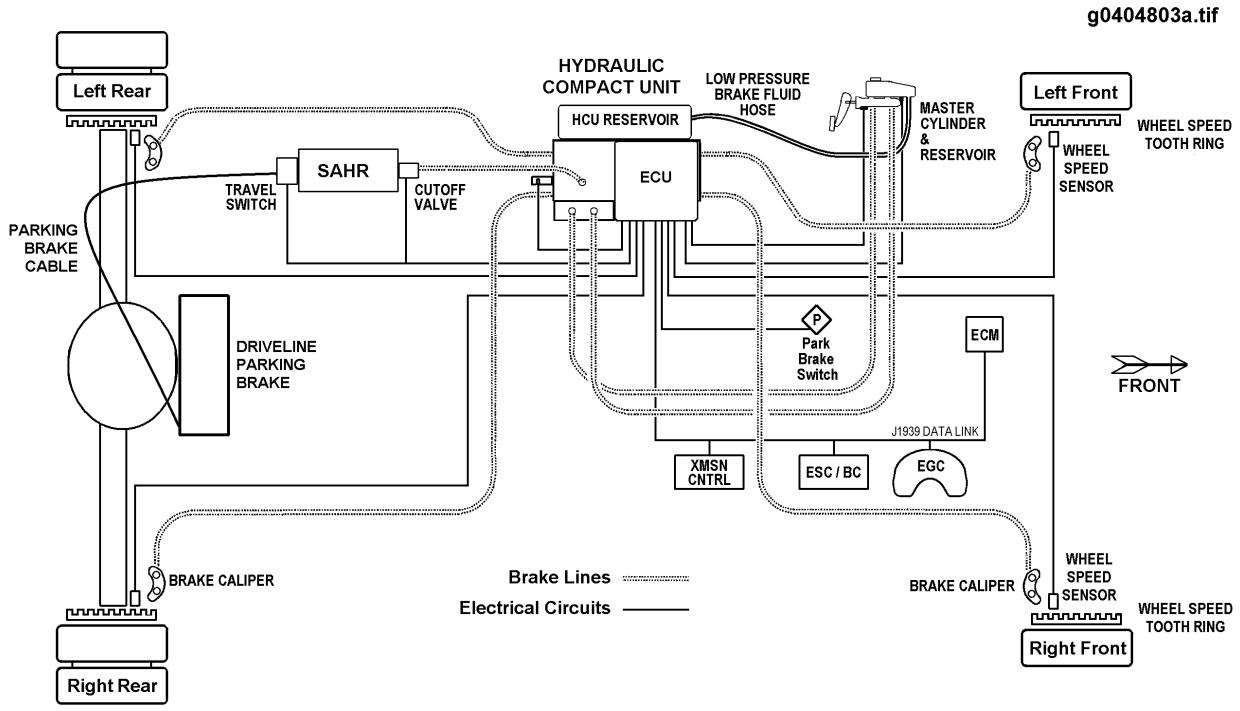

Figure 21 Diagram of the Full Power Brakes System

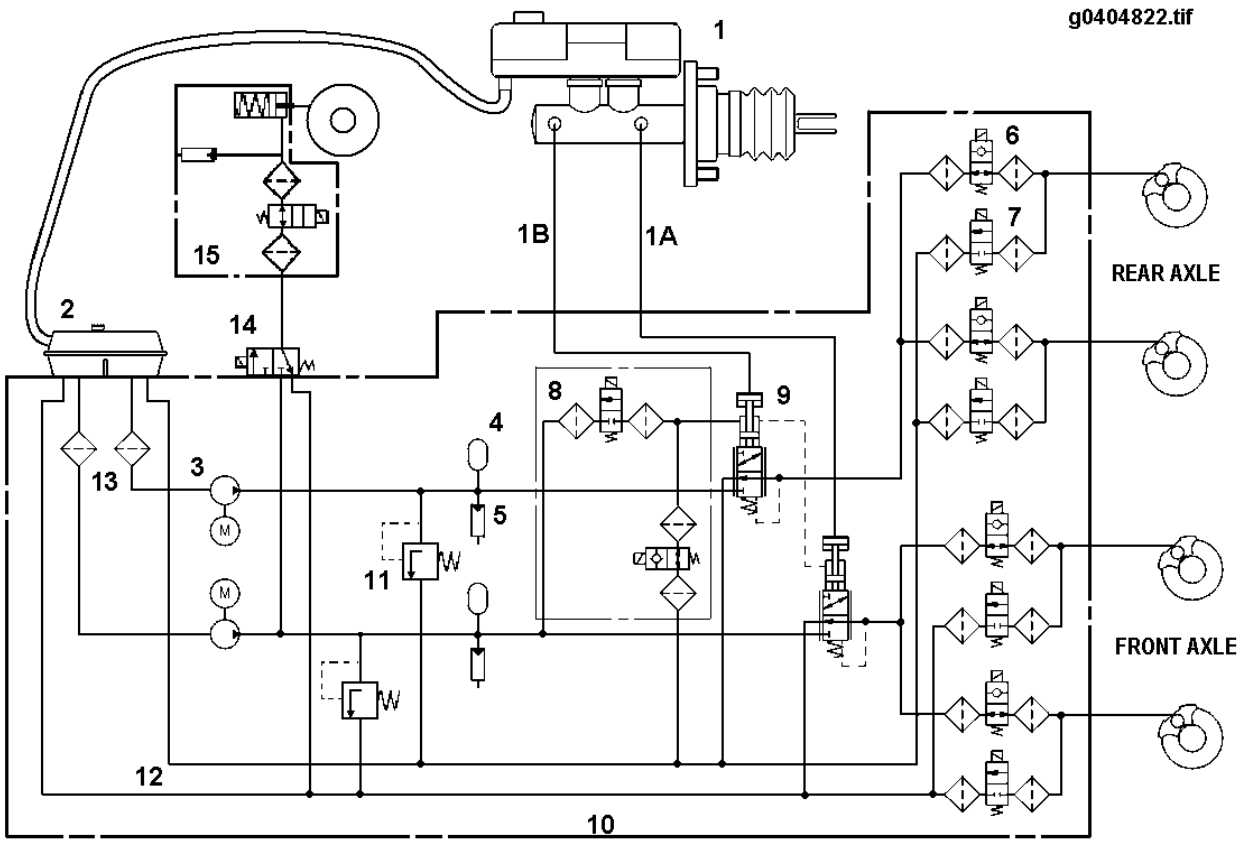

Figure 22 Overall System Hydraulic Diagram

1. MASTER CYLINDER
   - 1A. PRIMARY PILOT SIGNAL CIRCUIT
   - 1B. SECONDARY PILOT SIGNAL CIRCUIT
2. HCU RESERVOIR
3. E-MOTOR AND PUMP SYSTEM
4. ACCUMULATOR
5. PRESSURE SENSOR
6. INLET SOLENOID VALVE
7. OUTLET SOLENOID VALVE
8. ATC SOLENOID VALVES
9. RELAY VALVE
10. HYDRAULIC COMPACT UNIT (HCU) ASSEMBLY
11. PRESSURE RELIEF VALVE
12. RETURN CIRCUITS
13. SUPPLY CIRCUITS
14. PRESSURE SUPPLY VALVE (PSV)
15. SAHR CANISTER (INCLUDING CUT-OFF VALVE AND TRAVEL SWITCH)

3.1. WARNING INDICATORS

Six indicators located in the Electronic Gauge Cluster (EGC), are used to display the status of the brake system. Refer to FIGURE 20 (See Figure 20, page 33). Four of the indicators identify conditions that may require service. In addition, a warning buzzer is sounded for certain conditions. The following table includes brief descriptions of how each of the indicators is energized. In the event that a lit indicator is the result of a malfunction, diagnostic codes identifying the source of the malfunction will be stored in the ECU memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76). Although the following table lists possible malfunctions for each indicator, some malfunctions such as loss of data link communications, will result in more than one indicator being lit. When the IGN key is turned on a bulb check is performed. The indicators in the gauge cluster will light for about 3 seconds, then turn off. (NOTE: The PARK BRAKE indicator will remain lit until the park brake is released.)

Table 2 Warning Indicators

INDICATOR	SYSTEM CONDITION BEING INDICATED
BRAKE / **BRAKE PRESSURE**	Indicator differs by model year.
- SOLID ON	Half system failure. A sensor in the HCU has detected low pressure (<1550 psi) in the accumulator for either the front or rear brake circuit. The ECU sends a J1939 data link signal to the ESC/BC. The ESC/BC sends a J1939 data link signal to the EGC commanding it to turn on the indicator and sound the warning buzzer. If the fault is detected in the front brake circuit, once the parking brake has been set, it will not release until this fault is repaired and the ignition is cycled.
- FLASHING	Full system failure. Sensors in the HCU have detected low pressure (<1550 psi) in the accumulators for both the front and rear brake circuits. The ECU sends a J1939 data link signal to the ESC/BC. The ESC/BC sends a J1939 data link signal to the EGC commanding it to turn on the indicator and sound the warning buzzer. The ECU sends a J1939 data link signal to the ECM. Once vehicle speed drops below 25 mph, engine limiting will limit the vehicle speed to 25 mph or less. In addition, once the parking brake has been set, it will not release until this fault is repaired and the ignition is cycled.
- OFF	System pressures are in normal range.
BRAKE FLUID	
- SOLID ON	Low brake fluid level detected in the Master Cylinder reservoir. The fluid level sensor on the MC reservoir sends a signal to the ECU. The ECU sends a J1939 data link signal to the ESC/BC. The ESC/BC sends a J1939 data link signal to the EGC commanding it to turn on the indicator.
- OFF	Brake fluid level detected in the Master Cylinder reservoir is at or above MIN.

Table 2 Warning Indicators (cont.)

INDICATOR	SYSTEM CONDITION BEING INDICATED
ABS	
- SOLID ON	An ABS related fault has been detected by the ECU. -OR- Communications between the ECU and the ESC/BC have been lost. -OR- The ECU is not receiving power. When the ECU detects an ABS related fault, it sends a J1939 data link signal to the ESC/BC. The ESC/BC sends a J1939 data link signal to the EGC commanding it to turn on the indicator. When the ESC/BC does not receive a communication from the ECU within a predetermined period of time, it sends a J1939 data link signal to the EGC commanding it to turn on the indicator.
- OFF	The ECU is receiving power and is communicating with the ESC/BC, and no ABS related faults have been detected by the ECU.
PARK BRAKE	
- SOLID ON	Park brake is applied. Travel switch on SAHR canister detects that park brake is applied. Switch sends signal to ECU. The ECU sends a J1939 data link signal to the ESC/BC. The ESC/BC sends a J1939 data link signal to the EGC commanding it to turn on the indicator and sound the chime once.
- OFF	Park brake is not applied.
SERVICE PARK BRAKE	
- FLASHING/SOLID ON	A Park brake related fault has been detected by the ECU. The ECU sends a J1939 data link signal to the ESC/BC. The ESC/BC sends a J1939 data link signal to the EGC commanding it to flash the indicator and sound the alarm for approximately 20 seconds. After 20 seconds the signal sent by the ESC/BC will command the EGC to turn the indicator on continuously, and turn the alarm off.
- OFF	No park brake faults detected by the ECU.
TRAC CTRL	

Table 2 Warning Indicators (cont.)

INDICATOR	SYSTEM CONDITION BEING INDICATED
- SOLID ON	The TRAC CTRL indicator will be continuously lit whenever: A traction control related fault has been detected. - OR - The ATC system is operating correctly, and an ATC event is occurring. When the ECU experiences an ATC event or detects an ATC related fault, it sends a J1939 data link signal to the ESC/BC. The ESC/BC sends a J1939 data link signal to the EGC commanding it to turn on the indicator.
- FLASHING	The TRAC CTRL indicator will be flashing whenever the Mud and Snow mode has been selected using the traction control switch (switch indicator lit). The ESC/BC senses the position of the dash switch via the switch data link. The ESC/BC sends a J1939 data link signal to the ECU. The ECU sends a J1939 data link signal back to the ESC/BC indicating that the Mud and Snow mode is selected, and that no ATC related faults have been detected. The ESC/BC sends a J1939 data link signal to the EGC commanding it to flash the indicator.
- OFF	The ATC system is operating correctly, the Mud and Snow mode has not been selected, and the vehicle is not experiencing an ATC event.

3.2. NORMAL BRAKING OPERATION

To provide a means of comparison, the following paragraphs will describe the brake system without brakes applied and with brakes applied. NOTE: Parking brake operation will be described separately.

Normal Operation (Brakes not Applied)

Figure 23 shows the hydraulic system while in the Normal mode, without brakes applied. The system is divided into two channels: the primary channel (controls front axle) and the secondary channel (controls rear axle). The motor driven pumps maintain pressure in the accumulators where it is stored to provide braking energy. The pressure in each accumulator is maintained between 1770 psi and 2320 psi.

When the ignition key is set to ON the brake system indicator lights in the gauge cluster perform a bulb check. Each indicator turns on for approximately 3 seconds, then turns off. (NOTE: The PARK BRAKE indicator will stay on until the parking brake is released.) The ECU monitors the pressure of the accumulators. If either accumulator is below its cut-in pressure, the ECU applies power to the correct pump motor circuit to pressurize the accumulator until the cut-out pressure is reached. The ECU monitors the status of the brake light switch in the master cylinder to determine if the brakes have been applied. The brake light switch is a diagnosable switch that allows the ECU to determine if the switch circuit is malfunctioning. The ECU also monitors conditions throughout the brake system to verify that no faults are present.

In the event of a brake system malfunction, a warning lamp will illuminate and diagnostic codes identifying the source of the malfunction will be stored in the ECU memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

Without the brakes applied all of the solenoid valves are in their non-energized state. The only pressurized brake fluid is between the pump outlets and the relay valves. The state of the relay valves blocks the pressurized brake fluid from the rest of the system.

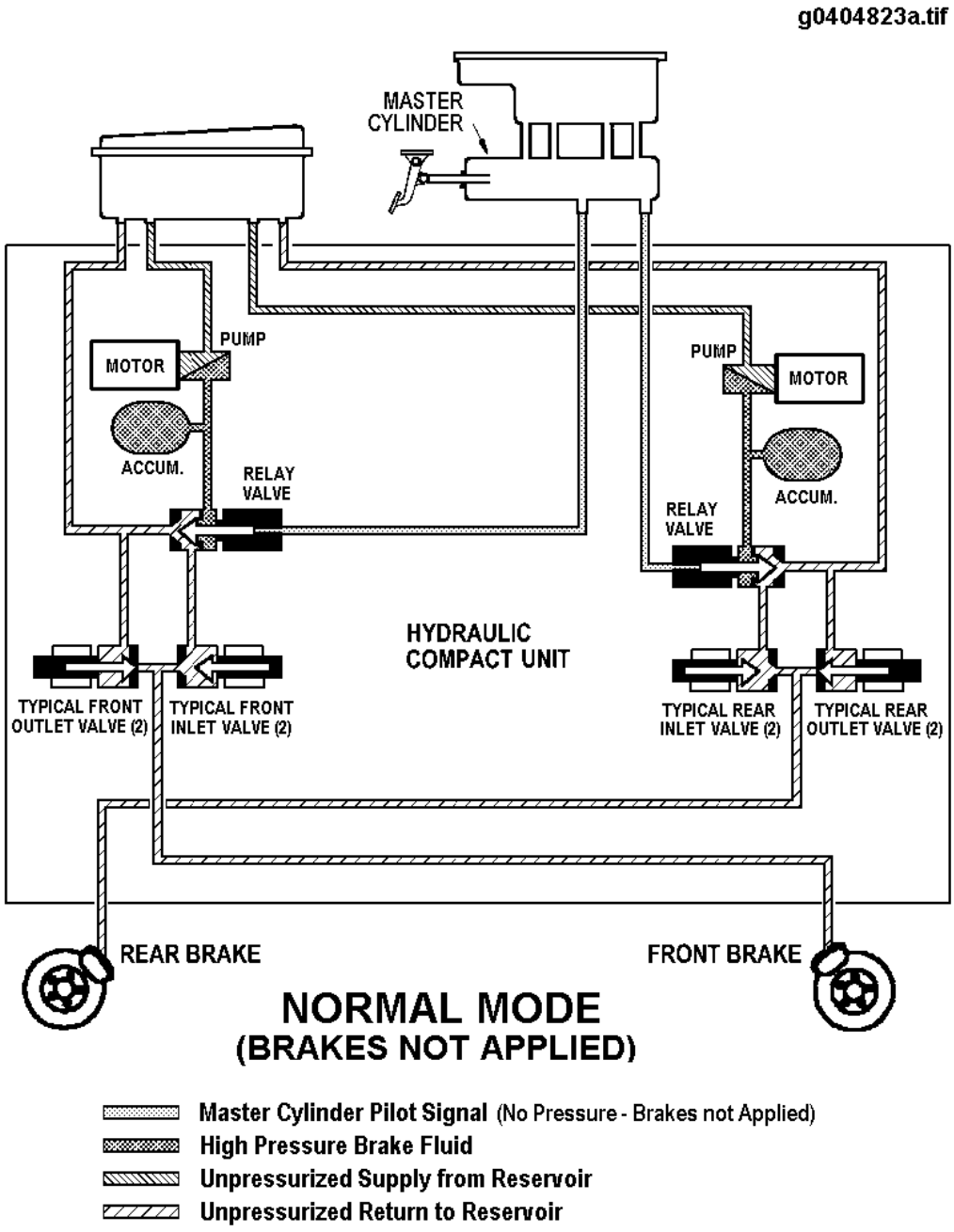

Figure 23 Brake Fluid Routing – Normal Operation (Brakes Not Applied)

Normal Operation (Brakes Applied)

The ECU monitors the status of the Master Cylinder (MC) brake light switch to determine when the brakes have been applied. Depressing the brake pedal causes the brake light switch to send a signal to the ECU. The ECU responds by sending two signals to the ESC/BC. A hardwired signal and a J1939 data link signal are

sent. If either signal, or both signals, are received by the ESC/BC; the brake lights are turned on. If only one of the signals is received by the ESC/BC, a fault is logged.

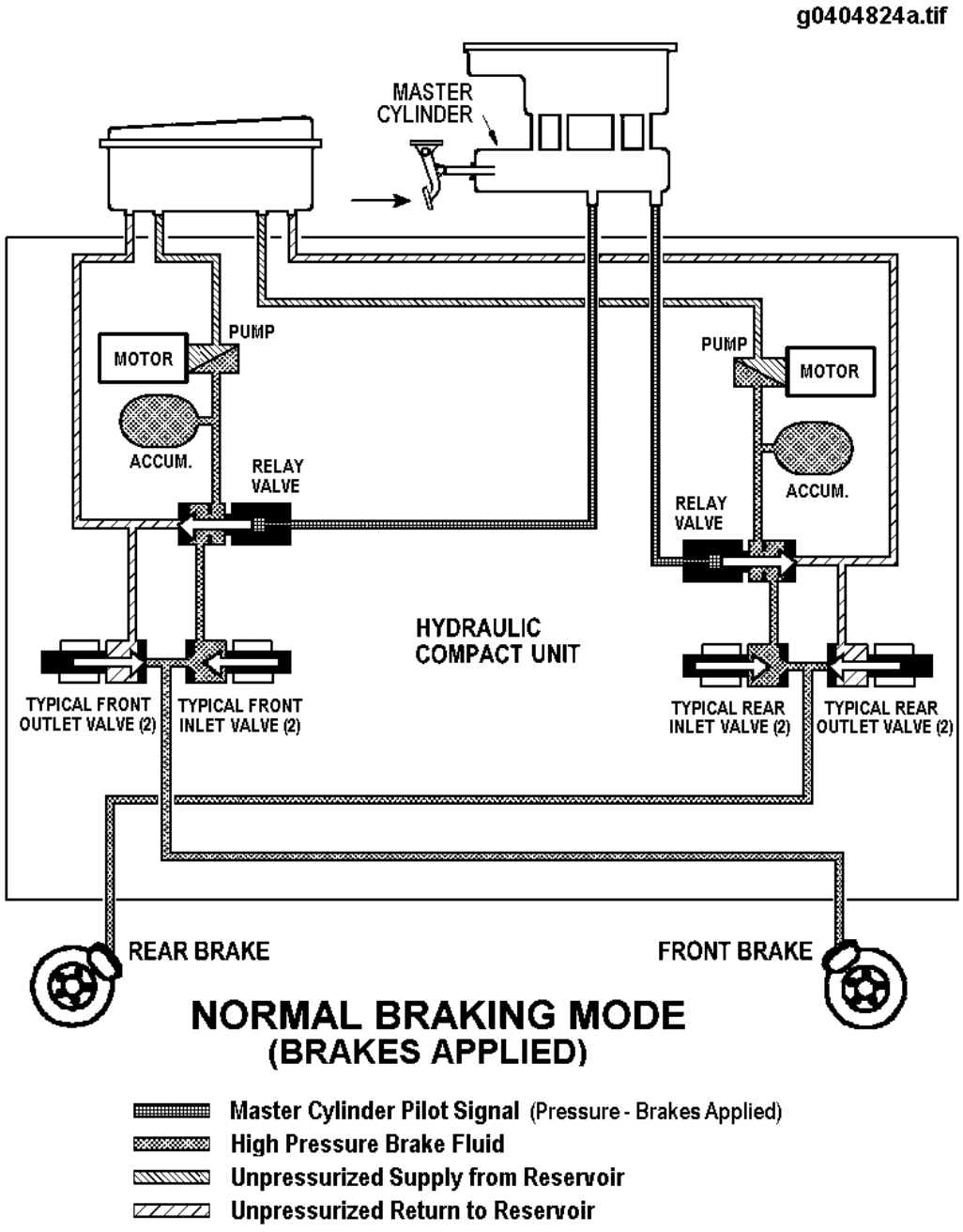

Figure 24 Brake Fluid Routing – Normal Operation (Brakes Applied)

In the hydraulic system, when the brake pedal is pressed, two ‘pilot signals’ are sent from the master cylinder to the HCU relay valve. These two hydraulic lines are dead-headed at the HCU relay valve. The fluid in these lines applies pressure to the relay valves but does not flow into the HCU. In response to the pilot signals the relay valves route pressurized brake fluid from the accumulators, through the ’normally open’ inlet valves, to the brake calipers at the wheel ends. The relay valves are designed to apply braking pressure to the wheel end calipers in proportion to the strength of the MC pilot signals. Figure 24 shows the hydraulic system with brakes applied in the Normal mode. When the brake pedal is released, the relay valve closes and the pressurized brake fluid in the accumulators is blocked. The pressurized brake fluid in the calipers is allowed to return to the HCU reservoir through the open inlet valve and the open portion of the relay valve.

3.3. ANTILOCK (ABS) BRAKING MODE

The ABS braking mode is entered from the Normal braking mode when the ECU determines that a wheel is about to lock up. During braking, in addition to monitoring the MC brake light switch, the ECU monitors the wheel speed sensors located at each of the 4 wheel ends. An ABS event occurs when the brake pedal is pressed and the ECU determines, from the sensor signals, that a wheel is about to lock up.

During an ABS event the ECU controls the ABS operation by energizing and de-energizing the solenoid controlled valves that route the brake fluid to the wheel end calipers. The valve coils are contained in the ECU assembly, while the valve cores are part of the HCU assembly. The wheels can enter the ABS mode independently. If one wheel is attempting to lock, it will operate in the ABS mode while the other 3 wheels continue to operate in the Normal braking mode.

While in the ABS mode the ECU adjusts the brakeforce, at the wheel being controlled, by electronically cycling through 3 stages several times a second. This essentially prevents the wheel(s) from locking up by modulating brake pressure for that wheel. The 3 ABS stages are: Decrease Pressure, Hold, and Increase Pressure. Once in the ABS mode, the system remains in that mode until either: the brake pedal is released (indicated by MC brake light switch); or, the wheel speed sensors no longer indicate a probable lock up condition.

In the event of an ABS system malfunction, the ABS function may remain partially operational. The level of ABS functionality during a malfunction depends on the type and location of the malfunction. Refer to Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76) for more information.

ABS Decrease Pressure Stage

In the first stage of an ABS event, the ECU enters the Decrease Pressure stage. In this stage the ECU switches the ’normally open’ inlet valve for the affected wheel to the closed state. In addition, the ’normally closed’ outlet valve is switched to the open state. This action decreases the brake fluid pressure applied to the wheel caliper, allowing the wheel to recover (continue rotating). The closed inlet valve isolates the caliper from the pressurized brake fluid in the accumulator. The open outlet valve allows the pressurized brake fluid in the caliper to return to the HCU reservoir. Figure 25 shows the hydraulic system while operating in the ABS Decrease Pressure stage.

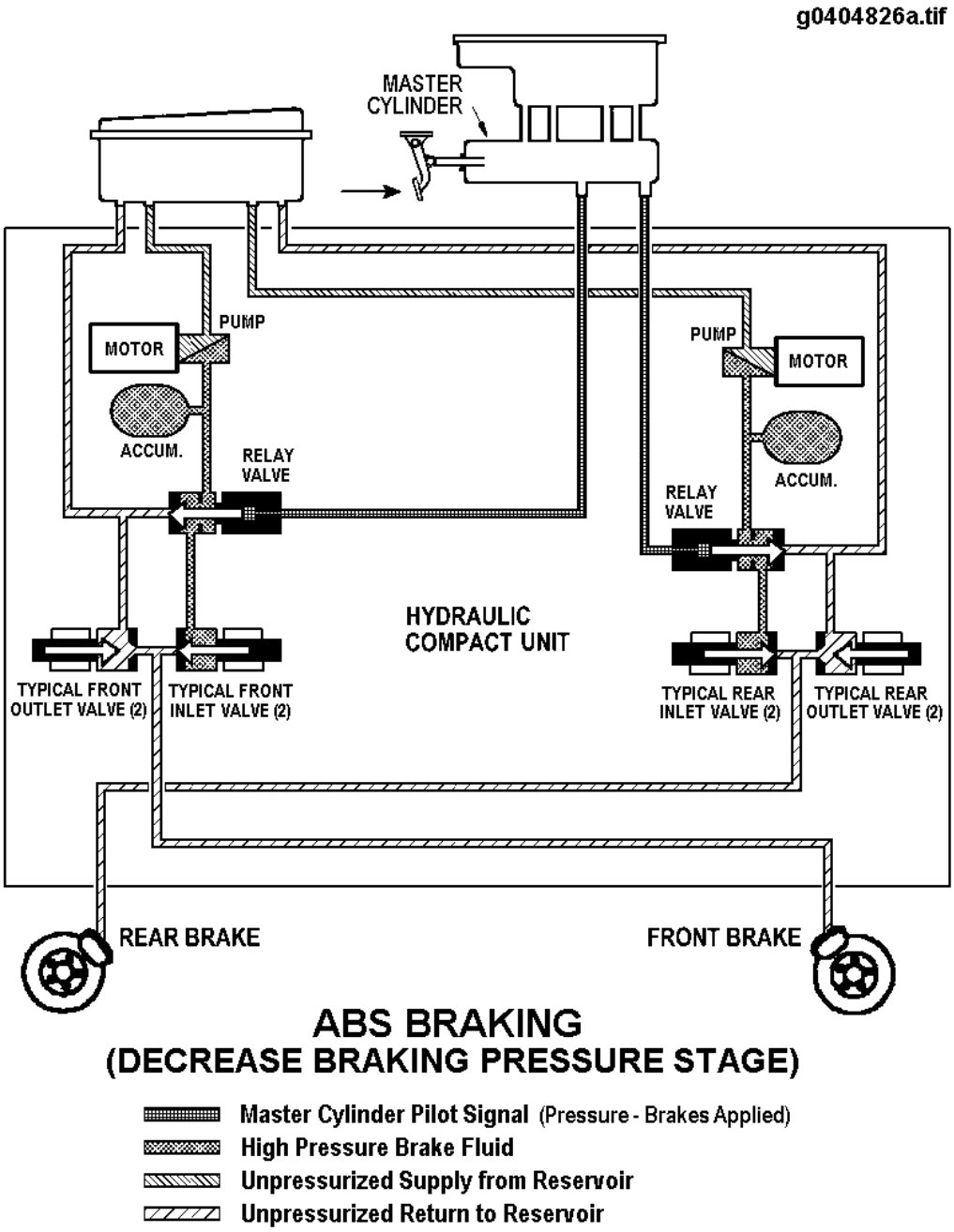

Figure 25 Brake Fluid Routing – ABS Decrease Pressure Stage

ABS Hold Stage

In the second stage the ECU keeps the 'normally open' inlet valve for the affected wheel in the closed state. Meanwhile, the outlet valve for that wheel is returned to its 'normally closed' state. This action isolates the caliper of the affected wheel to maintain (hold) the brake fluid pressure in that caliper at its current level. Figure 26 shows the hydraulic system while operating in the ABS Hold stage.

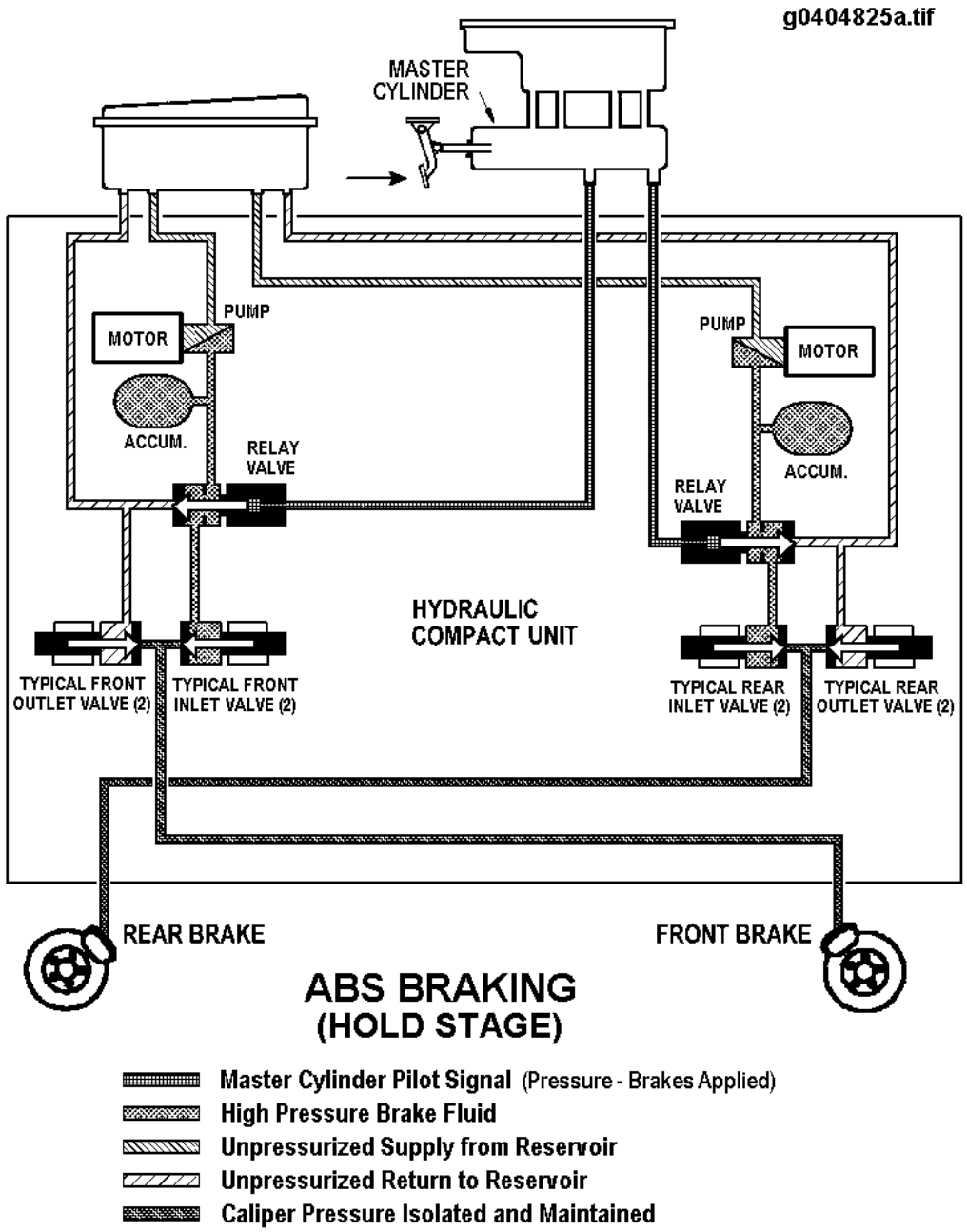

Figure 26 Brake Fluid Routing – ABS Hold Stage

ABS Increase Pressure Stage

In the third stage of an ABS event, the ECU enters the Increase Pressure stage. In this stage the ECU switches both the inlet and outlet valves, for the affected wheel, back to their 'normal' states. With the inlet valve open and the outlet valve closed, the brake fluid pressure applied to the wheel caliper will increase according to the pressure placed on the brake pedal. The pressurized brake fluid in the accumulator will be routed through the relay valve and inlet valve to the caliper, increasing braking force now that lock up has been prevented. FIGURE 27 shows the hydraulic system while operating in the ABS Increase Pressure stage.

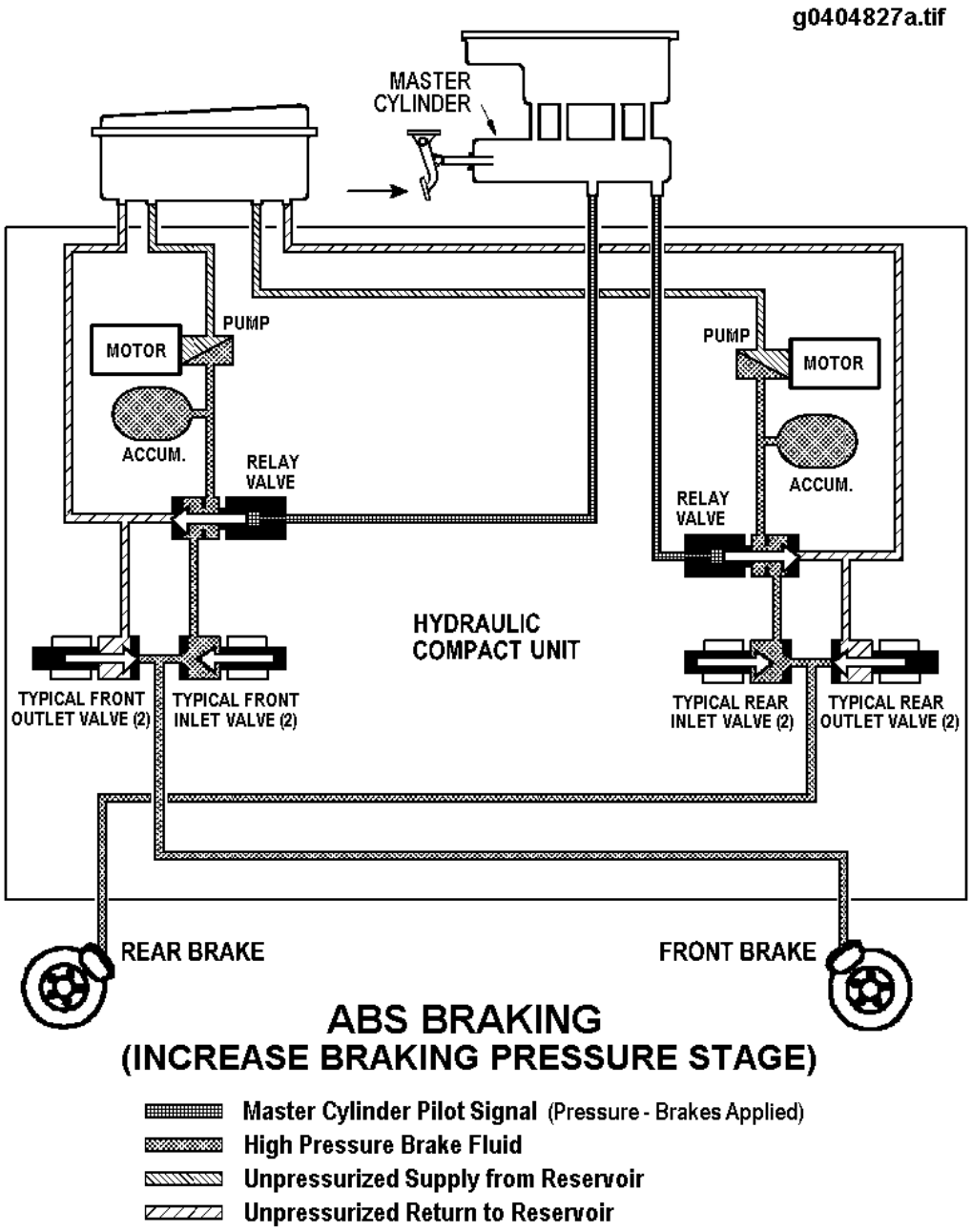

Figure 27 Brake Fluid Routing – ABS Increase Pressure Stage

3.4. AUTOMATIC TRACTION CONTROL (ATC) MODE

Automatic Traction Control uses the ABS components and concepts to improve vehicle traction while accelerating. The ATC function is disabled if the ECU senses a brake pedal actuation. As with ABS, the ECU uses the information from the wheel speed sensors to determine when the ATC mode is necessary. A drive wheel speed higher than the vehicle speed (based on the non-driven wheels) indicates that the drive wheel is losing traction. Traction control is provided in two stages. If only one drive wheel is losing traction, the ECU will control the valves in the HCU to provide braking to the spinning drive wheel, to correct the condition through differential braking. If both drive wheels are losing traction, the ECU will also send a J1939 message to the Engine Control Module (ECM) reducing the torque of the engine. Differential braking is limited to vehicle speeds of 31 mph and lower.

The dash-mounted traction control switch is used to select between two traction control modes (Normal or Mud and Snow). When operating in the Mud and Snow mode, the software in the ECU allows more wheel slippage to occur. This mode can be desirable when operating in deep snow, mud, or off-road conditions. Since the two modes differ in degree only, the basic theory of operation is the same for both. Therefore, unless noted otherwise, the following descriptions pertain to both ATC modes.

ATC Inactive (ATC Circuit Operation with No ATC Event Occurring)

This description and diagram are provided to allow a comparison for the ATC Active mode. When ATC is inactive the brake system is operating in the Normal (non-braking) mode (described earlier), and no ATC event is being experienced. For the sake of describing the ATC circuit, FIGURE 28 shows the ATC valves, as well as the ABS inlet and outlet valves. As illustrated in the figure, the ATC valves provide a second hydraulic input to the relay valves. When the ECU is not sensing an ATC event, the ATC valves are in their ’normal’ states. The ATC inlet valve is closed and the ATC outlet valve is open. In this condition the ATC inlet valve is blocking the pressurized brake fluid (stored in the primary accumulator) from reaching the ATC input of the relay valves . Instead, the open ATC outlet valve connects that line to the unpressurized reservoir return line.

