SERVICE MANUAL SECTION

SPLIT AIR BRAKE SYSTEM

s04008, Formerly CTS-5109

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1. GENERAL INFORMATION

Air brake equipment on International vehicles provides a means of controlling brakes through a medium of compressed air. The air system consists of various components required to maintain a supply of air, direct the flow of air and convert the energy of compressed air into mechanical force to apply the brakes. Different types and sizes of devices are used on different types of vehicles to meet operating requirements.

Brake standards on air brake-equipped vehicles are currently controlled by the Department of Transportation (DOT) under Federal Motor Vehicle Safety Standard (FMVSS) 121. Some examples of items controlled by FMVSS 121 are:

1. Split Brake System Concept
2. Air System Timing
3. Parking Capability
4. Service Brake Dynamometer Certification

The law has special requirements for emergency performance, which means if air loss occurs on any one of a vehicle's axles, the chassis must demonstrate stopping capability upon activation of the service brake control.

2. SPLIT AIR SYSTEM

The air system is a split system consisting of a primary service system and secondary service system.

This split system begins where the main air supply reservoir branches off into two separate (primary and secondary) systems. This takes place through a series of check valves, separate air reservoirs and a brake valve which has two supply and delivery systems for service and emergency braking. The purpose of this split system is to provide a means of making a controlled stop if a failure occurs in either the primary or secondary air system. A tractor with a trailer has the advantage of utilizing the trailer air brake system during emergency stopping.

2.1. AIR RESERVOIRS

There are three reservoirs in the split air system. Some air reservoirs will be a two or three compartment type.

1. **Supply Air Reservoir (Wet Tank)** - Filled directly by the air compressor.
2. **Primary Air Reservoir** - Air supply for the major portion of the split service brake system.
3. **Secondary Air Reservoir** - Air supply for the balance of the split system. This reservoir is also the air pressure supply for the brake inversion system on straight trucks.

2.2. STRAIGHT TRUCKS

The split air systems are illustrated in Figure 1 , Figure 2 and Figure 3 , and are characterized by the following:

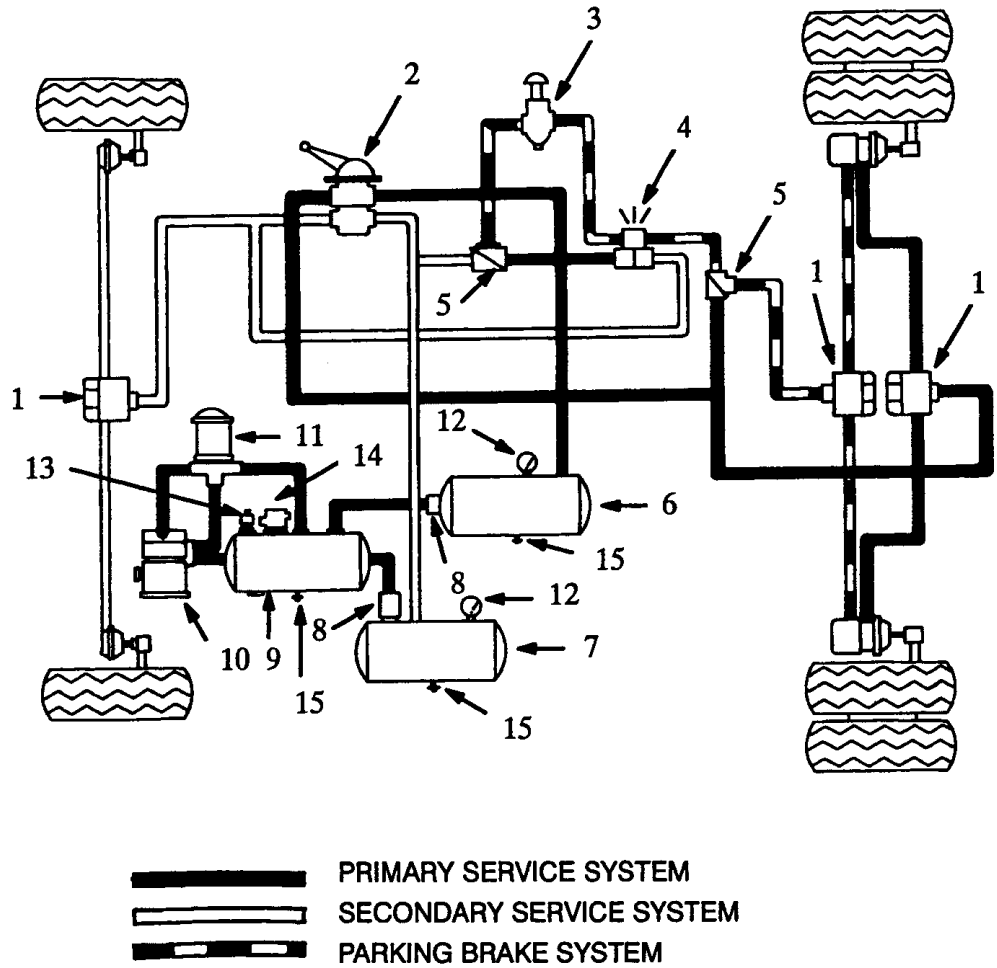

Figure 1 4x2 Straight Truck with Quick Release Valve System

1. QUICK RELEASE VALVE
2. BRAKE FOOT VALVE
3. PARKING BRAKE CONTROL VALVE
4. INVERSION VALVE
5. TWO-WAY CHECK VALVE
6. PRIMARY RESERVOIR
7. SECONDARY RESERVOIR
8. CHECK VALVE
9. SERVICE RESERVOIR (WET TANK)
10. AIR COMPRESSOR
11. AIR DRYER (OPTIONAL)
12. AIR GAUGE
13. PRESSURE RELIEF VALVE
14. LOW PRESSURE SWITCH
15. DRAIN COCK

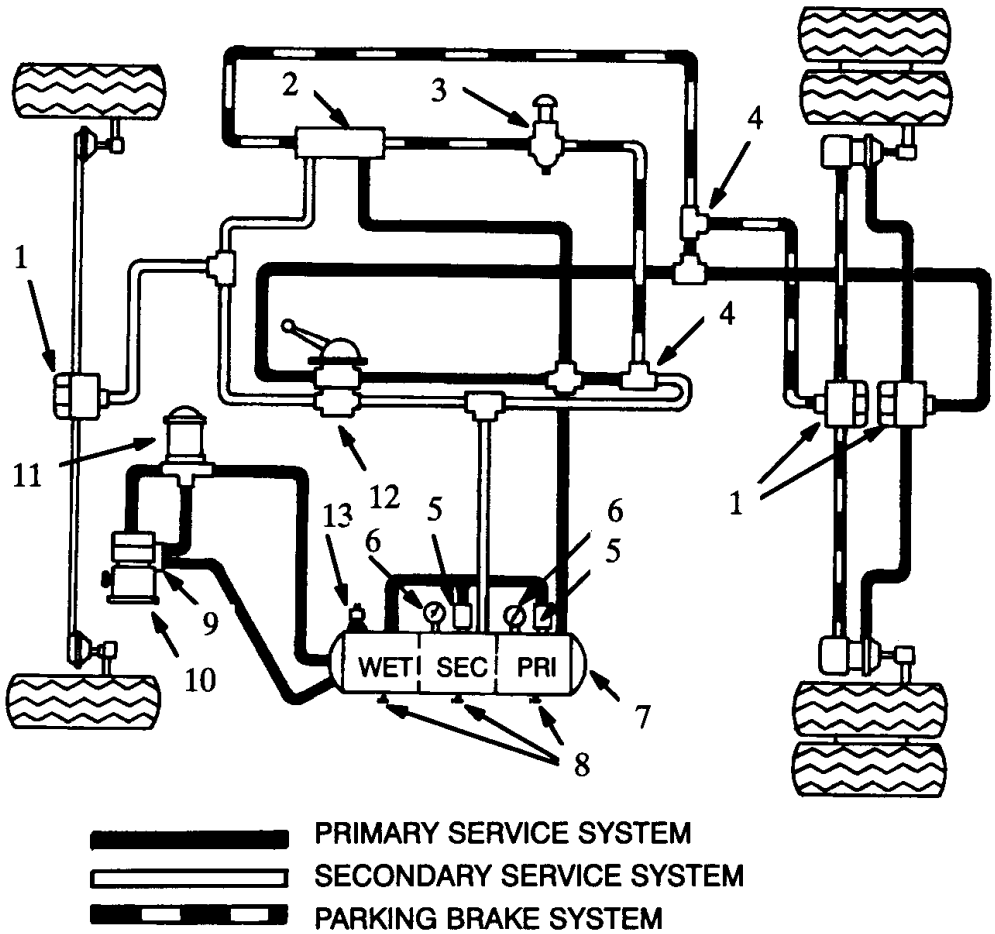

Figure 2 4x2 School Bus with Quick Release Valve System

1. QUICK RELEASE VALVE
2. INVERSION VALVE
3. PARKING BRAKE CONTROL VALVE
4. TWO-WAY CHECK VALVE
5. CHECK VALVE
6. AIR GAUGE
7. THREE (3) COMPARTMENT AIR TANK
8. DRAIN COCK
9. AIR COMPRESSOR GOVERNOR
10. AIR COMPRESSOR
11. AIR DRYER (OPTIONAL)
12. BRAKE FOOT VALVE
13. PRESSURE RELIEF VALVE

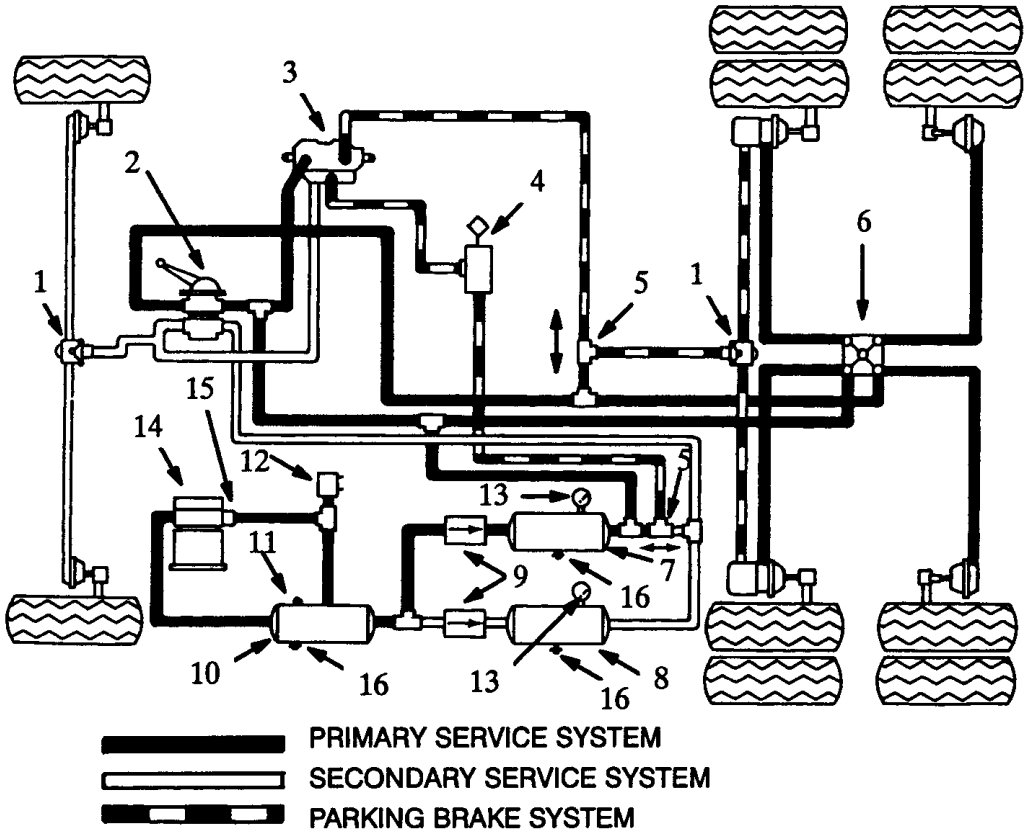

Figure 3 6x4 Straight Truck with Relay Valve System

1. QUICK RELEASE VALVE
2. BRAKE FOOT VALVE
3. INVERSION VALVE
4. PARKING BRAKE CONTROL VALVE
5. TWO-WAY CHECK VALVE
6. RELAY VALVE
7. PRIMARY RESERVOIR
8. SECONDARY RESERVOIR
9. CHECK VALVE
10. SUPPLY RESERVOIR (WET TANK)
11. PRESSURE RELIEF VALVE
12. LOW PRESSURE SWITCH
13. AIR GAUGE
14. AIR COMPRESSOR
15. GOVERNOR
16. DRAIN COCK

The primary service brakes are on the rear axle. The secondary service brakes are on the front axle. An inversion valve is used to apply the parking (spring) brakes on the rear axle by way of the secondary service brakes if air loss occurs in the primary system. Some vehicles with the same model design may have different components and component location.

