South Carolina Department of Education
School Bus Technical Training Series

School Bus Brakes

This workbook belongs to: __________

Issued on __ /__ /__

Chapter One

S.C.D.O.E.T.
Policy and Procedure

Brake Training Certification

The purpose of this training is to certify qualified technicians to make brake repairs according to SCDE policies and procedures, federal regulations and industry standards. Certified technicians should meet the following FMCSA §396.25 requirements

§ 396.25: Qualifications of brake inspectors.

(a) Motor carriers and intermodal equipment providers must ensure that all inspections, maintenance, repairs or service to the brakes of its commercial motor vehicles, are performed in compliance with the requirements of this section.

(b) For purposes of this section, ***brake inspector*** means any employee of a motor carrier or intermodal equipment provider who is responsible for ensuring that all brake inspections, maintenance, service, or repairs to any commercial motor vehicle, subject to the motor carrier's or intermodal equipment provider's control, meet the applicable Federal standards.

(c) No motor carrier or intermodal equipment provider may require or permit any employee who does not meet the minimum brake inspector qualifications of paragraph (d) of this section to be responsible for the inspection, maintenance, service or repairs of any brakes on its commercial motor vehicles.

(d) The motor carrier or intermodal equipment provider must ensure that each brake inspector is qualified as follows:

(1) Understands the brake service or inspection task to be accomplished and can perform that task; and

(2) Is knowledgeable of and has mastered the methods, procedures, tools and equipment used when performing an assigned brake service or inspection task; and

(3) Is capable of performing the assigned brake service or inspection by reason of experience, training, or both as follows:

(i) Has successfully completed an apprenticeship program sponsored by a State, a Canadian Province, a Federal agency or a labor union, or a training program approved by a State, Provincial or Federal agency, or has a certificate from a State or Canadian Province that qualifies the person to perform the assigned brake service or inspection task (including passage of Commercial Driver's License air brake tests in the case of a brake inspection); or

(ii) Has brake-related training or experience or a combination thereof totaling at least one year. Such training or experience may consist of:

(A) Participation in a training program sponsored by a brake or vehicle manufacturer or similar commercial training program designed to train students in brake maintenance or inspection similar to the assigned brake service or inspection tasks; or

(B) Experience performing brake maintenance or inspection similar to the assigned brake service or inspection task in a motor carrier or intermodal equipment provider maintenance program; or

(C) Experience performing brake maintenance or inspection similar to the assigned brake service or inspection task at a commercial garage, fleet leasing company, or similar facility.

(e) No motor carrier or intermodal equipment provider may employ any person as a brake inspector unless the evidence of the inspector's qualifications, required under this section, is maintained by the motor carrier or intermodal equipment provider at its principal place of business, or at the location at which the brake inspector is employed. The evidence must be maintained for the period during which the brake inspector is employed in that capacity and for one year thereafter. However, motor carriers and intermodal equipment providers do not have to maintain evidence of qualifications to inspect air brake systems for such inspections performed by persons who have passed the air brake knowledge and skills test for a Commercial Driver's License.

To meet the aforementioned requirements the technician should have at least one year of hands on experience in school bus brake repair. The Trades Specialist/shop foreman must ensure that the trainee technician has been shown and has performed correct repair procedures as required by SCDE. The Trades Specialist/shop foreman should give hands on training at the shop level by working with the trainee technician or pairing the trainee technician with a qualified brake repair technician. Any work performed by the trainee technician must be inspected by the Trades Specialist/shop foreman or qualified brake technician.

The technician will then complete classroom training and pass a knowledge test to obtain SCDE certification.

ASE certification in school bus brake repair will be accepted in lieu of SCDE certification.

Department Brake Policy

Listed here are a few reminders of our policies that pertain to brake repairs.

Wear items such as shoes, pads, linings, drums, and rotors are always replaced as an axle set. Do not replace on one wheel only.

Wheel end group parts, Hydraulic cylinders, calipers, cams, slack adjusters, and Chambers are replaced as needed. (Return springs are replaced every time the lining is replaced)

Wheel Bearing adjustment; Follow vehicle manufacturer's recommendation outlined in the service manual. We are looking for a .001 to .005 inch end play when finished.

Never run drums/rotors beyond the dimension stamped or cast into the part.
If replacing pads, shoes, or linings, you must have at least **.040** inch wear remaining on the drum/rotor to re-use it. This would be the manufacturer's re-machining dimension.
There may be some drums in use that are intended for extended service applications as well as normal use. These may be marked with .240-.250 inch maximum inside diameter. For example "max diameter 16.750 in." for a 16.5 drum. **DO NOT USE THIS DIMENSION** as it requires a different foundation brake. Our maximum Usable inside diameter will be .120 inch above drum size.

Our minimum lining thickness is ¼ inch (.250) from table/pad. **Do not measure rivet depth.**

AIR DRYER SERVICE

The Air dryer desiccant filter/cartridge must be changed, and the purge valve must be serviced during Annual Repair every three years or follow AssetWorks PM schedule.

At this time, air dryers, dryer housings, plumbing and all mounting attachments should also be inspected and serviced/replaced if any inspection indicates defects or possible failure.

All manufacturers' installation instructions must be followed whenever servicing/replacing air dryer systems.

SCDE VEHICLE AIR RESEVOIR DRAIN POLICY

This policy pertains to all SCDE air brake equipped vehicles. For additional instructions and information regarding buses, refer to the SCDE Driver Training manual.

Our policy on this matter is to ensure that no one can enter a parked bus and release the brakes without first starting the engine. To assist in complying with this policy, please provide the following instructions to all school districts, driver trainers, shop employees and others as may be appropriate:

On all vehicles equipped with air brakes, the air shall be fully exhausted from all brake system reservoirs at any time the vehicle is parked and left unattended. This may be accomplished by either fanning the brakes or by using air drain switch, if equipped.

USE OF VEHICLE END LIFTS

The following pages cover in detail the use of Vehicle End Lifts (bumper jacks) commonly used in our facilities. Additionally, this document will address the requirement for using jack stands and the placement of such.

Our shops have typically used jack stands with a height adjustment range of 20" -30". Because of different vehicle configurations and the service/repair being performed, some shops may need to purchase jack stands with different height range adjustments. The most common sizes available in suitable capacities (7 ton, 10 ton) for most school buses are: 12"-20", 20"-30", and 30"-50". This is not to be interpreted as a need to purchase all 3 sizes identified for all technicians. Jack stands are to be provided based on the actual needs of each individual shop and should be discussed with your Lead Supervisor prior to purchase.

Pay particular attention to the sections of the following pages regarding Type D buses that are designed with an inner chassis bumper and an outer body bumper. At NO time is it permissible to lift or support this type bus using only the outer body bumper.

NO work shall be performed on a vehicle that has been lifted from the ground without first placing appropriate jack stands under the vehicle. This includes tire service or other repairs being performed away from the shop.

USE OF VEHICLE END LIFT (BUMPER JACK)

Intended use of Vehicle End Lift: To engage the metal bumper of a vehicle and lift for the purpose of vehicle service/repair. Vehicle end lifts are designed to lift, but not continually support rated capacity loads. Immediately after lifting, the load must be transferred from the end lift to appropriately rated jack stands.

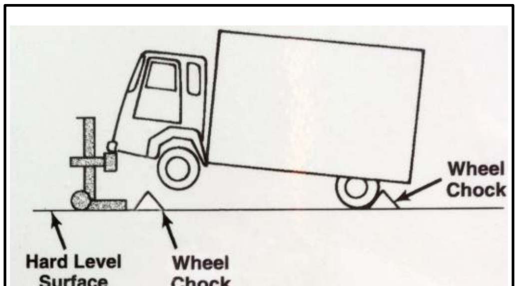
WARNING: Do not work under a vehicle supported by an end lift. Use appropriate jack stands properly placed and supporting the vehicle when working under vehicle.

Using Vehicle End Lift

WARNING: Prior to use of any lifting equipment; read equipment operating instructions and familiarize yourself with the product and all components. Always recognize the potential hazards associated with the use of any lifting equipment.

1. Park vehicle on level surface that provides the necessary firmness to support the weight of the vehicle concentrated on the footprint of the jack.

2. Place wheel chocks at the front of the front tire and the rear of the rear tire.



3. Inspect vehicle bumper for damage and all bumper attaching points for missing, loose, or damaged fasteners. Repair as necessary before proceding.

4. Ensure that lift is of sufficient capacity, that the lift rolls freely, that the air cylinder operates smoothly when the unloaded lift is raised/lowered throughout the lifting range, and that lift locking device functions as designed.

5. Ensure that lift is placed at the approximate centerline of the vehicle, that the lift saddles are equal distance from the lift center, that lift saddles are as close to the bumper to frame attachment points as possible, and that the saddles are positioned directly under the vehicle bumper. (Illustration 1)

Illustration 1

6. Release the vehicle parking brakes. Vehicle must be allowed to move (follow the jack) as it is being lifted.

7. As contact is made between the lift saddles and the bumper, inspect to ensure that lift saddles are properly positioned and the bumper is firmly seated on the saddle surface. (Illustration 2) **CAUTION**: **On Type D buses w/ an inner chassis bumper; ensure that both the inner chassis bumper and the outer body bumper are firmly seated on the lift saddles. (Illustration 3)**

Illustration 2

Illustration 3

8. Jack the vehicle only to the height necessary for the required service/repair.

9. After servicing is complete, lift the vehicle just enough to remove the jack stands and carefully lower vehicle.

Using Jack Stands

WARNING: Prior to use of jack stands always inspect for damage and to ensure that stands, including locking devices, function as designed.

1. Ensure jack stands are of sufficient capacity and are of appropriate height for vehicle service/repair being performed.

2. Always use jack stands in pairs when transferring load from end lift.

3. Jack stand should be placed on level surface that provides the necessary firmness to support the weight of the vehicle concentrated on the footprint of the jack stand.

4. Jack stands should be placed under the front bumper, front axle, frame rail, or rear axle housing. (See Illustrations below) **CAUTION**: **On Type D buses w/ an inner chassis bumper; do not place jack stands under the outer body bumper only.**

5. As contact is made between the jack stands and supporting member, inspect to ensure that saddles are properly positioned before engaging full load.

Front Bumper

Front Axle

Frame Rail

Rear Axle Housing

Signature: ______________________________ **Date:**_____________________________

WHEEL-BEARING ADJUSTMENT PROCEDURES - (NON DISC BRAKE BUSES)

Buses maintained by SCDE must have a verifiable wheel bearing end play of 0.001" to 0.005".

The following service procedures apply to steer and drive axle assemblies using conventional double nut or single nut systems. Follow these service procedures carefully to prevent premature wheel-end component failure and increase seal and bearing life.

ABS (anti-lock braking systems) and traction control systems with wheel-end sensing require precise bearing adjustment to function properly.

This procedure details proper service procedures for D-type, bendable-type, and dowel- type spindle nut washers.

NOTE: For single nut self-locking systems, consult manufacturer's instructions.

If you have a system that differs from what is indicated in this procedure, consult the vehicle manufacturer's recommended procedure.

WARNING: Never work under a vehicle supported by only a jack. Always support the vehicle with jack stands. Block the wheels and make sure the unit will not roll before releasing brakes.

CAUTION: If your axle is equipped with spoke wheels and the rim clamps have been dis-assembled to remove the tire and rim assembly, the tire and rim assembly must be reinstalled and the rim clamps properly torqued BEFORE adjusting the wheelbearings. Failure to do this may result in improper wheel bearing adjustment.

AIR DISC BRAKE EQUIPPED BUSES

These buses are equipped with Conmet Preset Hubs. Follow the manufactures recommendations for service and adjustment.

REFERENCES:

SCDE Brake Manual
TMC RP 622, Wheel Seal and Bearing Removal, Installation and Maintenance.

WHEEL BEARING/SEALSERVICE INTERVAL

<u>New Vehicles:</u> Each time a new vehicle is received at your shop, part of the inspection process will include raising the wheels and checking for excessive wheel bearing end play.

<u>1st Annual Repair:</u> As a part of the 1st Annual Repair, all vehicles will have the wheel bearings checked for proper wheel bearing adjustment.

Additional service/replacement requirements will be based on the type of bearing lubrication system and brake systems as indicated below.

<u>ALL Wheel End Groups (drum or disc) EXCEPT Outboard Mounted:</u>
Each time the brake drums/rotors are replaced; the wheel bearings must be removed, cleaned, inspected, replaced if necessary and properly lubricated. New grease seals must be installed and the bearings adjusted consistent with the manufacturer's recommendations.

<u>ALL Outboard Mounted Wheel End Groups: (drum or disc)</u>
A minimum of once every 100,000 miles the wheel bearings must be removed, cleaned, inspected, and replaced if necessary. New grease seals must be installed and the bearings adjusted consistent with the manufacturer's recommendations.

Wheel bearings/seals should also be serviced/replaced if any inspection of these items indicates possible failure. All shops must be installing unitized design seals whenever possible. This type of seal offers longer life and a greater degree of re-usability. All manufactures installation instructions and tools must be used when installing wheel seals.

VEHICLE AND EQUIPMENT REMAINING OEM

Vehicles and equipment should be repaired in such a way that they conform to the standard specifications for the particular vehicle or equipment. Therefore, when it becomes necessary to make repairs to buses, support vehicles or equipment, the repairs should be made so that the item will be the same as when it was received new.

This practice will ensure the highest level of safety and standardization, while ensuring warranty, EPA, NHTSA, OSHA and FMVSS compliance.

It may be necessary, however, that we make repairs or changes that are not consistent with the manufacturer's recommendations. If this is the case, these repairs must be discussed and approved by the assigned Engineering Associate. In such cases, a decision will be made at the state level prior to the individual shops making changes.

All support vehicles shall be kept clean and presentable, so as to represent the agency and its mission in a positive and professional manner.

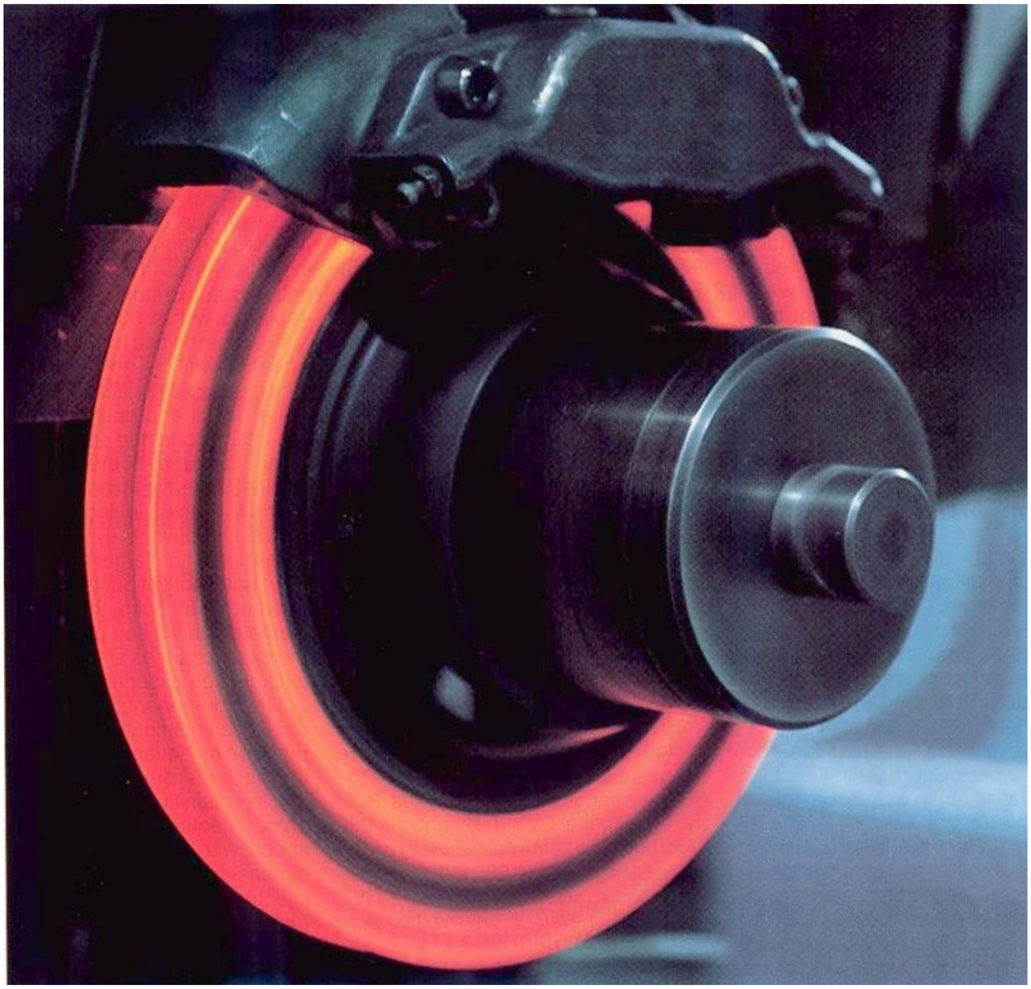
<u>Under no circumstances should an SCDE employee make any changes to vehicles or equipment that is not consistent with OEM recommendations without prior approval from your assigned Engineering Associate or the State Office.</u>

Chapter Two

Fundamentals

Fundamentals of Braking

BRAKING CHANGES THE ENERGY OF MOTION…



....into HEAT ENERGY

How do we "eliminate" kinetic energy in order to stop a vehicle? One of the basic laws of science is the law of the conservation of energy. It states that "energy" can neither be created nor destroyed. It can only be changed from one form to another. We use the brake system to convert the kinetic energy of the vehicle in motion into another form of energy, heat energy.

The secret of an effective brake is a heat machine that will create heat, using the heat energy to its advantage, and then dissipate the heat before it can damage the braking mechanism. The friction material used in the brake must tolerate the heat that is developed, and yet provide enough friction at elevated temperatures to continue the energy conversion process until the vehicle is stopped.

Balanced Brake Systems

The balancing of brakes is a vitally important servicing procedure needed to achieve safe and economical operation of heavy duty vehicles. In order to get safe, sure stops, the brakes at each wheel must do its own particular share of work. This fundamental rule applies to trucks, buses, or tractor trailer units without exception.

Every brake maintenance program should strive to maintain a balanced brake system. An unbalanced brake system is an inefficient one; safety is sacrificed and costs mount.

There are many factors which may cause imbalance, including components in the air or hydraulic system. If the cause for imbalance is traced to either of these, the manufacturer of the particular system involved should be consulted. These might include:

1. Improper distribution of power between axles.

2. Improper brake chamber

3. Incorrect slack adjuster length.

4. Overloaded vehicle.

When servicing braking systems to maintain balanced braking it is very important to make sure any components replaced have the same specifications as the original. This applies to all components such as wheel cylinders, calipers, brake chambers, shoes, drums, as well as lines, hoses, and fittings.

How can you quickly tell when a brake system is not balanced? All friction devices generate heat when they are working. The greater the heat, the more work they are doing. This is exactly the case with a brake system. If one brake drum assembly is cooler than its companions, that one is loafing on the job. You can make a quick, effective check as to whether a brake is absorbing its share of the load by means of a surface thermometer which can read drum temperatures to approximately 500 ° F. Those drums which are the coolest are the ones whose brakes are loafing. They deserve close attention. But if one drum is running considerably hotter than others, a malfunction is indicated.

In such cases, the things to look for are:

1. Sticky S-Cam

2. Frozen anchor pin

3. Weak return spring

4. Weak chamber spring

It is also important that the brake drum diameters on an axle be equal within .010 of an inch. If it is necessary to use a used drum, then a drum of equal diameter should be used on the opposite brake.

Note: The principal brake drum manufacturers in this country have endorsed .080"maximum wear when relining .

The ability of a brake to dissipate the energy absorbed is directly related to the mass or weight of the brake drum. If the drum has too much wear, it not only weakens the drum, causing excessive distortion, but greatly reduces its ability to absorb and dissipate the heat. Another way of saying this is that the heat sink quality of the brake drum is reduced.

When brake drums are replaced, the same type (manufacturer and configuration) should be used on the same axle.

Brake Drums

Their design, composition, thickness, relation to the wheel rim and surface grind are extremely important to safe, economical operations. To a large degree, lining performance and life is dependent on the brake drum. Drums should never be overlooked since the brake (being a heat machine) depends on the drum for its heat absorption and dissipation.

Don't overlook the outside of the drum. Any accumulation of mud, dirt, or rust on the outside of the drums should be removed. Foreign matter acts as an insulator, trapping the heat within the drum.

Drum Condition Friction surfaces must be smooth, true, and concentric with the center of the bearing or axle mounting. Any indication of scoring, glazing, or excessive wear requires immediate repair or replacement.

Heat Checking and Spotting Heat checking and spotting which are so common on the over the road vehicles are the result of a temperature differential in the drum wall between a relatively cool exterior and a hot friction surface. This expanding from within and contracting from without results in internal stresses causing cracks. These cracks not only can materially reduce the lining life because of their sharp edges but, when pronounced, a panic stop can result in a broken drum. Spotting is the result of metallurgical changes in the drum due to the temperature fluctuations.

Matching Drums The same manufacturer and design of drum should be used throughout the vehicle to avoid a variable in brake balance. The diameters should be within .010" on the same axle. Run out of the drums should not exceed a .010" limit.

When one brake drum on an axle has worn beyond the safety limit, always replace or match the opposite drum and the lining on the same axle. Make sure of identical size, inside diameter, design, and manufacturer source. Otherwise the result is mismatching and one or the other brake assembly will overwork.

Cleaning and Inspection

You can readily see the need for disassembling the brake to clean, inspect, and service the components. Clean the seals with hot soapy water, as gasoline or a solvent would damage them. It is permissible to use a solvent in cleaning the metal parts.

Shoe Mechanism- Inspecting for possible frozen anchor pins and excessive shoe component wear should be done before removing the brake shoes. If excessive travels had been the rule when adjusting for a free wheel, look for an out of round drum, an improper wheel bearing adjustment, a distorted spider or backing plate, also a worn slack adjuster. **The slack adjuster lengths must be equal on the same axle and their travels should always be identical.**

The cam profile should be checked for worn areas; check the camshaft for play; and inspect the rollers for flat spots. The shoes need to be inspected for enlarged anchor holes, weld breaks between web and table, and for a badly pitted or distorted shoe table. Check the anchor pin and camshaft holes in the brake spiders for enlargement or elongation. After long service life, wear and distortion may be found.

Brake Springs

Brake shoe return and chamber springs can become weak and unmatched. This may cause erratic performance, uneven wear, and unnecessary heat buildup. Properly functioning, shoe return springs should react quickly; therefore, each pair should be matched for equal tension so they return simultaneously to the "Off" position. This also applies to brake chamber springs, which should be balanced to prevent excessive wear and heat. Brake shoe springs cannot be overlooked. Besides being mated for tension, they should have the tension of new springs.

Lining wear and unmatched springs bring problems of pulling and dragging brakes. When time between brake adjustments are lengthened and the travels are extreme, the brake shoe springs are abnormally stretched. A condition of this kind can damage the spring by the excessive stretch. The stretching and contracting of the spring is always taking place in the confined heat area of the drum. Brake shoe return springs or retracting springs should never be replaced on one brake at a time. Always replace them on both brakes of the same axle.

Brake Chambers

Brake chambers should be inspected. Chambers should be checked for ruptures and possible leaks at time of reline. The brake chamber spring tension is vital to brake balance because any irregularity or variance, although considered minimal, can greatly change the brake distribution. This is because of the compounding factor of the leverage, the chamber area, and the delivery pressure.

When removing chambers, mark the exposed thread as a reference mark for reinstallation.

Wheel Bearings and Grease Seals

When removing the hub you can wrap the spindle threads with friction tape to protect the threads from damage. The wheel bearings should be cleaned and checked thoroughly. The bearing cups should be inspected for a tight fit in the hub. The race surfaces should be inspected for burrs or any roughness. The rollers should be checked for any roughness or damage. They should be wiped with and lint free towel and wrapped with oil proof paper or lint free towel to eliminate contamination until installation.

Grease seals should be replaced per SDE policy.

Bearing Adjustment- When adjusting wheel bearings, the vehicle manufacturer's recommendations should be carefully followed. Loose wheel bearings can cause erratic brakes and brake squeal, and it can result in excessive tire wear. Accuracy of the wheel bearing adjustment cannot be overemphasized as it has a direct effect on the brake performance because the proper brake adjustment and free wheel are all inter related. **You cannot properly adjust a brake if the wheel bearing has not been correctly adjusted.**

Wheel Torqueing Torque the wheel studs to the manufacturer's specification. The tightening should be in a crisscross order to prevent a distortion of the drum. An improperly tightened wheel could distort the drum sufficiently to make a proper brake adjustment impossible; thus brake performance is affected.

Lubrication

Good maintenance requires lubrication on a regularly scheduled basis. Don't pass up any grease fitting, as sluggishness will surely follow when lubrication is neglected. Nothing can be more damaging to brake performance than a hanging brake. Lubricate all brake linkages, anchor pins, camshafts and slack adjusters, as well as any other moving brake components that call for grease. A high temperature resistant lubricant should be used. **DO NOT LUBRICATE THE CAM FACE OR THE OUTSIDE OF THE SHOE ROLLER; THEY MUST BE DRY.**

Well lubricated shoe mechanisms make for a more responsive application and release of the brake, requiring less air in the application.

Over lubrication There is no excuse for grease getting on to brake lining, unless it is caused by a grease seal failure or some other unforeseen or unpredictable condition. In many instances, brake lining is ruined because of carelessness on the part of the man using the lubrication gun. Some anchor pins have grease fittings in the end. Just a light squirt of grease at reasonable intervals is all that is required. It is not unusual to see brake drums and linings loaded with grease because it was over lubricated.

Brake Adjustment

It is always advisable to adjust the brakes with the wheels off the floor. This is the only way of definitely knowing you have a free running brake. Be certain that the initial adjustment at time of reline affords extra lining to drum clearance because of the minimal lining swell that is inherent in all linings irrespective of manufacturing during the break in period.

Leverage The angle of the push rod and slack adjuster should be checked with the brakes fully applied. The angle should not be less than 90° for air. Movement beyond center drastically reduces the brake effectiveness as it shortens the effective length of the lever. Such a condition calls for readjustment. Push rods should be the same length and their travels identical on both brakes.

Investigating the Poor Stop

Should any interim complaints of poor stopping arise, the first step is to adjust the brake and check externally the speed of the application and release of the brakes. This can be observed from the movement of the slack adjuster and push rod. To check further requires determining the input at the brake which is accomplished by the use of a gauge at the chamber. If the input is found to be adequate, then the next place to check is the foundation brake. The wheel must be removed to observe the lining to-¬drum contact, the condition of the lining and drum surfaces, and the general condition of the shoe mechanism. You can expect marginal performance when you have a brake power system that is minimal for the job. The recognized minimum values that should be maintained and below which marginal effectiveness can be expected are as follows:

Air Reservoir =90 pounds

Air Chamber Delivery=Pressure 70 pounds

For a brake to perform satisfactorily under all conditions, a minimum of 90% of the original built in efficiency must be maintained. This emphasizes the need for the complete brake restoration when relining the brakes and a sound program of preventative maintenance.

Road Test Road test should follow the reline. First subject the brakes to a series of light snubs and follow with a series of normal service stops before making a panic stop. A 30 foot stop with the service brake from 20 mph is recognized as being satisfactory.

Chapter Three

Hydraulic Brakes General

DESCRIPTION (BRAKE SYSTEM)

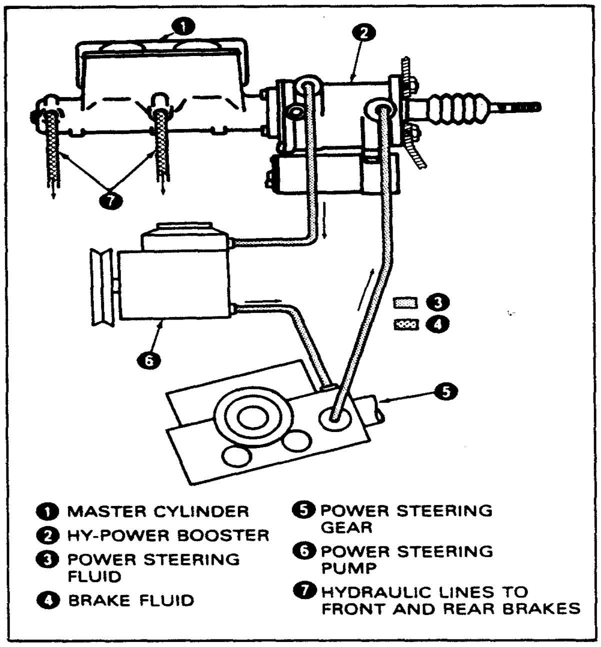


Figure 2 — Two Hydraulic Systems

This system uses two types of fluids as shown in Figure 2.

1. Hydraulic brake fluid in the master cylinder and hydraulic brake system to wheel brakes and filled at the master cylinder.

2. Power steering fluid in the hydraulic pump, steering gear (if equipped with power steering gear) and booster and electric pump units. The booster system is filled at the hydraulic pump reservoir.

The purpose of the split hydraulic brake system is to safeguard against complete loss of brakes if a failure should occur in either of the partial sections of the hydraulic system.

The hydraulic brake system has been divided into two independent brake systems utilizing a tandem or two section integral master cylinder.
The tandem master cylinder design provides two separate brake fluid systems, therefore, one section of the master cylinder will continue to operate should a failure occur in the other section.

The split system is designed so that each partial braking system is individual. During normal brake applications both sections function as a single system. The split brake system provides ability to stop if failure occurs in one of the partial systems. However, stopping ability is reduced by such failure.

The complete loss of vehicle brakes with the split system is considered unlikely during normal operation. However, accidental major damage to the vehicle could result in complete brake failure as could negligent continued operation with one failed system or failure to provide periodic brake maintenance based upon type and severity of vehicle service.

MAINTENANCE CHECKS

The brake system should be checked periodically for evidence of needed repairs. Before starting to check out the brake system itself, the following related components on the vehicle should be examined and serviced if found defective.

1. Tires.
2. Shock absorbers.
3. Wheel bearings.
4. Suspension.
5. Wheel alignment.

The following procedure is given as an aid in checking out the brake system.

PARK BRAKE INDICATOR

The "PARK BRAKE" indicator is operated in conjunction with the parking brake. During engine cranking period the "PARK BRAKE" indicator should illuminate. This light will go out after engine is started providing the parking brake is not applied. If parking brake is applied, this light will stay on after engine has started. If light does not illuminate during starting period, the light bulb may be defective.

BRAKE PEDAL

1. Pedal return should be unrestricted when pedal is fully released.

2. Excessive side movement indicates worn pedal mounting.

3. Interference should not occur when pedal is depressed.

4. There should be ample clearance between pedal and toe board when pedal is fully depressed (brakes applied).

MASTER CYLINDER

1. Fluid level should be 1/4" to 1/2" (6.4 to 12.7 mm) from top of reservoir.

2. Check for external leaks at hydraulic line connections or at master cylinder mounting flange.

3. Check compensating valve by watching for surge of fluid in reservoir when pedal is depressed.

4. Internal wear or leaks are indicated by pedal fading away under steady foot pressure (also sign of leak elsewhere in hydraulic brake system).

STOP LIGHT SWITCH

If stop lights are inoperative, it would indicate that there may be a blown fuse, a tripped circuit, defective bulbs, defective switch, loose or broken connections, or switch improperly positioned.

BRAKE LINES, FITTINGS AND HOSES

1. Check lines for kinks, dents or rupture.

2. Check hoses for abrasion, kinks, soft spots, rupture, collapse, cracks, twists or loose frame supports. When replacing hoses be sure there is adequate clearance of hose to avoid abrasion of new hose.

3. Examine all connections for leaks.

4. Carefully check for incomplete ruptures indicated by a bubble between the plies of the flexible hose or a tom inner liner (Figure 8).

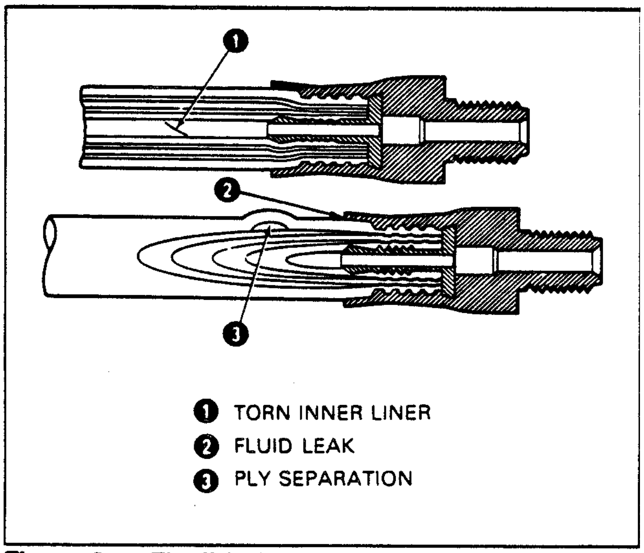


Figure 8 — Flexible Hose Damage

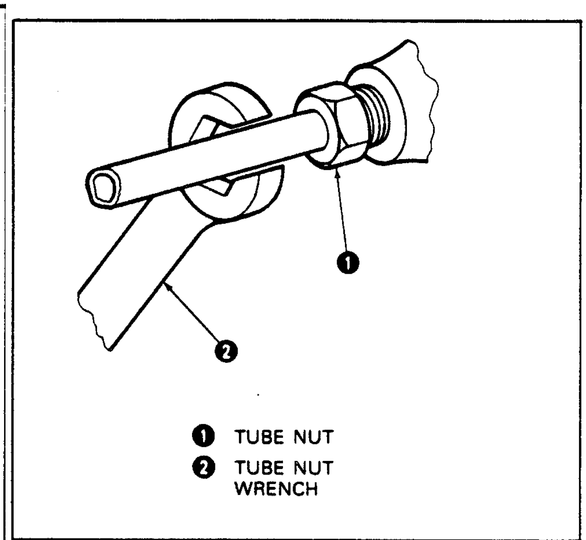


Figure 9 — Use of Tube Nut Wrench

5. Brake line fittings will sometimes become rusted or corroded to the wheel cylinder and/or brake line. Be careful not to twist the line causing a line fracture during removal or installation. Brake line open ends should be capped to prevent the entrance of foreign material.
   Always use correct type and size of wrench on fittings (Figure 9).

   Avoid damage to female fittings by supporting fitting with a spare tube nut during removal and installation (Figure 10).

6. Use only steel tubing when replacement of tubing is required. Use old tubing as a pattern for forming and routing the new. Avoid kinks and sharp bends when forming tube. Use tubing cutter to cut tubing to required length making allowance for flare at each end of tube.
   Assemble tube nuts on tubing before flaring. After flaring tube, blow out with air pressure to remove any particles of dirt or chips. Do not discard old tube nuts until you are certain that new ones are available.
   Most hydraulic brake tubes are of double walled steel tubing coated to resist rust. The tube ends are of a double flare design to guard against leakage (Figure 11).

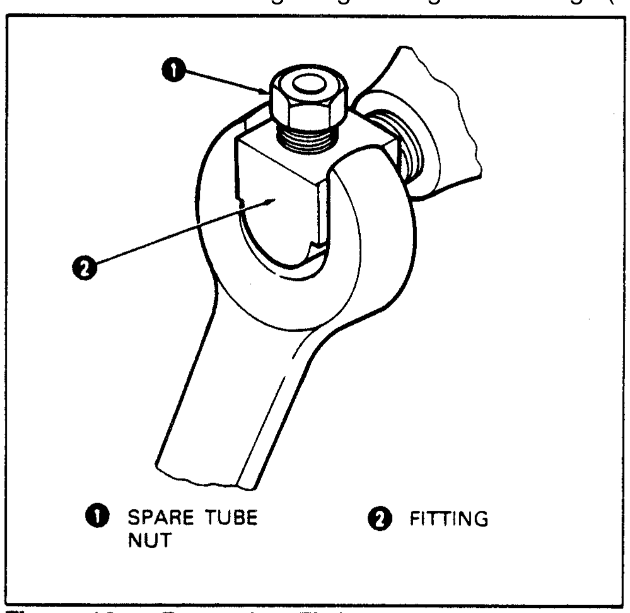


Figure 10 — Protecting Fitting Against Damage

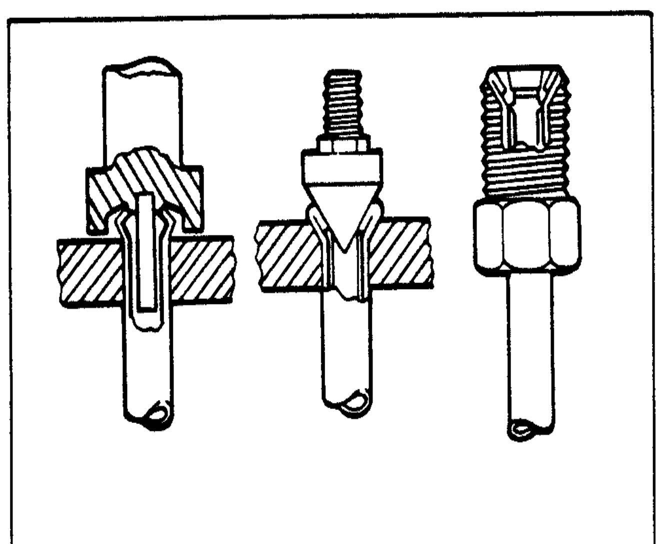


Figure 11 — Steps in Completing Double Flare

WHEEL CYLINDERS AND CALIPER CYLINDERS

Pull back rubber boots and check for leaks. If cylinders are disassembled, look for dirt, corrosion or pitting. If leakage is evident, the hydraulic cylinder should be repaired or replaced as required.

HYDRAULIC BRAKE FLUID

As a result of use, brake fluid becomes contaminated and loses some of its original qualities. It is good practice to bleed brake system until all old fluid is removed when performing major brake work. Also, old fluid should be bled from the system and replaced with clean brake fluid if any hydraulic system parts are corroded; fluid is discolored, contains water or is dirty.

If any rubber parts of the hydraulic system are soft or swollen, old fluid should be removed and hydraulic system should be flushed and refilled with brake fluid. All cups and seals should also be replaced. Do not reuse old brake fluid. For type of fluid, refer to brake fluid compatibility at the end of this section of the manual.

It is recommended that the hydraulic system be flushed when hydraulic cylinders are repaired or replaced to assure that hydraulic fluid is not contaminated. To flush hydraulic system, utilize normal bleeding procedures (refer to BLEEDING BRAKE SYSTEM) and flush system thoroughly until it appears clean.

BRAKE GROUPS

1. Check linings for being too thin, uneven wear, damaged, soiled with grease or brake fluid, or for being loose on shoes. Whenever brake lining or blocks are worn to within 1 /4" of shoe table, on medium and heavy duty trucks, brake shoes must be removed and relined. Be sure that all lining on one axle (both sides) is replaced at the same time. Inspect rotors for lateral run out, parallelism, cracks or burnt marks.

2. Examine brake shoes for worn anchor ends, damaged rims or webs, or cracked or broken welds.

3. Mechanical parts should be checked for heat damage, broken ends or loss of tension in shoe return springs, wear or corrosion of shoe hold-down pins, springs and cups, wear on adjusting screw, looseness of mounting or anchors and worn shoe ledges on backing plate.

DRUMS AND ROTORS

1. Check brake drums and rotors for scores, heat checks, out-of-roundness and oversize.

2. Inspect rotors for lateral run out, parallelism, cracks, or burnt marks.

   Disc brakes may have a slight amount of run out or wobble due to tolerances which are required in machining the large flat surfaces.

Refer to RECONDITIONING BRAKE DRUMS, SHOES, ROTORS AND PADS Section for complete service details covering Drums and Rotors.

Wheel bearings should be checked for wear. Also, check grease seals for evidence of grease leaks. Refer to WHEEL Service Manual sections.

WARNING - AN ACCIDENT COULD RESULT IF THE VEHICLE IS OPERATED WHILE ANY OF THE FOREGOING ITEMS NEED ATTENTION, OR IF ANY OTHER BRAKE SYSTEM SERVICE REQUIREMENTS ARE SUSPECTED.

SPECIAL FLUID PRECAUTIONS

WARNING - SOME BRAKE SYSTEMS CONSISTS OF TWO COMPLETELY SEPARATE HYDRAULIC SYSTEMS OPERATING ON TWO DIFFERENT AND INCOMPATIBLE FLUIDS; POWER STEERING FLUID AND HYDRAULIC BRAKE FLUID. FAILURE TO OBSERVE ALL PRECAUTIONS PREVENTING THE CONTAMINATION OF EITHER SYSTEM WITH FLUID FROM THE OTHER WILL RESULT IN THE SWELLING AND DETERIORATION OF RUBBER PARTS LEADING TO REDUCED BRAKE PERFORMANCE AND EVENTUAL FAILURE OF THE BRAKE SYSTEM AND COULD RESULT IN A VEHICLE ACCIDENT.

To avoid fluid contamination, the following should be observed:

1. Use only fluids specified (or equivalent). Refer to LUBRICATION Section of service manual.
2. Make sure that fluids are properly identified. Store only in original containers and carefully check the label before using.
3. Add fluids only to the following locations:

   a. Power steering fluid to the hydraulic pump reservoir.

b. Brake fluid to the brake master cylinder.

4. Discard - do not attempt to reuse - any fluid drained from either system.

5. Anytime a fluid hose or line is disconnected for maintenance, cover the open fittings and/or ports to prevent contamination of fluid.

6. Overhaul components in a clean work area, with clean tools and hands. Hands or tools exposed to one fluid could contaminate parts which operate in the other fluid.

7. Denatured alcohol may be used to clean parts. However, do not clean parts operating in one fluid with alcohol previously used to clean parts operating in the other fluid.

Approved cleaning Fluids:

Brake Fluid, Alcohol, Commercial brake parts cleaner, Soap and water (remove all water and coat with brake fluid to prevent rust)

MASTER CYLINDER

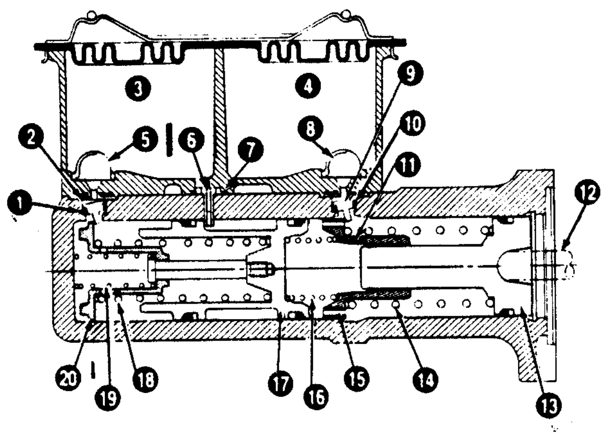
The basic component operation of the master cylinder:

When the master cylinder is in the released position (Figure 2), the actuator of the primary and secondary pistons are in contact with the compensating valve stems, which project into the cylinder bore, keeping the valves off their seats, allowing hydraulic fluid in the reservoirs to enter the cylinder bore.

The initial forward movement of the primary piston moves the primary actuator, permitting the compensating valve to seat, closing off the passage between the pressure chamber in the cylinder bore (Figure 3). Further movement of the piston rod causes the hydraulic pressure within the cylinder to move the secondary actuator allowing the secondary compensating valve to close (Figure 4) and secondary piston is no longer resting on the stop pin.

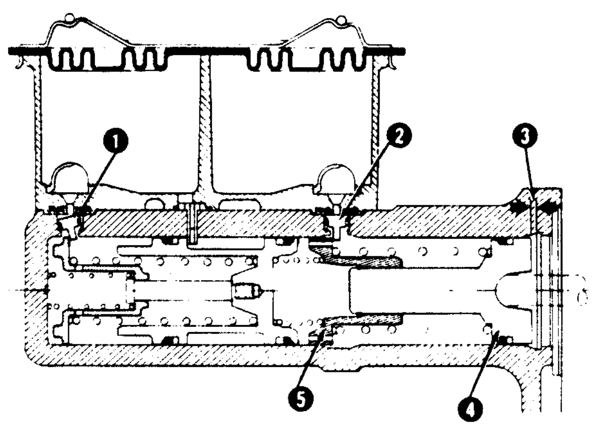
When the primary and secondary systems are at midstroke position (Figure 5), the primary piston and primary return spring has moved the primary actuator to the point where the actuator has contacted the secondary piston and secondary return spring force has bottomed the secondary actuator in the master cylinder bore.

When the master cylinder has obtained the full stroke mode in both primary and secondary systems (Figure 6), both the primary and secondary pistons have traveled their maximum travel and the primary and secondary actuators have bottomed out. The full stroke mode condition would only exist if both primary and secondary systems should fail or if a very poor brake adjustment condition should occur.



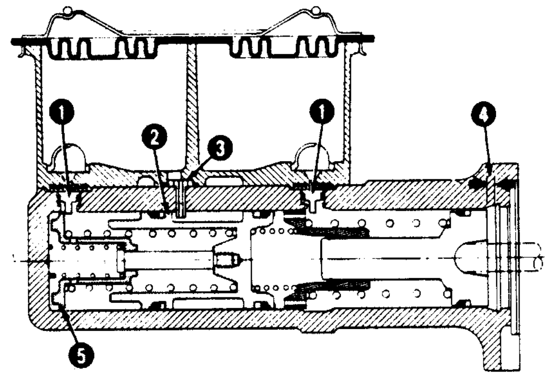
1. SPRING
2. COMPENSATING VALVE (OPEN)
3. SECONDARY RESERVOIR
4. PRIMARY RESERVOIR
5. FILTER
6. STOP PIN
7. SEAL
8. FILTER
9. COMPENSATING VALVE (OPEN)
10. SPRING
11. PRIMARY ACTUATOR
12. PISTON ROD
13. PRIMARY PISTON
14. PRIMARY RETURN SPRING
15. PRIMARY ACTUATOR
16. PRIMARY SPRING
17. SECONDARY PISTON
18. SECONDARY RETURN SPRING
19. SECONDARY SPRING
20. SECONDARY ACTUATOR

Figure 2 — Released Position



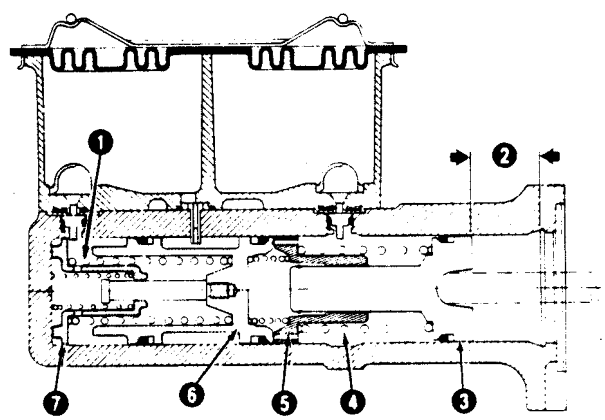
1. SECONDARY COMPENSATING VALVE OPEN
2. PRIMARY COMPENSATING VALVE CLOSED
3. INITIAL MOVEMENT OF PRIMARY PISTON
4. PRIMARY PISTON
5. PRIMARY ACTUATOR

Figure 3 — Primary Compensating Valve Closed



1. PRIMARY AND SECONDARY COMPENSATING VALVES CLOSED
2. SECONDARY PISTON
3. STOP PIN
4. ADDITIONAL MOVEMENT OF PRIMARY PISTON
5. SECONDARY ACTUATOR

Figure 4 — Primary and Secondary Compensating Valves Closed



1. SECONDARY RETURN SPRING
2. MID-STROKE
3. PRIMARY PISTON
4. PRIMARY RETURN SPRING
5. PRIMARY ACTUATOR
6. SECONDARY PISTON
7. SECONDARY ACTUATOR

Figure 5 — Primary and Secondary Systems at Mid-Stroke

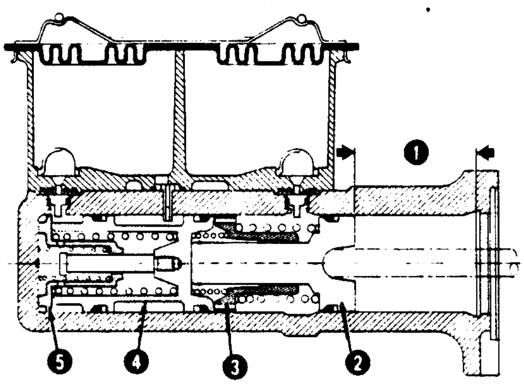


Figure 6 — Primary and Secondary Systems at Full Stroke

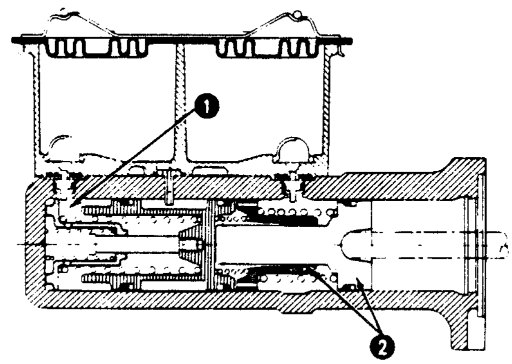


Figure 7 — Secondary System at Mid-Stroke With Primary System Failed

If the primary system should fail (Figure 7), there will be no fluid pressure in that portion of the brake system; therefore, the primary piston will bottom out the primary actuator. However, the secondary piston will develop fluid pressure in that system, thus stopping capabilities are still available in that portion of the brake system.

If a failure should occur in the secondary system (Figure 8), the secondary piston will bottom out in that side of the master cylinder, while the primary section will maintain the capabilities to enable stopping the vehicle.
It must be remembered that increased stopping distance will be required if a failure should occur in one of the two systems.

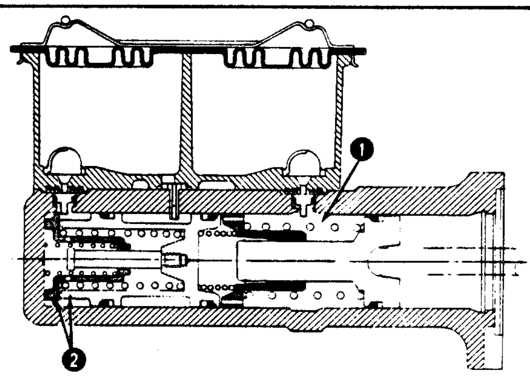


Figure 8 — Primary System at Mid-Stroke With Secondary System Failed

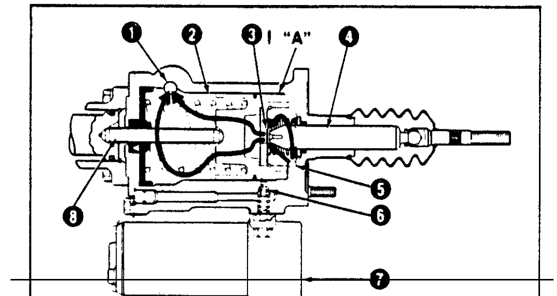


Figure 9 — Hydraulic Fluid Flow During Normal Engine Operation w/Brakes Released

BRAKE LINES, FITTINGS AND HOSES

Hydraulic lines (tubing and flexible hose), Figure 15, transmit fluid under pressure between master cylinder and wheel cylinders.

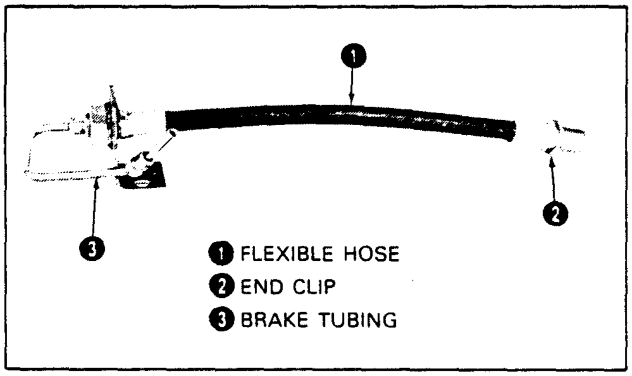


Figure 15 — Brake Line and Flexible Hose

Hoses are the flexible links between wheels or axles and the frame or body. They must withstand fluid pressure without expansion and must be free to flex during spring deflection and wheel turns without damaging the hose.

WARNING- HYDRAULIC LINES ARE SUBJECT TO DAMAGE AND DETERIORATION; THEREFORE, THEY SHOULD BE INSPECTED PERIODICALLY, TO AVOID PERS0NAL INJURY OR PROPERTY DAMAGE.

WHEEL CYLINDERS

The wheel cylinders are attached to brake backing plate. Their purpose is to convert hydraulic pressure from master cylinder to mechanical force required to expand brake shoes against the brake drum.

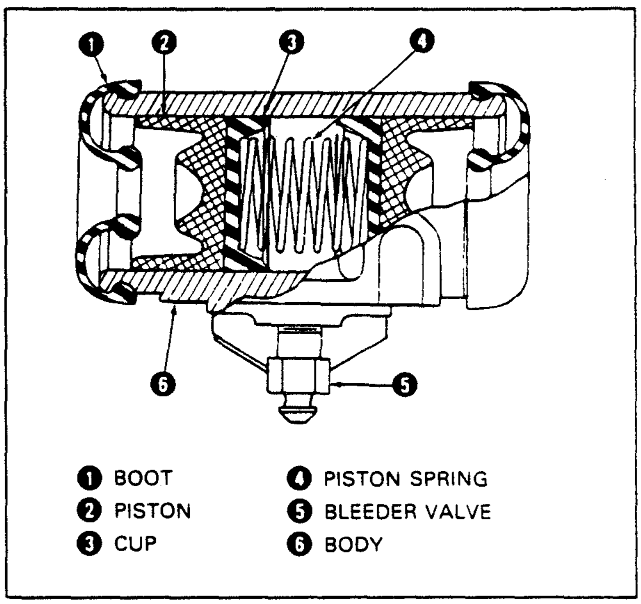


Figure 16 — Typical Double Piston Wheel Cylinder (Cross Sectional View)

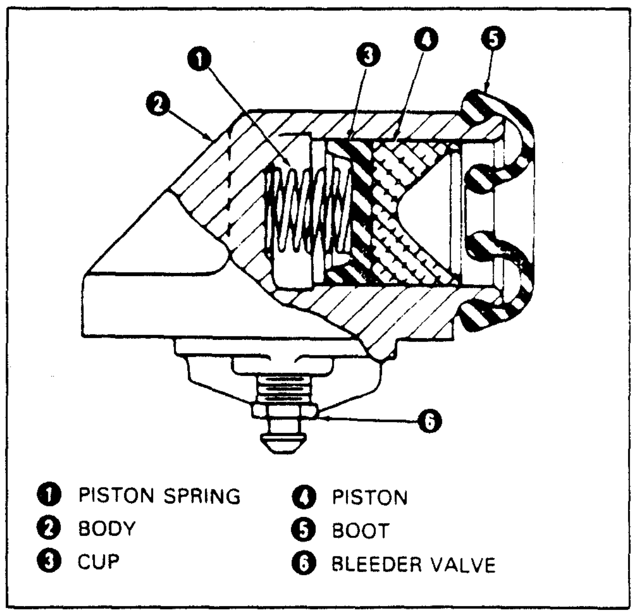


Figure 17 — Typical Single Piston Wheel Cylinder (Cross Sectional View)

The wheel cylinder consists of a body, piston spring, piston(s), rubber cup(s), boots(s) and bleeder valve. Figure 16 illustrates a double piston wheel cylinder and Figure 17 illustrates a single piston type wheel cylinder.

CALIPER CYLINDERS

The hydraulic cylinder used with caliper disc brakes, contains a piston, fixed position rectangular ring type seal and a dust boot.

The seal is located in a cylinder bore groove (hence the term fixed position seal) and fits around the outside of the piston to provide hydraulic seal between piston and cylinder wall.

The seal is designed with a certain amount of elasticity or flexibility, which allows inner diameter of seal to maintain a grip around piston and not a true wiping stroke along piston wall. However, a certain amount of piston movement in seal is needed to allow piston to move outward only to the extent needed to compensate for lining wear.

As illustrated in Figure 18, the retaining groove in cylinder wall is shallower toward the bottom of cylinder. With this designed groove, hydraulic pressure forces the seal against deeper side of groove. Thus, the seal produces a spring-like action returning piston and brake pad assembly when pressure is released.
In addition a molded rubber dust boot is installed in a cylinder bore groove and on piston outer surface to keep contaminants from cylinder wall and piston.

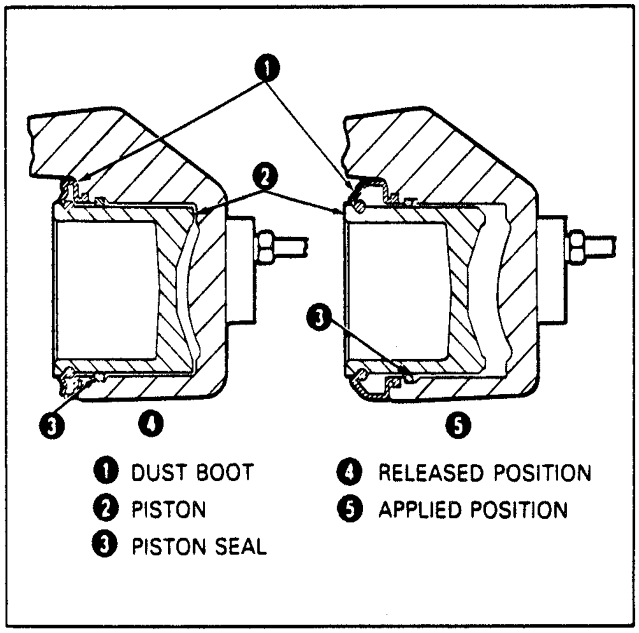


Figure 18 — Cross Sectional View of Caliper Cylinder

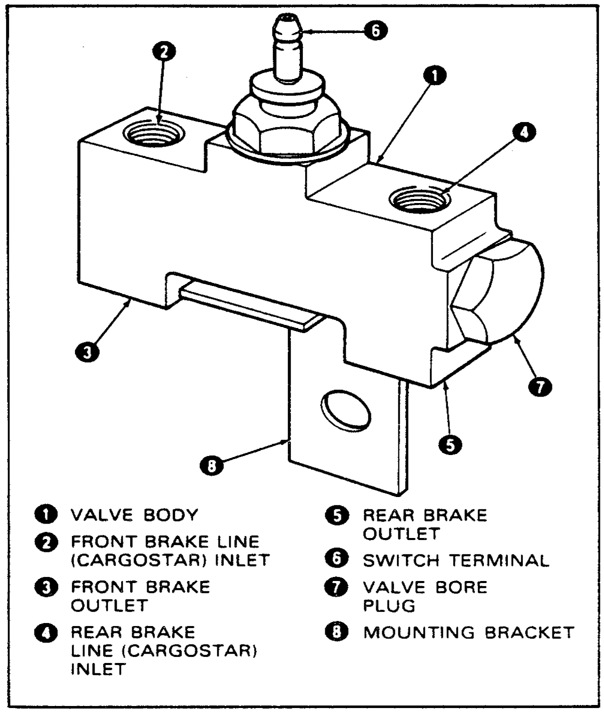


Figure 19 — Pressure Differential Valve

NOTE: It is not uncommon for disc brakes to have a slight drag. The amount of drag will depend upon the type of brake application made before the inspection is made.

PRESSURE DIFFERENTIAL VALVE (Brake Light Switch)

GENERAL

The pressure differential valve (Figure 19) is positioned in split brake system to sense a loss of hydraulic pressure in either side of the split hydraulic system and illuminate a Brake Pressure light at the instrument panel. Two versions of the brake pressure differential valve have been used.

The original version of the pressure differential valve has a piston retainer nut at each end of the valve (Figure 19) and a warning switch which has a blade type electrical terminal. The warning switch must be removed to reset the switch after making repairs to the hydraulic system.

The later version *of* the pressure differential valve has only one piston or spool retaining nut and the warning switch has a bullet type electrical terminal (Figure 22). This pressure differential does not require removal *of* the warning switch after completing repairs to the hydraulic system.

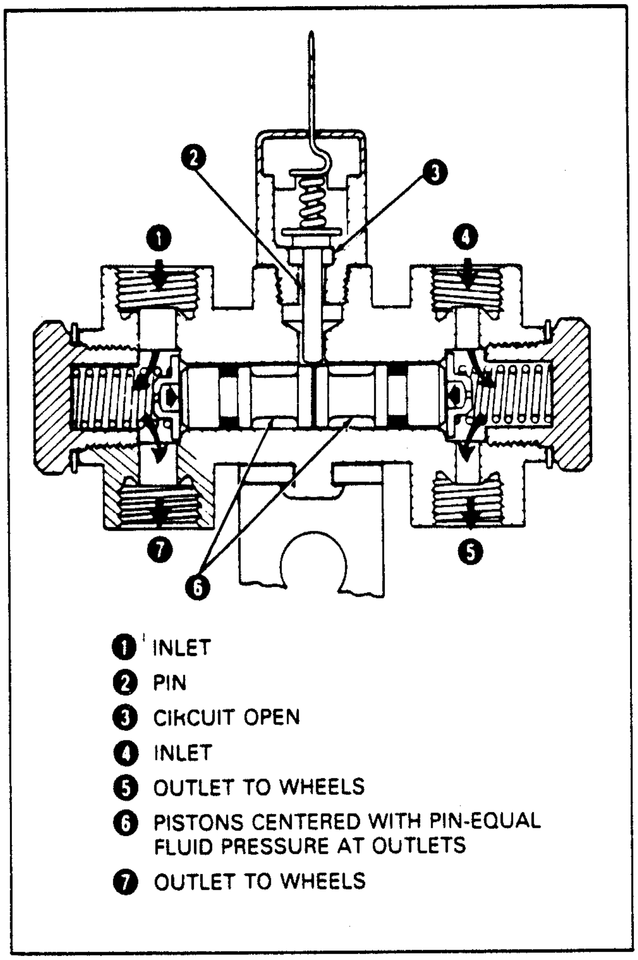


Figure 20 — Pressure Differential Valve With No System Failure

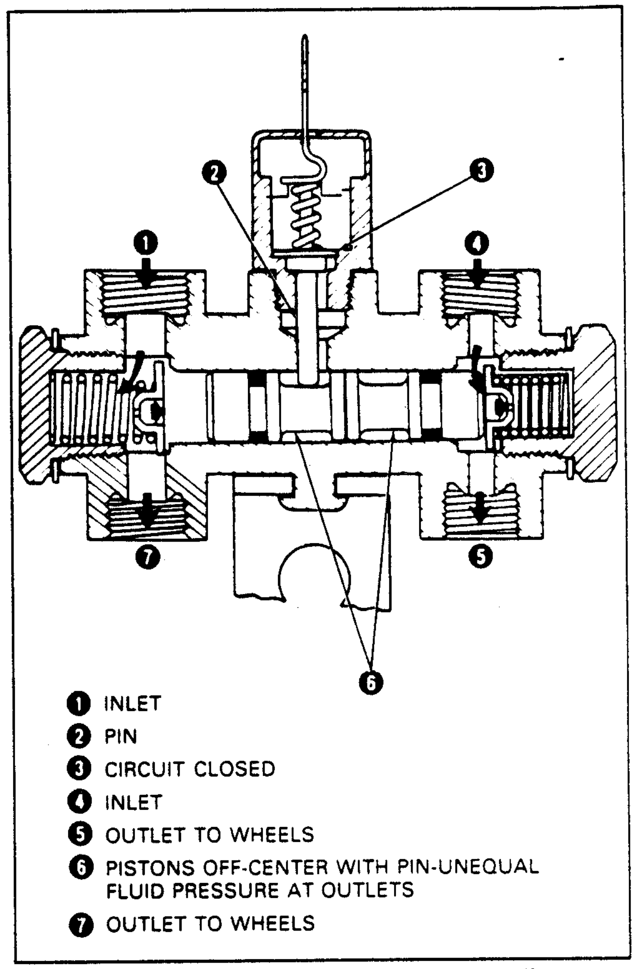


Figure 21 — Pressure Differential Valve With System Failure

OPERATION

The original and late version valves both operate much in the same manner. The major difference is the use of a spool with ramps in the later version of the valve instead of the two piston type design of the original design.

The Brake Pressure light is connected to a light switch (Figure 20). The end of one piston is subjected to line pressure from one side of the split brake system while opposite end of piston is subjected to line pressure from other side of the split brake system. If line pressure of one side of the split system differs by more than 85-150 psi (586 to 1034 kPa) from that of other, pistons are moved off center and electrical circuit closes (Figure 21), thus illuminating warning light at instrument panel. This is a positive warning to vehicle operator that a system failure has occurred.

The warning light will remain illuminated even after repairs have been performed. To return light to proper functioning cycle again, the switch must be removed from body and reinstalled (see RESETTING BRAKE PRESSURE LIGHT SWITCH).

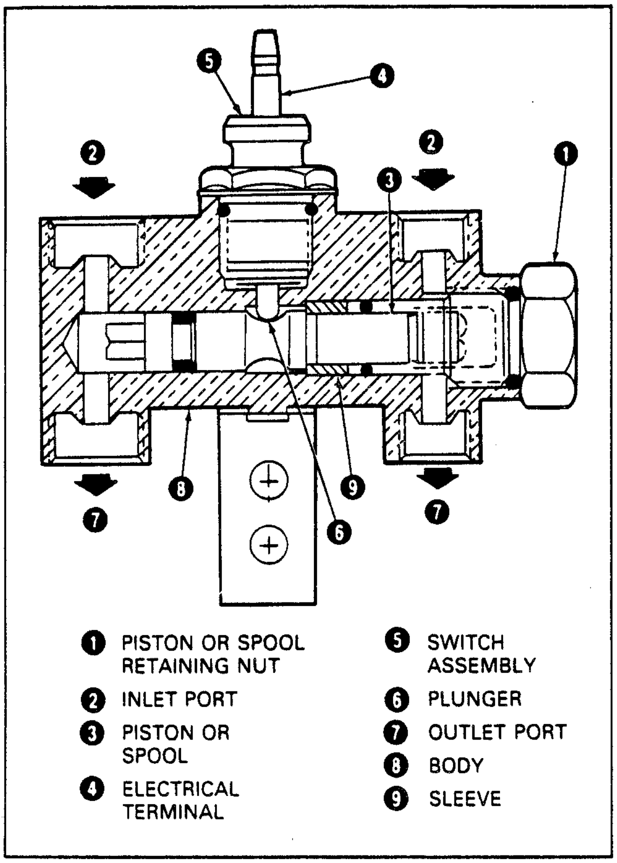


Figure 22 — Cross Sectional View of Late Design Pressure Differential Valve

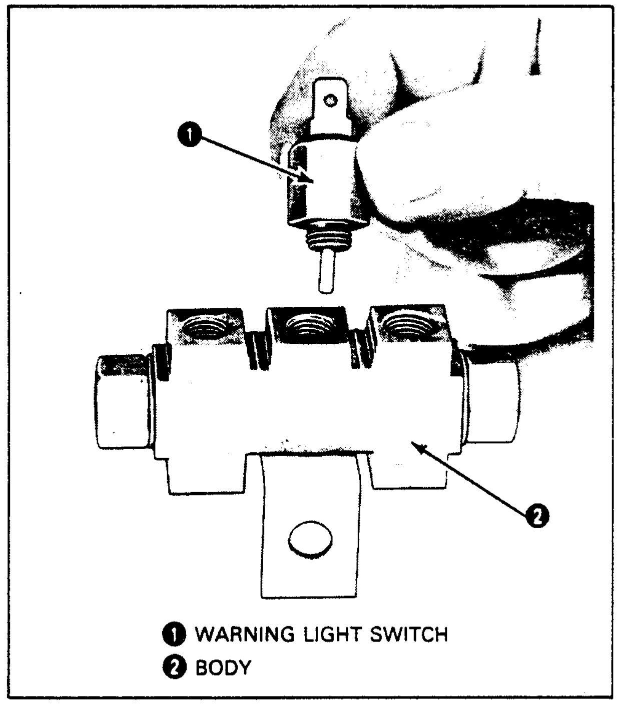


Figure 23 — Resetting Warning Light Switch

Refer to Figure 22 for late design pressure differential valve operation.

When line pressure at both inlet ports is equal the spool will be centered in the bore since pressure will be equal at both inlet ports. If one of the split hydraulic systems should fail, the un-failed system will shift the spool toward failed system. This will cause the switch plunger to slide up the spool ramp onto the diameter of the spool. In this position the warning switch is closed and the warning light will illuminate. The light switch will remain closed even when the brake system is not pressurized.

When normal hydraulic pressure is re-established in split system, the spool will center itself with normal application of the brake pedal. The warning switch plunger will move down the ramp of the spool and the switch will be open. The position of the spool is controlled by the small sleeve forming a stop against the shoulder on the spool and the shoulder in the body bore.

To test warning light circuit and prevent possible operation of vehicle with one brake system in a failed condition, the ignition switch is wired into the circuit. If light fails to illuminate when ignition switch is turned to ON position, it would indicate that a bulb is defective or there is an open circuit, such as a broken wire or loose connection. The light will go out when the engine starts only if the power booster system is functioning properly and there is no pressure difference greater than 85-150 psi (586 to 1034 kPa) in the split system.

WARNING - TO AVOID PERSONAL INJURY OR PROPERTY DAMAGE, THE VEHICLE SHOULD NOT BE OPERATED OTHER THAN TO THE NEAREST SERVICE FACILITY, AND THEN ONLY WITH EXTREME CAUTION SINCE ADDITIONAL STOPPING DISTANCE MAY BE REQUIRED.

MANUAL BLEEDING BRAKE SYSTEM

Fill the master cylinder fluid reservoirs with clean brake fluid
Be sure to remove the brake warning light switch from the original design pressure differential valve. It is suggested that the electrical lead to the electric hydraulic pump be disconnected during the manual bleeding to avoid needless pump operation.

BLEEDING SEQUENCE

Begin with the master cylinder by loosening the service brake line nuts with steady pressure applied to brake pedal. When all air has been bled from master cylinder, move to wheel units, longest line first, beginning with right rear brake group. Next bleed left rear and so on, completing the bleeding of all units and concluding with the left front service brake.

Attach a bleeder tube (hose) to right rear wheel cylinder bleeder valve (screw). Submerge free end of hose in brake fluid in a partially filled glass jar.

Apply steady pressure to brake pedal and open bleeder valve. When fluid coming from submerged end of hose is free of air bubbles, close bleeder valve and release brake pedal. If pedal goes to toe board while bleeding a wheel cylinder without removing all air bubbles, close bleeder valve and release pedal slowly. Repeat bleeding operation at this same wheel cylinder until clean fluid, free of air bubbles, flows from the submerged end of drain hose. Repeat same procedure at each wheel cylinder until all air is expelled from system. Check level of brake fluid in master cylinder frequently during bleeding operation and keep master cylinder reservoirs at least half full.

Be sure to check the brake fluid level frequently during bleeding procedure. Always use clean, fresh specified fluid.

After completing the bleeding operation be sure that master cylinder reservoirs are filled to 1 /4'° to 1 /2'° (6.4 to 12.7 mm) from top edge of master cylinder.

ROAD TEST

CAUTION: BEFORE ROAD TESTING A VEHICLE, DEPRESS BRAKE PEDAL TO BE SURE THERE IS ADEQUATE RESERVE PEDAL. MAKE A SERIES OF LOW SPEED STOPS TO BE SURE BRAKES ARE FUNCTIONING.

Road test vehicle and check general operation for the followings
1. Low Pedal
2. Vibrating Pedal
3. Spongy or Springy Pedal
4. Hard Pedal
5. Drag
6. Fade
7. Pull
8. Grab
9. Squeal or Other Abnormal Noise
10. Lock
11. Sluggish Response

If any of the above conditions are noted, refer to TROUBLE SHOOTING CHART and perform required service to correct problem.

Brake Fluid Compatibility Chart

	DOT 3	DOT 4	DOT 5	DOT 5.1
DOT 3	✔	✔	✖	✔
DOT 4	✔	✔	✖	✔
DOT 5	✖	✖	✔	✖
DOT 5.1	✔	✔	✖	✔

✔ Totally compatibile. May be mixed and used interchangeably

✖ Not compatible. Do not mix under any circumstances

Standards: Minimum Boiling Points by Brake Fluid Type

Brake Fluid	Dry Boiling Point	Wet Boiling Point
DOT 3	205 °C (401 °F)	140 °C (284 °F)
DOT 4	230 °C (446 °F)	155 °C (311 °F)
DOT 5	260 °C (500 °F)	180 °C (356 °F)
DOT 5.1	270 °C (518 °F)	190 °C (374 °F)

General Information

The major parts of the hydraulic disk brake system are:

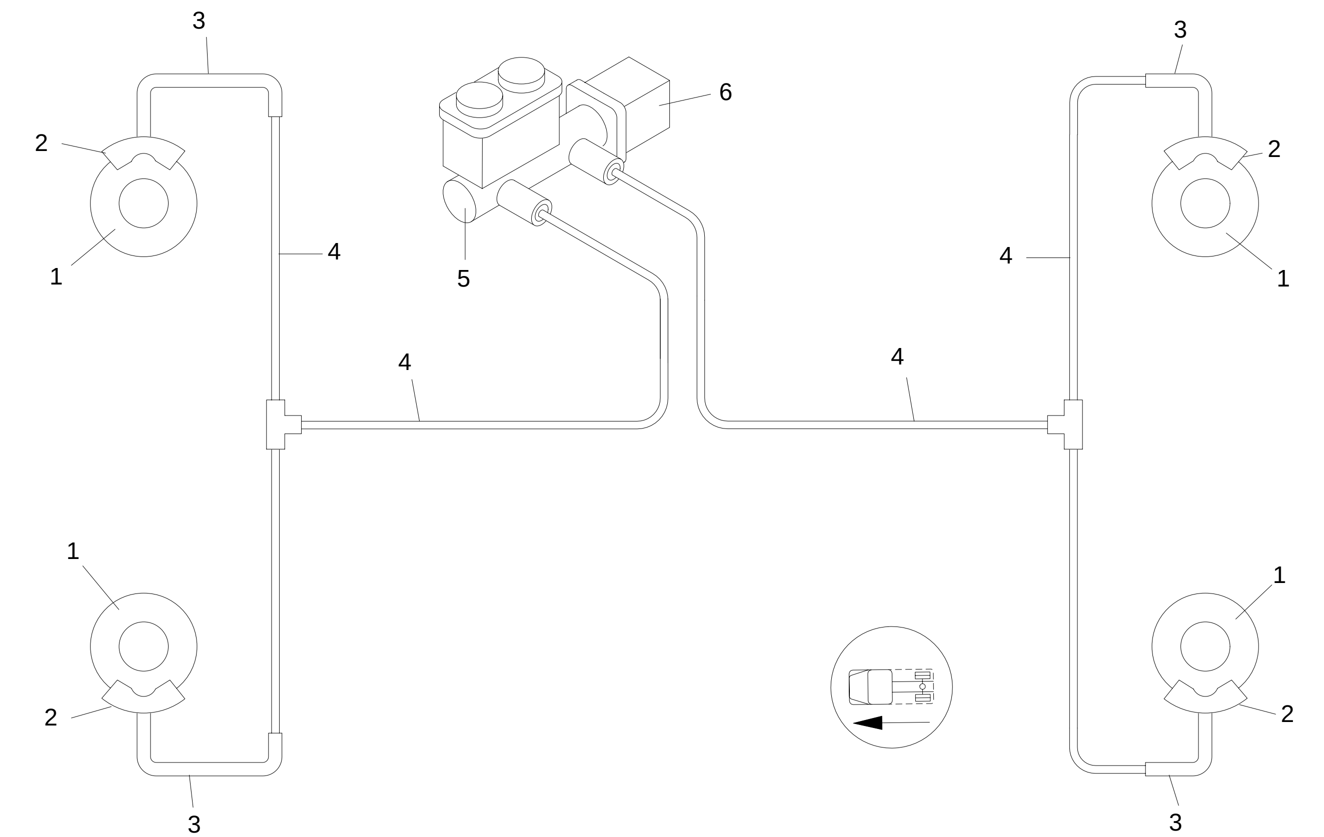
- Power brake booster
- Master cylinder
- Rigid steel hydraulic lines
- Flexible rubber hydraulic lines
- Brake caliper assembly at each rotor.

See **Fig. 1**.

NOTE: This document deals only with the hydraulic brake system. For antilock brake system (ABS) problems, see **Section 42.08**. Illustrations in this section do not show ABS components.

The hydraulic brake components include two completely separate hydraulic systems that use different and incompatible hydraulic fluids, lines, and seals. **The components of each *must* be kept separate from the other.** See **Fig. 2**, which shows the separate systems.

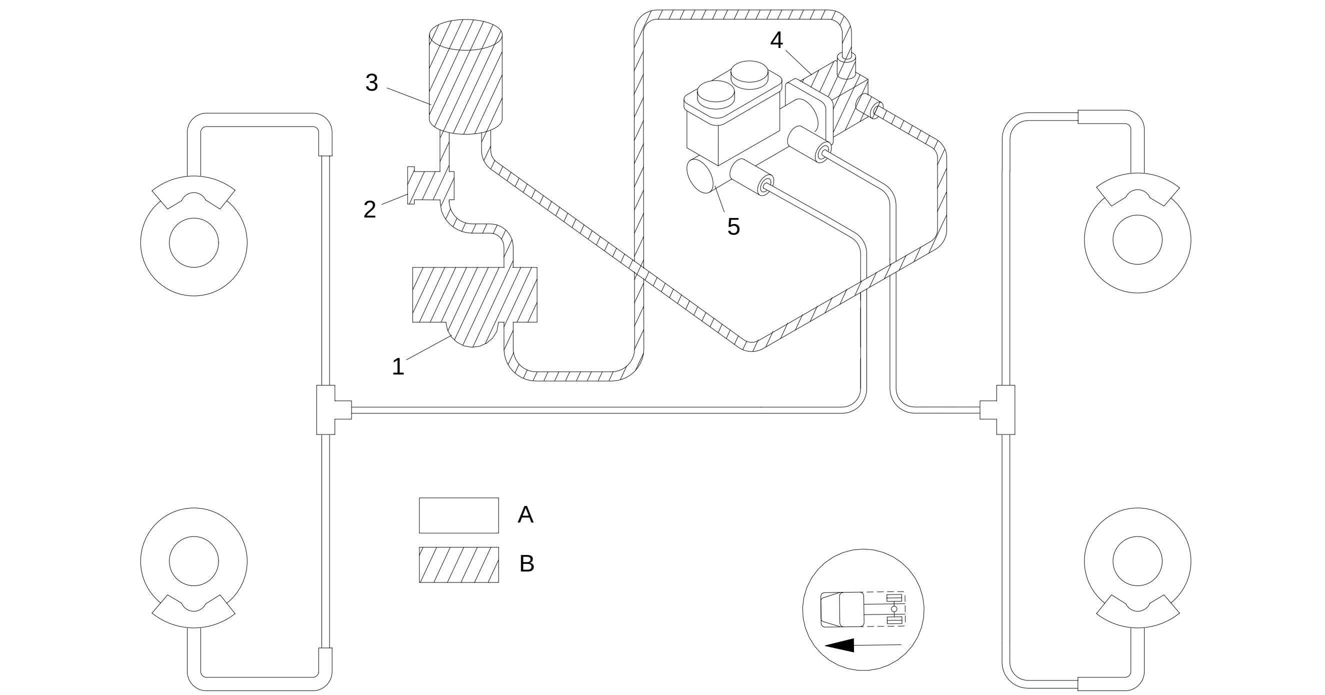
The power brake booster multiplies brake pedal effort to increase power to the brake master cylinder. The power increase comes from pressurized automatic transmission fluid (ATF) supplied by the power steer-



1. Rotor
2. Caliper and Pad Assembly
3. Flexible Brake Line
4. Rigid Brake Line
5. Master Cylinder
6. Power Brake Booster

Fig. 1, Brake System Major Parts

General Information



A. Service Brake System (DOT 3 Brake Fluid)
B. Power Brake Booster and Power Steering System (ATF)

1. Power Steering Gear
2. Power Steering Pump
3. Power Steering Reservoir
4. Power Brake Booster
5. Brake Master Cylinder

Fig. 2, Brake System Booster

ing pump. **Note that the power steering system contains ATF, not "power steering fluid."**

CAUTION

Do not put ATF in the brake master cylinder.

Do not put DOT 3 brake fluid in the power brake booster.

Contaminating either hydraulic system with the wrong fluid causes serious damage.

Power Brake Booster

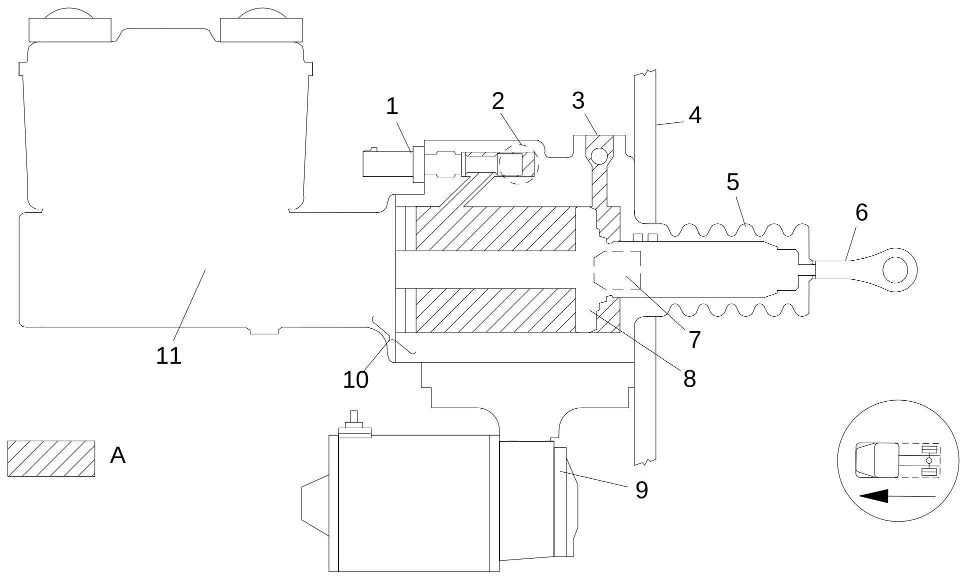
The major parts of the Hydro-Max® II power brake booster mounted on the frontwall are:

- reaction piston
- end-cap assembly
- electric backup pump

The brake master cylinder bolts to the front of the power brake booster.

The brake pedal rod connects the brake pedal to the power piston assembly in the power brake booster. See **Fig. 3**. The reaction piston is inside the power piston. The forward end of the power piston fits through the booster end-cap assembly and rests against the brake master cylinder. The end-cap assembly seals the ATF inside the power brake booster.

The power steering pump sends pressurized ATF to the power brake booster supply port. ATF returns to the power steering reservoir from the power brake booster return port. If the supply of pressurized ATF from the power steering pump to the power brake booster fails, a flow switch starts the electric backup pump to keep the power brakes working.



NOTE: Not all parts are shown.

A. Automatic Transmission Fluid (ATF)

1. Flow Switch
2. Return Port (to steering reservoir)
3. Supply Port (from steering gear)
4. Firewall
5. Rubber Boot
6. Brake Pedal Rod
7. Reaction Piston
8. Power Piston Assembly
9. Electric Backup Pump
10. End-Cap
11. Master Cylinder (DOT 3 brake fluid only)

Fig. 3, Power Brake Booster

Master Cylinder

The brake master cylinder bolts to the power brake booster and functions as a dual supply system. The primary subsystem supplies pressurized DOT 3 brake fluid to the rear brakes, the secondary subsystem supplies it to the front brakes. See **Fig. 4**. For safety, each subsystem is independent so a problem with one will not affect the other.

The master cylinder is mounted on the front of the power brake booster. For locations and names of the major master cylinder components, see **Fig. 5**.

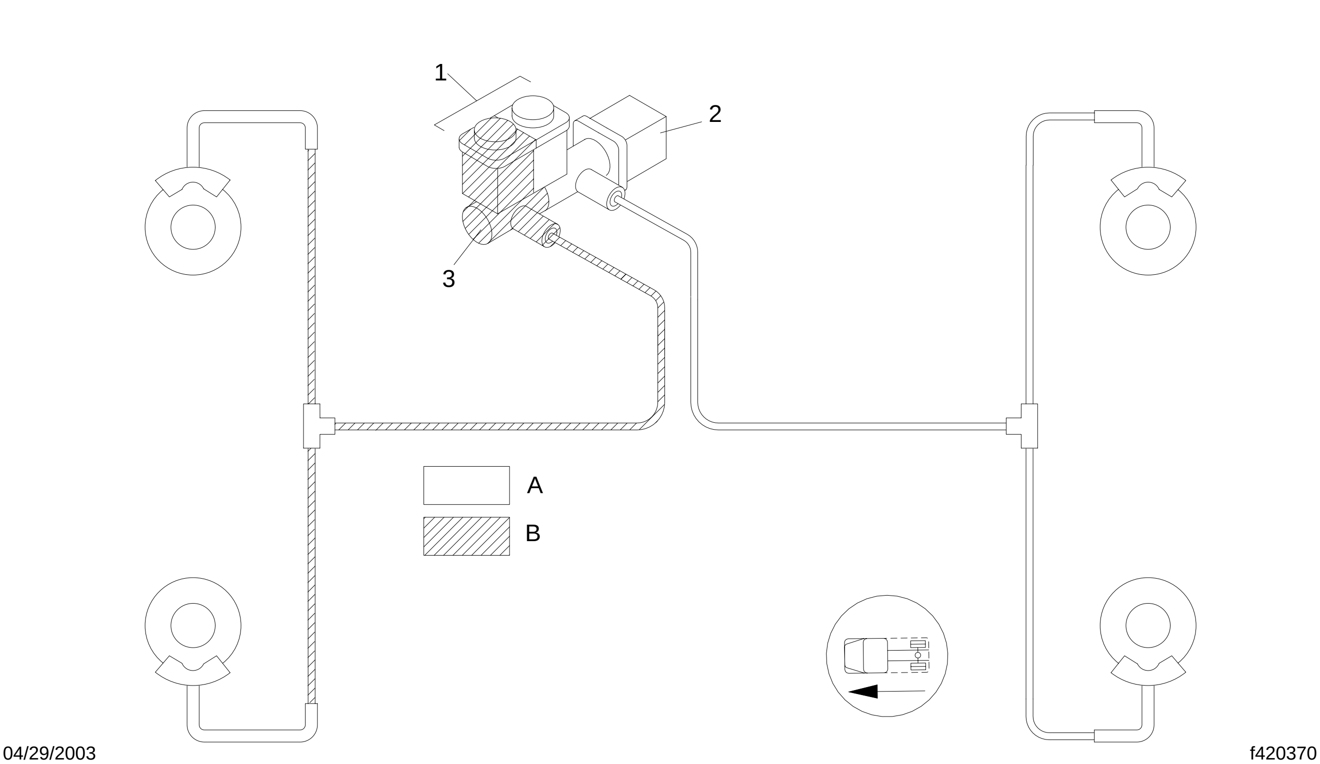
The pressure chambers connect to the front and rear brake caliper assemblies through hydraulic lines and hoses. There is a compensating valve at the bottom of each reservoir section that opens to connect the reservoir to its chamber in the master cylinder. When it is open, the compensation valve allows DOT 3 brake fluid in the reservoir to enter the brake lines to the calipers, to take up for lining wear. When it is closed, the compensation valve allows pressure to build in its subsystem. A pressure differential valve operates a pressure differential switch (not shown), which sets off a dash warning light and buzzer if one of the subsystems does not build pressure.

Non-ABS Brake Monitor Module

The brake monitor module, located behind the instrument control unit (ICU) on the driver side of the dash, monitors electrical signals from various sensors (but not ABS) in the service brake system and power brake booster system. If it detects a problem, the module lights the warning light and sounds the buzzer in the dashboard.

The monitor module has nine input terminals and three output terminals, with one ground terminal. See

General Information



A. Rear Brake Lines
B. Front Brake Lines

1. Master Cylinder Reservoir
2. Power Brake Booster (ATF only)
3. Master Cylinder (DOT 3 brake fluid only)

Fig. 4, Dual Supply System

Fig. 6. The output terminals connect to the brake system pressure and warning lights. The input terminals connect to sensors in the brake system that detect improper operation.

See **Table 1** for identification of the output and input terminals on the back of the module, and the circuits to which they are connected.

The monitor module, which operates on 9 to 16 volts DC, actively monitors the hydraulic brake system under any of the following conditions:

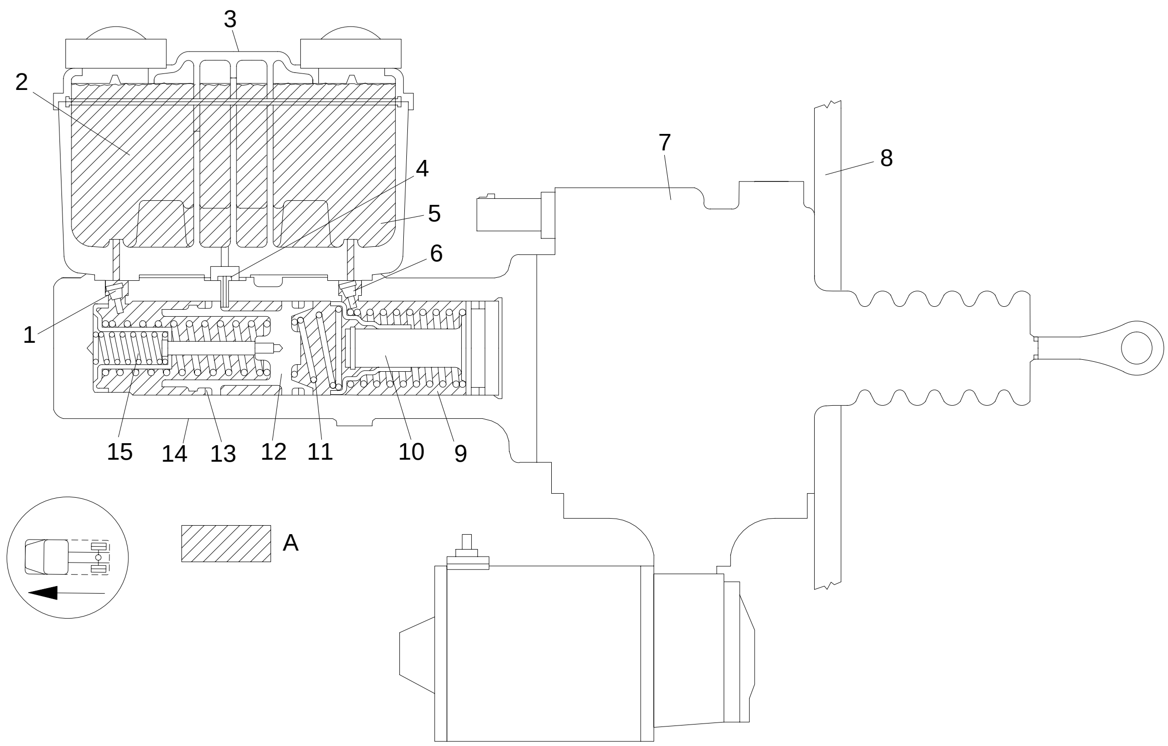
- When the ignition is on;
- When the brake pedal input terminal has power;
- If the ignition is off, but the driver's door is open and the parking brake is not applied.

When the ignition is turned on, the monitor module runs a self-test which lasts from 1 to 3 seconds. The warning light and buzzer come on, then go off if the system is working properly. The module then begins monitoring the hydraulic brake system. If it detects a problem, it turns on the brake warning light and buzzer.

NOTE: The buzzer is controlled by the instrument control unit (ICU).

Any of the following things can activate the brake pressure "R" light at output terminal 3:

- Reduced or lost flow of ATF to the power brake booster closes the flow switch on the power brake booster;
- Different pressures between the front and rear brake subsystems close the pressure differential switch;



05/09/2003 f420376a

NOTE: Not all parts are shown.

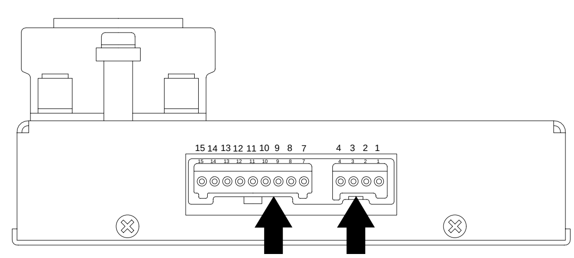
A. DOT 3 Brake Fluid

1. Secondary Compensating Valve (open)
2. Secondary Reservoir Section
3. DOT 3 Brake Fluid Reservoir
4. Piston Stop
5. Primary Reservoir Section
6. Primary Compensating Valve (open)
7. Power Brake Booster Assembly
8. Frontwall
9. Primary Pressure Chamber
10. Primary Piston/Actuator Assembly
11. Primary Piston Return Spring
12. Secondary Piston/Actuator Assembly
13. Secondary Pressure Chamber
14. Housing
15. Secondary Piston Return Spring

Fig. 5, Master Cylinder

- A drop in master cylinder fluid level closes the switch on the reservoir;
- Too much electrical resistance in the backup pump motor. This is often caused by a bad ground.
- No power to the backup pump at startup.

See **Table 2** for information about what activates the input terminals.



01/05/2000 f420759a

Fig. 6, Monitor Module Terminals

General Information

Monitor Module Terminal Identification		
Terminal Number	Function	Circuit Number
1	Not Used	—
2	Not Used	—
3	Light "R" (Brake System Pressure) Output	388H
4	Ground	GND
7	Ignition Input	81C
8	Not Used	—
9	Relay	388F
10	Not Used	—
11	Pressure Differential Switch Input	388A
12	Brake Pedal Input	388L
13	Backup Pump Motor	388C
14	Fluid Level Input	388B
15	Flow Switch Input	388G

Table 1, Monitor Module Terminal Identification

Applying the Brakes

Pushing the brake pedal moves the brake pedal rod against the actuator pin in the power brake booster, moving the reaction piston forward inside the power piston. See **Fig. 7**. This moves the throttle valve, restricting the flow of ATF through the power piston, which increases pressure. The increased ATF pressure pushes the power piston forward through the end-cap assembly and into the master cylinder.

As the primary piston/actuator assembly is pushed forward in the master cylinder, the primary compensating valve closes. This shuts the outlet at the primary reservoir section and raises hydraulic pressure in the primary pressure chamber.

The primary piston/actuator assembly motion also moves the secondary piston/actuator assembly. This closes the secondary compensating valve, pressurizing the secondary pressure chamber.

Both primary and secondary pressure chambers have outlets into individual brake lines leading to the brake calipers. The brake lines transmit the pressure through the brake fluid to the calipers, moving the dual piston pads against the rotors. Friction of the pads squeezing the rotors slows the wheel.

If the power brake booster loses pressure from the power steering pump, the flow switch turns on the backup pump. This closes the main supply check valve and opens the backup pump check valve. The electric backup pump then takes over pressurizing the ATF in the power brake booster, providing enough pressure for the master cylinder to operate the brakes.

Releasing the Brakes

When the brake pedal is released, a return spring in the booster opens the throttle valve, reducing ATF pressure in the power brake booster. See **Fig. 7**. The reduced power brake booster pressure allows the master cylinder and piston return springs to move the booster power piston back toward the frontwall side of the power brake booster housing.

In the master cylinder, the return springs push back the primary and secondary pistons, opening their compensating valves. This lowers hydraulic pressure in the master cylinder and the brake lines, allowing the caliper pistons and brake pads to back away from the brake rotors. With the brake pads no longer squeezing the rotors, the brakes let off and the rotors and wheel hubs can turn freely again.

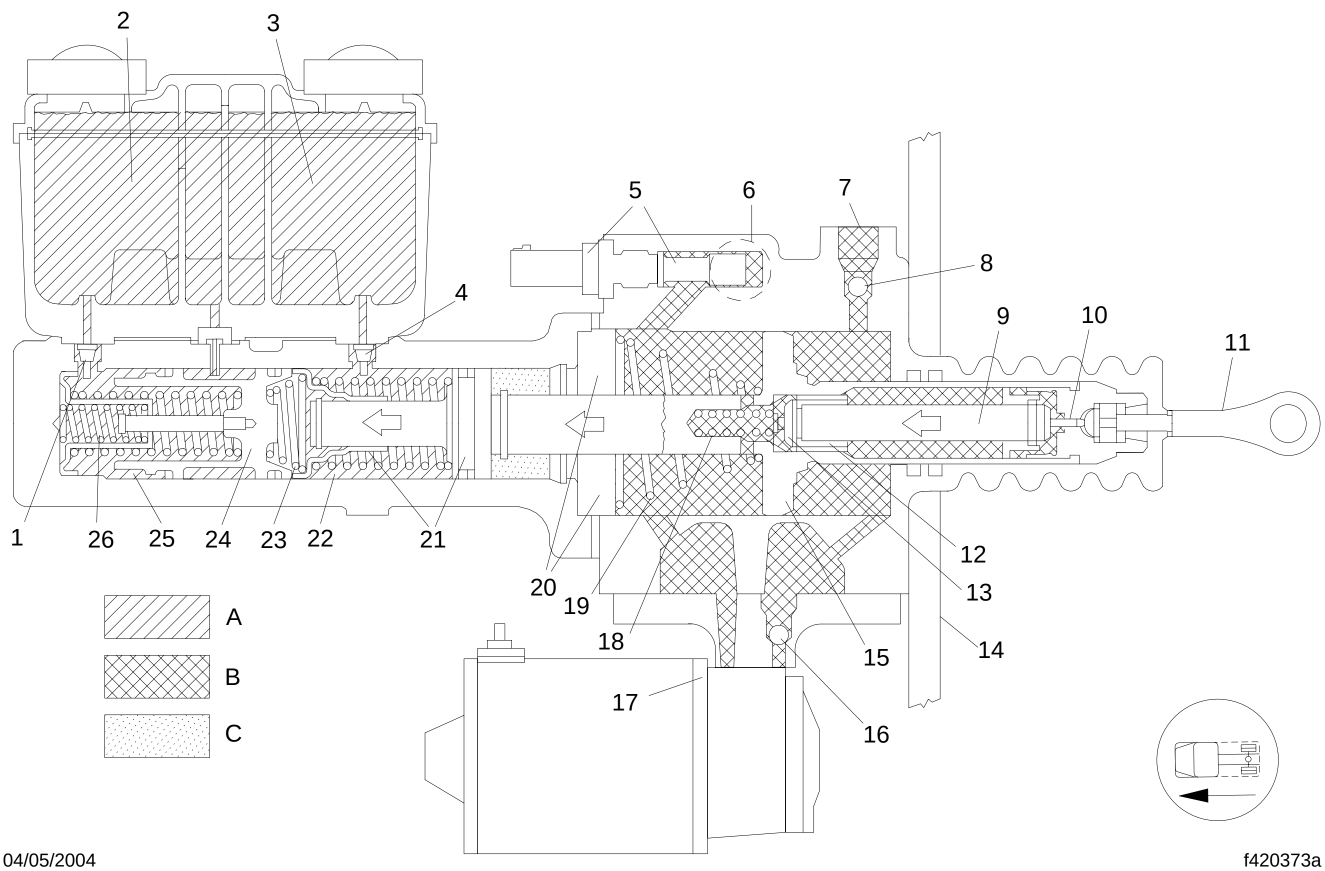
Input/Output Terminal Activation			
Terminal Number	Function	Circuit Number	Activated if
7	Ignition Input	81C	The ignition is on.
8	Not Used	—	—
9	Relay Output	388F	The ignition is on or brake pedal is depressed.
10	Not Used	—	—

General Information

Input/Output Terminal Activation			
Terminal Number	Function	Circuit Number	Activated if
11	Pressure Differential Switch Input	388A	Pressure difference between front and rear systems becomes more than 483 kPa (70 psi).
12	Brake Pedal Input	388L	Brake pedal depressed.
13	Pump Motor Input	388C	Electrical resistance of backup pump motor too high.
14	Fluid Level Input	388B	Fluid level of master cylinder below 25 percent capacity.
15	Flow Switch Input	388G	No hydraulic flow through power brake booster.

Table 2, Input/Output Terminal Activation

General Information



NOTE: Not all parts are shown.

A. DOT 3 Brake Fluid
B. ATF
C. Air Space

1. Secondary Compensating Valve (closed)
2. Secondary Reservoir Section
3. Primary Reservoir Section
4. Primary Compensating Valve (closed)
5. Flow Switch Assembly
6. Return Port
7. Supply Port
8. Supply Check Valve (shown open)
9. Pressure Regulator Assembly
10. Actuator Pin
11. Brake Pedal Rod
12. Reaction Piston
13. Throttle Valve
14. Frontwall
15. Power Piston
16. Backup Pump Check Valve (shown closed)
17. Electric Backup Pump
18. Throttle Valve Return Spring
19. Piston Return Spring
20. End-Cap
21. Primary Piston/Actuator Assembly
22. Primary Pressure Chamber
23. Primary Piston Return Spring
24. Secondary Piston/Actuator Assembly
25. Secondary Pressure Chamber
26. Secondary Piston Return Spring

Fig. 7, Power Brake Booster and Master Cylinder

DIAGNOSIS

CONDITION	POSSIBLE CAUSE	RESOLUTION
Excessive Pedal Effort, Fading Brakes, Hard Pedal	1. Overloaded vehicle.	1. Decrease load and advise operator of vehicle load limit.
	2. Excessive braking.	2. Advise operator.
	3. Linings worn, glazed contaminated, or incorrect type. Shoes badly lined, distorted or improperly installed.	3. Replace linings in axle sets. If glazed, lightly sand. Reposition shoes properly.
	4. Seized wheel cylinder piston.	4. Check cylinders, rebuild or replace as necessary.
	5. Binding brake pedal linkage caused by worn bushings or corrosion.	5. Replace worn bushings or clean and lubricate linkage.
	6. Worn or damaged Hydro-Max booster.	6. Replace booster.
	7. Restricted brake lines or hoses.	7. Repair or replace as required.
	8. Brake drum is bell-mouthed.	8. Refinish drum to proper limits or replace drum, if beyond finishing limits.
	9. Brake system pump belt loose, glazed, or broken 10. Excessive output pressure at brake system pump.	9. Inspect, adjust belt tension or replace as required. 10. Replace pump
	11. Internal wear or damage in brake system pump.	11. Replace pump.
Excessive Pedal Travel, Spongy Pedal, Low Pedal	1. Air in brake fluid.	1. Bleed system
	2. Low fluid level.	2. Add fluid and bleed system. Check for leaks and repair as needed.
	3. Drum brakes out of adjustment.	3. Adjust shoe to drum clearance.
	4. Front wheel bearing out of adjustment.	4. Adjust front wheel bearing.
	5. Master cylinder or booster dash unit mounting loose.	5. Tighten nuts and bolts to specification.
	6. Worn or damaged self-adjusters.	6. Check lining for proper adjustment. Replace or rebuild self-adjusters as needed.
	7. Glazed, worn, scored or damaged brake linings.	7. Replace brake shoes and linings in axle sets.
	8. Drums out of round or defective.	8. Refinish, or replace if wear exceeds limits.
	9. Brake tubing improperly positioned.	9. Check brake tubing for misposition near heat source. Hot fluid can boil and result in spongy pedal response.
	10. Shoes badly lined, distorted or mispositioned.	10. Reposition shoes or replace linings in axle sets.
	11. Incorrect cylinders installed.	11. Install correct cylinders.
	12. Blocked filler cap vent.	12. Check and repair or replace filler cap vent.
	13. Brake fluid contamination.	13. Flush system and replace fluid.
	14. Worn or swollen master cylinder seals.	14. Replace seals and change fluid.
	15. Loose or improper attachment of pedal to push rod.	15. Repair as required.
Refer to “Automatic Brake Shoe Adjustment” before proceeding.		
Drop In Brake Fluid Level	1. Worn linings.	1. Replace linings in axle sets.
	2. External leak.	2. Inspect system for fluid leak and repair or replace as necessary.

Brakes Bind, Drag, Slow or Incomplete Release	1. Brake pedal binding.	1. Repair, lubricate, or replace parts as required.
	2. Front wheel bearing out of adjustment.	2. Check bearings for adjustment, wear, or damage. Adjust bearings.
	3. Worn or damaged master cylinder.	3. Check master cylinder for open compensator ports. Repair or replace.
	4. Brakes out of adjustment.	4. Adjust brakes.
	5. Restriction in hydraulic system.	5. Repair or replace as needed.
	6. Seized wheel cylinders, pistons, or swollen seals.	6. Repair or replace as needed.
	7. Stoplight switch out of adjustment.	7. Adjust switch.
	8. No clearance at master cylinder push rod.	8. Check for clearance and repair or replace as needed.
	9. Malfunctioning power booster.	9. Repair or replace as needed.
	10. Shoe return springs weak or broken.	10. Check springs and replace if necessary.
	11. Parking brake not releasing completely.	11. Check brake chambers and parking system. Repair as needed. See, "Parking Brake Drag"
CONDITION	**POSSIBLE CAUSE**	**RESOLUTION**
Brakes Pull	1. Unequal air pressure in tires.	1. Inflate tires to correct pressure.
	2. Glazed linings. Grease or fluid on linings.	2. Clean, sand or replace linings.
	3. Improper size or type of lining on one wheel.	3. Replace with correct brake linings in axle sets.
	4. Improper size wheel cylinder on one wheel.	4. Replace with correct wheel cylinder.
	5. Stuck or seized pistons in wheel cylinders.	5. Repair or replace as required.
	6. Restricted brake lines or hoses.	6. Repair or replace as required.
	7. Other brake components: ▪ Improper adjustment of drum brakes. ▪ Improper adjustment of disc brakes shoe and lining in caliper. ▪ Distorted drum or brake shoes. ▪ Worn brake linings or variation in linings. ▪ Missing, broken or stretched retracting springs. ▪ Contaminated seals.	7. Inspect, adjust, repair, or replace as required.
	8. Brake system checks OK and complaint still exists.	8. See suspension, steering, and tire sections of shop manual.
Refer to "Automatic Brake Shoe Adjustment" before proceeding.		
Brakes Grab or Lock Up When Applied	1. Tires worn or incorrect pressure.	1. Inflate tires to correct pressure. Replace worn tires.
	2. Grease or fluid on linings, damaged linings.	2. Inspect, repair, or replace linings in axle sets.
	3. Improper size or type of linings.	3. Replace with correct brake linings in axle sets.
	4. Over reaction of brake booster.	4. Check brake booster over-reaction by comparing with a known quality vehicle. Replace brake booster if required.
	5. Worn damaged or dry wheel bearings.	5. Inspect, repair, or replace as required.
Intermittent Loss of Pedal	1. Brake fluid system.	1. Perform master cylinder diagnosis. Repair as required.
	2. Drum brakes our of adjustment, worn,	2. Repair or replace as required.

	bad wear pattern, or cracked drums.	
	3. Loose or improper attachment of pedal, pedal support, booster and master cylinder.	3. Repair or replace as required.
Noise at Wheels When Brakes Are Applied • **Snap or Clicks**	1. Cracked welds at brake shoe web.	1. Replace brake shoe and lining assemblies in axles sets.
	2. Machining marks on brake drums.	2. Refinish or replace brake drums.
	3. Other brake system components: ▪ Loose outer shoe crimping. ▪ Improper position, wear, or damage of caliper support spring or retaining key.	3. Inspect, repair or replace.
Noise at Wheels When Brakes Are Applied • **Scrape or Grind**	1. Worn brake linings, loose rivets, or foreign material.	1. Replace brake shoes and lining in axle sets. Refinish brake drums if excessively scored.
	2. Brake shoe interference with back of drum.	2. Inspect. Replace as necessary. Lubricate.
	3. Other brake system components: ▪ Warped or bent brake backing plate causing interference with brake drum. ▪ Cracked drums.	3. Inspect and repair as necessary.
	4. Tires rubbing against chassis or body.	4. Inspect, repair as necessary.
Noise at Wheels When Brakes Are Applied • **Squeaks, Squeals or Chatter**	1. Worn or scored brake drums and lining or rotors and pads.	1. Inspect, repair or replace as required.
	2. On disc brakes – missing or damaged brake pad insulators.	2. Replace disc brake pads.
	3. Burrs or rust on caliper that would obstruct seating of shoe to caliper.	3. Clean or deburr caliper.
	4. Dirty, greased, or glazed linings.	4. Clean or replace linings in axle sets.
	5. Improper lining parts.	5. Inspect for correct usage. If necessary replace with correct type in axle sets.
	6. Other brake system components: ▪ Loose lining rivets. ▪ Weak, damaged, or incorrect shoe retracting springs.	6. Inspect, repair or replace as required.
Noise at Wheels When Brakes Applied • **Groan, Roughness or Chatter**	1. Loose wheel lug nuts.	1. Tighten to specifications. Replace wheel if stud holes are elongated.
	2. Worn Damaged dry or improperly adjusted wheel bearings.	2. Inspect, lubricate or replace as needed.
	3. Loose or worn front suspension components.	3. Inspect, repair or replace as required.
	4. Brake drum cracked or out of round.	4. Replace drum, if necessary.
	5. Worn tires.	5. Replace tires.

Noise at Wheels, Brakes not Applied • **Squeak or Squeal**	1. Loose wheel attaching lug nuts.	1. Tighten to specifications. Replace wheel if stud holes are damaged.
	2. Worn, dry, or improperly adjusted wheel bearings.	2. Replace worn or damaged wheel bearings. Lubricate and adjust.
	3. Glazed linings or adjustments too tight.	3. Remove glaze from linings. Adjust brakes properly.
	4. Other brake system components: ▪ Stretched brake shoe retracting springs. ▪ Bent or warped backing plate causing interference with drum. ▪ Improper positioning of disc brake in caliper.	4. Inspect, repair or replace as required.
Noise at Wheels, Brakes not Applied • **Growling, Click or Rattle**	1. Loose wheel lug nuts.	1. Tighten to correct torque. Replace wheel if stud holes are elongated.
	2. Drum brakes loose or extra parts.	2. Inspect, remove or repair.
	3. Worn, damaged, or dry wheel bearings.	3. Inspect, lubricate, or replace. Adjust bearings properly.
Noise from Saginaw Pump	1. Loose, glazed, or worn belt.	1. Tighten belt to specified tension or replace as needed.
	2. Supply and return lines touching chassis.	2. Reroute lines out of contact with chassis.
	3. Low fluid level.	3. Refill to specified level.
	4. Aerated hydraulic fluid.	4. Bleed system.
	5. Contaminated fluid.	5. Replace fluid.
	6. Excessive back pressure caused by lines.	6. Replace lines.
	7. Internal pump damage.	7. Replace pump.
Leakage – Power Steering Fluid	1. Loose or damaged hose connections, lines or valves.	1. Repair or replace as required.
	2. Porous pump housing and/or worn pump.	2. Replace pump housing or pump as needed.
	3. Worn or damaged electric motor pump.	3. Replace pump and case.
	4. Worn or damaged boot on booster.	4. Replace boot on booster.
	5. Worn or damaged O-ring around flow switch.	5. Replace O-ring.
	6. Worn or damaged booster housing.	6. Replace booster housing.
	7. Pump, cap and dipstick.	7. Check for indications of false leakage – overfilled reservoir, improperly installed, damaged or lost cap or dipstick.
	8. Leakage at pump shaft seal area.	8. Replace shaft seal or pump.
	9. Ruptured brake chamber seat at piston, piston rod, or mounting tube instert.	9. Replace seals as necessary.
Parking Brake Drags	1. Hydraulic fluid pressure insufficient to fully compress power spring.	1. Check brake pump operation and for restricted hose or line. Repair or replace as needed.
	2. Internal leakage of the brake chamber.	2. Repair or replace brake chamber as required.
	3. Fluid leaks or restriction in hoses, lines, or fittings.	3. Remove restriction, repair of replace parts as necessary.
	4. Malfunctioning control valve or relay valve.	4. Repair or replace valve.
	5. Aerated hydraulic fluid.	5. Bleed system.

Insufficient Parking Brake Application.	1. Worn linings or drum.	1. Replace linings in axle sets. Service or replace drums as required.
	2. Expander/parking wheel cylinder malfunctioning.	2. Repair or replace cylinder.
	3. Brakes out of adjustment.	3. Adjust brakes.
	4. Power spring broken.	4. Replace spring.
Brake Chamber Will Not Release When Control Valve is Operated. (See "Parking Brake Drags")	1. Broken power spring blocking piston movement.	1. Replace spring.
Brake Chamber Cannot Be Manually Released	1. Release bolt threads stripped.	1. Replace release bolt, nut and pin.
	2. Release nut pin sheared.	2. Replace release bolt, nut and pin.
	3. Broken power spring blocking piston movement.	3. Replace spring.

Chapter Four

Air Supply and Control

Safety Precautions

Note: any audible air leaks are an out of service condition.

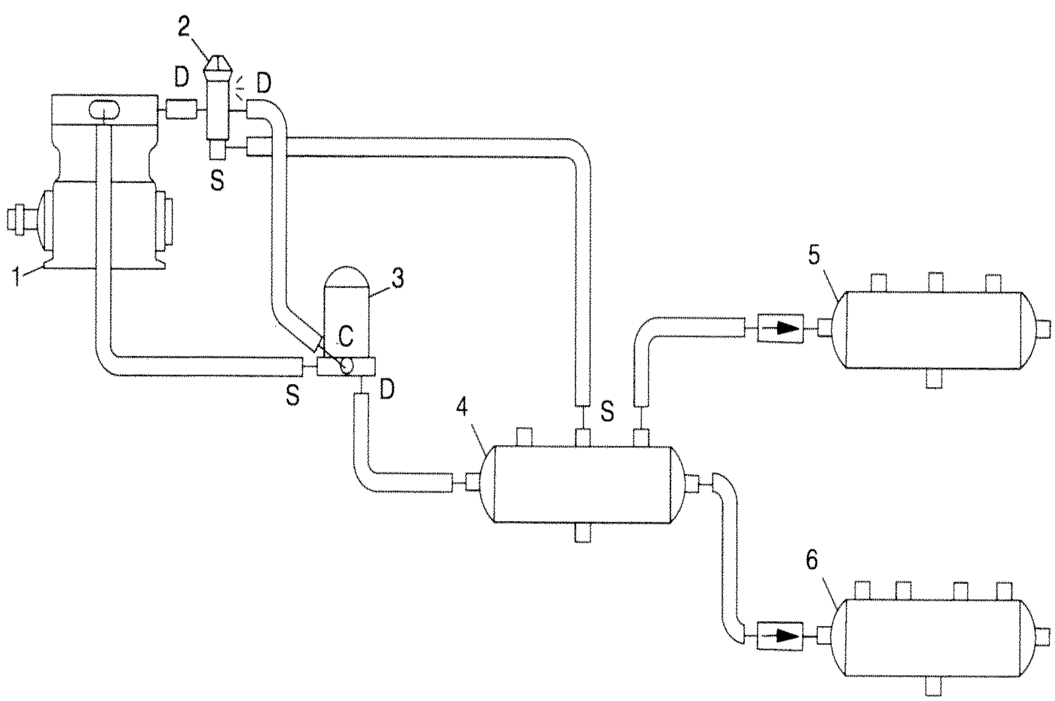
When working on or around air brake systems and components, observe the following precautions:

- Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber push rods and slack adjusters; the brakes may apply as air system pressure drops.

- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.

- Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.

- Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.



C. Control
D. Delivery
S. Supply

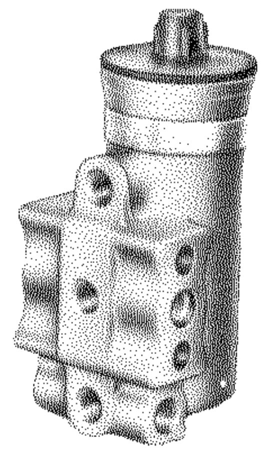
1. Air Compressor	3. Air Dryer	5. Primary
2. D–2 Governor	4. Supply	6. Secondary

Fig. 2, Standard Air Dryer Plumbing Diagram

The standard air dryer uses a metal seat turbo cutoff valve. The function of the metal seat is to prevent turbocharger boost pressure loss through the air dryer during the purge (compressor unloaded) mode. Some low level turbo air leakage can occur in the unloaded mode.

Valves

Note
Brake valves can be used by the manufacturer's in a vast combination to obtain the same results. Some valves can be combined to duplicate the function of other valves. Here is a listing of Bendix valves and a brief description of their function. The chassis manufacturer can use any combination of valves that will produce the desired results and cost while complying with any and all regulations, so you will have to have a service manual that pertains to the vehicle that you are dealing with. Later there will be a listing of each valve with detailed descriptions.



D-2

The **GOVERNOR** operates in conjunction with the compressor unloading mechanism and maintains reservoir air pressure between a predetermined maximum and minimum pressure. The D 2 Governor is an adjustable piston type valve available in various pressure settings. A non-adjustable pressure range between specified cut-in and cut-out pressures is designed into the D 2 Governor. Provisions are made for direct mounting to the compressor or for remote mounting if desired. The D 2 Governor is available in weatherproof and high temperature versions for special installations.

General Description and Principles of Operation

General Description

The governor (Fig. 1), operating in conjunction with the compressor unloading mechanism, automatically controls the air pressure in the air brake or air supply system between the desired, predetermined maximum and minimum pressures. Normal air pressure is a nominal 105 to 125 psi (724 to 862 kPa). The compressor runs continuously while the engine runs, but the actual compression of air is controlled by the governor actuating the compressor unloading mechanism, which either stops or starts compression when the maximum or minimum reservoir pressures are reached. The D 2 governor has a piston upon which air pressure acts to overcome the pressure setting spring, and control the inlet and exhaust valve to either admit or exhaust air to or from the compressor unloading mechanism.

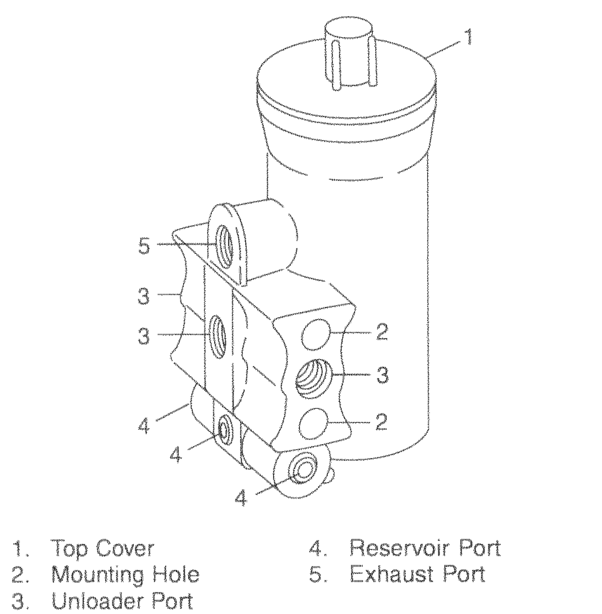


Fig. 1, Governor

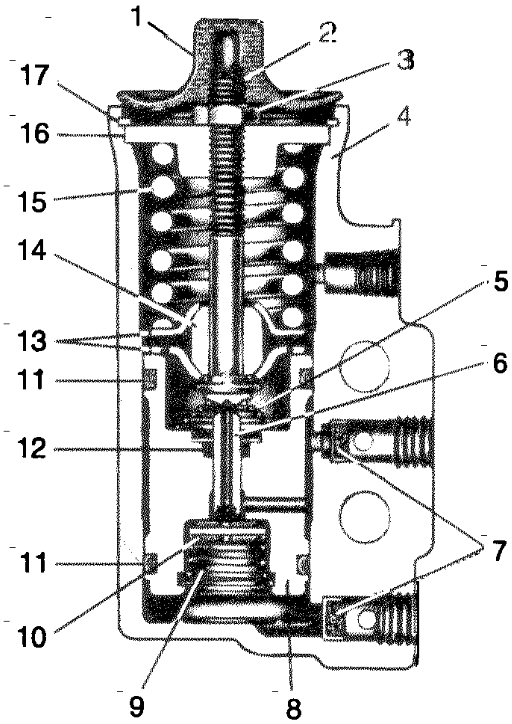
D 2 governors have mounting holes, which allow for direct mounting to the compressor.

Porting consists of 3 reservoir ports (1/8 inch NPT), 3 unloader ports (1/8 inch NPT), and 1 exhaust port (1/ 8 inch NPT).

Principles of Operation

Pressurized air enters the D 2 governor at one of its reservoir ports, and acts on the area of the piston and beneath the inlet and exhaust valve. See Fig. 2. As air, pressure builds up, the piston moves against the resistance of the pressure setting spring. The piston and inlet and exhaust valve move up when the reservoir air pressure reaches the cut out setting of the governor. The exhaust stem seats on the inlet and exhaust valve, and then the inlet passage opens. Reservoir air then flows by the open inlet valve, through the passage in the piston, and out the unloader port to the compressor unloading mechanism. Air also flows around the piston, and acts upon the additional area of the piston. This added force, which results from a larger area on the piston, ensures a positive action and fully opens the inlet valve.

As the system reservoir air pressure drops to the cut-in setting of the governor, the force exerted by the air pressure on the piston will be reduced so that the pressure setting spring will move the piston down. The inlet valve will close and the exhaust will open. With the exhaust open, the air in the unloader line will escape back through the piston, through the exhaust stem and out the exhaust port.



1. Cover
2. Adjusting Screw
3. Adjusting Screw Locknut
4. Body
5. Exhaust Stem Spring
6. Exhaust Stem
7. Filters
8. Piston
9. Inlet and Exhaust Valve Spring
10. Inlet and Exhaust Valve
11. O-Rings
12. Exhaust Stem O-Ring
13. Lower Spring Seats
14. Spring Guide
15. Pressure-Setting Spring
16. Upper Spring Seat
17. Retaining Ring

Fig. 2, Governor, Cross Section View

Air Governor Operating and Leakage Tests

Tests

The following test should be performed whenever the vehicle air pressure is incorrect and the causes are unknown.

If the governor does not function as described, or if leakage is excessive, replace it with a new or remanufactured unit, or repair it using genuine Bendix parts and the instructions in this section.

1. Apply the parking brakes, and chock the tires. Tilt the hood. Refer to the vehicle operator's manual for instructions.

2. Start the engine, and build up air pressure in the air brake system.

3. Check the pressure registered by the dash gauge or a test gauge at the time the governor cuts out, stopping the compression of air by the compressor. The cut out pressure should be a nominal 125 psi (862 kPa).