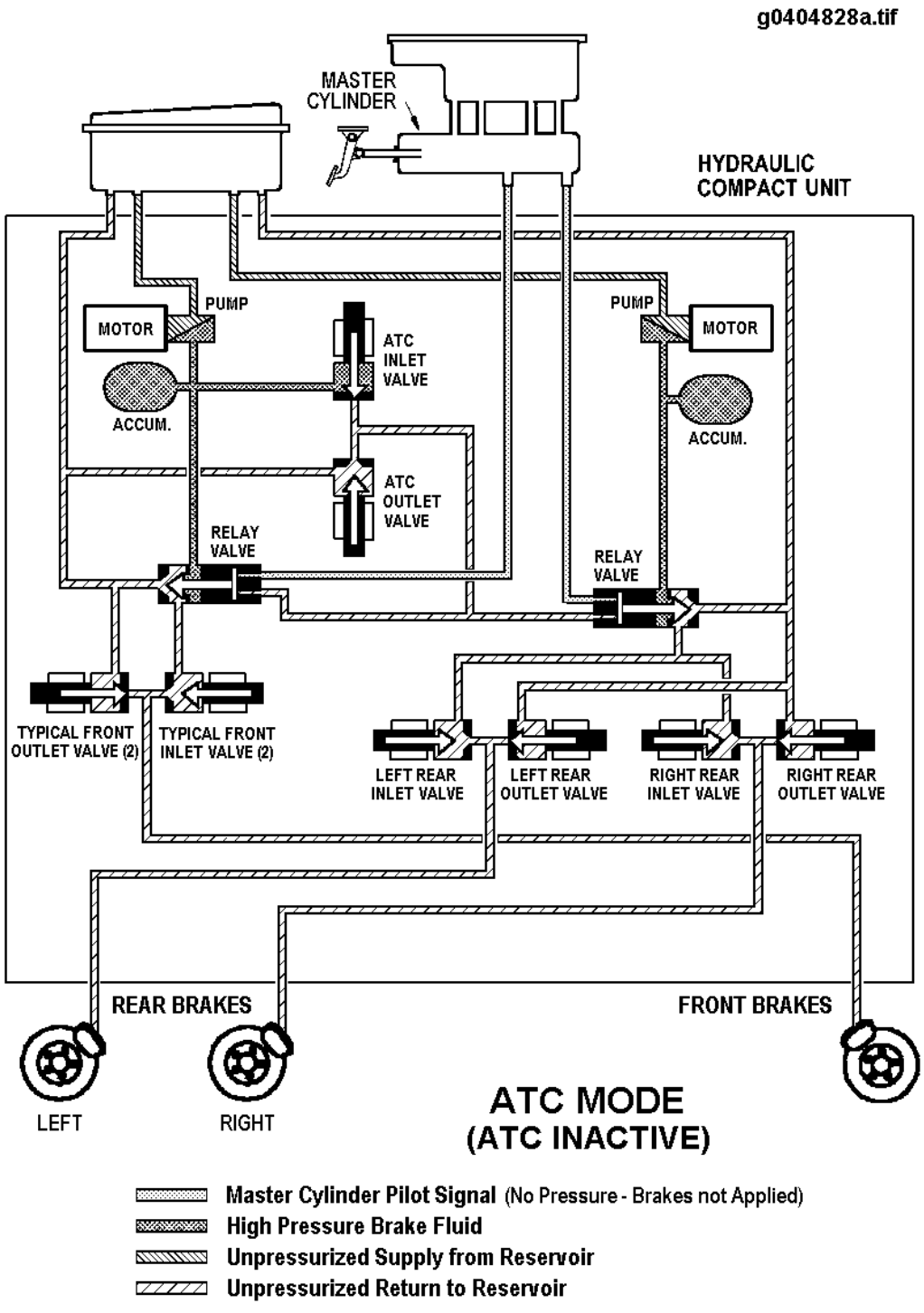

Figure 28 Brake Fluid Routing – ATC Inactive Mode

ATC Active (ATC Circuit Operation while Experiencing an ATC Event)

If the brake pedal is not pressed, and the wheel speed sensors indicate that one or both drive wheels are losing traction, the ECU will activate the ATC circuit. FIGURE 29 shows the hydraulic system while operating in the ATC active mode due to a slipping right rear wheel (vehicle speed is less than 31 mph).

As the right rear wheel begins to lose traction, the signal generated by its wheel speed sensor indicates the slippage to the ECU. When the ATC event is sensed by the ECU, it switches the states of the ATC valves and the ABS inlet and outlet valves to correct the traction problem. With the ATC inlet valve now in the open state, and the ATC outlet valve in the closed state, the pressurized brake fluid is routed from the primary accumulator to the relay valves. The relay valves respond by applying pressurized brake fluid from the accumulator to the ABS inlet valves for the wheels. Because the ECU recognizes that only the right rear wheel is slipping, the ABS inlet valves for the left rear wheel and both front wheels are energized. Meanwhile the ABS inlet and outlet valves for the right rear wheel modulate the brake pressure to that wheel. In this condition pressurized brake fluid is blocked from the other wheel calipers by their energized (closed) inlet valves. The pressurized brake fluid is routed only to the right rear wheel caliper (because of its open inlet valve), where it applies braking force to the slipping wheel. Since the differential tends to drive the wheel that presents the least resistance, applying a braking force to the right rear wheel causes the differential to shift more of the driving force to the left rear wheel. When the ECU no longer senses any wheel slippage, the ATC and ABS valves are returned to their normal positions (see ATC Inactive).

If both drive wheels were losing traction, the ECU would send a J1939 message to the Engine Control Module (ECM) reducing the torque of the engine until the ATC event had ended.

If the ECU determines that the vehicle speed is **above** 31 mph when an ATC event is sensed, it will not activate the ATC valves. Above 31 mph, reducing engine torque (via a J1939 message to the ECM) is the only form of traction control used. No active braking will be done above the 31 mph speed.

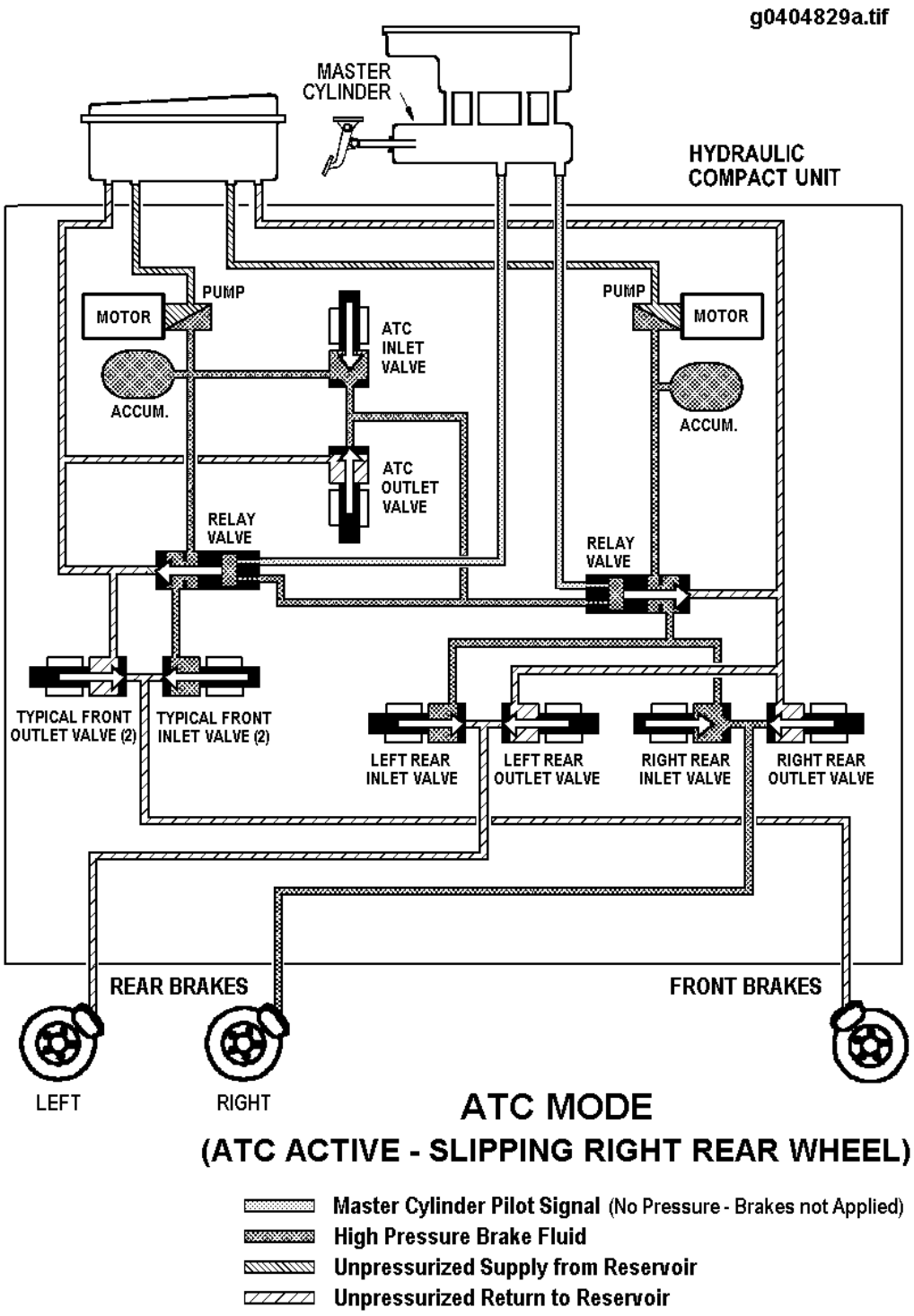

Figure 29 Brake Fluid Routing – ATC Active Mode

3.5. PARK BRAKE OPERATION

The parking brake system employs a cable actuated, drum-style, driveline parking brake (see FIGURE 30). When tension is applied to the brake cable, brake shoes are expanded inside of the drum, effectively locking the drive wheels. When tension is removed from the brake cable, springs retract the brake shoes, releasing the drum and unlocking the drive wheels. Refer to manual S04044 for more complete information on the driveline parking brake drum assembly.

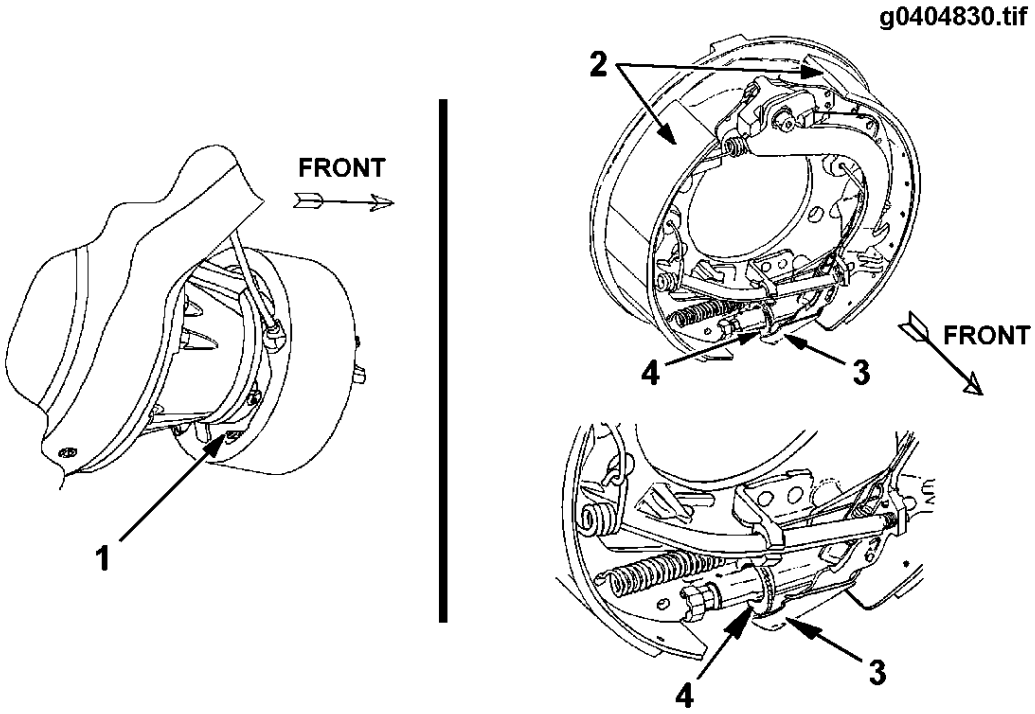

Figure 30 Driveline Parking Brake

1. ADJUSTMENT ACCESS WINDOW (DRUM MOUNTED)
2. BRAKE SHOES (DRUM REMOVED)
3. ADJUSTING LEVER (DRUM REMOVED)
4. STAR WHEEL (DRUM REMOVED)

Powered Parking Brake

The parking brake cable tension is controlled by a Spring Apply Hydraulic Release (SAHR) canister. Refer to FIGURE 31, FIGURE 21 (See Figure 21, page 35), and FIGURE 22 (See Figure 22, page 36). The state of the SAHR canister is hydraulically and electronically controlled by the HCU/ECU. The other components of the powered parking brake system are: the dash switch, the Pressure Supply Valve (PSV), the Cut-Off Valve, and the Travel Switch. Refer to FIGURE 32 (See Figure 32, page 52).

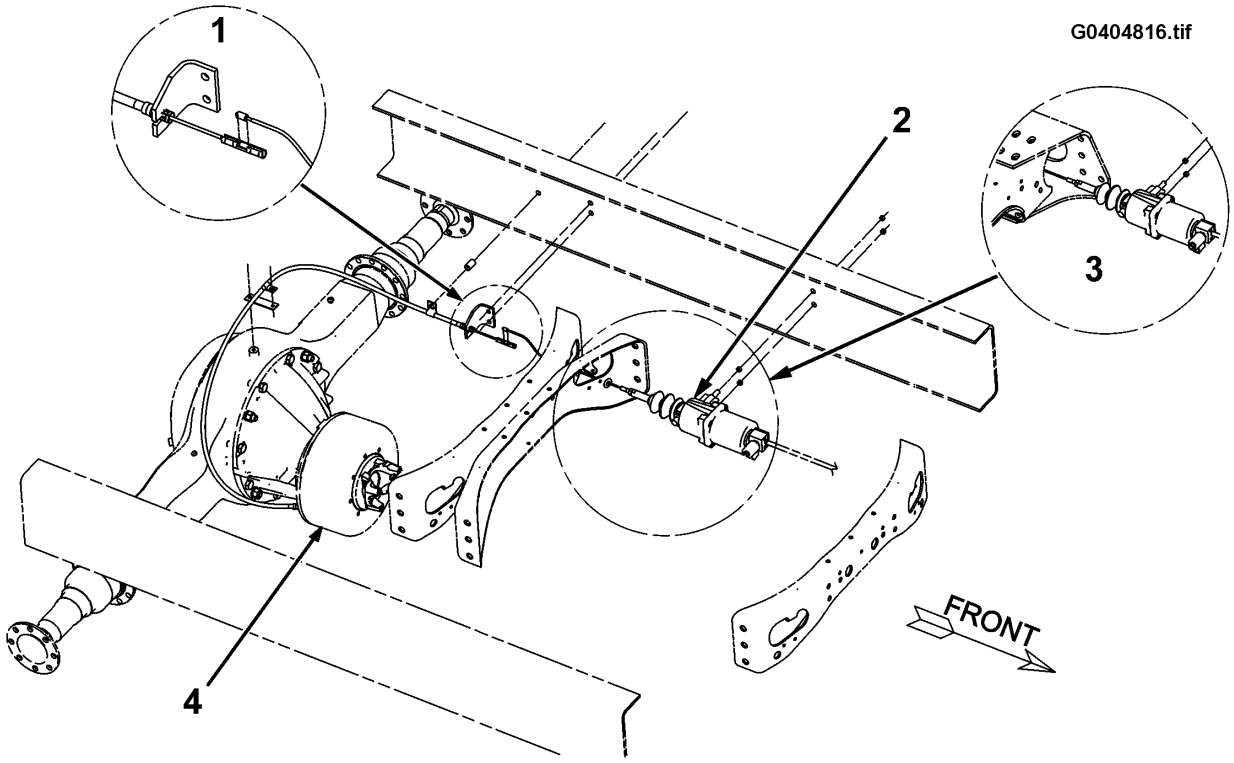

Figure 31 Location of SAHR Canister and Related Components

1. CONNECTION AT BRAKE CABLE UNION
2. SAHR CANISTER
3. CABLE ROUTING WITH ALTERNATE CROSSMEMBER
4. DRIVELINE PARKING BRAKE DRUM

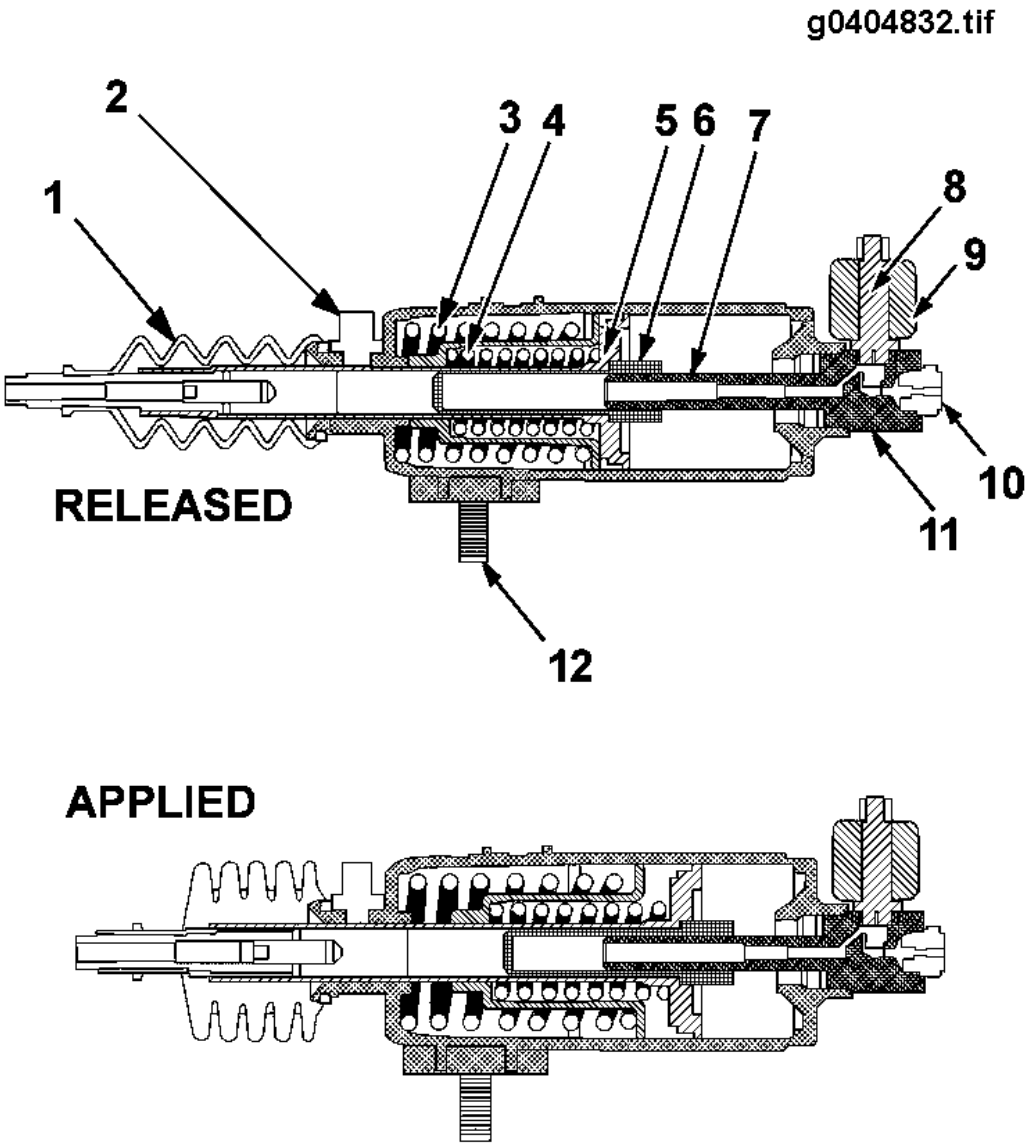

Figure 32 SAHR Canister Components/Operation

1. RUBBER BOOT
2. TRAVEL SWITCH
3. OUTER SPRING
4. INNER SPRING
5. OUTPUT SHAFT END PLATE
6. CYLINDER, PART OF MANIFOLD/CARTRIDGE ASSEMBLY
7. PISTON, PART OF MANIFOLD/CARTRIDGE ASSEMBLY
8. CUT-OFF VALVE CORE, PART OF MANIFOLD/CARTRIDGE ASSEMBLY
9. CUT-OFF VALVE COIL
10. THREAD SAVER FITTING
11. MANIFOLD/CARTRIDGE ASSEMBLY (PISTON/CYLINDER)
12. SAHR MOUNTING STUD

The parking brake dash switch has three switch states (positions): apply (out), neutral (center), and release (in). The switch is spring-loaded to return to the neutral (center) position after either of the other positions is selected. A resistor network in the switch assembly allows the ECU to detect the position of the switch by sensing a change in the resistance value of the switch circuit. The resistor network also allows the ECU to detect malfunctions in the switch circuit.

When the ECU detects the switch 'apply' actuation, it sets both the PSV and the cut-off valve to their non-energized states. When non-energized, the cut-off valve is normally open, and the PSV connects the SAHR brake line to the HCU reservoir (see FIGURE 33). This condition provides an open brake fluid connection between the SAHR canister and the HCU reservoir. With no pressurized fluid at the SAHR canister, the internal springs are used to retract the SAHR shaft, applying tension to the brake cable; which, in turn, applies the parking brake. The travel switch on the SAHR canister is used to indicate the shaft position to the ECU. If the shaft position does not indicate a properly applied parking brake, the ECU will generate a fault code and turn on the SERVICE PARK BRAKE indicator.

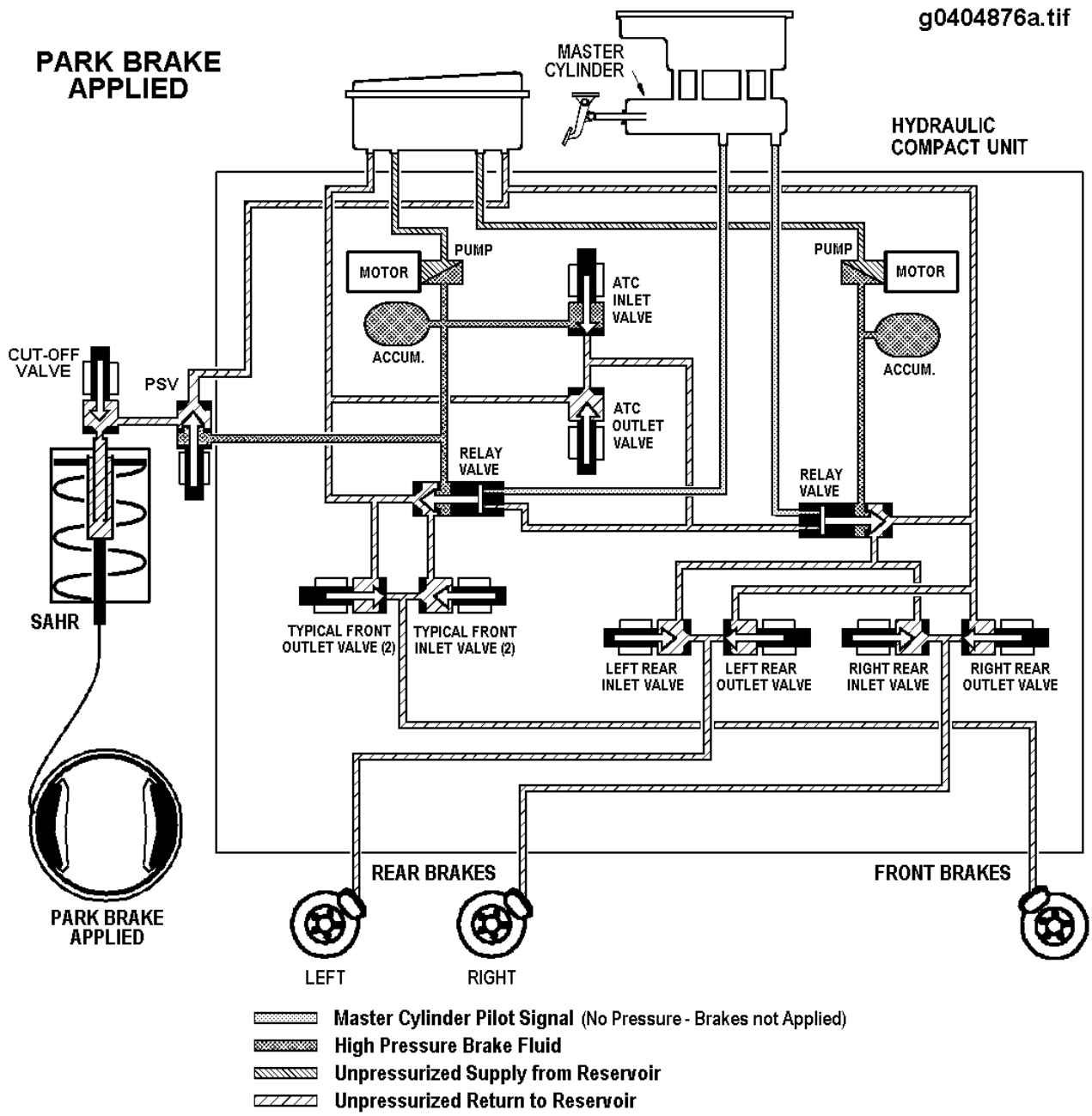

Figure 33 Brake Fluid Routing – Park Brake Applied

When the parking brake is released using the dash switch, the ECU electronically controls the PSV and the cut-off valve as follows. First, the PSV is energized to route brake fluid from the pressurized primary accumulator circuit to the SAHR canister. The cut-off valve remains non-energized (open) long enough for the pressurized brake fluid to overcome the force of the internal springs and extend the SAHR shaft (see FIGURE 34). Once the travel switch indicates that the shaft has extended, the ECU energizes (closes) the cut-off valve, preventing the pressurized brake fluid from leaving the SAHR canister. After a short delay the ECU returns the PSV to its non-energized state so that the parking brake line is again open to the HCU reservoir. This allows the parking brake line to be unpressurized even though the SAHR canister is pressurized (park brake released). Refer to FIGURE 35. With the SAHR shaft extended, the brake cable is no longer under tension

and the parking brake is released. The travel switch on the SAHR canister is used to indicate the shaft position to the ECU. If the shaft position does not indicate a properly released parking brake, the ECU will generate a fault code and turn on the SERVICE PARK BRAKE indicator.

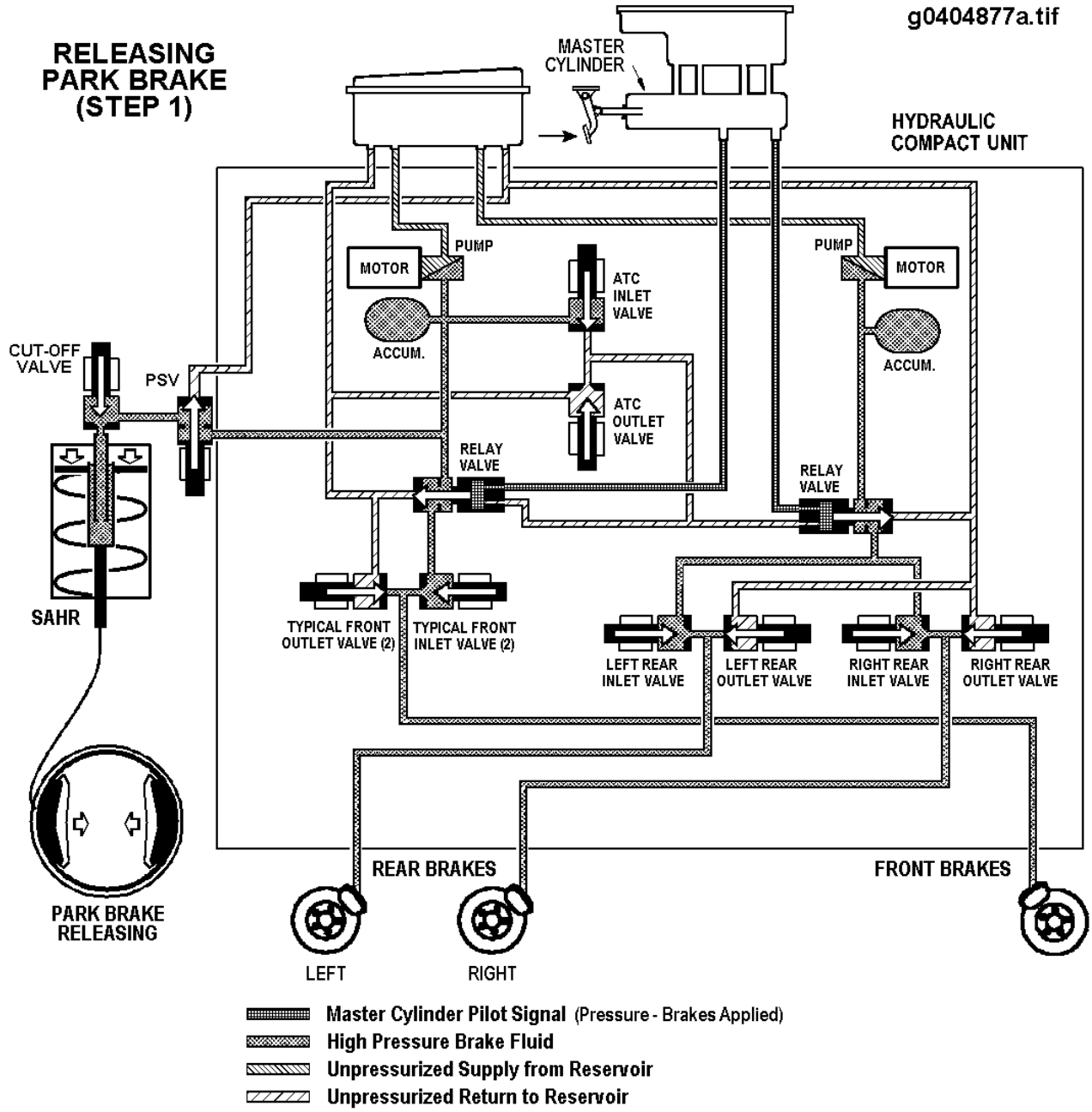

Figure 34 Brake Fluid Routing – Releasing Park Brake (Step 1)

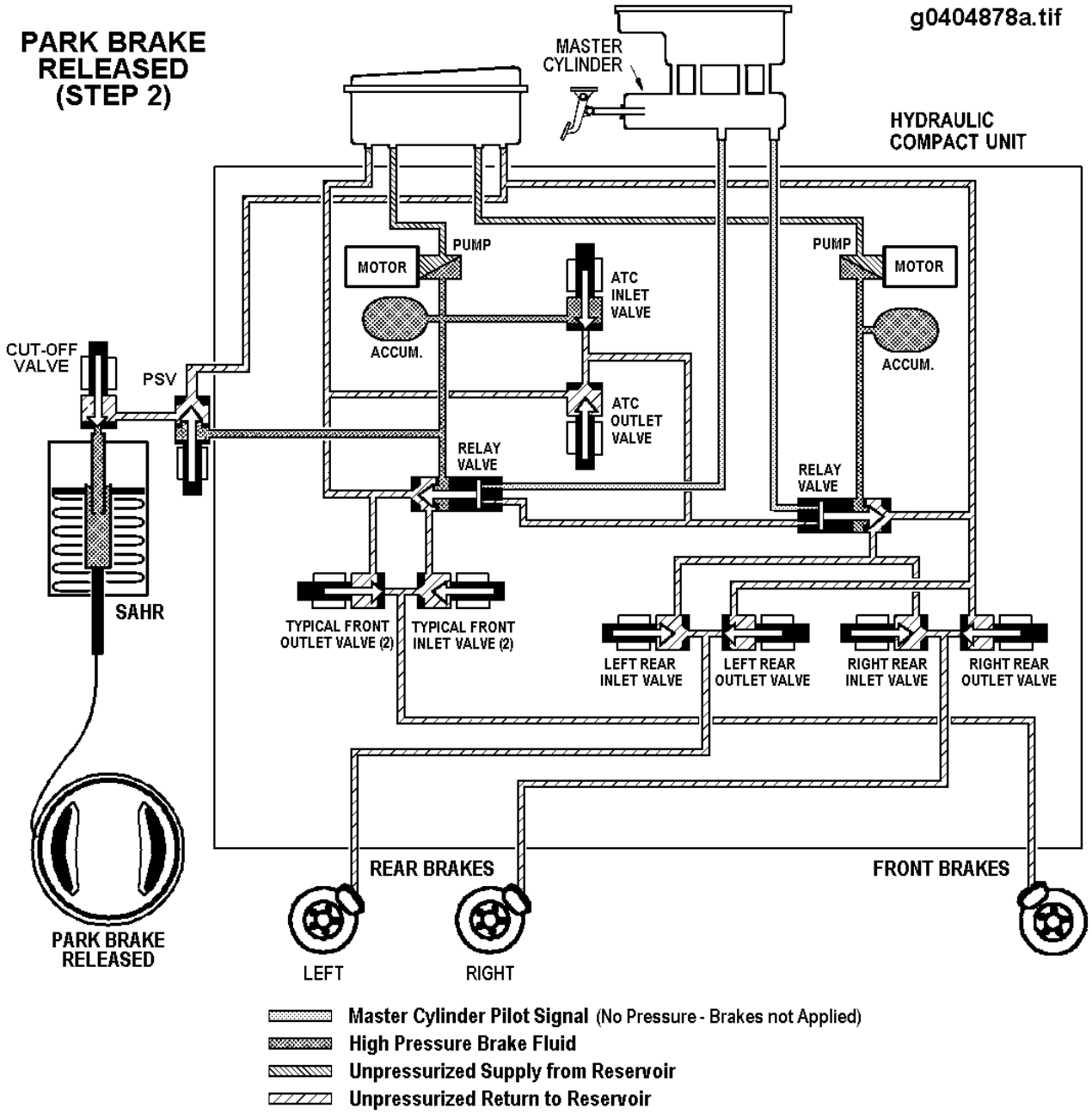

Figure 35 Brake Fluid Routing – Park Brake Released (Step 2)

When the parking brake is in its released state (SAHR canister pressurized), small reductions of pressure may occur over a period of time. To prevent the pressure from dropping far enough to allow a partial parking brake application; the ECU commands the PSV and cut-off valve to repressurize the SAHR canister whenever the travel switch indicates that the SAHR shaft has moved beyond a preset limit. If system leakage requires the SAHR canister to be replenished too frequently, the HCU/ECU will enter the ’backup mode’ and generate a fault code. The ’backup mode’ is described in the following paragraph. In this condition the HCU/ECU will also turn on the SERVICE PARK BRAKE indicator.

The system has a safety function (backup mode) to ensure that the parking brake will not apply unexpectedly if the cut-off valve fails. When the cut-off valve fails it assumes its 'normally open' state. When the ECU detects a cut-off valve failure, it uses the PSV as a backup. To provide pressurization of the SAHR canister (to keep the park brake released), the ECU energizes the PSV. The energized PSV routes pressurized brake fluid from the primary accumulator circuit to the SAHR canister continuously to keep the parking brake in its 'released' state (see FIGURE 36). The parking brake line is pressurized continuously during the backup mode. When the ECU detects the cut-off valve malfunction, it will generate a fault code and turn on the SERVICE PARK BRAKE indicator. The parking brake circuit is placed in the backup mode any time SERVICE PARK BRAKE indicator is turned on.

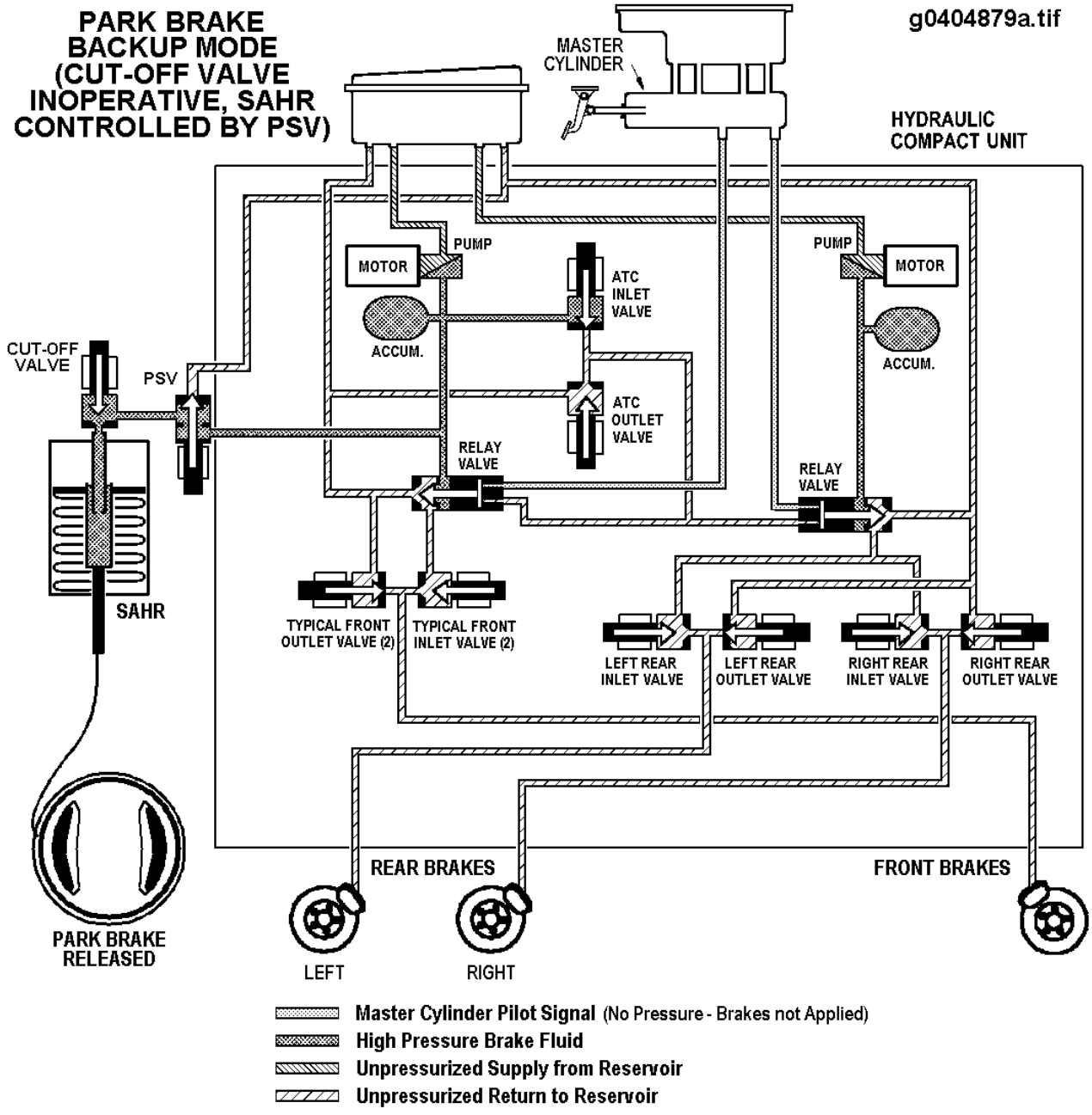

Figure 36 Brake Fluid Routing – Park Brake Backup Mode

A travel switch mounted on the SAHR canister monitors the action of the park brake shaft and cable. The state of this switch is read by the ECU to determine:

- if the parking brake is applied (ECU will send a signal to the ESC/BC requesting it to turn on the PARK BRAKE indicator.)
- if overtravel of the brake cable is occurring (possible worn brake shoes or stretched/broken cable)
- if undertravel of the brake cable is occurring (possible frozen park brake or cable).