On the 6x4, the primary service brake system is at the rear axle. The secondary service brake system is at the front axle. An inversion valve is used to apply the parking (spring) brake on the rear axle along with the secondary (front axle) service brakes if air loss occurs in the primary system.

Depending on the vehicle application, the parking spring brake chambers may be used on forward rear, rear rear, or both of the tandem rear axles.

2.3. TRACTORS

The split air systems for tractors are illustrated in Figure 4 , Figure 5 , Figure 6 and Figure 7 .

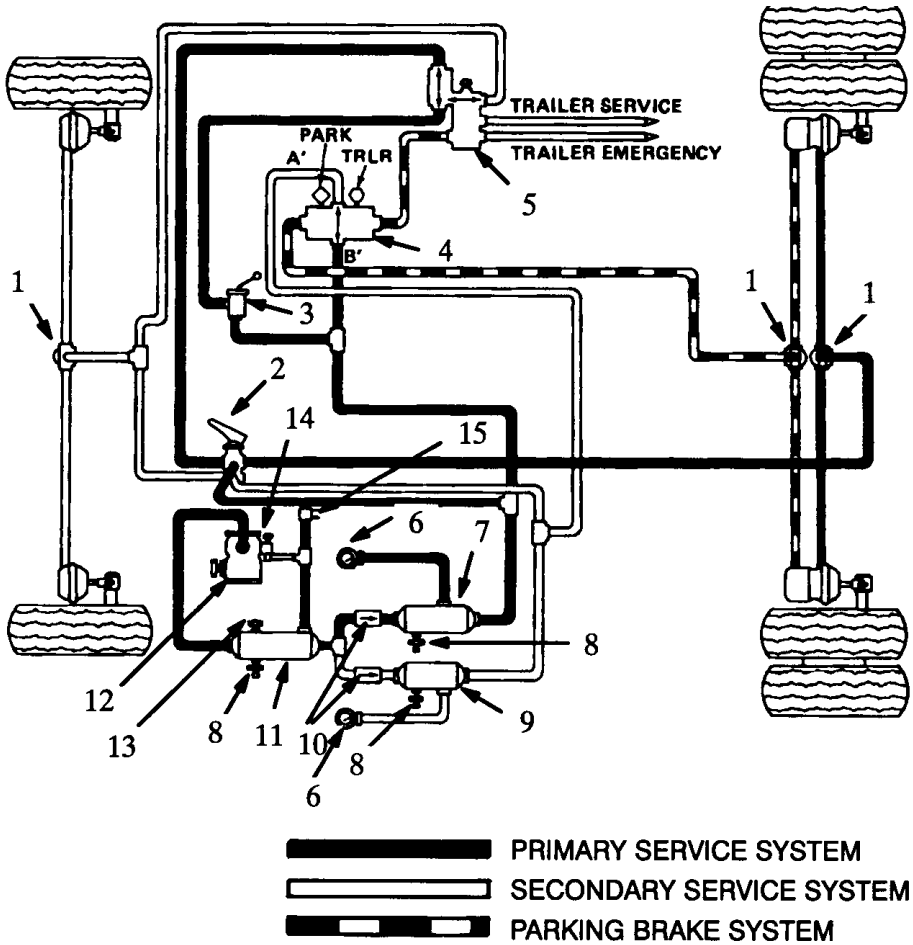

Figure 4 4x2 Tractor with Quick Release Valve System

1. QUICK RELEASE VALVE
2. BRAKE FOOT VALVE
3. HAND CONTROL VALVE
4. MODULAR (PUSH-PULL) CONTROL VALVE
5. TRACTOR PROTECTION VALVE
6. AIR GAUGE
7. PRIMARY RESERVOIR
8. DRAIN COCK
9. SECONDARY RESERVOIR
10. CHECK VALVE
11. SUPPLY RESERVOIR (WET TANK)
12. AIR COMPRESSOR
13. PRESSURE RELIEF VALVE
14. GOVERNOR
15. LOW PRESSURE SWITCH

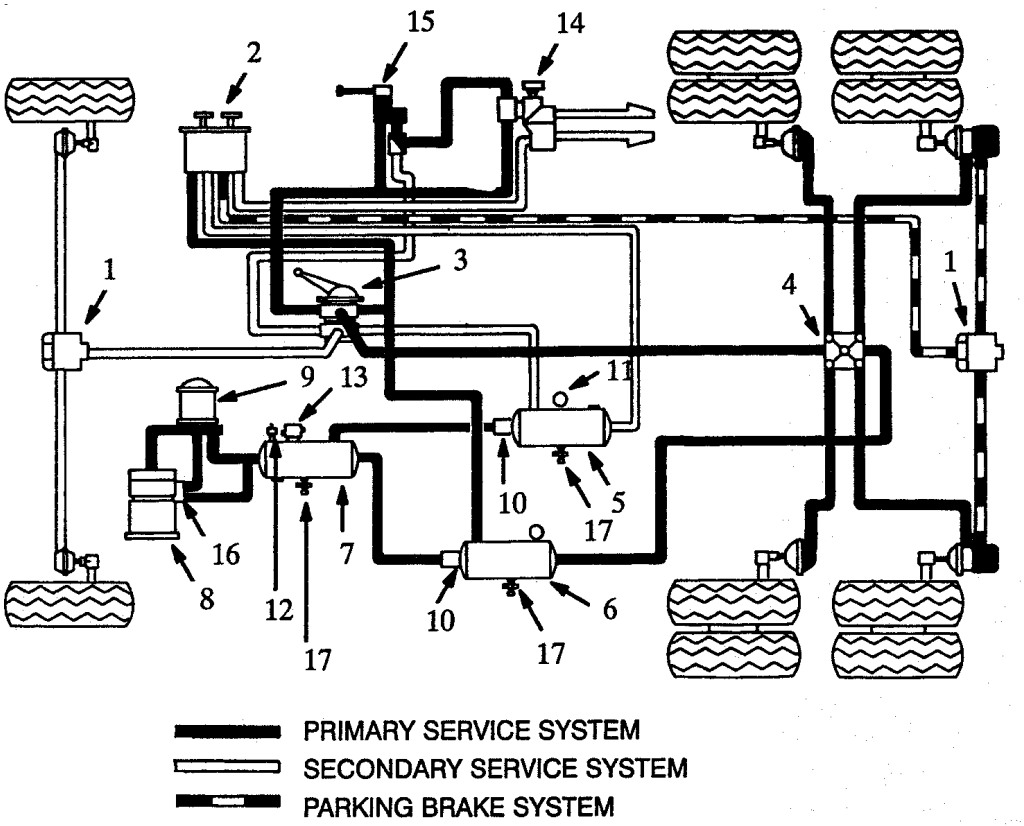

Figure 5 6x4 Tractor With Relay Valve System

1. QUICK RELEASE VALVE
2. MODULAR (PUSH-PULL) CONTROL
3. BRAKE FOOT VALVE
4. RELAY VALVE
5. SECONDARY RESERVOIR
6. PRIMARY RESERVOIR
7. SERVICE RESERVOIR (WET TANK)
8. AIR COMPRESSOR
9. AIR DRYER (OPTIONAL)
10. CHECK VALVE
11. AIR GAUGE
12. PRESSURE RELIEF VALVE
13. LOW PRESSURE SWITCH
14. TRACTOR PROTECTION VALVE
15. HAND CONTROL VALVE
16. GOVERNOR
17. DRAIN COCK

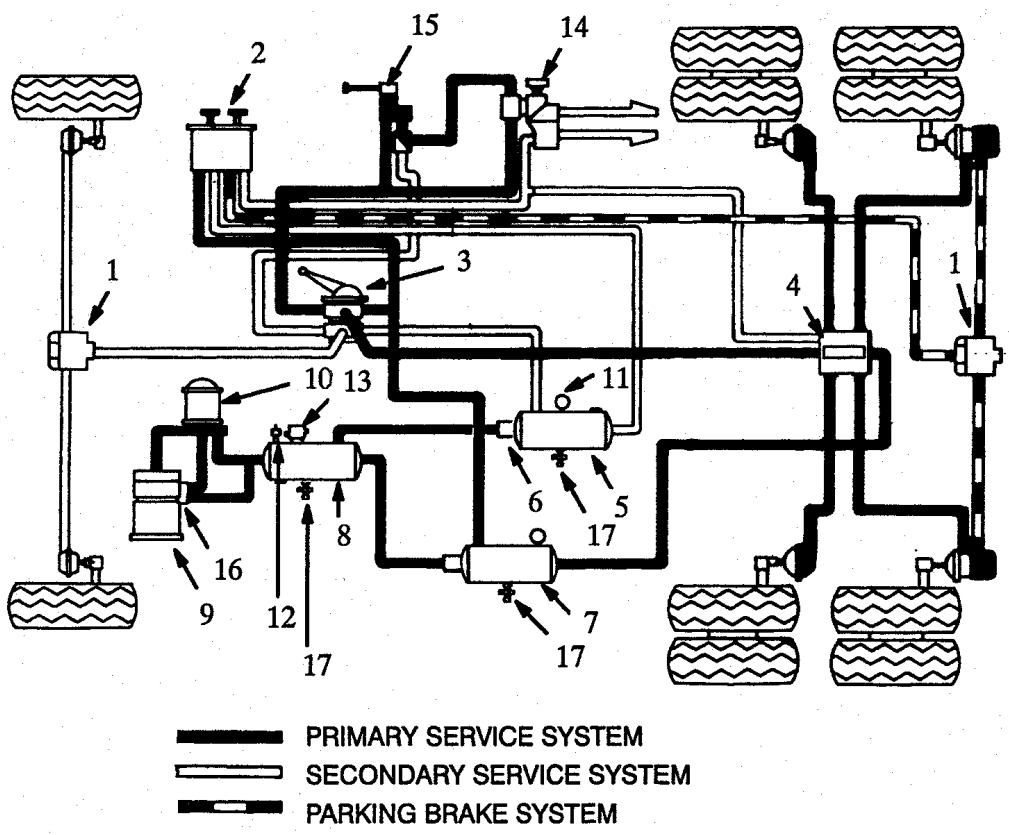

Figure 6 6x4 Tractor With Bobtail Proportioning System

1. QUICK RELEASE VALVE
2. MODULAR (PUSH-PULL) CONTROL
3. BRAKE FOOT VALVE
4. BP-R1 RELAY VALVE
5. SECONDARY RESERVOIR
6. CHECK VALVE
7. PRIMARY RESERVOIR
8. SERVICE RESERVOIR (WET TANK)
9. AIR COMPRESSOR
10. AIR DRYER (OPTIONAL)
11. AIR GAUGE
12. PRESSURE RELIEF VALVE
13. LOW PRESSURE SWITCH
14. TRACTOR PROTECTION VALVE
15. HAND CONTROL VALVE
16. GOVERNOR
17. DRAIN COCK

