

2012-04 – Hydraulic/Electric/Surge Brake System and Light-Duty Trailer Inspection Procedure

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Summary

This Inspection Bulletin describes inspection procedures and operating information for commercial motor vehicles and trailers with hydraulic and electric brake systems.

The inspection procedures described in this bulletin do not address every violation specified in the U.S. Federal Motor Carrier Safety Regulations (FMCSRs) Part 393 and Appendix A or the Canadian National Safety Code (NSC) Standard 11B. It is written to support roadside commercial motor vehicle inspections and is primarily intended to identify out-of-service (OOS) conditions.

An accompanying training video is available by logging into the CVSA member portal at www.cvsa.org/memberportal and selecting the “CVSA Learning” tab, and via the CVSA Out-of-Service Criteria app.

Inspection Procedure

The inspection procedure consists of five main steps.

1. Inspect wheel-end, under-vehicle and under-hood components.
 - a) Have the driver shut off the engine, chock the wheels and open the hood.
 - b) Referring to Addendum 3 as necessary, identify the type of hydraulic brake system in the vehicle.
 - c) Inspect the wheel-end brake components similar to an air braked vehicle. Also, inspect for brake fluid leaks at the brakes and inspect the brake hoses and tubing. When under the vehicle and under the hood, look for signs of leaking hydraulic fluid and damaged hydraulic lines and hoses. Pay close attention to components of the brake power-assist system (or brake power system, if so equipped) to determine if there are any leaks, or missing or damaged components. Confirm that wires are properly connected to the flow switch (Hy-Power/Hydro-Max), pressure differential switch and low brake fluid level sensors.
 - d) Inspect the level of brake fluid in the master cylinder reservoir(s). If the vehicle utilizes the power steering pump or special brake pump to provide hydraulic fluid to the power assist unit, inspect its reservoir as well. If it is necessary to remove the reservoir cap(s) to determine fluid level(s), have the driver do this. (See master cylinder reservoir(s) in Addendum 1.)

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2. Inspect the function of brake indicator lamp(s).

- a) With the engine stopped (ignition off), have the driver turn the ignition to the “on” or “run” position.
- b) Observe the location and operation of all brake indicators. All lamps should be on and stay on, with the exception of the Antilock Brake System (ABS) indicator, which will only remain on for 2-3 seconds as the system conducts a self-diagnostic check and then the indicator will go out.
- c) Have the driver start the engine, leave the key in the “on” position and release the park brake.
- d) Observe the brake indicator(s). All brake indicator lamps should go off.
- e) Have the driver apply the park brake while you observe the brake indicators. An indicator lamp must turn on to show that the park brake is applied.

3. Determine pedal reserve height and inspect the brake power-assist unit or brake power unit function.

- a) With the engine running, have the driver firmly apply the brake pedal (about 50 lbs of force) and hold it for approximately 10 seconds. Observe the brake indicator(s) and observe the height of the brake pedal above the floor.
- b) Inspect the operation of the brake power-assist unit or the brake power unit based on the specific procedure for the system being inspected. (See system-specific inspection procedures on the next page.*)

4. Inspect the parking/emergency brake.

- a) Ask the driver to apply the parking brake and attempt to move the vehicle in low forward gear without applying the throttle. The vehicle should not roll without resistance. (For manual transmissions, see NOTE below).
- b) Repeat with the driver using reverse gear and no throttle. The vehicle should not roll without resistance. (For manual transmissions, see NOTE below).

NOTE: For manual transmissions, have the driver put the vehicle in low forward or reverse gear and have the driver let out the clutch until it begins to engage. The throttle should not be applied.

- c) If the parking brake actuator utilizes air or hydraulic fluid to release the brake, inspect for leaks at the unit.

5. Inspect the function of the trailer brakes, if applicable (see Addendum 2).

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System-Specific Inspection Procedures for Power Assist Operation*

Vehicles with vacuum, hydraulic or air power-assist units (except those hydraulic assist systems using electric pump backup) – Have the driver turn off the engine and pump the brake pedal until all stored assist power is depleted. The pedal should get progressively harder and flow of the assist (vacuum, air or hydraulic fluid) should be heard as the assist “bleeds down.” This confirms that the backup is working. Once depleted, have the driver start the engine with his or her foot on the brake pedal and observe if the pedal height changes. A change in pedal height when the engine starts indicates that the assist is working. (See Addendum 3 – Type 1, 3, 4 and 5)

Vehicles with hydraulic power assist using electric pump backup – With the engine off and the ignition in the “on” position, have the driver apply the service brake. The backup electric pump should operate. An additional indicator lamp on the dash may illuminate when the electric pump backup is running and a buzzer may be heard; however, neither indication is required by the regulations. Next, have the driver start the engine. The backup motor and any backup pump indicators, if equipped, should shut off when the engine starts. This indicates that the brake power assist is working. (See Addendum 3 – Type 2)