The ECU also monitors the status of the park brake switch, and the current flow to the cut-off and pressure supply solenoid valves used to route brake fluid between the HCU and the SAHR canister. If any fault condition is detected, the ECU will send a signal to the ESC/BC requesting it to turn on the SERVICE PARK BRAKE indicator, and place the park brake circuit in the backup mode. In addition, a diagnostic code will be generated by the ECU and stored in memory. Retrieval of the diagnostic codes is explained in Section 5, DIAGNOSIS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

DYNAMIC PARKING BRAKE FUNCTION

This function is controlled by the ECU. The ECU is constantly monitoring vehicle speed. If it detects a parking brake apply signal while vehicle speed is above 2 mph, it uses the ATC and ABS valves to apply the rear service brakes. In addition, the ECU signals the ESC/BC to turn on the vehicle's brake lights. After the vehicle has come to a safe stop, the driveline parking brake is applied as described above.

PARKING BRAKE SAFETY INTERLOCKS

The parking brake apply/release input signal to the ECU is normally provided by the dash mounted park brake switch as described above. However, because the HCU/ECU is electronically controlled, various interlocks can be used to control the parking brake and even override the park brake switch. The following interlock functions are used to verify that safe conditions exist before allowing the parking brake to be applied or released.

- When the park brake is applied, driver cannot “drive” against the park brake. When the parking brake is applied the ECU sends a J1939 message to the engine control module to reduce engine torque.
- The parking brake applies automatically when the key is turned off and the vehicle is stopped. If the key is turned off while the vehicle is moving (more than 2 mph), the park brake is prevented from coming on. The ECU electronically monitors the vehicle speed and the position of the ignition key; and will apply the parking brake only when the correct conditions exist.
- The parking brake is released when the dash switch is pressed, ONLY when all of the following conditions are met. The ECU detects these conditions electronically and responds to the dash switch only when the correct conditions exist.
  - — The foot brake must be applied.
  - — The ignition key must be in the “On” position.
  - — There must be no major brake system faults.
  - — The transmission shifter must be in a position other than P or PB.

4. SYSTEM MAINTENANCE

IMPORTANT – The vehicles covered in this manual have used two different electrical controllers. Both controllers are mounted in the same location. The original controller was known as the Electrical System Controller (ESC). The current controller is known as the Body Controller (BC). In this manual the controller will be identified as the Body Controller or the ESC/BC.

This section contains general maintenance information and procedures. There is no regularly scheduled maintenance required for the Full Power Brake system.

During bleeding, special tools may be required. Because the Master Cylinder (MC) system is isolated from the wheel caliper system, brake pedal feel does not indicate properly bled brakes. Air can still exists in the lines between the HCU and the calipers. Insure that ALL NECESSARY bleeding procedures have been properly performed after any repairs that require disconnecting brake lines. If lines are disconnected in both the MC circuit and the wheel caliper circuits; then, both bleeding procedures must be performed. If the SAHR (parking brake) circuit is opened, the SAHR bleed procedure must be performed. If the HCU is removed or replaced, all three bleed procedures must be performed.

WARNING – When working around or under the vehicle, block the wheels to prevent the vehicle from moving. When raising the vehicle, support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Failure to follow this warning could result in property damage, personal injury or death.

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 property damage, personal injury or death.

WARNING – Brake pedal feel does not necessarily indicate properly bled brakes. Brake pedal can feel firm or "normal" if properly bled between the master cylinder reservoir and the HCU; and air can still exists between the HCU and the brake calipers. Failure to correctly bleed the system could cause reduced braking or loss of braking; which may result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the HPB system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact nor air being blown into the hydraulic ports prior to assembly to the vehicle.

NOTE – The brake system ECU may set fault codes any time the battery is disconnected. After completing repairs and reconnecting the battery, clear the fault codes stored in the ECU memory using the TOOLBOX™ program installed on the EZ-TECH® service tool.

NOTE – The vehicle ESC/BC may set fault codes any time the battery is disconnected. After completing repairs and reconnecting the battery, clear the fault codes stored by the ESC/BC using the Diamond Logic Builder™ program installed on the EZ-TECH® service tool.

NOTE – To determine the correct operation of the system, it may be necessary to identify the ECU version number. The ECU version may be identified using the TOOLBOX™ program installed on the EZ-TECH® service tool.

SERVICE PROCEDURES

After completing any repair or service procedure, use the EZ-TECH® and the TOOLBOX™ program to clear all brake system related inactive fault codes. (Codes may be set while disconnecting and reconnecting power to the system.) If active fault codes are indicated after making repairs, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition. Perform a brief after-service check based on the service performed. Check the operation of indicators and exercise any circuits or components that were repaired or replaced. A brief test drive should be performed after most repairs.

When working on or around a vehicle, the following general precautions should be observed.

A. Perform service inside a warm, well ventilated dry shop.

B. When working on the brake system keep the work area and tools as clean as possible. Also, clean all connections, ports or fittings before disconnecting or removing components. 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.

C. Cover all electrical connectors near the bleeder screws carefully to ensure that no brake fluid enters the terminals or plugs.

D. All brake system components and brake line openings should be immediately plugged during removal and remain so until installation to prevent the entry of dirt, moisture and other foreign material.

E. Never remove protective caps from components until the moment of assembly into the system.

F. Never install non-sealed components.

G. All brake line support clamps and strap locks must be reinstalled in their original positions.

H. All fittings must be tightened as specified in the TORQUE CHART (See TORQUE CHART, page 154). Use only a torque wrench known to be accurate.

I. Whenever possible use a backup wrench when loosening or tightening fittings.

J. Brake fluid quickly absorbs moisture. Keep brake fluid containers closed until ready to use. Close brake fluid container immediately after use.

K. During the bleeding procedures, never allow the brake fluid in the master cylinder reservoir to drop below the MIN mark.

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

4.1. PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM

IMPORTANT – During bleeding procedures, brake fluid level must not be allowed to fall below the MIN mark on the Master Cylinder (MC) reservoir. The MC reservoir should be regularly checked and filled to the MAX mark with new DOT 3 or DOT 4 brake fluid. Failure to keep the brake reservoir level above the MIN mark could result in more air entering the system, making it impossible to effectively bleed the system.

IMPORTANT – Do not add fluid above the MAX mark. When the system is depressurized during service, fluid stored in the accumulators is returned to the MC reservoir. If the reservoir is filled above the MAX mark a fluid spill could occur when these conditions exists.

IMPORTANT – Each bleeding procedure may be performed as a standalone procedure or in conjunction with installation or other bleeding procedures. In this section, the bleeding procedures are provided as standalone procedures including all of the necessary preparation steps. When a bleed procedure is referenced from another procedure, it is not necessary to repeat preparation steps that are duplicated.

Pressure bleeding is REQUIRED to properly bleed the Full Power Brake system. It requires the use of a pressure bleeder kit, a regulated, clean pressure source with gauge, tubing and adapter. Pressure bleeder kits are available from a number of manufacturers and include instructions for use. Do not attempt to use a vacuum bleeder on this system.

Required bleed equipment:

- One clean graduated glass or plastic bottle/receptacle. #
- One rubber/plastic bleed hose (preferably transparent). #
- Suitable crow's foot adapters for torque wrench (bleeder screws and brake lines).
- Pressurized fill and bleed equipment. Either of the following three types may be used:
  - — Fluid over fluid. Provides brake fluid (under pressure) from an external tank to the Master Cylinder (MC) reservoir. Regulated shop air may be used as the pressure source.
  - — Air over fluid. Pressurizes the master cylinder reservoir with clean, dry, regulated shop air. Air regulator/filter ZTSE4757-1, or equivalent, is required.
  - — Air over fluid. Pressurizes the master cylinder reservoir with regulated dry nitrogen.
- One MC reservoir cap adapter (International Service Tool – ZTSE4678).
- A sufficient supply of new DOT 3 or DOT 4 brake fluid from a sealed container.

(must be impervious to the effects of brake fluid).

Master Cylinder (MC) Circuit Bleeding Procedure

IMPORTANT – If the parking brake (SAHR) circuit is to be bled as part of this service, the parking brake cable must be disconnected. If the SAHR canister is operable, this should be done before depressurizing the brake system. Refer to SAHR POWERED PARKING BRAKE CIRCUIT BLEEDING PROCEDURE (See SAHR Parking Brake Circuit Bleeding Procedure, page 69) for instructions on disconnecting the cable. After the cable is disconnected, return to this point and complete all other bleeding procedures before performing the parking brake bleed procedure.

1. Install wheel chocks.

2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl (refer to FIGURE 37).

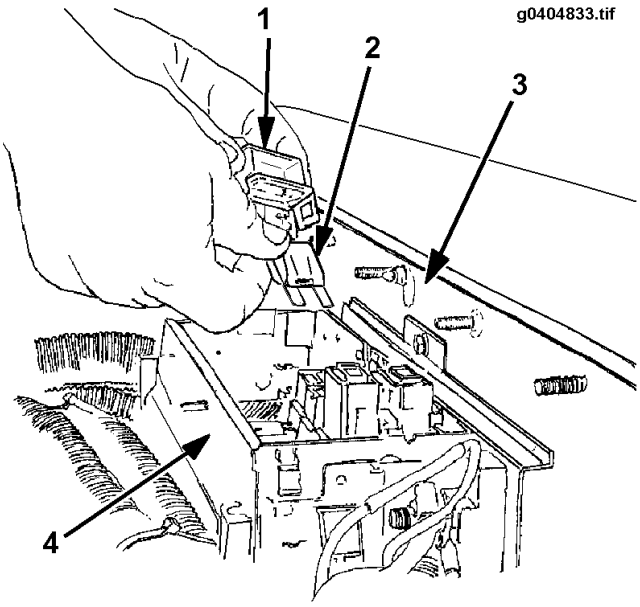

Figure 37 Location of Motor Fuses In Engine Compartment

1. FUSE COVER
2. FUSE
3. COWL
4. FUSE PANEL

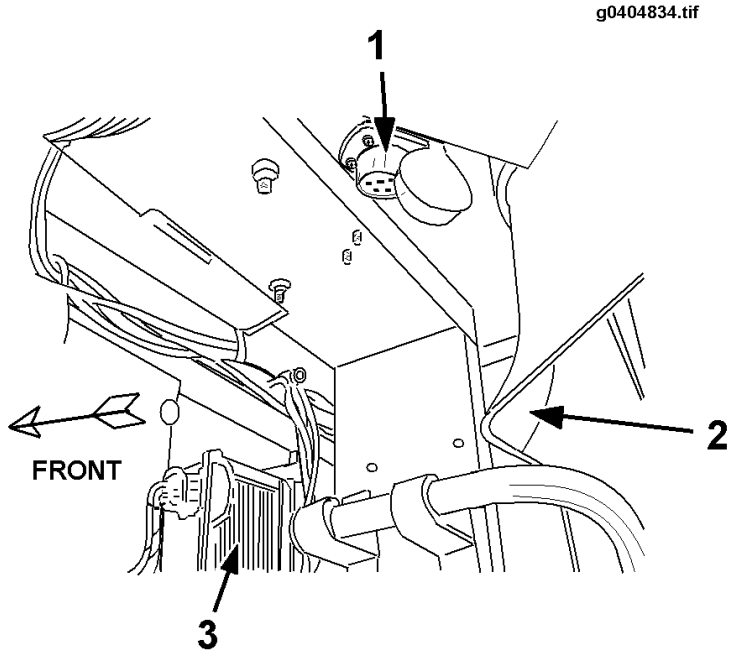

Figure 38 Location of Diagnostic Connector

1. DIAGNOSTIC CONNECTOR
2. DASH TRIM PANEL
3. ELECTRICAL SYSTEM CONTROLLER / BODY CONTROLLER (ESC/BC)

3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 38. Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

4. Verify that the brake fluid level in the MC reservoir is at the MAX mark.

5. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

6. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

7. Prepare the pressure bleeder according to the instructions provided with the equipment.
   - If a fluid bleeder system is used, fill the pressure bleeder with new specified brake fluid from a sealed container.
   - If an air bleeder system is used, **the fluid level in the MC reservoir must be monitored** to ensure that the level never drops below the MIN mark during the bleed procedure. A typical air-over-fluid bleeder setup using service tools ZTSE4757-1 and ZTSE4678 is shown in FIGURE 39.

8. Install the service tool adapter (ZTSE4678) between the bleed equipment and the MC reservoir filler neck. Ensure that the adapter is securely tightened onto the MC reservoir filler neck.

9. Apply 2.4 bar (35 PSI) pressure on the MC reservoir with the bleeding equipment.

10. Fit bleeder hose onto one relay valve bleeder screw located on the HCU. Refer to FIGURE 40. (NOTE: Both MC circuits can be bled at the same time by connecting two bleeder bottles.)

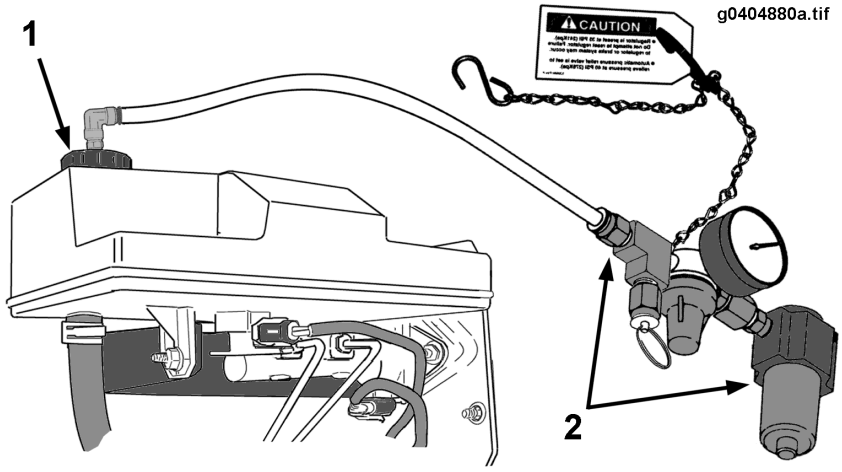

Figure 39 Typical Air-Over-Fluid Bleeder Setup

1. SERVICE TOOL ADAPTER (ZTSE4678)
2. AIR REGULATOR/FILTER (ZTSE4757-1)

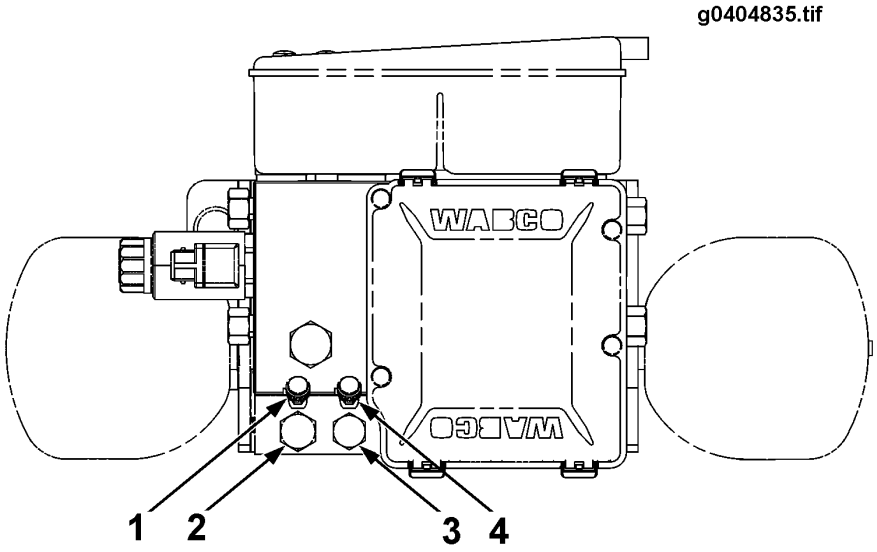

Figure 40 Bleeder Screws on HCU

1. BLEEDER PORT – PRIMARY MC CIRCUIT
2. MC INPUT PORT – PRIMARY CIRCUIT
3. MC INPUT PORT – SECONDARY CIRCUIT
4. BLEEDER PORT – SECONDARY MC CIRCUIT

11. Submerge free end of bleeder hose into the bleed bottle. (Note the fluid level in the bottle before starting.)

12. Open the 7 mm bleeder screw until the fluid begins to flow (about 3/4 turn). After draining 250 cc (8.5 oz) of fluid, check the stream for air bubbles. When no further air bubbles enter the bleed bottle, close the bleeder screw.

13. Remove the bleeder hose and torque the bleeder screw to 4 to 4.5 Nm (35.4 to 39.8 Lbf-in).

14. If only one MC circuit was bled, repeat the previous four steps with the second bleeder screw.

15. If the wheel calipers are to be bled, refer to the BRAKE CALIPER CIRCUIT BLEEDING PROCEDURE (See Brake Caliper Circuit Bleeding Procedure, page 66).

16. If the SAHR canister circuit is to be bled, refer to the SAHR CANISTER CIRCUIT BLEEDING PROCEDURE (See SAHR Parking Brake Circuit Bleeding Procedure, page 69).

17. If no further bleeding procedures are to be performed, connect the battery and install the two pump motor fuses.

18. Switch ON the ignition. HCU pump motors will start up automatically and fill the accumulators (running time approximately 45 seconds).*

19. Release pressure from the MC reservoir via the bleed equipment. Disconnect bleed equipment from MC reservoir filler neck and install the MC reservoir cap.

20. Fill (or drain) the MC reservoir to the MAX mark. Use new DOT 3 or DOT 4 brake fluid from a sealed container if filling.

21. Verify that the MC reservoir cap is installed.

22. If you were referred to this procedure from an installation procedure, return to the original procedure now; otherwise, proceed to the next step.

23. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76) to make the necessary repairs.

24. Set the ignition key to OFF and disconnect the EZ-TECH® from the diagnostic connector.

25. Remove wheel chocks.

* If 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. HCU pump motors should stop within 3 minutes, with brake warning light and buzzer OFF. If that is not the case (one or both pumps do not prime), refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76) to make the necessary repairs.

Brake Caliper Circuit Bleeding Procedure

1. Install wheel chocks.

2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 37 (See Figure 37, page 63).

3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 38 (See Figure 38, page 63). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

4. Verify that the brake fluid level in the MC reservoir is at the MAX mark.

5. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

6. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

7. Prepare the pressure bleeder according to the instructions provided with the equipment.
   - If a fluid bleeder system is used, fill the pressure bleeder with new specified brake fluid from a sealed container.
   - If an air bleeder system is used, **the fluid level in the MC reservoir must be monitored** to ensure that the level never drops below the MIN mark during the bleed procedure. A typical air-over-fluid bleeder setup is shown in FIGURE 39.

8. Install the service tool adapter (ZTSE4678) between the bleed equipment and the MC reservoir filler neck. Ensure that the adapter is securely tightened onto the MC reservoir filler neck.

9. Apply 2.4 bar (35 PSI) pressure on the MC reservoir with the bleeding equipment.

NOTE – If all wheel ends are being bled, they should be bled in the following order: right rear, left rear, right front, left front.

10. Fit bleeder hose onto the caliper bleeder screw at the first wheel end.

11. Submerge free end of bleeder hose into the bleed bottle. (Note the fluid level in the bottle before starting.)

12. Open the bleeder screw until the fluid begins to flow (about 3/4 turn). Refer to FIGURE 41. After draining 250 cc (8.5 oz) of fluid, check the stream for air bubbles. When no further air bubbles enter the bleed bottle, close the bleeder screw.

13. Remove the bleeder hose and torque the bleeder screw to 12 to 16 Nm (8.6 to 11.5 Lbf-ft).

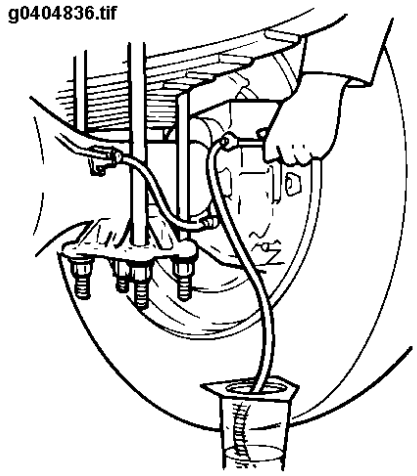

Figure 41 Typical Caliper Bleeding Setup

14. Repeat steps 10 through 13 for the other calipers being bled.

15. If other bleeding procedures are to be performed, proceed to those procedures at this time. If no further bleeding procedures are to be performed, proceed to the next step.

16. Connect the battery and install the two pump motor fuses.

17. Switch ON the ignition. HCU pump motors will start up automatically and fill the accumulators (running time approximately 45 seconds).*

18. Using the EZ-TECH® and the TOOLBOX™ program, select the DEPLETE ACCUMULATORS function from the EOL pull down menu. This function helps clear air from the system by depressurizing and repressurizing both accumulators. A dialog box will indicate when the function is complete.

19. Release pressure from the MC reservoir via the bleed equipment. Disconnect bleed equipment from MC reservoir filler neck and install the MC reservoir cap.

20. Run the DEPLETE ACCUMULATORS function again by selecting DEPLETE ACCUMULATORS from the EOL pull down menu.

21. When the DEPLETE ACCUMULATORS function has completed, fill (or drain) the MC reservoir to the MAX mark. Use new DOT 3 or DOT 4 brake fluid from a sealed container if filling.

22. Verify that the MC reservoir cap is installed.

23. If you were referred to this procedure from an installation procedure, return to the original procedure now; otherwise, proceed to the next step.

24. Using the EZ-TECH® and the TOOLBOX™ program, clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76) to make the necessary repairs.

25. Set the ignition key to OFF and disconnect the EZ-TECH® from the diagnostic connector.

26. Remove wheel chocks.

* If 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. HCU pump motors should stop within 3 minutes, with brake warning light and buzzer OFF. If that is not the case (one or both pumps do not prime), performing the DEPLETE ACCUMULATORS function in the following steps should correct the problem. After completing the DEPLETE ACCUMULATORS function, both accumulators should be fully charged as indicated on the TOOLBOX™ screen. If an accumulator is still not charging correctly refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76) to make the necessary repairs.

SAHR Parking Brake Circuit Bleeding Procedure

Before bleeding the SAHR circuit, the parking brake cable must be disconnected from the SAHR canister. This ensures that the SAHR piston achieves the full stroke and forces most of the fluid volume out of the SAHR canister, thus moving any trapped air into the bleeder screw area.

> **CAUTION – While removing a 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. Disconnect the parking brake cable. Refer to FIGURE 42.

   - If the parking brake system is **inoperable**, disconnect the cable as follows:

     A. Install wheel chocks, place the transmission in P, PB or N, and turn the key to OFF.

     B. 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.

     C. 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.

   - If the parking brake system is **operable**, disconnect the cable as follows:

     A. Install wheel chocks, place the transmission in neutral (N), **not** Park (P and PB), and turn the key ON.

     B. While pressing the brake pedal, press the dash mounted PARK BRAKE switch to release the parking brake. This will extend the SAHR canister shaft and relieve the tension on the parking brake cable.

     C. 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.

     D. 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.

     E. Turn the key to OFF.

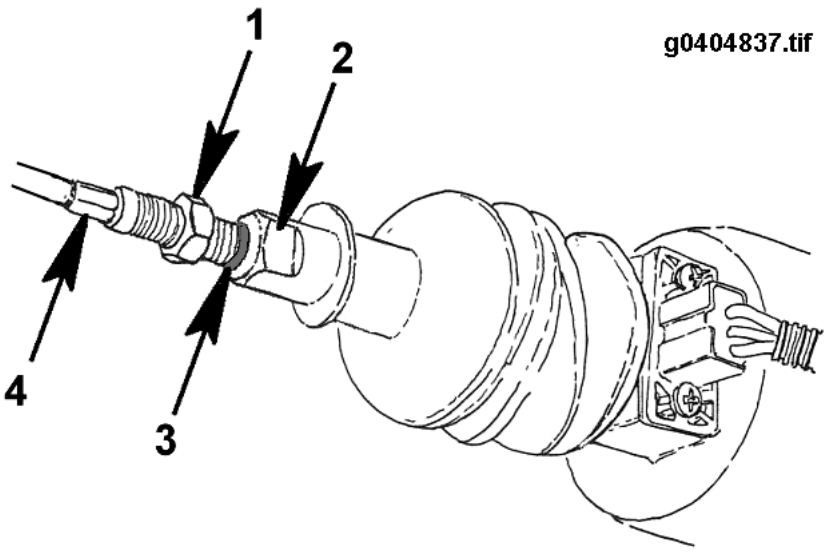

Figure 42 Park Brake Cable Connection to SAHR Canister

1. 16mm JAM NUT
2. SAHR CANISTER SHAFT 15mm
3. ADJUSTMENT INDICATOR, 'HASH' MARK
4. THREADED ROD 8mm

2. Verify that the key is OFF, and place the transmission in either the P, PB or N position.

3. Remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 37 (See Figure 37, page 63).

4. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 38 (See Figure 38, page 63). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

5. Verify that the brake fluid level in the MC reservoir is at the MAX mark.

6. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

7. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

8. Prepare the pressure bleeder according to the instructions provided with the equipment.

- If a fluid bleeder system is used, fill the pressure bleeder with new specified brake fluid from a sealed container.
- If an air bleeder system is used, **the fluid level in the MC reservoir must be monitored** to ensure that the level never drops below the MIN mark during the bleed procedure. A typical air-over-fluid bleeder setup is shown in FIGURE 39.

9. Install the service tool adapter (ZTSE4678) between the bleed equipment and the MC reservoir filler neck. Ensure that the adapter is securely tightened onto the MC reservoir filler neck.

10. Apply 2.4 bar (35 PSI) pressure on the MC reservoir with the bleeding equipment.

11. Fit bleeder hose onto the bleeder screw on the SAHR canister manifold. Refer to FIGURE 43. Submerge free end of bleeder hose into the bleed bottle. (Note the fluid level in the bottle before starting.)

12. Open the bleeder screw until the fluid begins to flow (about 3/4 turn). After draining 250 cc (8.5 oz) of fluid, check the stream for air bubbles. When no further air bubbles enter the bleed bottle, close the bleeder screw.

13. Remove the bleeder hose and torque the bleeder screw to 12 to 16 Nm (8.6 to 11.5 Lbf-ft).

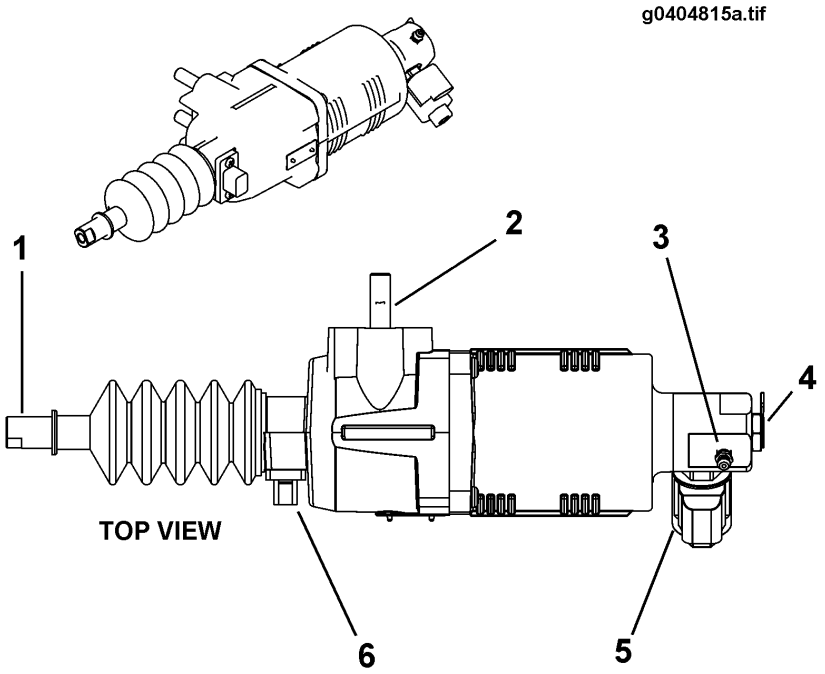

Figure 43 Location of SAHR Bleeder Screw

1. OUTPUT SHAFT
2. MOUNTING STUDS
3. BLEED PORT
4. BRAKE FLUID PORT
5. CUT-OFF SOLENOID VALVE
6. TRAVEL SWITCH

14. Connect the battery and install the two pump motor fuses.

15. Switch ON the ignition. HCU pump motors will start up automatically and fill the accumulators (running time approximately 45 seconds).*

16. Using the EZ-TECH® and the TOOLBOX™ program, select the DEPLETE ACCUMULATORS function from the EOL pull down menu. This function helps clear air from the system by depressurizing and repressurizing both accumulators. A dialog box will indicate when the function is complete.

17. Release pressure from the MC reservoir via the bleed equipment. Disconnect bleed equipment from MC reservoir filler neck and install the MC reservoir cap.

18. Using the EZ-TECH® and the TOOLBOX™ program, deplete the accumulators again by selecting the DEPLETE ACCUMULATORS function from the EOL pull down menu.

19. When the DEPLETE ACCUMULATORS function has completed, fill (or drain) the MC reservoir to the MAX mark. Use new DOT 3 or DOT 4 brake fluid from a sealed container if filling.

20. Verify that the MC reservoir cap is installed.

CAUTION – Before installing a parking brake cable, inspect the cable strands where visible. If the strands are damaged or starting to unwind, replace the cable.

CAUTION – While installing a parking brake cable, only the threaded rod should rotate. Do not allow the cable to twist during installation.

21. Connect the parking brake cable to the SAHR canister as follows:

    A. Place the transmission in neutral (N), **not** Park (P or PB), and turn the key ON.

    B. While pressing the brake pedal, press the dash mounted PARK BRAKE switch to release the parking brake. This should extend the SAHR canister shaft to allow easier connection of the parking brake cable.

        a. If the SAHR shaft is extended, proceed to step 21E.

        b. If the SAHR shaft is NOT extended, proceed to the following step.

    C. Connect the EZ-TECH® to the diagnostic connector and open the TOOLBOX™ program.

    D. Use TOOLBOX to release the parking brake (use the ‘Component Tests’ menu). Releasing the parking brake pressurizes the SAHR canister and extends the canister shaft.

    E. Lubricate the threaded rod end of the parking brake cable by placing a small amount of grease at the point where the threaded rod contacts the ’ball’ at the end of the inner cable (FIGURE 44). This will prevent the inner cable from twisting when the threaded rod is turned.

    F. Screw the threaded rod end of the cable into the SAHR canister shaft. While using a 15 mm wrench to hold the shaft, use an 8 mm wrench to continue threading the rod into the shaft until the ’hash’ mark on the threaded rod is flush with the end of the shaft. Refer to FIGURE 42.

    G. While using the 15 mm wrench to hold the SAHR canister shaft, use a 16 mm wrench to tighten the threaded rod jam nut against the end of the shaft.

22. Set the transmission to either the P or PB position (if available) and turn the key OFF. Verify that the parking brake applies.

23. If you were referred to this procedure from an installation procedure, return to the original procedure now; otherwise, proceed to the next step.

24. Set the ignition key to ON. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

25. Set the ignition key to OFF and disconnect the EZ-TECH® from the diagnostic connector.

26. Remove the wheel chocks.

* If 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. HCU pump motors should stop within 3 minutes, with brake warning light and buzzer OFF. If that is not the case (one or both pumps do not prime), performing the DEPLETE ACCUMULATORS function in the following steps should correct the problem. After completing the DEPLETE ACCUMULATORS function, both accumulators should be fully charged as indicated on the TOOLBOX™ screen. If an accumulator is still not charging correctly refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76) to make the necessary repairs.

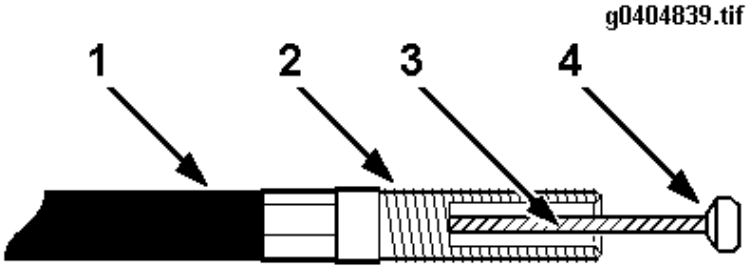

Figure 44 Parking Brake Cable Lubrication Point

1. PARKING BRAKE CABLE SHEATH
2. THREADED ROD
3. INNER CABLE
4. LUBRICATE ON THIS SIDE OF CABLE END BALL

4.2. WHEEL SPEED SENSOR ADJUSTMENT

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. Refer to FIGURE 45.

To adjust the sensor, push the sensor in until it contacts the tooth ring:

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

NOTE – No gap is allowable at installation. During normal operation a gap not to exceed 1.02 mm (0.04 inch) is allowable.

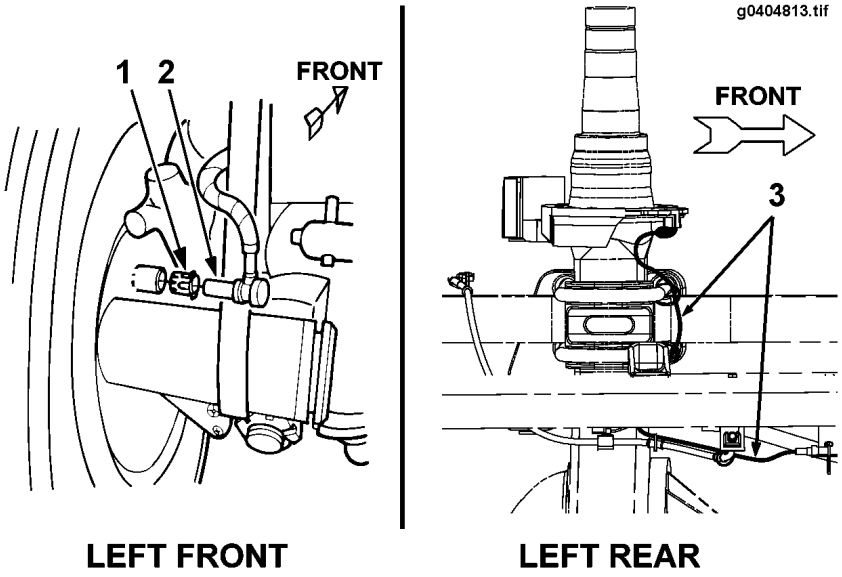

Figure 45 Typical Wheel Speed Sensor Locations

1. FRONT SENSOR BUSHING
2. FRONT SENSOR
3. REAR SENSOR CABLE

4.3. PARKING BRAKE CABLE RELEASE PROCEDURE

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.

In the event that the parking brake cable must be disconnected to allow the vehicle to be safely towed, perform the following steps. Refer to FIGURE 42 (See Figure 42, page 70).

1. If the parking brake system is **inoperable**, disconnect the cable as follows:
   a. Install wheel chocks, place the transmission in P, PB or N, and turn the key to OFF.
   b. 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.
   c. 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.
2. If the parking brake system is **operable**, disconnect the cable as follows:
   a. Install wheel chocks, place the transmission in neutral (N), **not** P or PB, and turn the key ON.
   b. While pressing the brake pedal, press the dash mounted PARK BRAKE switch to release the parking brake. This will extend the SAHR canister shaft and relieve the tension on the parking brake cable.

c. 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.

d. 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.

e. Turn the key to OFF.

3. Remove wheel chocks.

4.4. PARKING BRAKE CABLE CONNECT PROCEDURE

CAUTION – Before installing a parking brake cable, inspect the cable strands where visible. If the strands are damaged or starting to unwind, replace the cable.

CAUTION – While connecting the parking brake cable, only the threaded rod should rotate. Do not allow the cable to twist during installation.

To reconnect the parking brake cable after servicing the vehicle, perform the following steps. Refer to FIGURE 42 (See Figure 42, page 70).

1. Install wheel chocks.

2. Place the transmission in neutral (N), **not** P or PB, and turn the key ON.

3. While pressing the brake pedal, press the dash mounted PARK BRAKE switch to release the parking brake. This should extend the SAHR canister shaft to allow easier connection of the parking brake cable.

    A. If the SAHR shaft is extended, proceed to step 6.

    B. If the SAHR shaft is NOT extended, proceed to the following step.

4. Connect the EZ-TECH® to the diagnostic connector and open the TOOLBOX™ program.

5. Use TOOLBOX to release the parking brake (use the ‘Component Tests’ menu). Releasing the parking brake pressurizes the SAHR canister and extends the canister shaft.

6. Lubricate the threaded rod end of the parking brake cable by placing a small amount of grease at the point where the threaded rod contacts the ’ball’ at the end of the inner cable (FIGURE 44). This will prevent the inner cable from twisting when the threaded rod is turned.

7. Screw the threaded rod end of the cable into the SAHR canister shaft. While using a 15 mm wrench to hold the shaft, use an 8 mm wrench to continue threading the rod into the shaft until the ’hash’ mark on the threaded rod is flush with the end of the shaft. Refer to FIGURE 42.

8. While using the 15 mm wrench to hold the SAHR canister shaft, use a 16 mm wrench to tighten the threaded rod jam nut against the end of the shaft.

9. Set the transmission to the Park (P or PB) position (if available). On manual transmission vehicles apply the parking brake using the dash switch.

10. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

11. Set the ignition key to OFF and disconnect the EZ-TECH® from the diagnostic connector.

12. Remove the wheel chocks.

5. DIAGNOSTICS AND TROUBLESHOOTING

WARNING – When working around or under the vehicle, block the wheels to prevent the vehicle from moving. When raising the vehicle, support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Failure to follow this warning could result in property damage, personal injury or death.

NOTE – The diagnostic system in the ECU is sensitive to over and under voltage conditions that could be experienced during some service procedures (replacement of battery, jump starting). Fault codes may be set due to these conditions, and may not indicate a true fault. Codes generated during service must be cleared before placing the system back into service.

NOTE – To display operational information: the EZ-TECH® service tool must be connected to the vehicle; the TOOLBOX™ diagnostic program must be running; and the vehicle ignition must be ON.

NOTE – For complete instructions for using the TOOLBOX™ diagnostic program, refer to the User's Manual, TP-99102. Contact Meritor WABCO at 800–535–5560 (or www.meritorwabco.com) for information about TOOLBOX™ software.

IMPORTANT – The vehicles covered in this manual have used two different electrical controllers. Both controllers are mounted in the same location. The original controller was known as the Electrical System Controller (ESC). The current controller is known as the Body Controller (BC). In this manual the controller will be identified as the Body Controller or the ESC/BC.

Malfunctions in the brake system could be attributed to either hydraulic, mechanical, or electrical failures in the system. Hydraulic and mechanical malfunctions are covered in this manual. When an electrical malfunction is indicated, the procedures located in the ELECTRICAL SYSTEM TROUBLESHOOTING manual will be referenced. Use the troubleshooting procedures and table(s) in those manuals to isolate and repair any electrical malfunctions.

Diagnosis and troubleshooting of the brake system consists of the following steps:

- Diagnosis – identifying the general area of the system malfunction by observing the warning/status indicators and the recorded faults.
- Troubleshooting – following the repair instructions (presented in TOOLBOX™) to isolate the fault to a specific component.

5.1. DIAGNOSIS

Effective diagnosis of a malfunctioning system begins with observing the faults recorded by the system ECU. The faults, and their associated Diagnostic Trouble Codes (DTC's), are read using the EZ-TECH® service tool, running the TOOLBOX™ program. The TOOLBOX™ screen that displays the faults and their DTC's, also displays the appropriate Repair Instructions for the selected fault. A printed list of the faults, their DTC's, and the repair instructions is also provided in APPENDIX A (See APPENDIX A, page 162).