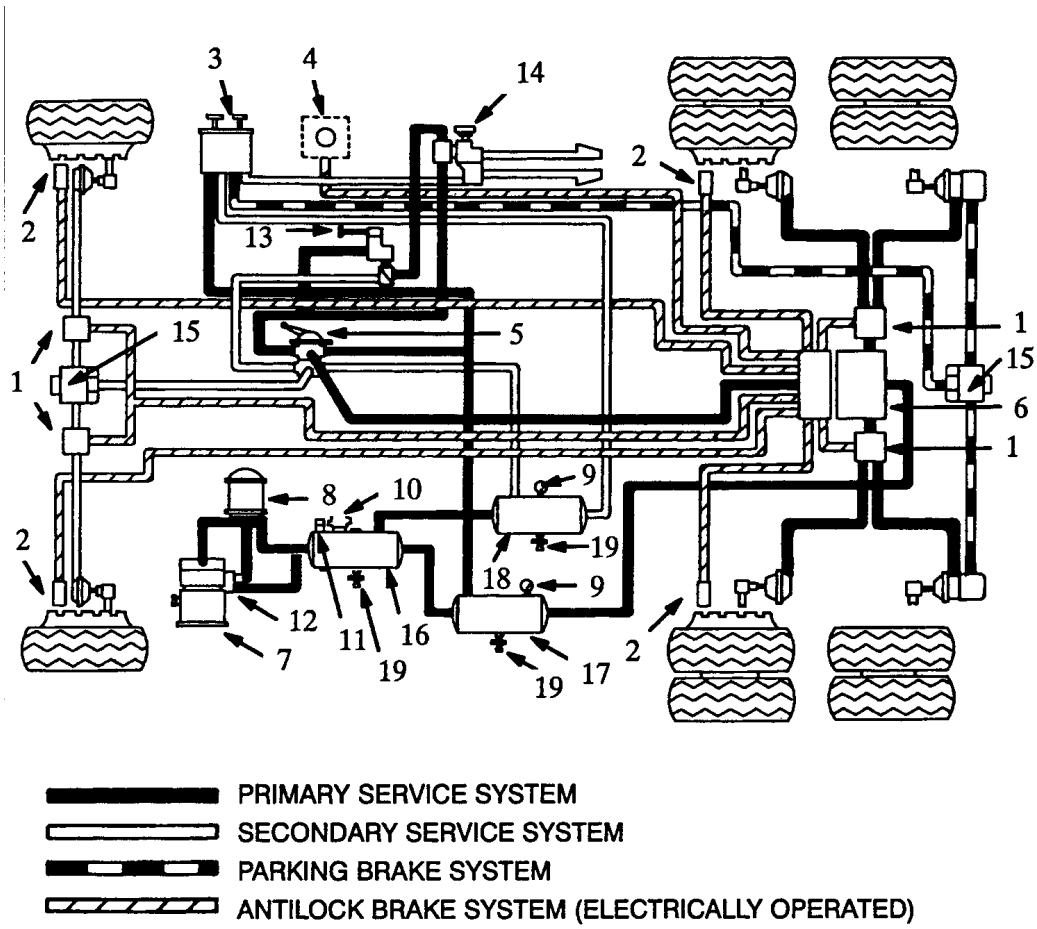

Figure 7 6x4 Tractor With Full Vehicle Control Antilock Brake System

1. M21 MODULATOR
2. WHEEL SPEED SENSORS
3. MODULAR (PUSH-PULL) CONTROL VALVE
4. ABS INDICATOR LIGHT
5. BRAKE FOOT VALVE
6. CR-15 CONTROLLER RELAY
7. AIR COMPRESSOR
8. AIR DRYER (OPTIONAL)
9. AIR GAUGE
10. LOW PRESSURE SWITCH
11. PRESSURE RELIEF VALVE
12. GOVERNOR
13. HAND CONTROL VALVE
14. TRACTOR PROTECTION VALVE
15. QUICK RELEASE VALVE
16. SERVICE RESERVOIR (WET TANK)
17. PRIMARY RESERVOIR
18. SECONDARY RESERVOIR
19. DRAIN COCK

Figure 4 , Figure 5 , Figure 6 and Figure 7 illustrate tractors with modular (push-pull) control valves for parking (spring) brake and tractor protection controls. The primary service system is at the rear axle and the secondary service system is at the front axle. In the event of partial brake system failure, the trailer service brakes will assist either the primary or secondary systems.

When performing a Split Air System Test on a vehicle with ANTILOCK BRAKES, the ANTILOCK braking system should be disconnected. To disconnect the ANTILOCK BRAKE system, remove the brake system fuse. After all tests are completed, reinstall fuse.

3. SPLIT AIR SYSTEM VALVES

NOTE – Complete detailed information pertaining to each of the air brake components may be found in GROUP 04 - BRAKES in the CTS-5000 Master Service Manual.

WARNING – A low air pressure warning buzzer will sound in the event of a failure in either the primary or secondary system. Under no circumstances should the vehicle continue to be operated when a failure is indicated since air pressure cannot be built up in the system until the air leak is corrected, even though air for emergency stopping is retained in that portion of the split air system not having a failure.

3.1. QUICK RELEASE VALVE

The function of the Quick Release Valve (Figure 8) is to "speed up" the exhaust of air from the brake chambers. It is generally mounted on the vehicle axle midway between the two brake chambers connected to it.

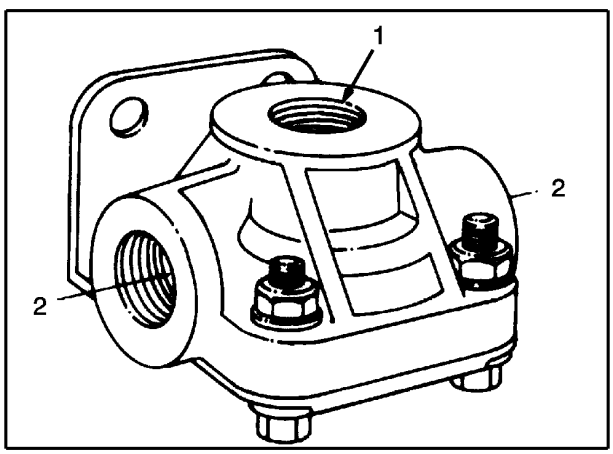

Figure 8 Quick Release Valve

1. SUPPLY
2. DELIVERY

3.2. INVERSION VALVE

An inversion valve (Figure 9) is used on the straight truck and bus split air systems. This valve is installed in the air brake system to modulate the parking (spring) brakes on the rear axle along with the secondary front axle service brakes if air loss occurs in the primary system.

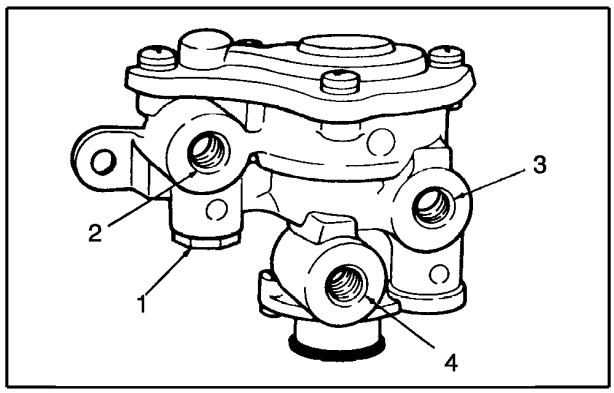

Figure 9 Inversion Valve

1. CONTROL PORT
2. RESERVOIR PORT
3. DELIVERY PORT
4. SUPPLY PORT

During normal brake operation, the inversion valve is simply a path for the signal air from the parking brake control valve to the parking brake quick release valve. This system can fully apply or fully release the parking brakes.

The split air brake system on most tractors functions in a similar manner as on a straight truck except there is no need for an inversion valve to apply the parking brakes. The trailer brakes, which operate off the primary or secondary tractor air system, provide braking effort to assist the tractor brake in an emergency situation if there is an air loss on one of the systems.

On a straight truck which is equipped with trailer towing provisions, the vehicle will have a split air system that includes a tractor protection valve and a hand control valve.

3.3. RELAY VALVE

The relay valve (Figure 10) in a split air brake system functions as a relay station to speed up the application and release of the brakes. The valve is normally mounted close to the chamber it serves. The valve operates as a remote controlled brake valve that delivers or releases air to the chamber in response to the control air delivered to it from the brake valve or other source.

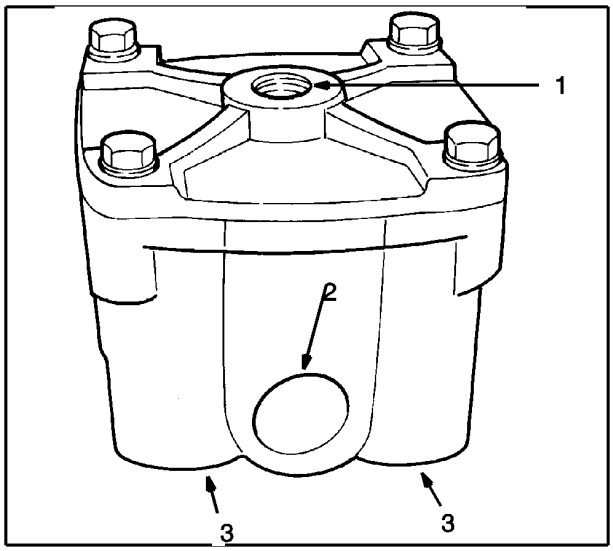

Figure 10 Relay Valve

1. SERVICE (CONTROL)
2. SUPPLY
3. DELIVERY

3.4. MODULAR (PUSH-PULL) CONTROL VALVE

A modular (push-pull) control valve (Figure 11) includes both parking brake and trailer air supply controls. This valve is also equipped with a shuttle type double check valve.

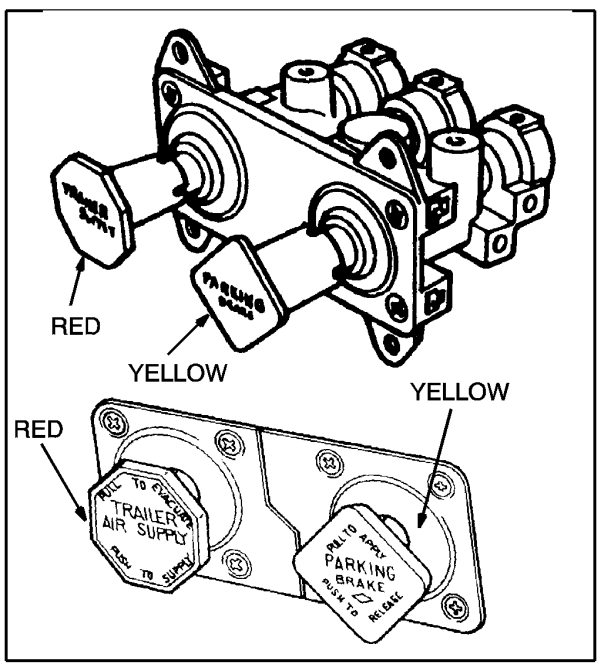

Figure 11 Modular Control Valve

This is a combination parking and trailer control system valve which is used to park the total combination and to activate the trailer brake system. This valve also has the capability to park only the tractor while maintaining air flow to the trailer system.

3.5. TRACTOR PROTECTION VALVE

The tractor protection valve (Figure 12) is controlled by the modular (push-pull) control valve. It is a type of manifold and shuttle valve that responds to the signal from the modular control valve. The primary purpose of this valve is to open and close the control and supply air to the trailer brake system.

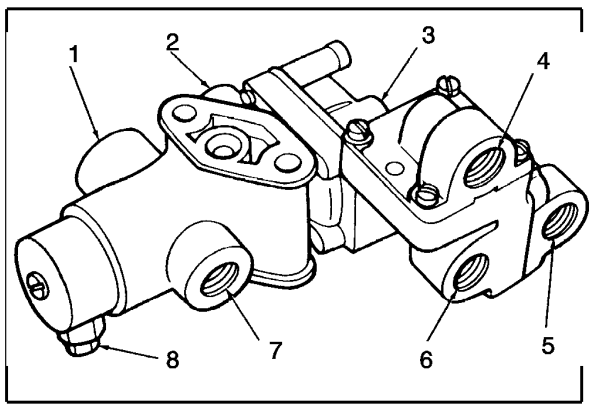

Figure 12 Tractor Protection Valve

1. TRAILER EMERGENCY
2. TRAILER SERVICE
3. STOPLIGHT SWITCH PORT
4. BRAKE VALVE SECONDARY
5. HAND CONTROL VALVE
6. BRAKE VALVE PRIMARY
7. TRACTOR EMERGENCY
8. EXHAUST

A tractor protection valve includes two double check valve assemblies along with the stoplight switch port. Vehicles with these valves also have the feature of Tractor Park Only and Trailer Charge with Tractor Parking (Spring) Brakes Applied (tractor park only).