Vehicles with dual full-power electro/hydraulic pumps and gas-filled accumulators (Meritor WABCO HPB) – Have the driver shut off the engine, return the ignition to the “on” position and pump the brake pedal. Flow of fluid from the accumulators should be heard. As pressures in the gas-filled accumulators drop, both brake fluid pumps should come on; although, not necessarily at the same time. (See Addendum 3 – Type 6)

Vehicles with air over hydraulic (full power) systems – Since this is considered to be an air brake system by standards FMVSS/CMVSS 121, the air components of the system should be inspected just like those in a full air brake system. There is no practical way to inspect the power units (which convert air pressure to hydraulic pressure) other than to be certain that they have adequate hydraulic fluid in the reservoirs and that any brake warning indicators are not illuminated. (See Addendum 3 – Type 7)

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Addendum 1 – General Information on Hydraulic Brake Systems

This addendum provides general information about inspecting hydraulic brake systems and components.

Background

There are several different types of hydraulic brake systems utilized on commercial motor vehicles. The differences have to do with the way each system translates the driver input at the brake pedal into hydraulic pressure at the brake wheel cylinders (drum brakes) or calipers (disc brakes). There are basically two fundamental approaches: (1) Power assist systems, where driver input force to the pedal is supplemented (assisted) to increase the force actuating the master cylinder or the pressure delivered by the master cylinder and (2) full power systems where the driver's input to the brake pedal controls the level of hydraulic pressure at the brakes, but the force at the pedal is not used to create the hydraulic brake pressure. The major difference is that power assist systems (also called power boosters) have a "push-through" capability, such that a failure in the assist unit still allows the driver to "push through" to actuate the master cylinder and develop brake pressure. Full power systems have no "push-through" capability.

The various types of power assist and full power systems used on hydraulically braked commercial motor vehicles are listed below and are described in detail in Addendum 3. Terms in parenthesis are manufacturer's trade names. All of these systems utilize hydraulically operated foundation (wheel-end) brakes.

Type 1. Vacuum Assist (Bendix Hydro-Vac)

Type 2. Hydraulic* Assist with Electric Pump Backup (Delco Hy-Power, Bosch/Bendix Hydro-Max)

Type 3. Hydraulic* Assist with Gas-Filled Accumulator Backup (Bosch/Bendix Hydro-Boost)

Type 4. Combined Hydraulic* and Vacuum Assist (Delco Dual Power)

Type 5. Air Assist

Type 6. Full Power Electro/Hydraulic with Gas-Filled Accumulator Backup (Meritor WABCO HPB)**

Type 7. Full Power Air Over Hydraulic ***

* Pressurized power-steering fluid is used to generate force that supplements the driver's input force to the master cylinder.

** Brake fluid in the accumulators is pressurized by an electric pump.

*** Brake fluid is pressurized by air. Defined by FMVSS/CMVSS 121 as an air brake system (FMVSS/CMVSS 105 does not apply).

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General Inspection Procedures

Despite the differences between the hardware and the operational modes of the various types of hydraulic brake systems used on commercial motor vehicles, a generalized inspection procedure can be utilized across all the systems.

The wheel-end, under-vehicle and under-hood portions of the inspection of vehicles with hydraulic brakes include many of the same items inspected when inspecting vehicles with air brakes (i.e. linings or pads, drums or discs, hoses, tubing, etc.). In addition, the specific type of hydraulic brake system on the vehicle is determined and the level of fluid in the reservoirs containing hydraulic brake fluid and brake power assist unit fluid (power steering fluid) is inspected.

Inspecting the brake indicator lamps is somewhat different in that there may be multiple lamps for the brake system. FMVSS/CMVSS 105 requires a brake indicator lamp that must come on if either brake fluid level is low or there is excessive pressure differential in the system. This can be implemented with one lamp or two separate lamps. The standards also require a lamp function to indicate that the parking brakes are applied (Note: not a requirement with air brakes) and this can be a separate lamp or combined with the previously mentioned brake indicator lamp. If the vehicle is required to have (antilock brake system) ABS, a separate ABS malfunction indicator lamp will be present. All required indicator lamps must illuminate when the ignition is turned to the “on” position prior to starting the engine. There may also be lamps related to the power assist function, but because there are no regulatory requirements for these, they are not part of this inspection process.

Inspecting the brake pedal height involves determining if the pedal has sufficient travel reserve when it is applied with moderate force. Also during this phase of the inspection, tests are run to determine if the brake power assist or brake power units are functioning properly. At this point in the inspection it is important to know the type of hydraulic brake system on the vehicle because the procedure used varies depending on the configuration of the brake power-assist unit or the brake power unit. Refer to Addendum 3 to help identify the system type.

The parking brake is tested by putting the transmission in gear in both forward and reverse with the throttle released (engine at idle) to determine if the vehicle moves.