4. With the engine still running, make a series of brake applications to reduce the air pressure, and observe at what pressure the governor cuts in the compressor. The cut in pressure should be a nominal 105 psi (724 kPa).

5. If either the cut out or cut in pressures are incorrect, adjust.

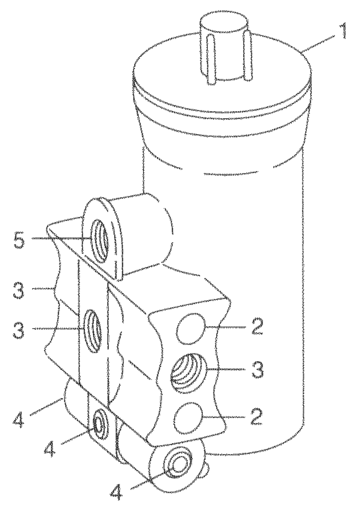
6. Test the leakage on the governor in both the cut in and cut out positions.

   6.1 With the compressor in the cut in position, apply a soap solution to the governor exhaust port. See Fig. 1. A slight bubble leakage is permitted. Excessive leakage indicates that the inlet valve or lower piston O ring is worn out.

   6.2 With the compressor in the cut out position, apply a soap solution to the governor exhaust port. See Fig. 1. A slight bubble leakage is permitted. Excessive leakage indicates that the exhaust valve seat, stem, O ring, or upper piston O ring is worn out.

NOTE: Never adjust the governor pressure settings unless they are checked with an accurate test gauge or a dash gauge that is registering accurately.

7. Return the hood to the operating position, and remove the chocks from the tires. Refer to the vehicle operator's manual for instructions.



1. Top Cover
2. Mounting Hole
3. Unloader Port
4. Reservoir Port
5. Exhaust Port

Fig. 1, Governor

Air Governor Adjustment

Adjustment

If the pressure settings of the governor are inaccurate, or if they need to be changed, proceed as follows:

1. Apply the parking brakes, and chock the tires. Open the hood. Refer to the vehicle operator's manual for instructions.

2. Remove the top cover from the governor, and loosen the adjusting screw locknut. See Fig. 1.

3. To raise the pressure settings, turn the adjusting screw counterclockwise. To lower the pressure setting, turn the adjusting screw clockwise.

NOTE: The pressure range between cut in and cut out is not adjustable.
If these adjustments do not correct the pressure settings, repair or replace the governor.

4. Tighten the adjusting screw locknut, and install the top cover.

5. Return the hood to the operating position, and remove the chocks from the tires. Refer to the vehicle operator's manual for instructions.

Air Dryer, Bendix AD-9

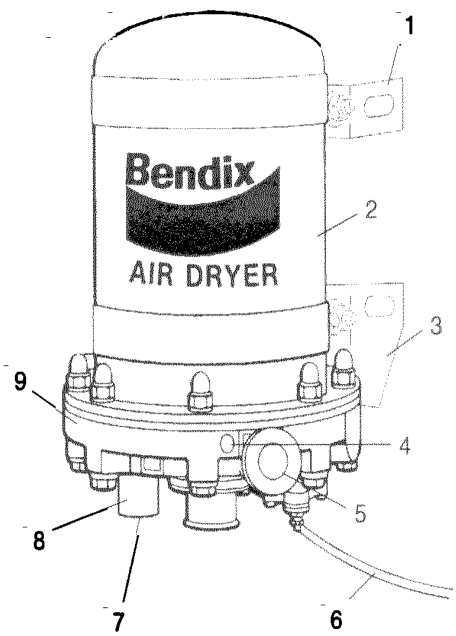
General Description and Principles of Operation

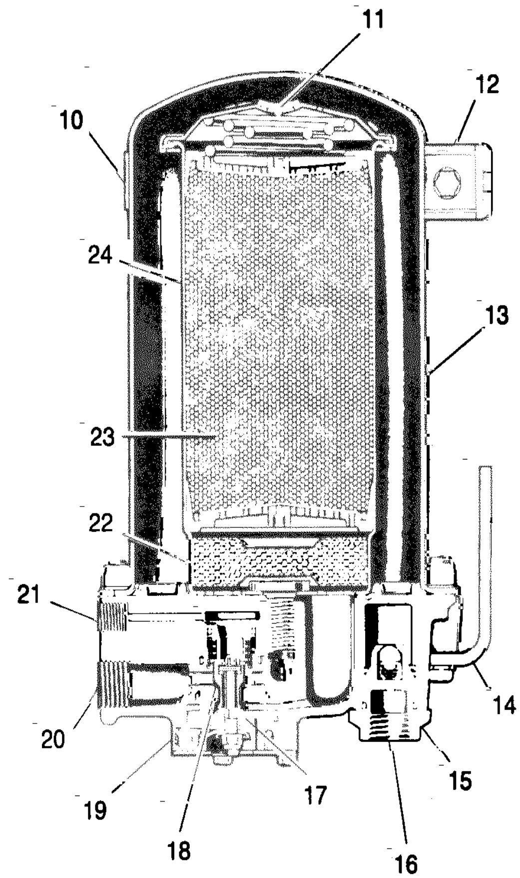
General Description

The function of the Bendix AD-9 air dryer (Fig. 1) is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system.

The AD-9 air dryer consists of the desiccant cartridge and a die-cast aluminum end cover secured to a cylindrical steel outer shell with eight cap screws and nuts. The end cover contains a check valve assembly, a safety valve, three threaded air connections and the purge valve housing assembly. The removable purge valve housing assembly features a purge valve mechanism and a turbocharger cutoff that are designed to prevent loss of engine turbo boost pressure during the purge cycle of the air dryer.

To ease servicing, the desiccant cartridge and discharge check valve assembly are screw-in types. The purge valve housing assembly, which includes the heater and thermostat assembly, and the discharge check valve assembly, can be serviced without removing the air dryer from the vehicle. The screw-in desiccant cartridge requires removal of the air dryer assembly from the vehicle.





1. Upper Bracket
2. Outer Shell
3. Lower Bracket
4. Control Port
5. Supply Port
6. Wiring Harness
7. Delivery Port
8. Check Valve Assembly
9. End Cover
10. Upper Bracket Strap
11. Check Valve
12. Upper Bracket
13. Housing
14. Lower Bracket
15. Check Valve Assembly
16. Delivery Port
17. Purge Valve
18. Turbo Cutoff Piston
19. Purge Valve Housing Assembly
20. Supply Port
21. Control Port
22. Oil Separator
23. Desiccant Bed
24. Desiccant Cartridge

Fig. 1, Bendix AD–9 Air Dryer and Cutaway View

The AD-9 has three female pipe thread air connections; each is identified as follows (see **Table 1):**

Port I.D.	Function/Connection
4-CON	Control Port (purge valve control and turbo cutoff)
11-SUP	Supply Port (air in)
2-DEL	Delivery Port (air out)

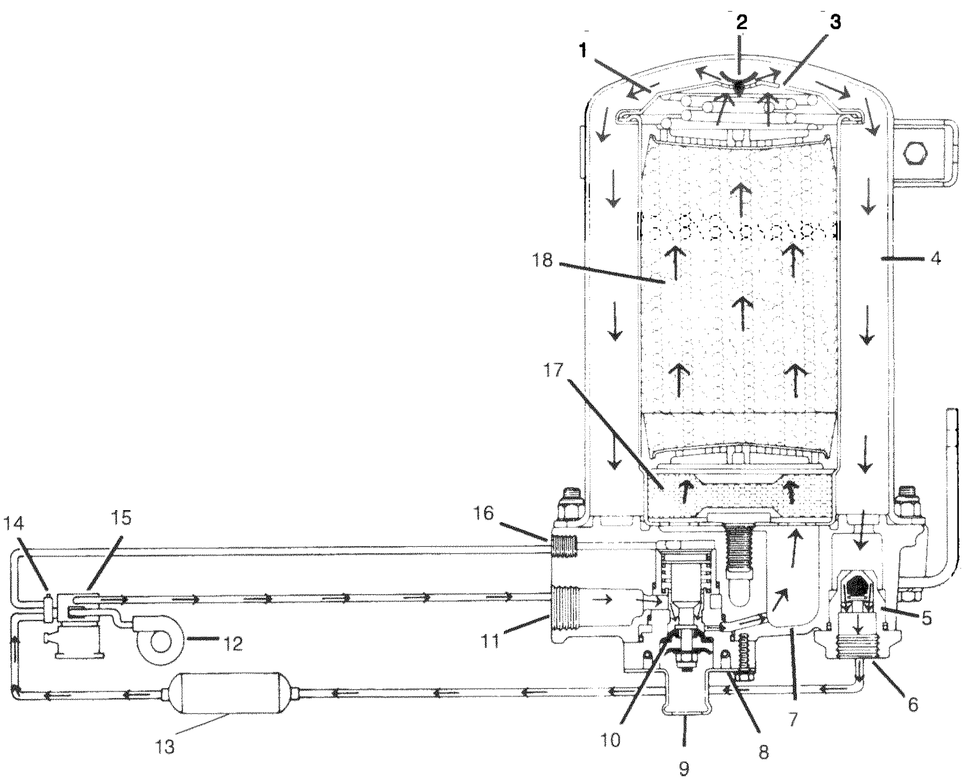
Table 1, Pipe Thread Connection Identification

The standard air dryer uses a metal seat turbo cutoff valve. The function of the metal seat is to prevent turbocharger boost pressure loss through the air dryer during the purge (compressor unloaded) mode. Some low level turbo air leakage can occur in the unloaded mode.

Principles of Operation

The AD-9 air dryer alternates between two operational modes or cycles during operation: the charge cycle and the purge cycle.

Charge Cycle **(See Fig. 6**)



1. Desiccant Cartridge
2. Check Valve
3. Orifice
4. Purge Volume
5. Check Valve Assembly
6. Delivery Port
7. Sump
8. Heater Element
9. Exhaust
10. Purge Valve
11. Supply Port
12. Engine Turbocharger
13. Reservoir
14. Governor
15. Compressor
16. Control Port
17. Oil Separator
18. Desiccant Bed

Fig. 6, AD–9 Charge Cycle

When the compressor is loaded (compressing air), pressurized air, along with oil, oil vapor, water, and water vapor flow through the compressor discharge line to the supply port of the air dryer end cover. As air travels through the end-cover assembly, its direction of flow changes several times, reducing the temperature, causing contaminants to condense and drop to the bottom or sump of the air dryer end cover.

After exiting the end cover, air flows into the desiccant cartridge. Once in the cartridge, air first flows through an oil separator, which removes water, oil, oil vapor, and solid contaminants.

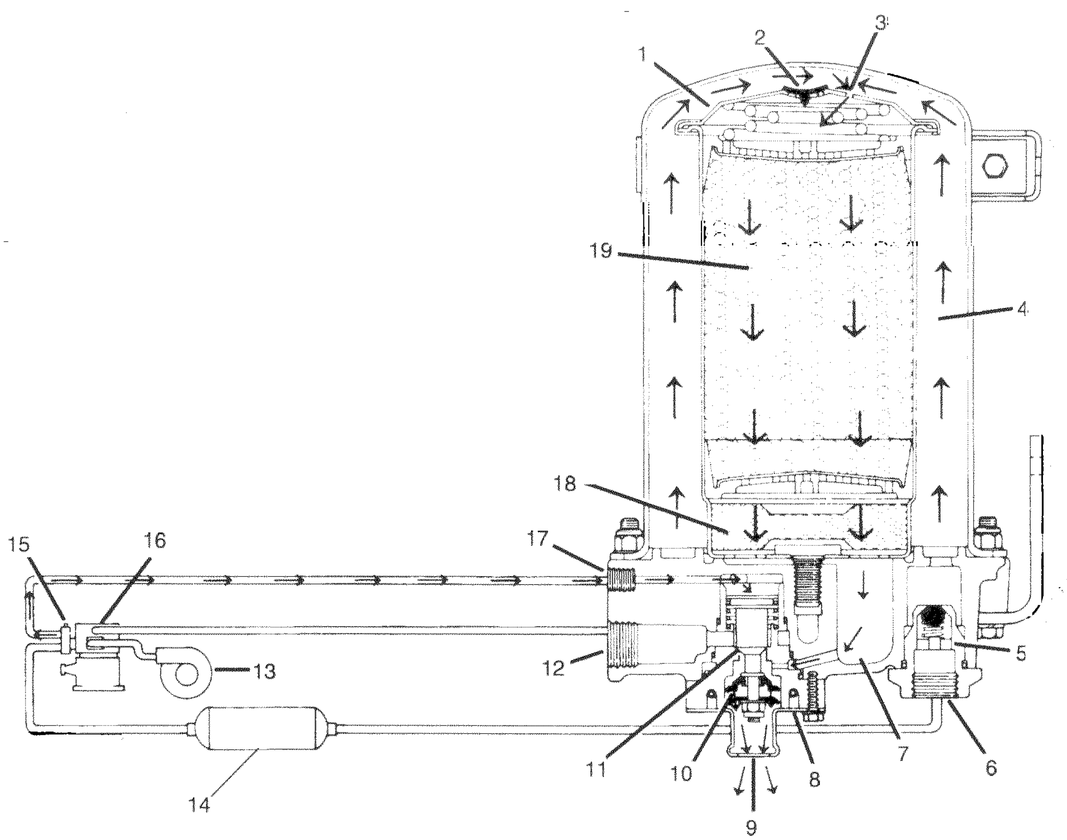
Air exits the oil separator and enters the desiccant drying bed. Air flowing through the column of desiccant becomes progressively drier as water vapor sticks to the desiccant material in a process known as adsorption. The desiccant cartridge, using the adsorption process typically removes 95 percent of the water vapor from the pressurized air.

Most of the dry air exits the desiccant cartridge through its integral single check valve to fill the purge volume between the desiccant cartridge and outer shell. Some air also exits the desiccant cartridge through the purge orifice adjacent to the check valve.

Dry air flows out of the purge volume through the single check valve assembly and out the delivery port to the first (supply) reservoir of the air system.

The air dryer remains in the charge cycle until air brake system pressure builds to the governor cutout setting.

Purge Cycle (See Fig. 7)



1. Desiccant Cartridge
2. Check Valve
3. Orifice
4. Purge Volume
5. Check Valve Assembly
6. Delivery Port
7. Sump
8. Heater Element
9. Exhaust
10. Purge Valve
11. Turbocharger Cutoff Piston
12. Supply Port
13. Engine Turbocharger
14. Reservoir
15. Governor
16. Compressor
17. Control Port
18. Oil Separator
19. Desiccant Bed

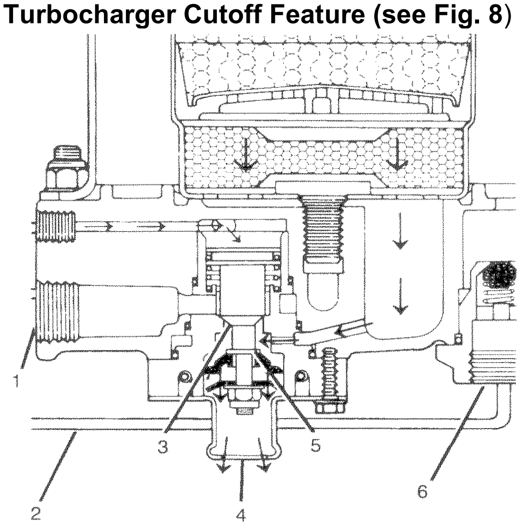
Fig. 7, AD–9 Purge Cycle

When the brake system pressure reaches the governor cutout setting, the compressor unloads (air compression stopped), and the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the unloader mechanism and line connecting the governor unloader port to the AD-9 end cover control port. The purge piston moves in response to air pressure causing the purge valve to open to atmosphere and partially close off the supply of air from the compressor. This is further discussed under "Turbo Cutoff Feature." Contaminants in the end cover sump are expelled immediately when the purge valve opens. Also, air that was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected by the oil separator are removed by air flowing from the desiccant drying bed to the open purge valve.

The initial purge and desiccant cartridge decompression last only a few seconds and are signaled by an audible burst of air at the AD-9 exhaust.
The actual reactivation of the desiccant drying bed begins as dry air flows from the purge volume through the desiccant cartridge purge orifice and into the desiccant drying bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume increased. Dry air flowing through the drying bed reactivates the desiccant material by removing the water vapor sticking to it. Generally, it takes 15 to 30 seconds for the entire purge volume of a standard AD-9 to flow through the desiccant drying bed.
The end cover single check valve assembly prevents compressed air in the brake system from returning to the air dryer during the purge cycle. After the 30 second purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

The purge valve will remain open after the purge cycle is complete, and will not close until air brake system pressure is reduced and the governor signals the compressor to charge.
NOTE: The air dryer should be periodically checked for operation and tested for leaks. Refer to the brake section in the chassis maintenance manual for intervals and procedures.

Turbocharger Cutoff Feature (see Fig. 8)



1. Supply Port
2. Discharge Line
3. Turbocharger Cutoff Piston
4. Exhaust
5. Purge Valve
6. Check Valve Assembly

Fig. 8, AD–9 Turbo Cutoff

Primarily, the turbo cutoff valve prevents loss of engine turbocharger air pressure through the AD-9 in systems where the compressor intake is connected to the engine turbocharger. The turbo cutoff valve also reduces the puffing of air out the open exhaust when a naturally aspirated, single cylinder compressor equipped with an inlet check valve is in use.

At the beginning of the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve (tapered portion of the purge piston) contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the discharge line and AD-9 supply port is restricted from entering the air dryer. While the turbo cutoff effectively prevents loss of turbocharger boost pressure to the engine, some seepage of air may be detected under certain conditions of compressor, engine, and turbocharger operation. Even so, there will be low pressure trapped in the discharge line.

Air Dryer Thermostat Testing

Testing

During cold-weather operation, check the operation of the end cover heater and thermostat assembly.

1. With the ignition on, check for voltage to the heater and thermostat assembly. Unplug the electrical connector at the air dryer, and place the test leads on each of the pins of the male connector. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check that a good ground path exists.

2. Check the thermostat and heater operation. Turn off the ignition switch and cool the end cover assembly to below 40°F (4°C). Using an ohmmeter, check the resistance between the electrical pins in the female connector. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly and 6.8 to 9.0 ohms for the 24-volt heater assembly.

NOTE: Some early models of the AD-9 will have resistance readings of 1.0 to 2.5 ohms for the 12volt heater assembly, and 4.8 to 7.2 ohms for the 24volt heater assembly. If the resistance is higher than this, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

3. Warm the end cover assembly to over 90°F (32°C) and again check the resistance. It should exceed 1000 ohms. If it does, the thermostat and heater assembly is operating properly. If it doesn't, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

Troubleshooting

Problem-Air Dryer Is Constantly Cycling or Purging

Problem-Air Dryer Is Constantly Cycling or Purging	
Possible Cause	**Remedy**
Excessive system leakage.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle-1 psi/min (7 kPa/min) per service reservoir • Tractor/Trailer-3 psi/min (21 kPa/min) per service reservoir
There is excessive leakage in the fittings, hoses, and tubing connected to the compressor, air dryer and wet tank.	Using a soap solution, test for leakage at the fittings, drain valve, and safety valve in the wet tank. Repair or replace as needed.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.
Governor is inoperative.	Test the governor for proper cut-in or cut-out pressures and excessive leakage in both positions.
Leaking purge-valve housing assembly or O-rings in the air dryer end cover.	With the supply port open to atmosphere, apply 120 psi (830 kPa) at the control port. Apply a soap solution to the supply port and exhaust port (purge valve seat area). Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. Repair or replace as needed.
Compressor unloader mechanism is leaking excessively.	Remove the air strainer or fitting from the compressor inlet cavity. With the compressor unloaded, check for unloader piston leakage. Slight leakage is allowed.
Holset "E" type compressor.	Test the air dryer system. For instructions, refer to Bendix Product Bulletin PRO-08-19 entitled "Troubleshooting the Holset "E" Compressor System with Bendix Air Dryer."
Lack of air at the governor RES port (rapid cycling of the governor)	Test the governor for proper pressure at the RES port. Pressure should not drop below cut-in pressure when the compressor begins the unloaded cycle. If the pressure does drop, check for kinks or restrictions in the line connected to the RES port. The line connected to the RES port on the governor must be the same diameter, or larger than the lines connected to the UNL ports on the governor.
Desiccant cartridge assembly contains excessive contaminants.	Replace the desiccant cartridge.
Discharge line is of improper length or material.	Discharge line must consist of at least 6 ft. (1.8m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Bendix representative for further information.
Air system was charged from an outside air source that did not pass through an air dryer.	If the system must have an outside air fill provision, the outside air should pass through an air dryer. This practice should be minimized.
Air dryer is not purging.	Refer to “Problem---Air Dryer Does Not Purge or Exhaust Air."
Purge (air exhaust) is insufficient due to excessive system leakage.	Refer to "Problem--Air Dryer Is Constantly Cycling or Purging."
Air bypasses the desiccant cartridge assembly.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed.
Purge(air exhaust) time is significantly less than the minimum allowable.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. Replace the desiccant cartridge assembly.
Excessive air usage-air dryer not compatible with vehicle air system.	Install an accessory bypass system. Consult your Bendix representative for additional information.

Problem-Safety Valve on Air Dryer Is Popping Off or Exhausting Air

Problem-Safety Valve on Air Dryer Is Popping Off or Exhausting Air	
Possible Cause	**Remedy**
Desiccant cartridge is plugged or saturated.	Check the compressor for excessive oil passing, or incorrect installation. Repair or replace as needed.
The check valve in the air dryer end cover is inoperative.	Test to determine if air is passing through the check valve. Repair or replace as needed.
There is a problem in the fittings, hose, or tubing between the air dryer and the wet tank.	See if air is reaching the first reservoir. Inspect for kinked tubing or hose. Check for undrilled or restricted hose or tubing fittings.
Safety valve setting is lower than the maximum system pressure.	Reduce the system pressure, or install a safety valve with a higher pressure setting.

Problem-Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure

Problem-Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure	
Possible Cause	**Remedy**
Air Dryer purge valve is leaking excessively.	With the compressor loaded, apply a soap solution on the purge valve exhaust to test for excessive leakage. Repair the purge valve as needed.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Purge control line is connected to the reservoir or exhaust port of the governor.	Connect the purge control line to the unloader port of the governor.
Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse.	Test the heater and thermostat, following instructions in the manual.
Inlet and outlet air connections are reversed-unable to build system pressure.	Reconnect the lines properly,
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.
System is leaking excessively.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single vehicle--1 psi/min (7 kPa/min) per service reservoir. • Tractor/Trailer--3 psi/min (21 kPa/min) per service reservoir.
Purge valve stays open; suppler air leaks to control side.	Replace the purge valve assembly 0-rings.

Problem-Air Dryer Does Not Purge or Exhaust Air

Problem-Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
Purge control line is broken, kinked, frozen, plugged, or disconnected.	See if air flows through the purge control line when the compressor is unloaded. The purge control line must be connected to the unloader port of the governor.
Air dryer purge valve isn't working.	See if air reaches the purge valve. If it does, repair the purge valve.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Inlet and outlet air connections are reversed-unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

freezing.	

Problem-Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life

Problem-Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life	
Possible Cause	**Remedy**
This problem usually occurs with one or more of the previous problems.	Refer to the appropriate corrections listed previously.
Air dryer is not securely mounted; there is excessive vibration.	Vibration should be held to a minimum. Tighten the mounting fasteners.
Cloth-covered perforated plate in the air dryer desiccant cartridge is damaged, or the cartridge was rebuilt incorrectly.	Replace the plate or cartridge as needed. High operating temperatures may cause deterioration of filter cloth. Check the installation.
Compressor is passing excessive oil.	Check for proper compressor installation; if symptoms persist, replace the compressor.
Heater and thermostat, wiring, or a fuse is at fault, and isn't allowing the air dryer to purge during cold weather.	Test the heater, and thermostat, following Instructions in the manual.
Desiccant cartridge not attached properly to the end cover.	Check the torque and tighten if necessary. Refer to manual for instructions.

Problem-Pinging Noise Is Excessive During Compressor Loaded Cycle

Problem-Pinging Noise Is Excessive During Compressor Loaded Cycle	
Possible Cause	**Remedy**
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-Up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 90 cubic in. reservoir between the compressor and the air dryer.

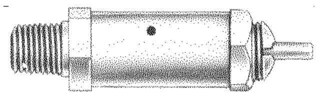
Problem-Constant Air Seepage at the Purge Valve (Non-Charging Mode)

Problem-Constant Air Seepage at the Purge Valve (Non-Charging Mode)	
Possible Cause	**Remedy**
Fair compressor inlet is pressurized by the engine turbocharger.	Some pressure leakage past the metal seat of the turbocharger cutoff feature of the AD-9 air dryer is normal, and may be heard. This slight loss of air will not affect the engine or turbocharger performance.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compress to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 Seconds. If there is excessive leakage, replace the check valve assembly.

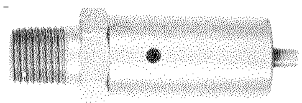
Problem-Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode

Problem-Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode	
Possible Cause	**Remedy**
Compressor does not unload.	Check the governor installation: there is no air line from the governor to the compressor, or the line is restricted. Repair or replace as needed.

The **SAFETY VALVE** (also called the POP OFF VALVE OR PRESSURE RELIEF VALVE) protects the air brake system against excessive air pressure build up. It must be installed in the same reservoir that the compressor discharge line is connected to. Safety Valves are available in both adjustable (ST 1) and non-adjustable (ST 3) styles, in various pressure settings, and with either 1/4" or 3/8" M.P.T.



ST-1



ST-3

Pressure Relief Valve, Bendix or Tramec

General Description and Principles of Operation

General Description

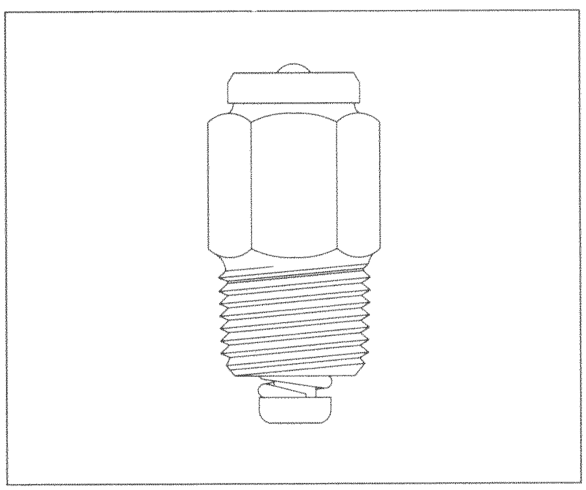


Fig. 1, Pressure Relief Valve

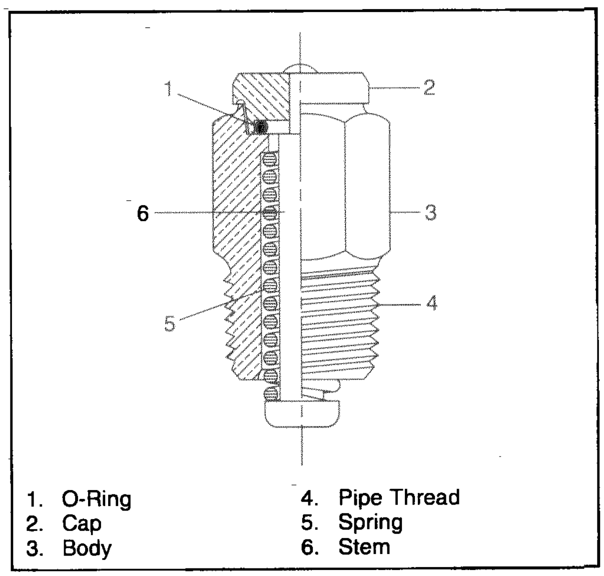


Fig. 2, Relief Valve Components

The pressure relief valve (Fig. 1) protects the air brake system against excessive air pressure build up. The valve has a spring loaded cap and O ring assembly which will exhaust air from the reservoir, if pressure rises above the valve's pressure setting. This setting is determined by the force of the spring.

Principles of Operation

To illustrate the operation of the pressure relief valve, note that the governor cut out pressure on all Freightliner vehicles is set at a maximum 125 psi (862 kPa). A pressure relief valve with a setting of 150 psi (1034 kPa) is then used. Should system pressure rise to approximately 150 psi (1034 kPa), air pressure will force the cap and O ring assembly off its seat, and allow the reservoir pressure to vent to the atmosphere. See Fig. 2.

When the reservoir pressure decreases sufficiently, the spring force will seat the cap and O ring assembly, sealing off reservoir pressure. This will occur at approximately 135 psi (931 kPa) for the 150 psi (1034 kPa) valve. Note that the desired pressure setting of the pressure relief valve is determined by the governor cut out pressure. The opening and closing pressures of the pressure relief valve should always be in excess of the governor cut out pressure setting.

Normally, the pressure relief valve remains inoperative and only functions if, for any reason, the reservoir pressure rises above the setting of the valve. Constant exhausting of the pressure relief valve can be caused by a faulty pressure relief valve, faulty governor, faulty compressor unloading mechanism, or a combination of any of the preceding.

Operating and Leakage Checks

Operating Check (see Fig. 1)

With air pressure built up in the system, proceed as follows:

WARNING: Wear safety goggles when exhausting the air system because debris could fly out at high speed. Failure to take all necessary precautions could result in personal injury.

1 With your index finger and thumb, pull the cap of the valve, removing the spring load from the O-ring. Air should exhaust from the valve.

2. Release the cap; the airflow should stop. Failure of a valve to pass the operating test indicates the valve should be replaced.

Leakage Check

Coat the exhaust port with a soap solution. Leakage resulting in a 1 inch (2.5 cm) bubble in 5 seconds is permitted. Excessive leakage indicates dirt in the valve or a faulty O ring or seat. The valve should be replaced.

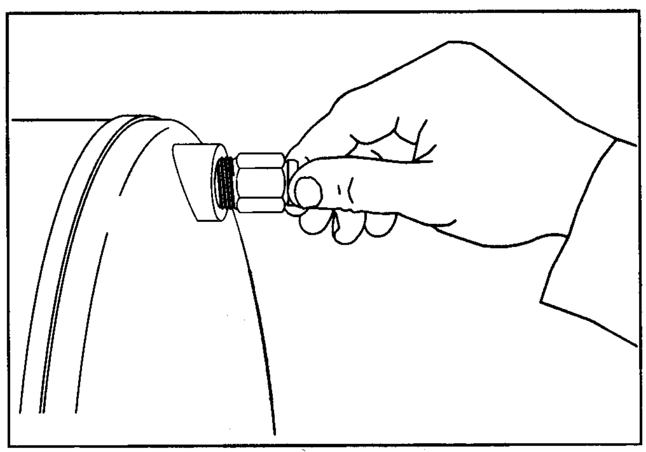
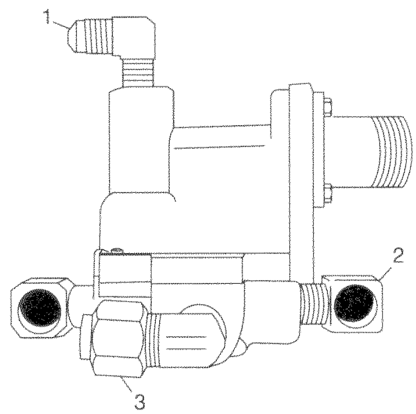


Fig. 1, Pull the Cap of the Valve

Air Lines and Fittings

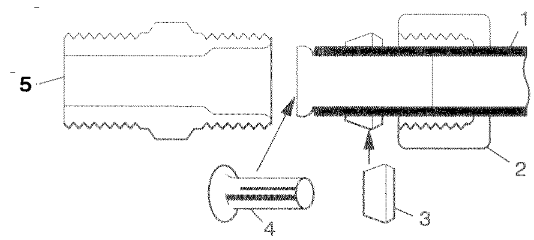
Installing Air Lines and Fittings

NYLON TUBES (See Fig. 1 and Fig. 2)



1. Wire Braid Hose Fitting
2. Pipe Fitting
3. Nylon Tube Fitting

Fig. 1, Tube and Hose Fittings (for reference only)



1. Nylon Tube
2. Nut
3. Sleeve
4. Brass Insert
5. Body

Fig. 2, Nylon Tube Fitting

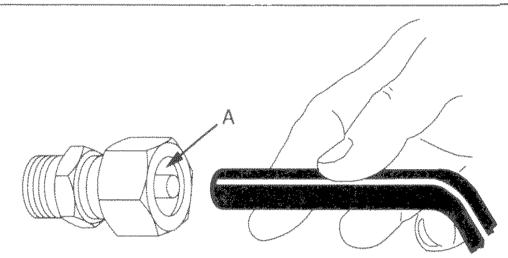
When installing a nylon tube, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate table in Specifications, 400.
CAUTION: If the tubing is bent to a radius smaller than the specified minimum bend radius, it may kink, and shut off normal airflow to the component.

1. Cut the end of the tubing smooth and square.

2. Make sure the nylon tubing ends and fittings are free of grease and debris. If the tubing is crimped or otherwise damaged, replace it with new tubing.

3. Install a new sleeve in the nut.

4. Insert the squared end of the tubing in the fitting, until it bottoms in the body of the fitting. See Fig. 3.



A. Tube end must bottom before tightening the nut.

Fig. 3, Installing Nylon Tubing

5. Tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut a minimum of 2 turns (refer to the appropriate table in Specifications, 400) or until one thread shows on the fitting body.

WIRE BRAID HOSES
When installing a wire braid hose, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate tables in Specifications, 400.

CAUTION: If the hose is bent to a radius smaller than the specified minimum bend radius, it may kink, and shut off normal airflow to the component.

Make sure the wire braid hose assembly is free of grease and dirt. Replace the assembly if the hose or fitting is crimped or otherwise damaged. Install the hose and tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the hose, tighten the nut until it seats solidly. Tighten the nut one-sixth turn more.

Installing Fittings

BRASS AND STEEL PIPE FITTINGS (See Fig. 1)

For brass pipe fittings, both male and female parts, tighten as follows:

1. Make sure the fittings are free of grease, dirt, and old sealant. Apply liquid Loctite° Hydraulic Sealant (brown), or an equivalent, to the threads, then tighten securely, finger-tight.

NOTE: Always apply the sealant to the external thread, so that any excess will be scraped off externally rather than internally to the joint.

2. For fittings that must be positioned, tighten one additional turn from finger-tight using a wrench. Then, continue tightening until the fitting is correctly positioned. For fittings that do not require positioning, tighten 1-1/2 additional turns from finger-tight.

COPPER TUBE FITTINGS

For copper tube fittings, tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut the number of turns shown in the table in Specifications.

QUICK-CONNECT FITTINGS

NOTE: If damaged, quick-connect fittings must be replaced as an assembly.

1. Push in on the fitting collar to release the air line. Pull the line out of the fitting. See Fig. 4.

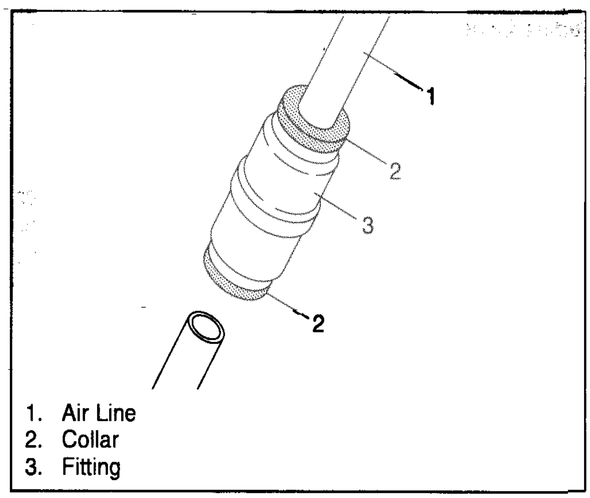


Fig. 4, Quick-Connect Fitting

2. Push the air line all the way into the fitting. Pull the collar away from the fitting to secure the air line. Check and make sure that the air line is seated in the fitting.

TUBE AND PIPE FITTINGS ON PLASTIC COMPONENTS

For tightening specifications, refer to the table in Specifications.

Specifications

Nylon Tube			
Number	Inside Diameter inch	Outside Diameter inch	Minimum Bend Radius inches (mm)
4	0.170	1/4	1.00 (25)
6	0.251	3/8	1.50 (38)
8	0.376	1 /2	2.00 (51)
10	0.439	5/8	2.50 (64)
12	0.566	3/4	3.00 (76)

Table 1, Nylon Tube

Additional Turns	
Tube Size (inches)	Additional Turns from Hand-Tight
1/4	3
3/8 or 1 /2	4
5/8 or 3/4	3-1/2

Table 2, Additional Turns from Hand-Tight (Nylon Tube)

Wire Braid (Medium Pressure)Hose			
Number	Inside Diameter inch	Outside Diameter inch	Minimum Bend Radius inches (mm)
4	3/16	0.52	3.00 (76)
5	1/4	0.58	3.38 (86)
6	5/16	0.67	4.00 (102)
8	13/32	0.77	4.63 (118)
10	1/2	0.92	5.50 (140)
12	5/8	1.08	6.50 (165)
16	7/8	1.23	7.38 (187)
20	1-1/8	1.50	9.00 (229)

Table 3, 211 Wire Braid (Medium Pressure) Hose (211 hose is identified by part number and size; for example, part numbers 211-4, 211-5, and so on)

Wire Braid (Diesel) Hose			
Number	Inside Diameter inch	Outside Diameter inch	Minimum Bend Radius inches (mm)
4	3/16	0.49	0.75 (19)
5	1/4	0.55	1.00 (25)
6	5/16	0.62	1.25 (32)
8	13/32	0.74	1.75 (44)
10	1 /2	0.83	2.25 (57)
12	5/8	0.96	2.75 (70)
16	7/8	1.21	3.50 (89)
20	1-1/8	1.49	4.50 (114)

Table 4, 213 Wire Braid (Diesel) Hose (213 hose is identified by two green stripes 180 degrees apart, part numbers, and size; for example, part numbers 213-4, 213-5, and so on)

Specifications(cont.)

Copper Tube Fittings			
Number	Outside Diameter (inches)	Additional Turns from Hand-Tight	
		Compression	Threaded Sleeve
2	1/8		
3	3/16	1-1/4	
4	1/4		
5	5/16	1-3/4	
6	3/8		
8	1/2		1-1/2
10	5/8		
12	3/4	2-1/4	
16	1		
20	1-1/4		

Table 5, Copper Tube Fittings

Tube and Pipe Fittings on Plastic Components			
Description	Port Size (inches)	Torque	
		N.cm (lbf.in)	N.m (lbf.ft)
Midland Quick Release Valve	3/8	680-1020 (60-90)*	--
	1/2	--	18-23 (13-17)*

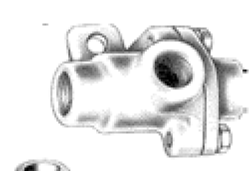
*Tighten to the lower torque value. Then, if needed, turn the fittings to allow for the proper routing of the air lines.

Table 6, Tube and Pipe Fittings on Plastic Components

A **DOUBLE CHECK VALVE** is used in the air system when a single function or component must be controlled by either of two sources of pressure. The double check valve will always transmit the higher of the two pressure sources to the outlet port. Double check valves are available in both disc and shuttle types and in various configurations for various applications. It is recommended that double check valves be mounted so that the shuttle operates horizontally.

The **IN LINE SINGLE CHECK VALVE** allows air flow in one direction only, preventing the flow of air in the reverse direction. Many styles of single check valves are available with both integral or replaceable seats, rubber and metal seats, and with ball or disc valves. Several sizes and configurations are available to accommodate various piping arrangements.

DC-4



Single Check Valve

General Information and Principles of Operation

General Information

The single check valve (Fig. 1 and Fig. 2) is installed in an air line to allow air flow in one direction and prevent air flow in the reverse direction. The check valve is installed in the upstream ends of the primary and secondary brake system air reservoirs to protect brake system air pressure in case the compressor, air pressure regulator or other air delivery component malfunctions.

Principles of Operation

When air in the system moves in the normal direction from the compressor to the air reservoir the check valve disk (Fig. 3, Ref. 4) compresses the spring (Ref. 2) and allows air to pass. When there is a drop in air pressure on the supply side of the valve, the spring pushes the check valve disk against the valve seat (Ref. 5) and prevents air from leaving the brake system.

Leakage Test

After repairing or replacing the single check valve, do the following test:

With the brake air system fully pressurized, drain the air from the supply reservoir (wet tank), and remove the air line from the supply side of the check valve. Coat the open end of the check valve with soap suds. A 1 inch (2.5 cm) or smaller bubble in five seconds is acceptable.

If the check valve is leaking too much, repair or replace it.

IMPORTANT: The Midland check valve is not serviceable. If it leaks or doesn't work, replace it.

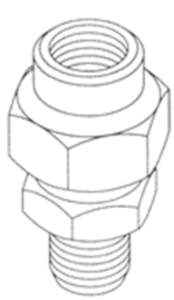


Fig. 1, Single Check Valve, Bendix

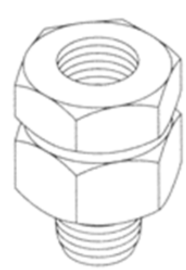
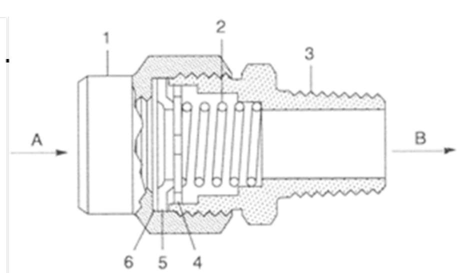
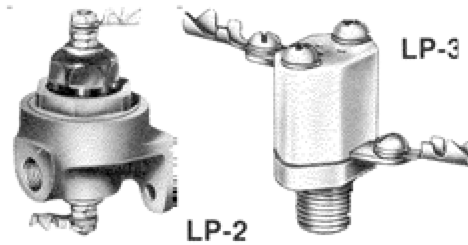


Fig. 2, Single Check Valve, Midland



A. Supply
B. Delivery
1. Body
2. Spring
3. Screw Cap
4. Disk
5. Seat
6. Shim

Fig. 3, Cross-Section (Bendix shown)



LOW PRESSURE INDICATORS are pr [illegible] hes that are designed to provide warning to the driver in the event air pressure in the service brake system is below a safe minimum for normal operation. The Low Pressure Indicator is available in various pressure settings, is not adjustable, and is generally used in conjunction with a dash mounted warning lamp or warning buzzer or both.

Air Reservoir

General Information

Air reservoirs serve two main purposes:

• They store compressed air used to apply the brakes and operate other air-powered devices.

• They provide a place where air, heated during compression, can cool and water vapor can condense into a liquid. Also, air reservoirs collect small amounts of oil passed by the compressor.

Primary reservoirs are air sources for the brakes on the rear axles. The primary reservoir is usually mounted above the secondary reservoir on the left-hand frame rail.

A secondary reservoir is the air source for the front axle brakes. It is usually mounted on the left-hand frame rail below the primary reservoir, and, like the primary reservoir, is equipped with an inline check valve.

The secondary reservoir supplies air to a pressure protection valve. This valve prevents complete loss of secondary air pressure if there is an air leak in any non-brake accessory.

The secondary reservoir also contains a wet tank to collect most of the water and oil condensate from the air. At the outlet port of the secondary reservoir (the port leading to the primary reservoir) is a safety valve, which protects the air system against excessive air pressure build-up.

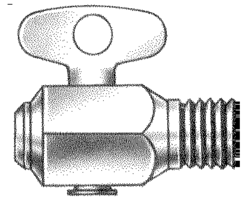
All air reservoirs are equipped with drain valves to eject the water and oil emulsion from the tanks

RESERVOIR DRAINING DEVICES are installed in air brake reservoirs. They allow the accumulation of contaminants collected in the reservoir to be drained off to atmosphere, and are available in both manual and automatic styles.

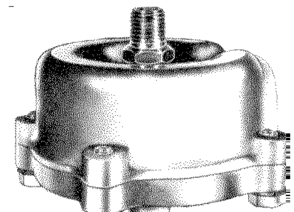
MANUAL DRAINING DEVICES consist of drain cocks which require manual operation at the point at which they are installed. Drain Cocks are available in various styles with pipe thread sizes of 1/8 ", 1/4", and 3/8".

The Remote Control Drain Valve consists of a drain valve installed into the reservoir and a control valve which is installed within the cab of the vehicle or any convenient servicing point.

The DV 2 AUTOMATIC RESERVOIR DRAIN VALVE is a completely automatic draining device. It is installed directly into the end or bottom drain port of the reservoir and does not require any additional control lines. It operates automatically from ascending and descending reservoir pressures. It is available in either the end port or bottom port version, and with or without a 12v or 24v heater.



DRAIN COCK



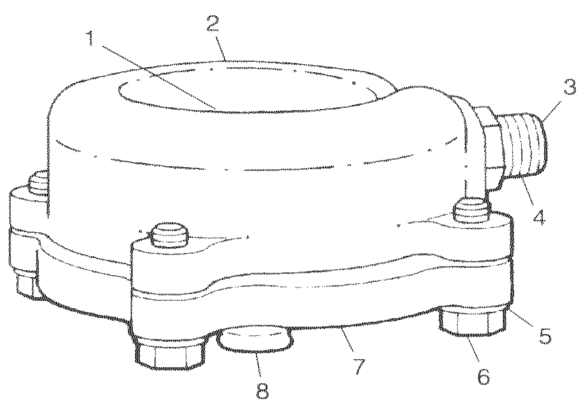
DV-2

Valves

Air Reservoir Automatic Drain Valve, Bendix DV 2

General Information and Principles of Operation

General Information



1. Top Reservoir Port
2. Valve Body
3. Hexhead Nipple
4. Side Reservoir Port
5. Lockwasher (4 qty.)
6. Capscrew (4 qty.)
7. Valve Cover
8. Exhaust Port

Fig. 1, DV-2 Valve

The DV 2 automatic reservoir drain valve (Fig. 1) automatically removes contaminants and water from the wet air tank each time the brakes are applied. The drain valve is attached to a drain cock located on the bottom of either end of the wet air tank. Since the brake application valve is protected by a check valve between the wet and dry air tanks, any leak or failure will not reduce the supply of air that is in the dry part of the system. If the leak is severe, it could prevent the continued resupply of air as it is used up when applying the brakes. A failed drain valve will allow moisture to build up in the wet tank which in turn could reach the dry tank, and then travel into the air brake system where it could cause brake failure. A leaking drain valve allows wet tank leak down which in turn can cause premature wear on the air compressor during vehicle operation as the air compressor continues to run to maintain wet tank air pressure

Principles of Operation

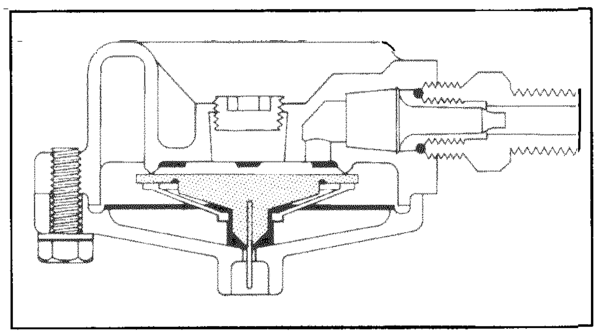


Fig. 2, No System Pressure

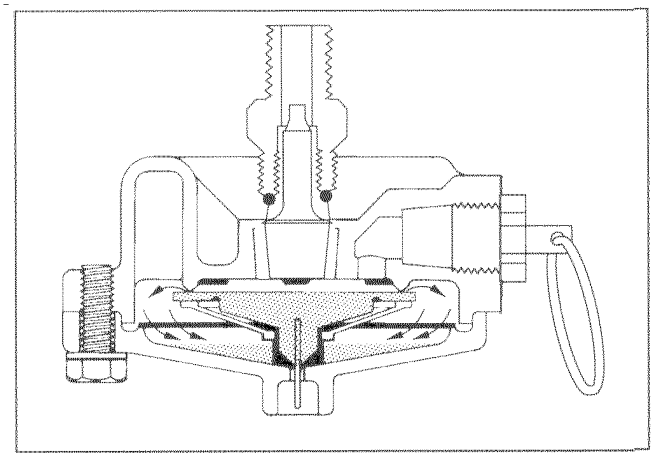


Fig. 3, Start of System Pressure Charging

With no pressure in the system, the drain valve's inlet and exhaust valves are closed. See Fig. 2. Upon charging the system, a slight pressure opens the inlet valve which permits air and contaminants to collect in the sump. See Fig. 3. The inlet valve remains open when pressure is rising in the system until the air compressor cuts off, allowing the spring action of the valve guide in the sump cavity to close the inlet valve. The inlet valve and the exhaust valve are now both closed. See Fig. 4. When the wet tank pressure drops approximately 2 psi (14 kPa), the air pressure in the sump cavity opens the exhaust valve and allows moisture and contaminants to be ejected from the sump cavity until pressure in the sump cavity drops sufficiently to close the exhaust valve. See Fig. 5. The length of time the exhaust valve remains open and the amount moisture and contaminants ejected depends upon the sump pressure and the wet tank pressure drop that occurs each time air is used from the system.

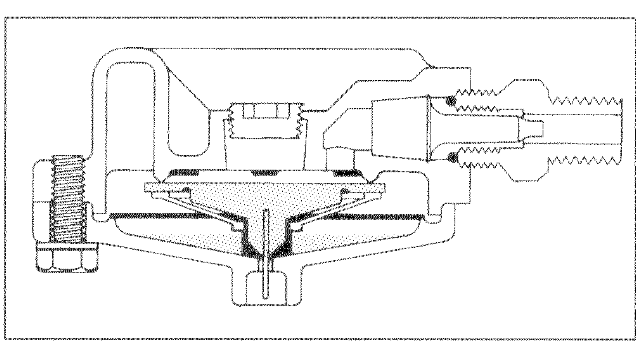


Fig. 4, System Pressure Rising

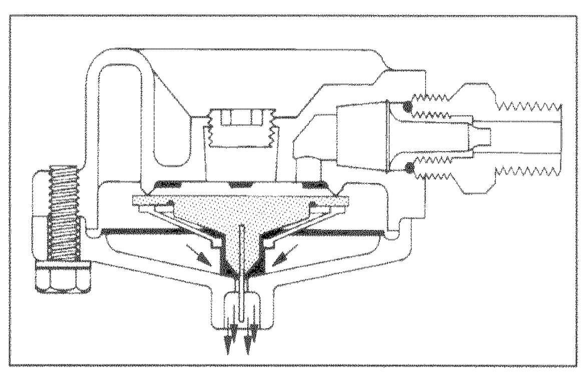


Fig. 5, Exhaust Cycle

Operating and Leakage Tests

Operating Test

IMPORTANT: Before working on or around air brake systems and components, review Safety Precautions, 100.

Perform the following test after repairing or replacing the DV 2 valve to ensure that the valve is functioning properly.

With the system charged, apply the brakes several times. Each time the brakes are applied, an exhaust of air should occur from the exhaust port of the drain valve. If no air comes out, push the wire stem located inside the exhaust port. If no air comes out after pushing the wire stem, there may be a plugged filter in the adapter which should be replaced.

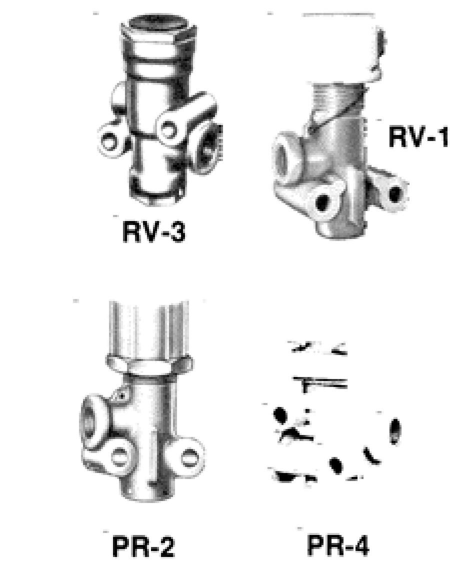
If the drain valve does not function properly, repair or replace it following instructions in this section.

Leakage Test

Perform the following test after repairing or replacing the DV 2 valve to ensure that the valve is functioning properly.

With the system charged and pressure stabilized in the system, there should be no leaks at the drain valve exhaust port. A constant slight exhaust of air at the drain valve exhaust port could be caused by excessive leakage in the air brake system.

If the drain valve is leaking excessively, repair or replace it following instructions in this section.



The PRESSURE REDUCING VALVE is used in various applications where a constant set air pressure lower than supply pressure is required. A typical application is an air operated accessory that requires less than system pressure for operation.
The RV 1 is available in wide range of pressure settings and also can be manually adjusted. The RV 3 is available with factory preset pressure settings only and cannot be manually adjusted.

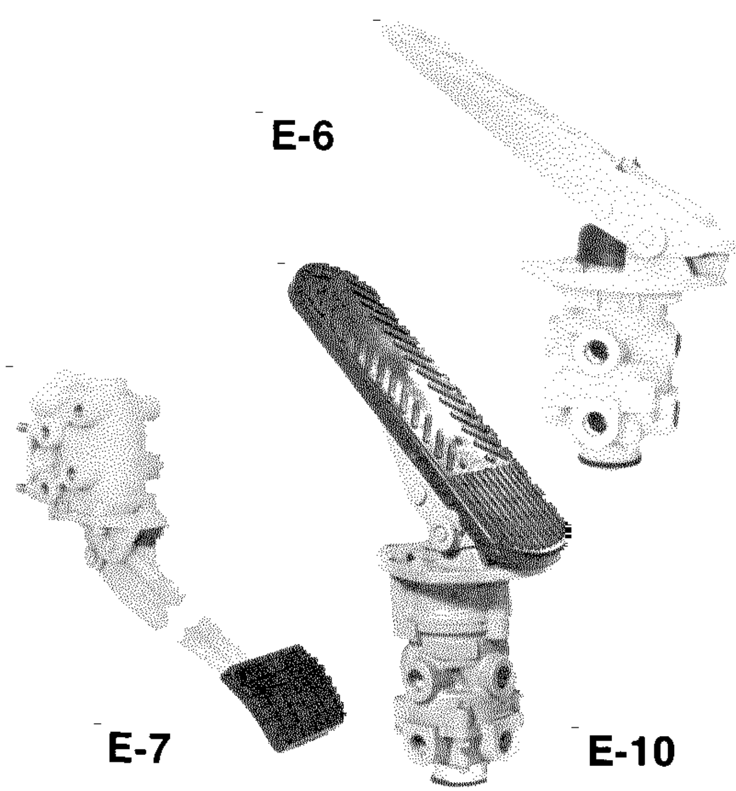
The PRESSURE PROTECTION VALVE is a normally closed pressure sensitive control valve. These valves can be used in many different applications. Typically, the valve is used to protect or isolate one reservoir supply from another, by closing automatically at its pressure setting. The valve is also commonly used in rapid buildup systems by delaying the filling of auxiliary reservoirs until a preset pressure is achieved in the primary reservoir.
The PR 2 valve is externally adjustable, while the PR 4 has a fixed setting. Both valves are available in various pressure settings.

Brake Valves

The **FOOT OPERATED BRAKE VALVE** is the control point of the vehicle air brake system. It provides the driver with an easily operated and graduated means of applying and releasing the brakes on a single vehicle or vehicles in combination (tractor and trailer).
Brake valves are available in various mounting configurations and, generally, are either floor or fire wall mounted. Actuation of the valve can be by treadle, pedal, or in some cases, with a lever/linkage arrangement.
The "feel" or sensitivity of the valve will vary, depending upon the method of actuation and the design of the valve. All brake valves are designed to provide a gradual means of applying air in the 5 P.S.I. to 80 P.S.I. range, with the capability of delivering full reservoir pressure.
Brake valves can generally be separated into two types; a single circuit valve and a dual circuit valve. Generally, pre 121 vehicles employ single circuit brake systems, and 121 vehicles utilize the dual circuit brake systems. A brief description of currently used brake valves is as follows:
DUAL CIRCUIT BRAKE VALVES utilize two separate supply and delivery circuits for service and secondary braking. The number one or primary circuit portion is mechanically operated through the action of the treadle/pedal and plunger. The number two or secondary circuit normally operates similarly to a relay valve, with control air delivered from the number one primary circuit. In the emergency mode (failure of the primary supply), the secondary inlet valve is mechanically opened by a push through mechanical force from the driver's foot via the treadle/pedal, plunger and primary piston.

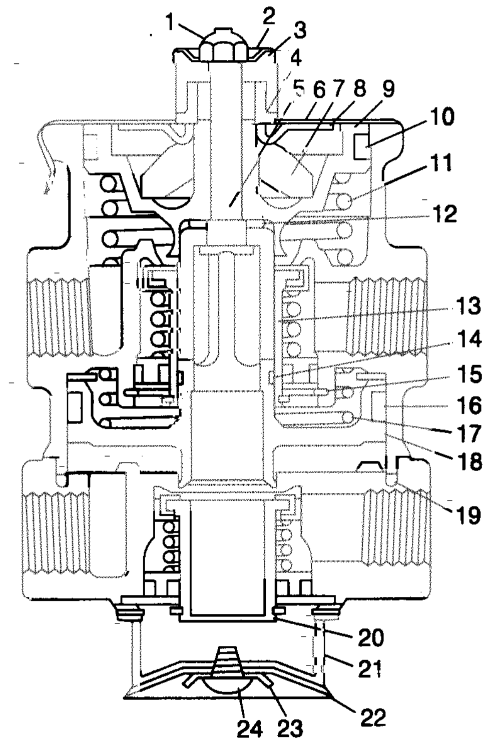
The **E 6 and E 10 DUAL BRAKE VALVES** are floor mounted, treadle operated valves with two separate supply and delivery circuits.

The **E 7 DUAL BRAKE VALVE** is a firewall mounted, suspended pedal valve with two separate supply and delivery circuits. Threaded supply and delivery ports for both circuits are provided at the back of the valve. For engine side firewall connections, an optional manifold is available.



Dual Brake Valve, Bendix E-6

General Description and Principles of Operation (See Fig. 1)



1. Locknut
2. Spring Seat
3. Stem Spring
4. Spring Seat Nut
5. Primary Piston Stem
6. Primary Piston Retainer
7. Rubber Spring
8. Spring Seat
9. Primary Piston
10. Primary Piston O-Ring
11. Primary Piston Return Spring
12. Small Washer
13. Upper Inlet and Exhaust Valve Assembly
14. Small O-Ring
15. Retaining Ring
16. Large O-Ring
17. Relay Piston Spring (if equipped)
18. Relay Piston
19. Rubber Seal Ring
20. Lower Inlet and Exhaust Valve Assembly
21. Exhaust Cover
22. Exhaust Diaphragm
23. Washer
24. Phillips Head Screw

Fig. 1, Bendix E-6 Dual Circuit Foot Valve (sectional view)

The dual circuit brake valve (foot valve) controls the air supply and delivery of the dual circuit brake system. The brake valve is mounted on the firewall.

APPLYING

The primary circuit of the brake valve is controlled by the brake pedal and a plunger. When the brake pedal is depressed, the plunger applies pressure on the spring seat, rubber spring, and the primary (upper) piston. The downward movement of the primary piston closes the upper exhaust valve, and then opens the upper inlet valve, allowing high pressure air from port 11 to flow to low pressure port 21.

The secondary circuit is pneumatically operated by the pressure from the primary circuit. Primary circuit pressure on top of the relay piston first closes the lower exhaust valve, and then opens the lower inlet valve, allowing high pressure from port 12 to flow to low pressure port 22.

HOLDING

As air pressure builds in the primary circuit, the pressure under the primary piston will match the pressure of the rubber spring. This allows the piston to move up enough to close the upper inlet valve, and prevent the flow of air from the primary air tank into the brake valve. The exhaust port remains closed.

RELEASING

When the pedal is released, the push rod releases pressure from the spring seat, rubber spring, and the primary (upper) piston. Air pressure builds to push the piston up, opening the upper exhaust valve and allowing air from the primary circuit to escape through the exhaust port.

In the secondary circuit, the release of primary air pressure allows air under the relay piston, pushing the piston up and opening the lower exhaust valve. All remaining air pressure is vented through the exhaust port.

Bendix E 6 Brake Valve Operating and Leakage Checks

Operating Checks

IMPORTANT: If there is a change in the way a vehicle brakes, or if low pressure warnings occur, check the operation of the brakes' air system. Although the brake system may continue to work, do not operate the vehicle until the braking circuits, including the pneumatic and mechanical devices, have been repaired and are operating normally. Always check the brake system for proper operation after doing brake work, and before returning the vehicle to service.

Check for the proper brake valve operation as follows:

1. Apply the parking brakes, and chock the tires.

2. Connect test gauges to the primary and secondary delivery ports on the brake valve. See Fig. 1.

NOTE: When checking the delivery pressure of the primary and secondary circuits, use test gauges that are accurate.

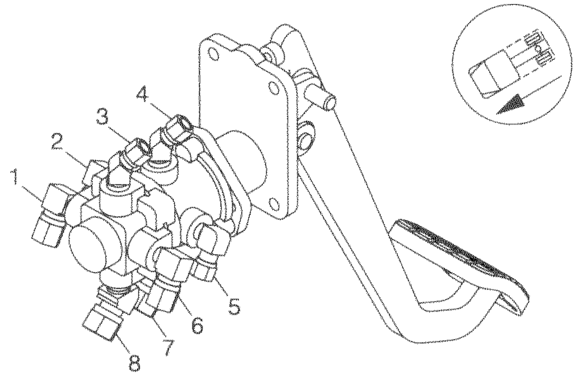
3. Start the engine and build air pressure to 120 psi (827 kPa).

4. Depress the pedal to several different positions; check the pressure on the test gauges to ensure that it varies equally and proportionately with the movement of the brake pedal.

5. Fully depress the brake pedal, then release it. After a full application is released, the reading on the test gauges should promptly fall to zero.

NOTE: Pressure in the primary delivery circuit will be about 2 psi (14 kPa) greater than pressure in the secondary delivery circuit (if both supply reservoirs are at the same pressure). This is normal for this valve.

6. Go to "Leakage Check."



1. Supply Circuit to Front Brake Valve
2. Primary Delivery Circuit to Tractor Protection Valve
3. Secondary Supply Circuit to Dash Valve
4. Primary Supply Circuit to Dash Valve
5. Delivery Circuit to Rear Brake Valve
6. Secondary Delivery Circuit to Tractor Protection Valve (if not equipped with a hand valve)
7. Primary Supply Circuit to Primary Supply Reservoir
8. Secondary Supply Circuit to Secondary Supply Reservoir

Fig. 1, Brake Valve Plumbing Circuits

Leakage Check

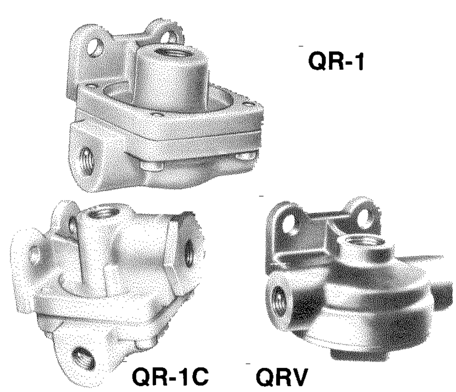
1. Make and hold a pressure application of 80 psi (552 kPa).

2. Check the air line fittings for leaks: tighten or replace fittings as needed.

3. Coat the exhaust port and body of the valve with a soap solution, and check for leakage. The leakage permitted is a one inch bubble in 3 seconds.

Note: If the brake valve does not function as described above, or if leakage is excessive, replace it with a new or remanufactured unit. Repeat the leakage test before placing the brake valve in service.

4. Remove the chocks from the tires.



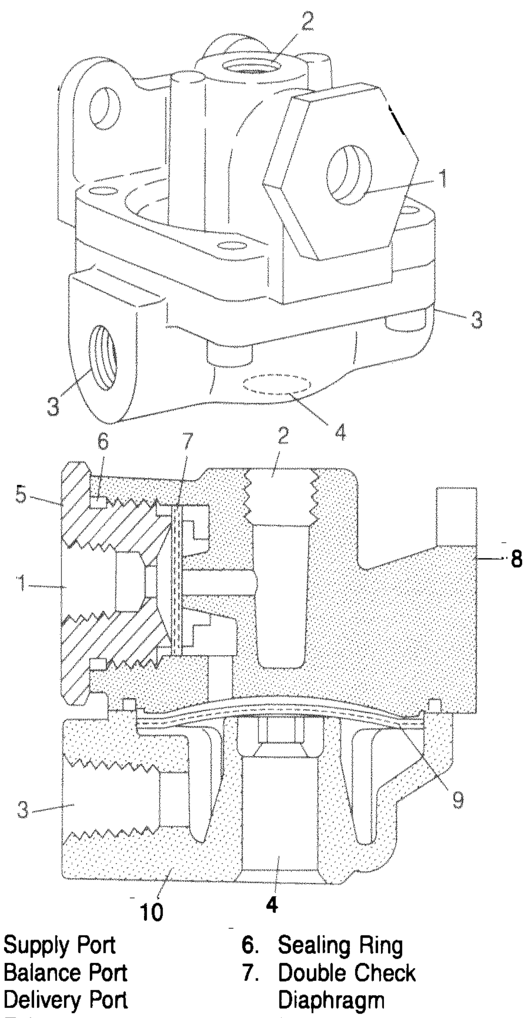
The function of a **QUICK RELEASE VALVE** is to rapidly exhaust air from the controlled device through the Quick Release Valve, which is normally located adjacent to the controlled device, rather than require the exhaust air to return and exhaust through the control valve. This decreases release time.
The OR 1 is the newer design; however, both the QRV and the OR 1 valves are functionally the same. The QR 1 C is a dual function valve. It functions as a quick release valve for the emergency side of the spring brakes and its integral double check valve prevents simultaneous application of the service and emergency side of the spring brakes, (anti compounding). Generally, Quick Release Valves are designed to deliver within 1 P.S.I. of control pressure.
Quick Release Valve, Bendix QR 1 C

General Information and Principles of Operation

General Information

The OR 1C quick release valve (Fig. 1) is a dual function valve. Its primary function is to speed up the release of air pressure from the service brake chambers. Additionally, the valve works as an anti-compound device. The double check valve feature prevents a service and parking brake application from occurring at the same time.

The QR 1 C valve is generally mounted near the rear axle. A balance line from the relay valve delivery port (port 2 on the WABCO combination valve) is
connected to the balance port on top of the OR 1 C quick release valve; the two side ports are for brake chamber connections; the supply port is connected to the delivery port of the parking brake control valve, and the exhaust port is located at the bottom of the valve.



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 1, QR-1C Valve and Cross Section

Principles of Operation (See Fig. 1)

Parking Brakes Released

When the parking brakes are released, air from the parking brake control valve flows through the GAR 1C valve. This forces the double check diaphragm and the quick release diaphragm to flex and seal the balance and exhaust ports. Air flows into the inlet ports of the parking brake chambers from the QR 1 C valve delivery ports.

Parking Brakes Applied

When the parking brakes are applied, supply line air pressure to the QR 1 C valve is exhausted through the parking brake control valve. As air pressure is exhausted from one side of the double check diaphragm and the quick release diaphragm, both diaphragms flex in the opposite direction to open the balance and exhaust ports. Parking brake pressure is released at the exhaust port of the QR 1 C valve while a small amount of air trapped between the two diaphragms is released through a relay valve or the foot valve exhaust port.

Anti-Compounding

When a service brake application is made with the parking brakes applied, service air enters the balance port and flows through the QR 1 C valve into the inlet ports of the parking brake chambers. This prevents application of the service and parking brakes at the same time. Service air passing through the QR¬1 C valve flexes the double check and quick release diaphragms, sealing the supply and exhaust ports. When the service brake application is released, air is exhausted from the parking brakes.

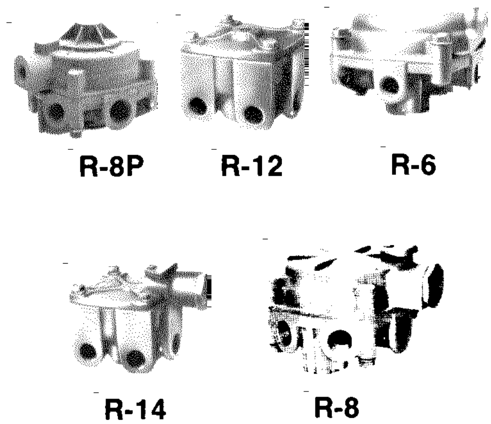
QR 1 C Quick Release Valve Operating and Leakage Tests

Operating and Leakage Tests

WARNING: Before working on or around air brake systems and components, review the safety precautions. Failure to do so could result in personal injury.

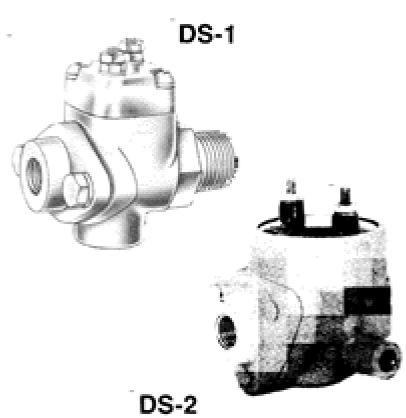
The following tests should also be performed after repairing or replacing the QR 1C valve to ensure that it is functioning properly.

1. Chock the tires.
2. Drain the air system.
3. Release the parking brakes.
4. Remove the air line from the valve balance port. Build system air pressure to 120 psi (827 kPa). Coat the exhaust and balance ports with a soap solution; leakage of a one inch (25 mm) bubble in five seconds at either port is allowable. Install the air line at the balance port.
5. Apply the parking brakes. Step on the foot brake; the QR 1 C valve should exhaust air at the exhaust port.
6. Drain the air system.
7. Remove the air line from the valve supply port. Build system air pressure to 120 psi (827 kPa). With the foot valve depressed, coat the supply port and the seam between the body and cover with a soap solution; leakage of a one inch bubble in five seconds at the supply port is allowable. No leakage between the body and cover is permitted. Install the air line at the supply port.
8. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.

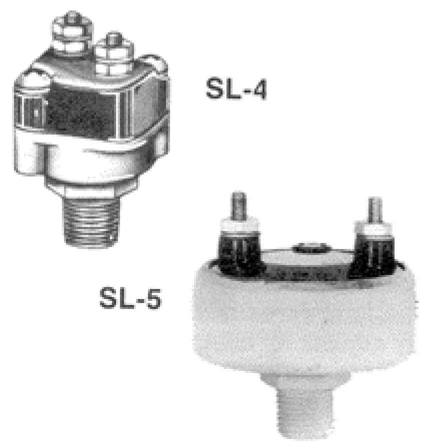


RELAY VALVES are primarily used on long wheelbase vehicles to apply and release rear axle(s) service or parking brakes. They are air-operated, graduating control valves of high capacity and fast response. Upon signal pressure from the service brake valve, they graduate, hold or release air pressure from the chambers to which they are connected. They are generally mounted close to the chambers they serve. These relay valves are available in both remote and reservoir mount designs and feature inlet/exhaust valve cartridge replacement without line removal.

The **SR7 Park Brake Valve** incorporates an integral balance port which provides an anti-compounding feature. The anti-compounding feature prevents parking brakes and service brakes from applying at the same time by releasing the park brakes the same amount as the service brakes are applied.

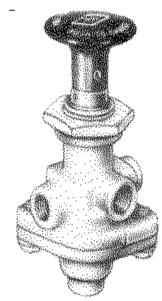


In today's air brake system it is common practice to combine two or more functions into one device such as the DOUBLE CHECK VALVE AND STOP LAMP SWITCH. This device performs the function of both a stop lamp switch and a double check valve. It accepts a signal or supply pressure from two sources, and delivers into a common outlet. Typical use would be in a single circuit system where the TC valve and Foot Brake Valve delivery lines are piped into the valve and pressure from either source will operate the stop lamp switch, lighting the stop lamps, and direct the flow of air pressure into a common outlet to control the brakes. The DS 1 was used primarily in pre 121 systems, and is serviceable. The DS 2 is designed to meet FMVSS 121 requirements and is non serviceable.



The SL 4 and SL 5 STOP LAMP SWITCHES are pressure sensitive electro pneumatic switches installed in the service application system. They operate the vehicle stop lamps, completing an electrical circuit and lighting the stop lamps each time a brake application is made.

CONTROL VALVES are used extensively in the air-brake system to control various system components. They are generally dash mounted, but may be mounted elsewhere, depending upon the specific application.



The **PUSH-PULL CONTROL VALVES** listed are pressure sensitive, on/off control valves which will automatically return to the exhaust (button out) position when supply pressure is below the required minimum. They may be manually operated to either position when pressure is above the required minimum. Pressure settings and button configuration and lettering may vary, depending on application.

The PP-1 is commonly used to control parking and emergency brakes.

Parking Brake Hand Valve, Bendix PP-DC

General Description and Principles of Operation

General Description

The Bendix PP-DC parking brake air valve is installed on vehicles with air brakes, and is used to control the rear axle parking brakes. It is a push-pull type of valve, and is mounted on the right side of the dash.

Principles of Operation

When the valve knob is pulled out, air is exhausted from the parking brake chambers, releasing the springs, and applying the parking brakes. When the knob is pushed in, air flows into the parking brake chambers from one of the reservoirs, and compresses the springs, releasing the parking brakes.

The PP-DC has a double check valve feature. The valve uses air pressure from the air system (primary or secondary) with the higher pressure for the parking brakes. If the pressure drops below 20 to 30 psi (138 to 207 kPa) in both air systems, the brakes will automatically apply. The parking brakes will not apply automatically unless pressure is lost from both systems.

Parking Brake Hand Valve Tests

IMPORTANT: To do the following tests, connect two separate 120 psi (827 kPa) air sources to the PPDC supply ports. See Fig. 1. Tee an accurate test gauge into the supply lines, and provide for a means to control supply line pressure. Connect a small volume air source with a gauge to the delivery port.

Operating Test

1. Chock the tires.

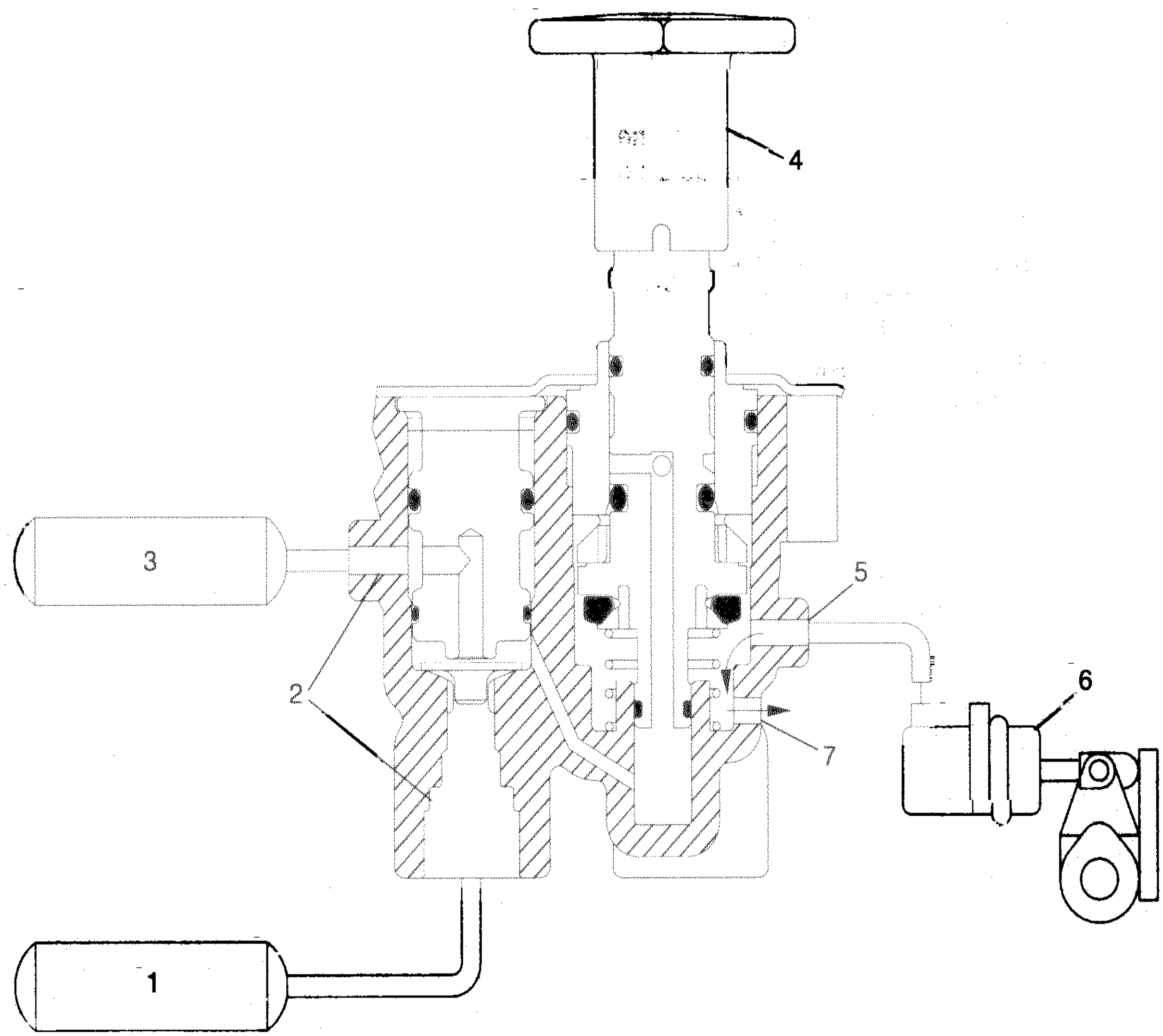
2. Start the engine and build up the air pressure to
the normal operating level.

3. With the valve knob pulled out, supply either supply port with 120 psi (827 kPa) of pressure. Push the valve knob
in. Air pressure should rise in the delivery line and equal supply line pressure. Pull the valve knob out. Delivery pressure should exhaust to zero.

4. Build air pressure to each supply source to 120 psi (827 kPa). Decrease supply pressure at the secondary service reservoir supply port at a rate of 10 psi (69 kPa) per second. Primary supply pressure and delivery pressure should not drop below 100 psi (689 kPa). Repeat this step for decreasing primary service reservoir pressure.

5. Build air pressure to each supply source to 120 psi (827 kPa). Then, decrease both supply pressures to below 20 to 30 psi (138 to 207 kPa). The valve knob should automatically pop out when the pressure is within that range.

6. If the valve does not work as described, repair the valve or replace it following instructions in manual.



1. Primary Service Reservoir
2. Supply Port
3. Secondary Service Reservoir
4. Valve Knob
5. Delivery Port
6. Brake Chamber
7. Exhaust Port

Fig. 1, Parking Brake Hand Valve (sectional view)

Leak Testing

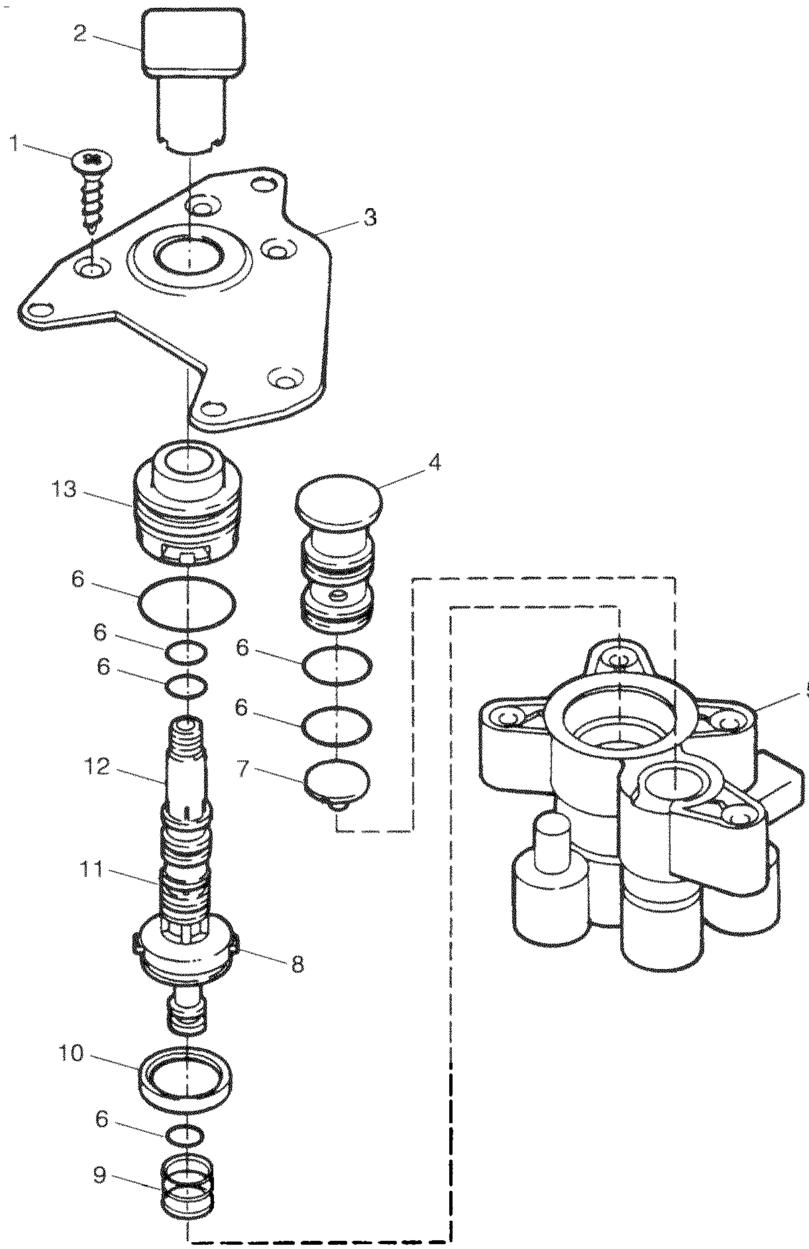
1. Chock the tires.

2 Supply the valve with 120 psi (827 kPa) from the primary reservoir supply port.

3. With the valve knob pulled out, coat the exhaust port and the plunger stem with a soapy solution. Leakage at either fitting should not exceed a 1-inch (2.5-cm) bubble every five seconds. There should be no leakage from the secondary reservoir supply port.

4. Supply the valve with 120 psi (827 kPa) from the secondary reservoir supply port. There should be no leakage from the primary reservoir supply port.

5. With the valve knob pushed in, coat the exhaust port and the plunger stem with a soapy solution. Leakage at the fittings should not exceed a 1-inch (2.5-cm) bubble every three seconds. If it does, replace it following instructions in manual.



1. Screw
2. Valve Knob
3. Cover
4. Check Valve Seat
5. Valve Body
6. O-Ring
7. Check Valve
8. Index Tab
9. Plunger Spring
10. Exhaust Seal
11. Plunger
12. Plunger Stem
13. Guide Spool

Fig. 1, Exploded View

Description

The Bendix SR-7™ spring brake modulating valve is used in conjunction with a dual air brake system and spring brake actuator, and performs the following functions. See **Fig. 1** and **Fig. 2**.

- Provides a rapid application of the spring brake actuator when parking.
- Modulates the spring brake actuator application using the dual brake valve should a primary failure occur in the service brake system.
- Prevents compounding of service and spring brake forces.

The SR-7 valve has one park control, one service control, one supply, one balance, four delivery NPT ports, and an exhaust port protected by an exhaust diaphragm. The valve incorporates two mounting studs for mounting the valve to the frame rail or crossmember.

WARNING

Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

Operation

The operation guidelines shown in this manual represent the relay-valve-based SR-7. A quick-release-based valve functions similarly to the relay-valve-based version with the exception that all air delivered to the spring brakes passes through the park control port through the in-line single check valve. The SR-7 quick-release style can be easily identified by the pipe plug in the supply port of the valve. See **Fig. 1**. For vehicle-specific plumbing diagrams, go to **EZWiring**.

Charging the Spring Brake Actuators Below 107 psi (737 kPa)

With the air brake system charged and the parking brakes released (by pushing in the dash valve button), air enters the park control port. This opens the SR-7 valve, to supply air pressure to the spring brake chambers. As illustrated, air pressure in the chambers is below 107 psi (737 kPa) (nominal). See **Fig. 3**.

Charging the Spring Brake Actuators Above 107 psi (737 kPa)

Once the SR-7 valve delivery pressure reaches 107 psi (nominal), the inlet and exhaust are closed (valve lap position). This maintains the spring brake hold-off pressure at 107 psi (nominal). See **Fig. 4**.

Normal Service Application

During a service brake application, the valve remains in the lap position. The SR-7 valve monitors the presence of air pressure in both primary and secondary delivery circuits. See **Fig. 5**.

Parking

Actuating the park brakes (by pulling out the dash valve button) exhausts spring brake air pressure through the SR-7 valve exhaust port. See **Fig. 6**.

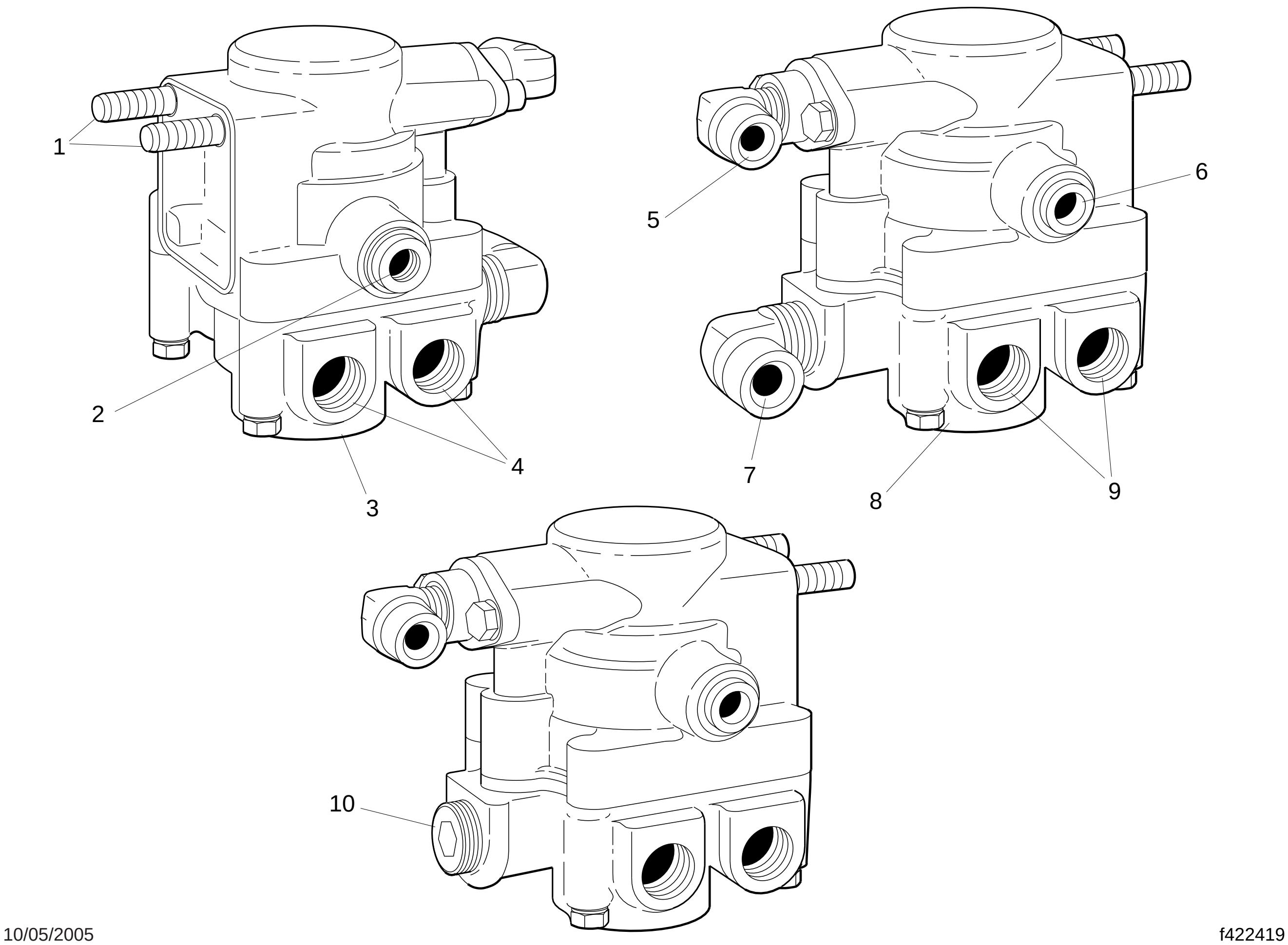
Service Application with Loss of Air in Primary Circuit

With the parking brakes released (dash valve button in) and the absence of air in the primary circuit delivery, a service brake application from the secondary circuit causes the pressure in the spring brakes to be exhausted proportionally to this application. This is known as spring brake modulation. A 30 psi (207 kPa) service brake application will exhaust the spring brake pressure to approximately 60 psi (414 kPa). See **Fig. 7**.

Service Application with Loss of Air in Secondary Circuit

With the parking brakes released (dash valve button in) and the absence of air in the secondary circuit reservoir, the external single check valve in the supply port seals to prevent air leakage to atmosphere from the SR-7 valve. The dash valve delivery air flows through the inline single check valve and becomes SR-7 valve supply air. This air is delivered to maintain at least 107 psi (737 kPa) (nominal) in the spring brake chambers. See **Fig. 8**.

General Information

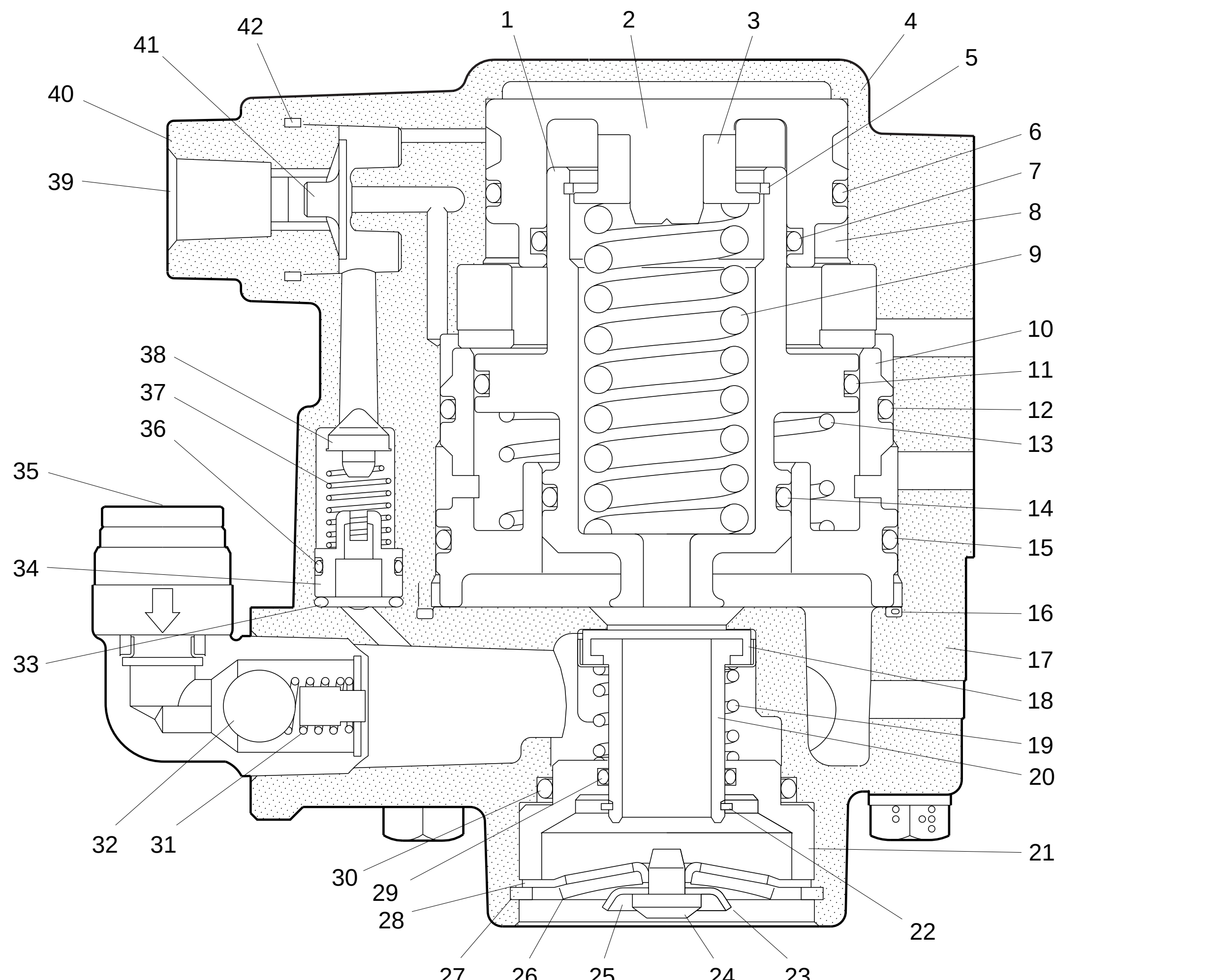


1. Mounting Studs
2. 42 Control Port
3. Exhaust
4. Delivery
5. 41 Park Control (from dash valve)
6. 41 Balance Port
7. Supply Port
8. Exhaust
9. Delivery
10. Pipe Plug (QRV applications only)

Fig. 1, SR-7 Spring Brake Modulating Valve (exterior views)

Anti-Compounding

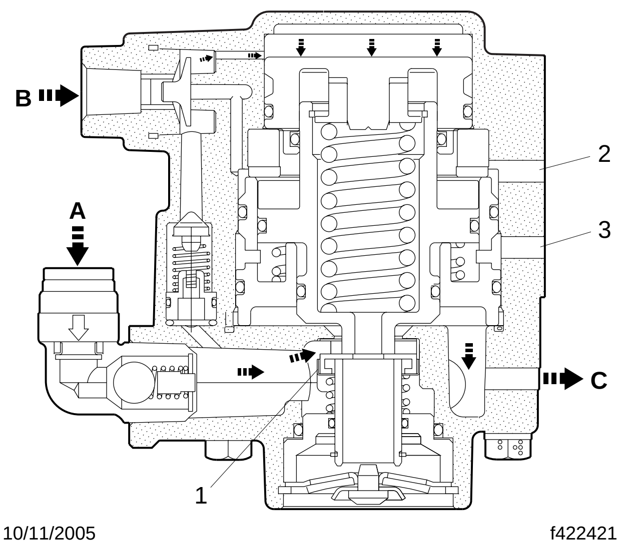
The SR-7 valve provides anti-compounding of the service and spring brake forces. When the park brakes are actuated (by pulling out the dash valve button), a service brake application will cause the SR-7 valve to deliver air pressure to the spring brake chambers. Thus the vehicle is held stationary using a service brake application. When the service brake application is released, the delivery pressure is exhausted from the spring brake chambers and the vehicle remains parked using the spring brake actuators. See **Fig. 9**.



1. Main Piston
2. Control Piston
3. Spring Guide
4. Upper Body
5. Retaining Ring
6. O-Ring
7. O-Ring
8. Spacer
9. Main Piston Spring
10. Static Piston
11. O-Ring
12. O-Ring
13. Static Piston Spring
14. O-Ring
15. O-Ring
16. O-Ring
17. Lower Body
18. Valve Retainer
19. Spring
20. Inlet/Exhaust Valve
21. Lower Valve Guide
22. Retaining Ring
23. Exhaust Port
24. #10 Torx Screw
25. Diaphragm Washer
26. Diaphragm
27. Retaining Ring
28. Valve Seat
29. O-Ring
30. O-Ring
31. Spring
32. Ball Check Valve
33. O-Ring
34. Check Valve Guide
35. Supply Port
36. O-Ring
37. Spring
38. Inline Single Check Valve
39. Park Control Port
40. Check Valve Cover
41. Double Check Valve
42. O-Ring

Fig. 2, SR-7 Spring Brake Modulating Valve (sectional view)

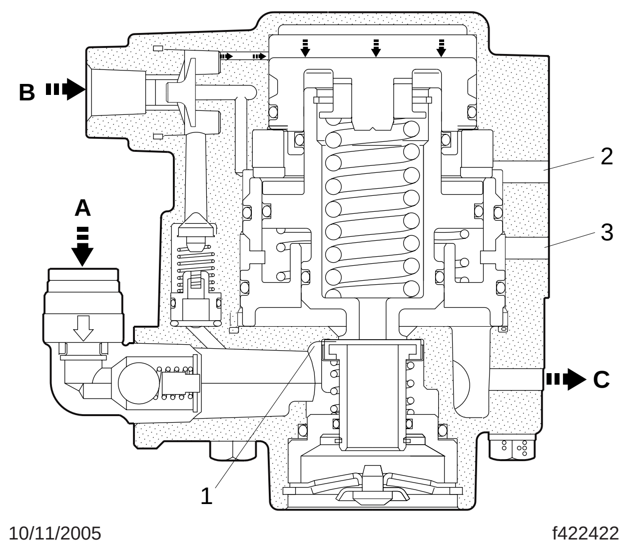
General Information



A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes

1. Inlet/Exhaust Valve Open
2. Balance Port
3. Control Port

Fig. 3, Charging the Spring Brake Actuators Below 107 psi (737 kPa)

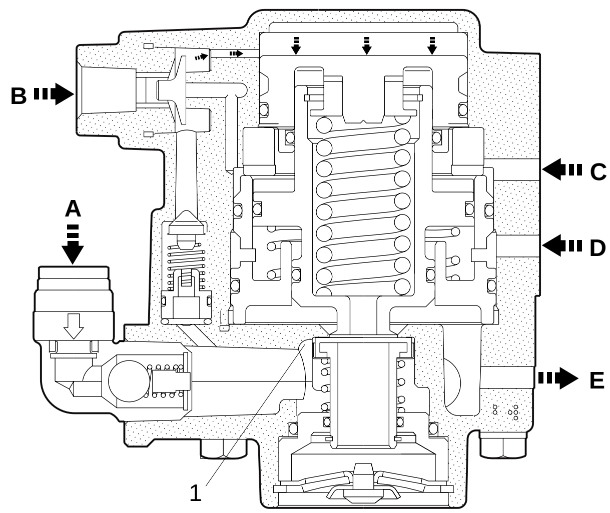


A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes

1. Inlet/Exhaust Valve Seated
2. Balance Port
3. Control Port

Fig. 4, Charging the Spring Brake Actuators Above 107 psi

General Information

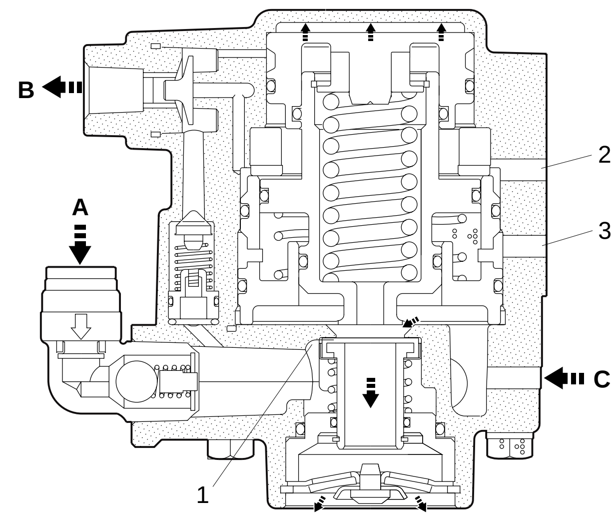


10/11/2005 f422423

A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes

1. Inlet/Exhaust Valve Seated

Fig. 5, Normal Service Application



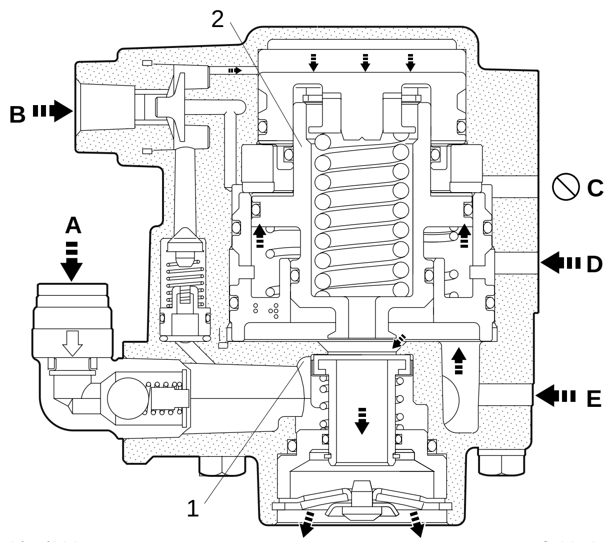
10/11/2005 f422424

A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes

1. Inlet/Exhaust Valve Seated
2. Balance Port
3. Control Port

Fig. 6, Parking

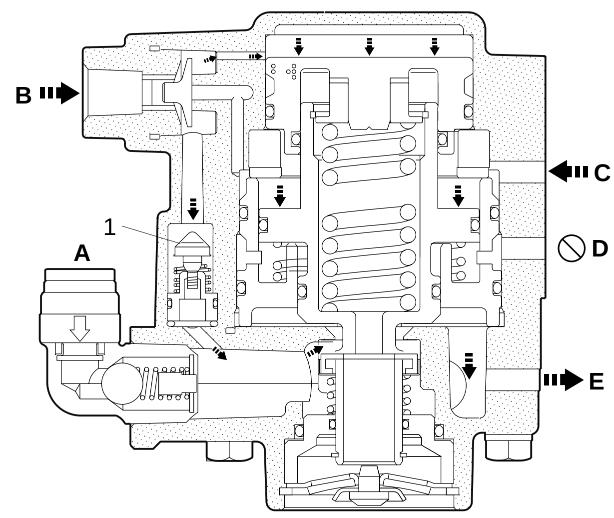
General Information



A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—loss of primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes

1. Inlet Valve Seated
2. Main Piston Moves Up

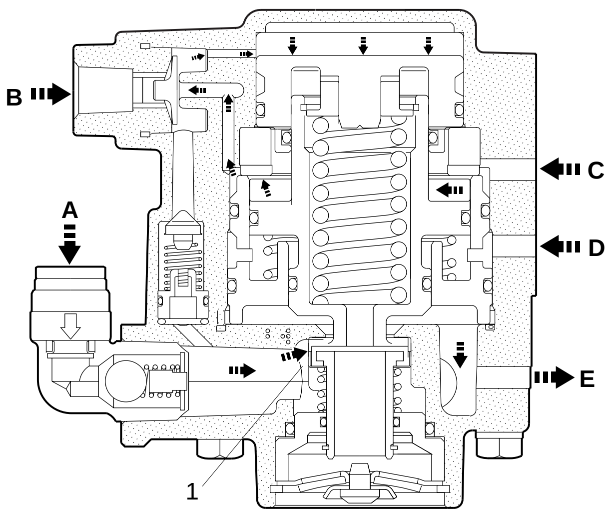
Fig. 7, Service Application with Loss of Air in Primary Circuit



A. Secondary reservoir no pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—loss of secondary circuit pressure
E. Delivery to spring brakes

1. Inline Single Check Valve

Fig. 8, Service Application with Loss of Air in Secondary Circuit



A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes

1. Inlet/Exhaust Valve Open

Fig. 9, Anti-Compounding

AIR DRYER SERVICE

Beginning with the 2013-2014 annual repair cycle, the following changes will apply to servicing/replacing air dyer desiccants and purge valves on all SCDE vehicles:

The Air dryer desiccant filter/cartridge must be changed, and the purge valve must be serviced, during Annual Repair every three years.

At this time, air dryers, dryer housings, plumbing and all mounting attachments should also be inspected and serviced/replaced if any inspection indicates defects or possible failure.

All manufacturers' installation instructions must be followed whenever servicing/replacing air dryer systems.

South Carolina Department of Education, Transportation
Air Brake System Test Sheet (Revised 3-2013)

Vehicle Number: ____________________ **Odometer Reading:** __________________

Test 1 Low Pressure Warning – Pressure Build-Up – Governor Cut Out

Procedure - Vehicle Parked, Wheels Chocked, All Brake Reservoirs Drained to 0 psi, Start Engine and Operate @ Fast Idle

	OK	Repaired
1. Low Pressure Warning Lights and Buzzers: A. Are Activated		
B. Are Deactivated @ 60-65 psi		
2. Pressure Build Time: Pressure Builds from 85 psi to 100 psi in less than 40 Seconds		
3. Governor Cut-Out Pressure: (120-125 psi)		
4. Governor Cut-In Pressure: Reduce Service Air Pressure to Reach Governor Cut-In Point. Note: The Difference Between Cut-In and Cut-Out Pressure Must Not Exceed 25 psi.		
Make All Necessary Repairs Before Proceeding to Test 2; See Checklist 1 for Common Corrections		

Test 2 Leakage – Reservoir, Air Supply

Procedure - Full System Pressure, Engine Stopped, Parking Brakes Applied, Allow Pressure to Stabilize for at Least 1 Minute

	OK	Repaired
1. Pressure Drop: Observe Dash Pressure Gauges for 2 Minutes, Note any Pressure Drop. Note: Single Vehicle - Maximum Allowable Drop is 4 psi Within 2 Minutes for Either Reservoir.		
Make All Necessary Repairs Before Proceeding to Test 3; See Checklist 2 for Common Corrections		

Test 3 Leakage – Service, Air Delivery

Procedure - Full System Pressure, Engine Stopped, Parking Brakes Applied, Make and Hold Brake Application, Allow Pressure to Stabilize for at Least 1 Minute

	OK	Repaired
1. Pressure Drop: Observe Dash Pressure Gauges for 2 Minutes, Note any Pressure Drop. Note: Single Vehicle - Maximum Allowable Drop is 6 psi Within 2 Minutes for Either Reservoir.		
Make All Necessary Repairs Before Proceeding to Test 4; See Checklist 3 for Common Corrections		

Test 4 Service Brakes, Application

Procedure - System Pressure at Minimum of 90 psi, Make and Hold Brake Application

	OK	Repaired
1. Stroke: Brake Chamber Push Rod Travel Is Within Tolerance. Note: See Chart Under Checklist 3 for Maximum Tolerances by Chamber Type.		
2. Angle: Brake Chamber Push Rod to Slack Adjuster Arm Angle Is Greater Than or Equal to 90 Degrees.		
Make All Necessary Repairs Before Proceeding to Test 5; See Checklist 4 for Common Corrections		

Test 5 Emergency Brakes, Manual

Procedure - Full System Pressure, Engine Idling @ 600-900 rpm

	OK	Repaired
1. Control Valve Operation: Manually Operate the Park Control Valve and Note that Parking Brakes Apply and Release Promptly as Control is Pushed In and Pulled Out.		
Make All Necessary Repairs Before Proceeding to Test 6; See Checklist 5 for Common Corrections		

Test 6 Emergency Brakes, Automatic

Procedure - Full System Pressure, Engine Stopped

	OK	Repaired
Drain Front Axle Reservoir To 0 Psi: Rear Axle Should Not Loose Pressure		
With No Air Pressure On Front Axle Reservoir: Make a Brake Application. Then Release Brake. A. Rear Axle Brakes Should Apply.		
B. Stop Lamps Should Light.		
C. Rear Axle Brakes Should Release.		
Slowly Drain Rear Axle Reservoir Pressure: The Spring Brake Push/Pull Valve Should Pop Out Between 20-45 Psi.		
Close Drain Cocks, Recharge System, Drain Rear Axle Reservoir, And Make Brake Application: A. Front Brakes Should Apply And Release.		
B. Rear Brakes Should Apply And Release.		
Make All Necessary Repairs Prior To Operating Vehicle; See Checklist 6 for Common Corrections		

Technician Signature: ____ Date: __________________

Check List 1

If the low pressure warning lights and/or buzzers do not come on:

1. Check wiring.
2. Check Bulb.
3. Repair or replace buzzer, bulb, or low pressure warning switch(es).

If low pressure warning deactivates below 60 psi or above 65 psi

1. Check the dash gauge with test gauge known to be accurate.
2. Repair or replace the faulty low pressure indicator.

If build up time exceeds 40 seconds:

1. Examine compressor air strainer and clean or replace.
2. Check for restricted inlet line if compressor does not have strainer. Repair or replace as necessary.
3. Check compressor discharge port and line for excessive carbon. Clean or replace as necessary.
4. With system charged and compressor governor in unloaded mode, listen at the compressor inlet for leakage. If leakage is heard apply a small amount of oil around unloader pistons. If no leakage is indicated, then leakage is through compressor discharge valves.

If governor cut-out is higher or lower than specified by the vehicle service manual:

1. Adjust the governor using a gauge of known accuracy.
2. Repair or replace governor as necessary after making sure that compressor unloader mechanism is operating correctly.

*** Retest To Check All Items Repaired Or Replaced.**

Check List 2

If there is excessive leakage in the supply side of the pneumatic system, one or more of the following devices could be causing the problem:

Supply Lines and Fittings (tighten)	Low Pressure Indicator(s)	Relay Valves / Antilock Modulators
Dual Brake Valve	Park Brake Control Valve	Pressure Protection Valve
Compressor Discharge Valves	Safety Valve in Reservoir(s) (pop-off)	Governor

Note: A leak detector or soap solution will aid in locating the faulty component.

*** Retest To Check All Items Repaired Or Replaced.**

Check List 3

If there is excessive leakage in the service side of the pneumatic system, one or more of the following devices could be causing the problem:

Service Lines and Fittings (tighten)	Stop light switch(es)	Brake Chamber Diaphragms
Relay Valve(s) / Antilock Modulators	Service Brake Valve	Front Axle Ratio Valve
Inverting Relay Spring Brake Valve (SR1)	Double Check Valve	Pressure Protection Valve

Note: A leak detector or soap solution will aid in locating the faulty component.

*** Retest To Check All Items Repaired Or Replaced.**

Check List 4

If the brake chamber push rod travel is at or near the "Maximum Legal Stroke", adjust the slack adjuster to obtain the desired setting. Brake adjustment for all axles should be matched.

Chamber Type	Maximum Legal Stroke	Chamber Type	Maximum Legal Stroke
12	1 3/8"	24 Long Stroke	2”
16	1 3/4"	30	2"
24	1 3/4"	30 Long Stroke	2 ½”

If the angle between the brake chamber push rod and the slack adjuster is less than 90 degrees with the brakes applied, adjust the slack adjuster arm to obtain the desired setting.

*** Retest To Check All Items Repaired Or Replaced.**

Check List 5

If sluggish performance is noted in either test, check for:

Dented or Kinked Lines	Improperly Installed Hose Fittings	Faulty Relay Emergency Valve
Faulty Modulators		

*** Retest To Check All Items Repaired Or Replaced.**

Check List 6

If the vehicle fails to pass the tests outlined, check the following components for leakage and proper operation:

Fittings	Kinked Hose or Tubing	Single Check Valves
Double Check Valves	Parking Control Valves	Relay Valves
Inverting Relay Spring Brake Valve (SR1)		

*** Retest To Check All Items Repaired Or Replaced.**

Troubleshooting

General Information and Safety Precautions

General Information

This troubleshooting guide is designed to help locate causes of problems originating in the air brake system. The corrective measures given are not intended to replace the detailed service information found in other sections of this manual or in the component manufacturer's service manuals. If the vehicle is equipped with ABS (antilock brake system), refer to the applicable section in this group for troubleshooting the ABS system.

Before attempting to isolate the causes of an air brake system problem, do the following.

1. Check the operation of the air compressor. Refer to the engine manufacturer's service manual. Check the pressure levels of the air reservoirs. Refer to the pretrip inspection and daily maintenance chapter in the vehicle operator's manual.
2. Be sure that all relay valves are operating. Refer to the brake section in the chassis maintenance manual.
3. Check the operation of the brake chambers as instructed in the brake section in the chassis maintenance manual.
4. Examine all tubing for kinks, dents, and other damage. Replace damaged tubing.
5. Examine all hoses for cracks, drying out, overheating, and other damage. Replace damaged hoses.
6. Examine all air line fittings. Tighten loose connections; replace fittings that are damaged. For instructions, refer elsewhere in this group.
7. Examine leaking pipe connections for cracks or thread damage; replace as needed. If there is no damage, retighten the fitting. For instructions, refer elsewhere in this group.

Safety Precautions

WARNING: Follow the manufacturer's procedures while working on any air device. Some parts are subject to mechanical (spring) or pneumatic propulsion and may cause personal injury or property damage when released. Failure to take all necessary precautions during servicing of the air brake system can result in personal injury or property damage.

Compression and storage of air in the air brake system is comparable to the energy in a coiled spring: when released, it may present a hazard. Because of this, certain precautions are required.

1. Chock the tires. This will prevent accidental rolling of the vehicle when air is released from the brake system.
2. Don't disconnect pressurized hoses because they will whip as air escapes from the line. Drain the air system before disconnecting the air hoses.
3. When draining the air system, do not look into the air jets or direct them toward another person: dirt particles or sludge may be carried in the air stream.
4. As air pressure is drained and the parking/ emergency brakes apply, keep your hands away from the brake chamber push rods and parking brake chambers, which will activate automatically with the loss of pressure.

Troubleshooting

Troubleshooting Tables

Problem—Vehicle Does not Slow Down Quickly Enough When Brakes Are Applied

Problem—Vehicle Does not Slow Down Quickly Enough When Brakes Are Applied	
Possible Cause	**Remedy**
The vehicle is overloaded.	Stay within the recommended maximum load limits.
Low air pressure in the brake system, about 60 psi (413 kPa) or lower.	The drain cock on the air reservoir was left open; close the drain cock.
	Check the compressor output pressure; correct as necessary.
	Check the setting of the air governor with an accurate test gauge. If the setting is incorrect replace the governor.
The application air lines are leaking excessively.	Check the application air line, brake valve, and the service and parking brake chambers for air leaks. Repair or replace the damaged components.
Brake valve delivery pressure is below normal.	Replace the brake valve as necessary.
Worn or glazed brake linings	Install new brake linings on the brake shoes on both sides of the axle.
Brakes need adjustment or lubrication.	Adjust and lubricate the brakes.
Automatic slack adjusters are not working.	Lubricate the automatic slack adjusters and check for binding, damaged, or inoperative slack adjuster parts. Replace damaged or inoperative parts, or eliminate the cause of the binding.
The brake cam has flipped over.	Replace the linings and the cam on both ends of the axle.
One or more of the brake drums is broken or cracked.	Replace faulty brake drums.
Wrong size brake linings were installed.	Replace the brake linings with the recommended size.
Wrong size brake chambers were fitted.	Replace the brake chambers with the recommended size. Be sure the brake chambers on each end of the axles are the same size.
A camshaft bracket or chamber mounting bracket is bent or broken.	Replace the camshaft bracket or chamber mounting bracket.
The brake chamber mounting stud nuts or brake chamber mounting bracket is loose.	Tighten the brake chamber to its mounting bracket, or the mounting bracket to the foundation brake housing.
There is a ruptured diaphragm in the service brake chamber.	Replace the diaphragm.

Problem—Service Brakes Release Too Slowly

Problem—Service Brakes Release Too Slowly	
Possible Cause	**Remedy**
The brake shoe anchor pins are frozen.	Inspect the anchor pins. If damaged, replace them; if not damaged, lubricate them.
Brake system components need lubrication.	Lubricate brake system components as necessary.
The brake foot valve is not returning to the fully released position.	Check for obstructions which might prevent the brake foot valve from returning to the fully released position. Remove any obstructions.
The exhaust port of the brake foot valve or quick-release valve is plugged.	Clear the exhaust port of obstruction.

Troubleshooting

Problem—Service Brakes Release Too Slowly	
Possible Cause	**Remedy**
The brake foot valve or quick-release valve is not working.	Replace valves as necessary.
The camshaft and bushings are binding.	Clean and lubricate the camshaft bushings.
The brake shoe return spring is weak or broken.	Replace if necessary.

Problem—Service Brakes Do Not Apply or Apply Too Slowly

Problem—Service Brakes Do Not Apply or Apply Too Slowly	
Possible Cause	**Remedy**
Foundation brake assembly needs lubrication.	Lubricate the foundation brake assembly components.
There is insufficient air pressure in the brake system.	Check all parts of the air pressure system for leaks or faulty components.
The brake foot valve or relay valve is not working.	Repair or replace the brake foot valve or relay valve.
The camshaft bushings are binding.	Clean and lubricate the camshaft bushings.

Problem—Service Brakes and Park Brakes Apply When the Park Brake Release Knob is Pushed

Problem—Service Brakes and Park Brakes Apply When the Park Brake Release Knob is Pushed	
Possible Cause	**Remedy**
The air delivery lines to the brake chamber are reversed.	Connect the brake chamber air lines properly.

Problem—Service Brakes Do Not Release

Problem—Service Brakes Do Not Release	
Possible Cause	**Remedy**
The brake shoes are incorrectly adjusted.	Adjust the brakes. Also, make sure the slack adjuster is operating correctly. If not, overhaul or replace the slack adjuster.
The brake foot valve may not be in the fully released position.	Check for obstructions which might prevent the brake foot valve from returning to the fully released position. Remove any obstructions.
The brake foot valve is not working.	Replace the brake foot valve.
There is restriction in the tubing, hose, or exhaust port of the brake foot valve or quick-release valve.	Check for bends or obstructions on the exhaust side of the service brakes. Remove any obstructions. Plumb the air lines so that bends are minimized.
A broken power spring may be blocking the parking brake piston movement.	Replace the parking brake chamber.

Troubleshooting

Problem—Service Brakes Grab or Pull

Problem—Service Brakes Grab or Pull	
Possible Cause	**Remedy**
Adjustment of the brakes on one axle is uneven.	Adjust the brakes.
Brake system components need lubrication.	Lubricate brake system components as necessary.
The brake mechanism is binding.	Lubricate the brake mechanism and make sure all parts are aligned with each other and are securely fastened.
The clevis pin or camshaft is binding at one or more wheels.	Clean and lubricate the clevis pin and camshaft bushings. Replace if necessary.
A brake spider is loose.	Tighten the mounting bolts or replace the brake spider.
A slack adjuster is damaged.	Replace the damaged slack adjuster.
The air chamber push rods or slack adjusters are a different length.	Replace the components with the correct size and material.
The brake foot valve is not working.	Replace the brake foot valve.
There is a flat or dent on the S-head camshaft or on the cam roller(s).	Replace damaged components.
Grease has saturated the brake linings or the linings are glazed.	Install a matched set of linings on both sets of brake shoes on that axle. Clean, turn, or replace both brake drums.
The brake linings are loose or broken.	Install a matched set of linings on both sets of brake shoes on that axle.
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new, matched set of brake linings.
A brake shoe is distorted or broken.	Replace the brake shoe. Install a new, matched set of linings on both sets of brake shoes on that axle.
The hub pilot pads are damaged, allowing the brake drum to be installed out-of-round.	Replace the wheel hub.
A brake drum is out-of-round to unacceptable limits.	Turn both the brake drums on that axle. If the maximum allowable diameter of either drum has been exceeded, replace that drum. For instructions on turning drums, refer to the brake manufacturer's service manual.
One or more brake drums is scored or broken.	Replace both of the drums on that axle.

Problem—Uneven Service Brakes

Problem—Uneven Service Brakes	
Possible Cause	**Remedy**
The wrong brake linings were installed, or the linings were not replaced in pairs.	Replace the brake linings with the recommended size. Install new linings on both sets of axle brake shoes.
Grease has saturated the brake linings or the linings are glazed.	Install a new, matched set of brake linings. Clean, turn, or replace both brake drums on that axle.
The brake drum is out-of-round to unacceptable limits.	Turn or replace both the brake drums on that axle.
A service brake chamber diaphragm is leaking.	Tighten the clamp ring. If leak persists, replace the service brake diaphragm.

Troubleshooting

Problem—Uneven Service Brakes	
Possible Cause	**Remedy**
The wheel bearings are out of adjustment.	Adjust the wheel bearings, or replace them if damaged. For instructions, see **Group 33** or **Group 35**.
A brake spider is damaged.	Replace the brake spider.
The brake shoes are bent or stretched.	Replace the axle brake shoes on each wheel.
Grease, oil, or dirt is on the linings.	Replace the linings on each set of axle brake shoes. Clean the brake drums.

Problem—Dragging Service Brake

Problem—Dragging Service Brake	
Possible Cause	**Remedy**
The service brake return spring is broken.	Replace the service brake return spring.
The service-application air is not exhausting, or not exhausting fast enough, due to blockage in the quick-release valve or the foot valve.	Test the air system valves for leakage and operation.
Binding is occurring in the camshaft linkage.	Lubricate the camshaft linkage. Replace bent or broken parts.

Problem—Park Brake Does Not Hold (park brake applied)

Problem—Park Brake Does Not Hold (park brake applied)	
Possible Cause	**Remedy**
The brakes are improperly adjusted.	Adjust the brakes.
A power spring is broken.	Replace the parking/emergency brake chamber.
A power spring in a parking brake is manually caged.	Release the power spring by screwing in the release bolt.

Problem—Dragging Brakes Due to Parking Brake Mechanism

Problem—Dragging Brakes Due to Parking Brake Mechanism	
Possible Cause	**Remedy**
The system air pressure is insufficient to fully release the parking brake.	Be sure that all air lines are clear. Check that the air governor cutout settings meet recommended specifications.
A parking brake diaphragm is ruptured or a piston seal is ineffective.	Replace the diaphragm or parking brake piston seal.

Problem—Air Pressure Will Not Rise to Normal

Problem—Air Pressure Will Not Rise to Normal	
Possible Cause	**Remedy**
The air pressure gauge(s) on the dash is (are) registering inaccurately.	Check the dash gauge(s) with an accurate test gauge. Replace the dash gauge(s) as needed.
There is excessive leakage.	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.

Troubleshooting

Problem—Air Pressure Will Not Rise to Normal	
Possible Cause	**Remedy**
The compressor is not working (can be excessive leakage from the compressor).	Replace the compressor.
The air reservoir drain cock has been left open.	Close the drain cock.
The air governor cutout setting is incorrect.	Check the setting with an accurate test gauge. If incorrect, replace the governor.
There is inadequate clearance at the compressor unloading valve.	Repair or adjust the compressor at the unloading valve.
Carbon is building up in the compressor cylinder head or discharge line.	Remove the carbon or replace the compressor as necessary.
The compressor driveshaft coupling is broken	Replace the coupling.