3.6. DIFFERENTIAL POWER DIVIDER LOCK VALVE

Air can be used to engage or disengage the power divider lock (Figure 13) used on tandem drive rear axles.

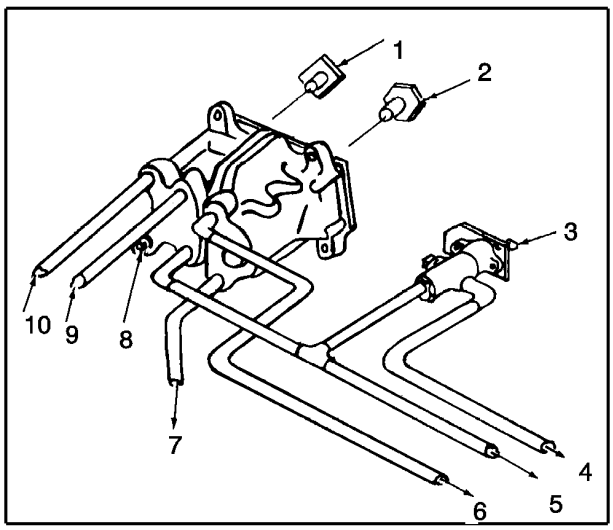

Figure 13 Modular Control Valve and Power Divider Lock Control

1. PARKING BRAKE CONTROL
2. TRAILER SUPPLY CONTROL
3. POWER DIVIDER LOCK CONTROL
4. TO POWER DIVIDER LOCK
5. TO PARKING (SPRING) BRAKE
6. AIR CONTROL TO TRACTOR PROTECTION VALVE
7. EXHAUST
8. AUXILIARY PORT (PLUGGED)
9. PRIMARY SUPPLY
10. SECONDARY SUPPLY

Some tandem axles are equipped with power divider locks which are disengaged (released) with air pressure and spring controlled in lock or engaged mode. Plumbing of the parking (spring) brakes and power divider lock in this condition eliminates the need for (spring) parking brakes at the rear axle(s). When the parking brakes are applied, air is expelled from the power divider lock allowing the spring pressure to lock up the differential and assist the parking brakes.

3.7. TREADLE TYPE BRAKE (FOOT) VALVE

The brake foot valve is the control unit of the air brake system. It provides the operator of the vehicle a means of applying or releasing the vehicle brakes (Figure 14).

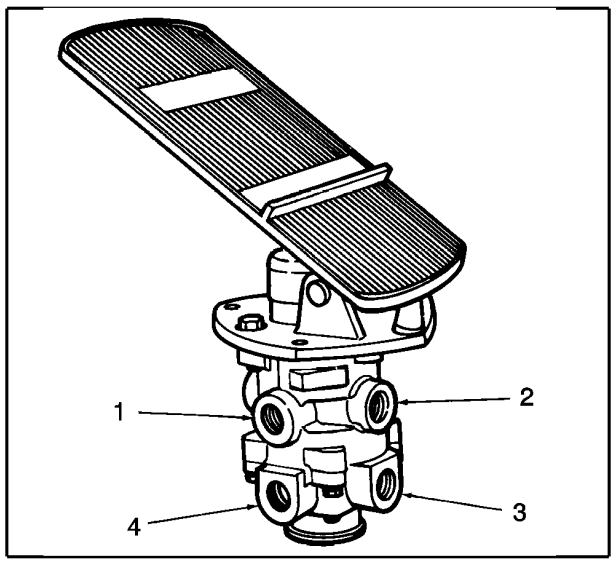

Figure 14 Treadle Type Brake Valve

1. PRIMARY SUPPLY
2. PRIMARY DELIVERY
3. SECONDARY DELIVERY
4. SECONDARY SUPPLY

4. OPERATIONAL CHECKS OF SPLIT AIR BRAKE SYSTEM

4.1. GENERAL OPERATIONAL CHECK OF SPLIT AIR SYSTEM

General

1. Block wheels to prevent vehicle from moving.

2. Inspect primary and secondary reservoir check valve operation.

   a. Build 110 psi (758 kPa) of air in system.

   b. With ignition switch "ON," open drain cock at service (wet) air reservoir and completely drain reservoir. Low air pressure buzzer should come on at approximately 70 psi (483 kPa).

   c. Both primary and secondary reservoirs should retain air pressure.

   d. If loss of air is noted in either system by observing the air gauges, the check valve could be faulty.

3. With the park brake control on tractors (yellow) and trailer supply control (red) in released position (in), open drain cocks in primary and secondary reservoirs.

4.

Straight Trucks

The park brake control (yellow) knob should automatically apply between 25 - 35 psi (172 - 241 kPa).

Tractors All

The red knob should pop out (exhaust position) when reservoir with highest pressure reaches 40 ± 5 psi (276 ± 34.5 kPa). The red knob could pop immediately if air is depleted quickly at the trailer supply (emergency) line.

When air pressure in reservoir with higher pressure reaches 30 ± 5 psi (207 ± 34.5 kPa), the yellow knob may pop out. When air is depleted to 25 ± 5 psi (172 ± 34.5 kPa), the yellow knob must pop out.

5. Close all reservoir drain cocks.

6. Build up air supply in chassis system to approximately 110 psi (758 kPa).

7. With red knob pushed in, disconnect trailer emergency coupling from bracket. The red knob should pop out instantaneously.

8. If red knob pops out, reconnect trailer emergency coupling. Push yellow knob (in) and pull red knob (out).

9. Check air pressure for leakage by observing air gauges on instrument panel. Leakage should not be greater than 2 psi (13.8 kPa) in one minute.

10. Open drain cock in secondary air reservoir. Drain cock must be opened all the way for quick loss of air.

    You will note loss of air by observing air gauges. One system will show a loss of air. With ignition switch on, low pressure indicator buzzer should sound at approximately 70 psi (483 kPa).

11. Apply service brakes and observe the slack adjusters and service brake chamber push rods. Movement of the brake chamber push rods should occur at axles as follows:

    a. Rear axles on all 4x2 vehicles.

    b. Both rear axles on 6x4 vehicles.

    If movement is noted at other axles, the primary reservoir was bled. Refer to Step 13. If brake chamber push rod travel movement is as described, the primary system is good.

12. Close drain cock in secondary air reservoir.

13. Build air supply in air system to 110 psi (758 kPa).

14. Open drain cock in primary reservoir. Observe opposite air pressure indicator for loss of air. Be sure to open drain cock all the way.

15. Apply service brakes and observe the slack adjusters and service brake chamber push rods.

    There should be movement of brake chamber push rod travel as follows:

    a. Steering axle on all 4x2 vehicles; the spring brakes will apply and release until air pressure drops to 25-35 psi (172-241 kPa), then full parking (spring) brake application will occur.

    b. Steering axle and any axle equipped with spring parking brake on 6x4 tractors.

16. When checking the system, the parking brakes will automatically apply on tractors when air pressure is depleted to 25 ± 5 psi (172 ± 34.5 kPa).

17. If movement of brake chamber push rods is as described, the secondary system is functioning as it should.

18. Close all drain cocks and return vehicle to service.

4.2. DETAILED OPERATIONAL CHECK OF TRAILER SUPPLY AND PARK BRAKE SYSTEMS

Modular (Push-Pull) Control Val ve

1. Use two air test gauges 0-160 psi (0-1103 kPa) or Duplex gauge with hoses and two additional trailer couplings (service and emergency); attach the gauges to service and emergency couplings on vehicle. Refer to SPECIAL TOOLS.

2. With the trailer supply knob (red) and parking brake knob (yellow) out, charge primary and secondary air systems to 65 psi (448 kPa). Push red knob in. The red knob should remain in; air pressure at the instrument panel and the test gauge at the trailer emergency port should read approximately the same. The test gauge at the service connection should show no pressure.

3. Push yellow knob in and apply foot valve to deplete air supply. The red knob should pop out when the reservoir with the highest pressure reaches 40 $\pm$ 5 psi (276 $\pm$ 34.5 kPa). The red knob could pop immediately if air is depleted quickly.

4. Apply foot valve to further deplete air pressure. Air should escape the exhaust port of the trailer supply portion of the valve. When air pressure in the reservoir with the higher pressure reaches 30 $\pm$ 5 psi (207 $\pm$ 34.5 kPa), the yellow knob may pop out (park brake application).

5. Deplete the air system even further using foot valve. At 25 $\pm$ 5 psi (172 $\pm$ 34.5 kPa), the yellow knob must pop out (park brake application).

6. Rebuild air supply to at least 40 psi (276 kPa) and push yellow knob in. It should remain in.

7. Push red knob in and pull yellow knob out. The red knob must pop out almost instantaneously.

8. Rebuild air supply to 100-125 psi (689- 861 kPa) in both primary and secondary reservoirs. Push red and yellow knobs in. Pressure at the trailer emergency connection should equal the pressure in the primary reservoir.

9. Reduce air pressure in the primary reservoir. Pressure at the trailer emergency connection should descend to 105-90 psi (724-621 kPa), at which point the double check valve in the modular control valve should switch to the secondary reservoir, and pressure at the emergency connection should adjust (equalize) to the secondary reservoir pressure. Close off leak at the primary reservoir.

10. With the red knob in and the hand control valve released, apply brake valve. Pressure at the trailer service should be within 5 psi (34.5 kPa) of the gauge at the instrument panel.

11. Replenish air system to 100-125 psi (689-861 kPa). Slowly vent the secondary reservoir pressure with yellow knob in. As the secondary pressure and trailer emergency pressure descend, between 115-105 psi (793-724 kPa) the double check shuttle in the valve should switch to the primary reservoir and the pressure should adjust to the primary reservoir pressure.

12. With the red knob pushed in, disconnect the trailer emergency coupling from the test gauge. The red knob should pop out instantaneously. If the red knob pops out, reconnect the trailer emergency coupling to gauge.

13. Replenish air in system. With the red knob in, apply the hand control valve. There should be a minimum of 85 psi (586 kPa) at the trailer service gauge.

14. Release hand control valve and apply foot valve. Pressure at the service port should be within 5 psi (34.5 kPa) of the pressure indicated at the instrument panel.

15. Close all vents or leakage points and charge system to 100-125 psi (689-861 kPa). Apply brake foot valve, pull red knob out (yellow knob in).

    The air gauge connected to the service connection should record the same value (100-125 psi or 689-861 kPa) as the gauge at the instrument panel. The gauge at the emergency connection should indicate "0."

16. With red knob out and yellow knob in, develop a leak in the parking (spring) brake delivery (line) and hold yellow knob in. The primary reservoir pressure must reduce to zero and secondary reservoir pressure to 20-30 psi (138-207 kPa). The double check valve in the modular control should cycle several times during the leak down period.

If the foregoing checks perform as described, the chassis is ready for service. Remove air test gauges from trailer couplings. If the operational checks revealed malfunctions within the system, a more detailed investigation of components will be required. For detailed information regarding service checks on various components, refer to GROUP 04 - BRAKES in the CTS- 5000 Master Service Manual.

4.3. TROUBLESHOOTING

Table 1 Troubleshooting Chart

CONDITION	POSSIBLE CAUSE	REMEDY
Insufficient Brakes	Brakes need adjusting or relining	Adjust, replace or reline as necessary
	Low air pressure in brake system	Check governor function
	Brake valve delivery pressure low	Check brake valve. Repair or replace as necessary
	Kinked air line	Repair or replace as necessary
	Excessive condensation in reservoir	Drain reservoirs
	Failure of part of a split air system	Repair or replace as necessary
Brakes Apply Too Slowly	Brakes need adjusting or lubricating	Adjust or lubricate as necessary
	Low air pressure in brake system	Check governor function. Adjust or repair as necessary
	Kinked air line	Repair as necessary
	Insufficient brake valve delivery pressure	Check brake valve. Repair or replace as necessary
	Excessive leakage with brakes applied	Check all connections, chamber diaphragms and hoses. Repair or replace as necessary
	Restricted tubing or hose	Repair or replace as necessary
	Treadle travel restricted	Repair or lubricate as necessary

Table 1 Troubleshooting Chart (cont.)