ABS Requirements

Prior to March 1, 1999 (U.S.) and April 1, 2000 (Canada), buses and trucks were not required to be equipped with ABS. The malfunction lamps on vehicles equipped with ABS manufactured before it was mandatory, operate in a variety of ways depending on the vehicle manufacturer. In some cases, the vehicle must travel up to 5 mph (7 km/h) to turn out the ABS malfunction lamp. Since this was not a regulated requirement at the time of manufacture, these vehicles are not subject to inspection for ABS system violations. For complete ABS inspection information on vehicles requiring ABS, refer to the CVSA Antilock Brake System (ABS) Inspections Inspection Bulletin.

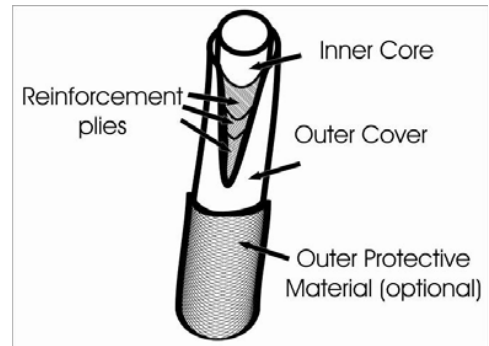
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Inspection of Specific System Components

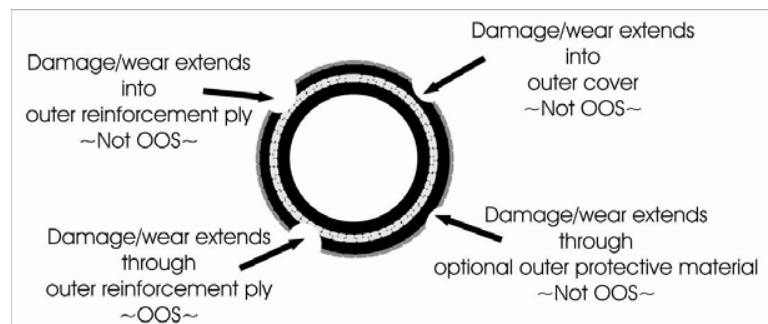
This section provides guidance on proper inspection of specific hydraulic brake system components. These inspection points are generally common to all the systems.

Brake Lines/Tubing and Hoses

Hydraulic brakes are applied by hydraulic fluid pressure distributed to the calipers or wheel cylinders through a series of steel brake lines and flex hoses. Flex lines are constructed with layers of material, as shown in the diagram. An inner core is surrounded by reinforcement layers made of fabric or steel, normally surrounded by an outer cover. There may also be a layer of outer protective material.



The inspection criteria indicate that the hose must be damaged through the outer reinforcement ply (or layer) in order to be OOS. When inspecting flex lines, utilize the following diagram to determine the severity of the condition.



Master Cylinder Reservoir(s)

All hydraulic vehicles have a master cylinder with a dual or single reservoir to house the hydraulic brake fluid. Some master cylinder fluid levels can be observed without removing the cap(s)/lid.

In the event that the fluid level cannot be detected without removal of the cap(s)/lid, inspectors should not remove the cap(s)/lid unless there is evidence during the inspection that a leak is present or there is some other condition representing a low fluid level. Removal of a cap(s)/lid presents a risk of contaminating the fluid.

If cap(s)/lid must be removed, the inspector should always have the driver remove and replace the cap or lid and instruct the driver to exercise caution when doing so.



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Brake Indicator(s) Requirements on Vehicles Having GVWR Above 10,000 lbs (4,536 kg)

All vehicles must have visual indicators to warn the driver of certain types of brake status, failure or malfunction. Brake system indicators have the following features:

- Brake indicators are in the form of two or more lamps on the instrument panel.
- A standard symbol can be used for brake indicators or the word “brake” can be used to explain lamp function.
- In some cases, a separate indicator lamp may be used for the ABS and a different symbol is used.
- One lamp is required and more are permitted for brake functions other than ABS.
- Lamps must be clearly visible in daylight conditions.
- Lamps may be either constantly burning or flashing.
- Lamps can also be accompanied by an audible indicator (alarm).
- The symbol, letters and background of a brake indicator must be of contrasting colors, one of which is red; except for the ABS indicator, which uses amber as the contrasting color.



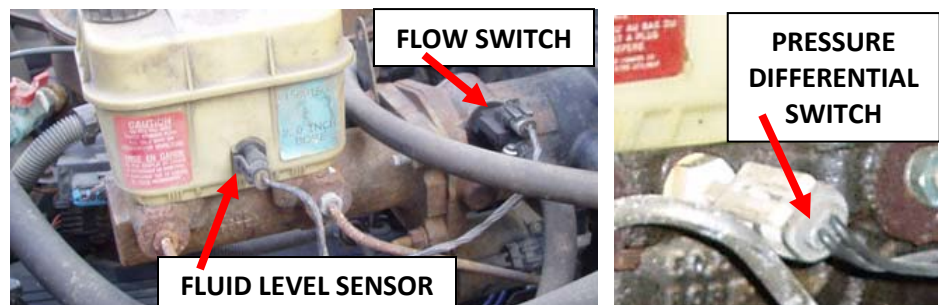
Except for the ABS indicator, the vehicle manufacturer has the option of combining brake indicators into a single lamp, splitting them or combining them in different ways. For example, the parking brake indicator may be combined with the warning for hydraulic failure.