Problem—Air Pressure Rises Above Normal

Problem—Air Pressure Rises Above Normal	
Possible Cause	**Remedy**
The air reservoir pressure dash gauge is inaccurate.	Check the dash gauge with an accurate test gauge. Replace the dash gauge as needed.
The compressor air governor is out of adjustment.	Check the setting with an accurate test gauge. If incorrect, replace the governor.
The air governor is not operating.	Replace the air governor.
There is too much clearance at the air compressor unloading valve.	Repair or adjust the compressor at the unloading valve.
The air compressor unloading valve cavities or the unloading valve passage is blocked with carbon.	

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Released

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Released	
Possible Cause	**Remedy**
The brake foot valve is leaking.	Replace the brake foot valve.
The air compressor discharge valve is leaking.	Repair or replace the discharge valve. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory-rebuilt or a new unit.
The air governor is leaking.	Replace the air governor.

Troubleshooting

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Fully Applied

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Fully Applied	
Possible Cause	**Remedy**
A service or parking brake chamber is leaking.	Tighten the clamp ring. If leaks persist, replace the diaphragm or assembly.
The brake foot valve or relay valve is leaking.	Repair or replace faulty components or assembly.
Service brake airline leaks.	Replace as necessary.

Problem—Compressor Knocks (continuously or intermittently)

Problem—Compressor Knocks (continuously or intermittently)	
Possible Cause	**Remedy**
There is a damaged or broken coupling or gear.	Replace components as necessary.
Backlash is in the compressor drive gears on the drive coupling.	Repair or replace the compressor drive gears or drive coupling.
The air compressor bearings are damaged or worn.	Replace the compressor.
There are carbon deposits in the compressor cylinder head.	Remove the carbon deposits or replace the compressor.

Problem—Pressure Relief Valve Activates

Problem—Pressure Relief Valve Activates	
Possible Cause	**Remedy**
The pressure relief valve is out of adjustment.	Adjust the pressure relief valve or install a new one.
There is excessive air pressure in the brake system.	Refer to the problem "Air Pressure Rises Above Normal."

Problem—Oil or Water in the Brake System

Problem—Oil or Water in the Brake System	
Possible Cause	**Remedy**
Excessive oil is passing through the air compressor.	Replace the compressor.
Draining of the air reservoirs needs to be performed more often.	Drain the air reservoirs daily.
If so equipped, the air dryer desiccant cartridge is oil saturated.	Install a new desiccant cartridge.

Troubleshooting

Problem—Frequent Compressor Cycling/Air Dryer Purge (Dash pressure gauges do not drop to cut-in pressure)

Problem—Frequent Compressor Cycling/Air Dryer Purge (Dash pressure gauges do not drop to cut-in pressure)	
Possible Cause	**Remedy**
A leak in the supply system. This would be characterized by frequent compressor cycling or dryer purging with no change in primary or secondary air pressure.	Repair leaks as necessary.

Chapter Five

Wheel end Groups

Wheel End Groups

Hydraulic Brakes

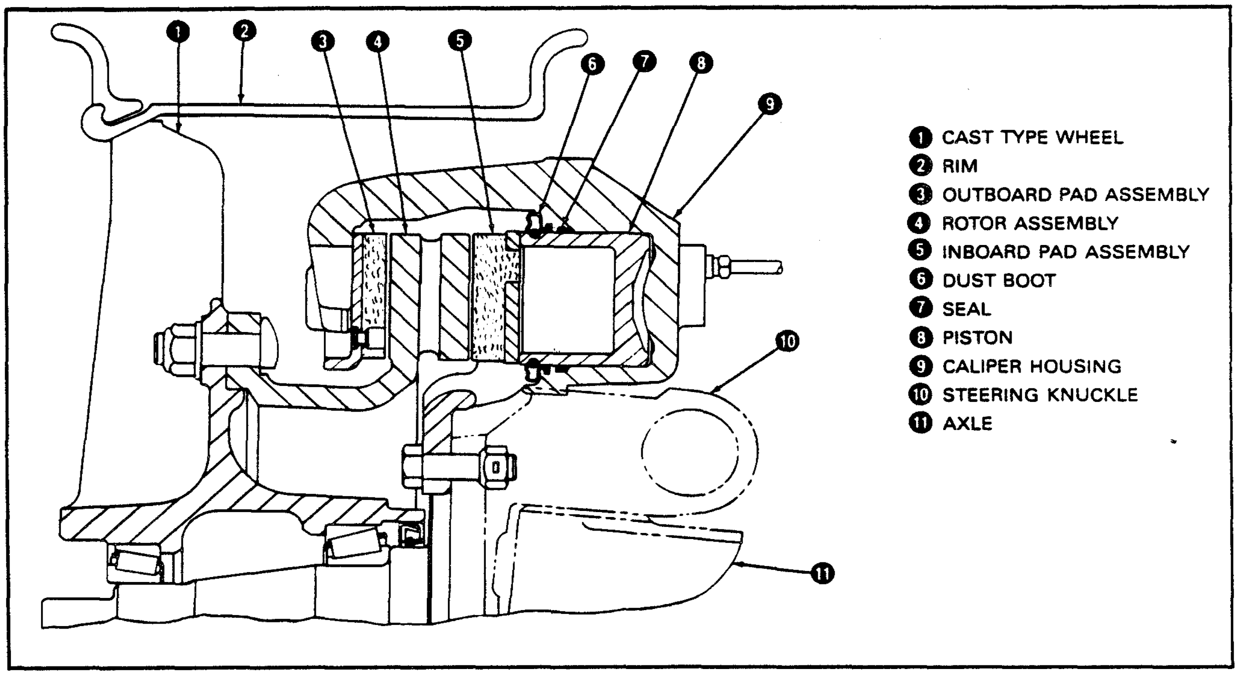


Figure 1 — Cross Section of Disc Brake Assembly at Front Axle (Code 04144)

There are two types of calipers, sliding or floating and fixed. The sliding caliper only has a piston or pistons on one side of the rotor. The caliper floats to compensate for lateral rotor run out. The fixed caliper has piston(s) on both sides of the rotor and does not move. The pistons move to compensate for lateral rotor run out. The floating caliper is by far the most common.

SLIDING (FLOATING) CALIPER DISC BRAKES

The caliper disc brake is basically made up of three major components: caliper, rotor and pads (shoes). One pad is mounted on each side of the rotor and grips the rotor when hydraulic pressure is applied by the two hydraulic pistons.

NOTE It is not uncommon for disc brakes to have a slight drag. The amount of drag will depend upon the type of brake application made before the inspection is made.

Chassis equipped with these disc brakes will have a split hydraulic brake system.

The split hydraulic system also includes a pressure differential valve and brake warning light switch assembly which senses a pressure loss in either of the hydraulic systems should a failure occur..

CALIPER AND ROTOR ASSEMBLY

The caliper is a single piece casting which is positioned on the anchor plate against machined surfaces located at the trailing ends of the anchor plate. A caliper support key is installed between the leading edge of the caliper and anchor plate, with a support spring inserted between the key and caliper. A key retaining screw keeps the support key from sliding out of the anchor plate assembly (Figure 4).

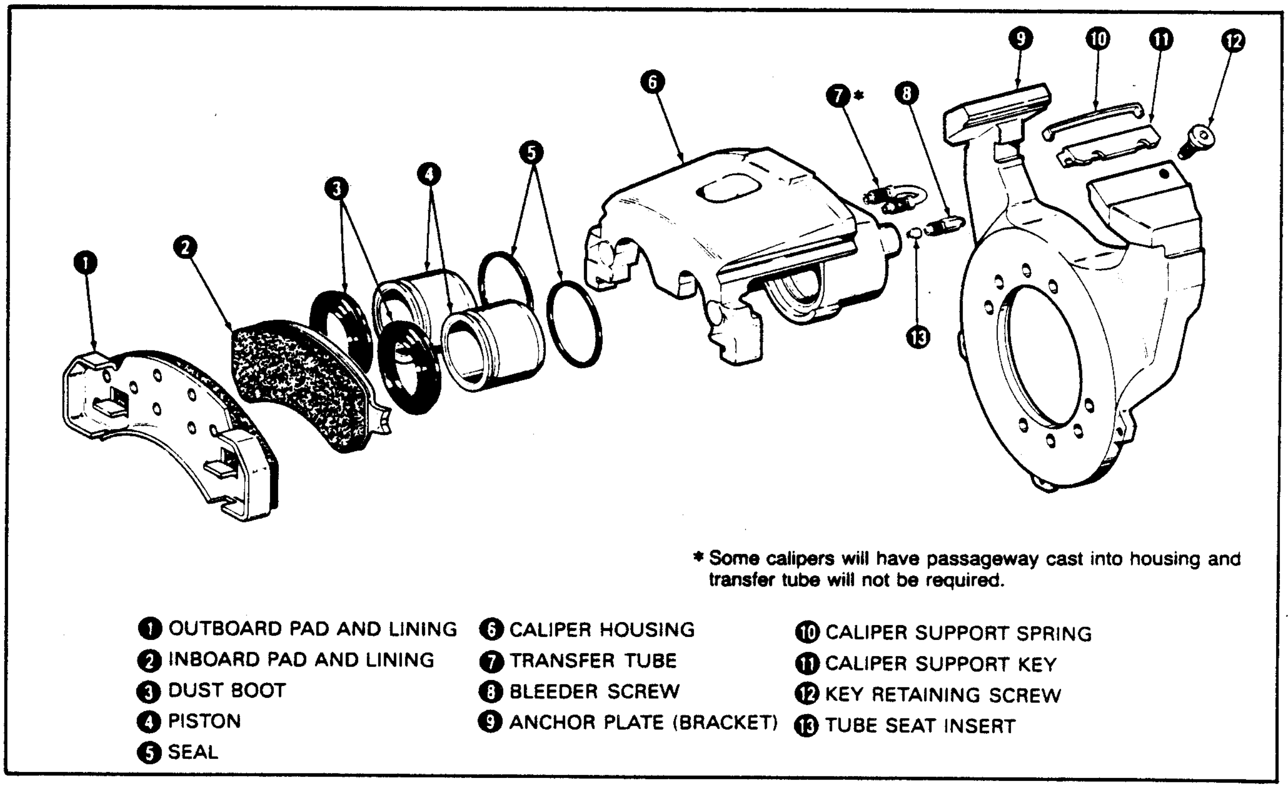


Figure 4 — Exploded View of Two Piston Caliper Assembly (Codes 04144 and 04237)

The cast rotor (disc) is bolted to the hub assembly in the same manner as brake drums. Cooling fins cast between the machined braking surfaces of the rotor allow air to flow between the rotor surfaces while the wheel turns. The rotors on both front and rear brake groups are protected on the inboard side by a splash shield bolted to the anchor plate.

The inner pad (shoe) assembly is positioned with both ends confined within the anchor plate.

The outer pad assembly is designed to locate on the formed surfaces of the caliper. Therefore, the inboard and outboard pads are not interchangeable (Figures 4 and 5).

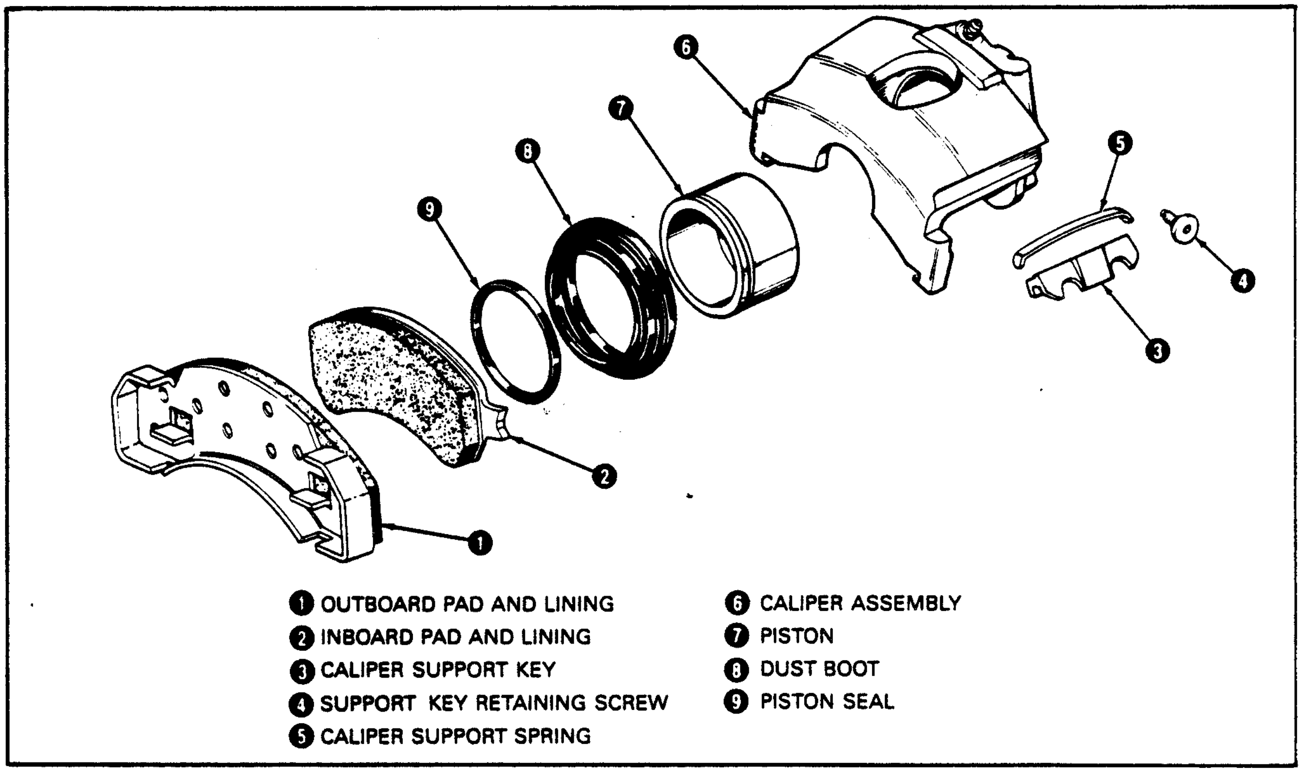


Figure 5 — Exploded View of Single Piston Caliper Assembly (Code 04145)

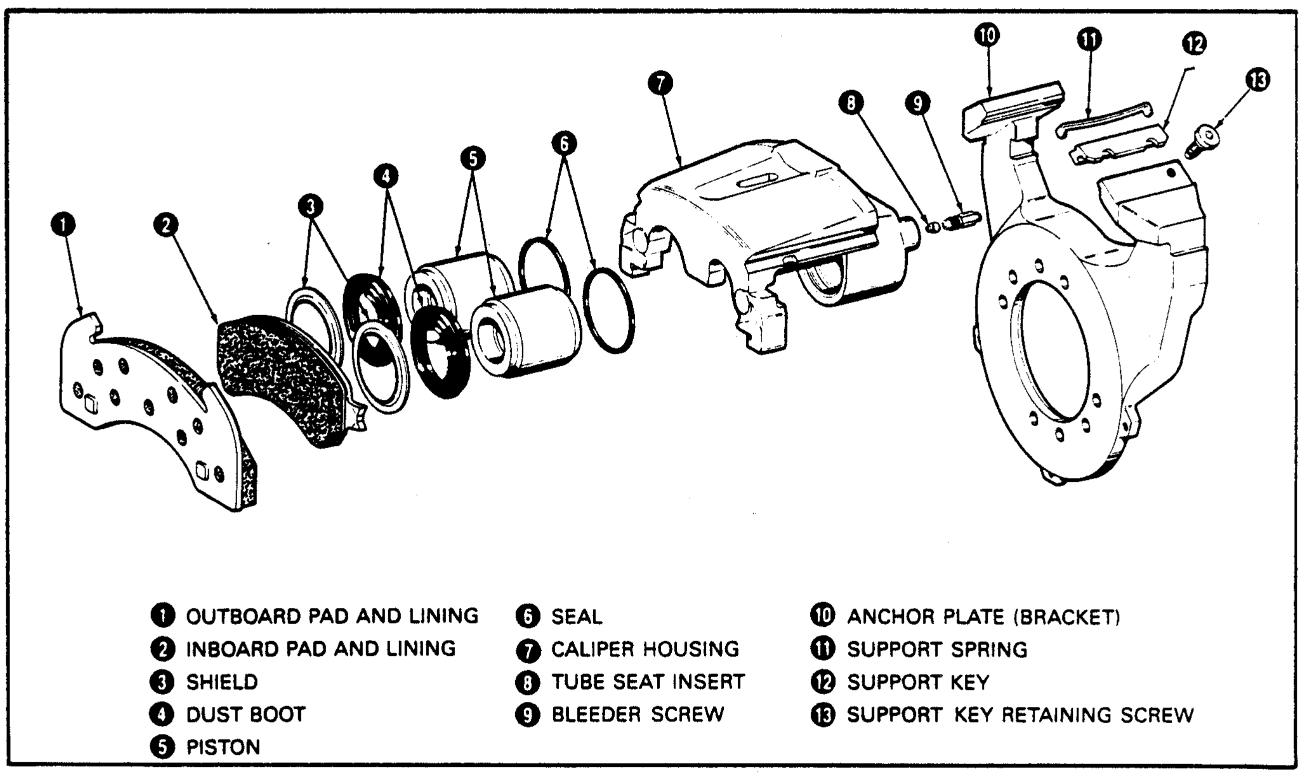


Figure 6 — Exploded View of Two Piston Caliper Assembly (Codes 04146 and 04238)

MAINTENANCE GENERAL

It is difficult to determine an exact maintenance interval (time or mileage) since vehicles will, be used in wide varieties of operational applications and conditions.
Vehicles operating under severe conditions such as frequent stop and go driving will require more service maintenance checks than a vehicle which is used over the road. Therefore, a regular schedule for periodic inspection should be established based on past experience and type of operation.
Disc brakes do not require adjustments since the clearance is maintained by the movement of the caliper piston.
Be sure to keep in mind that the Dual Power and Hy-Power booster systems consist of two completely separate hydraulic systems operating on two different incompatible fluids; power steering fluid and hydraulic brake fluid.

WHEEL BEARING ADJUSTMENT

It is important to the operation of disc brakes that the wheel bearing adjustment be maintained to limit excessive lateral run-out of the disc brake rotors.
Lateral runout or wobble in disc brakes can cause an increase in pedal travel due to piston knock back, brake pedal pulsation during brake applications and increase piston seal wear since the pad is required to follow the disc wobble. This wobbling condition causes the piston to become cocked in the piston bores, distorting the seals.
To limit lateral runout of a rotor due to loose bearings, adjust wheel bearings as instructed in Wheels, Rims and Tires section of the service manual.

BRAKE PADS

To inspect brake pads for wear, position vehicle on floor stands and remove tire and wheel (rim) assemblies.
Visually inspect the pad lining by checking each visible end and inspecting through opening of caliper assembly. If lining thickness at the thinnest point appears to be 4.76mm (3/16") or less, the pads must be replaced. Be sure that all pads on one axle (both sides) are replaced at the same time.

Brake pads should not be replaced because of moderate erosion or pitting. This is a normal characteristic of semi metallic pad lining material. Should erosion reduce the polished contact area to less than 20% of total surface area, replace pads.

CALIPERS

Visually inspect calipers for brake fluid leakage or any other defects. Rebuild or replace as necessary.

CALIPER SUPPORT HARDWARE

Visually inspect caliper support hardware for wear. If signs of wear exist refer to the service manual for repair procedures.

SERVICE PRECAUTIONS

1. When the vehicle is raised for inspection or servicing the brakes, be sure to position vehicle on floor stands.

2. As lining wears on the brake pads, brake fluid level in the reservoir will lower. Before servicing the caliper assemblies, inspect the fluid level. If the fluid level is at or near proper fluid level remove some brake fluid from the reservoir, using a siphon or syringe. When the pistons are pushed back into the caliper cylinder bores the fluid will be forced back to the reservoir and may overflow if not removed. Discard the used fluid removed from the master cylinder.

3. The caliper assembly must be removed before the hub and disc can be removed.

4. During service procedure, keep grease and other foreign material from caliper assembly, brake rotor and external surfaces of hub. Handle parts carefully to avoid damage to caliper, rotor, pads and brake lines.

5. If inspection reveals that caliper piston seals or dust boots are worn or damaged, replace them. Refer to Figures 4, 5, and 6.

6. Wheel bearing specified end play is most important. Check wheel bearing adjustment when brake service has been completed, before wheel is reinstalled. Refer to Wheels, Rims and Tires in the service manual for wheel bearing adjustment information.

7. In the event the original brake pads are to be used again, be sure to mark them in some manner so that they are reinstalled in the same location.

8. After any brake service, be sure to test brakes prior to returning vehicle to service. A firm pedal should be felt during brake application.

BRAKE DRUMS

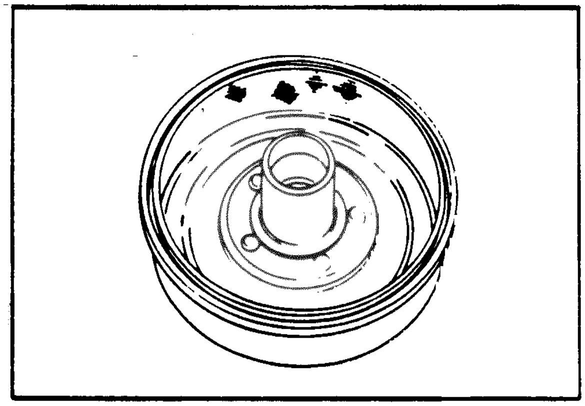


Figure 1 — Hard or Chill Spotted Drum

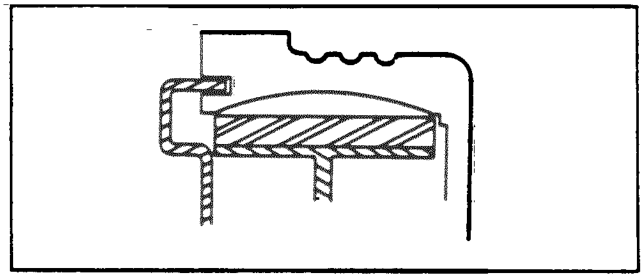


Figure 2 — Barrel Shaped Drum

INSPECTION OF DRUMS

The friction surface of brake drums must be smooth, true and concentric. Make certain with a visual check that drums are not barrel shaped, bell mouthed, scored or eccentric.

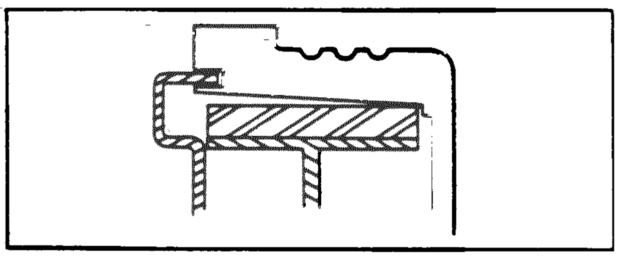


Figure 3 — Bellmouthed Drum

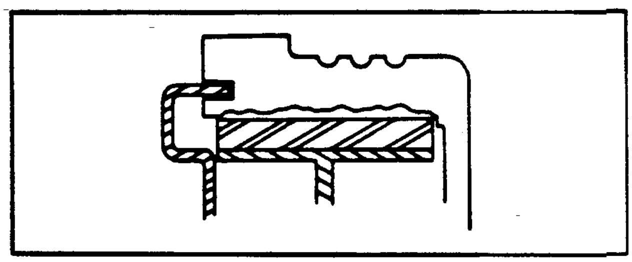


Figure 4 — Scored Drum

Hard or chill spots (Figure 1) in brake drum may produce pedal pulsation and roughness or brake surge. If these effects are present, drum should be replaced.

A barrel shaped drum (Figure 2) results from overheating. If this barrel shaped condition is not corrected, the braking surface is reduced and uneven lining wear results.

Extreme pressure which over a period of time will create a bell mouthed drum as shown in Figure 3. Brake linings on a bell mouthed brake drum will make contact only on the inner surface of the drum. In addition to cutting the braking surface to a minimum, it will also cause uneven and rapid wear.

Scored drums are the result of worn linings to the point where the drum to shoe contact is made or an accumulation of small steel particles imbed themselves in the brake lining (Figure 4). The steel particles form a tough scale which is sometimes harder than the drum. As a result, deep grooves are formed in friction surface of drum. Brake drum scoring never improves but continually gets worse until both lining and brake drum are useless. Attempting to reline brakes without turning scored brake drum surface will quickly destroy new lining and make effective braking impossible.

Brake lining in an eccentric or out of round drum cannot make full contact with the drum resulting in rapid or uneven lining wear and could even cause brakes to seize or chatter. Maximum allowable out of round or eccentricity should be .010 inch (.25 mm).

Brake drums should be checked with a drum mike for wear and out of round also. Maximum wear is 0.120”. If relining maximum wear is 0.080”.

AIR BRAKES

Brake Shoe Removal and Installation

WARNING: Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Removal

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.

2. Raise the front or rear axle, then place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

3. Remove the wheels and brake drums. For instructions, refer to the manual.

CAUTION: Before you back off automatic slack adjusters, refer to the applicable slack adjuster section in this group, or to the manufacturer's service information for instructions. Failure to do so could damage the automatic slack adjuster.

4. Back off the slack adjusters. For instructions, refer to the applicable slack adjuster section in this group for instructions on backing off the slack adjuster.

5. If equipped with 15-inch "Q" Plus Series brakes, go to the next step. If equipped with "Q" Plus Series brakes, or 16-1/ 2 inch "Q" Plus Series brakes, remove the brake shoes.

   5.1 Push down on the bottom brake shoe, and pull on the roller retaining clip to remove the bottom cam roller. See Fig. 1.

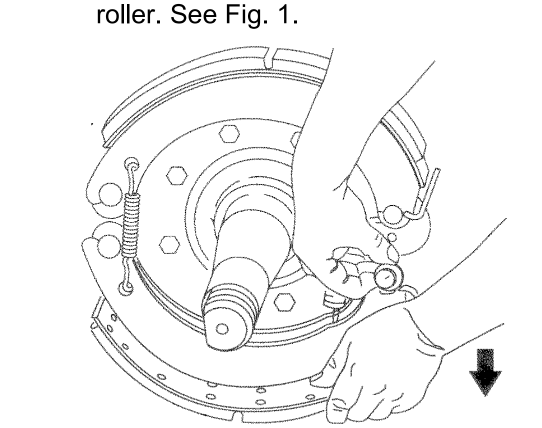


Fig. 1, Remove the Bottom Cam Roller

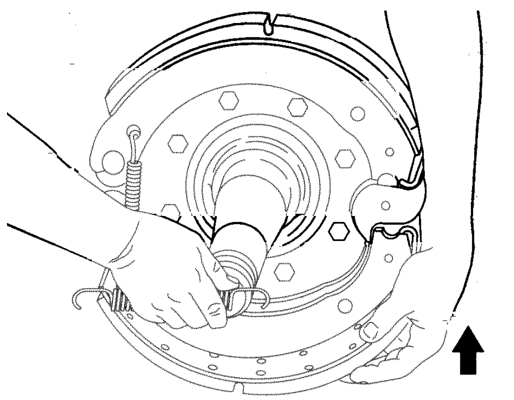


Fig. 2, Remove the Spring

   5.2 Lift the top brake shoe and pull on the roller retaining clip to remove the top cam roller.

   5.3 Lift the bottom shoe to release tension on the brake return spring. Remove the spring. See Fig. 2.

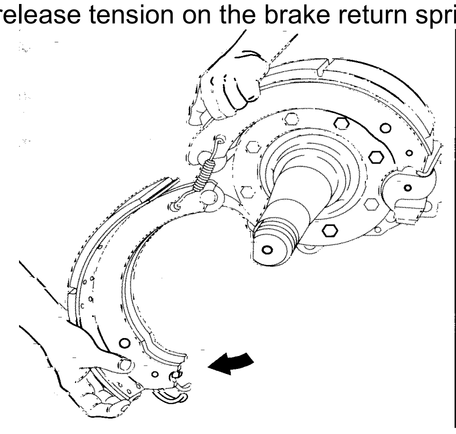


Fig. 3, Remove the Springs and Brake Shoes

5.4 Rotate the bottom shoe to release tension on the two retaining springs. Remove the springs and brake shoes. See Fig. 3.

6. If equipped with 15-inch brakes, remove the brake shoes.

6.1 Push down on the bottom brake shoe, and remove the bottom cam roller.

6.2 Lift the top brake shoe and remove the top cam roller.

6.3 Remove the brake shoe return spring.

6.4 Rotate the bottom shoe to release tension on the retaining spring. Remove the spring and the brake shoes.

7. Inspect the brake shoes and linings for wear or damage. For instructions, refer to Manual.

Installation

1. Apply a thin film of temperature resistant grease (Rockwell 0-616, or an equivalent) on the anchor pins where they touch the brakes shoes. Also, apply a multi-purpose chassis grease (Rockwell 0-617-A or 09-617-B, or an equivalent) on the retainer clips spider, and shoe rollers where they touch the brake shoes.

IMPORTANT: Don't apply any grease on the outer diameter of the roller that touches the cam head.

2. If equipped with 16-1/2 inch brakes, install the brakes shoes. If equipped with 15-inch brakes, go to the next step.

2.1 Place the upper brake shoe in position on the top anchor pin. Hold the lower brake shoe on the bottom anchor pin and attach two new brake shoe retaining springs. See Fig. 4.

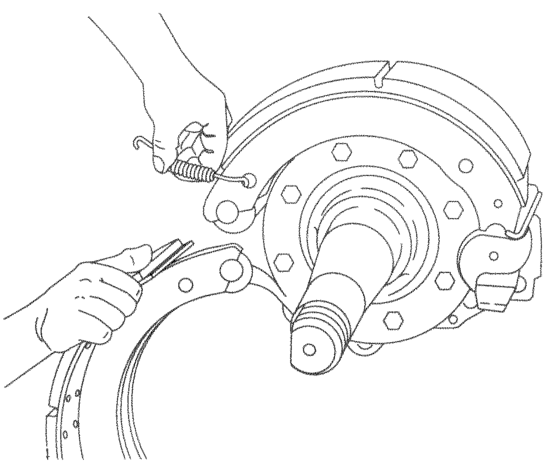


Fig. 4, Attach the Brake Shoe Retaining Springs

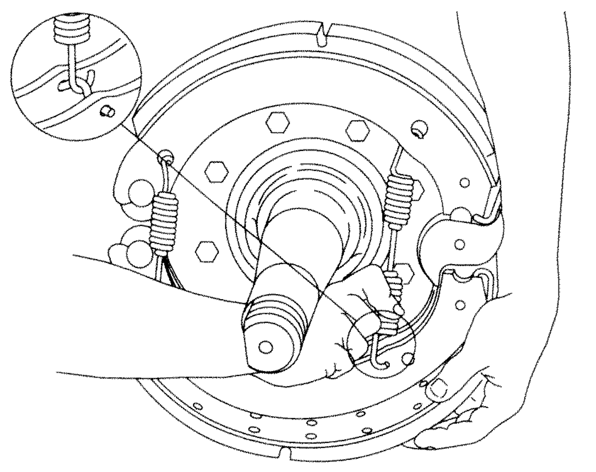
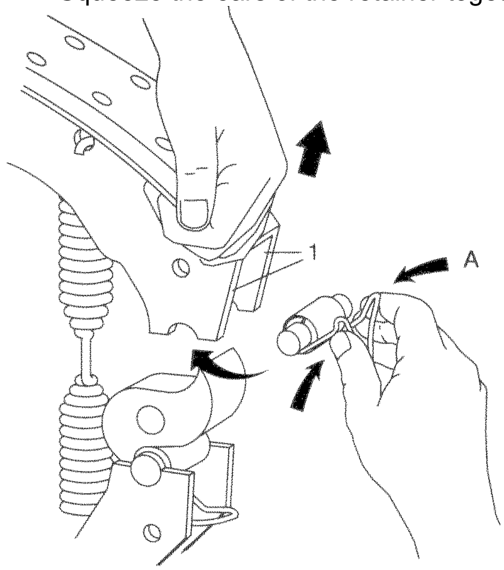


Fig. 5, Attach a New Brake Shoe Return Spring

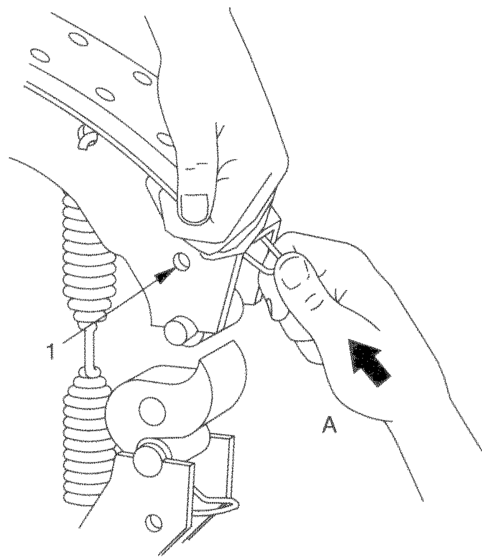
2.2 Turn the lower brake shoe forward and attach a new brake shoe return spring. See Fig. 5.

2.3 Pull each brake shoe away from the cam to allow enough space to install the cam rollers and retainers. Squeeze the ears of the retainer together to permit the retainer to fit between the brake shoe webs. See Fig. 6.



A. Squeeze
1. Web

Fig. 6, Squeeze the Ears of the Retainer



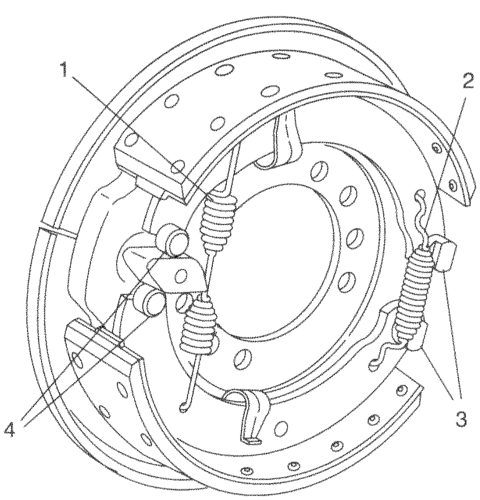
A. Push
1. Web Hole

Fig. 7, Push the Retainer into the Brake Shoe

2.4 Push the retainer into the brake shoe until the ears lock in the holes in the shoe webs. See Fig. 7.

3. If equipped with 15-inch brakes, install the brake shoes.

3.1 Install the retainer spring on the shoes and install the shoes on the anchor pins. See Fig. 8. Hold the bottom shoe in position and install the return spring.



1. Return Spring
2. Retainer Spring
3. Anchor Pins
4. Cam Rollers

Fig. 8, Install the Retainer Spring and the Brake Shoes

3.2 Pull each shoe away from the cam to allow enough space, then install the cam rollers.

4. Install the wheels and brake drums. For instructions, refer to the manual.

5. Adjust the brakes at the slack adjusters. For instructions, refer to manual.

6. Remove the safety stands, lower the vehicle, and remove the chocks from the tir

DANGER: Don't operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

7. In a safe area, check for proper brake operation.

   7.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

   7.2 Do several low speed stops to ensure proper parts replacement and full vehicle control.

   7.3 Make ten 40 to 20 mph (60 to 30 km/h) snubs to seat the linings.

   7.4 Make ten stops from 20 mph (30 km/h) at 50 percent air pressure.

   7.5 Make a full-pressure stop from 20 mph (30 km/h).

   7.6 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others shows a lack of braking effort on those wheels.

Inspection

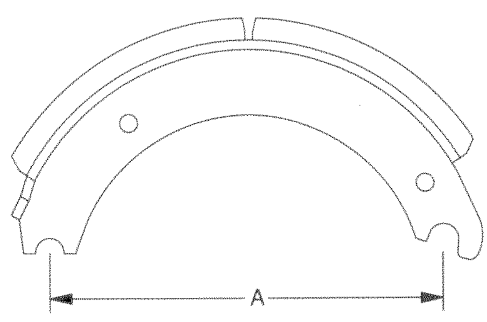
1. Remove the brake shoes.

2. Check the linings. If the linings are grease-or oil-soaked, cracked, or worn to less than 1/4-inch (6.4-mm) thickness at any point, replace them.

3. Check the shoes for bent or cracked webs or tables, broken welds, loose or out-of-round rivet or bolt holes. Replace the shoes if any of these conditions exist.

4. Check the anchor pin for looseness and the camshaft roller recesses in the shoe webs for visible wear. Replace the shoe if needed.

5. Check the shoe span. Measure the distances between the centerlines of the anchor pin and the camshaft roller pin recesses in the shoe web. If the measurement is more than 12-7/8 inches (327 mm), replace the shoe. See Fig. 1. (This may vary from One manufacturer to another, check service Manual)



A. 12-7/8" (327 mm)

Fig. 1, Measuring the Shoe Span

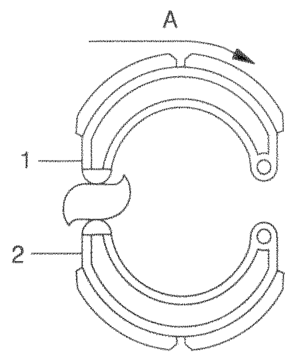
Brake Shoe Lining Replacement

Replacement

IMPORTANT: For the best brake performance, don't mix brake linings between axles. When relining brake shoes, both wheel ends of each axle must have the same linings. However, it is not necessary for the steering axle brakes to have the same linings as the rear drive axle brakes. Also, when the minimum thickness is reached for any of the brake linings on an axle, reline both brakes on that axle at the same time.

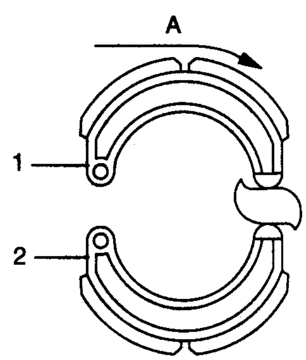
Combination linings with different friction ratings for the primary and secondary shoes are often used. When combination linings are used, install the forward blocks on the primary shoe (following the rotation of the drum, the first shoe after passing the cam or wheel cylinder is the primary shoe).

If the cam is behind the axle, the top shoe is the primary and the lower shoe is the secondary shoe. See Fig. 1. If the cam is in front of the axle, the lower shoe is the primary shoe. See Fig. 2.



A. Right wheel rotation
1. Primary Shoe 2. Secondary Shoe

Fig. 1, Camshaft Behind Axle



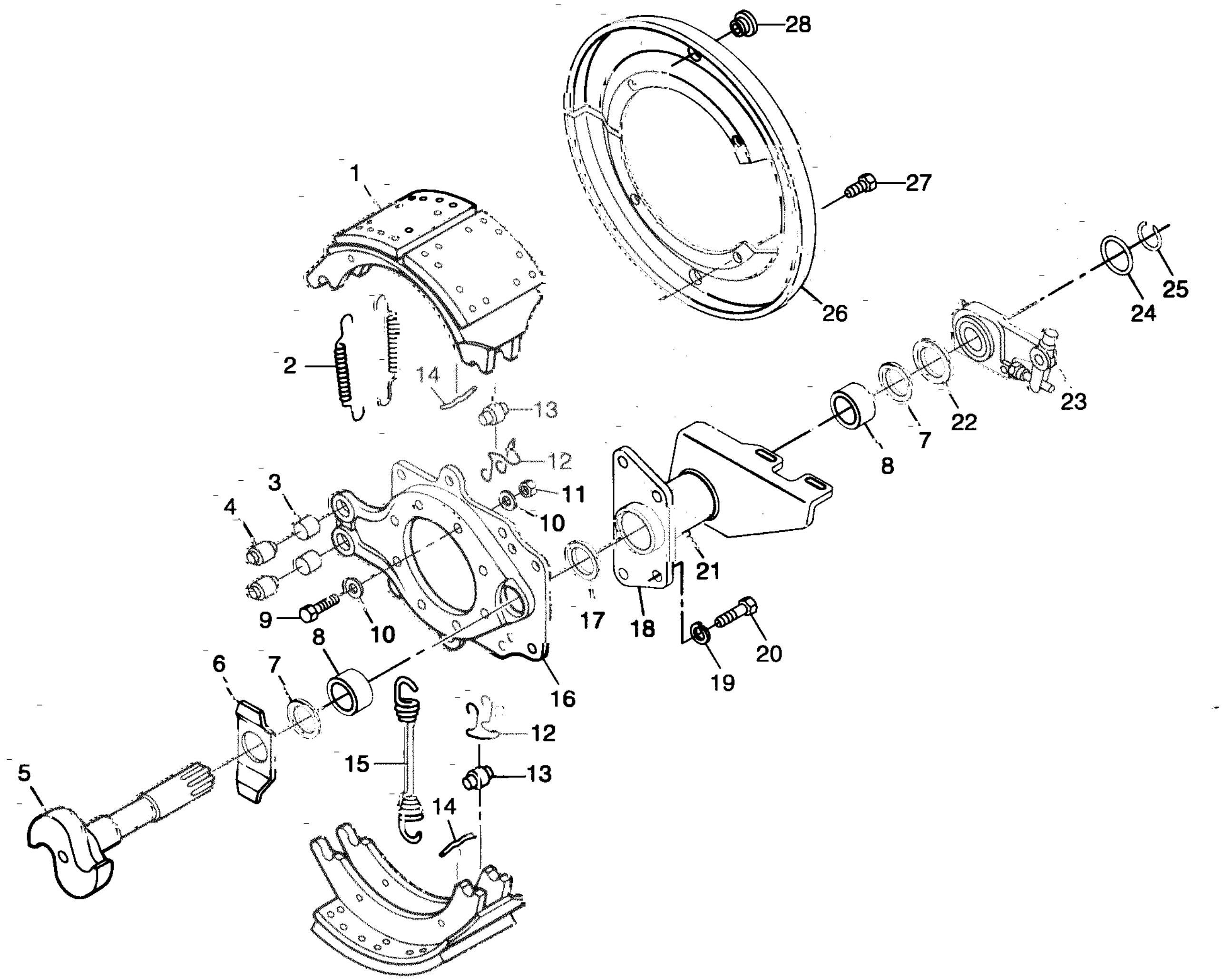
A. Right wheel rotation
1. Secondary Shoe 2. Primary Shoe

Fig. 2, Camshaft Ahead of Axle

IMPORTANT: When replacing the linings, check the camshaft end play. Using a dial indicator, measure the up-and-down and side-to-side end play of the camshaft. Replace the bushings if there is more than 0.030 inch (0.8 mm) of movement.

Brake Components Disassembly and Inspection,Cleaning, and Assembly

Disassembly and Inspection (See Fig. 1)

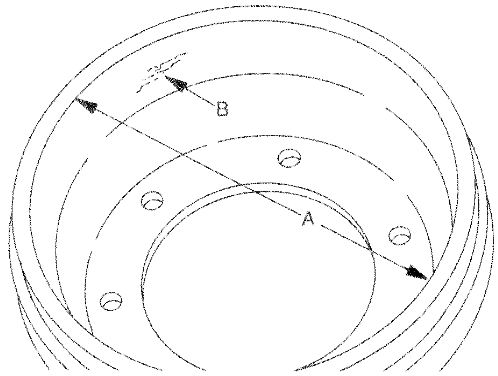


NOTE: 16–1/2 inch "Q" Plus Series shown.

1. Brake Shoe and Lining Assembly
2. Brake Shoe Retaining Spring
3. Anchor Pin Bushing
4. Brake Shoe Anchor Pin
5. S-Head Camshaft
6. Camhead Washer
7. Camshaft Grease Seal
8. Camshaft, Spider, and Bracket Bushing
9. Spider Mounting Bolt
10. Hardened Washer
11. Nut
12. Brake Shoe Roller Retainer
13. Brake Shoe Roller
14. Brake Shoe Return Spring Pin
15. Brake Shoe Return Spring
16. Brake Spider
17. Camshaft Support Bracket Gasket
18. Camshaft Support Bracket
19. Bracket Capscrew Washer
20. Camshaft Support Bracket Capscrew
21. Grease Fitting
22. Camshaft Washer
23. Automatic Slack Adjuster Assembly
24. Spacing Washer
25. Camshaft Lockring
26. Dust Shield
27. Dust Shield Capscrew
28. Plug

Fig. 1, Cam-Master Q Plus Series Brakes, Exploded View

1. Check the drum for cracks, heat-checks, glazing, grooving, and run-out. See Fig. 2. Measure the drum diameter. Replace the drum if it exceeds the maximum diameter stamped on it. Replace cracked drums.
2. Disconnect the slack adjuster from the push rod clevis. For instructions, refer elsewhere in this group, or to the slack adjuster manufacturer's service information for instructions.



A. Check for diameter and for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 2, Check the Drum

3. With the brake shoes removed, use a dial indicator to measure the up-and-down and side-to-side end play of the camshaft. Replace the bushings if there is more than 0.030 inch (0.8 mm) of movement.

4. Remove the slack adjuster. For instructions, refer elsewhere in this group, or to the manufacturer's service information for instructions.

5. Check the slack adjuster for damage and for binding.

   5.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines form chipped teeth and deformation. Replace as needed.

   5.2 Depress the locking sleeve, and turn the adjuster nut with a wrench at least one turn in each direction. If there is binding, or if excessive force is needed to turn the slack adjuster, replace it. For instructions, refer elsewhere in this group

IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.

6. Remove the camshaft by grasping its head and pulling the camshaft outboard.

7. Check the camshaft spline end for cracks, or worn or deformed splines. Replace the camshaft if damaged.

8. Check the camshaft bushing journals for wear or corrosion. Replace the camshaft if it is worn or if roughness is felt in the journal area.

9. Inspect the camshaft head for brinelling, cracking, or flat spots. Replace the camshaft if a ridge can be felt between the worn area and the cam head surface.

10. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the camshaft support bracket. Check the chamber for a cracked housing, bent push rod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace brake chamber parts as needed.

11. Remove and inspect the camshaft support bracket. Remove and discard its gasket. Check the bracket for a bent, broken or cracked arm, and cracked welds. Replace the bracket if any of these conditions exist.

12. Remove and inspect the old bushing and the grease seal.

    12.1 Check the camshaft bushing for wear. The inner surface must be smooth; if rough or abrasive, replace the bushing.

    12.2 Inspect the seal. Replace it if the lip is nicked, cut, or distorted.

13. Install the new bushing or seal with a suitable piloted driver.

14. Remove the spider-to-axle attaching nuts, hardened washers, and bolts. Remove the spider from the axle flange.

15. If equipped, remove the four capscrews that attach the dust shield to the spider; remove the dust shield.

16. Inspect the spider and parts for damage; replace as needed.

    16.1 Check for cracks at the bolt holes, cam area, and around the anchor pin. Replace if damaged.

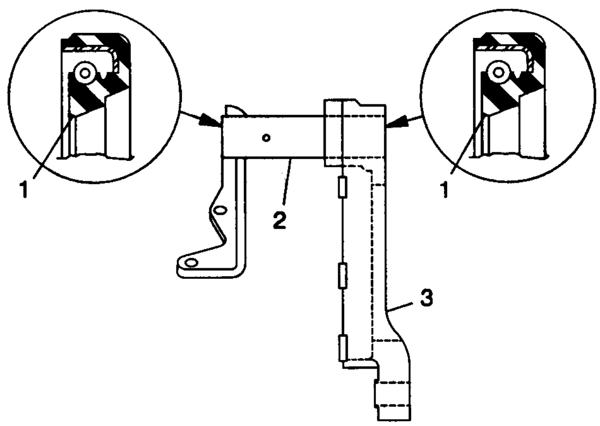
    16.2 Check the anchor pin. If worn or loose, replace it.

    16.3 Check the anchor pin and brake spider bushings for wear. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.

    16.4 Inspect the seal. Replace it if its lip is nicked, cut, or distorted.

17. Using a suitable piloted driver, install the new bushings and seal.

IMPORTANT: Grease seals are installed in both the bracket and the brake spider so that the seal lip is toward the slack adjuster end of the bracket tube. See Fig. 3.



NOTE: The seal lip is facing toward the slack adjuster.

1. Seal Lip
2. Camshaft Support Bracket
3. Brake Spider

Fig. 3, Positioning of Seals on the Camshaft

Cleaning

After removing the brake parts being serviced, do the following:

1. Wire brush all parts exposed to mud, road dirt, and salt, including the exterior of the drum, spider, brake chamber bracket, and dust shields (if equipped). If relining the shoes, thoroughly wirebrush the shoe tables, and paint them with a rust inhibitive coating.

CAUTION: A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire brushing, or damage to brake components could occur.

2. Using an industrial vacuum cleaner with a HEPA filter system, pick up excessive dust accumulation. Wipe the interior of the drums with a damp rag to remove lining dust.

3. Thoroughly clean all remaining brake parts with a damp rag. Wipe dry with a clean, lint-free cloth.

Assembly (See Fig. 1)

1. Install the dust shield, if equipped.
   Position the dust shield against the spider, and install the capscrews. Tighten the capscrews:

   - 3/8-16 Grade 5-25 to 35 Ibf-ft (34 to 47N-m)
   - 3/8-16 Grade 8-35 to 50 Ibf-ft (47 to 68N-m)

2. Install the spider.
   Place the spider on the axle flange. Using a hardened washer under the bolt head and the nut, install the mounting fasteners. Tighten the bolts in a cross pattern:

   - 1/2-13; 60 to 80 Ibf-ft (81 to 108 N-m)
   - 5/8-11 (flanged hexhead capscrew); 160 to 200 Ibf-ft (217 to 271 N-m)
   - 5/8-11 (hexhead capscrew); 130 to 160 Ibf-ft (176 to 217 N-m)

3. Install the brake chamber and bracket.

   3.1 Place the brake chamber on the mounting bracket with the chamber mounting studs through the bracket holes. Install the hardened flatwashers, lockwashers, and stud nuts. Tighten the nuts:

   - 3/8-1 Ei-37 to 50 ft-lbs. (47 to 68 N-m)
   - 1/2-13-70 to 100 ft-lbs. (95 to 136 N-m)

NOTE: If replacing a brake chamber, make sure that the new chamber is the same size and make as the brake chamber on the other side of the axle.

   3.2 Place the bracket against the spider, and install the lockwashers and capscrews. Tighten the capscrews:

   - 1/2-13-60 to 80 ft-lbs. (81 to 108 N-m)
   - 5/8-11-105 to 145 ft-lbs. (142 to 196 N-m)

4. Install the camshaft and parts in the spider; install the slack adjuster.

   4.1 Apply a thin film of chassis grease on the inside of the camshaft bushings and journals. Don't grease the camshaft head area.

   4.2 Apply a thin film of rust preventive grease (Rockwell 0-637, or an equivalent) on the camshaft splines.

   4.3 Carefully slip the camshaft into the spider and the mounting bracket tube.

   4.4 Install the thick camshaft washer on the camshaft.

   4.5 Install the slack adjuster on the camshaft with the adjuster nut on the side opposite of the brake chamber.

   4.6 Install the outer washers and snap ring.

5. Use a dial indicator to measure the end-play of the camshaft. There should be no more than 0.06(inch (1.5 mm) movement.

6. Pressure lube the camshaft bracket bushings. Pump multipurpose chassis grease (NLGI grade 1 or 2) into the chamber bracket until it appears a the slack adjuster end of the bracket. Use care tha no grease enters the drum cavity. If grease leak: out under the camhead, the camshaft grease sea is worn or damaged, or is installed backwards.

NOTE: The use of meter-type fittings, having a maximum 40 psi (276 kPa) pressure relief at shutoff, is recommended.

7. Align the appropriate hole in the slack adjuster with the hole in the brake chamber push-rod clevis.
   For instructions, refer elsewhere in this group or to the manufacturer's service information.

8. Install the brake shoes.

Specifications				
Description	Grade	Size	Torque lbf.in (N.cm)	lbf.ft (N-m)
Brake Shoe Lining Nuts		3/8"		18-23 (2431)
		1/4"	80-100 (900-1120)	
Dust Shield Capscrews	5	3/8-16		25-35 (34-47)
	8	3/8-16		35-50 (47-68)
Spider Mounting Bolts Hexhead Capscrew Flanged Hexhead Capscrew	8 8 8	1/2-13 5/8-11 5/8-11		60-80 (81-108) 130-160 (176-217) 160-200 (217-271)
Brake Chamber Mounting Nuts	8 8	3/8-16 1/2-13		37-50 (47-68) 70-100 (95-136)
Brake Chamber Bracket-to-SpiderCapscrews	8 8	1/2-13 5/8-11		60-80 (81-108) 105-145 (142-196)

Table 1, Fastner Torques

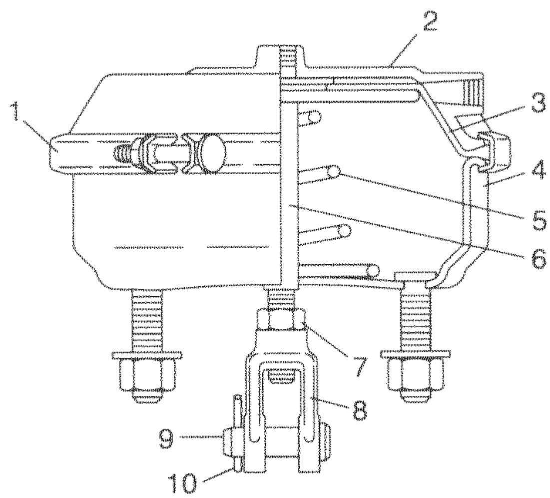
Front Service Brake Chamber

General Description and Principles of Operation

General Description

Brake chambers convert the energy of compressed air into the mechanical force and motion needed to apply the brakes. Two chambers operate the brakes, one on each side of the axle.

Each brake chamber consists of two dished metal sections: the pressure cap and the chamber, which are separated by a nylon-reinforced diaphragm. A metal two-segment clamp ring holds the assemblies together. See Fig. 1.



1. Clamp Ring
2. Pressure Cap
3. Diaphragm
4. Chamber Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Clevis Jam Nut
8. Clevis
9. Clevis Pin
10. Cotter Pin

Fig. 1, Sectional View

In front of the diaphragm are the piston rod assembly, and a piston rod spring. The threaded piston rod assembly extends through the bottom of the chamber and connects to the clevis. See Fig. 1.

Different sized brake chambers are identified by numbers, which specify the effective area of the diaphragm. For example, a type 16 brake chamber has 16 square inches of effective area.

Principles of Operation

The greater the air pressure admitted to the brake chamber, the greater the force applied by the piston rod. Piston rod force is determined by multiplying the delivered air pressure by the effective diaphragm area. For example, if 60 psi (415 kPa) is admitted to a type 16 brake chamber, the force on the end of the piston rod is about 960 lb (4270 N).

When the brake pedal is depressed, air pressure from the brake valve passes through the port in the brake chamber pressure cap to move the diaphragm and piston rod assembly forward. This compresses the spring, and applies a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

When the brake pedal is released, compressed air behind the diaphragm exhausts through the quick release valve. The spring then allows the piston rod assembly and diaphragm to return to their previous positions.

Service Brake Chamber Operating and LeakageTests

NOTE: For both of these tests, the air system must be pressurized to at least 80 psi (550 kPa).

Operating Test

1. Chock the tires.

2. Apply the brakes. Check that each piston rod moves out promptly, without binding.

3. Release the brakes. Check that each piston rod returns to the released position promptly, without binding.

4. Check the brake chamber stroke. It should be as short as possible without causing the brakes to drag. If needed,
adjust the travel of the piston rod at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

Leakage Test

1. Apply the brakes and hold them on full line pressure of at least 80 psi (550 kPa).

2. Using a soap solution, coat the clamp ring. Leakage is excessive if it produces a 1-inch (25-mm) bubble within five seconds.

CAUTION: Don't over tighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

3. If the leakage is excessive, tighten the clamp ring flange nuts evenly until the leakage is reduced. Do not tighten more than 25 to 30 ft-lbs (34 to 41 N-m).

4. Using a soap solution, coat the area around the piston-rod hole. No leakage is permitted. If there is leakage, replace the diaphragm.

Service Brake Chamber Diaphragm Replacement (optional)

NOTE: This procedure is for service of a leaking brake chamber *diaphragm only.* If there are any other problems, refer to the applicable subjects elsewhere in this section.

Replacement

1. Chock the tires.

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.

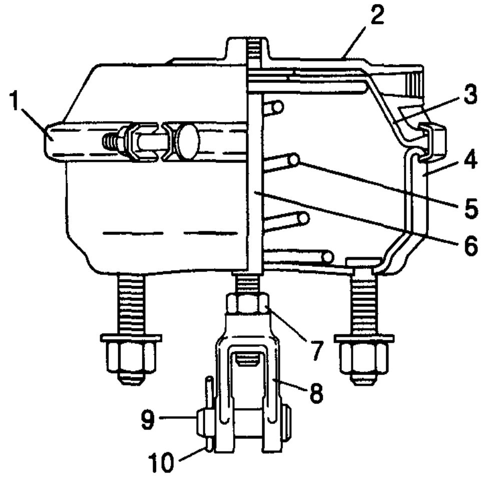
3. Back off the slack adjuster; for instructions, refer to the applicable slack adjuster section in this group. Pull out the piston rod. See Fig. 1. Clamp the rod at the chamber body to protect it from damage.

4. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. See Fig. 2.

5. Replace the diaphragm.

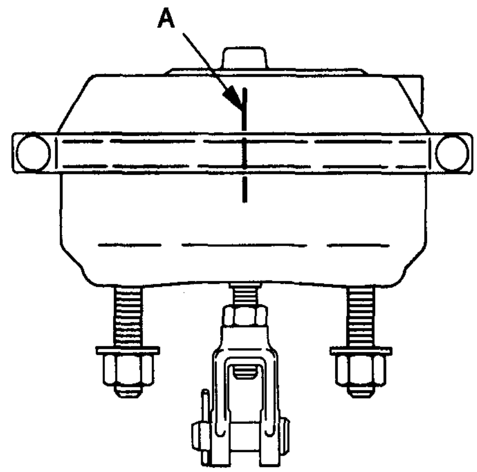
   5.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.

5.2 Remove the pressure cap, and replace the diaphragm.



1. Clamp Ring
2. Pressure Cap
3. Diaphragm
4. Chamber Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Clevis Jam Nut
8. Clevis
9. Clevis Pin
10. Cotter Pin

Fig. 1, Sectional View



A. Reference Line

Fig. 2, Mark a Reference Line

CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

5.3 Position the pressure cap and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly 25 to 30 lbf-ft (34 to 41 N-m) to eliminate leakage.

6. Release the clamp on the piston rod.

7. Do both of the tests in Subject 100.

8. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable brake section in this group.

9. Remove the chocks from the tires.

Service Brake Chamber Removal and Installation

Removal (See Fig. 1)

1 Chock the tires.

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in severe personal injury. Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.

3. Carefully disconnect the air line from the brake chamber.

4. Remove the brake chamber.

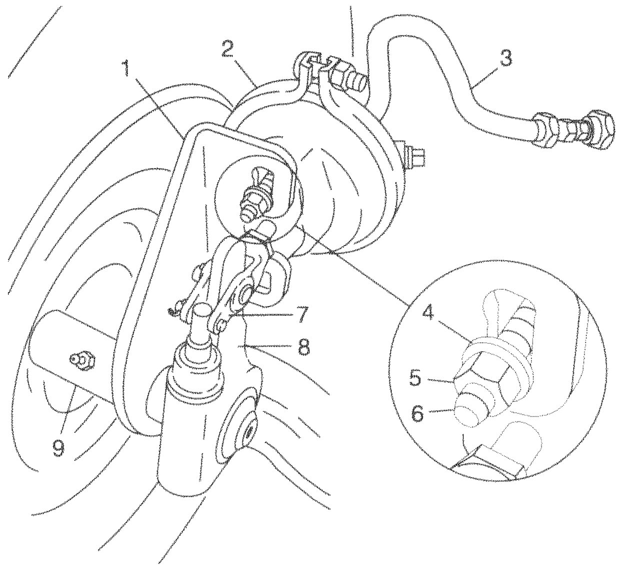
4.1 Remove the cotter pin(s) from the clevis pin(s).

NOTE: Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

4.2 Remove the clevis pin(s) from the slack adjuster.

4.3 From each mounting stud, remove any installed nuts and washers. Remove the brake chamber from the vehicle.

Installation (See Fig. 1)



1. Chamber Mounting Bracket
2. Brake Chamber
3. Air Line
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Chamber Mounting Stud
7. Clevis Assembly
8. Slack Adjuster (Automatic Type)
9. Camshaft Tube

Fig. 1, Brake Chamber Mounting

1. Before installing a new chamber, be sure the new chamber is the same size and make as the brake chamber on the other side of the axle.

2. Install the brake chamber.

   2.1 Attach the brake chamber to the mounting bracket using a hardened flatwasher and prevailing torque locknut. Install the flatwasher between the locknut and the mounting bracket.

   2.2 Tighten the locknuts. See Table 1 for the correct torque value.

   2.3 Connect the clevis pins to the slack adjuster.

   2.4 Install and lock the cotter pin(s) to secure the clevis pin(s).

NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

3. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable brake section in this group.

4. Connect the airline to the brake chamber.

   4.1 Check that the hoses are properly supported and, if needed, clamped to provide good clearance.

   4.2 Before connecting the air line, make sure the fittings are clean and free of debris.

4.3 Connect the airline as follows: tighten the nut finger-tight. Using a wrench, further tighten the nut until there is resistance, then tighten one-sixth turn more.

5. Do both of the tests.

6. Remove the chocks from the tires

Specifications

Description	Chamber Size (in2)	Torque lbf.ft (N.m)
Brake Chamber Mounting-Stud Locknuts	16	35-40 (47-54)
	20	100-115 (136-156)
	24	100-115 (136-156)

Table 1, Mounting Stud Locknut Torque Values

Service Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

Disassembly (See Fig. 1)

NOTE: If the brake chamber is to be disassembled without removing the body assembly from the vehicle, first back off the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

1. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. See Fig. 2.

2. Pull out the piston rod. Clamp the rod at the chamber body to protect it from damage.

3. Disassemble the brake chamber.

   3.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.

   3.2 Remove the pressure cap and the diaphragm.

   3.3 Remove the clevis locknut and clevis from the piston rod, and release the clamp on the piston rod, being careful to contain the piston rod assembly and body until the return spring is relaxed.

   3.4 Remove the piston rod assembly and spring.

Inspection and Cleaning

1. Clean all metal parts with cleaning solvent.

2. Inspect all parts for wear or damage; replace asneeded.

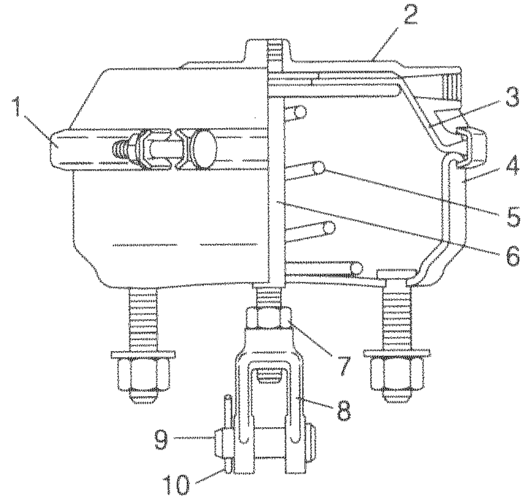
   2.1 Check the pressure cap and the chamber for dents. If any are too deep to be pounded out, replace as needed.

   2.2 Check the diaphragm for wear or deterioration and replace it if needed.

   2.3 Inspect all other parts not considered serviceable. Replace if needed.

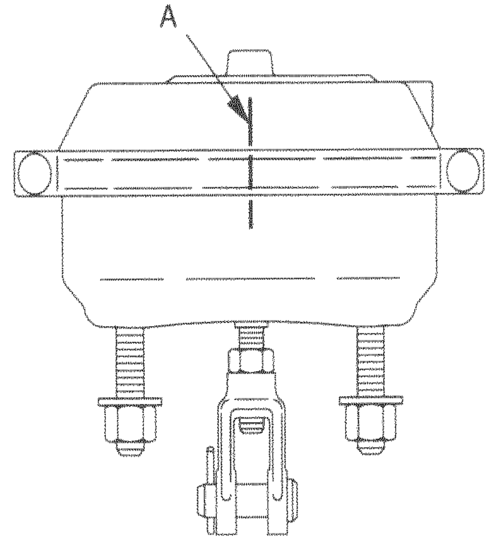
Assembly (See Fig. 1)

1. Stand the piston rod assembly upright on a flat surface (if the chamber was removed from the vehicle).



1. Clamp Ring
2. Pressure Cap
3. Diaphragm
4. Chamber Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Clevis Jam Nut
8. Clevis
9. Clevis Pin
10. Cotter Pin

Fig. 1, Sectional View



A. Reference Line

Fig. 2, Mark a Reference Line

2. Assemble the brake chamber.

   2.1 Place the return spring on the piston rod.

   2.2 Place the chamber on the piston rod assembly, and press the chamber down, working against the tension of the spring, until the chamber bottoms out on the flat surface. Clamp the rod at the chamber, making sure to protect the rod from damage. Insert the piston rod assembly through the chamber and clamp the rod (if the chamber wasn't removed from the vehicle).

   2.3 Place the diaphragm in the chamber.

CAUTION: Don't over tighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

   2.4 Position the pressure cap and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly 25 to 30 ft-lbs. (34 to41 N-m) to eliminate leakage.

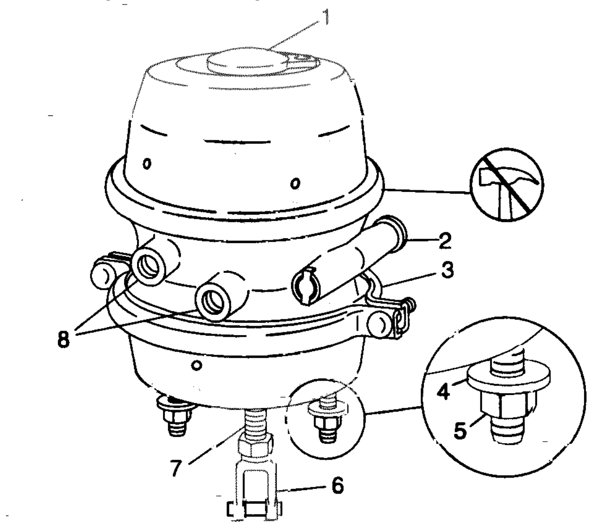
3. Install the clevis locknut and clevis, and release the clamp on the piston rod.

4. If the brake chamber was removed from the vehicle, install it.

5. Do both of the tests.

Rear or Spring Brake Chambers

General Information and Principles of Operation



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 1, Brake Chamber

DANGER: Don't attempt to remove the factory sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: The parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit.

General Information

Spring or rear brake chambers consist of a service brake section and a parking/emergency spring brake section. See Fig. 1. The service brake section is the smaller section near the clevis assembly.

In the service brake section, the service brake chamber contains a service return spring, piston rod assembly, and service brake diaphragm.

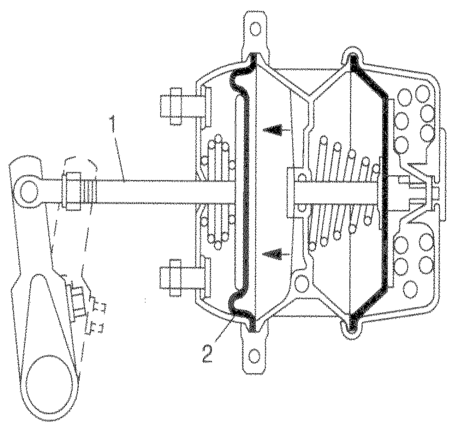
In the parking/emergency brake section, the adaptor and the parking brake chamber contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a pressure plate, a power spring, and a detachable release bolt.

All brake chambers are mounted to the frame using prevailing torque locknuts and hardened flatwashers.

Principles of Operation

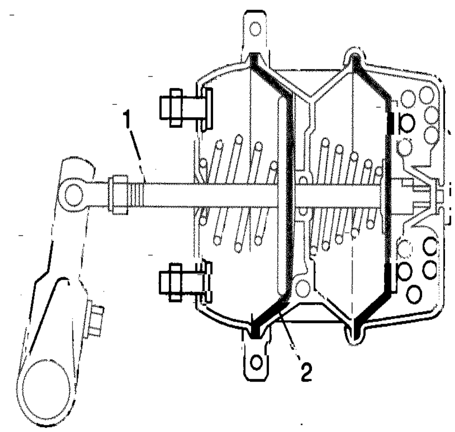
SERVICE BRAKES

As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes. See Fig. 2.



1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 2, Service Brakes Applied



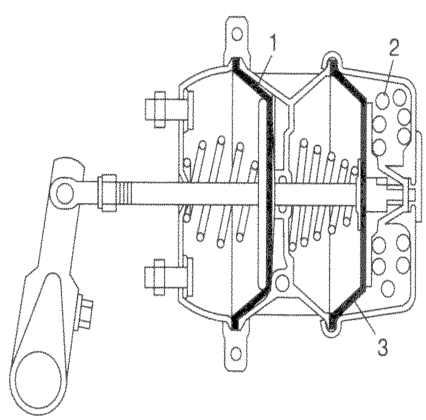
1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 3, Service Brakes Released

Then, when the brake pedal is released (see Fig. 3), air is exhausted from the service brake chamber, and the return spring allows the diaphragm, piston rod assembly, and slack adjuster to return to their normal positions, releasing the brakes.

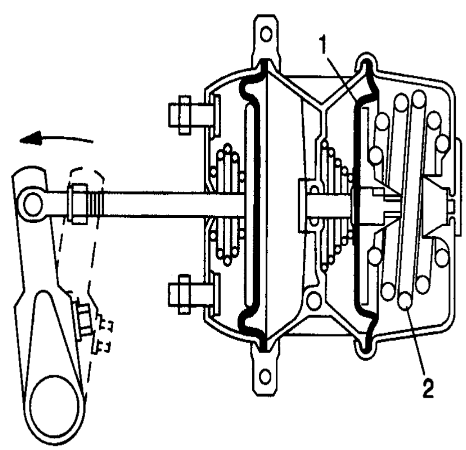
PARKING/EMERGENCY BRAKES

During parking brake release, compressed air enters the parking/emergency brake chamber below the diaphragm, forcing the diaphragm against the pressure plate to compress the power spring and release the parking/emergency brake. See Fig. 4. During parking brake application, a control valve in the cab exhausts air from the parking/emergency brake chamber. This allows the power spring to extend and apply the brakes. See Fig. 5.



1. Service Brake Diaphragm
2. Power Spring
3. Parking/Emergency Brake Diaphragm

Fig. 4, Parking/Emergency Brakes Released



1. Parking/Emergency Brake Diaphragm
2. Power Spring

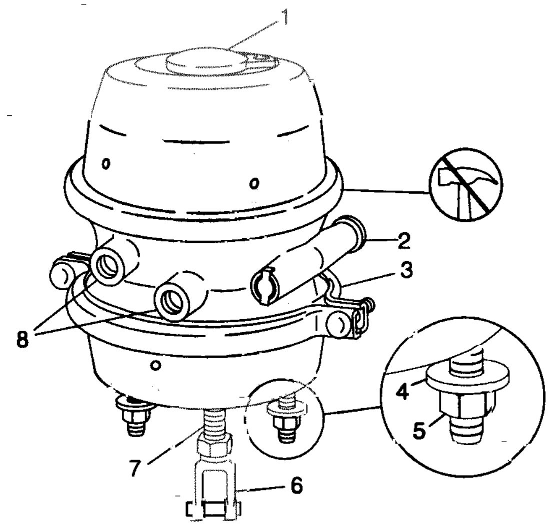
Fig. 5, Parking/Emergency Brakes Applied

Emergency brake application begins when air pressure in the service brake reservoir drops below about 80 to 85 psi (550 to 585 kPa). Maximum parking brake force is applied when air is entirely exhausted from the parking /

emergency brake chamber.

Power Spring Manual Compression and Reset

DANGER: Don't attempt to remove the factory sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 1, Brake Chamber

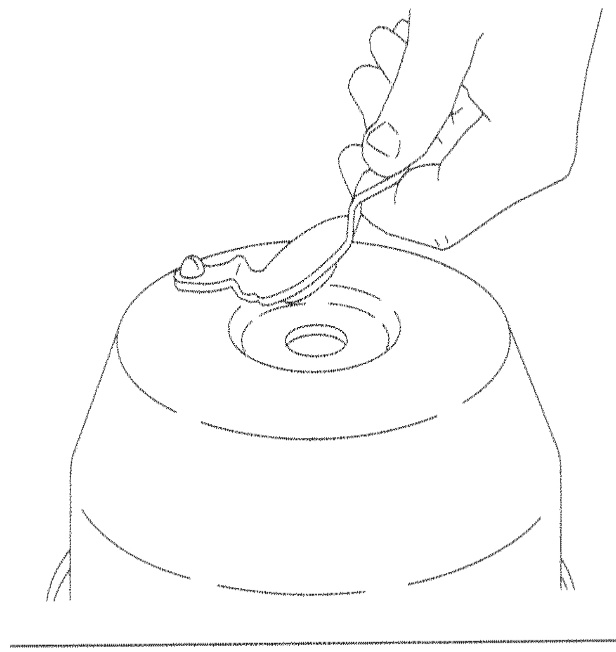


Fig. 2, Remove the Dust Plug

Manual Compression (Parking Brake Release)

1. Chock the tires.

2. Remove the dust plug from the center-hole in the head of the chamber. See Fig. 2.

DANGER: Do not attempt to cage the power spring if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber.

Remove the chamber carefully from its bracket, and disarm it inside a suitable container.

3. Manually release the parking brake (cage the power spring).

   3.1 Using a hand wrench, (don't use an impact wrench), unscrew the release nut, and remove the nut, flatwasher, and release bolt from the storage pocket on the side of the chamber. See Fig. 3.

IMPORTANT: If these parts are not stored on the chamber, they must be otherwise obtained or purchased; the parking brake cannot be manually released without them.

   3.2 Insert the release bolt into the center-hole in the chamber head (see Fig. 4). Continue to insert the bolt until it bottoms out into the hole in the pressure plate inside the chamber.

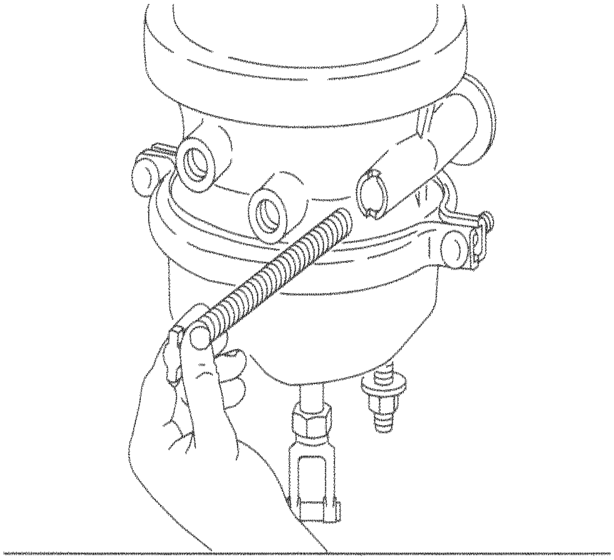


Fig. 3, Remove the Release Bolt

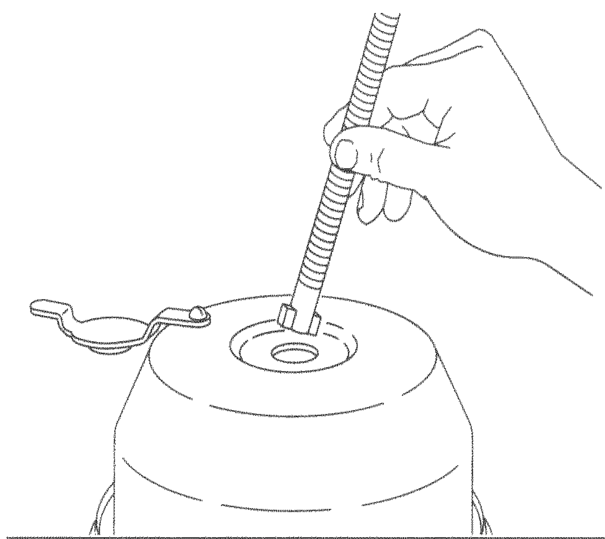


Fig. 4, Insert the Release Bolt

IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged the pressure plate correctly, repeat this step. Repeat it until you are absolutely sure.

3.3 Turn the release bolt one-quarter turn clockwise. Pull to seat the formed end of the release bolt in the recess of the pressure plate.

3.4 Holding the release bolt locked into the pressure plate, install the flatwasher and release nut on the end of the bolt, and turn down the nut against the flatwasher until it is finger-tight. See Fig. 5.

DANGER: Exhaust all air pressure before tightening the release nut more than finger-tight. Tightening this nut under pressure can damage the pressure plate and result in sudden release of the power spring, causing death or severe personal injury.

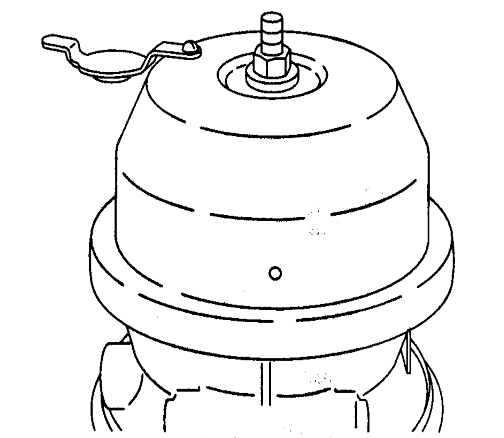
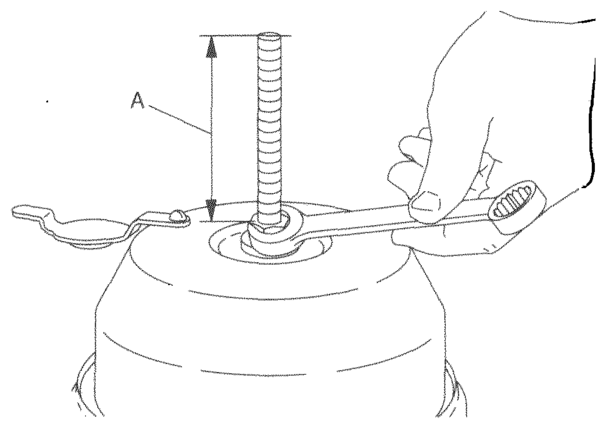


Fig. 5, Flatwasher and Release Nut Installed



A. Measure this distance.

Fig. 6, Turn the Release Nut

CAUTION: If equipped with S-cam or disc brakes, don't exceed 35 lbf ft (47 N -m) torque on the release nut; if equipped with wedge brakes, don't exceed 20 lbf-ft (27 N-m) torque on the release nut.

3.5 Using a hand wrench *(don't use an impact wrench),* turn the release nut clockwise until the power spring is caged (see Fig. 6):The bolt should extend above the nut at least 2.9 inches (74 mm) on 24-inch chambers, or 2.875 inches (73 mm) on 30-inch chambers.

IMPORTANT: Do not exceed these bolt lengths. If the bolt lengths can't be obtained without exceeding the recommended maximum torque values, replace the tandem brake chamber.

Manual Reset (Parking Brake Reset)

1. Uncage the power spring.

CAUTION: Don't use an impact wrench on this nut. Too much torque could damage the pressure plate and prevent manual release of the parking brake.

1.1 With air applied to the parking brake section (the parking brake control valve is in the "release" position), use a hand wrench to turn the release nut counterclockwise until the power spring extends back into the parking/emergency brake chamber.

NOTE: When the power spring is fully extended, force will no longer be felt on the release nut.

1.2 Remove the nut and flatwasher.

1.3 Turn the release bolt one-quarter turn counterclockwise and unlock the bolt from the receptacle in the pressure plate. Remove the release bolt from the center-hole of the chamber.

2. Using a hand wrench, *(don't use an impact wrench),* install the release bolt, flatwasher, and release nut in the storage pocket. Tighten the nut 60 to 96 lbf-in (680 to 1080 N-cm). See Fig. 7.

3. Snap the dust plug in place over the center-hole in the chamber head. See Fig. 8.

CAUTION: If a dust plug is missing or incorrectly installed, road dirt and debris can adversely affect the operation of the brake chamber. Once inside the chambers, dirt and debris cause the internal parts to deteriorate and shorten their lives.

4. Check the plastic dust plug periodically, and replace it with a new one at once if damaged or missing. For intervals, refer to the vehicle maintenance manual.

5. Remove the chocks from the tires.

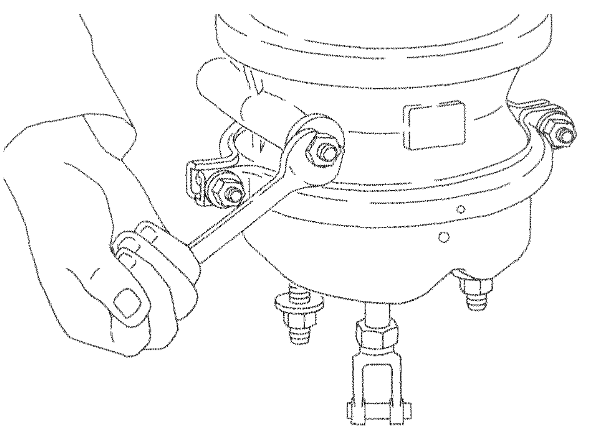


Fig. 7, Tighten the Release Nut

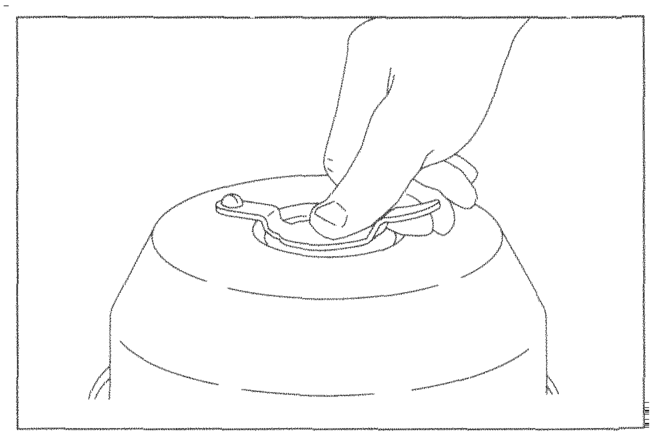
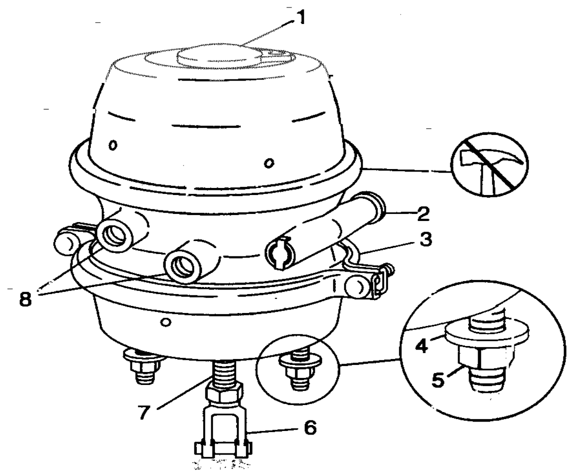


Fig. 8, Snap the Dust Plug in Place

Combination Service and Parking Brake Chamber Removal and Installation

DANGER: Don't attempt to remove the factory-sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 1, Brake Chamber

Removal

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section. When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

1. Manually release the parking brake (cage the power spring).

2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.

3. Remove the brake chamber from the vehicle.

   3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

NOTE: Automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   3.2 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

Installation

1 If installing a new brake chamber unit, do the following steps:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward).

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).

   1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

   1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber.

2. Clean the face of the mounting bracket, and position the chamber on the bracket. Pay close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

WARNING: Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench *(don't use an impact wrench),* tighten the nuts 110 to 150 lbf-ft (149 to 203 N.m). Make sure that the hardened flatwasher is installed between the locknut and the mounting bracket.

4. Check mating and alignment with the vehicle air lines.

DANGER: Don't attempt to remove the factory sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4.1 Using a hand wrench *(don't use an impact wrench),* loosen the clamp nuts on the *service* clamp ring *(do not disassemble the parking brake section).*

4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines. Alternately tighten each clamp nut in increments of 18 to 25 lbf-ft (24 to 34 N-m) while constantly rechecking the alignment of mating parts. If realignment is needed, loosen the nuts again, and repeat this sub step.

4.3 Lightly tap around the circumference of the service clamp ring to ensure full seating of the clamp.

5. Connect the slack adjuster. Refer to the applicable slack adjuster section in this group for installation instructions.

6. Inspect the piston rod to be sure it is not binding, and is square with the chamber bottom from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.

7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench *(don't use an impact wrench),* tighten the fittings 25 lbf-ft (34N-m).

8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). Using only soapy water *(never any type of* oil, which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf-ft (34 N-m).

DANGER: Don't attempt to remove the factory sealed clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, release all air pressure from the chamber, then retighten the clamp nuts until leaks cease *(do not touch the parking brake section).* Anchorlok recommends 18 to 25 lbf-ft (24 to 34 N-m) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the dust plug in place.

10. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

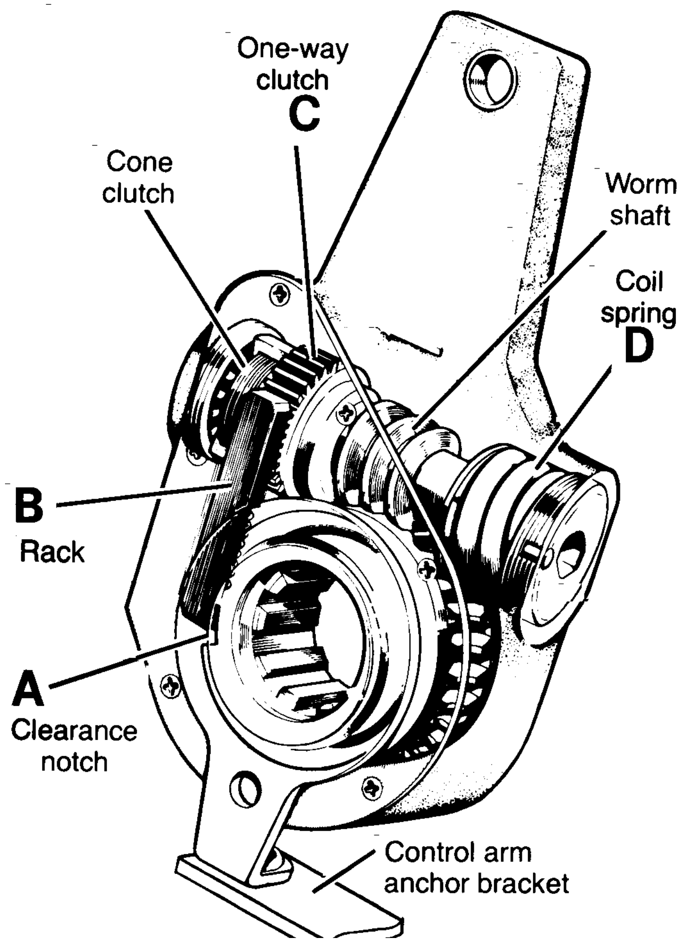
IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and brake adjustment. No brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section.

Specifications

Description	Torque	
	lbf.ft (N.m)	lbf.in (N.cm)
Spring Brake Release Bolt Nut: (in storage pocket) (caged)	 - 35 (47)	 60 to 96 (680 to 1080) -
Service Brake Clamp Ring Nut	18 to 25 (24 to 34)	-
Brake Chamber Mounting Stud Locknut	110 to 150 (149 to 203)	-
Air Hose Fitting-to Chamber	25 (34)	-

Table 1, Torque Values

Haldex Self-Adjusting Slack Adjuster



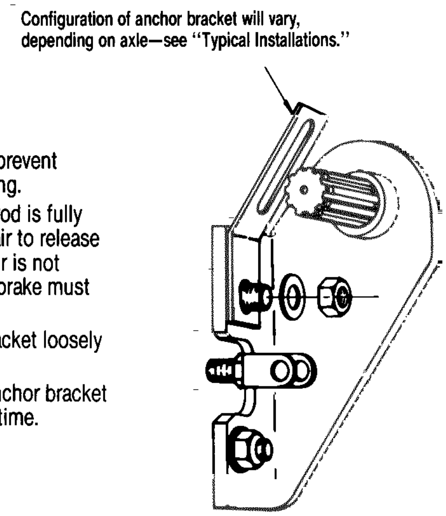
OPERATION:

Upon brake application the slack adjuster rotates -and moves the shoes into contact with the drum. The clearance notch (A) corresponds to the normal lining-to-drum clearance. As the brake application continues the rack (B) moves upwards and rotates the one-way clutch (C) which slips in this direction. As the brake torque increases the coil spring (D) load is overcome and the worm shaft is displaced axially releasing the cone clutch.

When the brake begins its return stroke the coil spring load returns to normal and the cone clutch is again engaged. The rack is pulled back to its original position in the notch, and any additional travel brought about by lining wear causes the rack to turn the locked one-way clutch and rotates the worm shaft through the locked cone clutch. The worm shaft then rotates the worm wheel and camshaft, adjusting the brakes.

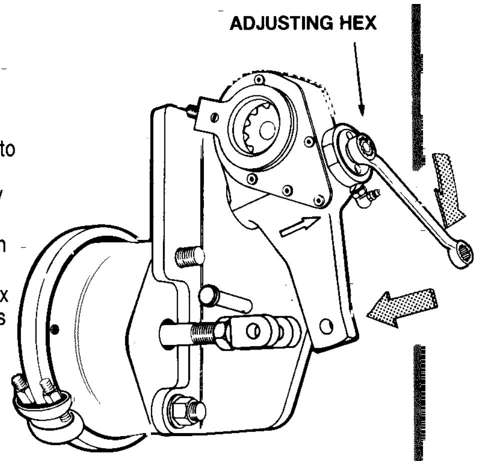
INSTALLATION INSTRUCTIONS

1



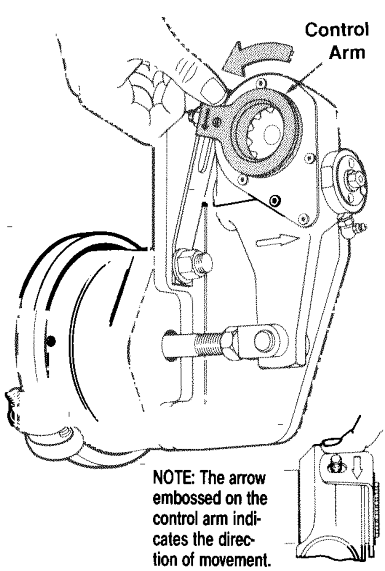
- Block wheels to prevent vehicle from rolling.
- Check that pushrod is fully retracted, apply air to release spring brake. If air is not available, spring brake must be caged back.
- Install anchor bracket loosely as illustrated.
- Do not tighten anchor bracket fasteners at this time.

2



- Install the slack adjuster onto the cam shaft with the adjusting hex pointing away from the brake chamber.
- Secure the slack adjuster on the cam shaft.
- Rotate the 7/16" adjusting hex nut **clockwise** until the clevis holes line up with the slack adjuster arm hole.
- Install the clevis pin.

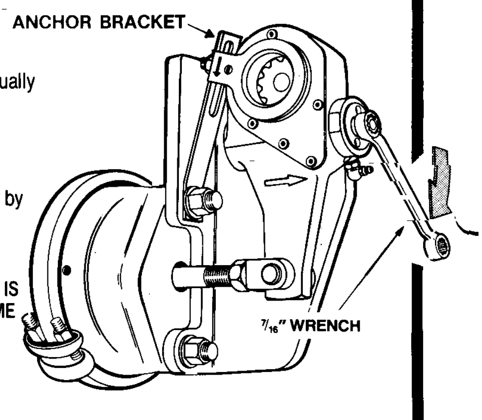
3



- Rotate the control arm away from the adjusting hex towards the air chamber, until it comes to a definite internal stop (as illustrated).
- Tap lightly in the direction shown to insure the correct position.
- **IF THE CONTROL POSITION IS WRONG, TIGHT BRAKES WILL OCCUR.**
- Tighten all anchor bracket fasteners (make sure the control arm does not move from its position while tightening the anchor bracket fasteners).

4

- The adjuster must be manually adjusted at this time.
- Rotate the adjusting hex clockwise until the lining contacts the drum.
- Then back-off the adjuster by turning the adjusting hex counter-clockwise three-quarters of a turn.
- **A MINIMUM OF 15 FT. LBS. IS NECESSARY TO OVERCOME THE INTERNAL CLUTCH. A RATCHETING SOUND WILL OCCUR.**



TROUBLE SHOOTING

TIGHT OR DRAGGING BRAKES
Check Foundation Brake Components For:

1. Control arm anchor bracket not positioned properly. (See Installation Instructions Step #3)

2. Brake chamber not fully releasing:
   -Spring brake not fully releasing.
   -Pushrod binding on chamber housing.
   -Air supply not exhausting completely.

3. Extreme differences in lining-to-drum clearances between shoes on same wheel.

4. Broken shoe return spring.

EXCESSIVE CHAMBER PUSHROD TRAVEL
Check Foundation Brake Components For:

1. Loose, broken or bent control arm anchor bracket.

2. Worn camshaft bushings.

3. Binding camshaft.

4. Worn clutch (See "Maintenance")

OPERATIONAL CHECK

Functional operation of the slack adjuster can be performed on vehicle by:

1. Block wheels to prevent vehicle from rolling.

2. Check that the push rod is fully retracted; apply air to release spring brake.

3. Manually de-adjust brakes (turn adjustment hex counterclockwise) to create an excessive clearance condition. (A ratcheting sound will occur)

4. Make a full service brake application, on release; allow sufficient time for brake to fully retract. During the brake release, observe rotation of the adjustment hex (attaching a wrench on the hex will make this rotation easier to see). This rotation indicates that an excessive clearance condition has been determined by the slack adjuster, and it is making an adjustment to compensate. On each subsequent brake release the amount of adjustment and pushrod travel will be reduced until the desired clearance is achieved and no additional adjustment is required.

5. See "In Service Checking Procedure" for proper pushrod stroke.

MAINTENANCE

During normal chassis lube, adjusters should be inspected for damage. Check anchor brackets to ensure they are tight.

During reline, check the de-adjustment torque. Place a torque wrench on the 7/16"adjusting hex. Turn the torque wrench counterclockwise and check that the clutch does not slip at the torque less than 13 Ft. Lbs. A ratcheting sound will occur while backing off. If clutch slips at a lesser torque, the adjuster must be replaced.

LUBRICATION

The Self-Adjusting Slack Adjuster should be lubricated in conjunction with the lubrication prescribed for the vehicle chassis. The lubrication interval should not, however, exceed 50,000 miles or 3 months. No special type of grease is required, however the use of moly-disulfide loaded grease or oil is not recommended since it may lower friction capabilities in the adjusting clutch parts, and decrease automatic adjustment reliability.

INSPECTION

1. During normal lubrication intervals, visually inspect slack adjuster and anchor bracket for damage. Check that anchor bracket is tight and the control arm is in it's "Full Release" position. (refer to Step #3 "Installation I instructions")

2. Maintaining proper brake adjustment and brake balance cannot be accomplished by the slack adjuster alone. The condition of foundation brake components has a direct bearing on the effectiveness of brake adjustment. Therefore, periodic inspection of these components is necessary.

   a. BRAKE CHAMBERS
   Check that brake chamber mounting bolts are tight and proper alignment is maintained to avoid interference between chamber pushrod and chamber housing. Verify that brake chamber pushrod length is equal on opposing brake chambers of the same axle.

   b. CAMSHAFT BUSHINGS
   Optimum brake adjustment cannot be achieved when worn bushings are used.

   c. WHEEL BEARING ADJUSTMENT
   Accurate wheel bearing pre-load is necessary to maintain proper alignment between the brake drum and brake shoes.

IN SERVICE CHECKING PROCEDURES

1. A self-adjusting slack adjuster should never have to be manually adjusted while in service. The only time it should be manually adjusted is during installation or at reline. By constantly manually adjusting, the internal clutch life can be shortened.

2. The true test of a self-adjusting slack adjuster is "Does it maintain a proper piston stroke".

80 to 90 PSI service brake application	
Type 30 air chamber	1 1/4" to 2" stroke
Type 24 Long Stroke	1 1/4" to 2" stroke
Type 20-24 air chamber	1 " to 1 3/4" stroke
Type 9-12-16 air chamber	3/4" to 1 1/2 " stroke,

If the adjuster cannot automatically maintain the proper stroke it should be removed and replaced. It cannot be operated like a manual adjuster.

3. The air chamber push rod stroke can be difficult to measure properly, the following methods can be used; Fig. #1, with a tape measure, measure the movement of the push rod from the completely released position to the applied position (80 to 90 PSI). This movement can also be measured by marking the push rod where it exits the air chamber (brake released), then apply the brake and measure the distance from the mark to the face of the air chamber.

   Fig. #2, a measuring stick with a 1 3/4"and 2"mark can be used. Hold measuring tool next to a reference point on the push rod, make a brake application, and make sure movement does not exceed the recommended stroke of the air chamber.

4. If the brakes have been running tight or the piston stroke measurement is less than 1 1/4" on the rear axle or 3/4" on the steer axle. The control arm location should be checked (See Fig. #3j.

5. Condition of the foundation brake affects total stroke. Foundation brake components should be checked before replacing slack adjuster, ie: worn cam shaft bushing.

FIGURE #1

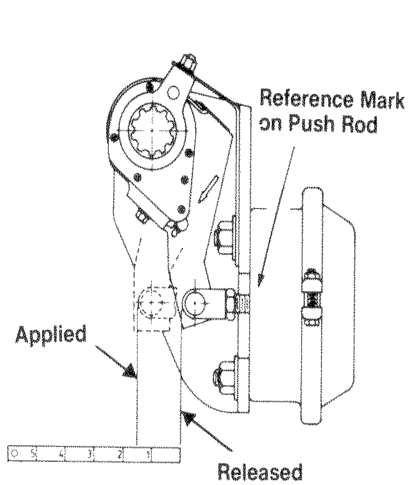


FIGURE #2

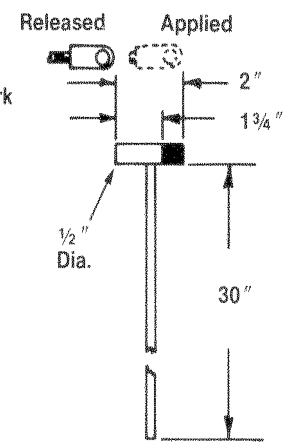
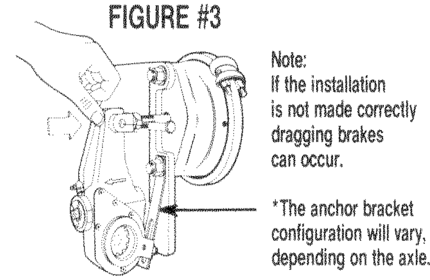


FIGURE #3



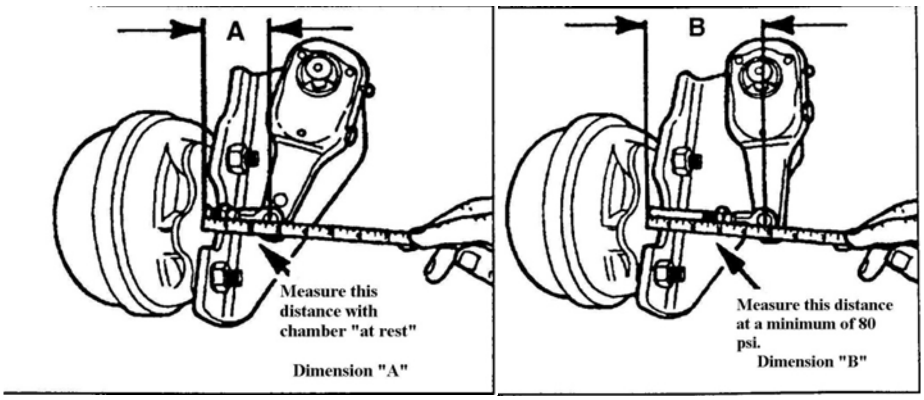
IMPORTANT: Check installation by removing clevis pin. Push the slack adjuster into the clevis. If the slack adjuster hole and clevis pin hole remain in alignment on release, the installation is **properly** made. Secure all fasteners.

If the slack adjuster hole is not aligned with the clevis pin hole, replace the clevis pin. Loosen the control arm fasteners and move the control arm towards the brake chamber until it comes to a definite internal stop. tighten the brake fasteners. **Repeat the final check.** If slack adjuster hole does not align with clevis pin hole, check for wear in the "S" cam bushing, change bushing if necessary.

AIR BRAKE ADJUSTMENT

The proper method for checking brake adjustment on air brake equipped vehicles is to measure the stroke of the brake chamber push rod. To determine the stroke of the brake chamber push rod:

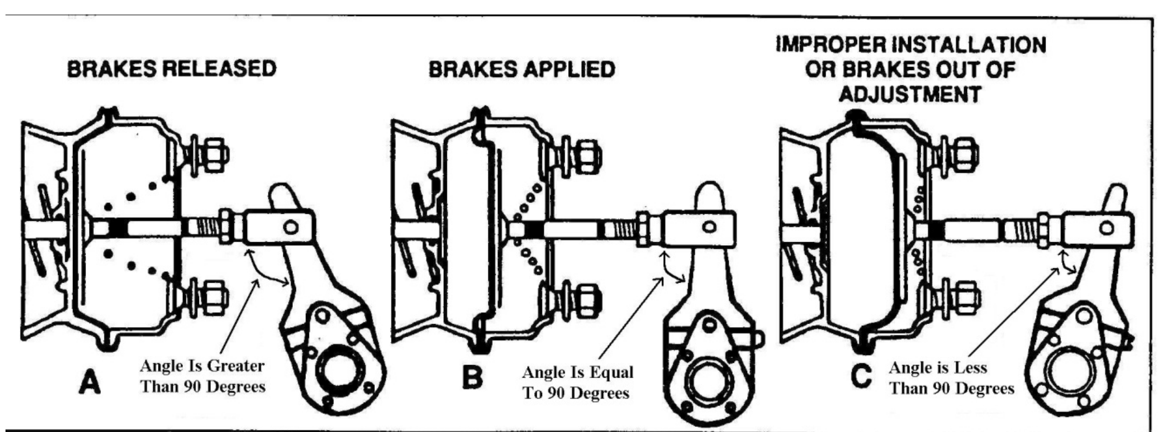
Measure the distance from the brake chamber to the center of the clevis pin with the brakes at rest (measurement A), measure the distance from the brake chamber to the center of the clevis pin with the brakes applied using a minimum of 80 psi air pressure (measurement B), and
subtract measurement A from measurement B to obtain actual stroke.



The stroke is then compared to the following table according to the type of brake chamber being measured. Measurements must never exceed the "Maximum Legal Stroke". * Readjustment is required if the measurements are at or near the "Maximum Legal Stroke".

Chamber Type	Maximum Legal Stroke
12	1 3/8"
16	1 ¾"
24	1 ¾"
30	2"
30 Long Stroke	2 ½"

Also of importance when checking brake measurements is to evaluate the angle created between the brake chamber push rod and the slack adjuster with the brakes applied. This angle should be greater than or equal to 90 degrees. If this angle becomes less than 90 degrees leverage is lost and braking capacity can be reduced.



If there are any questions about the proper methods for checking or making brake adjustments on vehicles equipped with air brakes, please contact your assigned Engineering Associate.

(*) Manually adjusting automatic slack adjusters should be done only during installation or for an emergency move to a repair facility. Manual adjustment fails to address the true reason why the brakes are not maintaining adjustment, giving the technician a false sense of security about the effectiveness of the brakes, which are likely to go out of adjustment again soon. This practice also can cause abnormal wear to the internal adjusting mechanism, which can lead to brake failure.

WHEEL-BEARING ADJUSTMENT PROCEDURES

Buses maintained by SCDE must have a verifiable wheel bearing end play of 0.001" to 0.005".

The following service procedures apply to steer and drive axle assemblies using conventional double nut or single nut systems. Follow these service procedures carefully to prevent premature wheel-end component failure and increase seal and bearing life.

ABS (anti-lock braking systems) and traction control systems with wheel-end sensing require precise bearing adjustment to function properly.

This procedure details proper service procedures for D-type, bendable-type, and dowel- type spindle nut washers.

NOTE: For single nut self-locking systems, consult manufacturer’s instructions.

If you have a system that differs from what is indicated in this procedure, consult the vehicle manufacturer's recommended procedure.

WARNING: Never work under a vehicle supported by only a jack. Always support the vehicle with jack stands. Block the wheels and make sure the unit will not roll before releasing brakes.

CAUTION: If your axle is equipped with spoke wheels and the rim clamps have been dis-assembled to remove the tire and rim assembly, the tire and rim assembly must be reinstalled and the rim clamps properly torqued BEFORE adjusting the wheel bearings. Failure to do this
may result in improper wheel bearing adjustment.

REFERENCES
TMC RP 622, Wheel Seal and Bearing Removal, Installation and Maintenance.

PROCEDURES:

Step 1: Lubricate the bearing with clean axle lubricant of the same type used in the axle sump or hub assembly.

IMPORTANT:

(a) In oil bath systems that rely on differential fill to provide lubricant to the wheel seals, do not pack bearings with grease before installation. Grease will temporarily restrict or prevent the proper circulation of axle lubricant and may contribute to wheel seal failure.

{b) Never use an impact wrench to adjust wheel bearings.

Step 2: After the wheel hub and bearings are assembled on the spindle or axle tube, torque the inner (adjusting) nut to 200 lb•ft while mounting the wheel hub assembly.

Refer to Table 1 at the end of this Policy.

Step 3: Back off the inner (adjusting) nut one full tum. Rotate the wheel.

Step 4: Re-torque the inner (adjusting) nut to 50 lb-ft. while rotating the wheel hub assembly. Refer to Table 1 at the end of this document.

Step 5: Back off the inner (adjusting) nut. Refer to Table 1 at the end of this Recommended Practice for the proper back-off amount.

Step 6: Install the locking washer. If dowel pin and washer (or washer tang and nut flat) are not aligned, remove the washer, turn it over and reinstall. If required, loosen the inner (adjusting) nut just enough for alignment.

IMPORTANT:

Never tighten thinner (adjusting) nut for alignment at this point of the procedure. This may pre-load the bearing and cause premature failure.

Step 7: Install and torque the outer Uam) nut. Refer to Table 1 at the end of this Recommended Practice for proper torque values.

NOTE: This adjustment allows the wheel to rotate freely with 0.001" to 0.005"
end play.

Step 8: Verify end play with a dial indicator. Wheel end play is the free movement of the tire and wheel assembly along the spindle axis.

(a) Make sure the brake drum-to-hub fasteners are tightened to the manufacturer’s specifications.

(b) Attach a dial indicator with its magnetic base to the hub or brake drum.

(c) Adjust the dial indicator so that its plunger or pointer is against the end of the spindle with its line of action approximately parallel to the axis of the spindle. See Fig. 1.

(d) Grasp the wheel assembly at the 3 o'clock and 9 o'clock positions. Push the wheel assembly in and out while oscillating it to seat the bearings. Read bearing end play as the total indicator movement.

NOTE: If end play is not within specification, re-adjustment is required.

Step 9: RE-ADJUSTMENT PROCEDURE

Excessive End Play-
If end play is too loose, remove the outer jam nut
and pull the washer away from the inner (adjusting) nut, but not off the spindle.

Tighten the inner (adjusting) nut to the next alignment hole of the washer. Reassemble the washer and re-torque the outer jam nut. Refer to Table 1 for torque values. Verify end play with a dial indicator.

Insufficient End Play-
If end play is not present, remove the outer jam nut and pull the washer away from the inner (adjusting) nut, but not off the spindle. Loosen the inner (adjust- ing) nut to the next alignment hole of the washer. Reassemble the washer and re-torque the outer jam nut.

Refer to Table 1 for torque values. Verify end play with a dial indicator.

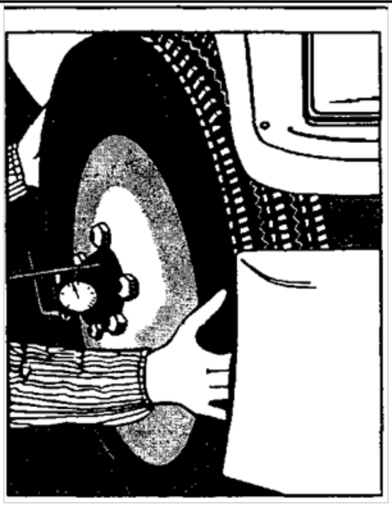
FINE TUNING THE ADJUSTMENT

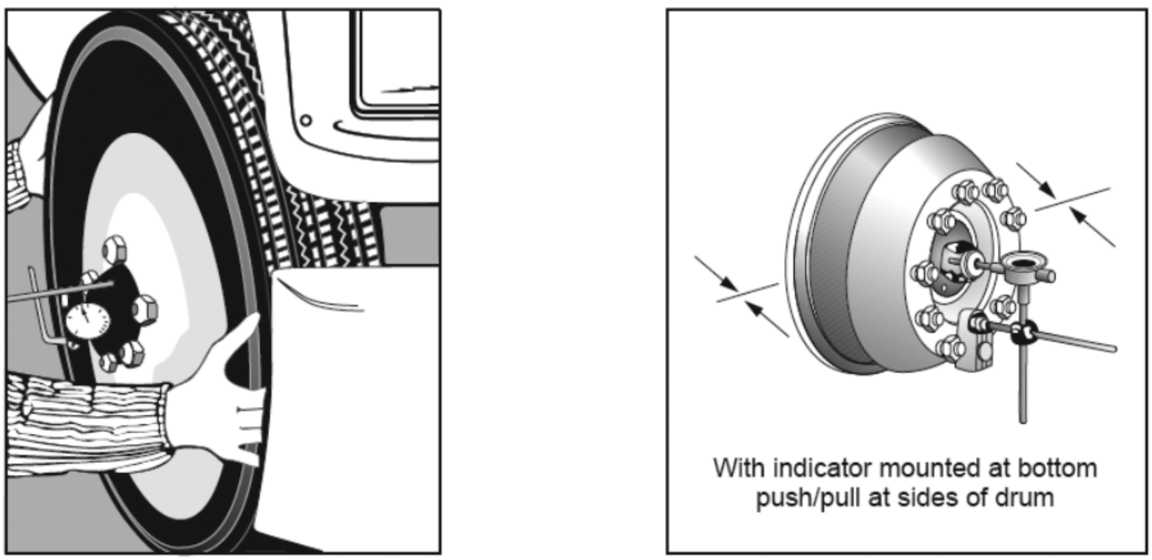
If, after performing the readjustment procedures, end play is not 0.001" - 0.005" range, repeat the appropriate procedures, removing the washer from the spindle, tighten or loosen the inner adjusting nut the equivalent of 1/2 of an alignment hole of the washer, or reversing the alignment washer, and reinstalling it onto the spindle. Reassemble and re-torque the outer jam nut.

Refer to Table 1 for torque values. Verify end play with a dial indicator.

NOTE: Bendable-type washer lock only: Secure nuts by bending one wheel nut washer tang over the inner and outer nut. Bend the tangs over the closest flap perpendicular to the tang. See Fig. 2.

CAUTION: Before operating the unit, the wheel hub cavities and bearings must be lubricated to prevent failure. For final wheel end assembly refer to TMC RP 622.

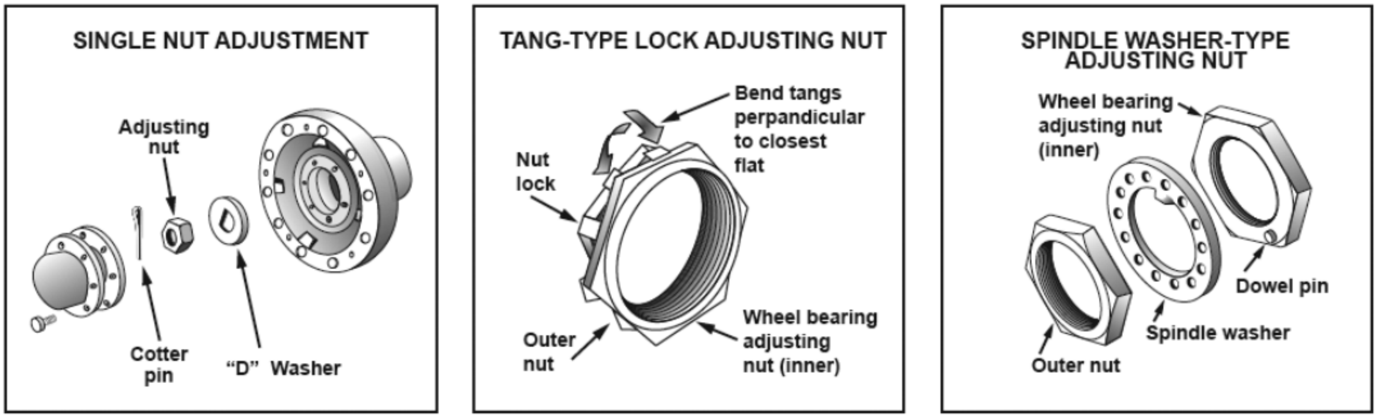




(a) with tire assembly

(b) without tire assembly

Fig. 1: Dial Indicator Set-Up



"D" Type "Tang" Type "Dowel" Type

Fig. 2: Adjusting Nut Identification and Installation

<table>
<tr><th colspan="9">TAPERED ROLLER BEARING ADJUSTMENT PROCEDURE
RP-618</th></tr>
<tr><td colspan="9">Step 1: Lubricate the tapered roller bearing with clean axle lubricant of the same type used in the axle sump or hub assembly.
NOTE: Never use an impact wrench when tightening or loosening lug nuts or bolts during the procedure.</td></tr>
<tr><th rowspan="2">Initial Adjusting Nut Torque</th><th rowspan="2">Initial Back Off</th><th rowspan="2">Final Adjusting Nut Torque</th><th colspan="2">Back Off</th><th rowspan="2">Final Back Off</th><th colspan="2">Jam Nut Torque</th><th rowspan="2">Acceptable End Play</th></tr>
<tr><th>Axle Type</th><th>Threads Per Inch</th><th>Nut Size</th><th>Torque Specifications</th></tr>
<tr><th>Step 2</th><th>Step 3</th><th>Step 4</th><th colspan="2">Step 5</th><th>Step 6</th><th colspan="2">Step 7</th><th>Step 8</th></tr>
<tr><td rowspan="8">200 lbf•ft (271N•m) While Rotating Wheel</td><td rowspan="8">One Full Turn</td><td rowspan="8">50 lbf•ft (68 N•m) While Rotating Wheels</td><td rowspan="4">Steer (Front) Non-Drive</td><td>12</td><td>1/6 Turn *</td><td colspan="2" rowspan="2">Install Cotter Pin to Lock Axle Nut in Position</td><td rowspan="8">0.001" - 0.005" (.025 - .127 mm)

As Measured Per Procedure With Dial Indicator</td></tr>
<tr><td>18</td><td>1/4 Turn *</td></tr>
<tr><td>14</td><td rowspan="2">1/2 Turn *</td><td rowspan="2">Less Than 2 5/8" (66.7 mm)</td><td rowspan="2">200-300 lbf•ft (271-407N•m)</td></tr>
<tr><td>18</td></tr>
<tr><td rowspan="2">Drive</td><td>12</td><td rowspan="2">1/4 Turn *</td><td>Dowel Type Washer</td><td>300-400 lbf•ft (407-542 N•m)</td></tr>
<tr><td>16</td><td>Tang Type Washer **</td><td>200-275 ibf•ft (271-373 N•m)</td></tr>
<tr><td rowspan="2">Trailer</td><td>12</td><td rowspan="2">1/4 Turn *</td><td rowspan="2">Less Than 2 5/8" (66.7mm)</td><td rowspan="2">300-400 lbf•ft (407-542 N•m)</td></tr>
<tr><td>16</td></tr>
<tr><td>*</td><td colspan="8">If dowel pin and washer (or washer tang and nut flat) are not aligned, remove the washer, turn it over and reinstall. If required, loosen the inner (adjusting) nut just enough for alignment.</td></tr>
<tr><td>**</td><td colspan="8">Bendable type washer lock only: Secure nuts by bending one wheel nut washer tang over the inner and outer nut. Bend the tangs over the closest flat perpendicular to the tang.</td></tr>
</table>

WHEEL BEARING/SEALSERVICE INTERVAL

New Vehicles: Each time a new vehicle is received at your shop, part of the inspection process will include raising the wheels and checking for excessive wheel bearing end play.

1st Annual Repair: As a part of the 1st Annual Repair, all vehicles will have the wheel bearings checked for proper wheel bearing adjustment.

Additional service/replacement requirements will be based on the type of bearing lubrication system and brake systems as indicated below.

ALL Wheel End Groups (drum or disc) EXCEPT Outboard Mounted:
Each time the brake drums/rotors are replaced; the wheel bearings must be removed, cleaned, inspected, replaced if necessary and properly lubricated. New grease seals must be installed and the bearings adjusted consistent with the manufacturer's recommendations.

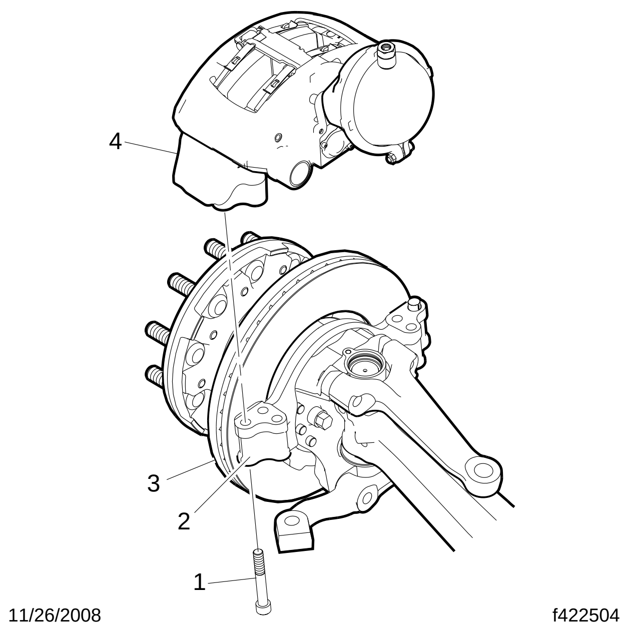
ALL Outboard Mounted Wheel End Groups: (drum or disc)

A minimum of once every 100,000 miles the wheel bearings must be removed, cleaned, inspected, and replaced if necessary. New grease seals must be installed and the bearings adjusted consistent with the manufacturer's recommendations.

Wheel bearings/seals should also be serviced/replaced if any inspection of these items indicates possible failure. All shops must be installing unitized design seals whenever possible. This type of seal offers longer life and a greater degree of re-usability. All manufactures installation instructions and tools must be used when installing wheel seals.

Description

Bendix air disc brakes use a floating caliper design to provide foundation braking on all axles. They are fitted with a standard brake chamber or a combination spring brake chamber, depending on the vehicle specification, and the position on the vehicle. The caliper-carrier and anchor plate are a proprietary design available only on Daimler vehicles. This design allows for easy removal and installation of the caliper/carrier assembly on all axles, without removing other major components. See **Fig. 1**.



1. Capscrew
2. Anchor Plate
3. Rotor
4. Caliper/Carrier

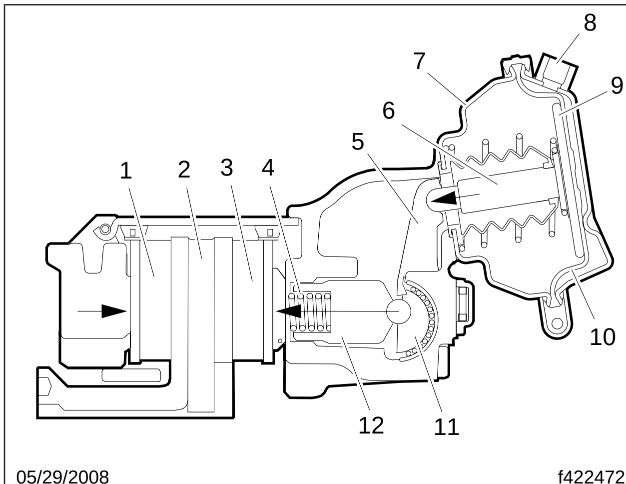
Fig. 1, Caliper/Carrier Installation

Operation

Bendix air disc brakes convert air pressure into braking force. See **Fig. 2**.

Brake Application

When the vehicle brakes are applied, air enters the service brake chamber through the supply port, applying pressure within the diaphragm. The pressure expands the diaphragm, applying force to the pressure plate and pushrod, and moving them forward.



1. Outer Brake Pad
2. Rotor
3. Inner Brake Pad
4. Return Spring
5. Lever
6. Pushrod
7. Brake Chamber
8. Supply Port
9. Pressure Plate
10. Diaphragm
11. Eccentric Bearing
12. Bridge

Fig. 2, Brake Operation

The pushrod presses against a cup in the internal lever, which pivots on an eccentric bearing, moving the bridge. Moving against a return spring, the bridge transfers the motion to two threaded tubes and tappets, which move the inner brake pad. The inner brake pad (from its normal position of having a running clearance between it and the rotor) moves into contact with the brake rotor. Further movement of the bridge forces the caliper, sliding on two stationary guide pins, away from the rotor, which pulls the outer brake pad into the rotor. The clamping action of the brake pads on the rotor applies braking force to the wheel.

Brake Release and Adjustment

When the vehicle brakes are released, the air pressure in the service brake chamber is exhausted, and the return springs in the chamber and the bridge return the caliper to a neutral, non-braked position. To maintain the running clearance gap between the rotor and the brake pads over time, the non-braked position is mechanically adjusted by a mechanism in the caliper. The adjustment mechanism operates automatically whenever the brakes are activated, to compensate for rotor and brake pad wear and to keep the running clearance constant. During pad or

General Information

rotor maintenance, the technician manually sets the system’s initial non-braked position. The total running clearance (sum of clearances on both sides of the rotor) should be between 0.024 to 0.043 in. (0.6 and 1.1 mm).

General Safety Precautions

WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake calipers, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc., should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

Asbestos and Non-Asbestos Safety

WARNING

Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH.