CONDITION	POSSIBLE CAUSE	REMEDY
Brakes Release Too Slowly	Brakes need adjusting or lubricating	Adjust or lubricate as necessary
	Brake valve not returning to fully released position	Clean, inspect and lubricate as necessary
	Restricted tubing or hose	Repair or replace as necessary
	Exhaust port of components restricted or plugged	Repair or replace as necessary
	Faulty components	Repair or replace as necessary
	Brake Valve, Quick Release Valve	Repair or replace as necessary
Brakes Do Not Apply	No air pressure in brake system	Check air compressor, governor, supply and delivery systems
	Restricted or broken compressor discharge line tubing or hose	Repair or replace as necessary
	Faulty brake valve	Repair or replace as necessary
	Kinked or restricted air line	Repair or replace as necessary
Brakes Do Not Release	Sticking shoe guide pins	Repair or replace as necessary
	Sticking anchor pins	Repair or replace as necessary
	Broken or weak return springs	Replace as necessary
	Brake valve not fully released	Check brake valve. Repair or replace as necessary
	Parking brake chamber leaking	Replace chamber
	Faulty brake valve or relay valve	Repair or replace as necessary
	Restricted or collapsed tubing or hose	Repair or replace as necessary
Brakes Grab or Erratic Braking	Grease and/or lube on brake lining	Reline brakes, or if lining is not badly saturated with grease or lube oil, clean lining with denatured alcohol. Sand lining lightly with medium grit emery cloth and air dry
	Faulty brake valve or relay valve	Repair or replace as necessary
	Sticking shoe guide pins	Repair or replace as necessary
	Sticking anchor pins	Repair or replace as necessary
	Broken or weak return springs	Repair or replace as necessary
	High brake pressure	Check air supply and delivery systems
	No vehicle load	Operate vehicle with caution when not under load
	Loose drum or brake mounting	Re-torque fasteners

Table 1 Troubleshooting Chart (cont.)

CONDITION	POSSIBLE CAUSE	REMEDY
Uneven Brakes	Brakes need adjusting or relining	Adjust or reline as necessary
	Improper axle mounting	Check and repair as necessary
	Grease on brake lining	Reline brakes, or if lining is not badly saturated with grease or lube oil, clean lining with denatured alcohol. Sand lining lightly with medium grit emery cloth and air dry
	Brake shoe return spring broken	Replace as necessary
	Brake drum out of round	Refinish drum if possible without exceeding maximum diameter, or replace as necessary
	Brake chamber diaphragm failure	Repair or replace as necessary
	Wrong or mixed brake lining	Replace as necessary
	Broken foundation brake parts	Repair or replace as necessary
Air Pressure Will Not Rise to Normal	Faulty air gauge (registering incorrectly)	Repair or replace as necessary
	Excessive valve or fitting leakage	Check all valves and connections. Repair or replace as necessary
	Governor out of adjustment	Adjust or replace as necessary
	Slipping compressor drive belt	Tighten or replace belt as necessary
	Broken supply line	Replace as necessary
	Faulty compressor	Repair or replace as necessary
Air Pressure Rises to Normal Too Slowly	Excessive valve or fitting leakage	Check all valves and connections. Repair or replace as necessary
	Clogged compressor air strainer	Repair or replace as necessary
	Engine speed too slow	Adjust or regulate as necessary
	Compressor discharge valve or inlet valves leaking	Repair or replace as necessary
	Compressor drive belt slipping or faulty drive coupling	Repair or replace as necessary
	Worn compressor	Repair or replace as necessary
	Excessive carbon in compressor cylinder head or discharge line	Repair or replace as necessary
Air Pressure Rises Above Normal	Faulty air gauge (registering incorrectly)	Repair or replace as necessary
	Governor out of adjustment	Adjust as necessary

Table 1 Troubleshooting Chart (cont.)

CONDITION	POSSIBLE CAUSE	REMEDY
	Faulty governor and safety valve	Repair or replace as necessary
	Frozen line to governor	Thaw and drain condensation
	Restriction in line between governor and compressor	Repair or replace as necessary
	Restricted unloading valve	Repair or replace as necessary
	Too much clearance at compressor unloader valves or compressor unloading mechanism stuck in closed position	Adjust or repair as necessary
Air Pressure Drops Quickly with Engine Stopped and Brakes Released	Leaking brake valve	Repair or replace as necessary
	Leaking tubing or hoses	Repair or replace as necessary
	Excessive leakage elsewhere in air brake supply system	Check air supply system. Repair or replace components as necessary
	Parking brake chamber leaking	Replace chamber
Air Pressure Drops Quickly with Engine Stopped and Brakes Fully Applied	Leaking brake chamber, actuator or brake cylinder	Repair or replace as necessary
	Leaking brake valve	Repair or replace as necessary
	Leaking tubing or hose line	Replace as necessary
Compress or Knocks Continuously or Intermittently	Loose drive pulley	Repair or replace as necessary
	Backlash in drive gears or drive coupling	Repair or replace as necessary
	Worn or burnt out bearings	Repair or replace as necessary
	Excessive carbon deposits in compressor cylinder head	Clean or repair as necessary
Safety Valve "Blows Off"	Air pressure in air brake system above normal	Check unloader mechanism. Repair or replace as necessary
	Faulty governor	Check governor function
	Frozen line to governor	Thaw and drain condensation
	Bad safety valve	Repair or replace as necessary
Excessive Oil in Brake System	Compressor passing excessive oil	Repair or replace compressor as necessary

Table 1 Troubleshooting Chart (cont.)

CONDITION	POSSIBLE CAUSE	REMEDY
	Compressor air strainer restricted	Repair or replace as necessary
	Excessive engine oil pressure	Check and adjust engine oil pressure as necessary
	Back pressure from engine crankcase	Check and repair/adjust as necessary
	Excessive oil in compressor crankcase	Drain excess from compressor and check return line

5. TRACTOR-TRAILER BRAKE ANALYSIS PROCEDURE

The air brake system on a tractor-trailer combination must provide balanced braking at all wheels and axles of the combination for optimum brake performance and life. This means that the braking effort produced at each wheel of the combination must be capable of doing its share of the work in controlling the speed of the two units.

There are several factors which can affect brake balance. These are:

1. **Loads must be properly distributed between tractor and trailer**. A balanced condition should not be expected with the combination vehicle if the load is not properly distributed.

   The brakes on each axle are designed to meet specific performance criteria based on the axle's Gross Axle Weight Rating (GAWR). For example, 34,000 lb. (15,400 kg) GAWR tandem axles used on both the tractor and trailer in combination are designed to meet similar performance standards. Overloading or underloading either the tractor or the trailer tandem axle can cause unbalanced braking in the combination vehicle. A typical symptom would be early lockup of the brakes on an axle loaded to less than the rated capacity.

2. **Tractor and trailer brakes must be compatible.** The foundation brakes used on the tractor and trailer should be of the same type. Operating characteristics, such as fade and speed sensitivity, are different for wedge, cam and disc-type brakes.Consequently, under some operating conditions, the intermixing of brake types can cause or exaggerate an imbalance condition between tractor and trailer(s). Extreme care must be used when operating a combination equipped with brakes of different types.

3. **Tractor and trailer brakes must be maintained in proper adjustment.** The force output of an air brake chamber push rod increases linearly for approximately 75% of its maximum travel. Beyond 75%, the force is reduced. Therefore, if the brake adjustment is not maintained within specification and the push rod travel is allowed to increase beyond 75% of maximum travel, the brake torque output at the wheel will be reduced.

   For example, when air pressure of 100 psi (689 kPa) is applied to a Type 30 service air brake chamber, approximately 3,000 lbs. of force is produced with a push rod travel of 1-1/2 in. (38mm) or less. When the push rod travel is increased to 2-1/4 in. (57mm) at the same air pressure, the force produced decreases to approximately 2,500 lbs., a reduction of about 17%. A reduction in force at the push rod causes a similar reduction in the brake torque output at the wheel. A reduction in the brake torque output capability at any one or several wheels of a combination vehicle places added work on the brakes at other wheels. The result can be uneven lining and drum or rotor wear (between brake assemblies), trailer surging and increased brake fade.

   If automatic adjusters are used, they should be used on both **tractor** and **trailer** to insure compatibility between the two units. While automatic adjusters do maintain the brakes in reasonable adjustment, it is important that the adjusters be inspected periodically to be sure that they are functioning properly.

4. **Tractor and trailer brake assemblies and air systems must be inspected and properly maintained.** Corroded anchor pins, frozen camshafts, worn bushings, weak or broken return springs, or deformed shoes, etc., can reduce the efficiency of the brake assembly at any wheel(s). It is important to inspect the air system — reservoirs, valves, fittings and lines — periodically for damage. This includes draining the reservoirs as required.

   Whenever complaints of touchy brakes, inadequate braking, short service life of brake linings or drums on either the tractor or the trailer (but not both) are encountered, there may be an imbalance between the tractor and trailer air brake systems.

   It is suggested that a brake analysis be performed. This analysis includes testing for 1) pressure balance, 2) pressure build-up rate (timing), and 3) torque balance. However, before conducting the tests, the following questions should be considered:

5. Are all or a majority of the drivers operating the combination units obtaining the same results or registering the same complaints?
6. Are the same results or complaints being registered on similar combination units?
7. Are the same results or complaints being registered under similar operating conditions?
8. Were complaints always received on the combination unit or did complaints originate after some brake service was performed, or vehicle operating conditions changed?
9. If the vehicle is equipped with Antilock Brakes, is the Antilock Brake system operating properly?

The answers to these questions may help in identifying the cause(s). Such problems could be the result of incorrect or malfunctioning brake components, or simply the conditions under which the combination vehicle is operated.

If the response to these questions seems to indicate that a brake imbalance condition may be present in the air brake system, the preliminary checks and test procedures in the following text can be used to isolate the cause.

5.1. PRELIMINARY CHECKS

NOTE – Before conducting the Pressure Balance, Pressure Build-up Rate, and the Torque Balance Tests, make the following checks of the air brake system on the tractor-trailer combination. These checks are intended to detect and correct conditions which otherwise could produce misleading or inconclusive test results.

1. Check the adjustment of all brakes on both the tractor and trailer(s). Adjust the brakes as required.

2. Visually check the slack adjuster movement (if applicable) to determine that all brakes are actuating and releasing freely. If not, inspect and lubricate the brakes thoroughly. **DO NOT** allow any lubricant on the linings, or drums.

3. Check the air brake system to be sure that it is free of significant air leaks. Air leakage should not exceed the following values with an air system pressure of 95 psi (655 kPa) or more and the brake pedal released:
   a. 2 psi (13.8 kPa) per minute, on tractor only.
   b. 3 psi (20.7 kPa) per minute, on tractor with trailer combination.
   c. 5 psi (34.5 kPa) per minute, on tractor with two-trailer combination.

4. Repair any leakage points if these values are exceeded.

5. Drain the reservoirs of any moisture and contamination.

6. Visually inspect for damage or kinked lines and replace any lines found to be defective.

7. Inspect combination units for loose fifth wheel and king pin condition. A loose fifth wheel to king pin fit can exaggerate an unbalanced brake condition and therefore must be adequately adjusted.

8. If vehicle is equipped with an Anti-Lock Brake System, disconnect the Anti-Lock Brake System by removing the fuse before performing any brake tests. After all tests have been completed, reinstall fuse.

Any deficiencies found in the above areas may be contributing factors to brake complaints. These should be considered in the overall analysis of the brake system.

5.2. TEST EQUIPMENT

Refer to SPECIAL TOOLS.

Double Gladhand Assembly (with quick- connect coupling and shut-off cock) - This assembly is used in the service line connection to the trailer for the torque balance test. Refer to Figure 15 for the parts and the manner of assembling this test equipment.