The vehicle shown in this photo has four separate brake indicator lamps and an ABS indicator lamp.



Sensors/Switches

Wires and connections to flow switch, pressure differential switch and fluid level sensor must be securely attached.



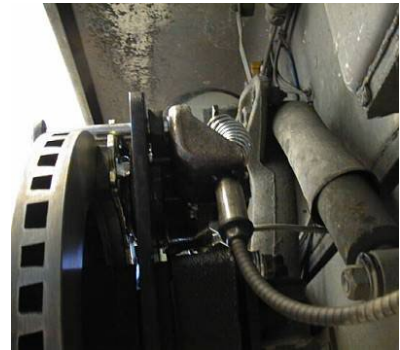
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Parking/Emergency Brake

Commercial motor vehicles must have a parking brake that is applied mechanically and is capable of holding the vehicle stationary. The parking brake can be located at the wheels or on the vehicle driveline. The parking brake is released by mechanical or hydraulic means, or by using compressed air.



Example of a driveline type and wheel type parking brake



Parking/Emergency Brake Controls

The parking brake actuator on lighter vehicles often consists of a lever capable of locking in the applied position using a latch or an over-center mechanism. The control may be floor mounted and operated by foot or mounted above the floor and operated by hand. This type of parking brake uses one or more cables to connect to a driveline brake or to brakes at the wheels.

The parking brake on heavier vehicles may consist of a hydraulic or air control that directs either pressurized fluid or compressed air to the parking brake to release it. The brake is held on by spring force so loss of the pressurized fluid or compressed air causes the brake to apply automatically. A brake that is spring applied with hydraulic release may be described with the acronym SAHR. A brake that is spring applied with air release may be described with the acronym SAAR (this is not considered an air-over hydraulic system).

A lever-actuated cable type parking brake uses fewer components than the SAHR or SAAR type; which require either a hydraulic pump or air compressor, lines and hoses, and actuators at or near the brake.



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Parking Operating Features

SAHR systems use hydraulic fluid from a hydraulic pump that may also be used for power steering and for boosting the service brakes. These systems may also have canisters mounted under the vehicle connecting to linkage. SAHR systems can be used to operate either a driveline or wheel-type parking brake.

This is an example of an SAHR system produced by Meritor Wabco. The actuator is mounted to the frame rail and operates a driveline brake.



This is an example of a SAHR produced by Lucas-Girling that is mounted at the wheel.

SAAR systems require an air compressor, air tank, an air control valve and normally also have an air pressure gauge and low air-pressure warning device. These systems should not be confused with air over-hydraulic brake systems or full air brake systems. SAAR systems can be used to operate either a driveline or wheel-type parking brake.



This is an example of SAAR that uses an actuator mounted to the frame rail.

NOTE – Service Brake Lock

A service brake lock is not considered a parking brake. They are intended to lock the brake fluid in the brake lines to the wheel brakes. Tow trucks often have this device; it allows them to hold the service brakes applied without applying the foot brake. Due to the fact that this is still using the service brake system, it is not a parking brake. A parking brake system has to be a completely separate means of braking.



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Addendum 2 – Inspection Information for Trailer Brake Systems

Trailer Brakes

When hydraulic-braked power units are towing a trailer heavy enough to require brakes, these trailers should be equipped with one of two types of braking systems. These systems, whether electric or hydraulic, must be in good working order and must adequately stop and hold the vehicle. If the trailer is required to have brakes, inspect the brakes and apply the OOS criteria, if applicable.

Electric Trailer Brakes

An electric brake controller is not a requirement of the regulation but is often mounted in the tow vehicle (usually under the dashboard, within easy reach of the driver). This controller takes 12 volts DC from the tow vehicle's electrical system and sends it back to the trailer brakes through a wiring system. The brake controller is tied directly into the tow vehicle's wiring and sends power back to the trailer brakes only when activated. It can be activated two ways, by the driver stepping on the brake pedal or by using the manual actuation lever or button.



When power is sent back to the trailer, the trailer brakes energize and the trailer brakes slow the trailer down. Electric brakes function with a magnet mounted inside the wheel hub assembly that, when energized, will contact the drum surface which causes the brake shoes to move outward toward the drum and push against it. Inspect the wires to each wheel and the condition of the drums and brake linings, where visible.



When inspecting a trailer with electric brakes, have the driver activate the manual brake controller at the current setting and put the vehicle in drive. An inspector should position themselves by the wheels of the trailer, there may be a humming sound from the magnets and the brakes should activate on the trailer once the vehicle has pulled ahead about a full turn of the wheel.



If the trailer is equipped with a breakaway device, this device will be attached to a cable that must be attached to the power unit and when pulled, this device will apply the trailer brakes. To inspect the electric trailer breakaway device, have the driver disconnect the power supply from the towing vehicle and verify the power supply (battery) for the trailer is present. Have the driver activate the breakaway device by pulling the plunger/pin and secure it (instruct the driver to observe how it was removed so it can be put back in). If the driver cannot or refuses to pull the pin/plunger, the breakaway is deemed inoperative. Have the driver return to the power unit and pull ahead; observe evidence of brake application of the trailer brakes (approximately a full turn of the wheel). Wheel lock up is not required.