Fault Detection

The ECU uses a set of software algorithms to control the Full Power Brake System. Some functions of the ECU software are:

- Keep the full power brake system operating within its optimum range by controlling the cycling of the pump motors to maintain the optimum quantity of pressurized brake fluid in the accumulators. The typical operating pressure range for the accumulators is 1770 to 2320 psi.
- Monitor the wheel speed sensors to detect an imminent wheel lockup (an ABS event). Then, prevent the lockup by controlling the pressure of the brake fluid routed to each wheel.
- Detect faults or abnormal conditions within the full power brake system.
- Maintain safe braking abilities by deactivating the ABS circuits when a serious fault condition is detected.
- Generate diagnostic trouble codes that may be used to diagnose and isolate problems in the system.

To perform these functions the software system in the ECU monitors signals from the brake system and its environment. When certain fault conditions are detected, the software system will keep the ABS system enabled while it stores a diagnostic trouble code in its memory, identifying the fault. A detected fault will also result in the ECU sending a J1939 message to the gauge cluster, via the ESC/BC, to activate one or more of the warning indicators used to advise the driver of the status of the system. If a more serious fault condition is detected, in addition to generating DTC's and activating warning indicators, the software system will disable all or part of the affected ABS or ATC functions.

The table in APPENDIX A lists which indicators are lit during each listed fault.

TOOLBOX™ Software

TOOLBOX™ is a diagnostic program that runs in Windows® 98, 2000, NT, or XP. The program displays system faults, fault codes and repair instructions. System operating conditions such as wheel speed data and accumulator pressures can be monitored in real time. In addition, various system electrical components can be activated to verify the individual components, as well as, installation wiring. The TOOLBOX™ software is available from SPX Service Solutions, 1-800-328-6657.

For complete instructions for using this program, refer to the User's Manual, TP-99102. Contact Meritor WABCO at 1-800-535-5560 (or www.meritorwabco.com) for information about TOOLBOX™ Software.

Diagnostic Trouble Codes

When a fault condition is detected, the ECU will generate a diagnostic trouble code (DTC). The unique DTC identifies the probable cause of the fault. When any brake system DTC is generated it is stored in the ECU memory even if the fault condition is only temporary. If a fault is detected once, and then not detected at a later time, the DTC for that fault is identified as a stored (inactive) fault. While a fault is present and being detected it is considered an active fault. The troubleshooting table, in APPENDIX A, lists the brake system related DTC's with their corresponding probable faults.

Some DTC's that indicate serious malfunctions are designed to inhibit vehicle operation in some way once they have been set. The malfunctions that generate these DTC's must be corrected, and the DTC must be cleared from memory, before normal vehicle operation can resume. Prior to clearing a DTC the ignition must be cycled off and back on to change the status of the DTC from 'Active' to 'Stored'.

The DTC's are observed by using the EZ-TECH® electronic service tool, running the TOOLBOX diagnostic software. While observing the DTC's, the stored (inactive) fault codes may be cleared by following the instructions within the TOOLBOX™ program.

Observing Signals With The EZ-Tech® Service Tool

To display operational information: the EZ-TECH® service tool must be connected to the vehicle; the TOOLBOX™ diagnostic program must be running; and the vehicle ignition must be ON.

In addition to observing recorded faults, the EZ-TECH® electronic service tool, running the TOOLBOX™ diagnostic software, allows the servicer to observe (and control) some of the signals in the brake system. Refer to the applicable ELECTRICAL CIRCUIT DIAGRAMS manual and/or ELECTRICAL SYSTEM TROUBLESHOOTING guide listed in ISIS. When used in conjunction with these manuals the EZ-Tech® allows the servicer to isolate electrical faults efficiently. Refer to the user manuals for the EZ-TECH® service tool and the TOOLBOX™ software for complete operational information.

Definitions

Terms related to diagnostic fault codes.

- **Active Fault:** A condition that currently exists in the brakes system; for example, a sensor circuit malfunction on the left front steering axle. When an active fault has been repaired, it becomes a stored fault after the next ignition cycle.
- **Stored Fault:** A condition that caused the system to register a fault, but **is no longer being detected.** For example, a loose wire that corrected itself. A stored fault can also be an active fault that has been corrected (refer to Active Fault).

5.2. TROUBLESHOOTING

Troubleshooting the brake system starts when one or more faults have been identified using the EZ-TECH® electronic service tool, running the TOOLBOX™ software. Troubleshooting consists of performing the Repair Instructions that correspond to the active fault displayed in the TOOLBOX™ table. A printed list of the faults, their DTC's, and the repair instructions is also provided in APPENDIX A (See APPENDIX A, page 162).

Overview Of Appendix A

The primary means of troubleshooting the full power brakes system is to connect the EZ-TECH® electronic service tool to the diagnostic connector, and run the TOOLBOX™ diagnostic program. The information in APPENDIX A is provided only as additional background information. The following is a brief description of the APPENDIX A contents.

General information regarding the driver interface:

This short table shows the circuit connections used by the system to drive the gauge cluster indicators. The indicators in the current full power brakes system are driven via the SAE J1939 data link. The hardwired connections listed in the table are NOT used.

Troubleshooting Table (System Reaction)

This table shows how the system reacts to each of the faults listed in the first column (Component). It also lists the Diagnostic Trouble Code (DTC) assigned to each fault, and refers the user to the Repair Instruction to be used for troubleshooting. The headings of the table are:

1. **Component** – This column lists the possible system faults, primarily organized by system component.

2. **SPN, SID, PID, FMI** – These columns list the fields that comprise the DTC assigned to the specific fault listed in the Component column.

3. **Repair instruction** – This column references the Repair Instruction to be used when troubleshooting the fault listed in the Component column. All repair instructions are found in the Repair Instructions table that follows the troubleshooting table.

4. **General Actions** – This column briefly describes how the internal operation of ECU changes to react to the fault listed in the Component column.

5. **ABS, ATC EBD, PB** – These columns show the status of each of the full power brakes subsystems, based on the occurrence of the fault listed in the Component column.

6. **Brake Warning Lamp (BRAKE PRESSURE), ABS Warning Lamp, ATC Info Lamp (TRAC CTRL), Audible Warning (Buzzer), Parking Brake Service Lamp (SERVICE), Parking Brake Indicator Lamp (PARK), Brake Fluid Indicator Lamp** – These columns show the status of each of the indicators, based on the occurrence of the fault listed in the Component column.

Multiple Failures Table

This is a supplemental table to the troubleshooting table. This table lists the system reaction to multiple faults. The table headings are the same as those described for the troubleshooting table.

Special System Conditions

This table lists the system reaction to special operational conditions. Most of these conditions are not faults. This table simply breaks down how the system reacts to the conditions listed. The table headings are the same as those described for the troubleshooting table. Any fault conditions listed in this table are also covered in the troubleshooting table.

NOTE: The full power brakes system is a multiplexed (muxed) system.

Repair Instructions

This table lists the repair instructions and is organized by Repair Instruction (R.I.) number. These repair instructions are referenced from the Troubleshooting and Multiple Failures tables. The information in this table is also provided in the TOOLBOX™ diagnostic program.

Warning Indicators

Troubleshooting brake system Warning Indicators should always begin by observing the brake system warning indicators during the power-up sequence to verify that the bulb is not defective.

If the ABS and ATC lamps do not turn off after the three second bulb check, the system may be looking for a wheel speed signal. Drive the vehicle at speeds of 10 to 15 mph (16 to 24 km/h). If the indicators turn off, the system is operating correctly. If the indicators remain lit, a system malfunction is indicated. Use the EZ-TECH® and the TOOLBOX™ software to read the DTC and the corresponding repair instructions.

General Electrical System

Some general electrical information is provided in this manual to support some general checks, such as, component tests and point to point continuity checks. The electrical diagram is meant to provide a better understanding of the system by showing the relationship of the system circuits. Refer to FIGURE 46. While this diagram identifies the inputs and outputs of the circuits shown it is not a true schematic. Intermediate wire harness connectors are not shown. Refer to FIGURE 47 for ECU connector pin identification.

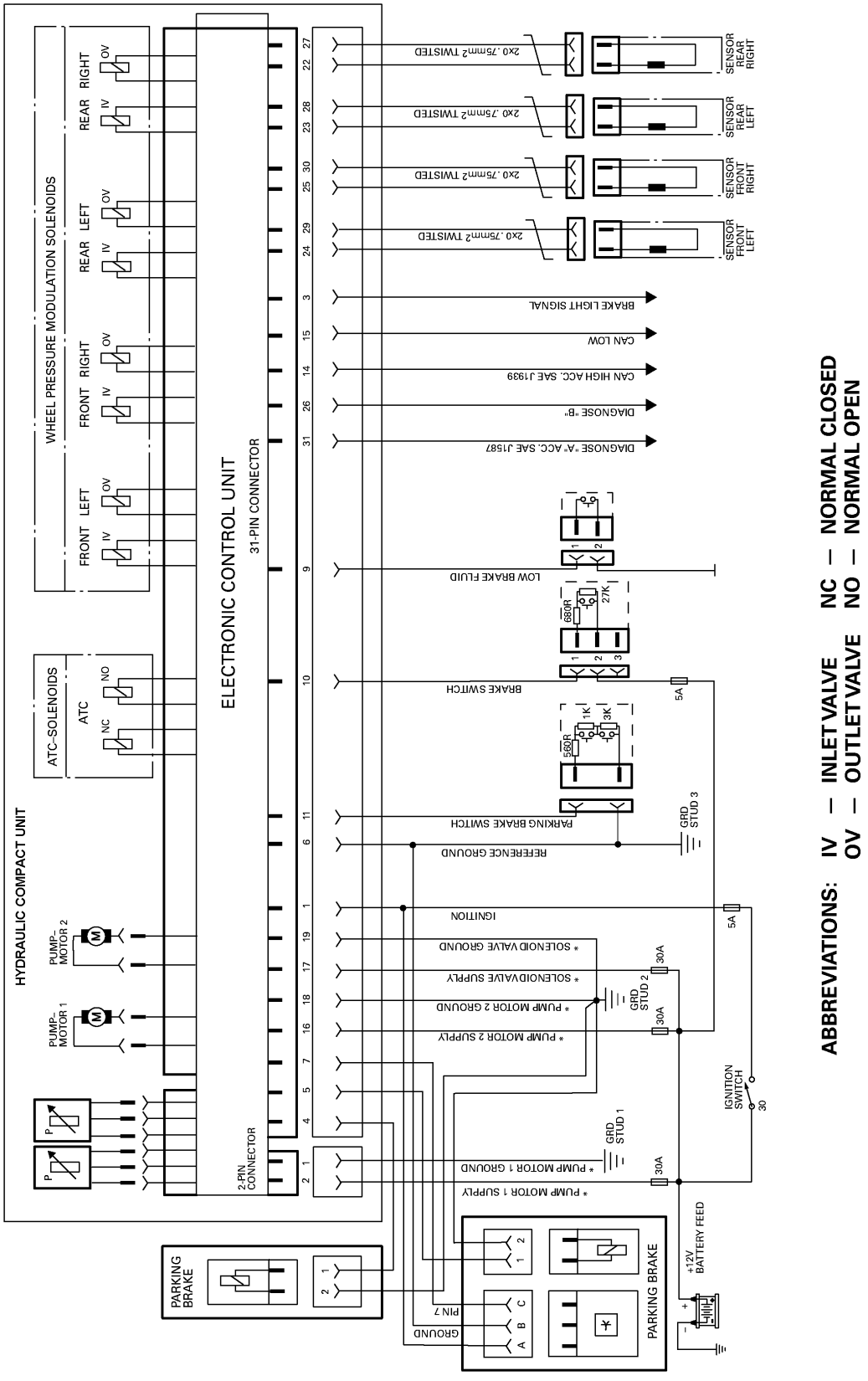

Figure 46 Full Power Brakes Electrical Circuit Diagram

In general, if the repair instructions (provided by the TOOLBOX™ diagnostic software) indicate an electrical circuit fault, refer to the applicable ELECTRICAL CIRCUIT DIAGRAMS manual and/or ELECTRICAL SYSTEM TROUBLESHOOTING guide listed in ISIS.

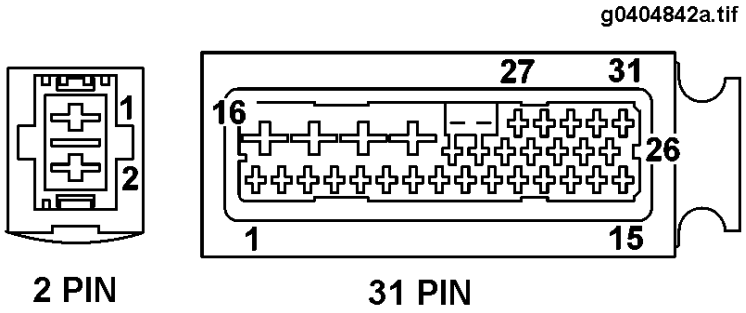

Figure 47 Pin Identification for Wire Harness Connectors to the ECU

ABS and ATC Wiring

The brake system wiring harnesses and connectors are weather resistant and sealed at the connector interface. When troubleshooting ABS wiring, some general rules should be followed where applicable.

1. Check all wiring and connectors to ensure they are secure and free from visible damage. Check for evidence of wire chafing due to poor routing or poor securing of wires. Check connectors for proper insertion and locking. Verify that the connector leads are properly greased with a nonconductive electrical grease compound and do not show signs of corrosion or exposure to the environment.

2. During wiring repair, a splice must be properly soldered and made waterproof.

3. Do not pierce wire insulation when checking for continuity.

4. Do not deform individual pins or sockets during probing with a volt/ohm meter.

5. Only use the correct crimping tool when replacing wire terminals and connectors.

6. Properly resecure all wiring harness and sensor leads when repairs are made.

Wheel Speed Sensor Output Voltage Test

The wheel sensor output signals should be measured at the 2 pin sensor connectors located near the wheel ends. This allows the sensors to be checked **without** disconnecting the ECU 31 pin connector, or the parking brake cable.

NOTE – If the ECU 31 pin connector is disconnected, the ECU will set fault codes AND momentarily turn on an HCU pump motor. Also, the parking brake will automatically apply, making it necessary to disconnect the park brake cable before testing the rear wheel speed sensors.

After reconnecting the connector and the parking brake cable, the EZ-TECH® and the TOOLBOX™ program must be used to clear all brake system related stored fault codes. If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

Sensor output voltage must be at least 0.2 volts AC at 30 rpm. Test the sensor output voltage as follows:

1. Turn ignition OFF.

WARNING – Block the wheels to 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. Failure to follow this warning could result in property damage, personal injury or death.

2. Put blocks under the front and rear tires to stop the vehicle from moving.

3. Raise the vehicle off the ground. Put safety stands under the axle(s).

FRONT AXLE

4. Disconnect the 2 pin sensor connector from the chassis wire harness. Refer to TABLE 3 for connector information.

5. Rotate wheel by hand at 30 rpm (1/2 revolution per second).

6. Measure the voltage across the two connector pins.

7. Reconnect the wheel speed sensor connector(s).

REAR AXLE

8. Turn key ON, DO NOT START the engine.

9. Set the transmission to neutral (N), **not** Park (P or PB).

10. Release the parking brake by depressing the brake pedal, then pressing the dash mounted park brake switch.

11. Disconnect the 2 pin sensor connector from the chassis wire harness. Refer to TABLE 3 for connector information.

12. Rotate wheel by hand at 30 rpm (1/2 revolution per second).

13. Measure the voltage across the two connector pins.

14. Reconnect the wheel speed sensor connector(s).

15. Turn key OFF and set the transmission to P or PB (if available).

Wheel Speed Sensor Resistance

The wheel speed sensor resistance must be between 500 and 2000 ohms. The resistance can be measured at the sensor connector, or at the pins on the harness connector to the ECU. Refer to TABLE 3 for connector information.

Making the measurement at the 2 pin sensor connectors allows the sensors to be checked **without** disconnecting the ECU 31 pin connector.

NOTE – If the ECU 31 pin connector is disconnected, the ECU will set fault codes AND momentarily turn on an HCU pump motor. After reconnecting the connector, the EZ-TECH® and the TOOLBOX™ program must be used to clear all brake system related stored fault codes. If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

1. Turn ignition OFF.

WARNING – Block the wheels to prevent the vehicle from moving. If the vehicle is raised, support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Failure to follow this warning could result in property damage, personal injury or death.

2. Put blocks under the front and rear tires to stop the vehicle from moving.

3. To measure resistance at the pins on ECU connector, disconnect the ECU connector from the ECU (see NOTE above). To measure resistance at the sensor connector(s), disconnect the sensor connector from the chassis wire harness near the wheel end.

4. Measure resistance between the pins indicated in TABLE 3.

   If measurement is not between 500 and 2000 ohms, replace the sensor.

5. Reconnect all connectors.

Table 3 Sensor Check Pins

Sensor	Pins (31-Pin Connector)	Sensor Connector
Left Front	24 and 29	Connector pins 1 and 2
Right Front	25 and 30	Connector pins 1 and 2
Left Rear	23 and 28	Connector pins 1 and 2
Right Rear	22 and 27	Connector pins 1 and 2

6. REMOVE AND INSTALL

IMPORTANT – The vehicles covered in this manual have used two different electrical controllers. Both controllers are mounted in the same location. The original controller was known as the Electrical System Controller (ESC). The current controller is known as the Body Controller (BC). In this manual the controller will be identified as the Body Controller or the ESC/BC.

This section contains the removal and installation procedures for the components of the brake system. After completing any repair or service procedure, use the EZ-TECH® and the TOOLBOX™ program to clear all brake system related inactive fault codes. (Codes may be set while disconnecting and reconnecting power to the system.) If active faults are indicated after making repairs, those faults must be rectified before returning the vehicle to service.

Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition. Perform a brief after-service check based on the service performed. Check

the operation of indicators and exercise any circuits or components that were repaired or replaced. A brief test drive should be performed after most repairs.

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 property damage, personal injury or death.

WARNING – The accumulators MUST NOT be removed until the system has been depressurized as described in the procedures. It is possible for a removed accumulator to retain an internal pressure of up to 1087 psi. Before disposing of an accumulator, verify its warranty status. If the accumulator is to be discarded, it must be depressurized and its pressure chamber must be disabled. Failure to follow this warning could result in property damage, personal injury or death.

WARNING – New accumulators are precharged to a pressure of 1087 psi. Puncturing or piercing an accumulator could result in property damage, personal injury or death.

WARNING – To prevent damage to the equipment and/or personal injury, unless otherwise instructed, always turn the vehicle ignition key OFF before performing Removal and Installation procedures. Failure to follow this warning could result in property damage, personal injury or death.

WARNING – To prevent eye injury, always wear safe eye protection when you perform vehicle maintenance or service. Failure to follow this warning could result in personal injury or death.

WARNING – When working around or under the vehicle, block the wheels to prevent the vehicle from moving. When raising the vehicle, support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Failure to follow this warning could result in property damage, personal injury or death.

WARNING – Failure to bleed the system whenever any hydraulic system fitting is loosened or disconnected will allow air to remain in the system. Air in hydraulic lines will greatly reduce the pressure available for braking. This can increase vehicle stopping distance which can result in property damage, personal injury or death.

WARNING – Do not reuse drained brake fluid. Hydraulic brake fluid that is removed can be contaminated and can cause system damage and/or loss of braking. Failure to follow this warning could result in property damage, personal injury or death. Properly discard hydraulic brake fluid that is removed from the brake system.

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. Non-specified hydraulic brake fluids will damage the rubber parts of the brake caliper and can cause system damage and/or, loss of braking. Failure to follow this warning could result in property damage, personal injury or death.

WARNING – Any form of contamination entering the system could prevent the system from operating correctly. Thoroughly clean the area around fittings before disconnecting the fittings. Always plug open ports and lines as quickly as possible. Failure to follow this warning could result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

CAUTION – Brake fluid is caustic. Contact with hydraulic brake fluid can cause skin irritation. When contact with brake fluid is possible wear the proper safety gear (gloves, safety glasses, etc.). 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.

NOTE – To display operational information: the EZ-TECH® service tool must be connected to the vehicle; the TOOLBOX™ diagnostic program must be running; and the vehicle ignition must be ON.

NOTE – Use DOT 3 or DOT 4 hydraulic brake fluid.

IMPORTANT –

A. To limit the amount of fluid loss, completely read each procedure before performing it. Whenever possible have the replacement component ready to install as you remove the original component.

B. In order to access the brake part being serviced, on some vehicles it may be necessary to move unrelated components, such as the air tank. If necessary, refer to the appropriate manual on ISIS for information before moving the component.

C. When working on the BRAKE system keep the work area and tools as clean as possible. Also, clean all connections, ports or fittings before disconnecting or removing components.

D. All BRAKE line openings should be immediately covered or plugged during removal and remain so until re-installation to prevent the entry of dirt, moisture and other foreign material. Even the slightest particle can cause problems if carried to a vulnerable place within the system.

E. Some brake system replacement parts have a limited shelf life. Check for expiration dates before installing replacement components.

F. Never remove protective caps from components until the moment of assembly into the system.

G. Never install non-sealed components.

H. All brake line tubing support clamps and strap locks must be reinstalled in their original positions.

I. Never bend a hose to a radius less than ten times the diameter of the hose.

J. Whenever possible use a backup wrench when loosening or tightening fittings

K. All fittings and mounting hardware must be tightened as specified in the TORQUE CHART. Use only a torque wrench known to be accurate.

Servicing of the following brake system related components is covered in greater detail in other manuals.

- Driveline park brake assembly and parking brake cable assembly – refer to s04044.
- Wheel end foundation brakes (calipers, rotors, brake pads, etc.) – refer to s04047.
- Electrical circuits (warning/status indicators, wiring, etc.) – refer to the applicable ELECTRICAL CIRCUIT DIAGRAMS manual and/or ELECTRICAL SYSTEM TROUBLESHOOTING guide listed in ISIS. Removal and installation procedures for some electrical components are included in this manual.

The removal and installation procedures for the following serviceable parts are included in this manual.

A. Master Cylinder without reservoir

B. brake light switch (mounted on MC)
C. Master Cylinder (MC) reservoir
D. fluid level switch (mounted to MC reservoir)
E. Electronic Control Unit (ECU)
F. accumulators
G. Hydraulic Compact Unit (HCU)
H. HCU reservoir
I. Pressure Supply Valve (PSV)
J. coil for PSV
K. relay valve assembly
L. HCU pumps
M. Spring Applied Hydraulically Release (SAHR) canister (complete)
N. coil for cut-off valve
O. manifold/piston and cylinder assembly, including cut-off valve core (part of SAHR canister)
P. parking brake travel switch (mounted on SAHR canister)
Q. park brake switch (dash mounted)
R. brake lines (general)
S. wheel speed sensors

The removal and installation procedures for this brake system are organized in the following order: master cylinder components, low pressure hose, HCU components, parking brake components and general components (brake lines, speed sensors, etc.).

6.1. MASTER CYLINDER (MC)

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

IMPORTANT – This component has a limited shelf life. When replacing this component, note the expiration date.

NOTE – 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. Do not install a damaged reservoir.

Removal

1. Install wheel chocks.

2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl (refer to FIGURE 48).

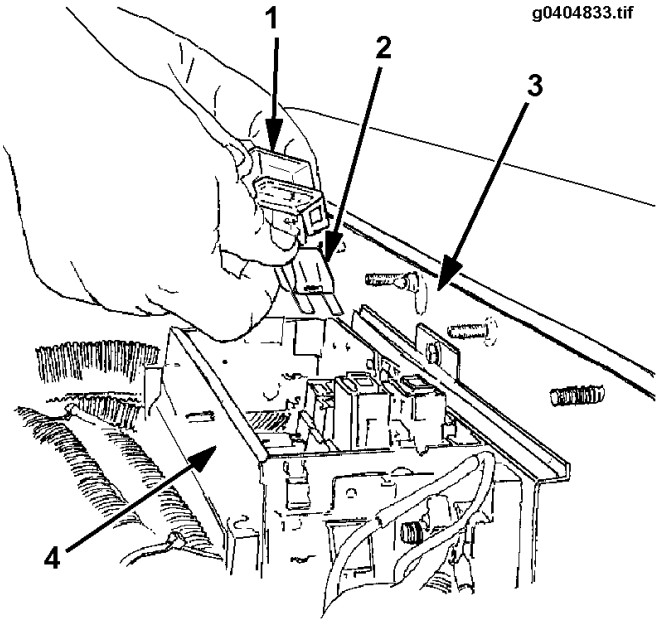

Figure 48 Location of Motor Fuses

1. FUSE COVER
2. FUSE
3. COWL
4. FUSE PANEL

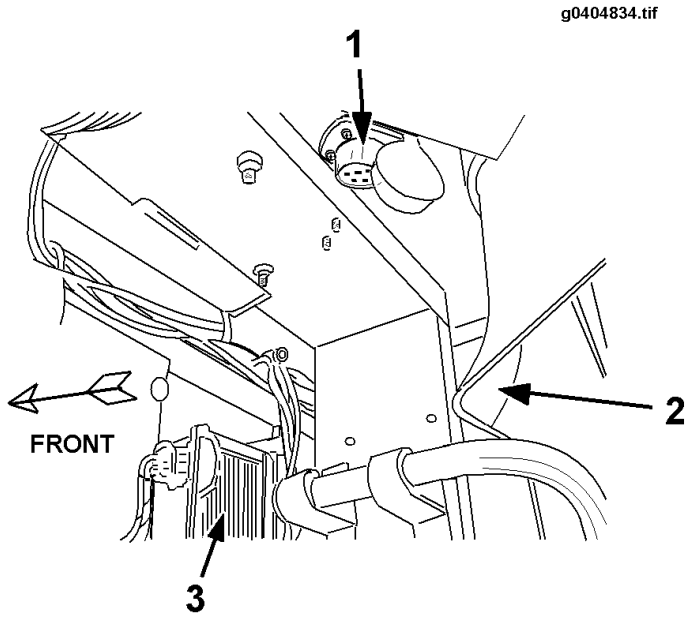

Figure 49 Location of Diagnostic Connector

1. DIAGNOSTIC CONNECTOR
2. DASH TRIM PANEL
3. ELECTRICAL SYSTEM CONTROLLER / BODY CONTROLLER (ESC/BC)

3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49. Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

4. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

5. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

6. Carefully clean the outside of the MC/reservoir assembly.

7. Disconnect the electrical connections from the brake light switch on the MC, and the fluid level switch on the MC reservoir. Refer to FIGURE 50.

8. Use a clamp to pinch the low pressure hose near the outlet of the MC reservoir, being careful not to damage the reservoir outlet. Refer to FIGURE 50.

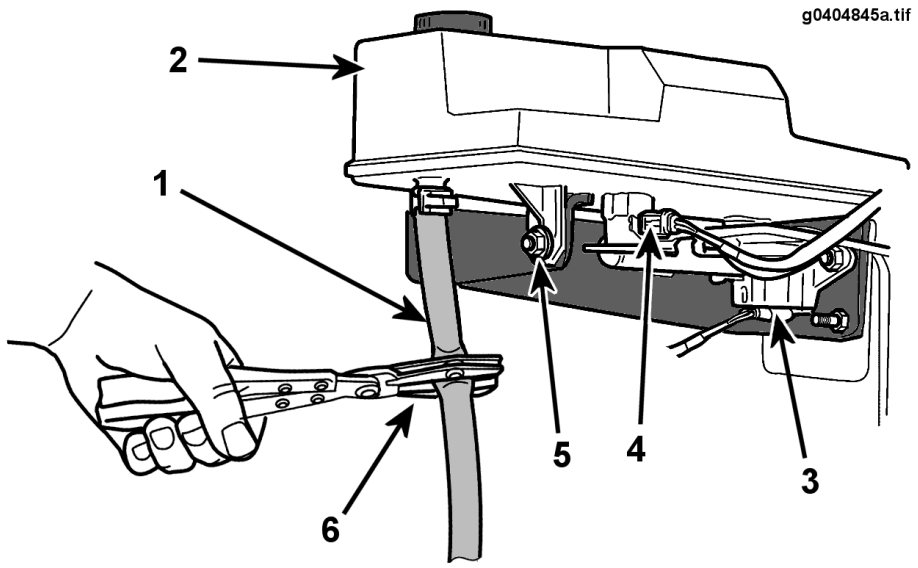

Figure 50 Low Pressure Hose Clamped at the Master Cylinder Reservoir

1. LOW PRESSURE HOSE
2. MASTER CYLINDER RESERVOIR
3. BRAKE LIGHT SWITCH
4. FLUID LEVEL SENSOR
5. RESERVOIR MOUNTING NUT
6. LOCKING CLAMP

NOTE – Before performing the following step, position a container under the MC to collect any drained or spilled brake fluid. Ensure that no fluid will spill onto the ground or damage the paint. Up to 3.4 liters (1 gal) of brake fluid will be drained.

9. Disconnect the low pressure hose from the MC reservoir. All the fluid coming out of the MC reservoir should drain into the container. Plug the low pressure hose to prevent contamination.

10. Remove the cap on the MC reservoir to assist draining.

11. Replace the reservoir cap and plug the reservoir outlet to prevent any remaining fluid from spilling during removal.

NOTE – Some brake fluid will remain in protected areas of the MC reservoir.

12. Disconnect the 2 brake tubes from the MC. Plug the brake tubes and the MC ports.

13. Disconnect the MC push rod clevis from the brake pedal by removing the clevis pin and spring retainer/clip. Refer to FIGURE 51.

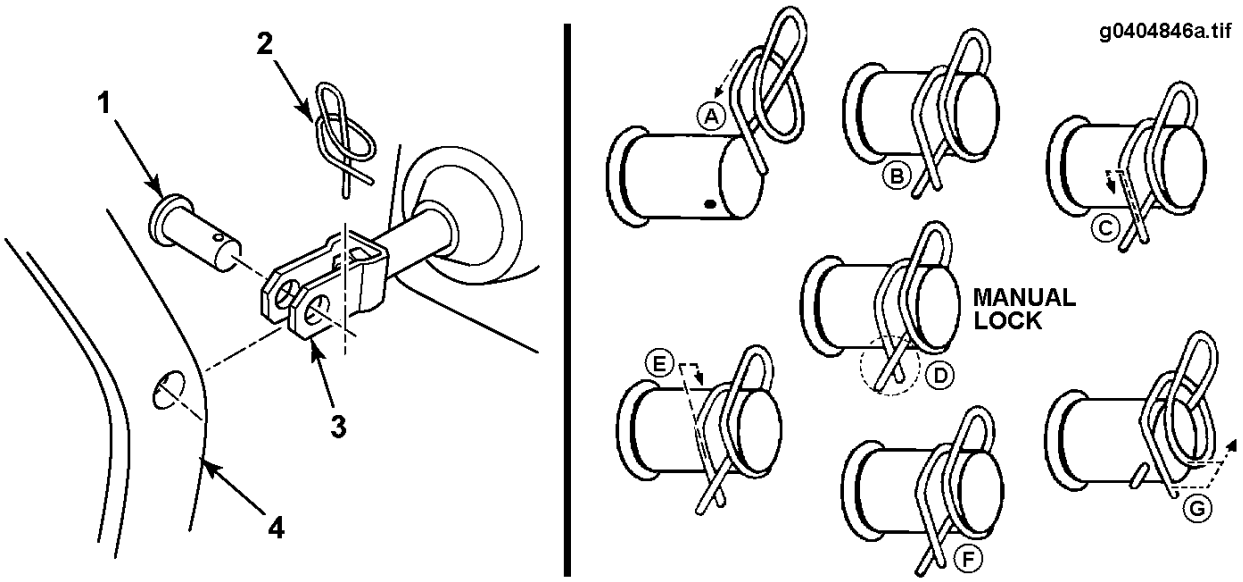

Figure 51 Connecting Master Cylinder Clevis to Brake Pedal Arm

1. CLEVIS PIN
2. RETAINING CLIP FOR CLEVIS PIN
   - A. To attach, insert main shaft into hole, slip forward tang and loop over end of shaft
   - B. Latched, but unlocked
   - C. To lock, place forward tang under main shaft
   - D. Locked position
   - E. To unlock, place forward tang over main shaft
   - F. Latched, but unlocked
   - G. To remove, lift loop and forward tang, and remove ring
3. CLEVIS ON MASTER CYLINDER PUSHROD
4. BRAKE PEDAL ARM

14. Unbolt the MC reservoir from the mounting bracket (1 nut). Refer to FIGURE 52.

15. Unbolt the MC from the mounting bracket (2 nuts). Remove MC and reservoir from bracket.

16. Pour any brake fluid remaining in the MC/reservoir assembly into a suitable container.

CAUTION – In the following step, care must be taken to protect the reservoir mounting tabs from excessive deflection when removing the roll pins. One method is to back up the mounting tab with a socket or similar object that allows the pins to be driven through the tab without deflecting the tab. Refer to FIGURE 53 (See Figure 53, page 94).

17. Disconnect the MC/reservoir by driving out the 2 roll pins securing the reservoir to the MC. Refer to FIGURE 52 (See Figure 52, page 93).

18. Lift the reservoir off of the MC. Some resistance will be felt due to the rubber seals between the MC and the reservoir.

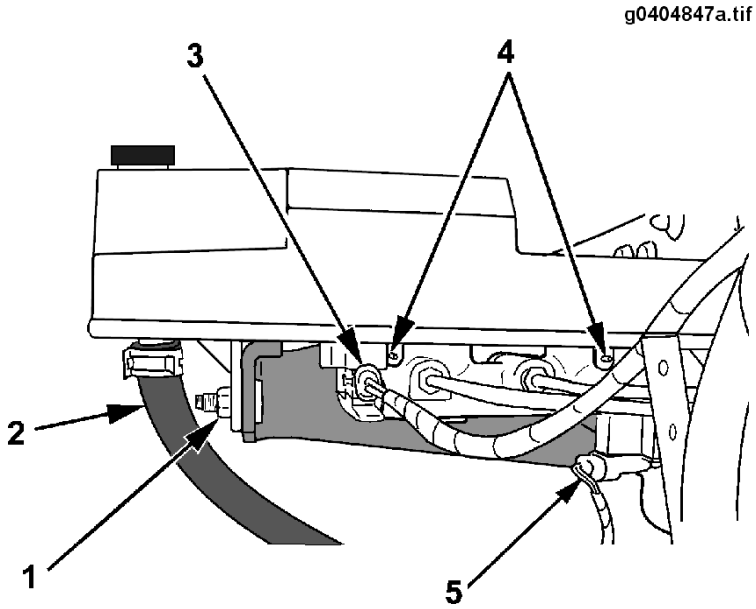

Figure 52 Roll Pins Securing Reservoir to Master Cylinder

1. RESERVOIR MOUNTING NUT
2. LOW PRESSURE HOSE
3. FLUID LEVEL SENSOR CONNECTOR
4. ROLL PINS
5. BRAKE LIGHT SWITCH CONNECTOR

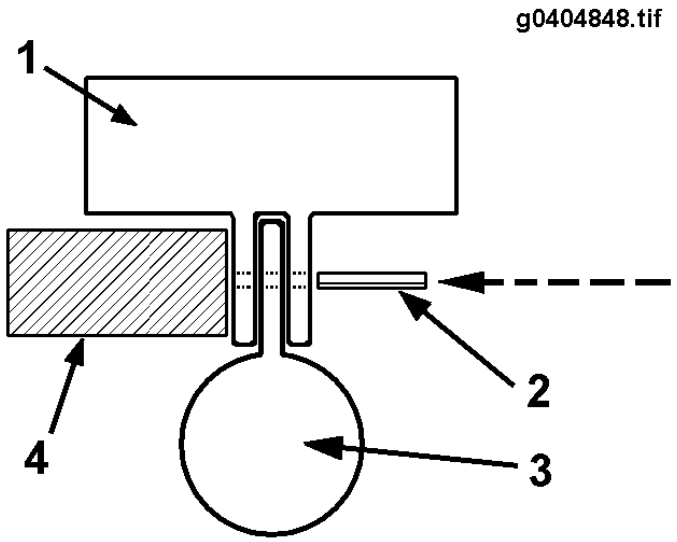

Figure 53 Suggested Method of Installing Roll Pins to Connect Master Cylinder Reservoir

1. MASTER CYLINDER RESERVOIR (NOT TO SCALE)
2. ROLL PIN
3. MASTER CYLINDER BODY (NOT TO SCALE)
4. SOCKET (OR OTHER SUITABLE OBJECT) PRESSED AGAINST RESERVOIR MOUNTING TAB

Installation

1. Assemble the new MC and reservoir.
   a. Lubricate 2 new black rubber MC–to–reservoir seals with new DOT 3 or DOT 4 brake fluid.
   b. Install the new seals into the ports on top of the MC.
   c. Install the reservoir by pressing it carefully and fully into the seals.

> **CAUTION – In the following step, care must be taken to protect the reservoir mounting tabs from excessive deflection when installing the roll pins. One method is to back up the mounting tab with a socket or similar object that allows the pins to be driven through the tab without deflecting the tab. It is important to line up the pin with the holes in the tabs. Refer to FIGURE 53.**

   d. Use the 2 roll pins from the replacement parts kit to attach the reservoir to the MC.

2. Install the MC/reservoir assembly so that the stud on the bracket is inserted into the reservoir mounting tab, the MC base slips over the 2 mounting studs on the bracket, and the MC clevis passes through the hole in the cowl.

3. Using 2 mounting nuts, secure the MC base to the bracket. Torque the nuts to 61 to 68 Nm (45 to 50 Lbf-ft).

4. Using 1 mounting nut, secure the reservoir to the bracket. Refer to FIGURE 52 (See Figure 52, page 93). Torque the nut to 29 to 32 Nm (21 to 24 Lbf-ft).

5. Connect the MC push rod clevis to the pedal assembly using the clevis pin and the spring retainer/clip. Lock the spring retainer/clip. Refer to FIGURE 51 (See Figure 51, page 92).

6. Connect the primary and secondary brake tubes to the MC. Tighten to 17 to 22.5 Nm (12.5 to 16.5 Lbf-ft).

7. Connect the low pressure hose to the MC reservoir using the existing hose clamp. Remove pinch clamp from hose.

WARNING – In the following step the electrical connection must be reconnected to the brake light switch on the MC to insure that the brake system ABS functions operate correctly. Failure to follow this warning could result in property damage, personal injury or death.

8. Connect the electrical connections to the brake light switch on the MC, and the fluid level switch on the MC reservoir. Refer to FIGURE 52 (See Figure 52, page 93).

9. Bleed MC circuit. Refer to PRESSURE BLEEDING THE FULL POWER BRAKES SYSTEM (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61).

WARNING – If leakage is noted in the following step, the system MUST be depressurized BEFORE making repairs. Perform steps 2 thru 5 of the MASTER CYLINDER REMOVAL procedures to verify that the system is depressurized. Failure to follow this warning could result in property damage, personal injury or death.

10. Check system for leakage. If leakage is present, depressurize the system before making repairs.

11. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

12. Disconnect the EZ-TECH® from the diagnostic connector.

13. Remove wheel chocks.

6.2. BRAKE LIGHT SWITCH (MOUNTED ON MC)

The brake light switch on the MC can be removed without opening the brake fluid system. Therefore, the switch can be replaced without depressurizing the brake system.