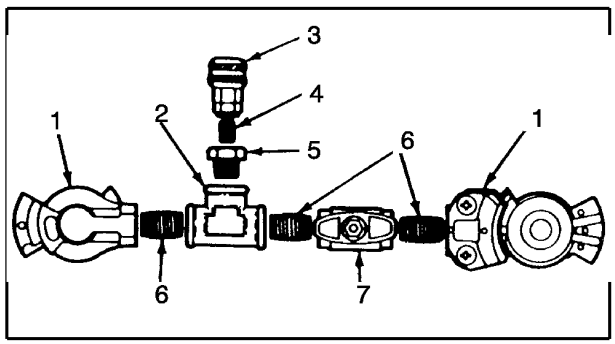

Figure 15 Double Gladhand Assembly Exploded View

1. GLADHAND (SERVICE) 295459-C91
2. TEE 1/2” NPT 144089
3. QUICK CONNECT FEMALE COUPLING SE-1284
4. NIPPLE 1/4” NPT X 7/8” 120286
5. REDUCER BUSHING 1/2” X 1/4” NPT 444033
6. PIPE NIPPLE 1/2” NPT 120460
7. SHUT-OFF VALVE 514799-C91

Duplex Air Gauges - Two sets are required. Each set includes one duplex gauge and two 25 ft. (7.62m) long air hoses. The air hoses used must be of the same length and same inside diameter. The duplex air gauges are required for all tests. Refer to SPECIAL TOOLS.

Additional Air Hoses for Long Single- Trailer and Multiple-Trailer Tests - Two are required which are of sufficient length and with quick-connection couplings. These hoses are used for making the test connections between the service brake chambers on the various axles of the tractor and trailer(s) and the air gauge(s).

Decelerometer - The decelerometer is required for conducting the Torque Balance Test. Refer to SPECIAL TOOLS.

Brake Timing Unit (Use optional) - This is a sophisticated test instrument. If this test is to be performed, contact vehicle manufacturer for detailed information.

NOTE – Special Tools are to be ordered through PDC.

5.3. TEST PROCEDURES

Before performing any of the test procedures which follow, record the preliminary data required on the Brake Test Data Sheet (Form CTS-1033H, Figure 16). This data includes the owner’s name, model, serial number, and GVWR for both the tractor and trailer. All of this information (except the owner’s name) can be obtained from the certification labels.

BRAKE TEST DATA SHEET

PRELIMINARY DATA

Record the combination vehicle information. This information (except for the owner's name) can be obtained from the certification labels.

VEHICLE	OWNER	MODEL	SERIAL NO.	GVWR
Tractor				
First Trailer				
Second Trailer*				

*If used

TEST APPLICATION PRESSURES « Tractor's Rearmost Axle	PRESSURE READINGS														
	FIRST TRAILER « Rearmost Axle					SECOND TRAILER (IF APPLICABLE) « Dolly Axle					« Rearmost Axle				
	Application				Press. Diff.†	Application				Press. Diff.†	Application				Press. Diff.†
kPa (PSI)	1st	2nd	3rd	Average		1st	2nd	3rd	Average		1st	2nd	3rd	Average	
PRESSURE BALANCE															
34 (5)															
69 (10)															
103 (15)															
138 (20)															
172 (25)															
207 (30)															
345 (50)															
483 (70)															
621 (90)															
Average															

PRESSURE BUILD-UP RATE (TIMING)

0-207 min. (0-30 min.)	PRESSURE DIFFERENCE, Lag (−) or Lead (+)														

TORQUE BALANCE

VEHICLE DATA	Tractor + Trailer
Typical Weight (Estimated)‡	Lbs.
Test Weight (Actual Axle Weights)	Lbs.

	TEST SPEED			TEST APPLICATION PRESSURES		DECELEROMETER READINGS (FT./SEC.²) Application			
	Recommended km/hr.	(mph)	Other (if used)	kPa	(PSI)	1st	2nd	3rd	Average
Using Tractor-Trailer Combination Brakes									
Using Tractor Brakes Only	64	(40)		276	(40)				
Using Trailer Brakes Only									
						TOTAL (Tractor Only + Trailer Only)			

† Compared to TEST APPLICATION PRESSURE « Tractor's Rearmost Axle.
‡ For Normal Highway Operation — Maximum.

BALANCE RATIO CALCULATION

[ ] Typical Tractor Weight ÷ [ ] Typical Trailer Weight × [ ] Average Trailer Deceleration Rate ÷ [ ] Average Tractor Deceleration Rate = [ ] Balance Ratio

INTERNATIONAL®

CTS-1033H

Figure 16 Brake Test Data Sheet

Pressure Balance and Pressure Build-Up Test

Conditions: This test is performed on the combination vehicle (tractor-trailer) with wheels blocked, parking brake released and air system fully charged.

1. Connect two test hoses to a duplex gauge.

2. Connect the hoses from the duplex gauge to the combination vehicle as follows (Figure 17):

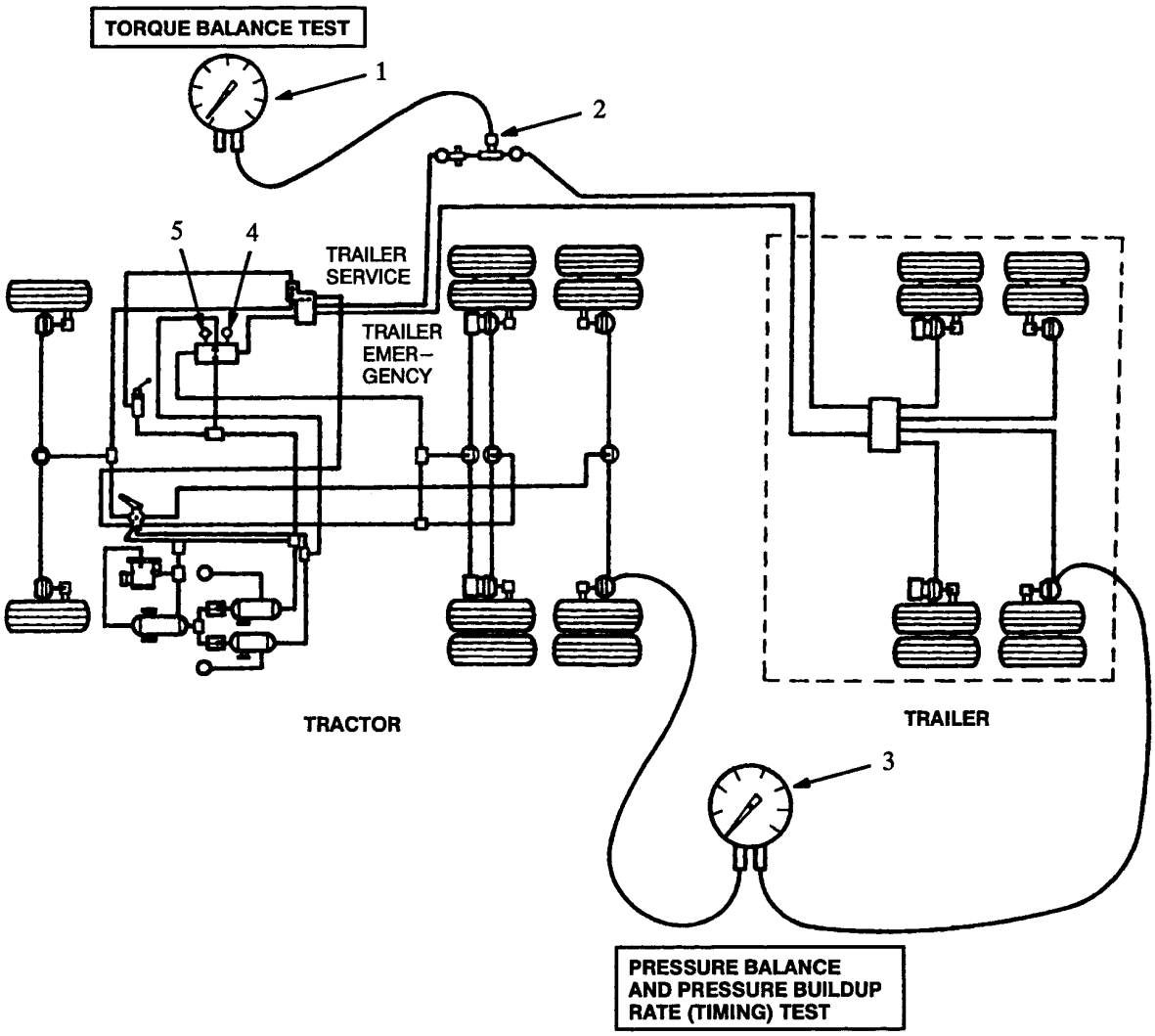

Figure 17 Test Connections-Single Trailer

1. DUPLEX GAUGE OR SINGLE GAUGE
2. DOUBLE GLADHAND ASSEMBLY
3. DUPLEX GAUGE
4. TRAILER SUPPLY CONTROL VALVE
5. PARK BRAKE CONTROL VALVE

a. One hose to the left service brake chamber on the **tractor's** rearmost axle. The gauge reading from this connection will be used as a reference for comparing pressure differences with other axles.

b. The remaining hose to the left service chamber on the **trailer's** rearmost axle.

NOTE – If unused chamber ports do not exist, it will be necessary to disconnect the service brake hose, install a tee fitting between the service brake hose and chamber (Figure 18), and then connect the test hose to the remaining opening in the tee fitting.

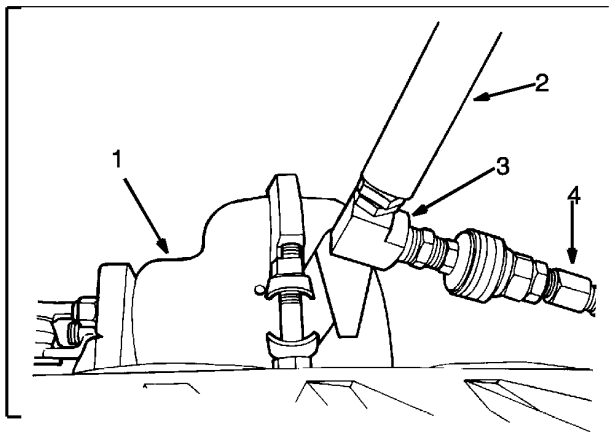

Figure 18 Test Gauge Hose Connection (At Service Brake Chamber)

1. BRAKE CHAMBER
2. SERVICE BRAKE HOSE
3. TEE FITTING
4. TEST LINE CONNECTION

3. **Check pressure balance as follows:** While observing the duplex gauge, slowly apply the service brakes in increments of 5 psi from 5 to 30 psi (34 kPa from 34 to 207 kPa) and increments of 20 psi from 30 to 90 psi (138 kPa from 207 to 621 kPa) respectively, as shown in Figure 19 . As each pressure increment is reached at the **tractor's** rearmost axle, note and record the pressure reading for the **trailer's** rearmost axle. Repeat this step three times.

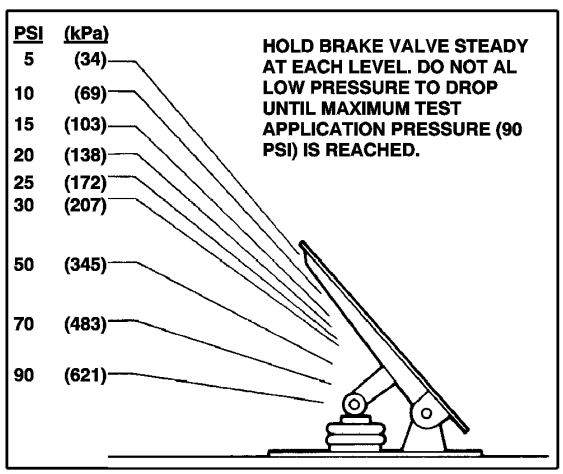

Figure 19 Brake Test Application Pressures

IMPORTANT – When applying the brakes, air pressure must be increased steadily and maintained at each step. Any slight decrease in pressure will affect the accuracy of the gauge readings and must be avoided. Note and record the pressure only after all gauge recordings are stabilized.

Under normal conditions, the average pressure variance between axles through the pressure range as tested should not exceed 4 psi (28 kPa) for optimum performance. The exception will be steering axle chambers controlled by automatic limiting valves. Refer to DATA INTERPRETATION AND CORRECTIVE MEASURES .