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Inspecting the Trailer Brake Controller (TBC) 2005 Ford SuperDuty Vehicles

The Ford integrated trailer brake controller (TBC) is more advanced and capable than other controllers in the market as it uses multiple pieces of vehicle information to provide smoother and more balanced stops proportional to how the vehicle is braking. It adapts to a broad variety of driving scenarios and provides significantly advanced diagnostic capabilities. The TBC output voltage also is adjusted according to the gain setting. For lower gain settings (which are assumed to be the case of a lightly loaded trailer), the output voltage can be very low. For a gain setting of zero, the voltage will be zero.

The Ford TBC manual activator is to be used to calibrate the appropriate gain setting of the TBC. This gain setting determines the maximum available output to the electric brakes. Calibration is performed by driving at speeds between 15 and 25 mph (24 and 40 km) and manually activating the trailer brakes. If they lock up, the driver is to tune the gain setting down to the level just below wheel lockup. For a heavy trailer, the gain setting may be set high and for a lightly loaded trailer, the gain setting may be low; but these also will depend upon road conditions. This is the primary and only suggested use by Ford for manual operation of the TBC. In addition, the Ford TBC is capable of detecting and indicating certain faults in the tow vehicle wiring and the trailer wiring/brake system to the operator.

At zero speed, the trailer brakes are operable with the Ford TBC by activating the towing vehicle brakes and, therefore, satisfy all applicable brake operating regulations. The trailer brakes will be controlled and operate as designed, but not at the application level that can be expected from aftermarket TBCs due to the circumstances noted above.

To test the Ford TBC system, the vehicles should be at rest. Set the controller gain to maximum (10.0 for the Ford TBC) and manually activate the controller with vehicle in park. Have the inspector kneel beside the trailer axles and listen for the "hum" an electric trailer brake will produce when current is being sent. If the hum is present, the trailer brakes are operating and the Ford TBC is sending its speed-adjusted output.



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Surge-Type Trailer Brakes

Surge brakes work using the deceleration force present as the tow vehicle stops. When the driver applies the foot brake on the commercial motor vehicle, the surge brakes' internal master cylinder compresses against the drawbar body, forcing brake fluid through the brake lines to the wheel cylinders forcing the brake shoes to apply against the drum. Surge brakes are more common on lighter trailers, but they can be found on heavy trailers as well.

There is a master cylinder located on the tongue of the trailer that must have fluid present for the brakes to work. Inspect the steel lines and/or flex lines to each wheel and the condition of the drums and brake linings, where visible.

If cap(s)/lid must be removed, the inspector should always have the driver remove and replace the cap or lid and instruct the driver to exercise caution when doing so.

If the trailer is equipped with a breakaway device, it will be on the tongue or a handle on the tongue of the trailer that must have a cable attached to the power unit. When the cable is pulled during a breakaway, hydraulic fluid from the master cylinder applies the trailer brakes. Inspect the cable to ensure it is connected to the towing vehicle but do not activate the breakaway device during the inspection.

Some systems are equipped with an override feature for backing up the trailer. If equipped, ensure that the feature is not engaged.



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Ball Hitch Trailer Procedure

When conducting the trailer brake test, if there is excessive play observed in the hitch with forward and rearward movement, ensure the movement is not being caused by a loose ball hitch. If the ball hitch is loose, declare the vehicle OOS for a loose ball hitch.

If the trailer hitch is marked so you can determine what size ball hitch is required, conduct the following procedure:

- Place chock blocks ahead and behind the trailer wheels.
- Have the driver lower the trailer jack.
- Have the driver raise the hitch from the ball high enough to examine the ball hitch for a size marking or, in the case of no marking, to take a measurement of the diameter of the ball.



Clear – 2 5/16"



Worn but still visible
2 5/16"



Worn – Not Visible

If the hitch is not marked to determine the required size of ball hitch, the mismatched ball hitch OOS condition cannot be determined, and the vehicle will not be placed OOS. There is no out-of-service condition for a measurable amount of play in the ball hitch.

If your agency has a policy NOT to uncouple trailers from power units for any reason, the OOS condition for a mismatched ball hitch cannot be determined other than in a post-crash situation.