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

Safety Precautions

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency particulate air (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

Brake Pad Removal, Inspection, and Installation

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

⚠ WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

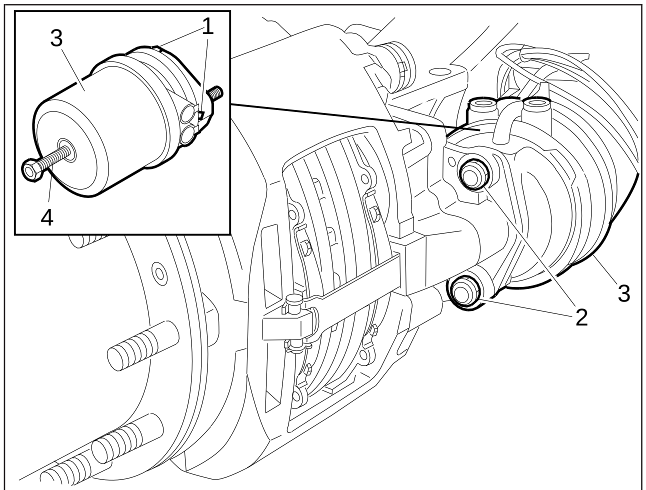
Removal

1. Shut down the engine. Chock the tires on the axle that is not being serviced.
2. If working on the drive axle, carefully cage and lock the spring brakes so that the springs cannot actuate during disassembly.

   Back out the release bolt using a maximum torque of 26 lbf·ft (35 N·m) to release spring force on the pushrod. See **Fig. 1**.
3. Drain the air from the air system.
4. Raise the front or rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
5. Remove the wheel(s). See **Group 40**.

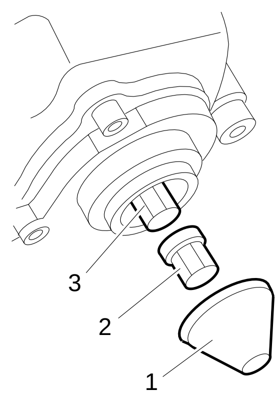
IMPORTANT: Before removing the brake pads, check the adjuster mechanism for proper operation.

6. Using the tab, pull off the adjuster cap, being sure to keep the shear adaptor in position on the adjuster. See **Fig. 2**.



1. Drain Plugs
2. Brake Chamber Nuts
3. Brake Chamber
4. Release Bolt

Fig. 1, Spring Brake Chamber Installation



1. Adjuster Cap
2. Shear Adaptor
3. Adjuster

Fig. 2, Shear Adaptor in Position

NOTICE

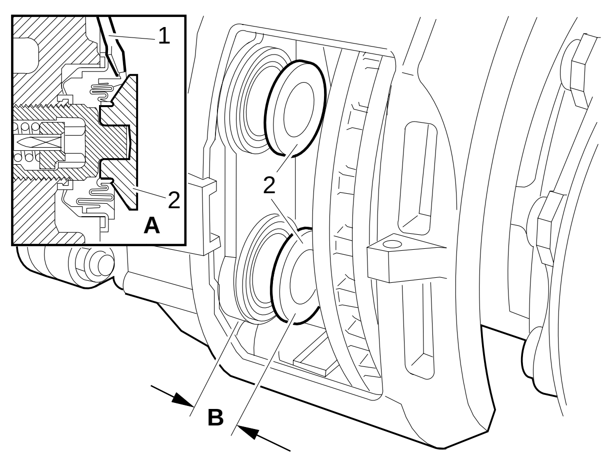
Do not use an open-ended wrench, as this may damage the adaptor.

IMPORTANT: Never turn the adjuster without the shear adaptor installed. The shear adaptor is a safety feature and is designed to prevent an excess of torque being applied to the adjuster. The shear adaptor will come loose if too much

Brake Pad Removal, Inspection, and Installation

torque is applied. If the shear adaptor fails, try again with a new adaptor. A second failure confirms that either the brake is applied or the adjustment mechanism is seized and the caliper/carrier assembly must be replaced.

7. Using a box-end wrench or socket, fully retract the tappet and boot assemblies by rotating the shear adaptor counterclockwise. See **Fig. 3**.



06/06/2008 f422481

A. Boot Location Ring
B. Extend less than 1.18 in (30 mm)

1. Boot Location Ring
2. Tappet and Boot Assembly

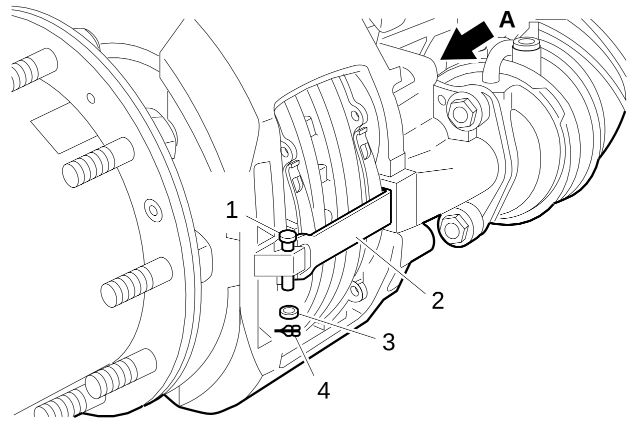
Fig. 3, Tappet and Boot Assembly

8. Remove the pad retainer clip and washer. See **Fig. 4**. Depress the pad retainer and remove the pad retainer pin. Discard all components that have been removed.
9. Slide the caliper to the outboard position. Remove the outer pad. See **Fig. 5**.
10. Slide the caliper to the inboard position. Remove the inner pad.

Inspection

Brake Pads

1. Measure the thickness of the friction material on the brake pad.

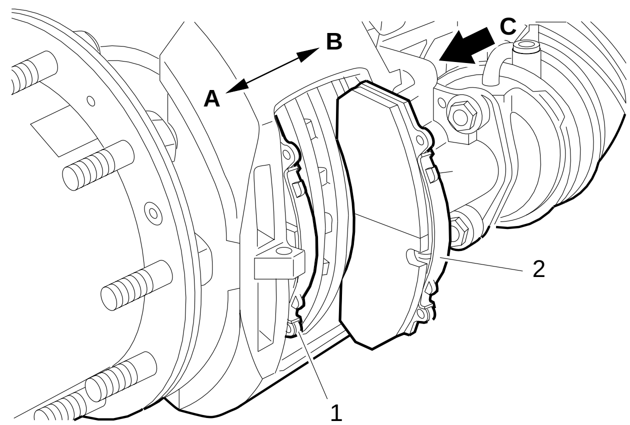


07/10/2008 f422471

A. Shear Adjuster Location

1. Pad Retainer Pin
2. Pad Retainer
3. Washer
4. Clip

Fig. 4, Caliper Assembly



12/11/2008 f422475

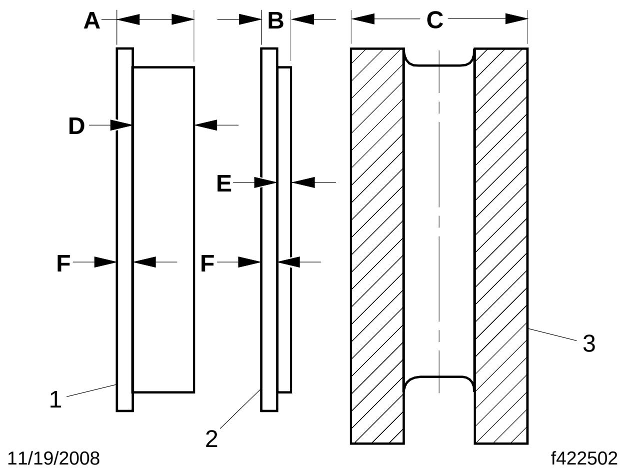
A. Outboard
B. Inboard
C. Area of Shear Adaptor

1. Outboard Brake Pad
2. Inboard Brake Pad

Fig. 5, Brake Pad Removal

If the thickness of the friction material is less than 0.079 in (2 mm) the pads must be replaced. See **Fig. 6**, Ref. E.

Most Bendix air disc brakes use 0.35 in (9 mm) backing plates. On a used brake pad, the combined pad and backing plate thickness should be no less than 0.43 in (11 mm).



1. New Pad
2. Used Pad
3. Rotor

A. New Pad Thickness 1.18 inch (30 mm)
B. Used Pad Thickness 0.43 inch (11 mm)
C. Rotor Thickness 1.77 to 1.46 inches (45 to 37 mm)
D. New Pad Friction Material Thickness
E. Used Pad Friction Material Thickness 0.079 inch (2 mm) minimum
F. Backing Plate Thickness 0.35 to 0.43 inch (9 mm to 11 mm)

Fig. 6, Brake Pad Inspection

2. If the pad thickness is within the acceptable range, inspect the pad surface.

   Minor damage (small amount of brake material chipped) at the edges is permitted, but replace the pads if major damage (section damaged or missing) is found on the surface.

Rotors

1. Examine the rotor and measure the thickness at the thinnest point. Avoid measuring near the edge of the rotor as minor burrs may be present. Replace the rotors when the minimum thickness is 1.46 in (37 mm), or when **one side** is greater than 0.15 inch (4 mm).

NOTE: It is recommended to replace the rotor with the same type that was originally installed on the vehicle and to replace the brake pads at the same time.

2. Inspect the rotor for grooves and cracks.

   Conventional rotors may be turned when changing pads, but is not normally necessary. In the case of severe grooving of the entire friction surface, then turning could be useful and may increase the load-bearing surface of the pads. To meet Bendix recommendations, the minimum rotor thickness after turning must be greater than 1.53 in (39 mm).

IMPORTANT: Always maintain air disc brake pads and rotors within specifications. Excessive pad or rotor wear will degrade optimum performance. When replacing rotors, be sure to adhere to Daimler Trucks North America (DTNA) recommended bolt tightening torques and sequence. See **Subject 130** for rotor replacement.

Installation

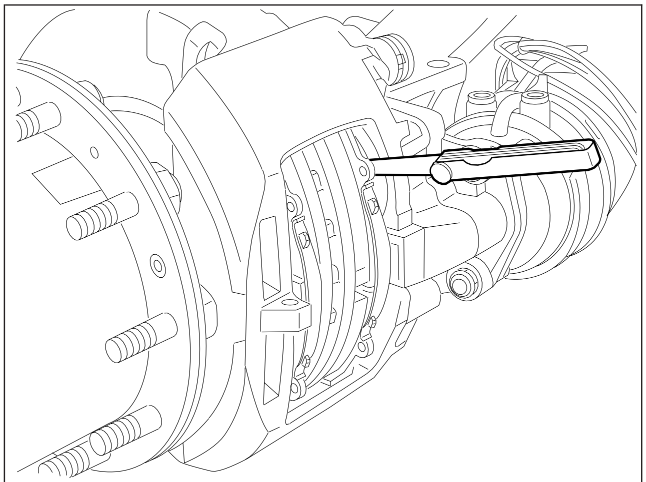
NOTE: When replacing brake pads, replace them as an axle set. Only use pads that have the same backing plate thickness as originally specified.

1. Install the outboard brake pad by sliding the caliper to the outboard position (be sure the brake lining material is facing the rotor).
2. Install the inboard pad by sliding the caliper to the inboard position.
3. Using a box-end wrench or socket, turn the shear adaptor clockwise until the pads come into contact with the rotor. Then turn the shear adaptor counterclockwise two clicks to set the initial running clearance.
4. Install the new pad retainer into the groove of the caliper. Depress the pad retainer, and install the new pad retainer pin so that it is pointing downward.
5. Install the new washer and spring clip to secure the pad retainer pin. See **Fig. 1**.

NOTE: The adjustment mechanism operates automatically whenever the brakes are activated, to compensate for rotor and brake pad wear and to keep the running clearance constant. During pad or rotor maintenance the technician is to manually set the systems' initial non-braked position.

Brake Pad Removal, Inspection, and Installation

6. Set the total running clearance (sum of clearances on both sides of the rotor), between 0.024 to 0.043 in (0.6 to 1.1 mm). See **Fig. 7**.



11/18/2008 f422497

Fig. 7, Checking Brake Pad Running Clearance

7. Uncage the spring brake.
8. Apply and release the brake, then check that the hub turns easily by hand.
9. Using white lithium-based grease, lightly grease and install the adjuster cap.
10. Install the wheel(s). See **Group 40**.
11. Remove the safety stands and lower the vehicle.

Brake Caliper/Carrier Assembly Removal and Installation

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

NOTE: Replacement bolts are not supplied with the caliper, use only bolts of a grade and type specified by Daimler Trucks North America (DTNA).

Replacement caliper/carrier assemblies may be delivered with a plastic cap, adhesive tape, or a breakthrough diaphragm in the area where the actuator is mounted. Remove the cap or tape only after installing the replacement caliper. If the replacement caliper has the breakthrough diaphragm, it should be left in place. Refer to **Fig. 1** for front caliper/carrier removal and installation.

Front Caliper/Carrier Assembly Removal

1. Apply the brakes and chock the tires.
2. Drain the air from the air system.
3. Raise the axle being serviced, and support it on a jackstand.
4. Remove the wheel. See **Group 40**.
5. Cut the zip ties holding the ABS harness to the brake hose as needed.

NOTE: If you are not replacing the caliper, it is not necessary to disconnect the air hose, if it can be safely supported out of the way while doing other work.

6. If replacing the caliper, disconnect the brake hose at the swivel connection at the frame rail, then remove the brake chamber from the caliper. See **Subject 150**.
7. With the caliper/carrier assembly securely supported, remove and discard the six bolts attaching the carrier to the anchor plate. Remove the caliper/carrier assembly.
8. Clean and inspect the anchor plate contact area. If damage is found, replace the anchor plate. See **Subject 140**.

Front Caliper/Carrier Assembly Installation

1. Position the carrier/caliper assembly, and attach it to the anchor plate with new bolts. Tighten 170 to 200 lbf·ft (230 to 271 N·m).
2. Install the brake pads, and brake pad shield, if equipped. See **Subject 110**.
3. Using new nuts, attach the brake chamber to the caliper/carrier assembly. Tighten 127 to 137 lbf·ft (172 to 186 N·m). See **Subject 150**.
4. Connect the brake hose.
5. Position the ABS harness, and install new zip ties to hold the harness to the brake hose. Leave room for movement.
6. Install the wheel. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

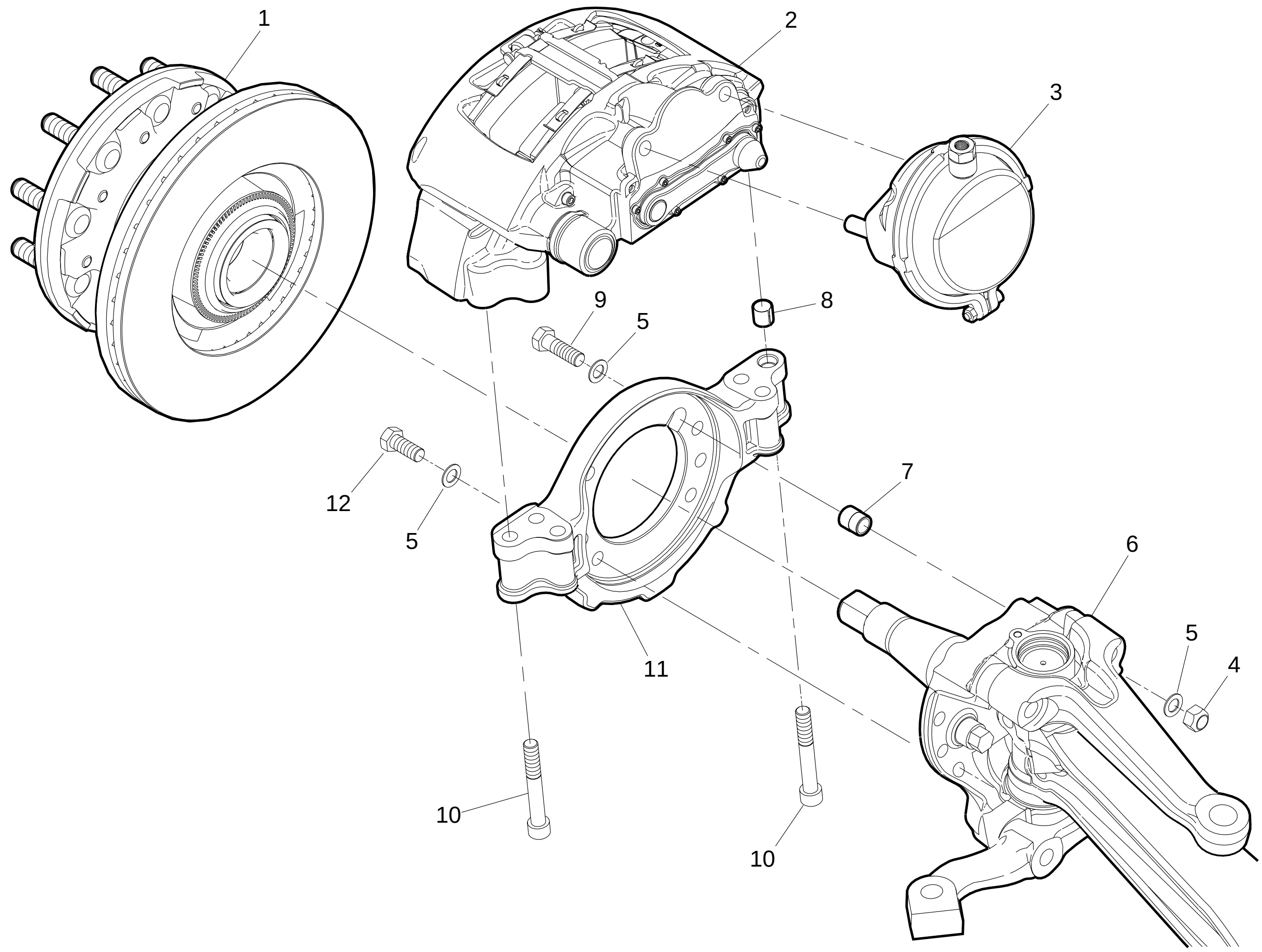
8. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 8.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
   - 8.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Rear Caliper/Carrier Assembly Removal

Refer to **Fig. 2** for rear caliper/carrier removal and installation.

1. Apply the brakes and chock the tires.

Brake Caliper/Carrier Assembly Removal and Installation



1. Hub and Disc Assembly
2. Caliper/Carrier Assembly
3. Brake Chamber
4. Nut
5. Washer
6. Spindle Assembly
7. ABS Sensor Bushing
8. Carrier Guide Bushing
9. Anchor Plate Bolt
10. Caliper Mounting Capscrew
11. Anchor Plate
12. Anchor Plate Capscrew

Fig. 1, Front Caliper and Carrier Assembly Installation

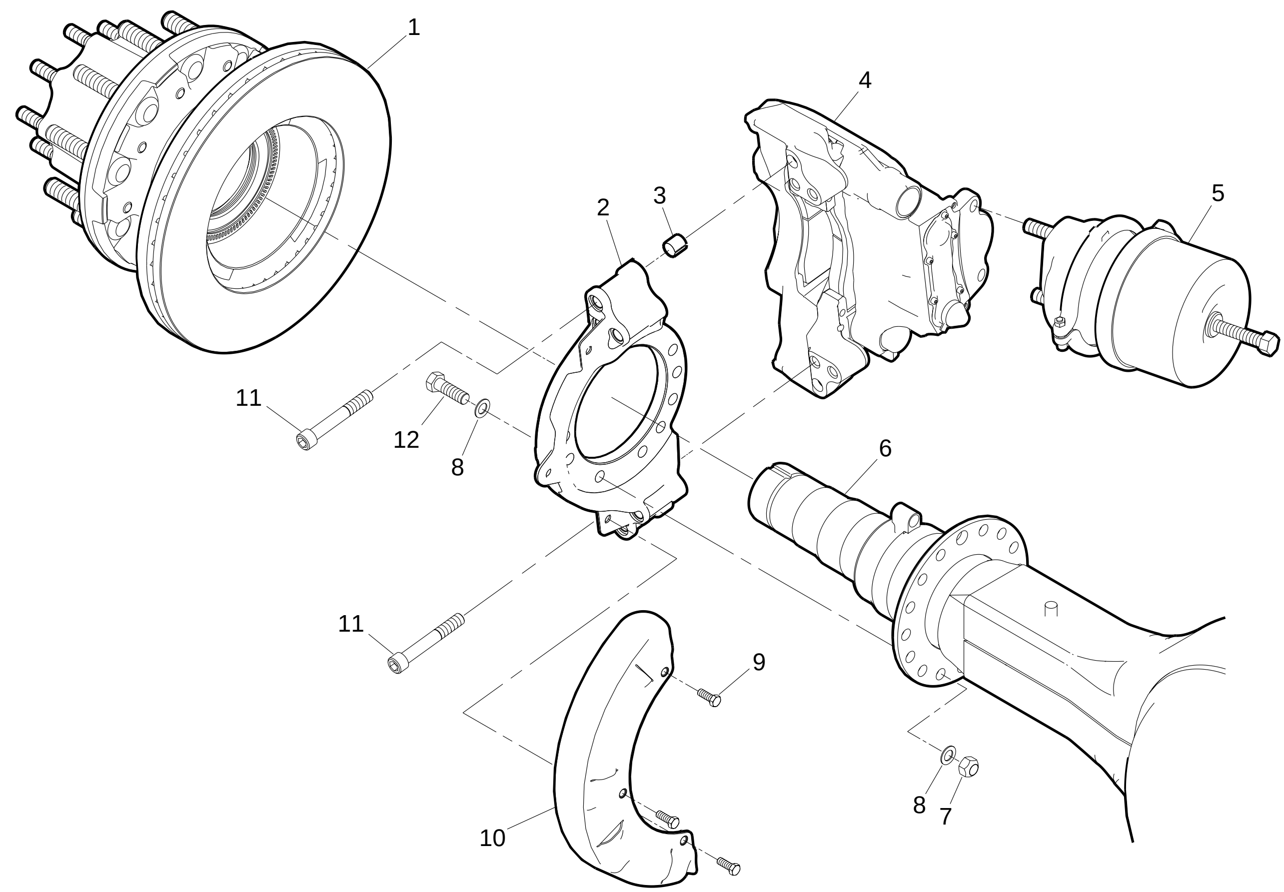
2. Raise the axle being serviced, and support it with an appropriate jackstand.
3. Remove the wheels. See **Group 40**.

WARNING

When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury or death.

4. Carefully cage and lock the spring brakes so that the springs cannot actuate during disassembly.

   Back out the release bolt using a maximum torque of 26 lbf·ft. (35 N·m) to release spring force on the pushrod. See **Fig. 3**.
5. Drain the air from the air system.



11/21/2008 f422507

1. Hub and Rotor Assembly
2. Anchor Plate
3. Carrier Guide Bushing
4. Caliper/Carrier Assembly
5. Spring Brake Chamber
6. Axle End
7. Nut
8. Washer
9. Rotor Shield Capscrew
10. Rotor Shield
11. Caliper Mounting Capscrew
12. Bolt

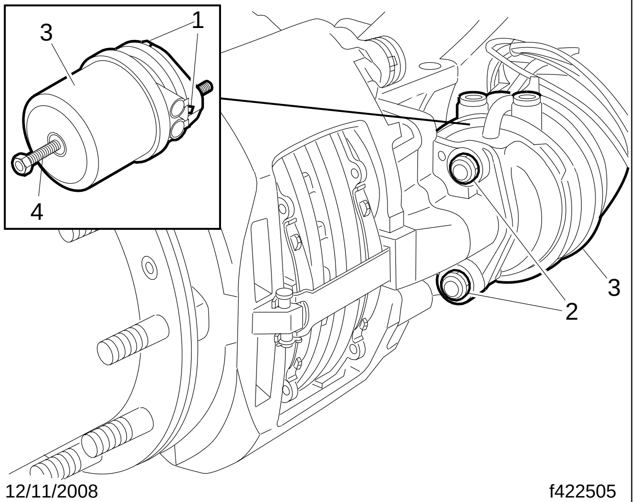
Fig. 2, Rear Caliper and Carrier Assembly Installation

6. Cut the zip ties holding the ABS harness to the brake hose as needed.
7. Remove the brake chamber from the caliper. See **Subject 150**.
8. Remove the rotor shield, if equipped.
9. With the caliper/carrier assembly securely supported, remove and discard the six bolts attaching the carrier to the anchor plate. Remove the caliper/carrier assembly.
10. Clean and inspect the anchor plate contact area. If damage is found, replace the anchor plate. See **Subject 140**.

Rear Caliper/Carrier Assembly Installation

1. Position the new carrier/caliper assembly, and attach it to the anchor plate with new bolts. Tighten 170 to 200 lbf·ft (230 to 271 N·m).

Brake Caliper/Carrier Assembly Removal and Installation



1. Drain Plugs
2. Brake Chamber Nuts
3. Brake Chamber
4. Release Bolt

Fig. 3, Spring Brake Chamber Installation

2. Install the brake pads, and brake pad shield, if equipped. See **Subject 110**.
3. Using new nuts, attach the brake chamber to the caliper/carrier assembly. Tighten 127 to 137 lbf·ft (172 to 186 N·m). See **Subject 150**.
4. Install the rotor shield, if equipped.
5. Uncage the spring brake chamber.
6. Install the wheels. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

8. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.

   8.1 Apply and release the brakes several times to check for air leaks and proper operation.

   8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

   8.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Brake Rotor Removal and Installation

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

⚠ WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

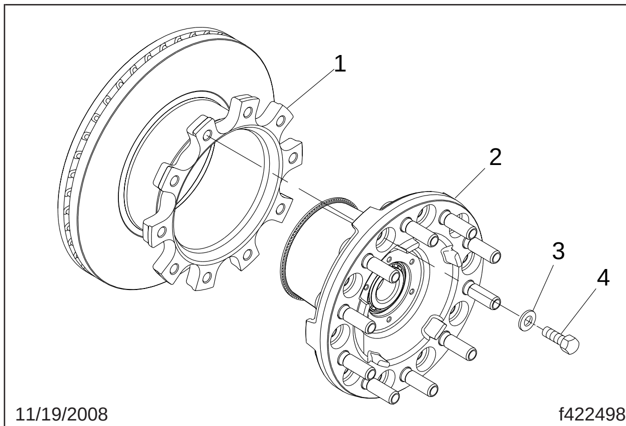
Brake Rotor Removal

1. Chock the wheels on an axle that is not being serviced.
2. Raise the axle end to be serviced, and secure it on a jackstand.
3. Remove the wheel(s). See **Group 40**.
4. Remove the brake caliper/carrier assembly. See **Subject 120**.
5. Remove the hub and rotor assembly. See **Group 33** for the front axle, or **Group 35** for the rear axle.

   If replacing the rotor, remove the capscrews from the hub, and remove the brake rotor. See **Fig. 1** for front axles, or **Fig. 2** for rear axles.

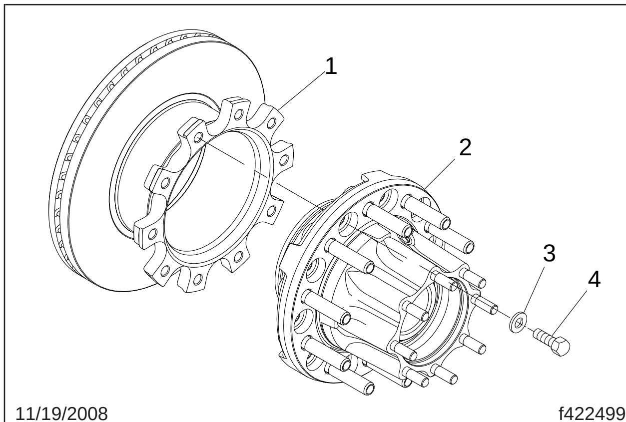
Brake Rotor Installation

1. If the rotor was removed from the hub, clean the mating surface of the hub and brake rotor as needed.



1. Rotor
2. Hub
3. Washer
4. Capscrew

Fig. 1, Front Rotor Installation



1. Rotor
2. Hub
3. Washer
4. Capscrew

Fig. 2, Rear Rotor Installation

NOTE: It may be necessary to install the hub prior to tightening the hub-to-rotor capscrews to their final torque setting.

2. If replacing the rotor, position the new rotor on the hub, and install the capscrews. See **Fig. 1** for front axles, or **Fig. 2** for rear axles. Tighten 190 to 210 lbf·ft (258 to 285 N·m) using the sequence shown in **Fig. 3**.
3. Install the hub and rotor assembly. See **Group 33** for the front axle, or **Group 35** for the rear axle.

Brake Rotor Removal and Installation

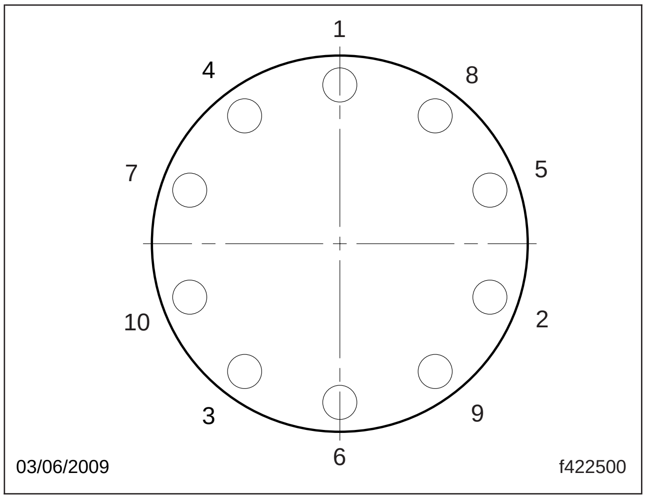


Fig. 3, Tightening Sequence

4. Install the brake caliper/carrier assembly. See **Subject 120**.
5. Install the wheel(s). See **Group 40**.
6. Remove the jackstand, and lower the vehicle.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

7. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 7.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 7.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
   - 7.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Anchor Plate Disassembly, Inspection, Cleaning, and Assembly

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

Front Anchor Plate Removal

1. Apply the brakes and chock the tires.
2. Drain the air from the air system.
3. Raise the axle being serviced, and support it on a jackstand.
4. Remove the wheel. See **Group 40**.
5. Remove the caliper/carrier assembly. See **Subject 120**.
6. Remove the hub and disc assembly. See **Subject 130**.
7. Pull the ABS sensor from its hole in the axle flange, and secure it in a safe place.
8. Remove the fasteners and remove the anchor plate. See **Fig. 1**.

Rear Anchor Plate Removal

1. Apply the brakes and chock the tires.
2. Drain the air from the air system.
3. Raise the axle being serviced, and support it on a jackstand.
4. Remove the wheels. See **Group 40**.
5. Remove the rotor shield, if equipped. See **Fig. 2**.
6. Remove the caliper/carrier assembly. See **Subject 120**.
7. Remove the hub and disc assembly. See **Subject 130**.
8. Cut the zip ties holding the ABS sensor harness in place.
9. Disconnect the ABS sensor harness at its connection to the chassis harness, then feed it through the hole in the anchor plate and secure it in a safe manner.
10. Remove the fasteners and remove the anchor plate.

Anchor Plate Cleaning and Inspection

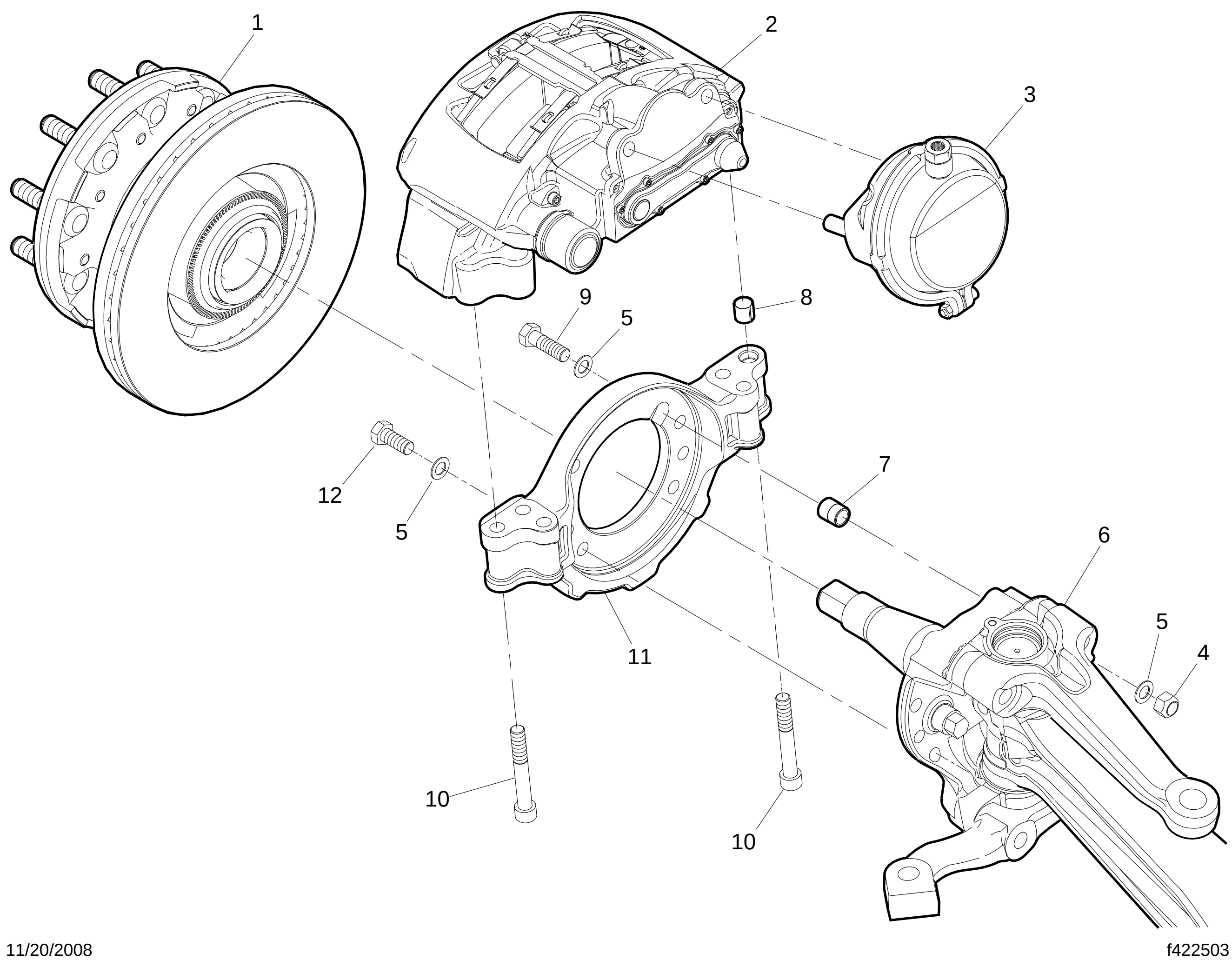
If replacing the anchor plate, it is not necessary to clean and inspect it. If the anchor plate will be re-used, clean and inspect it as follows.

1. Clean the anchor plate with a brush and solvent.
2. Inspect the anchor plate for cracks or other damage. If damage is found, replace the anchor plate.
3. Inspect the carrier and axle flange mounting surface of the anchor plate. All surfaces must be clean and free of any rust or corrosion. Use a hand-held wire brush to clean these surfaces, if needed.
4. Check that the carrier bolt hole threads are clean and free of foreign matter, and that the carrier guide bushing is secure and properly seated.

Front Anchor Plate Installation

1. Position the anchor plate on the spindle flange with the caliper mounting bosses facing up, and the ABS sensor hole (larger) aligned with the uppermost forward hole on the axle flange.
2. Install the capscrews, washers, and nuts, as shown in **Fig. 1**.
   - 2.1 Install the 2-inch capscrew, washers, and nut, in the hole next to the ABS sensor hole.
   - 2.2 Then install the 1-1/2-inch capscrews that thread into the steering knuckle.
   - 2.3 Tighten the 2-inch capscrew 144 to 164 lbf·ft (195 to 222 N·m), and the 1-1/2-inch capscrews 168 to 188 lbf·ft (228 to 255 N·m) using the sequence shown in **Fig. 3**.
3. Install the hub and disc assembly. See **Subject 130**.
4. Install the ABS sensor. Push it in by hand, as far as it will go.
5. Install the caliper/carrier assembly. See **Subject 120**.
6. Install the wheel. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

Anchor Plate Disassembly, Inspection, Cleaning, and Assembly



1. Hub and Disc Assembly
2. Caliper/Carrier Assembly
3. Brake Chamber
4. Nut
5. Washer
6. Spindle Assembly
7. ABS Sensor Bushing
8. Carrier Guide Bushing
9. Anchor Plate Bolt
10. Caliper Mounting Capscrew
11. Anchor Plate
12. Anchor Plate Capscrew

Fig. 1, Front Axle Anchor Plate Installation

WARNING

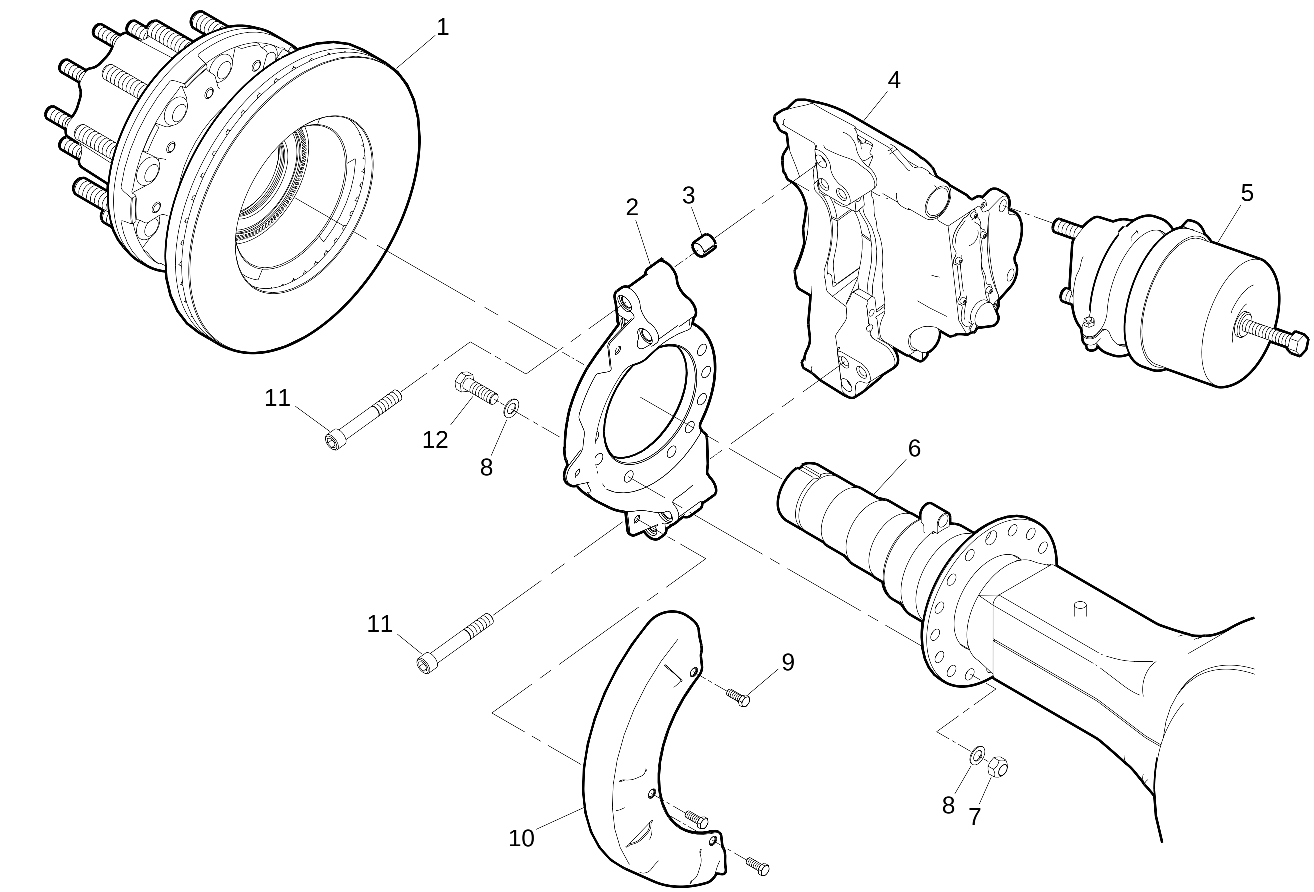
Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

8. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.

   8.1 Apply and release the brakes several times to check for air leaks and proper operation.

   8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

Anchor Plate Disassembly, Inspection, Cleaning, and Assembly



1. Hub and Rotor Assembly
2. Anchor Plate
3. Carrier Guide Bushing
4. Caliper/Carrier Assembly
5. Spring Brake Chamber
6. Axle End
7. Nut
8. Washer
9. Rotor Shield Capscrew
10. Rotor Shield
11. Caliper Mounting Capscrew
12. Bolt

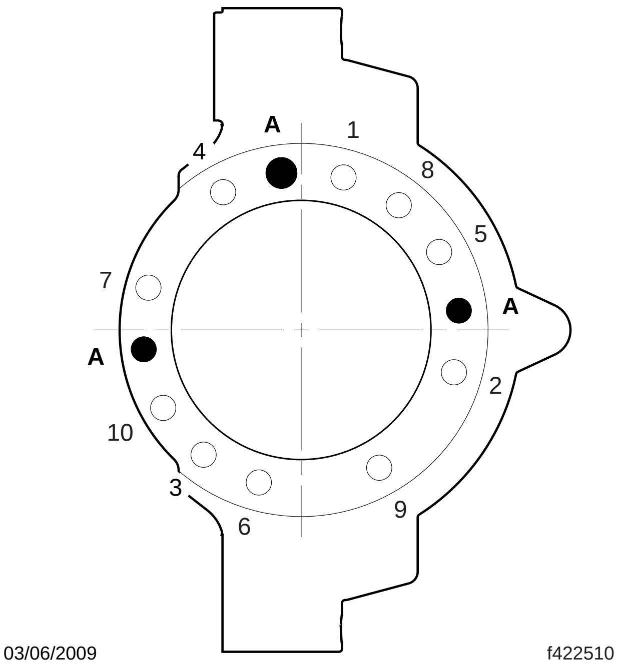
Fig. 2, Rear Axle Anchor Plate Installation

8.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Rear Anchor Plate Installation

1. Position the anchor plate on the axle flange with the ABS sensor hole at the 12 o'clock position on the axle flange. Install the ten capscrews, washers, and nuts, leaving the holes at 12, 3, and 9 o'clock positions empty. Tighten 144 to 164 lbf·ft (195 to 222 N·m), using the sequence shown in **Fig. 3**.
2. Feed the ABS sensor harness through the hole in the anchor plate, and connect it at the chassis harness. Secure it with zip ties as needed.
3. Install the hub and disc assembly. See **Subject 130**.
4. Install the caliper/carrier assembly. See **Subject 120**.
5. Install the rotor shield, if equipped.

Anchor Plate Disassembly, Inspection, Cleaning, and Assembly



A. Open Holes

Fig. 3, Tightening Sequence

6. Install the wheels. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

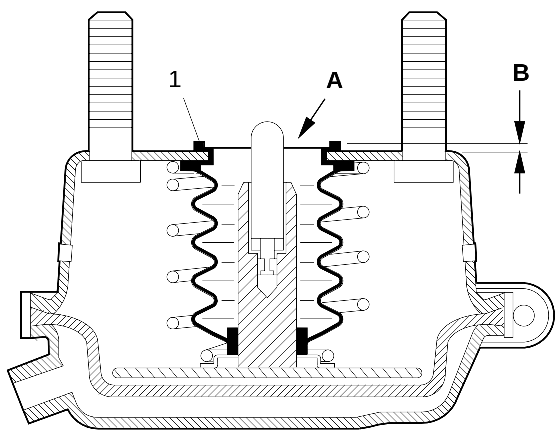
8. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 8.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
   - 8.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Brake Chamber, or Spring Brake Chamber, Removal and Installation

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

IMPORTANT: Replace the brake chamber, or spring-brake chamber, only with units that are the same as originally installed on the vehicle. Replacement with alternate equipment could compromise brake performance and the vehicle warranty. Do not use brake chambers with seals with a thickness less than 0.12 in. (3 mm). See **Fig. 1**. Use only brake chambers which are recommended by Daimler Trucks North America (DTNA).



07/01/2008 f422479

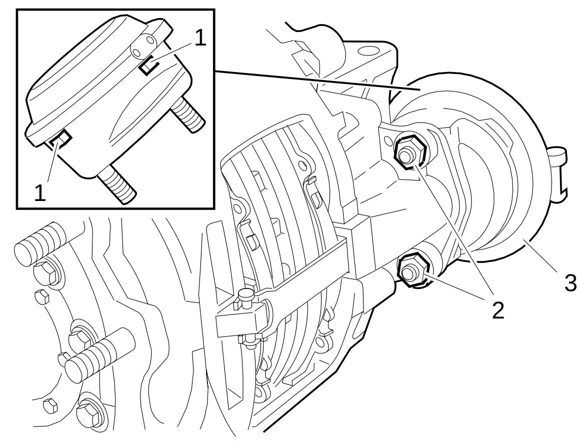
A. Pushrod Area
B. Do Not Use if Thickness is Less than 0.12 in (3 mm)
1. Seal

Fig. 1, Pushrod Area

NOTE: New brake chambers have drain hole plugs installed in all positions. After installation, remove whichever plug is at the lowest position. Be sure that all other drain holes remain plugged.

Front Brake Chamber Removal

1. Apply the brakes and chock the tires.
2. Remove the wheels.
3. Drain the air from the air system.
4. Cut the zip ties holding the ABS wire to the air hose.
5. Disconnect the air hose at the frame rail connection.
6. Remove and discard the brake chamber mounting nuts. See **Fig. 2**.



06/05/2008 f422477

1. Drain Plugs
2. Brake Chamber Mounting Nuts
3. Brake Chamber

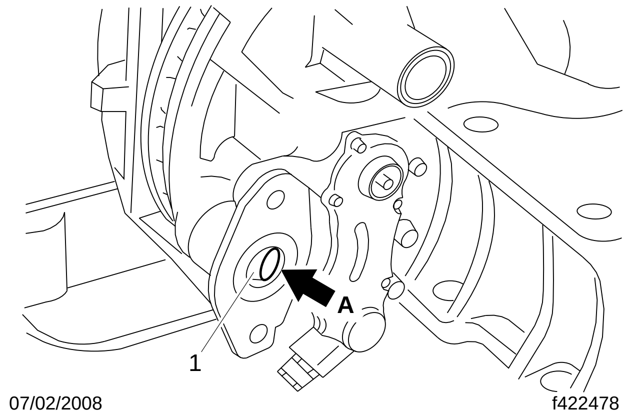
Fig. 2, Brake Chamber Installation

7. Remove the brake chamber.
8. If replacing the brake chamber, remove the air hose to use on the new one.

Front Brake Chamber Installation

1. If replacing the brake chamber, install the air hose from the old chamber.
2. Before installing the new brake chamber, clean and inspect the brake chamber flange for damage. See **Fig. 3**. The seal, as well as the pushrod area must be clean and dry. See **Fig. 1**.
3. Lubricate the spherical cup in the lever with white grease. Do not use grease containing molybdenum disulfate.

Brake Chamber, or Spring Brake Chamber, Removal and Installation



A. Actuator Flange

1. Spherical Cup in Lever

Fig. 3, Actuator Flange

4. Install the brake chamber using new self-locking nuts. Alternately tighten both nuts in increments to a final torque of 126 to 140 lbf·ft (170 to 190 N·m).
5. Connect the air hose. Be sure that the hose is not twisted, or in contact with moving vehicle components. The air hose routing must allow for full caliper travel.
6. Secure the ABS wire to the brake hose. Be sure to leave flex room.
7. Install the wheels.
8. Lower the vehicle.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

9. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.

   9.1 Apply and release the brakes several times to check for air leaks and proper operation.

   9.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

   9.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Spring Brake Chamber Removal

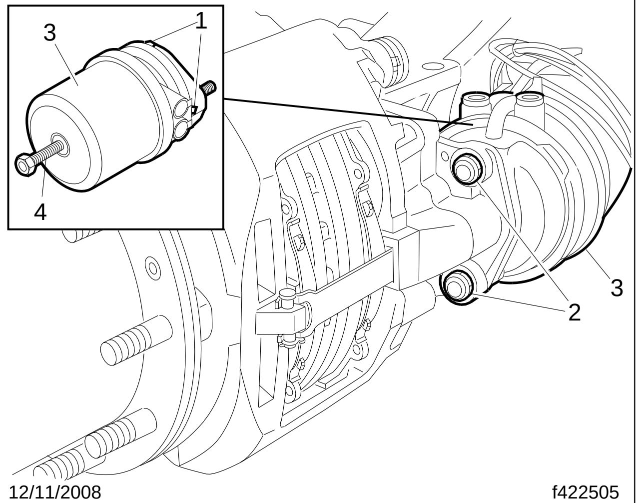
1. Set the brakes and chock the tires.
2. Remove the wheels.

WARNING

When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury or death.

3. Carefully cage and lock the spring brakes so that the springs cannot actuate during disassembly.

   Back out the release bolt using a maximum torque of 26 lbf·ft. (35 N·m) to release spring force on the pushrod. See **Fig. 4**.
4. Drain all the air pressure from the air brake system.



1. Drain Plugs
2. Brake Chamber Nuts
3. Brake Chamber
4. Release Bolt

Fig. 4, Spring Brake Chamber Installation

5. Cut the zip ties holding the ABS wire to the air hose.
6. Disconnect the air hose at the frame rail connection.
7. While supporting the spring brake chamber in position, remove and discard brake chamber mounting nuts. Remove the brake chamber.
8. If replacing the brake chamber, remove the air hose to use on the new one.

Spring Brake Chamber Installation

IMPORTANT: Replace the brake chamber, or spring-brake chamber, only with units that are the same as originally installed on the vehicle. Replacement with alternate equipment could compromise brake performance and the vehicle warranty. Do not use brake chambers with seals with a thickness less than 0.12 in. (3 mm). See **Fig. 1**. Use only brake chambers which are recommended by DTNA.

NOTE: New brake chambers have drain hole plugs installed in all positions. After installation, remove whichever plug is at the lowest position. Be sure that all other drain holes remain plugged.

1. If replacing the brake chamber, install the air hose from the old chamber.
2. Before installing the new brake chamber, clean and inspect the brake chamber flange for damage. The seal, as well as the pushrod area must be clean and dry. See **Fig. 3**.
3. Lubricate the spherical cup in the lever with white grease. Do not use grease containing molybdenum disulfate. See **Fig. 3**.
4. Install the brake chamber using new self-locking nuts. Alternately tighten both nuts in increments to a final torque of 126 to 140 lbf·ft (170 to 190 N·m).
5. Connect the air hose. Be sure that the hose is not twisted, or in contact with moving vehicle components. The air hose routing must allow for full caliper travel.
6. Secure the ABS wire to the brake hose. Be sure to leave flex room.
7. Uncage the spring brake.
8. Install the wheels.
9. Lower the vehicle.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

10. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
    - 10.1 Apply and release the brakes several times to check for air leaks and proper operation.
    - 10.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
    - 10.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

Specifications

Bendix Air Disc Brake Fastener Torque Specifications	
Installation	**Torque: lbf·ft (N·m)**
Hub to Rotor	190–210 (258–285)
Anchor Plate to Axle Flange: 2-inch (front)	144–164 (195–222)
Anchor Plate to Axle Flange: 1.5-inch (front)	168–188 (228–255)
Anchor Plate to Axle Flange (rear)	144–164 (195–222)
Caliper to Anchor Plate	170–200 (230–271)
Brake Chamber to Caliper	126–140 (170–190)
Rotor Shield to Anchor Plate	25–35 (34–47)

Table 1, Bendix Air Disc Brake Fastener Torque Specifications

Brake Rotor Runout and Parallelism Check

Runout Check

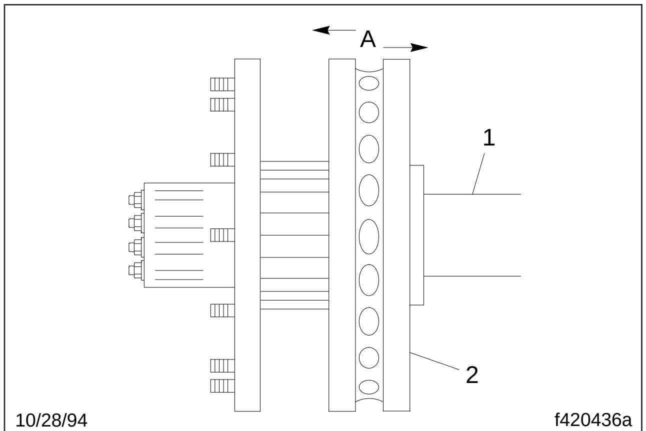
Brake rotor runout refers to the amount of lateral wobble the rotor has when it is turning, with the wheel bearings correctly adjusted. See **Fig. 1**. Check the rotor runout whenever you replace the brake pads.

1. If not already done, chock the tires, jack up the axle you are working on and support it with jackstands. Remove the wheels and tires.
2. If working on the rear axle, put the transmission in neutral.
3. Using a dial indicator, measure the amount of runout while spinning the rotor, as shown in **Fig. 2**. Make sure the indicator is centered on the rotor face (between the outer and inner edges).
4. If the runout is more than 0.015 inch (0.38 mm), check that the rotor is securely mounted to the hub. Also check the wheel bearing end-play, following the instructions in **Group 33** for the front axle or **Group 35** for the rear axle.
5. Repeat the runout measurement. If the runout is still more than 0.015 inch (0.38 mm), replace the rotor.

Parallelism Check

Parallelism is the difference in rotor thickness at different points around the rotor. It should be checked whenever the brake pads are replaced.

1. Using a micrometer, measure the thickness of the rotor (between the inboard and outboard faces) at four or more equally spaced points around the rotor. See **Fig. 3**.
2. If there is a difference of more than 0.005 inch (0.13 mm) between any two measurements, have the rotor resurfaced. If resurfacing will decrease the overall thickness of the rotor to 1.32 inches (33.5 mm) or less, replace the rotor.



A. Runout Dimensions
1. Axle
2. Rotor

Fig. 1, Brake Rotor Runout

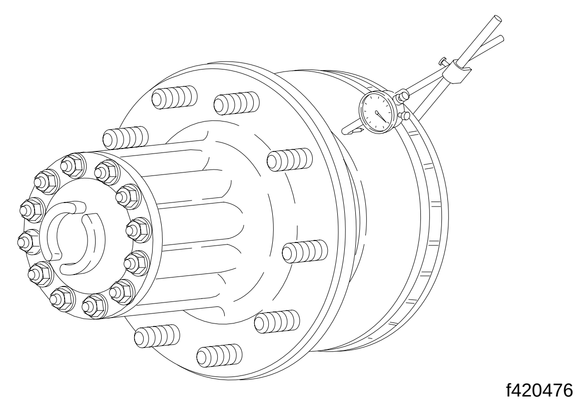
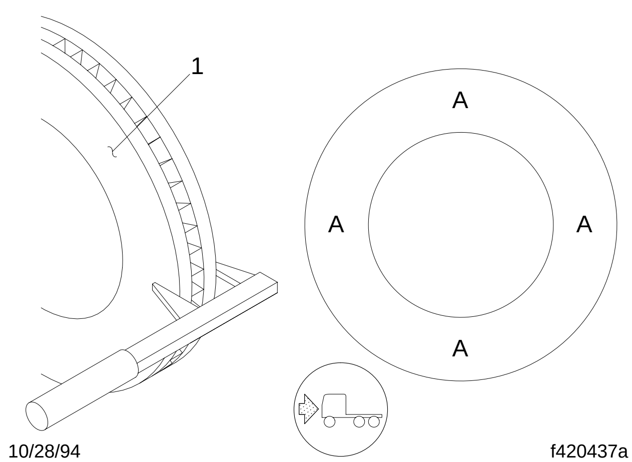


Fig. 2, Measure Runout

Brake Rotor Runout and Parallelism Check



A. Measure thickness here.

1. Rotor Face

Fig. 3, Measure Rotor Thickness

Chapter Six

Parking Brake Interlock

Parking Brake Interlocks

Parking brake interlocks are safety devices designed to prevent accidental bus roll off. These devices require an ignition signal and service brake application before park brake release.

During non-interlock park brake release the PP1 sends air pressure to the SR-1 valve. The SR-1 then sends air to the spring brake chambers to overcome spring pressure and release the parking brakes. Parking brake interlocks stop the air flow from the PP1 valve to downstream valves until certain conditions are met, namely ignition power and service brake application. There are several designs of interlocks some of which will be covered in this section of this manual.

Chapter Ten

Parking Brake Interlock

Parking Brake Interlocks

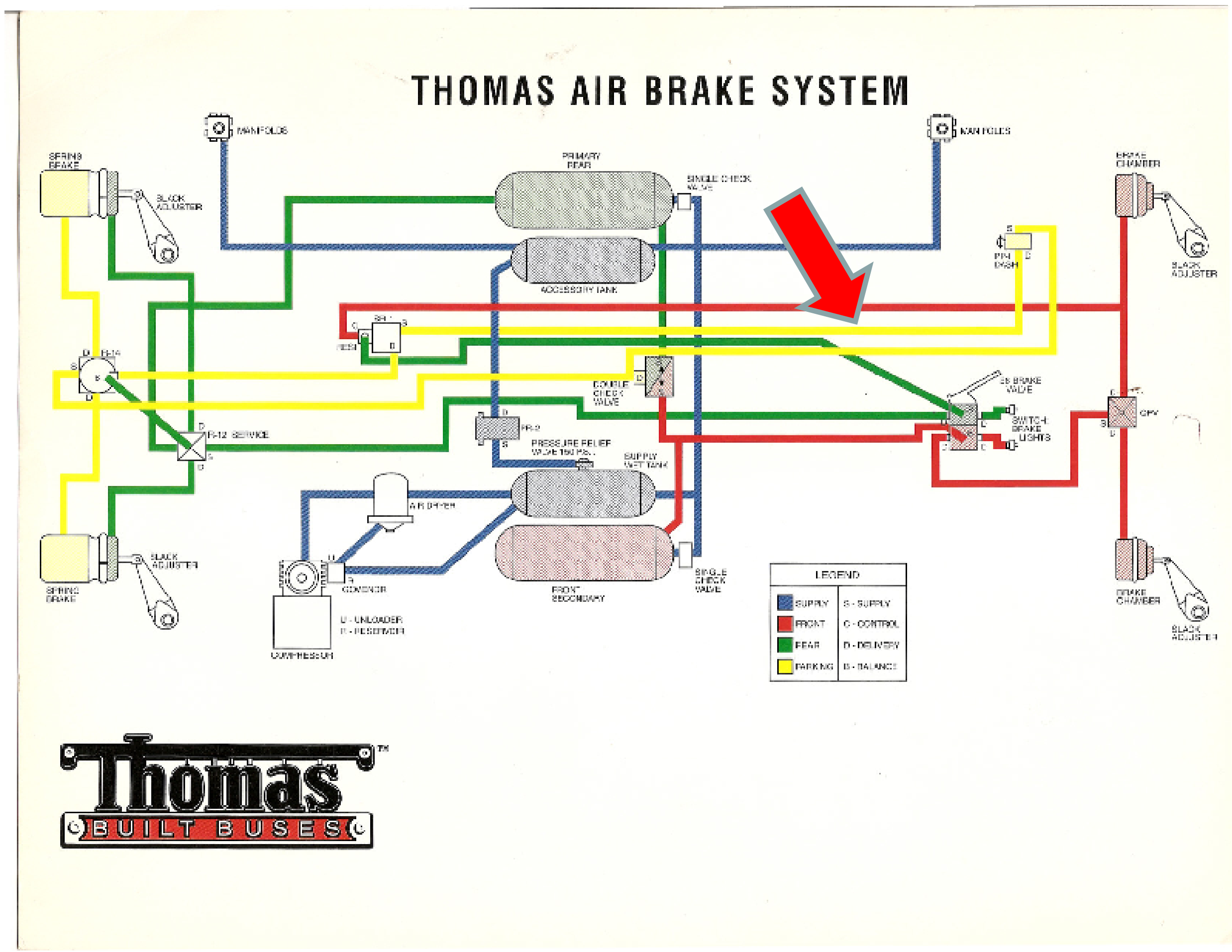
Parking brake interlocks are safety devices designed to prevent accidental bus roll off. These devices require an ignition signal and service brake application before park brake release.

During non-interlock park brake release the PP1 sends air pressure to the SR-1 valve. The SR-1 then sends air to the spring brake chambers to overcome spring pressure and release the parking brakes. Parking brake interlocks stop the air flow from the PP1 valve to downstream valves until certain conditions are met, namely ignition power and service brake application. There are several designs of interlocks some of which will be covered in this section of this manual.

Park Brake Interlock

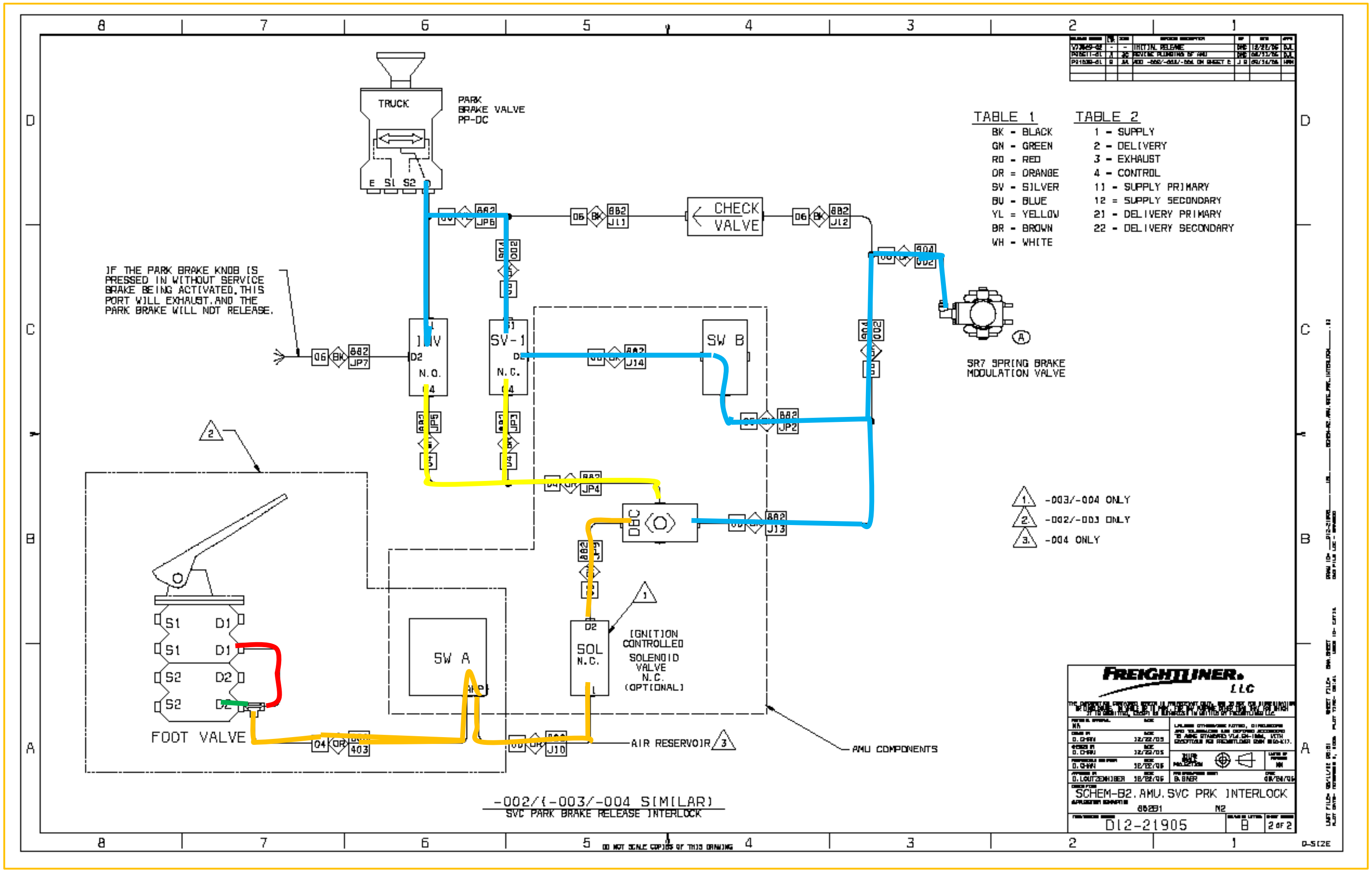
Diagnosing park brake interlock problems on C2s and HDXs

Standard Air Brake System

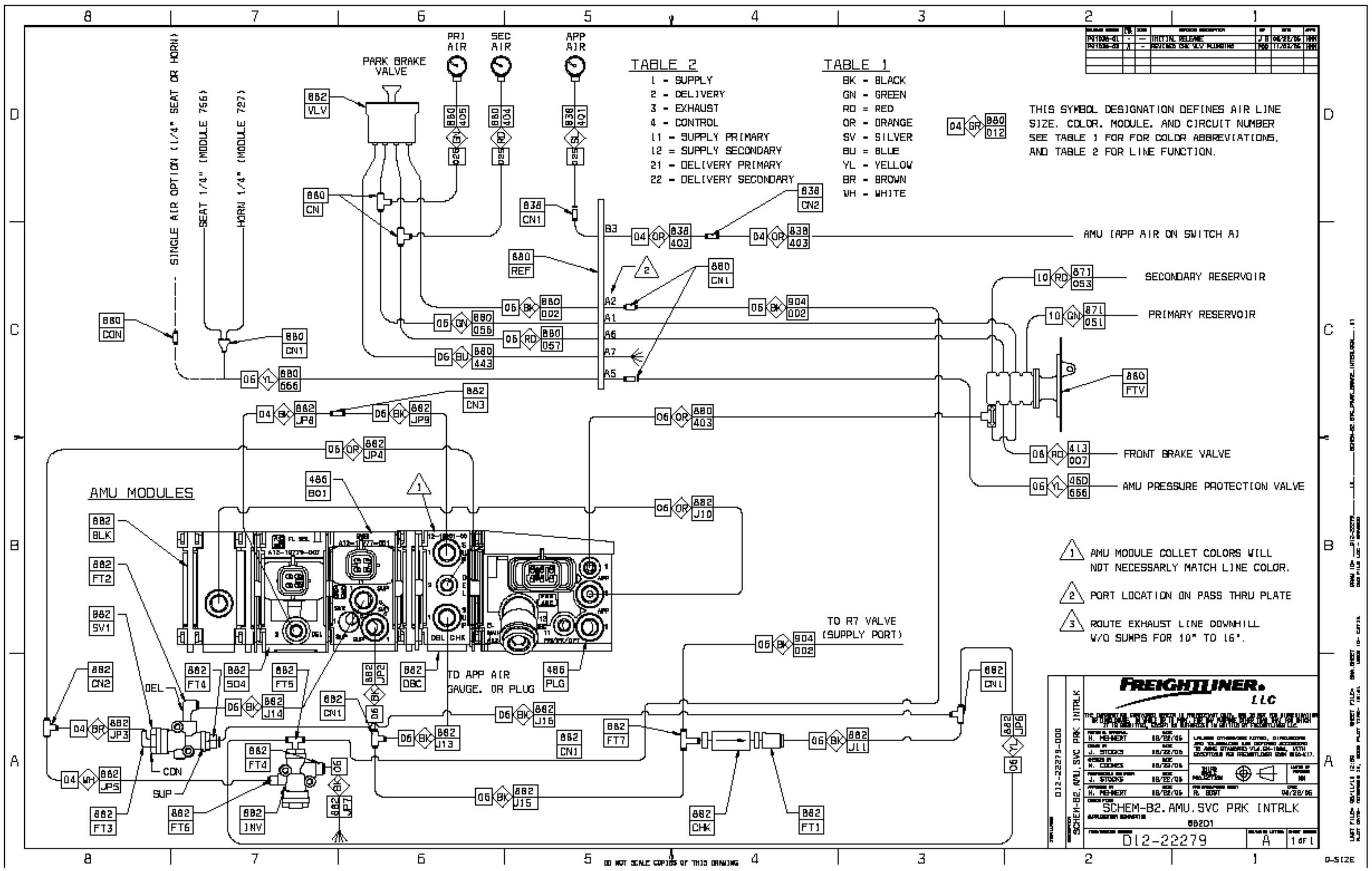


N/C valve installed in park brake line to SR1 or SR7 valve. Service brake signal opens the valve.

Schematic Bus Without DEF

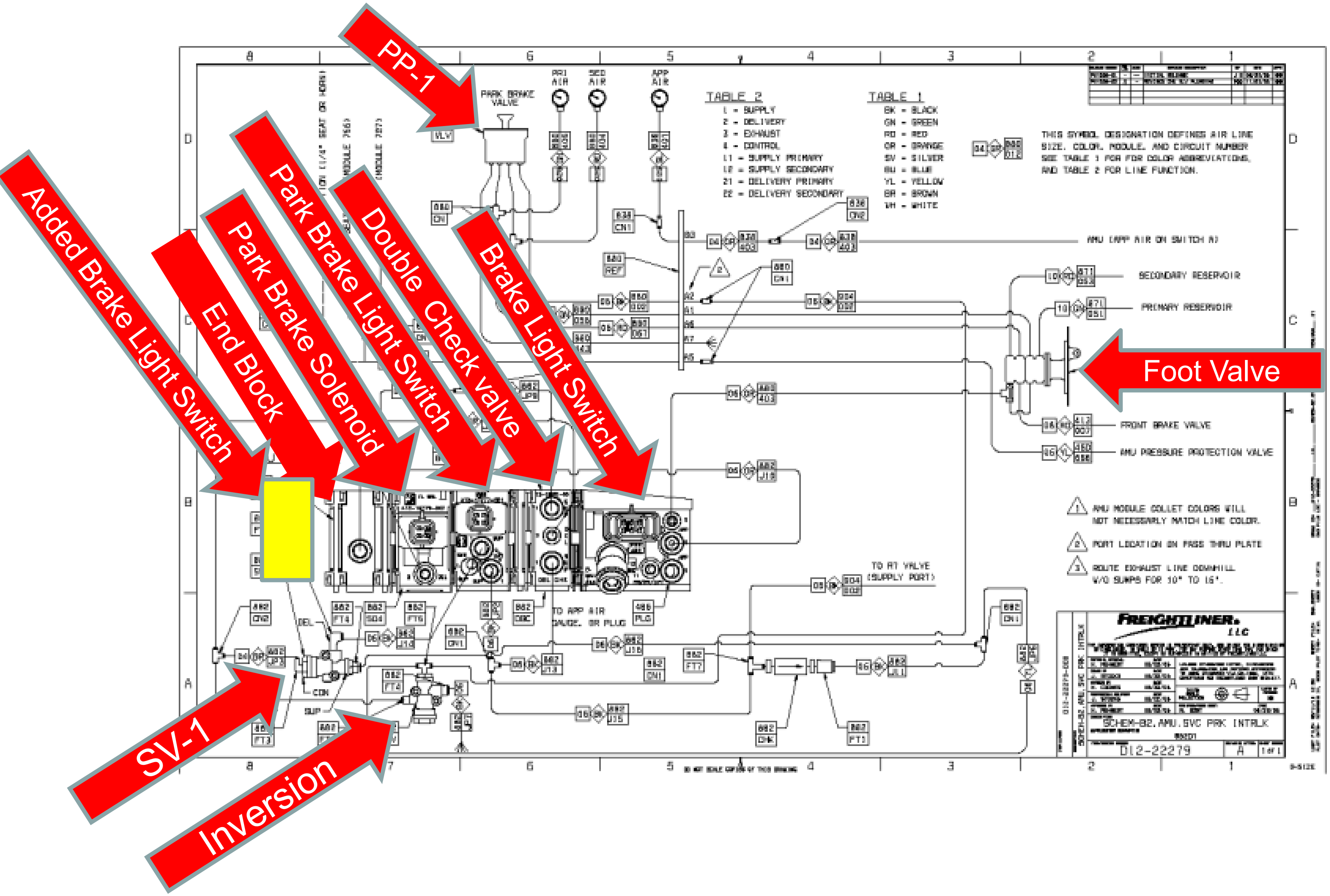


AMU



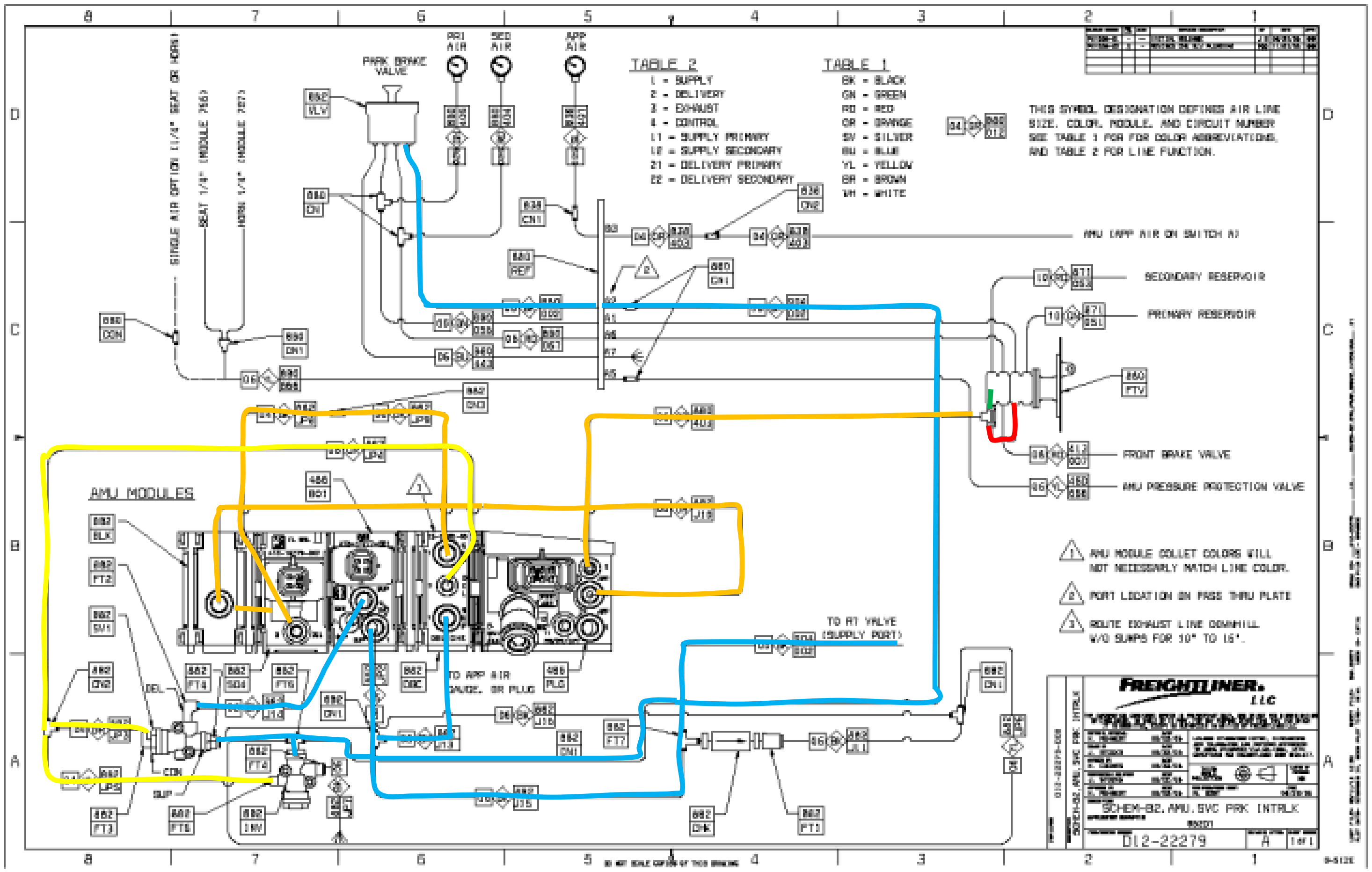
PARK BRAKE VALVE
PRI AIR
SEC AIR
APP AIR
TABLE 2
1 - SUPPLY
2 - DELIVERY
3 - EXHAUST
4 - CONTROL
11 - SUPPLY PRIMARY
12 - SUPPLY SECONDARY
21 - DELIVERY PRIMARY
22 - DELIVERY SECONDARY
TABLE 1
BK - BLACK
GN - GREEN
RD - RED
OR - ORANGE
SV - SILVER
BU - BLUE
YL - YELLOW
BR - BROWN
WH - WHITE
THIS SYMBOL DESIGNATION DEFINES AIR LINE SIZE, COLOR, MODULE, AND CIRCUIT NUMBER
SEE TABLE 1 FOR FOR COLOR ABBREVIATIONS, AND TABLE 2 FOR LINE FUNCTION.
SINGLE AIR OPTION (1/4" SEAT OR HORN)
SEAT 1/4" (MODULE 756)
HORN 1/4" (MODULE 727)
AMU (APP AIR ON SWITCH A)
SECONDARY RESERVOIR
PRIMARY RESERVOIR
FRONT BRAKE VALVE
AMU PRESSURE PROTECTION VALVE
AMU MODULES
TO R7 VALVE (SUPPLY PORT)
TO APP AIR GAUGE, OR PLUG
AMU MODULE COLLET COLORS WILL NOT NECESSARILY MATCH LINE COLOR.
PORT LOCATION ON PASS THRU PLATE
ROUTE EXHAUST LINE DOWNHILL W/O SUMPS FOR 10" TO 16".
FREIGHTLINER LLC
SCHEM-B2, AMU, SVC PRK INTRLK
D12-22279
DO NOT SCALE COPIES OF THIS DRAWING
D-SIZE

AMU



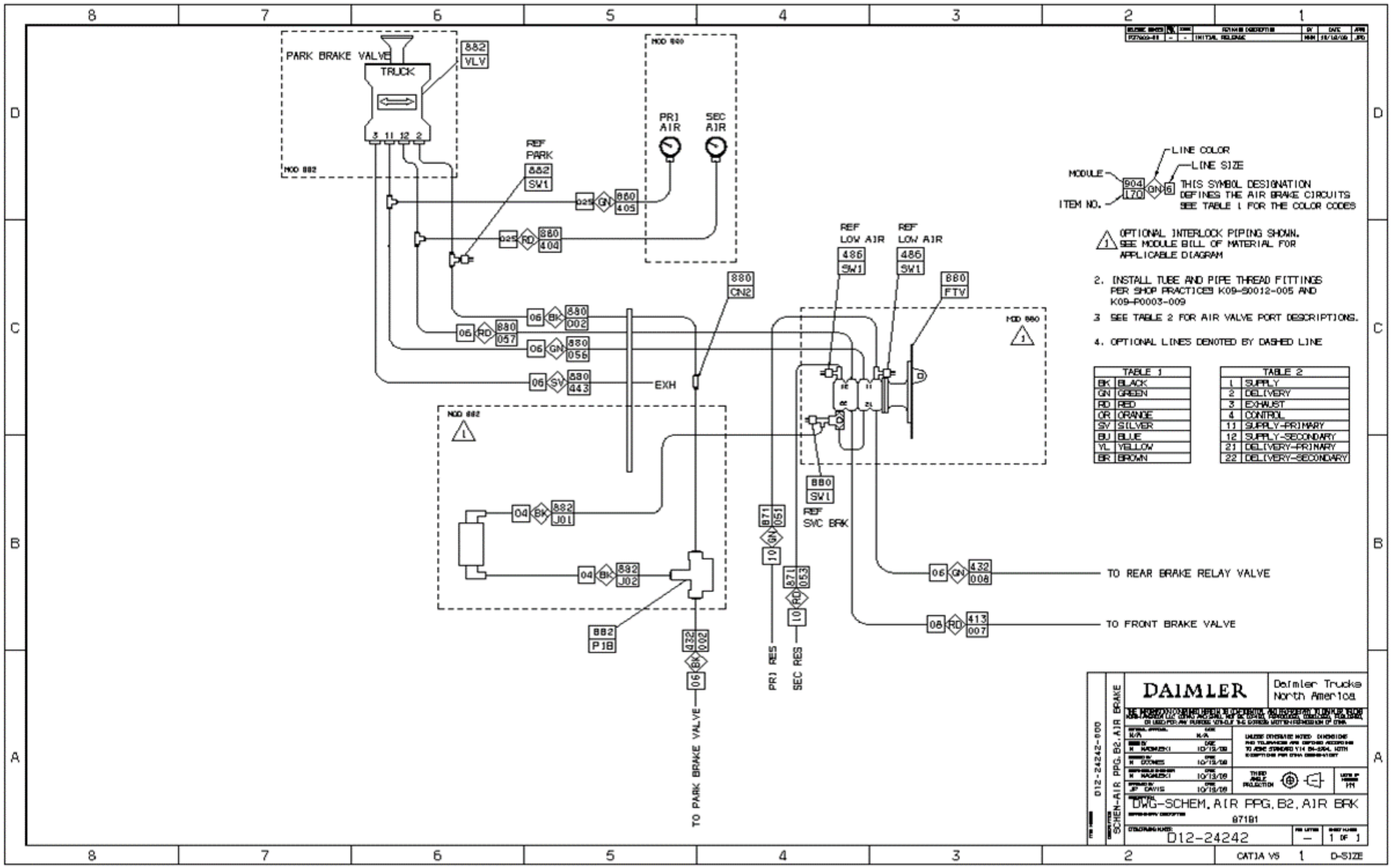
PP-1
Added Brake Light Switch
End Block
Park Brake Solenoid
Park Brake Light Switch
Double Check valve
Brake Light Switch
Foot Valve
SV-1
Inversion
PARK BRAKE VALVE
PRI AIR
SEC AIR
APP AIR
TABLE 2
1 = SUPPLY
2 = DELIVERY
3 = EXHAUST
4 = CONTROL
11 = SUPPLY PRIMARY
12 = SUPPLY SECONDARY
21 = DELIVERY PRIMARY
22 = DELIVERY SECONDARY
TABLE 1
BK = BLACK
GN = GREEN
RD = RED
OR = ORANGE
SV = SILVER
BU = BLUE
YL = YELLOW
BR = BROWN
WH = WHITE
THIS SYMBOL DESIGNATION DEFINES AIR LINE SIZE, COLOR, MODULE, AND CIRCUIT NUMBER
SEE TABLE 1 FOR FOR COLOR ABBREVIATIONS,
AND TABLE 2 FOR LINE FUNCTION.
AMU (APP AIR ON SWITCH A)
SECONDARY RESERVOIR
PRIMARY RESERVOIR
FRONT BRAKE VALVE
AMU PRESSURE PROTECTION VALVE
AMU MODULE COLLET COLORS WILL NOT NECESSARILY MATCH LINE COLOR.
PORT LOCATION ON PASS THRU PLATE
ROUTE EXHAUST LINE DOWNHILL W/O SUMPS FOR 10" TO 15".
TO R1 VALVE (SUPPLY PORT)
TO APP AIR GAUGE, OR PLUG
FREIGHTLINER LLC
SCHEM-B2, AMU, SVC PRK INTRLK
D12-22279

AMU

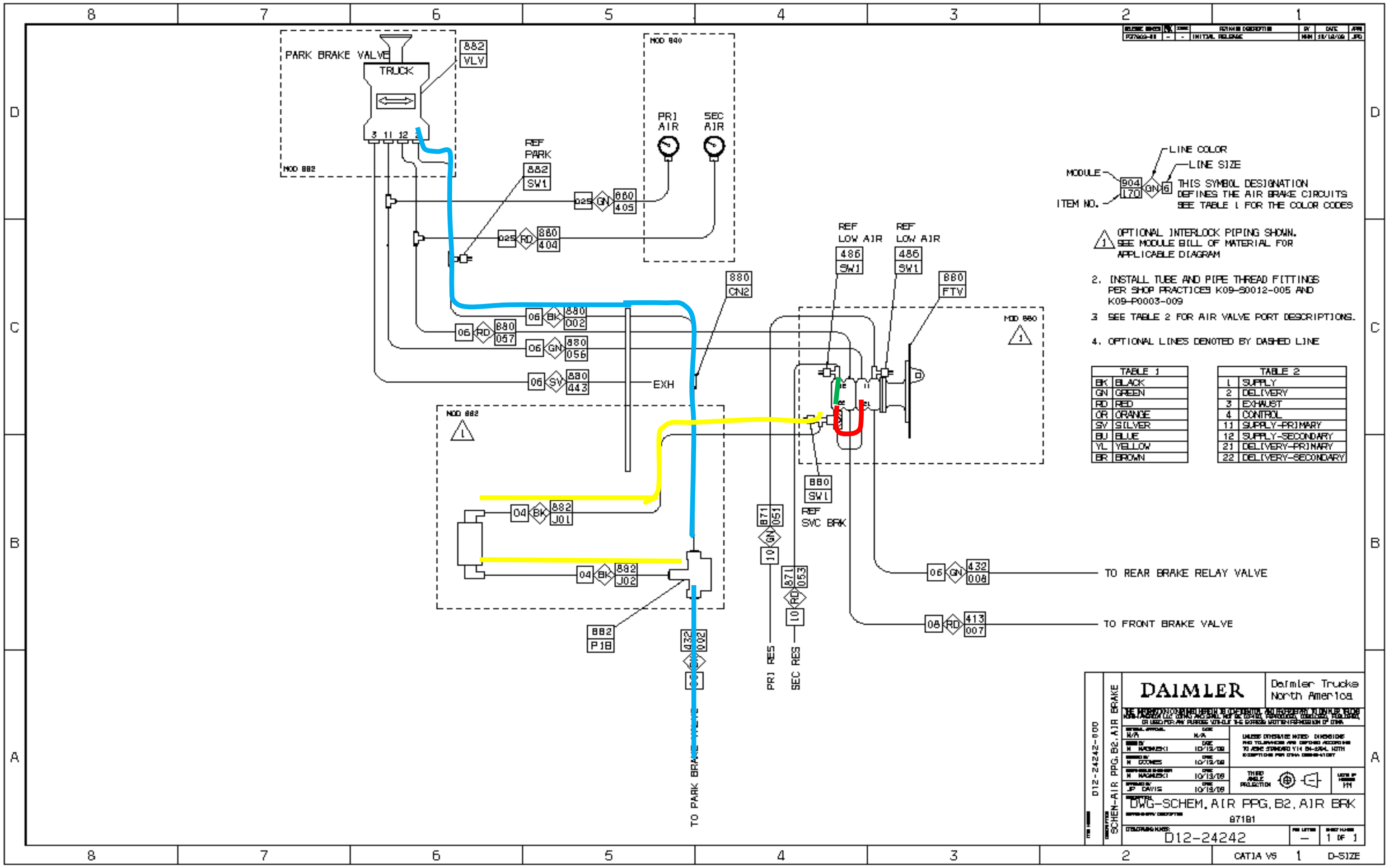


PARK BRAKE VALVE
PRI AIR
SEC AIR
APP AIR
TABLE 2
1 = SUPPLY
2 = DELIVERY
3 = EXHAUST
4 = CONTROL
11 = SUPPLY PRIMARY
12 = SUPPLY SECONDARY
21 = DELIVERY PRIMARY
22 = DELIVERY SECONDARY
TABLE 1
BK = BLACK
GN = GREEN
RD = RED
OR = ORANGE
SV = SILVER
BU = BLUE
YL = YELLOW
BR = BROWN
WH = WHITE
THIS SYMBOL DESIGNATION DEFINES AIR LINE SIZE, COLOR, MODULE, AND CIRCUIT NUMBER. SEE TABLE 1 FOR FOR COLOR ABBREVIATIONS, AND TABLE 2 FOR LINE FUNCTION.
AMU (APP AIR ON SWITCH A)
SECONDARY RESERVOIR
PRIMARY RESERVOIR
FRONT BRAKE VALVE
AMU PRESSURE PROTECTION VALVE
AMU MODULES
AMU MODULE COLLET COLORS WILL NOT NECESSARILY MATCH LINE COLOR.
PORT LOCATION ON PASS THRU PLATE
ROUTE EXHAUST LINE DOWNHILL W/O SUMPS FOR 10° TO 15°.
TO A1 VALVE (SUPPLY PORT)
TO APP AIR GAUGE, OR PLUG
SINGLE AIR OPTION (1/4" SEAT OR HORN)
SEAT 1/4" (MODULE 766)
HORN 1/4" (MODULE 287)
FREIGHTLINER LLC
SCHEM-B2, AMU, SVC PRK INTRLK
D12-22279

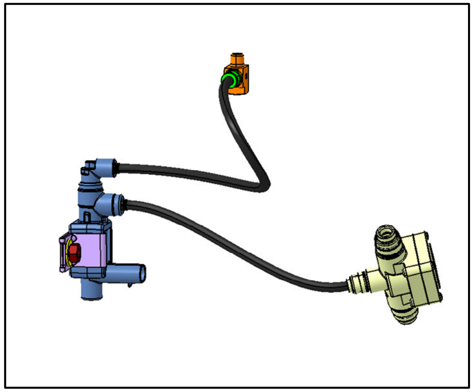
2010 and Up Design



Schematic for New Design

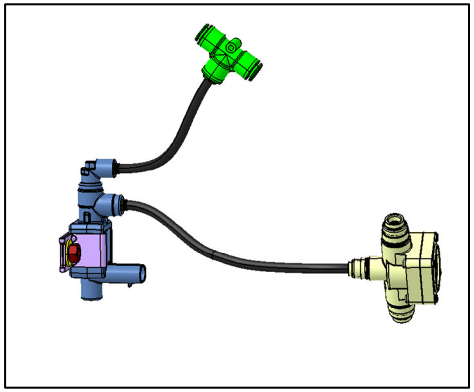


RELEASE NUMBER	REV LTR	REVISION DESCRIPTION	BY	DATE	APPD
P37802-02	-	INITIAL RELEASE	NHM	09/18/09	JPD
P38780-03	A	NOTES REVISED, SHEETS 1 AND 3	NHM	12/15/09	JPD



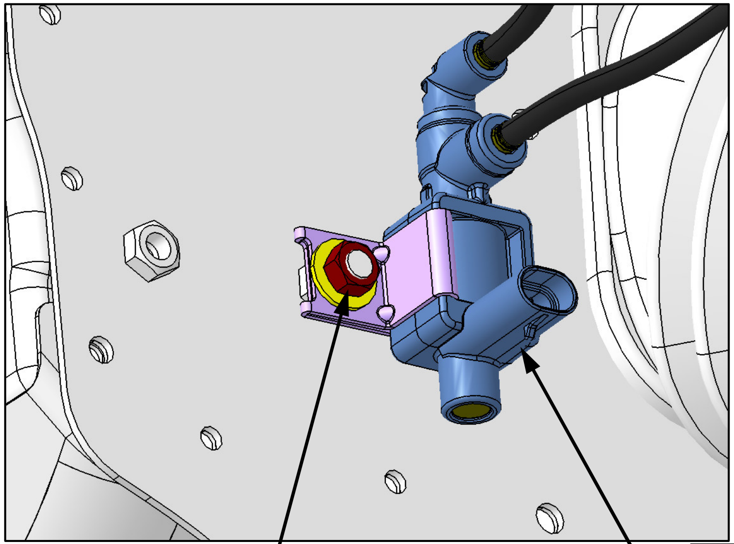
-000 INSTL

(AIR)



-001 INSTL

(HYD)



882
NUT
WSH
CLP

882
SOL

FWD

DETAIL A

1. CONNECTS TO DELIVERY ON PARK BRAKE VALVE, MOD 882 VLV.

2. CONNECTS TO R7 VALVE SUPPLY PORT.

3. CONNECTS TO MOD 904 FT2 AT QUICK RELEASE VALVE, MOD 904 QRV.

4. INSTALL THE PBI SO THAT THE EXHAUST IS NOT FACING UPWARD TO COLLECT WATER. TIE TO HOSE BUNDLE ABOVE AND BELOW PBI. A

5. PIPE CONNECTIONS PER K09-S0012-005

ITEM NUMBER	DESCRIPTION
D12-24157-001	INSTL-SERVICE PARK IINTERLOCK,B2,HYD
D12-24157-000	INSTL-SERVICE PARK IINTERLOCK,B2,AIR

DAIMLER

Daimler Trucks North America

		DATE
MATERIAL APPROVAL	N/A	N/A
DRAWN BY	N. MAGNUSKI	09/18/09
CHECKED BY	M. COOMES	09/18/09
RESPONSIBLE ENGINEER	N. MAGNUSKI	09/18/09
APPROVED BY	JP. DAVIS	09/18/09

UNLESS OTHERWISE NOTED, DIMENSIONS AND TOLERANCESARE DEFINED ACCORDING TO ASME Y14.5M- 1994,WITH EXCEPTION PER DTNA 09ENG-WI037

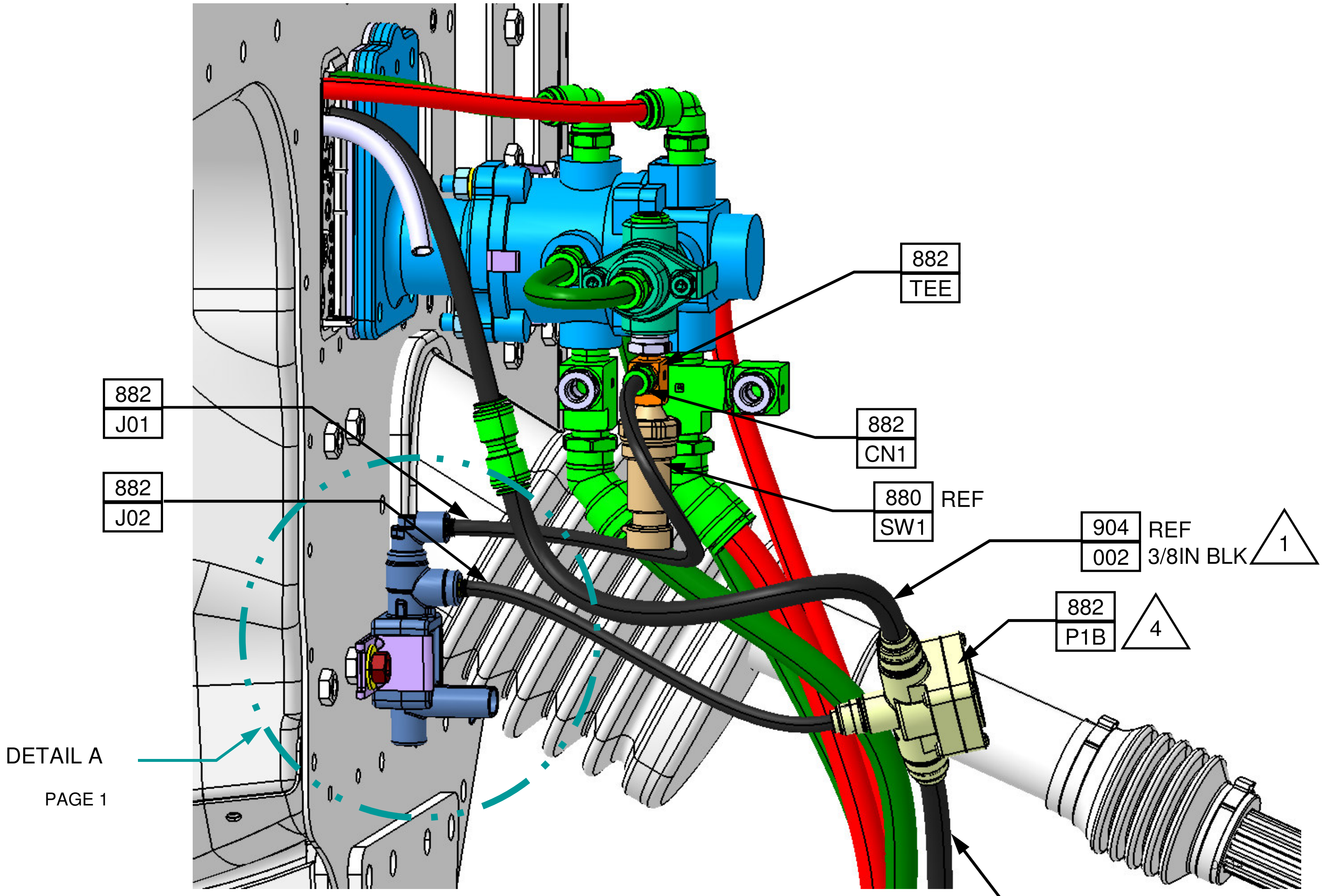
THIRD ANGLE PROJECTION

UNITS OF MEASURE MM

DESCRIPTION
DWG-INSTL,SERVICE PARK INTERLOCK,B2

SUPPLEMENTAL DESCRIPTION
882A1

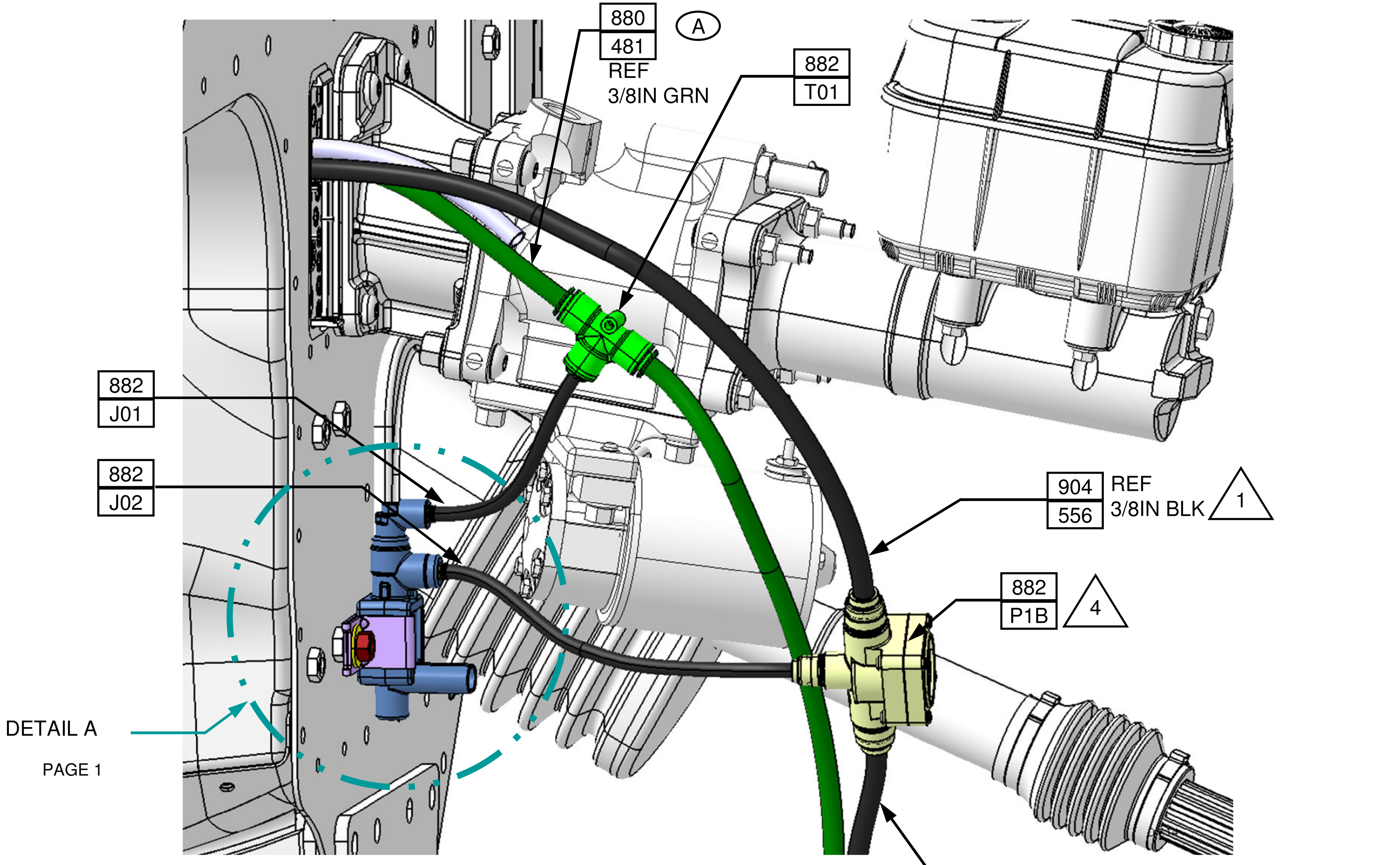
ITEM/DRAWING NUMBER	REVISION LETTER	PAGE
D12-24157	A	1 of 3



-000 INSTL

(AIR)

FWD



-001 INSTL

(HYD)

Chapter Seven

ABS/ESC
Anti-Lock Braking System
And
Electronic Stability Control

Meritor Wabco

Anti-Lock Braking System (ABS)

MERITOR WABCO

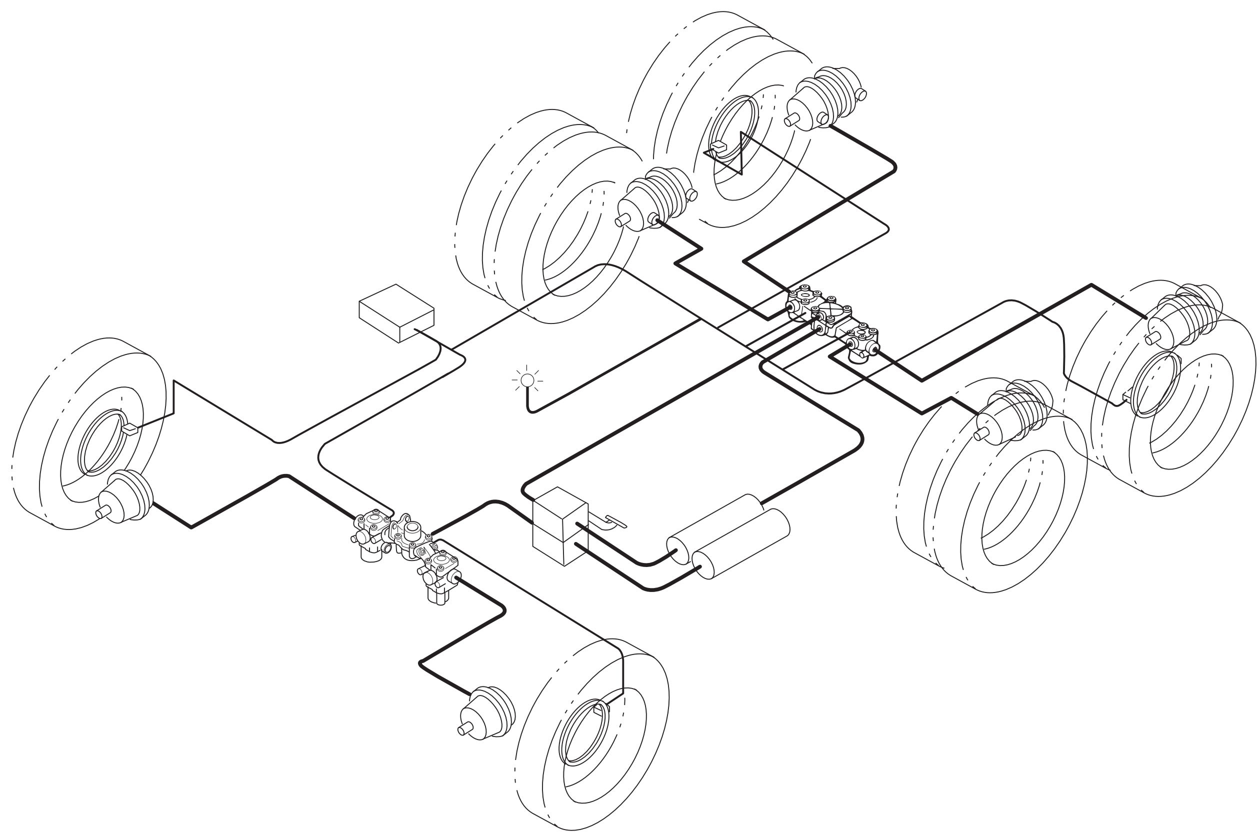
Maintenance Manual MM-0112

Anti-Lock Braking System (ABS) and Electronic Stability Controls (ESC)

For E Version ECUs

12-Volt and 24-Volt Systems

Revised 07-15



About This Manual

This manual contains maintenance procedures for Meritor WABCO's Anti-Lock Braking System (ABS), Roll Stability System (RSC), Electronic Stability Controls (ESC) and Hill Start Aid (HSA).

Before You Begin

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.
3. Follow your company's maintenance and service, installation and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Hazard Alert Messages and Torque Symbols

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

⚠ WARNING

A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.

⚠ CAUTION

A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.

This symbol alerts you to tighten fasteners to a specified torque value.

⚠ WARNING

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

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

⚠ CAUTION

When welding on an ABS- or ABS/ATC-equipped vehicle is necessary, disconnect the power connector from the ECU to prevent damage to the electrical system and ABS/ATC components.

How to Obtain Additional Maintenance, Service and Product Information

Visit Literature on Demand at meritor.com or meritorwabco.com to access and order additional information.

Contact the Meritor OnTrac™ Customer Call Center at 866-668-7221 (United States and Canada); 001-800-889-1834 (Mexico); or email OnTrac@meritor.com.

If Tools and Supplies are Specified in This Manual

Call Meritor's Commercial Vehicle Aftermarket at 888-725-9355 to obtain Meritor tools and supplies.

ASBESTOS FIBERS 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 Meritor.

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/m3 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.

Contents

Contents

This manual contains service information for the following systems.

- E version Meritor WABCO Anti-Lock Braking System (ABS)
- Automatic Traction Control (ATC)
- Roll Stability Control (RSC)
- Electronic Stability Controls (ESC) for trucks, tractors and buses

The ABS version is marked on the ECU. Figure 1.1. If you cannot identify the ECU version installed on your vehicle, contact the Meritor OnTrac™ Customer Call Center at 866-OnTrac1 (668-7221).

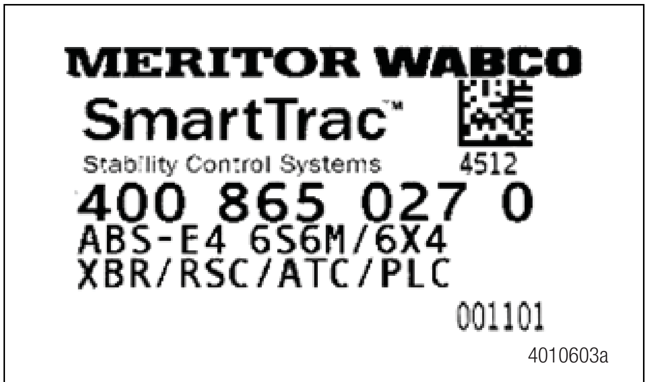


Figure 1.1

For Additional Information

Diagnostic and testing procedures for other ECU versions can be found in the following manuals.

- C version ECUs — Maintenance Manual 28, Anti-Lock Braking Systems (ABS) for Trucks, Tractors and Buses
- D version ECUs — Maintenance Manual 30, Anti-Lock Braking Systems (ABS) for Trucks, Tractors and Buses

Refer to the following manuals for Trailer ABS diagnostics and information.

- Maintenance Manual 33, Easy-Stop™ Trailer ABS
- Maintenance Manual MM-0180, Enhanced Easy-Stop™ Trailer ABS with PLC

Anti-Lock Braking System (ABS)

ABS is a system designed to provide and maintain the best possible traction and steering control during an extreme braking event. During a potential wheel lock event, the ABS ECU, using information provided by the wheel speed sensors, sends a signal(s) to the appropriate modulator valve(s) to hold, apply or release the brakes as needed. ABS works automatically, the driver does not have to select this feature.

System Components

Electronic Control Unit (ECU)

The ECU is the control center or "brain" of the ABS, RSC and ESC systems. It receives information from the sensors, processes data and sends signals to modulators and active braking valves to achieve different tasks. Depending on the system and vehicle configuration, ECUs are available for cab- or frame-mounted applications and are divided into Basic Cab, Universal Cab, Frame and Advance Frame models. RSC and ESC systems are only available on universal and advance frame ECUs. Figure 1.2.

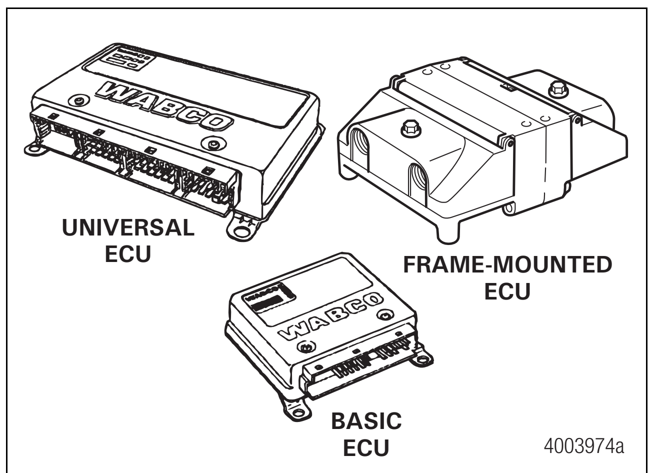


Figure 1.2

Wheel Speed Sensing Systems

Wheel speed sensing systems consist of a tooth wheel mounted on the hub or rotor of each monitored wheel and a speed sensor installed with its end against the tooth wheel. The sensor continuously sends wheel speed information to the ECU. A sensor clip holds the sensor in place and against the tooth wheel. Figure 1.3.

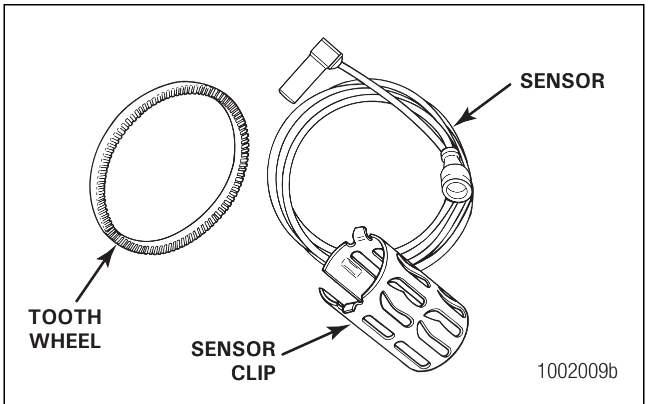


Figure 1.3

The type of axle determines sensor mounting location.

- Steering axle sensors are installed in the steering knuckle or in a bolted-on bracket.
- Drive axle sensors are mounted in a block attached to the axle housing or in a bolted-on bracket.

Check the wheel speed sensors for correct alignment and adjustment. Apply lubricant to the sensor and sensor clip whenever wheel-end maintenance is performed. Make sure tooth wheels are free of contaminants. Refer to Section 3 and Section 4 for more information.

Pressure Modulator Valves

A modulator valve controls air pressure to an affected wheel-end brake during an ABS, RSC or ESC event to reduce speed and prevent wheel lock up. Modulator valves are also used during ATC events to properly gain traction on the affected wheel end. Figure 1.4.

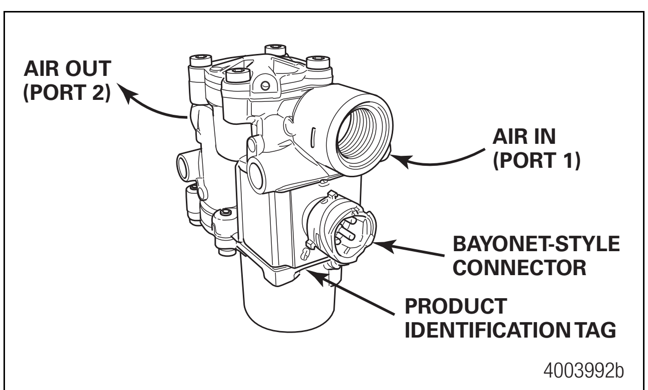


Figure 1.4

A modulator valve is usually located on a frame rail or cross member near the brake chamber or as part of a valve package. A valve package combines two modulator valves, a service relay (Figure 1.5) or quick release valve (Figure 1.6), and depending on the vehicle configuration, an active braking valve (ABV).

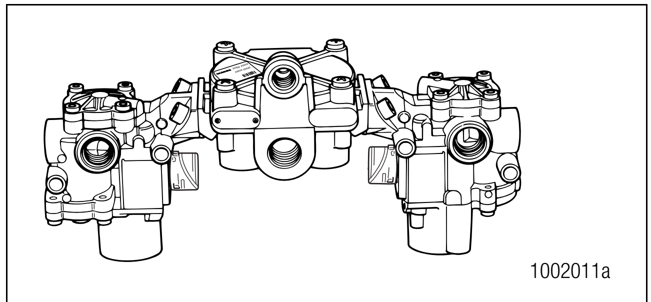


Figure 1.5

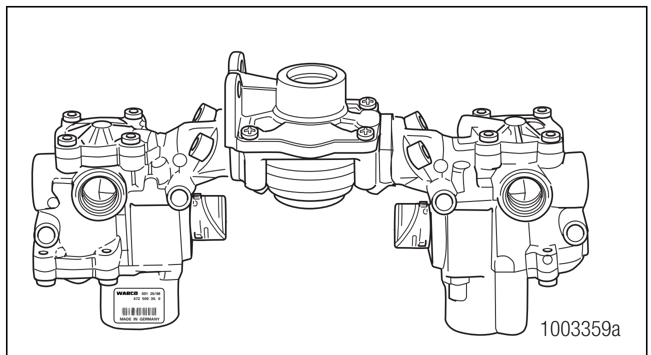


Figure 1.6

Easy Listening Tip!

To ensure the ABS valves are working — just listen! Figure 1.7.

⚠ WARNING

Park the vehicle on a level surface. 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 or fall over. Serious personal injury and damage to components can result.

1. Turn on the ignition.
2. Wait for the ABS indicator lamp to come on.
3. Listen for the valves to click or puff/chuff air in the order shown in Figure 1.7.

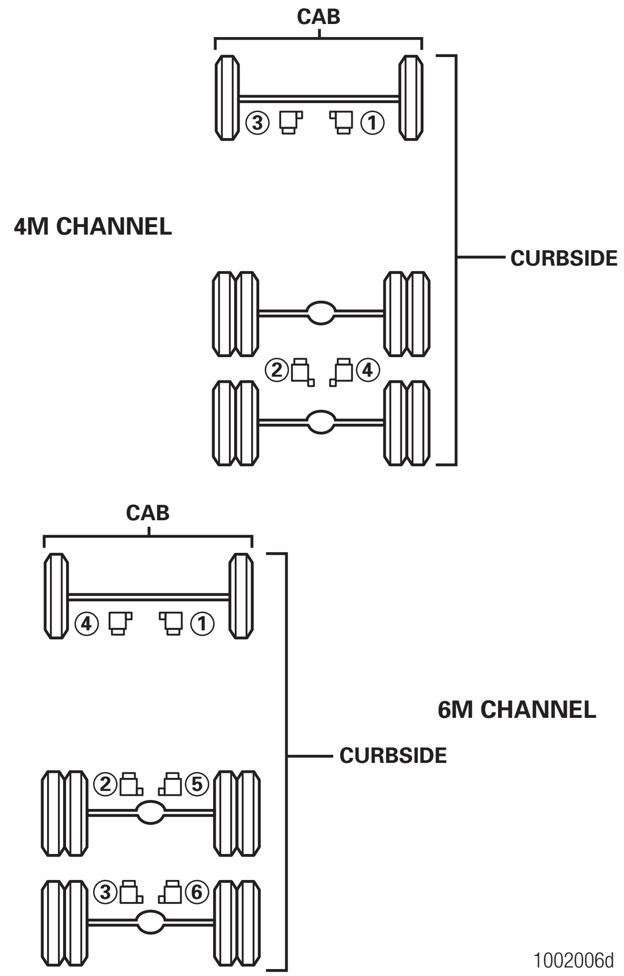


Figure 1.7

NOTE: In previous versions of ABS, the valves are cycled diagonally. Diagonal cycling does not occur with E version ABS.

Active Braking Valves (ABV)

Active Braking Valves, sometimes referred to as ABVs or 3/2 valve, are solenoid valves used for active braking during ATC, RSC or ESC events. Depending on system configurations, ABVs can be located in the front axle braking system, rear axle braking system and/or the trailer service brake system. Figure 1.8.

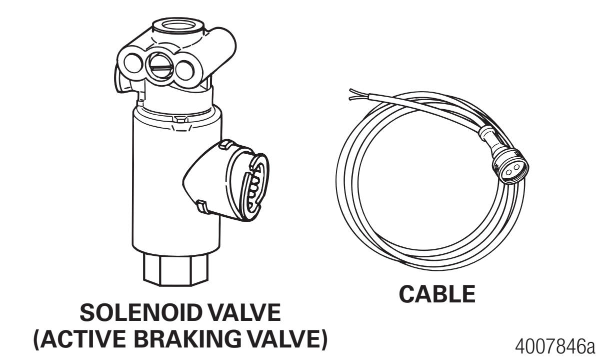


Figure 1.8

Brake Pressure Sensor (BPS)

The Brake Pressure Sensor or BPS is part of the RSC, ESC and HSA system. It provides the system with the driver's brake demand. The sensor can be located in the primary or secondary delivery circuit depending on the application. Figure 1.9.

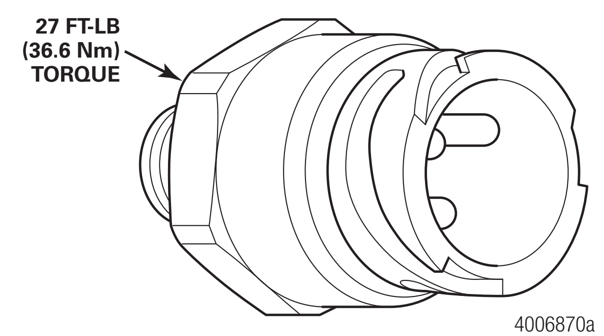
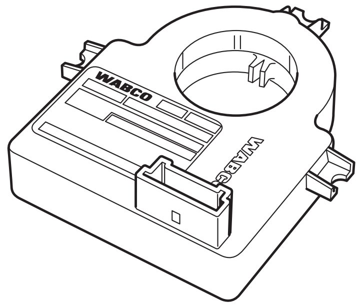


Figure 1.9

Steering Angle Sensor (SAS)

The Steering Angle Sensor (SAS) is part of the ESC system. The SAS delivers the driver's steering input (steering wheel position) to the ECU using a dedicated ESC system internal data link. The ECU supplies the sensor with voltage and ground. The SAS must be calibrated using diagnostic tools whenever it is replaced, or when any vehicle steering components are replaced or adjusted. Refer to Section 8. Figure 1.10.

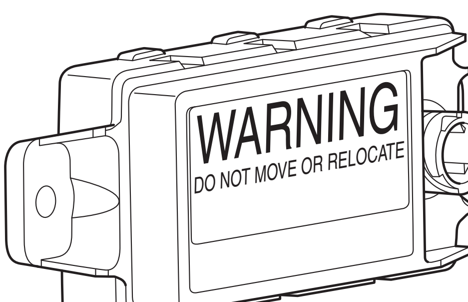


4006873a

Figure 1.10

Electronic Stability Control (ESC) Module

The ESC module is part of the ESC system. It measures the vehicle yaw rate as well as vehicle lateral acceleration. The ESC module includes part of the ESC control algorithm. It exchanges data with the ECU via the ESC system internal data link. The ECU supplies the module with voltage and ground. The ESC module must be initialized by diagnostic tools whenever the ECU or the ESC module is replaced. Refer to Section 8. Figure 1.11.



4010604a

Figure 1.11

Trailer Modulator Valve

In some stability control applications, an additional modulator valve (the same as what is used for ABS modulation) will be located in the trailer control line downstream of the 3/2 solenoid valve used to control the trailer.

Off-Road ABS Switch

On some vehicles, an off-road ABS switch can be included. The off-road ABS function improves vehicle control and helps reduce stopping distances in off-road conditions or on poor traction surfaces such as loose gravel, sand and dirt.

ATC Switch

A vehicle manufacturer might offer an ATC switch to control the ATC function. Depending on the vehicle ECU configuration for the switch, there are two function options.

- Deep snow and mud option
- ATC momentary override option

Refer to Section 2 for more information regarding these features.

Blink Code Switch

A vehicle manufacturer might offer a Blink Code switch to obtain simple troubleshooting information. Refer to Section 3 for more information about Blink Codes.

System Configuration

The system configuration is defined by the number of wheel end sensors and modulator valves. There are three common system configurations used with E version ECUs. Refer to Section 5 for more system configurations.

- 4S/4M (4 wheel speed sensors, 4 modulator valves)
- 6S/4M (6 wheel speed sensors, 4 modulator valves)
- 6S/6M (6 wheel speed sensors, 6 modulator valves)

Each system configuration can have features such as ATC, HSA, RSC or ESC. See Figure 1.12 and Figure 1.13 for an example.