4. **Check pressure build-up rate as follows:** While observing the duplex gauge, apply the service brake control moderately to at least 30 psi (207 kPa). The moderate rate of application should simulate that used in day-to-day braking under normal operating conditions. Observe and record the pressure difference between the hands on the test gauge dial (Figure 20). The dual pressure readings give an indication of the timing difference between the axles. If the pressure build-up in the trailer brakes leads the tractor brakes, the gauge reading should be recorded as a positive (+) number. If the pressure build-up lags, the reading should be recorded as a negative (-) number. Release the service brakes. Repeat this step at least three times and record the average of the total readings.

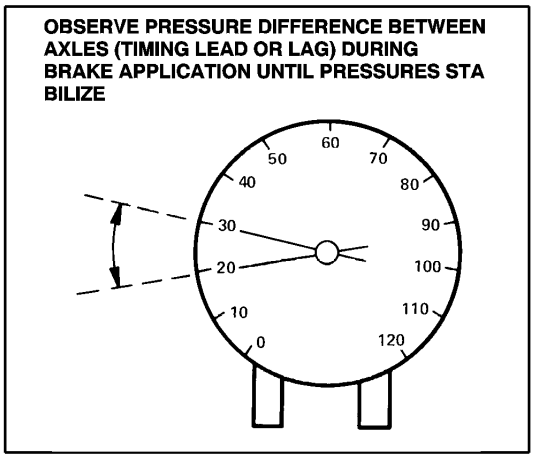

Figure 20 Gauge Reading-Pressure Balance Check

Initial pressure difference (lead or lag) between axles should normally be no greater than 10 psi (69 kPa) for single- trailer combinations before the pressures begin to equalize.

NOTE – Since pressure lead and lag derived from using a duplex test gauge are estimates only, pressure build-up rate tests involving large fleets of vehicles can be performed more easily and accurately using pneumatic timing devices. These instruments are available from PDC. The above check, however, will provide an indication if slow pressure build-up rate is a cause for compatibility complaints.

5. If **pressure balance** and/or **pressure build-up** rate differences between axles exceed the acceptable limit(s), refer to the DATA INTERPRETATION AND CORRECTIVE MEASURES SECTION .

Multiple Trailers

The Pressure Balance and Pressure Build-up Rate Test also can be used for checking combination vehicles with multiple trailers. One duplex test gauge is installed as described in the test procedure to read brake pressures at the rearmost axles of the tractor and the first trailer. A second duplex test gauge is installed to read pressure at the dolly axle and the rearmost axle of the second trailer (Figure 21). Two additional air hoses may be required to make the gauge connections at the second trailer in order to keep both duplex gauges at one observation point. The test is then conducted as described, noting and recording the pressure differentials and build-up times obtained from the four sources — the rearmost axles of the tractor and first trailer, and the dolly axle and rearmost axle of the second trailer.

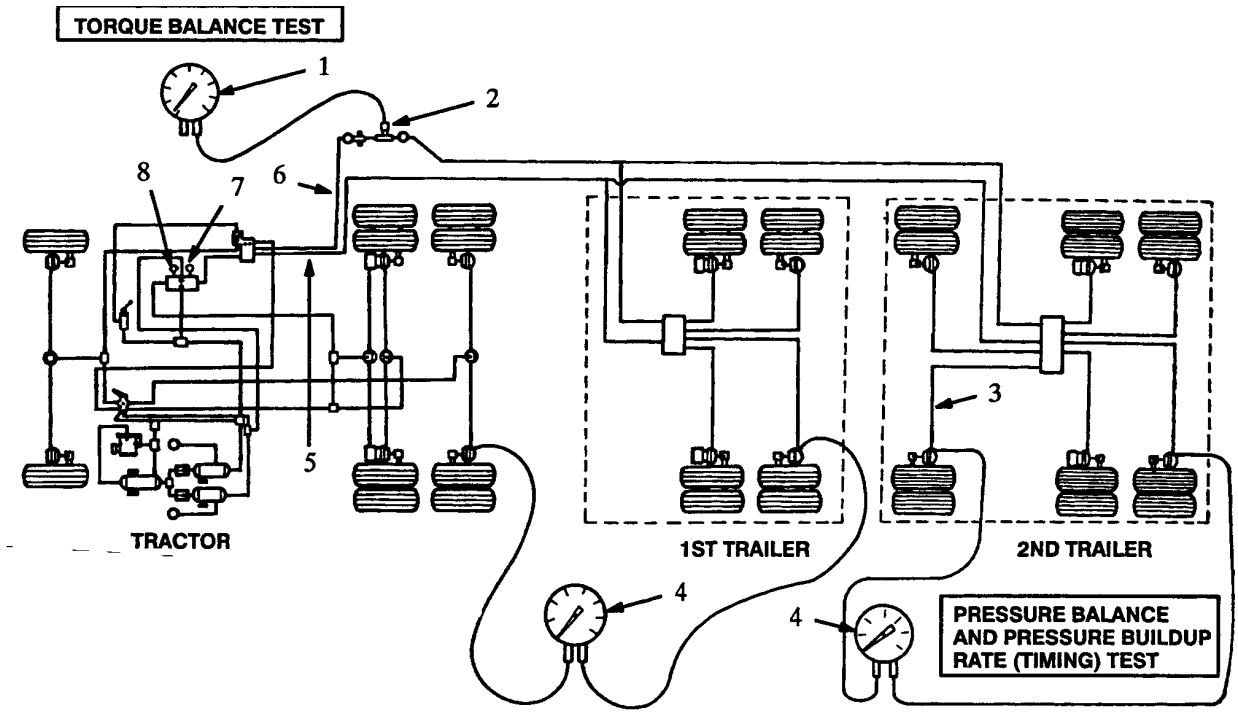

Figure 21 Test Connections-Multiple Trailers

1. DUPLEX GAUGE OR SINGLE GAUGE
2. DOUBLE GLADHAND ASSEMBLY
3. DOLLY AXLE
4. DUPLEX GAUGE
5. TRAILER EMERGENCY BRAKE SUPPLY
6. TRAILER SERVICE BRAKE SUPPLY
7. TRAILER SUPPLY CONTROL VALVE
8. PARK BRAKE CONTROL VALVE

Multiple-trailer combinations and their related complexity make it difficult to establish positive criteria. However, meeting the following guidelines should help optimize performance. For the **pressure balance** check, the average pressure difference between axles through the pressure range tested should fall within 4 psi (28 kPa) for optimum performance.

For the **pressure build-up rate** check, the maximum pressure difference (lead or lag) between axles should normally be no greater than 15 psi (103 kPa) before the pressures equalize.

Again, if the pressure balance and/or pressure build-up rate differences exceed the acceptable limit(s), refer to the DATA INTERPRETATION AND CORRECTIVE MEASURES SECTION .

Torque Balance Test

NOTE – If the pressure difference recorded for the pressure balance check exceeds the acceptable limit, the imbalance must be corrected before a Torque Balance Test is performed. However, if the pressure build-up rate indicates a problem condition, the Torque Balance Test can and should be conducted, especially if the operator's basic concern is that of uneven lining wear between tractor and trailer.

1. Mount a decelerometer (Figure 22) to the inside of windshield as follows:

Figure 22 Test Instrumentation (In-Cab)

1. DECELEROMETER
2. DUPLEX AIR GAUGE

a. Moisten the vacuum cups and press the decelerometer assembly to the windshield so it can be read by the observer.

b. Loosen the bracket lower clamp nut and adjust the decelerometer so that its sides are parallel to the direction of travel, then tighten the clamp nut.

c. Loosen the side adjusting clamp nut and adjust the vertical position so that the fluid registers zero when the truck is on level ground, then tighten the clamp nut.

2. Install the single or duplex air test gauge (Figure 22) and connections as follows:

a. Install the double gladhand assembly in the tractor to trailer service line (Figure 23).

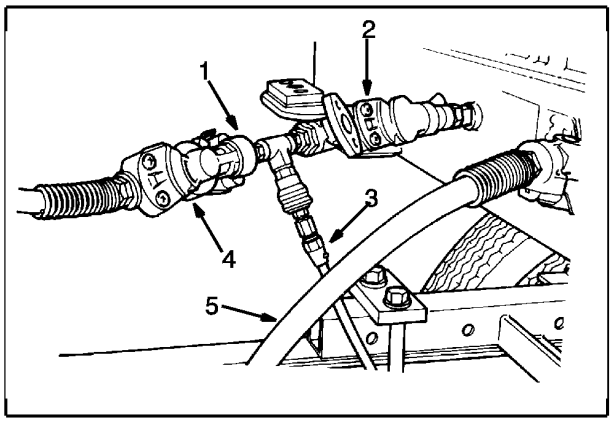

Figure 23 Double Gladhand Assembly Installation

1. DOUBLE GLADHAND ASSEMBLY
2. TRAILER SERVICE BRAKE CONNECTION
3. TO DUPLEX AIR GAUGE
4. TRACTOR SERVICE BRAKE CONNECTION
5. TRACTOR EMERGENCY BRAKE CONNECTION

b. Mount the single or duplex test gauge in the cab so it can be seen by both the driver and the observer.

c. Connect an air hose between the double gladhand assembly and the gauge.

d. Secure the air hose to the vehicle so that it will not snag when the vehicle is turned (Figure 24).

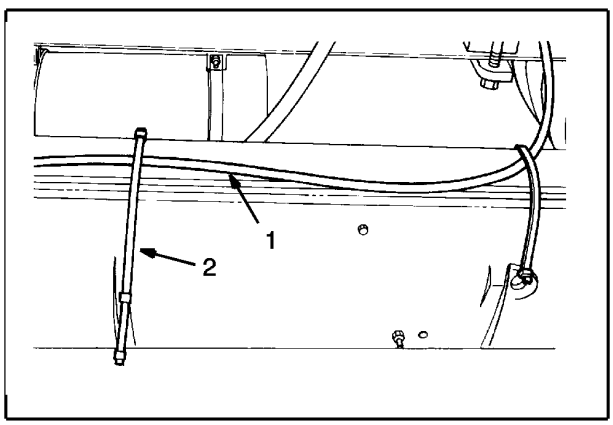

Figure 24 Gauge Test Hose Routing

1. AIR HOSE BETWEEN DOUBLE GLADHAND ASSEMBLY AND DUPLEX AIR GAUGE
2. NYLON TIE STRAP

3. Record the following Preliminary Data (vehicle information) on the Data Sheet (CTS-1033H) before initiating the test:

   a. Typical Weight (estimated) for normal maximum highway operation.

   b. Test Weight (actual axle weight or best estimate). The vehicle should be loaded to the extent that wheel lockup will not occur with a 40 psi (276 kPa) brake application at a test speed of 40 mph (64 kmh).

c. Initial Test Speed — if the recommended 40 mph (64 kmh) is not permitted in the area chosen for the test, the test speed for the snubs can be reduced to 30 mph. Whatever speed is used, it should be the same for each of the checks noted below.

4. Check the brake torque output of the tractor and trailer in combination and individually as follows:

NOTE – An observer should be used to record all data for these tests. Only the SUSTAINED decelerometer readings should be recorded and not the peak readings at the beginning and end of each step.

a. Tractor-Trailer Combination Torque Output

The initial step in evaluating the performance of a tractor-trailer is to determine whether the combination is capable of operating at its designed performance level.

While operating the tractor-trailer combination in a suitable test area, make three (3) stops from 40 mph (64 kmh) at 40 psi (276 kPa) brake application pressure. Record the sustained deceleration reading (to the nearest .5 ft./sec.^{2}) for each stop in the appropriate space on the Data Sheet.

b. Run three tests each at 15 and 40 psi control line pressure to establish average decel at each pressure level. If at 15 psi control pressure, both tractor and trailer run separately fail to produce 1.0 decel, advance to 20 psi. Tests include total combination, tractor only, trailer only. Total of tractor only plus trailer only should be within $\pm$ 1 decel of combination at 40 psi. Tests using pressure of 20 and 30 psi may be conducted as optional steps.

Determine the average for the three readings.

c. Tractor Torque Output

With the service brakes released, **close** the shut-off cock in the double gladhand connection between the tractor and trailer.