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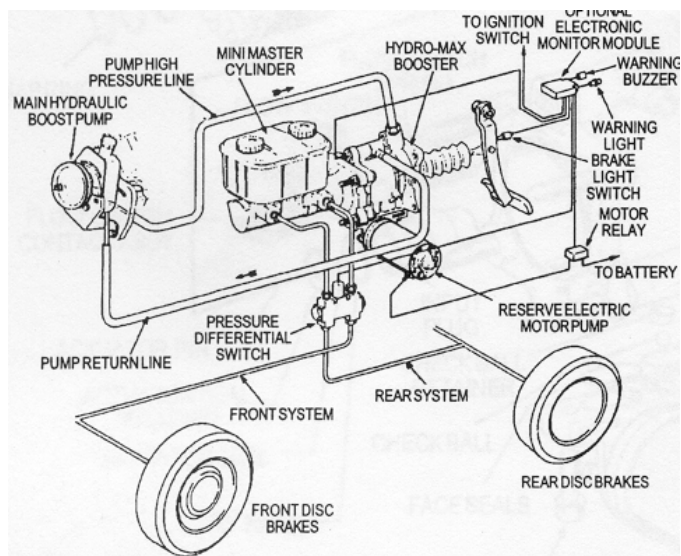
Hydraulic Assist System with Electric Pump Backup (Hy-Power, Hydro-Max)

These firewall-mounted systems utilize pressurized power steering fluid from the power steering pump or a separate engine-driven pump. The system is acting on a piston in concert with the master cylinder pushrod to supplement the drivers input force to the master cylinder.

The fluid pressure level in the assist unit behind the piston is controlled by the brake pedal (the harder the driver pushes, the higher the assist force). In the event there is no fluid flow from the main pump, there is a backup system consisting of an electric motor-driven pump that provides power assist. When fluid flow drops below a predetermined level, a flow switch activates the backup electric pump upon brake application.

Once activated, the backup electric pump will circulate power steering fluid into the power assist unit. This provides assisted braking, but at approximately a 50 percent reduction in the normal braking rate (deceleration) over the power assist unit. If the power assist unit fails as a result of the engine stalling and the backup electric pump is not functioning, or the system runs out of power steering fluid, the remaining braking capability available to the operator is extremely low.

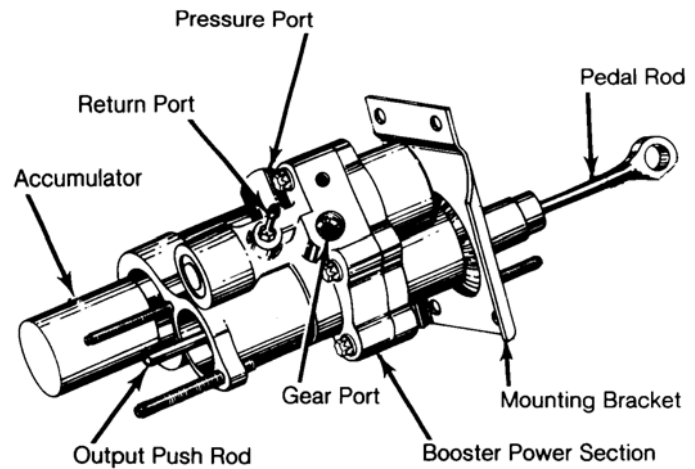
Most vehicles have an indicator light on the dash that illuminates when the backup pump is running and may also have an audible alarm. Such indicators and alarms are not required by FMVSS/CMVSS 105.



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Hydraulic Assist System with Gas Accumulator Backup (Hydro-Boost)

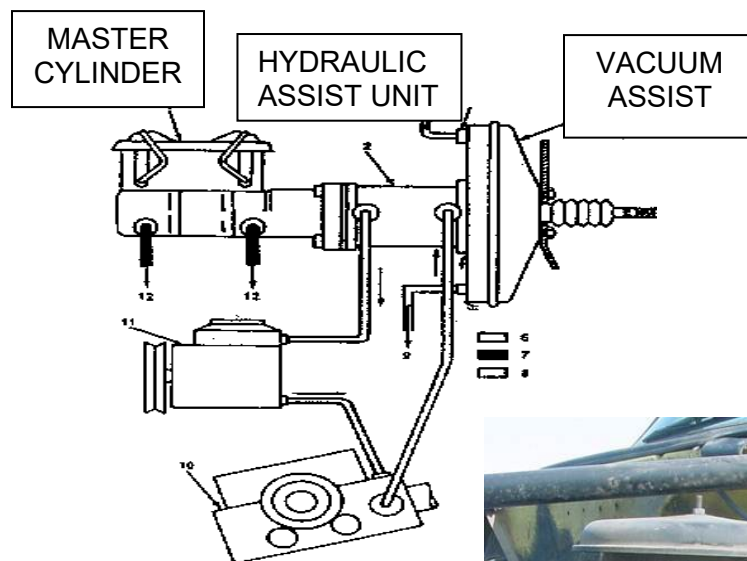
These firewall-mounted systems utilize pressurized power-steering fluid from the power steering pump acting on a piston in concert with the master cylinder pushrod to supplement the driver's input force to the master cylinder. The fluid pressure level behind the piston in the assist unit is controlled by the brake pedal (the harder the driver pushes, the higher the assist force). Backup is provided by a gas-filled accumulator, charged by the power steering pump that pressurizes the assist piston for a few brake applications if the fluid flow from the power steering pump is disrupted. This system is typically used on lighter weight vehicles where the "push through" capability can still provide significant braking even after the accumulator backup is depleted.