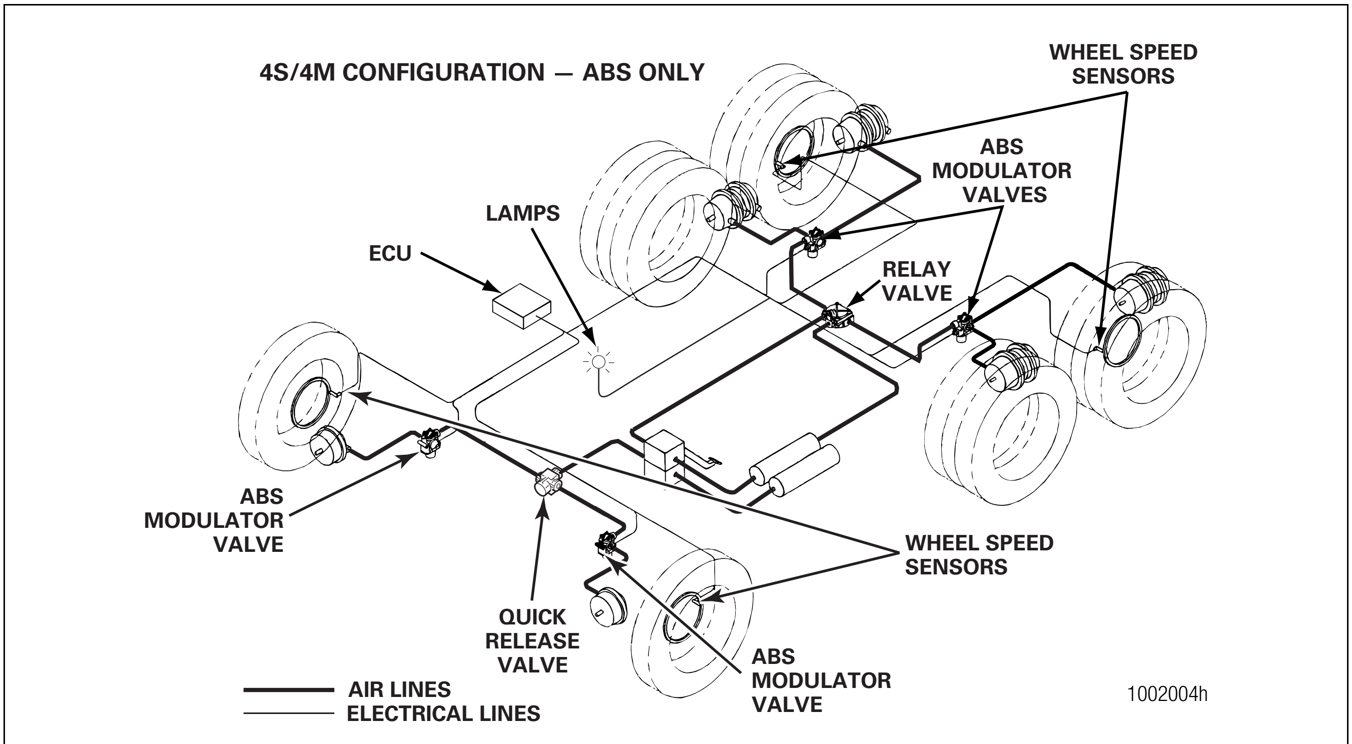


Figure 1.12

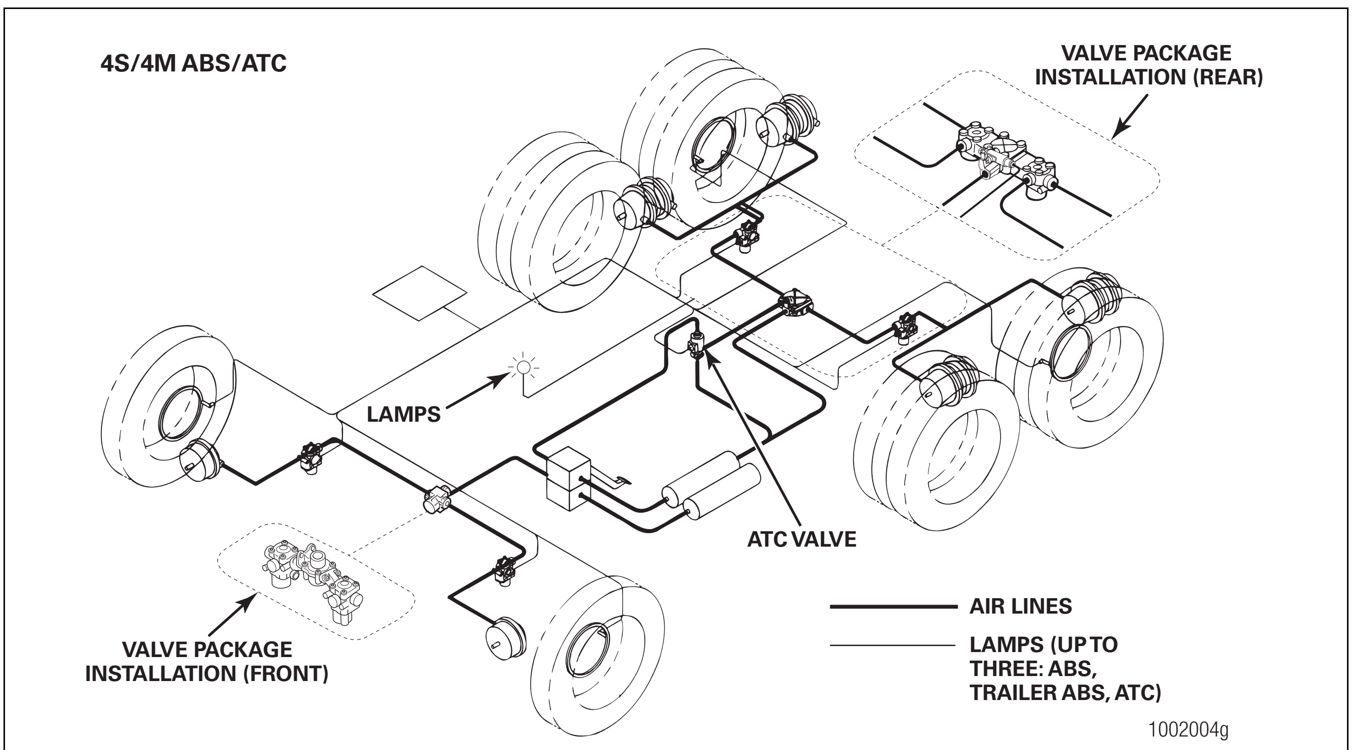


Figure 1.13

ATC

Automatic Traction Control is available as an option on all E version ECUs and is standard on most. ATC helps improve traction in low traction road conditions. ATC reduces the potential of jackknifing caused by excessive wheel spin during acceleration or in curves. ATC works automatically in two different ways.

A. When one drive wheel is spinning at a different speed than the other, ATC momentarily applies the brake until traction is regained.

B. When both drive wheels are spinning on a poor-traction surface, ATC automatically reduces engine power to attain optimum tire-to-road traction.

ATC will automatically turn on and off. Driver input is not required to turn this feature on. If the vehicle experiences a traction control event, the ATC indicator lamp will come on, indicating ATC is active. The light turns off when the event has ended. Figure 2.1.

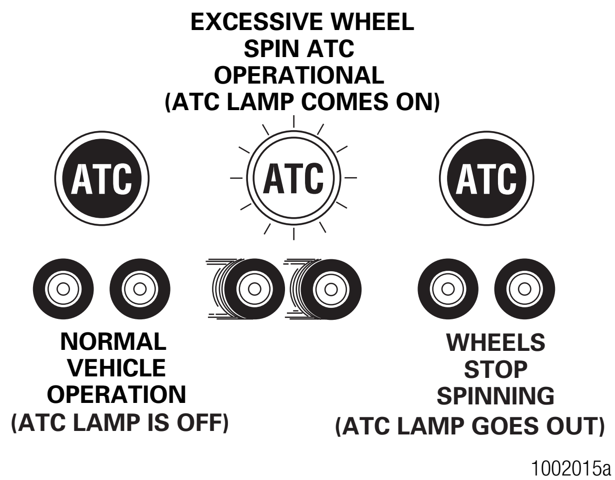


Figure 2.1

NOTE: Some vehicle manufacturers may refer to ATC as Anti-Spin Regulation (ASR).

If ATC is installed, there will be an indicator lamp on the vehicle dash or instrument panel marked ATC, ASR, or potentially Stability Control, depending on the application.

ATC Components

ATC uses the base ABS components plus an active braking valve that can be installed with individual modulator valves, or installed as part of the rear valve package.

When installed with individual modulator valves, the active braking valve is mounted on the frame or cross member, near the rear of the vehicle.

When it is part of the rear valve package, the active braking valve is attached to the relay valve. Figure 2.2.

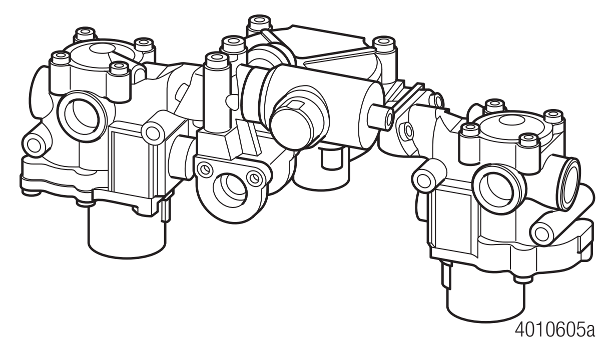


Figure 2.2

ATC Switch

If the vehicle manufacturer offers an ATC switch to control the ATC functionality, there are two common types of configuration settings as follows.

- **Deep snow and mud option:** This function helps to increase available traction on extra soft surfaces like snow, mud or gravel, by slightly increasing the permissible wheel spin.
- **ATC momentary override option:** This function allows the driver to momentarily disable/override ATC for the duration of the ignition cycle.

When either option is in use, the ATC indicator lamp blinks continuously to inform the driver. Figure 2.3.

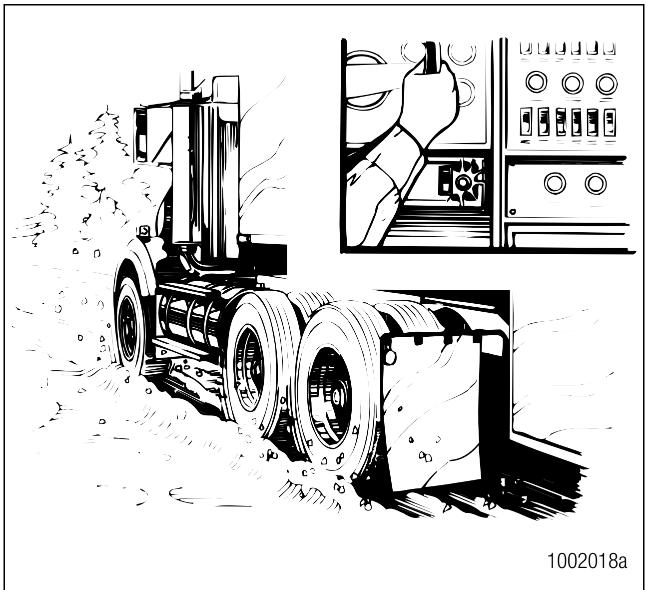


Figure 2.3

Switch and lamp locations as well as ATC switch configuration will vary depending on the vehicle make and model. Please check with the vehicle manufacturer for correct information.

Here's how the ATC switch works.

		Function	
Driver Action	System Response	Active	Not Active
Press ATC switch	ATC lamp blinks continuously	X	
Press ATC switch again	ATC lamp stops blinking		X

NOTE: Turning off the ignition will also deactivate either ATC function.

Roll Stability Control (RSC)

Roll stability control is an option designed to assist drivers in managing the conditions that may result in vehicle rollovers. When RSC senses conditions that may result in a rollover, it may reduce engine torque, engage the engine retarder, apply pressure to the drive axle brakes and may modulate the trailer brakes to slow the vehicle down. Depending on the application and vehicle configuration, the steer axle brakes may be applied as well.

Similar to ATC, RSC works automatically. The driver does not have to select this feature. Unlike ATC, RSC cannot be turned off by the driver.

RSC Components

RSC uses many of the same components used by ABS/ATC including modulator valves, active braking valves and wheel speed sensors. RSC ECUs are different from ABS ECUs as they contain an internal accelerometer that measures and updates the lateral acceleration of the vehicle and compares it to a critical threshold at which rollover may occur.

Depending on the vehicle manufacturer, RSC ECUs have orientation on the XX/YY or ZZ axis. For correct operation and the best performance, verify the ECU is correctly leveled and securely mounted. Figure 2.4, Figure 2.5 and Figure 2.6.

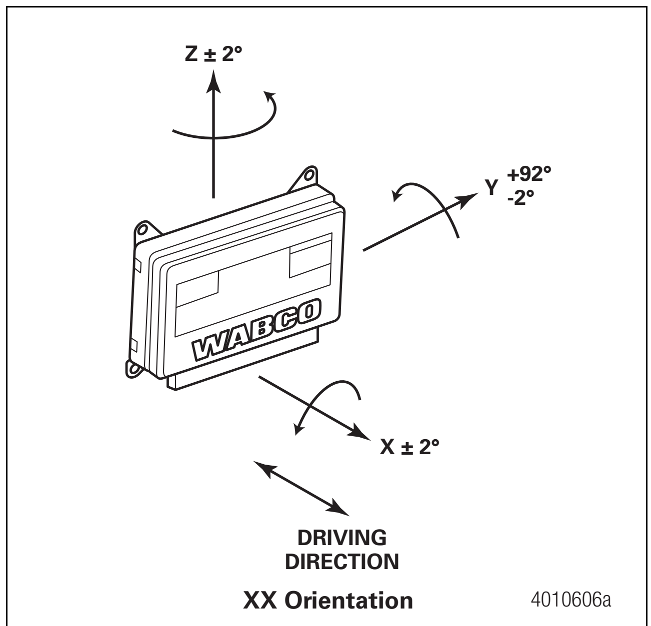


Figure 2.4

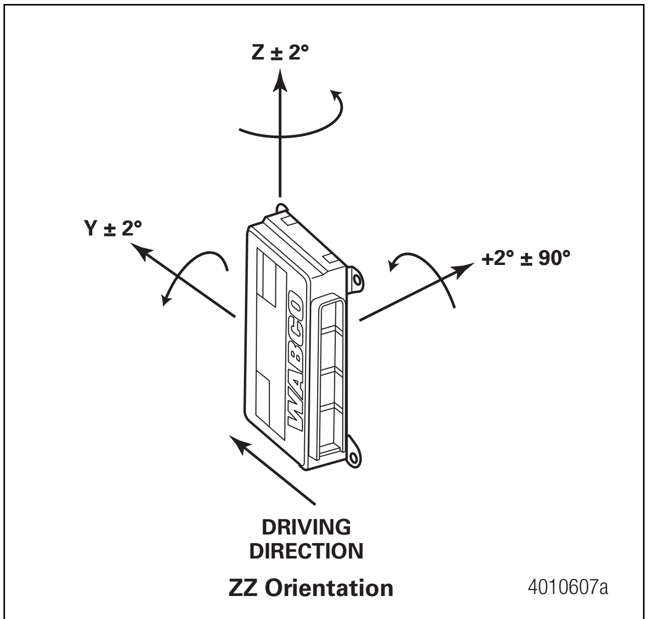


Figure 2.5

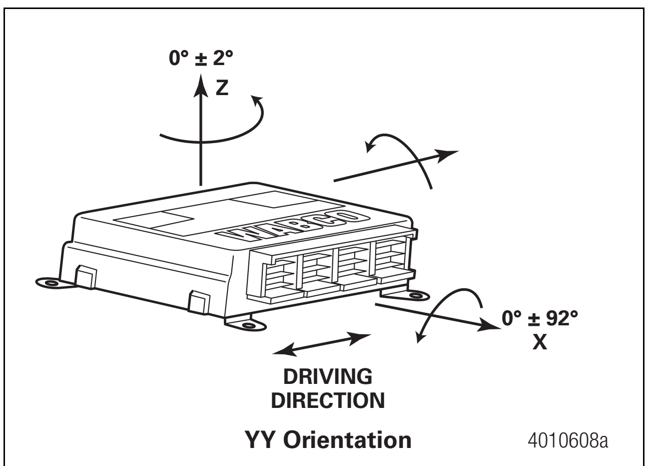


Figure 2.6

Certain vehicle configurations can have an additional active braking valve for trailer service brakes, an active braking valve for front axle brakes and a brake pressure sensor.

The active braking valve for trailer braking is a stand-alone valve that is not available as part of the ABS/ATC valve package. Depending on the application, a modulator valve may be located downstream of the solenoid valve. Figure 2.7.

⚠ WARNING

RSC helps reduce the tendency of the vehicle to roll over when cornering or changing directions, however, IT CAN NOT PREVENT ALL ROLLOVERS FROM OCCURRING.

When operating the vehicle, always use safe driving techniques. The driver is always the most important factor in safe vehicle operation.

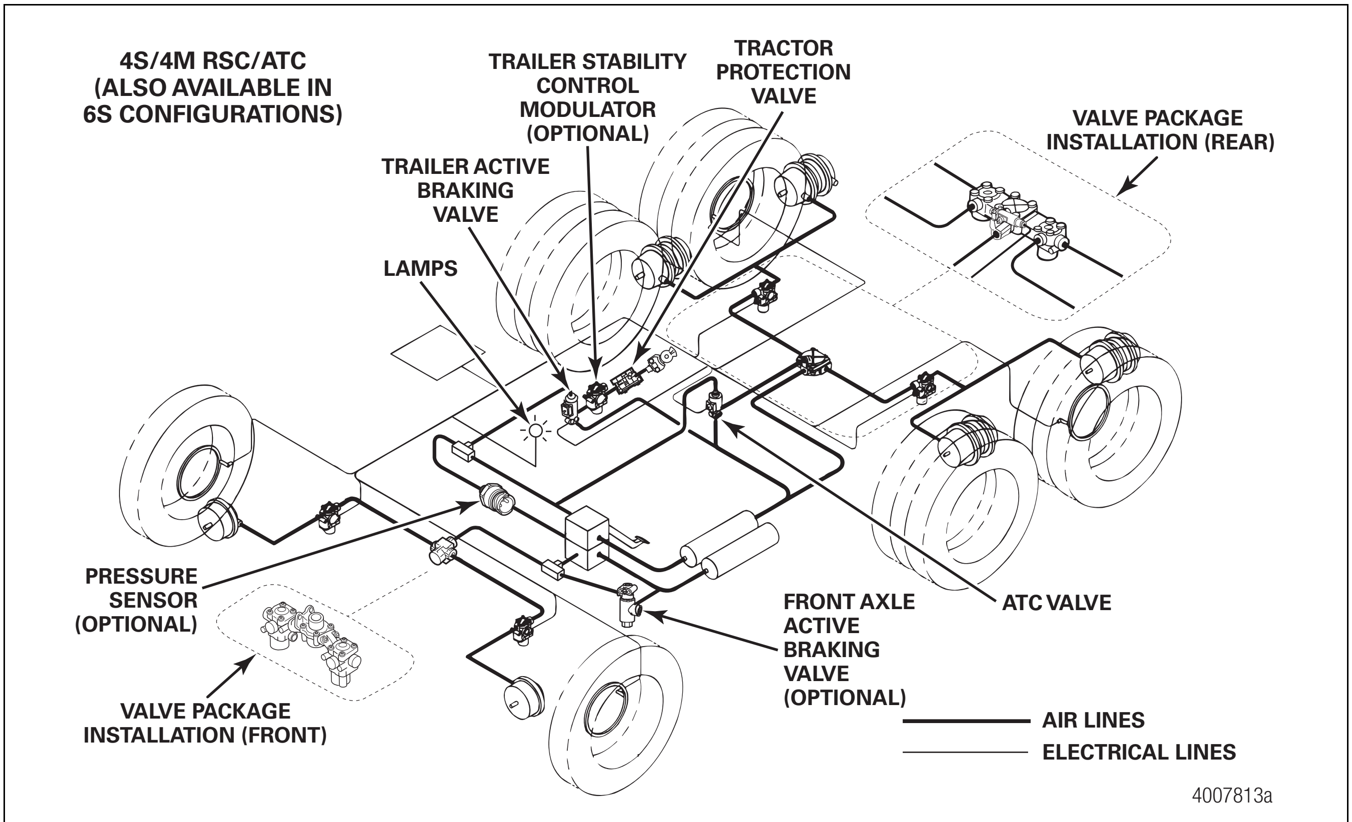


Figure 2.7

Electronic Stability Control (ESC)

Electronic Stability Control (ESC) combines the rollover prevention of Roll Stability Control (RSC) with directional stability in order to keep the vehicle traveling on its intended path by providing spinout and drift out control.

Like RSC, ESC is automatic. It becomes active when the system senses imminent directional or roll instabilities, often before the driver is aware. You will notice a difference in the vehicle when stability control is functioning, but you should continue to drive as normal and provide any additional needed corrections.

You may again notice a reduction in engine torque and additional deceleration from the retarder, if so equipped. You also may notice individual or all brakes applying depending on whether the vehicle is in a roll or directional control event.

ESC Components

ESC is built from the ABS platform and uses many of the same components as ATC and RSC. An active braking valve to control the front axle brakes, a pressure sensor, an ESC module and a Steering Angle Sensor (SAS) are required in addition to the components necessary for RSC. Figure 2.8 and Figure 2.9. These components are also described in the following section.

Note that for ESC applications on a non-towing vehicle (straight truck), the trailer active braking valve is not required.

The ESC ECU is available in both Cab- and Frame-mounted versions. The Universal Cab-Mounted ECU with ESC is an upgraded version of the current Universal ABS ECU with a fourth connector containing the necessary inputs/outputs required for full stability control. The Frame-Mounted Advance ECU with ESC is an upgraded version of the current ABS Frame-Mounted ECU with six additional pins on both the X1 and X2 connectors of the ECU. These ECUs support 4S4M, 6S4M and 6S6M vehicle configurations and are compatible with 12V electrical systems. For pinout information, refer to Section 6 of this manual.

The ESC ECU contains parameter settings which are specific to a vehicle configuration validated by Meritor WABCO Engineering. It is imperative that the correct ECU is installed on your vehicle in service. Contact Meritor WABCO or your respective vehicle OEM with any questions regarding ESC ECU. Figure 2.8 and Figure 2.9.

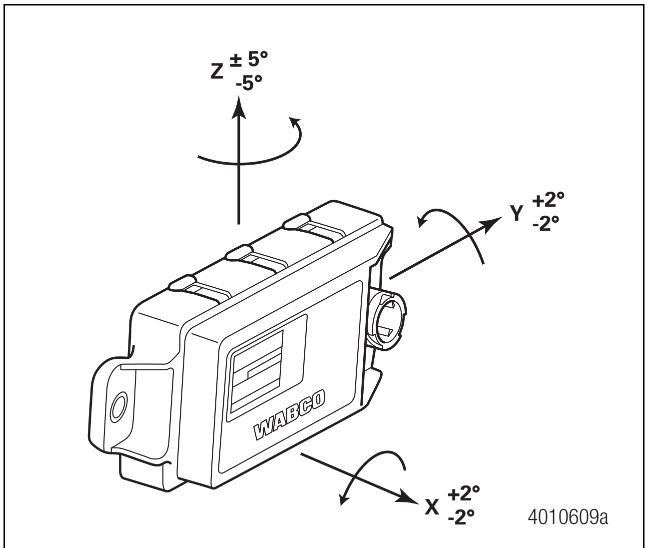


Figure 2.8

NOTE: ESC modules are installed by the OEM close to the vehicle center of gravity. Depending on the vehicle manufacturer, the ESC module might face towards the front of the vehicle or rear. For correct operation and the best performance, verify the ESC module is correctly leveled and securely mounted according to OEM specifications. Do not move the module to a different location as this will affect the system performance.

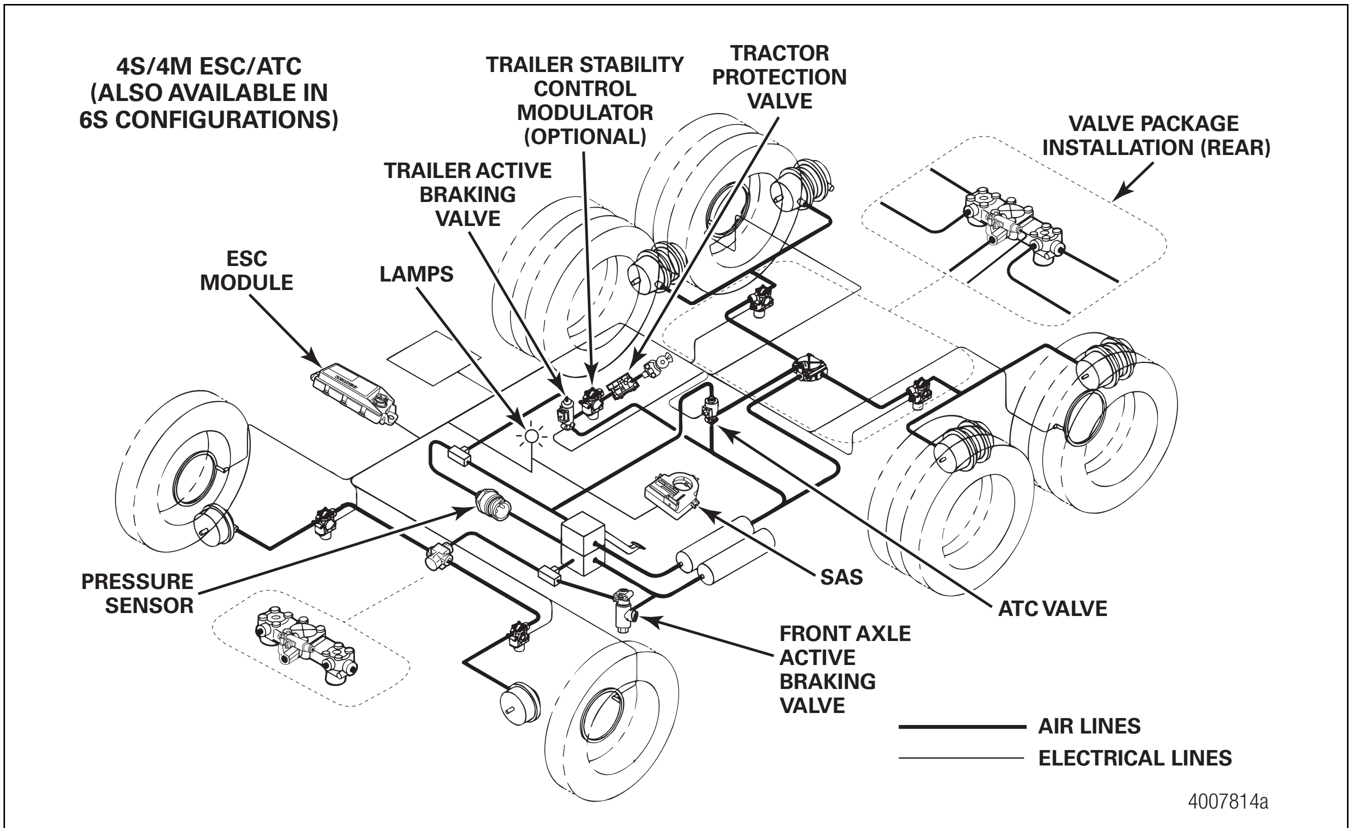


Figure 2.9

Hill Start Aid (HSA)

Hill Start Aid (HSA) supports select automated manual transmissions in reducing/totally eliminating the rolling back of the vehicle while launching on a grade. When requested from the transmission, HSA holds pressure in the service brakes of all axles of the towing vehicle when the vehicle is standing still. HSA will hold pressure for a maximum of three seconds following full release of the brake pedal. Communication between the transmission and the ECU takes place via the J1939 data link.

HSA grade threshold parameters may be modified in the Transmission ECU. These parameters must be reviewed with the transmission manufacturer prior to making any modifications in order to ensure safe operation.

HSA Components

HSA is available on ABS ECUs with E4.4 software revision or higher. Same as ESC, HSA is built from the ABS platform and uses many of the same components as ATC and RSC. HSA uses the front axle active braking valve as well as the rear active braking valve to help maintain the pressure trapped during HSA activation.

A pressure sensor provides the system with the driver's brake demand. The measured pressure is used by HSA to set the trapped pressure and/or activate the HSA function.

The vehicle manufacturer can provide an HSA switch multiplexed through the dashboard or hard wired for momentary HSA deactivation.

An HSA lamp, either hard wired or multiplexed, provides the driver with a visual indication of system deactivation and/or active fault. If the lamp is hard wired, it must be an incandescent lamp or LED with a resistor to prevent the ECU from setting a fault code.

A failure detected on any of these components will lead to no HSA availability. To troubleshoot the HSA, refer to Section 3 – Diagnostics, Troubleshooting and Testing.

Drag Torque Control

The ABS ECU has the ability to send a message to the engine to increase engine RPM to prevent drive axle lock-up, if the vehicle is on a downhill grade and in the incorrect gear.

Lift Axle Capability

Certain six sensor ABS ECUs with ATC allow third axle sensors to be installed on a lift axle. These ECUs will not log a fault for the axle being in the raised position while the vehicle is moving.

General

Maintenance Information

There is no regularly scheduled maintenance required for the Meritor WABCO ABS, ATC, RSC or ESC systems. However, this does not change current vehicle maintenance requirements.

- **Lamp Check:** To ensure the ABS tractor lamp is operating, drivers should check the lamp every time the vehicle is started. When the vehicle is started, the ABS lamp should come on momentarily. If it does not come on, it could mean a burned-out bulb.
- **ABS Wheel Speed Sensors:** Check the wheel speed sensor adjustment and lubricate the sensor and sensor clip whenever wheel-end maintenance is performed. Use only Meritor WABCO-recommended lubricant, as specified in Section 4.

ABS Indicator Lamp

Two ABS indicator lamps, one for tractor and one for trailer, let drivers know the status of the system. Figure 3.1. The tractor ABS lamp is also used to display tractor blink code diagnostics. The location of the ABS indicator lamps varies depending on the make and model of the vehicle.

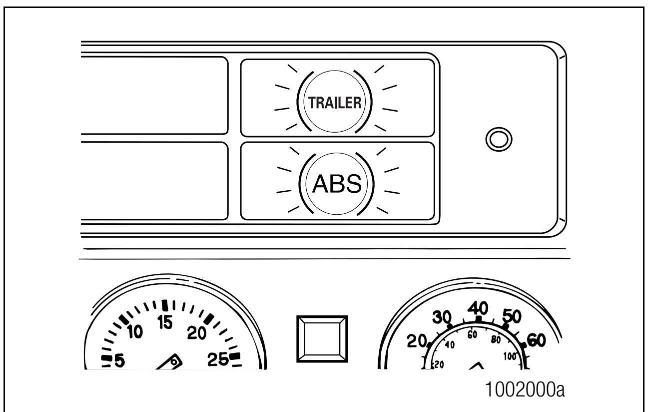


Figure 3.1

ATC and RSC/ESC functions may share the same dash indicator lamp. Therefore, understanding how the ABS and ATC/RSC/ESC lamps work is very important.

- If the vehicle is equipped with ATC, but not RSC/ESC, when the ignition is turned to the ON position, the ABS and ATC lamps will light for approximately three seconds, and then both lamps will turn off simultaneously. Figure 3.2.
- If the vehicle is equipped with ATC and RSC/ESC, when the ignition is turned to the ON position, the ABS and ATC/RSC/ESC will both light but the ATC/RSC/ESC lamp will stay lit briefly after the ABS lamp goes out.

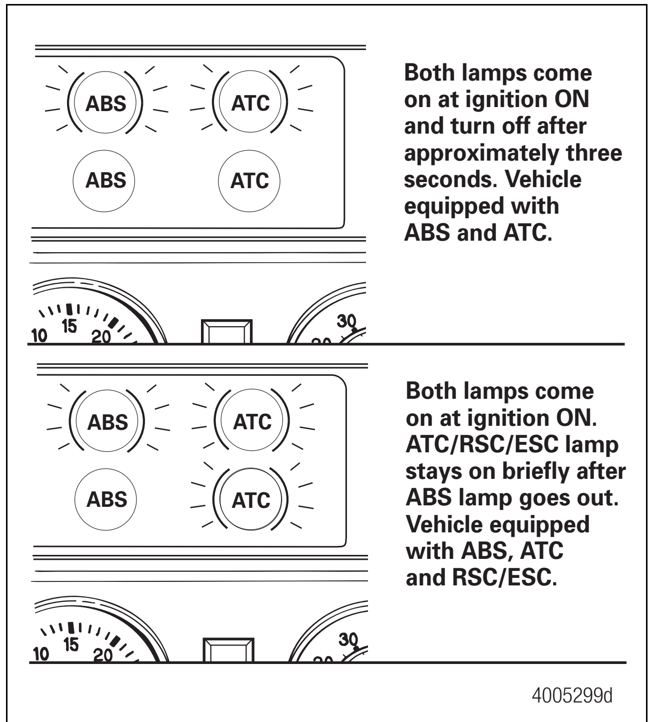
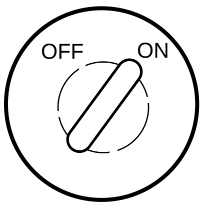


Figure 3.2

The ABS indicator lamp works as follows:

NOTE: If the ECU senses a tractor ABS fault during normal vehicle operation, the ABS indicator lamp will come on and stay on.

Ignition ON	Normal Operation	ABS lamp comes on at ignition momentarily for a bulb check, then goes out.	System is OK.
 1002005a	After servicing ABS components	ABS lamp does not go out at ignition.	When vehicle is driven at speeds above 4 mph (6 km/h), lamp goes out. System is OK.
	Off-road ABS operation. Refer to the off-road ABS information in this section.	ABS lamp flashes during vehicle operation.	The vehicle's normal ABS function is being modified due to road conditions.
	Existing fault or lamp issue	ABS lamp does not go out at ignition.	Lamp does not go out at speeds above 4 mph (6 km/h) — a fault may exist in the ABS system or lamp is permanently shorted.

Diagnostics

Use any of the following methods to diagnose E version ECUs:

- Meritor Wabco TOOLBOX™ Software, a PC-based diagnostic and testing program that runs in Microsoft Windows® XP, Vista, Windows 7 or Windows 8 operating system.
- Blink Codes. Refer to the information in this section.
- OEM Diagnostic Displays. Refer to the vehicle operator's manual.

If you have any questions about system diagnostics, please contact the Meritor OnTrac™ Customer Call Center at 866-OnTrac1 (668-7221).

TOOLBOX™ Software Diagnostics

For complete instructions for installing and using TOOLBOX™ Software, refer to the User's Manual posted on meritorwabco.com.

Meritor WABCO TOOLBOX™ Software provides computer-based diagnostic capabilities for the complete range of Meritor WABCO vehicle control systems. The program provides the following functions:

- Displays both static (e.g., ECU number) and dynamic (e.g., RPMs) information from the system under test.
- Displays both active and stored system faults, as well as the appropriate repair instructions.
- Activates system components to verify system integrity, correct component operation and installation wiring.

To display E version ABS, RSC, ESC or HSA faults:

1. Connect the computer to the vehicle:
   - Attach the USB/serial cable from your computer's USB or serial port to the adapter.
   - Attach the Deutsch diagnostic cable from the adapter to the vehicle. Figure 3.3.

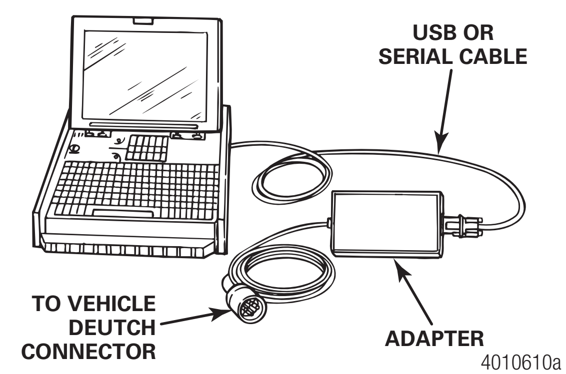


Figure 3.3

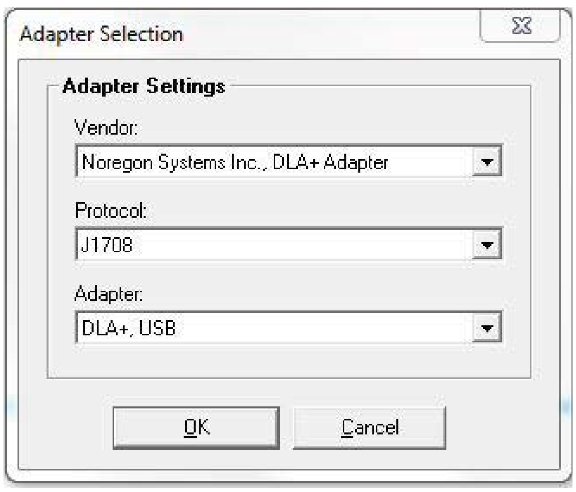
2. Select the TOOLBOX™ Software icon from the desktop or from the Windows® Start Menu to display the Main Menu.
3. **Adapter Selection**

   Verify the TOOLBOX™ Software is set for the device and communication protocol that will be used.

   To access "Adapter Selection" for TOOLBOX™ Software 11 or newer, click on "Utilities" from the main TOOLBOX™ page or under "System Setup" in "J1707/PLC TOOLBOX" from the main TOOLBOX page. Figure 3.5.

To access “Comport Settings” for TOOLBOX™ Software versions prior to TOOLBOX™ Software 11, click on “System Setup” from the main TOOLBOX™ page. Figure 3.6.

Make sure the “Vendor:” and “Adapter:” drop-downs are set for the device being used and set the “Protocol:” drop-down to J1708 OR J1939 according to the system you will be communicating through, and click “OK”. Figure 3.4.



4011997a

Figure 3.4

NOTE: When switching between J1939 and J1708 communications with TOOLBOX™ Software 11, the vehicle ignition must be cycled between sessions to correctly communicate with the ECU.

NOTE: TOOLBOX™ Software must be connected to the vehicle and the vehicle ignition must be ON in order to display information. If unable to communicate with the ECU:

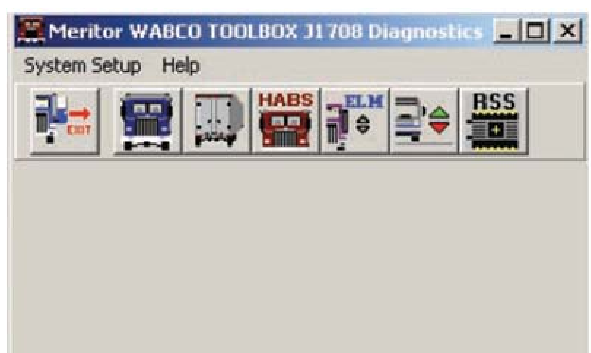
- Verify device and data link connections are secure.
- Verify the device is RP1210A compliant and that the comport settings (Vendor, Protocol, Adapter) in TOOLBOX™ Software are correct.
- Verify the device software and firmware is up to date.
- Check all the powers and grounds coming to the ECU including load testing.
- Check J1587 circuit at the ECU and the data link connector.
- Check J1939 circuit at the ECU and the data link connector.

4. Depending on the software version used, there will be two options to communicate with the vehicle:
   - If using TOOLBOX™ 11 or higher and a vehicle with Software ECU E4.4b or higher, diagnostics over J1939 communications can be possible. Figure 3.5.
   - J1708 communications are possible with any TOOLBOX™ Software version and any D or E Version ECU. Figure 3.6.

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

4010611a

Figure 3.5



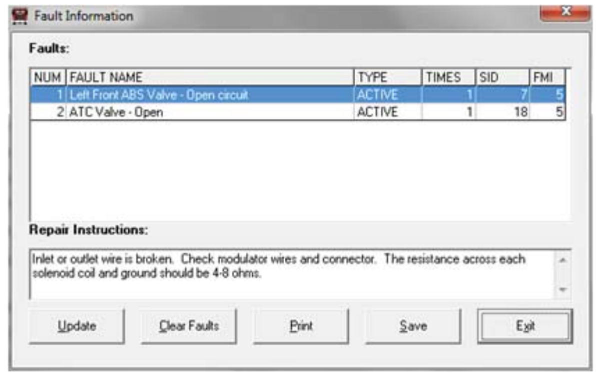
4010612a

Figure 3.6

5. In the **Main Menu**, select **J1939 Tractor ABS** or **J1708 TOOLBOX™**, then **Tractor ABS**. The **ABS Main Screen** will appear. Figure 3.7 and Figure 3.8.

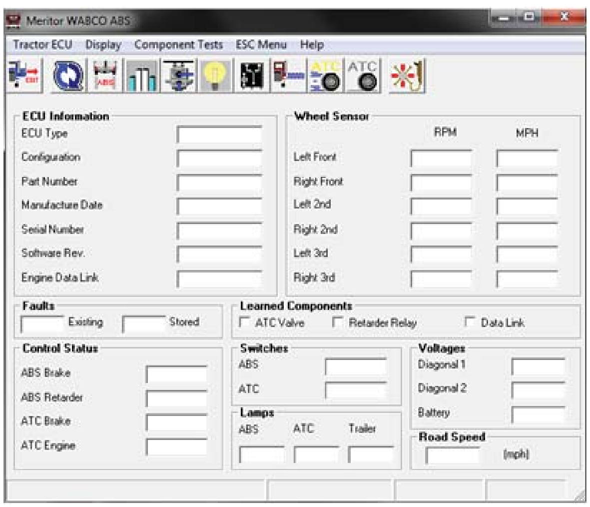
4010613a

Figure 3.7



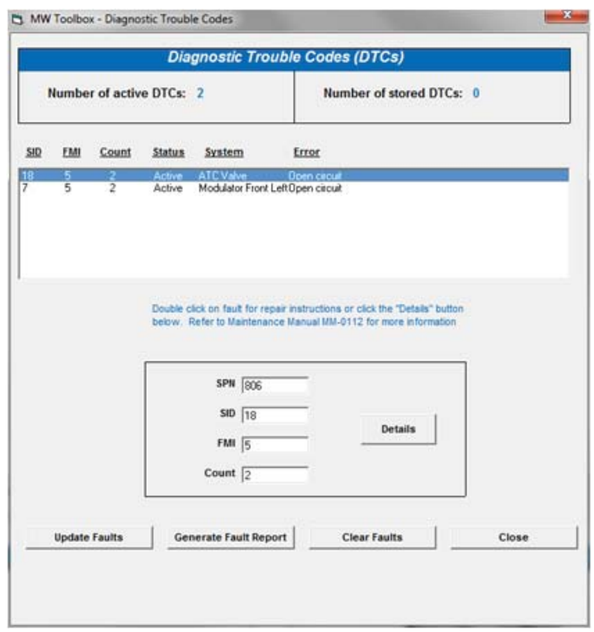
4010615a

Figure 3.9



4010614a

Figure 3.8



4010616a

Figure 3.10

6. Select **Display** from the top menu.

7. From the pull-down menu, select **Faults** or **Diagnostic Trouble Codes**. This will open the Fault Information screen. Figure 3.9 and Figure 3.10.

8. A description of the fault, the number of times the fault occurred, the system identifier (SID), the failure mode (FMI) and Suspect Parameter Number (SPN) are all displayed in the fault information window. Basic repair instructions for each fault are also provided. More detailed information about SID and FMI troubleshooting and repair is provided in the following section as well as the SID FMI table.

Double-clicking on the fault, or clicking on **Details**, will provide troubleshooting and detailed repair instructions. TOOLBOX™ Software version 11 also provides links to the appropriate system schematic which are also provided in this maintenance manual.

NOTE: If you are using TOOLBOX™ Software version 11, Internet Explorer is required to load files containing repair information, maintenance manual and schematics.

Faults that may occur after the screen is displayed will not appear until screen is manually updated. Use the **Update** button to refresh the fault information table.

After making the necessary repairs, use the **clear faults** button to clear the fault. Use the **Update** button to refresh the fault information table and display the new list of faults. Some faults may require vehicle ignition to be cycled and vehicle speed over 4 mph (6.4 kph) to clear them.

Use the **Save** or **Print** button to save or print the fault information data.

NOTE: If the TOOLBOX™ Software is unable to communicate with the ECU, verify the system is self-testing when the key is cycled.

If the system is not self-testing: Check all the powers and grounds connecting to the ECU including load testing.

If the system is self-testing: Check the following.

- Verify the ECU part number.
- Verify device and data link connections are secure.
- Verify the device is RP1210A compliant and that the comport settings (Vendor, Protocol, Adapter) in TOOLBOX™ Software are correct.
- Verify the device software and firmware is up-to-date.

Blink Code Diagnostics (ABS Only)

Definitions

Blink codes can be used to obtain fault information for ABS components, however, due to the advanced level of complexity of ESC, RSC and HSA, it is recommended to use Meritor WABCO TOOLBOX™ Software for detailed troubleshooting of any of these systems.

Before using blink code diagnostics, you should be familiar with a few basic terms. If you used previous versions of Meritor WABCO's blink code diagnostics, review these definitions to identify major changes.

ABS Indicator Lamp: This lamp serves two purposes: it alerts drivers to an ABS tractor fault and it is used during diagnostics to display the blink code.

Blink Code: A series of blinks or flashes that describe a particular ABS fault or condition. Codes are displayed in two-digit blink codes.

Blink Code Cycle: Two sets of flashes with each set separated by a one-and-one-half second pause. Blink codes are defined in the blink code identification information in this section.

Blink Code Switch: A momentary switch that activates blink code diagnostic capabilities. Switch types and locations vary, depending on the make and model of the vehicle.

Clear: The process of erasing faults from the ECU.

Diagnostics: The process of using blink codes to determine ABS faults.

Fault: An ABS malfunction detected and stored in memory by the Meritor WABCO ECU. System faults may be Active or Stored.

Active Fault: A condition that currently exists in the ABS; for example: A sensor circuit malfunctions on the left front steering axle. An active fault must be repaired before it can be cleared from memory — and before you can display additional blink code faults.

Stored Fault: There are two types of stored faults:

A. A repaired active fault that **has not been cleared** from the ECU.

B. A fault that occurred but **no longer exists**. For example, a loose wire that makes intermittent contact. Because stored faults are not currently active, they do not have to be repaired before they can be cleared from memory.

Meritor WABCO recommends you keep a record of these faults for future reference.

System Configuration Code: One-digit code displayed during the clear mode. Blink codes for common ABS configurations are shown in Figure 3.11.

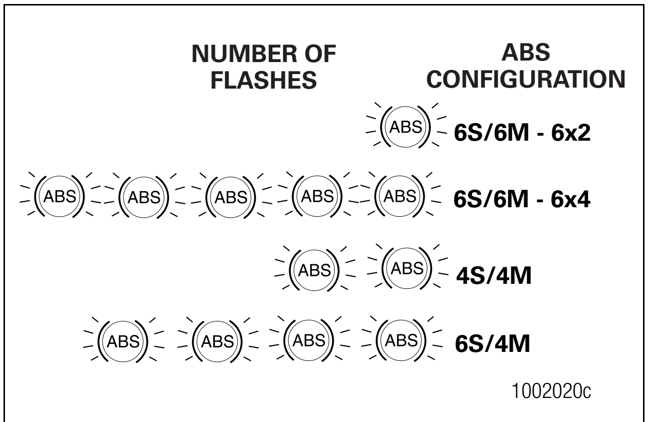


Figure 3.11

Clear Mode

To erase faults from the ECU, you must be in the clear mode. To enter the clear mode, press and hold the blink code switch for at least three seconds, then release.

If the system displays eight quick flashes followed by a system configuration code, the clear was successful. Stored ABS faults have been cleared from memory.

If you do not receive eight flashes, there are still active faults that must be repaired before they can be cleared.

NOTE: The clear mode is also used to disable the ATC function.

Table A: Troubleshooting with Blink Code Diagnostics

Procedure	System Response	Action
	Diagnostics Mode	
Step I.	Possible responses:	
Turn ignition ON.	ABS indicator lamp comes on momentarily then goes out, indicating System OK.	No recognizable active faults in the ABS. No action required.
	ABS indicator lamp does not light, indicating possible wiring fault or burned-out bulb.	Inspect wiring. Inspect bulb. Make necessary repairs.
	ABS indicator lamp stays on, indicating:	
	• Fault, or faults, in the system.	Continue with blink code diagnostics. **(Go to Step II.)**
	• Sensor fault during last operation.	Continue with blink code diagnostics. **(Go to Step II.)**
	• Faults cleared from ECU, but vehicle not driven.	Drive vehicle — lamp will go out when vehicle reaches 4 mph (6 km/h).
	• ECU disconnected.	Connect ECU.
	• Power or ground wiring issue.	Check harness powers and grounds at the ECU.
Step II. **Press and hold Blink Code Switch for one second, then release.**	ABS indicator lamp begins flashing two-digit blink code(s).	Determine if fault is active or stored: **Active Fault:** Lamp will repeatedly display one code. **Stored Fault:** Lamp will display code for each stored fault then stop blinking. Faults will be displayed **one time only.**
Step III. **Count the flashes to determine the blink code.**	First Digit: 1-8 flashes, Pause (1-1/2 seconds) Second Digit: 1-6 flashes, Pause (4 seconds)	Find definition for blink code on blink code chart.

Procedure	System Response	Action
Step IV. **Turn ignition OFF.**	Active Fault	Make the necessary repairs. Repeat Step 1, Step II and Step III until System OK, code (1-1) received.
Repair and record faults.	Stored Fault	Record for future reference. **NOTE:** Last fault stored is first fault displayed.
	Clear Mode	
Step V.	ABS indicator lamp flashes eight times.	All stored faults successfully cleared.
Turn ignition ON.		Turn ignition OFF.
Clear Faults from memory: Press and hold blink code switch for at least three seconds, then release.	Eight flashes not received.	Active faults still exist, repeat Step I through Step V.

Blink Code Illustrations

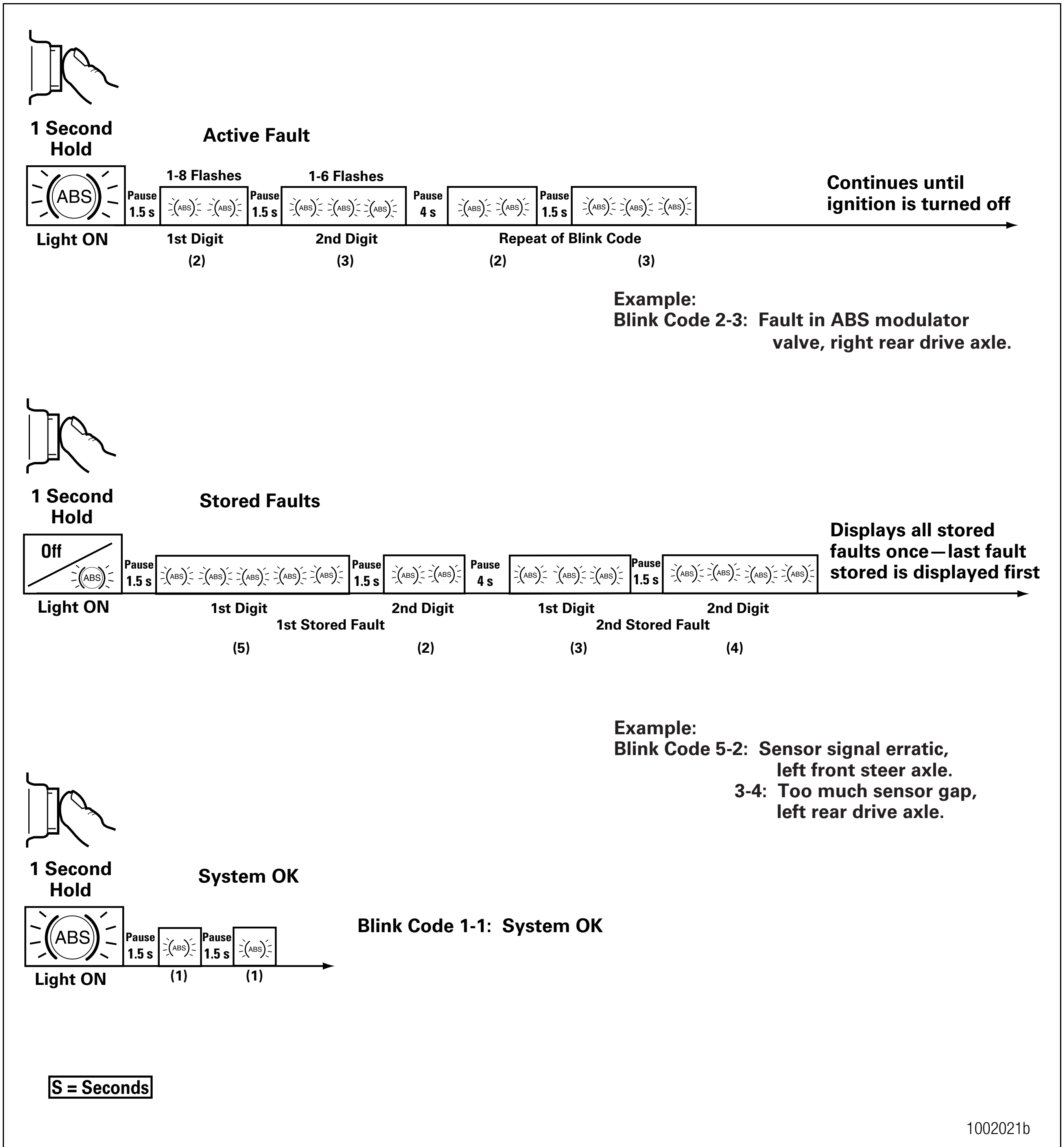


Figure 3.12

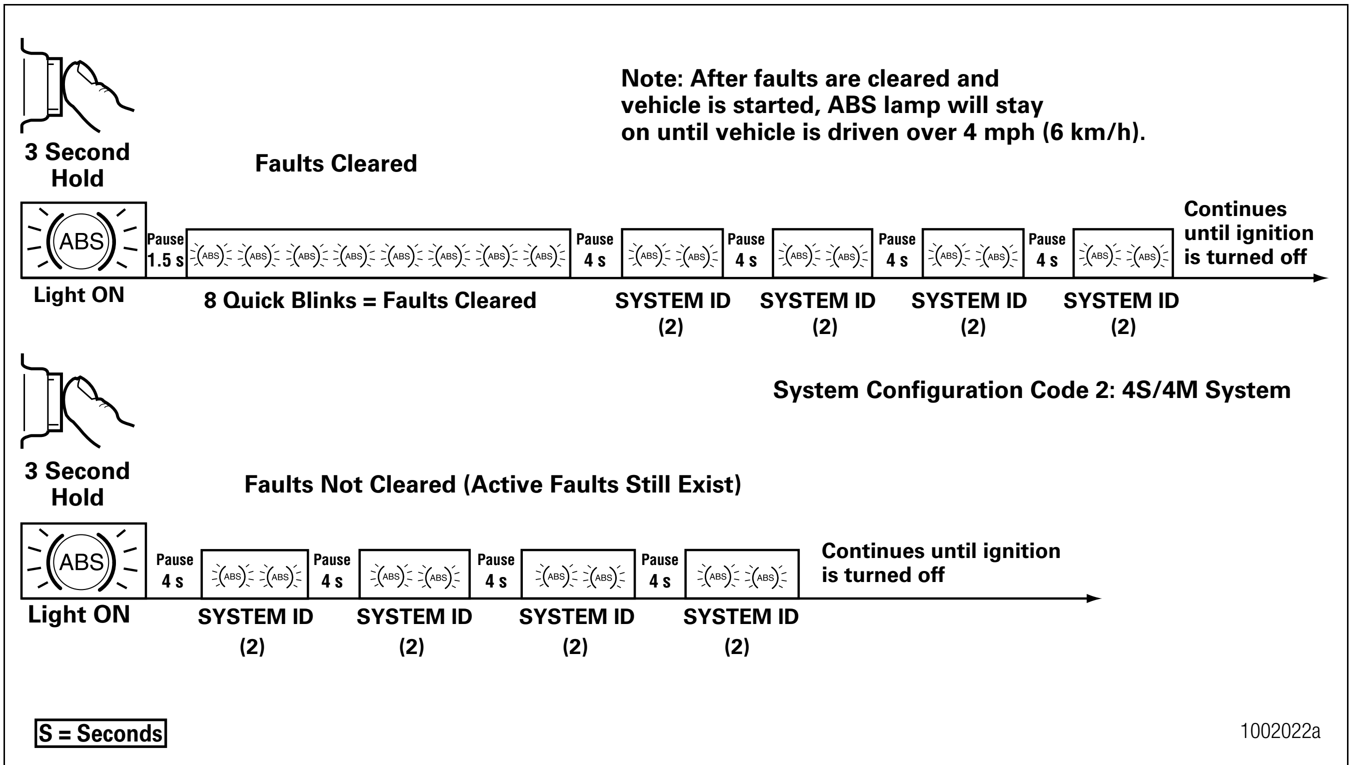


Figure 3.13

NOTE: If the vehicle does not have a blink code switch, a test lead/ jumper wire may be installed as a temporary blink code switch.

For Cab mounted ECUs: Back probe pin 15 of the X1 connector to ground for 1 second to obtain codes or back probe pin 15 for 3 seconds to clear codes.

For Frame mounted ECUs with all 12 pin connectors: Back probe pin 10 of the X1 connector to ground for 1 second to obtain codes or back probe pin 10 for 3 seconds to clear codes.

For Frame mounted ECUs with all 18 pin connectors: Back probe pin 15 of the X1 connector to ground for 1 second to obtain codes or back probe pin 15 for 3 seconds to clear codes.

Blink Code Conditions

When using blink code diagnostics, the following conditions could occur:

Table B: Blink Code Conditions

Condition	Reason	Action
ABS indicator lamp does not come on at ignition.	Loose or burned-out bulb.	Check bulb. Check connections. Make necessary repairs.
	Voltage not within acceptable range (9.5-14.0 volts) (18-32 for 24V system).	Check connections. Measure voltage. Make necessary repairs.

Condition	Reason	Action
Can't use blink code diagnostics. ABS indicator lamp will not go off when blink code is activated.	Switch not held for correct length of time: 1 Second — Diagnostics Mode 3 Seconds — Clear All Mode	Repeat procedure, hold switch for correct length of time.
	Incorrect or faulty wiring.	Inspect and repair wiring.
	Fault not erased from ECU after report.	Repeat procedure until System O.K. code received.
Eight flashes not received after blink code switch pressed for at least three seconds, then released.	Active faults still exist.	Identify active faults, then make necessary repairs. Turn ignition OFF, then repeat Blink Code Diagnostics.

Blink Code Identification

Use the following information to identify the blink code:

First Digit (Type of Fault)	Second Digit — Specific Location of Fault
1 No faults	1 No faults
2 ABS modulator valve 3 Too much sensor gap 4 Sensor short or open 5 Sensor signal erratic/tire size 6 Tooth wheel	1 Right front steer axle (curb side) 2 Left front steer axle (driver's side) 3 Right rear drive axle (curb side) 4 Left rear drive axle (driver's side) 5 Right rear/additional axle (curb side) 6 Left rear/additional axle (driver's side)
7 System function	1 J1939 or proprietary ESC CAN. Several sensors out of adjustment 2 ATC 3/2 valve 3 Retarder relay or third brake relay such as drive line brake, exhaust brake or engine brake 4 ABS indicator lamp 5 ATC configuration 6 Trailer active braking valve or front axle active braking valve 7 Brake pressure sensor 8 Tire pressure monitoring
8 ECU	1 Low power supply 2 High power supply 3 Internal fault 4 System configuration error 5 Ground 6 RSC accelerometer or ESC module

Testing

Wheel Speed Sensor Testing

Sensor Adjustment

- Push the sensor in until it contacts the tooth wheel.
- Do not pry or push sensors with sharp objects.
- Sensors will self-adjust during wheel rotation.

Electrical Checks

- Check wheel speed sensor by itself for resistance.
- Check ECU harness and sensor together for resistance. Figure 3.14 and Figure 3.15.
- Verify no change in resistance or open circuit between sensor by itself and through harness.
- Check harness by itself for any shorts to battery and shorts to ground.
- Measurements should read as follows:

Location	Measurement
Between sensor leads	900-2000 ohm
At ECU harness pins with sensor connected	Same as above, no more than 1 ohm difference
ECU harness by itself for DC voltage or ground	No continuity
Sensor output voltage	At least 0.2 volt AC at 30 rpm

NOTE: Sensor resistance can change with temperature. All readings should be taken at the same time and before vehicle is driven.

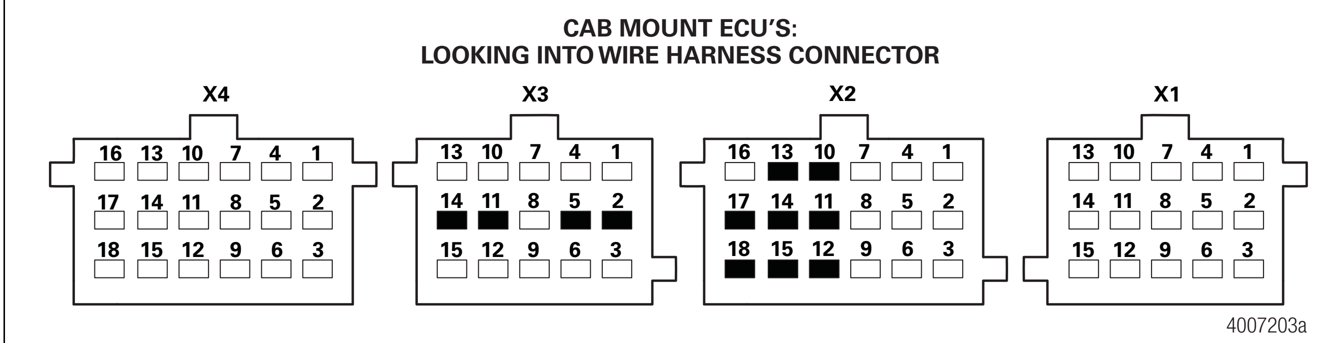


Figure 3.14

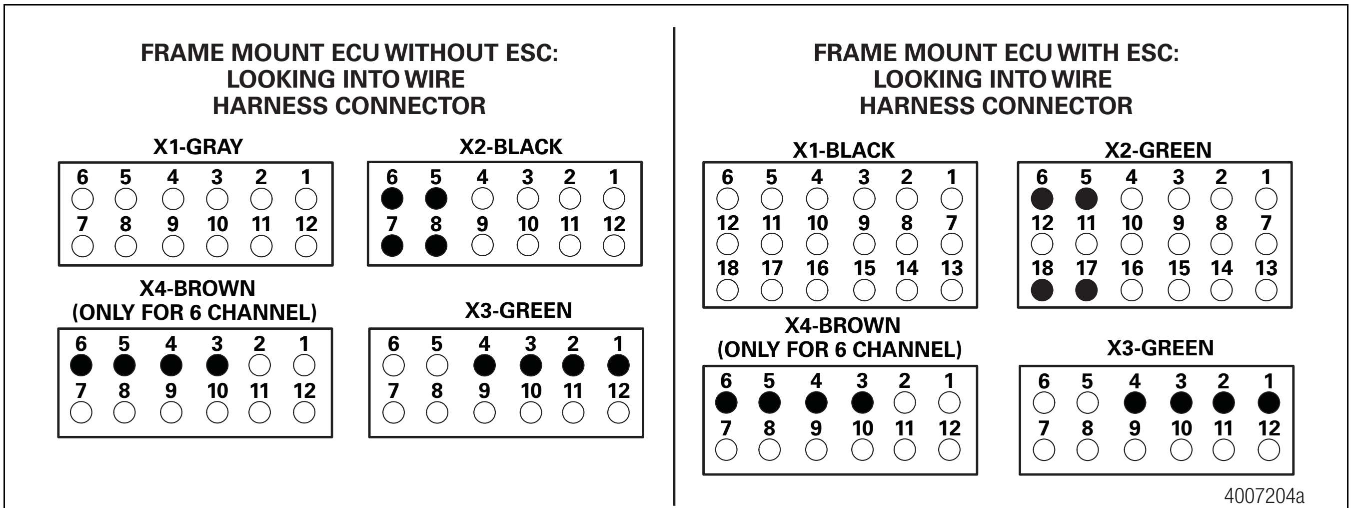


Figure 3.15

ECU	Sensor	Connector	Pins
Cab-Mounted Universal with ESC, Universal or Basic	LF	X2-18 pin	12 and 15
	RF	X2-18 pin	10 and 13
	LR	X2-18 pin	11 and 14
	RR	X2-18 pin	17 and 18
	LR (3rd axle)	X3-15 pin	2 and 5
	RR (3rd axle)	X3-15 pin	11 and 14
Frame-Mounted Non-ESC	LF	X2-Black	7 and 8
	RF	X2-Black	5 and 6
	LR	X3-Green	1 and 2
	RR	X3-Green	3 and 4
	LR (3rd axle)	X4-Brown	3 and 4
	RR (3rd axle)	X4-Brown	5 and 6
Frame-Mounted With ESC	LF	X2-Green	17 and 18
	RF	X2-Green	5 and 6
	LR	X3-Green	1 and 2
	RR	X3-Green	3 and 4
	LR (3rd axle)	X4-Brown	3 and 4
	RR (3rd axle)	X4-Brown	5 and 6

Modulator Valve Testing

Electrical Checks

- Check modulator valve by itself for resistance. Figure 3.16 and Figure 3.17.
- Check ECU harness and modulator valve together for resistance. Figure 3.18 and Figure 3.19.
- Verify no change in resistance or open circuit between valve by itself and through harness.
- Check harness by itself for any shorts to battery and shorts to ground.
- Measurements should read as follows:

Location	Measurement
Inlet valve pin to Ground	4.0-9.0 ohm for 12V system 11.0-21.0 ohm for 24V system
Outlet valve pin to Ground	4.0-9.0 ohm for 12V system 11.0-21.0 ohm for 24V system
At ECU harness pins with modulator valve connected	Same as above, no more than 1 ohm difference
ECU harness by itself for battery voltage or ground	No continuity

NOTE: If resistance exceeds 9.0 ohm for 12V system (21.0 ohm for 24V system), verify the reading was not taken between the inlet and outlet. If the correct pins were tested, clean the electrical contacts at the modulator and retest.

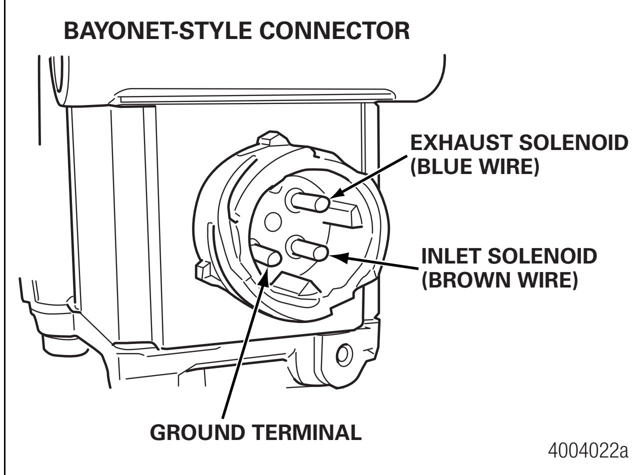


Figure 3.16

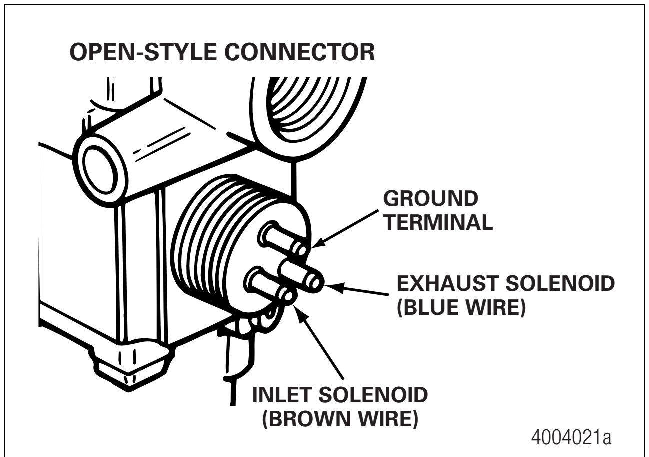


Figure 3.17

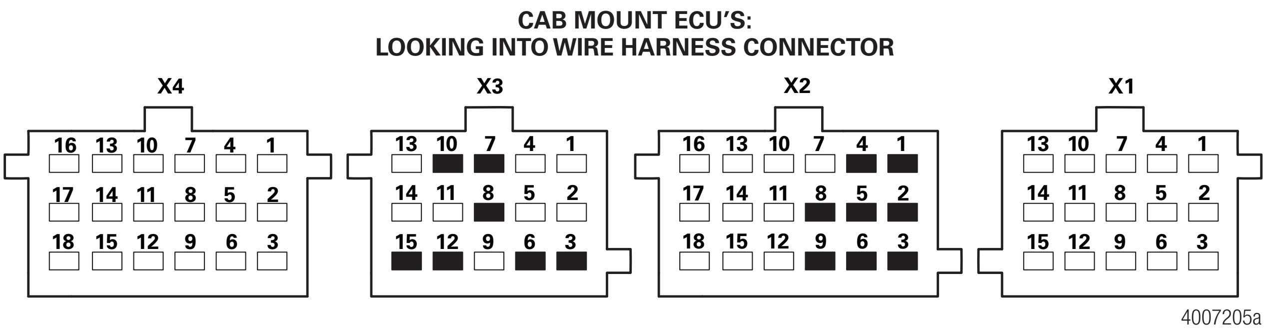


Figure 3.18

ECU	Modulator Circuit	Connector	Pins
Cab-Mounted	LF IV	X2-18 pin	3
Universal with ESC, Universal or Basic	LF OV	X2-18 pin	6
	RF IV	X2-18 pin	1
(ABS modulators are grounded externally, i.e., common is fed to external ground)	RF OV	X2-18 pin	4
	LR IV	X2-18 pin	2
	LR OV	X2-18 pin	5
	RR IV	X2-18 pin	8
	RR OV	X2-18 pin	9
	LR (3rd Axle) IV	X3-15 pin	3
	LR (3rd Axle) OV	X3-15 pin	6
	RR (3rd Axle) IV	X3-15 pin	12
	RR (3rd Axle) OV	X3-15 pin	15
Optional with Stability Control	Trailer IV	X3-15 pin	7
	Trailer OV	X3-15 pin	10
	Trailer Common	X3-15 pin	8

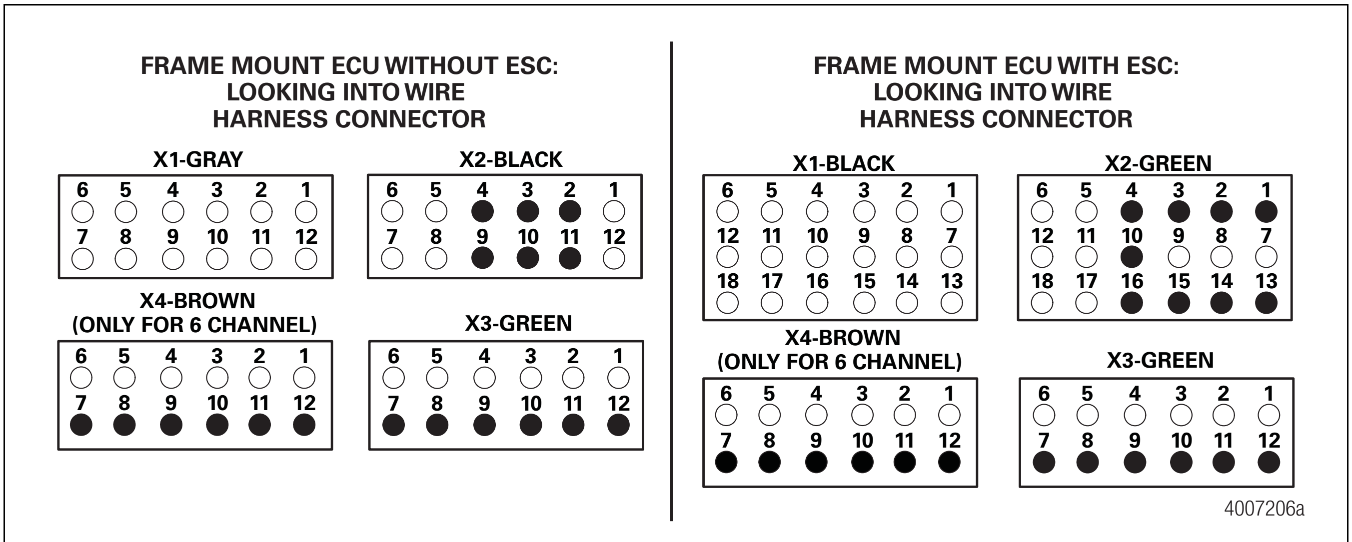


Figure 3.19

ECU	Modulator Circuit	Connector	Pins
Frame-Mounted	LF IV	X2-Black	2
Non-ESC	LF OV	X2-Black	10
	LF Common	X2-Black	11
	RF IV	X2-Black	4
	RF OV	X2-Black	3
	RF Common	X2-Black	9
	LR IV	X3-Green	12
	LR OV	X3-Green	10
	LR Common	X3-Green	11
	RR IV	X3-Green	9
	RR OV	X3-Green	7
	RR Common	X3-Green	8
	LR (3rd Axle) IV	X4-Brown	12
	LR (3rd Axle) OV	X4-Brown	10
	LR (3rd Axle) Common	X4-Brown	11
	RR (3rd Axle) IV	X4-Brown	9
	RR (3rd Axle) OV	X4-Brown	7
	RR (3rd Axle) Common	X4-Brown	8

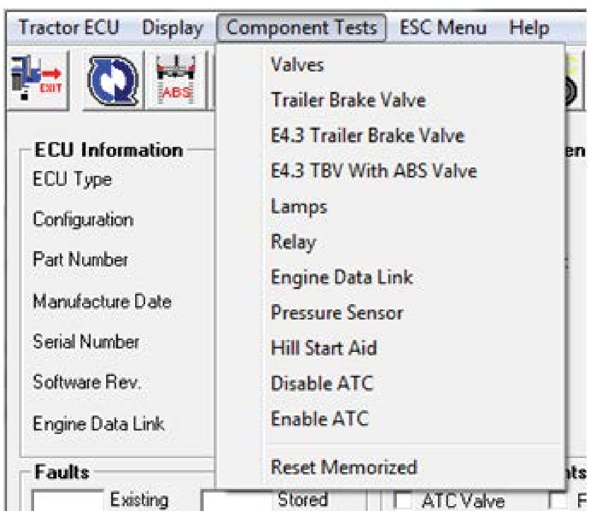
ECU	Modulator Circuit	Connector	Pins
Frame-Mounted	LF IV	X2-Green	2
With ESC	LF OV	X2-Green	15
	LF Common	X2-Green	14
	RF IV	X2-Green	4
	RF OV	X2-Green	3
	RF Common	X2-Green	16
	LR IV	X3-Green	12
	LR OV	X3-Green	10
	LR Common	X3-Green	11
	RR IV	X3-Green	9
	RR OV	X3-Green	7
	RR Common	X3-Green	8
	LR (3rd Axle) IV	X4-Brown	12
	LR (3rd Axle) OV	X4-Brown	10
	LR (3rd Axle) Common	X4-Brown	11
	RR (3rd Axle) IV	X4-Brown	9
	RR (3rd Axle) OV	X4-Brown	7
	RR (3rd Axle) Common	X4-Brown	8

ECU	Modulator Circuit	Connector	Pins
Optional with Stability Control	Trailer IV	X2-Green	1
	Trailer OV	X2-Green	10
	Trailer Common	X2-Green	13

Modulator Valve Testing Available in Meritor WABCO TOOLBOX™ Software (PC Diagnostics)

The ABS modulator valves as well as the trailer modulator valve can be cycled using Meritor WABCO TOOLBOX™ Software.

To cycle the modulator valves, choose the option “Valves” from the “Component Tests” drop-down menu. Or, if you are using TOOLBOX™ Software version 11 or higher, from “Components”. Figure 3.20.

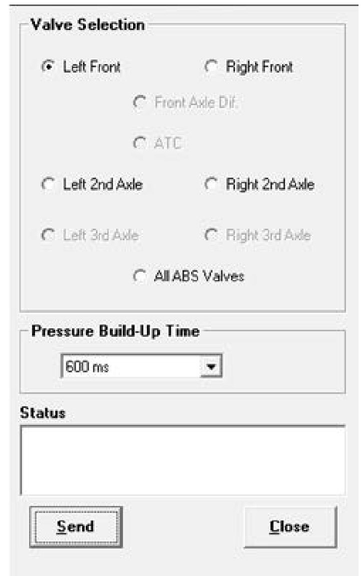


4010617a

Figure 3.20

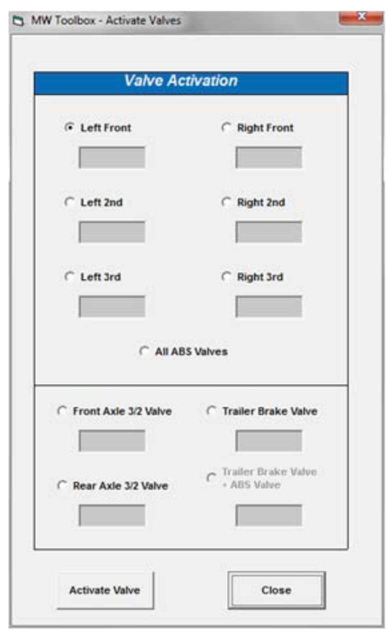
The valve selection screen will appear where you can choose to cycle each valve individually or you can choose to cycle all valves in a pre-determined order. Figure 3.21 and Figure 3.22.

Then, listen to ensure the correct valve is cycling. This is helpful in verifying correct operation, installation and wiring.



4010619a

Figure 3.21



4010620a

Figure 3.22

NOTE: If you are using versions older than TOOLBOX™ Software V11, to test the function of the Trailer Stability Control Modulator valve, choose “E4.3 TBV with ABS Valve” from the “Component Tests” drop-down menu. Listen to ensure the correct valve is cycling.

Active Braking Valves (ABV) Testing

Electrical Checks

- Check ABV 3/2 solenoid by itself for resistance.
- Check ECU harness and ABV 3/2 solenoid together for resistance. Figure 3.23 and Figure 3.24.
- Verify no change in resistance or open circuit between ABV by itself and through harness.
- Check harness by itself for any shorts to battery and shorts to ground.
- Measurements should read as follows:

Location	Measurement
ABV Supply to ABV Common	7.0-14.0 ohm for 12V system 26.3-49.0 ohm for 24V system
At ECU harness pins with ABV connected	Same as above, no more than 1 ohm difference
ECU harness by itself for battery voltage or ground	No continuity

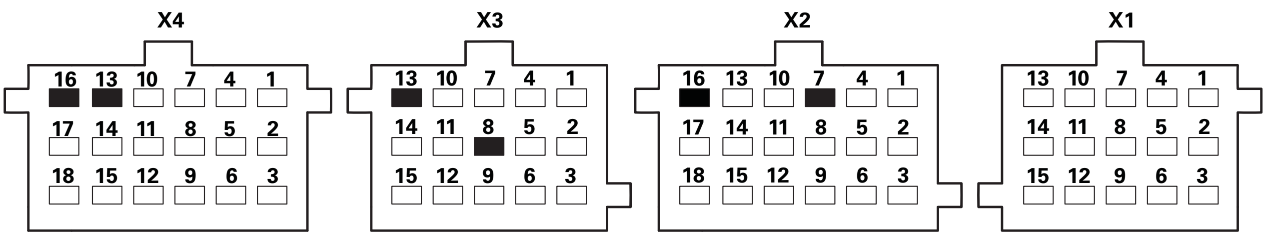


Figure 3.23

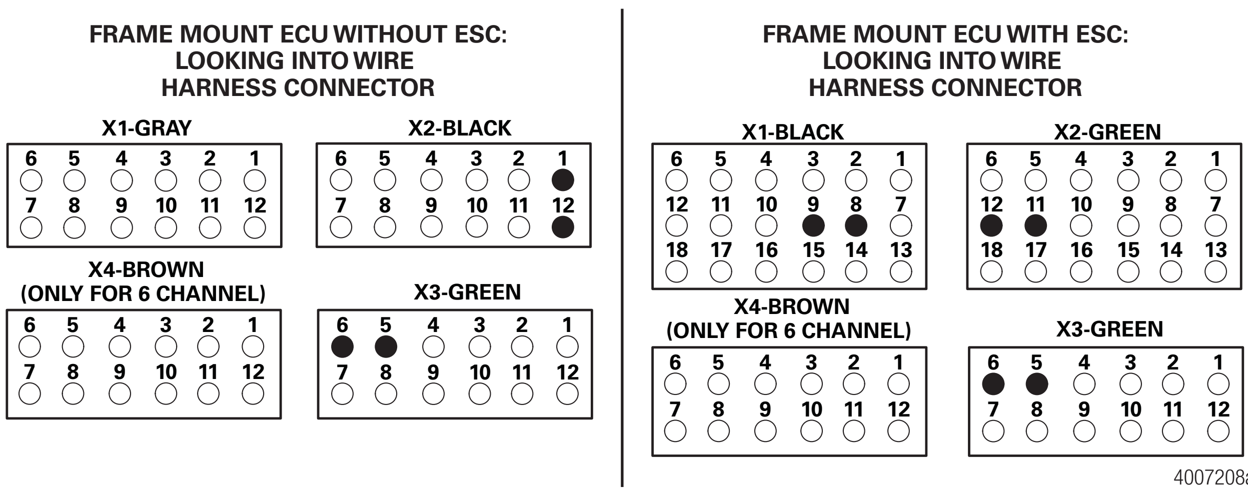


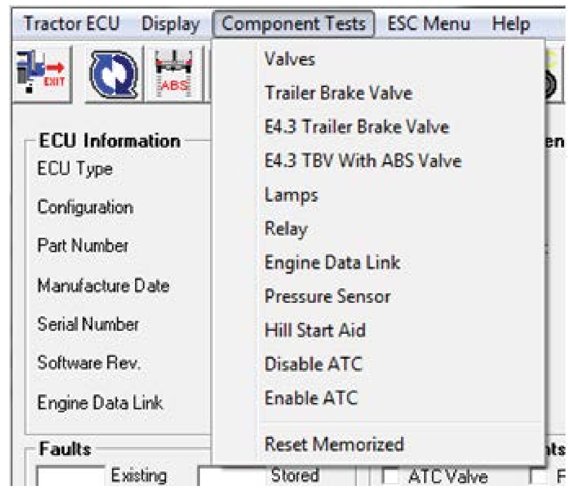
Figure 3.24

ECU	Active Braking Valve Circuit	Connector	Pins
Cab-Mounted Universal with ESC, Universal or Basic	Drive Axle ABV Supply	X2-18 pin	16
	Drive Axle ABV Common	X2-18 pin	7
	Steer Axle ABV Supply	X4-18 pin	16
	Steer Axle ABV Common	X4-18 pin	13
	Trailer ABV Supply	X3-15 pin	13
	Trailer ABV Common	X3-15 pin	8
Frame-Mounted Non-ESC	Drive Axle ABV Supply	X3-Green	5
	Drive Axle ABV Common	X3-Green	6
	Trailer ABV Supply	X2-Black	1
	Trailer ABV Common	X2-Black	12
Frame-Mounted With ESC	Drive Axle ABV Supply	X3-Green	5
	Drive Axle ABV Common	X3-Green	6
	Steer Axle ABV Supply	X2-Green	12
	Steer Axle ABV Common	X2-Green	11
	Trailer ABV Supply	X1-Black	9
	Trailer ABV Common	X1-Black	8

ABV Testing Available in Meritor WABCO TOOLBOX™ Software

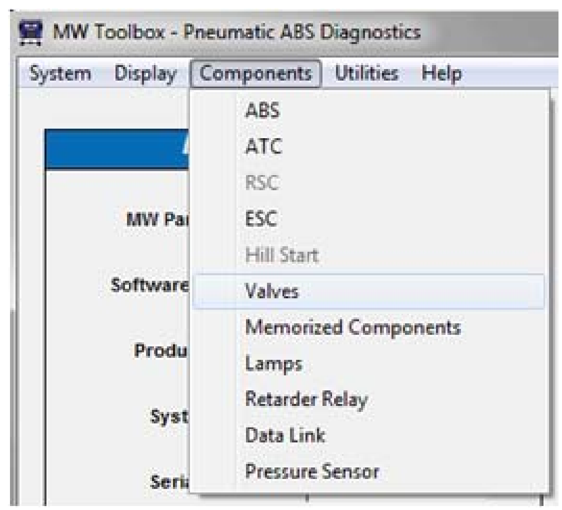
The Active Braking Valves can be cycled using Meritor WABCO TOOLBOX™ Software.

To cycle the ABVs, choose the option “Valves” from the “Component Tests” drop-down menu. Figure 3.25. Or if you are using TOOLBOX™ Software version 11 or higher, from “Components”. Figure 3.26.



4010621a

Figure 3.25

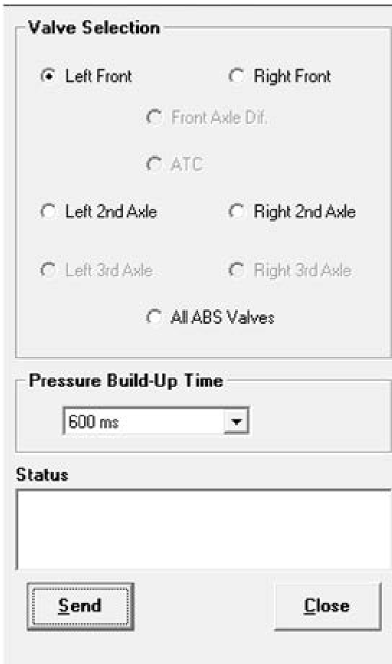


4010622a

Figure 3.26

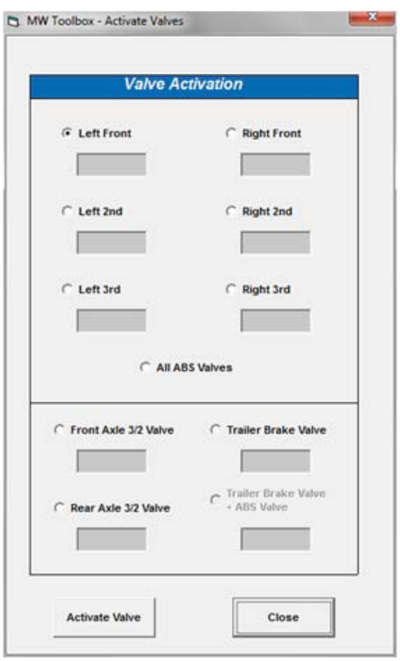
The valve selection screen will appear where you can choose to cycle Front Axle ABV, Rear Axle ABV or Trailer ABV individually. Figure 3.27 or Figure 3.28.

Then, listen to ensure the correct valve is cycling. This is helpful in verifying correct operation, installation and wiring.



4010623a

Figure 3.27



4010624a

Figure 3.28

NOTE: If you are using versions older than TOOLBOX™ Software version 11, to test the function of the Trailer ABV, choose “Trailer Brake Valve” or “E4.3 Trailer Brake Valve” from the “Component Tests” drop-down menu. Listen to ensure the correct valve is cycling. If you are unsure which test option to choose, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221 and have your ECU part number available.

Brake Pressure Sensor Testing

Electrical Checks

For the following check, all of the ECU connectors must be plugged in as the ECU provides voltage and ground to the BPS.

- Take measurements at the pressure sensor harness connector. Figure 3.29.
- Measure Voltage Supply to Ground on Pin 1 of the BPS Connector Key ON.

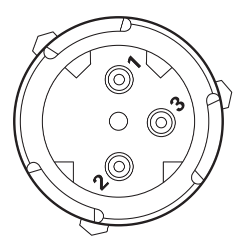
With ECU and BPS disconnected:

- Verify continuity end to end on all 3 lines.
- Verify no shorts to ground or battery on all 3 lines.
- Verify no continuity between pins.

Measurements should read as below.

Location	Measurement
Voltage Supply to Ground	8.0-16.0V
Pressure Signal or Ground Line short to battery or ground	No continuity

PRESSURE SENSOR CONNECTOR



4007210a

Figure 3.29

Pin	Circuit
1	Voltage Supply
2	Ground
3	Pressure Signal

Pressure Sensor Testing Available in Meritor WABCO TOOLBOX™ Software

The pressure sensor test can be accessed through Meritor WABCO TOOLBOX™ Software under Component Tests, Pressure Sensor.

- Ensure brake pedal position and pressure is displayed in the corresponding boxes. Figure 3.30 and Figure 3.31.

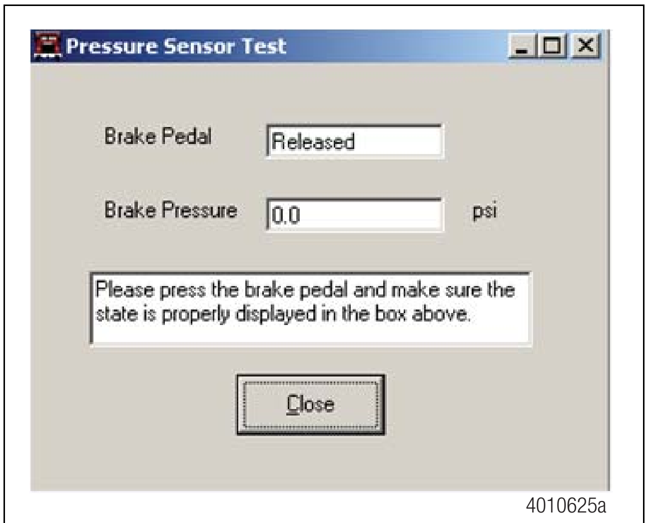


Figure 3.30

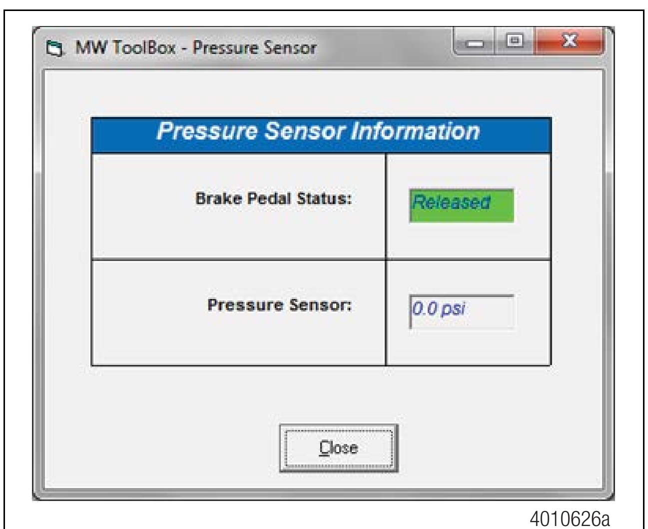


Figure 3.31

ESC CAN Network Testing

The ECU, SAS and ESC module are all connected on propriety CAN network with internal terminating resistors on each one of these components. A failure to one of the components will cause others to fault out. Figure 3.32 and Figure 3.33.

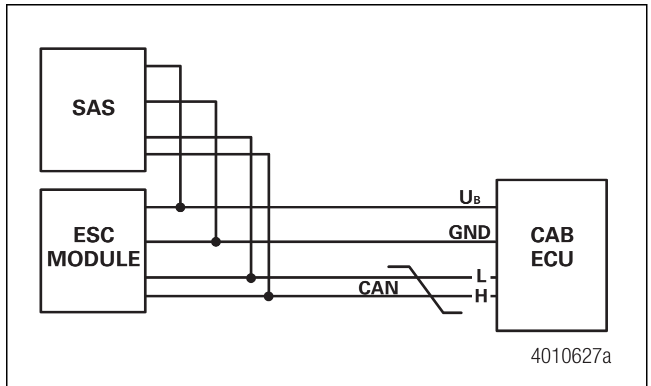


Figure 3.32

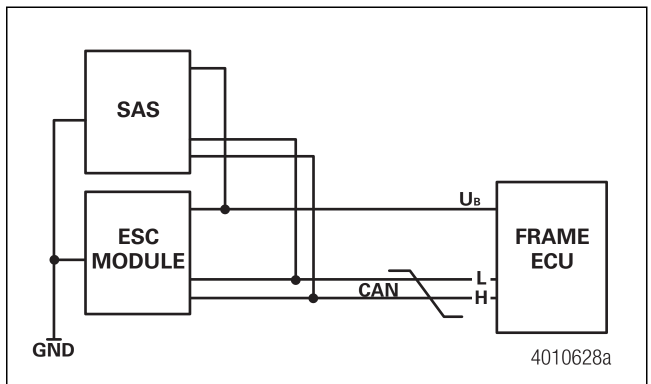


Figure 3.33

ESC Module Testing

Electrical Checks

For the following checks, all of the ECU connectors must be plugged in as well as the SAS. The ECU provides voltage, ground and CAN communication to ESC module.

- Take measurements at the ESC module harness connector. Figure 3.34 and Figure 3.35.
- Measure voltage supply Key ON.
- Measure CAN High voltage Key ON.
- Measure CAN Low voltage Key ON.

- Measure terminating resistance across CAN High and Low with Key OFF.
- Frame-mounted ECU only: Measure ground resistance Key OFF to chassis ground.

With ECU and ESC Module disconnected:

- Verify continuity end to end on each line
- Verify no shorts to ground or battery on all lines.
- Verify no continuity between pins.

Measurements should read as follows:

Pins	Circuit	Measurement
1	Voltage Supply to Chassis Ground	8.0-16.0V
2	(Frame-mounted only) ESC Ground to Chassis Ground	Less than 1 ohm resistance
2	(Cab-mounted only) ESC Ground to Chassis Ground	Should have continuity but will not be less than 1 ohm
3 and 4	Terminating Resistance between ESC CAN-High to ESC CAN-Low	Approximately 90 ohms
1	With ECU disconnected, check power supply for battery voltage or ground.	No continuity
2	With ECU disconnected, check ground for battery voltage or ground.	No continuity
3 and 4	With ECU disconnected, check CAN lines for battery voltage or ground.	No continuity
3	CAN High Voltage to Chassis Ground	2.5-5.0V
4	CAN Low Voltage to Chassis Ground	0.1-2.4V

NOTE: Do not load test across power and ground at the ESC Module.

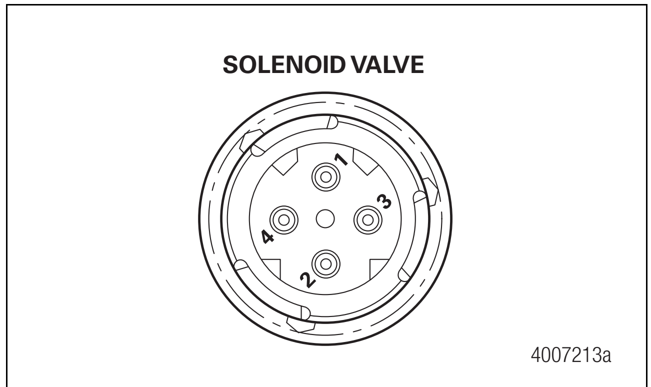


Figure 3.34

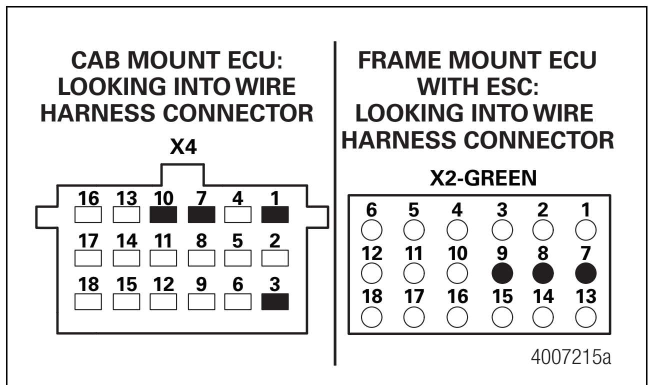


Figure 3.35

ECU	ESC Module Circuit	Connector	Pins
Cab-Mounted	Power Supply	X4-18 pin	7
Universal with ESC	Ground	X4-18 pin	10
	ESC CAN-Low	X4-18 pin	1
	ESC CAN-High	X4-18 pin	3
Frame-Mounted	Power Supply	X2-Green	9
With ESC	Ground	X2-Green	External
	ESC CAN-Low	X2-Green	7
	ESC CAN-High	X2-Green	8

ESC Module Mounting

The ESC module contains sensors which measure both lateral acceleration and yaw rate. Thus, it is critical that the module is securely mounted, leveled and in correct location to the vehicle and that the module is mounted as expected by the ECU and as per vehicle OEM specifications.

The module should be installed in a manner where the label is right side up. The module must be mounted perpendicular to the vehicle frame rails on a cross member or cross member bracket. The module connector could be facing the front or rear of the vehicle depending on the OEM's specified mounting. It is critical that the unit be mounted in the exact location and manner as originally installed by the vehicle manufacturer. Figure 3.36.

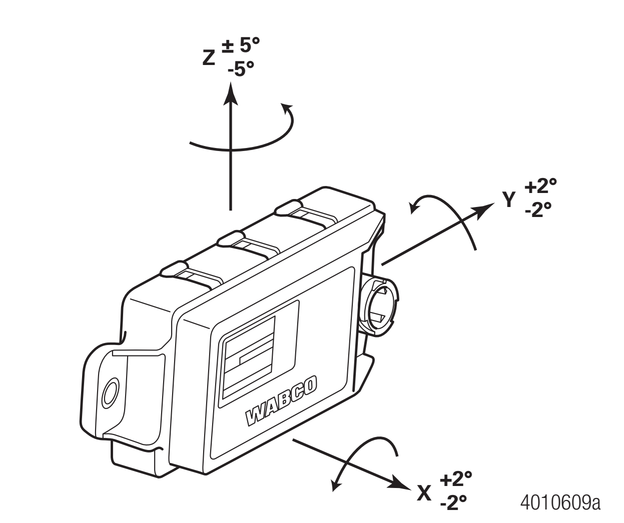


Figure 3.36

ESC Information Available in Meritor WABCO TOOLBOX™ Software 11 or Higher

ESC Information can be accessed through Meritor WABCO TOOLBOX™ Software 11 or higher under Components, ESC.

To access the ESC Information:

- If you are using TOOLBOX™ Software version 11 or higher, click on the "Components" button. A drop-box will appear. Select "ESC" then select "ESC Info". Figure 3.37 and Figure 3.38.

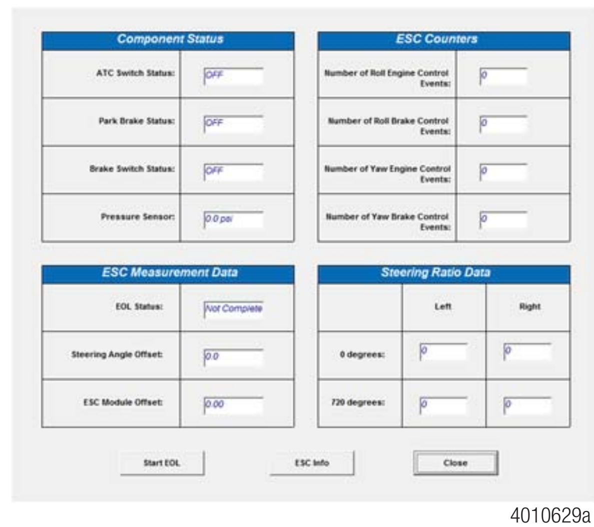


Figure 3.37

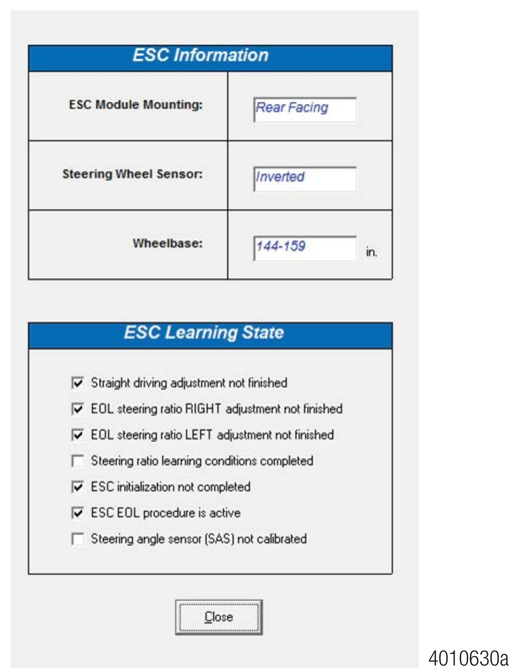


Figure 3.38

Steering Angle Sensor (SAS) Testing

Electrical Checks

The following tests are for Meritor WABCO SAS Only.

- Disconnect SAS and check terminating resistance across Pin 1 and Pin 2 of the SAS. Figure 3.39 and Figure 3.40.

For the following checks, all the ECU and ESC module connectors must be plugged in as the ECU provides all voltage, ground and CAN communications. Figure 3.42 and Figure 3.43.

- Take measurements at the SAS harness connector side. Figure 3.41.
  - Check Key On CAN Low voltage on Pin 1.
  - Check Key On CAN High voltage on Pin 4.
  - Check Key On Voltage Supply on Pin 5.
  - Check Key Off resistance across CAN low Pin 1 and CAN High Pin 4.

Location	Measurement
Meritor Wabco SAS terminating resistor on sensor	Approximately 180 ohms
CAN High Voltage	2.5-5.0V
CAN Low Voltage	0.1-2.4V
Voltage Supply to Ground	8.0-16.0V
ESC CAN-High to ESC CAN-Low	Approximately 90 ohm
SAS harness jumper (Pin 2 to Pin 4 or Pin 2 to Pin 3)	Continuity
ESC CAN-High or CAN-Low to Power or Ground (with ECU, ESC Module and SAS unplugged)	No continuity

NOTE: For correct sensor operation, there must be a jumper wire on the harness side across either Pin 2 to Pin 3 or Pin 4 so terminating resistor is connected as shown in Figure 3.40.

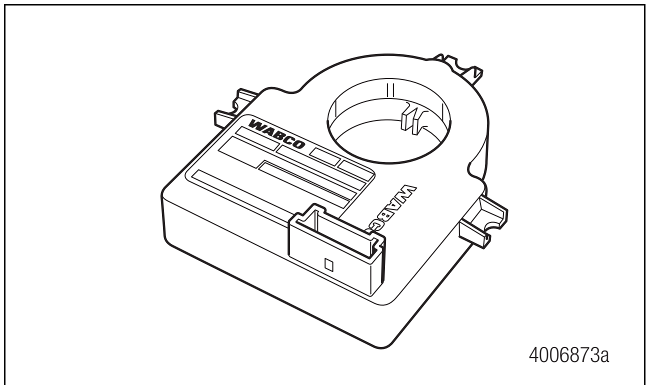


Figure 3.39

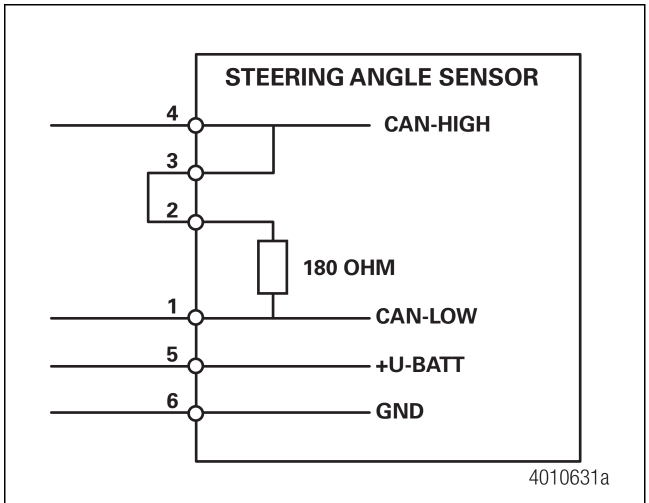


Figure 3.40

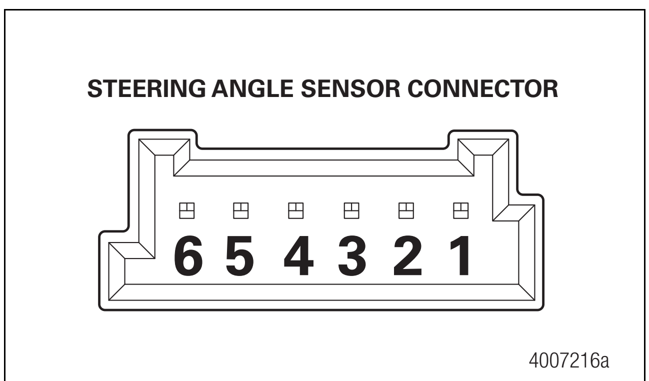


Figure 3.41

Pin	Circuit
1	CAN-Low
2	Terminating Resistor
3	CAN-High
4	CAN-High
5	Power
6	Ground

NOTE: Do not load test across power and ground at the SAS.

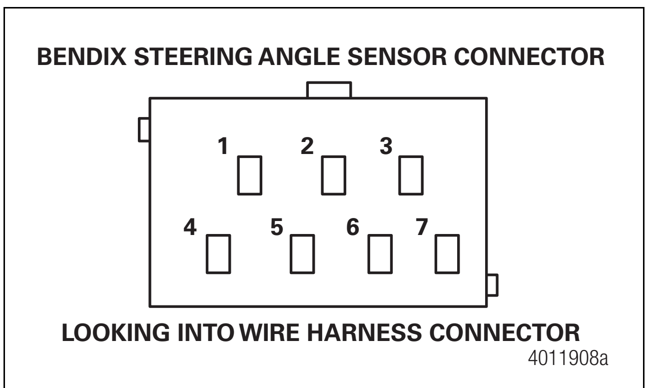


Figure 3.42

Pin	Circuit
1	Ground
2	Power
3	CAN-High
4	CAN-Low

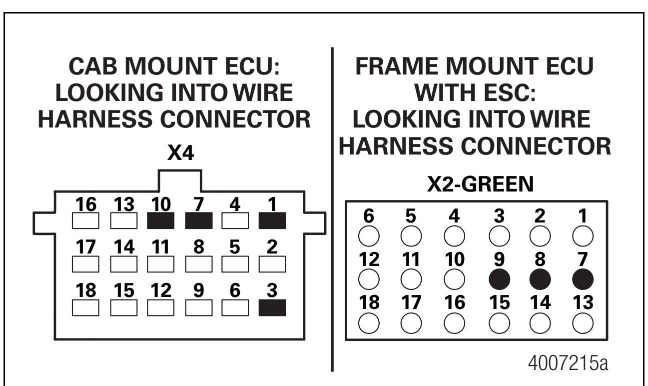


Figure 3.43

ECU Circuit Testing

Electrical Checks

- Verify vehicle batteries, charging system and fuses are in good working condition.
- Load test battery and ignition circuits to ground at the ECU harness using a 2-4 amp sealed lamp and verify lamp does not flicker and it is on steady.
- Take measurements at the ECU harness pins. Figure 3.44 and Figure 3.45.

Measurements should read as follows:

Location	Measurement
Supply Voltage, Battery to chassis Ground	9.0-16.0V for 12V system 18.0-32.0V for 24V system
Supply Voltage, Ignition to chassis Ground	9.0-16.0V for 12V system 18.0-32.0V for 24V system
ECU ground to chassis ground	Less than 1 ohm resistance
Main ground to chassis ground	Less than 1 ohm resistance

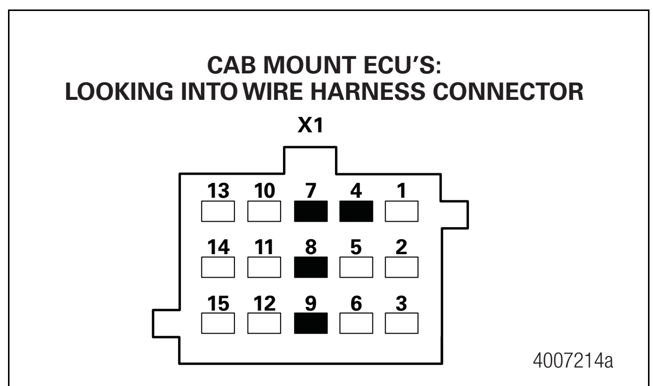


Figure 3.44

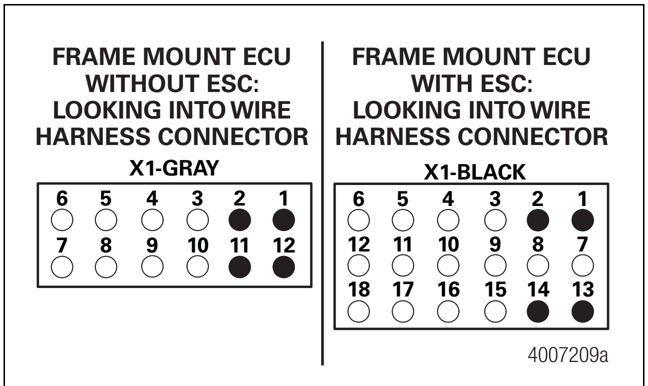


Figure 3.45

ECU	Power Supply Circuit	Connector	Pins
Cab-Mounted Universal with ESC, Universal or Basic	Supply Voltage, Battery	X1-15 pin	8
	Supply Voltage, Ignition	X1-15 pin	7
	Central Ground	X1-15 pin	4, 9
Frame-Mounted Non-ESC	Supply Voltage, Battery (Could be IGN)	X1-Gray	1
	Supply Voltage, Ignition	X1-Gray	2
	Central Ground	X1-Gray	11, 12
Frame-Mounted With ESC	Supply Voltage, Battery	X1-Black	1
	Supply Voltage, Ignition	X1-Black	2
	Central Ground	X1-Black	13, 14

J1939 Serial Communications Testing

Electrical Checks

- If the ABS ECU is the only ECU on the J1939 datalink which cannot communicate, then take measurements at the ABS ECU connector. If other ECUs are not communicating, then troubleshoot the vehicle datalink backbone and contact the vehicle OEM for technical assistance if required.
- Check for devices that could be overloading the J1939 datalink slowing down communications.
- Verify J1939 High and Low have correct voltage readings, Key ON, while datalink communications are active.
- For resistance measurements, the vehicle battery must be disconnected and the ignition must be OFF. Figure 3.46, Figure 3.47, Figure 3.48 and Figure 3.49.

Measurements should read as follows:

Location	Measurement
Across J1939 High and Low	Approximately 60 ohms
J1939 Low voltage	0.1V-2.4V
J1939 High voltage	2.5V-5.0V
J1939 High or J1939 Low to Ground or Power Supply	No continuity

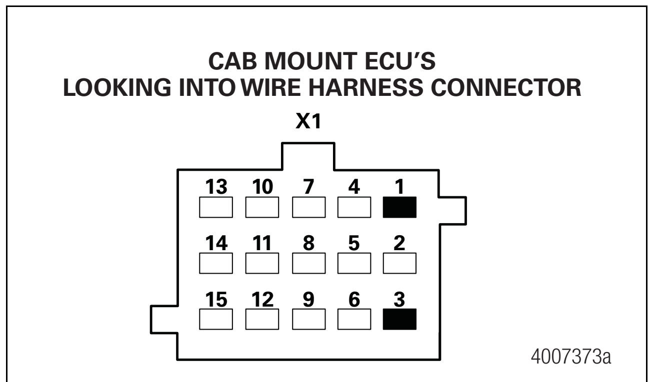


Figure 3.46

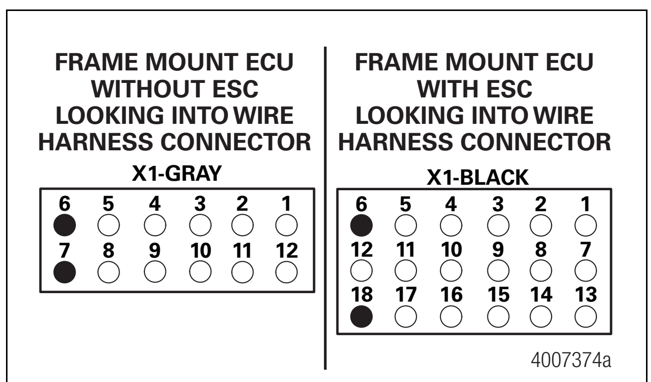


Figure 3.47

ECU	J1939 Datalink Circuit	Connector	Pins
Cab-Mounted	J1939 High	X1-15 pin	3
All	J1939 Low	X1-15 pin	1
Frame-Mounted	J1939 High	X1-Gray	7
Without ESC	J1939 Low	X1-Gray	6
Frame-Mounted	J1939 High	X1-Black	18
With ESC	J1939 Low	X1-Black	6

ECU	J1587 Datalink Circuit	Connector	Pins
Cab-Mounted ECU	J1939 High	X1	11
	J1939 Low		10
Frame-Mounted ECU without ESC	J1939 High	X1-Gray	4
	J1939 Low		9
Frame-Mounted ECU with ESC	J1939 High	X1-Black	4
	J1939 Low		16

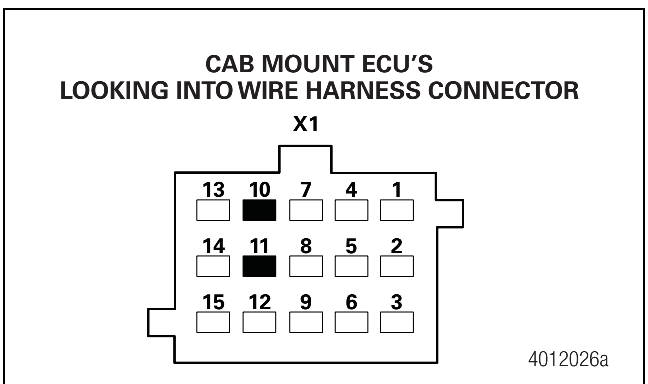


Figure 3.48

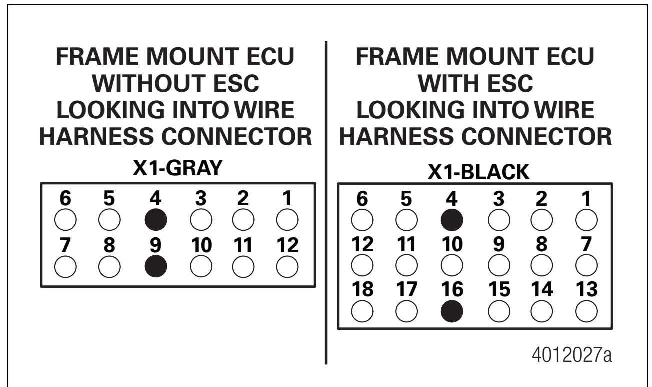


Figure 3.49

Hazard Alert Messages

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

⚠ WARNING

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

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

⚠ CAUTION

When welding on an ABS- or ABS/ATC-equipped vehicle is necessary, disconnect the power connector from the ECU to prevent damage to the electrical system and ABS/ATC components.

Component Removal and Installation

Wheel Speed Sensors

Sensor Lubricant Specification

Meritor WABCO specifications call for a sensor lubricant with the following characteristics:

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

Lubricants approved for use on Meritor WABCO sensors and spring clips are as follows. Figure 4.1.

- Mobilith SHC-220 (Mobil)
- TEK 662 (Roy Dean Products)
- Staburags NBU 30 PTM (Kluber Lubrication)
- Valvoline EP 633

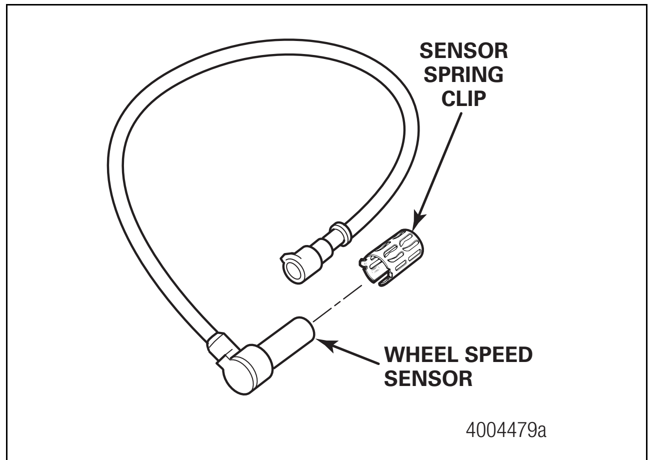


Figure 4.1

Removal

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

⚠ WARNING

Park the vehicle on a level surface. 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. Serious personal injury and damage to components can result.

1. Place blocks under the tires to stop the vehicle from moving. Apply the parking brake.
2. If necessary, raise the tires off the ground. Place safety stands under the axle.
3. Depending on the axle, wheel hub and brake configurations, some components might have to be removed to obtain access to wheel speed sensor. Follow the vehicle OEMs guidelines to gain access to wheel speed sensor.
4. Disconnect the fasteners that hold the sensor cable to other components.
5. Disconnect the sensor cable from the chassis harness.
6. Remove the sensor from the sensor holder. Use a twisting motion if necessary. **Do not pull on the cable.** Figure 4.2 and Figure 4.3.

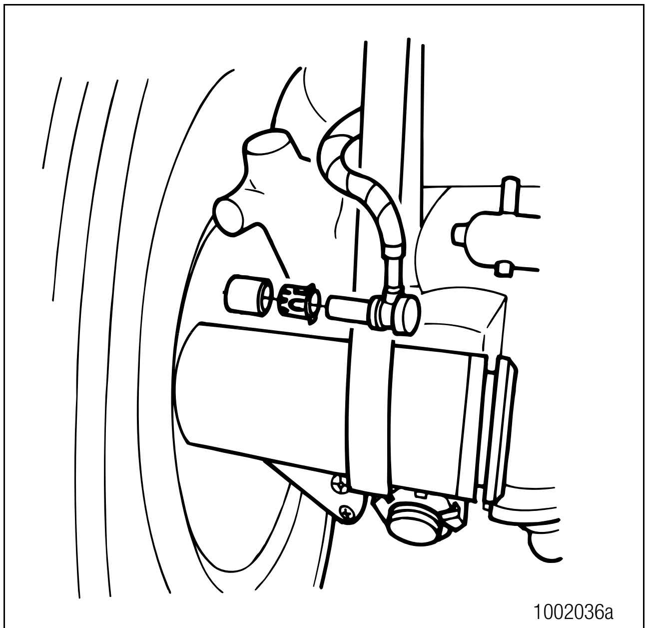


Figure 4.2

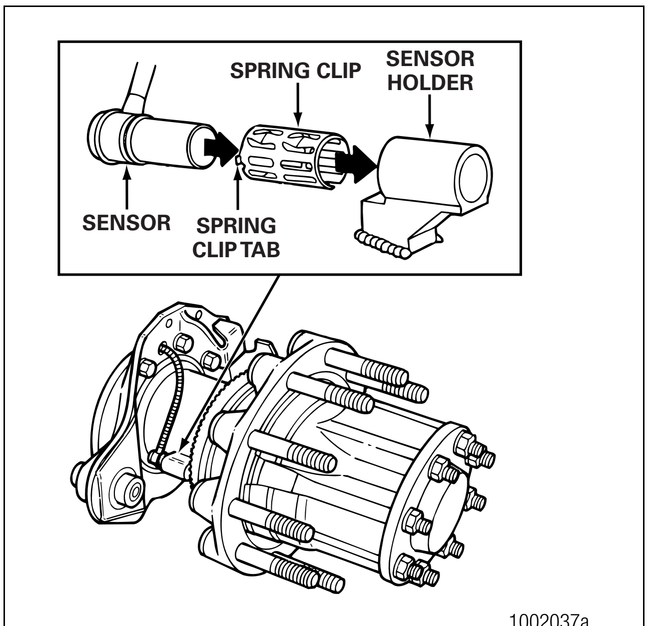


Figure 4.3

7. Remove the sensor spring clip.

Installation

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

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

7. Remove the blocks and safety stands.

Modulator Valves

Removal

⚠ WARNING

Park the vehicle on a level surface. 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. Serious personal injury and damage to components can result.

1. Turn the ignition switch to the OFF position. Apply the parking brake.
2. Place blocks under the front and rear tires to stop the vehicle from moving.
3. If necessary, raise the vehicle off the ground and place safety stands under the axle.
4. Disconnect the wiring connector from the ABS valve.
5. Disconnect the air lines from Ports 1 (air supply) and 2 (air discharge) of the ABS valve. Figure 4.4.

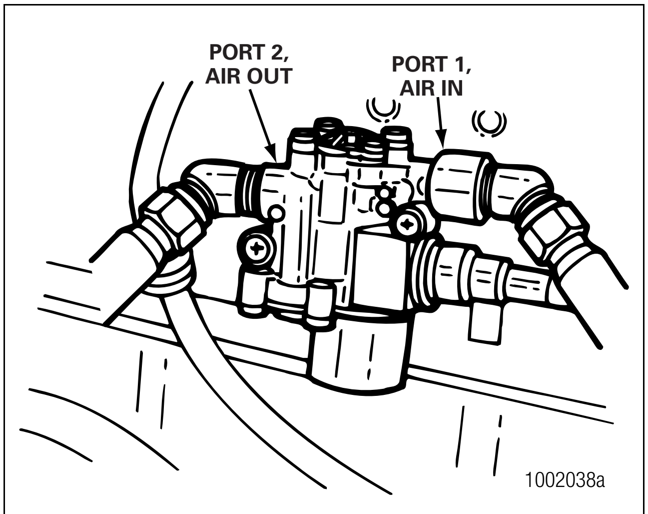


Figure 4.4

6. Remove the two mounting capscrews and nuts.
7. Remove the ABS valve.

Installation

CAUTION

Moisture can affect the performance of all ABS/ATC systems, as well as the standard braking system. Moisture in air lines can cause air lines to freeze in cold weather.

1. Install the ABS valve with two mounting capscrews and nuts. Tighten the capscrews per the manufacturer's recommendation.
2. Connect the line to the brake chambers to Port 2 of the ABS valve. Connect the air supply line to Port 1 of the ABS valve.
3. Connect the wiring connector to the ABS valve. Hand tighten only.
4. Remove the blocks and stands.
5. Test the installation.

Checking the Installation

1. Apply the brakes. Listen for leaks at the modulator valve.
2. Turn the ignition on and listen to the modulator valve cycle. If the valve fails to cycle, check the electrical cable connection. Make repairs as needed.
3. After any repair has been performed, cycle the ignition key and test drive the vehicle. Verify that the ABS indicator lamp operates correctly.

Active Braking Valves (ABV)

Removal

Depending on the OEM specs and vehicle system configuration, ABVs may be located near the rear axle, front axle and in line with trailer service/control line. Consult the vehicle OEM for exact location of these valves.

WARNING

Park the vehicle on a level surface. 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. Serious personal injury and damage to components can result.

1. Turn the ignition switch to the OFF position. Apply the parking brake.
2. Place blocks under the front and rear tires to stop the vehicle from moving.
3. If necessary, raise the vehicle off the ground. Place safety stands under the axle.

WARNING

Relieve line pressure by bleeding the air from the appropriate supply tank. Pressurized air can cause serious personal injury.

4. Disconnect the wiring from the valve.
5. Disconnect the air lines from Port 1 (air supply), Port 2 (air discharge) and Port 3 (treadle) of the ATC valve. Figure 4.5.

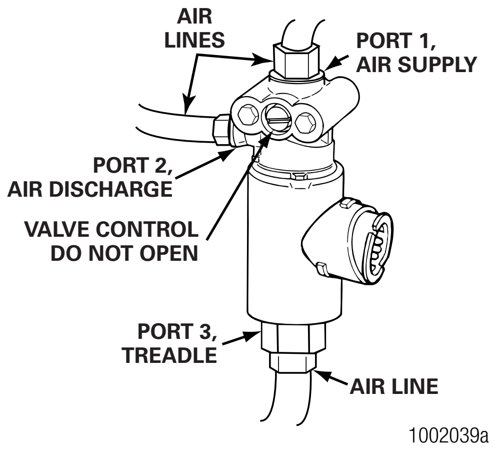


Figure 4.5

6. Remove the two mounting capscrews and nuts. Remove the valve.

Installation

1. Install the valve with two mounting capscrews and nuts. Tighten the capscrews per the manufacturer's recommendation.
2. Connect the air supply, discharge and treadle lines to Ports 1, 2 and 3 of the valve.
3. Connect the harness connector to the valve. Hand tighten only.
4. Remove the blocks and stands.
5. Test the installation.