> **WARNING – Since closing the shut-off cock makes the trailer service brakes inoperative, allow more distance for stopping the combination vehicle. If possible, use a non-public area for conducting the test.**

Again, operate the tractor-trailer combination, this time using the tractor brakes only to make three (3) stops from 40 mph (64 kmh) at 40 psi (276 kPa) brake application pressure. Record the decelerometer readings on the Data Sheet; determine and record the average reading.

d. Trailer Torque Output

With the service brakes released, open the shut-off cock in the double gladhand assembly.

Again, operate the tractor-trailer combination and, using only the trailer hand control valve (Figure 25), make three stops from 40 mph (64 kmh) at 40 psi (276 kPa) and record the readings and average on the Data Sheet.

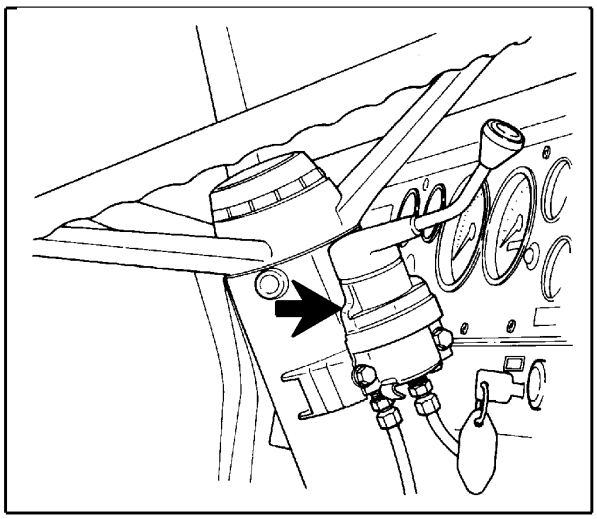

Figure 25 Trailer Hand Control Valve

NOTE — It may be helpful to preload the trailer air lines for smooth brake application and more accurate test results. This is accomplished by maintaining vehicle speed while lightly applying the hand control valve just prior to the test stop.

5. Add the average deceleration reading for the tractor to the average deceleration reading for the trailer.

   The sum should be within ± .5 ft./sec.² of the average deceleration reading obtained from the **combination** test. If not, the individual tractor and trailer torque output tests must be rerun.

Evaluating the Performance of Tractor and Trailer

1. From the test results, compute the Balance Ratio using the following formula:

Balance Ratio =
Typical Tractor Weight/Typical Trailer Weight X
Average Trailer Deceleration Rate/Average Tractor Deceleration Rate

NOTE – Typical Weights in the formula are those weights normally being carried by the vehicle. If a realistic estimate cannot be made, it is recommended that the tractor and trailer (with typical load) be weighed.

2. Record the Balance Ratio on the Data Sheet
   a. If the balance ratio is 1.00, the tractor-trailer combination is in ideal torque balance.
   b. If the balance ratio is below 0.75, the combination unit is out of balance and the tractor is providing more than its share of braking efforts.
   c. If the balance ratio is above 1.25, the trailer is providing more than its share of braking efforts.

5.4. DATA INTERPRETATION AND CORRECTIVE MEASURES

After the test, the data needs to be interpreted. Guidelines and concepts are provided below but it must be recognized that values which are acceptable depend on many factors. These factors include terrain, weather, operator and fleet preference, maintenance, and the tractor and trailer foundation brake and vehicle characteristics as well as the interrelationship of pressure balance, pressure build-up rate and torque balance.

Also, it must be remembered that data taken on one vehicle combination may or may not be representative of other units in a fleet.

Pressure Balance

Combination Units - A 4 psi (28 kPa) or less pressure differential is generally acceptable between the tractor rearmost axle and the trailer rearmost axle. Some users prefer to have a slightly higher pressure at the trailer than at the tractor. This may require special valves on the tractor.

For combinations involving multiple trailers, it is the preference of some operators to have lower pressure in the dolly axle brake chambers than at other axle brake chambers.

Individual Valves - If the pressure differential between the tractor and trailer brake chambers exceeds the above guidelines, the system should be checked for pressure drops across individual valves. This is accomplished by connecting air lines from the duplex test gauge to the inlet and outlet ports of the individual valves and checking the variation of input to output pressures at 5 psi (34 kPa) increments up to 30 psi (207 kPa).

Combination Unit Overview

The vast majority of brake applications are made at less than 30 psi (207 kPa). Due to this fact, minimizing pressure differentials between the tractor and trailer(s) brake chambers becomes very important if each axle is to do its share of braking the combination. For example, if on a specific brake application the drive axle receives 15 psi (103 kPa) and the trailer axle(s) only 8 psi (55 kPa), then the tractor brakes could be doing almost 50% more work in slowing the combination than the trailer brakes. Therefore, minimizing the pressure differentials on the trailer axle(s) is very important to optimize performance, wear and stability.

It is extremely difficult to obtain exactly the same pressure on all axles due to the additional valves used on each of the trailer axles. However, controlling differentials and maintaining them within the 4 psi (28 kPa) noted earlier is important.

NOTE – A point to remember is that the newer vehicles have good aerodynamic design and up-to-date technology on engine design. Also, the new designs and gear ratios on transmissions and differentials, not to mention the different types of lubricants, including synthetic lubricant all affect the vehicle when braking. The braking system has to work a lot harder with all these vehicle advancements than it did in the past. These factors should be considered when doing a brake test.

Pressure Build-Up Rate (Timing)

Tractors and trailers built since 1975 are required to meet FMVSS-121 application and release timing requirements. However, meeting these requirements does not insure timing compatibility. Evaluating the time it takes to build up pressure in the various axle brake chambers and the time to exhaust this pressure from these chambers takes sophisticated equipment normally not available to the user. If such a check is desired, the vehicle manufacturer should be contacted.

However, a general comparison of the pressure build-up rates in the tractor and trailer chambers can be checked by the procedure noted earlier. This check will give you an indication if the pressure build-up differential between the tractor and trailer is reasonable. Usually, there will be a difference (the trailer will usually be slower) due to the added piping and valves required to actuate the trailer brakes. Minimizing this difference is important in achieving combination compatibility. As noted earlier, maintaining this lag to 10 psi (69 kPa) or less should be the objective.

If the Pressure Build-Up Rate Test indicates the lag is not within the 10 psi (69 kPa) guideline, the system should be checked for restrictions in the lines and hoses, damaged fittings, or incorrect lines or fitting sizes. If no problem is noted, the individual valves should be checked for contamination and/or failed components.

Torque Balance

Normally, acceptable combination unit performance can be achieved with a tractor- trailer balance ratio of between .75 and 1.25.

If these guidelines are exceeded, the modifications to consider include:

1. If ratio is less than .75
   a. Increase the power of the trailer brakes - or
   b. Decrease the power of the tractor brakes.
2. If ratio is greater than 1.25
   a. Decrease the power of the trailer brakes - or
   b. Increase the power of the tractor brakes

   NOTE – A tractor-trailer combination (with each axle loaded to its GAWR) that meets the performance criteria for pressure balance and timing, and torque balance should also reach a 9-1/2 + 1 ft./sec.² deceleration (minimum) without any wheel lock from 40 mph (64 kmh) at 40 psi (276 kPa).

   Common causes of torque imbalance or lack of combination unit performance include:
3. Use of replacement parts, particularly linings, other than those originally specified.
4. Tractor and/or trailer brake torque output(s) not compatible with the loads being carried.
5. Lining contamination, poorly maintained brakes, and broken or malfunctioning brake components.
6. Brakes out of adjustment.

The trailer and/or tractor manufacturer should be consulted for any modifications to the respective trailer and/or tractor system that would cause deviation from the original specification.

The following test procedure and criteria are intended to supplement the preceding combination vehicle brake analysis procedure. The use of electronic test equipment and real world operating conditions have been taken into consideration in the scope of the changes and additions.

6. GLOSSARY OF BRAKE TERMINOLOGY

BRAKE ACTIVATION TIME:..... The length of time required for a given amount of air to start a mechanical movement in the brake system foundation brake.

BRAKE FADE:..... Denotes loss of vehicle brake effectiveness. Fade can be caused by mechanical deficiencies such as improperly fitted shoes, water or oil on the linings, or excessive heat.

COEFFICIENT OF FRICTION:..... The amount of force required to move one body while it remains in contact with another.

DECELERATION:..... The actual rate at which a moving body is losing speed; expressed by number of miles per hour or feet per second.

KINETIC (MOTION) ENERGY:..... Heat that is produced by friction during brake lining-rotor/drum contact while the vehicle is in motion (decelerating).

MODULATED PARKING (SPRING) BRAKE CONTROL:..... Referring to the fact that spring brakes are applied with some degree of control.

REACTION TIME:..... The time required from the operator's initial thought of stopping to the activation of the brake system.

7. SPECIAL TOOLS

7.1. TEST EQUIPMENT

The test equipment shown (Figure 26) is required to conduct the pressure balance, pressure build-up rate and torque balance tests. Order through PDC.

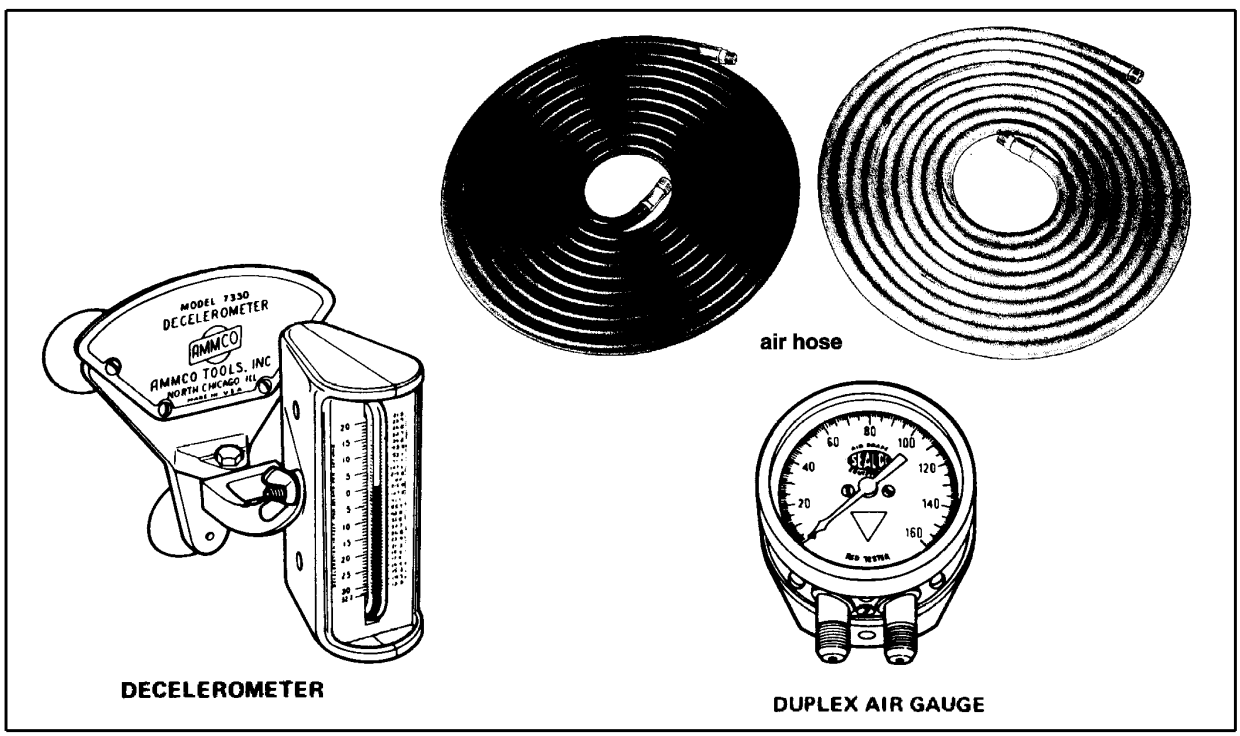

Figure 26 Air Brake Test Equipment

Tool Number

Decelerometer..... ZTSE 2210A
Duplex Gauge and Hoses..... ZTSE 2325A