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Combination Hydraulic and Vacuum Assist (Dual Power) System

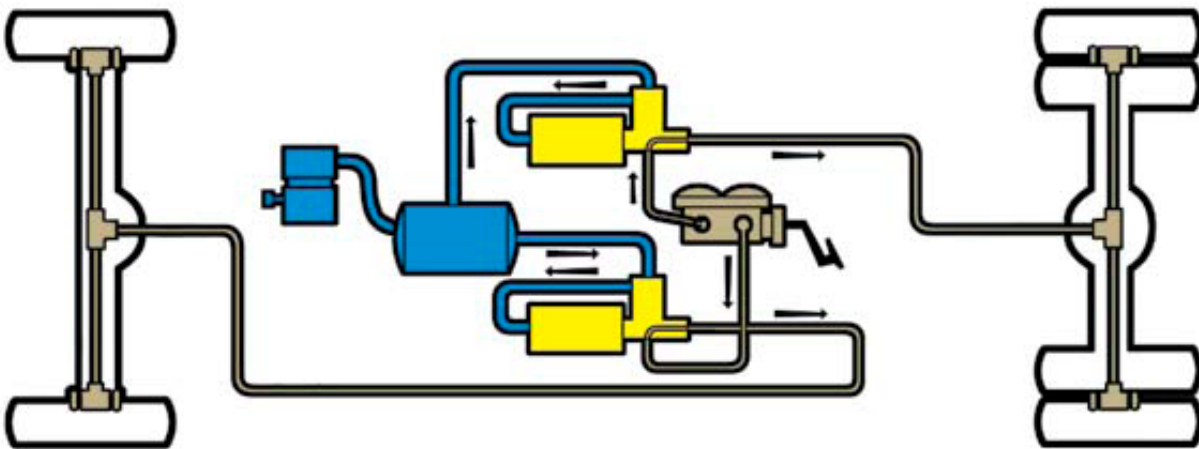
These firewall-mounted systems utilize pressurized fluid from the power steering pump acting on a piston as well as engine vacuum acting on a diaphragm (both in series with the master cylinder pushrod) to supplement the driver's input force to the master cylinder. The fluid pressure level behind the hydraulic unit piston and the vacuum level acting on the diaphragm are controlled by the brake pedal (the harder the driver pushes, the higher the assist forces). Backup is essentially provided by the redundancy of two independent assist units and the vacuum stored in the vacuum unit. In the event the engine were to stall, both engine vacuum supply and hydraulic pressure would be lost but the stored vacuum in the vacuum unit would be held by the check valve, allowing a few brake applications with vacuum assist. After that, only "push-through" capability would be available.