Checking the ABV Installation

To test the active braking valve:

1. Turn the ignition to the ON position and verify that the ATC/ Stability Control lamp operates correctly.
2. Start the vehicle.
3. Fully charge the reservoirs with air. Shut off the vehicle.
4. Apply the brakes.
5. Listen for air leaks at the valve.
6. Release the brakes.
7. Activate the valve using TOOLBOX™ Software. Verify correct operation and that there are no active codes.
8. Make necessary repairs if needed.
9. Drive the vehicle. Verify that the ATC indicator lamp operates correctly.

Checking the Trailer ABV Installation

1. Connect the blue glad hand to a 50 cu. in. (819 cu. cm) air tank.
2. Start the vehicle.
3. Fully charge the reservoirs with air. Shut off the vehicle.
4. Activate the valve using TOOLBOX™ Software; verify correct operation and no active codes.
5. Listen for air leaks at the valve.
6. Make necessary repairs if needed.
7. Turn the ignition ON. Verify that the ATC/Stability Control indicator lamp operates correctly.

ABS Valve Packages

Removal and Installation — Complete Package

⚠ WARNING

Park the vehicle on a level surface. 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. Serious personal injury and damage to components can result.

⚠ WARNING

Relieve line pressure by bleeding the air from the appropriate supply tank. Pressurized air can cause serious personal injury.

1. Place blocks under tires to stop the vehicle from moving.
2. If necessary, raise the tires off the ground.
3. Drain the air from all system air tanks.
4. Remove all the air lines and connections from the ABS valve package. Figure 4.6 and Figure 4.7.

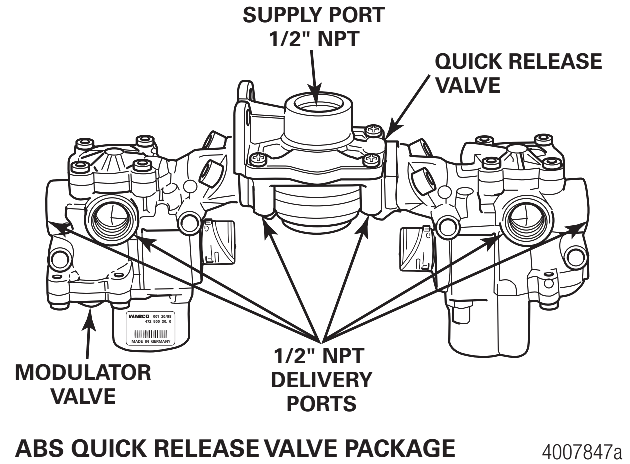


Figure 4.6

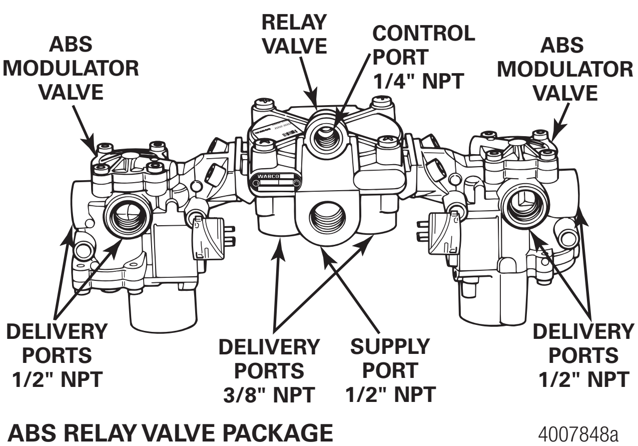


Figure 4.7

5. Remove the mounting bolts from the valve package. Remove the valve package from the vehicle.
6. **Replace the ABS valve package:** Tighten the bolts to the vehicle manufacturer's recommendation. Remove the blocks and safety stands as necessary.
7. Test the installation.

Removal and Installation — Component Valves

1. Remove the ABS valve package from the vehicle. Figure 4.8.

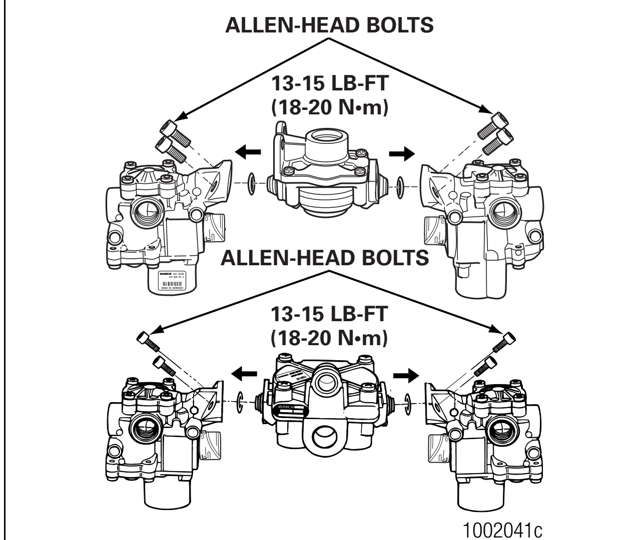


Figure 4.8

2. Use a 6 mm Allen wrench to loosen and remove the Allen-head bolts.
3. Carefully separate the ABS modulator valve(s) from the relay or quick release valve.
4. Remove and discard old O-rings. Lubricate replacement O-rings with the grease provided.
5. Plug any unused ports on the replacement valve(s).
6. Attach the ABS modulator valve(s) to the relay or quick release valve. Use a 6 mm Allen wrench to tighten the Allen-head bolts to 13-15 lb-ft (18-20 N•m).
7. **Replace the ABS valve package:** Tighten the bolts to the vehicle manufacturer's recommendation. Remove the blocks and safety stands as necessary.
8. Check the valves for leaks:
   - Modulator valve(s). Refer to the procedure for checking the modulator valve installation in this section.
   - Relay or quick release valve. Refer to the procedure for checking the quick release or relay valve installation in this section.

Active Braking Valve on the ABS Valve Package

Removal

NOTE: If there is enough room to work, it is not necessary to remove the valve package from the vehicle before replacing the active braking valve (solenoid valve). If the valve package must be removed, follow the instructions for removing and replacing the ABS Valve Package that appear in this section of the manual.

WARNING

Relieve line pressure by bleeding air from the appropriate supply tank. Pressurized air can cause serious personal injury.

When installing the new active braking valve (solenoid valve) on the valve package, you must use the new O-rings, seals, mounting bolts and lubricant included with the replacement kit.

1. Turn the ignition switch to the OFF position. Apply the parking brake.
2. Place blocks under the front and rear tires to stop the vehicle from moving.
3. If necessary, raise the vehicle off the ground. Place safety stands under the axle.

WARNING

Relieve line pressure by bleeding the air from the appropriate supply tank. Pressurized air can cause serious personal injury.

4. Disconnect the wiring from the solenoid valve.
5. Disconnect the supply air line from the adapter and the treadle air line from the solenoid valve.
6. Use a 5 mm Allen wrench to remove the two screws that hold the adapter piece to the relay valve portion of the valve package.
7. Use a 6 mm Allen wrench to remove the two mounting bolts that hold the solenoid valve to the adapter piece. Remove the solenoid valve from the adapter piece. Remove the solenoid valve.
8. Remove the adapter piece, seal and O-rings from the valve package. Figure 4.9.

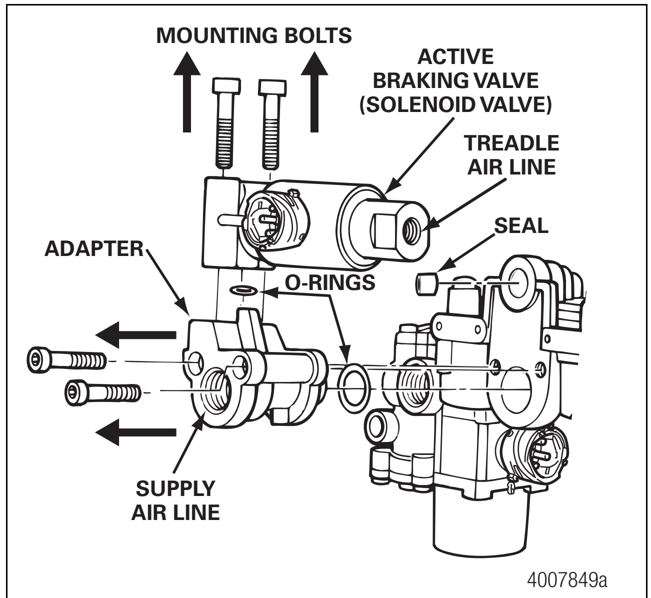


Figure 4.9

Installation

1. Clean and lubricate the small adapter piece O-ring. Install the O-ring on the adapter piece.
2. Use the two new M8 Allen-head bolts to attach the solenoid valve to the adapter piece. Use a 6 mm Allen-head tool to tighten to 13-15 lb-ft (18-20 N•m). Figure 4.10.

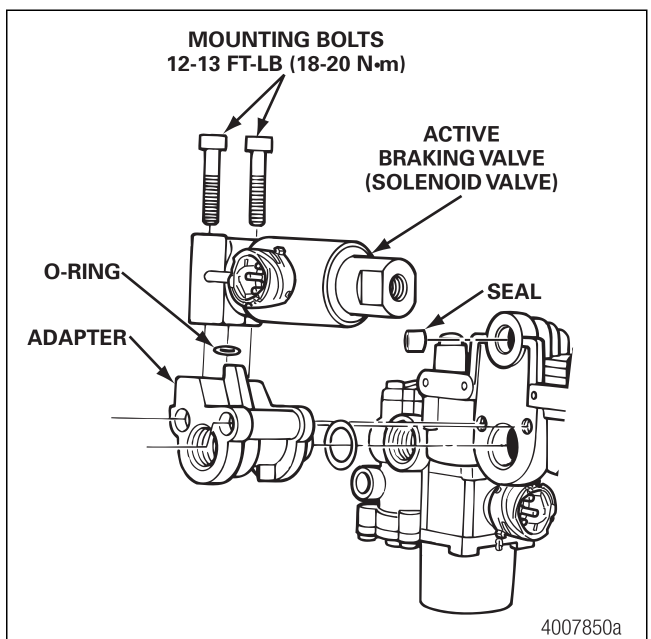


Figure 4.10

3. Lubricate the replacement seal and install it in Port 2 of the solenoid valve.
4. Lubricate the large replacement O-ring and install it in the groove of the relay valve supply port. Figure 4.11.

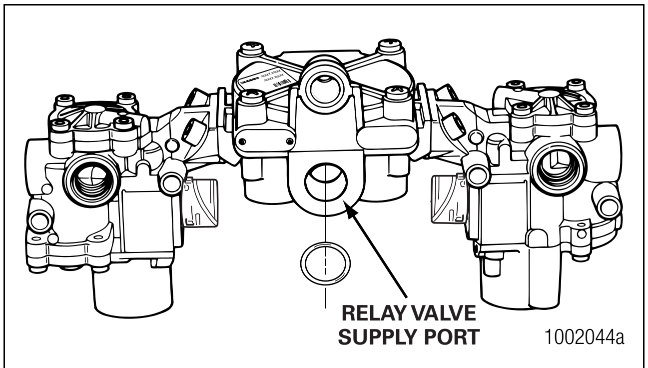


Figure 4.11

NOTE: Use Meritor WABCO-recommended lubricant.

5. Use the two M6 Allen-head bolts to attach the adapter to the relay valve. Use a 5 mm Allen-head tool to tighten to 4-5 lb-ft (6-8 N•m). Figure 4.12.

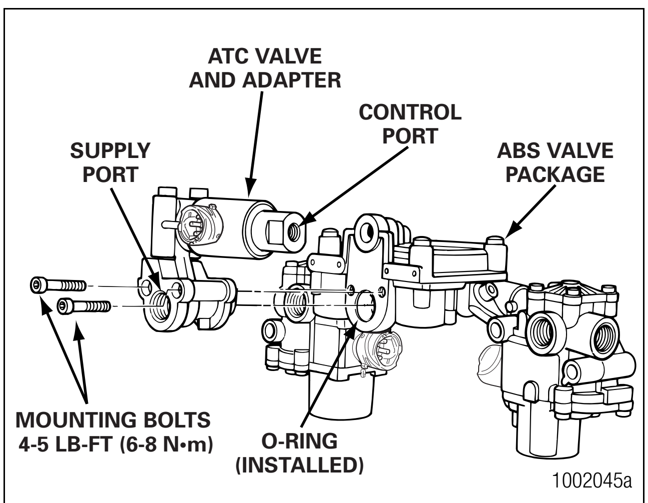


Figure 4.12

6. Connect the supply air line to the supply port on the adapter.
7. Connect the treadle air line to the control port on the solenoid valve. Place a wrench on the adapter to prevent the control port from twisting. Tighten the fitting to 15 ft-lb (20 N•m). Do not over tighten.
8. Attach the wiring connector to the solenoid valve. Hand tighten only.
9. Remove the blocks and stands.
10. Test the installation.

Checking the Installation

1. Start the vehicle.
2. Fully charge the reservoirs with air. Shut off the vehicle.
3. Apply the brakes.
4. Listen for air leaks at all valves.
5. Drive the vehicle. Verify that the ABS indicator lamp operates correctly.

Electronic Control Unit (ECU)

Removal

⚠ WARNING

Park the vehicle on a level surface. 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 or fall over. Serious personal injury and damage to components can result.

1. Turn the ignition switch to the OFF position. Apply the parking brake.
2. Place blocks under the front and rear tires to prevent the vehicle from moving.
3. Disconnect the wiring harness connectors from the ECU.
4. Remove the mounting hardware. Remove the ECU. Figure 4.13.

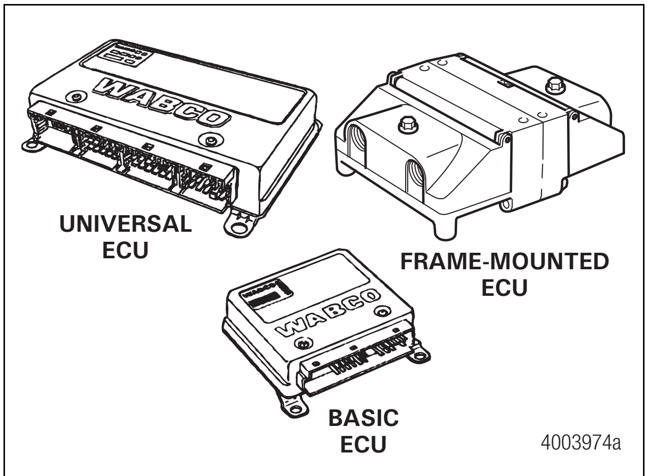


Figure 4.13

Installation

1. Install the ECU using the manufacturer's mounting hardware. Tighten the hardware per the manufacturer's recommendation.
2. Install the wiring harness connectors to the ECU.
3. Remove the blocks.
4. Test the installation.

   NOTE: If ECU has roll stability control (RSC), mounting of the ECU is crucial for proper operation due to internal accelerometer. Note the location installation of the ECU before removal. After installing ECU, verify the ECU is properly leveled and securely mounted on the right location as per OEM specs. See Section 2 RSC components for further information.

Testing the Installation

To test the ECU installation:

1. Turn the ignition ON and verify that the ABS self test and ABS light comes on and goes off.
   - Wheel speed related faults require a vehicle speed over 4 mph before the ABS light turns off and the code clears.
2. Use TOOLBOX™ Software to verify system has no active faults.
   - ECUs with Electronic Stability Control (ESC) will require system to be calibrated whenever a component has been replaced.
   - Follow the ESC End of Line Calibration Procedure described in this manual.
   - When the ESC End of Line Calibration Procedure is completed, the ABS and ATC/ESC lamps should come on and go back off when ignition power is turned on. The ATC/ESC lamp may remain on briefly after the ABS lamp goes off.
3. There should not be any active faults displayed in the ECU memory.

Steering Angle Sensor (SAS) — Meritor WABCO Only

Removal

⚠ WARNING

Park the vehicle on a level surface. 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 or fall over. Serious personal injury and damage to components can result.

⚠ WARNING

If equipped, disable the supplemental restraint system (air bag) to avoid serious personal injury. Refer to the vehicle manufacturer's service publication for further information.

1. Center the steering wheel with the front wheels positioned straight ahead.
2. Turn the ignition switch to the OFF position. Apply the parking brake.
3. Place blocks under the front and rear tires to prevent the vehicle from moving.
4. Locate the SAS on the steering column shaft, either near the universal joint on the bottom of the column or under the steering wheel near the top of the column.
5. If the SAS is located at the top of the steering column, remove the vehicle steering wheel using the recommended steering wheel puller.
6. The SAS is attached by three screws to the steering column with the center tab located in the grooved steering column shaft. Figure 4.14.

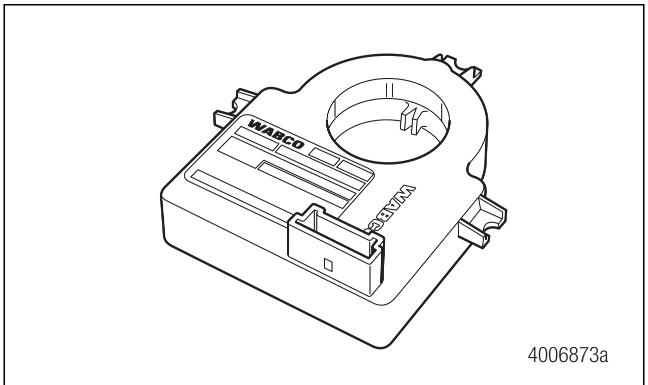


Figure 4.14

7. Disconnect the wiring harness connector from the SAS. (Note the position of the connector either facing up or down.)
8. Remove the attaching screws and slide the SAS off of the steering column shaft.

Installation

⚠ CAUTION

If the SAS is not installed in the correct orientation, it will not function correctly and may become damaged.

1. Apply a small amount of the supplied grease to the tab in the center of the SAS and to the machined groove on the steering shaft.
2. Install the SAS with the connector facing the same direction as the original. Place the SAS over the steering column shaft and slide it into place with the SAS tab placed in the groove that is machined on the steering column shaft.
3. Using the new furnished screws, replace the attaching screws and tighten to a maximum of 22 in-lb (2.5 N•m).
4. Install the SAS wiring harness connector by pushing the connector together until the small tab snaps into place.
5. Install the steering wheel and tighten per the manufacturer's recommendation.
6. Remove the blocks.
7. Test the installation.

Test the Installation

To test the SAS installation, the system must be calibrated.

1. Follow the ESC End of Line Calibration Procedure described in this manual.
2. When the ESC End of Line Calibration Procedure is completed, the ABS and ATC/ESC lamps should come on and go back off when ignition power is turned on. The ATC/ESC lamp may remain on briefly after the ABS lamp goes off.
3. There should not be any active faults displayed in the ECU memory.

Electronic Stability Control (ESC) Module

Removal

⚠ WARNING

Park the vehicle on a level surface. 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. Serious personal injury and damage to components can result.

1. Turn the ignition switch to the OFF position. Apply the parking brake.
2. Place blocks under the front and rear tires to prevent the vehicle from moving.
3. If necessary, raise the vehicle off the ground and place safety stands under the vehicle.
4. Disconnect the wiring harness connector from the ESC module. Figure 4.15 and Figure 4.16.

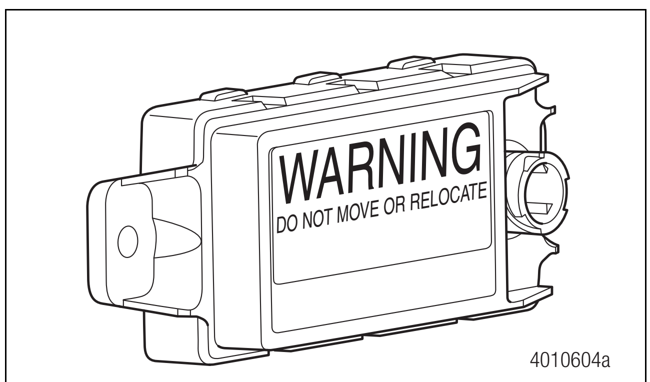


Figure 4.15

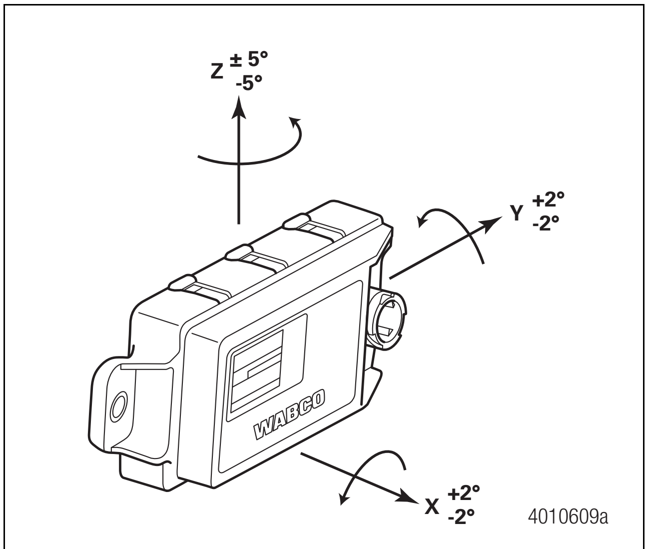


Figure 4.16

5. Remove the two mounting capscrews and nuts. Remove the ESC module.

   NOTE: ESC modules are installed by the OEM close to the vehicle center of gravity. Depending on the vehicle manufacturer, the ESC module might face towards the front of the vehicle or rear. For correct operation and the best performance, verify the ESC module is correctly leveled and securely mounted as per OEM specs. Do not move the module to a different location as this will affect the system performance.

Installation

NOTE: It is important that the module is aligned correctly and the tab on the ESC mounting surface fits into the appropriate hole.

1. Install the ESC module with the two capscrews and nuts. Tighten the capscrews per the manufacturer's recommendation.
2. Connect the wiring harness connector to the ESC module. Hand tighten only.
3. Remove the stands and blocks.
4. Test the installation.

Test the Installation

To test the ESC module installation, the system must be calibrated.

1. Follow the ESC End of Line Calibration Procedure described in this manual.
2. When the ESC End of Line Calibration Procedure is completed, the ABS and ATC/ESC lamps should come on and go back off when ignition power is turned on. The ATC/ESC lamp may remain on briefly after the ABS lamp goes off.
3. There should not be any active faults displayed in the ECU memory.

Brake Pressure Sensor

Removal

⚠ WARNING
Park the vehicle on a level surface. 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. Serious personal injury and damage to components can result.

1. Turn the ignition switch to the OFF position. Apply the parking brake.
2. Place blocks under the front and rear tires to prevent the vehicle from moving.
3. If necessary, raise the vehicle off the ground and place safety stands under the vehicle.

⚠ WARNING
Relieve line pressure by bleeding the air from the appropriate supply tank. Pressurized air can cause serious personal injury.

4. Disconnect the wiring harness connector from the brake pressure sensor. Figure 4.17.

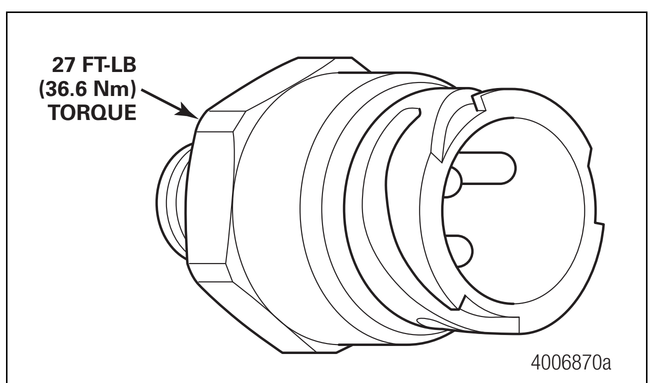


Figure 4.17

5. Disconnect the air line or unscrew the brake pressure sensor from the air line fitting.
6. Remove the brake pressure sensor.

Installation

1. Connect the brake pressure sensor to the air line or attach the sensor to the air line fitting.
2. Connect the wiring harness connector to the brake pressure sensor. Hand tighten only.
3. Remove the stands and blocks.
4. Test the installation.

Test the Installation

To test the brake pressure sensor:

1. Turn the ignition on and verify that the ATC/ESC lamp operates correctly.
2. Start the vehicle and fully charge the reservoirs with air. Shut off the vehicle.
3. Apply the brakes and check for air leaks at the brake pressure sensor.
4. There should not be any active faults displayed in the ECU memory.

System Configuration Layouts

The most common configurations are shown in this section. Always refer back to the vehicle OEM for the correct configuration of your vehicle.

Refer to Figure 5.1, Figure 5.2, Figure 5.3, Figure 5.4, Figure 5.5, Figure 5.6 and Figure 5.7 for system configuration layouts.

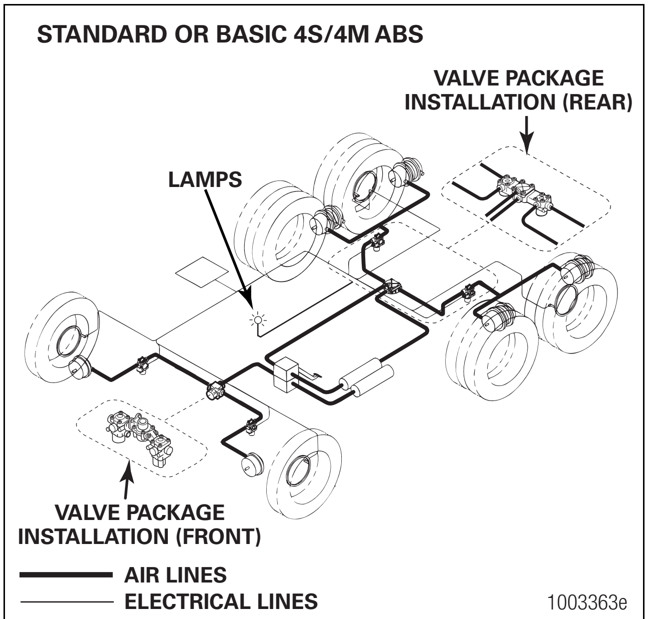


Figure 5.1

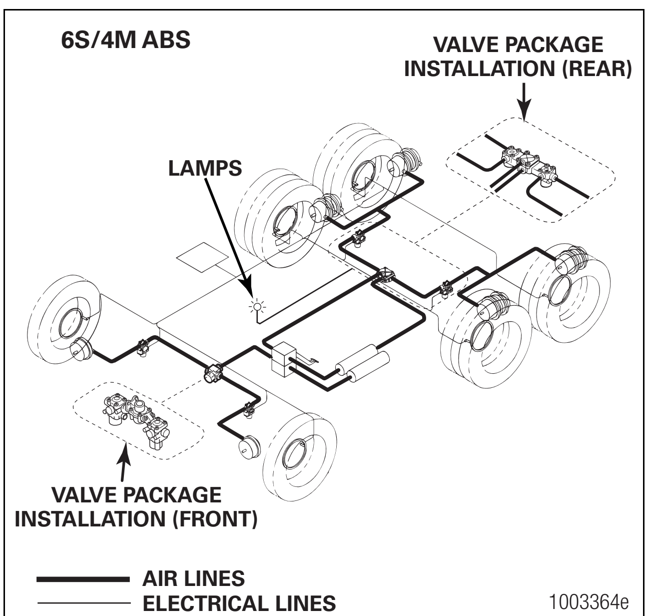


Figure 5.2

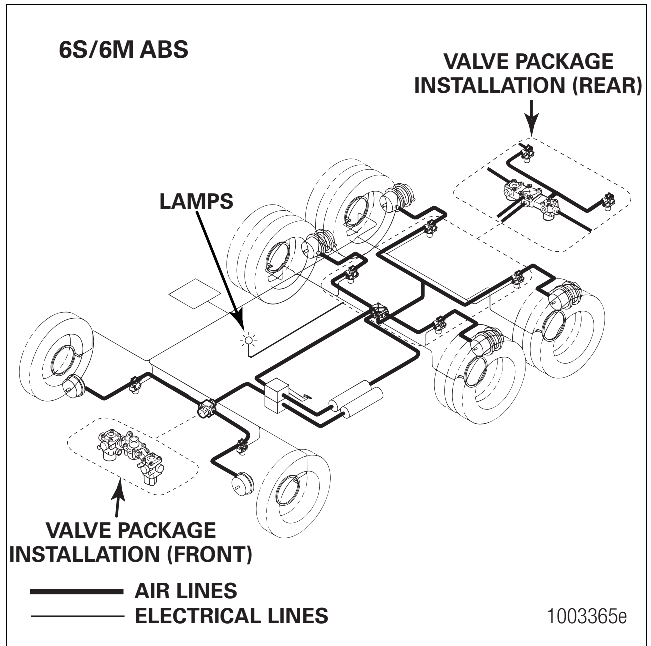


Figure 5.3

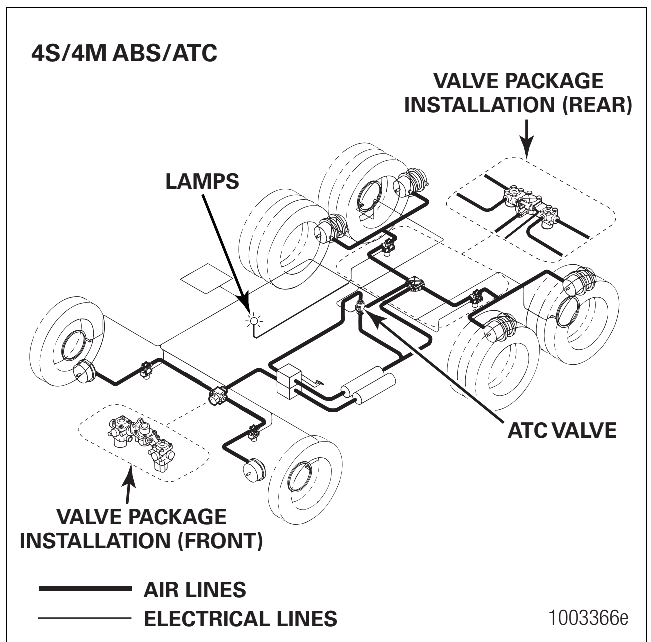


Figure 5.4

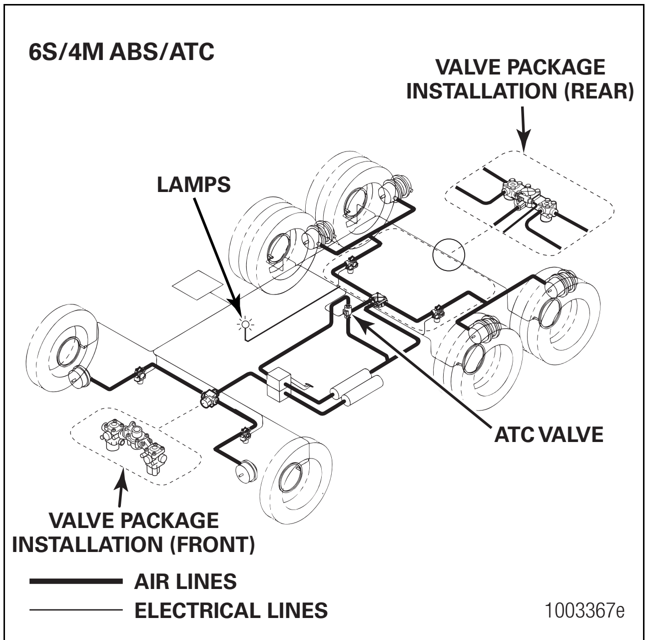


Figure 5.5

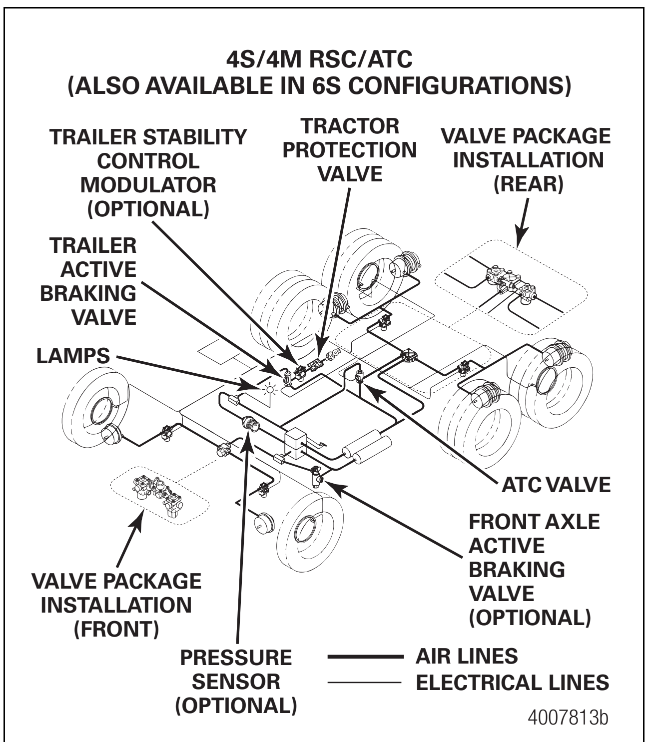


Figure 5.6

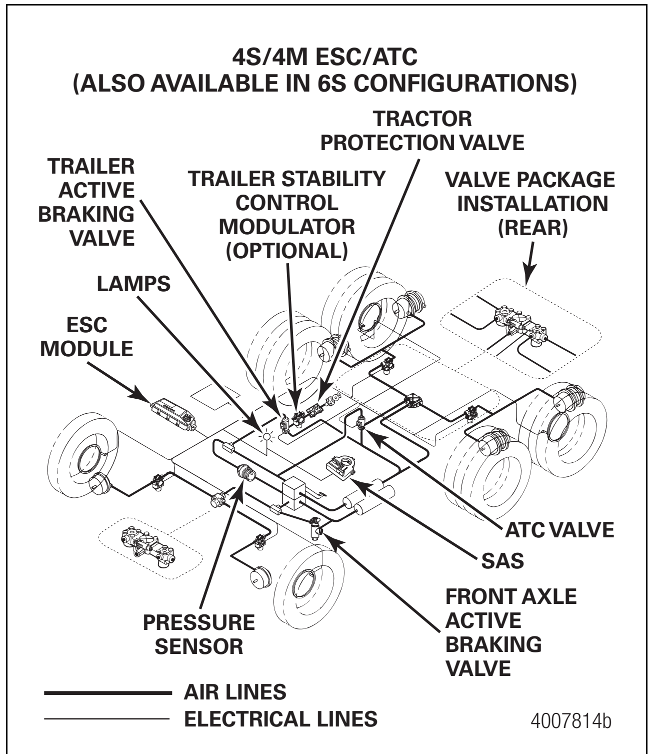
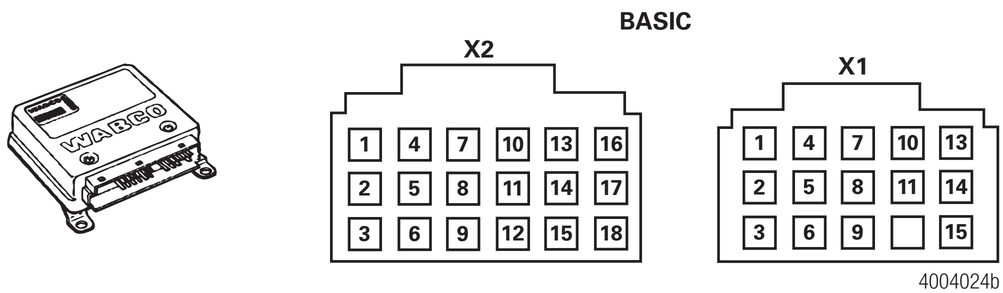


Figure 5.7

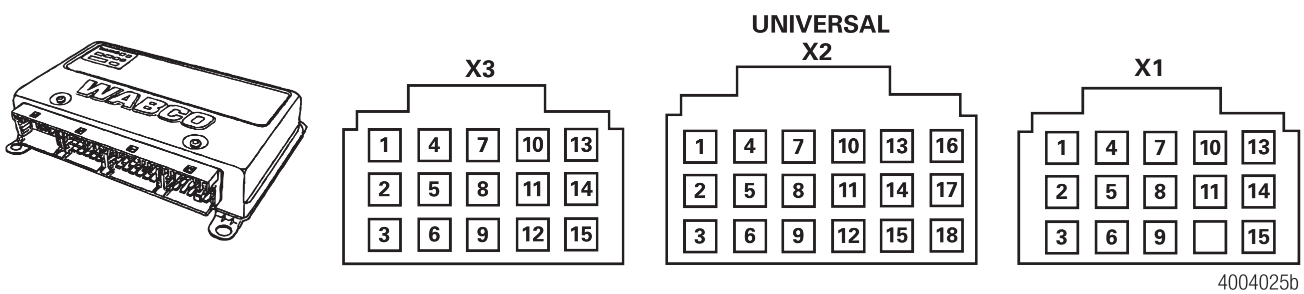
ECU Connector Pin Assignments

Refer to Figure 6.1, Figure 6.2, Figure 6.3, Figure 6.4, Figure 6.5, Figure 6.6, Figure 6.7, Figure 6.8, Figure 6.9, Figure 6.10, Figure 6.11, Figure 6.12, Figure 6.13, Figure 6.14 and Figure 6.15 for ECU wiring diagrams.



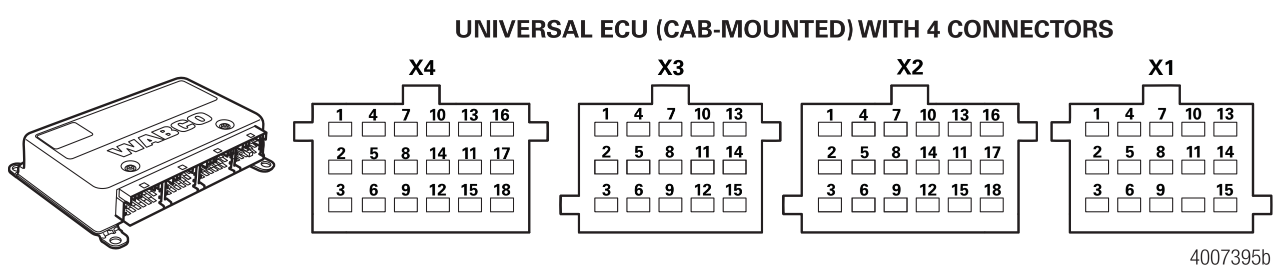
BASIC ECU (CAB-MOUNTED)

Figure 6.1



UNIVERSAL ECU (CAB-MOUNTED)

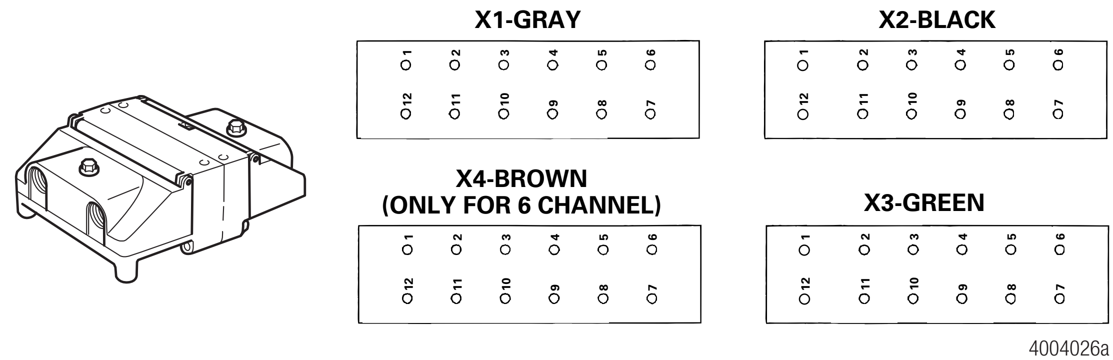
Figure 6.2



UNIVERSAL ECU (CAB-MOUNTED) WITH 4 CONNECTORS

Figure 6.3

ECU (Frame-mounted)



FRAME-MOUNTED ECU

Figure 6.4

ECU (Frame-mounted) with ESC and/or HSA

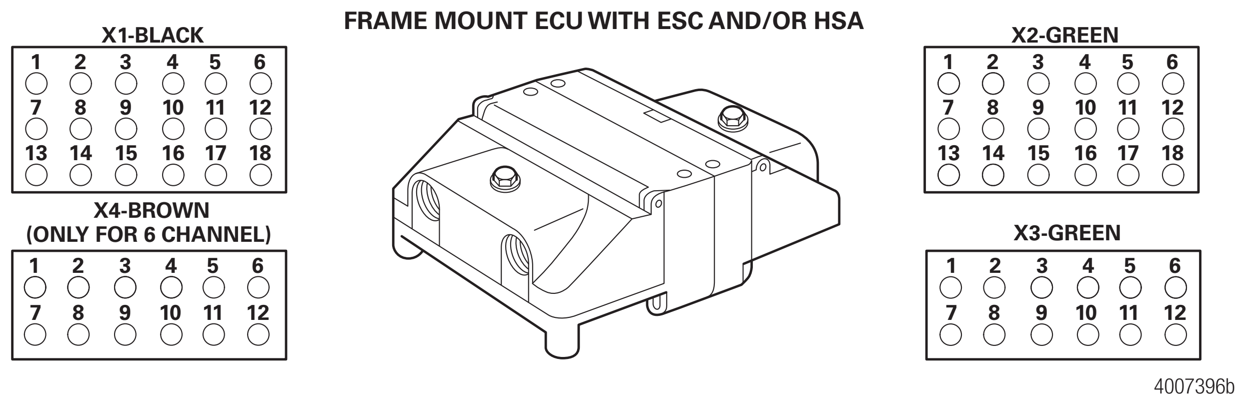


Figure 6.5

Basic ECU ABS Only with Optional Automatic Traction Control (ATC) (Cab-mounted)

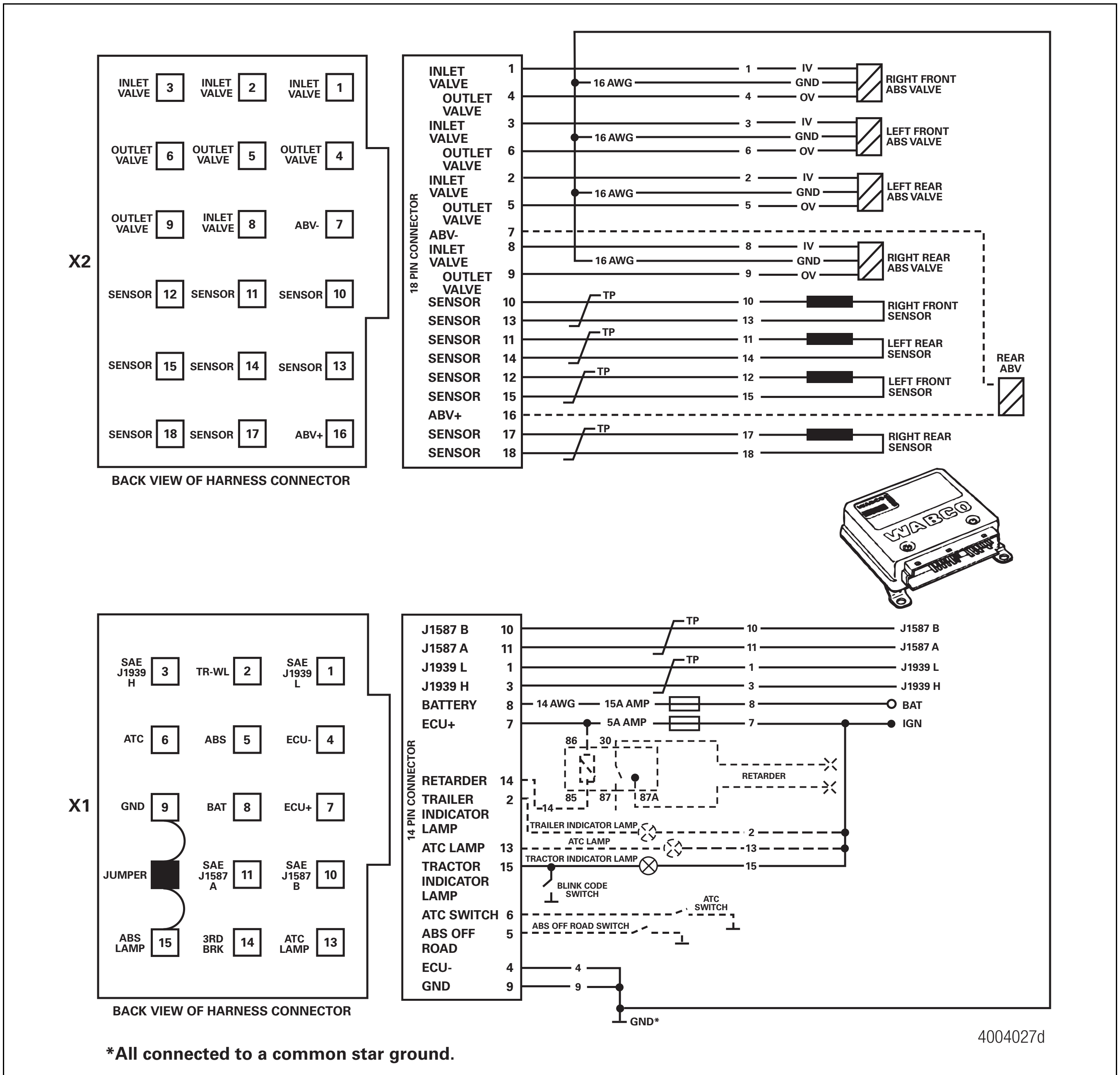


Figure 6.6

6S/6M Universal ECU ABS Only with Optional Automatic Traction Control (ATC) (6S/4M and 4S/4M Configurations are also available)

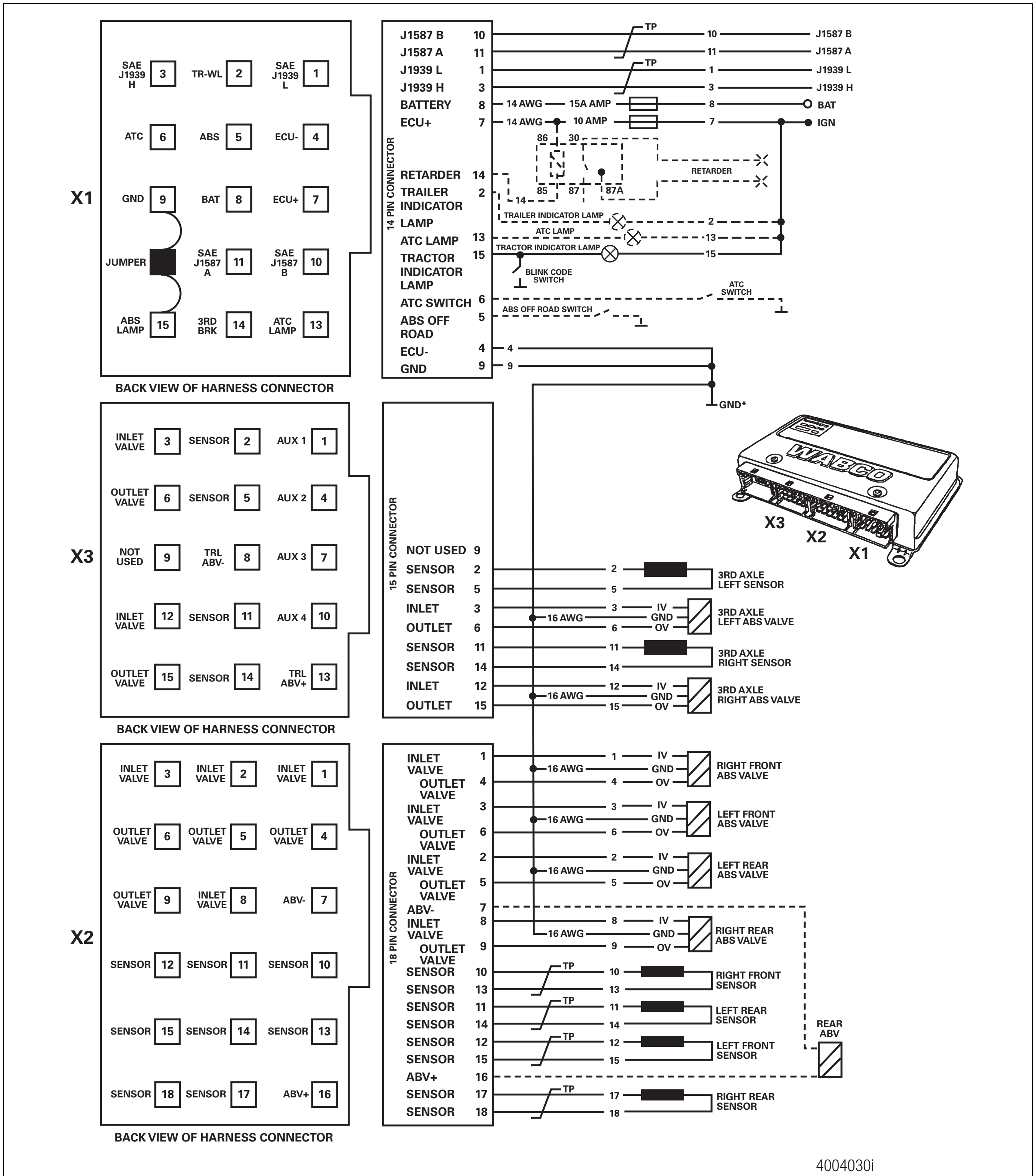


Figure 6.7

6S/6M Universal ECU with Roll Stability Control (RSC) (6S/4M and 4S/4M Configurations are also available)

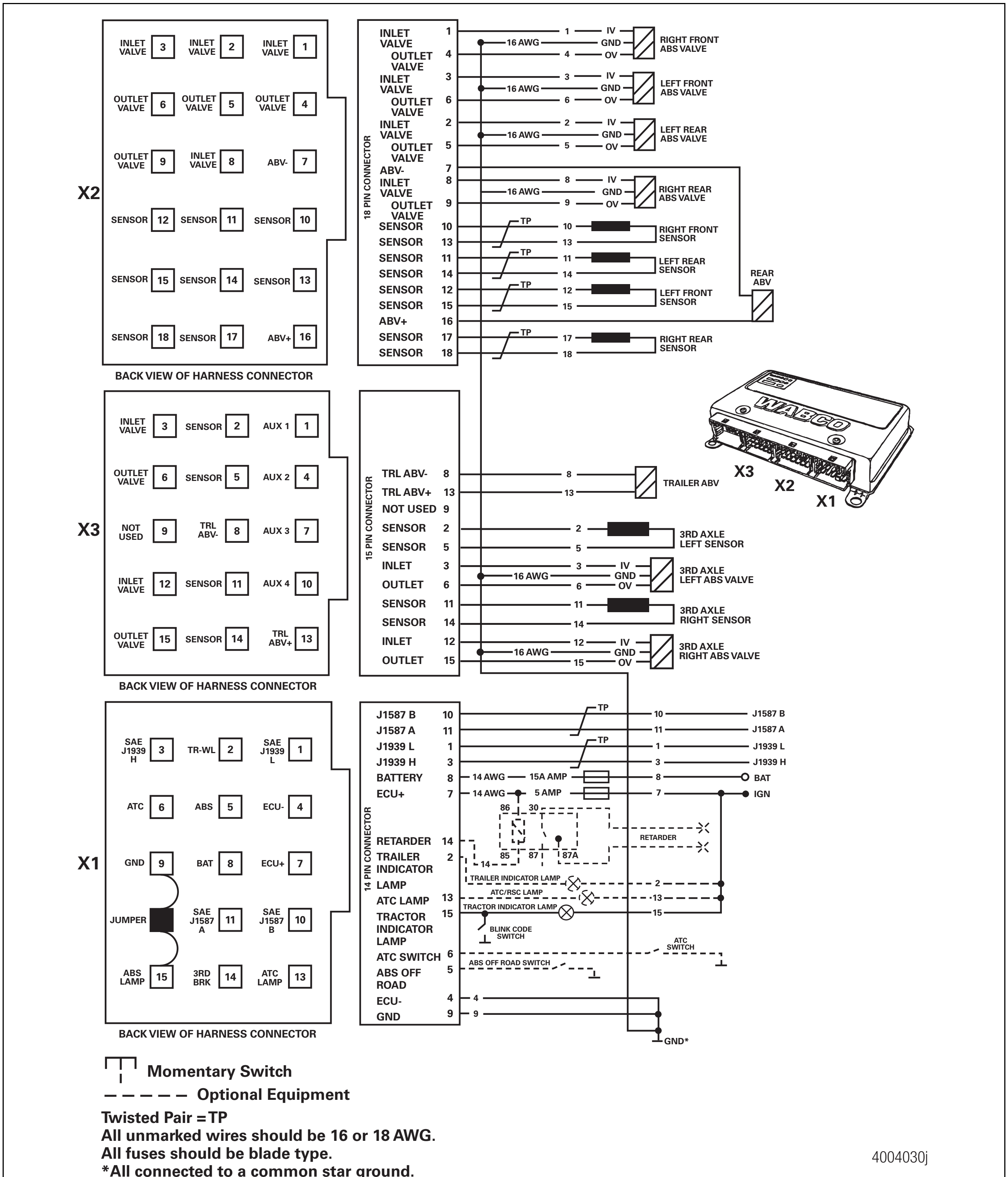
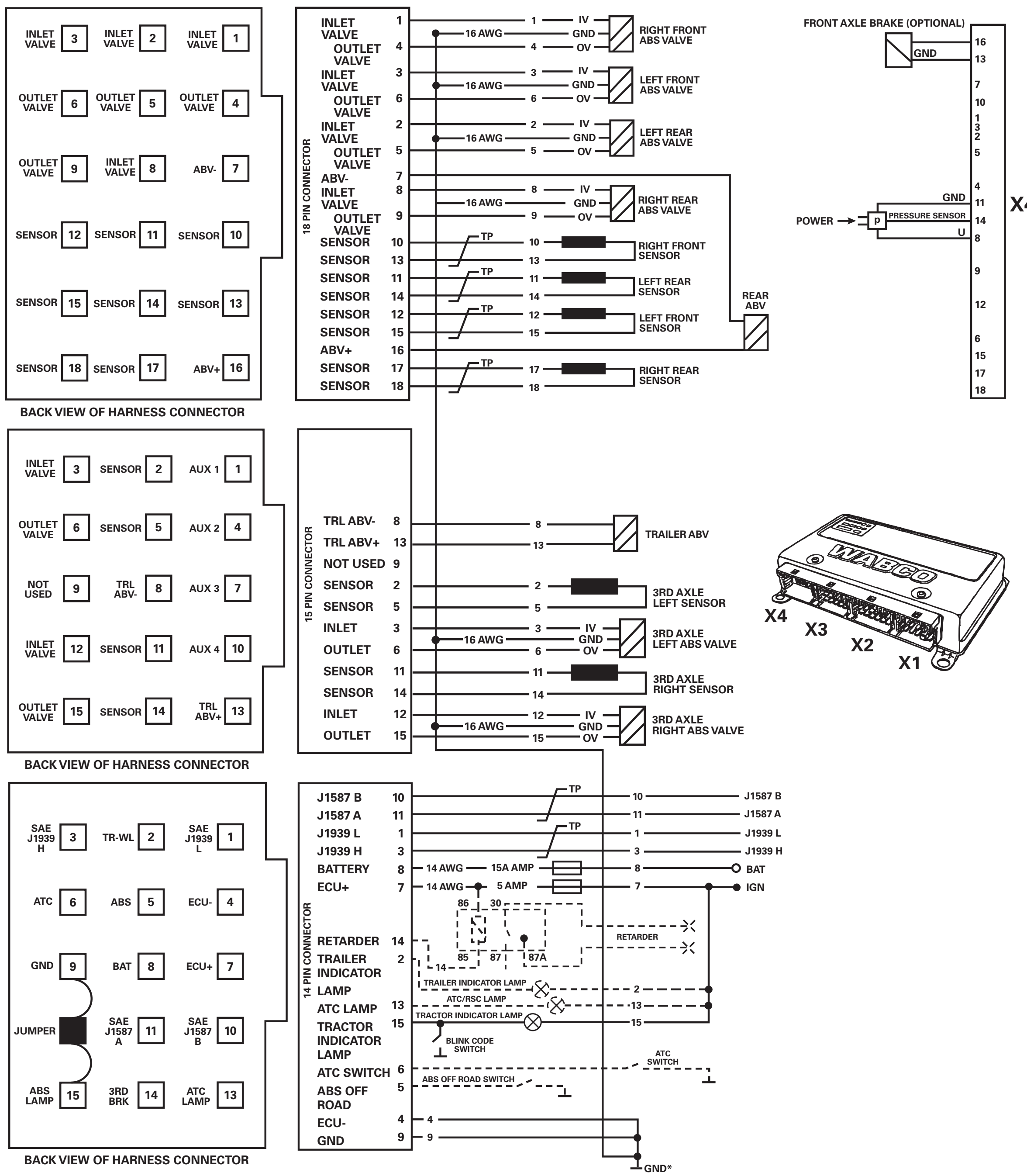


Figure 6.8

6S/6M Universal ECU with RSC and Optional Front Axle Brake (6S/4M and 4S/4M Configurations are also available)



Momentary Switch

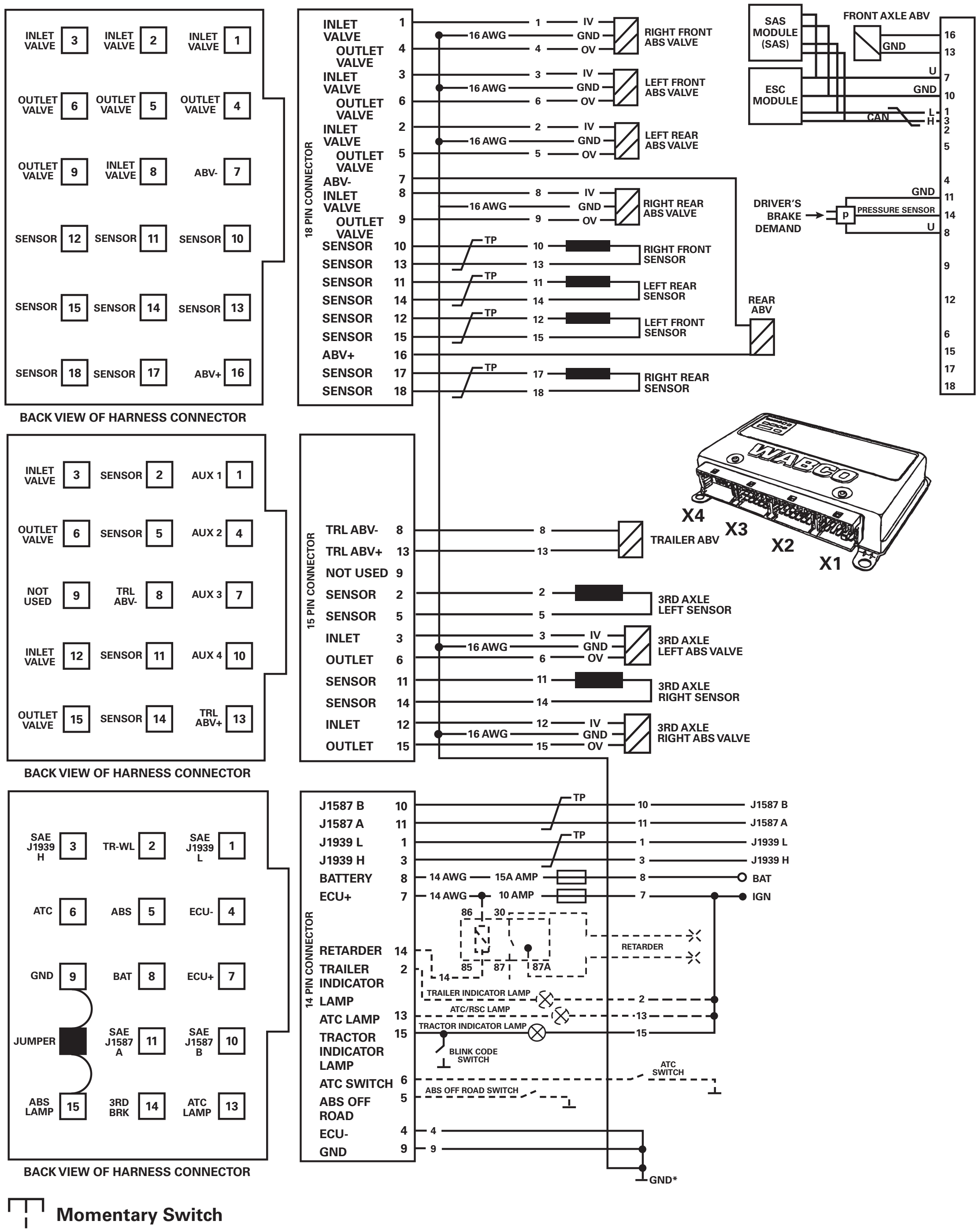
— — — — — Optional Equipment

Twisted Pair = TP
All unmarked wires should be 16 or 18 AWG.
All fuses should be blade type.
***All connected to a common star ground.**

4004030k

Figure 6.9

6S/6M Universal ECU with Electronic Stability Control (ESC) (6S/4M and 4S/4M Configurations are also available)

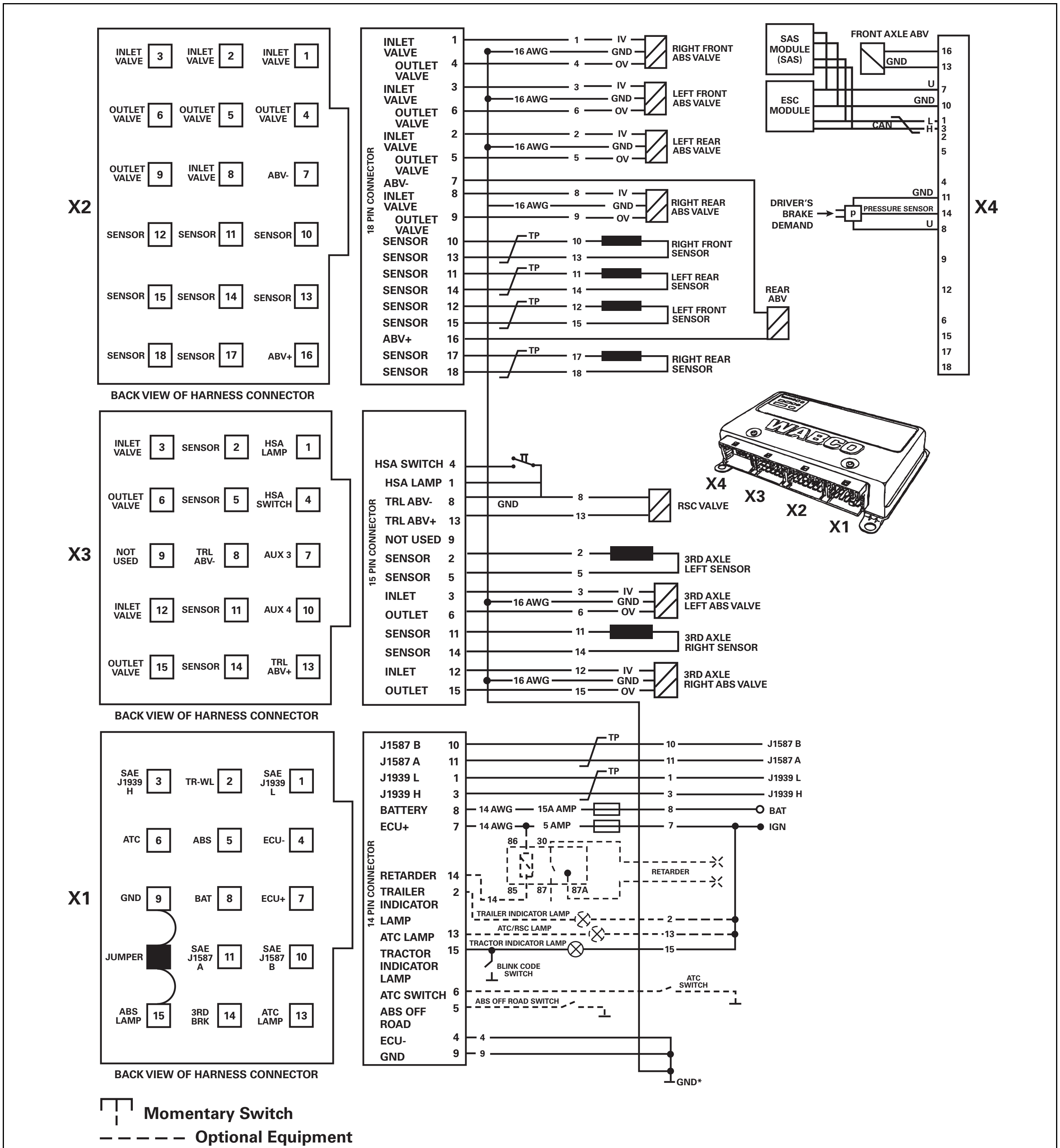


Twisted Pair = TP
All unmarked wires should be 16 or 18 AWG.
All fuses should be blade type.
*All connected to a common star ground.

4007397b

Figure 6.10

6S/6M Universal ECU with ESC and Hill Start Aid (HSA) (6S/4M and 4S/4M Configurations are also available)



Twisted Pair = TP
All unmarked wires should be 16 or 18 AWG.
All fuses should be blade type.
*All connected to a common star ground.

4008457b

Figure 6.11

6S/6M Frame-mounted ECU ABS or RSC (6S/4M and 4S/4M Configurations are also available)

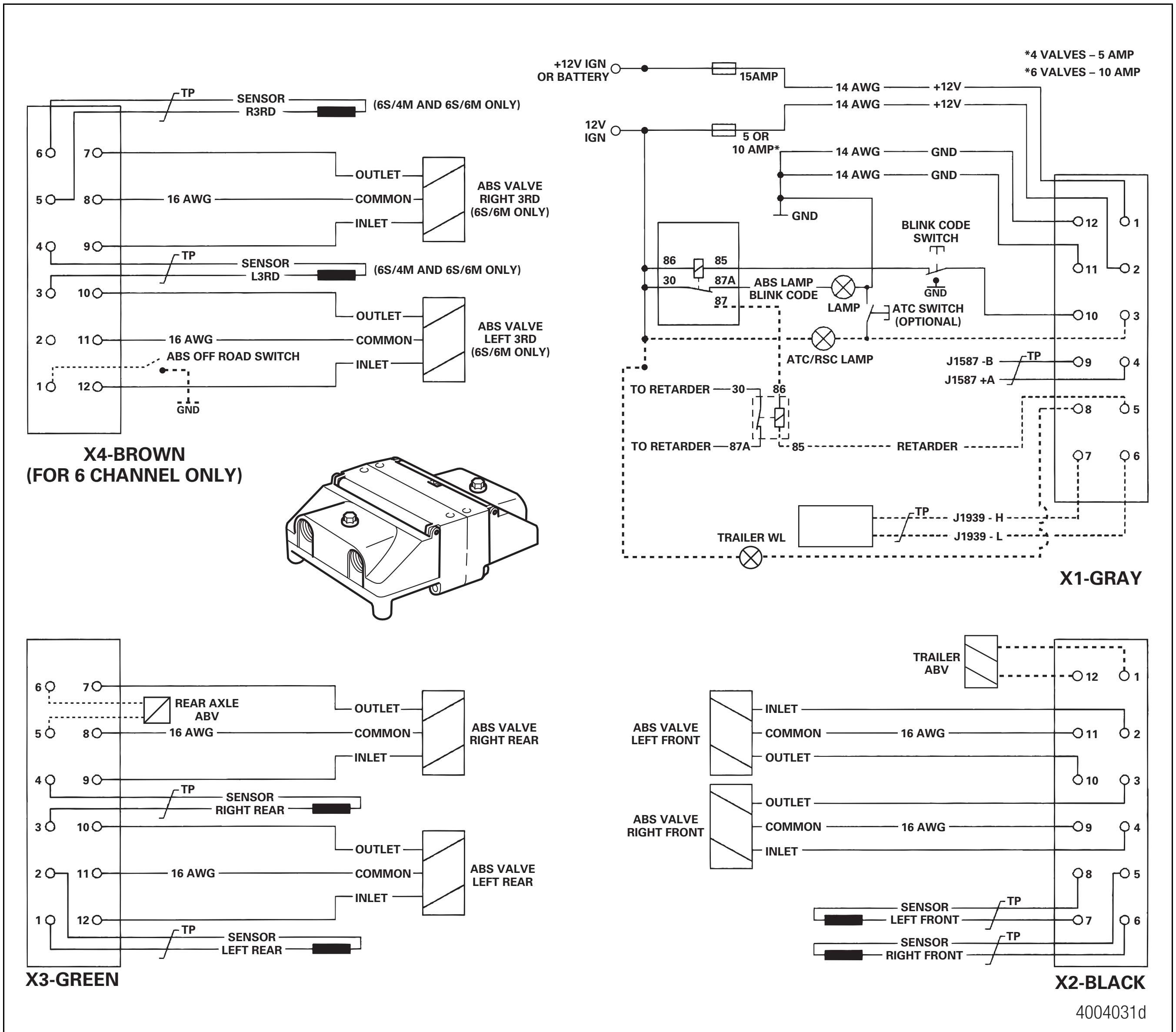


Figure 6.12

6S/6M Frame-mounted ECU with ESC (6S/4M and 4S/4M Configurations are also available)

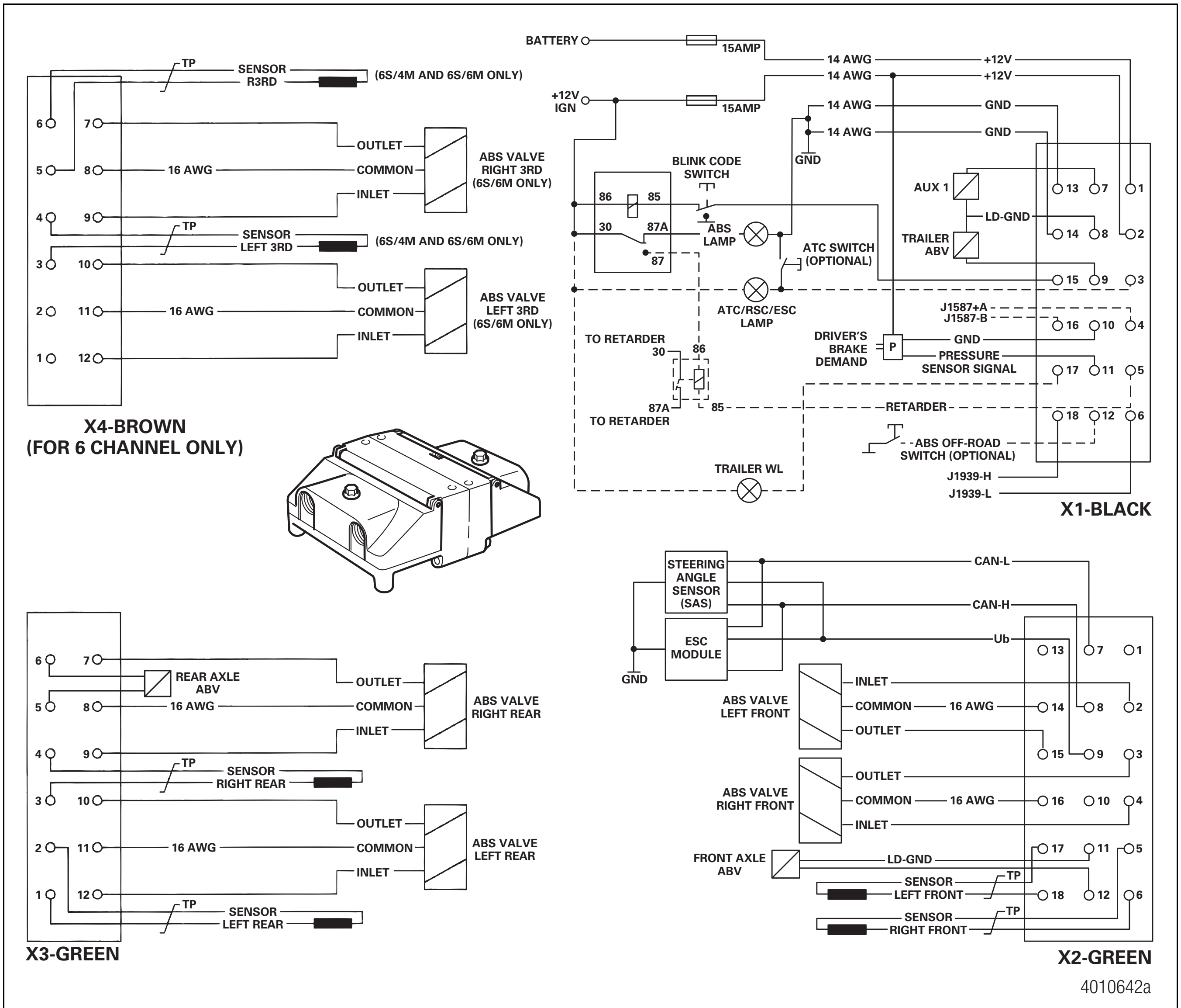


Figure 6.13

4S/4M Frame-mounted ECU with Supervised-Lock-Control (SLC) Feature

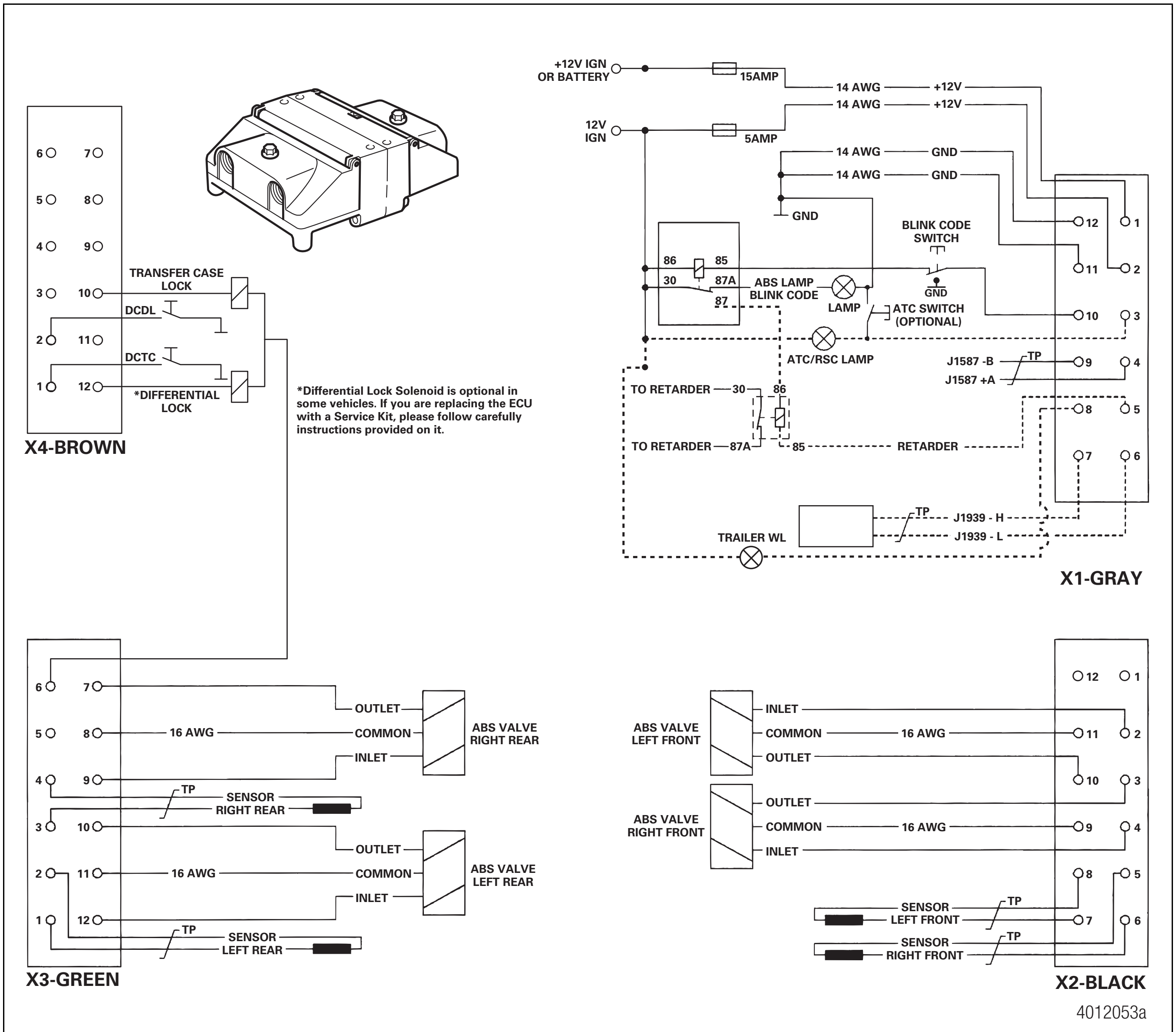


Figure 6.14

6S/6M Frame-mounted ECU with ESC and Hill Start Aid (HSA) (6S/4M and 4S/4M with HSA and without ESC Configurations are also available)

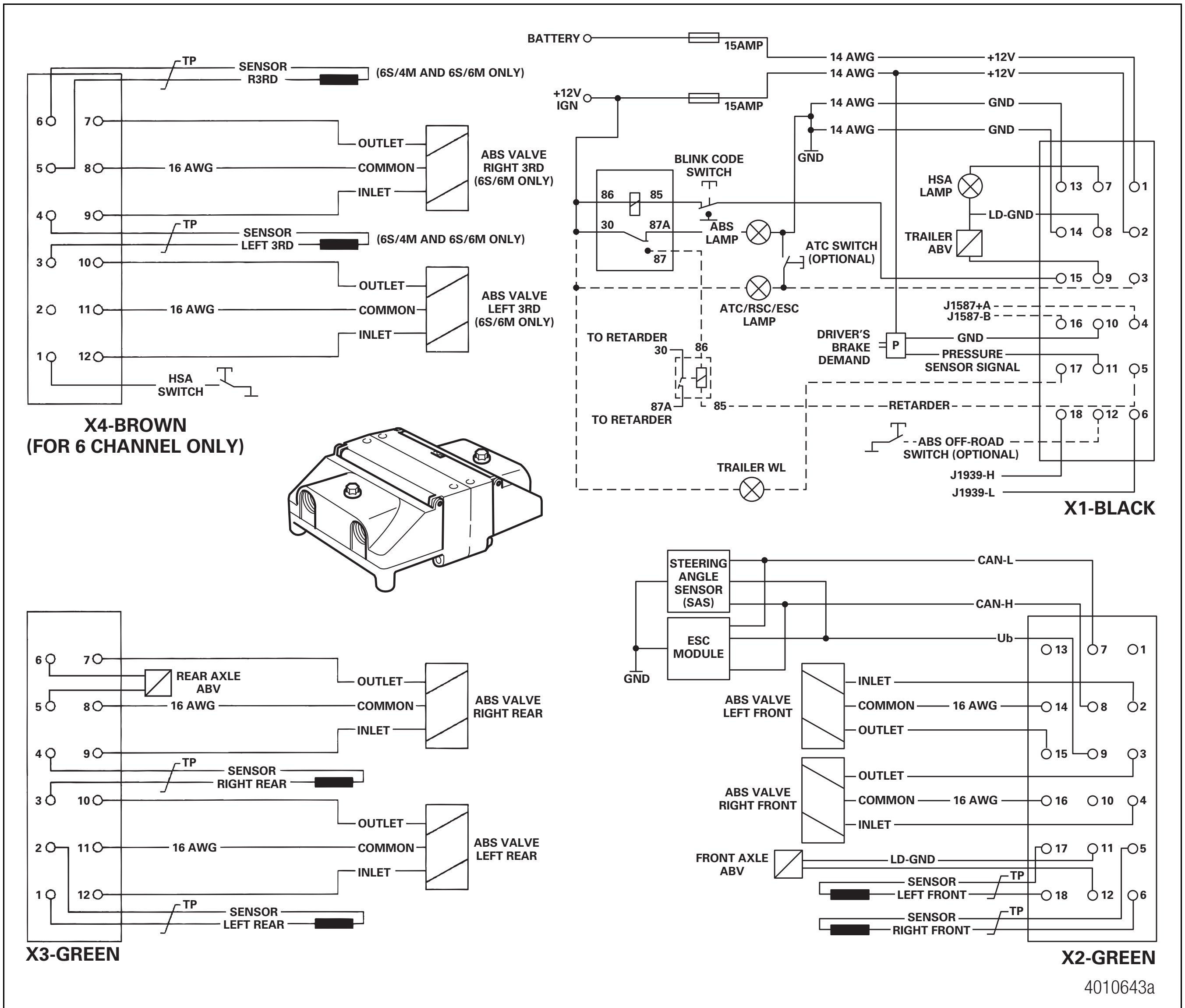


Figure 6.15

SPN, SID, FMI Diagnostic Trouble Code List

Figure 7.1

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
Left Front Wheel Speed Sensor								
	0	1		TOOLBOX Communication Issue	ABS WL		ABS ECU not fully communicating with TOOLBOX	• Check communication device connections. • Verify protocol (J1708/J1939) was not changed on the same key cycle. • Verify RP1012A compliant device, and verify the device software and firmware are up to date. • Check data link connector for issues.
789	1	1	3 + 2	Air Gap	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Sensor air gap is too large; sensor output voltage is too low but is high enough to be read by ECU.	• Adjust wheel sensor to touch tone ring. • Check condition of ABS sensor head. • Check for loose wheel bearings or excessive hub runout. • Check mounting of ABS tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
789	1	2	5 + 2	Incorrect Tire	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	System has detected a significant difference in the proportion of tire diameter to number of tone ring teeth between wheel ends. 10% (+/-2%)	• Check for tire size mismatch. • Check for correct number of tone ring teeth. • Verify that ECU is programmed for the correct vehicle.
789	1	3	4 + 2	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and battery voltage (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Verify no DC voltage through sensor circuit Key ON. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
789	1	4	4 + 2	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and ground (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for continuity between the ABS sensor connection and ground. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Verify wheel speed sensor wires are not switched left/right.
789	1	5	4 + 2	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	An open circuit has been detected, i.e. ECU detects a disconnected wheel speed sensor.	• Check sensor, sensor cable and connectors to verify no loose or damaged connection. • Verify 900-2000 ohms resistance through sensor circuit. • Verify wheel speed sensor wires are not switched left/right.
789	1	6	4 + 2	Short Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity interruption between the sensor connections (short circuit) has been detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
789	1	7	6 + 2	Incorrect Tone Ring	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel speed signal drops out periodically at speeds higher than 6 mph	• Check for damaged or missing teeth on tone ring. • Verify tone ring is not corroded or with contamination.
789	1	8	3 + 2	Excessive Slip	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel slip over 16 seconds continuously has been detected.	• Adjust wheel sensor to touch tooth wheel. • Check sensor gap. • Check for loose wheel bearings or excessive hub runout.
789	1	9	5 + 2	Wires Mismatched	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A sensor lead from an incorrect wheel end has been detected.	• Check for mismatch fault of another sensor. • Verify correct harness location and wiring for sensor. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
789	1	10	3 + 2	Speed Drop-Out	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A temporary loss of the ABS wheel speed signal has been detected.	• Adjust wheel speed sensor until it touches the tone ring. • Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check condition of ABS sensor head. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
789	1	11	5 + 2	Abnormal Speed (Chatter)	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Brake drag or chatter has been detected. Abnormal vibrations detected which affect sensor signal.	• Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip as well as the mounting block. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
789	1	12	5 + 2	Frequency Too High	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A non-plausible sensor frequency has been measured.	• Check sensor wiring and connectors for intermittent contact. • Check if brake at this location is operating correctly, i.e., potentially dragging. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
789	1	13	N/A	Brake Performance issue LF,RR, L3rd	ATC WL	N/A	Brake performance monitor condition exceeded.	• Check the foundation brakes for all wheel ends.

Figure 7.2

Figure 7.3

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
Right Front Wheel Speed Sensor								
790	2	1	3 + 1	Air Gap	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Sensor air gap is too large, sensor output voltage is too low but is high enough to be read by ECU.	• Adjust wheel sensor to touch tone ring. • Check condition of ABS sensor head. • Check for loose wheel bearings or excessive hub runout. • Check mounting of ABS tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
790	2	2	5 + 1	Incorrect Tire	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	System has detected a significant difference in the proportion of tire diameter to number of tone ring teeth between wheel ends. 10% (+/-2%)	• Check for tire size mismatch. • Check for correct number of tone ring teeth. • Verify that ECU is programmed for the correct vehicle. • Contact Meritor WABCO or OEM.
790	2	3	4 + 1	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and battery voltage (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Verify no DC voltage through sensor circuit Key ON. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
790	2	4	4 + 1	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and ground (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for continuity between the ABS sensor connection and ground. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Verify wheel speed sensor wires are not switched left/right.
790	2	5	4 + 2	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	An open circuit has been detected, i.e. ECU detects a disconnected wheel speed sensor.	• Check sensor, sensor cable and connectors to verify no loose or damaged connection. • Verify 900-2000 ohms resistance through sensor circuit. • Verify wheel speed sensor wires are not switched left/right.
790	2	6	4 + 1	Short Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity interruption between the sensor connections (short circuit) has been detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
790	2	7	6 + 1	Incorrect Tone Ring	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel speed signal drops out periodically at speeds higher than 6 mph	• Check for damaged or missing teeth on tone ring. • Verify tone ring is not corroded or with contamination.
790	2	8	3 + 1	Excessive Slip	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel slip over 16 seconds continuously has been detected.	• Adjust wheel sensor to touch tooth wheel. • Check sensor gap. • Check for loose wheel bearings or excessive hub runout.
790	2	9	5 + 1	Wires Mismatched	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A sensor lead from an incorrect wheel end has been detected.	• Check for mismatch fault of another sensor. • Verify correct harness location and wiring for sensor. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
790	2	10	3 + 1	Speed Drop-Out	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A temporary loss of the ABS wheel speed signal has been detected.	• Adjust wheel speed sensor until it touches the tone ring. • Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check condition of ABS sensor head. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
790	2	11	5 + 1	Abnormal Speed (Chatter)	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Brake drag or chatter has been detected. Abnormal vibrations detected which affect sensor signal.	• Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip as well as the mounting block. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
790	2	12	5 + 1	Frequency Too High	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A non-plausible sensor frequency has been measured.	• Check sensor wiring and connectors for intermittent contact. • Check if brake at this location is operating correctly, i.e., potentially dragging. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.

Figure 7.4

Figure 7.5

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
Left Rear Wheel Speed Sensor								
791	3	1	3 + 4	Air Gap	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Sensor air gap is too large, sensor output voltage is too low but is high enough to be read by ECU.	• Adjust wheel sensor to touch tone ring. • Check condition of ABS sensor head. • Check for loose wheel bearings or excessive hub runout. • Check mounting of ABS tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
791	3	2	5 + 4	Incorrect Tire	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	System has detected a significant difference in the proportion of tire diameter to number of tone ring teeth between wheel ends. 10% (+/-2%)	• Check for tire size mismatch. • Check for correct number of tone ring teeth. • Verify that ECU is programmed for the correct vehicle.
791	3	3	4 + 4	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and battery voltage (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Verify no DC voltage through sensor circuit Key ON. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
791	3	4	4 + 4	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and ground (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for continuity between the ABS sensor connection and ground. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Verify wheel speed sensor wires are not switched left/right.
791	3	5	4 + 4	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	An open circuit has been detected, i.e. ECU detects a disconnected wheel speed sensor.	• Check sensor, sensor cable and connectors to verify no loose or damaged connection. • Verify 900-2000 ohms resistance through sensor circuit. • Verify wheel speed sensor wires are not switched left/right.
791	3	6	4 + 4	Short Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity interruption between the sensor connections (short circuit) has been detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
791	3	7	6 + 4	Incorrect Tone Ring	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel speed signal drops out periodically at speeds higher than 6 mph	• Check for damaged or missing teeth on tone ring. • Verify tone ring is not corroded or with contamination.
791	3	8	3 + 4	Excessive Slip	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel slip over 16 seconds continuously has been detected.	• Adjust wheel sensor to touch tooth wheel. • Check sensor gap. • Check for loose wheel bearings or excessive hub runout.
791	3	9	5 + 4	Wires Mismatched	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A sensor lead from an incorrect wheel end has been detected.	• Check for mismatch fault of another sensor. • Verify correct harness location and wiring for sensor. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
791	3	10	3 + 4	Speed Drop-Out	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A temporary loss of the ABS wheel speed signal has been detected.	• Adjust wheel speed sensor until it touches the tone ring. • Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check condition of ABS sensor head. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
791	3	11	5 + 4	Abnormal Speed (Chatter)	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Brake drag or chatter has been detected. Abnormal vibrations detected which affect sensor signal.	• Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip as well as the mounting block. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
791	3	12	5 + 4	Frequency Too High	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A non-plausible sensor frequency has been measured.	• Check sensor wiring and connectors for intermittent contact. • Check if brake at this location is operating correctly, i.e., potentially dragging. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
789	3	13	N/A	Brake Performance issue RF,LR, R3rd	ATC WL	N/A	Brake performance monitor condition exceeded	• Check the foundation brakes for all wheel ends.

Figure 7.6

Figure 7.7

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
Right Rear Wheel Speed Sensor								
792	4	1	3 + 3	Air Gap	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Sensor air gap is too large, sensor output voltage is too low but is high enough to be read by ECU.	• Adjust wheel sensor to touch tone ring. • Check condition of ABS sensor head. • Check for loose wheel bearings or excessive hub runout. • Check mounting of ABS tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
792	4	2	5 + 3	Incorrect Tire	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	System has detected a significant difference in the proportion of tire diameter to number of tone ring teeth between wheel ends. 10% (+/-2%)	• Check for tire size mismatch. • Check for correct number of tone ring teeth. • Verify that ECU is programmed for the correct vehicle. • Contact Meritor WABCO or OEM.
792	4	3	4 + 3	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and battery voltage (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Verify no DC voltage through sensor circuit Key ON. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
792	4	4	4 + 3	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and ground (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for continuity between the ABS sensor connection and ground. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Verify wheel speed sensor wires are not switched left/right.
792	4	5	4 + 3	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	An open circuit has been detected, i.e. ECU detects a disconnected wheel speed sensor.	• Check sensor, sensor cable and connectors to verify no loose or damaged connection. • Verify 900-2000 ohms resistance through sensor circuit. • Verify wheel speed sensor wires are not switched left/right.
792	4	6	4 + 3	Short Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity interruption between the sensor connections (short circuit) has been detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.

Figure 7.8

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
792	4	7	6 + 3	Incorrect Tone Ring	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel speed signal drops out periodically at speeds higher than 6 mph	• Check for damaged or missing teeth on tone ring. • Verify tone ring is not corroded or with contamination.
792	4	8	3 + 3	Excessive Slip	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel slip over 16 seconds continuously has been detected.	• Adjust wheel sensor to touch tooth wheel. • Check sensor gap. • Check for loose wheel bearings or excessive hub runout.
792	4	9	5 + 3	Wires Mismatched	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A sensor lead from an incorrect wheel end has been detected.	• Check for mismatch fault of another sensor. • Verify correct harness location and wiring for sensor. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
792	4	10	3 + 3	Speed Drop-Out	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A temporary loss of the ABS wheel speed signal has been detected.	• Adjust wheel speed sensor until it touches the tone ring. • Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check condition of ABS sensor head. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
792	4	11	5 + 3	Abnormal Speed (Chatter)	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Brake drag or chatter has been detected. Abnormal vibrations detected which affect sensor signal.	• Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip as well as the mounting block. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
792	4	12	5 + 3	Frequency Too High	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A non-plausible sensor frequency has been measured.	• Check sensor wiring and connectors for intermittent contact. • Check if brake at this location is operating correctly, i.e., potentially dragging. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.

Figure 7.9

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
Left Third Axle Wheel Speed Sensor								
793	5	1	3 + 6	Air Gap	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Sensor air gap is too large, sensor output voltage is too low but is high enough to be read by ECU.	• Adjust wheel sensor to touch tone ring. • Check condition of ABS sensor head. • Check for loose wheel bearings or excessive hub runout. • Check mounting of ABS tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
793	5	2	5 + 6	Incorrect Tire	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	System has detected a significant difference in the proportion of tire diameter to number of tone ring teeth between wheel ends. 10% (+/-2%)	• Check for tire size mismatch. • Check for correct number of tone ring teeth. • Verify that ECU is programmed for the correct vehicle. • Contact Meritor WABCO or OEM.
793	5	3	4 + 6	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and battery voltage (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Verify no DC voltage through sensor circuit Key ON. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
793	5	4	4 + 6	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and ground (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for continuity between the ABS sensor connection and ground. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Verify wheel speed sensor wires are not switched left/right.
793	5	5	4 + 6	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	An open circuit has been detected, i.e. ECU detects a disconnected wheel speed sensor.	• Check sensor, sensor cable and connectors to verify no loose or damaged connection. • Verify 900-2000 ohms resistance through sensor circuit. • Verify wheel speed sensor wires are not switched left/right.
793	5	6	4 + 6	Short Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity interruption between the sensor connections (short circuit) has been detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
793	5	7	6 + 6	Incorrect Tone Ring	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel speed signal drops out periodically at speeds higher than 6 mph	• Check for damaged or missing teeth on tone ring. • Verify tone ring is not corroded or with contamination.
793	5	8	3 + 6	Excessive Slip	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel slip over 16 seconds continuously has been detected.	• Adjust wheel sensor to touch tooth wheel. • Check sensor gap. • Check for loose wheel bearings or excessive hub runout.
793	5	9	5 + 6	Wires Mismatched	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A sensor lead from an incorrect wheel end has been detected.	• Check for mismatch fault of another sensor. • Verify correct harness location and wiring for sensor. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
793	5	10	3 + 6	Speed Drop-Out	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A temporary loss of the ABS wheel speed signal has been detected.	• Adjust wheel speed sensor until it touches the tone ring. • Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check condition of ABS sensor head. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
793	5	11	5 + 6	Abnormal Speed (Chatter)	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Brake drag or chatter has been detected. Abnormal vibrations detected which affect sensor signal.	• Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip as well as the mounting block. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
793	5	12	5 + 6	Frequency Too High	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A non-plausible sensor frequency has been measured.	• Check sensor wiring and connectors for intermittent contact. • Check if brake at this location is operating correctly, i.e., potentially dragging. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.

Figure 7.10

Figure 7.11

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
Right Third Axle Wheel Speed Sensor								
794	6	1	3 + 5	Air Gap	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Sensor air gap is too large, sensor output voltage is too low but is high enough to be read by ECU.	• Adjust wheel sensor to touch tone ring. • Check condition of ABS sensor head. • Check for loose wheel bearings or excessive hub runout. • Check mounting of ABS tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
794	6	2	5 + 5	Incorrect Tire	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	System has detected a significant difference in the proportion of tire diameter to number of tone ring teeth between wheel ends. 10% (+/-2%)	• Check for tire size mismatch. • Check for correct number of tone ring teeth. • Verify that ECU is programmed for the correct vehicle. • Contact Meritor WABCO or OEM.
794	6	3	4 + 5	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and battery voltage (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Verify no DC voltage through sensor circuit Key ON. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
794	6	4	4 + 5	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between the sensor connection and ground (short circuit) is detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for continuity between the ABS sensor connection and ground. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Verify wheel speed sensor wires are not switched left/right.
794	6	5	4 + 5	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	An open circuit has been detected, i.e. ECU detects a disconnected wheel speed sensor.	• Check sensor, sensor cable and connectors to verify no loose or damaged connection. • Verify 900-2000 ohms resistance through sensor circuit. • Verify wheel speed sensor wires are not switched left/right.
794	6	6	4 + 5	Short Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity interruption between the sensor connections (short circuit) has been detected.	• Verify 900-2000 ohms resistance through sensor circuit. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
794	6	7	6 + 5	Incorrect Tone Ring	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel speed signal drops out periodically at speeds higher than 6 mph	• Check for damaged or missing teeth on tone ring. • Verify tone ring is not corroded or with contamination.
794	6	8	3 + 5	Excessive Slip	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Wheel slip over 16 seconds continuously has been detected.	• Adjust wheel sensor to touch tooth wheel. • Check sensor gap. • Check for loose wheel bearings or excessive hub runout.
794	6	9	5 + 5	Wires Mismatched	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A sensor lead from an incorrect wheel end has been detected.	• Check for mismatch fault of another sensor. • Verify correct harness location and wiring for sensor. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.
794	6	10	3 + 5	Speed Drop-Out	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A temporary loss of the ABS wheel speed signal has been detected.	• Adjust wheel speed sensor until it touches the tone ring. • Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check condition of ABS sensor head. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
794	6	11	5 + 5	Abnormal Speed (Chatter)	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Brake drag or chatter has been detected. Abnormal vibrations detected which affect sensor signal.	• Check for loose wheel bearings or excessive hub runout. • Check sensor wiring and connectors for intermittent contact. • Check mounting of tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip as well as the mounting block. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor. • Turn the wheel at half a revolution per second and verify 0.2 AC volt sensor output voltage.
794	6	12	5 + 5	Frequency Too High	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A non-plausible sensor frequency has been measured.	• Check sensor wiring and connectors for intermittent contact. • Check if brake at this location is operating correctly, i.e., potentially dragging. • Check for corroded or damaged wiring between the ECU and the ABS wheel speed sensor.

Figure 7.12

Figure 7.13

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
Left Front Modulator Valve								
795	7	3	2 + 2	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and battery voltage or another modulator wire (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Verify no voltage between Inlet/Outlet circuit and ground at the valve. • Verify no voltage through the harness with ECU unplugged and Key ON. • Check for corroded or damaged wiring between the ECU and the modulator valve.
795	7	5	2 + 2	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/HSA Disabled	ECU has detected that Inlet (IV), Outlet (OV) or both are not connected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check if connectors are fully seated and verify no open connections. • Check for corroded or damaged wiring between the ECU and the modulator valve.
795	7	6	2 + 2	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and ground (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check for corroded or damaged wiring between the ECU and the modulator valve.
Right Front Modulator Valve								
796	8	3	2 + 1	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and battery voltage or another modulator wire (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Verify no voltage between Inlet/Outlet circuit and ground at the valve. • Verify no voltage through the harness with ECU unplugged and Key ON. • Check for corroded or damaged wiring between the ECU and the modulator valve.
796	8	5	2 + 1	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/HSA Disabled	ECU has detected that Inlet (IV), Outlet (OV) or both are not connected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check if connectors are fully seated and verify no open connections. • Check for corroded or damaged wiring between the ECU and the modulator valve.
796	8	6	2 + 1	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and ground (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check for corroded or damaged wiring between the ECU and the modulator valve.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
Left Rear Modulator Valve								
797	9	3	2 + 4	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and battery voltage or another modulator wire (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Verify no voltage between Inlet/Outlet circuit and ground at the valve. • Verify no voltage through the harness with ECU unplugged and Key ON. • Check for corroded or damaged wiring between the ECU and the modulator valve.
797	9	5	2 + 4	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	ECU has detected that Inlet (IV), Outlet (OV) or both are not connected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check if connectors are fully seated and verify no open connections. • Check for corroded or damaged wiring between the ECU and the modulator valve.
797	9	6	2 + 4	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and ground (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check for corroded or damaged wiring between the ECU and the modulator valve.
Right Rear Modulator Valve								
798	10	3	2 + 3	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and battery voltage or another modulator wire (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Verify no voltage between Inlet/Outlet circuit and ground at the valve. • Verify no voltage through the harness with ECU unplugged and Key ON. • Check for corroded or damaged wiring between the ECU and the modulator valve.
798	10	5	2 + 3	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	ECU has detected that Inlet (IV), Outlet (OV) or both are not connected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check if connectors are fully seated and verify no open connections. • Check for corroded or damaged wiring between the ECU and the modulator valve.
798	10	6	2 + 3	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and ground (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check for corroded or damaged wiring between the ECU and the modulator valve.

Figure 7.14

Figure 7.15

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
Left Third Axle Modulator Valve								
799	11	3	2 + 6	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and battery voltage or another modulator wire (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Verify no voltage between Inlet/Outlet circuit and ground at the valve. • Verify no voltage through the harness with ECU unplugged and Key ON. • Check for corroded or damaged wiring between the ECU and the modulator valve.
799	11	5	2 + 6	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	ECU has detected that Inlet (IV), Outlet (OV) or both are not connected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check if connectors are fully seated and verify no open connections. • Check for corroded or damaged wiring between the ECU and the modulator valve.
799	11	6	2 + 6	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and ground (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check for corroded or damaged wiring between the ECU and the modulator valve.
Right Third Axle Modulator Valve								
800	12	3	2 + 5	Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and battery voltage or another modulator wire (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Verify no voltage between Inlet/Outlet circuit and ground at the valve. • Verify no voltage through the harness with ECU unplugged and Key ON. • Check for corroded or damaged wiring between the ECU and the modulator valve.
800	12	5	2 + 5	Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	ECU has detected that Inlet (IV), Outlet (OV) or both are not connected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check if connectors are fully seated and verify no open connections. • Check for corroded or damaged wiring between the ECU and the modulator valve.
800	12	6	2 + 5	Shorted to Ground	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between Inlet (IV) or Outlet (OV) and ground (short circuit) is detected.	• Verify valve resistance of 4.0-9.0 ohm between IV to ground and OV to ground for 12v system (11.0-21.0 ohms for 24v system). • Verify resistance through harness and valve together is the same as valve by itself. • Check for corroded or damaged wiring between the ECU and the modulator valve.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
Engine Retarder Relay, Automatic Third Brake Application Relay								
801	13	3	7 + 3	Shorted to UBATT	ABS WL	Hardwired Retarder Control is Disabled	Continuity between the retarder relay output and the battery voltage has been detected.	• Check for continuity between the retarder relay output and voltage supply. • Check for corroded or damaged wiring between the ECU and the relay. • Verify if vehicle is equipped with an engine retarder relay or a third brake relay such as driveline brake, exhaust brake or engine brake. If hardwired retarder control is not installed on the vehicle but this fault is present, the operator should perform “Reset Memorized Components” TOOLBOX™ Software procedure. • Verify with the OEM if (connector X1 pin 14 Cab ECU or connector X1 pin 5 Frame ECU) circuit is used on the vehicle, circuit has many possible uses other than a retarder, prior to performing a “Reset Memorized” or “Reconfiguring” the ECU.
801	13	5	7 + 3	Open Circuit	ABS WL	Hardwired Retarder Control is Disabled	ECU has detected that the retarder relay is not connected but was previously learned.	• Check for broken wires or connectors and verify all connections are fully seated, relay present and operational. • Check for corroded or damaged wiring between the ECU and the relay. • Verify if vehicle is equipped with an engine retarder relay or a third brake relay such as driveline brake, exhaust brake or engine brake. If hardwired retarder control is not installed on the vehicle but this fault is present, the operator should perform “Reset Memorized Components” through” TOOLBOX™ Software procedure. • Verify with the OEM if (connector X1 pin 14 Cab ECU or connector X1 pin 5 Frame ECU) circuit is used on the vehicle, circuit has many possible uses other than a retarder, prior to performing a “Reset Memorized” or “Reconfiguring” the ECU.
801	13	6	7 + 3	Shorted to Ground	ABS WL	Hardwired Retarder Control is Disabled	Continuity between the retarder relay output and ground has been detected.	• Check for continuity between the retarder relay output and ground. • Check for corroded or damaged wiring between the ECU and the relay. • Verify if vehicle is equipped with an engine retarder relay or a third brake relay such as driveline brake, exhaust brake or engine brake. If hardwired retarder control is not installed on the vehicle but this fault is present, the operator should perform “Reset Memorized Components” through ” TOOLBOX™ Software procedure. • Verify with the OEM if (connector X1 pin 14 Cab ECU or connector X1 pin 5 Frame ECU) circuit is used on the vehicle, circuit has many possible uses other than a retarder, prior to performing a “Reset Memorized” or “Reconfiguring” the ECU.
Other Components								
802	14	4	8 + 1	Supply Voltage is too Low	ABS WL (while supply voltage is detected as too low)	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	The supply voltage is temporarily too low.	• Measure the battery or ignition voltage under load. Verify voltage does not drop below 9v (12v system) or 18v (24v system). • Verify proper ECU and battery ground (less than 1 ohm) • Check the vehicle battery and associated components (alternator). • Check for corroded or damaged wiring between the ECU and voltage supply as well as ground path. • Check conditions of fuses.
802	14	5	8 + 5	ECU Central Ground Open Circuit	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	The ECUs connection to central ground has been interrupted or the resistance measured is too high.	• Verify proper ECU central ground (less than 1 ohm resistance). • Check for corroded, loose or damaged wiring between the ECU and central ground path.
802	14	7	8 + 3	Internal Voltage SUpply	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A failure was detected on the internal ECU relay 1.	• Measure the battery or ignition voltage supply. Verify voltage is between 9v-16v (12v system) or 18v-32v (24v system). • Verify proper ECU and battery ground (less than 1 ohm) • Check for corroded or damaged wiring between the ECU and voltage supply as well as ground path. • If all wiring checks are within specs and if fault repeats and does not clear, this may indicate the ECU has failed.
803	15	3	8 + 5	All ABVs Output Shorted to UBATT	ABS WL	ESC/RSC/ATC Disabled	Continuity between suspect Active Braking Valve output and voltage supply (short circuit) is detected.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Check for continuity between suspect ABV ground circuit and voltage supply. • Check for corroded or damaged wiring between the ECU and ABV. • Fault may indicate an issue with the BPS in certain vintage ECUs, See SID 55 FMI 3.

Figure 7.16

Figure 7.17

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
803	15	4	8 + 1	ECU Voltage is too Low	ABS WL (while supply voltage is detected as too low)	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	The supply voltage is temporarily too low.	• Measure the battery or ignition voltage under load. Verify voltage does not drop below 9v (12v system) or 18v (24v system). • Verify proper ECU and battery ground (less than 1 ohm) • Load Test between ECU powers and grounds. • Check the vehicle battery and associated components (alternator). • Check for corroded or damaged wiring between the ECU and voltage supply as well as ground path. • Check conditions of fuses.
803	15	5	8 + 5	All ABVs High impedance	ABS WL	ESC/RSC/ATC/ HSA Disabled	ECU has detected that the suspect Active Braking Valve circuit is not detected, has high impedance or the circuit has been interrupted.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Verify if connectors are fully seated, check for corroded or damaged wiring between the ECU and ABVs. • Replace ECU if all wiring checks are within spec and if fault repeats and does not clear. • Fault may indicate an issue with the BPS in certain vintage ECUs, See SID 55 FMI 5.
803	15	6	8 + 5	All ABVs Shorted to ground	ABS WL	N/A	Continuity between suspect Active Braking Valve circuit and ground is detected.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Check for continuity between suspect Active Braking Valve circuit and ground. • Check for corroded or damaged wiring between the ECU and ABVs. • Check ECU grounds should be less than 1 ohm of resistance to ground. • Replace ECU if all wiring checks are within spec and if fault repeats and does not clear.
803	15	7	8 + 3	Internal Voltage Supply	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	A failure was detected on the internal ECU relay 2.	• Measure the battery or ignition voltage supply. Verify voltage is between 9v-16v (12v system) or 18v-32v (24v system). • Verify proper ECU and battery ground (less than 1 ohm) • Load Test between ECU powers and grounds. • Check for corroded or damaged wiring between the ECU and voltage supply as well as ground path. • If all wiring checks are within specs and if fault repeats and does not clear, this may indicate the ECU has failed.
1045	16	3	7 + 7	E401 and E404 version only. Pressure Sensor shorted to UBATT	ABS WL	ESC/RSC/ATC/ HSA Disabled	Continuity between pressure signal circuit and voltage supply (short circuit) is detected. E401 and E404 version only	• Check for continuity between pressure sensor signal circuit and voltage supply. • Check connectors and pressure sensor for corrosion. • It could also be possible that the ECU has detected a permanent braking signal from the pressure sensor between zero to 30 mph. • Fault only for E401 and E404 versions only.
1045	16	5	7 + 7	E401 and E404 version only. Pressure Sensor shorted to ground	ABS WL	ESC/RSC/ATC/ HSA Disabled	Continuity between pressure signal circuit and ground (short circuit) or an open circuit is detected. E401 and E404 version only	• Verify if connectors are fully seated, check for corroded or damaged wiring between the ECU and component. • Check for continuity between pressure sensor signal circuit and ground. • The pressure sensor supply line could be also clogged or frozen up. • Fault only for E401 and E404 versions only .
806	18	3	7 + 2	ABV Drive Axle. Shorted to UBATT	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	Continuity between suspect Active Braking Valve circuit and voltage supply (short circuit) is detected.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Check for continuity between suspect ABV ground circuit and voltage supply. • Check for corroded or damaged wiring between the ECU and ABV.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
806	18	5	7 + 2	ABV Drive Axle. Open Circuit	ABS WL	ESC/RSC/ATC/ HSA Disabled	ECU has detected that the suspect Active Braking Valve circuit is not detected or the circuit has been interrupted.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Verify if connectors are fully seated, check for corroded or damaged wiring between the ECU and ABV.
806	18	6	7 + 2	ABV Drive Axle. Shorted to Ground	ABS WL	ESC/RSC/ATC/ HSA Disabled	Continuity between suspect Active Braking Valve circuit and ground is detected.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Check for continuity between suspect Active Braking Valve circuit and ground. • Check for corroded or damaged wiring between the ECU and ABVs.
807	19	1	7 + 6	ABV Front Axle. Shorted to UBATT	ABS WL	ESC/RSC/ATC/ HSA Disabled	Continuity between suspect Active Braking Valve circuit and voltage supply (short circuit) is detected.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Check for continuity between suspect ABV ground circuit and voltage supply. • Check for corroded or damaged wiring between the ECU and ABV.
807	19	2	7 + 6	ABV Front Axle. Open Circuit	ABS WL	ESC/RSC/ATC/ HSA Disabled	ECU has detected that the suspect Active Braking Valve circuit is not detected or the circuit has been interrupted.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Verify if connectors are fully seated, check for corroded or damaged wiring between the ECU and ABV. • May also indicate incorrect ECU for type of transmission.
807	19	3	7 + 6	ABV Trailer Control. Shorted to UBATT	ABS WL	ESC/RSC/ATC Disabled	Continuity between suspect Active Braking Valve circuit and voltage supply (short circuit) is detected.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Check for continuity between suspect ABV ground circuit and voltage supply. • Check for corroded or damaged wiring between the ECU and ABV.
807	19	4	7 + 6	ABV Front Axle. Shorted to Ground	ABS WL	ESC/RSC/ATC/ HSA Disabled	Continuity between suspect Active Braking Valve circuit and ground is detected.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Check for continuity between suspect Active Braking Valve circuit and ground. • Check for corroded or damaged wiring between the ECU and ABV.
807	19	5	7 + 6	ABV Trailer Control. Open Circuit	ABS WL	ESC/RSC Disabled	ECU has detected that the suspect Active Braking Valve circuit is not detected or the circuit has been interrupted.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Verify if connectors are fully seated, check for corroded or damaged wiring between the ECU and ABV. • If SLC ECU may indicate issue with diff lock solenoid or transfer case lock solenoid.
807	19	6	7 + 6	ABV Trailer Control. Shorted to Ground	ABS WL	ESC/RSC Disabled	Continuity between suspect Active Braking Valve circuit and ground is detected.	• Verify 7.0-14.0 ohm between ABV supply and ABV common for 12V system (26.3-49.0 ohm for 24V system). • Check for continuity between suspect Active Braking Valve circuit and ground. • Check for corroded or damaged wiring between the ECU and ABV.

Figure 7.18

Figure 7.19

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
807	19	7	7 + 6	Aux 1, 2, 3 or 4. Shorted to UBATT	ABS WL	ESC/RSC/ATC/ HSA Disabled	Continuity between Auxiliary port circuits and voltage supply (short circuit) is detected.	• Verify if vehicle is equipped with Dual Trailer Stability Control Modulator Valve (ABV 3/2 solenoid + Modulator valve) or Hill Start Aid switch and lamp. Depending on the vehicle configuration, these components use Aux 1 through 4. • Check for continuity between component and voltage supply. • Check for corroded or damaged wiring between the ECU and component.
807	19	8	7 + 6	Aux 1, 2, 3 or 4. Open Circuit	ABS WL	ESC/RSC Disabled	ECU has detected an open circuit in auxiliary port circuit or circuit was once learned and it is no longer available.	• Verify if vehicle is equipped with Dual Trailer Stability Control Modulator Valve (ABV 3/2 solenoid + Modulator valve) or Hill Start Aid switch* and lamp. Depending on the vehicle configuration, these components use Aux 1 through 4. • HSA switch open fault detection is not activated in ECU as switch could be multiplexed. • Check for continuity between component and ECU. • Verify if connectors are fully seated, check for corroded or damaged wiring between the ECU and component. • If hardwired components for Aux 1-4 are not installed on the vehicle but are checked as learned in TOOLBOX™ Software and this fault is present, the operator should perform “Reset Memorized Components” through ”TOOLBOX™ Software procedure. • If SLC ECU may indicate issue with Diff lock solenoid or transfer case lock solenoid.
807	19	9	7 + 6	Aux 1, 2, 3 or 4. Shorted to Ground	ABS WL	ESC/RSC Disabled	Continuity between auxiliary port circuit and ground is detected.	• Verify if vehicle is equipped with Dual Trailer Stability Control Modulator Valve (ABV 3/2 solenoid + Modulator valve) or Hill Start Aid switch* and lamp. Depending on the vehicle configuration, these components use Aux 1 through 4. • Check for continuity between Auxiliary port component and ground. • Verify if connectors are fully seated, check for corroded or damaged wiring between the ECU and component.
807	19	10	N/A	SAS & ESC Module supply line. Shorted to UBATT	ABS WL	N/A	Continuity between SAS or ESC supply line and high voltage supply is detected.	• Verify SAS, ESC and ECU are properly connected. • Disconnect ECU, SAS and ESC module and check wiring between components for continuity to battery voltage with Key On. • Check for corroded or damaged wiring between the ECU, SAS and ESC.
807	19	11	8 + 6	SAS & ESC Module supply line. Open Circuit	ABS WL	N/A	ECU has detected an open circuit in between SAS or ESC supply line and ECU.	• Verify SAS, ESC and ECU are properly connected. • Check for corroded or damaged wiring between the ECU, SAS and ESC.
807	19	12	8 + 6	SAS & ESC Module supply line. Shorted to Ground	ABS WL	ESC/RSC Disabled	Continuity between SAS or ESC supply line and ground is detected.	• Verify SAS, ESC and ECU are properly connected. • Disconnect ECU, SAS and ESC module and check wiring between components for continuity to ground. • Check for corroded or damaged wiring between the ECU, SAS and ESC.
810	22	8	7 + 1	Tire size broadcast error	ABS WL (Only at start up)	ABS/ESC/RSC/ ATC/HSA Disabled	Tire size data has not been received from engine ECU at start up. E452 version only	• Check availability of engine data information and communication between Engine ECU and the ABS ECU. • Contact OEM to verify Engine is correctly broadcasting tire size.
810	22	14	3 + 7	ABS Complete Shut-off	ABS WL	Complete Shut-Off	It was detected by the ABS ECU, that the number of stored wheel speed sensor failures is greater than 100. An absence of repair is the cause of this failure. If this failure is detected, ABS completely shuts-off.	• Repair all other active faults and road test vehicle over 4 mph. • Check sensor adjustment, condition of tone rings, wheel end play. This fault is generated by speed signal issues and usually is a wheel end issue. • Once sensor issue has been corrected, may try to perform “Reset Memorized” to clear code.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
811	23	5	7 + 4	Warning Light Relay (E_Frame)	ABS WL if grounded. Off if burned out	N/A	Output detects no load to battery or is permanently grounded.	• Verify ABS WL is working correctly during self test. • Verify wire and/or bulb is not damaged. • Blink code activation via switch longer than 16 sec could cause. Verify blink code switch is not permanently grounded.
1045	55	3	7 + 7	Pressure Sensor shorted to UBATT	ABS WL	ESC/RSC/ATC/ HSA Disabled	Continuity between pressure signal circuit and voltage supply (short circuit) is detected.	• Verify if connectors are fully seated, check for corroded, damaged or shorted connectors or wiring between the ABS ECU and the pressure sensor. • Verify there is no continuity between pressure sensor signal circuit and voltage supply. • It could also be possible that the ECU has detected a permanent braking signal from the pressure sensor between zero to 30 mph. • If all wiring and connector checks pass, may indicate a pressure sensor failure. • If DTC persists after completing previous checks and repairs, may indicate the ECU has failed.
1045	55	5	7 + 7	Pressure Sensor shorted to ground	ABS WL	ESC/RSC/ATC/ HSA Disabled	Continuity between pressure signal circuit and ground (short circuit) or an open circuit is detected.	• Verify if connectors are fully seated, check for corroded, damaged or shorted connectors or wiring between the ABS ECU and the pressure sensor. • Verify there is no continuity between pressure sensor signal circuit and ground. • Verify there is 8.0-16.0 volts across pins 1-2 at the pressure sensor harness connector. • If all wiring and connector checks pass, may indicate a pressure sensor failure. • If no voltage is found, verify if the ECU will self-test. • If no self-test, verify power and ground to the ECU. • If DTC persists after completing previous checks and repairs, may indicate the ECU has failed.
1045	55	7	7 + 7	CAN BLS (Brake light Switch) signal faulty	ABS WL	RSC Disabled	Fault only for RSC systems with ECU E440. ECU has detected the brake light switch signal is faulty.	• Refer to OEM Brake light switch troubleshooting. • Check the BLS switch (installation, wire, connector) • Only relevant for RSC systems without Pressure Sensor installed, with BLS over CAN-Bus and ECU E440 only
1069	79	1	7 + 8	Tire Pressure Monitor (TPM)	ATC WL if Parameter is set	N/A	Tire pressure loss detected by change of wheel circumference.	• Check and correct tire pressure. • Only available if ECU has been programmed for TPM use.
2622	94	2	7 + 1	HSA active Fault	HSA WL	HSA Disabled	It was detected that HSA was continuous-ly active for more than 90s or ECU detected no HSA switch information in the EBC1 Message if switch is multiplexed.	• Verify if ECU is correct for vehicle application • Contact vehicle OEM to verify broadcast of HSA switch is correct
ESC								
520210	88	1	N/A	ESC Initialization Not Complete	ATC WL Blinking	ESC Disabled	ECU has recognized that the ESC module is currently in initialization mode and has not been completed.	• Follow the ESC Initialization (End of Line) calibration. Refer to Section 8.
520210	88	2	8 + 6	ESC System Configuration	ATC WL	ESC Disabled	The ESC module is not compatible with the ABS ECU	• Verify correct ABS ECU with OEM.
520210	88	5	7 + 1	ESC CAN Datalink Fault	ATC WL	ESC Disabled	Loss of CAN communication between the ESC module and the ABS ECU	• Check CAN wiring between ABS-ECU and ESC-module for interruptions and short circuits. • Check CAN wiring between ABS-ECU and SAS for interruptions and short circuits. • Check for corroded or damaged wiring between the ECU, SAS and ESC Module.
520210	88	6	7 + 1	ESC CAN Datalink Fault	ATC WL	ESC Disabled	Loss of CAN communication between the ESC module and the ABS ECU	• Check CAN wiring between ABS-ECU and ESC-module for interruptions and short circuits. • Check CAN wiring between ABS-ECU and SAS for interruptions and short circuits. • Check for corroded or damaged wiring between the ECU, SAS and ESC Module.