Removal

1. Install wheel chocks and turn key off.

2. Disconnect the electrical connection to the brake light switch. Refer to FIGURE 52 (See Figure 52, page 93).

3. Remove the 2 screws securing the switch to the MC, and pull the switch straight down. Note the orientation of the switch for proper installation of the replacement switch.

4. Remove and discard the old switch gasket.

Installation

1. Position the replacement switch and gasket so that the mounting holes align with the holes on the MC body. Secure the switch with 2 mounting screws, and torque to 3 to 4 Nm (26.5 to 35.4 lbf-in).

2. Connect the electrical connection to the MC travel switch.

3. Turn key on and perform an operational check by verifying that the brake lamps light when the brake pedal is pressed.

4. Turn key off and remove wheel chocks.

6.3. MASTER CYLINDER RESERVOIR

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

Removal

1. Install wheel chocks.

2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 48 (See Figure 48, page 89).

3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

4. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

5. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

6. Carefully clean the outside of the master cylinder/reservoir assembly.

7. Disconnect the electrical connections from the brake light switch on the Master Cylinder (MC), and the fluid level switch on the MC reservoir. Refer to FIGURE 52 (See Figure 52, page 93).

8. Use a clamp to pinch the low pressure hose near the outlet of the MC reservoir, being careful not to damage the reservoir outlet. Refer to FIGURE 50 (See Figure 50, page 91).

NOTE – Before performing the following step, position a container under the MC reservoir to collect any drained or spilled brake fluid. Ensure that no fluid will spill onto the ground or damage the paint. Up to 3.4 liters (1 gal) of brake fluid will be drained.

9. Disconnect the low pressure hose from the MC reservoir. All the fluid coming out of the MC reservoir should drain into the container. Plug the low pressure hose to prevent contamination.

10. Remove the cap on the MC reservoir to assist draining.

11. Replace the reservoir cap and plug the reservoir outlet to prevent any remaining fluid from spilling during removal.

CAUTION – Some brake fluid will remain in protected areas of the MC reservoir.

12. Remove the 1 nut securing the reservoir to the MC bracket. Refer to FIGURE 52 (See Figure 52, page 93). Retain the nut for use during installation.

CAUTION – In the following step, care must be taken to protect the reservoir mounting tabs from excessive deflection when removing the roll pins. One method is to back up the mounting tab with a socket or similar object that allows the pins to be driven through the tab without deflecting the tab. Refer to FIGURE 53 (See Figure 53, page 94).

13. Remove the 2 roll pins securing the reservoir to the MC. Refer to FIGURE 52 (See Figure 52, page 93).

NOTE – Before performing the following step, position a container under the MC reservoir to collect any drained or spilled brake fluid. Ensure that no fluid will spill onto the ground or damage the paint.

14. Lift the reservoir off of the MC. Some resistance will be felt due to the rubber seals between the MC and the reservoir.

15. Verify that the 2 rubber seals were removed from the MC with the reservoir. If not, remove the old seals from the ports on top of the MC.

16. Plug the MC ports to insure that no contamination will enter the MC.

17. Pour the fluid remaining in the reservoir into a suitable container.

18. Carefully clean the top of the MC that was previously covered by the reservoir.

Installation

1. Carefully clean the top of the MC that was previously covered by the reservoir.

2. Install 2 new black rubber MC–to–reservoir seals into the ports on top of the MC.

3. Lubricate the reservoir seals with new DOT 3 or DOT 4 brake fluid.

4. Install the new reservoir by placing it on the mounting bracket stud and carefully pivoting it downward to seat it fully into the MC seals.

CAUTION – In the following step, care must be taken to protect the reservoir mounting tabs from excessive deflection when installing the roll pins. One method is to back up the mounting tab with a socket or similar object that allows the pins to be driven through the tab without deflecting the tab. It is important to line up the pin with the holes in the tabs. Refer to FIGURE 53 (See Figure 53, page 94).

5. Use the 2 roll pins from the replacement parts kit to attach the reservoir to the MC.

6. Use the nut removed earlier to attach the reservoir to the bracket. Refer to FIGURE 52 (See Figure 52, page 93). Torque the nut to 29 to 32 Nm (21 to 24 Lbf-ft).

7. Secure the low pressure hose to the MC reservoir outlet with the existing hose clamp.

8. Release the pinch clamp on the low pressure hose.

WARNING – In the following step the electrical connection must be reconnected to the brake light switch on the MC to insure that the brake system ABS functions operate correctly. Failure to follow this warning could result in property damage, personal injury or death.

9. Connect the electrical connections to the brake light switch on the MC, and the fluid level switch on the MC reservoir. Refer to FIGURE 52 (See Figure 52, page 93).

10. Fill the reservoir up to the MAX mark with new DOT 3 or DOT 4 brake fluid from a sealed container.

11. Bleed MC circuit. Refer to PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61).

WARNING – If leakage is noted in the following step, the system MUST be depressurized BEFORE making repairs. Perform steps 2 thru 5 of the MASTER CYLINDER RESERVOIR REMOVAL procedures to verify that the system is depressurized. Failure to follow this warning could result in property damage, personal injury or death.

12. Check system for leakage. If leakage is present, depressurize the system before making repairs.

13. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

14. Disconnect the EZ-TECH® from the diagnostic connector.

15. Remove wheel chocks.

NOTE – Further bleeding of the system is not necessary.

6.4. FLUID LEVEL SWITCH (MOUNTED ON MC RESERVOIR)

The fluid level switch is located on the bottom of the MC reservoir. Refer to FIGURE 52 (See Figure 52, page 93). The switch can be removed without opening the brake fluid system; therefore, it can be replaced without depressurizing the system.

Removal

1. Install wheel chocks and turn key off.

2. Disconnect the electrical connection to the fluid level switch.

3. On the opposite end of the switch body from the electrical connector, squeeze the lock tabs and push the switch out of its holder tube.

Installation

1. Push the replacement switch into the holder tube until the locking tabs expand to hold the switch in place.

2. Connect the electrical connection to the switch.

3. Remove wheel chocks.

6.5. LOW PRESSURE HOSE

WARNING – The design and composition of the low pressure hose is critical. The low pressure hose must be replaced with the same design as installed by the manufacturer. The use of an incompatible hose assembly may cause system damage and loss of braking. Failure to follow this warning could result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

Removal

1. Install wheel chocks.
2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 48 (See Figure 48, page 89).
3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.
4. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

5. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).
6. Carefully clean the outside of the Hydraulic Compact Unit (HCU) and the Master Cylinder (MC) reservoir assembly.

7. Clean the area of the crossmember that the low pressure hose passes through, and the 2 clamps that secure the hose to the chassis. Refer to FIGURE 54.

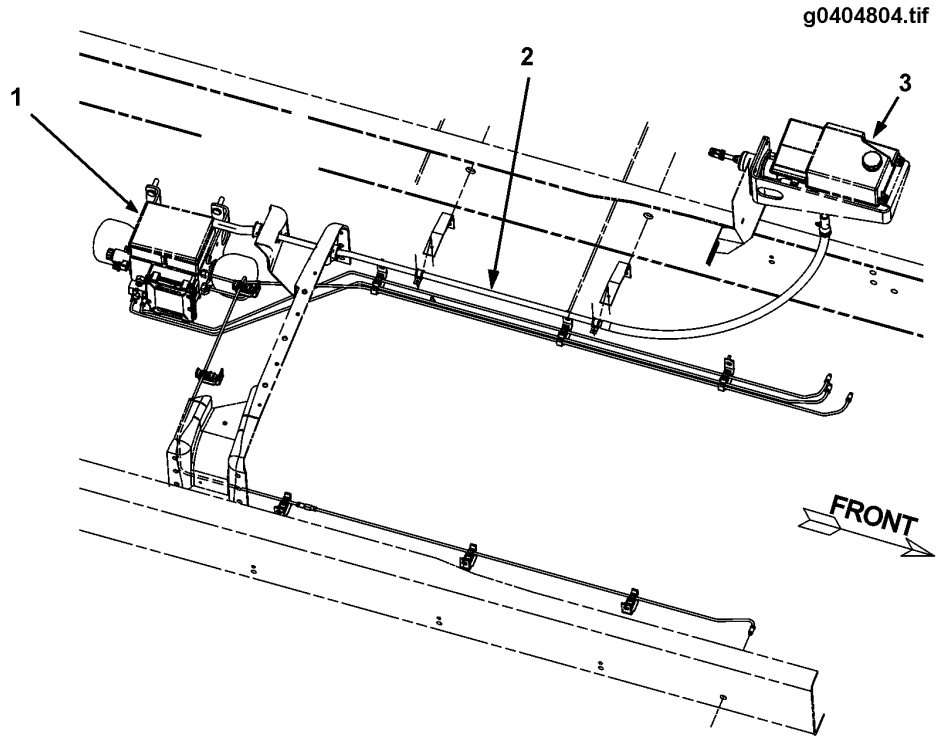

Figure 54 Low Pressure Hose from Master Cylinder to HCU

1. HYDRAULIC COMPACT UNIT (HCU)
2. LOW PRESSURE HOSE
3. MASTER CYLINDER AND RESERVOIR

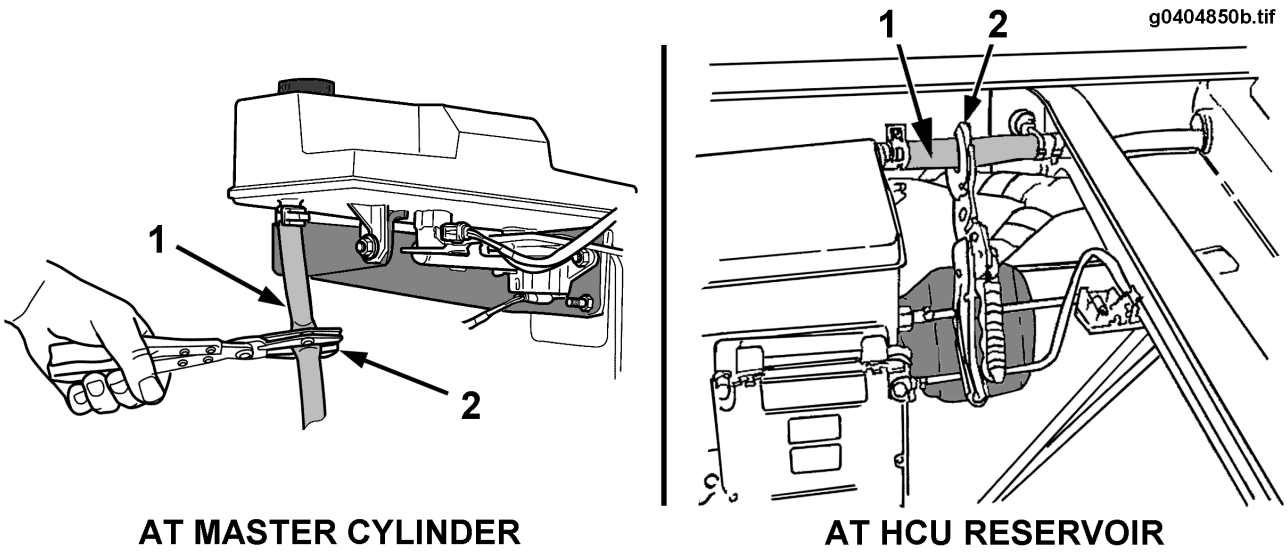

Figure 55 Clamping the Low Pressure Hose

1. LOW PRESSURE HOSE
2. LOCKING CLAMP

8. Use a clamp to pinch the low pressure hose at the inlet to the HCU reservoir. Place the clamp midway between the HCU reservoir inlet and the crossmember, being careful not to damage the reservoir inlet. In some vehicle applications the rubber section of the low pressure hose is too short to provide a leakproof clamp at this location. If necessary, clamp the low pressure hose 4 or 5 inches below the master cylinder outlet. Refer to FIGURE 55 (See Figure 55, page 102).

9. Remove the 2 clamps (see FIGURE 54) securing the middle section of the low pressure hose to the chassis. Note the clamp positions to assist installation of new hose.

NOTE – Before performing the following step, position a container to collect any drained or spilled brake fluid to ensure that no fluid will spill onto the ground or damage the paint. In the next 4 steps up to 3.4 liters (1 gal) of brake fluid will be drained.

10. Disconnect the low pressure hose from the HCU reservoir.

11. Plug the low pressure hose and the reservoir inlet to prevent system contamination.

12. Verify that the container is positioned to catch fluid rapidly draining from the hose.

13. Remove the cap on the MC reservoir, remove the plug from the low pressure hose, and carefully open the clamp on the low pressure hose. The fluid remaining in the MC reservoir and the low pressure hose will drain into the container.

14. Disconnect the hose from the MC reservoir. Plug the reservoir port. Plug the hose to prevent leakage during removal.

15. Remove the hose from the vehicle.

Installation

> **CAUTION – To prevent contamination of the system, keep the ends of the replacement hose sealed until you are ready to connect them.**

IMPORTANT – In the following step, position the hose clamps at the MC reservoir and the HCU reservoir so that the pinch tabs are easily accessible.

1. Install the new hose. Make sure hose does not contact sharp edges, moving components or hot components.
   a. Verify that the grommets are installed where the hose is routed through the crossmember.
   b. Connect the hose to the HCU reservoir and install clamp.
   c. Connect the hose to the MC reservoir and install clamp.
   d. Install the center clamps at the positions noted during removal.
2. Using new DOT 3 or DOT 4 brake fluid from a sealed container, fill the MC reservoir to the MAX mark. About 3.2 liters (0.9 gallons) are needed.
3. Connect the battery and install the two pump motor fuses.
4. Switch ON the ignition. The HCU pump motors will start and run for approximately 45 seconds. This will fill the accumulators and pressurize the system.
5. Verify that the fluid level in the MC reservoir is at the MAX mark.
6. Remove the two pump motor fuses.
7. Decrease pressure in the system by applying the brake pedal a minimum of 30 times. This will force fluid from the accumulators back into the HCU reservoir to purge trapped air from the reservoir, through the low pressure hose.
8. Install the two pump motor fuses.
9. Switch ON the ignition. The pump motors will start and run for approximately 45 seconds. This will fill the accumulators, pressurizing the system.
10. Pump the brakes rapidly 4 times to activate both HCU pump motors. After motors stop, fill the MC reservoir up to the MAX mark with new DOT 3 or DOT 4 brake fluid from a sealed container.

> **WARNING – If leakage is noted in the following step, the system MUST be depressurized BEFORE making repairs. Perform steps 2 thru 5 of the LOW PRESSURE HOSE REMOVAL procedures to verify that the system is depressurized. Failure to follow this warning could result in property damage, personal injury or death.**

11. Check system for leakage. If leakage is present, depressurize the system before making repairs.

12. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

13. Disconnect the EZ-TECH® from the diagnostic connector.

14. Remove wheel chocks.

NOTE – Further bleeding of the system is not necessary.

6.6. ELECTRONIC CONTROL UNIT (ECU)

WARNING – Changing the ECU does not require depressurizing the system. HOWEVER, if any additional service is to be performed on the brake system, depressurizing the system may be necessary to prevent injury. Check the procedures for the specific service being performed. Failure to follow this warning could result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

CAUTION – To prevent damage to the ECU, due to electrostatic discharge, the battery must always be disconnected before servicing.

IMPORTANT – This component has a limited shelf life. When replacing this component, note the expiration date.

NOTE – The ECU has programmable parameters that vary by vehicle wheelbase and configuration. The replacement ECU is programmed with the default settings for these parameters. After replacing an ECU, refer to ISIS to modify the programmable parameters to match those assigned to the vehicle's VIN number. This modification requires the use of the EZ-Tech® service tool and the TOOLBOX™ diagnostic software.

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

Removal

1. Install wheel chocks.

> **WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.**

2. Disconnect the battery negative cable (including the ECM ground cable).
3. Clean the outside of the Hydraulic Compact Unit (HCU) carefully.
4. Unlatch and disconnect both electrical connectors from the ECU module. Refer to FIGURE 56.
5. Using a 4 mm Allen wrench, remove the 4 screws that attach the ECU module to the HCU in the sequence shown in FIGURE 57.

> **CAUTION – In the following 3 steps, do not touch the 2 pressure sensor connectors on the rear of the ECU. The connectors are sensitive and can be easily contaminated and damaged.**

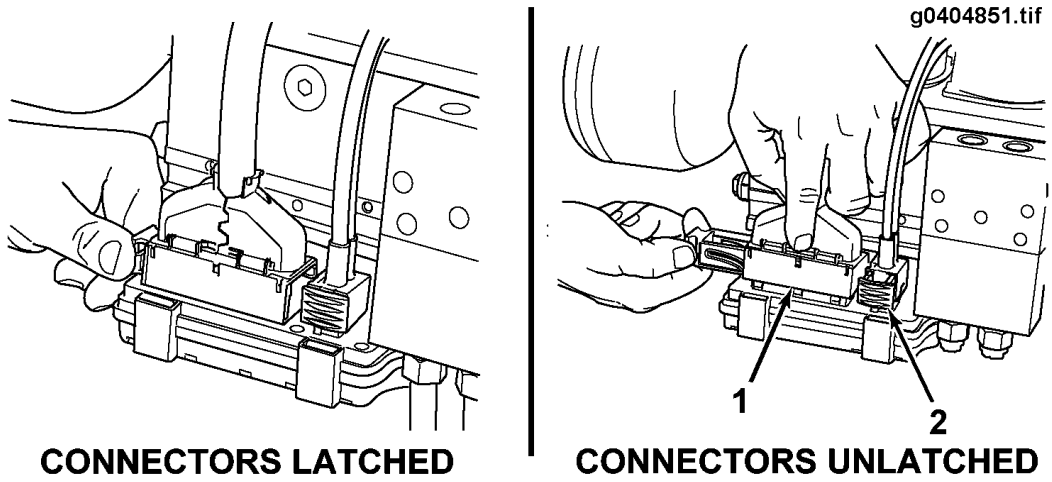

Figure 56 Unlatching the ECU Connectors

1. 31 PIN CONNECTOR
2. 2 PIN CONNECTOR

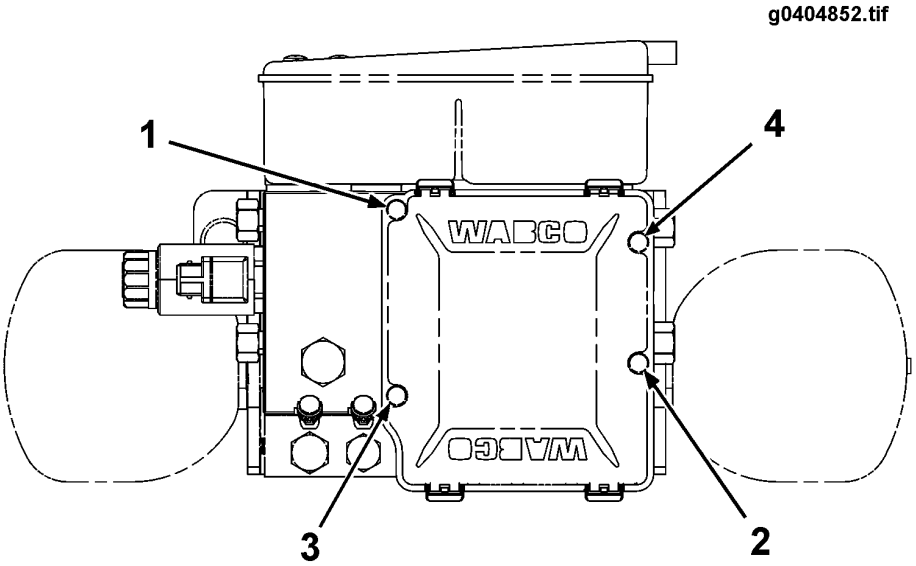

Figure 57 Loosening/Tightening Pattern for ECU Mounting Screws

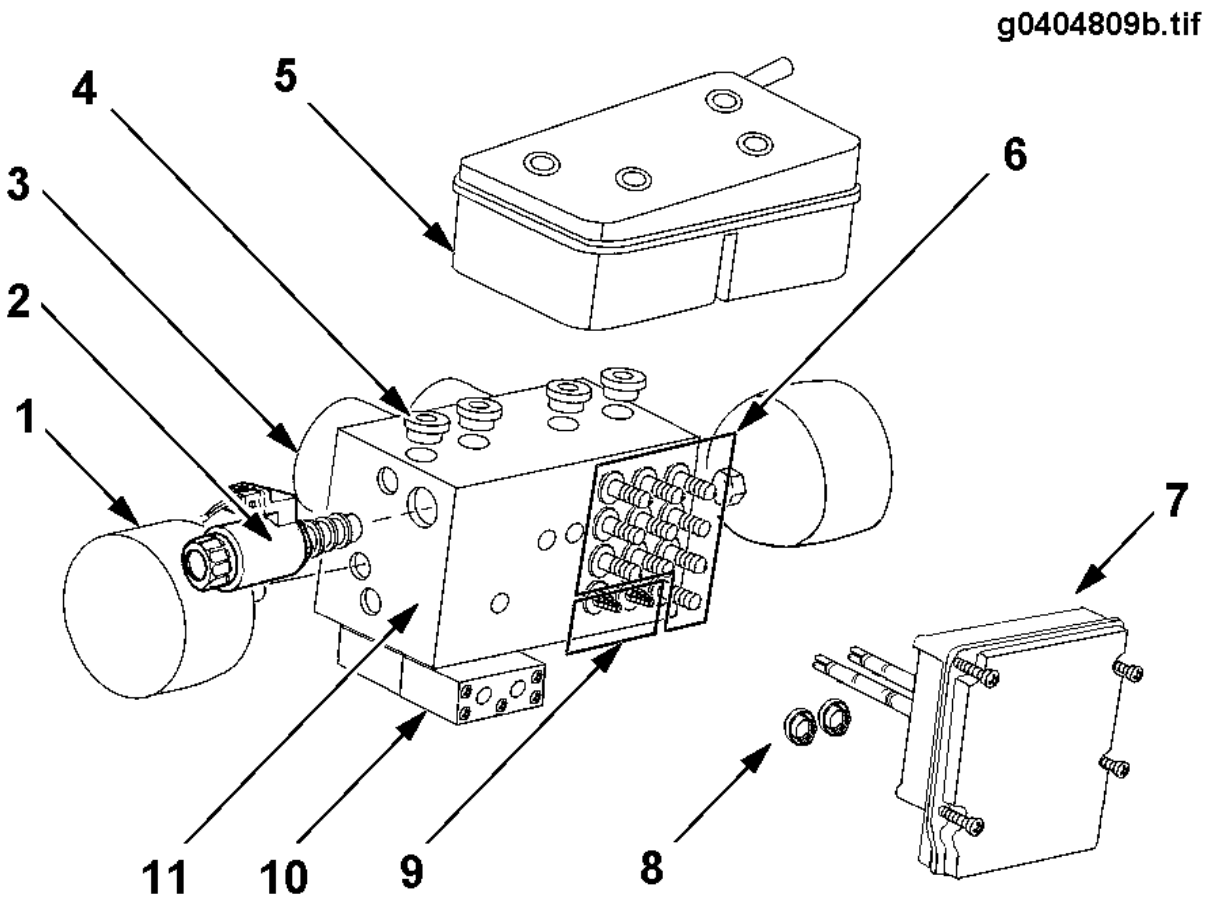

Figure 58 Hydraulic Compact Unit Exploded View

1. ACCUMULATOR (2)
2. PRESSURE SUPPLY VALVE (PSV)
3. PUMP MOTOR (2)
4. SEALS FOR HCU RESERVOIR (4)
5. HCU RESERVOIR
6. SOLENOID VALVES (8 ABS AND 2 ATC)
7. ELECTRONIC CONTROL UNIT (ECU)
8. O-RING SEALS FOR PRESSURE SENSORS (2)
9. PRESSURE SENSORS (2)
10. RELAY VALVE ASSEMBLY
11. VALVE BODY

CAUTION – In the following step, to prevent damage to the HCU, remove the ECU by carefully pulling it straight away from the HCU.

6. Remove the ECU module by pulling simultaneously on all sides. To avoid damage to the HCU, do not cock the ECU module during removal. Refer to FIGURE 58.

7. Carefully wipe the area around the valves formerly covered by the ECU module. Do not touch the two pressure sensor connectors. (Connectors are sensitive and can be easily contaminated and damaged.)

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

Installation

CAUTION – When handling a new ECU, avoid contacting the pins of the 31 pin connector. Under certain circumstances, some of the internal circuitry of the ECU may be subject to damage from Electrostatic Discharge (ESD). Damaged circuitry would prevent the ECU from operating correctly in the ABS and/or ATC modes.

CAUTION – In the following steps, do not touch the two pressure sensor connectors on the rear of the ECU. The connectors are sensitive and can be easily contaminated and damaged.

NOTE – Replacement ECU modules are supplied as a kit that includes two orange seals and four screws.

1. Assemble the new orange pressure sensor seals into the new ECU module.

CAUTION – The ECU module must not be cocked when installing it onto the HCU. Excessive force will damage the ECU module housing.

2. Carefully position the ECU module onto the HCU valves, and seat it by pressing simultaneously on all sides. Ensure that the motor connectors achieve full depth into the HCU before inserting the screws. The gap between the HCU body and ECU module housing should be approximately 2 mm (0.08 in). If this gap cannot be achieved; remove the ECU module, check for obstructions, verify seals are correctly installed, and reinstall the ECU module.

3. Secure the ECU module using the four new 4 mm Allen-head screws. Using the tightening pattern shown in FIGURE 57, torque the screws to 1.5 Nm (14 Lbf-in). Verify that the metal sleeves of the ECU module housing rest flat on the HCU body.

4. Using the tightening pattern shown in FIGURE 57, increase the torque on the mounting screws to 2.5 to 3.5 Nm (21 to 30 Lbf-in).

WARNING – In the following step, insure that the ECU connectors are properly installed and latched to prevent them from becoming disconnected. Failure to securely connect AND LATCH the ECU connectors could result in loss of braking functions during vehicle operation. Failure to follow this warning could result in property damage, personal injury or death.

5. Connect both electrical connectors to the ECU module and secure the connectors by engaging the latches.

6. Route and secure the wire harness in its original position.

7. Connect the battery.

8. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

9. Disconnect the EZ-TECH® from the diagnostic connector.

10. Remove wheel chocks.

NOTE – Bleeding the brake system is not necessary.

6.7. ACCUMULATOR

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 property damage, personal injury or death.

WARNING – The accumulators MUST NOT be removed until the system has been depressurized as described in the procedures. It is possible for a removed accumulator to retain an internal pressure of up to 1087 psi. Before disposing of an accumulator, verify its warranty status. If the accumulator is to be disposed of, it must be depressurized and its pressure chamber must be disabled. Failure to follow this warning could result in property damage, personal injury or death.

WARNING – New accumulators are precharged to a pressure of 1087 psi. Puncturing or piercing an accumulator may result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

IMPORTANT – Because the accumulators are precharged, they have a limited shelf life. When replacing an accumulator, note the expiration date on the replacement accumulator.

IMPORTANT – Always replace the accumulators in pairs even if only one is diagnosed as defective.

Removal

1. Install wheel chocks.
2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 48 (See Figure 48, page 89).
3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.
4. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

5. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).
6. Carefully clean the outside of the Hydraulic Compact Unit (HCU) around and above the accumulator mounting point.
7. Position a container to collect the drained brake fluid in the next step. Ensure that no fluid will spill onto the ground or damage the paint.
8. Using a strap wrench, remove the accumulator, (right hand thread).

9. Clean the counterbore carefully. Verify that the O-ring seal was removed with the accumulator. Plug the counterbore to ensure that no dust will get into the HCU. If the same accumulator is to be reinstalled, plug the port on the accumulator to prevent contamination.

10. Remove the second accumulator by repeating steps 6 to 9.

WARNING – It is possible for a removed accumulator to retain an internal pressure of up to 1087 psi. Before disposing of an accumulator, verify its warranty status. If the accumulator is to be discarded, it must be depressurized and its pressure chamber must be disabled. Failure to follow this warning could result in property damage, personal injury or death.

11. If the accumulator(s) are to be discarded, perform the ACCUMULATOR DISPOSAL PROCEDURE to depressurize the accumulator and disable its pressure chamber (See Accumulator Disposal Procedure, page 113).

Installation

WARNING – A new accumulator is precharged to a pressure of 1087 psi. Puncturing or piercing an accumulator may result in personal injury or death.

1. Remove the plug from the accumulator counterbore in the HCU. Clean the HCU counterbore and the surrounding area.

2. Lubricate the O-ring on the new accumulator with clean brake fluid.

3. Install the new accumulator and tighten by hand until snug. Then, tighten the accumulator using a torque wrench with a strap wrench attachment. Torque at the accumulator mounting must be 58.8 to 67.8 Nm (43.4 to 50 Lbf-ft). To achieve this using a torque wrench with a strap wrench head, use a torque range of 51.5 to 56.9 Nm (38 to 42 Lbf-ft), while keeping the wrench handle in line with the centerline axis of the accumulator. Refer to FIGURE 59 (See Figure 59, page 112).

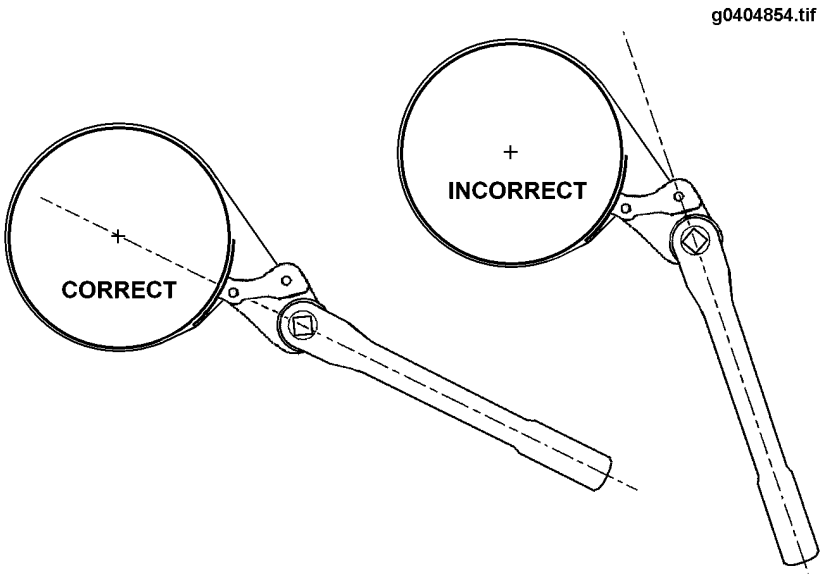

Figure 59 Correct Torque Wrench Orientation

4. Install the second accumulator by repeating steps 1 to 3.

5. Make sure fluid is at or above the MAX mark in the Master Cylinder (MC) reservoir. If not, fill the reservoir up to the MAX mark with new, DOT 3 or DOT 4 brake fluid from a sealed container.

6. Connect the battery and install the two pump motor fuses.

7. Switch ON the ignition. The HCU pump motors will start and run for approximately 45 seconds. This will fill the accumulators and pressurize the system.

8. After pump motors stop, fill the MC reservoir up to the MAX mark with new, DOT 3 or DOT 4 brake fluid from a sealed container.

9. Pump the brakes rapidly 4 times to activate both HCU pump motors.

10. After pump motors stop, fill the MC reservoir up to the MAX mark with new, DOT 3 or DOT 4 brake fluid from a sealed container.

WARNING – If accumulator leakage is noted in the following step, the system MUST be depressurized BEFORE making repairs. Perform steps 2 thru 5 of the ACCUMULATOR Removal procedure to verify that the system is depressurized. Failure to follow this warning could result in property damage, personal injury or death.

11. Check accumulator connections for leakage. If leakage is present, depressurize the system before making repairs.

12. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault

codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

13. Disconnect the EZ-TECH® from the diagnostic connector.

14. Remove wheel chocks.

NOTE – Bleeding the system is not necessary.

Accumulator Disposal Procedure

An internal chamber in the accumulators is precharged with gas pressure to 1087 psi. Accumulators that have been removed must be depressurized and disabled, as described in the following procedure, before they can be scrapped.

WARNING – It is possible for a removed accumulator to retain an internal pressure of up to 1087 psi. Before disposing of an accumulator, verify its warranty status. If the accumulator is to be discarded, perform the following steps to depressurize the accumulator and disable its pressure chamber. Failure to follow this warning could result in property damage, personal injury or death.

WARNING – The appropriate safety measures must be taken when performing the following procedure. Safety goggles (not glasses) must be worn. The accumulator must be oriented correctly (see FIGURE 60), and securely clamped in the drill press vise to prevent it from rolling or falling. Any liquid spilled or drained from the accumulator should be treated as waste brake fluid, and must be disposed of properly. Personnel should remain a safe distance from the work area during this procedure, and/or a protective shield should be positioned to prevent any projected metal shavings from reaching the drill operator and/or nearby personnel. Failure to follow this warning could result in property damage, personal injury or death.

IMPORTANT – Before disabling an accumulator, check its warranty status. Parts that are to be returned under warranty must not be drilled.

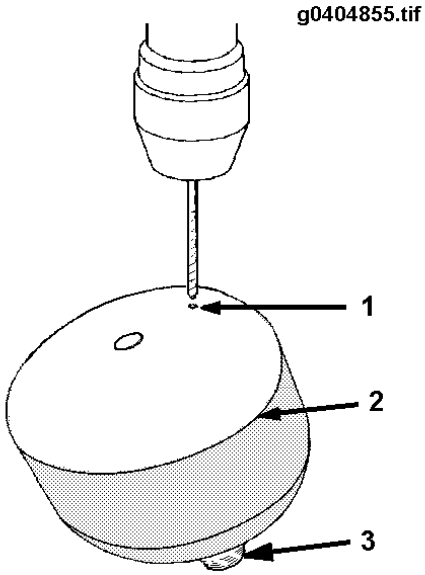

Figure 60 Orientation of Accumulator for Drilling and Disposal

1. CENTER-PUNCHED DRILLING POINT
2. WELDED SEAM
3. THREADED PORT

1. Secure the accumulator on a drill press table using a vise or clamp that will allow the accumulator to be oriented as shown in FIGURE 60. The drilling point will be on the opposite side of the welded seam from the threaded port.

2. Center-punch the accumulator at the location to be drilled.

CAUTION – In the following step, a slight hissing sound may be heard when the wall of the accumulator is pierced. Also, metal shavings may be blown away from the hole.

3. Using a 3mm drill bit (1/8 inch will work), slowly and carefully drill approximately 1/2 inch into the accumulator.

4. After releasing the internal pressure, the accumulator may be scrapped.

6.8. HYDRAULIC COMPACT UNIT

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

CAUTION – The HCU contains brake fluid and must be handled with appropriate care when removed from the vehicle. It should not be exposed to impact loads, excessive vibrations or compressed air blown into the hydraulic ports.

IMPORTANT – This component has a limited shelf life. When replacing this component, note the expiration date.

NOTE – The ECU has programmable parameters that vary by vehicle wheelbase and configuration. The replacement ECU is programmed with the default settings for these parameters. After replacing an ECU, refer to ISIS to modify the programmable parameters to match those assigned to the vehicle's VIN number. This modification requires the use of the EZ-Tech® service tool and the TOOLBOX™ diagnostic software.

Removal

1. Install wheel chocks.

2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 48 (See Figure 48, page 89).

3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

4. Depressurize the system as follows:

   a. Depress the brake pedal a minimum of 30 times.

   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

5. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

6. Carefully clean the area around the HCU, including the outside of the HCU itself.

7. Unlatch and disconnect both electrical connectors from the ECU module. Refer to FIGURE 56 (See Figure 56, page 105). Disconnect the electrical connector from the Pressure Supply Valve on the HCU. Refer to FIGURE 61 (See Figure 61, page 116).

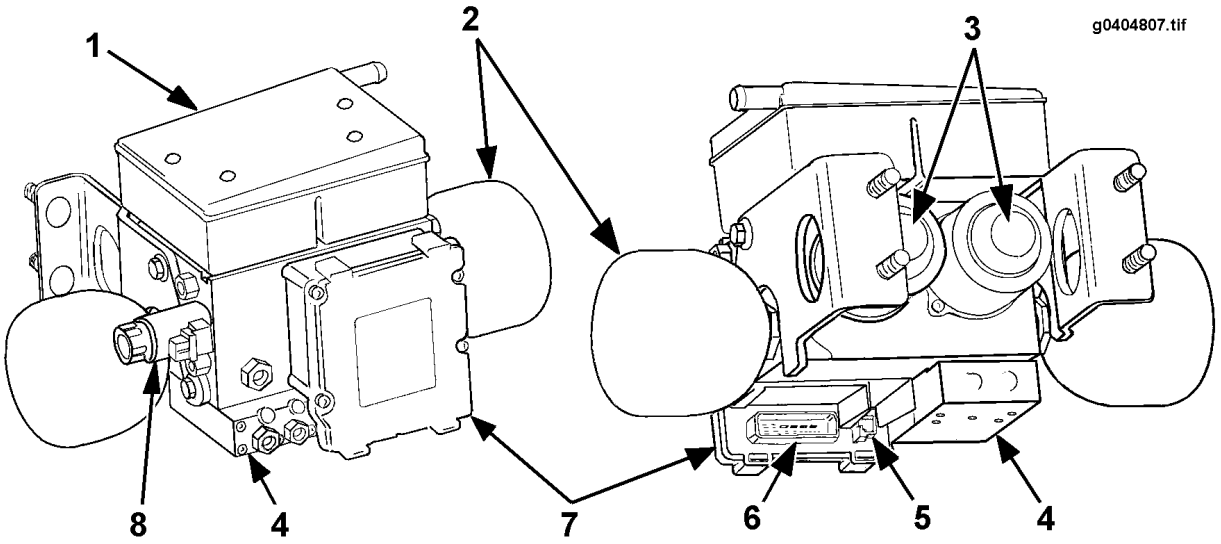

Figure 61 Locations of HCU Components and Connectors

1. RESERVOIR
2. ACCUMULATORS
3. PUMP MOTORS
4. RELAY VALVE
5. 2-PIN CONNECTOR
6. 31-PIN CONNECTOR
7. ELECTRONIC CONTROL UNIT (ECU)
8. PRESSURE SUPPLY VALVE WITH CONNECTOR

8. Use a clamp to pinch the low pressure hose at the inlet to the HCU reservoir. Place the clamp midway between the HCU reservoir inlet and the crossmember, being careful not to damage the reservoir inlet. Refer to FIGURE 55 (See Figure 55, page 102).

9. To provide better access to other components and reduce the weight of the HCU, remove both accumulators from the HCU. Refer to ACCUMULATOR Removal procedures (See ACCUMULATOR, page 109). Retain these accumulators for reinstallation unless they are to be replaced.

10. If necessary, loosen the 2 clamps (see FIGURE 54) securing the middle section of the low pressure hose to the chassis (See Figure 54, page 101). Clamps must be loose enough to allow the hose to slide forward in the next step.

NOTE – Before performing the following 3 steps, position a container to collect any drained or spilled brake fluid to ensure that no fluid will spill onto the ground or damage the paint.

11. Disconnect the low pressure hose from the HCU reservoir.

12. Plug the low pressure hose and the reservoir inlet to prevent system contamination.

NOTE – When removing brake lines from the HCU, use a backup wrench to prevent loosening of the adapter fittings from the HCU body.

13. Disconnect the 7 brake line fittings from HCU, and protect the tubes and the ports on the HCU from contamination by installing matching plugs. Refer to FIGURE 62.