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Air Assist System

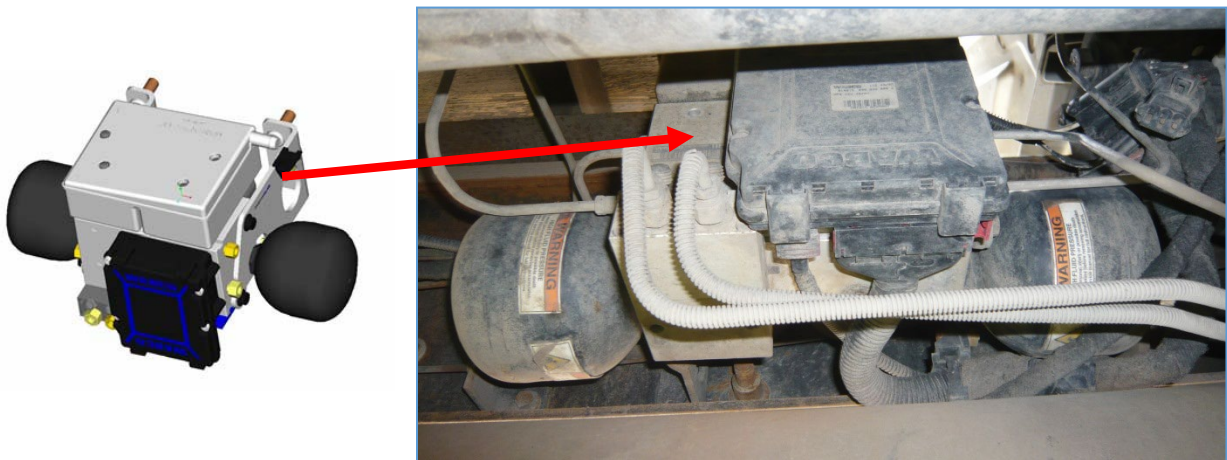
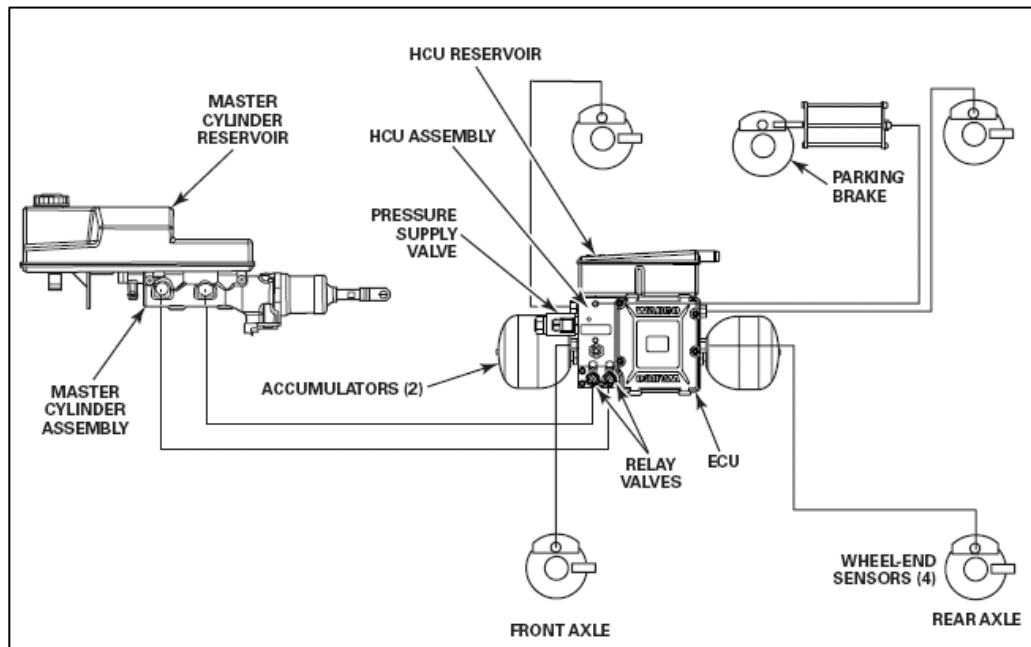
These systems, which are somewhat similar to vacuum assist systems, utilize pressurized air from a compressor and reservoir to operate a diaphragm or piston that increases the hydraulic brake pressure. Due to the air pressure being much higher (100 psi or more) than vacuum (less than -15 psi), the pistons or diaphragms can be much smaller. The air pressure level in the assist unit is controlled by the brake pedal (the harder the driver pushes, the higher the assist force). These systems have a “push-through” capability (brake pressure can be developed at a reduced level if the air pressure is not available) and may utilize two assist units for redundancy. The primary differences between an air assist system and an air over hydraulic system are the push through capability of the air assist system and the fact that the air assist system utilizes a hydraulic master cylinder to control the pressure intensifiers instead of an air brake valve.



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Full Power System with Electrically Driven High-Pressure Pumps and Gas-Pressurized Accumulators (Meritor WABCO HPB)

These systems, which are considered brake power units as opposed to brake power assist units, utilize two electric motor-driven pumps to pressurize two gas-filled accumulators with brake fluid. They have no “push-through” capability. The frame-mounted compact hydraulic power unit (HCU), controlled by a firewall-mounted master cylinder, meters the brake fluid directly to the brakes. Backup is provided by the redundancy of the pump units in the HCU as well as stored pressure in the two independent accumulators.



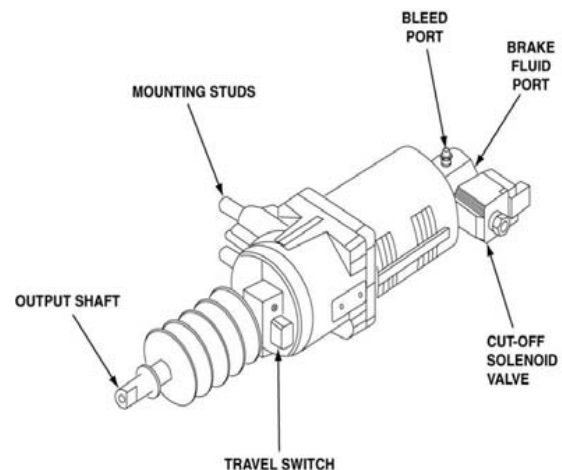
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Full Power System with Electrically Driven High-Pressure Pumps and Gas-Pressurized Accumulators (Meritor WABCO HPB) - continued



This is the firewall-mounted master cylinder.

The Meritor Wabco HPB system may be coupled with a spring applied/hydraulically released (SAHR) parking brake actuator operating a driveshaft brake. Hydraulic pressure to release this actuator is provided by the same electric pumps that provide the pressure to actuate the service brakes.



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Air over Hydraulic Brake System

While this system could be considered a full-power hydraulic brake system because it has no push through capability, safety standards FMVSS/CMVSS 121 define it as an air brake system and they govern its performance. This type of system utilizes frame-mounted units that contain an air chamber attached to a master cylinder. Air is supplied and controlled much the same way it is in an air brake system except that air from the foot valve goes to the actuator (brake chamber) acting on the master cylinder which then converts air pressure in to the hydraulic pressure that applies the brakes. Vehicles built after 1975 must have a split air system and two independent air to hydraulic pressure converters to meet the emergency brake requirements of the standard.