Figure 7.20

Figure 7.21

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
520210	88	9	7 + 1	ESC CAN messages missing, data erratic or incorrect	ATC WL	ESC Disabled	Data communication between the ESC module, SAS and the ABS ECU is missing or incorrect	• Check CAN wiring between ABS-ECU and ESC-module for interruptions and short circuits. • Check CAN wiring between ABS-ECU and SAS for interruptions and short circuits. • Check for corroded or damaged wiring between the ECU, SAS and ESC Module.
520210	88	12	8 + 6	ESC System Failure	ATC WL	ESC Disabled	ECU has detected ESC system failure due to missing or incorrect data from ESC Module or SAS	• Check CAN wiring between ABS-ECU, ESC-module and SAS for interruptions and short circuits. • Check for corroded or damaged wiring between the ECU, SAS and ESC Module. • Check for stray single power wires on or near the ESC module. • Check for damaged or incorrectly mounted SAS. • Verify ESC module is securely mounted, leveled and in correct location. • Verify ABS ECU and ESC has been properly calibrated. Follow the ESC Initialization (End of Line) calibration. Refer to Section 8.
520210	88	13	8 + 6	ESC Initialization required	ATC WL	ESC Disabled	The system has detected that the ABS ECU, ESC module or parameters were exchanged and ESC initialization is required	• Follow the ESC Initialization (End of Line) calibration. Refer to Section 8.
520210	88	14	8 + 6	ESC Module Mounting Fault	ATC WL	ESC Disabled	The ESC module mounting is not in accordance with specification.	• Verify ESC module is securely mounted, leveled and in correct location.
1807	89	1	8 + 6	SAS Offset Fault	ATC WL	ESC Disabled	The Steering Angle Sensor offset is out of tolerance.	• Check for damaged or incorrectly mounted SAS. • If work has been performed on the vehicle which affects the steering system or front end alignment, perform SAS Calibration and ESC Initialization. Refer to Section 8.
1807	89	2	8 + 6	SAS Not Plausible	ATC WL	ESC Disabled	The ESC module has detected an implausible steering angle compared to the measured yaw rate.	• Check for correct mounting of the SAS and ESC module.
1807	89	7	8 + 6	Steering Ratio Fault	ATC WL	ESC Disabled	The calculated steering ratio of the vehicle is not plausible.	• Check for correct mounting of the SAS and ESC module. • If work has been performed on the vehicle which affects the steering system or front end alignment, perform SAS Calibration and ESC Initialization. Refer to Section 8.
1807	89	8	7 + 1	SAS Calibration Fault	ATC WL	ESC Disabled	The Steering Angle Sensor calibration failed.	• Verify SAS is correctly mounted. • Perform SAS Calibration and ESC Initialization. Refer to Section 8.
1807	89	9	7 + 1	SAS CAN Fault	(temp) ATC WL	ESC Disabled (temp possible)	Data communication faults with ESC module.	• Check harness between ABS ECU and SAS. • Check parameter setting of ABS ECU. • Check SAS operation if fault persists.
1807	89	12	8 + 6	SAS Failure	ATC WL	ESC Disabled	The Steering Angle Sensor is communicating an internal error to the ABS ECU.	• Check CAN wiring between ABS-ECU and SAS for interruptions and short circuits. • Check for corroded or damaged wiring between the SAS and ESC Module.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
1807	89	13	8 + 6	SAS not Calibrated	ATC WL	ESC Disabled	The ECU has detected that SAS out of calibration.	• Follow the SAS calibration procedure. Refer to Section 8.
1807	89	14	8 + 6	SAS Internal Fault	ATC WL	ESC Disabled	The Steering Angle Sensor is communicating an internal error to the ABS ECU.	• Check the installation and condition of the SAS and steering system.
Datalink J1939								
639	231	2	7 + 1	SAE J1939 Data Link VSC1 speed erratic, intermittent or incorrect	ABS WL	N/A	Received vehicle speed and ABS vehicle speed is incorrect. Supervision normally not activated	• Check tire size and verify ECU is for the correct vehicle application.
639	231	5	7 + 1	SAE J1939 Data Link open or short circuit	ABS WL	ESC/RSC/ATC/ HSA Disabled	SAE J1939 communication is not possible.	• If ABS ECU is only vehicle ECU not communicating, verify J1939 wiring between ABS ECU and J1939 backbone. • Resistance should be 60 ohms between J1939 high and low. • Key on, check voltage to ground at the ECU harness connector J1939 pins and verify the high side has 2.5 to 5 volts and the low side has 2.49 volts or less.The readings will fluctuate but should be in range and should never be the same. The total of both readings together should be approximately 5 volts.
639	231	6	7 + 1	SAE J1939 No Access	WL ABS	ESC/RSC/ATC/ HSA Disabled	SAE J1939 communication is not possible.	• If ABS ECU is only vehicle ECU not communicating, verify J1939 wiring between ABS ECU and J1939 backbone. • Resistance should be 60 ohms between J1939 high and low. • Key on, check voltage to ground at the ECU harness connector J1939 pins and verify the high side has 2.5 to 5 volts and the low side has 2.49 volts or less.The readings will fluctuate but should be in range and should never be the same. The total of both readings together should be approximately 5 volts.
639	231	9	7 + 1	SAE J1939 Data Link EEC1 Timeout	ABS WL	ESC/RSC/ATC/ HSA Disabled	There is either too much time in between EEC1 broadcasts from the engine or the message content is not as expected.	• Contact OEM to verify J1939 wiring between engine ECU and vehicle J1939 backbone is correct and messages are correct. • If ABS ECU is only vehicle ECU not communicating, verify J1939 wiring between ABS ECU and J1939 backbone. • Resistance should be 60 ohms between J1939 high and low. • Key on, check voltage to ground at the ECU harness connector J1939 pins and verify the high side has 2.5 to 5 volts and the low side has 2.49 volts or less. The readings will fluctuate but should be in range and should never be the same. The total of both readings together should be approximately 5 volts.
639	231	10	7 + 1	SAE J1939 XBR Timeout	Temporary ABS WL	XBR Disabled	The external brake request message (XBR) is expected but is not being received in expected time or not at all.	• Verify J1939 wiring between external ECU which is sending request and J1939 backbone. • This message is most likely to come from Adaptive Cruise or a Collision Mitigation system such as OnGuard.
639	231	12	7 + 1	SAE J1939 Internal Error	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	An internal fault related to the CAN controller is detected.	• Verify J1939 wiring between ABS ECU and J1939 backbone. • Resistance should be 60 ohms between J1939 high and low. • Key on, check voltage to ground at the ECU harness connector J1939 pins and verify the high side has 2.5 to 5 volts and the low side has 2.49 volts or less. The readings will fluctuate but should be in range and should never be the same. The total of both readings together should be approximately 5 volts.
639	231	13	7 + 1	SAE J1939 XBR Timeout	Temporary ABS WL	XBR Disabled	The external brake request message (XBR) has been received incorrectly.	• Verify J1939 wiring between external ECU which is sending request and J1939 backbone. • This message is most likely to come from Adaptive Cruise or a Collision Mitigation system such as OnGuard.

Figure 7.22

Figure 7.23

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
639	231	14	7 + 1	SAE J1939 Data Link ESC1 Timeout	ATC WL	ESC Disabled	The electronic steering control message (ESC1) is expected but is not being received in expected time or not at all.	• Verify J1939 wiring between external ECU which is sending request and J1939 backbone. • This message is most likely to come from a steering tag axle controller.
Internal								
627	251	3	8 + 2	Overvoltage	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/HSA Disabled	A supply voltage which is too high has been measured by the ECU for more than 5 seconds.	• Measure the battery or ignition voltage under load. Check the vehicle battery and associate components (alternator). • Check the battery and ensure it is correct for the ECU, i.e., ensure a 24V battery is not being used with a 12V ECU. • Check for corroded or damaged wiring between the ECU and voltage supply as well as ground path.
630	253	1	7 + 5	ATC Configuration Issue	ABS WL	ATC Disabled	ABS ECU can see ATC valve but not the data link.	• Verify data link circuit voltage and resistance. • Try engine derate test. If test fails, indicates issue with data link circuit.
630	253	2	8 + 2	Incorrect ABS System Configuration. EEPROM or Wheel Parameter Incorrect	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/HSA Disabled	The ECU memorized system is not in accordance with the harness. There are loads detected at outputs which should be open circuits. Wheel parameters (number of tone ring teeth or tire size) are out of tolerance.	• Check number of sensors, modulators, 3/2 valves and other components match ECU configurations.(Parameters and installed components are not matching). • Verify the installed wheel size matches ECU wheel parameter. • On E452 ECUs with tire data available on request: check Engine ECU, availability of engine data information and communication between Engine ECU and the ABS ECU.
630	253	12	8 + 4	EEPROM Checksum	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/HSA Disabled	There is an incorrect checksum in the EEPROM. A diagnostic tool may have been disconnected during active diagnosis or programming.	• Reset ECU by cycling the ignition or by using the reset option in TOOLBOX™. • Retry the programming that was being attempted.
630	253	13	8 + 4	ABS System Fault	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/HSA Disabled	The ECU memorized system is not in accordance with the harness.	• Check number of sensors and modulators and correct wiring compared to ECU type.
630	253	14	8 + 6	EEPROM ESC Parameter Incorrect	ATC WL	ESC Disabled	The stability control parameters set in the ECU are not in accordance with what is detected or learned on the vehicle.	• Contact vehicle OEM to obtain correct ECU part number for vehicle.

SPN	SID	FMI	Blink Code	Description	Warning Light	System Reaction	Cause	Action
629	254	5	8 + 4	No Loads Detected	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	The ECU detects that no modulators are connected. This is a common fault during end of line testing or programming if only the X1 connector is connected.	• Check harness to ensure that modulators are connected and check fuses.
629	254	8	7 + 1	Excessive Slip	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	One axle is detected to be rotating much faster than another. This fault is common if vehicle has been on a dyno and detection is not disabled via diagnostic command. It is also possible that there are excessive sensor air gaps on multiple wheel ends.	• Use the "Disable ATC" diagnostic command when the vehicle is on a Dyno. • Check for excessive ABS sensor gap on multiple wheel ends.
629	254	9	2 + 1	Excessive Modulator Activation Time	ABS WL	ABS Wheel Disabled ESC/RSC Disabled ATC Disabled if Fault on Driven Wheel	An ABS modulator was activated for an abnormally long time.	• Adjust wheel sensor to touch tone ring. • Check condition of ABS sensor head. • Check for loose wheel bearings or excessive hub runout. • Check mounting of ABS tone ring and condition of teeth. • Check condition and retention of ABS sensor spring clip. • Check ABS sensor cable routing and clipping.
629	254	12	8 + 3	Internal Error	ABS WL	ABS Wheel Disabled ESC/RSC/ATC/ HSA Disabled	There are multiple causes. Valves may have been activated too long during diagnostic testing. Internal ECU communication is not correct.	• Reset ECU by cycling the ignition or by using the reset option in TOOLBOX™. • If fault persists, check ABS ECU powers, grounds and load test. • After checking powers, grounds and load testing, if fault still persists may indicate the ECU has failed.
629	254	13	8 + 6	Accelerometer Out of Range	ABS WL	RSC Disabled	The measured lateral acceleration by the ECU is out of range.	• Verify that the ECU is securely mounted, leveled and in correct location as per OEM specification. • Reset ECU by cycling the ignition or by using the reset option in TOOLBOX™.
629	254	14	8 + 6	ECU Mounting, Accelerometer Not Plausible	ABS WL	RSC Disabled	The measured lateral acceleration is not plausible or the learned offset is too high. ECU may be mounted incorrectly.	• Verify that the ECU is securely mounted, leveled and in correct location as per OEM specification. • Reset ECU by cycling the ignition or by using the reset option in TOOLBOX™.

Figure 7.24

Reconfiguration Procedure

How to Reconfigure an ECU (E Version)

Before reconfiguring the ECU, contact the Meritor OnTrac™ Customer Call Center at 866-668-7221 for additional information.

E version ECUs will automatically learn and memorize the following components if they are connected at start up:

- ATC valve
- Retarder relay or third brake relay
- Datalink SAE J1939
- Auxiliary inputs and outputs 1-5

NOTE: Depending on the ECU configuration (RSC, ESC or HSA), ATC Valve and auxiliary 1 through 5 cannot be reconfigured to remove these components. Only the retarder relay is memorized or cleared.

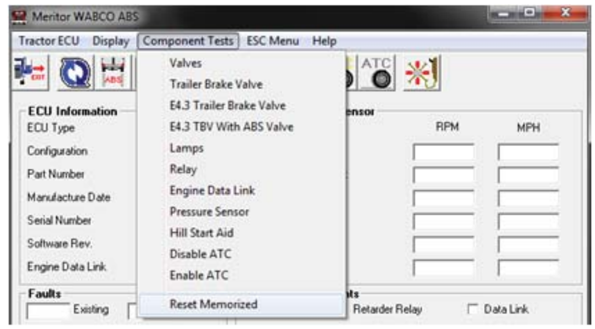
Once these components have been memorized, the ECU will look for them at each start up. If a memorized component is not present, the ECU will record a fault. For example, if an ATC valve is memorized, but is not present at the next start up, the ECU records a fault. This can occur if an ECU is moved from one truck to another and one or more of the memorized components are not available on the new truck. If this occurs, use TOOLBOX™ Software to reconfigure the ECU. If you do not have TOOLBOX™ Software, follow the manual reconfiguration instructions in this section.

TOOLBOX™ Software

NOTE: For complete instructions for using TOOLBOX™ Software, refer to the TOOLBOX™ User's Manual, TP-99102.

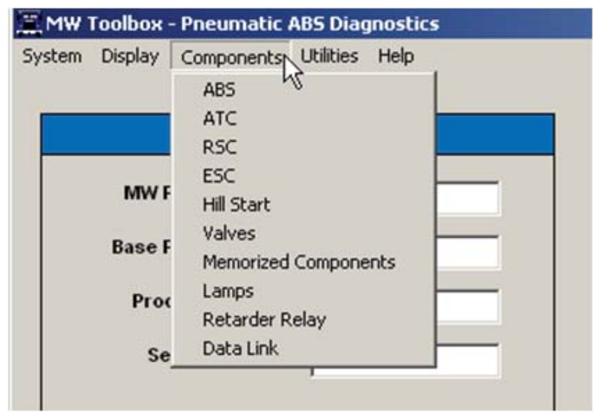
To reconfigure the ECU with TOOLBOX™ Software, use the ***Reset Memorized*** command.

Select ***Reset Memorized*** from the pull-down menu to tell the ECU to reset the memorized or "learned" components. Figure 8.1. If you are using TOOLBOX™ Software version 11 or higher, choose Components, Memorized Components and Reset Memorized. Figure 8.2 and Figure 8.3.



4010669a

Figure 8.1



4010670a

Figure 8.2

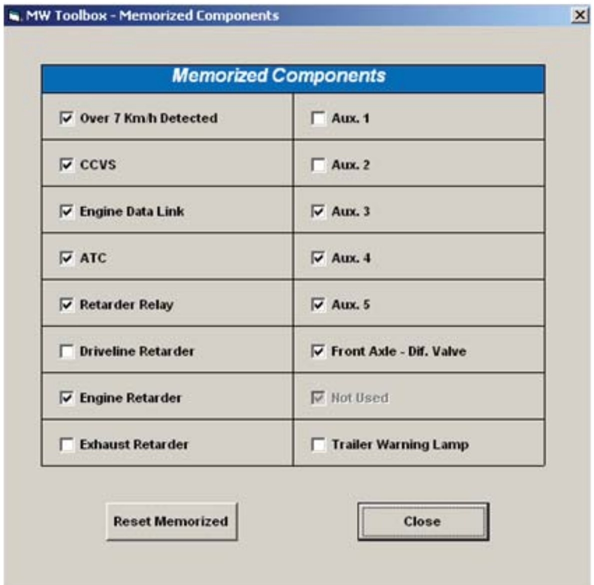


Figure 8.3

NOTE: Vehicle Ignition must be cycled and vehicle test driven over 4 mph (6.4 kph) to complete reset memorization.

Manual Reconfiguration

Refer to Table C and Figure 8.4 for information on manual reconfiguration.

Table C

Action	Result	Reason
1. **Turn the ignition ON.** 2. **Press and hold the blink switch for at least three seconds.** **NOTE:** Do not hold this switch longer than seven seconds.	The ABS lamp displays the ABS system configuration code: • One blink: 6S/6M 6X2 • Two blinks: 4S/4M • Four blinks: 6S/4M • Five blinks: 6S/6M 6X4 **NOTE:** The ABS lamp may display eight quick flashes before the system configuration code begins.	Stored faults cleared, no active faults present. Continue with reconfiguration. **NOTE:** The reconfiguration procedure cannot be conducted if there are active faults present. These must be repaired before proceeding with the reconfiguration.

Action	Result	Reason
Observe the ABS and ATC lamps.	The ATC lamp comes on and stays on.	A complete ATC system — including an ATC lamp — is installed. If not, the ATC lamp will not come on.
	The ABS lamp will continuously blink the system configuration code.	ECU reconfiguring the system. The ECU checks the following components and reprograms itself based on the new system: • ATC valve AND/OR • Retarder relay AND/OR • Datalink J1939
While the configuration code is flashing, press the blink code switch three times (one second each, with a one second pause between each). **Turn the ignition OFF.**	The ABS lamp displays **four quick flashes**, followed by a continuous display of the system configuration code. **NOTE:** The system configuration code continues until ignition is turned OFF.	Successfully reconfigured.

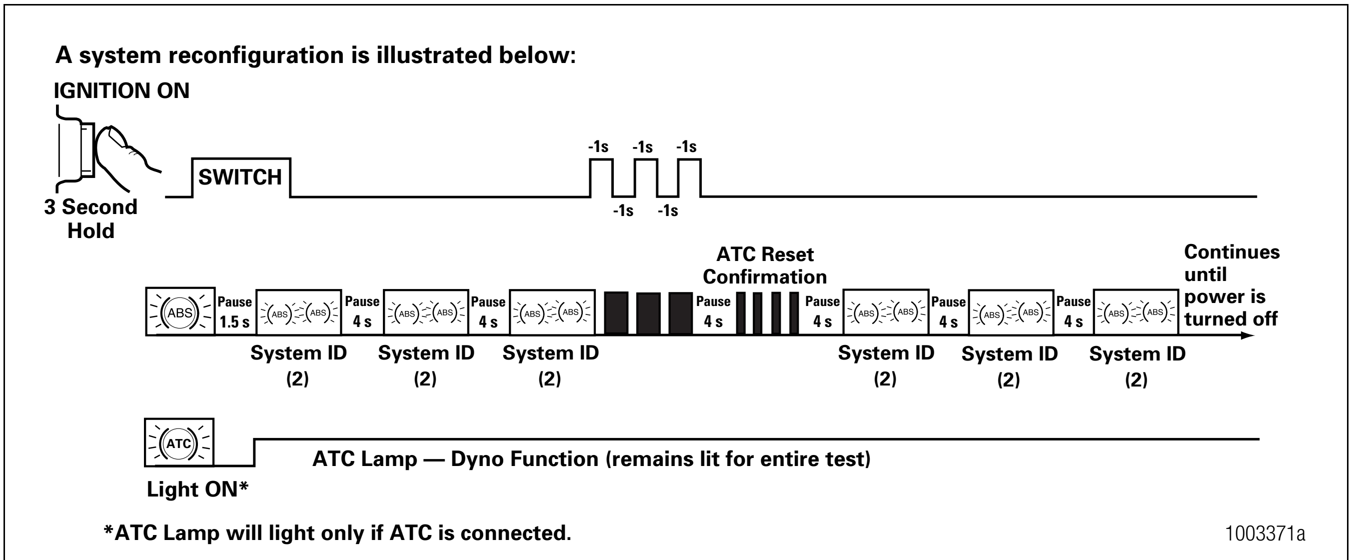


Figure 8.4

ESC End of Line Calibration Procedure

This procedure is performed as part of the final assembly of the vehicle at the manufacturing site. Also, this procedure must be performed in the field by a trained technician if components are replaced such as the Steering Angle Sensor (SAS), the Electronic Stability Control (ESC) module or the ESC Electronic Control Unit (ECU). This calibration should also be performed when a major steering repair or replacement has taken place.

The process consists of two operations. The first one is the SAS Calibration while the vehicle is stationary, followed by the ESC Initialization while driving the vehicle. The status of the ESC End of Line (EOL) procedure can be verified using one of the following allowed faults.

- SAS not calibrated — SID 89, FMI 13
- ESC initialization required — SID 88, FMI 13
- ESC initialization not completed — SID 88, FMI 1

CAUTION

Additional faults must not be active. Any other faults must be resolved before one of the main menu items is available.

NOTE: To prevent incorrect activations, SAS Calibration and ESC Initialization must be done separately. It is necessary to perform the SAS calibration prior to the ESC initialization.

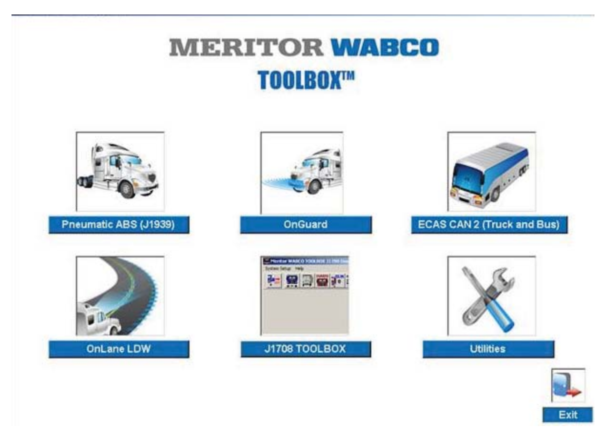
For any questions or assistance, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221 or visit www.meritorwabco.com for further details.

SAS Calibration

NOTE: The SAS Calibration must be done after a front wheel alignment has been performed.

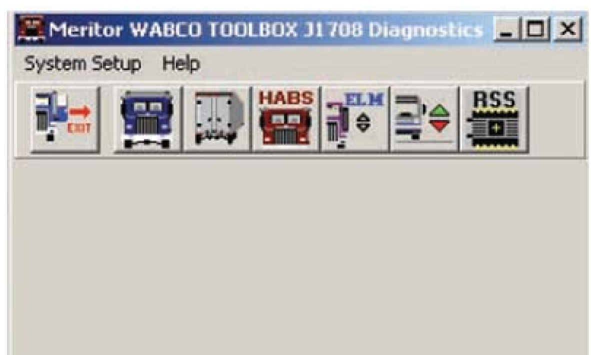
Depending on the software version used, there will be two options to communicate with the vehicle:

- If you are using TOOLBOX™ Software version 11 or higher and a vehicle with ECUs E4.4b or higher, Tractor ABS J1939 communications can be possible. Figure 9.1.
- J1708 communications are possible with any TOOLBOX™ Software version and any ABS ECU. Figure 9.2.



4010611a

Figure 9.1



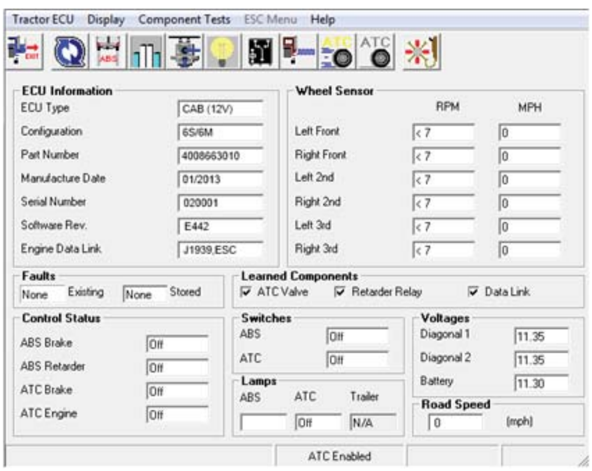
4010612a

Figure 9.2

In the Main Menu, select J1939 Tractor ABS or J1708 TOOLBOX™, then Tractor ABS. The ABS Main Screen will appear. Figure 9.3 and Figure 9.4.

4010672a

Figure 9.3

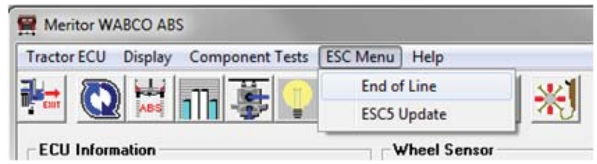


4010673a

Figure 9.4

To access the ESC EOL:

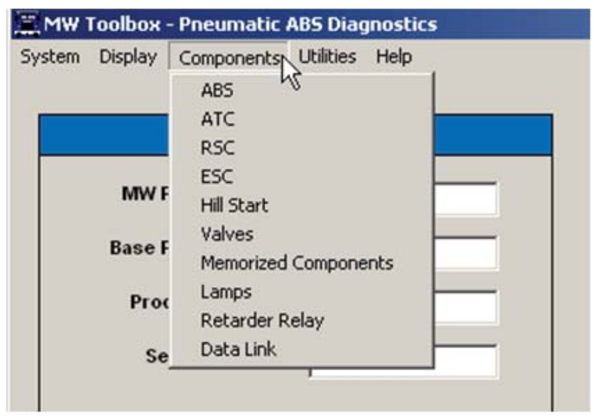
- From the bar menu at the initial screen, click on the "ESC Menu" button. A drop-down box will appear. Select the option "End of Line." Figure 9.5.



4010689a

Figure 9.5

- If you are using TOOLBOX™ Software version 11 or higher, click on "Components" button. A drop box will appear, Select "ESC" then select "Start EOL". Figure 9.6 and Figure 9.7.



4010674a

Figure 9.6

4010675a

Figure 9.7

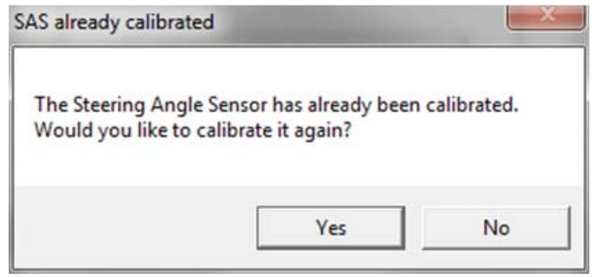
In the message box that appears, click the "SAS Calibration" button. Figure 9.8.

4010676a

Figure 9.8

NOTE: If SAS has NOT been replaced but vehicle has had an alignment performed or other steering components have been replaced, it is necessary to recalibrate SAS regardless of current calibration. Figure 9.9 may appear if unit has had SAS calibrate at some point. Click on Yes to recalibrate SAS. Figure 9.10.

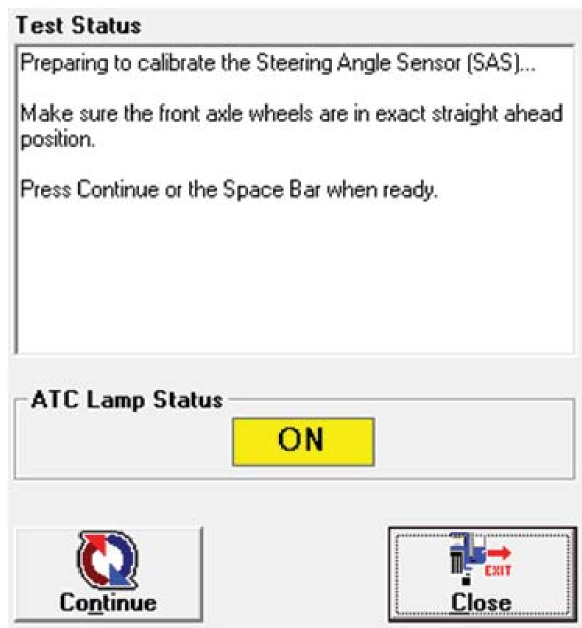
NOTE: The vehicle needs to be sitting still during SAS calibration.



4010677a

Figure 9.9

NOTE: Depending on your version of TOOLBOX™ Software, the message in Figure 9.9 may appear. If it does, always click "Yes" to recalibrate the Steering Angle Sensor in order to complete the ESC Initialization.



4010678a

Figure 9.10

The message will let you know when the SAS has been calibrated. Once the SAS is calibrated, press the "Close" button or the space bar to continue. Figure 9.11.

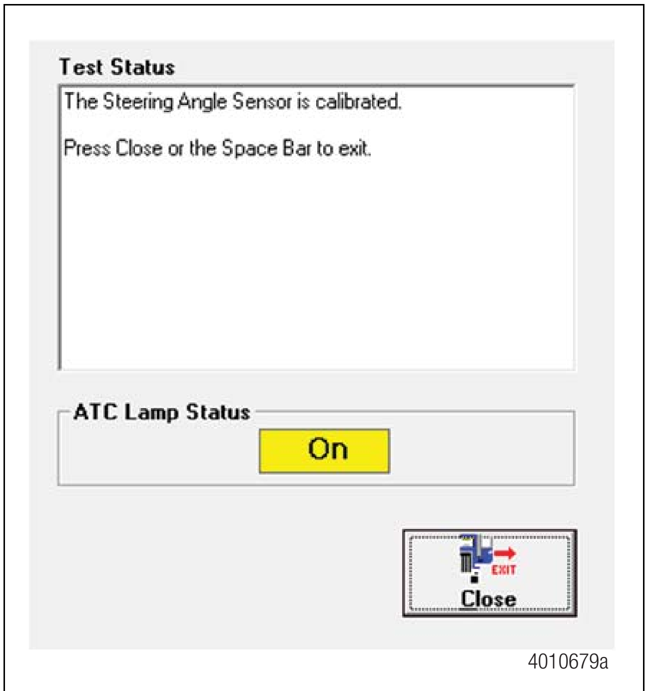


Figure 9.11

The SAS calibration is now completed. The ATC lamp will blink continuously to inform driver ECU is in learning mode.

If SAS calibration fails; recheck the SAS connection and verify SAS mounting. Cycle ignition and retry SAS calibration again.

ESC Initialization

Access the ESC EOL menu as in SAS calibration but instead in the message box that appears, click the "ESC Initialization" button. Figure 9.12.

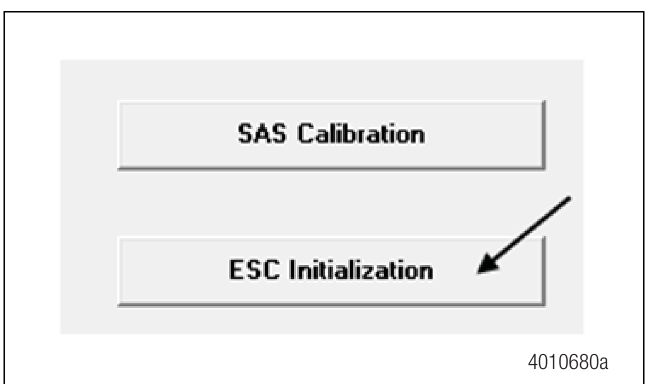


Figure 9.12

Check the message box that appears. Press the space bar or click the "Continue" button when ready to proceed. Figure 9.13. The ATC lamp will start blinking to inform driver ECU is in learning mode.

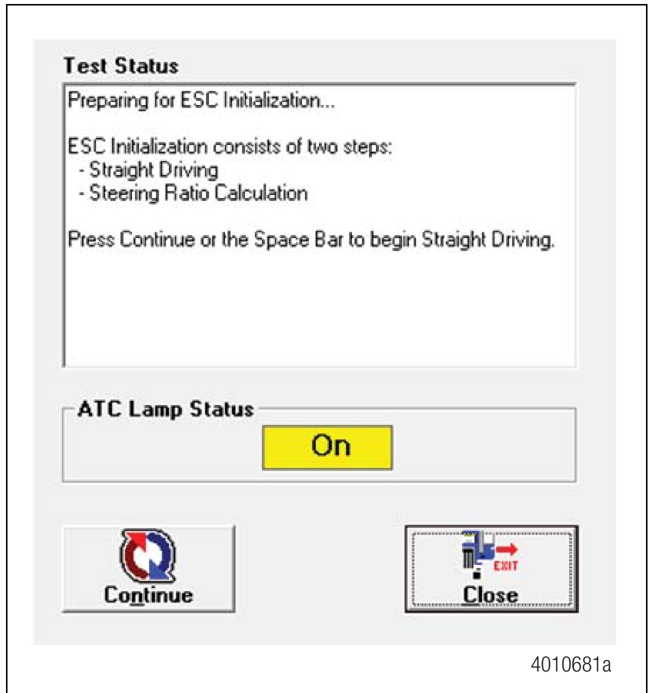
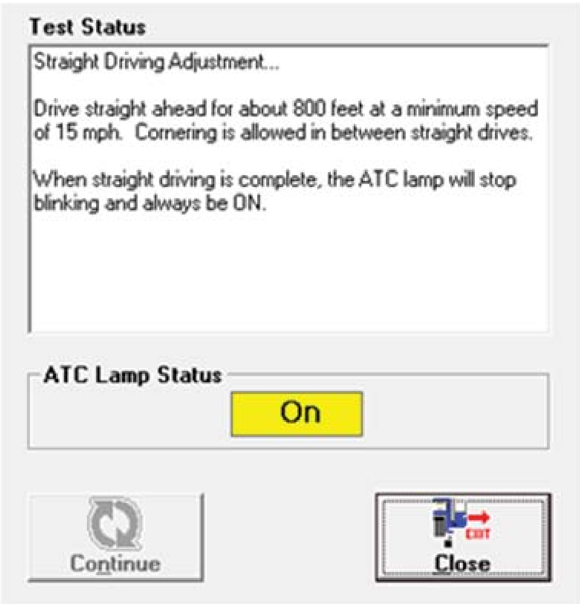


Figure 9.13

Tip: Carefully follow the instructions that appear in the message box. Figure 9.13. Once the ESC initialization is started, the messages will automatically change as the requirements are met. DO NOT click the "continue" button again as this may cause the process to fail. The ESC Initialization procedure requires the vehicle to be driven.

NOTE: If SAS calibration was completed before ESC initialization, the ATC lamp will be continuously blinking before ESC initialization begins. Figure 9.14.



4010682a

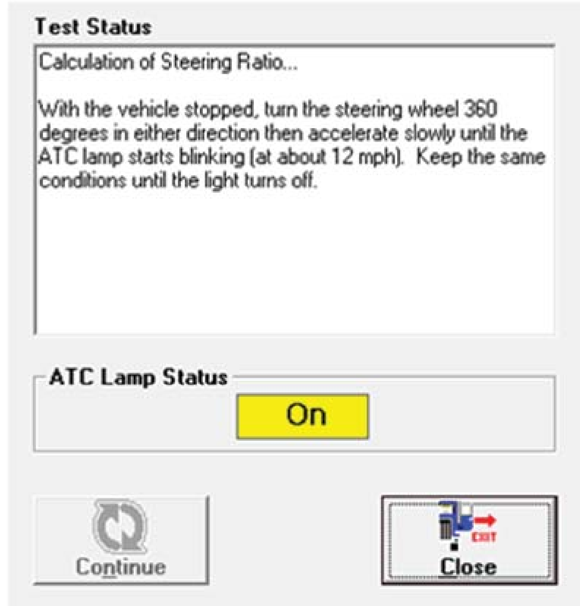
Figure 9.14

The straight driving adjustment can be done in segments as the ECU will accumulate the information until the 800 feet is reached. Cornering and stopping is allowed as long as calibration is done within the same ignition cycle.

When the Straight Driving Adjustment is completed after ECU accumulated 800 feet of straight driving, the ATC lamp will stop blinking and will remain ON.

NOTE: Certain vehicles may not require you to perform the turning portion of the ESC initialization steering ratio calculation process. For these vehicles, the ATC lamp will go out. Follow the instructions on the screen.

The screen will automatically change to the next portion of the procedure. Figure 9.15.



4010683a

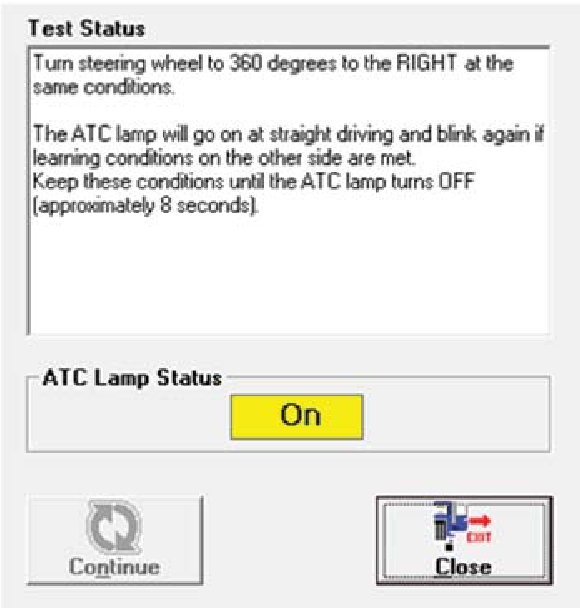
Figure 9.15

Tip: The vehicle MUST come to a complete stop before starting the steering ratio calculation and turning the steering wheel 360 degrees for the first time.

Once steering wheel is turned one revolution in either direction (360 degrees) accelerate slowly until 12 mph (19 kph) is reached.

Continue driving in a circle until the screen automatically changes to inform the steering ratio is being calculated. Maintain the vehicle speed and conditions (approximately 8 seconds) until ATC lamp turns off.

The screen will automatically change to the next portion of the procedure. Figure 9.16.



4010684a

Figure 9.16

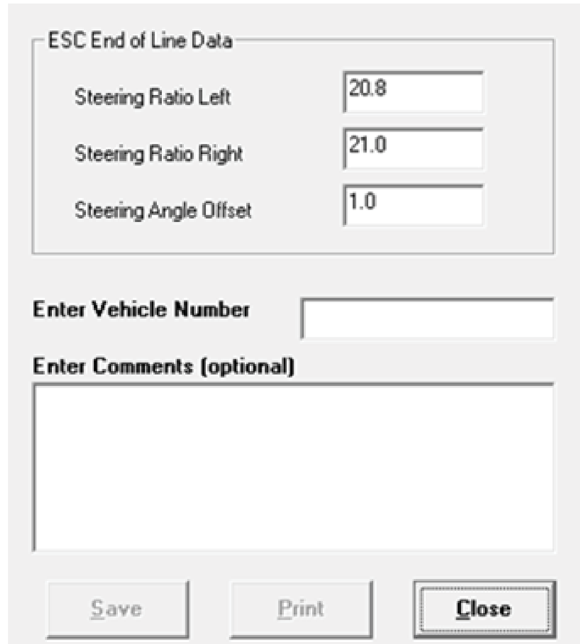
Tip: The vehicle does not have to come to a complete stop before turning the steering wheel 360 degrees in the other direction but it is recommended to make sure wheels are in the straight position before making the turn.

Turn the steering wheel 360 degrees in the opposite direction and repeat the driving conditions. The ATC lamp will start blinking when the required conditions are met. Keep driving in those conditions (approximately 8 seconds) until the lamp turns off.

The screen will automatically change to show ESC End of the Line data and ratios. Figure 9.17.

Make sure to stop the vehicle once steering ratio calculation has been completed.

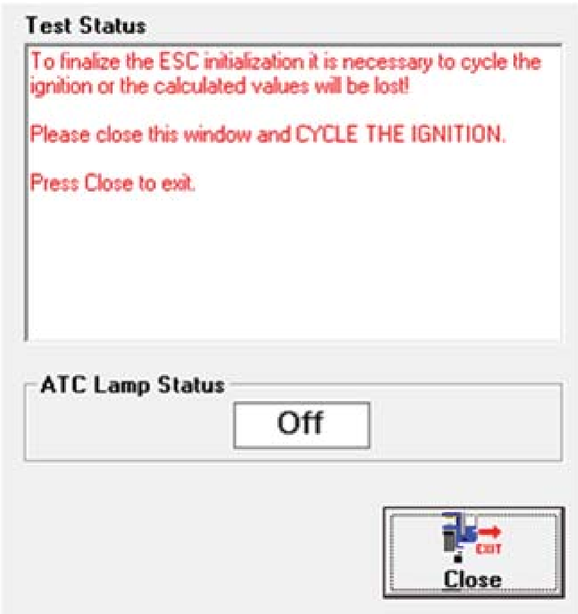
NOTE: The circle driving (Calculation of Steering Ratio) can be done in segments as the ECU will accumulate the information until the desired distance is reached, but must be done within the same ignition cycle. The calibration requires driving in both directions with the steering wheel rotated 360 degrees.



4010685a

Figure 9.17

With the vehicle stopped, ESC End of Line Data with the Steering Ratios and Steering Angle Offset values will appear. The data can be saved or printed for maintenance records. If saving or printing is not desired, click "Close". The next screen will automatically appear to complete the ESC initialization. Figure 9.18.



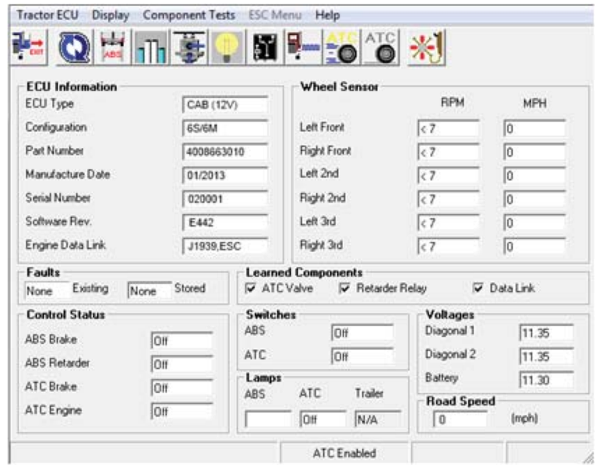
4010686a

Figure 9.18

For the ECU to be able to save ratios and ESC EOL data, the ignition MUST be cycled. With the vehicle stopped, close window that appeared and cycle the ignition for around 10 seconds.

NOTE: Power down cycle time and sequence will vary amongst vehicle manufacturers. Some vehicles might require the key to be removed from the ignition for ignition power to be completely turned off. Please follow the vehicle manufacturer procedure to make sure ignition is turned off.

When the ignition is turned back ON, check that no active or stored faults are logged in the ECU and that the ABS and ATC/ESC warning lamps are OFF. Figure 9.19 and Figure 9.20.



4010687a

Figure 9.19

4010688a

Figure 9.20

The ESC EOL Initialization procedure is completed.

NOTE: If ESC EOL initialization was not properly completed and/or ratios correctly saved, code SID 88 FMI 1 will be active. Follow the ESC initialization again and make sure each portion is successfully completed. Make sure ignition power down is completed for the ECU to successfully save data.

Aftermarket Programming

Aftermarket programming is a method of servicing most pneumatic ABS ECUs. Instead of swapping one fully programmed ECU for another, programmable ECUs can be stocked at the point of service and programmed using a purchased configuration file. The process can be completed in the following steps.

1. Acquire a programmable replacement ECU from Meritor's Commercial Vehicle Aftermarket by calling 888-725-9355.
2. Install the replacement ECU into the vehicle.
3. Acquire a configuration file from https:// meritorwabco.snapon.com.
4. Load the configuration file into the ECU using Meritor WABCO's TOOLBOX™ Aftermarket Programming application.

   NOTE: Aftermarket programming does not change the functionality of the ABS-based safety system as installed in the vehicle.

Before programming the ECU, verify TOOLBOX™ Software version 11.5 or higher is installed on the service computer.

Aftermarket Programming Procedures

Step 1: Acquire a programmable replacement ECU from Meritor's Commercial Vehicle Aftermarket by calling 888-725-9355.

Meritor's Commercial Vehicle Aftermarket will provide the correct aftermarket programmable replacement ECU for the vehicle being serviced. Regardless of order method, Meritor's Commercial Vehicle Aftermarket will ship a programmable ECU replacement if one is available. Programmable ECUs are clearly identified with a large orange sticker indicating it must be programmed. Programmable ECUs are also shipped with an instruction sheet explaining how to complete the service operation. Figure 10.1.

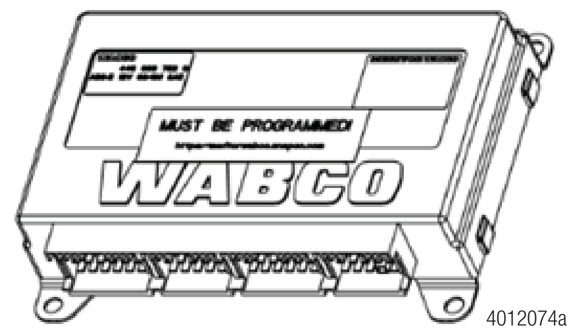


Figure 10.1

Step 2: Install the replacement ECU into the vehicle.

The programmable ECU should be installed in the vehicle in the same manner and location as the ECU being replaced. Connect all electrical connectors.

NOTE: Aftermarket programmable ECUs are backwards compatible with the ECUs they replace, so there should be no modifications required to either the mounting or electrical connections.

When the replacement ECU is installed, the ABS lamp will be lit due to an active DTC:

SID	SPN	FMI	Description
253	630	2	Calibration Memory – Wheel Parameter Incorrect

NOTE: This DTC will clear after a configuration file has been successfully loaded into the ECU. The ABS lamp will remain on until the vehicle has been driven above 4 mph (6 km/h).

Step 3: Acquire a configuration file from https:// meritorwabco.snapon.com.

Configuration files are available for purchase at https:// meritorwabco.snapon.com. Begin by either creating an account or logging into an account created during a previous purchase from the site. Figure 10.2.

NOTE: If you purchased TOOLBOX™ Software, then you already have an account, and that account information should be used to log in.

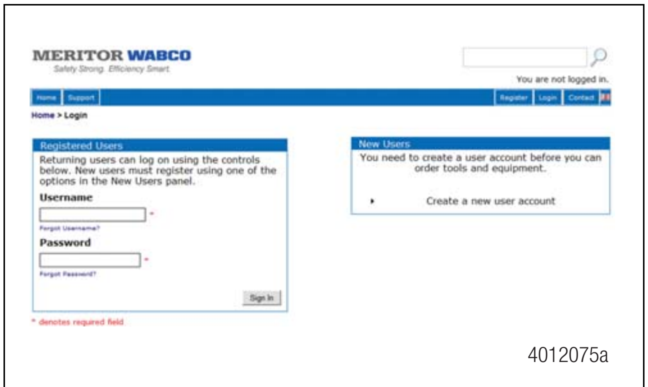


Figure 10.2

Click the Aftermarket Programming Configuration Files button at the top of the screen. Figure 10.3.

NOTE: If TOOLBOX™ Software is not available at the point of service, it can be purchased by clicking the TOOLBOX™ Software button.

Figure 10.3

Enter the part details for the vehicle being worked on and the part being replaced. Figure 10.4.

- The VIN must include all 17 characters.
- The part number of the ECU being replaced must be entered.
- The serial number of the ECU being replaced may be entered, but is not required.

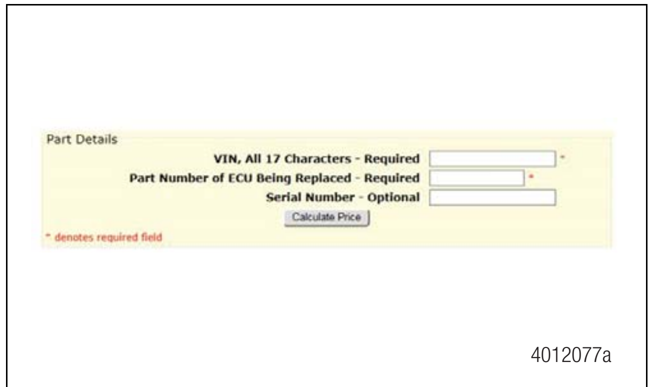
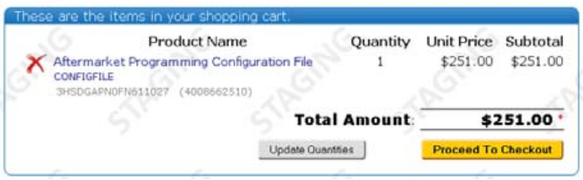


Figure 10.4

The next screen will show the details of the configuration file linked to the part number and VIN combination entered. The price for the configuration file will also be displayed. Verify the VIN, part number and details of the ECU functionality match those of the ECU being replaced. If this information is correct, click the Add to shopping cart button. Figure 10.5.

Figure 10.5

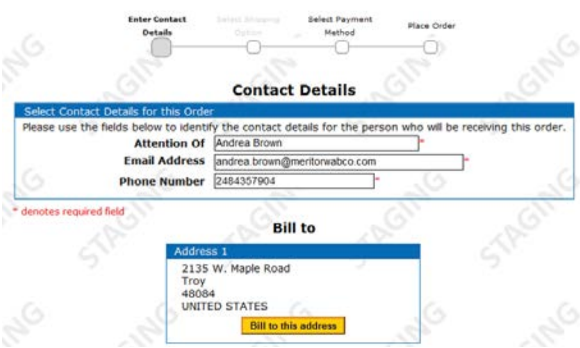
After the configuration file has been added to the shopping cart, the shopping cart will be displayed. Clicking Proceed to Checkout will step through the configuration file purchase process. Figure 10.6.



4012079a

Figure 10.6

The first step in the checkout process is to verify contact information. The information will automatically populate based on login information; all fields can be edited. When the correct contact details are displayed, click Bill to this address. Figure 10.7.



4012080a

Figure 10.7

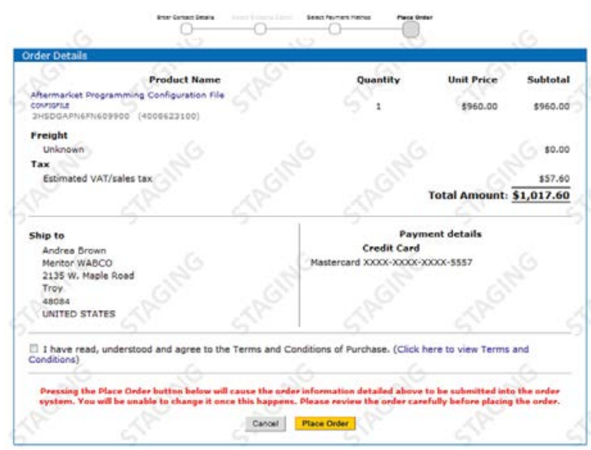
The select payment method screen appears next. Enter the credit card information for the purchase, or select an alternative payment method. Once the information is entered, click Pay by Credit Card.

NOTE: Purchasing the configuration file by credit card is recommended for immediate download of the configuration file. Users of other payment methods may experience a delay while payment is processed. Figure 10.8.

4012081a

Figure 10.8

The final screen of the purchase process allows the details of the purchase to be reviewed before placing the order. If all of the information is correct, check the box acknowledging the terms and conditions of the purchase and click Place Order. Figure 10.9.



4012082a

Figure 10.9

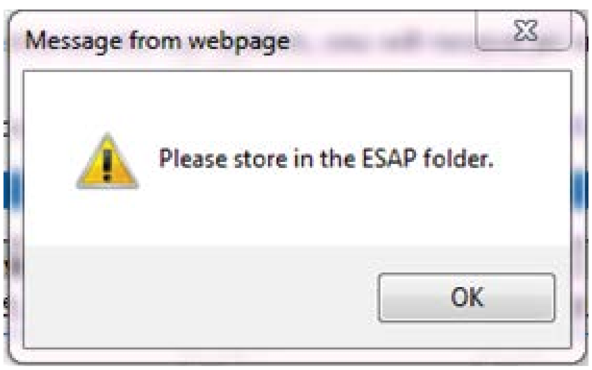
The order will be processed, and a link to download the configuration file will be displayed. Click the hyperlink to download the configuration file. Figure 10.10.

NOTE: The link will remain available for seven days. The configuration file download must be completed in that time.

4012083a

Figure 10.10

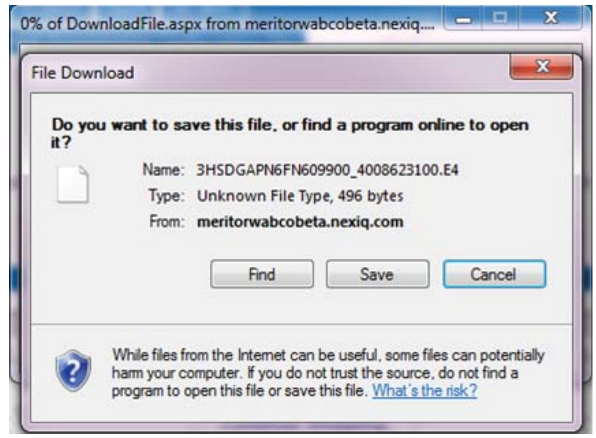
The following message will be displayed regarding the recommended file storage location. Press OK to continue with saving the file. Figure 10.11.



4012084a

Figure 10.11

When the following screen is displayed, press Save to continue with saving the file. Figure 10.12.



4012085a

Figure 10.12

NOTE: Save the configuration file to a location that can be accessed while connected to the vehicle. The Aftermarket Programming application will allow the selection of the file from any location.

Step 4: Load the configuration file into the ECU using Meritor WABCO's TOOLBOX™ Aftermarket Programming application.

Start by connecting TOOLBOX™ Software 11.5 or higher to the vehicle using any J1939 RP1210 diagnostic adapter. Turn the ignition on, open TOOLBOX™ Software, and click the Aftermarket Programming application to start programming the ECU. Figure 10.13.

NOTE: Wireless diagnostic adapters should not be used for aftermarket programming or any other Meritor WABCO programming operation.

NOTE: It is recommended that aftermarket programming be completed with ignition on only. Do not cycle the key until the programming operation is complete. Verify the battery is fully charged prior to performing the programming operation; the vehicle should not be connected to a battery charger during programming.

NOTE: For complete instructions for using TOOLBOX™ Software, refer to the TOOLBOX™ User's Manual, TP-99102.

4012086a

Figure 10.13

A message will be displayed indicating that the ECU will be changed as a result of programming. Click Yes to continue with programming the ECU. Figure 10.14.

4012087a

Figure 10.14

The Aftermarket Programming application will then locate the configuration file. Click OK to select the file. Figure 10.15.

4012088a

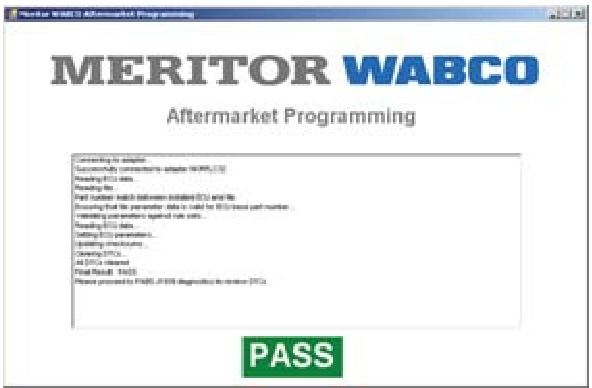
Figure 10.15

Use the file selection box to locate the configuration file that matches the VIN and part number of the vehicle being serviced. Select the file by clicking on it, and then click Open. Figure 10.16.

4012089a

Figure 10.16

The Aftermarket Programming application will automatically run from this point. The progress of the programming operation will be displayed in the dialogue box. Once ECU programming is successfully completed, a green PASS indicator will appear at the bottom of the Aftermarket Programming application window. Figure 10.17.



4012090a

Figure 10.17

If the programming operation fails for any reason, a red FAIL indicator will appear at the bottom of the Aftermarket Programming application window. Within the text box, an error code will be displayed with instructions. If the programming operation cannot be completed, record the error code and contact the Meritor OnTrac™ Customer Call Center at 866-668-7221. Figure 10.18.

4012091a

Figure 10.18

NOTE: ESC ECUs will require the ESC End of Line procedure to be completed following ECU replacement. Refer to Appendix II.

Aftermarket Programming Failure Codes List

SID	SPN	FMI	Warning Light	Programming Error Code	Message Displayed	Description/Action
253	630	2	ABS WL	None	None	This DTC is active for all programmable ECUs that have not been programmed with a configuration file. Completion of the programming operation will clear this DTC. If this code is active for a non-programmable ECU, refer to the SPN, SID, FMI Fault Codes section in this manual.
253	630	2	ABS WL	B1	Unable to connect to adapter [Adapter Name] (Error: B1). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	The diagnostic adapter selection does not match the selection in TOOLBOX™ Software or the diagnostic adapter is not capable of J1939 communications. Return to the TOOLBOX main screen. Select Utilities --> Adapter Selection. Select the diagnostic adapter being used from the list of options.
253	630	2	ABS WL	B2	Unable to start diagnostic session with ECU (Error: B2). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B3	Unable to read ECU Production Data (Error: B3). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B4	Unable to read ECU Component ID (Error: B4). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B5	Aftermarket programming configuration file for download not found (Error: B5).	This error will occur if the configuration file is moved or changed during a configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off).
253	630	2	ABS WL	B6	Error reading the Aftermarket Programming configuration file (Error: B6).	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B7	Selected file for download has been successfully used before. Please restart Aftermarket Programming and select a different file (Error: B7).	This failure will occur when a user tries to use a configuration file that has already been used to successfully configure an ECU. Purchase a new configuration file at https://meritorwabco.snapon.com.

4012092a

Figure 10.19

SID	SPN	FMI	Warning Light	Programming Error Code	Message Displayed	Description/Action
253	630	2	ABS WL	B8	Module of the Aftermarket Programming file for download is incorrect for this application (Error: B8). Ensure that the Aftermarket Programming file extension was not renamed. Please exit this window and select Aftermarket Programming to try again.	This error will occur if the configuration file is moved or changed during a configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off).
253	630	2	ABS WL	B9	Part number of installed ECU [part number] does not match part number of Aftermarket Programming configuration file (Error: B9). Contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure will occur when the part number in the configuration file does not match the aftermarket programmable ECU part number. Verify that the aftermarket programmable replacement ECU is correct for the ECU previously installed on the vehicle.
253	630	2	ABS WL	B10	This Aftermarket Programming configuration file does not work for this vehicle (Error: B10). Contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure will only occur when the VIN for the configuration file does not match the actual VIN of the vehicle being serviced. Verify that the VIN used to purchase the configuration file matches that of the vehicle the aftermarket programmable replacement ECU is being installed in/programmed on.
253	630	2	ABS WL	B11	Invalid ECU part number [part number] for programming (Error: B11).	This failure will occur when attempting to configure an ECU that does not require aftermarket programming. Verify the ECU does not require programming and refer to the SPN, SID, FMI Fault Codes section in this manual.
253	630	2	ABS WL	B12	Unable to read parameters from ECU (Error: B12). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B13	Unable to gain security access to ECU (Error: B13). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B14	Unable to write VIN to the ECU (Error: B14). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B15	Unable to write checksum to ECU: Block [block information] (Error: B15). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.

4012093a

Figure 10.20

Figure 10.21

SID	SPN	FMI	Warning Light	Programming Error Code	Message Displayed	Description/Action
253	630	2	ABS WL	B16	Communication Error (Error: B16). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B17	Parameter Incompatibility (Error: B17). Contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off).
253	630	2	ABS WL	B18	Unable to read memory address before setting parameter (Error: B18). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B19	VCP program error: ByteToChange for [parameter information] neither 0 nor 1 (Error: B19). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B20	Unable to write parameter: [parameter information] (Error: B20). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	B21	Error while trying to set parameters (Error: B21). Please exit this window, cycle power and try again. If the problem persists, please contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	This failure may occur if communication with the ECU is interrupted during the configuration session. Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off). This failure will also occur when one or more of the following are not connected: Power, Ground, J1939 CAN High or J1939 CAN Low. Check for continuity.
253	630	2	ABS WL	A1	Error parsing the Aftermarket Programming configuration file (Error: A1).	Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off).
253	630	2	ABS WL	A2	No parameters were found in the Aftermarket Programming configuration file (Error: A2).	Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off).
253	630	2	ABS WL	A3	Part number is missing from the Aftermarket Programming configuration file (Error: A4). Contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off).

4012094a

SID	SPN	FMI	Warning Light	Programming Error Code	Message Displayed	Description/Action
253	630	2	ABS WL	A4	VIN not found in the Aftermarket Programming configuration file (Error: A4). Contact the Meritor OnTrac™ Customer Call Center at 866-668-7221.	Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off).
253	630	2	ABS WL	C1	Mismatch found between installed ECU and the configuration file (Error: C1).	Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off).
253	630	2	ABS WL	C2	[Parameter] Incorrect for installed ECU part number (Error: C2).	Close the TOOLBOX™ Software, reopen it and restart the aftermarket programming application. If the problem persists, repeat with key on only (IGN off).

4012095a

Figure 10.22

Meritor WABCO Vehicle Control Systems
2135 West Maple Road
Troy, MI 48084-7121
866-OnTrac1 (668-7221)
meritorwabco.com

Printed in USA

Revised 07-15
Maintenance Manual MM-0112 (16579)

MERITOR WABCO

BENDIX

Anti-Lock Braking System (ABS)

Bendix®

Service Data

SD-13-4869

Bendix® EC-60™ ABS / ATC / ESP Controllers (Advanced)

See SD-13-4863 for Standard and Premium Controllers

See SD-13-21021 for the Bendix® eTrac™ Automated Air Suspension Transfer System

FIGURE 1 - *EC-60™ ADVANCED CONTROLLER*

The driver is always responsible for the control and safe operation of the vehicle at all times. The Bendix® ESP® stability system does not replace the need for a skilled, alert professional driver, reacting appropriately and in a timely manner, and using safe driving practices.

TABLE OF CONTENTS	PAGE

INTRODUCTION

The Bendix® EC-60™ advanced controller is a member of a family of electronic **Antilock Braking System (ABS)** devices designed to help improve the braking characteristics of air braked vehicles - including heavy- and medium-duty buses, trucks, and tractors. ABS controllers are also known as **Electronic Control Units (ECUs)**.

Bendix® ABS uses wheel speed sensors, ABS pressure modulator valves, and an ECU to control either four or six wheels of a vehicle. The Bendix EC-60 controller monitors individual wheel turning motion during braking and adjusts or modulates the brake pressure at the wheel end. When excessive wheel slip, or wheel lock-up is detected, the Bendix EC-60 controller will activate the pressure modulator valves to automatically reduce the brake pressure at one or more of the wheel ends. By these actions, the ABS system helps to maintain the vehicle's lateral stability and steerability during heavy brake applications and during braking on slippery surfaces.

In addition to the ABS function, advanced models of the EC-60™ controller provide ABS-based stability features referred to as **ESP® Electronic Stability Program**. The Bendix ESP system is an ABS-based stability system that enhances vehicle stability by both reducing engine throttle and by applying vehicle braking based on actual vehicle dynamics. Accordingly, the ESP system is available only on specific approved vehicle platforms after vehicle application and development efforts and validation testing. Only certain limited variations of an approved vehicle platform are permitted without further validation of the ESP system application.

ESP stability system consists of Yaw Control (YC) and Roll Stability Program (RSP) features.

Additional features include **Automatic Traction Control (ATC)**. Bendix ATC can improve vehicle traction during acceleration, and lateral stability while accelerating through curves. ATC utilizes **Engine Torque Limiting (ETL)** where the ECU communicates with the engine's controller and/or **Differential Braking (DB)** where individual wheel brake applications are used to improve vehicle traction. Advanced Bendix EC-60 controllers have a drag torque control feature which reduces driven-axle wheel slip (due to driveline inertia) by communicating with the engine's controller and increasing the engine torque.

For vehicles with the **Hill Start Feature** optional feature, this system interfaces between the transmission and braking system to help the driver prevent the vehicle from rolling downhill when moving up a steep incline from a stationary position.

GENERAL SAFETY GUIDELINES

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following guidelines should be observed AT ALL TIMES:

- ▲ **Park the vehicle on a level surface, apply the parking brakes and always block the wheels. Always wear personal protection equipment.**
- ▲ **Stop the engine and remove the ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically-charged components.**
- ▲ **Do not attempt to install, remove, disassemble or assemble a component until you have read, and thoroughly understand, the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
- ▲ **If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle. If the vehicle is equipped with a Bendix® AD-IS® air dryer system, a Bendix® DRM™ dryer reservoir module, or a Bendix® AD-9si® air dryer, be sure to drain the purge reservoir.**
- ▲ **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.**
- ▲ **Never exceed manufacturer's recommended pressures.**
- ▲ **Never connect or disconnect a hose or line containing pressure; it may whip and/or cause hazardous airborne dust and dirt particles. Wear eye protection. Slowly open connections with care, and verify that no pressure is present. Never remove a component or plug unless you are certain all system pressure has been depleted.**
- ▲ **Use only genuine Bendix® brand replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, wiring, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.**
- ▲ **Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.**
- ▲ **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**
- ▲ **For vehicles with Automatic Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.**
- ▲ **The power MUST be temporarily disconnected from the radar sensor whenever any tests USING A DYNAMOMETER are conducted on a vehicle equipped with a Bendix® Wingman® system.**
- ▲ **You should consult the vehicle manufacturer's operating and service manuals, and any related literature, in conjunction with the Guidelines above.**

CAUTION

Even with ESP-equipped vehicles, the driver remains responsible for ensuring vehicle stability during operation. The ESP system can only function within the limits of physics. ESP functionality mitigates potential vehicle stability incidents, but cannot prevent them in all cases. Other factors such as driving too fast for road, traffic or weather conditions, oversteering, an excessively high vehicle Center of Gravity (CG), or poor road conditions can cause vehicle instability that is beyond the capability of any stability system to mitigate. In addition, the effectiveness of ESP can be greatly reduced on vehicles towing multiple trailer combinations.

CAUTION

The ESP stability system may only be used on vehicles tested and approved by Bendix engineering. ESP installations require on-vehicle testing and Bendix® EC-60™ parameter tuning. See "Advanced ABS with Stability Control" on page 12 for further details.

Accordingly, the Bendix EC-60 controller is provided with a corresponding parameter data set that is validated for a specific vehicle platform. Therefore, specific steps are necessary should a replacement ECU be required. See "Obtaining a New Bendix EC-60 Advanced Controller" on page 18 for further details.

ESP-equipped vehicles should not be driven on high-banked roads – such as those found on high-speed test or race tracks. Test personnel must have ESP functionality disabled prior to operating an ESP vehicle on such tracks.

YAW CONTROL (YC)

Advanced ECU can include Yaw Control (YC) functionality, which has the ability to apply brakes to individual wheel ends, as well as applying the trailer brakes, to counteract trailer “push” that, during certain maneuvers, could lead to a loss-of-control or a jackknife incident. See "Yaw Stability" on page 9 for further details.

ROLL STABILITY PROGRAM (RSP)

The Bendix Roll Stability Program (RSP), is an all-axle ABS solution that helps reduce vehicle speed by reducing the engine's throttle and applying all vehicle brakes as needed, reducing the vehicle's tendency to roll over. RSP focuses on reducing the vehicle’s speed below the critical roll threshold during direction-changing maneuvers such as driving on curved highway exit ramps or obstacle avoidance maneuvers on dry, high friction surfaces. See "Advanced ABS with Stability Control" on page 12 for further details.

⚠ WARNING

During an RSP system intervention, the vehicle **automatically decelerates.** RSP can slow the vehicle with or **without the operator applying the brake pedal**, and **even when the operator is applying the throttle.**

COMPONENTS

The Bendix EC-60 controller’s ABS function utilizes the following components:

- Bendix® WS-24™ wheel speed sensors (4 or 6, depending on configuration). Each sensor is installed with a Bendix Sensor Clamping Sleeve
- Bendix® M-32™ or M-32QR™ Pressure Modulator Valves (4, 5, or 6 depending on configuration)
- Dash-mounted tractor ABS Indicator Lamp
- Service brake relay valve
- Dash-mounted trailer ABS Indicator Lamp
- Optional blink code activation switch
- Optional ABS off-road switch

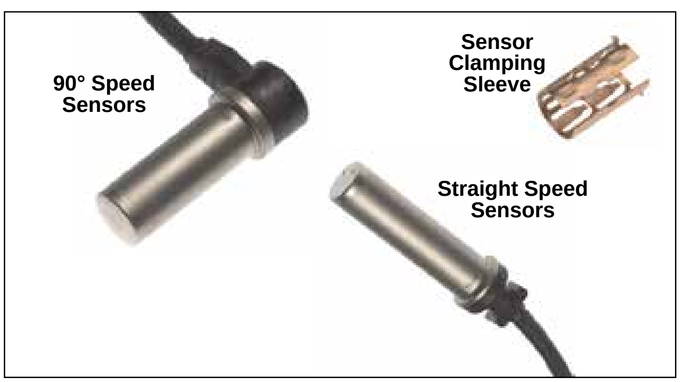


FIGURE 2 - ***BENDIX® WS-24™ WHEEL SPEED SENSORS***

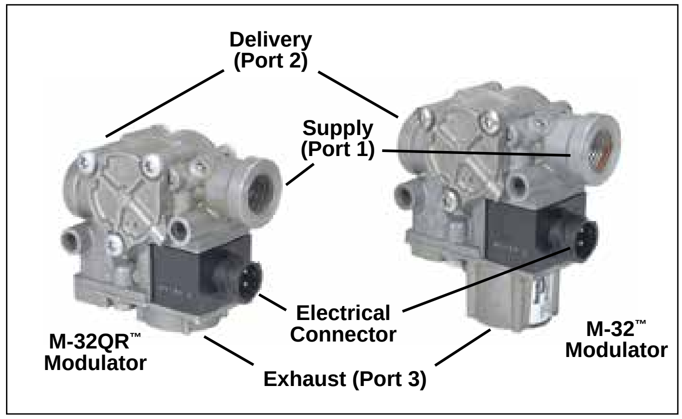


FIGURE 3 - ***M-32™ AND M-32QR™ MODULATORS***

The Bendix EC-60 controller ESP/RSP function utilizes the following additional components:

- Steer Axle Traction Control Valve (may be integral to the service brake relay valve or a stand-alone device)
- Dash-mounted ESP status/indicator lamp (also serves as the ATC status/indicator lamp)
- Bendix SAS-60™ Steering Angle Sensor (mounted to the steering column - *See Figure 4*)

  ⚠ **CAUTION**: When replacing a steering wheel, take care not to damage the Steering Angle Sensor or interfere with its operation, and the Steering Angle Sensor must be recalibrated *(see Troubleshooting section)*
- Bendix® YAS-60™ or YAS-70X™ Yaw Rate/Lateral Acceleration Sensors (typically mounted to a cross-member near the back of the vehicle cab)
- Brake Demand Sensors (installed in the primary and secondary delivery circuits)
- Load Sensor (typically installed in the suspension air bag)
- An additional Modulator Valve (Bendix® M-32™ or M-32QR™ Pressure Modulator Valve) that controls pressure apply to trailer brakes during system intervention

FIGURE 4 - ***STEERING ANGLE SENSORS***

The Bendix® EC-60™ controller ATC function utilizes the following additional components:

- Drive axle traction control valve (may be integral to the service brake relay valve or a stand-alone device)
- Dash-mounted ATC status/indicator lamp
- J1939 serial communication to engine control module
- Stop lamp switch input (may be provided using the ECU hardware input or J1939)
- Optional ATC mud/snow switch (sometimes referred to as an ATC off-road switch)

The EC-60 controller Hill Start Feature utilizes the following additional components:

- Bendix® AT-3™ Traction control valve
- Dash-mounted HSA Status/indicator lamp
- Dash-mounted enable/disable Switch
- Bendix® RV-3™ Pressure reducing valve
- Bendix® DC-4® Double check valve

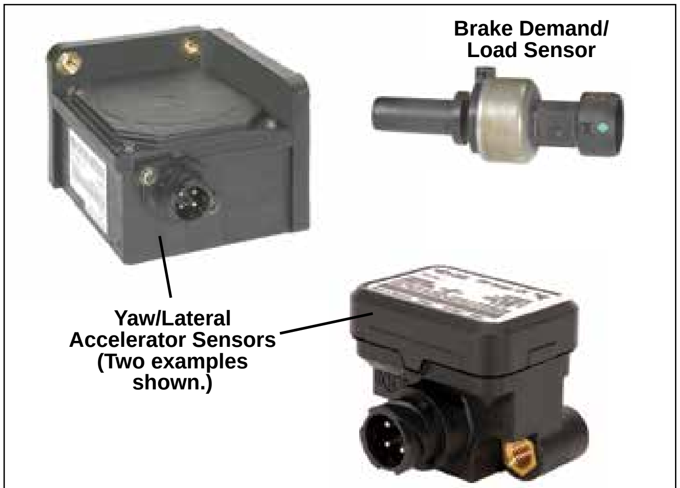


FIGURE 5 - ***YAW AND BRAKE DEMAND/LOAD SENSORS***

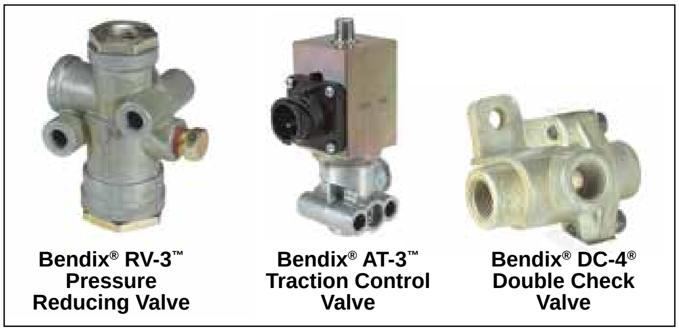


FIGURE 6 - ***ADDITIONAL VALVES NECESSARY FOR THE HILL START FEATURE***

BENDIX® ETRAC™ AUTOMATED AIR SUSPENSION TRANSFER SYSTEM

The Bendix® eTrac™ automated air pressure transfer system is used on 6 x 2 semi-tractors that feature Bendix® premium and advanced Antilock Brake Systems (ABS). This system complements the Bendix® Smart Automatic Traction Control (ATC™) feature of our ABS system to provide improved traction at low speeds (e.g. pulling away on an inclined ramp, or in slippery conditions such as mud or snow-covered surfaces, etc.) When active, the Bendix eTrac system vents — or "dumps" — the air pressure of the tag axle suspension air bags, and increases the air pressure in the drive axle suspension air bags to a pre-determined maximum. This action helps the drive axle to gain more traction.

See SD-13-21021 for more information.

ECU MOUNTING

The Bendix® EC-60™ advanced cab-mounted controller is not protected against moisture, and must be mounted in an environmentally protected area.

All wire harness connectors must be properly seated. The use of secondary locks is strongly recommended.

Cab ECUs utilize connectors from the AMP MCP 2.8 product family.

HARDWARE CONFIGURATIONS

Advanced Bendix® EC-60™ controllers support applications up to six sensor/six modulator (6S/6M) installations with ATC and drag torque control. They can support HSA functions. All 12 volt models support PLC. 24 volt models do not support PLC. *See Chart 1 for more details.*

ABS Off-Road	ATC	ATC Mud/Snow	Blink Codes	ESP/RSP	HSA	*Bendix® eTrac™ system**	Input Voltage	PLC	PMVs	Retarder Relay	Sensors	Serial Communication	
												J1587	J1939
✔	✔	Optional	✔	✔	Optional	Optional	12/24	✔	4/5/6	✔	4/6	✔	✔
****For information about the Bendix® eTrac™ automated air suspension transfer system, see SD-13-21021***													

CHART 1 - ***BENDIX® EC-60™ ADVANCED CONTROLLER FEATURES***

ADVANCED BENDIX EC-60 CONTROLLERS USE POWER LINE CARRIER (PLC)

All new towing vehicles built since March 1, 2001 have had an in-cab trailer ABS Indicator Lamp installed.

Trailers built since March 1, 2001 transmit the status of the trailer ABS over the power line (the blue wire of the J560 connector) to the tractor using a Power Line Carrier (PLC) signal. See Figures 7 and 8. Typically the signal is broadcast by the trailer ABS ECU.

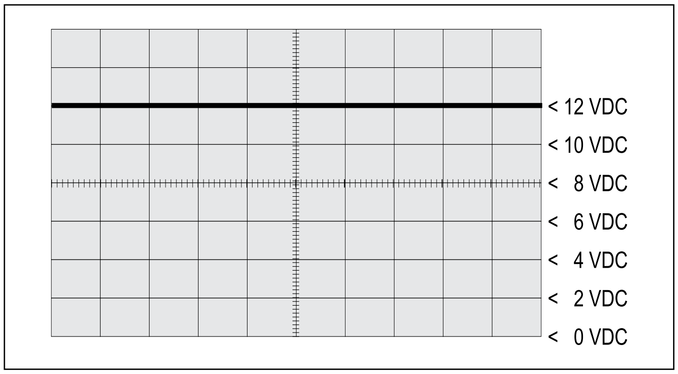


FIGURE 7 - ***POWER LINE WITHOUT PLC SIGNAL***

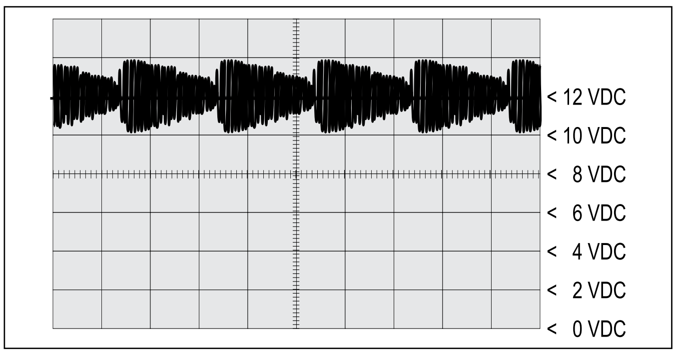


FIGURE 8 - ***POWER LINE WITH PLC SIGNAL***

The application of PLC technology for the heavy vehicle industry in North America is known as “PLC4Trucks.”

The Advanced Bendix EC-60 controller supports PLC communications in accordance with SAE J2497.

PLC SIGNAL

An oscilloscope can be used to measure or identify the presence of a PLC signal on the power line. The PLC signal is an amplitude and frequency modulated signal. Depending on the filtering and load on the power line, the PLC signal amplitude can range from 5.0mVp-p to 7.0 Vp-p. Suggested oscilloscope settings are AC coupling, 1 volt/div, 100 µsec/div. The signal should be measured at the ignition power input of the Bendix EC-60 controller.

Note: An ABS trailer equipped with PLC, or a PLC diagnostic tool, must be connected to the vehicle in order to generate a PLC signal on the power line.

BENDIX EC-60 CONTROLLER INPUTS

Battery and Ignition Inputs

The ECU operates at a nominal supply voltage of 12 or 24 volts, depending on the ECU. The battery input is connected through a 30 amp fuse directly to the battery.

The ignition input is applied by the ignition switch circuit through a 5 amp fuse.

Ground Input

The Bendix EC-60 controller supports one ground input. See page 48 for a system schematic.

ABS Indicator Lamp Ground Input

Advanced Bendix EC-60 cab ECUs require a second ground input (X1-12) for the ABS indicator lamp. The X1 wire harness connector contains an ABS indicator lamp interlock (X1-15), which shorts the ABS indicator lamp circuit (X1-18) to ground if the connector is removed from the ECU.

Bendix® WS-24™ Wheel Speed Sensors

Wheel speed data is provided to the Bendix EC-60 controller from the WS-24™ wheel speed sensor (see Figure 2). Vehicles have an exciter ring (or “tone ring”) as part of the wheel assembly, and as the wheel turns, the teeth of the exciter ring pass the wheel speed sensor, generating an AC signal. The Bendix EC-60 controller receives the AC signal, which varies in voltage and frequency as the wheel speed changes.

Vehicle axle configurations determine the number of WS-24™ wheel speed sensors that must be used. A vehicle with a single rear axle requires four wheel speed sensors. Vehicles with two rear axles can utilize six wheel speed sensors for optimal performance.

Diagnostic Blink Code Switch

A momentary switch that grounds the ABS Indicator Lamp output is used to place the ECU into the diagnostic blink code mode and is typically located on the vehicle’s dash panel.

Optional ABS Off-Road Switch and Indicator Lamp Operation

Advanced Bendix EC-60 controllers use an optional dash-mounted switch for the operator to place the ECU into the ABS off-road mode. See "Optional ABS Off-Road Mode" on page 10 for further details. In some cases, ECUs may also be put into the ABS off-road mode by one of the other vehicle control modules, using a J1939 message to the Bendix EC-60 controller.

(If you need to know if this Bendix EC-60 controller uses a J1939 message to operate the lamp, e-mail ABS@bendix.com, specifying the ECU part number, or call 1-800-AIR-BRAKE and speak to the Bendix TechTeam.)

⚠ **WARNING:** The ABS off-road mode should not be used on normal, paved road surfaces because vehicle stability and steerability may be adversely affected. When the ECU is placed in the ABS off-road mode, the ABS Indicator Lamp will flash constantly (at a rate of once per 2.5 seconds) to notify the vehicle operator that the off-road mode is active.

Optional ATC Mud/Snow (Off-Road) Switch and Indicator Lamp Operation (see also page 8.)

Advanced controllers use a dash-mounted switch for the operator to place the ECU into the ATC Mud/Snow mode.

Optional Hill Start Feature Switch and Indicator Lamp Operation (see also page 8.)

Advanced controllers use a dash-mounted switch for the operator to place the ECU into the Hill Start Assist (HSA) mode. HSA interfaces between the transmission and braking system to help the driver prevent the vehicle from rolling downhill when moving up a steep incline from a stationary position.

⚠ **WARNING:** With HSA option you lose the ABS off-road function and the retarder relay output.

When the ECU is placed in the HSA off-road mode, the HSA Indicator Lamp will flash constantly (at a rate of once per 2.5 seconds) to notify the vehicle operator that the HSA mode is active. The ECU receives J1939 messages from the transmission to engage the HSA components. When engaged, the HSA system applies 44 psi to the rear brakes for three (3) seconds then releases. This function is totally controlled by the automatic transmission.

Stop Lamp Switch (SLS)

The Advanced Bendix EC-60 controller monitors the vehicle stop lamp status. Certain vehicle functions, such as ATC and All-Wheel Drive (AWD), use the status of the stop lamp to determine when the driver makes a brake application. This can be provided to the ECU via J1939 communications, or hardware input.

Brake Demand Sensors

The brake demand sensors provide the controller with an indication of driver-applied brake pressure. One is installed in the primary air brake circuit, and another is installed in the secondary air brake circuit.

Load Sensor

The load sensor provides the controller with an indication of the vehicle load. It is typically installed in one of the suspension air bags.

Bendix® SAS-60™ Steering Angle Sensor

The Steering Angle Sensor (SAS) is used to provide driver steering input to the controller. It reports the steering wheel position to the controller utilizing a dedicated serial communications link that is shared with the Yaw Rate sensor. The controller supplies the power and ground inputs to the Bendix SAS-60 sensor.

The Bendix SAS-60 sensor is available with two different styles of wire harness connectors. (See Figure 4.)

Bendix® YAS-60™ or YAS-70X™ Yaw Rate/Lateral Acceleration Sensors

Bendix yaw rate/lateral acceleration sensors are used to provide the controller an indication of vehicle lateral acceleration and rotation around the vertical axis. This information is provided to the controller utilizing a dedicated serial communications link that is shared with the Bendix SAS-60 sensor. The controller supplies the power and ground inputs to the yaw rate sensor.

BENDIX® EC-60™ CONTROLLER OUTPUTS

Bendix® M-32™ and M-32QR™ Pressure Modulator Valves (PMV)

The Bendix M-32 and M-32QR pressure modulator valves (PMV) are operated by the Bendix EC-60 controller to modify driver applied air pressure to the service brakes during ABS, ATC, RSP or YC activation (See page 3). The PMV is an electropneumatic control valve and is the last valve that air passes through on its way to the brake chamber. The modulator hold and release solenoids are activated to "modulate" or "control" the brake pressure during an antilock braking event. The hold solenoid is normally open and the release solenoid is normally closed, such that the PMV nominally allows air to flow through. This design allows for air delivery to brake chambers in the event of electrical trouble.

The Advanced Bendix EC-60 controller also utilizes an additional PMV for control of the trailer service brakes during stability interventions.

Traction Control Valve (TCV)

Advanced Bendix EC-60 controllers use two TCVs, one on the steer axle and one on the drive axle. The TCV may be a separate valve or integrated into the rear axle relay valve.

The controller will activate the drive axle TCV during differential braking ATC events.

During stability interventions, the ECU will activate both the steer axle and drive axle TCVs as required.

Stop Lamp Output

The controller provides an output to control a relay that illuminates the vehicle stop lamps during stability interventions. This information is also available using the J1939 serial communications link.

ABS Indicator Lamp Control with Optional Diagnostic Blink Code Switch

The Advanced Bendix EC-60 controller has internal circuitry to control the ABS Indicator Lamp on the dash panel.

The ABS Lamp Illuminates:

1. During power up (e.g. when the vehicle is started) for approximately 3 seconds and turns off after the self test is completed, providing no **Diagnostic Trouble Codes (DTCs)** are present on the ECU.
2. When full ABS operation is not available due to presence of a DTC on the ECU.
3. If the ECU is unplugged or has no power.
4. When the ECU is placed into the ABS off-road mode (the lamp flashes steadily at a rate of once per 2.5 sec.).
5. To display blink codes for diagnostic purposes after the external diagnostic switch is activated.

The Bendix EC-60 controller may communicate with other vehicle control modules to operate the ABS Indicator Lamp using serial communications. (If you need to know if this Bendix® EC-60™ controller uses serial communications to operate the lamp, e-mail ABS@bendix.com, specifying the ECU part number, or call 1-800-AIR-BRAKE and speak to the Bendix Tech Team.)

Indicator Lamp Control Using Serial Communications Links

As mentioned above, depending on the vehicle manufacturer, the dash indicator lamps (ABS, ATC, ESP and trailer ABS) may be controlled using serial communications links. In these cases, the EC-60™ controller will send a serial communications message over the J1939 or J1587 links indicating the required status of the lamp(s). Another vehicle control module receives the message and controls the indicator lamp(s).

Dynamometer Mode Indicator Lamp Operation

When the Bendix® EC-60™ controller is put into the Dynamometer mode for testing purposes, the ATC Indicator Lamp will be illuminated.

Retarder Relay Disable Output

The retarder relay disable output may be used to control a retarder disable relay. When configured to use this output, the ECU will energize the retarder disable relay and inhibit the use of the retarder as needed.

If the ECU is configured for Hill Start Assist (HSA), the retarder relay output pin is used to control the HSA status lamp. The vehicle loses the retarder relay function.

SAE J1939 Serial Communications

A Controller Area Network (CAN) data link (SAE J1939) is provided for communication. This link is used for various functions, such as:

- To disable retarding devices during ABS operation.
- To request that the torque converter disable lock-up during ABS operation
- To share information such as wheel speed and ECU status with other vehicle control modules.

Advanced Bendix EC-60 controllers utilize the J1939 data link for:

- ATC and drag torque control functions.
- Vehicle stability functions.

Trailer ABS Indicator Lamp Control

The Advanced Bendix EC-60 controller will activate a trailer ABS Indicator Lamp (located on the dash panel) that indicates the status of the trailer ABS unit on one, or more trailers, or dollies that are equipped with PLC functionality. Typically, the Bendix EC-60 controller directly controls the trailer ABS Indicator Lamp based on the information it receives from the trailer ABS, via PLC.

Alternatively, some vehicles require the Bendix EC-60 controller to activate the trailer ABS Indicator Lamp by communicating with other vehicle controllers using serial communications.

(If you need to know if this Bendix EC-60 controller uses a serial communications message to operate the lamp, e-mail ABS@bendix.com, specifying the ECU part number, or call 1-800-AIR-BRAKE and speak to the Bendix TechTeam.)

SAE J1708/J1587 Serial Communications

An SAE J1708 data link, implemented according to SAE J1587 recommended practice, is available for diagnostic purposes, as well as ECU status messages.

Interaxle Differential Lock Control (AWD Transfer Case)

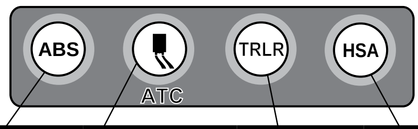
Advanced ECUs can control the interaxle differential lock (AWD transfer case). This is recommended on AWD vehicles, but the ECU must be specially configured to provide this feature. E-mail ABS@bendix.com for more details.

INDICATOR LAMPS AND POWER-UP SEQUENCE

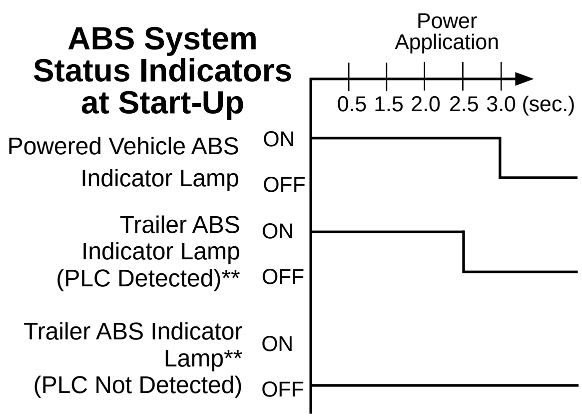
NOTICE: The vehicle operator should verify proper operation of all installed indicator lamps (ABS, ATC/ESP, and trailer ABS) when applying ignition power and during vehicle operation. *See Chart 2.*

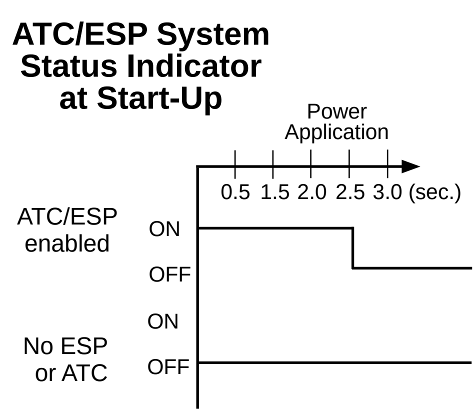
Lamps that do not illuminate as expected when ignition power is applied, or remain illuminated, indicate the need for maintenance.

Dash Lamps



	Mode		ABS Lamp	ATC/ESP Lamp	Trailer ABS Lamp	HSA Lamp	Comments
At Vehicle Start Up	**Ignition on** - start up (trailer with PLC)		On for 3 seconds*	On for 2.5 seconds*	On for 3 seconds**	On for 3 seconds	***If any of the described lamp behaviors do not occur — or if the lamp remains on during operation — have the vehicle serviced by a qualified mechanic as soon as possible to restore full system functionality.
At Vehicle Start Up	**3 seconds after ignition** (with no Diagnostic Trouble Codes)		Lamp Off*	Lamp Off*	Lamp Off*	Lamp Off*	
Special Mode Operation	**ABS Off-Road Mode**	Normal	Lamp flashes slowly (every 2.5 seconds)	Lamp OFF			• Uses dash switch • Not for firm road surfaces • Allows more wheel lock-up (less ABS intervention) • Mode only applies under 25 mph (Over 25 mph, the system reverts to full ABS — including ATC/ESP — and lamp goes off.)
Special Mode Operation	**ABS Off-Road Mode**	During an ATC Event	Lamp flashes slowly (every 2.5 seconds)	Flashes quickly			
Special Mode Operation	**Vehicles with the Hill Start Feature** **("Hill Start Assist")**			During HSA Event		Lamp OFF	Lamp remains ON if HSA DTC is present
Special Mode Operation	**Vehicles with the Hill Start Feature** **("Hill Start Assist")**			HSA Manually Disabled		Flashes slowly	
Special Mode Operation	Deep Mud/ Snow/ Mode	Normal	Off	Flashes slowly (every 2.5 seconds)			• Uses dash switch • Increases allowable wheel slip during ATC interventions • Not for firm road surfaces
Special Mode Operation	Deep Mud/ Snow/ Mode	During an ATC/ ESP Event	Off	Flashes quickly			
	During an Automatic Traction Control (ATC) Event			Flashes quickly			• Reduces wheel slip during acceleration at low speeds
	During Dynamometer Mode			Lamp ON (ATC Disabled)			• Disables ATC monitoring functions • When not in Dynamometer Mode, an illuminated lamp indicates an ATC trouble code is present
	During an ESP Event			Flashes quickly			• System intervenes to reduce the risk of rollovers, loss-of-control, etc.





*Some vehicle manufacturers may illuminate the trailer ABS indicator lamp at power-up regardless of whether a PLC signal is detected from the trailer or not. Consult the vehicle manufacturer's documentation for more details.

CHART 2 - *BENDIX® EC-60™ INDICATOR LAMP BEHAVIOR*

ABS Indicator Lamp Operation (Bulb Check)

The ECU will illuminate the ABS Indicator Lamp for approximately three seconds when ignition power is applied, after which the lamp will extinguish if no diagnostic trouble codes are detected.

The ECU will illuminate the ABS Indicator Lamp whenever full ABS operation is not available due to a diagnostic trouble code. In most cases, partial ABS is still available.

ATC/ESP Status/Indicator Lamp Operation

The ECU will illuminate the ATC/ESP lamp for approximately 2.5 seconds when ignition power is applied, after which the lamp will extinguish, if no diagnostic trouble codes are detected. The ECU will continuously illuminate the ATC/ESP Indicator Lamp whenever ESP or ATC is disabled due to a diagnostic trouble code.

During an ESP or ATC intervention, the lamp will flash rapidly (2.5 times per second). When the ECU is placed in the ATC Mud/Snow (off-road) mode, the lamp will flash slowly at a rate of once every 2.5 seconds.

Trailer ABS Indicator Lamp Operation

The ECU will control the Trailer ABS Indicator Lamp when a PLC signal (SAE J2497) from a trailer ABS ECU is detected.

Hill Start Assist (HSA) Indicator Lamp Operation

Vehicles with HSA enabled, will illuminate the HSA Indicator Lamp when ignition power is applied, after which the lamp will extinguish if there are no issues with the HSA system.

ECU Configuration Test

Within two seconds of the application of ignition power, the ECU will perform a test to detect system configuration with regards to the number of wheel speed sensors and PMVs. This can be audibly detected by a rapid cycling of the PMVs.

(Note: The ECU will not perform the configuration test when wheel speed sensors show that the vehicle is in motion.)

Pressure Modulator Valve and Traction Control Valve Chuff Test

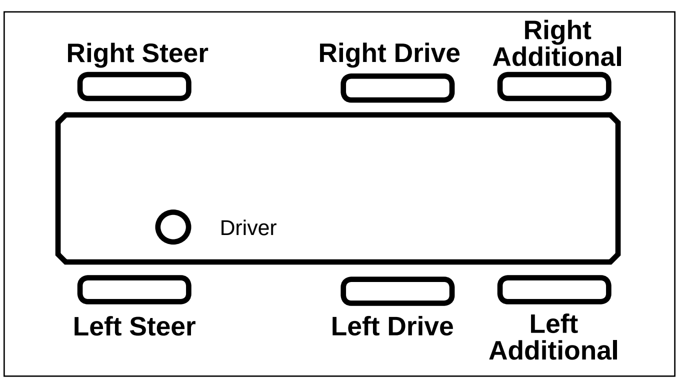


FIGURE 9 - ***VEHICLE ORIENTATION (TYPICAL)***

After the performance of the configuration test, the Bendix® EC-60™ controller will perform a Bendix-patented PMV and TCV Chuff Test. The Chuff Test is an electrical and pneumatic PMV test that can assist maintenance personnel in verifying proper PMV wiring and installation.

When ignition power is applied, each modulator solenoid is briefly energized. If the air system is fully charged and the service brake pedal is depressed during ignition, the modulator creates a single, sharp audible "chuff" of air pressure. The modulators are energized in a certain pattern, as follows: right front, left front, right rear, left rear.

This test is performed only when the vehicle is stationary (if the vehicle moves the chuff test will not be performed).

The Bendix EC-60 controller will perform a PMV chuff test on all installed modulators in the following order:

- Steer Axle Right PMV
- Steer Axle Left PMV
- Drive Axle Right PMV
- Drive Axle Left PMV
- Additional Axle Right PMV
- Additional Axle Left PMV
- Drive Axle TCV

The pattern will then repeat itself.

If equipped with a Bendix EC-60 advanced controller, following the completion of the second round of PMV & TCV chuff tests, the controller (if configured to do so) will perform a test to cross-check the trailer PMV operation with the vehicle stop lamps. If the trailer PMV circuit is mis-wired (including the steer axle TCV), the PMV will exhaust a large amount of air, or none at all.

NOTICE: If there are any active Diagnostic Trouble Codes, the stop lamp cross-check portion of the chuff test will not be carried out until all DTCs are fully diagnosed and corresponding repairs are successfully conducted. The ESP/ATC dash indicator will also be illuminated when there are active ABS, ATC or ESP DTCs.

The ECU will not perform the PMV Chuff Test when wheel speed sensors show that the vehicle is in motion.

ABS OPERATION

Bendix® ABS uses wheel speed sensors, ABS pressure modulator valves, and an ECU to control either four or six wheels of a vehicle. The Bendix EC-60 controller monitors individual wheel turning motion during braking and adjusts or modulates the brake pressure at the wheel end. When excessive wheel slip, or wheel lock-up is detected, the Bendix EC-60 controller will activate the pressure modulator valves to automatically reduce the brake pressure at one or more of the wheel ends. By these actions, the ABS system helps to maintain the vehicle's lateral stability and steerability during heavy brake applications and during braking on slippery surfaces.

Steer Axle Control

Although both wheels of the steer axle have their own wheel speed sensor and pressure modulator valve, the Bendix EC-60 controller blends the applied braking force between the two steering axle brakes. This Bendix patented brake application control, called Modified Individual Regulation (MIR), is designed to help reduce steering wheel pull during an ABS event on road surfaces with poor traction (or areas of poor traction, e.g. asphalt road surfaces with patches of ice).

Single Drive Axle Control (4x2 Vehicle)

For vehicles with a single rear drive axle (4x2), the brakes are operated independently by the Bendix EC-60 controller, based on the individual wheel behavior.

Dual Drive Axle Control (4S/4M Configuration)

For vehicles with dual drive axles (6x4) using a 4S/4M configuration, one ABS modulator controls both right-side rear wheels and the other modulator controls both left-side rear wheels. Both wheels on each side receive equal brake pressure during an ABS stop. The rear wheel speed sensors must be installed on the axle with the lightest load.

Dual Rear Axle Control (6S/6M Configuration)

For vehicles with dual rear axles (6x4, 6x2) using a 6S/6M configuration, the rear wheels are controlled independently. Therefore, brake application pressure at each wheel is adjusted according to the individual wheel behavior on the road surface.

6x2 Vehicles with 6S/5M Configuration

6x2 vehicles can utilize a 6S/5M configuration, with the additional axle (a non-driven rear axle) having two sensors, but only one Pressure Modulator Valve. In this case, the PMV controls both wheels on the additional axle. The additional axle wheels would receive equal brake pressure, based on the wheel that is currently experiencing the most wheel slip.

Normal Braking

During normal braking, brake pressure is delivered through the ABS PMV and into the brake chamber. If the ECU does not detect excessive wheel slip, it will not activate ABS control, and normal vehicle service braking is applied.

Retarder Brake System Control

On surfaces with low traction, application of the retarder can lead to high levels of wheel slip at the drive axle wheels, which can adversely affect vehicle stability.

To prevent this, the Bendix® EC-60™ controller switches off the retarder as soon as a lock-up is detected at one (or more) of the drive axle wheels.

When the ECU is placed in the ABS off-road mode (on vehicles equipped with this optional feature), it will switch off the retarder only when ABS is active on a steer axle wheel and a drive axle wheel.

Optional ABS Off-Road Mode

On some road conditions, particularly when the driving surface is soft, the stopping distance with conventional ABS may be longer than without ABS. This can occur when a locked wheel on soft ground or loose gravel plows up the road surface in front of the tire, changing the rolling friction value. Although vehicle stopping distance with a locked wheel (in the absence of ABS) may be shorter than corresponding stopping distance with conventional ABS control, vehicle steerability and stability would be reduced.

Advanced Bendix EC-60 controllers have an optional dash switch that initiates a modified ABS control mode (know as "off-road ABS") that more effectively accommodates these soft road conditions to shorten stopping distance while maintaining optimal vehicle steerability and stability.

Note: Off-road mode is not available if the vehicle is equipped with Hill Start Assist (HSA).

⚠ WARNING: The ABS off-road mode should not be used on normal, paved road surfaces because vehicle stability and steerability may be reduced. The ABS Indicator Lamp will flash slowly to indicate to the driver that the ABS off-road mode is engaged.

⚠ CAUTION: When ABS off-road mode is engaged, stability functions are disabled at speeds below approximately 25 mph. The ATC/ESP dash lamp will illuminate to indicate to the driver that the stability system is disabled.

The vehicle manufacturer should provide the optional ABS off-road function only for vehicles that operate on unpaved surfaces or that are used in off-road applications, and is responsible for ensuring that vehicles equipped with the ABS off-road function meet all FMVSS-121 requirements and have adequate operator indicators and instructions.

The vehicle operator activates the off-road function with a switch on the dash panel. A flashing ABS Indicator Lamp indicates to the driver that the ABS off-road function is engaged. To exit the ABS off-road mode, depress and release the switch. A new ignition cycle will also cause the ECU to exit the ABS off-road mode.

All-Wheel Drive (AWD) Vehicles

AWD vehicles with an engaged interaxle differential (steer axle to rear axle)/AWD transfer case may have negative effects on ABS performance. Optimum ABS performance is achieved when the lockable differentials are disengaged, allowing individual wheel control.

Advanced Bendix EC-60 controllers can be programmed specifically for this configuration to control the differential lock/unlock solenoid in the AWD transfer case. When programmed to do so, the ECU will disengage the locked interaxle/AWD transfer case during an ABS event and reengage it once the ABS event has ended.

ATC OPERATION

ATC Functional Overview

Just as ABS improves vehicle stability during braking, ATC improves vehicle stability and traction during vehicle acceleration. The Bendix EC-60 controller ATC function uses the same wheel speed information and modulator control as the ABS function. The Bendix EC-60 controller detects excessive drive wheel speed, compares the speed to the front, non-driven wheels, and reacts to help bring the wheel spin under control. The controller can be configured to use engine torque limiting and/or differential braking to control wheel spin. For optimal ATC performance, both methods are recommended.

ATC/ESP Lamp Output/ATC Mud/Snow Switch Input

Advanced ECUs control the ATC/ESP dash lamp as follows.

The ATC/ESP dash lamp illuminates:

1. During power up (e.g. when the vehicle is started) for approximately 2.5 seconds and turns off after the self test is completed, providing no diagnostic trouble codes are present.
2. When ESP or ATC is disabled for any reason.
3. During an ESP or ATC event (the lamp will flash rapidly at a rate of 2.5 times per second).
4. When the ECU is placed in the ATC off-road mode (the lamp will flash steadily at a rate of once per 2.5 seconds). This notifies the vehicle operator that the ATC Mud/Snow mode is active.
5. When the ECU is placed in the ABS off-road mode. When in this mode, ESP will be disabled below 25 mph and its inactive status will be indicated by a steadily illuminated ATC/ESP lamp.

Differential Braking

Differential braking within ATC is automatically activated when drive wheel(s) on one side of the vehicle are spinning excessively, which typically occurs on road surfaces with patches of ice. The traction system will then lightly apply the brake to the drive wheel(s) that are spinning excessively. The vehicle differential will then drive the wheels on the other side of the vehicle.

Differential braking (as part of ATC functionality) is available at vehicle speeds up to 25 MPH.

Disabling ATC Differential Braking

ATC differential braking is disabled under the following conditions:

1. During power up (e.g. when the vehicle is started), until the ECU detects a service brake application.
2. If the ECU receives a J1939 message indicating that the vehicle is parked.
3. When the dynamometer test mode is active. The dynamometer test mode is entered using the diagnostic blink code switch or by using a diagnostic tool (such as Bendix® ACom® Diagnostics).
4. In response to a serial communications request from a diagnostic tool.
5. If ATC Differential Braking function is activated for a long time period to avoid overheating of the brakes. It would take approximately 3 continuous minutes of activation for the timeout to occur. Once timed out, approixmately 2 minutes of "cool off" time would be required before ATC Differential Braking can be used again.
6. When certain diagnostic trouble code conditions are detected.

Engine Torque Limiting with Smart ATC™ Traction Control

The Bendix EC-60 controller uses Engine Torque Limiting to control drive axle wheel slip. This is communicated to the engine control module (using J1939), and is available at all vehicle speeds.

Bendix® Smart ATC™ Traction Control

The Bendix EC-60 controller has an additional feature known as Smart ATC™ traction control. Smart ATC™ traction control monitors the accelerator pedal position (using J1939) to help provide optimum traction and vehicle stability. By determining the driver's throttle input and adapting the target slip of the drive wheels to the driving situation, the Smart ATC™ traction control allows higher wheel slip when the accelerator pedal is applied above a preset level.

The wheel slip allowed by Smart ATC™ is decreased when driving through a curve for improved stability.

Disabling ATC Engine Control and Smart ATC™ Traction Control

ATC Engine Control and Smart ATC™ traction control will be disabled under the following conditions:

1. In response to a serial communications request from an off-board tool.
2. At power-up until the ECU detects a service brake application.
3. If the ECU receives a J1939 message indicating that the vehicle is parked.
4. If the dynamometer test mode is active. This may be accomplished via an off-board tool or the diagnostic blink code switch.
5. When certain diagnostic trouble code conditions are detected.

Optional ATC Mud/Snow (Off-Road) Mode

In some road conditions, the vehicle operator may desire additional drive wheel slip when ATC is active. The Advanced Bendix EC-60 controller has an optional control mode to permit this desired performance.

The vehicle operator can activate the Mud/Snow function with a switch on the dash panel. Alternately, a J1939 message may be used to place the vehicle in this mode. The ATC/ESP Indicator Lamp will flash steadily at a rate of once every 2.5 seconds to confirm that the ATC mud/snow mode is engaged.

To exit the ATC Mud/Snow mode, depress and release the ATC Mud/Snow switch.

Drag Torque Control Functional Overview

Advanced Bendix® EC-60™ controllers have a feature referred to as drag torque control which reduces wheel slip on a driven axle due to driveline inertia. This condition is addressed by increasing the engine torque to overcome the inertia.

Drag torque control increases vehicle stability on low-traction road surfaces during down-shifting or retarder braking.

ADVANCED ABS WITH STABILITY CONTROL

Overview

ESP stability system reduces the risk of rollovers, jackknifing and other loss-of-control events. ESP features include Roll Stability Program (RSP) and Yaw Control. During operation, the ECU of the Bendix Advanced ABS system constantly compares performance models to the vehicle's actual movement, using the wheel speed sensors of the ABS system, as well as lateral, yaw, and steering angle sensors. If the vehicle shows a tendency to leave an appropriate travel path, or if critical threshold values are approached, the system will intervene to assist the driver.

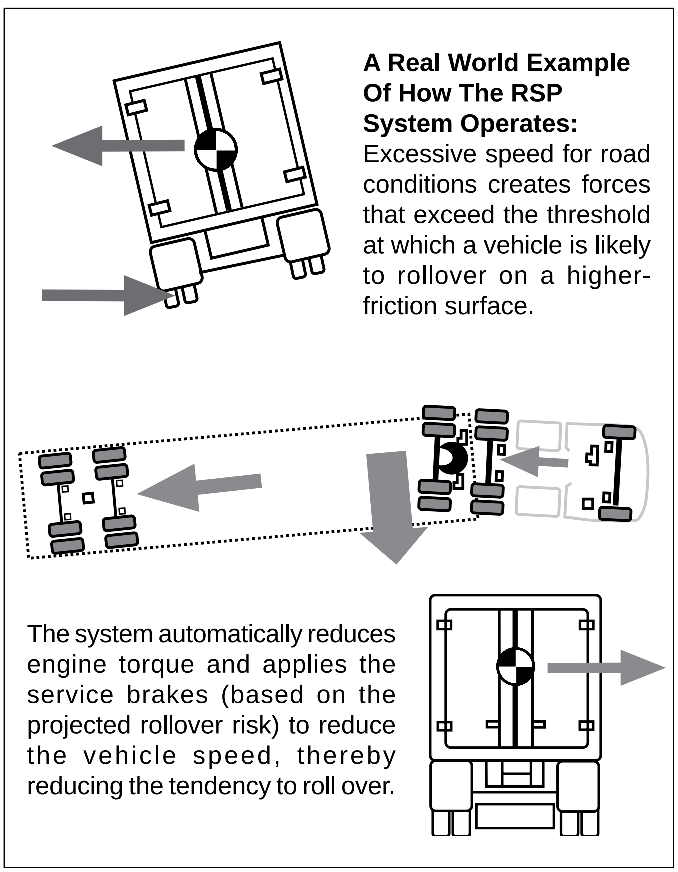


FIGURE 11 - *RSP EXAMPLE*

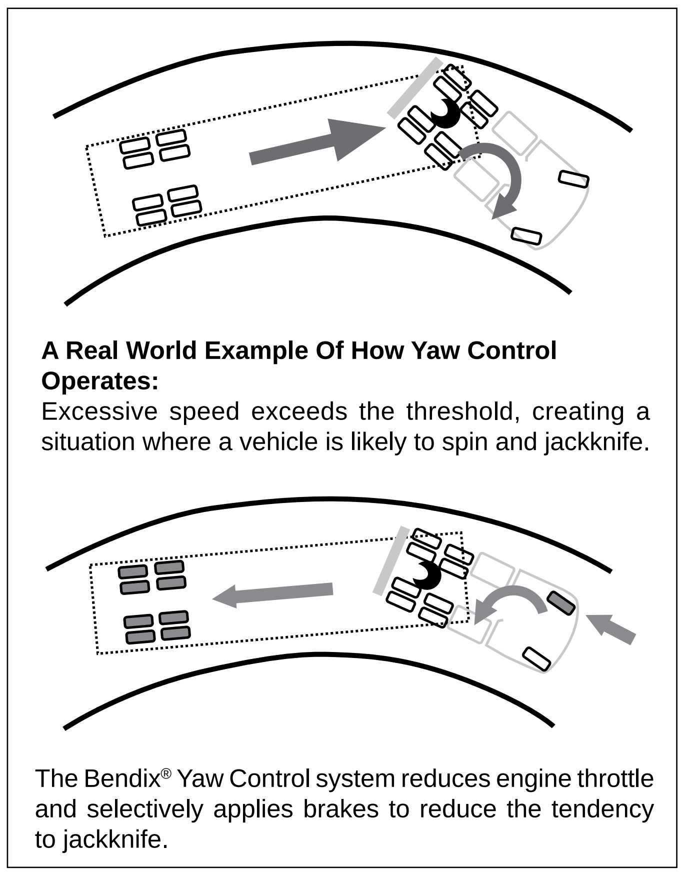


FIGURE 12 - *YAW CONTROL EXAMPLE*

Roll Stability Program

Bendix RSP, an element of the overall ESP system, addresses rollover conditions. In the case of a potential roll event, the ECU will override the throttle and quickly apply brake pressure at all wheel ends to slow the vehicle combination. The level of braking application during an RSP event will be proportional to roll risk. *See Figure 11*.

Yaw Stability

Yaw stability counteracts the tendency of a vehicle to spin about its vertical axis. During operation, if the friction between the road surface and the tires is not sufficient to oppose lateral (side) forces, one or more of the tires can slide, causing the truck/tractor to spin. These events are referred to as either an "under-steer" situation (where there is a lack of vehicle response to steering input due to tire slide on the steer axle) or an "over-steer" (where the tractor's rear end slides out due to tire slide on the rear axle) situation. Generally, shorter wheelbase vehicles (tractors, for instance) have less natural yaw stability, while longer wheelbase vehicles (straight trucks, for instance) have greater natural yaw stability. Factors that influence yaw stability are: wheelbase, suspension, steering geometry, weight distribution front to rear, and vehicle track width.

Yaw Control

Yaw Control responds to a wide range of low- to high-friction surface scenarios including rollover, jackknife and loss-of-control. It is the recommended system for all power vehicles and especially critical for tractors pulling trailers. In the case of vehicle slide (over-steer or under-steer situations), the system will reduce the throttle and then brake one or more of the “four corners” of the vehicle (in addition to potentially applying the trailer brakes), thus applying a counter-force to better align the vehicle with an appropriate path of travel.

For example, in an over-steer situation, the system applies the “outside” front brake; while in an under-steer condition, the “inside” rear brake is applied. (See Figure 12)

IMPORTANT SAFETY INFORMATION ABOUT THE BENDIX® ESP® STABILITY SYSTEM

ESP May Reduce The Vehicle Speed Automatically

ESP can make the vehicle **decelerate automatically.** ESP can slow the vehicle with or **without the operator applying the brake,** and **even when the throttle is being applied.**

⚠ CAUTION

To minimize unexpected deceleration and reduce the risk of a collision the operator must:

- Avoid aggressive driving maneuvers, such as sharp turns or abrupt lane changes at high speeds, which might trigger the stability system.
- Always operate the vehicle safely, drive defensively, anticipate obstacles and pay attention to road, weather and traffic conditions. ABS, ATC and ESP stability systems are no substitute for prudent, careful driving.

Towing Doubles Or Triples May Reduce The Effectiveness Of Stability Systems

ESP is designed and optimized for trucks and for tractors that tow single trailers. If a tractor equipped with ESP is used to power multiple trailer combinations (known as “doubles” or “triples”) **the effectiveness of the ESP system may be greatly reduced.** Extremely careful driving is always required when towing doubles or triples. Excessive speed and aggressive maneuvers, such as sharp turns, sudden steering inputs or abrupt lane changes should be avoided.

Limitations Of Stability Systems

The ESP stability system’s effectiveness may be greatly reduced if:

- The load shifts due to improper retention, accident damage or the inherently mobile nature of some loads (for example, hanging meat, live animals or partially laden tankers),
- The vehicle has an unusually high or off-set center of gravity (CG),
- One side of the vehicle drops off the pavement at an angle that is too large to be counteracted by a reduction in speed,
- The vehicle is used to haul double or triple trailer combinations,
- If very rapidly winding steering inputs are inputted at high speeds,
- There are mechanical problems with suspension leveling of the tractor or trailer resulting in uneven loads,
- The vehicle is maneuvering on a high banked road creating either additional side forces due to the weight (mass) of the vehicle or a deviation between expected & actual yaw rates,
- Gusty winds are strong enough to cause significant side forces on the vehicle and any towed vehicles.

To Maximize The Effectiveness Of ESP:

- Loads must be properly secured at all times.
- Drivers need to exercise extreme caution at all times, and avoid sharp turns, sudden steering inputs or abrupt lane changes at high speeds, particularly if:
  - › the vehicle hauls loads that could shift,
  - › the vehicle or load has a high or off-set center of gravity (CG) when loaded, or
  - › the vehicle tows doubles or triples.

Truck Chassis Modifications

If the vehicle's chassis components are altered (for example, a wheel base extension or reduction, tag axle addition or removal, a major body change such as conversion of a tractor into a truck, or an axle, suspension, or steering system component modification) the Bendix® ESP® system must be disabled. Have a qualified mechanic replace the Advanced EC-60 ECU with a Premium EC-60 ECU and secure the X4 connector which will no longer be used. The ATC/ESP indicator lamp would continue to function as an ATC indicator lamp, and should be designated as ATC only.

WARNING: If a modified vehicle does not have the ESP system disabled, serious vehicle braking and performance issues could result, including unnecessary ESP system interventions. This can lead to a loss-of-control of the vehicle. In addition, remove all cab signage (e.g. visor labels, etc.) used to show that Bendix ESP was installed and make any necessary notations in the vehicle manual(s), so that drivers do not misunderstand which ABS options are installed on the vehicle.

Sensor Location Modifications

The location and orientation of the Steering Angle Sensor and Yaw Rate Sensor must not be altered. When servicing, an identical component must be used in the same orientation (using OEM brackets & torque requirements). During installation follow the OEM leveling guidelines.

Steering Angle Sensor Re-Calibration

Whenever maintenance or repair work is performed to the steering mechanism, linkage, steering gear, adjustment of the wheel track, or if the steering angle sensor is replaced, a recalibration of the Steering Angle Sensor must be performed.

WARNING! If the Steering Angle Sensor is not recalibrated, the yaw control system may not function properly, which can result in incidents leading to loss of vehicle control. See page 19 of this document for more details on this procedure.

DYNAMOMETER TEST MODE

CAUTION: ATC and ESP must be disabled prior to conducting any dynamometer testing. When the Dynamometer Test Mode is engaged, ATC brake control and engine control along with drag torque control and ESP are turned off. This test mode is used to avoid torque reduction or torque increase and brake control activation when the vehicle is operated on a dynamometer for testing purposes.

The Dynamometer Test Mode may be activated by pressing and releasing the diagnostic blink code switch five times or by using a hand-held or PC-based diagnostic tool.

During Dynamometer Test Mode the ATC lamp remains ON.

Advanced Bendix® EC-60™ Contollers will remain engaged in the Dynamometer Test Mode even if power to the ECU is removed and re-applied. To exit the test mode, press and release the blink code switch three times, or use a hand-held or PC-based diagnostic tool.

AUTOMATIC TIRE SIZE CALIBRATION

The ECU requires a precise rolling circumference ratio between steer axle and drive axle tires in order for ABS, ATC, and ESP to perform in an optimal manner. For this reason, a continuously monitoring process takes place in which the precise ratio is calculated. This calculated value is stored in the ECU memory provided the following conditions are met:

1. Rolling-circumference ratio is within the permissible range.
2. Vehicle speed is greater than approximately 12 MPH.
3. No acceleration or deceleration is taking place.
4. There are no active speed sensor diagnostic trouble codes.

The ECU is provided with a ratio value of 1.00 as a default setting. If the automatic tire size alignment calculates a different value, this is used to overwrite the original figure in the memory. This process adapts the ABS and ATC function to the vehicle.

Acceptable Tire Sizes

The speed calculation for an exciter ring with 100 teeth is based on a default tire size of 510 revolutions per mile. This figure is based on the actual rolling circumference of the tires, which varies with tire size, tire wear, tire pressure, vehicle loading, etc.

The ABS response sensitivity is reduced when the actual rolling circumference is excessive on all wheels. For a 100 tooth exciter ring, the minimum number of tire revolutions per mile is 426, and the maximum is 567. The ECU will set diagnostic trouble codes if the number of revolutions is out of this range.

In addition, the size of the steer axle tires compared to the drive axle tires also has to be within the ABS system design. To avoid diagnostic trouble codes, the ratio of the effective rolling circumference of the steer axle, divided by the effective rolling circumference of the drive axle, must be between 0.85 to 1.15.

⚠ **CAUTION: The ESP system effectiveness relies on the accuracy of vehicle speed. If a major change on the tire sizes occurs such that the odometer setting needs to be changed, the Advanced ABS controller's setting of tire sizes must be reprogrammed to new values at the same time by a certified mechanic.**

SYSTEM IMPACT DURING ACTIVE TROUBLE CODES

ABS PARTIAL SHUTDOWN

Depending on which component the trouble code is detected, the ABS, ATC, and ESP functions may be fully or partially disabled. Even with the ABS indicator lamp illuminated, the Bendix EC-60 controller may still provide ABS function on wheels that are not affected. The ABS system controller should be serviced as soon as possible.

Steer Axle ABS Modulator Diagnostic Trouble Code

ABS on the affected wheel is disabled. ABS and ATC on all other wheels remains active. ESP is disabled.

Drive Axle/Additional Axle ABS Modulator Diagnostic Trouble Code

ATC is disabled. ABS on the affected wheel is disabled. ABS on all other wheels remains active. ESP is disabled.

Steer Axle Wheel Speed Sensor Diagnostic Trouble Code

The wheel with the diagnostic trouble code is still controlled by using input from the remaining wheel speed sensor on the steer axle. ABS remains active on the rear wheels. ATC and ESP are disabled.

Drive Axle/Additional Axle Wheel Speed Sensor Diagnostic Trouble Code

ATC and ESP are disabled. In a four sensor system, ABS on the affected wheel is disabled, but ABS on all other wheels remains active.

In a six sensor system, ABS remains active by using input from the remaining rear wheel speed sensor on the same side.

ATC Modulator Diagnostic Trouble Code

ATC and ESP are disabled. ABS remains active.

J1939 Communication Diagnostic Trouble Code

ATC and ESP are disabled. ABS remains active.

ECU Diagnostic Trouble Code

ABS, ATC, and ESP are disabled. The system reverts to normal braking.

Voltage Diagnostic Trouble Code

While voltage is out of range, ABS, ATC, and ESP are disabled. The system reverts to normal braking. When the correct voltage level is restored, full ABS and ATC function is available. The operating voltage range is 9.0 to 17.0 VDC for 12 volt systems, and 20 to 33.5 volts for 24 volt systems.

Steering Angle Sensor Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

Yaw Rate/Lateral Acceleration Sensor Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

Brake Demand Pressure Sensor Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

Load Sensor Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

Steer Axle TCV Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

Trailer PMV Diagnostic Trouble Code

ESP is disabled. ABS and ATC remain active.

SYSTEM RECONFIGURATION

The Bendix® EC-60™ controller is designed to allow the technician to change the default system settings (chosen by the vehicle OEM) to provide additional or customized features.

Depending on the model, the customizable features include ABS control settings, engine module communication etc. Many of these settings can be reconfigured using a hand-held or PC-based software, such as the Bendix® ACom® Diagnostics program.

ECU RECONFIGURATION

Reconfiguring a Bendix EC-60 controller may be carried out by using the Blink Code Switch or by using a hand-held or PC-based diagnostic tool.

Note: During the reconfiguration process, and independently from any reconfiguration being carried out by the technician, the ECU will automatically check the J1939 serial link and communicate with other vehicle modules. In particular, if the serial link shows that the vehicle has a retarder device present, the ECU will configure itself to communicate with the retarder device for improved ABS performance. For example, if the ECU detects the presence of a retarder disable relay during a reconfiguration, it will configure itself to control the relay to disable the retarding device as needed.

Reconfiguration Using the Blink Code Switch

With ignition power removed from the Bendix EC-60 controller, depress the blink code switch. After the ignition power is activated, depress and release the switch seven times to initiate a reconfiguration event.

Diagnostic Tool

A reconfiguration event may be initiated using a hand-held or PC-based diagnostic tool to communicate with the ECU over the SAE J1587 diagnostic link.

6S/5M Configuration

Advanced Bendix® EC-60™ controllers will configure for 6S/5M operation when a reconfiguration event is initiated and the ECU detects that an additional axle PMV is wired as follows:

PMV Connector	ECU Connector
Hold	Right Additional Axle Hold
Release	Left Additional Axle Release
Common	Right Additional Axle Common

Troubleshooting: General

GENERAL SAFETY GUIDELINES

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following guidelines should be observed AT ALL TIMES:

- ▲ **Park the vehicle on a level surface, apply the parking brakes and always block the wheels. Always wear personal protection equipment.**
- ▲ **Stop the engine and remove the ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically-charged components.**
- ▲ **Do not attempt to install, remove, disassemble or assemble a component until you have read, and thoroughly understand, the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
- ▲ **If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle. If the vehicle is equipped with a Bendix® AD-IS® air dryer system, a Bendix® DRM™ dryer reservoir module, or a Bendix® AD-9si® air dryer, be sure to drain the purge reservoir.**
- ▲ **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.**
- ▲ **Never exceed manufacturer's recommended pressures.**
- ▲ **Never connect or disconnect a hose or line containing pressure; it may whip and/or cause hazardous airborne dust and dirt particles. Wear eye protection. Slowly open connections with care, and verify that no pressure is present. Never remove a component or plug unless you are certain all system pressure has been depleted.**
- ▲ **Use only genuine Bendix® brand replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, wiring, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.**
- ▲ **Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.**
- ▲ **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**
- ▲ **For vehicles with Automatic Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.**
- ▲ **The power MUST be temporarily disconnected from the radar sensor whenever any tests USING A DYNAMOMETER are conducted on a vehicle equipped with a Bendix® Wingman® system.**
- ▲ **You should consult the vehicle manufacturer's operating and service manuals, and any related literature, in conjunction with the Guidelines above.**

REMOVING THE BENDIX® EC-60™ CONTROLLER ASSEMBLY

1. Turn vehicle ignition off.
2. Remove as much contamination as possible prior to disconnecting electrical connections.
3. Note the Bendix EC-60 controller assembly mounting position on the vehicle.
4. Disconnect the electrical connectors from the Bendix EC-60 controller.
5. Remove and retain the mounting bolts that secure the Bendix EC-60 controller.

CAUTION

The VIN of the vehicle is stored in the ECU internal memory, and is cross-checked by the ECU using information obtained from other vehicle controllers. If the VIN stored in the ECU does not match the VIN obtained from the other vehicle controller, the ECU will generate an ECU Internal VIN Mismatch DTC.

Accordingly, do not switch Advanced controllers from one vehicle to another.

OBTAINING A NEW BENDIX EC-60 ADVANCED CONTROLLER

Should the Advanced Bendix EC-60 controller require replacement, certain steps must be followed:

1. Record the vehicle model, VIN, year and date of manufacture from the vehicle.
2. Record the part number of the Bendix EC-60 Advanced Controller.
3. Provide this information to your local OEM vehicle service department to obtain a new ECU. The OEM service department will install the same parameter set in the new controller that was loaded into the original ECU at the vehicle OEM assembly facility.

INSTALLING A NEW BENDIX® EC-60™ CONTROLLER

CAUTION When replacing the Bendix EC-60 controller, verify with the OEM service department that the unit you are installing has the correct parameter set. Failure to do so could result in a loss of features or degraded ESP performance.

For further information, contact either the vehicle manufacturer, Bendix or your local authorized Bendix dealer.

1. Position and secure the Bendix® EC-60™ controller in the original mounting orientation using the mounting bolts retained during removal. Use no more torque than is necessary to firmly secure the ECU into position. Over-tightening the mounting hardware can cause damage to the EC-60™ controller.
2. Reconnect the electrical connectors to the EC-60™ controller.
3. Apply power and monitor the Bendix EC-60 controller power-up sequence to verify proper system operation.