14. To allow easy removal of the HCU, LOOSEN the two bolts securing either HCU mounting bracket to the frame rail. The bolts should be left in place, but must be loose enough to allow slight movement of the mounting bracket. Refer to FIGURE 63.

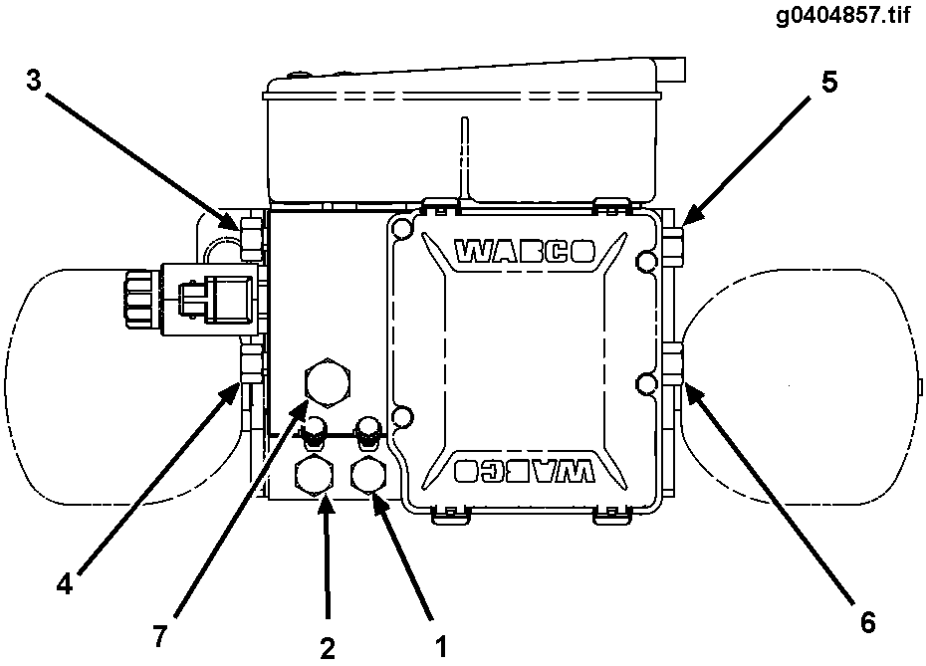

Figure 62 HCU Brake Line Ports

1. PORT 1 – SECONDARY MASTER CYLINDER (REAR BRAKE CIRCUIT)
2. PORT 2 – PRIMARY MASTER CYLINDER (FRONT BRAKE CIRCUIT)
3. PORT 3 – LEFT REAR
4. PORT 4 – RIGHT REAR
5. PORT 5 – LEFT FRONT
6. PORT 6 – RIGHT FRONT
7. PORT 7 – SAHR PORT

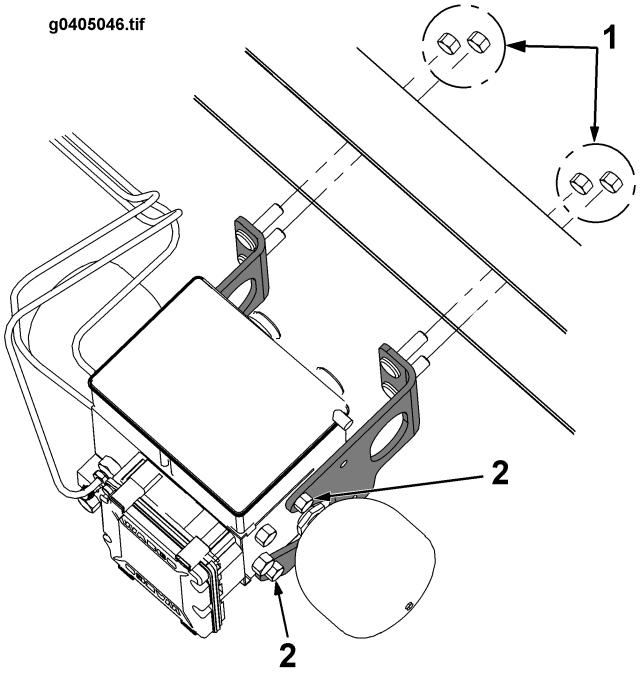

Figure 63 Location of HCU Mounting Hardware

1. BRACKET-TO-FRAME MOUNTING HARDWARE (4)
2. HCU-TO-BRACKET BOLTS (4) – (REAR BRACKET BOLTS HIDDEN)

15. Detach the HCU from the HCU mounting brackets by removing the 2 bolts securing the HCU to each bracket. Remove the HCU by sliding it downwards. Retain the mounting hardware (4 bolts and 4 bushings) for use with the replacement HCU.

16. Empty the HCU reservoir (still attached to the HCU) by pouring the brake fluid into a suitable container.

17. Remove parking brake Pressure Supply Valve and coil for transfer to replacement HCU. Refer to PRESSURE SUPPLY VALVE procedures (See PRESSURE SUPPLY VALVE, page 123). Also, remove brake line fitting from SAHR port (see FIGURE 62) for transfer to replacement HCU. Other brake line fittings are supplied with the replacement HCU.

Installation

CAUTION – Refer to the figures to verify that disconnected brake lines are reconnected to the correct ports. Incorrect installation may result in brake, ABS or ATC malfunction. Inadvertent braking of the front wheels could result.

IMPORTANT – Adjacent brake lines are fitted with difference size fittings so that they cannot be connected incorrectly. However, to prevent thread damage it is advisable to review the figures if there is any question about how the lines are to be connected.

IMPORTANT – Verify that the HCU being installed contains the same components as the HCU being replaced.

IMPORTANT – Replacement HCU's are supplied as an assembly containing the following parts: both pump motors, ECU, relay valve assembly, all internal valves, reservoir, both accumulators, and brake line fitting inserts for the master cylinder and wheel end brake lines. The reservoir is shipped unmounted.

IMPORTANT – The replacement HCU is precharged with brake fluid to ensure successful bleeding and to protect the pumps against dry operation. To prevent fluid loss, do not remove protection caps from HCU until you are ready to connect the brake lines.

1. If necessary, transfer parking brake Pressure Supply Valve and coil to the replacement HCU. Refer to PRESSURE SUPPLY VALVE procedures (See PRESSURE SUPPLY VALVE, page 123). Also, transfer the brake line fitting from the SAHR port to the replacement HCU. (Other brake line fittings are supplied with the replacement HCU.)

2. Remove the protection caps from the HCU reservoir seals. Install the new reservoir onto the new HCU by pressing it carefully and fully into the seals.

3. Using the four new mounting screws and a Phillips-head screwdriver, attach the reservoir to the HCU. Tighten the screws to 5 to 6.7 Nm (44 to 60 Lbf-in).

4. After verifying that all HCU ports are plugged, fill the HCU reservoir with approximately 2 quarts of new DOT 3 or DOT 4 brake fluid from a sealed container.

5. Place 4 bushings into the HCU mounting holes in both HCU brackets (2 bushings per bracket). The stepped bushings are pushed into the holes from the inside surfaces of the brackets.

6. Position the HCU between the mounting brackets and secure it using 2 bolts per bracket. Verify that the mounting bushings remained in place. Torque HCU mounting bolts to 43–46 Nm (32–34 Lbf-ft).

7. Tighten the two bolts (securing the HCU mounting bracket to the frame rail) that were loosened previously. Torque these bolts to 108–135 Nm (79.7–99.6 Lbf-ft).

8. Connect the brake lines to the HCU as indicated in FIGURE 62 (See Figure 62, page 117). Torque these fittings to 12.2 to 19 Nm (9 to 14 Lbf-ft).

IMPORTANT – In the following step, position the hose clamp at the HCU reservoir so that the pinch tabs are easily accessible.

9. Connect the low pressure hose to the HCU reservoir and secure with hose clamp. Position the hose clamp so that the pinch tabs are easily accessible.

10. If the HCU being installed is missing accumulators, install both accumulators at this time. Refer to the ACCUMULATOR Installation procedures (See ACCUMULATOR, page 109).

    If the accumulators are already on the HCU, proceed to the next step.

11. Remove the clamp used to pinch the low pressure hose during removal.

12. If the center clamps on the low pressure hose were loosened previously, tighten them to secure the low pressure hose.

WARNING – In the following step, insure that the ECU connectors are properly installed and latched to prevent them from becoming disconnected. Failure to securely connect AND LATCH the ECU connectors could result in loss of braking functions during vehicle operation. Failure to follow this warning could result in property damage, personal injury or death.

13. Connect the 2 electrical connectors to the HCU ECU. Secure the electrical connectors by engaging the latches. Connect the 1 electrical connector to the parking brake Pressure Supply Valve.

14. Bleed the MC circuit. Refer to PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61).

15. Bleed the brake caliper circuits. Refer to PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61).

16. Bleed the SAHR circuit. Refer to PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61).

17. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 48 (See Figure 48, page 89).

18. Depressurize the system by depressing the brake pedal a minimum of 30 times.

NOTE – This will force fluid from the accumulators back into the HCU reservoir to purge trapped air from the reservoir, through the low pressure hose.

19. Install the two pump motor fuses.

20. Switch ON the ignition. HCU pump motors will start up automatically and fill the accumulators (running time approximately 45 seconds).*

21. Pump the brakes rapidly 4 times to activate both HCU pump motors. After pumps stop, fill the MC reservoir up to the MAX mark with new DOT 3 or DOT 4 brake fluid from a sealed container.

22. Install the MC reservoir cap.

WARNING – If leakage is noted in the following step, the system MUST be depressurized BEFORE making repairs. Perform steps 2 thru 5 of the HYDRAULIC COMPACT UNIT REMOVAL procedures to verify that the system is depressurized. Failure to follow this warning could result in property damage, personal injury or death.

23. Check system for leakage. If leakage is present, depressurize the system before making repairs.

24. Using the EZ-Tech® service tool and the TOOLBOX™ diagnostic software, refer to ISIS to program the replacement ECU to match the vehicle's VIN number.

25. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

26. Disconnect the EZ-TECH® from the diagnostic connector.

27. Remove wheel chocks.

6.9. HCU RESERVOIR

WARNING – Any form of contamination entering the system could prevent the system from operating correctly. Thoroughly clean the area around fittings before disconnecting the fittings. Always plug open ports and lines as quickly as possible. Contamination in the system could result in loss of braking functions during vehicle operation. Failure to follow this warning could result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

Access to the HCU reservoir depends on the body installed on the vehicle; therefore, removal of the entire HCU (with reservoir) is required, prior to replacement of the reservoir. The reservoir can then be replaced on the bench.

Removal

1. Remove the HCU. Refer to the HYDRAULIC COMPACT UNIT Removal procedures (See HYDRAULIC COMPACT UNIT, page 115). Do NOT remove components from the HCU assembly until instructed to do so in this procedure.

2. Empty the reservoir (still attached to the HCU) by pouring the brake fluid into a suitable container.

3. Inspect the area between the body of the HCU and the HCU reseroir to ensure the area is free of any dirt or other contaminants. Clean if necessary. Do not allow any contaminants to enter the HCU ports.

4. Using a number 4 Phillips–head screwdriver, remove the 4 HCU reservoir mounting screws.

5. Lift the reservoir off of the HCU. Some resistance will be felt due to the rubber seals between the HCU and the reservoir. Refer to FIGURE 64.

6. Verify that the four rubber seals were removed from the HCU with the reservoir. If not, remove the old seals from the ports on top of the HCU.

7. Plug the reservoir ports to insure that no contamination will enter the HCU.

8. Carefully clean the top of the HCU that was previously covered by the reservoir.

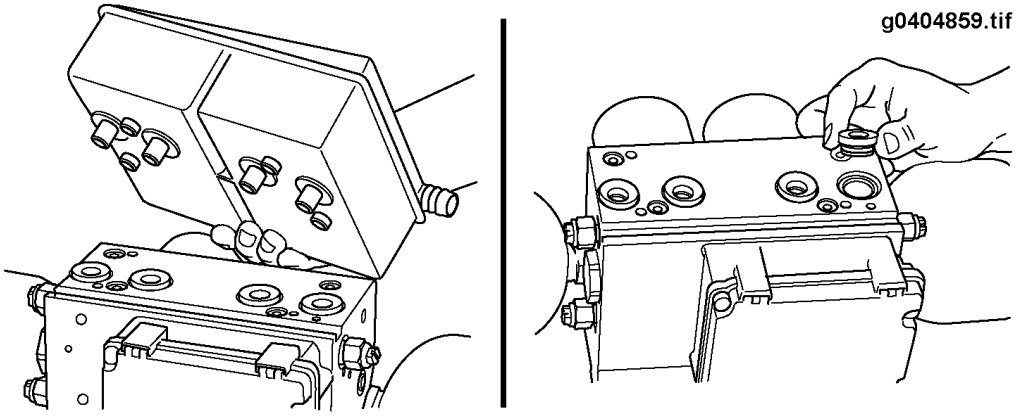

Figure 64 HCU Reservoir and Reservoir Seals

Installation

NOTE – Replacement HCU reservoirs are supplied as a kit that includes four seals and four screws.

1. Carefully clean the top of the HCU that was previously covered by the reservoir.

2. Install four new black rubber HCU – to – reservoir seals into the ports on top of the HCU.

3. Lubricate the reservoir seals with new DOT 3 or DOT 4 brake fluid.

NOTE – When installing the reservoir in the following step, insure that it is oriented correctly. The mounting screw holes must line up and the inlet port for the low pressure hose must face the front.

4. Install the new reservoir by pressing it carefully and fully into the seals.

5. Using the four new mounting screws and a Phillips-head screwdriver, attach the reservoir to the HCU. Tighten the screws to 5 to 6.7 Nm (44 to 60 Lbf-in).

NOTE – While performing the following step, it is not necessary to program the ECU after installation, because it was not replaced. However, any brake system related inactive diagnostic codes should be cleared using the EZ-TECH® and the TOOLBOX™ program. If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

6. Install the HCU. Perform the HYDRAULIC COMPACT UNIT Installation procedures (See HYDRAULIC COMPACT UNIT, page 115).

6.10. 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 property damage, personal injury or death.

WARNING – Any form of contamination entering the system could prevent the system from operating correctly. Thoroughly clean the area around fittings before disconnecting the fittings. Always plug open ports and lines as quickly as possible. Contamination in the system could result in loss of braking functions during vehicle operation. Failure to follow this warning could result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

Removal

1. Install wheel chocks.

2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 48 (See Figure 48, page 89).

3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

4. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

5. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

6. Carefully clean the outside of the Hydraulic Compact Unit (HCU) and the Pressure Supply Valve (PSV).

7. Disconnect the electrical connector from the PSV. Refer to FIGURE 65.

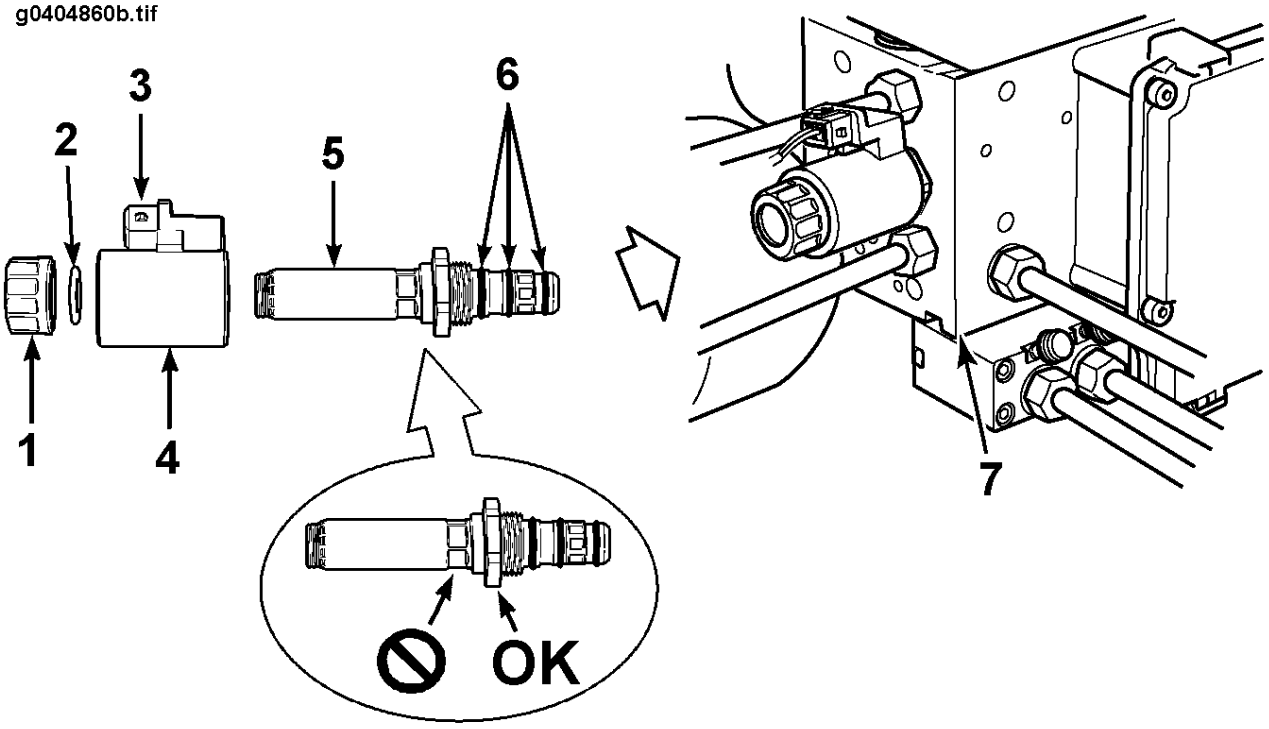

Figure 65 Exploded View of Pressure Supply Valve

1. PLASTIC NUT
2. LARGE O-RING
3. PSV CONNECTOR
4. COIL
5. PSV CORE (APPLY TORQUE TO BASE HEX NUT ONLY)
6. SMALL O-RINGS
7. HCU

8. Use a clamp to pinch the low pressure hose at the inlet to the HCU reservoir. Place the clamp about midway between the HCU reservoir inlet and the crossmember, being careful not to damage the reservoir inlet. Refer to FIGURE 55 (See Figure 55, page 102).

9. Unscrew the black plastic retaining nut from the end of the PSV. NOTE: This will be easier if the coil is grasped along with the retaining nut. If the nut cannot be loosened by hand, use a strap wrench.

10. Remove the O-ring and coil assembly from the PSV core.

11. Position a container to collect the drained brake fluid in the next step. Ensure that no fluid will spill onto the ground or damage the paint.

WARNING – The PSV core must be loosened and tightened only by the hex nut that forms its base. The flats on the PSV core body MUST NOT BE USED (FIGURE 65). Applying torque to the flats on the core body may damage the PSV.

Engaging the base of the PSV core requires an extra deep, thin-walled, deep well socket, such as service tool ZTSE4781 (or equivalent).

Failure to follow this warning could result in property damage, personal injury or death.

12. Remove the PSV core from the HCU using a 1 3/16 inch thin-walled, deep well socket, such as service tool ZTSE4781 (or equivalent).

13. To prevent system contamination and fluid loss, immediately plug the PSV port, or install the replacement PSV.

Installation

1. Remove the O-ring and coil from the replacement PSV core.

2. Remove the plug from the PSV port. Verify that the old O-ring seals have not remained in the PSV port. Clean the PSV port and the surrounding area.

3. Lubricate the O-rings on the new PSV core with new DOT 3 or DOT 4 brake fluid from a sealed container.

WARNING – The PSV core must be loosened and tightened only by the hex nut that forms its base. The flats on the PSV core body MUST NOT BE USED (FIGURE 65). Applying torque to the flats on the core body may damage the PSV.

Engaging the base of the PSV core requires an extra deep, thin-walled, deep well socket, such as service tool ZTSE4781 (or equivalent).

Failure to follow this warning could result in property damage, personal injury or death.

4. Install the new PSV core and tighten by hand until snug. Then, using a torque wrench and a 1 3/16 inch thin-walled, deep well socket, such as service tool ZTSE4781 (or equivalent); tighten the PSV core to 40 to 50 Nm (29.5 to 36.8 Lbf-ft).

5. Install the coil onto the PSV core so that the connector is correctly positioned (plug is oriented away from the frame and facing the rear).

6. Place the large O-ring onto the valve core after the coil, then secure the coil with the black plastic retaining nut. Tighten the nut snugly by hand. Do not overtighten.

7. Connect the wire harness electrical connector to the PSV coil.

8. Carefully remove the clamp used to pinch the low pressure hose during removal.

9. Make sure fluid is at or above the MAX mark in the Master Cylinder (MC) reservoir. If not, fill the reservoir to the MAX mark with new, DOT 3 or DOT 4 brake fluid from a sealed container.

10. Connect the battery and install the two pump motor fuses.

11. Switch ON the ignition. The HCU pump motors will start and run for approximately 45 seconds. This will fill the accumulators and pressurize the system.

12. After the pump motors stop, fill the MC reservoir up to the MAX mark with new, DOT 3 or DOT 4 brake fluid from a sealed container.

13. Release and apply the parking brake several times using the parking brake switch. The key must be on and the brake pedal must be depressed. Leave parking brake in the applied position.

14. Bleed the parking brake circuit, following the service bleeding procedure. Refer to PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61).

WARNING – If leakage is noted in the following step, the system MUST be depressurized BEFORE making repairs. Perform steps 2 thru 5 of the PRESSURE SUPPLY VALVE REMOVAL procedure to verify that the system is depressurized. Failure to follow this warning could result in property damage, personal injury or death.

15. Check PSV connections for leakage. If leakage is present, depressurize the system before making repairs.

16. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

17. Apply and release the parking brake several times to verify correct operation. Also verify that the SERVICE PARK BRAKE warning indicator did not light, and no new fault codes were generated.

18. Turn the key off and disconnect the EZ-TECH® from the diagnostic connector.

19. Remove wheel chocks.

6.11. COIL FOR PSV

Removal

1. Install wheel chocks and turn key off.

2. Carefully clean the outside of the Pressure Supply Valve (PSV).

3. Disconnect the electrical connector from the PSV. Refer to FIGURE 65 (See Figure 65, page 124).

4. Unscrew the black plastic PSV retaining nut from the PSV. NOTE: This will be easier if the coil is grasped along with the retaining nut. If the nut cannot be loosened by hand, use a strap wrench.

5. Remove the O-ring and the coil assembly from the PSV core.

Installation

1. Install the replacement coil onto the PSV core so that the connector is correctly positioned (plug is away from the frame and facing the rear).

2. Place the O-ring on the PSV after the coil, then secure the coil with the black plastic retaining nut. Tighten the nut snugly by hand. Do not overtighten.

3. Connect the electrical connector to the PSV coil.

4. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

5. Turn key on, depress the brake pedal; then, apply and release the parking brake several times to verify correct operation. Also verify that the SERVICE PARK BRAKE warning indicator did not light, and no new fault codes were generated.

6. Turn the key off and disconnect the EZ-TECH® from the diagnostic connector.

7. Remove wheel chocks.

6.12. RELAY VALVE ASSEMBLY

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 property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

Removal

1. Install wheel chocks.

2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 48 (See Figure 48, page 89).

3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

4. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

> **WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.**

5. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

6. Use a clamp to pinch the low pressure hose at the inlet to the HCU reservoir. Place the clamp midway between the HCU reservoir inlet and the crossmember, being careful not to damage the reservoir inlet. In some vehicle applications the rubber section of the low pressure hose is too short to provide a leakproof clamp at this location. If necessary, clamp the low pressure hose 4 or 5 inches below the master cylinder outlet. Refer to FIGURE 55 (See Figure 55, page 102).

7. Carefully clean the relay valve assembly and the area around it. Refer to FIGURE 66.

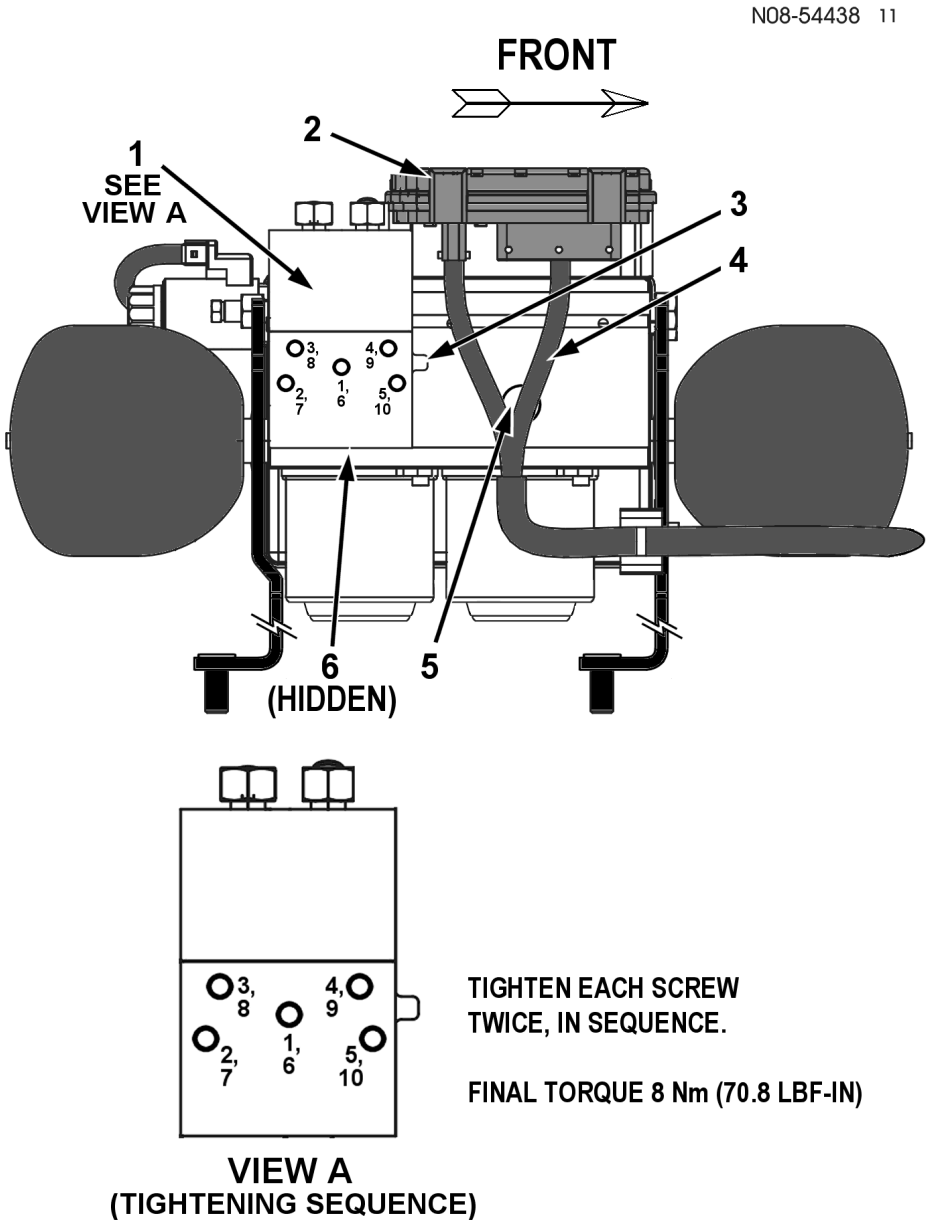

Figure 66 HCU Bottom View

1. RELAY VALVE ASSEMBLY
2. ECU
3. ORIENTATION TAB ON SEAL PLATE
4. ECU ELECTRICAL HARNESS
5. RETAINING PLUG FOR SECONDARY (REAR) SYSTEM PUMP
6. RETAINING PLUG FOR PRIMARY (FRONT) SYSTEM PUMP (UNDER ITEM 1)

NOTE – Before performing the following steps, position a container to collect any drained or spilled brake fluid to ensure that no fluid will spill onto the ground or damage the paint.

8. Disconnect both master cylinder brake lines from the relay valve assembly on the HCU. Plug the brake lines and position them out of the way. Refer to FIGURE 62 (See Figure 62, page 117).

9. Using a 4 mm Allen wrench, remove the 5 screws that attach the relay valve assembly to the HCU. Refer to FIGURE 67.

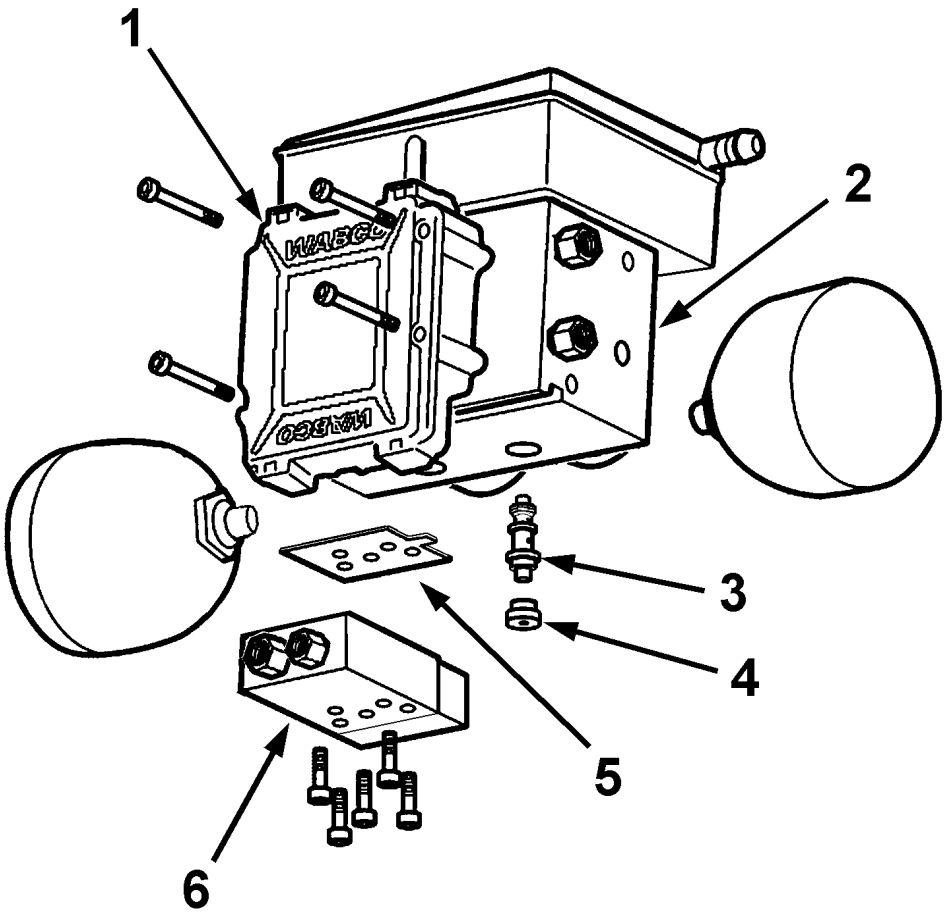

Figure 67 HCU Exploded View

1. ECU
2. HCU
3. SECONDARY (REAR SYSTEM) PUMP
4. PUMP RETAINING PLUG
5. RELAY VALVE ASSEMBLY SEAL PLATE
6. RELAY VALVE ASSEMBLY

CAUTION – If the relay valve assembly is to be re-used, no rubber or other material must be allowed to enter the orifices on the top of the assembly.

10. Remove the rubber coated relay valve seal plate. Bend the seal plate to prevent re-use, and discard.

Installation

NOTE – If it is necessary to clean the mating surfaces of the HCU and relay valve assembly, use denatured alcohol and a lint-free cloth.

IMPORTANT – The relay valve seal plate must be positioned with the orientation tab in the correct location, **AND** the mounting screw holes aligned with those in the relay valve assembly.

1. Position a new seal plate on the relay valve assembly, as follows;
   a. Insert two mounting screws into the relay valve assembly. In order for the screws to protrude through the relay valve, they must be held with Allen wrenches or other tools.
   b. Using the screws as a guide, position the new, clean seal plate onto the top of the relay valve assembly with the orientation tab located as indicated in FIGURE 66.
   c. Position the relay valve assembly against the bottom of the HCU, and thread the 2 screws into the HCU. Finger tighten only.
2. Install the remaining 4 mounting screws, and torque all 6 screws to 8.0 Nm (70.8 lbf-in) in a two step process. Torque each screw twice following the sequence indicated in FIGURE 66.
3. Connect the master cylinder brake lines to the relay valve assembly as indicated in FIGURE 62 (See Figure 62, page 117). Torque these fittings to 12.2 to 19 Nm (9 to 14 Lbf-ft).
4. Remove the clamp used to pinch the low pressure hose during removal.
5. Fill the master cylinder reservoir up to the MAX mark with new DOT 3 or DOT 4 brake fluid from a sealed container.

IMPORTANT – The fluid level in the MC reservoir may drop when pressure is applied in the following step. Whenever the MC reservoir is pressurized with air **the fluid level in the reservoir must be monitored** to ensure that the level never drops below the MIN mark. If necessary, remove pressure from the reservoir and add brake fluid to the MAX mark.

6. Using service tool adapter ZTSE4678 and regulator/filter (ZTSE4757-1 or equivalent), pressurize the MC reservoir with filtered air regulated to 35 psi. Ensure that the adapter is securely tightened onto the MC reservoir filler neck, and that the air lines and connections are not placing undue stress on the MC reservoir filler neck. Refer to FIGURE 39 (See Figure 39, page 65).
7. Connect the battery and install the two pump motor fuses.
8. Switch ON the ignition. HCU pump motors will start up automatically and fill the accumulators (running time approximately 45 seconds)*.
9. Check the fluid level in the MC reservoir. If the fluid level is at or below the MIN mark, remove air pressure from the reservoir and fill to the MAX mark with new DOT 3 or DOT 4 brake fluid from a sealed container. Repressurize the MC reservoir to 35 psi, as in step 6.
10. Using the EZ-TECH® and the TOOLBOX™ program, perform the DEPLETE ACCUMULATORS function. Select the DEPLETE ACCUMULATORS function from the EOL pull down menu. This function helps clear air from the system by depressurizing and repressurizing both accumulators. A dialog box will indicate when the function is complete.
11. Release the pressure from the MC reservoir.

12. Verify that the fluid in the MC reservoir is at or near the MAX mark.

13. Using the EZ-TECH® and the TOOLBOX™ program, perform the DEPLETE ACCUMULATORS function two more times.

14. Bleed the master cylinder circuits. Refer to PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61).

WARNING – If leakage is noted in the following step, the system MUST be depressurized BEFORE making repairs. Perform steps 2 thru 5 of the RELAY VALVE ASSEMBLY REMOVAL procedures to verify that the system is depressurized. Failure to follow this warning could result in property damage, personal injury or death.

15. Check system for leakage. If leakage is present, depressurize the system before making repairs.

16. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

17. Set the ignition key to OFF and disconnect the EZ-TECH® from the diagnostic connector.

18. Remove wheel chocks.

* If 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. HCU pump motors should stop within 3 minutes, with brake warning light and buzzer OFF. If that is not the case (one or both pumps do not prime), performing the DEPLETE ACCUMULATORS function in the following steps should correct the problem. After completing the DEPLETE ACCUMULATORS function, both accumulators should be fully charged as indicated on the TOOLBOX™ screen. If an accumulator is still not charging correctly refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76) to make the necessary repairs.

6.13. HCU PUMPS

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 property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

Both pumps are located in cavities in the HCU, and are accessed from the bottom of the HCU. The retaining plug for the secondary system pump is visible on the bottom of the HCU (FIGURE 66). While this pump is located nearest the front of the HCU, it pressurizes the rear axle brake system.

The retaining plug for the primary system pump is located under the relay valve assembly. This pump pressurizes the front axle brake system. Accessing the primary system pump requires moving the relay valve assembly. This can be done without disconnecting the master cylinder brake lines; therefore, it is not necessary to bleed the master cylinder circuit after performing this procedure.

If both HCU pumps are being replaced, replace the secondary pump first. It is unnecessary to perform the DEPLETE ACCUMULATORS steps after replacing the first pump. After replacing the first pump proceed directly to the removal of the second pump, skipping any common preparation steps. Performing the DEPLETE ACCUMULATORS steps after replacing the second pump will remove air from both pump circuits.

Secondary HCU Pump Removal and Installation

1. Install wheel chocks.

2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 48 (See Figure 48, page 89).

3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

4. Depressurize the system as follows:

a. Depress the brake pedal a minimum of 30 times.

b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

5. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

6. Use a clamp to pinch the low pressure hose at the inlet to the HCU reservoir. Place the clamp midway between the HCU reservoir inlet and the crossmember, being careful not to damage the reservoir inlet. In some vehicle applications the rubber section of the low pressure hose is too short to provide a leakproof clamp at this location. If necessary, clamp the low pressure hose 4 or 5 inches below the master cylinder outlet. Refer to FIGURE 55 (See Figure 55, page 102).

7. Unlatch and disconnect both electrical connectors from the ECU module, and position the loose harnesses out of the way. Refer to FIGURE 66 and FIGURE 56 (See Figure 56, page 105).

8. Carefully clean the bottom surface of the HCU. Be careful not to contaminate the connectors/pins of the ECU.

NOTE – Before performing the following steps, position a container to collect any drained or spilled brake fluid to ensure that no fluid will spill onto the ground or damage the paint.

9. Prepare a replacement pump for installation by lubricating both pump O-rings with clean brake fluid; and then actuating the pump several times by depressing the spring-loaded pump button by hand. Note: The initial force required to actuate the pump (depress the pump button) may be high. After the first actuation the force required to depress the button should be reduced.

10. Using a 6 mm Allen wrench, remove the secondary pump retaining plug from the HCU (FIGURE 67).

CAUTION – The condition of the pump bore is very important. Do not allow tools to damage the surface of the bore.

CAUTION – In the following steps, do not damage the pump O-rings while installing the replacement pump. The O-rings must be lubricated with clean brake fluid.

IMPORTANT – To minimize the amount of brake fluid spilled, insure that the replacement pump is prepared and within reach **before** removing the pump.

11. Using clean needle nose pliers (with a good grip) remove the secondary pump from the bore. Allowing the pliers to slip could create metal shavings that must be removed.

12. Immediately install the replacement pump. Carefully seat the pump into the bore, using light hand pressure only. Refer to FIGURE 67 (See Figure 67, page 130).

13. Verify that the retaining plug is clean; then install the plug and torque it to 20 to 24 Nm (14.8 to 17.7 lbf-ft).

14. Clean spilled brake fluid from the surface of the HCU.

WARNING – In the following step, insure that the ECU connectors are properly installed and latched to prevent them from becoming disconnected. Failure to securely connect AND LATCH the ECU connectors could result in loss of braking functions during vehicle operation. Failure to follow this warning could result in property damage, personal injury or death.

15. Connect the 2 electrical connectors to the HCU ECU. Secure the electrical connectors by engaging the latches. Refer to FIGURE 66 and FIGURE 56 (See Figure 56, page 105).

16. Remove the clamp used to pinch the low pressure hose during removal.

17. Fill the MC reservoir up to the MAX mark with new DOT 3 or DOT 4 brake fluid from a sealed container.

IMPORTANT – The fluid level in the MC reservoir may drop when pressure is applied in the following step. Whenever the MC reservoir is pressurized with air **the fluid level in the reservoir must be monitored** to ensure that the level never drops below the MIN mark. If necessary, remove pressure from the reservoir and add brake fluid to the MAX mark.

18. Using service tool adapter ZTSE4678 and regulator/filter (ZTSE4757-1 or equivalent), pressurize the MC reservoir with filtered air regulated to 35 psi. Ensure that the adapter is securely tightened onto the MC reservoir filler neck, and that the air lines and connections are not placing undue stress on the MC reservoir filler neck. Refer to FIGURE 39 (See Figure 39, page 65).

19. Connect the battery and install the two pump motor fuses.

20. Switch ON the ignition. HCU pump motors will start up automatically and fill the accumulators (running time approximately 45 seconds).*

21. Check the fluid level in the MC reservoir. If necessary, remove air pressure from the reservoir and fill to the MAX mark with new DOT 3 or DOT 4 brake fluid from a sealed container. Repressurize the MC reservoir to 35 psi, as in step 17.

22. Using the EZ-TECH® and the TOOLBOX™ program, perform the DEPLETE ACCUMULATORS function. Select the DEPLETE ACCUMULATORS function from the EOL pull down menu. This function helps clear air from the system by depressurizing and repressurizing both accumulators. A dialog box will indicate when the function is complete.

23. Release the pressure from the MC reservoir and remove the pressure bleeder equipment.

24. Verify that the fluid in the MC reservoir is at the MAX mark, then install the MC reservoir cap.

25. Using the EZ-TECH® and the TOOLBOX™ program, perform the DEPLETE ACCUMULATORS function two more times.

WARNING – If leakage is noted in the following step, the system MUST be depressurized BEFORE making repairs. Perform steps 2 thru 5 of these procedures to verify that the system is depressurized. Failure to follow this warning could result in property damage, personal injury or death.

26. Check system for leakage. If leakage is present, depressurize the system before making repairs.

27. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

28. Set the ignition key to OFF and disconnect the EZ-TECH® from the diagnostic connector.

29. Remove wheel chocks.

* If 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. HCU pump motors should stop within 3 minutes, with brake warning light and buzzer OFF. If that is not the case (one or both pumps do not prime), performing the DEPLETE ACCUMULATORS function in the following steps should correct the problem. After completing the DEPLETE ACCUMULATORS function, both accumulators should be fully charged as indicated on the TOOLBOX™ screen. If an accumulator is still not charging correctly refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING (See DIAGNOSTICS AND TROUBLESHOOTING, page 76) to make the necessary repairs.

Primary HCU Pump Removal and Installation

IMPORTANT – When moving the relay valve assembly to gain access to the HCU pump, **DO NOT** disconnect the master cylinder brake lines. If these lines are disconnected, the master cylinder circuit must be bled as indicated in the RELAY VALVE ASSEMBLY Installation procedures (See RELAY VALVE ASSEMBLY, page 127).

1. Prepare a replacement pump for installation by lubricating both pump O-rings with clean brake fluid; and then actuating the pump several times by depressing the spring-loaded pump button by hand. Note: The initial force required to actuate the pump (depress the pump button) may be high. After the first actuation the force required to depress the button should be reduced.

2. Remove the relay valve assembly from the HCU, but **DO NOT** disconnect the master cylinder brake lines. Refer to the RELAY VALVE ASSEMBLY Removal procedures (See RELAY VALVE ASSEMBLY, page 127).

3. Taking care not to kink or bend the brake lines, reposition the relay valve assembly (**with the brake lines attached**) to allow access to the bottom of the HCU.

4. Using a 6 mm Allen wrench, remove the primary pump retaining plug from the HCU (FIGURE 67).

CAUTION – The condition of the pump bore is very important. Do not allow tools to damage the surface of the bore.

CAUTION – In the following steps, do not damage the pump O-rings while installing the replacement pump. The O-rings must be lubricated with clean brake fluid.

IMPORTANT – To minimize the amount of brake fluid spilled, insure that the replacement pump is prepared and within reach **before** removing the pump.

5. Using clean needle nose pliers (with a good grip) remove the primary pump from the bore. Allowing the pliers to slip could create metal shavings that must be removed.

6. Immediately install the replacement pump. Carefully seat the pump into the bore, using light hand pressure only. Refer to FIGURE 67 (See Figure 67, page 130).

7. Verify that the retaining plug is clean; then install the plug and torque it to 20 to 24 Nm (14.8 to 17.7 lbf-ft).

8. Install the relay valve assembly. Refer to the RELAY VALVE ASSEMBLY Installation procedures (See RELAY VALVE ASSEMBLY, page 127). If the master cylinder brake lines were not disconnected, it is not necessary to bleed the master cylinder circuit.

6.14. SPRING APPLIED HYDRAULICALLY RELEASED (SAHR) CANISTER

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 property damage, personal injury or death.

WARNING – Any form of contamination entering the system could prevent the system from operating correctly. Thoroughly clean the area around fittings before disconnecting the fittings. Always plug open ports and lines as quickly as possible. Contamination in the system could result in loss of braking functions during vehicle operation. Failure to follow this warning could result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

Removal

1. Install wheel chocks.

CAUTION – While removing a 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.

2. Disconnect the parking brake cable. Refer to FIGURE 68.

- If the parking brake system is **inoperable**, disconnect the cable as follows:

    A. Place the transmission in Park (P or PB) if available; otherwise, use neutral (N). Turn the key to OFF.

    B. 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.

    C. 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.

- If the parking brake system is **operable**, disconnect the cable as follows:

    A. Place the transmission in neutral (N), **not** P or PB. Turn the key ON.

    B. While pressing the brake pedal, press the dash mounted PARK BRAKE switch to release the parking brake. This will extend the SAHR canister shaft and relieve the tension on the parking brake cable.

    C. 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.

    D. 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.

    E. Turn the key to OFF.

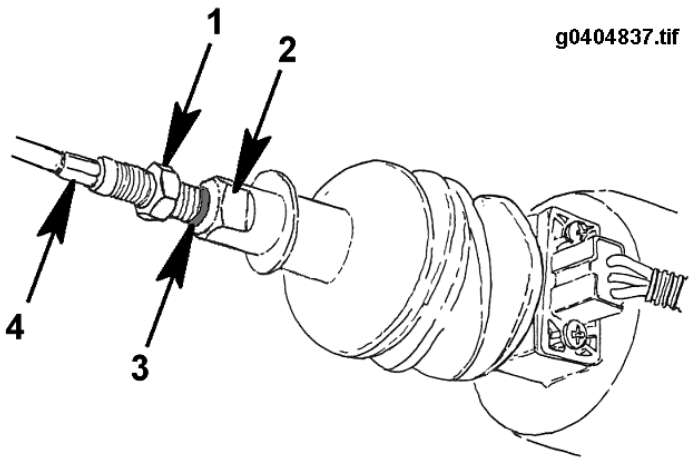

Figure 68 Park Brake Cable Adjustment Components

1. 16mm JAM NUT
2. SAHR CANISTER SHAFT 15mm
3. ADJUSTMENT INDICATOR, 'HASH' MARK
4. THREADED ROD 8mm

3. Place the transmission in the N, P or PB position.

4. Verify that the ignition key is OFF, and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 48 (See Figure 48, page 89).

5. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

6. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.

7. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

8. Use a clamp to pinch the low pressure hose at the inlet to the HCU reservoir. Place the clamp midway between the HCU reservoir inlet and the crossmember, being careful not to damage the reservoir inlet. Refer to FIGURE 55 (See Figure 55, page 102).

9. Carefully clean the outside of the SAHR canister.

10. Disconnect the electrical connectors from the cut-off solenoid valve and the travel switch, both located on the SAHR canister. Refer to FIGURE 69 (See Figure 69, page 140).

11. Cut or remove any cable ties securing cables to the canister.

12. Position a container to collect the drained brake fluid in the next step. Ensure that no fluid will spill onto the ground or damage the paint.

NOTE – In the following step, use a backup wrench to prevent the threadsaver fitting from being removed.

13. Disconnect the brake line from the front of the SAHR canister. Plug the line and the port on the canister to prevent contamination.

14. Remove the two 12 mm mounting nuts securing the canister to the frame rail, and remove the canister. Verify that the nylon bushings are removed from the mounting holes in the frame. Retain the bushings and mounting nuts for use during installation.

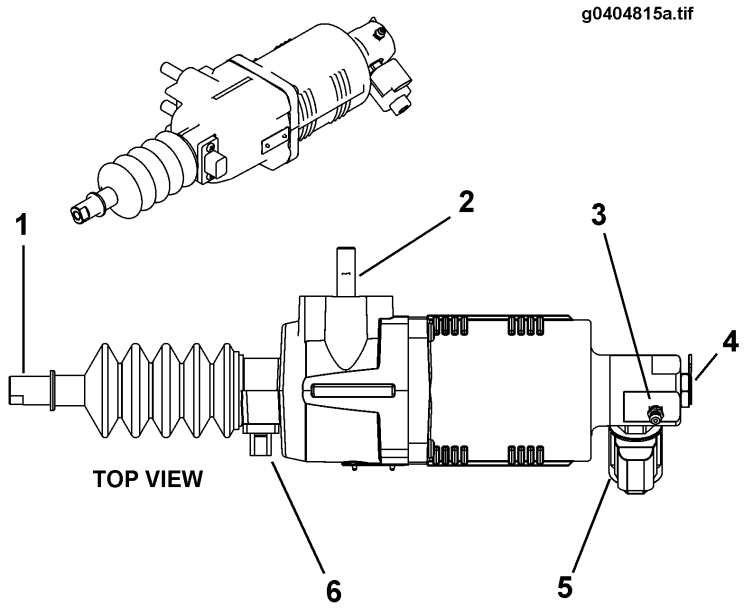

Figure 69 Location of SAHR Canister Components

1. OUTPUT SHAFT
2. MOUNTING STUDS
3. BLEED PORT
4. BRAKE FLUID PORT
5. CUT-OFF SOLENOID VALVE
6. TRAVEL SWITCH

Installation

1. Secure the canister to the frame rail using the two bushings and nuts removed earlier. Torque the nuts to 75 to 81 Nm (55 to 60 Lbf-ft).

2. Connect the brake line to the front of the SAHR canister. Torque fitting to 12 to 19 Nm (9 to 14 Lbf-ft).

3. Carefully remove the clamp used to pinch the low pressure hose during removal.

4. Connect the electrical connectors to the cut-off valve and the travel switch, both located on the SAHR canister. Refer to FIGURE 69.

5. Secure the wire harness to the canister using cable ties.

6. Make sure fluid is at or above the MAX mark in the Master Cylinder (MC) reservoir. If not, fill the reservoir up to the MAX mark with new, DOT 3 or DOT 4 brake fluid from a sealed container.

NOTE – The parking brake circuit must be bled before the parking brake cable can be reconnected. The procedure for connecting the parking brake cable is part of the bleeding procedure referenced in the following step.

7. Bleed the parking brake circuit, following the service bleeding procedure. Refer to PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61). **The parking brake bleeding procedures include the procedure for reconnecting the parking brake cable.**

WARNING – If leakage is noted in the following step, the system MUST be depressurized BEFORE making repairs. Perform steps 3 thru 7 of the SAHR CANISTER REMOVAL procedure to verify that the system is depressurized. Failure to follow this warning could result in property damage, personal injury or death.

8. Check SAHR connections for leakage. If leakage is present, depressurize the system before making repairs.

9. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

10. Turn key on; and with the brake pedal depressed, apply and release the parking brake several times to verify correct operation. The PARK BRAKE indicator should light when park brake is applied. Also verify that the SERVICE PARK BRAKE warning indicator does not light, and no new fault codes are generated.

11. Turn the key off and disconnect the EZ-TECH® from the diagnostic connector.

12. Set the transmission to the P or PB position (if available), and remove wheel chocks.

6.15. COIL FOR CUT-OFF VALVE

Refer to FIGURE 70 for component location information while performing the following procedures.

Removal

1. Install wheel chocks and turn key off.

2. Carefully clean the outside of the SAHR canister in the area of the cut-off valve.

3. Disconnect the electrical connector from the cut-off valve.

4. Remove the 3/4 inch retaining nut from the cut-off valve coil assembly.

5. Remove the coil assembly from the cut-off valve.

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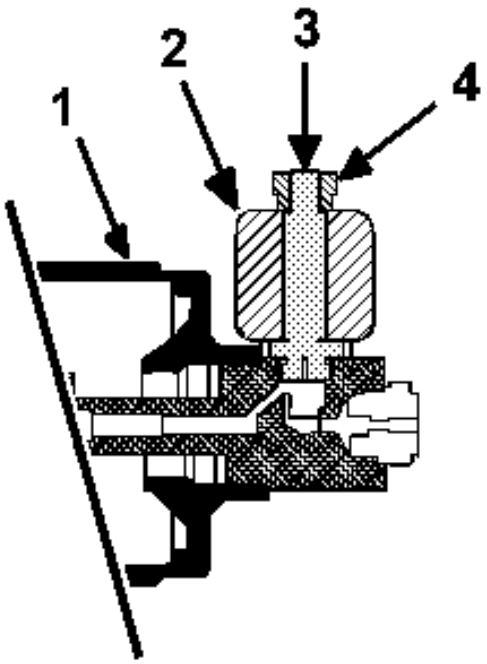

Figure 70 Cut-Off Valve Components

1. SAHR CANISTER
2. COIL FOR CUT-OFF VALVE
3. CUT-OFF VALVE CORE
4. RETAINING NUT

Installation

1. Verify that the cut-off valve core is torqued to 26 to 28 Nm (19 to 21 Lbf-ft). NOTE: Valve core may have been loosened during removal of cut-off coil retaining nut.

> **CAUTION – In the following step do not tighten the coil retaining nut to more than 6.7 Nm (60 Lbf-in). Overtightening the nut will damage the cut-off valve core.**

2. Place the coil onto the cut-off valve core so that the connector is correctly positioned, and secure with the retaining nut. Tighten the nut to 5 to 6.7 Nm (44 to 60 Lbf-in).

3. Connect the 2 pin harness connector to the cut-off valve coil.

4. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Start the EZ-TECH® and open the TOOLBOX™ program.

5. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

6. Turn key on; then apply and release the parking brake several times to verify correct operation. Also verify that the SERVICE PARK BRAKE warning indicator did not light, and no new fault codes were generated.

7. Turn the key off and disconnect the EZ-TECH® from the diagnostic connector.

8. Remove wheel chocks.

6.16. MANIFOLD/CARTRIDGE ASSEMBLY (PART OF SAHR CANISTER)

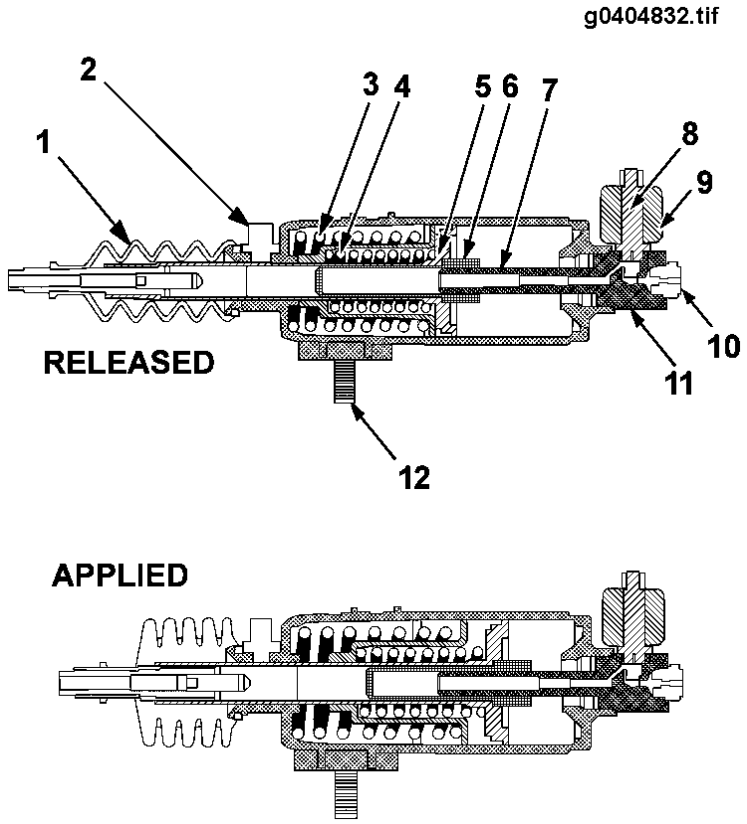

Figure 71 SAHR Canister Components

1. RUBBER BOOT
2. TRAVEL SWITCH
3. OUTER SPRING
4. INNER SPRING
5. OUTPUT SHAFT END PLATE
6. CYLINDER, PART OF MANIFOLD/CARTRIDGE ASSEMBLY
7. PISTON, PART OF MANIFOLD/CARTRIDGE ASSEMBLY
8. CUT-OFF VALVE CORE, PART OF MANIFOLD/CARTRIDGE ASSEMBLY
9. CUT-OFF VALVE COIL
10. THREAD SAVER FITTING
11. MANIFOLD/CARTRIDGE ASSEMBLY (PISTON/CYLINDER)
12. SAHR MOUNTING STUD

The manifold/cartridge assembly comprises the active hydraulic components located inside of the SAHR canister. A malfunction requiring replacement of this component may cause brake fluid to leak into the SAHR canister, therefore removal of the canister is recommended prior to removing this component. The manifold/cartridge can then be replaced on the bench. Refer to FIGURE 71 for component location information while performing the following procedures.

Removal

1. Remove the SAHR canister from the frame rail. Refer to the SAHR CANISTER Removal procedures (See SPRING APPLIED HYDRAULICALLY RELEASED (SAHR) CANISTER, page 137). Do NOT remove components from the SAHR assembly until instructed to do so in these procedures.

2. Using a suitable container drain the brake fluid from the brake line fitting on the canister.

3. Move the SAHR canister to a work bench.

4. Remove the coil assembly from the cut-off valve. Do not remove the cut-off valve core. Retain the coil and retaining nut for use during installation.

NOTE – If the manifold/cartridge is being replaced due to a seal failure, brake fluid may be present inside of the canister body. This fluid can only be drained once the manifold has been removed. While performing the next 2 steps assume that fluid is present in the canister body, and be prepared to prevent leakage.

5. Carefully clamp the body of the SAHR canister in a vise to prevent it from turning. If possible, position the canister with the boot down and the manifold up. This will prevent any brake fluid in the canister from leaking out when the manifold is removed.

6. Using a wrench on the flats of the manifold, unscrew the manifold/cartridge assembly from the SAHR canister by turning it in a ccw direction.

7. Remove the manifold/piston and cylinder assembly from the canister by pulling it straight out of the canister housing. Verify that the cylinder was removed from the canister housing.

8. Verify that the urethane O-ring seal for the manifold assembly has been removed from the canister housing.

9. Unclamp the canister and drain all fluid from the canister into a suitable container.

Installation

1. Carefully clamp the body of the SAHR canister in a vise to prevent it from turning.

2. Ensure that the new urethane O-ring seal is seated at the base of the threads on the manifold/piston and cylinder assembly.

> **CAUTION – When handling the new manifold assembly do not damage the cut-off valve core. Any damage to the cut-off valve core could prevent the parking brake from operating correctly.**

3. Thread the manifold/piston and cylinder assembly into the canister (turn cw) by hand until snug.

4. Using a wrench on the flats of the manifold, torque the manifold/piston assembly to 50 lbf-ft. The cut-off valve must be on the opposite side of the canister from the mounting studs.

NOTE – The SAHR canister has a double set of threads. If the cut-off valve is not oriented correctly after installation of the manifold, loosen the manifold until the threads just disengage; continue rotating the assembly ccw for 180 degrees; then, reinstall the manifold assembly.

CAUTION – In the following step do not tighten the coil retaining nut to more than 6.7 Nm (60 Lbf-in). Overtightening the nut will damage the cut-off valve core.

5. Place the coil onto the cut-off valve core so that the connector is correctly positioned, and secure with the retaining nut. Tighten the nut to 5 to 6.7 Nm (44 to 60 Lbf-in).

6. Install the SAHR canister on the frame rail. Refer to SAHR CANISTER Installation procedures (See SPRING APPLIED HYDRAULICALLY RELEASED (SAHR) CANISTER, page 137).

6.17. PARKING BRAKE TRAVEL SWITCH (MOUNTED ON SAHR CANISTER)

The parking brake travel switch (located on the SAHR canister) can be removed without opening the brake fluid system. The switch can be replaced without depressurizing the brake system. Refer to FIGURE 71 for component location information while performing the following procedures (See Figure 71, page 143).

Removal

1. Install wheel chocks and turn key off.

2. Carefully clean the outside of the SAHR canister in the area of the parking brake travel switch.

3. Disconnect the electrical connection to the parking brake travel switch.

4. Remove the 2 screws securing the switch to the SAHR canister, and remove the switch with its short pigtail harness.

5. Cover the hole where the travel switch was located to prevent contamination.

Installation

1. Position the replacement switch so that the mounting screw holes are aligned.

2. Secure the switch with the 2 mounting screws.

3. Connect the electrical connection to the parking brake travel switch.

4. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs.

5. Turn key on; then apply and release the parking brake several times to verify correct operation. Also verify that the SERVICE PARK BRAKE warning indicator does not light, and no new fault codes are generated.

6. Turn the key off.

7. Disconnect the EZ-TECH® from the diagnostic connector.

8. Remove wheel chocks.

6.18. PARK BRAKE SWITCH AND KNOB (DASH MOUNTED)

The parking brake switch is an electrical switch located on the instrument panel. Refer to FIGURE 72 for typical component location information while performing the following procedures.

Removal

1. Park the vehicle on a level surface and install wheel chocks.

2. Remove the knob from the Parking Brake switch. (Push the knob in slightly, rotate it 90 degrees counterclockwise and pull.) Retain the knob for use with the replacement switch.

3. Remove the center and right wing plastic bezels from the instrument panel. Each bezel is secured with 4 fasteners (one in each corner), and the center bezel must be removed first. Retain all fasteners for use during installation.

4. Remove the 3 screws and lockwashers securing the switch assembly to the dash panel. Retain the mounting hardware for use during installation.

5. Remove the switch from behind the dash panel.

6. Disconnect the electrical connector on the switch assembly pigtail from the wire harness.

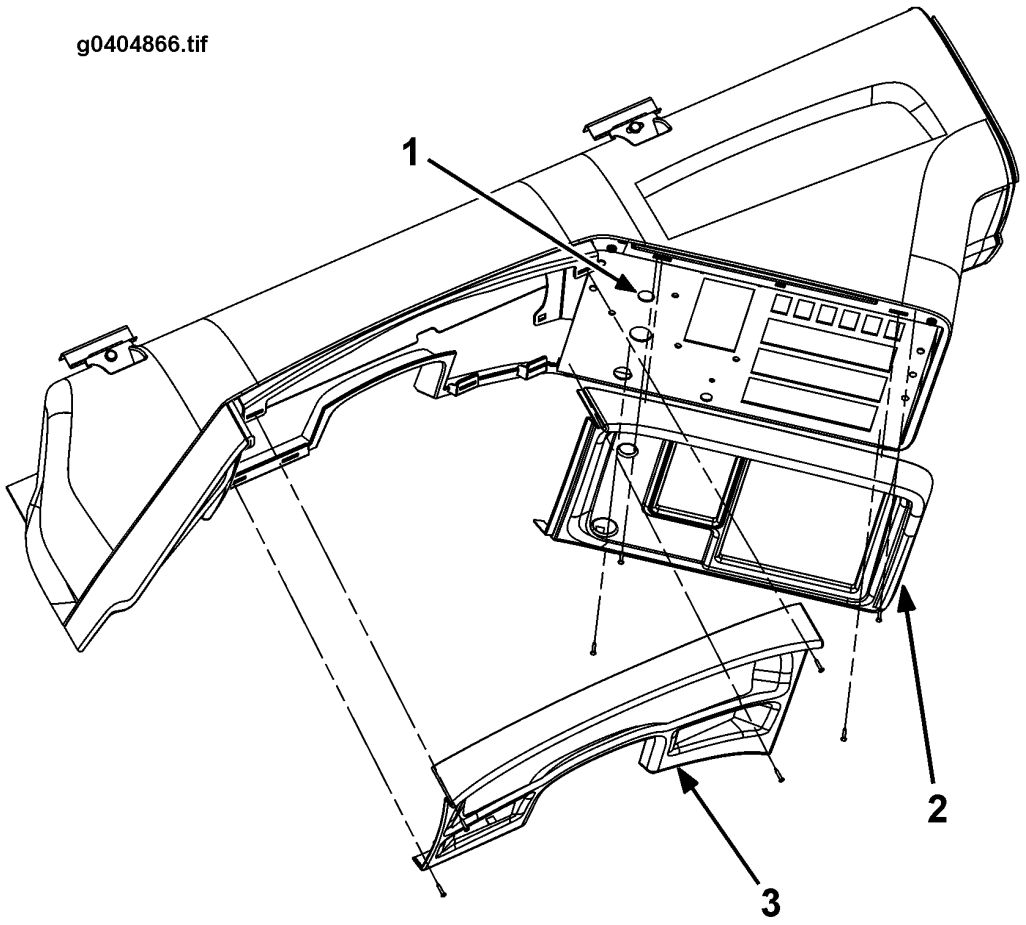

Figure 72 Typical Instrument Panel Bezel Removal/Installation

1. PARK BRAKE SWITCH LOCATION
2. INSTRUMENT PANEL RIGHT WING BEZEL
3. INSTRUMENT PANEL CENTER WING BEZEL

Installation

1. If a knob is on the replacement switch, remove it. (Push the knob in slightly, rotate it 90 degrees counterclockwise and pull.)

2. Connect the connector on the switch assembly pigtail to the wire harness, and position the switch at its mounting location behind the dash panel.

3. Secure the switch assembly at its mounting location using the 3 screws and lockwashers removed previously.

4. Install the center and right wing plastic bezels onto the instrument panel, using the hardware removed previously. Each bezel is secured with 4 fasteners (one in each corner), and the center bezel must be installed last.

5. Install the knob onto the switch shaft by pushing it onto the shaft and rotating it 90 degrees in a clockwise direction. The graphics on the knob must be correctly oriented.

6. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

7. Remove the wheel chocks.

6.19. BRAKE LINES (GENERAL)

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 property damage, personal injury or death.

WARNING – Any form of contamination entering the system could prevent the system from operating correctly. Thoroughly clean the area around fittings before disconnecting the fittings. Always plug open ports and lines as quickly as possible. Contamination in the system could result in loss of braking functions during vehicle operation. Failure to follow this warning could result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

The following procedures are general procedures to be performed when replacing any of the hydraulic brake lines.

Removal

1. Install wheel chocks.

2. Set the ignition key to OFF and remove the two 30 Amp fuses that provide power to the brake system motors. They are in the fuse panel located on the engine side of the cowl. Refer to FIGURE 48 (See Figure 48, page 89).

3. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Set the ignition key to ON, start the EZ-TECH® and open the TOOLBOX™ program.

4. Depressurize the system as follows:
   a. Depress the brake pedal a minimum of 30 times.
   b. Use the EZ-TECH® and TOOLBOX™ to verify that pressure at both accumulators is at 0 psi.

> ⚠ **WARNING – Batteries expel explosive gases. Keep sparks, flames, burning cigarettes, or other ignition sources away at all times. Always wear safety glasses and a face shield when working near batteries to prevent personal injury.**

5. Set the ignition key to OFF and disconnect the battery negative cable (including the ECM ground cable).

6. Carefully clean the fittings at each end of the brake line being removed.

7. Remove or loosen any clips or clamps used to secure the line being replaced. Note the original routing of the line to aid in the installation of the replacement line.

> **CAUTION – Whenever possible use a backup wrench when loosening the end fittings on the brake lines.**

8. Remove the line being replaced and plug the open ports to prevent contamination of the system.

Installation

1. Install the replacement line in its original location using the appropriate clips and clamps.

2. Torque the line fittings to the value listed in the TORQUE CHART (See TORQUE CHART, page 154). Fittings not listed in the TORQUE CHART should be torqued to 17 to 19 Nm (12.5 to 14 Lbf-ft). Do not over-torque fittings.

3. When installing flexible hoses to calipers, secure bulkhead nut, to prevent kinking the hose.

4. Make sure fluid is at or above the MAX mark in the Master Cylinder (MC) reservoir. If not, fill the reservoir up to the MAX mark with new, specified brake fluid from a sealed container.

5. Bleed the circuit affected by the brake line change, as follows:

   - Brake lines from master cylinder to HCU – bleed master cylinder circuit. Refer to MASTER CYLINDER CIRCUIT BLEEDING PROCEDURE (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61).
   - Brake lines from HCU to wheel ends – bleed the wheel end circuit affected (front or rear). Refer to BRAKE CALIPER CIRCUIT BLEEDING PROCEDURE (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61).

- Parking brake lines from HCU to SAHR can – bleed the SAHR circuit. Refer to SAHR POWERED PARKING BRAKE CIRCUIT BLEEDING PROCEDURE (See PRESSURE BLEEDING THE FULL POWER BRAKE SYSTEM, page 61).

WARNING – If leakage is noted in the following step, the system MUST be depressurized BEFORE making repairs. Perform steps 2 thru 5 of the BRAKE LINES REMOVAL procedure to verify that the system is depressurized. Failure to follow this warning could result in property damage, personal injury or death.

6. Check new brake line connections for leakage. If leakage is present, depressurize the system before making repairs.

7. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Start the EZ-TECH® and open the TOOLBOX™ program.

8. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

9. Disconnect the EZ-TECH® from the diagnostic connector.

10. Remove wheel chocks.

6.20. WHEEL SPEED SENSOR

WARNING – Block the wheels to prevent the vehicle from moving. When working under a raised vehicle, support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Failure to follow this warning could result in property damage, personal injury or death.

CAUTION – Individuals without factory training are advised not to work on the Full Power Brakes system to replace or repair items.

This is a modern, complex system offering greater braking proficiency and features than previous systems. If the system sustains damage or a component malfunctions and items need to be replaced, users are strongly advised to contact the nearest International dealer for professional assistance and repair. However, if location and circumstances prevent consulting the dealer, and components are to be replaced, the prescribed procedure must be followed accurately.

Precharged HCU's and spare parts must be handled with the appropriate care and attention and should not be exposed to excessive vibration or impact, nor air being blown into the hydraulic ports prior to assembly to the vehicle.

CAUTION – Clean the area around the wheel sensor before performing service.

Refer to FIGURE 73 for component location information while performing the following procedures (See Figure 73, page 152).

Sensor Lube Specification

Meritor WABCO 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).

Removal

1. Install wheel chocks and turn the key off.
2. If it is necessary to remove the tire to access the wheel speed sensor, place safety stands under the axle.
3. Disconnect the fasteners that hold the sensor cable to other components.
4. Disconnect the sensor cable from the chassis harness.
5. Clean the area around the sensor to prevent contamination when the sensor is removed.

CAUTION – In the following step, do not pull on the sensor cable to remove the sensor.

6. Using a twisting motion pull the sensor from the sensor bushing. Do not pull on the cable. If necessary, use a suitable lever to gently pry the sensor from the bushing.
7. Remove the sensor and cable from the vehicle.
8. Remove the sensor bushing.

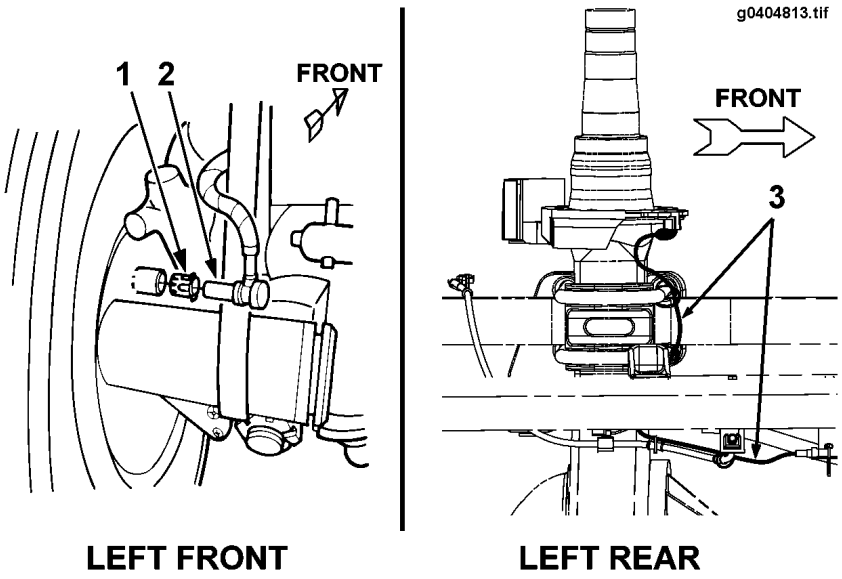

Figure 73 Typical Speed Sensor Locations

1. FRONT SENSOR BUSHING
2. FRONT SENSOR
3. REAR SENSOR CABLE

Installation

CAUTION – Overtightening the sensor cable tie wraps may damage the cables.

1. Clean the area where the sensor is to be installed.
2. Lubricate the new sensor bushing with the Meritor WABCO - recommended lubricant.
3. Install the sensor bushing by pushing it into the wheel end bracket. Make sure the sensor bushing tabs are on the inboard side of the vehicle.
4. Apply Meritor WABCO - recommended grease to the wheel speed sensor.
5. Push the sensor completely into the bushing until it contacts the tooth ring. The sensor will self adjust when the vehicle is driven.
6. Connect the sensor cable to the chassis harness.
7. Fasten the sensor cable with tie straps every 12 inches. Do not overtighten the tie straps. Correctly bundle and store any excess cable in the sub-frame.
8. If tire was removed previously, reinstall tire and remove safety stands.
9. Connect the EZ-TECH® to the diagnostic connector located under the center of the instrument panel. Refer to FIGURE 49 (See Figure 49, page 90). Start the EZ-TECH® and open the TOOLBOX™ program.

10. Using the EZ-TECH® and the TOOLBOX™ program clear all brake system related inactive fault codes. (Codes may have been set while disconnecting and reconnecting power to the system.) If active fault codes are indicated, refer to Section 5, DIAGNOSTICS AND TROUBLESHOOTING to make the necessary repairs (See DIAGNOSTICS AND TROUBLESHOOTING, page 76).

11. Disconnect the EZ-TECH® from the diagnostic connector.

12. Remove wheel chocks.

7. SPECIFICATIONS

IMPORTANT – The vehicles covered in this manual have used two different electrical controllers. Both controllers are mounted in the same location. The original controller was known as the Electrical System Controller (ESC). The current controller is known as the Body Controller (BC). In this manual the controller will be identified as the Body Controller or the ESC/BC.

7.1. TORQUE CHART

Table 4 Torque Chart

Item No.*	Item Description (Quantity)	Torque Value		
		Nm	Lbf-ft	Lbf-in
1	Master Cylinder Reservoir to Mounting Bracket (1)	29 to 32	21 to 24	
2	Brake Tubes to Master Cylinder (2)	17 to 22.5	12.5 to 16.5	
3	Master Cylinder to Mounting Bracket (2)	61 to 68	45 to 50	
4	HCU Reservoir Mounting Bolts/Screws (4)	5 to 6.7		44 to 60
5	HCU Bracket to Frame Rail (4)	108 to 135	79.7 to 99.6	
6	HCU Mounting Bracket to HCU (4)	43 to 46	32 to 34	
7	Pressure Supply Valve Core to HCU	40 to 50	27 to 34	
8	Brake Tubes to HCU (All)	12.2 to 19	9 to 14	
9	Accumulators (2)	51.5 to 56.9**	38 to 42**	
10	ECU Mounting Bolts/Screws (4) Torque in two stage sequence (FIGURE 57).	Two stage Stage 1: 1.5 Stage 2: 2.5 to 3.5		Two stage Stage 1: 14 Stage 2: 21 to 30
11	Bleeder Screws on HCU (for Master Cylinder lines)	4 to 4.5		34.7 to 39
12	SAHR Canister to Frame Rail (2)	75 to 81	55 to 60	
13	Bleeder Screw at SAHR Canister	12 to 16	8.6 to 11.5	
14	Brake Tube to SAHR Canister	12 to 19	9 to 14	
15	Cut-off Valve Retaining Nut	5 to 6.7		44 to 60
16	Cut-off Valve Core	26 to 28	19 to 21	
17	Brake Light Switch Mounting Screws (on Master Cylinder)	3 to 4		26.5 to 35.4
18	Relay Valve Mounting Screws (5) Torque twice in sequence (FIGURE 66).	8.0		70.8

Table 4 Torque Chart (cont.)

Item No.*	Item Description (Quantity)	Torque Value		
		Nm	Lbf-ft	Lbf-in
19	HCU Pump Retaining Plug (2) Plug for Primary Pump is located under Relay Valve.	20 to 24	14.8 to 17.7	
	Bleeder Screws at Calipers	12 to 16	8.6 to 11.5	

NOTES:

* Refer to the four torque location diagrams (FIGURE 74, FIGURE 75, FIGURE 76 and FIGURE 77) that follow this table.

** Indicates torque value using a strap wrench attachment on the torque wrench. This value will provide 58.8 to 67.8 Nm (43.4 to 50 Lbf-ft) torque at the accumulator mounting.