See Troubleshooting: Wiring section beginning on page 45 for more information on wire harnesses.

WARNING: Bendix ESP stability system is validated with specific Bendix® brand components. Always use Bendix® brand replacement parts to prevent compromising system performance. Bendix is not able to validate the safe and reliable use of substitute or alternate components that may be available from other manufacturers. Further, suppliers of a non-Bendix® brand ABS component may implement design changes in their component (without the knowledge or approval of Bendix) which could negatively affect antilock system reliability and braking performance issues.

REMOVAL OF THE STEERING ANGLE SENSOR

Service Checks:

1. Check all wiring and connectors. Some installations also include an intermediate connector from the steering angle sensor to the main vehicle wire harness. Make sure all connections are free from visible damage.
2. Examine the sensor. Make sure the sensor, its mounting screws, and the interface between the hub and the steering column are not damaged.

Diagnostics:

The steering angle sensor is only operational in conjunction with an Advanced ABS ECU. No independent diagnostics can be performed on the sensor.

Removal:

1. Remove steering column sheathing.
2. Depending upon manufacturer, the steering angle sensor could be located either near the steering wheel, necessitating the removal of the steering wheel, or near the joint to the vehicle steering mechanism, necessitating the disconnection of this linkage.
3. Unplug sensor cable assembly from body of sensor. Squeeze the mounting tabs and pull gently on the connector until it disengages.
4. Unscrew all three of the mounting screws that hold the body of the sensor to the steering column body.
5. Slide the sensor over the column to remove. Take note if the sensor label is facing upward or downward.

Installation:

1. Obtain a new sensor. The sensor is not repairable in the field.
2. Slide the sensor over the column. The center hub of the sensor must be aligned with the corresponding notch in the column. Different column manufacturers may implement this hub alignment in different ways. The sensor label should be facing in the same direction as the removed sensor.
3. Assemble to column non-moving plate with three self-locking screws.
4. Tighten screws to steering column manufacturer's recommended torque specification.
5. Reconnect the connector. Ensure that there will be no force applied to the sensor because the connector is pulling on the sensor body.
6. If the wire harness leading to the sensor is being replaced, ensure that it is adequately tie wrapped so that the full motion of the steering column can be achieved without pulling apart the connectors.
7. Reinstall the column sheathing. The sensor is not protected against dirt or water intrusion, so care must be taken not to introduce these elements during installation.

STEERING ANGLE SENSOR CALIBRATION

The steering angle sensor calibration can only be achieved when the sensor is powered by the Advanced ABS ECU. No stand-alone sensor calibration can be carried out. The calibration procedure is performed using Bendix® ACom® Diagnostic V4.0 or higher. See "Troubleshooting Diagnostic Trouble Codes: Steering Angle Sensor (SAS-60)" for the calibration procedure using this tool. The sensor must be recalibrated using ACom Diagnostics after any of these situations:

- Replacement of the steering angle sensor
- Any opening of the connector hub from the steering angle sensor to the column
- Any maintenance or repair work on the steering linkage, steering gear or other related mechanism
- Adjustment of the wheel alignment or wheel track
- After an accident that may have led to damage of the steering angle sensor or assembly

WARNING: If the steering angle sensor is not properly recalibrated as needed, the yaw control system may not function properly, which can result in a loss of vehicle control.

REMOVAL OF THE YAW RATE/LATERAL ACCELERATION SENSOR

WARNING: Different generations of yaw rate/lateral acceleration sensors are not compatible. Only replace these sensors with exactly the same device.

Service Checks:

1. Check all wiring and connectors. Make sure all connections are free from visible damage.
2. Examine the sensor. Make sure the sensor, its mounting bolts, and the mounting bracket are not damaged.
3. Check the vent hole in underbody of sensor housing. The vent hole should remain free from paint and debris at all times.

Diagnostics:

The yaw rate sensor is only operational in conjunction with an Advanced ABS ECU. No independent diagnostics can be performed on the sensor.

Removal:

1. Unplug sensor cable assembly from body of sensor. The connector must be twisted and pulled gently to release.
2. In some mounting configurations, the sensor can be removed independently from its mounting bracket. Otherwise, remove entire assembly, then remove sensor from bracket.
3. Take note of the direction in which the connector is pointed.

Installation:

1. Obtain a new sensor. The sensor is not repairable in the field.

WARNING: The location of the Yaw Rate Sensor on the vehicle, the means of fastening the unit to the vehicle, and the sensor's orientation, MUST NOT BE ALTERED. When servicing, an identical component must be used in the same orientation (using OEM brackets & torque requirements). During installation, follow the OEM leveling guidelines. If any of these requirements are not followed, the advanced ABS control system may not function properly, which can result in incidents leading to loss of vehicle control.

2. Assembly yaw rate sensor housing to mounting bracket. The bracket must be the same design as used on the original vehicle configuration.
3. For Bendix® YAS-60™ Yaw Rate Sensors, the correct fasteners are three M8 size bolts, and the fixing torque should be 20Nm (±2 Nm). For Bendix® YAS-70X™ Yaw Rate Sensors, the correct fasteners are two M10 size bolts (1.5 mm pitch angle), or OEM-supplied hardware, and the fixing torque should be 46Nm (±9 Nm). Note that the Bendix YAS-70X sensor has two alternate designs, one with an aligning post — see the kit instruction sheet for more information. In all cases, the connector should be facing in the same direction as the removed sensor. The unit must not be installed upside-down where there is a pressure-balancing hole.
4. The sensor should be as level as possible and parallel to the road surface when installed on the vehicle.
5. Reconnect the connector. Ensure that there will be no force applied to the sensor because the connector is pulling on the sensor body.

CAUTION: When removing or installing the sensor, care must be used to prevent damage. Do not strike or pry the sensor. Do not use an impact tool to install the mounting hardware.

Sensor Location Modifications

The location and orientation of the Yaw Rate Sensor must not be altered. When servicing, an identical component must be used in the same orientation (using OEM brackets & torque requirements). During installation follow the OEM leveling guidelines.

Yaw Rate Sensor Calibration:

The yaw rate sensor calibration can only be achieved via the Advanced ABS ECU. The sensor must be recalibrated after any of these situations:

- Replacement of the sensor
- After an accident that may have led to damage of the yaw rate sensor

The calibration procedure is preformed using Bendix® ACom® Diagnostics V4.0 or higher.

See "Troubleshooting Diagnostic Trouble Codes: Yaw Rate Sensor" for the calibration procedure.

BRAKE DEMAND SENSOR CALIBRATION

Calibration must be performed under the following conditions:

- After servicing any pressure sensor related DTCs
- Replacement of any sensor

The calibration procedure is performed using Bendix ACom Diagnostics V4.0 or newer versions.

See "Troubleshooting Diagnostic Trouble Codes: Brake Demand Sensor/Load Sensor" for the calibration procedure.

PRESSURE SENSOR INSTALLATION REQUIREMENTS

Service Checks:

1. Check all wiring and connectors. Make sure all connections are free from visible damage.
2. Examine the sensor. Make sure the sensor and its interface to the pressure location are not damaged.

Diagnostics:

The pressure sensor can be independently diagnosed when supplied with a five volt voltage supply to the B location and ground to the A location. Signal output on the C location should read approximately 0.5V if there is no pressure applied. The signal output should increase proportionately as pressure is applied, up to a maximum of 4.5V at 150 psi.

Removal:

1. Unplug sensor cable assembly from body of sensor. Pull gently on the mounting tab and connector until it disengages.
2. Remove sensor from its pressure mounting using approved air brake push in fitting tools.

Installation:

1. Obtain a new sensor. The sensor is not repairable in the field.
2. Insert sensor into pressure fitting using approved tools.
3. Reconnect the connector. Ensure that there will be no force applied to the sensor because the connector is pulling on the sensor body.
4. If the wire harness leading to the sensor is being replaced, ensure that it is adequately tie wrapped.

Pressure Sensor Calibration:

There is no need for pressure sensor calibration as long as the part replaced is identical to the part removed and a component approved for use with the Bendix Advanced ABS system. However, replacement of brake demand sensors or clearing of demand pressure sensor related DTCs require the following:

1. Use of ACom V4 or newer to clear the active p-sensor fault.
2. Carrying out the demand p-sensor initialization procedure which involves applying service brakes of 90 psi or greater for 3 sec (while stationary).

Once this procedure is carried out successfully, if there are no other active DTCs, ATC/ESP indicator will no longer illuminate.

Troubleshooting: Blink Codes and Diagnostic Modes

ECU DIAGNOSTICS

The Bendix® EC-60™ controller contains self-testing diagnostic circuitry that continuously checks for the normal operation of internal components and circuitry, as well as external ABS components and wiring.

Active Diagnostic Trouble Codes

When an erroneous system condition is detected, the EC-60™ controller:

1. Illuminates the appropriate indicator lamp(s) and disengages part or all of the ABS, ATC and ESP functions. *(See ABS Partial Shutdown, on page 15.)*
2. Places the appropriate trouble code information in the ECU memory.
3. Communicates the appropriate trouble code information over the serial communications diagnostic link as required. Hand-held or PC-based diagnostic tools attach to the vehicle diagnostic connector, typically located on or under the dash (see Figure 13).

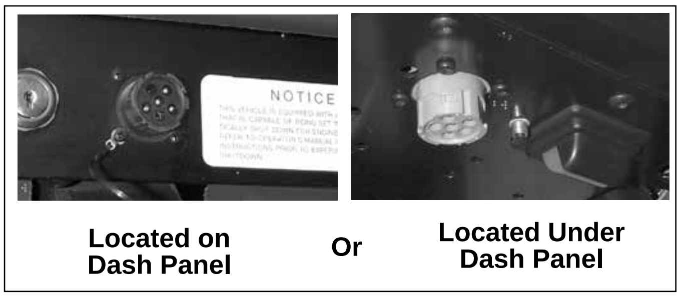


FIGURE 13 - ***TYPICAL VEHICLE DIAGNOSTIC CONNECTOR LOCATIONS (J1708/J1587, J1939)***

BLINK CODES

Blink codes allow a technician to troubleshoot ABS problems without using a hand-held or PC-based diagnostic tool. Instead, information about the ABS system is communicated by the ECU using the ABS indicator lamp to display sequences of blinks.

Note: The ECU will not enter the diagnostic blink code mode if the wheel speed sensors show that the vehicle is in motion. If the ECU is in the diagnostic blink code mode and then detects vehicle motion, it will exit the blink code mode.

In addition, by operating the blink code switch as described below, one of several diagnostic modes can be entered. See Diagnostic Modes below.

Blink Code Switch Activation

When activating the blink code switch:

1. Wait at least two seconds after "ignition on." (Except when entering Reconfiguration Mode - *see Reconfiguration section on page 16*.)
2. For the ECU to recognize that the switch is activated "on," the technician must press for at least 0.1 seconds, but less than 5 seconds. (If the switch is held for more than 5 seconds, the ECU will register a malfunctioning switch.)
3. Pauses between pressing the switch when a sequence is required, (e.g. when changing mode) must not be longer than 2 seconds.
4. After a pause of 3.5 seconds, the ECU will begin responding with output information blinks. *See Figure 14 for an example.*

Blink Code Timing

The ECU responds with a sequence of blink codes. The overall blink code response from the ECU is called a "message." Each message includes, depending on the mode selected by the technician, a sequence of one or more groups of blinks. Simply record the number of blinks for each sequence and then use the troubleshooting index on page 26 for active or inactive trouble codes and you will be directed to the page that provides troubleshooting information.

NOTE:

1. Sequences of blinks illuminate the ABS indicator lamp for half a second, with half-second pauses between them.
2. Pauses between blink code digits are 1.5 seconds.
3. Pauses between blink code messages are 2.5 seconds.
4. The lamp remains on for 5 seconds at the end of messages.

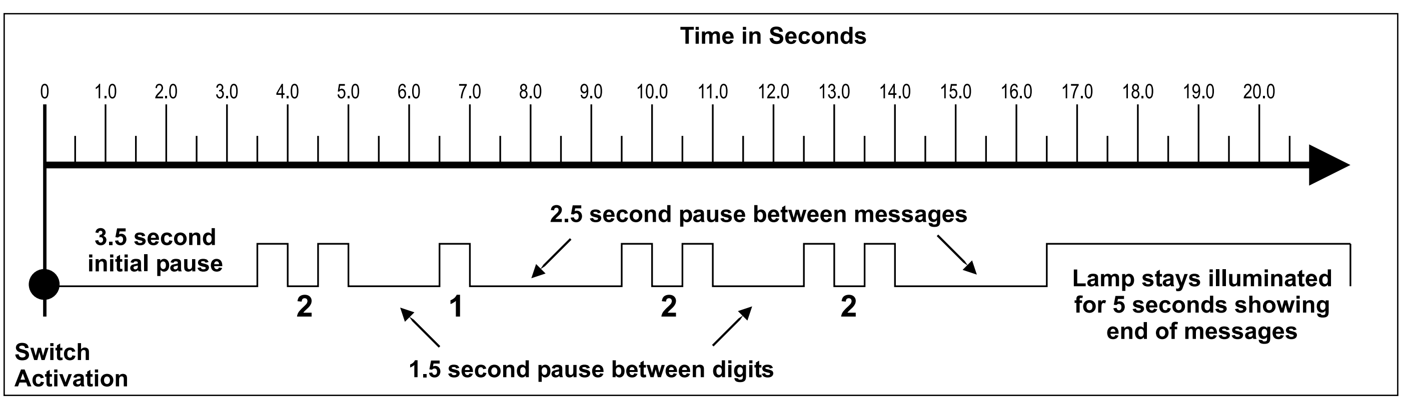


FIGURE 14 - ***EXAMPLE OF BLINK CODE MESSAGE***

Once the ABS indicator lamp begins displaying a sequence of codes, it continues until all blink code messages have been displayed and then returns to the normal operating mode. During this time, the ECU will ignore any additional blink code switch activation.

All trouble codes, with the exception of voltage and J1939 trouble codes, will remain in an active state for the remainder of the power cycle.

Voltage trouble codes will clear automatically when the voltage returns within the required limits. All ABS functions will be re-engaged.

J1939 trouble codes will clear automatically when communications are re-established.

DIAGNOSTIC MODES

In order to communicate with the ECU, the controller has several modes that the technician can select, allowing information to be retrieved, or other ECU functions to be accessed.

Diagnostic Modes

To enter the various diagnostic modes:

No. of Times to Press the Blink Code Switch	System Mode Entered
1	Active diagnostic trouble code retrieval
2	Inactive diagnostic trouble code retrieval
3	Clear active diagnostic trouble codes
4	System configuration check
5	Dynamometer Test Mode
7*	Reconfigure ECU

***** To enter the Reconfiguration Mode, the switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.

CHART 2 - *DIAGNOSTIC MODES*

Active Diagnostic Trouble Code Mode

For troubleshooting, typically the Active and Inactive Diagnostic Trouble Retrieval Modes are used. The technician presses the blink code switch once and the ABS indicator lamp flashes a first group of two codes, and if there are more trouble codes recorded, this is followed by a second set of codes, etc. *(See page 26 for a directory of these codes.)* All active trouble codes may also be retrieved using a hand-held or PC-based diagnostic tool, such as the Bendix® ACom® Diagnostics software.

To clear active diagnostic trouble codes (as problems are fixed), simply clear (or "self-heal") by removing and re-applying ignition power. The only exception is for wheel speed sensor trouble codes, which clear when power is removed, re-applied, and the ECU detects valid wheel speed from all wheel speed sensors. Alternately, codes may be cleared by pressing the diagnostic blink code switch 3 times (to enter the Clear Active Diagnostic Trouble Code Mode) or by using a hand-held or PC-based diagnostic tool. Hand-held or PC-based diagnostic tools are able to clear wheel speed sensor trouble codes without the vehicle being driven.

Inactive Diagnostic Trouble Code Mode

The ECU stores past trouble codes and comments (such as configuration changes) in its memory. This record is commonly referred to as "event history." When an active trouble code is cleared, the ECU stores it in the event history memory as an inactive trouble code.

Using blink codes, the technician may review all inactive trouble codes stored on the ECU. The ABS indicator lamp will display inactive diagnostic blink codes when the diagnostic blink code switch is depressed and released two times. See page 26 for the index showing trouble codes and the troubleshooting guide page to read for help.

Inactive trouble codes, and event history, may be retrieved and cleared by using a hand-held or PC-based diagnostic tool, such as the Bendix® ACom® Diagnostics software.

Clearing Active Diagnostic Trouble Codes

The ECU will clear active trouble codes when the diagnostic blink code switch is depressed and released three times.

System Configuration Check Mode

The ABS indicator lamp will display system configuration information when the diagnostic blink code switch is depressed and released four times. The lamp will blink out configuration information codes using the following patterns. (See Chart 3).

In this mode the ECU tells the technician, by means of a series of seven blink codes, the type of ABS system that the ECU has been set up to expect. For example, if the fourth blink code is a two, the technician knows that a 6S/4M sensor/modulator configuration has been set.

Dynamometer Test Mode

The Dynamometer Test Mode is used to disable ESP & ATC when needed (e.g. when performing any vehicle maintenance where the wheels are lifted off the ground and moving, including dyno testing). **For Advanced ABS controllers this mode will remain engaged even if power to the ECU is removed and re-applied.**

To exit the Dynamometer Test Mode, press and release the blink code switch three times, or use a hand-held or PC-based diagnostic tool.

1st Number	System Power
1	12 Volts
2nd Number	**Wheel Speed Sensors**
4	4 Sensors
6	6 Sensors
3rd Number	**Pressure Modulator Valves**
4	4 Modulators
5	5 Modulators
6	6 Modulators
4th Number	**ABS Configuration**
1	4S/4M or 6S/6M
2	6S/4M
3	6S/5M
5th Number	**Traction Control Configuration**
2	No ATC
3	ATC Engine Control Only
4	ATC Brake Control Only
5	Full ATC (Engine Control & Brake Control)
6th Number	**Retarder Configuration**
1	No Retarder
2	J1939 Retarder
3	Retarder Relay
4	J1939 Retarder, Retarder Relay
7th Number	**Stability Configuration**
1	No Stability Program
2	Electronic Stability Program (ESP), which includes RSP
3	Roll Stability Program (RSP) Only

CHART 3 - *SYSTEM CONFIGURATION CHECK*

Reconfigure ECU Mode

Controller reconfiguration is carried out by using the Reconfigure ECU Mode. *(See page 16.)*

Note: To enter the Reconfiguration Mode, the blink code switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.

Troubleshooting and diagnostic trouble code clearing (as well as reconfiguration) may also be carried out using hand-held or PC-based diagnostic tools such as the Bendix® Remote Diagnostic Unit (RDU™), Bendix® ACom® Diagnostics software, or the ProLink tool.

Troubleshooting: Using Hand-Held or PC-Based Diagnostic Tools

Bendix® RDU™ (Remote Diagnostic Unit)

The Bendix® RDU™ tool provides the technician with a visual indication of Antilock Braking System (ABS) component **Diagnostic Trouble Code (DTC)** information. The RDU™ tool is specifically designed for use with Bendix® ABS systems and Bendix makes no claims for its operation and/or usability with other brands of ABS systems.

FIGURE 15 - *THE BENDIX® REMOTE DIAGNOSTIC UNIT*

Features of the Bendix® RDU™ Tool

The RDU™ tool attaches to the 9 pin diagnostic connector in the cab of the vehicle. An adapter cable (Bendix part number 801872) is available to connect the RDU to vehicles with a 6-pin diagnostic connector.

The RDU™ tool allows the technician to:

- Troubleshoot ABS system component problems using Diagnostic Trouble Code reporting via LEDs.
- Reset Diagnostic Trouble Codes on Bendix® ABS ECUs by holding a magnet over the reset in the center of the RDU™ tool for less than 6 seconds.
- Enter the Self-Configuration Mode used by Bendix® ABS ECUs by holding a magnet over the reset area for greater than 6 seconds but less than 30 seconds.

How the Bendix® RDU™ Operates

See Figure 13 for typical vehicle connector locations.

When the RDU™ tool is plugged into the diagnostic connector, all the LEDs will illuminate, and the green LED will flash 4 times to indicate communications have been established.

If the ABS ECU has no active Diagnostic Trouble Codes, only the green LED will remain illuminated.

If the ABS ECU has at least one active Diagnostic Trouble Code the RDU™ tool displays the first diagnostic trouble code by illuminating the red LEDs, indicating the malfunctioning ABS component and its location on the vehicle. (See Figure 15.) If there are multiple diagnostic trouble codes on the ABS system, the RDU™ tool will display one diagnostic trouble code first, then once that Diagnostic Trouble Code has been repaired and cleared, the next code will be displayed.

Typical Combination Diagnostic Trouble Codes are:

- Right steer sensor
- Left steer sensor
- Right drive sensor
- Left drive sensor
- Right additional sensor
- Left additional sensor
- Right steer modulator
- Left steer modulator
- Right drive modulator
- Left drive modulator
- Right additional modulator
- Left additional modulator
- Rear Axle Traction modulator
- ECU
- Engine serial communication
- MOD red LED illuminated, shows the "Common" connection of one or more modulators is shorted to battery or ground
- VLT (Flashing indicates either over- or under-voltage condition)

To pinpoint the root cause and to ensure the system diagnostic trouble code is properly corrected the first time, additional troubleshooting may be necessary. Note: The RDU is not capable of diagnosing ESP-specific diagnostic trouble codes including additional sensors: steering angle sensors, yaw sensors, pressure sensors, or modulator valves (trailer pressure modulating valves or front axle traction control valves.)

LED DIAGNOSTIC TROUBLE CODES

LFT -	Left	SEN -	Wheel Speed Sensor
RHT -	Right		
DRV -	Drive Axle	MOD -	Pressure Modulator Valve
ADD -	Additional		
STR -	Steer Axle	TRC -	Traction Control
VLT -	Power		
ECU -	ABS Controller		

Example: If the Diagnostic Trouble Code is "Right Steer Axle Sensor", the RDU™ unit will display one green and three red LEDs

FIGURE 16 - *DIAGNOSTIC TROUBLE CODES*

Bendix® RDU™ Reset Function

The magnetic reset switch is located in the center top of the RDU™ tool. Activation requires a magnet with 30 gauss minimum.

The reset operations are:

1. If the magnet is held over the switch for less than 6 seconds the "clear current diagnostic trouble codes" command is sent.
2. If the magnet is held over the switch for more than 6 seconds, but less than 30 seconds, the Bendix® ABS "self-configuration command" is sent.

Additionally, it is recommended at the end of any inspection that the user switches off and restores the power to the ABS ECU, then check the ABS Indicator Lamp operation and RDU™ tool to see if they indicate any remaining Diagnostic Trouble Codes.

Bendix® RDU™ Communication Problems

If the ABS ECU does not respond to the RDU™ tool's request for diagnostic trouble codes, the RDU™ tool will illuminate each red LED in a clockwise pattern. This pattern indicates the loss of communication and will continue until the ABS ECU responds and communication has been established.

Possible sources of communication problems are:

1. A problem with the J1587 link at the in-cab off-board diagnostic connector (9 or 6 Pin).
2. The ECU does not support PID194.
3. No power is being supplied to the ECU and/or the diagnostic connector.
4. The J1587 bus is overloaded with information and the RDU can not arbitrate access.
5. A malfunctioning RDU™ tool.

Nexiq Bendix Application Card

Nexiq provides a Bendix application card for use with the ProLink tool. It can also be used to diagnose the EC-30™, EC-17™, Gen 4™, Gen 5™, and MC-30™ ABS Controllers.

For more information on the Bendix application card visit www.bendix.com, Nexiq at www.nexiq.com, or your local authorized Bendix parts outlet.

Bendix® ACom® Diagnostics Software

Bendix® ACom® Diagnostics is a PC-based software program and is designed to meet RP-1210 industry standards developed by the Truck Maintenance Council (TMC). This software provides the technician with access to all the available ECU diagnostic information and configuration capability, including:

- ECU information
- Diagnostic trouble codes and repair information
- Configuration (ABS, ATC, and more)
- Wheel speed information
- Perform component tests
- Save and print information

FIGURE 17 - *NEXIQ (MPSI) PRO-LINK TOOL*

FIGURE 18 - *BENDIX® ACOM® DIAGNOSTICS*

ACom® Diagnostics V4.0 software is required to calibrate the Steering Angle Sensor, the Yaw Rate/Lateral Acceleration Sensor, the Brake Demand Sensors and the Load Sensor.

When using ACom® Diagnostics V4.0 (or higher) software to diagnose the Bendix EC-60 ABS ECU, the computer's serial or parallel port needs to be connected to the vehicle's diagnostic connector.

For more information on ACom® Diagnostics software or RP1210 compliant tools, go to www.bendix.com or visit your local authorized Bendix parts outlet.

See pages 51-60 for Appendices showing J1587 SID, FMI, and UDS codes and their Bendix blink code equivalents.

www.bendix.com

For the latest information, and for free downloads of the Bendix® ACom® Diagnostics software, and its User Guide, visit the Bendix website at www.bendix.com.

Bendix Technical Assistance Team

For direct telephone technical support, call the Bendix technical assistance team at:

1-800-AIR-BRAKE (1-800-247-2725),

Monday through Friday, 8:00 A.M. to 6:00 P.M. EST, and follow the instructions in the recorded message.

Or, you may e-mail the Bendix technical assistance team at: techteam@bendix.com.

Active or Inactive Diagnostic Trouble Codes:

INDEX

How to interpret the first digit of messages received when Active or Inactive Diagnostic Trouble Code Mode is entered.

Example: For a message sequence of:

3, 2   12, 4

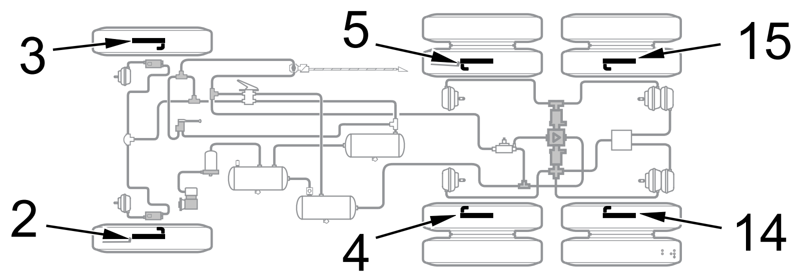
For the first sequence go to page 27 and for the second sequence go to page 34.

See Page 51 for APPENDIX B: J1587 SID and FMI Codes and their Bendix Blink Code Equivalents

See Page 56 for APPENDIX C: UDS Codes and their Bendix Blink Code Equivalents

Troubleshooting Diagnostic Trouble Codes: Wheel Speed Sensors

1st. Blink Code	Location
2	Left Steer Axle Sensor
3	Right Steer Axle Sensor
4	Left Drive Axle Sensor
5	Right Drive Axle Sensor
14	Left Additional Axle Sensor
15	Right Additional Axle Sensor



2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Excessive Air Gap	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
2	Output Low at Drive-off	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
3	Open or Shorted	Verify 1500 – 2500 ohms across sensor leads. Verify no continuity between sensor leads and ground or voltage. Verify no continuity between sensor leads and other sensors. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
4	Loss of Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
5	Wheel End	Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check mechanical function of brake. Check for kinked or restricted air lines.
6	Erratic Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
7	Tire Size Calibration	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth.
10	Configuration Error	ECU is configured for four sensors, but has detected the presence of additional sensors. Verify sensor wiring and ECU configuration.

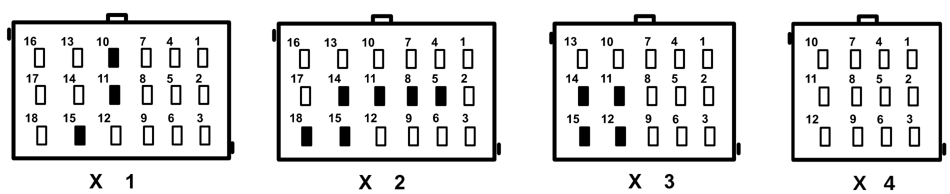
Speed Sensor Repair Tests:

1. Take all measurements at ECU harness connector pins in order to check wire harness and sensor. Probe the connector carefully so that the terminals are not damaged.
2. Wheel speed sensor measurements should read:

Location	Measurement
Sensor	1500 - 2500 Ohms
Sensor to voltage or ground	Open Circuit (no continuity)
Sensor output voltage	>0.25 of VAC sensor output at ~ 0.5 revs/sec.

3. Clear DTC after issue is corrected. The sensor DTC will remain until the power is cycled to the ABS ECU and vehicle is driven above 15 MPH or DTC was cleared using either the diagnostic blink code switch or diagnostic tool.

Cab-mount ECU: Looking into wire harness connector



Connector	Pin	Wheel Speed Sensor Location
X1 18 Way	10	Right Drive Axle (+)
	11	Right Drive Axle (-)
X2 18 Way	5	Left Steer Axle (+)
	8	Left Steer Axle (-)
	11	Right Steer Axle (+)
	14	Right Steer Axle (-)
	15	Left Drive Axle (+)
	18	Left Drive Axle (-)
X3 15 Way (if ECU is configured for 6 sensors)	11	Left Additional Axle (+)
	14	Left Additional Axle (-)
	12	Right Additional Axle (+)
	15	Right Additional Axle (-)

Troubleshooting Diagnostic Trouble Codes: Power Supply

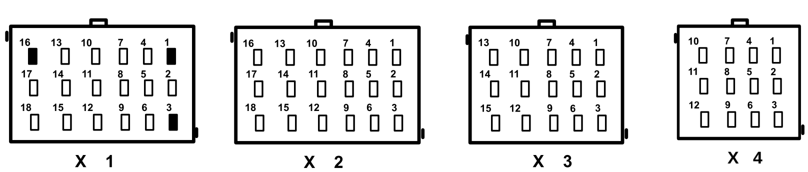
1st. Blink Code	Location
6	Power Supply

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Battery Voltage Too Low	Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
2	Battery Voltage Too High	Measure battery voltage under load. Ensure that battery voltage is correct for the ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
3	Battery Voltage Too Low During ABS	Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
4	Battery Voltage Open Circuit	Measure battery voltage under load. Check condition of fuse. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
5	Ignition Voltage Too Low	Measure ignition voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections. Check condition of fuse.
6	Ignition Voltage Too High	Measure ignition voltage. Ensure that ignition voltage is correct for the ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
7	Ignition Voltage Too Low During ABS	Measure ignition voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
8	Input Voltage Has Excessive Noise (Temporary)	Check alternator output for excessive noise. Check for other devices causing excessive noise.
9	Input Voltage Has Excessive Noise	Check alternator output for excessive noise. Check for other devices causing excessive noise.

Power Supply Tests:

1. Take all measurements at ECU harness connector.
2. Place a load (e.g. an 1157 stop lamp) across battery or ignition and ground connection, measure ignition and battery voltage with the load. Ignition to Ground should measure between 9 to 17 VDC. Battery to Ground should also measure between 9 to 17 VDC.
3. Check for damaged wiring, damaged or corroded connectors and connections.
4. Check condition of vehicle battery and associated components, ground connection good and tight.
5. Check alternator output for excessive noise.

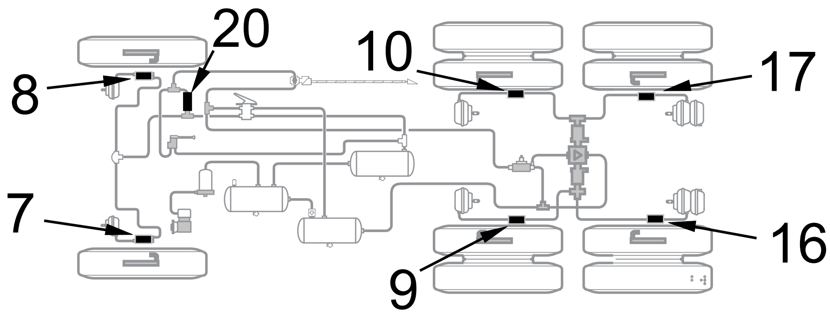
Cab-mount ECU: Looking into wire harness connector



Connector	Pin	Power Supply Test
X1	1	Ground
18 Way	3	Ignition
	16	Battery

Troubleshooting Diagnostic Trouble Codes: Pressure Modulator Valves

1st. Blink Code	Location
7	Left Steer Axle
8	Right Steer Axle
9	Left Drive Axle
10	Right Drive Axle
16	Left Additional Axle
17	Right Additional Axle
20	Trailer PMV



2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Release Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
2	Release Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
3	Release Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
4	Hold Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
5	Hold Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN & HLD CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
6	Hold Solenoid Shorted to Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between the ECU and PMV.
7	CMN Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between the ECU and PMV. Potentially a miswired or internal mechanical problem.
8	Configuration Error	A mis-match exists between the ECU configuration and the modulator installation and wiring. Verify PMV wiring and installation. Verify ECU configuration. Special Note regarding Trailer PMV: Pneumatic issues can result in this DTC being set. Verify all lines are free from debris or other obstructions, kinks, etc.

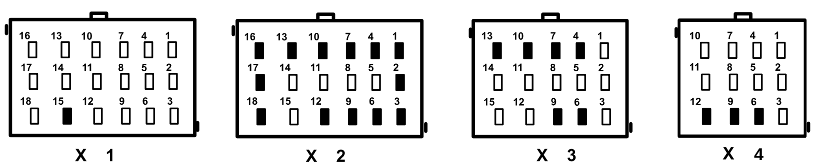
Pressure Modulator Valve Repair Tests:

1. Take all measurements at ECU harness connector pins in order to check wire harness and PMV. Probe the connector carefully so that the terminals are not damaged.
2. Pressure modulator resistance should read:

Location	Measurement
Release to Common	4.9 to 5.5 Ohms
Hold to Common	4.9 to 5.5 Ohms
Release to Hold	9.8 to 11.0 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)

CAUTION: When troubleshooting modulator trouble codes, check inactive trouble codes and event history for over-voltage or excessive noise trouble codes. If one of these is found, troubleshoot these trouble codes first before the PMV.

Cab-mount ECU: Looking into wire harness connector



Connector	Pin	PMV Location
X2 18 Way	1	Left Steer Axle Hold
	2	Left Steer Axle Release
	3	Left Steer Axle Common
	4	Right Steer Axle Hold
	6	Right Steer Axle Common
	7	Right Steer Axle Release
	9	Right Drive Axle Common
	10	Right Drive Axle Hold
	13	Right Drive Axle Release
	12	Left Drive Axle Common
	16	Left Drive Axle Hold
	17	Left Drive Axle Release
X3 15 Way (if ECU is configured for 6 modulators)	4	Left Additional Axle Hold
	6	Left Additional Axle Common
	7	Left Additional Axle Release
	9	Right Additional Axle Common
	10	Right Additional Axle Hold
	13	Right Additional Axle Release
X4 12 Way	6	Trailer PMV Hold
	9	Trailer PMV Release
	12	Trailer PMV Common

Troubleshooting Diagnostic Trouble Codes: J1939 Serial Communications

1st. Blink Code	Location:
11	J1939

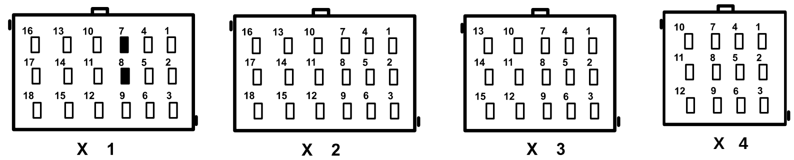
2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	J1939 Serial Link	Loss of communications between the Bendix® EC-60™ controller and other devices connected to the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
2	J1939 Retarder	Loss of communications between the Bendix EC-60 controller and other devices connected to the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of retarder on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
3	J1939 Engine Communications	Loss of communications between the Bendix EC-60 controller and the engine ECU over the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of engine ECU on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
4	J1939 Invalid Data (Engine Retarder)	Invalid data received from the engine or retarder. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Verify presence of engine and/or retarder on J1939. Verify proper programming of engine and/or retarder. Check for other devices inhibiting J1939 communications.
5	J1939 Supply Pressure	Invalid pressure signals received from a vehicle controller. Verify proper operation of brake demand sensors. Check wiring between brake demand sensors and the vehicle controller. Verify proper programming of vehicle controller. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Check for other devices inhibiting J1939 communications.
6	J1939 ESP Messages Invalid Data	Invalid ESP messages on the J1939 link. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Verify presence of engine and/or retarder on J1939. Verify proper programming of engine and/or retarder. Check for other devices inhibiting J1939 communications.
7	J1939 Transmission Communication for HSA	Loss of communications between the EC-60 ECU and the transmission ECU over the J1939 link. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Verify presence of transmission ECU on J1939 link. Check for other devices inhibiting J1939 communications.
8	J1939 Invalid Data	Invalid ESP messages on the J1939 link indicating the additional axle left is not valid. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Check for other devices inhibiting J1939 communications.
10	J1939 Invalid Data from Transmission	Invalid data from transmission message on the J1939 link. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Verify presence of transmission on J1939. Verify proper programming of transmission. Check for other devices inhibiting J1939 communications.
12	J1939 HSA Switch Error	Invalid HSA messages on the J1939 link indicating an HSA switch error or unavailable. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Verify presence of HSA switch on J1939. Check for other devices inhibiting J1939 communications.
13	J1939 Invalid Data	Invalid ESP messages on the J1939 link indicating error for ESP AWD function. Check for damaged or reversed J1939 wiring. Check for damaged or corroded connectors. Check for other devices inhibiting J1939 communications.

J1939 Troubleshooting Tests:

1. Take all measurements at ECU harness connector
2. Check for damaged or reversed J1939 wiring
3. Check for corroded or damaged wiring connector problems such as (opens or shorts to voltage or ground)
4. Check for other J1939 devices which may be loading down (inhibiting) J1939 communication

Cab-mount ECU:

Looking into wire harness connector



Connector	Pin	J1939
X1	7	J1939 Low
18 Way	8	J1939 High

Troubleshooting Diagnostic Trouble Codes: Miscellaneous

1st. Blink Code	Location:
12	Miscellaneous

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Stop Lamp Switch Not Detected	ECU has not detected the presence of the stop lamp switch since ignition power was applied (note that stop lamp switch input may be applied to the Bendix® EC-60™ controller using either hardwire input or J1939). Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.
2	Stop Lamp Switch Defective	Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.
3	ATC Disabled or Dynamometer Test Mode Active	ATC is disabled. ECU has been placed in the Dynamometer Test Mode by either the diagnostic blink code switch or a hand-held or PC-based diagnostic tool. Clear DTCs to exit Dynamometer Test Mode.
4	Retarder Relay or HSA Lamp Open Circuit or Shorted to Ground	Verify vehicle contains a retarder relay or Hill Start Assist (HSA) lamp. Verify ECU configuration. Check wiring between ECU and retarder relay or HSA lamp. Verify no continuity between retarder disable output or HSA lamp output of Bendix EC-60 controller and ground. Verify condition and wiring of the retarder relay or HSA lamp.
5	Retarder Relay or HSA Lamp Circuit Shorted to Voltage	Check wiring between ECU and retarder relay or HSA lamp. Verify no continuity between retarder disable output or HSA lamp output of Bendix EC-60 controller and voltage. Verify condition and wiring of the retarder relay or HSA lamp.
6	ABS Indicator Lamp Circuit DTC	Check operation of diagnostic blink code switch. Check wiring of diagnostic blink code switch (verify ABS wire is not grounded where used) and ABS Indicator Lamp. Verify ABS Indicator Lamp ground input. On some vehicles with multi-plex dashes, the ground wire may not be present - *see ECU 19 DTC.*
7	PMV Common Shorted to Ground	Verify no continuity between the Release, Hold and CMN of all PMVs, TCV, HSA, Diff Lock Solenoid and ground. Check for corroded/damaged wiring or connectors between the ECU and CMN of all PMVs, TCV, and Diff Lock Solenoid. See extended troubleshooting for this code in Appendix A.
8	PMV Common Shorted to Voltage	Verify no continuity between the Release, Hold and CMN of all PMVs, TCV, HSA, Diff Lock Solenoid and voltage. Check for corroded/damaged wiring or connectors between the ECU and CMN of all PMVs, TCV, and Diff Lock Solenoid.
9	ATC Disabled to Prevent Brake Fade	ATC is temporarily disabled to prevent excessive heating of the foundation brakes.
10	Tire Size Out of Range (Front to Rear)	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth. Verify that the ECU has the proper tire size settings.
11	Wheel Speed Sensors Reversed on an Axle	Sensors are reversed (left to right) on one of the axles. Verify proper installation, connection, and wiring of the sensors.

Troubleshooting Diagnostic Trouble Codes: Miscellaneous Continued

1st. Blink Code 12 — **Location: Miscellaneous**

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
12	Diff. Lock Solenoid Shorted to Ground or Open Circuit	Verify no continuity between the Diff Lock Solenoid and ground. Check for corroded/damaged wiring or connectors between the ECU and Diff Lock Solenoid.
13	Diff. Lock Solenoid Shorted to Voltage	Verify no continuity between the Diff Lock Solenoid and voltage. Check for corroded/damaged wiring or connectors between the ECU and Diff Lock Solenoid. Issue a "Clear DTC" command to exit Dynamometer Test Mode.
14	Sensor CAN Supply Voltage Error	Incorrect supply voltage for the SAS-60 and the Yaw Rate sensor. Verify proper voltage at sensor connectors. Verify wiring between the ECU and the sensors. Verify proper output voltage from ECU. *Note: When checking for voltage at YAW/LAS & SAS, the voltage will only be present momentarily at key ON*.
15-21	Reserved	
22	ESP Sensor Voltage Out of Range	Incorrect supply voltage for the SAS-60 and the Yaw Rate sensor. Verify proper voltage at sensor connectors. Verify wiring between the ECU and the sensors. Verify proper output voltage from ECU. *Note: When checking for voltage at YAW/LAS & SAS, the voltage will only be present momentarily at key ON*.
23	Short to Voltage	I/O 2 or I/O 3 Shorted to Voltage. *(A good location to check first, is the ECU Stop Lamp Relay wiring output X3-8.)*
24	HSA Solenoid Shorted to Voltage	Verify no continuity between the HSA Solenoid and voltage. Check for corroded/damaged wiring or connectors between the ECU and HSA solenoid.
25	HSA Solenoid Open or Shorted to Ground	HSA solenoid is shorted to ground or has a broken wire. Verify no continuity between the HSA solenoid and ground. Check for corroded/damaged wiring or connectors between the ECU and the HSA solenoid.
26	HSA Solenoid Shorted to Voltage	Verify no continuity between the HSA Solenoid and voltage. Check for corroded/damaged wiring or connectors between the ECU and HSA Solenoid.
27	Brake Lamp	Brake lamp input mismatch with brake lamp output

Troubleshooting Diagnostic Trouble Codes: ECU

1st. Blink Code 13

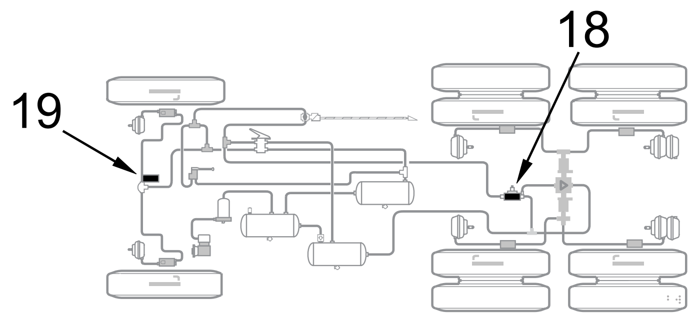
Location: ECU

2nd Blink Code	Bendix® ACom® Software Description	Repair Information
1	ECU DTC '02'	13-1 through 13-7: Check for damaged or corroded connectors. Check for damaged wiring including power and ground wiring. Clear the trouble codes. If Diagnostic Trouble Codes (DTCs) return, contact the Bendix Tech Team at 1-800-AIR-BRAKE (1-800-247-2725) for further troubleshooting assistance.
2	ECU DTC '10'	
3	ECU DTC '11'	
4	ECU DTC '12'	
5	ECU DTC '13'	
6	ECU DTC '14'	
7	ECU DTC '15'	
8	Invalid ABS Cofiguration ECU DTC '16'	**Codes 13-8 and 13-18:** Check the ECU for damaged or corroded connectors. Check for damaged wiring including power and ground wiring. Clear the trouble codes. If one of these DTCs return, contact the Bendix Tech Team at 1-800-AIR-BRAKE (1-800-247-2725) for further troubleshooting assistance. When troubleshooting either of these DTCs, it is important to inspect the ATR valves used for full stability and — if they have a DTC — repair them first. *Note: Never run an ECU self-configuration **before** completing the ATC repair and clearing its DTC, or a misleading 13-8 or 13-18 DTC may result.*
9	ECU DTC '17'	13-9 through 13-17: Check for damaged or corroded connectors. Check for damaged wiring including power and ground wiring. Clear the trouble codes. If Diagnostic Trouble Codes (DTCs) return, contact the Bendix Tech Team at 1-800-AIR-BRAKE (1-800-247-2725) for further troubleshooting assistance.
10	ECU DTC '18'	
11	ECU DTC '1A'	
12	ECU DTC '1B'	
13	ECU DTC '80'	
14	ECU DTC '04'	
15	ECU DTC '06'	
16	ECU DTC '0E'	
17	ECU DTC '0D'	
18	Invalid ESP Configuration ECU DTC '19'	***See 13-8 above...*** Additionally, a 13-19 DTC can be the result of a parameter file not having been downloaded. To verify that vehicle-specific parameters have been loaded, contact Bendix for more information at 1-800-AIR-BRAKE (1-800-247-2725).
19	ECU DTC '1C'	13-19 through 13-24: Check for damaged or corroded connectors. Check for damaged wiring including power and ground wiring. Clear the trouble codes. If DTCs return, contact the Bendix Tech Team at 1-800-AIR-BRAKE (1-800-247-2725) for further troubleshooting assistance.
20	ECU DTC '27'	
21	ECU DTC '1D'	
22	ECU DTC '1E'	
23	ECU DTC '28'	
24	ECU DTC '37'	
25	ECU Internal VIN Mismatch	The ECU internally-stored VIN does not match the VIN of the vehicle. Ensure that the ECU is installed on the correct vehicle. Verify ECU programming. Verify engine programming.

Troubleshooting Diagnostic Trouble Codes: Traction Control Valves

1st. Blink Code	Location
18	Drive Axle Traction Control Valve
19	Steer Axle Traction Control Valve

NOTE: Also see ECU 13-8 and 13-18 DTC repair information on page 36, for a potential connection between these TCV DTCs and ECU DTCs.



2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	TCV Solenoid Shorted to Ground	Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and ground. Check for corroded/damaged wiring or connectors between ECU and TCV.
2	TCV Solenoid Shorted to Voltage	Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and voltage. Check for corroded/damaged wiring or connectors between ECU and TCV.
3	TCV Solenoid Open Circuit	Verify 7 to 19 ohms between TCV and TCV common. Check for corroded/damaged wiring or connectors between ECU and TCV.
4	TCV Configuration Error	The ECU is not configured for ESP or ATC, but has detected the presence of a TCV. Verify TCV wiring. Inspect for the presence of a TCV. Verify ECU configuration.

ATR valve inspections should include: looking for kinked air hoses; inside the harness socket on the valve for removed or corroded connector pins; and a test to verify that the ATC valve solenoids are functioning correctly.

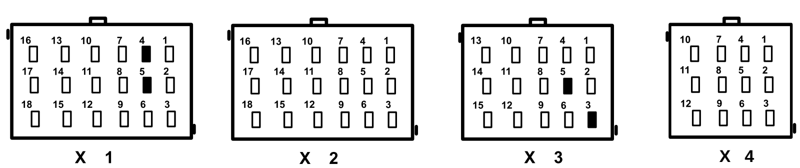
Traction Control Valve Repair Tests:

1. Take all measurements at ECU harness connector pins in order to check wire harness and traction control valve. Probe the connector carefully so that the terminals are not damaged.
2. Tractor Control Valve resistance measurements should read:

Location	Measurement
TCV to TCV Common	7 to 19 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)

Cab-mount ECU:

Looking into wire harness connector



Connector	Pin	Traction Control Test
X1	4	Drive Axle Traction Control Valve Common
18 Way	5	Drive Axle Traction Control Valve

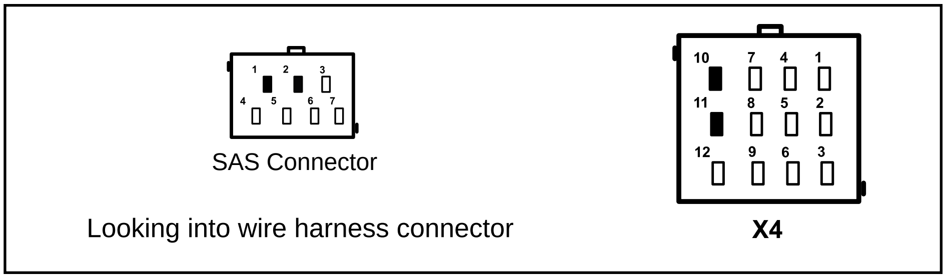
Connector	Pin	Traction Control Test
X3	3	Steer Axle Traction Control Valve Common
15 Way	5	Steer Axle Traction Control Valve

Troubleshooting Diagnostic Trouble Codes: Steering Angle Sensor (SAS-60™ sensor)

1st. Blink Code 21 — **Location: Steering Angle Sensor**

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	SAS Not Calibrated	SAS has not been calibrated. Perform SAS calibration procedure.
2	SAS Calibration in Progress	SAS calibration procedure is underway.
3	SAS Static Signal	SAS signal incorrect. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output.
4	SAS Signal Out of Range	SAS signal incorrect. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output. Perform SAS calibration procedure.
5	SAS Signal Reversed	SAS signal is reversed. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output.
6	SAS Invalid Signal	SAS signal is invalid. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output. Verify that correct SAS is being used.
7	SAS Gradient Error	SAS signal is invalid. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output. Verify that correct SAS is being used.
8	SAS CAN Timeout	Loss of CAN communications between the ECU and the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output.
9	SAS Long Term Calibration Error	SAS calibration error. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output. Verify that correct SAS is being used. Verify proper ECU programming. Perform SAS calibration procedure.
10	SAS Plausibility Check	ECU has detected incorrect SAS signal as compared to the Yaw Rate sensor signal. Verify proper installation of the SAS. Verify proper wiring between the ECU and the SAS. Check SAS output. Verify that correct SAS is being used. Verify proper ECU programming. Perform SAS calibration procedure.

Troubleshooting Diagnostic Trouble Codes: Steering Angle Sensor (SAS-60™ sensor) (continued)



(Note: When checking for voltage at YAW/LAS & SAS, the voltage will only be present momentarily at key ON.).

Steering Angle Sensor Tests

1. Measure resistance between input voltage and ground at the sensor wiring harness connector.

Verify continuity between ECU and SAS-60 and YAS-60.

Connector	Pin	Function
SAS	2	Voltage Input
	1	Ground Input
ECU		
X4	11	Power
12 Way	10	Common

2. Verify wiring between the Steering Angle Sensor and the ECU.

SAS Wire Harness Terminal	ECU Wire Harness Terminal	Measurement
4	7	Verify Continuity
3	8	Verify Continuity

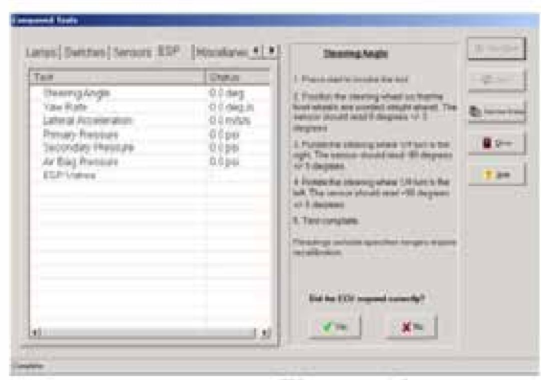
3. Verify wiring between the Steering Angle Sensor and power/ground.

SAS Wire Harness Terminal	Measurement
4 to Voltage & Ground	Verify open circuit (no continuity)
3 to Voltage & Ground	Verify open circuit (no continuity)

4. To perform a calibration procedure of the Steering Angle Sensor, ACom® Diagnostics V4.0 or higher is required. Using the program, select the "Configuration" option, followed by the "Calibrate" option. The following screen should be displayed.

5. Follow the prompts to perform a calibration of the Steering Angle Sensor.

6. To test the Steering Angle Sensor, ACom V4.0, or higher, is required. Using Bendix ACom V4.0 or higher, select the "Component Test" option, followed by the "ESP Test" option. The following screen should be displayed.



7. Follow the prompts to perform a test of the Steering Angle Sensor.

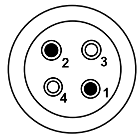
Troubleshooting Diagnostic Trouble Codes: Yaw Rate Sensor (YRS)

1st. Blink Code 22

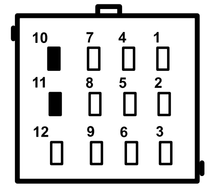
Location: **Yaw Rate Sensor**

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	YRS Signal Out of Range	YRS signal incorrect. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Perform YRS calibration procedure.
2	YRS Sensor Reversed Signal	YRS signal is reversed. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output.
3	YRS Invalid Signal	YRS signal is invalid. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used.
4	YRS Gradient Error	YRS signal is invalid. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used.
5	YRS CAN Timeout	Loss of CAN communications between the ECU and the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output.
6	YRS Static BITE Error	YRS signal fails static self-test. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
7	YRS Dynamic BITE Error	YRS signal fails self-test conducted while vehicle is in motion. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
8	YRS Fast Calibration Error	YRS calibration error. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
9	YRS Static Calibration Error	YRS calibration error. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
10	YRS Normal Calibration Error	YRS calibration error. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
11	YRS Sensitivity Calibration Error	YRS calibration error. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
12	YRS Plausibility Check (Ref Yaw Rate)	ECU has detected an incorrect YRS signal. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
13	YRS Plausibility Error (Inside Model Based Limits)	ECU has detected an incorrect YRS signal. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
14	YRS Plausibility Error (Outside Model Based Limits)	ECU has detected an incorrect YRS signal. Verify proper installation of the YRS. Verify proper wiring between the ECU and the YRS. Check YRS output. Verify that correct YRS is being used. Verify proper ECU programming. Perform YRS calibration procedure.
15	YRS - SAS Signal Cross-check Incomplete	ECU (if configured) must confirm that YRS and SAS signals match. The vehicle must be exposed to an S-shaped driving maneuver for this DTC to automatically clear. If the DTC does not clear even after the S-shaped driving maneuver, check and correct the orientation of the YRS and repeat maneuver.
16	YRS - Vibration Detected	Inspect YRS mounting and verify it is securely mounted. Note that YRS may not be relocated from OEM-installed position on vehicle without written Bendix Engineering approval.

Troubleshooting Diagnostic Trouble Codes: Yaw Rate Sensor (YRS) (continued)



Yaw Connector



Looking into wire harness connector

X4

(Note: When checking for voltage at YAW/LAS & SAS, the voltage will only be present momentarily at key ON.).

Yaw Rate Sensor Tests

1. Verify continuity between ECU and YAS-60.

Connector	Pin	Function
YAS	1	Power
	2	Ground
ECU		
X4	11	Power
12 Way	10	Common

2. Verify wiring between the Yaw Rate Sensor and the ECU.

YRS Wire Harness Terminal	ECU Wire Harness Terminal	Measurement
4	7	Verify Continuity
3	8	Verify Continuity

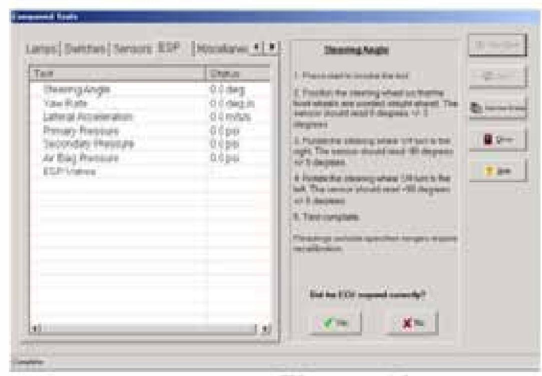
3. Verify wiring between the Yaw Rate Sensor and power/ground.

YRS Wire Harness Terminal	Measurement
4 to Voltage & Ground	Verify open circuit (no continuity)
3 to Voltage & Ground	Verify open circuit (no continuity)

4. To perform a calibration procedure of the Yaw Rate Sensor, AComⓇ Diagnostics V4.0 or higher is required. Using the program, select the “Configuration” option, followed by the “Calibrate” option. The following screen should be displayed.

5. Follow the prompts to perform a calibration of the Yaw Rate Sensor.

6. To test the Yaw Rate Sensor, ACom V4.0, or higher, is required. Using Bendix ACom V4.0 or higher, select the “Component Test” option, followed by the “ESP Test” option. The following screen should be displayed.



7. Follow the prompts to perform a test of the Yaw Rate Sensor.

Troubleshooting Diagnostic Trouble Codes: Lateral Acceleration Sensor (LAS)

1st. Blink Code	Location:
23	Lateral Acceleration Sensor

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	LAS Signal Out of Range	LAS signal incorrect. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Perform LAS calibration procedure.
2	LAS Calibration in Progress	LAS calibration procedure is underway.
3	LAS Static Calibration Error	LAS calibration error. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Verify that correct YRS/LAS is being used. Verify proper ECU programming. Perform LAS calibration procedure.
4	LAS Long Term Calibration Error	LAS calibration error. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Verify that correct YRS/LAS is being used. Verify proper ECU programming. Perform LAS calibration procedure.
5	LAS Plausibility Error (Inside ECU-specific Limits)	ECU has detected an incorrect LAS signal. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Verify that correct YRS/LAS is being used. Verify proper ECU programming. Perform LAS calibration procedure.
6	LAS Plausibility Error (Outside ECU –specific Limits)	ECU has detected an incorrect LAS signal. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Verify that correct YRS/LAS is being used. Verify proper ECU programming. Perform LAS calibration procedure.
7	Erratic ESP Sensor Signal	ECU has detected an erratic signal. Verify proper installation of the YRS/LAS. Verify proper wiring between the ECU and the YRS/LAS. Check YRS/LAS output. Verify that correct YRS/LAS is being used. Verify proper ECU programming. Perform LAS calibration procedure.

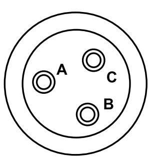
(Note: When checking for voltage at YRS/LAS & SAS, the voltage will only be present momentarily at key ON.).

1. Follow the steps shown in the Yaw Rate Sensor troubleshooting section for calibration and troubleshooting of the Lateral Acceleration Sensors.

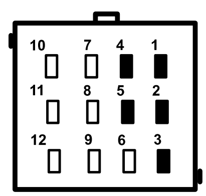
Troubleshooting Diagnostic Trouble Codes
Brake Demand/Load Sensors

1st. Blink Code	Location:
24	Brake Demand/ Load Sensor

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	PS1 Open or Shorted	Check wiring between Brake Demand Sensor (primary brake circuit) and ECU. Verify operation of pressure sensor.
2	PS2 Open or Shorted	Check wiring between Brake Demand Sensor (secondary brake circuit) and ECU. Verify operation of pressure sensor.
3	PS3 Open or Shorted	Check wiring between Load Sensor and ECU. Verify operation of pressure sensor.
4	PS1/2 Plausibility Error	ECU has detected an invalid pressure sensor signal from one of the Brake Demand Sensors.
5	PS Supply Voltage Error	Incorrect supply voltage to the sensors. Verify proper voltage at sensor connectors. Verify wiring between the ECU and the sensors. Verify proper output voltage from the ECU (Specifically, ensure that X4-4 PS_SPL is not shorted to ground).
6	PS Not Calibrated	Perform static sensor calibration procedure. *(NOTE: When replacing an ECU, this DTC may occur.)*
7	PS Error	Verify operation of pressure sensor.



Looking into wire harness connector



X4

Brake Demand/Load Sensor Tests

1. Verify continuity between the ECU and the pressure sensor power and ground.

Test	Measurement
Power and Ground Input	X4 - 4 Power
B = Power Input	X4 - 1 Common
A = Ground Input	

2. Verify wiring between the Load Sensor and the ECU.

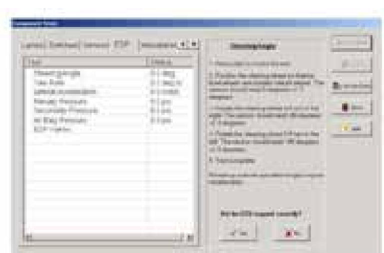
Load Sensor Wire Harness Terminal	ECU Wire Harness Terminal	Measurement
C	X4 - 2 Brake Demand Sensor (primary brake circuit)	Verify Continuity
	X4 - 5 Brake Demand Sensor (secondary brake circuit)	Verify Continuity
	X4 - 3 Load Sensor	Verify Continuity

3. Verify wiring between the Load Sensor and power/ ground.

Load Sensor Harness Terminal	Measurement
C to Voltage & Ground	Verify open circuit (no continuity)

4. To perform a calibration procedure of the Brake Demand Sensor(s), ensure that the air system is fully charged. Apply ignition power, and wait 30 seconds. Perform a full application of the service brake and hold for 5 seconds. Release the service brake.

5. To test the Brake Demand Sensor and/or the Load Sensor, ACom V4.0 or higher is required. Using the program, select the "Component Test" option, followed by the "ESP Test" option. The following screen should be displayed.

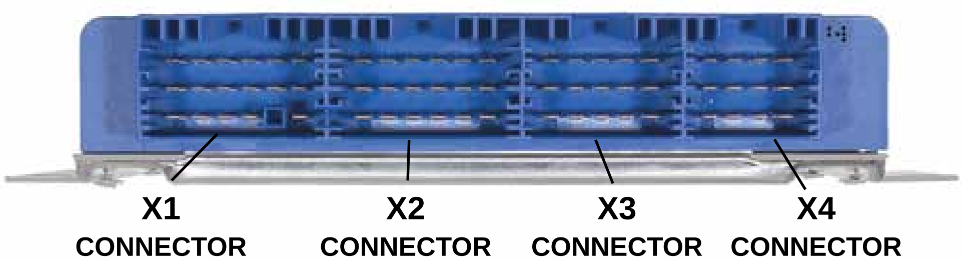


6. Follow the prompts to test the Brake Demand Sensor(s) and/or the Load Sensor.

Troubleshooting: Connectors

Bendix® EC-60™ Controller Wire Harness
Connector Part Numbers and Pin Assignments:

ADVANCED CAB



Advanced Cab Bendix EC-60 Controller

Advanced cab models utilize four AMP connectors for wire harness connections.

	X1 Connector Pin Assignments	X2 Connector Pin Assignments	X3 Connector Pin Assignments	X4 Connector Pin Assignments
Pin	Designation	Designation	Designation	Designation
1	Ground	PMV SA Left HLD	ABS ORS	Pressure Sensor CMN
2	Trailer ABS Indicator	PMV SA Left REL	Diff. Lock SOL*	Brake Demand Primary CKT Signal
3	Ignition	PMV SA Left CMN	TCV CMN (SA)	Load Sensor Signal
4	TCV CMN (DA)	PMV SA Right HLD	PMV AA Left HLD	Pressure Sensor Supply
5	TCV (DA)	WSS SA Left (+)	TCV (SA)	Brake Demand Secondary CKT Signal
6	ATC/ESP Indicator and ATC ORS	PMV SA Right CMN	PMV AA Left CMN	PMV Trailer HLD
7	J1939 Low	PMV SA Right REL	PMV AA Left REL	Sensor CAN Low
8	J1939 High	WSS SA Left (-)	Stop Lamp Output	Sensor CAN High
9	SLS Input	PMV DA Right CMN	PMV AA Right CMN	PMV Trailer REL
10	WSS DA Right (+)	PMV DA Right HLD	PMV AA Right HLD	Sensor CAN Common
11	WSS DA Right (-)	WSS SA Right (+)	WSS AA Left (+)	Sensor CAN Supply
12	ABS Indicator Ground	PMV DA Left CMN	WSS AA Right (+)	PMV Trailer CMN
13	J1587 (B)	PMV DA Right REL	PMV AA Right REL	
14	J1587 (A)	WSS SA Right (-)	WSS AA Left (-)	
15	ABS Indicator Interlock	WSS DA Left (+)	WSS AA Right (-)	
16	Battery	PMV DA Left HLD		
17	Retarder	PMV DA Left REL		
18	ABS Dash Indicator	WSS DA Left (-)		
*AWD vehicles only. (AWD Transfer Case)				

Troubleshooting: Wiring

ABS/ATC WIRING

ECU Wiring Harness Connectors

The Advanced Bendix® EC-60™ controller is designed to interface with AMP MCP 2.8 connectors as referenced in Chart 4. Follow all AMP requirements for the repair of wire harnesses.

All wire harness connectors must be properly seated. The use of secondary locks is strongly advised.

CAUTION: All unused ECU connectors must be covered and receive proper environmental protection.

ABS Wiring Requirements

As a matter of good practice and to ensure maximum system robustness, always use the maximum size wire supported by the wire harness connectors for battery, ignition, ground, PMV, TCV, Interaxle Differential Lock and indicator lamp circuits.

All sensor and serial communications circuits (J1587 and J1939) must use twisted pair wiring (one to two twists per inch). See the appropriate SAE document for additional details.

CAUTION: All wires must be carefully routed to avoid contact with rotating elements. Wiring must be properly secured approximately every 6 to 12 inches using UV stabilized, non-metallic hose clamps or bow-tie cable ties to prevent pinching, binding or fraying.

It is recommended that wires be routed straight out of a connector for a minimum of three inches before the wire is allowed to bend.

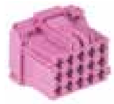
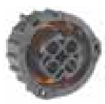
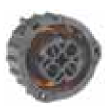
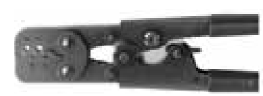
Battery and ground wires should be kept to a minimum length.

If convoluted tubing is used, its I.D. must match the size of the wire bundle as closely as possible.

CAUTION: Wire harness lengths must be carefully selected for the vehicle. Excess lengths of wire are **not** to be wound to form coils, instead re-route, repair or replace wire harness to avoid the possibility of electrical interference and wire damage. Do not attempt to stretch harnesses that are too short, since mechanical strain can result in wire breakage.

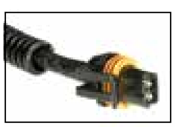
SAS-60™ Sensors and YAS-60™, or YAS-70X™, Sensor Wiring

If it is necessary to replace the wiring that connects the SAS-60™ or the Yaw Rate sensor to the ECU, it is important to use the same wiring as that used by the vehicle OEM.

ABS Component	Connector	Wire Terminal	Wire Seal/ Plug	Terminal Lock	Terminal Crimp Tool
In-Cab Controller Harness 17-Way AMP MCP 2.8 (X1)	 1718091-1	 927768-9 1 - 2.5 mm^2 X1-12 & 18	N/A	 967634	 539723-2
In-Cab Controller Harness 18-Way AMP MCP 2.8 (X2)	 8-968974-1		N/A	N/A	
In-Cab Controller Harness 15-Way AMP MCP 2.8 (X3)	 8-968973-1	968874 2.5 - 4 mm^2 	N/A	N/A	
Controller Harness 12-Way AMP MCP 2.8 (X4)	 8-968972-1	968873 1.0 - 2.5 mm^2	N/A	N/A	
ABS Modulator Harness AMP Twist-Lock (Bayonet)	 1-967325-2	 929975-1	N/A	N/A	 539635-1
ATC Modulator Harness AMP Twist-Lock (Bayonet)	 1-967325-3		N/A	N/A	
ABS Modulator Harness 3-pin Packard Metri-Pack 280 Series	 12040977	 12077411	 12015323	 12034145	 12155975

WS-24™ Wheel Speed Sensor Connectors


Packard GT 150 series


Packard Metripack 150.2 series


Deutsch DTM06 series


Packard Metripack 280 series (female)


Packard Metripack 280 series (male)


Deutsch DT04 series


Standard round two pin

Yaw Rate Sensor Wire Harness Connectors (4 contact):
Straight Connector: Schlemmer 9800 351 (shown)
AMP Connector 2-967325-1
ITT Cannon Connector 121583-001
90 degree Connector: Schlemmer 9800 331

Yaw Rate Sensor Wire Harness Contact Pin Terminals:
Schlemmer 7814 125
AMP 0-962981-1
ITT Cannon 031-8717-120

Brake Demand Sensor/Load Sensor Wire Harness Connectors:
Metri-Pack (Packard) 1206 5287
Contact Pins:
Packard 1210 3881

SAS-60™ Sensor Connectors:
Robert Bosch 1 928 404 025,
Robert Bosch 1 928 498 001
One Meter Adapter to Connector:
Bendix 5015242 (shown)
Packard 12092162, pins 12064971

CHART 4 - *EC-60™ CONTROLLER COMPONENT CONNECTORS*

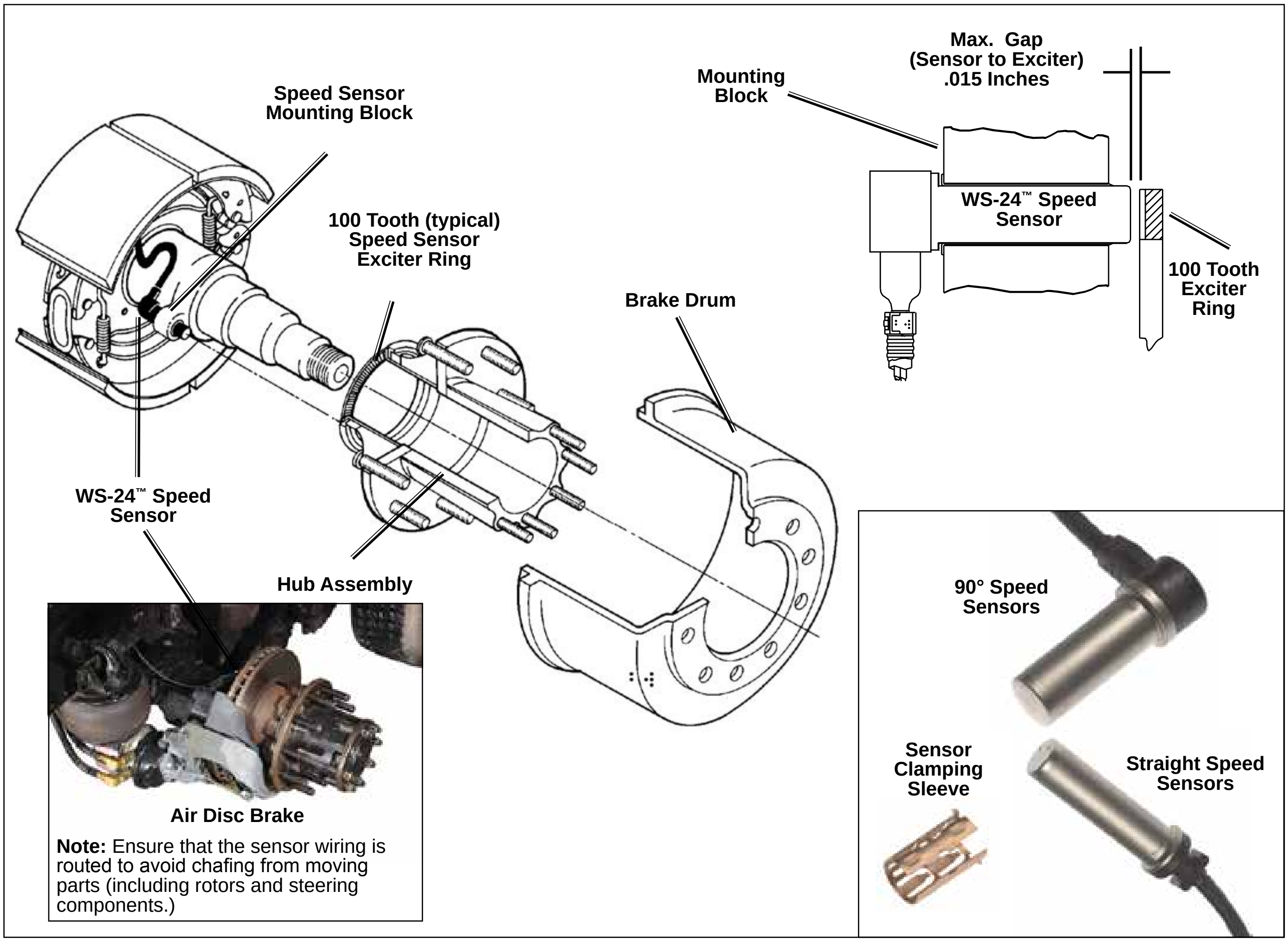


FIGURE 19 - *WS-24™ WHEEL SPEED SENSOR INSTALLATION (S-CAM AND AIR DISC BRAKE)*

Wheel Speed Sensor Wiring

Route sensor wiring coming out of the wheel ends away from moving brake components. Sensor wiring needs to be secured to the axle to prevent excess cable length and wiring damage. It is required that cable ties be installed to the sensor wire within 3 inches (76.2 mm) of the sensor head to provide strain relief.

Following the axle, the sensor wires must be attached along the length of the service brake hoses using cable ties with ultraviolet protection and secured every 6 to 8 inches (152 to 203 mm). Sufficient – but not excessive – cable length must be provided to permit full suspension travel and steering axle movement. Install wires so that they cannot touch rotating elements such as wheels, brake discs or drive shafts. Radiation protection may be necessary in the area of brake discs.

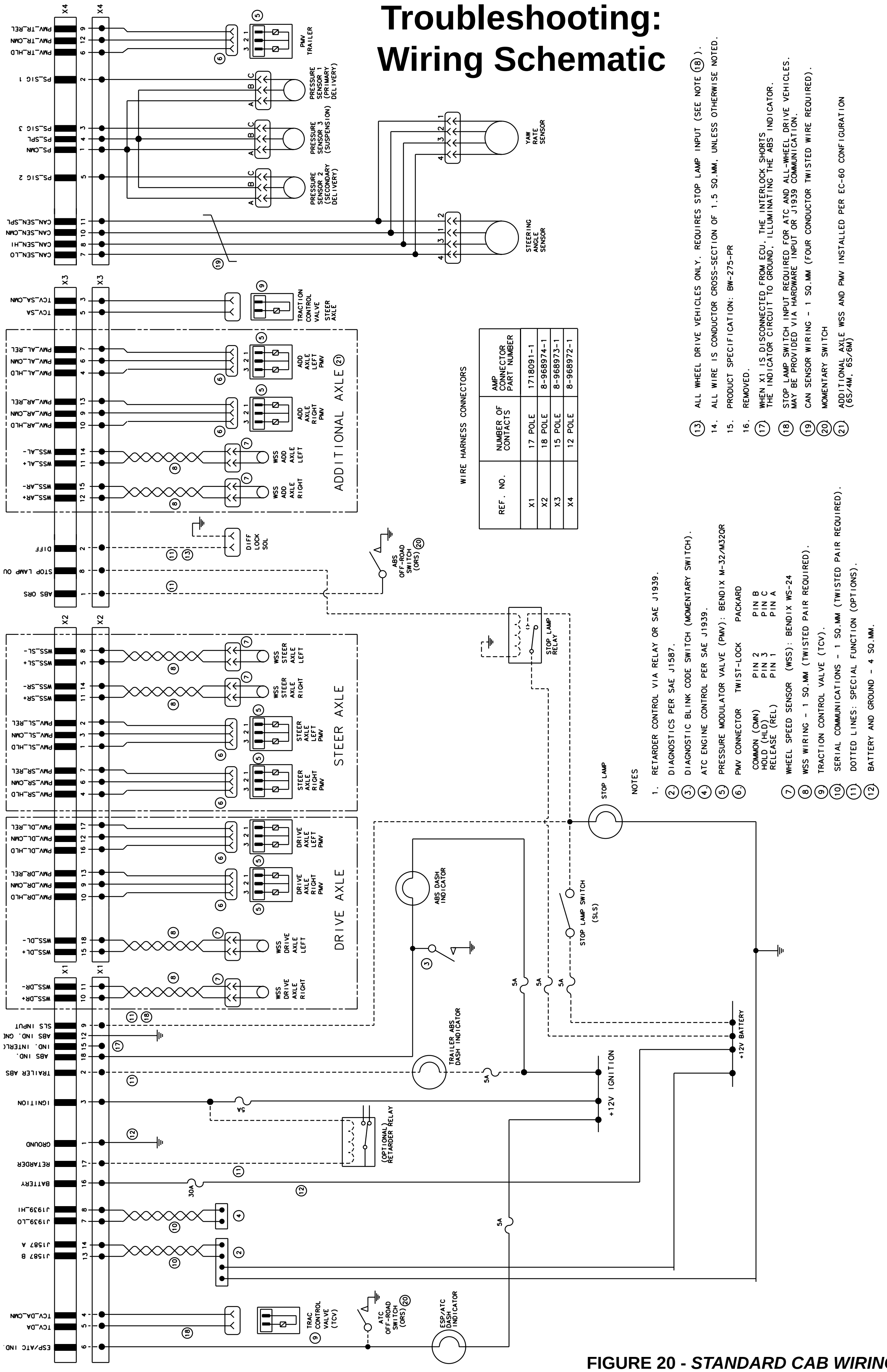
Bendix does not recommend using standard tie-wraps to secure wiring harnesses directly to rubber air lines. This may cause premature wiring failure from the pressure exerted on the wiring when air pressure is applied through the air line. Non-metallic hose clamps or bow-tie tie-wraps are preferred.

The use of grommets or other suitable protection is required whenever the cable must pass through metallic frame members.

All sensor wiring must utilize twisted pair wire, with approximately one to two twists per inch.

It is recommended that wires be routed straight out of a connector for a minimum of three inches before the wire is allowed to bend.

Troubleshooting: Wiring Schematic



REF. NO.	NUMBER OF CONTACTS	AMP CONNECTOR PART NUMBER
X1	17 POLE	1718091-1
X2	18 POLE	8-968974-1
X3	15 POLE	8-968973-1
X4	12 POLE	8-968972-1

FIGURE 20 - ***STANDARD CAB WIRING SCHEMATIC***

Glossary

ABS — Antilock Brake System.

ABS Event — Impending wheel lock situation that causes the ABS controller to activate the modulator valve(s).

ABS Indicator Lamp — An amber lamp which indicates the operating status of an antilock system. When the indicator lamp is on, ABS is disabled and the vehicle reverts to normal brake operation.

Air Gap — Distance between the Sensor and tone ring.

ASR — Automatic Slip Regulation. Another name for traction control.

ATC — Automatic Traction Control. An additional ABS function in which engine torque is controlled and brakes are applied differentially to enhance vehicle traction.

ATC/ESP Lamp — A lamp that indicates when stability functions, including traction control, roll stability program or yaw control are operating.

Channel — A controlled wheel site.

CAN — Controller Area Network. J1939 is an SAE version of the CAN link.

Clear Codes — System to erase historical diagnostic trouble codes from the ECU, from either the Diagnostic Switch or from a hand-held diagnostic tool (only repaired diagnostic trouble codes may be cleared).

Configuration — The primary objective is to identify a "normal" set of sensors and modulators for the Electronic Control Unit, so that it will identify future missing sensors and modulators.

Diagnostic Connector — Diagnostic receptacle in vehicle cab for connection of J1587 hand-held or PC based test equipment. The tester can initiate test sequences, and can also read system parameters.

Diagnostic Switch — A switch used to activate blinks codes.

Differential Braking — Application of brake force to a spinning wheel so that torque can be applied to wheels which are not slipping.

ECU — Electronic Control Unit.

ESP — Electronic Stability Program. Full stability function that includes RSP & YC subfunctions.

Diagnostic Trouble Code — A condition that interferes with the generation or transmission of response or control signals in the vehicle's ABS system that could lead to the functionality of the ABS system becoming inoperable in whole or in part.

FMVSS-121 — Federal Motor Vehicle Safety Standard which regulates air brake systems.

HSA — Hill Start Assist. HSA interfaces between the transmission and braking system to help the driver prevent the vehicle from rolling downhill when moving up a steep incline from a stationary position.

IR — Independent Regulation. A control method in which a wheel is controlled at optimum slip, a point where retardation and stability are maximized. The brake pressure that is best for the wheel in question is directed individually into each brake chamber.

J1587 — The SAE heavy duty standard diagnostic data link.

J1708 — An SAE standard which defines the hardware and software protocol for implementing 9600 baud heavy vehicle data links. J1587 version of a J1708 data link.

J1939 — A high speed data link used for communications between the ABS ECU engine, transmission and retarders.

LAS — Lateral Acceleration Sensor.

MIR — Modified Independent Regulation. A method of controlling the opposite sides of a steer axle during ABS operation so that torque steer and stopping distance are minimized.

PLC — Power Line Carrier. The serial communication protocol used to communicate with the trailer over the blue full time power wire.

PMV — Pressure Modulator Valve. An air valve which is used to vent or block air to the brake chambers to limit or reduce brake torque.

QR — Quick Release. Quick release valves allow faster release of air from the brake chamber after a brake application. To balance the system, quick release valves have hold off springs that produce higher crack pressures (when the valves open).

Relay Valve — Increases the application speed of the service brake. Installed near brakes with larger air chambers (type 24 or 30). The treadle valve activates the relay valve with an air signal. The relay valve then connects its supply port to its delivery ports. Equal length air hose must connect the delivery ports of the relay valve to the brake chambers.

Retarder Relay — A relay which is used to disable a retarder when ABS is triggered.

RSP — Roll Stability Program. An all-axle ABS solution that helps reduce vehicle speed by applying all vehicle brakes as needed, reducing the tendency to roll over.

SAS — Steering Angle Sensor.

Sensor Clamping Sleeve — A beryllium copper sleeve which has fingers cut into it. It is pressed between an ABS sensor and mounting hole to hold the sensor in place.

Stored Diagnostic Trouble Codes — A diagnostic trouble code that occurred.

TCS — Traction Control System, another name for ATC or ASR.

Tone Ring — A ring that is usually pressed into a wheel hub that has a series of teeth (usually 100) and provides actuation for the speed sensor. Note maximum run out is .008.

YC — Yaw Control. Helps stabilize rotational dynamics of vehicle.

YRS — Yaw Rate Sensor.

Advanced In-Cab ECU

1) Remove X1, X2, X3 and X4 connector from the ECU.
2) Using X1-1 as the ground connection, check for resistance for the entire X2 connector. There should be no resistance to ground found. Please fill out attached worksheet.
3) Using X1-1 as the ground connection, check for resistance for X1-4 and X1-5. There should be no resistance to ground.
4) Using X1-1 as the ground connection, check for resistance for X3-4, X3-6, X3-7, X3-9, X3-10, X3-13, X3-3 and X3-5. There should be no resistance to ground. (Even if the vehicle is not configured for 6S/6M).
5) Using X1-1 as the ground connection, check for resistance for X4-6, X4-9 and X4-12. There should be no resistance to ground.
6) Troubleshoot any pin that has resistance to ground. If no issues are found continue to step 7.
7) Reconnect the X1 connector only and apply IGN power to the ECU and using the DTC screen of Bendix® ACom® Diagnostics, clear all DTCs. Re-check for any DTCs. If the 12-7 DTC is still present, the problem is the Traction Solenoid Wiring or Solenoid.
8) If the 12-7 DTC does not reappear, remove power and connect the X2 connector, reapply power, then clear all DTCs. If the 12-7 DTC is no longer present, connect the X3 connector and clear all DTCs.
9) If at this point the 12-7 DTC is not present, the problem is with the X4 connector.

For Peterbilt® & Kenworth® Trucks Only:	
10)	Clear all DTCs. If the 12-7 DTC reappears, the issue is on the X4 connector. Otherwise, proceed to the next step.
11)	Disconnect all modulators and the traction solenoid. Clear all DTCs. If the DTC does not reappear, connect one modulator and Traction Solenoid at a time, until the DTC reappears. Otherwise, continue to the next step.
12)	Make sure all modulators and the traction solenoid are connected. Disconnect the ABS bulkhead connector at the engine (top-left side) and remove Pins 1, 2, 11 &12. Reconnect the connector and apply IGN power to the ECU. Using Bendix ACom Diagnostics, clear all DTCs. If the 12-7 DTC returns, the problem is either the wiring harness inside the cab or the ECU.

Record Resistances Below:

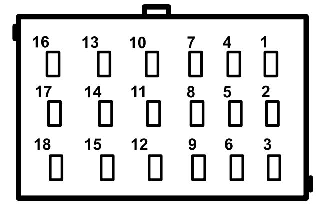
X1-1 for ground point

X1 Pin	Resistance
X1-4	
X1-5	

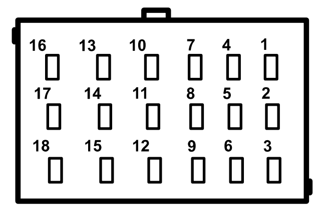
X2 Pin	Resistance
X2-1	
X2-2	
X2-3	
X2-4	
X2-5	
X2-6	
X2-7	
X2-8	
X2-9	
X2-10	
X2-11	
X2-12	
X2-13	
X2-14	
X2-15	
X2-16	
X2-17	
X2-18	

X3 Pin	Resistance
X3-4	
X3-5	
X3-6	
X3-7	
X3-8	
X3-9	
X3-10	
X3-13	

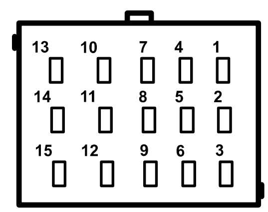
X4 Pin	Resistance
X4-6	
X4-9	
X4-12	



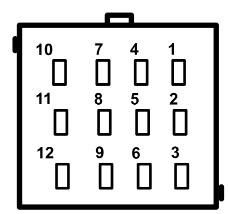
X 1



X 2



X 3



X 4

APPENDIX B: J1587 SID and FMI Codes and their Bendix Blink Code Equivalents					
SID (J1587)	SPN (J1939)	FMI (J1587/ J1939)	Bendix Blink Code Equivalent(s) (1st Digit)	(2nd Digit)	Diagnostic Trouble Code Description
-		-	1	1	No DTCs
Wheel Speed Sensor DTCs					
1	789	1	2	1	SA Left WSS Excessive Air Gap
1	789	2	2	3	SA Left WSS Open or Shorted
1	789	7	2	5	SA Left WSS Wheel End
1	789	8	2	6	SA Left WSS Erratic Sensor Signal
1	789	10	2	4	SA Left WSS Loss of Sensor Signal
1	789	13	2	7	SA Left WSS Tire Size Calibration
1	789	14	2	2	SA Left WSS Output Low @ Drive-Off
2	790	1	3	1	SA Right WSS Excessive Air Gap
2	790	2	3	3	SA Right WSS Open or Shorted
2	790	7	3	5	SA Right WSS Wheel End
2	790	8	3	6	SA Right WSS Erratic Sensor Signal
2	790	10	3	4	SA Right WSS Loss of Sensor Signal
2	790	13	3	7	SA Right WSS Tire Size Calibration
2	790	14	3	2	SA Right WSS Output Low @ Drive-Off
3	791	1	4	1	DA Left WSS Excessive Air Gap
3	791	2	4	3	DA Left WSS Open or Shorted
3	791	7	4	5	DA Left WSS Wheel End
3	791	8	4	6	DA Left WSS Erratic Sensor Signal
3	791	10	4	4	DA Left WSS Loss of Sensor Signal
3	791	13	4	7	DA Left WSS Tire Size Calibration
3	791	14	4	2	DA Left WSS Output Low @ Drive-Off
4	792	1	5	1	DA Right WSS Excessive Air Gap
4	792	2	5	3	DA Right WSS Open or Shorted
4	792	7	5	5	DA Right WSS Wheel End
4	792	8	5	6	DA Right WSS Erratic Sensor Signal
4	792	10	5	4	DA Right WSS Loss of Sensor Signal
4	792	13	5	7	DA Right WSS Tire Size Calibration
4	792	14	5	2	DA Right WSS Output Low @ Drive-Off
5	793	1	14	1	AA Left WSS Excessive Air Gap
5	793	2	14	3	AA Left WSS Open or Shorted
5	793	7	14	5	AA Left WSS Wheel End
5	793	8	14	6	AA Left WSS Erratic Sensor Signal
5	793	10	14	4	AA Left WSS Loss of Sensor Signal
5	793	13	14	7	AA Left WSS Tire Size Calibration
5	793	13	14	10	AA Left WSS Configuration Error
5	793	14	14	2	AA Left WSS Output Low @ Drive-Off
6	794	1	15	1	AA Right WSS Excessive Air Gap
6	794	2	15	3	AA Right WSS Open or Shorted
6	794	7	15	5	AA Right WSS Wheel End
6	794	8	15	6	AA Right WSS Erratic Sensor Signal
6	794	10	15	4	AA Right WSS Loss of Sensor Signal
6	794	13	15	7	AA Right WSS Tire Size Calibration
6	794	13	15	10	AA Right WSS Configuration Error
6	794	14	15	2	AA Right WSS Output Low @ Drive-Off
Pressure Modulator Valve DTCs					
7	795	5	7	7	SA Left PMV CMN Open Circuit
7	795	13	7	8	SA Left PMV Configuration Error
8	796	5	8	7	SA Right PMV CMN Open Circuit
8	796	13	8	8	SA Right PMV Configuration Error
9	797	5	9	7	DA Left PMV CMN Open Circuit
9	797	13	9	8	DA Left PMV Configuration Error
10	798	5	10	7	DA Right PMV CMN Open Circuit
10	798	13	10	8	DA Right PMV Configuration Error
11	799	5	16	7	AA Left PMV CMN Open Circuit
11	799	13	16	8	AA Left PMV Configuration Error
12	800	5	17	7	AA Right PMV CMN Open Circuit
12	800	13	17	8	AA Right PMV Configuration Error

SID (J1587)	SPN (J1939)	FMI (J1587/ J1939)	Bendix Blink Code Equivalent(s) (1st Digit)	(2nd Digit)	Diagnostic Trouble Code Description
APPENDIX B: J1587 SID and FMI Codes and their Bendix Blink Code Equivalents					
Miscellaneous DTCs					
13	801	2	12	4	Retarder Relay or HSA Lamp Open Circuit or Shorted to Ground
13	801	3	12	5	Retarder Relay Circuit or HSA Lamp Shorted to Voltage
17	576	14	12	3	Dynamometer Test Mode
17	614	14	12	9	ATC Disabled to Prevent Brake Fade
TCV DTCs					
18	806	3	18	2	TCV DA Solenoid Shorted to Voltage
18	806	4	18	1	TCV DA Solenoid Shorted to Ground
18	806	5	18	3	TCV DA Solenoid Open Circuit
18	806	13	18	4	TCV DA Configuration Error
19	807	3	19	3	TCV SA Solenoid Shorted to Voltage
19	807	4	19	1	TCV SA Solenoid Shorted to Ground
19	807	5	19	2	TCV SA Solenoid Open Circuit
19	807	13	19	4	TCV SA Configuration Error
Miscellaneous DTCs					
22	810	7	12	11	Wheel Speed Sensors Reversed on an Axle
23	811	2	12	6	ABS Dash Indicator Circuit DTC
Pressure Modulator Valve DTCs					
42	795	3	7	5	SA Left PMV HLD Solenoid Shorted to Voltage
42	795	4	7	4	SA Left PMV HLD Solenoid Shorted to Ground
42	795	5	7	6	SA Left PMV HLD Solenoid Open Circuit
43	796	3	8	5	SA Right PMV HLD Solenoid Shorted to Voltage
43	796	4	8	4	SA Right PMV HLD Solenoid Shorted to Ground
43	796	5	8	6	SA Right PMV HLD Solenoid Open Circuit
44	797	3	9	5	DA Left PMV HLD Solenoid Shorted to Voltage
44	797	4	9	4	DA Left PMV HLD Solenoid Shorted to Ground
44	797	5	9	6	DA Left PMV HLD Solenoid Open Circuit
45	798	3	10	5	DA Right PMV HLD Solenoid Shorted to Voltage
45	798	4	10	4	DA Right PMV HLD Solenoid Shorted to Ground
45	798	5	10	6	DA Right PMV HLD Solenoid Open Circuit
46	799	3	16	5	AA Left PMV HLD Solenoid Shorted to Voltage
46	799	4	16	4	AA Left PMV HLD Solenoid Shorted to Ground
46	799	5	16	6	AA Left PMV HLD Solenoid Open Circuit
47	800	3	17	5	AA Right PMV HLD Solenoid Shorted to Voltage
47	800	4	17	4	AA Right PMV HLD Solenoid Shorted to Ground
47	800	5	17	6	AA Right PMV HLD Solenoid Open Circuit
48	800	3	7	2	SA Left PMV REL Solenoid Shorted to Voltage
48	795	4	7	1	SA Left PMV REL Solenoid Shorted to Ground
48	795	5	7	3	SA Left PMV REL Solenoid Open Circuit
49	795	3	8	2	SA Right PMV REL Solenoid Shorted to Voltage
49	796	4	8	1	SA Right PMV REL Solenoid Shorted to Ground
49	796	5	8	3	SA Right PMV REL Solenoid Open Circuit
50	796	3	9	2	DA Left PMV REL Solenoid Shorted to Voltage
50	797	4	9	1	DA Left PMV REL Solenoid Shorted to Ground
50	797	5	9	3	DA Left PMV REL Solenoid Open Circuit
51	797	3	10	2	DA Right PMV REL Solenoid Shorted to Voltage
51	798	4	10	1	DA Right PMV REL Solenoid Shorted to Ground
51	798	5	10	3	DA Right PMV REL Solenoid Open Circuit
52	798	3	16	2	AA Left PMV REL Solenoid Shorted to Voltage
52	799	4	16	1	AA Left PMV REL Solenoid Shorted to Ground
52	799	5	16	3	AA Left PMV REL Solenoid Open Circuit
53	799	3	17	2	AA Right PMV REL Solenoid Shorted to Voltage
53	800	4	17	1	AA Right PMV REL Solenoid Shorted to Ground
53	800	5	17	3	AA Right PMV REL Solenoid Open Circuit
For more Pressure Modulator Valve DTCs - see SIDs 66 and 93 below...					

APPENDIX B: J1587 SID and FMI Codes and their Bendix Blink Code Equivalents					
SID (J1587)	SPN (J1939)	FMI (J1587/ J1939)	Bendix Blink Code Equivalent(s) (1st Digit)	(2nd Digit)	Diagnostic Trouble Code Description
Miscellaneous DTCs					
55	1045	2	12	2	Stop Lamp Switch Defective
55	1045	4	12	27	Brake Lamp Input Mismatch with Brake Lamp Output
55	1045	7	12	1	Stop Lamp Switch Not Detected
Pressure Modulator Valve DTCs					
66	1056	3	20	2	Trailer PMV REL Solenoid Shorted to Voltage
66	1056	3	20	5	Trailer PMV HLD Solenoid Shorted to Voltage
66	1056	4	20	1	Trailer PMV REL Solenoid Shorted to Ground
66	1056	4	20	4	Trailer PMV HLD Solenoid Shorted to Ground
66	1056	5	20	3	Trailer PMV REL Solenoid Open Circuit
66	1056	5	20	6	Trailer PMV HLD Solenoid Open Circuit
66	1056	5	20	7	Trailer PMV CMN Open Circuit
66	1056	7	20	8	PMV Configuration Error
For more Pressure Modulator Valve DTCs - see SID 93 below...					
Brake Demand/Load Sensor DTCs					
69	1059	2	24	3	Open or Shorted Load Sensor
77	1067	2	24	1	Shorted Brake Demand Sensor (Primary CKT) Open
77	1067	2	24	5	PS Supply Voltage Error
77	1067	7	24	6	PS Not Calibrated
77	1067	11	24	4	Plausibility Error Brake Demand Sensor
78	1068	2	24	2	Shorted Brake Demand Sensor (Secondary CKT) Open
Miscellaneous DTCs					
79	1069	13	12	10	Tire Size Out of Range (Front to Rear)
Steering Angle Sensor DTCs					
89	1807	2	21	3	SAS Static Signal
89	1807	2	21	4	SAS Signal Out of Range
89	1807	2	21	5	SAS Signal Reversed
89	1807	2	21	7	SAS Gradient Error
89	1807	2	21	9	SAS Long Term Calibration Error
89	1807	2	21	10	SAS Plausibility Check (Ref Yaw Rate)
89	1807	9	21	8	SAS CAN Timeout
89	1807	12	21	6	SAS Invalid Signal
89	1807	13	21	1	SAS Not Calibrated
89	1807	13	21	2	Steering Angle Sensor Calibration Not Finished
89	1808	13	22	15	YRS Sign Check Not Finished
Pressure Modulator Valve DTCs					
93	802	3	12	8	PMV Common Shorted to Voltage
93	802	4	12	7	PMV Common Shorted to Ground
HSA DTCs					
94	2622	2	12	4	HSA lamp shorted to ground or broken wire
94	2622	3	12	5	HSA lamp shorted to Voltage
94	2622	3	12	24	HSA solenoid shorted to Voltage (total shutdown)
94	2622	3	12	26	HSA solenoid shorted to Voltage (ATC & ESP shutdown)
94	2622	5	12	25	HSA solenoid shorted to ground or broken wire
94	2622	13	12	24	HSA solenoid shorted to Voltage
Lateral Acceleration Sensor DTCs					
99	1809	2	23	1	LAS Signal Out of Range
99	1809	2	23	3	LAS Static Calibration Error
99	1809	2	23	4	LAS Long Term Calibration Error
99	1809	2	23	5	LAS Plausibility Error (Inside ECU-Specific Limits)
99	1809	2	23	6	LAS Plausibility Error (Outside ECU-Specific Limits)
99	1809	13	23	2	LAS Calibration in Progress
99	1808	14	23	7	Erratic ESP Sensor Signal

APPENDIX B: J1587 SID and FMI Codes and their Bendix Blink Code Equivalents					
SID (J1587)	SPN (J1939)	FMI (J1587/ J1939)	Bendix Blink Code Equivalent(s)		Diagnostic Trouble Code Description
			(1st Digit)	(2nd Digit)	
Miscellaneous DTCs					
102	564	3	12	13	HSA Solenoid Shorted to Voltage (high)
102	564	5	12	12	HSA Solenoid Shorted to Ground (Low) or Open circuit
103	1808	2	12	14	Sensor CAN Supply Voltage Error
103	1808	2	12	22	ESP Sensor Voltage Out of Range
Yaw Rate Sensor DTCs					
103	1808	2	22	1	YRS Signal Out of Range
103	1808	2	22	2	YRS Sensor Reversed Signal
103	1808	2	22	3	YRS Invalid Signal
103	1808	2	22	4	YRS Gradient Error
103	1808	2	22	6	YRS Static BITE Error
103	1808	2	22	7	YRS Dynamic BITE Error
103	1808	2	22	8	YRS Fast Calibration Error
103	1808	2	22	9	YRS Static Calibration Error
103	1808	2	22	10	YRS Normal Calibration Error
103	1808	2	22	11	YRS Sensitivity Calibration Error
103	1808	2	22	12	YRS Plausibility Check (Ref Yaw Rate)
103	1808	2	22	13	YRS Plausibility Error (Inside ECU-Specific Limits)
103	1808	2	22	14	YRS Plausibility Error (Outside ECU-Specific Limits)
103	1808	2	22	16	Yaw Rate Sensor Vibration Detected
103	1808	9	22	5	YRS CAN Timeout
Miscellaneous					
151	611	14	12	18	wheel speed sensor failure in previous power on cycle
154	614	3	12	23	i/o 2 or i/o 3 Shorted to Voltage
J1939 DTCs					
231	639	2	11	3	J1939 Engine Communications
231	639	2	11	4	J1939 Invalid Data (Engine/Retarder)
231	639	2	11	5	J1939 Supply Pressure
231	639	2	11	6	J1939 ESP Messages Invalid Data
231	639	2	11	7	Timeout or invalid data on ETC7/VP15 (for HSA-function)
231	639	2	11	8	timeout or invalid data on XBR
231	639	2	11	10	Invalid Data From Transmisson
231	639	2	11	12	J1939 HSA switch error or unavailable
231	639	2	11	13	timeout or invalid data for ESP AWD operation
231	639	12	11	1	J1939 Serial Link
231	639	14	11	2	J1939 Retarder
Power Supply DTCs					
251	627	2	6	8	Input Voltage Excessive Noise (Temp.)
251	627	3	6	2	Battery Voltage Too High
251	627	3	6	6	Ignition Voltage Too High
251	627	4	6	1	Battery Voltage Too Low
251	627	4	6	3	Battery Voltage Too Low During ABS
251	627	4	6	5	Ignition Voltage Too Low
251	627	4	6	7	Ignition Voltage Too Low During ABS
251	627	5	6	4	Battery Voltage Input Open Circuit
251	627	14	6	9	Input Voltage Excessive Noise (Latched)

APPENDIX B: J1587 SID and FMI Codes and their Bendix Blink Code Equivalents					
SID (J1587)	SPN (J1939)	FMI (J1587/ J1939)	Bendix Blink Code Equivalent(s)		Diagnostic Trouble Code Description
			(1st Digit)	(2nd Digit)	
ECU DTCs					
253	630	12	13	19	ECU (1C)
253	630	12	13	20	ECU (27)
253	630	13	13	21	ECU (1D)
253	630	13	13	22	ECU (1E)
253	630	13	13	23	ECU (28)
254	629	2	13	4	ECU (12)
254	629	2	13	5	ECU (13)
254	629	2	13	7	ECU (15)
254	629	2	13	17	ECU (0D)
254	629	2	13	18	Invalid ESP Configuration
254	629	12	13	1	ECU (02)
254	629	12	13	2	ECU (10)
254	629	12	13	3	ECU (11)
254	629	12	13	6	ECU (14)
254	629	12	13	10	ECU (18)
254	629	12	13	11	ECU (1A)
254	629	12	13	12	ECU (1B)
254	629	12	13	13	ECU (80)
254	629	12	13	14	ECU (04)
254	629	12	13	15	ECU (06)
254	629	12	13	16	ECU (0E)
254	629	12	13	24	ECU (37)
254	629	12	13	25	ECU Internal VIN Mismatch
254	629	13	13	8	Invalid ABS Configuration
254	630	13	13	9	ECU (17)

APPENDIX C: UDS Codes and their Bendix Blink Code Equivalents						
UDS Code	**US-Spec. Blink Code**	**J1587 PID194 (SID/ FMI)**	**J1939/73 DM1/2 SPN/FMI**	**DTC Description**	**Lamp Status**	
					ABS	ATC/ ESP
0	01-01	000-00	---	no DTC	-	-
1	14-03	005-02	0793-02	AA Left WSS Open or Shorted	ON	ON
3	14-10	005-13	0793-13	AA Left WSS Configuration Error	ON	ON
4	13-14	254-12	0629-12	ECU (04)	ON	ON
5	14-05	005-07	0793-07	AA Left WSS Wheel End	ON	ON
6	13-15	254-12	0629-12	ECU (06)	ON	ON
7	14-01	005-01	0793-01	AA Left WSS Excessive Air Gap	ON	ON
8	14-02	005-14	0793-14	AA Left WSS Output Low @ Drive-Off	ON	ON
9	14-06	005-08	0793-08	AA Left WSS Erratic Sensor Signal	ON	ON
10	14-04	005-10	0793-10	AA Left WSS Loss of Sensor Signal	ON	ON
13	13-17	254-02	0629-02	ECU (0D)	ON	ON
14	13-16	254-12	0629-12	ECU (0E)	ON	ON
15	12-14	103-02	1808-02	Sensor CAN Supply Voltage Error	-	ON
16	13-02	254-12	0629-12	ECU (10)	ON	ON
17	13-03	254-12	0629-12	ECU (11)	ON	ON
18	13-04	254-02	0629-02	ECU (12)	ON	ON
19	13-05	254-02	0629-02	ECU (13)	ON	ON
20	13-06	254-12	0629-12	ECU (14)	ON	ON
21	13-07	254-02	0629-02	ECU (15)	ON	ON
22	13-08	254-13	0630-13	ECU (16)	ON	ON
23	13-09	254-13	0630-13	ECU (17)	ON	ON
24	13-10	254-12	0630-12	ECU (18)	ON	ON
25	13-18	254-02	0629-02	ECU (19)	ON	ON
26	13-11	254-12	0802-12	ECU (1A)	ON	ON
27	13-12	254-12	0802-12	ECU (1B)	ON	-
28	13-19	253-12	0630-12	ECU (1C)	-	-
29	13-21	253-13	0630-13	ECU (1D)	ON	ON
30	13-22	253-13	0630-13	ECU (1E)	ON	ON
32	06-06	251-03	0627-03	Ignition Voltage Too High	ON	ON
33	06-05	251-04	0627-04	Ignition Voltage Too Low	ON	ON
34	06-07	251-04	0627-04	Ignition Voltage Too Low During ABS	ON	ON
35	06-02	251-03	0627-03	Battery Voltage Too High	ON	ON
36	06-01	251-04	0627-04	Battery Voltage Too Low	ON	ON
37	06-03	251-04	0627-04	Battery Voltage Too Low During ABS	ON	ON
38	06-04	251-05	0627-05	Battery Voltage Input Open Circuit	ON	ON
39	13-20	253-12	0630-12	ECU (27)	ON	ON
40	13-23	253-13	0630-13	ECU (28)	ON	ON
41	12-08	093-03	0802-03	PMV Common Shorted to Voltage	ON	ON
42	12-07	093-04	0802-04	PMV Common Shorted to Ground	ON	ON
43	11-07	231-02	0639-02	Timeout or invalid CAN data for ETC7/VP15	-	-
44	11-04	231-02	0639-02	J1939 Invalid Data (Engine/Retarder)	-	ON
45	11-05	231-02	0639-02	J1939 Supply Pressure	-	ON
46	11-08	231-02	0639-02	Timeout or invalid CAN data - XBR	-	-

APPENDIX C: UDS Codes and their Bendix Blink Code Equivalents						
UDS Code	US-Spec. Blink Code	J1587 PID194 (SID/ FMI)	J1939/73 DM1/2 SPN/FMI	DTC Description	Lamp Status	
					ABS	ATC/ ESP
48	12-05	013-03	0801-03	Retarder Relay Circuit Shorted to Voltage	ON	-
48	12-05	094-03	2622-03	Retarder Relay Circuit or Hill Start Assist Lamp Shorted to Voltage	ON	-
49	12-04	013-02	0801-02	Retarder Relay Open Circuit or Shorted to Ground	ON	-
49	12-04	094-02	2622-02	Retarder Relay Circuit or Hill Start Assist Lamp open or Shorted to Ground	ON	-
50	19-02	019-05	0807-05	TCV SA Solenoid Open Circuit	ON	ON
51	11-01	231-12	0639-12	J1939 Serial Link	ON	ON
52	11-02	231-14	0639-14	J1939 Retarder	ON	ON
53	11-03	231-02	0639-02	J1939 Engine Communications	-	ON
54	11-10	231-02	0639-02	Invalid Data from Transmission	ON	-
55	13-24	254-12	0629-12	ECU (37)	-	ON
56	19-01	019-04	0807-04	TCV SA Solenoid Shorted to Ground	-	ON
57	19-03	019-03	0807-03	TCV SA Solenoid Shorted to Voltage	-	ON
58	18-03	018-05	0806-05	TCV DA Solenoid Open Circuit	-	ON
59	18-01	018-04	0806-04	TCV DA Solenoid Shorted to Ground	-	ON
60	18-02	018-03	0806-03	TCV DA Solenoid Shorted to Voltage	ON	ON
61	18-04	018-13	0806-13	TCV DA Configuration Error	ON	ON
62	19-04	019-13	0807-13	TCV SA Configuration Error	ON	ON
63	11-11	231-02	0639-02	Timeout or invalid CAN data - AUX I/O	-	-
64	24-03	069-02	1059-02	Open or Shorted Load Sensor	-	ON
65	02-03	001-02	0789-02	SA Left WSS Open or Shorted	ON	ON
66	24-01	077-02	1067-02	Shorted Brake Demand Sensor (Primary CKT) Open	-	ON
67	24-02	078-02	1068-02	Shorted Brake Demand Sensor (Secondary CKT) Open	-	ON
68	24-04	077-11	1067-11	Plausibility Error Brake Demand Sensor	-	ON
69	02-05	001-07	0789-07	SA Left WSS Wheel End	ON	ON
70	24-05	077-02	1067-02	PS Supply Voltage Error	-	ON
71	02-01	001-01	0789-01	SA Left WSS Excessive Air Gap	ON	ON
72	02-02	001-14	0789-14	SA Left WSS Output Low @ Drive-Off	ON	ON
73	02-06	001-08	0789-08	SA Left WSS Erratic Sensor Signal	ON	ON
74	02-04	001-10	0789-10	SA Left WSS Loss of Sensor Signal	ON	ON
77	23-02	099-13	1809-13	LAS Calibration in Progress	-	ON
78	23-07	099-14	1808-14	Erratic ESP Sensor Signal	-	ON
79	21-02	089-13	1807-13	SAS Calibration in Progress	-	ON
80	21-01	089-13	1807-13	SAS Not Calibrated	-	ON
81	07-06	042-05	0795-05	SA Left PMV HLD Solenoid Open Circuit	ON	ON
82	07-04	042-04	0795-04	SA Left PMV HLD Solenoid Shorted to Ground	ON	ON
83	07-05	042-03	0795-03	SA Left PMV HLD Solenoid Shorted to Voltage	ON	ON
84	07-07	007-05	0795-05	SA Left PMV CMN Open Circuit	ON	ON
85	07-03	048-05	0795-05	SA Left PMV REL Solenoid Open Circuit	ON	ON
86	07-01	048-04	0795-04	SA Left PMV REL Solenoid Shorted to Ground	ON	ON
87	07-02	048-03	0795-03	SA Left PMV REL Solenoid Shorted to Voltage	ON	ON
88	21-08	089-09	1807-09	SAS CAN Timeout	-	ON
89	21-04	089-02	1807-02	SAS Signal Out of Range	-	ON
90	21-06	089-12	1807-12	SAS Invalid Signal	-	ON

APPENDIX C: UDS Codes and their Bendix Blink Code Equivalents						
UDS Code	US-Spec. Blink Code	J1587 PID194 (SID/ FMI)	J1939/73 DM1/2 SPN/FMI	DTC Description	Lamp Status	
					ABS	ATC/ ESP
91	21-07	089-02	1807-02	SAS Gradient Error	-	ON
92	21-09	089-02	1807-02	SAS Long Term Calibration Error	-	ON
93	07-08	007-13	0795-13	SA Left PMV Configuration Error	ON	ON
94	21-03	089-02	1807-02	SAS Static Signal	-	ON
95	21-05	089-02	1807-02	SAS Signal Reversed	-	ON
96	21-10	089-02	1807-02	SAS Plausibility Check (Ref Yaw Rate)	-	ON
97	05-03	004-02	0792-02	DA Right WSS Open or Shorted	ON	ON
98	22-05	103-09	1808-09	YRS CAN Timeout	-	ON
99	22-01	103-02	1808-02	YRS Signal Out of Range	-	ON
100	22-03	103-02	1808-02	YRS Invalid Signal	-	ON
101	05-05	004-07	0792-07	DA Right WSS Wheel End	ON	ON
102	22-06	103-02	1808-02	YRS Static BITE Error	-	ON
103	05-01	004-01	0792-01	DA Right WSS Excessive Air Gap	ON	ON
104	05-02	004-14	0792-14	DA Right WSS Output Low @ Drive-Off	ON	ON
105	05-06	004-08	0792-08	DA Right WSS Erratic Sensor Signal	ON	ON
106	05-04	004-10	0792-10	DA Right WSS Loss of Sensor Signal	ON	ON
109	22-07	103-02	1808-02	YRS Dynamic BITE Error	-	ON
110	22-04	103-02	1808-02	YRS Gradient Error	-	ON
111	22-08	103-02	1808-02	YRS Fast Calibration Error	-	ON
112	22-09	103-02	1808-02	YRS Static Calibration Error	-	ON
113	10-06	045-05	0798-05	DA Right PMV HLD Solenoid Open Circuit	ON	ON
114	10-04	045-04	0798-04	DA Right PMV HLD Solenoid Shorted to Ground	ON	ON
115	10-05	045-03	0798-03	DA Right PMV HLD Solenoid Shorted to Voltage	ON	ON
116	10-07	010-05	0798-05	DA Right PMV CMN Open Circuit	ON	ON
117	10-03	051-05	0798-05	DA Right PMV REL Solenoid Open Circuit	ON	ON
118	10-01	051-04	0798-04	DA Right PMV REL Solenoid Shorted to Ground	ON	ON
119	10-02	051-03	0798-03	DA Right PMV REL Solenoid Shorted to Voltage	ON	ON
120	22-10	103-02	1808-02	YRS Normal Calibration Error	-	ON
121	22-11	103-02	1808-02	YRS Sensitivity Calibration Error	-	ON
122	22-12	103-02	1808-02	YRS Plausibility Check (Ref Yaw Rate)	-	ON
123	22-02	103-02	1808-02	YRS Sensor Reversed Signal	-	ON
124	22-13	103-02	1808-02	YRS Plausibility Error (Inside Model Based Limits)	-	ON
125	10-08	010-13	0798-13	DA Right PMV Configuration Error	ON	ON
126	22-14	103-02	1808-02	YRS Plausibility Error (Outside Model Based Limits)	-	ON
127	11-06	231-02	0639-02	J1939 ESP Messages Invalid Data	-	ON
128	13-13	254-12	0629-12	ECU (80)	ON	ON
129	03-03	002-02	0790-02	SA Right WSS Open or Shorted	ON	ON
130	06-08	251-02	0627-02	Input Voltage Excessive Noise (Temp.)	ON	ON
131	06-09	251-14	0627-14	Input Voltage Excessive Noise (Latched)	ON	ON
132	12-22	103-02	1808-02	ESP Sensor Voltage Out of Range	-	ON
133	03-05	002-07	0790-07	SA Right WSS Wheel End	ON	ON
134	24-06	077-07	1067-07	PS Not Calibrated	-	ON
135	03-01	002-01	0790-01	SA Right WSS Excessive Air Gap	ON	ON

APPENDIX C: UDS Codes and their Bendix Blink Code Equivalents						
UDS Code	US-Spec. Blink Code	J1587 PID194 (SID/ FMI)	J1939/73 DM1/2 SPN/FMI	DTC Description	Lamp Status	
					ABS	ATC/ ESP
136	03-02	002-14	0790-14	SA Right WSS Output Low @ Drive-Off	ON	ON
137	03-06	002-08	0790-08	SA Right WSS Erratic Sensor Signal	ON	ON
138	03-04	002-10	0790-10	SA Right WSS Loss of Sensor Signal	ON	ON
141	13-25	254-12	0629-12	ECU Internal VIN Mismatch	-	ON
142	20-08	066-07	1056-07	Trailer PMV potentially miswired or internal mechanical problem	-	ON
143	22-15	089-13	1808-13	YRS Sign Check Not Finished	-	ON
144	12-23	154-03	0614-03	i/o 2 or i/o 3 shorted high or Stop Lamp Output Error	-	ON
145	08-06	043-05	0796-05	SA Right PMV HLD Solenoid Open Circuit	ON	ON
146	08-04	043-04	0796-04	SA Right PMV HLD Solenoid Shorted to Ground	ON	ON
147	08-05	043-03	0796-03	SA Right PMV HLD Solenoid Shorted to Voltage	ON	ON
148	08-07	008-05	0796-05	SA Right PMV CMN Open Circuit	ON	ON
149	08-03	049-05	0796-05	SA Right PMV REL Solenoid Open Circuit	ON	ON
150	08-01	049-04	0796-04	SA Right PMV REL Solenoid Shorted to Ground	ON	ON
151	08-02	049-03	0796-03	SA Right PMV REL Solenoid Shorted to Voltage	ON	ON
155	11-12	231-02	0639-02	J1939 HSA switch error or unavailable	-	-
156	12-24	094-03	2622-03	Hill Start Assist solenoid shorted to voltage	ON	ON
157	08-08	008-13	0796-13	SA Right PMV Configuration Error	ON	ON
158	12-25	094-05	2622-05	Hill Start Assist solenoid shorted to ground or open circuit	-	-
161	04-03	003-02	0791-02	DA Left WSS Open or Shorted	ON	ON
165	04-05	003-07	0791-07	DA Left WSS Wheel End	ON	ON
167	04-01	003-01	0791-01	DA Left WSS Excessive Air Gap	ON	ON
168	04-02	003-14	0791-14	DA Left WSS Output Low @ Drive-Off	ON	ON
169	04-06	003-08	0791-08	DA Left WSS Erratic Sensor Signal	ON	ON
170	04-04	003-10	0791-10	DA Left WSS Loss of Sensor Signal	ON	ON
174	22-16	103-02	1808-02	Yaw Rate Sensor Vibration Detected	-	ON
175	12-09	017-14	0614-14	ATC Disabled to Prevent Brake Fade	-	ON
177	09-06	044-05	0797-05	DA Left PMV HLD Solenoid Open Circuit	ON	ON
178	09-04	044-04	0797-04	DA Left PMV HLD Solenoid Shorted to Ground	ON	ON
179	09-05	044-03	0797-03	DA Left PMV HLD Solenoid Shorted to Voltage	ON	ON
180	09-07	009-05	0797-05	DA Left PMV CMN Open Circuit	ON	ON
181	09-03	050-05	0797-05	DA Left PMV REL Solenoid Open Circuit	ON	ON
182	09-01	050-04	0797-04	DA Left PMV REL Solenoid Shorted to Ground	ON	ON
183	09-02	050-03	0797-03	DA Left PMV REL Solenoid Shorted to Voltage	ON	ON
189	09-08	009-13	0797-13	DA Left PMV Configuration Error	ON	ON
192	20-06	066-05	1056-05	Trailer PMV HLD Solenoid Open Circuit	-	ON
193	15-03	006-02	0794-02	AA Right WSS Open or Shorted	ON	ON
194	20-04	066-04	1056-04	Trailer PMV HLD Solenoid Shorted to Ground	-	ON
195	15-10	006-13	0794-13	AA Right WSS Configuration Error	ON	ON
196	20-05	066-03	1056-03	Trailer PMV HLD Solenoid Shorted to Voltage	ON	ON
197	15-05	006-07	0794-07	AA Right WSS Wheel End	ON	ON
198	20-07	066-05	1056-05	Trailer PMV CMN Open Circuit	-	ON
199	15-01	006-01	0794-01	AA Right WSS Excessive Air Gap	ON	ON
200	15-02	006-14	0794-14	AA Right WSS Output Low @ Drive-Off	ON	ON

APPENDIX C: UDS Codes and their Bendix Blink Code Equivalents						
UDS Code	US-Spec. Blink Code	J1587 PID194 (SID/ FMI)	J1939/73 DM1/2 SPN/FMI	DTC Description	Lamp Status	
					ABS	ATC/ ESP
201	15-06	006-08	0794-08	AA Right WSS Erratic Sensor Signal	ON	ON
202	15-04	006-10	0794-10	AA Right WSS Loss of Sensor Signal	ON	ON
205	20-03	066-05	1056-05	Trailer PMV REL Solenoid Open Circuit	-	ON
206	20-01	066-04	1056-04	Trailer PMV REL Solenoid Shorted to Ground	-	ON
207	20-02	066-03	1056-03	Trailer PMV REL Solenoid Shorted to Voltage	ON	ON
209	12-06	023-02	0811-02	ABS Indicator Lamp Circuit	ON	-
210	12-10	079-13	1069-13	Tire Size Out of Range (Front to Rear)	ON	ON
212	12-11	022-07	0810-07	Wheel Speed Sensors Reversed on an Axle	ON	ON
213	12-01	055-07	1045-07	Stop Lamp Switch Not Detected	-	ON
214	12-03	017-14	0576-14	ATC Disabled or Dynamometer Test Mode Active	-	ON
216	12-02	055-02	1045-02	Stop Lamp Switch Defective	ON	ON
220	12-13	102-03	0564-03	Diff Lock Solenoid Shorted to Voltage (total shutdown)	ON	ON
221	12-12	102-05	0564-05	Diff Lock Shorted to Ground or Open Circuit	ON	-
225	16-06	046-05	0799-05	AA Left PMV HLD Solenoid Open Circuit	ON	ON
226	16-04	046-04	0799-04	AA Left PMV HLD Solenoid Shorted to Ground	ON	ON
227	16-05	046-03	0799-03	AA Left PMV HLD Solenoid Shorted to Voltage	ON	ON
228	16-07	011-05	0799-05	AA Left PMV CMN Open Circuit	ON	ON
229	16-03	052-05	0799-05	AA Left PMV REL Solenoid Open Circuit	ON	ON
230	16-01	052-04	0799-04	AA Left PMV REL Solenoid Shorted to Ground	ON	ON
231	16-02	052-03	0799-03	AA Left PMV REL Solenoid Shorted to Voltage	ON	ON
232	11-13	231-02	0639-02	timeout or invalid data on J1939 AWD params for ESP AWD operation	-	ON
237	16-08	011-13	0799-13	AA Left PMV Configuration Error	ON	ON
238	13-26	155-14	0615-14	Maximum number of PCV cycles reached	-	-
239	13-27	155-14	0615-14	Maximum number of TCV cycles reached	-	-
240	23-01	099-02	1809-02	LAS Signal Out of Range	-	ON
241	17-06	047-05	0800-05	AA Right PMV HLD Solenoid Open Circuit	ON	ON
242	17-04	047-04	0800-04	AA Right PMV HLD Solenoid Shorted to Ground	ON	ON
243	17-05	047-03	0800-03	AA Right PMV HLD Solenoid Shorted to Voltage	ON	ON
244	17-07	012-05	0800-05	AA Right PMV CMN Open Circuit	ON	ON
245	17-03	053-05	0800-05	AA Right PMV REL Solenoid Open Circuit	ON	ON
246	17-01	053-04	0800-04	AA Right PMV REL Solenoid Shorted to Ground	ON	ON
247	17-02	053-03	0800-03	AA Right PMV REL Solenoid Shorted to Voltage	ON	ON
248	23-04	099-02	1809-02	LAS Long Term Calibration Error	-	ON
249	23-03	099-02	1809-02	LAS Static Calibration Error	-	ON
250	23-05	099-02	1809-02	LAS Plausibility Error (Inside Model Based Limits)	-	ON
251	23-06	099-02	1809-02	LAS Plausibility Error (Outside Model Based Limits)	-	ON
253	17-08	012-13	0800-13	AA Right PMV Configuration Error	ON	ON