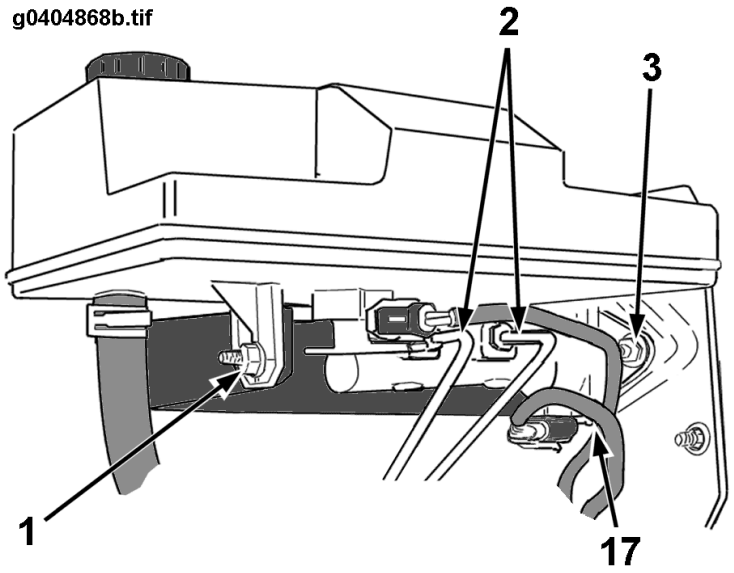

Figure 74 Torque Locations Diagram (1 of 4)

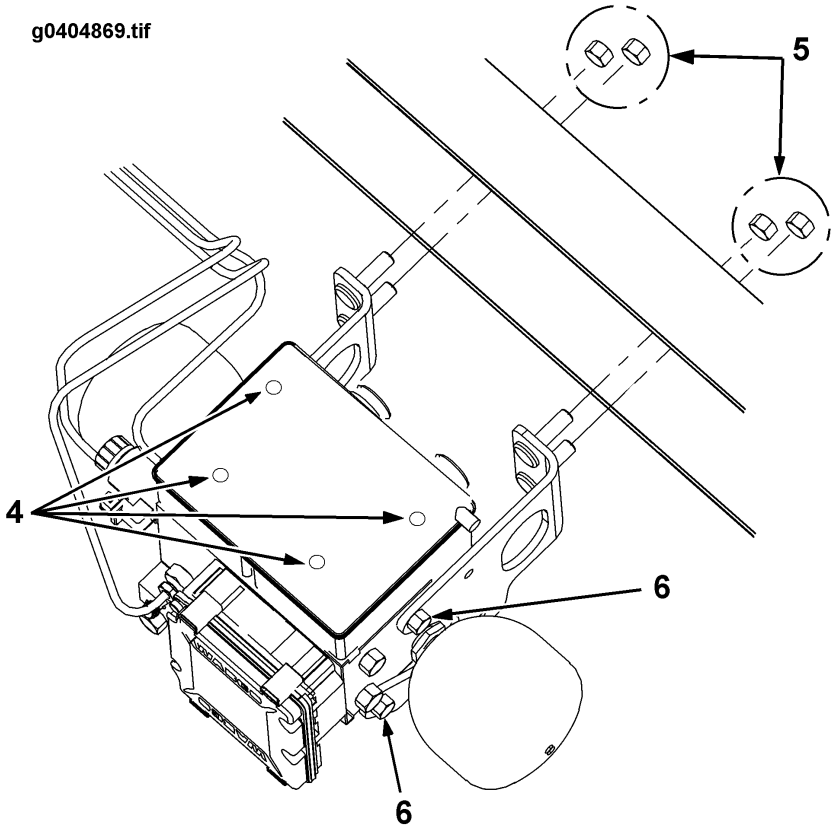

Figure 75 Torque Locations Diagram (2 of 4)

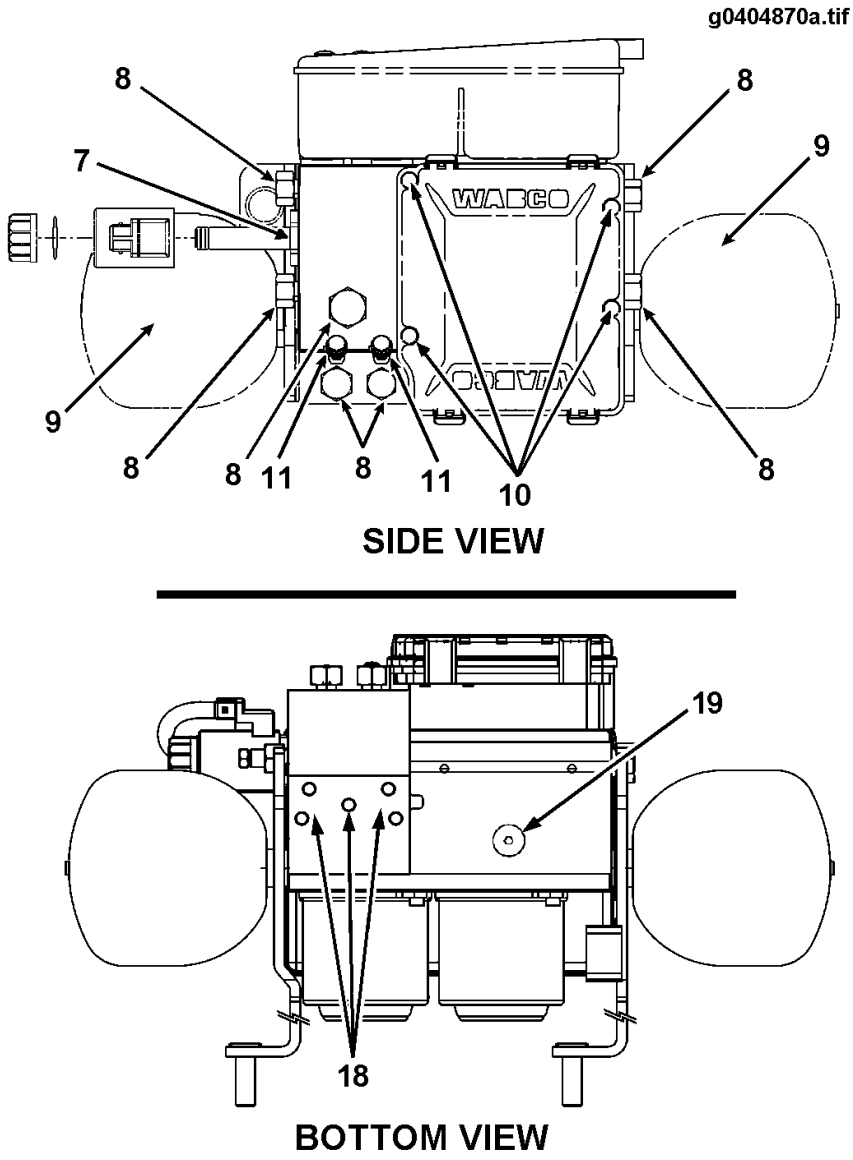

Figure 76 Torque Locations Diagram (3 of 4)

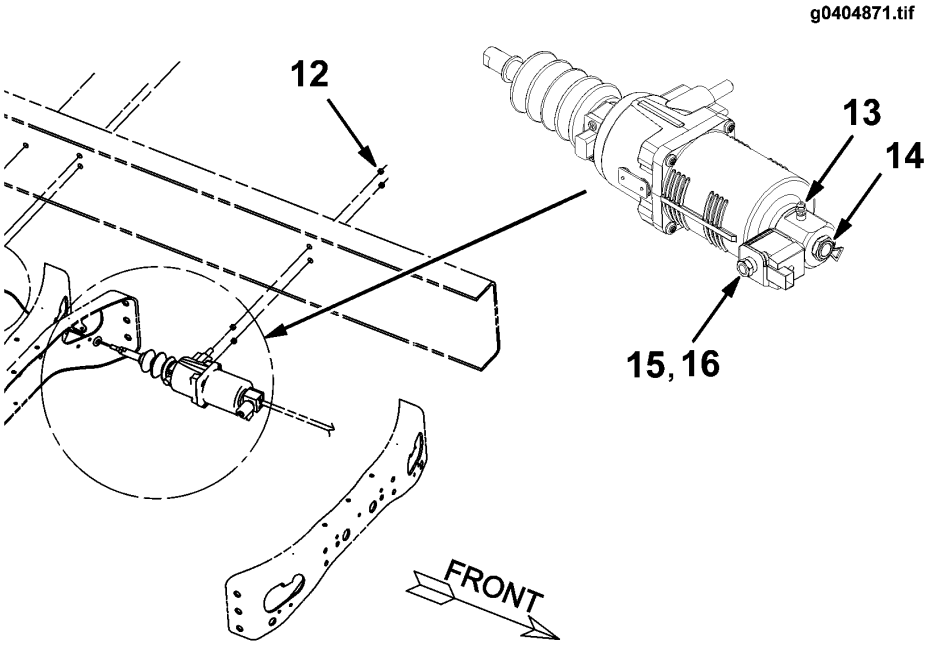

Figure 77 Torque Locations Diagram (4 of 4)

7.2. FULL POWER BRAKE SYSTEM SPECIFICATIONS

Table 5 Full Power Brake System Specifications

ITEM	SPECIFICATION
Brake Fluid Type	DOT 3 or DOT 4
Brake Fluid Quantity (Complete System) **NOTE: Quantity varies according to vehicle wheelbase.**	6.0 to 6.6 liters (12.7 to 13.9 pints)
Brake Fluid Quantity (Master Cylinder Reservoir to MAX mark)	2.4 liters (5.1 pints)
Brake Fluid Quantity (HCU Reservoir)	1.7 liters (3.6 pints)
Lubricant (wheel speed sensors only)	Mineral oil based and must contain molydisulfide. It should have excellent anti-corrosion and adhesion characteristics. Must be capable of continuous function from –40° to 300°F (-40° to 150°C)
Park Brake Stroke (Measured at SAHR Canister)	1.5 ±0.25 inches
Accumulator Pump Turn On Pressure	approx. 1770 psi

Table 5 Full Power Brake System Specifications (cont.)

ITEM	SPECIFICATION
Accumulator Pump Turn Off Pressure	approx. 2320 psi
System Voltage (Ignition ON), Measured at the following points: A. 31 Pin Connector • Pin 1 to pin 6 (gnd) • Pin 16 to pin 18 (gnd) • Pin 17 to pin 19 (gnd) B. 2 Pin Connector • Pin 2 to pin 1 (gnd)	10 to 16 Vdc

TIRE SIZE RANGE

For proper 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%. Calculate the tire size range with the equation in FIGURE 78.

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

NOTE: RPM = Tire Revolutions per Mile

Figure 78 Formula for Calculating Tire Size Range

8. SPECIAL TOOLS

Servicing brake systems efficiently and effectively requires the proper tools and equipment. The recommended tools, as well as some necessary common tools, are shown and discussed below.

8.1. ESSENTIAL TOOLS

The tools listed in Table 6 can be ordered through SPX.

Table 6 Special Service Tools

DESCRIPTION	PART NO.
Brake Bleeding Adapter	ZTSE4678
Regulator/Filter Assembly	ZTSE4757-1
1 3/16 Inch Extra Deep, Thin-Walled, Deep Well Socket (or equivalent)	ZTSE4781

Table 6 Special Service Tools (cont.)

DESCRIPTION	PART NO.
EZ-TECH® Electronic Service Tool (with Interface Cable)	
Meritor WABCO Hydraulic ABS Diagnostic Software (TOOLBOX™) Contact SPX Service Solutions 1-800-328-6657	

Brake Bleeding Adapter (ZTSE4678)

The brake bleeding adapter (FIGURE 79) provides a secure connection between the bleeding equipment and the master cylinder reservoir.

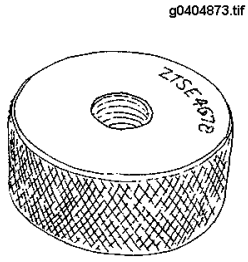

Figure 79 Brake Bleeding Adapter (ZTSE4678)

Regulator/Filter (ZTSE4757-1)

The regulator/filter (FIGURE 80) provides a means of safely using nearly any air source to pressurize the brake system during the bleeding procedures. When connected to various air sources, the pre-set regulator insures that 2.4 bar (35 PSI) is applied to the master cylinder reservoir.

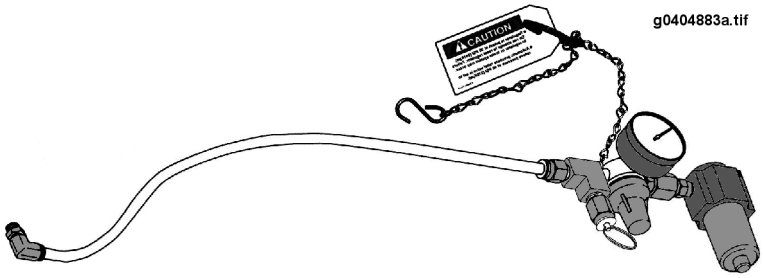

Figure 80 Regulator/Filter (ZTSE4757-1)

Thin-Walled, Deep Well Socket, 1 3/16 Inch Extra Deep (ZTSE4781)

This socket provides a means of safely removing and installing the core of the Pressure Supply Valve (PSV). The PSV core must be loosened and tightened only by the hex nut that forms its base. Engaging the base of the PSV core requires an extra deep, thin-walled, deep well socket.

Electronic Service Tool (EST), EZ-TECH®

The EZ-TECH® electronic service tool (FIGURE 81), can be used to monitor certain vehicle parameters, list active and inactive diagnostic trouble codes, and in some cases override inputs and outputs of electrical controllers. While running the TOOLBOX™ diagnostic software, the EZ-TECH® allows the servicer to monitor

and/or exercise the various brake circuits. The EZ-TECH® is connected to the vehicle diagnostic connector through an interface connector. See ISIS for ordering information on the EZ-TECH® electronic service tool.

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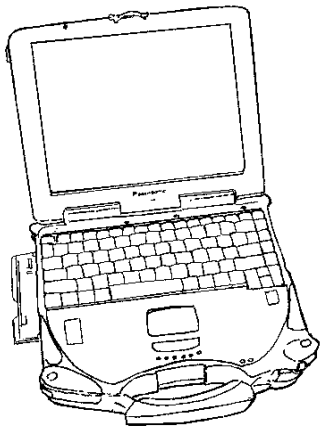

Figure 81 The EZ-Tech® Electronic Service Tool

TOOLBOX Diagnostic Software

TOOLBOX™ is a diagnostic program that runs in the Windows® environment. The program displays system faults, fault codes and repair instructions. System operating conditions such as wheel speed data and accumulator pressures can be monitored in real time. In addition, various system electrical components can be activated to verify the individual components, as well as, installation wiring. The TOOLBOX™ software is available from SPX Service Solutions, 1-800-328-6657.

For complete instructions for using this program, refer to the User's Manual, TP-99102. Contact Meritor WABCO at 1-800-535-5560 for information about TOOLBOX™ Software.

8.2. COMMON TOOLS

The tools in the following list can be obtained from local sources.

- Strap wrench head for torque wrench – must be capable of gripping the accumulator.
- 1 3/16 inch extra deep, thin-walled, deep well socket, such as ZTSE4781 (or equivalent).
- Pressurized brake bleeding system
    - Air-over-fluid bleeding systems require a regulator/filter, such as ZTSE4757-1 (or equivalent). Refer to FIGURE 80.

9. GLOSSARY

The following terms, abbreviations and acronyms may appear in descriptions of the full powered brakes system.

- AA - Auto Apply
- ABS - Antilock Brake System
- ACCUMULATOR - A pressurized storage container for brake fluid.
- ATC - Automatic Traction Control

- BC - Body Controller (Known previously as the Electrical System Controller)
- EBD - Electronic Brakeforce Distribution
- ECU - Electronic Control Unit
- ESC - Electrical System Controller
- ESC/BC - Electrical System Controller / Body Controller
- FPB - Full Power Brakes
- HCU - Hydraulic Compact Unit
- IV - Input Valve
- J1587 - Engine Control Data Link
- J1939 - Diagnostics Data Link
- MC - Master Cylinder
- OV - Outlet Valve
- PRESSURE TRANSDUCER - A device with electrical characteristics that vary according to the pressure it senses.
- PSV - Pressure Supply Valve
- SAHR - Spring Apply Hydraulic Release

10. APPENDIX A

Effective diagnosis of a malfunctioning system begins with observing the faults recorded by the system ECU. The faults, and their associated Diagnostic Trouble Codes (DTC's), are read using the EZ-TECH® service tool, running the TOOLBOX™ program. The TOOLBOX™ screen that displays the faults and their DTC's, also displays the appropriate Repair Instructions for the selected fault. A printed list of the faults, their DTC's, and the repair instructions is also provided in this appendix.

The information in APPENDIX A is provided only as additional background information. The following is a brief description of the APPENDIX A contents.

General information regarding the driver interface:

This short table shows the circuit connections used by the system to drive the gauge cluster indicators. The indicators in the current full power brakes system are driven via the SAE J1939 data link. The hardwired connections listed in the table are NOT used.

Troubleshooting Table (System Reaction)

This table shows how the system reacts to each of the faults listed in the first column (Component). It also lists the Diagnostic Trouble Code (DTC) assigned to each fault, and refers the user to the Repair Instruction to be used for troubleshooting. The headings of the table are:

1. **Component** – This column lists the possible system faults, primarily organized by system component.

2. **SPN, SID, PID, FMI** – These columns list the fields that comprise the DTC assigned to the specific fault listed in the Component column.

3. **Repair instruction** – This column references the Repair Instruction to be used when troubleshooting the fault listed in the Component column. All repair instructions are found in the Repair Instructions table that follows the troubleshooting table.

4. **General Actions** – This column briefly describes how the internal operation of ECU changes to react to the fault listed in the Component column.

5. **ABS, ATC EBD, PB** – These columns show the status of each of the full power brakes subsystems, based on the occurrence of the fault listed in the Component column.

6. **Brake Warning Lamp (BRAKE PRESSURE), ABS Warning Lamp, ATC Info Lamp (TRAC CTRL), Audible Warning (Buzzer), Parking Brake Service Lamp (SERVICE), Parking Brake Indicator Lamp (PARK), Brake Fluid Indicator Lamp** – These columns show the status of each of the indicators, based on the occurrence of the fault listed in the Component column.

Multiple Failures Table

This is a supplemental table to the troubleshooting table. This table lists the system reaction to multiple faults. The table headings are the same as those described for the troubleshooting table.

Special System Conditions

This table lists the system reaction to special operational conditions. Most of these conditions are not faults. This table simply breaks down how the system reacts to the conditions listed. The table headings are the same as those described for the troubleshooting table. Any fault conditions listed in this table are also covered in the troubleshooting table.

NOTE: The full power brakes system is a multiplexed (muxed) system.

Repair Instructions

This table lists the repair instructions and is organized by Repair Instruction (R.I.) number. These repair instructions are referenced from the Troubleshooting and Multiple Failures tables. The information in this table is also provided in the TOOLBOX™ diagnostic program.

System Reaction Strategy on failures and special system conditions for HPB

General information regarding the driver interface:

Indicator type	position	
	hardwired	***via SAE J1939***
Brake Warning Lamp	Pin 20 of 31-way connector (X1)	EBC1, Byte 6, Bits 4,3 *(on status: 01b)*
ABS-Warning Lamp	Pin 21 of 31-way connector (X1)	EBC1, Byte 6, Bits 6,5 *(on status: 01b)*
ATC-Info Lamp	Pin 13 of 31-way connector (X1)	EBC1, Byte 6, Bits 8,7 *(on status: 01b)*
Audible Warning (Buzzer)	Pin 12 of 31-way connector (X1)	HBS, Byte 4, Bits 2,1 *(on status: 01b)*
Parking Brake Service Lamp	Pin 2 of 31-way connector (X1)	Brakes, Byte 4, Bits 4,3 *(on status 01b)*
Parking Brake Indicator Lamp		Brakes, Byte 4, Bits 2,1 *(on status 01b)*
Brake Fluid Indicator Lamp		HBS, Byte 4, Bits 4,3 *(on status: 00b)*

system reaction / Component	SPN	SID	PID	FMI	Repair Instruction	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp
main controller, safety controller	254	254		12	1.1	brake valve power supply switched off	disabled	disabled	disabled	park brake status will be maintained	**on**	**on**	**on**	**on**	**on**	according to SAHR status	
sensor front right																	
airgap				1	2.1 / 2.4		selective switched off	disabled				**on**	**on**				
impedance				5	2.5		selective switched off	disabled				**on**	**on**				
pole wheel				7	2.4		selective switched off	disabled				**on**	**on**				
no trigger at all	2	2		8	2.1 / 2.3 / 2.4 / 2.5 / 2.6		selective switched off	disabled	enabled	full functionality	off	**on**	**on**	off	off	according to SAHR status	
Inlet valve actuation time not plausible (75 % switch on time within 5 minutes)	254	254		9	2.1 / 2.4 / 2.5		selective switched off	disabled				**on**	**on**				
brake chatter	2	2		11			temporary selective switched off	temporary selective switched off				**lamp on only during cycling**	**lamp on only during cycling**				
tire combination				13	2.2		selective switched off	disabled				**on**	**on**				

system reaction / Component	SPN	SID	PID	FMI	Repair Instruction	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp
sensor rear left																	
airgap	3	3		1	2.1 / 2.4	take over speed from other rear wheel	enabled	disabled	enabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
impedance				5	2.5		enabled	disabled				**on**	**on**				
pole wheel				7	2.4		enabled	disabled				**on**	**on**				
no trigger at all				8	2.1 / 2.3 / 2.4 / 2.5 / 2.6		enabled	disabled				**on**	**on**				
Inlet valve actuation time not plausible (75 % switch on time within 5 minutes)	254	254		9	2.1 / 2.4 / 2.5		enabled	disabled				**on**	**on**				
brake chatter	3	3		11			temporary selective switched off	temporary selective switched off				**lamp on only during cycling**	**lamp on only during cycling**				
tire combination				13	2.2	take over speed from other rear wheel	enabled	disabled				**on**	**on**				
sensor front left																	
airgap	1	1		1	2.1 / 2.4		selective switched off	disabled	enabled	full functionality	off	**on**	**on**	off	off	according to SAHR status	
impedance				5	2.5		selective switched off	disabled				**on**	**on**				
pole wheel				7	2.4		selective switched off	disabled				**on**	**on**				
no trigger at all				8	2.1 / 2.3 / 2.4 / 2.5 / 2.6		selective switched off	disabled				**on**	**on**				
Inlet valve actuation time not plausible (75 % switch on time within 5 minutes)	254	254		9	2.1 / 2.4 / 2.5		selective switched off	disabled				**on**	**on**				
brake chatter	1	1		11			temporary selective switched off	temporary selective switched off				**lamp on only during cycling**	**lamp on only during cycling**				
tire combination				13	2.2		selective switched off	disabled				**on**	**on**				

system reaction / Component	SPN	SID	PID	FMI	Repair Instruction	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp
sensor rear right																	
airgap				1	2.1 / 2.4		enabled	disabled				**on**	**on**				
impedance				5	2.5		enabled	disabled				**on**	**on**				
pole wheel	4	4		7	2.4	take over speed from other rear wheel	enabled	disabled	enabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
no trigger at all				8	2.1 / 2.3 / 2.4 / 2.5 / 2.6		enabled	disabled				**on**	**on**				
Inlet valve actuation time not plausible (75 % switch on time within 5 minutes)	254	254		9	2.1 / 2.4 / 2.5		enabled	disabled				**on**	**on**				
brake chatter	4	4		11			selective switch off only during cycling	selective switch off only during cycling				**lamp on only during cycling**	**lamp on only during cycling**				
tire combination				13	2.2	take over speed from other rear wheel	enabled	disabled				**on**	**on**				
power amp. iv front right																	
shorted to ubat	43	43		3	1.1	brake valve power supply switched off	disabled	disabled	disabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
open circuit				5			selective switched off		enabled	full functionality					off		
shorted to ground				6			selective switched off		enabled								
power amp. ov front right																	
shorted to ubat	49	49		3	1.1	brake valve power supply switched off	disabled	disabled	disabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
open circuit				5			selective switch off		enabled	full functionality					off		
shorted to ground				6			selective switch off		enabled								
power amp. iv front left																	
shorted to ubat	42	42		3	1.1	brake valve power supply switched off	disabled	disabled	disabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
open circuit				5			selective switched off		enabled	full functionality					off		
shorted to ground				6			selective switched off		enabled								

system reaction / Component	SPN	SID	PID	FMI	Repair Instruction	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp
power amp. ov front left																	
shorted to ubat	48	48		3	1.1	valve power supply off	disabled	disabled	disabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
open circuit				5			selective switched off	disabled	enabled	full functionality					off		
shorted to ground				6			selective switched off	disabled	enabled								
power amp. iv rear left																	
shorted to ubat	44	44		3	1.1	brake valve power supply switched off	disabled	disabled	disabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
open circuit				5			selective switch off										
shorted to ground				6			selective switch off										
power amp. ov rear left																	
shorted to ubat	50	50		3	1.1	brake valve power supply switched off	disabled	disabled	disabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
open circuit				5			selective switched off										
shorted to ground				6			selective switched off										
power amp. iv rear right																	
shorted to ubat	45	45		3	1.1	brake valve power supply switched off	disabled	disabled	disabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
open circuit				5			selective switched off										
shorted to ground				6			selective switched off										
power amp. ov rear right																	
shorted to ubat	51	51		3	1.1	brake valve power supply switched off	disabled	disabled	disabled	no service brake intervention	off	off	**on**	off	on	according to SAHR status	
open circuit				5			selective switched off										
shorted to ground				6			selective switched off										

system reaction / Component	SPN	SID	PID	FMI	Repair Instruction	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp
power amp. ATC nc																	
shorted to ubat	18	18		3	1.1	brake valve power supply switched off	disabled	disabled	disabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
open circuit				5			enabled										
shorted to ground				6			enabled		enabled			off					
power amp. ATC no																	
shorted to ubat	19	19		3	1.1	brake valve power supply switched off	disabled	disabled	disabled	no service brake intervention	off	**on**	**on**	off	on	according to SAHR status	
open circuit				5			enabled		enabled								
shorted to ground				6			enabled		enabled			off					
power amp. endurance brake relay																	
shorted to ubat	13	13		3	15.1		enabled	enabled	enabled	full functionality	off	**on**	off	off	off	according to SAHR status	
open circuit				5	15.2												
shorted to ground				6	15.3												
power amp. brake light signal																	
shorted to ubat	100	100		3	16.1		enabled	enabled	enabled	full functionality	off	off	**on**	off	off	according to SAHR status	
open circuit				5	16.2												
shorted to ground				6	16.3												

system reaction / Component	SPN	SID	PID	FMI	Repair Instruction	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp
power amp. parking brake pressure supply valve																	
shorted to ubat	234	234		3	4.1		enabled	enabled	enabled	SAHR backup mode 2: close cut off valve if parking brake is applied	off	off	off	off	**on**	according to SAHR status	
open circuit				5	4.2					SAHR backup mode 3: no replenishment if PB is released							
shorted to ground				6	4.3												
power amp. parking brake pressure cut-off valve																	
shorted to ubat	235	235		3	5.1		enabled	enabled	enabled	parking brake could not be applied if released; no strategy to avoid this	off	off	off	off	**on**	according to SAHR status	
open circuit				5	5.2					SAHR backup mode 1: actuate supply valve permanently if parking brake should be released							
shorted to ground				6	5.3												
internal valve relay (provides supply voltage for ABS/ATC pressure control valves)																	
can't switch off	30	30		3	1.1		disabled	disabled	disabled	full functionality	off	**on**	**on**	off	off	according to SAHR status	
can't switch on				4	11.1					no service brake intervention					on		
abs warning light bulb (if available)	1438	23		5	12.1		enabled	enabled	enabled	full functionality	off	-	**on**	off	off	according to SAHR status	
brake warning light bulb (if available)	1439	101		5	13.1		enabled	enabled	enabled	full functionality	-	**on**	**on**	off	off	according to SAHR status	
buzzer (if available)	224	224		5	14.1		enabled	enabled	enabled	full functionality	off	**on**	**on**	-	off	according to SAHR status	
ECU main ground or reference ground connection	98	98		2	11.2 / 11.3		disabled	disabled	disabled	park brake status will be maintained	**on**	**on**	**on**	off	**on**	according to SAHR status	
low voltage (< 10.0 V) corresponding parameter is set	251	251		4	11.5		enabled during ABS cycling; disabled afterwards	disabled	enabled	full functionality	off	**on**	**on**	off	off	according to SAHR status	
low voltage (< 10.0 V) corresponding parameter is not set																	
high voltage (> 16.5 V)	251	251		3	11.4		enabled										

system reaction / Component	SPN	SID	PID	FMI	Repair Instruction	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp
accumulator pressure sensing front axle	59	59				**level 1 warning;** pump actuation on brake application for a speed dependent time of 5..15 s	disabled on front axle	disabled	enabled	release independent of pressure level in circuit 1; pump actuation during release sequence (max. 60 s)	**on**	**on**	**on**	**on**	off	according to SAHR status	
shorted to ubat				3	3.1												
shorted to ground				4	3.1												
abnormal high pressure gradient (short charge time)				10	7.1												
accumulator pressure sensing rear axle	62	62				**level 1 warning;** pump actuation on brake application for a speed dependent time of 5..15 s	disabled on rear axle	disabled	enabled	release independent of pressure level in circuit 2	**on**	**on**	**on**	**on**	off	according to SAHR status	
shorted to ubat				3	3.1												
shorted to ground				4	3.1												
abnormal high pressure gradient (short charge time)				10	7.1												
electronic pressure control front axle	2580	57				**level 1 warning**	disabled on front axle	disabled	disabled	**pressure level in circuit 1 above 1525 PSI**: full functionality **pressure level in circuit 1 below 1525 PSI**: no replenishment; auto apply still possible; application still possible via auto apply, driver demand (dash switch) or ignition off during vehicle stationary	**on**	**on**	**on**	**on**	**on**	according to SAHR status	
pump monitor voltage unexpected high				3	6.6												
supply voltage for pump motor missing				5	6.3												
pump monitor voltage unexpected low (motor monitor indicates motor on although driver is off)				4 & 6	6.4												
master cylinder brake circuit				7	18.1												
diaphragm accumulator precharge level too low (detected by short run time and high switch on frequency)				8	7.1												
leakage too high				9	6.1												
abnormal low pressure gradient				10	6.5												

system reaction / Component	SPN	SID	PID	FMI	Repair Instruction	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp
electronic pressure control rear axle																	
pump monitor voltage unexpected high				3	6.6												
pump monitor voltage unexpected low (motor monitor indicates motor on although driver is off)				4	6.3 / 6.4												
supply voltage for pump motor missing	2581	60		5	6.3	**level 1 warning**	disabled on rear axle	disabled	enabled	full functionality but release independent of pressure level in circuit 2	**on**	**on**	**on**	**on**	off	according to SAHR status	
pump monitor voltage unexpected low (motor monitor indicates motor on although driver is off)				4 & 6	6.4												
master cylinder brake circuit				7	18.1												
diaphragm accumulator precharge level too low				8	7.1												
leakage too high				9	6.2												
abnormal low pressure gradient				10	6.5												
foot brake switch						foot brake switch status on J1939 turned to error condition in order to disable cruise control											
out of range	246	246		3	9.1		enabled	disabled	disabled	release independent of foot brake switch on auto transmission vehicle	**on**	off	off	off	off	according to SAHR status	
long term supervision				10													
parking brake switch										park brake status prior to the fault will be maintained; if released, apply will only be possible with ignition off and vehicle stationary, auto apply still possible on auto transmission vehicle							
out of range	70		70	3	10.1		enabled	enabled	enabled		off	off	off	off	**on**	according to SAHR status	
long term supervision				10													
parking brake system																	
park brake travel switch output implausible	619		61	3	17.1		enabled	enabled	enabled	SAHR backup mode 1: actuate supply valve permanently if parking brake should be released	off	off	off	off	**on**	according to SAHR status	
could not be released				4	17.2												
overtravel				13	17.3												

system reaction / Component	SPN	SID	PID	FMI	Repair Instruction	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp
j1939 communication																	
bus error				5	8.1					no auto apply on auto transmission vehicle		**on**	**on**	off	**on**	according to SAHR status	
internal error				12	1.1					no auto apply on auto transmission vehicle	off	**on**	**on**		**on**	according to SAHR status	
message time out																	
engine ECU (EEC1)	231	231					enabled	enabled	enabled	full functionality		off	**on**		off	according to SAHR status	
engine retarder driveline retarder exhaust retarder										full functionality		**on**	off		off	according to SAHR status	
engine ECU, engine hours (EH_R)				9	8.1					full functionality		off	off		off	according to SAHR status	
engine ECU, vehicle speed (VSC1)										full functionality		**on**	off		off	according to SAHR status	
transmission ECU, selected gear (ETC2)										no auto apply on auto transmission vehicle		off	off		**on**	according to SAHR status	
transmission ECU, shift inhibit (ETC7)										no auto apply on auto transmission vehicle		off	off		**on**	according to SAHR status	
system controller										full functionality		off	**on**		off	according to SAHR status	

2. Multiple failures

system reaction / Component	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp	Repair Instruction
both pressure circuits affected	**level 2 warning,** Reduce speed to 25 mph if once below.	disabled	disabled	disabled	Apply PB if pressure in both circuits drops below 1300 PSI when vehicle stationary	**flashing**	**on**	**on**	**on**	**on**	according to SAHR status		refer to Repair Instructions of single failures
both supply voltages for the pump motors missing	**level 2 warning,** Reduce speed to 25 mph if once below.	disabled	disabled	disabled	PB cuts in because both valves are deactuated.	**flashing**	**on**	**on**	**on**	**on**	according to SAHR status		
sensor failures at both rear axle wheel ends		disabled	disabled	disabled	full functionality	off	**on**	**on**	off	off	according to SAHR status		
more than 100 sensor faults on the same wheel end		**control functions permanently disabled at this wheel end**			full functionality	off	**on**	**on**	off	off	according to SAHR status		
power amp. failures on both rear axle wheel ends		disabled	disabled	disabled	full functionality	off	**on**	**on**	off	off	according to SAHR status		
power amp. failures on both wheel ends of one side		disabled	disabled	disabled	full functionality	off	**on**	**on**	off	off	according to SAHR status		

For any other failure constellation see combination of single failures.

3. Special System Conditions

system reaction / Component	general actions	ABS	ATC	EBD	PB	Brake-Warning Lamp	ABS-Warning Lamp	ATC-Info Lamp	Audible Warning	Parking Brake Service Lamp	Parking Brake Indicator Lamp	Brake Fluid Indicator Lamp
low fluid level		enabled	enabled	enabled	full functionality	**on** (on non-muxed systems)	off	off	off	off	according to SAHR status	**on** (on muxed systems)
pressure level below 1525 PSI in circuit 1 or circuit 2		disabled	disabled	disabled	release request postponed until both pressure level exceed 1525 PSI.	**on**	**on**	**on**	**on**	off	according to SAHR status	
parking brake applied	Engine torque limited to 50 %/ 20% (auto / manual transmission) of maximum torque	enabled	enabled	enabled	full functionality	**on** (on non-muxed systems)	off	off	off	off	**on** (on muxed systems)	
parking brake release request rejected because of: - **pressure level in at least one circuit below 1525 PSI** - **Shift Inhibit active (if available)** - **foot brake switch not actuated (on auto transmission vehicle)** - **transmission in park (on auto transmission vehicle)**		enabled	enabled	enabled	release request rejected	off	off	off	**500 ms audible warning**	off	according to SAHR status	
service brake intervention due to parking brake application request during vehicle driving	Actuate brake signal output in order to illuminate brake lights	enabled	enabled	enabled	full functionality	off	off	off	off	off	according to SAHR status	
ATC off-road switch applied		enabled	enabled with increased thresholds	enabled	full functionality	off	off	**flashes with 0.33 Hz**	off	off	according to SAHR status	
ATC controls brakes or engine		enabled	enabled	enabled	full functionality	off	off	**on**	off	off	according to SAHR status	
Sensor failure detected during the last drive cycle		disabled, until all wheel speeds passed sensor test	disabled, until all wheel speeds passed sensor test	enabled	full functionality	off	**on**, until all wheel speeds passed sensor test	**on**, until all wheel speeds passed sensor test	off	off	according to SAHR status	

Repair Instructions

R.I. Number	R.I. Sub-Number	Instruction
1		***ECU***
	1	Replace ECU.
2		***Sensor / Tone ring combination***
	1	Amplitude of sensor signal is too low. Check bearing play and tone ring run out. Eliminate root cause for airgap extension and push sensor back in afterwards.
	2	Wheel sizes or number of tone ring teeth are different.
	3	Check J1939 communication with engine controller.
	4	Check tone ring for damage (missing teeth, corrosion). Replace tone ring if necessary.
	5	Check sensor wiring and connectors for intermittent contact. Replace sensor and/or sensor wiring if necessary.
	6	Check for extremely large airgap.
3		***Pressure Sensors***
	1	Remove ECU and check pressure sensor connections. In case of visual damage on ECU-side change ECU, otherwise change HCU.
4		***Parking Brake Pressure Supply Valve***
	1	Shorted to Ubat. Check wiring and connectors for short circuit. If further failure occurs -> 1.1.
	2	Open circuit. Check wiring and connectors for short circuit. Replace coil if necessary. Check front axle pump motor fuse and replace if broken. If further failure occurs -> 1.1.
	3	Shorted to ground. Check wiring and connectors for intermittent contact. Replace coil if necessary. Check front axle pump motor fuse and replace if broken. If further failure occurs -> 1.1.
5		***Parking Brake Pressure Cut-Off Valve***
	1	Shorted to Ubat. Check wiring and connectors for short circuit. If further failure occurs -> 1.1.
	2	Open circuit. Check wiring and connectors for short circuit. Replace coil if necessary. Check rear axle pump motor fuse and replace if broken. If further failure occurs -> 1.1.
	3	Shorted to ground. Check wiring and connectors for intermittent contact, replace coil if necessary. Check rear axle pump motor fuse and replace if broken. If further failure occurs -> 1.1.
6		***Pump Motor***
	1	Check front axle pump motor circuit for external leakage. Observe frequency of pump motor operation. Proceed Diagnostic Service to actuate the parking brake valves for about 3 minutes. If frequency is significant lower change supply valve. If not change HCU.
	2	Check rear axle pump motor circuit for external leakage. If no leakage found change HCU.
	3	Check corresponding pump motor fuse and wiring and replace/repair if broken.
	4	Check if corresponding pump motor is able to run. If not change HCU. If pump motor runs permanently -> 1.1.

	5	1. Check accumulator precharge level of the corresponding circuit by using special diagnostic software and replace accumulator if necessary. 2. Check hose and pipes between master cylinder reservoir and HCU reservoir for any flow restrictions. 3. Run system without filler cap. Replace filler cap if failure disappears. 4. Bleed System according to bleeding procedure. 5. Replace HCU reservoir. 6. Change HCU
	6	Check pump motor current draw of the corresponding circuit. Current should be less than 30 A. If value exceeded change HCU. If not exceeded -> 1.1.
7		***Accumulator***
	1	Check accumulator precharge level of the corresponding circuit by using special diagnostic service and replace accumulator if necessary.
8		***J1939-Interface***
	1	Check J1939 bus
9		***Foot Brake Switch***
	1	Check switch wiring and connectors, replace Foot Brake Switch if necessary.
10		***Parking Brake Switch***
	1	Check switch wiring and connectors, replace parking brake switch if necessary.
11		***Supply Voltage, Ground connection***
	1	Check valve supply voltage fuse and wiring. If fuse OK -> 1.1
	2	Check wiring and connectors of the ECU ground connections.
	3	Check wiring and connectors of reference ground.
	4	Supply voltage too high. Check alternator and battery.
	5	Supply voltage too low. Check alternator and battery.
12		***ABS-Warning Light bulb***
	1	Check wiring and connections of the ABS-Warning light bulb. Replace bulb if necessary
13		***Brake-Warning Light bulb***
	1	Check wiring and connections of the Brake-Warning light bulb. Replace bulb if necessary
14		***Buzzer***
	1	Check wiring and connections of the Buzzer. Replace Buzzer if necessary
15		***Endurance Brake Relay (EBR)***
	1	Shorted to Ubat. Check wiring and connections of the EBR. Replace EBR if necessary. If further failure occurs -> 1.1.
	2	Open circuit. Check wiring and connections of the EBR. Replace EBR if necessary. If further failure occurs -> 1.1.
	3	Shorted to Ground. Check wiring and connections of the EBR. Replace EBR if necessary. If further failure occurs -> 1.1.
16		***Brake Light Signal (BLS)***
	1	Shorted to Ubat. Check wiring and connections of the BLS. If further failure occurs -> 1.1.
	2	Open circuit. Check wiring and connections of the BLS. If further failure occurs -> 1.1.
	3	Shorted to Ground. Check wiring and connections of the BLS. If further failure occurs -> 1.1.
17		***SAHR (Parking Brake System)***

	1	Parking Brake could not be applied. - Check SAHR for correct mechanical functionality - Check brake lining (overtravel) - Check travel switch (always in the released position) - Check pressure supply valve - Check pressure cut off valve
	2	Parking Brake could not be released. - Check SAHR for correct mechanical functionality - Check travel switch (always in the applied position) - Check SAHR chamber for leakage - Check pressure supply valve - Check pressure cut off valve - Check brake line to SAHR
	3	SAHR overtravel detected Check actuation cable between SAHR and drive line brake. Check SAHR brake lining.
18		***Master Cylinder Circuit / Relay Valves***
	1	- Check Relay Valve of the corresponding circuit. - Check brake lines between Master Cylinder and Relay Valves of the corresponding circuit. - Check bleeding condition for Master Cylinder circuit. - Check brake performance on dynamometer if possible. - Check Master Cylinder itself.